SMOS
Pilot-Mission Exploitation Platform
(Pi-MEP)

STATUS of the pre-operational platform

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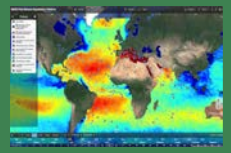
4. Telespazio-Vega UK Ltd for ESA, ESRIN, Frascati, Italy

Ocean Salinity Science Conference, Paris
November 6, 2018

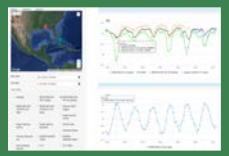
Pi-MEP design

Visualization

Syntool



Plots interface



Merginator

Reports & Plots

Enhanced validation

Off-line processing

- Match-up generation
- Systematic validation reports
- Satellite SSS intercomparison (systematic bias)
- Spectral analysis

On demand user processing

- User extraction on Match-up (Space, time,…)
- Automatic validation report w.r. to user criteria
- Upload of personal datasets

Case studies

1)Large river plume Monitoring

2) Mesoscale Signatures in Western Boundary Current

3) High Latitude & closed seas

Pi-MEP website

BETA

smos pi-mep

SMOS Pilot-Mission Exploitation Platform

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Latest news

2018-10-29 **2019 Living Planet Symposium**
13-17 May 2019, Milan, Italy
More details...

2018-10-29 **OceanObs'19 Conference**
16-20 September 2019, Honolulu, Hawaii, USA
More details...

2018-05-16 **2018 Ocean Salinity Science conference**
6-9 Nov 2018, Sorbonne University, Paris, France
More details...

Latest reports

2018-10-15 **In-situ**

2018-05-17 **EO-10 - smos-l3-catds-cpdc-v3-10d-25km vs tsg-gosud-sailing-ship**

2018-05-17 **EO-10 - smos-l3-catds-cpdc-v3-10d-25km vs tsg-legos-dm**

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2018-05-17 **GBRP - smos-l3-catds-cpdc-v3-10d-25km vs tsg-gosud-sailing-ship**

2018-05-17 **GBRP - smos-l3-catds-cpdc-v3-10d-**

SMOS Pilot-Mission Exploitation Platform (Pi-MEP): A hub for validation and exploitation of ESA SMOS Sea Surface Salinity data

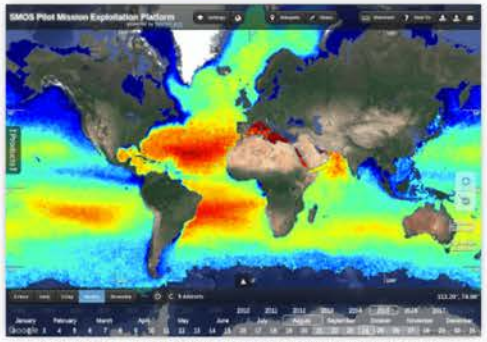
The Soil Moisture and Ocean Salinity (SMOS) mission was launched on 2nd November 2009 as the second Earth Explorer Opportunity mission within ESA's Living Planet programme. It has been continuously providing brightness temperature data in L-Band since January 2010, which are used to retrieve Soil Moisture (SM) and Sea Surface Salinity (SSS) data over land and ocean, respectively. This project funded by ESA is aims at setting up a Pilot Mission Exploitation Platform (Pi-MEP), focussing on ESA's SMOS mission and supporting enhanced validation and scientific process studies over ocean.

Pi-MEP project objectives:

- Focus 1 - Enhanced validation of satellite SSS and products assessment
- Focus 2 - Oceanographic exploitation and case-studies monitoring

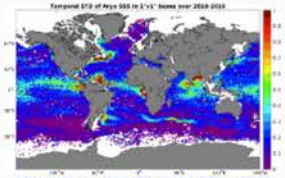
	Validation	Exploitation
User	Systematic validation reports and monitoring	Systematic assessment and monitoring selected process studies
Platform	Inspection, visualisation, extraction, computation data/products for validation	Inspection, merging, computation data/products for oceanographic applications

The platform provides several tools and facilities which are described in the overview.

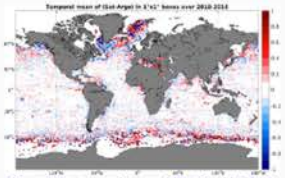


Explore available datasets and perform basic comparisons

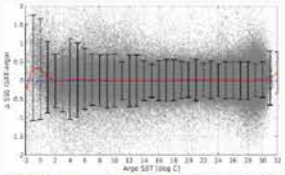
Dashboard - recent activities



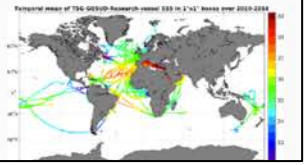
Map of the temporal STD of Argo SSS in 1°x1° boxes over 2010-2016



Map of the temporal mean of (Sat-Argo) in 1°x1° boxes over 2010-2016

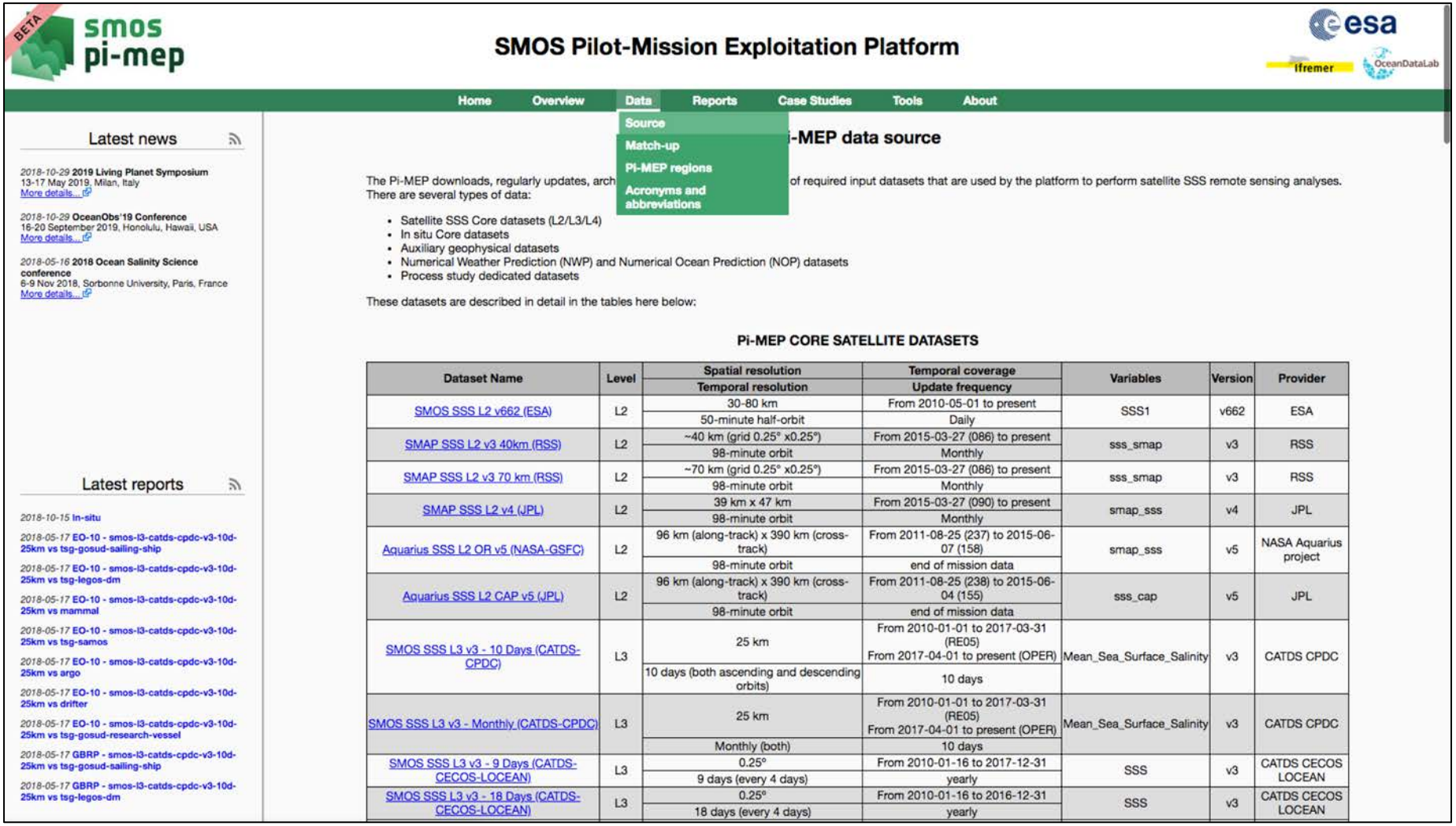


Scatter plot of ΔSSS (SAT-Argo) vs Argo SST (deg C)



https://pimep-test.oceandatalab.com

Input data



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Source
Match-up
Pi-MEP regions
Acronyms and abbreviations

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2018-05-17 GBRP - smos-l3-catds-cpdc-v3-10d-25km vs tsg-gosud-sailing-ship

2018-05-17 GBRP - smos-l3-catds-cpdc-v3-10d-25km vs tsg-legos-dm

-MEP data source

The Pi-MEP downloads, regularly updates, arch of required input datasets that are used by the platform to perform satellite SSS remote sensing analyses.
There are several types of data:

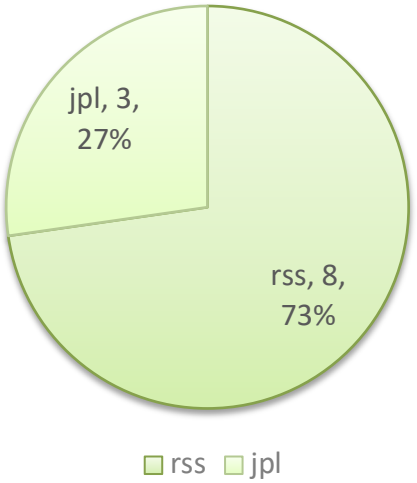
- Satellite SSS Core datasets (L2/L3/L4)
- In situ Core datasets
- Auxiliary geophysical datasets
- Numerical Weather Prediction (NWP) and Numerical Ocean Prediction (NOP) datasets
- Process study dedicated datasets

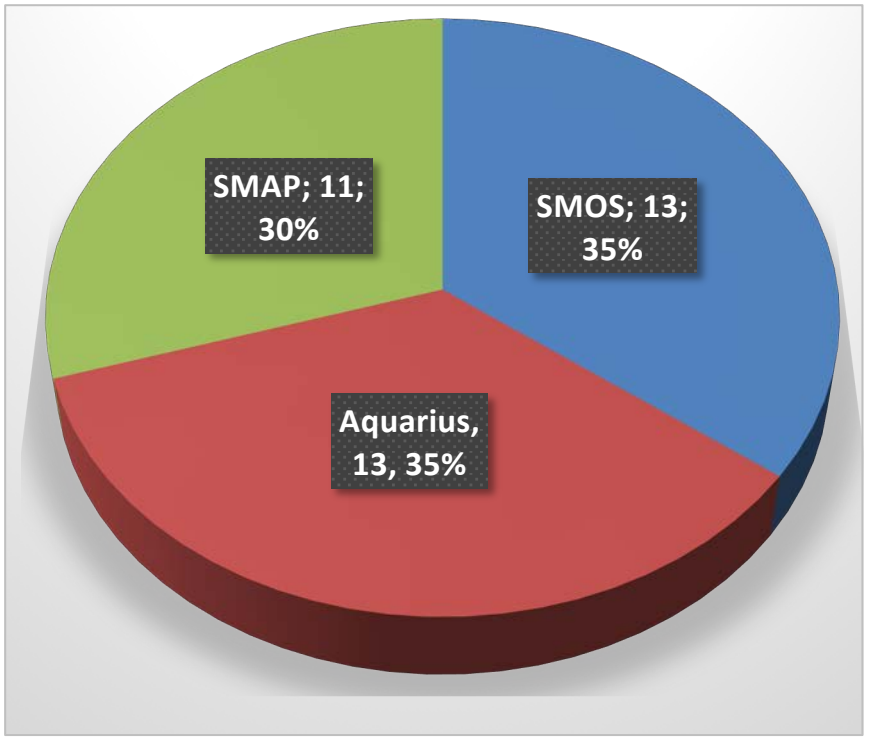
These datasets are described in detail in the tables here below:

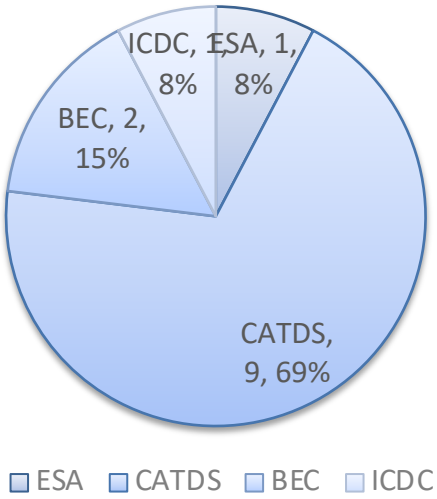
Pi-MEP CORE SATELLITE DATASETS

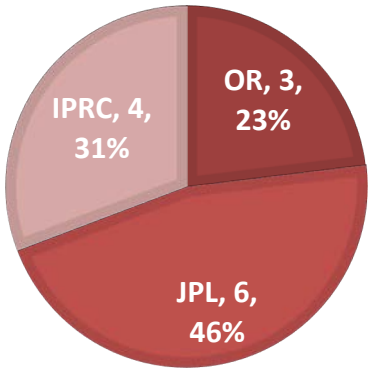
Dataset Name	Level	Spatial resolution / Temporal resolution	Temporal coverage / Update frequency	Variables	Version	Provider
SMOS SSS L2 v662 (ESA)	L2	30-80 km / 50-minute half-orbit	From 2010-05-01 to present / Daily	SSS1	v662	ESA
SMAP SSS L2 v3 40km (RSS)	L2	~40 km (grid 0.25° x0.25°) / 98-minute orbit	From 2015-03-27 (086) to present / Monthly	sss_smap	v3	RSS
SMAP SSS L2 v3 70 km (RSS)	L2	~70 km (grid 0.25° x0.25°) / 98-minute orbit	From 2015-03-27 (086) to present / Monthly	sss_smap	v3	RSS
SMAP SSS L2 v4 (JPL)	L2	39 km x 47 km / 98-minute orbit	From 2015-03-27 (090) to present / Monthly	smap_sss	v4	JPL
Aquarius SSS L2 OR v5 (NASA-GSFC)	L2	96 km (along-track) x 390 km (cross-track) / 98-minute orbit	From 2011-08-25 (237) to 2015-06-07 (158) / end of mission data	smap_sss	v5	NASA Aquarius project
Aquarius SSS L2 CAP v5 (JPL)	L2	96 km (along-track) x 390 km (cross-track) / 98-minute orbit	From 2011-08-25 (238) to 2015-06-04 (155) / end of mission data	sss_cap	v5	JPL
SMOS SSS L3 v3 - 10 Days (CATDS-CPDC)	L3	25 km / 10 days (both ascending and descending orbits)	From 2010-01-01 to 2017-03-31 (RE05) From 2017-04-01 to present (OPER) / 10 days	Mean_Sea_Surface_Salinity	v3	CATDS CPDC
SMOS SSS L3 v3 - Monthly (CATDS-CPDC)	L3	25 km / Monthly (both)	From 2010-01-01 to 2017-03-31 (RE05) From 2017-04-01 to present (OPER) / 10 days	Mean_Sea_Surface_Salinity	v3	CATDS CPDC
SMOS SSS L3 v3 - 9 Days (CATDS-CECOS-LOCEAN)	L3	0.25° / 9 days (every 4 days)	From 2010-01-16 to 2017-12-31 / yearly	SSS	v3	CATDS CECOS LOCEAN
SMOS SSS L3 v3 - 18 Days (CATDS-CECOS-LOCEAN)	L3	0.25° / 18 days (every 4 days)	From 2010-01-16 to 2016-12-31 / yearly	SSS	v3	CATDS CECOS LOCEAN

Satellite SSS products



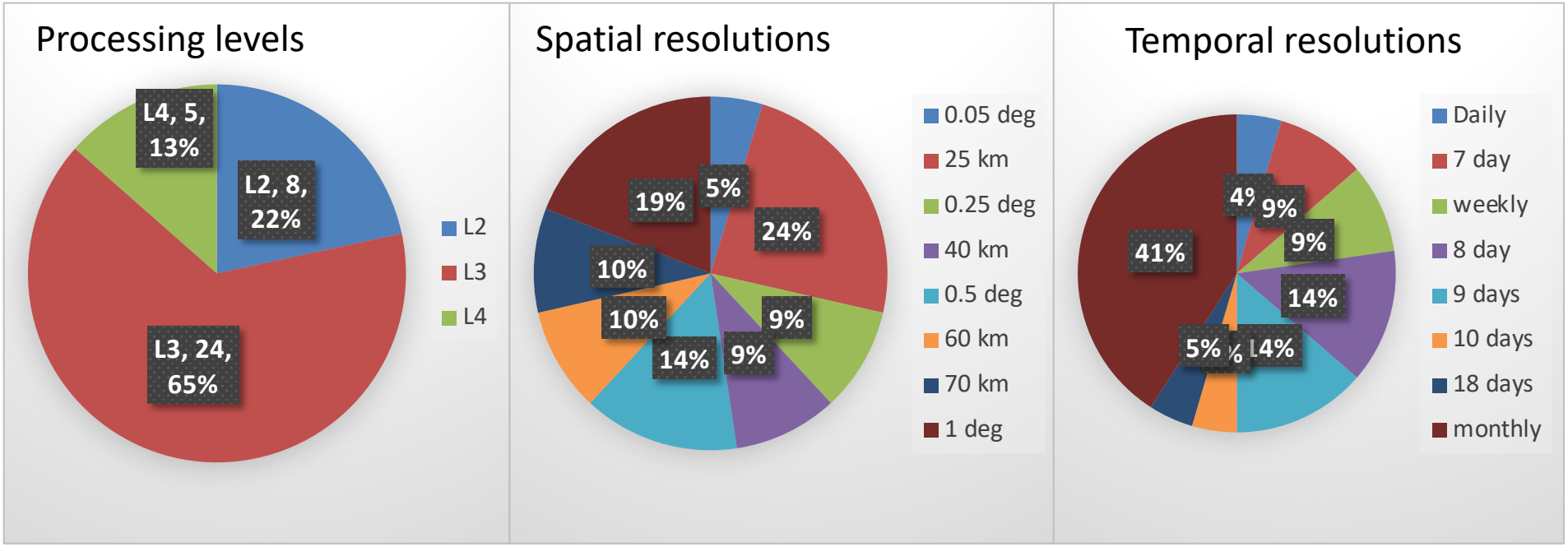






- **37 satellite SSS products**
- **8 different providers**

Satellite SSS products



- **3 different processing levels: L2/L3/L4**
- **8 different spatial resolutions**
- **8 different temporal resolutions**

Pi-MEP datasets

- 37 satellite SSS products (13 SMOS / 13 Aquarius / 11 SMAP)

  > 120 different satellite SSS sub-datasets

- 5 in situ datasets (ARGO, TSG, Moorings, Surf. drifters, Marine mammals)
- 8 analysed in situ datasets (ISAS, EN4, JAMSTEC, SCRIPPS, IPRC, WOA09-13)
- 3 numerical models (HYCOM, MERCATOR (NEMO), ECCO (mitGCM))
- 21 thematic datasets (MLD, SST, RAIN RATE, Surf. Currents, evaporation …)
- 8 process study dedicated datasets

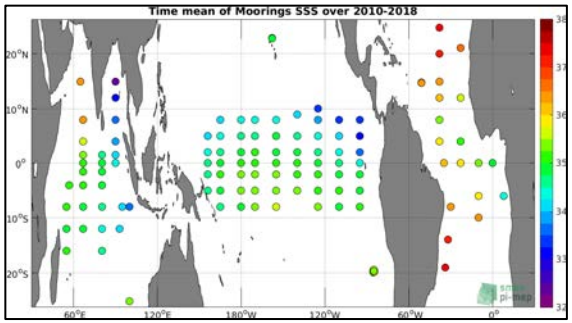
  = > 82 datasets (30 min to Monthly, 0.05º to 1º)

  = > 15 To stored on Datarmor (SuperComputer in Brest, France)

  = > Update daily

In situ SSS database

- ARGO floats (Coriolis)
- Moorings (TAO,TRITON, PIRATA, NTAS, STRATUS, SPURS1-2, WHOTS)
- Surface Drifters (LOCEAN)
- TSG (LEGOS, GOSUD, SAMOS)
- Marine mammals (MEOP)



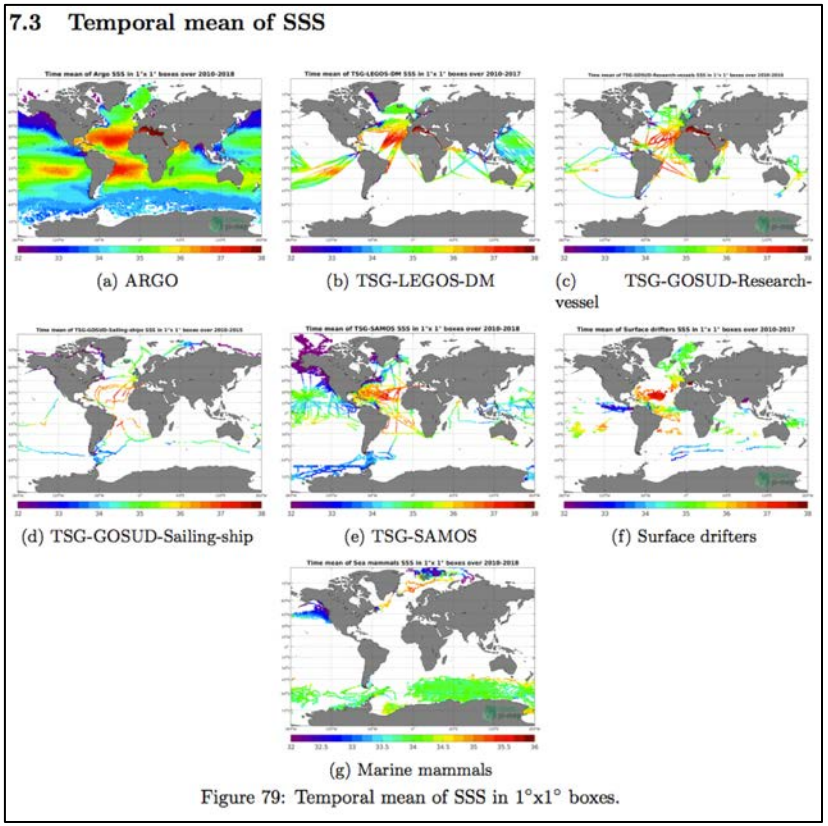
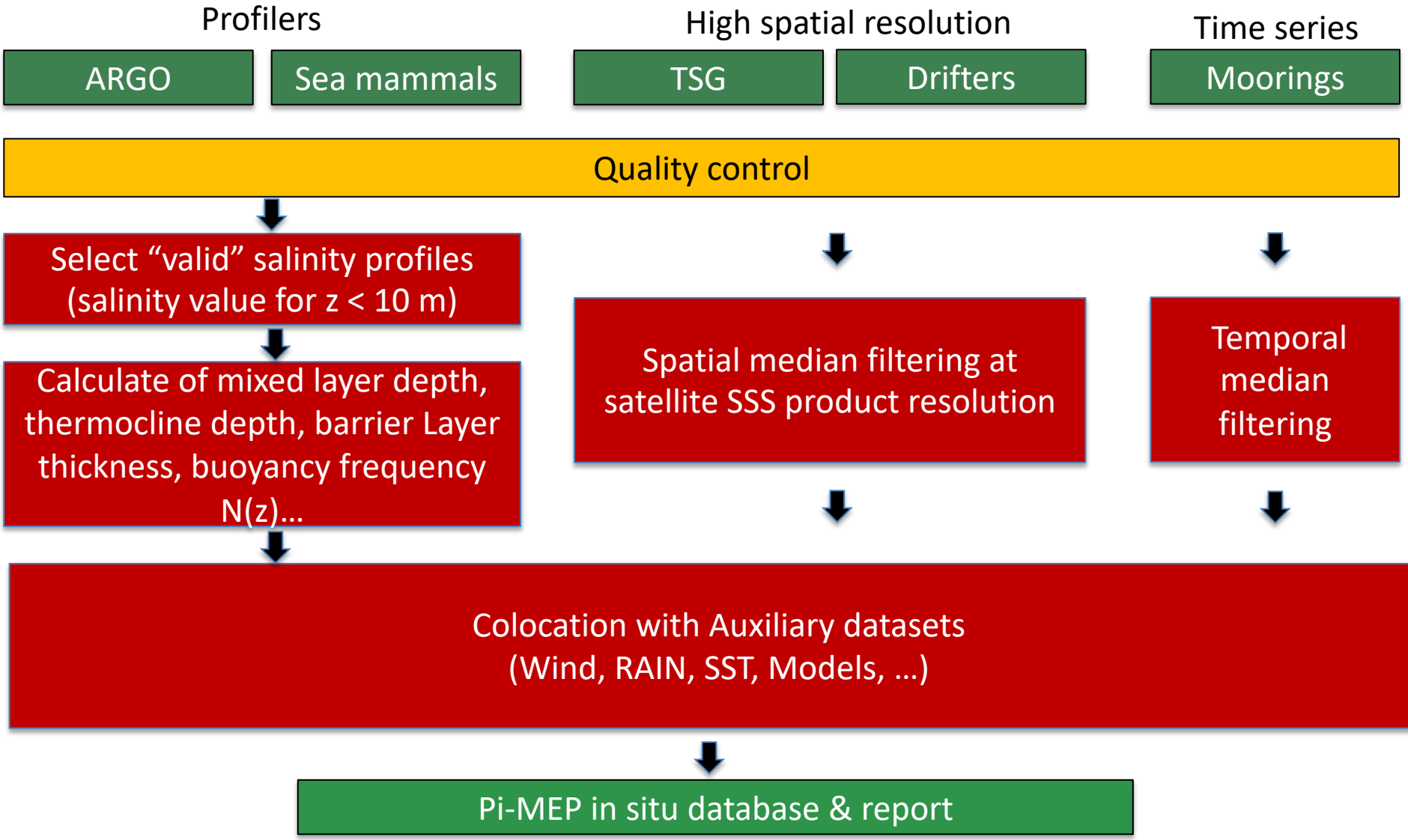
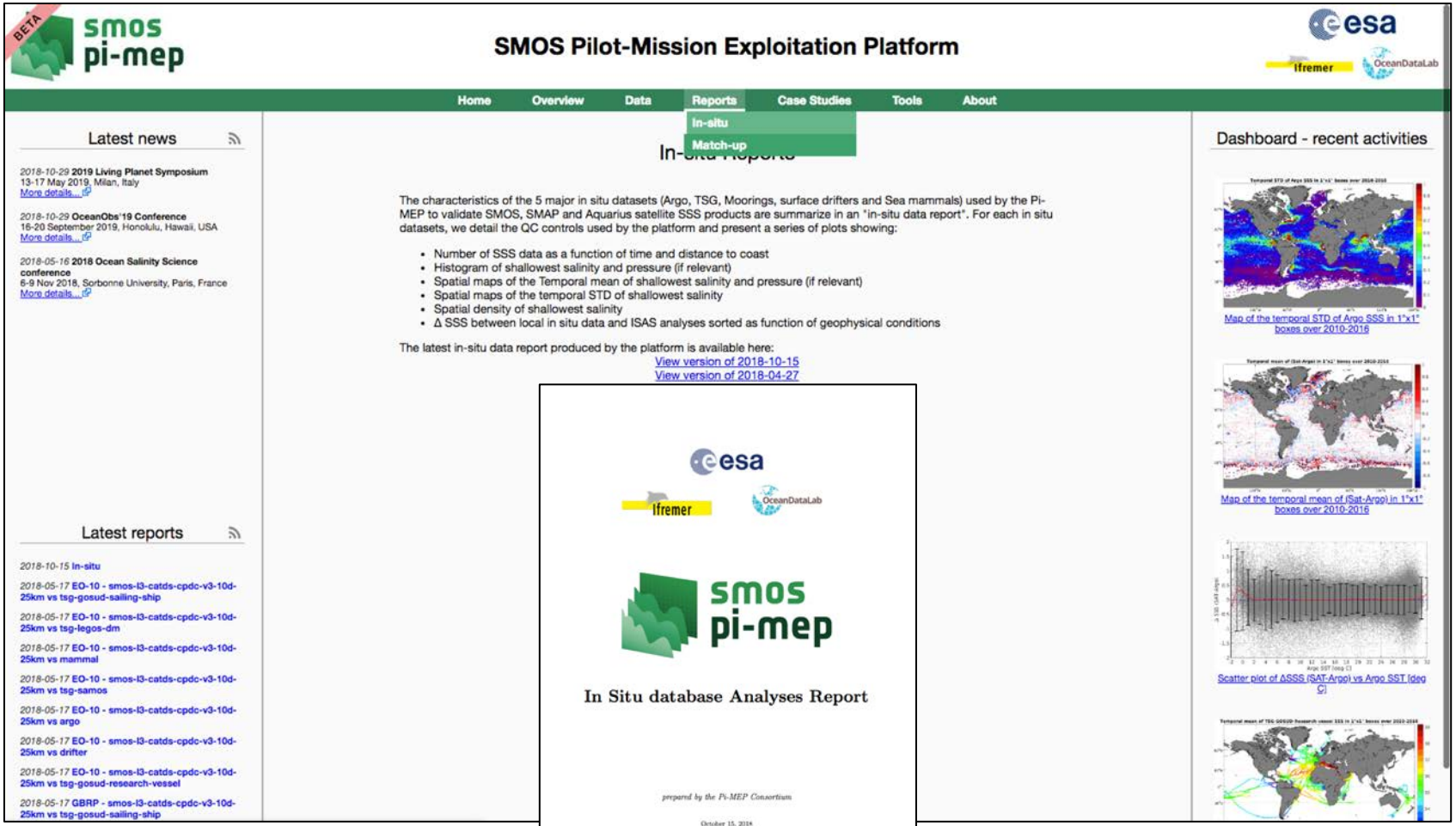


Figure 79: Temporal mean of SSS in 1°x1° boxes.

In situ SSS database



In situ SSS database



In situ SSS database: report

esa

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In Situ database Analyses Report

prepared by the Pi-MEP Consortium

October 15, 2018

Database	#	$Time_{min}$	$Time_{max}$	S_{min}	S_{max}	S_{Mean}
Argo	1191285	01/01/2010	11/10/2018	2.32	44.69	34.81
TSG LEGOS-DM	4356334	05/01/2010	11/08/2017	0.04	42.74	34.57
TSG GOSUD-research vessels	2929464	05/01/2010	30/12/2016	0.01	42.00	35.50
TSG GOSUD-sailing ships	863277	03/06/2010	08/09/2015	0.01	38.33	32.96
TSG SAMOS	20165465	07/01/2010	25/09/2018	5.03	41.99	33.41
Surface Drifters	1803639	01/01/2010	14/08/2017	1.03	40.56	35.99
Mammals	199580	01/01/2010	14/01/2018	4.06	36.67	33.95
Moorings	4830384	01/01/2010	22/10/2018	26.50	38.44	34.99
Total	36339428	01/01/2010	22/10/2018	0.01	44.69	34.52

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

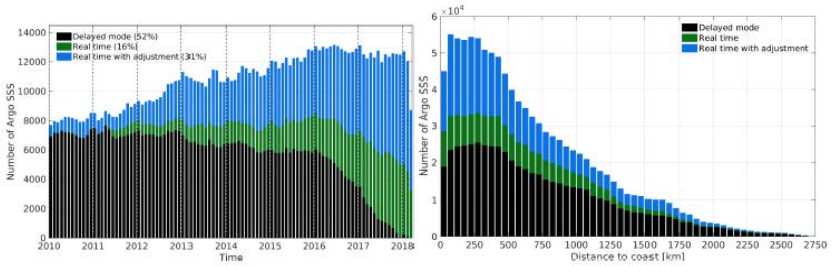


Figure 1: Number of SSS from Argo floats as a function of time (left) and distance to coast (right).

2.3 Histogram of shallowest salinity and pressure

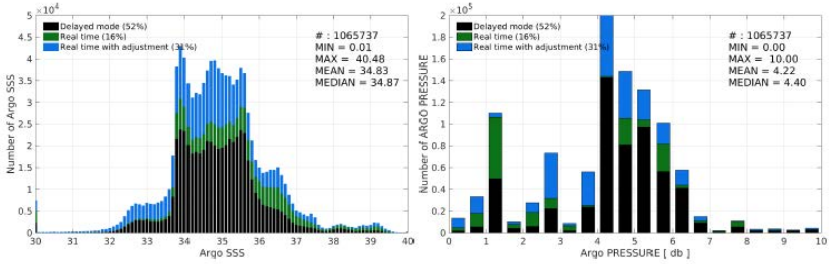


Figure 2: Distribution of SSS (left) and pressure (right) from Argo floats per bins of 0.1 and 0.5, respectively.

In situ SSS database: report

2.4 Temporal mean of shallowest salinity and pressure

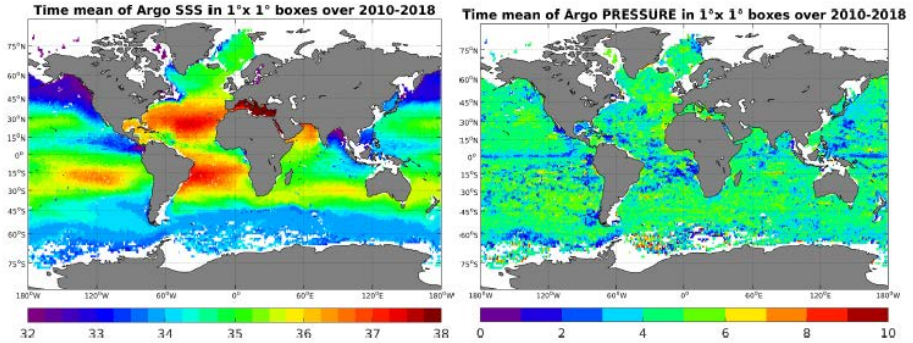


Figure 3: Time-mean SSS and pressure from Argo floats in 1°x1° boxes.

2.5 Temporal STD of SSS

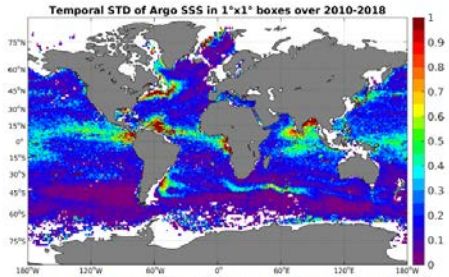


Figure 4: Temporal STD of SSS from Argo floats in 1°x1° boxes.

2.6 Spatial density of SSS

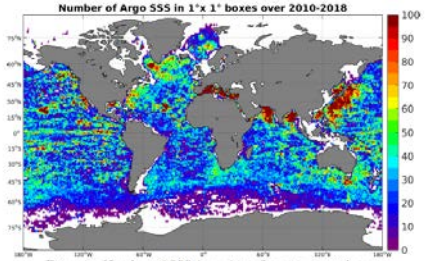
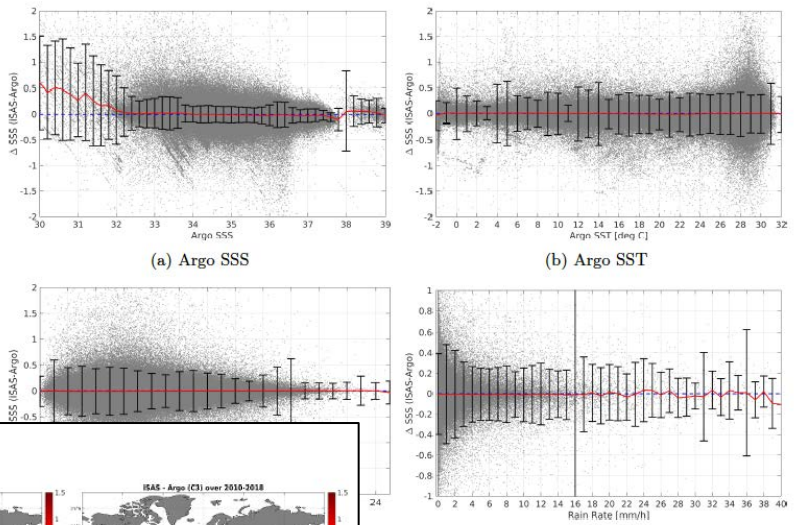


Figure 5: Number of SSS from Argo floats in 1°x1° boxes.

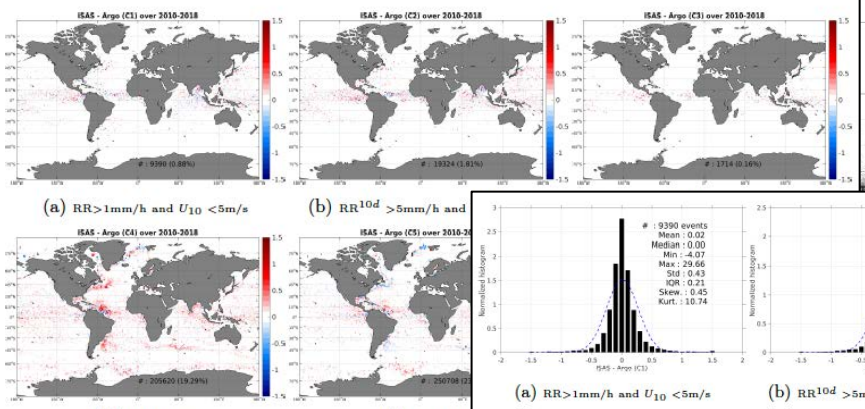
2.7 ΔSSS sorted as geophysical conditions



(a) Argo SSS (b) Argo SST

(d) CMORPH Rain rate

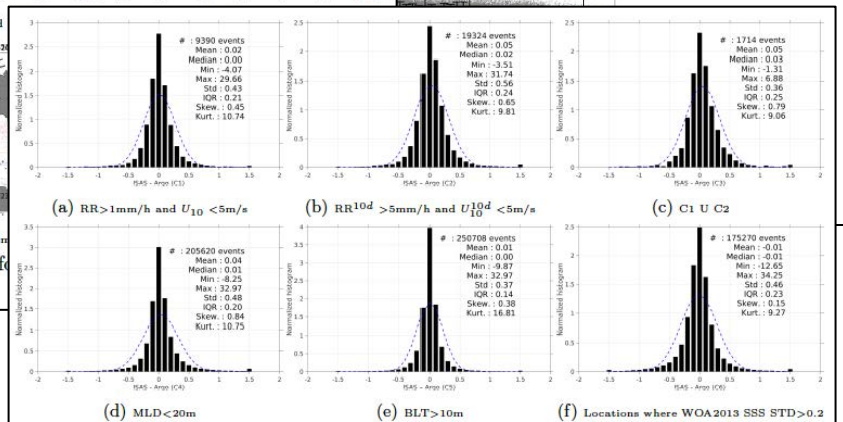
2.8 Conditional analyses



(a) RR>1mm/h and U_{10} <5m/s (b) RR^{10d} >5mm/h and

(d) MLD<20m (e) BLT>10m

Figure 7: Temporal mean of ΔSSS (ISAS - Argo) f
C1 (a),..., C6 (f).



(a) RR>1mm/h and U_{10} <5m/s (b) RR^{10d} >5mm/h and U_{10}^{10d} <5m/s (c) C1 U C2

(d) MLD<20m (e) BLT>10m (f) Locations where WOA2013 SSS STD>0.2

Figure 8: Normalized histogram of ΔSSS (ISAS - Argo) for 6 different subdatasets corresponding to C1 (a),..., C6 (f).

Match-up database

INPUTS

SMOS, SMAP, Aquarius L2 to L4

In situ

+ Auxiliary parameters (rain, wind, sst, mld, …)

Match-up generator

MDB generator code design

1)Read a SSS satellite file
Store temporal/spatial resolution (Res) and grid of the satellite products for further collocation (cf 3))

2) Select quality controlled In situ data falling in the time window (±6h for L2, ±D/2 for L3/L4)

3) Find nearest L2-L4 pixel within a distance R=[0,Res/2] for each in situ data

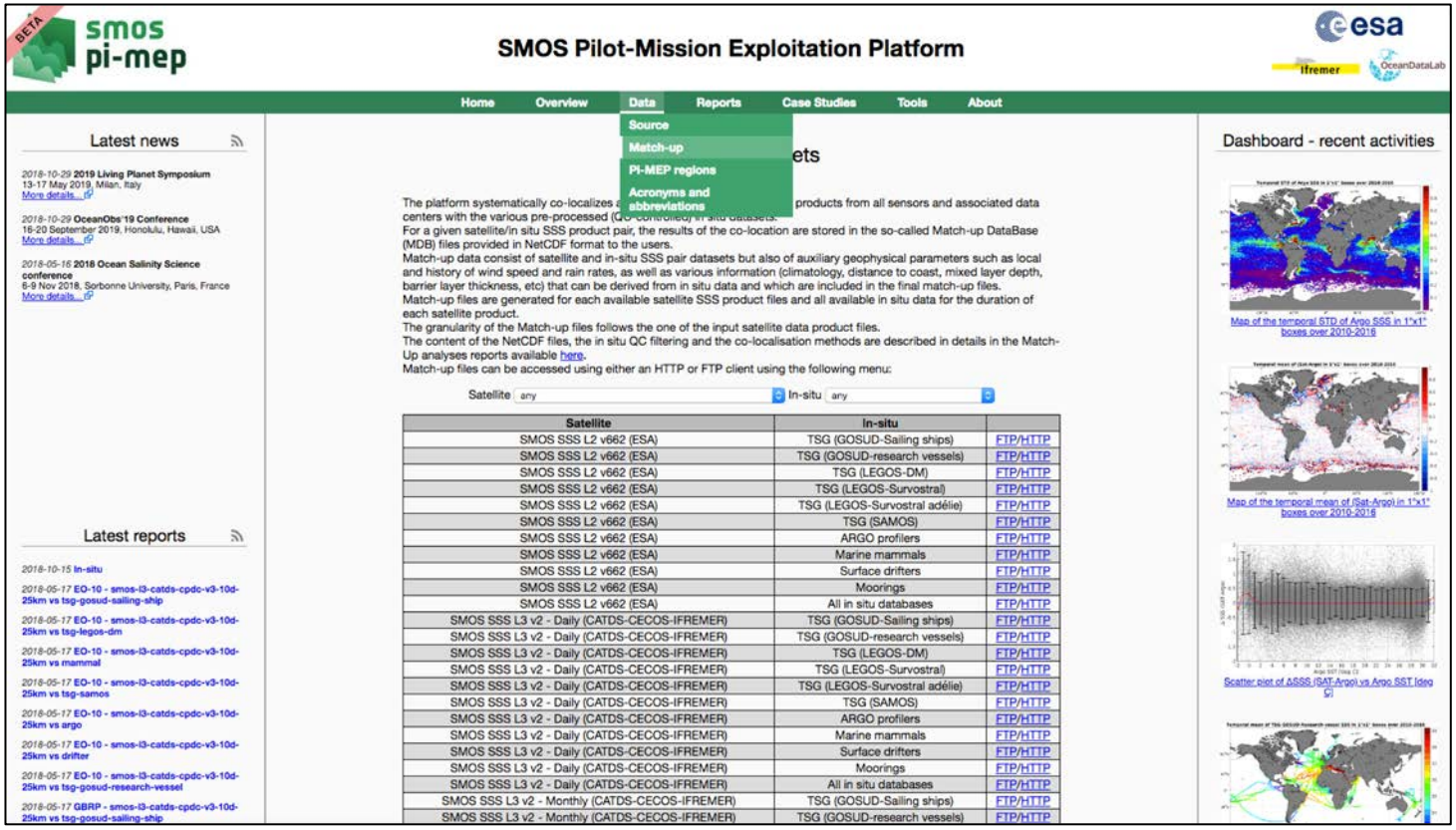
4) Store actual Δt & Δdistance between product pixel & in situ data

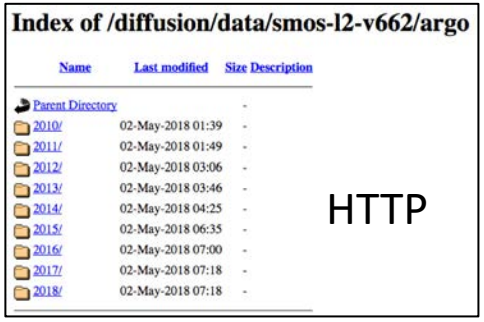
5) Generate NetCDF4 files

OUTPUTS

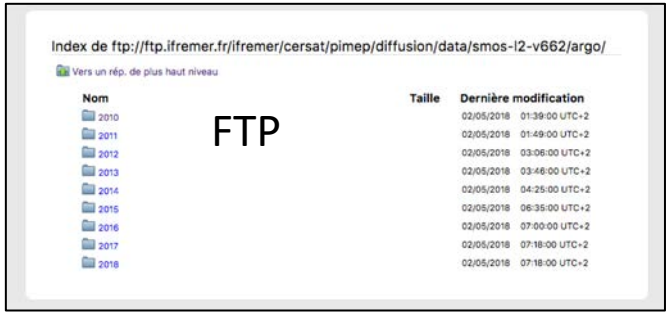
pimep-mdb_satelliteID_insituID_Time_V01.nc

Match-up database





HTTP



FTP

Match-up database

- 37 satellites products
- 10 in situ datasets

$\Rightarrow$200 Gb ~ 600.000 files

$\Rightarrow$Processing time ~ 3 days (parallelized)

Reprocessing: once/year

Monthly update: only new pairs in situ/satellite are generated.

Analyses Regions

smos pi-mep (BETA)

SMOS Pilot-Mission Exploitation Platform

esa · Ifremer · OceanDataLab

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Latest news

2018-10-29 **2019 Living Planet Symposium**
13-17 May 2019, Milan, Italy
More details...

2018-10-29 **OceanObs'19 Conference**
16-20 September 2019, Honolulu, Hawaii, USA
More details...

2018-05-16 **2018 Ocean Salinity Science conference**
6-9 Nov 2018, Sorbonne University, Paris, France
More details...

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2018-10-15 **In-situ**

2018-05-17 **EO-10 - smos-l3-catds-cpdc-v3-10d-25km vs tsg-gosud-sailing-ship**

2018-05-17 **EO-10 - smos-l3-catds-cpdc-v3-10d-25km vs tsg-legos-dm**

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2018-05-17 **EO-10 - smos-l3-catds-cpdc-v3-10d-25km vs drifter**

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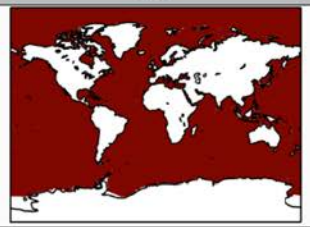
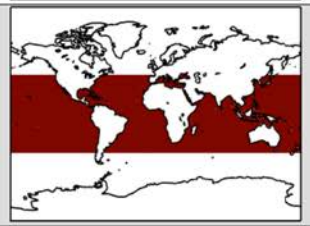
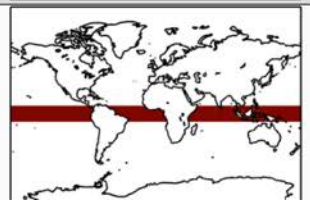
2018-05-17 **GBRP - smos-l3-catds-cpdc-v3-10d-25km vs tsg-gosud-sailing-ship**

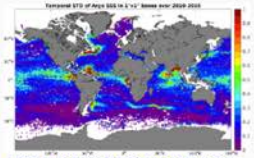
2018-05-17 **GBRP - smos-l3-catds-cpdc-v3-10d-**

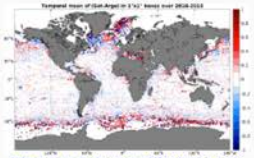
Pi-MEP Regions

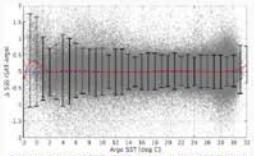
Match-up databases are analyzed globally but also for each Pi-MEP validation region. A dedicated MDB report is provided for each triplet: Pi-MEP Region-Satellite SSS product-In situ SSS product.
These regions are defined in the following table:

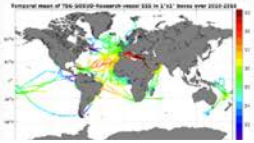
Pi-MEP Region#	Short Name	Name	Lon/Lat Range	Map	Mask
1	GO	Global Ocean	[-180 180] / [-78 90]		netcdf
2	MLL-45	Mid-Low Latitudes 45N-45S	[-180 180] / [-45 45]		netcdf
3	EO-10	Equatorial Ocean 10N-10S	[-180 180] / [-10 10]		netcdf

Dashboard - recent activities

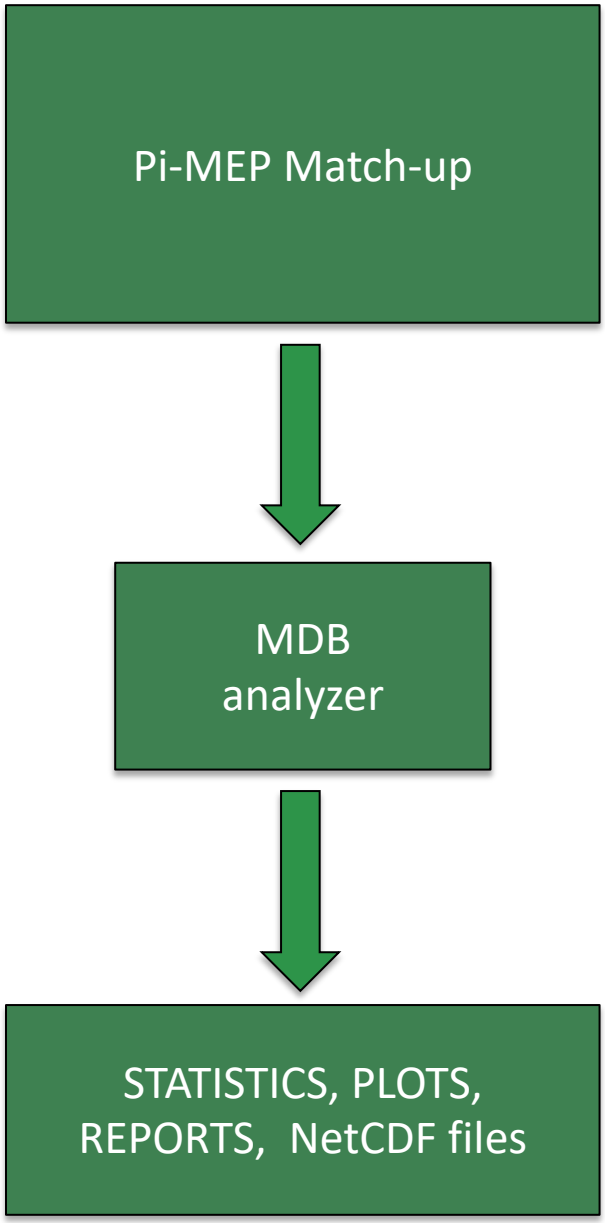

Map of the temporal STD of Argo SSS in 1°x1° boxes over 2010-2016


Map of the temporal mean of (Sat-Argo) in 1°x1° boxes over 2010-2016


Scatter plot of ΔSSS (SAT-Argo) vs Argo SST [deg C]



Match-up database reports



INPUTS

pimep-mdb_satelliteID_insituID_*_V01.nc

MDB analyzer code design

1)Read each MDB dataset file

2) Extraction of sub-dataset corresponding to the predefined Pi-MEP region

3) Systematically generate predefined plots, tables and statistics for each zone

4) Generate pdf reports

OUTPUTS

pimep-mdb-report_regionID_satelliteID_insituID.pdf
pimep-mdb-figure_satelliteID_insituID.png
pimep-mdb-ncfile_satelliteID_insituID.nc
pimep-mdb-stat_satelliteID_insituID.csv

Match-up database reports

smos pi-mep (BETA)

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Reports: In-situ | Match-up

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2018-05-17 **GBRP - smos-l3-catds-cpdc-v3-10d-25km vs tsg-gosud-sailing-ship**

Match-up Reports

Results of systematic analyses of the Match-up DataBase (MDB) files generated by the Pi-MEP are provided to the users in the form of specific PDF reports here below. MDB files are analyzed for all pairs of Satellite/In situ SSS data and for an ensemble of 30 geographical Pi-MEP regions. Each report presents successively:
The MDB file DataSets:

- A short description of the satellite SSS product considered in the match-up
- A short description of the In situ SSS dataset considered in the match-up
- A short description of the auxiliary geophysical datasets co-localized with SSS pairs
- An overview of how the Match-ups were evaluated
- An overview of the MDB characteristics for the particular in situ/satellite pairs

The major results of the MDB file Analyses:

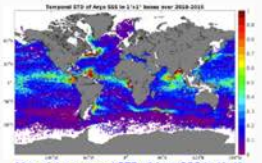
- Spatial Maps of the Time-mean and temporal STD of in situ and satellite SSS and of the ΔSSS where $\Delta SSS = SSS_{SAT} - SSS_{insitu}$ denotes the difference between the satellite and in situ SSS at the colocalized points that form the MDB,
- Time series of the monthly averaged mean and STD of in situ and satellite SSS and of the ΔSSS,
- Zonally-averaged Time-mean and temporal STD of in situ and satellite SSS and of the ΔSSS,
- Scatterplots of satellite vs in situ SSS by latitudinal bands,
- Time series of the monthly averaged mean and STD of the ΔSSS sorted by latitudinal bands,
- ΔSSS sorted as function of geophysical conditions,
- A summary with tables of statistics and validation metrics.

All analyses are conducted over the user-chosen Pi-MEP Region, satellite/In situ SSS pair and over the full satellite SSS product period. The Match-Up analyses reports can be accessed using the menu below:

Region: Global Ocean | Satellite: any | In-situ: any

Date	Satellite	In-situ	
2018-05-17	SMOS SSS L3 v3 - 10 Days (CATDS-CPDC)	ARGO profilers	View
2018-05-17	SMOS SSS L3 v3 - 10 Days (CATDS-CPDC)	Surface drifters	View
2018-05-17	SMOS SSS L3 v3 - 10 Days (CATDS-CPDC)	Marine mammals	View
2018-05-17	SMOS SSS L3 v3 - 10 Days (CATDS-CPDC)	TSG (GOSUD-research vessels)	View
2018-05-17	SMOS SSS L3 v3 - 10 Days (CATDS-CPDC)	TSG (GOSUD-Sailing ships)	View
2018-05-17	SMOS SSS L3 v3 - 10 Days (CATDS-CPDC)	TSG (LEGOS-DM)	View
2018-05-17	SMOS SSS L3 v3 - 10 Days (CATDS-CPDC)	TSG (SAMOS)	View
2018-05-16	Aquarius SSS L2 CAP v5 (JPL)	ARGO profilers	View
2018-05-16	Aquarius SSS L2 CAP v5 (JPL)	Surface drifters	View
2018-05-16	Aquarius SSS L2 CAP v5 (JPL)	Marine mammals	View
2018-05-16	Aquarius SSS L2 CAP v5 (JPL)	TSG (GOSUD-research vessels)	View
2018-05-16	Aquarius SSS L2 CAP v5 (JPL)	TSG (GOSUD-Sailing ships)	View
2018-05-16	Aquarius SSS L2 CAP v5 (JPL)	TSG (LEGOS-DM)	View
2018-05-16	Aquarius SSS L2 CAP v5 (JPL)	TSG (SAMOS)	View
2018-05-16	Aquarius SSS L2 OR v5 (NASA-GSFC)	ARGO profilers	View

Dashboard - recent activities



Map of the temporal STD of Argo SSS in 1°x1°

esa · Ifremer · OceanDataLab

smos pi-mep

Match-up database Analyses Report

Aquarius-L2-OR-V5

Argo

Global Ocean

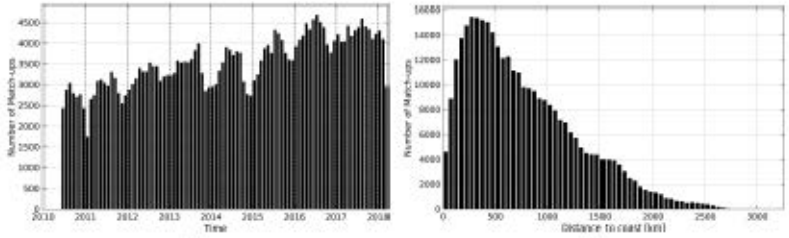
prepared by the Pi-MEP Consortium

May 15, 2018

Match-up characteristics

2.5 MDB characteristics for the particular in situ/satellite pairs

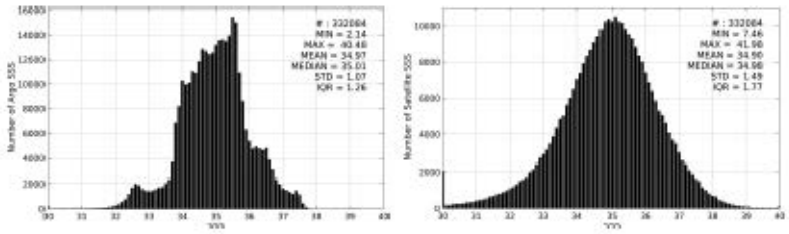
2.5.1 Number of paired SSS data as a function of time and distance to coast



(a) (b)

Figure 1: Number of match-ups between Argo and SMOS-L2-DPGS-v662 SSS as a function of time (a) and as function of the distance to coast (b) over the Global Ocean Pi-MEP region and for the full satellite product period.

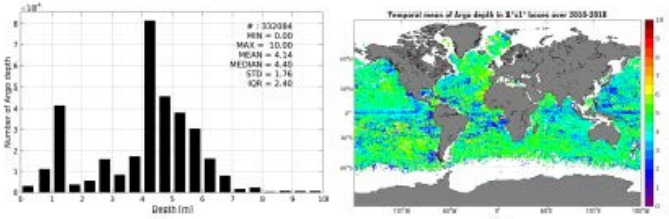
2.5.2 Histograms of the SSS match-ups



(a) (b)

Figure 2: Histograms of SSS from Argo (a) and SMOS-L2-DPGS-v662 (b) considering all match-up pairs per bins of 0.1 over the Global Ocean Pi-MEP region and for the full satellite product period.

2.5.3 Distribution in situ SSS depth in match-ups pairs



(a) (b)

Figure 3: Histograms of the depth of the upper level SSS measurements from Argo in the Match-up DataBase for the Global Ocean Pi-MEP region (a) and temporal mean spatial distribution of pressure of the in situ SSS data over 1°x1° boxes and for the full satellite product period (b).

2.5.4 Spatial Distribution of Match-ups

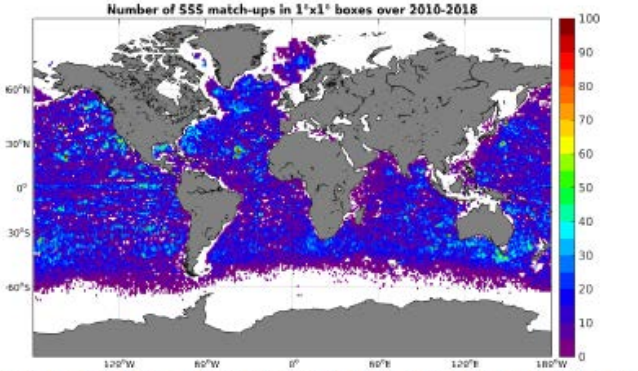
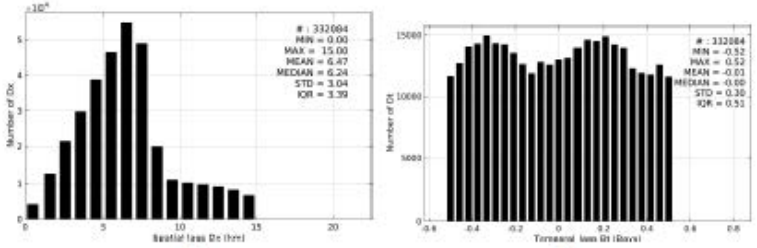


Figure 4: Number of SSS match-ups between Argo SSS and the SMOS-L2-DPGS-v662 SSS product for the Global Ocean Pi-MEP region over 1°x1° boxes and for the full satellite product period.

2.5.5 Histograms of the spatial and temporal lags of the match-ups pairs



(a) (b)

Figure 5: Histograms of the spatial (a) and temporal (b) lags between the time of the Argo measurements and the date of the corresponding SMOS-L2-DPGS-v662 SSS product.

Match-up analyses

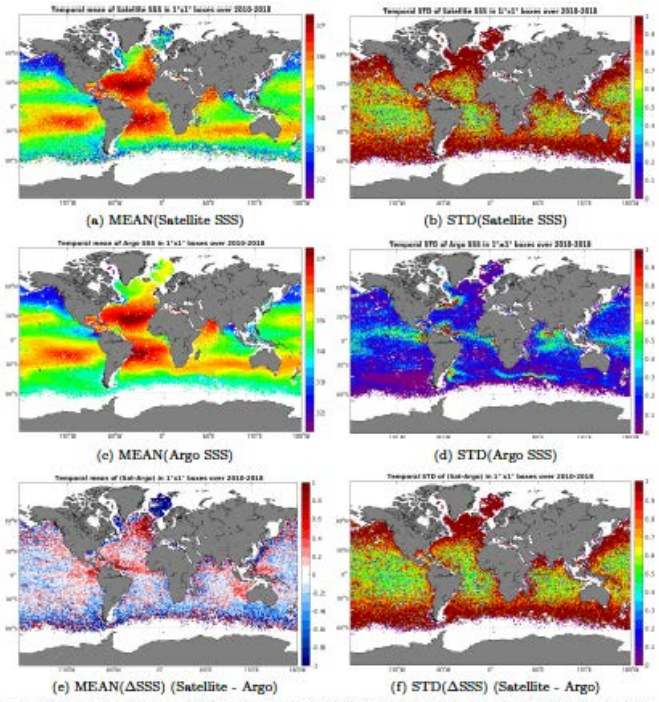


Figure 6: Temporal mean (left) and STD (right) of SSS from SMOS-L2-DPGS-v662 (top), Argo (middle), and of ΔSSS (Satellite - Argo). Only match-up pairs are used to generate these maps.

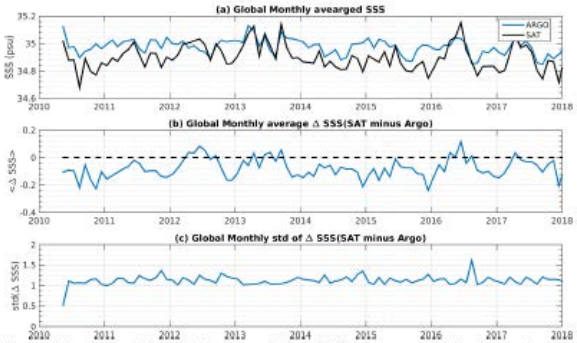


Figure 7: Time series of the monthly averaged mean SSS (top), mean ΔSSS (Satellite - Argo) and STD of ΔSSS (Satellite - Argo) over the Global Ocean Pi-MEP region considering all match-ups collected by the Pi-MEP platform.

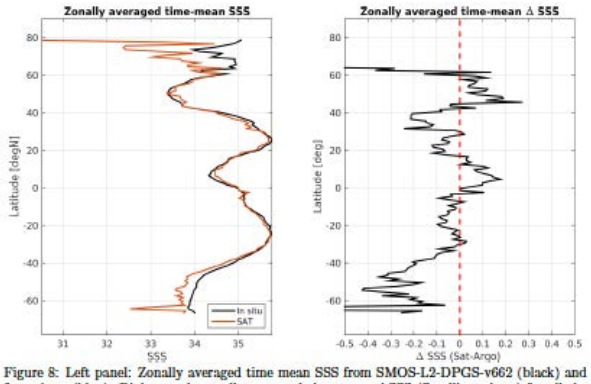
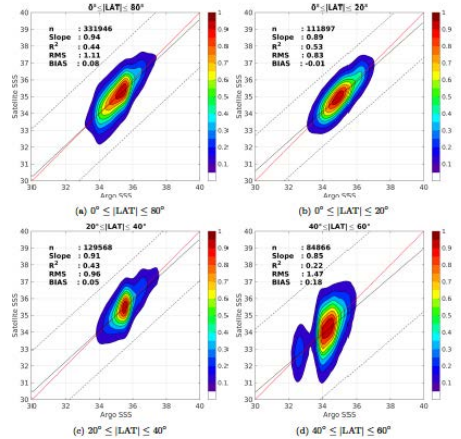
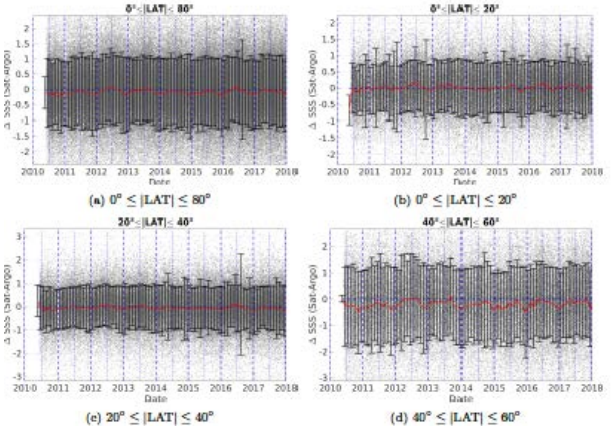
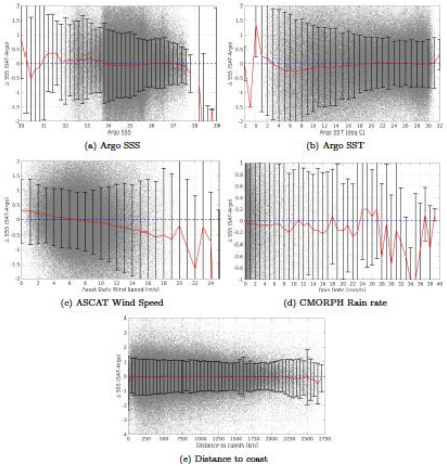
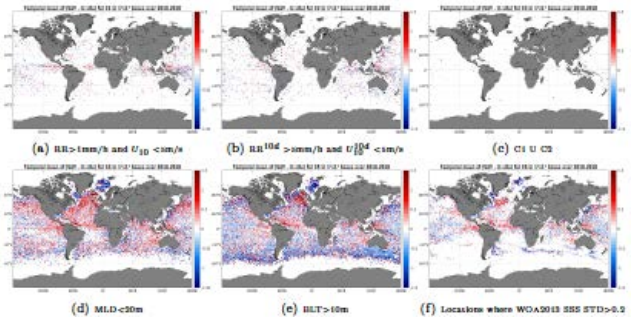


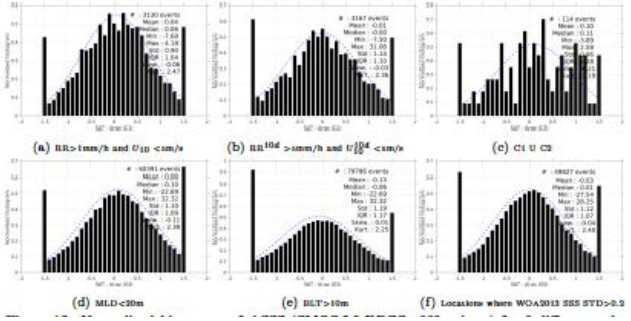
Figure 8: Left panel: Zonally averaged time mean SSS from SMOS-L2-DPGS-v662 (black) and from Argo (blue). Right panel: zonally averaged time-mean ΔSSS (Satellite - Argo) for all the collected Pi-MEP match-up pairs estimated over the full satellite product period.











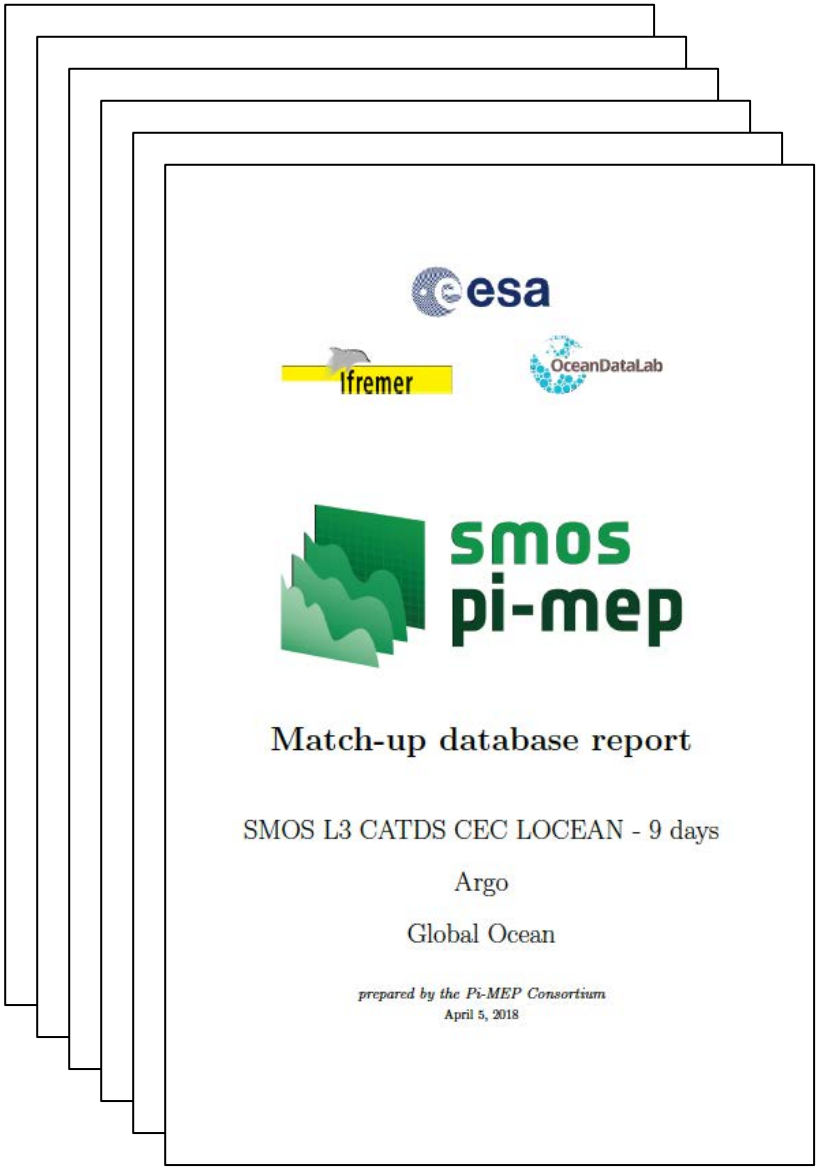
Pi-MEP systematic reporting

- By satellite products (37)
- By in situ database (10)
- By Pi-MEP region (30)

~ 9.000 reports

~40 plots/report

~1 min to generate 1 report

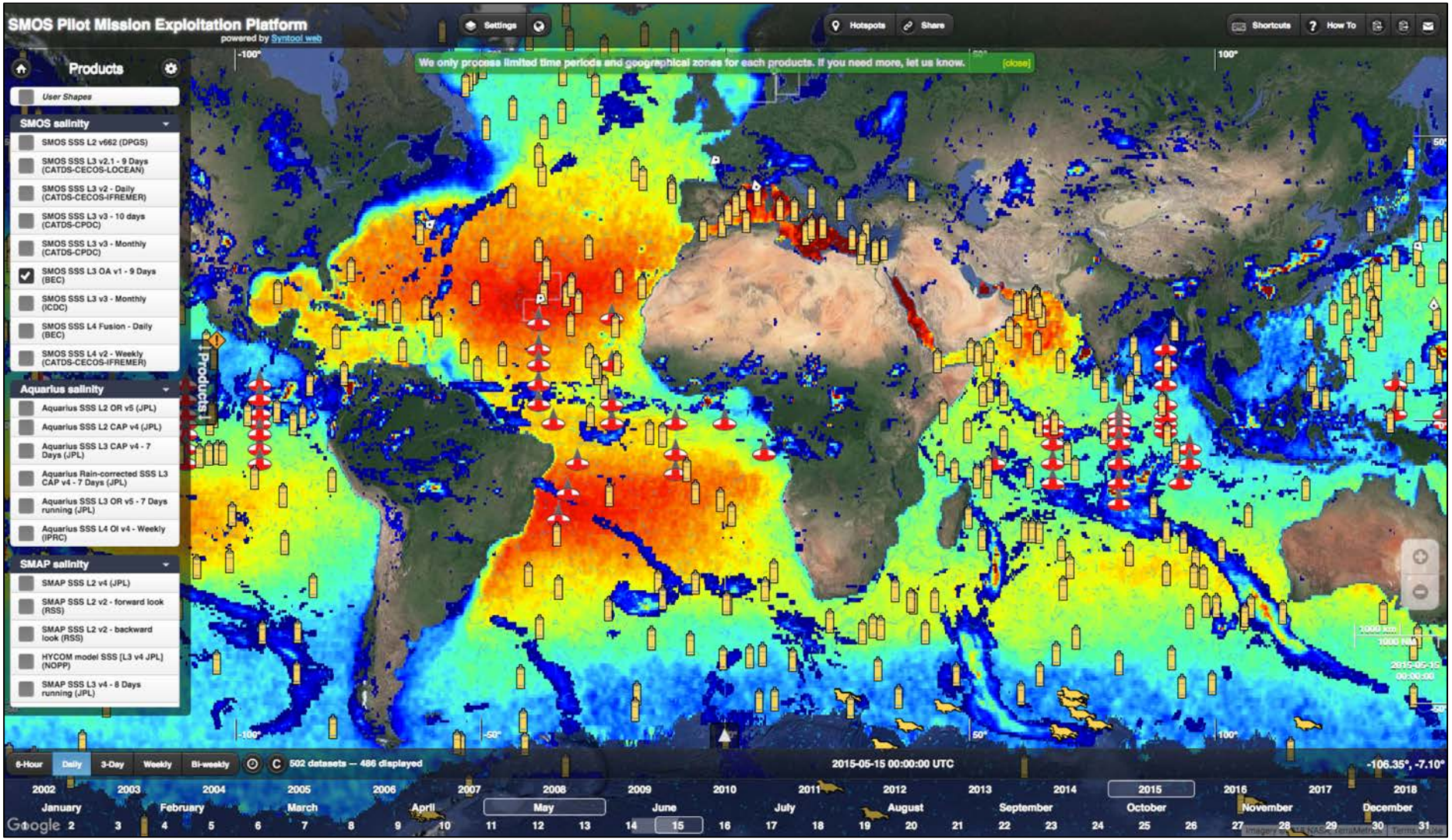


Pi-MEP TOOLS

Pi-MEP provides 5 different tools to **explore**, **visualize** and **extract** SSS related datasets:

- Syntool
- Plots interface
- Match-up interface
- Merginator
- Jupyter

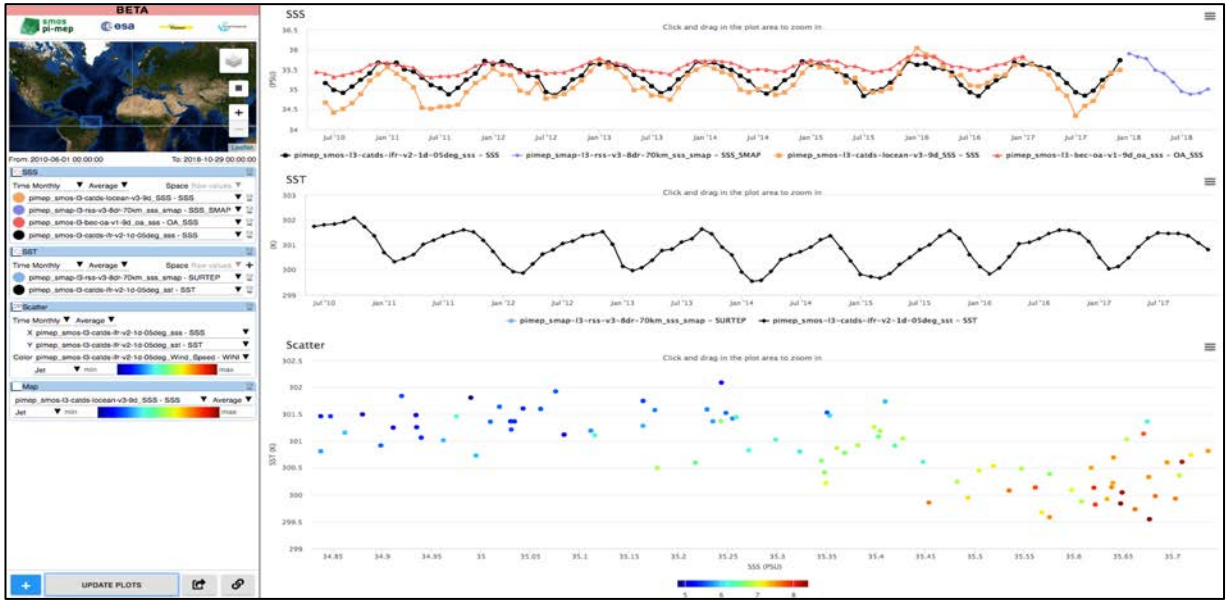
Syntool

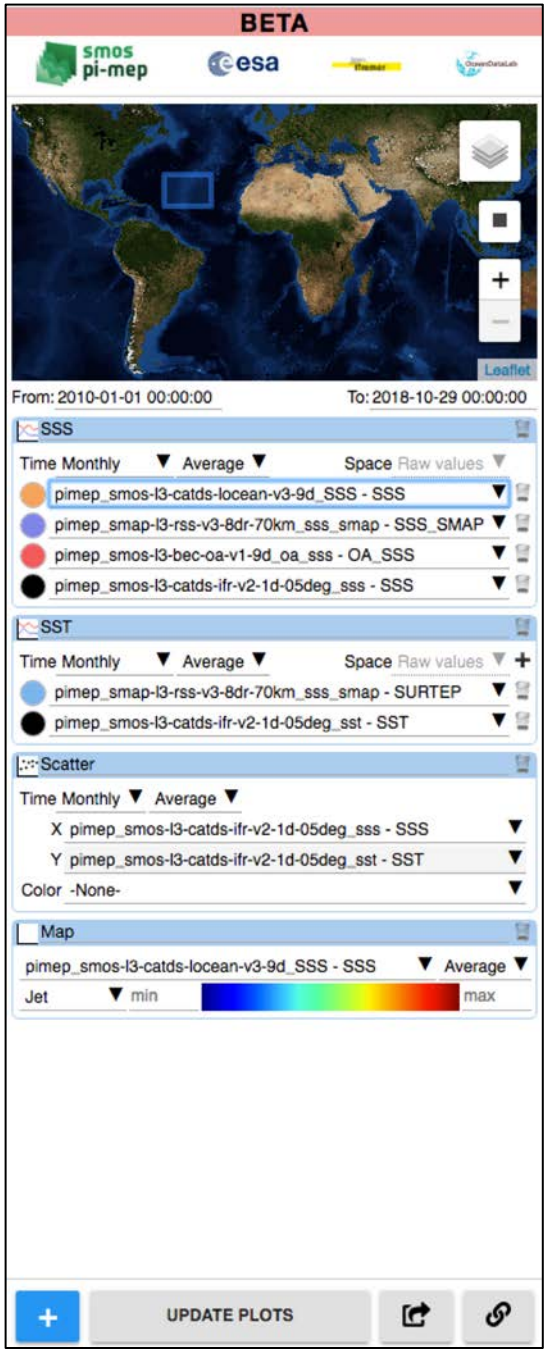

SMOS Pilot Mission Exploitation Platform
powered by Syntool web
Settings
Hotspots
Share
Shortcuts
How To
Products
User Shapes
SMOS salinity
SMOS SSS L2 v662 (DPGS)
SMOS SSS L3 v2.1 - 9 Days (CATDS-CECOS-LOCEAN)
SMOS SSS L3 v2 - Daily (CATDS-CECOS-IFREMER)
SMOS SSS L3 v3 - 10 days (CATDS-CPDC)
SMOS SSS L3 v3 - Monthly (CATDS-CPDC)
SMOS SSS L3 OA v1 - 9 Days (BEC)
SMOS SSS L3 v3 - Monthly (ICDC)
SMOS SSS L4 Fusion - Daily (BEC)
SMOS SSS L4 v2 - Weekly (CATDS-CECOS-IFREMER)
Aquarius salinity
Aquarius SSS L2 OR v5 (JPL)
Aquarius SSS L2 CAP v4 (JPL)
Aquarius SSS L3 CAP v4 - 7 Days (JPL)
Aquarius Rain-corrected SSS L3 CAP v4 - 7 Days (JPL)
Aquarius SSS L3 OR v5 - 7 Days running (JPL)
Aquarius SSS L4 OI v4 - Weekly (IPRC)
SMAP salinity
SMAP SSS L2 v4 (JPL)
SMAP SSS L2 v2 - forward look (RSS)
SMAP SSS L2 v2 - backward look (RSS)
HYCOM model SSS [L3 v4 JPL] (NOPP)
SMAP SSS L3 v4 - 8 Days running (JPL)
We only process limited time periods and geographical zones for each products. If you need more, let us know.
[close]
Products
8-Hour
Daily
3-Day
Weekly
Bi-weekly
502 datasets — 486 displayed
2015-05-15 00:00:00 UTC
-106.35°, -7.10°
2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
January February March April May June July August September October November December
Google

Plots interface

Interface with five types of plots :

- Time series
- Scatterplots
- Histograms
- Hovmöller diagrams
- Maps

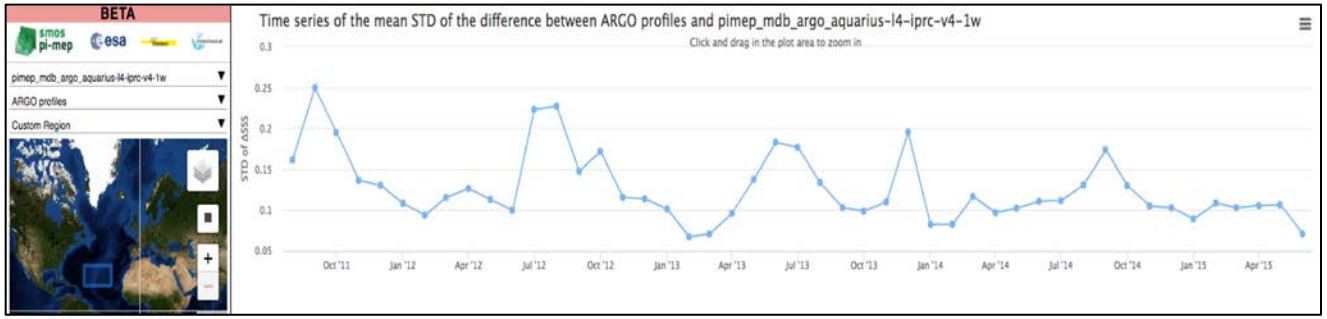


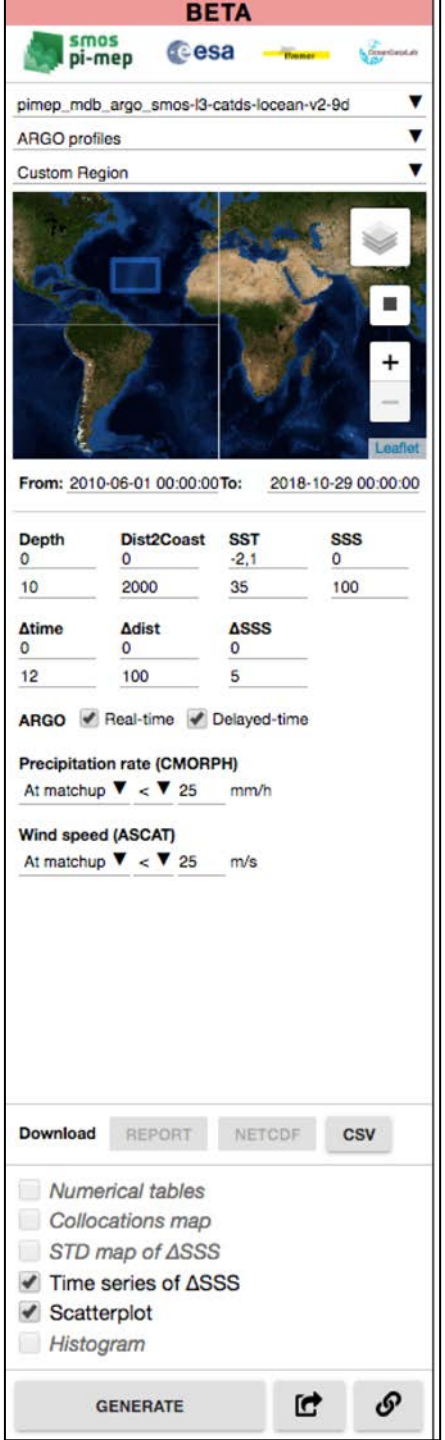


Match-up interface

Interface to query MDB data and :

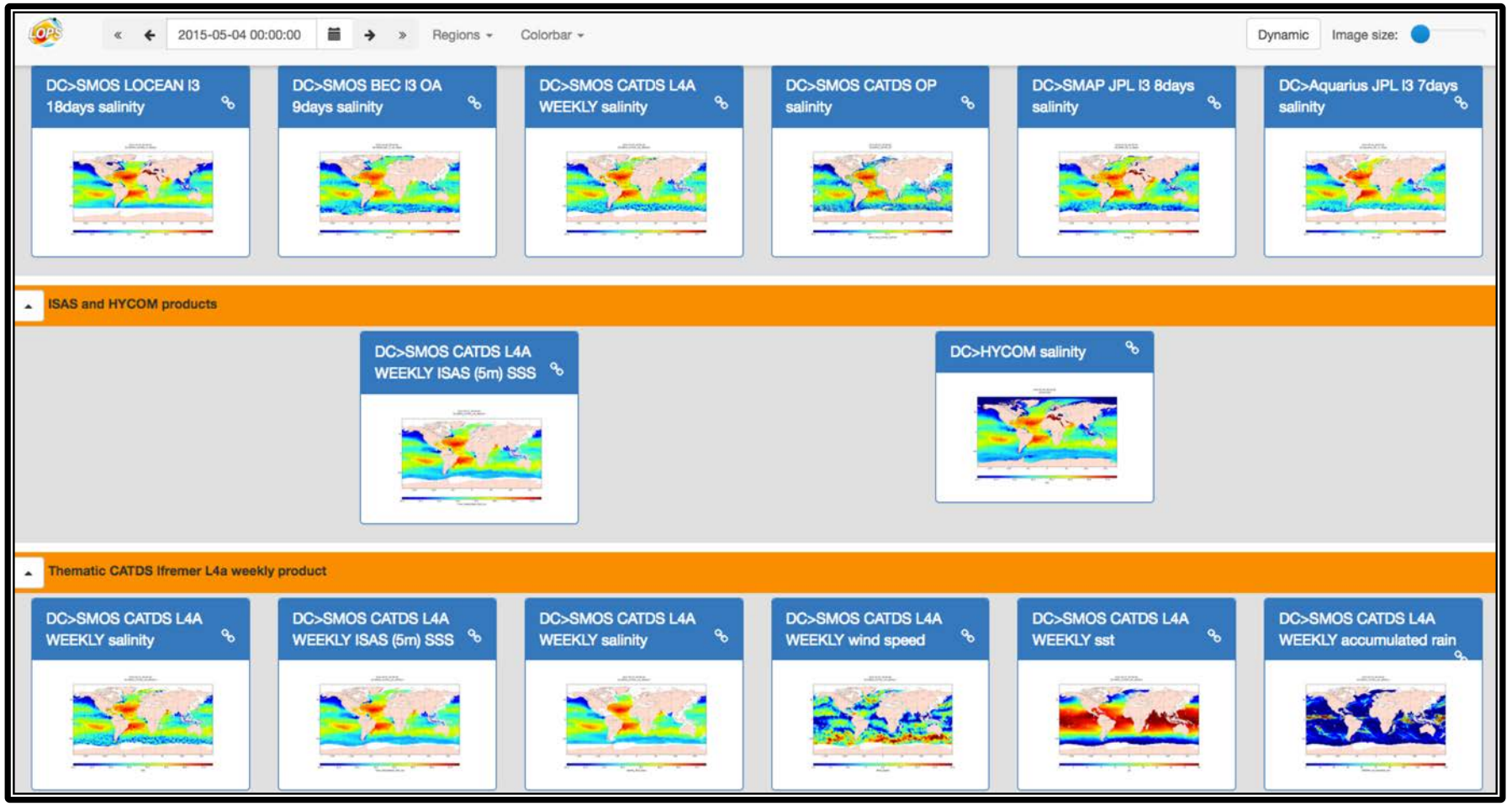
- Extract match-ups (CSV, JSON or NetCDF)
- Generate plots for match-up metrics
- Produce custom PDF reports





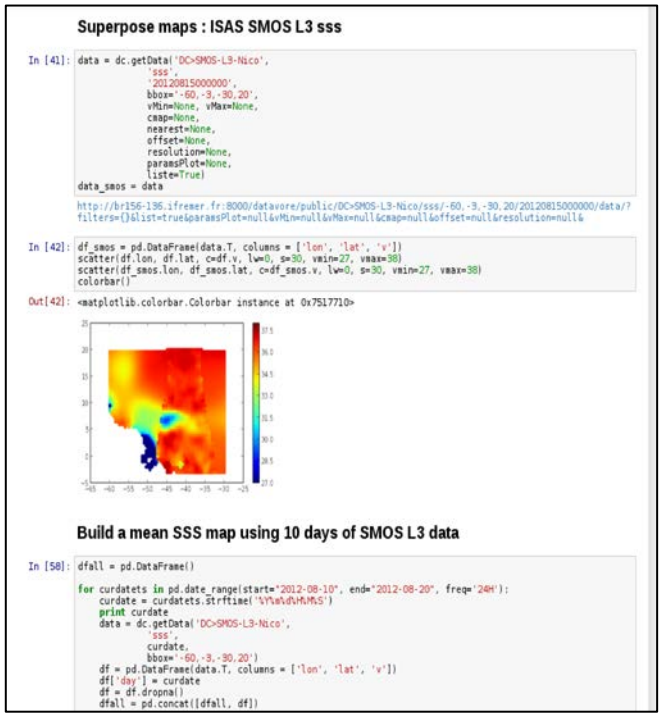
MERGINATOR

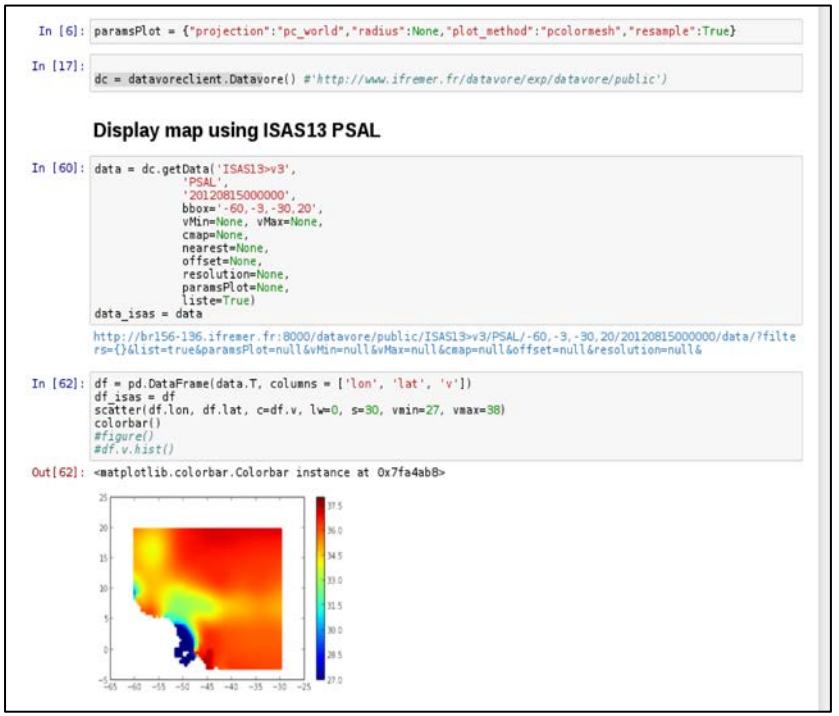
- Explore spatial patterns of numerous datasets at a glance



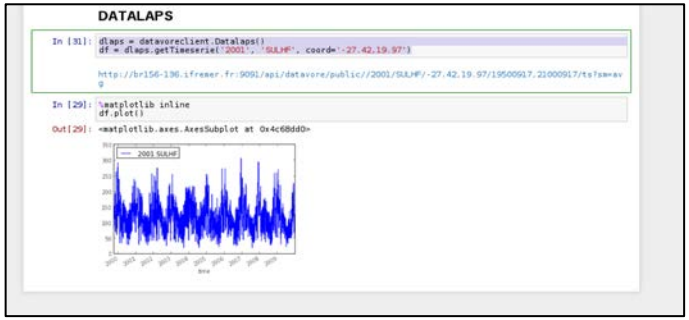
Jupyter

Interactive analysis of data on a distant server via a web browser





- Python console in a webpage
- Code executed on the platform (direct access to data)
- Results displayed in the web browser
- Python environment pre-installed
- Authenticated/Trusted users only

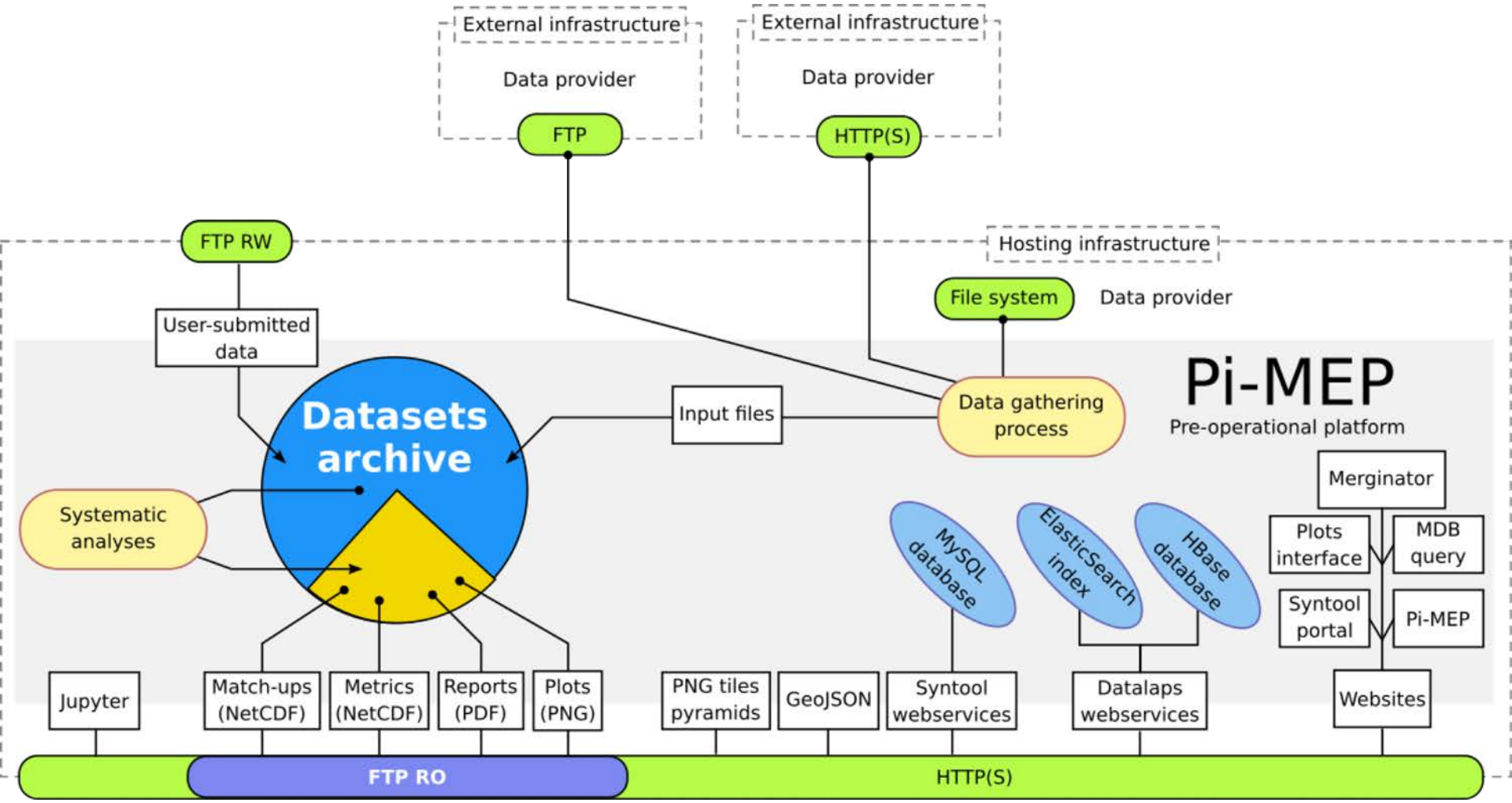


Summary

- DEMO this evening during the POSTER session
- MAY 2019, ESA Living planet symposium

  =>Pi-MEP operational phase

Pi-MEP Platform architecture



Work in progress

Home | Overview | Data | Reports | Case Studies | About

MDB Temporal Spectrum

Work in progress

Using Moorings data

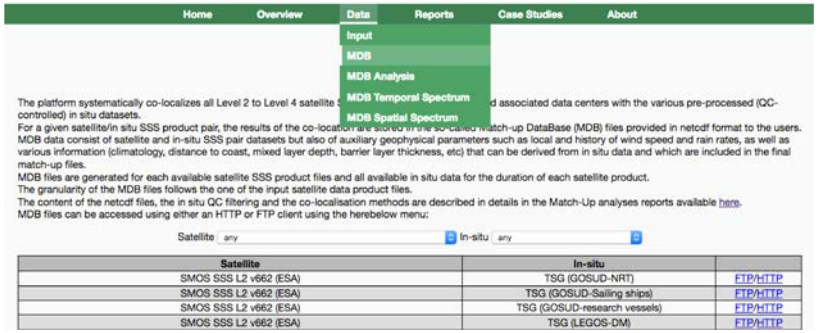
Home | Overview | Data | Reports | Case Studies | About

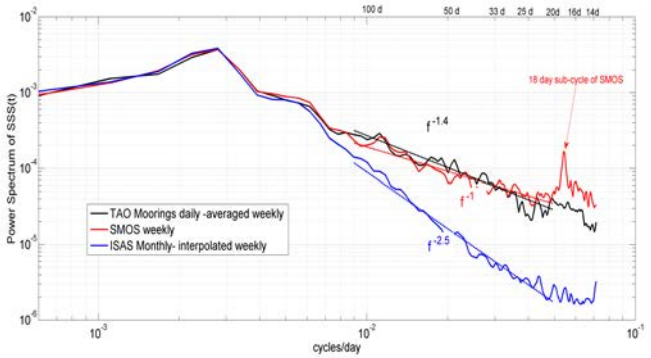
MDB Spatial Spectrum

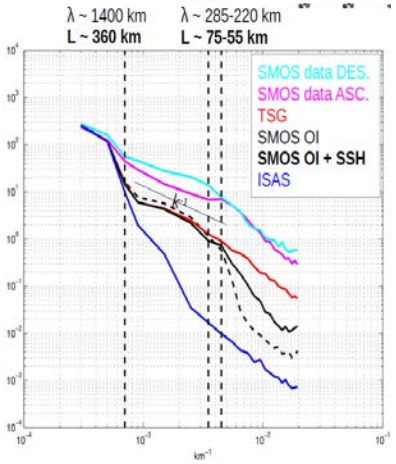
Work in progress

Using TSG data in predefined areas

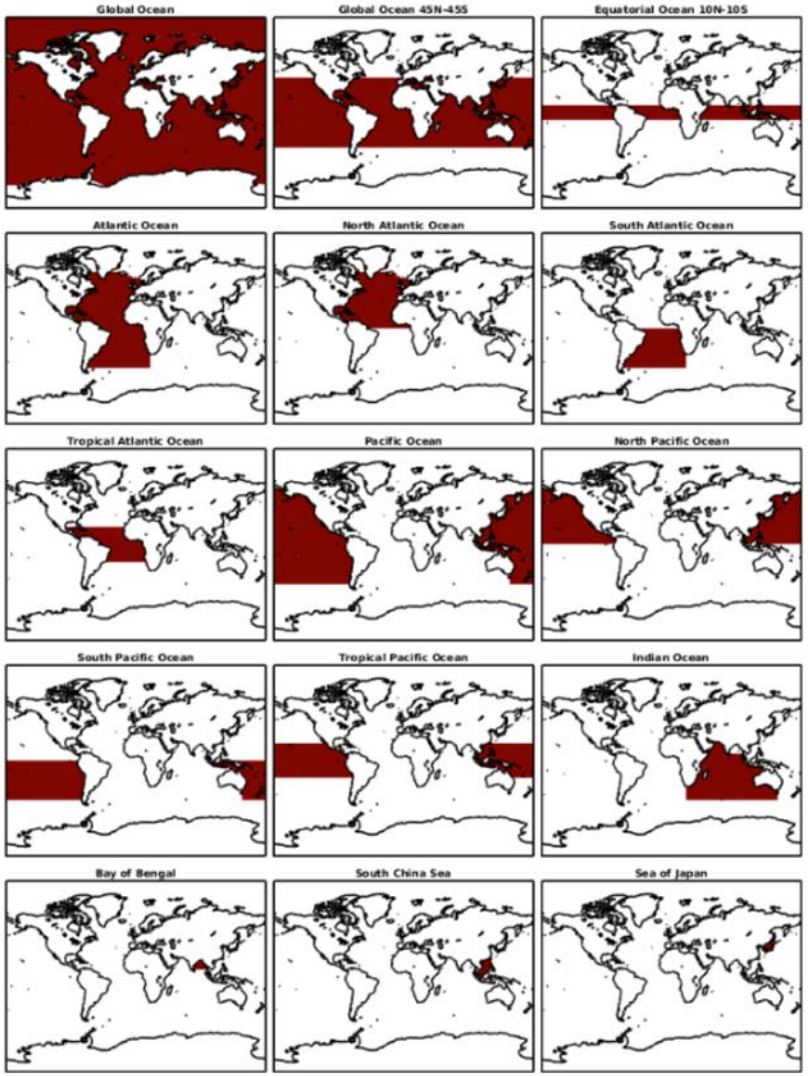
Satellite inter-comparisons reports/metrics

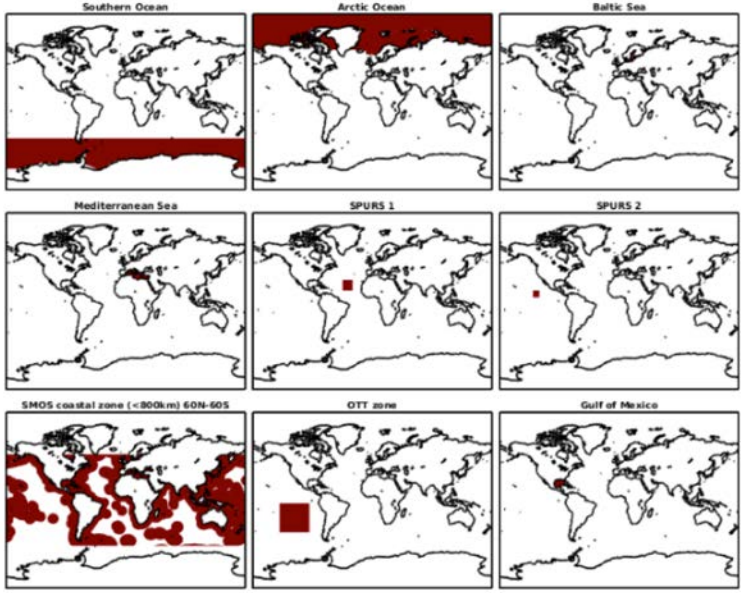






24 regions





Maps of the 24 Pi-MEP Validation regions shown in red.

+ 6 case study regions
+ user-defined regions