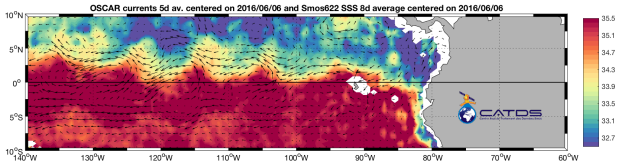
SMOS and SMAP in good agreement after the revision of SMOS/CATDS systematic errors mitigation

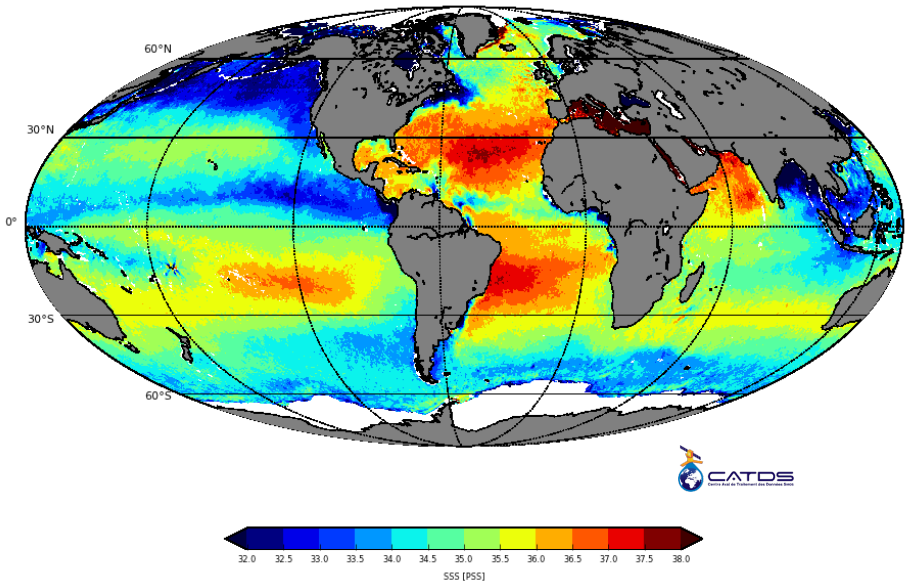
J. Boutin (LOCEAN/CNRS) and the SMOS-CATDS OCEAN team

Tropical instability waves

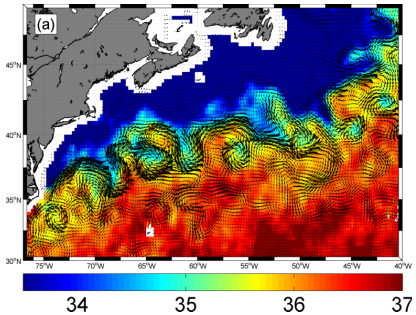


Yin et al. JGR 2014

SMOS SSS (October 2016)

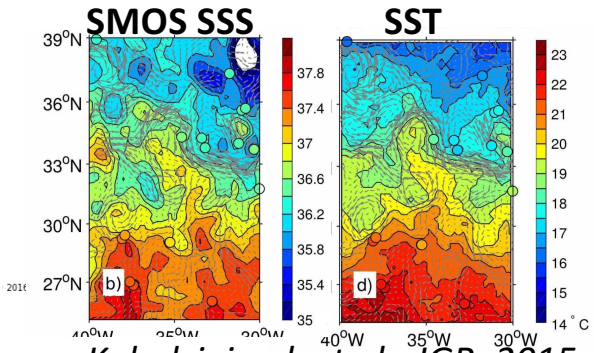


Gulf stream rings



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

SMOS CATDS RE05
corrected

Main changes:

- SSS bias removal near land
- Latitudinal-seasonal bias correction

www.catds.fr

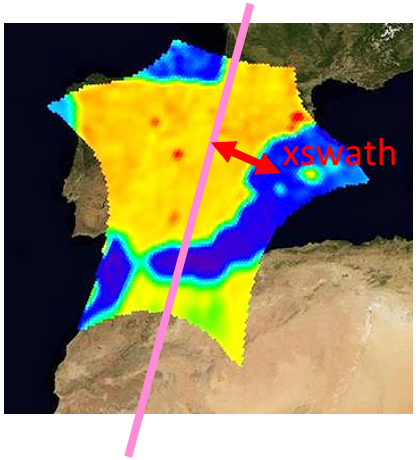
LAND CONTAMINATION CORRECTION IN CATDS

Bias_tot(lat, lon, xswath, t, Pass)

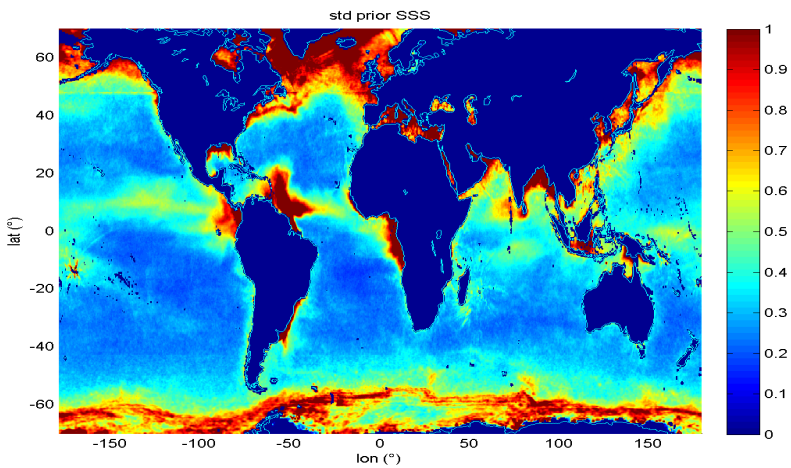
= Bias_Land(lat, lon, xswath, Pass)

+ Bias_Lat(lat, xswath, t, orbit)

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



AND Improved filtering taking into account SMOS derived SSS natural variability



LAND CONTAMINATION CORRECTION IN CATDS

Bias_tot(lat, lon, xswath, t, Pass)

= Bias_Land(lat, lon, xswath, Pass)

+ Bias_Lat(lat, xswath, t, 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):

LAND CONTAMINATION CORRECTION IN CATDS

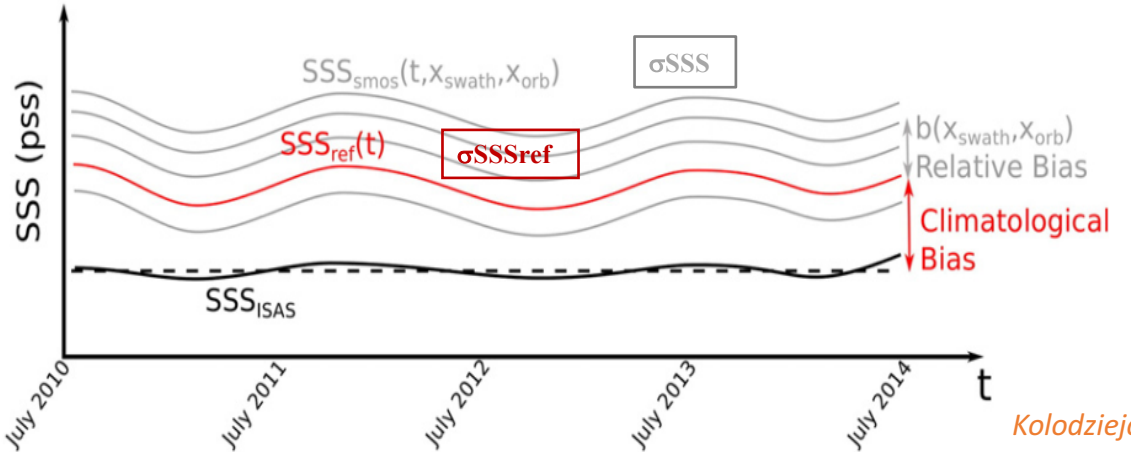
Bias_tot(lat, lon, xswath, t, Pass)

= Bias_Land(lat, lon, xswath, Pass)

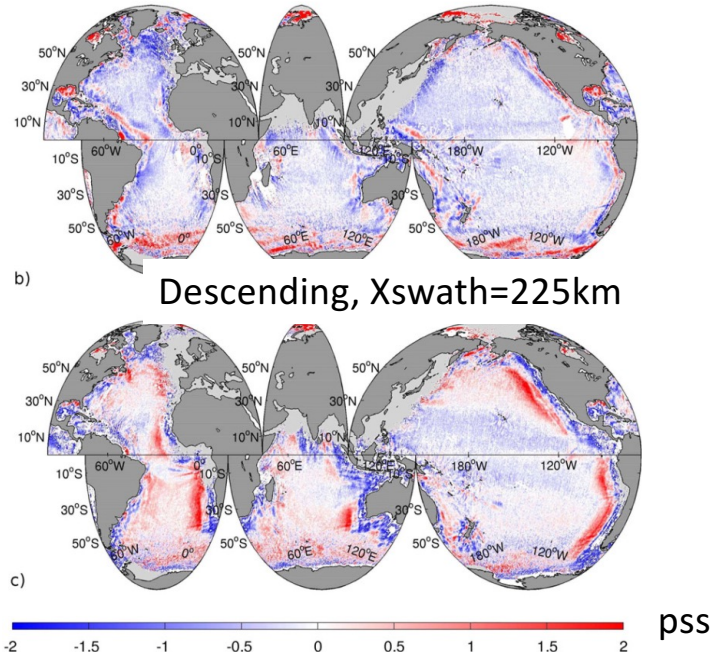
+ Bias_Lat(lat, xswath, t, orbit)

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

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).



Median SSS bias
Ascending, Xswath=0



Descending, Xswath=225km

Kolodziejczyk et al. RSE 2016.

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.argans.co.uk

SMOS CATDS RE05 corrected

Main changes:

- **SSS bias removal near land**
- **Latitudinal-seasonal bias correction**

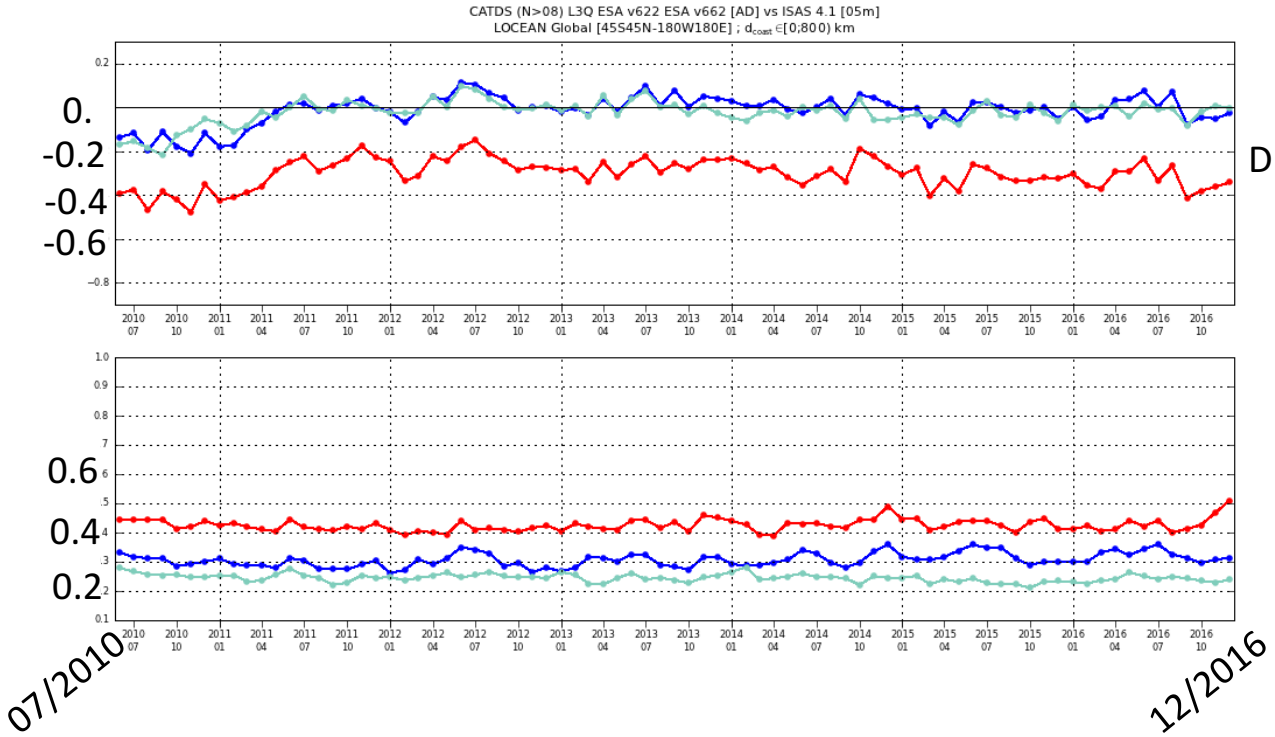
www.catds.fr

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

ESA v622 Corrected ESA v662 Corrected CATDS



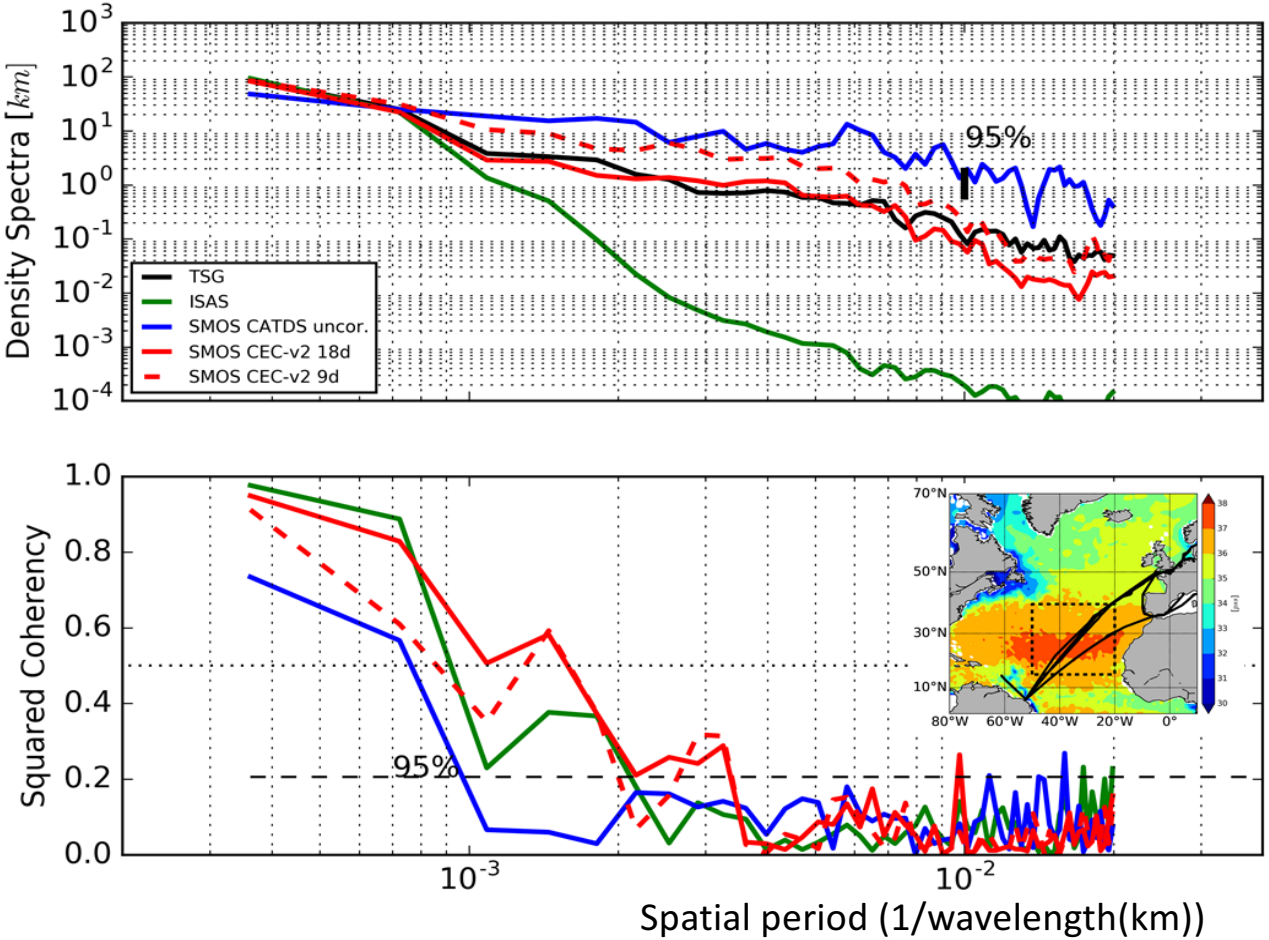
Difference (SMOS-ISAS)

Std (SMOS-ISAS)

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

SMOS averages 100x100km^2-1month

Comparison with ship measurements



~ ESA v622

Ship

CATDS corrected (~RE05)

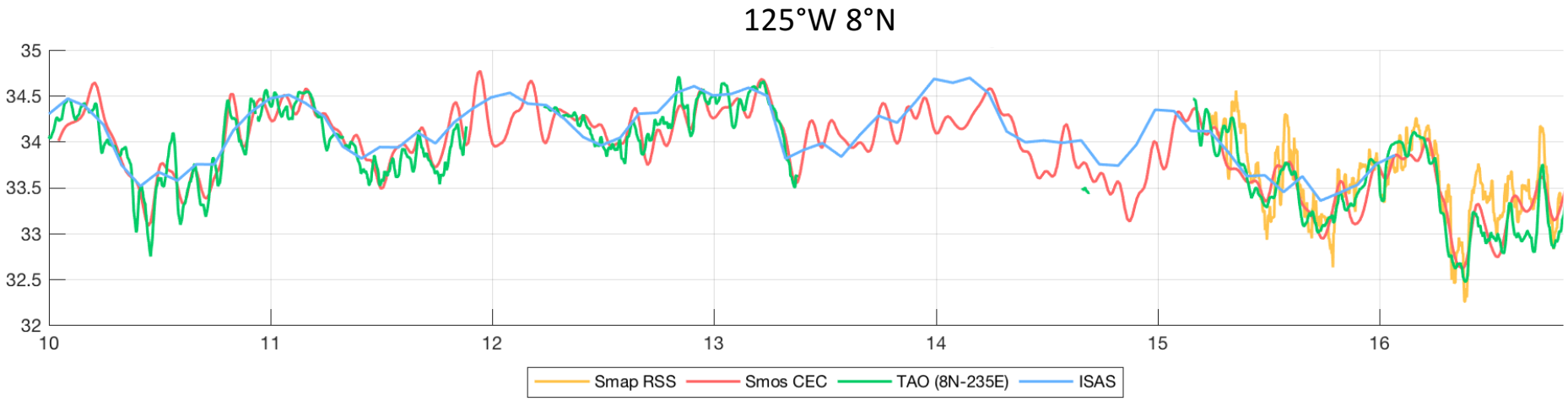
ISAS (Argo)

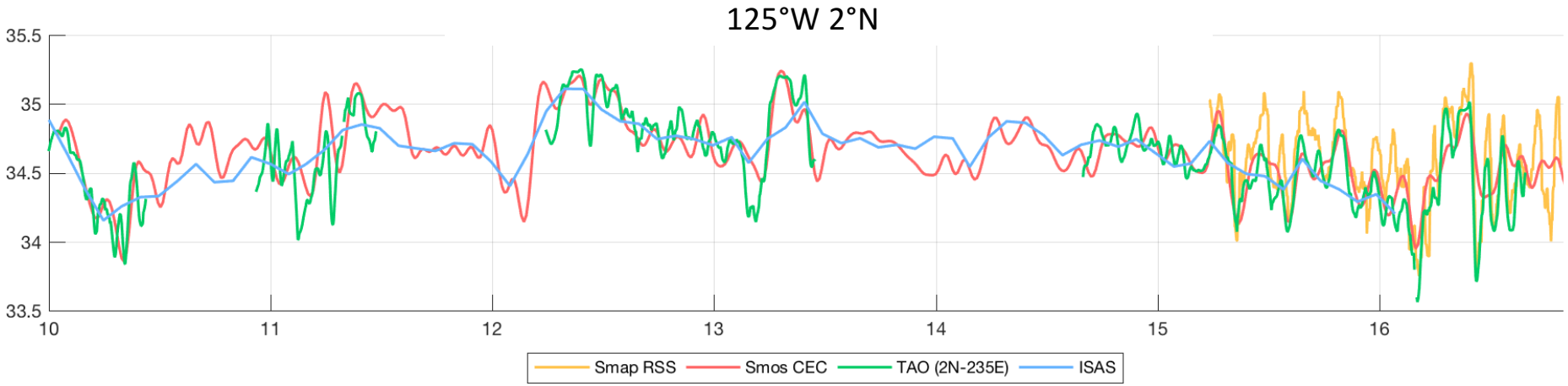
SMOS CEC and ship SSS consistently captures scales of variability up to about 100km

N. Kolodziejczyk

Northern subtropical in 2013. Ship SSS measured on regular merchant ships transects (14 regular transects in 2013).

Examples of TAO-SMOS-SMAP-ISAS

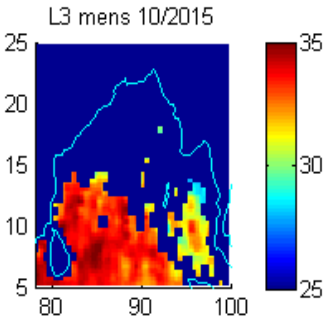




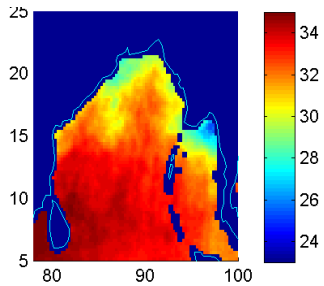
Evolution of bias correction at CATDS:

The different steps

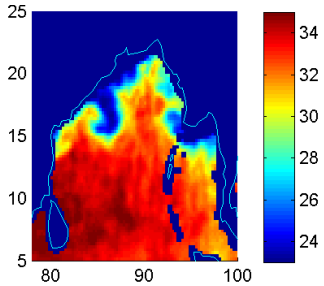
No debiasing, RE04



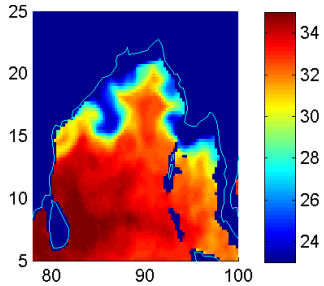
CEC LOCEAN Debias v1



CEC LOCEAN Debias v2



SMAP



Bias correction + data filtering

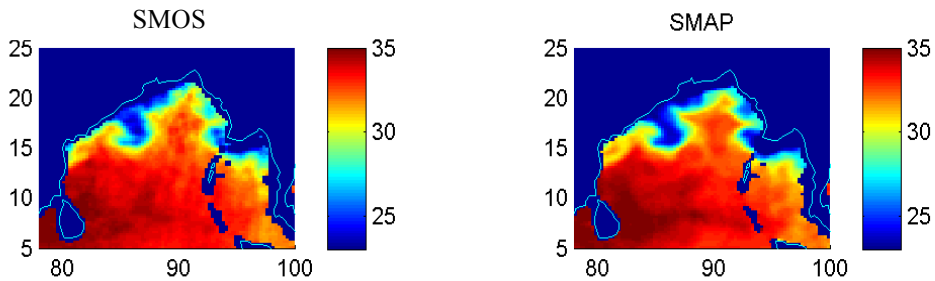
Data filtering taking into account natural variability

Validation with respect to SMAP

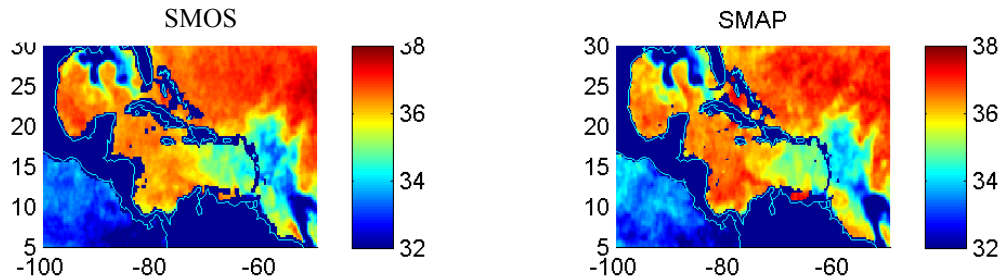
CATDS CPDC RE05 corrected (CSQ3 product)

Freshwater river plumes from SMOS (CATDS) and SMAP(CAP) => monitoring at ~50km resolution

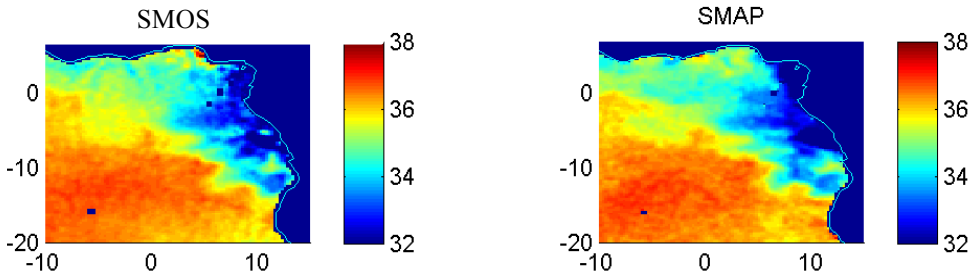
Bay of Bengale



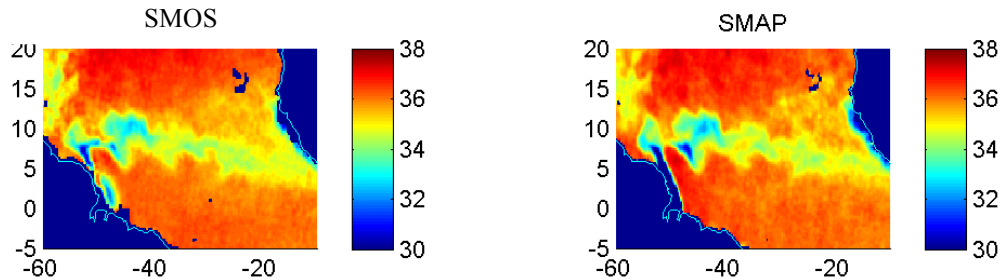
Gulf of Mexico



Eastern tropical Atlantic



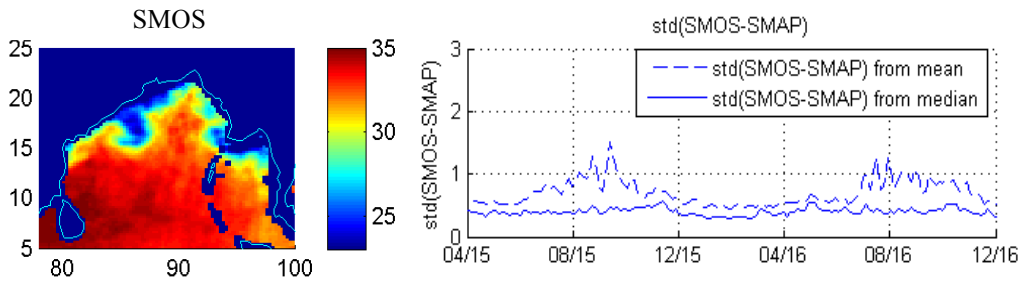
Amazone plume



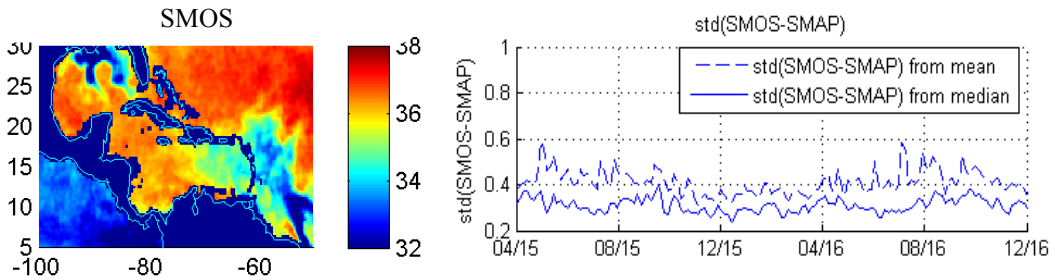
Boutin et al., subm RSE, 2017

Freshwater river plumes from SMOS (CATDS) and SMAP(CAP) => monitoring at ~50km resolution

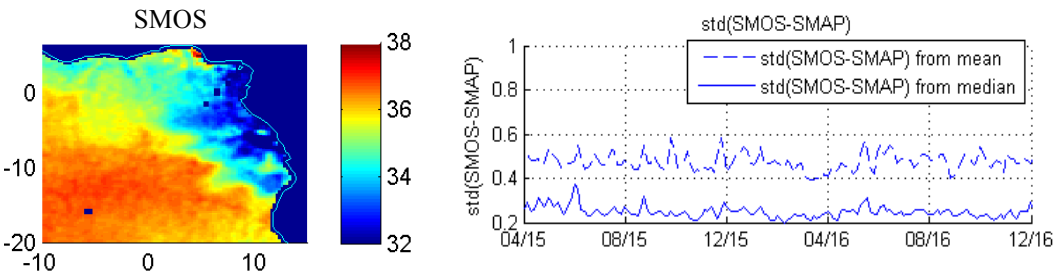
Bay of Bengale



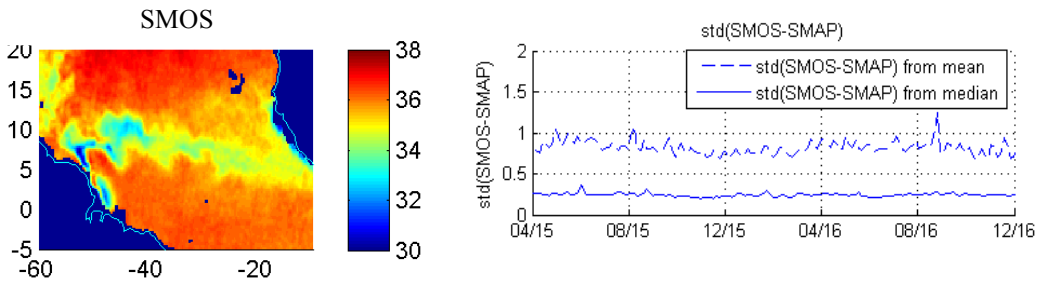
Gulf of Mexico



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

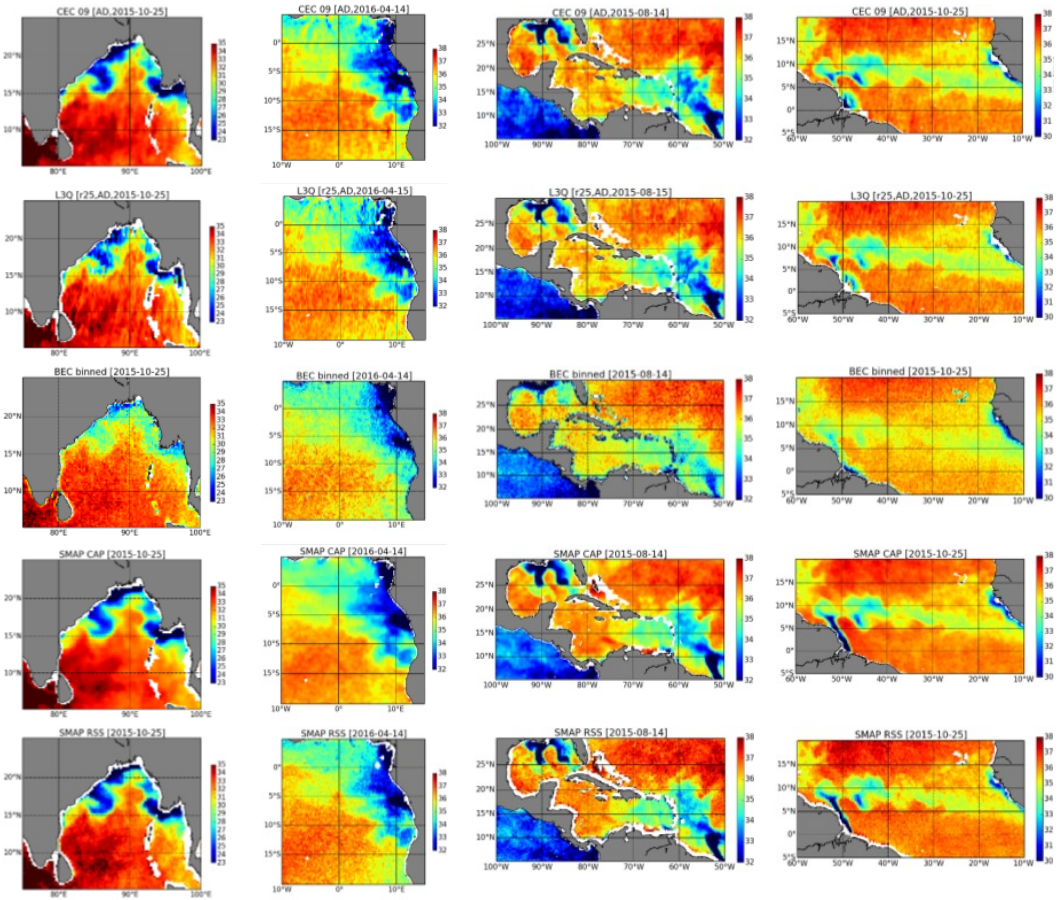
SMOS CATDS CEC LOCEAN Debias_v2 (RE05)

SMOS CATDS CPDC L3Q Binned - near-real time

SMOS BEC non bayesian binned

SMAP CAP/JPL

SMAP RemSS



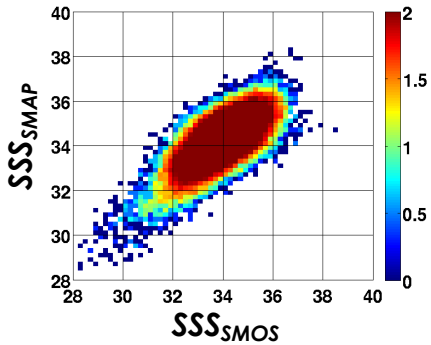
Boutin et al., subm. RSE, 2017

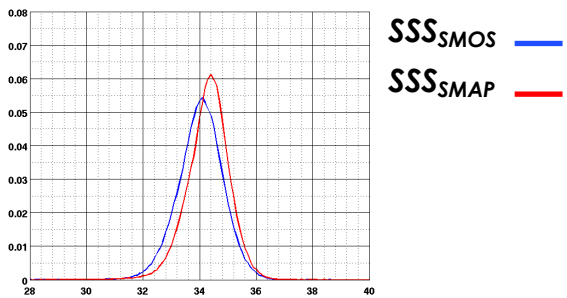
A tentative estimate of *SMAP/CAP individual SSS error* based on comparison with SMOS SSS

ITCZ (180°W-110°W;0°N-10°N)

01/01/2016 -> 31/07/2016

DeltaTime < 15 min





	Mean	Std
SSS	*SMOS : 34.03* *SMAP: 34.29*	*0.80* *0.75*

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

Supply et al. 2017

Assuming:

$$\sigma^2_{tot\ SMOS} = \sigma^2_{err\ SMOS} + \sigma^2_{nat} \ \mathbf{(1)}$$

$$\sigma^2_{tot\ SMAP} = \sigma^2_{err\ SMAP} + \sigma^2_{nat} \ \mathbf{(2)}$$

$$\sigma^2_{err\ SMAP} = \sigma^2_{err\ SMOS} + \sigma^2_{tot\ SMAP} - \sigma^2_{totSMOS} \ \mathbf{(2) - (1)}$$

$\sigma_{errSMOS}$ ~ 0.48pss (theoretical error on SMOS SSS = observed std without rain in these tropical regions (hot regions))

=> $\sigma_{errSMAP}$ ~0.39pss

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

Quarterly Journal of the Royal Meteorological Society Q. J. R. Meteorol. Soc. (2017) DOI:10.1002/qj.3110

Precipitation estimates from SMOS sea-surface salinity

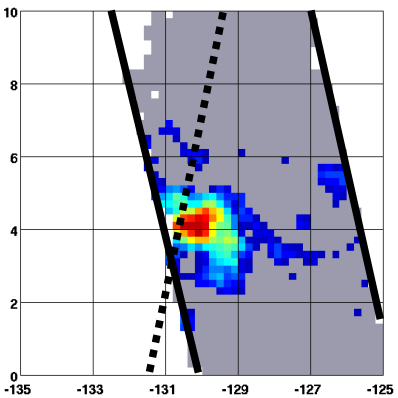
A. Supply,[a*] J. Boutin,[a] J.-L. Vergely,[b] N. Martin,[a†] A. Hasson,[a] G. Reverdin,[a] C. Mallet[c] and N. Viltard[c]

Time:

2016-02-06

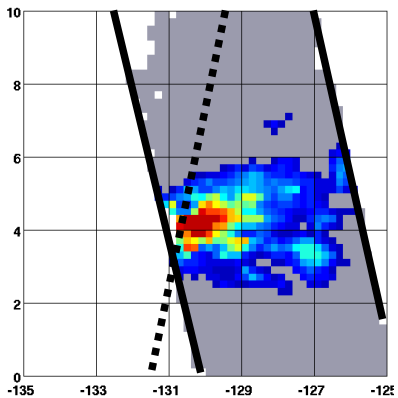
R_{SMOS}

14:30

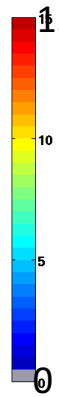


$R_{IMERG\ (GPROF2014)}$

14:31



Rain Rate



15mm/hr

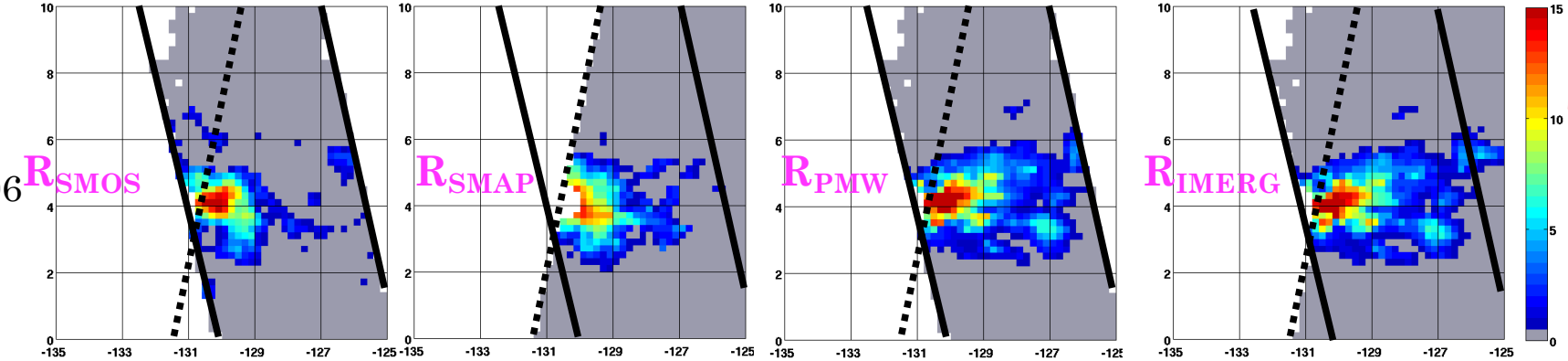
0 mm/hr

Quarterly Journal of the Royal Meteorological Society Q. J. R. Meteorol. Soc. (2017) DOI:10.1002/qj.3110

What SMOS and SMAP could bring to GPM constellation and IMERG (morphing of PMW rain rate) ?

Time: 14:30 14:25 14:31 14:30

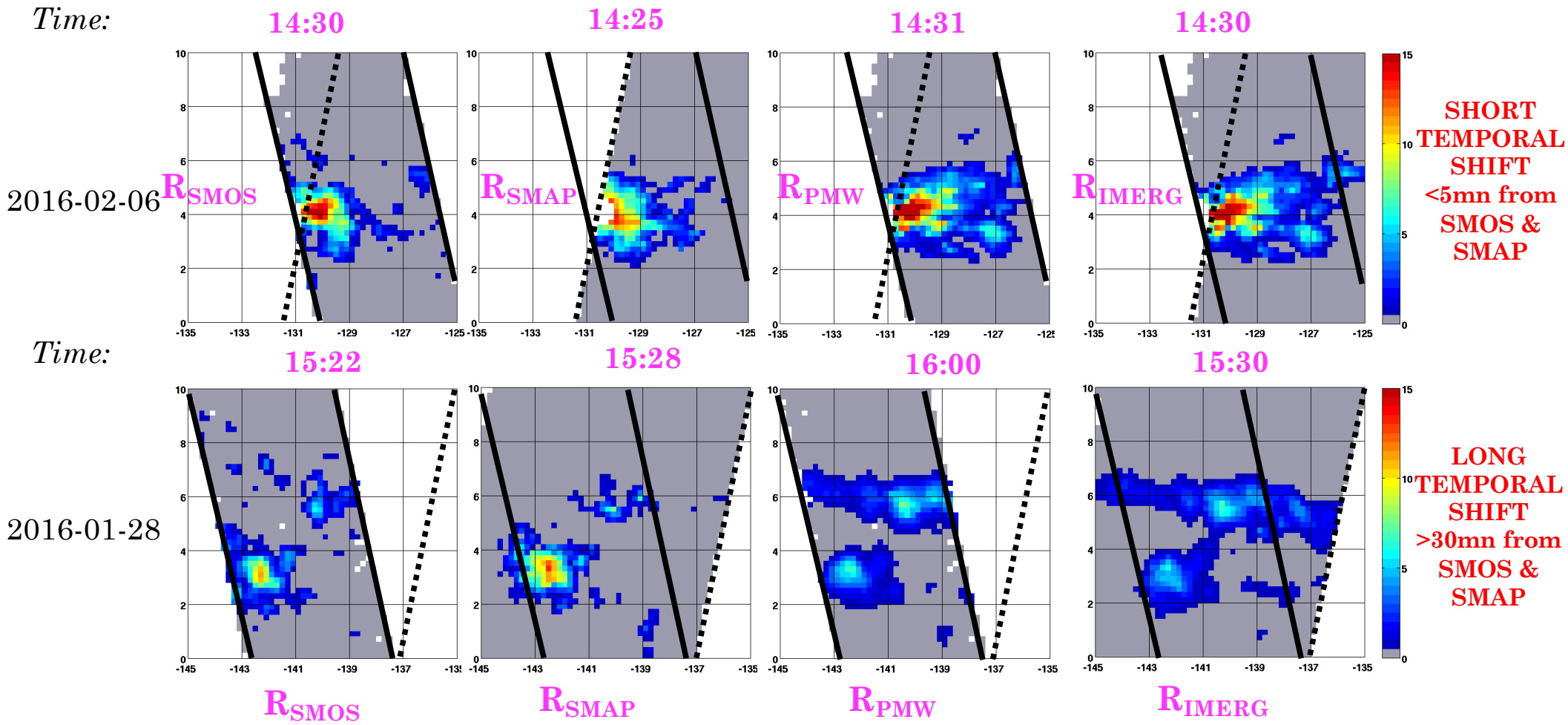
2016-02-06



SHORT TEMPORAL SHIFT <5mn from SMOS & SMAP

Quarterly Journal of the Royal Meteorological Society Q. J. R. Meteorol. Soc. (2017) DOI:10.1002/qj.3110

What SMOS and SMAP could bring to GPM constellation and IMERG (morphing of PMW rain rate) ?



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

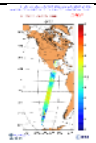
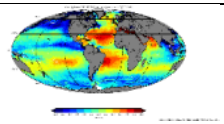
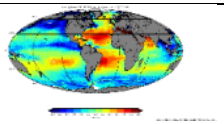
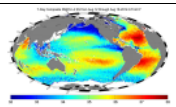
- In cold water, SMOS pseudo-dielectric constant agree well with recent measurements of Lang et al (2016) and Zhou et al. (2017) derived relationship

=> See Emmanuel's and Audrey's Poster for more information

SMOS SSS products

Operational centers

Expertise centers

	ESA	CATDS CPDC	CATDS CEC LOCEAN	CATDS CEC IFREMER	BEC
Type of retrieval	Full Pol/Bayesian	Full Pol/Bayesian	Full Pol/Bayesian	ST1	
Level of product	L2	L3 (& L4)	L3	L3 & L4	L3 & L4
					See E. Olmedo's presentation
Products before May 2017	V622	RE04	Debias_v1	**L4** (adjusted to ISAS + other paramers)	
May 2017 products including systematic errors corrections	**V662 NoCorr** **V662 Corr**	**RE05 NoCorr** **RE05 Corr**	**Debias_v2**	L4 (in prep. see N. Kolodziejczyk presentation)	

In bold, publicly available and maintained products

www.esa.int

catds.ifremer.fr

cp34-bec.cmima.csic.es