SMOS mission: a new way for monitoring Sea Surface Salinity?

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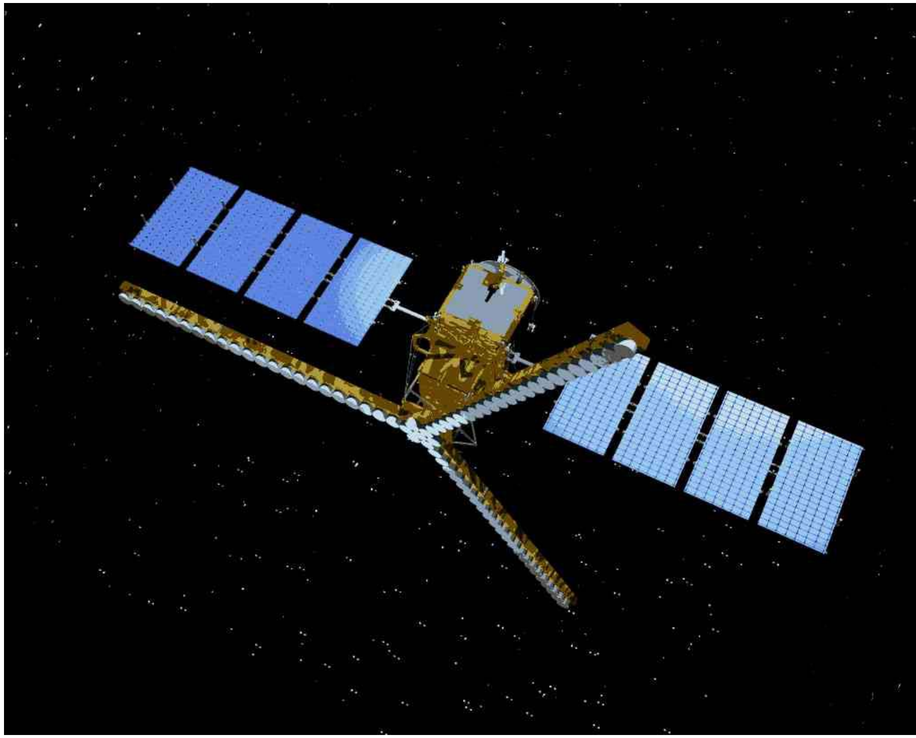
Thanks to T. Delcroix (LEGOS/IRD) and F. Petitcolin (ACRI-st)

How GOSUD and SAMOS data could help for SMOS Cal/Val?

(SMOS/GLOSCAL *(Global Ocean sea surface Salinity : CALibration and validation for SMOS)* project)

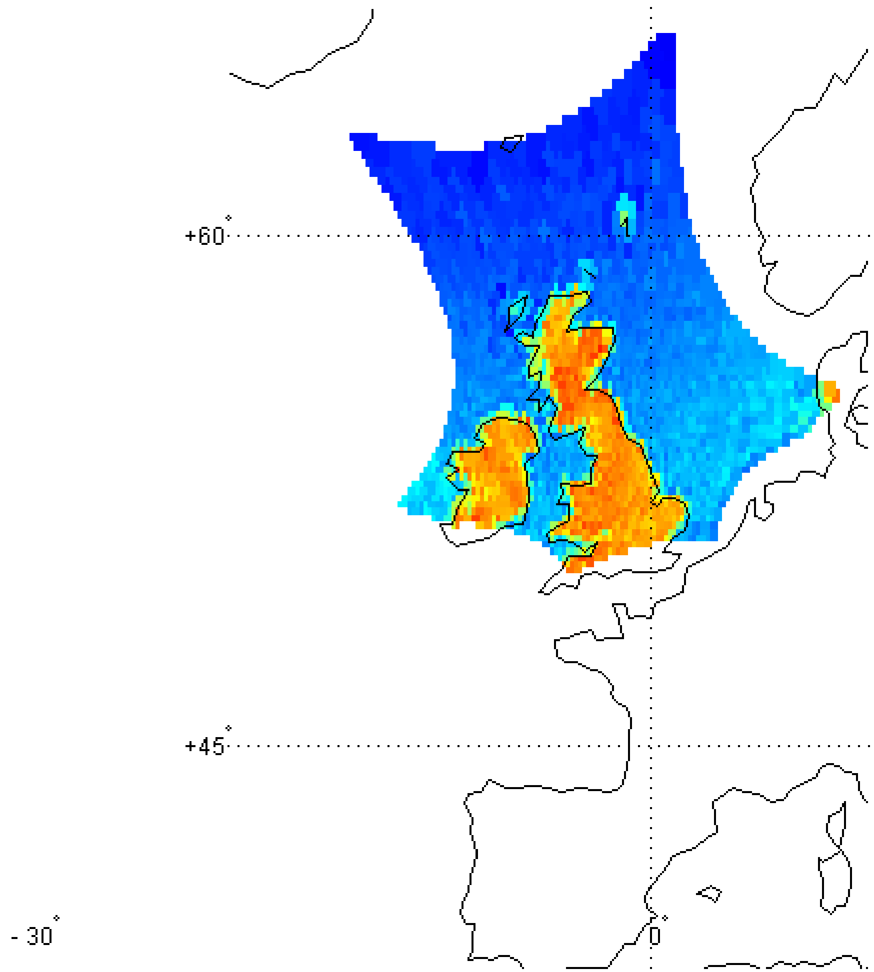
(IFREMER, LEGOS/IRD, LOCEAN/SA/IPSL, Meteo-France, CLS, ACRI-st)

SMOS (Soil Moisture and Ocean Salinity)



- Should be launched in 2007
- Goal:
  SSS accuracy: 0.1-0.2psu over $200x200km^2$ 10days
- L-band radiometer (λ=21cm) =>SSS of upper 1cm depth
- Synthetic Aperture radiometer => spatial resolution ~ 40km
- 3 arms =>
  bidimensional field of view

SMOS 2-D FIELD OF VIEW (one over 10 FOV), (F. Petitcolin, Acri-st)



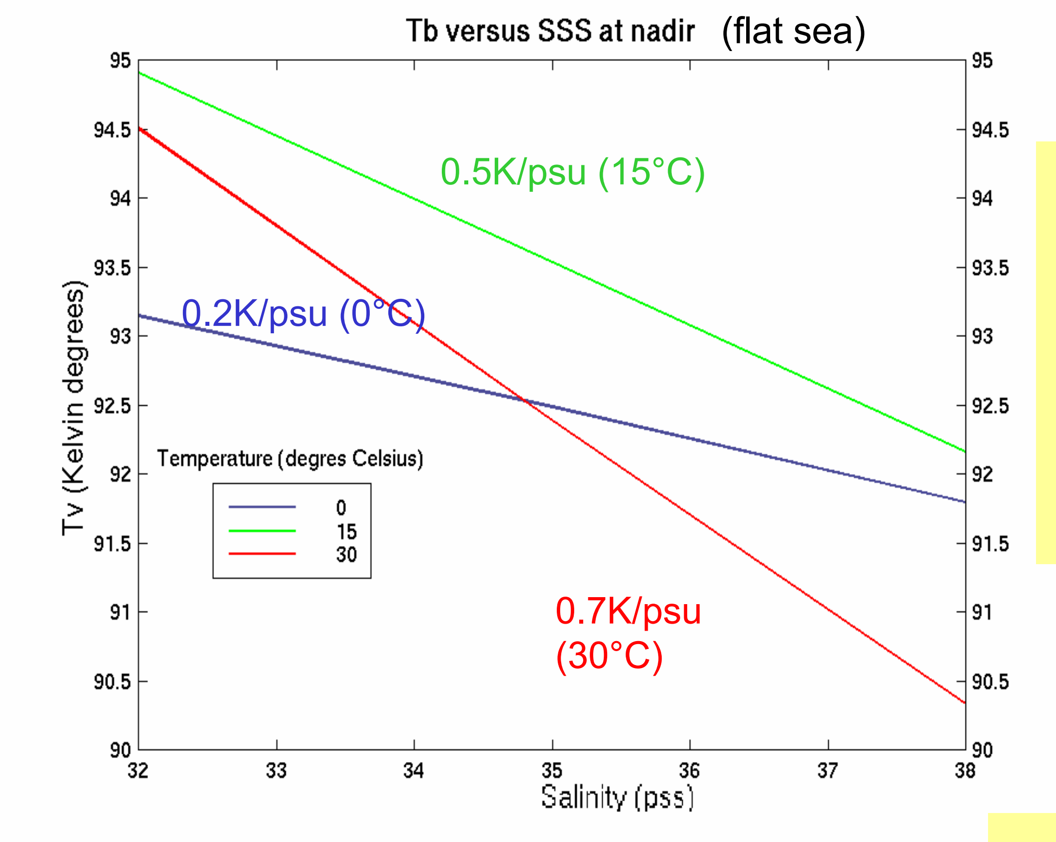
SEPSv3 simulations

S90	216s
S80	192s
S70	168s
S60	144s
S50	120s
S40	96s
S30	72s
S20	48s
S10	24s
S1	T0

Satellite passes at 6AM and 6PM UTC

Sensitivity of L-band Tb to SSS

Flat sea (*Klein and Swift model)*



Sensitivity of Tb to SSS is:

-small: always less than 1K/psu (SMOS radiometric precision of 1 Tb: several K)

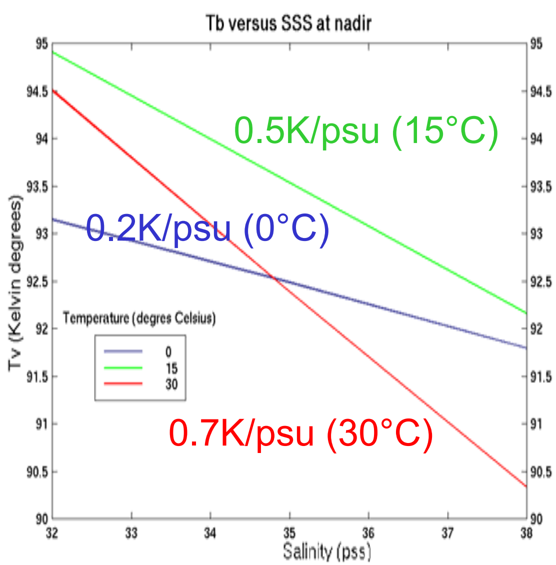
-Higher in warm water

NB: L-band radiometer measurements are representative of top 1cm surface ocean

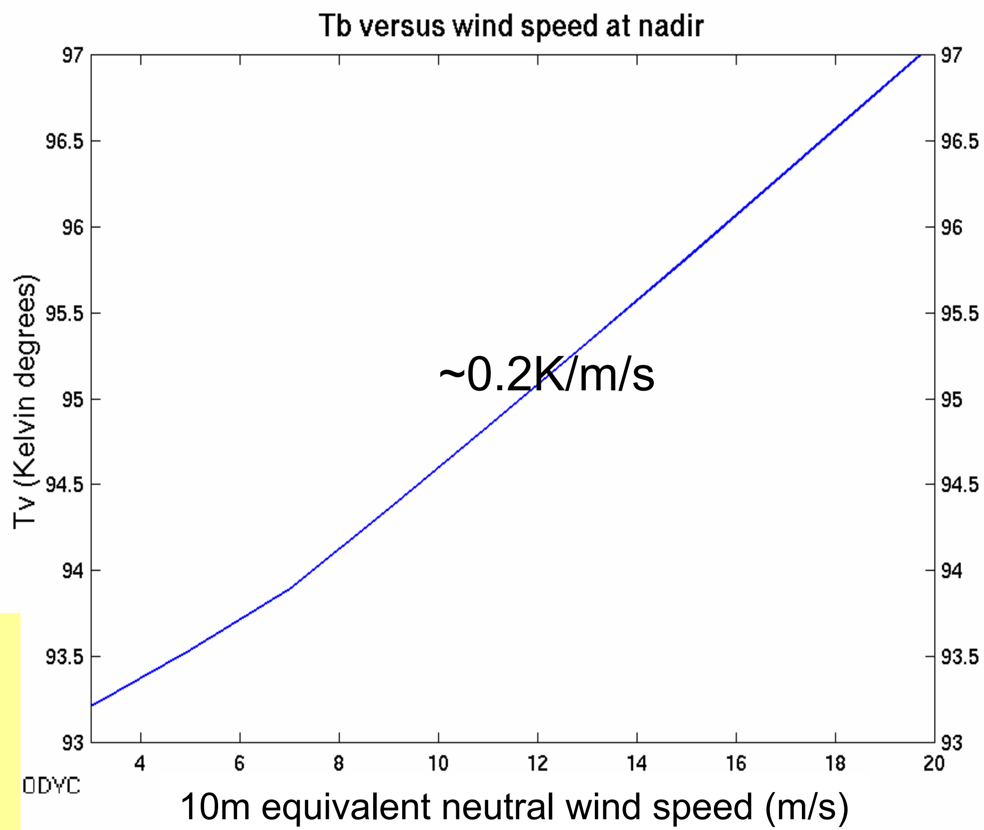
Brightness temperature of the sea surface for a rough sea surface

2 scale emissivity model: small waves superimposed on large tilted waves

Flat sea



Rough sea (without foam)



At 15°C, a 0.1K Tb variation can be generated by :
-0.2psu SSS variation
or
- 0.5m/s wind speed variation

Dinnat et al., IJRS, 2002, Radio Science, 2003

SSS retrieved from multiangular Tb measurements

An iterative retrieval algorithm is used to retrieve SSS, SST, surface roughness parameters the most consistent with Tb measurements

Cost Function to be minimized:

$$\chi^2 = \sum_{i=1}^{N} \left[\frac{Tb_i^{meas} - Tb_i^{\mathrm{mod}}}{\sigma_i} \right]^2 + \sum_{k=1}^{K} \left[\frac{P_k - P_{k0}}{\sigma_k} \right]^2$$

Tb^{mod}: Tb estimated with a direct forward model

N: number of Tb observations

P: geophysical parameters responsible for Tb variations (e.g.: SSS, SST, wind ; depend on forward model)

σ_i: errors on Tb^{meas}

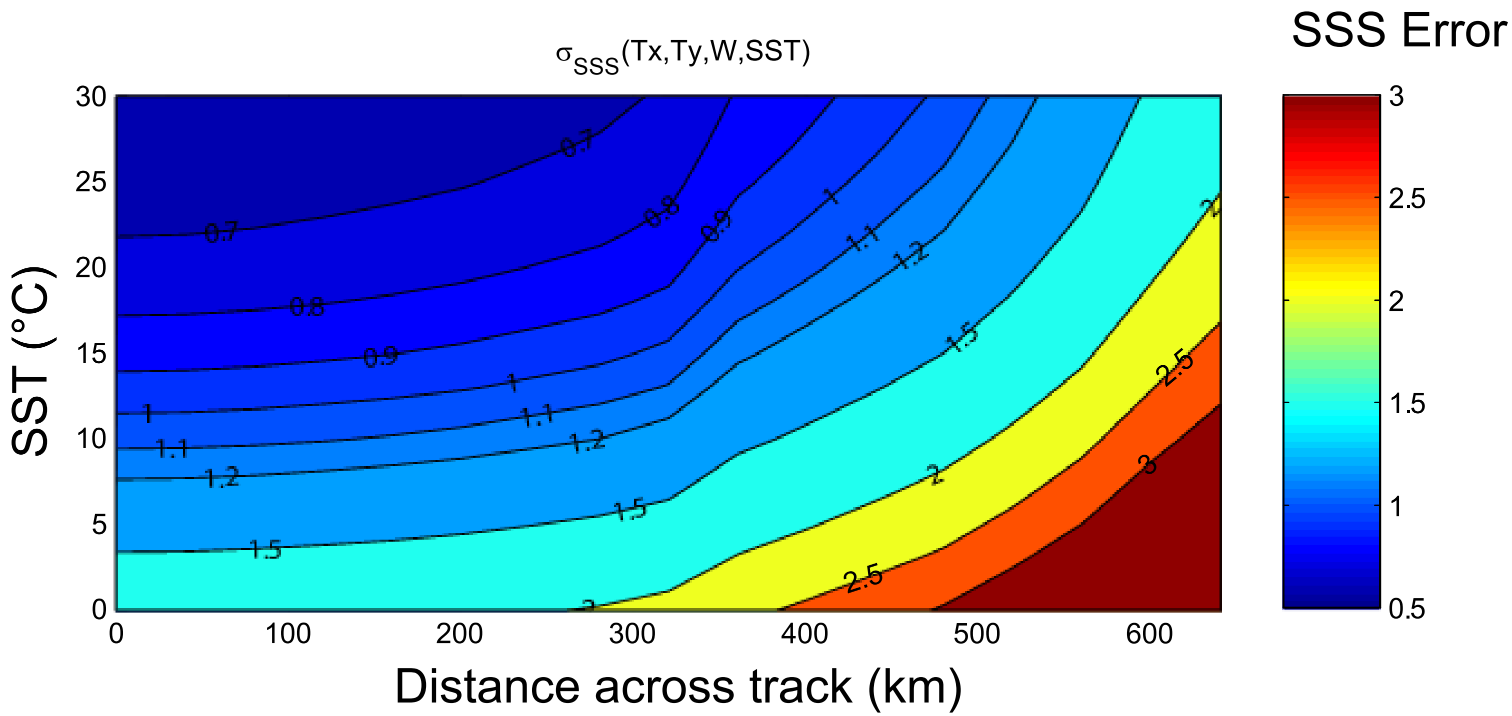
σ_k: Prescribed errors on auxiliary parameters (typical values): σ_U = 2m/s; σ_{SST} = 1°C

Retrieved parameters: SSS, SST, equivalent neutral wind speed (depend on forward model)

Minimization: Levenberg-Marquardt algorithm

Error on retrieved SSS (estimated with Dinnat et al. Model)

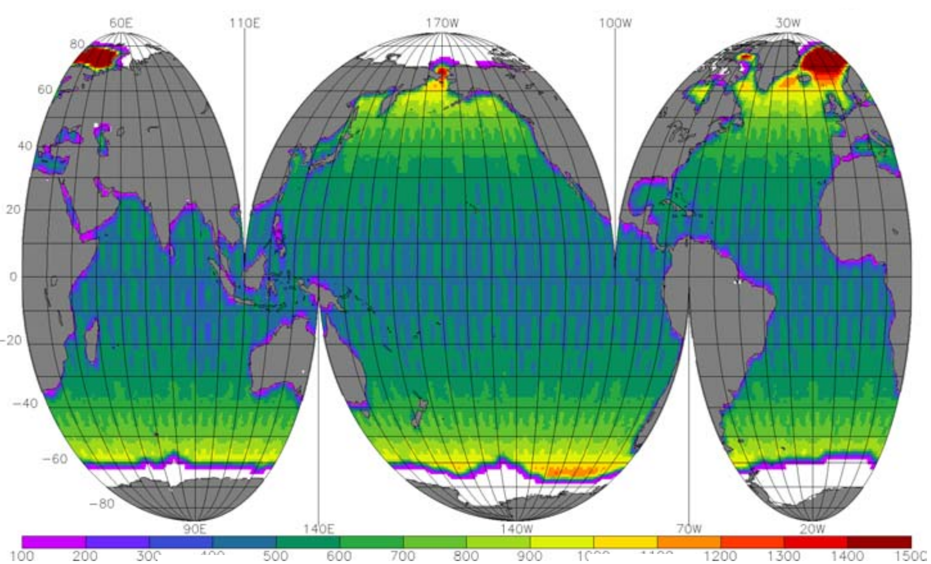
1 satellite pass - 40x40km pixels
(1 to 3K random error on individual Tb, U error 2m/s, SST error 1°C)



Boutin et al., 2004

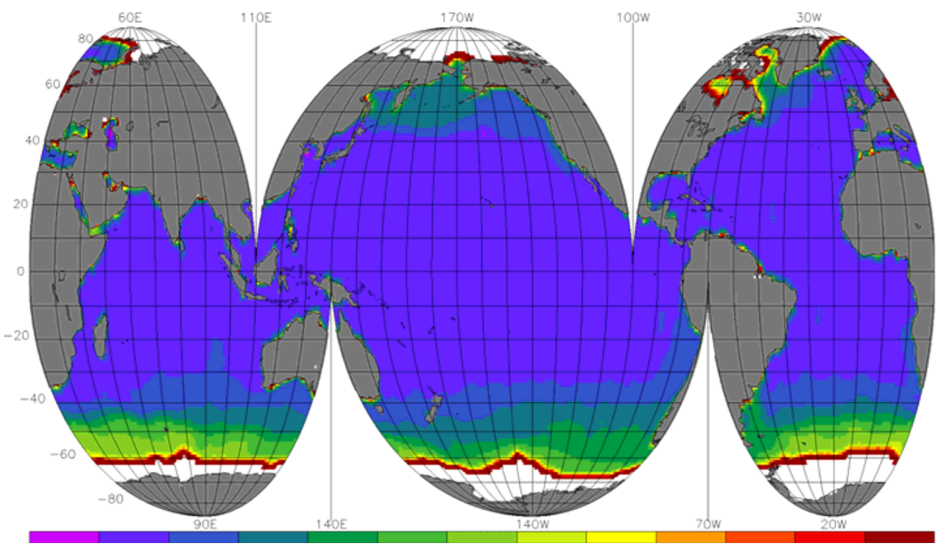
Error on retrieved SSS averaged in ‘Godae’ boxes ($200x200km^2$; 10 days)

Number of retrieved SSS in GODAE box
(200km x 200km over 10 days)



400 1000

Error on mean SSS (computed as $2\sigma/\sqrt{N}$)



0.04 0.1 PSU 0.2 0.3

Boutin et al, JAOT,2004

Encouraging simulation but ‘optimistic’ hypothesis:
-random noise on Tb and auxiliary parameters
-knowledge of the true forward model
To be checked during Cal/Val in 2007!!!!

Goals of CAL/VAL using in situ data

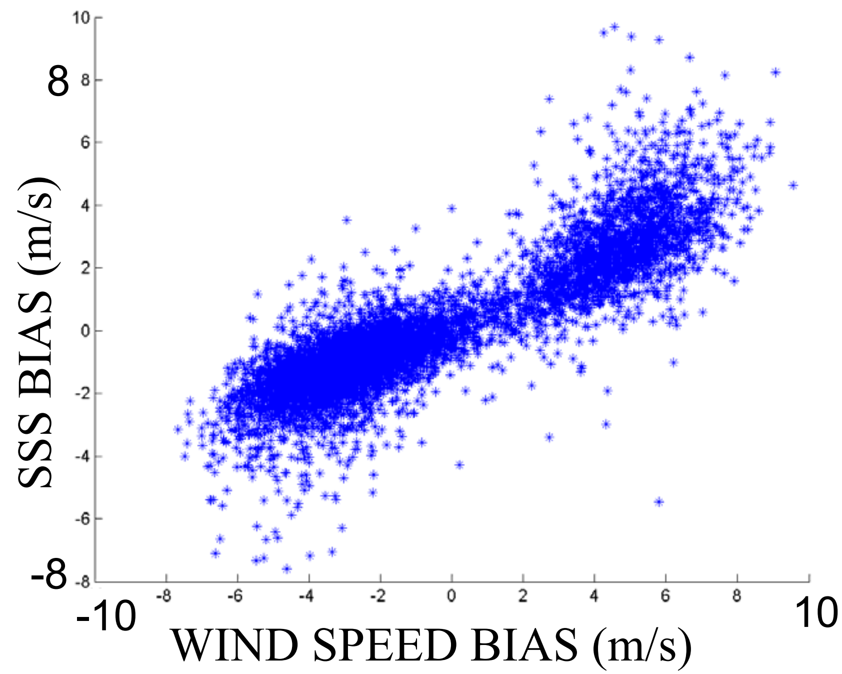
1) Estimate SMOS SSS accuracy and precision:
 -Compare SMOS SSS with in-situ SSS   Need for SSS data

2) Identify error and biases sources:
 -flaws in direct emissivity models / instrument drifts
 -Compare SMOS Tb with Tb derived from direct forward models
 Data needed to compute Tb: **SSS, wind, SST,** atmospheric pressure, Tair
 Other useful information: Rain, wave, swell, currents
 -flaws in auxiliary parameters (coming from ECMWF model/Reynolds analysis) used in the SSS inversion
 -Compare them with in situ data   Need for **wind,SST**,Patm,Tair

Sampling, Precision and Accuracy of in situ data well adapted for SMOS Cal/Val depends on:
 Sensitivity of SMOS retrieved SSS to biases on auxiliary parameters
 Natural variability of SSS (and auxiliary parameters)

Simulations of SSS retrieved from biased wind speeds

SSS bias as a function of wind speed bias

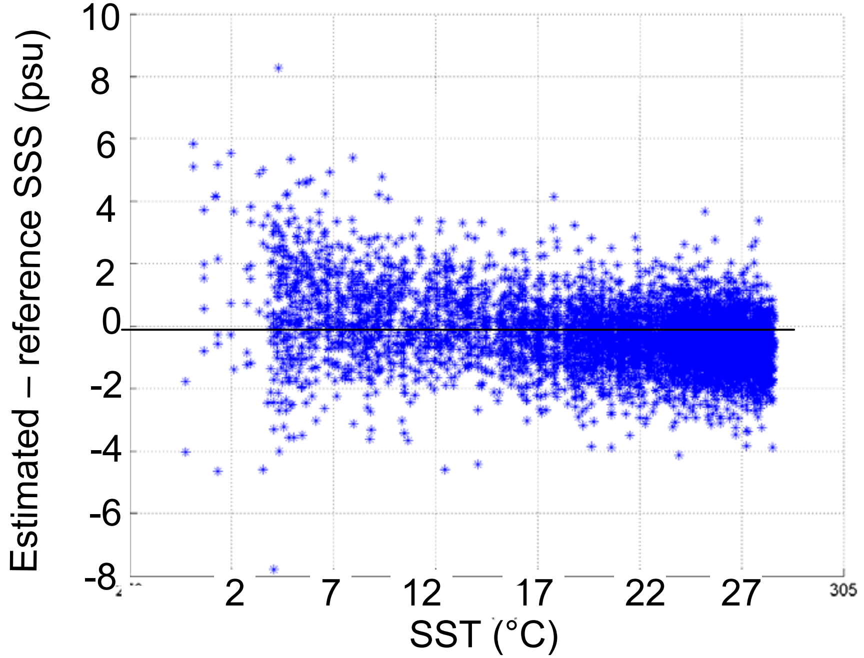


SSS bias mostly related to wind speed bias (at 15°C, 1psu bias <-> 2m/s bias);

In order to get SSS bias<0.1psu , need for bias on wind speed data < 0.2m/s

Influence of SST bias on retrieved SSS

SSS bias as a function of SST
(SST bias=5°C)



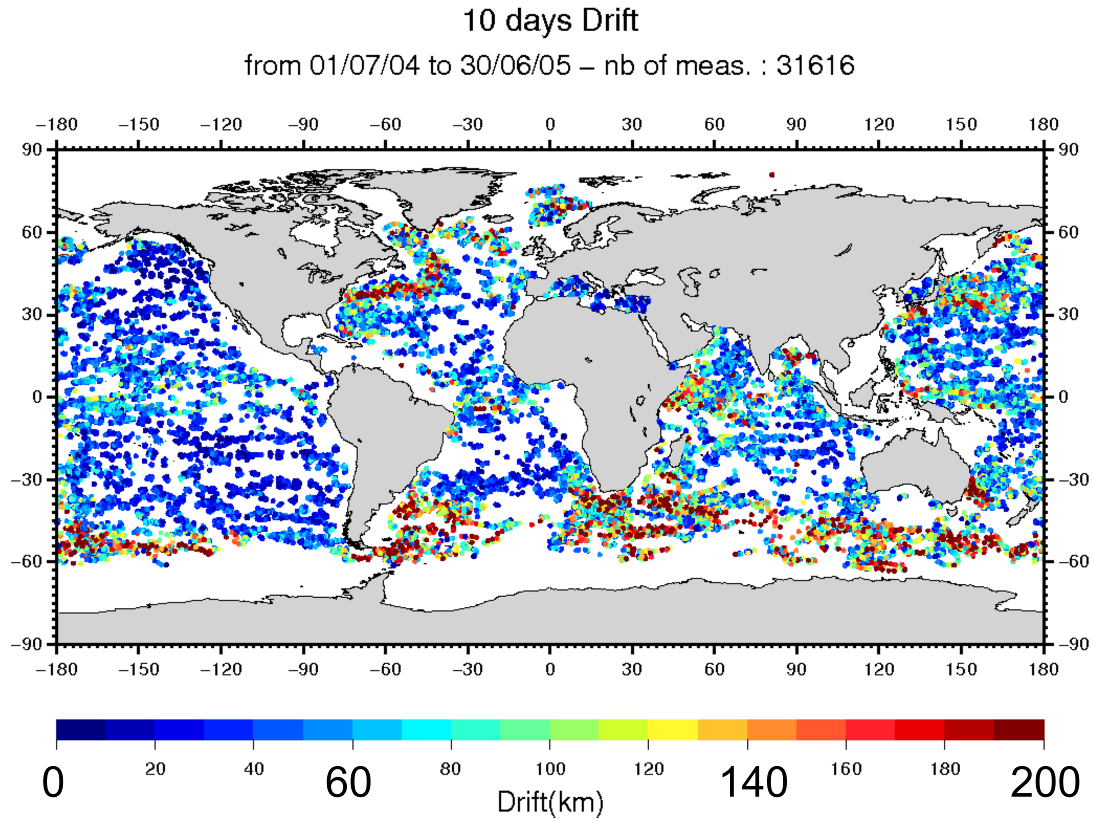
SSS bias strongly dependent on SST: almost no bias around 15°C; >0 biases at low SST and <0 biases at high SST

In order to get SSS bias < 0.1psu, need unbiased SST especially at low and high SST:

-at SST=30°C: SST bias<0.5°C

-at SST=0°C: SST bias<0.3°C (extreme value!)

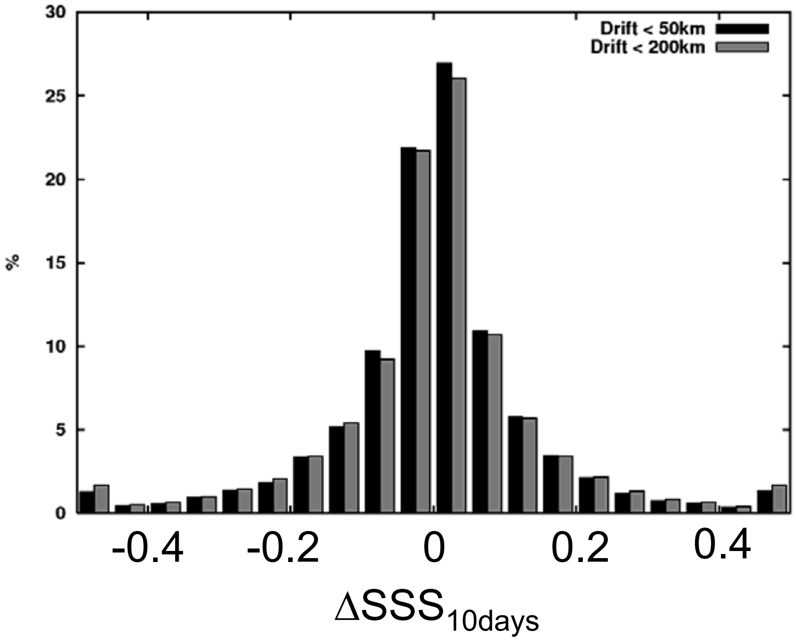
10day-horizontal variability of SSS as detected by ARGO floats



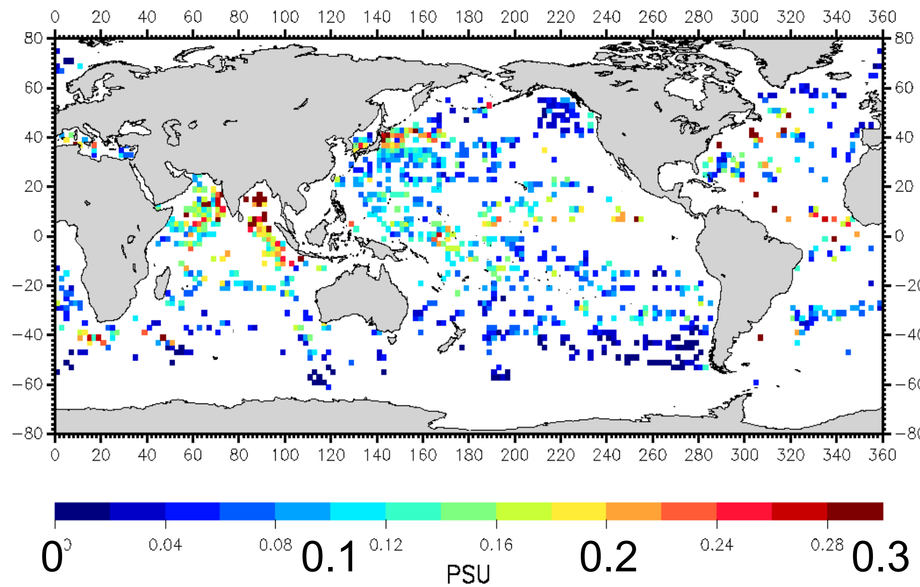
At 10 day interval ARGO floats drift over 56km on average (up to 200km in frontal regions) => difference between SSS recorded at 10 day interval by the same float represents SSS variability at 10 day-20km to 200km scale

10day-horizontal variability of ARGO measurements

Difference in SSS measured by the same float at 10 days interval



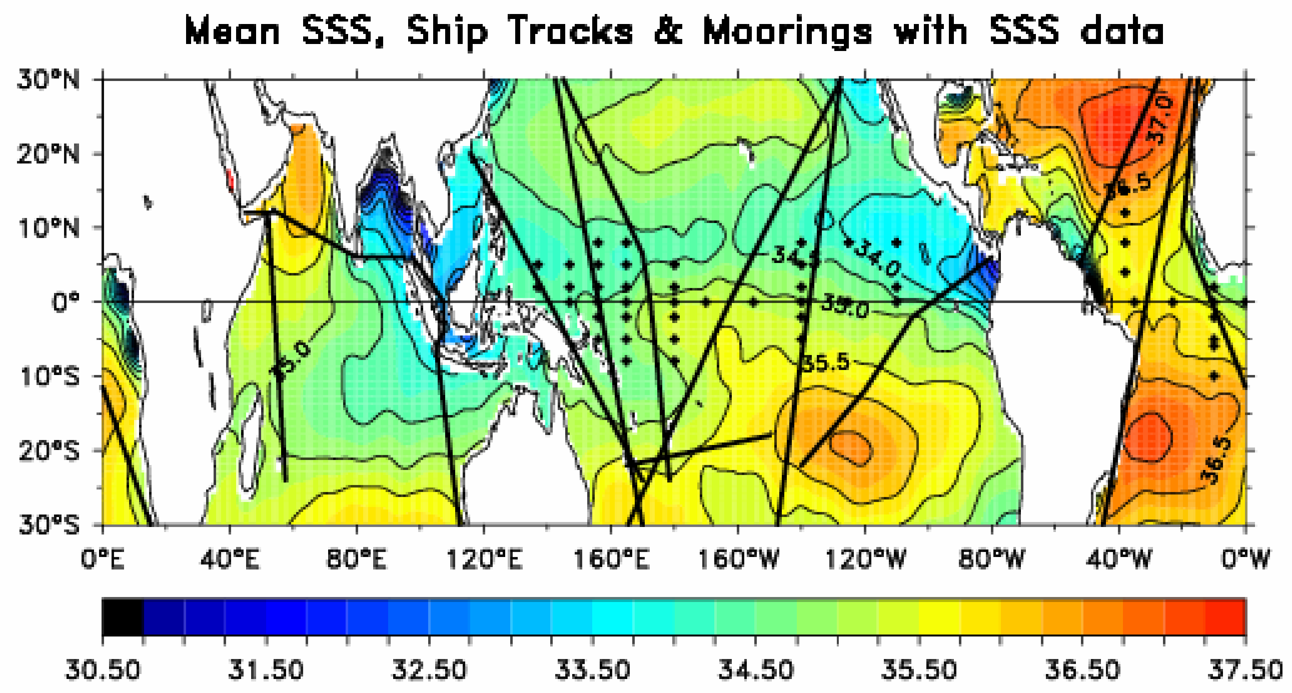
Quadratic mean of ΔSSS_{10days} in 2°x2° pixels (N>10) July 2004-July 2005



$\sigma(\Delta SSS_{10days})$=0.2psu;
largest differences in tropical regions;
similar results for 10days-20-50km and 10days-50-200km drift =>
Number of measurements needed to achieve an accuracy of (a=0.1psu) on a 10day-20-200km mean: $N = 4\,\sigma^2 / a^2$ => N = 16 observations

Boutin and Martin, 2006

SSS variability derived from ships and moorings measurements



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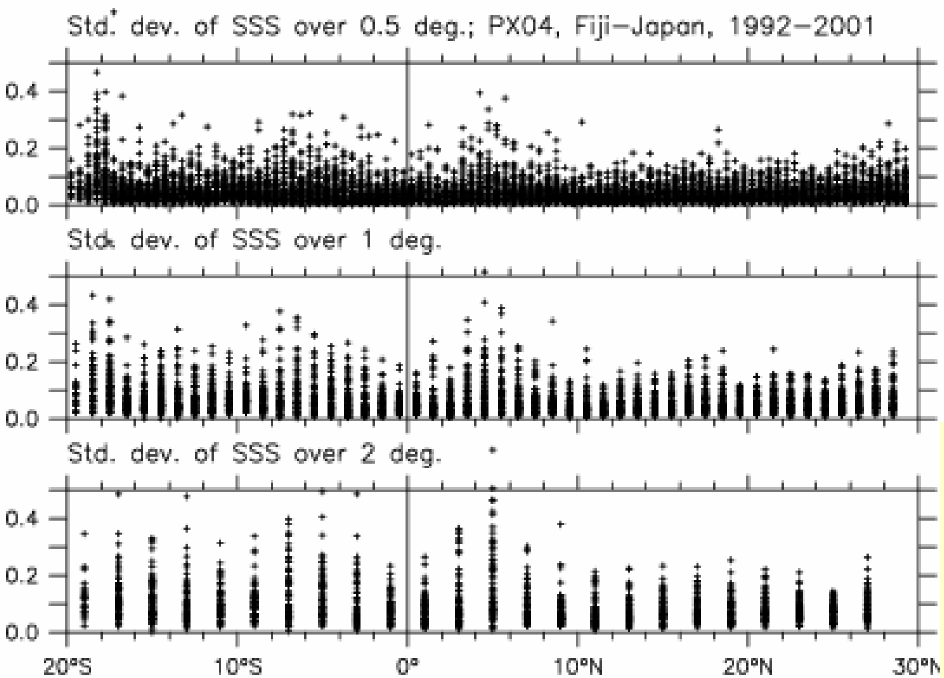
Estimate spatial SSS variability from ship measurements and temporal SSS variability from mooring measurements

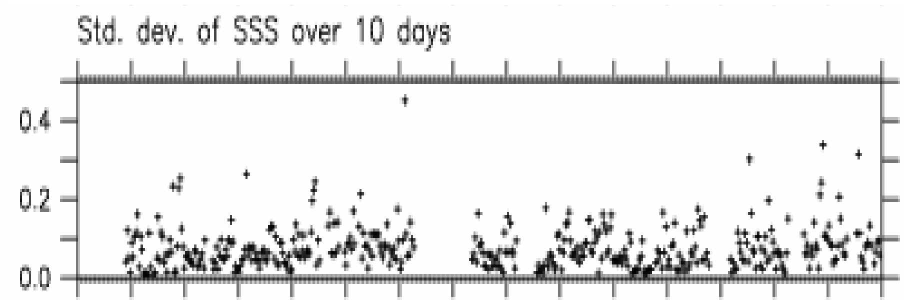
Delcroix et al., 2005

SSS variability derived from ships and moorings measurements

SMALL SCALE VARIABILITY IN THE SPACE (N-S) DOMAIN (PX04; Fiji-Japan line)



SMALL SCALE VARIABILITY IN THE TIME DOMAIN, 0-165E



The **mean** standard deviation of SSS over :

-1° latitude is 0.1 psu

-2° longitude is 0.12 psu

-10 days is 0.10 psu

(such values are variable in space and time)

=> The **mean** expected variability within a box of 1°x2°x10 days is σ=0.2 psu => Nmin to achieve 0.1psu accuracy: $N = 4\,\sigma^2 / a^2$ => **N = 16 observations**

Delcroix et al., 2005

Summary: requirements on in situ measurements for SMOS/Cal Val

	Sampling	Accuracy	Precision	Remarks
Parameters needed to compute Tb with present forward models (resolution ~40km):				
SSS	Nmeas=16 in 40x40km pixel (optimal)	0.05psu	0.1psu	Depth: Upper layer (same as SST)
SST	Similar to SSS	0.3°C	0.5°C	Depth: Upper layer (diurnal cycle) (L-band signal coming from 1cm depth)
Wind speed (direction)	hourly	0.2m/s	1m/s	Computed at 10m height (equivalent neutral)

Additional information very useful for interpreting SSS differences:

Rain;

Surface roughness: Currents; Waves and swell

Conclusions/Remarks

Advantages of GOSUD/SAMOS measurements w/r to other measurements:

-w/r to moorings: almost 'global ocean'coverage : sampling of very variable meteorological and oceanographic conditions

-w/r to ARGO floats: provide meteorological measurements and complementary information necessary for interpreting differences between in situ and SMOS SSS.

Remarks:

It would be very convenient to get colocated ocean surface and meteorological parameters or software generating colocated measurements.

Colocations useful for other applications?

-Study of air-sea interactions (e.g. CO_2 air-sea flux in case ocean CO_2 measurements, see Lefevre et al. poster)

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