Sea Water Permittivity Model and Differences in Sea Surface Salinity Retrieved from SMOS and Aquarius

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Introduction

3 models of sea water permittivity:

- Meissner and Wentz (2004) “modified” - **MW04m**
  Aquarius model
- Klein & Swift (1977) – **KS77**
  SMOS model
- George Washington University – **GW12**
  (Roger Lang, personal communication)

Comparison of permittivity models:

- Inter-calibration of Aquarius and SMOS
  (not necessarily the best SSS) – KS77 vs MW04m
- “Absolute” calibration of SSS, correct dependence on SST
  KS77, MW04m, GW12, ground truth validation

Summary

Impact of permittivity model on

- Tb and inverted SSS vs [SSS,SST]
  no Tb calibration
- Aquarius L2 SSS global map
  after Tb calibration
- SSS difference SMOS – Aquarius using various permittivity models

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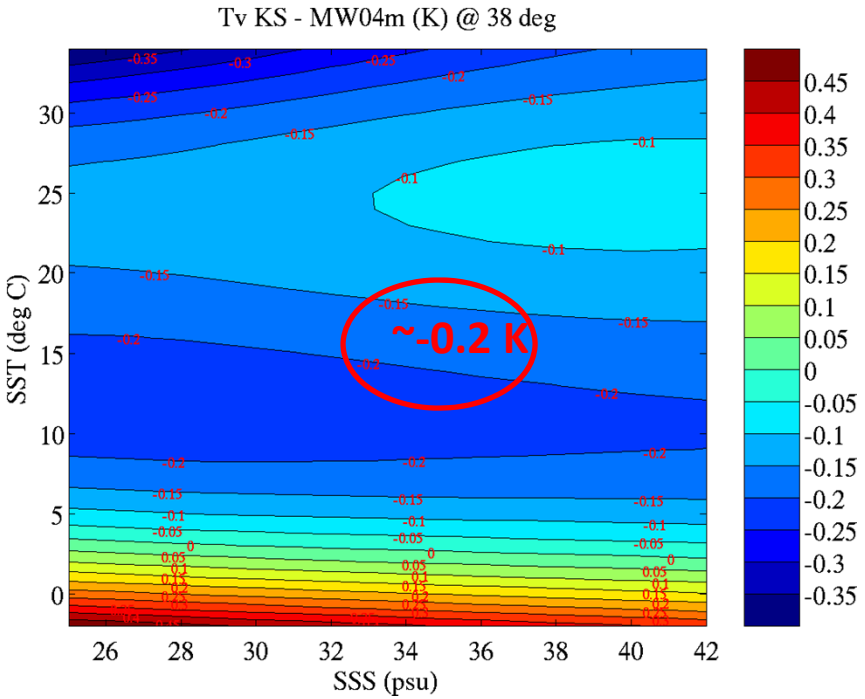
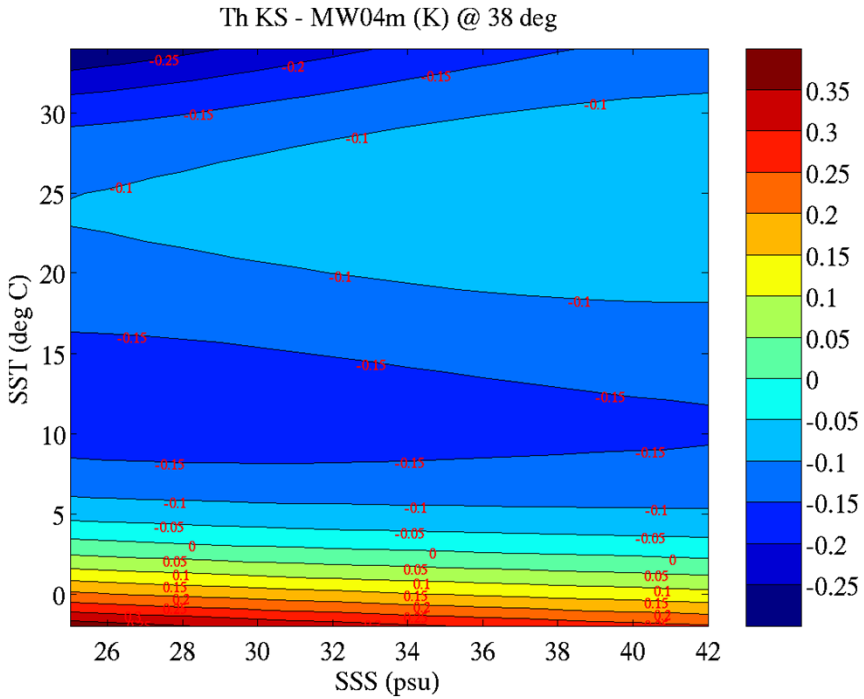
Differences in Permittivity Models
Effect on Tb of flat surface

V-pol, θ=38 deg
KS77 – MW04m



H-pol, θ=38 deg
KS77 – MW04m



Difference mostly depends on SST; smallest for cold waters, but larger sensitivity to SST.

Differences in Permittivity Models
Effect on Tb of flat surface

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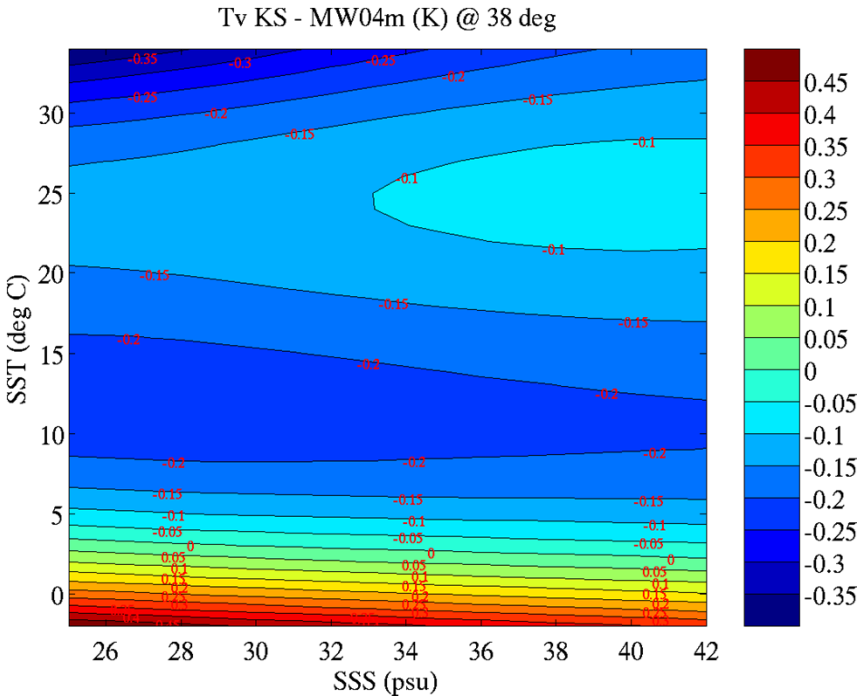
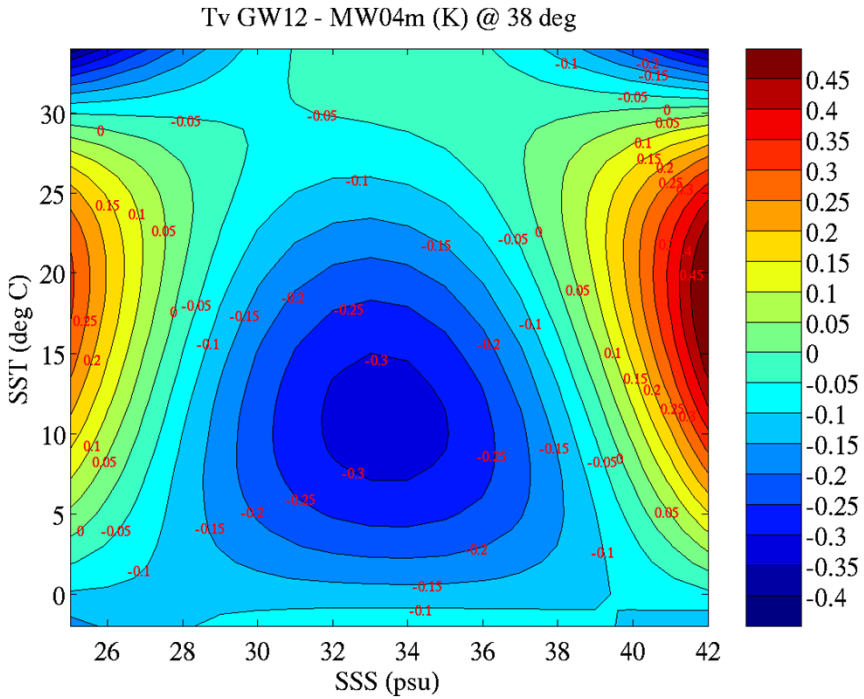


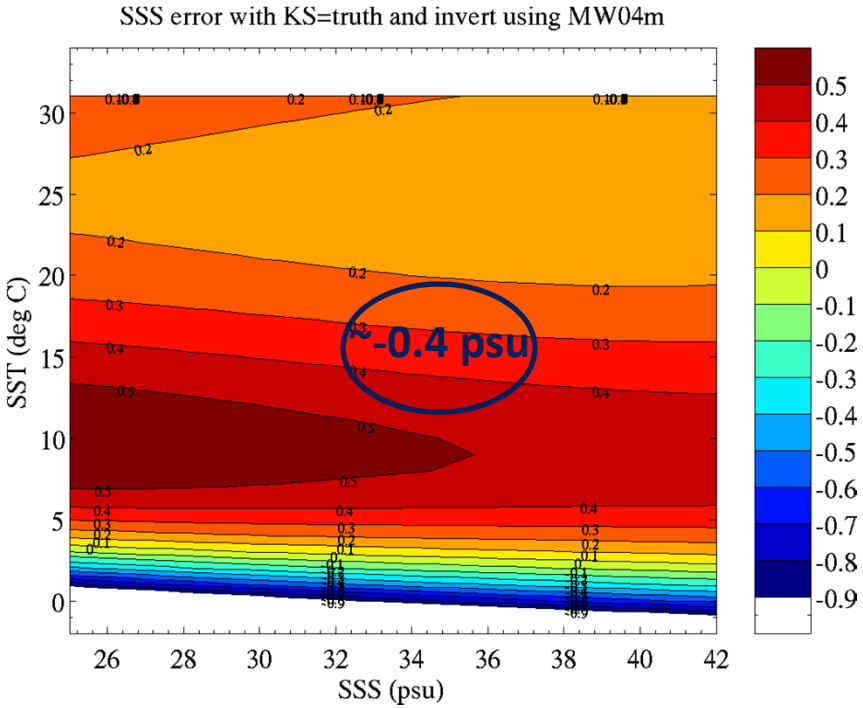
V-pol, θ=38 deg
GW12 – MW04m



GW12 difference with MW04m depends significantly on SSS (contrary to KS77 – MW04m)

Differences in Permittivity Models Effect on **Retrieved** Salinity

SSS 'error' @ θ=38 deg
KS77 => Tb truth, retrieval = MW04m



SSS 'error' @ θ=38 deg
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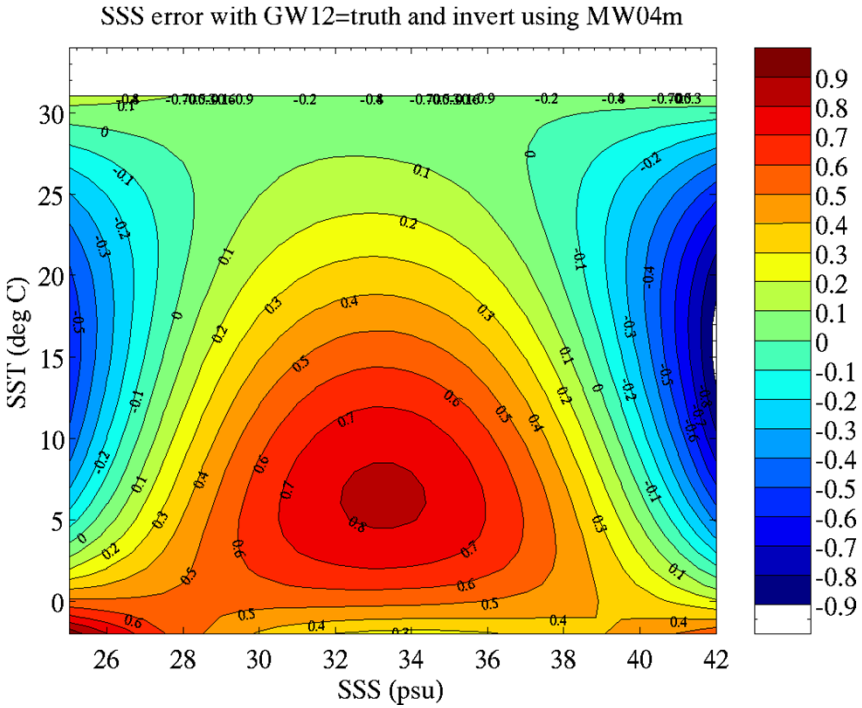

Not Representative of impact on Aquarius retrieved SSS because of empirical calibration!

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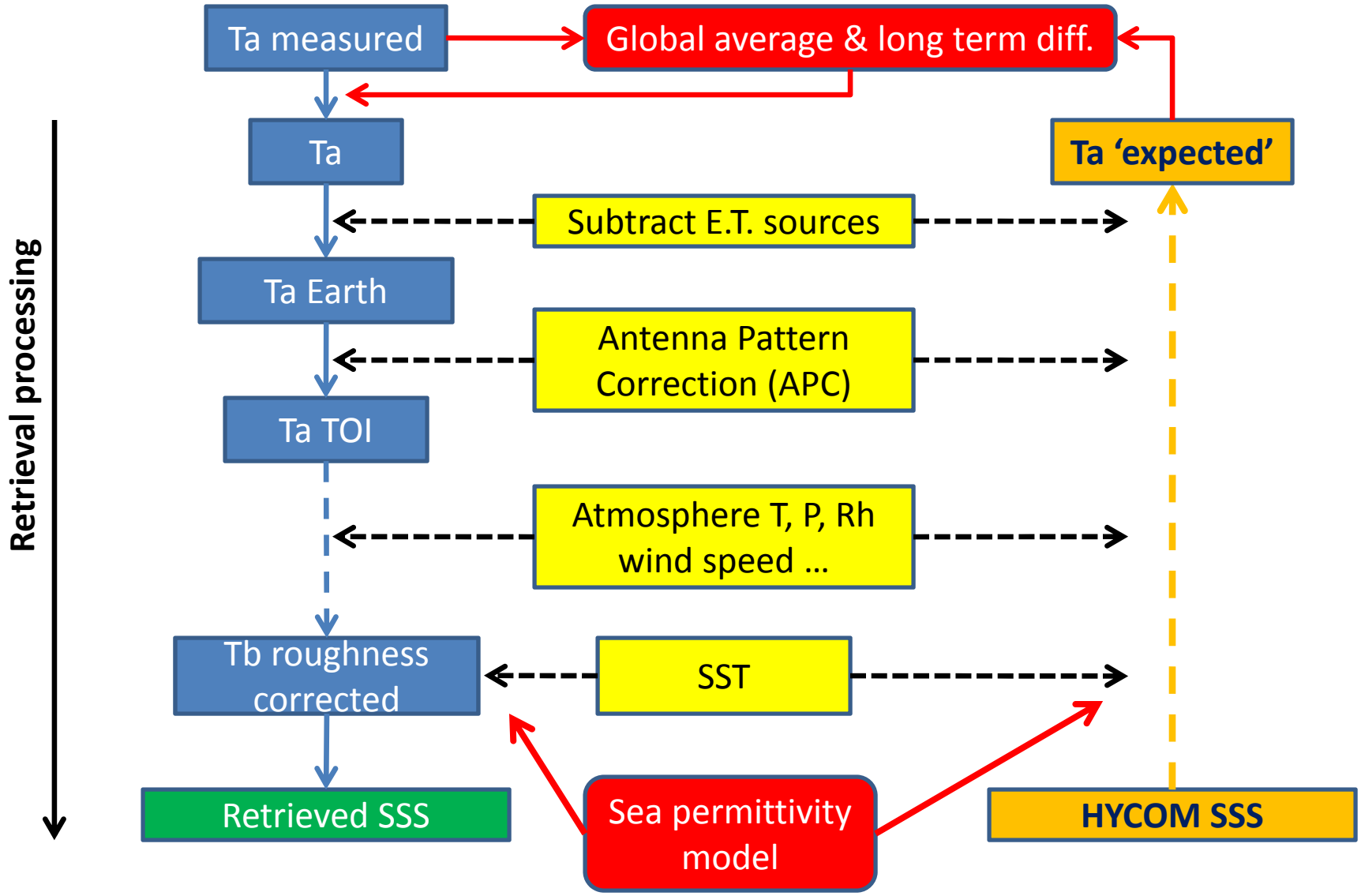
Aquarius Ta calibration

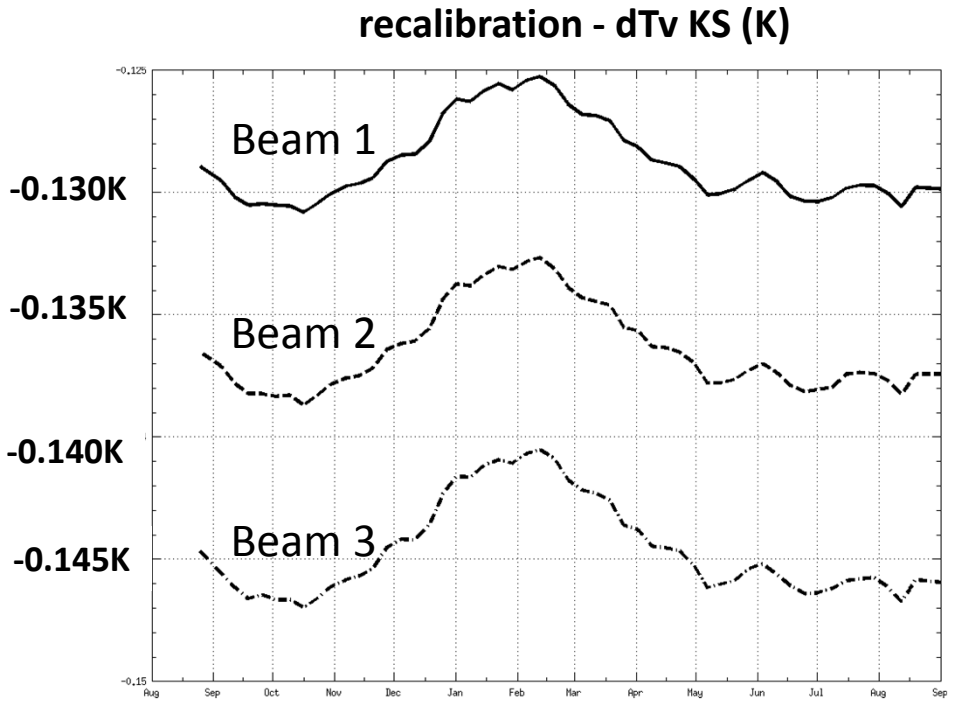


Reprocessing of Aquarius data Re-calibration & inversion with 'new' permittivity model

Sea water permittivity model impacts:

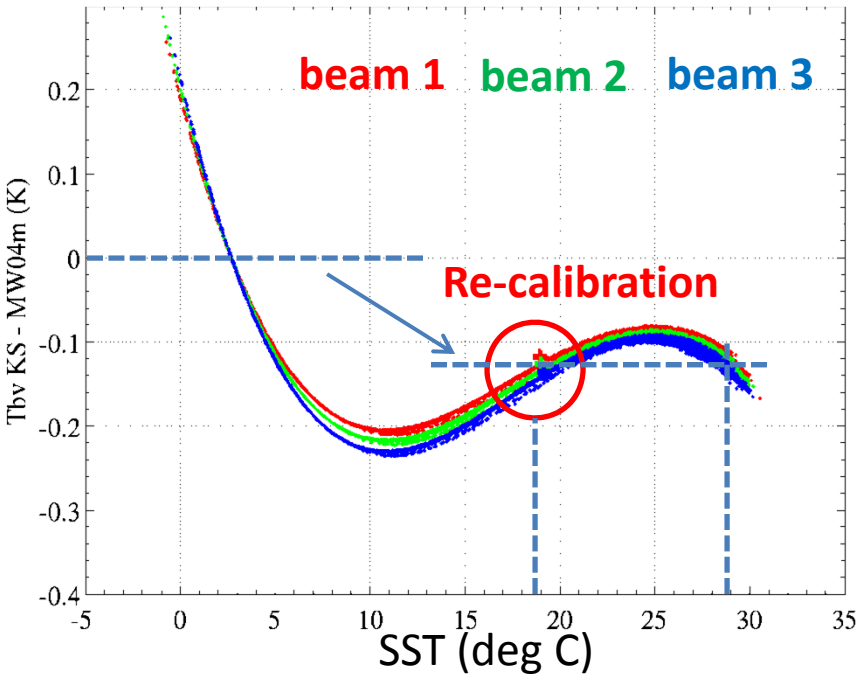
- SSS inversion from Tb surface
- Calibration of Ta, with <Ta – Ta exp> subtracted from measured Ta

L2 Tb are re-calibrated by adding <ΔTb exp> and then inverted to SSS using KS77 and GW12 instead of MW04m.



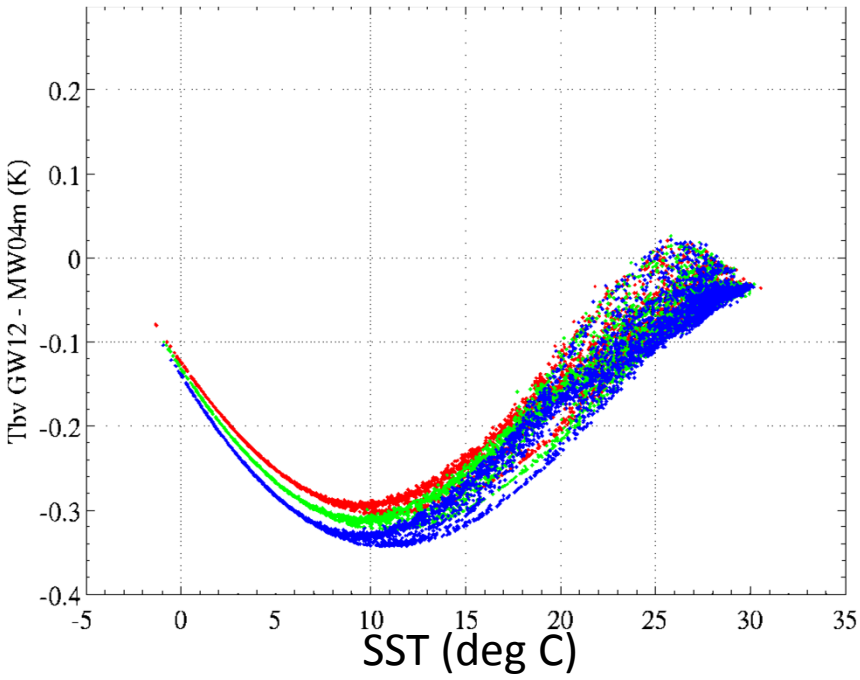
Re-calibration: example of dTb versus SST over 3 weeks

KS77 – MW04m



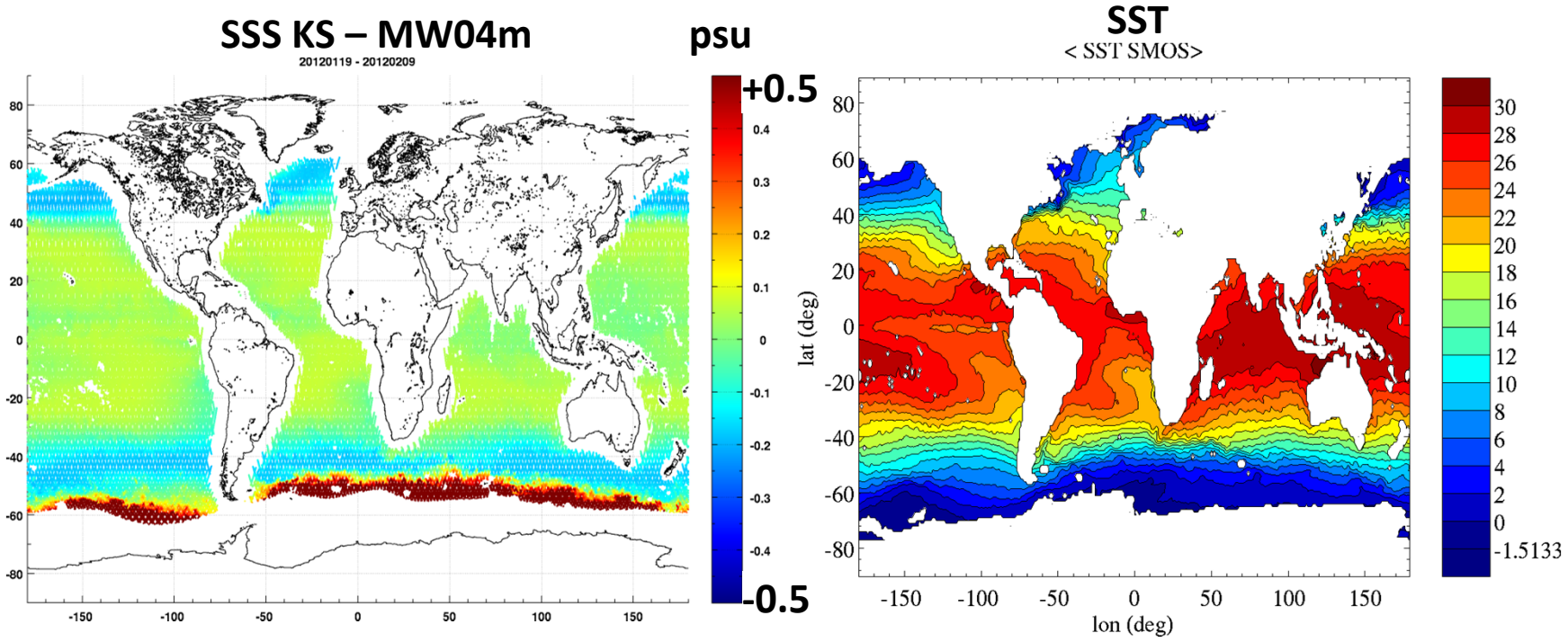
ΔTb is within +/- 0.05K close to recalibration point.
Increases largely for cold water. Small sensitivity to SSS.

GW12 – MW04m



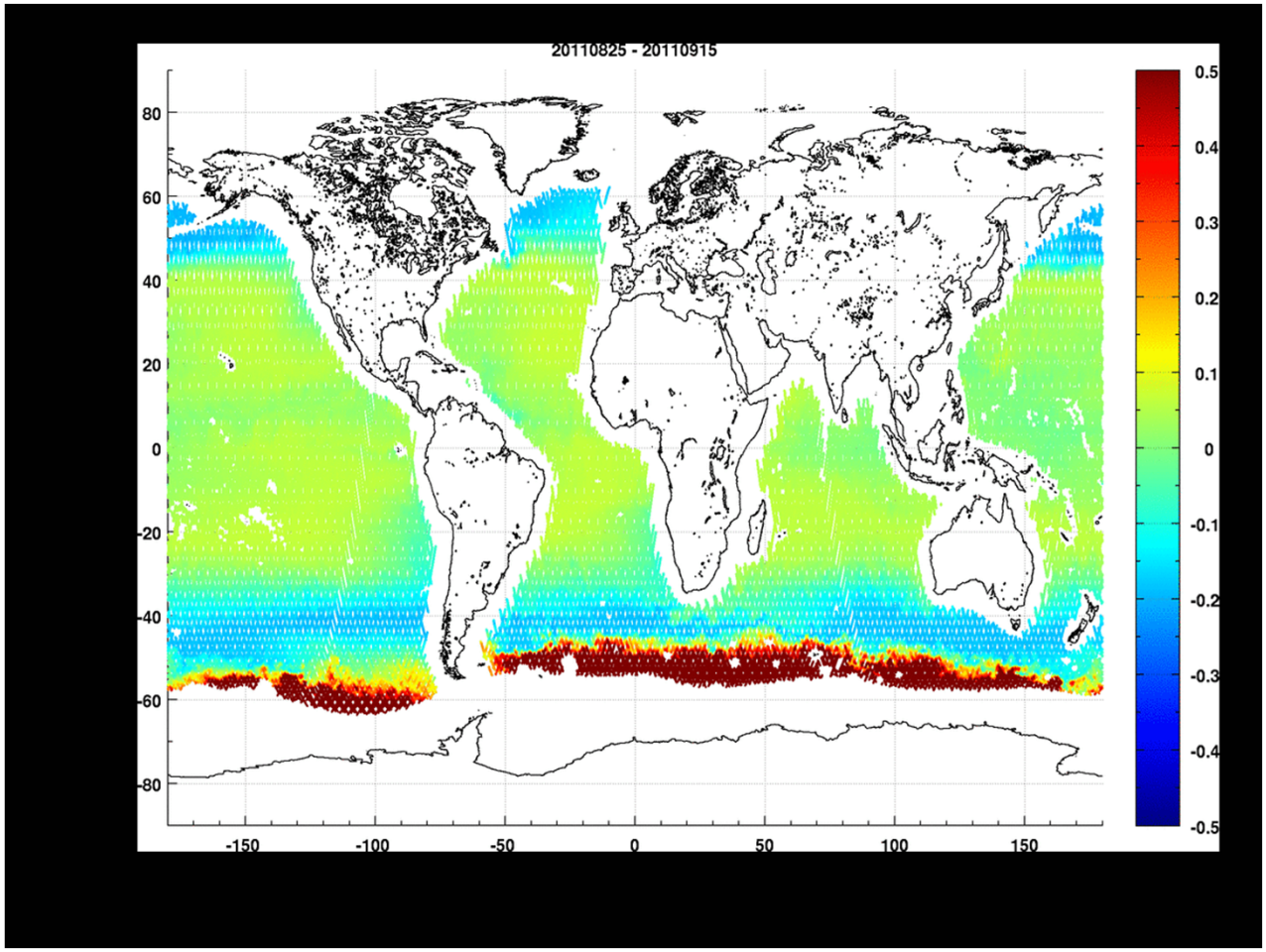
ΔTb varies significantly around recalibration point.
Lower sensitivity in cold water + larger sensitivity to SSS than KS.

Difference in Aquarius L2 SSS reprocessed using KS77, January 2012

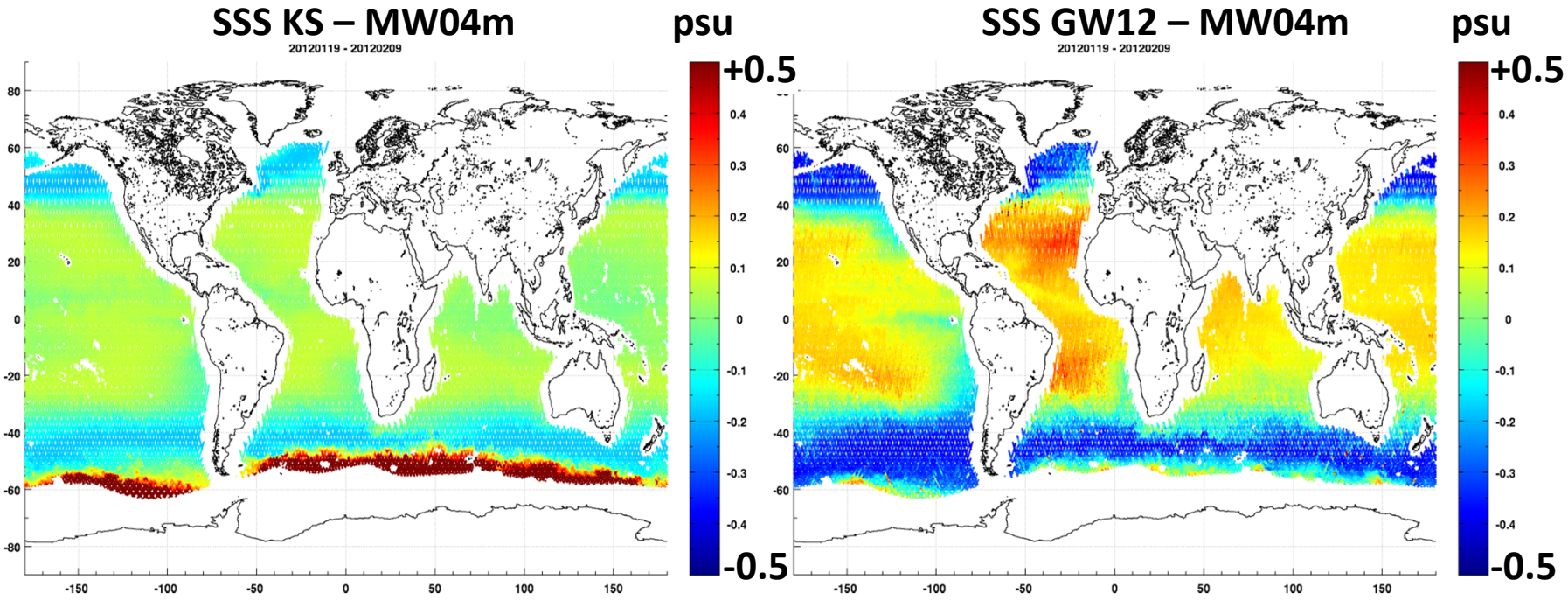


Re-calibration => SSS difference is within +/- 0.1 psu over low and mid latitudes where SST > 15 deg C. Much larger differences found in cold waters.

Difference in Aquarius L2 SSS reprocessed using KS77 - time evolution



Difference in Aquarius L2 SSS reprocessed using KS77 & GW12



GW12 shows much larger influence of SSS on ΔSSS difference, and larger influence of SST except for cold waters.

Summary

Impact of permittivity model on

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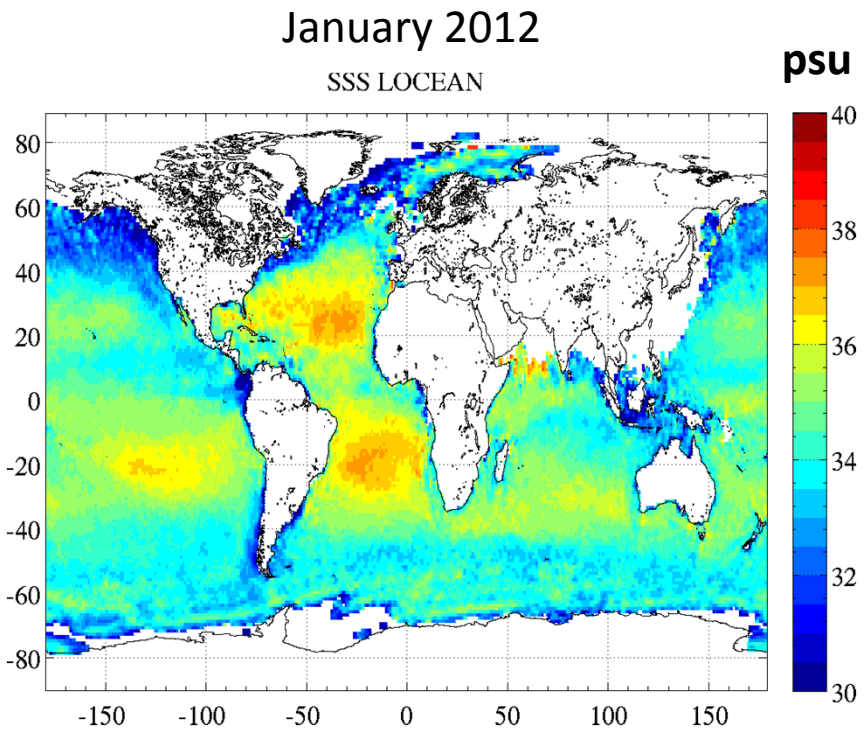
- SSS difference SMOS – Aquarius using various permittivity models

SMOS product



SMOS L3 processed by LOCEAN
1 deg x 1 deg, monthly

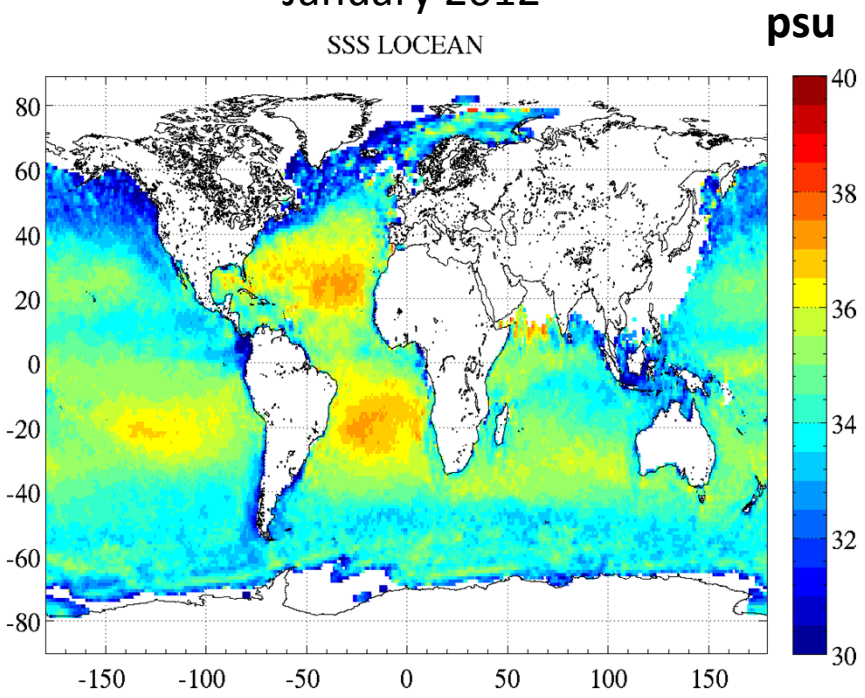
⇒ no SSS calibration to climatology

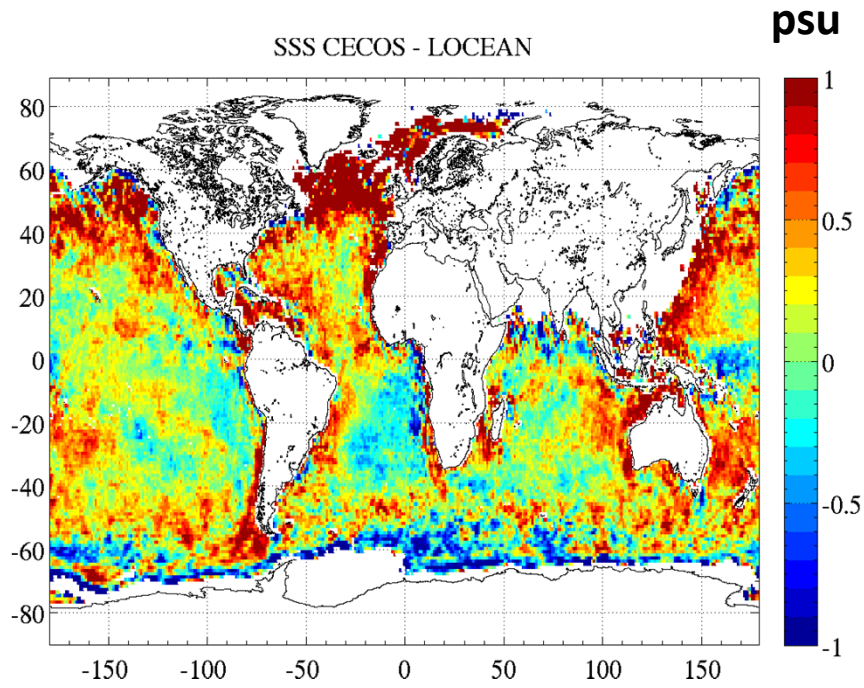
⇒ calibration to forward Tb model (using KS77)

⇒ Significantly low-SSS halo around coasts

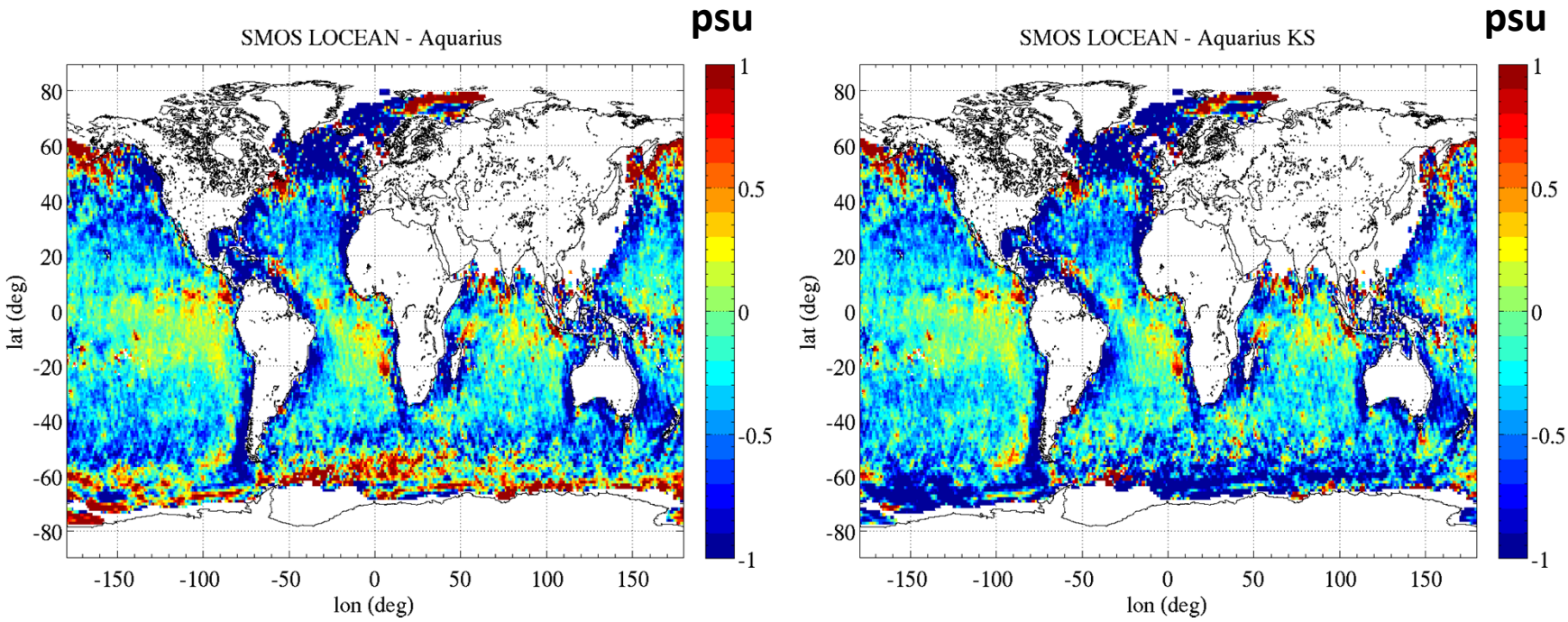
SMOS product

January 2012

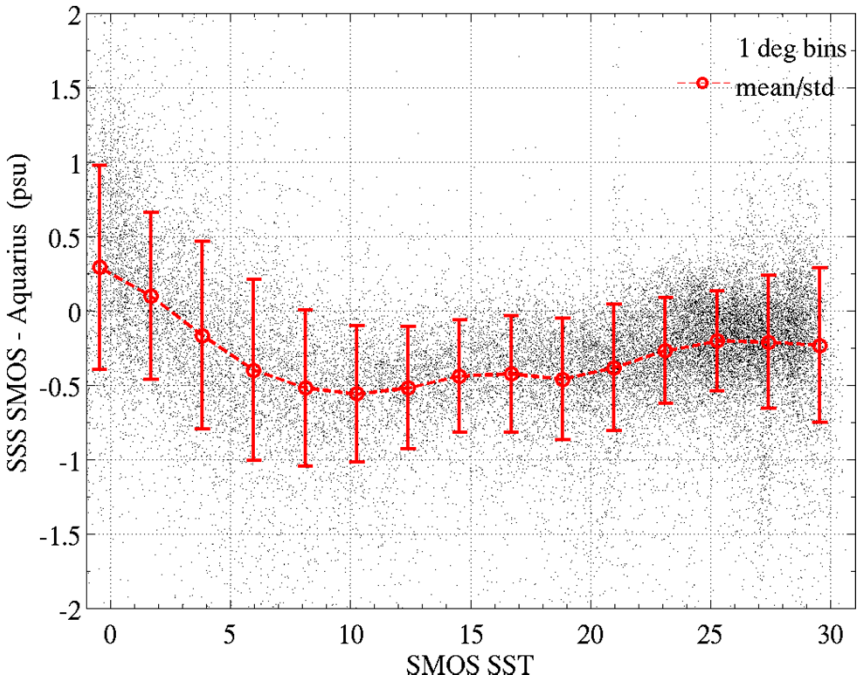




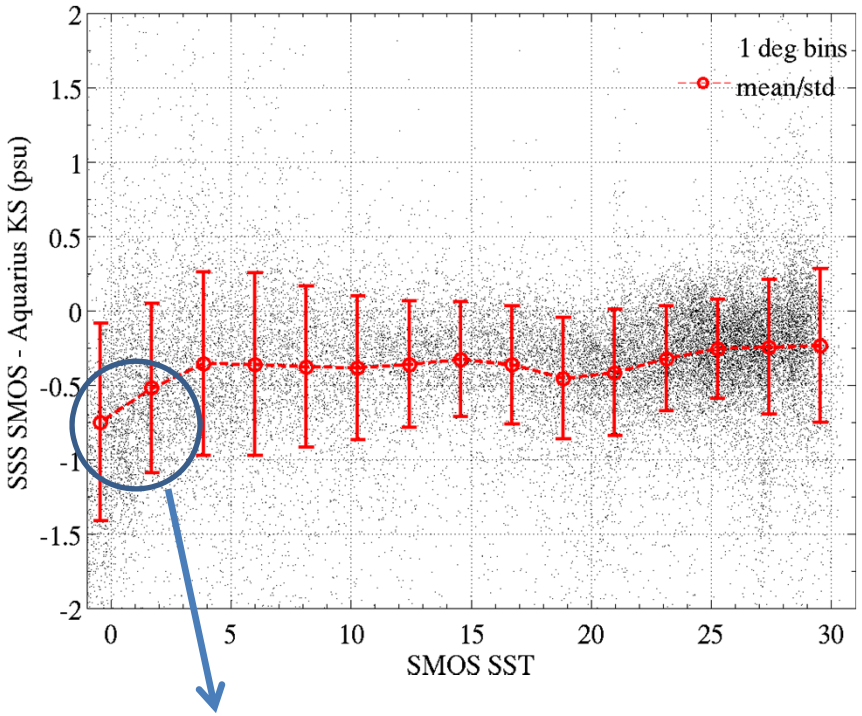
SSS SMOS – Aquarius



SSS difference vs. SST
Before and after KS77 reprocessing



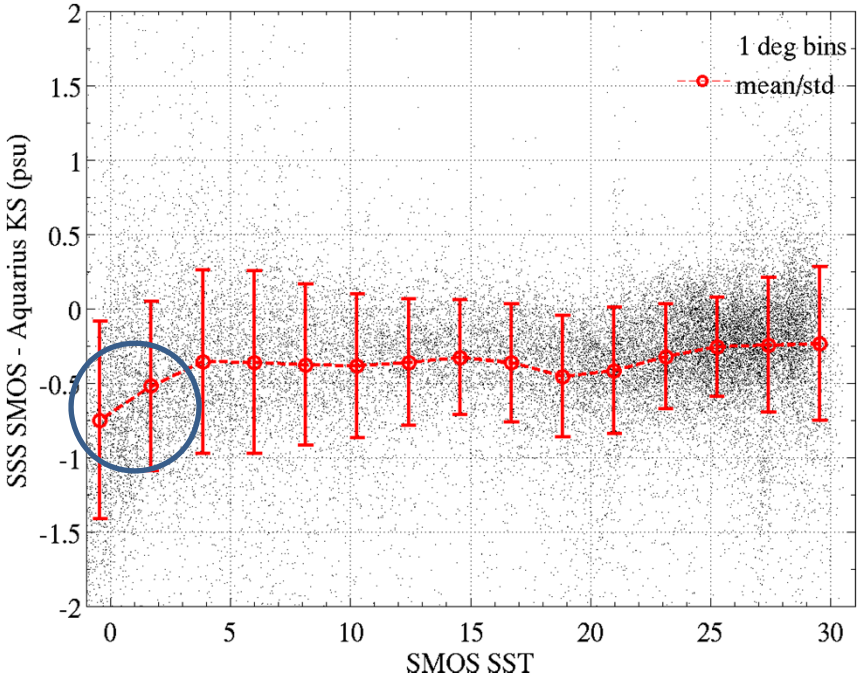
Reprocessed using KS77



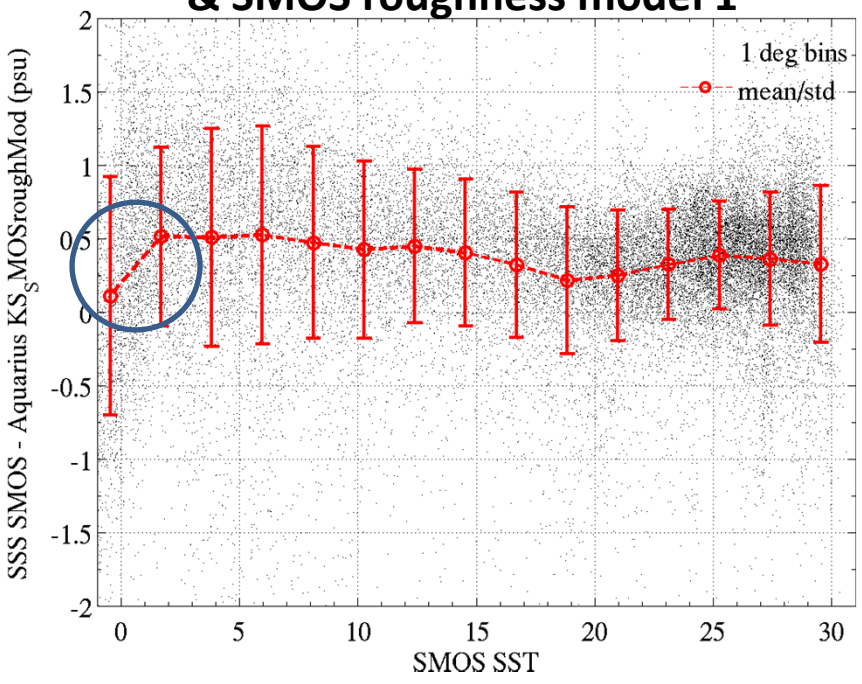
Ice correction?
Cold SST ~ large wind speeds
=> roughness correction?

SSS difference vs. SST
Using SMOS roughness model

Reprocessed using KS77



Reprocessed using KS77 & SMOS roughness model 1



No re-calibration for roughness!

Conclusion and future work

Difference Klein & Swift (1977) & Meissner and Wentz (2004) depends mostly on SST & sensitivity to SST is largest in cold waters.
re-calibration SST ~ 18 deg C => ΔSSS small for waters > 15 deg C; **larger in cold water**.
Difference GWU (2012) & Meissner and Wentz (2004) is very sensitive to SST **and SSS**

ΔSSS SMOS – Aquarius ~ [-1, +0.5] psu & large trend for waters < 10 degC
small effect of permittivity model on waters > 15 degC
Cold water trend in ΔSSS is very sensitive to permittivity model
=> smaller trend using KS77 model for Aquarius. (roughness and ice effect TBD)

Significant differences between SMOS & Aquarius SSS, many of which are not corrected with permittivity model, but Southern Ocean/cold waters comparisons can be improved.

Future Work

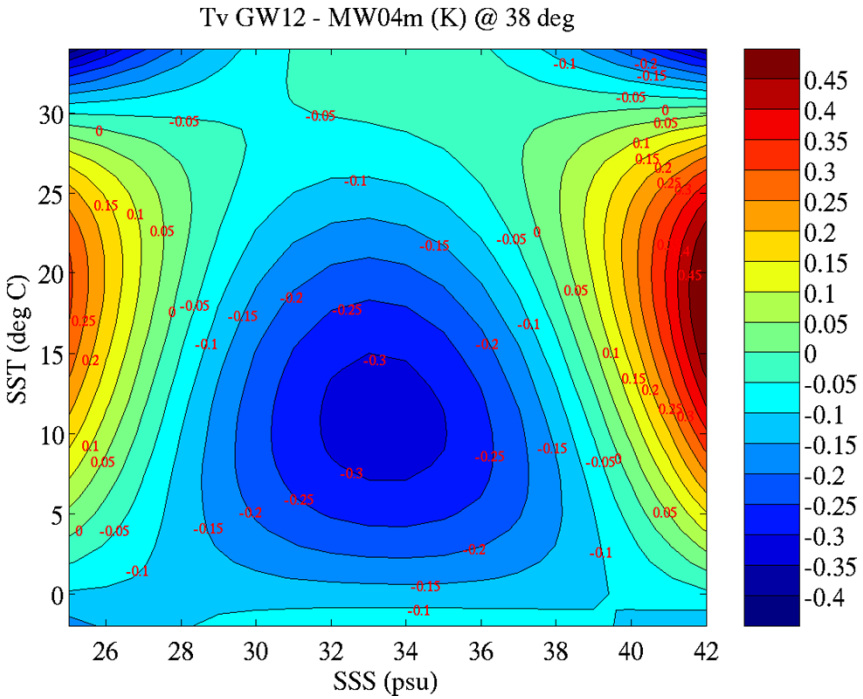
- Comparisons with SMOS:
  - In selected regions (avoid coastal halo regions)
  - Parting Ascending/Descending orbits
  - Look at shorter time resolution/higher spatial resolutions
  - longer term (seasonal variations)
- Assess effect of Aquarius ice correction in Southern Ocean.
- Ultimately, compare(/validate) all datasets to in situ SSS, particularly in cold waters.

Acknowledgements:
Jacqueline Boutin (LOCEAN) for the SMOS L3 SSS products.
Roger Lang (GWU) for the GWU sea water permittivity model.

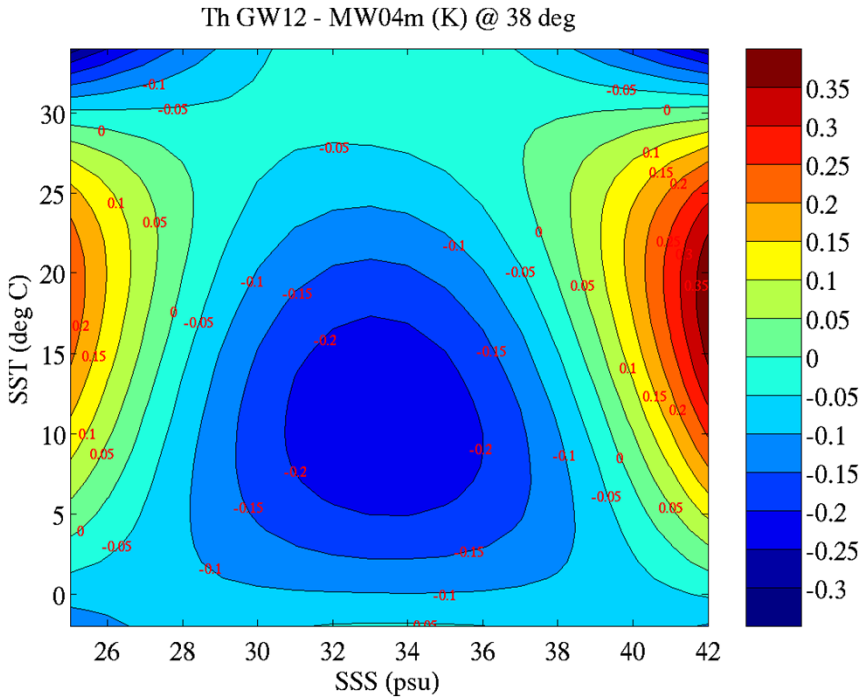
Backup slides

Differences of Permittivity and effect on Tb flat

V-pol, θ=38 deg
GWU – MW04m

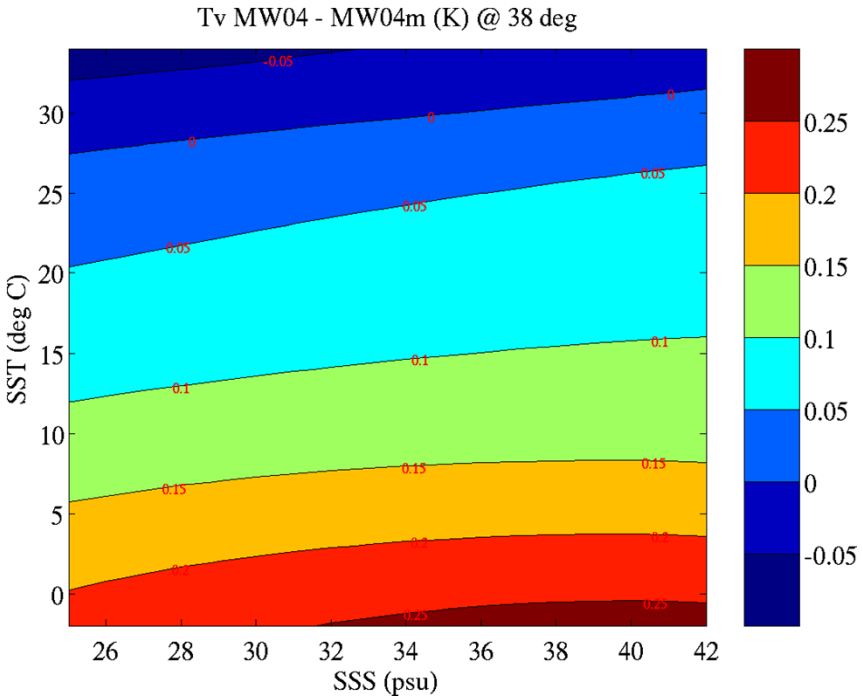


H-pol, θ=38 deg
GWU – MW04m

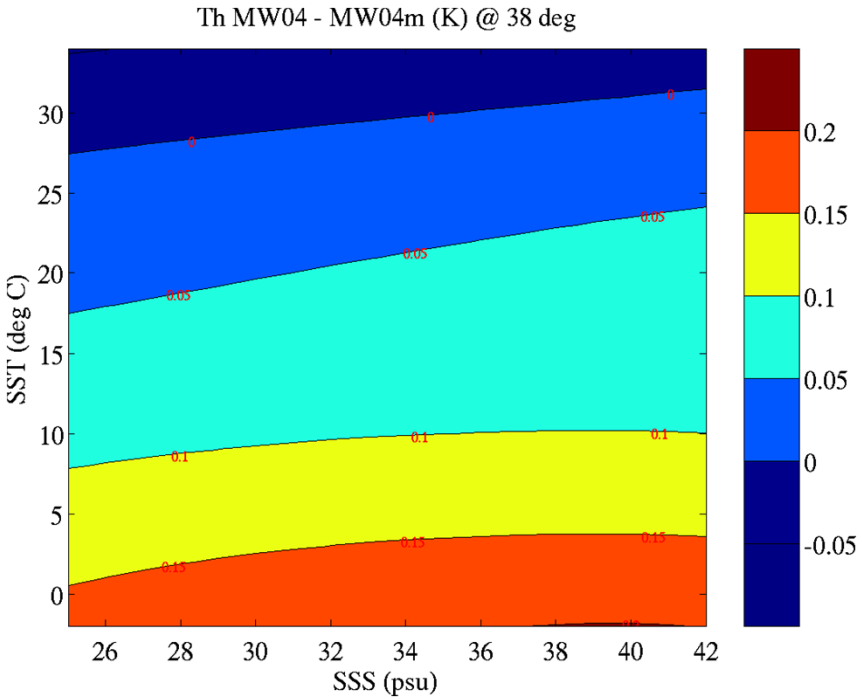


Differences of Permittivity and effect on Tb flat

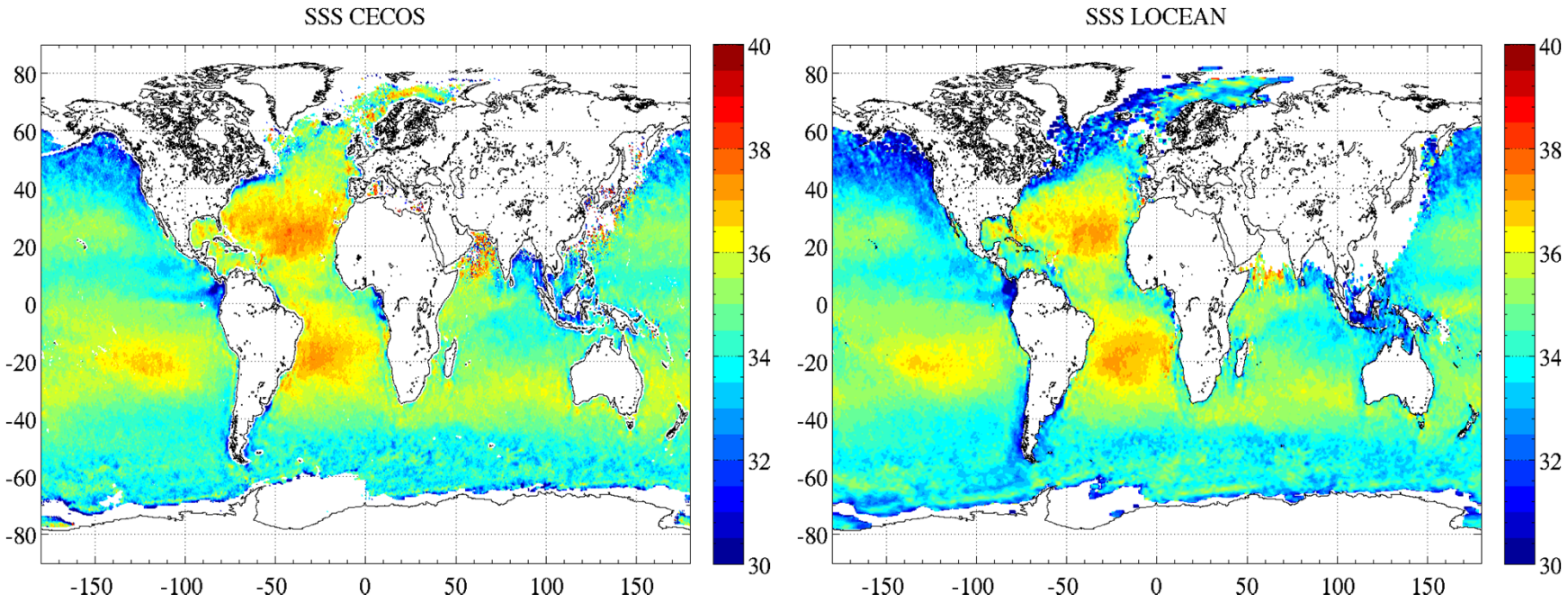
V-pol, θ=38 deg
MW04 – MW04m



H-pol, θ=38 deg
MW04 – MW04m

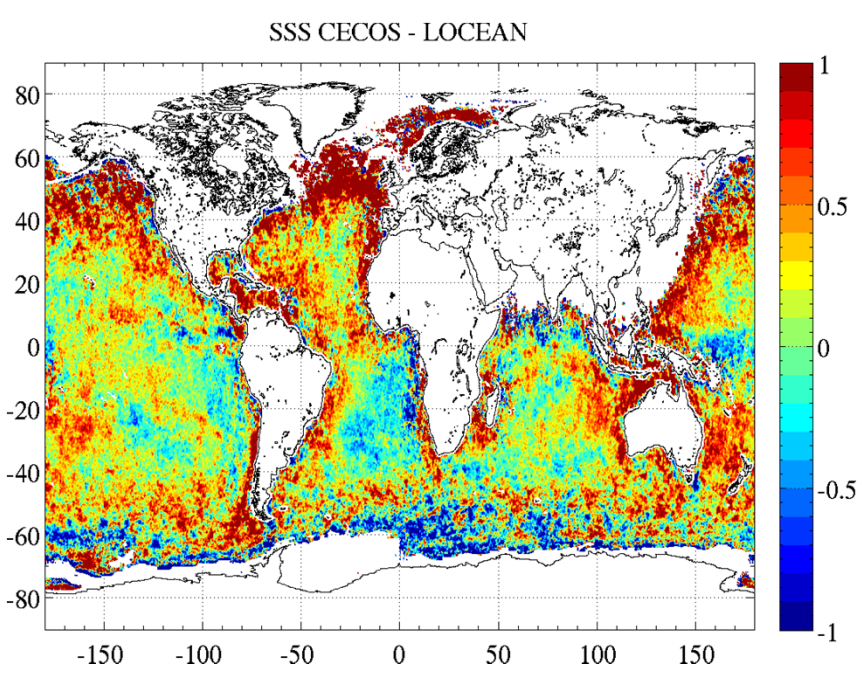


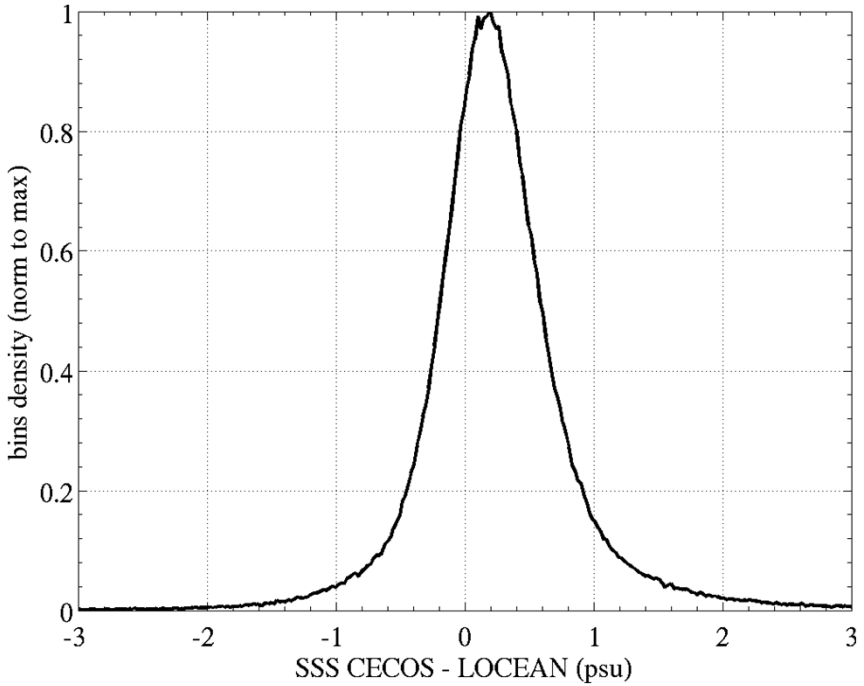
Difference SMOS & Aquarius
Which SMOS L3 product?



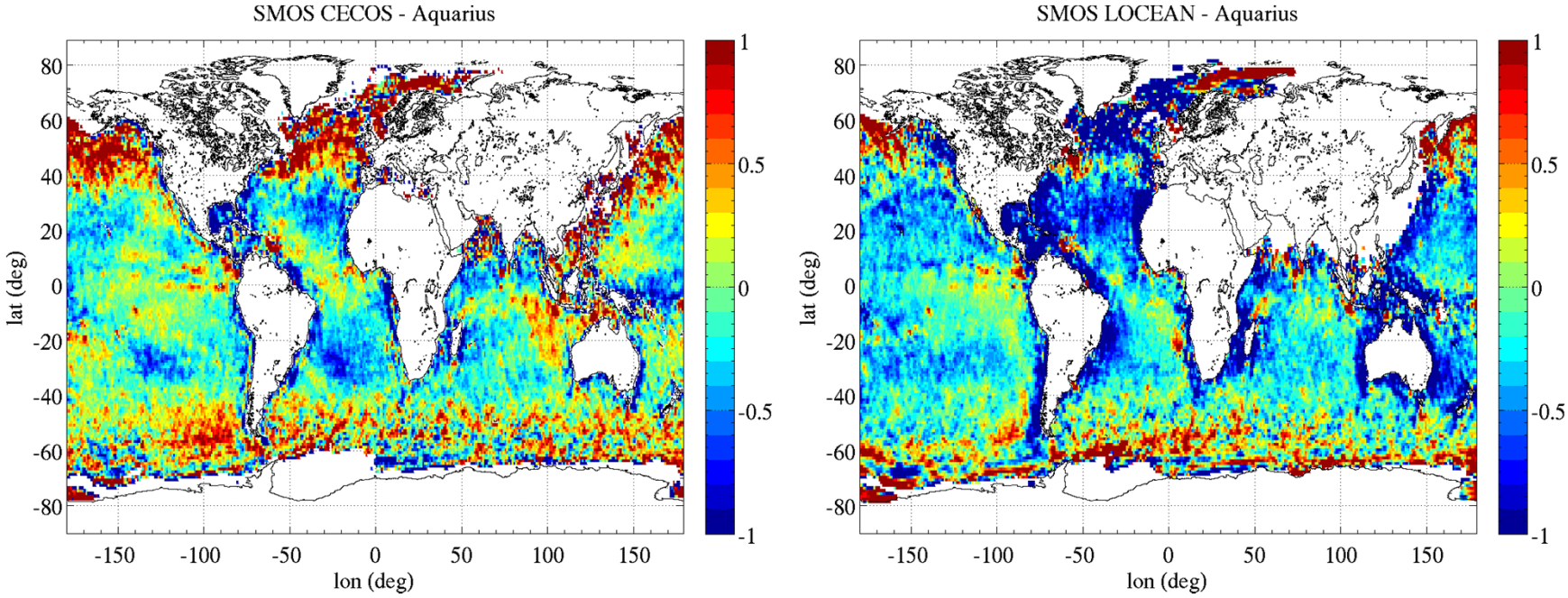
CECOS: *[…]unresolved instrumental issues induce significant drifts in the retrieved SSS fields at Level 3. […] a 5°x5° large scale bias pattern has been estimated between SMOS retrievals and the World Ocean Atlas 2001 monthly SSS climatology, temporally interpolated at the SMOS acquisition day. SSS retrieved from SMOS was then systematically corrected for these large scale spatio-temporal biases to finally compensate for residual instrumental drifts.*

Difference SMOS & Aquarius
Which SMOS L3 product?

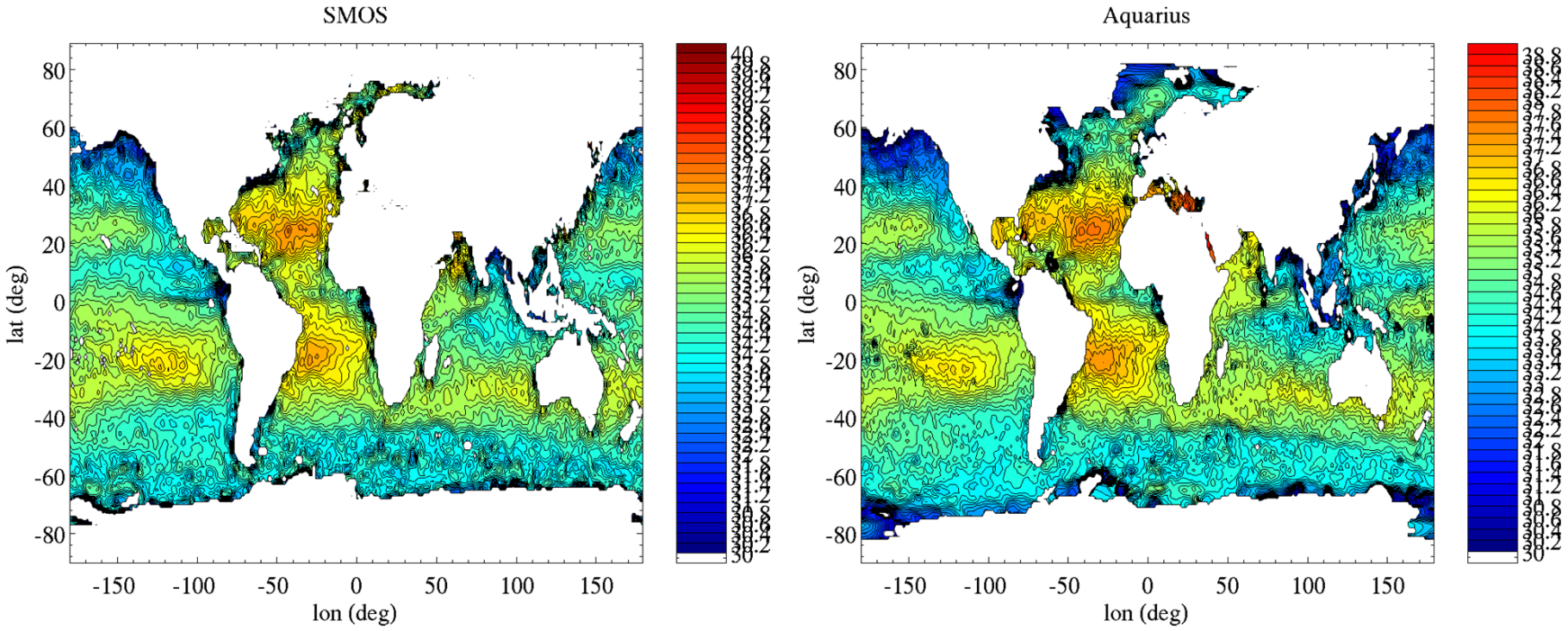




SSS differences SMOS & Aquarius



Comparisons to SMOS L3 SSS (CATDS)
SSS map January 2012



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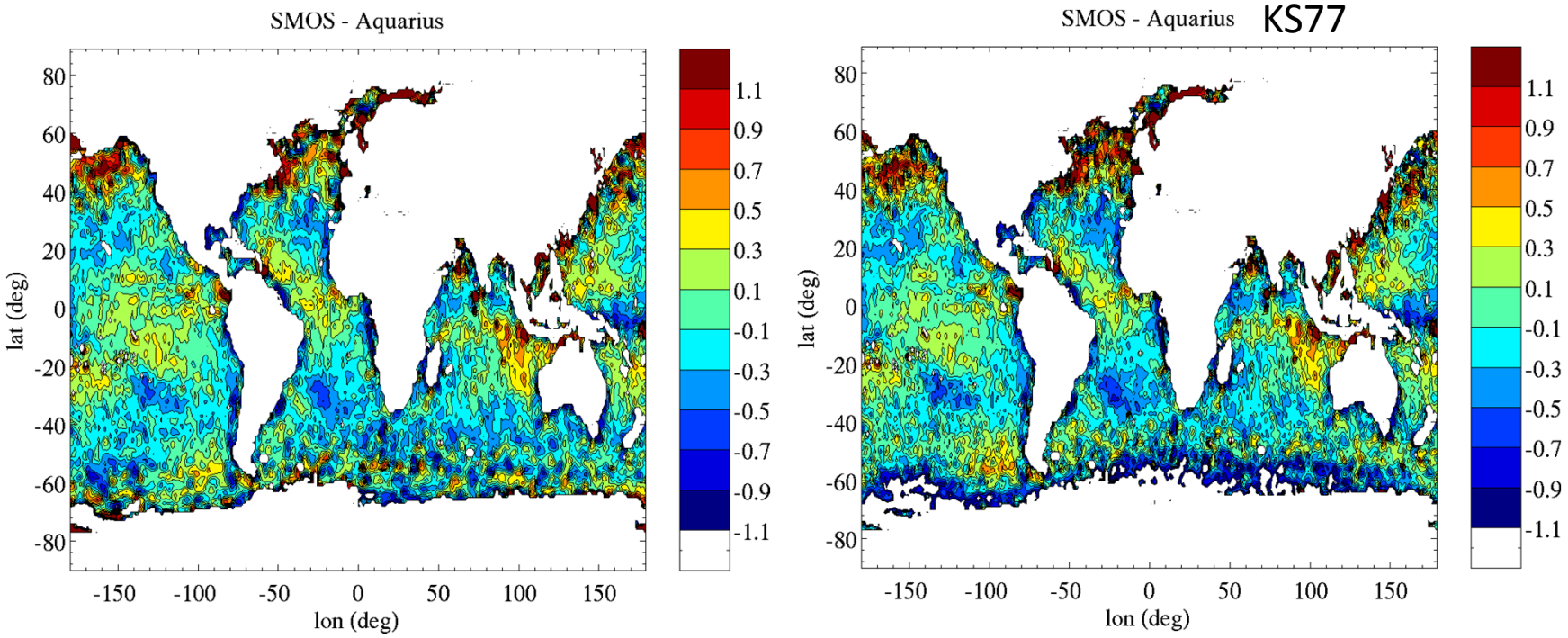

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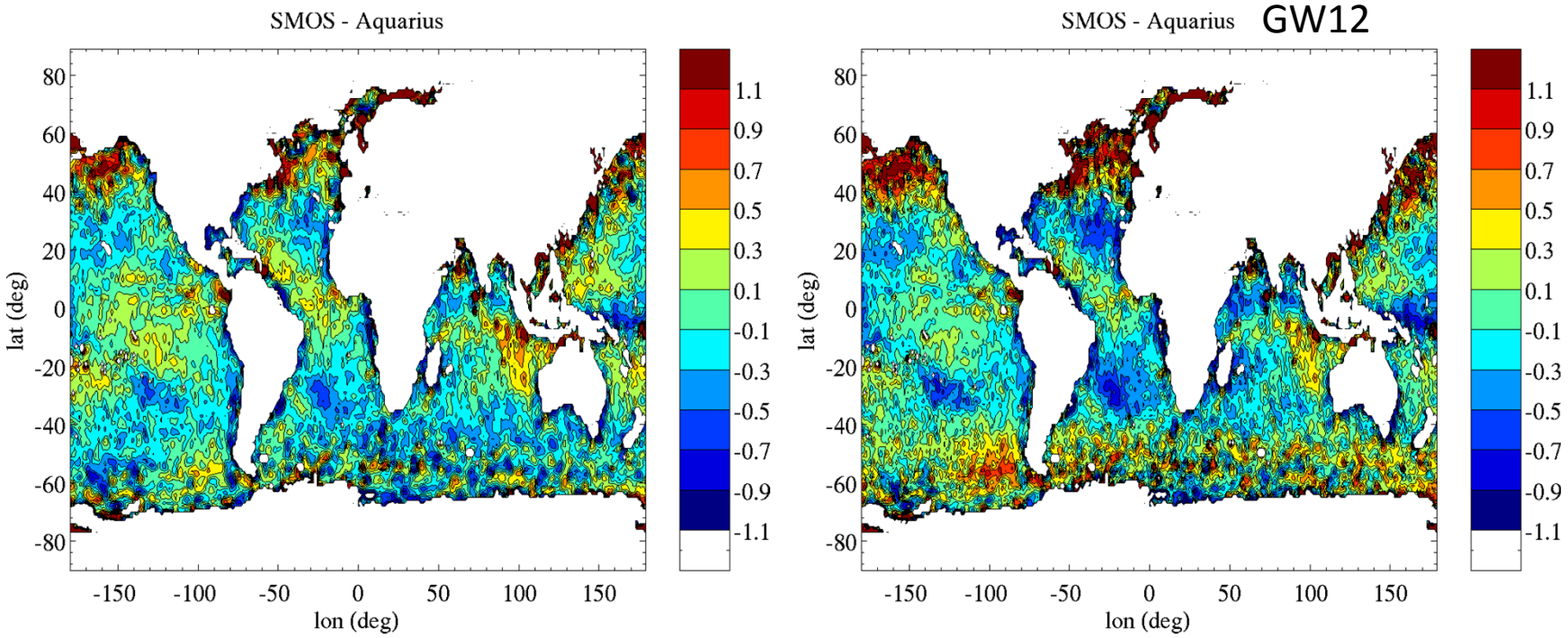
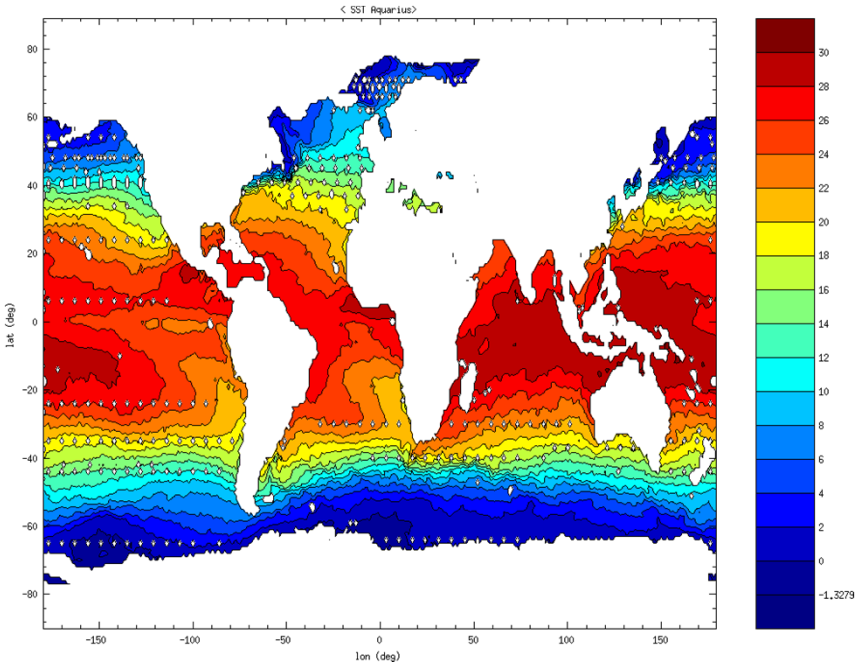
SSS map January 2012




< SST Aquarius>
lat (deg)
lon (deg)
-150
-100
-50
0
50
100
150
80
60
40
20
0
-20
-40
-60
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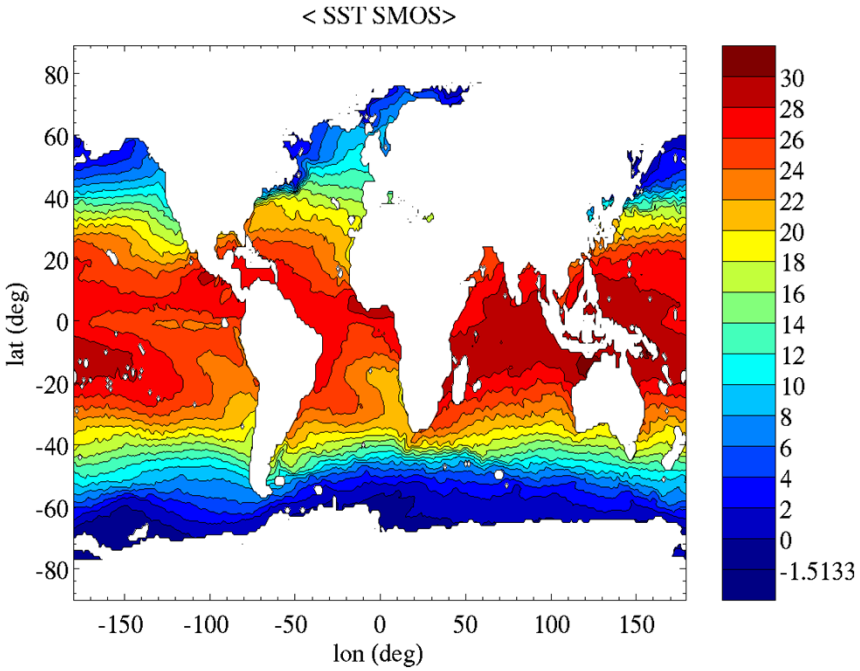
< SST SMOS>
lat (deg)
lon (deg)
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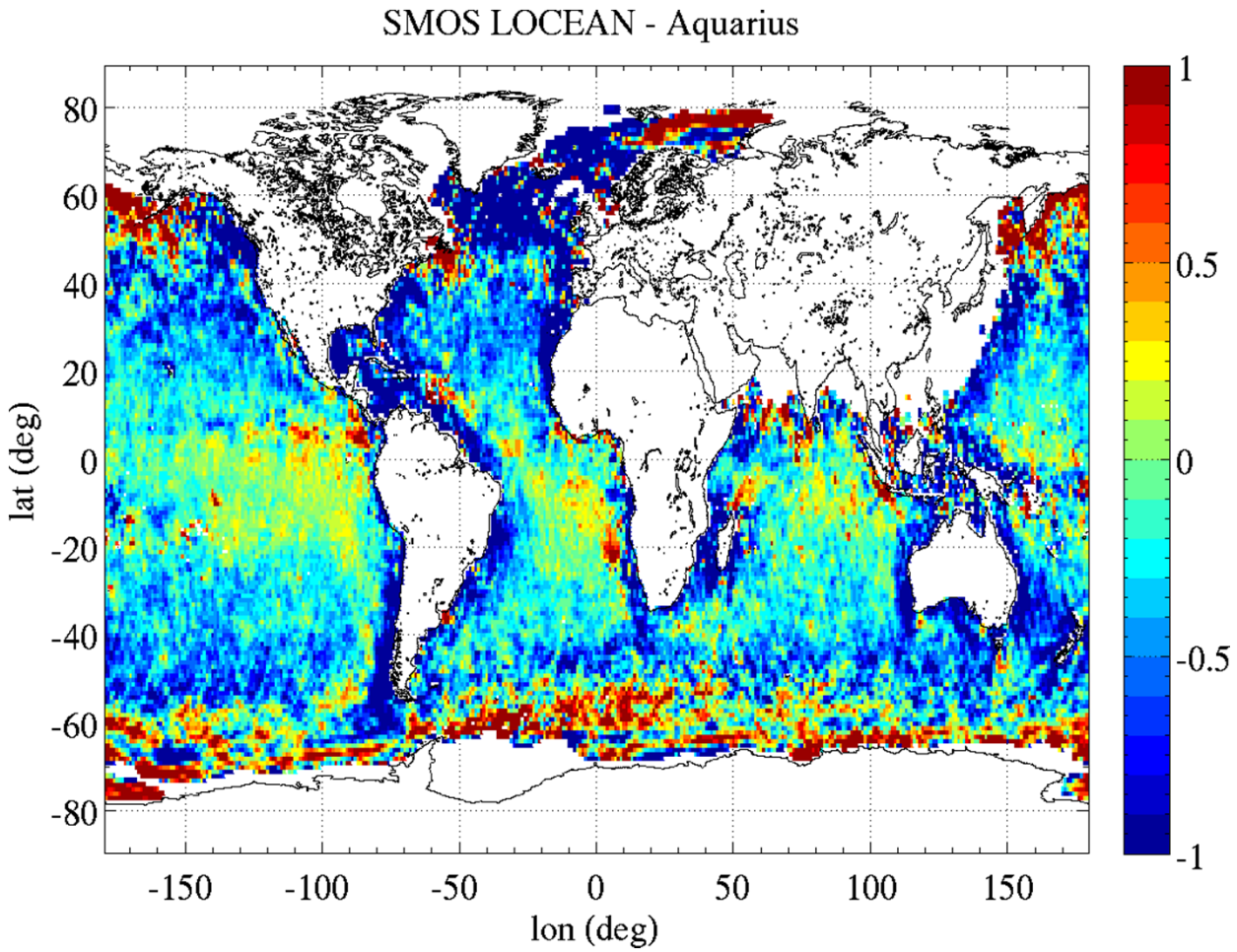
SMOS LOCEAN - Aquarius
lat (deg)
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60
40
20
0
-20
-40
-60
-80
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-100
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0
50
100
150
lon (deg)
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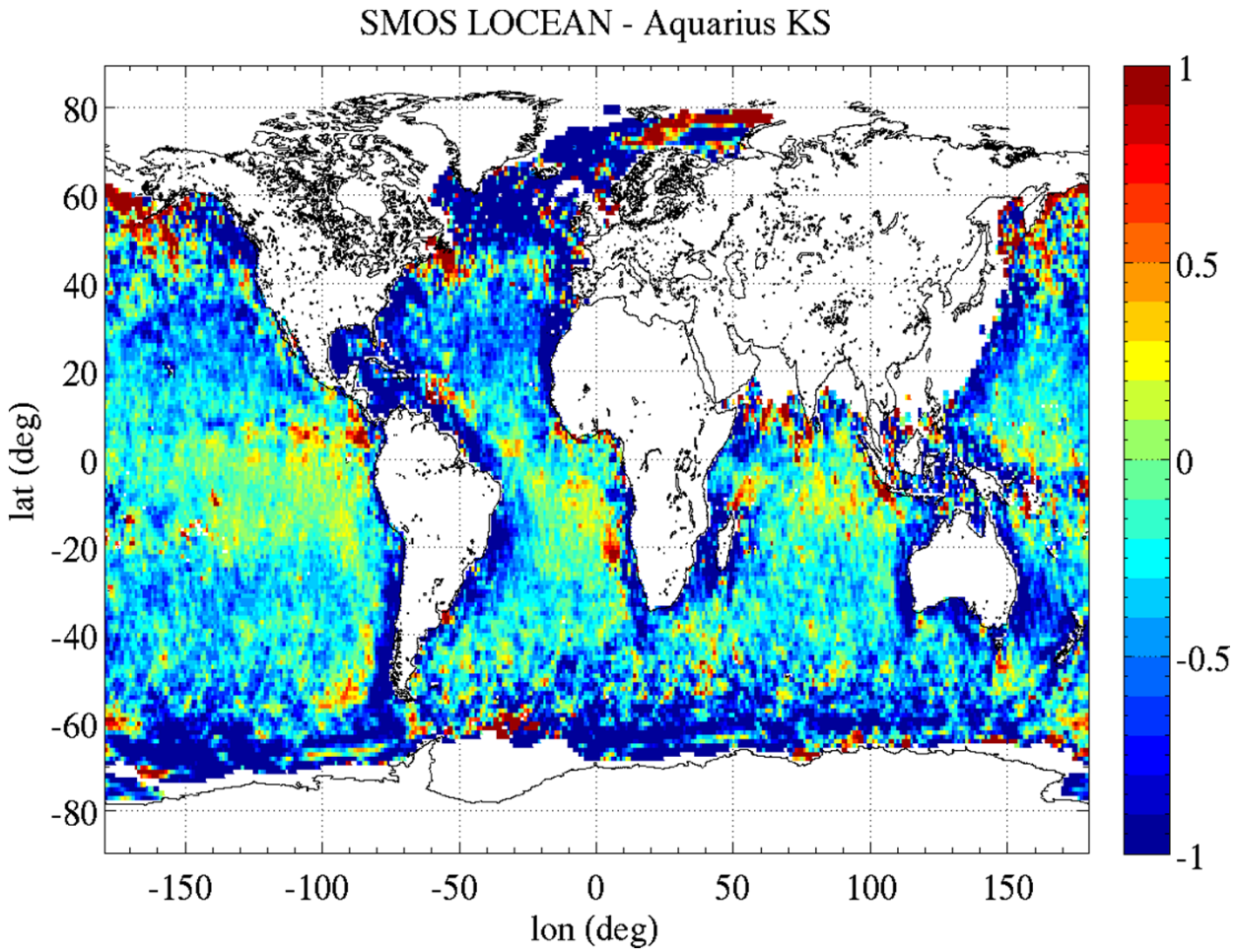
0
-0.5
-1


SMOS LOCEAN - Aquarius KS
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-80
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-100
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0
50
100
150
lon (deg)
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0.5
0
-0.5
-1