Satellite Oceanography - Ocean Salinity

Roberto Sabia

Post-doc Research Fellow
European Space Agency, ESA-ESRIN

Lecture

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Bio

- **Mar. 2002 – MSc. Env. Sciences – Oceanography, Univ. Parthenope, Napoli, Italy,**
  Prof. M. Migliaccio
- **2Q. 2006 – Stage, National Oceanography Centre, Southampton, UK,**
  Dr. C. Gommenginger
- **Oct. 2008 – PhD, Remote Sensing, UPC, Barcelona, Spain,**
  Prof. A. Camps, Prof. M. Vall-llossera
- **2009-2010 – Post-doc, SMOS-BEC, Barcelona, Spain,**
  Dr. J. Font, Dr. M. Portabella
- **Nov. 2010 – Research fellow, ESA-ESRIN, Frascati, Italy,**
  Dr. D. Fernàndez-Prieto

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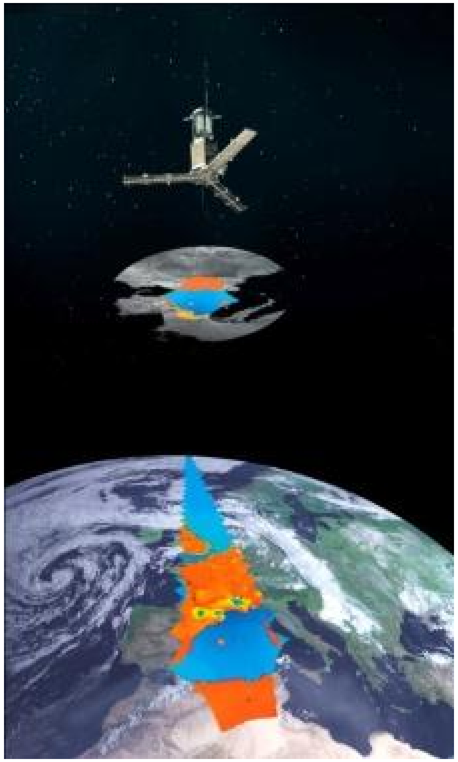

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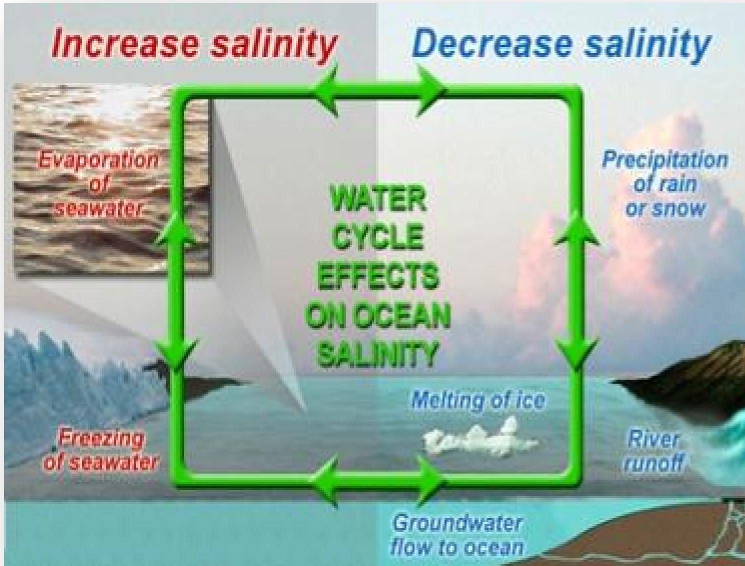
1. Ocean salinity monitoring: motivation / overview

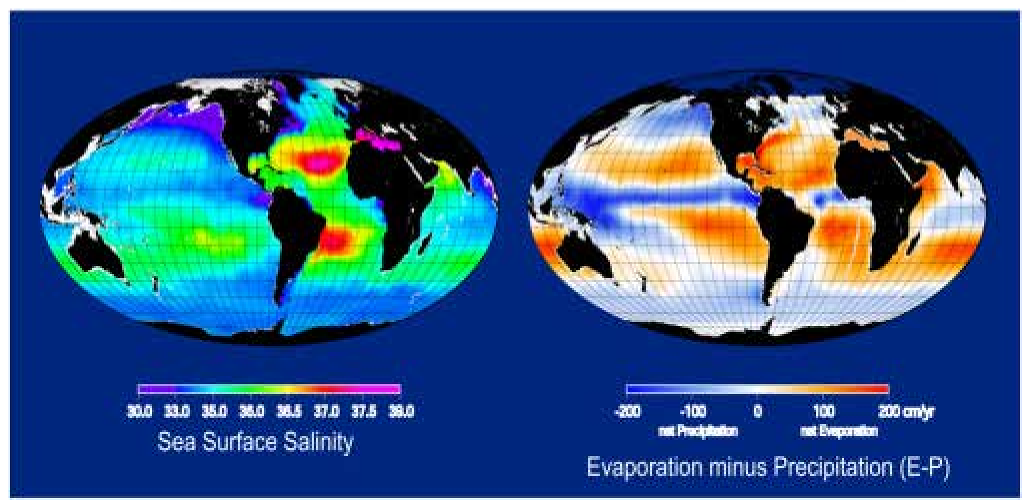
Motivation / Overview (i)

Why should SSS be measured?



"Conveyor belt"

- SSS variations governed by:
  - **E-P balance**
  - **freezing / melting ice**
  - **freshwater run-off**
- Key oceanographic parameter (**density**)
- **Thermohaline** circulation and heat redistribution

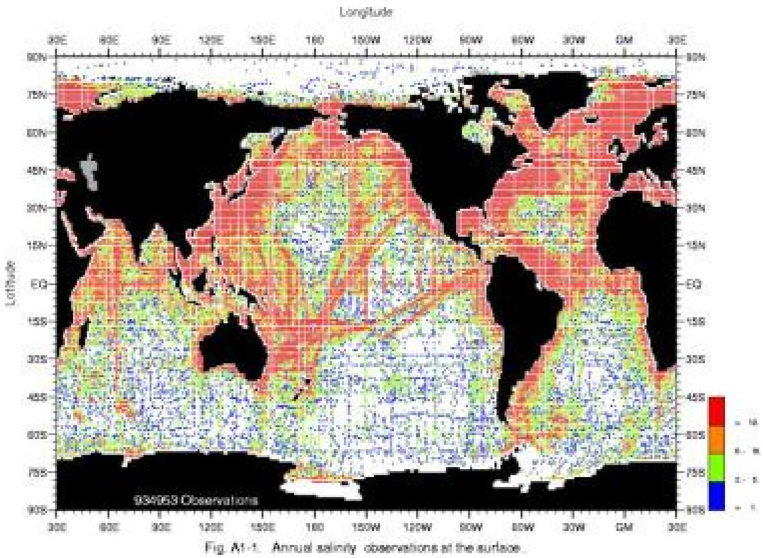


Surface salinity distribution closely tied to E-P patterns

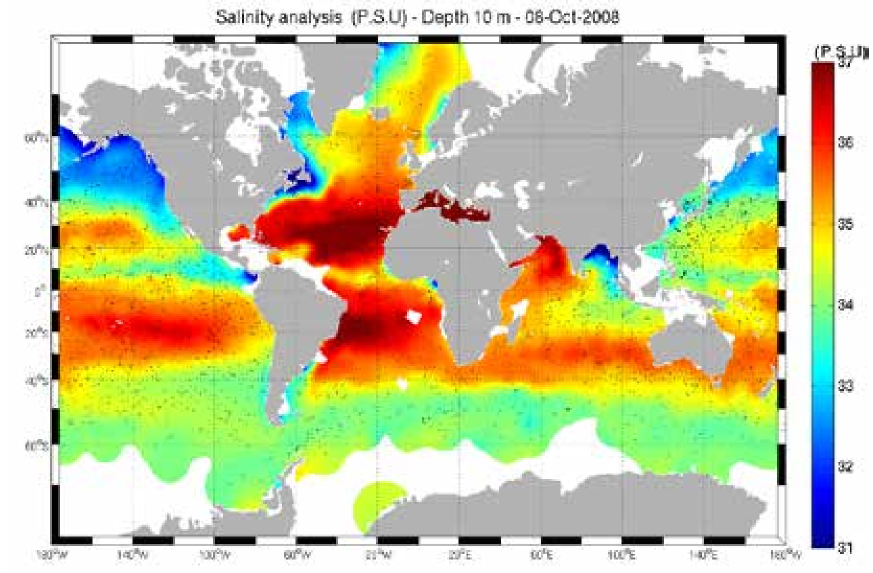
Motivation / Overview (ii)

Why should SSS be measured?

Historical lack of SSS observations



SSS time-series before ARGO deployment



10-m depth salinity field reconstructed from Argo floats data. There are still “holes” and spatial resolution is low

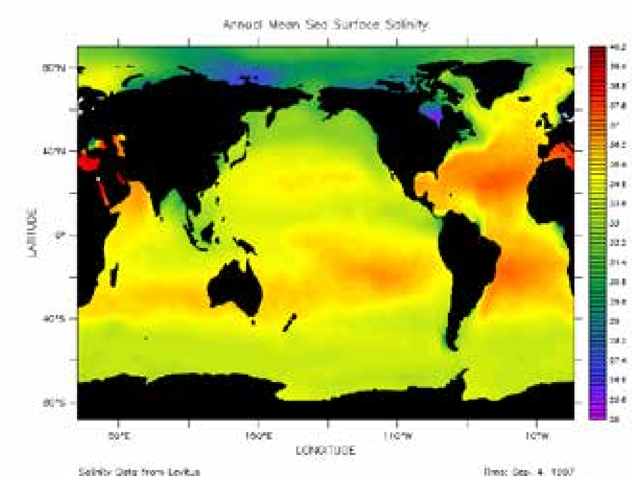
Oceanographic models already assimilate SST and SSH from satellite data, while SSS is still climatologic

Erroneous salinity estimates in ocean models can lead to significant errors:

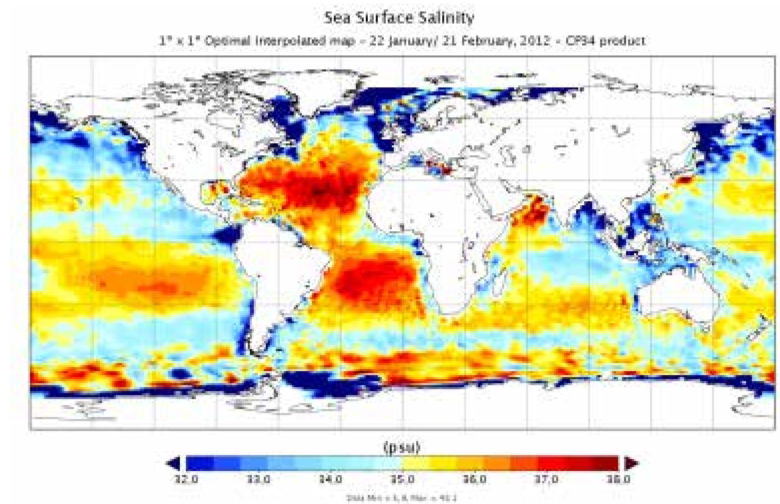
- Near-surface currents errors [Acero-Schetzer et al., 1997]
- Tropical dynamics [Murtugudde and Busalacchi, 1998]
- Dynamic height difference [Maes et al., 1999; Ji et al., 2000]
- Spurious convection [Troccoli et al., 2000]
- ENSO predictions [Ballabrera-Poy et al., 2002]

Motivation / Overview (iii)

Why should SSS be measured?



SSS WOA climatology



SMOS L3 SSS

Overall SMOS scientific goal

To provide global coverage of Sea Surface Salinity fields, with repetition rate and accuracy adequate for oceanographic, climatological and hydrological studies and increase the present knowledge on:

- **Large-scale ocean circulation**
- **Water cycle exchange rates quantitative estimation**
- **Occurrence frequency of natural catastrophic events**
- **Management of water resources**
- **Role of the ocean in the climate system**

SSS identified by UNFCCC as Essential Climate Variable (ECV) → WCRP IPCC

2. SMOS salinity measurement: rationale and features

Rationale / Features (i)

What will be measured?

TB = e·Tph

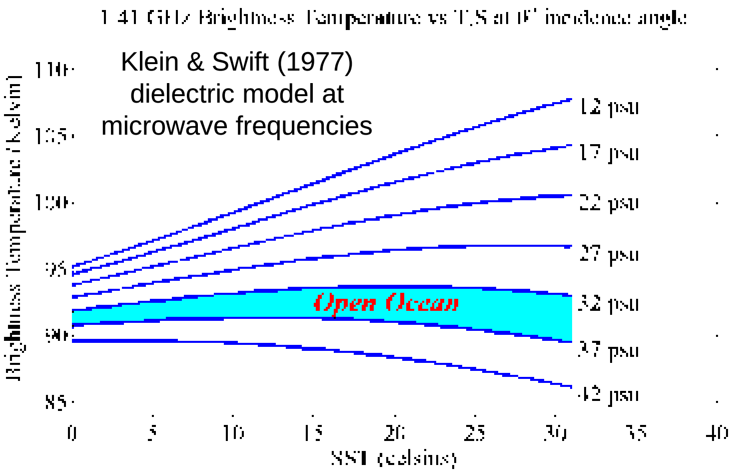
$$T_B(q, pol) = SST \times \left(1 - \left|R_{H,V}\left(q, e_r\left(f, SST, SSS\right)\right)\right|^2\right) + DT_B(q, pol)$$

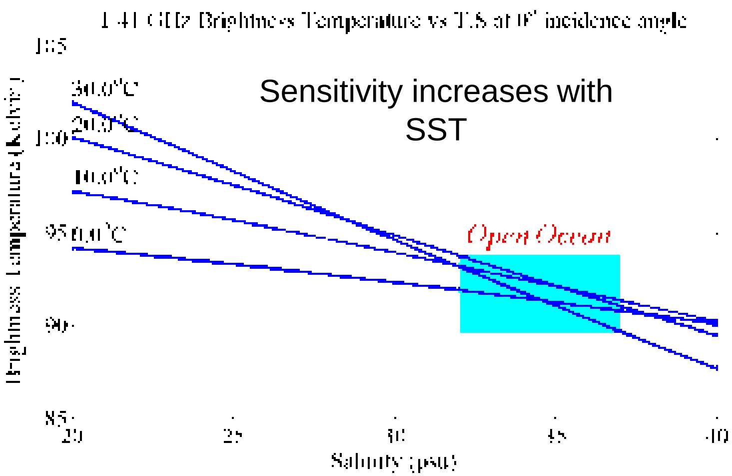
Configuration Parameters

- **Frequency (*f*)**
- **Polarization (pol)**
- **Incidence angle (θ)**
- **Azimuth angle (φ)**

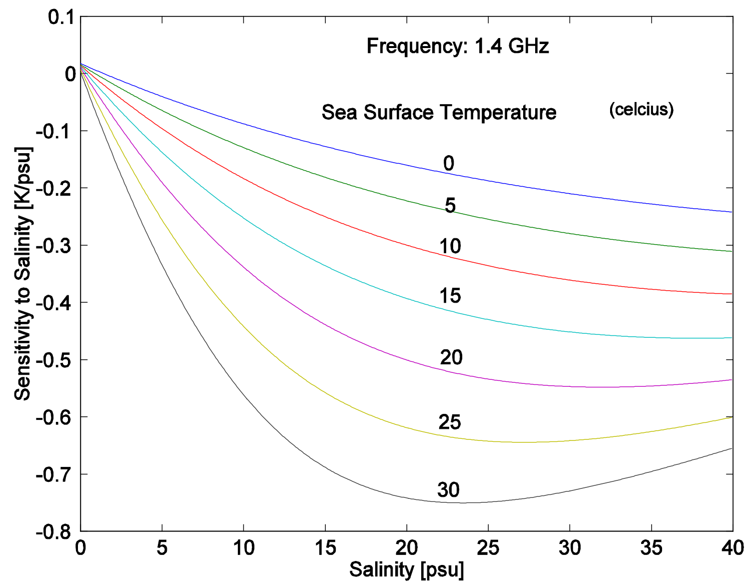
Scene Parameters

- **Sea Surface Salinity (SSS)**
- **Sea Surface Temperature (SST)**
- **Sea roughness (WS, SWH, sea state)**



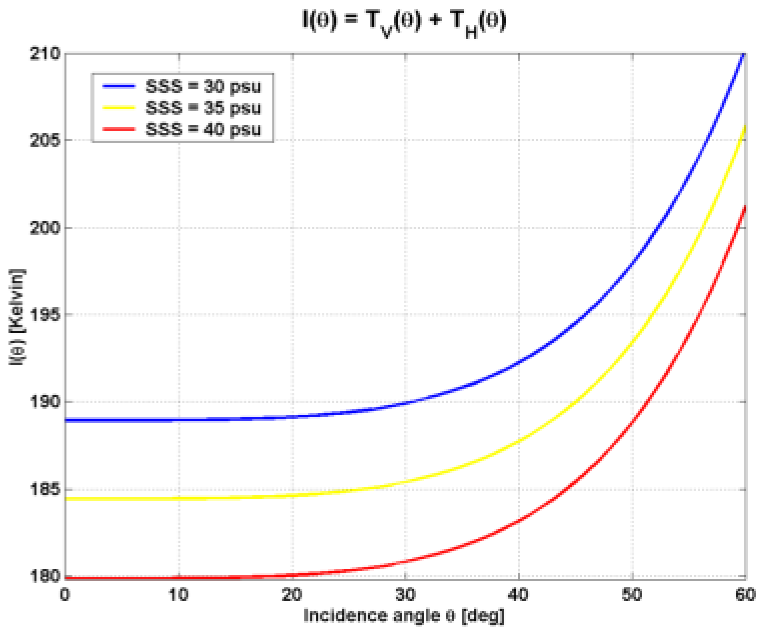


TB variation versus SST and SSS

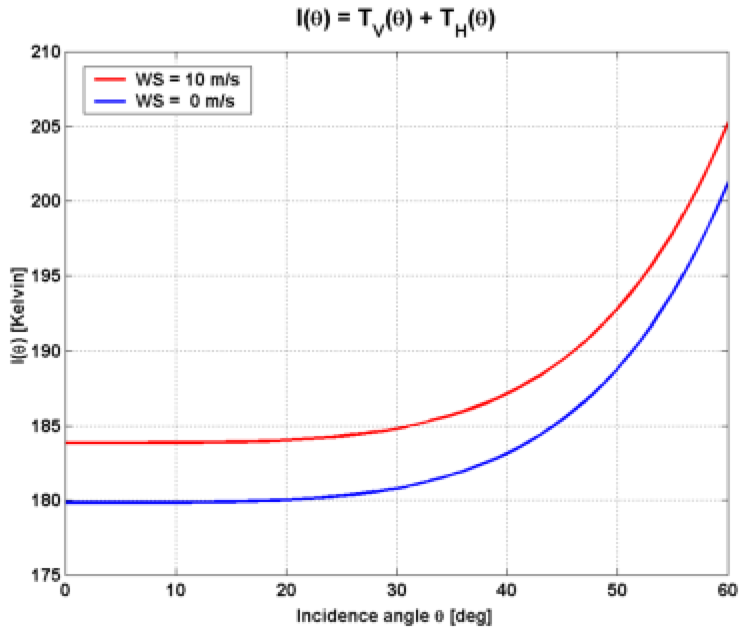


TB sensitivity versus SSS (nadir and flat sea)

Angular T_B variation and sensitivities



First Stokes angular variation (no wind, different SSS)



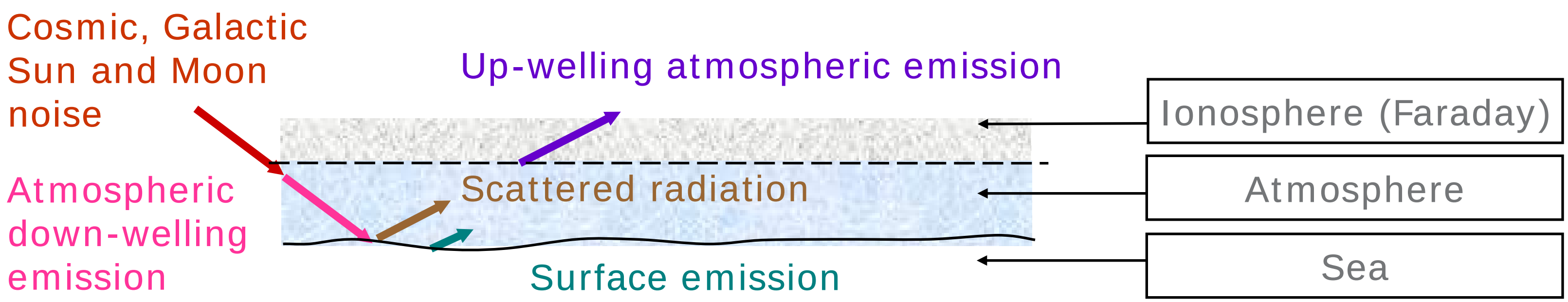
First Stokes angular variation (40 psu, different winds)

TB Sensitivity to SSS in open ocean : 0.2 to 0.8 K/psu
TB Sensitivity to WS at nadir : 0.25 K/m/s

SSS retrieval more challenging at high latitudes

Few K Sensitivity of TB to SSS, compared to ≈100 K for TB to SM

Correction terms to be applied in T_B computation

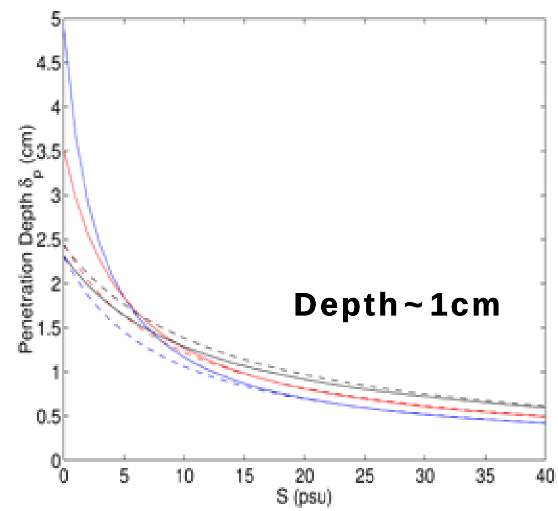


$$T_{B,pol} = T_{B,pol}^{TOA} L(\theta) - \left[\Gamma_{pol}(\theta) \frac{T_{SKY}}{L(\theta)} + T_{UP\,atm}(\theta) L(\theta) \right] - \Gamma_{pol}(\theta) T_{DN\,atm}(\theta)$$

$L(\theta)$, T_{SKY}, $T_{UP\,atm}(\theta)$ and $T_{DN\,atm}(\theta)$ terms account for:

Major perturbation sources
- Sun
- Galactic Noise

Minor perturbation sources
- Water vapor
- Clouds
- Rain
- Moon



L-band penetration depth

Rationale / Features (iv)

How will this be measured?

Earth Explorer Missions

Science

- 2009 → **GOCE** ESA's Gravity Mission
- 2009 → **SMOS** ESA's Water Mission
- 2010 → **CryoSat2** ESA's Ice Mission
- 2012 → **ADM/Aeolus** ESA's Wind Mission
- 2012 → **SWARM** ESA's Magnetic Field Mission
- 2013 → **EarthCare** ESA's Cloud & Aerosol Mission

- ESA Earth Explorer Opportunity Mission
- Living Planet program
- Novel Earth observation techniques demostration
- Novel data provision to the science community
- Small and flexible

SMOS: Soil Moisture and Ocean Salinity

- Two key variables for the study of the water cycle and climate variability on planet Earth
- At present, scarce global coverage
- No dedicated space mission so far, due to technical complexity

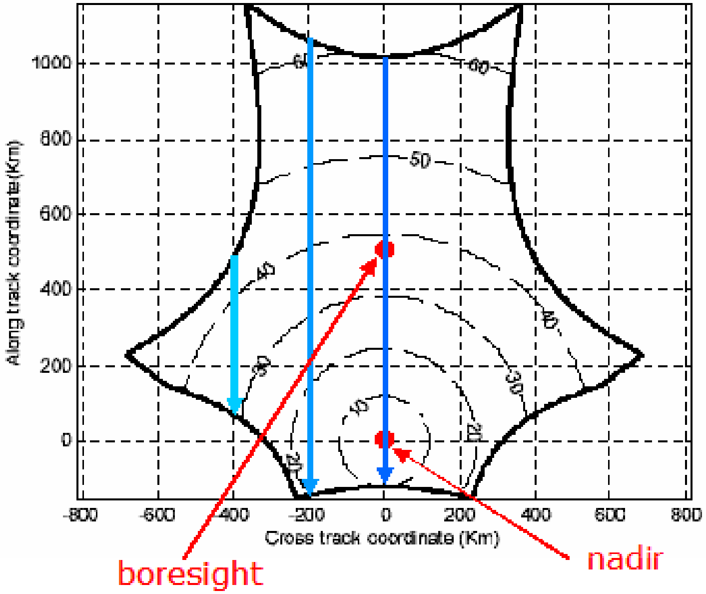
SMOS: general features

1.4 GHz, L-band (dedicated)

- Optimum SSS sensitivity
- Reasonable pixel dimension
- Atmosphere almost transparent

- Synthetic Aperture Radiometer (MIRAS)
- Sun-synchronous LEO orbit, 3 days revisit time
- 69 elements array, Y-array: arms 120º apart
- Free-alias Field Of View about 1000 km
- Full-polarimetric
- Multi-angular capabilities
- Spatial Resolution: at best 32 km (boresight)

- Full scene acquired every 2.4 s
- Variable number of observations according to the satellite sub-track distance
- Different measurements of T_B corresponding to a single SSS under different incidence angles



Processing chain / Requirements

Level **0** Raw data

Level **1A** Calibrated Visibilities

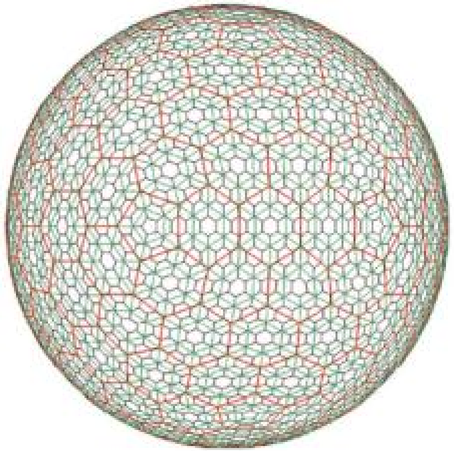
Level **1B** T_B Fourier components

Level **1C** T_B geocoded (ISEA4H9)

Level **2** Salinity Maps (single-overpass)

Level **3** Spatio-temporal averaged SSS

Level 4 Merged product



ISEA DGGs (Discrete Global Grids)

Scientific requirements for salinity retrieval

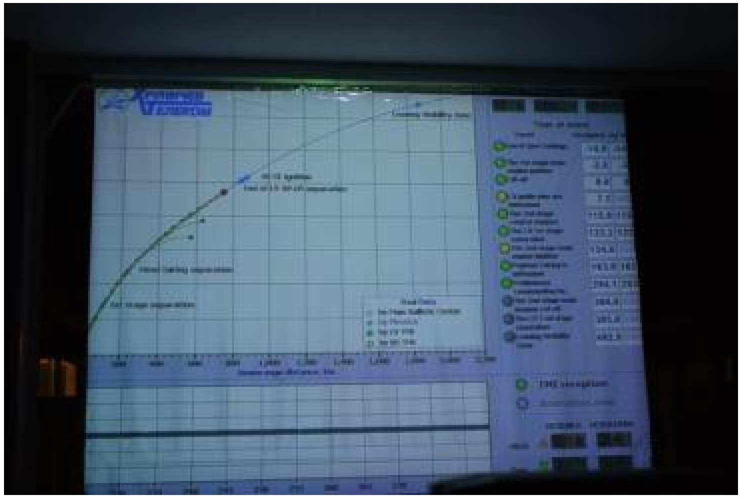
- Global Ocean Data Assimilation Experiment (**GODAE**, 1997)
  0.1 psu, 200 km, 10 days
- Salinity and Sea Ice Working Group (**SSIWG**, 2000)
  0.1 psu, 100 km, 30 days
- **SMOS** (**M**ission **R**equirements **D**ocument **v5**, 2002)
  0.1 psu, 200 km, 30 days

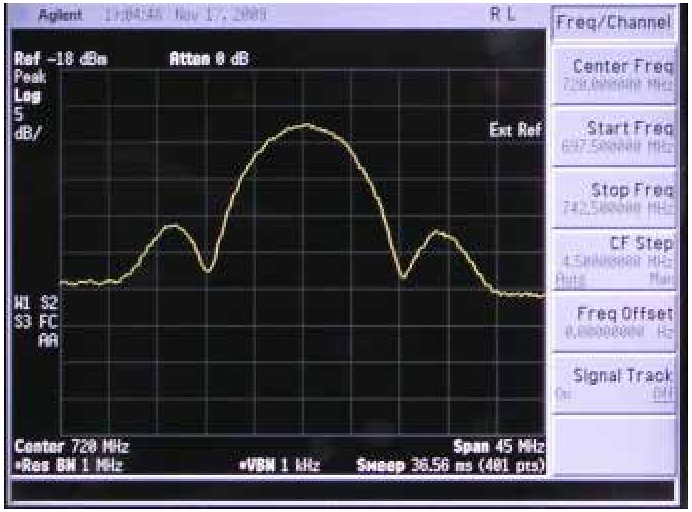
lower accuracy, higher resolution products (e.g. 100 km, 10 days or single passes) are useful for applications other than climate and large scale studies

SMOS Launch

Plesetsk, Russia, Rockot launcher

02.11.2009, 1h 50’ 51’’



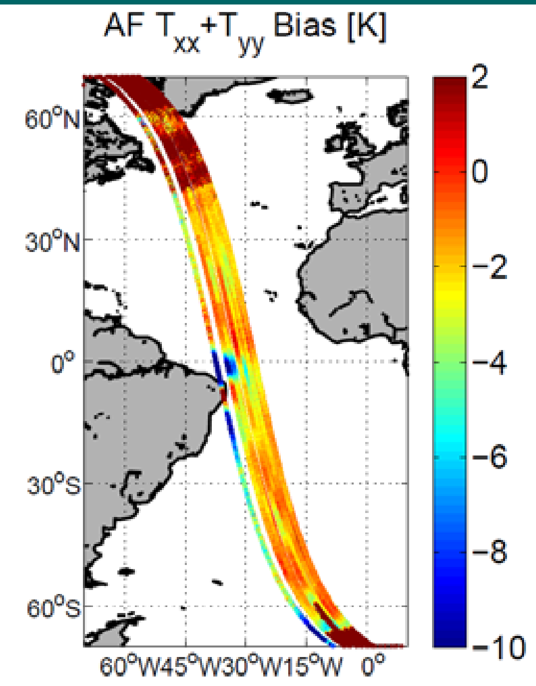


First signal detected

3. L1 (TB) features / issues / objectives

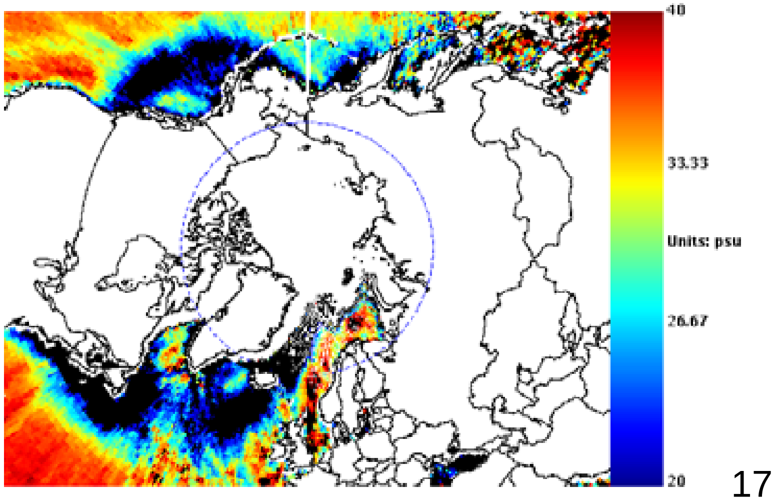
- Short- and long-term instrumental drift (Thermal drifts, antenna pattern uncertainties, polarization leakage etc.)
- LO frequency calibration
- FTT calibration

- Bias mitigation
- RFI
- Full-polarimetric signal characterization
- Land/Sea/Ice transitions-induced contamination
- Sun correction

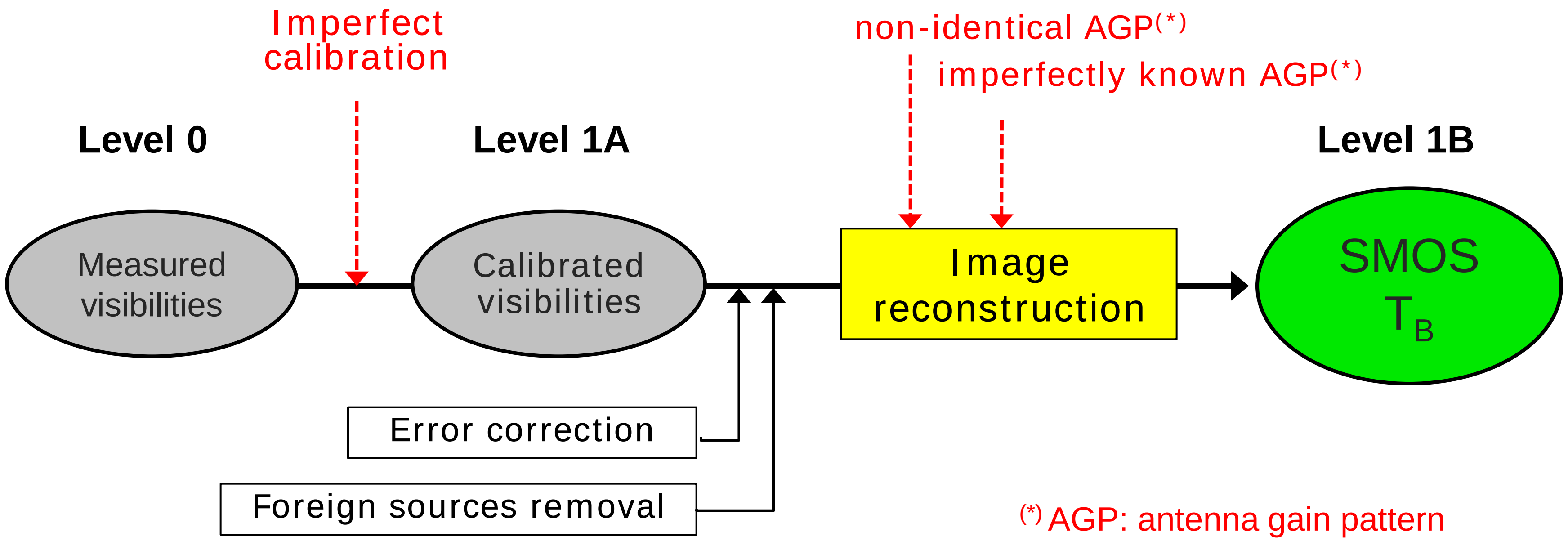


Land / Sea contamination

RFI detection / mitigation



Systematic TB errors

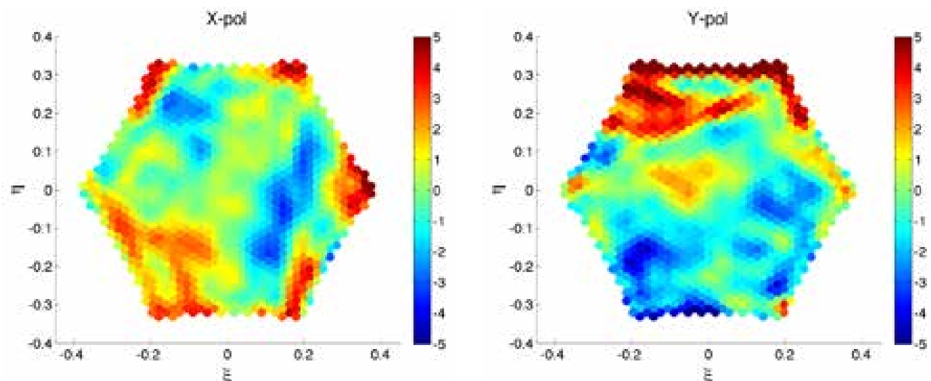


… as foreseen by Camps [1998, 2005], Anterrieu [2003]

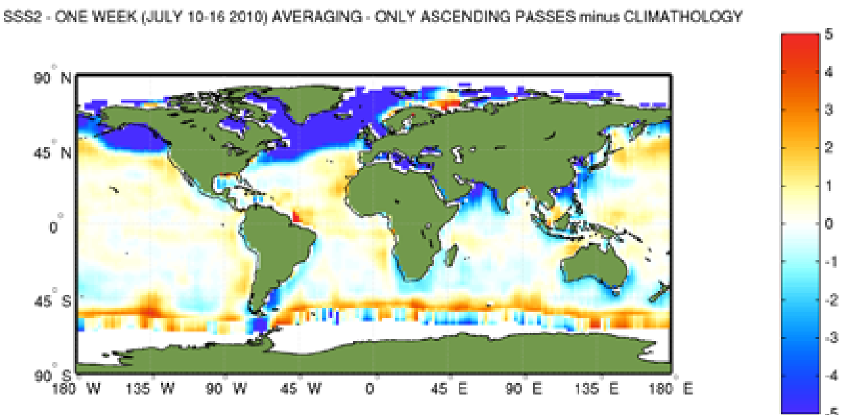
Ocean Target Transformation

Average instrumental spatial pattern against an ocean target, to be subtracted from TB measurements prior to SSS retrieval

$$OTT(x,h) = \langle (TB_{SMOS}(x,h) - TB_{model}(x,h)) \rangle$$



OTT XX and YY pol (in K)



L3 SSS anomaly with OTT (in psu)

- Spatial pattern persistent along and in different orbits
- Similar using different ocean emissivity models: related to instrument and image reconstruction imperfections
- Additive OTT implemented in L2OS processor allowed retrieving realistic SSS
- Even if biases were anticipated, they were expected to be smaller after applying FTT
- Alternative solutions under investigation

Systematic T_B Patterns Mitigation (ii) – OTT self consistent

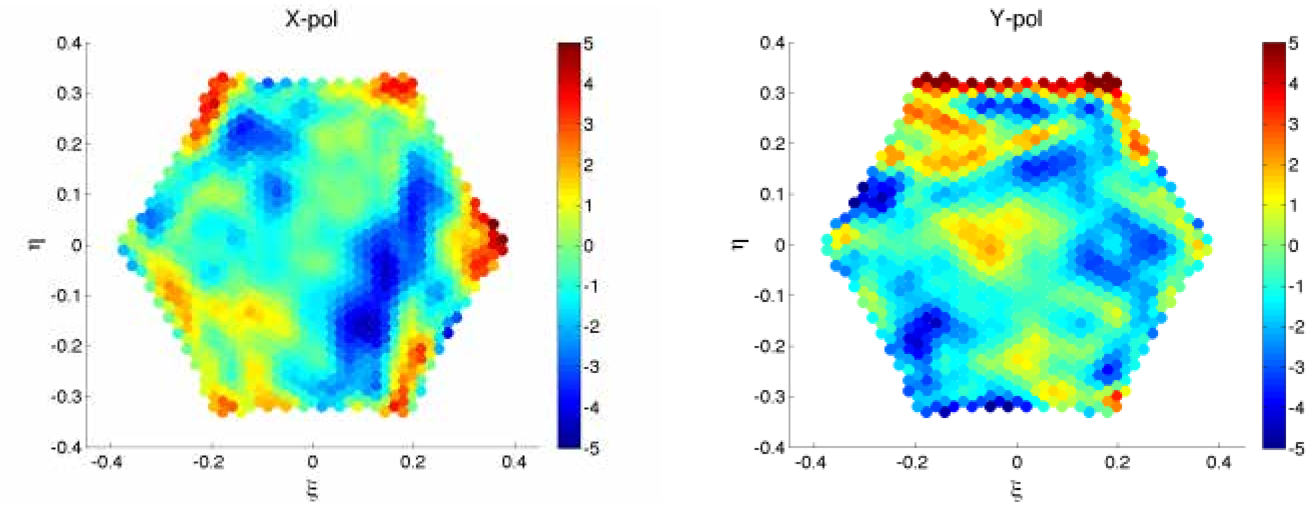
Model-independent (self-consistent) bias mitigation

Rationale

Avoiding model-related additional errors

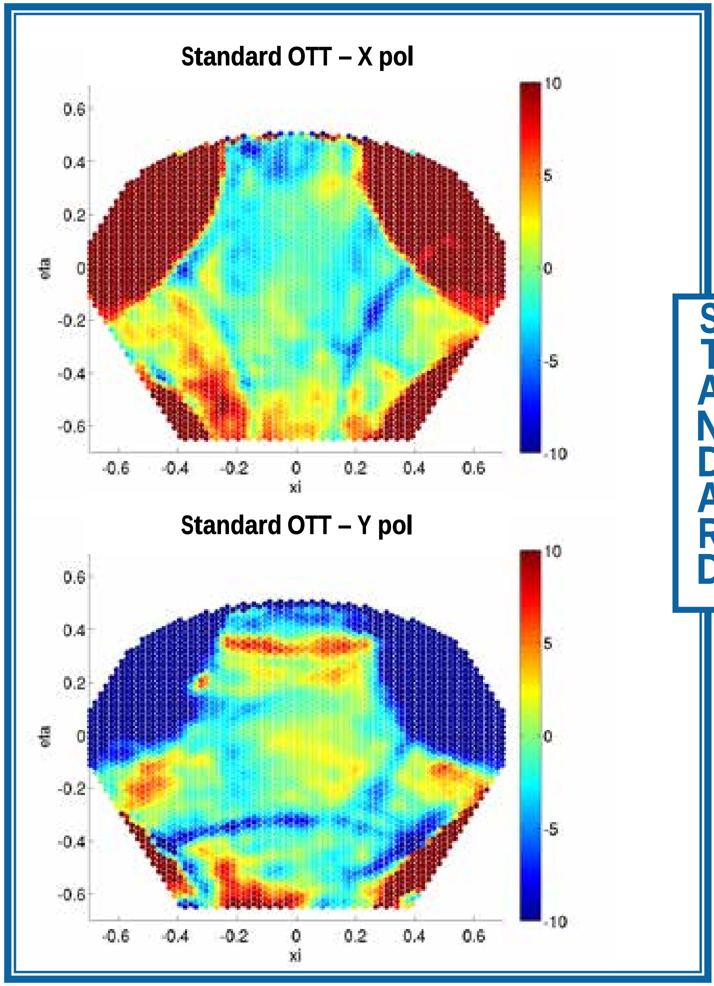
Processing steps

- Large ensemble of SMOS measured T_B at L1B
- Adequate data filtering
- Angular dependency characterization and removal
- Systematic spatial patterns **with homogenization** of the geophysical parameters distribution in terms of environmental conditions



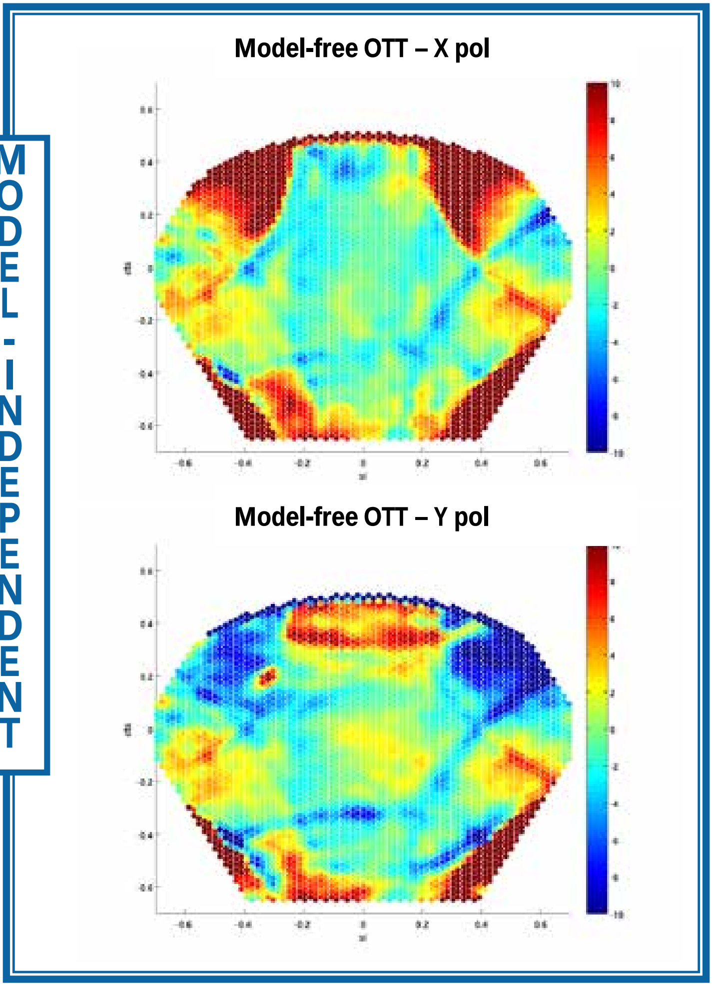
by J. Gourrion, SMOS-BEC

The standard and the model-independent OTTs computed **after the homogenization** of the geophysical parameters are shown.

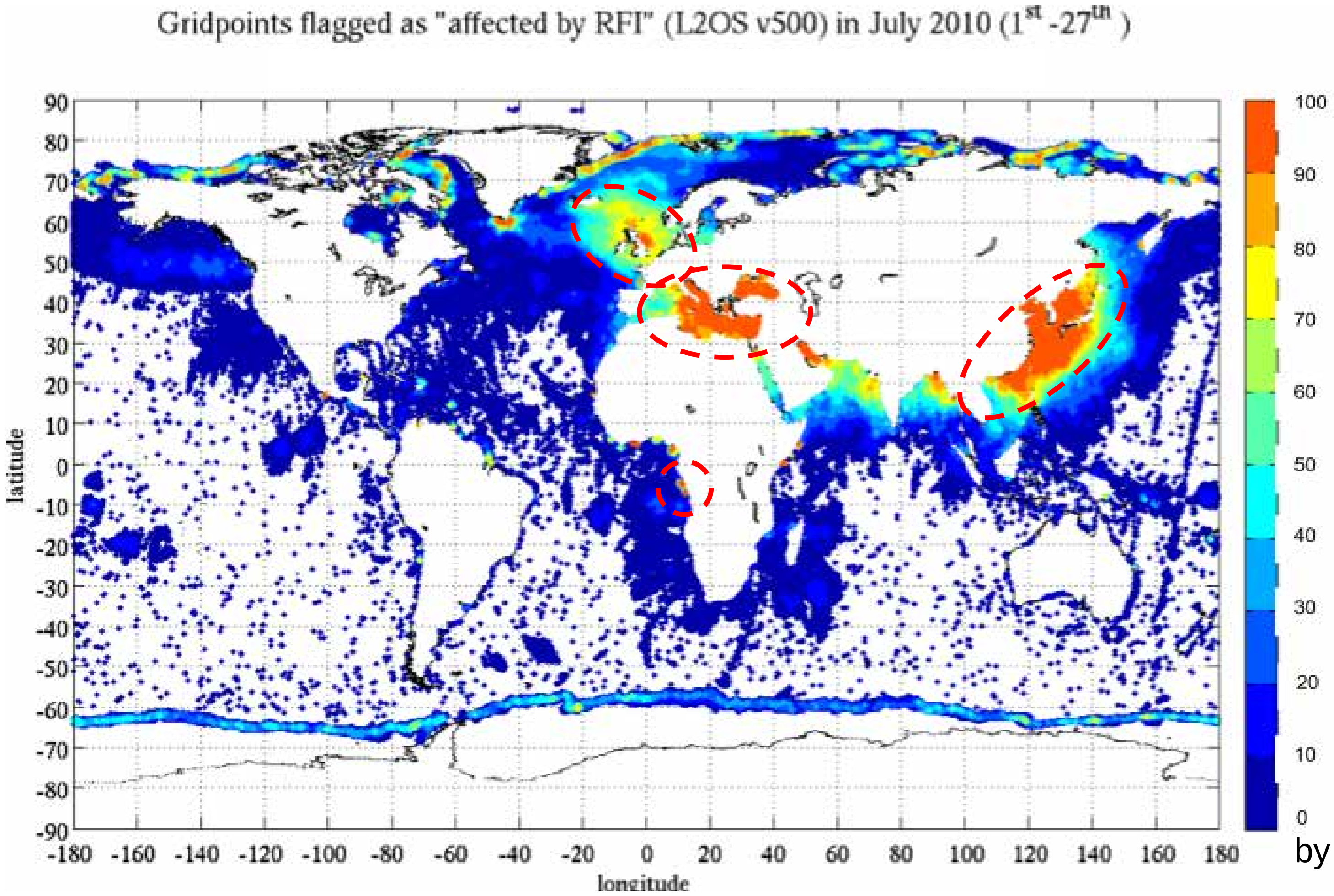


STANDARD

MODEL - INDEPENDENT



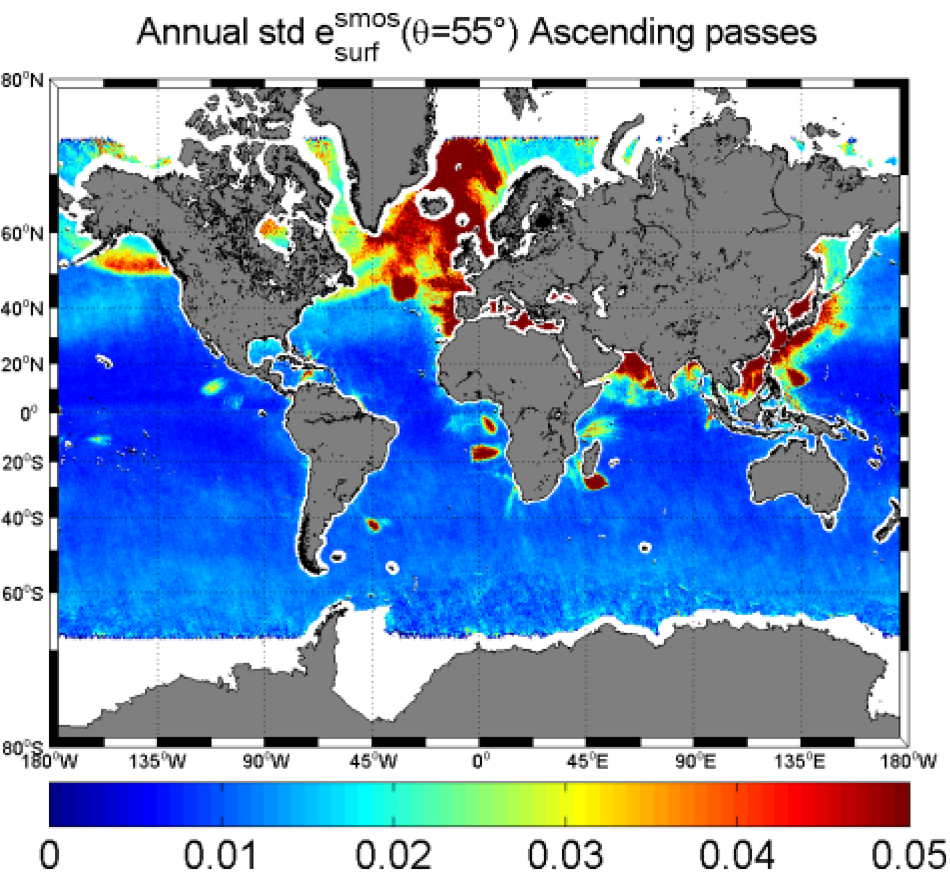
Contamination from Radio Frequency Interferences (RFI)

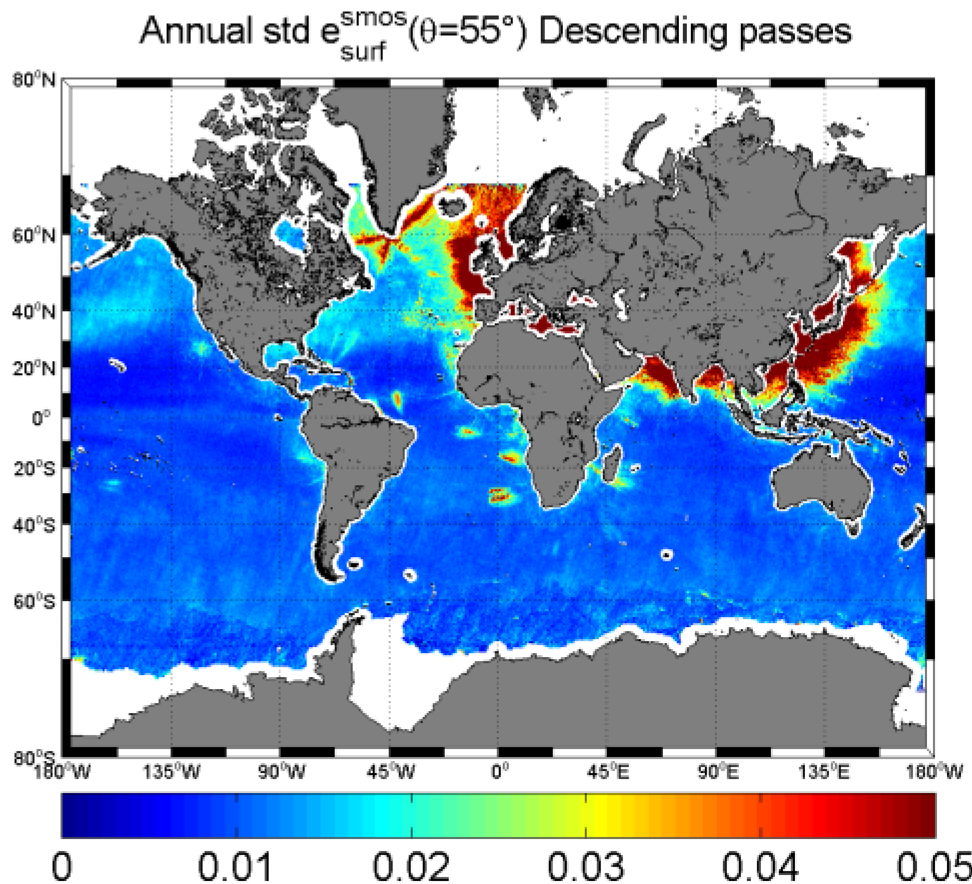


by C. Hénocq, ACRI-ST

- Emissions within the SMOS protected band (1400-1427 MHz)
- Foreseen over land, but not thought to be so strong over oceans
- Amplified due to MIRAS large incidence angles range

RFI variation with incidence angle

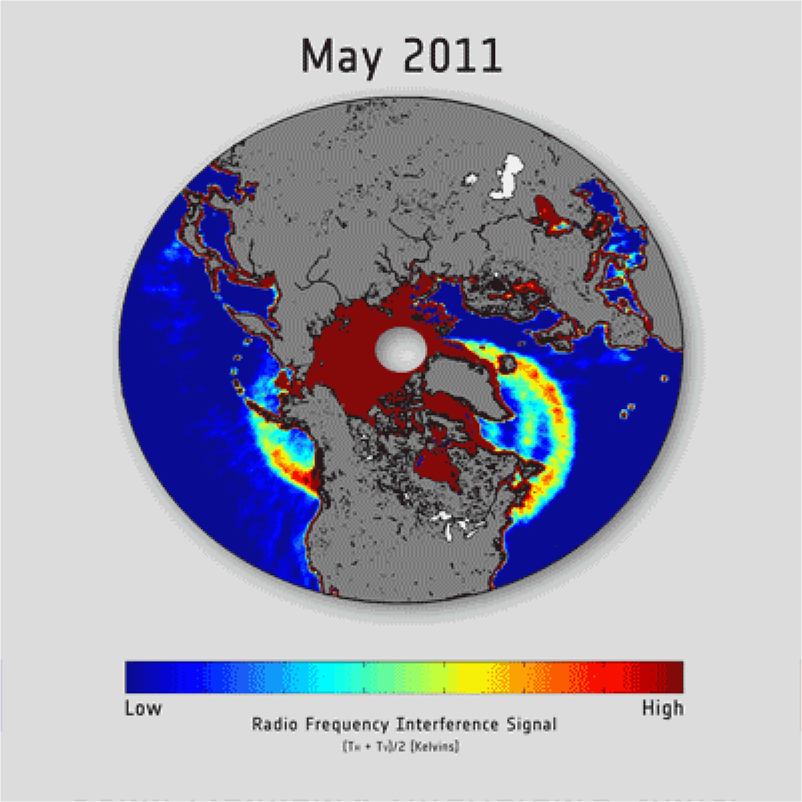




Annual variance of the surface emissivity over 2010 from 15° to 55° incidence angle for both passes (by N. Reul, IFREMER)

Areas with variances higher than 0.03-0.04 are clearly RFI-contaminated

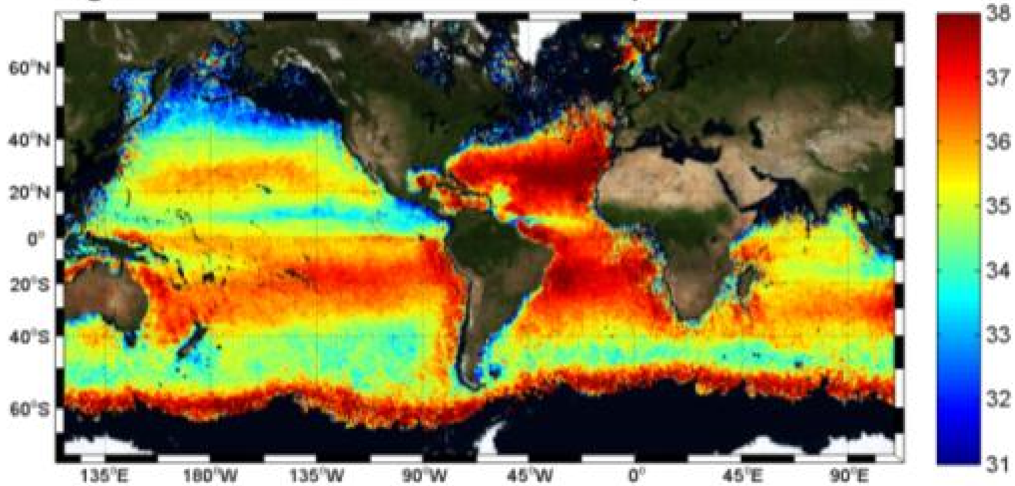
Switching off RFI sources



Credits: N. Reul, IFREMER/CATDS

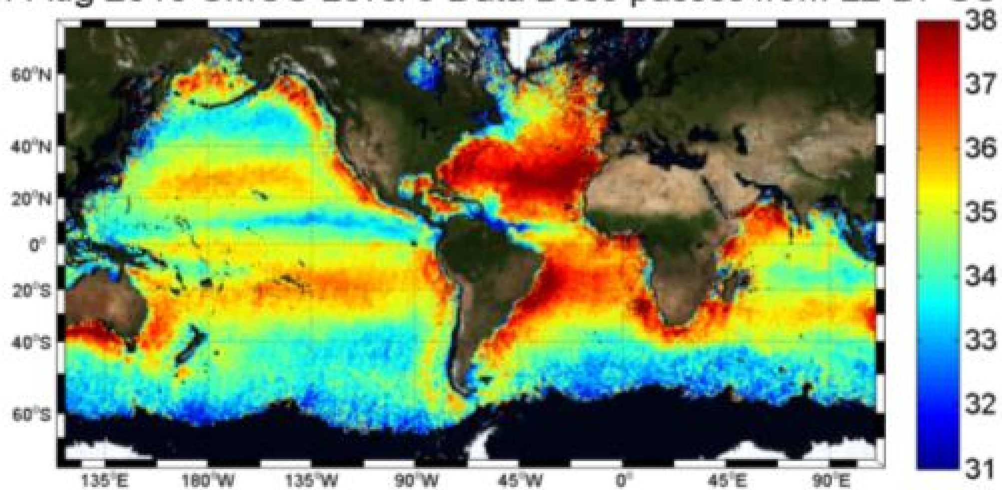
Land/Sea contamination at L1

1-31 Aug 2010 SMOS Level 3 Data Asc passes from L2 DPGS



Ascending passes

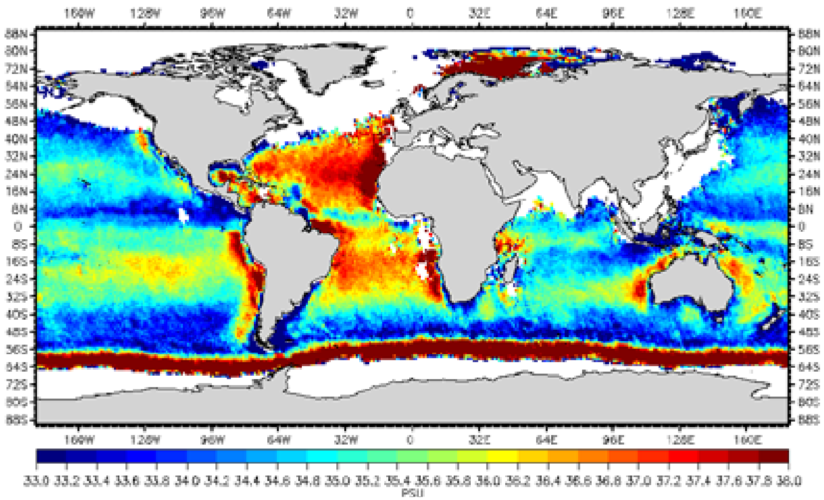
1-31 Aug 2010 SMOS Level 3 Data Desc passes from L2 DPGS



Descending passes

Reduced Land/Sea contamination at L1

L1 Commissionning Reprocessing

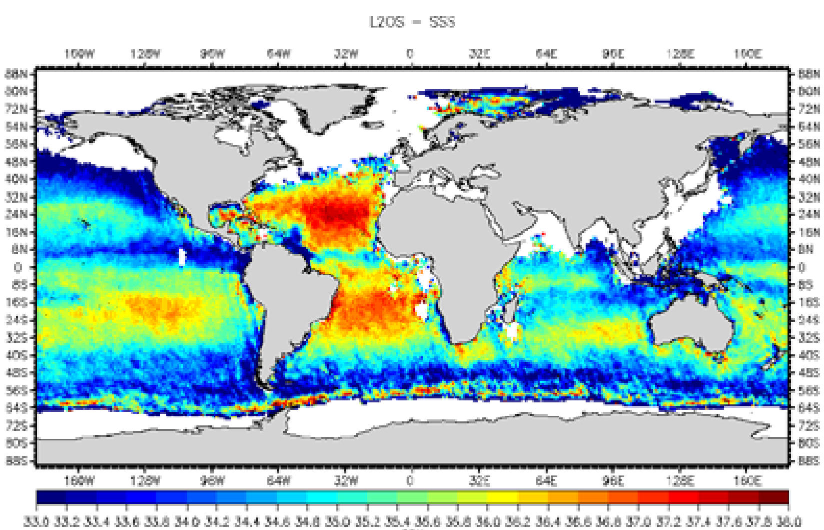


L2 v500 Ascending orbits
SSS Center swath July 2010

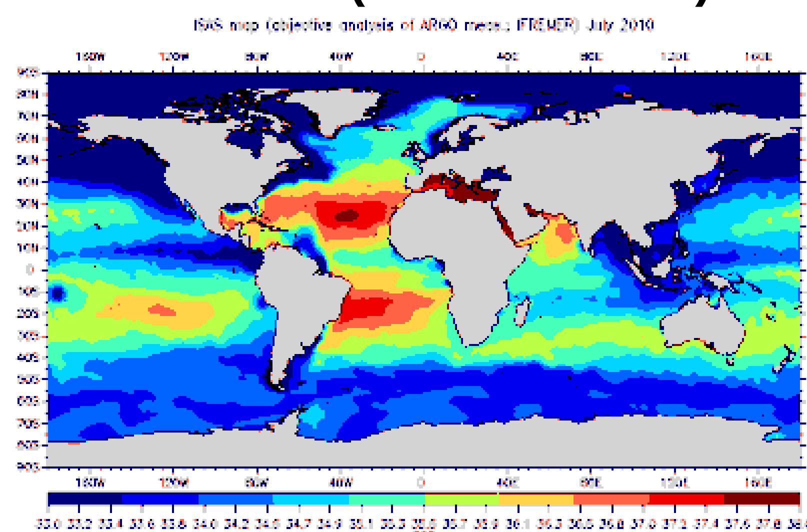
Improvement close to land and ice, but still negative biases close to land and positive biases close to ice

by J. Boutin, LOCEAN

L1 v500



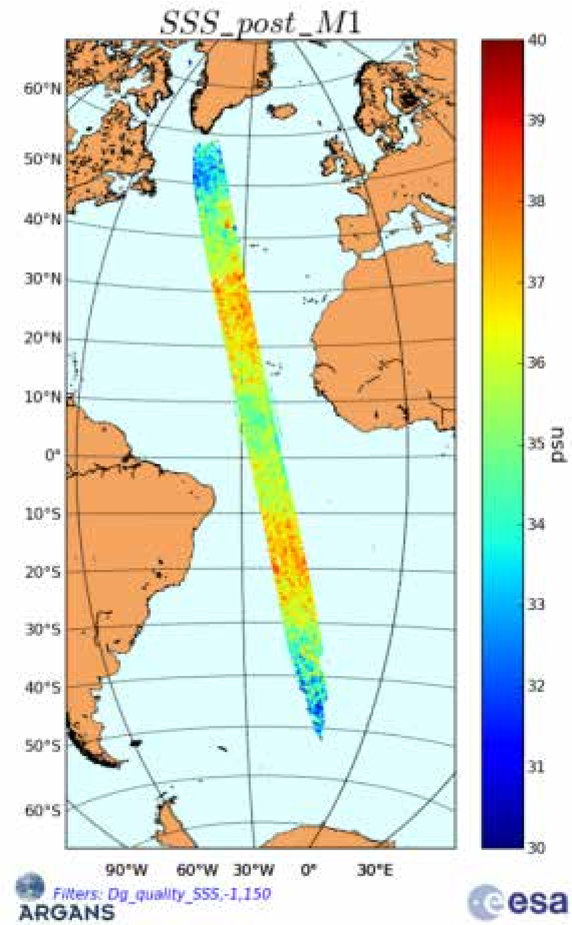
ARGO OA (Gaillard et al.)



4. L2 (SSS) features / issues / objectives

L2 Salinity Retrieval

- Bias mitigation: OTT characterization and OTT self-consistent
- L- band GMF: improvement roughness
- Auxiliary data: SST and U10 collocation and uncer TGARS, 2006]
- Cost function settings and tuning
- Full-polarimetric retrieval (T3, T4)
- Tx/Ty vs St1 (First Stokes parameter)
- AF-FOV vs EAF-FOV
- Ascending/descending passes
- Filtering/thresholds
- Sun glint
- Galactic noise
- TEC estimation (Faraday rotation)



Sample filtered L2 SSS product (credit ARGANS) - http://www.argans.co.uk/smos/pages/products.php

L2 features / issues / objectives

Cost function (i)

Inversion scheme

T_B à **SSS** single overpass

Iterative minimization algorithm à **Cost function**

$$\chi^2 = \frac{1}{N_{obs}} \left(\sum_{n=1}^{N_{obs}} \frac{\left\| F_n^{meas} - F_n^{model} \right\|^2}{\sigma_{F_n}^2} \right) + \frac{\left(SSS - SSS_{aux}\right)^2}{\sigma_{SSS}^2} + \frac{\left(SST - SST_{aux}\right)^2}{\sigma_{SST}^2} + \frac{\left(U_{10} - U_{10aux}\right)^2}{\sigma_{U_{10}}^2}$$

$$F = \left[\overline{T}_h, \overline{T}_v\right]$$

$$F = \left[\overline{T}_x, \overline{T}_y\right]$$

$$F = \left[\overline{I}\right] = \left[\overline{T}_h + \overline{T}_v\right] = \left[\overline{T}_x + \overline{T}_y\right]$$

- Levenberg-Marquardt method
- Multi-parameter (SSS, SST, U_{10}) retrieval
- Fixed upper and lower boundaries
- Semi-empirical forward model (model #3)

N_{Obs} **Number of pixel observations**

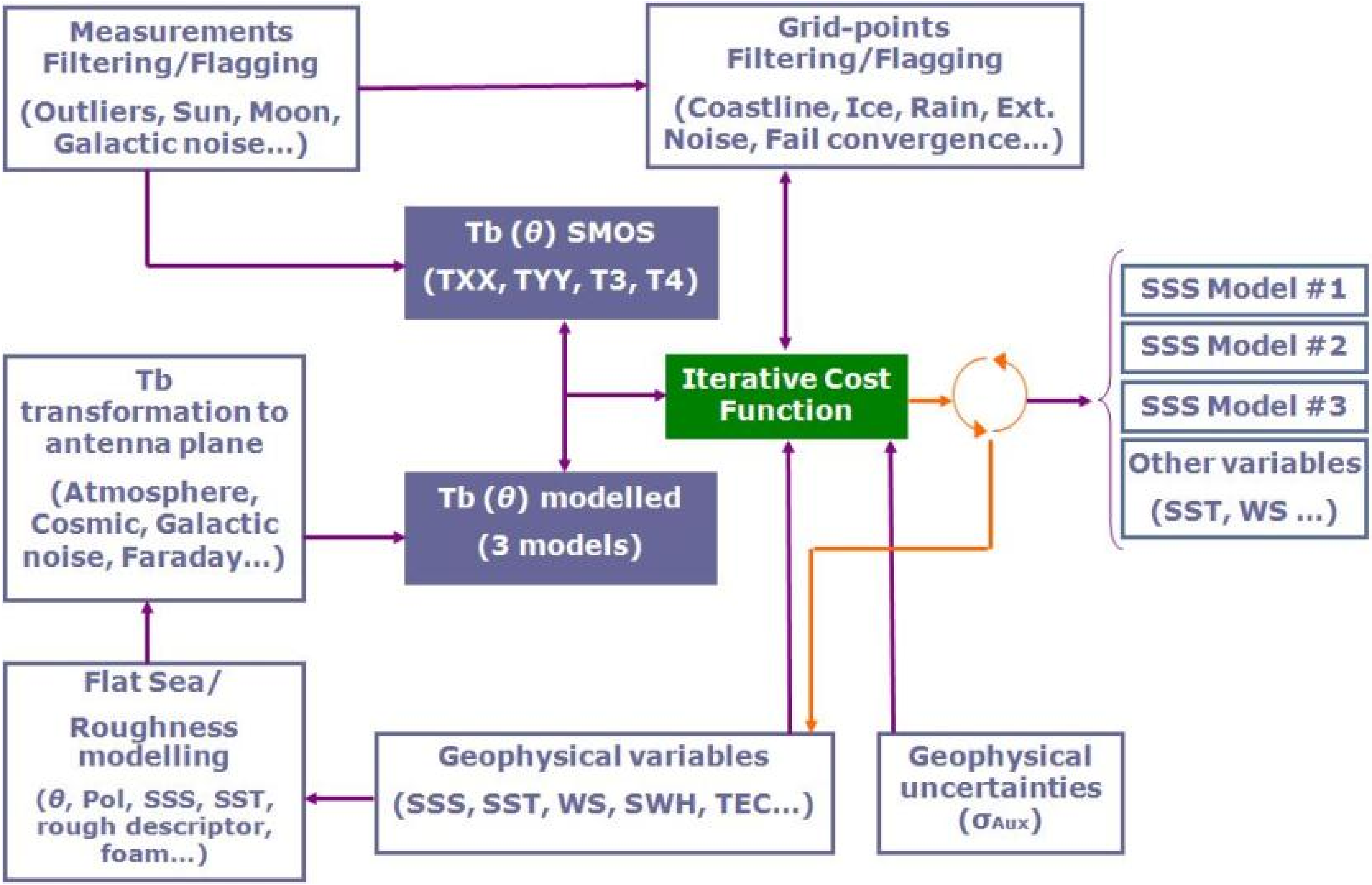
F^{meas} **SMOS measured data**

F^{model} **Forward model data**

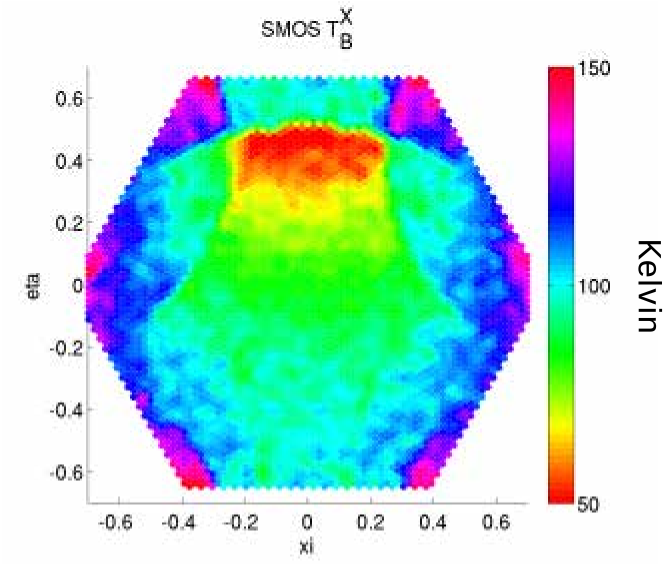
$SSS_{aux}, SST_{aux}, U_{10aux}$ **Reference auxiliary data**

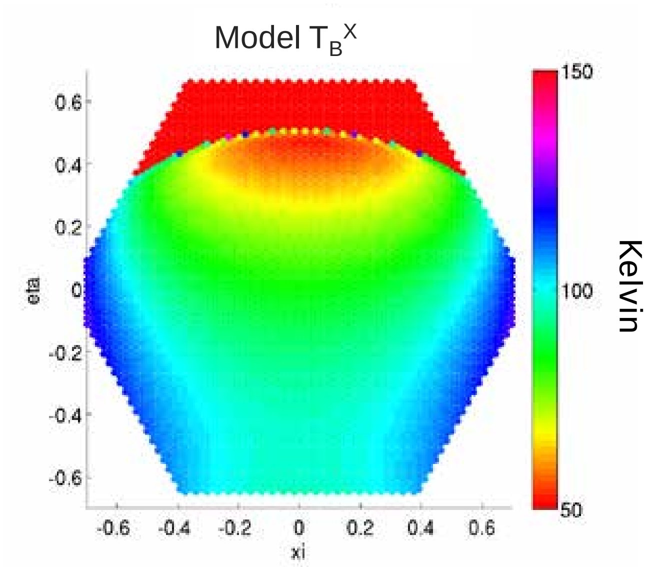
$\sigma_{SSS}, \sigma_{SST}, \sigma_{U_{10}}$ ***A priori* prescribed auxiliary data errors**

Flowchart


Measurements Filtering/Flagging
(Outliers, Sun, Moon, Galactic noise...)
Grid-points Filtering/Flagging
(Coastline, Ice, Rain, Ext. Noise, Fail convergence...)
Tb (θ) SMOS
(TXX, TYY, T3, T4)
Iterative Cost Function
SSS Model #1
SSS Model #2
SSS Model #3
Other variables
(SST, WS ...)
Tb transformation to antenna plane
(Atmosphere, Cosmic, Galactic noise, Faraday...)
Tb (θ) modelled
(3 models)
Flat Sea/
Roughness modelling
(θ, Pol, SSS, SST, rough descriptor, foam...)
Geophysical variables
(SSS, SST, WS, SWH, TEC...)
Geophysical uncertainties
(σAux)

Over a given ensemble of observations, the departure between reconstructed and modeled T_B is minimized to infer the surface geophysical parameters.

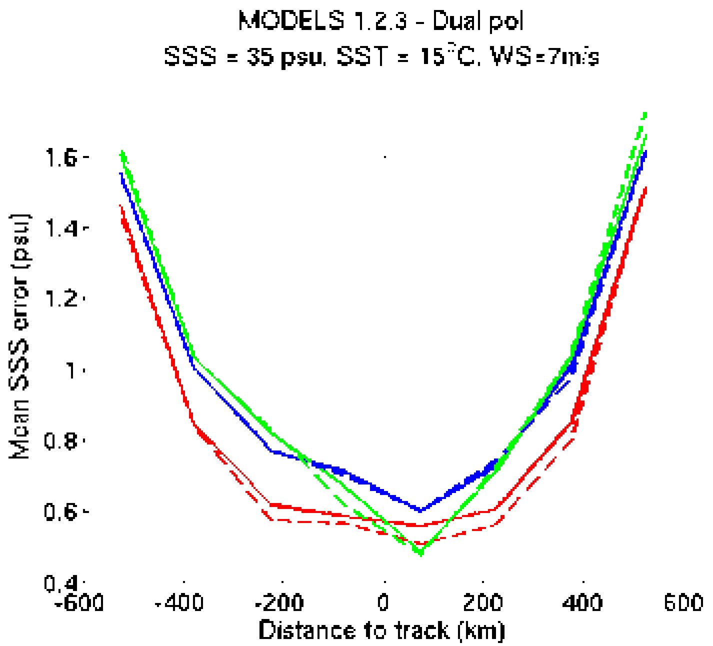




by J. Gourrion

- emission from a flat dielectric sea surface (SST,SSS)
  - + effect of a rough surface (surface wind)
  - + celestial reflection
  - + atmospheric effects
  - + change of polarization frame

L2 SSS official processor



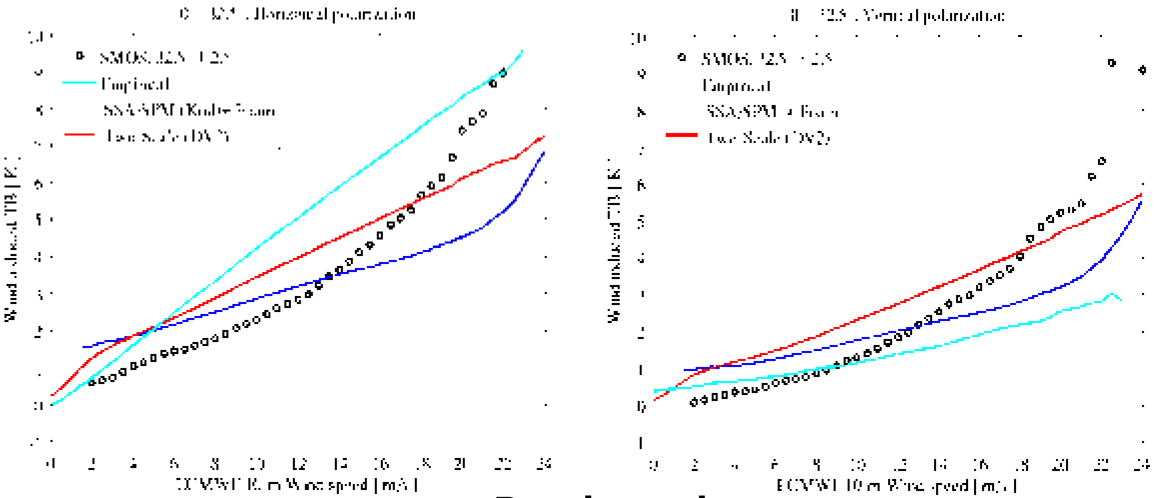
- **Sea surface emissivity models**
- **Dielectric constant** of sea water [Klein and Swift, 1977]
- **Roughness** models
  - Model 1: [Dinnat et al., 2002] (2-scale, Durden-Vesecky spectrum × 2)
  - Model 2: [Johnson and Zhang, 1999] (SSA, Kudryavtsev spectrum)
  - Model 3: [Gabarró et al., 2004] (empirical, f (WS, SWH, U*, Ω, MSS)
- **Foam** (Reul and Chapron, 2003)

- **Additional parameterizations**
- **Atmosphere**: [Liebe, 1993]
- **Faraday rotation**: [Waldteufel et al, 2004]
- **Sky radiation**: reflected / scattered
- **Sun glint**: [Reul et al., 2007]

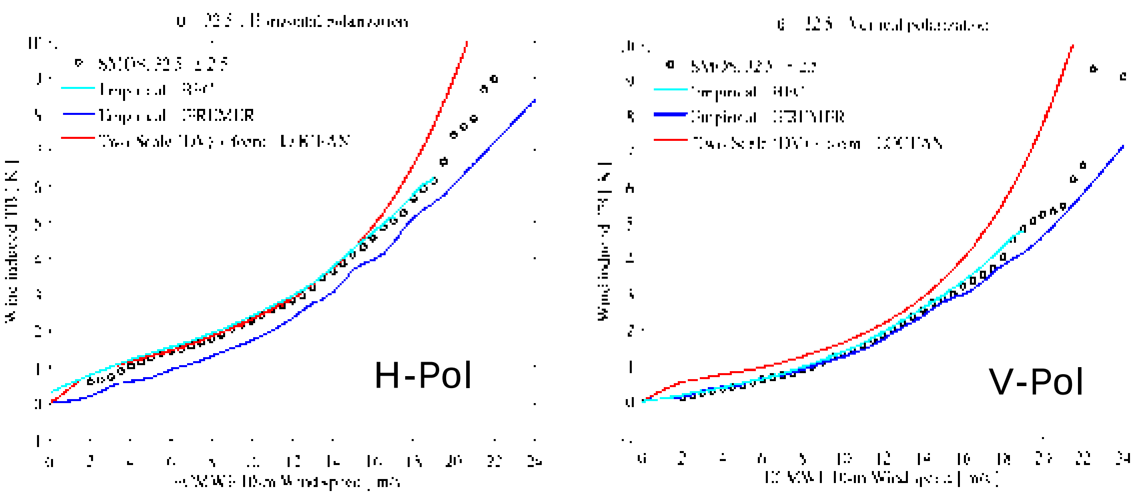
- Three days (84 semi-orbits) needed for full Earth coverage
- Level 2 expected to be very noisy, especially in the outer swath. Average needed to meet mission requirements (Level 3)

Forward models improvement

Pre- and post-launch roughness models fit to SMOS data



Pre-launch



Post-launch

Wind induced excess TB at θ=32.5 ° (3 models and SMOS data)

Pre-launch: misfit wrt ECMWF wind speed sensitivity

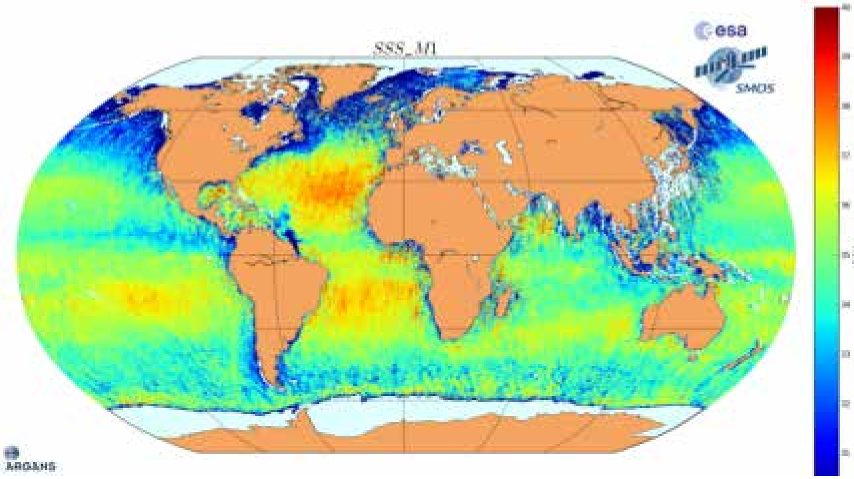
Tuned after analysis of SMOS data: relatively good agreement

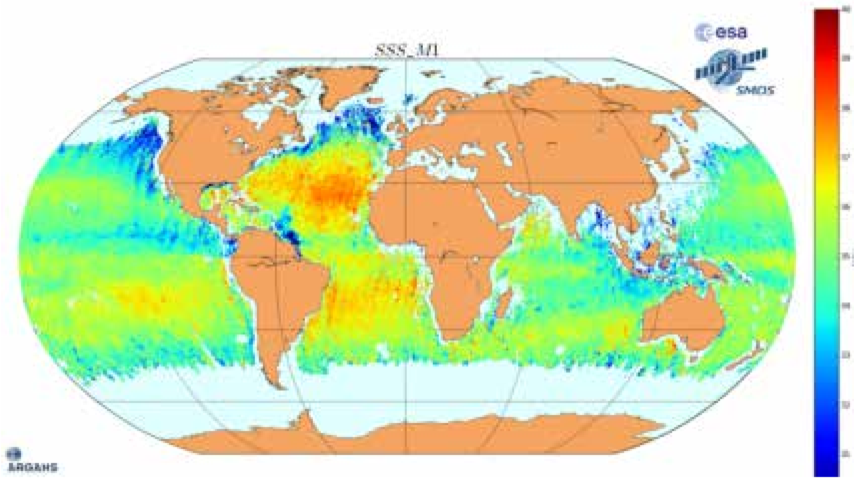
Noticeable non-linear behavior with wind speed

L2 OS UDP: for each GP (ISEA4H9, approx. 15 km):

- Time and Geographical coordinates, Aux/retrieved parameters:
  - 3 SSS, Acard, SST, WS, TB_42.5,
  - Theoretical uncertainties
- 27 control flags (retrieval conditions)
  - e.g. num. outliers above threshold
- 31 confidence descriptors
  - e.g. quality index for retrieval fit
- 22 science flags (geophysical cond.)
  - e.g. wind range (low, medium, high)

SMOS Level 2 and Auxiliary Data Products Specifications (SO-TN-IDR-GS-0006)

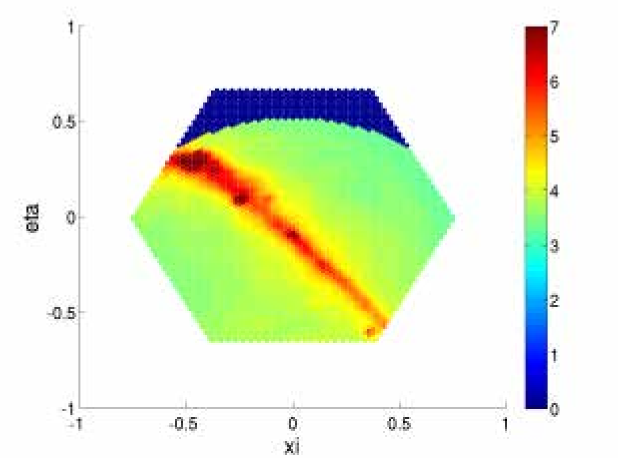




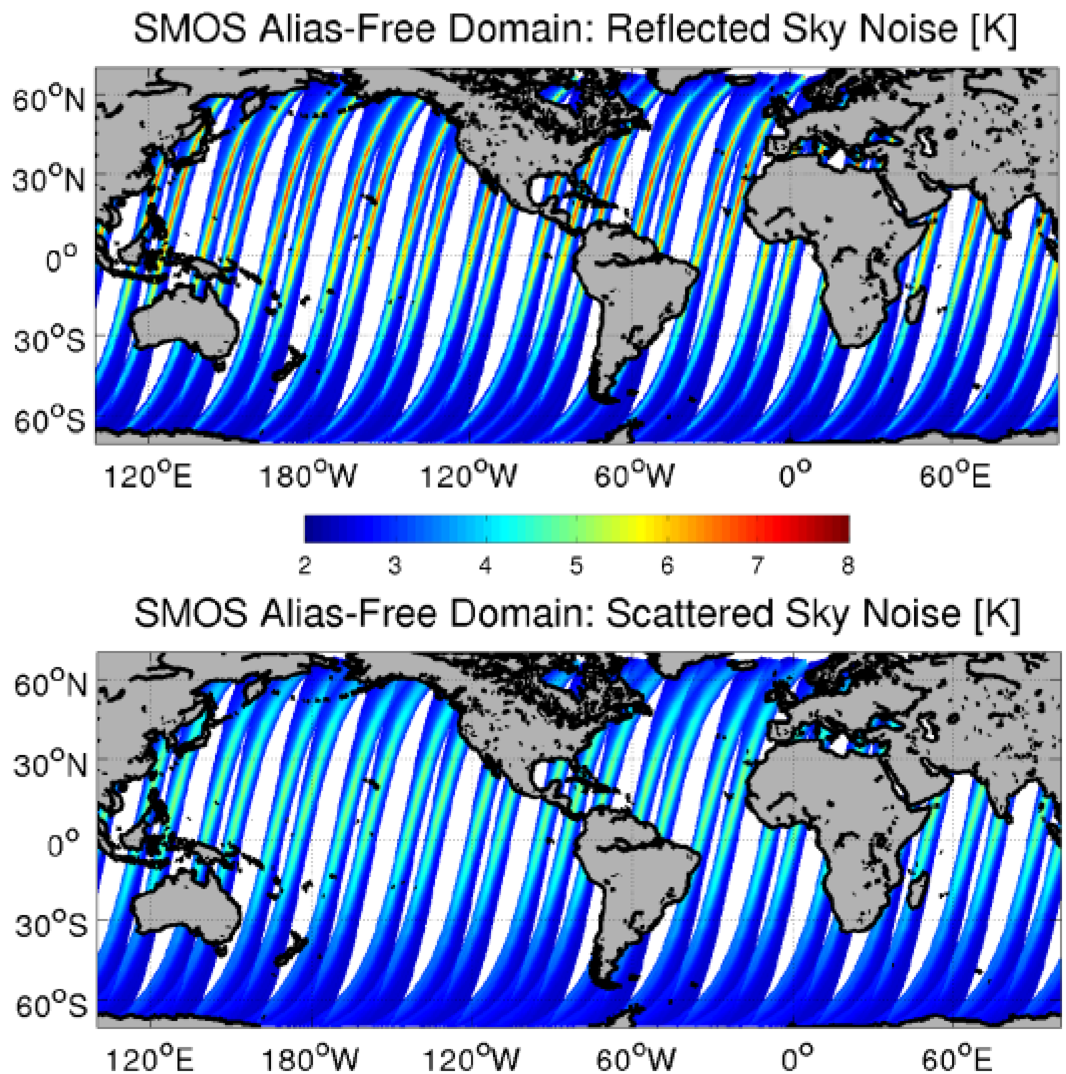
Galactic noise correction

Celestial sky noise (with galactic plane) impact on SMOS measurements depends strongly on:

- Overpass direction (A/D)
- Year timeline
- Surface roughness

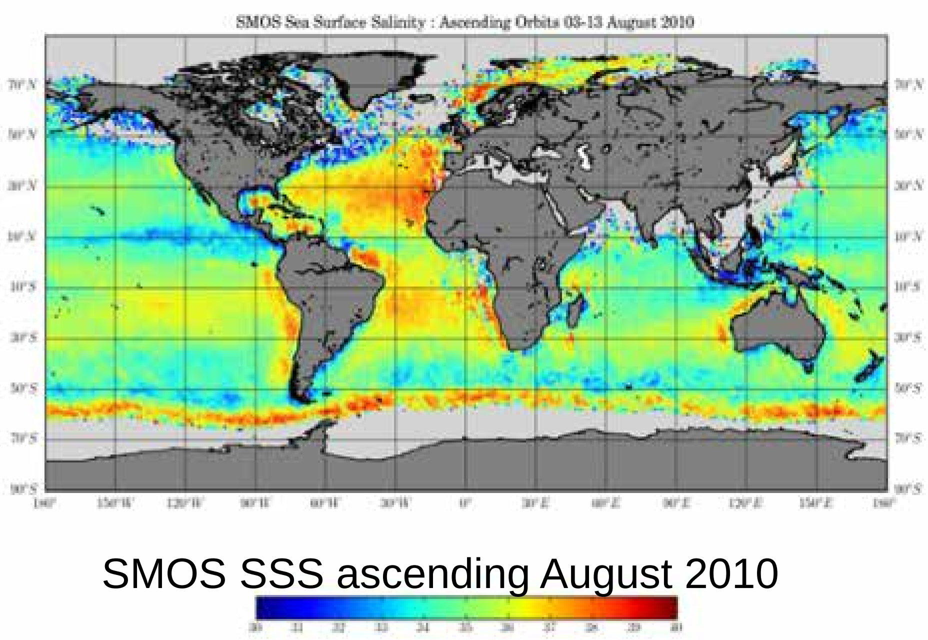


Celestial Sky noise contaminated by Galaxy plane

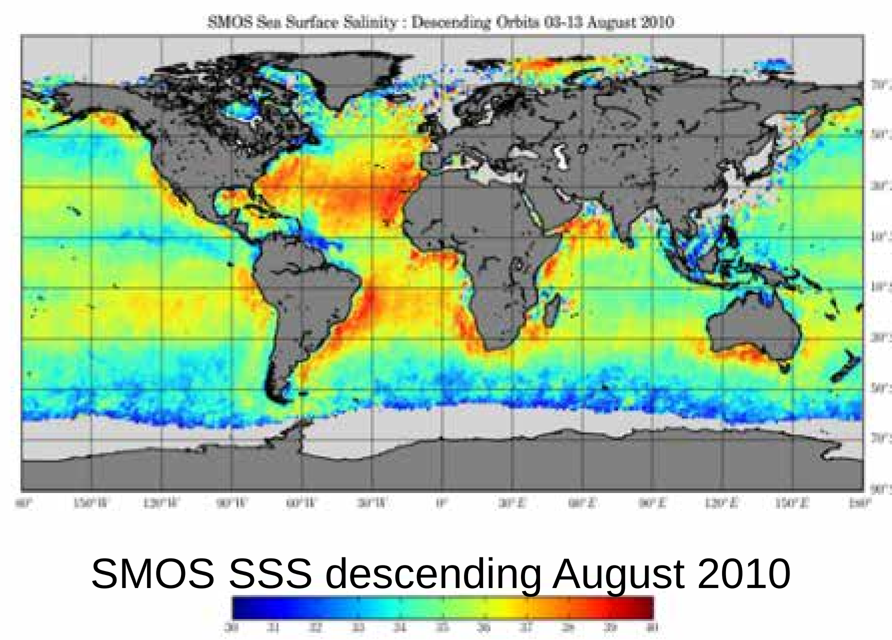


by J. Tenerelli, CLS

Asymmetry Ascending/Descending passes



SMOS SSS ascending August 2010



SMOS SSS descending August 2010

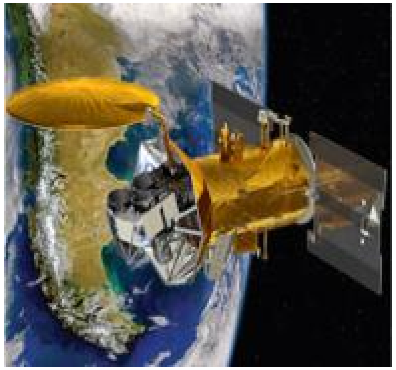
by J. Boutin, LOCEAN

- Different land contamination impact
- Different Sun position wrt spacecraft (antennas heating)
- Different Galactic noise reflection
- Instrument orbital drift

5. L3 (avg SSS) features / issues / objectives

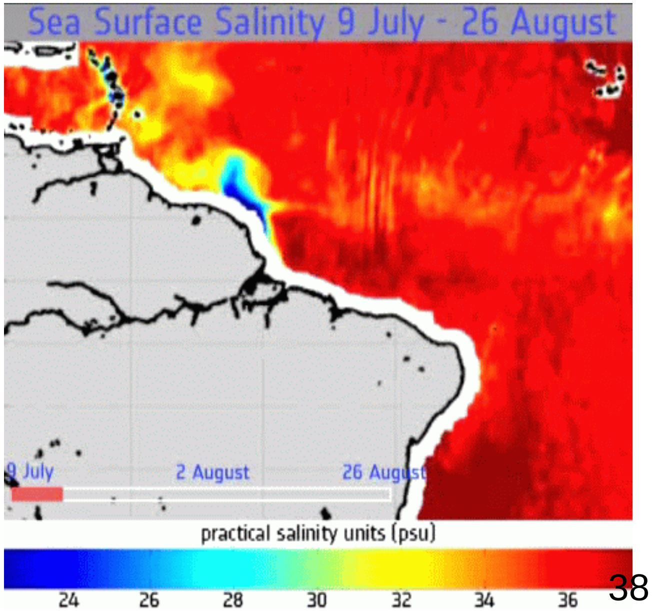
SSS retrieval issues/objectives: L3/L4

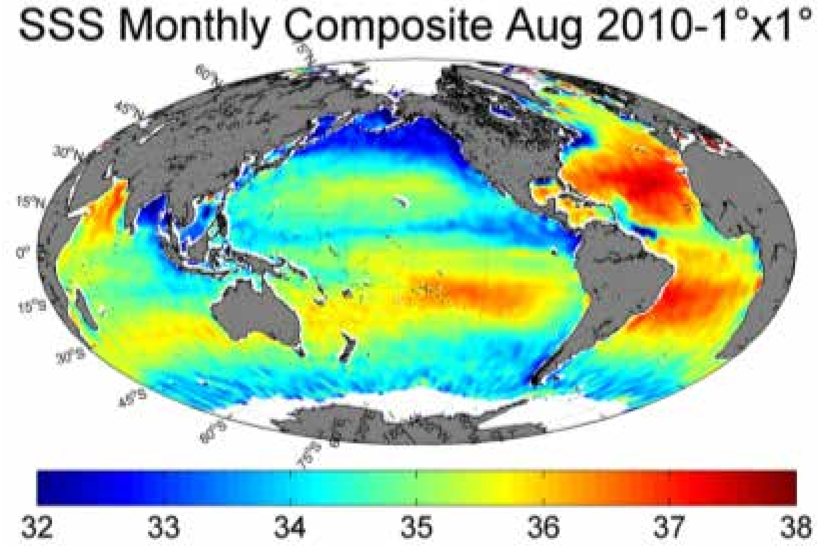
- L3 maps weighted vs OI
- Representativeness of SSS misfit derivation vs climatology
- Validation in-situ/models
- Data Assimilation
- Vertical gradients SSS
- L4 Aquarius synergy
- L4 T/S diagrams; Density



Aquarius/SAC-D comparison

Amazon plume detection, IFREMER



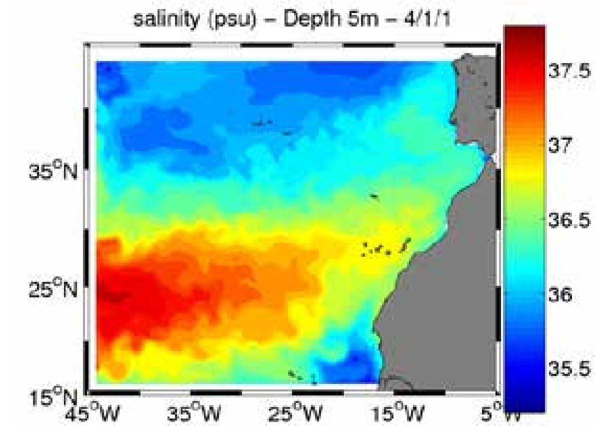


L3 features / issues / objectives

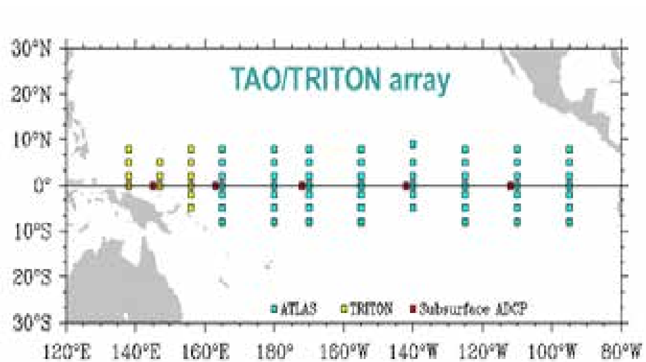
SSS validation

SMOS Validation

- **SMOS product to product comparison**
  - Fixed platforms
  - Cruises, VOS
  - Drifters
  - ARGO
- **SMOS product to external data comparison**
  - *In situ* data
  - model data
    - HYCOM
    - HYCOM
    - Mercator

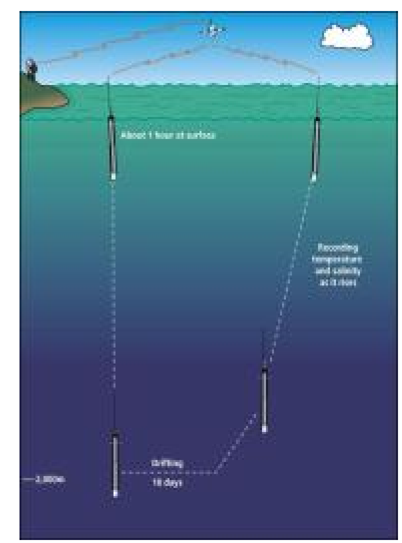


Validation versus models



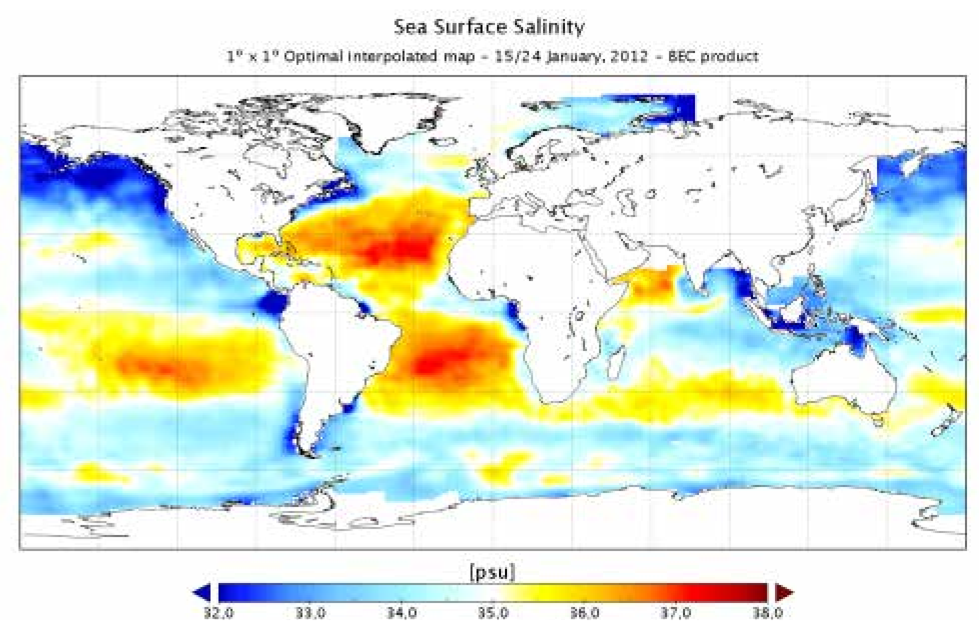
Moored buoys

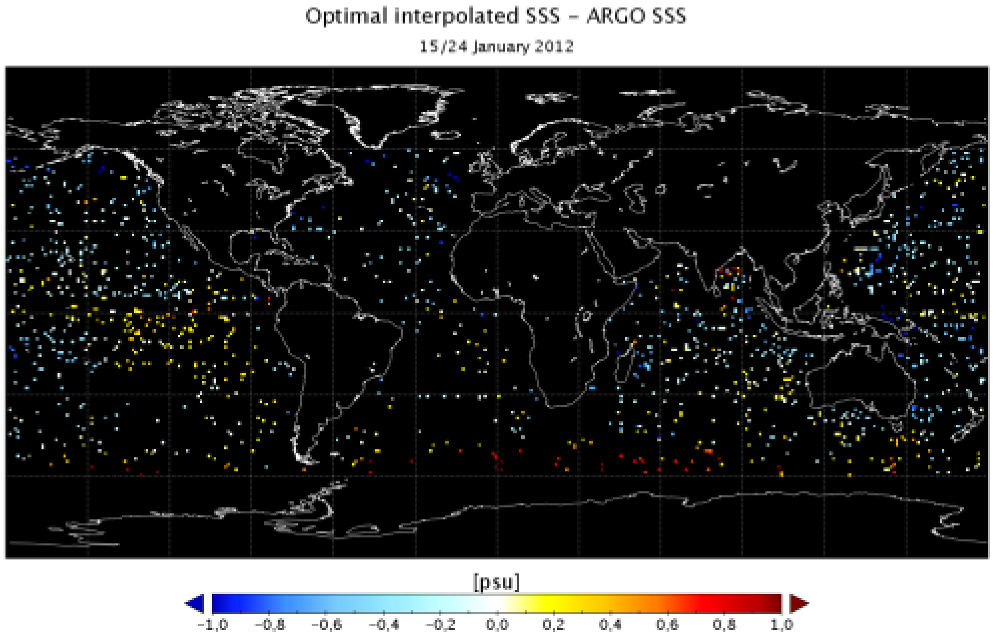
VOS network



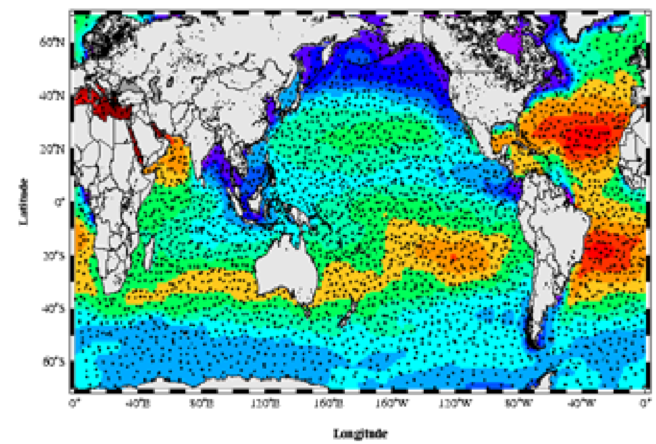
ARGO "lifestyle"

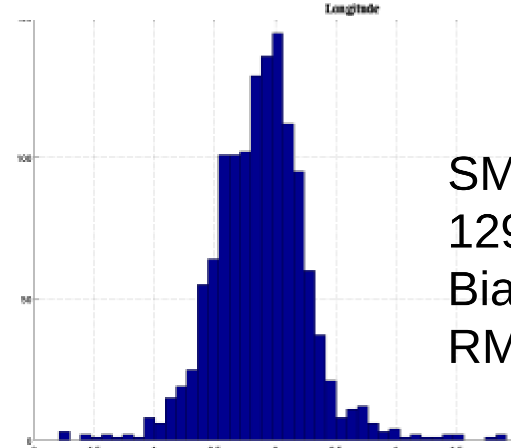
L3 features / issues / objectives
Global SMOS OS validation





- SMOS OS L3 BEC map 1ºx1º
- Optimal Interpolation using WOA2009 as background
- 15-24 Jan. 2012
- Argo SSS interpolated at **-7.5 m**

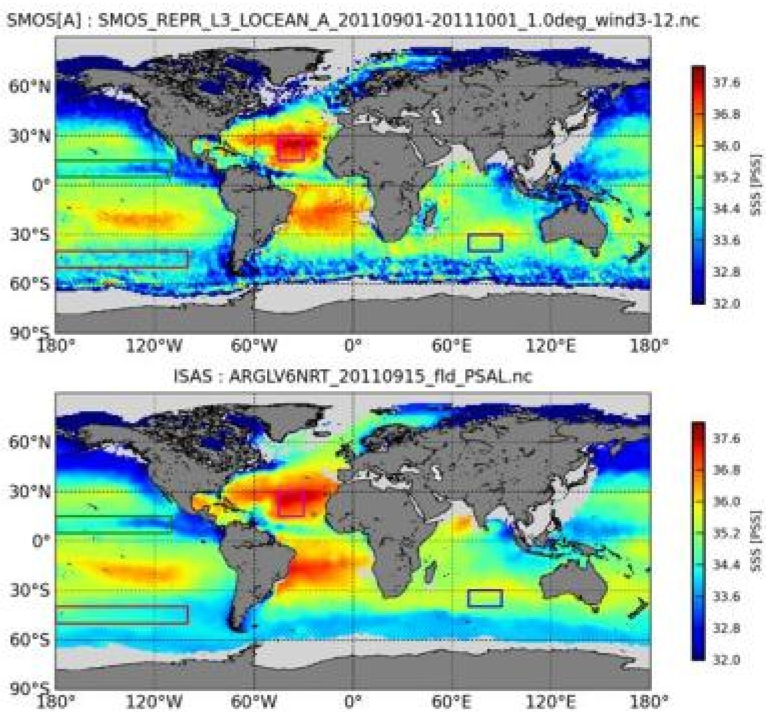




SMOS - Argo
1299 points
Bias = -0.11
RMS = 0.42

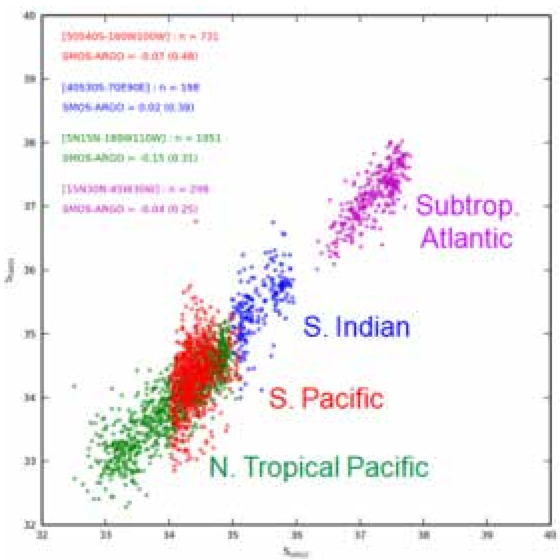
by J. Martínez, ICM/SMOS-BEC

: ARGO regional comparisons



SSS September 2011
SMOS (up), Argo (bottom)

- SMOS ascending orbits, Monthly 1º maps
- ±300 km
- 3-12 m/s wind



Bias	- 0.04
	0.02
	- 0.07
	- 0.15
STD	0.25
	0.38
	0.48
	0.31

by J. Boutin et al., LOCEAN

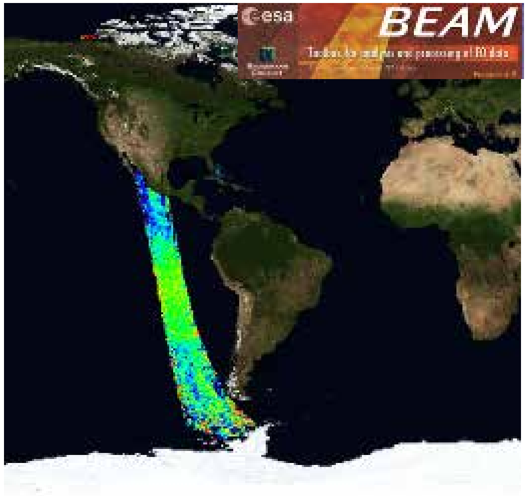
L3 features / issues / objectives
SSS performances at decreasing SST - Approach

- **Adequate spatio-temporal averaging (L3) of the retrieved SSS has to be performed to meet the proposed accuracy of the mission.**

- **Higher latitudes: low SST and decreased T_B sensitivity to SSS**

  TB Sensitivity to SSS: 0.5 K/psu at 20 ˚C
  TB Sensitivity to SSS: 0.25 K/psu at 5 ˚C

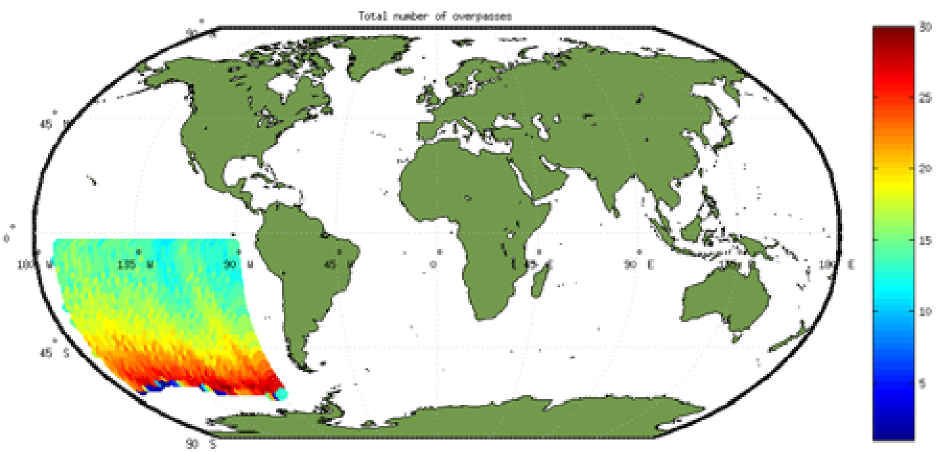
- **Nevertheless, improvement in the L3 accuracy at higher latitudes is expected, due to the increased number of sampled pixels**



Sample L2 SSS retrieval

$$\sigma_{L3theo} = 1/\sqrt{N} * \sigma_{L2}$$

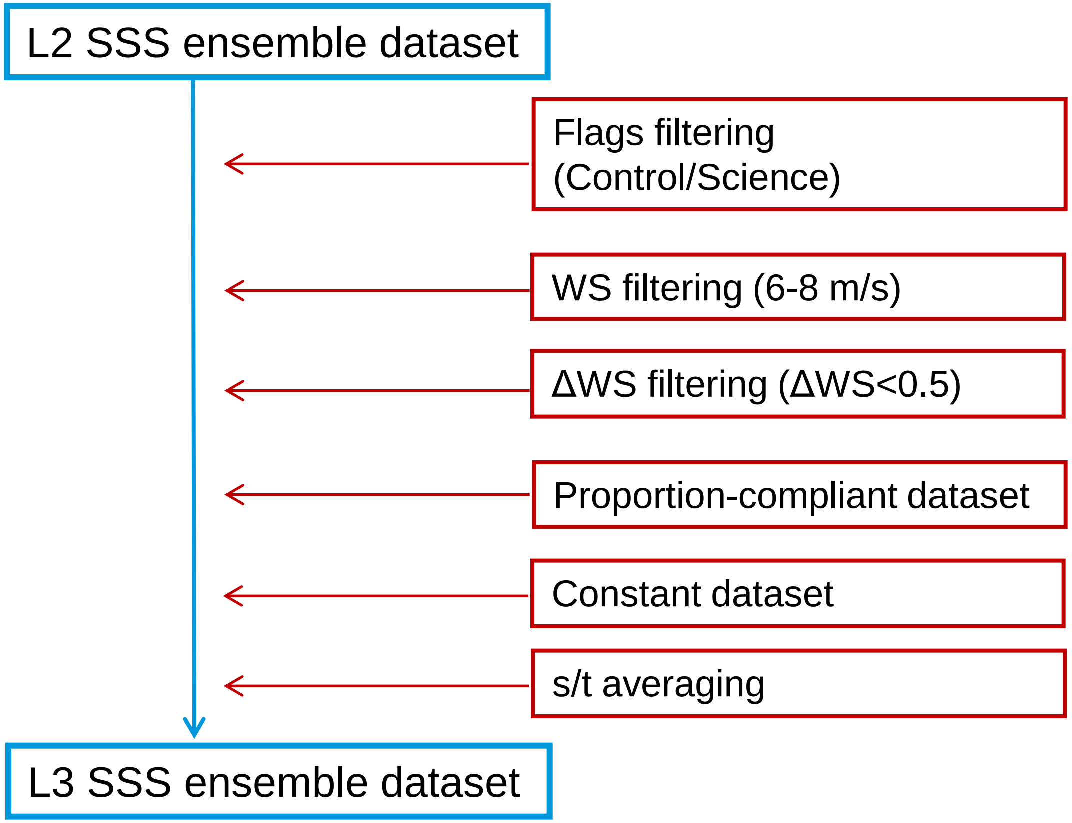
The trade-off between the geophysical effects at low SST and the concomitant temporal oversampling is meant to be evaluated.



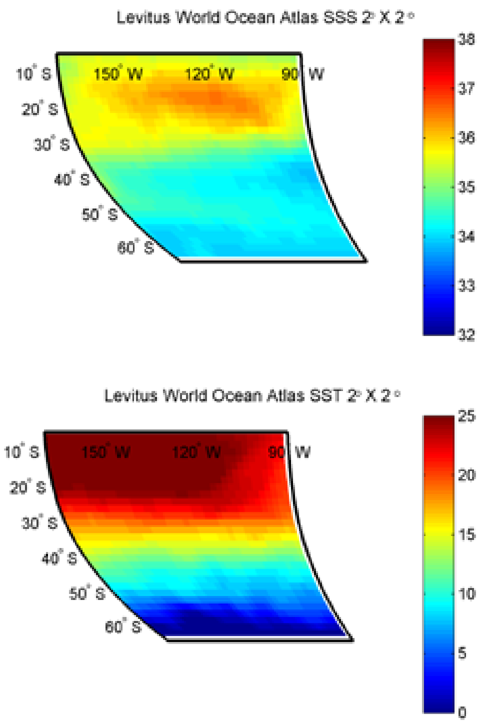
Overall number of overpasses

A. Cristo, Univ. Extremadura, Spain, staigiaire ESRIN

- **Meridional transect spanning from 5º to 55º S (five bands) over 50° Longitude range.**
- **36 days of reprocessed L2 SSS data (two sub-cycles) in Nov. 2010, resulting in about 160 ascending overpasses. Area restricted to pixels away from islands. Averaging boxes in km.**
- **Two kind of weights applied to build L3 SSS:**
  - **Number of L1 valid measurements Dg (W1)**
  - **L2OS processor error - 1/σL2 (W2)**

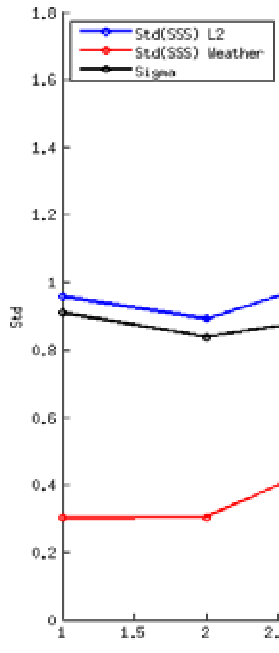


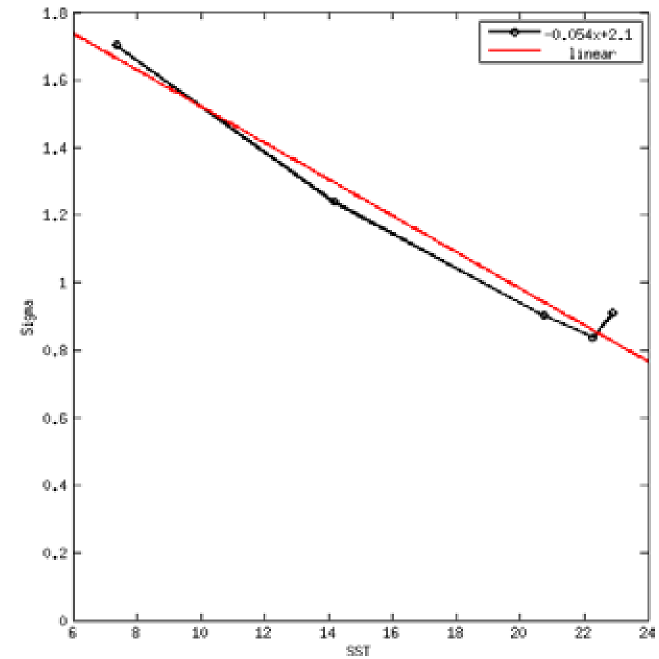
- **σ(SSS) per band, removing the intrinsic variability of the field.**
- **For each band, mean SST is computed. Ratio σ SSS/SST estimated**
- **Predominant effect of degraded sensitivity at cold SST**



Climatology (WOA 2005)

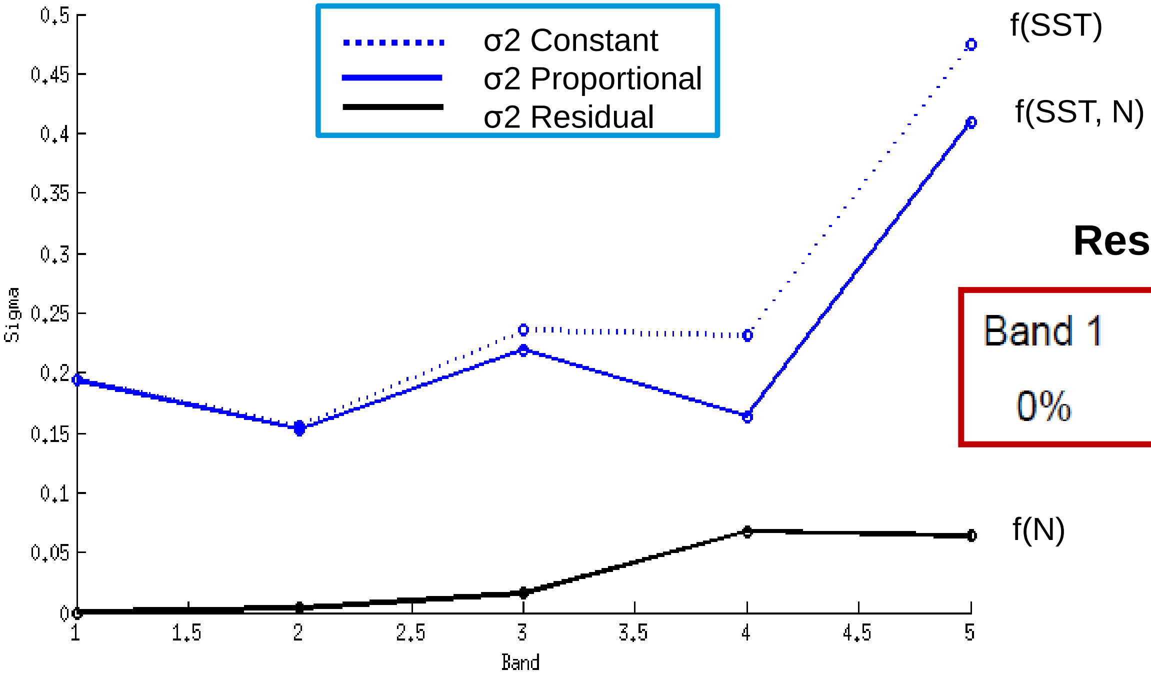
SSS (top) and SST (bottom) fields





Δ σL2/ Δ SST= -0.054 psu/C deg

- **Variance (SSS) per band for both proportion-compliant and constant datasets**
- **By comparison, the net oversampling effect is quantified**



Residual net effect oversampling

Band 1	Band 2	Band 3	Band 4	Band 5
0%	2.03%	6.71%	29.21%	13.54%

L2 SSS retrieval error increases at higher latitudes due to low sensitivity at cold waters; quantitative rate of changes with ΔSST studied (intrinsic field variability and wind effect removed).

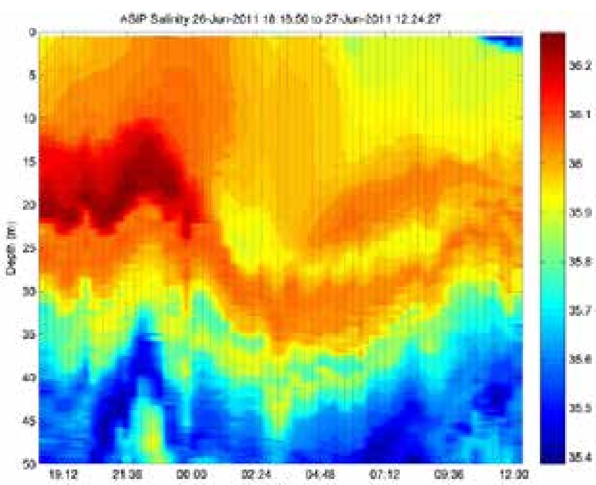
L2 SSS latitudinal worsening is not compensated by the enhanced sampling at L3. Quantitative estimation of the net error reduction due to oversampling.

Computed σL3 is noticeably higher than theoretical, due to spatial correlation patterns.

SSS Vertical structure

- Questioning the vertical SSS structure derived from ARGO-buoys
    - Surface-salinity vs Skin-salinity
    - Rain cells issue

Air / Sea Interaction Profilers (ASIP)

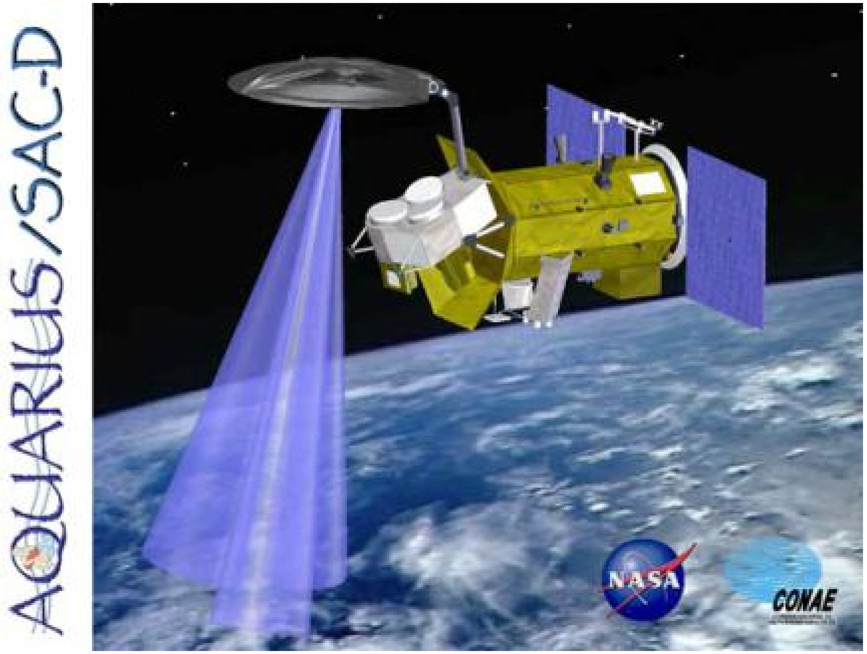


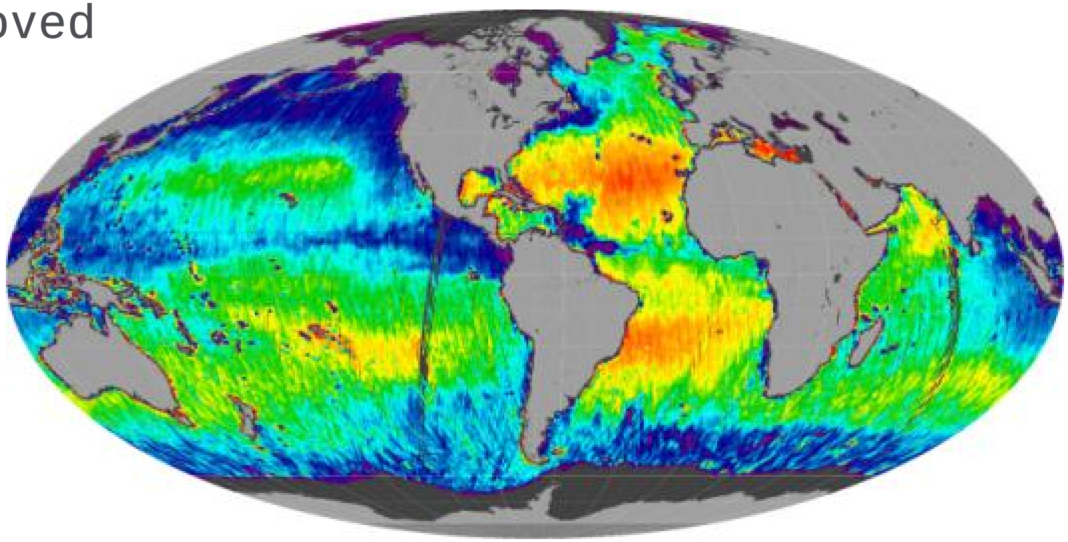
- Autonomous profiling instrument measuring the upward salinity vertical distribution up to the ocean-atmosphere interface
- Provides insights in the current knowledge of the near-surface salinity structure
- Assesses ocean surface salinity gradient decoupling the validation measurement (usually at 1 m depth vs the remote measurement at 0.5 cm depth).

The Air-Sea Interaction Profiler (ASIP)

The Aquarius Mission

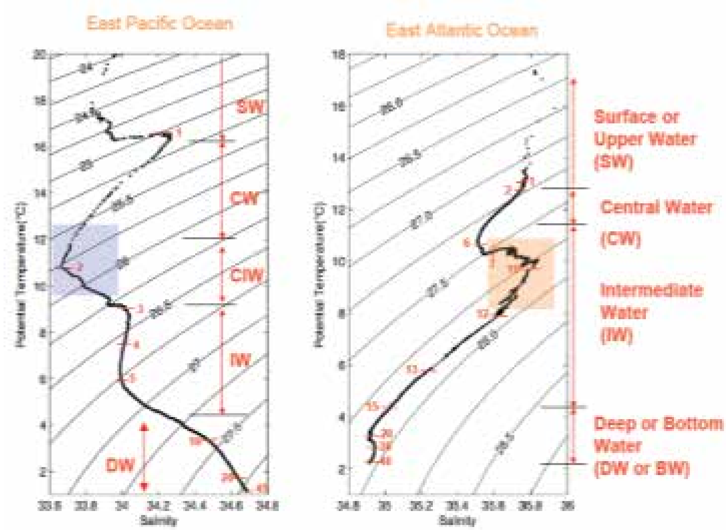
- Joint US/Argentinian mission (ocean salinity only)
- Launched June 2011
- 3 beam push-broom system
  - Well-proven technology but poorer radiometric and spatio-temporal resolution
  - 0.2 psu, 150 km, monthly
  - Payload includes L-band scatterometer for coincident roughness data (Improved geophysical model)



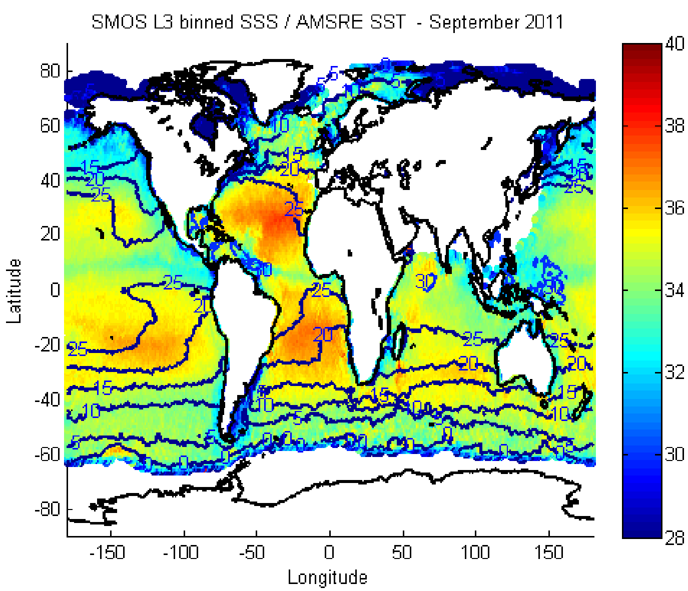


Satellite-based T/S diagrams
Approach

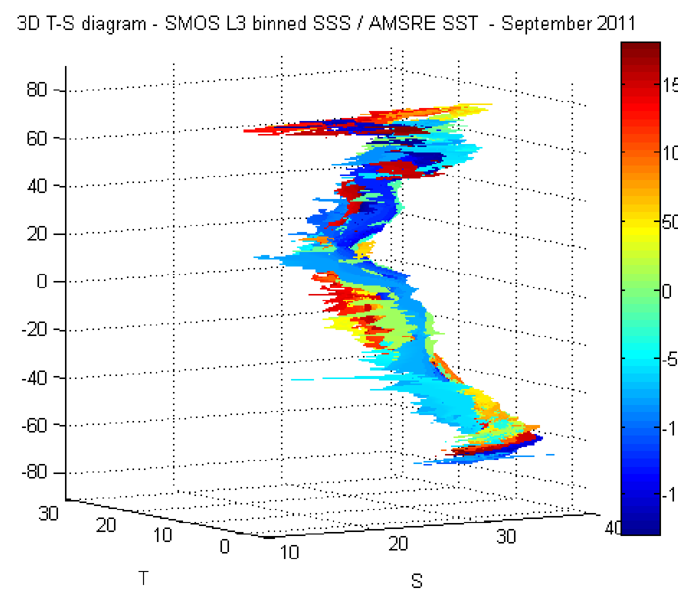
- T/S diagrams: canonical tools used in oceanography to identify and trace water masses
- Attempt of deriving purely satellite-based T/S diagrams (profiting from SMOS)
- A baseline T-S diagram is sketched from climatology data (WOA 2005) to analyze geographical mismatches wrt satellite data



Typical T/S diagrams (by C. Chen)

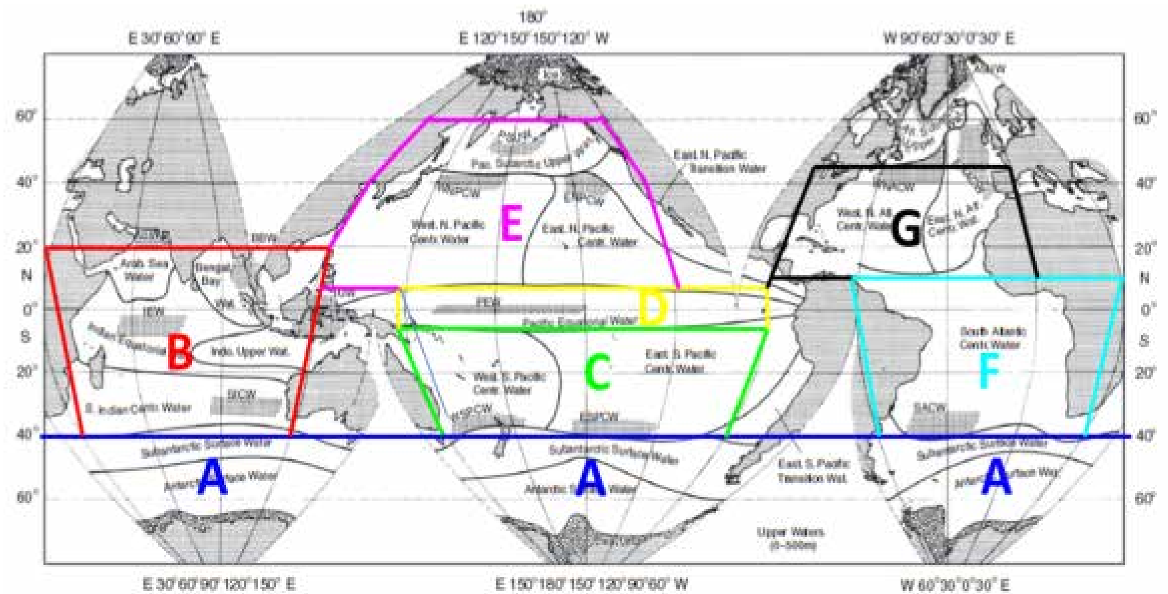


Lat-Lon domain



T-S domain

Clustering methodology



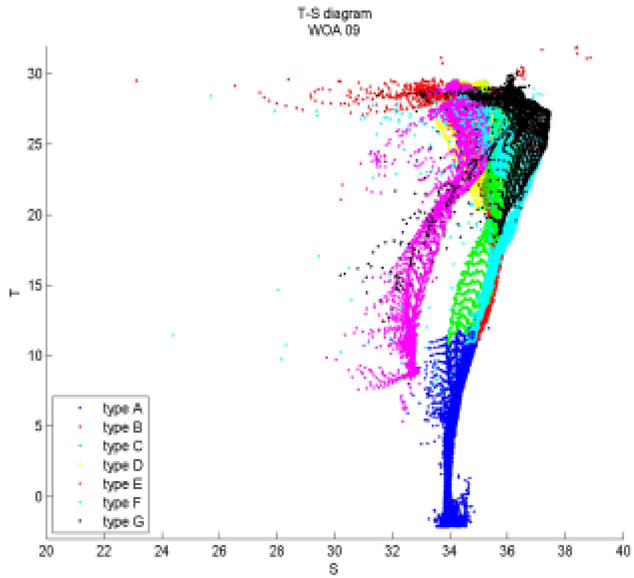
19 upper water masses according to [Emery, 2003] clustered into 7 oceans regions

- Type A - SubAntarctic Surface Water (SASW) + Antarctic Surface Water (AASW)
- Type B - South Indian Central Water (SICW) + Indian Equatorial Water (IEW) + Indonesian Upper Water (IUW) + Arabian Sea Water (ASW) + Bengal Bay Water (BBW)
- Type C - Western South Pacific Central Water (WSPCW) + Eastern South Pacific Central Water (ESPCW)
- Type D - Pacific Equatorial Water (PEW)
- Type E - Western North Pacific Central Water (WNPCW) + Eastern North Pacific Central Water (ENPCW) + Pacific Subarctic Upper Water (PSUW)
- Type F - South Atlantic Central Water (SACW)
- Type G - Western North Atlantic Central Water (WNACW) + Eastern North Atlantic Central Water (ENACW)

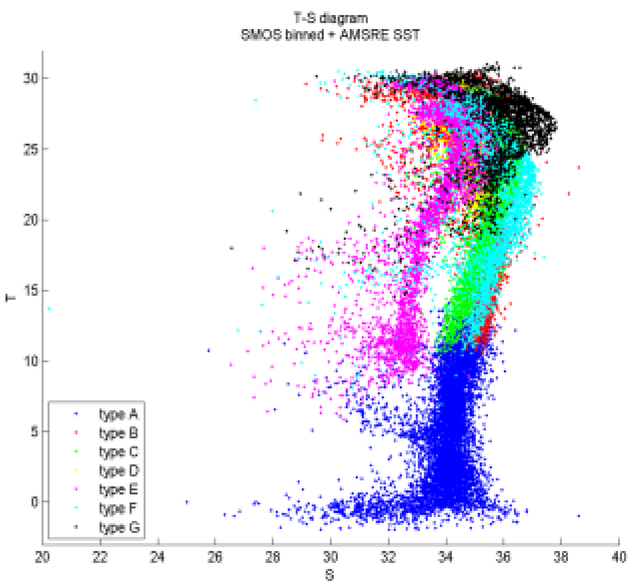
Overall T/S diagrams

Segmentation of the T-S maps into several geometric locii of T-S mutual relationships

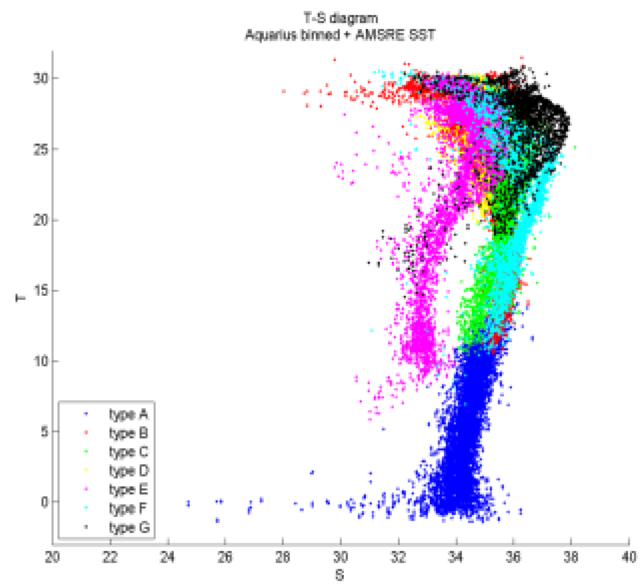
WOA 2009 clima



SMOS

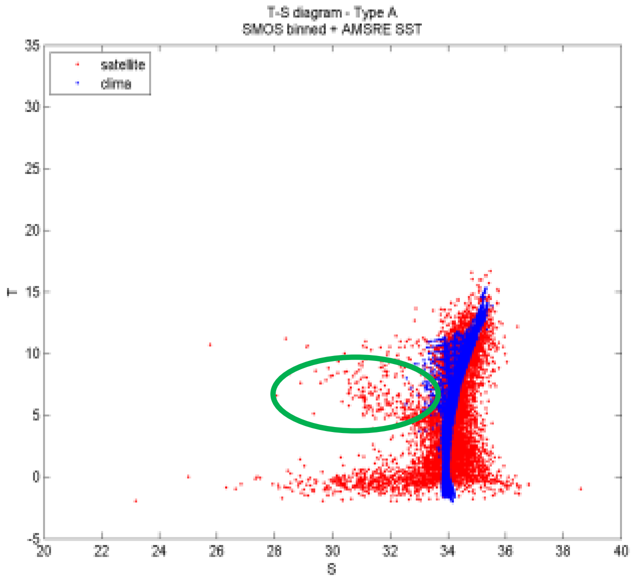


Aquarius

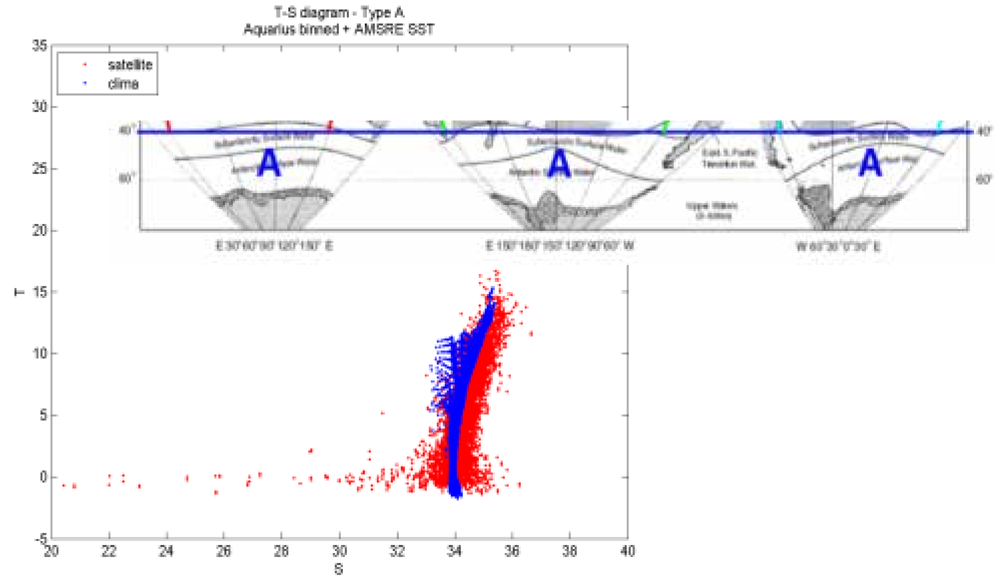


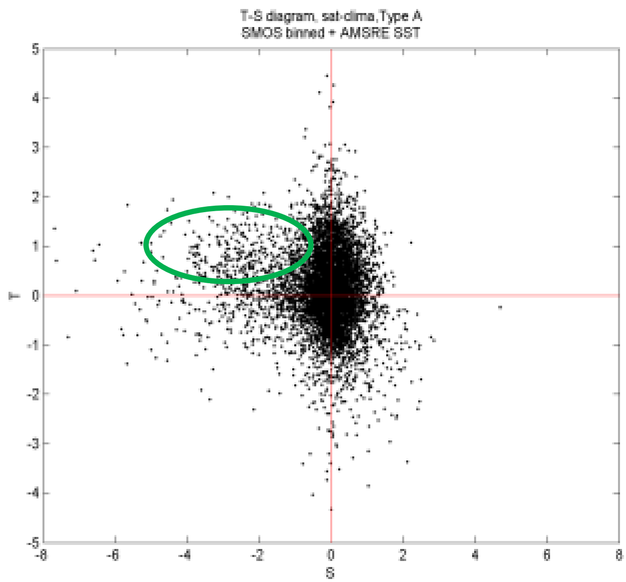
T/S diagrams - Type A

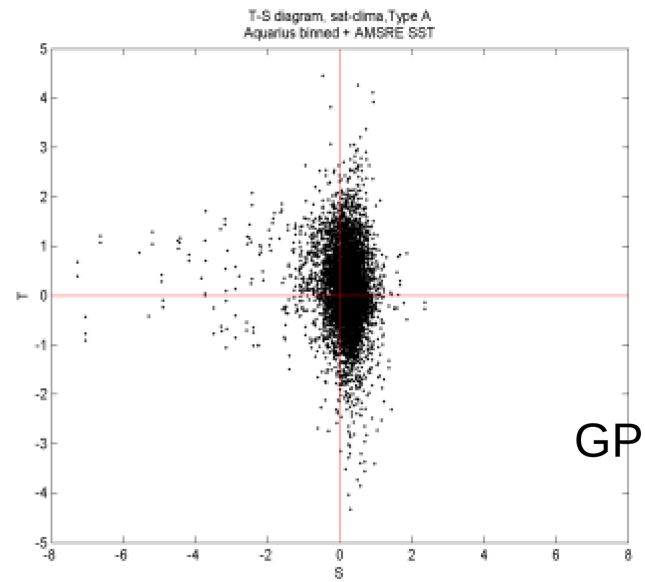
SMOS



Aquarius



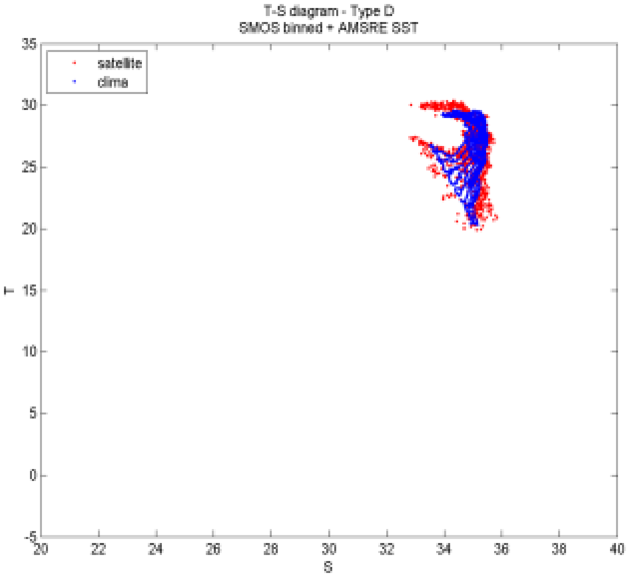




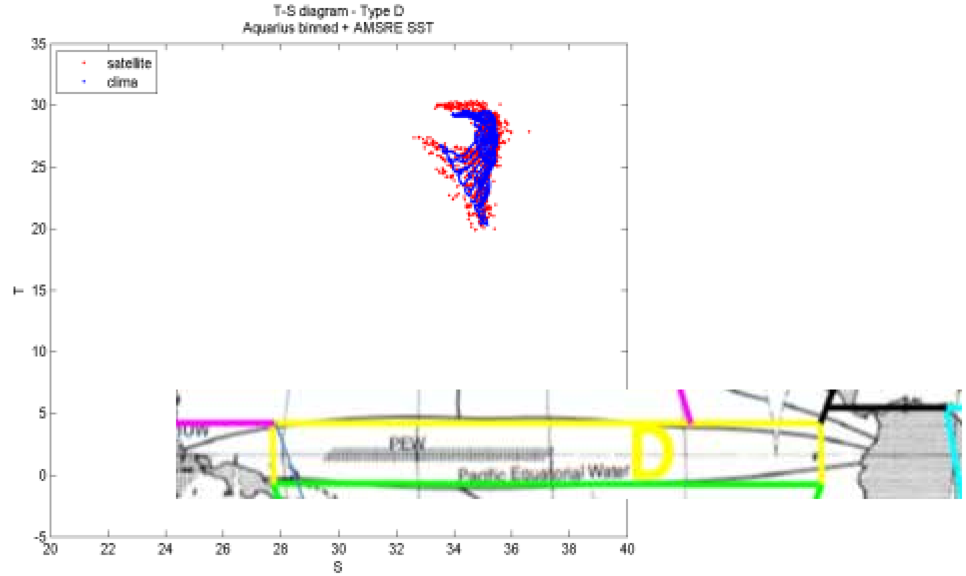
GP mismatches

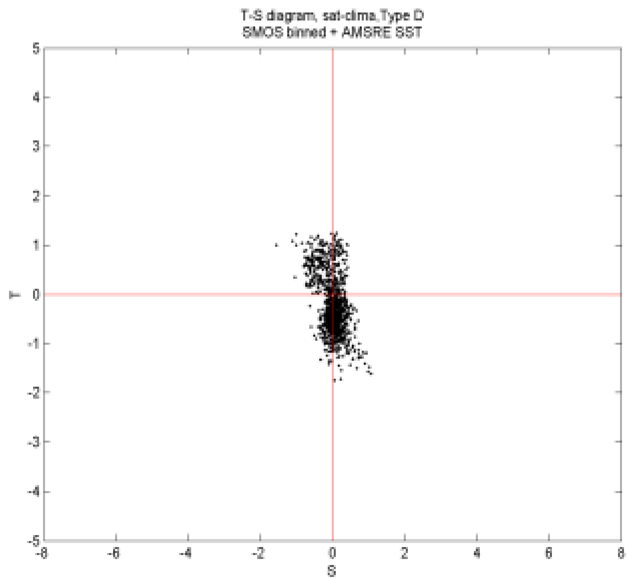
T/S diagrams - Type D

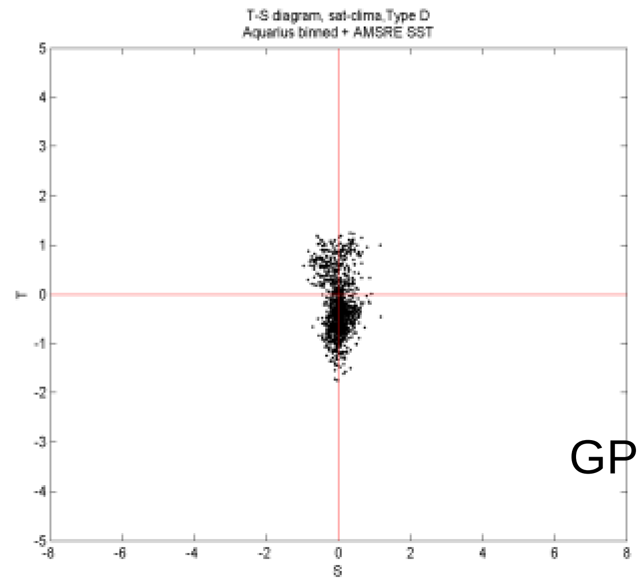
SMOS



Aquarius

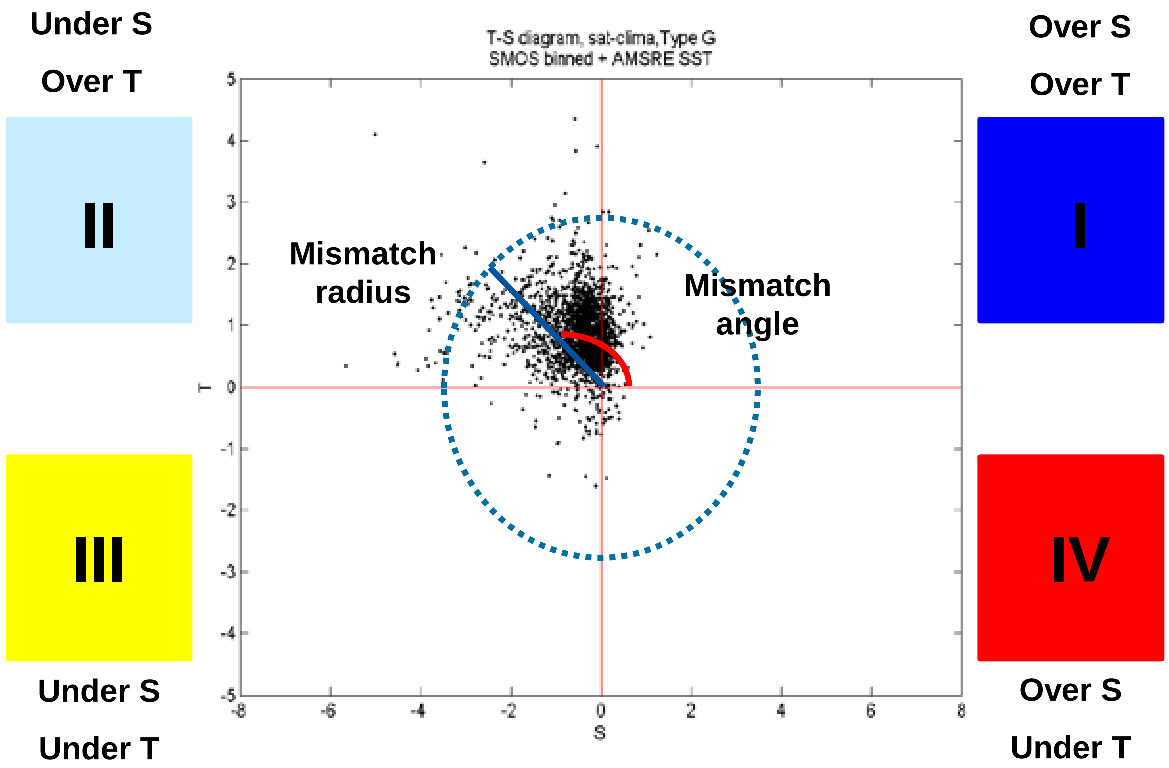






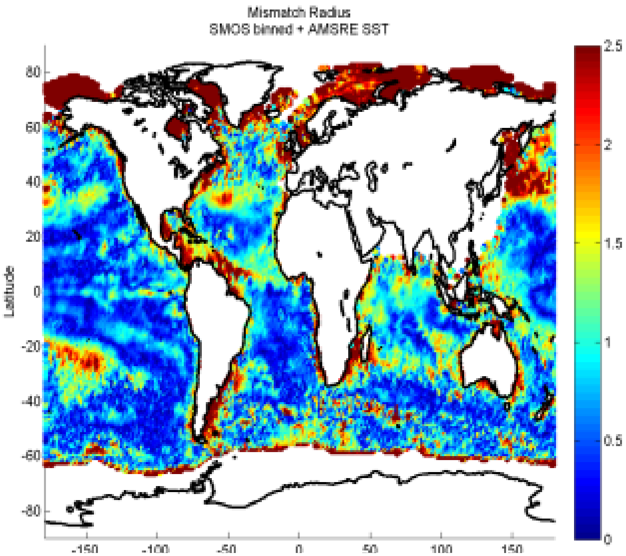
GP mismatches

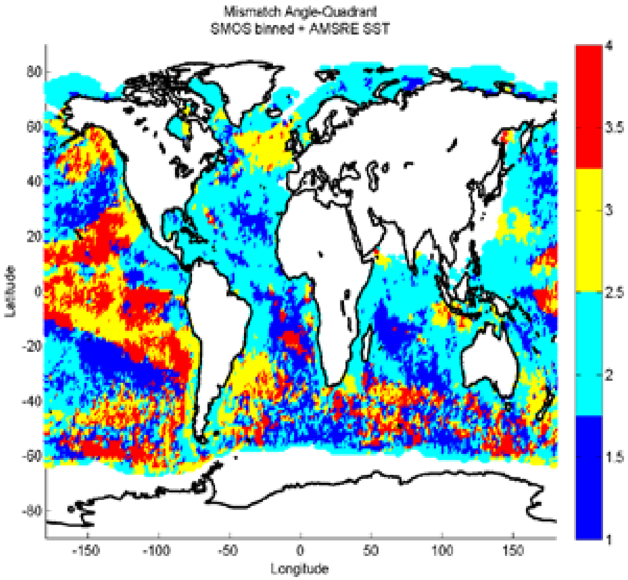
Overall mismatch indexes



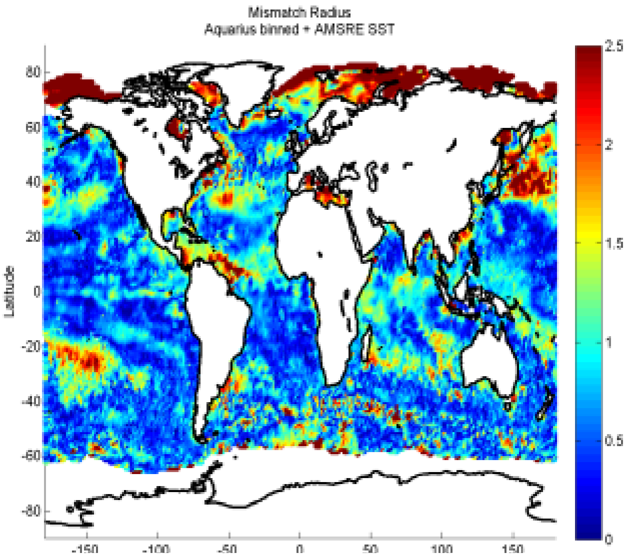
Mismatch radius and quadrants

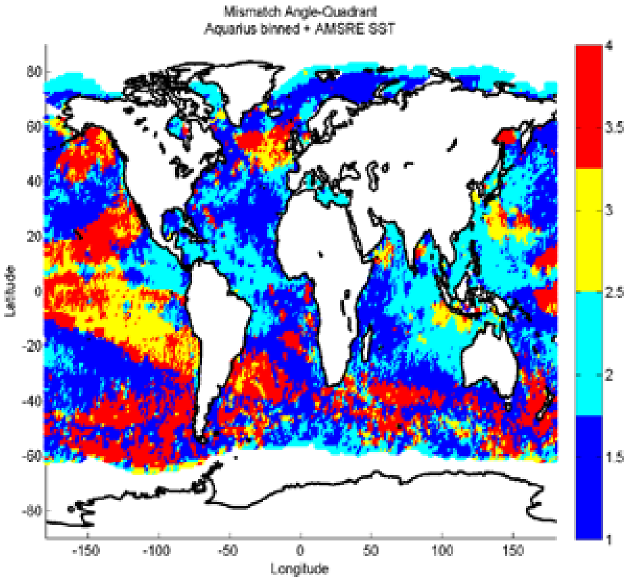
SMOS





Aquarius

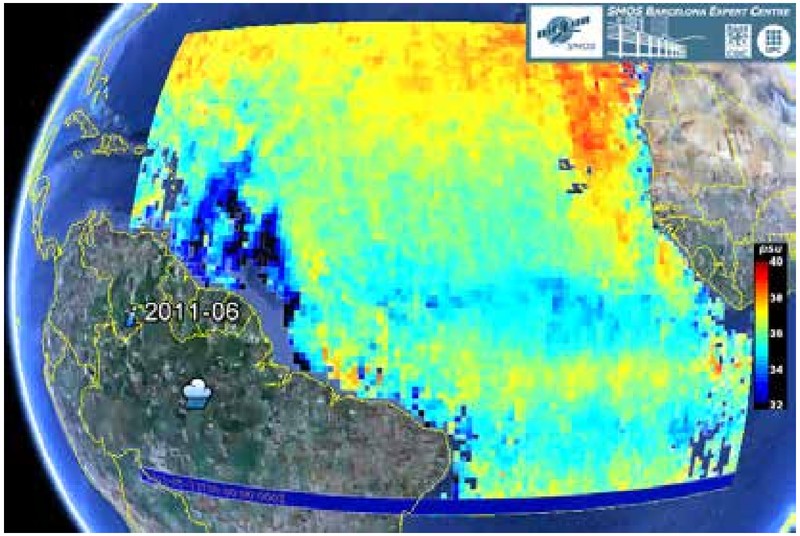




6. Summary and remarks

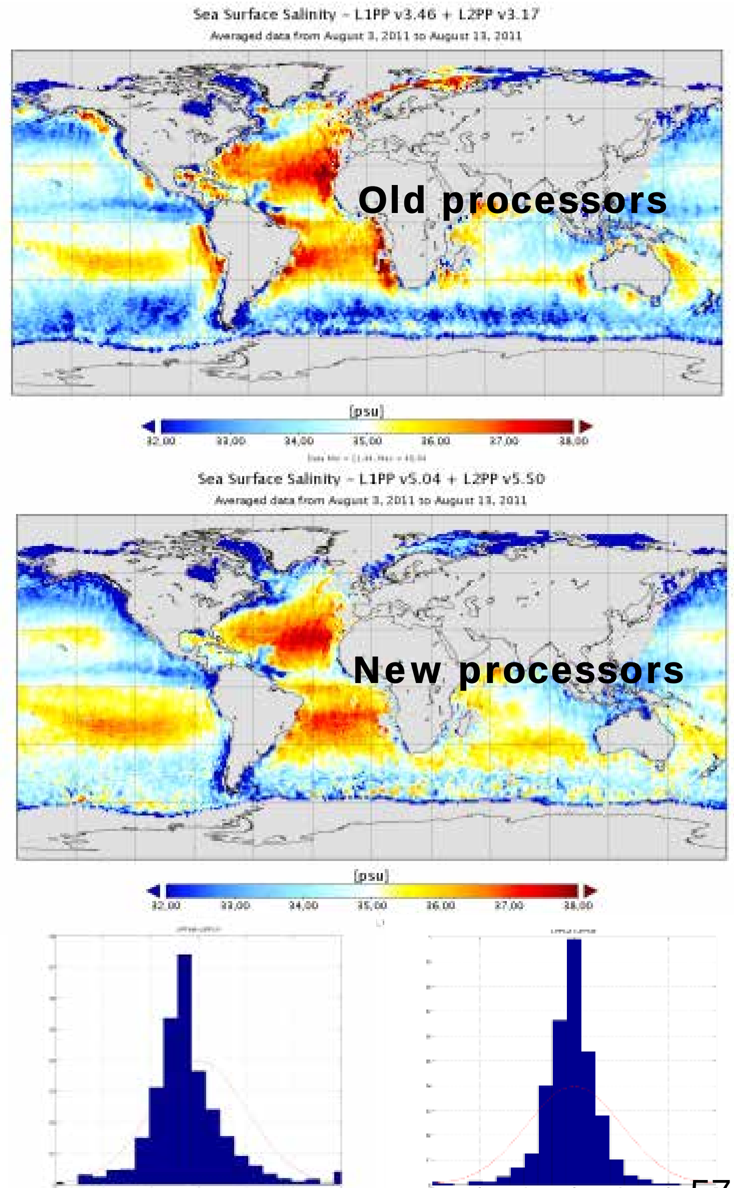
Summary

- **SMOS salinity measurement:**
    - **Motivation**
    - **Rationale**
    - **Features**
- **L1 features / issues / objectives**
    - **Bias mitigation techniques**
    - **Land / Sea contamination**
    - **RFI**
- **L2 features / issues / objectives**
    - **GMF model improvement**
    - **L2 flagging strategies**
    - **External noise sources**
- **L3 features / issues / objectives**
    - **SSS validation (in-situ / OA)**
    - **SSS performance at cold SST**
    - **SSS vertical structure**
    - **T / S diagrams**



2011-2012 Improvements (including 1st mission reprocessing)

- **Reduced temporal drifts**
- **Strong decrease in SSS contamination in land / sea / ice transitions**
- **Better quality retrieval due to outliers and RFI detection / mitigation at L2**
- **Decrease in ascending and descending overpasses mismatches due to correction of short-term drift**
- **Improved roughness correction models (adjusted to SMOS measurements)**
- **Improved flagging strategies**
- **Better characterization of external noise sources**
- **Use of World Ocean Atlas 2009 SSS climatology**



SSS pending issues and tasks

- A **time-varying OTT** sorted for ascending / descending overpasses still needed
- Optimal additive / multiplicative OTT or alternative method for residual bias and long-term drift removal to be investigated
- **Residual land / sea contamination** still present
- **Sun** effects correction at L1 to be improved
- **Galactic** noise correction model still unsatisfactory
- TEC gradient along dwell line to be taken into account
- **RFI** mitigation to be improved
- **Full-pol** measurements (T3, T4) characterization ongoing
- Alternative inversion techniques
- Improving L3 maps by objective analysis techniques

SMOS-MODE - EU COST Action

esa

SMOS-MODE – SMOS-Mission Oceanographic Data Exploitation

www.smos-mode.eu
info@smos-mode.eu

- SMOS-MODE supports the **network** of SMOS ocean-related R&D
  - Meetings
  - Workshops
  - Training school
  - Short term scientific missions
- **Overall Aim**:
  - To coordinate pan-European teams to define common protocols to produce **high-level salinity maps and related products**, and broaden expertise in their use for **operational applications**.
  - To **bridge** remote sensing and applications communities
- 14 countries represented so far. **Co-chairs**:
  - Antonio Turiel, SMOS Barcelona Expert Centre (SMOS-BEC), Barcelona, Spain
  - Nicolas Reul, IFREMER, Brest, France
- Next WGs meetings foreseen in Cyprus on **October 2012**

Additional institutions and countries are welcome!

SMOS-MODE

cost
EUROPEAN COOPERATION
IN SCIENCE AND TECHNOLOGY

Websites of interest

http://www.esa.int/esaLP/LPsmos.html

https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/smos

http://www.cp34-smos.icm.csic.es/

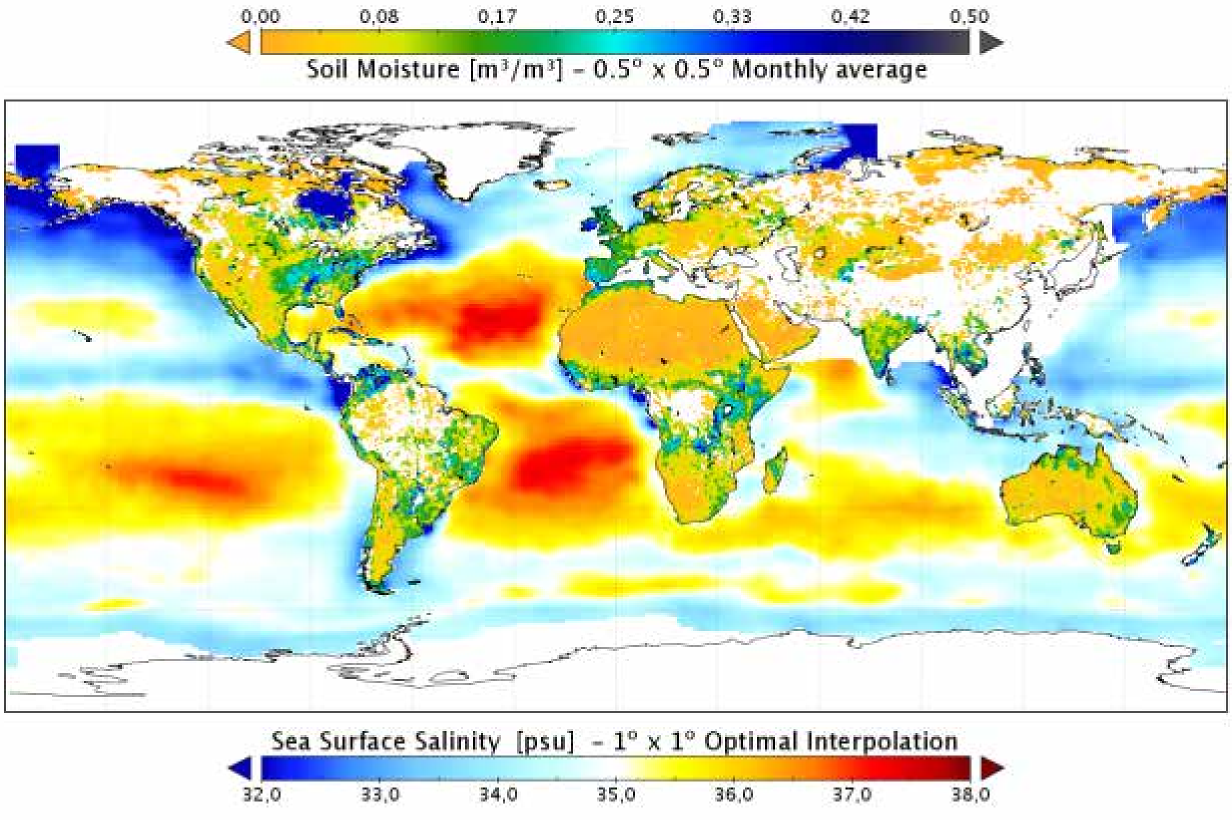
http://www.catds.fr/

Credits

A. Camps
J. Font
M. Talone
M. Portabella
A. Turiel
J. Ballabrera
J. Gourrion
C. Gabarró
J. Martinez
M. Vall-llossera
I. Corbella
F. Perez
A. Monerris
S. Guimbard
A.L. Aretxabaleta
B. Mourre
P. Spurgeon
A. Chuprin
R. Oliva
J. Munoz-Sabater

D. Fernandez
S. Mecklenburg
S. Delwart
A. De La Fuente
N. Reul
J. Tenerelli
C. Gommenginger
C. Banks
J. Boutin
X. Lin
G. Lagerloef
B. Ward
R. Schmitt
W. Emery
M. Marconcini
T. Katagis
A. Cristo
C. Donlon
E. Bayler
Y. Chao

Land SM / Ocean SSS L3 map - November 2011



Grazie!

roberto.sabia@esa.int

Bdg 9, Office 09114

All of us have in our veins the exact same percentage of salt in our blood that exists in the ocean, and, therefore, we have salt in our blood, in our sweat, in our tears. We are tied to the ocean.

J.F. Kennedy

Speech given at the America’s Cup Race, 1962