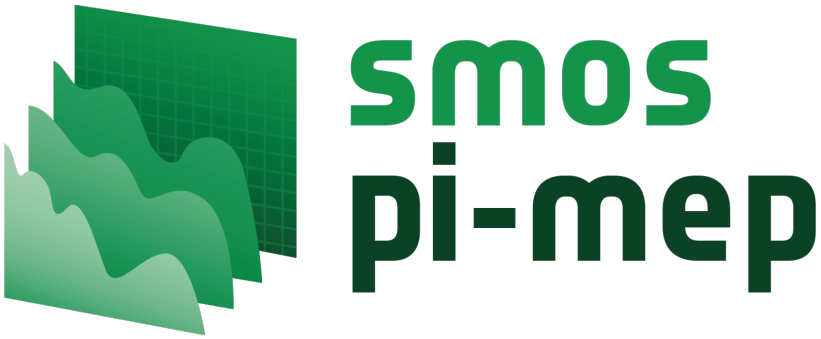


In Situ database Analyses Report

prepared by the Pi-MEP Consortium

June 15, 2023

Contents

Acronym

Aquarius	NASA/CONAE Salinity mission
ASCAT	Advanced Scatterometer
ATBD	Algorithm Theoretical Baseline Document
BLT	Barrier Layer Thickness
CMORPH	CPC MORPHing technique (precipitation analyses)
CPC	Climate Prediction Center
CTD	Instrument used to measure the conductivity, temperature, and pressure of seawater
DM	Delayed Mode
EO	Earth Observation
ESA	European Space Agency
FTP	File Transfer Protocol
GOSUD	Global Ocean Surface Underway Data
GTMBA	The Global Tropical Moored Buoy Array
Ifremer	Institut français de recherche pour l'exploitation de la mer
IPEV	Institut polaire français Paul-Émile Victor
IQR	Interquartile range
ISAS	*In Situ* Analysis System
Kurt	Kurtosis (fourth central moment divided by fourth power of the standard deviation)
L2	Level 2
LEGOS	Laboratoire d'Etudes en Géophysique et Océanographie Spatiales
LOCEAN	Laboratoire d'Océanographie et du Climat : Expérimentations et Approches Numériques
LOPS	Laboratoire d'Océanographie Physique et Spatiale
MDB	Match-up Data Base
MEOP	Marine Mammals Exploring the Oceans Pole to Pole
MLD	Mixed Layer Depth
NCEI	National Centers for Environmental Information
NRT	Near Real Time
NTAS	Northwest Tropical Atlantic Station
OI	Optimal interpolation
Pi-MEP	Pilot-Mission Exploitation Platform
PIRATA	Prediction and Researched Moored Array in the Atlantic
QC	Quality control
R_{sat}	Spatial resolution of the satellite SSS product
RAMA	Research Moored Array for African-Asian-Australian Monsoon Analysis and Prediction
r^2	Square of the Pearson correlation coefficient
RMS	Root mean square
RR	Rain rate
SAMOS	Shipboard Automated Meteorological and Oceanographic System
Skew	Skewness (third central moment divided by the cube of the standard deviation)
SMAP	Soil Moisture Active Passive (NASA mission)
SMOS	Soil Moisture and Ocean Salinity (ESA mission)
SPURS	Salinity Processes in the Upper Ocean Regional Study
SSS	Sea Surface Salinity
SSS_{insitu}	*In situ* SSS data considered for the match-up

SSS_{SAT}	Satellite SSS product considered for the match-up
ΔSSS	Difference between satellite and *in situ* SSS at colocalized point (ΔSSS = SSS_{SAT}- SSS_{insitu})
SST	Sea Surface Temperature
Std	Standard deviation
Std*	Robust Standard deviation = median(abs(x-median (x)))/0.67 (less affected by outliers than Std)
Stratus	Surface buoy located in the eastern tropical Pacific
Survostral	SURVeillance de l'Océan AuSTRAL (Monitoring the Southern Ocean)
TAO	Tropical Atmosphere Ocean
TSG	ThermoSalinoGraph
WHOI	Woods Hole Oceanographic Institution
WHOTS	WHOI Hawaii Ocean Time-series Station
WOA	World Ocean Atlas

1 Overview

This report presents some characteristics of the 6 major types of *in situ* datasets (Argo, Marine mammals, Surface drifters, Saildrones, TSG, Moorings) used by the Pi-MEP to validate SMOS, SMAP and Aquarius satellite SSS products. Salinity data from various sensors coming from 2 scientific campaigns SPURS-2 and EUREC4A have also been added, as well as a compilation of 4 different salinity datasets ICES. For each *in situ* datasets, a series of plots show:

- Number of SSS data as a function of time and distance to coast
- Histogram of shallowest salinity and pressure (if relevant)
- Temporal mean of shallowest salinity pressure measurements (if relevant)
- Spatial density of shallowest salinity
- Spatial Maps of the Time-mean and temporal Std of *in situ* and satellite SSS and of the ΔSSS
- Time series of the monthly median and Std of *in situ* and satellite SSS and of the ΔSSS
- Zonal mean and Std of *in situ* and satellite SSS and of the ΔSSS
- Scatterplots of ISAS vs *in situ* SSS by latitudinal bands
- Time series of the monthly median and Std of the ΔSSS sorted by latitudinal bands
- ΔSSS sorted as function of geophysical parameters
- ΔSSS maps and statistics for different geophysical conditions

1.1 *In situ* datasets

The following table resumes some characteristics (number of points, first and last date, minimum, maximum and mean value of the SSS distribution) of the different *in situ* datasets used by the Pi-MEP.

***In situ* datasets**	#	$\mathbf{Time}_{min}$	$\mathbf{Time}_{max}$	$\mathbf{S}_{min}$	$\mathbf{S}_{max}$	$\mathbf{S}_{Mean}$
Argo	1742042	01/01/2010	01/05/2023	2.14	40.48	34.73
Marine mammals	348682	01/01/2010	19/11/2019	4.07	36.97	33.95
Surface drifters	2215429	01/01/2010	22/09/2020	1.03	44.22	35.62
Saildrone	914382	02/09/2017	07/11/2022	0.00	39.29	33.31
TSG (LEGOS-DM)	8095635	01/01/2010	28/12/2021	0.03	42.74	34.58
TSG (GOSUD-Research-vessel)	5799920	05/01/2010	30/12/2020	0.01	42.00	35.66
TSG (GOSUD-Sailing-ship)	1727960	08/01/2010	28/01/2021	0.01	42.00	34.09
TSG (SAMOS)	31820461	07/01/2010	23/04/2023	5.03	39.80	32.86
TSG (CSIC-UTM)	2869180	05/01/2010	06/12/2022	0.57	40.29	35.60
TSG (Polarstern)	504269	01/01/2010	11/10/2020	20.30	37.75	34.08
TSG (NCEI-0170743)	590389	08/12/2010	02/02/2017	32.41	35.78	34.26
TSG (LEGOS-Survostral)	654661	01/01/2010	02/03/2020	22.67	35.73	34.17
TSG (LEGOS-Surv-Adel)	38903	09/01/2010	25/01/2012	28.14	34.37	34.04
Moorings	7085913	01/01/2010	09/05/2023	27.02	37.81	35.02
Salinity Snake (SPURS 2)	3428541	20/08/2016	13/11/2017	24.04	34.34	33.12
Saildrone (SPURS 2)	9218	16/10/2017	17/11/2017	30.75	33.85	33.29
Waveglider (SPURS 2)	642340	24/08/2016	10/11/2017	27.48	34.47	33.51
Seaglider (SPURS 2)	73542	24/08/2016	07/11/2017	28.99	34.86	33.27
EUREC4A	267680	01/01/2020	30/03/2020	30.20	37.31	35.75
ICES	2257228	06/01/2010	02/12/2022	0.01	39.94	30.10
Total	71086375	01/01/2010	09/05/2023	0.00	44.22	34.05

1.1.1 Argo

Argo is a global array of 3,000 free-drifting profiling floats that measures the temperature and salinity of the upper 2000 m of the ocean. This allows continuous monitoring of the temperature and salinity of the upper ocean, with all data being relayed and made publicly available within hours after collection. The array provides around 100,000 temperature/salinity profiles per year distributed over the global oceans at an average of 3-degree spacing. Only Argo salinity and temperature float data with quality index set to 1 or 2 and data mode set to real time (RT), real time adjusted (RTA) and delayed mode (DM) are considered in the Pi-MEP. Argo floats which may have problems with one or more sensors appearing in the grey list maintained at the Coriolis/GDACs are discarded. Furthermore, Pi-MEP provides an additional list of ∼1000 "suspicious" argo salinity profiles that are also removed before analysis. The upper ocean salinity and temperature values recorded between 0m and 10m depth are considered as Argo sea surface salinities (SSS) and sea surface temperatures (SST). These data were collected and made freely available by the international Argo project and the national programs that contribute to it (Argo (2023)).

1.1.2 Marine mammals

Instrumentation of southern elephant seals with satellite-linked CTD tags proposes unique temporal and spatial coverage. This includes extensive data from the Antarctic continental slope and shelf regions during the winter months, which is outside the conventional areas of Argo autonomous floats and ship-based studies. The use of elephant seals has been particularly effective to sample the Southern Ocean and the North Pacific. Other seal species have been successfully used in the North Atlantic, such as hooded seals. The marine mammal dataset (MEOP-CTD database) is quality controlled and calibrated using delayed-mode techniques involving compar-

isons with other existing profiles as well as cross-comparisons similar to established protocols within the Argo community, with a resulting accuracy of ±0.03 °C in temperature and ±0.05 in salinity or better (Treasure et al. (2017)). The marine mammal data were collected and made freely available by the International MEOP Consortium and the national programs that contribute to it (http://www.meop.net). This dataset is updated once a year and can be downloaded here (Roquet et al. (2021)). A preprocessing stage is applied to the database before being used by the Pi-MEP which consists in keeping only profiles with salinity, temperature and pressure quality flags set to 1 or 2 and if at least one measurement is in the top 10 m depth. Marine mammal SSS corresponds to the top (shallowest) profile salinity data provided that profile depth is 10 m or less.

1.1.3 Surface drifters

The skin depth of the L-band radiometer signal over the ocean is about 1 cm whereas classical surface salinity measured by ships or Argo floats are performed at a few meters depth. In order to improve the knowledge of the SSS variability in the first 50 cm depth, to better document the SSS variability in a satellite pixel and to provide ground-truth as close as possible to the sea surface for validating satellite SSS, the L-band remotely sensed community proposed to deploy numerous surface drifters over various parts of the ocean. Surface drifter data are provided by the LOCEAN (see https://www.locean-ipsl.upmc.fr/smos/drifters/). Only validated data are considered with uncertainty order of 0.01 and 0.1.

1.1.4 Saildrones

Saildrone is a state-of-the-art, remotely guided, wind and solar powered unmanned surface vehicle (USV) capable of long distance deployments lasting up to 12 months. It is equipped with a suite of instruments and sensors providing high quality, georeferenced, near real-time, multi-parameter surface ocean and atmospheric observations while transiting at typical speeds of 3-5 knots. All freely available data are included coming from different providers (Saildrone, NOAA/PMEL, ...) and easely accessible via NOAA ERDAP. When 2 different sensors are available, usually from different brands (SeaBird or RBR), the RBR sensor is kept with the exception for the Atlantic to Mediterranean 2019-2020 campaign for which the salinity data from RBR are clearly corrupted. One-minute samples of the original data were resampled every 10 minutes using linear interpolation to reduce the number of point.

1.1.5 TSG

The TSG dataset is subdivided into 9 subdatasets following TSG data providers subdivisions:

- LEGOS-DM:
  The TSG (LEGOS-DM) dataset corresponds to sea surface salinity delayed mode data derived from voluntary observing ships collected, validated, archived, and made freely available by the French Sea Surface Salinity Observation Service (Alory et al. (2015)). The network is global though more concentrated in the tropical Pacific and North Atlantic oceanic basins. The acquisition system is autonomous with real time transmission and is regularly serviced at harbor calls. The high resolution data retrieved from the acquisition system during ship calls is processed through a dedicated software (freely available) for attribution of data quality flags by visual inspection, and correction of TSG time series by comparison with climatology, onboard daily water samples and collocated Argo data. Adjusted values when available and only collected TSG data that exhibit quality flags=1 and 2 were used.

- GOSUD-Research-vessel:
  The TSG (GOSUD-Research-vessel) dataset corresponds to French research vessels SSS data that have been collected since the early 2000 as a contribution to the Global Ocean Surface Underway Data (GOSUD) program. The set of homogeneous instruments is permanently monitored and regularly calibrated. Water samples are taken on a daily basis by the crew and later analysed in the laboratory. The careful calibration and instrument maintenance, complemented with a rigorous adjustment on water samples, lead to reach an accuracy of a few 10^{-2} PSS in salinity. This delayed mode dataset (Kolodziejczyk et al. (2021)) is updated annually and freely available here. Adjusted values when available and only collected TSG data that exhibit quality flags 1 or 2 were used.

- GOSUD-Sailing-ship: The TSG (GOSUD-Sailing-ship) dataset corresponds to observations of sea surface salinity obtained from voluntary sailing ships using medium or small size sensors. They complement the networks installed on research vessels or commercial ships. This delayed mode dataset (Reynaud et al. (2021)) is updated annually as a contribution to GOSUD (`http://www.gosud.org`) and freely available here. Adjusted values when available and only collected TSG data that exhibit quality flags=1 and 2 were used.

- SAMOS: The TSG (SAMOS) dataset corresponds to "Research" quality data from the US Shipboard Automated Meteorological and Oceanographic System (SAMOS) initiative (Smith et al. (2009)). Data are available at `http://samos.coaps.fsu.edu/html/`. Adjusted values when available and only collected TSG data that exhibit quality flags=1 and 2 were used. After visual inspection, data from the NANCY FOSTER (ID="WTER", IMO="008993227") with date 2011/03/21 and all data from the ATLANTIS (ID="KAQP", IMO="009105798") for year 2010 have been removed from this dataset. For years, 2013 to 2022, RV Laurence Gould And Nathaniel Palmer data are coming from the "Intermediate" repository.

- CSIC-UTM: The TSG (CSIC-UTM) dataset contains sea surface temperature and salinity data collected from 2010 to 2022 mainly in the Atlantic Ocean, Mediterranean Sea and the Southern Ocean from 3 CSIC-UTM research vessels (B/O Sarmiento de Gamboa, R/V Hespérides and R/V García del Cid). Measurements have been obtained through thermosalinograph (TSG) during more than 100 cruises. On-board TSG devices have been regularly calibrated and continuously monitored in-between cruises. The data has been gathered through the `http://data.utm.csic.es/portal/` data portal.

- Polarstern: The TSG (Polarstern) dataset has been gathered through the `https://www.pangaea.de/` data warehouse utility using the following criteria: basis:"Polarstern" , device:"Underway cruise track measurements (CT)" , time coverage form 2010/01/01 to present. The result of the query is a collection of 79 different datasets with the following identification numbers: 736345, 742729, 753224, 753225, 753226, 753227, 758080, 760120, 760121, 761277, 770034, 770035, 770828, 776596, 776597, 780004, 802809, 802810, 802811, 802812, 803431, 808835, 808836, 808838, 809727, 810678, 816055, 819831, 823259, 839406, 839407, 839408, 848615, 858879, 858880, 858881, 858882, 858883, 858884, 858885, 863228, 863229, 863230, 863231, 863232, 863234, 873145, 873147, 873151, 873153, 873155, 873156, 873158, 887767, 889444, 889513, 889515, 889516, 889517, 889535, 889542, 889548, 895578, 895579, 895581, 898225, 898233, 898266, 905555, 905562, 905608, 905610, 905734, 930022, 930023, 930024, 930026, 930027, 930028.

- NCEI-0170743: The TSG (NCEI-0170743) dataset (Aulicino et al. (2018)) contains sea surface temperature and salinity data collected from 2010 to 2017 in the South Atlantic Ocean

and Southern Ocean from S.A. Agulhas and Agulhas-II research vessels, in the framework of South African National Antarctic Programme (SANAP), South African Department of Environmental Affairs (DEA) and Italian National Antarctic Research Programme (PNRA) scientific activities. Measurements have been obtained through thermosalinograph (TSG) during several cruises to both Antarctica and sub-Antarctic islands. On-board TSG devices have been regularly calibrated and continuously monitored in-between cruises; no appreciable sensor drift emerged. Independent water samples taken along the cruises have been used to validate the data; salinity measurement error was a few hundredths of a unit on the practical salinity scale. A careful quality control allowed to discard bad data for each single campaign.

- LEGOS-Survostral: The TSG (LEGOS-Survostral) dataset corresponds to delayed mode regional data from TSG installed on the Astrolabe vessel (IPEV) during the round trips between Hobart (Tasmania) and the French Antarctic base at Dumont d'Urville (Morrow and Kestenare (2014)). It is provided by the Survostral project and available here. Adjusted values when available and only collected TSG data that exhibit quality flags=1 and 2 were used.

- LEGOS-Survostral-Adélie: The TSG (LEGOS-Survostral-Adelie) dataset corresponds to delayed mode regional dataset along the Adelie coast provided by the Survostral project and available via here. Adjusted values when available and only collected TSG data that exhibit quality flags=1 and 2 were used.

1.1.6 Moorings

The Pi-MEP collects data from the Global Tropical Moored Buoy Array (GTMBA), a multinational effort to provide data in real-time for climate research and forecasting. Major components include the TAO/TRITON array in the Pacific, PIRATA in the Atlantic, and RAMA in the Indian Ocean. Data collected within TAO/TRITON, PIRATA and RAMA come primarily from ATLAS and TRITON moorings. These two mooring systems are functionally equivalent in terms of sensors, sample rates, and data quality. The data are directly downloaded from ftp.pmel.noaa.gov every day and stored in the Pi-MEP. Only salinity data measured at 1 or 1.5 meter depth with standard (pre-deployment calibration applied) and highest quality (pre/post calibration in agreement) are considered. A careful filtering of suspiciously erroneous mooring salinity data when compared with all satellite data has also been performed (cf. presentation). The Pi-MEP project acknowledges the GTMBA Project Office of NOAA/PMEL for providing the data. Data from the Ocean Station PAPA are also added to the Pi-MEP *in situ* database.

From the Upper Ocean Processes Group at Woods Hole Oceanographic Institution (WHOI), several moorings data are also included in the Pi-MEP. Namely, delayed mode surface mooring salinity records under the stratus cloud deck in the eastern tropical Pacific (Stratus), in the trade wind region of the northwest tropical Atlantic (NTAS), 100 km north of Oahu at the WHOI Hawaii Ocean Time-series Site (WHOTS), in the salinity maximum region of the subtropical North Atlantic (SPURS-1) and in the Pacific intertropical convergence zone (SPURS-2).

1.2 Auxiliary geophysical datasets

Additional EO datasets are used to characterize the geophysical conditions at the *in situ* measurement locations and time, and 10 days prior to the measurements, to get an estimate of the geophysical concomitant condition and history. As discussed in Boutin et al. (2016), the presence of vertical gradients in, and horizontal variability of, sea surface salinity indeed complicates

comparison of satellite and *in situ* measurements. The additional EO data are used here to get a first estimates of conditions for which L-band satellite SSS measured in the first centimeters of the upper ocean within a 50-150 km diameter footprint might differ from pointwise *in situ* measurements performed in general between 10 and 5 m depth below the surface. The spatio-temporal variability of SSS within a satellite footprint (50-150 km) is a major issue for satellite SSS validation in the vicinity of river plumes, frontal zones, and significant precipitation areas, among others. Rainfall can in some cases produce vertical salinity gradients exceeding 1 pss m^{-1}; consequently, it is recommended that satellite and *in situ* SSS measurements less than 3–6 h after rain events should be considered with care when used in satellite calibration/validation analyses. To identify such situation, the Pi-MEP platform is first using CMORPH products to characterize the local value and history of rain rate and ASCAT gridded data are used to characterize the local surface wind speed and history. For validation purpose, the ISAS monthly SSS *in situ* analysed fields at 5 m depth are collocated and compared with the *in situ* SSS value. The use of ISAS is motivated by the fact that it is used in the SMOS L2 official validation protocol in which systematic comparisons of SMOS L2 retrieved SSS with ISAS are done. In complement to ISAS, annual std climatological field from the World Ocean Atlas (WOA13) at the *in situ* location are also used to have an a priori information of the local SSS variability.

1.2.1 CMORPH

Precipitation are estimated using the CMORPH 3-hourly products at 1/4° resolution (Joyce et al. (2004)). CMORPH (CPC MORPHing technique) produces global precipitation analyses at very high spatial and temporal resolution. This technique uses precipitation estimates that have been derived from low orbiter satellite microwave observations exclusively, and whose features are transported via spatial propagation information that is obtained entirely from geostationary satellite IR data. At present NOAA incorporate precipitation estimates derived from the passive microwaves aboard the DMSP 13, 14 and 15 (SSM/I), the NOAA-15, 16, 17 and 18 (AMSU-B), and AMSR-E and TMI aboard NASA's Aqua, TRMM and GPM spacecraft, respectively. These estimates are generated by algorithms of Ferraro (1997) for SSM/I, Ferraro et al. (2000) for AMSU-B and Kummerow et al. (2001) for TMI. Note that this technique is not a precipitation estimation algorithm but a means by which estimates from existing microwave rainfall algorithms can be combined. Therefore, this method is extremely flexible such that any precipitation estimates from any microwave satellite source can be incorporated.

With regard to spatial resolution, although the precipitation estimates are available on a grid with a spacing of 8 km (at the equator), the resolution of the individual satellite-derived estimates is coarser than that - more on the order of 12 x 15 km or so. The finer "resolution" is obtained via interpolation.

In effect, IR data are used as a means to transport the microwave-derived precipitation features during periods when microwave data are not available at a location. Propagation vector matrices are produced by computing spatial lag correlations on successive images of geostationary satellite IR which are then used to propagate the microwave derived precipitation estimates. This process governs the movement of the precipitation features only. At a given location, the shape and intensity of the precipitation features in the intervening half hour periods between microwave scans are determined by performing a time-weighting interpolation between microwave-derived features that have been propagated forward in time from the previous microwave observation and those that have been propagated backward in time from the following microwave scan. NOAA refer to this latter step as "morphing" of the features.

For the present Pi-MEP products, we only considered the 3-hourly products at 1/4 degree resolution. The entire CMORPH record (December 2002-present) for 3-hourly, 1/4 de-

gree lat/lon resolution can be found at: ftp://ftp.cpc.ncep.noaa.gov/precip/CMORPH_V1.0/CRT/. CMORPH estimates cover a global belt (-180°W to 180°E) extending from 60°S to 60°N latitude and are available for the complete period of the Pi-MEP core datasets (Jan 2010-now).

1.2.2 ASCAT

Advanced SCATterometer (ASCAT) daily data produced and made available at Ifremer/CERSAT on a 0.25°x0.25° resolution grid (Bentamy and Fillon (2012)) since March 2007 are used to characterize the mean daily wind at the match-up pair location as well as the wind history during the 10-days period preceding the in situ measurement date. These wind fields are calculated based on a geostatistical method with external drift. Remotely sensed data from ASCAT are considered as observations while those from numerical model analysis (ECMWF) are associated with the external drift. The spatial and temporal structure functions for wind speed, zonal and meridional wind components are estimated from ASCAT retrievals. Furthermore, the new procedure includes a temporal interpolation of the retrievals based on the complex empirical orthogonal function (CEOF) approach, in order to enhance the sampling length of the scatterometer observations. The resulting daily wind fields involves the main known surface wind patterns as well as some variation modes associated with temporal and spatial moving features. The accuracy of the gridded winds was investigated through comparisons with moored buoy data in Bentamy et al. (2012) and resulted in rms differences for wind speed and direction are about 1.50 m.s^{-1} and 20°.

1.2.3 ISAS

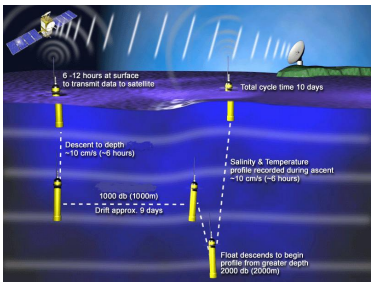
The In Situ Analysis System (ISAS), as described in Gaillard et al. (2016) is a data based re-analysis of temperature and salinity fields over the global ocean 70°N–70°S on a 1/2° grid. It was initially designed to synthesize the temperature and salinity profiles collected by the Argo program. It has been later extended to accommodate all type of vertical profile as well as time series. ISAS gridded fields are entirely based on *in situ* measurements. The methodology and configuration have been conceived to preserve as much as possible the data information content and resolution. ISAS is developed and run in a research laboratory (LOPS) in close collaboration with Coriolis, one of Argo Global Data Assembly Center and unique data provider for the Mercator operational oceanography system. In Pi-MEP, the products used are the INSITU_GLO_PHY_TS_OA_MY_013_052 for the period 2010 to 2021 and the INSITU_GLO_PHY_TS_OA_NRT_013_002 for the Near-Real Time (2022-2023) derived at the Coriolis data center and provided by the Copernicus Marine Environment Monitoring Service (CMEMS). The major contribution to the data set is from Argo array of profiling floats, reaching an approximate resolution of one profile every 10-days and every 3-degrees over the satellite SSS period (http://www.umr-lops.fr/SNO-Argo/Products/ISAS-T-S-fields/). The ISAS optimal interpolation involves a structure function modeled as the sum of two Gaussian functions, each associated with specific time and space scales, resulting in a smoothing over typically 3 degrees. The smallest scale which can be retrieved with ISAS analysis is not smaller than 300–500 km (Kolodziejczyk et al. (2015)). For validation purpose, the ISAS monthly SSS fields at 5 m depth are collocated and compared with the satellite SSS products and included in the Pi-MEP Match-up files. In addition, the "percentage of variance" fields (PCTVAR) contained in the ISAS analyses provide information on the local variability of *in situ* SSS measurements within 1/2°x1/2° boxes.

1.2.4 World Ocean Atlas Climatology

The World Ocean Atlas 2013 version 2 (WOA13 V2) is a set of objectively analyzed (1° grid) climatological fields of *in situ* temperature, salinity and other variables provided at standard depth levels for annual, seasonal, and monthly compositing periods for the World Ocean. It also includes associated statistical fields of observed oceanographic profile data interpolated to standard depth levels on 5°, 1°, and 0.25° grids. We use these fields in complement to ISAS to characterize the climatological fields (annual mean and std) at the match-up pairs location and date.

2 Argo

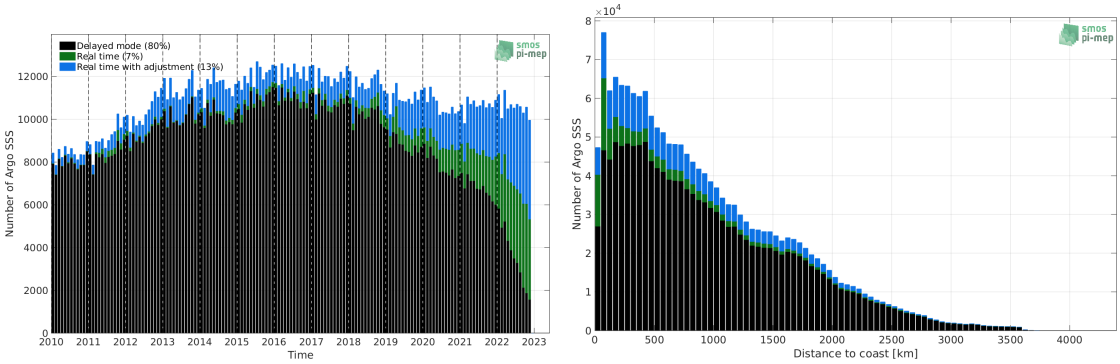
2.1 Introduction



Argo is a global array of 3,000 free-drifting profiling floats that measures the temperature and salinity of the upper 2000 m of the ocean. This allows continuous monitoring of the temperature and salinity of the upper ocean, with all data being relayed and made publicly available within hours after collection. The array provides around 100,000 temperature/salinity profiles per year distributed over the global oceans at an average of 3-degree spacing. Only Argo salinity and temperature float data with quality index set to 1 or 2 and data mode set to real time (RT), real time adjusted (RTA) and delayed mode (DM) are considered in the Pi-MEP. Argo floats which may have problems with one or more sensors appearing in the grey list maintained at the Coriolis/GDACs are discarded. Furthermore, Pi-MEP provides an additional list of ∼1000 "suspicious" argo salinity profiles that are also removed before analysis. The upper ocean salinity and temperature values recorded between 0m and 10m depth are considered as Argo sea surface salinities (SSS) and sea surface temperatures (SST). These data were collected and made freely available by the international Argo project and the national programs that contribute to it (Argo (2023)).

2.2 Number of SSS data as a function of time and distance to coast

Figure 1 shows the time (a) and distance to coast (b) distributions of the Argo *in situ* dataset.

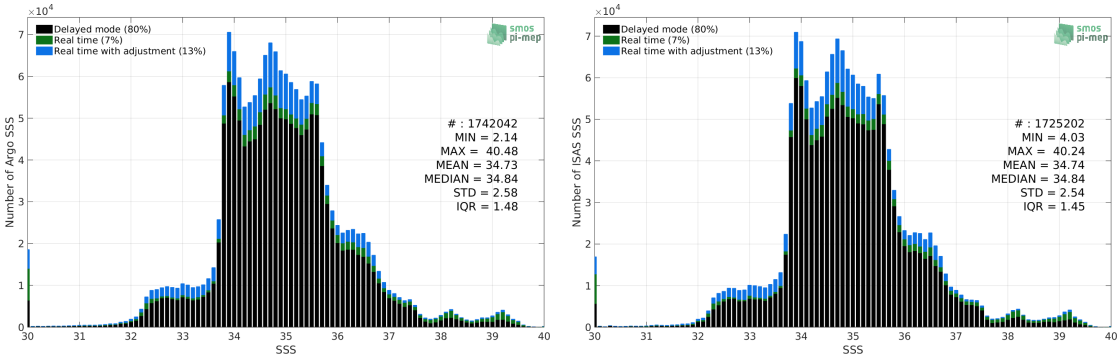


(a) (b)

Figure 1: Number of SSS from Argo as a function of time (a) and distance to coast (b).

2.3 Histograms of SSS

Figure 2 shows the SSS distribution of the Argo (a) and colocalized ISAS (b) dataset.

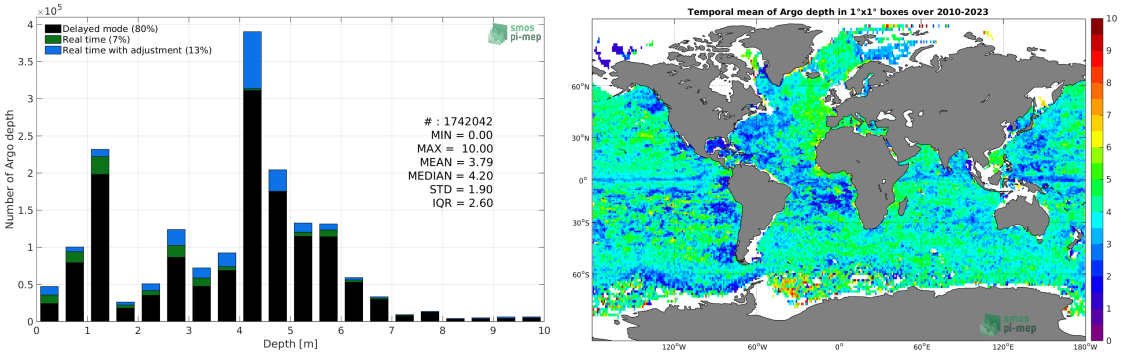


(a) (b)

Figure 2: Histograms of SSS from Argo (a) and ISAS (b) per bins of 0.1.

2.4 Distribution of *in situ* SSS depth measurements

In Figure 3, we show the depth distribution of the *in situ* salinity dataset (a) and the spatial distribution of the depth temporal mean in 1°x1° boxes and considering the full *in situ* dataset period (b).



(a) (b)

Figure 3: Depth distribution of the upper level SSS measurements from Argo (a) and spatial distribution of the *in situ* SSS depth measurements showing the mean value in 1°x1° boxes and considering the full *in situ* dataset period (b).

2.5 Spatial distribution of SSS

In Figure 4, the number of Argo SSS measurements in 1°x1° boxes is shown.

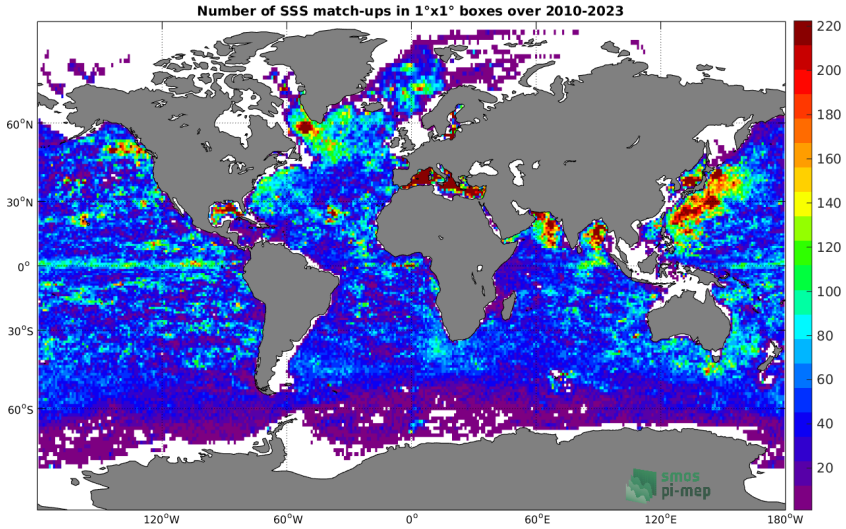
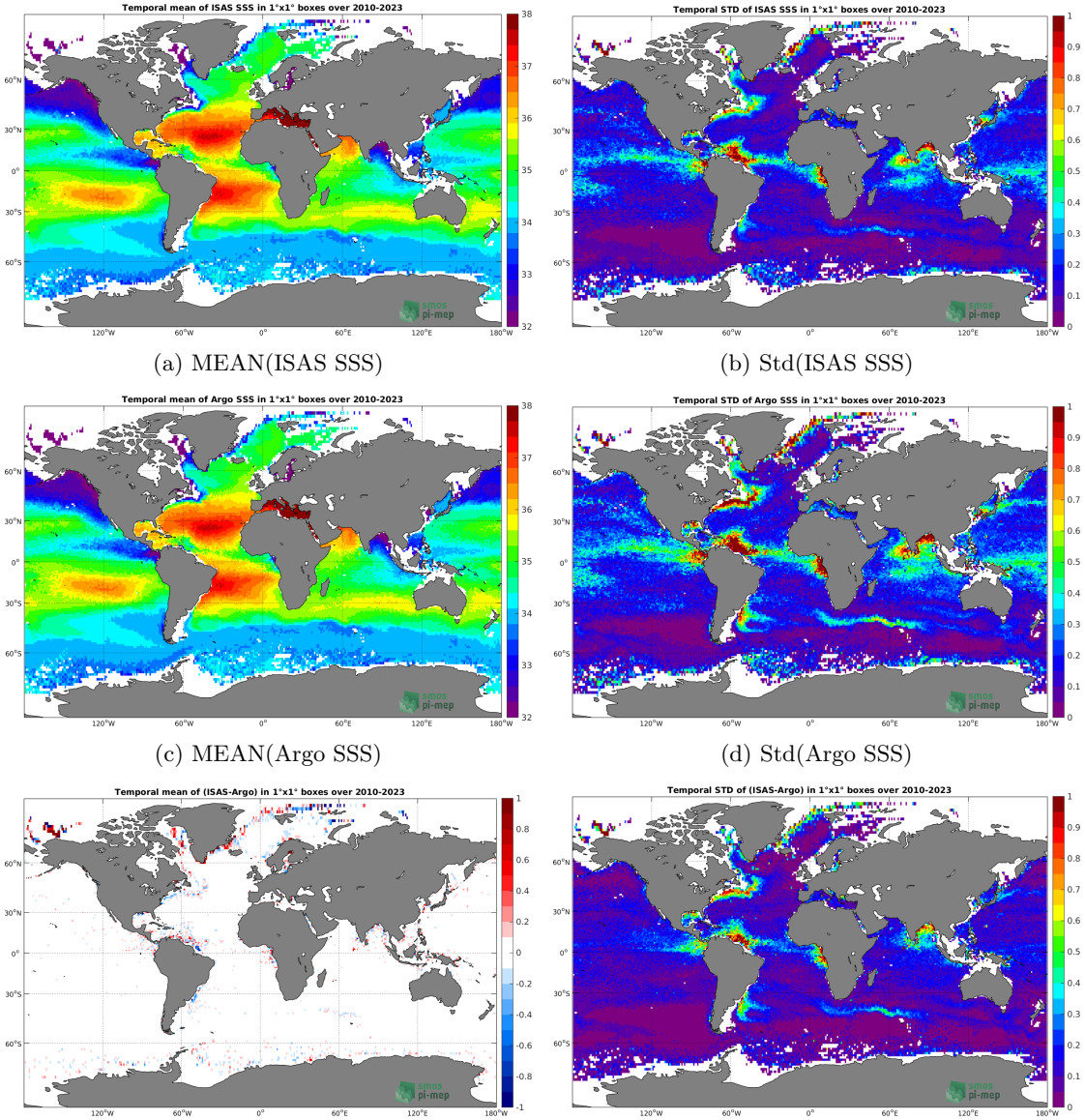


Figure 4: Number of SSS from Argo in 1°x1° boxes.

2.6 Spatial Maps of the Temporal mean and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

In Figure 5, maps of temporal mean (left) and standard deviation (right) of ISAS (top), Argo *in situ* dataset (middle) and the difference ΔSSS(ISAS -Argo) (bottom) are shown. The temporal mean and std are calculated using all match-up pairs falling in spatial boxes of size 1°x1° over the full Argo dataset period.



(a) MEAN(ISAS SSS)

(b) Std(ISAS SSS)

(c) MEAN(Argo SSS)

(d) Std(Argo SSS)

(e) MEAN(ΔSSS) (ISAS - Argo)

(f) Std(ΔSSS) (ISAS - Argo)

Figure 5: Temporal mean (left) and Std (right) of SSS from ISAS (top), Argo (middle), and of ΔSSS (ISAS - Argo). Only match-up pairs are used to generate these maps.

2.7 Time series of the monthly median and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

In the top panel of Figure 6, we show the time series of the monthly median SSS estimated for both ISAS SSS product (in black) and the Argo *in situ* dataset (in blue) at the collected Pi-MEP match-up pairs.

In the middle panel of Figure 6, we show the time series of the monthly median of ΔSSS (ISAS - Argo) for the collected Pi-MEP match-up pairs.

In the bottom panel of Figure 6, we show the time series of the monthly standard deviation of the ΔSSS (ISAS - Argo) for the collected Pi-MEP match-up pairs.

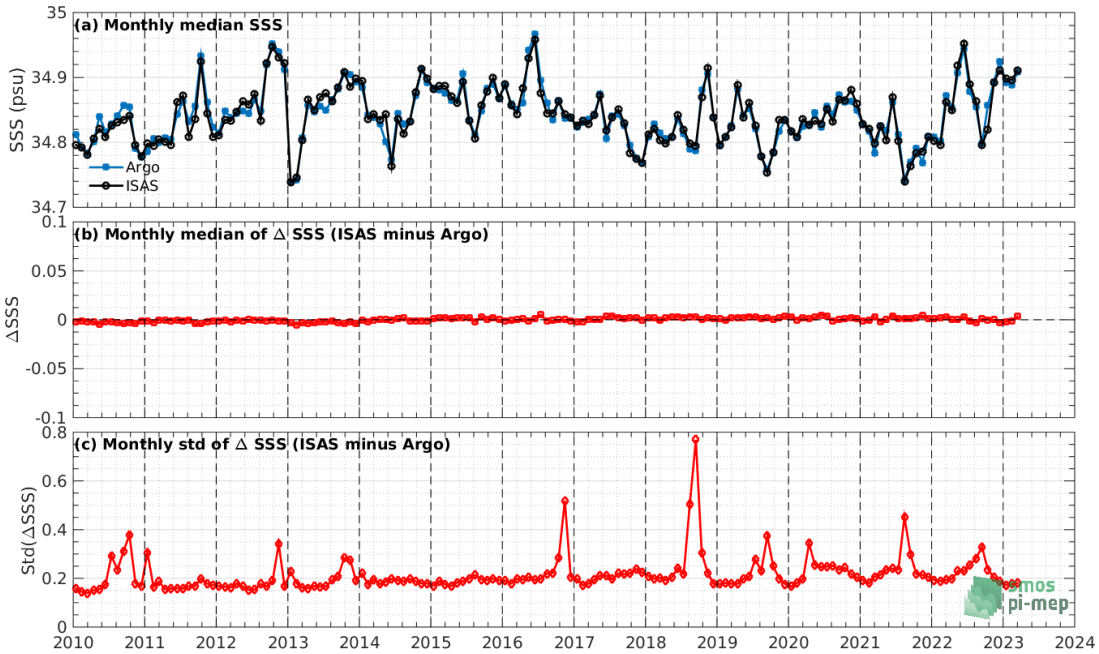


Figure 6: Time series of the monthly median SSS (top), median of ΔSSS (ISAS - Argo) and Std of ΔSSS (ISAS - Argo) considering all match-ups collected by the Pi-MEP.

2.8 Zonal mean and Std of *in situ* and ISAS SSS and of the difference ΔSSS

In Figure 7 left panel, we show the zonal mean SSS considering all Pi-MEP match-up pairs for both ISAS SSS product (in black) and the Argo *in situ* dataset (in blue). The full *in situ* dataset period is used to derive the mean.

In the right panel of Figure 7, we show the zonal mean of ΔSSS (ISAS - Argo) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

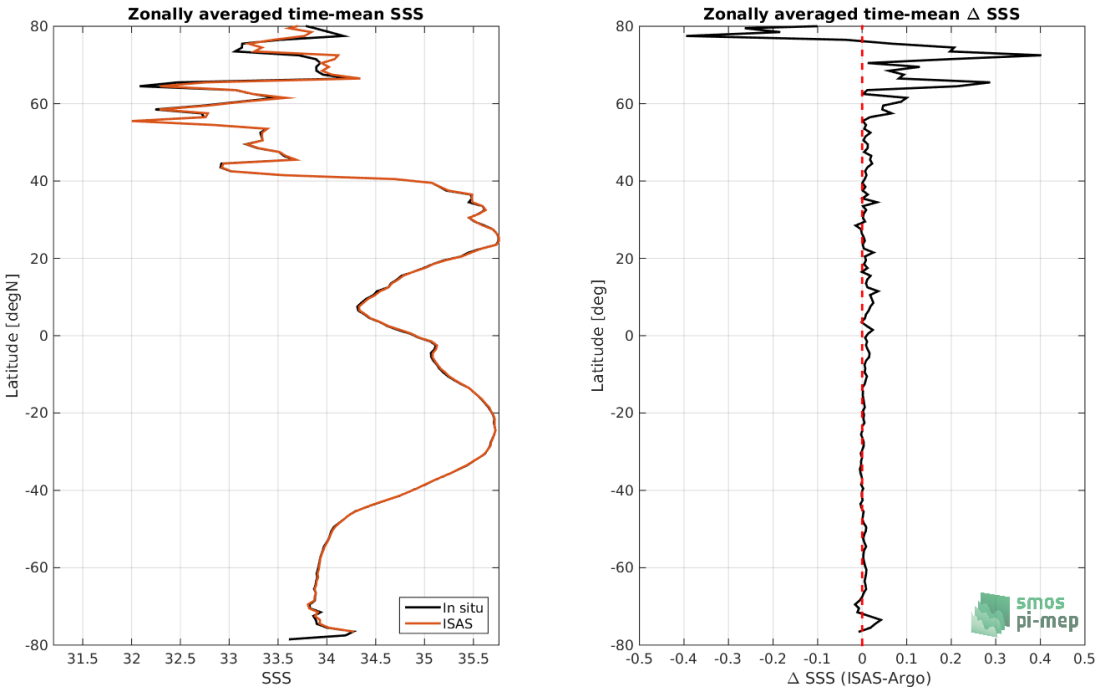
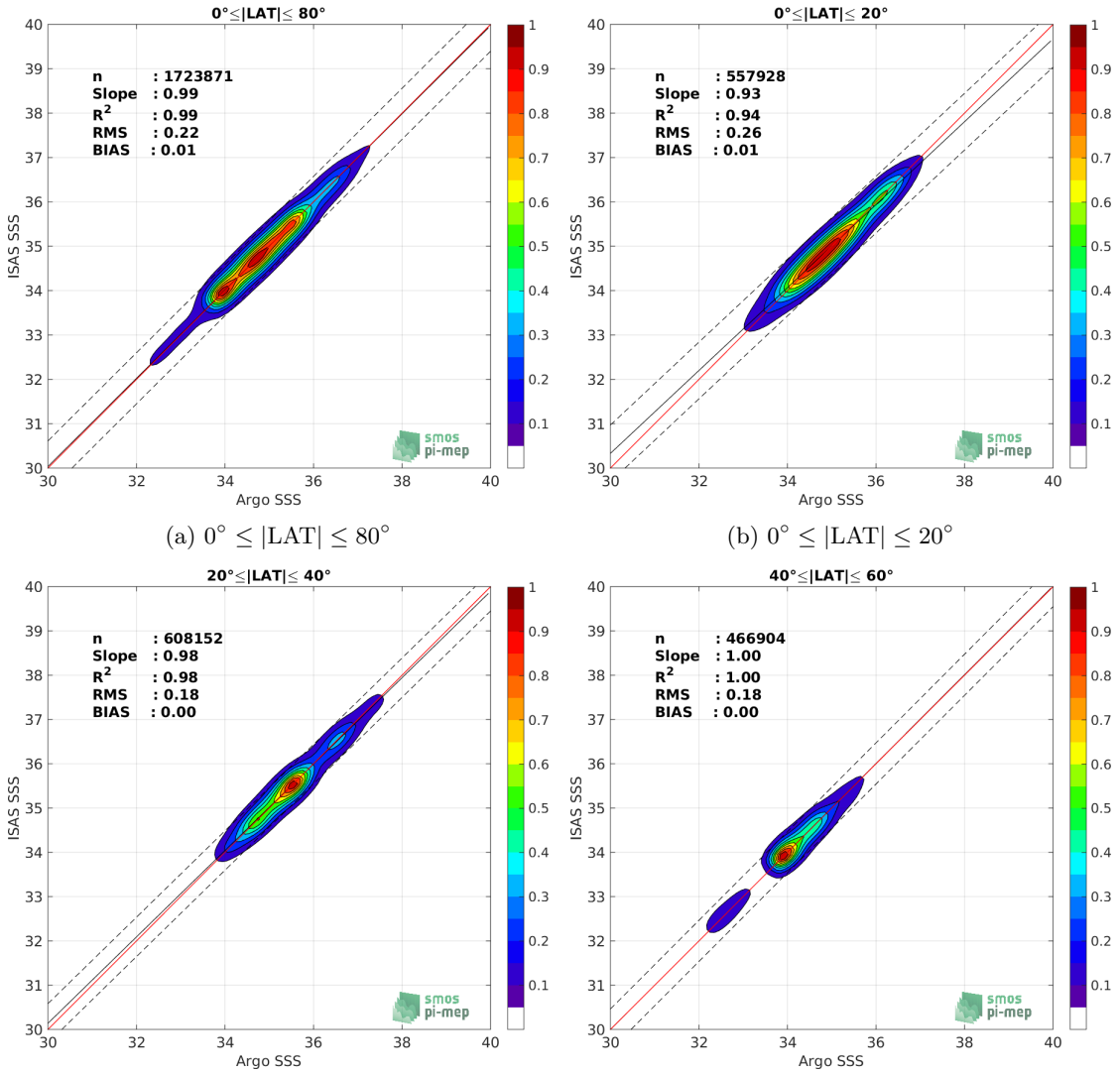


Figure 7: Left panel: Zonal mean SSS from ISAS product (black) and from Argo (blue). Right panel: Zonal mean of ΔSSS (ISAS - Argo) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

2.9 Scatterplots of ISAS vs *in situ* SSS by latitudinal bands

In Figure 8, contour maps of the concentration of ISAS SSS (y-axis) versus Argo SSS (x-axis) at match-up pairs for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.



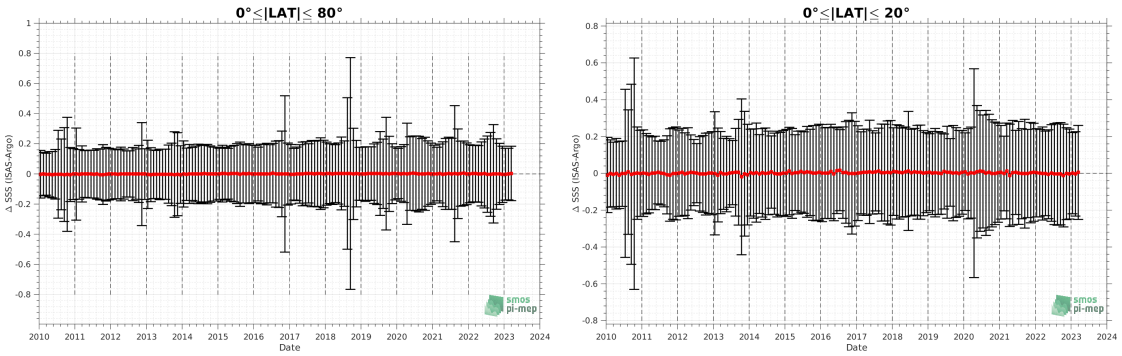
(a) $0° \leq |\text{LAT}| \leq 80°$ (b) $0° \leq |\text{LAT}| \leq 20°$

(c) $20° \leq |\text{LAT}| \leq 40°$ (d) $40° \leq |\text{LAT}| \leq 60°$

Figure 8: Contour maps of the concentration of ISAS SSS (y-axis) versus Argo SSS (x-axis) at match-up pairs for different latitude bands. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.

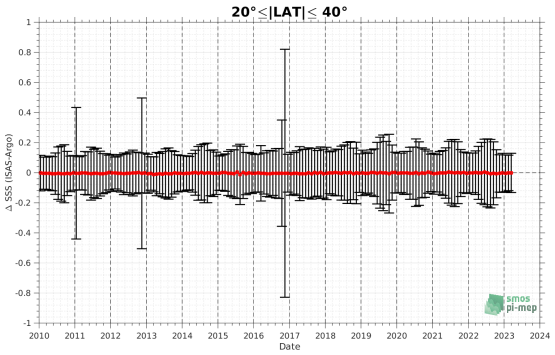
2.10 Time series of the monthly median and Std of the difference ΔSSS sorted by latitudinal bands

In Figure 9, time series of the monthly median (red curves) of ΔSSS (ISAS - Argo) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs estimated for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.

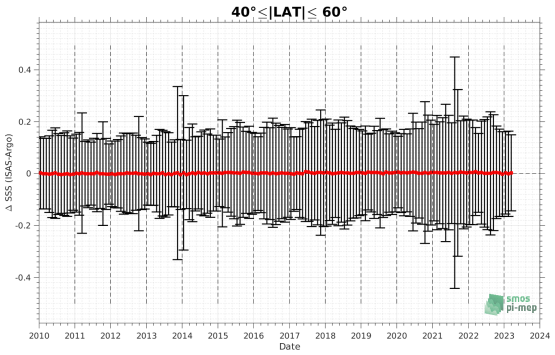


(a) $0° \leq |\text{LAT}| \leq 80°$

(b) $0° \leq |\text{LAT}| \leq 20°$



(c) $20° \leq |\text{LAT}| \leq 40°$



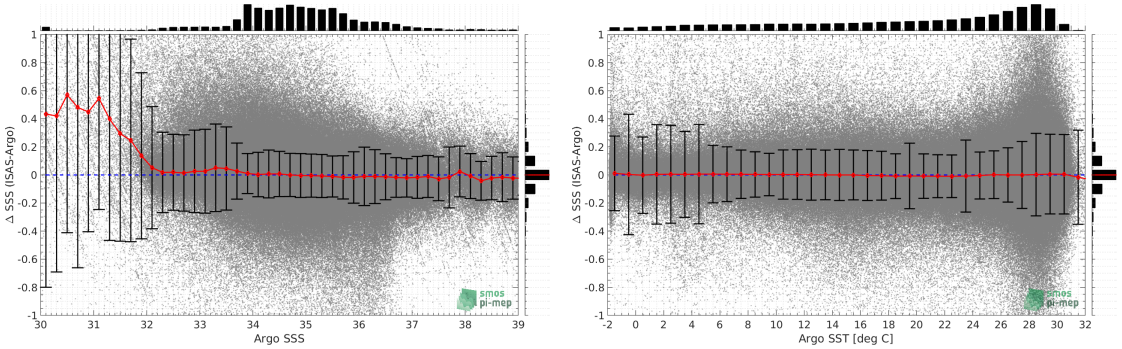
(d) $40° \leq |\text{LAT}| \leq 60°$

Figure 9: Monthly median (red curves) of ΔSSS (ISAS - Argo) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.

2.11 ΔSSS sorted as geophysical conditions

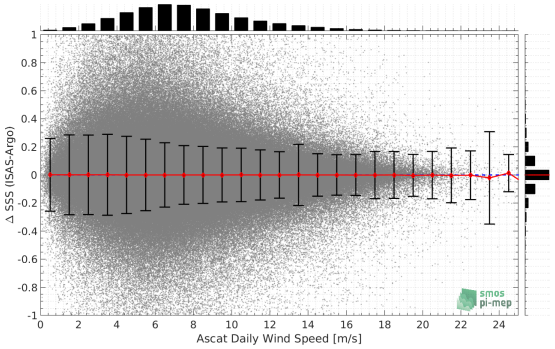
In Figure 10, we classify the match-up differences ΔSSS (ISAS - *in situ*) as function of the geophysical conditions at match-up points. The mean and std of ΔSSS (ISAS - Argo) is thus evaluated as function of the

- *in situ* SSS values per bins of width 0.2,
- *in situ* SST values per bins of width 1°C,
- ASCAT daily wind values per bins of width 1 m/s,
- CMORPH 3-hourly rain rates per bins of width 1 mm/h, and,
- distance to coasts per bins of width 50 km,
- *in situ* measurement depth (if relevant).

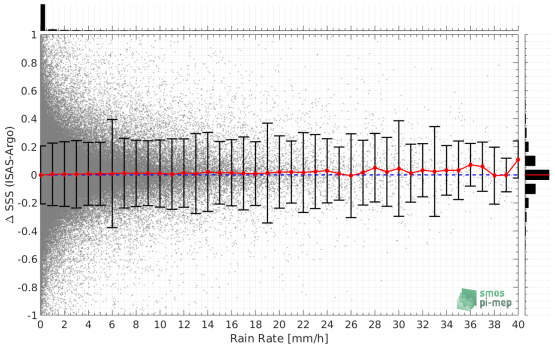


(a) Argo SSS

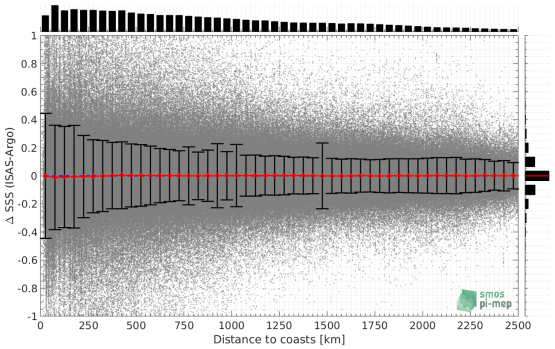
(b) Argo SST



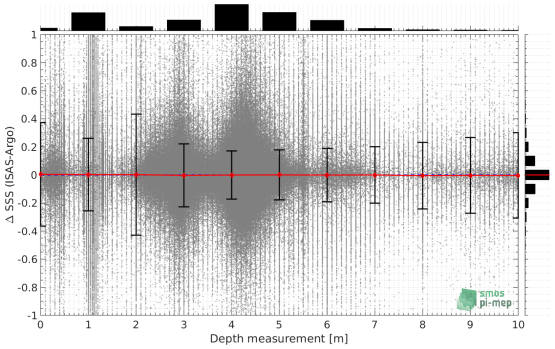
(c) ASCAT Wind Speed



(d) CMORPH Rain rate



(e) Distance to coast



(f) Depth

Figure 10: Δ SSS (ISAS - Argo) sorted as geophysical conditions: Argo SSS a), Argo SST b), ASCAT Wind speed c), CMORPH rain rate d), distance to coast (e) and depth measurements (f).

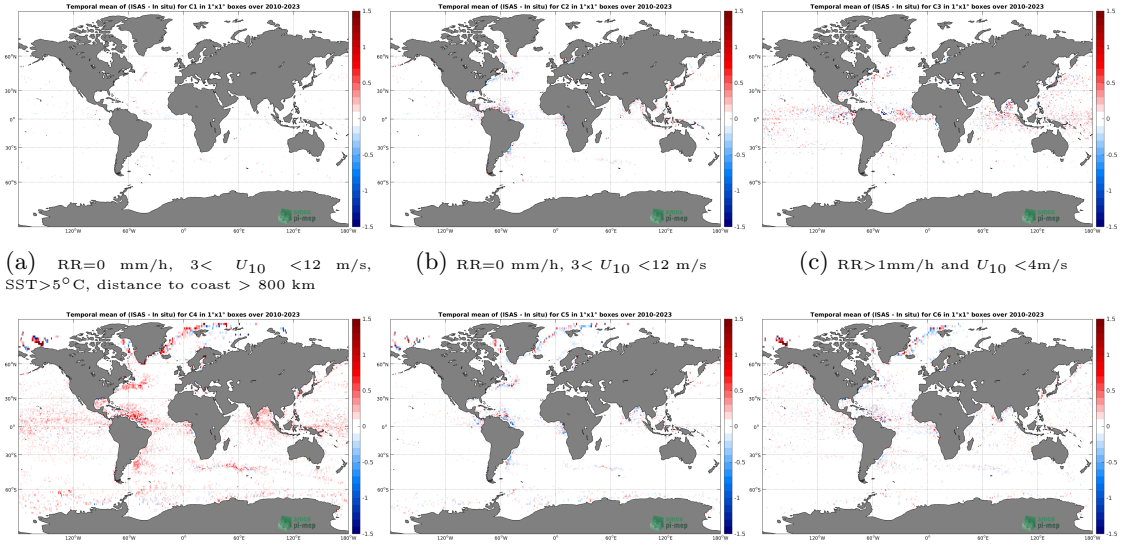
2.12 ΔSSS maps and statistics for different geophysical conditions

In Figures 11 and 12, we focus on sub-datasets of the match-up differences ΔSSS (ISAS - *in situ*) for the following specific geophysical conditions:

- **C1**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is in the range [3, 12] m/s, the SST is $> 5°$C and distance to coast is > 800 km.

- **C2**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is in the range [3, 12] m/s.
- **C3**:if the local value at *in situ* location of estimated rain rate is high (ie. $>$ 1 mm/h) and mean daily wind is low (ie. $<$ 4 m/s).
- **C4**:if the mixed layer is shallow with depth <20m.
- **C5**:if the *in situ* data is located where the climatological SSS standard deviation is low (ie. above $<$ 0.2).
- **C6**:if the *in situ* data is located where the climatological SSS standard deviation is high (ie. above $>$ 0.2).

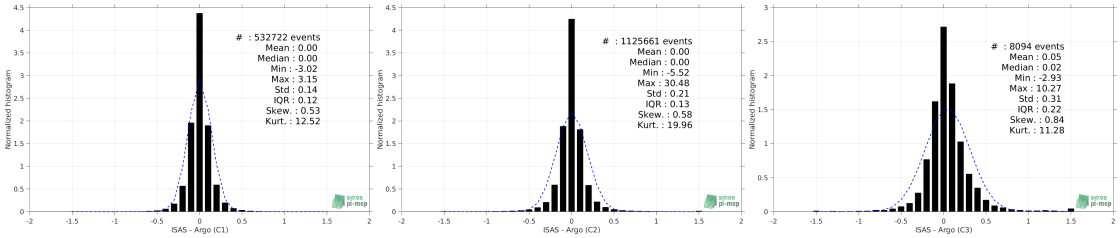
For each of these conditions, the temporal mean (gridded over spatial boxes of size 1°x1°) and the histogram of the difference ΔSSS (ISAS - *in situ*) are presented.



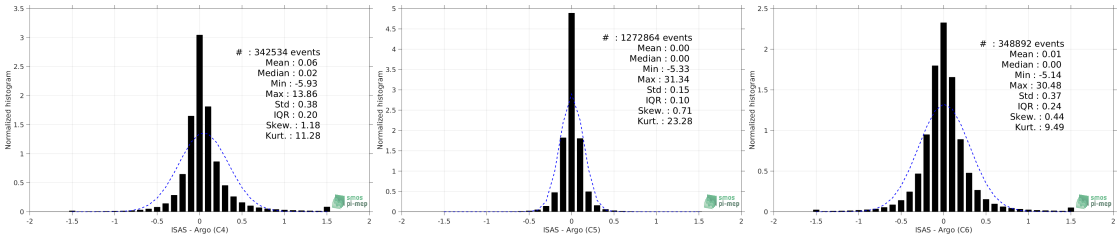
(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s

(d) MLD<20m (e) WOA2013 SSS Std<0.2 (f) WOA2013 SSS Std>0.2

Figure 11: Temporal mean gridded over spatial boxes of size 1°x1° of ΔSSS (ISAS - Argo) for 6 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast $>$ 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),MLD<20m (d),WOA2013 SSS Std<0.2 (e),WOA2013 SSS Std>0.2 (f).



(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s



(d) MLD<20m (e) WOA2013 SSS Std<0.2 (f) WOA2013 SSS Std>0.2

Figure 12: Normalized histogram of ΔSSS (ISAS - Argo) for 6 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).

2.13 Summary

Table 1 shows the mean, median, standard deviation (Std), root mean square (RMS), interquartile range (IQR), correlation coefficient (r^2) and robust standard deviation (Std*) of the match-up differences ΔSSS (ISAS - Argo) for the following conditions:

- all: All the match-up pairs satellite/in situ SSS are used to derive the statistics
- C1: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km
- C2: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s
- C3: only pairs where RR>1mm/h and U_{10} <4m/s
- C4: only pairs where MLD<20m
- C5: only pairs where WOA2013 SSS Std<0.2
- C6: only pairs where WOA2013 SSS Std>0.2
- C7a: only pairs where distance to coast is < 150 km.
- C7b: only pairs where distance to coast is in the range [150, 800] km.
- C7c: only pairs where distance to coast is > 800 km.
- C8a: only pairs where in situ SST is < 5°C.
- C8b: only pairs where in situ SST is in the range [5, 15]°C.

- C8c: only pairs where in situ SST is $> 15°C$.
- C9a: only pairs where in situ SSS is < 33.
- C9b: only pairs where in situ SSS is in the range [33, 37].
- C9c: only pairs where in situ SSS is > 37.

Table 1: Statistics of ΔSSS (ISAS - Argo)

Condition	#	Median	Mean	Std	RMS	IQR	r^2	Std*
all	1725202	0.00	0.01	0.23	0.23	0.12	0.992	0.09
C1	532722	0.00	0.00	0.14	0.14	0.12	0.979	0.09
C2	1125661	0.00	0.00	0.21	0.21	0.13	0.993	0.09
C3	8094	0.02	0.05	0.31	0.32	0.22	0.979	0.16
C4	342534	0.02	0.06	0.38	0.38	0.20	0.991	0.14
C5	1272864	0.00	0.00	0.15	0.15	0.10	0.994	0.08
C6	348892	0.00	0.01	0.37	0.37	0.24	0.987	0.18
C7a	183547	-0.01	0.02	0.39	0.39	0.17	0.997	0.13
C7b	717972	0.00	0.01	0.25	0.25	0.13	0.965	0.09
C7c	822296	0.00	0.00	0.15	0.15	0.11	0.976	0.08
C8a	167297	0.00	0.03	0.34	0.34	0.07	0.988	0.05
C8b	367276	0.00	0.01	0.18	0.18	0.08	0.997	0.06
C8c	1188794	0.00	0.00	0.22	0.22	0.15	0.987	0.11
C9a	104499	0.02	0.13	0.63	0.64	0.18	0.993	0.12
C9b	1530831	0.00	0.00	0.17	0.17	0.12	0.961	0.09
C9c	89872	-0.02	-0.02	0.15	0.15	0.14	0.963	0.10

Table 1 numerical values can be downloaded as a csv file here.

3 Marine mammals

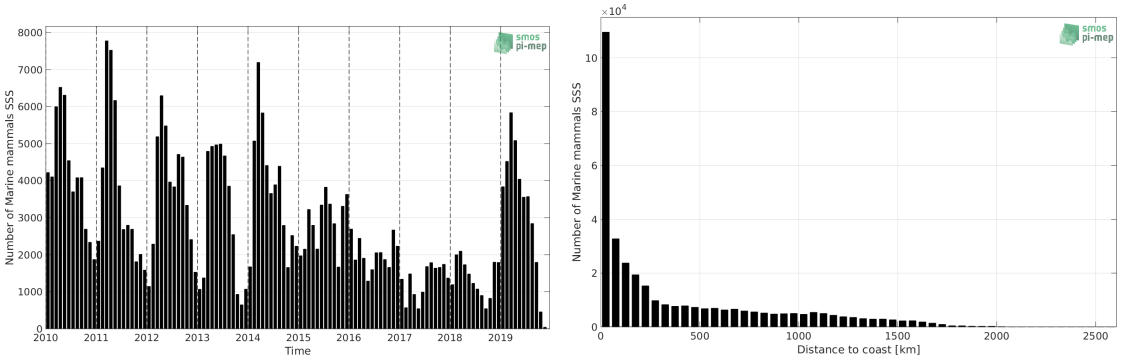
3.1 Introduction

Instrumentation of southern elephant seals with satellite-linked CTD tags proposes unique temporal and spatial coverage. This includes extensive data from the Antarctic continental slope and shelf regions during the winter months, which is outside the conventional areas of Argo autonomous floats and ship-based studies. The use of elephant seals has been particularly effective to sample the Southern Ocean and the North Pacific. Other seal species have been successfully used in the North Atlantic, such as hooded seals. The marine mammal dataset (MEOP-CTD database) is quality controlled and calibrated using delayed-mode techniques involving comparisons with other existing profiles as well as cross-comparisons similar to established protocols within the Argo community, with a resulting accuracy of ±0.03 °C in temperature and ±0.05 in salinity or better (Treasure et al. (2017)). The marine mammal data were collected and made freely available by the International MEOP Consortium and the national programs that contribute to it (`http://www.meop.net`). This dataset is updated once a year and can be downloaded here (Roquet et al. (2021)). A preprocessing

stage is applied to the database before being used by the Pi-MEP which consists in keeping only profiles with salinity, temperature and pressure quality flags set to 1 or 2 and if at least one measurement is in the top 10 m depth. Marine mammal SSS corresponds to the top (shallowest) profile salinity data provided that profile depth is 10 m or less.

3.2 Number of SSS data as a function of time and distance to coast

Figure 13 shows the time (a) and distance to coast (b) distributions of the Marine mammals *in situ* dataset.

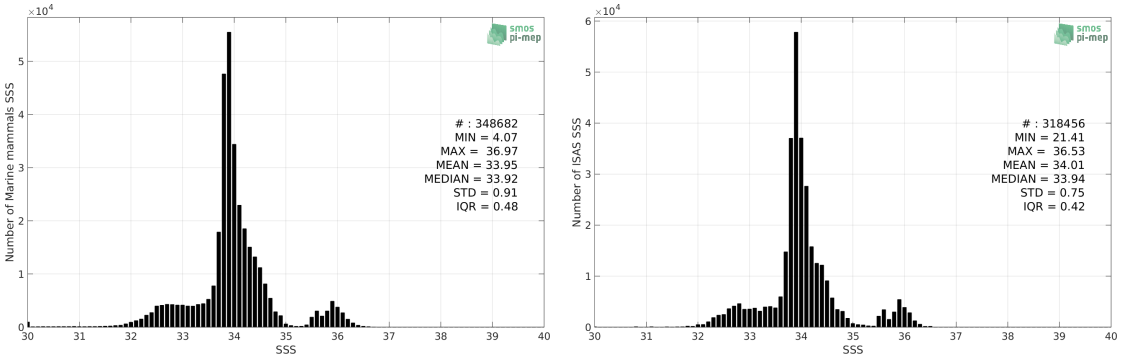


(a) (b)

Figure 13: Number of SSS from Marine mammals as a function of time (a) and distance to coast (b).

3.3 Histograms of SSS

Figure 14 shows the SSS distribution of the Marine mammals (a) and colocalized ISAS (b) dataset.

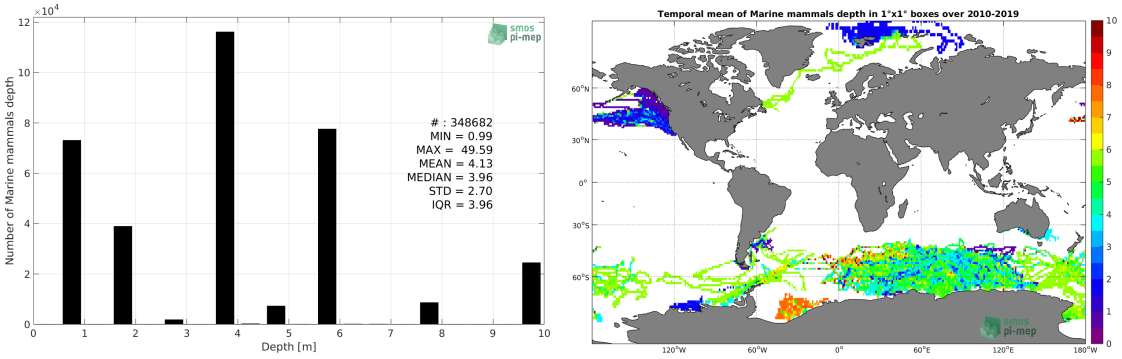


(a) (b)

Figure 14: Histograms of SSS from Marine mammals (a) and ISAS (b) per bins of 0.1.

3.4 Distribution of *in situ* SSS depth measurements

In Figure 15, we show the depth distribution of the *in situ* salinity dataset (a) and the spatial distribution of the depth temporal mean in 1°x1° boxes and considering the full *in situ* dataset period (b).



(a) (b)

Figure 15: Depth distribution of the upper level SSS measurements from Marine mammals (a) and spatial distribution of the *in situ* SSS depth measurements showing the mean value in 1°x1° boxes and considering the full *in situ* dataset period (b).

3.5 Spatial distribution of SSS

In Figure 16, the number of Marine mammals SSS measurements in 1°x1° boxes is shown.

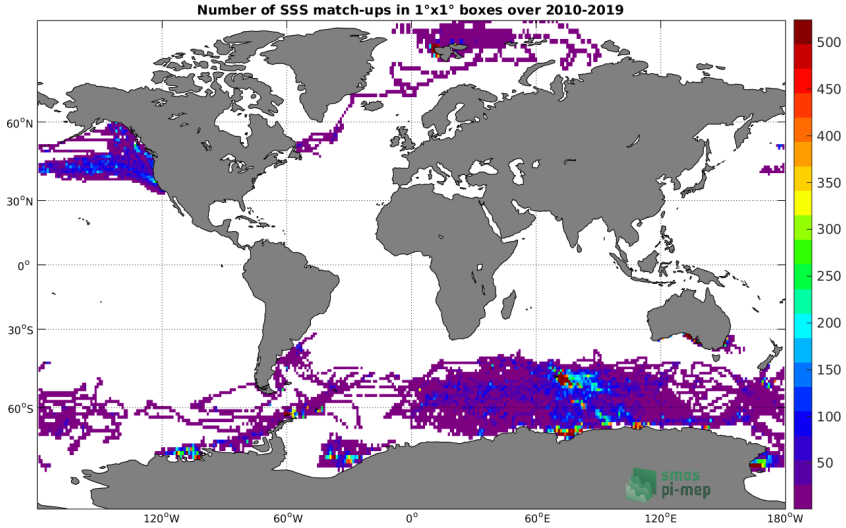
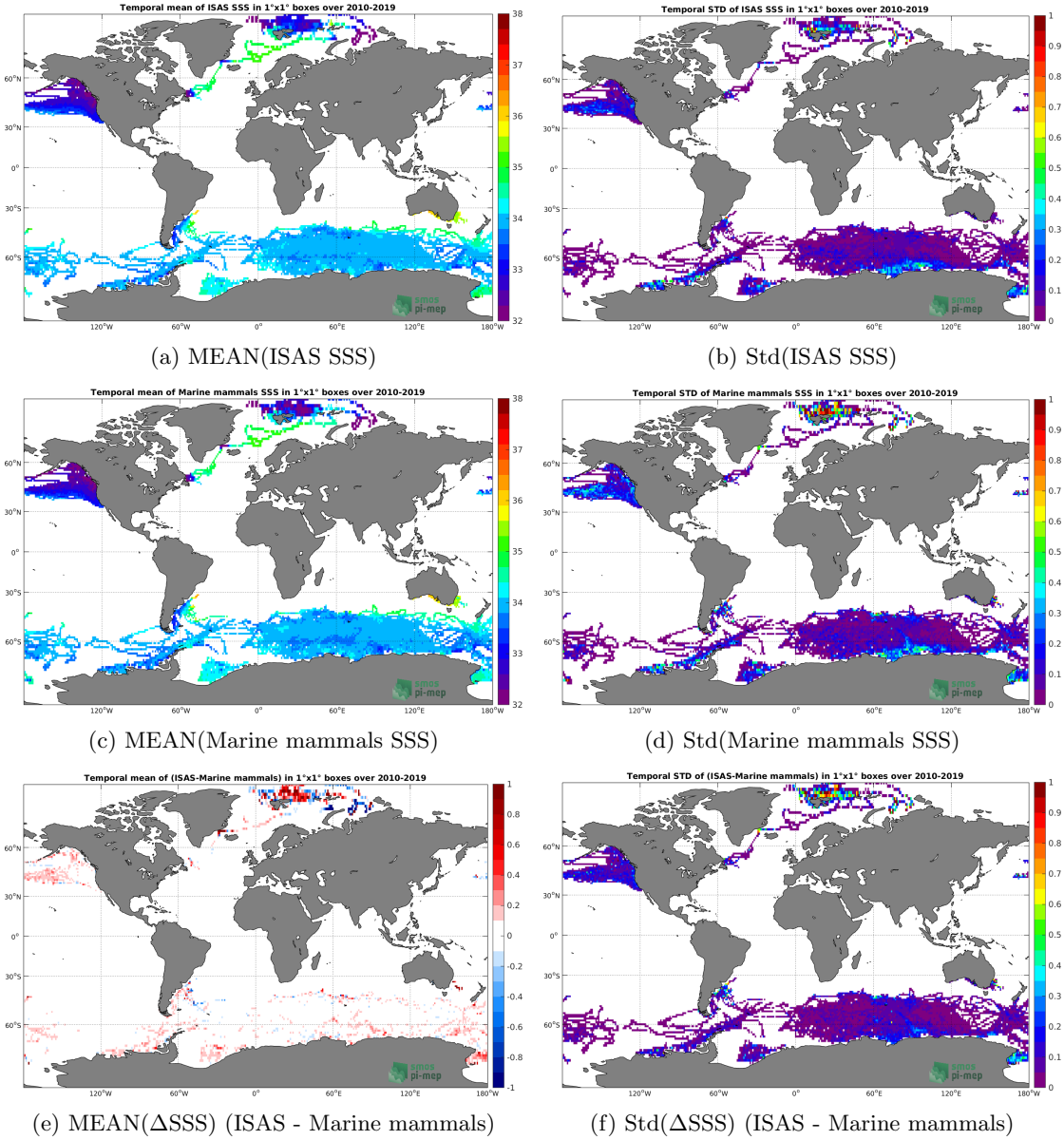


Figure 16: Number of SSS from Marine mammals in 1°x1° boxes.

3.6 Spatial Maps of the Temporal mean and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

In Figure 17, maps of temporal mean (left) and standard deviation (right) of ISAS (top), Marine mammals *in situ* dataset (middle) and the difference ΔSSS(ISAS -Marine mammals) (bottom) are shown. The temporal mean and std are calculated using all match-up pairs falling in spatial boxes of size 1°x1° over the full Marine mammals dataset period.



(a) MEAN(ISAS SSS)

(b) Std(ISAS SSS)

(c) MEAN(Marine mammals SSS)

(d) Std(Marine mammals SSS)

(e) MEAN(ΔSSS) (ISAS - Marine mammals)

(f) Std(ΔSSS) (ISAS - Marine mammals)

Figure 17: Temporal mean (left) and Std (right) of SSS from ISAS (top), Marine mammals (middle), and of ΔSSS (ISAS - Marine mammals). Only match-up pairs are used to generate these maps.

3.7 Time series of the monthly median and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

In the top panel of Figure 18, we show the time series of the monthly median SSS estimated for both ISAS SSS product (in black) and the Marine mammals *in situ* dataset (in blue) at the collected Pi-MEP match-up pairs.

In the middle panel of Figure 18, we show the time series of the monthly median of ΔSSS

(ISAS - Marine mammals) for the collected Pi-MEP match-up pairs.

In the bottom panel of Figure 18, we show the time series of the monthly standard deviation of the ΔSSS (ISAS - Marine mammals) for the collected Pi-MEP match-up pairs.

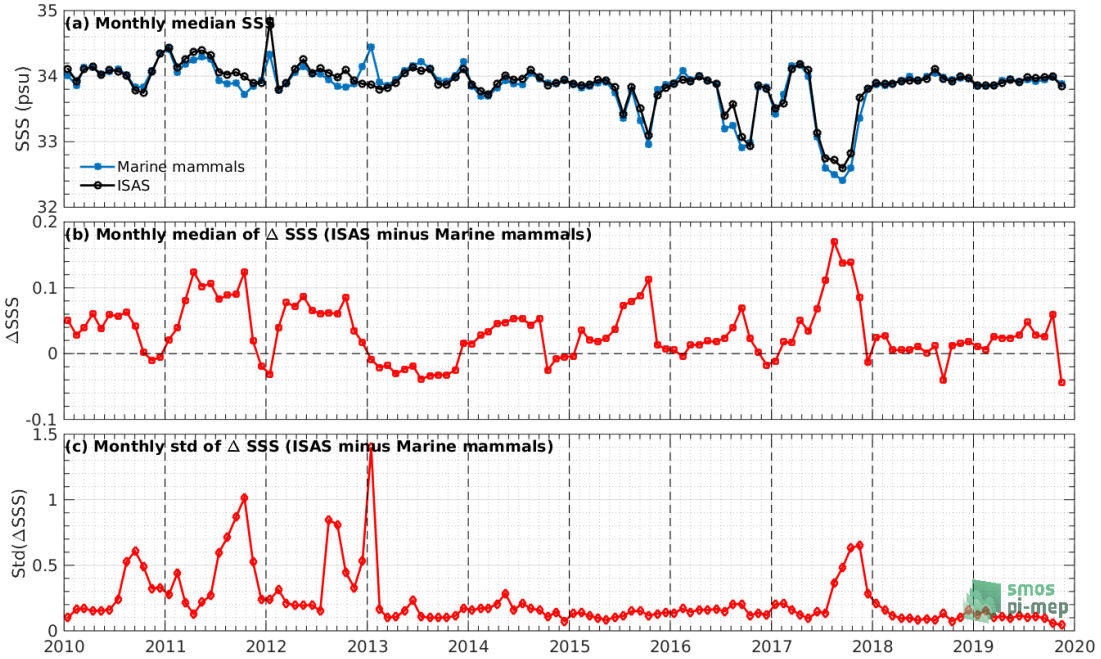


Figure 18: Time series of the monthly median SSS (top), median of ΔSSS (ISAS - Marine mammals) and Std of ΔSSS (ISAS - Marine mammals) considering all match-ups collected by the Pi-MEP.

3.8 Zonal mean and Std of *in situ* and ISAS SSS and of the difference ΔSSS

In Figure 19 left panel, we show the zonal mean SSS considering all Pi-MEP match-up pairs for both ISAS SSS product (in black) and the Marine mammals *in situ* dataset (in blue). The full *in situ* dataset period is used to derive the mean.

In the right panel of Figure 19, we show the zonal mean of ΔSSS (ISAS - Marine mammals) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

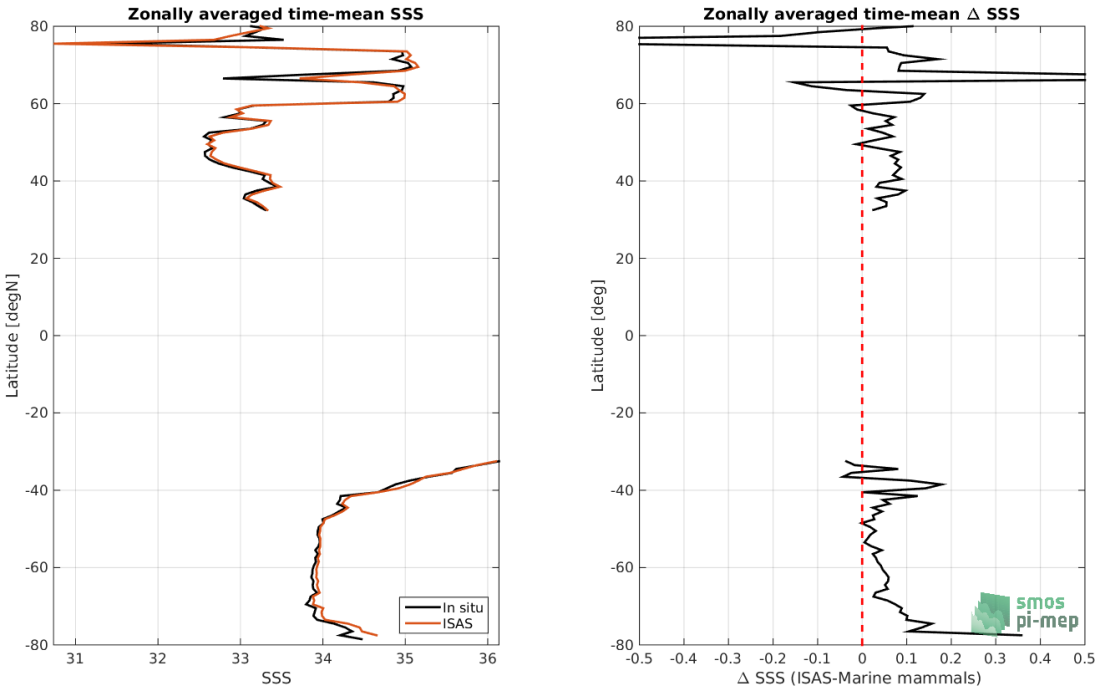
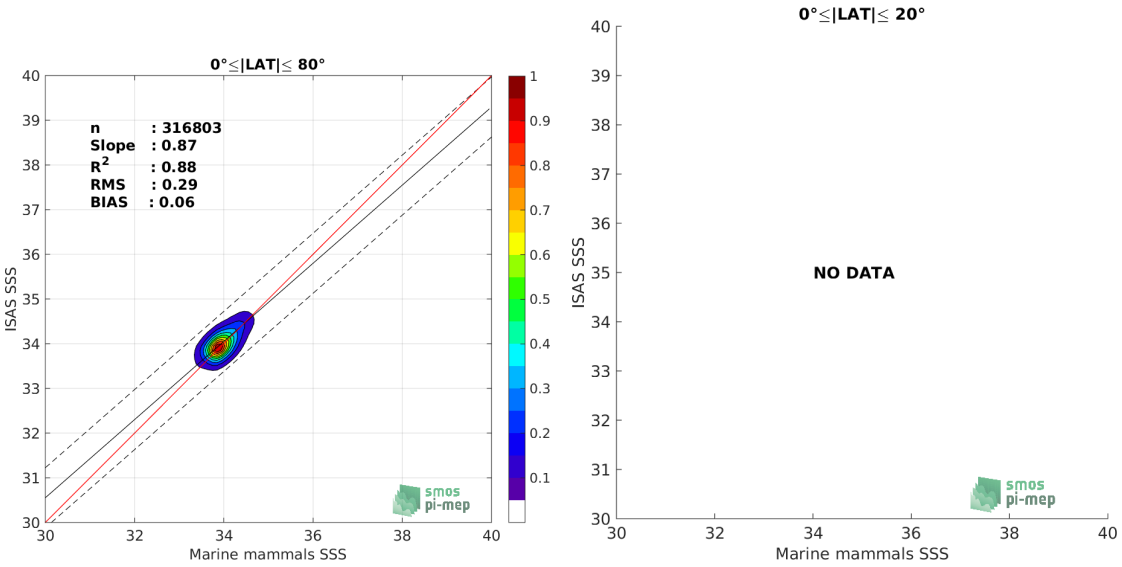


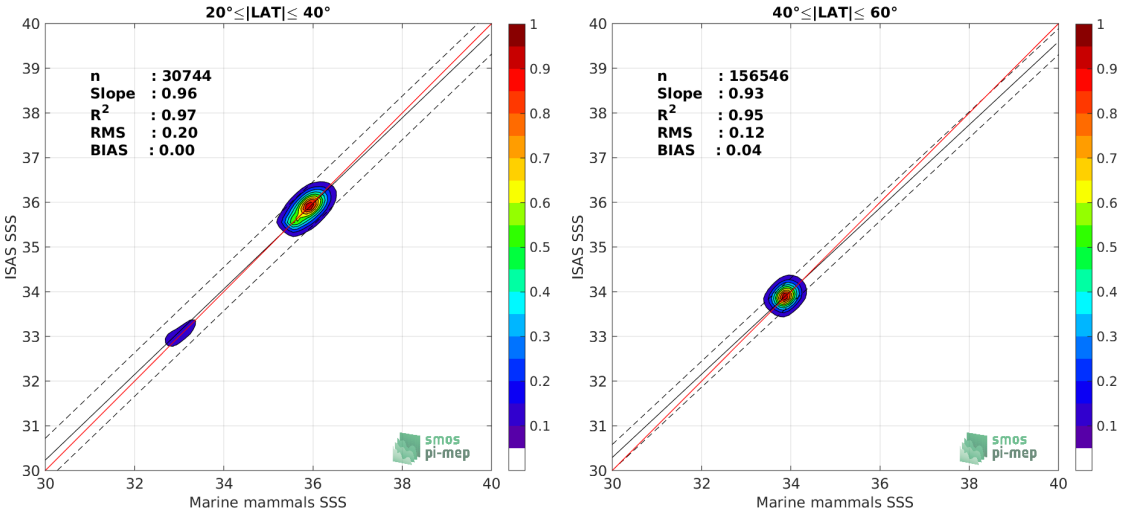
Figure 19: Left panel: Zonal mean SSS from ISAS product (black) and from Marine mammals (blue). Right panel: Zonal mean of ΔSSS (ISAS - Marine mammals) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

3.9 Scatterplots of ISAS vs *in situ* SSS by latitudinal bands

In Figure 20, contour maps of the concentration of ISAS SSS (y-axis) versus Marine mammals SSS (x-axis) at match-up pairs for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.



(a) $0° \leq |\text{LAT}| \leq 80°$ (b) $0° \leq |\text{LAT}| \leq 20°$



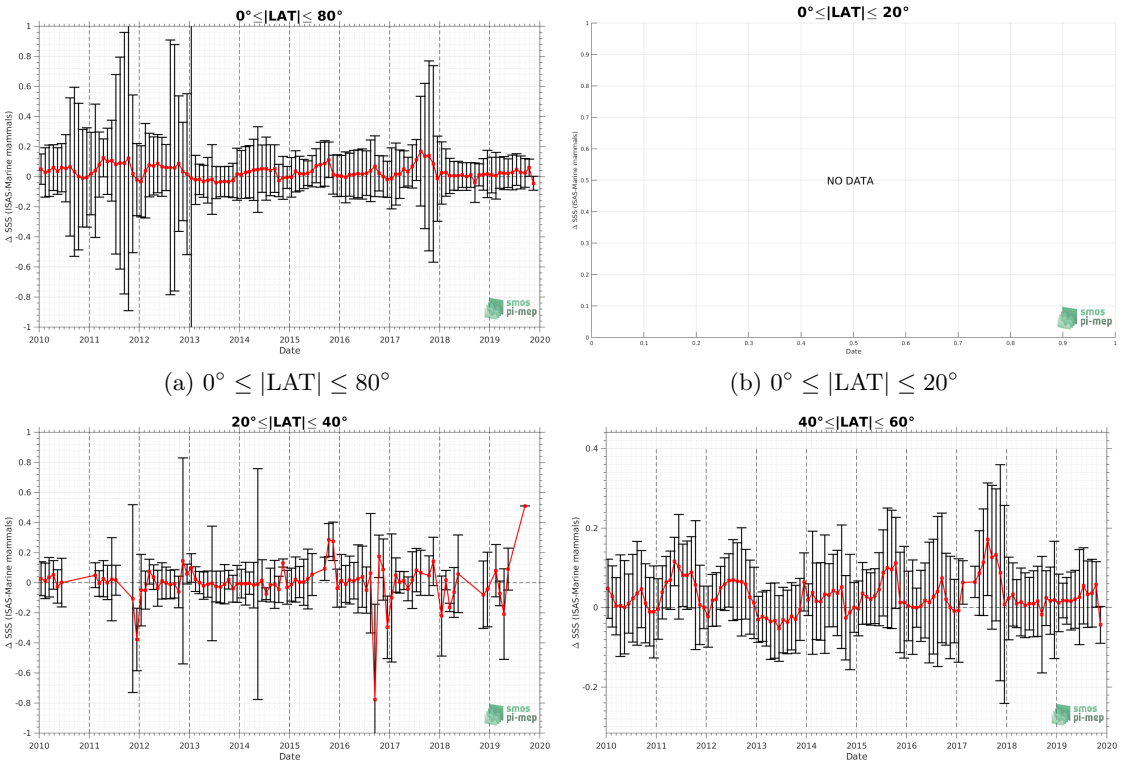
(c) $20° \leq |\text{LAT}| \leq 40°$ (d) $40° \leq |\text{LAT}| \leq 60°$

Figure 20: Contour maps of the concentration of ISAS SSS (y-axis) versus Marine mammals SSS (x-axis) at match-up pairs for different latitude bands. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.

3.10 Time series of the monthly median and Std of the difference ΔSSS sorted by latitudinal bands

In Figure 21, time series of the monthly median (red curves) of ΔSSS (ISAS - Marine mammals) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up

pairs estimated for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.



(a) $0° \leq |\text{LAT}| \leq 80°$

(b) $0° \leq |\text{LAT}| \leq 20°$

(c) $20° \leq |\text{LAT}| \leq 40°$

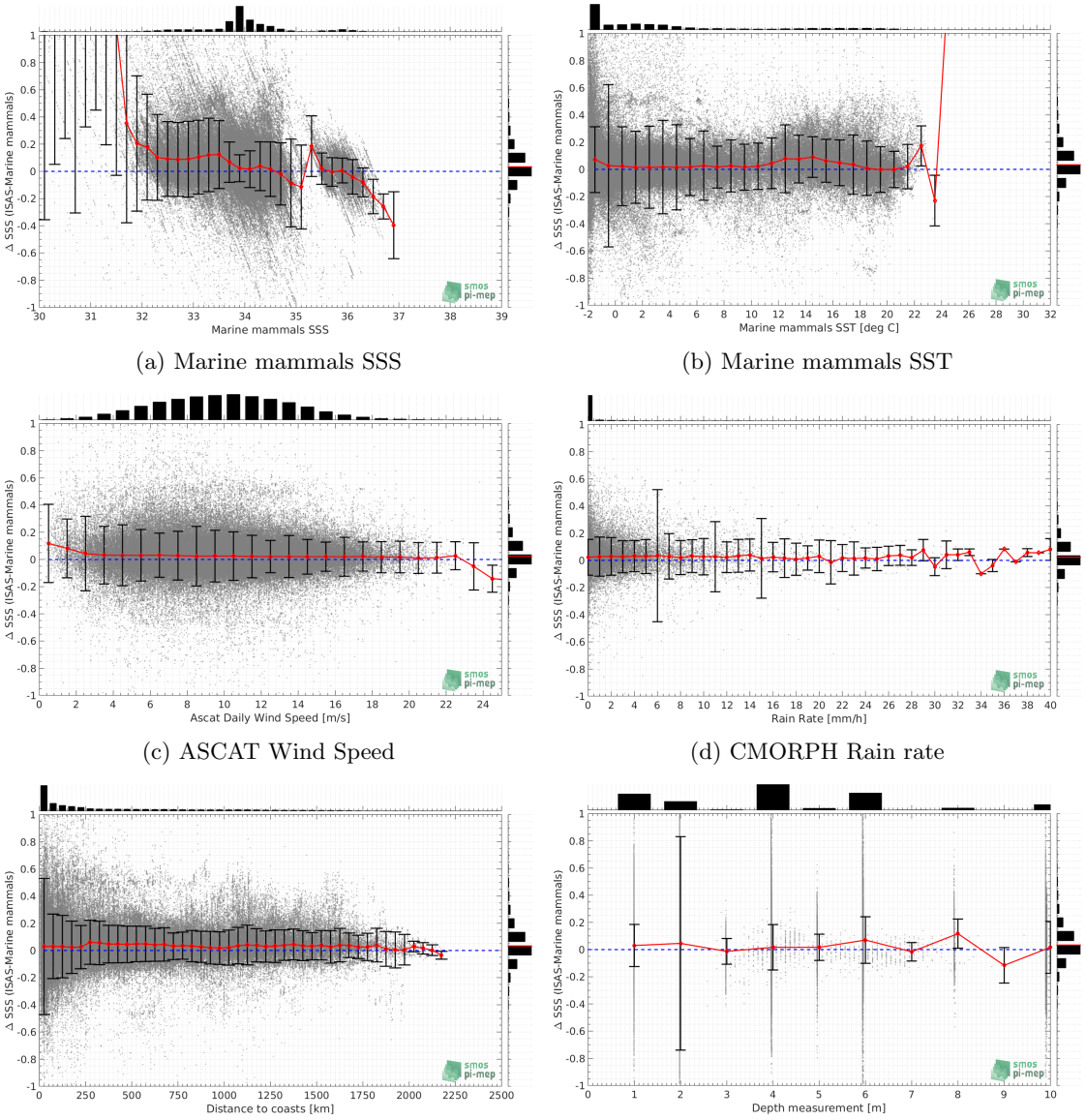
(d) $40° \leq |\text{LAT}| \leq 60°$

Figure 21: Monthly median (red curves) of ΔSSS (ISAS - Marine mammals) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.

3.11 ΔSSS sorted as geophysical conditions

In Figure 22, we classify the match-up differences ΔSSS (ISAS - *in situ*) as function of the geophysical conditions at match-up points. The mean and std of ΔSSS (ISAS - Marine mammals) is thus evaluated as function of the

- *in situ* SSS values per bins of width 0.2,
- *in situ* SST values per bins of width 1°C,
- ASCAT daily wind values per bins of width 1 m/s,
- CMORPH 3-hourly rain rates per bins of width 1 mm/h, and,
- distance to coasts per bins of width 50 km,
- *in situ* measurement depth (if relevant).



(a) Marine mammals SSS

(b) Marine mammals SST

(c) ASCAT Wind Speed

(d) CMORPH Rain rate

(e) Distance to coast

(f) Depth

Figure 22: Δ SSS (ISAS - Marine mammals) sorted as geophysical conditions: Marine mammals SSS a), Marine mammals SST b), ASCAT Wind speed c), CMORPH rain rate d), distance to coast (e) and depth measurements (f).

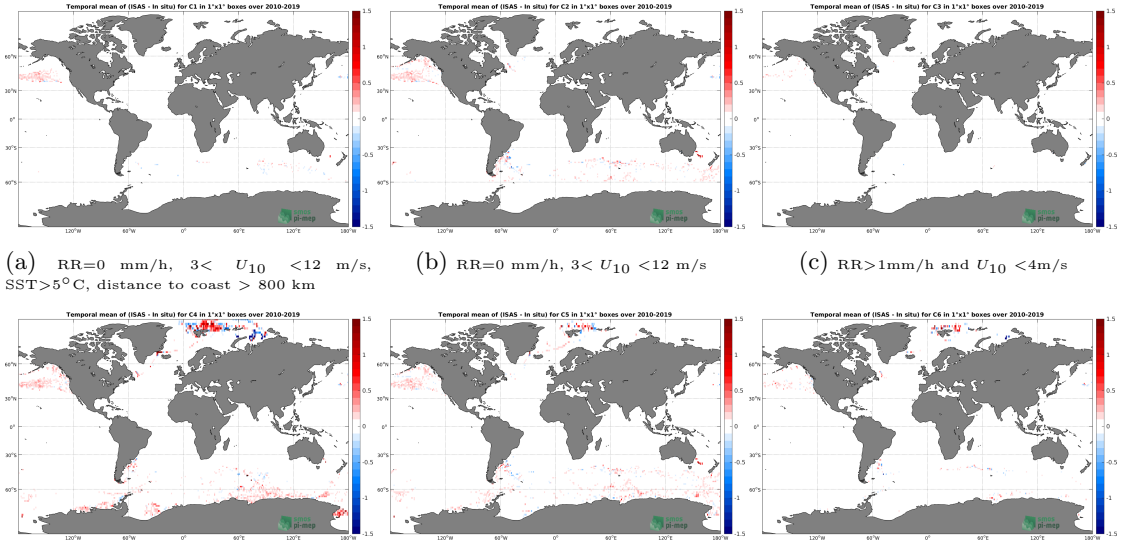
3.12 ΔSSS maps and statistics for different geophysical conditions

In Figures 23 and 24, we focus on sub-datasets of the match-up differences ΔSSS (ISAS - *in situ*) for the following specific geophysical conditions:

- **C1**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is in the range [3, 12] m/s, the SST is $> 5°$C and distance to coast is > 800 km.

- **C2**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is in the range [3, 12] m/s.
- **C3**:if the local value at *in situ* location of estimated rain rate is high (ie. $>$ 1 mm/h) and mean daily wind is low (ie. $<$ 4 m/s).
- **C4**:if the mixed layer is shallow with depth <20m.
- **C5**:if the *in situ* data is located where the climatological SSS standard deviation is low (ie. above $<$ 0.2).
- **C6**:if the *in situ* data is located where the climatological SSS standard deviation is high (ie. above $>$ 0.2).

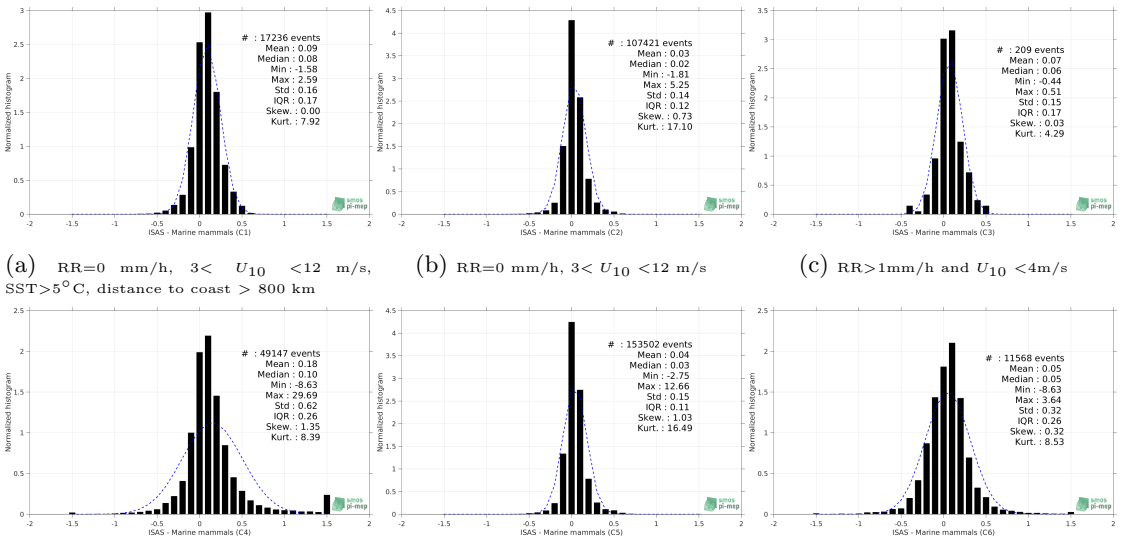
For each of these conditions, the temporal mean (gridded over spatial boxes of size 1°x1°) and the histogram of the difference ΔSSS (ISAS - *in situ*) are presented.



(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s

(d) MLD<20m (e) WOA2013 SSS Std<0.2 (f) WOA2013 SSS Std>0.2

Figure 23: Temporal mean gridded over spatial boxes of size 1°x1° of ΔSSS (ISAS - Marine mammals) for 6 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),MLD<20m (d),WOA2013 SSS Std<0.2 (e),WOA2013 SSS Std>0.2 (f).



(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s

(d) MLD<20m (e) WOA2013 SSS Std<0.2 (f) WOA2013 SSS Std>0.2

Figure 24: Normalized histogram of ΔSSS (ISAS - Marine mammals) for 6 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).

3.13 Summary

Table 1 shows the mean, median, standard deviation (Std), root mean square (RMS), interquartile range (IQR), correlation coefficient (r^2) and robust standard deviation (Std*) of the match-up differences ΔSSS (ISAS - Marine mammals) for the following conditions:

- all: All the match-up pairs satellite/in situ SSS are used to derive the statistics
- C1: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km
- C2: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s
- C3: only pairs where RR>1mm/h and U_{10} <4m/s
- C4: only pairs where MLD<20m
- C5: only pairs where WOA2013 SSS Std<0.2
- C6: only pairs where WOA2013 SSS Std>0.2
- C7a: only pairs where distance to coast is < 150 km.
- C7b: only pairs where distance to coast is in the range [150, 800] km.
- C7c: only pairs where distance to coast is > 800 km.
- C8a: only pairs where in situ SST is < 5°C.
- C8b: only pairs where in situ SST is in the range [5, 15]°C.

- C8c: only pairs where in situ SST is $> 15°C$.
- C9a: only pairs where in situ SSS is < 33.
- C9b: only pairs where in situ SSS is in the range [33, 37].
- C9c: only pairs where in situ SSS is > 37.

Table 1: Statistics of ΔSSS (ISAS - Marine mammals)

Condition	#	Median	Mean	Std	RMS	IQR	r^2	Std*
all	318456	0.03	0.06	0.29	0.29	0.14	0.874	0.10
C1	17236	0.08	0.09	0.16	0.18	0.17	0.932	0.13
C2	107421	0.02	0.03	0.14	0.14	0.12	0.983	0.09
C3	209	0.06	0.07	0.15	0.16	0.17	0.991	0.13
C4	49147	0.10	0.18	0.62	0.64	0.26	0.702	0.19
C5	153502	0.03	0.04	0.15	0.16	0.11	0.958	0.09
C6	11568	0.05	0.05	0.32	0.32	0.26	0.867	0.20
C7a	135832	0.03	0.07	0.41	0.42	0.18	0.826	0.13
C7b	113695	0.04	0.05	0.15	0.16	0.12	0.928	0.09
C7c	68885	0.03	0.05	0.12	0.13	0.11	0.949	0.08
C8a	229750	0.03	0.06	0.32	0.33	0.13	0.575	0.10
C8b	51624	0.04	0.04	0.20	0.20	0.15	0.941	0.11
C8c	37082	0.02	0.04	0.18	0.19	0.16	0.986	0.12
C9a	32192	0.11	0.24	0.75	0.79	0.23	0.170	0.16
C9b	286264	0.03	0.04	0.16	0.16	0.13	0.935	0.10
C9c	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN

Table 1 numerical values can be downloaded as a csv file here.

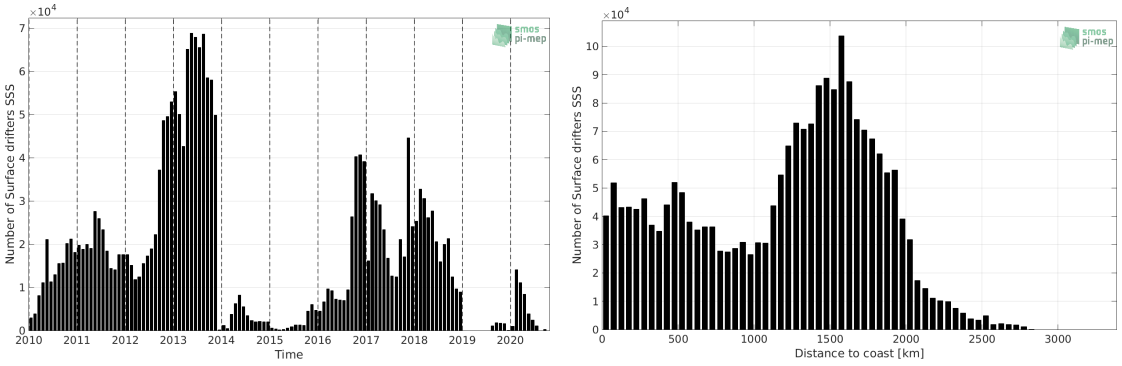
4 Surface drifters

4.1 Introduction

The skin depth of the L-band radiometer signal over the ocean is about 1 cm whereas classical surface salinity measured by ships or Argo floats are performed at a few meters depth. In order to improve the knowledge of the SSS variability in the first 50 cm depth, to better document the SSS variability in a satellite pixel and to provide ground-truth as close as possible to the sea surface for validating satellite SSS, the L-band remotely sensed community proposed to deploy numerous surface drifters over various parts of the ocean. Surface drifter data are provided by the LOCEAN (see https://www.locean-ipsl.upmc.fr/smos/drifters/). Only validated data are considered with uncertainty order of 0.01 and 0.1.

4.2 Number of SSS data as a function of time and distance to coast

Figure 25 shows the time (a) and distance to coast (b) distributions of the Surface drifters *in situ* dataset.

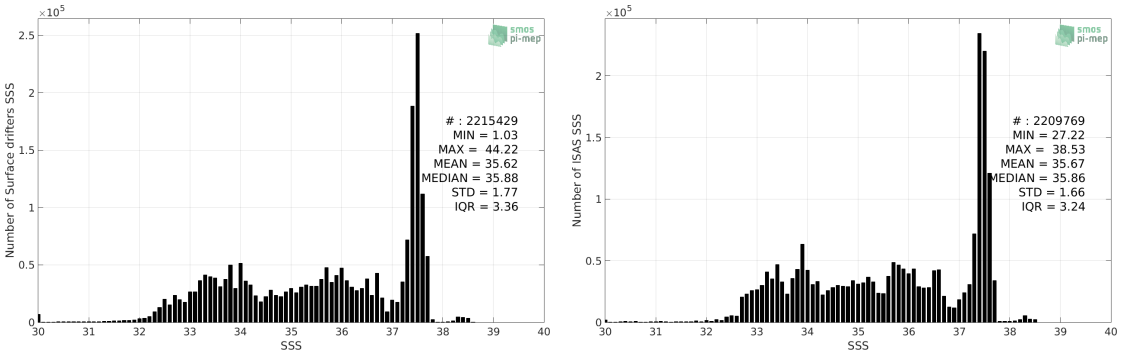


(a) (b)

Figure 25: Number of SSS from Surface drifters as a function of time (a) and distance to coast (b).

4.3 Histograms of SSS

Figure 26 shows the SSS distribution of the Surface drifters (a) and colocalized ISAS (b) dataset.

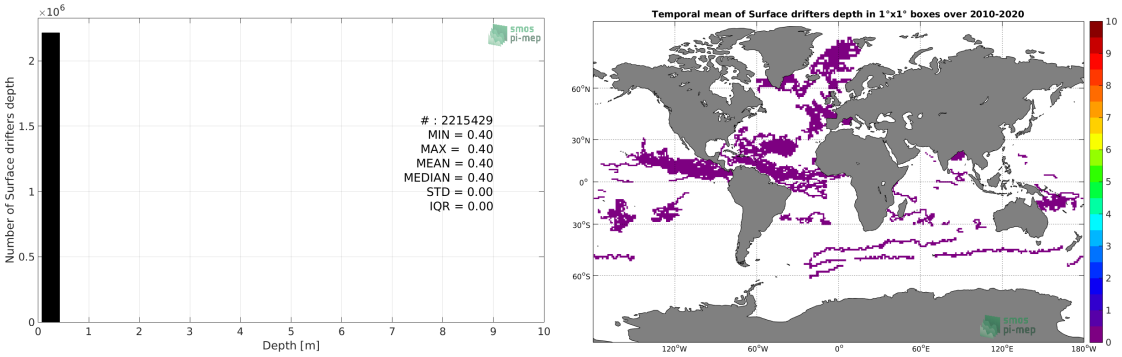


(a) (b)

Figure 26: Histograms of SSS from Surface drifters (a) and ISAS (b) per bins of 0.1.

4.4 Distribution of *in situ* SSS depth measurements

In Figure 27, we show the depth distribution of the *in situ* salinity dataset (a) and the spatial distribution of the depth temporal mean in 1°x1° boxes and considering the full *in situ* dataset period (b).



(a) (b)

Figure 27: Depth distribution of the upper level SSS measurements from Surface drifters (a) and spatial distribution of the *in situ* SSS depth measurements showing the mean value in 1°x1° boxes and considering the full *in situ* dataset period (b).

4.5 Spatial distribution of SSS

In Figure 28, the number of Surface drifters SSS measurements in 1°x1° boxes is shown.

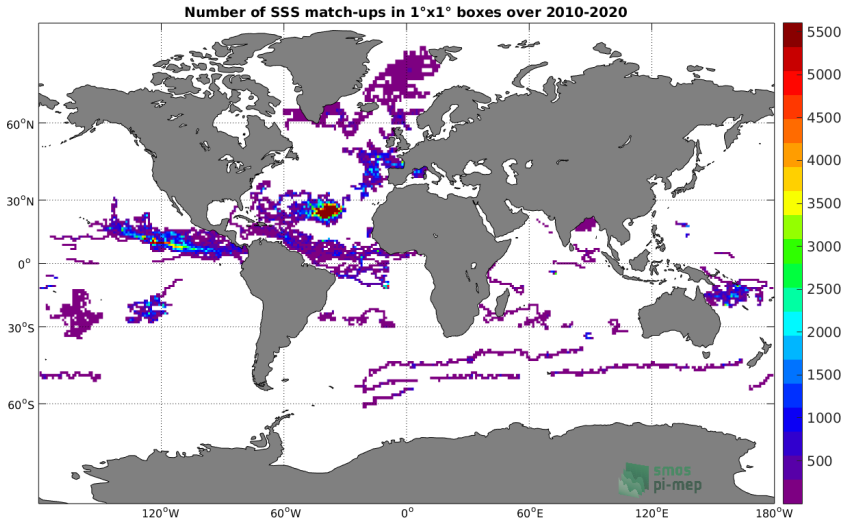
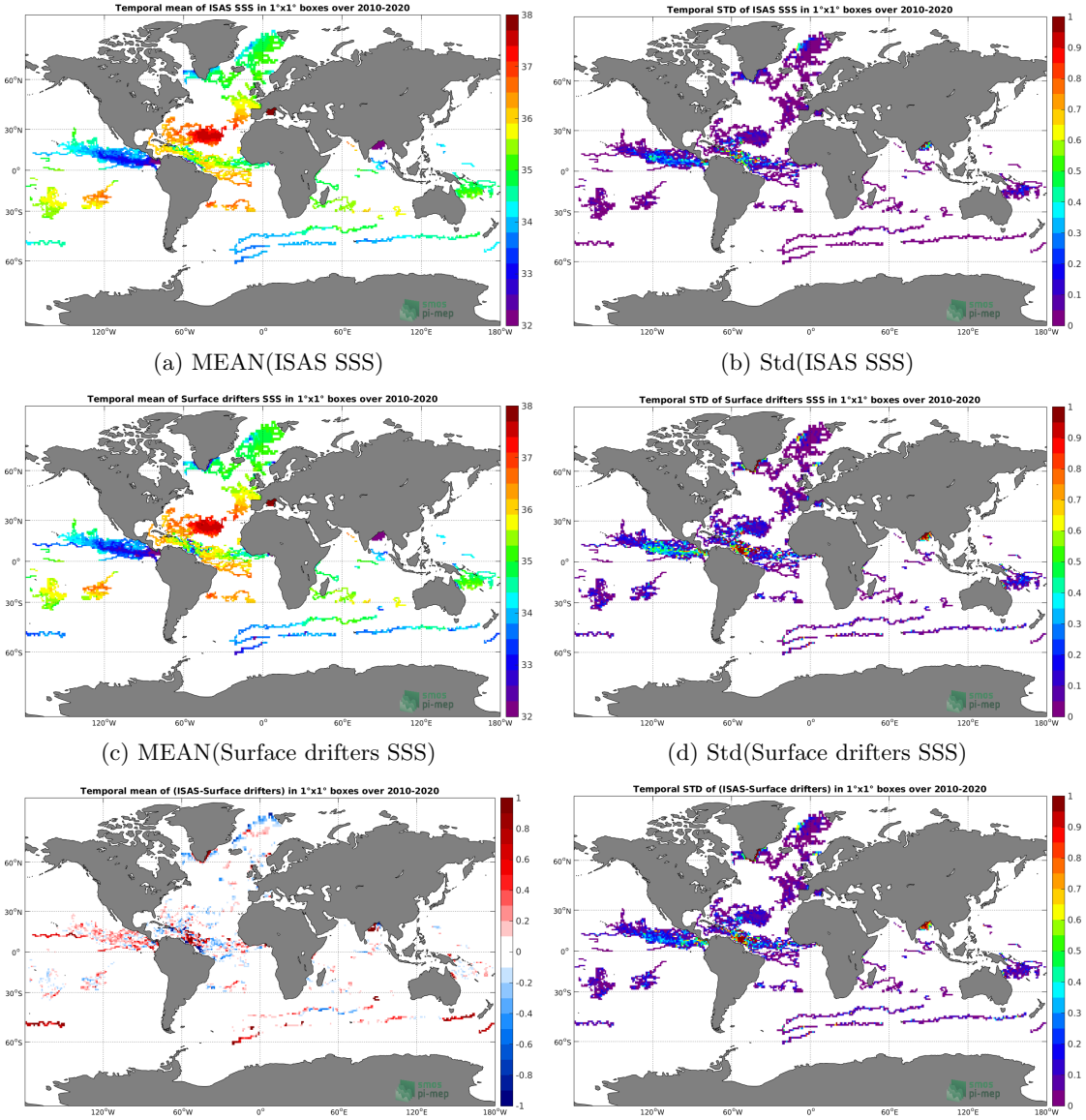


Figure 28: Number of SSS from Surface drifters in 1°x1° boxes.

4.6 Spatial Maps of the Temporal mean and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

In Figure 29, maps of temporal mean (left) and standard deviation (right) of ISAS (top), Surface drifters *in situ* dataset (middle) and the difference ΔSSS(ISAS -Surface drifters) (bottom) are shown. The temporal mean and std are calculated using all match-up pairs falling in spatial boxes of size 1°x1° over the full Surface drifters dataset period.



(a) MEAN(ISAS SSS)

(b) Std(ISAS SSS)

(c) MEAN(Surface drifters SSS)

(d) Std(Surface drifters SSS)

(e) MEAN(ΔSSS) (ISAS - Surface drifters)

(f) Std(ΔSSS) (ISAS - Surface drifters)

Figure 29: Temporal mean (left) and Std (right) of SSS from ISAS (top), Surface drifters (middle), and of ΔSSS (ISAS - Surface drifters). Only match-up pairs are used to generate these maps.

4.7 Time series of the monthly median and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

In the top panel of Figure 30, we show the time series of the monthly median SSS estimated for both ISAS SSS product (in black) and the Surface drifters *in situ* dataset (in blue) at the collected Pi-MEP match-up pairs.

In the middle panel of Figure 30, we show the time series of the monthly median of ΔSSS

(ISAS - Surface drifters) for the collected Pi-MEP match-up pairs.

In the bottom panel of Figure 30, we show the time series of the monthly standard deviation of the ΔSSS (ISAS - Surface drifters) for the collected Pi-MEP match-up pairs.

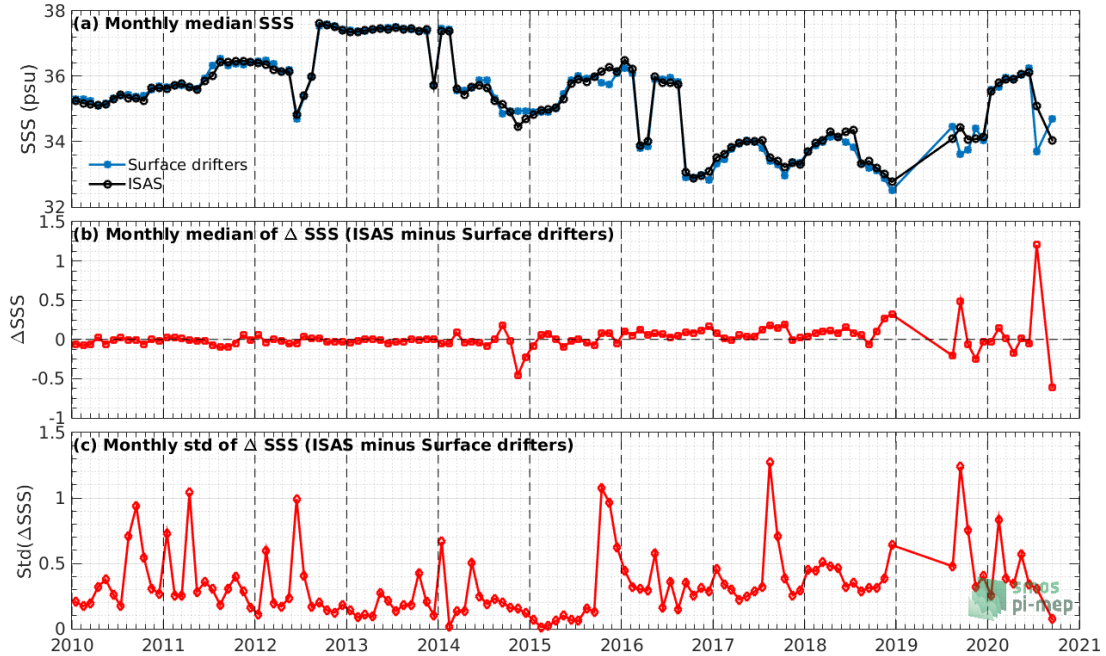


Figure 30: Time series of the monthly median SSS (top), median of ΔSSS (ISAS - Surface drifters) and Std of ΔSSS (ISAS - Surface drifters) considering all match-ups collected by the Pi-MEP.

4.8 Zonal mean and Std of *in situ* and ISAS SSS and of the difference ΔSSS

In Figure 31 left panel, we show the zonal mean SSS considering all Pi-MEP match-up pairs for both ISAS SSS product (in black) and the Surface drifters *in situ* dataset (in blue). The full *in situ* dataset period is used to derive the mean.

In the right panel of Figure 31, we show the zonal mean of ΔSSS (ISAS - Surface drifters) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

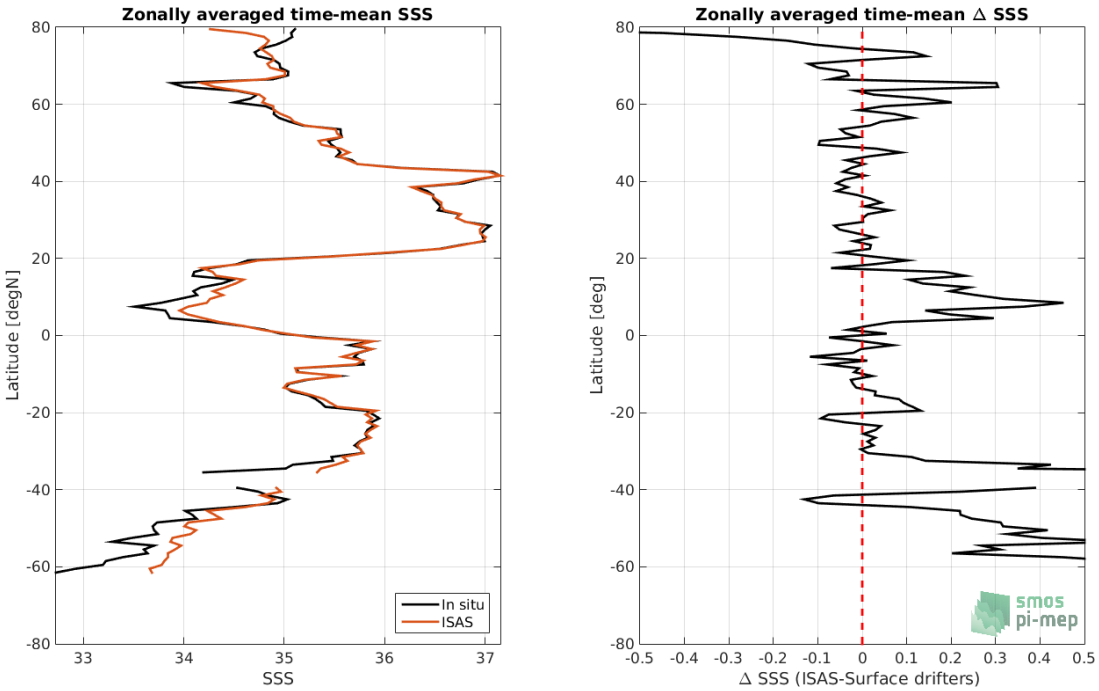
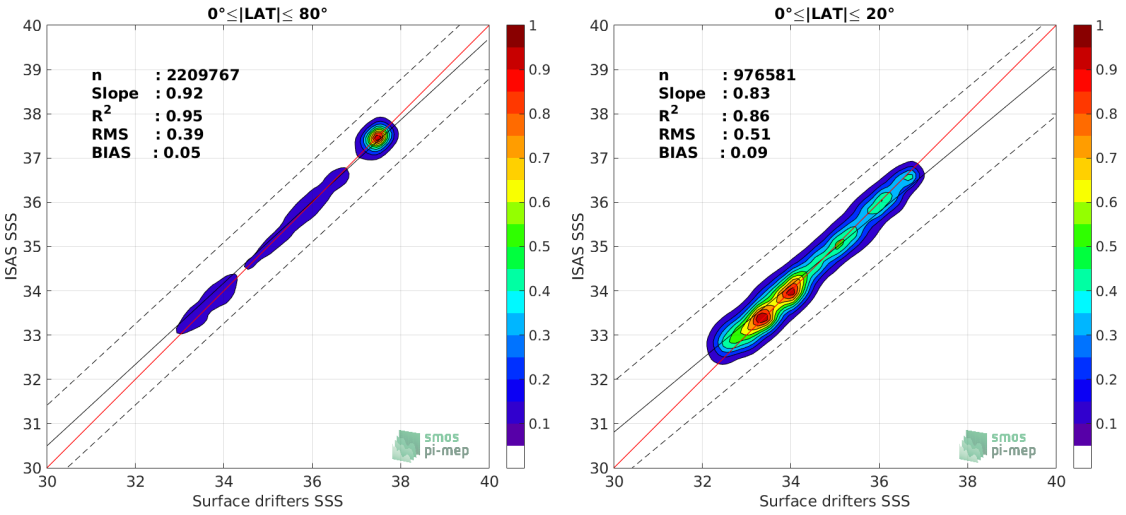


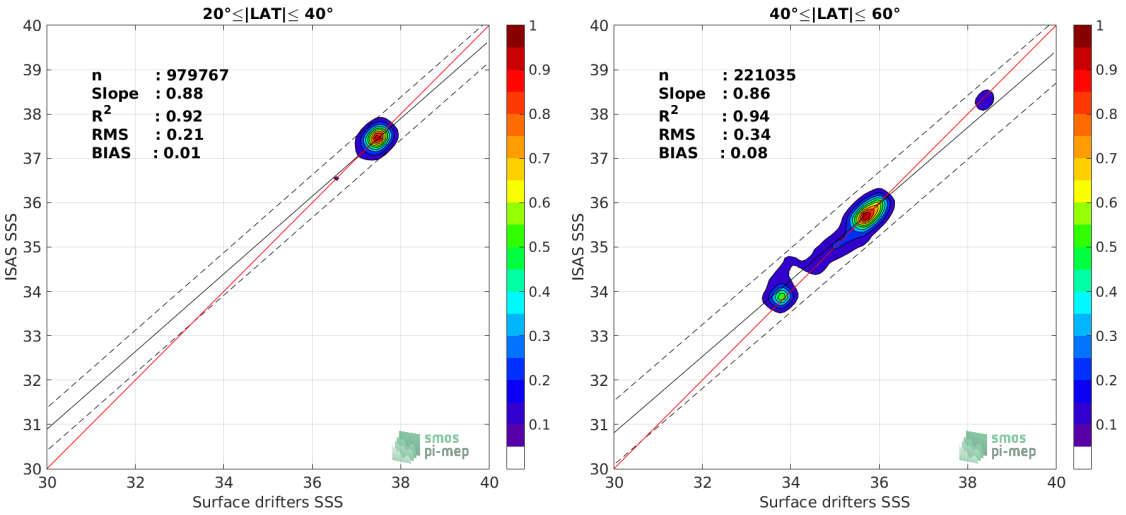
Figure 31: Left panel: Zonal mean SSS from ISAS product (black) and from Surface drifters (blue). Right panel: Zonal mean of ΔSSS (ISAS - Surface drifters) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

4.9 Scatterplots of ISAS vs *in situ* SSS by latitudinal bands

In Figure 32, contour maps of the concentration of ISAS SSS (y-axis) versus Surface drifters SSS (x-axis) at match-up pairs for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.



(a) $0° \leq |\text{LAT}| \leq 80°$ (b) $0° \leq |\text{LAT}| \leq 20°$

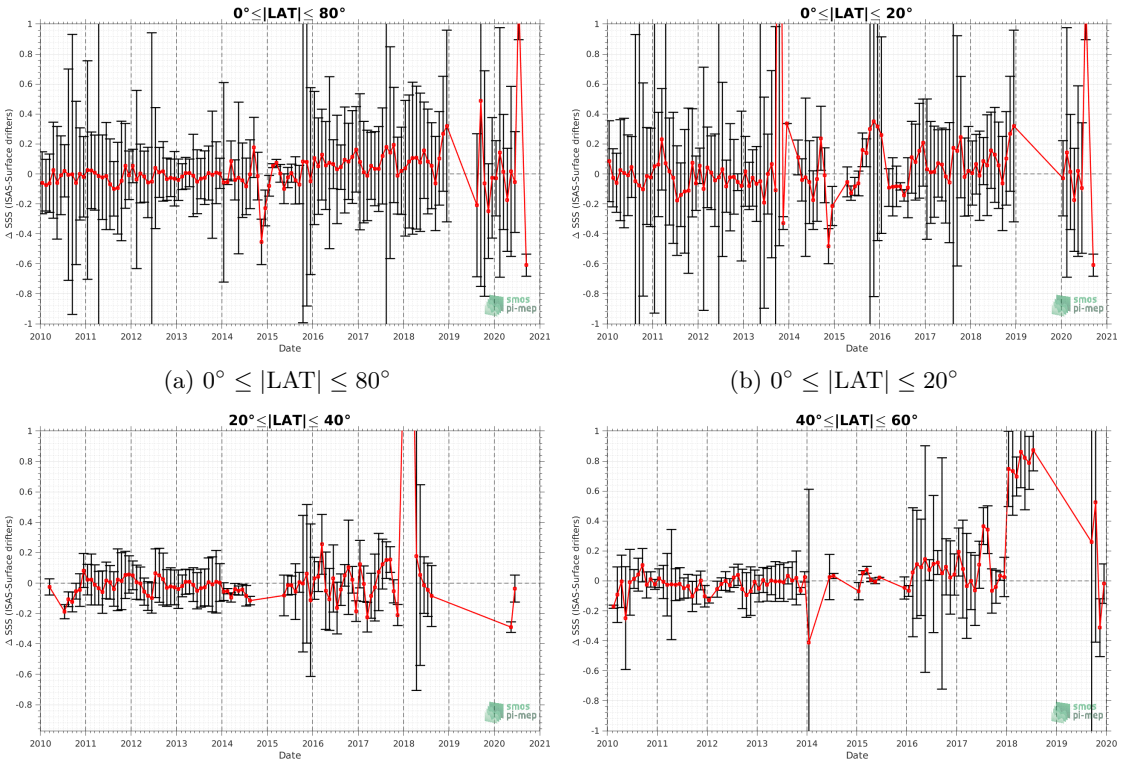


(c) $20° \leq |\text{LAT}| \leq 40°$ (d) $40° \leq |\text{LAT}| \leq 60°$

Figure 32: Contour maps of the concentration of ISAS SSS (y-axis) versus Surface drifters SSS (x-axis) at match-up pairs for different latitude bands. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.

4.10 Time series of the monthly median and Std of the difference ΔSSS sorted by latitudinal bands

In Figure 33, time series of the monthly median (red curves) of ΔSSS (ISAS - Surface drifters) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs estimated for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.



(a) $0° \leq |\text{LAT}| \leq 80°$

(b) $0° \leq |\text{LAT}| \leq 20°$

(c) $20° \leq |\text{LAT}| \leq 40°$

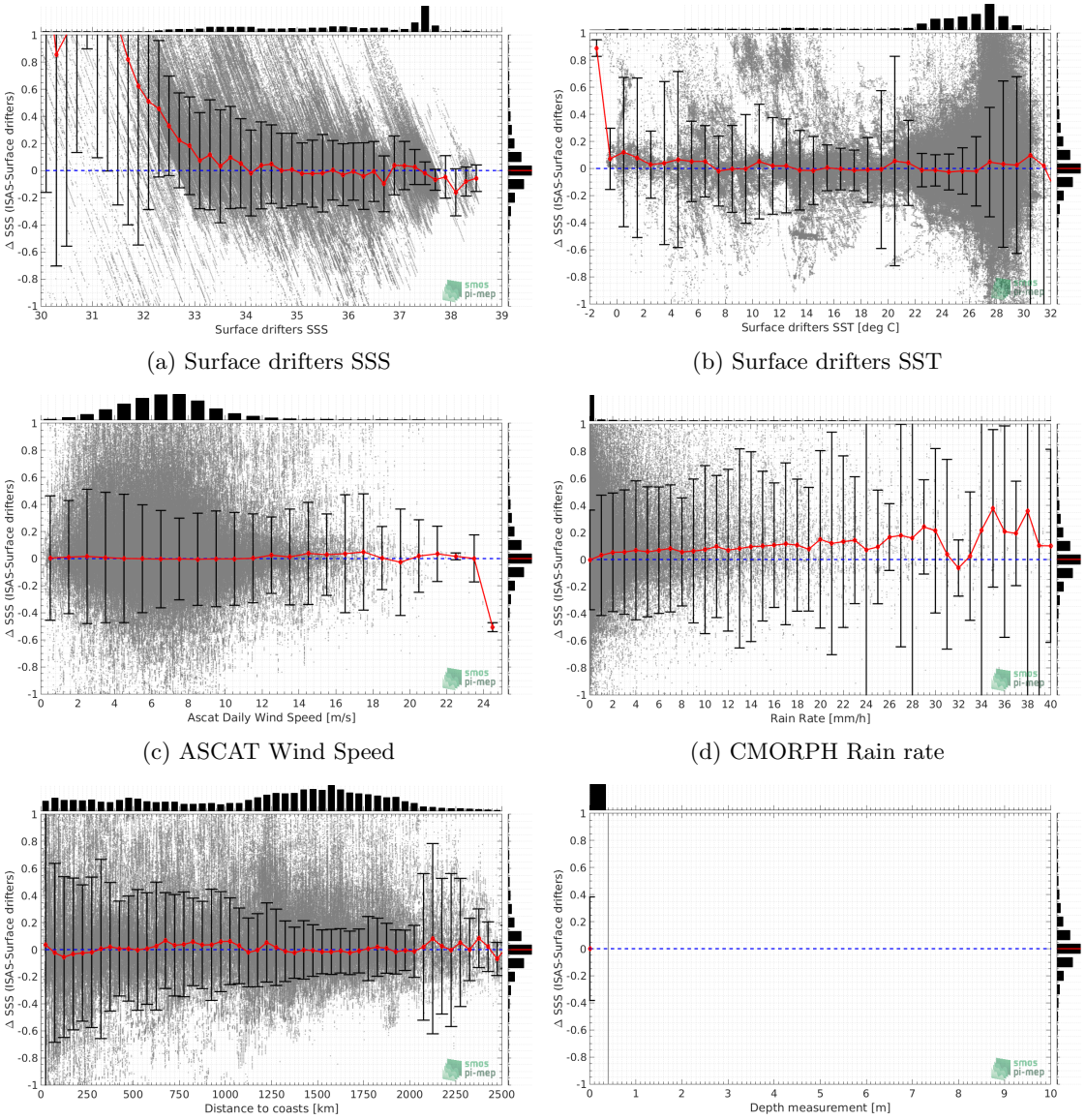
(d) $40° \leq |\text{LAT}| \leq 60°$

Figure 33: Monthly median (red curves) of ΔSSS (ISAS - Surface drifters) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.

4.11 ΔSSS sorted as geophysical conditions

In Figure 34, we classify the match-up differences ΔSSS (ISAS - *in situ*) as function of the geophysical conditions at match-up points. The mean and std of ΔSSS (ISAS - Surface drifters) is thus evaluated as function of the

- *in situ* SSS values per bins of width 0.2,
- *in situ* SST values per bins of width 1°C,
- ASCAT daily wind values per bins of width 1 m/s,
- CMORPH 3-hourly rain rates per bins of width 1 mm/h, and,
- distance to coasts per bins of width 50 km,
- *in situ* measurement depth (if relevant).



(a) Surface drifters SSS

(b) Surface drifters SST

(c) ASCAT Wind Speed

(d) CMORPH Rain rate

(e) Distance to coast

(f) Depth

Figure 34: Δ SSS (ISAS - Surface drifters) sorted as geophysical conditions: Surface drifters SSS a), Surface drifters SST b), ASCAT Wind speed c), CMORPH rain rate d), distance to coast (e) and depth measurements (f).

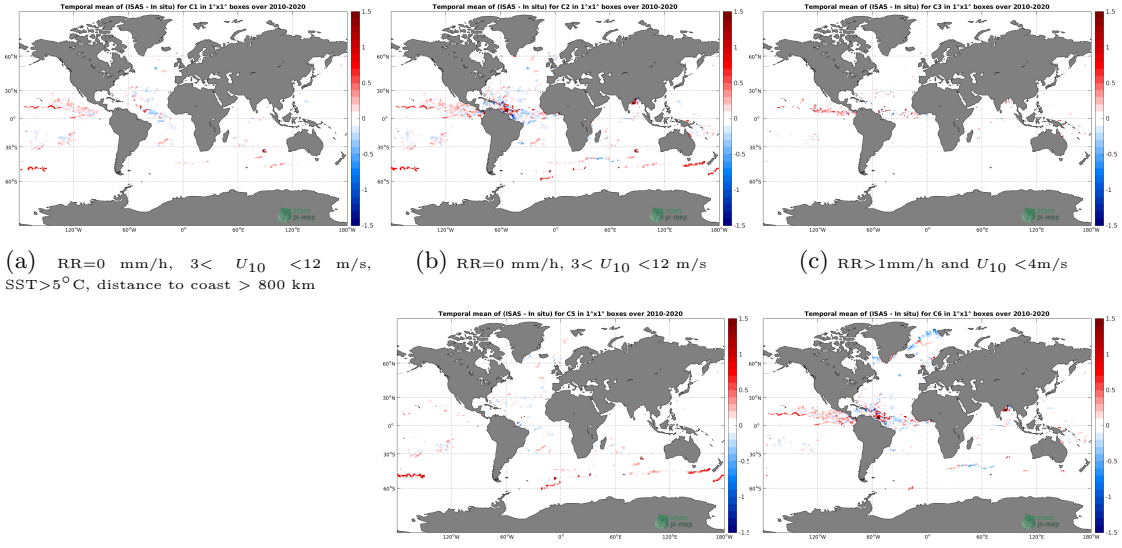
4.12 ΔSSS maps and statistics for different geophysical conditions

In Figures 35 and 36, we focus on sub-datasets of the match-up differences ΔSSS (ISAS - *in situ*) for the following specific geophysical conditions:

- **C1**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is in the range [3, 12] m/s, the SST is $> 5°$C and distance to coast is > 800 km.

- **C2**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is in the range [3, 12] m/s.
- **C3**:if the local value at *in situ* location of estimated rain rate is high (ie. $>$ 1 mm/h) and mean daily wind is low (ie. $<$ 4 m/s).
- **C5**:if the *in situ* data is located where the climatological SSS standard deviation is low (ie. above $<$ 0.2).
- **C6**:if the *in situ* data is located where the climatological SSS standard deviation is high (ie. above $>$ 0.2).

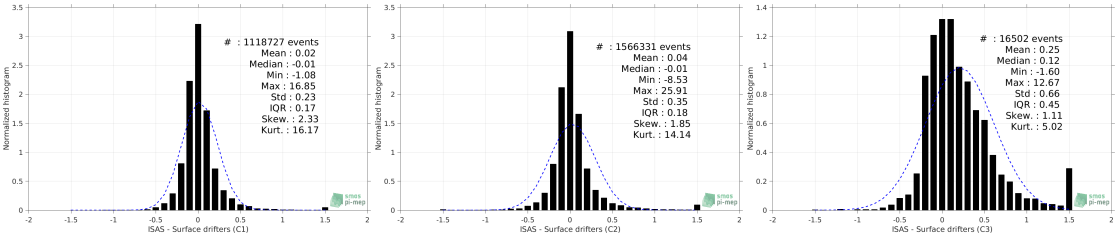
For each of these conditions, the temporal mean (gridded over spatial boxes of size 1°x1°) and the histogram of the difference ΔSSS (ISAS - *in situ*) are presented.



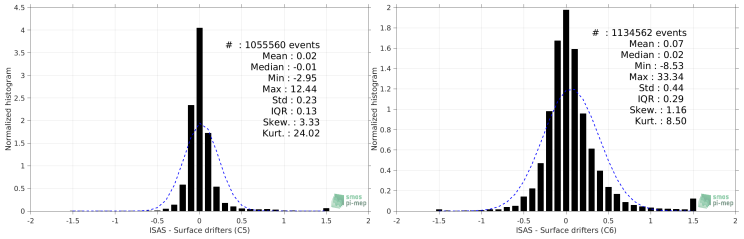
(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s

(d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 35: Temporal mean gridded over spatial boxes of size 1°x1° of ΔSSS (ISAS - Surface drifters) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).



(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s



(d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 36: Normalized histogram of ΔSSS (ISAS - Surface drifters) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).

4.13 Summary

Table 1 shows the mean, median, standard deviation (Std), root mean square (RMS), interquartile range (IQR), correlation coefficient (r^2) and robust standard deviation (Std*) of the match-up differences ΔSSS (ISAS - Surface drifters) for the following conditions:

- all: All the match-up pairs satellite/in situ SSS values are used to derive the statistics
- C1: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km
- C2: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s
- C3: only pairs where RR>1mm/h and U_{10} <4m/s
- C5: only pairs where WOA2013 SSS Std<0.2
- C6: only pairs where WOA2013 SSS Std>0.2
- C7a: only pairs with a distance to coast < 150 km.
- C7b: only pairs with a distance to coast in the range [150, 800] km.
- C7c: only pairs with a distance to coast > 800 km.
- C8a: only pairs where SST is < 5°C.
- C8b: only pairs where SST is in the range [5, 15]°C.
- C8c: only pairs where SST is > 15°C.

- C9a: only pairs where SSS is < 33.
- C9b: only pairs where SSS is in the range [33, 37].
- C9c: only pairs where SSS is > 37.

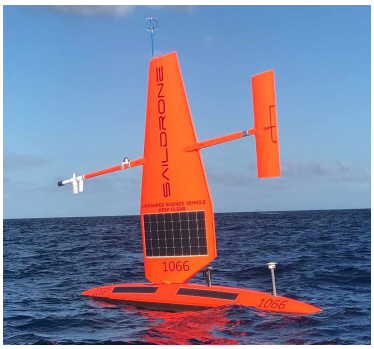
Table 1: Statistics of ΔSSS (ISAS - Surface drifters)

Condition	#	Median	Mean	Std	RMS	IQR	r^2	Std*
all	2209769	0.00	0.05	0.38	0.39	0.19	0.954	0.14
C1	1118727	-0.01	0.02	0.23	0.23	0.17	0.982	0.13
C2	1566331	-0.01	0.04	0.35	0.35	0.18	0.957	0.13
C3	16502	0.12	0.25	0.66	0.71	0.45	0.844	0.32
C5	1055560	-0.01	0.02	0.23	0.23	0.13	0.965	0.10
C6	1134562	0.02	0.07	0.44	0.45	0.29	0.928	0.21
C7a	131297	-0.02	0.13	0.91	0.91	0.30	0.798	0.21
C7b	519947	0.01	0.08	0.47	0.47	0.21	0.871	0.16
C7c	1558469	0.00	0.04	0.25	0.26	0.19	0.981	0.14
C8a	33057	0.07	0.23	0.55	0.60	0.13	0.467	0.09
C8b	144866	0.01	0.08	0.33	0.34	0.16	0.923	0.12
C8c	2026237	0.00	0.05	0.38	0.38	0.20	0.955	0.14
C9a	165932	0.29	0.50	0.97	1.10	0.44	0.153	0.32
C9b	1283786	0.01	0.03	0.31	0.31	0.24	0.929	0.18
C9c	760051	-0.02	-0.02	0.11	0.11	0.11	0.707	0.08

Table 1 numerical values can be downloaded as a csv file here.

5 Saildrones

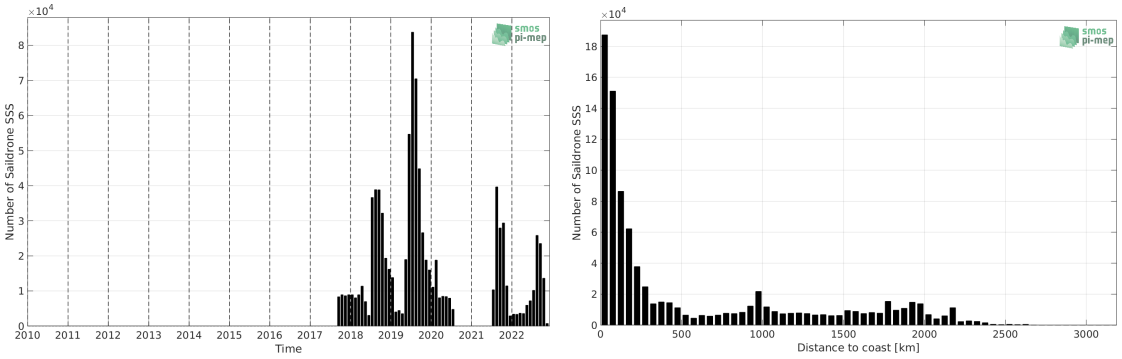
5.1 Introduction



Saildrone is a state-of-the-art, remotely guided, wind and solar powered unmanned surface vehicle (USV) capable of long distance deployments lasting up to 12 months. It is equipped with a suite of instruments and sensors providing high quality, georeferenced, near real-time, multi-parameter surface ocean and atmospheric observations while transiting at typical speeds of 3-5 knots. All freely available data are included coming from different providers (Saildrone, NOAA/PMEL, ...) and easely accessible via NOAA ERDAP. When 2 different sensors are available, usually from different brands (SeaBird or RBR), the RBR sensor is kept with the exception for the Atlantic to Mediterranean 2019-2020 campaign for which the salinity data from RBR are clearly corrupted. One-minute samples of the original data were resampled every 10 minutes using linear interpolation to reduce the number of point.

5.2 Number of SSS data as a function of time and distance to coast

Figure 37 shows the time (a) and distance to coast (b) distributions of the Saildrones *in situ* dataset.

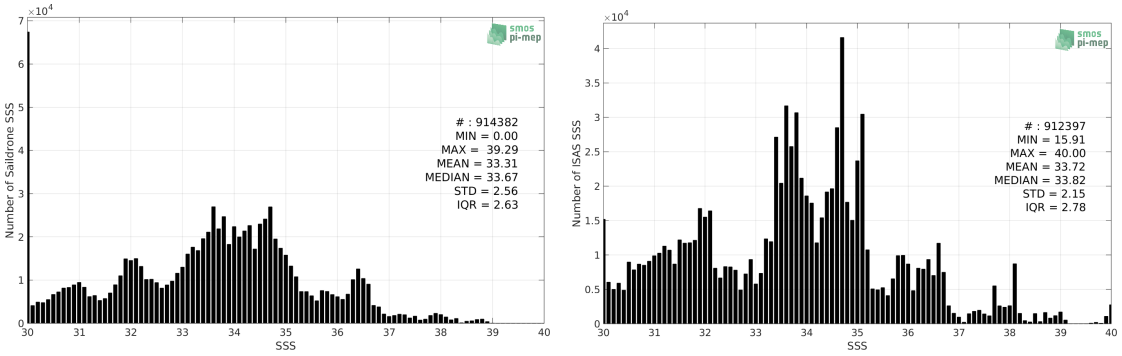


(a) (b)

Figure 37: Number of SSS from Saildrones as a function of time (a) and distance to coast (b).

5.3 Histograms of SSS

Figure 38 shows the SSS distribution of the Saildrones (a) and colocalized ISAS (b) dataset.

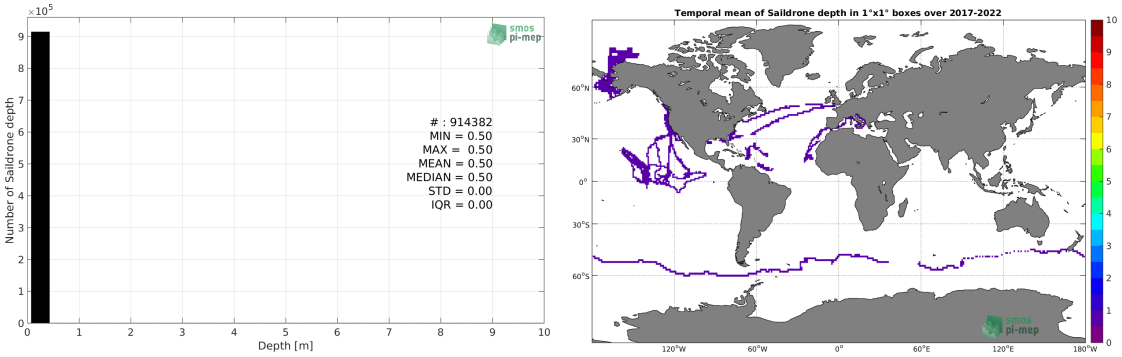


(a) (b)

Figure 38: Histograms of SSS from Saildrones (a) and ISAS (b) per bins of 0.1.

5.4 Distribution of *in situ* SSS depth measurements

In Figure 39, we show the depth distribution of the *in situ* salinity dataset (a) and the spatial distribution of the depth temporal mean in 1°x1° boxes and considering the full *in situ* dataset period (b).



(a) (b)

Figure 39: Depth distribution of the upper level SSS measurements from Saildrones (a) and spatial distribution of the *in situ* SSS depth measurements showing the mean value in 1°x1° boxes and considering the full *in situ* dataset period (b).

5.5 Spatial distribution of SSS

In Figure 40, the number of Saildrones SSS measurements in 1°x1° boxes is shown.

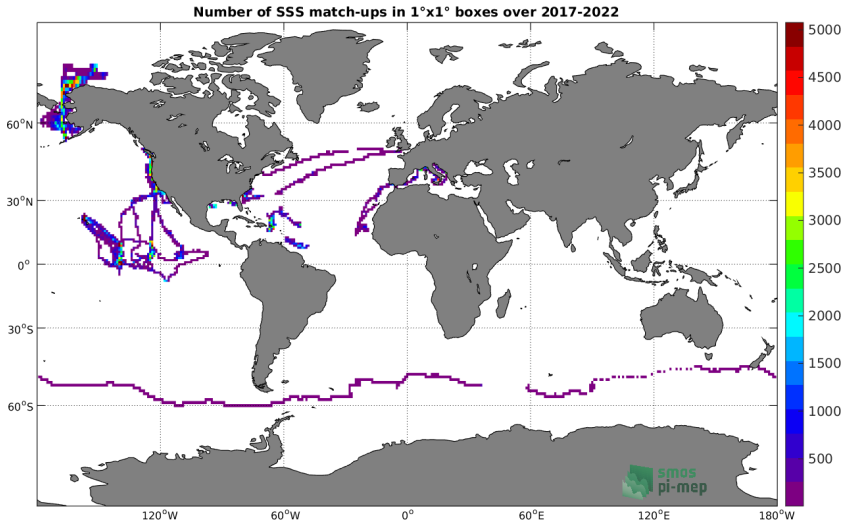
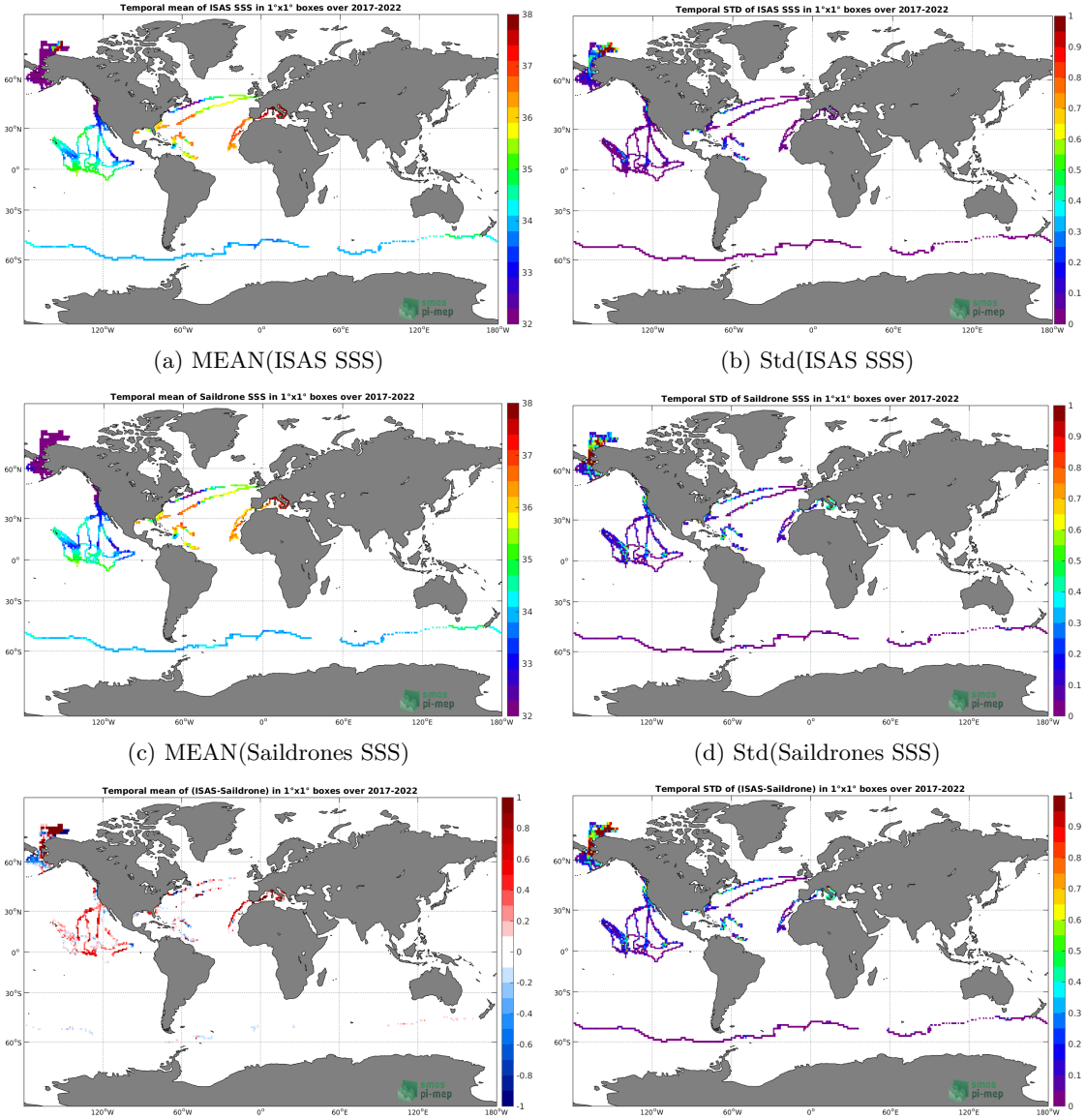


Figure 40: Number of SSS from Saildrones in 1°x1° boxes.

5.6 Spatial Maps of the Temporal mean and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

In Figure 41, maps of temporal mean (left) and standard deviation (right) of ISAS (top), Saildrones *in situ* dataset (middle) and the difference ΔSSS(ISAS -Saildrones) (bottom) are shown. The temporal mean and std are calculated using all match-up pairs falling in spatial boxes of size 1°x1° over the full Saildrones dataset period.



(a) MEAN(ISAS SSS)

(b) Std(ISAS SSS)

(c) MEAN(Saildrones SSS)

(d) Std(Saildrones SSS)

(e) MEAN(ΔSSS) (ISAS - Saildrones)

(f) Std(ΔSSS) (ISAS - Saildrones)

Figure 41: Temporal mean (left) and Std (right) of SSS from ISAS (top), Saildrones (middle), and of ΔSSS (ISAS - Saildrones). Only match-up pairs are used to generate these maps.

5.7 Time series of the monthly median and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

In the top panel of Figure 42, we show the time series of the monthly median SSS estimated for both ISAS SSS product (in black) and the Saildrones *in situ* dataset (in blue) at the collected Pi-MEP match-up pairs.

In the middle panel of Figure 42, we show the time series of the monthly median of ΔSSS (ISAS - Saildrones) for the collected Pi-MEP match-up pairs.

In the bottom panel of Figure 42, we show the time series of the monthly standard deviation of the ΔSSS (ISAS - Saildrones) for the collected Pi-MEP match-up pairs.

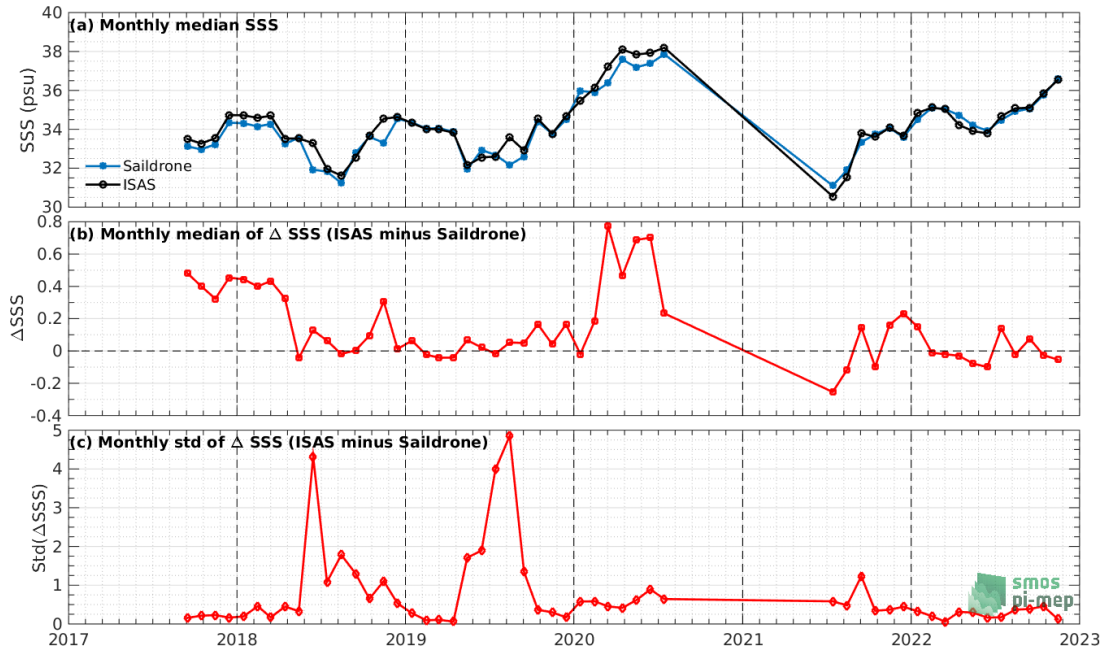


Figure 42: Time series of the monthly median SSS (top), median of ΔSSS (ISAS - Saildrones) and Std of ΔSSS (ISAS - Saildrones) considering all match-ups collected by the Pi-MEP.

5.8 Zonal mean and Std of *in situ* and ISAS SSS and of the difference ΔSSS

In Figure 43 left panel, we show the zonal mean SSS considering all Pi-MEP match-up pairs for both ISAS SSS product (in black) and the Saildrones *in situ* dataset (in blue). The full *in situ* dataset period is used to derive the mean.

In the right panel of Figure 43, we show the zonal mean of ΔSSS (ISAS - Saildrones) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

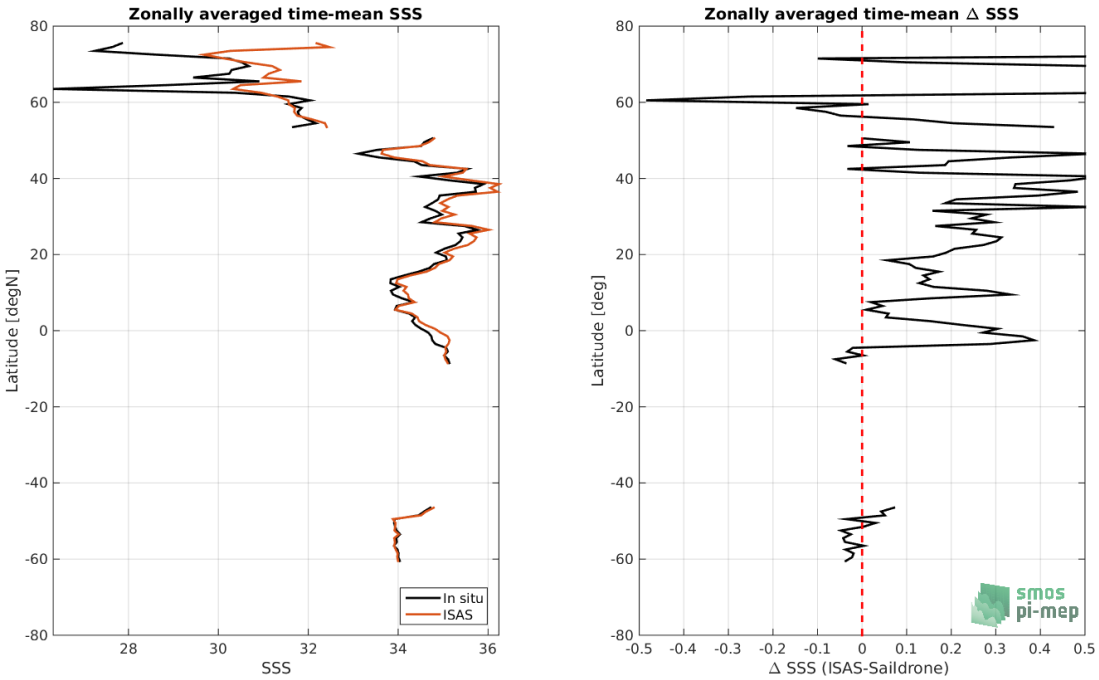
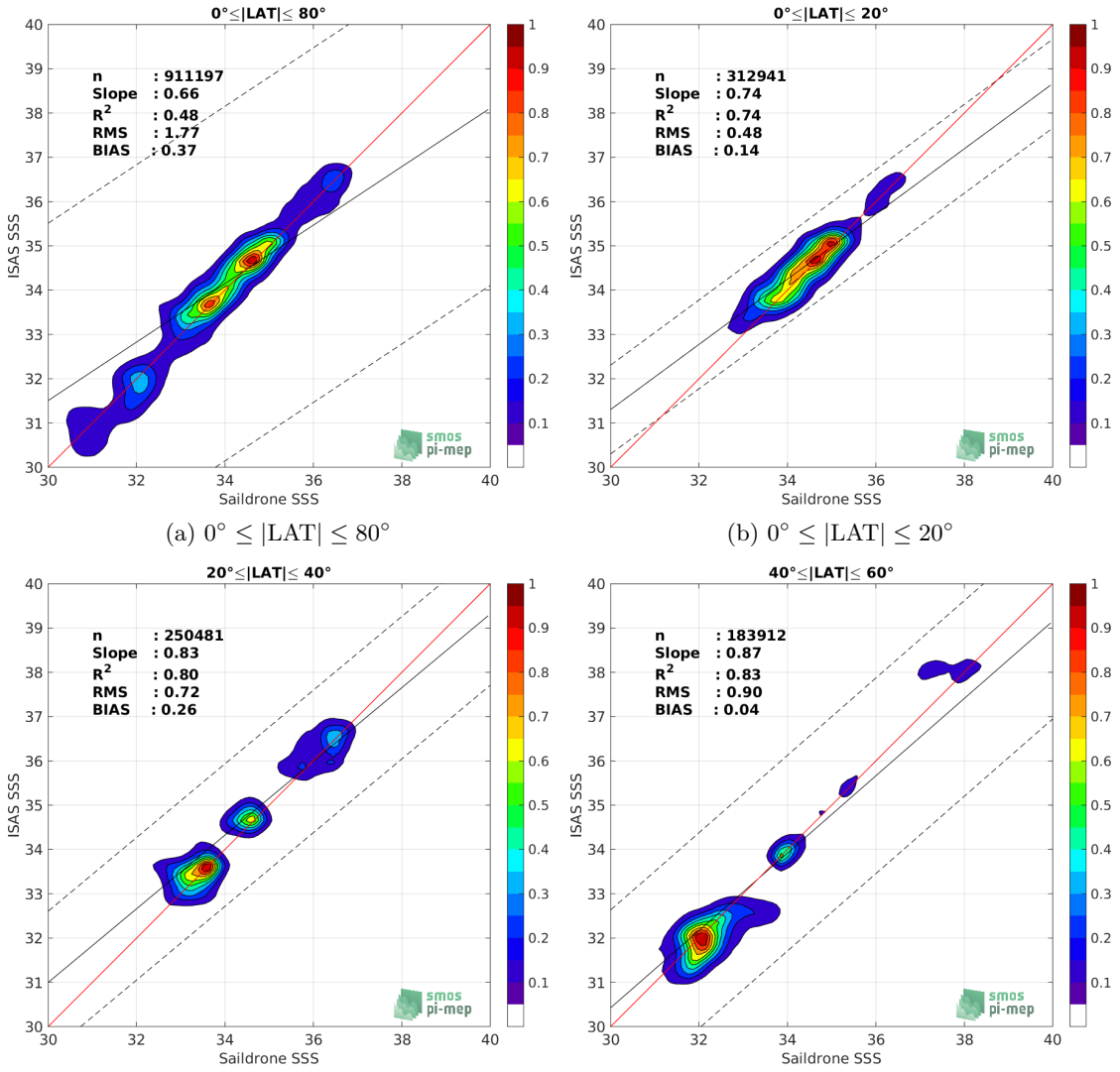


Figure 43: Left panel: Zonal mean SSS from ISAS product (black) and from Saildrones (blue). Right panel: Zonal mean of ΔSSS (ISAS - Saildrones) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

5.9 Scatterplots of ISAS vs *in situ* SSS by latitudinal bands

In Figure 44, contour maps of the concentration of ISAS SSS (y-axis) versus Saildrones SSS (x-axis) at match-up pairs for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.



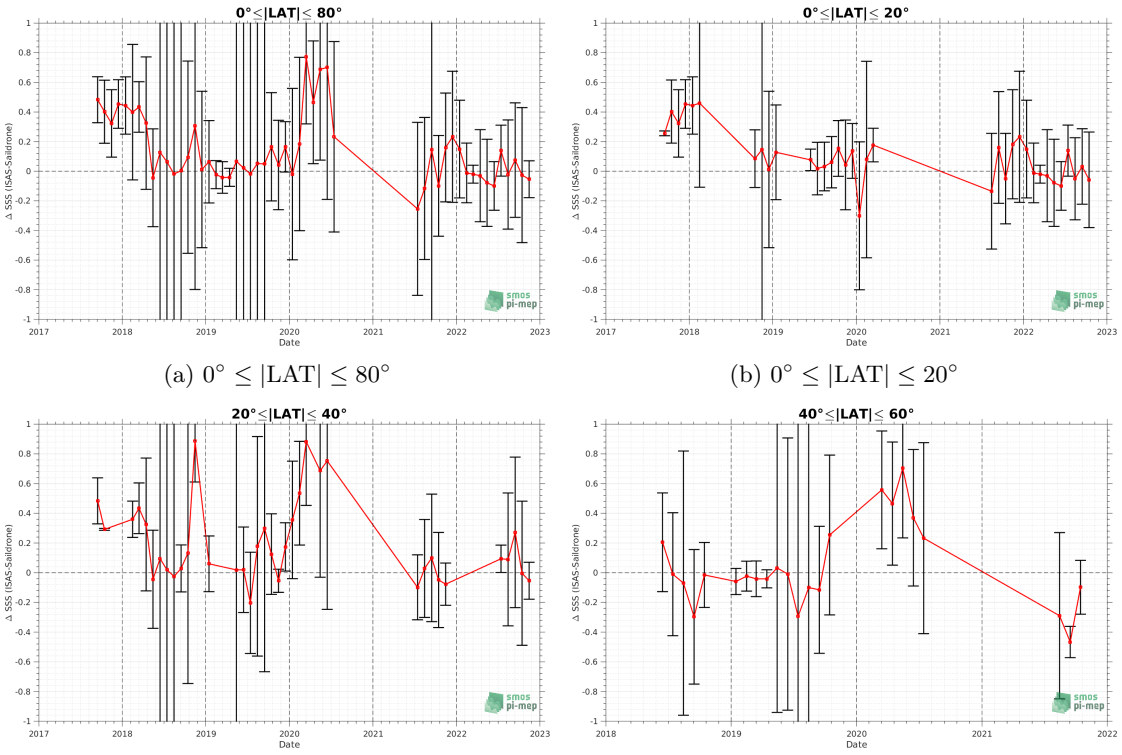
(a) $0° \leq |\text{LAT}| \leq 80°$ (b) $0° \leq |\text{LAT}| \leq 20°$

(c) $20° \leq |\text{LAT}| \leq 40°$ (d) $40° \leq |\text{LAT}| \leq 60°$

Figure 44: Contour maps of the concentration of ISAS SSS (y-axis) versus Saildrones SSS (x-axis) at match-up pairs for different latitude bands. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.

5.10 Time series of the monthly median and Std of the difference ΔSSS sorted by latitudinal bands

In Figure 45, time series of the monthly median (red curves) of ΔSSS (ISAS - Saildrones) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs estimated for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.



(a) $0° \leq |\text{LAT}| \leq 80°$

(b) $0° \leq |\text{LAT}| \leq 20°$

(c) $20° \leq |\text{LAT}| \leq 40°$

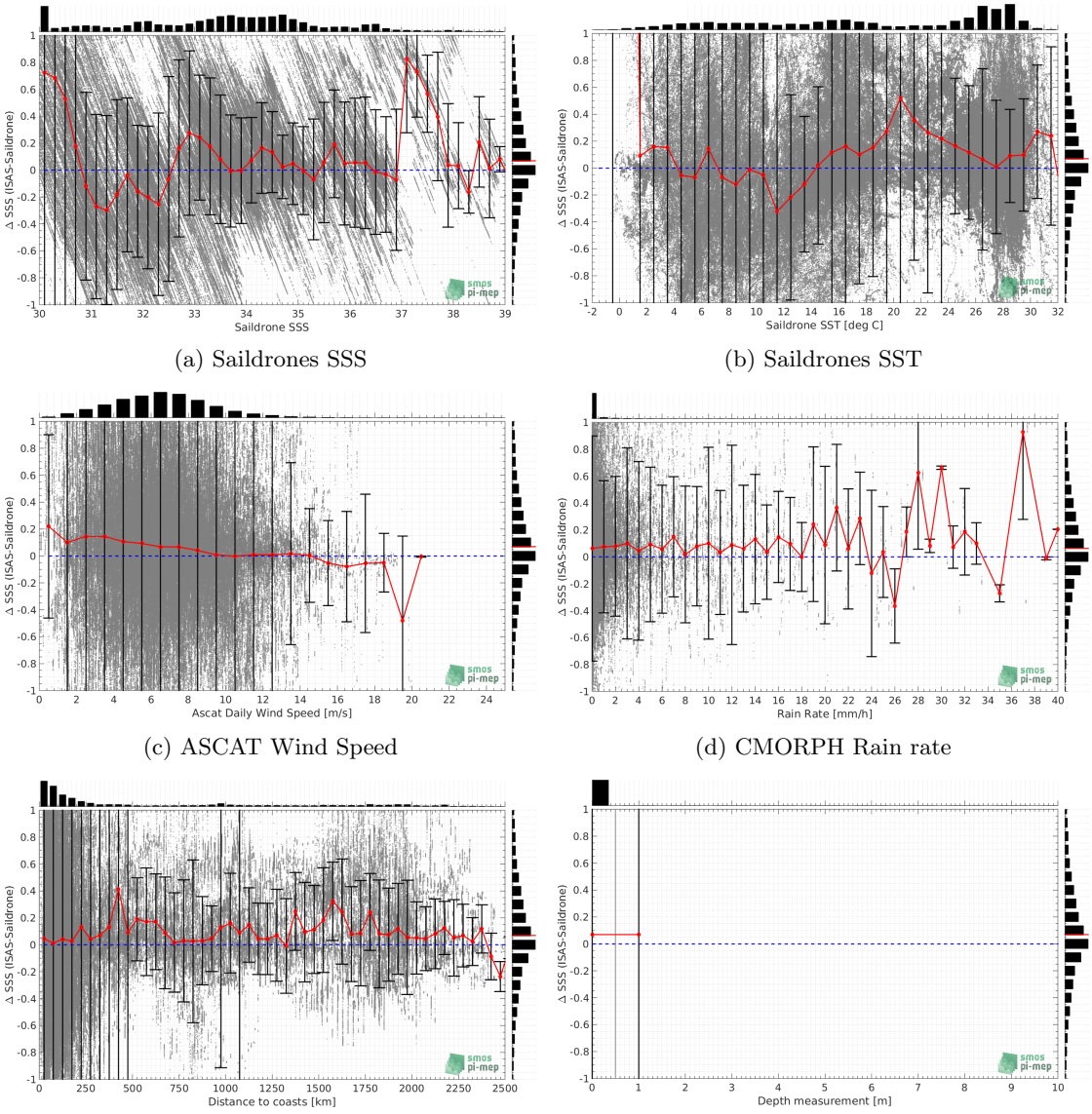
(d) $40° \leq |\text{LAT}| \leq 60°$

Figure 45: Monthly median (red curves) of ΔSSS (ISAS - Saildrones) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.

5.11 ΔSSS sorted as geophysical conditions

In Figure 46, we classify the match-up differences ΔSSS (ISAS - *in situ*) as function of the geophysical conditions at match-up points. The mean and std of ΔSSS (ISAS - Saildrones) is thus evaluated as function of the

- *in situ* SSS values per bins of width 0.2,
- *in situ* SST values per bins of width 1°C,
- ASCAT daily wind values per bins of width 1 m/s,
- CMORPH 3-hourly rain rates per bins of width 1 mm/h, and,
- distance to coasts per bins of width 50 km,
- *in situ* measurement depth (if relevant).



(a) Saildrones SSS

(b) Saildrones SST

(c) ASCAT Wind Speed

(d) CMORPH Rain rate

(e) Distance to coast

(f) Depth

Figure 46: Δ SSS (ISAS - Saildrones) sorted as geophysical conditions: Saildrones SSS a), Saildrones SST b), ASCAT Wind speed c), CMORPH rain rate d), distance to coast (e) and depth measurements (f).

5.12 ΔSSS maps and statistics for different geophysical conditions

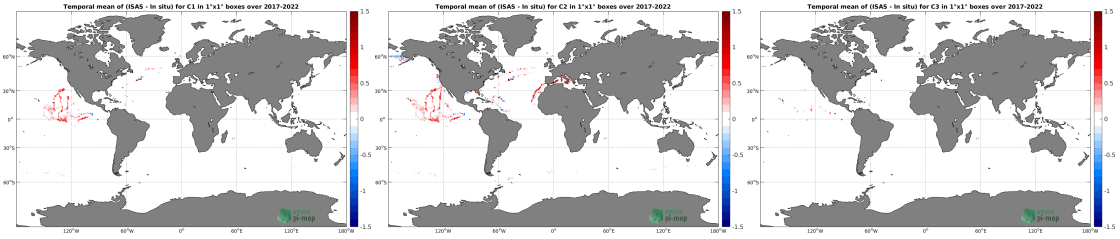
In Figures 47 and 48, we focus on sub-datasets of the match-up differences ΔSSS (ISAS - *in situ*) for the following specific geophysical conditions:

- **C1**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is in the range [3, 12] m/s, the SST is $> 5°$C and distance to coast is > 800 km.
- **C2**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is

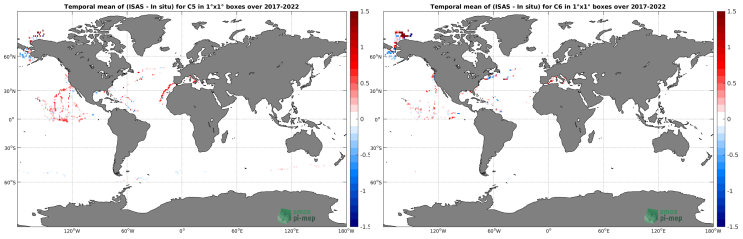
in the range [3, 12] m/s.

- **C3**:if the local value at *in situ* location of estimated rain rate is high (ie. $>$ 1 mm/h) and mean daily wind is low (ie. $<$ 4 m/s).
- **C5**:if the *in situ* data is located where the climatological SSS standard deviation is low (ie. above $<$ 0.2).
- **C6**:if the *in situ* data is located where the climatological SSS standard deviation is high (ie. above $>$ 0.2).

For each of these conditions, the temporal mean (gridded over spatial boxes of size 1°x1°) and the histogram of the difference ΔSSS (ISAS - *in situ*) are presented.

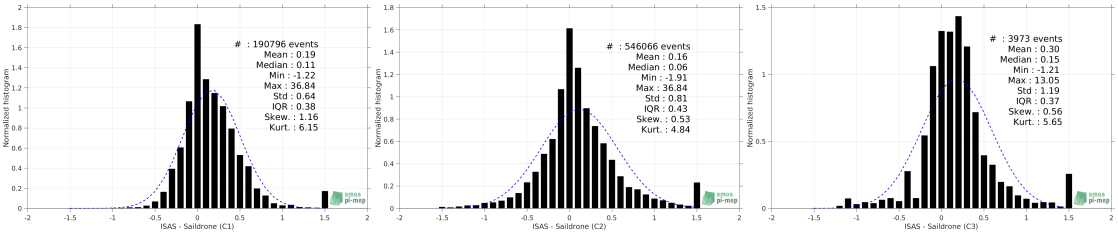


(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s



(d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 47: Temporal mean gridded over spatial boxes of size 1°x1° of ΔSSS (ISAS - Saildrones) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).



(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s

(d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 48: Normalized histogram of ΔSSS (ISAS - Saildrones) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).

5.13 Summary

Table 1 shows the mean, median, standard deviation (Std), root mean square (RMS), interquartile range (IQR), correlation coefficient (r^2) and robust standard deviation (Std*) of the match-up differences ΔSSS (ISAS - Saildrones) for the following conditions:

- all: All the match-up pairs satellite/in situ SSS values are used to derive the statistics
- C1: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km
- C2: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s
- C3: only pairs where RR>1mm/h and U_{10} <4m/s
- C5: only pairs where WOA2013 SSS Std<0.2
- C6: only pairs where WOA2013 SSS Std>0.2
- C7a: only pairs with a distance to coast < 150 km.
- C7b: only pairs with a distance to coast in the range [150, 800] km.
- C7c: only pairs with a distance to coast > 800 km.
- C8a: only pairs where SST is < 5°C.
- C8b: only pairs where SST is in the range [5, 15]°C.
- C8c: only pairs where SST is > 15°C.

- C9a: only pairs where SSS is < 33.
- C9b: only pairs where SSS is in the range [33, 37].
- C9c: only pairs where SSS is > 37.

Table 1: Statistics of ΔSSS (ISAS - Saildrones)

Condition	#	Median	Mean	Std	RMS	IQR	r^2	Std*
all	912397	0.07	0.41	2.08	2.12	0.53	0.388	0.39
C1	190796	0.11	0.19	0.64	0.66	0.38	0.480	0.27
C2	546066	0.06	0.16	0.81	0.82	0.43	0.760	0.31
C3	3973	0.15	0.30	1.19	1.23	0.37	0.629	0.28
C5	403848	0.08	0.28	1.32	1.35	0.41	0.565	0.28
C6	337278	0.05	0.35	2.04	2.07	0.66	0.452	0.49
C7a	422897	0.03	0.29	1.53	1.56	0.68	0.639	0.50
C7b	216707	0.10	0.94	3.58	3.70	0.63	0.141	0.46
C7c	272778	0.10	0.17	0.57	0.60	0.37	0.588	0.26
C8a	71110	0.07	2.14	5.19	5.62	4.29	0.004	0.97
C8b	244997	-0.06	0.33	2.33	2.36	0.79	0.203	0.58
C8c	589695	0.10	0.23	0.85	0.89	0.42	0.722	0.30
C9a	325944	0.12	0.97	3.36	3.50	1.22	0.000	0.81
C9b	562051	0.06	0.09	0.40	0.41	0.36	0.856	0.27
C9c	24402	0.20	0.31	0.47	0.56	0.79	0.338	0.50

Table 1 numerical values can be downloaded as a csv file here.

6 TSG

The TSG dataset is subdivided into 9 subdatasets following TSG data providers subdivisions.

- LEGOS-DM
- GOSUD-Research-vessel
- GOSUD-Sailing-ship
- SAMOS
- CSIC-UTM
- Polarstern
- NCEI-0170743
- LEGOS-Survostral
- LEGOS-Survostral-Adélie

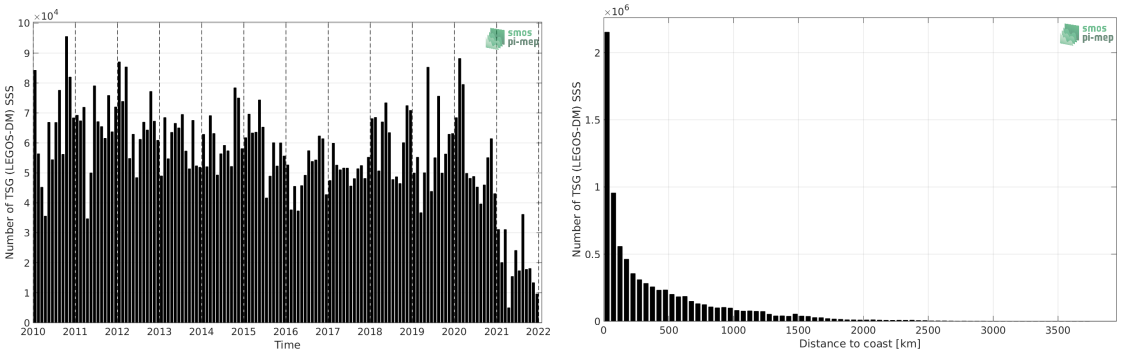
6.1 TSG (LEGOS-DM)

6.1.1 Introduction

The TSG (LEGOS-DM) dataset corresponds to sea surface salinity delayed mode data derived from voluntary observing ships collected, validated, archived, and made freely available by the French Sea Surface Salinity Observation Service (Alory et al. (2015)). The network is global though more concentrated in the tropical Pacific and North Atlantic oceanic basins. The acquisition system is autonomous with real time transmission and is regularly serviced at harbor calls. The high resolution data retrieved from the acquisition system during ship calls is processed through a dedicated software (freely available) for attribution of data quality flags by visual inspection, and correction of TSG time series by comparison with climatology, onboard daily water samples and collocated Argo data. Adjusted values when available and only collected TSG data that exhibit quality flags=1 and 2 were used.

6.1.2 Number of SSS data as a function of time and distance to coast

Figure 49 shows the time (a) and distance to coast (b) distributions of the TSG (LEGOS-DM) *in situ* dataset.

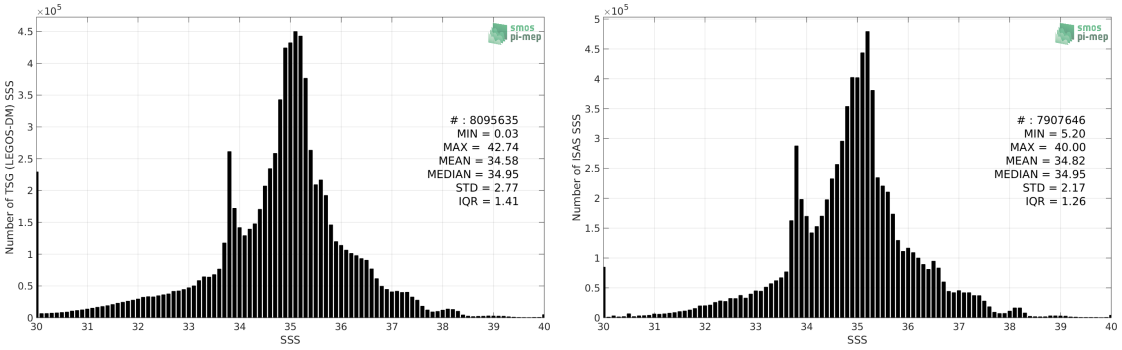


(a) (b)

Figure 49: Number of SSS from TSG (LEGOS-DM) as a function of time (a) and distance to coast (b).

6.1.3 Histograms of SSS

Figure 50 shows the SSS distribution of the TSG (LEGOS-DM) (a) and colocalized ISAS (b) dataset.

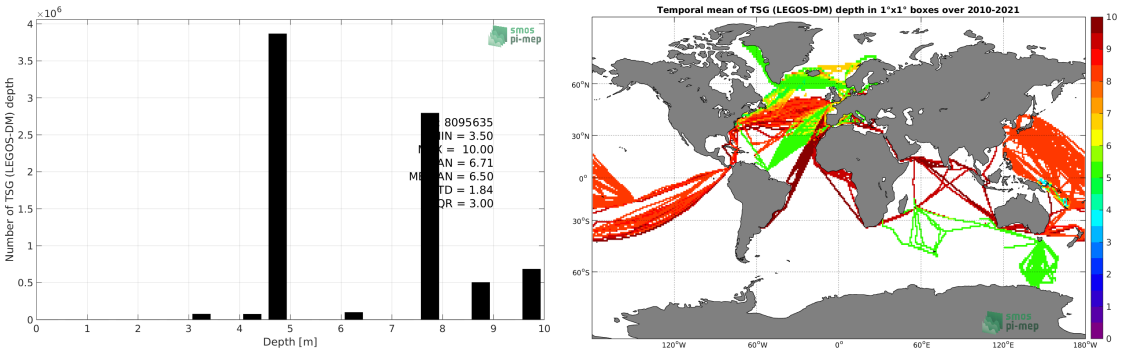


(a) (b)

Figure 50: Histograms of SSS from TSG (LEGOS-DM) (a) and ISAS (b) per bins of 0.1.

6.1.4 Distribution of *in situ* SSS depth measurements

In Figure 51, we show the depth distribution of the *in situ* salinity dataset (a) and the spatial distribution of the depth temporal mean in 1°x1° boxes and considering the full *in situ* dataset period (b).



(a) (b)

Figure 51: Depth distribution of the upper level SSS measurements from TSG (LEGOS-DM) (a) and spatial distribution of the *in situ* SSS depth measurements showing the mean value in 1°x1° boxes and considering the full *in situ* dataset period (b).

6.1.5 Spatial distribution of SSS

In Figure 52, the number of TSG (LEGOS-DM) SSS measurements in 1°x1° boxes is shown.

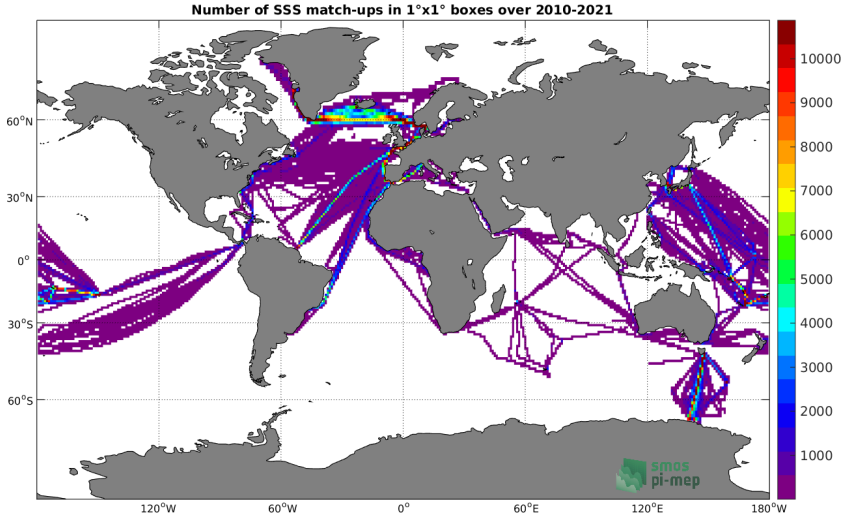
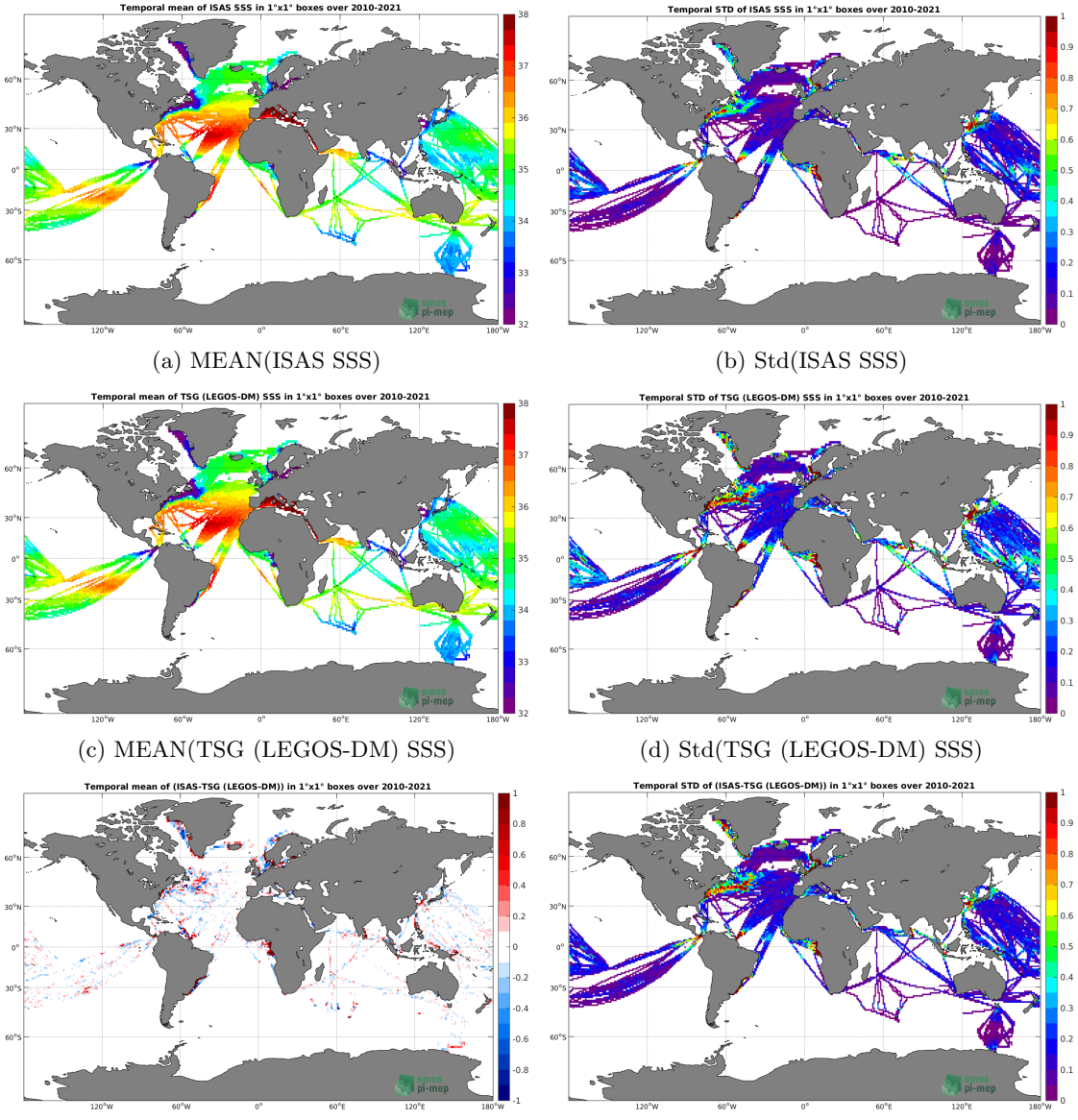


Figure 52: Number of SSS from TSG (LEGOS-DM) in 1°x1° boxes.

6.1.6 Spatial Maps of the Temporal mean and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

In Figure 53, maps of temporal mean (left) and standard deviation (right) of ISAS (top), TSG (LEGOS-DM) *in situ* dataset (middle) and the difference ΔSSS(ISAS -TSG (LEGOS-DM)) (bottom) are shown. The temporal mean and std are calculated using all match-up pairs falling in spatial boxes of size 1°x1° over the full TSG (LEGOS-DM) dataset period.



(a) MEAN(ISAS SSS)

(b) Std(ISAS SSS)

(c) MEAN(TSG (LEGOS-DM) SSS)

(d) Std(TSG (LEGOS-DM) SSS)

(e) MEAN(ΔSSS) (ISAS - TSG (LEGOS-DM))

(f) Std(ΔSSS) (ISAS - TSG (LEGOS-DM))

Figure 53: Temporal mean (left) and Std (right) of SSS from ISAS (top), TSG (LEGOS-DM) (middle), and of ΔSSS (ISAS - TSG (LEGOS-DM)). Only match-up pairs are used to generate these maps.

6.1.7 Time series of the monthly median and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

In the top panel of Figure 54, we show the time series of the monthly median SSS estimated for both ISAS SSS product (in black) and the TSG (LEGOS-DM) *in situ* dataset (in blue) at the collected Pi-MEP match-up pairs.

In the middle panel of Figure 54, we show the time series of the monthly median of ΔSSS

(ISAS - TSG (LEGOS-DM)) for the collected Pi-MEP match-up pairs.

In the bottom panel of Figure 54, we show the time series of the monthly standard deviation of the ΔSSS (ISAS - TSG (LEGOS-DM)) for the collected Pi-MEP match-up pairs.

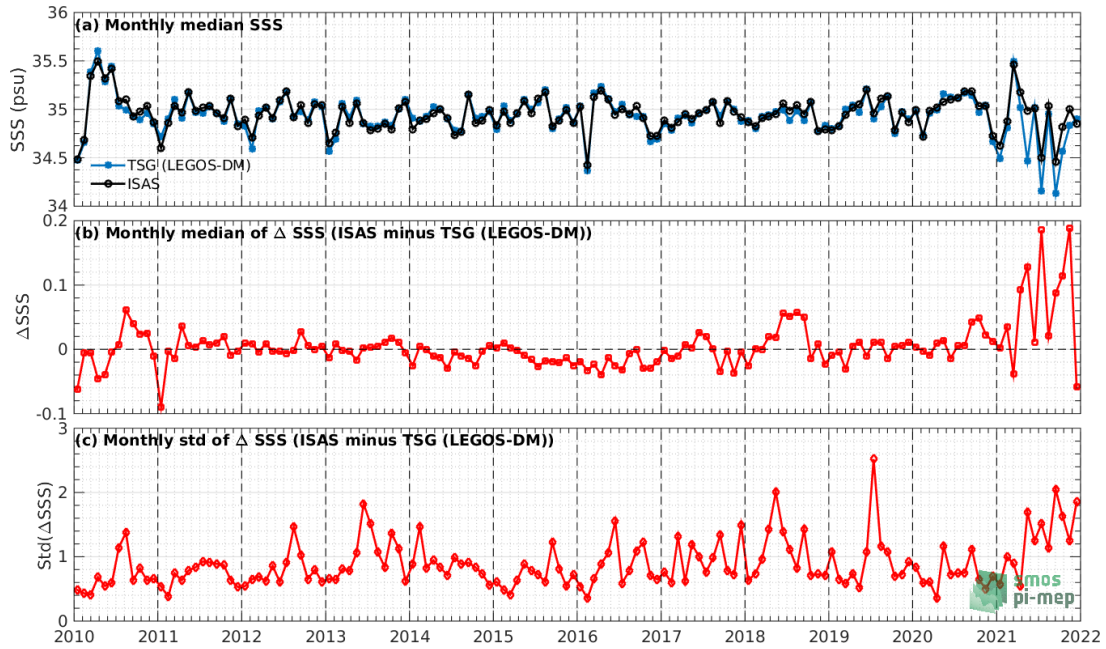


Figure 54: Time series of the monthly median SSS (top), median of ΔSSS (ISAS - TSG (LEGOS-DM)) and Std of ΔSSS (ISAS - TSG (LEGOS-DM)) considering all match-ups collected by the Pi-MEP.

6.1.8 Zonal mean and Std of *in situ* and ISAS SSS and of the difference ΔSSS

In Figure 55 left panel, we show the zonal mean SSS considering all Pi-MEP match-up pairs for both ISAS SSS product (in black) and the TSG (LEGOS-DM) *in situ* dataset (in blue). The full *in situ* dataset period is used to derive the mean.

In the right panel of Figure 55, we show the zonal mean of ΔSSS (ISAS - TSG (LEGOS-DM)) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

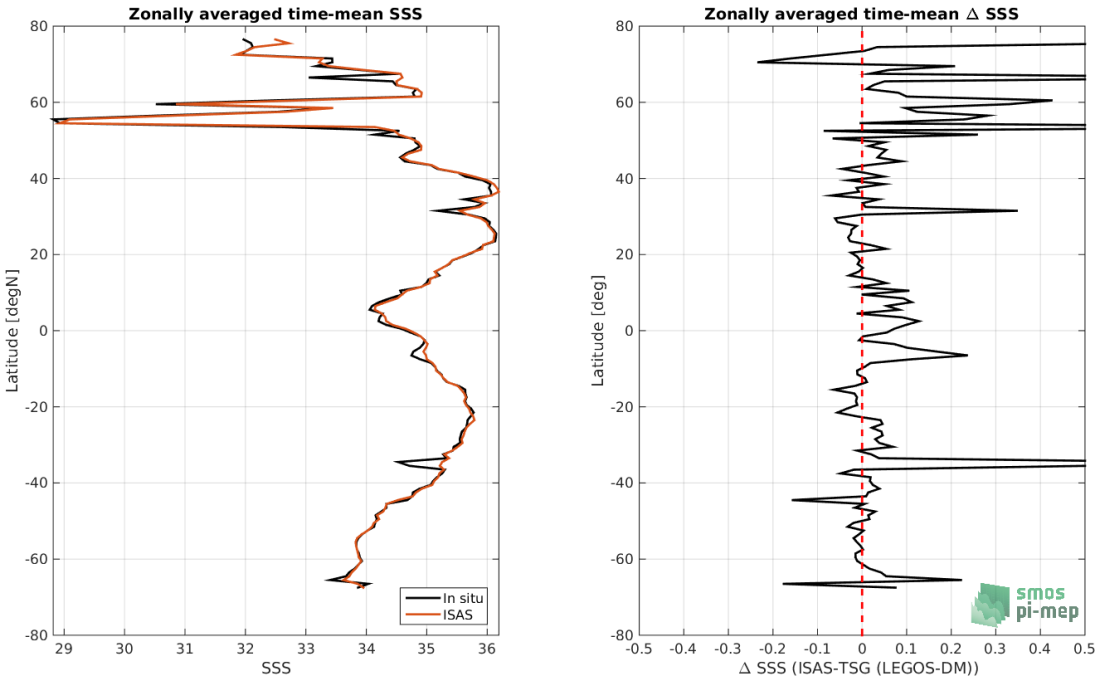
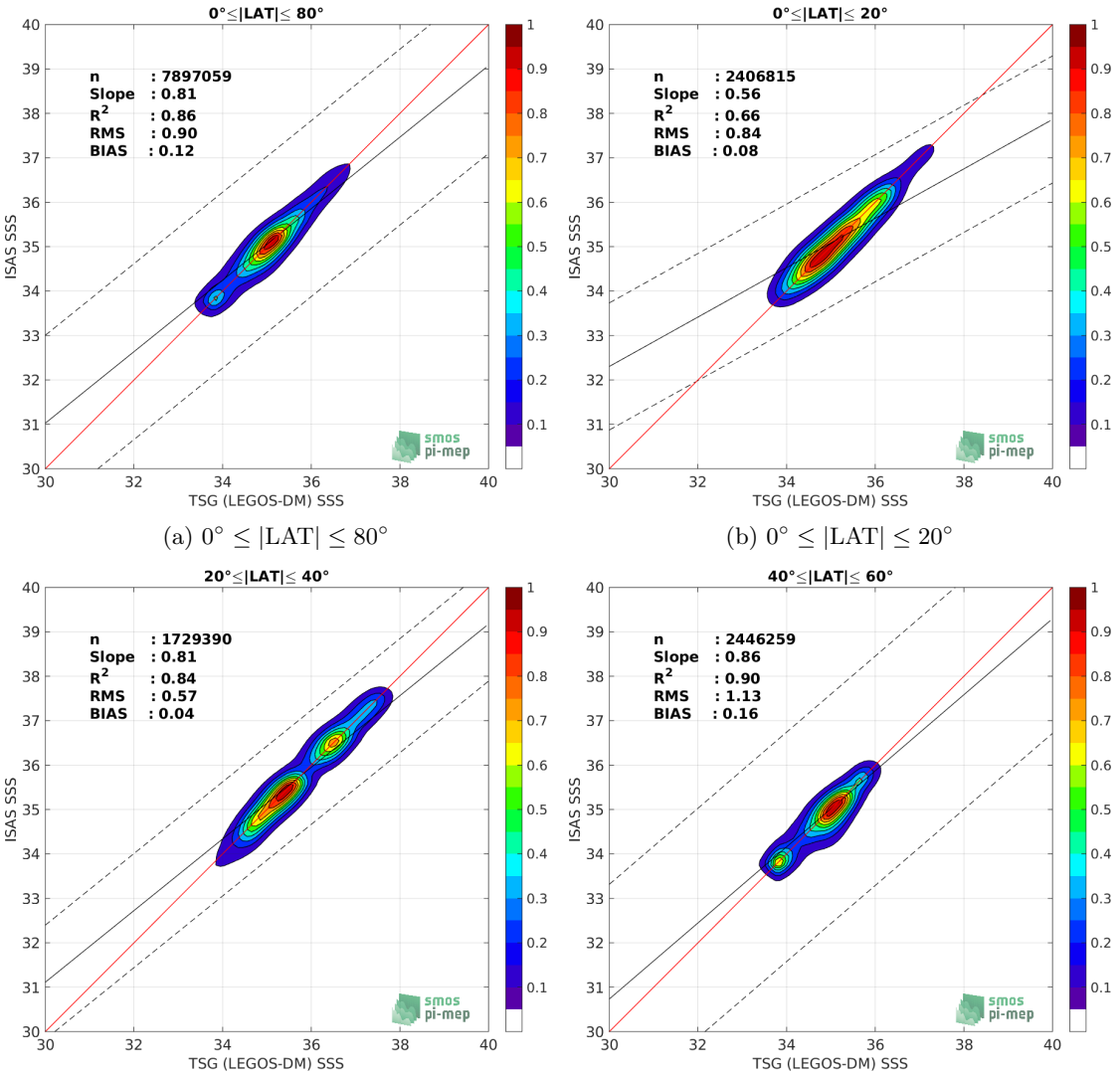


Figure 55: Left panel: Zonal mean SSS from ISAS product (black) and from TSG (LEGOS-DM) (blue). Right panel: Zonal mean of ΔSSS (ISAS - TSG (LEGOS-DM)) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

6.1.9 Scatterplots of ISAS vs *in situ* SSS by latitudinal bands

In Figure 56, contour maps of the concentration of ISAS SSS (y-axis) versus TSG (LEGOS-DM) SSS (x-axis) at match-up pairs for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.



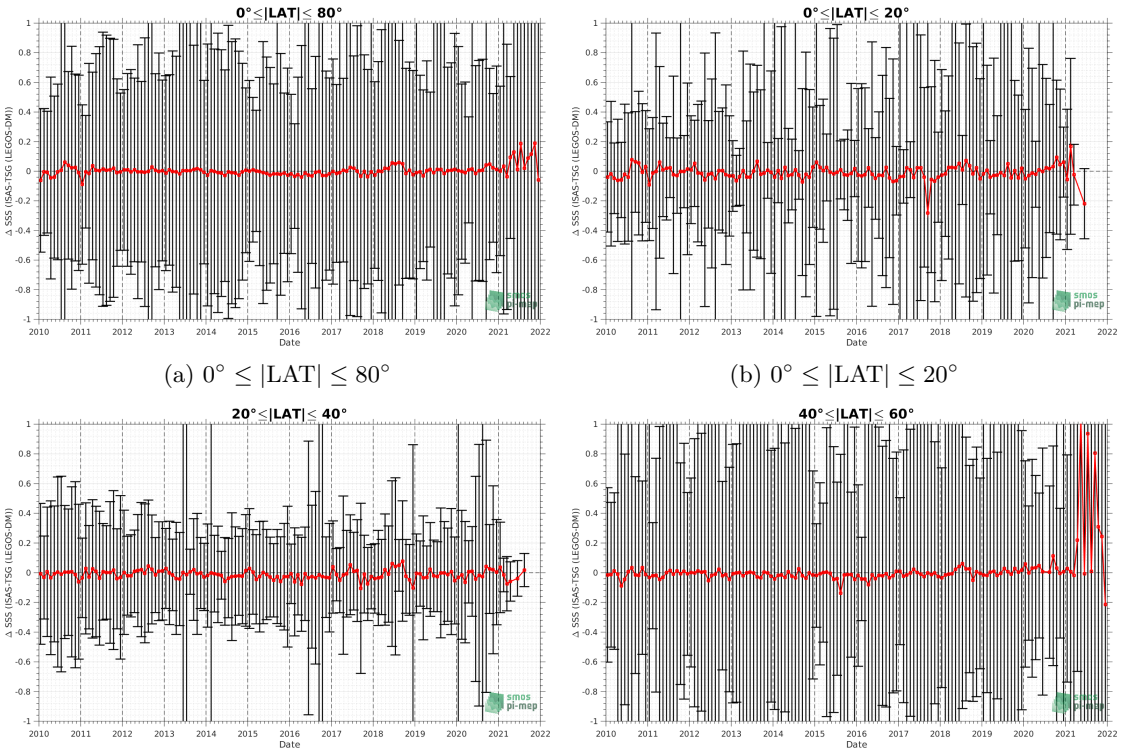
(a) $0° \leq |\text{LAT}| \leq 80°$ (b) $0° \leq |\text{LAT}| \leq 20°$

(c) $20° \leq |\text{LAT}| \leq 40°$ (d) $40° \leq |\text{LAT}| \leq 60°$

Figure 56: Contour maps of the concentration of ISAS SSS (y-axis) versus TSG (LEGOS-DM) SSS (x-axis) at match-up pairs for different latitude bands. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.

6.1.10 Time series of the monthly median and Std of the difference ΔSSS sorted by latitudinal bands

In Figure 57, time series of the monthly median (red curves) of ΔSSS (ISAS - TSG (LEGOS-DM)) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs estimated for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.



(a) $0° \leq |\text{LAT}| \leq 80°$

(b) $0° \leq |\text{LAT}| \leq 20°$

(c) $20° \leq |\text{LAT}| \leq 40°$

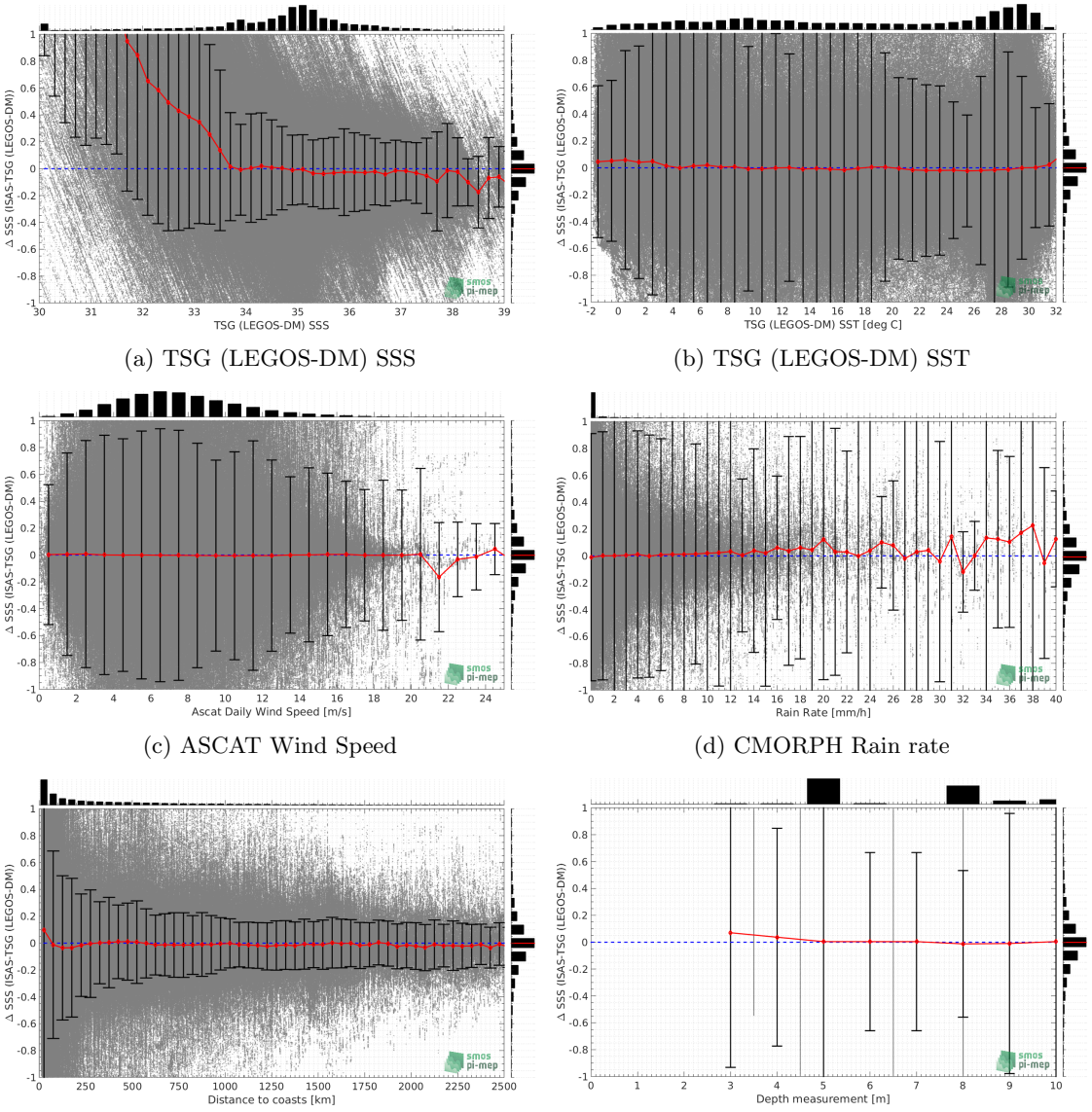
(d) $40° \leq |\text{LAT}| \leq 60°$

Figure 57: Monthly median (red curves) of ΔSSS (ISAS - TSG (LEGOS-DM)) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.

6.1.11 ΔSSS sorted as geophysical conditions

In Figure 58, we classify the match-up differences ΔSSS (ISAS - *in situ*) as function of the geophysical conditions at match-up points. The mean and std of ΔSSS (ISAS - TSG (LEGOS-DM)) is thus evaluated as function of the

- *in situ* SSS values per bins of width 0.2,
- *in situ* SST values per bins of width 1°C,
- ASCAT daily wind values per bins of width 1 m/s,
- CMORPH 3-hourly rain rates per bins of width 1 mm/h, and,
- distance to coasts per bins of width 50 km,
- *in situ* measurement depth (if relevant).



(a) TSG (LEGOS-DM) SSS

(b) TSG (LEGOS-DM) SST

(c) ASCAT Wind Speed

(d) CMORPH Rain rate

(e) Distance to coast

(f) Depth

Figure 58: Δ SSS (ISAS - TSG (LEGOS-DM)) sorted as geophysical conditions: TSG (LEGOS-DM) SSS a), TSG (LEGOS-DM) SST b), ASCAT Wind speed c), CMORPH rain rate d), distance to coast (e) and depth measurements (f).

6.1.12 ΔSSS maps and statistics for different geophysical conditions

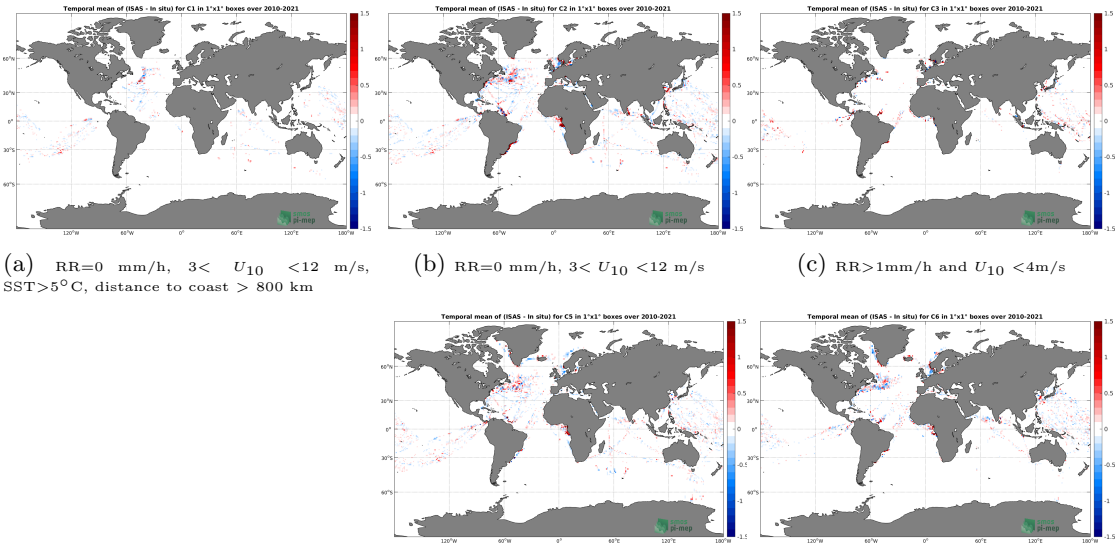
In Figures 59 and 60, we focus on sub-datasets of the match-up differences ΔSSS (ISAS - *in situ*) for the following specific geophysical conditions:

- **C1**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is in the range [3, 12] m/s, the SST is $> 5°C$ and distance to coast is > 800 km.
- **C2**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is

in the range [3, 12] m/s.

- **C3**:if the local value at *in situ* location of estimated rain rate is high (ie. > 1 mm/h) and mean daily wind is low (ie. < 4 m/s).
- **C5**:if the *in situ* data is located where the climatological SSS standard deviation is low (ie. above < 0.2).
- **C6**:if the *in situ* data is located where the climatological SSS standard deviation is high (ie. above > 0.2).

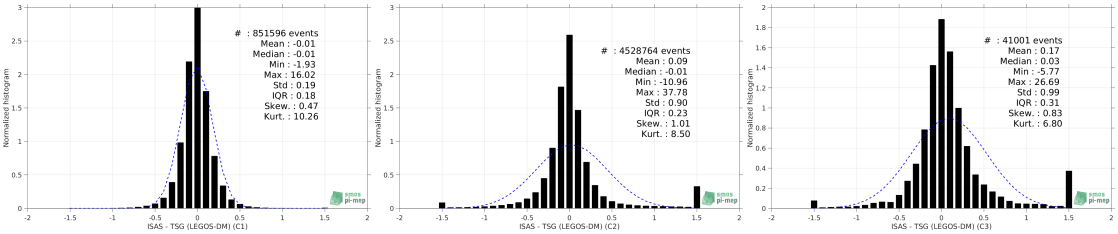
For each of these conditions, the temporal mean (gridded over spatial boxes of size 1°x1°) and the histogram of the difference ΔSSS (ISAS - *in situ*) are presented.



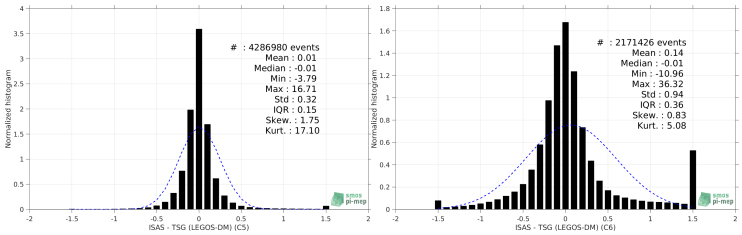
(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s

(d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 59: Temporal mean gridded over spatial boxes of size 1°x1° of ΔSSS (ISAS - TSG (LEGOS-DM)) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).



(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s



(d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 60: Normalized histogram of ΔSSS (ISAS - TSG (LEGOS-DM)) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).

6.1.13 Summary

Table 1 shows the mean, median, standard deviation (Std), root mean square (RMS), interquartile range (IQR), correlation coefficient (r^2) and robust standard deviation (Std*) of the match-up differences ΔSSS (ISAS - TSG (LEGOS-DM)) for the following conditions:

- all: All the match-up pairs satellite/in situ SSS values are used to derive the statistics
- C1: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km
- C2: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s
- C3: only pairs where RR>1mm/h and U_{10} <4m/s
- C5: only pairs where WOA2013 SSS Std<0.2
- C6: only pairs where WOA2013 SSS Std>0.2
- C7a: only pairs with a distance to coast < 150 km.
- C7b: only pairs with a distance to coast in the range [150, 800] km.
- C7c: only pairs with a distance to coast > 800 km.
- C8a: only pairs where SST is < 5°C.
- C8b: only pairs where SST is in the range [5, 15]°C.
- C8c: only pairs where SST is > 15°C.

- C9a: only pairs where SSS is < 33.
- C9b: only pairs where SSS is in the range [33, 37].
- C9c: only pairs where SSS is > 37.

Table 1: Statistics of ΔSSS (ISAS - TSG (LEGOS-DM))

Condition	#	Median	Mean	Std	RMS	IQR	r^2	Std*
all	7907646	0.00	0.13	0.93	0.94	0.23	0.866	0.17
C1	851596	-0.01	-0.01	0.19	0.19	0.18	0.963	0.14
C2	4528764	-0.01	0.09	0.90	0.90	0.23	0.872	0.17
C3	41001	0.03	0.17	0.99	1.01	0.31	0.806	0.23
C5	4286980	-0.01	0.01	0.32	0.32	0.15	0.939	0.11
C6	2171426	-0.01	0.14	0.94	0.95	0.36	0.859	0.27
C7a	3477752	0.02	0.30	1.35	1.38	0.46	0.858	0.32
C7b	3100448	-0.01	0.00	0.35	0.35	0.16	0.861	0.12
C7c	1323778	-0.01	-0.01	0.19	0.19	0.16	0.967	0.12
C8a	1056265	0.02	0.34	0.93	0.99	0.51	0.775	0.24
C8b	2312107	0.00	0.13	1.10	1.11	0.18	0.881	0.13
C8c	4539273	-0.01	0.08	0.83	0.84	0.25	0.844	0.19
C9a	774406	1.03	1.52	2.40	2.84	1.97	0.813	1.39
C9b	6796324	-0.01	-0.02	0.33	0.33	0.20	0.846	0.15
C9c	336916	-0.05	-0.08	0.28	0.29	0.22	0.823	0.16

Table 1 numerical values can be downloaded as a csv file here.

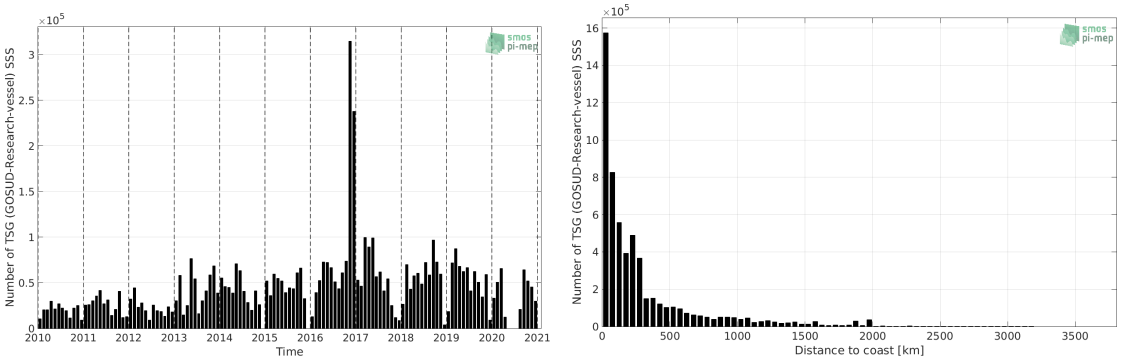
6.2 TSG (GOSUD-Research-vessel)

6.2.1 Introduction

The TSG (GOSUD-Research-vessel) dataset corresponds to French research vessels SSS data that have been collected since the early 2000 as a contribution to the Global Ocean Surface Underway Data (GOSUD) program. The set of homogeneous instruments is permanently monitored and regularly calibrated. Water samples are taken on a daily basis by the crew and later analysed in the laboratory. The careful calibration and instrument maintenance, complemented with a rigorous adjustment on water samples, lead to reach an accuracy of a few 10^{-2} PSS in salinity. This delayed mode dataset (Kolodziejczyk et al. (2021)) is updated annually and freely available here. Adjusted values when available and only collected TSG data that exhibit quality flags 1 or 2 were used.

6.2.2 Number of SSS data as a function of time and distance to coast

Figure 61 shows the time (a) and distance to coast (b) distributions of the TSG (GOSUD-Research-vessel) *in situ* dataset.

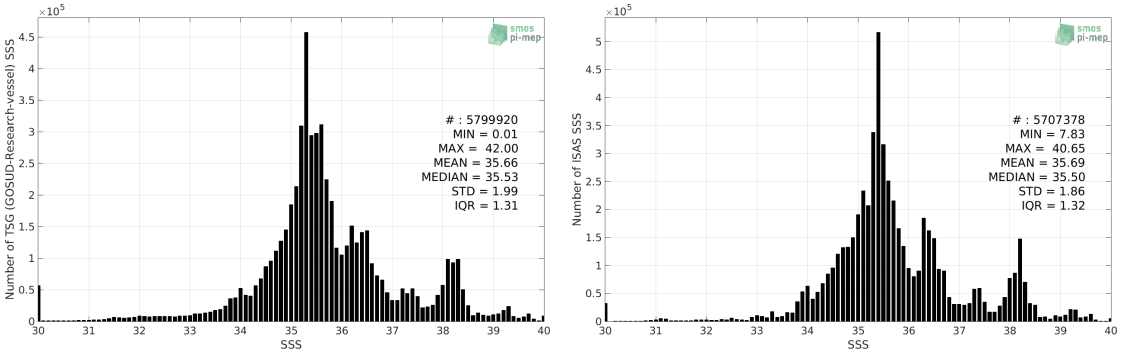


(a) (b)

Figure 61: Number of SSS from TSG (GOSUD-Research-vessel) as a function of time (a) and distance to coast (b).

6.2.3 Histograms of SSS

Figure 62 shows the SSS distribution of the TSG (GOSUD-Research-vessel) (a) and colocalized ISAS (b) dataset.

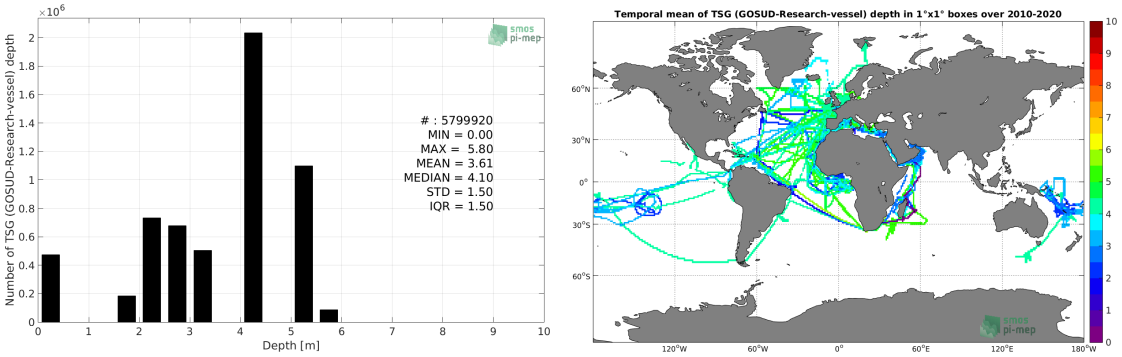


(a) (b)

Figure 62: Histograms of SSS from TSG (GOSUD-Research-vessel) (a) and ISAS (b) per bins of 0.1.

6.2.4 Distribution of *in situ* SSS depth measurements

In Figure 63, we show the depth distribution of the *in situ* salinity dataset (a) and the spatial distribution of the depth temporal mean in 1°x1° boxes and considering the full *in situ* dataset period (b).



(a) (b)

Figure 63: Depth distribution of the upper level SSS measurements from TSG (GOSUD-Research-vessel) (a) and spatial distribution of the *in situ* SSS depth measurements showing the mean value in 1°x1° boxes and considering the full *in situ* dataset period (b).

6.2.5 Spatial distribution of SSS

In Figure 64, the number of TSG (GOSUD-Research-vessel) SSS measurements in 1°x1° boxes is shown.

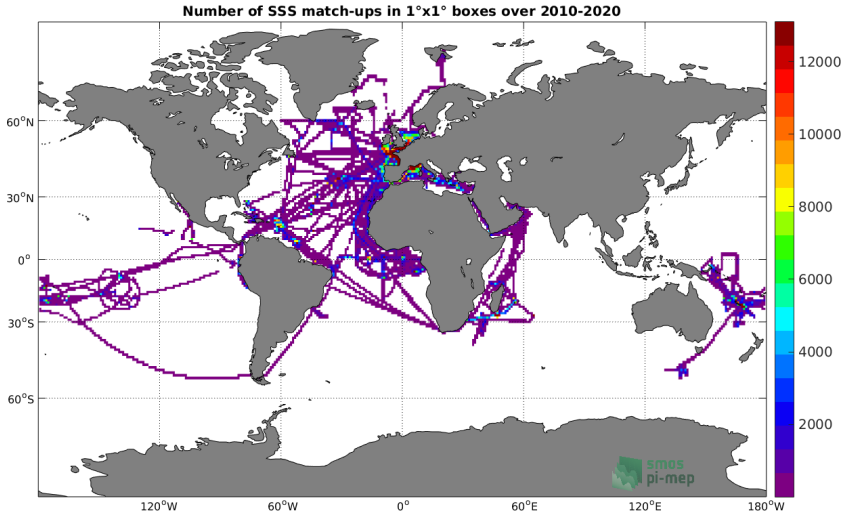
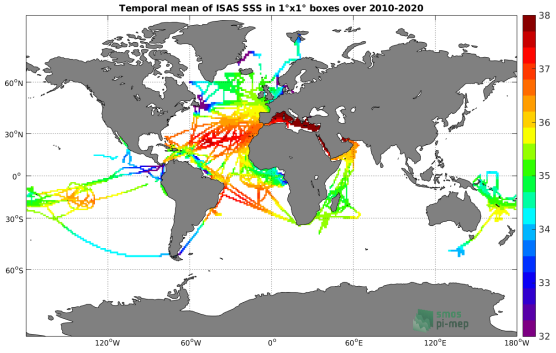


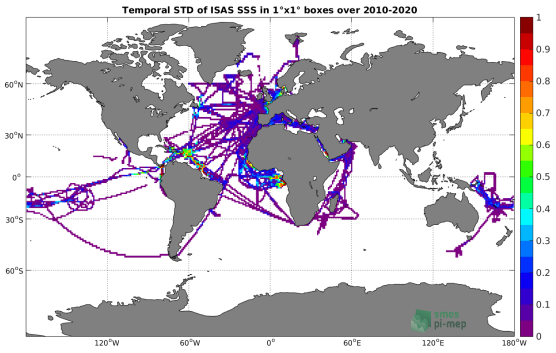
Figure 64: Number of SSS from TSG (GOSUD-Research-vessel) in 1°x1° boxes.

6.2.6 Spatial Maps of the Temporal mean and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

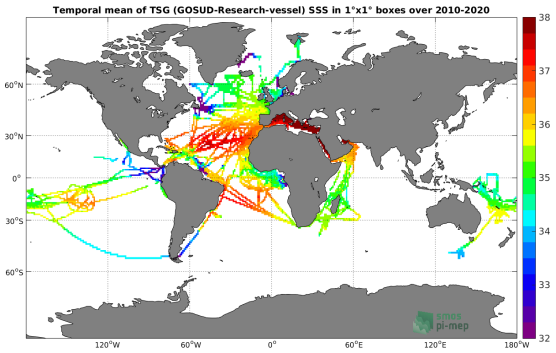
In Figure 65, maps of temporal mean (left) and standard deviation (right) of ISAS (top), TSG (GOSUD-Research-vessel) *in situ* dataset (middle) and the difference ΔSSS(ISAS -TSG (GOSUD-Research-vessel)) (bottom) are shown. The temporal mean and std are calculated using all match-up pairs falling in spatial boxes of size 1°x1° over the full TSG (GOSUD-Research-vessel) dataset period.



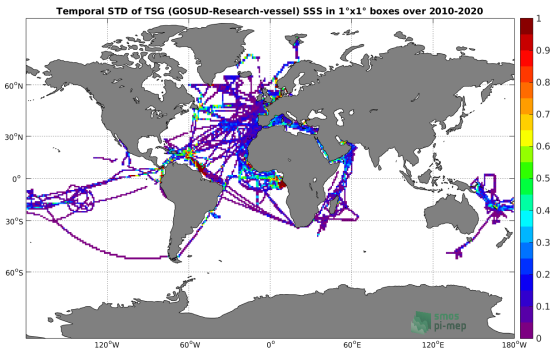
(a) MEAN(ISAS SSS)



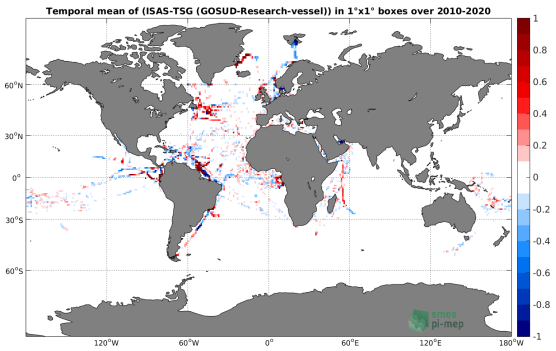
(b) Std(ISAS SSS)



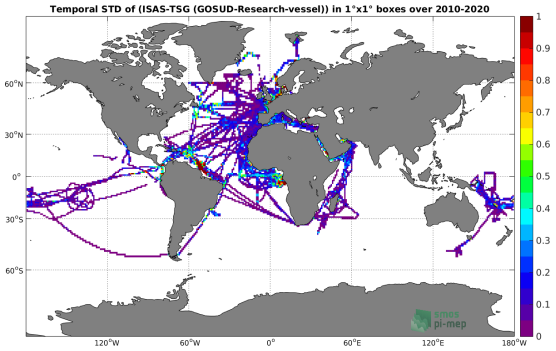
(c) MEAN(TSG (GOSUD-Research-vessel) SSS)



(d) Std(TSG (GOSUD-Research-vessel) SSS)



(e) MEAN(ΔSSS) (ISAS - TSG (GOSUD-Research-vessel))



(f) Std(ΔSSS) (ISAS - TSG (GOSUD-Research-vessel))

Figure 65: Temporal mean (left) and Std (right) of SSS from ISAS (top), TSG (GOSUD-Research-vessel) (middle), and of ΔSSS (ISAS - TSG (GOSUD-Research-vessel)). Only match-up pairs are used to generate these maps.

6.2.7 Time series of the monthly median and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

In the top panel of Figure 66, we show the time series of the monthly median SSS estimated for both ISAS SSS product (in black) and the TSG (GOSUD-Research-vessel) *in situ* dataset (in blue) at the collected Pi-MEP match-up pairs.

In the middle panel of Figure 66, we show the time series of the monthly median of ΔSSS

(ISAS - TSG (GOSUD-Research-vessel)) for the collected Pi-MEP match-up pairs.

In the bottom panel of Figure 66, we show the time series of the monthly standard deviation of the ΔSSS (ISAS - TSG (GOSUD-Research-vessel)) for the collected Pi-MEP match-up pairs.

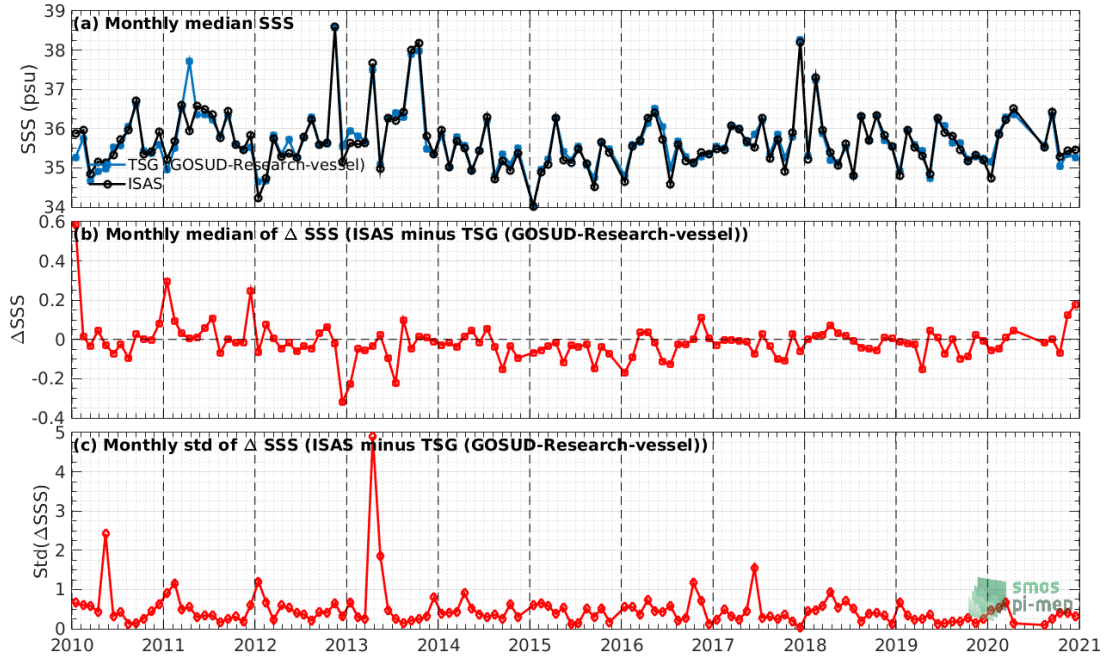


Figure 66: Time series of the monthly median SSS (top), median of ΔSSS (ISAS - TSG (GOSUD-Research-vessel)) and Std of ΔSSS (ISAS - TSG (GOSUD-Research-vessel)) considering all match-ups collected by the Pi-MEP.

6.2.8 Zonal mean and Std of *in situ* and ISAS SSS and of the difference ΔSSS

In Figure 67 left panel, we show the zonal mean SSS considering all Pi-MEP match-up pairs for both ISAS SSS product (in black) and the TSG (GOSUD-Research-vessel) *in situ* dataset (in blue). The full *in situ* dataset period is used to derive the mean.

In the right panel of Figure 67, we show the zonal mean of ΔSSS (ISAS - TSG (GOSUD-Research-vessel)) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

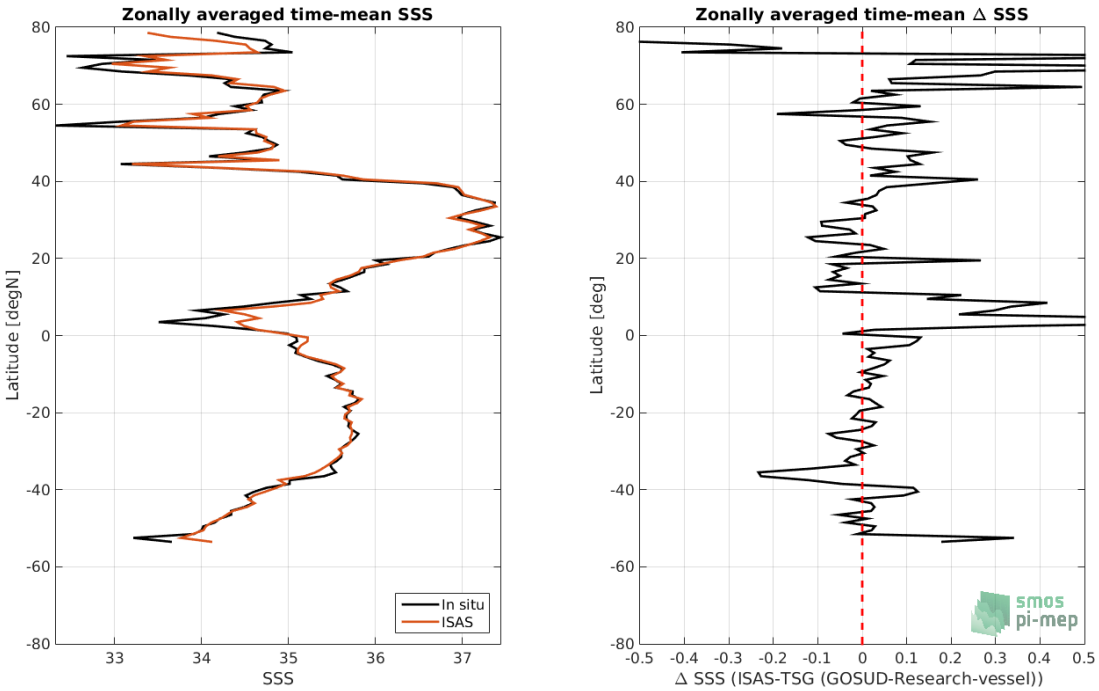
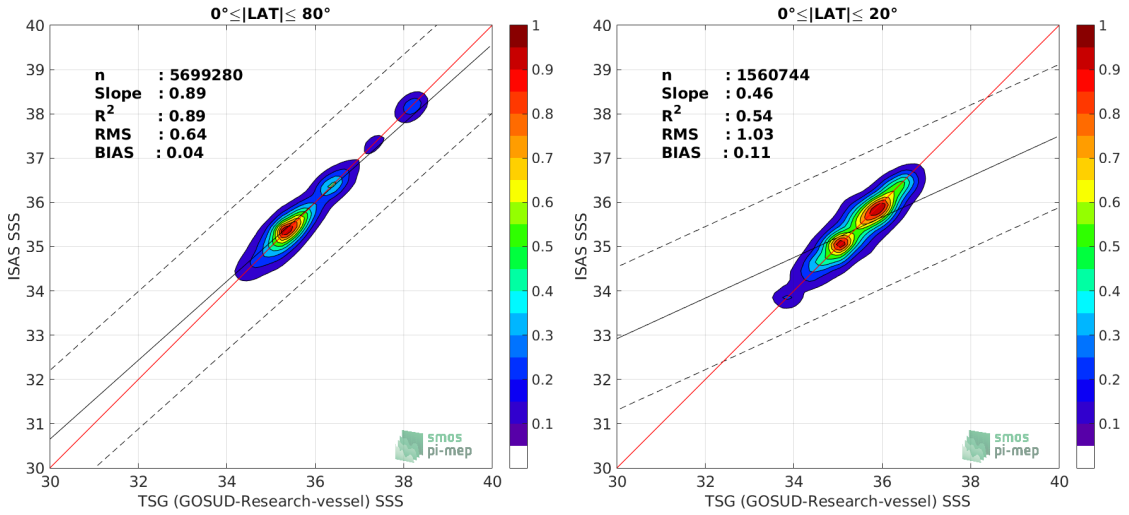


Figure 67: Left panel: Zonal mean SSS from ISAS product (black) and from TSG (GOSUD-Research-vessel) (blue). Right panel: Zonal mean of ΔSSS (ISAS - TSG (GOSUD-Research-vessel)) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

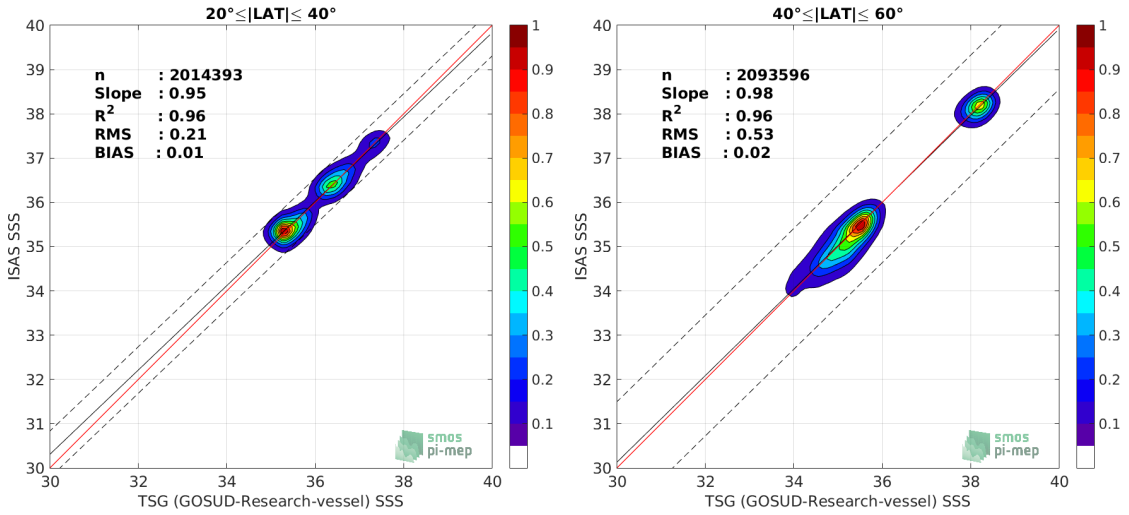
6.2.9 Scatterplots of ISAS vs *in situ* SSS by latitudinal bands

In Figure 68, contour maps of the concentration of ISAS SSS (y-axis) versus TSG (GOSUD-Research-vessel) SSS (x-axis) at match-up pairs for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.



(a) $0° \leq |\text{LAT}| \leq 80°$

(b) $0° \leq |\text{LAT}| \leq 20°$



(c) $20° \leq |\text{LAT}| \leq 40°$

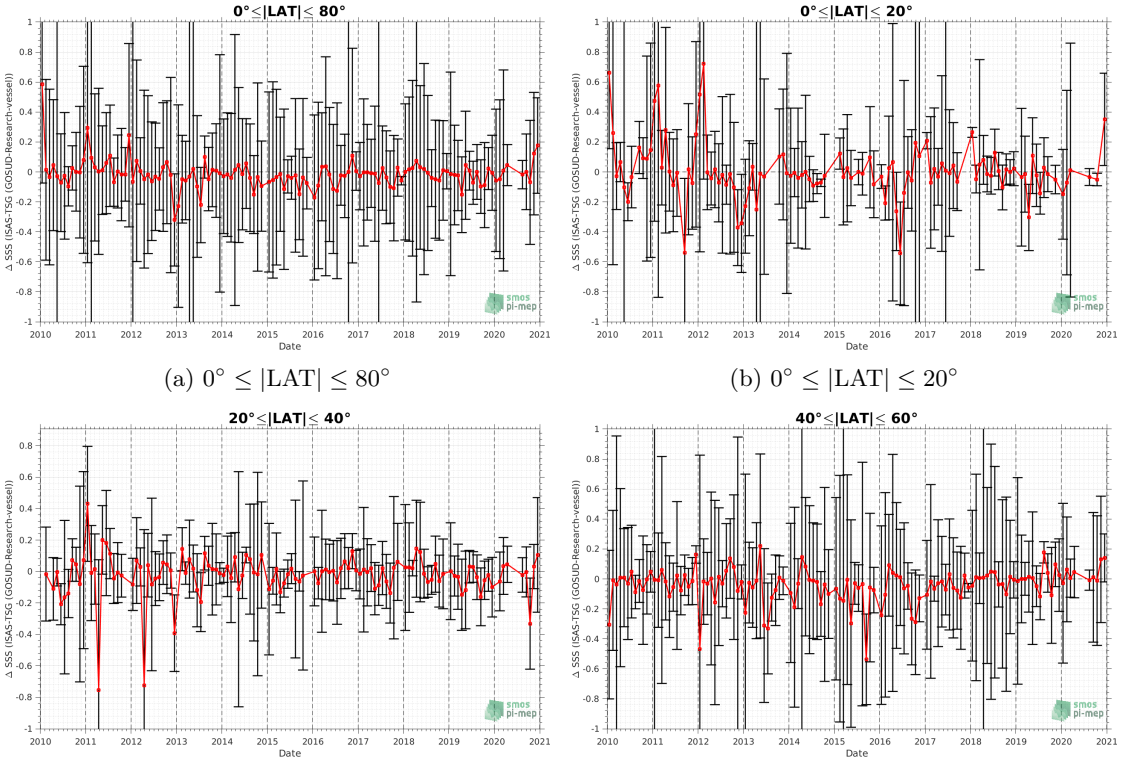
(d) $40° \leq |\text{LAT}| \leq 60°$

Figure 68: Contour maps of the concentration of ISAS SSS (y-axis) versus TSG (GOSUD-Research-vessel) SSS (x-axis) at match-up pairs for different latitude bands. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.

6.2.10 Time series of the monthly median and Std of the difference ΔSSS sorted by latitudinal bands

In Figure 69, time series of the monthly median (red curves) of ΔSSS (ISAS - TSG (GOSUD-Research-vessel)) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs estimated for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S

and 40°N-60°N.



(a) $0° \leq |\text{LAT}| \leq 80°$

(b) $0° \leq |\text{LAT}| \leq 20°$

(c) $20° \leq |\text{LAT}| \leq 40°$

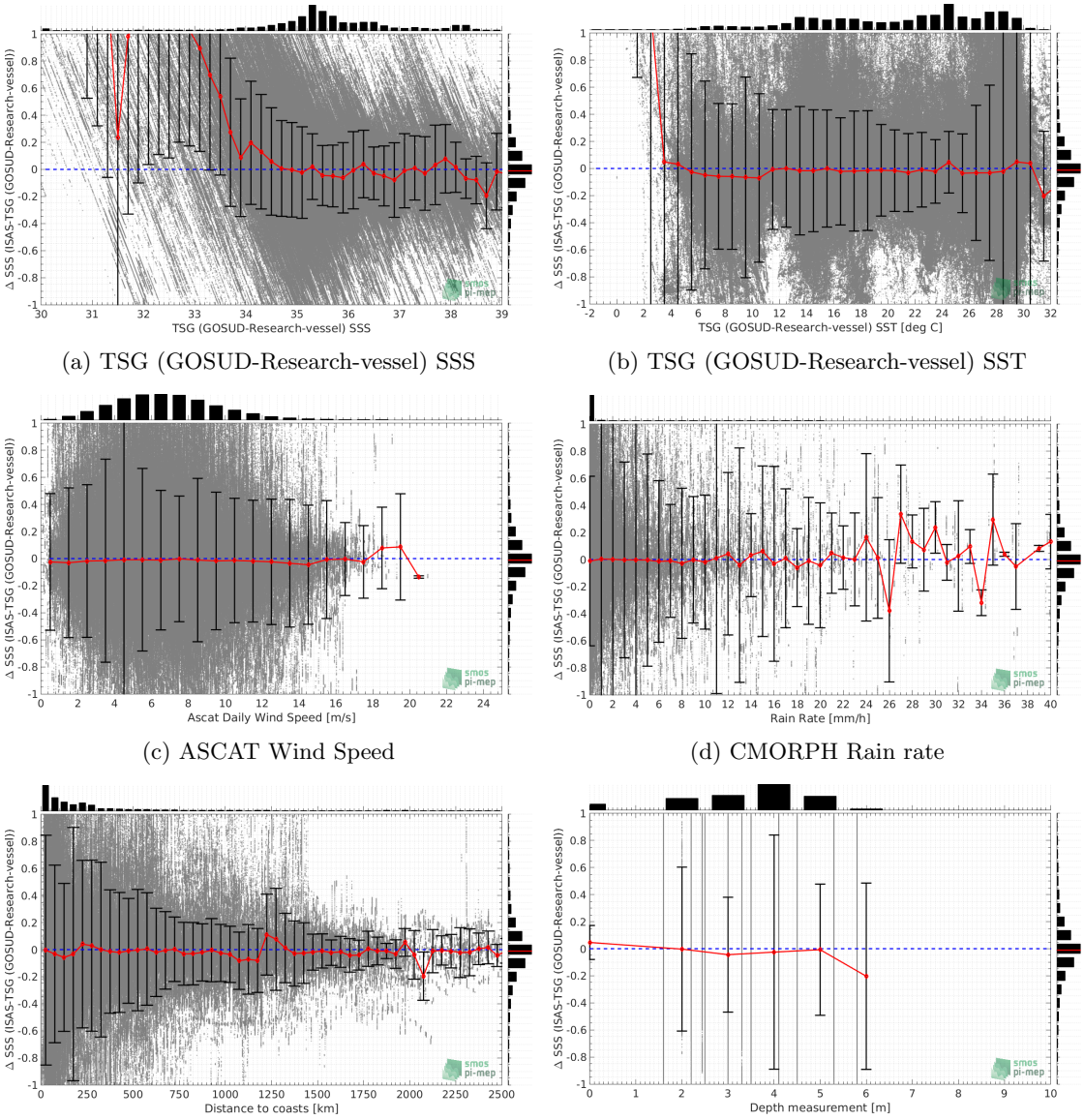
(d) $40° \leq |\text{LAT}| \leq 60°$

Figure 69: Monthly median (red curves) of ΔSSS (ISAS - TSG (GOSUD-Research-vessel)) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.

6.2.11 ΔSSS sorted as geophysical conditions

In Figure 70, we classify the match-up differences ΔSSS (ISAS - *in situ*) as function of the geophysical conditions at match-up points. The mean and std of ΔSSS (ISAS - TSG (GOSUD-Research-vessel)) is thus evaluated as function of the

- *in situ* SSS values per bins of width 0.2,
- *in situ* SST values per bins of width 1°C,
- ASCAT daily wind values per bins of width 1 m/s,
- CMORPH 3-hourly rain rates per bins of width 1 mm/h, and,
- distance to coasts per bins of width 50 km,
- *in situ* measurement depth (if relevant).



(a) TSG (GOSUD-Research-vessel) SSS

(b) TSG (GOSUD-Research-vessel) SST

(c) ASCAT Wind Speed

(d) CMORPH Rain rate

(e) Distance to coast

(f) Depth

Figure 70: Δ SSS (ISAS - TSG (GOSUD-Research-vessel)) sorted as geophysical conditions: TSG (GOSUD-Research-vessel) SSS a), TSG (GOSUD-Research-vessel) SST b), ASCAT Wind speed c), CMORPH rain rate d), distance to coast (e) and depth measurements (f).

6.2.12 ΔSSS maps and statistics for different geophysical conditions

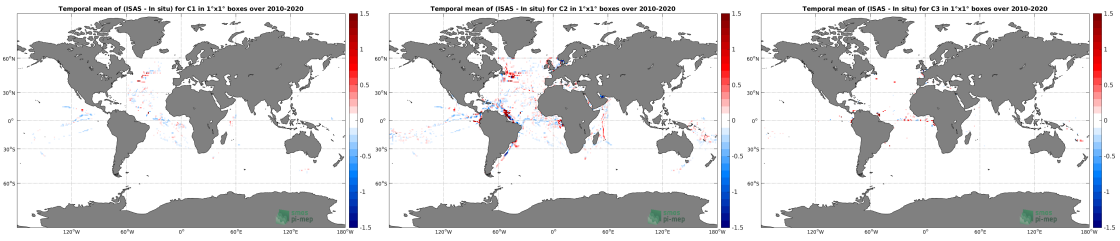
In Figures 71 and 72, we focus on sub-datasets of the match-up differences ΔSSS (ISAS - *in situ*) for the following specific geophysical conditions:

- **C1**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is in the range [3, 12] m/s, the SST is $> 5°$C and distance to coast is > 800 km.
- **C2**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is

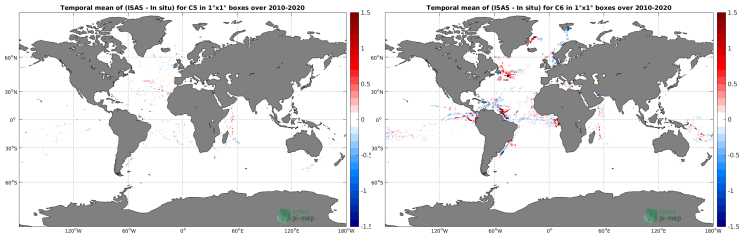
in the range [3, 12] m/s.

- **C3**:if the local value at *in situ* location of estimated rain rate is high (ie. $>$ 1 mm/h) and mean daily wind is low (ie. $<$ 4 m/s).
- **C5**:if the *in situ* data is located where the climatological SSS standard deviation is low (ie. above $<$ 0.2).
- **C6**:if the *in situ* data is located where the climatological SSS standard deviation is high (ie. above $>$ 0.2).

For each of these conditions, the temporal mean (gridded over spatial boxes of size 1°x1°) and the histogram of the difference ΔSSS (ISAS - *in situ*) are presented.

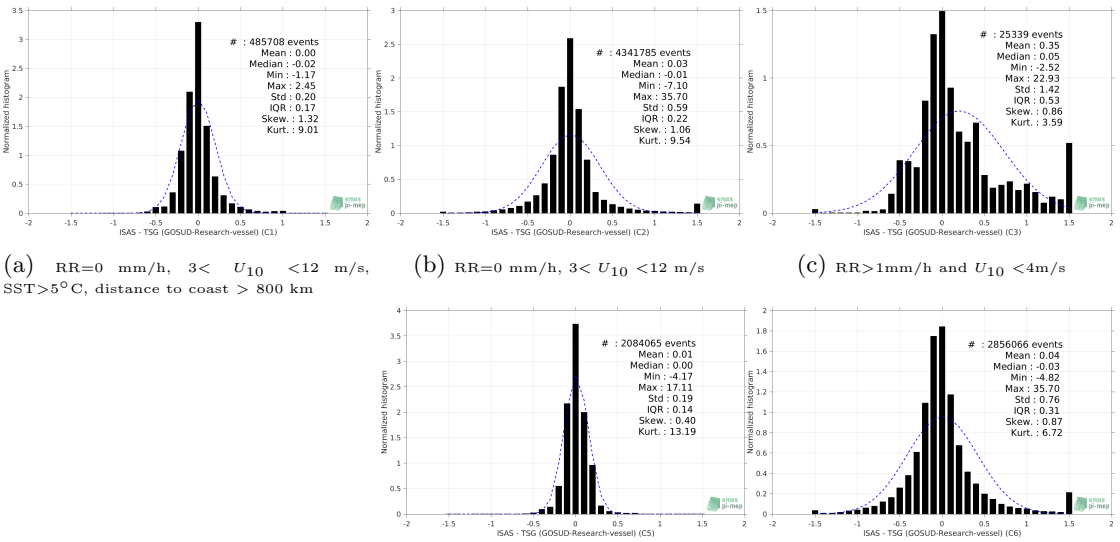


(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s



(d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 71: Temporal mean gridded over spatial boxes of size 1°x1° of ΔSSS (ISAS - TSG (GOSUD-Research-vessel)) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).



(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s

(d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 72: Normalized histogram of ΔSSS (ISAS - TSG (GOSUD-Research-vessel)) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).

6.2.13 Summary

Table 1 shows the mean, median, standard deviation (Std), root mean square (RMS), interquartile range (IQR), correlation coefficient (r^2) and robust standard deviation (Std*) of the match-up differences ΔSSS (ISAS - TSG (GOSUD-Research-vessel)) for the following conditions:

- all: All the match-up pairs satellite/in situ SSS values are used to derive the statistics
- C1: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km
- C2: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s
- C3: only pairs where RR>1mm/h and U_{10} <4m/s
- C5: only pairs where WOA2013 SSS Std<0.2
- C6: only pairs where WOA2013 SSS Std>0.2
- C7a: only pairs with a distance to coast < 150 km.
- C7b: only pairs with a distance to coast in the range [150, 800] km.
- C7c: only pairs with a distance to coast > 800 km.
- C8a: only pairs where SST is < 5°C.
- C8b: only pairs where SST is in the range [5, 15]°C.
- C8c: only pairs where SST is > 15°C.

- C9a: only pairs where SSS is < 33.
- C9b: only pairs where SSS is in the range [33, 37].
- C9c: only pairs where SSS is > 37.

Table 1: Statistics of ΔSSS (ISAS - TSG (GOSUD-Research-vessel))

Condition	#	Median	Mean	Std	RMS	IQR	r^2	Std*
all	5707378	-0.01	0.04	0.66	0.66	0.23	0.888	0.17
C1	485708	-0.02	0.00	0.20	0.20	0.17	0.959	0.13
C2	4341785	-0.01	0.03	0.59	0.59	0.22	0.908	0.17
C3	25339	0.05	0.35	1.42	1.47	0.53	0.655	0.36
C5	2084065	0.00	0.01	0.19	0.19	0.14	0.960	0.11
C6	2856066	-0.03	0.04	0.76	0.76	0.31	0.893	0.23
C7a	2869194	-0.03	0.04	0.75	0.75	0.28	0.909	0.21
C7b	2214243	0.01	0.05	0.63	0.63	0.20	0.774	0.15
C7c	623089	-0.02	0.00	0.22	0.22	0.18	0.953	0.13
C8a	27431	0.13	0.51	1.47	1.56	1.54	0.918	1.17
C8b	1135698	-0.02	0.01	0.53	0.53	0.22	0.850	0.16
C8c	4267025	-0.01	0.04	0.69	0.70	0.23	0.890	0.17
C9a	183963	1.06	1.55	2.89	3.28	2.39	0.773	1.78
C9b	4615639	-0.01	0.00	0.32	0.32	0.23	0.813	0.17
C9c	907776	-0.03	-0.04	0.25	0.25	0.19	0.859	0.14

Table 1 numerical values can be downloaded as a csv file here.

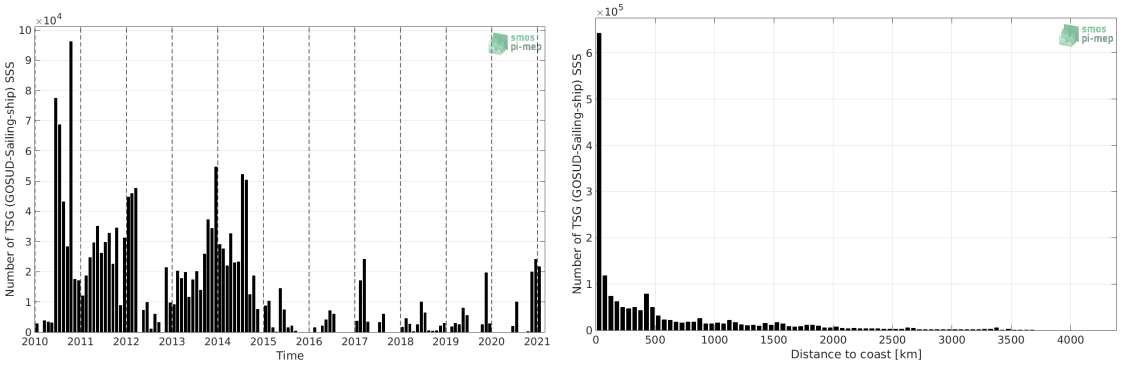
6.3 TSG (GOSUD-Sailing-ship)

6.3.1 Introduction

The TSG (GOSUD-Sailing-ship) dataset corresponds to observations of sea surface salinity obtained from voluntary sailing ships using medium or small size sensors. They complement the networks installed on research vessels or commercial ships. This delayed mode dataset (Reynaud et al. (2021)) is updated annually as a contribution to GOSUD (`http://www.gosud.org`) and freely available here. Adjusted values when available and only collected TSG data that exhibit quality flags=1 and 2 were used.

6.3.2 Number of SSS data as a function of time and distance to coast

Figure 73 shows the time (a) and distance to coast (b) distributions of the TSG (GOSUD-Sailing-ship) *in situ* dataset.

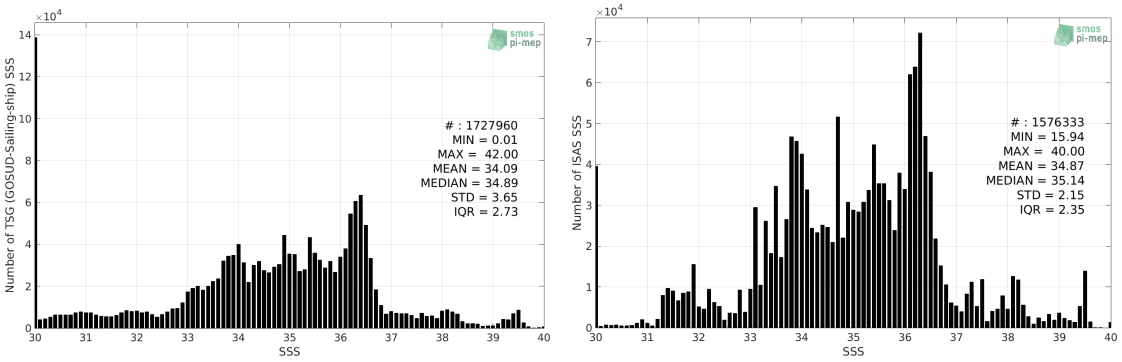


(a) (b)

Figure 73: Number of SSS from TSG (GOSUD-Sailing-ship) as a function of time (a) and distance to coast (b).

6.3.3 Histograms of SSS

Figure 74 shows the SSS distribution of the TSG (GOSUD-Sailing-ship) (a) and colocalized ISAS (b) dataset.

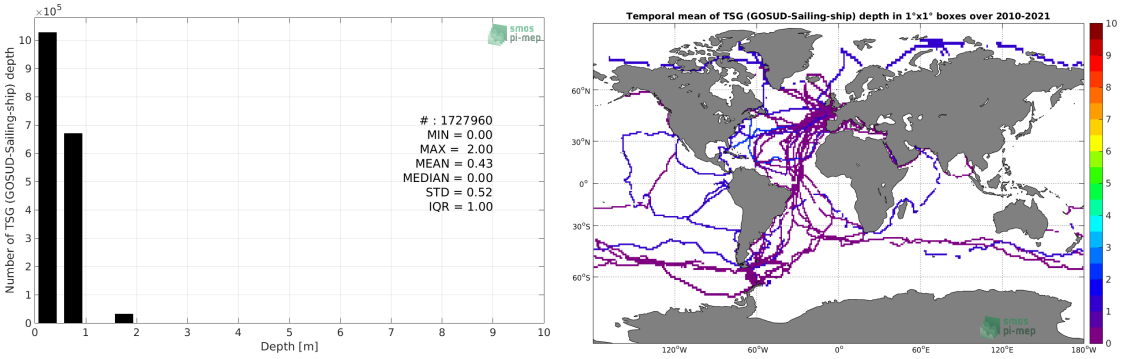


(a) (b)

Figure 74: Histograms of SSS from TSG (GOSUD-Sailing-ship) (a) and ISAS (b) per bins of 0.1.

6.3.4 Distribution of *in situ* SSS depth measurements

In Figure 75, we show the depth distribution of the *in situ* salinity dataset (a) and the spatial distribution of the depth temporal mean in 1°x1° boxes and considering the full *in situ* dataset period (b).



(a) (b)

Figure 75: Depth distribution of the upper level SSS measurements from TSG (GOSUD-Sailing-ship) (a) and spatial distribution of the *in situ* SSS depth measurements showing the mean value in 1°x1° boxes and considering the full *in situ* dataset period (b).

6.3.5 Spatial distribution of SSS

In Figure 76, the number of TSG (GOSUD-Sailing-ship) SSS measurements in 1°x1° boxes is shown.

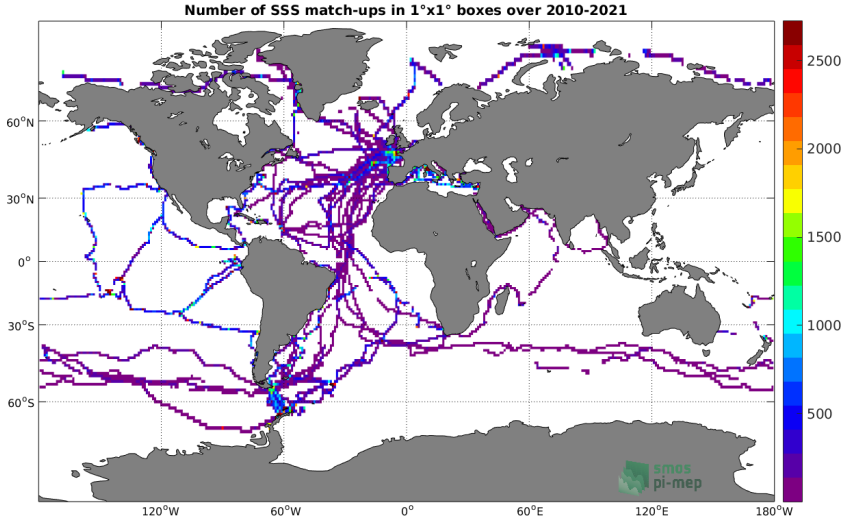
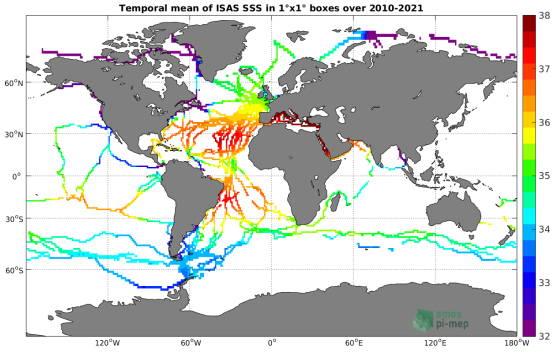


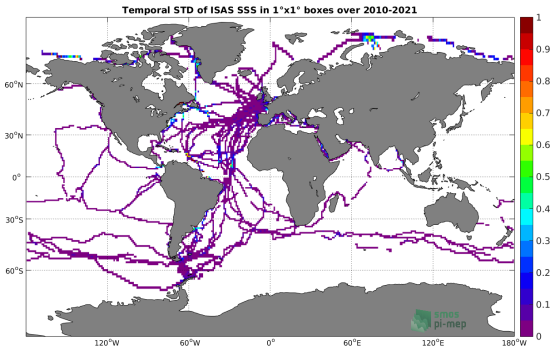
Figure 76: Number of SSS from TSG (GOSUD-Sailing-ship) in 1°x1° boxes.

6.3.6 Spatial Maps of the Temporal mean and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

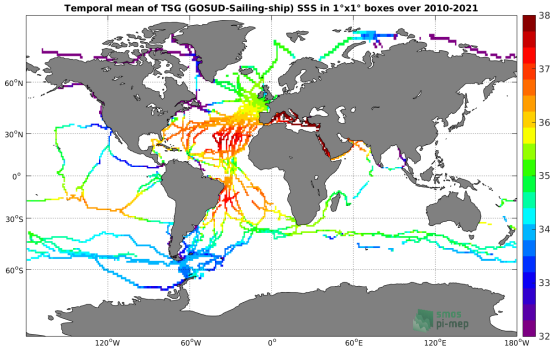
In Figure 77, maps of temporal mean (left) and standard deviation (right) of ISAS (top), TSG (GOSUD-Sailing-ship) *in situ* dataset (middle) and the difference ΔSSS(ISAS -TSG (GOSUD-Sailing-ship)) (bottom) are shown. The temporal mean and std are calculated using all match-up pairs falling in spatial boxes of size 1°x1° over the full TSG (GOSUD-Sailing-ship) dataset period.



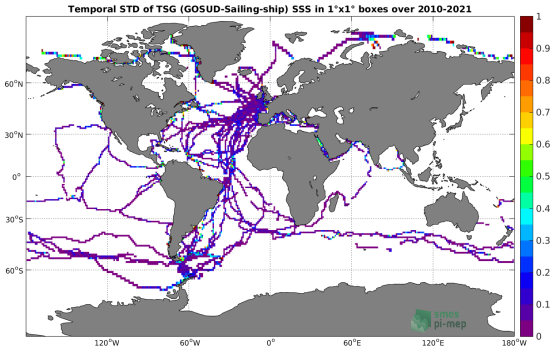
(a) MEAN(ISAS SSS)



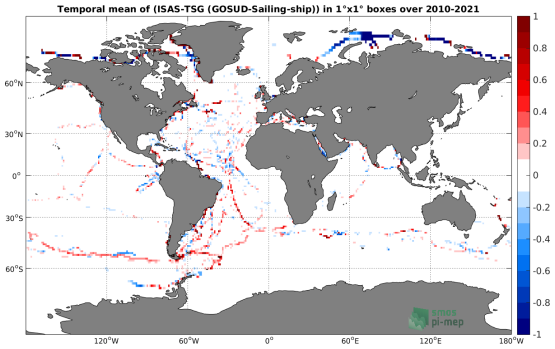
(b) Std(ISAS SSS)



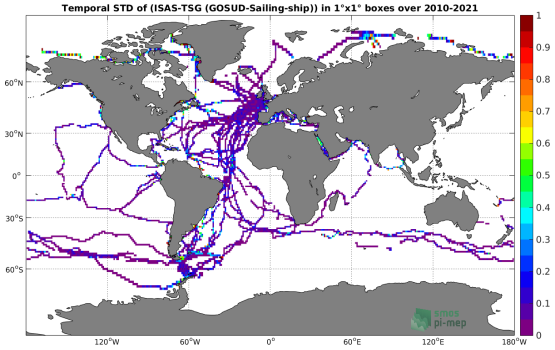
(c) MEAN(TSG (GOSUD-Sailing-ship) SSS)



(d) Std(TSG (GOSUD-Sailing-ship) SSS)



(e) MEAN(ΔSSS) (ISAS - TSG (GOSUD-Sailing-ship))



(f) Std(ΔSSS) (ISAS - TSG (GOSUD-Sailing-ship))

Figure 77: Temporal mean (left) and Std (right) of SSS from ISAS (top), TSG (GOSUD-Sailing-ship) (middle), and of ΔSSS (ISAS - TSG (GOSUD-Sailing-ship)). Only match-up pairs are used to generate these maps.

6.3.7 Time series of the monthly median and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

In the top panel of Figure 78, we show the time series of the monthly median SSS estimated for both ISAS SSS product (in black) and the TSG (GOSUD-Sailing-ship) *in situ* dataset (in blue) at the collected Pi-MEP match-up pairs.

In the middle panel of Figure 78, we show the time series of the monthly median of ΔSSS

(ISAS - TSG (GOSUD-Sailing-ship)) for the collected Pi-MEP match-up pairs.

In the bottom panel of Figure 78, we show the time series of the monthly standard deviation of the ΔSSS (ISAS - TSG (GOSUD-Sailing-ship)) for the collected Pi-MEP match-up pairs.

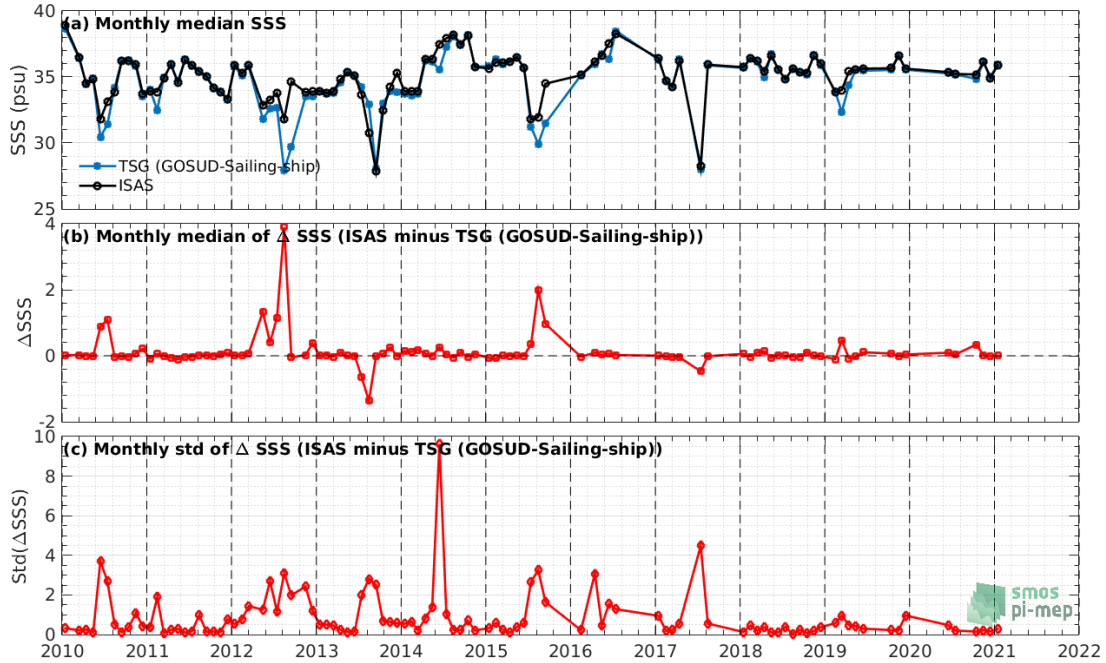


Figure 78: Time series of the monthly median SSS (top), median of ΔSSS (ISAS - TSG (GOSUD-Sailing-ship)) and Std of ΔSSS (ISAS - TSG (GOSUD-Sailing-ship)) considering all match-ups collected by the Pi-MEP.

6.3.8 Zonal mean and Std of *in situ* and ISAS SSS and of the difference ΔSSS

In Figure 79 left panel, we show the zonal mean SSS considering all Pi-MEP match-up pairs for both ISAS SSS product (in black) and the TSG (GOSUD-Sailing-ship) *in situ* dataset (in blue). The full *in situ* dataset period is used to derive the mean.

In the right panel of Figure 79, we show the zonal mean of ΔSSS (ISAS - TSG (GOSUD-Sailing-ship)) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

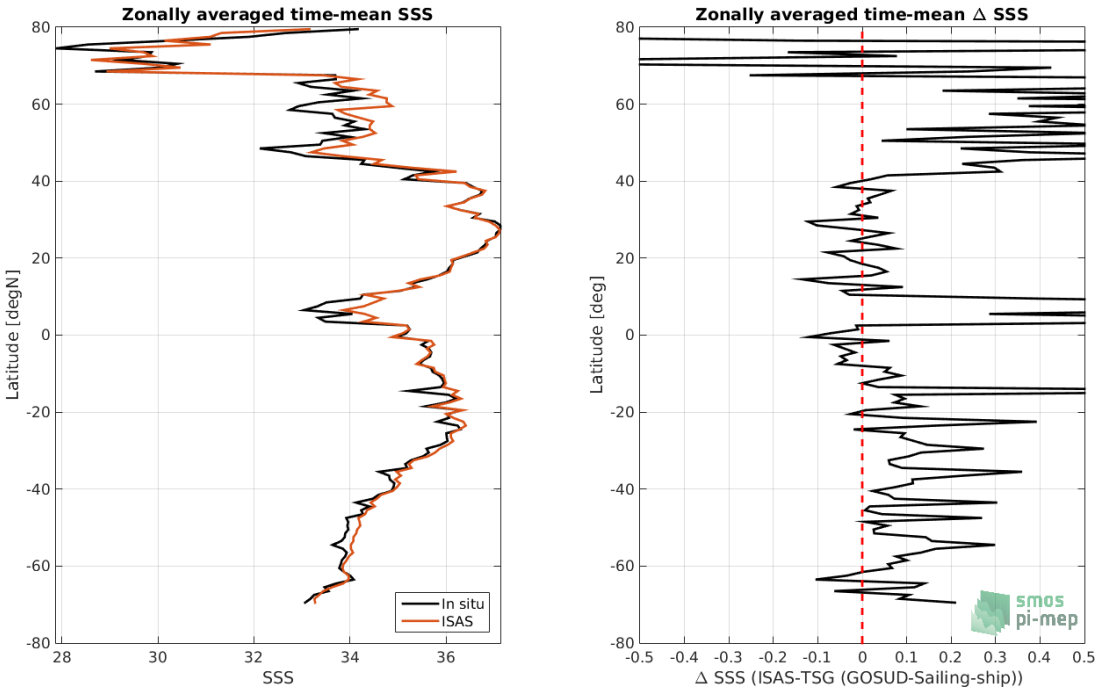
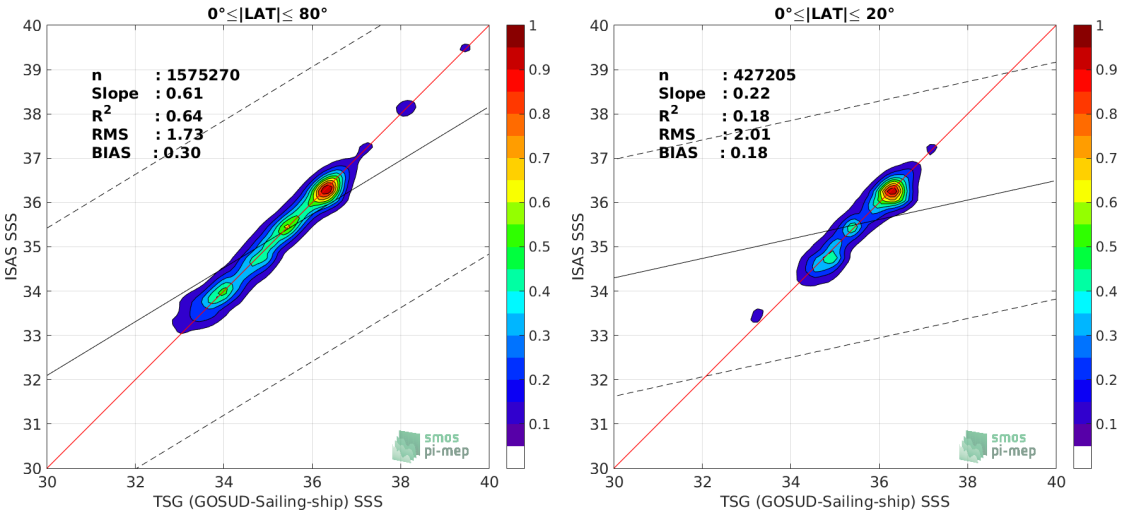


Figure 79: Left panel: Zonal mean SSS from ISAS product (black) and from TSG (GOSUD-Sailing-ship) (blue). Right panel: Zonal mean of ΔSSS (ISAS - TSG (GOSUD-Sailing-ship)) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

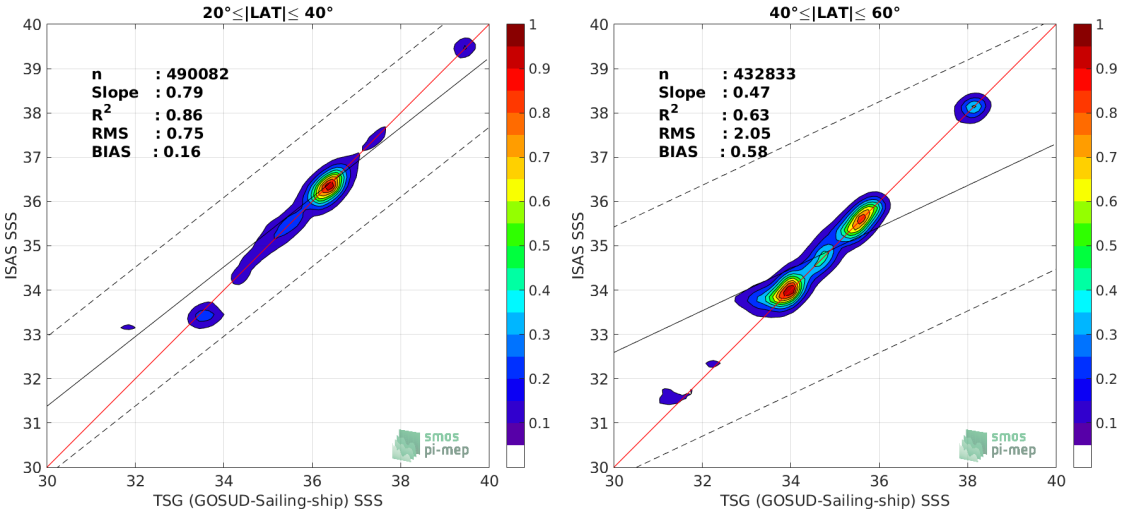
6.3.9 Scatterplots of ISAS vs *in situ* SSS by latitudinal bands

In Figure 80, contour maps of the concentration of ISAS SSS (y-axis) versus TSG (GOSUD-Sailing-ship) SSS (x-axis) at match-up pairs for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.



(a) $0° \leq |\text{LAT}| \leq 80°$

(b) $0° \leq |\text{LAT}| \leq 20°$



(c) $20° \leq |\text{LAT}| \leq 40°$

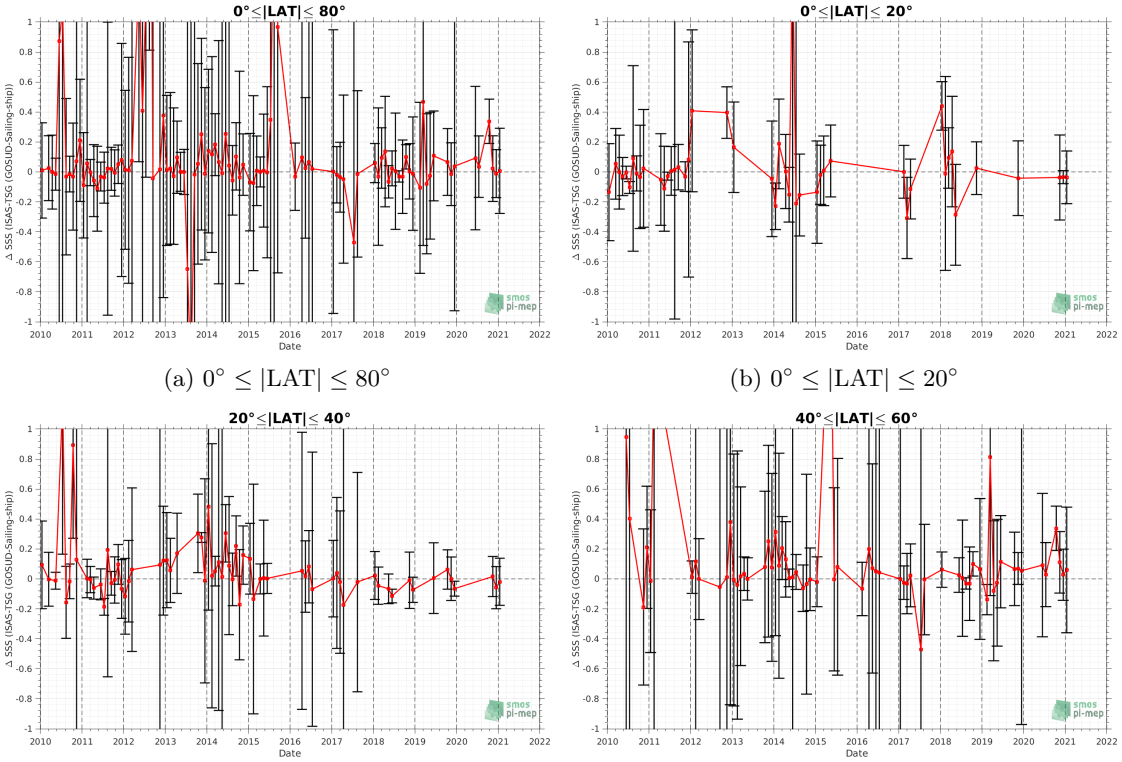
(d) $40° \leq |\text{LAT}| \leq 60°$

Figure 80: Contour maps of the concentration of ISAS SSS (y-axis) versus TSG (GOSUD-Sailing-ship) SSS (x-axis) at match-up pairs for different latitude bands. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.

6.3.10 Time series of the monthly median and Std of the difference ΔSSS sorted by latitudinal bands

In Figure 81, time series of the monthly median (red curves) of ΔSSS (ISAS - TSG (GOSUD-Sailing-ship)) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs estimated for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S

and 40°N-60°N.



(a) 0° ≤ |LAT| ≤ 80°

(b) 0° ≤ |LAT| ≤ 20°

(c) 20° ≤ |LAT| ≤ 40°

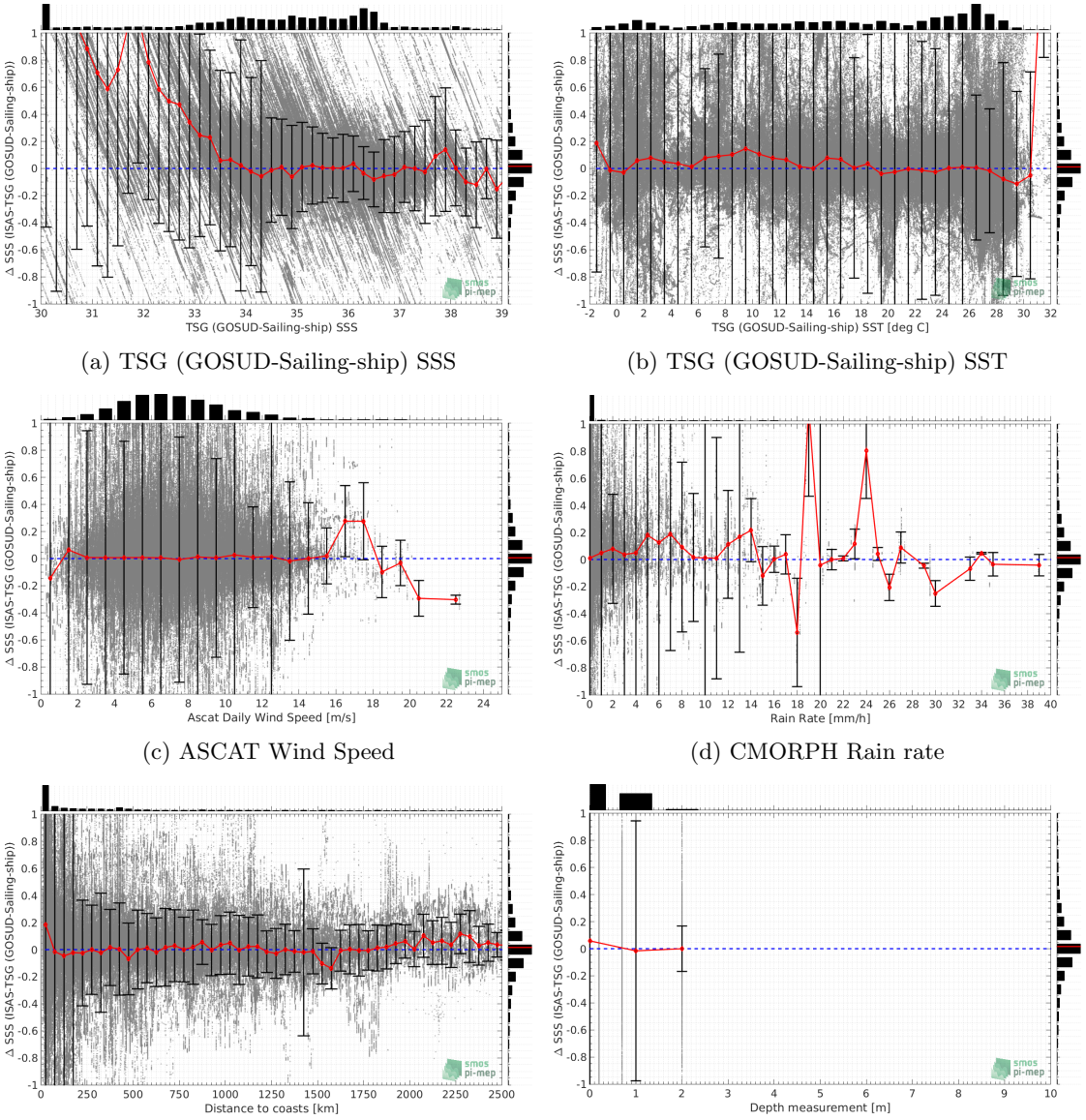
(d) 40° ≤ |LAT| ≤ 60°

Figure 81: Monthly median (red curves) of ΔSSS (ISAS - TSG (GOSUD-Sailing-ship)) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.

6.3.11 ΔSSS sorted as geophysical conditions

In Figure 82, we classify the match-up differences ΔSSS (ISAS - *in situ*) as function of the geophysical conditions at match-up points. The mean and std of ΔSSS (ISAS - TSG (GOSUD-Sailing-ship)) is thus evaluated as function of the

- *in situ* SSS values per bins of width 0.2,
- *in situ* SST values per bins of width 1°C,
- ASCAT daily wind values per bins of width 1 m/s,
- CMORPH 3-hourly rain rates per bins of width 1 mm/h, and,
- distance to coasts per bins of width 50 km,
- *in situ* measurement depth (if relevant).



(a) TSG (GOSUD-Sailing-ship) SSS

(b) TSG (GOSUD-Sailing-ship) SST

(c) ASCAT Wind Speed

(d) CMORPH Rain rate

(e) Distance to coast

(f) Depth

Figure 82: Δ SSS (ISAS - TSG (GOSUD-Sailing-ship)) sorted as geophysical conditions: TSG (GOSUD-Sailing-ship) SSS a), TSG (GOSUD-Sailing-ship) SST b), ASCAT Wind speed c), CMORPH rain rate d), distance to coast (e) and depth measurements (f).

6.3.12 ΔSSS maps and statistics for different geophysical conditions

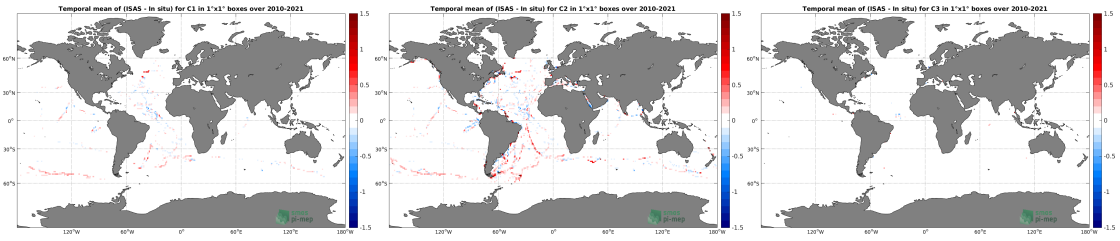
In Figures 83 and 84, we focus on sub-datasets of the match-up differences ΔSSS (ISAS - *in situ*) for the following specific geophysical conditions:

- **C1**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is in the range [3, 12] m/s, the SST is $> 5°$C and distance to coast is > 800 km.
- **C2**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is

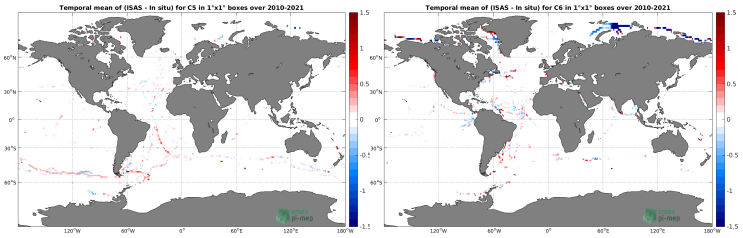
in the range [3, 12] m/s.

- **C3**:if the local value at *in situ* location of estimated rain rate is high (ie. $>$ 1 mm/h) and mean daily wind is low (ie. $<$ 4 m/s).
- **C5**:if the *in situ* data is located where the climatological SSS standard deviation is low (ie. above $<$ 0.2).
- **C6**:if the *in situ* data is located where the climatological SSS standard deviation is high (ie. above $>$ 0.2).

For each of these conditions, the temporal mean (gridded over spatial boxes of size 1°x1°) and the histogram of the difference ΔSSS (ISAS - *in situ*) are presented.

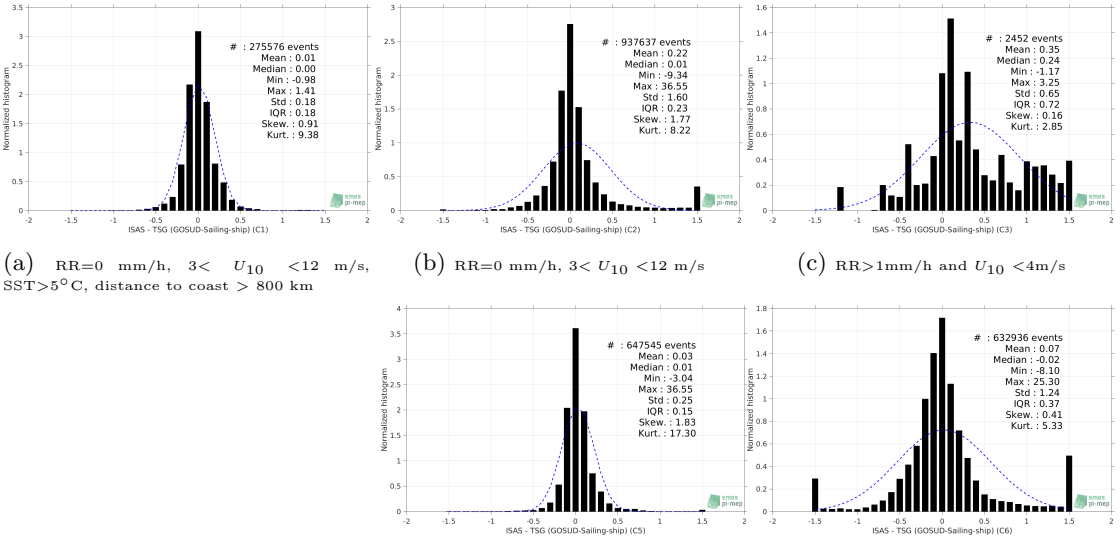


(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s



(d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 83: Temporal mean gridded over spatial boxes of size 1°x1° of ΔSSS (ISAS - TSG (GOSUD-Sailing-ship)) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).



(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s

(d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 84: Normalized histogram of ΔSSS (ISAS - TSG (GOSUD-Sailing-ship)) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).

6.3.13 Summary

Table 1 shows the mean, median, standard deviation (Std), root mean square (RMS), interquartile range (IQR), correlation coefficient (r^2) and robust standard deviation (Std*) of the match-up differences ΔSSS (ISAS - TSG (GOSUD-Sailing-ship)) for the following conditions:

- all: All the match-up pairs satellite/in situ SSS values are used to derive the statistics
- C1: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km
- C2: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s
- C3: only pairs where RR>1mm/h and U_{10} <4m/s
- C5: only pairs where WOA2013 SSS Std<0.2
- C6: only pairs where WOA2013 SSS Std>0.2
- C7a: only pairs with a distance to coast < 150 km.
- C7b: only pairs with a distance to coast in the range [150, 800] km.
- C7c: only pairs with a distance to coast > 800 km.
- C8a: only pairs where SST is < 5°C.
- C8b: only pairs where SST is in the range [5, 15]°C.
- C8c: only pairs where SST is > 15°C.

- C9a: only pairs where SSS is < 33.
- C9b: only pairs where SSS is in the range [33, 37].
- C9c: only pairs where SSS is > 37.

Table 1: Statistics of ΔSSS (ISAS - TSG (GOSUD-Sailing-ship))

Condition	#	Median	Mean	Std	RMS	IQR	r^2	Std*
all	1576333	0.02	0.30	1.79	1.81	0.30	0.614	0.21
C1	275576	0.00	0.01	0.18	0.18	0.18	0.971	0.13
C2	937637	0.01	0.22	1.60	1.61	0.23	0.563	0.16
C3	2452	0.24	0.35	0.65	0.74	0.72	0.940	0.44
C5	647545	0.01	0.03	0.25	0.26	0.15	0.961	0.11
C6	632936	-0.02	0.07	1.24	1.24	0.37	0.793	0.27
C7a	682646	0.08	0.71	2.62	2.71	0.78	0.536	0.41
C7b	506386	-0.01	-0.02	0.54	0.54	0.20	0.900	0.15
C7c	387171	0.00	0.02	0.22	0.22	0.18	0.960	0.13
C8a	218628	0.05	-0.02	1.47	1.47	0.60	0.721	0.44
C8b	322858	0.05	0.58	1.85	1.94	0.38	0.643	0.22
C8c	983777	0.00	0.21	1.76	1.77	0.23	0.457	0.17
C9a	242798	1.00	1.97	4.04	4.49	2.22	0.123	1.44
C9b	1201251	0.00	0.00	0.48	0.48	0.22	0.819	0.17
C9c	132284	0.00	0.01	0.33	0.33	0.21	0.850	0.16

Table 1 numerical values can be downloaded as a csv file here.

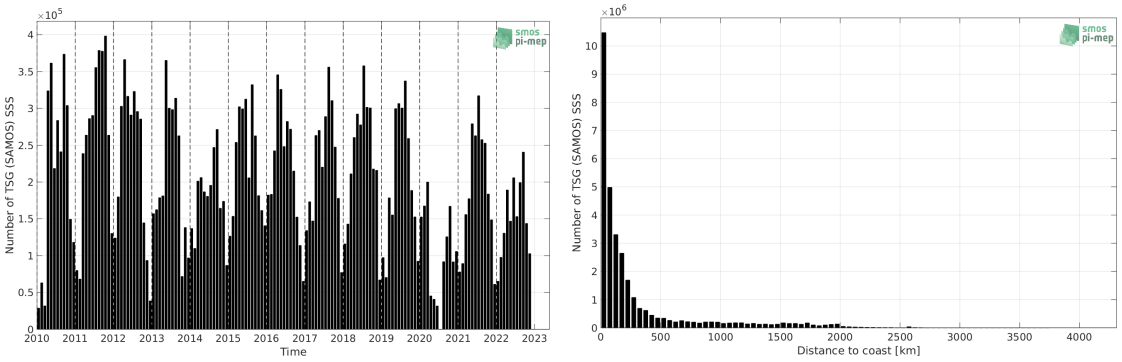
6.4 TSG (SAMOS)

6.4.1 Introduction

The TSG (SAMOS) dataset corresponds to "Research" quality data from the US Shipboard Automated Meteorological and Oceanographic System (SAMOS) initiative (Smith et al. (2009)). Data are available at http://samos.coaps.fsu.edu/html/. Adjusted values when available and only collected TSG data that exhibit quality flags=1 and 2 were used. After visual inspection, data from the NANCY FOSTER (ID="WTER", IMO="008993227") with date 2011/03/21 and all data from the ATLANTIS (ID="KAQP", IMO="009105798") for year 2010 have been removed from this dataset. For years, 2013 to 2022, RV Laurence Gould And Nathaniel Palmer data are coming from the "Intermediate" repository.

6.4.2 Number of SSS data as a function of time and distance to coast

Figure 85 shows the time (a) and distance to coast (b) distributions of the TSG (SAMOS) *in situ* dataset.

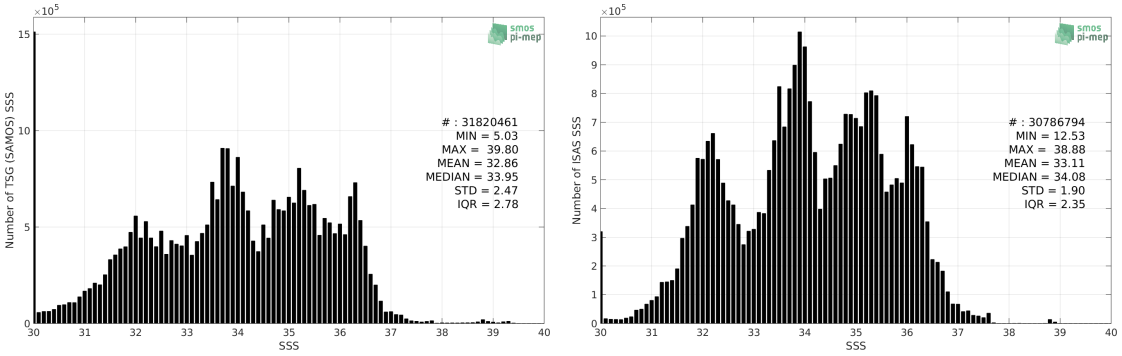


(a) (b)

Figure 85: Number of SSS from TSG (SAMOS) as a function of time (a) and distance to coast (b).

6.4.3 Histograms of SSS

Figure 86 shows the SSS distribution of the TSG (SAMOS) (a) and colocalized ISAS (b) dataset.

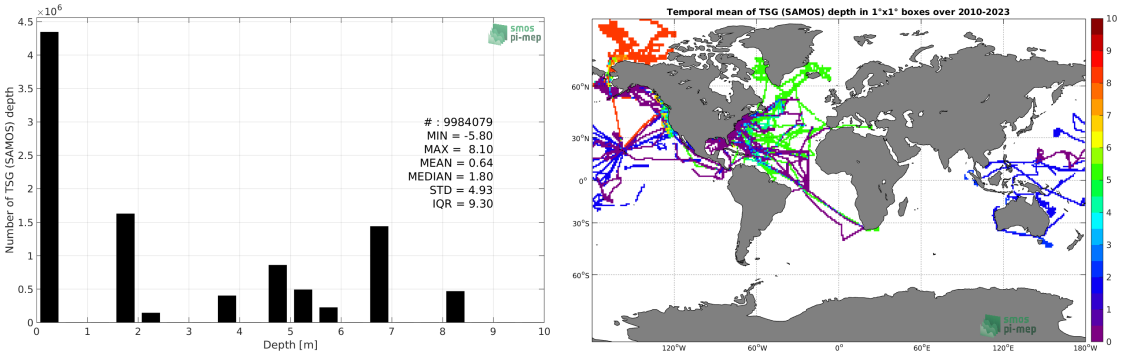


(a) (b)

Figure 86: Histograms of SSS from TSG (SAMOS) (a) and ISAS (b) per bins of 0.1.

6.4.4 Distribution of *in situ* SSS depth measurements

In Figure 87, we show the depth distribution of the *in situ* salinity dataset (a) and the spatial distribution of the depth temporal mean in 1°x1° boxes and considering the full *in situ* dataset period (b).



(a) (b)

Figure 87: Depth distribution of the upper level SSS measurements from TSG (SAMOS) (a) and spatial distribution of the *in situ* SSS depth measurements showing the mean value in 1°x1° boxes and considering the full *in situ* dataset period (b).

6.4.5 Spatial distribution of SSS

In Figure 88, the number of TSG (SAMOS) SSS measurements in 1°x1° boxes is shown.

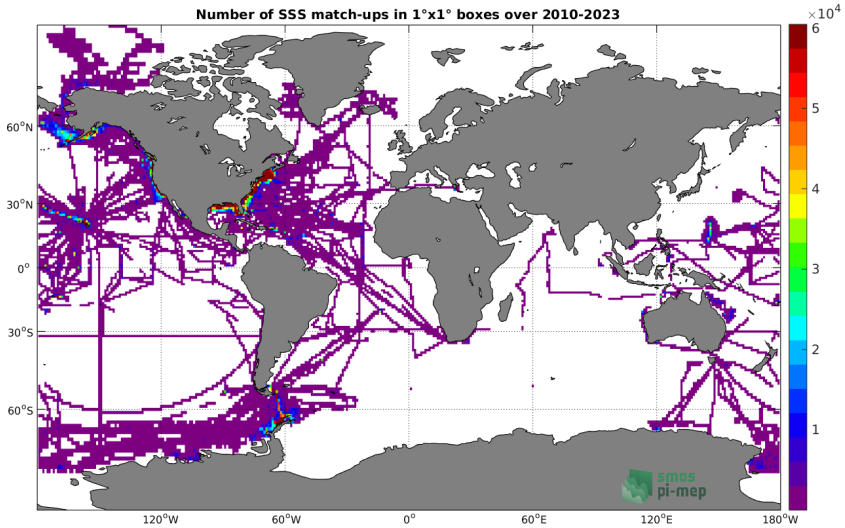
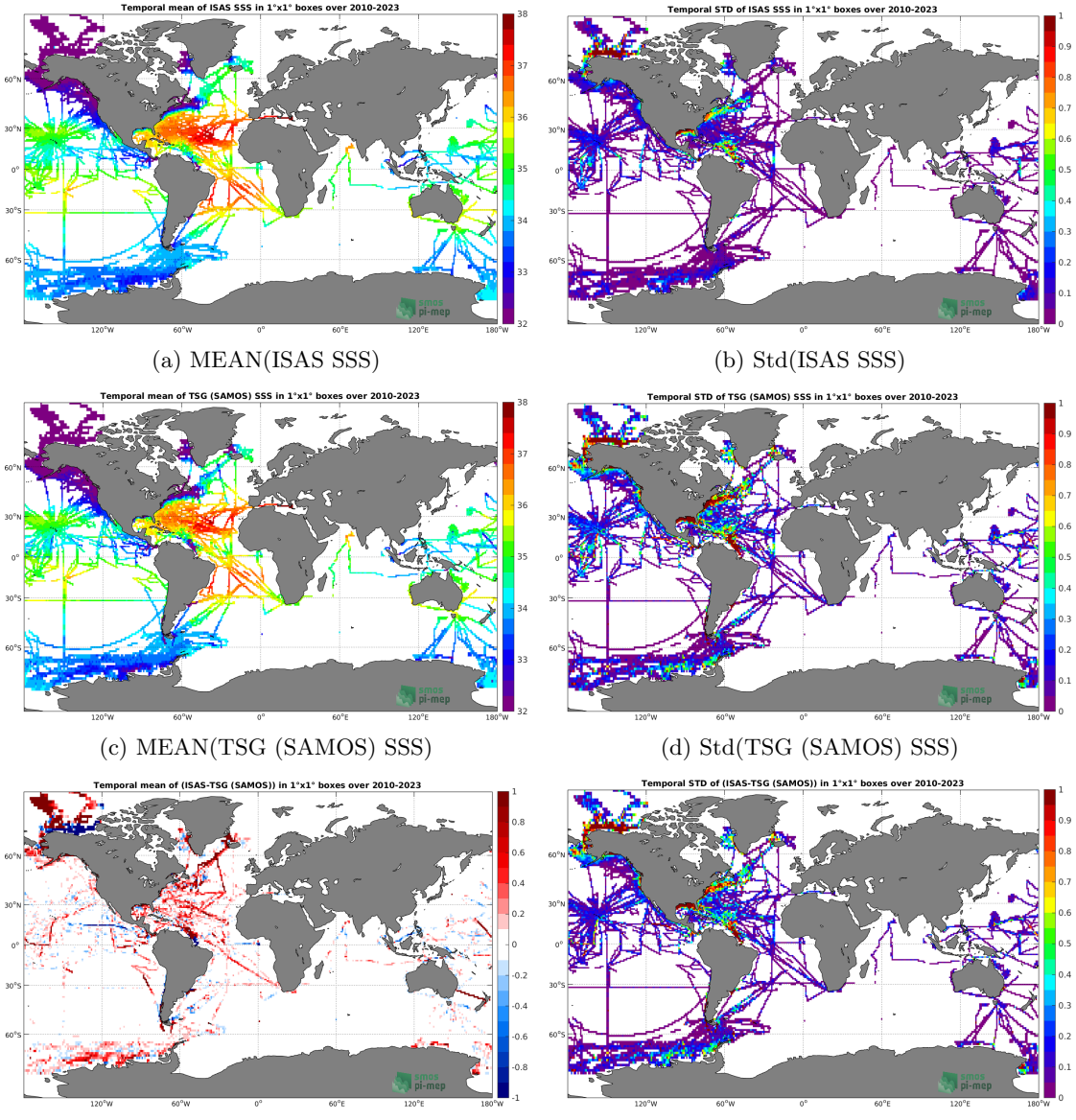


Figure 88: Number of SSS from TSG (SAMOS) in 1°x1° boxes.

6.4.6 Spatial Maps of the Temporal mean and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

In Figure 89, maps of temporal mean (left) and standard deviation (right) of ISAS (top), TSG (SAMOS) *in situ* dataset (middle) and the difference ΔSSS(ISAS -TSG (SAMOS)) (bottom) are shown. The temporal mean and std are calculated using all match-up pairs falling in spatial boxes of size 1°x1° over the full TSG (SAMOS) dataset period.



(a) MEAN(ISAS SSS)

(b) Std(ISAS SSS)

(c) MEAN(TSG (SAMOS) SSS)

(d) Std(TSG (SAMOS) SSS)

(e) MEAN(ΔSSS) (ISAS - TSG (SAMOS))

(f) Std(ΔSSS) (ISAS - TSG (SAMOS))

Figure 89: Temporal mean (left) and Std (right) of SSS from ISAS (top), TSG (SAMOS) (middle), and of ΔSSS (ISAS - TSG (SAMOS)). Only match-up pairs are used to generate these maps.

6.4.7 Time series of the monthly median and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

In the top panel of Figure 90, we show the time series of the monthly median SSS estimated for both ISAS SSS product (in black) and the TSG (SAMOS) *in situ* dataset (in blue) at the collected Pi-MEP match-up pairs.

In the middle panel of Figure 90, we show the time series of the monthly median of ΔSSS

(ISAS - TSG (SAMOS)) for the collected Pi-MEP match-up pairs.

In the bottom panel of Figure 90, we show the time series of the monthly standard deviation of the ΔSSS (ISAS - TSG (SAMOS)) for the collected Pi-MEP match-up pairs.

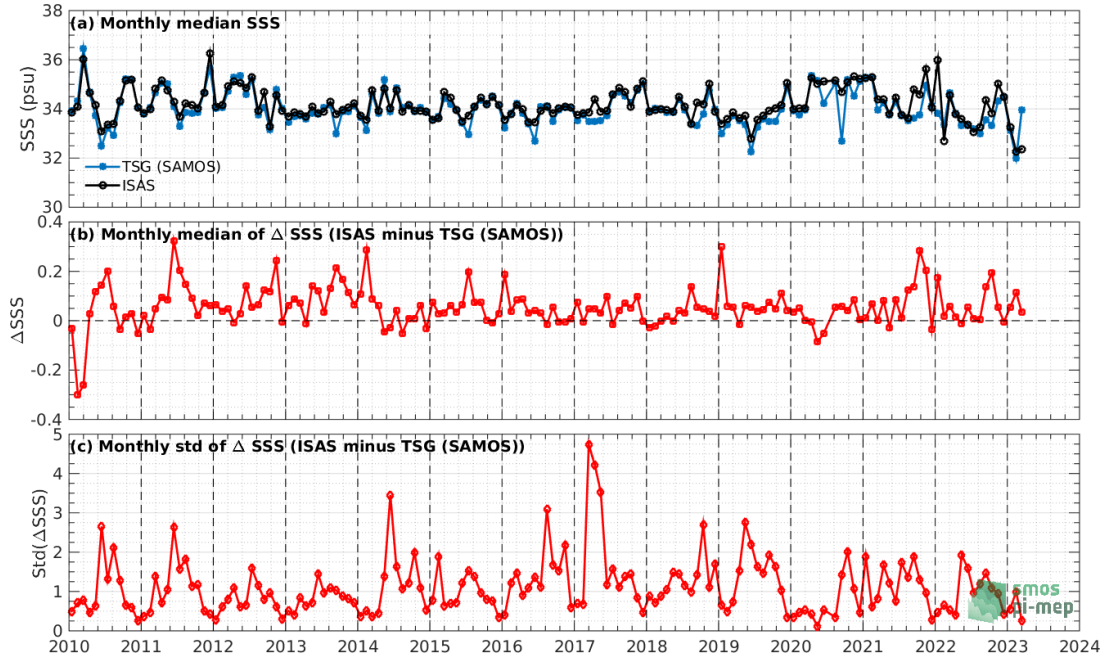


Figure 90: Time series of the monthly median SSS (top), median of ΔSSS (ISAS - TSG (SAMOS)) and Std of ΔSSS (ISAS - TSG (SAMOS)) considering all match-ups collected by the Pi-MEP.

6.4.8 Zonal mean and Std of *in situ* and ISAS SSS and of the difference ΔSSS

In Figure 91 left panel, we show the zonal mean SSS considering all Pi-MEP match-up pairs for both ISAS SSS product (in black) and the TSG (SAMOS) *in situ* dataset (in blue). The full *in situ* dataset period is used to derive the mean.

In the right panel of Figure 91, we show the zonal mean of ΔSSS (ISAS - TSG (SAMOS)) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

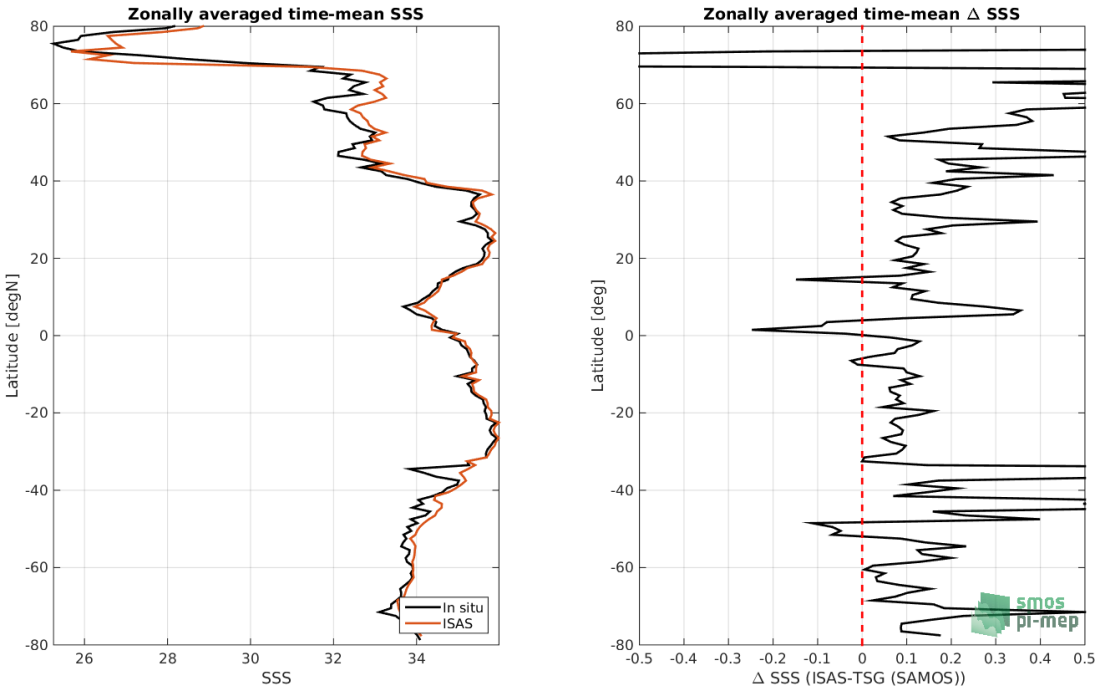
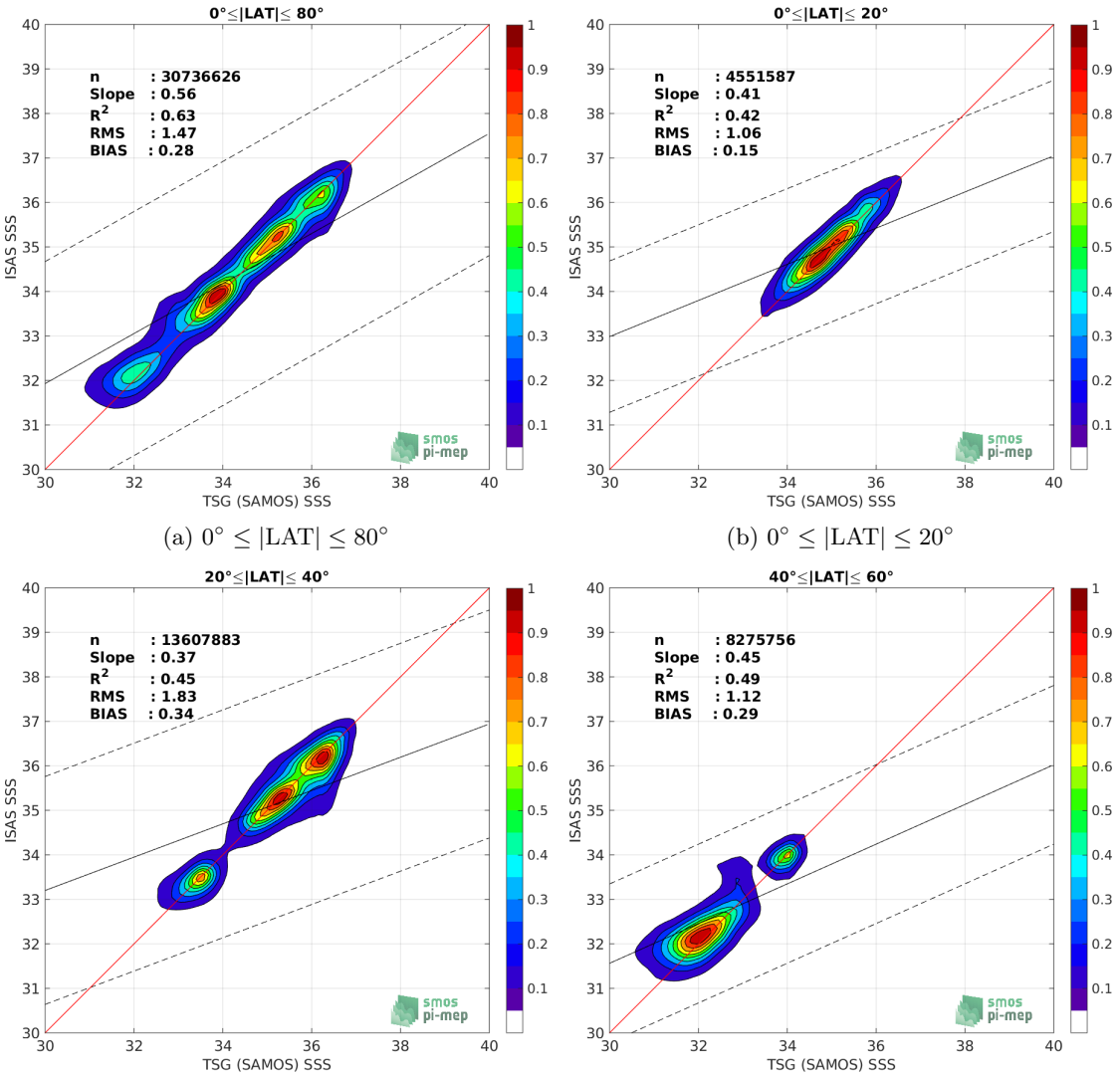


Figure 91: Left panel: Zonal mean SSS from ISAS product (black) and from TSG (SAMOS) (blue). Right panel: Zonal mean of ΔSSS (ISAS - TSG (SAMOS)) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

6.4.9 Scatterplots of ISAS vs *in situ* SSS by latitudinal bands

In Figure 92, contour maps of the concentration of ISAS SSS (y-axis) versus TSG (SAMOS) SSS (x-axis) at match-up pairs for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.



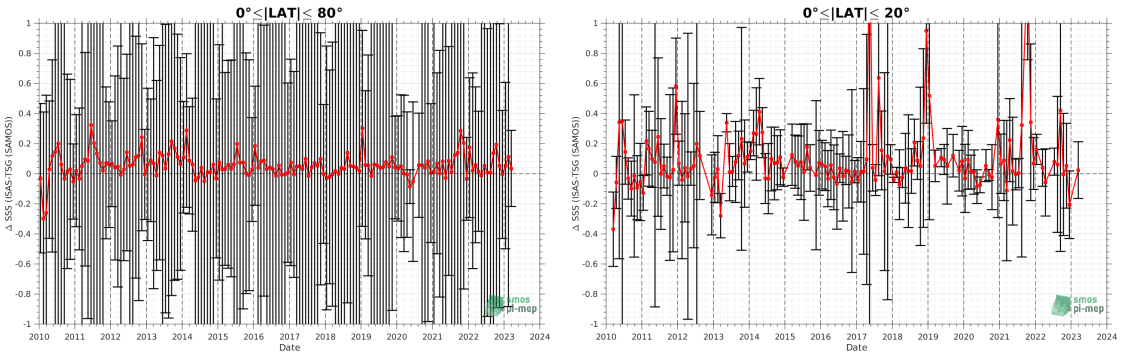
(a) $0° \leq |\text{LAT}| \leq 80°$ (b) $0° \leq |\text{LAT}| \leq 20°$

(c) $20° \leq |\text{LAT}| \leq 40°$ (d) $40° \leq |\text{LAT}| \leq 60°$

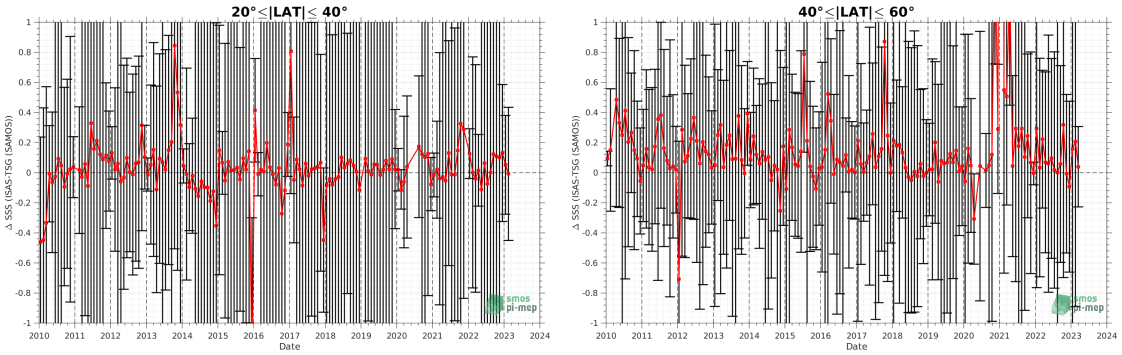
Figure 92: Contour maps of the concentration of ISAS SSS (y-axis) versus TSG (SAMOS) SSS (x-axis) at match-up pairs for different latitude bands. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.

6.4.10 Time series of the monthly median and Std of the difference ΔSSS sorted by latitudinal bands

In Figure 93, time series of the monthly median (red curves) of ΔSSS (ISAS - TSG (SAMOS)) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs estimated for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.



(a) $0° \leq |\text{LAT}| \leq 80°$ (b) $0° \leq |\text{LAT}| \leq 20°$



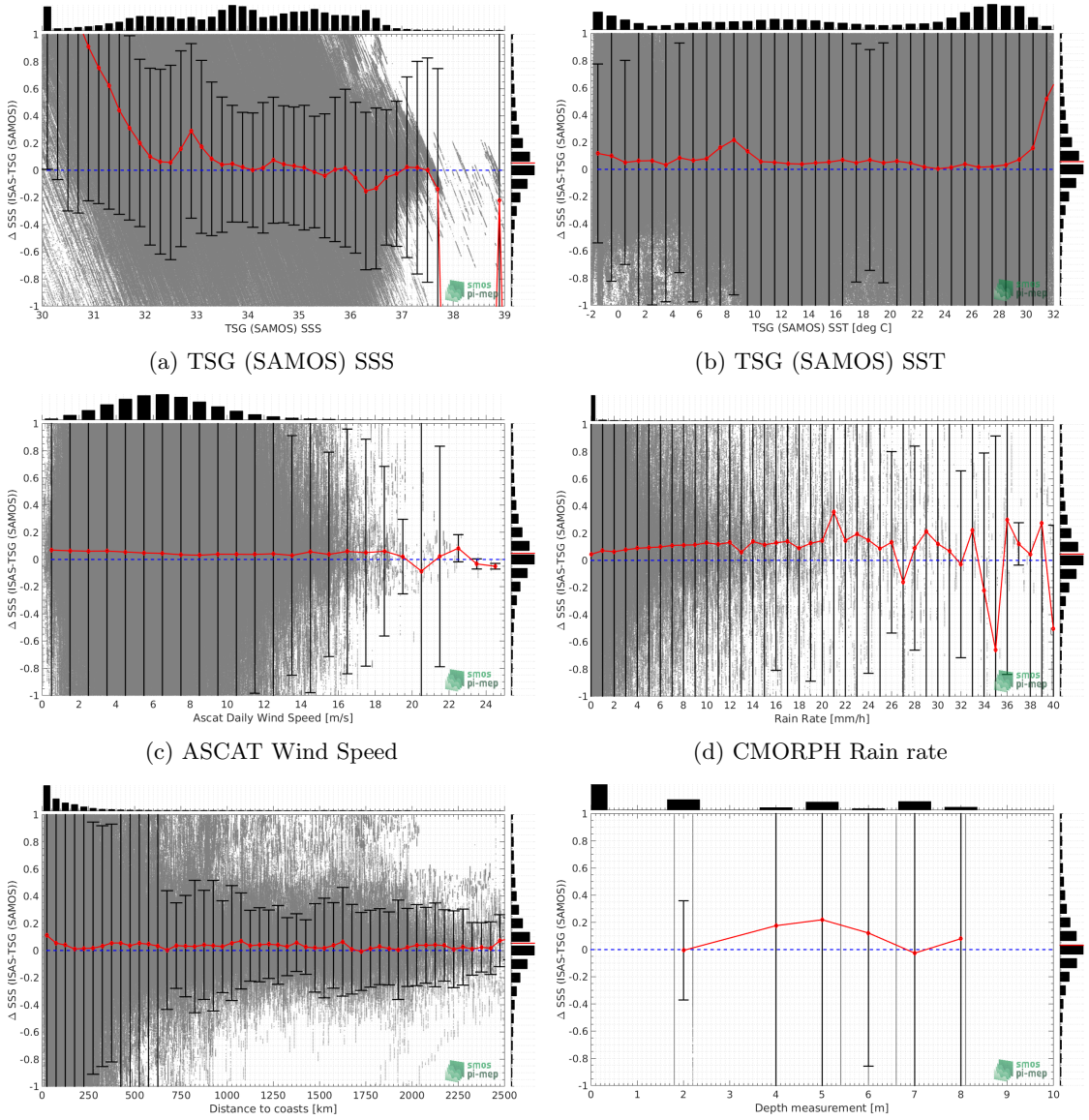
(c) $20° \leq |\text{LAT}| \leq 40°$ (d) $40° \leq |\text{LAT}| \leq 60°$

Figure 93: Monthly median (red curves) of ΔSSS (ISAS - TSG (SAMOS)) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.

6.4.11 ΔSSS sorted as geophysical conditions

In Figure 94, we classify the match-up differences ΔSSS (ISAS - *in situ*) as function of the geophysical conditions at match-up points. The mean and std of ΔSSS (ISAS - TSG (SAMOS)) is thus evaluated as function of the

- *in situ* SSS values per bins of width 0.2,
- *in situ* SST values per bins of width 1°C,
- ASCAT daily wind values per bins of width 1 m/s,
- CMORPH 3-hourly rain rates per bins of width 1 mm/h, and,
- distance to coasts per bins of width 50 km,
- *in situ* measurement depth (if relevant).



(a) TSG (SAMOS) SSS

(b) TSG (SAMOS) SST

(c) ASCAT Wind Speed

(d) CMORPH Rain rate

(e) Distance to coast

(f) Depth

Figure 94: Δ SSS (ISAS - TSG (SAMOS)) sorted as geophysical conditions: TSG (SAMOS) SSS a), TSG (SAMOS) SST b), ASCAT Wind speed c), CMORPH rain rate d), distance to coast (e) and depth measurements (f).

6.4.12 ΔSSS maps and statistics for different geophysical conditions

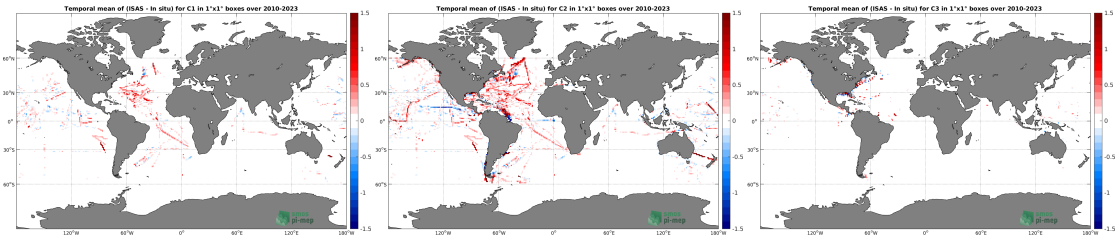
In Figures 95 and 96, we focus on sub-datasets of the match-up differences ΔSSS (ISAS - *in situ*) for the following specific geophysical conditions:

- **C1**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is in the range [3, 12] m/s, the SST is $> 5°$C and distance to coast is > 800 km.
- **C2**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is

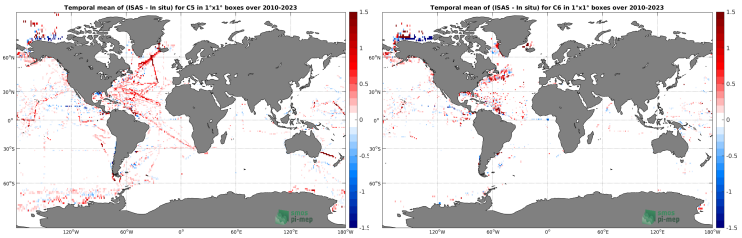
in the range [3, 12] m/s.

- **C3**:if the local value at *in situ* location of estimated rain rate is high (ie. $>$ 1 mm/h) and mean daily wind is low (ie. $<$ 4 m/s).
- **C5**:if the *in situ* data is located where the climatological SSS standard deviation is low (ie. above $<$ 0.2).
- **C6**:if the *in situ* data is located where the climatological SSS standard deviation is high (ie. above $>$ 0.2).

For each of these conditions, the temporal mean (gridded over spatial boxes of size 1°x1°) and the histogram of the difference ΔSSS (ISAS - *in situ*) are presented.

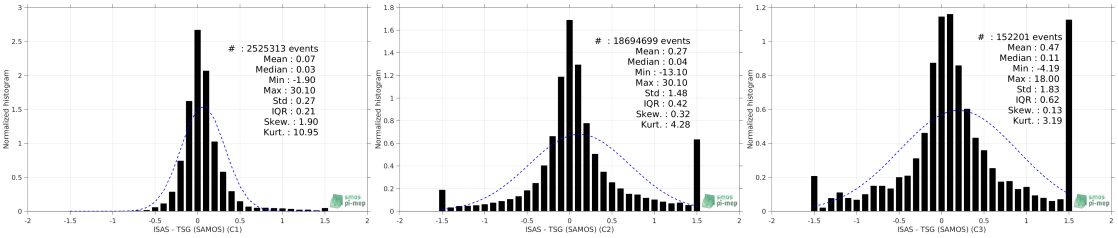


(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s



(d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

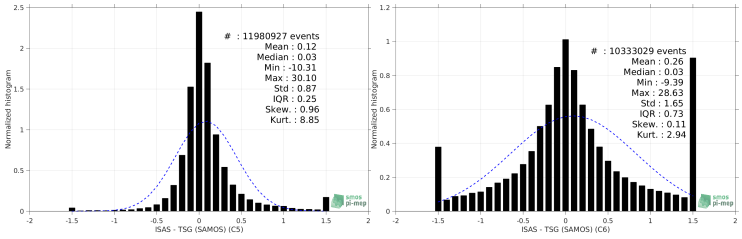
Figure 95: Temporal mean gridded over spatial boxes of size 1°x1° of ΔSSS (ISAS - TSG (SAMOS)) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).



(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km

(b) RR=0 mm/h, 3< U_{10} <12 m/s

(c) RR>1mm/h and U_{10} <4m/s



(d) WOA2013 SSS Std<0.2

(e) WOA2013 SSS Std>0.2

Figure 96: Normalized histogram of ΔSSS (ISAS - TSG (SAMOS)) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).

6.4.13 Summary

Table 1 shows the mean, median, standard deviation (Std), root mean square (RMS), interquartile range (IQR), correlation coefficient (r^2) and robust standard deviation (Std*) of the match-up differences ΔSSS (ISAS - TSG (SAMOS)) for the following conditions:

- all: All the match-up pairs satellite/in situ SSS values are used to derive the statistics
- C1: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km
- C2: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s
- C3: only pairs where RR>1mm/h and U_{10} <4m/s
- C5: only pairs where WOA2013 SSS Std<0.2
- C6: only pairs where WOA2013 SSS Std>0.2
- C7a: only pairs with a distance to coast < 150 km.
- C7b: only pairs with a distance to coast in the range [150, 800] km.
- C7c: only pairs with a distance to coast > 800 km.
- C8a: only pairs where SST is < 5°C.
- C8b: only pairs where SST is in the range [5, 15]°C.
- C8c: only pairs where SST is > 15°C.

- C9a: only pairs where SSS is < 33.
- C9b: only pairs where SSS is in the range [33, 37].
- C9c: only pairs where SSS is > 37.

Table 1: Statistics of ΔSSS (ISAS - TSG (SAMOS))

Condition	#	Median	Mean	Std	RMS	IQR	r^2	Std*
all	30786794	0.05	0.28	1.44	1.47	0.44	0.630	0.31
C1	2525313	0.03	0.07	0.27	0.28	0.21	0.916	0.16
C2	18694699	0.04	0.27	1.48	1.51	0.42	0.576	0.30
C3	152201	0.11	0.47	1.83	1.89	0.62	0.493	0.43
C5	11980927	0.03	0.12	0.87	0.88	0.25	0.741	0.18
C6	10333029	0.03	0.26	1.65	1.67	0.73	0.502	0.54
C7a	17834915	0.08	0.39	1.67	1.72	0.58	0.495	0.40
C7b	8953395	0.03	0.13	1.21	1.21	0.35	0.638	0.26
C7c	3969498	0.03	0.09	0.33	0.35	0.22	0.919	0.16
C8a	5167845	0.08	0.16	0.86	0.88	0.36	0.709	0.25
C8b	7195006	0.08	0.29	1.30	1.33	0.59	0.401	0.41
C8c	16703261	0.04	0.32	1.63	1.66	0.41	0.512	0.29
C9a	9410604	0.37	0.98	2.33	2.52	1.05	0.061	0.67
C9b	21085018	0.01	-0.02	0.51	0.52	0.30	0.831	0.22
C9c	291172	-0.07	-1.02	1.57	1.87	2.82	0.074	0.33

Table 1 numerical values can be downloaded as a csv file here.

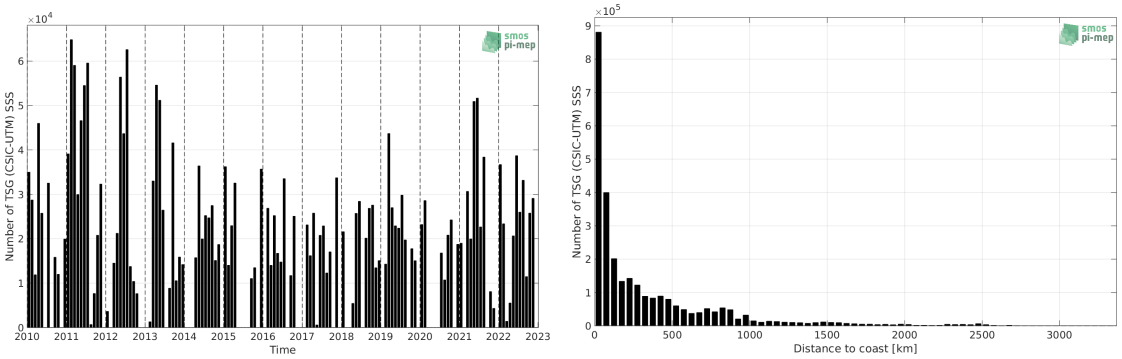
6.5 TSG (CSIC-UTM)

6.5.1 Introduction

The TSG (CSIC-UTM) dataset contains sea surface temperature and salinity data collected from 2010 to 2022 mainly in the Atlantic Ocean, Mediterranean Sea and the Southern Ocean from 3 CSIC-UTM research vessels (B/O Sarmiento de Gamboa, R/V Hespérides and R/V García del Cid). Measurements have been obtained through thermosalinograph (TSG) during more than 100 cruises. On-board TSG devices have been regularly calibrated and continuously monitored in-between cruises. The data has been gathered through the http://data.utm.csic.es/portal/ data portal.

6.5.2 Number of SSS data as a function of time and distance to coast

Figure 97 shows the time (a) and distance to coast (b) distributions of the TSG (CSIC-UTM) *in situ* dataset.

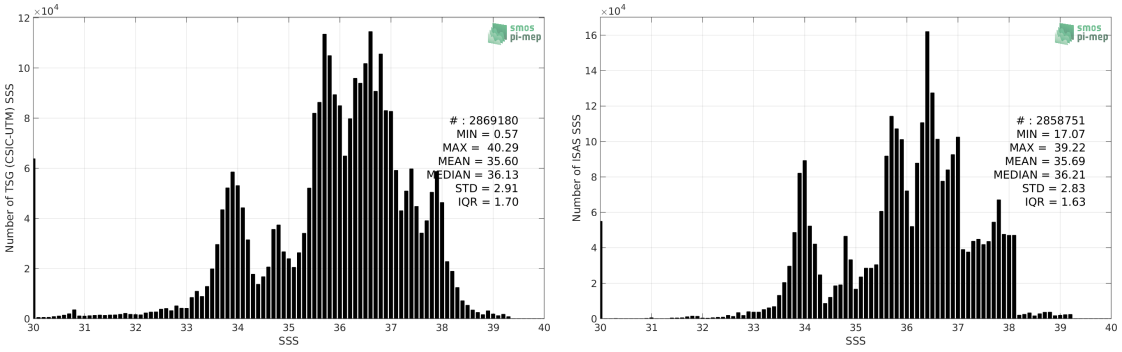


(a) (b)

Figure 97: Number of SSS from TSG (CSIC-UTM) as a function of time (a) and distance to coast (b).

6.5.3 Histograms of SSS

Figure 98 shows the SSS distribution of the TSG (CSIC-UTM) (a) and colocalized ISAS (b) dataset.

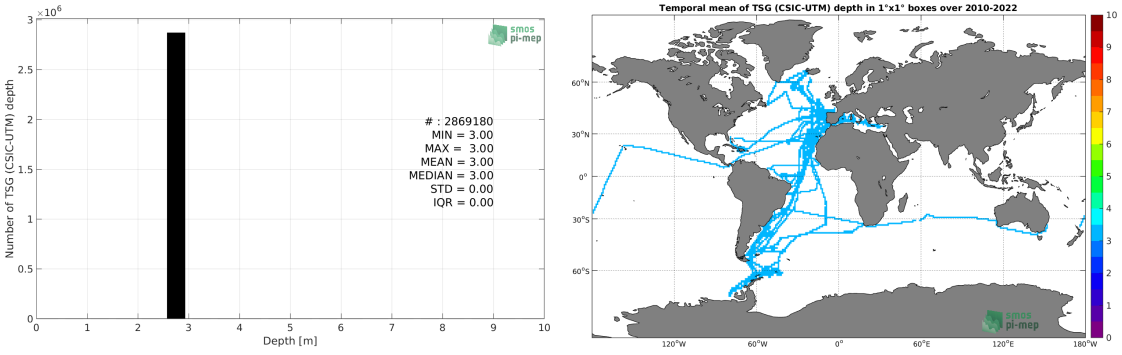


(a) (b)

Figure 98: Histograms of SSS from TSG (CSIC-UTM) (a) and ISAS (b) per bins of 0.1.

6.5.4 Distribution of *in situ* SSS depth measurements

In Figure 99, we show the depth distribution of the *in situ* salinity dataset (a) and the spatial distribution of the depth temporal mean in 1°x1° boxes and considering the full *in situ* dataset period (b).



(a) (b)

Figure 99: Depth distribution of the upper level SSS measurements from TSG (CSIC-UTM) (a) and spatial distribution of the *in situ* SSS depth measurements showing the mean value in 1°x1° boxes and considering the full *in situ* dataset period (b).

6.5.5 Spatial distribution of SSS

In Figure 100, the number of TSG (CSIC-UTM) SSS measurements in 1°x1° boxes is shown.

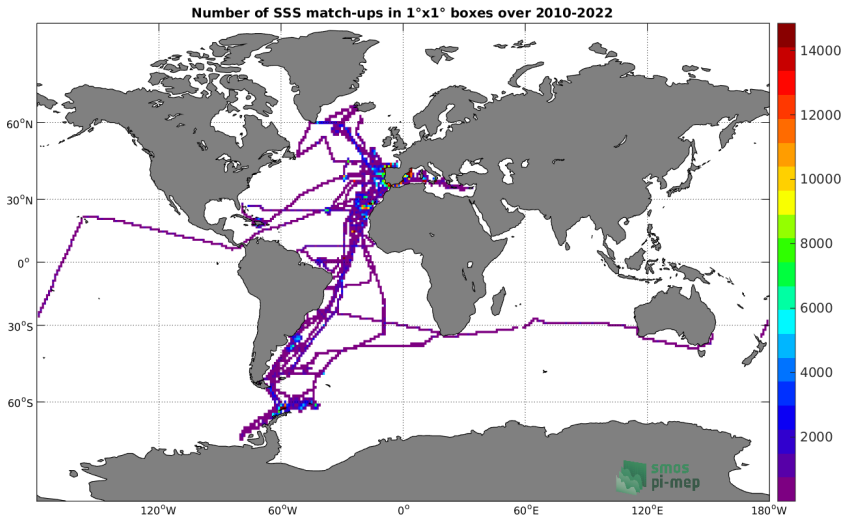
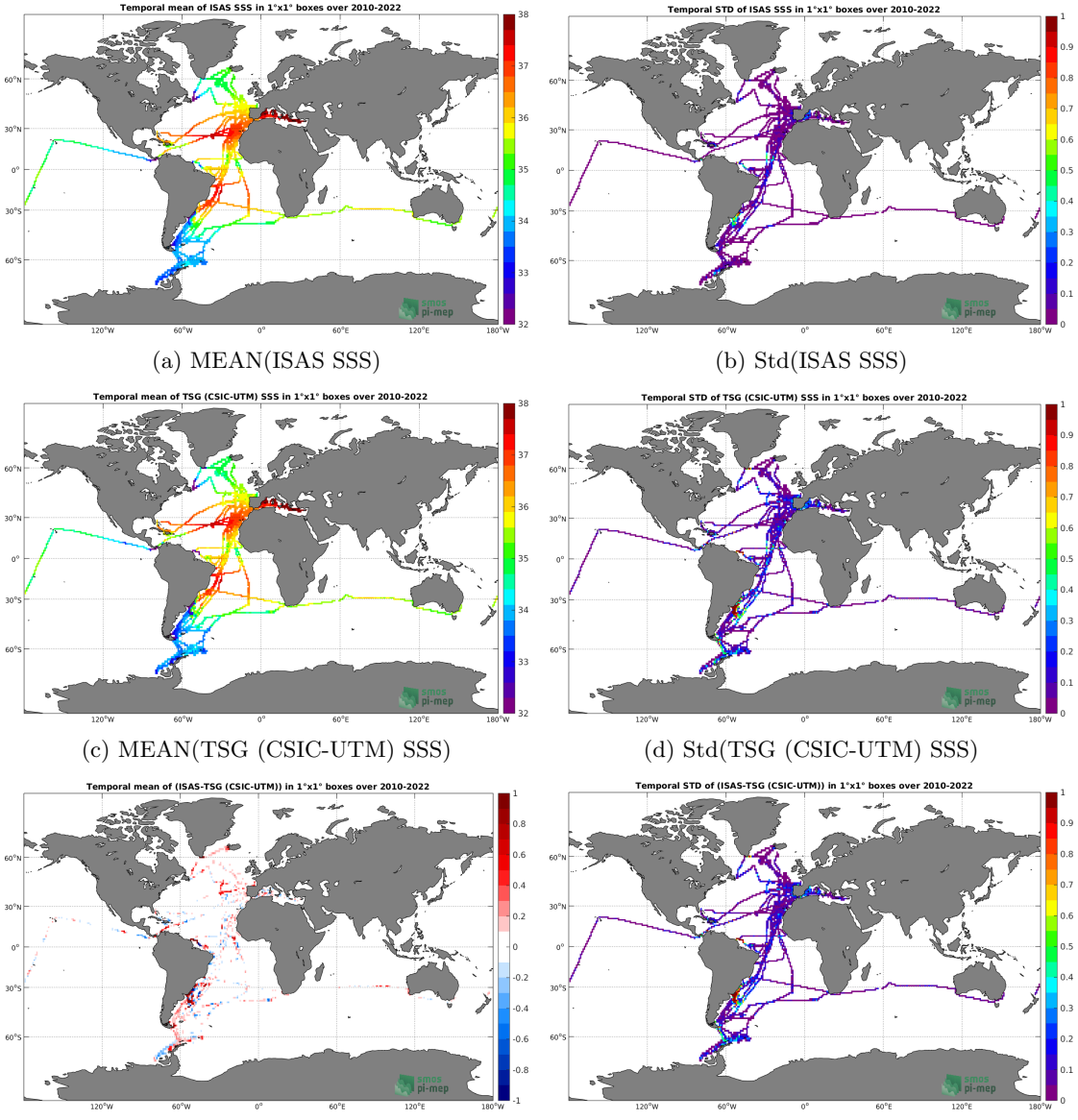


Figure 100: Number of SSS from TSG (CSIC-UTM) in 1°x1° boxes.

6.5.6 Spatial Maps of the Temporal mean and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

In Figure 101, maps of temporal mean (left) and standard deviation (right) of ISAS (top), TSG (CSIC-UTM) *in situ* dataset (middle) and the difference ΔSSS(ISAS -TSG (CSIC-UTM)) (bottom) are shown. The temporal mean and std are calculated using all match-up pairs falling in spatial boxes of size 1°x1° over the full TSG (CSIC-UTM) dataset period.



(a) MEAN(ISAS SSS)

(b) Std(ISAS SSS)

(c) MEAN(TSG (CSIC-UTM) SSS)

(d) Std(TSG (CSIC-UTM) SSS)

(e) MEAN(ΔSSS) (ISAS - TSG (CSIC-UTM))

(f) Std(ΔSSS) (ISAS - TSG (CSIC-UTM))

Figure 101: Temporal mean (left) and Std (right) of SSS from ISAS (top), TSG (CSIC-UTM) (middle), and of ΔSSS (ISAS - TSG (CSIC-UTM)). Only match-up pairs are used to generate these maps.

6.5.7 Time series of the monthly median and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

In the top panel of Figure 102, we show the time series of the monthly median SSS estimated for both ISAS SSS product (in black) and the TSG (CSIC-UTM) *in situ* dataset (in blue) at the collected Pi-MEP match-up pairs.

In the middle panel of Figure 102, we show the time series of the monthly median of ΔSSS

(ISAS - TSG (CSIC-UTM)) for the collected Pi-MEP match-up pairs.

In the bottom panel of Figure 102, we show the time series of the monthly standard deviation of the ΔSSS (ISAS - TSG (CSIC-UTM)) for the collected Pi-MEP match-up pairs.

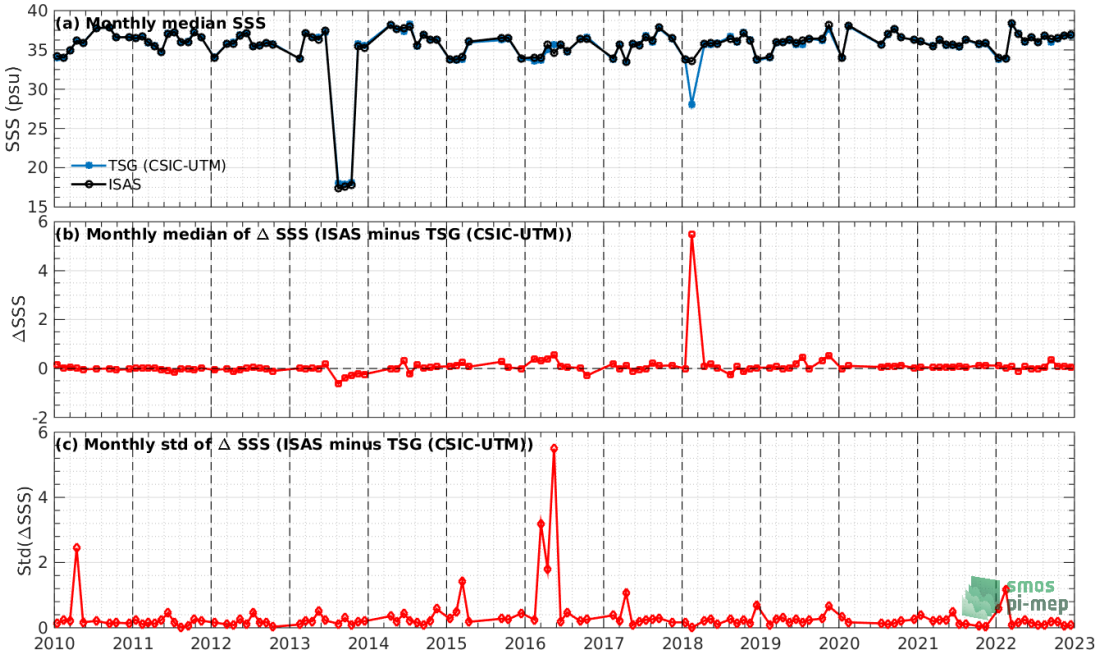


Figure 102: Time series of the monthly median SSS (top), median of ΔSSS (ISAS - TSG (CSIC-UTM)) and Std of ΔSSS (ISAS - TSG (CSIC-UTM)) considering all match-ups collected by the Pi-MEP.

6.5.8 Zonal mean and Std of *in situ* and ISAS SSS and of the difference ΔSSS

In Figure 103 left panel, we show the zonal mean SSS considering all Pi-MEP match-up pairs for both ISAS SSS product (in black) and the TSG (CSIC-UTM) *in situ* dataset (in blue). The full *in situ* dataset period is used to derive the mean.

In the right panel of Figure 103, we show the zonal mean of ΔSSS (ISAS - TSG (CSIC-UTM)) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

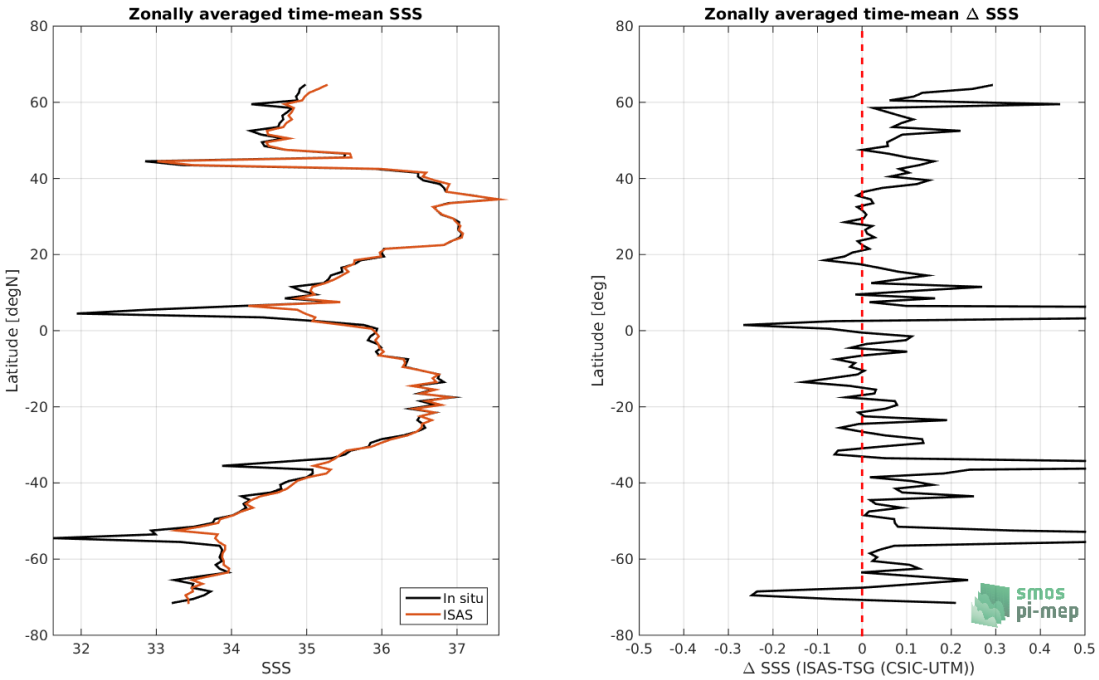
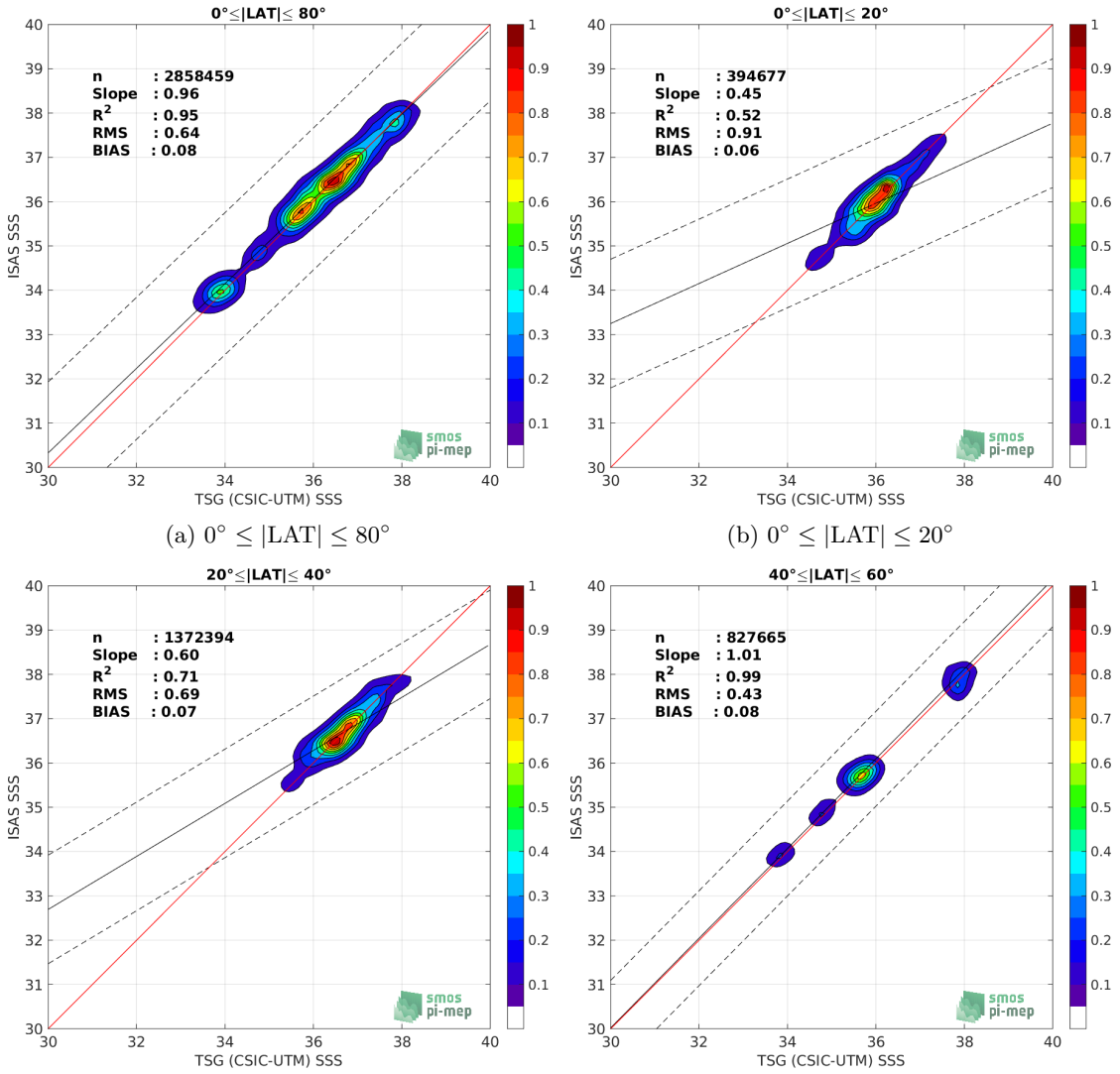


Figure 103: Left panel: Zonal mean SSS from ISAS product (black) and from TSG (CSIC-UTM) (blue). Right panel: Zonal mean of ΔSSS (ISAS - TSG (CSIC-UTM)) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

6.5.9 Scatterplots of ISAS vs *in situ* SSS by latitudinal bands

In Figure 104, contour maps of the concentration of ISAS SSS (y-axis) versus TSG (CSIC-UTM) SSS (x-axis) at match-up pairs for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.



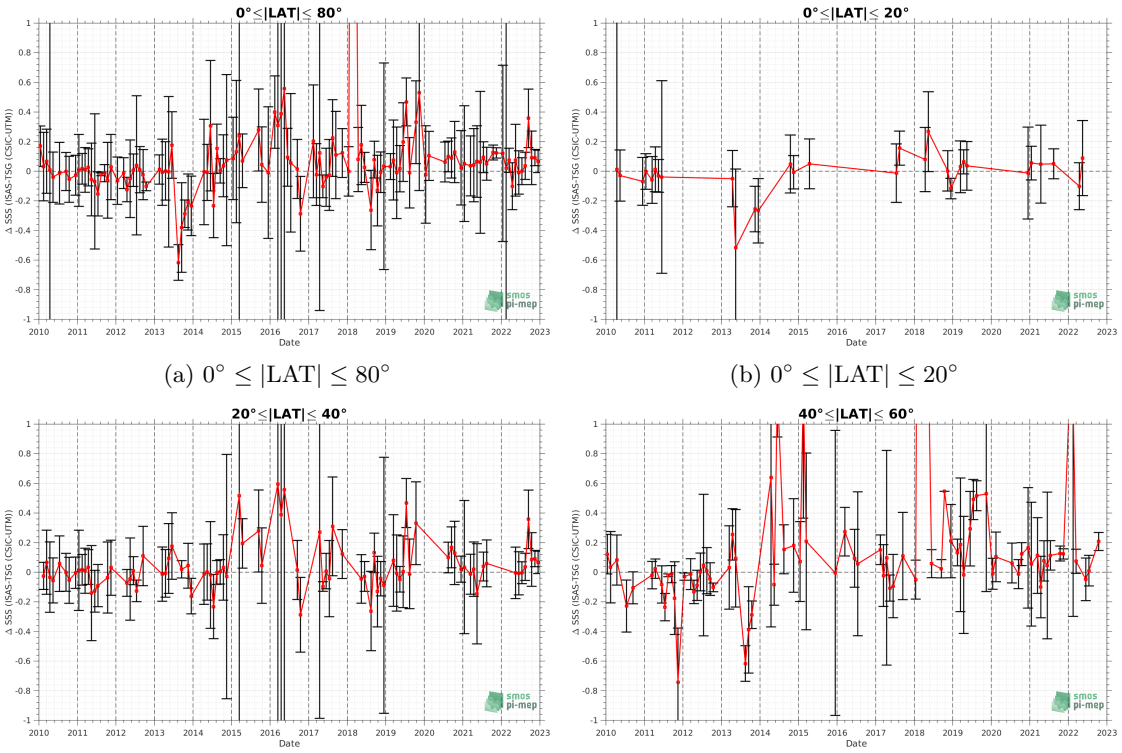
(a) $0° \leq |\text{LAT}| \leq 80°$ (b) $0° \leq |\text{LAT}| \leq 20°$

(c) $20° \leq |\text{LAT}| \leq 40°$ (d) $40° \leq |\text{LAT}| \leq 60°$

Figure 104: Contour maps of the concentration of ISAS SSS (y-axis) versus TSG (CSIC-UTM) SSS (x-axis) at match-up pairs for different latitude bands. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.

6.5.10 Time series of the monthly median and Std of the difference ΔSSS sorted by latitudinal bands

In Figure 105, time series of the monthly median (red curves) of ΔSSS (ISAS - TSG (CSIC-UTM)) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs estimated for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.



(a) $0° \leq |\text{LAT}| \leq 80°$

(b) $0° \leq |\text{LAT}| \leq 20°$

(c) $20° \leq |\text{LAT}| \leq 40°$

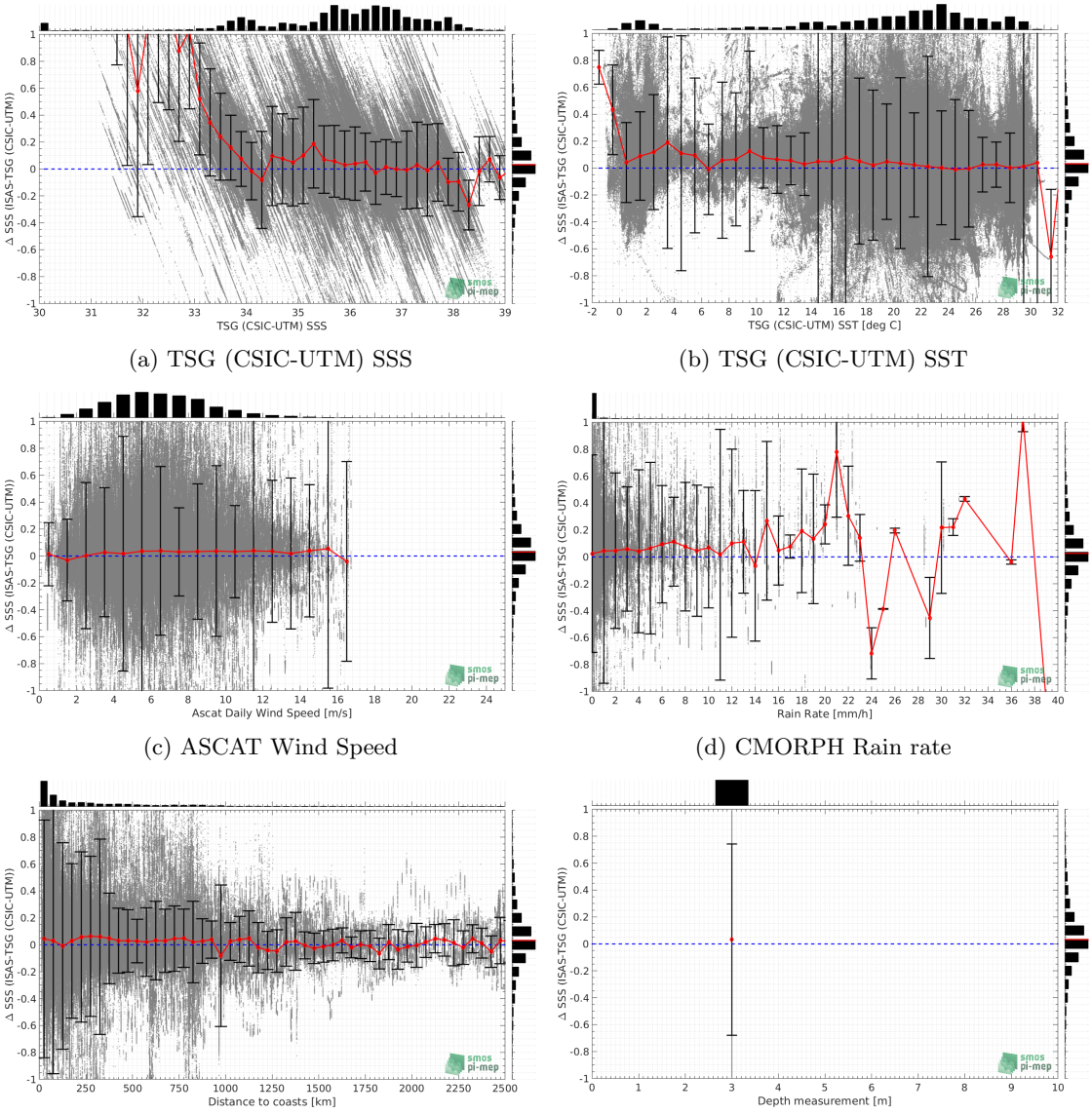
(d) $40° \leq |\text{LAT}| \leq 60°$

Figure 105: Monthly median (red curves) of ΔSSS (ISAS - TSG (CSIC-UTM)) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.

6.5.11 ΔSSS sorted as geophysical conditions

In Figure 106, we classify the match-up differences ΔSSS (ISAS - *in situ*) as function of the geophysical conditions at match-up points. The mean and std of ΔSSS (ISAS - TSG (CSIC-UTM)) is thus evaluated as function of the

- *in situ* SSS values per bins of width 0.2,
- *in situ* SST values per bins of width 1°C,
- ASCAT daily wind values per bins of width 1 m/s,
- CMORPH 3-hourly rain rates per bins of width 1 mm/h, and,
- distance to coasts per bins of width 50 km,
- *in situ* measurement depth (if relevant).



(a) TSG (CSIC-UTM) SSS

(b) TSG (CSIC-UTM) SST

(c) ASCAT Wind Speed

(d) CMORPH Rain rate

(e) Distance to coast

(f) Depth

Figure 106: Δ SSS (ISAS - TSG (CSIC-UTM)) sorted as geophysical conditions: TSG (CSIC-UTM) SSS a), TSG (CSIC-UTM) SST b), ASCAT Wind speed c), CMORPH rain rate d), distance to coast (e) and depth measurements (f).

6.5.12 ΔSSS maps and statistics for different geophysical conditions

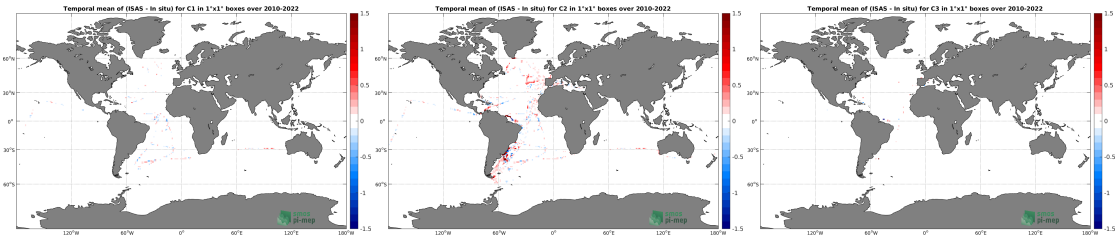
In Figures 107 and 108, we focus on sub-datasets of the match-up differences ΔSSS (ISAS - *in situ*) for the following specific geophysical conditions:

- **C1**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is in the range [3, 12] m/s, the SST is $> 5°$C and distance to coast is > 800 km.
- **C2**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is

in the range [3, 12] m/s.

- **C3**:if the local value at *in situ* location of estimated rain rate is high (ie. $>$ 1 mm/h) and mean daily wind is low (ie. $<$ 4 m/s).
- **C5**:if the *in situ* data is located where the climatological SSS standard deviation is low (ie. above $<$ 0.2).
- **C6**:if the *in situ* data is located where the climatological SSS standard deviation is high (ie. above $>$ 0.2).

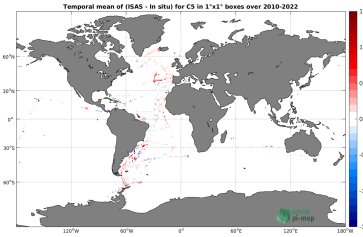
For each of these conditions, the temporal mean (gridded over spatial boxes of size 1°x1°) and the histogram of the difference ΔSSS (ISAS - *in situ*) are presented.



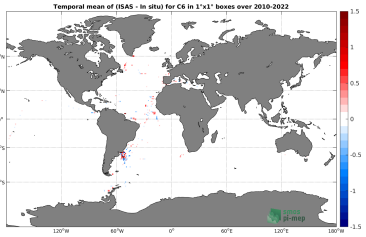
(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km

(b) RR=0 mm/h, 3< U_{10} <12 m/s

(c) RR>1mm/h and U_{10} <4m/s

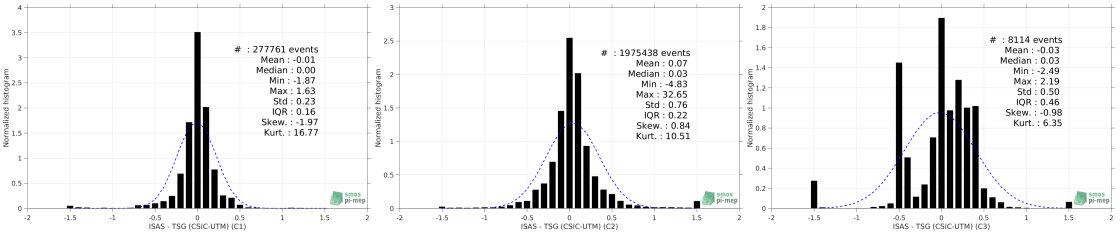


(d) WOA2013 SSS Std<0.2

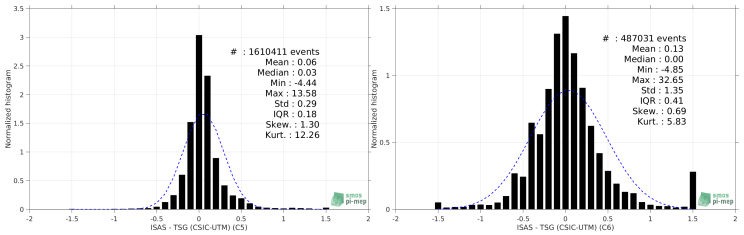


(e) WOA2013 SSS Std>0.2

Figure 107: Temporal mean gridded over spatial boxes of size 1°x1° of ΔSSS (ISAS - TSG (CSIC-UTM)) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).



(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s



(d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 108: Normalized histogram of ΔSSS (ISAS - TSG (CSIC-UTM)) for 5 different sub-datasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).

6.5.13 Summary

Table 1 shows the mean, median, standard deviation (Std), root mean square (RMS), interquartile range (IQR), correlation coefficient (r^2) and robust standard deviation (Std*) of the match-up differences ΔSSS (ISAS - TSG (CSIC-UTM)) for the following conditions:

- all: All the match-up pairs satellite/in situ SSS values are used to derive the statistics
- C1: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km
- C2: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s
- C3: only pairs where RR>1mm/h and U_{10} <4m/s
- C5: only pairs where WOA2013 SSS Std<0.2
- C6: only pairs where WOA2013 SSS Std>0.2
- C7a: only pairs with a distance to coast < 150 km.
- C7b: only pairs with a distance to coast in the range [150, 800] km.
- C7c: only pairs with a distance to coast > 800 km.
- C8a: only pairs where SST is < 5°C.
- C8b: only pairs where SST is in the range [5, 15]°C.
- C8c: only pairs where SST is > 15°C.

- C9a: only pairs where SSS is < 33.
- C9b: only pairs where SSS is in the range [33, 37].
- C9c: only pairs where SSS is > 37.

Table 1: Statistics of ΔSSS (ISAS - TSG (CSIC-UTM))

Condition	#	Median	Mean	Std	RMS	IQR	r^2	Std*
all	2858751	0.03	0.08	0.71	0.72	0.23	0.940	0.17
C1	277761	0.00	-0.01	0.23	0.23	0.16	0.939	0.12
C2	1975438	0.03	0.07	0.76	0.76	0.22	0.934	0.16
C3	8114	0.03	-0.03	0.50	0.50	0.46	0.757	0.32
C5	1610411	0.03	0.06	0.29	0.30	0.18	0.968	0.13
C6	487031	0.00	0.13	1.35	1.35	0.41	0.945	0.31
C7a	1471655	0.03	0.11	0.90	0.91	0.31	0.946	0.23
C7b	1019618	0.04	0.08	0.47	0.48	0.18	0.863	0.14
C7c	367305	0.00	-0.02	0.25	0.25	0.16	0.928	0.12
C8a	284249	0.09	0.18	0.42	0.46	0.30	0.206	0.22
C8b	350036	0.06	0.14	0.99	1.00	0.18	0.910	0.13
C8c	2224448	0.02	0.06	0.69	0.69	0.24	0.944	0.18
C9a	117479	0.07	1.12	3.06	3.26	1.92	0.851	0.92
C9b	2138546	0.04	0.06	0.27	0.28	0.22	0.931	0.16
C9c	602726	-0.02	-0.04	0.28	0.29	0.25	0.650	0.18

Table 1 numerical values can be downloaded as a csv file here.

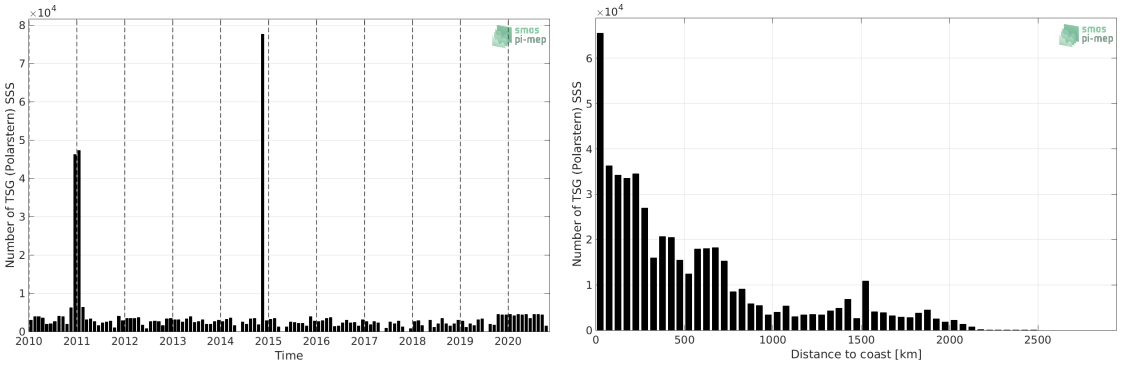
6.6 TSG (Polarstern)

6.6.1 Introduction

The TSG (Polarstern) dataset has been gathered through the https://www.pangaea.de/ data warehouse utility using the following criteria: basis:"Polarstern" , device:"Underway cruise track measurements (CT)" , time coverage form 2010/01/01 to present. The result of the query is a collection of 79 different datasets with the following identification numbers: 736345, 742729, 753224, 753225, 753226, 753227, 758080, 760120, 760121, 761277, 770034, 770035, 770828, 776596, 776597, 780004, 802809, 802810, 802811, 802812, 803431, 808835, 808836, 808838, 809727, 810678, 816055, 819831, 823259, 839406, 839407, 839408, 848615, 858879, 858880, 858881, 858882, 858883, 858884, 858885, 863228, 863229, 863230, 863231, 863232, 863234, 873145, 873147, 873151, 873153, 873155, 873156, 873158, 887767, 889444, 889513, 889515, 889516, 889517, 889535, 889542, 889548, 895578, 895579, 895581, 898225, 898233, 898266, 905555, 905562, 905608, 905610, 905734, 930022, 930023, 930024, 930026, 930027, 930028.

6.6.2 Number of SSS data as a function of time and distance to coast

Figure 109 shows the time (a) and distance to coast (b) distributions of the TSG (Polarstern) *in situ* dataset.

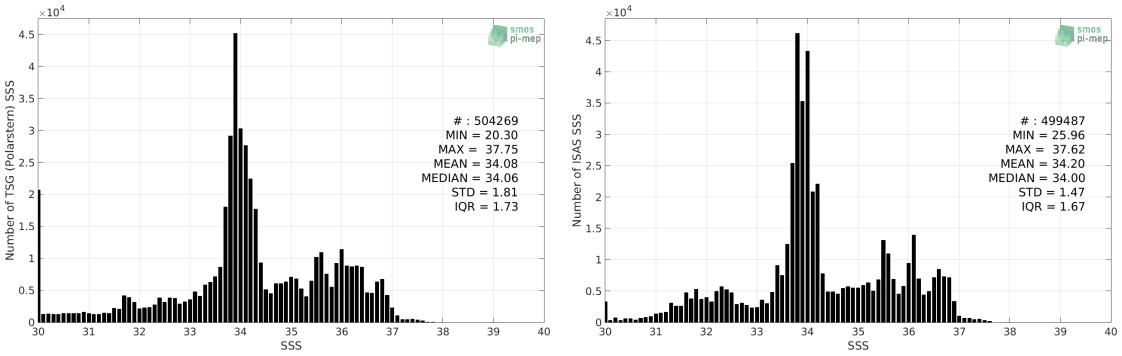


(a) (b)

Figure 109: Number of SSS from TSG (Polarstern) as a function of time (a) and distance to coast (b).

6.6.3 Histograms of SSS

Figure 110 shows the SSS distribution of the TSG (Polarstern) (a) and colocalized ISAS (b) dataset.

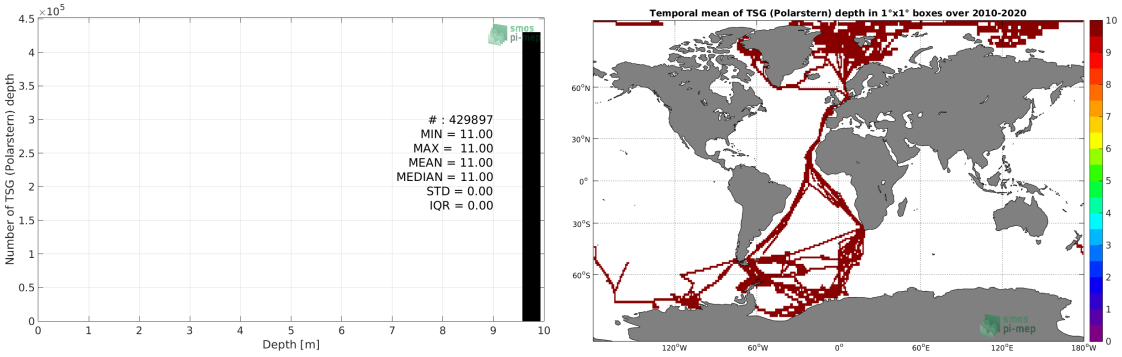


(a) (b)

Figure 110: Histograms of SSS from TSG (Polarstern) (a) and ISAS (b) per bins of 0.1.

6.6.4 Distribution of *in situ* SSS depth measurements

In Figure 111, we show the depth distribution of the *in situ* salinity dataset (a) and the spatial distribution of the depth temporal mean in 1°x1° boxes and considering the full *in situ* dataset period (b).



(a) (b)

Figure 111: Depth distribution of the upper level SSS measurements from TSG (Polarstern) (a) and spatial distribution of the *in situ* SSS depth measurements showing the mean value in 1°x1° boxes and considering the full *in situ* dataset period (b).

6.6.5 Spatial distribution of SSS

In Figure 112, the number of TSG (Polarstern) SSS measurements in 1°x1° boxes is shown.

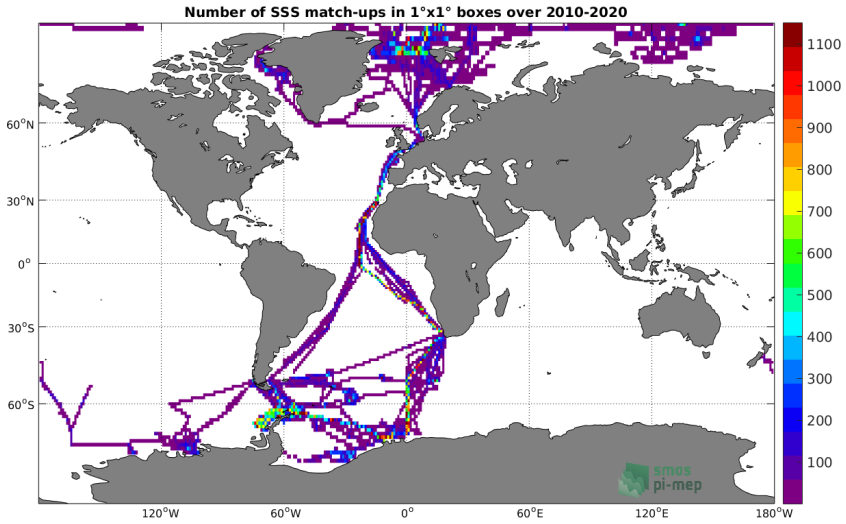
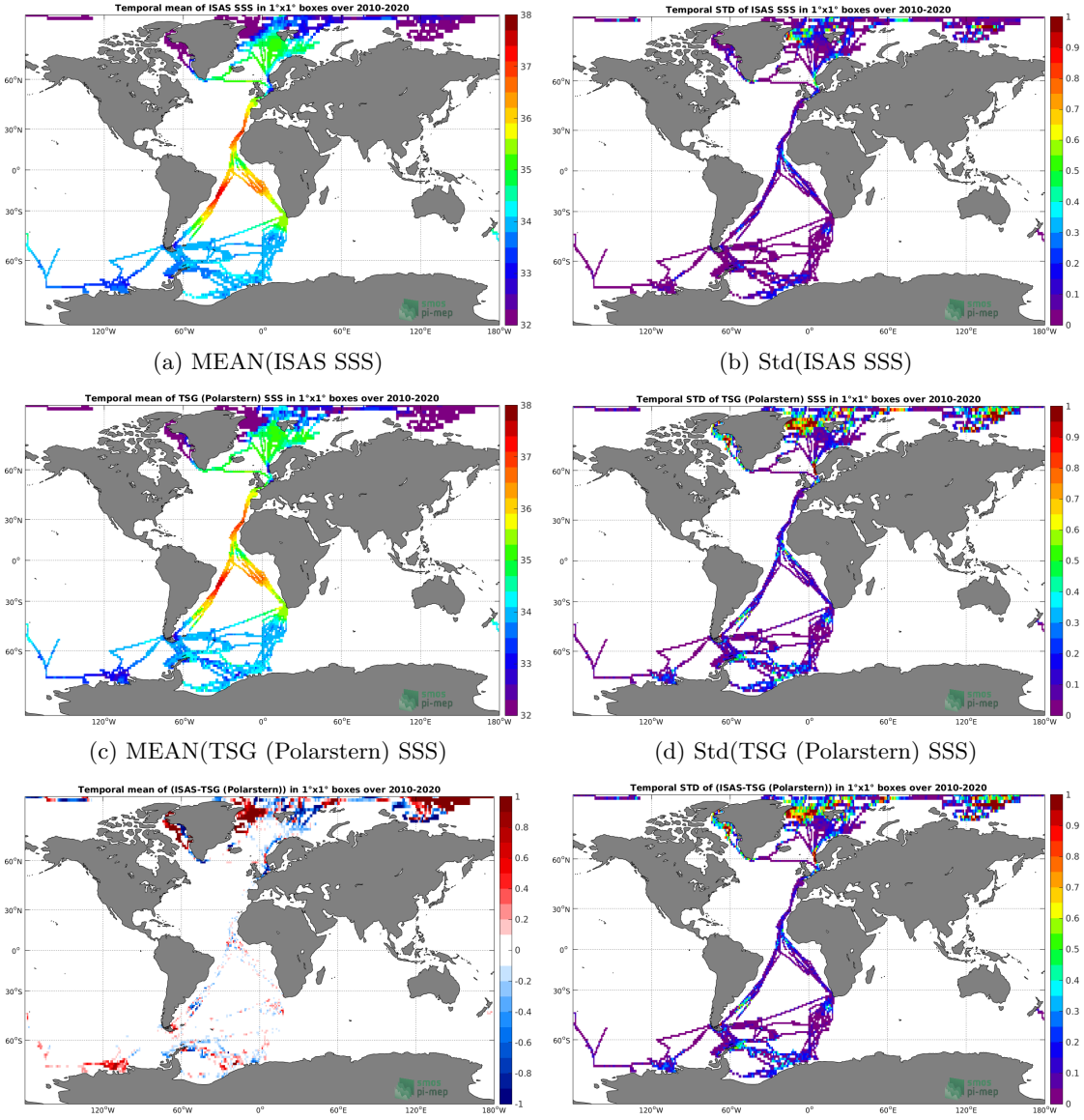


Figure 112: Number of SSS from TSG (Polarstern) in 1°x1° boxes.

6.6.6 Spatial Maps of the Temporal mean and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

In Figure 113, maps of temporal mean (left) and standard deviation (right) of ISAS (top), TSG (Polarstern) *in situ* dataset (middle) and the difference ΔSSS(ISAS -TSG (Polarstern)) (bottom) are shown. The temporal mean and std are calculated using all match-up pairs falling in spatial boxes of size 1°x1° over the full TSG (Polarstern) dataset period.



(a) MEAN(ISAS SSS)

(b) Std(ISAS SSS)

(c) MEAN(TSG (Polarstern) SSS)

(d) Std(TSG (Polarstern) SSS)

(e) MEAN(ΔSSS) (ISAS - TSG (Polarstern))

(f) Std(ΔSSS) (ISAS - TSG (Polarstern))

Figure 113: Temporal mean (left) and Std (right) of SSS from ISAS (top), TSG (Polarstern) (middle), and of ΔSSS (ISAS - TSG (Polarstern)). Only match-up pairs are used to generate these maps.

6.6.7 Time series of the monthly median and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

In the top panel of Figure 114, we show the time series of the monthly median SSS estimated for both ISAS SSS product (in black) and the TSG (Polarstern) *in situ* dataset (in blue) at the collected Pi-MEP match-up pairs.

In the middle panel of Figure 114, we show the time series of the monthly median of ΔSSS (ISAS - TSG (Polarstern)) for the collected Pi-MEP match-up pairs.

In the bottom panel of Figure 114, we show the time series of the monthly standard deviation of the ΔSSS (ISAS - TSG (Polarstern)) for the collected Pi-MEP match-up pairs.

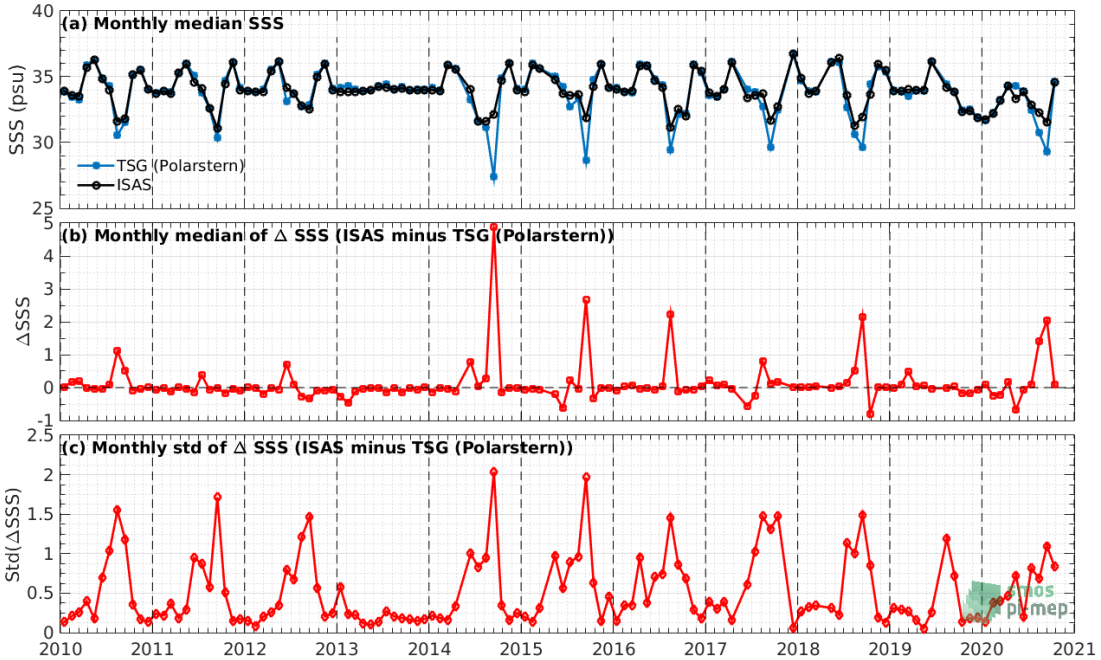


Figure 114: Time series of the monthly median SSS (top), median of ΔSSS (ISAS - TSG (Polarstern)) and Std of ΔSSS (ISAS - TSG (Polarstern)) considering all match-ups collected by the Pi-MEP.

6.6.8 Zonal mean and Std of *in situ* and ISAS SSS and of the difference ΔSSS

In Figure 115 left panel, we show the zonal mean SSS considering all Pi-MEP match-up pairs for both ISAS SSS product (in black) and the TSG (Polarstern) *in situ* dataset (in blue). The full *in situ* dataset period is used to derive the mean.

In the right panel of Figure 115, we show the zonal mean of ΔSSS (ISAS - TSG (Polarstern)) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

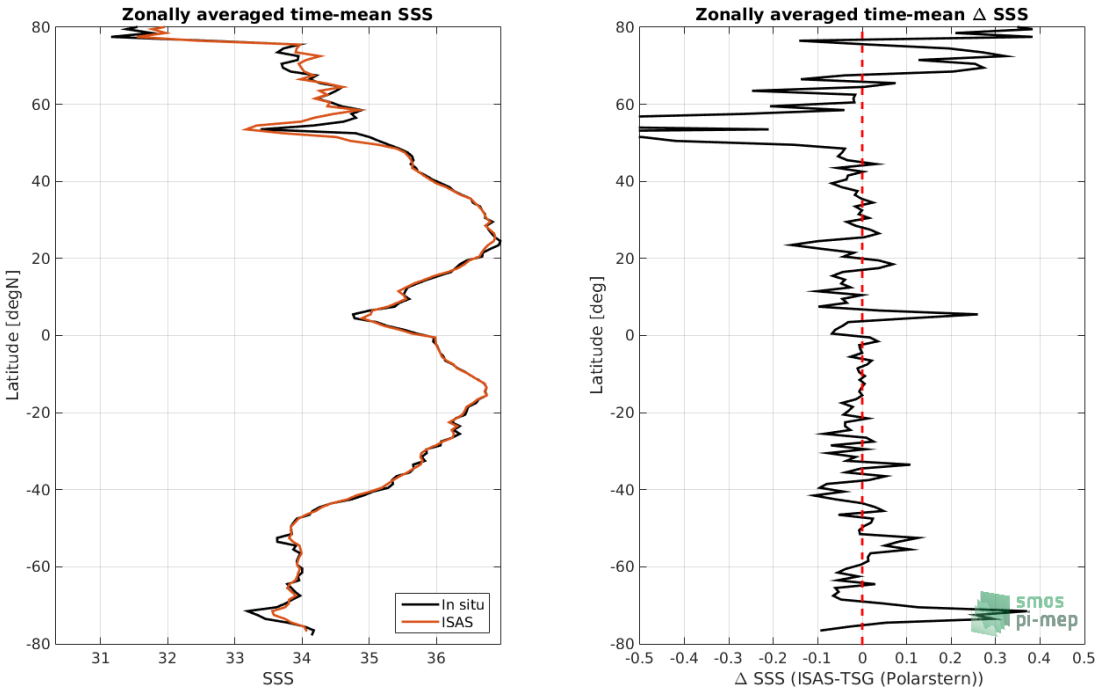
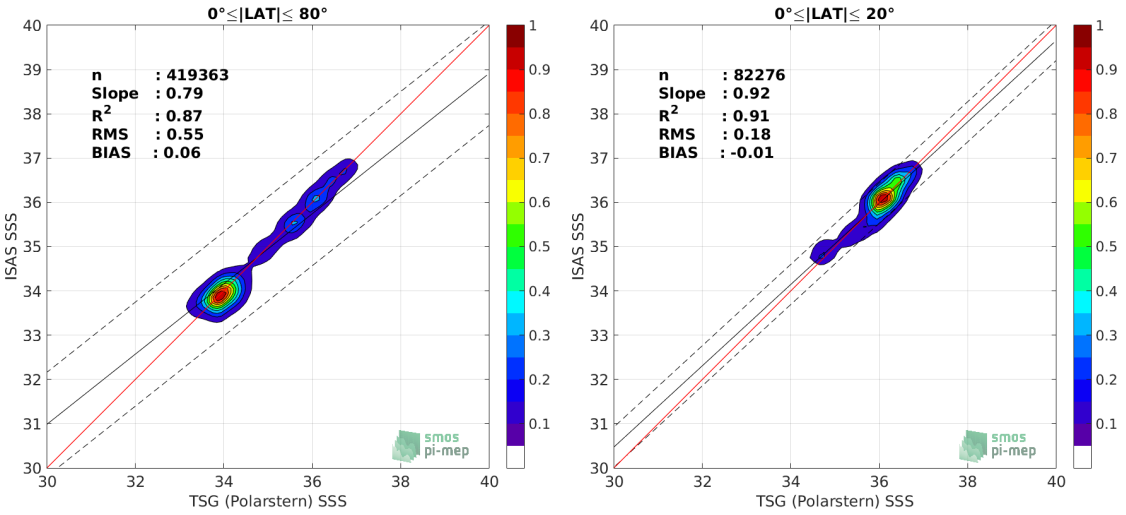


Figure 115: Left panel: Zonal mean SSS from ISAS product (black) and from TSG (Polarstern) (blue). Right panel: Zonal mean of ΔSSS (ISAS - TSG (Polarstern)) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

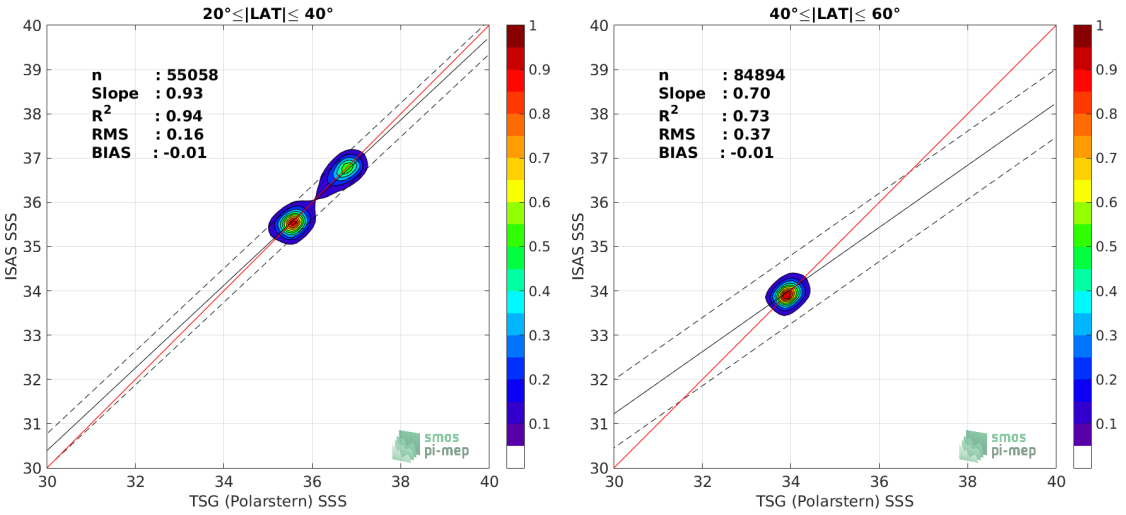
6.6.9 Scatterplots of ISAS vs *in situ* SSS by latitudinal bands

In Figure 116, contour maps of the concentration of ISAS SSS (y-axis) versus TSG (Polarstern) SSS (x-axis) at match-up pairs for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.



(a) $0° \leq |\text{LAT}| \leq 80°$

(b) $0° \leq |\text{LAT}| \leq 20°$



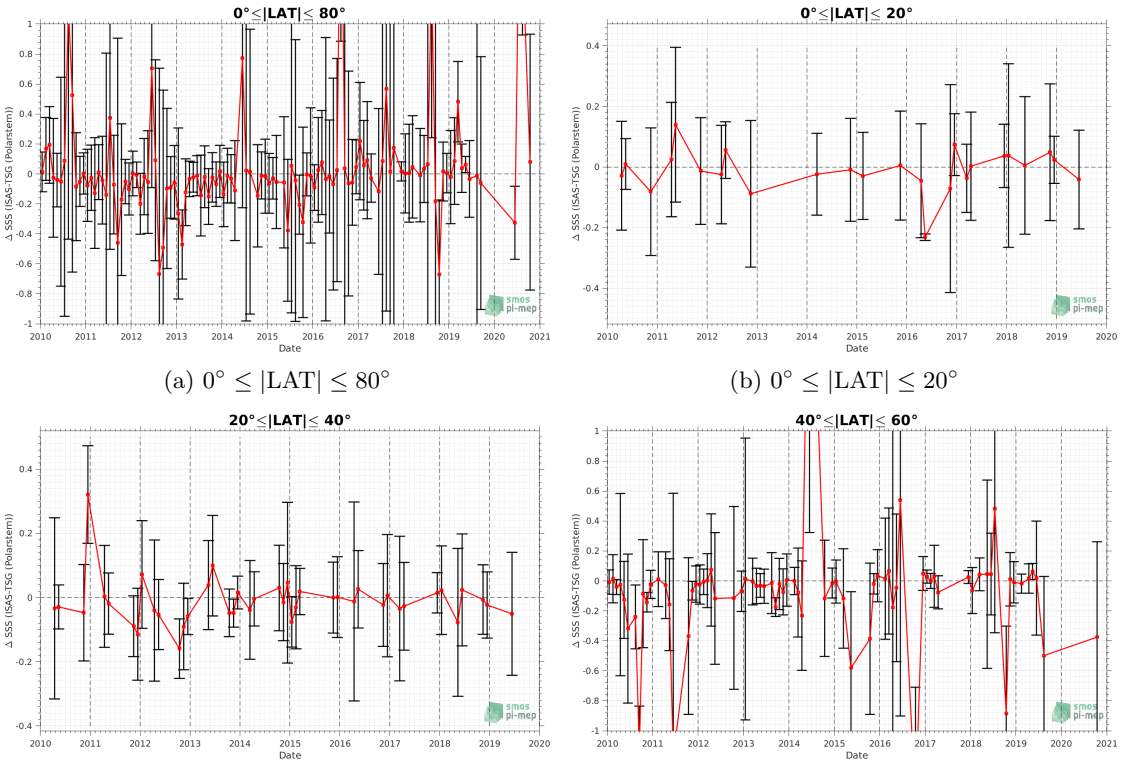
(c) $20° \leq |\text{LAT}| \leq 40°$

(d) $40° \leq |\text{LAT}| \leq 60°$

Figure 116: Contour maps of the concentration of ISAS SSS (y-axis) versus TSG (Polarstern) SSS (x-axis) at match-up pairs for different latitude bands. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.

6.6.10 Time series of the monthly median and Std of the difference ΔSSS sorted by latitudinal bands

In Figure 117, time series of the monthly median (red curves) of ΔSSS (ISAS - TSG (Polarstern)) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs estimated for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.



(a) $0° \leq |\text{LAT}| \leq 80°$

(b) $0° \leq |\text{LAT}| \leq 20°$

(c) $20° \leq |\text{LAT}| \leq 40°$

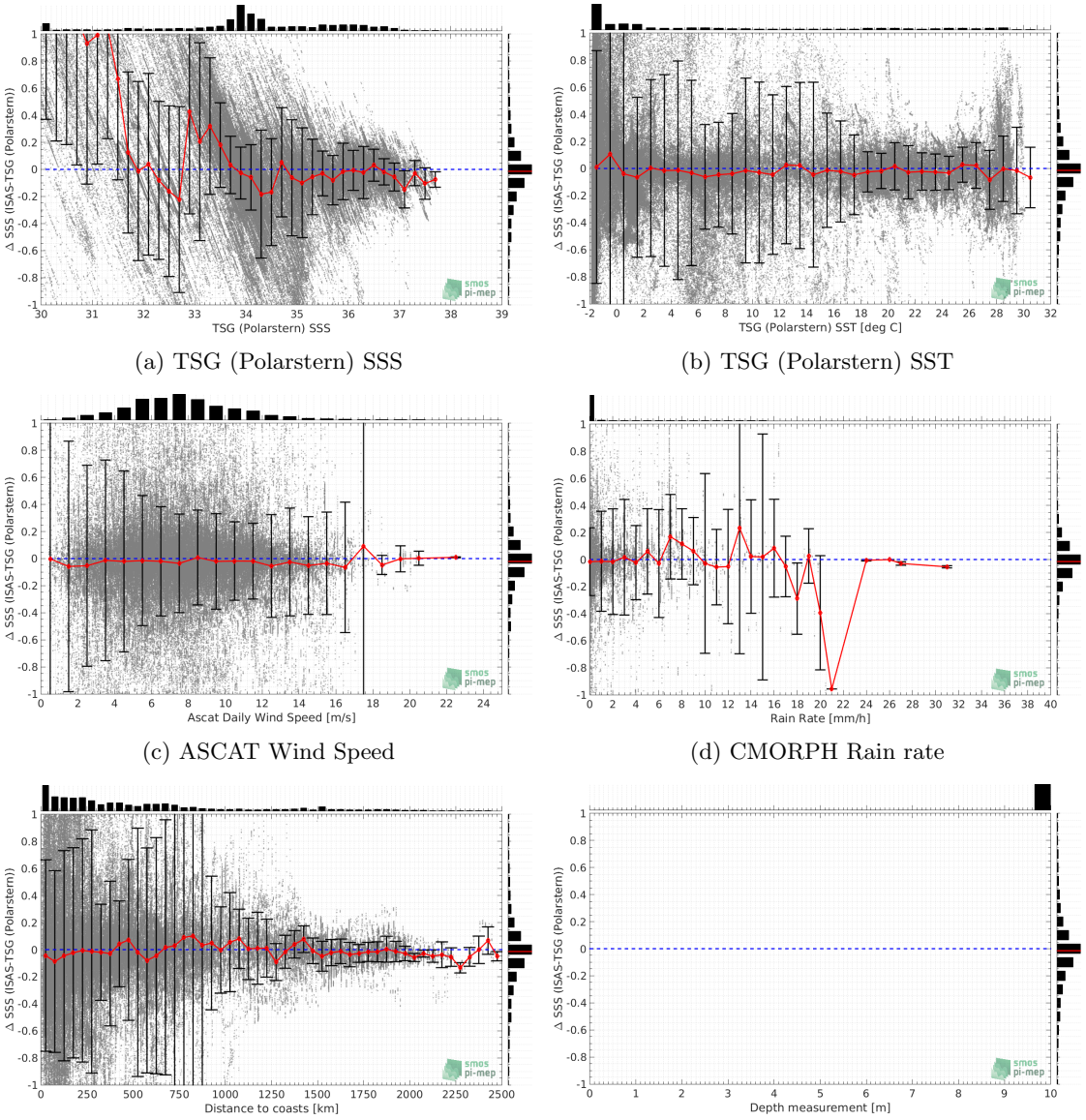
(d) $40° \leq |\text{LAT}| \leq 60°$

Figure 117: Monthly median (red curves) of ΔSSS (ISAS - TSG (Polarstern)) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.

6.6.11 ΔSSS sorted as geophysical conditions

In Figure 118, we classify the match-up differences ΔSSS (ISAS - *in situ*) as function of the geophysical conditions at match-up points. The mean and std of ΔSSS (ISAS - TSG (Polarstern)) is thus evaluated as function of the

- *in situ* SSS values per bins of width 0.2,
- *in situ* SST values per bins of width 1°C,
- ASCAT daily wind values per bins of width 1 m/s,
- CMORPH 3-hourly rain rates per bins of width 1 mm/h, and,
- distance to coasts per bins of width 50 km,
- *in situ* measurement depth (if relevant).



(a) TSG (Polarstern) SSS

(b) TSG (Polarstern) SST

(c) ASCAT Wind Speed

(d) CMORPH Rain rate

(e) Distance to coast

(f) Depth

Figure 118: Δ SSS (ISAS - TSG (Polarstern)) sorted as geophysical conditions: TSG (Polarstern) SSS a), TSG (Polarstern) SST b), ASCAT Wind speed c), CMORPH rain rate d), distance to coast (e) and depth measurements (f).

6.6.12 ΔSSS maps and statistics for different geophysical conditions

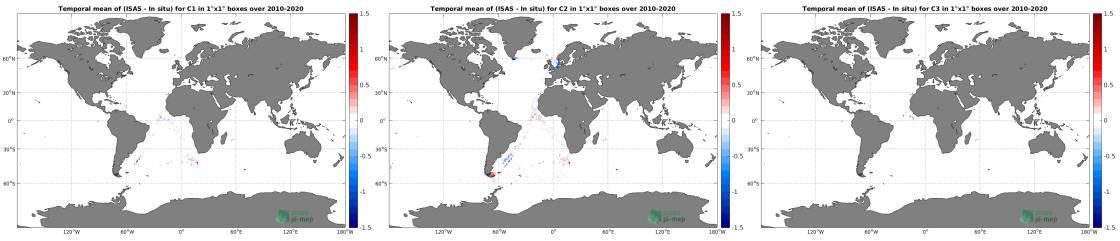
In Figures 119 and 120, we focus on sub-datasets of the match-up differences ΔSSS (ISAS - *in situ*) for the following specific geophysical conditions:

- **C1**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is in the range [3, 12] m/s, the SST is $> 5°$C and distance to coast is > 800 km.
- **C2**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is

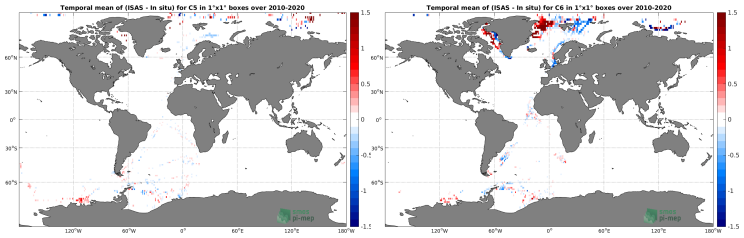
in the range [3, 12] m/s.

- **C3**:if the local value at *in situ* location of estimated rain rate is high (ie. $>$ 1 mm/h) and mean daily wind is low (ie. $<$ 4 m/s).
- **C5**:if the *in situ* data is located where the climatological SSS standard deviation is low (ie. above $<$ 0.2).
- **C6**:if the *in situ* data is located where the climatological SSS standard deviation is high (ie. above $>$ 0.2).

For each of these conditions, the temporal mean (gridded over spatial boxes of size 1°x1°) and the histogram of the difference ΔSSS (ISAS - *in situ*) are presented.

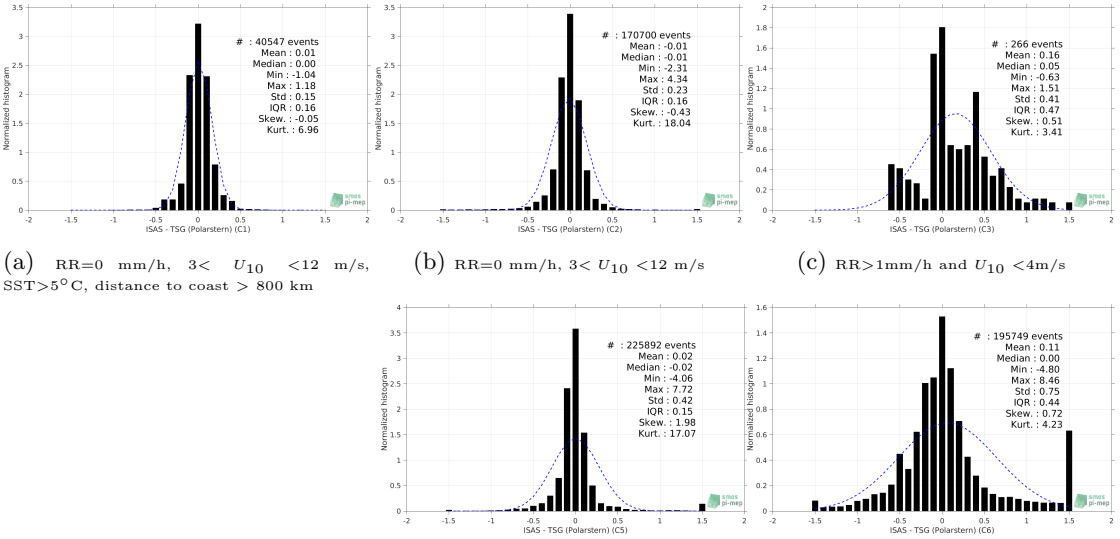


(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s



(d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 119: Temporal mean gridded over spatial boxes of size 1°x1° of ΔSSS (ISAS - TSG (Polarstern)) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).



(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s

(d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 120: Normalized histogram of ΔSSS (ISAS - TSG (Polarstern)) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).

6.6.13 Summary

Table 1 shows the mean, median, standard deviation (Std), root mean square (RMS), interquartile range (IQR), correlation coefficient (r^2) and robust standard deviation (Std*) of the match-up differences ΔSSS (ISAS - TSG (Polarstern)) for the following conditions:

- all: All the match-up pairs satellite/in situ SSS values are used to derive the statistics
- C1: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km
- C2: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s
- C3: only pairs where RR>1mm/h and U_{10} <4m/s
- C5: only pairs where WOA2013 SSS Std<0.2
- C6: only pairs where WOA2013 SSS Std>0.2
- C7a: only pairs with a distance to coast < 150 km.
- C7b: only pairs with a distance to coast in the range [150, 800] km.
- C7c: only pairs with a distance to coast > 800 km.
- C8a: only pairs where SST is < 5°C.
- C8b: only pairs where SST is in the range [5, 15]°C.
- C8c: only pairs where SST is > 15°C.

- C9a: only pairs where SSS is < 33.
- C9b: only pairs where SSS is in the range [33, 37].
- C9c: only pairs where SSS is > 37.

Table 1: Statistics of ΔSSS (ISAS - TSG (Polarstern))

Condition	#	Median	Mean	Std	RMS	IQR	r^2	Std*
all	499487	-0.01	0.11	0.77	0.77	0.27	0.830	0.20
C1	40547	0.00	0.01	0.15	0.15	0.16	0.973	0.12
C2	170700	-0.01	-0.01	0.23	0.23	0.16	0.956	0.12
C3	266	0.05	0.16	0.41	0.44	0.47	0.878	0.37
C5	225892	-0.02	0.02	0.42	0.42	0.15	0.912	0.11
C6	195749	0.00	0.11	0.75	0.76	0.44	0.826	0.33
C7a	131773	-0.05	0.03	0.72	0.72	0.40	0.809	0.31
C7b	257674	0.00	0.16	0.85	0.86	0.30	0.809	0.22
C7c	110003	-0.01	0.08	0.59	0.59	0.16	0.882	0.12
C8a	288338	0.00	0.21	0.95	0.97	0.40	0.662	0.28
C8b	69242	-0.04	-0.05	0.56	0.57	0.26	0.687	0.19
C8c	105979	-0.02	-0.02	0.21	0.21	0.18	0.904	0.13
C9a	85630	0.59	0.94	1.45	1.73	1.85	0.244	1.19
C9b	409548	-0.03	-0.06	0.31	0.32	0.22	0.914	0.16
C9c	4309	-0.09	-0.11	0.13	0.17	0.20	0.744	0.15

Table 1 numerical values can be downloaded as a csv file here.

6.7 TSG (NCEI-0170743)

6.7.1 Introduction

The TSG (NCEI-0170743) dataset (Aulicino et al. (2018)) contains sea surface temperature and salinity data collected from 2010 to 2017 in the South Atlantic Ocean and Southern Ocean from S.A. Agulhas and Agulhas-II research vessels, in the framework of South African National Antarctic Programme (SANAP), South African Department of Environmental Affairs (DEA) and Italian National Antarctic Research Programme (PNRA) scientific activities. Measurements have been obtained through thermosalinograph (TSG) during several cruises to both Antarctica and sub-Antarctic islands. On-board TSG devices have been regularly calibrated and continuously monitored in-between cruises; no appreciable sensor drift emerged. Independent water samples taken along the cruises have been used to validate the data; salinity measurement error was a few hundredths of a unit on the practical salinity scale. A careful quality control allowed to discard bad data for each single campaign.

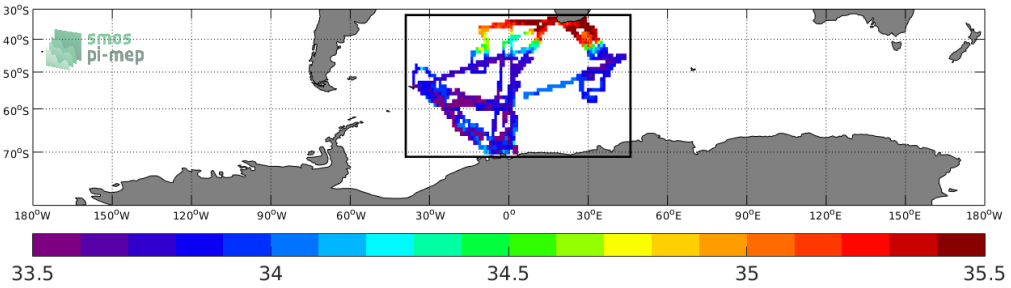
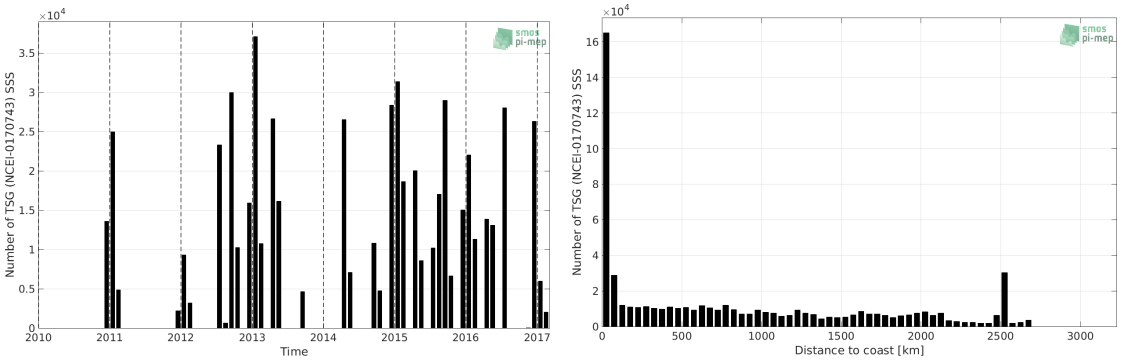


Figure 121: Location of the TSG (NCEI-0170743) dataset.

6.7.2 Number of SSS data as a function of time and distance to coast

Figure 122 shows the time (a) and distance to coast (b) distributions of the TSG (NCEI-0170743) *in situ* dataset.

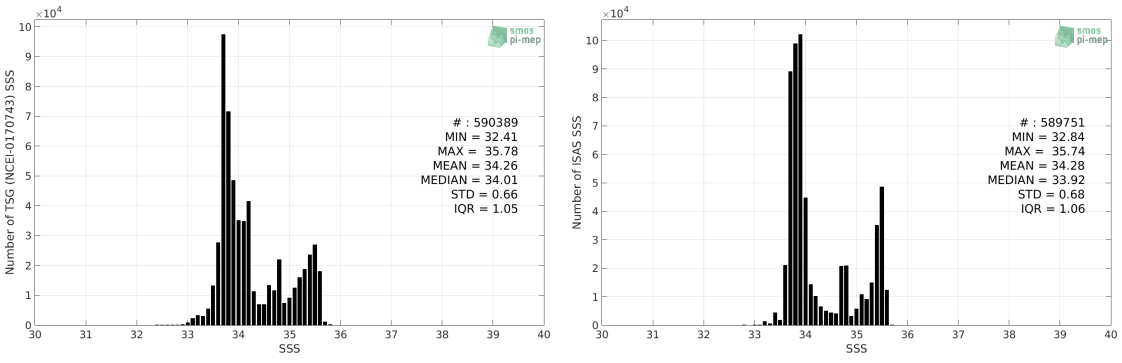


(a) (b)

Figure 122: Number of SSS from TSG (NCEI-0170743) as a function of time (a) and distance to coast (b).

6.7.3 Histograms of SSS

Figure 123 shows the SSS distribution of the TSG (NCEI-0170743) (a) and colocalized ISAS (b) dataset.

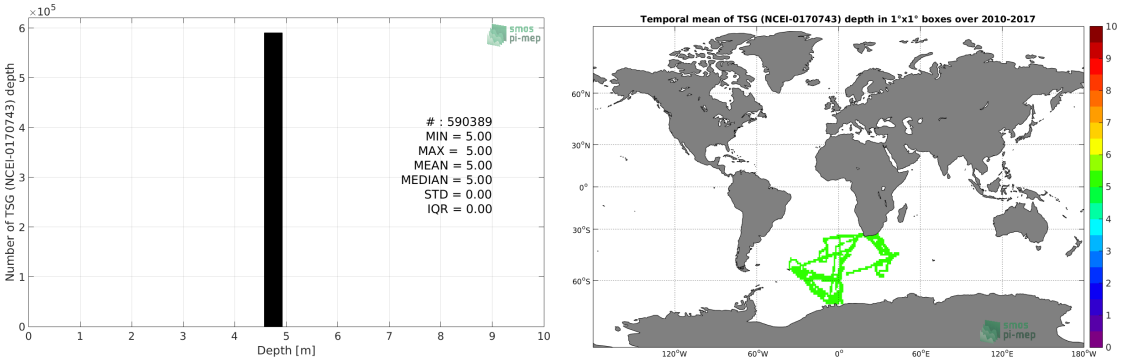


(a) (b)

Figure 123: Histograms of SSS from TSG (NCEI-0170743) (a) and ISAS (b) per bins of 0.1.

6.7.4 Distribution of *in situ* SSS depth measurements

In Figure 124, we show the depth distribution of the *in situ* salinity dataset (a) and the spatial distribution of the depth temporal mean in 1°x1° boxes and considering the full *in situ* dataset period (b).



(a) (b)

Figure 124: Depth distribution of the upper level SSS measurements from TSG (NCEI-0170743) (a) and spatial distribution of the *in situ* SSS depth measurements showing the mean value in 1°x1° boxes and considering the full *in situ* dataset period (b).

6.7.5 Spatial distribution of SSS

In Figure 125, the number of TSG (NCEI-0170743) SSS measurements in 1°x1° boxes is shown.

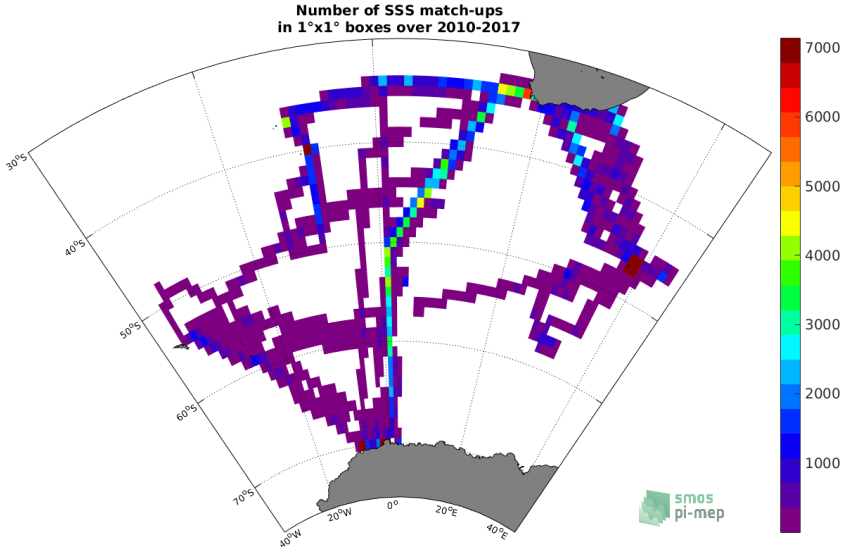
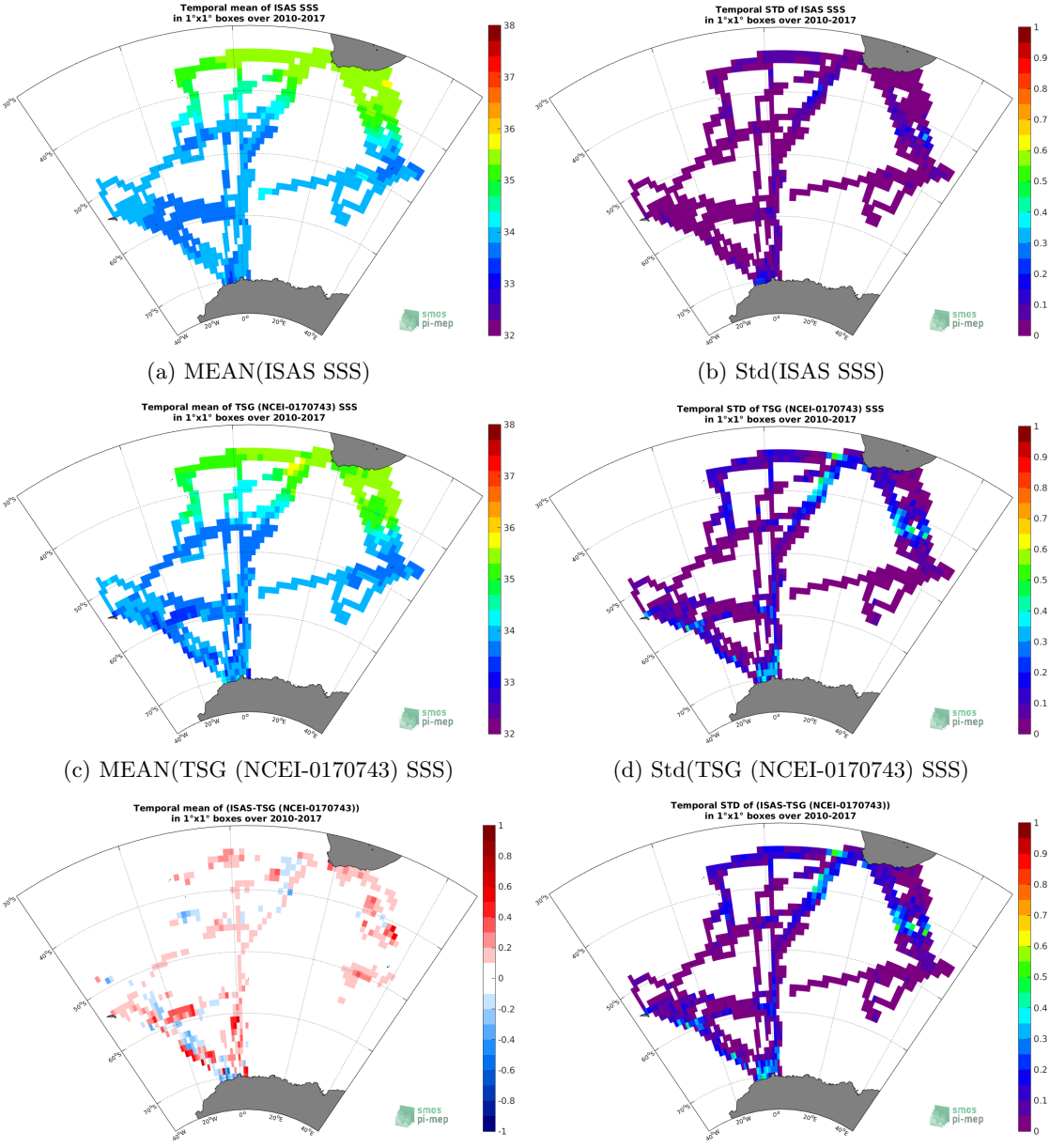


Figure 125: Number of SSS from TSG (NCEI-0170743) in 1°x1° boxes.

6.7.6 Spatial Maps of the Temporal mean and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

In Figure 126, maps of temporal mean (left) and standard deviation (right) of ISAS (top), TSG (NCEI-0170743) *in situ* dataset (middle) and the difference ΔSSS(ISAS -TSG (NCEI-0170743)) (bottom) are shown. The temporal mean and std are calculated using all match-up pairs falling in spatial boxes of size 1°x1° over the full TSG (NCEI-0170743) dataset period.



(a) MEAN(ISAS SSS)

(b) Std(ISAS SSS)

(c) MEAN(TSG (NCEI-0170743) SSS)

(d) Std(TSG (NCEI-0170743) SSS)

(e) MEAN(ΔSSS) (ISAS - TSG (NCEI-0170743))

(f) Std(ΔSSS) (ISAS - TSG (NCEI-0170743))

Figure 126: Temporal mean (left) and Std (right) of SSS from ISAS (top), TSG (NCEI-0170743) (middle), and of ΔSSS (ISAS - TSG (NCEI-0170743)). Only match-up pairs are used to generate these maps.

6.7.7 Time series of the monthly median and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

In the top panel of Figure 127, we show the time series of the monthly median SSS estimated for both ISAS SSS product (in black) and the TSG (NCEI-0170743) *in situ* dataset (in blue) at the collected Pi-MEP match-up pairs.

In the middle panel of Figure 127, we show the time series of the monthly median of ΔSSS (ISAS - TSG (NCEI-0170743)) for the collected Pi-MEP match-up pairs.

In the bottom panel of Figure 127, we show the time series of the monthly standard deviation of the ΔSSS (ISAS - TSG (NCEI-0170743)) for the collected Pi-MEP match-up pairs.

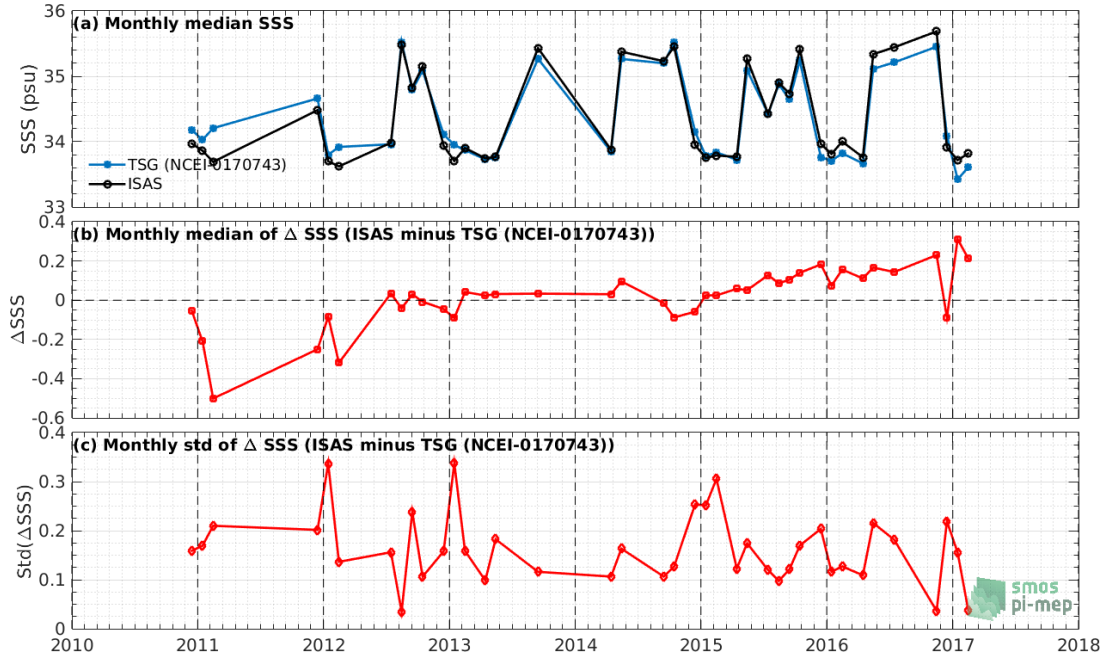


Figure 127: Time series of the monthly median SSS (top), median of ΔSSS (ISAS - TSG (NCEI-0170743)) and Std of ΔSSS (ISAS - TSG (NCEI-0170743)) considering all match-ups collected by the Pi-MEP.

6.7.8 Zonal mean and Std of *in situ* and ISAS SSS and of the difference ΔSSS

In Figure 128 left panel, we show the zonal mean SSS considering all Pi-MEP match-up pairs for both ISAS SSS product (in black) and the TSG (NCEI-0170743) *in situ* dataset (in blue). The full *in situ* dataset period is used to derive the mean.

In the right panel of Figure 128, we show the zonal mean of ΔSSS (ISAS - TSG (NCEI-0170743)) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

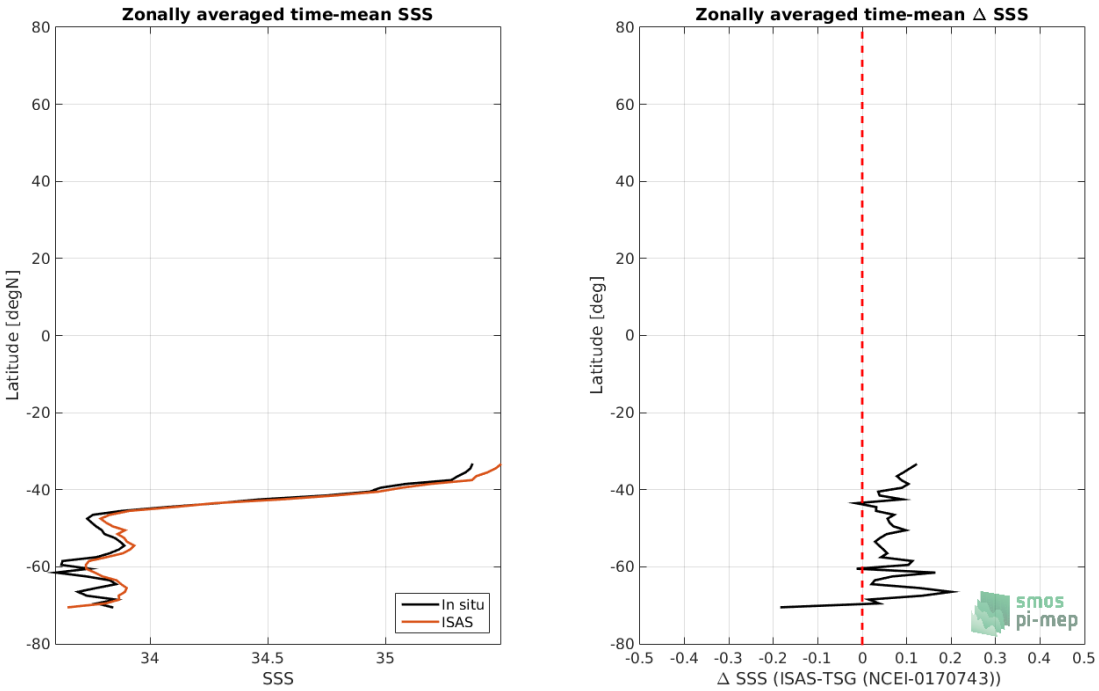
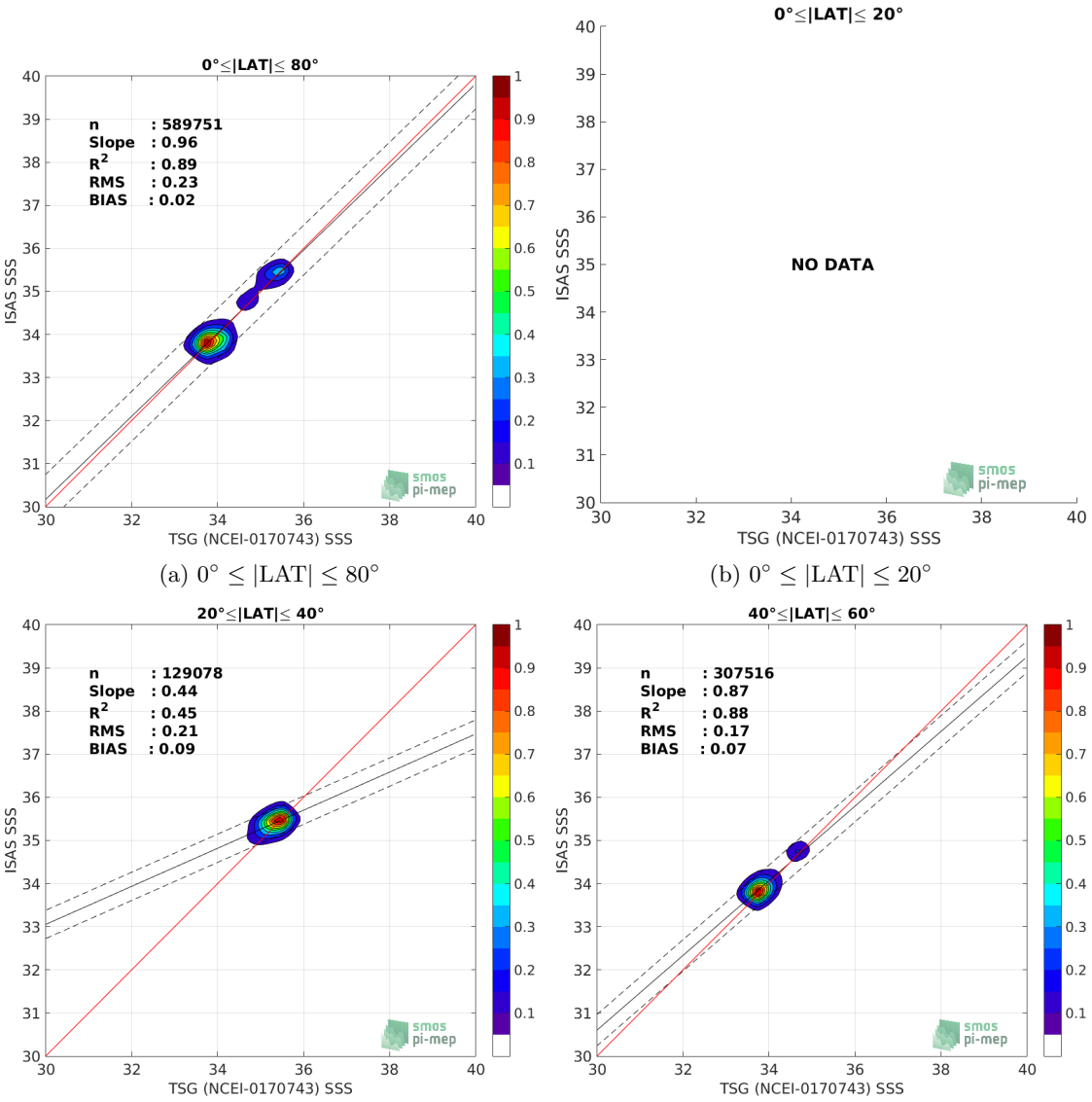


Figure 128: Left panel: Zonal mean SSS from ISAS product (black) and from TSG (NCEI-0170743) (blue). Right panel: Zonal mean of ΔSSS (ISAS - TSG (NCEI-0170743)) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

6.7.9 Scatterplots of ISAS vs *in situ* SSS by latitudinal bands

In Figure 129, contour maps of the concentration of ISAS SSS (y-axis) versus TSG (NCEI-0170743) SSS (x-axis) at match-up pairs for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.



(a) $0° \leq |\text{LAT}| \leq 80°$

(b) $0° \leq |\text{LAT}| \leq 20°$

(c) $20° \leq |\text{LAT}| \leq 40°$

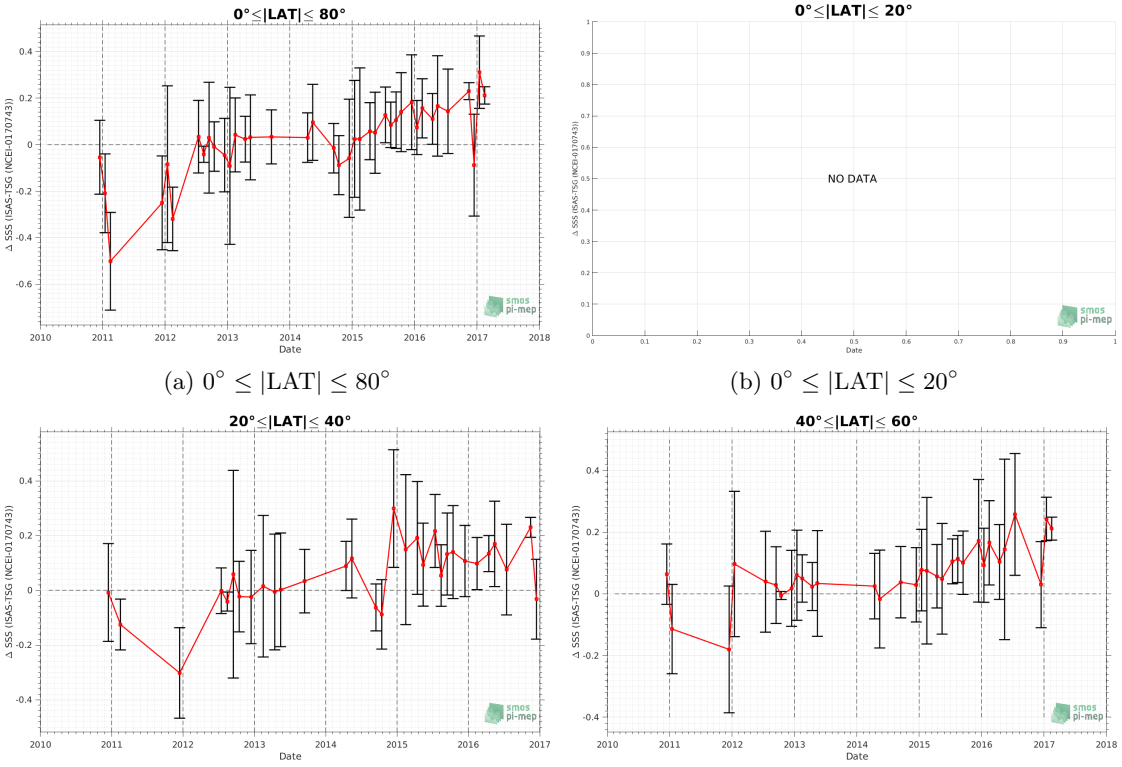
(d) $40° \leq |\text{LAT}| \leq 60°$

Figure 129: Contour maps of the concentration of ISAS SSS (y-axis) versus TSG (NCEI-0170743) SSS (x-axis) at match-up pairs for different latitude bands. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.

6.7.10 Time series of the monthly median and Std of the difference ΔSSS sorted by latitudinal bands

In Figure 130, time series of the monthly median (red curves) of ΔSSS (ISAS - TSG (NCEI-0170743)) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP

match-up pairs estimated for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.



(a) $0° \leq |\text{LAT}| \leq 80°$

(b) $0° \leq |\text{LAT}| \leq 20°$

(c) $20° \leq |\text{LAT}| \leq 40°$

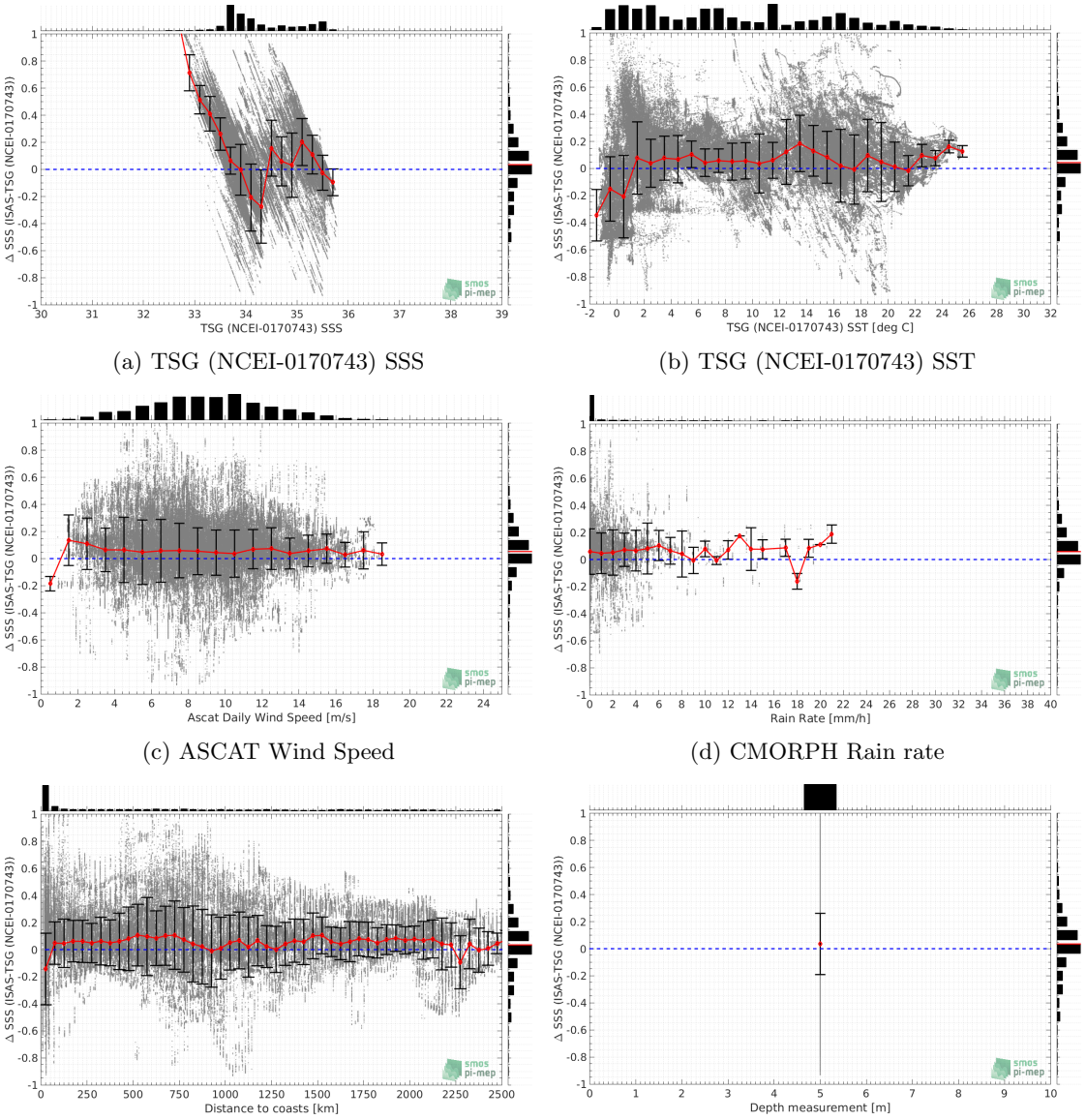
(d) $40° \leq |\text{LAT}| \leq 60°$

Figure 130: Monthly median (red curves) of ΔSSS (ISAS - TSG (NCEI-0170743)) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.

6.7.11 ΔSSS sorted as geophysical conditions

In Figure 131, we classify the match-up differences ΔSSS (ISAS - *in situ*) as function of the geophysical conditions at match-up points. The mean and std of ΔSSS (ISAS - TSG (NCEI-0170743)) is thus evaluated as function of the

- *in situ* SSS values per bins of width 0.2,
- *in situ* SST values per bins of width 1°C,
- ASCAT daily wind values per bins of width 1 m/s,
- CMORPH 3-hourly rain rates per bins of width 1 mm/h, and,
- distance to coasts per bins of width 50 km,
- *in situ* measurement depth (if relevant).



(a) TSG (NCEI-0170743) SSS

(b) TSG (NCEI-0170743) SST

(c) ASCAT Wind Speed

(d) CMORPH Rain rate

(e) Distance to coast

(f) Depth

Figure 131: Δ SSS (ISAS - TSG (NCEI-0170743)) sorted as geophysical conditions: TSG (NCEI-0170743) SSS a), TSG (NCEI-0170743) SST b), ASCAT Wind speed c), CMORPH rain rate d), distance to coast (e) and depth measurements (f).

6.7.12 ΔSSS maps and statistics for different geophysical conditions

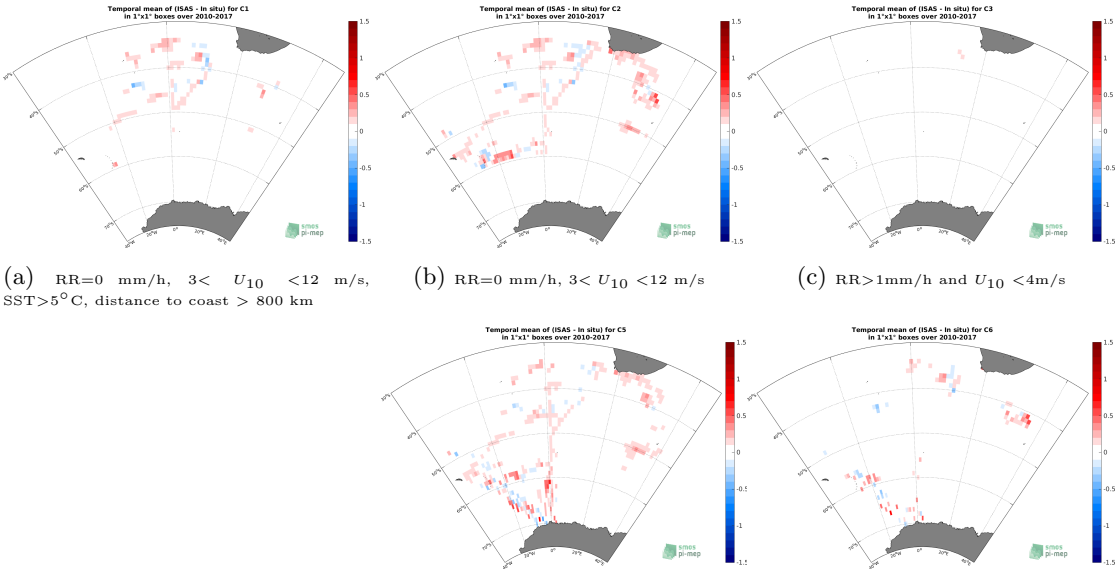
In Figures 132 and 133, we focus on sub-datasets of the match-up differences ΔSSS (ISAS - *in situ*) for the following specific geophysical conditions:

- **C1**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is in the range [3, 12] m/s, the SST is $> 5°C$ and distance to coast is > 800 km.
- **C2**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is

in the range [3, 12] m/s.

- **C3**:if the local value at *in situ* location of estimated rain rate is high (ie. $>$ 1 mm/h) and mean daily wind is low (ie. $<$ 4 m/s).
- **C5**:if the *in situ* data is located where the climatological SSS standard deviation is low (ie. above $<$ 0.2).
- **C6**:if the *in situ* data is located where the climatological SSS standard deviation is high (ie. above $>$ 0.2).

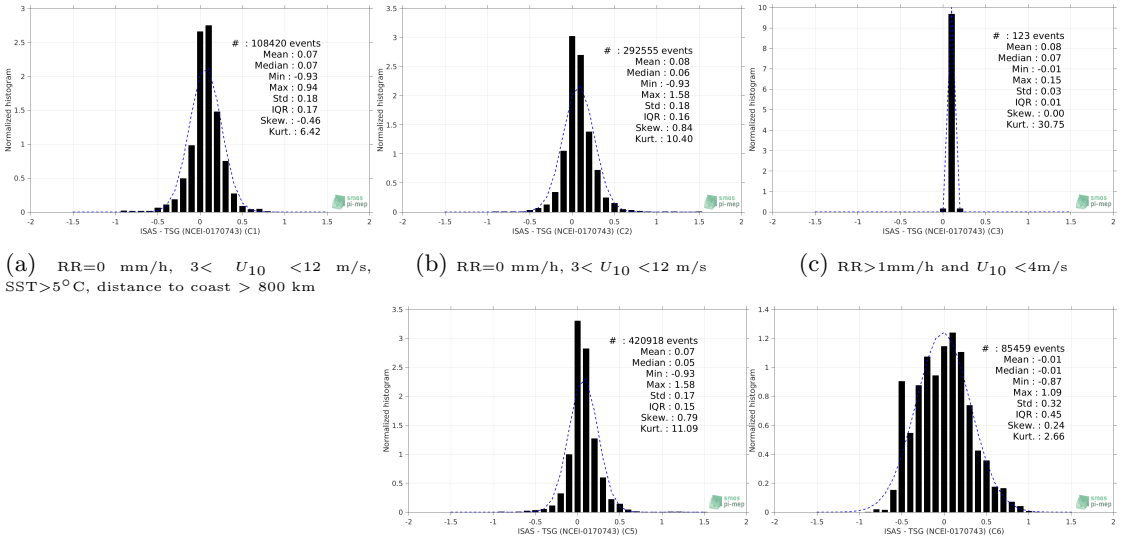
For each of these conditions, the temporal mean (gridded over spatial boxes of size 1°x1°) and the histogram of the difference ΔSSS (ISAS - *in situ*) are presented.



(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s

(d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 132: Temporal mean gridded over spatial boxes of size 1°x1° of ΔSSS (ISAS - TSG (NCEI-0170743)) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).



(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s (d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 133: Normalized histogram of ΔSSS (ISAS - TSG (NCEI-0170743)) for 5 different sub-datasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).

6.7.13 Summary

Table 1 shows the mean, median, standard deviation (Std), root mean square (RMS), interquartile range (IQR), correlation coefficient (r^2) and robust standard deviation (Std*) of the match-up differences ΔSSS (ISAS - TSG (NCEI-0170743)) for the following conditions:

- all: All the match-up pairs satellite/in situ SSS values are used to derive the statistics
- C1: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km
- C2: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s
- C3: only pairs where RR>1mm/h and U_{10} <4m/s
- C5: only pairs where WOA2013 SSS Std<0.2
- C6: only pairs where WOA2013 SSS Std>0.2
- C7a: only pairs with a distance to coast < 150 km.
- C7b: only pairs with a distance to coast in the range [150, 800] km.
- C7c: only pairs with a distance to coast > 800 km.
- C8a: only pairs where SST is < 5°C.
- C8b: only pairs where SST is in the range [5, 15]°C.
- C8c: only pairs where SST is > 15°C.

- C9a: only pairs where SSS is < 33.
- C9b: only pairs where SSS is in the range [33, 37].
- C9c: only pairs where SSS is > 37.

Table 1: Statistics of ΔSSS (ISAS - TSG (NCEI-0170743))

Condition	#	Median	Mean	Std	RMS	IQR	r^2	Std*
all	589751	0.03	0.02	0.23	0.23	0.21	0.890	0.16
C1	108420	0.07	0.07	0.18	0.19	0.17	0.906	0.13
C2	292555	0.06	0.08	0.18	0.19	0.16	0.941	0.12
C3	123	0.07	0.08	0.03	0.09	0.01	1.000	0.01
C5	420918	0.05	0.07	0.17	0.18	0.15	0.943	0.11
C6	85459	-0.01	-0.01	0.32	0.32	0.45	0.792	0.34
C7a	205194	-0.01	-0.08	0.26	0.27	0.35	0.793	0.25
C7b	138113	0.07	0.09	0.21	0.23	0.22	0.932	0.16
C7c	246444	0.06	0.07	0.17	0.18	0.16	0.925	0.12
C8a	194461	0.00	-0.03	0.26	0.26	0.35	0.044	0.24
C8b	219434	0.06	0.08	0.15	0.17	0.13	0.919	0.09
C8c	124692	0.04	0.06	0.23	0.23	0.22	0.776	0.16
C9a	940	0.87	0.86	0.20	0.88	0.31	0.202	0.27
C9b	588811	0.03	0.02	0.22	0.22	0.21	0.892	0.15
C9c	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN

Table 1 numerical values can be downloaded as a csv file here.

6.8 TSG (LEGOS-Survostral)

6.8.1 Introduction

The TSG (LEGOS-Survostral) dataset corresponds to delayed mode regional data from TSG installed on the Astrolabe vessel (IPEV) during the round trips between Hobart (Tasmania) and the French Antarctic base at Dumont d'Urville (Morrow and Kestenare (2014)). It is provided by the Survostral project and available here. Adjusted values when available and only collected TSG data that exhibit quality flags=1 and 2 were used.

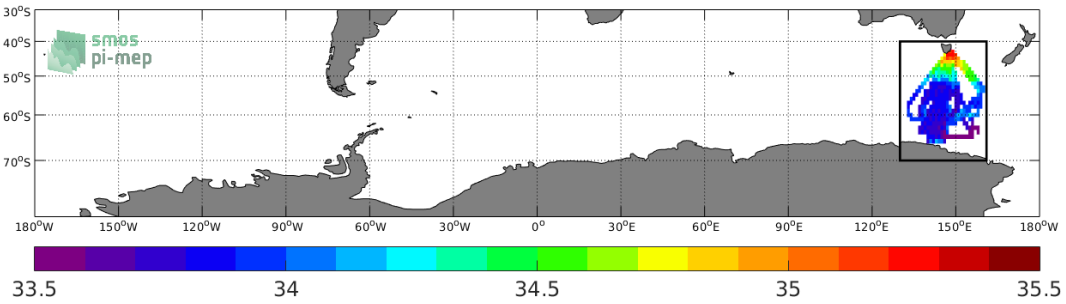
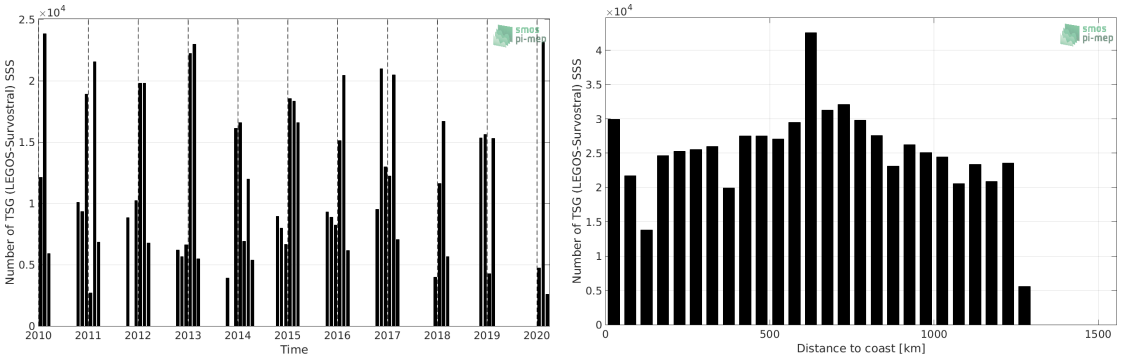


Figure 134: Location of the TSG (LEGOS-Survostral) dataset.

6.8.2 Number of SSS data as a function of time and distance to coast

Figure 135 shows the time (a) and distance to coast (b) distributions of the TSG (LEGOS-Survostral) *in situ* dataset.

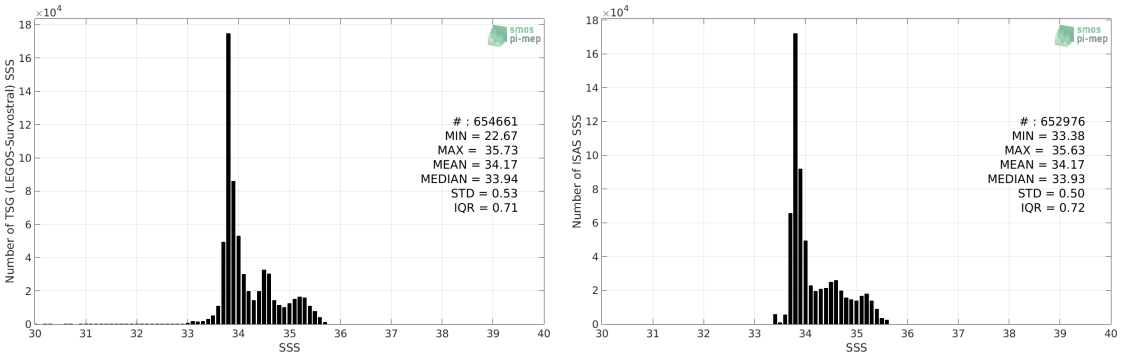


(a) (b)

Figure 135: Number of SSS from TSG (LEGOS-Survostral) as a function of time (a) and distance to coast (b).

6.8.3 Histograms of SSS

Figure 136 shows the SSS distribution of the TSG (LEGOS-Survostral) (a) and colocalized ISAS (b) dataset.

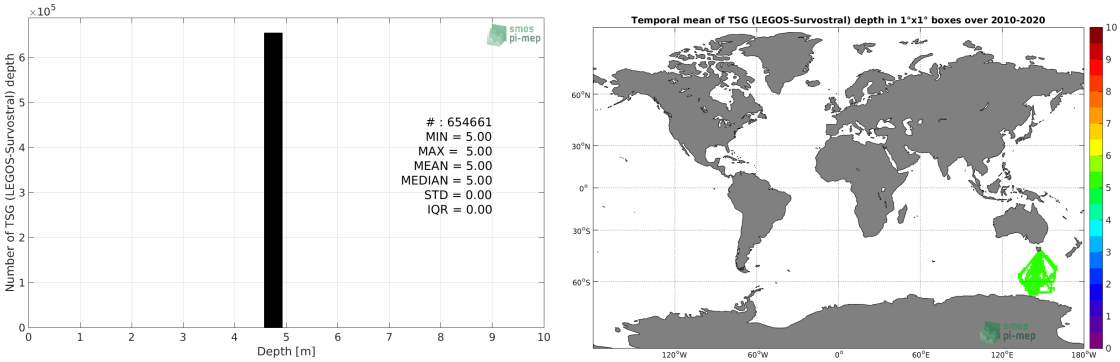


(a) (b)

Figure 136: Histograms of SSS from TSG (LEGOS-Survostral) (a) and ISAS (b) per bins of 0.1.

6.8.4 Distribution of *in situ* SSS depth measurements

In Figure 137, we show the depth distribution of the *in situ* salinity dataset (a) and the spatial distribution of the depth temporal mean in 1°x1° boxes and considering the full *in situ* dataset period (b).



(a) (b)

Figure 137: Depth distribution of the upper level SSS measurements from TSG (LEGOS-Survostral) (a) and spatial distribution of the *in situ* SSS depth measurements showing the mean value in 1°x1° boxes and considering the full *in situ* dataset period (b).

6.8.5 Spatial distribution of SSS

In Figure 138, the number of TSG (LEGOS-Survostral) SSS measurements in 1°x1° boxes is shown.

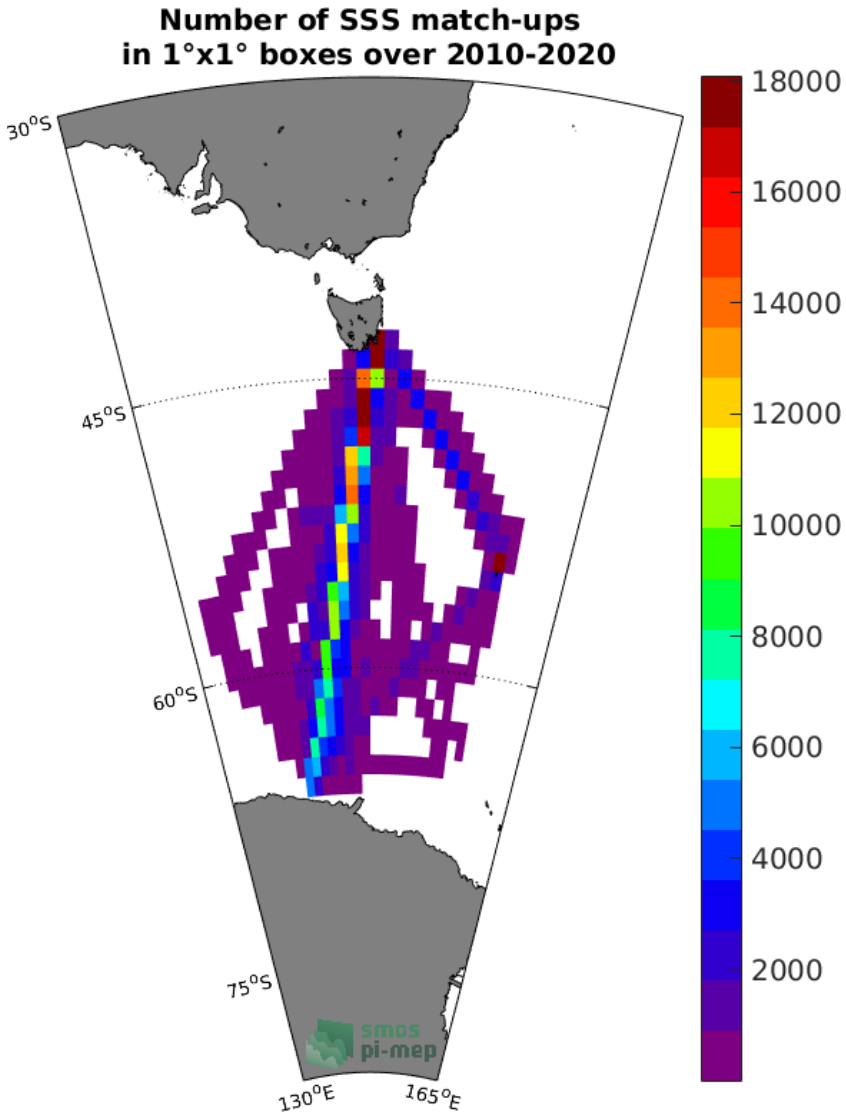
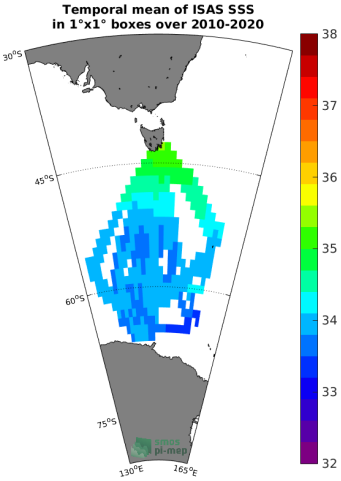


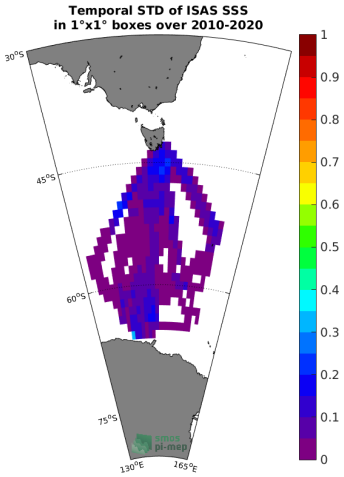
Figure 138: Number of SSS from TSG (LEGOS-Survostral) in 1°x1° boxes.

6.8.6 Spatial Maps of the Temporal mean and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

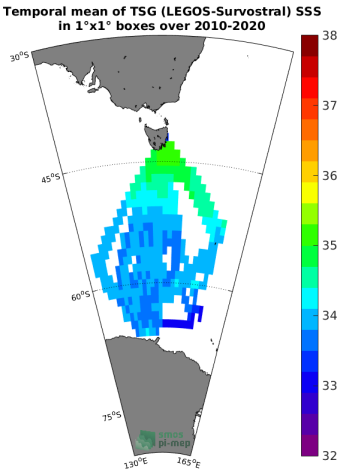
In Figure 139, maps of temporal mean (left) and standard deviation (right) of ISAS (top), TSG (LEGOS-Survostral) *in situ* dataset (middle) and the difference ΔSSS(ISAS -TSG (LEGOS-Survostral)) (bottom) are shown. The temporal mean and std are calculated using all match-up pairs falling in spatial boxes of size 1°x1° over the full TSG (LEGOS-Survostral) dataset period.



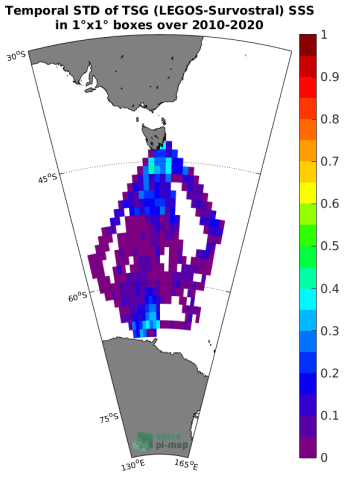
(a) MEAN(ISAS SSS)



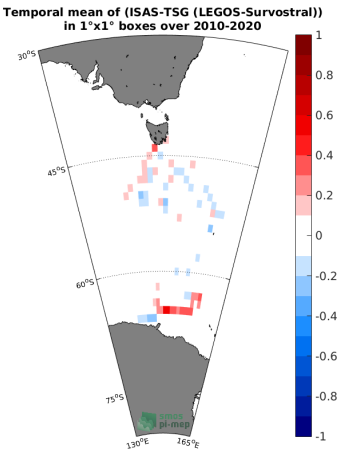
(b) Std(ISAS SSS)



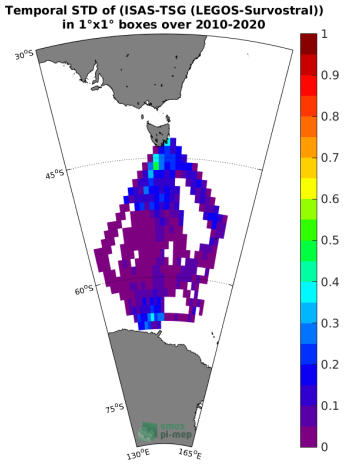
(c) MEAN(TSG (LEGOS-Survostral) SSS)



(d) Std(TSG (LEGOS-Survostral) SSS)



(e) MEAN(ΔSSS) (ISAS - TSG (LEGOS-Survostral))



(f) Std(ΔSSS) (ISAS - TSG (LEGOS-Survostral))

Figure 139: Temporal mean (left) and Std (right) of SSS from ISAS (top), TSG (LEGOS-Survostral) (middle), and of ΔSSS (ISAS - TSG (LEGOS-Survostral)). Only match-up pairs are used to generate these maps.

6.8.7 Time series of the monthly median and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

In the top panel of Figure 140, we show the time series of the monthly median SSS estimated for both ISAS SSS product (in black) and the TSG (LEGOS-Survostral) *in situ* dataset (in blue) at the collected Pi-MEP match-up pairs.

In the middle panel of Figure 140, we show the time series of the monthly median of ΔSSS (ISAS - TSG (LEGOS-Survostral)) for the collected Pi-MEP match-up pairs.

In the bottom panel of Figure 140, we show the time series of the monthly standard deviation of the ΔSSS (ISAS - TSG (LEGOS-Survostral)) for the collected Pi-MEP match-up pairs.

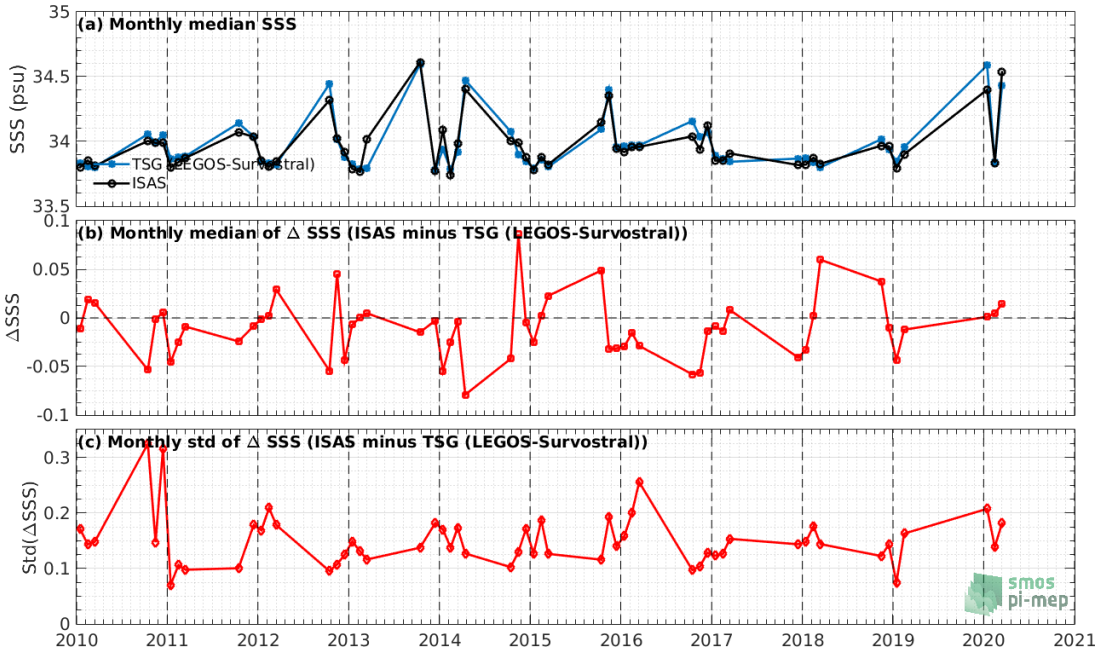


Figure 140: Time series of the monthly median SSS (top), median of ΔSSS (ISAS - TSG (LEGOS-Survostral)) and Std of ΔSSS (ISAS - TSG (LEGOS-Survostral)) considering all match-ups collected by the Pi-MEP.

6.8.8 Zonal mean and Std of *in situ* and ISAS SSS and of the difference ΔSSS

In Figure 141 left panel, we show the zonal mean SSS considering all Pi-MEP match-up pairs for both ISAS SSS product (in black) and the TSG (LEGOS-Survostral) *in situ* dataset (in blue). The full *in situ* dataset period is used to derive the mean.

In the right panel of Figure 141, we show the zonal mean of ΔSSS (ISAS - TSG (LEGOS-Survostral)) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

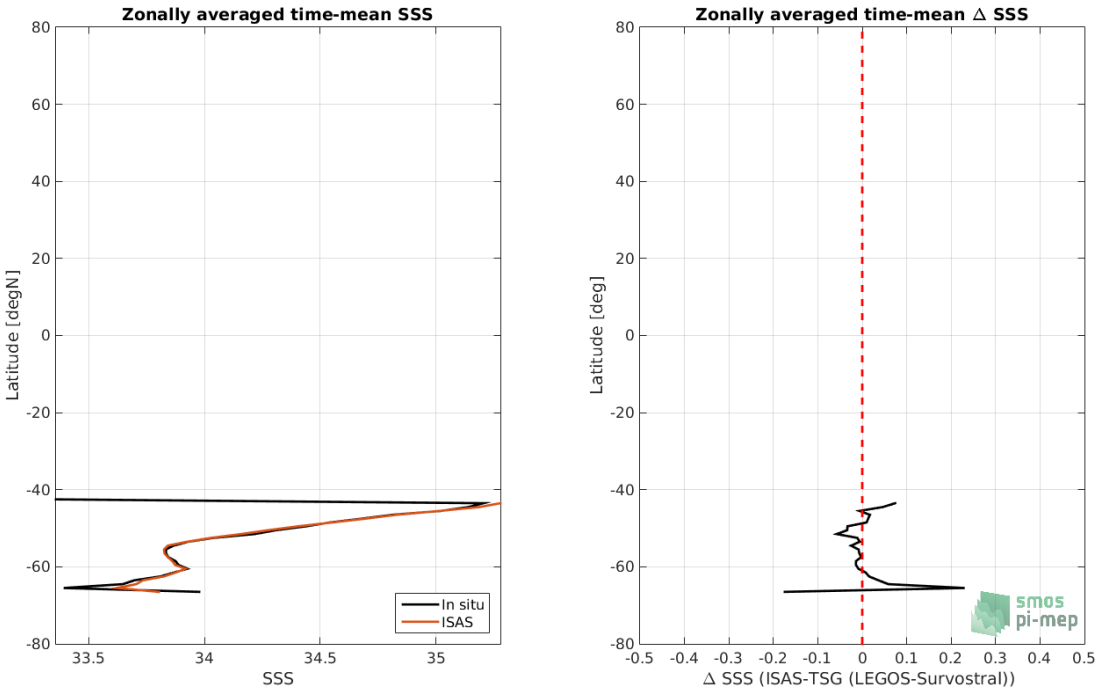
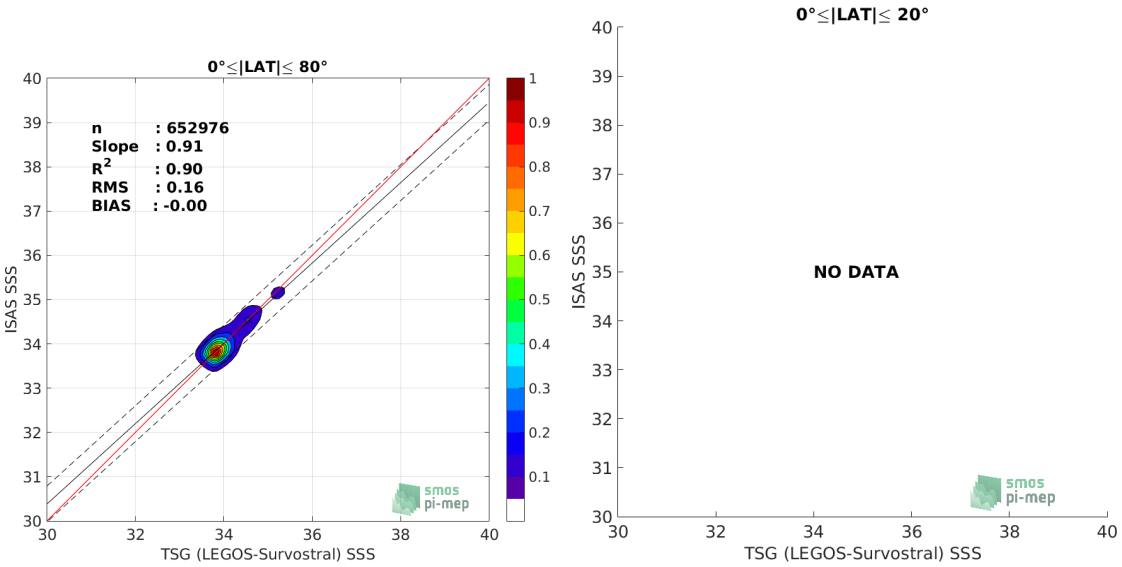


Figure 141: Left panel: Zonal mean SSS from ISAS product (black) and from TSG (LEGOS-Survostral) (blue). Right panel: Zonal mean of ΔSSS (ISAS - TSG (LEGOS-Survostral)) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

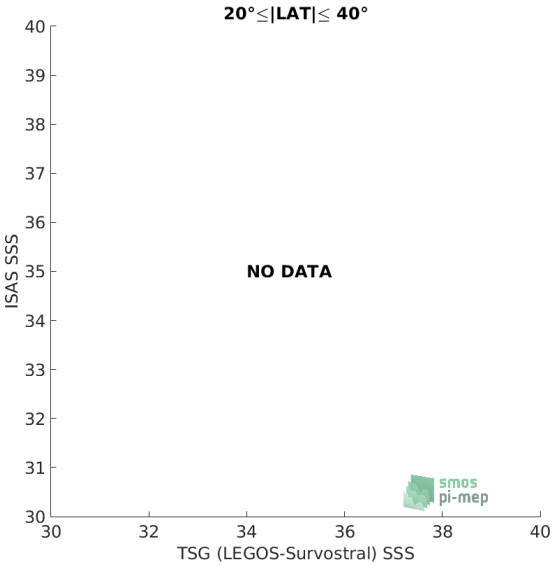
6.8.9 Scatterplots of ISAS vs *in situ* SSS by latitudinal bands

In Figure 142, contour maps of the concentration of ISAS SSS (y-axis) versus TSG (LEGOS-Survostral) SSS (x-axis) at match-up pairs for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.

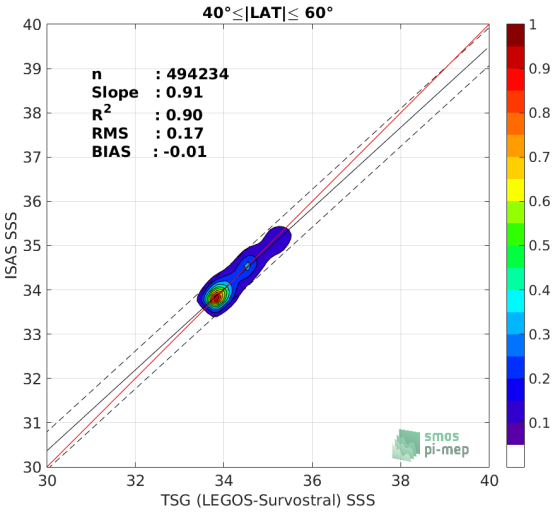


(a) $0° \leq |\text{LAT}| \leq 80°$

(b) $0° \leq |\text{LAT}| \leq 20°$



(c) $20° \leq |\text{LAT}| \leq 40°$

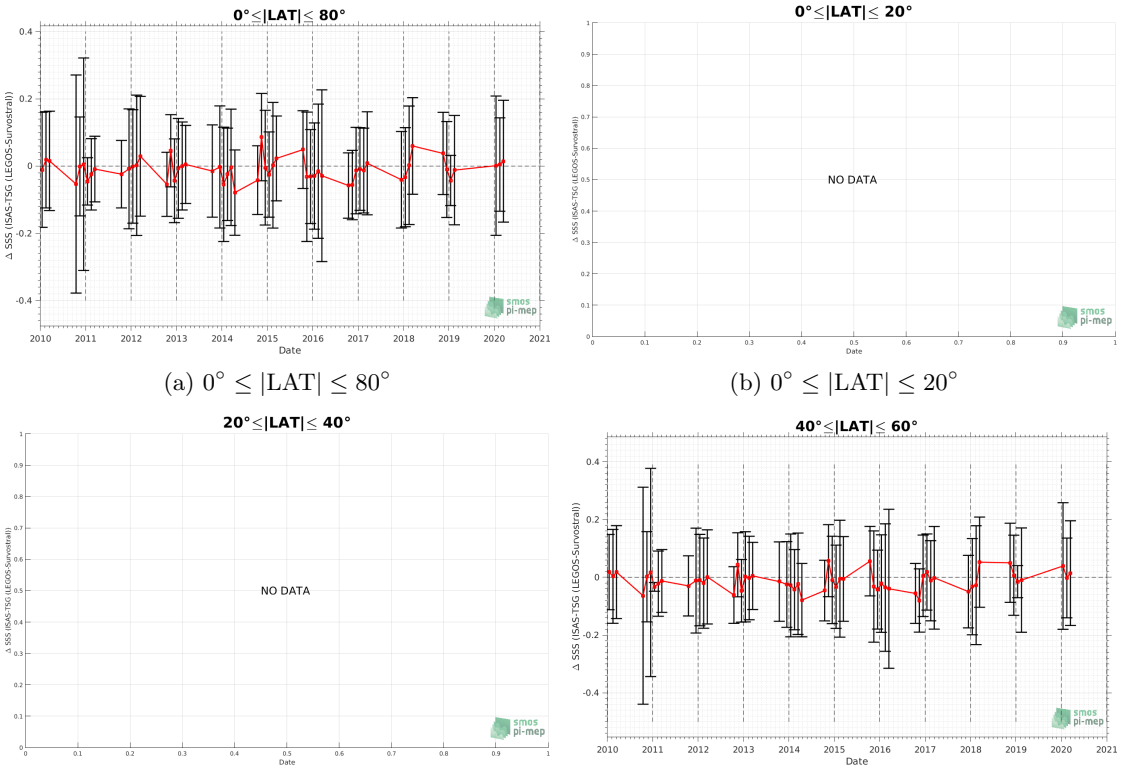


(d) $40° \leq |\text{LAT}| \leq 60°$

Figure 142: Contour maps of the concentration of ISAS SSS (y-axis) versus TSG (LEGOS-Survostral) SSS (x-axis) at match-up pairs for different latitude bands. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.

6.8.10 Time series of the monthly median and Std of the difference ΔSSS sorted by latitudinal bands

In Figure 143, time series of the monthly median (red curves) of ΔSSS (ISAS - TSG (LEGOS-Survostral)) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs estimated for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.



(a) 0° ≤ |LAT| ≤ 80°

(b) 0° ≤ |LAT| ≤ 20°

(c) 20° ≤ |LAT| ≤ 40°

(d) 40° ≤ |LAT| ≤ 60°

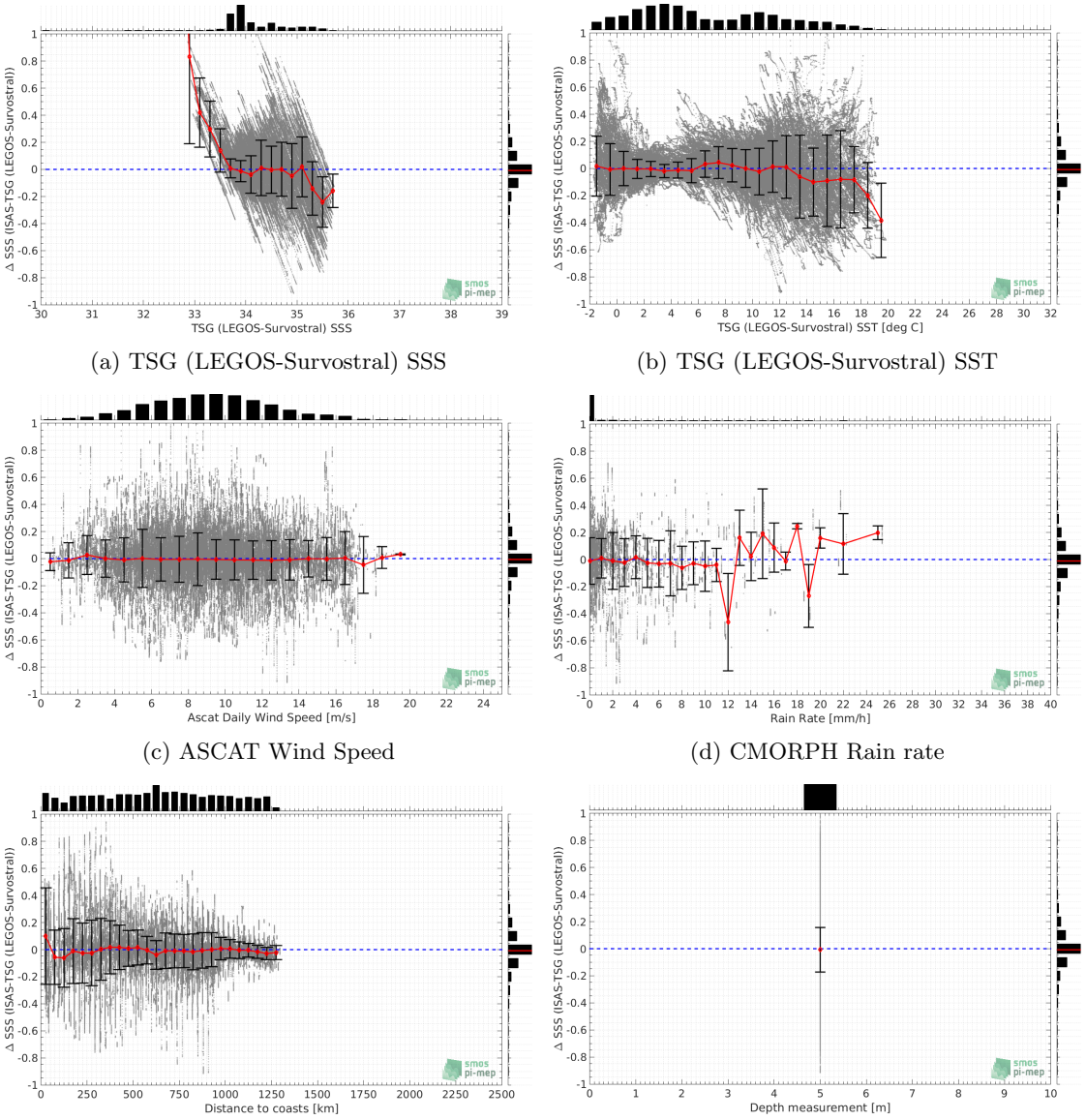
Figure 143: Monthly median (red curves) of ΔSSS (ISAS - TSG (LEGOS-Survostral)) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.

6.8.11 ΔSSS sorted as geophysical conditions

In Figure 144, we classify the match-up differences ΔSSS (ISAS - *in situ*) as function of the geophysical conditions at match-up points. The mean and std of ΔSSS (ISAS - TSG (LEGOS-Survostral)) is thus evaluated as function of the

- *in situ* SSS values per bins of width 0.2,
- *in situ* SST values per bins of width 1°C,
- ASCAT daily wind values per bins of width 1 m/s,

- CMORPH 3-hourly rain rates per bins of width 1 mm/h, and,
- distance to coasts per bins of width 50 km,
- *in situ* measurement depth (if relevant).



(a) TSG (LEGOS-Survostral) SSS

(b) TSG (LEGOS-Survostral) SST

(c) ASCAT Wind Speed

(d) CMORPH Rain rate

(e) Distance to coast

(f) Depth

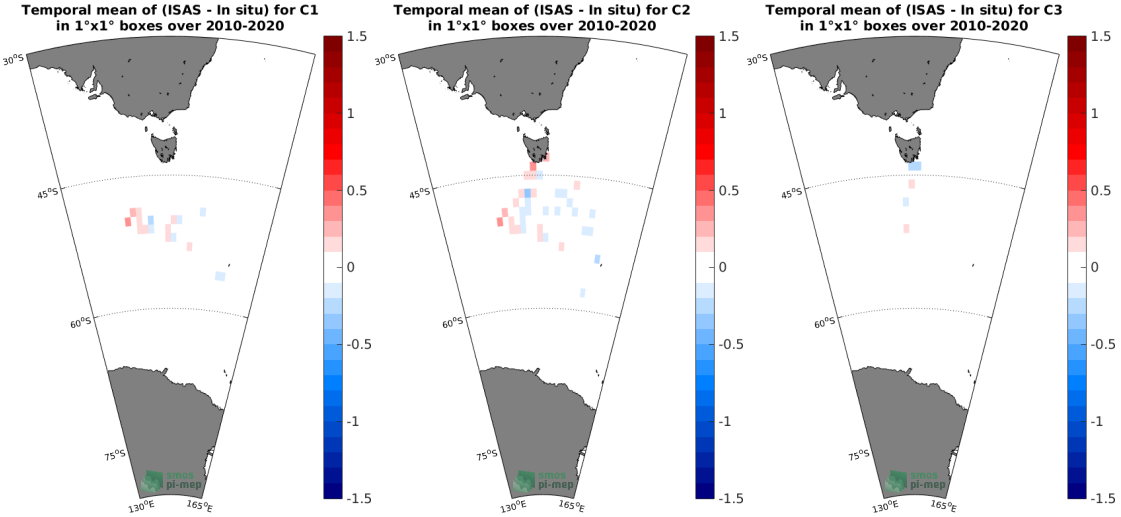
Figure 144: Δ SSS (ISAS - TSG (LEGOS-Survostral)) sorted as geophysical conditions: TSG (LEGOS-Survostral) SSS a), TSG (LEGOS-Survostral) SST b), ASCAT Wind speed c), CMORPH rain rate d), distance to coast (e) and depth measurements (f).

6.8.12 ΔSSS maps and statistics for different geophysical conditions

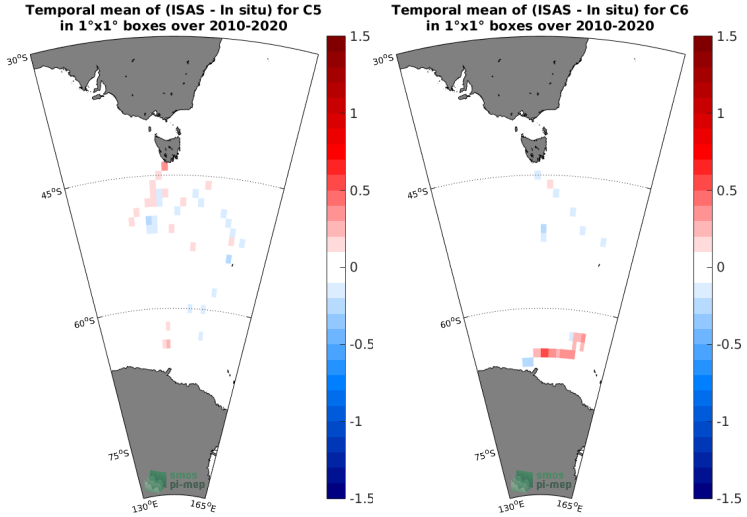
In Figures 145 and 146, we focus on sub-datasets of the match-up differences ΔSSS (ISAS - *in situ*) for the following specific geophysical conditions:

- **C1**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is in the range [3, 12] m/s, the SST is $> 5°$C and distance to coast is > 800 km.
- **C2**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is in the range [3, 12] m/s.
- **C3**:if the local value at *in situ* location of estimated rain rate is high (ie. > 1 mm/h) and mean daily wind is low (ie. < 4 m/s).
- **C5**:if the *in situ* data is located where the climatological SSS standard deviation is low (ie. above < 0.2).
- **C6**:if the *in situ* data is located where the climatological SSS standard deviation is high (ie. above > 0.2).

For each of these conditions, the temporal mean (gridded over spatial boxes of size 1°x1°) and the histogram of the difference ΔSSS (ISAS - *in situ*) are presented.

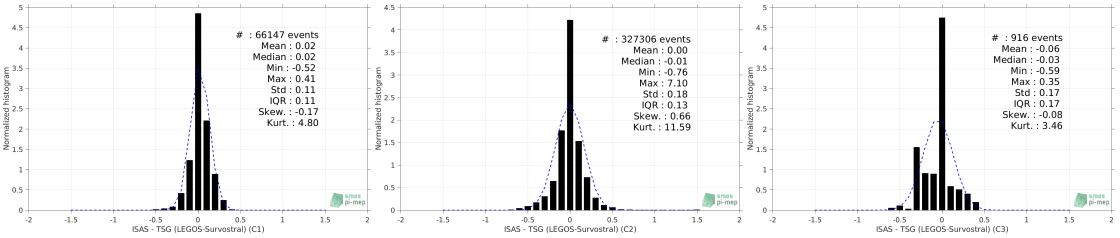


(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s

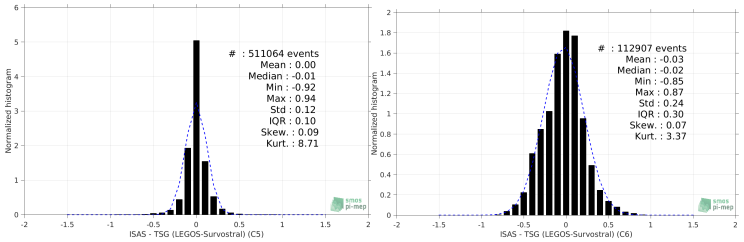


(d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 145: Temporal mean gridded over spatial boxes of size 1°x1° of ΔSSS (ISAS - TSG (LEGOS-Survostral)) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).



(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s



(d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 146: Normalized histogram of ΔSSS (ISAS - TSG (LEGOS-Survostral)) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).

6.8.13 Summary

Table 1 shows the mean, median, standard deviation (Std), root mean square (RMS), interquartile range (IQR), correlation coefficient (r^2) and robust standard deviation (Std*) of the match-up differences ΔSSS (ISAS - TSG (LEGOS-Survostral)) for the following conditions:

- all: All the match-up pairs satellite/in situ SSS values are used to derive the statistics
- C1: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km
- C2: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s
- C3: only pairs where RR>1mm/h and U_{10} <4m/s
- C5: only pairs where WOA2013 SSS Std<0.2
- C6: only pairs where WOA2013 SSS Std>0.2
- C7a: only pairs with a distance to coast < 150 km.
- C7b: only pairs with a distance to coast in the range [150, 800] km.
- C7c: only pairs with a distance to coast > 800 km.
- C8a: only pairs where SST is < 5°C.
- C8b: only pairs where SST is in the range [5, 15]°C.
- C8c: only pairs where SST is > 15°C.

- C9a: only pairs where SSS is < 33.
- C9b: only pairs where SSS is in the range [33, 37].
- C9c: only pairs where SSS is > 37.

Table 1: Statistics of ΔSSS (ISAS - TSG (LEGOS-Survostral))

Condition	#	Median	Mean	Std	RMS	IQR	r^2	Std*
all	652976	-0.01	0.00	0.16	0.16	0.12	0.902	0.09
C1	66147	0.02	0.02	0.11	0.11	0.11	0.743	0.08
C2	327306	-0.01	0.00	0.18	0.18	0.13	0.897	0.09
C3	916	-0.03	-0.06	0.17	0.18	0.17	0.917	0.08
C5	511064	-0.01	0.00	0.12	0.12	0.10	0.923	0.07
C6	112907	-0.02	-0.03	0.24	0.24	0.30	0.855	0.22
C7a	63782	0.00	0.03	0.29	0.29	0.31	0.847	0.23
C7b	368723	-0.01	-0.01	0.17	0.17	0.15	0.898	0.11
C7c	220471	-0.01	0.00	0.09	0.09	0.08	0.738	0.06
C8a	308616	-0.01	0.00	0.10	0.10	0.08	0.520	0.06
C8b	295347	0.00	0.00	0.18	0.18	0.19	0.845	0.14
C8c	42997	-0.10	-0.07	0.32	0.33	0.38	0.004	0.28
C9a	400	0.92	1.73	1.27	2.15	1.77	0.155	0.76
C9b	652576	-0.01	0.00	0.16	0.16	0.12	0.912	0.09
C9c	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN

Table 1 numerical values can be downloaded as a csv file here.

6.9 TSG (LEGOS-Survostral-Adelie)

6.9.1 Introduction

The TSG (LEGOS-Survostral-Adelie) dataset corresponds to delayed mode regional dataset along the Adelie coast provided by the Survostral project and available via here. Adjusted values when available and only collected TSG data that exhibit quality flags=1 and 2 were used.

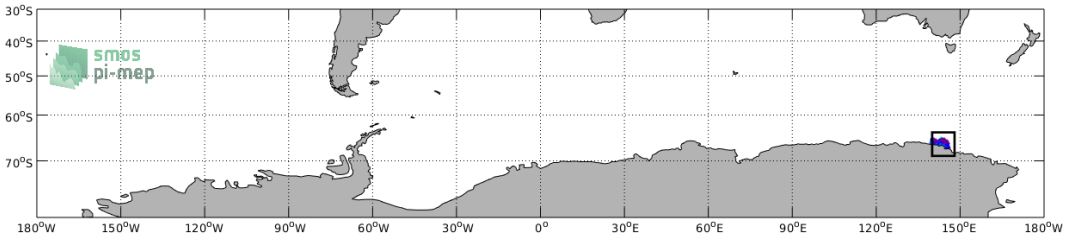
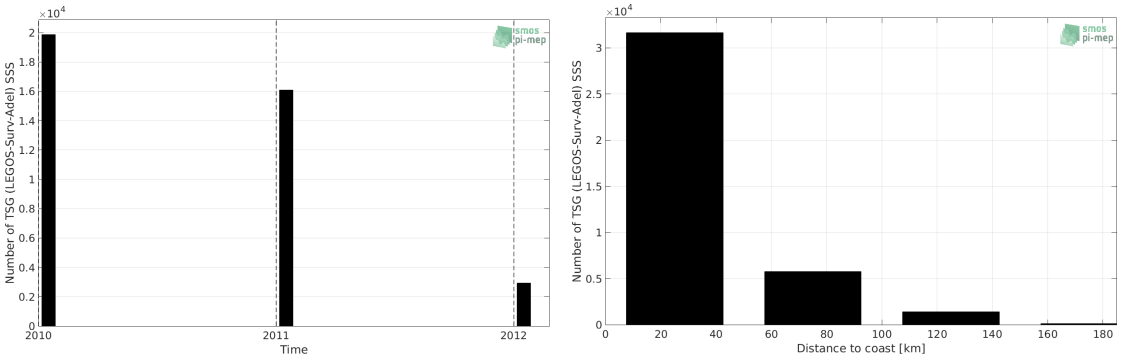


Figure 147: Location of the TSG (LEGOS-Survostral-Adélie) dataset.

6.9.2 Number of SSS data as a function of time and distance to coast

Figure 148 shows the time (a) and distance to coast (b) distributions of the TSG (LEGOS-Survostral-Adélie) *in situ* dataset.

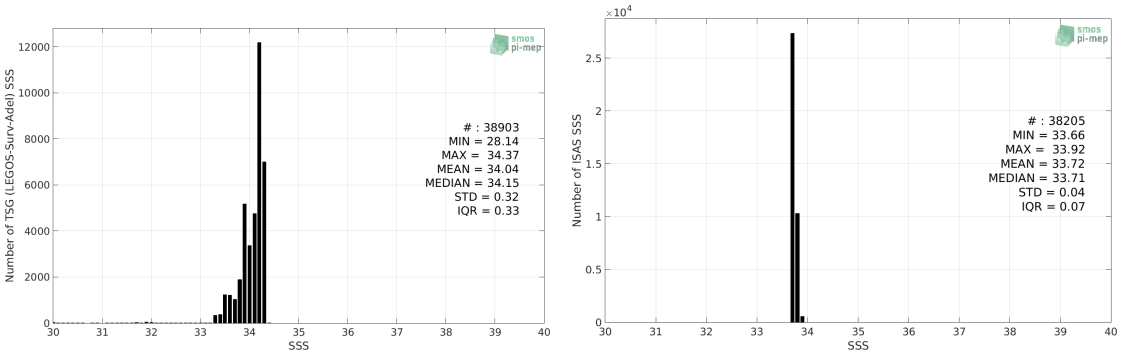


(a) (b)

Figure 148: Number of SSS from TSG (LEGOS-Survostral-Adélie) as a function of time (a) and distance to coast (b).

6.9.3 Histograms of SSS

Figure 149 shows the SSS distribution of the TSG (LEGOS-Survostral-Adélie) (a) and colocalized ISAS (b) dataset.

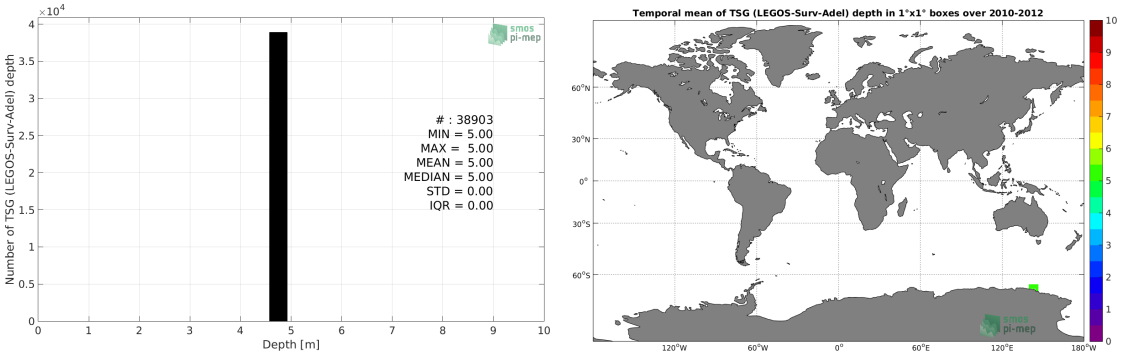


(a) (b)

Figure 149: Histograms of SSS from TSG (LEGOS-Survostral-Adélie) (a) and ISAS (b) per bins of 0.1.

6.9.4 Distribution of *in situ* SSS depth measurements

In Figure 150, we show the depth distribution of the *in situ* salinity dataset (a) and the spatial distribution of the depth temporal mean in 1°x1° boxes and considering the full *in situ* dataset period (b).



(a) (b)

Figure 150: Depth distribution of the upper level SSS measurements from TSG (LEGOS-Survostral-Adélie) (a) and spatial distribution of the *in situ* SSS depth measurements showing the mean value in 1°x1° boxes and considering the full *in situ* dataset period (b).

6.9.5 Spatial distribution of SSS

In Figure 151, the number of TSG (LEGOS-Survostral-Adélie) SSS measurements in 1°x1° boxes is shown.

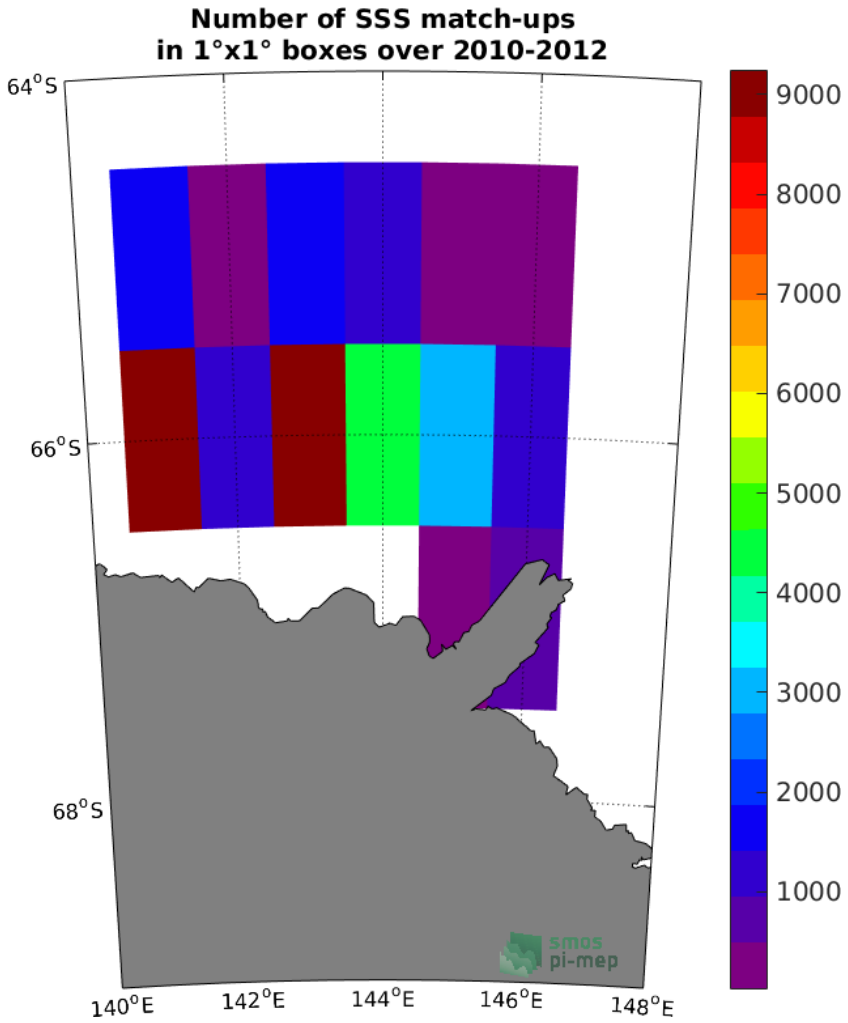
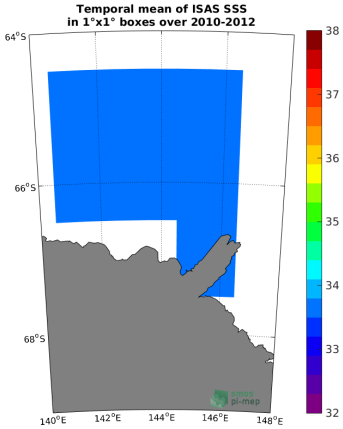


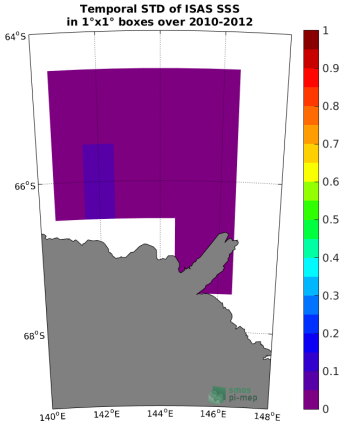
Figure 151: Number of SSS from TSG (LEGOS-Survostral-Adélie) in 1°x1° boxes.

6.9.6 Spatial Maps of the Temporal mean and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

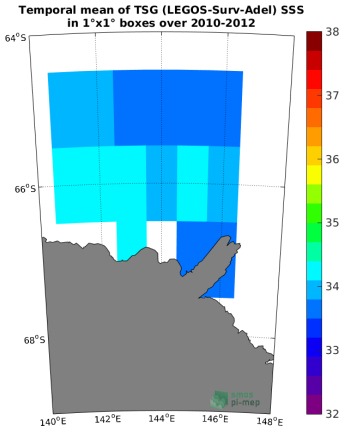
In Figure 152, maps of temporal mean (left) and standard deviation (right) of ISAS (top), TSG (LEGOS-Survostral-Adélie) *in situ* dataset (middle) and the difference ΔSSS(ISAS -TSG (LEGOS-Survostral-Adélie)) (bottom) are shown. The temporal mean and std are calculated using all match-up pairs falling in spatial boxes of size 1°x1° over the full TSG (LEGOS-Survostral-Adélie) dataset period.



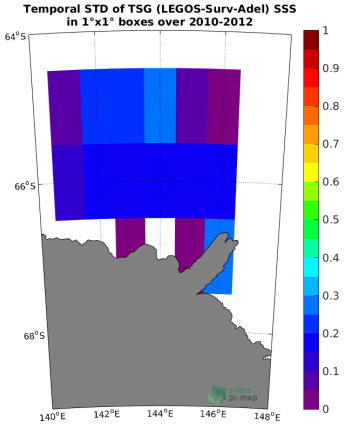
(a) MEAN(ISAS SSS)



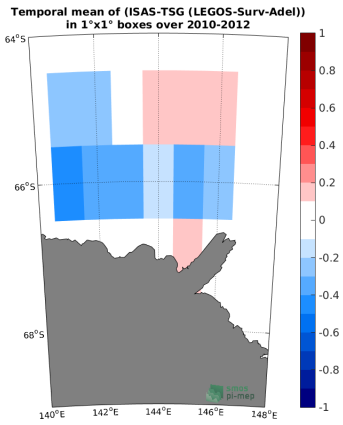
(b) Std(ISAS SSS)



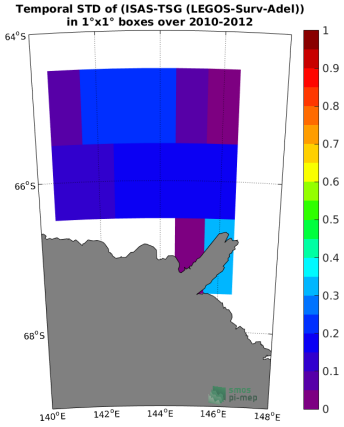
(c) MEAN(TSG (LEGOS-Survostral-Adélie) SSS)



(d) Std(TSG (LEGOS-Survostral-Adélie) SSS)



(e) MEAN(ΔSSS) (ISAS - TSG (LEGOS-Survostral-Adélie))



(f) Std(ΔSSS) (ISAS - TSG (LEGOS-Survostral-Adélie))

Figure 152: Temporal mean (left) and Std (right) of SSS from ISAS (top), TSG (LEGOS-Survostral-Adélie) (middle), and of ΔSSS (ISAS - TSG (LEGOS-Survostral-Adélie)). Only match-up pairs are used to generate these maps.

6.9.7 Time series of the monthly median and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

In the top panel of Figure 153, we show the time series of the monthly median SSS estimated for both ISAS SSS product (in black) and the TSG (LEGOS-Survostral-Adélie) *in situ* dataset (in blue) at the collected Pi-MEP match-up pairs.

In the middle panel of Figure 153, we show the time series of the monthly median of ΔSSS (ISAS - TSG (LEGOS-Survostral-Adélie)) for the collected Pi-MEP match-up pairs.

In the bottom panel of Figure 153, we show the time series of the monthly standard deviation of the ΔSSS (ISAS - TSG (LEGOS-Survostral-Adélie)) for the collected Pi-MEP match-up pairs.

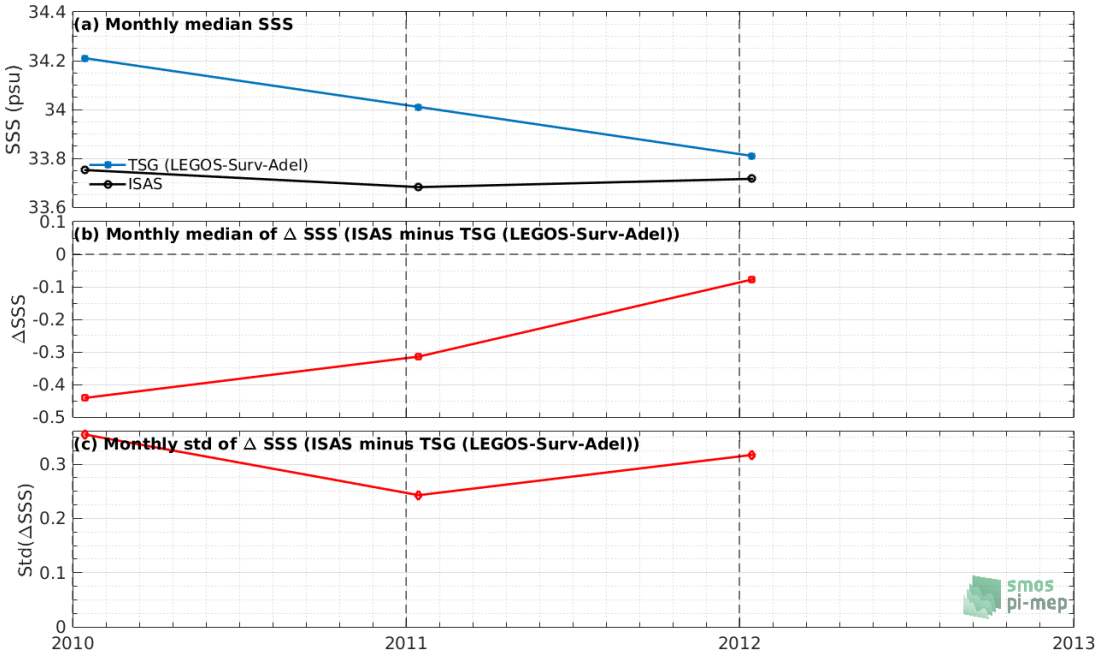


Figure 153: Time series of the monthly median SSS (top), median of ΔSSS (ISAS - TSG (LEGOS-Survostral-Adélie)) and Std of ΔSSS (ISAS - TSG (LEGOS-Survostral-Adélie)) considering all match-ups collected by the Pi-MEP.

6.9.8 Zonal mean and Std of *in situ* and ISAS SSS and of the difference ΔSSS

In Figure 154 left panel, we show the zonal mean SSS considering all Pi-MEP match-up pairs for both ISAS SSS product (in black) and the TSG (LEGOS-Survostral-Adélie) *in situ* dataset (in blue). The full *in situ* dataset period is used to derive the mean.

In the right panel of Figure 154, we show the zonal mean of ΔSSS (ISAS - TSG (LEGOS-Survostral-Adélie)) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

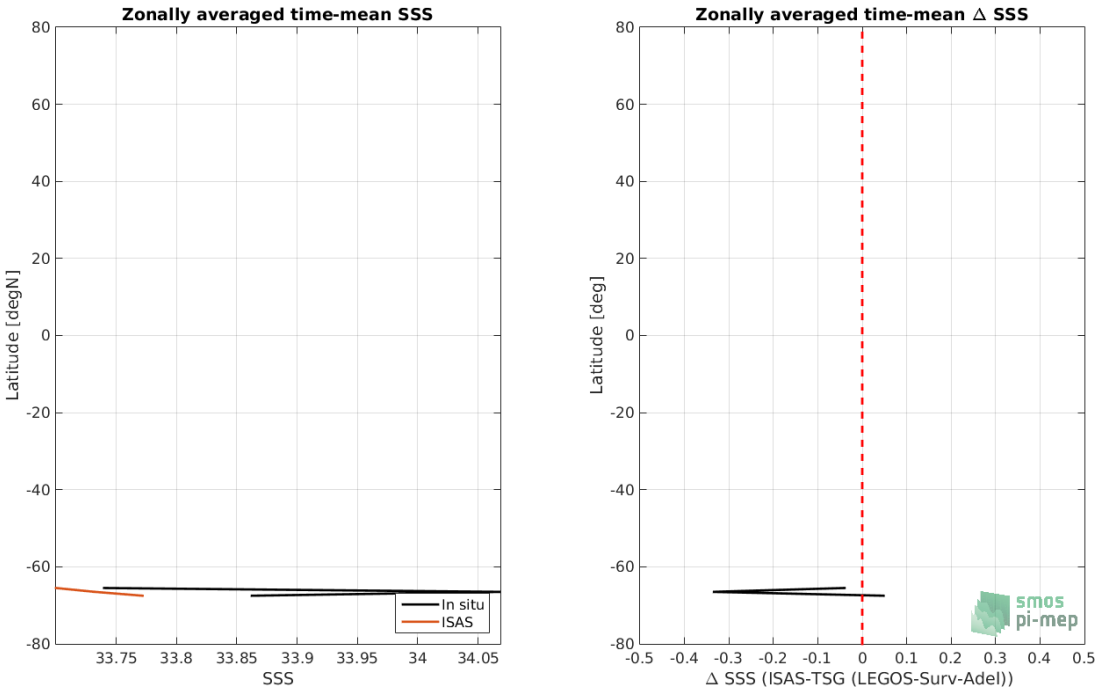
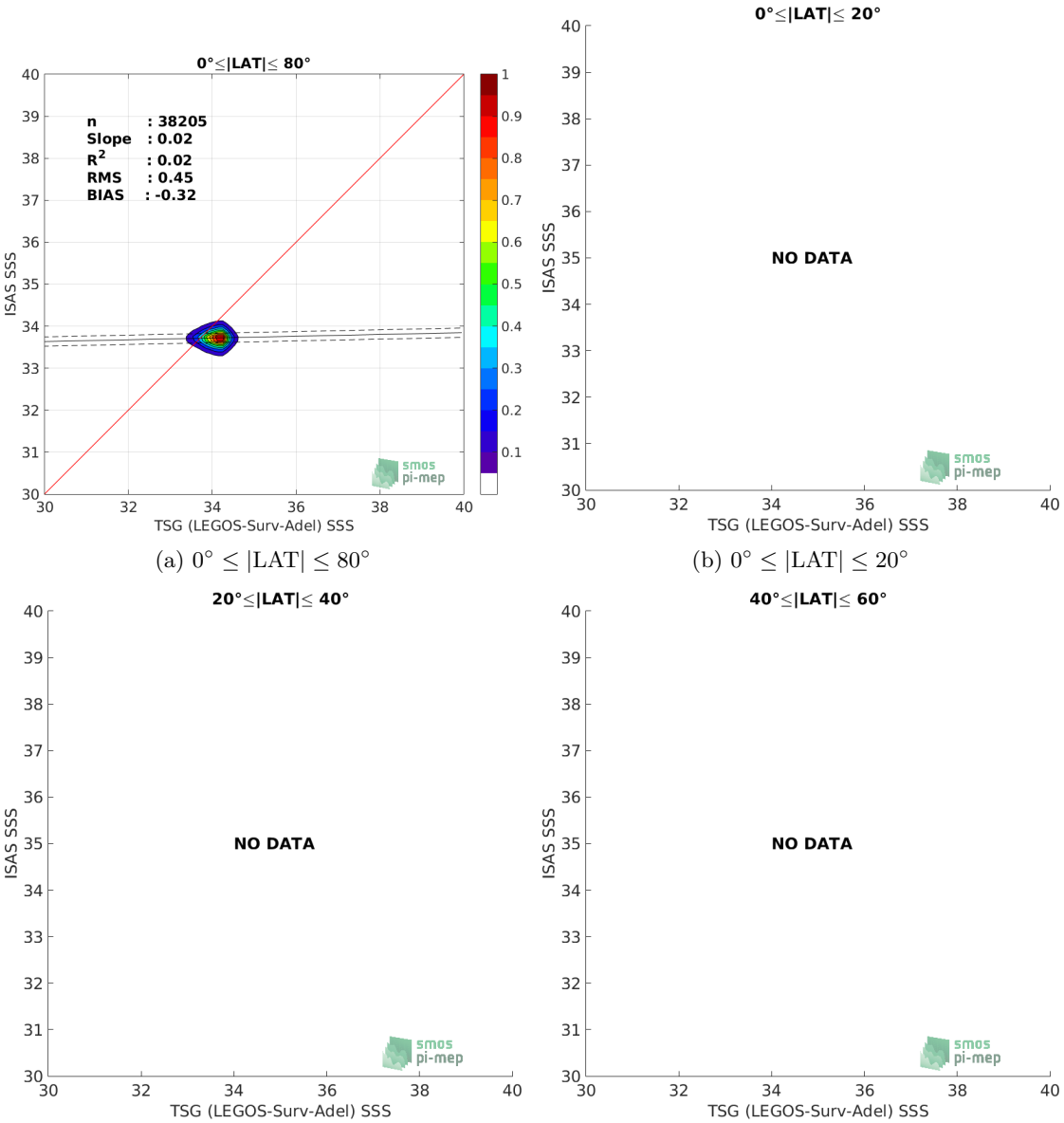


Figure 154: Left panel: Zonal mean SSS from ISAS product (black) and from TSG (LEGOS-Survostral-Adélie) (blue). Right panel: Zonal mean of ΔSSS (ISAS - TSG (LEGOS-Survostral-Adélie)) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

6.9.9 Scatterplots of ISAS vs *in situ* SSS by latitudinal bands

In Figure 155, contour maps of the concentration of ISAS SSS (y-axis) versus TSG (LEGOS-Survostral-Adélie) SSS (x-axis) at match-up pairs for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.



(a) $0° \leq |\text{LAT}| \leq 80°$

(b) $0° \leq |\text{LAT}| \leq 20°$

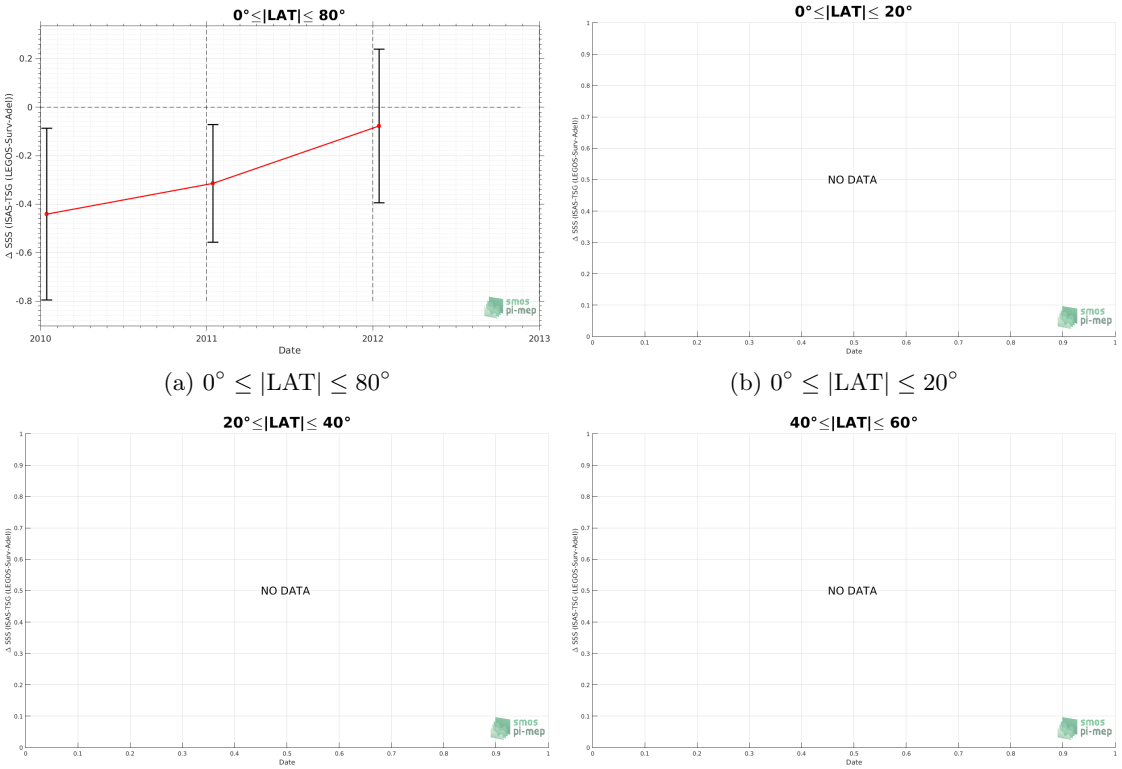
(c) $20° \leq |\text{LAT}| \leq 40°$

(d) $40° \leq |\text{LAT}| \leq 60°$

Figure 155: Contour maps of the concentration of ISAS SSS (y-axis) versus TSG (LEGOS-Survostral-Adélie) SSS (x-axis) at match-up pairs for different latitude bands. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.

6.9.10 Time series of the monthly median and Std of the difference ΔSSS sorted by latitudinal bands

In Figure 156, time series of the monthly median (red curves) of ΔSSS (ISAS - TSG (LEGOS-Survostral-Adélie)) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs estimated for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.



(a) 0° ≤ |LAT| ≤ 80°

(b) 0° ≤ |LAT| ≤ 20°

(c) 20° ≤ |LAT| ≤ 40°

(d) 40° ≤ |LAT| ≤ 60°

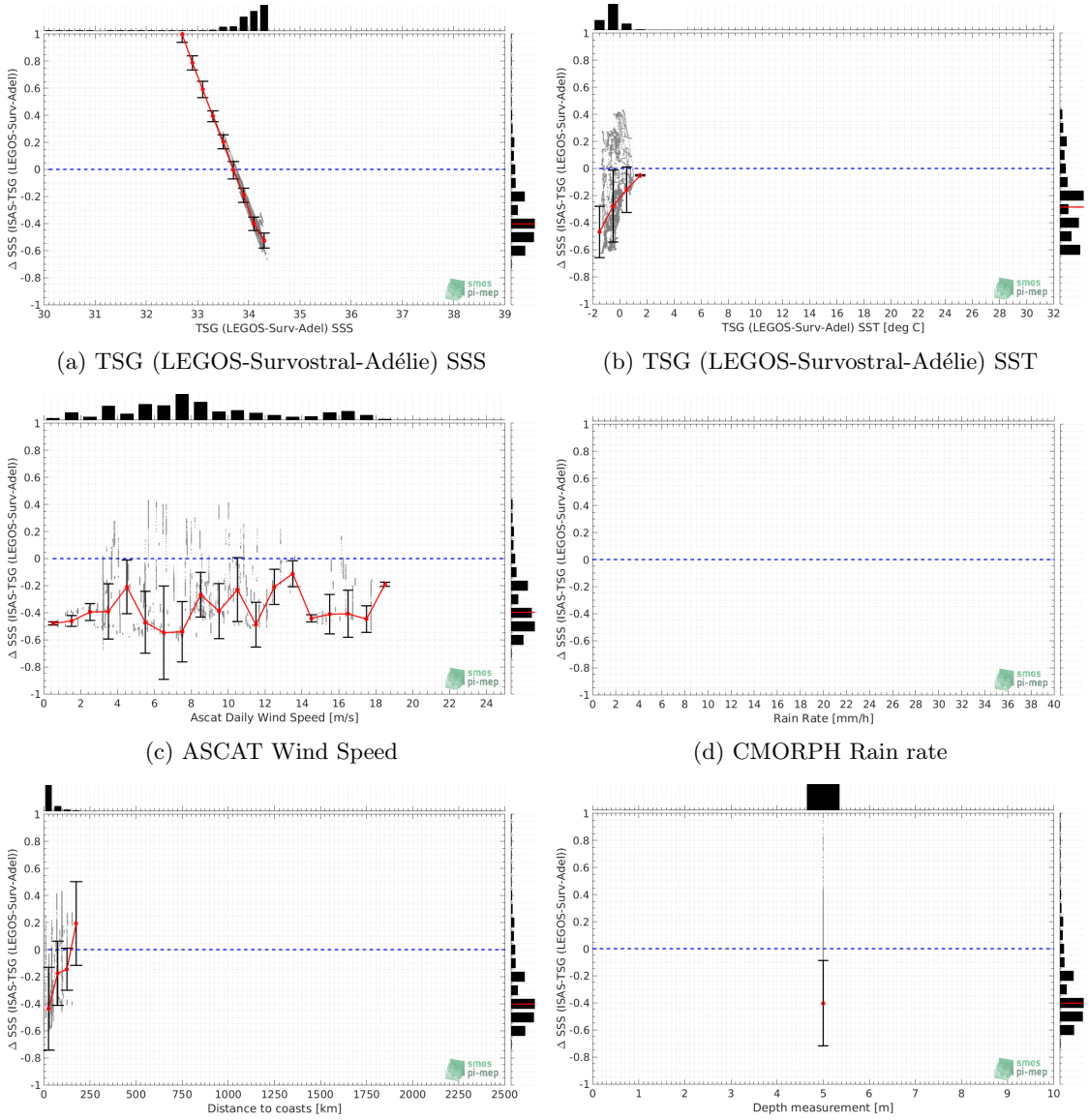
Figure 156: Monthly median (red curves) of ΔSSS (ISAS - TSG (LEGOS-Survostral-Adélie)) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.

6.9.11 ΔSSS sorted as geophysical conditions

In Figure 157, we classify the match-up differences ΔSSS (ISAS - *in situ*) as function of the geophysical conditions at match-up points. The mean and std of ΔSSS (ISAS - TSG (LEGOS-Survostral-Adélie)) is thus evaluated as function of the

- *in situ* SSS values per bins of width 0.2,
- *in situ* SST values per bins of width 1°C,
- ASCAT daily wind values per bins of width 1 m/s,

- CMORPH 3-hourly rain rates per bins of width 1 mm/h, and,
- distance to coasts per bins of width 50 km,
- *in situ* measurement depth (if relevant).



(a) TSG (LEGOS-Survostral-Adélie) SSS

(b) TSG (LEGOS-Survostral-Adélie) SST

(c) ASCAT Wind Speed

(d) CMORPH Rain rate

(e) Distance to coast

(f) Depth

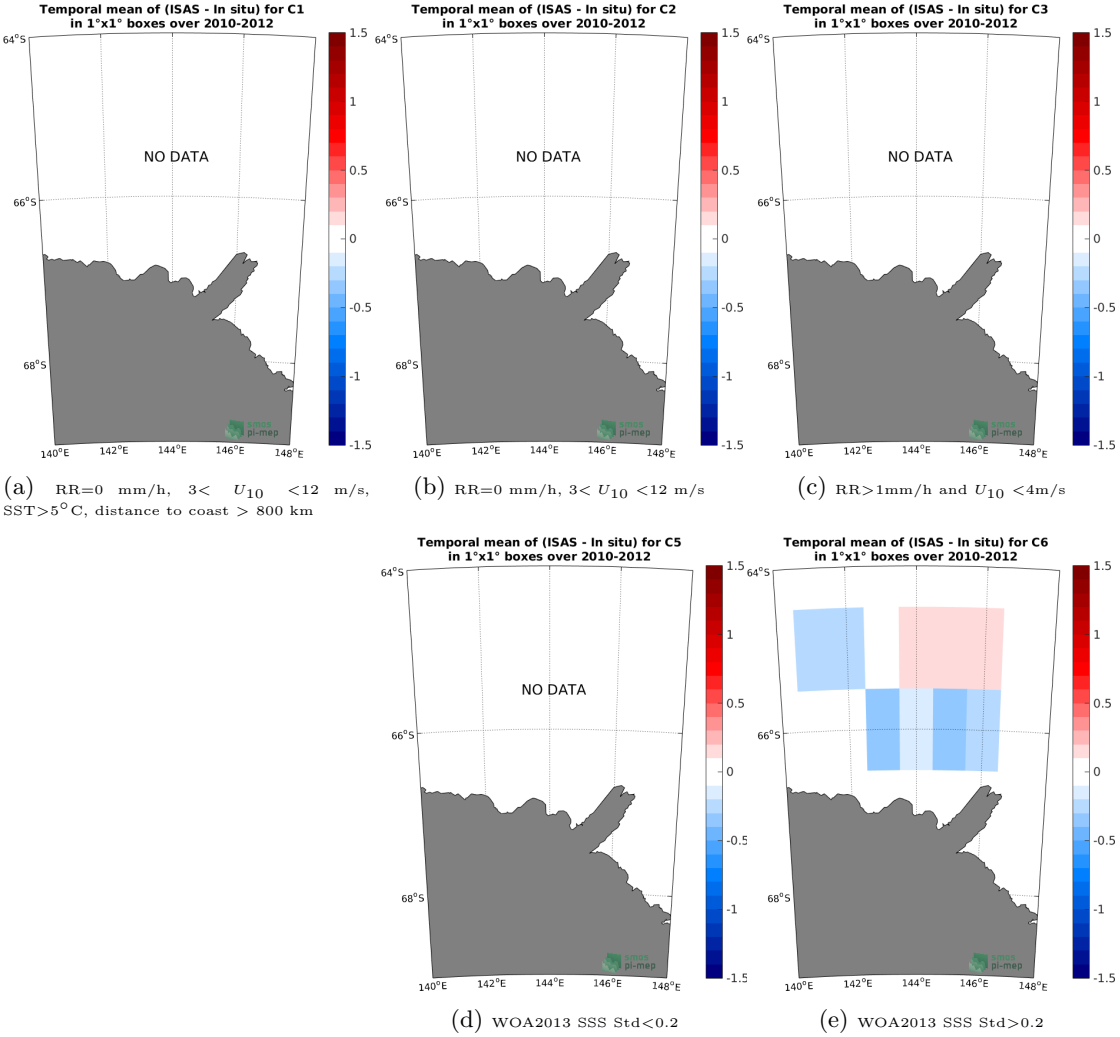
Figure 157: Δ SSS (ISAS - TSG (LEGOS-Survostral-Adélie)) sorted as geophysical conditions: TSG (LEGOS-Survostral-Adélie) SSS a), TSG (LEGOS-Survostral-Adélie) SST b), ASCAT Wind speed c), CMORPH rain rate d), distance to coast (e) and depth measurements (f).

6.9.12 ΔSSS maps and statistics for different geophysical conditions

In Figures 158 and 159, we focus on sub-datasets of the match-up differences ΔSSS (ISAS - *in situ*) for the following specific geophysical conditions:

- **C1**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is in the range [3, 12] m/s, the SST is $> 5°$C and distance to coast is > 800 km.
- **C2**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is in the range [3, 12] m/s.
- **C3**:if the local value at *in situ* location of estimated rain rate is high (ie. > 1 mm/h) and mean daily wind is low (ie. < 4 m/s).
- **C5**:if the *in situ* data is located where the climatological SSS standard deviation is low (ie. above < 0.2).
- **C6**:if the *in situ* data is located where the climatological SSS standard deviation is high (ie. above > 0.2).

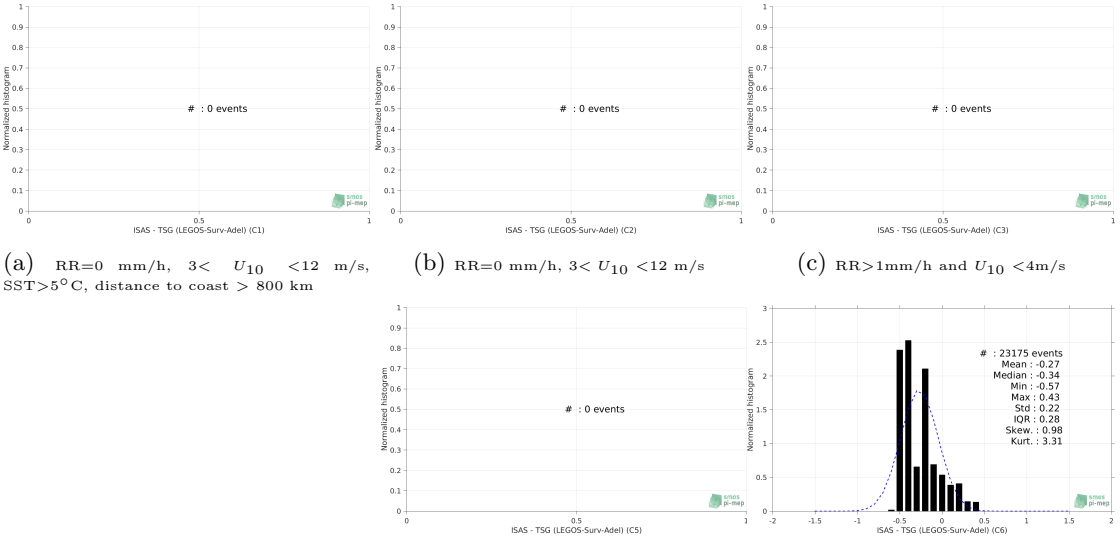
For each of these conditions, the temporal mean (gridded over spatial boxes of size 1°x1°) and the histogram of the difference ΔSSS (ISAS - *in situ*) are presented.



(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s

(d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 158: Temporal mean gridded over spatial boxes of size 1°x1° of ΔSSS (ISAS - TSG (LEGOS-Survostral-Adélie)) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).



(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s (d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 159: Normalized histogram of ΔSSS (ISAS - TSG (LEGOS-Survostral-Adélie)) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).

6.9.13 Summary

Table 1 shows the mean, median, standard deviation (Std), root mean square (RMS), interquartile range (IQR), correlation coefficient (r^2) and robust standard deviation (Std*) of the match-up differences ΔSSS (ISAS - TSG (LEGOS-Survostral-Adélie)) for the following conditions:

- all: All the match-up pairs satellite/in situ SSS values are used to derive the statistics
- C1: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km
- C2: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s
- C3: only pairs where RR>1mm/h and U_{10} <4m/s
- C5: only pairs where WOA2013 SSS Std<0.2
- C6: only pairs where WOA2013 SSS Std>0.2
- C7a: only pairs with a distance to coast < 150 km.
- C7b: only pairs with a distance to coast in the range [150, 800] km.
- C7c: only pairs with a distance to coast > 800 km.
- C8a: only pairs where SST is < 5°C.
- C8b: only pairs where SST is in the range [5, 15]°C.
- C8c: only pairs where SST is > 15°C.

- C9a: only pairs where SSS is < 33.
- C9b: only pairs where SSS is in the range [33, 37].
- C9c: only pairs where SSS is > 37.

Table 1: Statistics of ΔSSS (ISAS - TSG (LEGOS-Survostral-Adélie))

Condition	#	Median	Mean	Std	RMS	IQR	r^2	Std*
all	38205	-0.40	-0.32	0.32	0.45	0.30	0.024	0.20
C1	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
C2	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
C3	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
C5	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
C6	23175	-0.34	-0.27	0.22	0.35	0.28	0.405	0.21
C7a	38109	-0.40	-0.32	0.32	0.45	0.30	0.023	0.20
C7b	96	0.19	0.00	0.31	0.31	0.65	0.991	0.12
C7c	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
C8a	18615	-0.29	-0.27	0.26	0.37	0.34	0.218	0.26
C8b	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
C8c	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
C9a	270	1.76	2.09	1.16	2.39	0.93	0.000	0.59
C9b	37935	-0.40	-0.34	0.22	0.40	0.30	0.031	0.20
C9c	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN

Table 1 numerical values can be downloaded as a csv file here.

7 Moorings

7.1 Introduction

The Pi-MEP collects data from the Global Tropical Moored Buoy Array (GTMBA), a multi-national effort to provide data in real-time for climate research and forecasting. Major components include the TAO/TRITON array in the Pacific, PIRATA in the Atlantic, and RAMA in the Indian Ocean. Data collected within TAO/TRITON, PIRATA and RAMA come primarily from ATLAS and TRITON moorings. These two mooring systems are functionally equivalent in terms of sensors, sample rates, and data quality. The data are directly downloaded from ftp.pmel.noaa.gov every day and stored in the Pi-MEP. Only salinity data measured at 1 or 1.5 meter depth with standard (pre-deployment calibration applied) and highest quality (pre/post calibration in agreement) are considered. A careful filtering of suspiciously erroneous mooring salinity data when compared with all satellite data has also been performed (cf. presentation). The Pi-MEP project acknowledges the GTMBA Project Office of NOAA/PMEL for providing the data. Data from the Ocean Station PAPA are also added to the Pi-MEP *in situ* database.

From the Upper Ocean Processes Group at Woods Hole Oceanographic Institution (WHOI), several moorings data are also included in the Pi-MEP. Namely, delayed mode surface mooring salinity records under the stratus cloud deck in the eastern tropical Pacific (Stratus), in the trade wind region of the northwest tropical Atlantic (NTAS), 100 km north of Oahu at the WHOI Hawaii Ocean Time-series Site (WHOTS), in the salinity maximum region of the subtropical North Atlantic (SPURS-1) and in the Pacific intertropical convergence zone (SPURS-2).

7.2 Number of SSS data as a function of time and distance to coast

Figure 160 shows the time (a) and distance to coast (b) distributions of the Moorings *in situ* dataset.

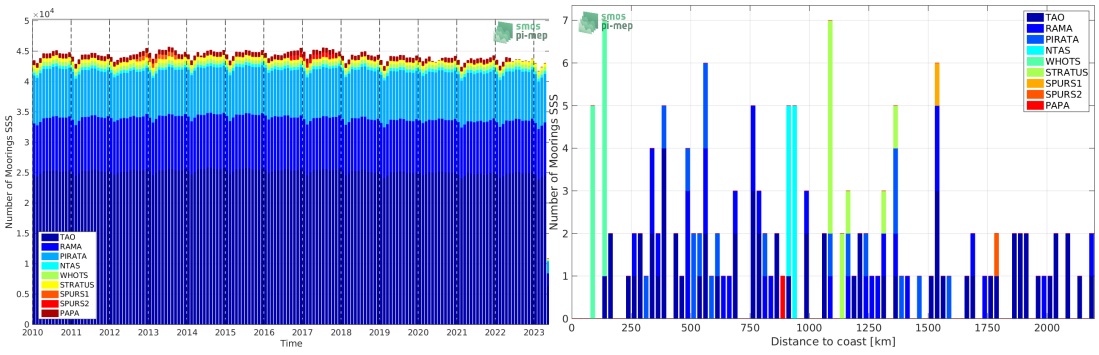


Figure 160: Number of SSS from Moorings as a function of time (left) and distance to coast (right).

7.3 Histogram of SSS

Figure 161 shows the SSS distribution of the Moorings.

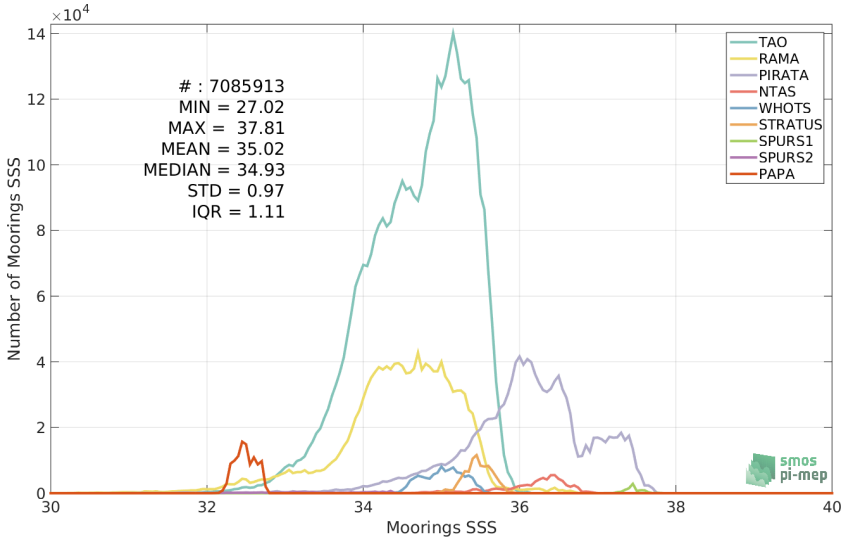


Figure 161: Distribution of SSS from Moorings per bins of 0.1.

7.4 Temporal mean of shallowest salinity

Figure 162 show a map of the mooring locations and the color of each circle indicates the temporal mean calculated using the full time series from 2010 to now of each mooring.

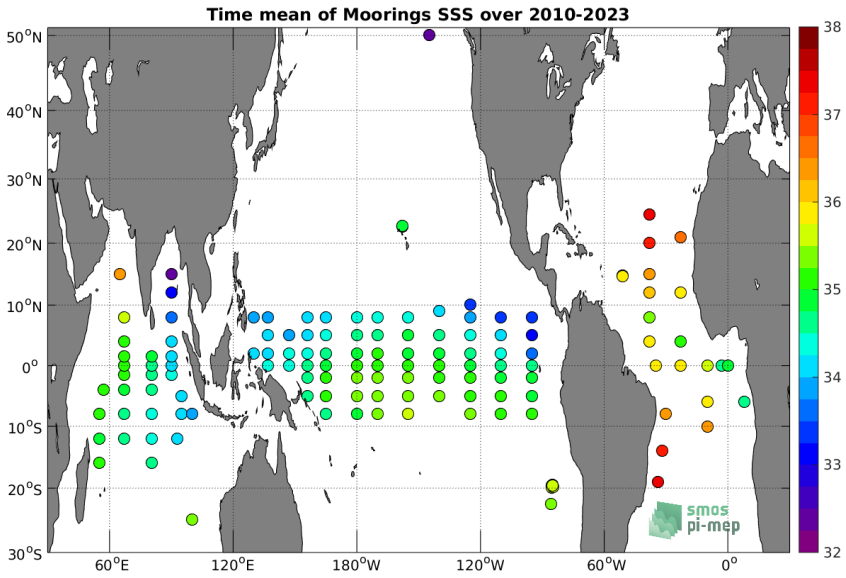


Figure 162: Temporal mean SSS from Moorings.

7.5 Temporal Std of shallowest salinity

Figure 163 show maps of the mooring locations and the color of each circle indicates the temporal standard deviation calculated using the full time series from 2010 to now of each mooring.

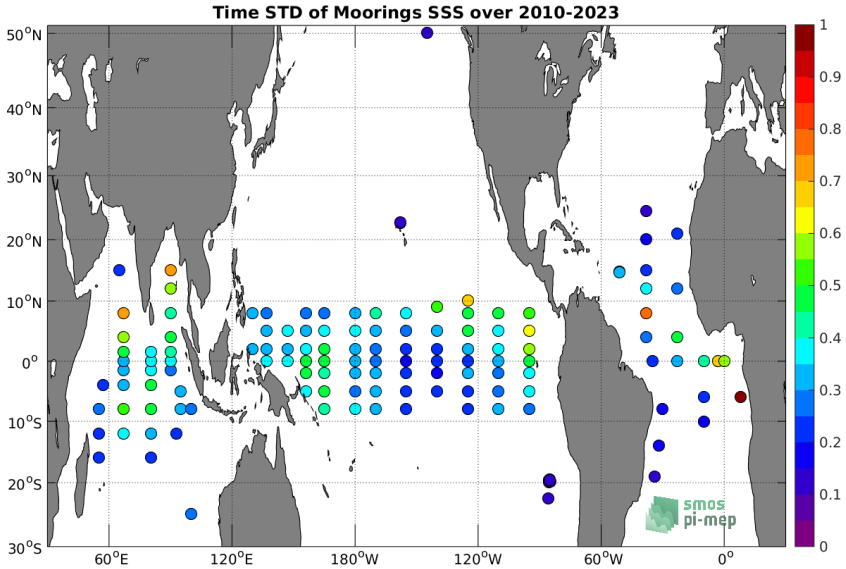


Figure 163: Temporal Std of SSS from Moorings.

7.6 Number of shallowest salinity

Figure 164 show maps of the mooring locations and the color of each circle indicates the number of SSS data measured by each mooring from 2010 to now.

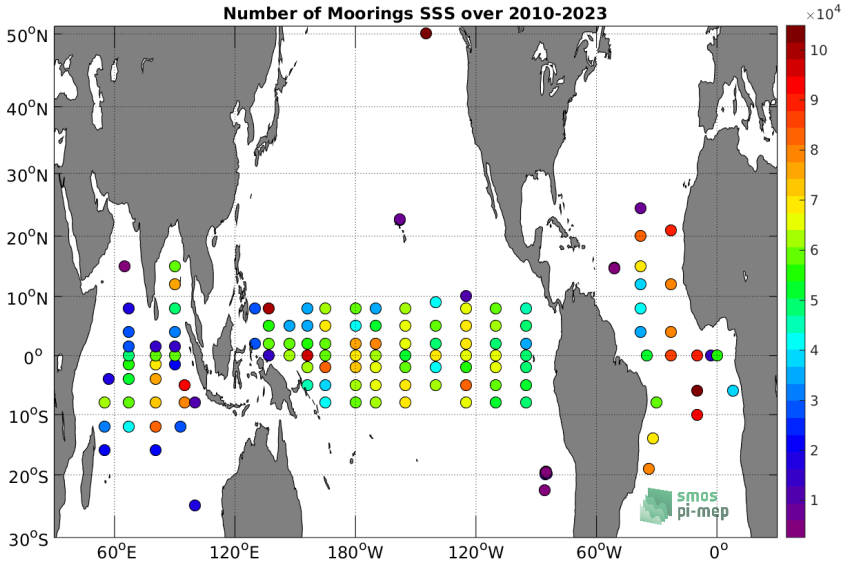


Figure 164: Number of SSS from Moorings.

7.7 Time series of shallowest salinity

The following figures (165) show time series of shallowest salinity for each mooring. To switch from a mooring to another, you can play with the arrows between the plot and the caption.

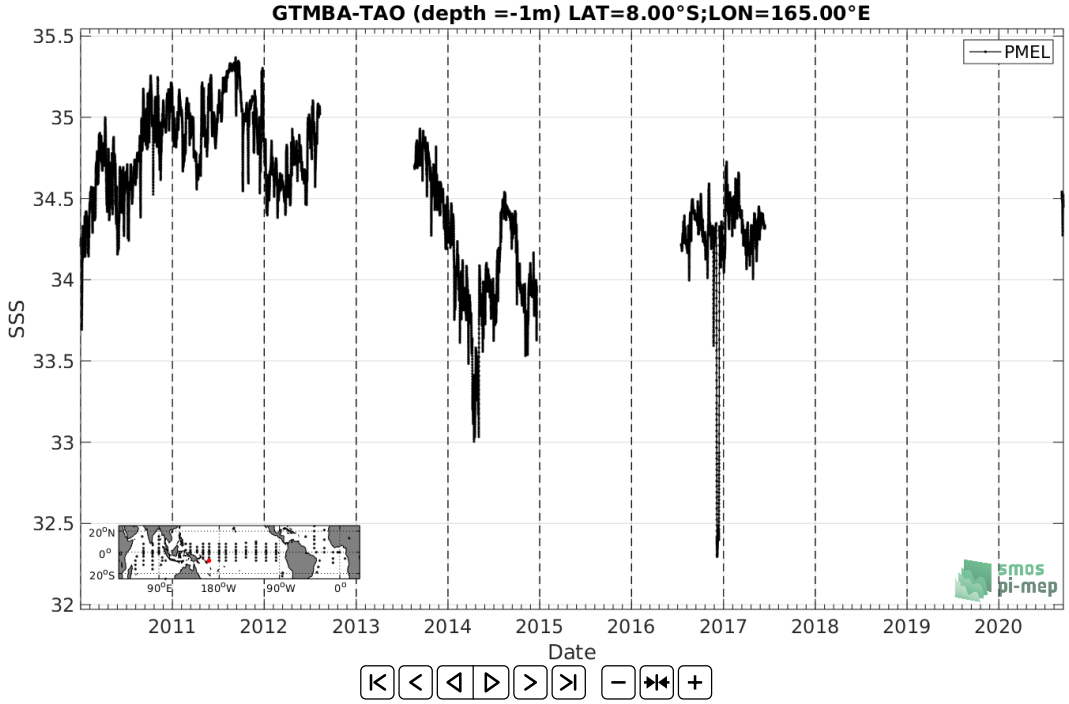


Figure 165: Time series of mooring shallowest salinity

8 SPURS-2

The SPURS-2 dataset is subdivided into 4 subdatasets following sensor type subdivisions.

- Salinity snake
- Saildrone
- Waveglider
- Seaglider

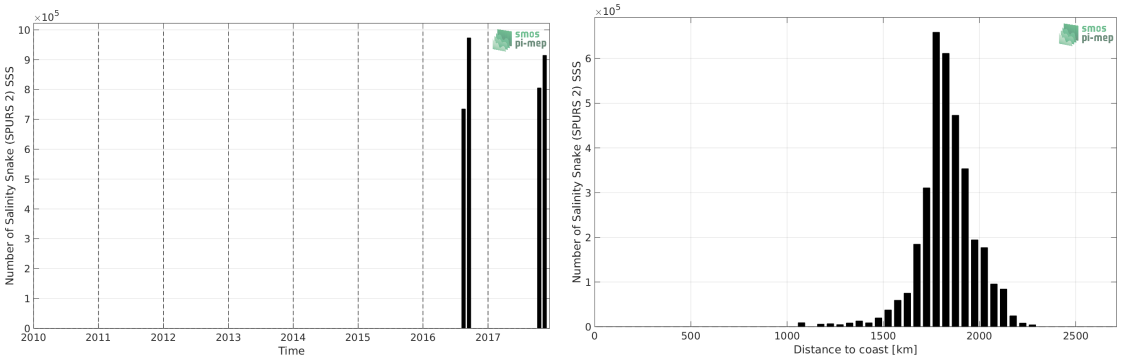
8.1 Salinity Snake

8.1.1 Introduction

The Salinity Snake (SS) measures sea surface salinity in the top 1 - 2 cm of the water column, which is the radiometric depth of L-Band satellite radiometers such as on Aquarius/SAC-D, SMAP and SMOS satellites that measure salinity remotely. The SS consists of four key components: a 10m boom mast, a hose, which is deployed from this boom, a powerful self-priming peristaltic pump which transports a constant stream of a seawater/air emulsion, and a shipboard apparatus, which filters, de-bubbles, sterilizes and analyses the salinity of the water. The SS (https://doi.org/10.5067/SPUR2-SNAKE) was deployed during both SPURS-2 Revelle cruises in August 2016 and October 2017. Focused around a central mooring located near 10°N,125°W, the objective of SPURS-2 (NASA-funded oceanographic process study) was to study the dynamics of the rainfall-dominated surface ocean at the western edge of the eastern Pacific fresh pool subject to high seasonal variability and strong zonal flows associated with the North Equatorial Current and Countercurrent.

8.1.2 Number of SSS data as a function of time and distance to coast

Figure 166 shows the time (a) and distance to coast (b) distributions of the Salinity snake *in situ* dataset.

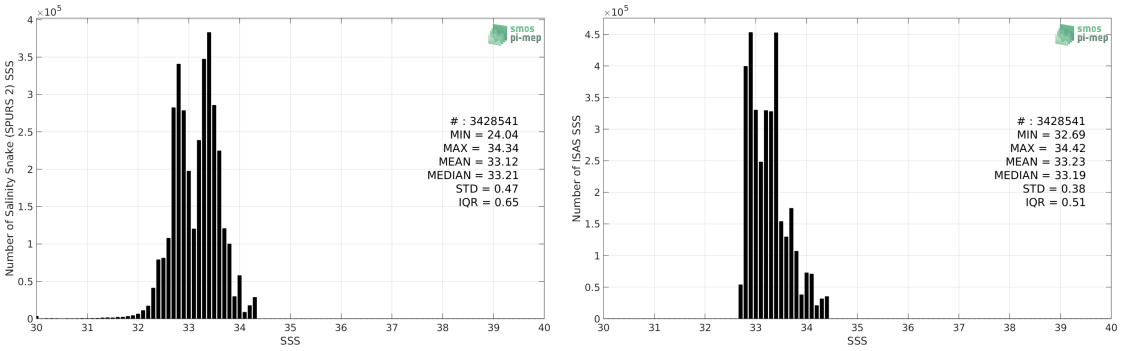


(a) (b)

Figure 166: Number of SSS from Salinity snake as a function of time (a) and distance to coast (b).

8.1.3 Histograms of SSS

Figure 167 shows the SSS distribution of the Salinity snake (a) and colocalized ISAS (b) dataset.

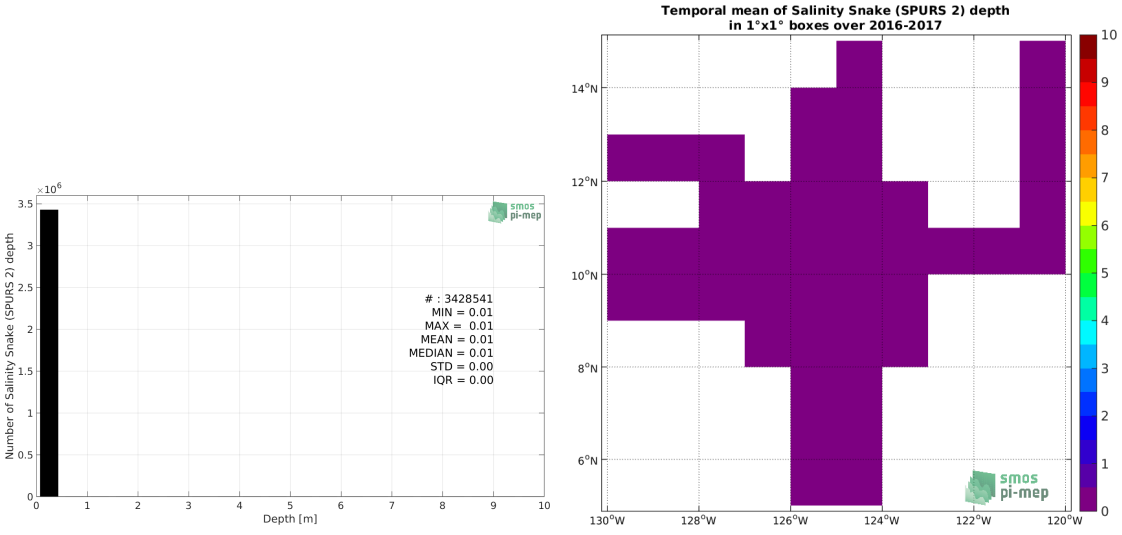


(a) (b)

Figure 167: Histograms of SSS from Salinity snake (a) and ISAS (b) per bins of 0.1.

8.1.4 Distribution of *in situ* SSS depth measurements

In Figure 168, we show the depth distribution of the *in situ* salinity dataset (a) and the spatial distribution of the depth temporal mean in 1°x1° boxes and considering the full *in situ* dataset period (b).



(a) (b)

Figure 168: Depth distribution of the upper level SSS measurements from Salinity snake (a) and spatial distribution of the *in situ* SSS depth measurements showing the mean value in 1°x1° boxes and considering the full *in situ* dataset period (b).

8.1.5 Spatial distribution of SSS

In Figure 169, the number of Salinity snake SSS measurements in 1°x1° boxes is shown.

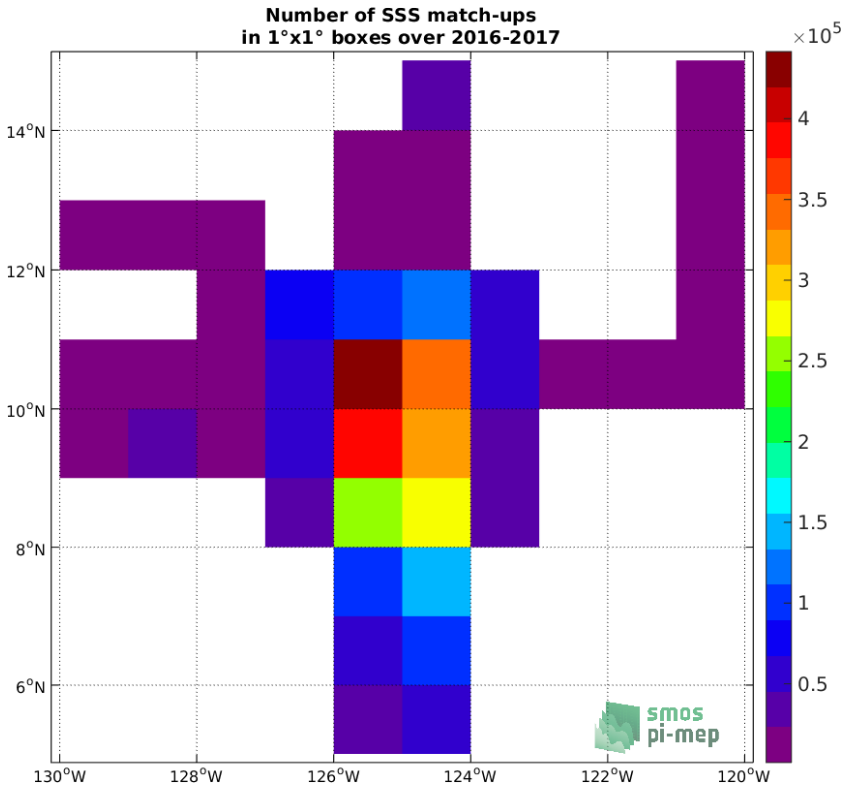
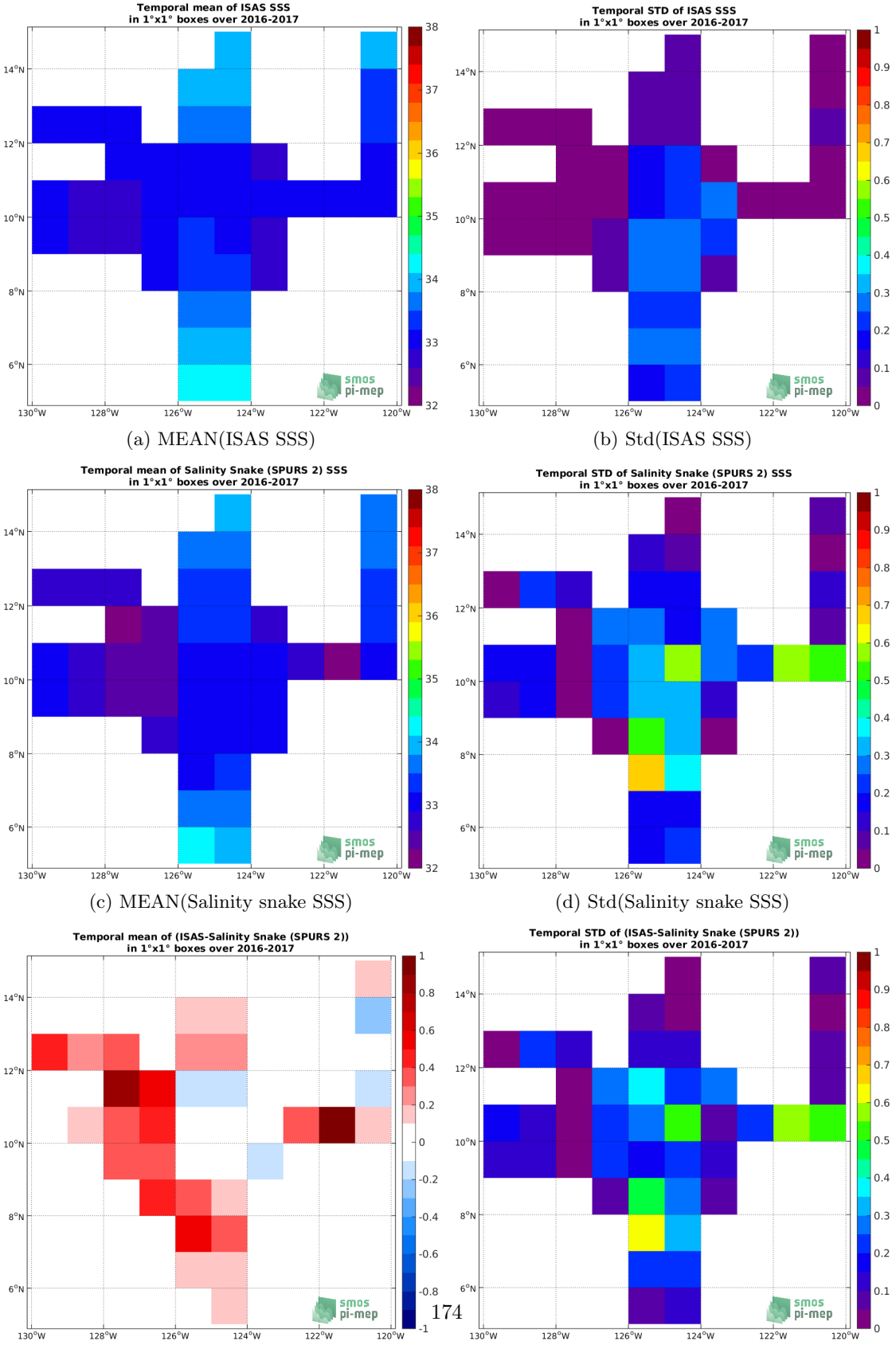


Figure 169: Number of SSS from Salinity snake in 1°x1° boxes.

8.1.6 Spatial Maps of the Temporal mean and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

In Figure 170, maps of temporal mean (left) and standard deviation (right) of ISAS (top), Salinity snake *in situ* dataset (middle) and the difference ΔSSS(ISAS -Salinity snake) (bottom) are shown. The temporal mean and std are calculated using all match-up pairs falling in spatial boxes of size 1°x1° over the full Salinity snake dataset period.



(a) MEAN(ISAS SSS)

(b) Std(ISAS SSS)

(c) MEAN(Salinity snake SSS)

(d) Std(Salinity snake SSS)

(e) MEAN(ΔSSS) (ISAS - Salinity snake)

(f) Std(ΔSSS) (ISAS - Salinity snake)

Figure 170: Temporal mean (left) and Std (right) of SSS from ISAS (top), Salinity snake (middle), and of ΔSSS (ISAS - Salinity snake). Only match-up pairs are used to generate these maps.

8.1.7 Time series of the monthly median and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

In the top panel of Figure 171, we show the time series of the monthly median SSS estimated for both ISAS SSS product (in black) and the Salinity snake *in situ* dataset (in blue) at the collected Pi-MEP match-up pairs.

In the middle panel of Figure 171, we show the time series of the monthly median of ΔSSS (ISAS - Salinity snake) for the collected Pi-MEP match-up pairs.

In the bottom panel of Figure 171, we show the time series of the monthly standard deviation of the ΔSSS (ISAS - Salinity snake) for the collected Pi-MEP match-up pairs.

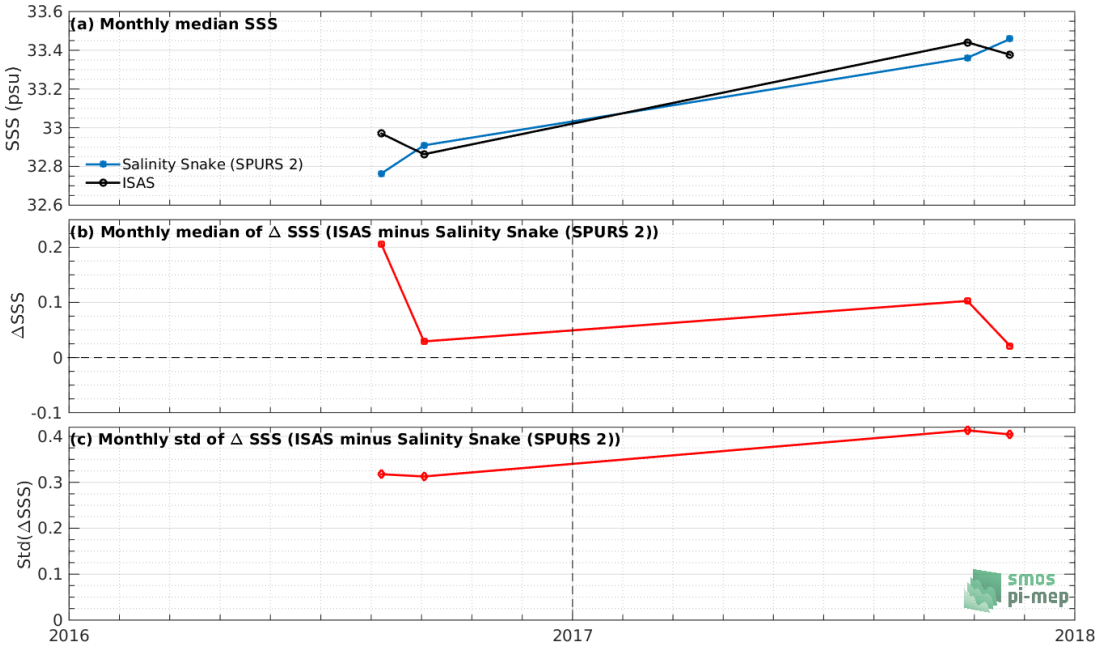


Figure 171: Time series of the monthly median SSS (top), median of ΔSSS (ISAS - Salinity snake) and Std of ΔSSS (ISAS - Salinity snake) considering all match-ups collected by the Pi-MEP.

8.1.8 Zonal mean and Std of *in situ* and ISAS SSS and of the difference ΔSSS

In Figure 172 left panel, we show the zonal mean SSS considering all Pi-MEP match-up pairs for both ISAS SSS product (in black) and the Salinity snake *in situ* dataset (in blue). The full *in situ* dataset period is used to derive the mean.

In the right panel of Figure 172, we show the zonal mean of ΔSSS (ISAS - Salinity snake) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

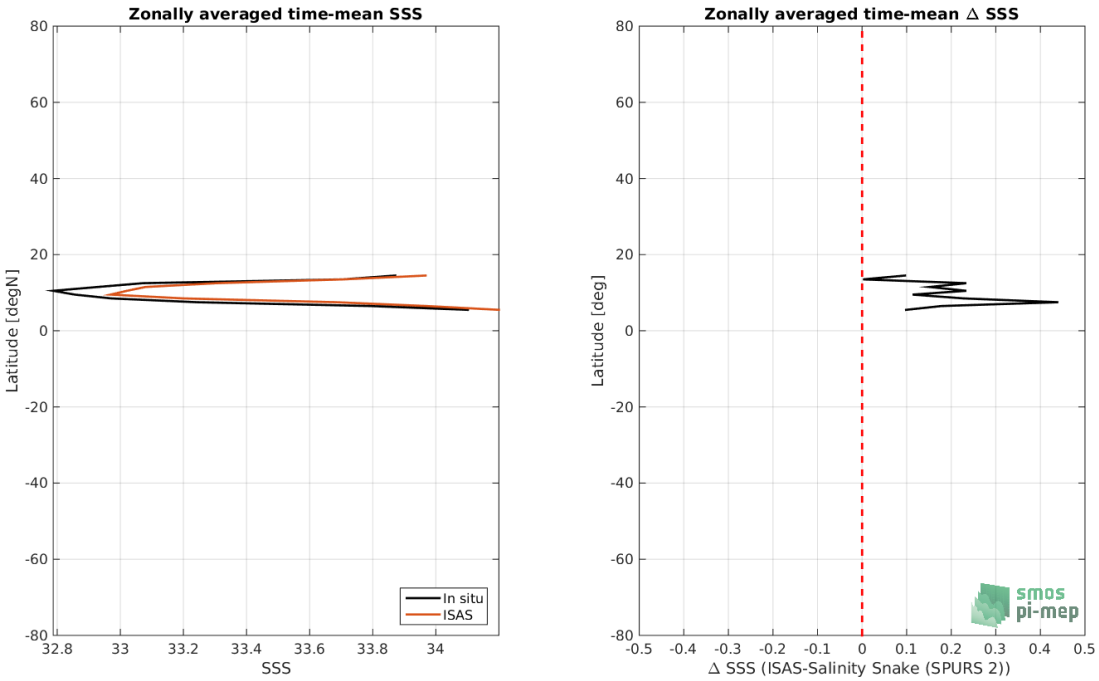
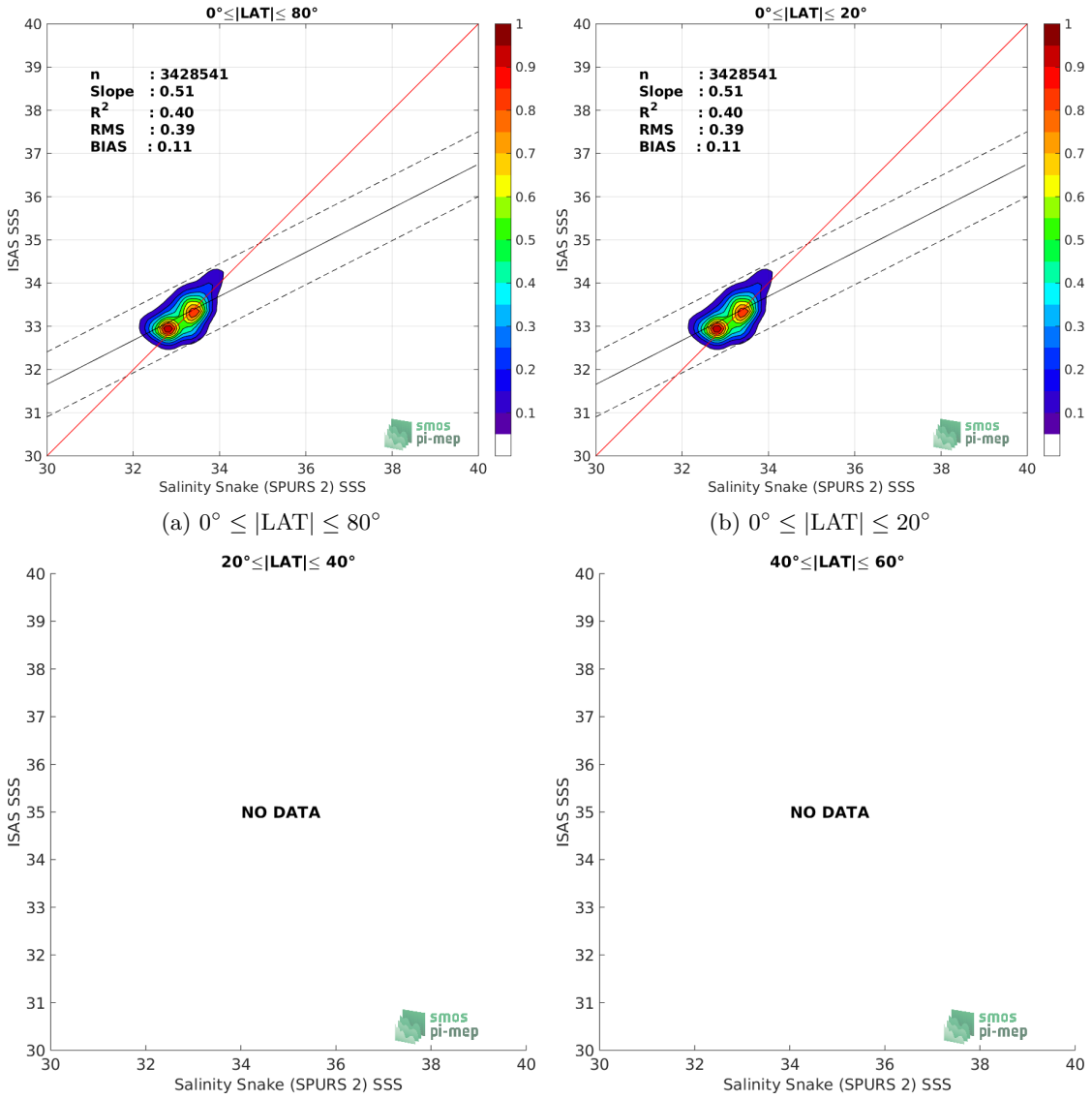


Figure 172: Left panel: Zonal mean SSS from ISAS product (black) and from Salinity snake (blue). Right panel: Zonal mean of ΔSSS (ISAS - Salinity snake) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

8.1.9 Scatterplots of ISAS vs *in situ* SSS by latitudinal bands

In Figure 173, contour maps of the concentration of ISAS SSS (y-axis) versus Salinity snake SSS (x-axis) at match-up pairs for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.



(a) $0° \leq |\text{LAT}| \leq 80°$ (b) $0° \leq |\text{LAT}| \leq 20°$

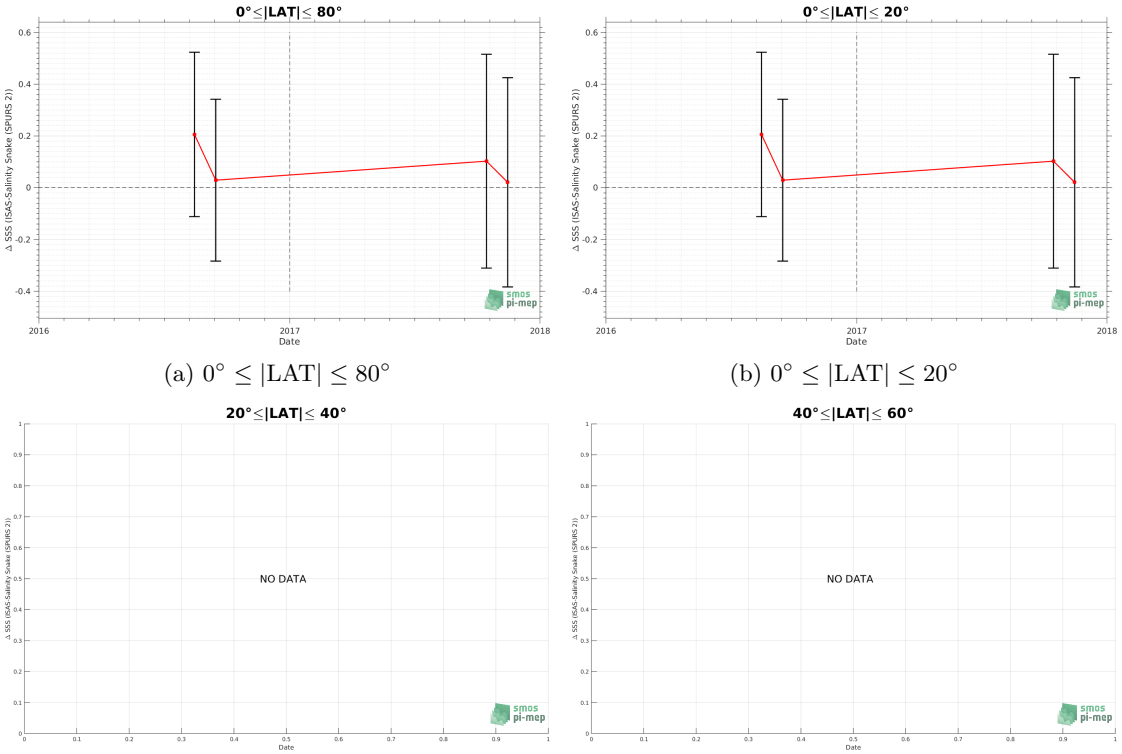
(c) $20° \leq |\text{LAT}| \leq 40°$ (d) $40° \leq |\text{LAT}| \leq 60°$

Figure 173: Contour maps of the concentration of ISAS SSS (y-axis) versus Salinity snake SSS (x-axis) at match-up pairs for different latitude bands. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.

8.1.10 Time series of the monthly median and Std of the difference ΔSSS sorted by latitudinal bands

In Figure 174, time series of the monthly median (red curves) of ΔSSS (ISAS - Salinity snake) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up

pairs estimated for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.



(a) $0° \leq |\text{LAT}| \leq 80°$

(b) $0° \leq |\text{LAT}| \leq 20°$

(c) $20° \leq |\text{LAT}| \leq 40°$

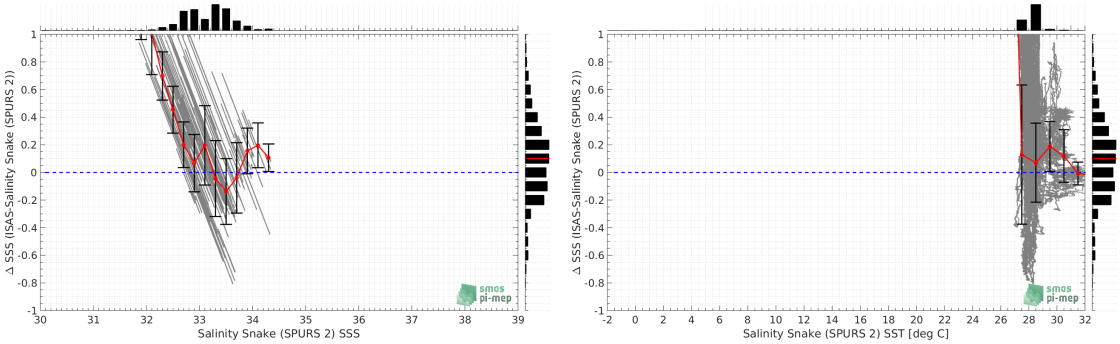
(d) $40° \leq |\text{LAT}| \leq 60°$

Figure 174: Monthly median (red curves) of ΔSSS (ISAS - Salinity snake) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.

8.1.11 ΔSSS sorted as geophysical conditions

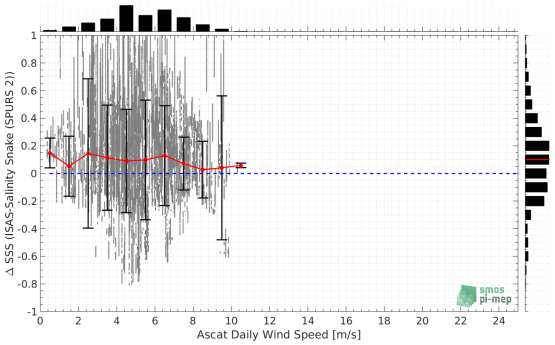
In Figure 175, we classify the match-up differences ΔSSS (ISAS - *in situ*) as function of the geophysical conditions at match-up points. The mean and std of ΔSSS (ISAS - Salinity snake) is thus evaluated as function of the

- *in situ* SSS values per bins of width 0.2,
- *in situ* SST values per bins of width 1°C,
- ASCAT daily wind values per bins of width 1 m/s,
- CMORPH 3-hourly rain rates per bins of width 1 mm/h, and,
- distance to coasts per bins of width 50 km,
- *in situ* measurement depth (if relevant).

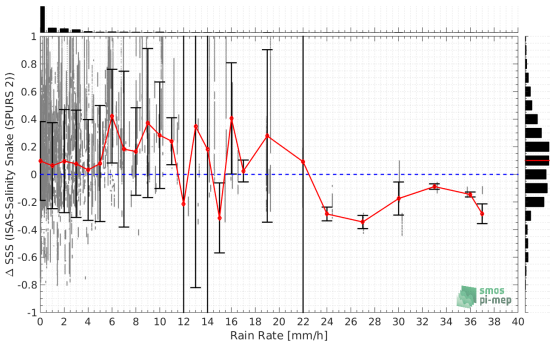


(a) Salinity snake SSS

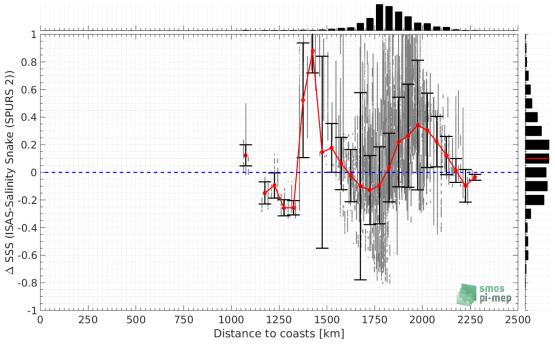
(b) Salinity snake SST



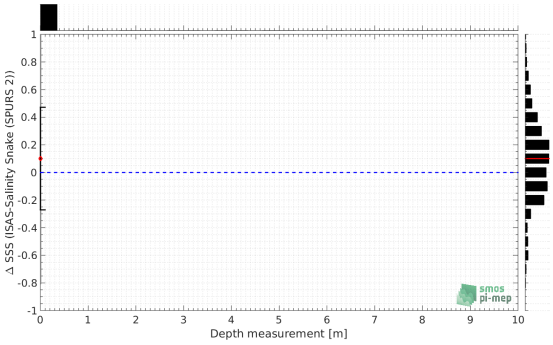
(c) ASCAT Wind Speed



(d) CMORPH Rain rate



(e) Distance to coast



(f) Depth

Figure 175: Δ SSS (ISAS - Salinity snake) sorted as geophysical conditions: Salinity snake SSS a), Salinity snake SST b), ASCAT Wind speed c), CMORPH rain rate d), distance to coast (e) and depth measurements (f).

8.1.12 ΔSSS maps and statistics for different geophysical conditions

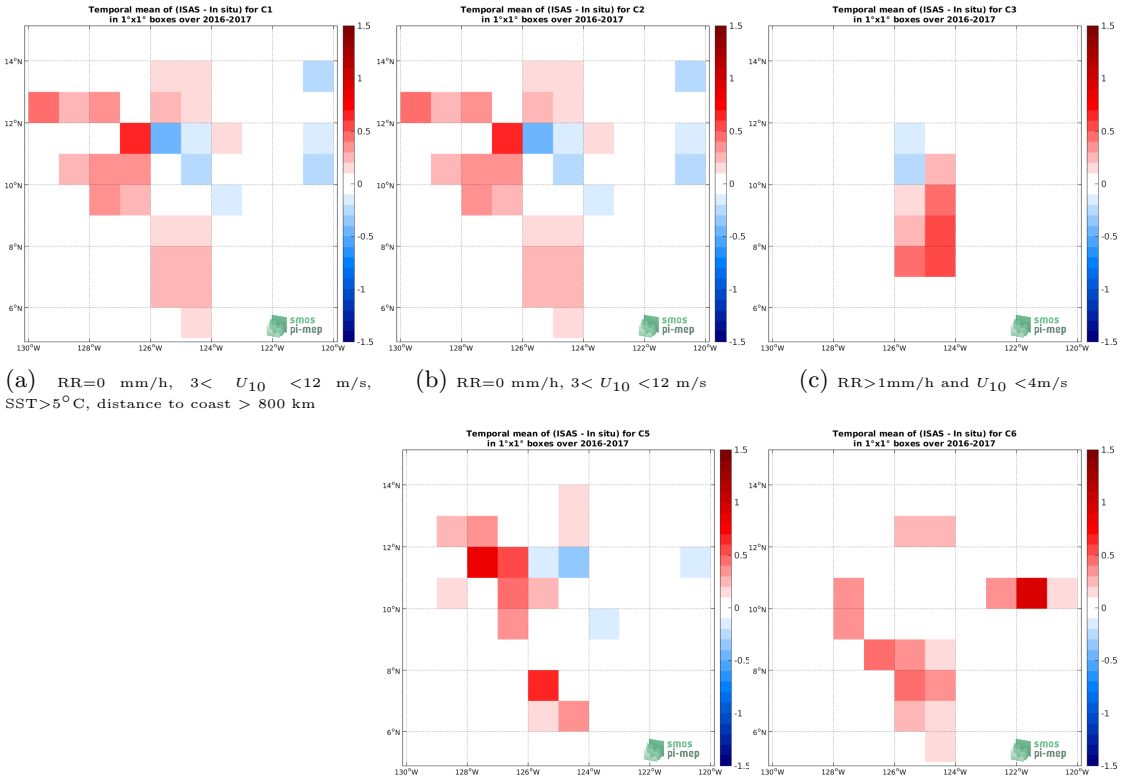
In Figures 176 and 177, we focus on sub-datasets of the match-up differences ΔSSS (ISAS - *in situ*) for the following specific geophysical conditions:

- **C1**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is in the range [3, 12] m/s, the SST is $> 5°$C and distance to coast is > 800 km.
- **C2**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is

in the range [3, 12] m/s.

- **C3**:if the local value at *in situ* location of estimated rain rate is high (ie. $>$ 1 mm/h) and mean daily wind is low (ie. $<$ 4 m/s).
- **C5**:if the *in situ* data is located where the climatological SSS standard deviation is low (ie. above $<$ 0.2).
- **C6**:if the *in situ* data is located where the climatological SSS standard deviation is high (ie. above $>$ 0.2).

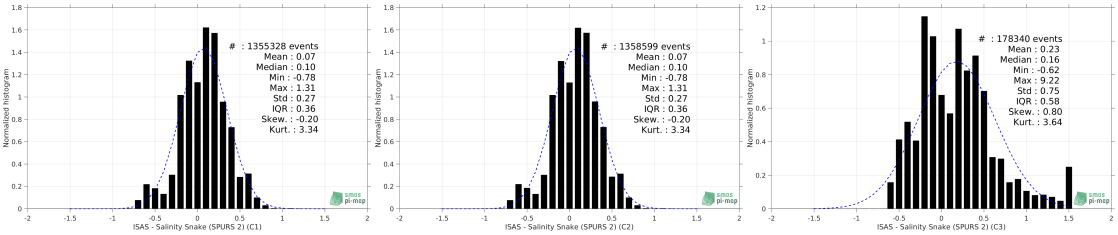
For each of these conditions, the temporal mean (gridded over spatial boxes of size 1°x1°) and the histogram of the difference ΔSSS (ISAS - *in situ*) are presented.



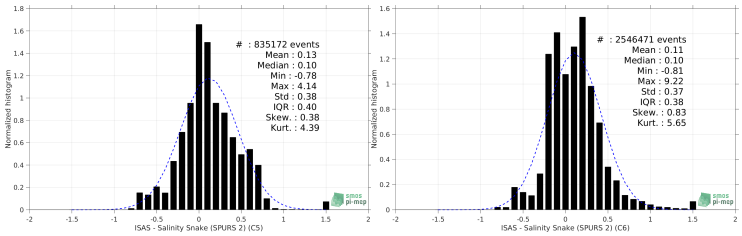
(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s

(d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 176: Temporal mean gridded over spatial boxes of size 1°x1° of ΔSSS (ISAS - Salinity snake) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).



(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s



(d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 177: Normalized histogram of ΔSSS (ISAS - Salinity snake) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).

8.1.13 Summary

Table 1 shows the mean, median, standard deviation (Std), root mean square (RMS), interquartile range (IQR), correlation coefficient (r^2) and robust standard deviation (Std*) of the match-up differences ΔSSS (ISAS - Salinity snake) for the following conditions:

- all: All the match-up pairs satellite/in situ SSS values are used to derive the statistics
- C1: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km
- C2: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s
- C3: only pairs where RR>1mm/h and U_{10} <4m/s
- C5: only pairs where WOA2013 SSS Std<0.2
- C6: only pairs where WOA2013 SSS Std>0.2
- C7a: only pairs with a distance to coast < 150 km.
- C7b: only pairs with a distance to coast in the range [150, 800] km.
- C7c: only pairs with a distance to coast > 800 km.
- C8a: only pairs where SST is < 5°C.
- C8b: only pairs where SST is in the range [5, 15]°C.
- C8c: only pairs where SST is > 15°C.

- C9a: only pairs where SSS is < 33.
- C9b: only pairs where SSS is in the range [33, 37].
- C9c: only pairs where SSS is > 37.

Table 1: Statistics of ΔSSS (ISAS - Salinity snake)

Condition	#	Median	Mean	Std	RMS	IQR	r^2	Std*
all	3428541	0.10	0.11	0.37	0.39	0.39	0.403	0.29
C1	1355328	0.10	0.07	0.27	0.28	0.36	0.681	0.27
C2	1358599	0.10	0.07	0.27	0.28	0.36	0.681	0.27
C3	178340	0.16	0.23	0.75	0.78	0.58	0.003	0.45
C5	835172	0.10	0.13	0.38	0.40	0.40	0.405	0.30
C6	2546471	0.10	0.11	0.37	0.38	0.38	0.374	0.29
C7a	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
C7b	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
C7c	3428541	0.10	0.11	0.37	0.39	0.39	0.403	0.29
C8a	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
C8b	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
C8c	3402834	0.10	0.11	0.37	0.39	0.39	0.400	0.30
C9a	1385563	0.20	0.29	0.42	0.51	0.36	0.041	0.26
C9b	2042978	-0.03	-0.01	0.27	0.27	0.37	0.427	0.26
C9c	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN

Table 1 numerical values can be downloaded as a csv file here.

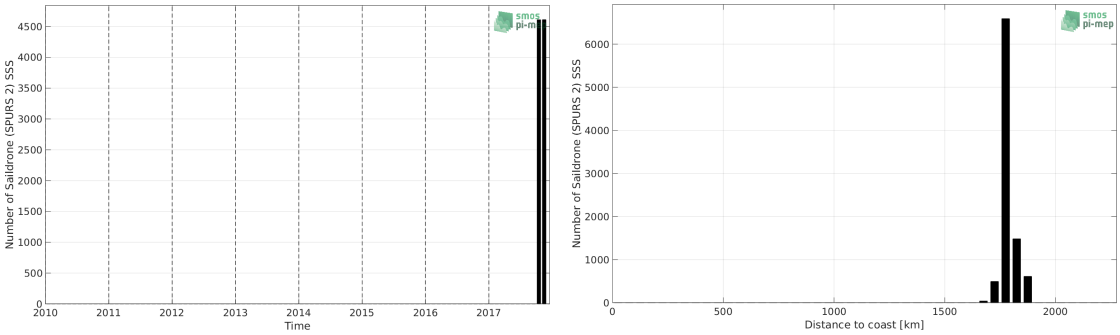
8.2 Saildrone

8.2.1 Introduction

Saildrone is a state-of-the-art, remotely guided, wind and solar powered unmanned surface vehicle (USV) capable of long distance deployments lasting up to 12 months. It is equipped with a suite of instruments and sensors providing high quality, georeferenced, near real-time, multi-parameter surface ocean and atmospheric observations while transiting at typical speeds of 3-5 knots. Two saildrones (https://doi.org/10.5067/SPUR2-SDRON) were deployed over a month period during the second SPURS-2 R/V Revelle cruise in 2017. The SPURS-2 campaign involved two month-long cruises by the R/V Revelle in August 2016 and October 2017 combined with complementary sampling on a more continuous basis over this period by the schooner Lady Amber. Focused around a central mooring located near 10°N,125°W, the objective of SPURS-2 (NASA-funded oceanographic process study) was to study the dynamics of the rainfall-dominated surface ocean at the western edge of the eastern Pacific fresh pool subject to high seasonal variability and strong zonal flows associated with the North Equatorial Current and Countercurrent.

8.2.2 Number of SSS data as a function of time and distance to coast

Figure 178 shows the time (a) and distance to coast (b) distributions of the Saildrone *in situ* dataset.

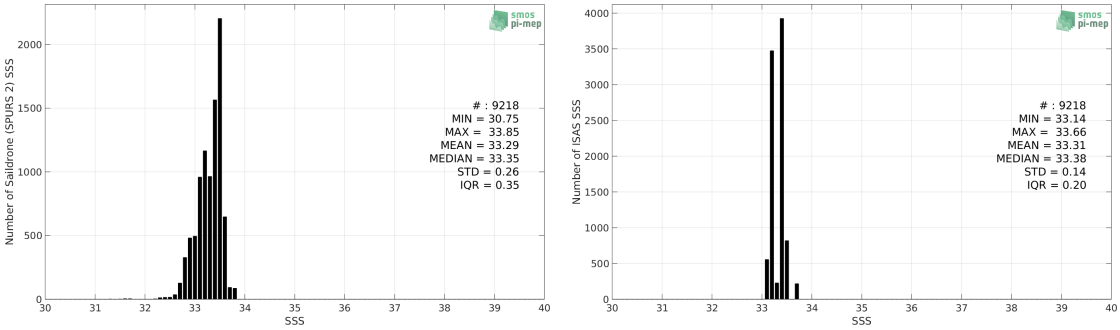


(a) (b)

Figure 178: Number of SSS from Saildrone as a function of time (a) and distance to coast (b).

8.2.3 Histograms of SSS

Figure 179 shows the SSS distribution of the Saildrone (a) and colocalized ISAS (b) dataset.

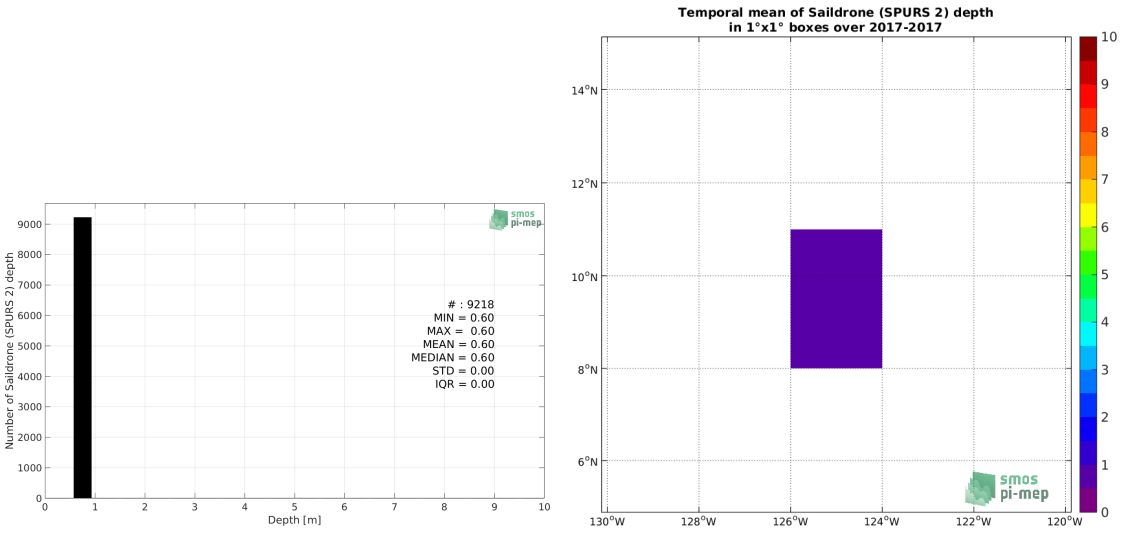


(a) (b)

Figure 179: Histograms of SSS from Saildrone (a) and ISAS (b) per bins of 0.1.

8.2.4 Distribution of *in situ* SSS depth measurements

In Figure 180, we show the depth distribution of the *in situ* salinity dataset (a) and the spatial distribution of the depth temporal mean in 1°x1° boxes and considering the full *in situ* dataset period (b).



(a) (b)

Figure 180: Depth distribution of the upper level SSS measurements from Saildrone (a) and spatial distribution of the *in situ* SSS depth measurements showing the mean value in 1°x1° boxes and considering the full *in situ* dataset period (b).

8.2.5 Spatial distribution of SSS

In Figure 181, the number of Saildrone SSS measurements in 1°x1° boxes is shown.

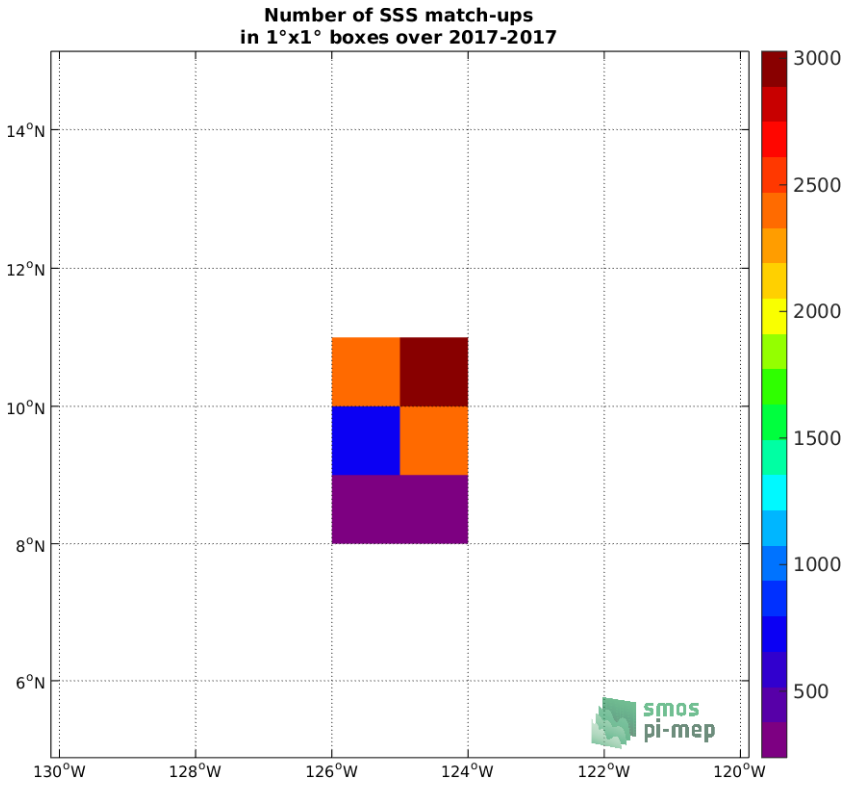
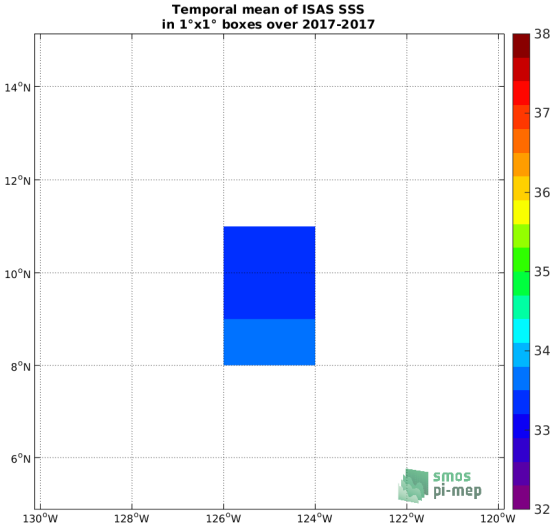


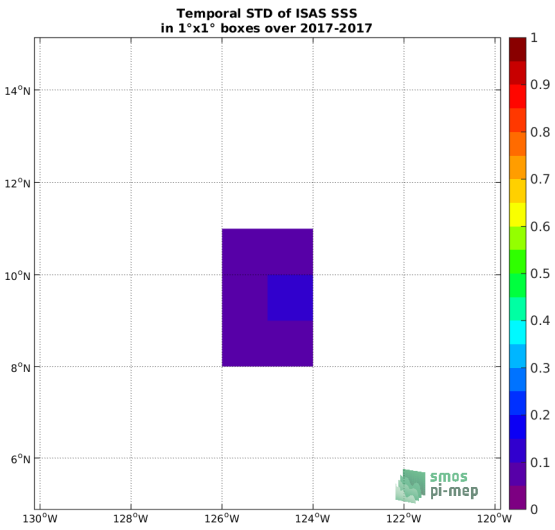
Figure 181: Number of SSS from Saildrone in 1°x1° boxes.

8.2.6 Spatial Maps of the Temporal mean and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

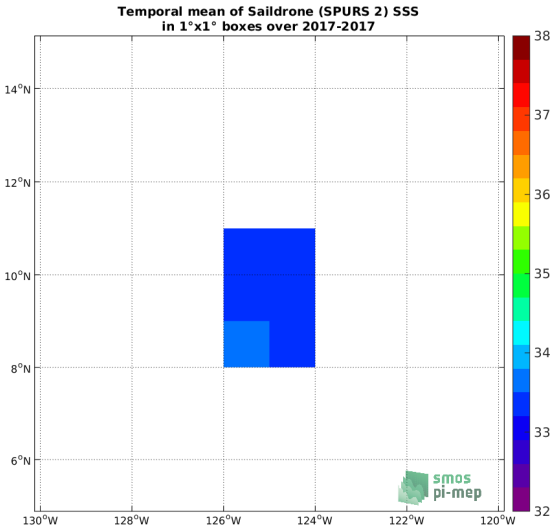
In Figure 182, maps of temporal mean (left) and standard deviation (right) of ISAS (top), Saildrone *in situ* dataset (middle) and the difference ΔSSS(ISAS -Saildrone) (bottom) are shown. The temporal mean and std are calculated using all match-up pairs falling in spatial boxes of size 1°x1° over the full Saildrone dataset period.



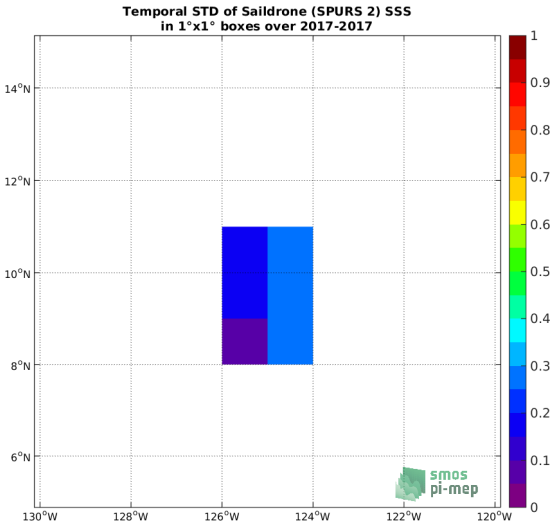
(a) MEAN(ISAS SSS)



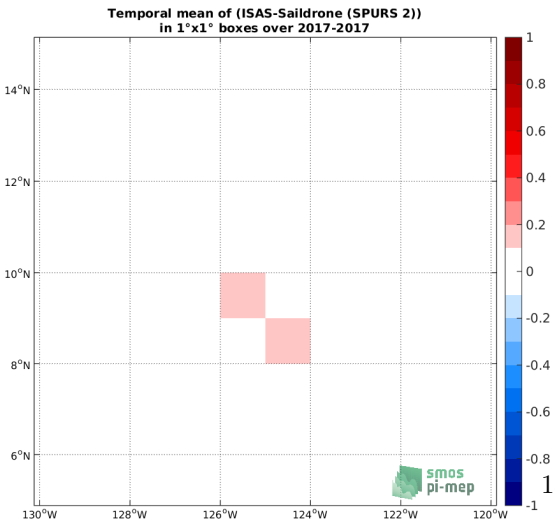
(b) Std(ISAS SSS)



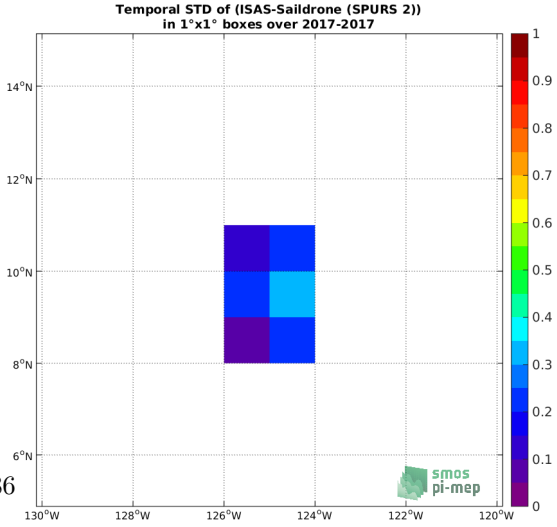
(c) MEAN(Saildrone SSS)



(d) Std(Saildrone SSS)



(e) MEAN(ΔSSS) (ISAS - Saildrone)



(f) Std(ΔSSS) (ISAS - Saildrone)

Figure 182: Temporal mean (left) and Std (right) of SSS from ISAS (top), Saildrone (middle), and of ΔSSS (ISAS - Saildrone). Only match-up pairs are used to generate these maps.

8.2.7 Time series of the monthly median and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

In the top panel of Figure 183, we show the time series of the monthly median SSS estimated for both ISAS SSS product (in black) and the Saildrone *in situ* dataset (in blue) at the collected Pi-MEP match-up pairs.

In the middle panel of Figure 183, we show the time series of the monthly median of ΔSSS (ISAS - Saildrone) for the collected Pi-MEP match-up pairs.

In the bottom panel of Figure 183, we show the time series of the monthly standard deviation of the ΔSSS (ISAS - Saildrone) for the collected Pi-MEP match-up pairs.

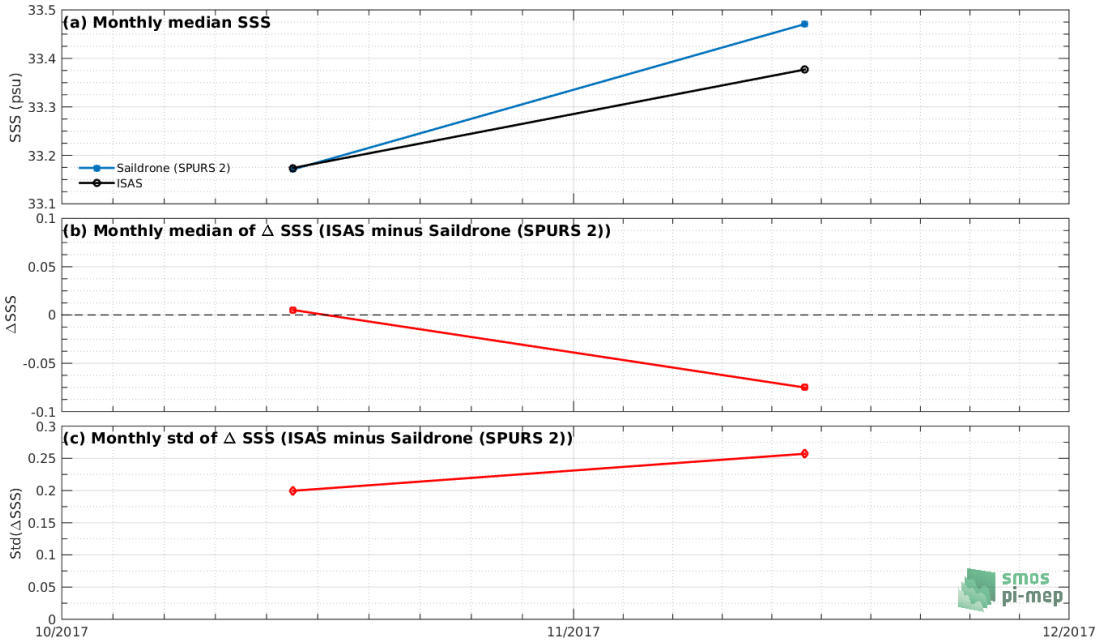


Figure 183: Time series of the monthly median SSS (top), median of ΔSSS (ISAS - Saildrone) and Std of ΔSSS (ISAS - Saildrone) considering all match-ups collected by the Pi-MEP.

8.2.8 Zonal mean and Std of *in situ* and ISAS SSS and of the difference ΔSSS

In Figure 184 left panel, we show the zonal mean SSS considering all Pi-MEP match-up pairs for both ISAS SSS product (in black) and the Saildrone *in situ* dataset (in blue). The full *in situ* dataset period is used to derive the mean.

In the right panel of Figure 184, we show the zonal mean of ΔSSS (ISAS - Saildrone) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

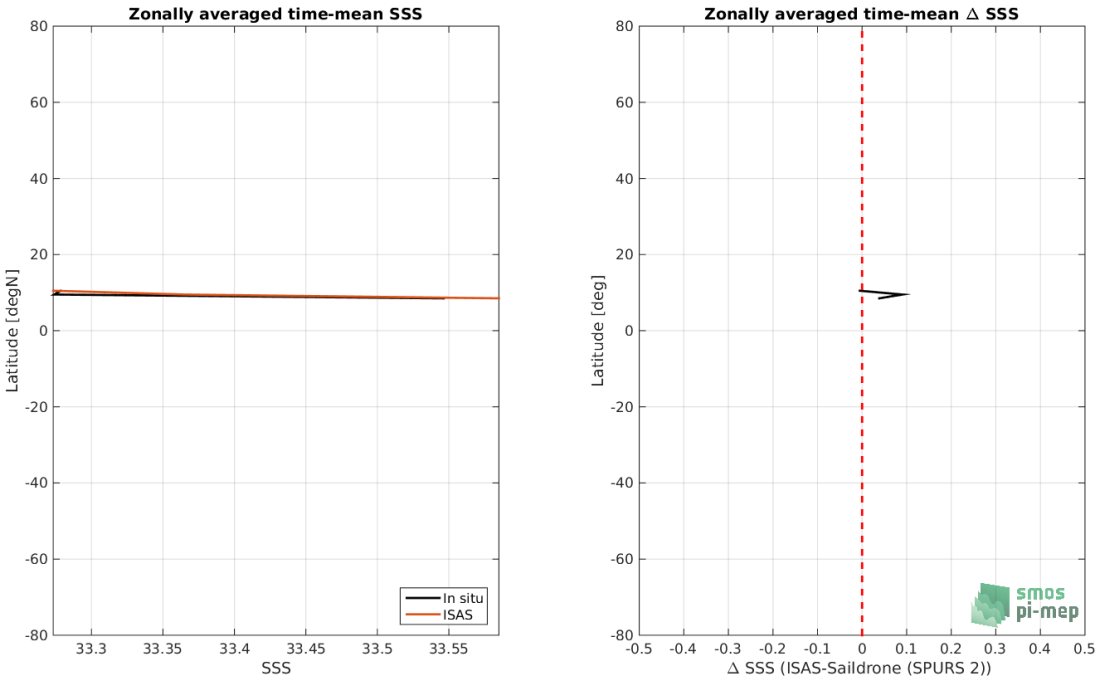
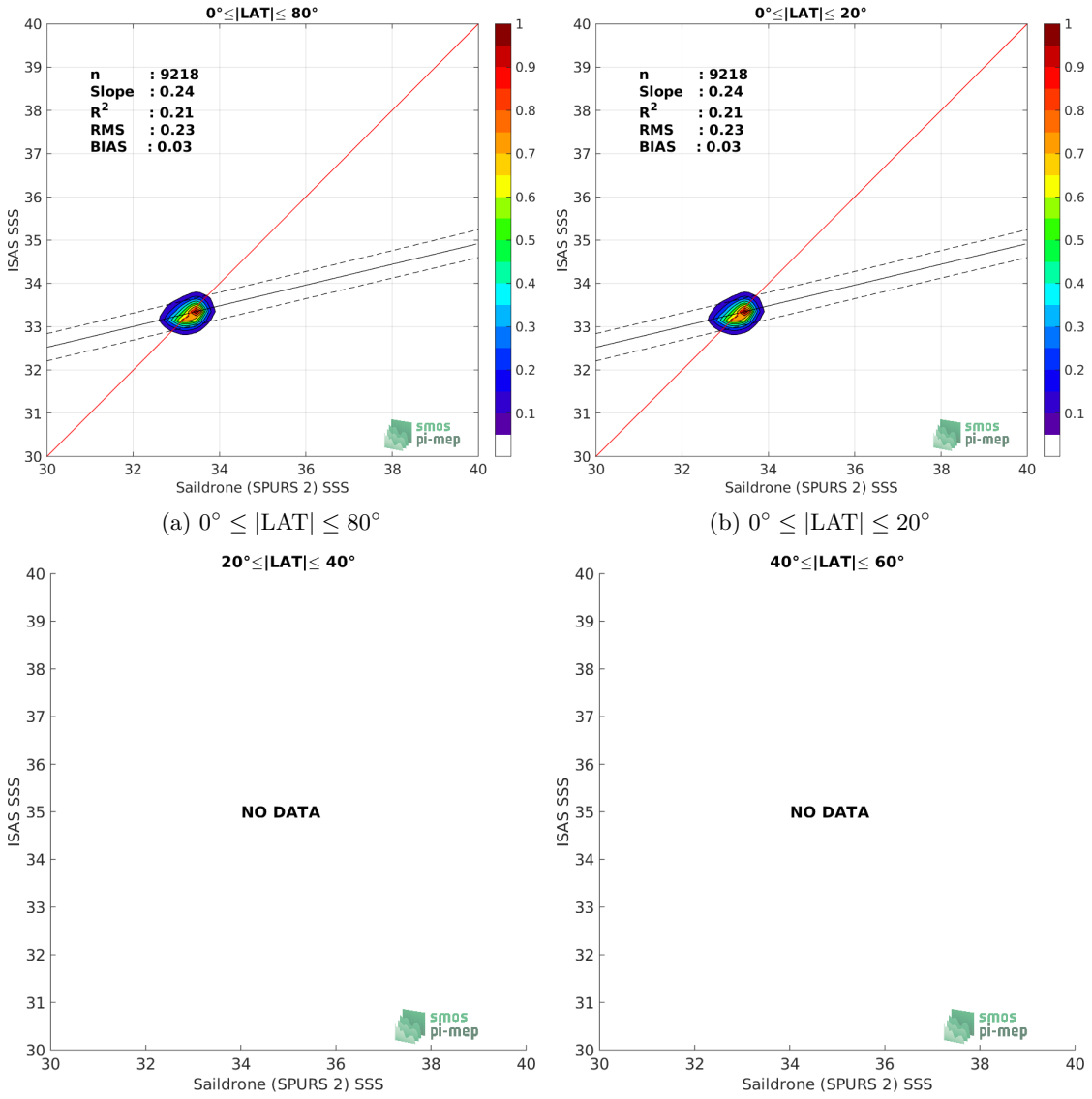


Figure 184: Left panel: Zonal mean SSS from ISAS product (black) and from Saildrone (blue). Right panel: Zonal mean of ΔSSS (ISAS - Saildrone) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

8.2.9 Scatterplots of ISAS vs *in situ* SSS by latitudinal bands

In Figure 185, contour maps of the concentration of ISAS SSS (y-axis) versus Saildrone SSS (x-axis) at match-up pairs for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.



(a) $0° \leq |\text{LAT}| \leq 80°$

(b) $0° \leq |\text{LAT}| \leq 20°$

(c) $20° \leq |\text{LAT}| \leq 40°$

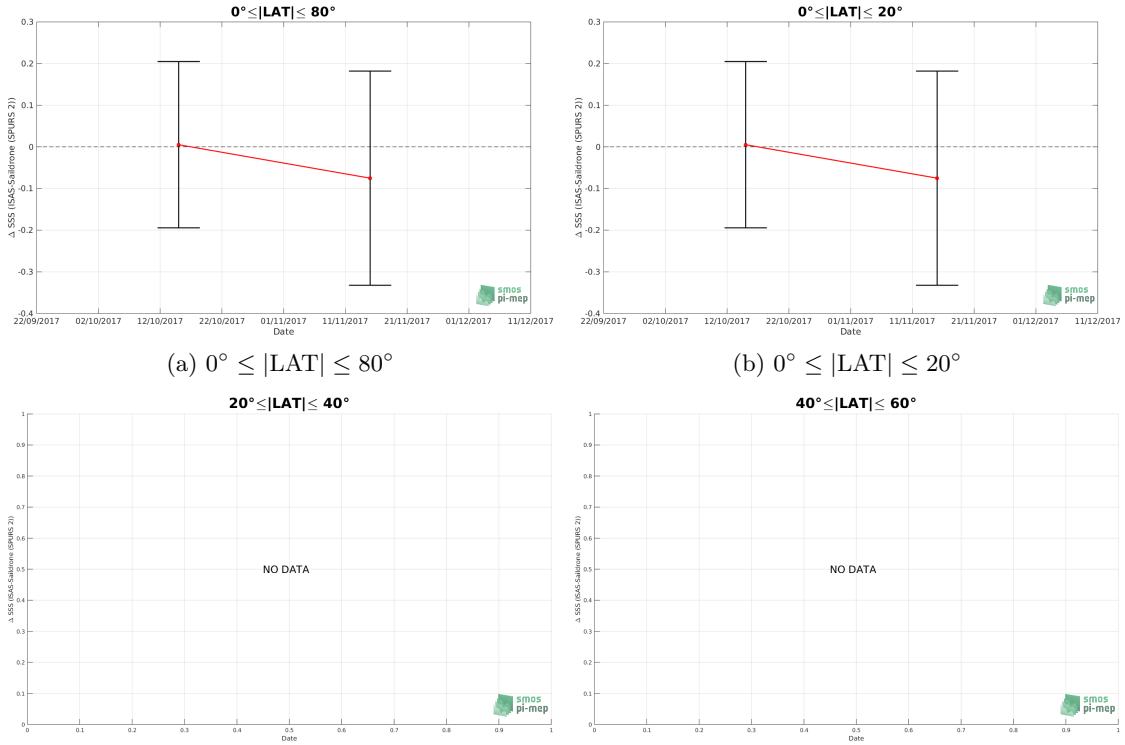
(d) $40° \leq |\text{LAT}| \leq 60°$

Figure 185: Contour maps of the concentration of ISAS SSS (y-axis) versus Saildrone SSS (x-axis) at match-up pairs for different latitude bands. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.

8.2.10 Time series of the monthly median and Std of the difference ΔSSS sorted by latitudinal bands

In Figure 186, time series of the monthly median (red curves) of ΔSSS (ISAS - Saildrone) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up

pairs estimated for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.



(a) $0° \leq |\text{LAT}| \leq 80°$

(b) $0° \leq |\text{LAT}| \leq 20°$

(c) $20° \leq |\text{LAT}| \leq 40°$

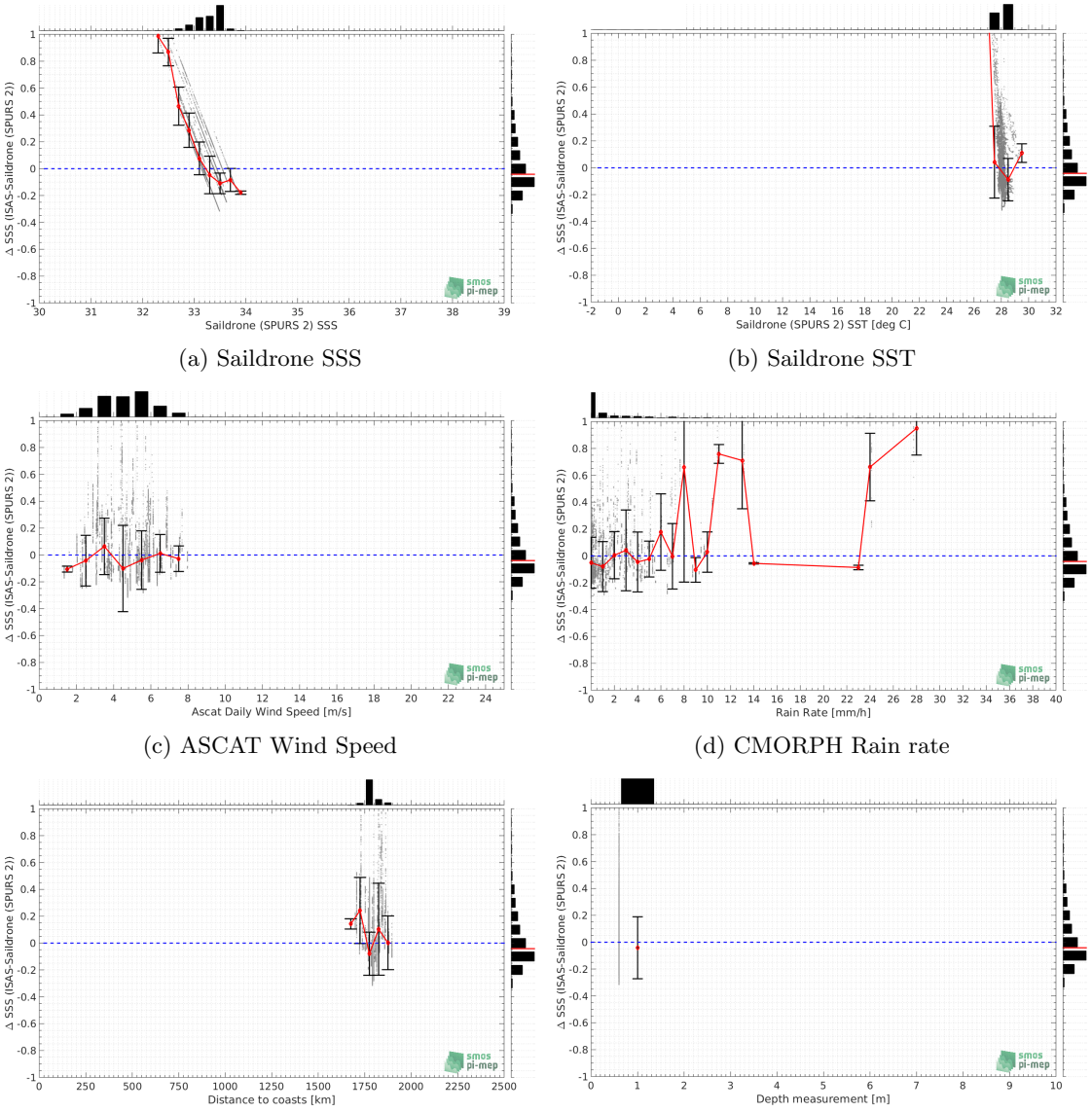
(d) $40° \leq |\text{LAT}| \leq 60°$

Figure 186: Monthly median (red curves) of ΔSSS (ISAS - Saildrone) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.

8.2.11 ΔSSS sorted as geophysical conditions

In Figure 187, we classify the match-up differences ΔSSS (ISAS - *in situ*) as function of the geophysical conditions at match-up points. The mean and std of ΔSSS (ISAS - Saildrone) is thus evaluated as function of the

- *in situ* SSS values per bins of width 0.2,
- *in situ* SST values per bins of width 1°C,
- ASCAT daily wind values per bins of width 1 m/s,
- CMORPH 3-hourly rain rates per bins of width 1 mm/h, and,
- distance to coasts per bins of width 50 km,
- *in situ* measurement depth (if relevant).



(a) Saildrone SSS

(b) Saildrone SST

(c) ASCAT Wind Speed

(d) CMORPH Rain rate

(e) Distance to coast

(f) Depth

Figure 187: Δ SSS (ISAS - Saildrone) sorted as geophysical conditions: Saildrone SSS a), Saildrone SST b), ASCAT Wind speed c), CMORPH rain rate d), distance to coast (e) and depth measurements (f).

8.2.12 ΔSSS maps and statistics for different geophysical conditions

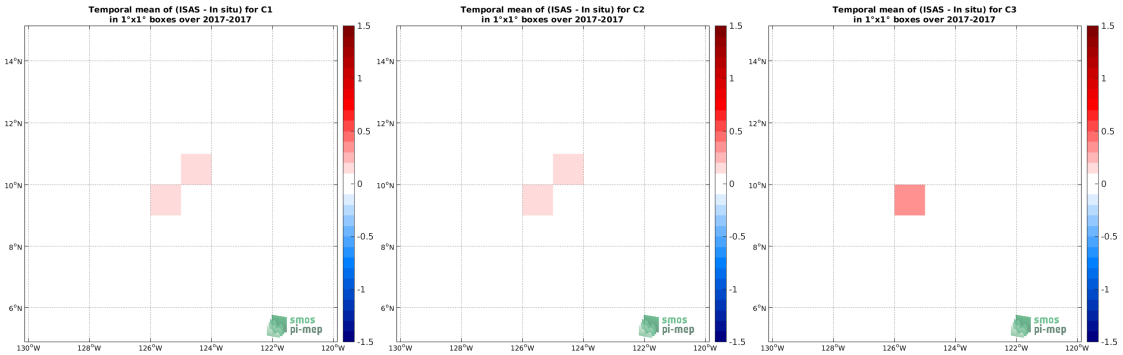
In Figures 188 and 189, we focus on sub-datasets of the match-up differences ΔSSS (ISAS - *in situ*) for the following specific geophysical conditions:

- **C1**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is in the range [3, 12] m/s, the SST is $> 5°C$ and distance to coast is > 800 km.
- **C2**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is

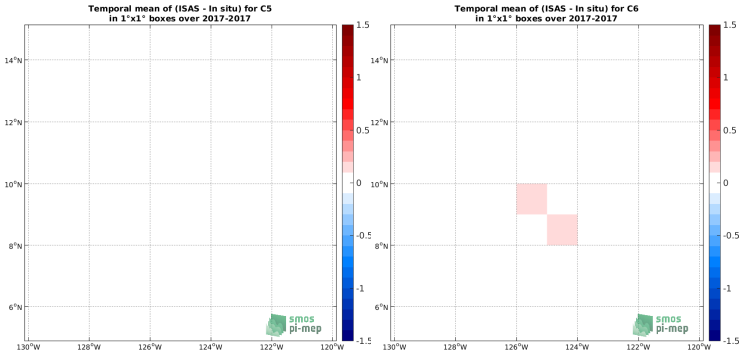
in the range [3, 12] m/s.

- **C3**:if the local value at *in situ* location of estimated rain rate is high (ie. $>$ 1 mm/h) and mean daily wind is low (ie. $<$ 4 m/s).
- **C5**:if the *in situ* data is located where the climatological SSS standard deviation is low (ie. above $<$ 0.2).
- **C6**:if the *in situ* data is located where the climatological SSS standard deviation is high (ie. above $>$ 0.2).

For each of these conditions, the temporal mean (gridded over spatial boxes of size 1°x1°) and the histogram of the difference ΔSSS (ISAS - *in situ*) are presented.

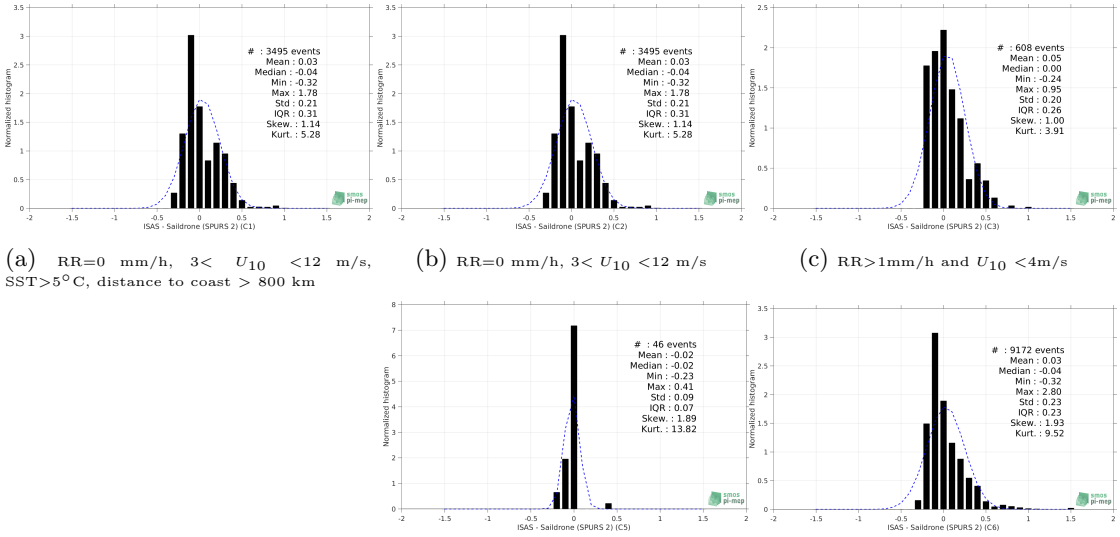


(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s



(d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 188: Temporal mean gridded over spatial boxes of size 1°x1° of ΔSSS (ISAS - Saildrone) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast $>$ 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).



(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s

(d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 189: Normalized histogram of ΔSSS (ISAS - Saildrone) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).

8.2.13 Summary

Table 1 shows the mean, median, standard deviation (Std), root mean square (RMS), interquartile range (IQR), correlation coefficient (r^2) and robust standard deviation (Std*) of the match-up differences ΔSSS (ISAS - Saildrone) for the following conditions:

- all: All the match-up pairs satellite/in situ SSS values are used to derive the statistics
- C1: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km
- C2: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s
- C3: only pairs where RR>1mm/h and U_{10} <4m/s
- C5: only pairs where WOA2013 SSS Std<0.2
- C6: only pairs where WOA2013 SSS Std>0.2
- C7a: only pairs with a distance to coast < 150 km.
- C7b: only pairs with a distance to coast in the range [150, 800] km.
- C7c: only pairs with a distance to coast > 800 km.
- C8a: only pairs where SST is < 5°C.
- C8b: only pairs where SST is in the range [5, 15]°C.
- C8c: only pairs where SST is > 15°C.

- C9a: only pairs where SSS is < 33.
- C9b: only pairs where SSS is in the range [33, 37].
- C9c: only pairs where SSS is > 37.

Table 1: Statistics of ΔSSS (ISAS - Saildrone)

Condition	#	Median	Mean	Std	RMS	IQR	r^2	Std*
all	9218	-0.04	0.03	0.23	0.23	0.23	0.207	0.15
C1	3495	-0.04	0.03	0.21	0.21	0.31	0.362	0.17
C2	3495	-0.04	0.03	0.21	0.21	0.31	0.362	0.17
C3	608	0.00	0.05	0.20	0.21	0.26	0.294	0.19
C5	46	-0.02	-0.02	0.09	0.09	0.07	0.000	0.05
C6	9172	-0.04	0.03	0.23	0.23	0.23	0.206	0.15
C7a	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
C7b	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
C7c	9218	-0.04	0.03	0.23	0.23	0.23	0.207	0.15
C8a	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
C8b	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
C8c	9218	-0.04	0.03	0.23	0.23	0.23	0.207	0.15
C9a	1210	0.35	0.43	0.30	0.52	0.23	0.175	0.15
C9b	8008	-0.06	-0.04	0.14	0.14	0.17	0.382	0.12
C9c	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN

Table 1 numerical values can be downloaded as a csv file here.

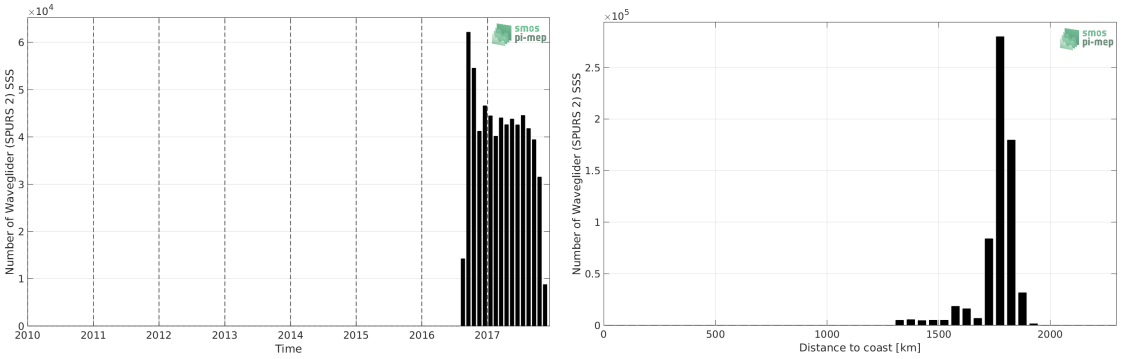
8.3 Waveglider

8.3.1 Introduction

A Waveglider is an autonomous platform propelled by the conversion of ocean wave energy into forward thrust and employing solar panels to power instrumentation. For SPURS-2, sensors included a CTD at the near-surface and another at 6 m depth, providing continuous salinity and temperature observations plus air temperature and wind measurements. Three wavegliders (https://doi.org/10.5067/SPUR2-GLID3) were deployed from the Revelle in August 2016 and again in November 2017 before final retrieval at the conclusion on the second cruise. Waveglider trajectories followed a 20x20km square loop around the moorings and a butterfly pattern around the neutrally-buoyant float. Focused around a central mooring located near 10°N,125°W, the objective of SPURS-2 (NASA-funded oceanographic process study) was to study the dynamics of the rainfall-dominated surface ocean at the western edge of the eastern Pacific fresh pool subject to high seasonal variability and strong zonal flows associated with the North Equatorial Current and Countercurrent.

8.3.2 Number of SSS data as a function of time and distance to coast

Figure 190 shows the time (a) and distance to coast (b) distributions of the Waveglider *in situ* dataset.

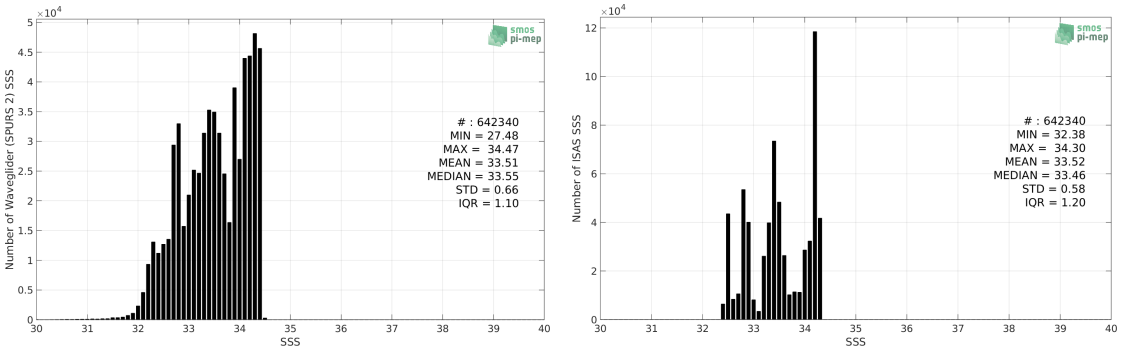


(a) (b)

Figure 190: Number of SSS from Waveglider as a function of time (a) and distance to coast (b).

8.3.3 Histograms of SSS

Figure 191 shows the SSS distribution of the Waveglider (a) and colocalized ISAS (b) dataset.

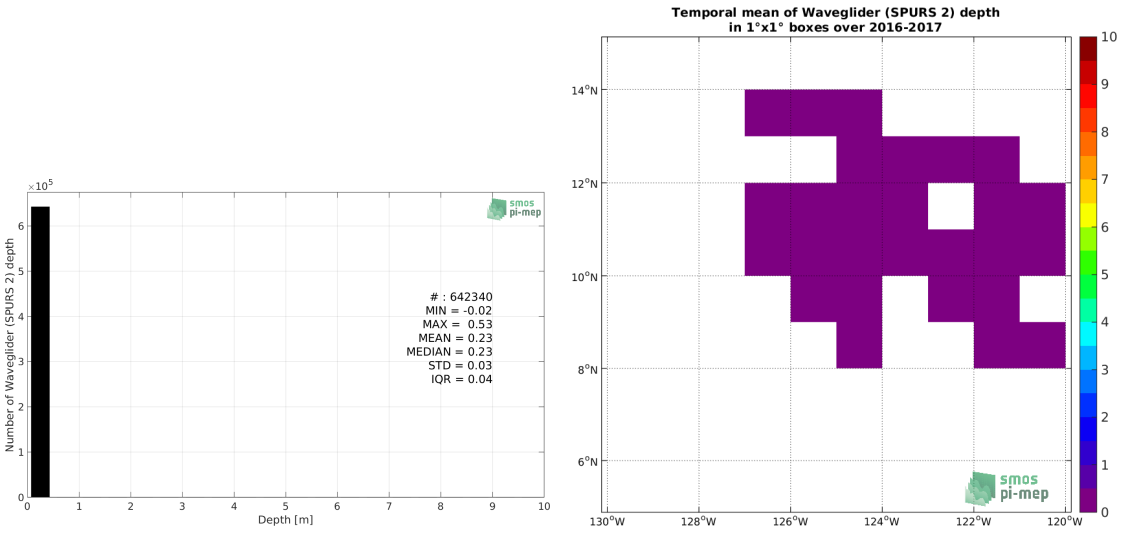


(a) (b)

Figure 191: Histograms of SSS from Waveglider (a) and ISAS (b) per bins of 0.1.

8.3.4 Distribution of *in situ* SSS depth measurements

In Figure 192, we show the depth distribution of the *in situ* salinity dataset (a) and the spatial distribution of the depth temporal mean in 1°x1° boxes and considering the full *in situ* dataset period (b).



(a) (b)

Figure 192: Depth distribution of the upper level SSS measurements from Waveglider (a) and spatial distribution of the *in situ* SSS depth measurements showing the mean value in 1°x1° boxes and considering the full *in situ* dataset period (b).

8.3.5 Spatial distribution of SSS

In Figure 193, the number of Waveglider SSS measurements in 1°x1° boxes is shown.

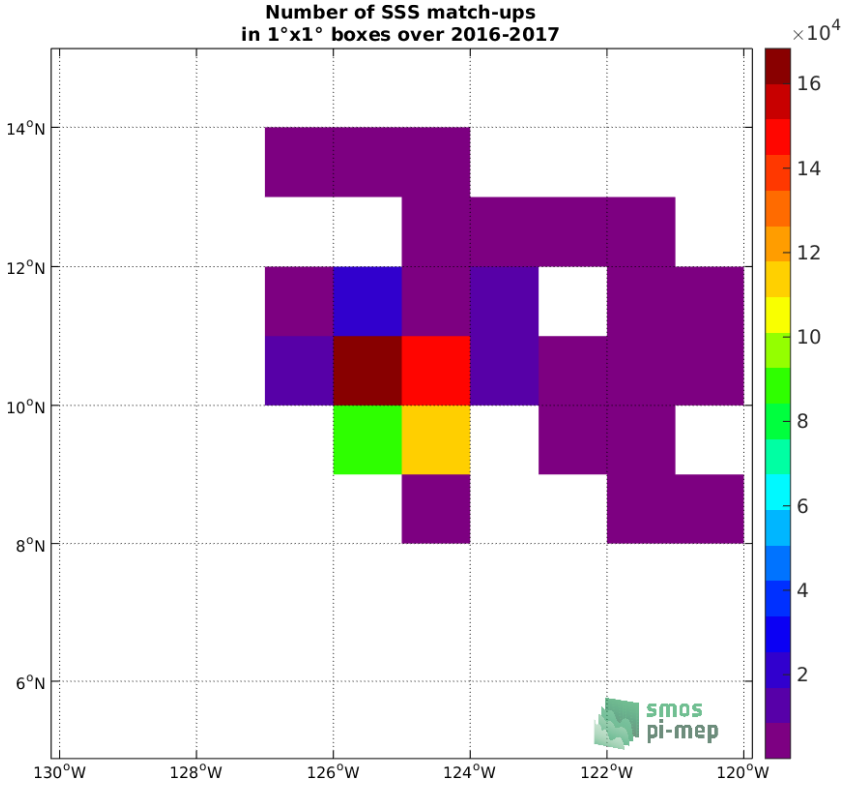
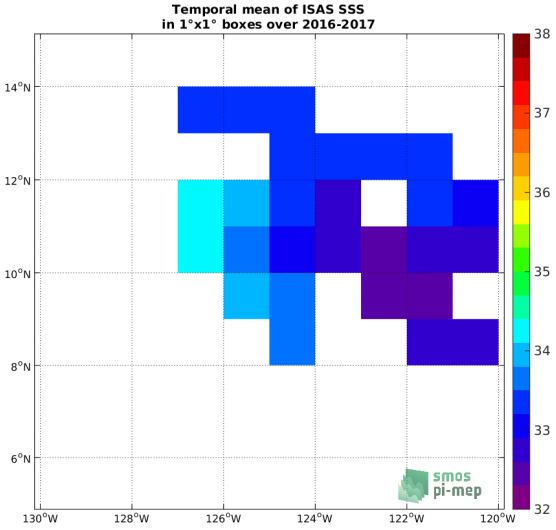


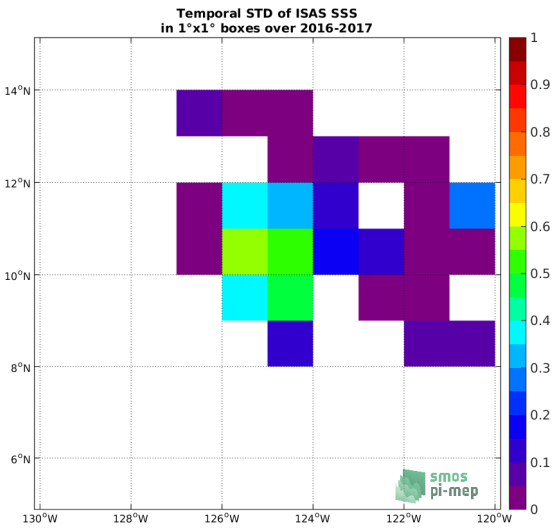
Figure 193: Number of SSS from Waveglider in 1°x1° boxes.

8.3.6 Spatial Maps of the Temporal mean and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

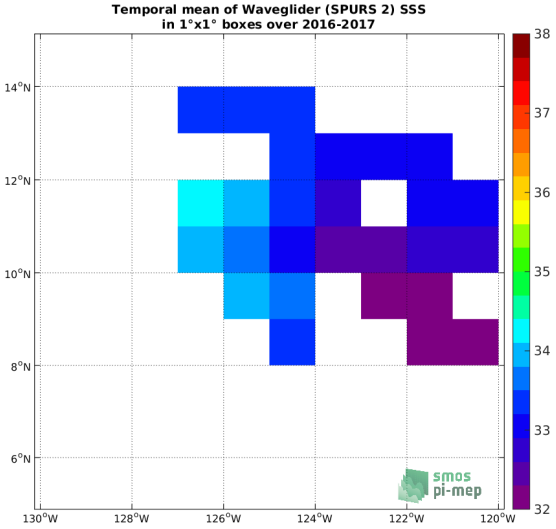
In Figure 194, maps of temporal mean (left) and standard deviation (right) of ISAS (top), Waveglider *in situ* dataset (middle) and the difference ΔSSS(ISAS -Waveglider) (bottom) are shown. The temporal mean and std are calculated using all match-up pairs falling in spatial boxes of size 1°x1° over the full Waveglider dataset period.



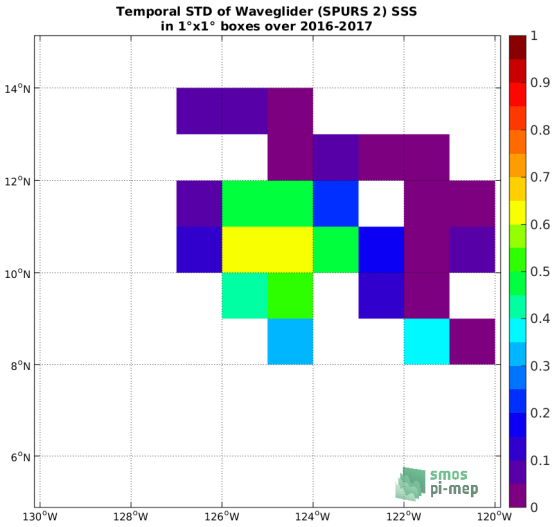
(a) MEAN(ISAS SSS)



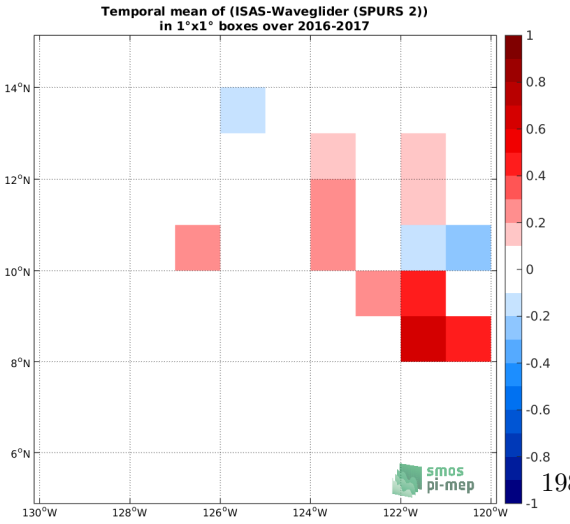
(b) Std(ISAS SSS)



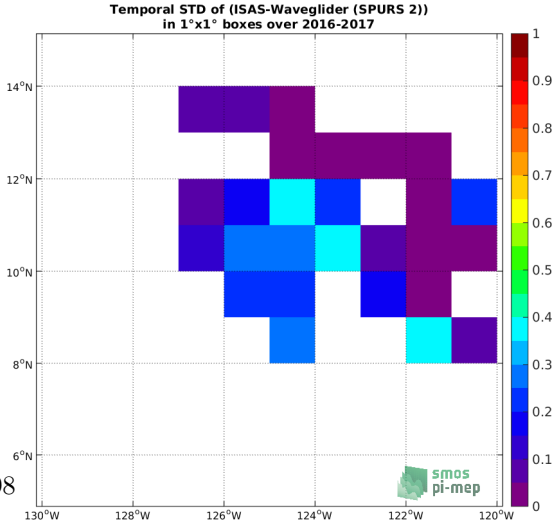
(c) MEAN(Waveglider SSS)



(d) Std(Waveglider SSS)



(e) MEAN(ΔSSS) (ISAS - Waveglider)



(f) Std(ΔSSS) (ISAS - Waveglider)

Figure 194: Temporal mean (left) and Std (right) of SSS from ISAS (top), Waveglider (middle), and of ΔSSS (ISAS - Waveglider). Only match-up pairs are used to generate these maps.

8.3.7 Time series of the monthly median and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

In the top panel of Figure 195, we show the time series of the monthly median SSS estimated for both ISAS SSS product (in black) and the Waveglider *in situ* dataset (in blue) at the collected Pi-MEP match-up pairs.

In the middle panel of Figure 195, we show the time series of the monthly median of ΔSSS (ISAS - Waveglider) for the collected Pi-MEP match-up pairs.

In the bottom panel of Figure 195, we show the time series of the monthly standard deviation of the ΔSSS (ISAS - Waveglider) for the collected Pi-MEP match-up pairs.

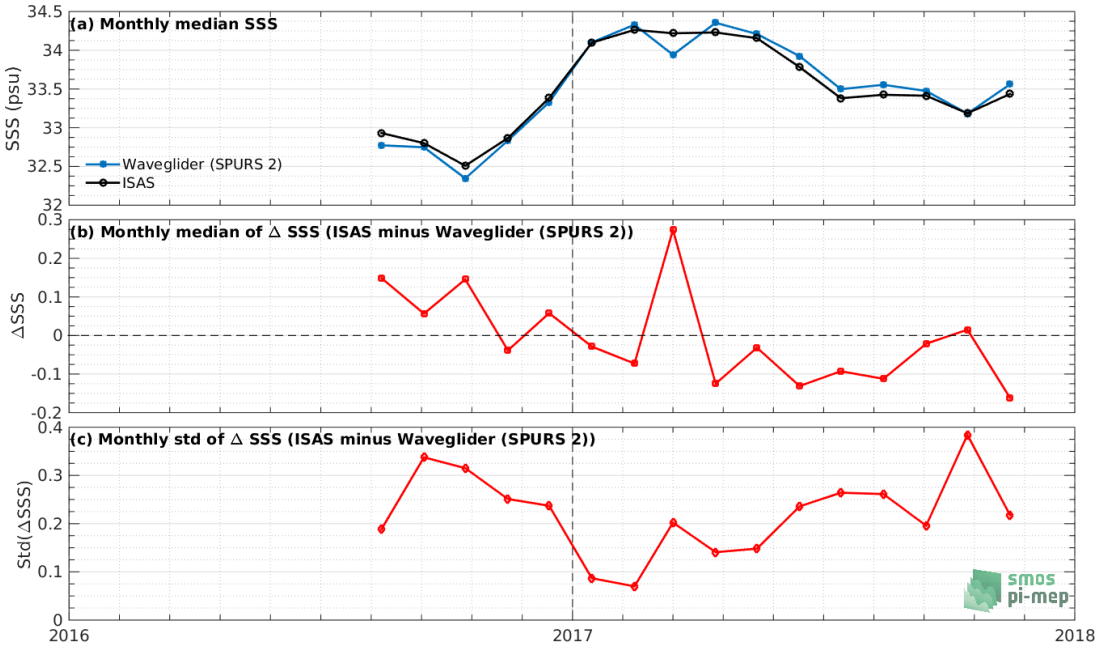


Figure 195: Time series of the monthly median SSS (top), median of ΔSSS (ISAS - Waveglider) and Std of ΔSSS (ISAS - Waveglider) considering all match-ups collected by the Pi-MEP.

8.3.8 Zonal mean and Std of *in situ* and ISAS SSS and of the difference ΔSSS

In Figure 196 left panel, we show the zonal mean SSS considering all Pi-MEP match-up pairs for both ISAS SSS product (in black) and the Waveglider *in situ* dataset (in blue). The full *in situ* dataset period is used to derive the mean.

In the right panel of Figure 196, we show the zonal mean of ΔSSS (ISAS - Waveglider) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

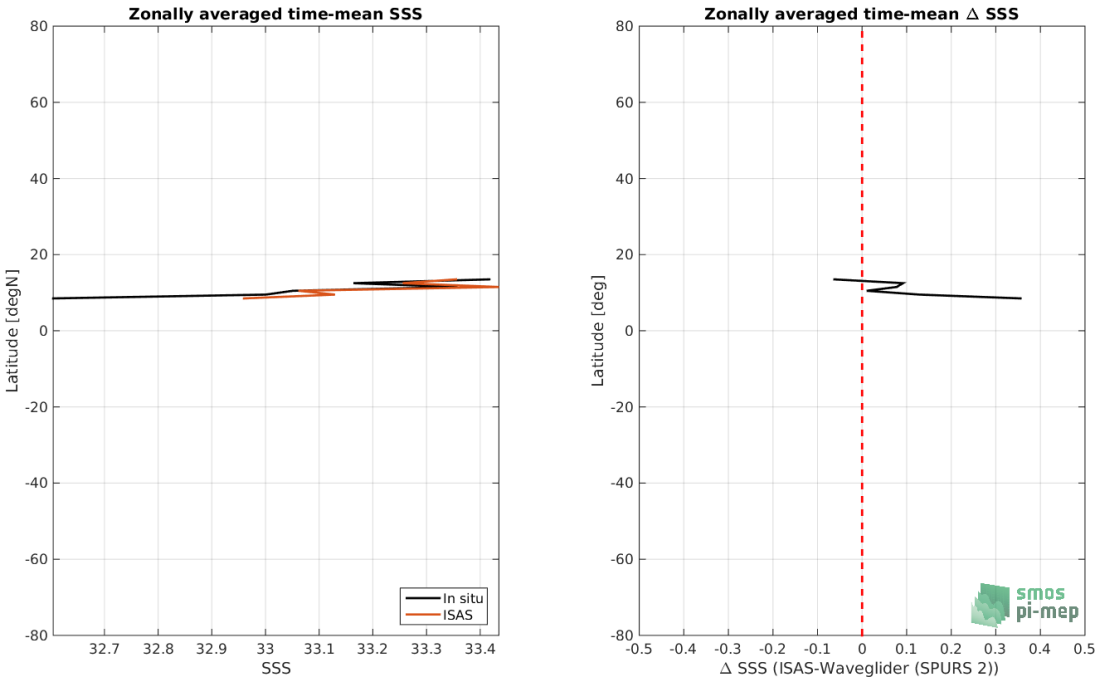
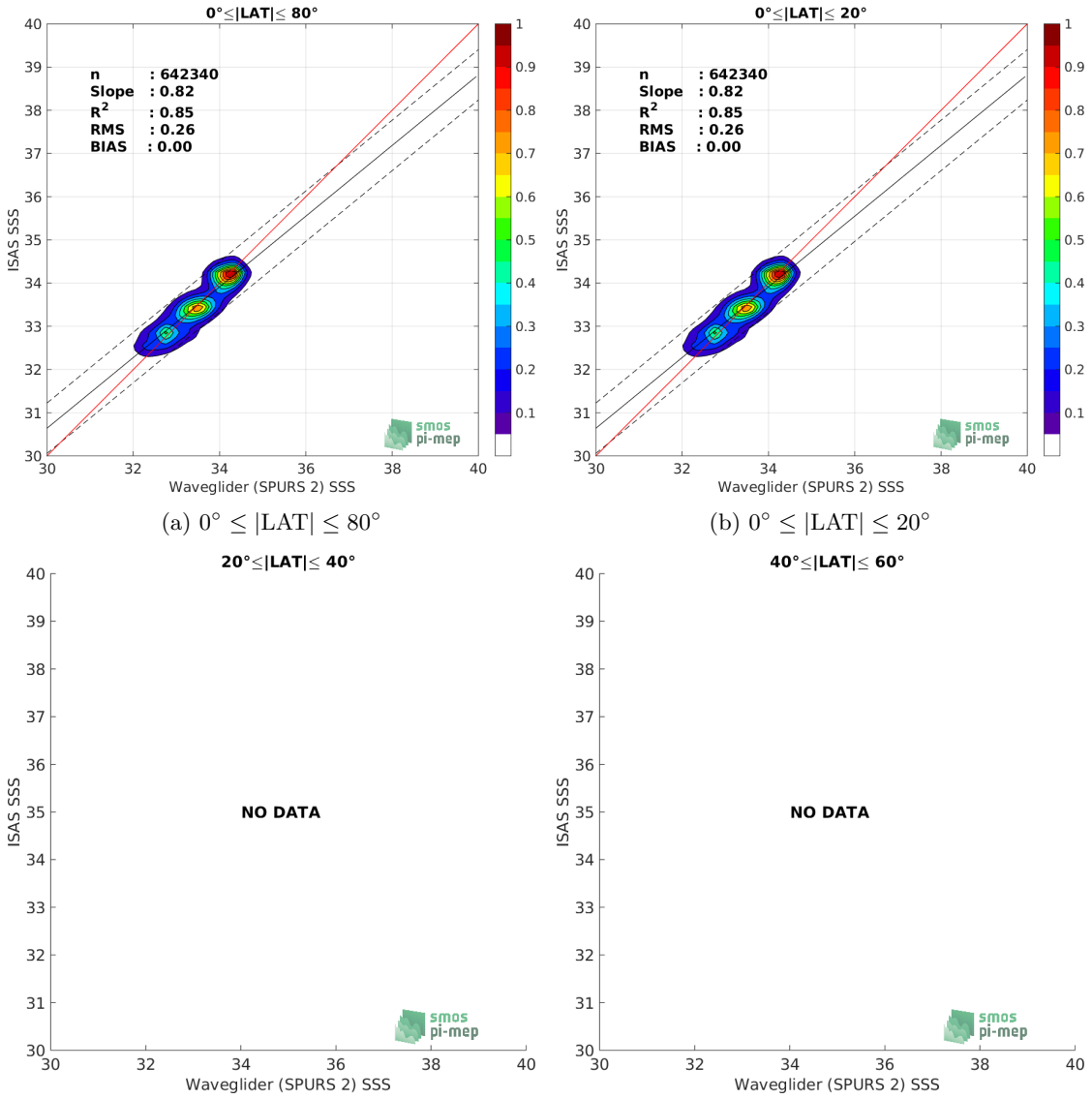


Figure 196: Left panel: Zonal mean SSS from ISAS product (black) and from Waveglider (blue). Right panel: Zonal mean of ΔSSS (ISAS - Waveglider) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

8.3.9 Scatterplots of ISAS vs *in situ* SSS by latitudinal bands

In Figure 197, contour maps of the concentration of ISAS SSS (y-axis) versus Waveglider SSS (x-axis) at match-up pairs for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.



(a) $0° \leq |\text{LAT}| \leq 80°$ (b) $0° \leq |\text{LAT}| \leq 20°$

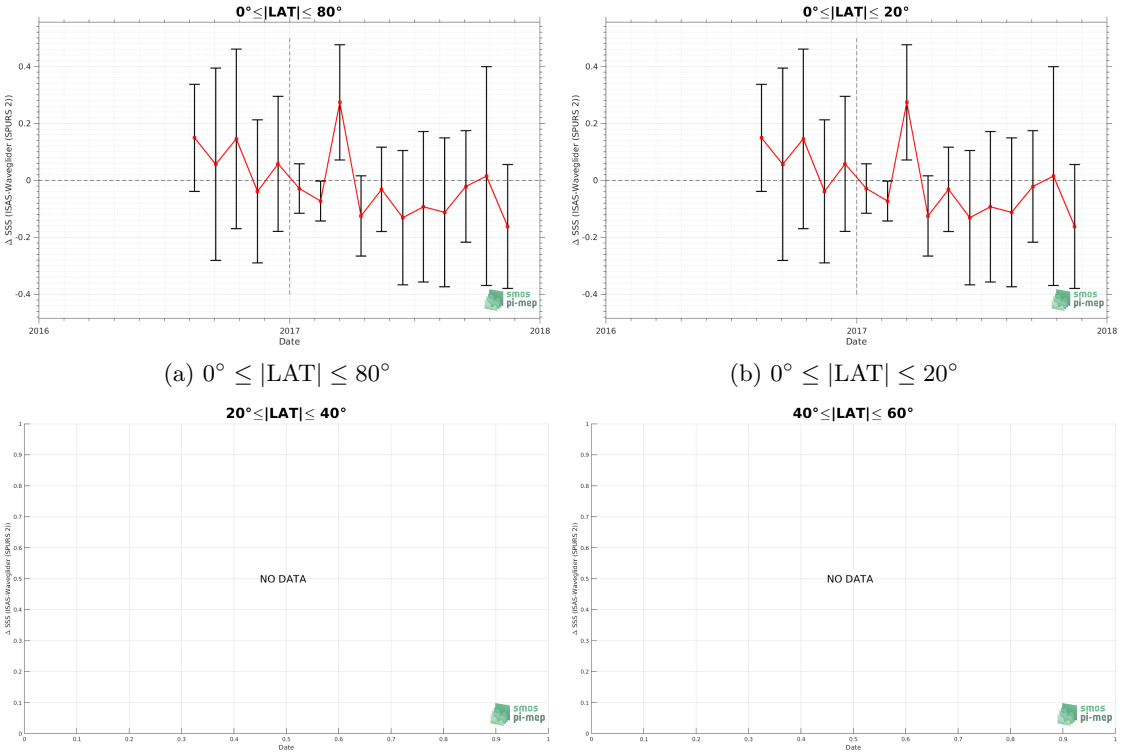
(c) $20° \leq |\text{LAT}| \leq 40°$ (d) $40° \leq |\text{LAT}| \leq 60°$

Figure 197: Contour maps of the concentration of ISAS SSS (y-axis) versus Waveglider SSS (x-axis) at match-up pairs for different latitude bands. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.

8.3.10 Time series of the monthly median and Std of the difference ΔSSS sorted by latitudinal bands

In Figure 198, time series of the monthly median (red curves) of ΔSSS (ISAS - Waveglider) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up

pairs estimated for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.



(a) $0° \leq |\text{LAT}| \leq 80°$

(b) $0° \leq |\text{LAT}| \leq 20°$

(c) $20° \leq |\text{LAT}| \leq 40°$

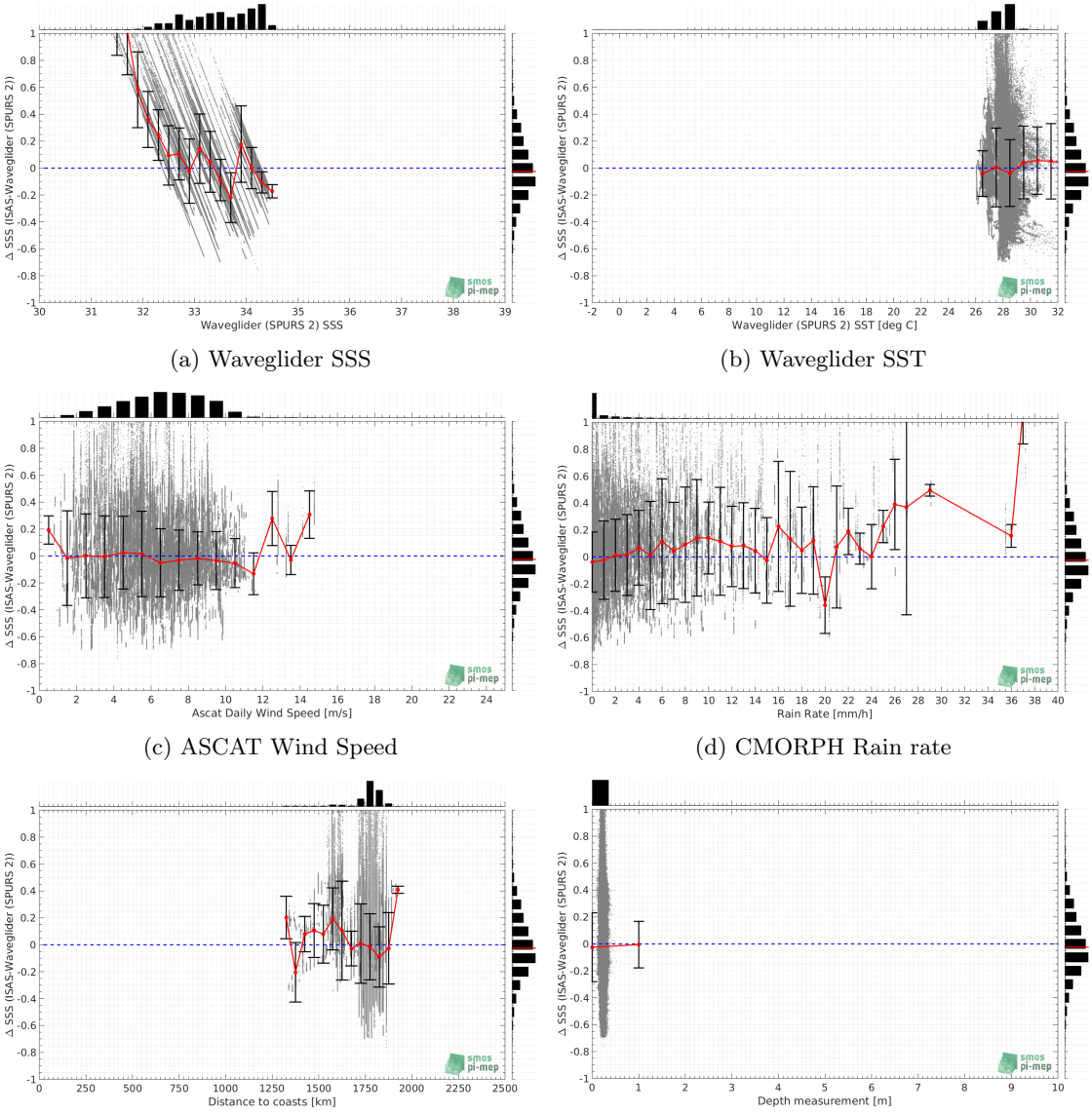
(d) $40° \leq |\text{LAT}| \leq 60°$

Figure 198: Monthly median (red curves) of ΔSSS (ISAS - Waveglider) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.

8.3.11 ΔSSS sorted as geophysical conditions

In Figure 199, we classify the match-up differences ΔSSS (ISAS - *in situ*) as function of the geophysical conditions at match-up points. The mean and std of ΔSSS (ISAS - Waveglider) is thus evaluated as function of the

- *in situ* SSS values per bins of width 0.2,
- *in situ* SST values per bins of width 1°C,
- ASCAT daily wind values per bins of width 1 m/s,
- CMORPH 3-hourly rain rates per bins of width 1 mm/h, and,
- distance to coasts per bins of width 50 km,
- *in situ* measurement depth (if relevant).



(a) Waveglider SSS

(b) Waveglider SST

(c) ASCAT Wind Speed

(d) CMORPH Rain rate

(e) Distance to coast

(f) Depth

Figure 199: Δ SSS (ISAS - Waveglider) sorted as geophysical conditions: Waveglider SSS a), Waveglider SST b), ASCAT Wind speed c), CMORPH rain rate d), distance to coast (e) and depth measurements (f).

8.3.12 ΔSSS maps and statistics for different geophysical conditions

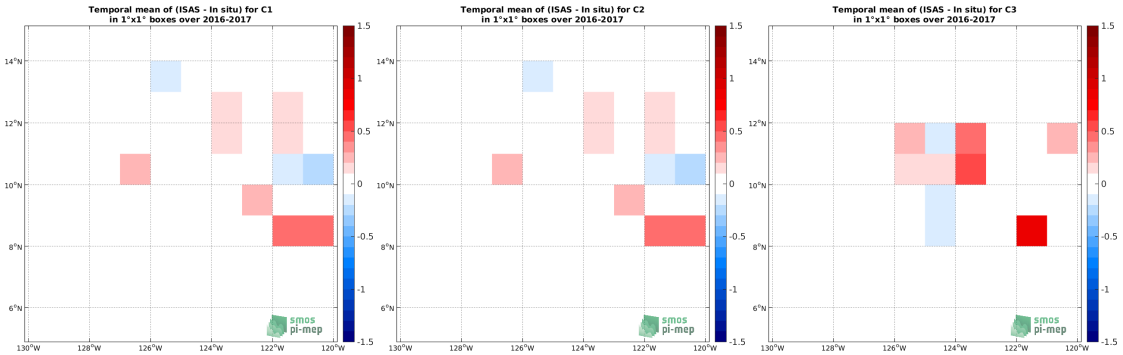
In Figures 200 and 201, we focus on sub-datasets of the match-up differences ΔSSS (ISAS - *in situ*) for the following specific geophysical conditions:

- **C1**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is in the range [3, 12] m/s, the SST is $> 5°$C and distance to coast is > 800 km.
- **C2**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is

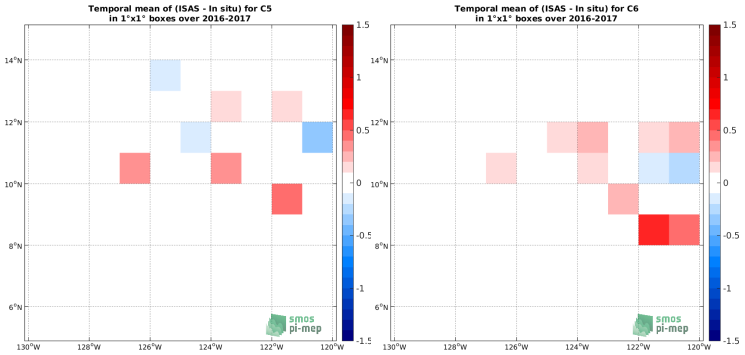
in the range [3, 12] m/s.

- **C3**:if the local value at *in situ* location of estimated rain rate is high (ie. $>$ 1 mm/h) and mean daily wind is low (ie. $<$ 4 m/s).
- **C5**:if the *in situ* data is located where the climatological SSS standard deviation is low (ie. above $<$ 0.2).
- **C6**:if the *in situ* data is located where the climatological SSS standard deviation is high (ie. above $>$ 0.2).

For each of these conditions, the temporal mean (gridded over spatial boxes of size 1°x1°) and the histogram of the difference ΔSSS (ISAS - *in situ*) are presented.

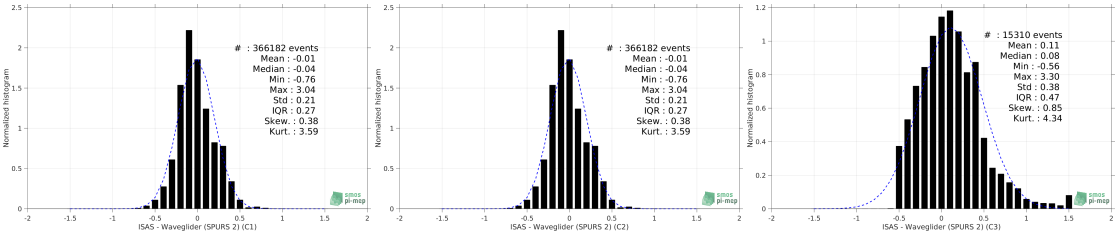


(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s



(d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

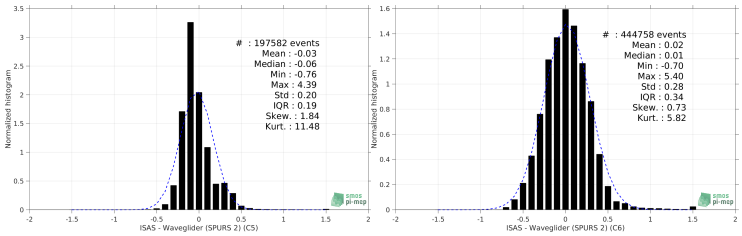
Figure 200: Temporal mean gridded over spatial boxes of size 1°x1° of ΔSSS (ISAS - Waveglider) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast $>$ 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).



(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km

(b) RR=0 mm/h, 3< U_{10} <12 m/s

(c) RR>1mm/h and U_{10} <4m/s



(d) WOA2013 SSS Std<0.2

(e) WOA2013 SSS Std>0.2

Figure 201: Normalized histogram of ΔSSS (ISAS - Waveglider) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).

8.3.13 Summary

Table 1 shows the mean, median, standard deviation (Std), root mean square (RMS), interquartile range (IQR), correlation coefficient (r^2) and robust standard deviation (Std*) of the match-up differences ΔSSS (ISAS - Waveglider) for the following conditions:

- all: All the match-up pairs satellite/in situ SSS values are used to derive the statistics
- C1: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km
- C2: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s
- C3: only pairs where RR>1mm/h and U_{10} <4m/s
- C5: only pairs where WOA2013 SSS Std<0.2
- C6: only pairs where WOA2013 SSS Std>0.2
- C7a: only pairs with a distance to coast < 150 km.
- C7b: only pairs with a distance to coast in the range [150, 800] km.
- C7c: only pairs with a distance to coast > 800 km.
- C8a: only pairs where SST is < 5°C.
- C8b: only pairs where SST is in the range [5, 15]°C.
- C8c: only pairs where SST is > 15°C.

- C9a: only pairs where SSS is < 33.
- C9b: only pairs where SSS is in the range [33, 37].
- C9c: only pairs where SSS is > 37.

Table 1: Statistics of ΔSSS (ISAS - Waveglider)

Condition	#	Median	Mean	Std	RMS	IQR	r^2	Std*
all	642340	-0.02	0.00	0.26	0.26	0.30	0.850	0.21
C1	366182	-0.04	-0.01	0.21	0.21	0.27	0.883	0.19
C2	366182	-0.04	-0.01	0.21	0.21	0.27	0.883	0.19
C3	15310	0.08	0.11	0.38	0.40	0.47	0.605	0.35
C5	197582	-0.06	-0.03	0.20	0.20	0.19	0.854	0.13
C6	444758	0.01	0.02	0.28	0.28	0.34	0.809	0.26
C7a	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
C7b	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
C7c	642340	-0.02	0.00	0.26	0.26	0.30	0.850	0.21
C8a	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
C8b	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
C8c	642340	-0.02	0.00	0.26	0.26	0.30	0.850	0.21
C9a	158669	0.14	0.17	0.31	0.36	0.32	0.144	0.24
C9b	483671	-0.07	-0.05	0.21	0.21	0.25	0.789	0.18
C9c	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN

Table 1 numerical values can be downloaded as a csv file here.

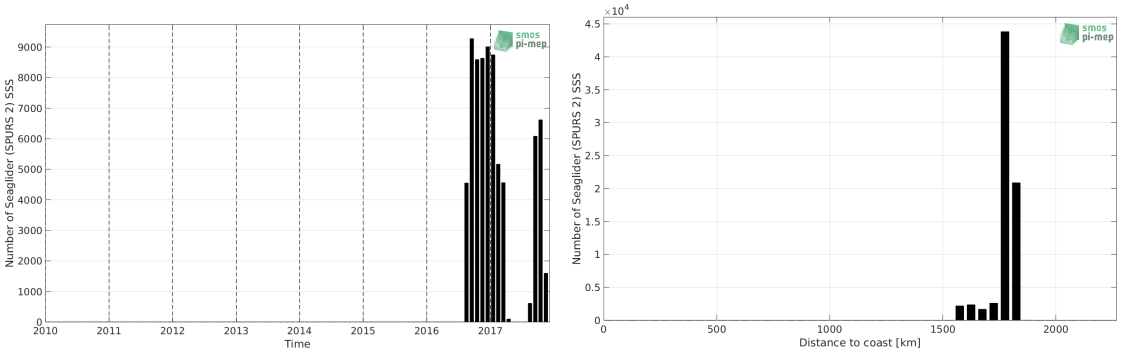
8.4 Seaglider

8.4.1 Introduction

The Seaglider is an autonomous profiler measuring salinity and temperature. A total of five Seagliders https://doi.org/10.5067/SPUR2-GLID1) were deployed over the two SPURS2 cruises. Three Seagliders were deployed on the first Revelle cruise in August 2016, recovered by the Lady Amber after 7 months and redeployed, to be retrieved finally during the second cruise in November 2017. One of the Seagliders was deployed alongside and tracked the Lagrangian array across the study region, diving to depths of 1000m. Focused around a central mooring located near 10°N,125°W, the objective of SPURS-2 (NASA-funded oceanographic process study) was to study the dynamics of the rainfall-dominated surface ocean at the western edge of the eastern Pacific fresh pool subject to high seasonal variability and strong zonal flows associated with the North Equatorial Current and Countercurrent.

8.4.2 Number of SSS data as a function of time and distance to coast

Figure 202 shows the time (a) and distance to coast (b) distributions of the Seaglider *in situ* dataset.

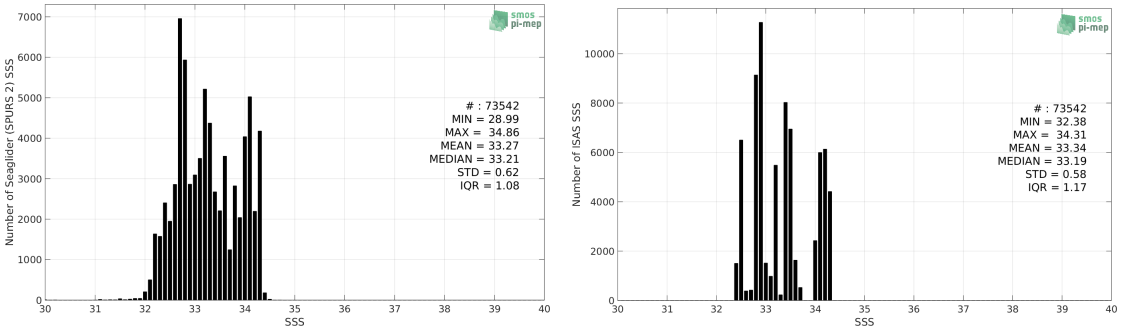


(a) (b)

Figure 202: Number of SSS from Seaglider as a function of time (a) and distance to coast (b).

8.4.3 Histograms of SSS

Figure 203 shows the SSS distribution of the Seaglider (a) and colocalized ISAS (b) dataset.

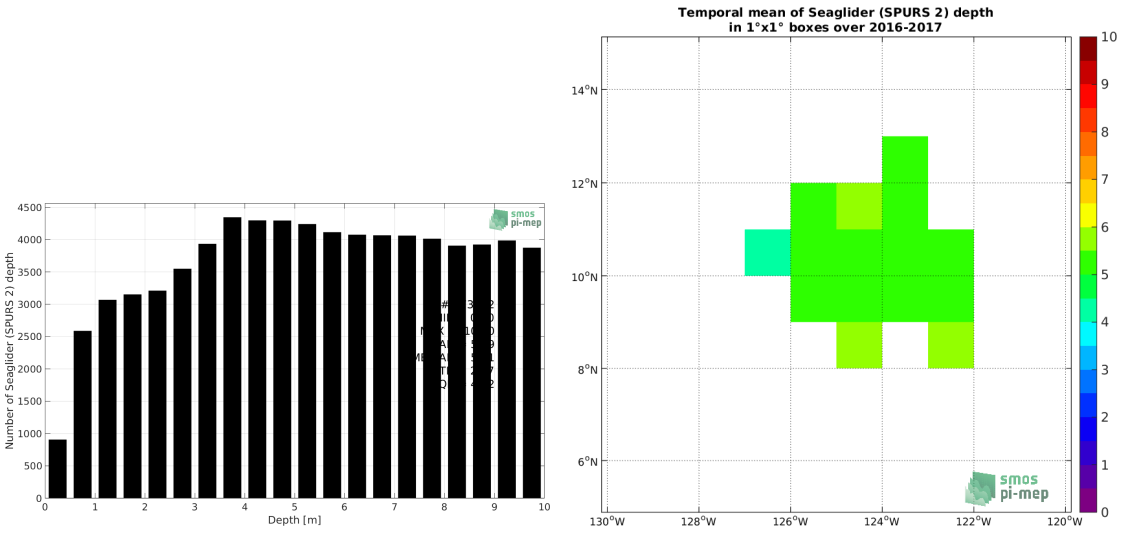


(a) (b)

Figure 203: Histograms of SSS from Seaglider (a) and ISAS (b) per bins of 0.1.

8.4.4 Distribution of *in situ* SSS depth measurements

In Figure 204, we show the depth distribution of the *in situ* salinity dataset (a) and the spatial distribution of the depth temporal mean in 1°x1° boxes and considering the full *in situ* dataset period (b).



(a) (b)

Figure 204: Depth distribution of the upper level SSS measurements from Seaglider (a) and spatial distribution of the *in situ* SSS depth measurements showing the mean value in 1°x1° boxes and considering the full *in situ* dataset period (b).

8.4.5 Spatial distribution of SSS

In Figure 205, the number of Seaglider SSS measurements in 1°x1° boxes is shown.

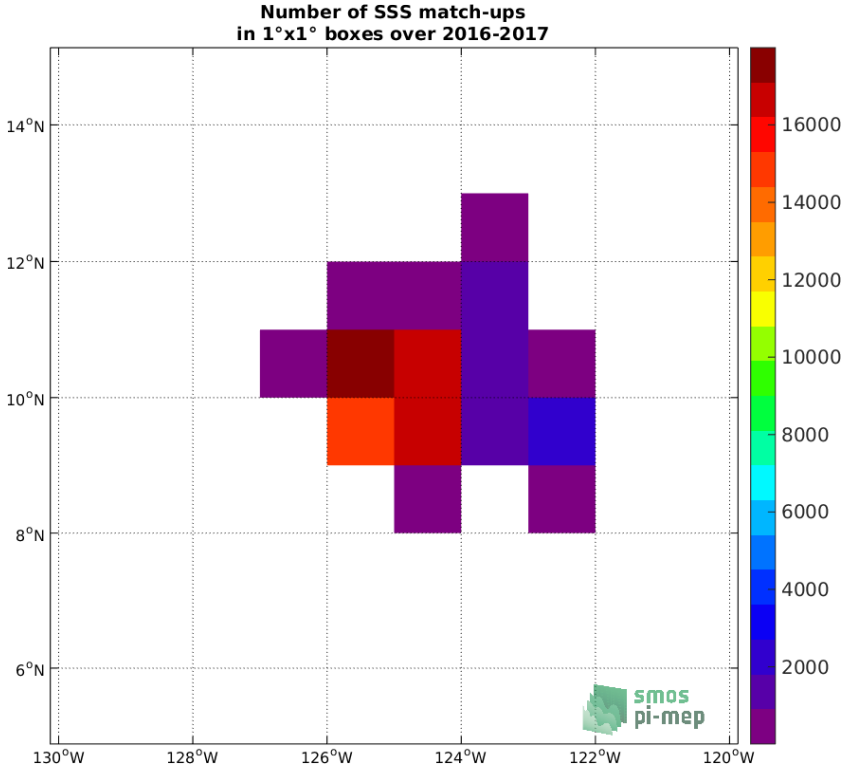
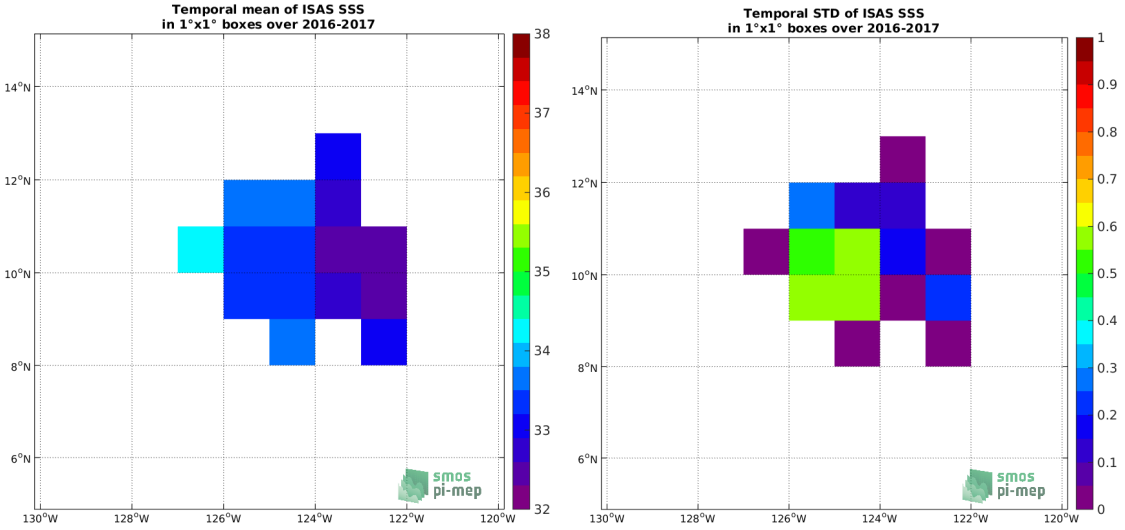


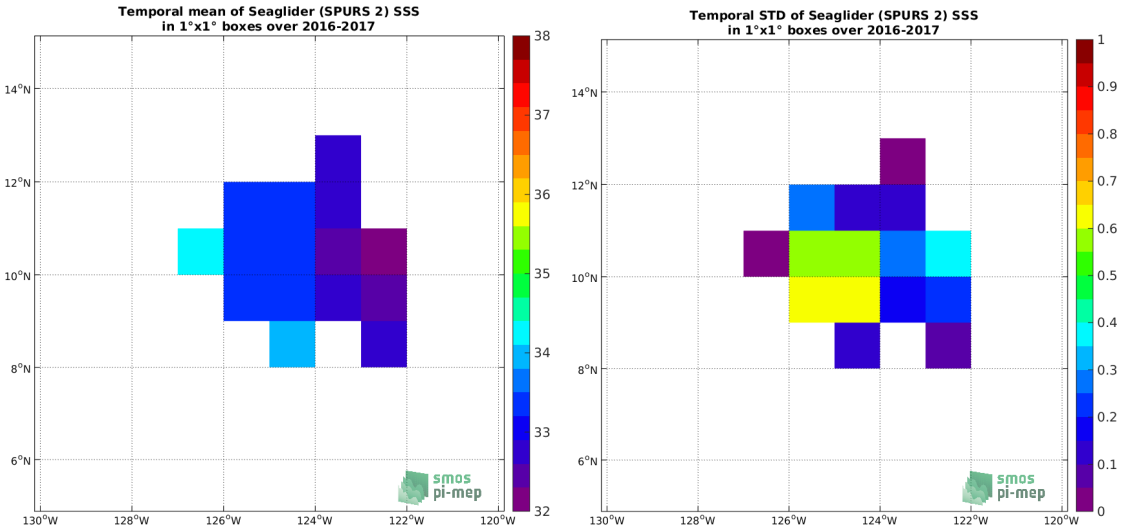
Figure 205: Number of SSS from Seaglider in 1°x1° boxes.

8.4.6 Spatial Maps of the Temporal mean and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

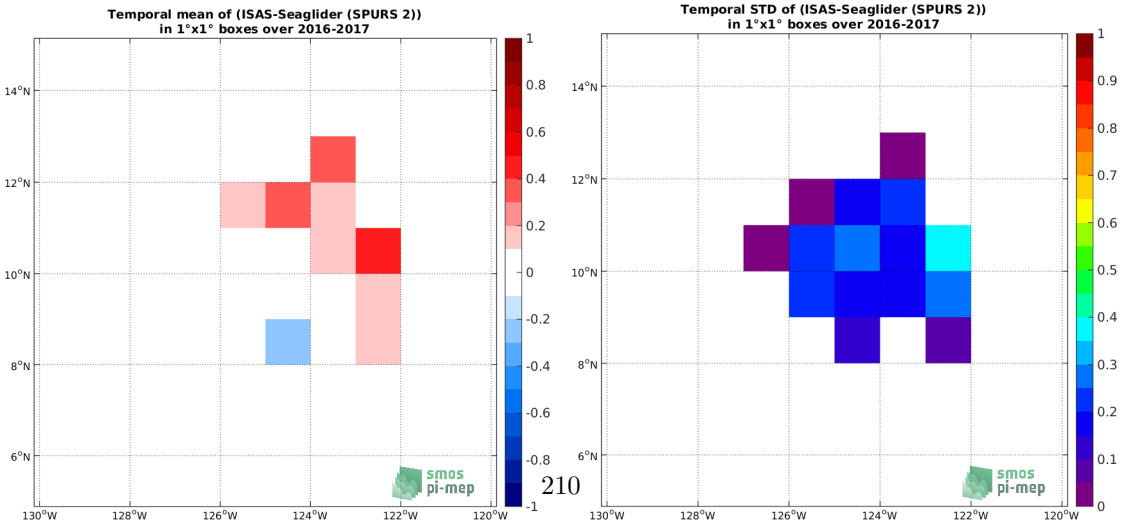
In Figure 206, maps of temporal mean (left) and standard deviation (right) of ISAS (top), Seaglider *in situ* dataset (middle) and the difference ΔSSS(ISAS -Seaglider) (bottom) are shown. The temporal mean and std are calculated using all match-up pairs falling in spatial boxes of size 1°x1° over the full Seaglider dataset period.



(a) MEAN(ISAS SSS) (b) Std(ISAS SSS)



(c) MEAN(Seaglider SSS) (d) Std(Seaglider SSS)



(e) MEAN(ΔSSS) (ISAS - Seaglider) (f) Std(ΔSSS) (ISAS - Seaglider)

Figure 206: Temporal mean (left) and Std (right) of SSS from ISAS (top), Seaglider (middle), and of ΔSSS (ISAS - Seaglider). Only match-up pairs are used to generate these maps.

8.4.7 Time series of the monthly median and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

In the top panel of Figure 207, we show the time series of the monthly median SSS estimated for both ISAS SSS product (in black) and the Seaglider *in situ* dataset (in blue) at the collected Pi-MEP match-up pairs.

In the middle panel of Figure 207, we show the time series of the monthly median of ΔSSS (ISAS - Seaglider) for the collected Pi-MEP match-up pairs.

In the bottom panel of Figure 207, we show the time series of the monthly standard deviation of the ΔSSS (ISAS - Seaglider) for the collected Pi-MEP match-up pairs.

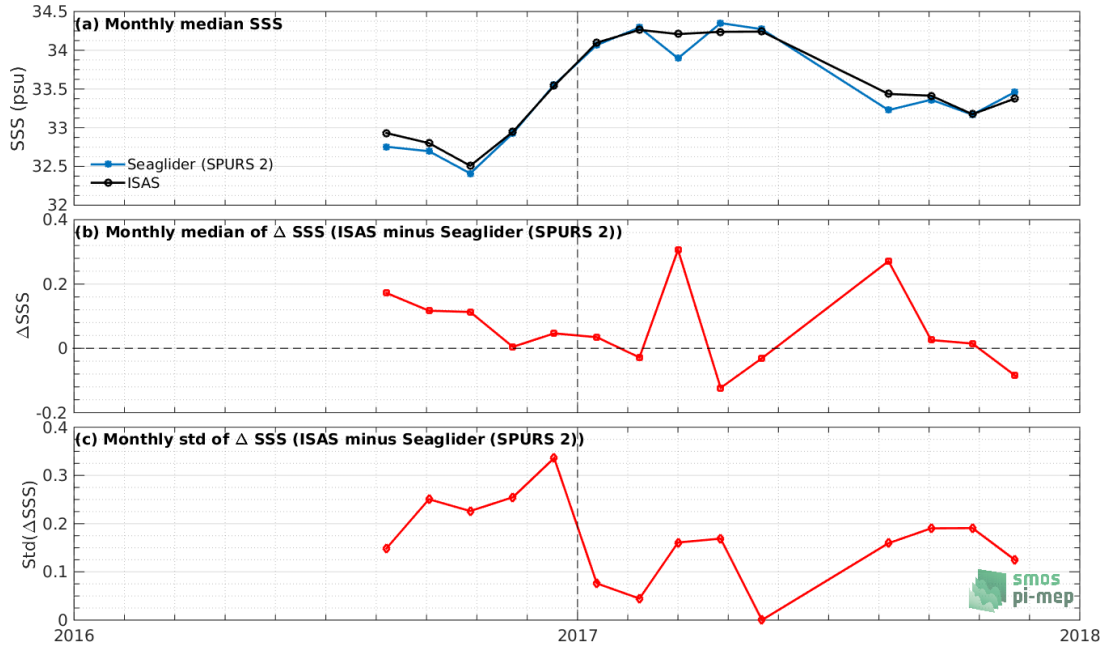


Figure 207: Time series of the monthly median SSS (top), median of ΔSSS (ISAS - Seaglider) and Std of ΔSSS (ISAS - Seaglider) considering all match-ups collected by the Pi-MEP.

8.4.8 Zonal mean and Std of *in situ* and ISAS SSS and of the difference ΔSSS

In Figure 208 left panel, we show the zonal mean SSS considering all Pi-MEP match-up pairs for both ISAS SSS product (in black) and the Seaglider *in situ* dataset (in blue). The full *in situ* dataset period is used to derive the mean.

In the right panel of Figure 208, we show the zonal mean of ΔSSS (ISAS - Seaglider) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

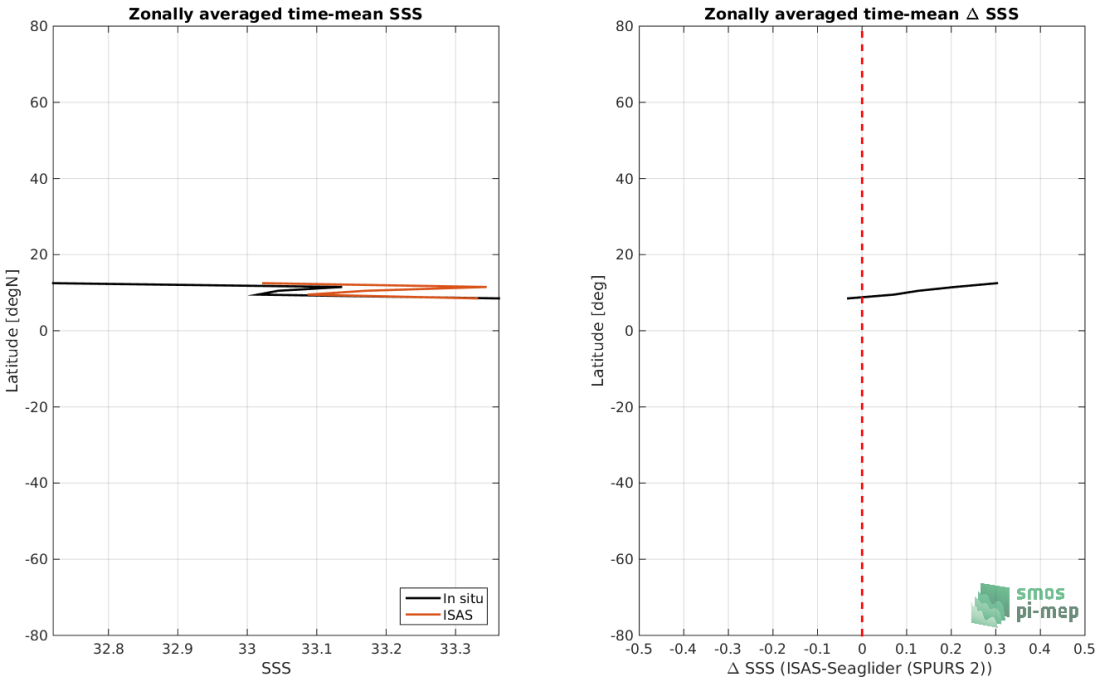
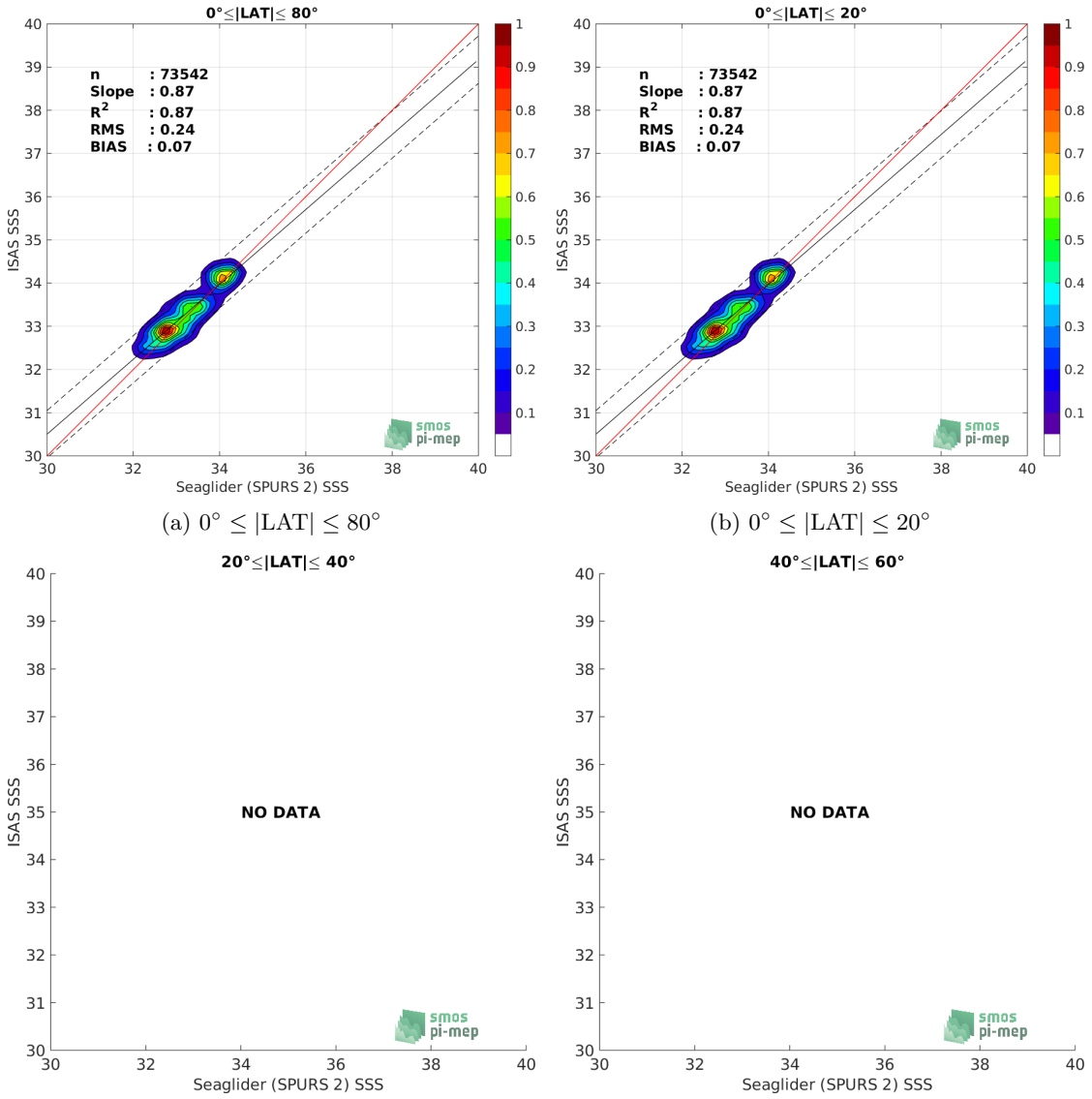


Figure 208: Left panel: Zonal mean SSS from ISAS product (black) and from Seaglider (blue). Right panel: Zonal mean of ΔSSS (ISAS - Seaglider) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

8.4.9 Scatterplots of ISAS vs *in situ* SSS by latitudinal bands

In Figure 209, contour maps of the concentration of ISAS SSS (y-axis) versus Seaglider SSS (x-axis) at match-up pairs for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.



(a) $0° \leq |\text{LAT}| \leq 80°$ (b) $0° \leq |\text{LAT}| \leq 20°$

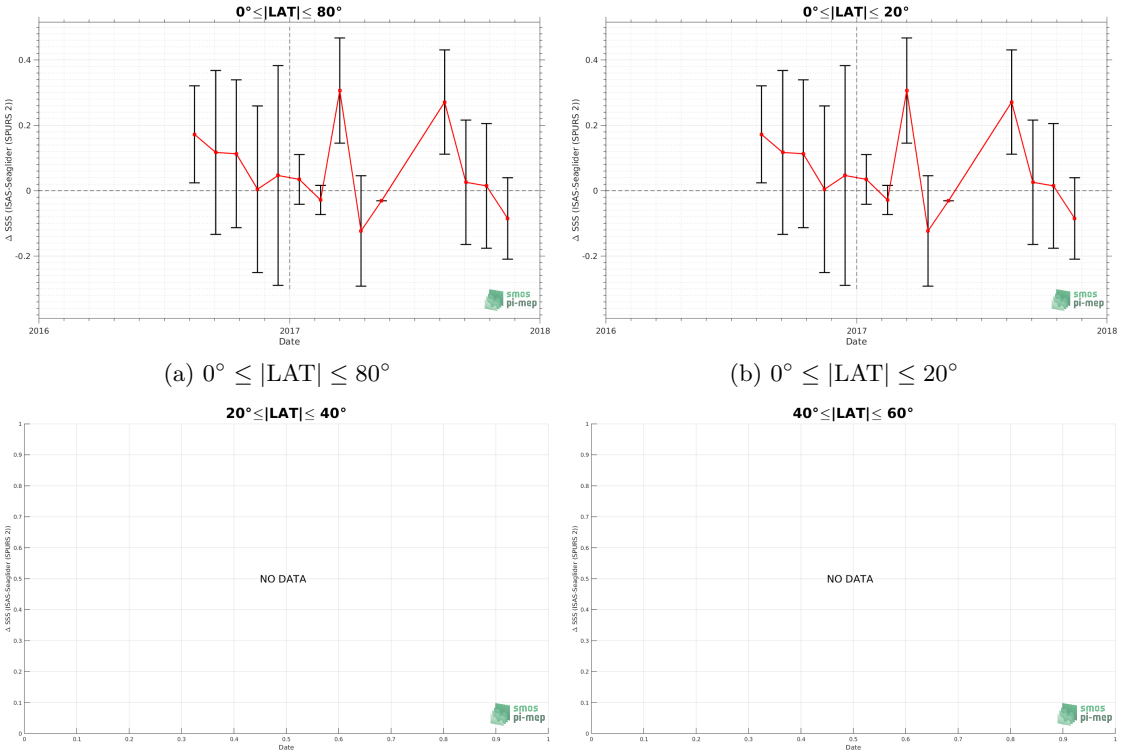
(c) $20° \leq |\text{LAT}| \leq 40°$ (d) $40° \leq |\text{LAT}| \leq 60°$

Figure 209: Contour maps of the concentration of ISAS SSS (y-axis) versus Seaglider SSS (x-axis) at match-up pairs for different latitude bands. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.

8.4.10 Time series of the monthly median and Std of the difference ΔSSS sorted by latitudinal bands

In Figure 210, time series of the monthly median (red curves) of ΔSSS (ISAS - Seaglider) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up

pairs estimated for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.



(a) $0° \leq |\text{LAT}| \leq 80°$

(b) $0° \leq |\text{LAT}| \leq 20°$

(c) $20° \leq |\text{LAT}| \leq 40°$

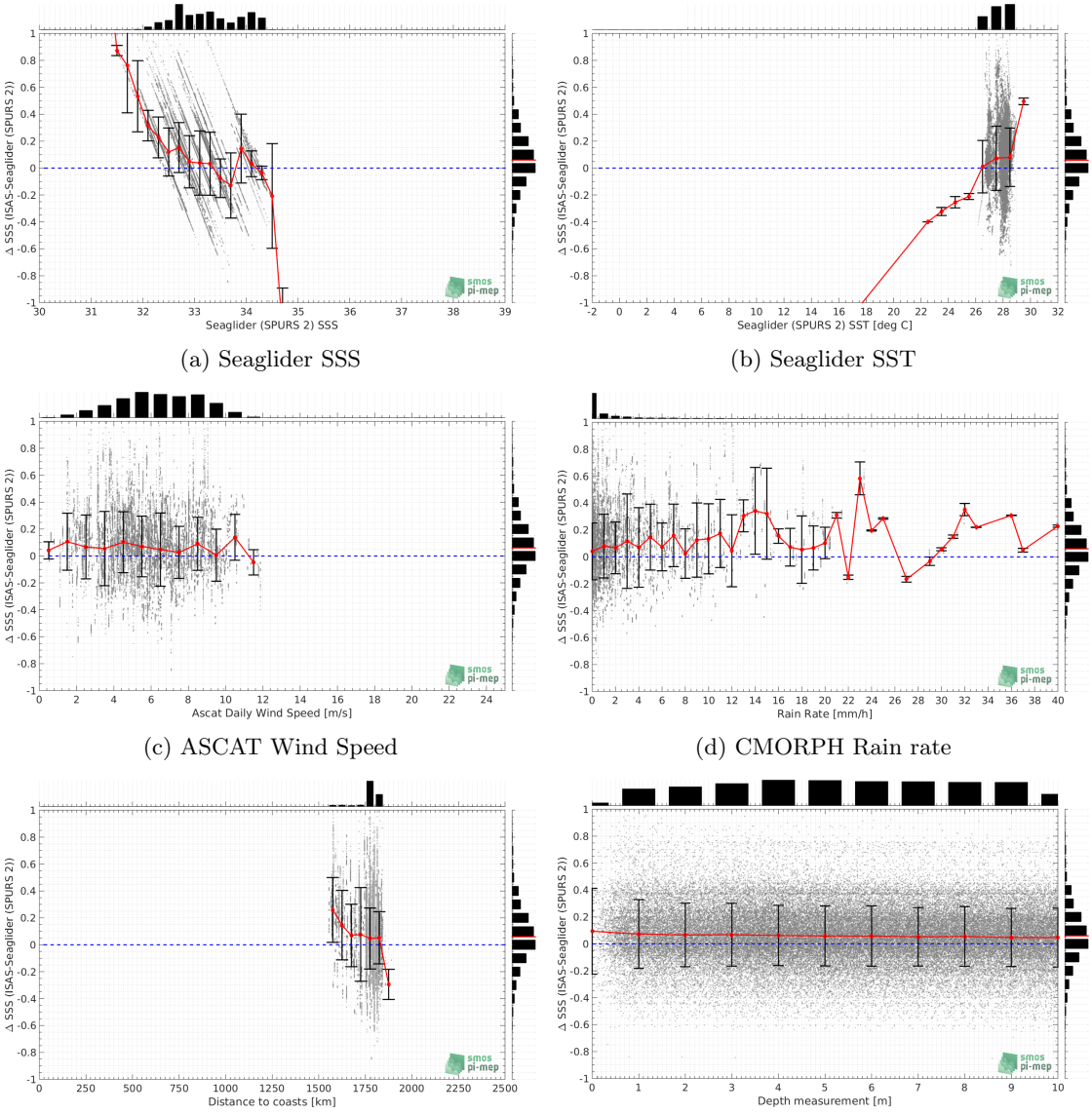
(d) $40° \leq |\text{LAT}| \leq 60°$

Figure 210: Monthly median (red curves) of ΔSSS (ISAS - Seaglider) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.

8.4.11 ΔSSS sorted as geophysical conditions

In Figure 211, we classify the match-up differences ΔSSS (ISAS - *in situ*) as function of the geophysical conditions at match-up points. The mean and std of ΔSSS (ISAS - Seaglider) is thus evaluated as function of the

- *in situ* SSS values per bins of width 0.2,
- *in situ* SST values per bins of width 1°C,
- ASCAT daily wind values per bins of width 1 m/s,
- CMORPH 3-hourly rain rates per bins of width 1 mm/h, and,
- distance to coasts per bins of width 50 km,
- *in situ* measurement depth (if relevant).



(a) Seaglider SSS

(b) Seaglider SST

(c) ASCAT Wind Speed

(d) CMORPH Rain rate

(e) Distance to coast

(f) Depth

Figure 211: Δ SSS (ISAS - Seaglider) sorted as geophysical conditions: Seaglider SSS a), Seaglider SST b), ASCAT Wind speed c), CMORPH rain rate d), distance to coast (e) and depth measurements (f).

8.4.12 ΔSSS maps and statistics for different geophysical conditions

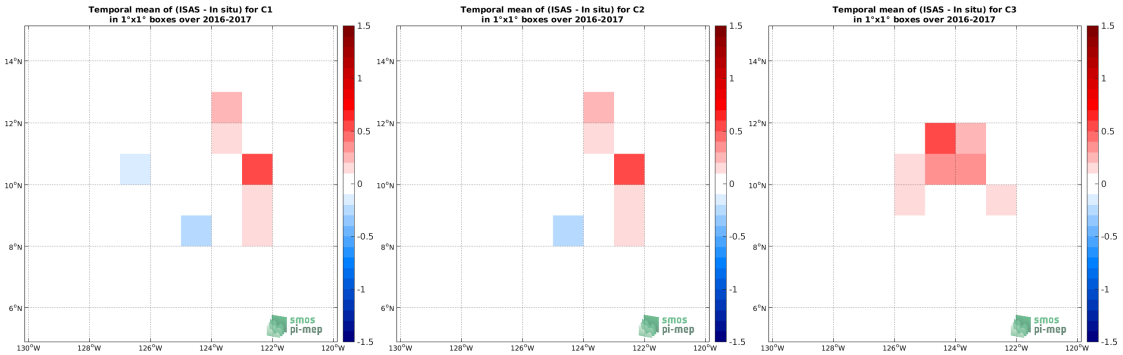
In Figures 212 and 213, we focus on sub-datasets of the match-up differences ΔSSS (ISAS - *in situ*) for the following specific geophysical conditions:

- **C1**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is in the range [3, 12] m/s, the SST is $> 5°$C and distance to coast is > 800 km.
- **C2**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is

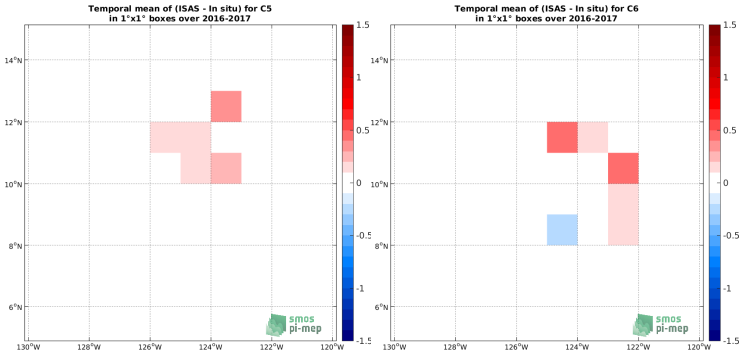
in the range [3, 12] m/s.

- **C3**:if the local value at *in situ* location of estimated rain rate is high (ie. $>$ 1 mm/h) and mean daily wind is low (ie. $<$ 4 m/s).
- **C5**:if the *in situ* data is located where the climatological SSS standard deviation is low (ie. above $<$ 0.2).
- **C6**:if the *in situ* data is located where the climatological SSS standard deviation is high (ie. above $>$ 0.2).

For each of these conditions, the temporal mean (gridded over spatial boxes of size 1°x1°) and the histogram of the difference ΔSSS (ISAS - *in situ*) are presented.

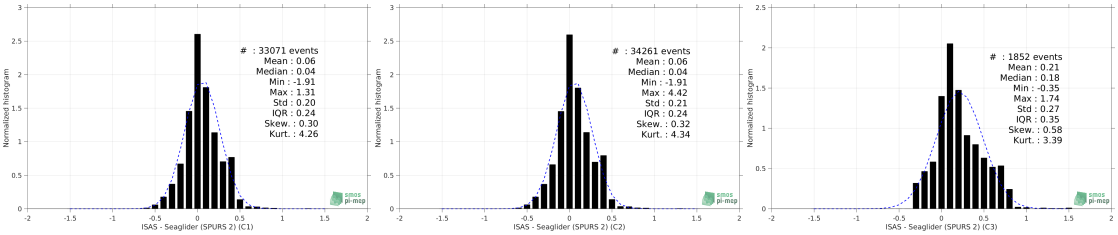


(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s

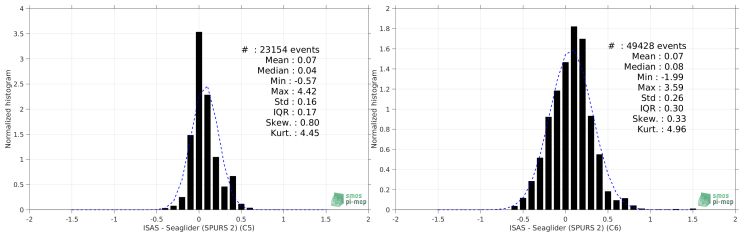


(d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 212: Temporal mean gridded over spatial boxes of size 1°x1° of ΔSSS (ISAS - Seaglider) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast $>$ 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).



(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s



(d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 213: Normalized histogram of ΔSSS (ISAS - Seaglider) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).

8.4.13 Summary

Table 1 shows the mean, median, standard deviation (Std), root mean square (RMS), interquartile range (IQR), correlation coefficient (r^2) and robust standard deviation (Std*) of the match-up differences ΔSSS (ISAS - Seaglider) for the following conditions:

- all: All the match-up pairs satellite/in situ SSS values are used to derive the statistics
- C1: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km
- C2: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s
- C3: only pairs where RR>1mm/h and U_{10} <4m/s
- C5: only pairs where WOA2013 SSS Std<0.2
- C6: only pairs where WOA2013 SSS Std>0.2
- C7a: only pairs with a distance to coast < 150 km.
- C7b: only pairs with a distance to coast in the range [150, 800] km.
- C7c: only pairs with a distance to coast > 800 km.
- C8a: only pairs where SST is < 5°C.
- C8b: only pairs where SST is in the range [5, 15]°C.
- C8c: only pairs where SST is > 15°C.

- C9a: only pairs where SSS is < 33.
- C9b: only pairs where SSS is in the range [33, 37].
- C9c: only pairs where SSS is > 37.

Table 1: Statistics of ΔSSS (ISAS - Seaglider)

Condition	#	Median	Mean	Std	RMS	IQR	r^2	Std*
all	73542	0.06	0.07	0.23	0.24	0.25	0.865	0.19
C1	33071	0.04	0.06	0.20	0.21	0.24	0.903	0.17
C2	34261	0.04	0.06	0.21	0.22	0.24	0.900	0.17
C3	1852	0.18	0.21	0.27	0.35	0.35	0.504	0.26
C5	23154	0.04	0.07	0.16	0.17	0.17	0.947	0.12
C6	49428	0.08	0.07	0.26	0.26	0.30	0.747	0.23
C7a	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
C7b	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
C7c	73542	0.06	0.07	0.23	0.24	0.25	0.865	0.19
C8a	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
C8b	3	-1.97	-1.96	0.04	1.96	0.04	0.977	0.02
C8c	70905	0.06	0.07	0.22	0.23	0.25	0.871	0.19
C9a	28790	0.15	0.16	0.23	0.28	0.20	0.326	0.15
C9b	44752	0.00	0.01	0.21	0.21	0.22	0.801	0.17
C9c	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN

Table 1 numerical values can be downloaded as a csv file here.

9 EUREC4A

9.1 Introduction

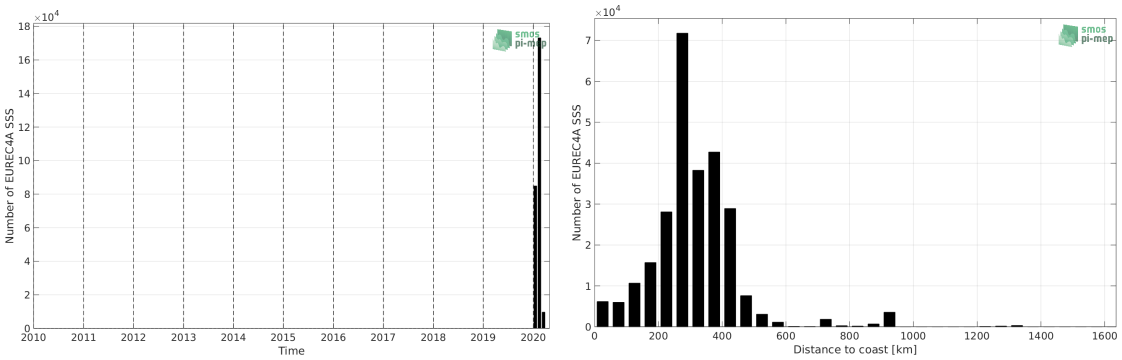
The field campaign, EUREC^{4}A, is an international initiative in support of the World Climate Research Programme's Grand Science Challenge on Clouds, Circulation and Climate Sensitivity (Bony et al. (2017)). EUREC^{4}A took place between January and March 2020 with operations based out of Barbados. The EUREC^{4}A Pi-MEP in situ dataset is composed of upper ocean salinity and temperature measurements recorded between 0 m and 10 m depth coming from the following patforms:

- 4 research vessels: R/V L'Atalante, R/V Maria S. Merian, R/V Meteor and R/V Ron Brown,
- 3 Autonomous Saildrone vehicles (https://www.saildrone.com/),
- 4 ocean gliders,
- 24 Argo floats (around 470 profiles),
- 9 SVP drifters provided by NOAA/AOML under the ATOMIC program.

All the data are freely available here.

9.2 Number of SSS data as a function of time and distance to coast

Figure 214 shows the time (a) and distance to coast (b) distributions of the EUREC4A *in situ* dataset.

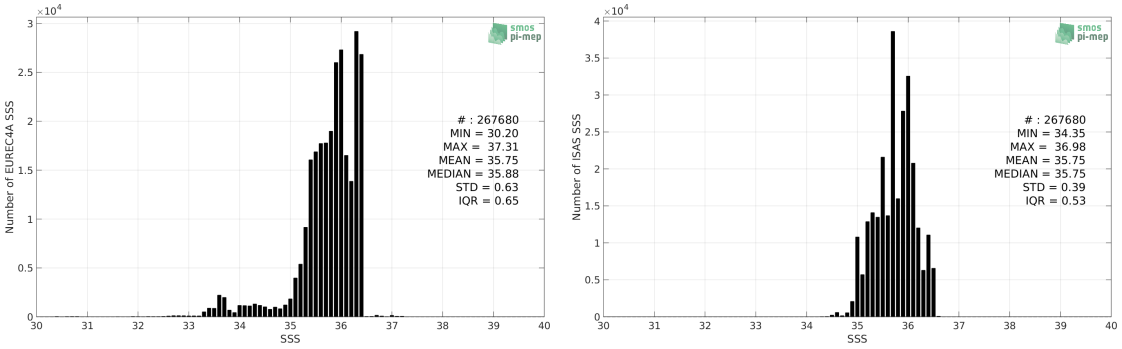


(a) (b)

Figure 214: Number of SSS from EUREC4A as a function of time (a) and distance to coast (b).

9.3 Histograms of SSS

Figure 215 shows the SSS distribution of the EUREC4A (a) and colocalized ISAS (b) dataset.

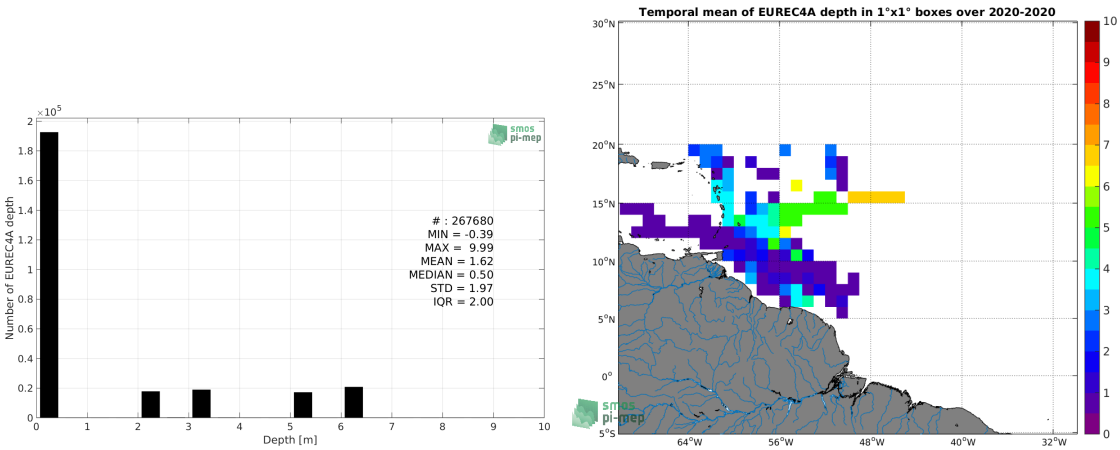


(a) (b)

Figure 215: Histograms of SSS from EUREC4A (a) and ISAS (b) per bins of 0.1.

9.4 Distribution of *in situ* SSS depth measurements

In Figure 216, we show the depth distribution of the *in situ* salinity dataset (a) and the spatial distribution of the depth temporal mean in 1°x1° boxes and considering the full *in situ* dataset period (b).



(a) (b)

Figure 216: Depth distribution of the upper level SSS measurements from EUREC4A (a) and spatial distribution of the *in situ* SSS depth measurements showing the mean value in 1°x1° boxes and considering the full *in situ* dataset period (b).

9.5 Spatial distribution of SSS

In Figure 217, the number of EUREC4A SSS measurements in 1°x1° boxes is shown.

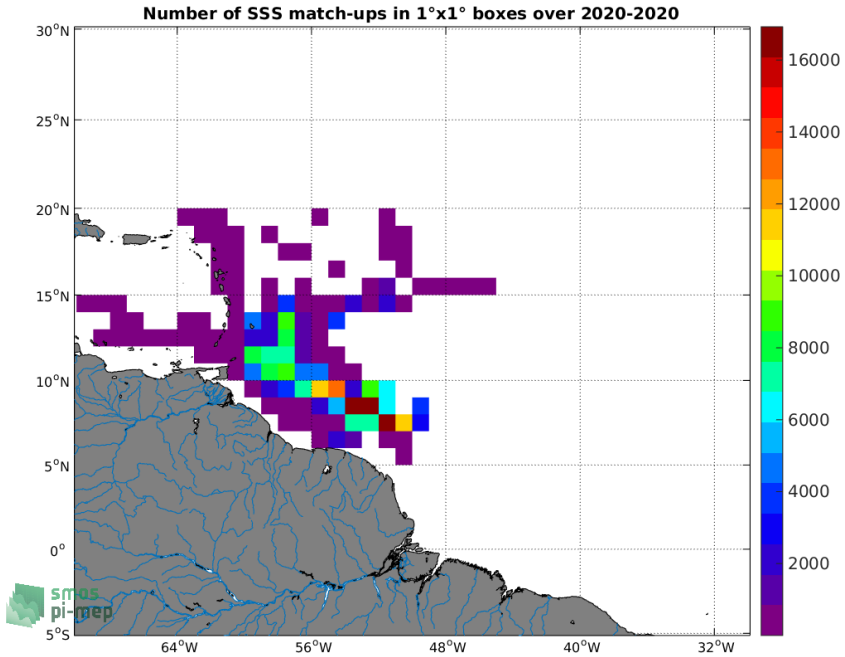
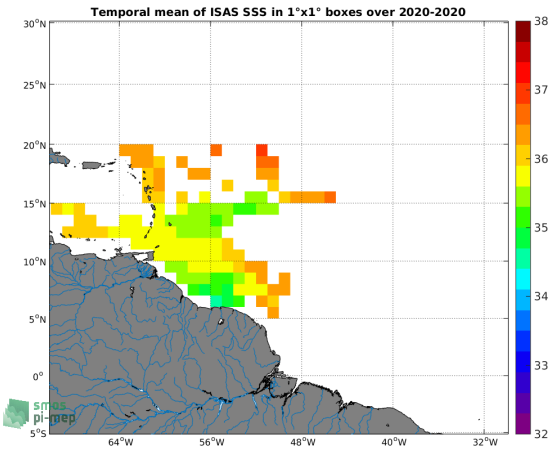


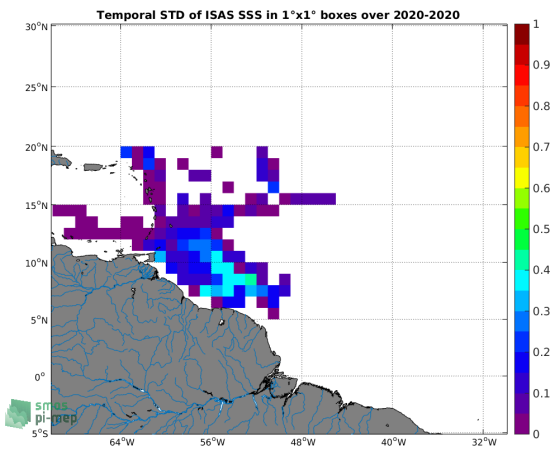
Figure 217: Number of SSS from EUREC4A in 1°x1° boxes.

9.6 Spatial Maps of the Temporal mean and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

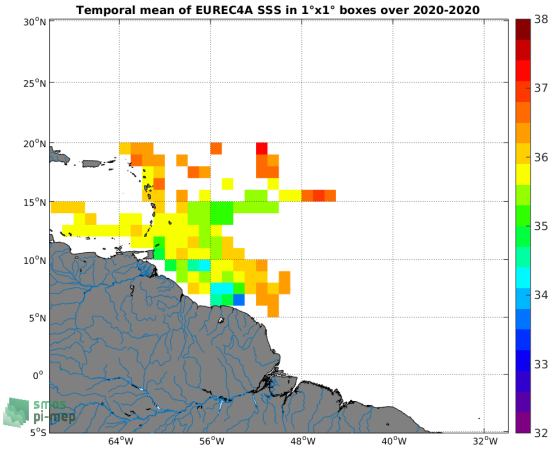
In Figure 218, maps of temporal mean (left) and standard deviation (right) of ISAS (top), EUREC4A *in situ* dataset (middle) and the difference ΔSSS(ISAS -EUREC4A) (bottom) are shown. The temporal mean and std are calculated using all match-up pairs falling in spatial boxes of size 1°x1° over the full EUREC4A dataset period.



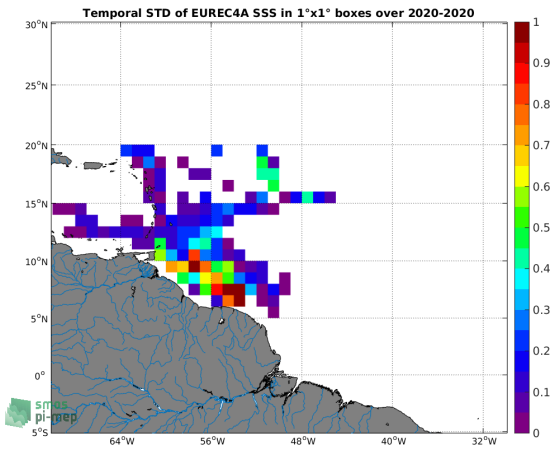
(a) MEAN(ISAS SSS)



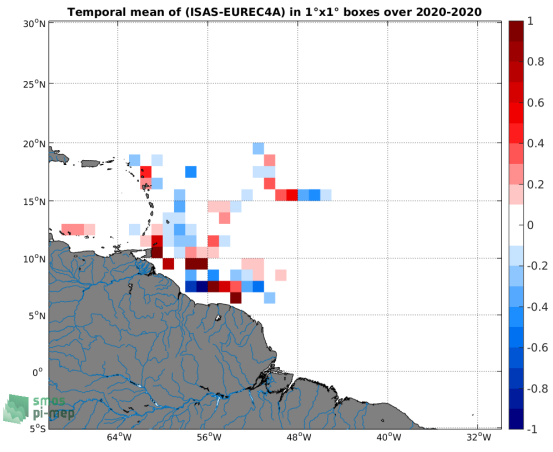
(b) Std(ISAS SSS)



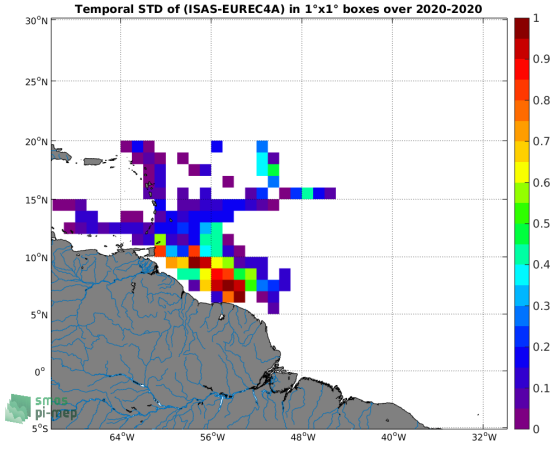
(c) MEAN(EUREC4A SSS)



(d) Std(EUREC4A SSS)



(e) MEAN(ΔSSS) (ISAS - EUREC4A)



(f) Std(ΔSSS) (ISAS - EUREC4A)

Figure 218: Temporal mean (left) and Std (right) of SSS from ISAS (top), EUREC4A (middle), and of ΔSSS (ISAS - EUREC4A). Only match-up pairs are used to generate these maps.

9.7 Time series of the monthly median and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

In the top panel of Figure 219, we show the time series of the monthly median SSS estimated for both ISAS SSS product (in black) and the EUREC4A *in situ* dataset (in blue) at the collected Pi-MEP match-up pairs.

In the middle panel of Figure 219, we show the time series of the monthly median of ΔSSS (ISAS - EUREC4A) for the collected Pi-MEP match-up pairs.

In the bottom panel of Figure 219, we show the time series of the monthly standard deviation of the ΔSSS (ISAS - EUREC4A) for the collected Pi-MEP match-up pairs.

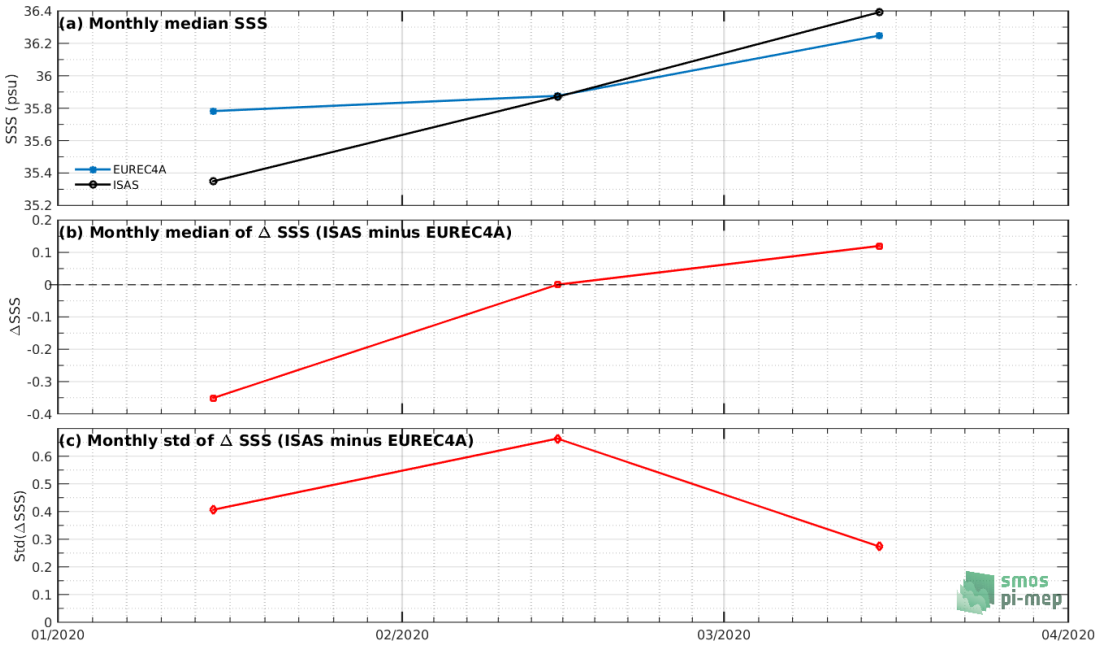


Figure 219: Time series of the monthly median SSS (top), median of ΔSSS (ISAS - EUREC4A) and Std of ΔSSS (ISAS - EUREC4A) considering all match-ups collected by the Pi-MEP.

9.8 Zonal mean and Std of *in situ* and ISAS SSS and of the difference ΔSSS

In Figure 220 left panel, we show the zonal mean SSS considering all Pi-MEP match-up pairs for both ISAS SSS product (in black) and the EUREC4A *in situ* dataset (in blue). The full *in situ* dataset period is used to derive the mean.

In the right panel of Figure 220, we show the zonal mean of ΔSSS (ISAS - EUREC4A) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

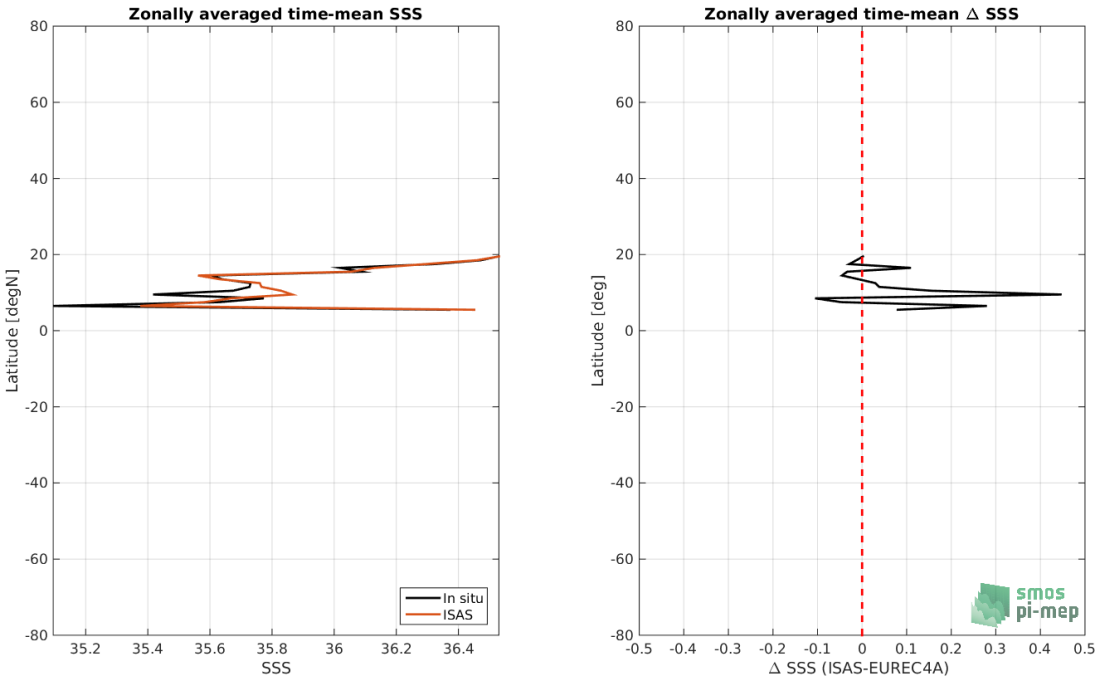
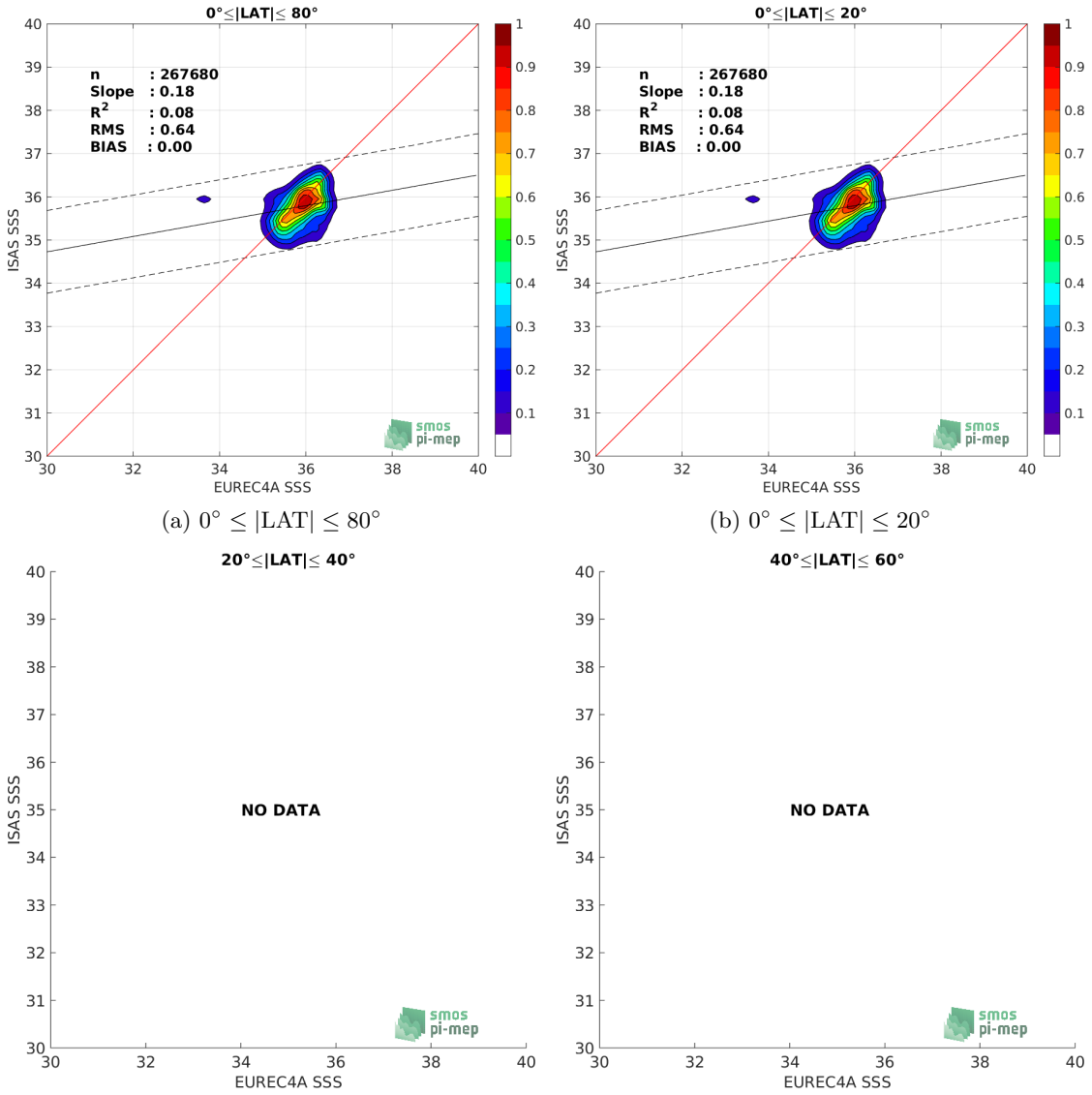


Figure 220: Left panel: Zonal mean SSS from ISAS product (black) and from EUREC4A (blue). Right panel: Zonal mean of ΔSSS (ISAS - EUREC4A) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

9.9 Scatterplots of ISAS vs *in situ* SSS by latitudinal bands

In Figure 221, contour maps of the concentration of ISAS SSS (y-axis) versus EUREC4A SSS (x-axis) at match-up pairs for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.



(a) $0° \leq |\text{LAT}| \leq 80°$ (b) $0° \leq |\text{LAT}| \leq 20°$

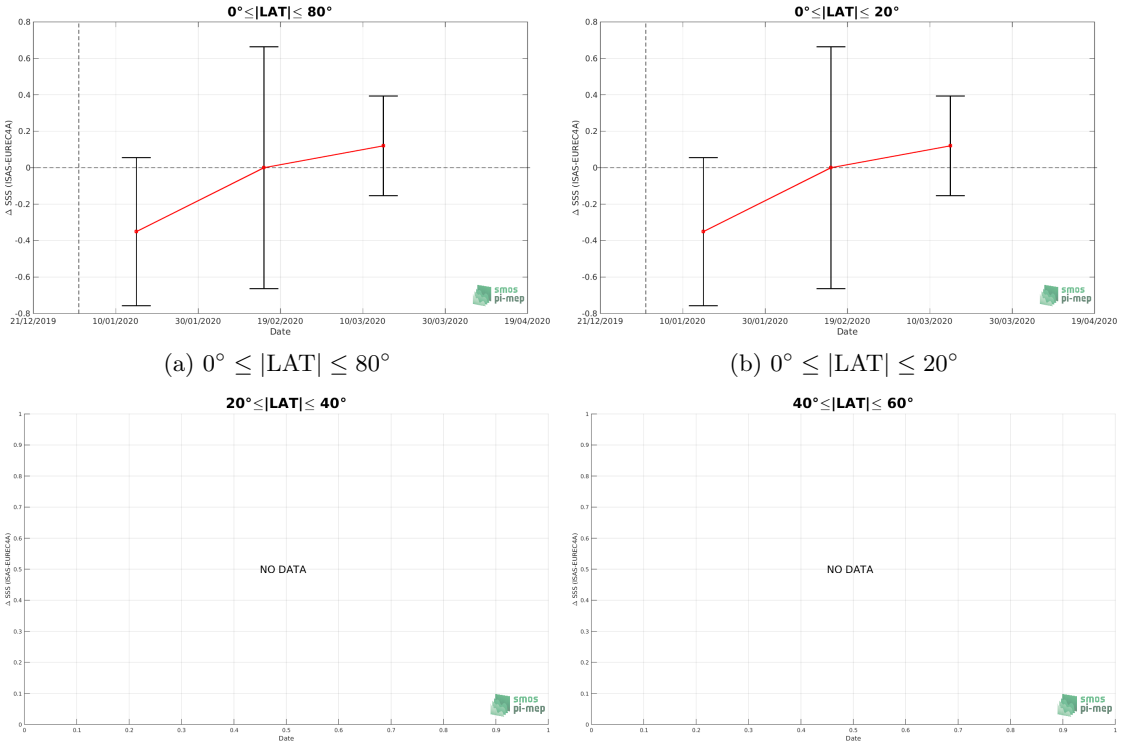
(c) $20° \leq |\text{LAT}| \leq 40°$ (d) $40° \leq |\text{LAT}| \leq 60°$

Figure 221: Contour maps of the concentration of ISAS SSS (y-axis) versus EUREC4A SSS (x-axis) at match-up pairs for different latitude bands. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.

9.10 Time series of the monthly median and Std of the difference ΔSSS sorted by latitudinal bands

In Figure 222, time series of the monthly median (red curves) of ΔSSS (ISAS - EUREC4A) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up

pairs estimated for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.



(a) $0° \leq |\text{LAT}| \leq 80°$

(b) $0° \leq |\text{LAT}| \leq 20°$

(c) $20° \leq |\text{LAT}| \leq 40°$

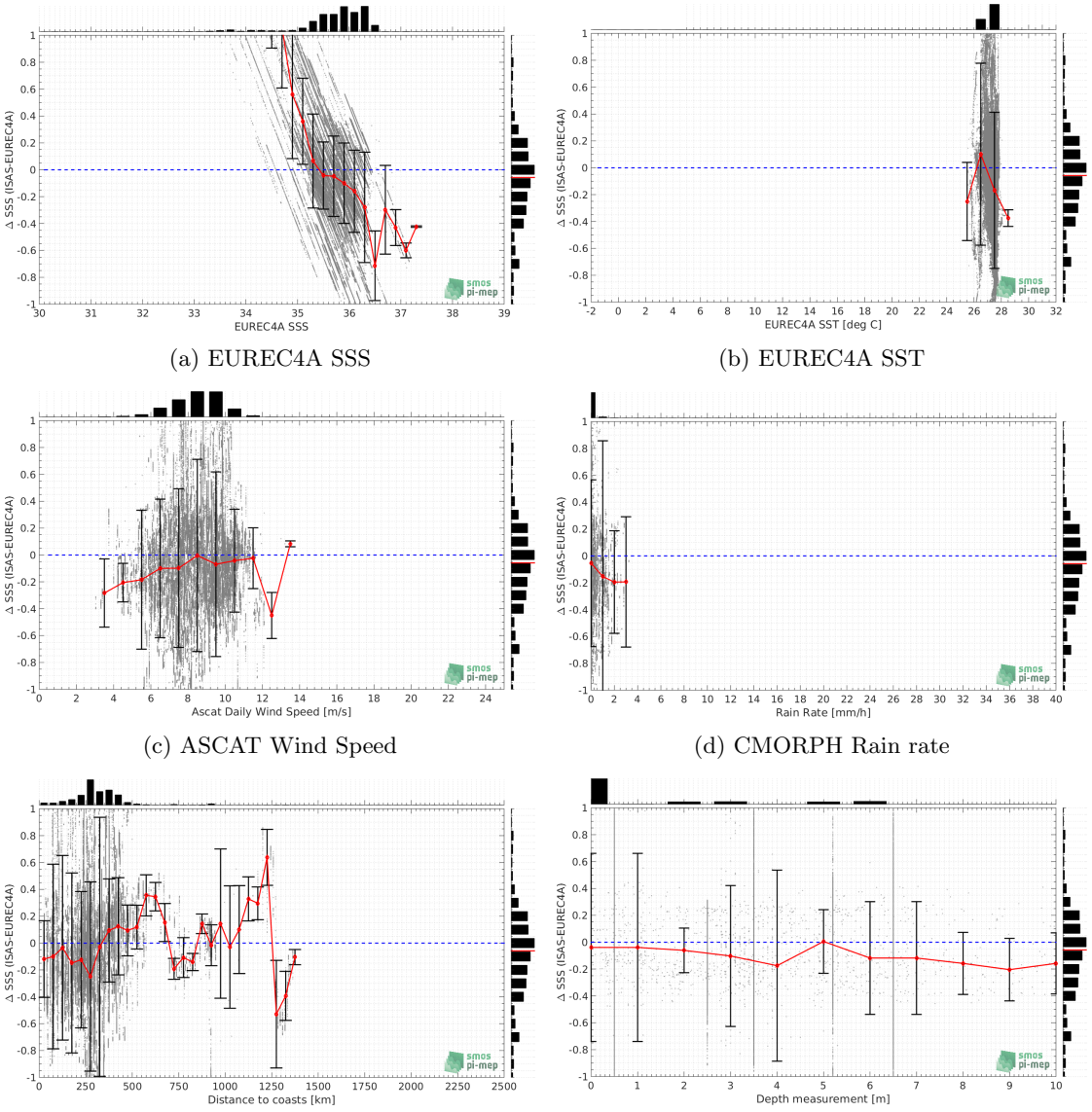
(d) $40° \leq |\text{LAT}| \leq 60°$

Figure 222: Monthly median (red curves) of ΔSSS (ISAS - EUREC4A) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.

9.11 ΔSSS sorted as geophysical conditions

In Figure 223, we classify the match-up differences ΔSSS (ISAS - *in situ*) as function of the geophysical conditions at match-up points. The mean and std of ΔSSS (ISAS - EUREC4A) is thus evaluated as function of the

- *in situ* SSS values per bins of width 0.2,
- *in situ* SST values per bins of width 1°C,
- ASCAT daily wind values per bins of width 1 m/s,
- CMORPH 3-hourly rain rates per bins of width 1 mm/h, and,
- distance to coasts per bins of width 50 km,
- *in situ* measurement depth (if relevant).



(a) EUREC4A SSS

(b) EUREC4A SST

(c) ASCAT Wind Speed

(d) CMORPH Rain rate

(e) Distance to coast

(f) Depth

Figure 223: Δ SSS (ISAS - EUREC4A) sorted as geophysical conditions: EUREC4A SSS a), EUREC4A SST b), ASCAT Wind speed c), CMORPH rain rate d), distance to coast (e) and depth measurements (f).

9.12 ΔSSS maps and statistics for different geophysical conditions

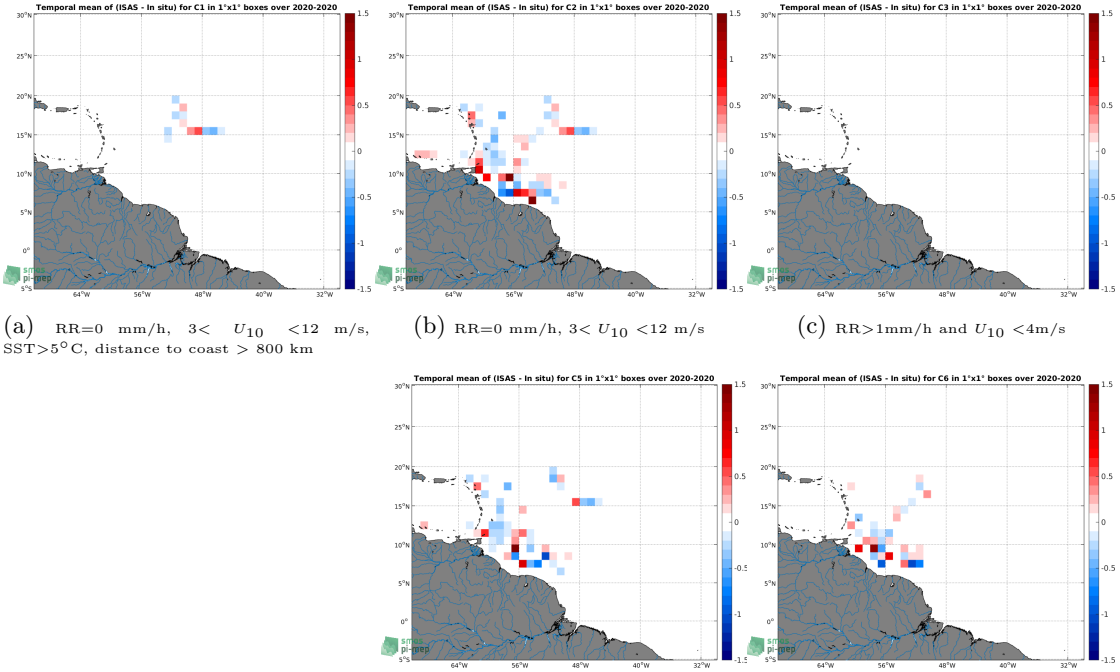
In Figures 224 and 225, we focus on sub-datasets of the match-up differences ΔSSS (ISAS - *in situ*) for the following specific geophysical conditions:

- **C1**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is in the range [3, 12] m/s, the SST is $> 5°$C and distance to coast is > 800 km.
- **C2**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is

in the range [3, 12] m/s.

- **C3**:if the local value at *in situ* location of estimated rain rate is high (ie. $>$ 1 mm/h) and mean daily wind is low (ie. $<$ 4 m/s).
- **C5**:if the *in situ* data is located where the climatological SSS standard deviation is low (ie. above $<$ 0.2).
- **C6**:if the *in situ* data is located where the climatological SSS standard deviation is high (ie. above $>$ 0.2).

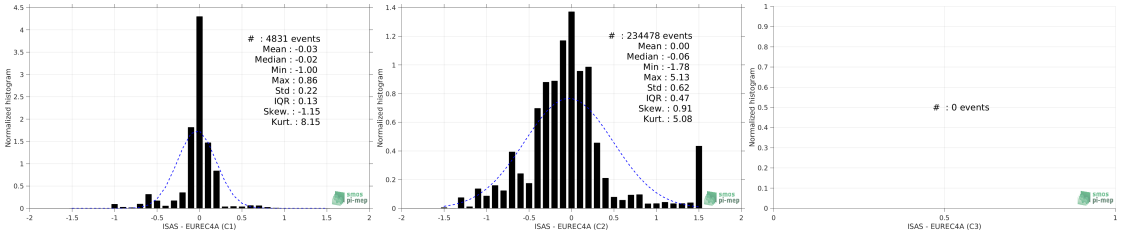
For each of these conditions, the temporal mean (gridded over spatial boxes of size 1°x1°) and the histogram of the difference ΔSSS (ISAS - *in situ*) are presented.



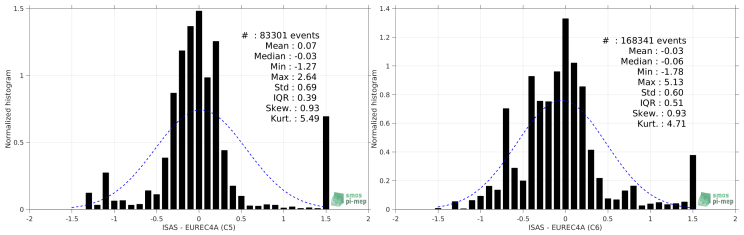
(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s

(d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 224: Temporal mean gridded over spatial boxes of size 1°x1° of ΔSSS (ISAS - EUREC4A) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).



(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s



(d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 225: Normalized histogram of ΔSSS (ISAS - EUREC4A) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).

9.13 Summary

Table 1 shows the mean, median, standard deviation (Std), root mean square (RMS), interquartile range (IQR), correlation coefficient (r^2) and robust standard deviation (Std*) of the match-up differences ΔSSS (ISAS - EUREC4A) for the following conditions:

- all: All the match-up pairs satellite/in situ SSS values are used to derive the statistics
- C1: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km
- C2: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s
- C3: only pairs where RR>1mm/h and U_{10} <4m/s
- C5: only pairs where WOA2013 SSS Std<0.2
- C6: only pairs where WOA2013 SSS Std>0.2
- C7a: only pairs with a distance to coast < 150 km.
- C7b: only pairs with a distance to coast in the range [150, 800] km.
- C7c: only pairs with a distance to coast > 800 km.
- C8a: only pairs where SST is < 5°C.
- C8b: only pairs where SST is in the range [5, 15]°C.
- C8c: only pairs where SST is > 15°C.

- C9a: only pairs where SSS is < 33.
- C9b: only pairs where SSS is in the range [33, 37].
- C9c: only pairs where SSS is > 37.

Table 1: Statistics of ΔSSS (ISAS - EUREC4A)

Condition	#	Median	Mean	Std	RMS	IQR	r^2	Std*
all	267680	-0.06	0.00	0.64	0.64	0.47	0.085	0.35
C1	4831	-0.02	-0.03	0.22	0.23	0.13	0.787	0.09
C2	234478	-0.06	0.00	0.62	0.62	0.47	0.107	0.35
C3	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
C5	83301	-0.03	0.07	0.69	0.69	0.39	0.100	0.30
C6	168341	-0.06	-0.03	0.60	0.60	0.51	0.046	0.40
C7a	22855	-0.05	0.03	0.61	0.61	0.29	0.280	0.22
C7b	239671	-0.07	0.00	0.65	0.65	0.50	0.060	0.37
C7c	5154	-0.02	-0.03	0.22	0.23	0.14	0.794	0.09
C8a	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
C8b	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
C8c	267680	-0.06	0.00	0.64	0.64	0.47	0.085	0.35
C9a	984	2.84	3.11	0.91	3.24	1.37	0.000	0.64
C9b	266474	-0.06	-0.01	0.61	0.61	0.47	0.078	0.35
C9c	222	-0.60	-0.59	0.06	0.60	0.08	0.264	0.05

Table 1 numerical values can be downloaded as a csv file here.

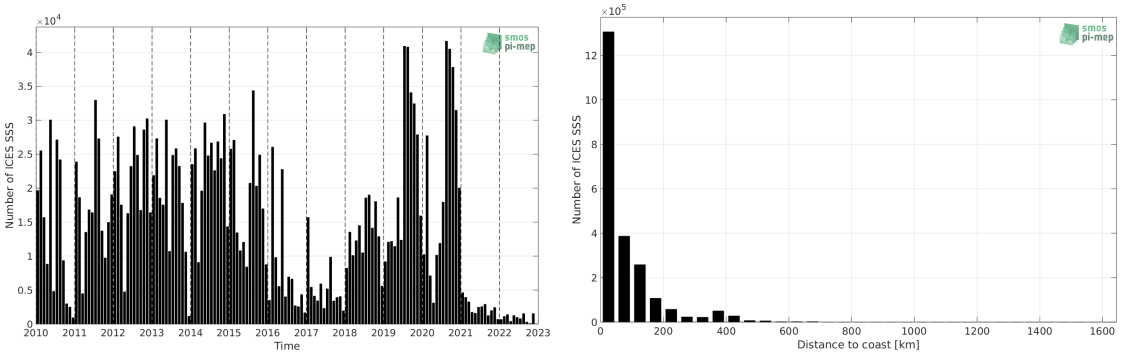
10 ICES

10.1 Introduction

The International Council for the Exploration of the Sea (ICES) oceanographic database holds a wealth of oceanographic data from 1877 to present (ice). All data are quality controlled according to documented guidelines and visually inspected by experienced staff to further improve the quality of the data. The ICES Pi-MEP in situ dataset is a collection of the Surface data, Pump data and High resolution CTD data freely available via the following link `https://data.ices.dk/view-map?theme=201809`.

10.2 Number of SSS data as a function of time and distance to coast

Figure 226 shows the time (a) and distance to coast (b) distributions of the ICES *in situ* dataset.

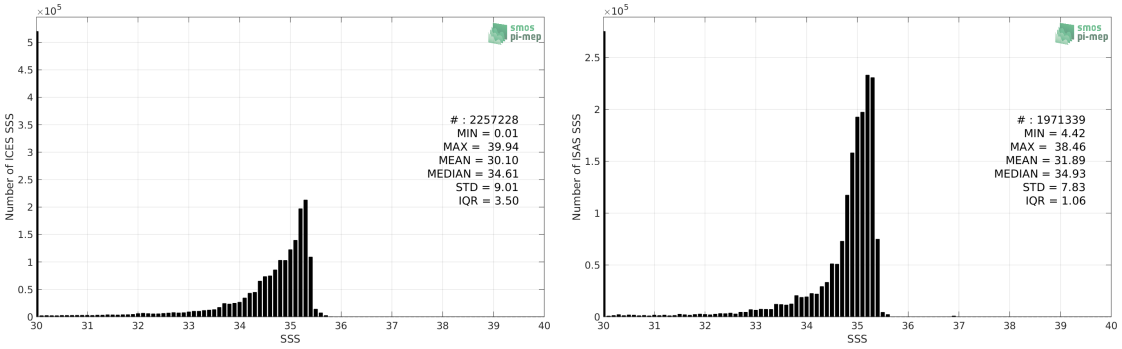


(a) (b)

Figure 226: Number of SSS from ICES as a function of time (a) and distance to coast (b).

10.3 Histograms of SSS

Figure 227 shows the SSS distribution of the ICES (a) and colocalized ISAS (b) dataset.

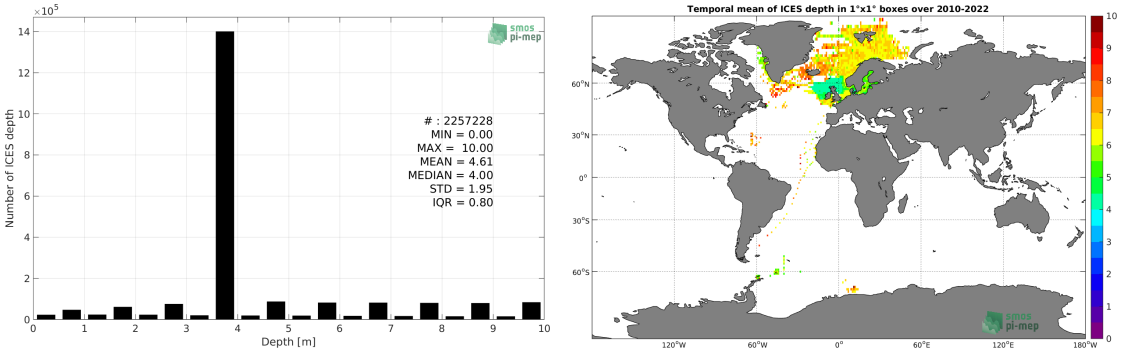


(a) (b)

Figure 227: Histograms of SSS from ICES (a) and ISAS (b) per bins of 0.1.

10.4 Distribution of *in situ* SSS depth measurements

In Figure 228, we show the depth distribution of the *in situ* salinity dataset (a) and the spatial distribution of the depth temporal mean in 1°x1° boxes and considering the full *in situ* dataset period (b).



(a) (b)

Figure 228: Depth distribution of the upper level SSS measurements from ICES (a) and spatial distribution of the *in situ* SSS depth measurements showing the mean value in 1°x1° boxes and considering the full *in situ* dataset period (b).

10.5 Spatial distribution of SSS

In Figure 229, the number of ICES SSS measurements in 1°x1° boxes is shown.

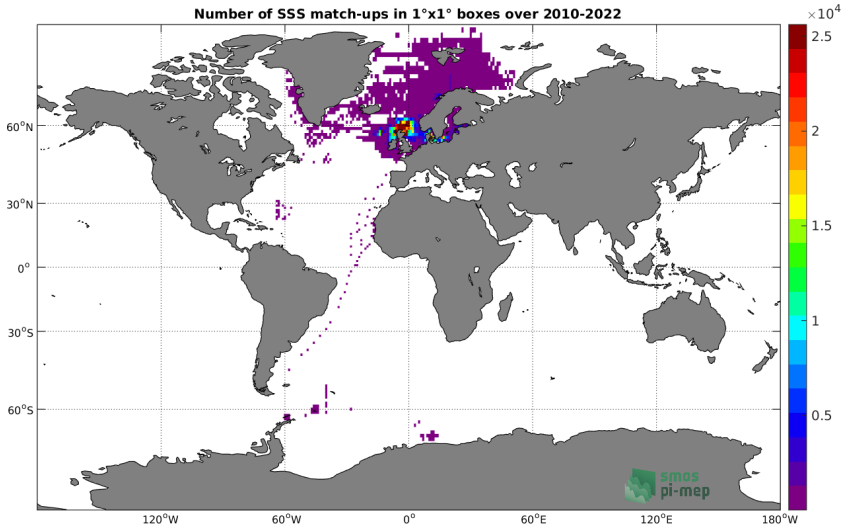
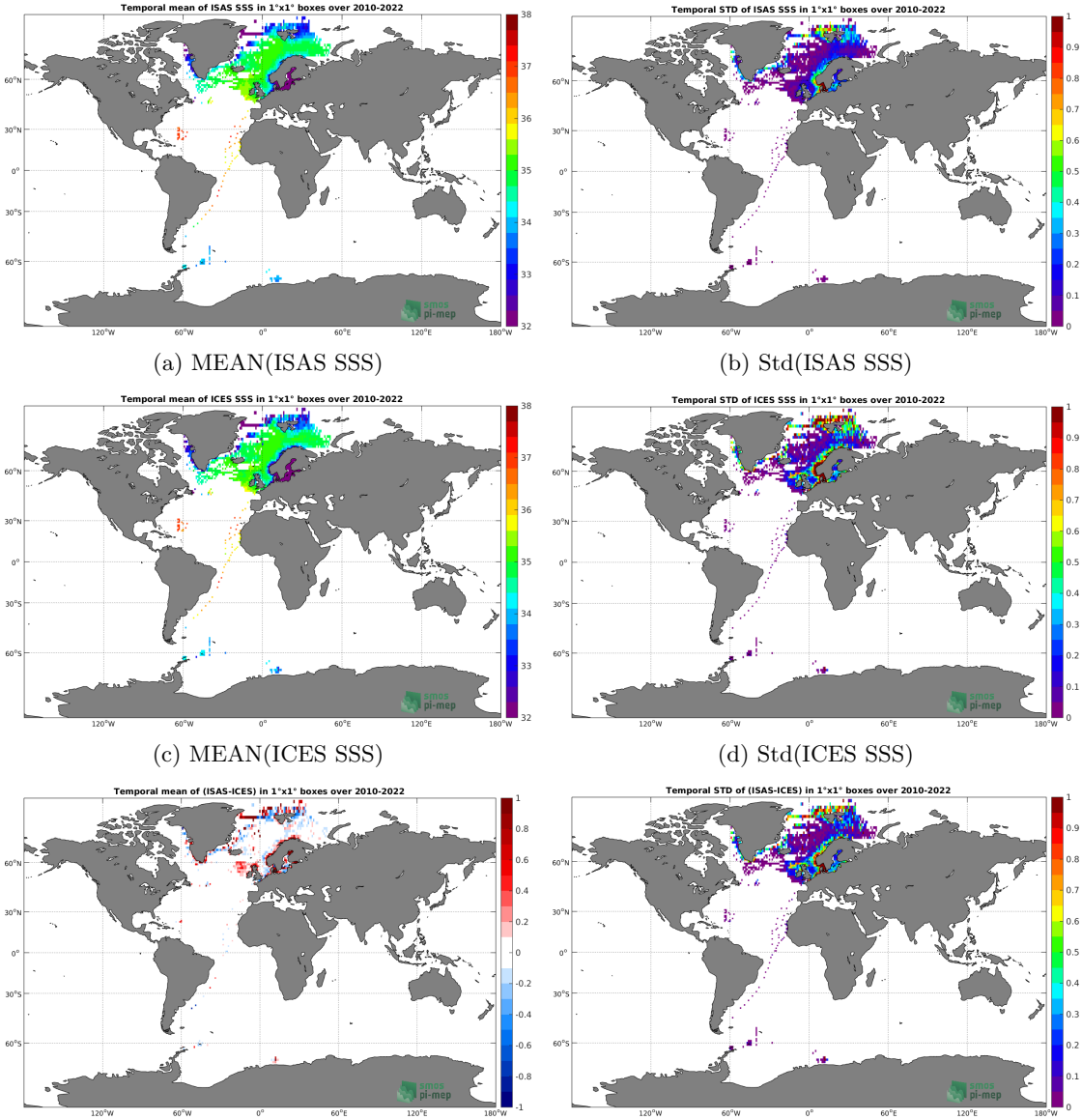


Figure 229: Number of SSS from ICES in 1°x1° boxes.

10.6 Spatial Maps of the Temporal mean and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

In Figure 230, maps of temporal mean (left) and standard deviation (right) of ISAS (top), ICES *in situ* dataset (middle) and the difference ΔSSS(ISAS -ICES) (bottom) are shown. The temporal mean and std are calculated using all match-up pairs falling in spatial boxes of size 1°x1° over the full ICES dataset period.



(a) MEAN(ISAS SSS) (b) Std(ISAS SSS)

(c) MEAN(ICES SSS) (d) Std(ICES SSS)

(e) MEAN(ΔSSS) (ISAS - ICES) (f) Std(ΔSSS) (ISAS - ICES)

Figure 230: Temporal mean (left) and Std (right) of SSS from ISAS (top), ICES (middle), and of ΔSSS (ISAS - ICES). Only match-up pairs are used to generate these maps.

10.7 Time series of the monthly median and Std of *in situ* and ISAS SSS and of the difference (ΔSSS)

In the top panel of Figure 231, we show the time series of the monthly median SSS estimated for both ISAS SSS product (in black) and the ICES *in situ* dataset (in blue) at the collected Pi-MEP match-up pairs.

In the middle panel of Figure 231, we show the time series of the monthly median of ΔSSS (ISAS - ICES) for the collected Pi-MEP match-up pairs.

In the bottom panel of Figure 231, we show the time series of the monthly standard deviation of the ΔSSS (ISAS - ICES) for the collected Pi-MEP match-up pairs.

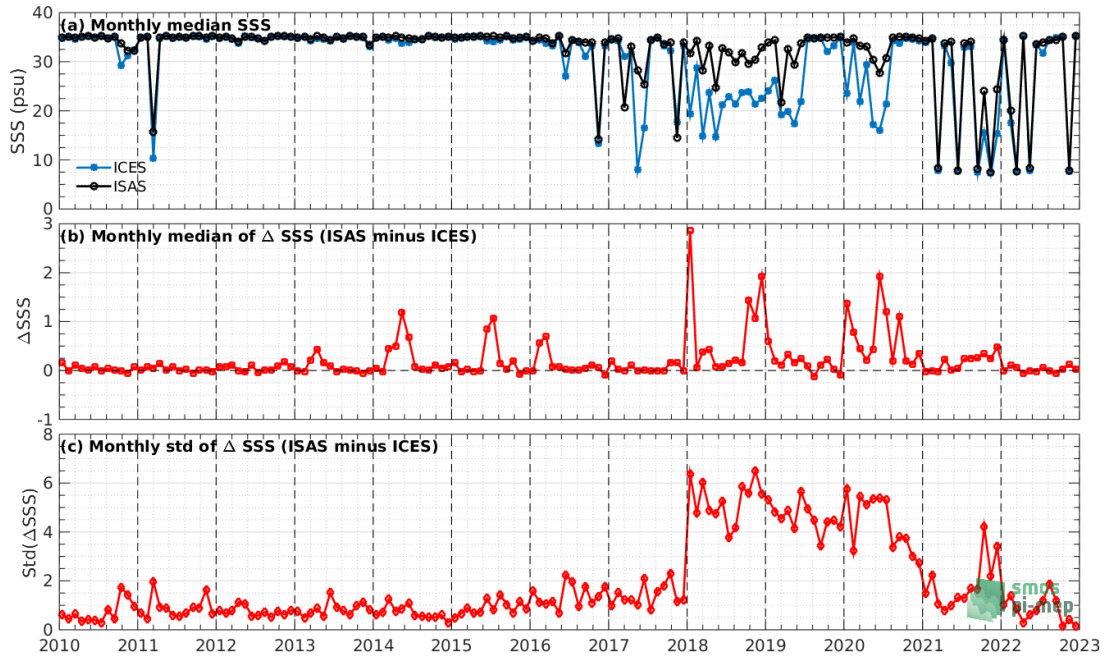


Figure 231: Time series of the monthly median SSS (top), median of ΔSSS (ISAS - ICES) and Std of ΔSSS (ISAS - ICES) considering all match-ups collected by the Pi-MEP.

10.8 Zonal mean and Std of *in situ* and ISAS SSS and of the difference ΔSSS

In Figure 232 left panel, we show the zonal mean SSS considering all Pi-MEP match-up pairs for both ISAS SSS product (in black) and the ICES *in situ* dataset (in blue). The full *in situ* dataset period is used to derive the mean.

In the right panel of Figure 232, we show the zonal mean of ΔSSS (ISAS - ICES) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

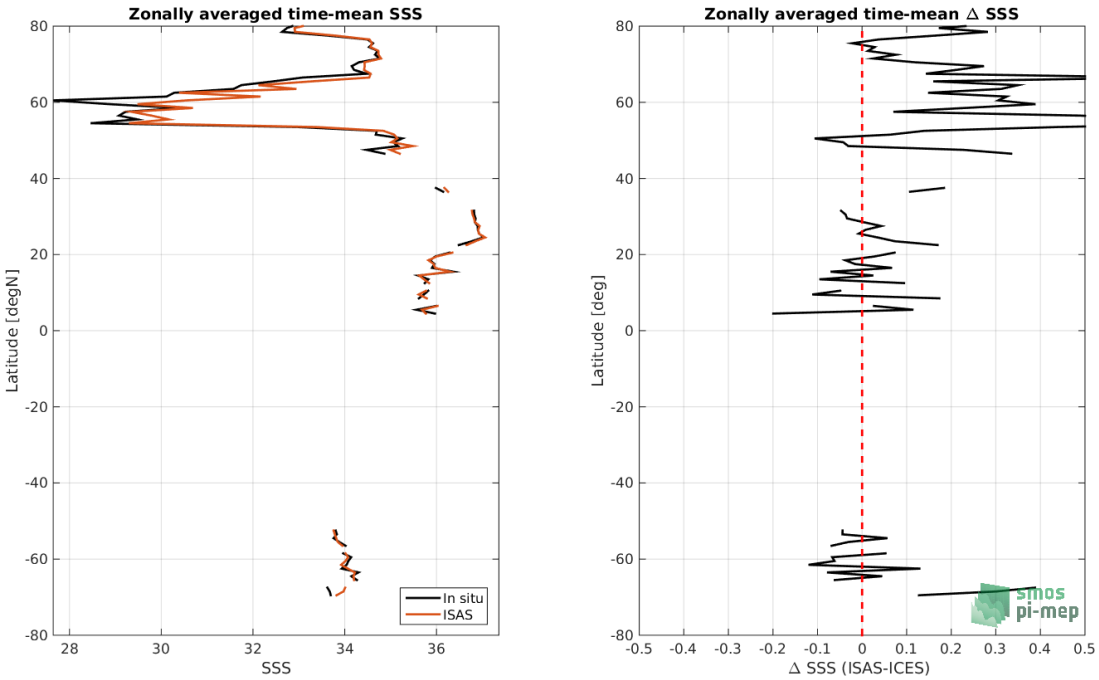
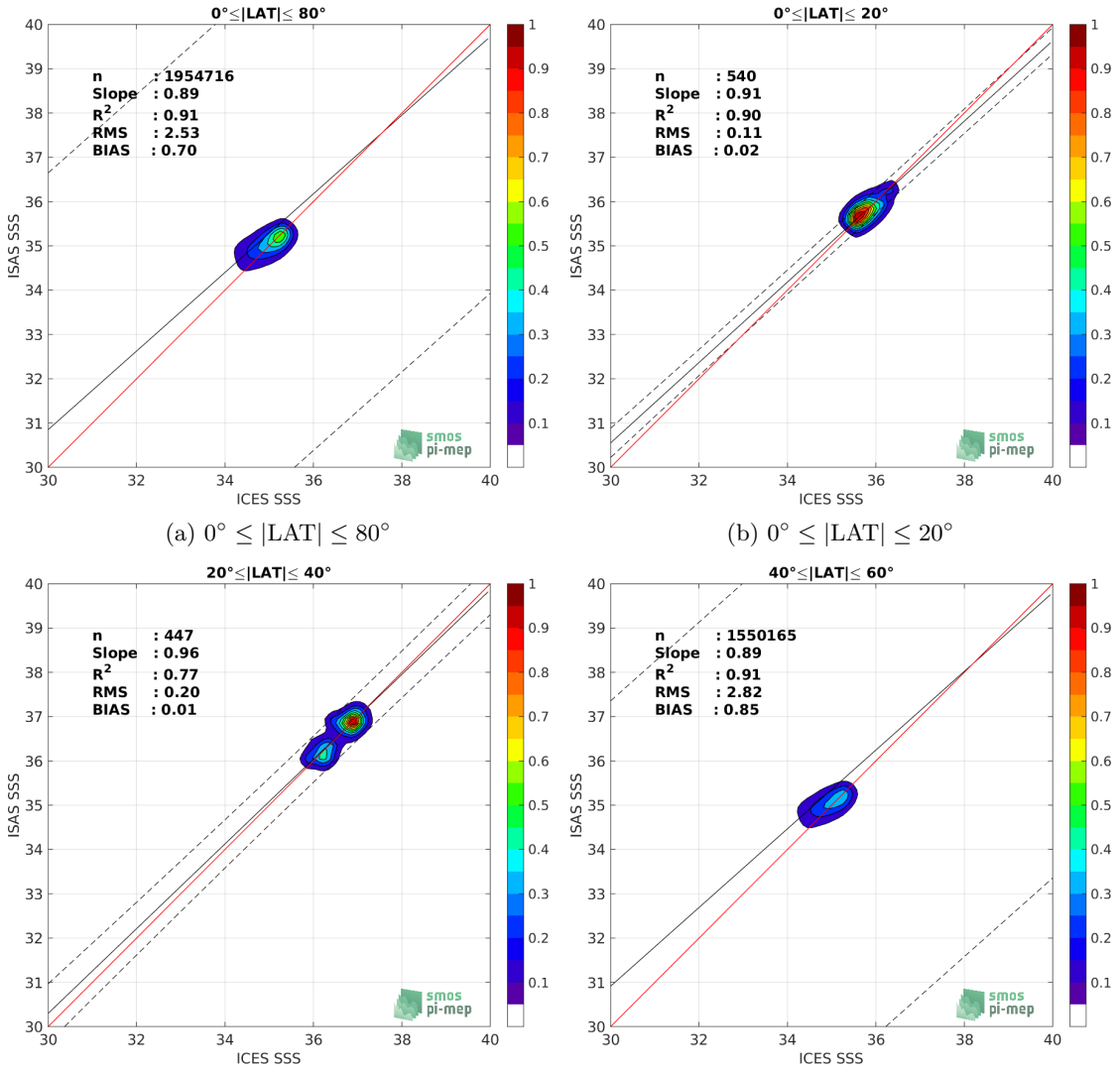


Figure 232: Left panel: Zonal mean SSS from ISAS product (black) and from ICES (blue). Right panel: Zonal mean of ΔSSS (ISAS - ICES) for all the collected Pi-MEP match-up pairs estimated over the full *in situ* dataset period.

10.9 Scatterplots of ISAS vs *in situ* SSS by latitudinal bands

In Figure 233, contour maps of the concentration of ISAS SSS (y-axis) versus ICES SSS (x-axis) at match-up pairs for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.



(a) $0° \leq |\text{LAT}| \leq 80°$

(b) $0° \leq |\text{LAT}| \leq 20°$

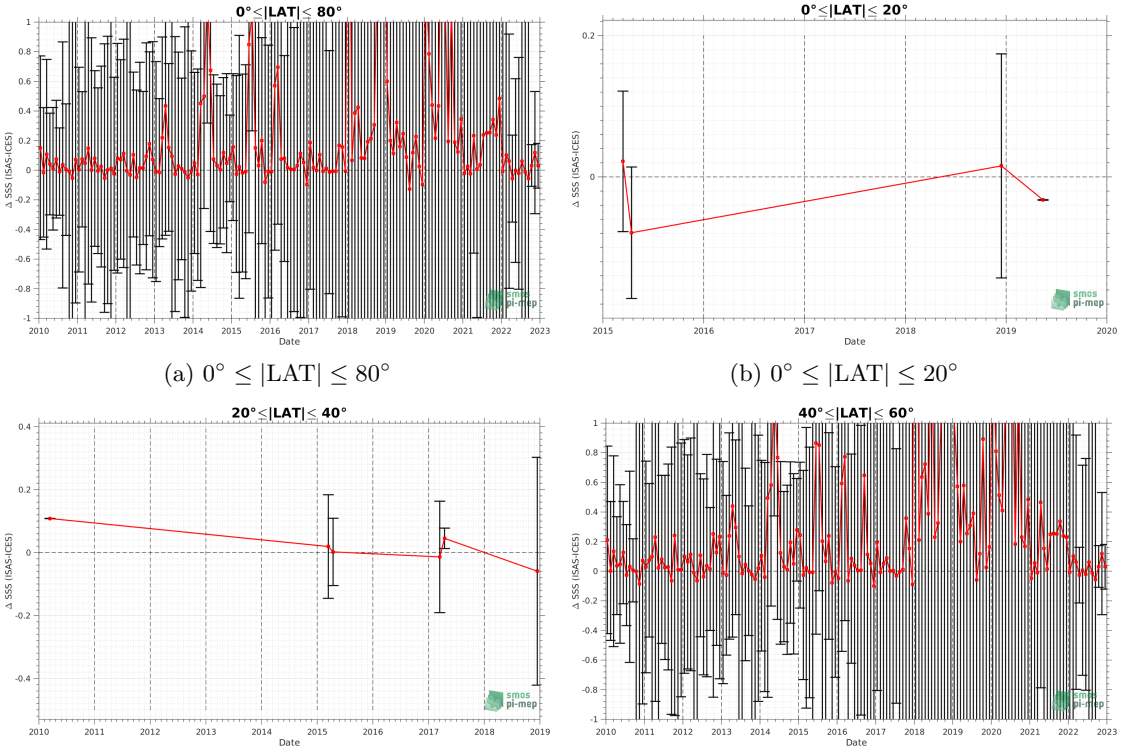
(c) $20° \leq |\text{LAT}| \leq 40°$

(d) $40° \leq |\text{LAT}| \leq 60°$

Figure 233: Contour maps of the concentration of ISAS SSS (y-axis) versus ICES SSS (x-axis) at match-up pairs for different latitude bands. For each plot, the red line shows x=y. The black thin and dashed lines indicate a linear fit through the data cloud and the ±95% confidence levels, respectively. The number match-up pairs n, the slope and R^2 coefficient of the linear fit, the root mean square (RMS) and the mean bias between ISAS and *in situ* data are indicated for each latitude band in each plots.

10.10 Time series of the monthly median and Std of the difference ΔSSS sorted by latitudinal bands

In Figure 234, time series of the monthly median (red curves) of ΔSSS (ISAS - ICES) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs estimated for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.



(a) $0° \leq |\text{LAT}| \leq 80°$

(b) $0° \leq |\text{LAT}| \leq 20°$

(c) $20° \leq |\text{LAT}| \leq 40°$

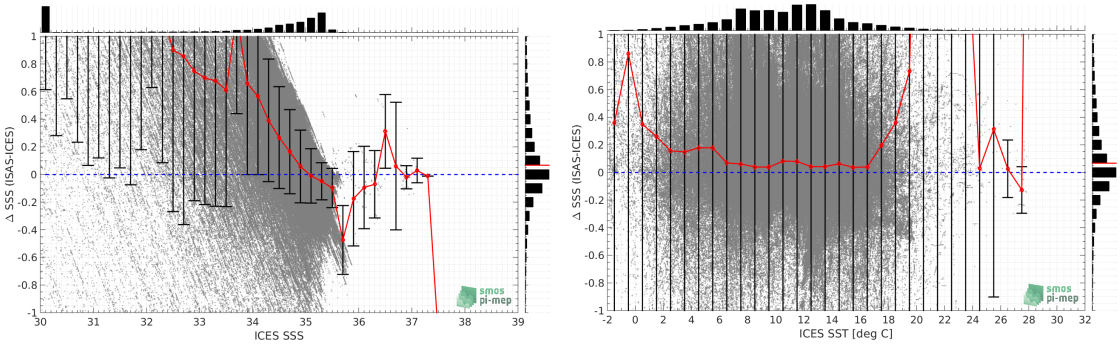
(d) $40° \leq |\text{LAT}| \leq 60°$

Figure 234: Monthly median (red curves) of ΔSSS (ISAS - ICES) and ±1 Std (black vertical thick bars) as function of time for all the collected Pi-MEP match-up pairs for the full *in situ* dataset period are shown for different latitude bands: (a) 80°S-80°N, (b) 20°S-20°N, (c) 40°S-20°S and 20°N-40°N and (d) 60°S-40°S and 40°N-60°N.

10.11 ΔSSS sorted as geophysical conditions

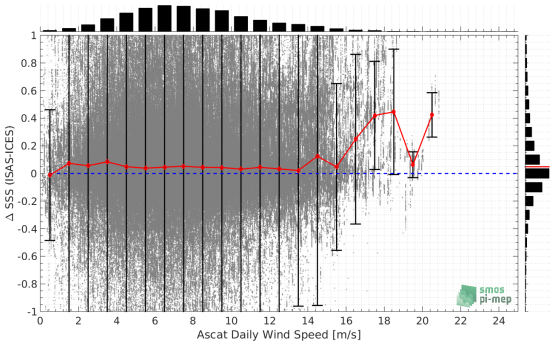
In Figure 235, we classify the match-up differences ΔSSS (ISAS - *in situ*) as function of the geophysical conditions at match-up points. The mean and std of ΔSSS (ISAS - ICES) is thus evaluated as function of the

- *in situ* SSS values per bins of width 0.2,
- *in situ* SST values per bins of width 1°C,
- ASCAT daily wind values per bins of width 1 m/s,
- CMORPH 3-hourly rain rates per bins of width 1 mm/h, and,
- distance to coasts per bins of width 50 km,
- *in situ* measurement depth (if relevant).

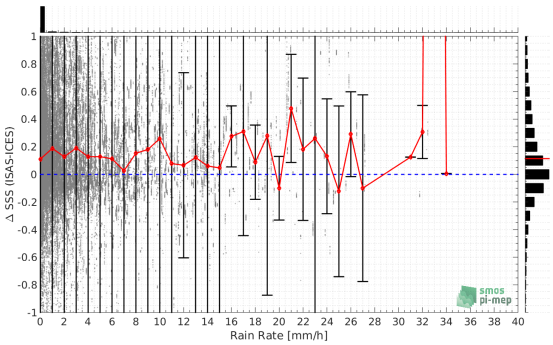


(a) ICES SSS

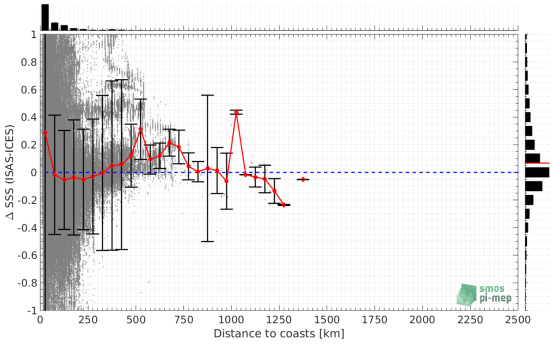
(b) ICES SST



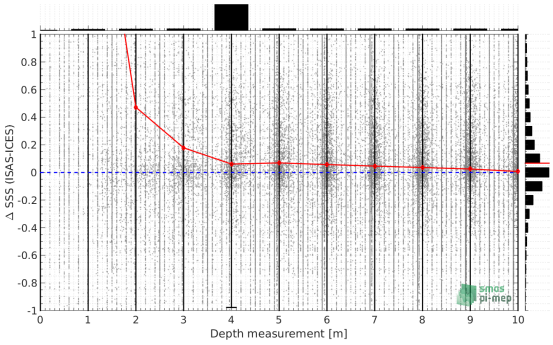
(c) ASCAT Wind Speed



(d) CMORPH Rain rate



(e) Distance to coast



(f) Depth

Figure 235: Δ SSS (ISAS - ICES) sorted as geophysical conditions: ICES SSS a), ICES SST b), ASCAT Wind speed c), CMORPH rain rate d), distance to coast (e) and depth measurements (f).

10.12 ΔSSS maps and statistics for different geophysical conditions

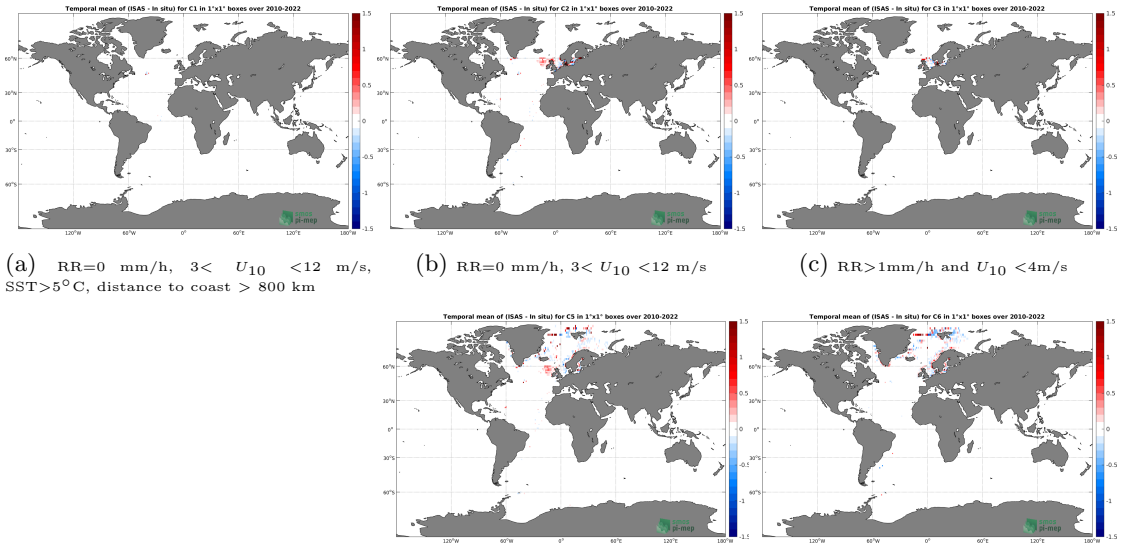
In Figures 236 and 237, we focus on sub-datasets of the match-up differences ΔSSS (ISAS - *in situ*) for the following specific geophysical conditions:

- **C1**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is in the range [3, 12] m/s, the SST is $> 5°$C and distance to coast is > 800 km.
- **C2**:if the local value at *in situ* location of estimated rain rate is zero, mean daily wind is

in the range [3, 12] m/s.

- **C3**:if the local value at *in situ* location of estimated rain rate is high (ie. $>$ 1 mm/h) and mean daily wind is low (ie. $<$ 4 m/s).
- **C5**:if the *in situ* data is located where the climatological SSS standard deviation is low (ie. above $<$ 0.2).
- **C6**:if the *in situ* data is located where the climatological SSS standard deviation is high (ie. above $>$ 0.2).

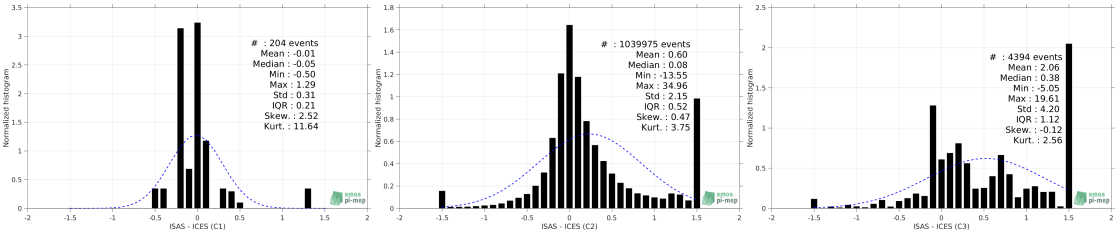
For each of these conditions, the temporal mean (gridded over spatial boxes of size 1°x1°) and the histogram of the difference ΔSSS (ISAS - *in situ*) are presented.



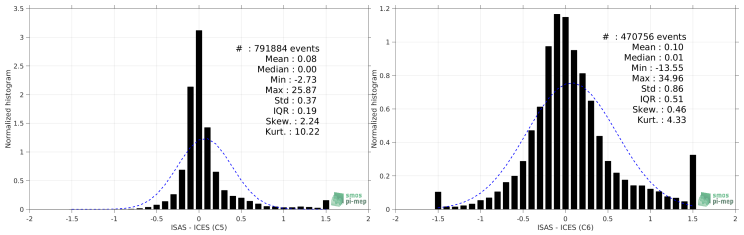
(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s

(d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 236: Temporal mean gridded over spatial boxes of size 1°x1° of ΔSSS (ISAS - ICES) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).



(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s



(d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 237: Normalized histogram of ΔSSS (ISAS - ICES) for 5 different subdatasets corresponding to:RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (a), RR=0 mm/h, 3< U_{10} <12 m/s (b), RR>1mm/h and U_{10} <4m/s (c),WOA2013 SSS Std<0.2 (d),WOA2013 SSS Std>0.2 (e).

10.13 Summary

Table 1 shows the mean, median, standard deviation (Std), root mean square (RMS), interquartile range (IQR), correlation coefficient (r^2) and robust standard deviation (Std*) of the match-up differences ΔSSS (ISAS - ICES) for the following conditions:

- all: All the match-up pairs satellite/in situ SSS values are used to derive the statistics
- C1: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km
- C2: only pairs where RR=0 mm/h, 3< U_{10} <12 m/s
- C3: only pairs where RR>1mm/h and U_{10} <4m/s
- C5: only pairs where WOA2013 SSS Std<0.2
- C6: only pairs where WOA2013 SSS Std>0.2
- C7a: only pairs with a distance to coast < 150 km.
- C7b: only pairs with a distance to coast in the range [150, 800] km.
- C7c: only pairs with a distance to coast > 800 km.
- C8a: only pairs where SST is < 5°C.
- C8b: only pairs where SST is in the range [5, 15]°C.
- C8c: only pairs where SST is > 15°C.

- C9a: only pairs where SSS is < 33.
- C9b: only pairs where SSS is in the range [33, 37].
- C9c: only pairs where SSS is > 37.

Table 1: Statistics of ΔSSS (ISAS - ICES)

Condition	#	Median	Mean	Std	RMS	IQR	r^2	Std*
all	1971339	0.07	0.73	2.55	2.65	0.53	0.909	0.31
C1	204	-0.05	-0.01	0.31	0.31	0.21	0.826	0.17
C2	1039975	0.08	0.60	2.15	2.23	0.52	0.946	0.33
C3	4394	0.38	2.06	4.20	4.68	1.12	0.843	0.70
C5	791884	0.00	0.08	0.37	0.38	0.19	0.993	0.14
C6	470756	0.01	0.10	0.86	0.86	0.51	0.992	0.37
C7a	1664688	0.09	0.84	2.76	2.88	0.59	0.907	0.35
C7b	306323	0.01	0.11	0.49	0.51	0.23	0.297	0.16
C7c	328	-0.01	-0.01	0.26	0.26	0.19	0.908	0.10
C8a	143777	0.20	1.44	3.57	3.85	1.31	0.916	0.63
C8b	1615818	0.06	0.48	1.93	1.99	0.45	0.920	0.27
C8c	210759	0.11	2.10	4.59	5.04	2.28	0.817	0.64
C9a	424732	1.05	2.94	4.83	5.66	4.29	0.821	1.90
C9b	1546566	0.03	0.12	0.44	0.45	0.34	0.410	0.23
C9c	41	0.02	-0.46	1.44	1.50	0.20	0.772	0.06

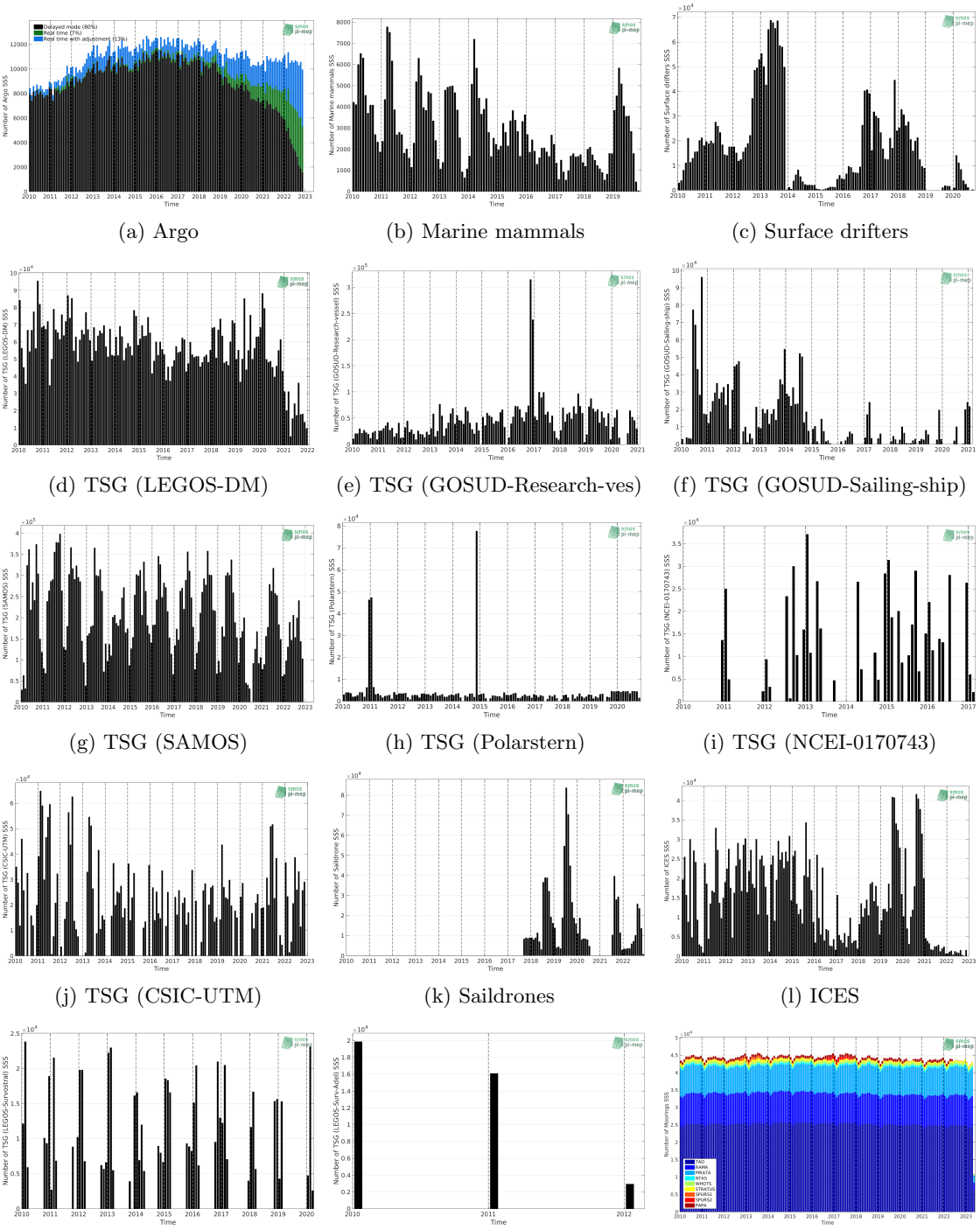
Table 1 numerical values can be downloaded as a csv file here.

11 Summary

In the following summary section, some of the plots presented in the previous sections corresponding to the time distribution [11.1], SSS distribution [11.2], temporal mean [11.3] and std [11.4], and spatial density [11.5], are combined to emphasize similarities/differences between each *in situ* datasets. Some characteristics of each *in situ* datasets for each Pi-MEP region are also presented in 11.6.

11.1 Number of SSS data as a function of time

Figures 238 show the time distribution of the different *in situ* datasets.



(a) Argo (b) Marine mammals (c) Surface drifters

(d) TSG (LEGOS-DM) (e) TSG (GOSUD-Research-ves) (f) TSG (GOSUD-Sailing-ship)

(g) TSG (SAMOS) (h) TSG (Polarstern) (i) TSG (NCEI-0170743)

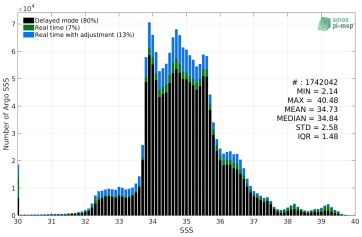
(j) TSG (CSIC-UTM) (k) Saildrones (l) ICES

(m) TSG (LEGOS-Survostral) (n) TSG (Survostral-Adélie) (o) Moorings

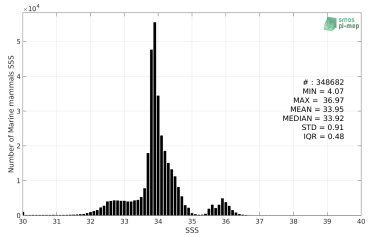
Figure 238: Number of SSS data as a function of time of the different *in situ* datasets

11.2 Histogram of SSS

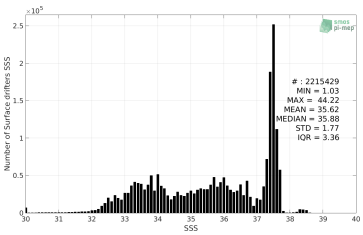
Figures 239 show the SSS distribution of the different *in situ* datasets.



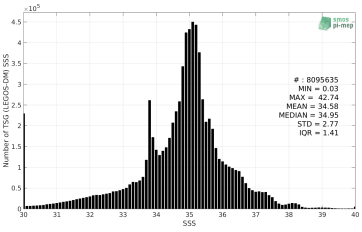
(a) Argo



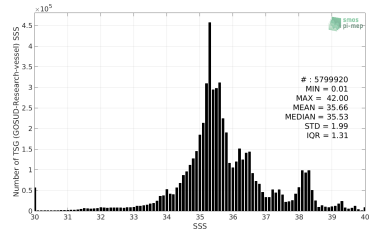
(b) Marine mammals



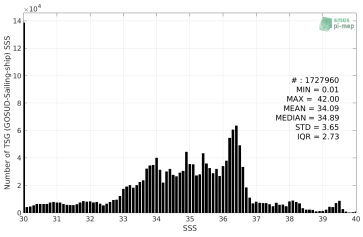
(c) Surface drifters



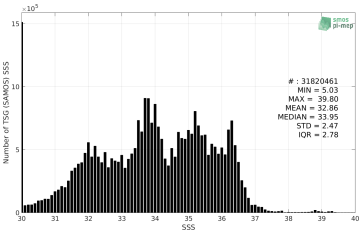
(d) TSG (LEGOS-DM)



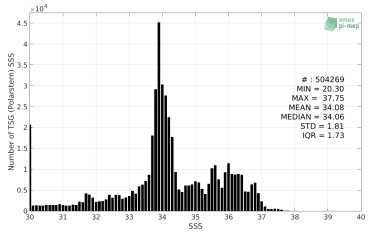
(e) TSG (GOSUD-Research-ves)



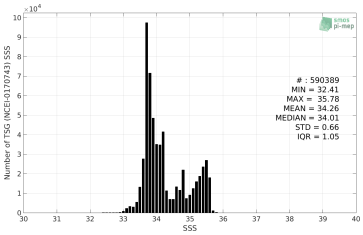
(f) TSG (GOSUD-Sailing-ship)



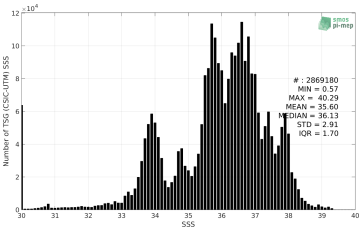
(g) TSG (SAMOS)



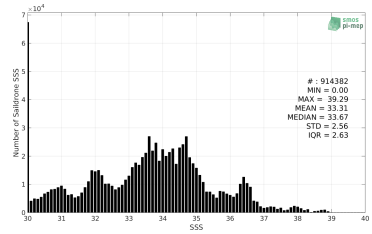
(h) TSG (Polarstern)



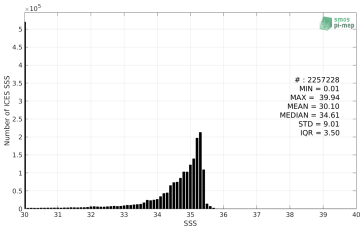
(i) TSG (NCEI-0170743)



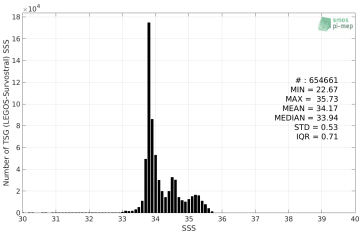
(j) TSG (CSIC-UTM)



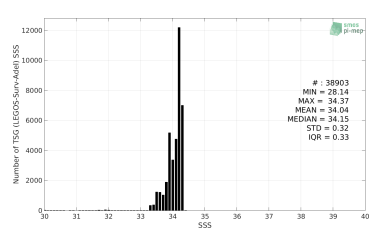
(k) Saildrones



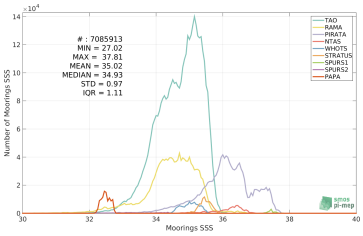
(l) ICES



(m) TSG (LEGOS-Survostral)



(n) TSG (Survostral-Adélie)

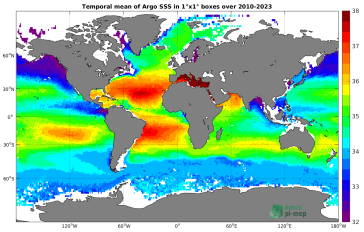


(o) Moorings

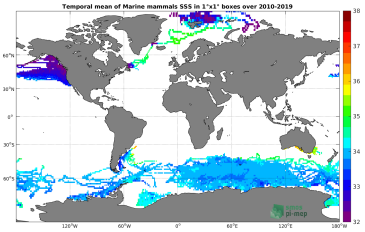
Figure 239: Distribution of SSS per bins of 0.1 of the different *in situ* datasets.

11.3 Temporal mean of SSS

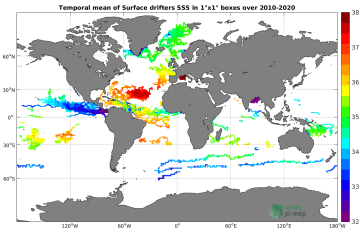
Figures 240 show the temporal mean gridded over spatial boxes of size 1°x1° using the full period of each *in situ* datasets.



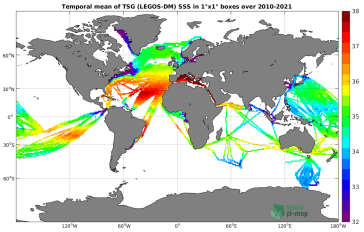
(a) Argo



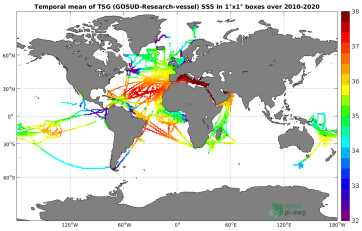
(b) Marine mammals



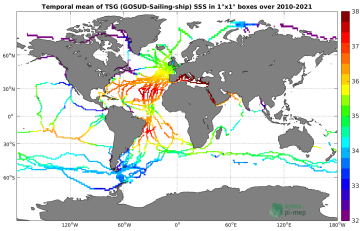
(c) Surface drifters



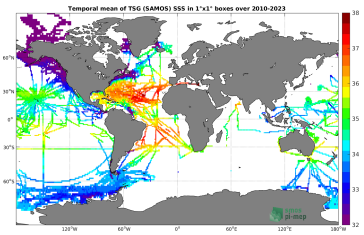
(d) TSG (LEGOS-DM)



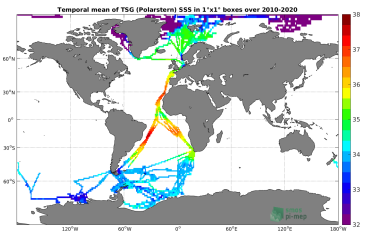
(e) TSG (GOSUD-Research-ves)



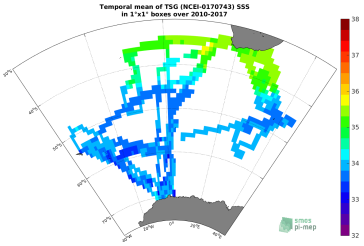
(f) TSG (GOSUD-Sailing-ship)



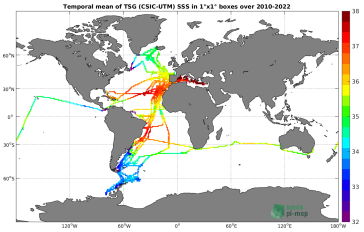
(g) TSG (SAMOS)



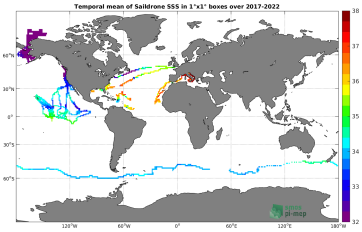
(h) TSG (Polarstern)



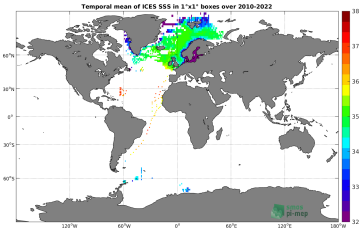
(i) TSG (NCEI-0170743)



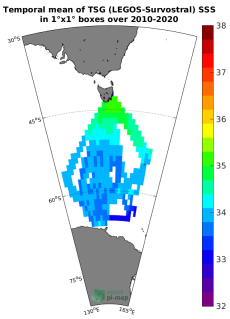
(j) TSG (CSIC-UTM)



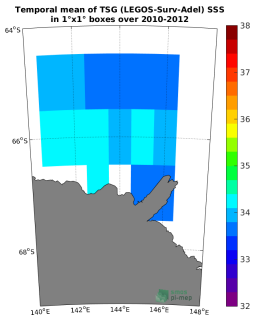
(k) Saildrones



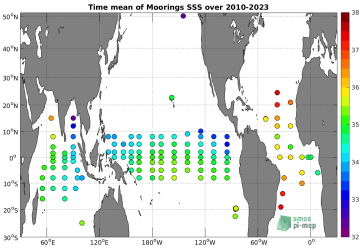
(l) ICES



(m) TSG (LEGOS-Survostral)



(n) TSG (Survostral-Adélie)

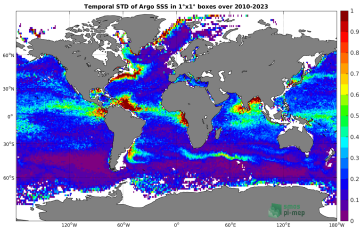


(o) Moorings

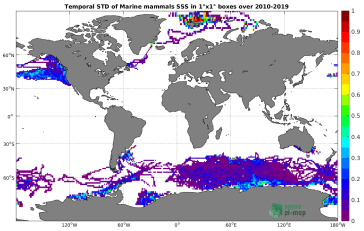
Figure 240: Temporal mean of SSS in 1°x1° boxes.

11.4 Temporal Std of SSS

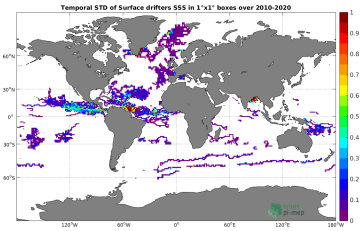
Figures 241 show the temporal standard deviation (std) gridded over spatial boxes of size 1°x1° using the full period of each *in situ* datasets.



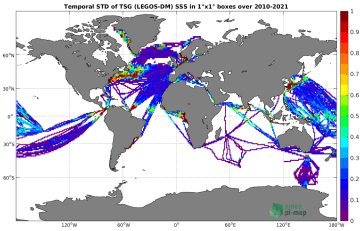
(a) Argo



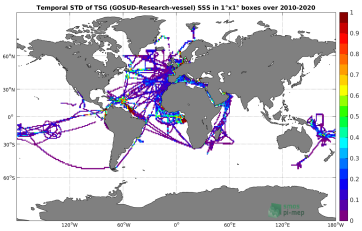
(b) Marine mammals



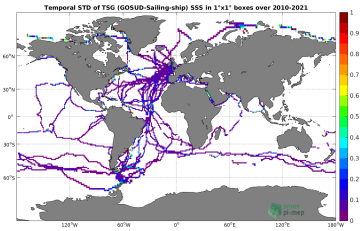
(c) Surface drifters



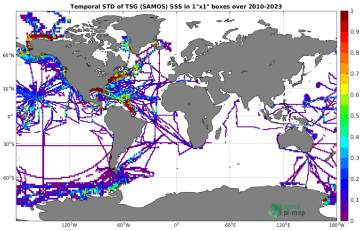
(d) TSG (LEGOS-DM)



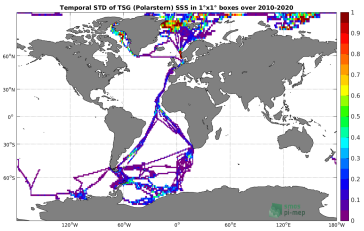
(e) TSG (GOSUD-Research-ves)



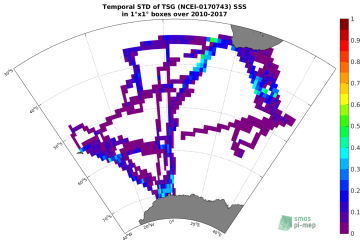
(f) TSG (GOSUD-Sailing-ship)



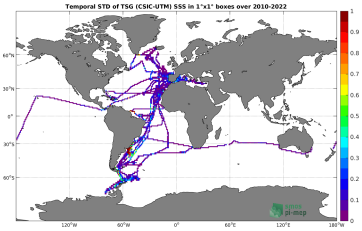
(g) TSG (SAMOS)



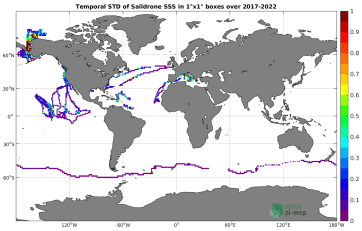
(h) TSG (Polarstern)



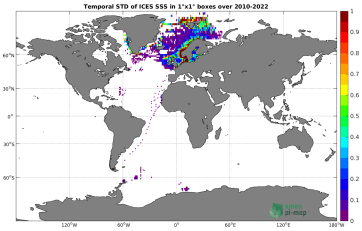
(i) TSG (NCEI-0170743)



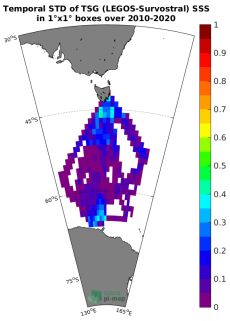
(j) TSG (CSIC-UTM)



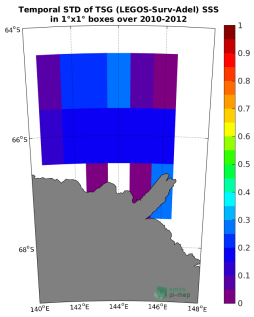
(k) Saildrones



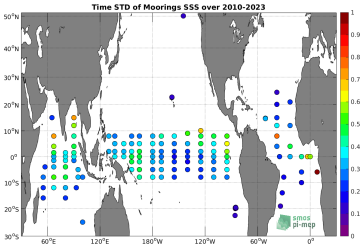
(l) ICES



(m) TSG (LEGOS-Survostral)



(n) TSG (Survostral-Adélie)

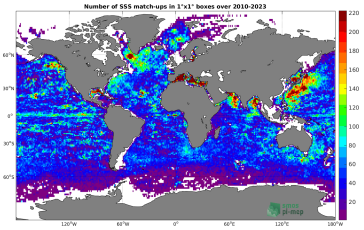


(o) Moorings

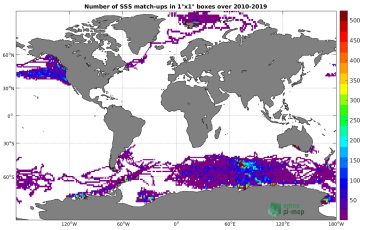
Figure 241: Temporal Std of SSS in 1°x1° boxes.

11.5 Spatial density of SSS

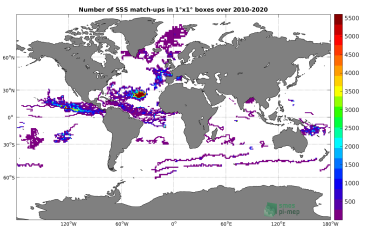
Figures 242 show the spatial distribution of SSS gridded over spatial boxes of size 1°x1° using the full period of each *in situ* datasets.



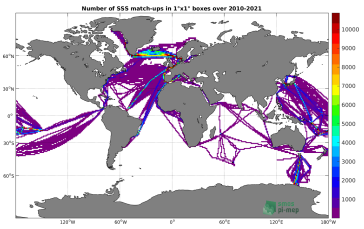
(a) Argo



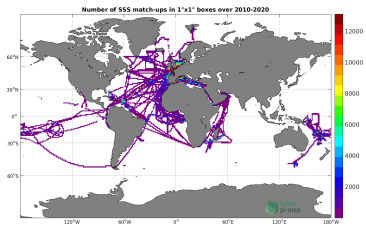
(b) Marine mammals



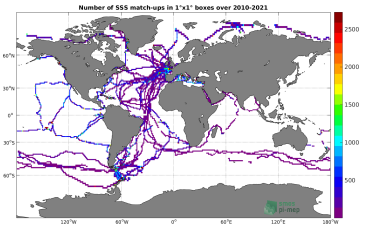
(c) Surface drifters



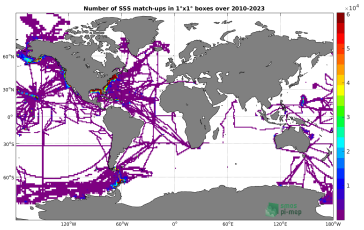
(d) TSG (LEGOS-DM)



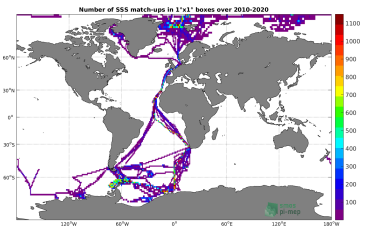
(e) TSG (GOSUD-Research-ves)



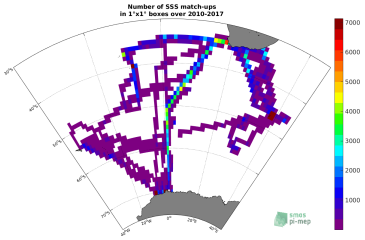
(f) TSG (GOSUD-Sailing-ship)



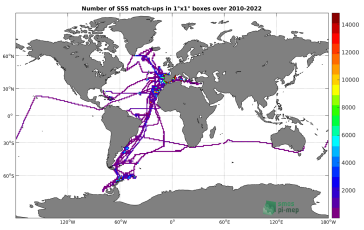
(g) TSG (SAMOS)



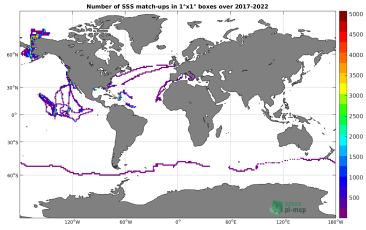
(h) TSG (Polarstern)



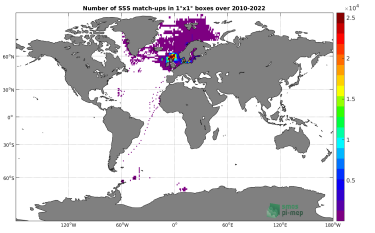
(i) TSG (NCEI-0170743)



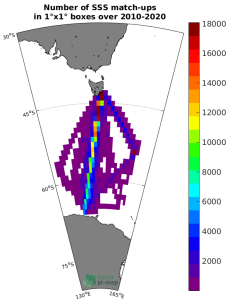
(j) TSG (CSIC-UTM)



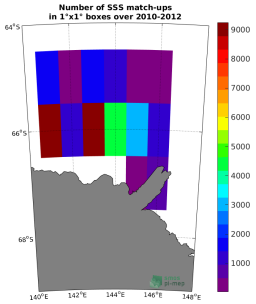
(k) Saildrones



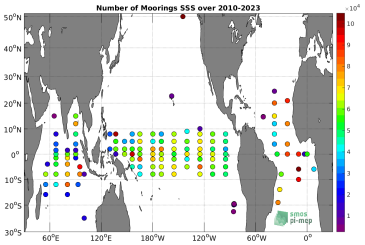
(l) ICES



(m) TSG (LEGOS-Survostral)



(n) TSG (Survostral-Adélie)



(o) Moorings

Figure 242: Number of SSS in 1°x1° boxes.

11.6 Characteristics for each Pi-MEP region

The following tables show some characteristics of each *in situ* dataset after applying the different Pi-MEP region masks described here. To switch from a region to another, you can play with the arrows between the plot and the caption.

In situ datasets	**#**	**Time**$_{min}$	**Time**$_{max}$	**S**$_{min}$	**S**$_{max}$	**S**$_{Mean}$
Argo	1738227	01/01/2010	01/05/2023	2.14	40.48	34.73
Marine mammals	303095	01/01/2010	19/11/2019	16.15	36.97	33.95
Surface drifters	2209796	01/01/2010	22/09/2020	1.03	44.22	35.63
Saildrone	882016	02/09/2017	07/11/2022	0.00	39.29	33.34
TSG (LEGOS-DM)	7701182	01/01/2010	28/12/2021	0.04	42.35	34.70
TSG (GOSUD-Research-vessel)	5462841	05/01/2010	30/12/2020	0.01	42.00	35.66
TSG (GOSUD-Sailing-ship)	1263691	08/01/2010	28/01/2021	0.01	42.00	34.97
TSG (SAMOS)	27986398	07/01/2010	23/04/2023	5.04	39.52	33.13
TSG (CSIC-UTM)	2564842	05/01/2010	06/12/2022	0.57	40.29	35.58
TSG (Polarstern)	490683	01/01/2010	11/10/2020	20.30	37.75	34.09
TSG (NCEI-0170743)	568423	08/12/2010	02/02/2017	32.41	35.78	34.28
TSG (LEGOS-Survostral)	632082	01/01/2010	02/03/2020	32.87	35.73	34.17
TSG (LEGOS-Surv-Adel)	34818	09/01/2010	25/01/2012	33.19	34.37	34.05
Salinity Snake (SPURS 2)	3428541	20/08/2016	13/11/2017	24.04	34.34	33.12
Saildrone (SPURS 2)	9218	16/10/2017	17/11/2017	30.75	33.85	33.29
Waveglider (SPURS 2)	642340	24/08/2016	10/11/2017	27.48	34.47	33.51
Seaglider (SPURS 2)	73542	24/08/2016	07/11/2017	28.99	34.86	33.27
EUREC4A	264899	01/01/2020	30/03/2020	30.20	37.31	35.75
ICES	1676043	06/01/2010	02/12/2022	0.11	39.94	31.56
Total	57932677	01/01/2010	01/05/2023	0.00	44.22	34.15

Table 1: Number of points, first and last date, minimum, maximum and mean value of the SSS distribution of the different *in situ* datasets available for the **Global Ocean** Pi-MEP region.

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