SMOS and in situ salinity: rain and near-surface vertical stratification effects

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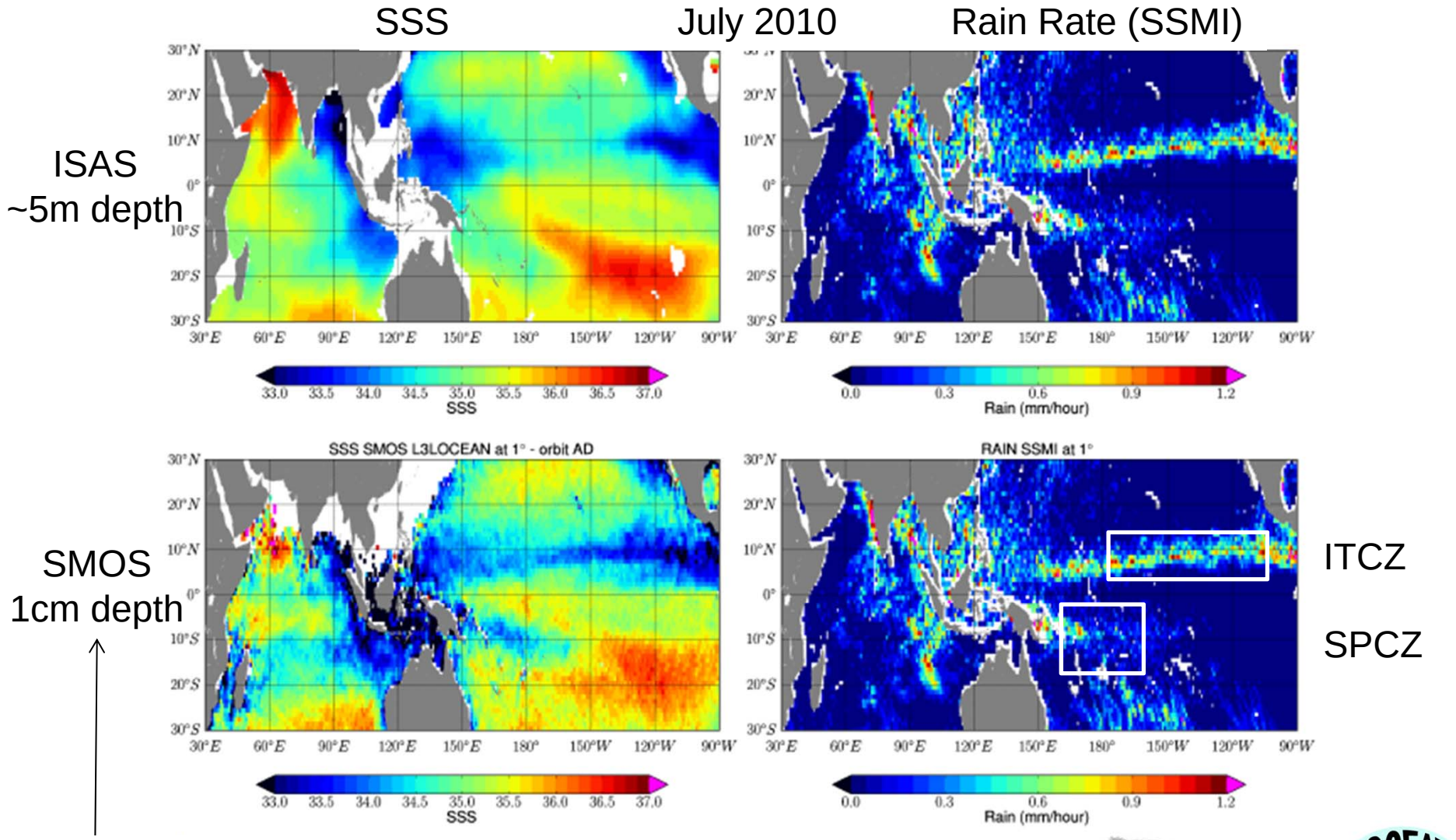
Motivation:
SMOS S_{1cm} fresher than in situ $S_{\sim 5m}$

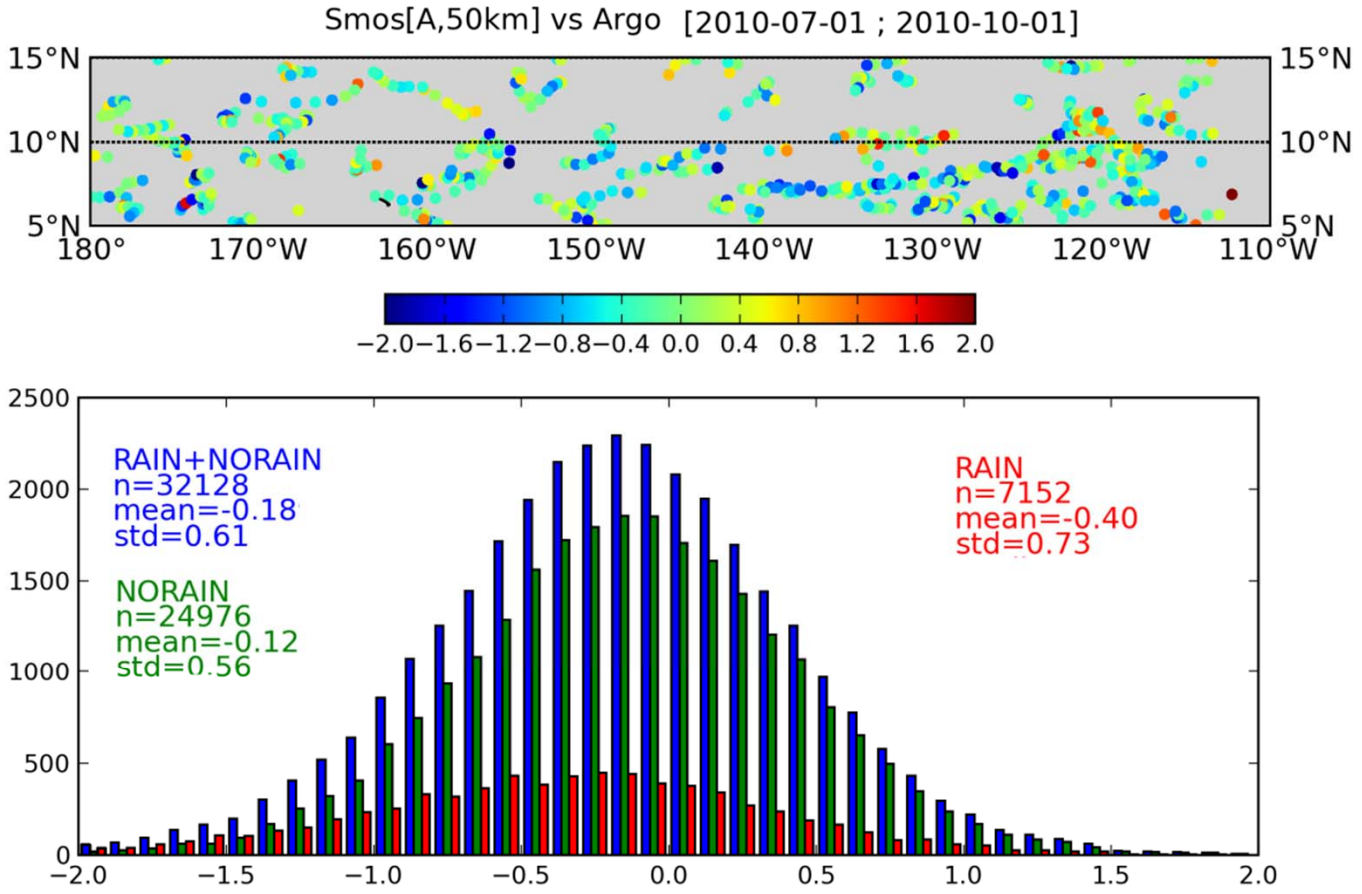


CATDS-CEC/LOCEAN_v2013 product, Boutin et al. 2013

See description of various CATDS/OS products on www/.catds.fr

	CATDS CEC-IFREMER v2	CATDS CPDC (real time)	CATDS CEC-LOCEAN v2013
T_b	L1b Reconstructed on EASE grid	L1b Reconstructed on EASE grid (>=25km)	ESA L1c (reconstructed on ISEA-15km grid)
SSS retrieval	SSS(T_{bx}+T_{by}) *+: not affected by Faraday rotation* *-: no check of dwell line consistency*	L2OS v5 (Dwell-line; iterative retrieval) *+: Tb weighted by radiometric accuracy; wind adjusted & theoretical error estimate* *-: complex*	L2OS v5 (Dwell-line; iterative retrieval) *+: Tb weighted by radiometric accuracy; wind adjusted & theoretical error estimate* *-: complex*
Wind-model	Model 2	Model 1	Model 1
Calibration	**Single OTT + daily 5°x5° adjustment wrt SSS climato** ***+: single OTT calibration*** ***-: need additional bias correction (in time and space) that mask part of interannual variability***	**Variable OTT (~every 2 weeks)** ***+: correct most seasonal biases(in reprocessed version only)*** ***-: remaining latitudinal biases(within ~+/-0.5pss)***	**Variable OTT (~every 2 weeks)** ***+: correct most seasonal biases*** ***-: remaining latitudinal biases(within ~+/-0.5pss)***
Flagging	**interorbit consistency / RFI %** ***+: more refined than L2OS flags***	**L2OS 'retrieval flags'** ***-: insufficient sorting of RFI***	**L2OS 'retrieval flags' and L2OS RFI flag** ***+/-: better RFI sorting than CPDC but less efficient than CEC-IFREMER***
Region of FOV considered	AFFOV only *+: avoid suspicious Tb in EAFFOV* *-: reduced number of Tbs*	EAFFOV (+/-400km from swath centre) *+: keep large incidence angle variation (=> better wind adjustment)* *-: more suspicious Tb in EAFFOV than in AFFOV*	EAFFOV provided 130T_b in AFFOV (~+/-300km from swath centre) *+: keep large incidence angle variation (=> better wind adjustment) and numerous Tb in AFFOV* *-: more suspicious Tb in EAFFOV than in AFFOV*
Average	Simple average after thorough filtering of inconsistent SSS *+ interorbit consistency check*	Simple average *- no interorbit consistency check*	Weighted by retrieval error and SSS equivalent resolution *+measurement spatial resolution* *- no interorbit consistency check*
Format	Netcdf – rectangular grid	Netcdf – EASE grid	Netcdf – rectangular grid
Access	support@catds.fr	support@catds.fr	support@catds.fr
Period	June 2010-December 2012	Reprocessed: Jan 2010-April 2012/ Real time up to now	Jan 2010-Dec 2012
Resolution	Daily, 10-days, Monthly, 0.25°, 0.5°, 1°	Daily, 10-days, Monthly, 50km,100km,200km	Monthly, 10-days, 0.25° (SSS averaged over

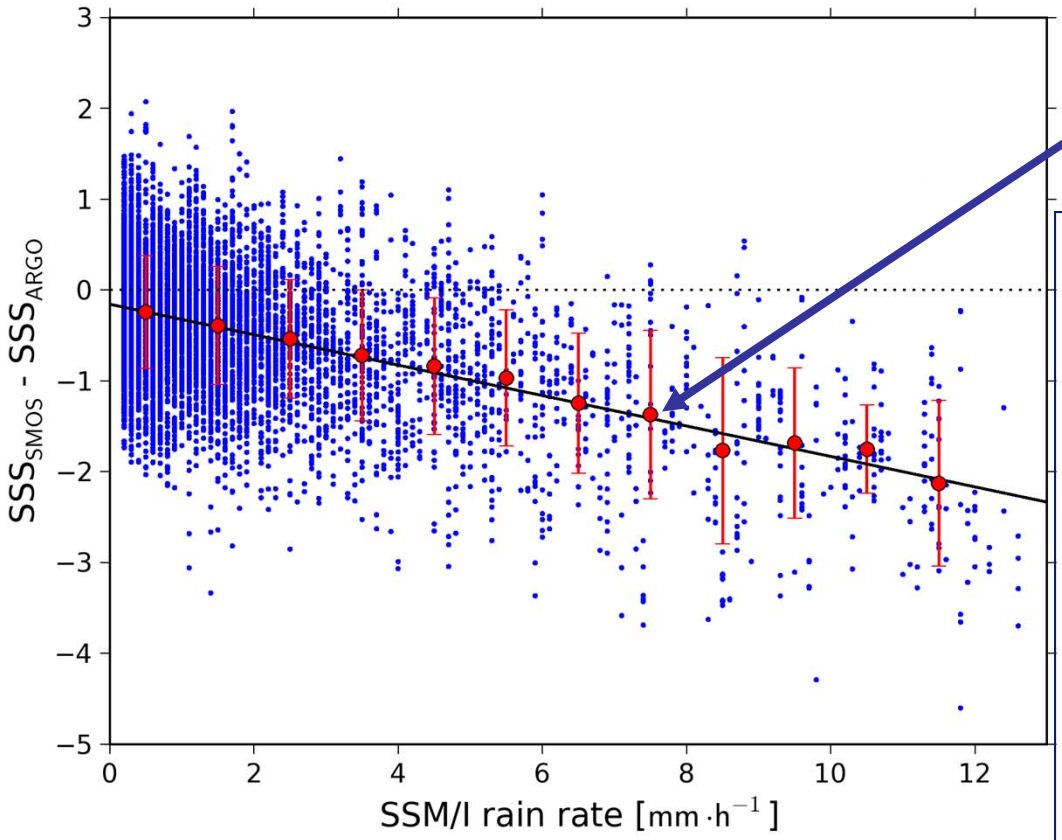
SMOS S_{1cm} – ARGO $S_{\sim 5m}$ & SSMI RR
SMOS ascending passes (6am)
ITCZ



Boutin et al., Ocean Science, 2013

SSSsmos-SSSargo

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



-0.17 pss/ mm/hr
r = -0.5

-0.17 pss/mm/hr
>>
atmospheric contribution
~ - 0.03pss/mm/hr
Rayleigh approximation (e.g., Peichl et al., 2004; Wentz, 2005) **:**

=> slope corrected from atm.
~-0.14pss/mm/hr

Fresher 1cm SSS linked to rain???
Roughness effect ???

Boutin et al, 2013

Questions

- How robust is S_{smos}-S_{argo} ~ -0.17pss/mm/hr ?
- How does it compare with rain signature detected on in situ drifters salinity (~45cm depth)?

Data & Methods

SATELLITE

SMOS SSS

ESA v5 reprocessing

SSS at 1cm depth ; ~40km resolution or averaged ***(CATDS-CEC/LOCEAN_v2013 product available at www.catds.fr)***

Rain Rate:

-SSM/I F16 & F17**;** 0.25° resolution**;** SMOS SSS colocated *within -80mn, +40mn*

RemSSS: www.ssmi.com

-TRMM 3B42 v7: average of satellite RR every 3 hours; 0.25° resolution; SMOS SSS & TRMM RR colocated *within -3hr, 0hr* before SMOS measurement

IN SITU SSS

ARGO INDIVIDUAL PROFILES

'SSS' between 10m and 4m depth; Colocation with SMOS within +/-5days, +/-50km

CORIOLIS GDAAC: http://www.coriolis.eu.org

ARGO + TSG OPTIMAL INTERPOLATED SSS MAPS *(ISAS)*

Monthly maps from In-Situ Analysis System v6

http://wwz.ifremer.fr/lpo/SO-Argo/Products/Global-Ocean-T-S

SEA SURFACE AUTONOMOUS DRIFTER SSS

Upper S at 45cm depth; Pacific Gyre drifter

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

SSSsmos-SSSargo = fn(RR) under various conditions

Influence of rain tested with:

- SMOS SSS along descending orbits,

- TRMM 3B42 RR instead of SSMI RR
  => 3hr RRaverages instead of coloc at -80mn+60mn from SMOS but data at all local times
  =>test various colocations criteria (mean TRMM3B42 time 0-3hr before SMOS, within -2hr;+1hr from SMOS)

- After selecting only ARGO SSS with no rain on TRMM 3B42 RR

SSSsmos-SSSargo = fn(RR) under various conditions

Influence of rain tested with:
SSMI RR along descending orbits,
TRMM 3B42 with various colocations criteria (Asc & Desc Orbits),
After selecting only ARGO SSS with no rain on TRMM 3B42

Zone ITCZ	Rain	aRR+b	r	N	
SsmosA-Sargo	SSMI -80mn +60mn	-0,17RR-0,16	-0,49	7152	
SsmosD-Sargo	SSMI -80mn +60mn	-0,13RR+0,00	-0,36	7101	

SSSsmos-SSSargo = fn(RR) under various conditions

Influence of rain tested with:
SSMI RR along descending orbits,
TRMM 3B42 with various colocations criteria (Asc & Desc Orbits),
After selecting only ARGO SSS with no rain on TRMM 3B42

Zone ITCZ	Rain	aRR+b	r	N	
SsmosA-Sargo	SSMI -80mn +60mn	-0,17RR-0,16	-0,49	7152	
SsmosD-Sargo	SSMI -80mn +60mn	-0,13RR+0,00	-0,36	7101	
SsmosA-Sargo	TRMM 3B42 0-3h before SMOS	-0,14RR-0,26	-0,30	11273	
	TRMM3B42 0-2h before; 0-1hr after	-0,13RR-0,26	-0,32	6038	
SsmosD-Sargo	TRMM 3B42 0-3h before SMOS	-0,11RR-0,04	-0,17	12411	
	TRMM 3B420-2h before; 0-1hr after	-0,15RR-0,02	-0,26	6735	

SSSsmos-SSSargo = fn(RR) under various conditions

Influence of rain tested with:
SSMI RR along descending orbits,
TRMM 3B42 with various colocations criteria (Asc & Desc Orbits),
After selecting only ARGO SSS with no rain/rain on TRMM 3B42

Zone ITCZ	Rain	aRR+b	r	N	
SsmosA-Sargo	SSMI -80mn +60mn	-0,17RR-0,16	-0,49	7152	
SsmosD-Sargo	SSMI -80mn +60mn	-0,13RR+0,00	-0,36	7101	
SsmosA-Sargo	TRMM 3B42 0-3h before SMOS	-0,14RR-0,26	-0,30	11273	
	TRMM3B42 0-2h before; 0-1hr after	-0,13RR-0,26	-0,32	6038	
SsmosD-Sargo	TRMM 3B42 0-3h before SMOS	-0,11RR-0,04	-0,17	12411	
	TRMM 3B420-2h before; 0-1hr after	-0,15RR-0,02	-0,26	6735	
SsmosA-Sargo (norain)	TRMM 3B42 0-3h before SMOS	-0,14RR-0,25	-0,33	6083	

SSSsmos-SSSargo = fn(RR) under various conditions

Influence of rain tested with:
SSMI RR along descending orbits,
TRMM 3B42 with various colocations criteria (Asc & Desc Orbits),
After selecting only ARGO SSS with no rain/rain on TRMM 3B42

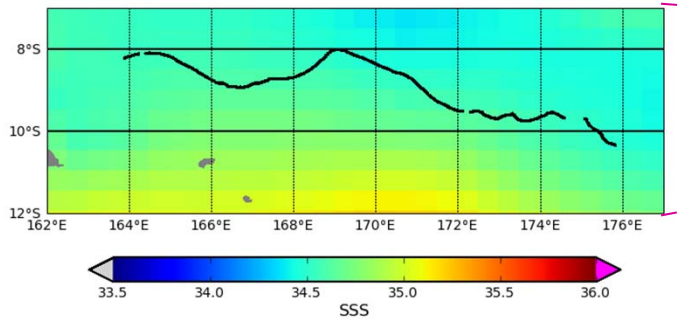
Zone ITCZ	Rain	aRR+b	r	N
SsmosA-Sargo	SSMI -80mn +60mn	-0,17RR-0,16	-0,49	7152
SsmosD-Sargo	SSMI -80mn +60mn	-0,13RR+0,00	-0,36	7101
SsmosA-Sargo	TRMM 3B42 0-3h before SMOS	-0,14RR-0,26	-0,30	11273
	r after	-0,13RR-0,26	-0,32	6038
S	S	-0,11RR-0,04	-0,17	12411
	r after	-0,15RR-0,02	-0,26	6735
S	S	-0,14RR-0,25	-0,33	6083

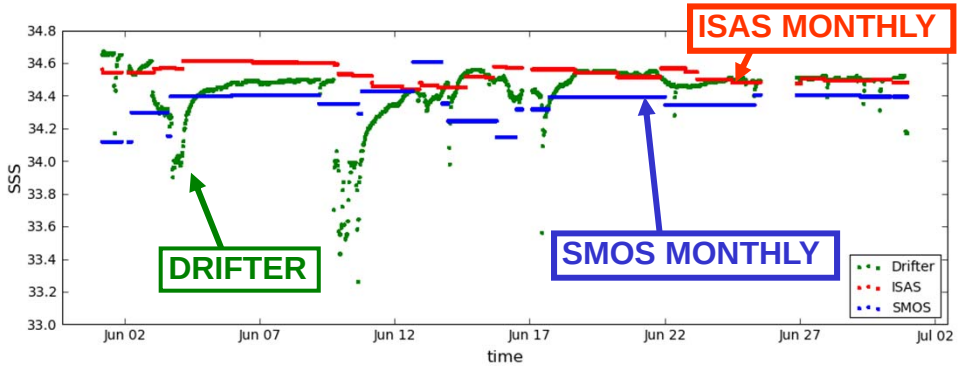
Sensitivity to SSMI RR
Ssmos-Sargo~ -0.13 RR - -0.17 RR (mm/hr) (ITCZ region)

Better correlation with SSMI F16 & F17 RR than with TRMM 3B42
⇒ sensitivity to temporal colocation distance
Ssmos-Sargo always negatively correlated with RR

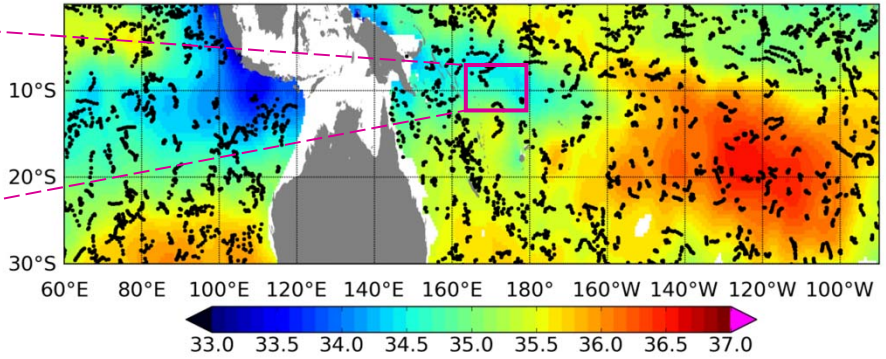
June 2010 SSS in SPCZ
Surface autonomous drifter (S at 45cm depth)

June 2010

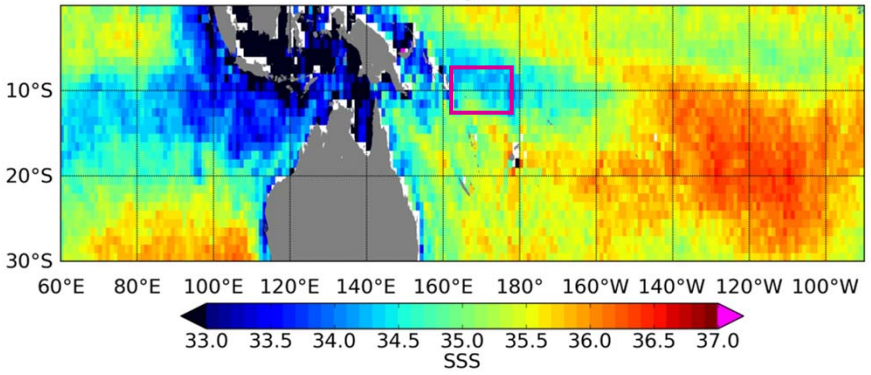




SSS ISAS

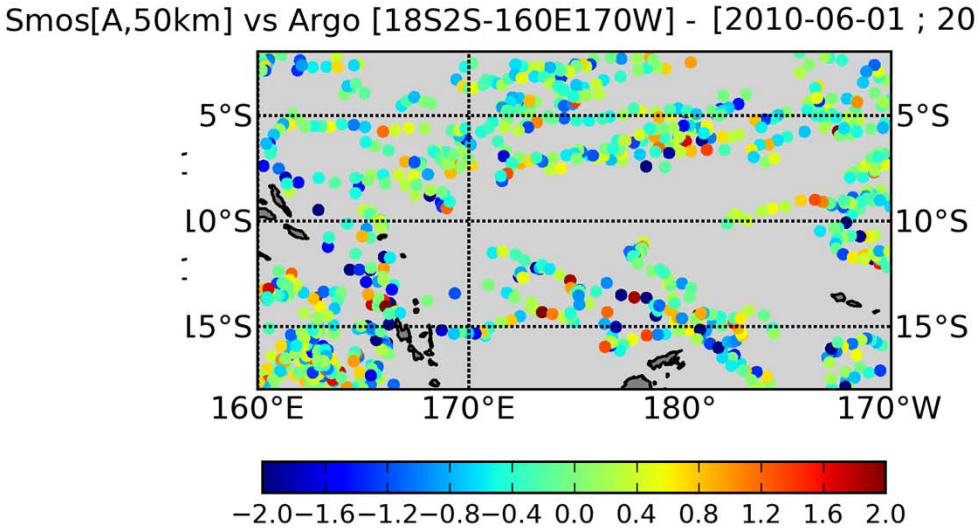


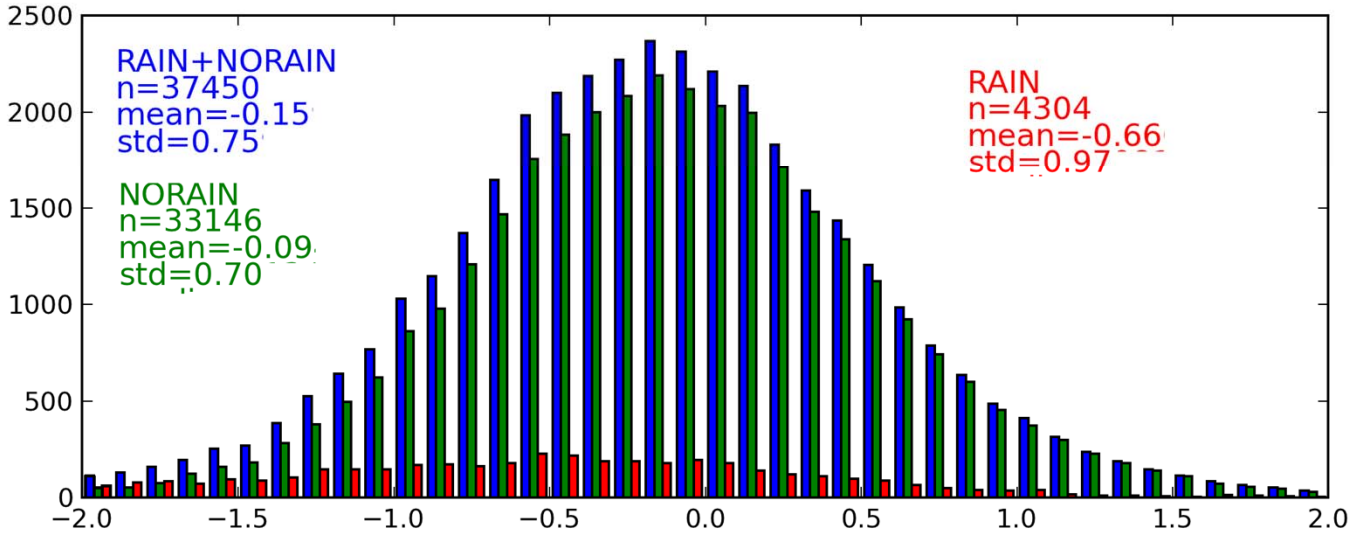
SSS SMOS



Again fresh region in 2010 fresher in SMOS than in ISAS maps

SMOS S_{1cm} – ARGO $S_{\sim 5m}$ & SSMI RR
SMOS ascending passes (6am)
SPCZ





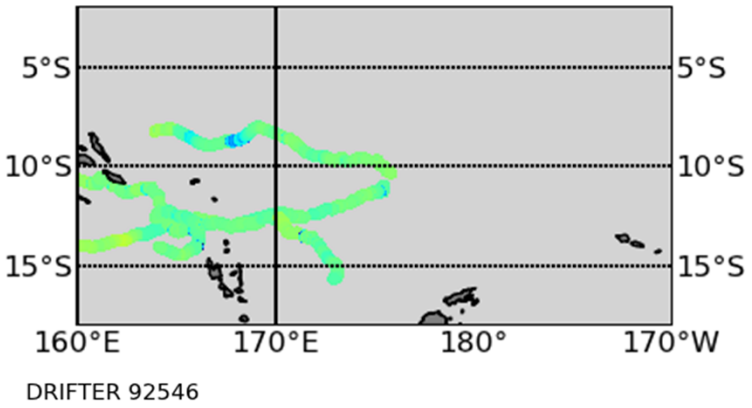
SMOS S_{1cm} – ARGO $S_{\sim 5m}$ =fn(RR) SPCZ

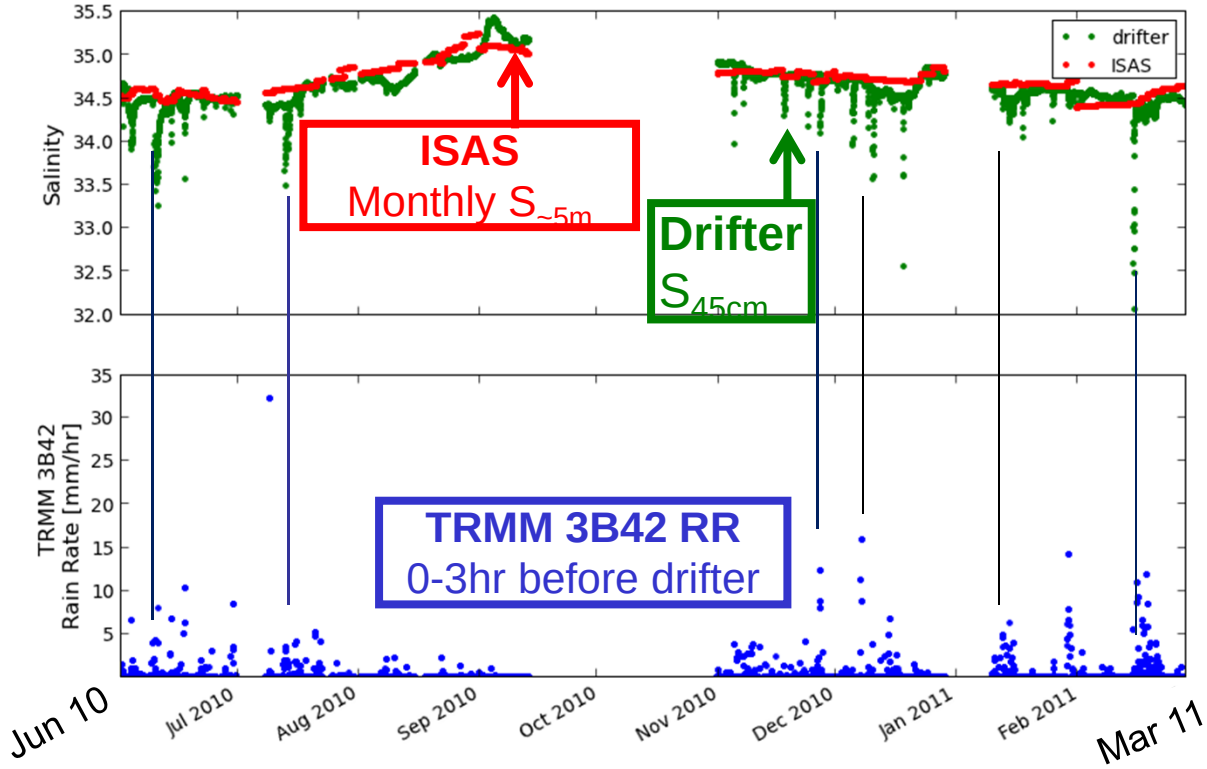
Zone ITCZ	Rain	aRR+b	r	N
SsmosA-Sargo	SSMI -80mn +60mn	-0,17RR-0,16	-0,49	7152
Zone SPCZ				
SsmosA-Sargo	SSMI -80mn +60mn	-0,22RR-0,26	-0,51	4305
SsmosD-Sargo	SSMI -80mn +60mn	-0,19RR-0,29	-0,40	2716
SsmosA-Sargo	TRMM 3h before	-0,15RR-0,20	-0,33	8352
SsmosD-Sargo	TRMM 3h before	-0,16RR-0,23	-0,32	5537

Better correlation with SSMI F16 & F17 RR than with TRMM 3B42
$\Rightarrow$ sensitivity to temporal colocation distance
Ssmos-Sargo always negatively correlated with RR
ITCZ + SPCZ

Sensitivity to SSMI RR (r>0.4)
Ssmos-Sargo~ -0.17 RR - -0.22 RR (mm/hr) (ITCZ+SPCZ)

S_{45cm} vs S_{isas}(June 2010-Feb 2011)





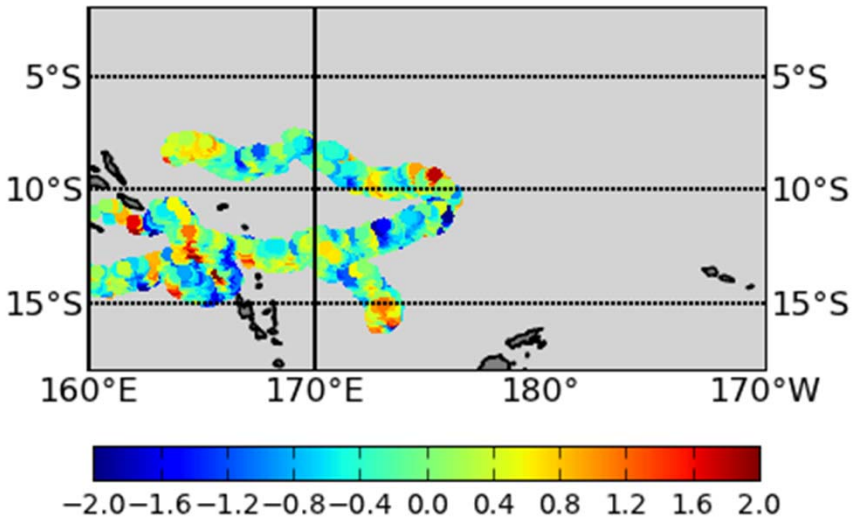
No rain]-3-0hr]
<Sdrifter – Sisas>= -0.04 +/0.13

Rain]-3-0hr]
<Sdrifter – Sisas>= -0.11 +/0.20

⇒ **Mean effect of rain (as determined on TRMM 3B42) ~ -0.07 at 45cm depth**

Rain on drifter in 25% of cases
<RR>=1,44mm/hr

S_{smos} vs S_{isas}(June 2010-Feb 2011)



No rain]-3-0hr]
<Ssmos – Sisas>= -0.15 +/0.65

Rain]-3-0hr]
<Ssmos – Sisas>= -0.34 +/0.80

=> Mean effect of rain (as determined on TRMM 3B42) : ~-0.19

Rain on SMOS in 25% of cases
<RR>=1,40mm/hr

A *tentative* comparison between effect of rain on SMOS and on drifter SSS:

Effect of rain on SMOS SSS (1cm depth) ~-0.19

⇒ After correction of atmospheric effect: **~-0.15**

Effect of rain on drifter at 45cm depth ~ -0.07

=> At 15cm depth **~ -0.09**

(Assuming a 20% increased effect at 15cm depth wrt 45cm depth (as suggested by comparisons from drifters (Reverdin et al. 2012))

Summary

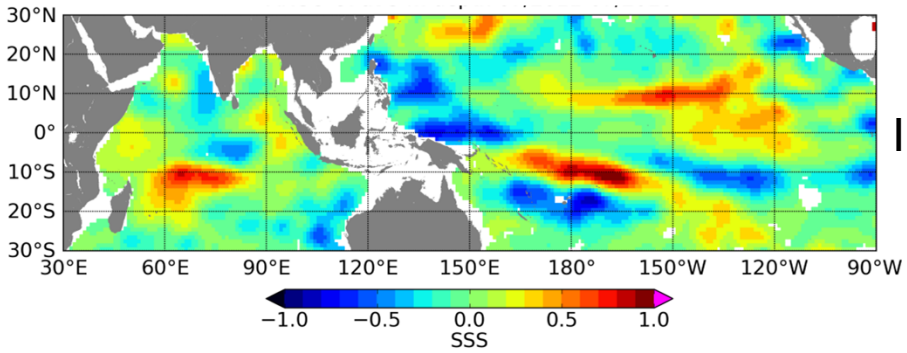
- SSSsmos-$S_{\sim 5m}$ ~ 0.2 RR (mm/hr)
- SSMIS at less than 80mn from SMOS better to caracterize rain events affecting SSSsmos-$S_{\sim 5m}$ than TRMM 3B42
- Preliminary comparison with drifter => after atmospheric correction, ~60% (~0.1RR?) of observed SMOS freshening after rain events is likely a true surface salinity effect – *Ongoing work; Need further comparisons with other surface measurements, closer RR colocations...*
- No evidence of a roughness effect of RR in ITCZ (not shown)
- Rain effect has impacts on large scale SSS variability observed from SMOS and from in situ SSS

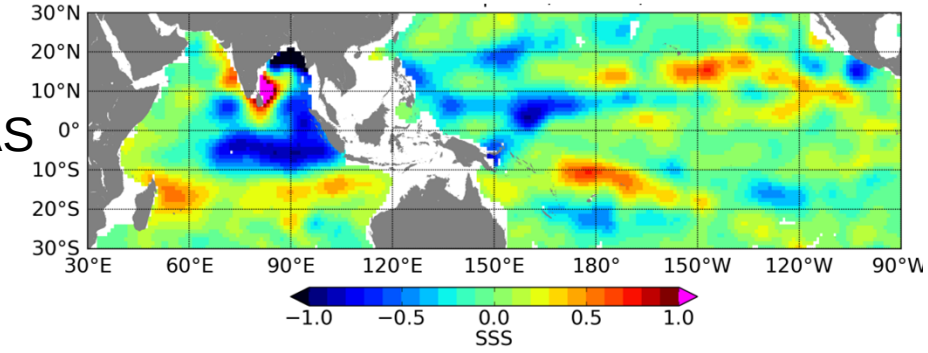
2011-2010 SSS variability (Strong La Niña in 2010)

July 2011-July2010

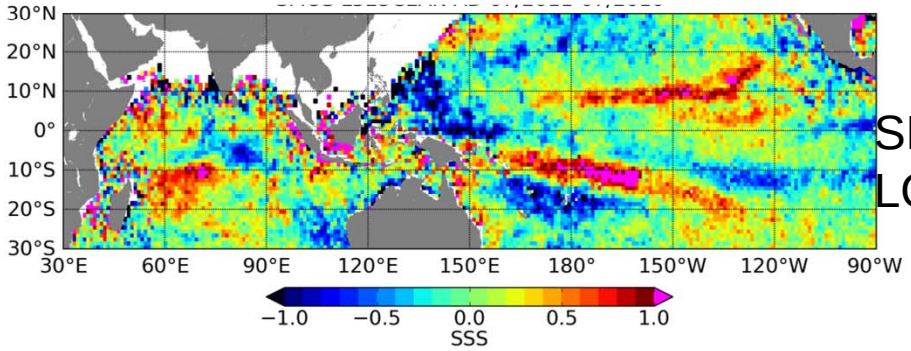
November 2011-November 2010

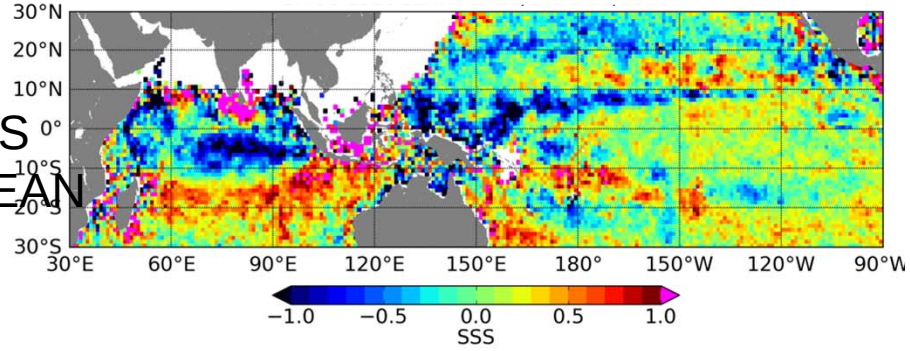
ISAS





SMOS LOCEAN





See monthly animations on SMOS blog and CATDS news

Larger contrasts on SMOS SSS anomalies than on ISAS SSS anomalies

A consequence of systematic negative difference of SMOS SSS – ISAS SSS in low SSS/rainy regions