Sea water dielectric constant, temperature and remote sensing of Sea Surface Salinity

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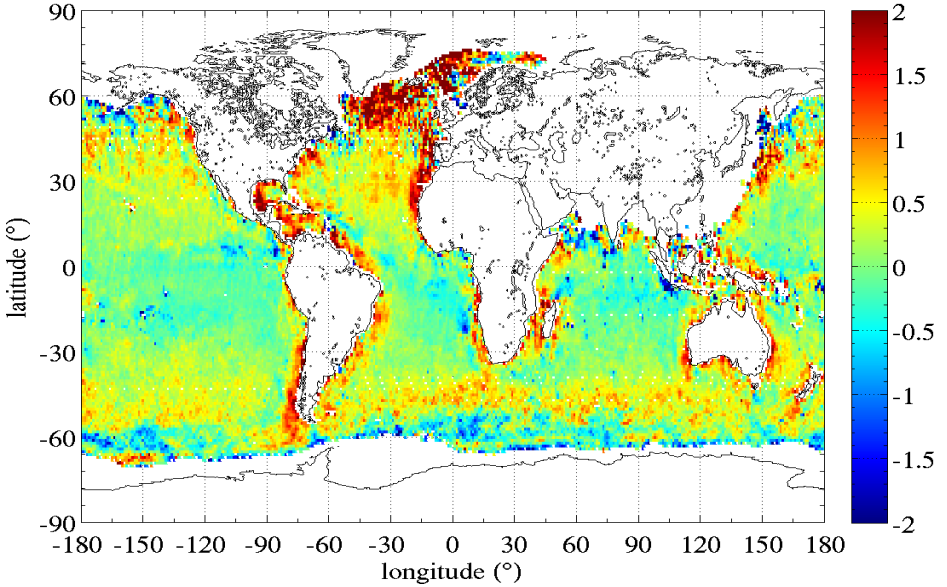
Motivation

SSS retrieved by SMOS and Aquarius differs significantly.

Effects of dielectric constant model, ancillary data for SST?

SSS: Aquarius – SMOS (Jan 2012)



Outline

- Presentation of SMOS and Aquarius
  - Mission parameters
  - Quick overview of calibration and retrieval algorithm
- Comparison of SSS from SMOS and Aquarius
- Impact of:
  - sea water dielectric constant model
  - ancillary SST
- Comparisons with Argo in situ data
- Summary

SMOS and Aquarius/SAC-D Mission Parameters

Both measure sea surface salinity (SSS) globally, monthly, precision ~ 0.2 psu.

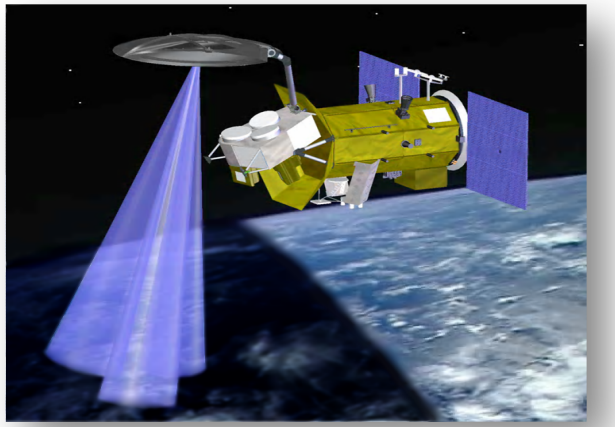
L-band radiometry.

Sun synchronous polar orbit (equatorial ascending node = 6 PM for Aquarius, = 6AM for SMOS)

Aquarius has 3 beams pointing across track (pushbroom) towards the night side.

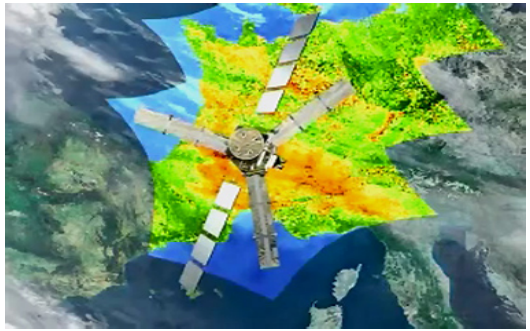
SMOS is an imager (interferometer): better spatial resolution, multiple incidence angles over a wide range.

Aquarius has a better radiometric sensitivity & scatterometer to correct for effects of surface roughness.

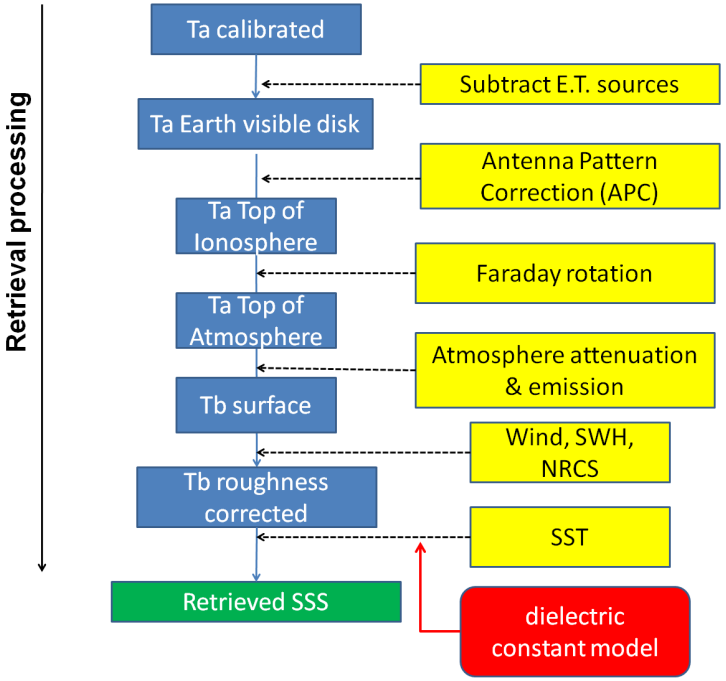


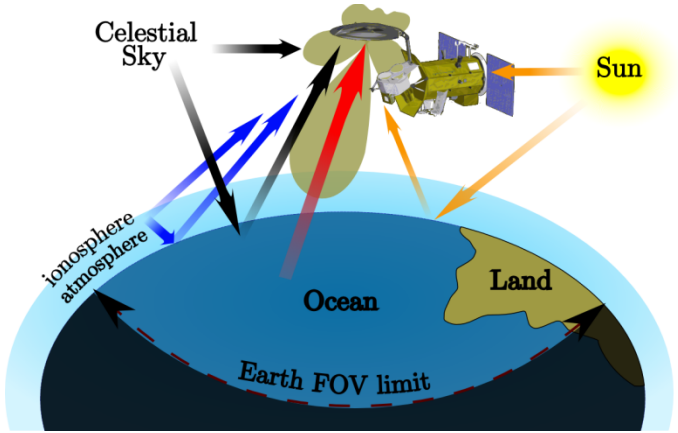
Aquarius has 3 beams pointing toward the night side of the Earth

SMOS images a large area under multiple incidence angle and at high resolution

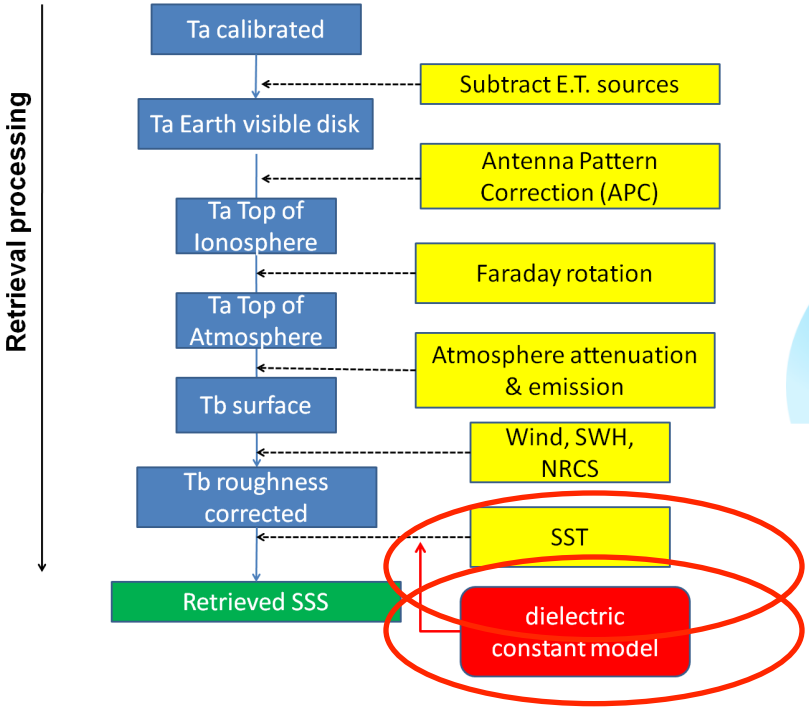


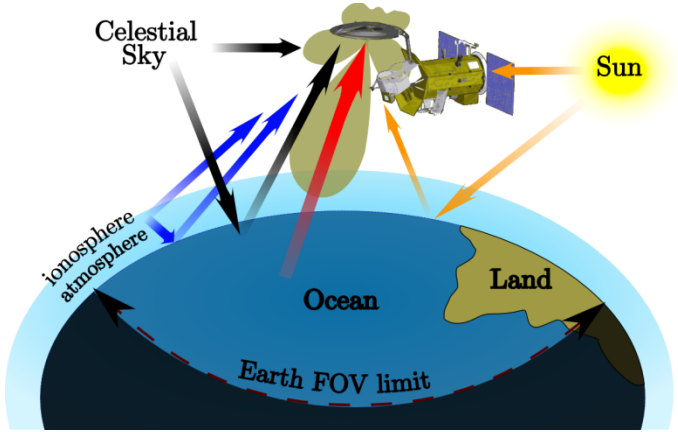
SMOS and Aquarius/SAC-D
Algorithm and vicarious calibration



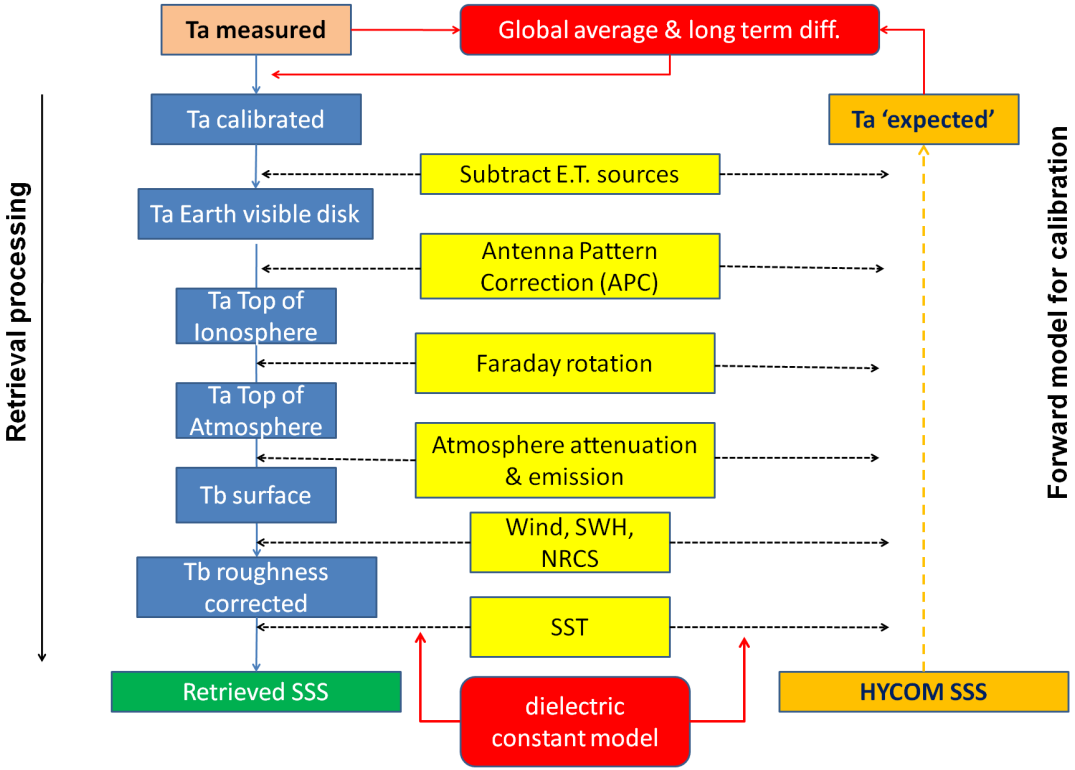


SMOS and Aquarius/SAC-D
Algorithm and vicarious calibration





SMOS and Aquarius/SAC-D
Algorithm and vicarious calibration



Comparison of SSS from SMOS and Aquarius
Data sources and processing

Aquarius

SSS L2 V3.0

Source:

Physical Oceanography Distributed Active Archive Center

http://podaac.jpl.nasa.gov/

Along track 1.44 sec.

Binned monthly at 1°x1°

Ascending & descending orbits combined

SMOS

SSS L3 (LOCEAN processing)

Source:

Centre Aval de Traitement des Données SMOS (CATDS)

eftp.ifremer.fr/salinity/

Monthly maps at 0.25°x0.25°

Binned monthly at 1°x1°

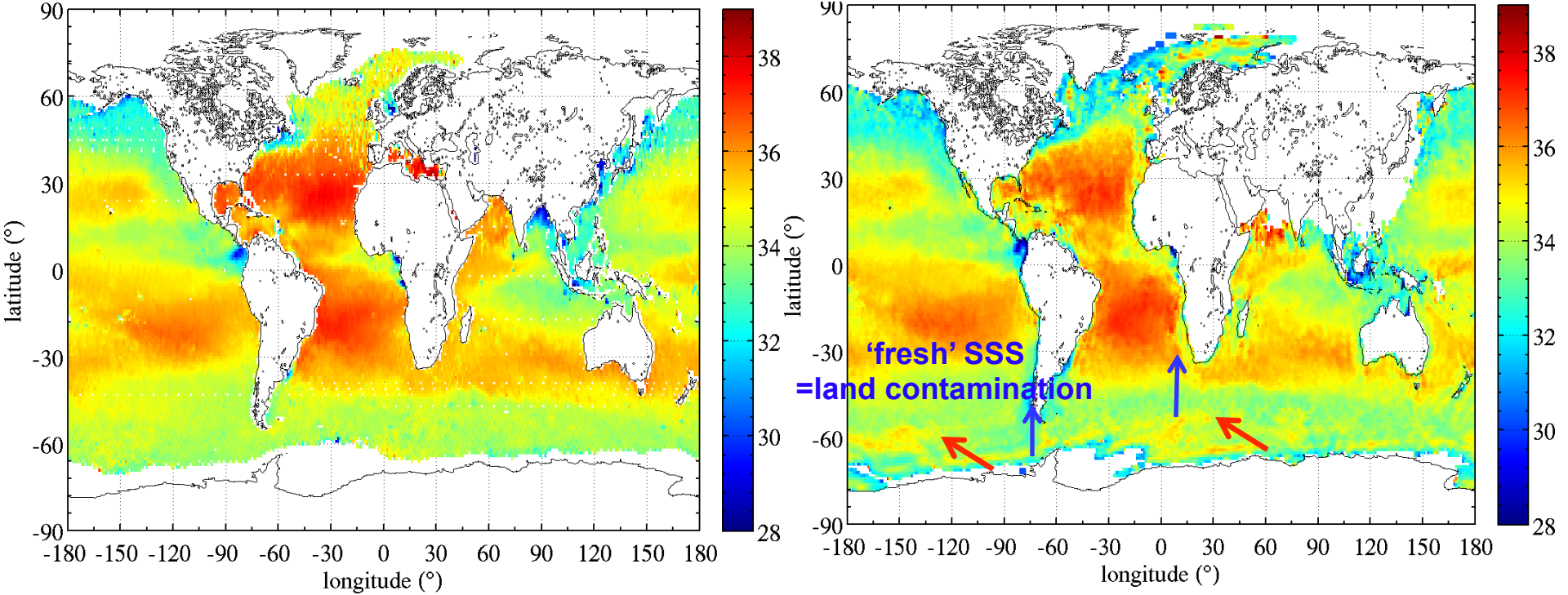
Ascending & descending orbits combined

Comparison of SSS from SMOS and Aquarius

Global map of SSS from Aquarius and SMOS (Jan 2012)

Aquarius

SMOS

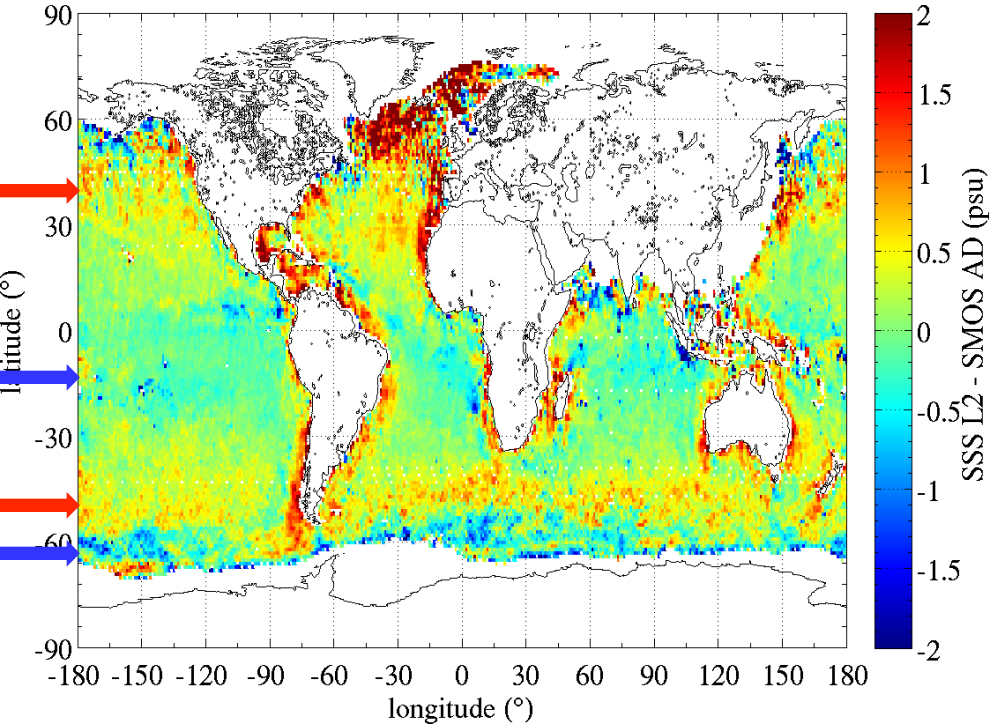


Very similar large-scale structures, but significant regional differences
(e.g. freshening around coastlines for SMOS, higher SSS close to ice edge at 60S).

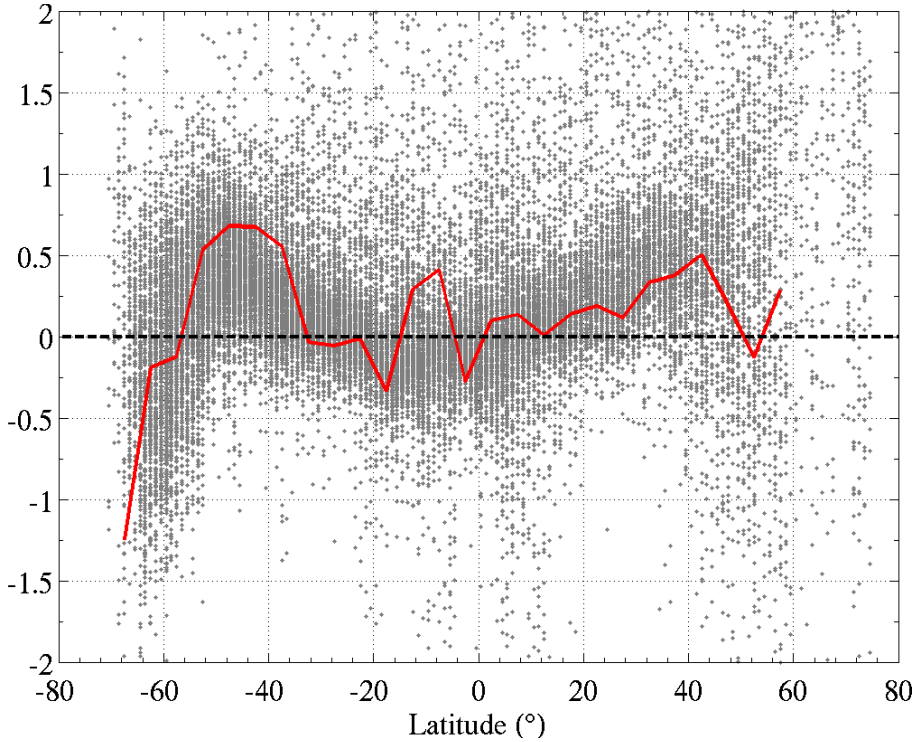
Comparison of SSS from SMOS and Aquarius

Differences SSS Aquarius – SMOS versus latitude

Aquarius - SMOS



Aquarius – SMOS vs Latitude

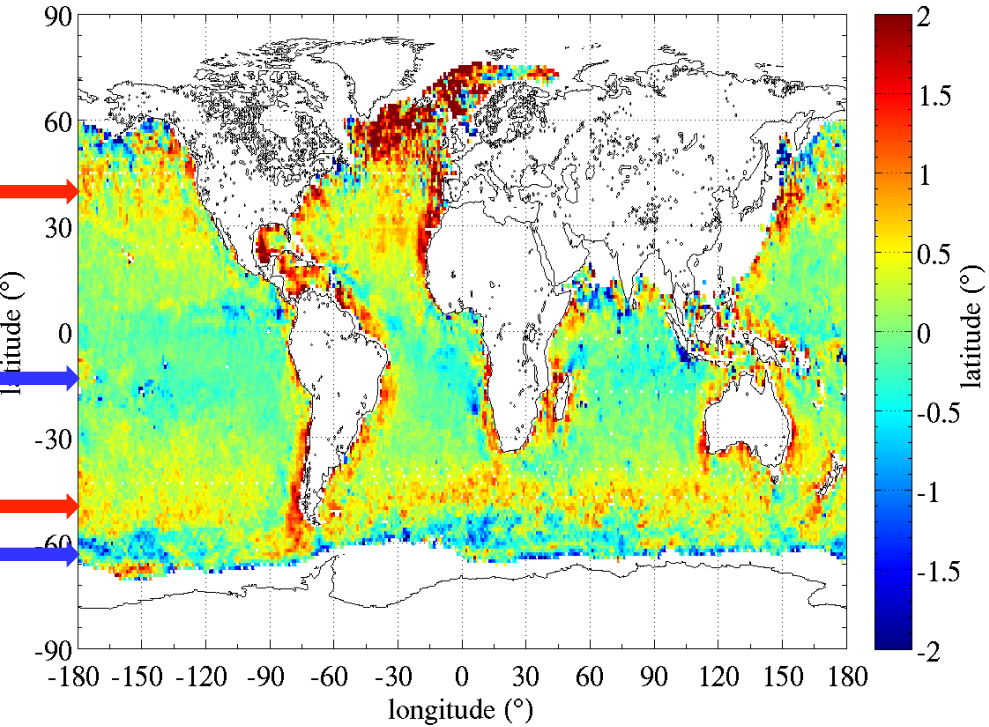


Differences shows large dependence on latitude, cf. around 40N, 50S and 60S.

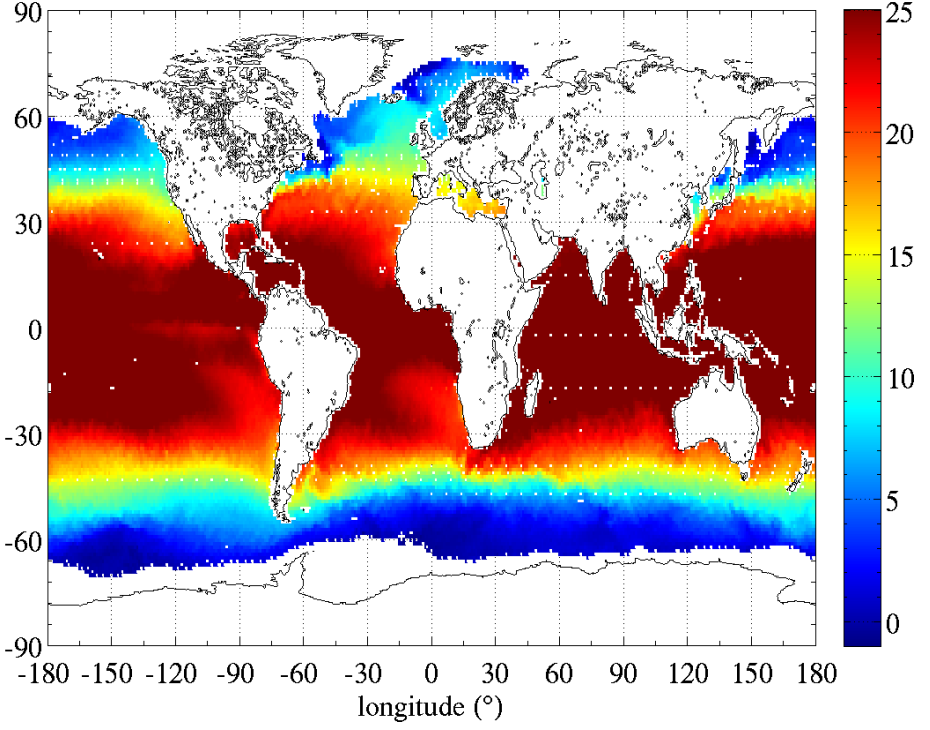
Comparison of SSS from SMOS and Aquarius

Differences SSS Aquarius – SMOS depends on SST

Aquarius - SMOS



SST

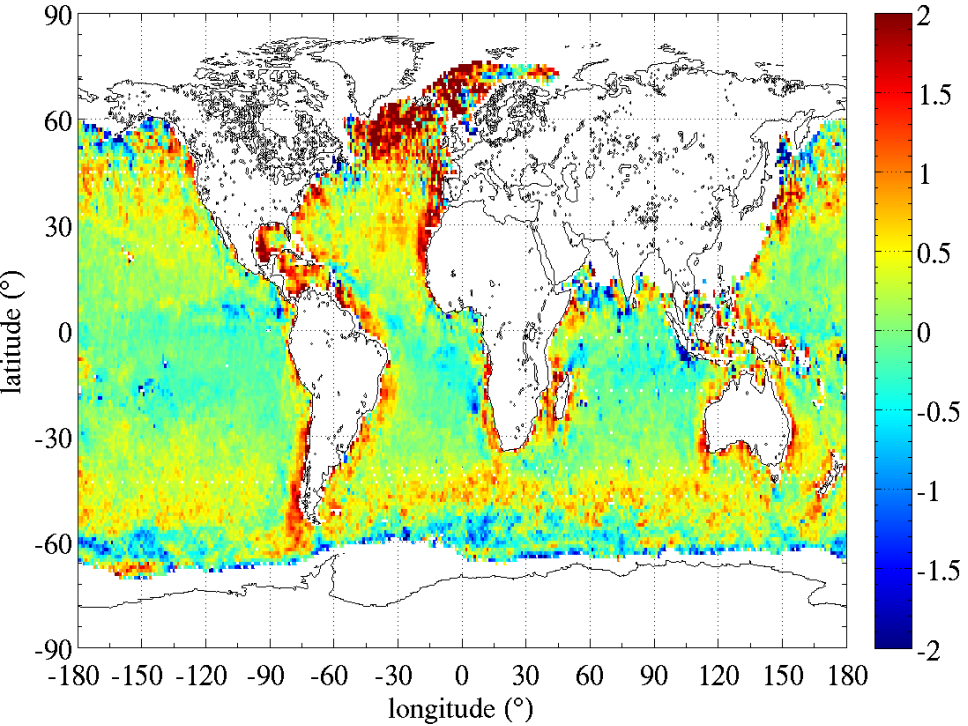


Differences pattern is similar to SST pattern.

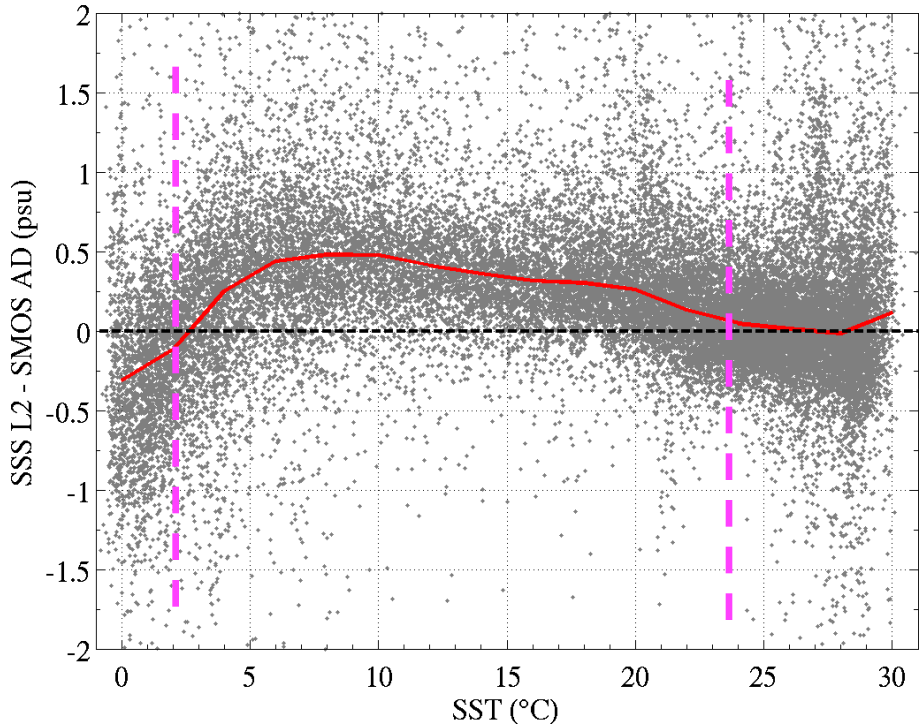
Comparison of SSS from SMOS and Aquarius

Differences SSS Aquarius – SMOS versus SST

Aquarius - SMOS



Aquarius – SMOS vs SST



Aquarius SSS is 1/ fresher for very cold water (< 3°C) , 2/ saltier for most ocean (3°C – 24°C) 3/ similar to SMOS for warmer waters (> 22°C)

Impact of the dielectric constant model

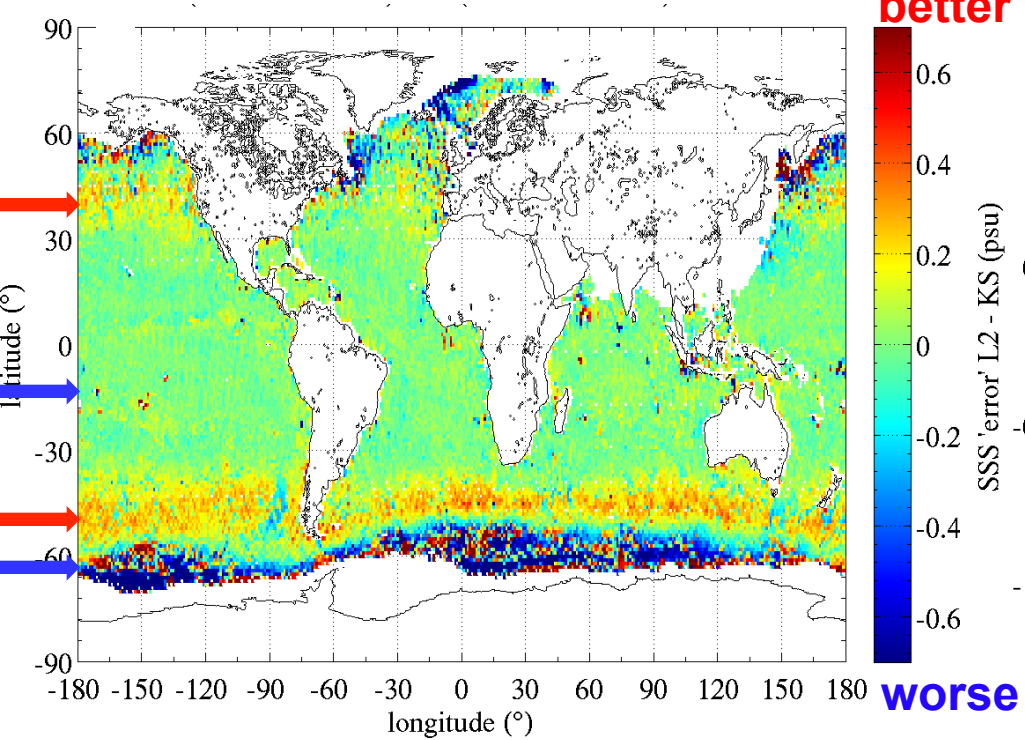
We reprocess Aquarius data using SMOS dielectric constant model (i.e. Klein and Swift 1977) for:

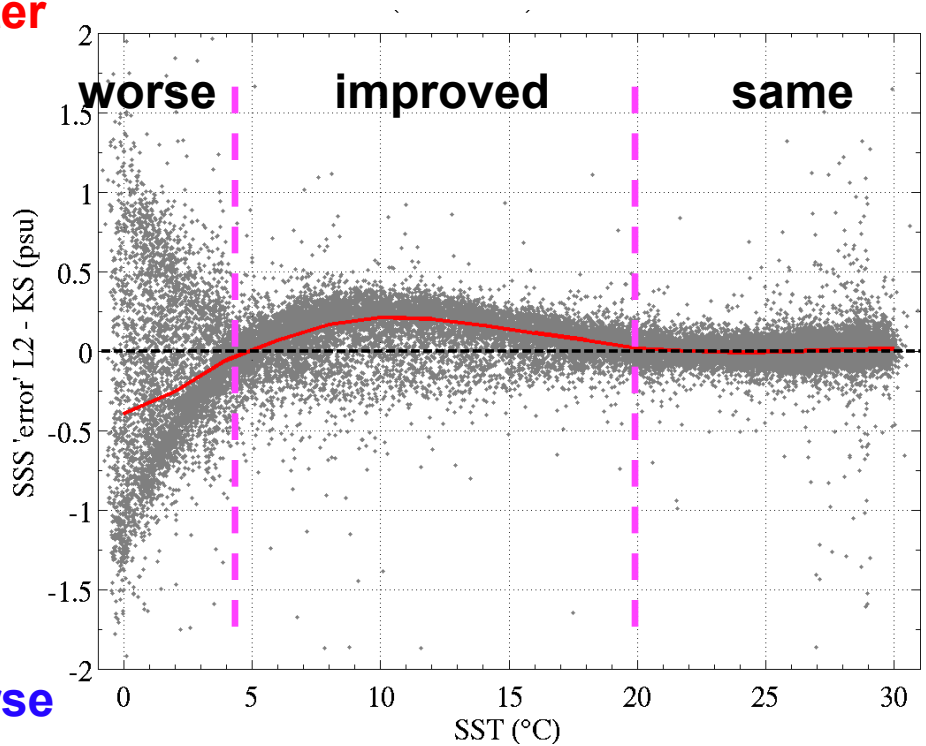
- Radiometers Calibration
- SSS Retrieval

Impact of the dielectric constant model

Aquarius reprocessed with SMOS dielectric constant

|Aq – SMOS| - |Aq_repr – SMOS|





Aquarius match with SMOS is improved between 6°C and 18°degC (~ 0.2 psu)

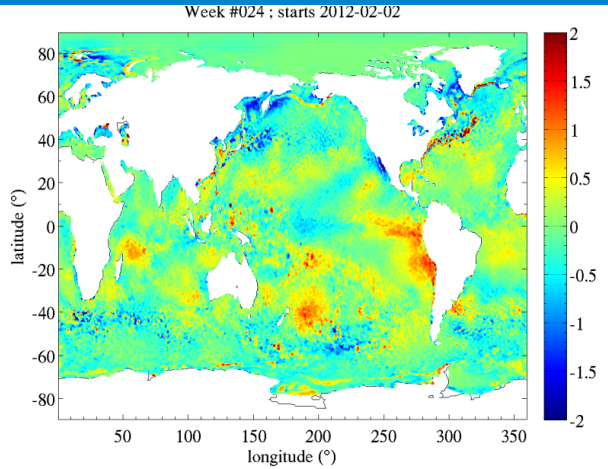
Impact of SST ancillary product

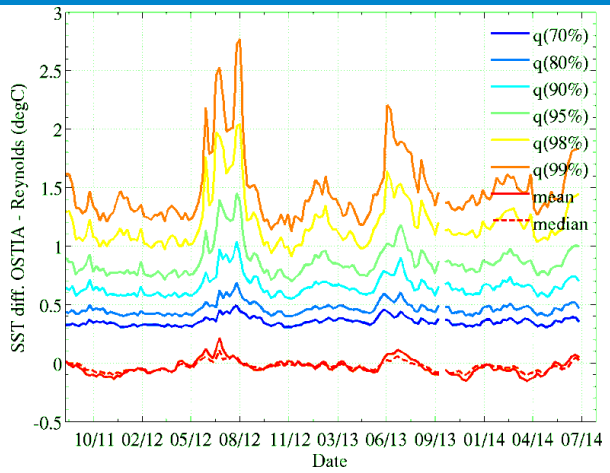
Aquarius : NOAA Optimally Interpolated SST (IR satellite) “Reynolds”

SMOS : Operational Sea Surface Temperature and Sea Ice Analysis OSTIA (IR and microwave satellites)

Impact of SST ancillary product

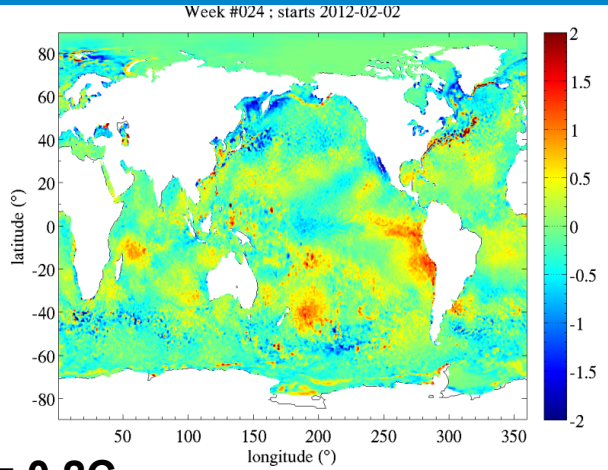
SST differences OSTIA – Reynolds NOAA OI





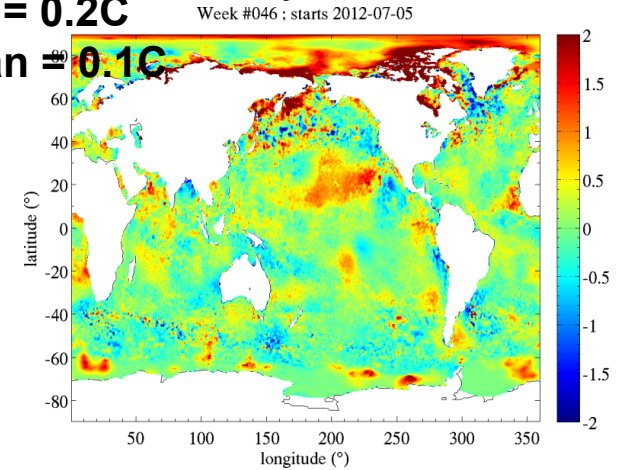
Impact of SST ancillary product

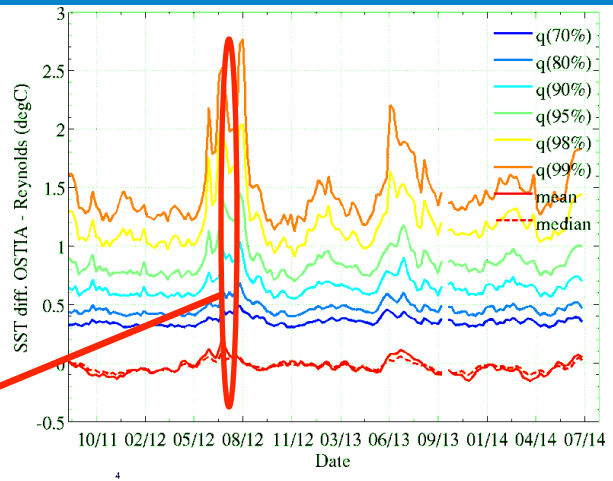
SST differences OSTIA – Reynolds NOAA OI

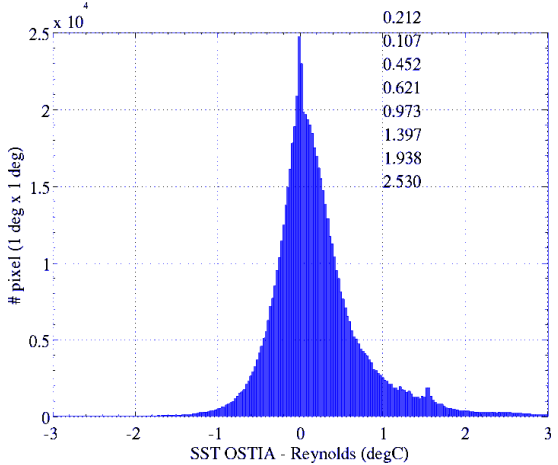


Mean = 0.2C

Median = 0.1C

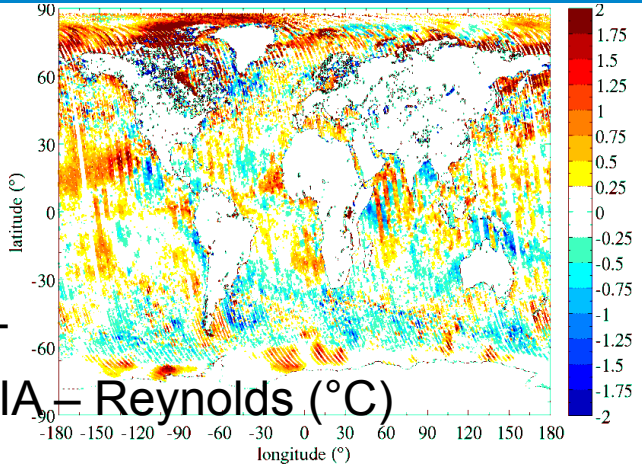




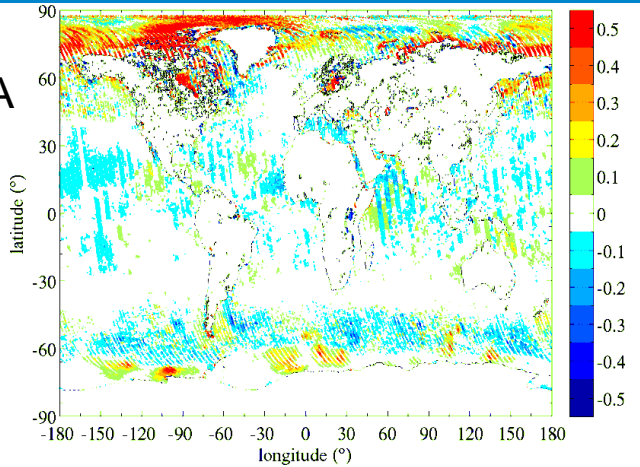


Impact of SST ancillary product
SST interpolated at Aquarius footprints

ΔSST
OSTIA – Reynolds (°C)

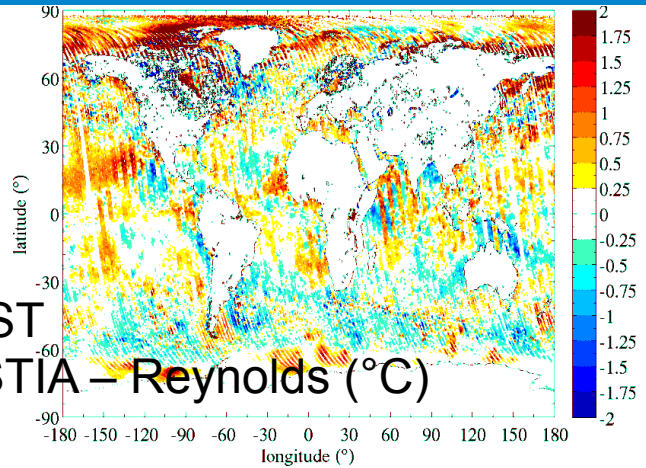


ΔTbV
OSTIA – NOAA
(K)

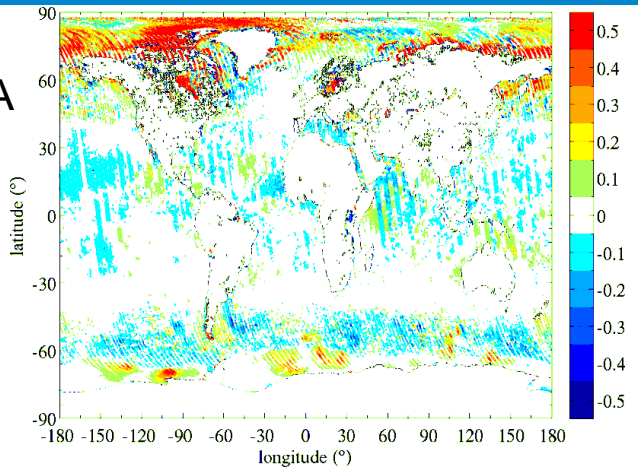


Impact of SST ancillary product
SST interpolated at Aquarius footprints

ΔSST
OSTIA – Reynolds (°C)

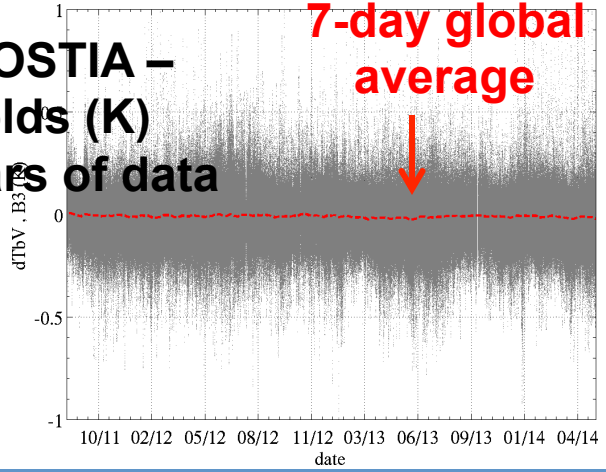


ΔTbV
OSTIA – NOAA
(K)



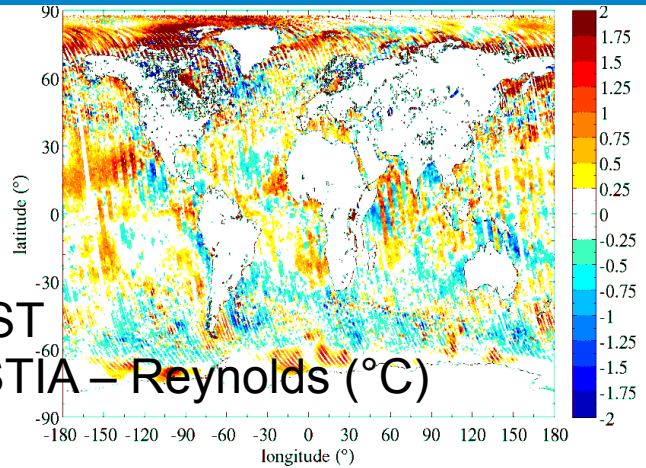
ΔTbV OSTIA – Reynolds (K)
~ 3years of data

7-day global average

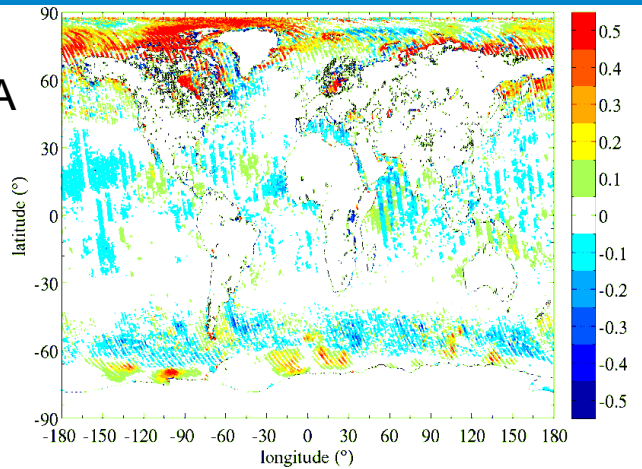


Impact of SST ancillary product
SST interpolated at Aquarius footprints

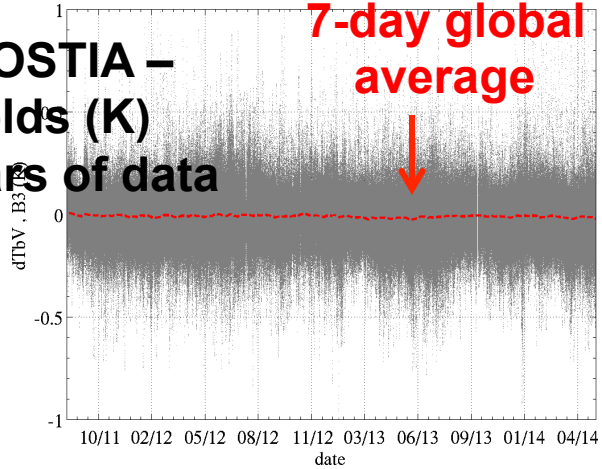
ΔSST
OSTIA – Reynolds (°C)



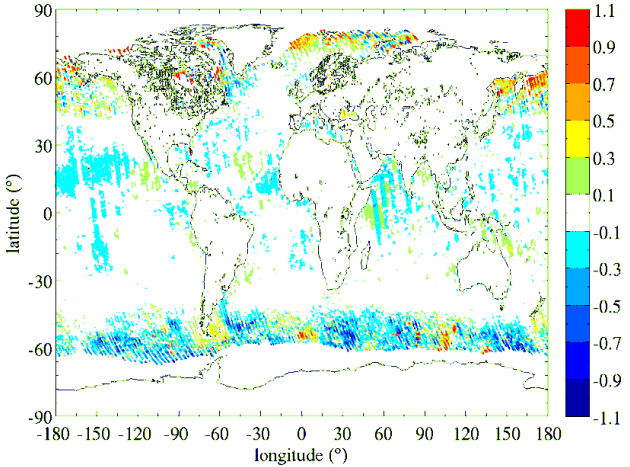
ΔTbV
OSTIA – NOAA
(K)



ΔTbV OSTIA – Reynolds (K)
~ 3years of data



ΔSSS OSTIA – Reynolds (K) Week 46

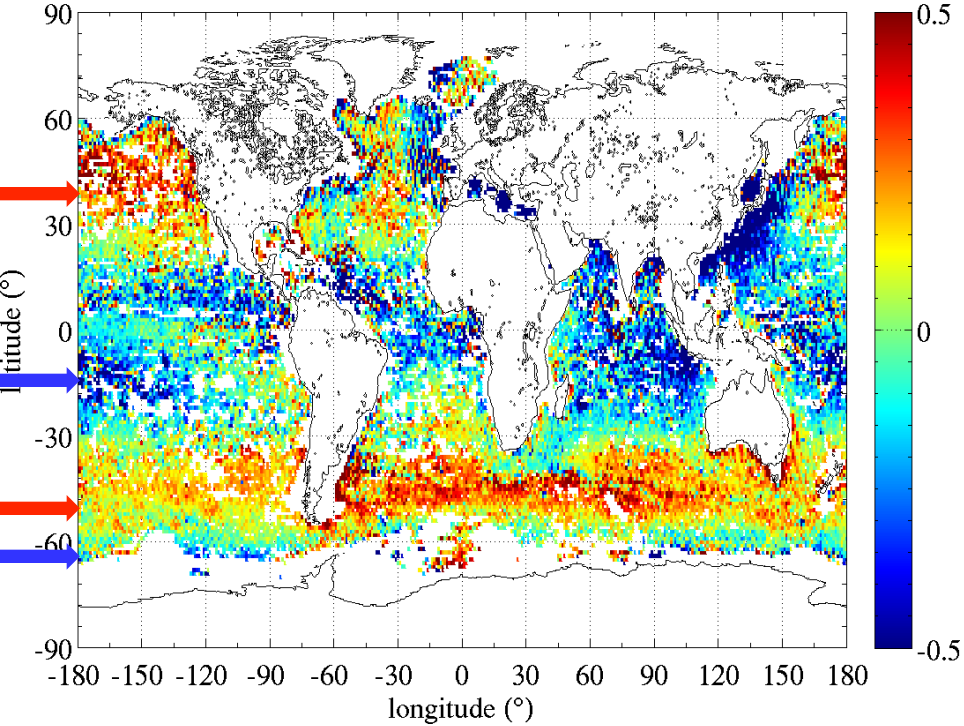


Comparison to Argo in situ data

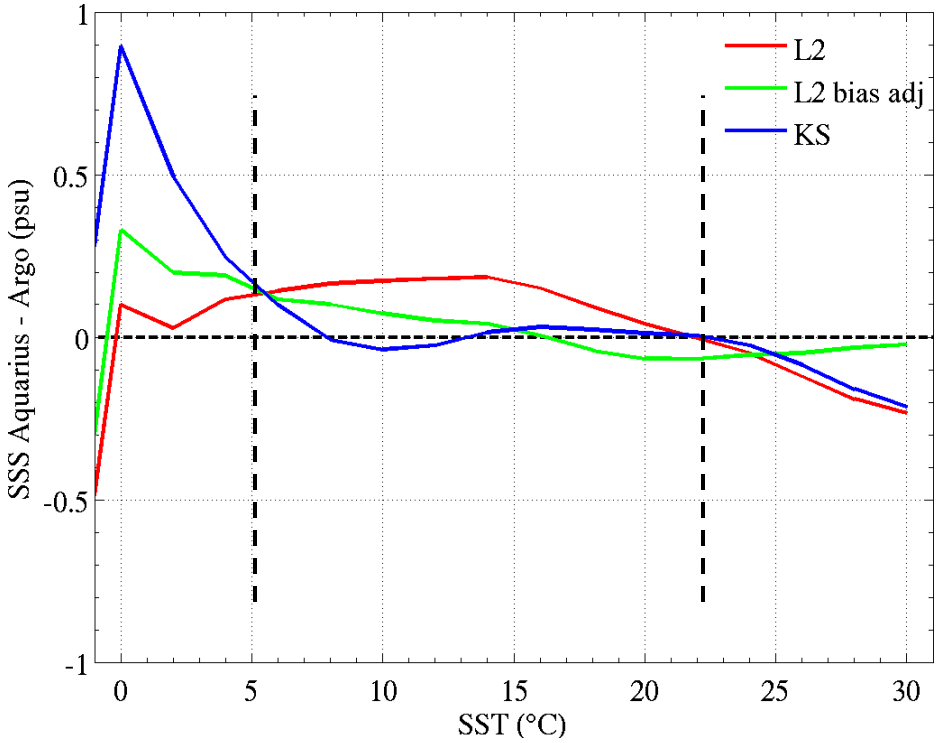
(*) global network of 3000 free-drifting profiling floats (http://www.argo.net/)

SSS difference with Argo for all algorithms

Aquarius (nominal) - Argo



Aquarius – Argo SSS (psu)



Summary

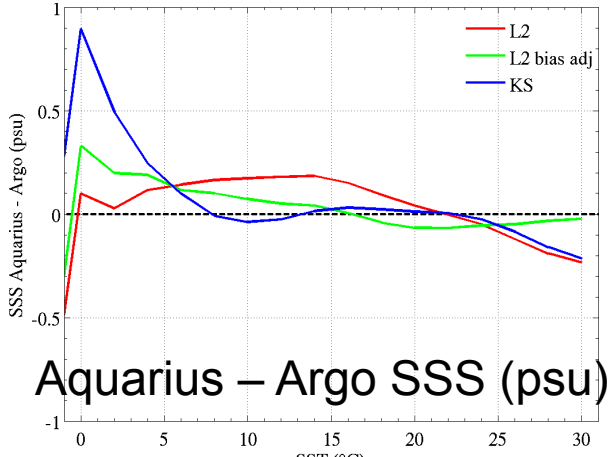
SSS difference between Aquarius and SMOS is in part due to dielectric constant model (~0.2 psu in temperate waters)

Large differences remain in very cold waters and around coastlines

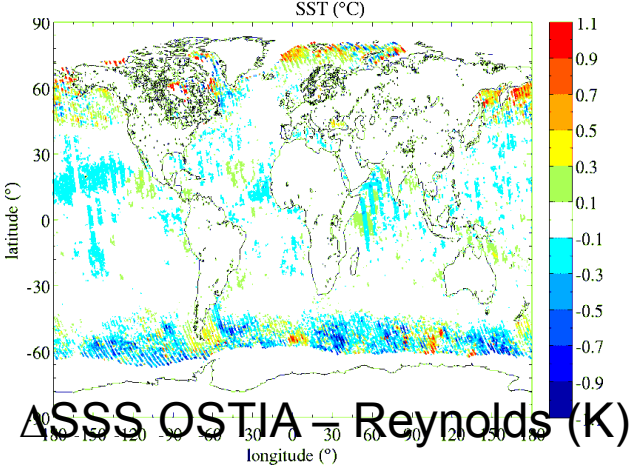
Differences in ancillary SST:

no impact on calibration

large (~1 psu) SSS differences in cold waters.

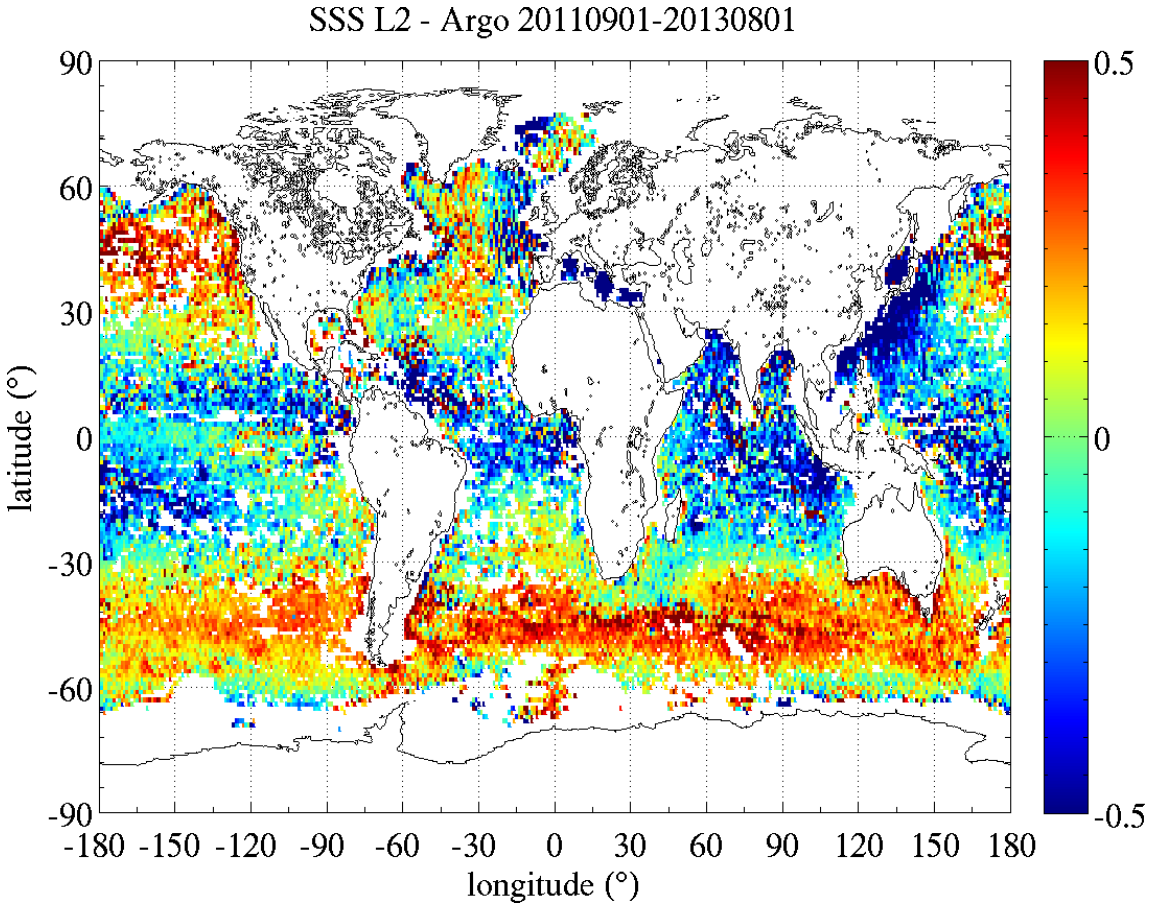


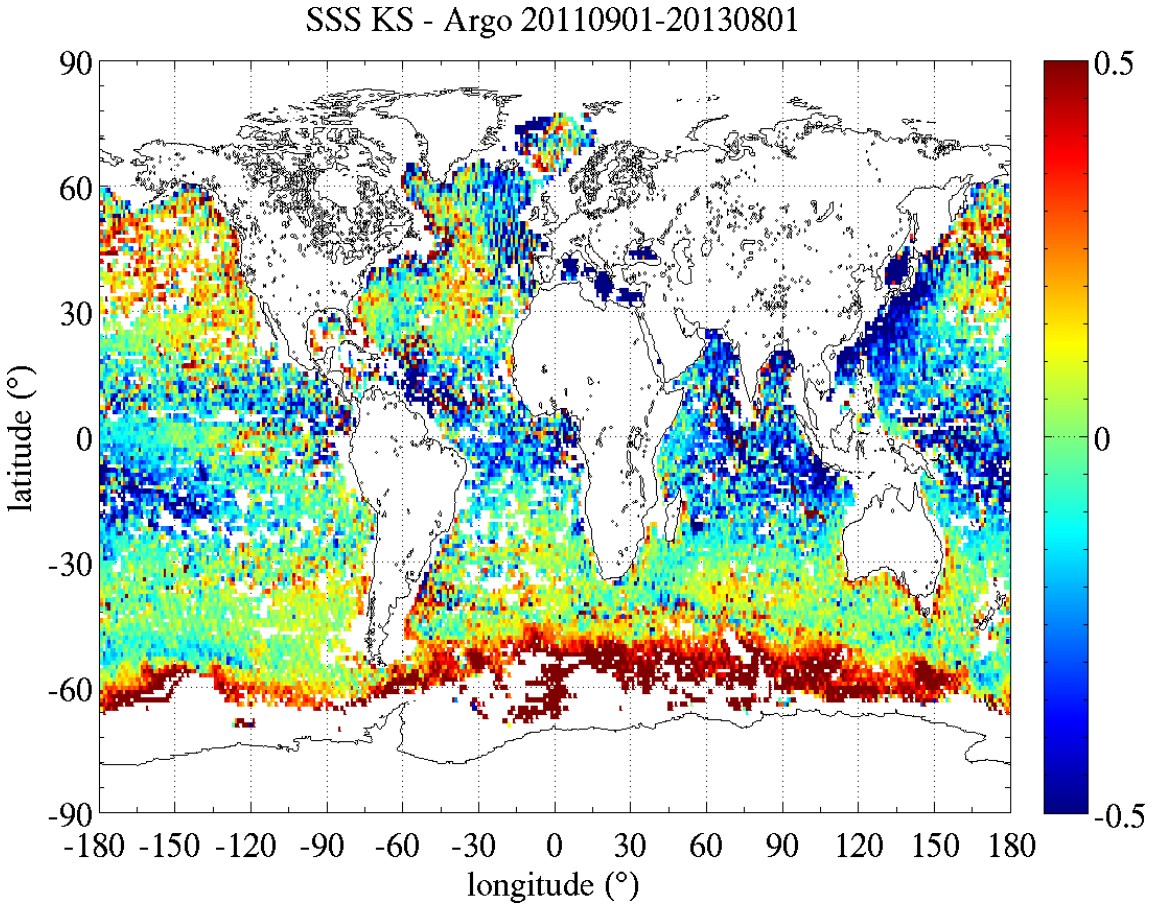
Aquarius – Argo SSS (psu)



ΔSSS OSTIA – Reynolds (K)

BACKUP


SSS L2 - Argo 20110901-20130801
90
60
30
0
-30
-60
-90
latitude (°)
-180 -150 -120 -90 -60 -30 0 30 60 90 120 150 180
longitude (°)
0.5
0
-0.5

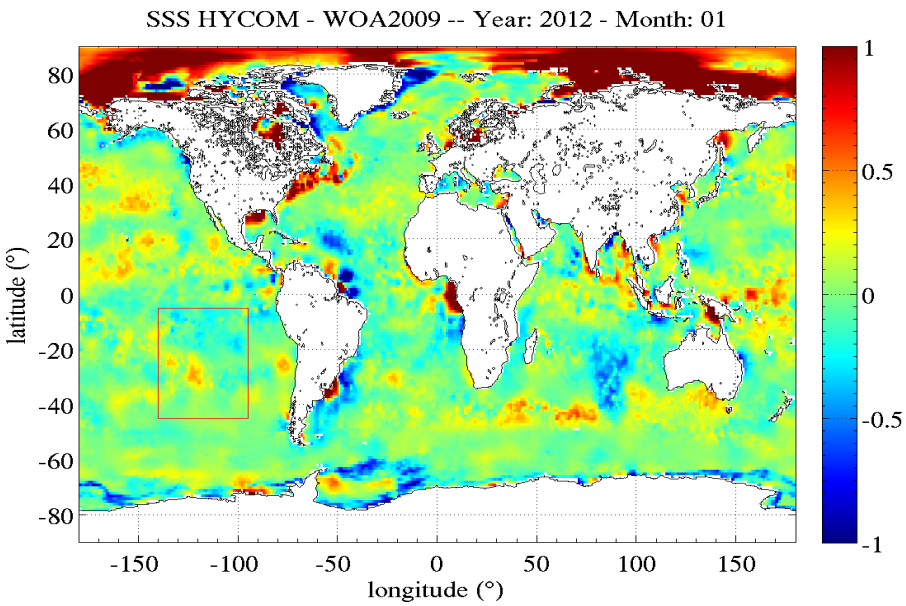

SSS KS - Argo 20110901-20130801
90
60
30
0
-30
-60
-90
latitude (°)
-180 -150 -120 -90 -60 -30 0 30 60 90 120 150 180
longitude (°)
0.5
0
-0.5

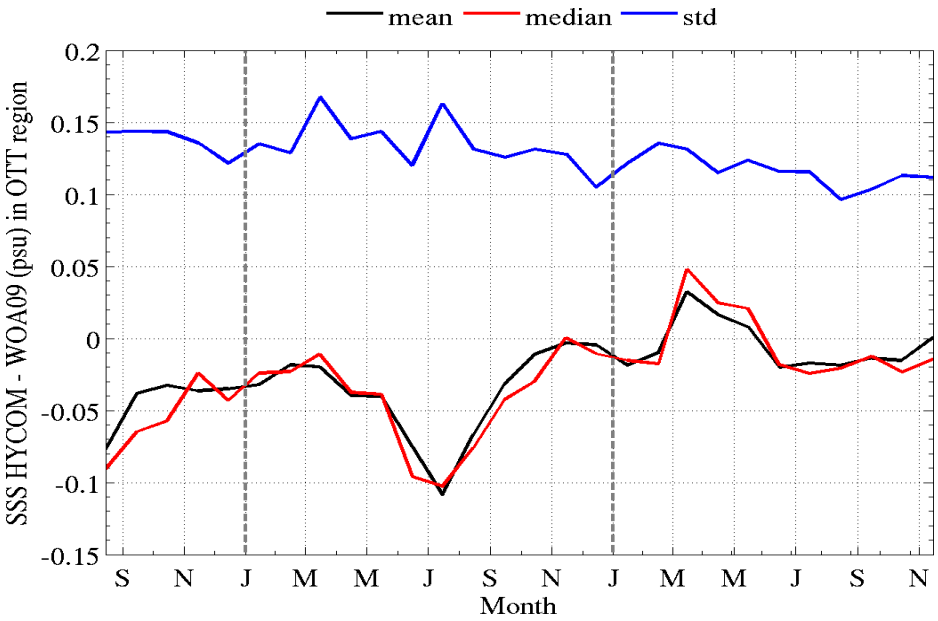
Differences in ancillary SSS used in calibration

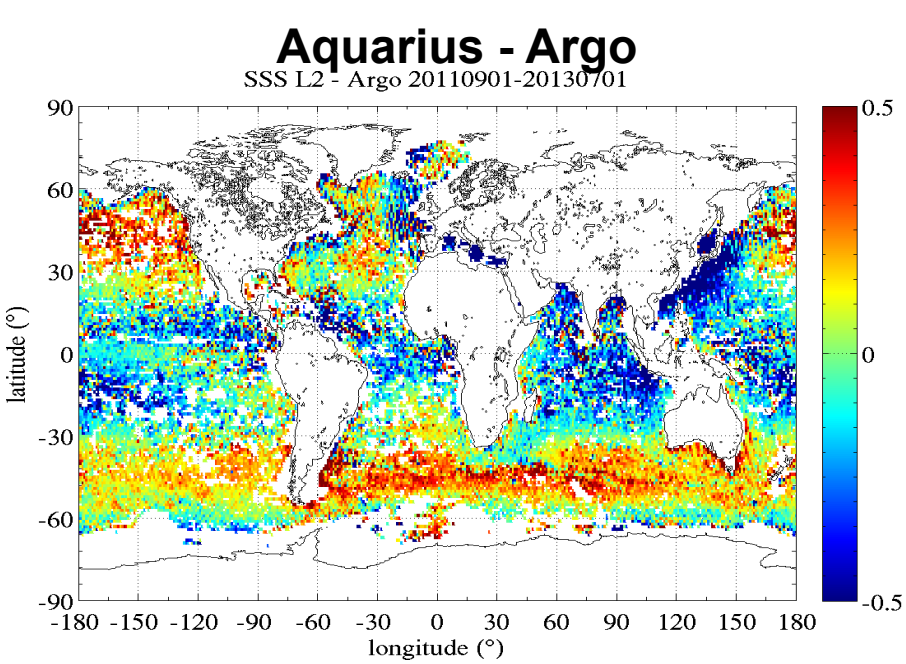
SMOS: region in Pacific ocean to compute and Ocean Target Transformation (OTT)

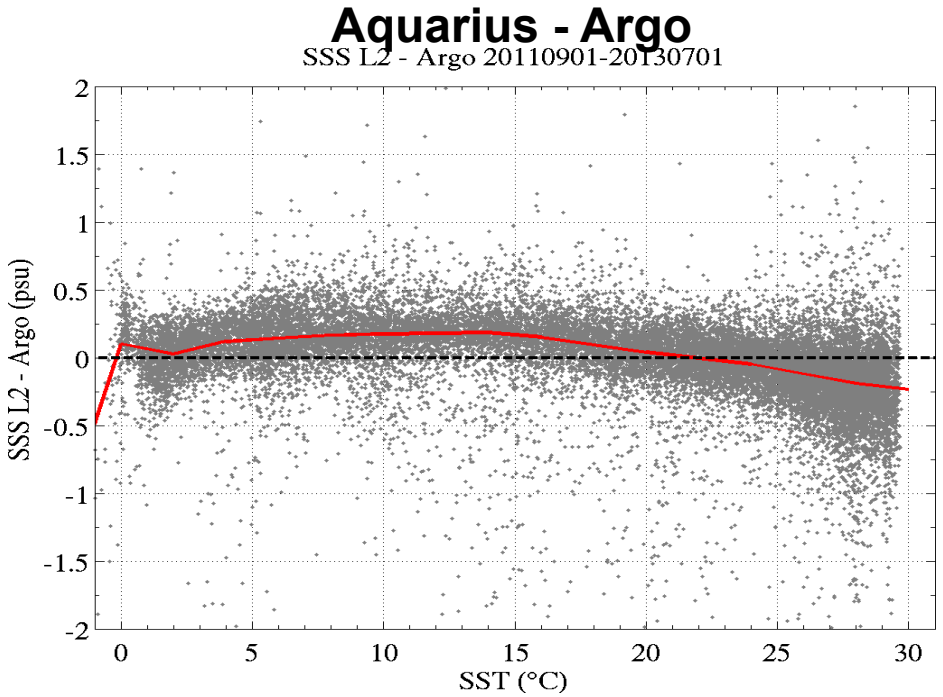
The OTT consists of removing average difference between measured Tb and forward model

OTT uses ancillary SSS


SSS HYCOM - WOA2009 -- Year: 2012 - Month: 01
latitude (°)
80
60
40
20
0
-20
-40
-60
-80
-150
-100
-50
0
50
100
150
longitude (°)
1
0.5
0
-0.5
-1


mean
median
std
SSS HYCOM - WOA09 (psu) in OTT region
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
S
N
J
M
M
J
S
N
J
M
M
J
S
N
Month





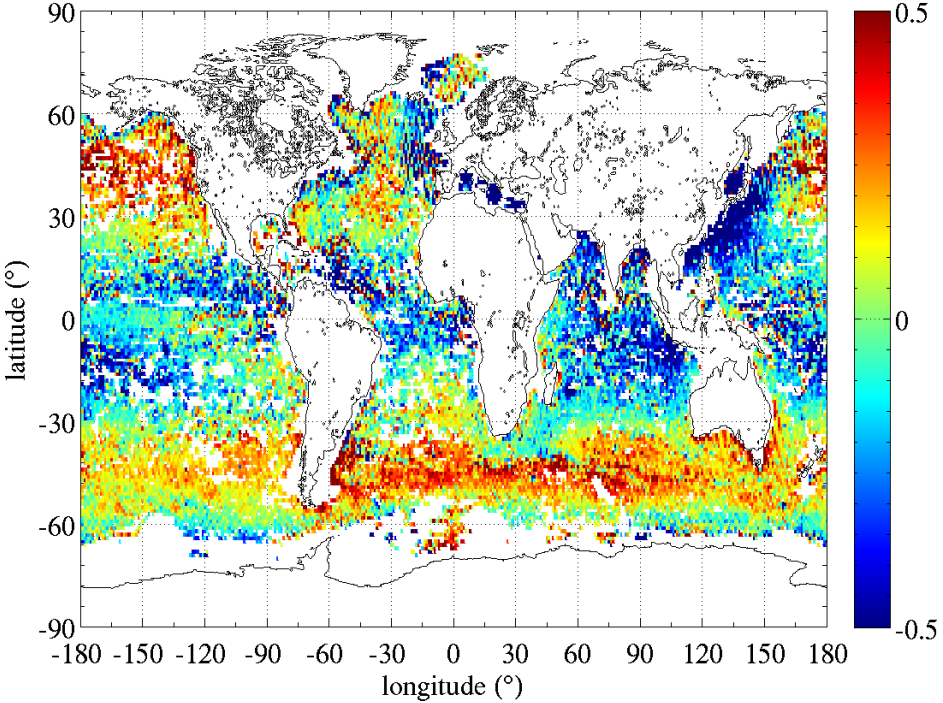
SSS 'error' (= difference with Argo) depends on SST

⇒ An empirical correction to SSS is introduced in V3.0 as a function of SST:

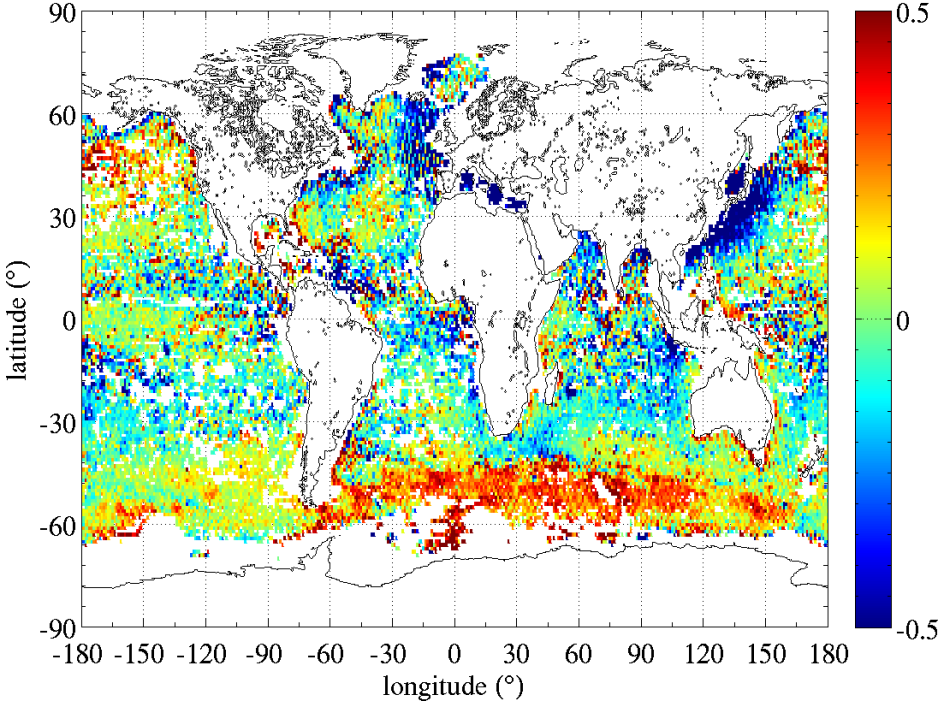
$$\Delta SSS = -0.0019594*T^2 + 1.1257*T - 161.4934$$

SSS V3.0 – Argo : Nominal and 'bias adjusted'

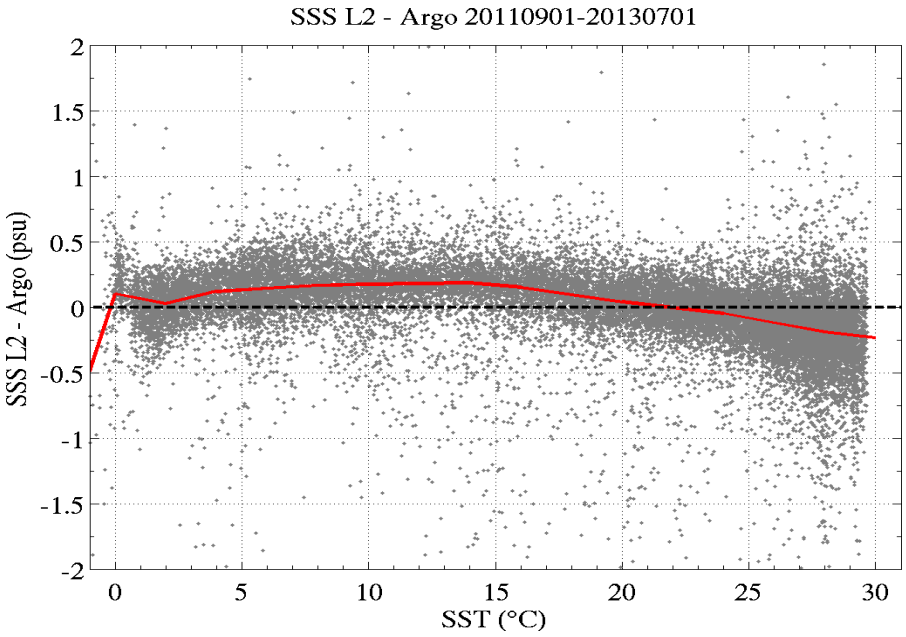
Aquarius - Argo



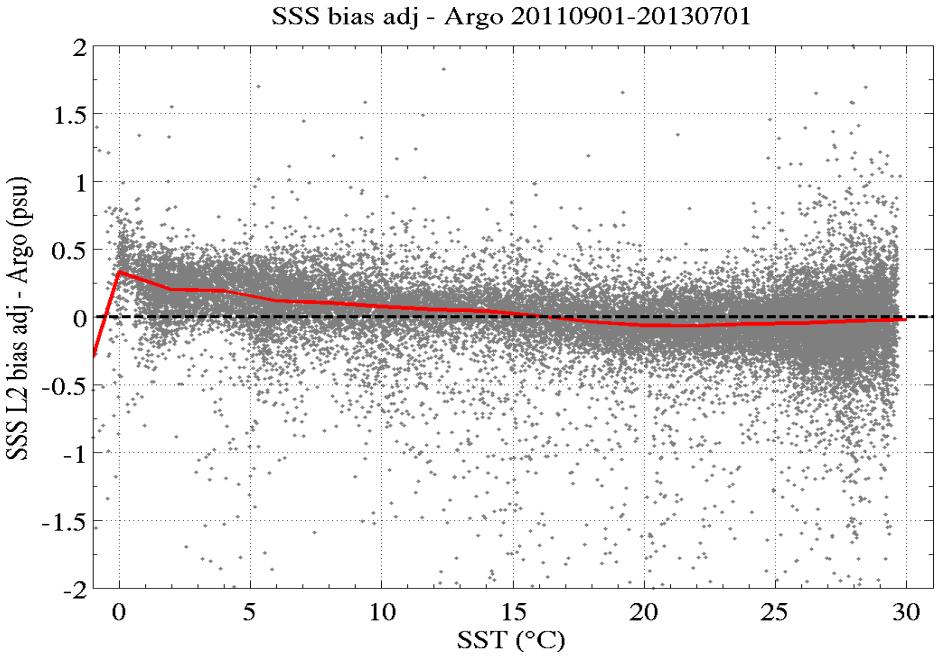
Aquarius bias adjusted - Argo



Aquarius - Argo



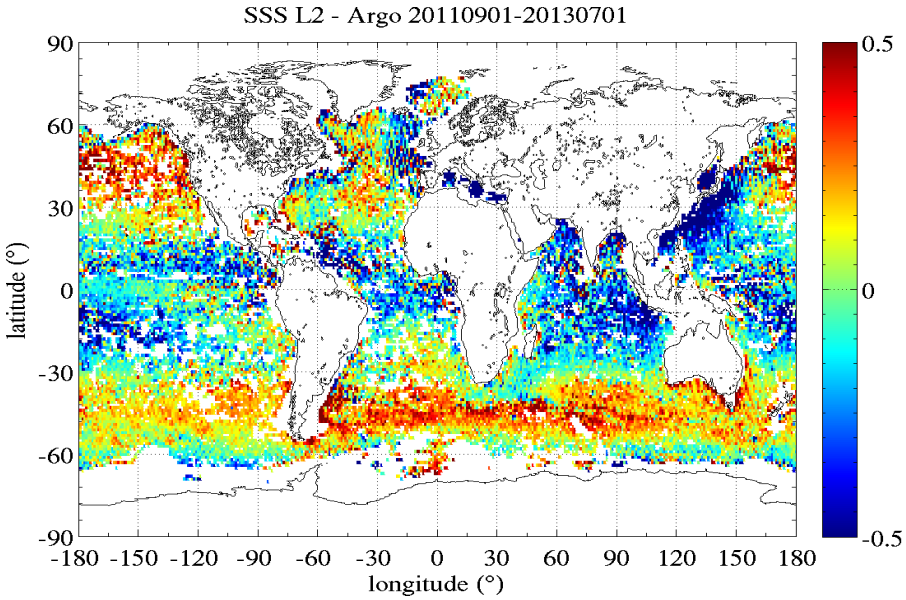
Aquarius bias adjusted- Argo



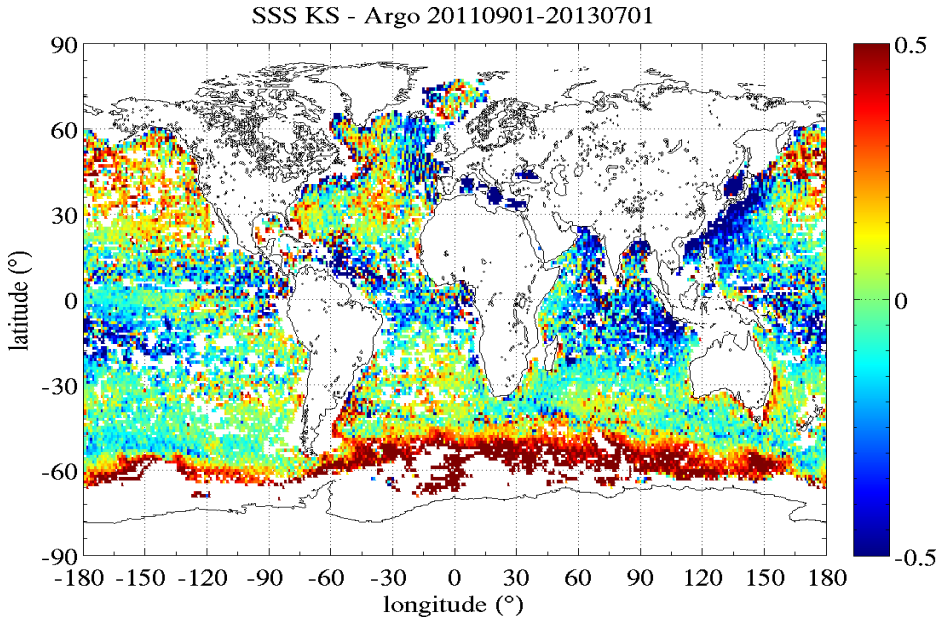
V3.0 bias adjustment reduces error except for very cold waters

SSS V3.0 – Argo : Nominal and reprocessed with Klein and Swift model

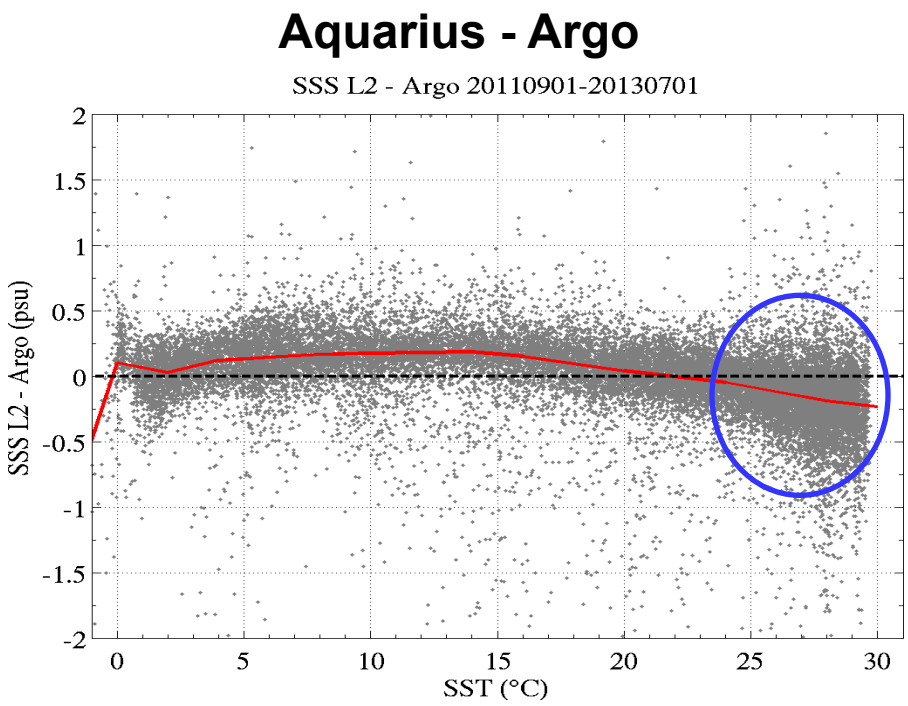
Aquarius - Argo

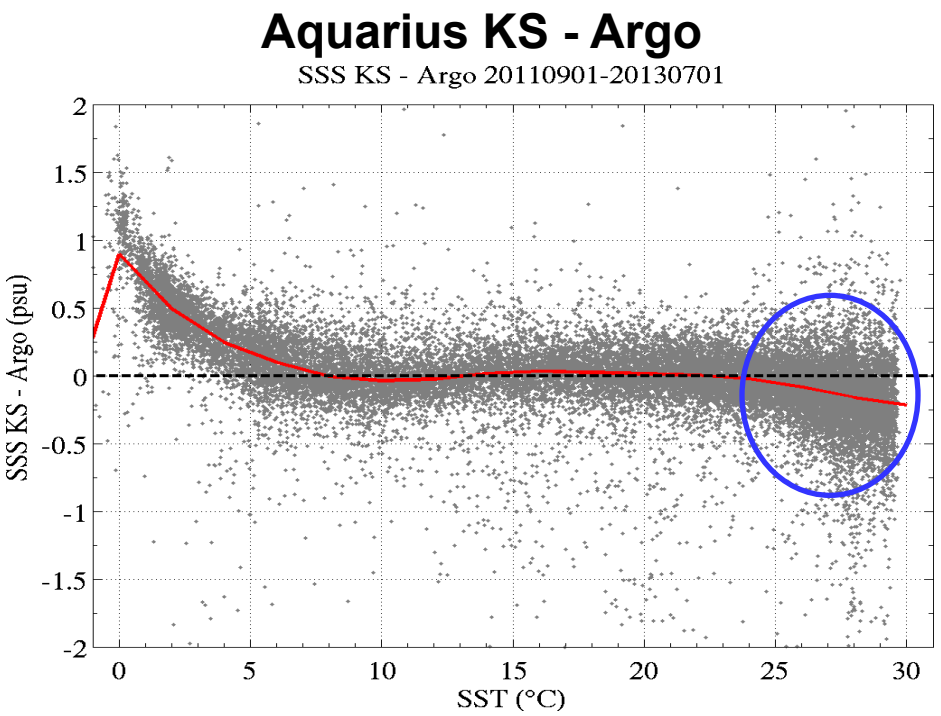


Aquarius KS - Argo



SSS V3.0 – Argo : Nominal and reprocessed with Klein and Swift model vs SST

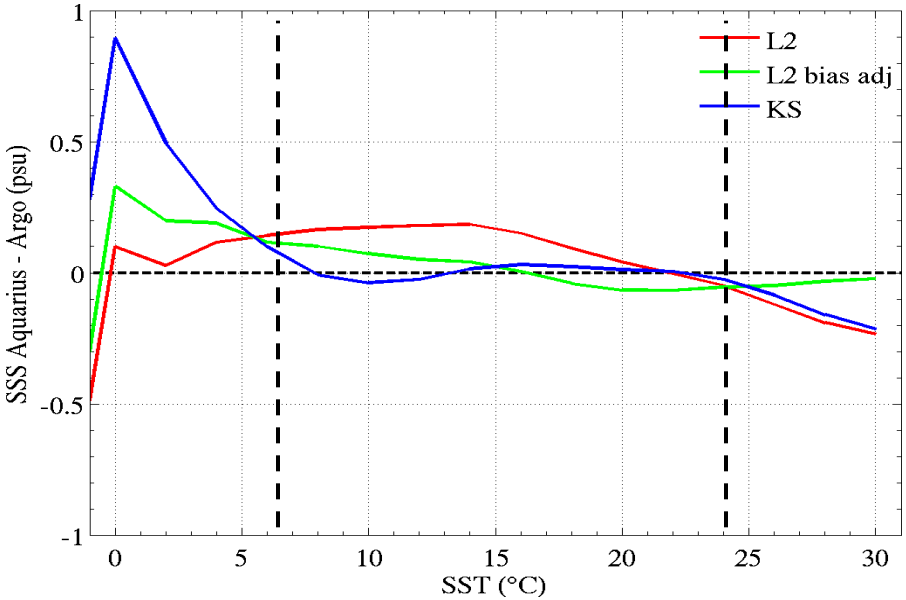




Both model show fresher water than Argo in warm water (precipitations/stratification)

KS model shows smallest differences from 6 degC to 22 degC

Very cold waters are worsened by the reprocessing



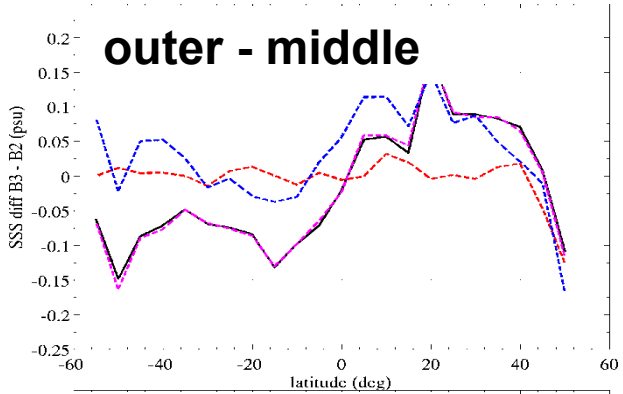
- Cold waters < 6 deg C nominal L2 matches Argo the best
- 6 < SST < 22 deg C

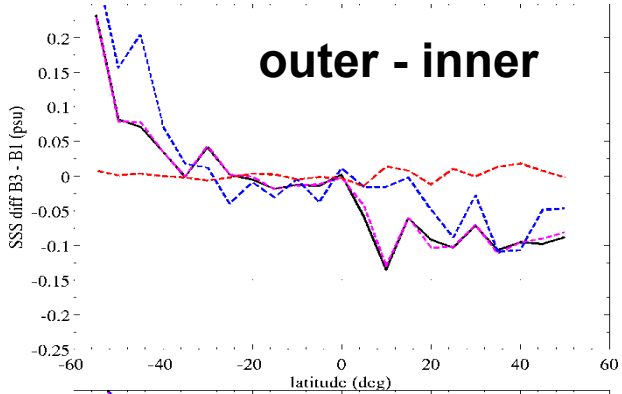
  bias adjusted SSS reduces bias in nominal L2, KS provides the best match

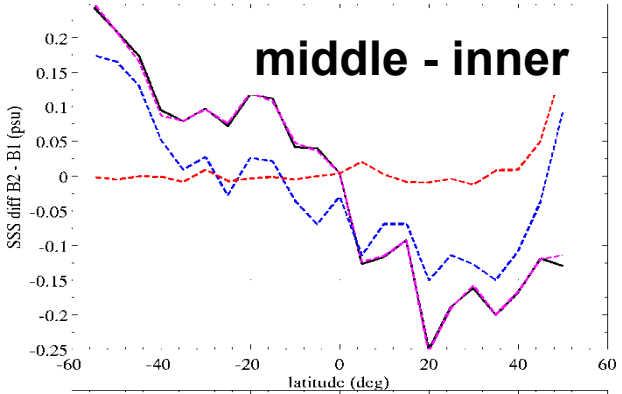
- SST > 25 degC

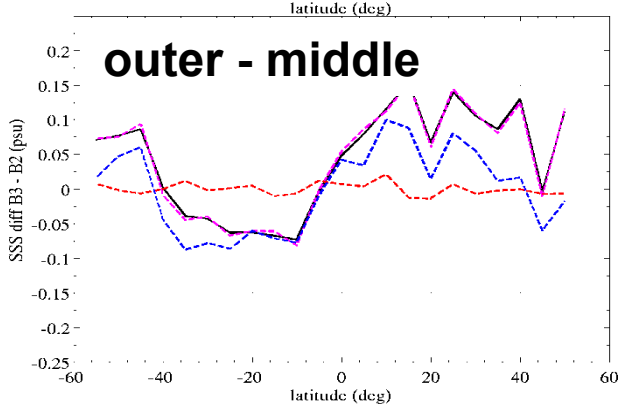
  bias adjusted SSS provides the best match, but the lower SSS in other products could be due to precipitations. Should it be adjusted?

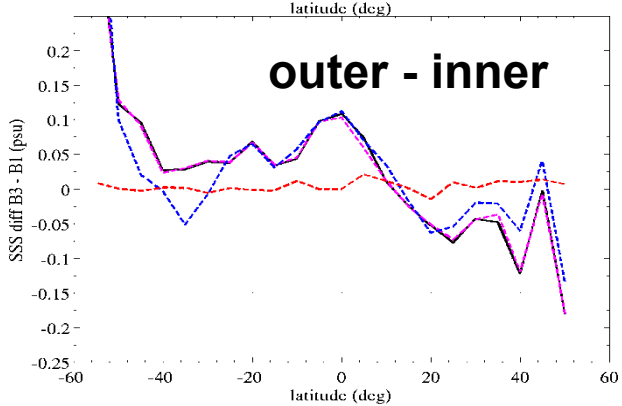
Inter-beam difference vs latitude
(top) ascending and (bottom) descending orbits

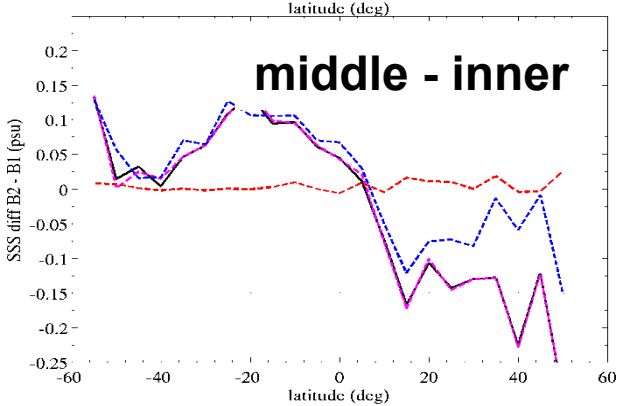






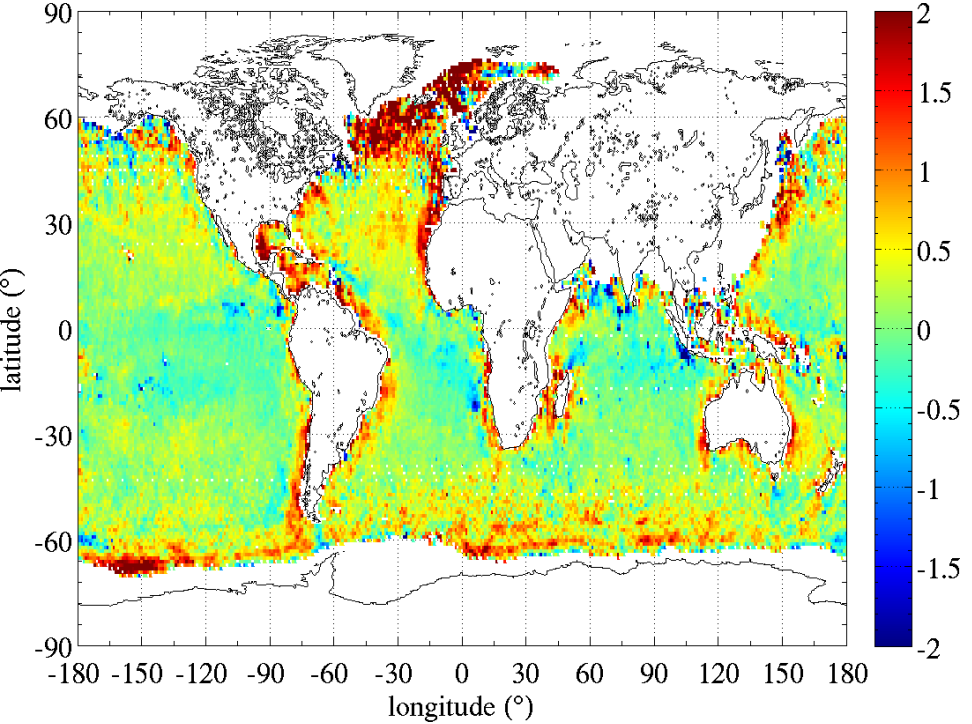




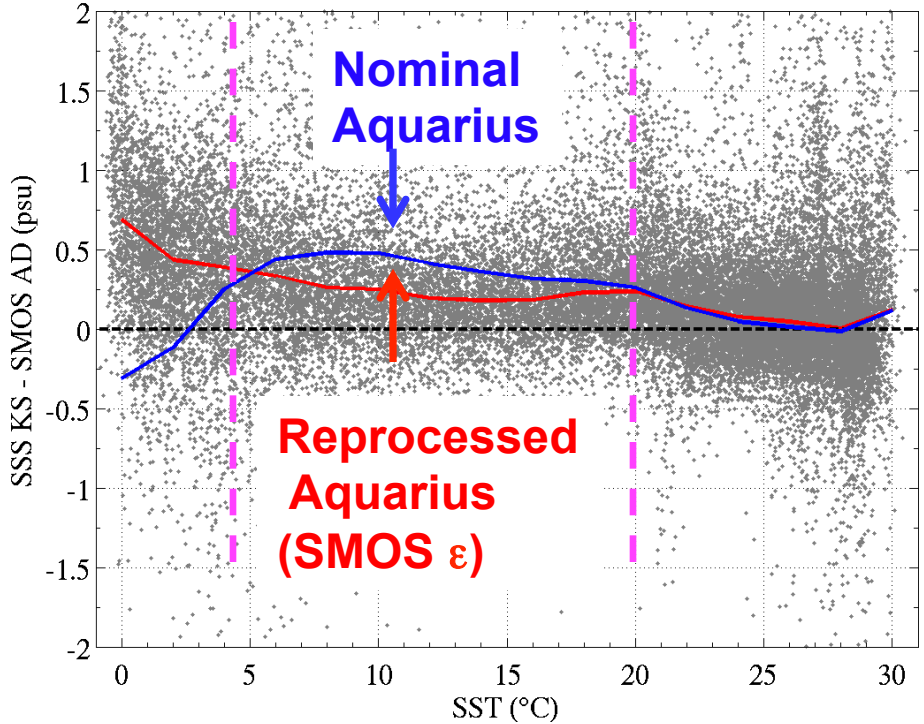


SSS difference between Aquarius reprocessed and SMOS

Aquarius (Reprocessed) - SMOS



Aquarius (Reprocessed) - SMOS



Reprocessed Aquarius SSS have reduced differences with SMOS SSS for SST between 6°C and 18°C