SMOS Pilot-Mission Exploitation Platform (Pi-MEP) for Salinity –

Project introduction and SAG involvement

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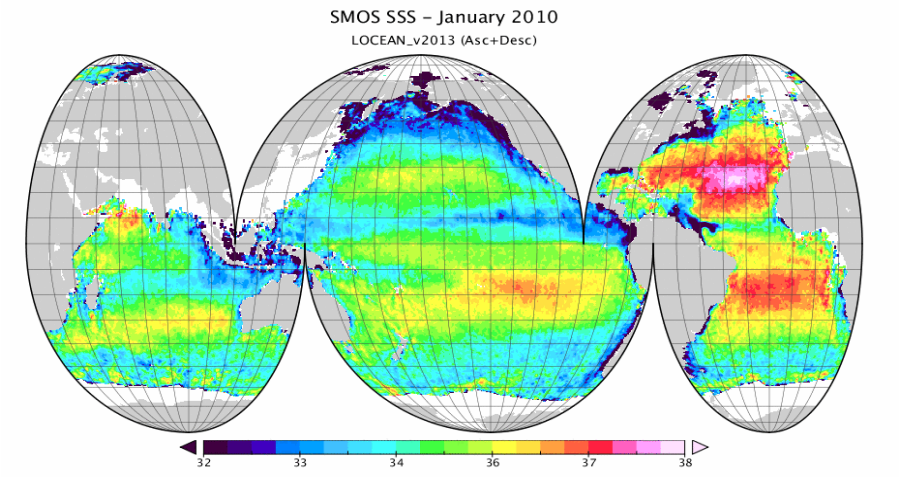
Pi-MEP SAG CM1

May 3rd, 2017

ESA-ESTEC, Noordwijk, the Netherlands

Outline

- SMOS Mission and Level 2 Ocean Salinity status
- Recommendations by ESAC panel from mission extension review in 2014
- SMOS Pilot-Mission Exploitation Platform (Pi-MEP)
  - Rationale and objectives
  - Features and implementation
- SMOS Pi-MEP SAG: membership and involvements
- SAG CM1 agenda

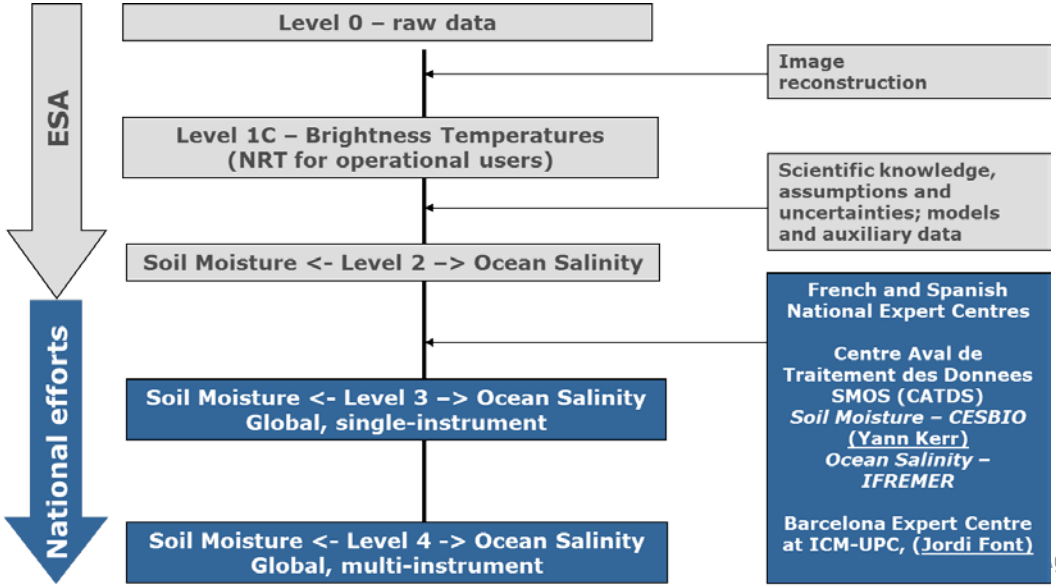


SMOS in a nutshell (i)

SMOS - Background and Motivation

- ESA **Earth Explorer** Opportunity Mission - **Living Planet** program
- Novel Earth Observation techniques demonstration; novel data provision to the science community
- Direct response to the current lack of global observations of **soil moisture** and **ocean salinity**, needed to further our knowledge of the **water cycle**, and to contribute to better weather and extreme-event forecasting and seasonal-climate forecasting
- Launch: **November 2nd, 2009** - SMOS mission operations confirmed by ESA definitively till 2019, while beyond 2019+ pending mid-term-extension-review (end ~2018)

ESA SMOS satellite



SMOS processing chain

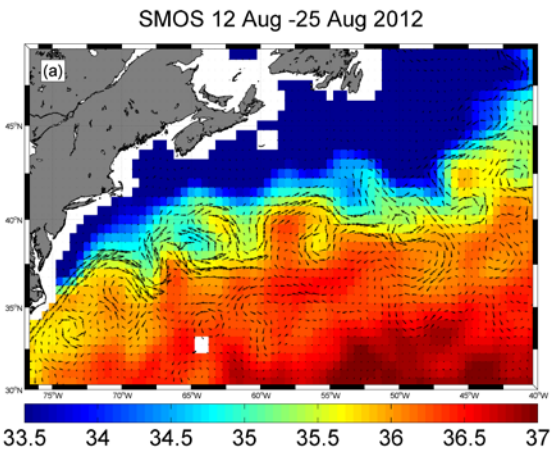
SMOS in a nutshell (ii)

Level 2 / Level 3 – Ocean Salinity

- **Sea Surface Salinity** variations governed by: E-P balance, freezing / melting ice, freshwater run-off and horizontal / vertical advection
- Key oceanographic parameter (density); triggers thermohaline circulation and heat redistribution

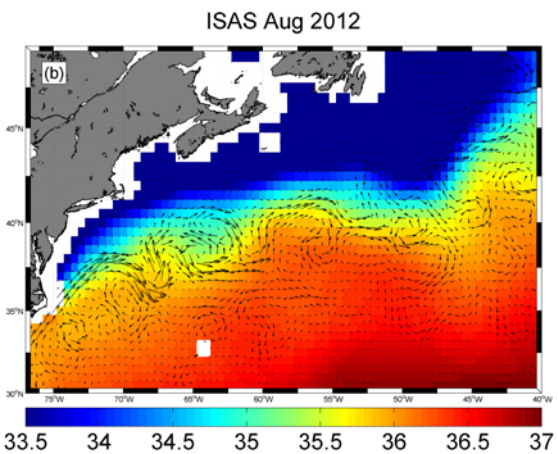
- Reprocessed data from L1 and L2 v6 are available to users.
- Data are available from new SMOS data dissemination platform:

https://smos-ds-02.eo.esa.int/oads/access/



	Accuracy	Spatial res.	Revisit time
Ocean salinity	0.5-1.5 psu for single observation 0.1 psu for a 10-30 day average for a open ocean area of 200x200 km	200 km	10-30 days

SMOS detects Gulf-stream rings and meanders ~50-100 km, whilst global In situ analyzed products are limited to scales > ~300 km (Reul et al., GRL 2014; Umbert et al., JGR 2015)



SMOS L2OS status – upcoming developments

Land-Sea Contamination sources (L1)

- ❑ Residual calibration errors
- ❑ Floor errors (aliasing)
- ❑ Uncertainties in antenna patterns

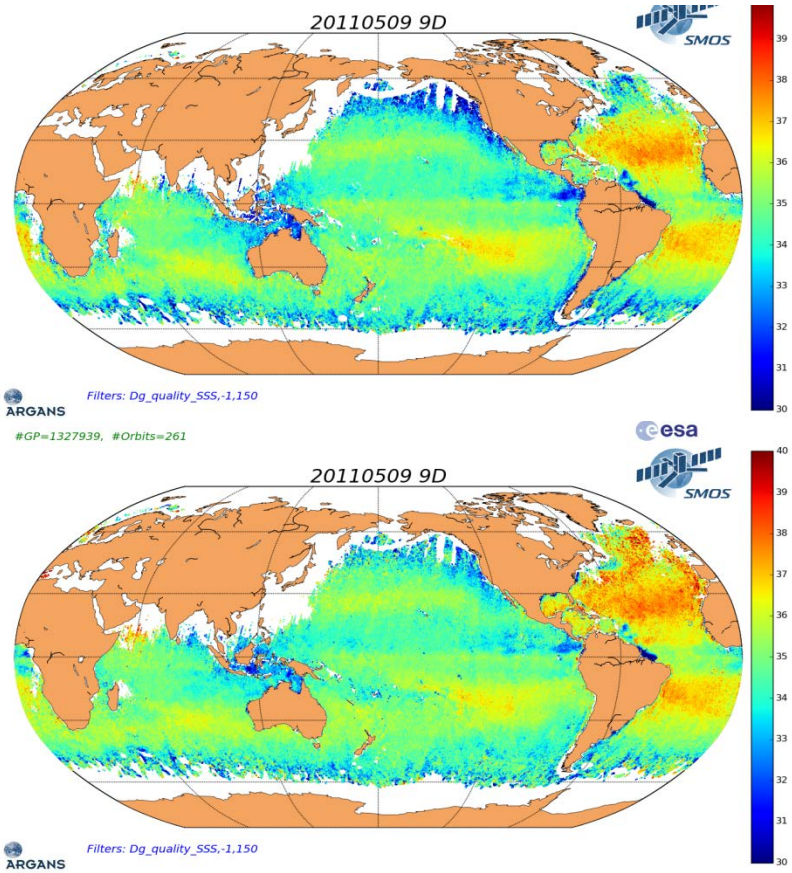
Level 2 OS empirical correction

- ❑ Empirical method developed by ESL L2OS (J. Tenerelli, OceanDataLab) determines the LSC bias as a function of polarization, overpass direction, geographic position and across-track distance.

L2 OS v662 (delivered October 2016) features

- Single roughness model selected (SSS1)
- LSC-correction implemented
- SSS anomaly (currently wrt WOA)
- Improved data filtering (RFI and Sun)

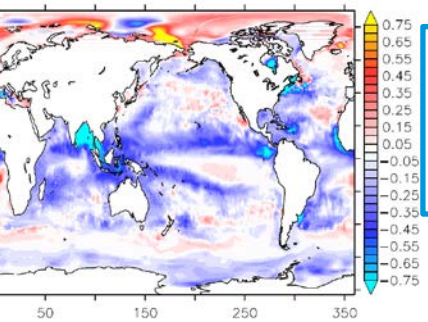
- Dedicated L2OS v662 reprocessing just completed
- Dissemination to community May 2017



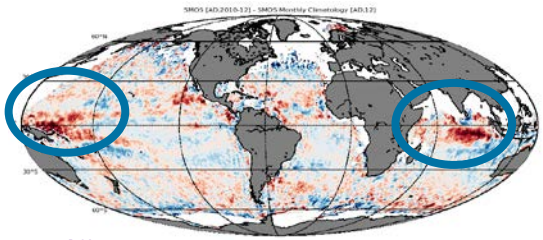
Global results before and after applying LSC-correction. Biases along the coasts are remarkably reduced. Credit: ODL

SMOS oceanographic applications

Samples of the wide range of applications stemming in the last few years from the use of SMOS SSS



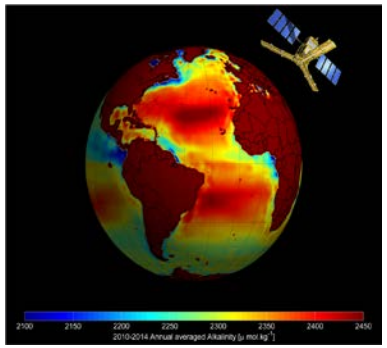
Ocean Circulation Modeling



La Niña detection (Boutin et al.)

Climate indexes

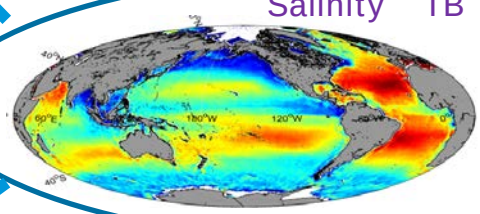
Total Alkalinity (Land et al.)

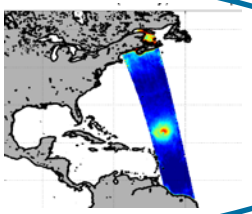


Marine Biology & Biogeochemistry

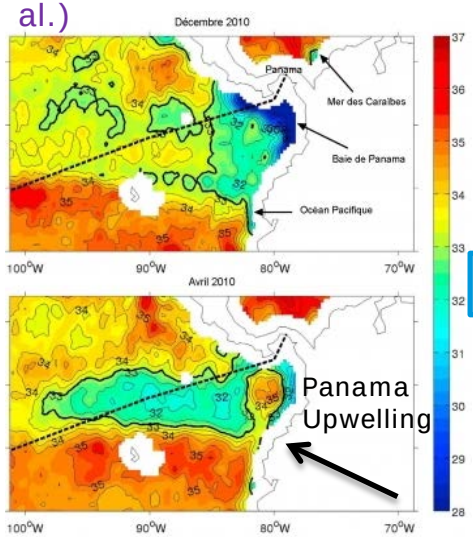
SSS Data Assimilation (Köhl et al.)

Salinity TB



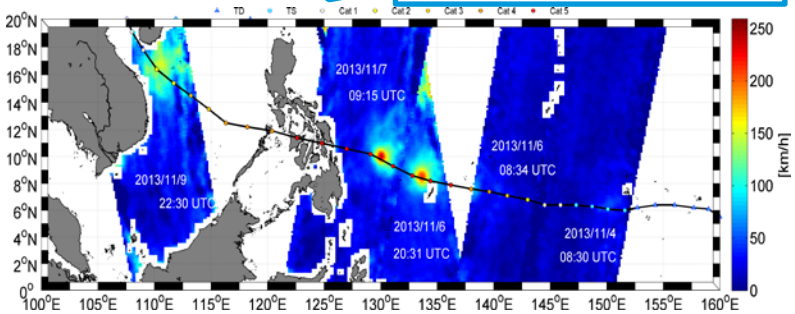


Weather Predictions



Air-Sea interactions

Upwelling detection (Alory et al.)



Hurricane tracking (Reul et al.)

ESAC recommendations from 2014 extension

ESAC recommendations triggered Actions	Actions undertaken L2 OS
Improve SSS data quality (#6)	Selection of a reference roughness model (SSS1)
Improve SSS data quality (#6)	Land-Sea-Contamination correction
Improve SSS data validation (#3,#6)	Revised ESL validation protocol (since July 2015)
Improve SSS data validation (#3,#6)	**Pi-MEP** Salinity: enhanced validation platform (from January 2017)
Synergy with additional data (#4)	**Pi-MEP** for process studies over ocean; In general, synergy ever increasing (SST, WS, rain rates, currents, Ocean colour, SLA, etc)

Pi-MEP Salinity – Semantic, Foci and Objectives

Pilot [Exploratory, precursory, trial]

Mission [ESA SMOS mission]

Exploitation [Increased, synergetic uptake of SMOS data in a variety of oceanographic domains]

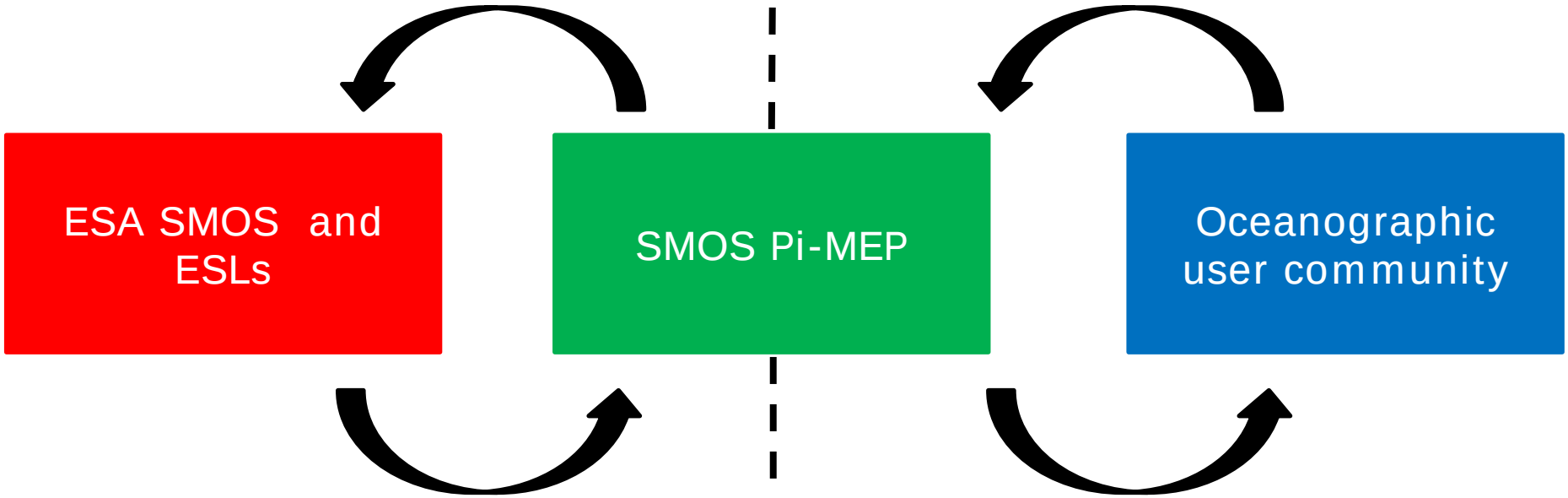
Platform [web-based, user-friendly, data-intensive IT environment]

Focus #1 – To serve as enhanced **validation platform** [matchup in-situ, filtering/QC, spatial/temporal scales, -> ESL validation testbed and "plug-in"]

Focus #2 – To offer a testbed to enable and monitor **oceanographic process studies** [data synergy, statistical and computational IT tools, on-demand processing etc.]

- **One-stop-shop** for scientific validation, monitoring, assessment and exploitation of the SMOS salinity data
- Receiving inputs from and providing support to **ESA SMOS ESLs** activities in terms of validation and assessment
- Receiving inputs from and providing support to the **wider ocean community** activities in terms of synergistic exploitation of SMOS salinity data

Twofold scope of Pi-MEP Salinity



ESA SMOS and ESLs

- Inputs to Pi-MEP: current validation protocol, advisory (SAG)
- Outputs from Pi-MEP: enhanced validation protocol, assessment, monitoring
- (SMOS salinity)-centric

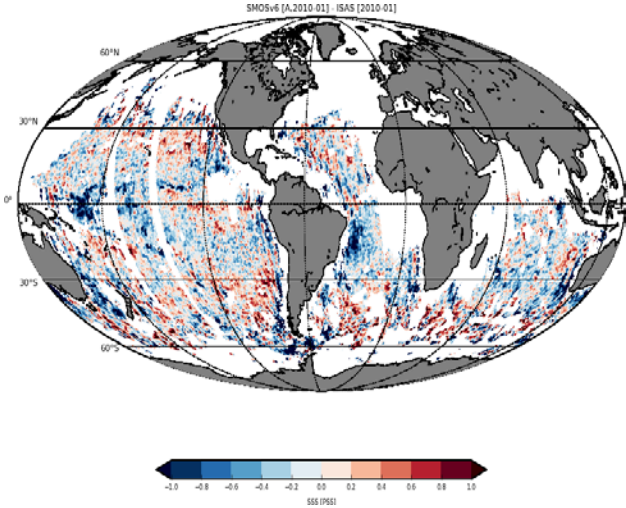
Oceanographic user community

- Inputs to Pi-MEP: literature process studies, datasets (tbc), user coding (tbc), advisory (SAG)
- Outputs from Pi-MEP: visualization, statistical and computational tools, selected case studies monitoring
- (SMOS salinity)-synergistic

Pi-MEP Salinity – Focus #1

SMOS L2 ESL standard Validation protocol

- SMOS reference: L2 **SSS1**, spatio (100km)-temporally (1 month) averaged using a weighting function; filtered for quality flags.
- *In-situ* reference: **Argo** float (4-10m) and optimally-interpolated fields of SSS (5m) generated using the In-Situ Analysis System (**ISAS**, Gaillard, 2009).
- Colocalization SMOS/In situ: spatial radius of 50km, temporal range of +/-15 days around Argo measurements.



Monthly difference between SMOS (v6) and ISAS SSS – credits: LOCEAN

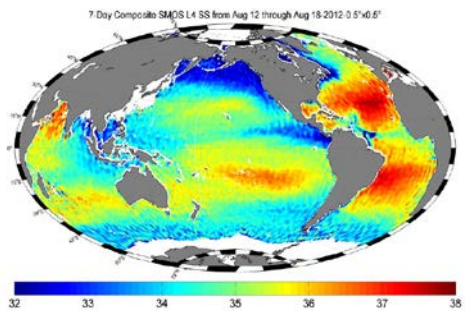
Satellite dataset	SSS_{L3_1}	SSS_{L3_2}	SSS_{L3_3}	…
In-situ ground-truth	Argo/ISAS	TSG	Drifters, mooring	…
s/t scales	100 km/1m	100 km/10dd	50 km/1m	…
Processing Level	L3	L2	L1	…
Processing criteria	Filtering and collocation criteria	Other filtering and collocation criteria	Other filtering and collocation criteria	…
Satellite mission	SMOS	Aquarius	SMAP	…
Performance indicators	Statistics (mean, std, RMS)	Other Statistics (median, mode, correlation)	Other Statistics (skewness, kurtosis)	…

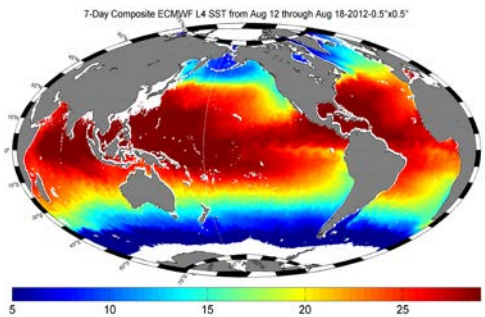
SMOS ESL Validation protocol will be revised and enlarged -> enhanced validation platform (Focus #1)

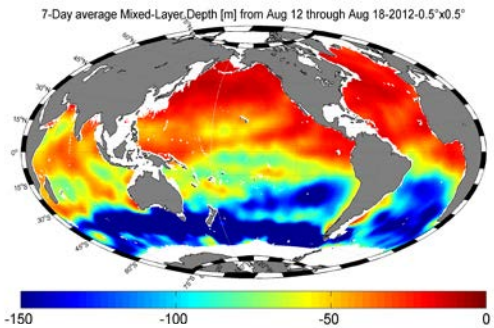
Conceptually, the ESL validation protocol is only a "vector" of the Pi-MEP "matrix" (enhanced validation platform)

Pi-MEP Salinity – Focus #2

SSS | SST | rain | currents | E-P fluxes | wind stress | MLD



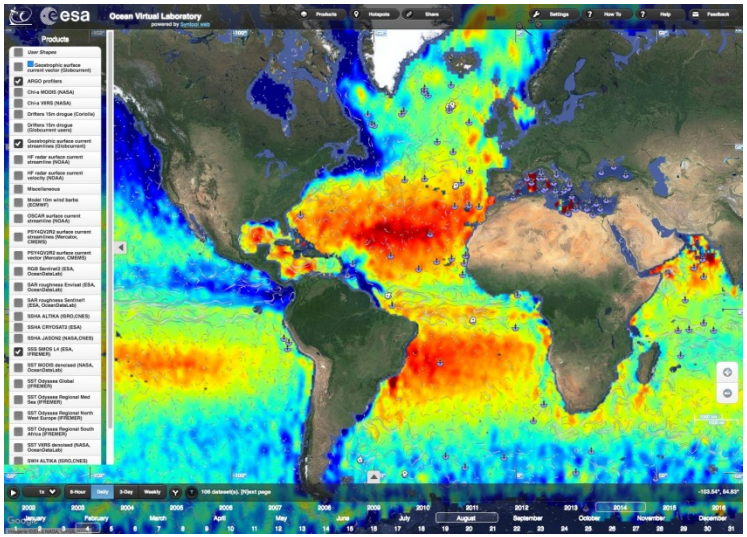




"Salt budget" equation (encompassing various oceanographic satellite datasets)

$$\frac{\partial S}{\partial t} = \frac{(E - P - R)S}{h} - \boldsymbol{u} \cdot \nabla S - \Gamma(w_e)\frac{w_e(S - S_d)}{h} + \kappa \nabla^2 S$$

Credits:
N. Reul, IFREMER



Sample view of *Syntool Web*, providing integrated access and multidimensional inter-comparison of EO, in-situ and model data. In the background, a L4 SSS map and Argo profilers (credits: ODL, IFREMER).

Pi-MEP Salinity – Implementation

Tasks

Task 1: Definition of the requirements baseline for the Pi-MEP

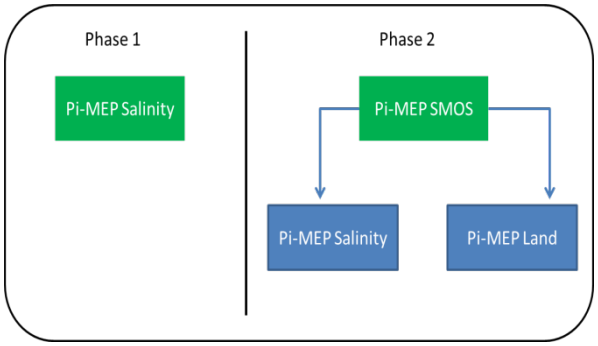
Task 2: Definition of the overall technical design for the Pi-MEP

Task 3: Implementation of the Pi-MEP Salinity

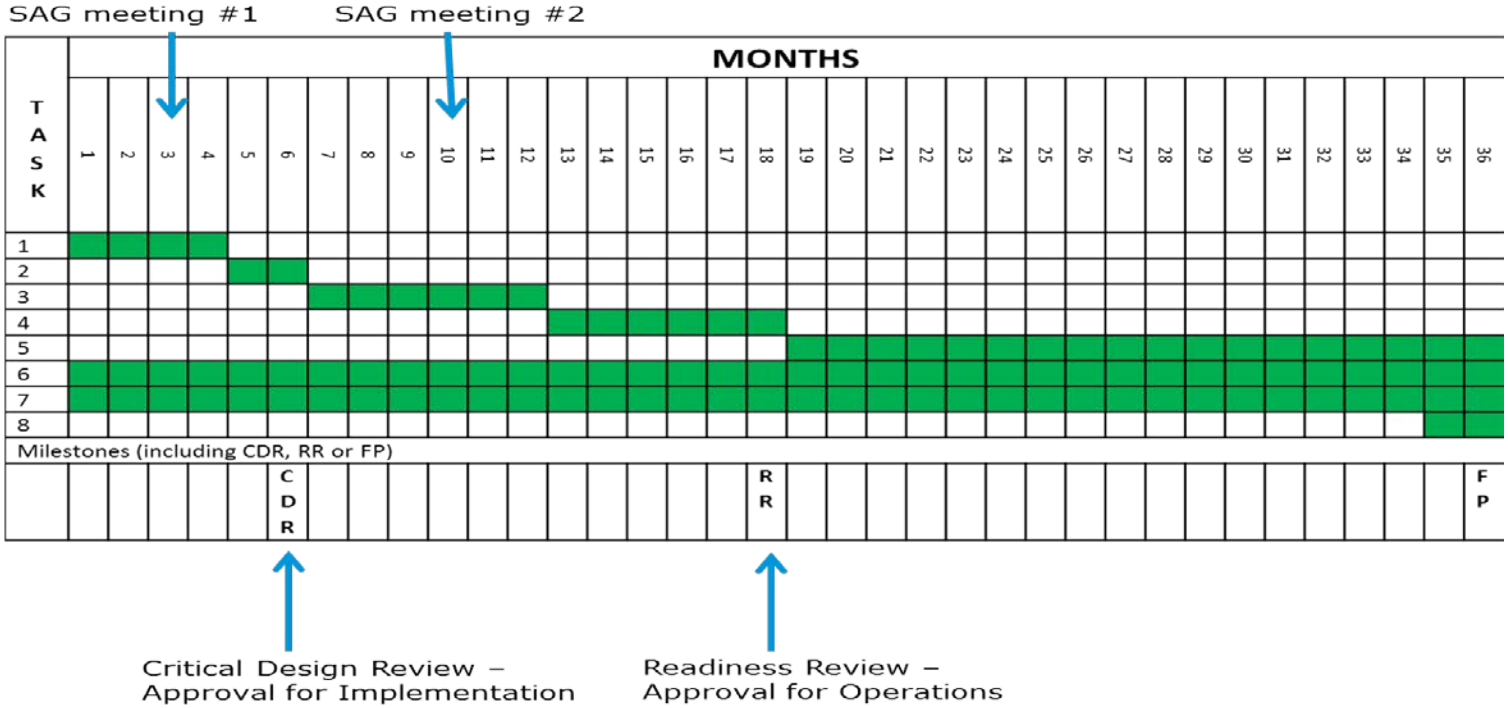
Task 4: Pre-operational phase of the Pi-MEP Salinity

Task 5: Operational phase and maintenance of the Pi-MEP Salinity

Task 6/8: Project management, Community animation, Outreach and Promotion, Evolution roadmap



Phase 1 (Tasks 1/4): 0-18 m
Phase 2 (Task 5): 18-36 m
Pi-MEP Land still optional, so far



KO: Jan-2017

SAG - Scientific Advisory Group (25-people , scientific advisory and pre-ops Platform testing)

SAG meeting #1: May 3rd, 2017, ESA-ESTEC

Pi-MEP – platforms benchmarks

Benchmark 1	Data provision centre; “passive” user only download the data (eg., any data dissemination centre)
Benchmark 2	Providing several quicklooks, statistics and plots (besides downloading); user can browse but still “static” (eg. CATDS)
Benchmark 3	Providing tools for merging data and process them at user discretion (scales, filtering, etc); user can interact but at a level decided by host (eg. BEAM software) [Spotify and satellite TV on-demand]
Benchmark 4	Fully designed to ingest user algos and datasets; users to data concept (eg. GPOD)

Pi-MEP: min requirement

Pi-MEP: optimal/future requirement

SAG panel – invitation and TOR

Ifremer
oceandatalab

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Laboratory of Physical and Spatial Oceanography
Institut Français de Recherche et d'Exploitation de la MER (IFREMER)
Phone: +33 (0)4 94 30 44 86
E-mail: nreul@ifremer.fr

Subject: Invitation to join the Scientific Advisory Group for the SMOS Pilot Mission Exploitation Platform

Dear Sir/Madam,

I am writing to you regarding the SMOS Pilot Mission Exploitation Platform (Pi-MEP) for Salinity, which is a recent initiative to support and widen the uptake of SMOS data over ocean. We would like to invite you to become a member of the Scientific Advisory Group for this initiative.

The Pi-MEP salinity will:

i) serve as an **enhanced validation platform**, complementing and expanding the efforts of the SMOS Expert Support Laboratories (ESLs) through, for example, exploring satellite performances at different spatial/temporal scales, applying different filtering criteria, or verifying SMOS outputs against various ground-truth data;

ii) offer a testbed to enable **oceanographic process studies**, capitalizing on SMOS salinity data in synergy with additional satellite products (e.g., SST, WS, currents, rain estimates). The platform will offer a series of statistical and computational tools in a user-oriented scientific environment to foster an increased uptake of SMOS salinity data in combination with other relevant oceanographic parameters.

The project started in January 2017. The first task will be to consolidate the user requirements baseline, before proceeding to the technical design of the platform. In the subsequent period, the implementation and pre-operation phase will give way to the platform operations in mid-2018.

Instrumental to the activities of the SMOS Pi-MEP Salinity is a dedicated Scientific Advisory Group (SAG), which will provide valuable inputs to the scientific/industrial team in charge (led by IFREMER and OceanDataLab). The SAG inputs will allow to set up this platform by helping to define the requirements of the user community and by providing scientific expertise and advice. The SAG will also serve as super-user of the platform functionalities before the opening to the wider oceanographic community.

A SAG one-day workshop is currently foreseen for **May 3rd, 2017** at **ESA-ESTEC** premises in **Noordwijk, the Netherlands**. ESA will support the costs incurred for your efforts as a member of the SAG. A second SAG meeting is foreseen at the beginning of 2018 to follow-up Pi-MEP activities.

As a member of the Pi-MEP SAG you will support the definition of:

- Satellite/in-situ datasets to be included in the Pi-MEP catalogue
- The scientific analyses foreseen in the requirements baseline definition phase
- Additional tests/criteria to be assessed in the enhanced SMOS validation protocol
- The technical design of the platform
- A list of oceanographic process studies to be supported by Pi-MEP
- The metrics for the performance assessment of the platform in the pre-operational phase

In the subsequent evaluation phase, you will provide feedback on the implementation of the platform.

Thank you for considering your participation in this initiative. Please let us know your availability by **March, 27th, 2017.**

Your sincerely

SAG - Scientific Advisory Group
(~25-people, scientific advisory and pre-ops Platform testing)

SAG meeting #1: **May 3rd, 2017**, ESA-ESTEC

Agenda and presentations to support the discussion distributed on **April 26th, 2017,** following the Pi-MEP PM1

Terms of Reference

Pi-MEP SAG members will support the definition of:

- **Satellite / in-situ datasets** to be included in the Pi-MEP catalogue
- The **scientific analyses** foreseen in the requirements baseline definition phase
- Additional tests/criteria to be assessed in the **enhanced SMOS validation protocol**
- The **technical design** of the platform
- A list of **oceanographic process studies** to be supported by Pi-MEP
- The **metrics** for the performance assessment of the platform in the pre-operational phase

In the subsequent evaluation phase, Pi-MEP SAG members will:

- provide **feedback** on the implementation of the platform

SAG panel– membership and involvement

Antonio	TURIEL	ICM
Jacqueline	BOUTIN	LOCEAN
Manuel	ARIAS	ARGANS
Jean-Luc	VERGELY	ACRI-ST
Stéphane	TAROT	Ifremer
Justino	MARTÍNEZ	ICM
Tong	LEE	JPL
Thomas	MEISSNER	RSS
Gilles	REVERDIN	LOCEAN
Nicolas	KOLODZIEJCZYK	Univ. Brest
Benoît	TRANCHANT	CLS
Lisan	YU	WHOI
Julian J.	SCHANZE	ESR
Johnny	JOHANNESSEN	NERSC
Adrien	MARTIN	NOCS
Chris	BANKS	NOCS
Marie-Hélène	RIO	CLS
Christophe	MAES	IRD
Lars	KALESCHKE	Univ. Hamburg
Jamie D.	SHUTLER	Univ. of Exeter
Sébastien	CLERC	ACRI-ST

- Provide guidance as per the points described in the SAG Invitation Letter
- Inspect slides sent before the SAG CM1 workshop (those not attending) and provide feedback on the Table with seed questions
- Participate in the discussion at the SAG CM1 workshop (those attending) driven by the Table with seed questions
- Participate in the discussion/wrap-up at the WHOI salinity and water cycle workshop – late May (those attending)
- Revise outcome/feedback document to be produced and shared as output of this meeting
- Gather for the SAG CM2 – Jan 2018 (tentative), once the design of the Platform is complete and its implementation is ongoing

SAG CM1 Agenda (i)

1. Presentation of the Project & SAG involvement

1.1 Pi-MEP Project introduction and SAG involvement (R. Sabia, ESA/ESRIN)	09:30-10:00
1.2 Overview of the Pi-MEP activities (N. Reul, IFREMER)	10:00-10:30
Coffee Break	10:30:10:45

2. Definition of the Pi-MEP Required Data Sets

2.1 Presentation of the Pi-MEP proposed datasets (S. Guimbard, ODL) 10:45-11:45

- Satellite SSS data & related datasets
- In Situ SSS data
- Auxiliary Geophysical information
- NWP and NOP model data

2.2 Discussion & Requirements for Datasets with SAG (All) 11:45-12:45

SAG CM1 Agenda (ii)

3. Definition of the Analyses/Processing to be implemented

3.1 Presentation of proposed Analyses/processing (N. Reul, IFREMER) 13:45-14:30

- The Satellite/In situ Match-Up Database production
- Product inter-comparison Metrics
- Enhanced Validation Protocols & Metrics

3.2 Presentation of available tools (S. Guimbard, ODL) 14:30-15:00

- L2/CEC Validation Protocol tool
- Naiad & Felyx
- CATDS/CEC-IFREMER Match-up DataBase chains
- Datavor, DataLaps, Merginator
- Vizualisation with Syntool
- ipython notebooks

3.3 Discussion on Analyses & processing (all) 15:00-16:00

4. Oceanographic processes monitoring capabilities

4.1 Presentation of selected oceanographic Case studies (N. Reul, IFREMER) 16:15-17:15

4.2 Discussion & requirements on Case studies with SAG (All) 17:15-18:00

Contacts:

- **Roberto Sabia – roberto.sabia@esa.int**
- **Nicolas Reul - Nicolas.Reul@ifremer.fr**

smos pi-mep

Back-up slides

Recommendation	Addressing SMOS mission extension review recommendations (2014)
#1 Extension of SMOS mission	Mission extended to 2017 by both ESA and CNES.
#2 NRT products	• SMOS brightness temperatures data available in NRT used in NWP (over land implemented, future work: hurricane forecasting, sea ice thickness), • Sea ice thickness data product available from the University of Hamburg since October 2014. • New soil moisture product in NRT available for operational applications, including NWP and hydrological forecasting, from spring 2016, • Operational agencies use SMOS data for forest fire monitoring, ship routing, food security, drought monitoring, • Skill of SMOS data for severe wind tracking currently assessed by IFREMER and UK Metoffice. • Working with WMO Flash Flood Guidance System (FFGS) to test skill of SMOS data in hydrological forecasting, • Future products include improved vegetation product for agricultural applications and freeze/thaw product.
#3 Scientific data product consolidation	• Continuous validation of operational products , including comparison to in-situ data over land and ocean and ground based L-Band radiometers e.g. at DOME-C in Antarctica, ECMWF monitoring, • Validation of new data products through dedicated campaigns, e.g. sea ice campaign in Arctic in Spring 2014, definition of vegetation campaign for future improved vegetation products.
#4 New scientific approaches	• Synergistic use of SMOS data other satellite mission on-going, e.g. with Sentinels (S-1 for downscaled soil moisture) and CryoSat for combined sea ice product, • Preparation for merged data sets with Aquarius and SMAP on-going for consolidated L1 through international WG on cross-calibration, • Preparing the integration of SMOS soil moisture data into CCI Soil Moisture, • Continuous collaboration with SMAP and Aquarius teams on calibration/validation and coordination on RFI detection.
#5 Sustained observations and collaboration with NASA	• Preparing the integration of SMOS soil moisture data into CCI Soil Moisture. Collaboration with NASA: • Working groups on cross calibration/comparison and salinity stratification on-going, • Active exchange of calibration/validation results between SMOS-SMAP-Aquarius and definition of common validation approaches, e.g. using DOME-C data, on-going. SMOS follow-on mission: • Gathering user requirements: ISSI forum on L-Band continuity in 2014, SMOS science conferences and workshops, • SMOS Ops (ESA) and SMOS NEXT (CNES) concepts are developed advancing existing technology considering in-orbit experience and changing user requirements, • ESA led requirements collection study for SMOS follow-on planned for 2015/16, • No clear route to SMOS follow on implementation identified.
#6 Ocean Salinity Level-2 Processor	• Revised validation protocol for L2 SSS assessment in place • Pilot MEP Salinity evolving towards an enhanced validation platform, • ECMWF focus shifting to ocean for assimilating SMOS data, • Additional SSS community tailored data product planned for 2016.

Pi-MEP Salinity – Semantic, Foci and Objectives

Objectives (as per the SoW)

1. Capitalize on and further evolve existing validation efforts;
2. Assemble a match-up database to perform validation activities;
3. Host (or link to) the required satellite and in-situ data products:
4. Identify an optimal strategy to filter and QC the data for the relevant analyses;
5. Produce meaningful statistics to evaluate the processor evolution at different Levels and with different SMOS products;
6. Allow systematic comparison of satellite and in–situ data products at different s/t scales;
7. Develop scientific algorithms to advance the exploitation of the SMOS data products in conjunction with other satellite and in-situ datasets;
8. Foster the scientific uptake of the data towards process studies.