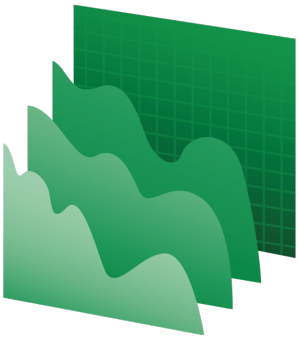


In Situ database Analyses Report

TSG

prepared by the Pi-MEP Consortium

September 15, 2019

Contents

Acronym

Aquarius	NASA/CONAE Salinity mission
ASCAT	Advanced Scatterometer
ATBD	Algorithm Theoretical Baseline Document
BLT	Barrier Layer Thickness
CMORPH	CPC MORPHing technique
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 TSG in situ dataset used by the Pi-MEP to validate SMOS, SMAP and Aquarius satellite SSS products. A series of plots is proposed showing:

- 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 and pressure (if relevant)
- Temporal STD of shallowest salinity
- Spatial density of shallowest salinity
- ΔSSS between local in situ data and ISAS analyses sorted as function of geophysical conditions
- Conditional analyses

The conditional analyses proposed in the document, correspond to filter/subdivide the different in situ datasets 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 conditions, the temporal mean (gridded over spatial boxes of size 1°x1°) and the histogram of the difference ΔSSS between ISAS and in situ SSS value are presented. The use of ISAS (monthly SSS in situ analysed field) 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.

1.1 In situ dataset

1.1.1 TSG

The TSG dataset is subdivided into 8 subdatasets following TSG data providers subdivisions:

- LEGOS-DM:
  The TSG-LEGOS-DM dataset correspond 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)). 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 correspond to French research vessels that have been collecting thermo-salinometer (TSG) data since the early 2000 in contribution to the 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. (2015a)) is updated annually and freely available here. Adjusted values when available and only collected TSG data that exhibit quality flags=1 and 2 were used.

- GOSUD-Sailing-ship: The TSG-GOSUD-Sailing-ship dataset correspond 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. (2015)) 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 correspond 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 has been remove from this dataset.

- LEGOS-Survostral: The TSG-LEGOS-Survostral dataset correspond 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 via ftp. Adjusted values when available and only collected TSG data that exhibit quality flags=1 and 2 were used.

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

- 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 72 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, 803312, 803431, 808835, 808836, 808838, 809727, 810678, 816055, 819831, 823259, 831976, 832269, 839406, 839407, 839408, 845130, 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.

- 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 termosalinograph (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.

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 the measurements to get an estimate of the geophysical 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. 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 test 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 degree 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 reanalysis of temperature and salinity fields over the global ocean. 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. At the moment the period covered starts in 2002 and only the upper 2000 m are considered. The gridded fields were produced over the global ocean 70°N–70°S on

a 1/2° grid by the ISAS project with datasets downloaded from the Coriolis data center (for more details on ISAS see Gaillard et al. (2009)). In the Pi-MEP, the product in used is the INSITU_GLO_TS_OA_NRT_OBSERVATIONS_013_002_a v6.2 NRT 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/); in this version SSS from ship of opportunity thermosalinographs are not used, so that we can consider SMOS SSS validation using these measurements independent of ISAS. 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. (2015b)). 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.

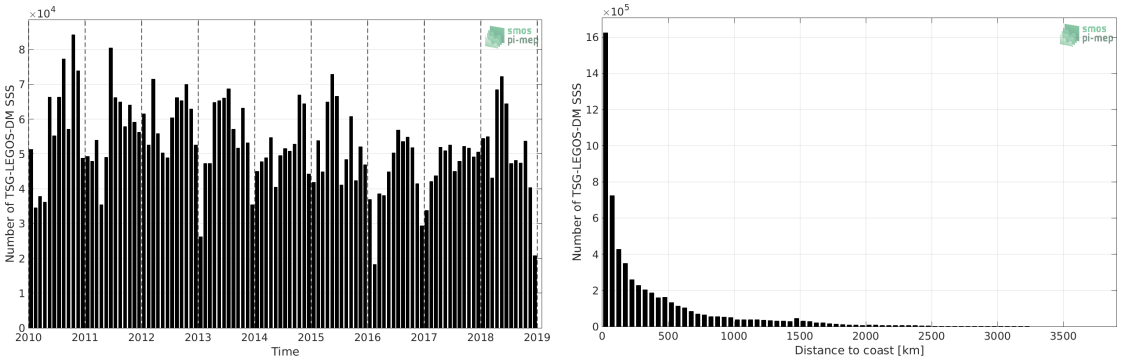
2 In Situ Dababase Analyses

2.1 TSG-LEGOS-DM

2.1.1 Introduction

The TSG-LEGOS-DM dataset correspond 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)). Adjusted values when available and only collected TSG data that exhibit quality flags=1 and 2 were used.

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



(a) (b)

Figure 1: Number of SSS from TSG-LEGOS-DM as a function of time (a) and distance to coast (b).

2.1.3 Histogram of SSS

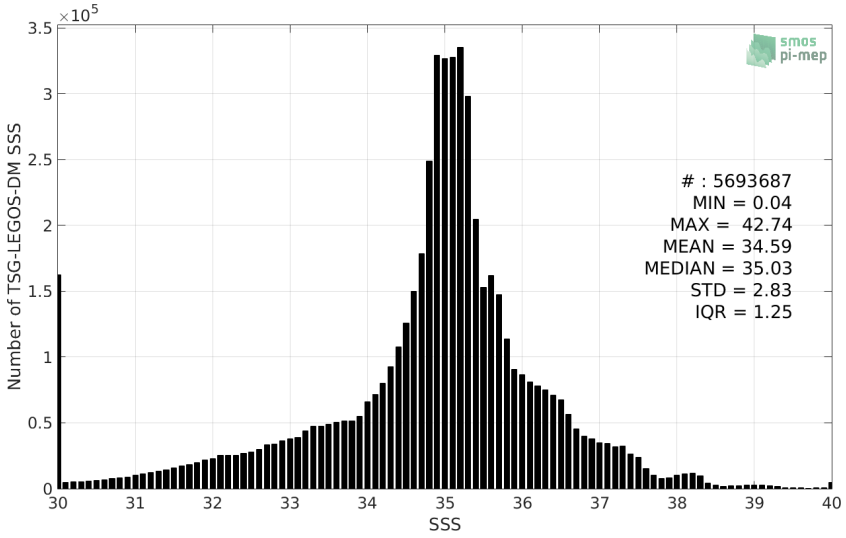


Figure 2: Distribution of SSS from TSG-LEGOS-DM per bins of 0.1.

2.1.4 Temporal mean of SSS

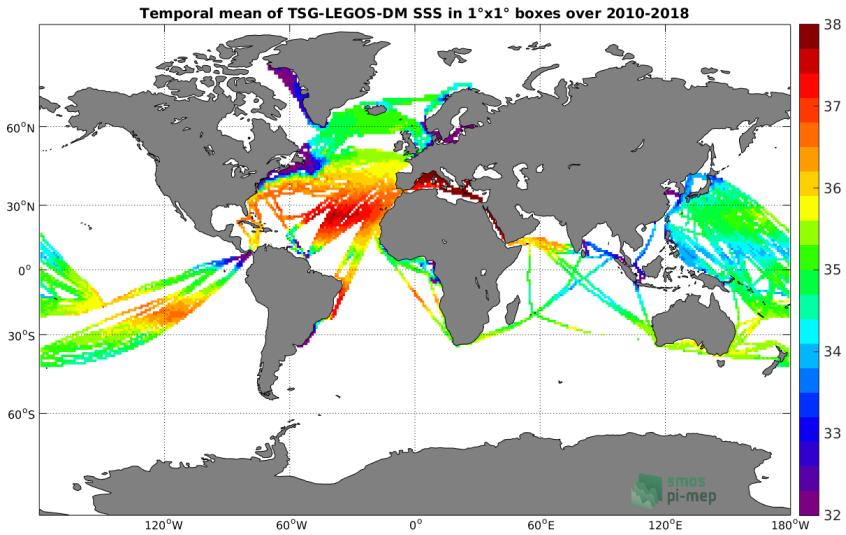


Figure 3: Time-mean SSS from TSG-LEGOS-DM in 1°x1° boxes.

2.1.5 Temporal STD of SSS

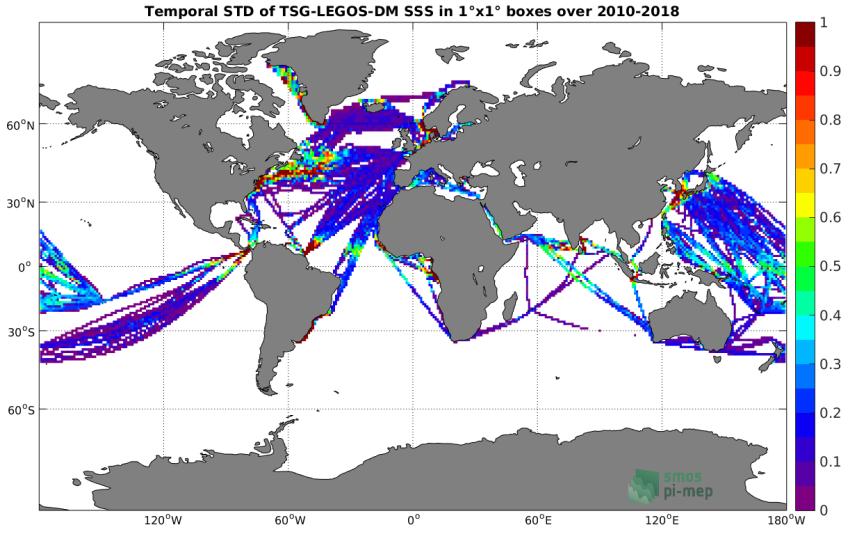


Figure 4: Temporal STD of SSS from TSG-LEGOS-DM in 1°x1° boxes.

2.1.6 Spatial density of SSS

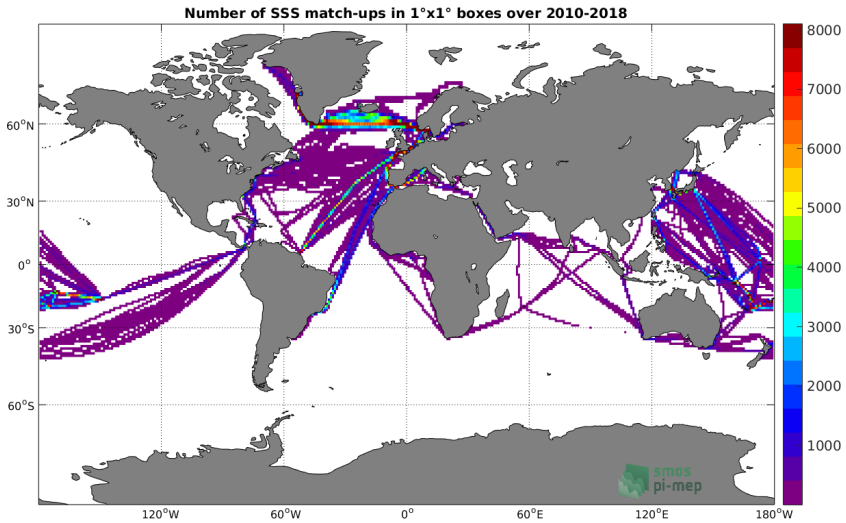
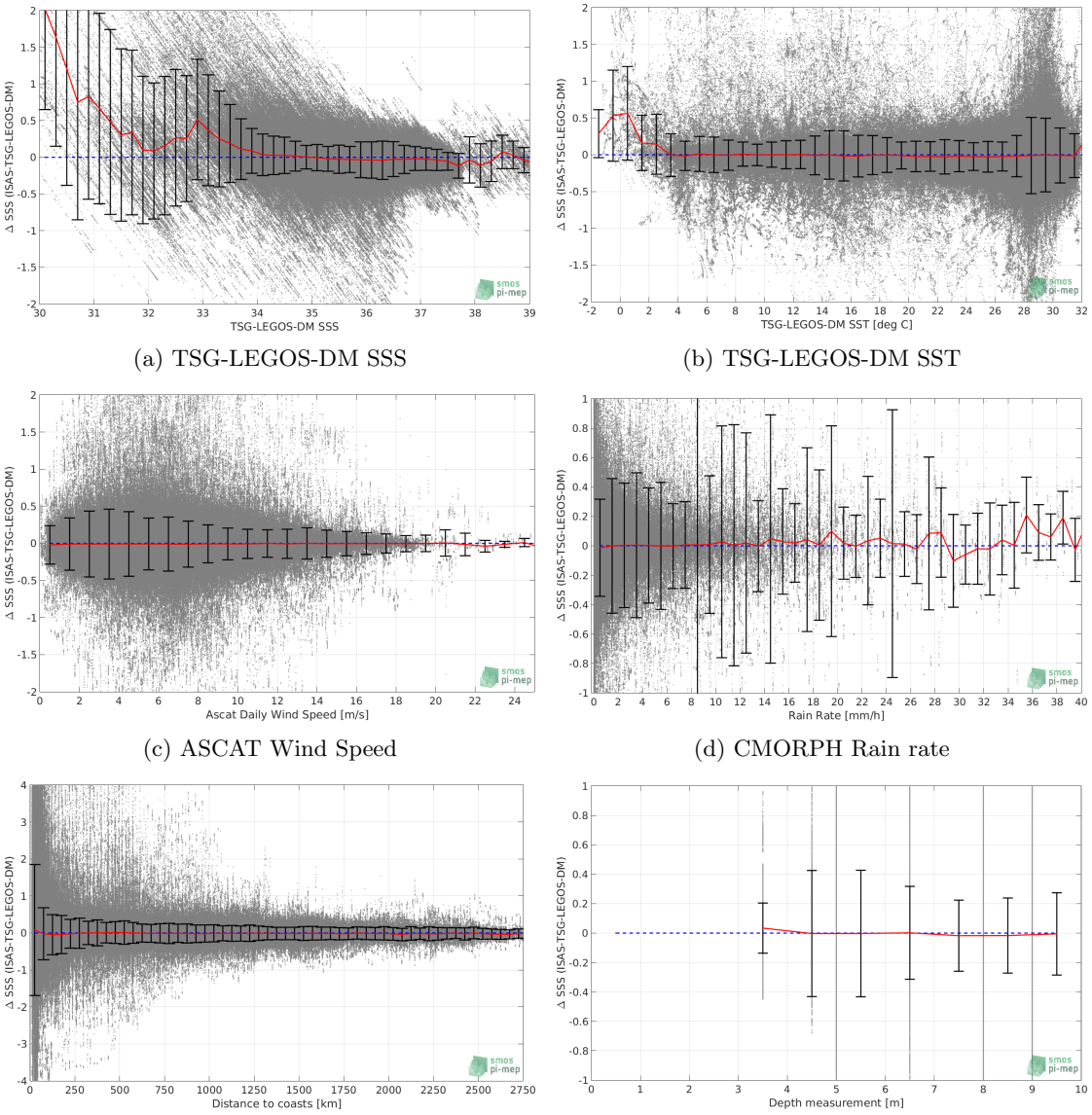


Figure 5: Number of SSS from TSG-LEGOS-DM in 1°x1° boxes.

2.1.7 ΔSSS sorted as geophysical conditions



(a) TSG-LEGOS-DM SSS

(b) TSG-LEGOS-DM SST

(c) ASCAT Wind Speed

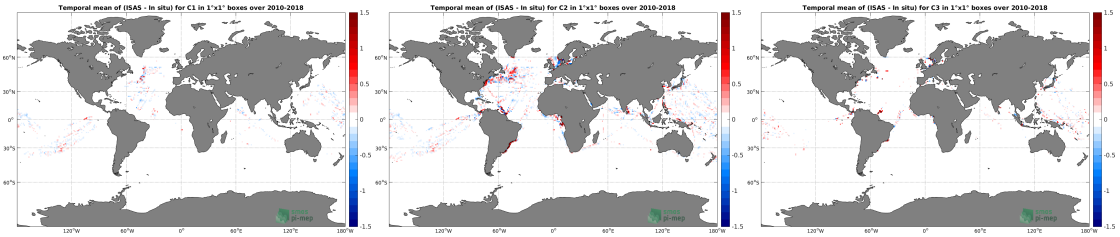
(d) CMORPH Rain rate

(e) Distance to coast

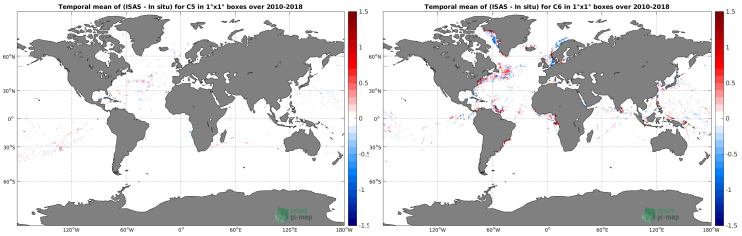
(f) Depth

Figure 6: 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).

2.1.8 Conditional analyses

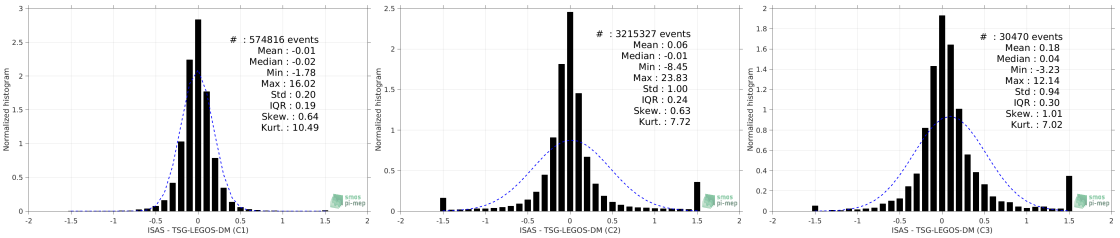


(a) RR=0 mm/h, 3< U_{10} <12 m/s, SST>5°C, distance to coast > 800 km (b) RR=0 mm/h, 3< U_{10} <12 m/s (c) RR>1mm/h and U_{10} <4m/s

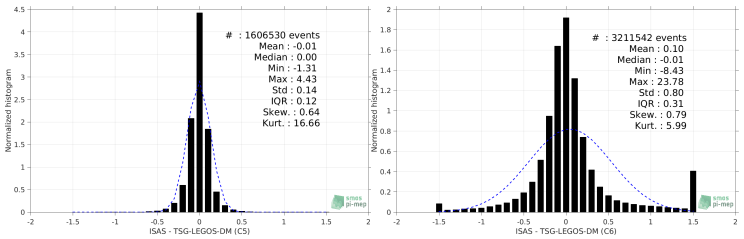


(d) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 7: Temporal mean of ΔSSS (ISAS - TSG-LEGOS-DM) for 5 different subdatasets corresponding to C1 (a), C2 (b), C3 (c), C5 (d) and C6 (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 8: Normalized histogram of ΔSSS (ISAS - TSG-LEGOS-DM) for 5 different subdatasets corresponding to C1 (a), C2 (b), C3 (c), C5 (d) and C6 (e).

2.1.9 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	5488750	0.00	0.10	1.00	1.00	0.25	0.86	0.18
C1	574816	-0.02	-0.01	0.20	0.20	0.19	0.96	0.14
C2	3215327	-0.01	0.06	1.00	1.00	0.24	0.86	0.18
C3	30470	0.04	0.18	0.94	0.95	0.30	0.76	0.22
C5	1606530	0.00	-0.01	0.14	0.14	0.12	0.97	0.09
C6	3211542	-0.01	0.10	0.80	0.81	0.31	0.86	0.23
C7a	2587326	0.01	0.22	1.40	1.42	0.47	0.85	0.33
C7b	2100913	-0.01	0.00	0.37	0.37	0.15	0.84	0.11
C7c	800511	-0.01	-0.01	0.20	0.20	0.20	0.95	0.15
C8a	493201	0.17	0.48	1.27	1.35	1.07	0.73	0.70
C8b	1563434	-0.01	0.04	1.13	1.13	0.18	0.89	0.14
C8c	3432115	-0.01	0.08	0.87	0.88	0.24	0.82	0.18
C9a	570376	0.98	1.24	2.62	2.90	2.13	0.79	1.55
C9b	4632254	-0.01	-0.03	0.39	0.39	0.21	0.79	0.16
C9c	286120	-0.05	-0.07	0.29	0.30	0.22	0.83	0.16

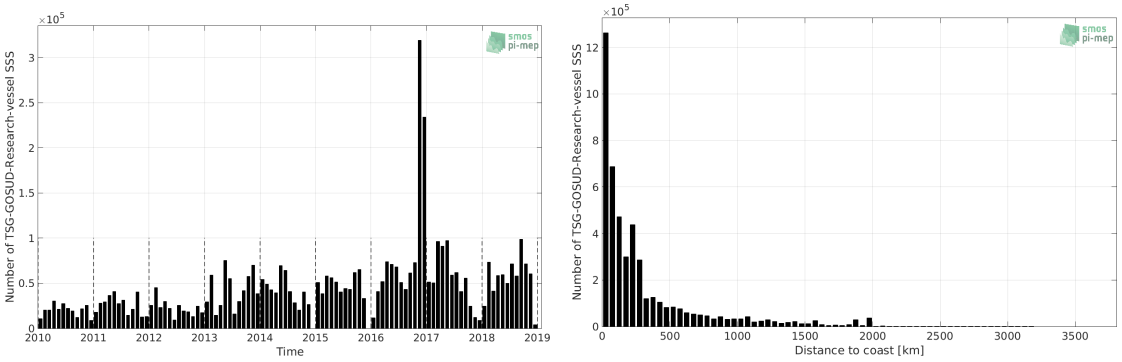
Table 1 numerical values can be downloaded as a csv file here.

2.2 TSG-GOSUD-Research-vessel

2.2.1 Introduction

The TSG-GOSUD-Research-vessel dataset correspond to French research vessels that have been collecting thermo-salinometer (TSG) data since the early 2000 in contribution to the 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. (2015a)) is updated annually and freely available here. Adjusted values when available and only collected TSG data that exhibit quality flags=1 and 2 were used.

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



(a) (b)

Figure 9: Number of SSS from TSG-GOSUD-Research-vessel as a function of time (a) and distance to coast (b).

2.2.3 Histogram of SSS

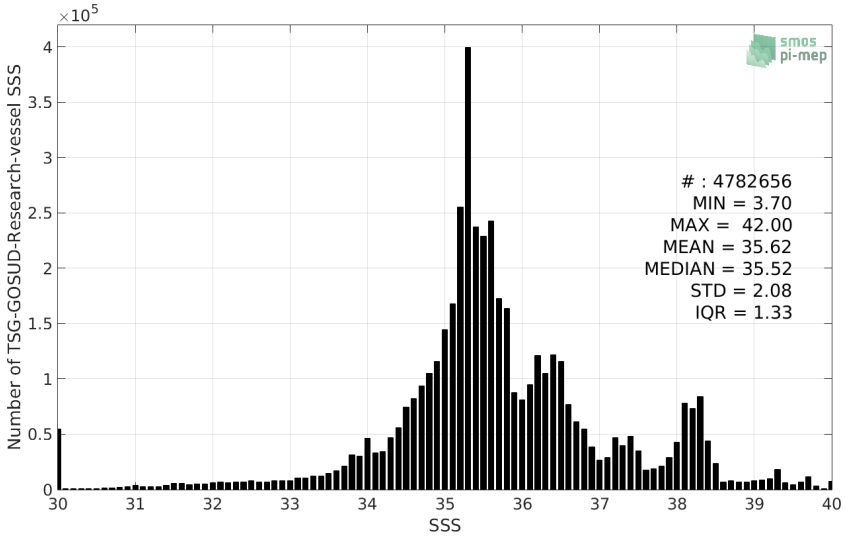


Figure 10: Distribution of SSS from TSG-GOSUD-Research-vessel per bins of 0.1.

2.2.4 Temporal mean of SSS

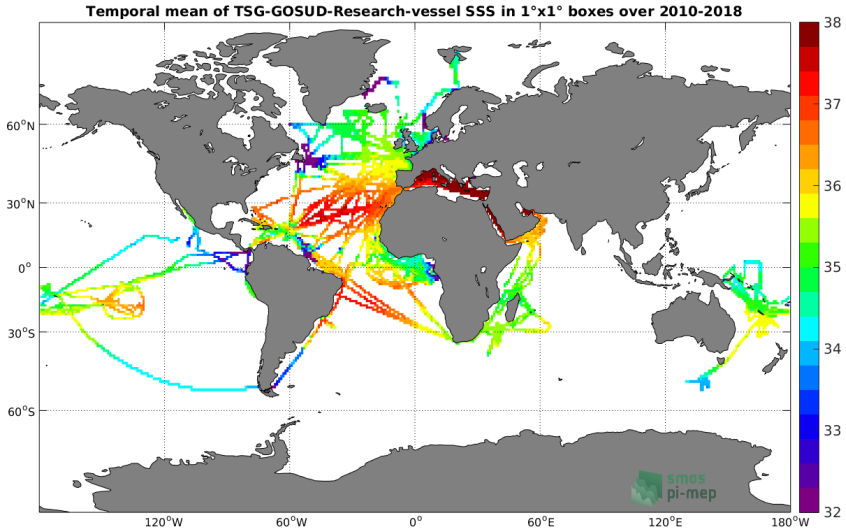


Figure 11: Time-mean SSS from TSG-GOSUD-Research-vessel in 1°x1° boxes.

2.2.5 Temporal STD of SSS

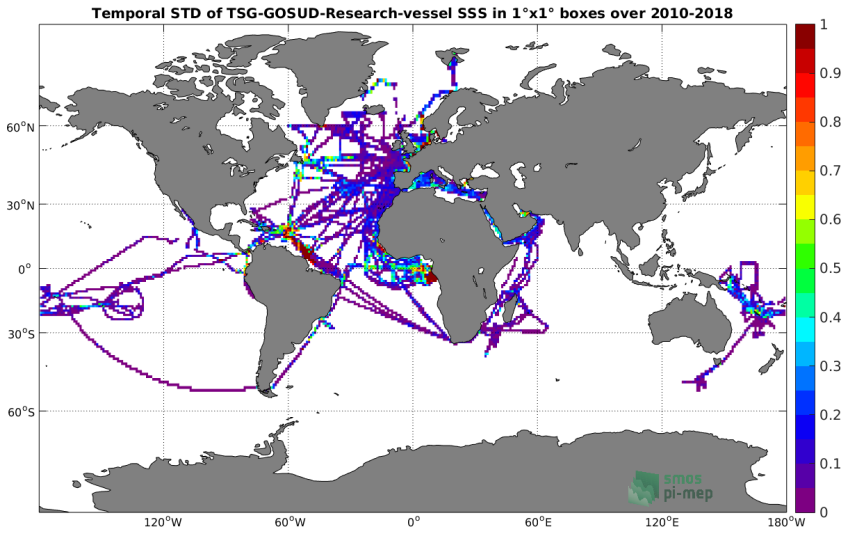


Figure 12: Temporal STD of SSS from TSG-GOSUD-Research-vessel in 1°x1° boxes.

2.2.6 Spatial density of SSS

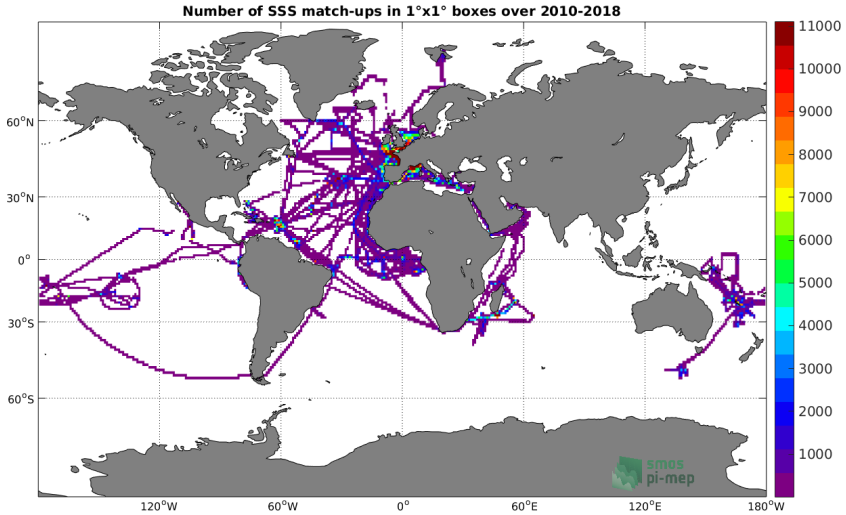
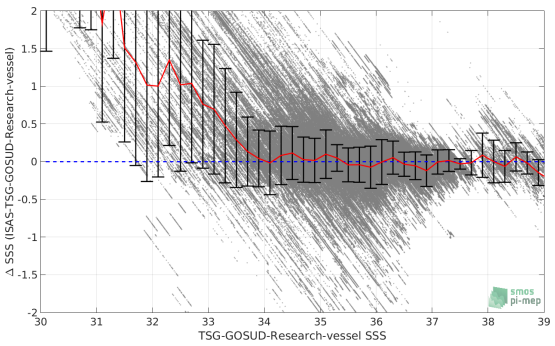
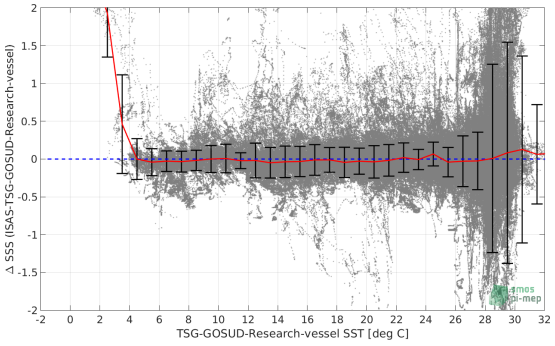


Figure 13: Number of SSS from TSG-GOSUD-Research-vessel in 1°x1° boxes.

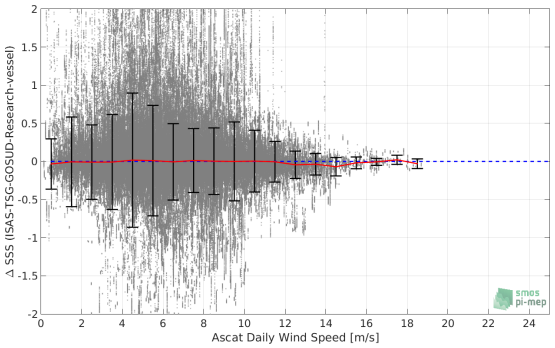
2.2.7 ΔSSS sorted as geophysical conditions



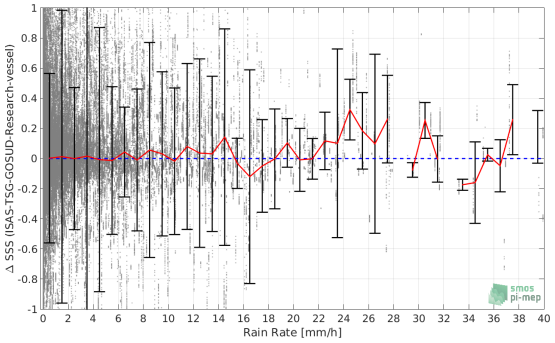
(a) TSG-GOSUD-Research-vessel SSS



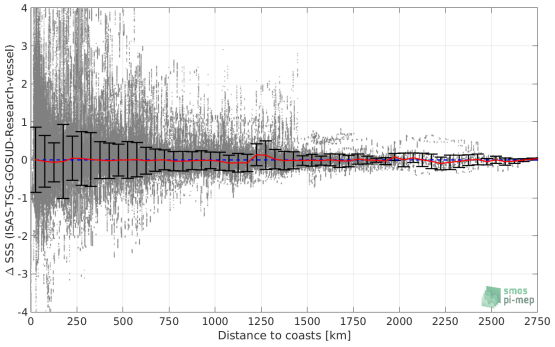
(b) TSG-GOSUD-Research-vessel SST



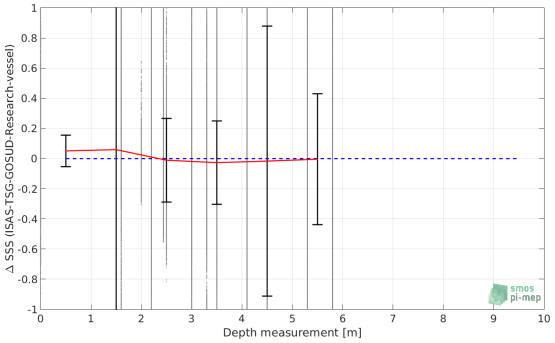
(c) ASCAT Wind Speed



(d) CMORPH Rain rate



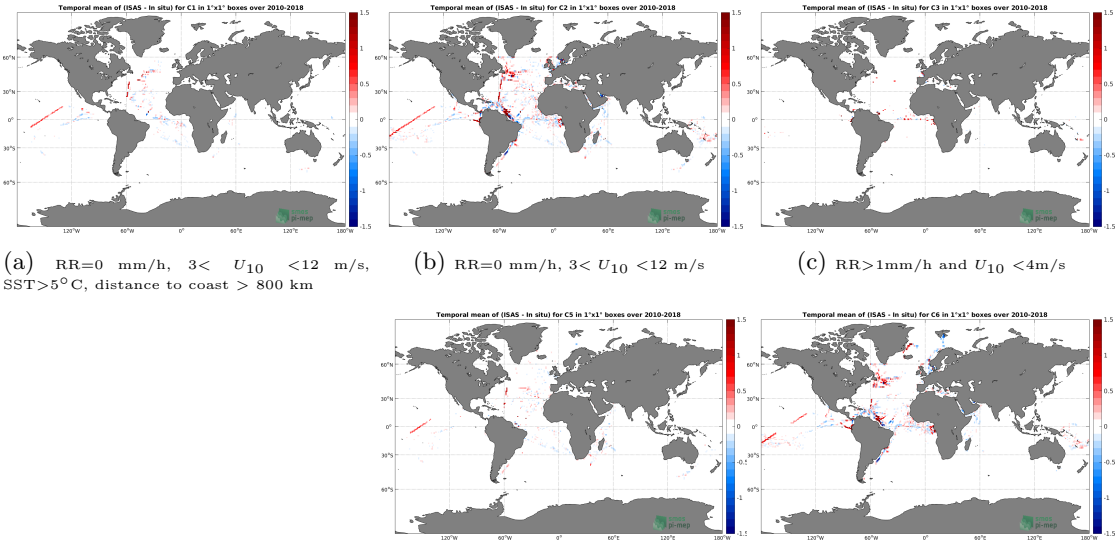
(e) Distance to coast



(f) Depth

Figure 14: 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).

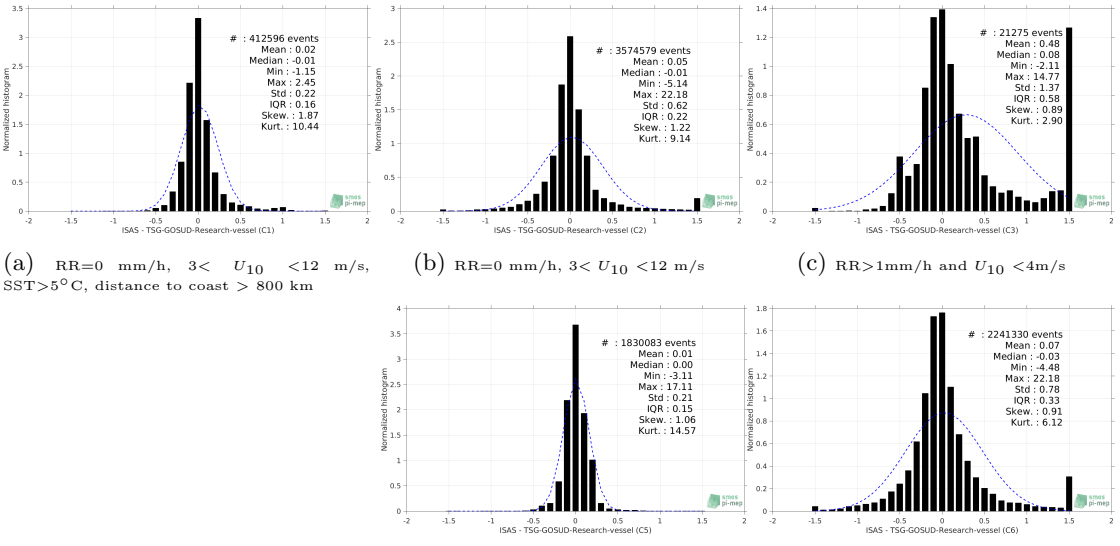
2.2.8 Conditional analyses



(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 15: Temporal mean of ΔSSS (ISAS - TSG-GOSUD-Research-vessel) for 5 different sub-datasets corresponding to C1 (a), C2 (b), C3 (c), C5 (d) and C6 (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 16: Normalized histogram of ΔSSS (ISAS - TSG-GOSUD-Research-vessel) for 5 different subdatasets corresponding to C1 (a), C2 (b), C3 (c), C5 (d) and C6 (e).

2.2.9 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	4689558	-0.01	0.06	0.67	0.67	0.23	0.90	0.17
C1	412596	-0.01	0.02	0.22	0.22	0.16	0.96	0.12
C2	3574579	-0.01	0.05	0.62	0.62	0.22	0.91	0.17
C3	21275	0.08	0.48	1.37	1.45	0.58	0.70	0.38
C5	1830083	0.00	0.01	0.21	0.21	0.15	0.95	0.11
C6	2241330	-0.03	0.07	0.78	0.79	0.33	0.90	0.25
C7a	2336837	-0.03	0.06	0.75	0.76	0.29	0.92	0.21
C7b	1820813	0.01	0.07	0.64	0.65	0.20	0.78	0.15
C7c	531908	-0.01	0.02	0.23	0.23	0.17	0.95	0.13
C8a	27203	0.12	0.50	1.47	1.55	1.54	0.92	1.17
C8b	936218	-0.04	0.01	0.54	0.54	0.22	0.84	0.17
C8c	3483051	0.00	0.07	0.71	0.71	0.23	0.90	0.17
C9a	171718	1.34	1.70	2.58	3.09	2.27	0.83	1.71
C9b	3770063	-0.01	0.00	0.34	0.34	0.23	0.79	0.17
C9c	747777	-0.02	-0.03	0.25	0.25	0.18	0.87	0.13

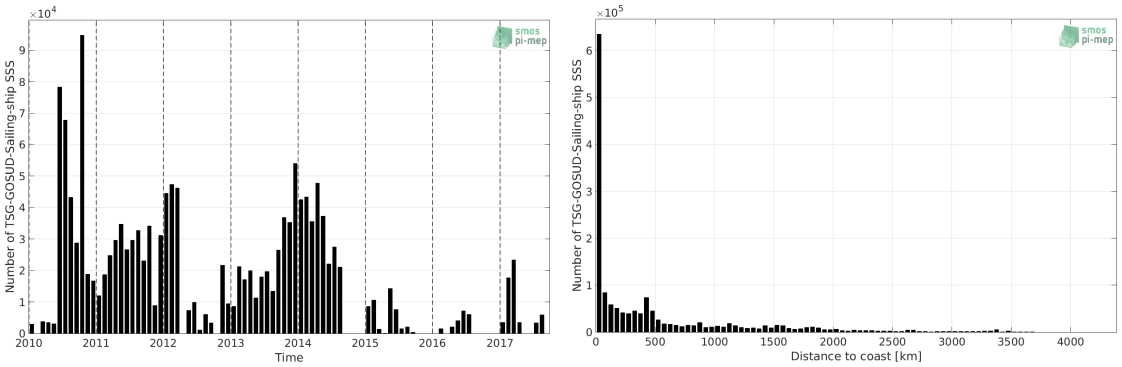
Table 1 numerical values can be downloaded as a csv file here.

2.3 TSG-GOSUD-Sailing-ship

2.3.1 Introduction

The TSG-GOSUD-Sailing-ship dataset correspond 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. (2015)) 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.

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



(a) (b)

Figure 17: Number of SSS from TSG-GOSUD-Sailing-ship as a function of time (a) and distance to coast (b).

2.3.3 Histogram of SSS

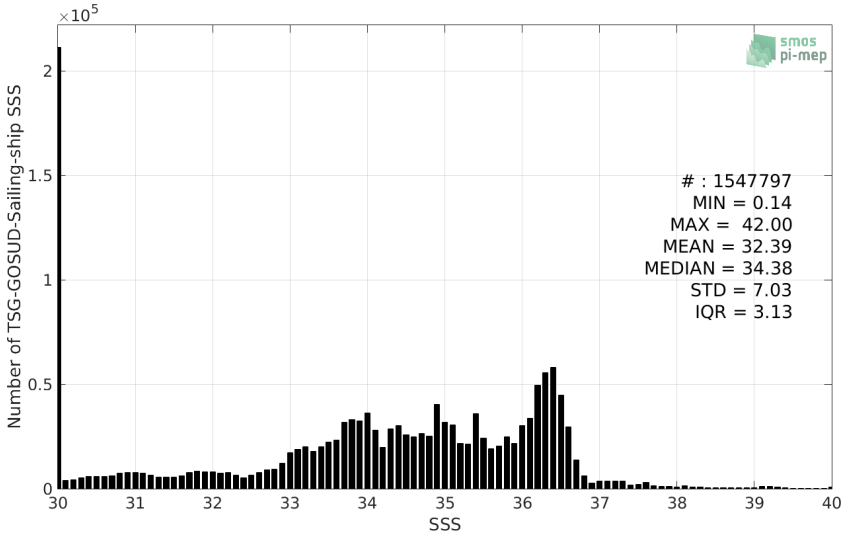


Figure 18: Distribution of SSS from TSG-GOSUD-Sailing-ship per bins of 0.1.

2.3.4 Temporal mean of SSS

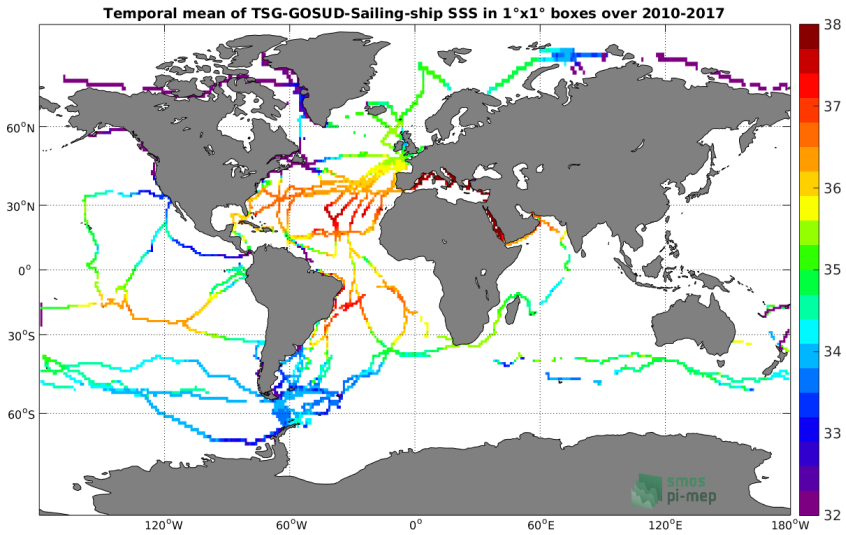


Figure 19: Time-mean SSS from TSG-GOSUD-Sailing-ship in 1°x1° boxes.

2.3.5 Temporal STD of SSS

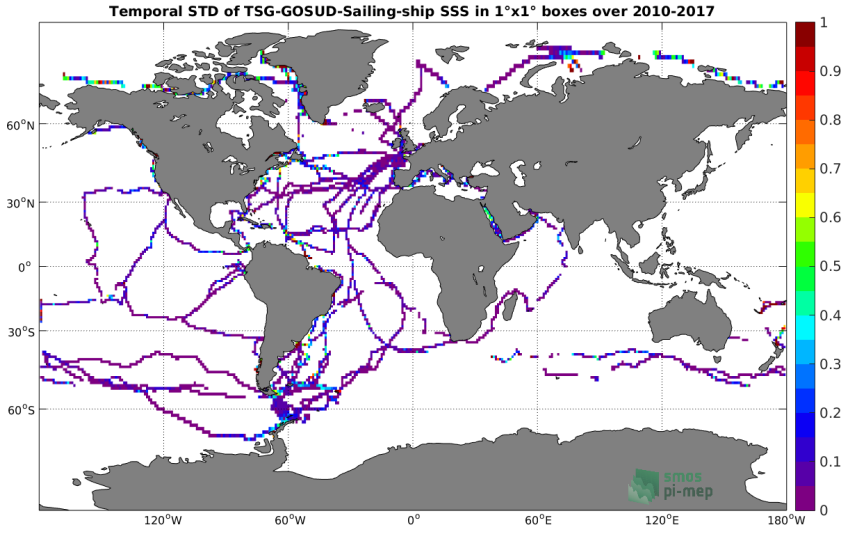


Figure 20: Temporal STD of SSS from TSG-GOSUD-Sailing-ship in 1°x1° boxes.

2.3.6 Spatial density of SSS

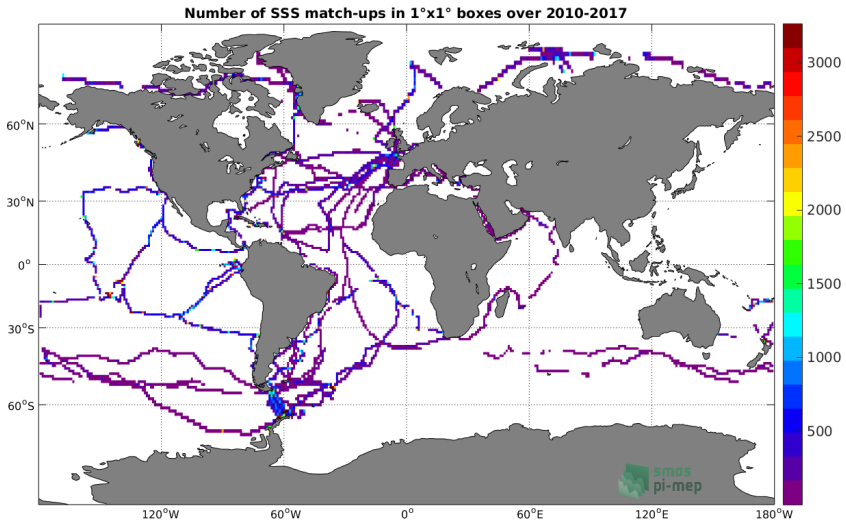
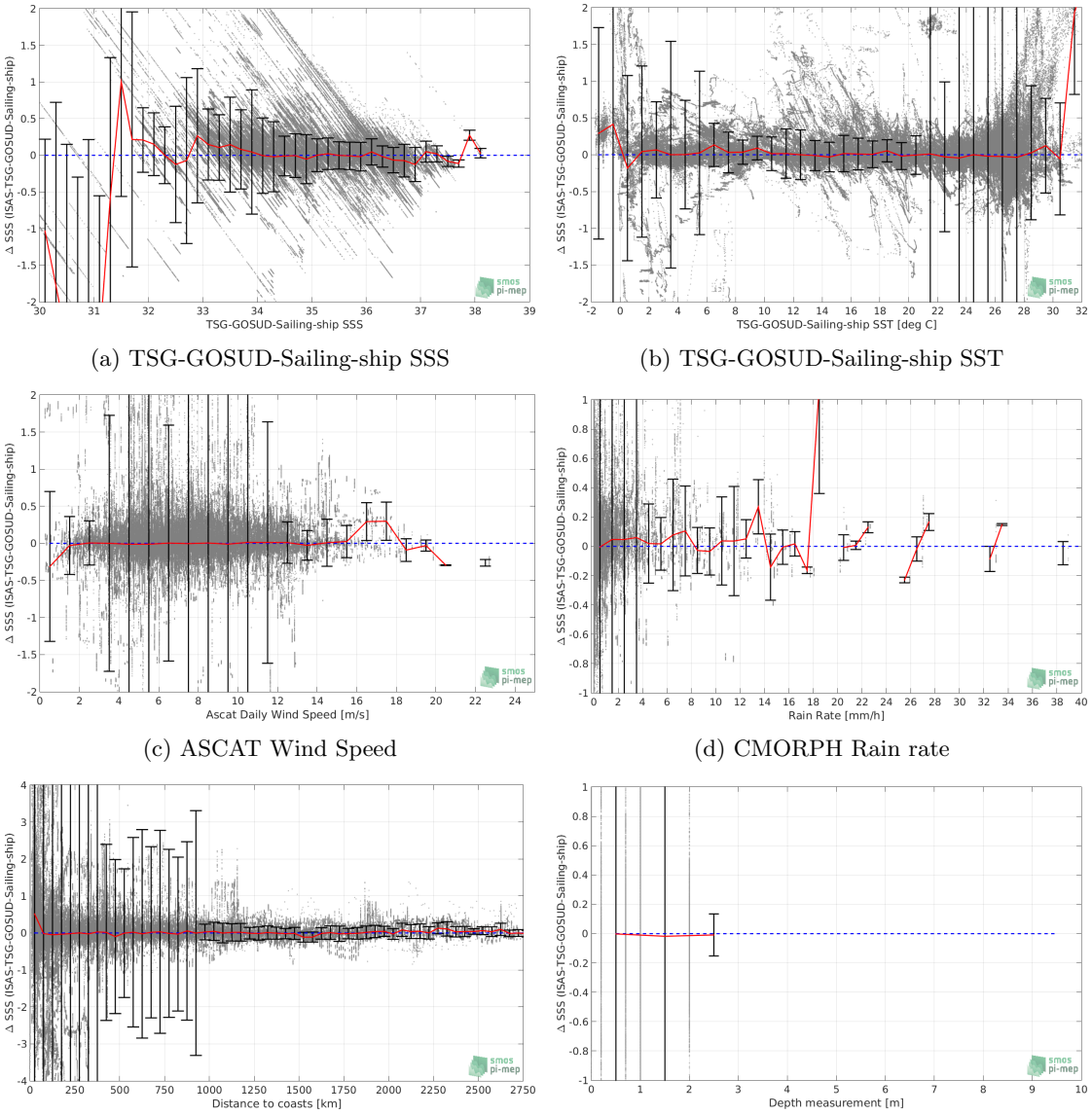


Figure 21: Number of SSS from TSG-GOSUD-Sailing-ship in 1°x1° boxes.

2.3.7 ΔSSS sorted as geophysical conditions



(a) TSG-GOSUD-Sailing-ship SSS

(b) TSG-GOSUD-Sailing-ship SST

(c) ASCAT Wind Speed

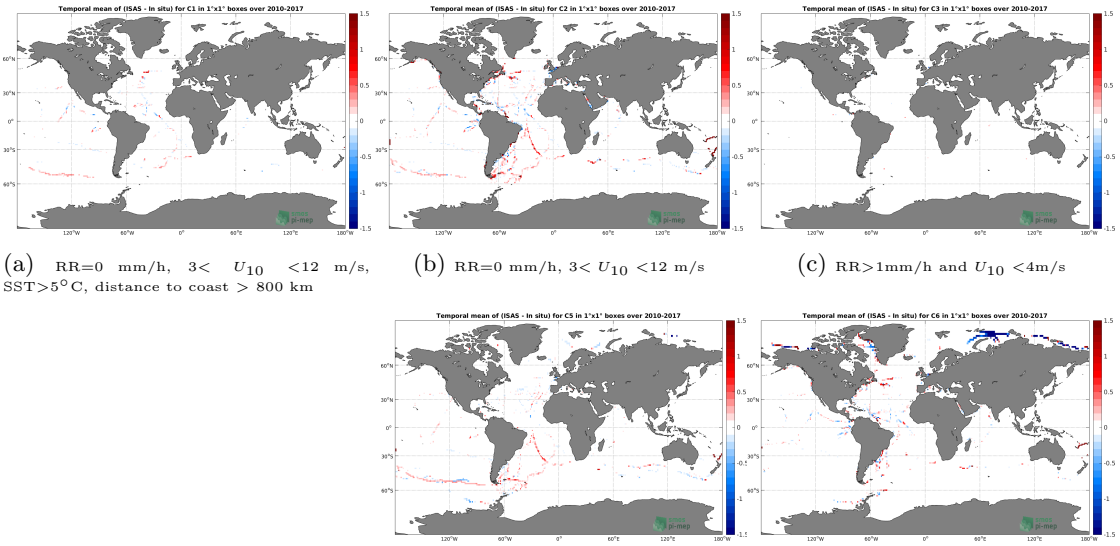
(d) CMORPH Rain rate

(e) Distance to coast

(f) Depth

Figure 22: 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).

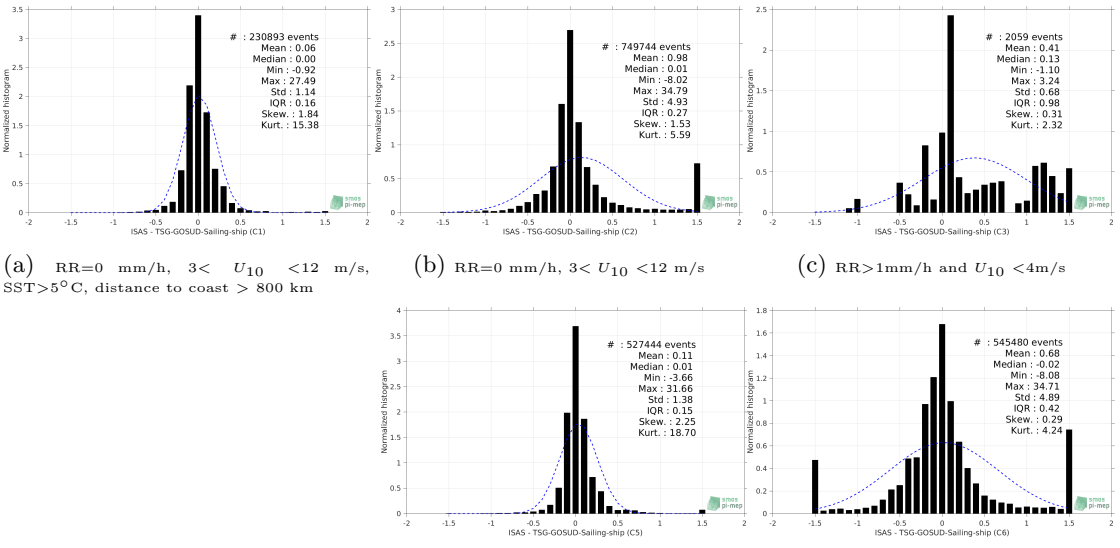
2.3.8 Conditional analyses



(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 23: Temporal mean of ΔSSS (ISAS - TSG-GOSUD-Sailing-ship) for 5 different sub-datasets corresponding to C1 (a), C2 (b), C3 (c), C5 (d) and C6 (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 24: Normalized histogram of ΔSSS (ISAS - TSG-GOSUD-Sailing-ship) for 5 different subdatasets corresponding to C1 (a), C2 (b), C3 (c), C5 (d) and C6 (e).

2.3.9 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	1384330	0.03	1.41	5.74	5.91	0.42	0.08	0.26
C1	230893	0.00	0.06	1.14	1.14	0.16	0.45	0.12
C2	749744	0.01	0.98	4.93	5.02	0.27	0.07	0.18
C3	2059	0.13	0.41	0.68	0.79	0.98	0.94	0.48
C5	527444	0.01	0.11	1.38	1.39	0.15	0.40	0.11
C6	545480	-0.02	0.68	4.89	4.93	0.42	0.15	0.31
C7a	616353	0.23	2.83	7.70	8.20	1.52	0.02	0.79
C7b	436334	0.00	0.42	3.85	3.87	0.22	0.13	0.17
C7c	331643	0.00	0.05	0.95	0.96	0.17	0.55	0.12
C8a	210096	0.06	-0.12	1.66	1.67	0.64	0.67	0.47
C8b	278092	0.08	0.65	2.03	2.13	0.64	0.59	0.30
C8c	846186	0.01	2.01	7.08	7.36	0.28	0.05	0.20
C9a	300822	1.47	6.53	10.81	12.63	5.77	0.07	2.18
C9b	1051781	0.00	-0.02	0.57	0.57	0.23	0.77	0.17
C9c	31727	-0.02	-0.04	0.36	0.36	0.26	0.81	0.19

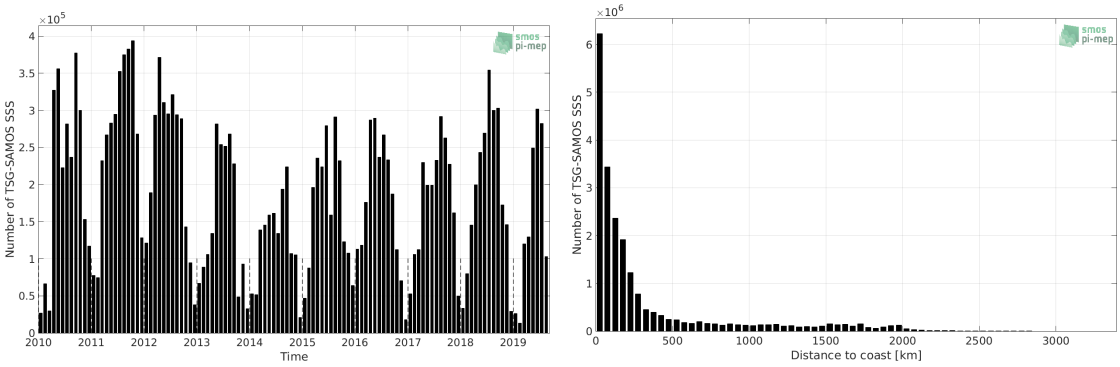
Table 1 numerical values can be downloaded as a csv file here.

2.4 TSG-SAMOS

2.4.1 Introduction

The TSG-SAMOS dataset correspond 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 has been remove from this dataset.

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



(a) (b)

Figure 25: Number of SSS from TSG-SAMOS as a function of time (a) and distance to coast (b).

2.4.3 Histogram of SSS

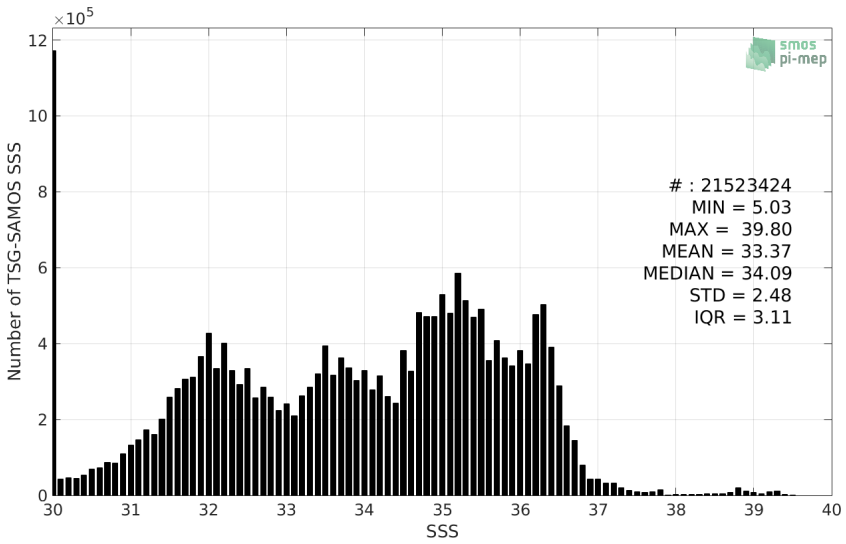


Figure 26: Distribution of SSS from TSG-SAMOS per bins of 0.1.

2.4.4 Temporal mean of SSS

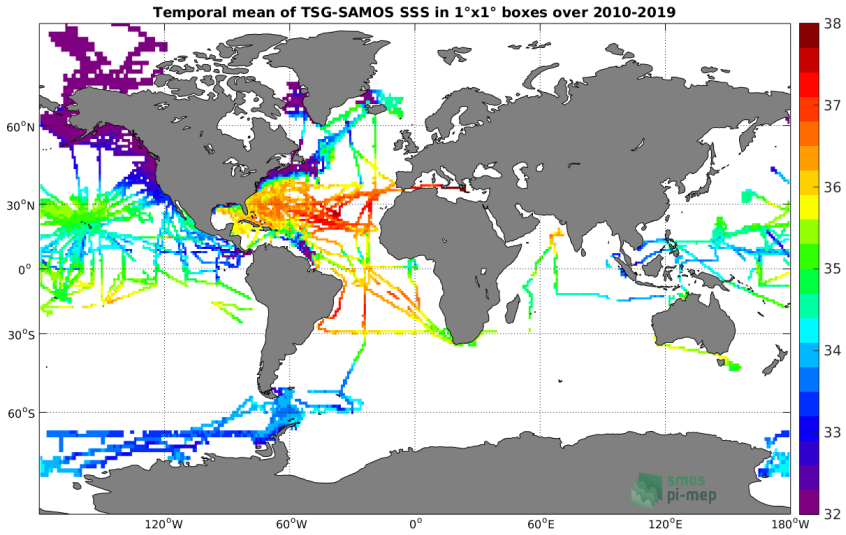


Figure 27: Time-mean SSS from TSG-SAMOS in 1°x1° boxes.

2.4.5 Temporal STD of SSS

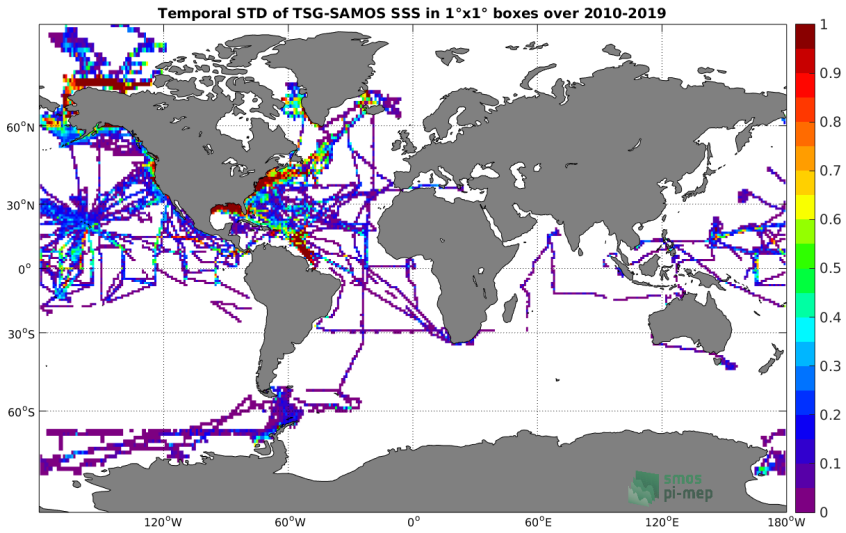


Figure 28: Temporal STD of SSS from TSG-SAMOS in 1°x1° boxes.

2.4.6 Spatial density of SSS

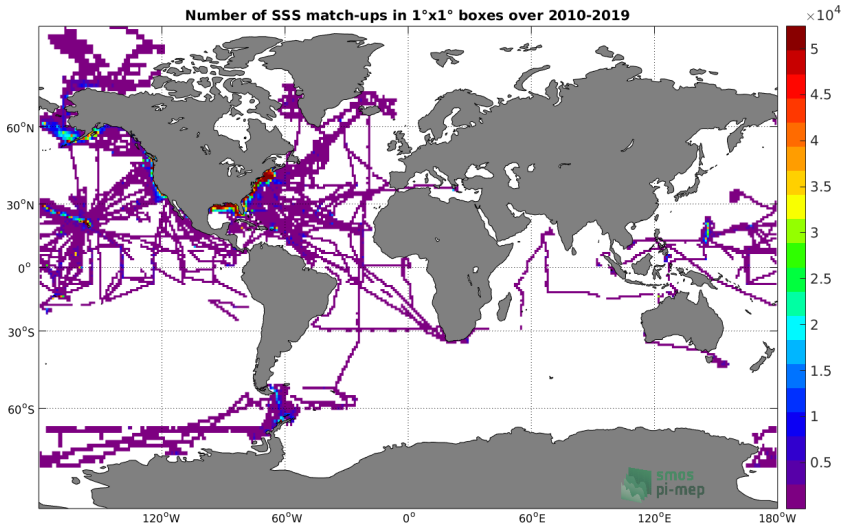
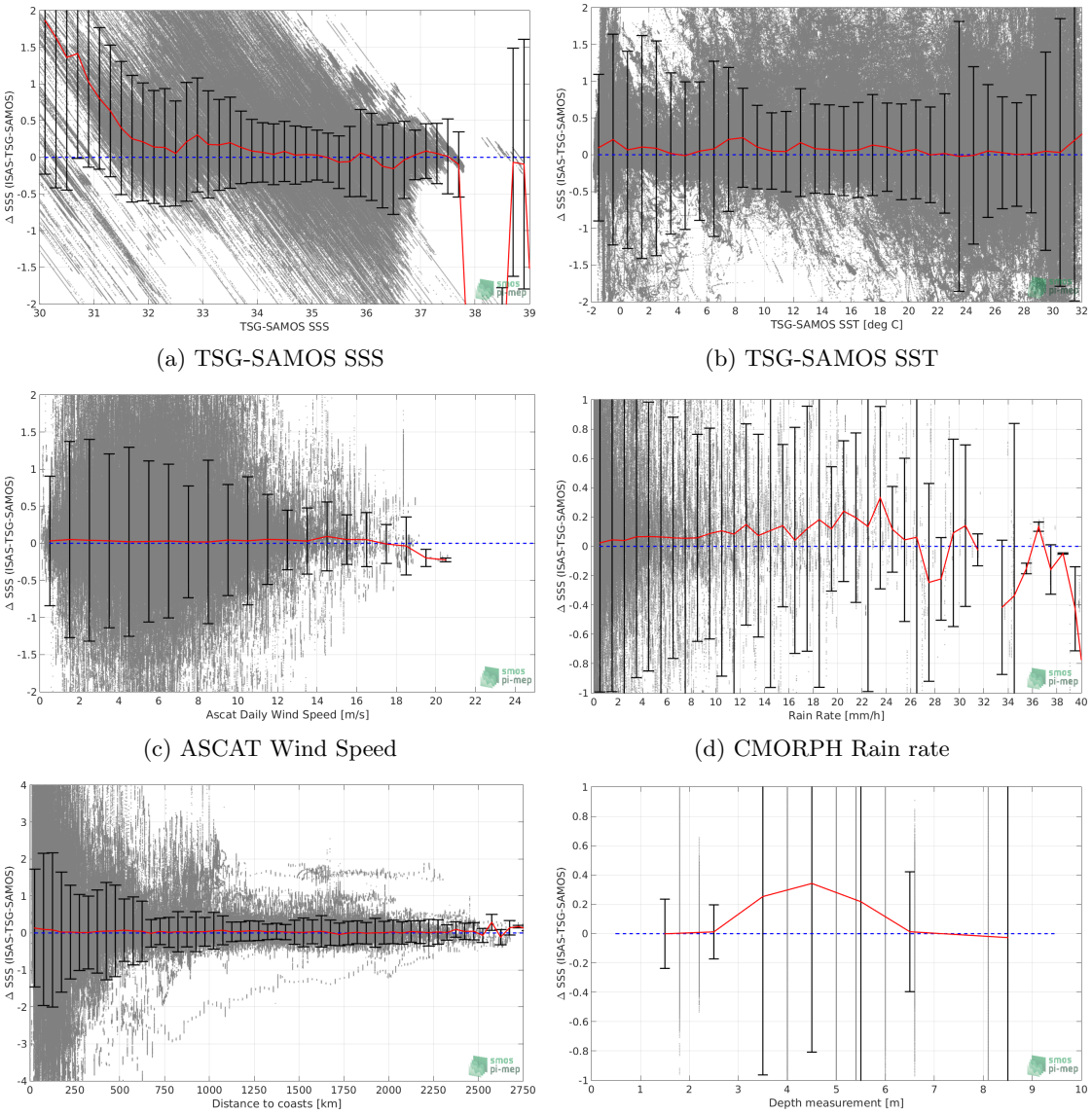


Figure 29: Number of SSS from TSG-SAMOS in 1°x1° boxes.

2.4.7 ΔSSS sorted as geophysical conditions



(a) TSG-SAMOS SSS

(b) TSG-SAMOS SST

(c) ASCAT Wind Speed

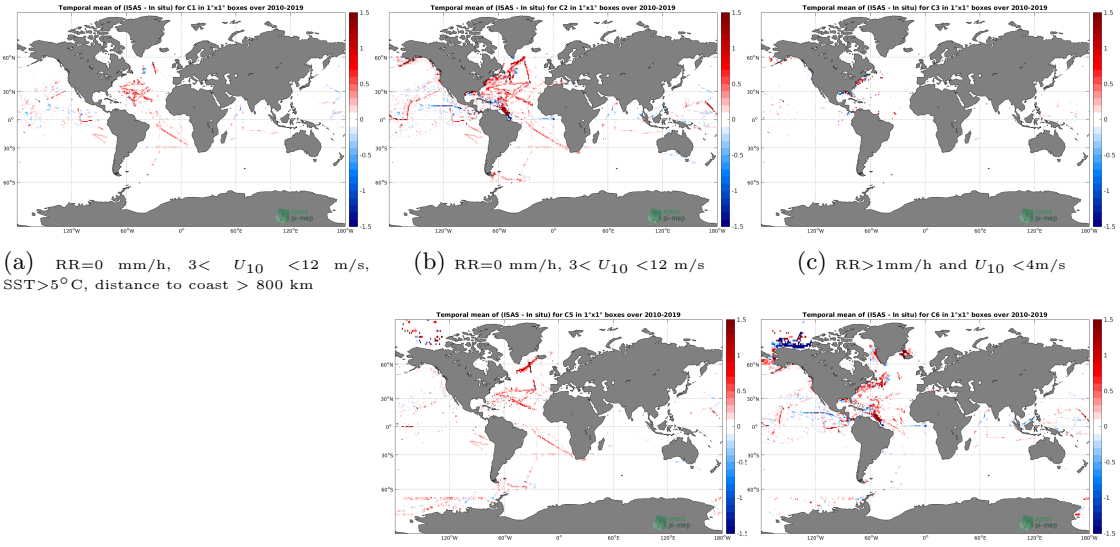
(d) CMORPH Rain rate

(e) Distance to coast

(f) Depth

Figure 30: 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).

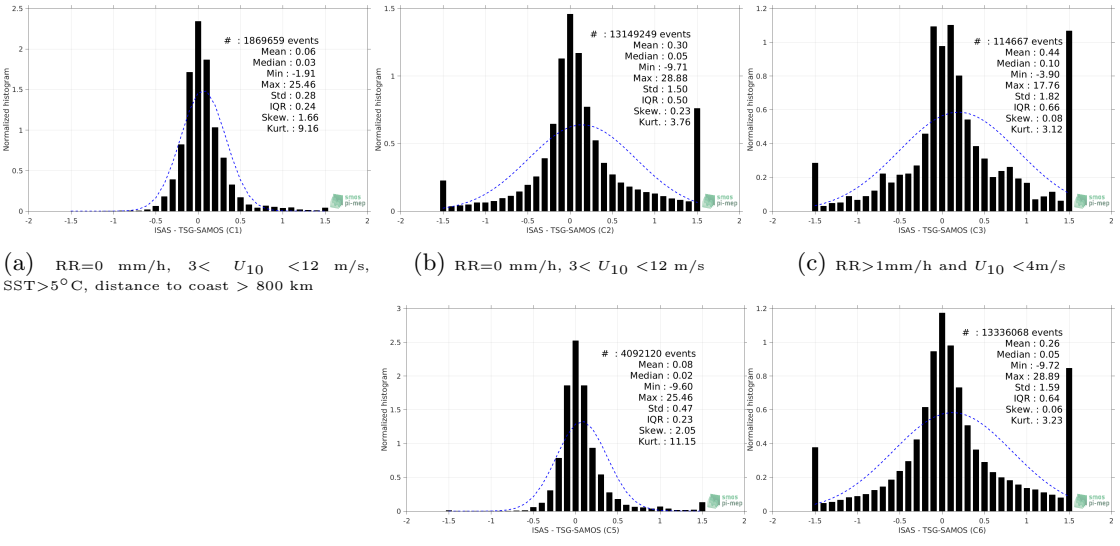
2.4.8 Conditional analyses



(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 31: Temporal mean of ΔSSS (ISAS - TSG-SAMOS) for 5 different subdatasets corresponding to C1 (a), C2 (b), C3 (c), C5 (d) and C6 (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 32: Normalized histogram of ΔSSS (ISAS - TSG-SAMOS) for 5 different subdatasets corresponding to C1 (a), C2 (b), C3 (c), C5 (d) and C6 (e).

2.4.9 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	20667736	0.06	0.31	1.55	1.58	0.54	0.58	0.37
C1	1869659	0.03	0.06	0.28	0.28	0.24	0.90	0.18
C2	13149249	0.05	0.30	1.50	1.52	0.50	0.57	0.35
C3	114667	0.10	0.44	1.82	1.88	0.66	0.42	0.45
C5	4092120	0.02	0.08	0.47	0.48	0.23	0.86	0.17
C6	13336068	0.05	0.26	1.59	1.61	0.64	0.55	0.46
C7a	11262238	0.11	0.47	1.85	1.91	0.77	0.47	0.51
C7b	6412390	0.03	0.13	1.26	1.27	0.46	0.65	0.33
C7c	2993108	0.03	0.09	0.36	0.37	0.25	0.91	0.18
C8a	1806739	0.12	0.07	1.25	1.25	0.52	0.76	0.37
C8b	4985763	0.13	0.31	1.28	1.32	0.76	0.36	0.54
C8c	12452819	0.05	0.36	1.72	1.75	0.47	0.47	0.32
C9a	6937940	0.42	0.98	2.39	2.59	1.28	0.08	0.83
C9b	13471503	0.01	-0.01	0.57	0.57	0.34	0.71	0.25
C9c	258293	-0.10	-1.08	1.54	1.88	2.80	0.06	0.45

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

2.5 TSG-LEGOS-Survostral

2.5.1 Introduction

The TSG-LEGOS-Survostral dataset correspond 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 via ftp. Adjusted values when available and only collected TSG data that exhibit quality flags=1 and 2 were used.

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

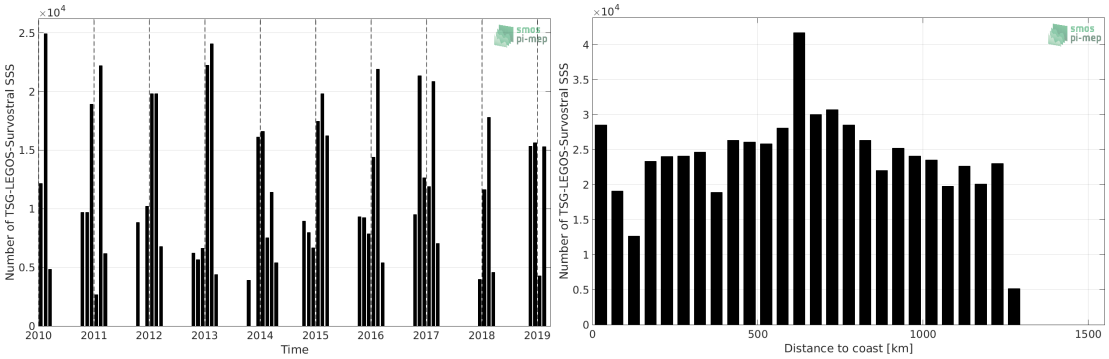


Figure 33: Number of SSS from TSG-LEGOS-Survostral as a function of time (left) and distance to coast (right).

2.5.3 Histogram of SSS

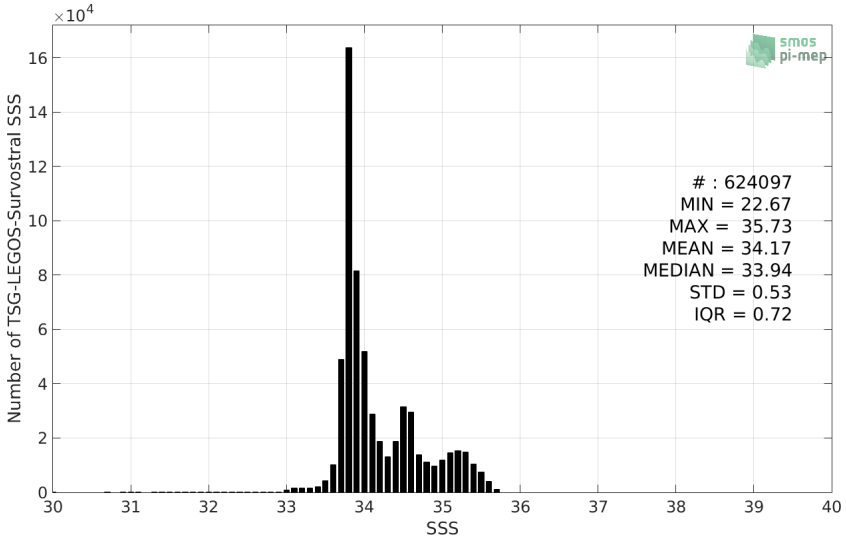


Figure 34: Distribution of SSS from TSG-LEGOS-Survostral per bins of 0.1.

2.5.4 Temporal mean of SSS

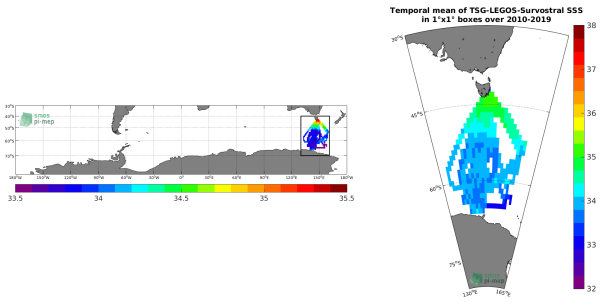


Figure 35: Time-mean SSS from TSG-LEGOS-Survostral in 1°x1° boxes.

2.5.5 Temporal Std of SSS

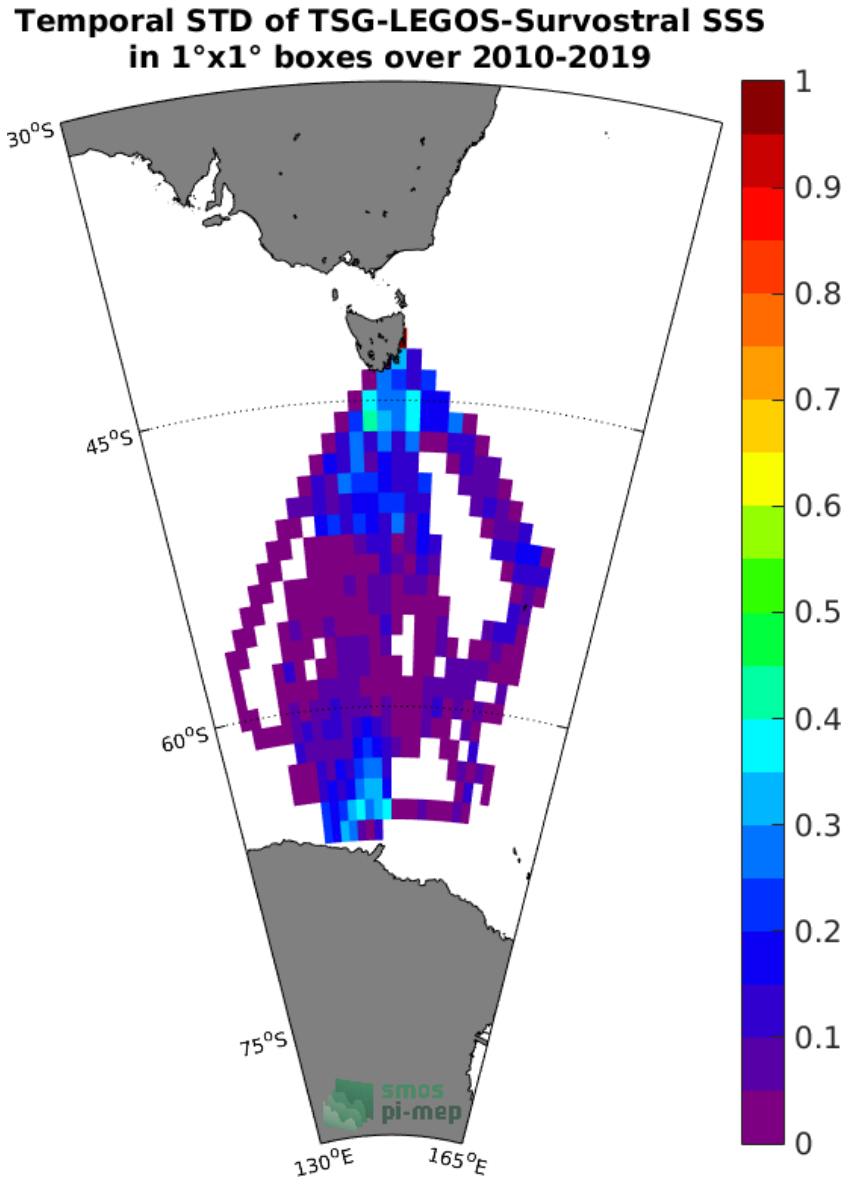


Figure 36: Temporal Std of SSS from TSG-LEGOS-Survostral in 1°x1° boxes.

2.5.6 Spatial density of SSS

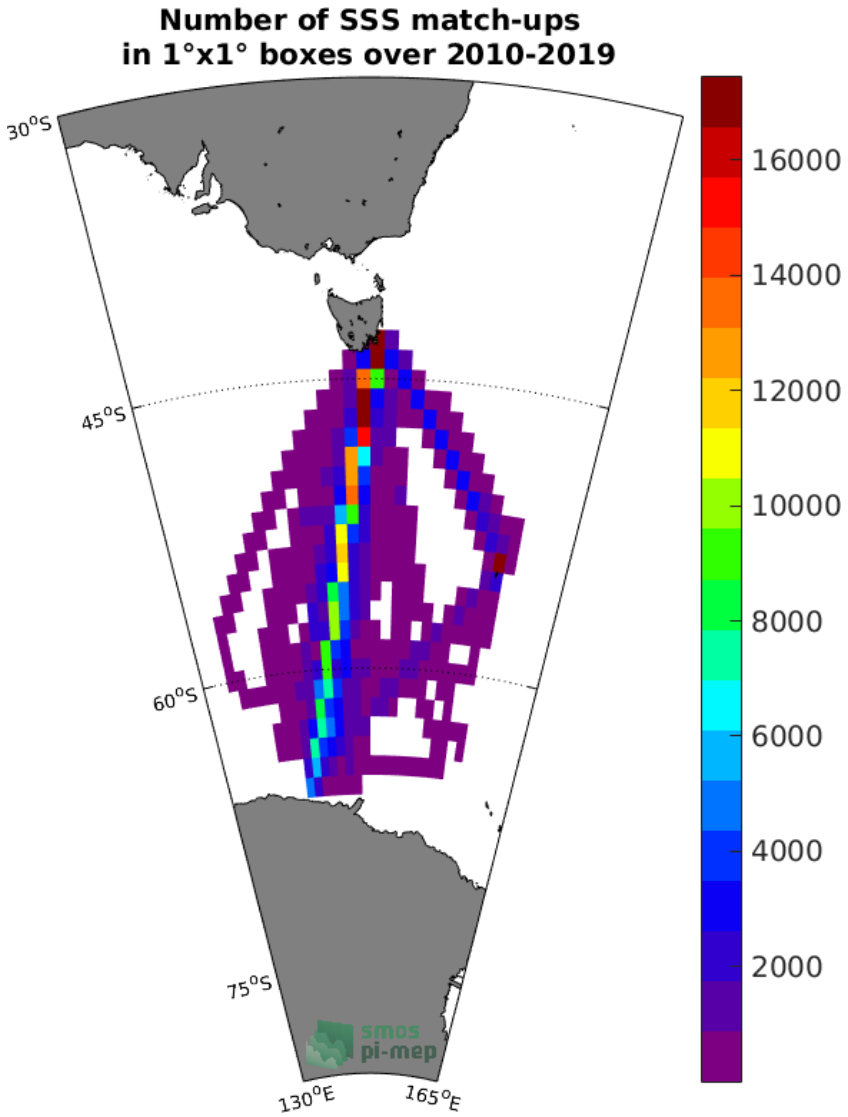
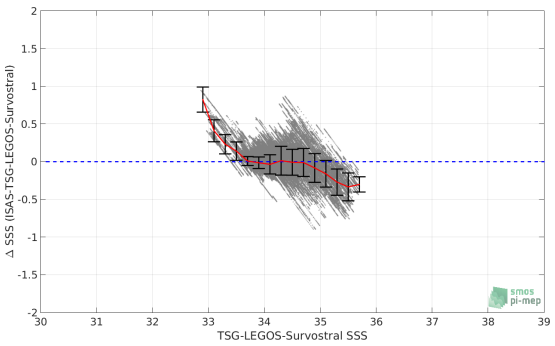
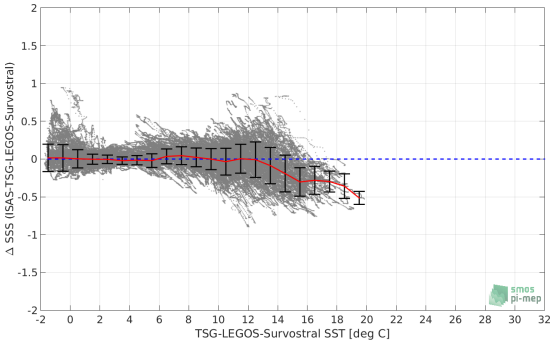


Figure 37: Number of SSS from TSG-LEGOS-Survostral in 1°x1° boxes.

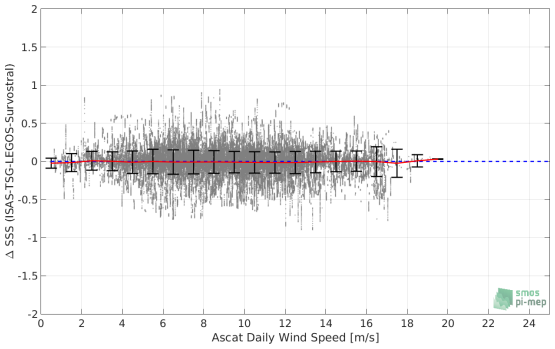
2.5.7 ΔSSS sorted as geophysical conditions



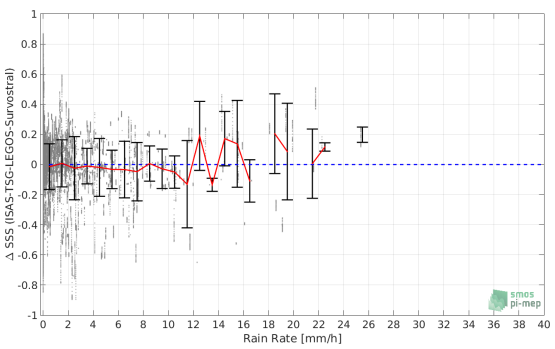
(a) TSG-LEGOS-Survostral SSS



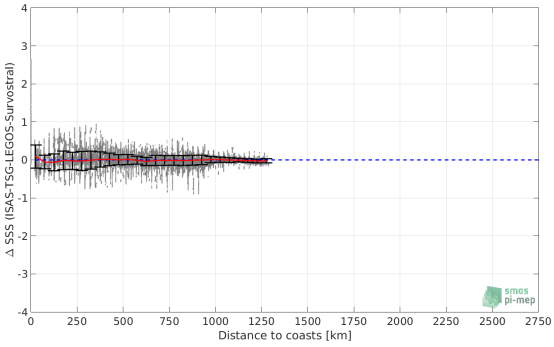
(b) TSG-LEGOS-Survostral SST



(c) ASCAT Wind Speed



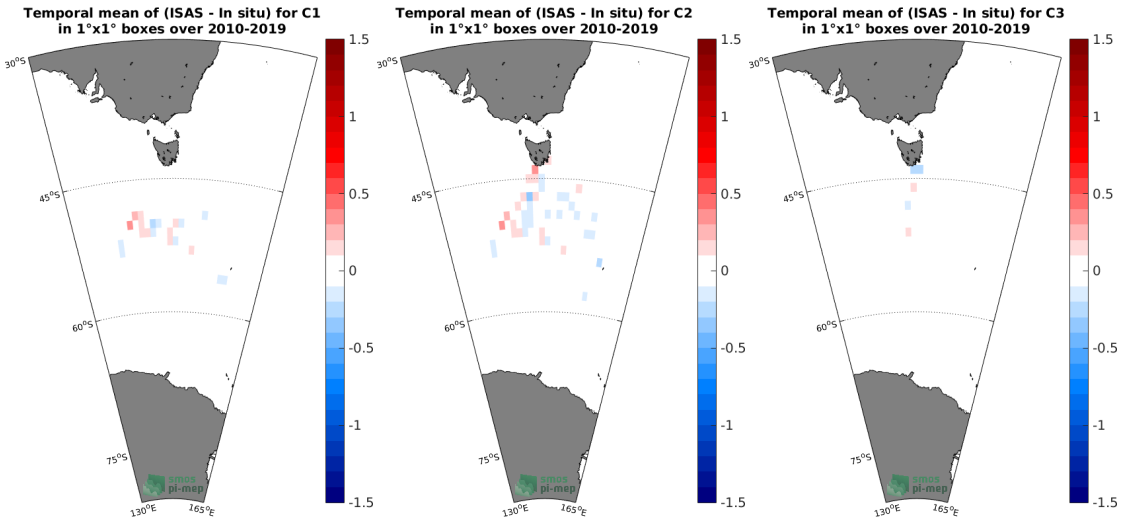
(d) CMORPH Rain rate



(e) Distance to coast

Figure 38: 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) and distance to coast (e).

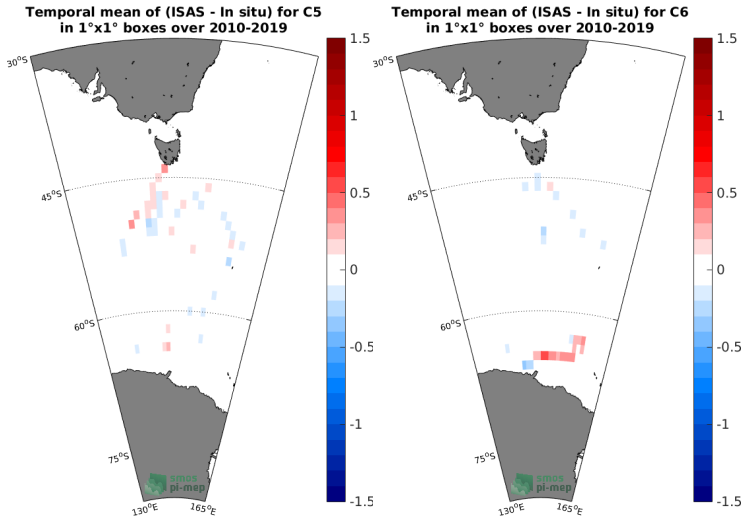
2.5.8 Conditional analyses



(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

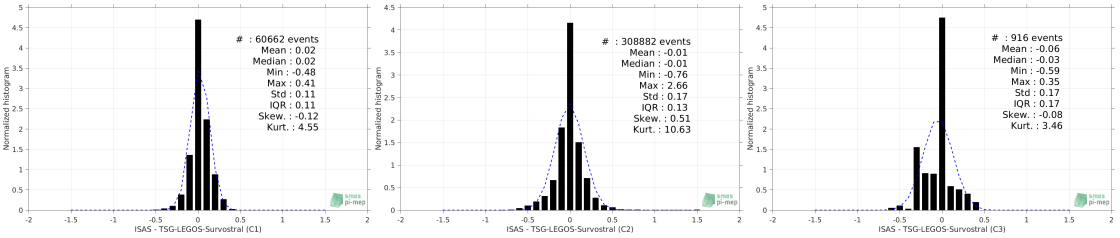
(c) RR>1mm/h and U_{10} <4m/s



(d) WOA2013 SSS Std<0.2

(e) WOA2013 SSS Std>0.2

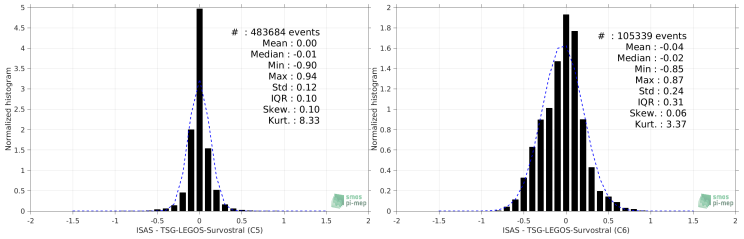
Figure 39: Temporal mean of ΔSSS (ISAS - TSG-LEGOS-Survostral) for 5 different subdatasets corresponding to C1 (a), C2 (b), C3 (c), C5 (d) and C6 (f).



(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) WOA2013 SSS Std<0.2

(e) WOA2013 SSS Std>0.2

Figure 40: Normalized histogram of ΔSSS (ISAS - TSG-LEGOS-Survostral) for 5 different sub-datasets corresponding to C1 (a), C2 (b), C3 (c), C5 (d) and C6 (f).

2.5.9 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	616277	-0.01	-0.01	0.16	0.16	0.12	0.91	0.09
C1	60662	0.02	0.02	0.11	0.11	0.11	0.75	0.08
C2	308882	-0.01	-0.01	0.17	0.17	0.13	0.90	0.09
C3	916	-0.03	-0.06	0.17	0.18	0.17	0.92	0.08
C5	483684	-0.01	0.00	0.12	0.12	0.10	0.92	0.07
C6	105339	-0.02	-0.04	0.24	0.24	0.31	0.85	0.22
C7a	58116	-0.02	0.01	0.26	0.26	0.29	0.87	0.21
C7b	349042	-0.01	-0.01	0.17	0.17	0.15	0.89	0.11
C7c	209119	-0.01	0.00	0.09	0.09	0.08	0.74	0.06
C8a	289880	-0.01	0.00	0.10	0.10	0.08	0.54	0.06
C8b	280359	0.00	0.00	0.17	0.17	0.19	0.86	0.14
C8c	40022	-0.11	-0.09	0.31	0.33	0.38	0.01	0.28
C9a	338	0.85	1.35	0.83	1.59	1.61	0.51	0.34
C9b	615939	-0.01	-0.01	0.16	0.16	0.12	0.91	0.09
C9c	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN

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

2.6 TSG-LEGOS-Survostral-Adelie

2.6.1 Introduction

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

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

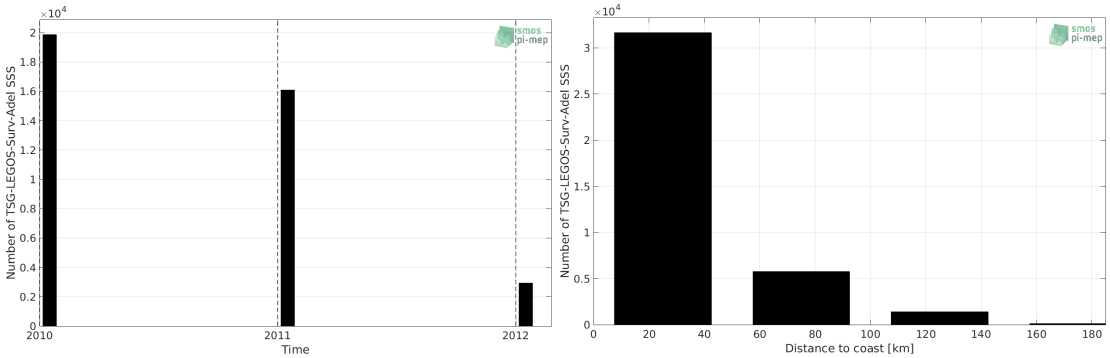


Figure 41: Number of SSS from TSG-LEGOS-Surv-Adel as a function of time (left) and distance to coast (right).

2.6.3 Histogram of SSS

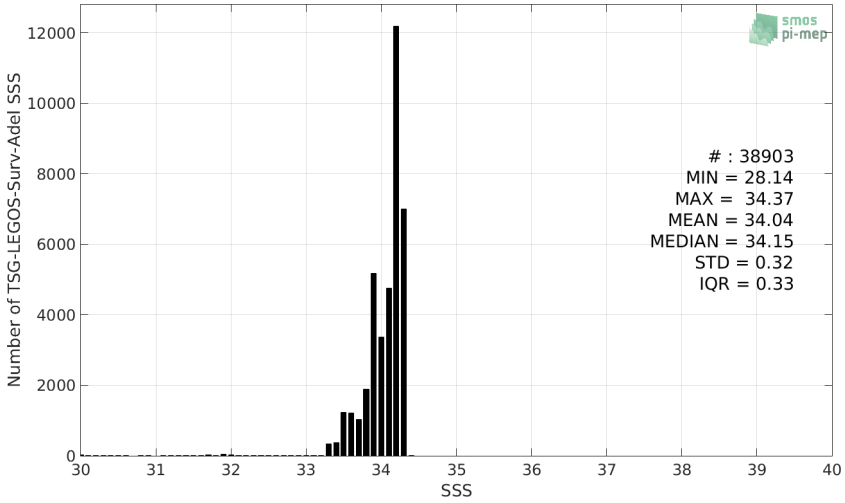


Figure 42: Distribution of SSS from TSG-LEGOS-Surv-Adel per bins of 0.1.

2.6.4 Temporal mean of SSS

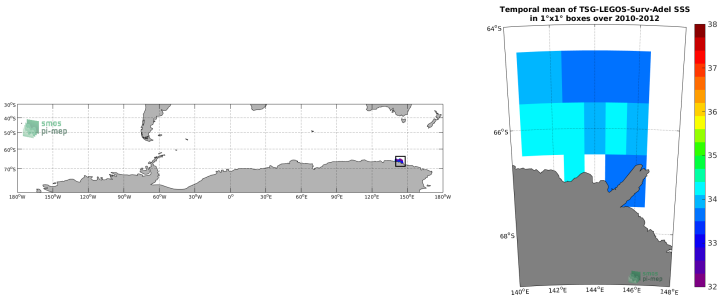


Figure 43: Time-mean SSS from TSG-LEGOS-Surv-Adel in 1°x1° boxes.

2.6.5 Temporal Std of SSS

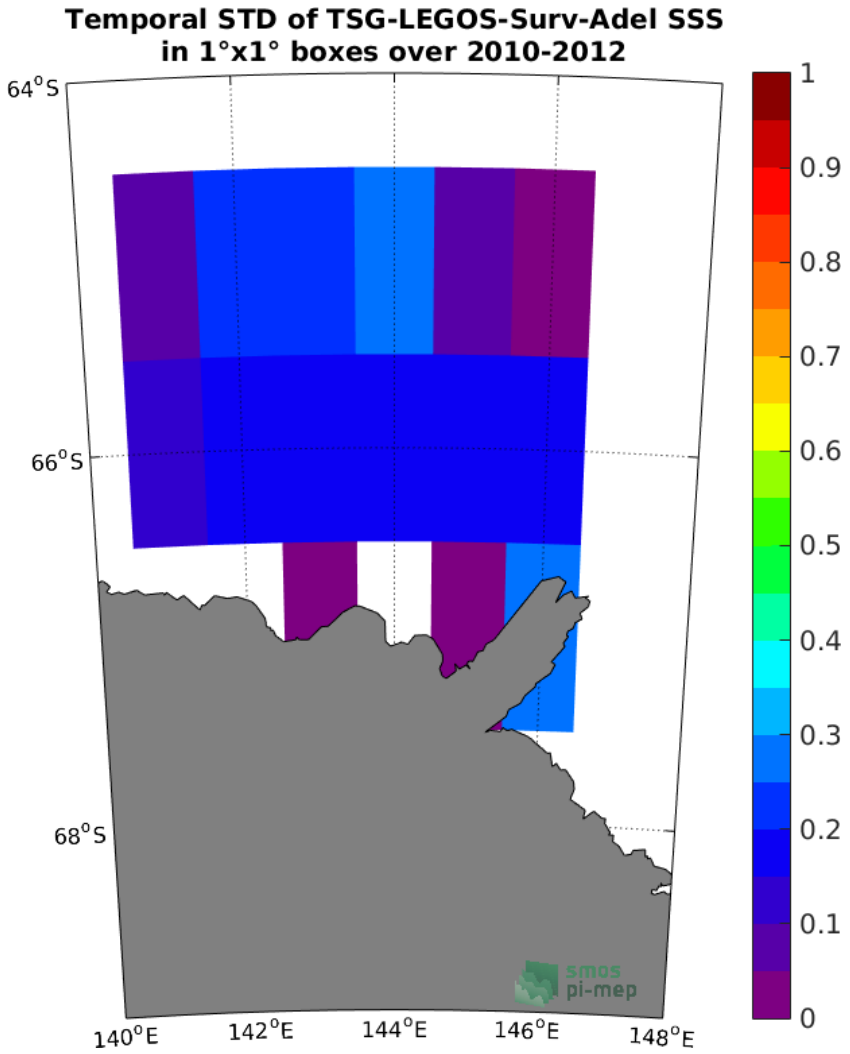


Figure 44: Temporal Std of SSS from TSG-LEGOS-Surv-Adel in 1°x1° boxes.

2.6.6 Spatial density of SSS

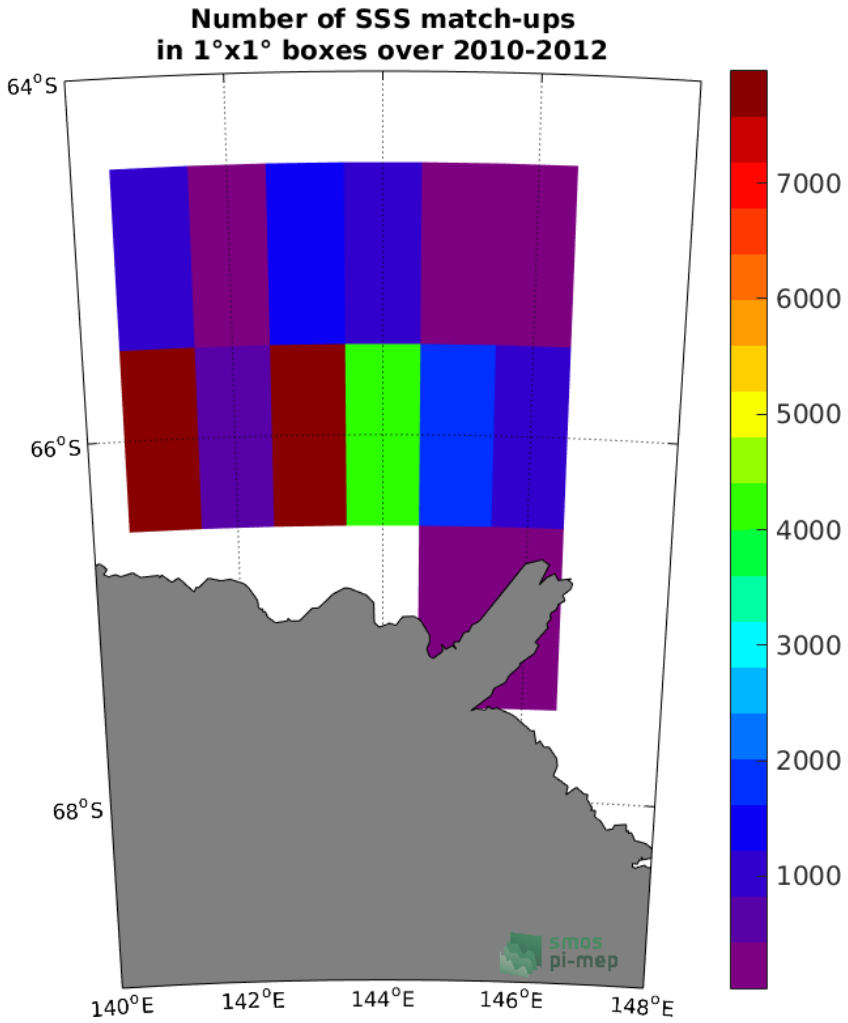
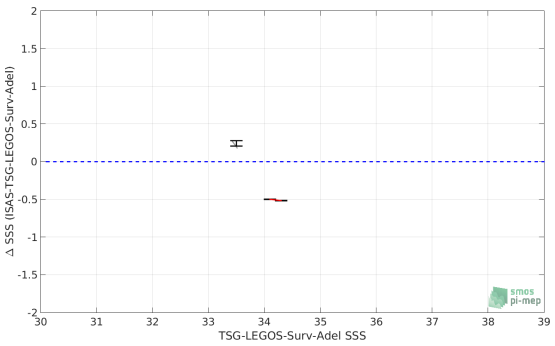
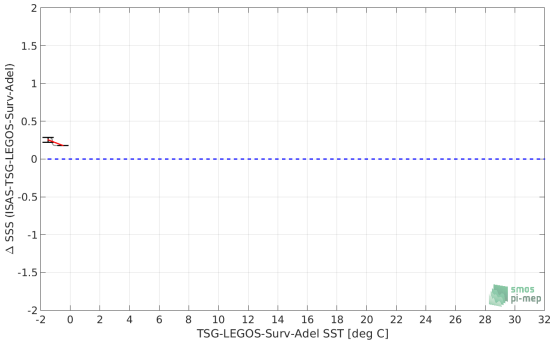


Figure 45: Number of SSS from TSG-LEGOS-Surv-Adel in 1°x1° boxes.

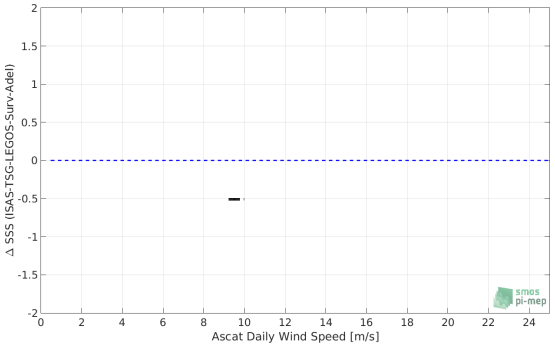
2.6.7 ΔSSS sorted as geophysical conditions



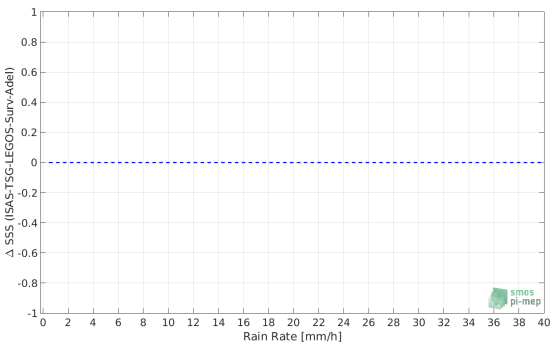
(a) TSG-LEGOS-Surv-Adel SSS



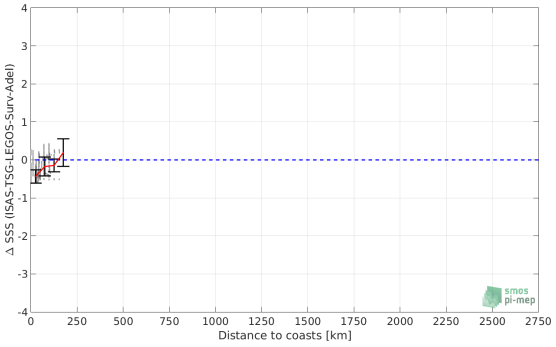
(b) TSG-LEGOS-Surv-Adel SST



(c) ASCAT Wind Speed



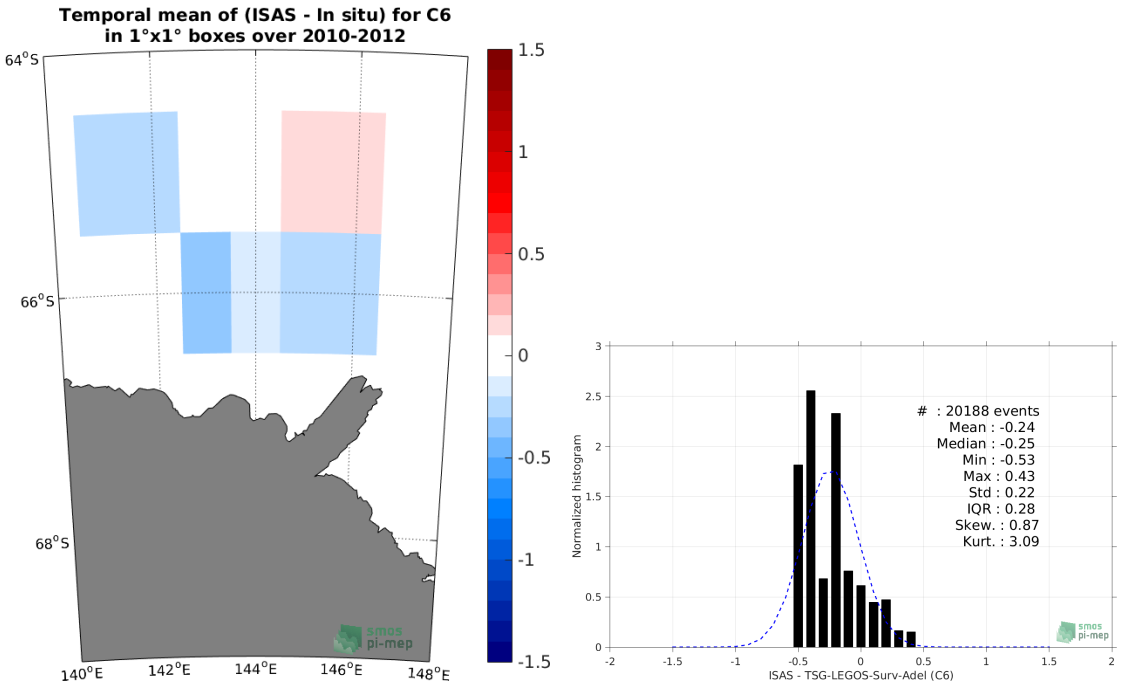
(d) CMORPH Rain rate



(e) Distance to coast

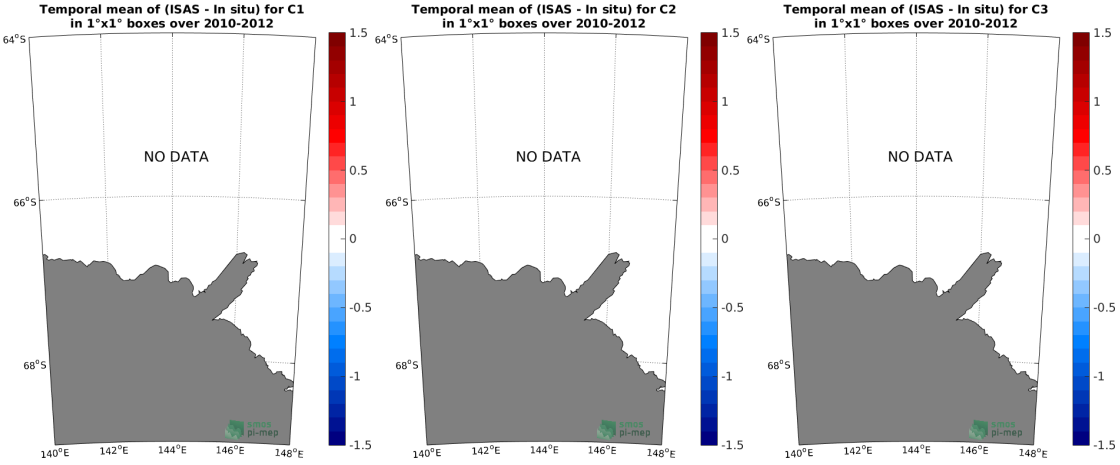
Figure 46: Δ SSS (ISAS - TSG-LEGOS-Surv-Adel) sorted as geophysical conditions: TSG-LEGOS-Surv-Adel SSS a), TSG-LEGOS-Surv-Adel SST b), ASCAT Wind speed c), CMORPH rain rate d) and distance to coast (e).

2.6.8 Conditional analyses



(a) WOA2013 SSS Std>0.2 (b) WOA2013 SSS Std>0.2

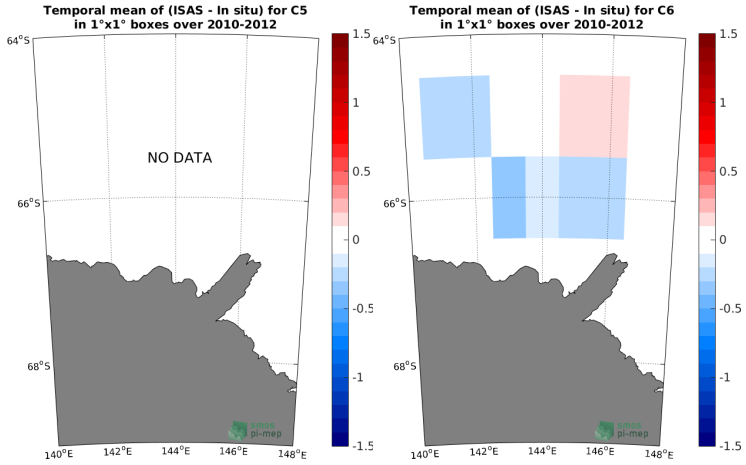
Figure 47: Temporal mean (a) and normalized histogram (b) of ΔSSS (ISAS - TSG-LEGOS-Surv-Adel) for 1 subdataset corresponding to C6.



(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

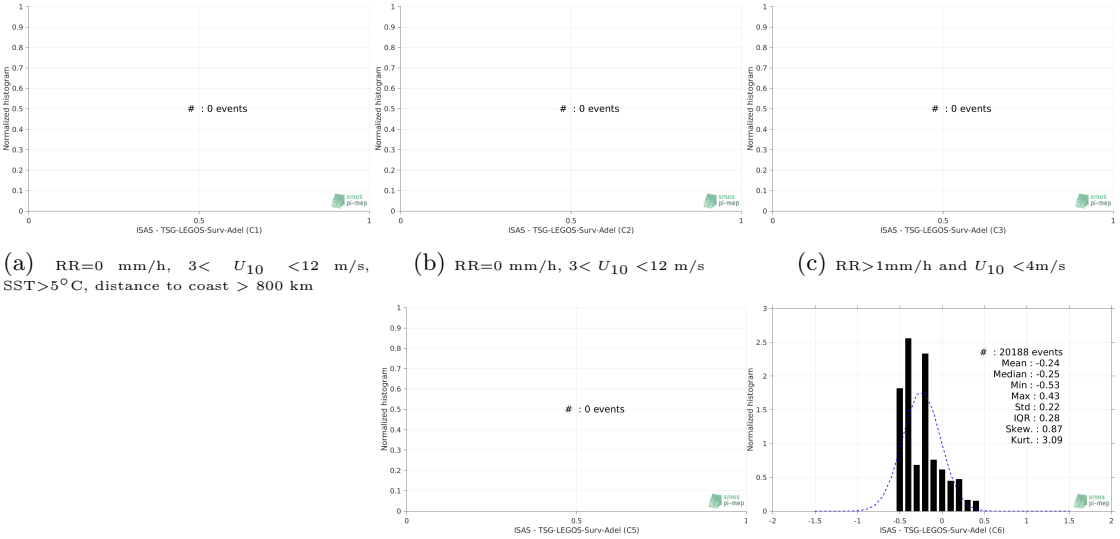
(c) RR>1mm/h and U_{10} <4m/s



(d) WOA2013 SSS Std<0.2

(e) WOA2013 SSS Std>0.2

Figure 48: Temporal mean of ΔSSS (ISAS - TSG-LEGOS-Surv-Adel) for 5 different subdatasets corresponding to C1 (a), C2 (b), C3 (c), C5 (d) and C6 (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) WOA2013 SSS Std<0.2 (e) WOA2013 SSS Std>0.2

Figure 49: Normalized histogram of ΔSSS (ISAS - TSG-LEGOS-Surv-Adel) for 5 different sub-datasets corresponding to C1 (a), C2 (b), C3 (c), C5 (d) and C6 (f).

2.6.9 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-Surv-Adel) 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-Surv-Adel)

Condition	#	Median	Mean	Std	RMS	IQR	r^2	Std*
all	31485	-0.40	-0.33	0.23	0.40	0.31	0.00	0.23
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	20188	-0.25	-0.24	0.22	0.33	0.28	0.38	0.24
C7a	31389	-0.40	-0.33	0.23	0.40	0.31	0.00	0.23
C7b	96	0.19	-0.04	0.36	0.36	0.76	0.78	0.12
C7c	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
C8a	18615	-0.29	-0.27	0.26	0.37	0.34	0.22	0.26
C8b	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
C8c	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
C9a	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN
C9b	31485	-0.40	-0.33	0.23	0.40	0.31	0.00	0.23
C9c	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN

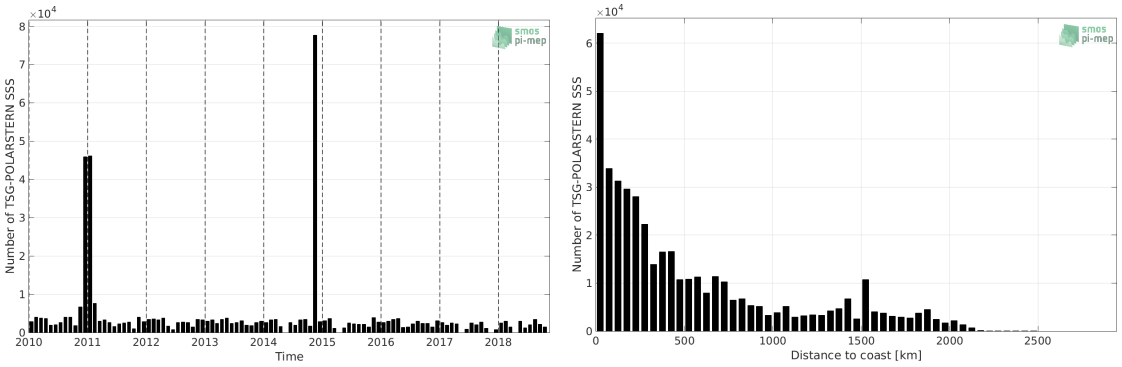
Table 1 numerical values can be downloaded as a csv file here.

2.7 TSG-Polarstern

2.7.1 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 72 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, 803312, 803431, 808835, 808836, 808838, 809727, 810678, 816055, 819831, 823259, 831976, 832269, 839406, 839407, 839408, 845130, 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.

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



(a) (b)

Figure 50: Number of SSS from TSG-POLARSTERN as a function of time (a) and distance to coast (b).

2.7.3 Histogram of SSS

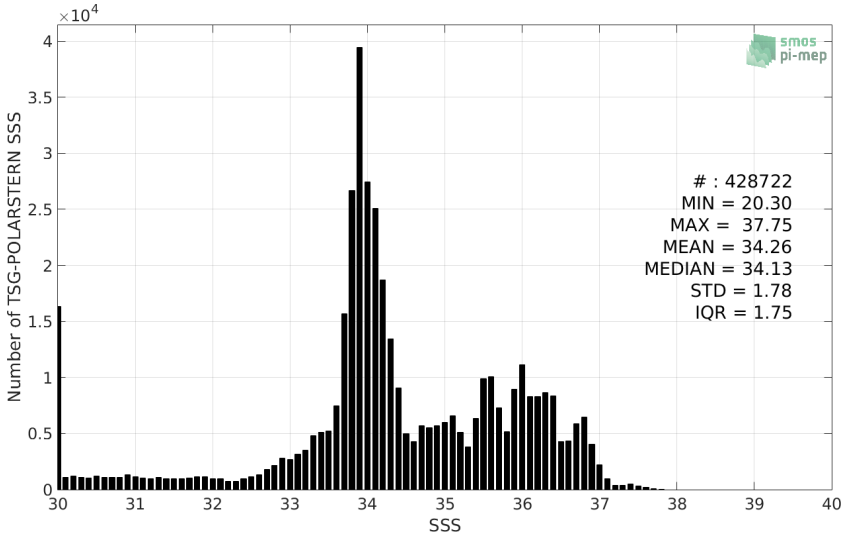


Figure 51: Distribution of SSS from TSG-POLARSTERN per bins of 0.1.

2.7.4 Temporal mean of SSS

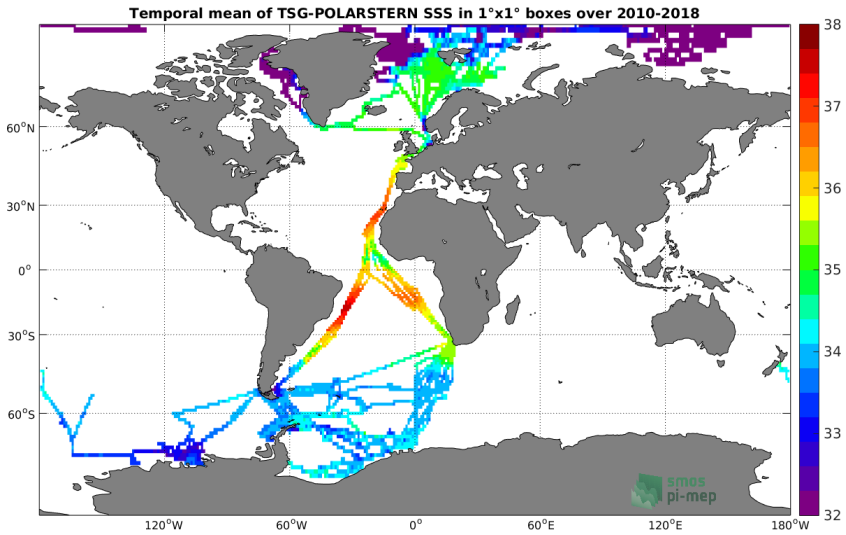


Figure 52: Time-mean SSS from TSG-POLARSTERN in 1°x1° boxes.

2.7.5 Temporal STD of SSS

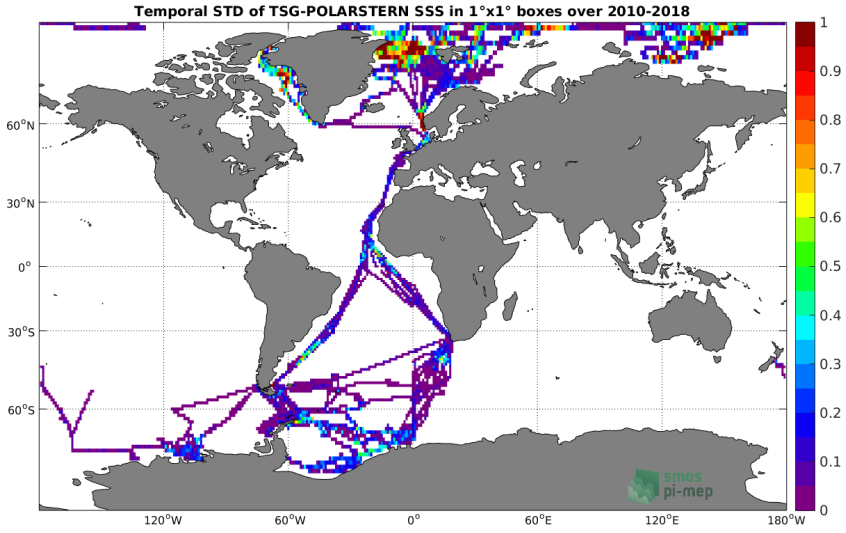


Figure 53: Temporal STD of SSS from TSG-POLARSTERN in 1°x1° boxes.

2.7.6 Spatial density of SSS

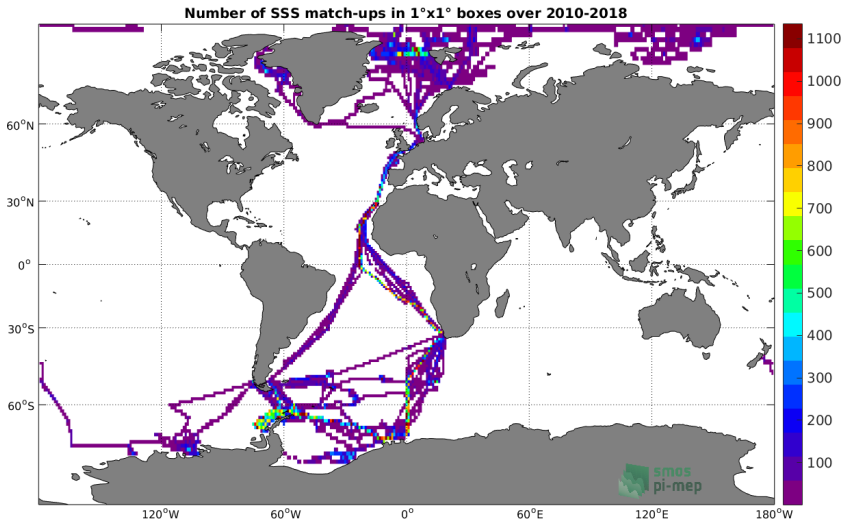
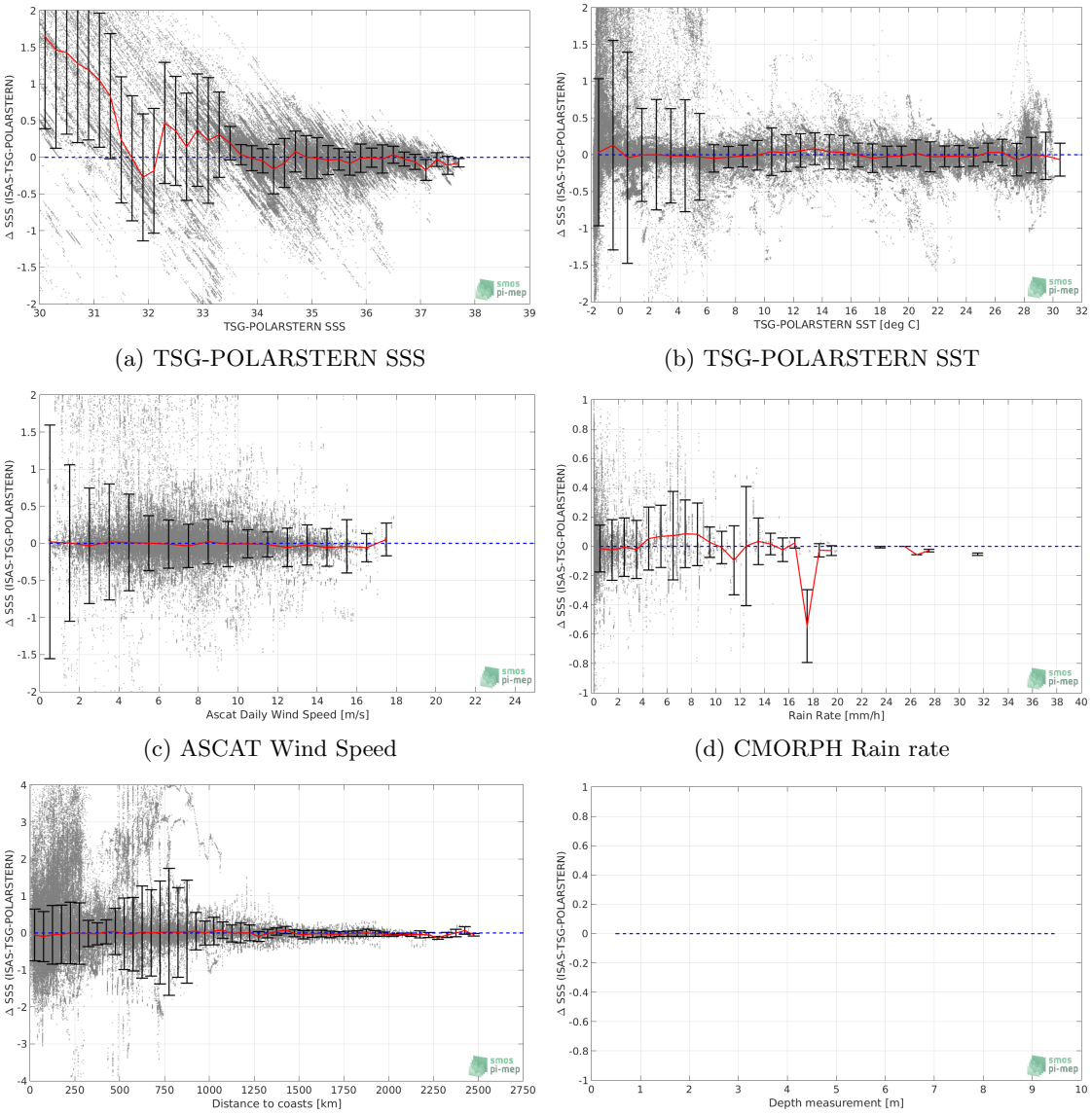


Figure 54: Number of SSS from TSG-POLARSTERN in 1°x1° boxes.

2.7.7 ΔSSS sorted as geophysical conditions



(a) TSG-POLARSTERN SSS

(b) TSG-POLARSTERN SST

(c) ASCAT Wind Speed

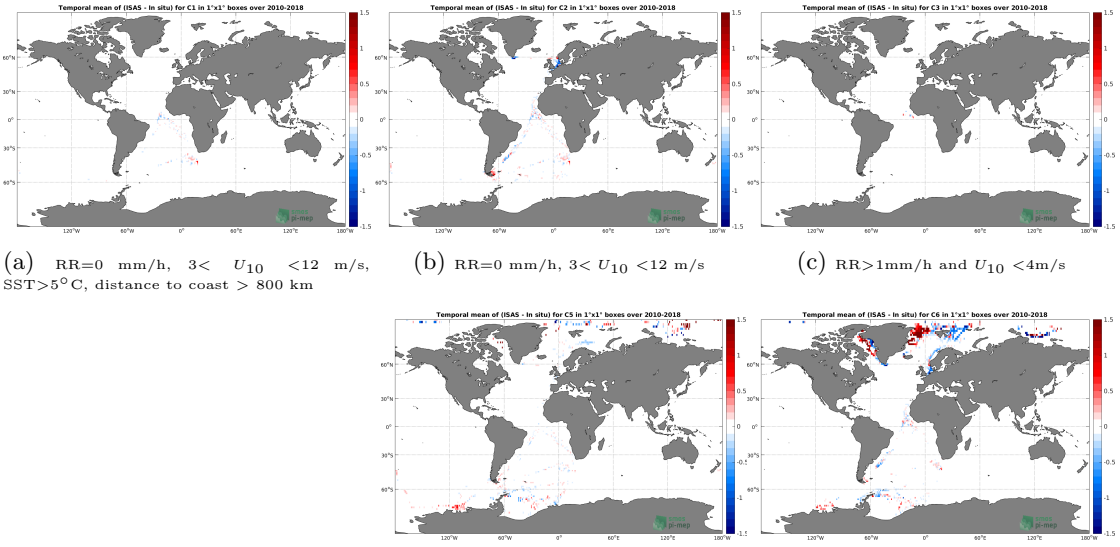
(d) CMORPH Rain rate

(e) Distance to coast

(f) Depth

Figure 55: 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).

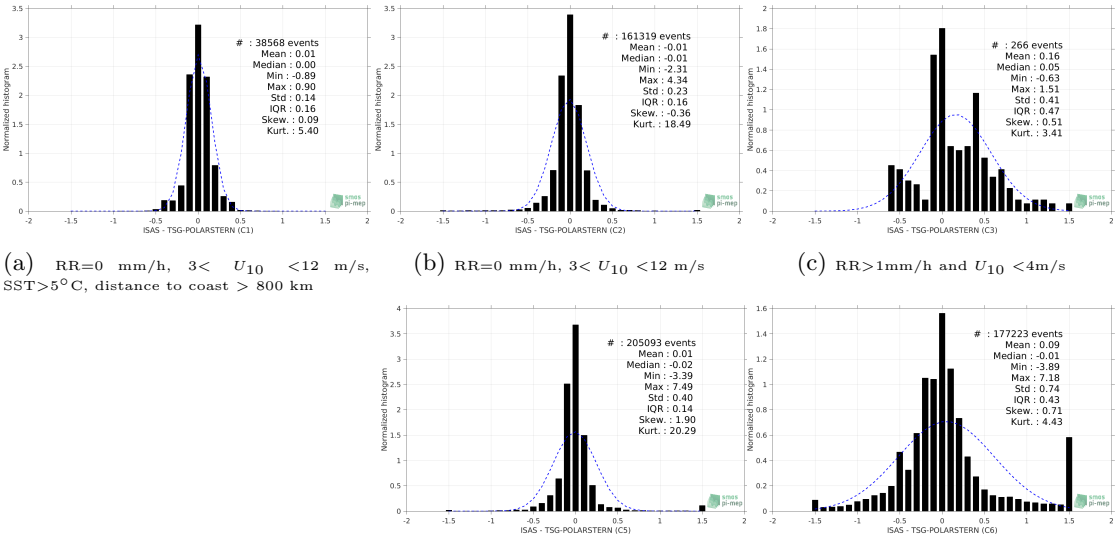
2.7.8 Conditional analyses



(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 56: Temporal mean of ΔSSS (ISAS - TSG-POLARSTERN) for 5 different subdatasets corresponding to C1 (a), C2 (b), C3 (c), C5 (d) and C6 (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 57: Normalized histogram of ΔSSS (ISAS - TSG-POLARSTERN) for 5 different subdatasets corresponding to C1 (a), C2 (b), C3 (c), C5 (d) and C6 (e).

2.7.9 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	422383	-0.02	0.10	0.76	0.77	0.24	0.83	0.18
C1	38568	0.00	0.01	0.14	0.14	0.16	0.98	0.12
C2	161319	-0.01	-0.01	0.23	0.23	0.16	0.96	0.12
C3	266	0.05	0.16	0.41	0.44	0.47	0.88	0.37
C5	205093	-0.02	0.01	0.40	0.40	0.14	0.92	0.11
C6	177223	-0.01	0.09	0.74	0.75	0.43	0.83	0.33
C7a	123076	-0.06	0.02	0.72	0.72	0.39	0.81	0.29
C7b	195770	0.00	0.18	0.89	0.90	0.26	0.81	0.19
C7c	103537	-0.01	0.04	0.50	0.50	0.15	0.88	0.11
C8a	221573	-0.01	0.21	0.98	1.00	0.34	0.66	0.25
C8b	65369	-0.04	-0.04	0.57	0.58	0.26	0.69	0.19
C8c	99513	-0.02	-0.02	0.20	0.20	0.18	0.90	0.13
C9a	51440	0.98	1.26	1.63	2.06	1.93	0.25	1.40
C9b	366984	-0.03	-0.06	0.29	0.30	0.21	0.93	0.15
C9c	3959	-0.09	-0.11	0.13	0.17	0.21	0.74	0.16

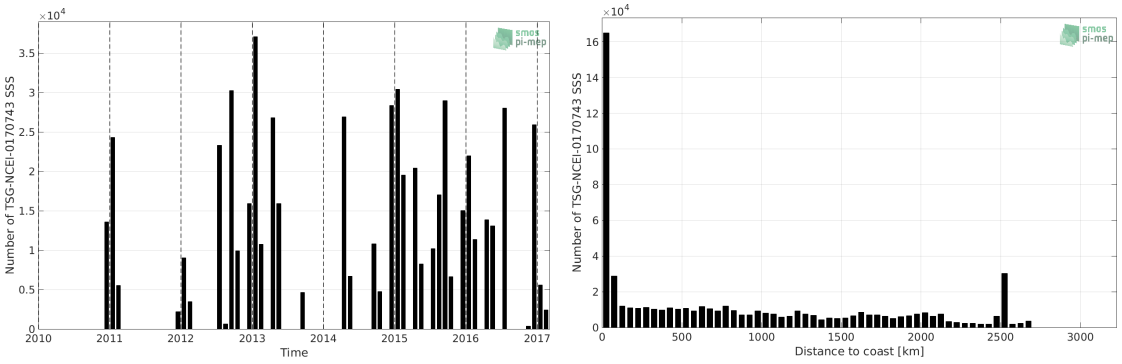
Table 1 numerical values can be downloaded as a csv file here.

2.8 TSG-NCEI-0170743

2.8.1 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 termosalinograph (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.

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



(a) (b)

Figure 58: Number of SSS from TSG-NCEI-0170743 as a function of time (a) and distance to coast (b).

2.8.3 Histogram of SSS

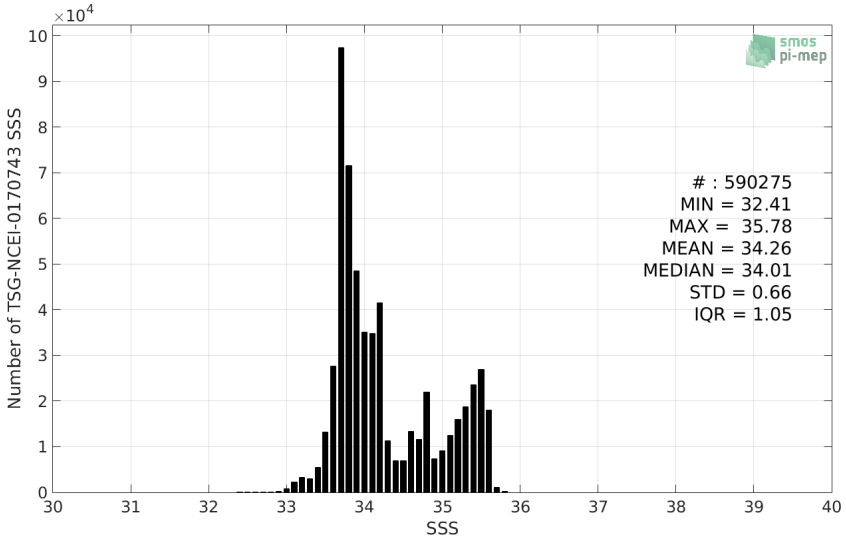


Figure 59: Distribution of SSS from TSG-NCEI-0170743 per bins of 0.1.

2.8.4 Temporal mean of SSS

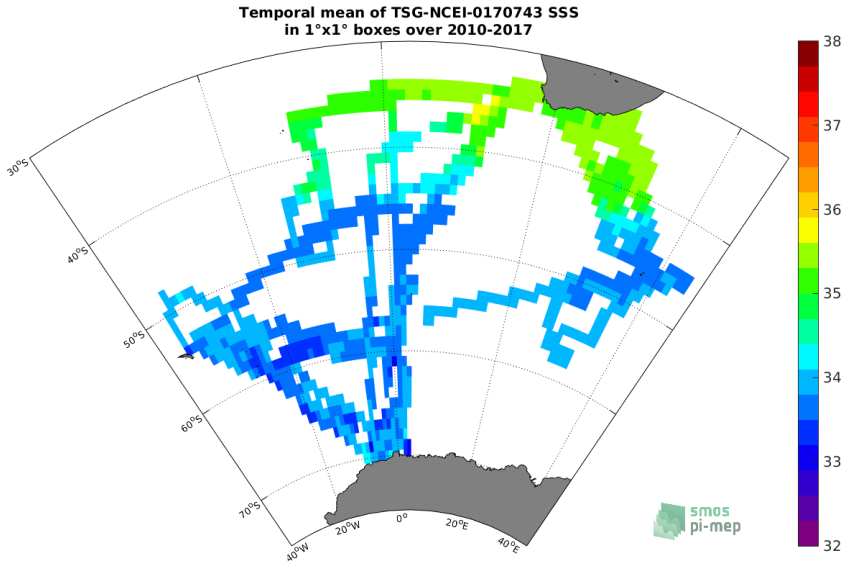


Figure 60: Time-mean SSS from TSG-NCEI-0170743 in 1°x1° boxes.

2.8.5 Temporal STD of SSS

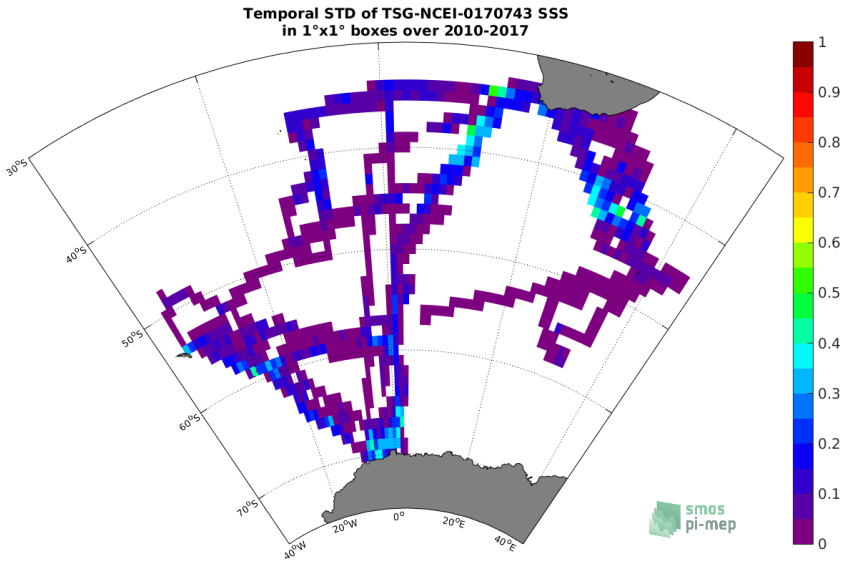


Figure 61: Temporal STD of SSS from TSG-NCEI-0170743 in 1°x1° boxes.

2.8.6 Spatial density of SSS

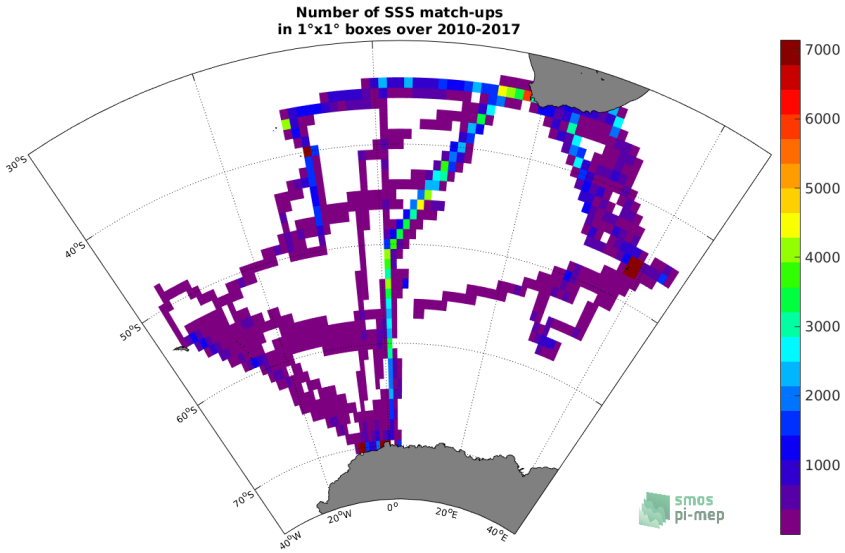
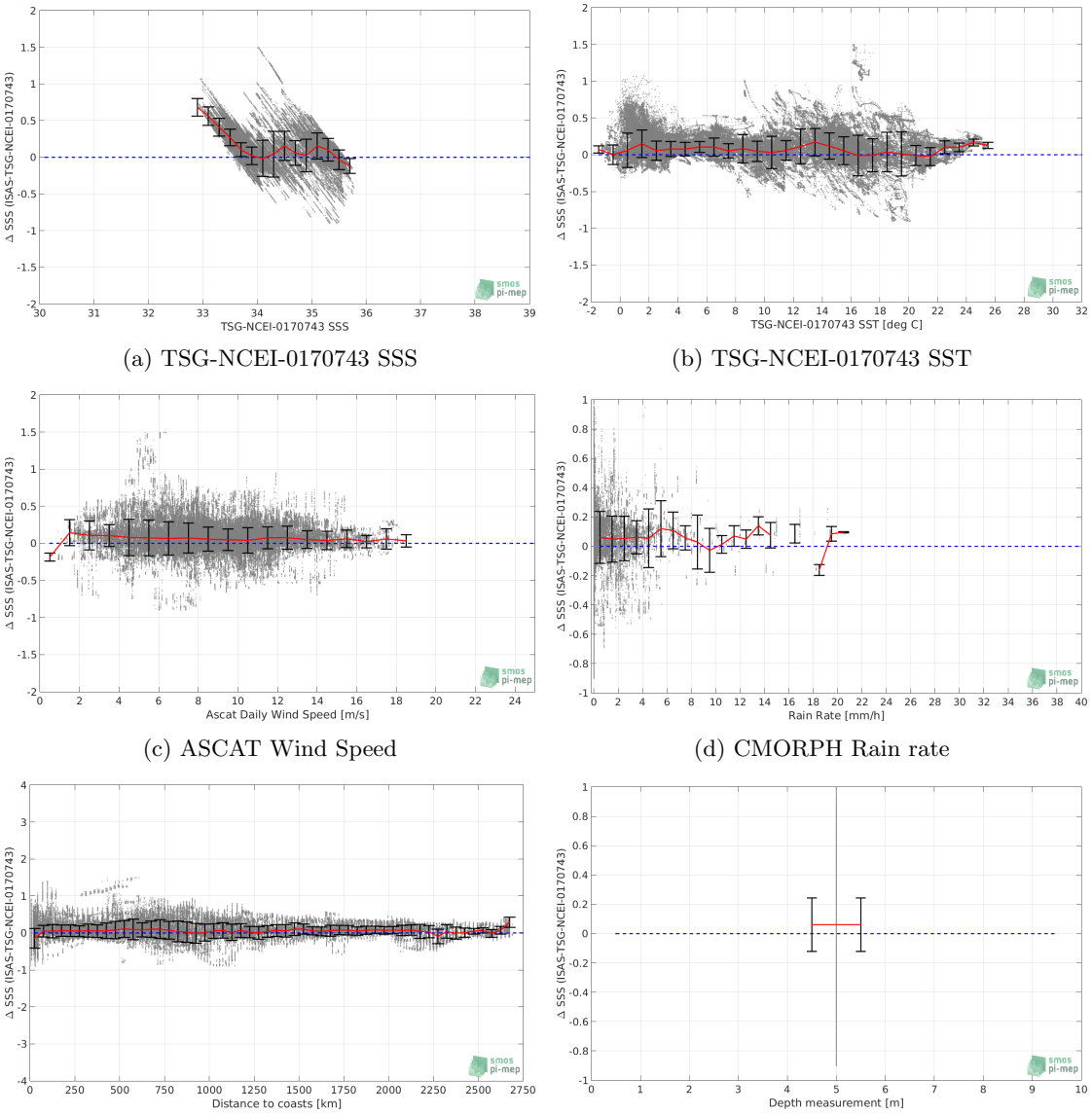


Figure 62: Number of SSS from TSG-NCEI-0170743 in 1°x1° boxes.

2.8.7 ΔSSS sorted as geophysical conditions



(a) TSG-NCEI-0170743 SSS

(b) TSG-NCEI-0170743 SST

(c) ASCAT Wind Speed

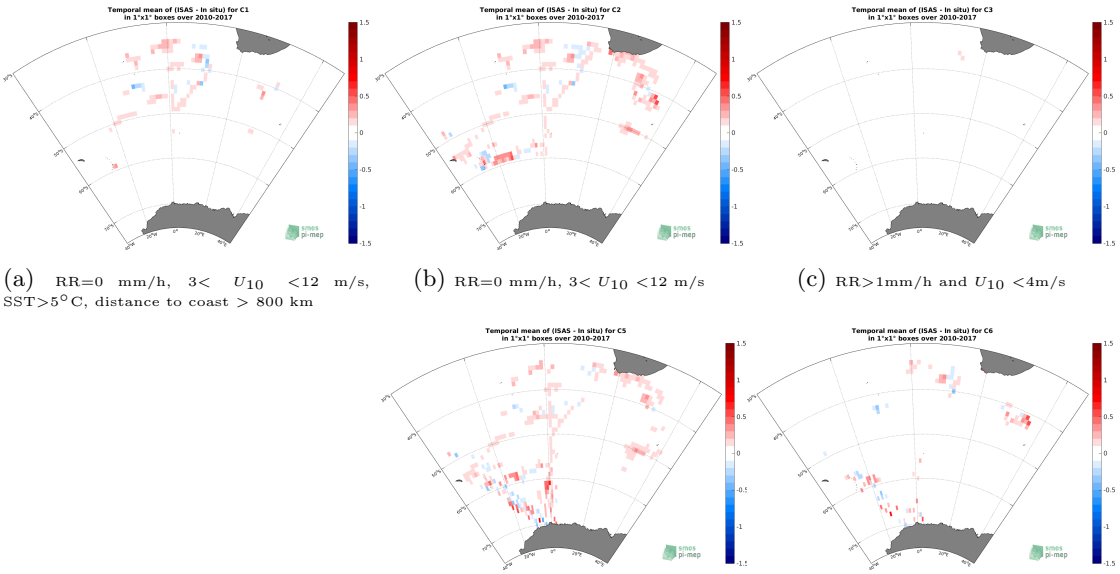
(d) CMORPH Rain rate

(e) Distance to coast

(f) Depth

Figure 63: 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).

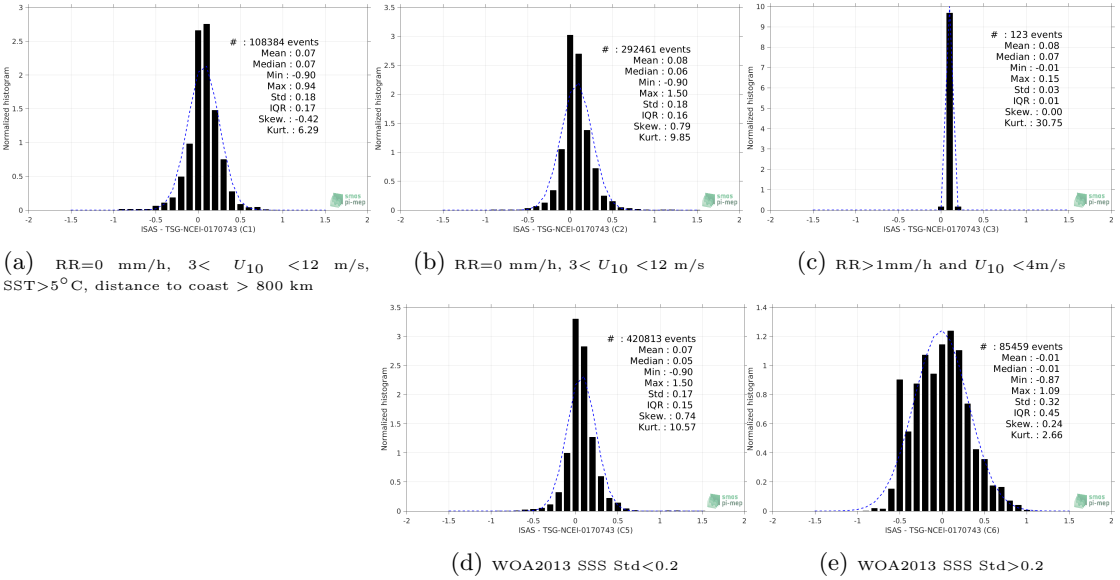
2.8.8 Conditional analyses



(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 64: Temporal mean of ΔSSS (ISAS - TSG-NCEI-0170743) for 5 different subdatasets corresponding to C1 (a), C2 (b), C3 (c), C5 (d) and C6 (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 65: Normalized histogram of ΔSSS (ISAS - TSG-NCEI-0170743) for 5 different subdatasets corresponding to C1 (a), C2 (b), C3 (c), C5 (d) and C6 (e).

2.8.9 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.

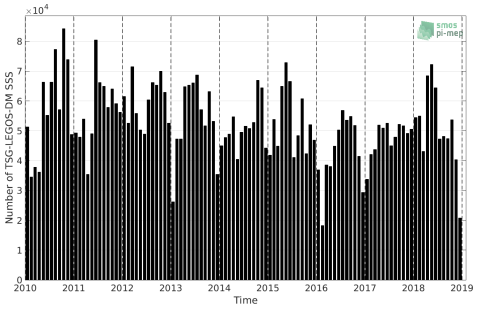
Table 1: Statistics of ΔSSS (ISAS - TSG-NCEI-0170743)

Condition	#	Median	Mean	Std	RMS	IQR	r^2	Std*
all	589637	0.03	0.02	0.23	0.23	0.21	0.89	0.16
C1	108384	0.07	0.07	0.18	0.19	0.17	0.91	0.13
C2	292461	0.06	0.08	0.18	0.19	0.16	0.94	0.12
C3	123	0.07	0.08	0.03	0.09	0.01	1.00	0.01
C5	420813	0.05	0.07	0.17	0.18	0.15	0.94	0.11
C6	85459	-0.01	-0.01	0.32	0.32	0.45	0.79	0.34
C7a	205174	-0.01	-0.08	0.26	0.27	0.35	0.79	0.25
C7b	138055	0.07	0.09	0.21	0.23	0.22	0.93	0.16
C7c	246408	0.06	0.07	0.17	0.18	0.16	0.93	0.12
C8a	194460	0.00	-0.03	0.26	0.26	0.35	0.04	0.24
C8b	219434	0.06	0.08	0.15	0.17	0.13	0.92	0.09
C8c	124598	0.04	0.06	0.23	0.23	0.22	0.78	0.16
C9a	940	0.87	0.86	0.20	0.88	0.31	0.20	0.27
C9b	588697	0.03	0.02	0.22	0.22	0.21	0.89	0.15
C9c	0	NaN	NaN	NaN	NaN	NaN	NaN	NaN

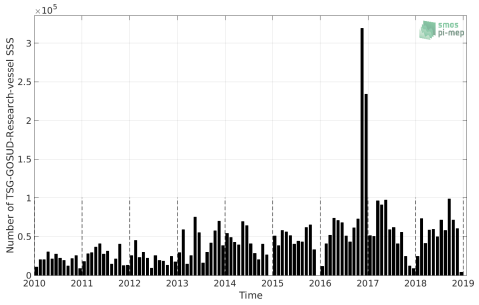
Table 1 numerical values can be downloaded as a csv file here.

3 Summary

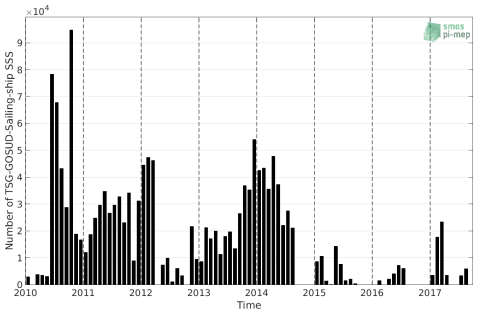
3.1 Number of SSS data as a function of time



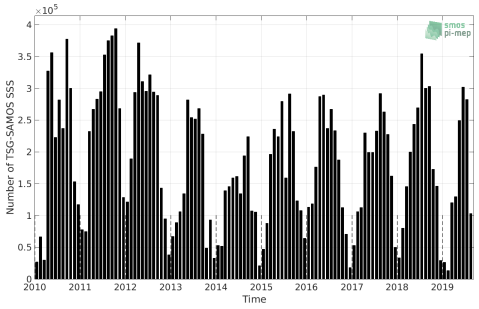
(a) TSG-LEGOS-DM



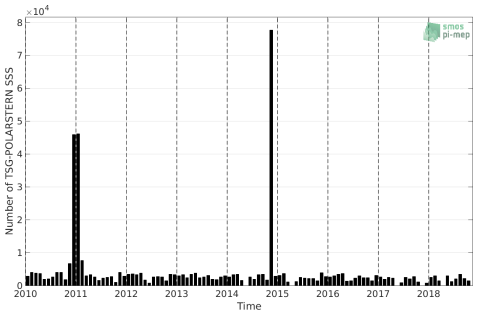
(b) TSG-GOSUD-Research-vessel



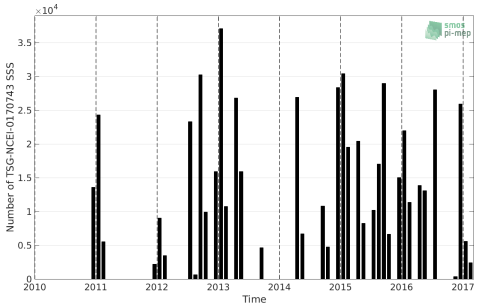
(c) TSG-GOSUD-Sailing-ship



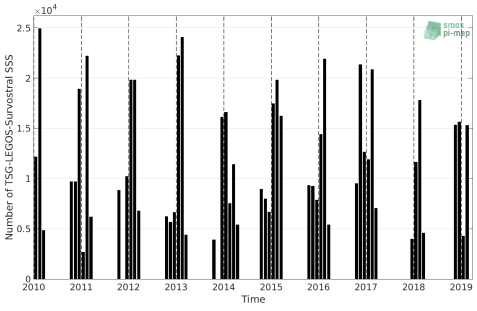
(d) TSG-SAMOS



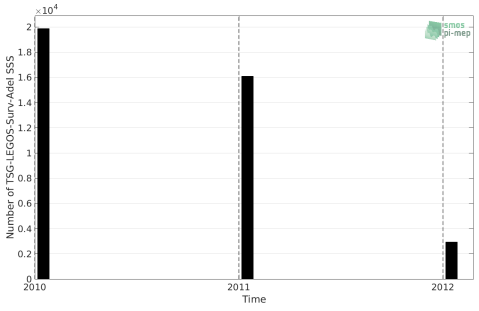
(e) TSG-Polarstern



(f) TSG-NCEI-0170743



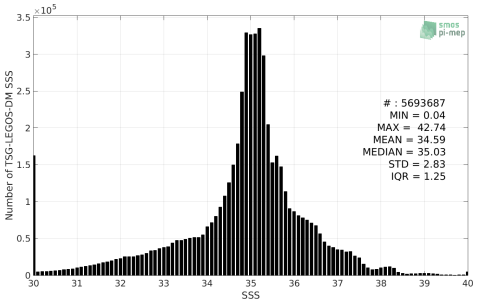
(g) TSG-LEGOS-Survostral



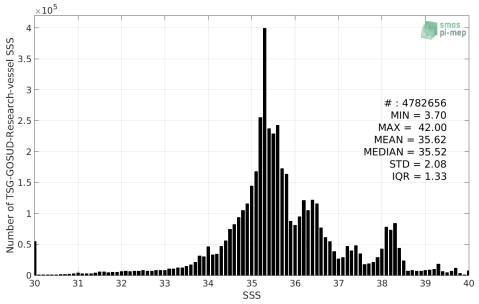
(h) TSG-LEGOS-Survostral-Adélie

Figure 66: Number of SSS data as a function of time.

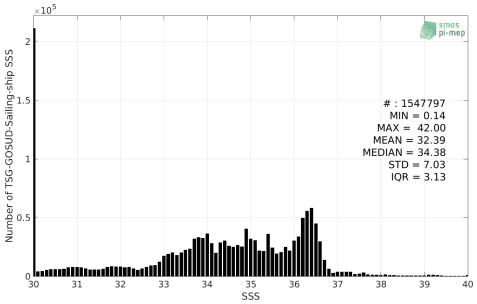
3.2 Histogram of SSS



(a) TSG-LEGOS-DM



(b) TSG-GOSUD-Research-vessel



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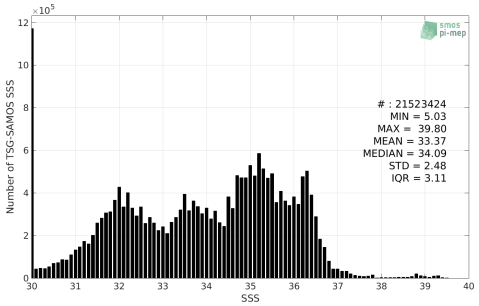

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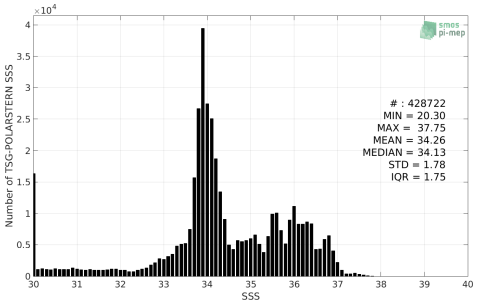
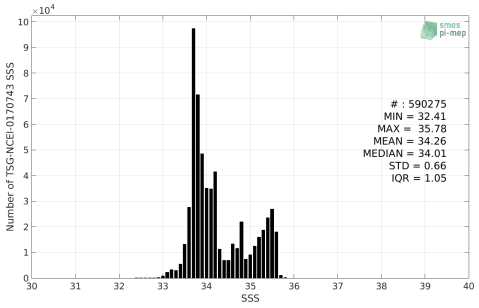
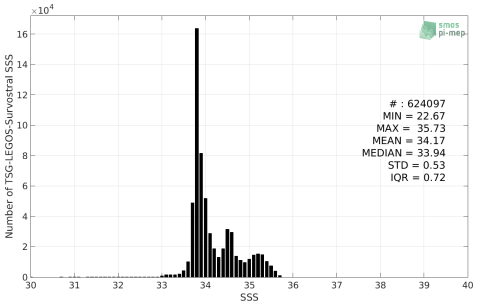


(e) TSG-Polarstern



(f) TSG-NCEI-0170743



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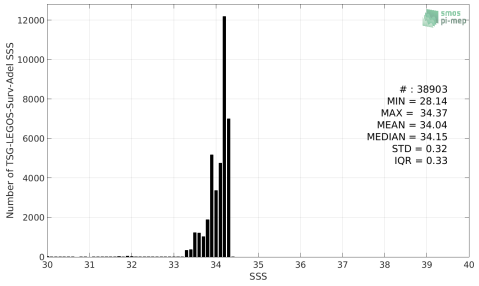
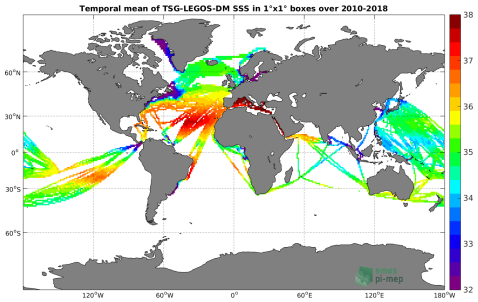


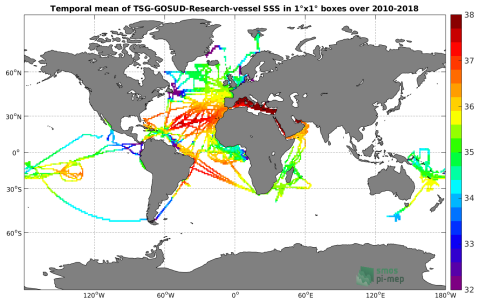
(h) TSG-LEGOS-Survostral-Adélie

Figure 67: Distribution of SSS per bins of 0.1.

3.3 Temporal mean of SSS



(a) TSG-LEGOS-DM



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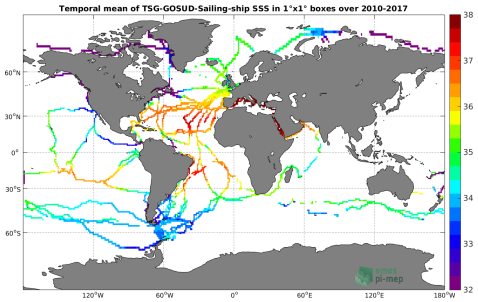
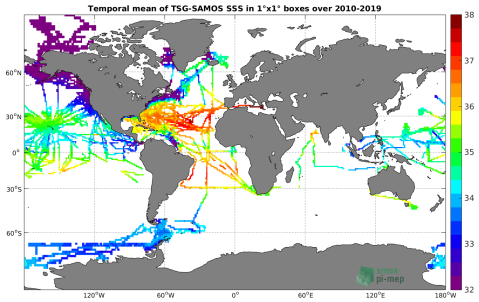
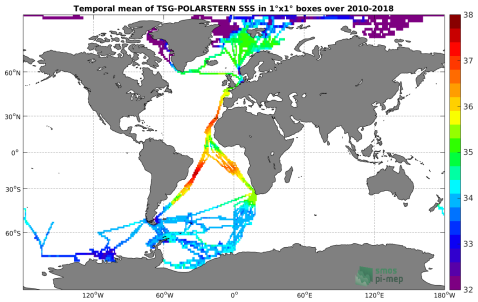


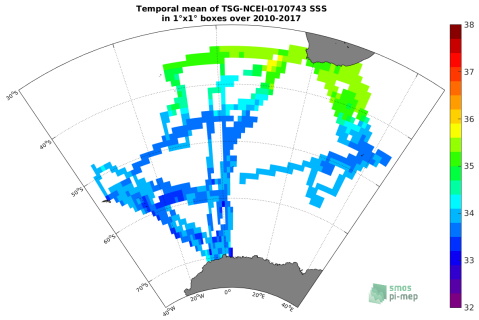
(c) TSG-GOSUD-Sailing-ship



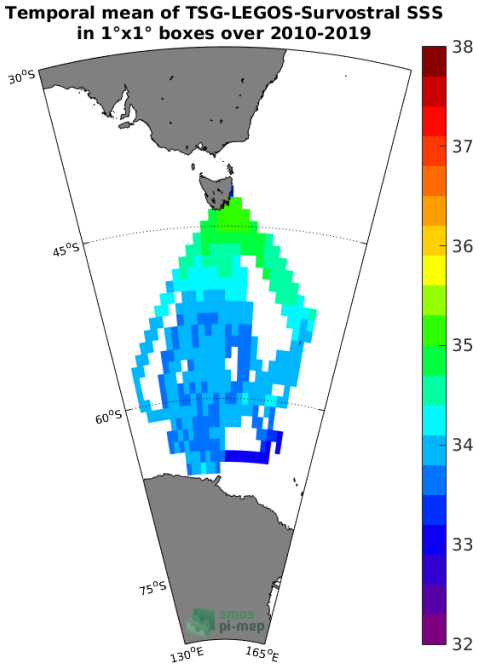
(d) TSG-SAMOS



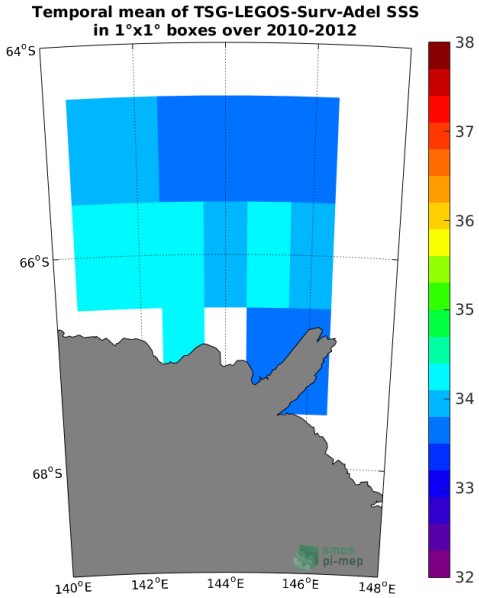
(e) TSG-Polarstern



(f) TSG-NCEI-0170743



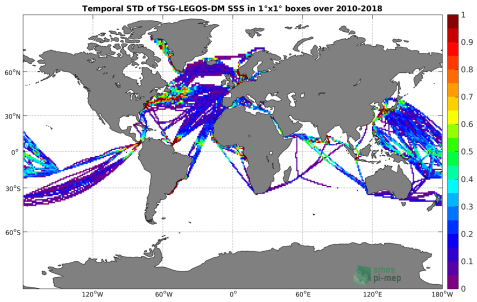
(g) TSG-LEGOS-Survostral



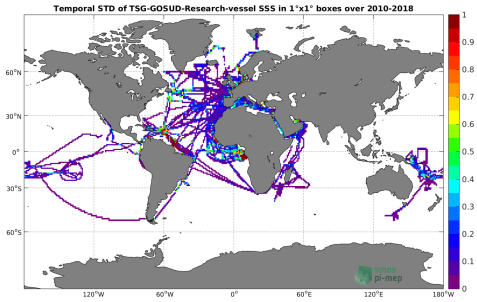
(h) TSG-LEGOS-Survostral-Adélie

Figure 68: Temporal mean of SSS in 1°x1° boxes.

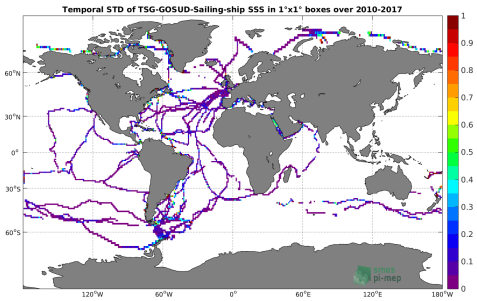
3.4 Temporal Std of SSS



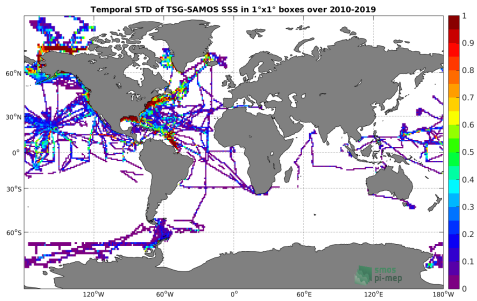
(a) TSG-LEGOS-DM



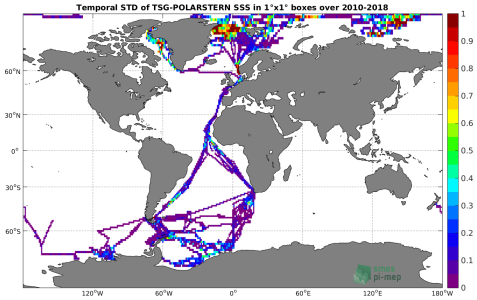
(b) TSG-GOSUD-Research-vessel



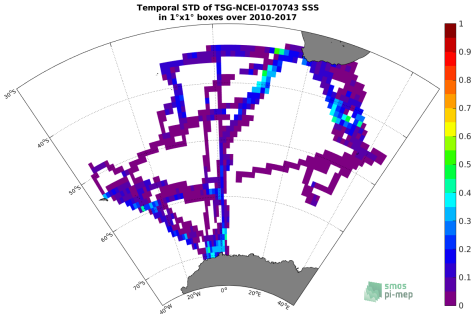
(c) TSG-GOSUD-Sailing-ship



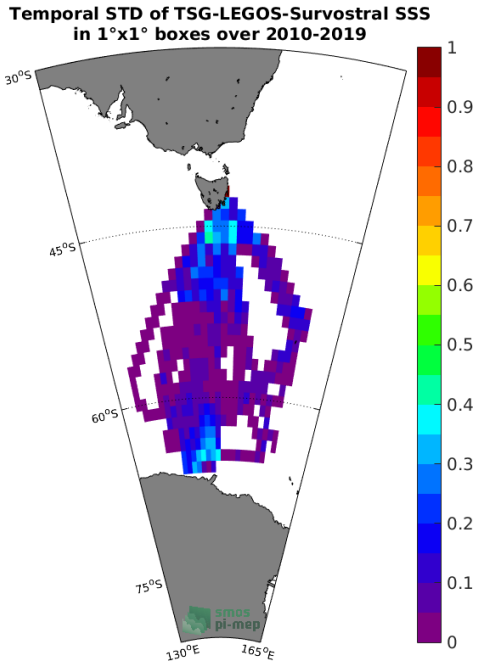
(d) TSG-SAMOS



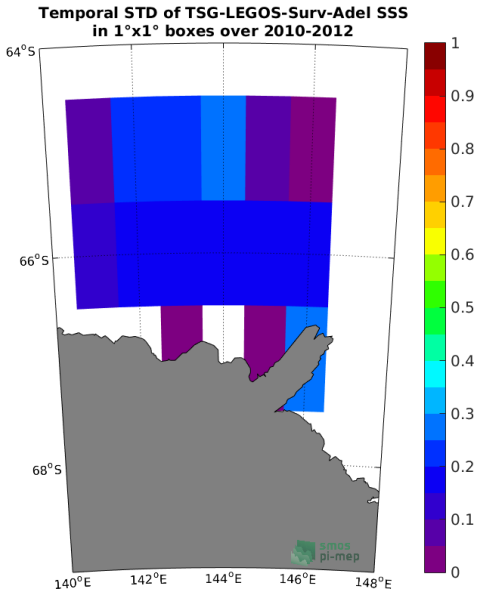
(e) TSG-Polarstern



(f) TSG-NCEI-0170743



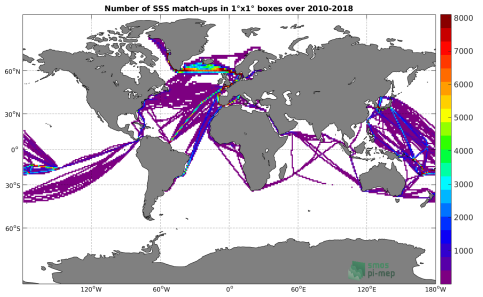
(g) TSG-LEGOS-Survostral



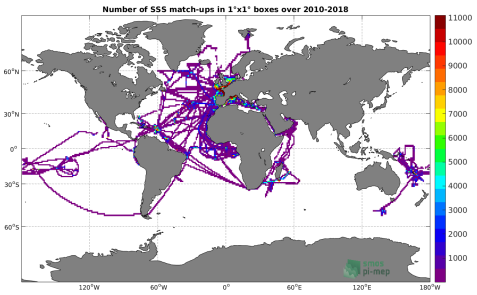
(h) TSG-LEGOS-Survostral-Adélie

Figure 69: Temporal Std of SSS in 1°x1° boxes.

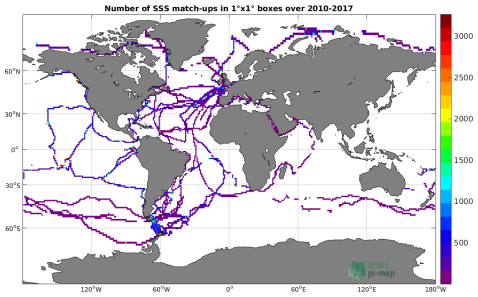
3.5 Spatial density of SSS



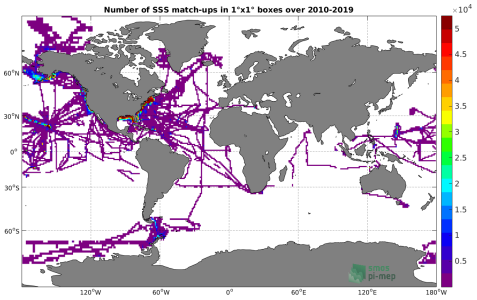
(a) TSG-LEGOS-DM



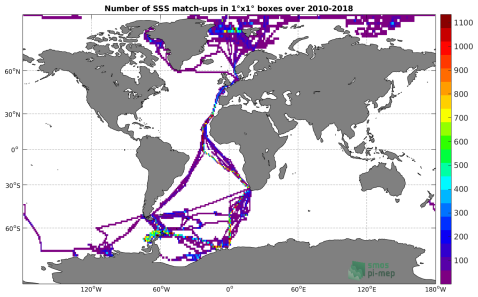
(b) TSG-GOSUD-Research-vessel



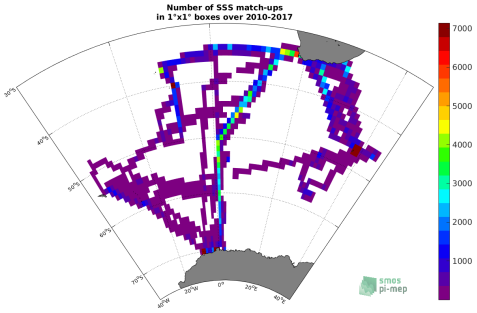
(c) TSG-GOSUD-Sailing-ship



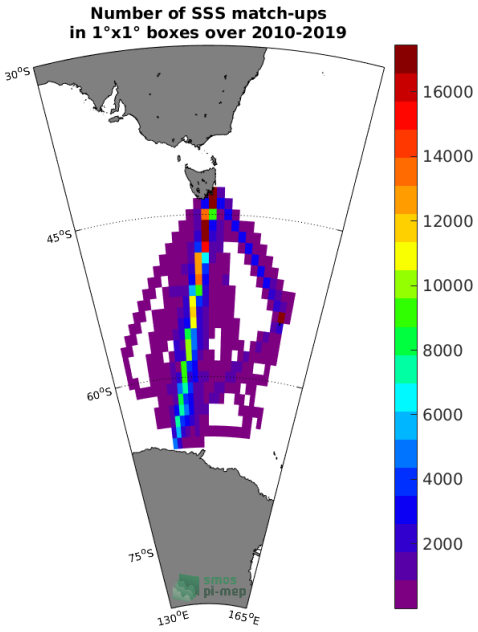
(d) TSG-SAMOS



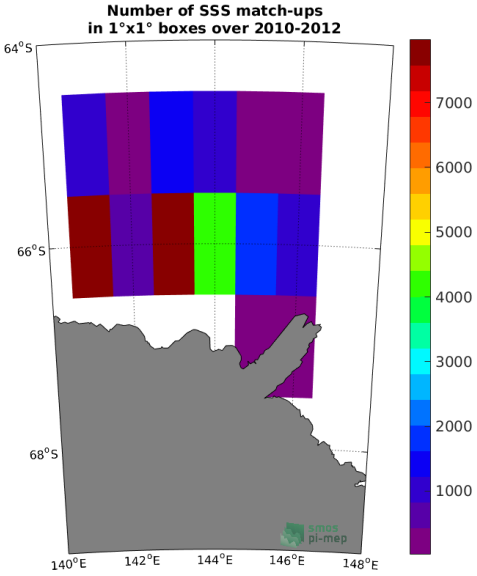
(e) TSG-Polarstern



(f) TSG-NCEI-0170743



(g) TSG-LEGOS-Survostral



(h) TSG-LEGOS-Survostral-Adélie

Figure 70: Number of SSS in 1°x1° boxes.

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