SMOS and SMAP in good agreement after the revision of SMOS/CATDS systematic errors mitigation

J. Boutin (LOCEAN/CNRS) and the SMOS-CATDS OCEAN team

Tropical instability waves

Yin et al. JGR 2014

Gulf stream rings

Reul et al. GRL 2014

T/S compensation Azores current

Kolodziejczyk et al., JGR, 2015
Outline

• New mitigation of SMOS systematic errors
  • Method
  • Comparisons with Argo interpolated field (ISAS)
  • Comparisons with Ship SSS
  • Comparisons with Mooring SSS
  • Comparisons with SMAP SSS

• SMOS-derived Rain Rate

• Conclusion
SMOS ESA V622 ~ CATDS RE04

Main changes:
- SSS bias removal near land
- Latitudinal-seasonal bias correction

SMOS CATDS RE05 corrected

www.catds.fr
Bias_{tot}(lat, lon, xswath, t, Pass) 

= Bias_{Land}(lat, lon, xswath, Pass) 

+ Bias_{Lat}(lat, xswath, t, orbit) 

AND Improved filtering taking into account SMOS derived SSS natural variability 

Pass = pass direction. 
Xswath = distance from nadir 
t = month of the year
LAND CONTAMINATION CORRECTION IN CATDS

\[ \text{Bias\_tot}(\text{lat}, \text{lon}, \text{xswath}, t, \text{Pass}) = \text{Bias\_Land}(\text{lat}, \text{lon}, \text{xswath}, \text{Pass}) + \text{Bias\_Lat}(\text{lat}, \text{xswath}, t, \text{orbit}) \]

Pass = pass direction.
Xswath = distance from nadir
t = month of the year

*Seasonal latitudinal bias correction* (reference: the less biased Xswath)
Bias computed over 7 years

*Works for sun, sun glint, galactic noise corrections*

12 sets of latitudinal corrections are estimated on all dwell lines.
The distinction between contaminated and uncontaminated is done wrt 6 years of ISAS data for that specific month.
The unbiased dwell lines are averaged (in the Pacific far from coast) and provide a reference SSS along all latitudes.

*CATDS CEC LOCEAN debias_v2 (Boutin et al. subm. RSE, 2017):*
Bias\_tot(lat, lon, xswath, t, Pass) = Bias\_Land(lat, lon, xswath, Pass) + Bias\_Lat(lat, xswath, t, orbit)

Empirical land contamination correction:
Self consistency criteria on SMOS SSS low frequency variability in different across track locations.
Final adjustment: 4year mean ISAS (Argo OI).
SMOS ESA V622 ~ CATDS RE04

SMOS ESA V662 corrected

Main changes:
• Tb bias removal near land
• Improved RFI filtering (elimination of snapshots with hot Tbs identified from successive snapshots)

SMOS CATDS RE05 corrected

Main changes:
• SSS bias removal near land
• Latitudinal-seasonal bias correction

smos.argans.co.uk

www.catds.fr
Land-sea correction in ESA and CATDS processings: major improvements

Comparisons of SMOS with Argo OI (ISAS) SSS
45S-45N - 0 to 800km from land

Further than 800km from land std(SMOS-ISAS) = 0.2

SMOS averages 100x100km² - 1 month
Comparison with ship measurements

Examples of TAO-SMOS-SMAP-ISAS

125°W 8°N

125°W 2°N
Evolution of bias correction at CATDS: The different steps

- No debiasing, RE04
- CEC LOCEAN Debias v1
- CEC LOCEAN Debias v2
- SMAP

Validation with respect to SMAP

Bias correction + data filtering

Data filtering taking into account natural variability

CATDS CPDC RE05 corrected (CSQ3 product)
Freshwater river plumes from SMOS (CATDS) and SMAP (CAP) => monitoring at ~50km resolution

Bay of Bengal

Gulf of Mexico

Eastern tropical Atlantic

Amazone plume

Boutin et al., subm RSE, 2017
Freshwater river plumes from SMOS (CATDS) and SMAP(CAP) => monitoring at ~50km resolution

Bay of Bengale

Gulf of Mexico

Eastern tropical Atlantic

Amazone plume

Std from bi-weekly 25km fields – std from median = abs(x-median (x))/0.67
New CATDS SMOS SSS in very good agreement with SMAP data in river plumes

- SMOS CATDS CEC LOCEAN Debias_v2 (RE05)
- SMOS CATDS CPDC L3Q Binned - near-real time
- SMOS BEC non bayesian binned
- SMAP CAP/JPL
- SMAP RemSS

Boutin et al., subm. RSE, 2017
A tentative estimate of *SMAP/CAP individual SSS error* based on comparison with SMOS SSS

**ITCZ (180°W-110°W;0°N-10°N)**  
01/01/2016 -> 31/07/2016  
**DeltaTime < 15 min**

<table>
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<tr>
<th></th>
<th>Mean</th>
<th>Std</th>
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<tbody>
<tr>
<td>SSS</td>
<td>SMOS: 34.03</td>
<td>0.80</td>
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<tr>
<td></td>
<td>SMAP: 34.29</td>
<td>0.75</td>
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</table>

N.B.: SMAP bias in ITCZ remains when compared with ISAS

Assuming:

\[
\sigma^2_{\text{tot SMOS}} = \sigma^2_{\text{err SMOS}} + \sigma^2_{\text{nat}} \quad (1)
\]

\[
\sigma^2_{\text{tot SMAP}} = \sigma^2_{\text{err SMAP}} + \sigma^2_{\text{nat}} \quad (2)
\]

\[
\sigma^2_{\text{err SMAP}} = \sigma^2_{\text{err SMOS}} + \sigma^2_{\text{tot SMAP}} - \sigma^2_{\text{tot SMOS}} \quad (2) - (1)
\]

\[\sigma_{\text{errSMOS}} \sim 0.48\text{pss} \] (theoretical error on SMOS SSS = observed std without rain in these tropical regions (hot regions))  
\[\Rightarrow \sigma_{\text{errSMAP}} \sim 0.39\text{pss}\]

*Supply et al. 2017*
Outline

• New mitigation of SMOS systematic errors
  • Method
  • Comparisons with Argo interpolated field
  • Comparisons with ship SSS
  • Comparisons with SMAP SSS

• **SMOS derived Rain Rate**

• Conclusion
Precipitation estimates from SMOS sea-surface salinity

A. Supply, a* J. Boutin, a J.-L. Vergely, b N. Martin, a† A. Hasson, a G. Reverdin, a C. Mallet c and N. Viltard c
What SMOS and SMAP could bring to GPM constellation and IMERG (morphing of PMW rain rate)?

Time:

2016-02-06

14:30

14:25

14:31

14:30

SHORT TEMPORAL SHIFT <5mn from SMOS & SMAP
What SMOS and SMAP could bring to GPM constellation and IMERG (morphing of PMW rain rate)?

**Time:**

### 2016-02-06

<table>
<thead>
<tr>
<th>Time</th>
<th>SMOS</th>
<th>SMAP</th>
<th>PMW</th>
<th>IMERG</th>
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**2016-01-28**

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**Time:**

### SHORT TEMPORAL SHIFT <5mn from SMOS & SMAP

### LONG TEMPORAL SHIFT >30mn from SMOS & SMAP
SUMMARY

SMOS mission provides unique spatio-temporal monitoring of SSS for more than 7 years.

Need to continue the SSS monitoring from space

⇒ new constraints for a better understanding and modelling of the water cycle, ocean circulation, ocean mesoscale, air-sea exchange, biogeochemistry

• CATDS empirical corrections for systematic biases improves especially in river plumes areas; in tropical-subtropical ocean, scales of variability of SMOS SSS and ship SSS agrees up to about 100km

• SMOS and SMAP measure very consistent SSS features

• SMOS and SMAP freshenings provide new estimate of instantaneous rain rate

• In cold water, SMOS pseudo-dielectric constant agree well with recent measurements of Lang et al (2016) and Zhou et al. (2017) derived relationship

⇒ See Emmanuel’s and Audrey’s Poster for more information
# SMOS SSS products

<table>
<thead>
<tr>
<th></th>
<th>ESA</th>
<th>CATDS CPDC</th>
<th>CATDS CEC LOCEAN</th>
<th>CATDS CEC IFREMER</th>
<th>BEC</th>
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<tr>
<td><strong>Type of retrieval</strong></td>
<td>Full Pol/Bayesian</td>
<td>Full Pol/Bayesian</td>
<td>Full Pol/Bayesian</td>
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<td>L3 &amp; L4</td>
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<td><strong>Level of product</strong></td>
<td>L2</td>
<td>L3 (&amp; L4)</td>
<td>L3</td>
<td>L3 &amp; L4</td>
<td>L3 &amp; L4</td>
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<tr>
<td><strong>Products before May 2017</strong></td>
<td>V622</td>
<td>RE04</td>
<td>Debias_v1</td>
<td>L4 (adjusted to ISAS + other parameters)</td>
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<tr>
<td><strong>May 2017 products including systematic errors corrections</strong></td>
<td>V662 NoCorr V662 Corr</td>
<td>RE05 NoCorr RE05 Corr</td>
<td>Debias_v2</td>
<td>L4 (in prep. see N. Kolodziejczyk presentation)</td>
<td></td>
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</tbody>
</table>

*In bold, publicly available and maintained products*

- [www.esa.int](http://www.esa.int)
- [catds.ifremer.fr](http://catds.ifremer.fr)
- [cp34-bec.cmima.csic.es](http://cp34-bec.cmima.csic.es)