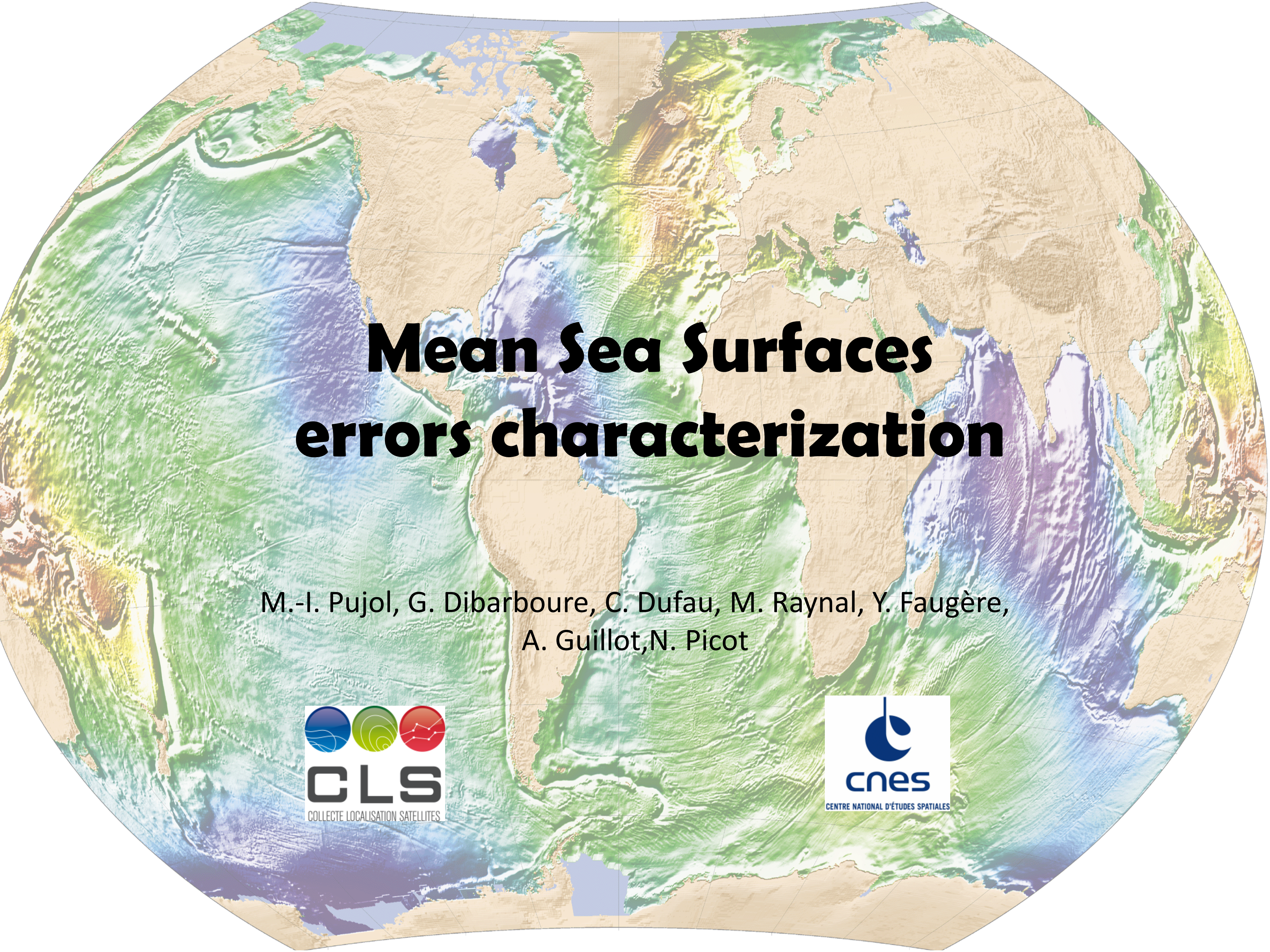

Mean Sea Surfaces errors characterization

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Motivation

Toward a new era of altimetry :

– New technologies (SAR, wide-swath)

– Improved data processing (retracking, noise reduction, improved environmental/geophysical corrections, …)

➔ Able to observe small/sub-mesoscales

➔Need high quality MSS field at these wavelengths

Focus on the characterization of the MSS errors
for wavelengths < ~100 km in open ocean

Overview

Focus on short wavelengths, open ocean, far from repeat tracks :

1) Methodology : analysis of the spectral content
2) Results:
   – MSS errors when no geodetic mission are used
   – Contribution and limits of geodetic measurements
3) summary and conclusions

3 MSS considered:

MSS_CNES_CLS11

- geodesic mission used : ERS-1

MSS_CNES_CLS15
(Schaeffer et al, OSTST 2016)

- geodesic mission used : ERS-1; J1G, C2[2011,2014]

MSS_DTU15

- Use geodetic mission for small scales (< ~250km) information : Geosat ; ERS-1; J1G ; C2[2011-2014]; ENN

Methodology

We consider :

H = SLA signal including the MSS errors (e) and the SLA signal free from MSS errors (h)

A and B = two different cycles

3 assumptions:

1) There is no covariance between the SLA signal and the MSS errors

2) The SLA signal is completely decorrelated between the two cycles considered

3) The MSS error is the same whatever the cycle considered

1) We use a mission/period independent from MSS computation: S3PP/CNES Sentinel-3A (20Hz)

2) We chose A and B far enough from each other: cycles 4 and 7 and/or 4 and 8

3) We use a repetitive mission

$$\boxed{0.5\ V(H_A - H_B) - 0.5\ V(H_A + H_B) = 2\ V(e)}$$

Mean spectral content of the h signal

Mean spectral content of the h+e signal

Before use of geodetic measurements

MSS errors along Sentinel-3A tracks

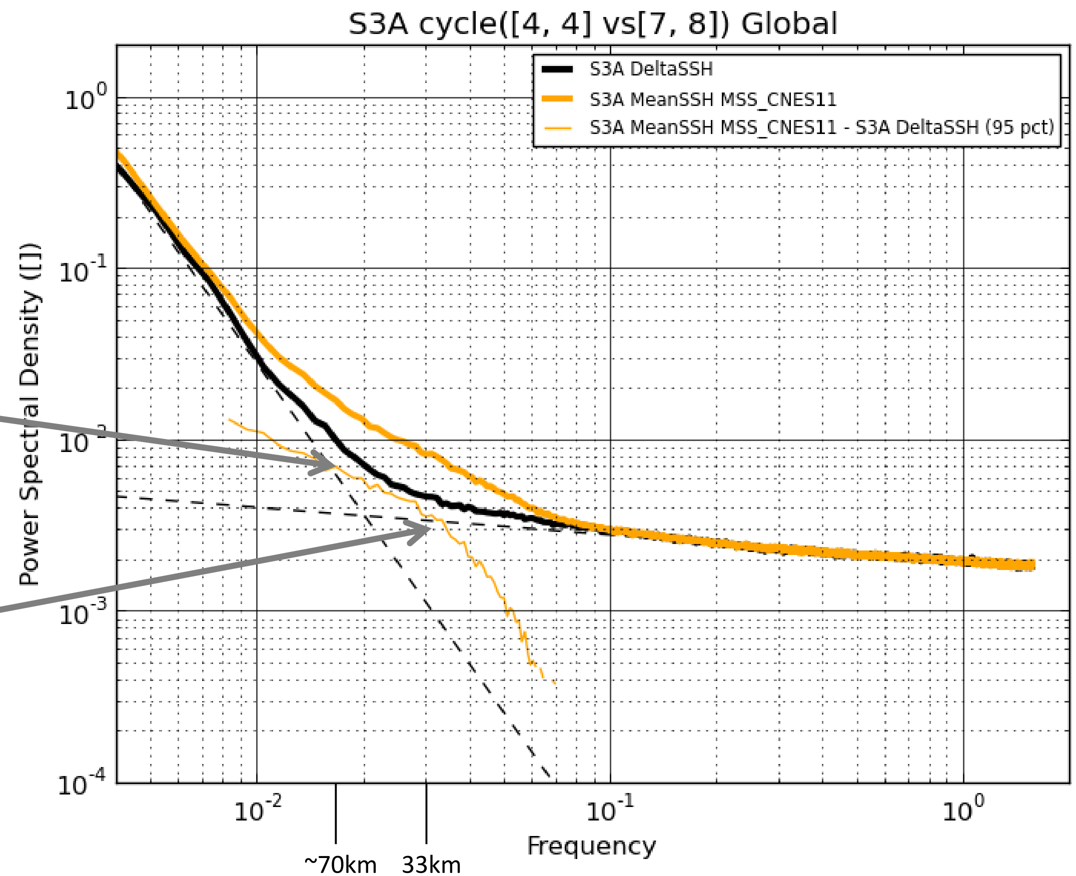
$0.5\ V(H_A - H_B) - 0.5\ V(H_A + H_B) = 2\ V(e)$

MSS_CNES_CLS11 errors significant for wavelengths 125-15km

Mean error at wavelength 100-30km:
MSS_CNES_CLS11: 0.82 cm (72% of signal variance)
= ~5 x the error observed along AltiKa repetitive tracks

Ratio SLA signal / MSS errors = 2 for wavelengths ~70km

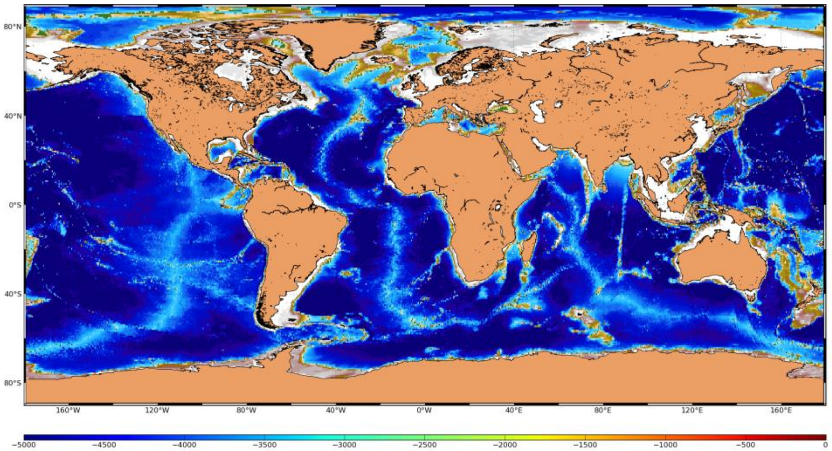
Ratio SLA noise/ MSS errors = 2 for wavelengths ~30km



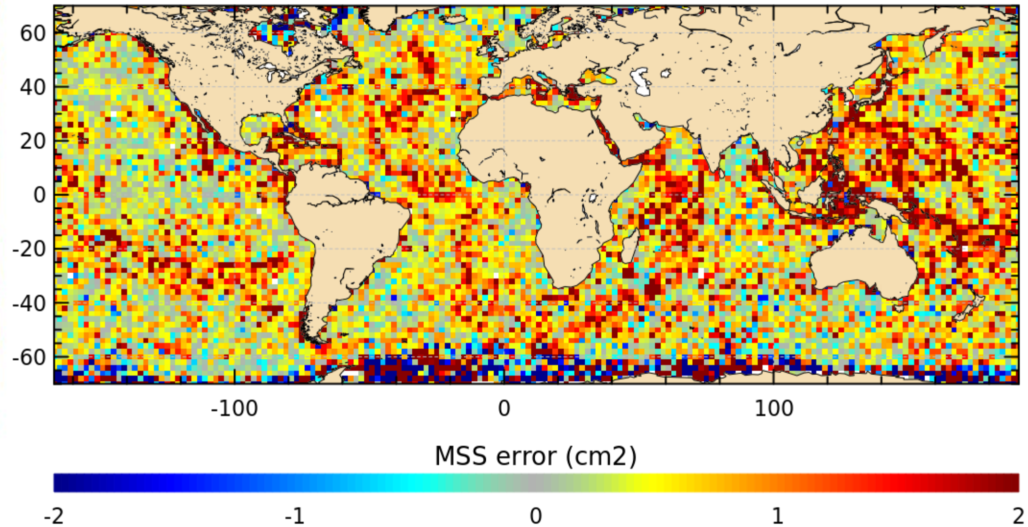
Before use of geodetic measurements

MSS errors along S3A tracks

Bathymetry



Var(error MSS_CNES_CLS11)
Λ=[10, 100km]



- MSS_CNES_CLS11: Significant errors mainly along geodetic structures

MSS errors along Sentinel-3A tracks

$0.5\ V(H_A - H_B) - 0.5\ V(H_A + H_B) = 2\ V(e)$

MSS_CNES_CLS15 errors significant for wavelengths 100-15km

Mean error at wavelength 100-30km:

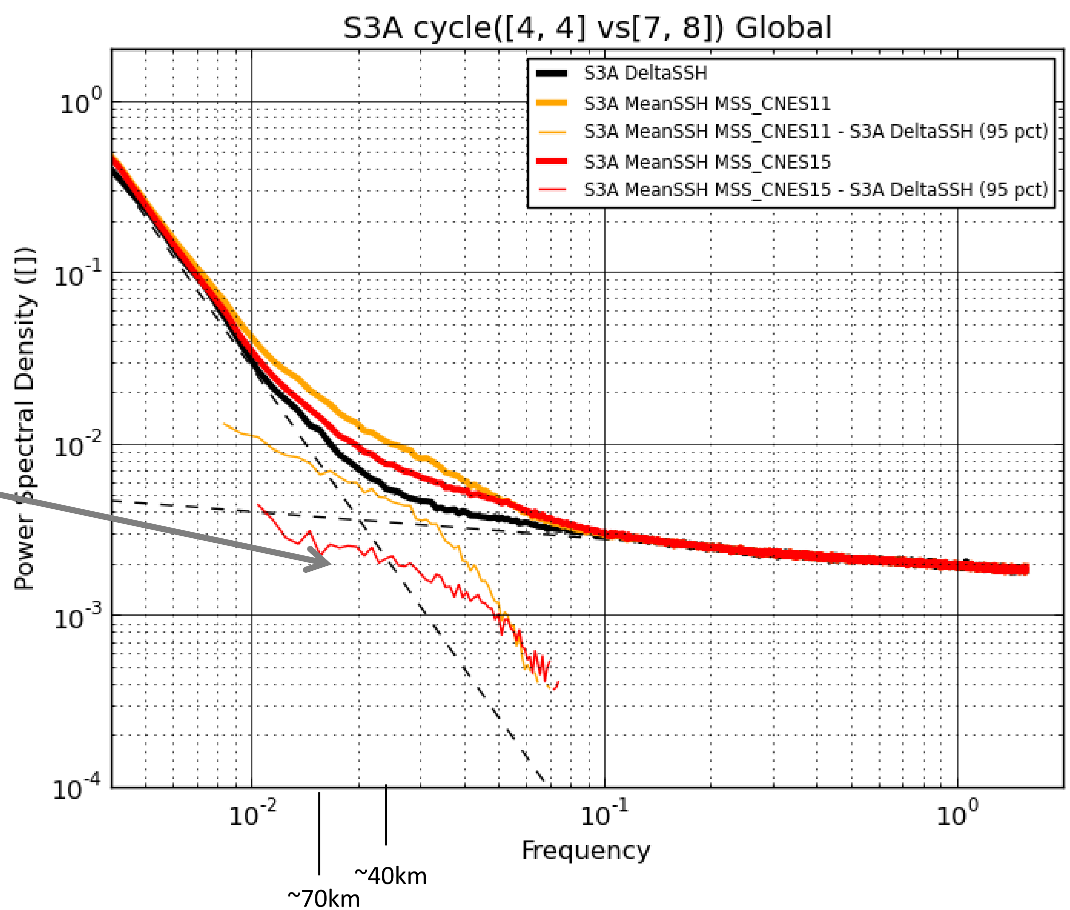
MSS_CNES_CLS11: 0.82 cm (72% of signal variance)

-60%

MSS_CNES_CLS15: 0.52 cm (29% of signal variance)
=~ 2.5 x the error observed along AL tracks

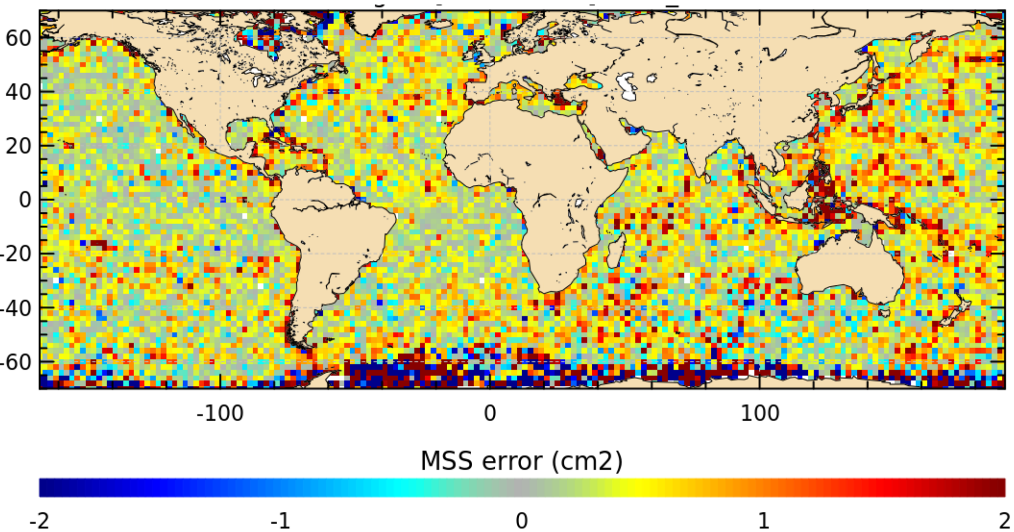
Ratio SLA signal / MSS errors = 2
for wavelengths ~40km

Ratio SLA noise/ MSS errors = 2
for wavelengths ~100km



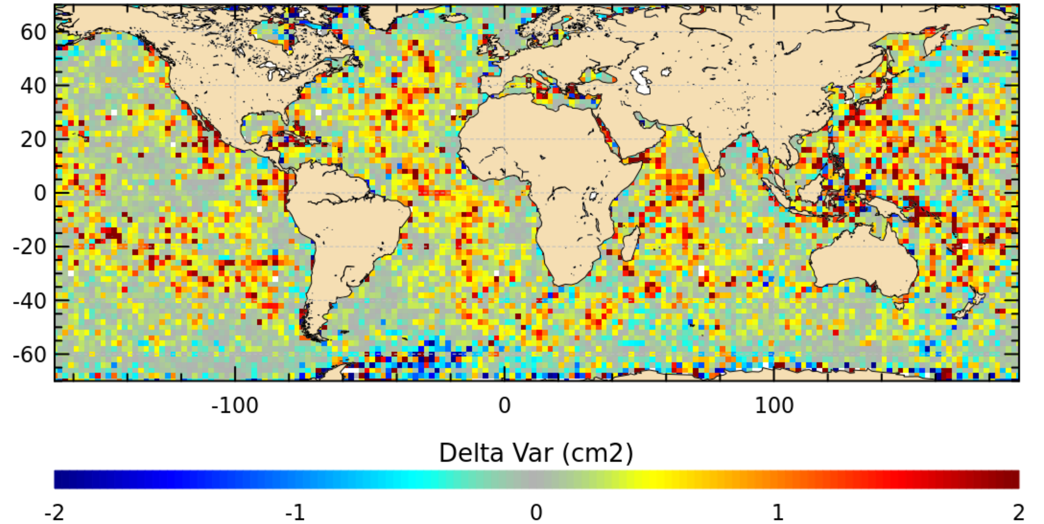
MSS errors along S3A tracks

Var(error MSS_CNES_CLS15)
Λ=[10, 100km]



➢MSS_CNES_CLS_2015 Errors larger in East Pacific areas and on local geodetic structures

Var(error MSS_CNES_CLS11) –
Var(error MSS_CNES_CLS15)
Λ=[10, 100km]



➢Error reduction mainly along geodetic structures when comparing MSS_CNES_CLS15 with MSS_CNES_CLS11: locally more than 2 cm² at wavelengths [10, 100km]

Contribution of geodetic measurements

MSS errors along Sentinel-3A tracks

$$0.5\,V(H_A - H_B) - 0.5\,V(H_A + H_B) = 2\,V(e)$$

Mean error at wavelength 100-30km:

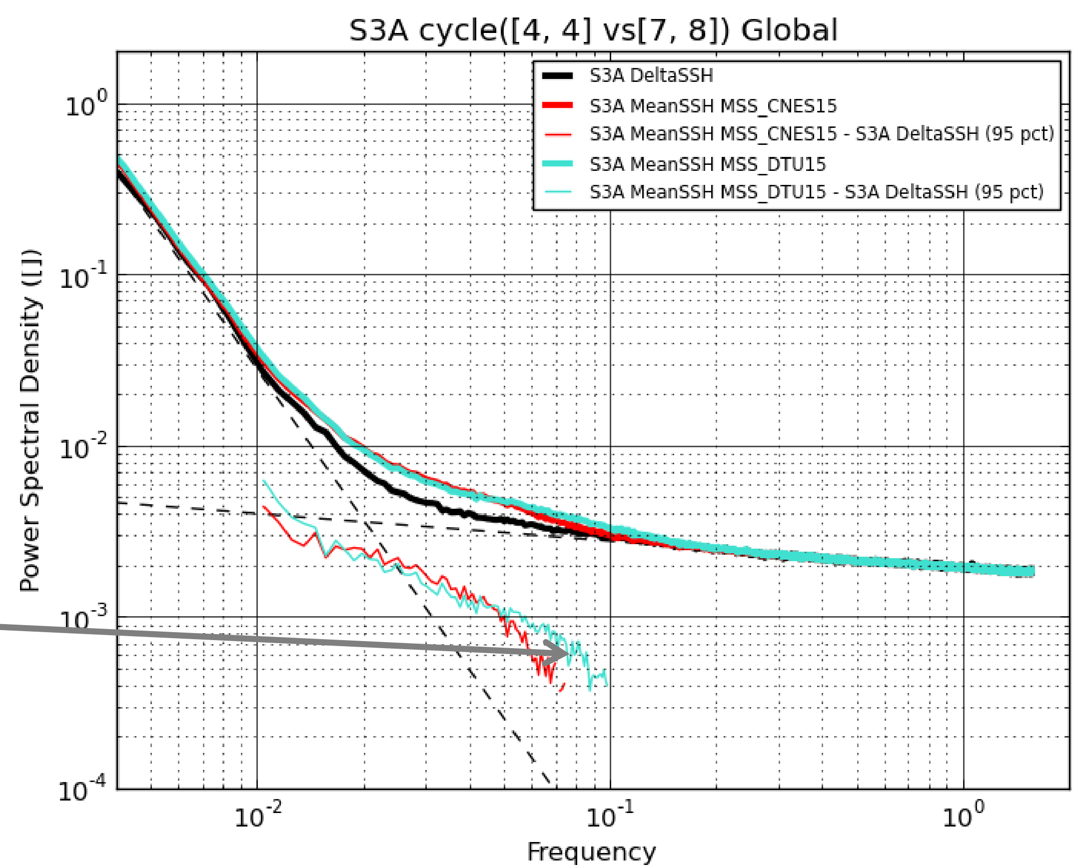
MSS_CNES_CLS11: 0.82 cm (72% of signal variance)

MSS_CNES_CLS15: 0.52 cm (29%)

MSS_DTU15: 0.53 cm (30%)

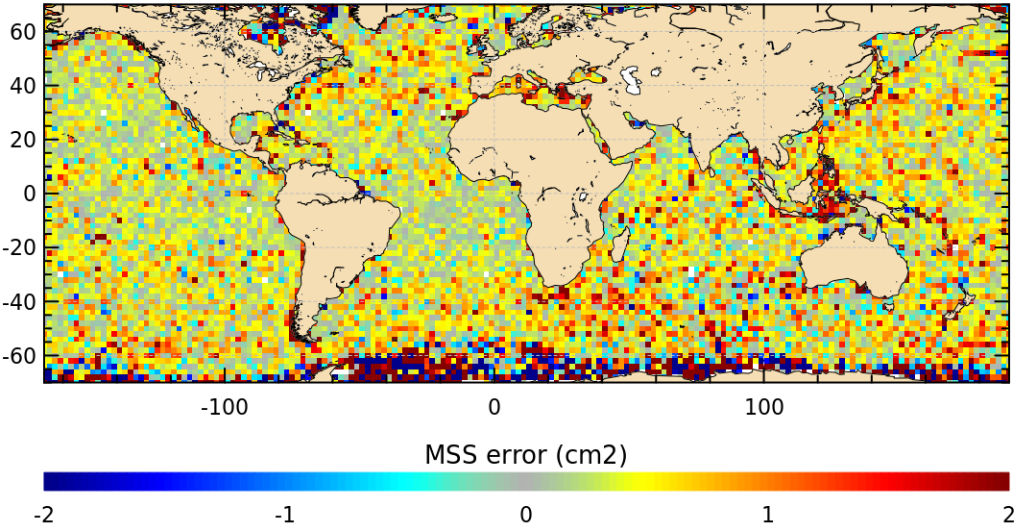
Nearly the same error budget as MSS_CNES_CLS15 for wavelengths 100-30km

Additional MSS error for MSS_DTU15 for wavelengths < 20km → noise-like signal on MSS ?



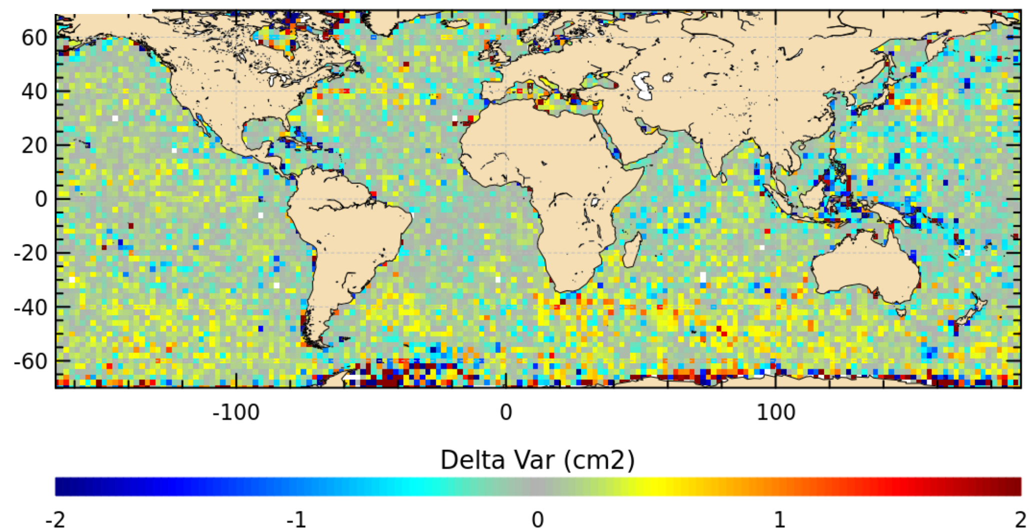
MSS errors along S3A tracks

Var(error MSS_DTU_2015)
Λ=[10, 100km]



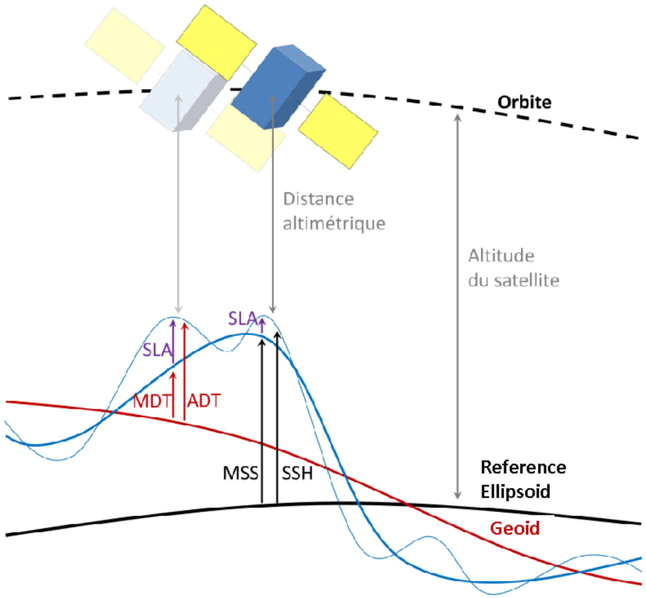
➢Homogeneous MSS_DTU15 Errors . Slightly larger on high variability areas

Var(error MSS_DTU15) – Var(error MSS_CNES_CLS15)
Λ=[10, 100km]



➢Nearly the same capability of retrieving geodetic structures in both the MSS CNES_CLS15 and DTU15 solutions
➢Error reduction with DTU15 mainly in Indonesian area.
➢Larger errors with DTU15 in high variability areas: commission error

Signature of the MSS commission error on SLA



SSH = Sea Surface Height above ellipsoid
MSS = Mean SSH
SLA = Sea Level Anomaly above MSS: SLA = SSH-MSS

MSS and its error e

$$SLA' = SSH - (MSS + e)$$

$$V(SLA') = V(SLA) + V(e) - 2C(SLA, e)$$

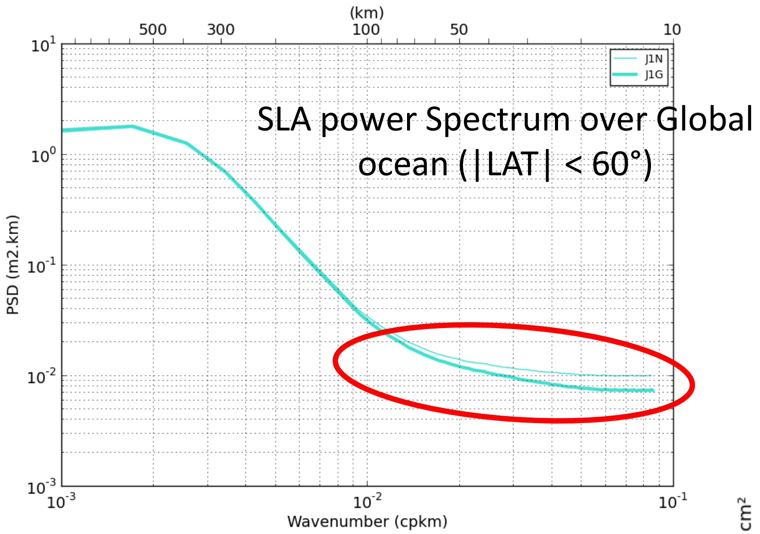
SLA signal and MSS errors are expected to be decorrelated : C(SLA, e) = 0
It is not the case when a fraction of the dynamical signal is in the MSS = ocean surface variability not accurately corrected
➔ In that case, **the variance of the SLA is under-estimated**

Test case: SLA along Jason-1 geodetic tracks , when Jason-1 geodetic is used for the MSS estimation.

Limitation of geodetic measurements

Method: Results: conclusions

SLA analysis along J1N & J1G tracks
Λ=[0, 250km]



MSS_DTU15:

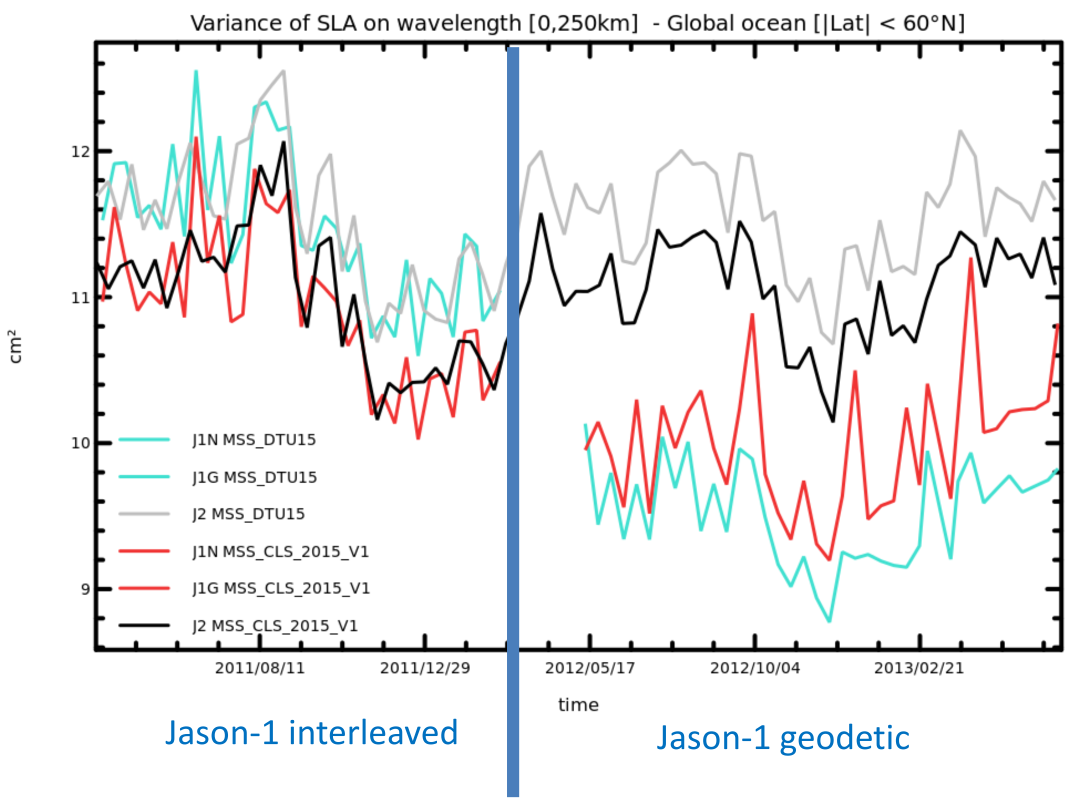
- Loss of SLA variance for wavelength <250km]: -17% (~-1.4 cm rms)

➔ Commission errors suspected: part of the ocean variability and measurement short wavelengths errors observed with J1G are introduced in the MSS

Use of geodetic missions for MSS computation can also introduce commission errors:

MSS_CNES_CLS15:

- Loss of SLA variance for wavelength <250km]: -9.3% (-1 cm rms)



Summary & Conclusions

Previous MSS versions (MSS_CNES_CLS11):

Show significant omission errors at wavelengths ~100-30 km :

- Geodetic structures inaccurately retrieved at these wavelengths. MSS errors are a limitation for observation of wavelengths < ~70km (MSS error > SLA signal)

Up-to-date MSS (MSS_CNES_CLS15 & MSS_DTU15):

Omission errors largely reduced thanks to geodetic measurements at wavelengths ~100-30 km :

- Geodetic structures accurate enough for some applications ➔ MSS_CNES_CLS15 soon in CMEMS products
- MSS errors still < noise measurement for wavelengths < ~100km (S3A red noise hypothesis)
- MSS errors are still a limitation for observation of wavelengths < ~40-30km (MSS error > SLA signal)
- Commission error signature in high variability areas: inaccurate correction of the ocean variability at small wavelengths (and perhaps also measurement noise signature)

Recommendations

Toward Higher resolution MSS:

Omissions errors reduction :

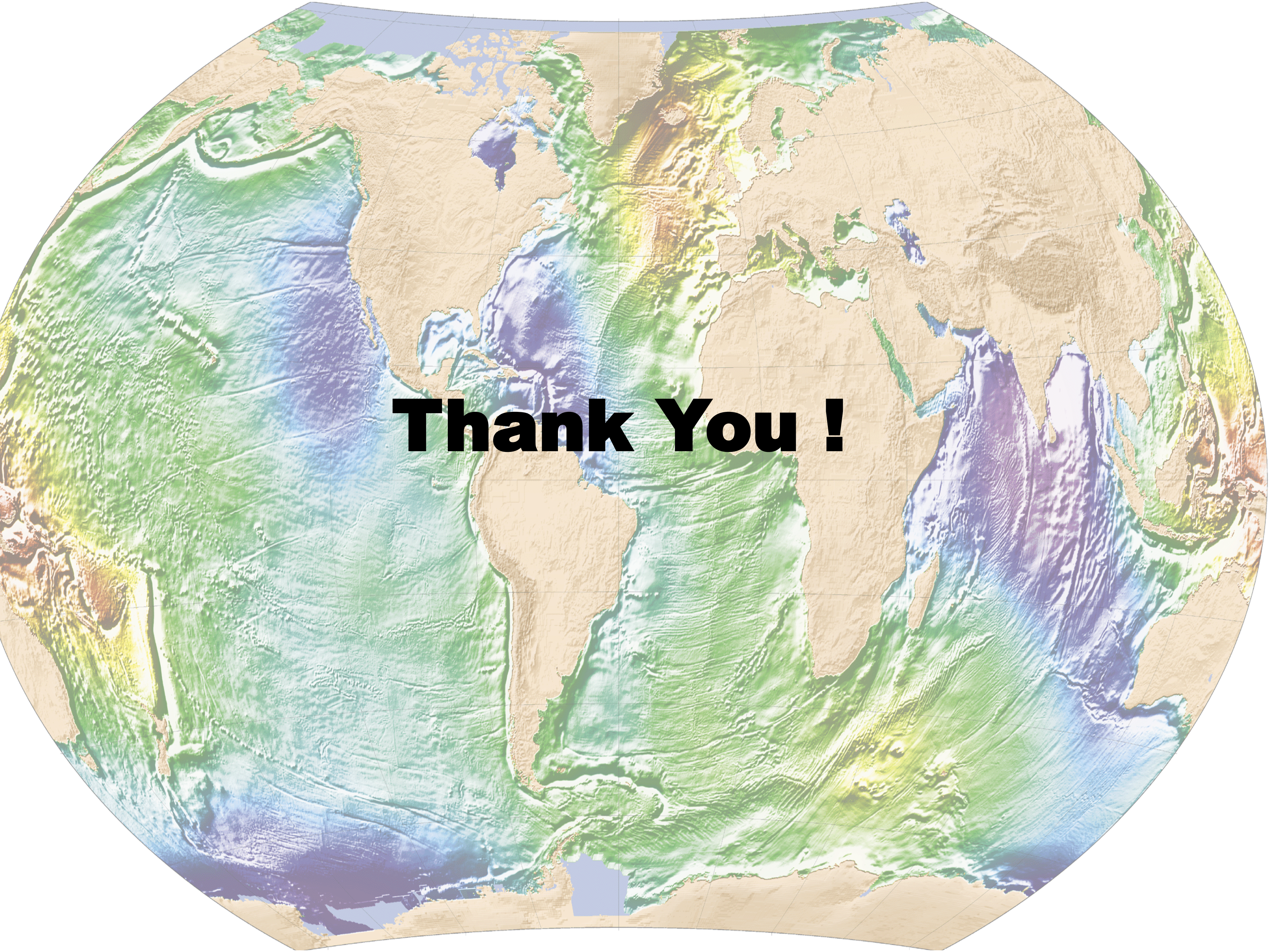
– Use geodetic measurements

– Improve the MP along-track resolution ; use HR measurements

Commissions errors reduction:

– Improve the correction of the ocean variability (especially along geodetic tracks); use geodetic measurements over an extended period.

– Improve reduction of the noise measurement errors (spectral bump and red noises included).


Thank You !