Salinity variability in satellite subpixels: impact on satellite in-situ comparisons.

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Introduction

Validation of satellite Sea Surface Salinities (SSSsat) is often based on comparisons with in-situ near surface salinity measurements (e.g. Argo), SSSref, using the std of the difference (SSSsat-SSSref). But part of these differences might come from a sampling mismatch between in-situ and satellite measurements.

In this study we quantify the std difference (SSSsat-SSSref) explained by the natural variability of SSS in order to refine the uncertainty budget of satellite SSS.

Data and methods

- CCIv2.3 : Combination of SMOS, Aquarius, SMAP. Resolution of 50km, weekly or monthly, 2010-2019

- Comparisons between CCIv2.3 SSS and Argo floats S (PIMEP) : colocations at +/3.5 days (weekly products), or +/-15 days (monthly products)

- **Satellite uncertainty budget**, assuming a large number of realisation and no correlation between uncertainties:

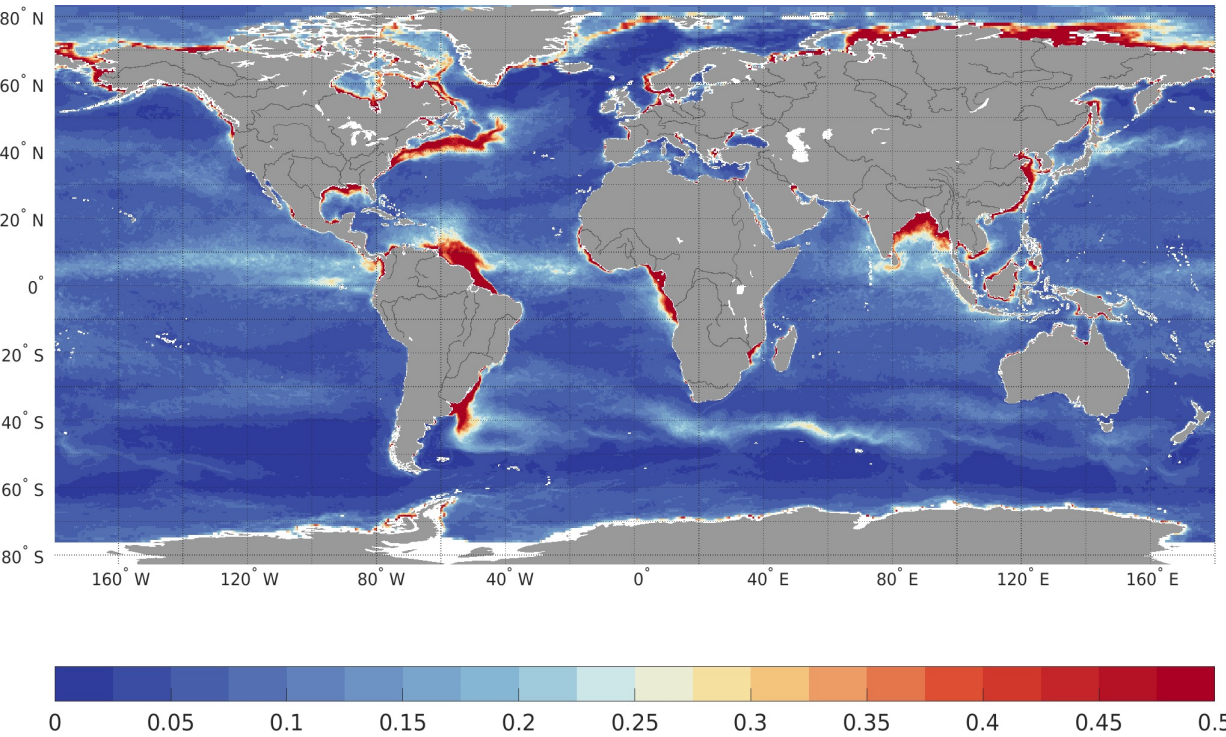
$$STD_{x_{SAT}-x_{REF}} = \sqrt{\langle U_{SAT}{}^2 \rangle + \langle U_{mis}{}^2 \rangle + \langle U_{ref}{}^2 \rangle}$$

U_{SAT}: Uncertainties for each SSS satellite measurement
$STD_{x_{SAT}-x_{REF}}$: standard deviation of observed differences between the satellite SSS and in situ salinity
U_{mis} : Uncertainties due to mismatch between satellite and in situ samplings
U_{ref}: Uncertainties of reference measured values being used as validation points

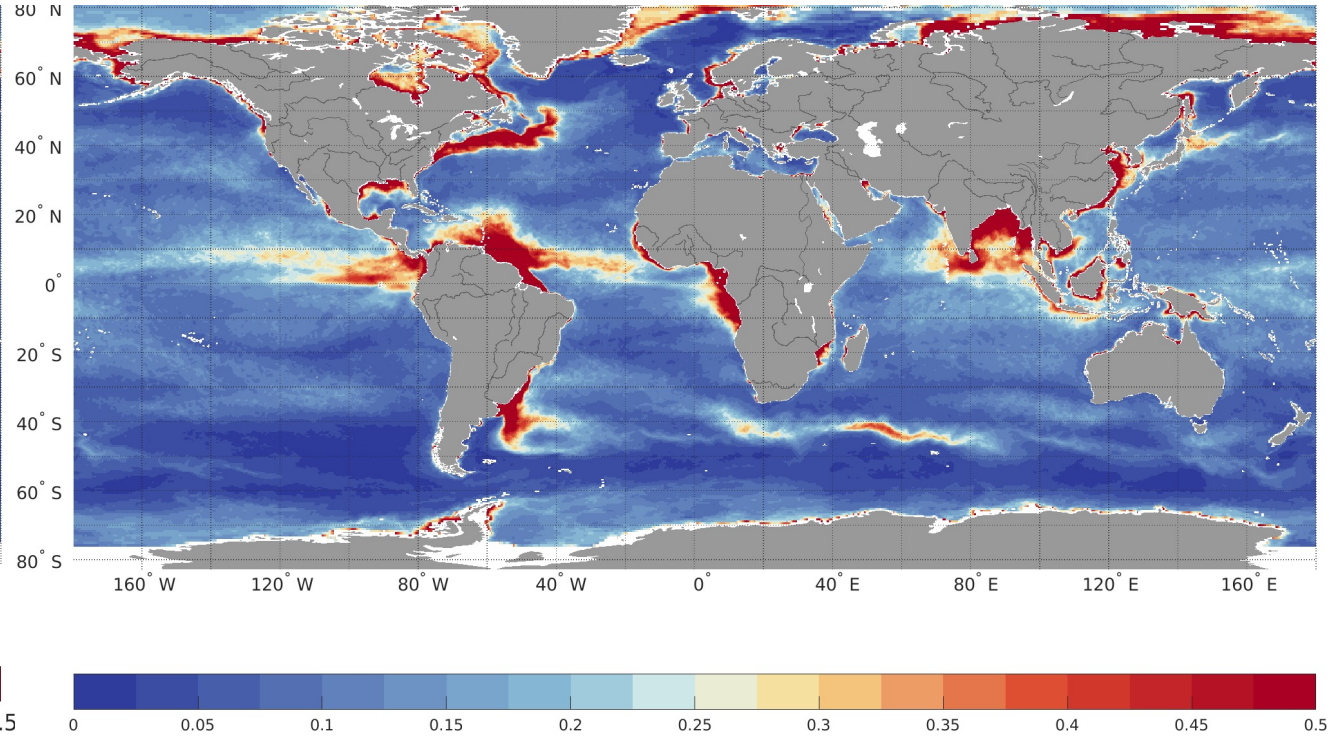
- U_{mis} is estimated from mercator ocean model analyses 1/12°, 1day, using punctual Mercator SSS at 5m depth and Mercator SSS averaged over 50x50 km^2 at 0.5m depth (to simulate Argo at ~5m depth and satellite SSS at ~1cm depth)

Sampling Mismatch $\sqrt{\langle U_{mis}{}^2 \rangle}$

Std of Mercator 1day 1/12° salinity at 5m depth versus mean near-surface salinity at different time/spatial scales



Sampling mismatch - 7days 50x50km²

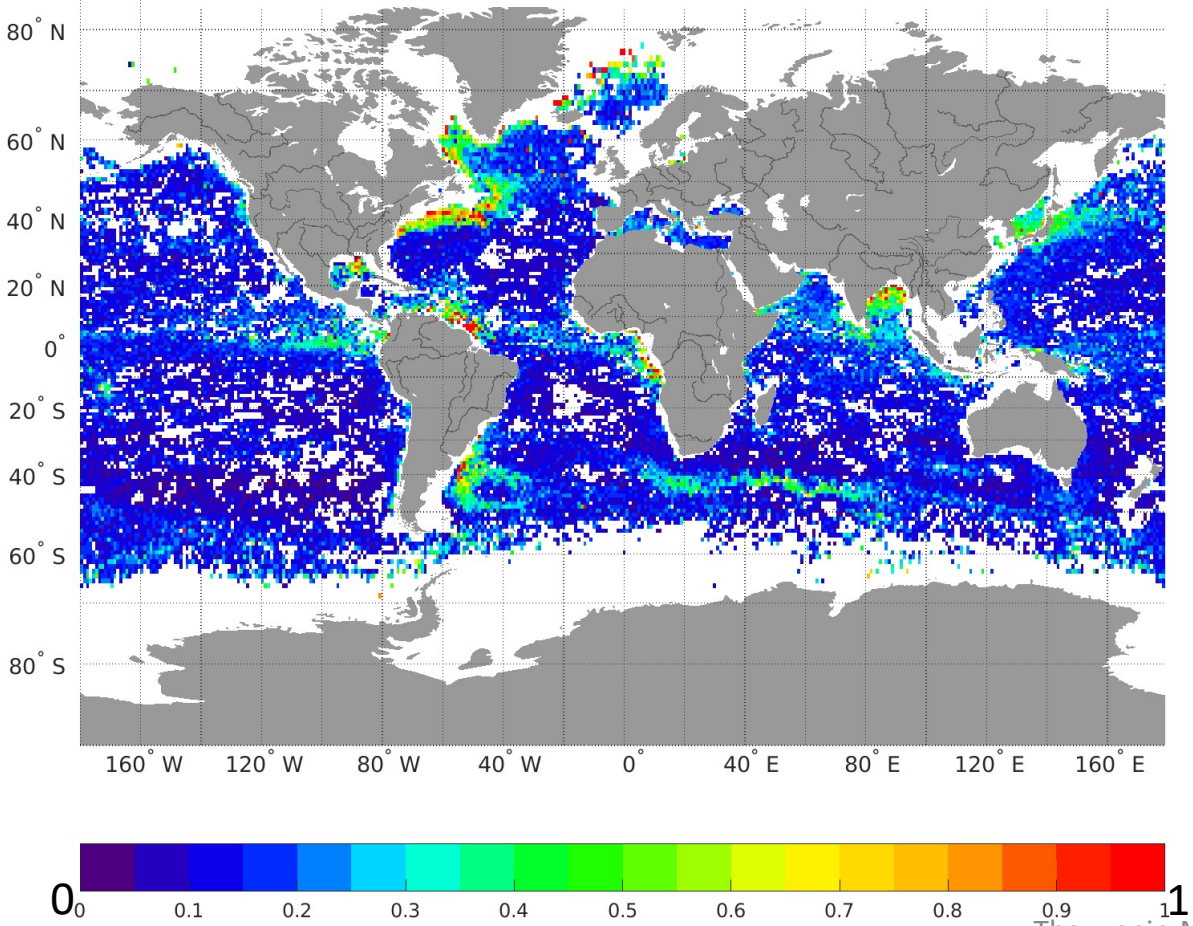


Sampling mismatch - 30days 50x50km²

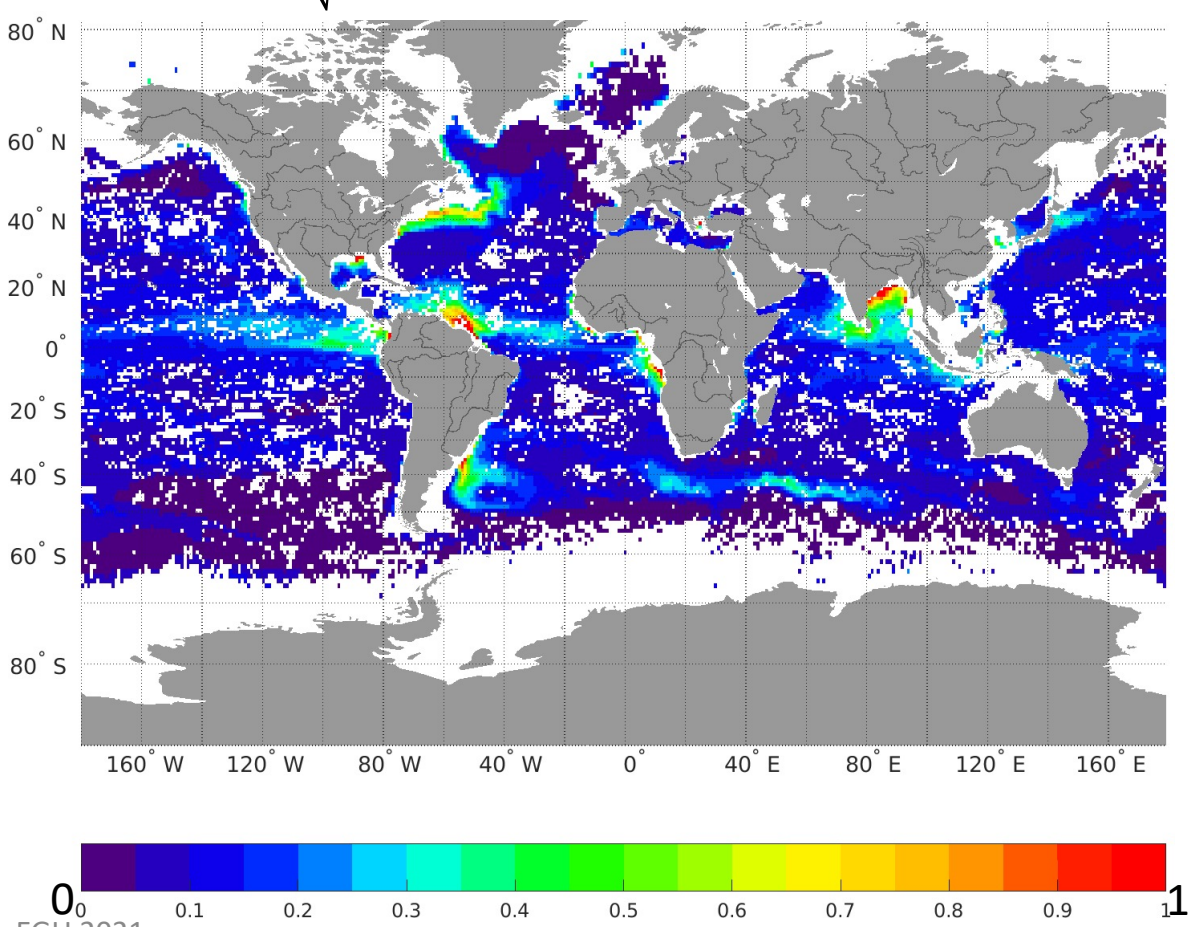
Satellite – Argo SSS and sampling mismatch, Monthly

$\sqrt{\langle U_{mis}{}^2 \rangle} \approx STD_{x_{SAT}-x_{REF}}$ where sampling uncertainties dominate the satellite uncertainties (river plumes, currents…)

$STD_{x_{SAT}-x_{REF}}$: Std(CCI - ARGO) from PIMEP in 1x1°



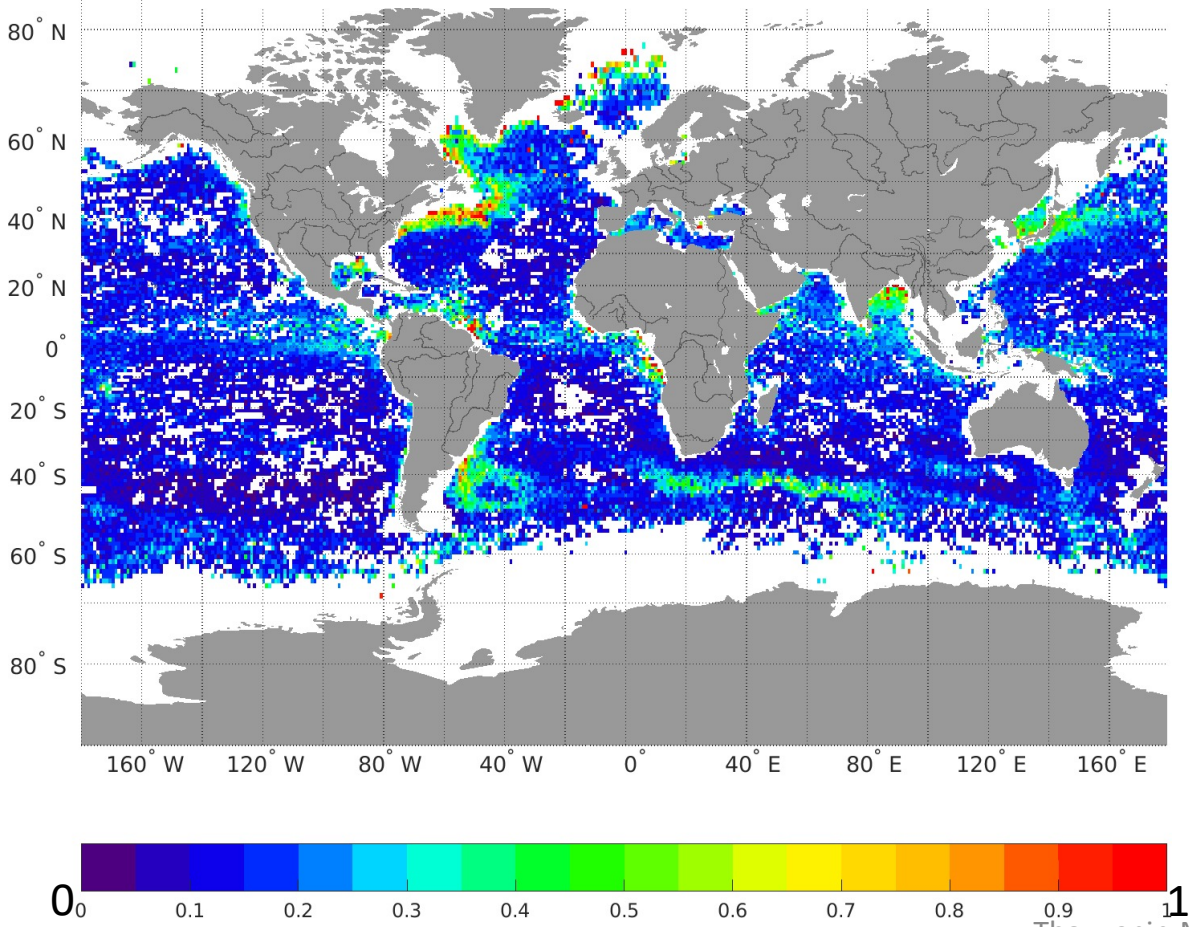
$\sqrt{\langle U_{mis}{}^2 \rangle}$: sampling uncertainties in 1x1°



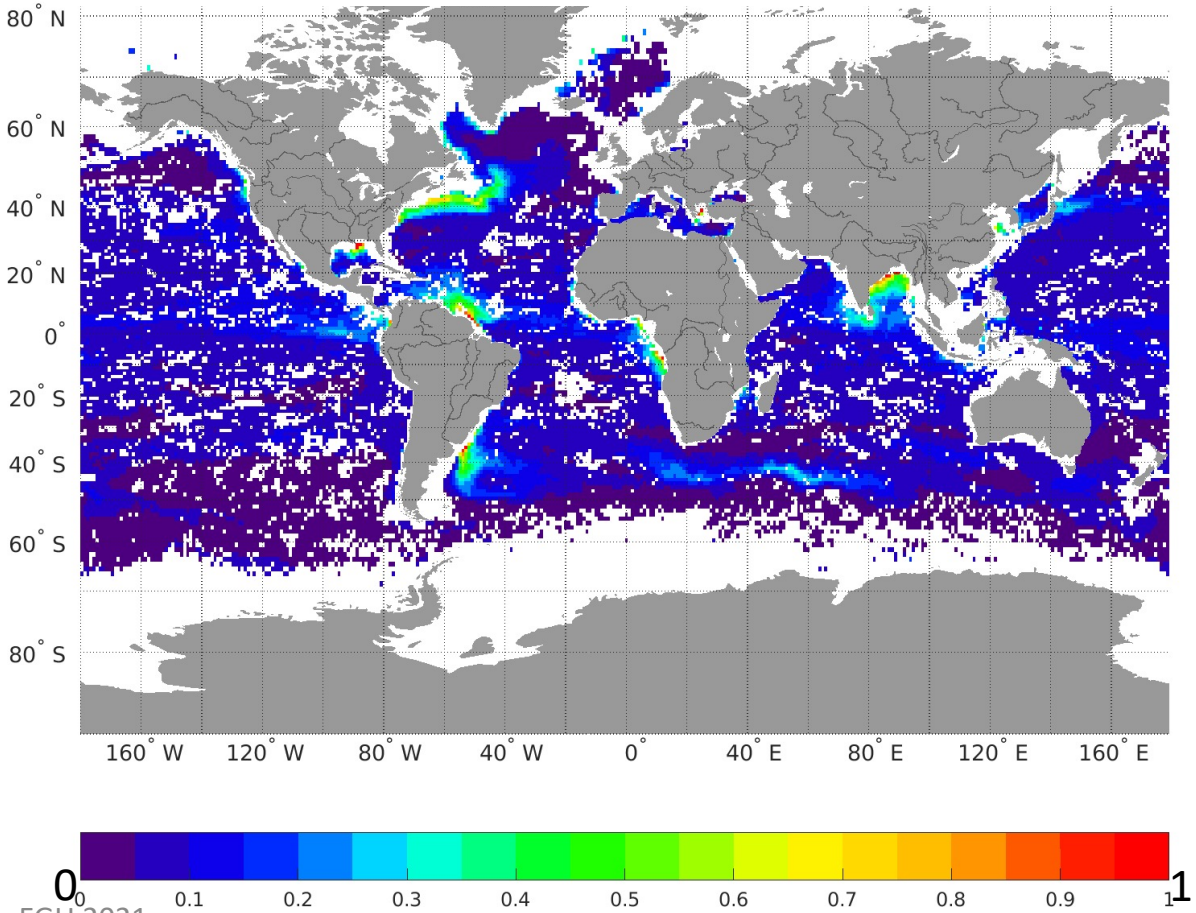
Satellite – Argo SSS and sampling mismatch, Weekly

$\sqrt{\langle U_{mis}{}^2 \rangle}$ still dominates $STD_{x_{SAT}-x_{REF}}$ in variable regions

$STD_{x_{SAT}-x_{REF}}$: Std(CCI - ARGO) from PIMEP in 1x1°



$\overline{\sqrt{\langle U_{mis}{}^2 \rangle}}$: sampling uncertainties in 1x1°



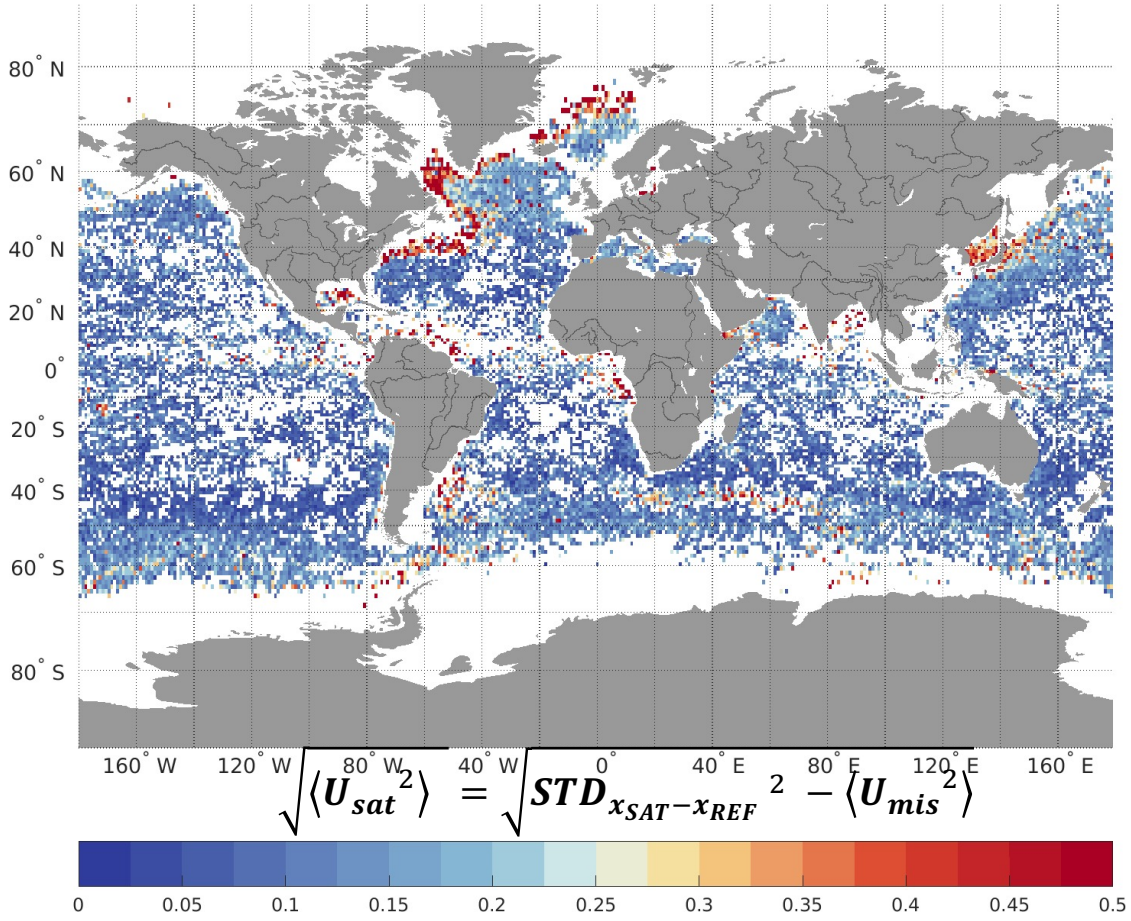
Estimation of the SSS satellite uncertainties $\sqrt{\langle U_{sat}{}^2 \rangle}$, Monthly

$STD_{x_{SAT}-x_{REF}}$	0.26
$STD^*{}_{x_{SAT}-x_{REF}}$	0.16

$\sqrt{\langle U_{sat}{}^2 \rangle}$	0.21

STD^*: robust std

At global scale, the sampling mismatch $\sqrt{\langle U_{sat}{}^2 \rangle}$ represents about 20% of the std difference $STD_{x_{SAT}-x_{REF}}$



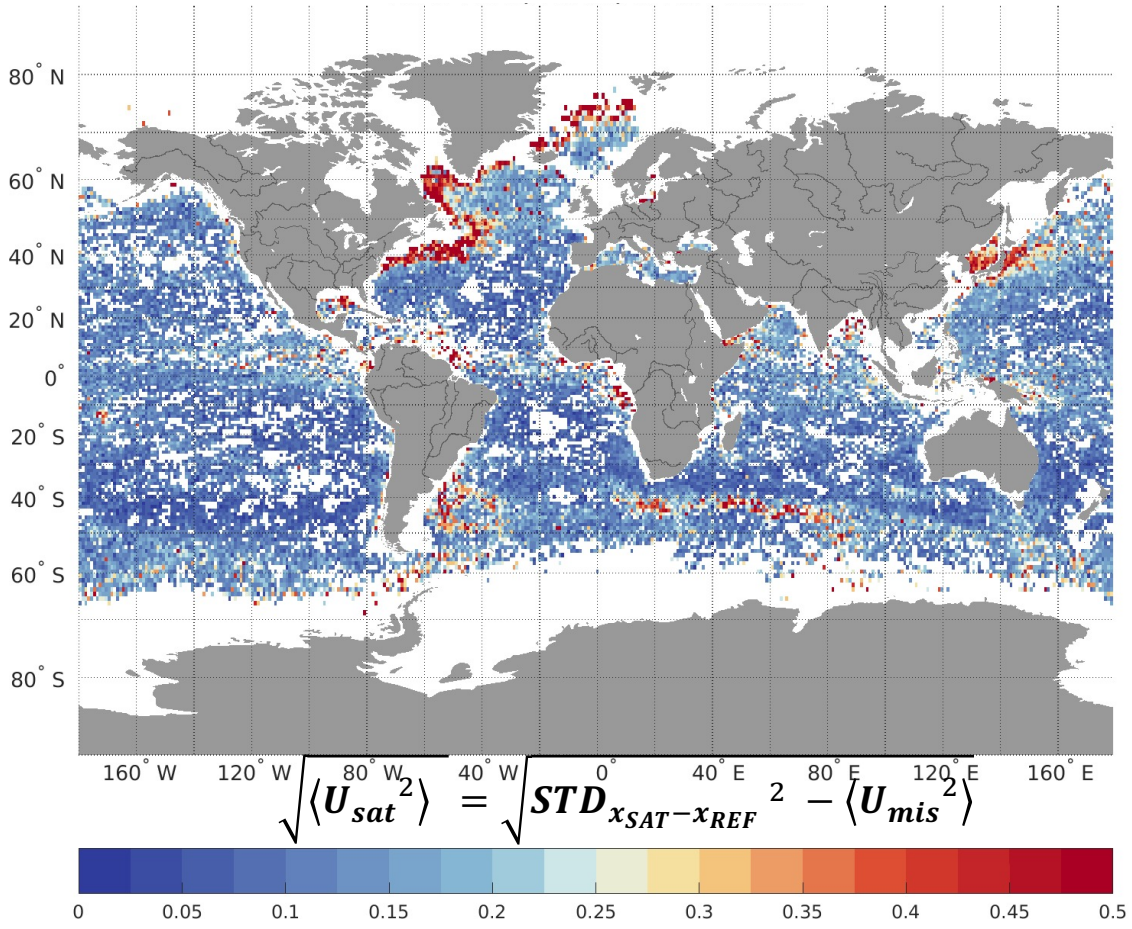
Estimation of the SSS satellite uncertainties $\sqrt{\langle U_{sat}{}^2 \rangle}$, Weekly

$STD_{x_{SAT}-x_{REF}}$	0.27
$STD^*{}_{x_{SAT}-x_{REF}}$	0.17

$\sqrt{\langle U_{sat}{}^2 \rangle}$	0.22

$\boldsymbol{STD}^*$: robust std

At global scale, the sampling mismatch $\sqrt{\langle U_{sat}{}^2 \rangle}$ represents about 20% of the std difference $\boldsymbol{STD}_{x_{SAT}-x_{REF}}$



Conclusion

- Satellite SSS are often validated using comparisons with Argo measurements which provide a regular global coverage of the ocean
- SMOS and SMAP satellite missions sample salinity at 1cm depth and over ~50x50km^2 while Argo salinities are punctual, at ~5m depth.
- The effect of mismatch sampling is comparable or larger to std(Sat – Argo) in variable areas because the SSS variability is well above the uncertainty of weekly and monthly satellite SSS
- Removing the effect of mismatch between sat and in-situ data decreases global std diff. by ~20% (from 0.26 to 0.21 for Monthly products and from 0.27 to 0.22 for Weekly products).

Perspectives

Our sampling mismatch estimate is likely underestimated in very variable regions because of Mercator model caracteristics (resolution (1/12°), climatological runoffs)

The estimate of satellite SSS uncertainty could be refined, e.g., by filtering very variable regions, using dedicated regional models, or using better resolved in situ measurements where they exist.