# SMOS and Aquarius: SSS and Wind Effect

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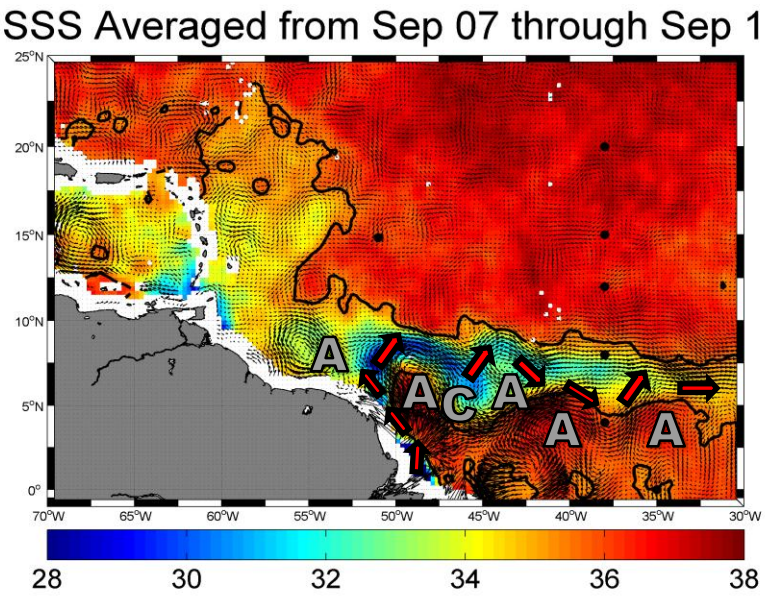
*ESA/CNES SMOS CAL/VAL project (GLOSCAL)*

*NASA ROSES project (Intercalibration of SMOS and Aquarius)*

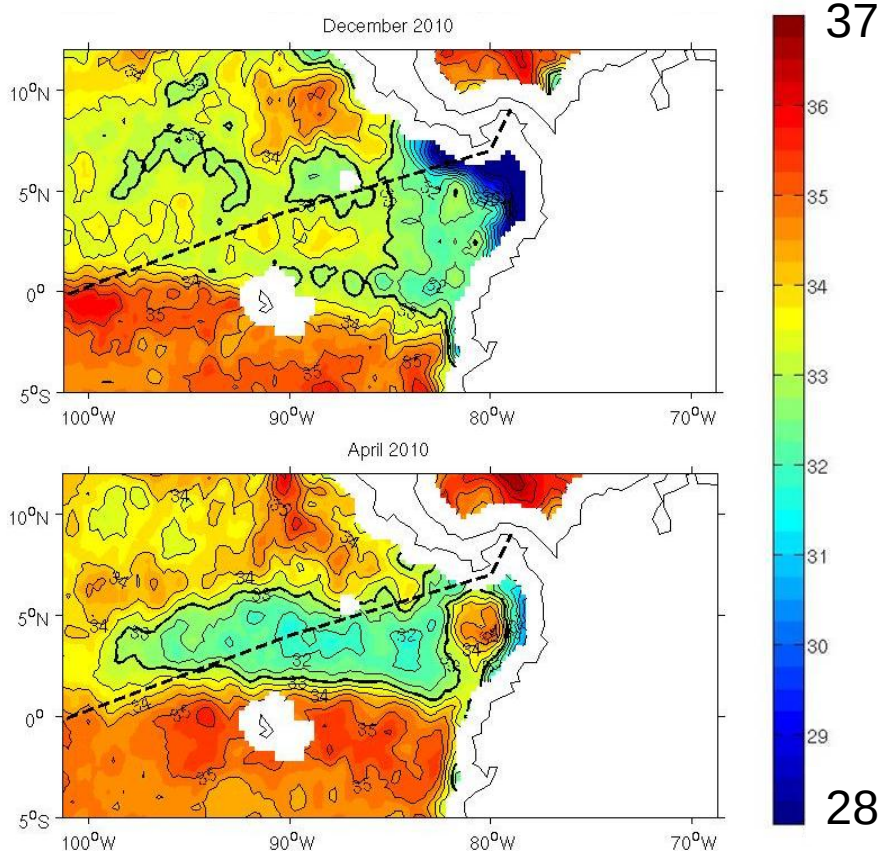
# Examples of SSS variability analyzed from SMOS CEC-CATDS 2010 products

## Amazone Plume Region




*Reul et al, 2011, 2012;*
*See http://www.salinityremotesensing.ifremer.fr/*

## Panama region




*Alory, et al., Seasonal dynamics of Sea Surface Salinity off Panama: the Far Eastern Pacific Fresh Pool, JGR Ocean, in press, 2012.*

# Overview of this presentation

- SMOS – Aquarius – ARGO maps
- SMOS & Aquarius wind dependencies
- Precision of SMOS SSS wrt in situ measurements (ship and ARGO)
- Rain-freshening issue

# Data

***SATELLITE SSS***

**-SMOS SSS reprocessed by ESA v5.5** (wind-model 1)

*Improvements with respect to previous versions:*

-Reduced coastal bias; OTT (systematic bias in the Field of View) every 2 weeks and separetely for ascending and descending orbits; improved wind correction ; improved RFI & outlier sorting

*SSS averages weighted by the variance of the error of the retrieved SSS (Boutin et al., TGRS, 2012, in press), and restricted to wind speed between 3 and 12m/s*

**-AQUARIUS level 3 maps v1.2.3**

***IN SITU SSS***

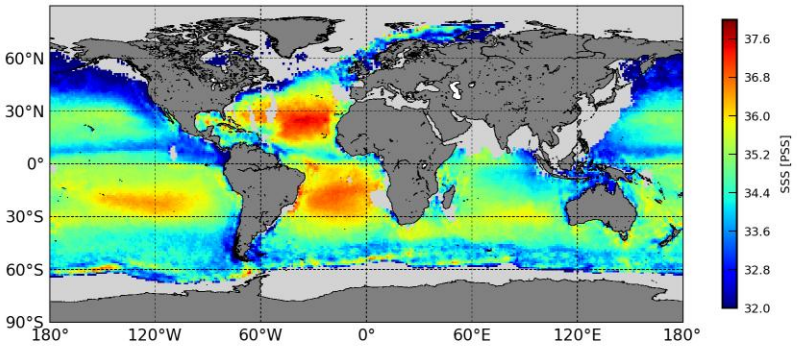
**-Optimal Interpolation of ARGO SSS**: IFREMER In Situ Analysis System (ISAS) (Gaillard et al. 2009)

**-ARGO SSS** (upper SSS between 10m and 0.5m depth) (CORIOLIS GDAAC)

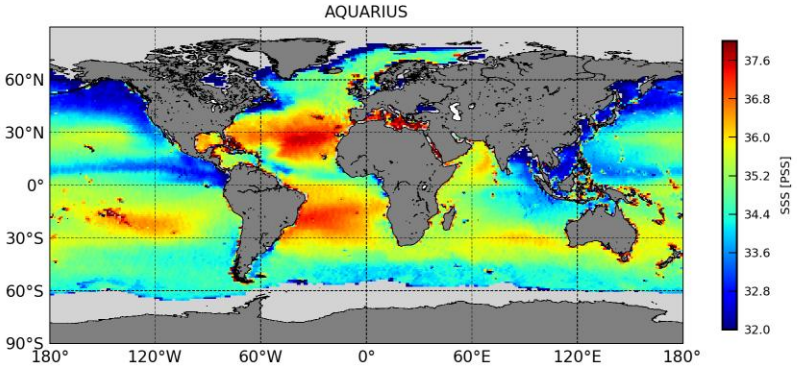
**-Ships of Opportunity** (Delayed mode data delivered by SSS observatory (http://www.legos.obs-mip.fr/observations/sss/))

**-Surface drifters** (http://www.locean-ipsl.upmc.fr/smos/drifters)

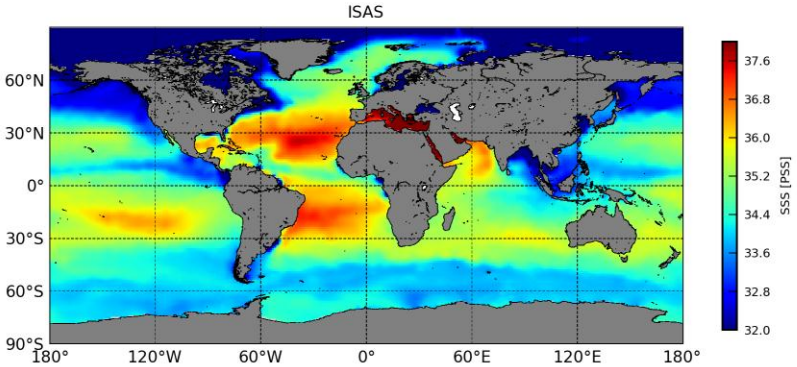
# SMOS - AQUARIUS – ARGO SSS – Sept-Dec 2011




SMOS v5.5
(Ascending Orbits)




Aquarius v1.2.3

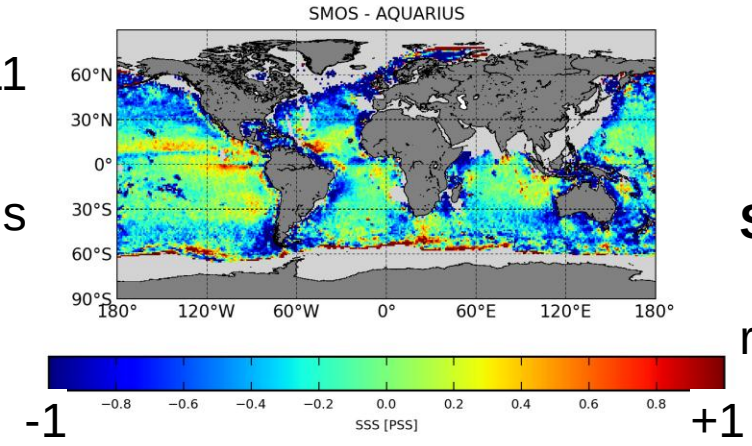



ARGO OI

pril 2012

Sept-Dec 2011

SMOS-Aquarius




-1 +1

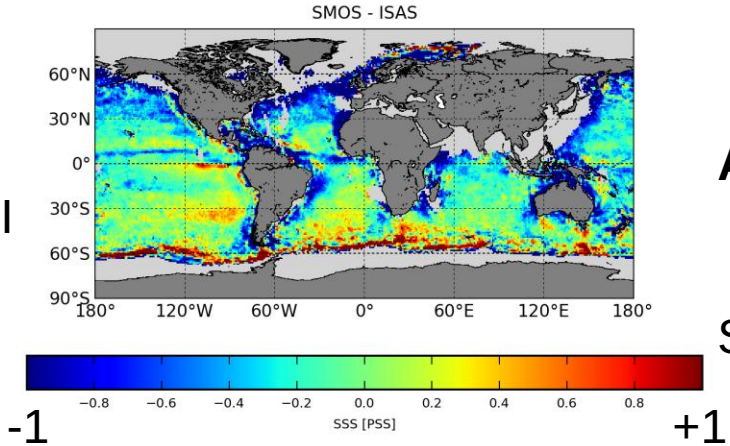
**SMOS features**:

-issues close to land (image reconstruction)

-Large RFI (N. Atl., Asian coasts)

-Ice edge

SMOS-ARGO OI



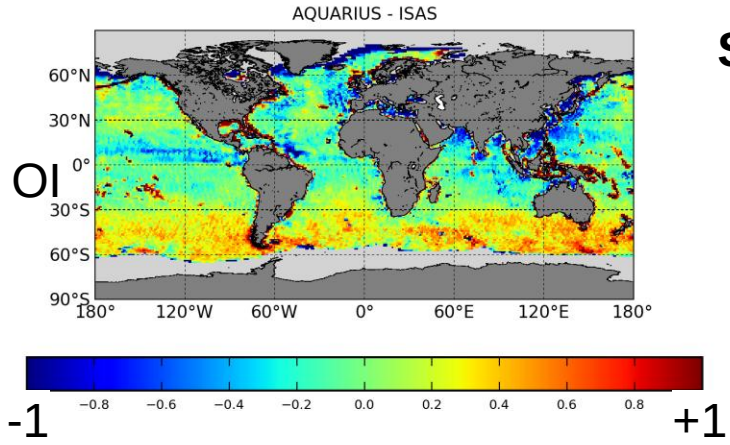

-1 +1

**Aquarius features**:

-Underestimates in Southern Ocean

-Overestimates close to islands (e.g. S. Pac ).

Aquarius-ARGO OI




-1 +1

**SMOS & Aquarius features**:

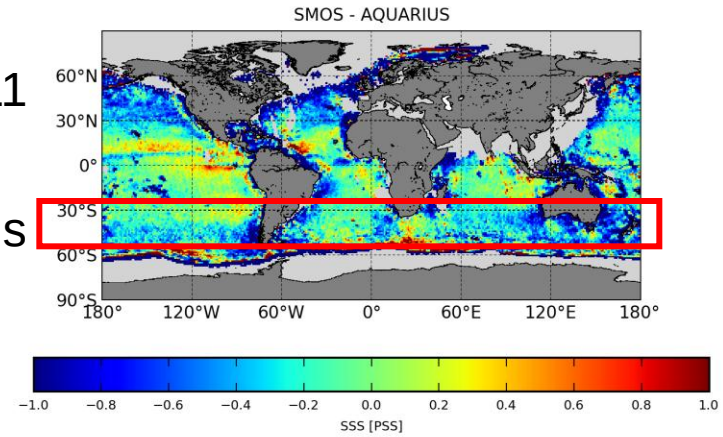
-Better resolution of Amazone Plume

-Lower SSS in rainy regions

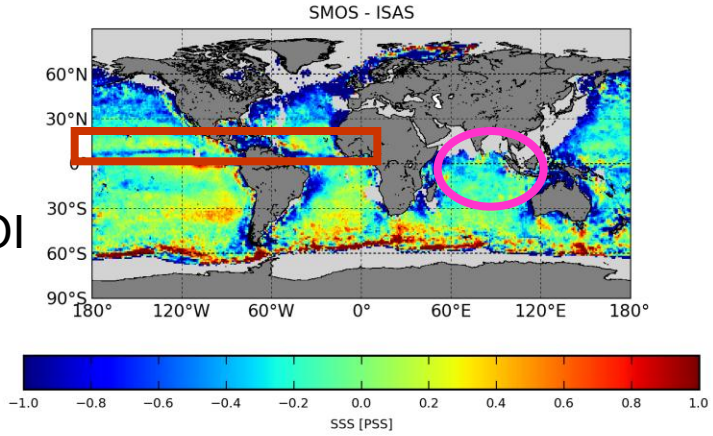
-Lower SSS in Indian Ocean

Sept-Dec 2011

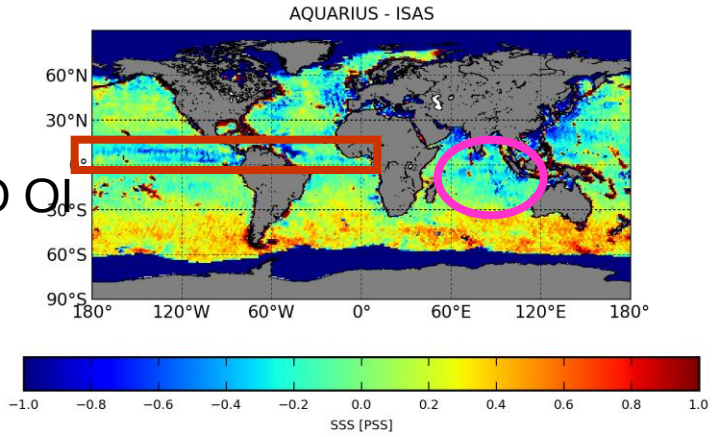
SMOS-Aquarius




SMOS-ARGO OI




Aquarius-ARGO OI




## FOCUSES

**1- Why such differences in SO? SMOS and Aquarius Tb-Wind?**

**2- SMOS and Aquarius SSS lower than ISAS in subtropical Indian Ocean: SMOS & ARGO OI versus Ship**

**3- SMOS and Aquarius SSS fresher than ARGO OI in rainy regions: effect of rain on SMOS SSS? Ship and ARGO colocations**

# SMOS & AQUARIUS WIND DEPENDENCIES

**Aquarius Tb-wind** :

-empirical wrt SSMI wind speed + NCEP wind direction (Yueh)

-empirical wrt NCEP wind (Dinnat)

**SMOS Tb-wind** :

-Adjusted rough & foam models wrt SSMI wind speed (Yin et al, TGRS, 2012 in press)

-Adjusted rough & foam models wrt ECMWF wind speed (Yin et al, TGRS, 2012 in press)

-Empirical model wrt ECMWF wind speed (Tenerelli, 2011)

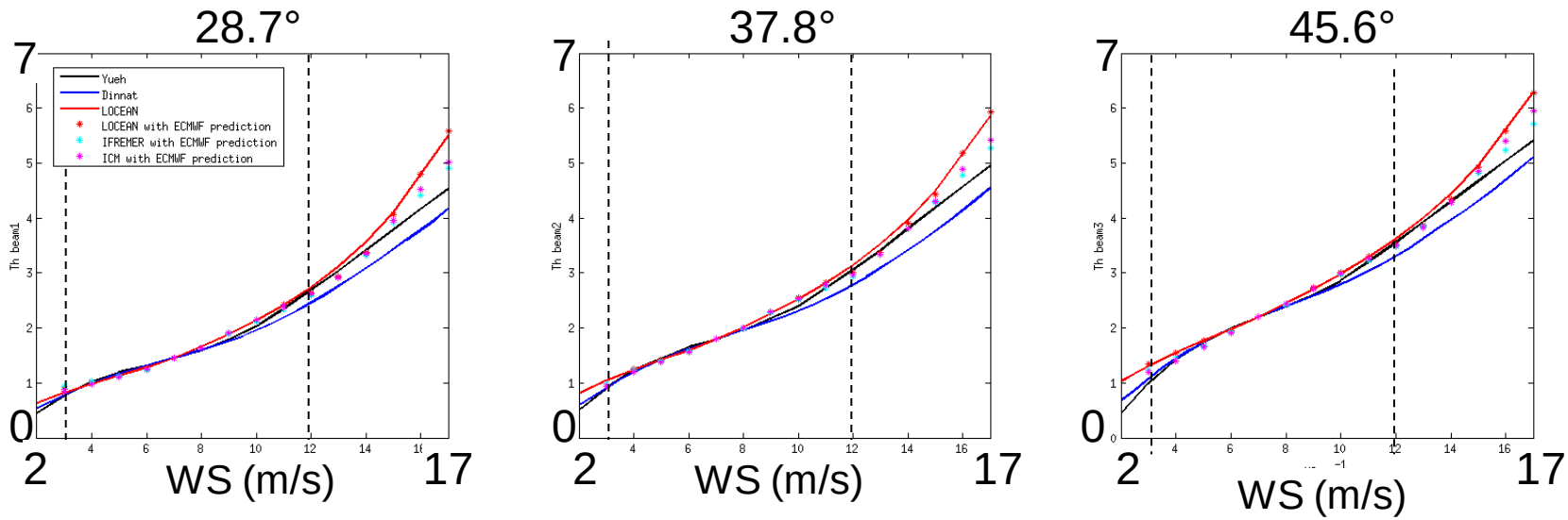
-Empirical model wrt ECMWF wind speed (Guimbard et al, 2012)

Given the uncertainty about the absolute bias between model and data (need for OTT correction for SMOS) all the curves have been adjusted at 7m/s

# Omnidirectional Tb-Wind dependencies

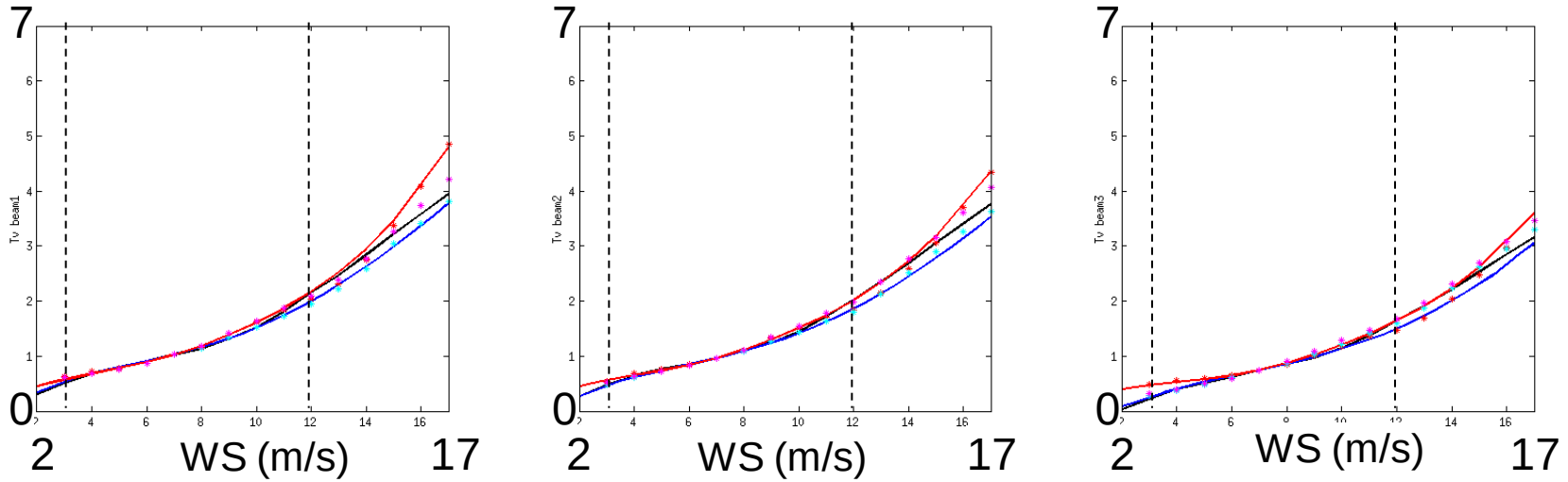
Very similar SMOS and Aquarius Tb-Wind omnidirectional dependencies 3<WS<12 m/s
Above 15m/s SMOS ΔT higher than Aquarius ΔT (especially in H polarization)

ΔTh (K)



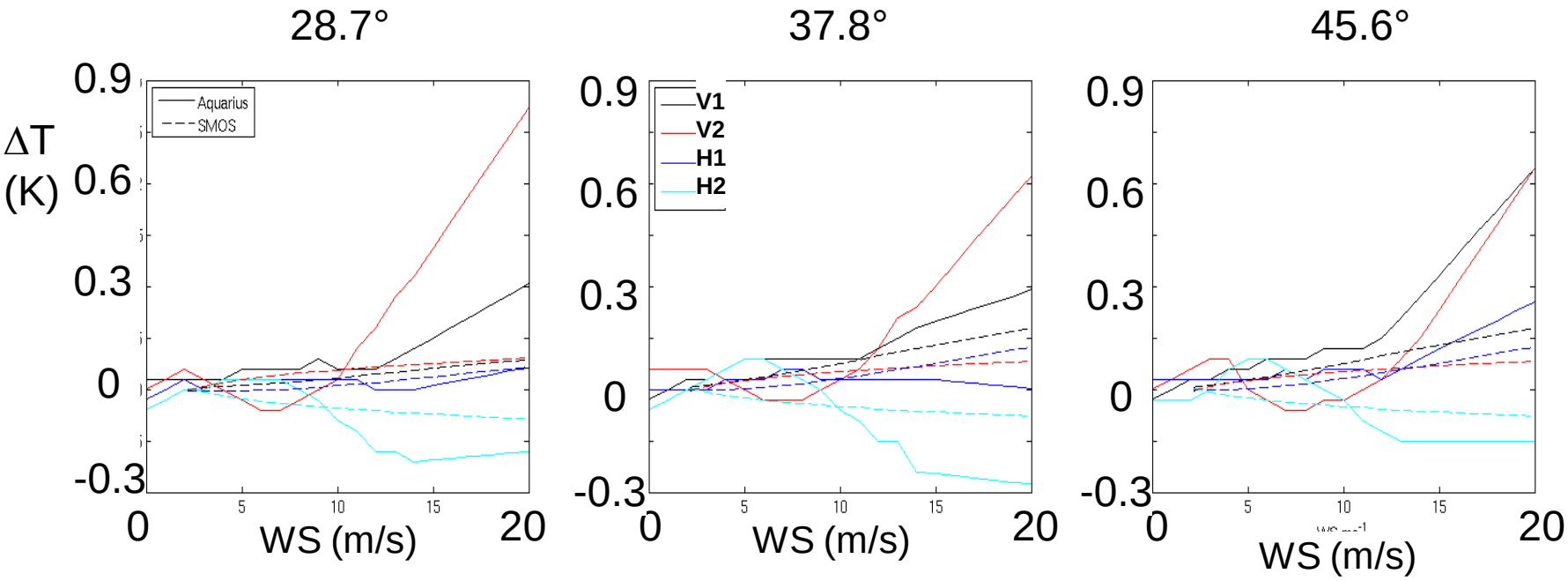

**Aquarius (SSMI WS); Aquarius (NCEP WS); SMOS (SSMI WS); *,*,* SMOS (ECMWF WS)**

ΔTv (K)



# Tb dependency with Wind Direction

Much larger dependency in Aquarius than in SMOS functions at high WS!




**Aquarius**

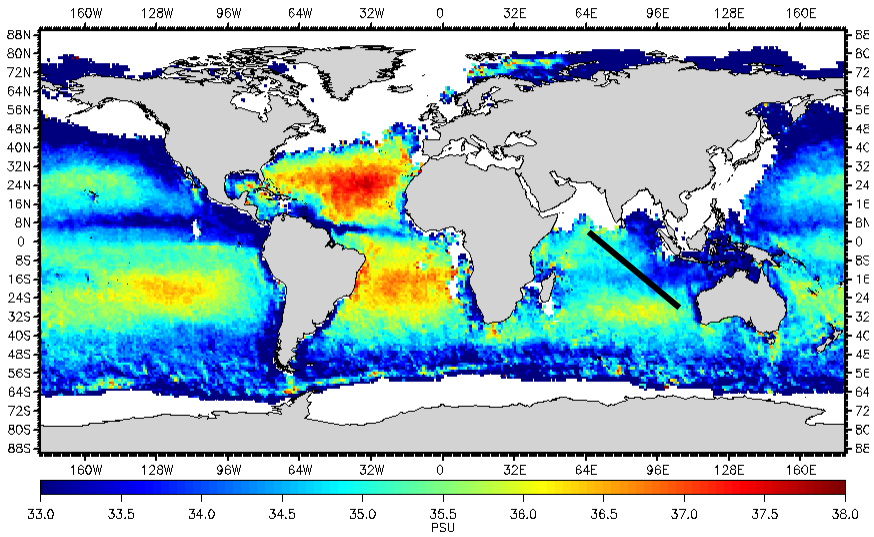
**SMOS model 1**

Tb=Tbwind + **Tb1** cos(Phi) + **Tb2** cos(2Phi)

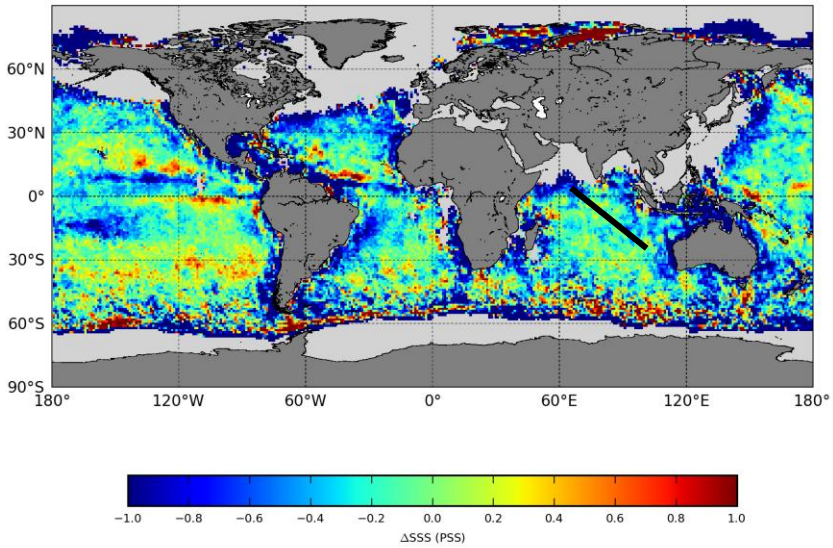
**TbV1** **TbV2** **TbH1** **TbH2**

# Indian Ocean: SMOS–Lavender Ship SSS 19 Sep – 1 Oct 2010

Sept 2010 - SMOS SSS (Asc orbits)

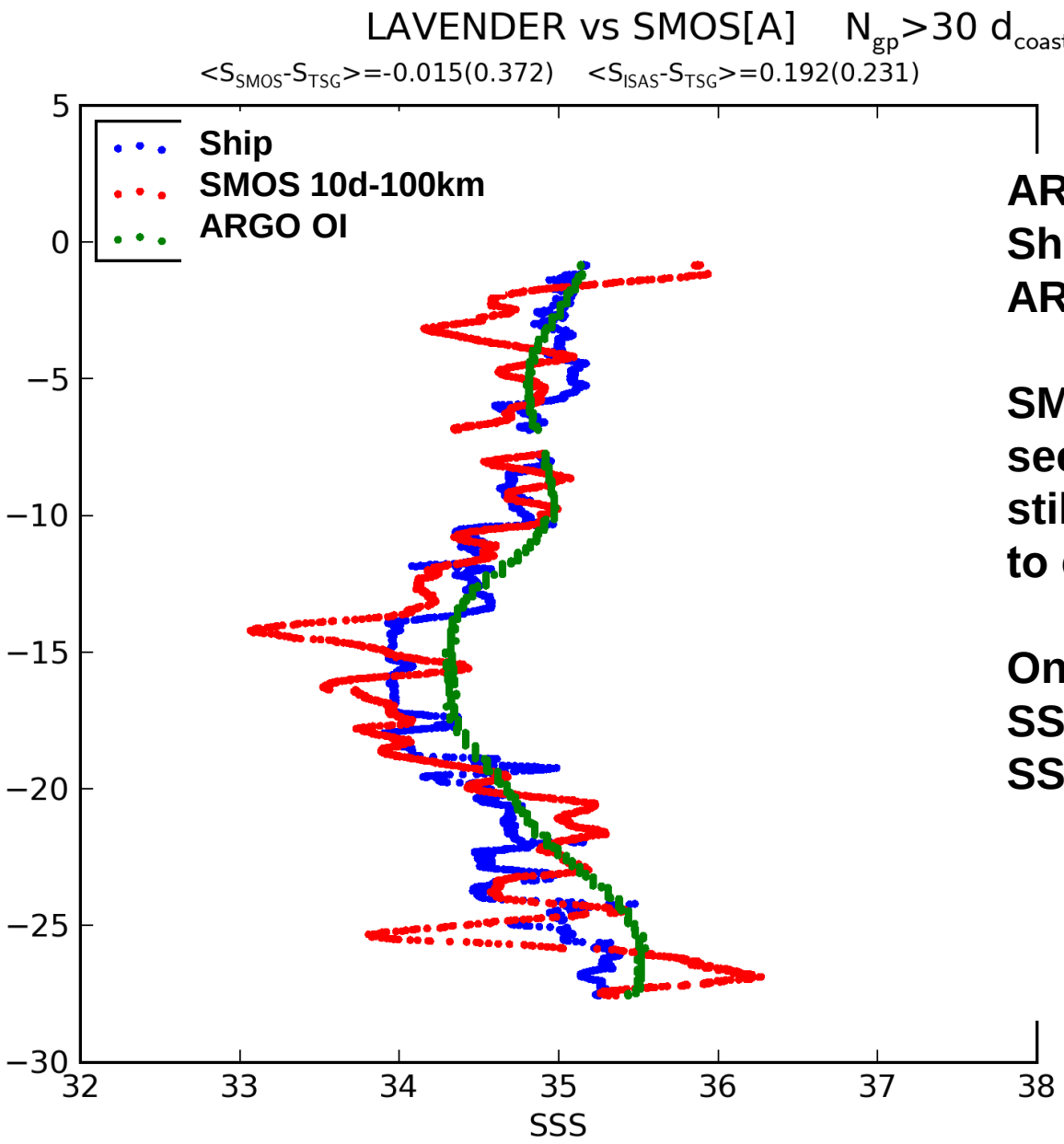



SMOS – ARGO OI SSS




Next slides:
SMOS SSS averaged over 10 days and 100km around Lavender time and location

# SSS latitudinal profiles – Ship-ARGO OI-SMOS

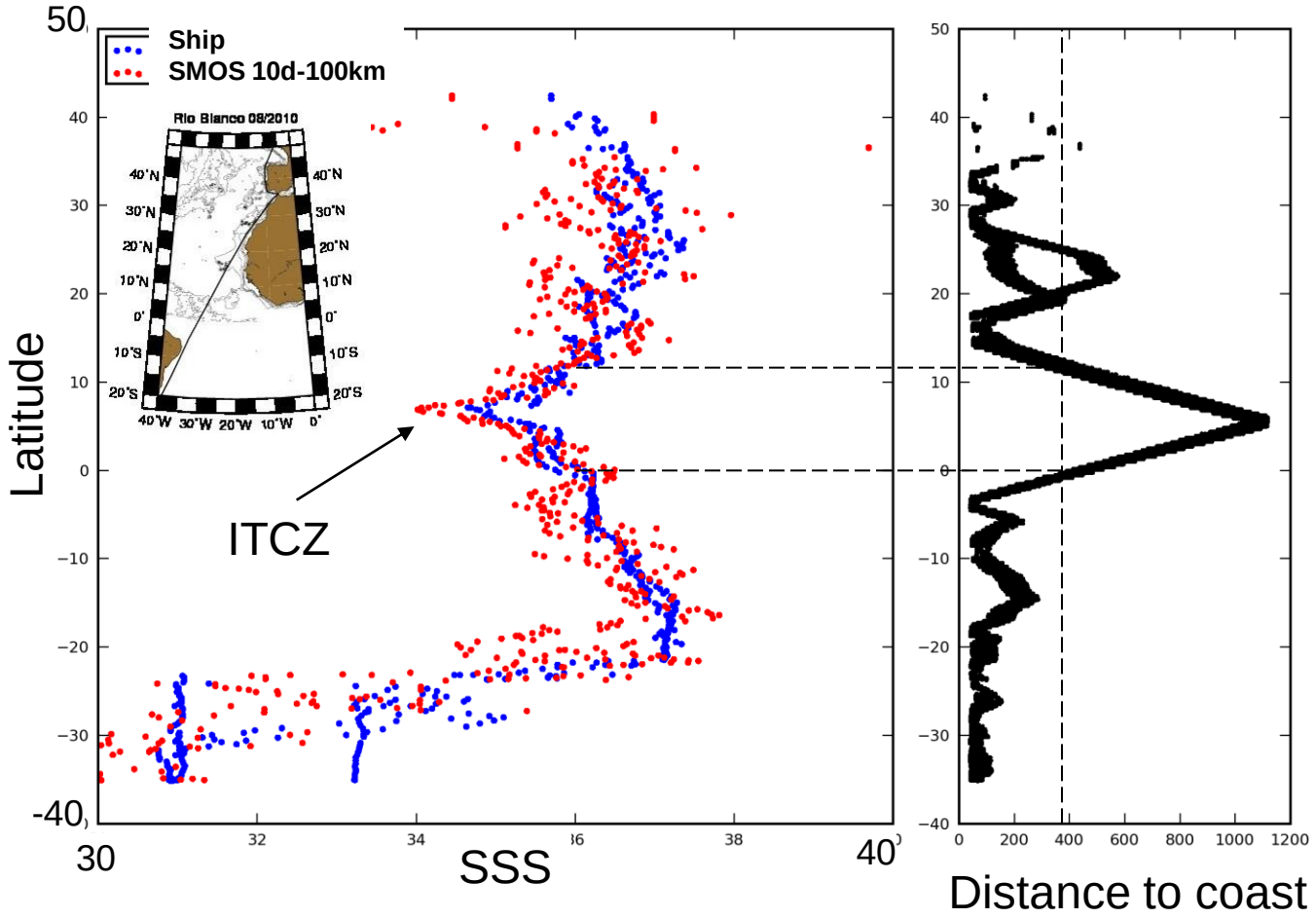



**ARGO OI much smoother than Ship SSS: monthly map & ~1 ARGO meas./10days, 2°**

**SMOS (40km resolution) better sees small scale variability, but still some deficiencies (distance to coast? , RFI, islands…)**

**On average:**
**$SSS_{ARGO\_OI}$-$SSS_{TSG}$ = 0.2 (0.23)**
**$SSS_{SMOS}$-$SSS_{TSG}$ = 0.0 (0.37)**

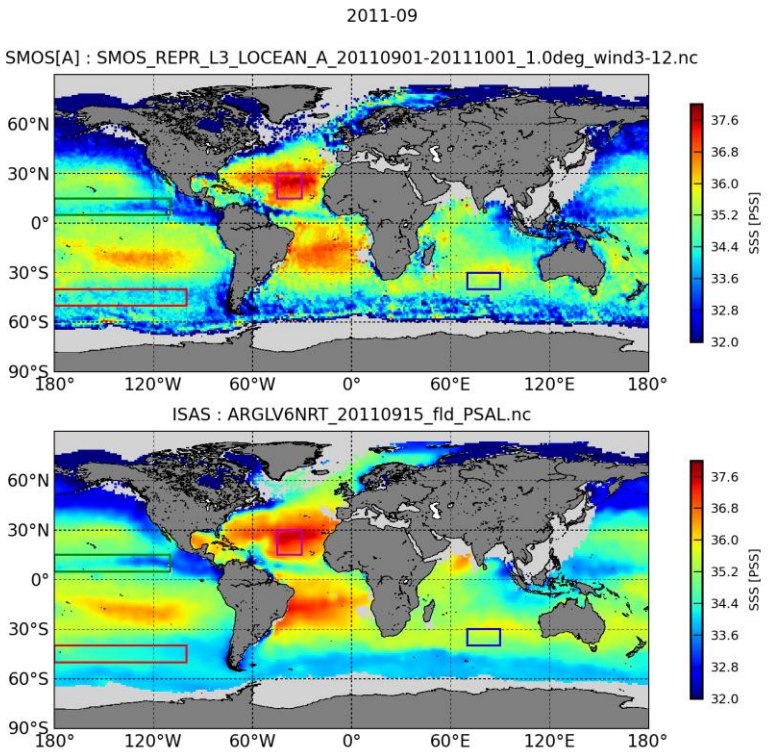
# Atlantic Ocean SSS: SMOS and Rio Blanco Ship (Aug-Sep 2010)

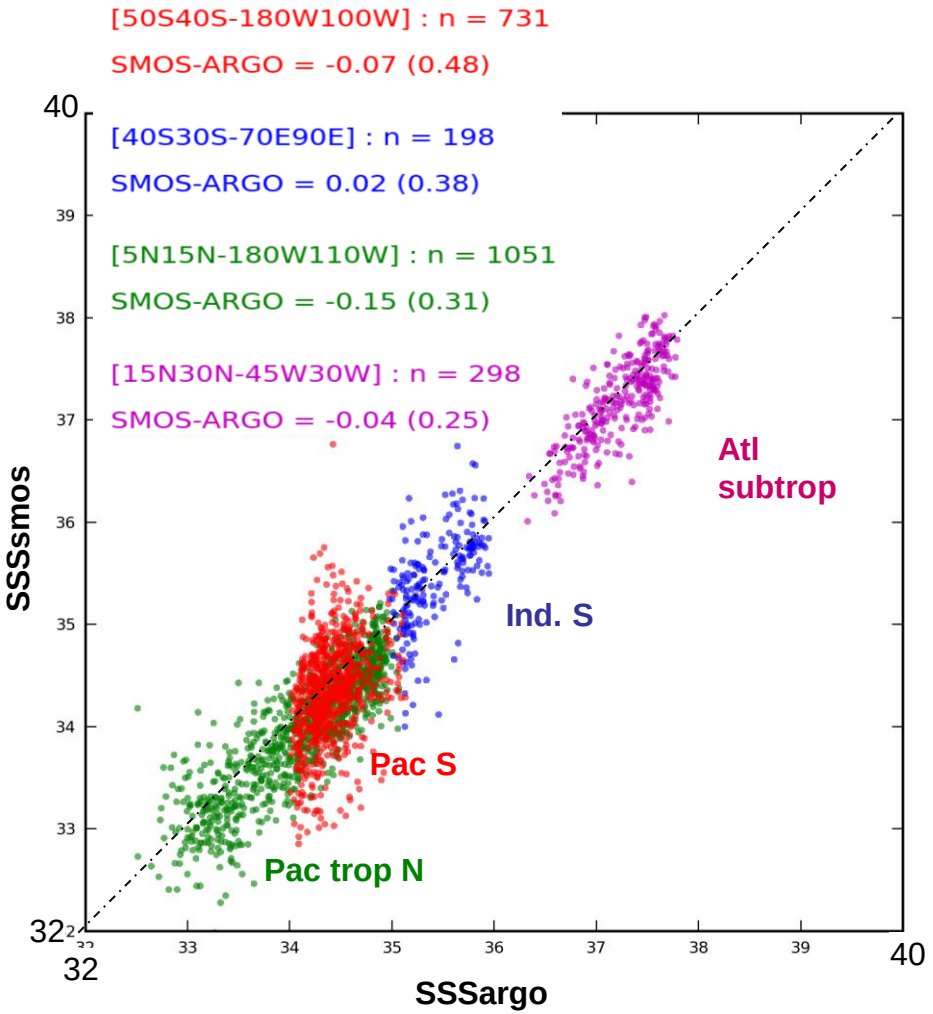



High noise close to land but qualitative agreement
SMOS SSS fresher than ship in ITCZ

Boutin et al., 7th Aquarius/SAC-D Science Meeting, 11-13 April 2012

# Comparisons with ARGO in selected regions far from land (Aug-Sept 2010 & 2011)



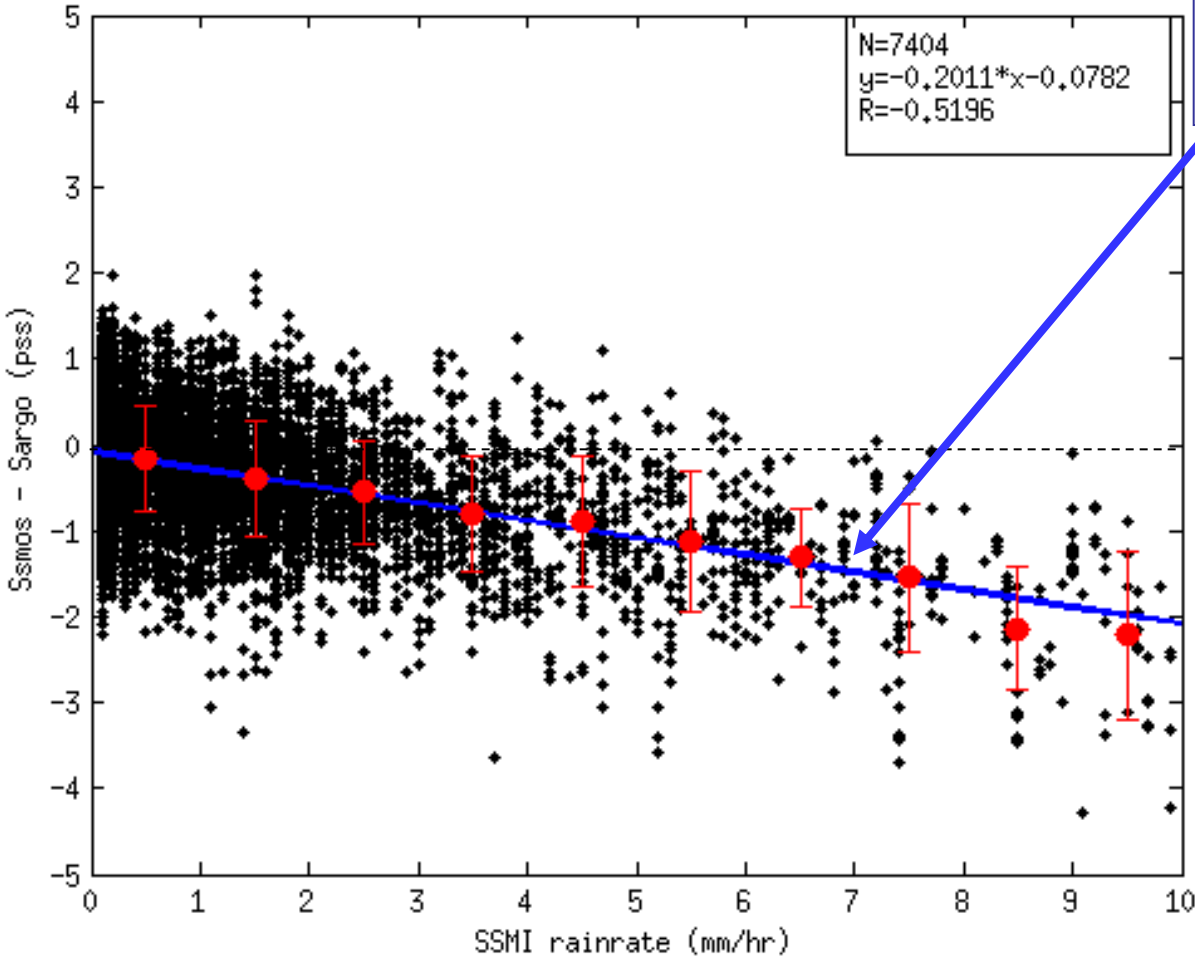




(SMOS SSS weighted averaged over 100km-10days around ARGO)
SMOS – ARGO SSS in tropical Pacific 0.1 fresher than in other regions: rain?

# SMOS SSS & SSMI Rain Rate colocation in tropical Pacific Ocean (5N-15N)

- **SMOS SSS - 40km resolution**
- Rain Rate deduced from SSMI F16 and F17 (RemSS version 7); 32km spatial resolution
- Colocation of SMOS SSS and SSMI Rain Rate: closest RR within -80mn and +40mn from SMOS time
- **Statistics of SSSsmos-SSSargo depending on SSM/I RR**

# SMOS SSS- ARGO SSS versus SSMI RR
# Tropical Pacific 5S-5N (July-Sept 2010)




-0.2 pss/ mm/hr
R=-0.5

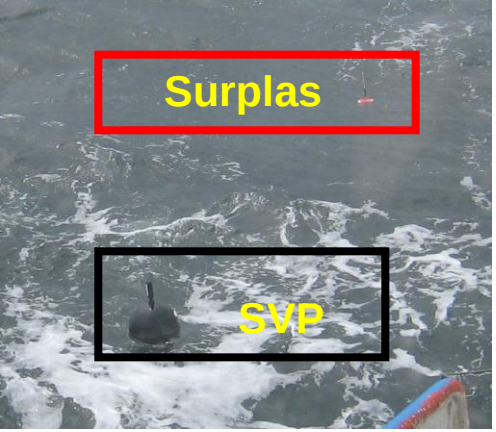
**A much larger effect than the one expected from atmospheric effect (e.g. J. Schulz, 2004, Wentz, 2005) (~0.4pss at 10mm/hr)**

**1cm SSS freshening linked to rain???**

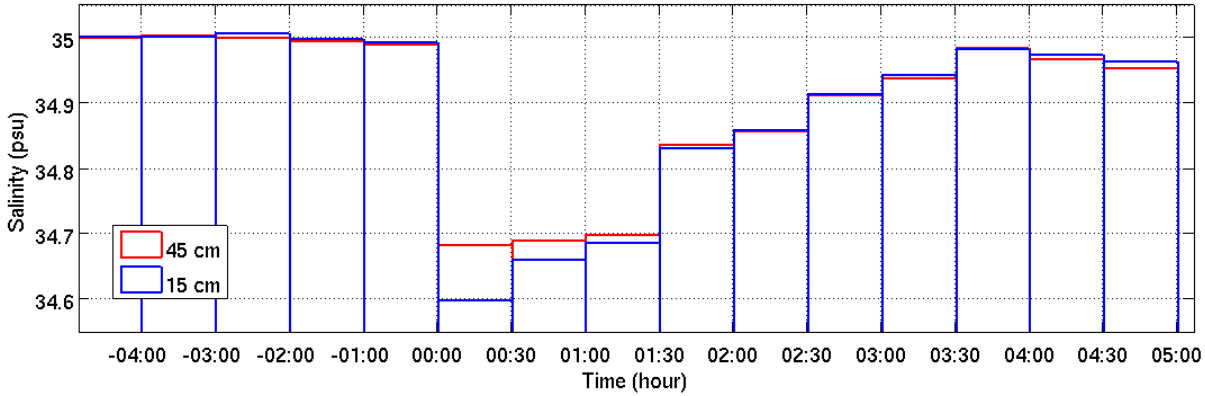
**Need for in situ measurements at cm depth for validation!!!**

# Vertical gradients 15cm – 45 cm as seen by surface drifters

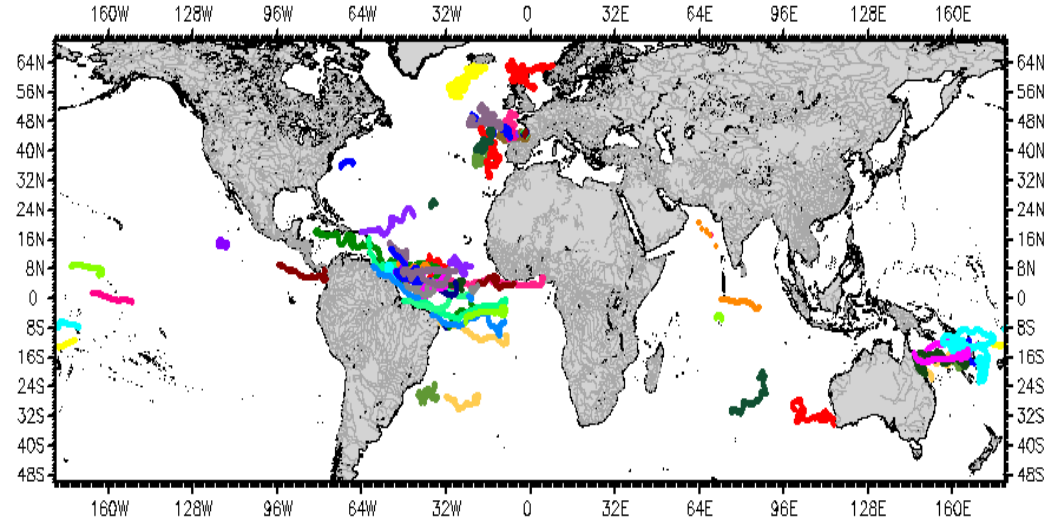
## 17 events SVP-BS / Surplas




SURPLAS tied to a SVP-BS drifter (CAROLS2010 cruise, Gulf of Biscay)




*Reverdin et al. JGR 2012, in press*




SVP SSS floats 2007-2012

http://www.locean-ipsl.upmc.fr/smos/drifters/

# Conclusion

**SMOS SSS:**

- In tropical-subtropical regions, far from land, in non rainy region, **precision at 100x100km$^2$-10days ~0.3**
- SMOS SSS freshening wrt in situ SSS (~5m depth) in rainy conditions: true salinity effect? Needs for surface drifters for validation (needs for a lot of matchups!!!)
- ARGO: very useful for large scale validation;
- Ship TSG: very useful for validating 'small scale' (<200km) variability (gradients) seen by SMOS
- Still issues (sun aliases, land vicinity, ice edge, RFI sorting …): image reconstruction still in progress

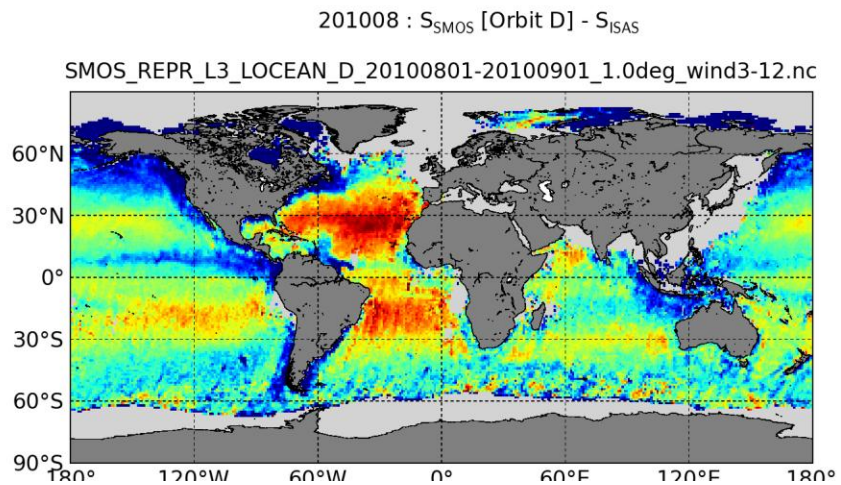
**SMOS and Aquarius wind models**

- Tb-wind SMOS and Aquarius very similar: 3-12m/s but Aquarius lower above 12m/s; Aquarius azimuth dependency much larger at high wind speed

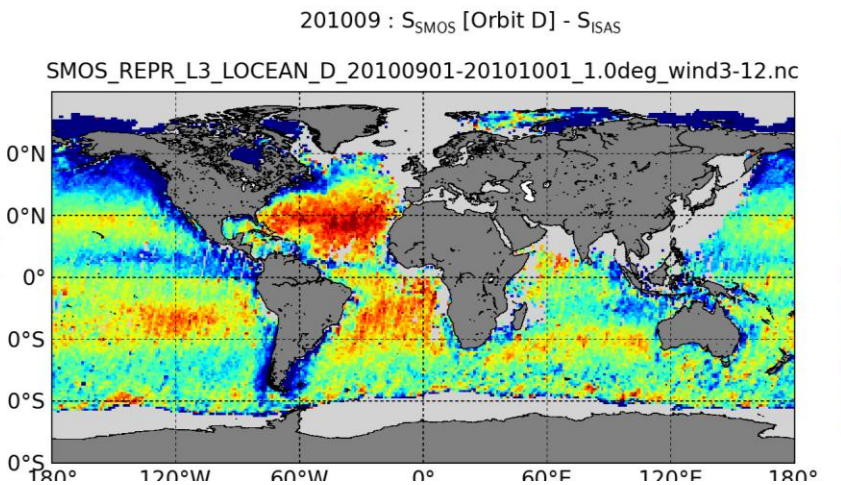
- Additional slides

# SSS v5 Descending August & September 2010 & 2011

## August 2010



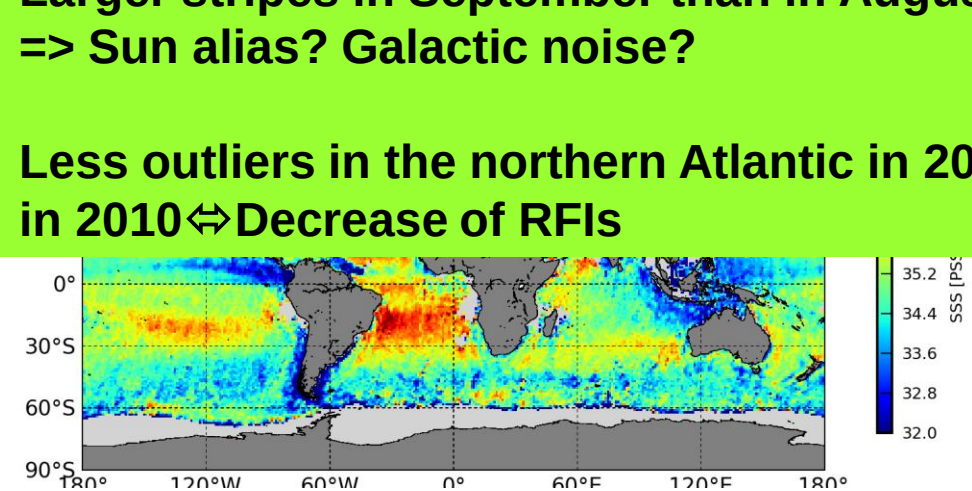

## September2010

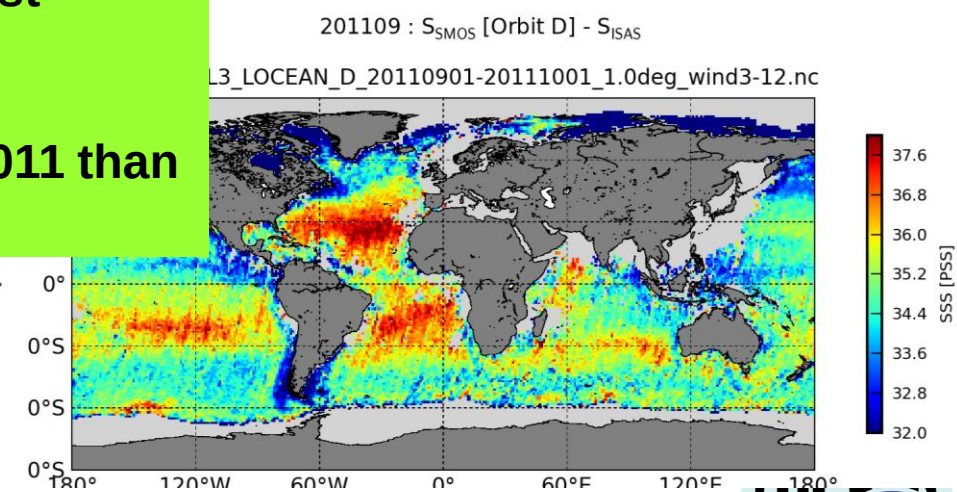



**Descending OTTs not enough to remove stripes**
**Larger stripes in September than in August**
**=> Sun alias? Galactic noise?**

**Less outliers in the northern Atlantic in 2011 than in 2010⇔Decrease of RFIs**

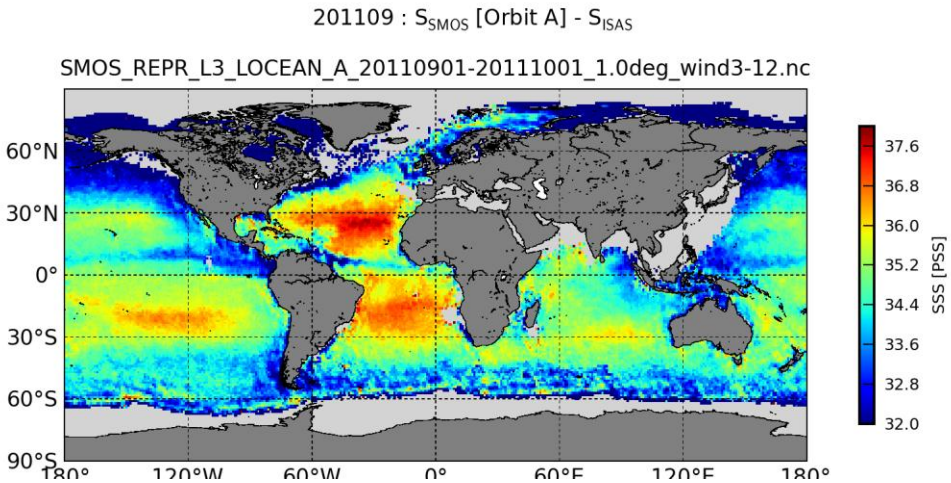
## September 2011



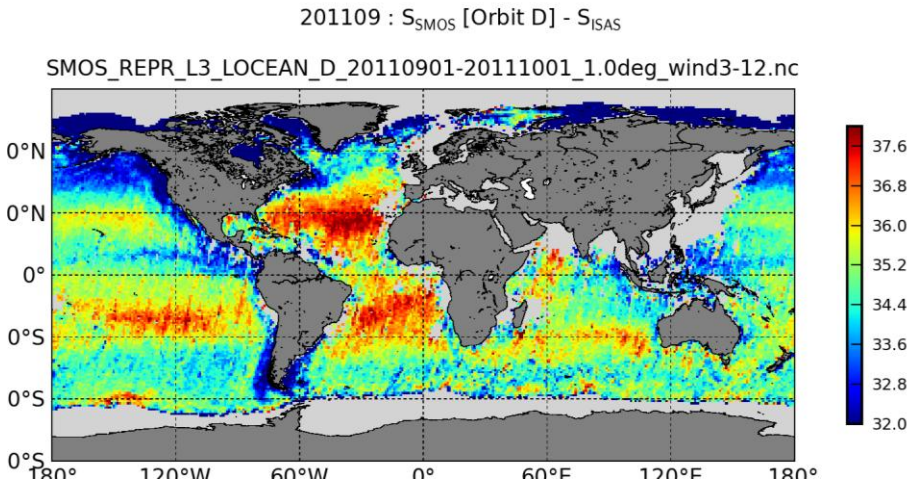



# Error on retrieved SSS: Sept 2011

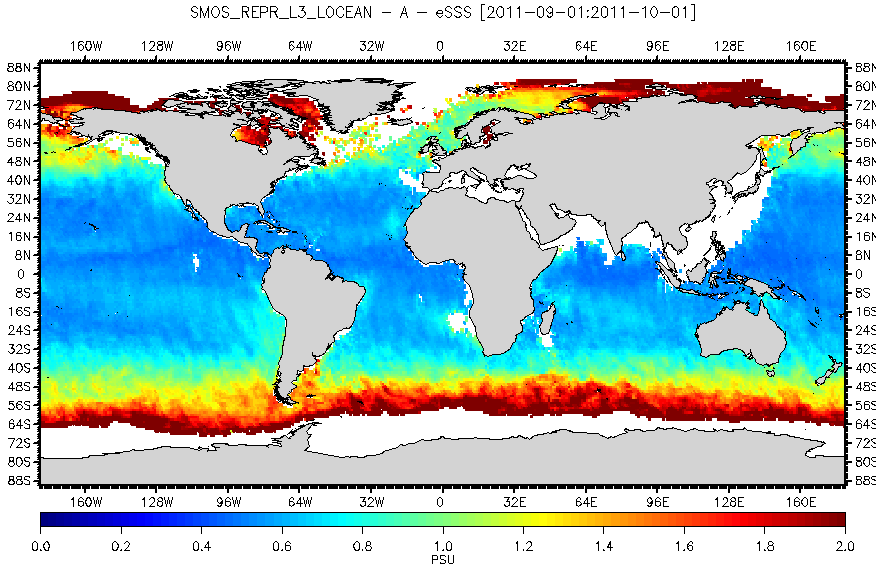
## SSS Ascending orbits



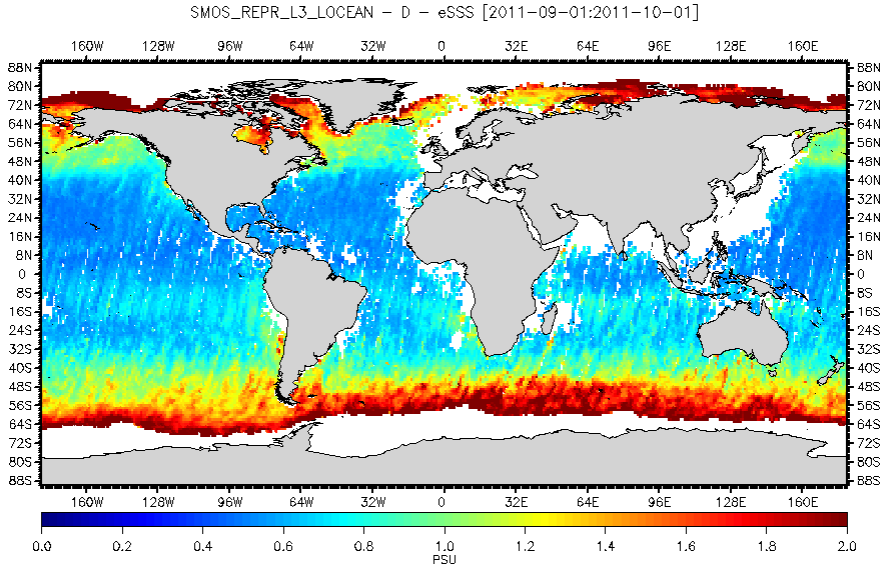

## SSS Descending orbits




## SSS error Ascending orbits

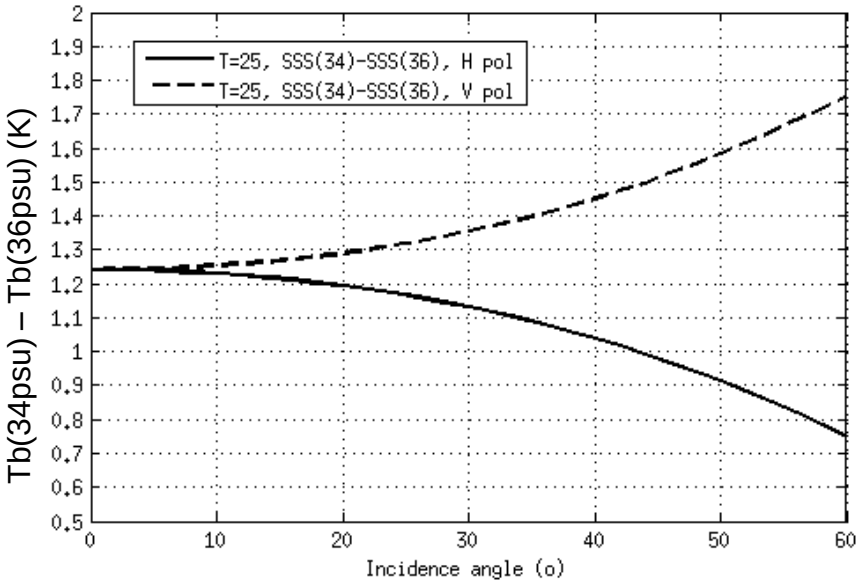



## SSS error Descending orbits

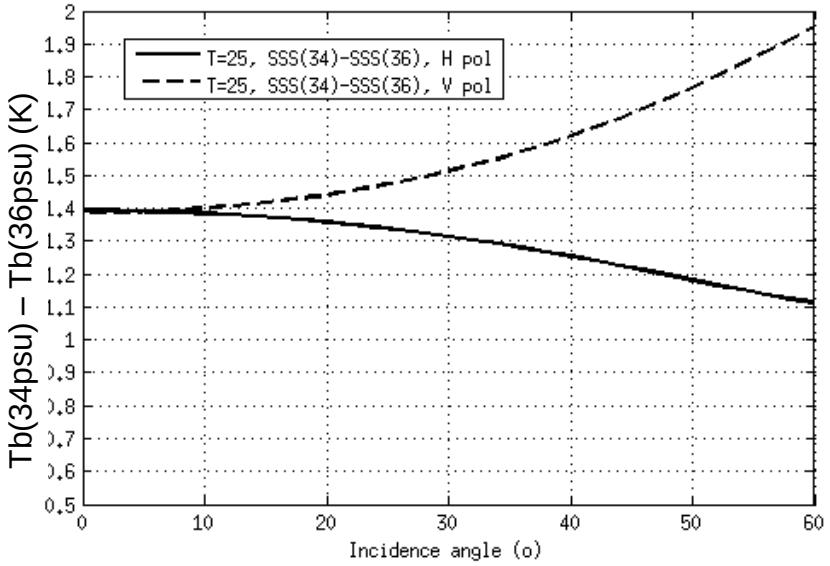


# Angular variation of Tv and Th for a 2psu freshening and 10mm/hr rain rate

SSS effect only

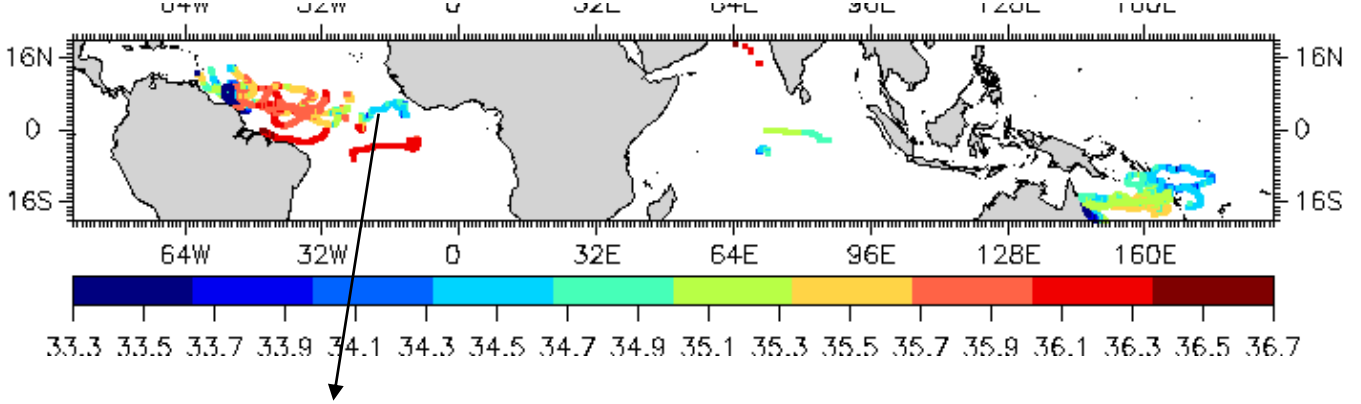



SSS effect + atmospheric Rayleigh scattering (extrapolation from Wentz (2005))

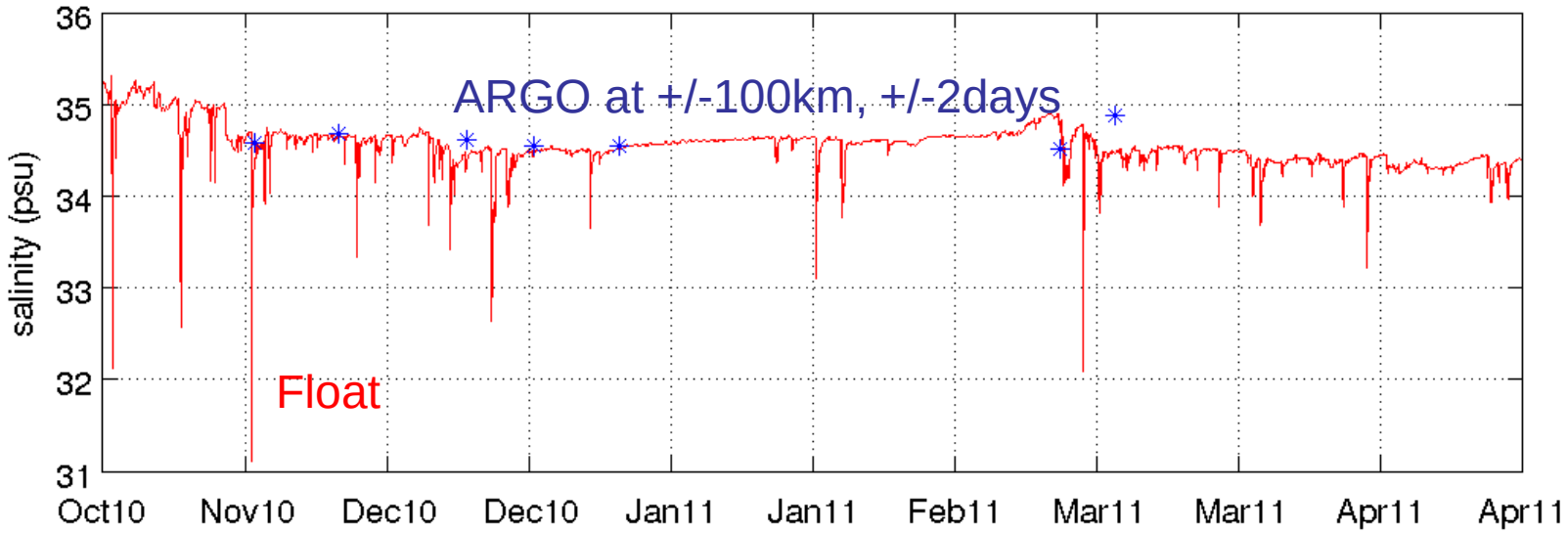



Atmospheric effect is relatively small compared to the SSS anomaly we see


# Autonomous drifter (~50cm depth)

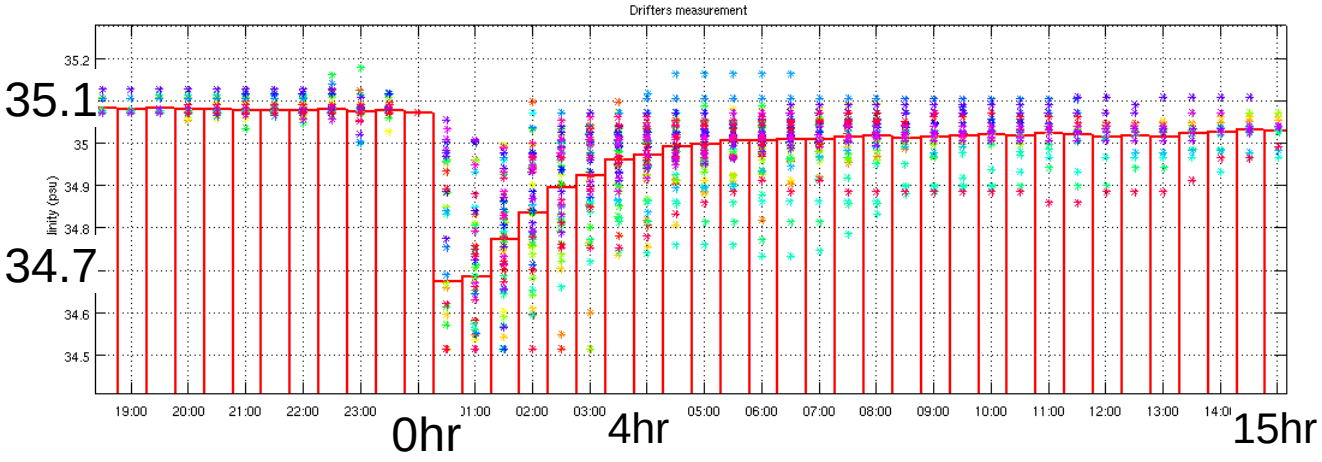



# Example of SSS freshening in Atlantic ITCZ

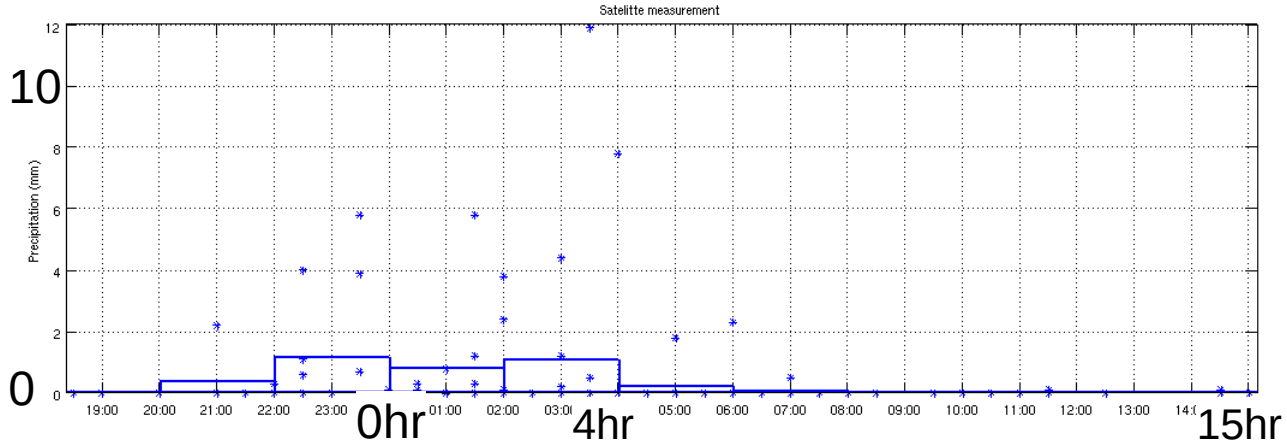



*Reverdin et al. JGR 2012 in press*

# SSS rain-freshening temporal evolution as seen by 60 drifters in the tropical Oceans




SSS temporal evolution after a freshening event (time 0)

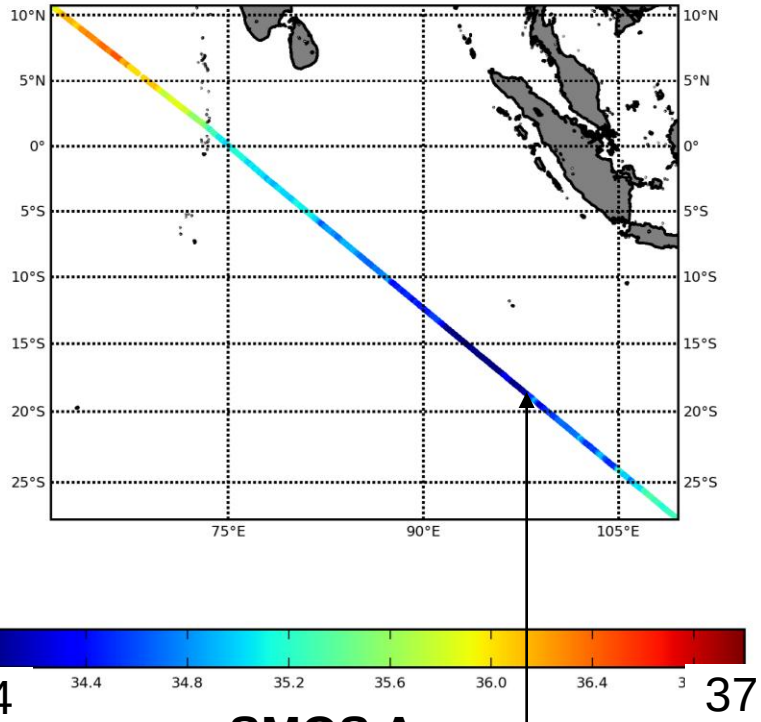



Satellite Rain Rates (SSM/I, TMI, AMSRE (www.ssmi.com)) colocated with floats SSS

**Figure 7**: Average cycle of salinity (upper panel) among 60 salinity drop events (relative to a common time of beginning of event). Individual records are shifted to a common salinity value at the initial drop time and the magnitude of the drop is adjusted to the mean drop. The average is plotted as well as individual events. The associated average reported rainfall (mm/hour) is plotted in the lower panel by 2-hour average, as well as the individual values at the exact time of reports.

*Reverdin et al. JGR 2012, in press*

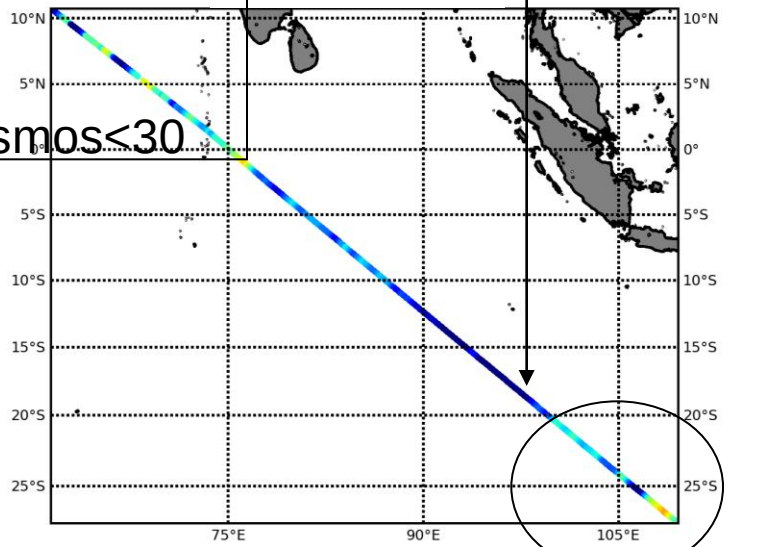
Lavender SSS




34 37

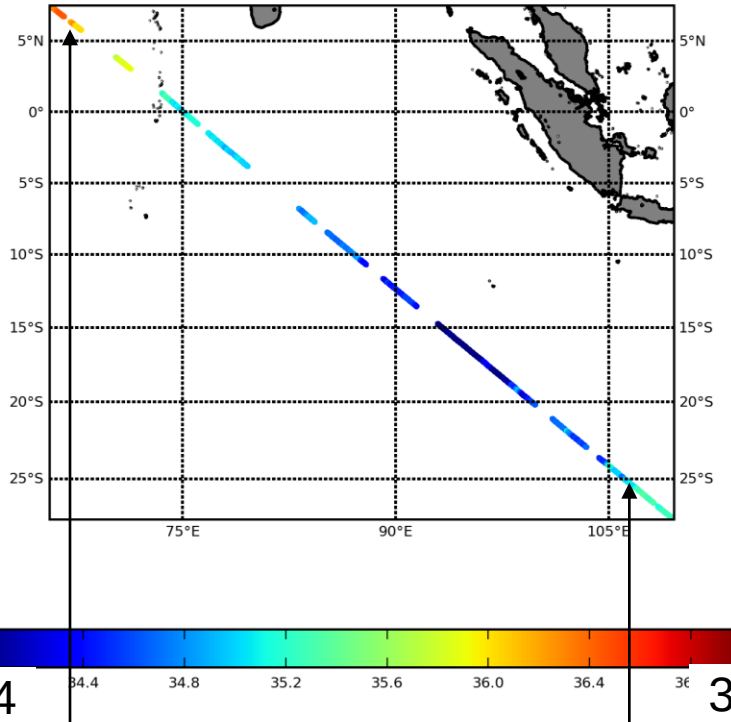
**SMOS Asc.**

RFI
Nbsmos<30



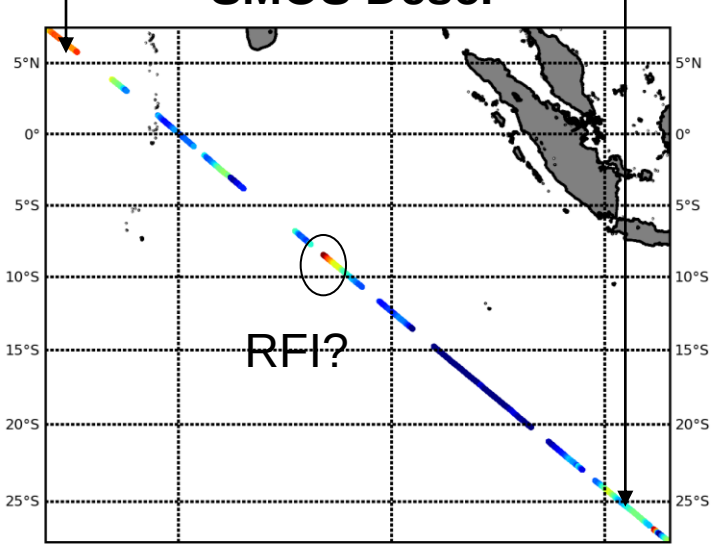

RFI, Australia vicinity?

Lavender SSS



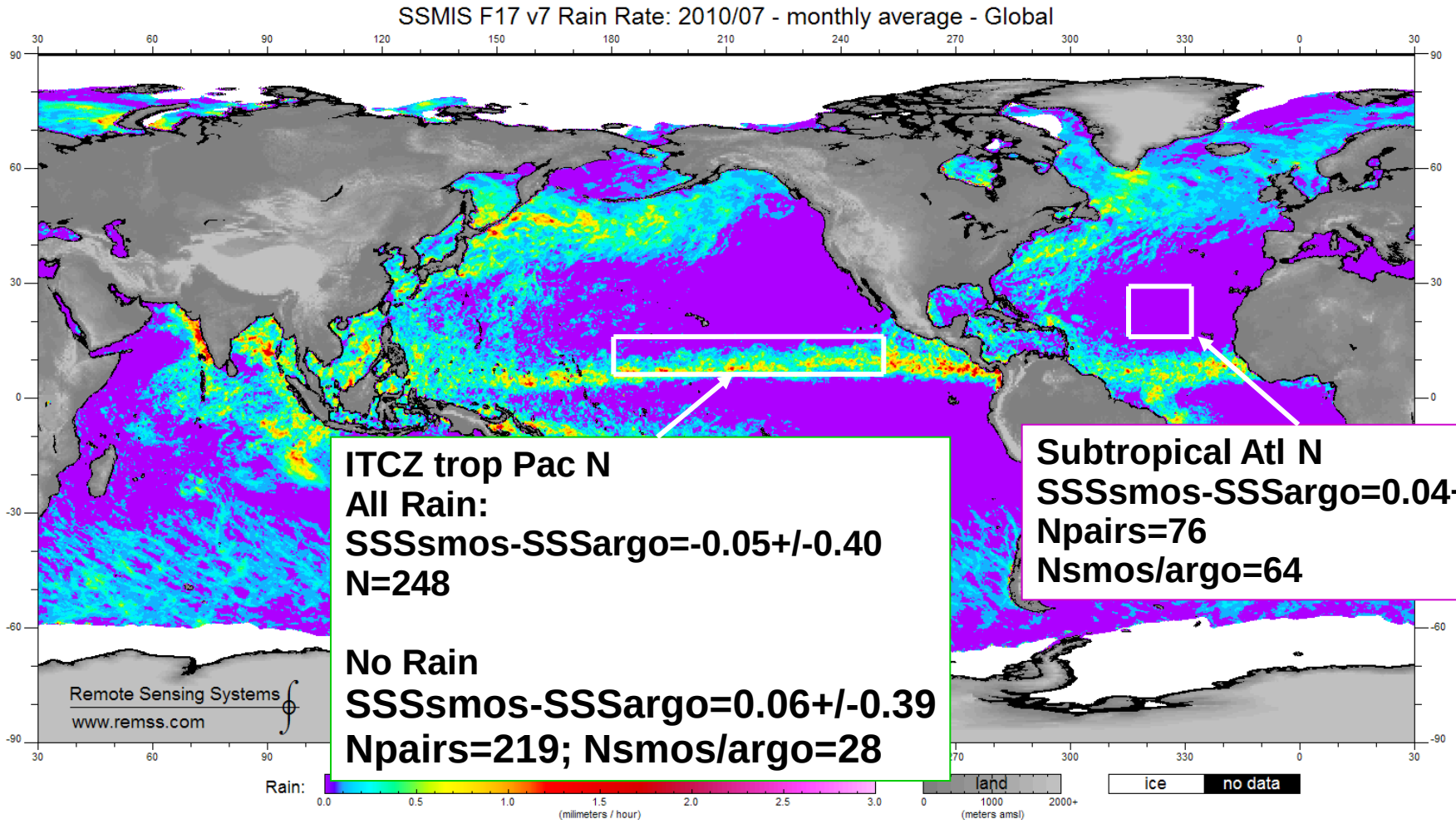

34 37

**SMOS Desc.**




Scie

# Comparison with ARGO:
# SMOS averaged over 10 days-100km around ARGO (July 2010)

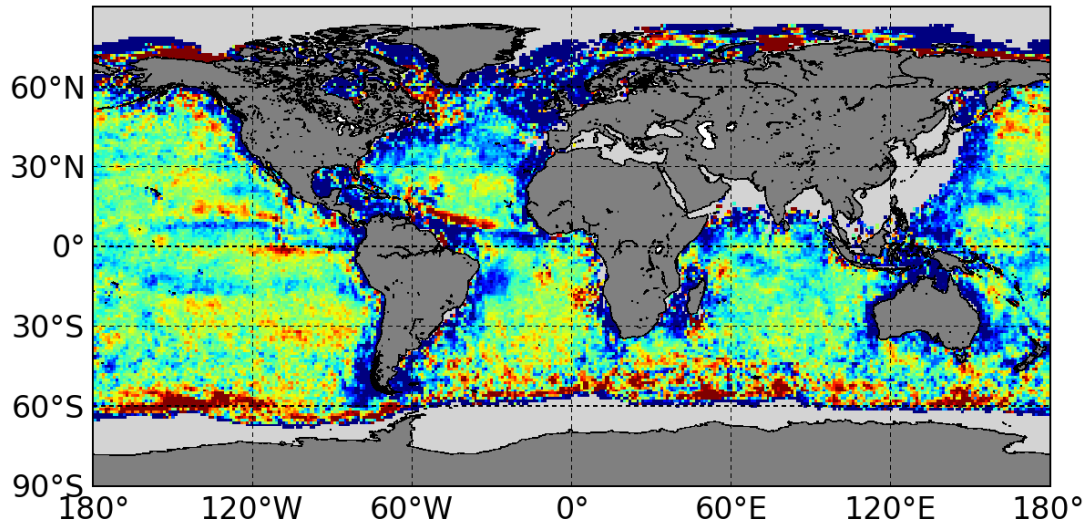



Ascending orbits (center of orbit; OTT asc) 3<WS<12m/s
SMOS SSS averaged around ARGO (+/-50km; +/-10days)

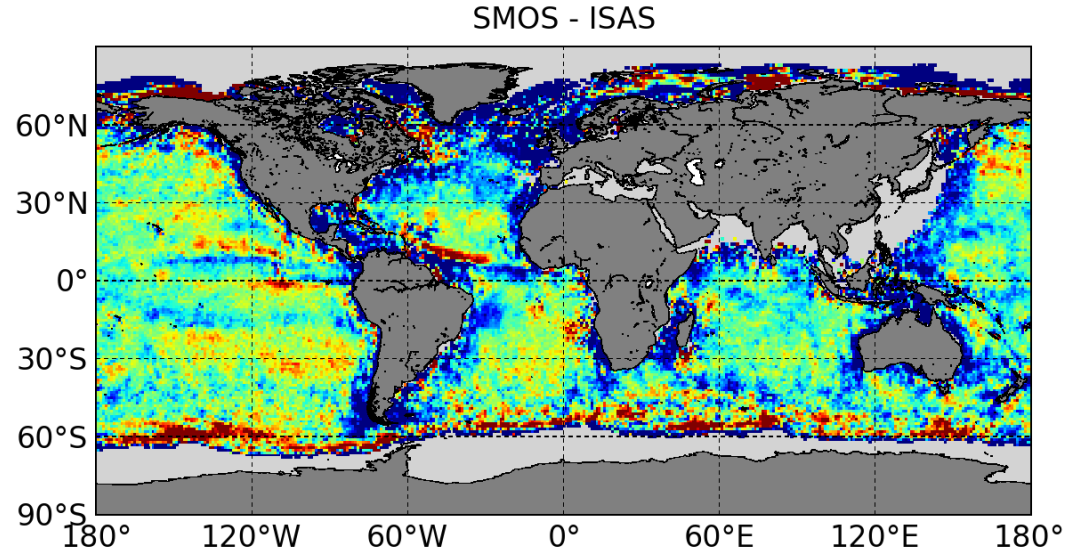
# SMOS - ISAS SSS – 3<WS<12m/s AND ALL WS

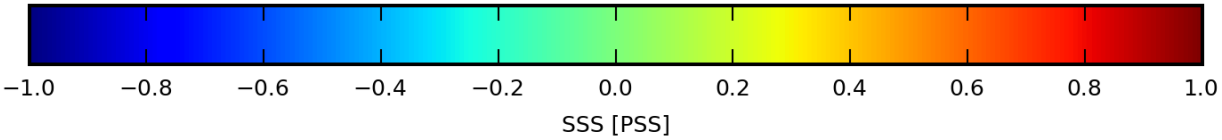
Sept 2011

SMOS-ISAS
3-12m/s

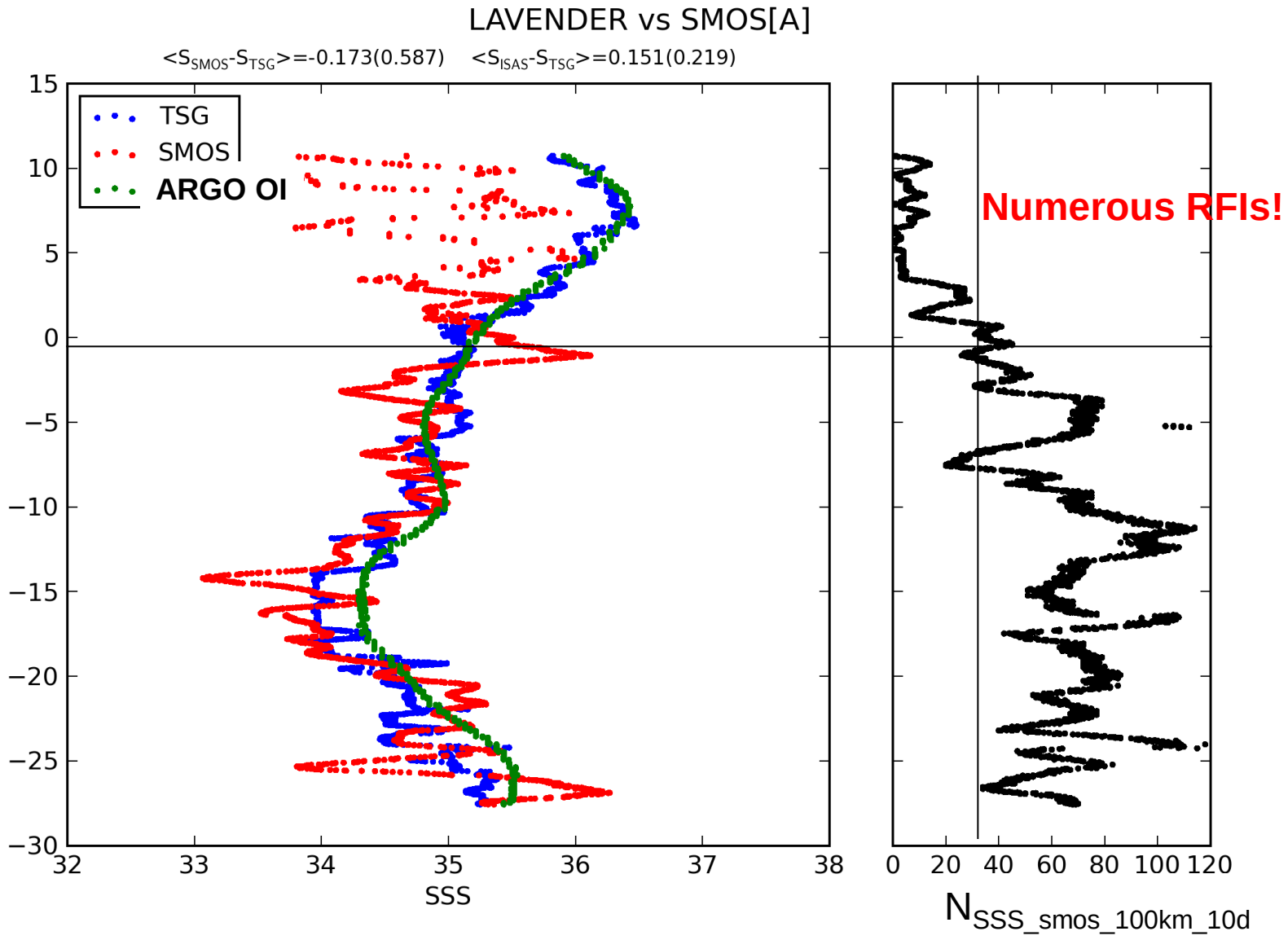



SMOS-ISAS
ALL WS



# SSS latitudinal profiles – Ship-ARGO OI-SMOS




SMOS SSS averaged over 10 days and 100km around Lavender time and location