Aquarius/SAC-D Science Team Meeting
11-13 April 2012, Buenos Aires

# SMOS salinity data processing status and Some results


*Physical Oceanography Department*
*Institute of Marine Sciences (ICM)*
*CSIC*

S. Guimbard, J. Font, J. Ballabrera, A. Turiel, J. Martínez, M. Portabella, J. Gourrion, F. Perez

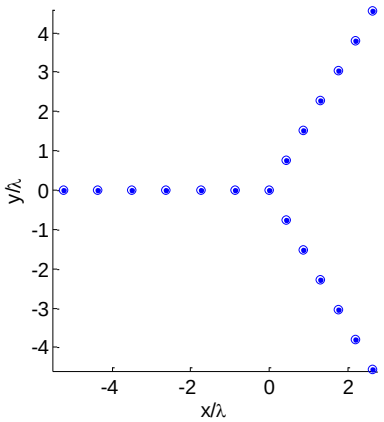
# Outline

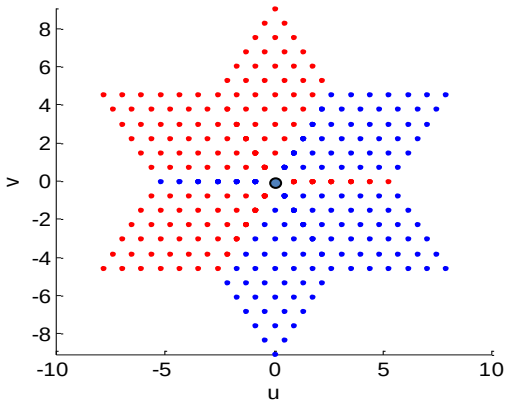
- Introduction
- Level 1 processor status
- Level 2 processor status
- Level 3 & 4 data products
- Qualitative comparisons of SMOS reprocessed data with Aquarius
- Conclusions

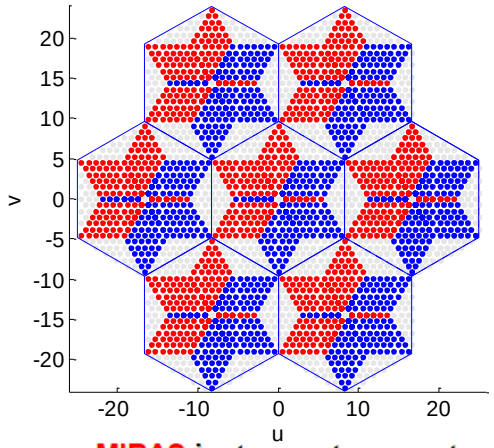
# The Soil Moisture & Ocean Salinity ESA earth explorer mission

In orbit since November 2009 (heliosynchronous, Ascending 6am equator)

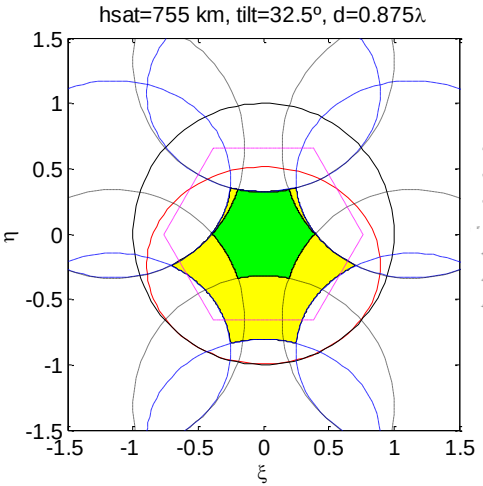
Microwave Imaging Radiometer using Aperture Synthesis
(2D imaging by Fourier synthesis)

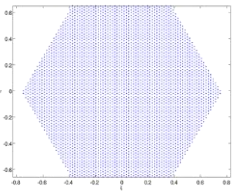


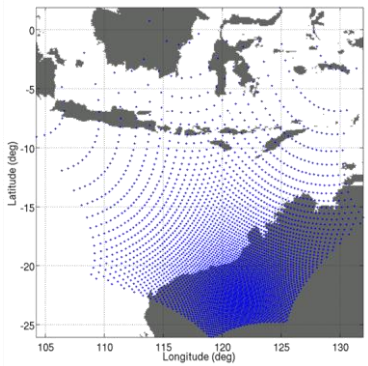




- **MIRAS instrument concept**
  - Y-shaped array (arm length ~ 4.5 m)
  - 21 dual-pol. L-band antennas / arm
  - spacing 0.875 λ (~1400 MHz)
  - no scanning mechanisms,
    2D imaging by Fourier synthesis
  - (u,v) antenna separation in wavelengths





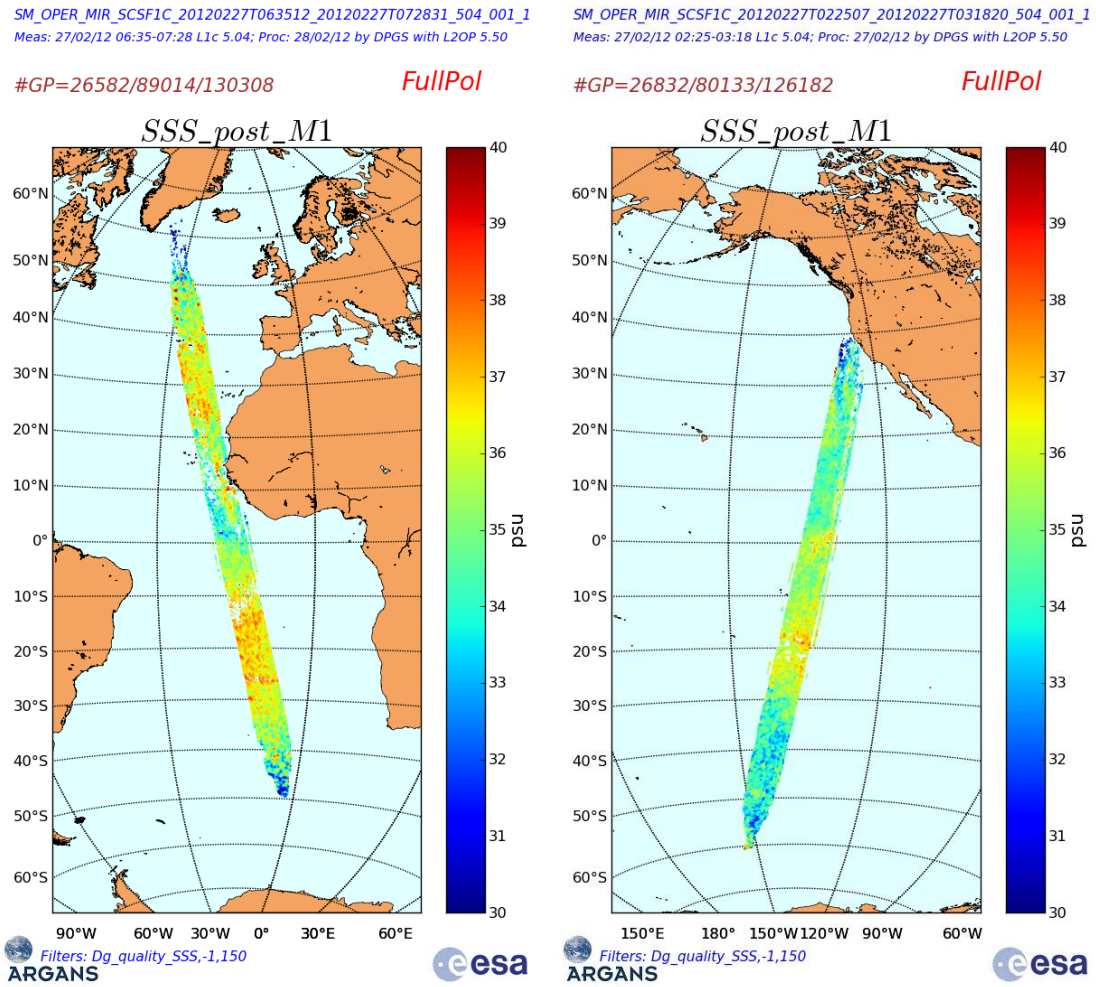

Corbella et al., IGARSS 2011

2D images formed by Fourier Synthesis (ideal case). Cross correlation of the signals collected by each antenna pair gives the so-called: Visibility samples V(u,v):

$$V(u,v) = \langle b_1(t) b_2^*(t) \rangle = \mathcal{F}\left[ \frac{T_B(\xi,\eta) - T_{ph}}{\sqrt{1-\xi^2-\eta^2}} |F(\xi,\eta)|^2 \right]$$

# SMOS sea surface salinity status

- SMOS salinity data are provided by ESA as semi-orbit swath products ( L2OS processor outputs)



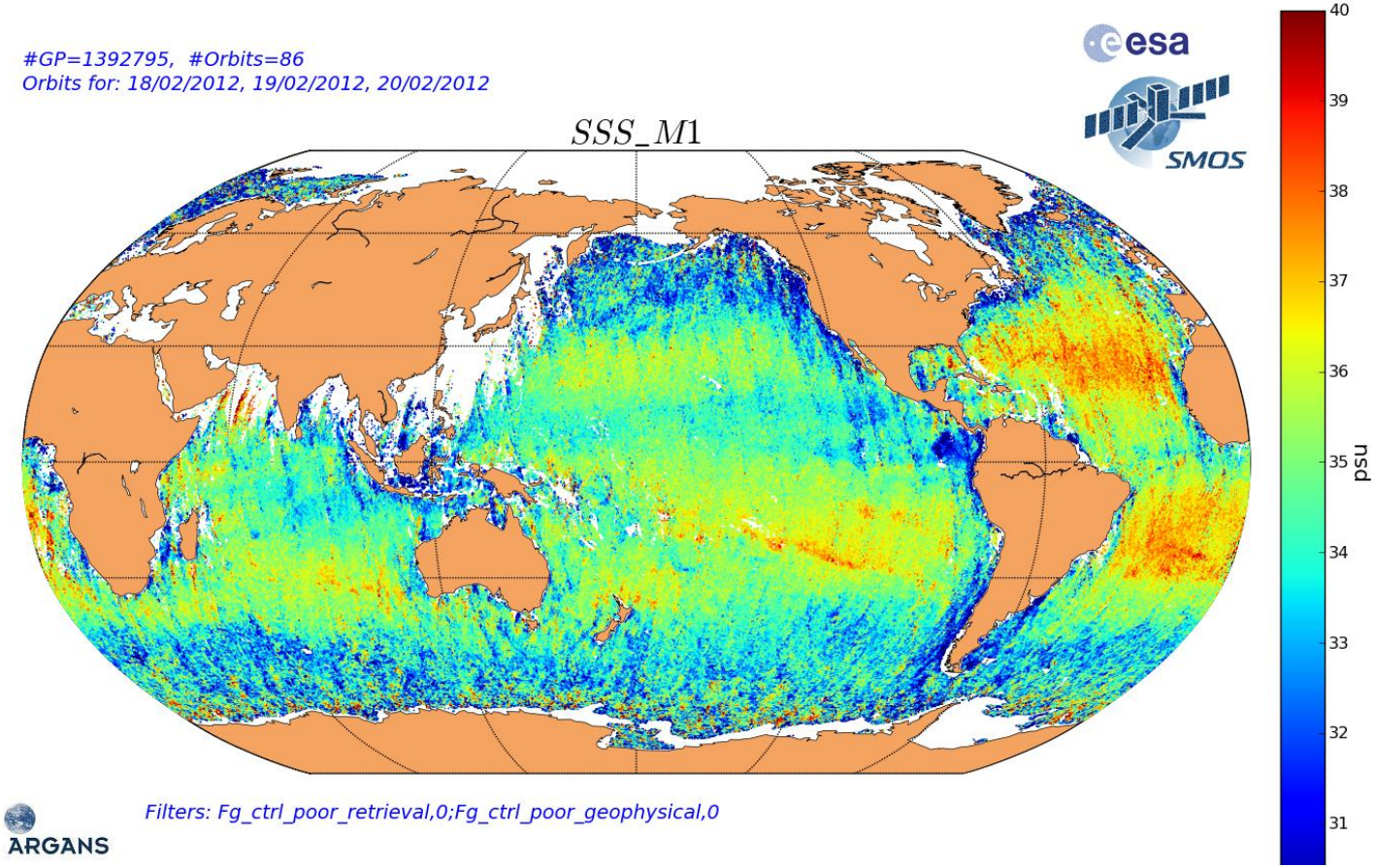

Example: one ascending and one descending semi-orbit from SMOS measurements on 27 Feb 2012

Three days (84 semi-orbits) needed for full Earth coverage

Level 2 very noisy, especially in the outer swath. Average needed

# SMOS L2 products

- Superposition and averaging of L2 OS products




Three days of filtered SMOS L2OS products, 18-20 February 2012: full Earth coverage

# SMOS L1OP processor v5.04

- In operation since November 2011
- Used to reprocess the full 2010-2011 data set
- Principal modifications:
  - Reduction of short and long term drifts
  - Strong decrease in contamination near to land/ice
  - Better RFI detection/mitigation
  - Improved Sun impact correction
- Caveats:
  - Fixed spatial bias (2.8K RMS) -> corrected at L2
  - Software anomalies: L1C sun glint flag not correctly set, corrupted measurements in polar region (Sea-ice conditions and salinity studies not possible)

  -> Next L1C data reprocessing: April2012

# SMOS L2 OS processor v5.50

- In operation since December 2011
- Used to reprocess the full 2010-2011 data set
- Principal modifications:
  - Time-varying residual spatial bias correction (Ocean Target Transformation); different ascending/descending
  - Roughness effect correction models tuned to SMOS data
  - Improved flagging /data filtering strategy

# L3 & L4 SMOS products: CP34 & CATDS

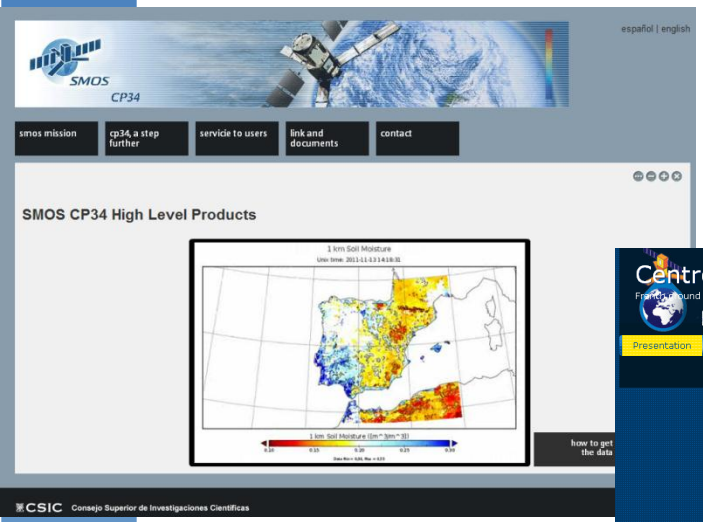
SMOS level 3 and 4 data production centre:

- **CP34:**

**http://www.cp34-smos.icm.csic.es/** for information
**http://www.cp34-users.cmima.csic.es/** for registration

- **CATDS:**

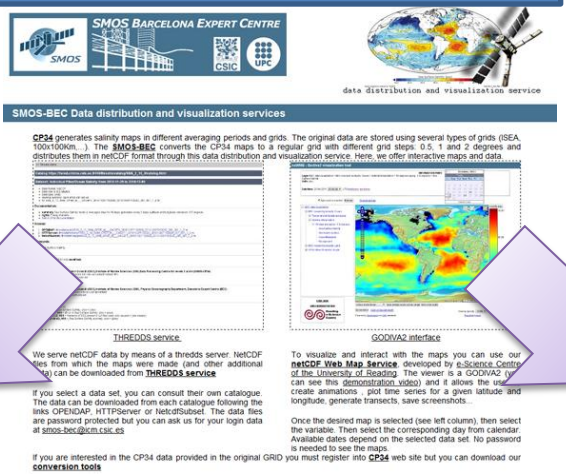
http://catds.ifremer.fr/Data/Research-Products-from-Expertise-Centers



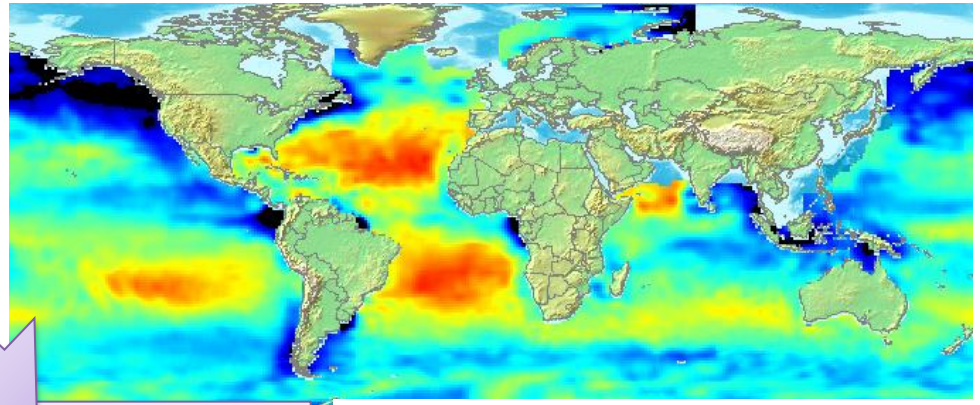


# BEC L3-L4 Products Server

http://tarod.cmima.csic.es

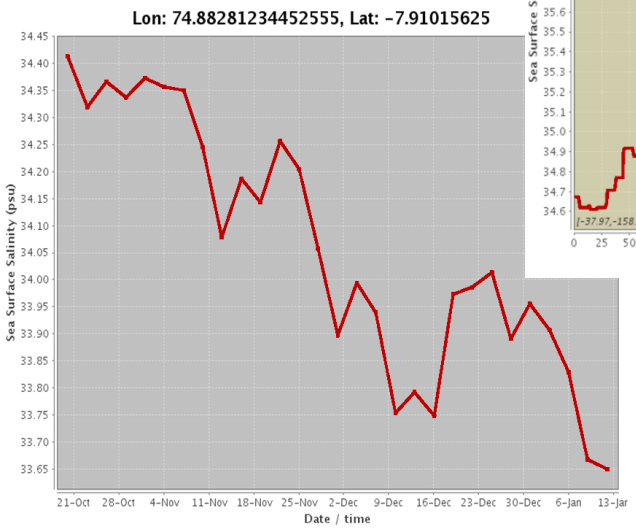


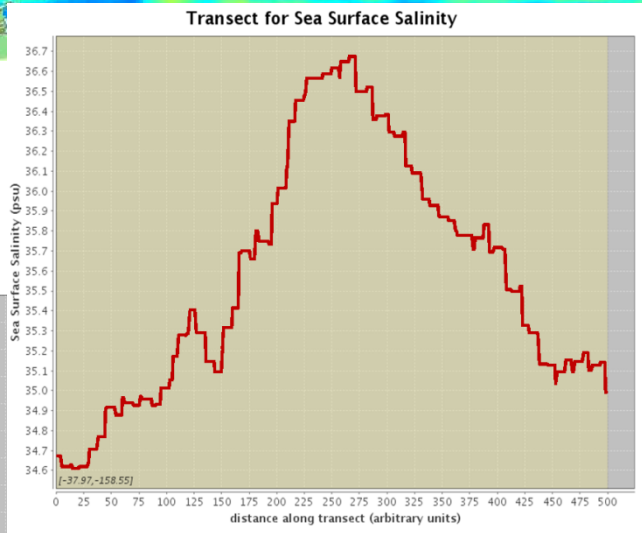

netCDF files



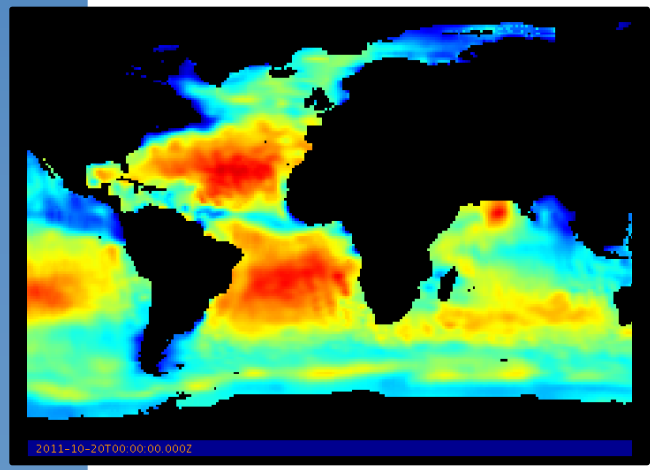
MAP VISUALIZATION TOOLS

*Temporal evolution*



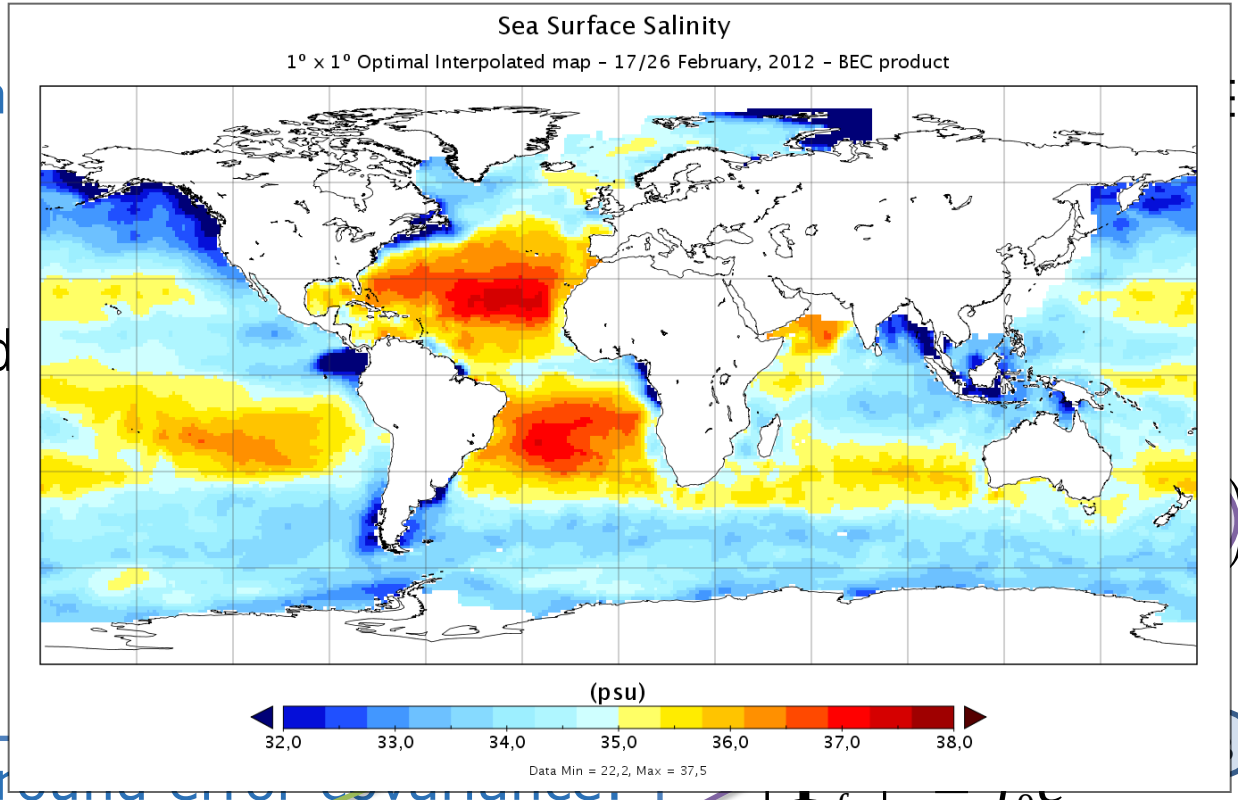

*Transects*




*Animations*

# SMOS BEC L3 products

## Objective analysis: Optimal interpolation




- We wa… $\Re^n$
- From:
  - set
  - and

$$\Delta y_{ij}^2 \quad \mathbf{C}\,\Delta x_{ij}\Delta y_{ij}$$

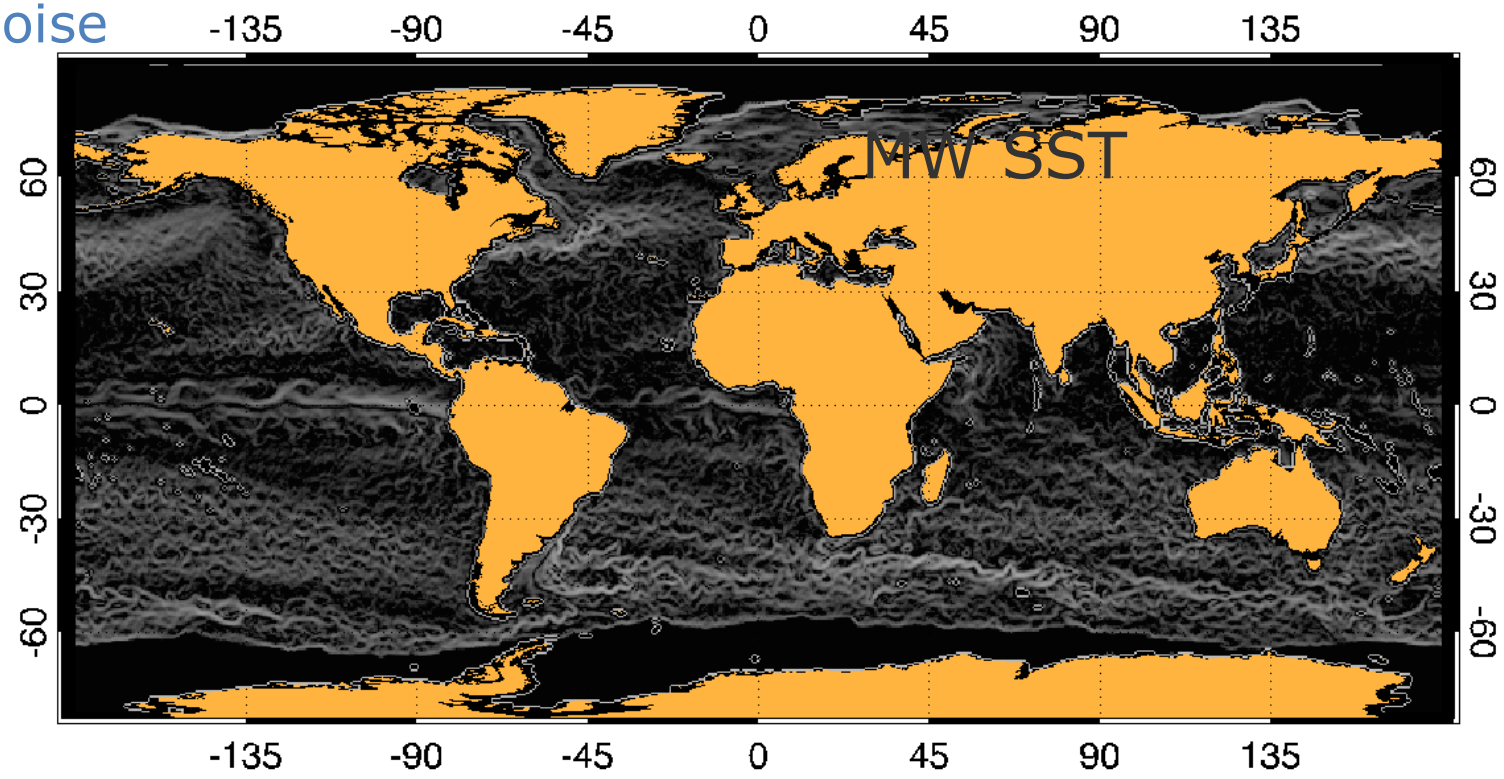
$$\left[\mathbf{I} + f\right]_{ij} \qquad I_0$$

- Backgr… error covariance
- Observation error covariance
- Innovation vector

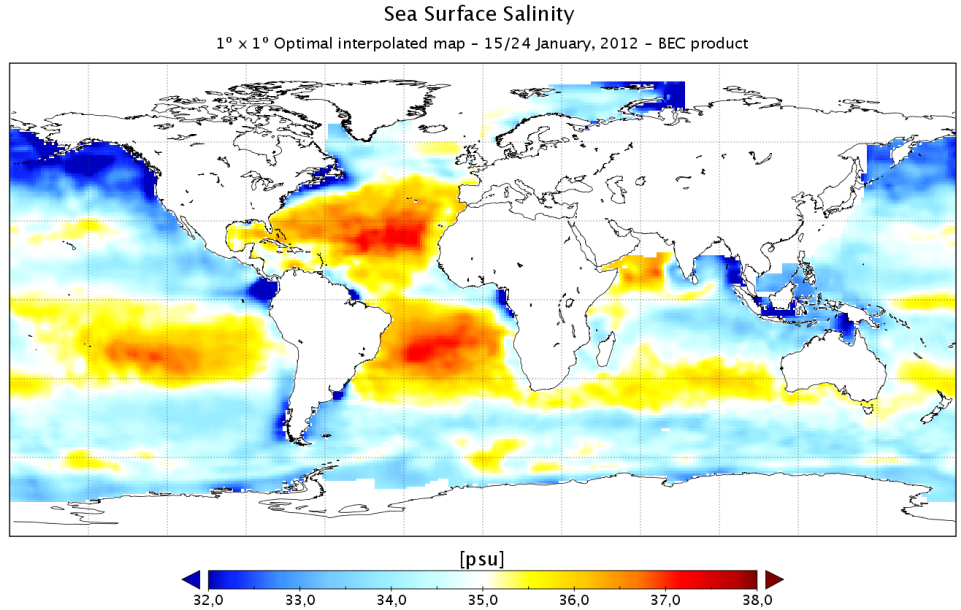
Correlation parameters

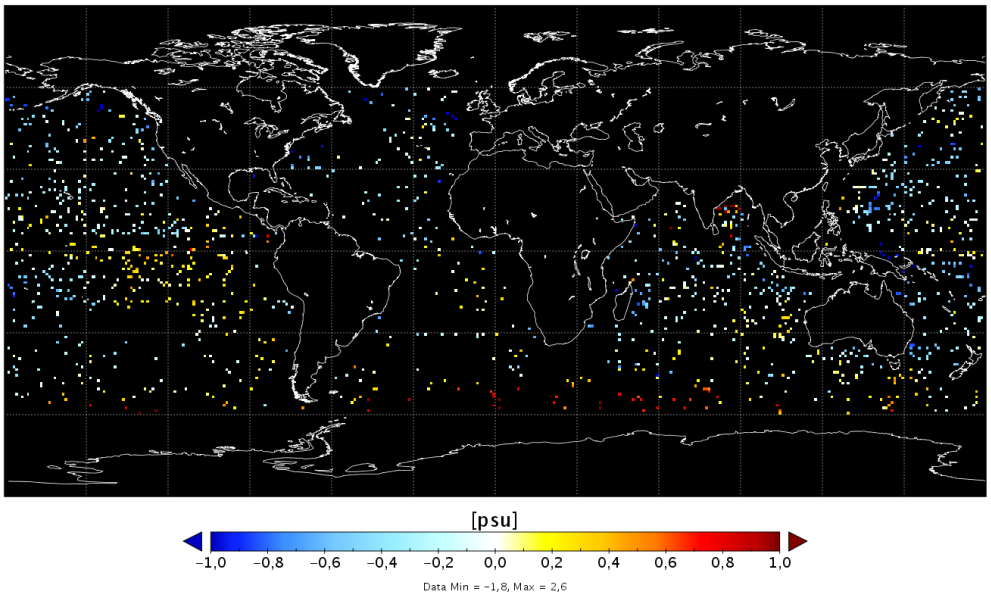
# SMOS BEC OS L4 products

- Hence, singularity exponents are the same for any scalar.
- A new image processing technique allows to calculate singularity exponents with great accuracy.
- The analysis of the output of different numerical simulations confirm that SST and SSS have the same exponents (synergic effect)
- Singularity exponents are related to the flow dynamics: they trace streamlines.
- This implies that locally there is a linear relation between SSS and SST ⇒ SST can be used as template to remove noise

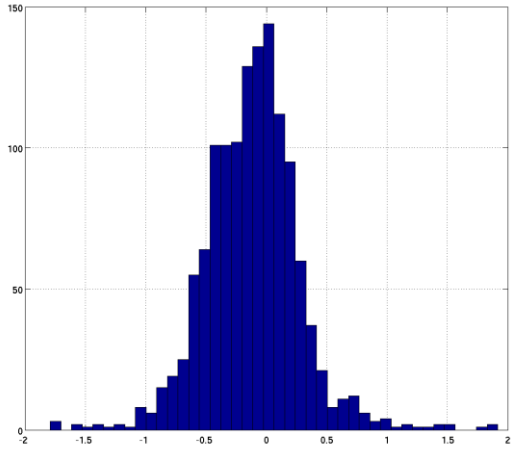


# BEC OS products validation: L3



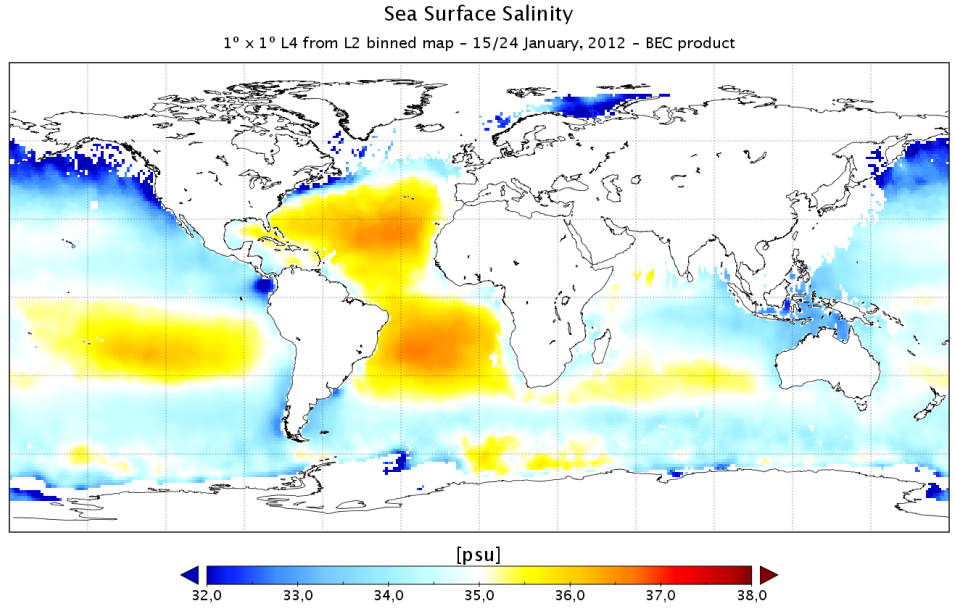



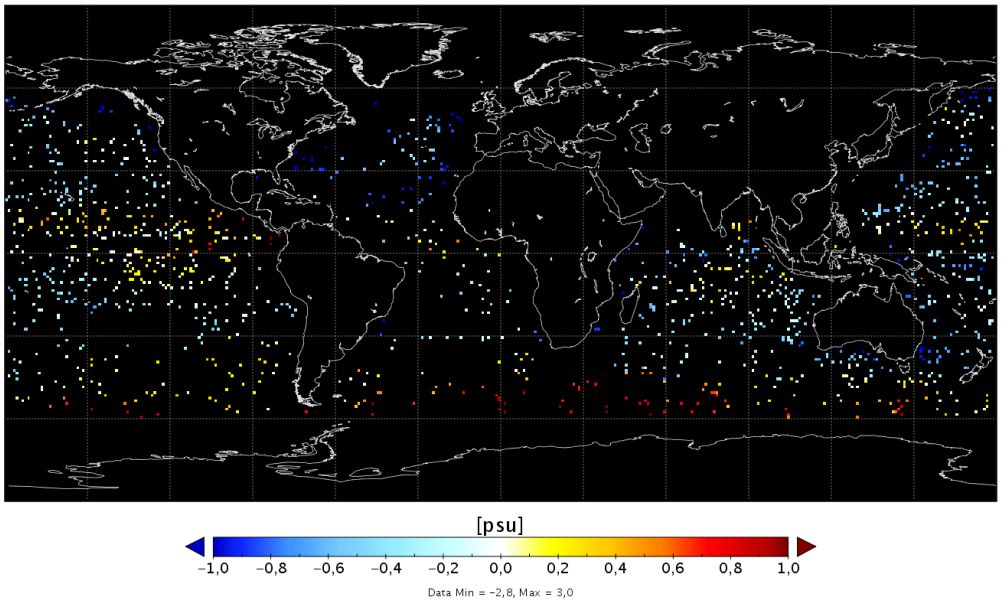

- SMOS OS L3 map 1ºx1º
- Optimal Interpolation using WOA2009 as background
- 15-24 Jan. 2012
- Argo SSS interpolated at **7.5m** depth



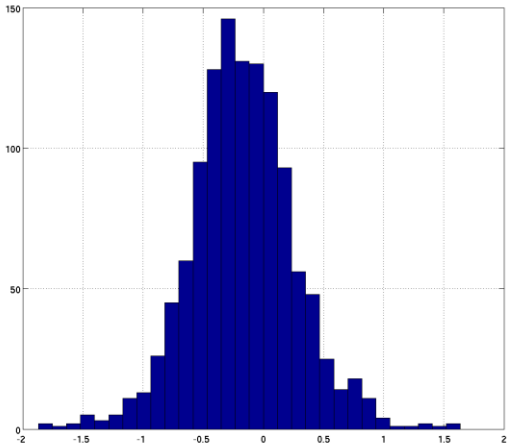

SMOS - Argo
1299 points
Bias = -0.11
RMS = 0.42

# BEC OS products validation: L4



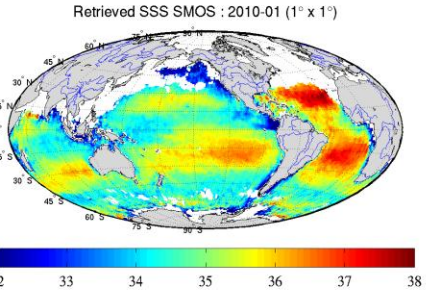



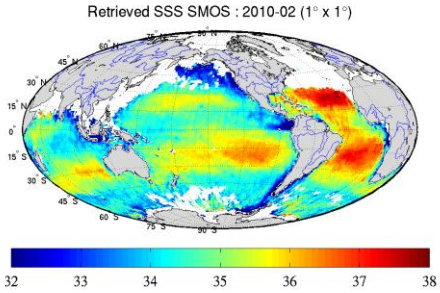

- SMOS OS L4 map 1ºx1º
- Generated from L3 binned + SST singularity exponents
- 15-24 Jan. 2012
- Argo SSS interpolated at **7.5m** depth

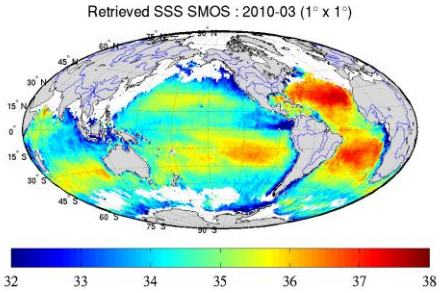


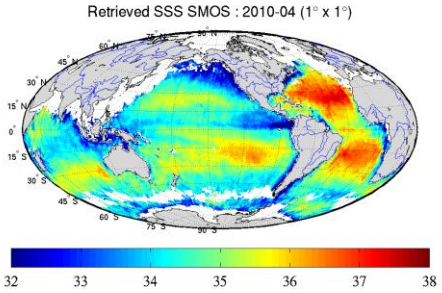

SMOS - Argo
1202 points
Bias = -0.17
RMS = 0.49

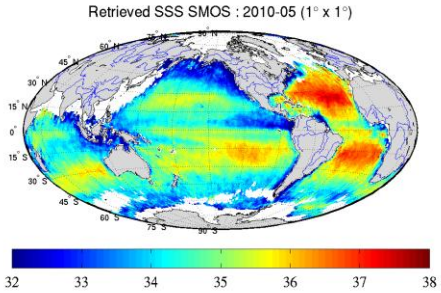
# Monthly bin averaged SMOS SSS (1°x1°) 2010

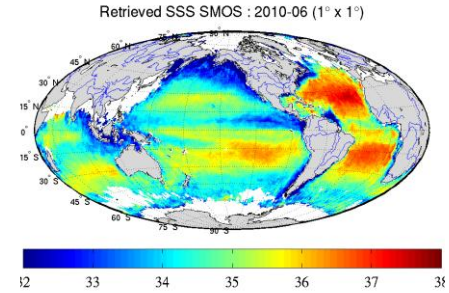


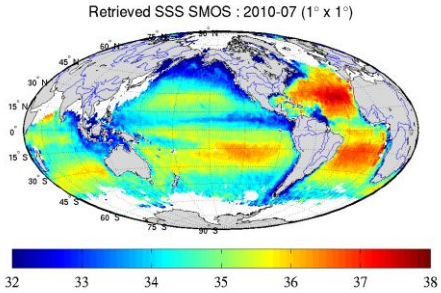



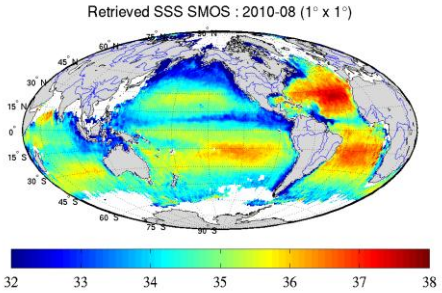



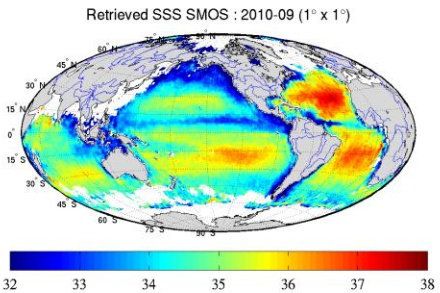



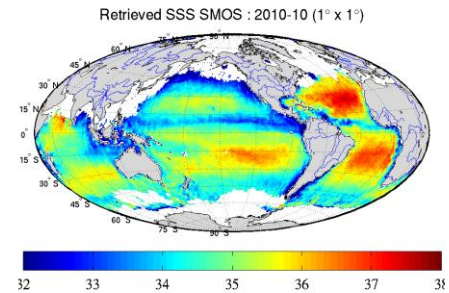



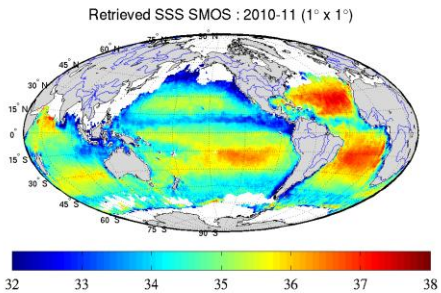



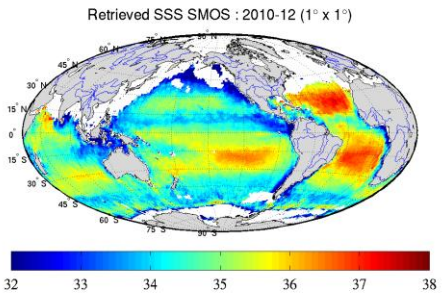



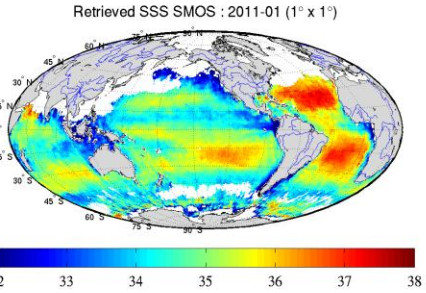



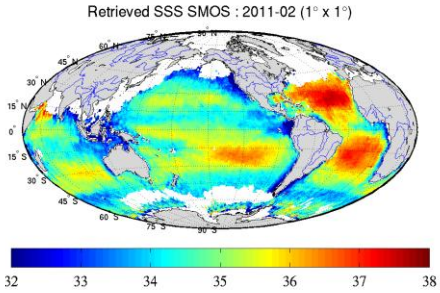



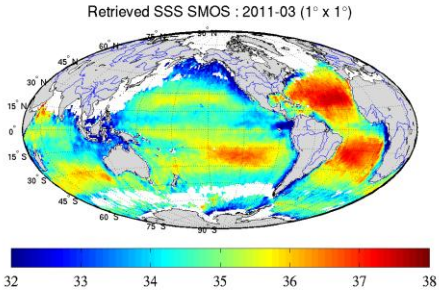



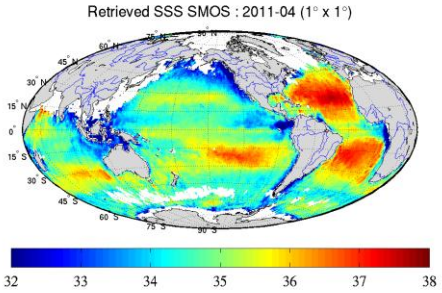



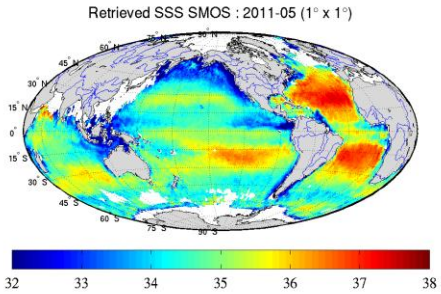
# Monthly bin averaged SMOS SSS (1°x1°) 2011

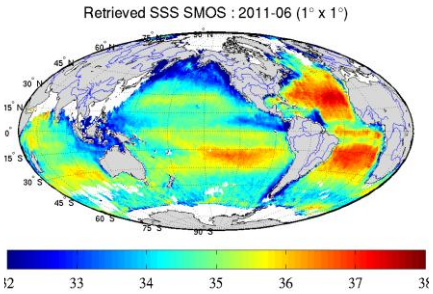


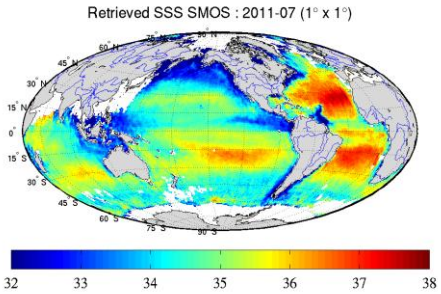



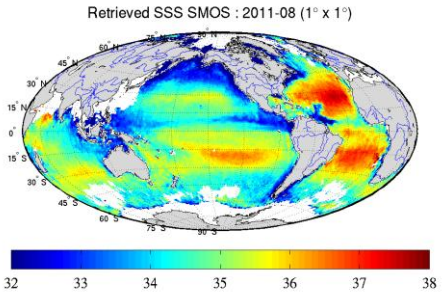



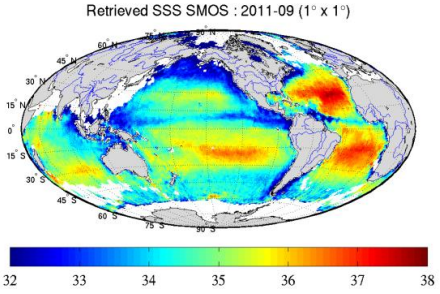



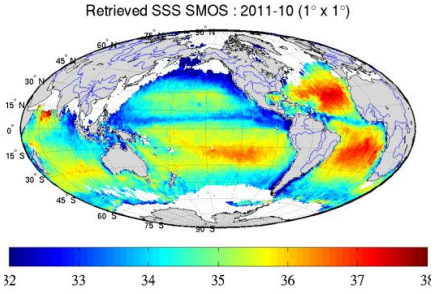



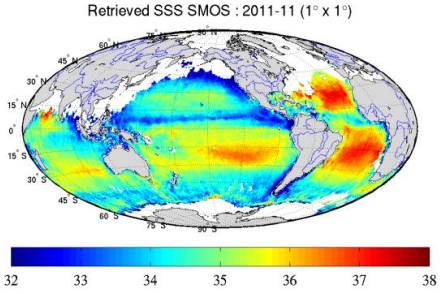



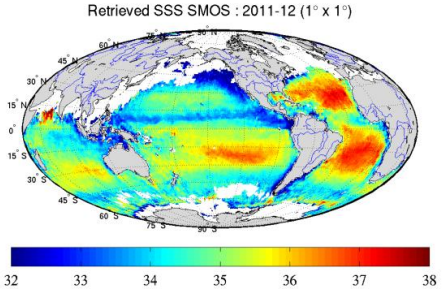



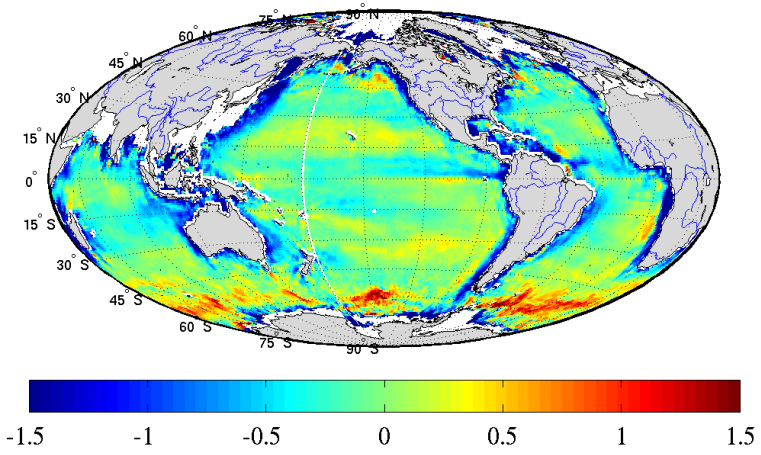



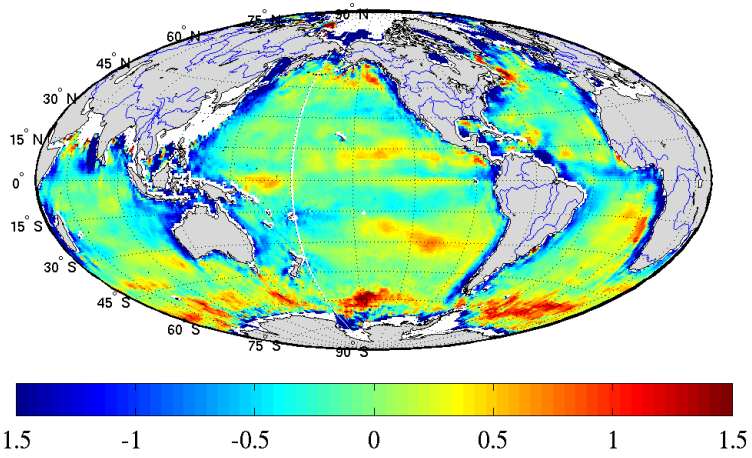



# Yearly SMOS SSS anomalies

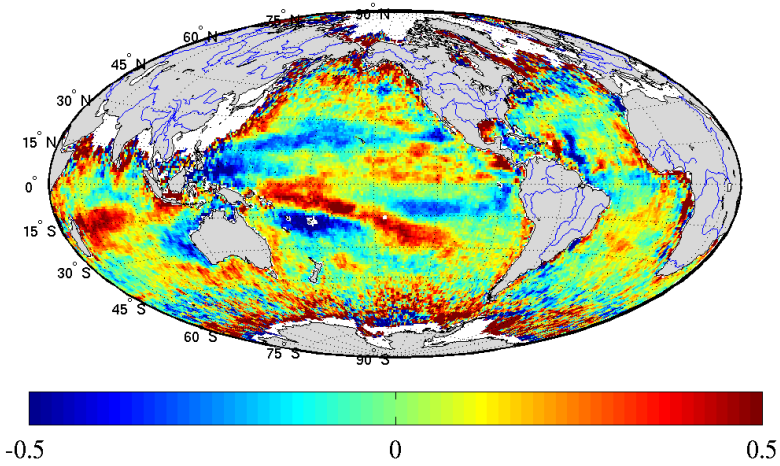
**2010**




**2011**



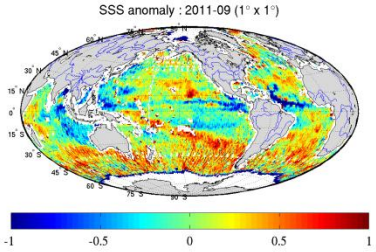

**2011-2010**

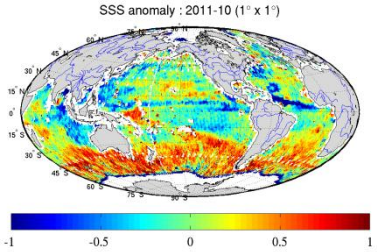


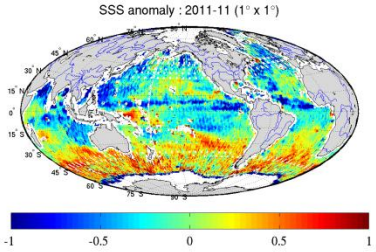

WOA 2009

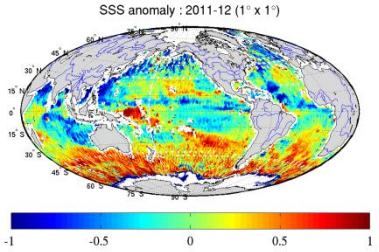
# L3 binned SSS anomaly (Aquarius-WOA09)

2011

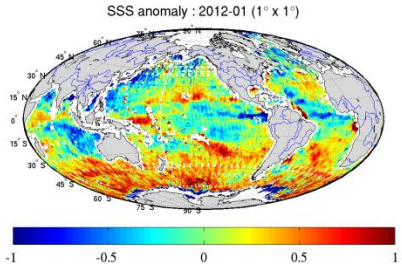


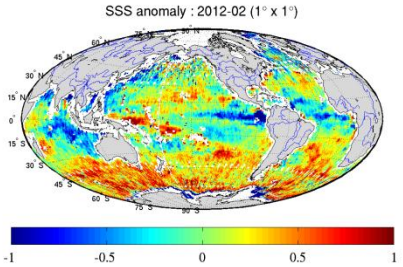



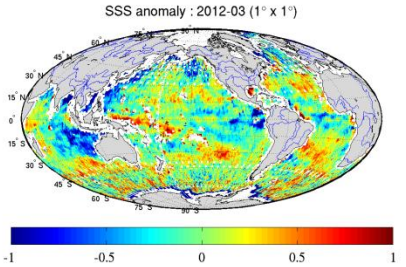




2012



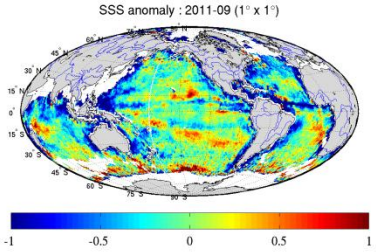



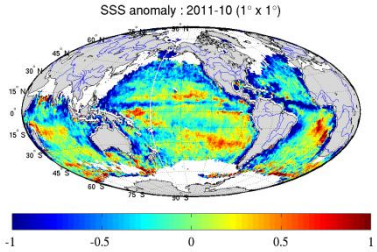



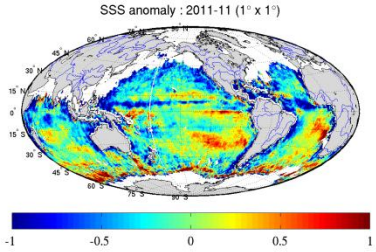

L2 v1.3 Aquarius data bin averaged on a regular grid of 1°x1°
Minus monthly World Ocean Atlas 2009 OI SSS

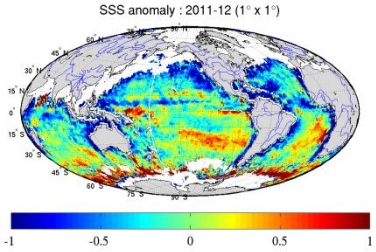
# L3 binned SSS anomaly (SMOS-WOA09)

2011

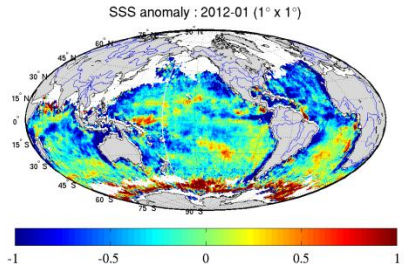


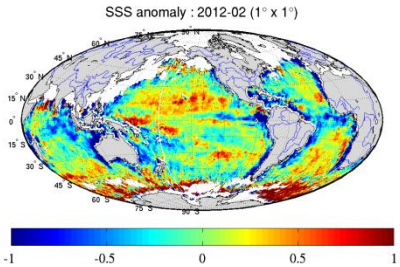



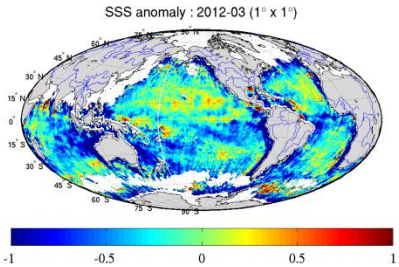




2012



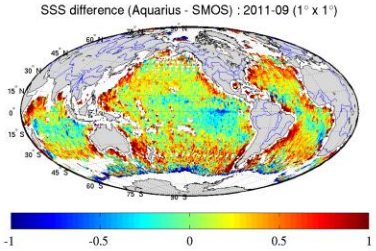



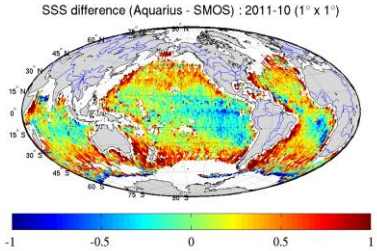



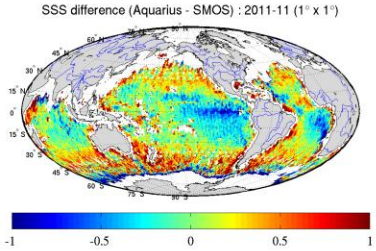

L2 reprocessed SMOS data bin averaged on a regular grid of 1°x1° minus monthly World Ocean Atlas 2009 OI SSS

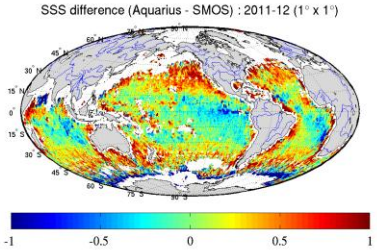
# L3 binned SSS difference (Aquarius-SMOS)

## 2011

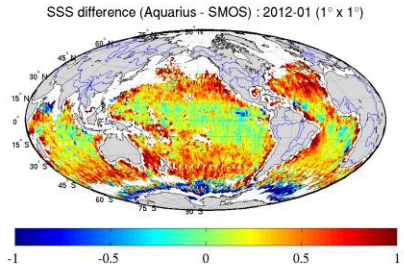


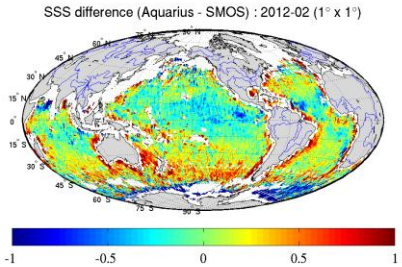



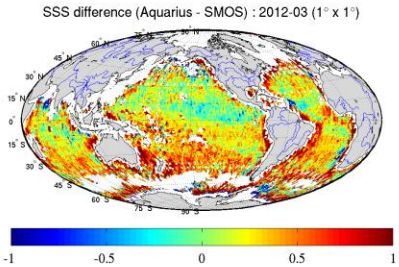



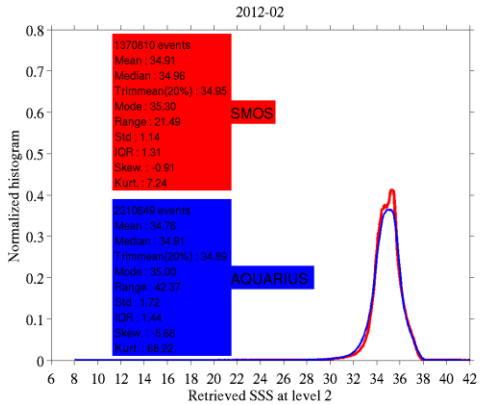



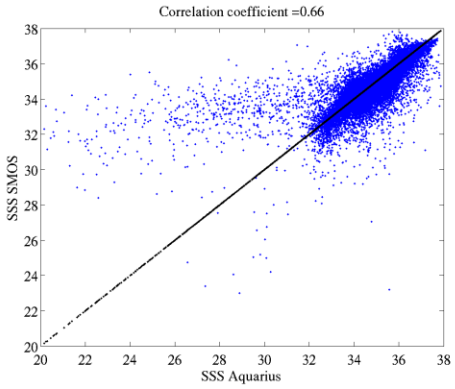

## 2012

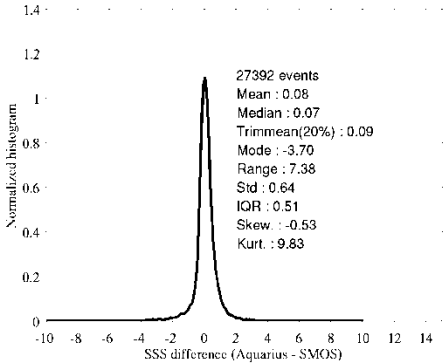


# SMOS Future improvements

- Improving land/sea transition impact on L1 signal (Gibbs phenomenon)
- Better residual bias removal techniques under analysis (understanding the problem at L1; mitigating it as L2 pre-processing)
- Galactic noise degrades retrieval in function of region and season. New correction model at L2 tested and ready for operational implementation.
- Sun signal tails on alias-free field-of-view still a problem. Removal techniques under investigation
- RFI degrades/corrupts salinity retrieval in large areas. Switching-off illegal sources and improving mitigation procedures
- **SMOS salinity at L3 now validated within 0.3-0.4 .**

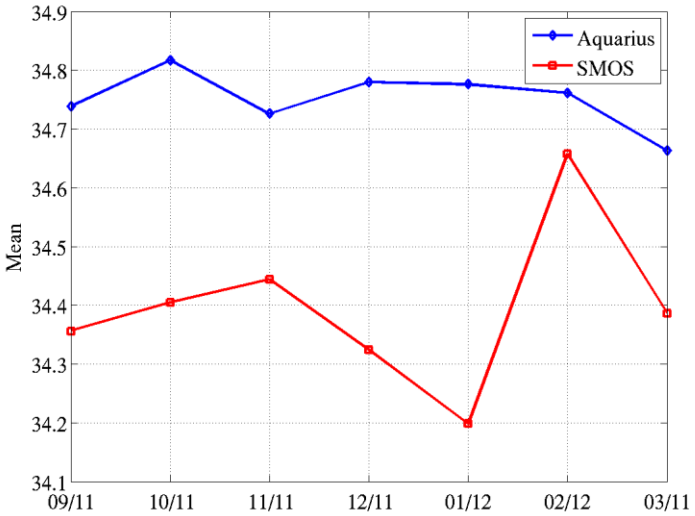
# Conclusions

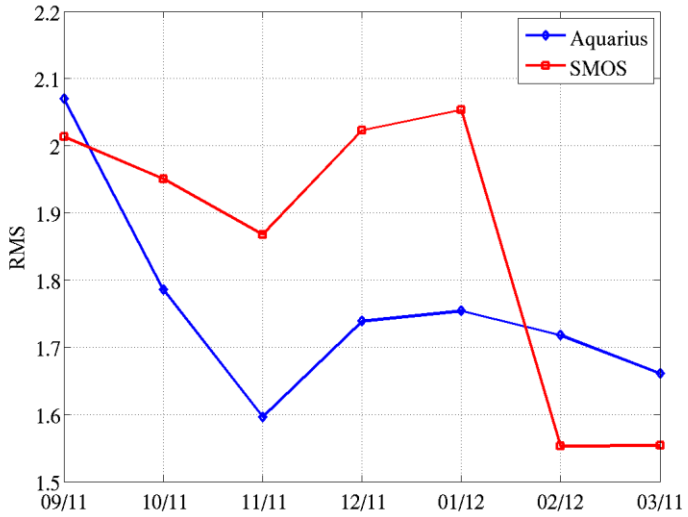
- ESA are provided SMOS Level 2 SSS products
- L3 & L4 are provided by Cp34 & CATDS
- At BEC, new data fusion algorithm for Level 4 products based on singularity exponents
- The synergy SMOS /Aquarius can begin

And if you have questions, I am sure you have, I will try to answer them latter.
->No more time for question

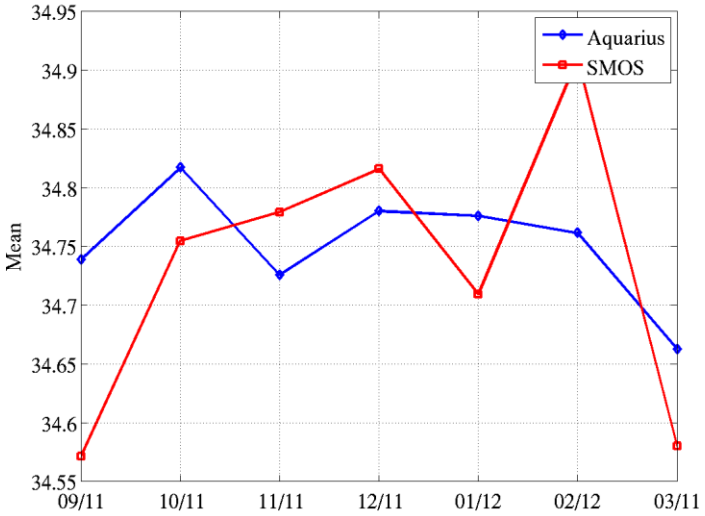
# Global L2 retrieved SSS temporal evolution

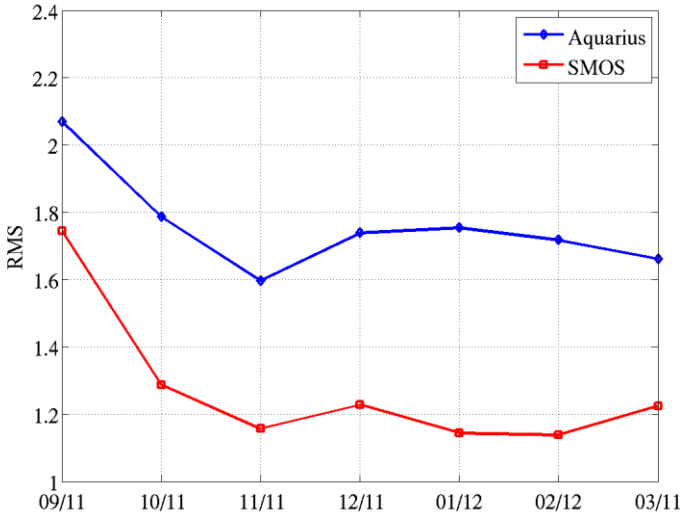
NO filtering



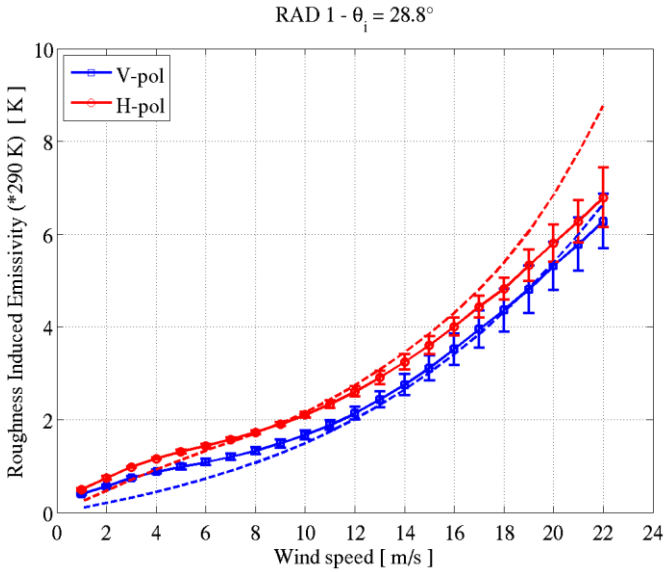



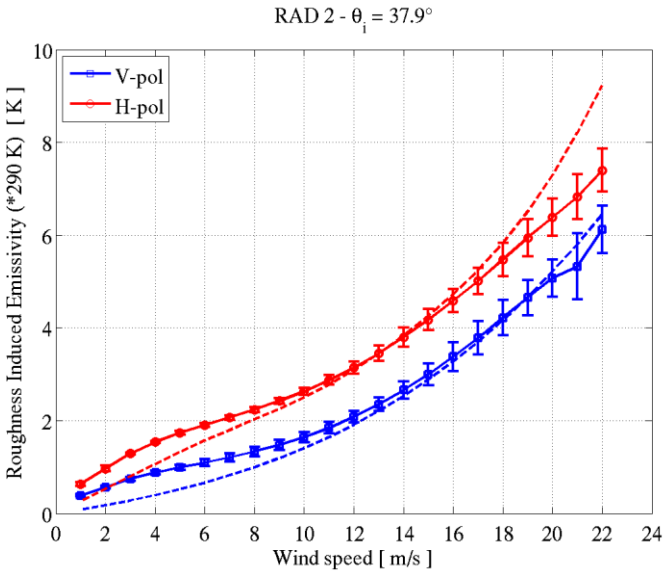

Filtered

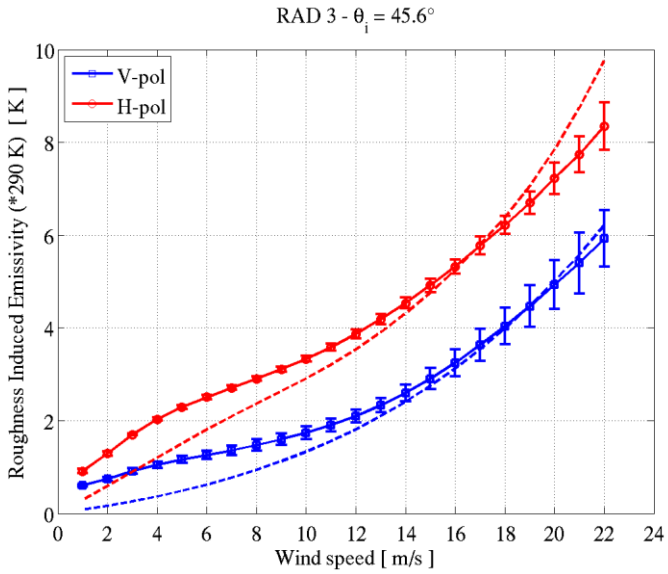


# Roughness TB modulation

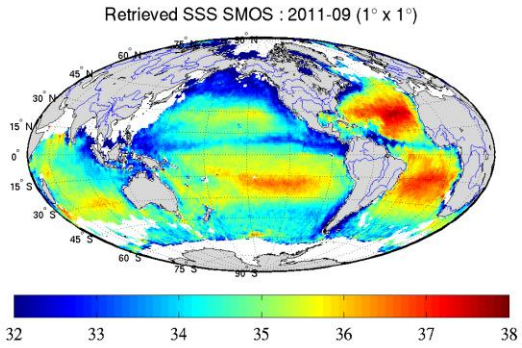


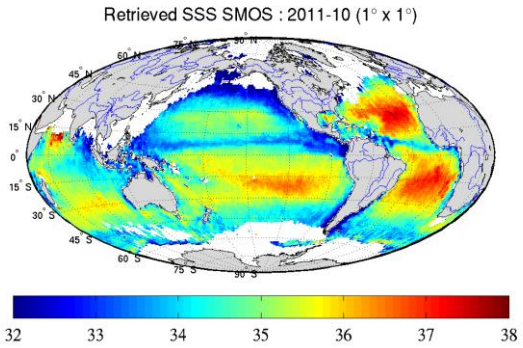



# Monthly averaged SMOS SSS

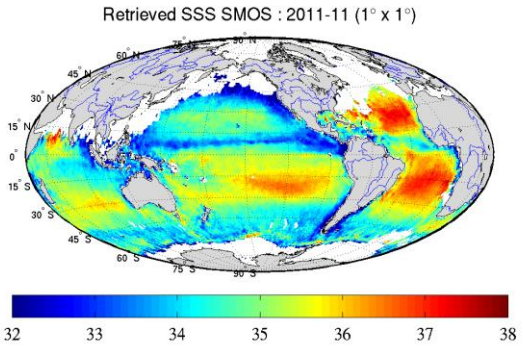
Sept-2011



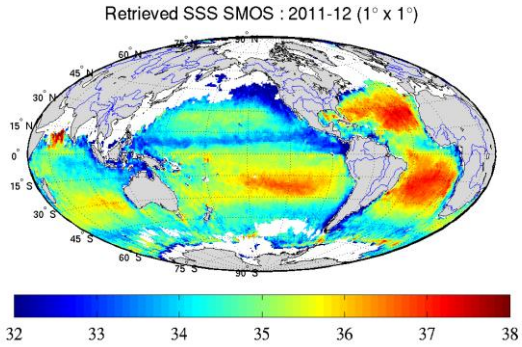

Oct-2011



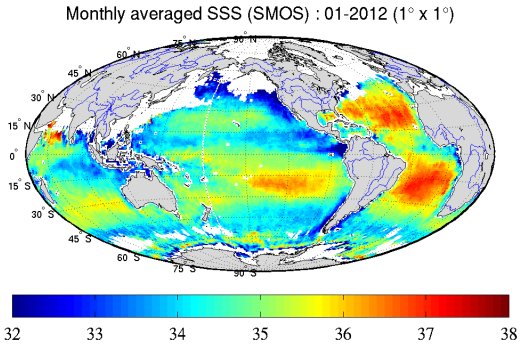

Nov-2011




Dec-2011




Jan-2012




Feb-2012