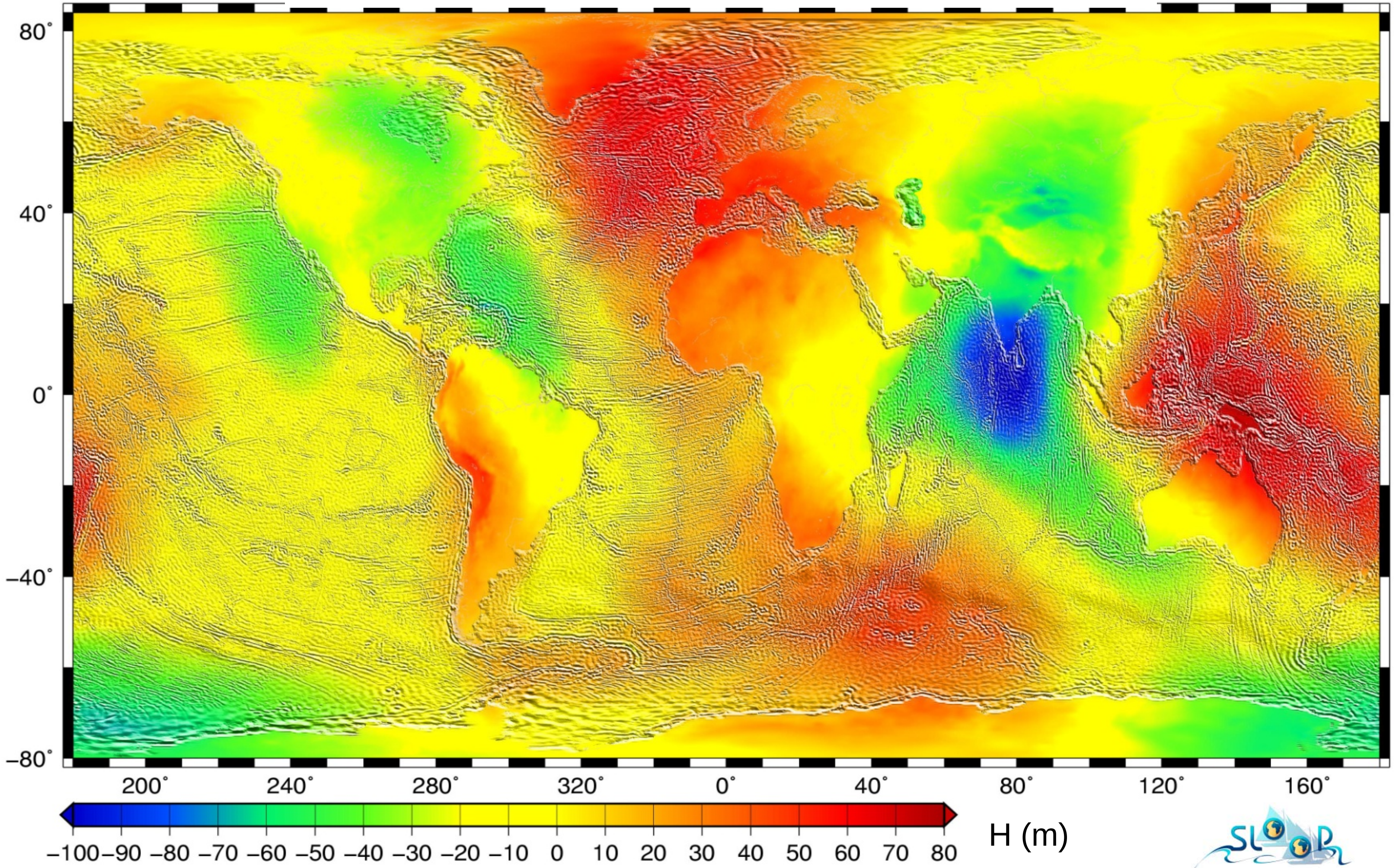
P. Schaeffer, A. Ollivier, Y. Faugere (CLS),
E. Bronner, N. Picot (CNES).

The new CNES CLS 2010 Mean Sea surface



OST-ST, Lisbon, October 2010.

The CNES/CLS 10 MSS

MSS dedicated for oceanographic applications

<u>Characteristics</u>

- **Dataset: using a total of 16 years of altimetric data.**

  ➢ **<u>ERM</u>: T/P, T/P TDM, ERS2 ERM, ENVISAT, Jason-1, and GFO.**

  ➢ **<u>GM</u>: ERS-1**, *no GEOSAT-GM data included because removing of the ocean variability must be improved in regions with strong oceanic activity (Kuroshio).*

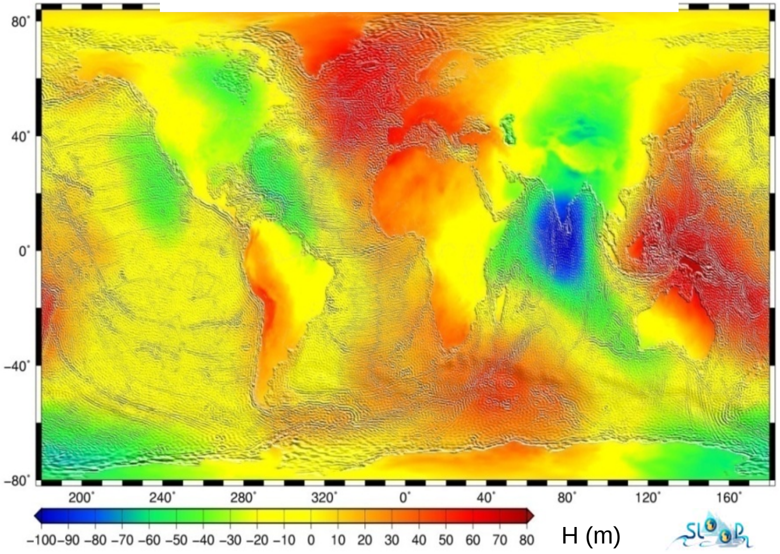
- **Using the T/P + Jason-1 Mean Profile as reference.**

- **Reference: 1993-1999 period**

  ⇒oceanic contents = 7 yrs.

- **Based on GDR-C standard.**

The new CNES CLS 2010 Mean Sea surface



- **Methodology (OI): Anisotropic covariance model, new noise budget (3 components: instrumental, <u>residual effect of the seasonal variability</u>, long wavelength bias).**

- **Over Continents : MSS is connected to the EIGEN_GRACE_5C Geoid model**

  (Foerste, C. et all (2008), EIGEN-GL05C - A new global combined high-resolution GRACE-based gravity field model of the GFZ-GRGS cooperation, presented at the EGU in Vienna).

- **Coverage 80°S / 84°N. Cartesian grid with a step of 2 minutes.**

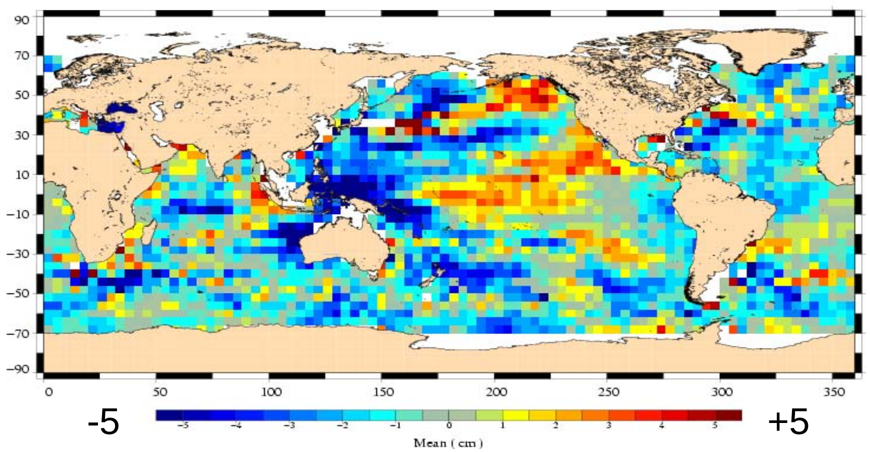
The CNES/CLS 10 MSS

Oceanic variability

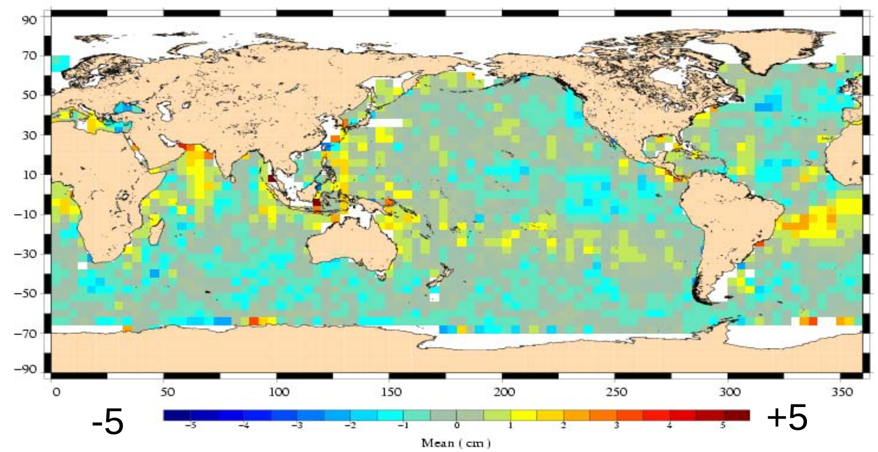
Removal of the oceanic seasonal variability:
one of the most important problems solved by an iterative method !

Impact on the crossover differences of ERS-1/2 MP (**Δt =5 yrs**).

Crossover Differences without correction of variability



Crossover Differences with correction of variability



Without removing the variability: crossover differences frequently exceed 3 cm.

With correction of the variability: most of the differences remain below 2 cm!

FIRST conclusion: it is essential to properly correct the oceanic variability included in the altimetric data before computation of a mean profile, otherwise the MSS may be contaminated by residues of variability (particularly where it is not just cyclical).

The CNES/CLS 10 MSS

Oceanic variability

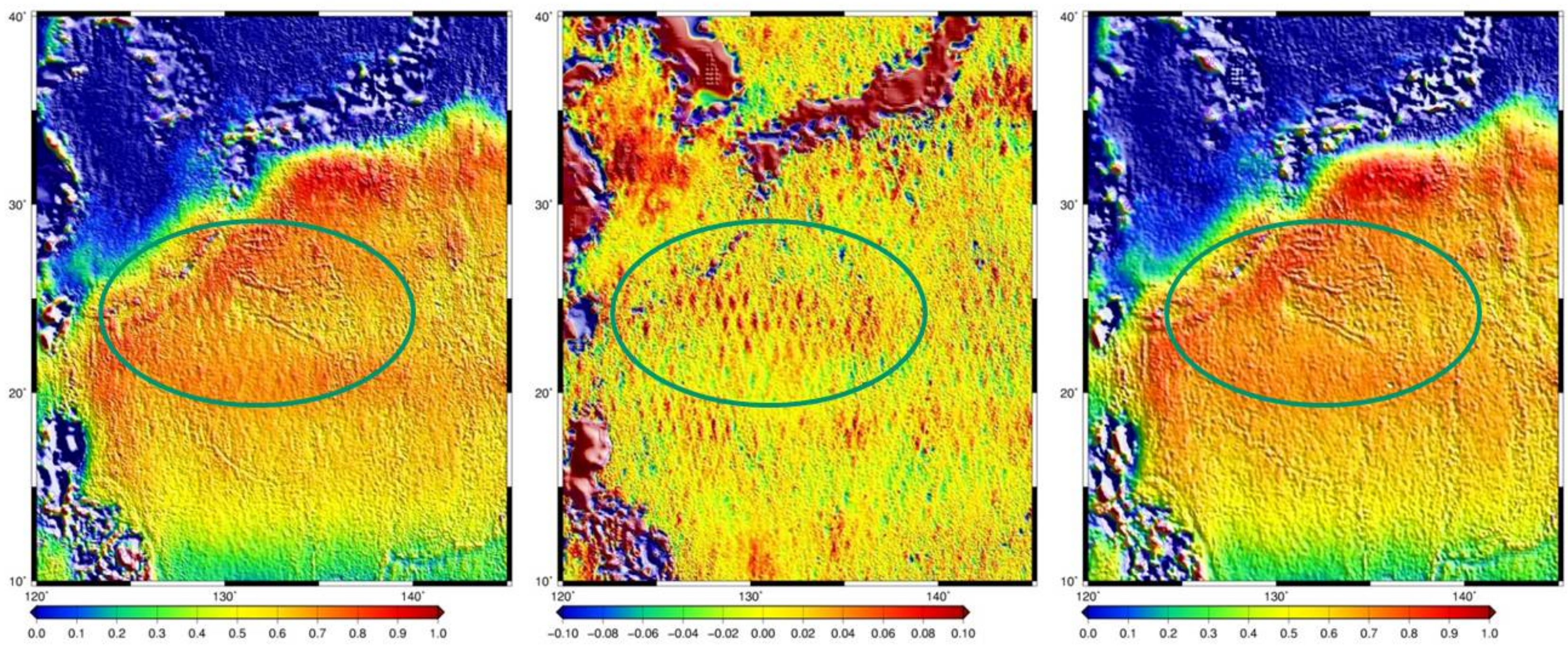
CLS
COLLECTE LOCALISATION SATELLITES

cnes
CENTRE NATIONAL D'ÉTUDES SPATIALES

SALP
Service Altimetrie & Localisation Precise

Improving removing of oceanic variability

CLS01 –EGM08 | Difference (m) | CNES/CLS10 –EGM08



A new modeling of the noise of residual effect of seasonal variability allows a draconian reduction of this effect …..

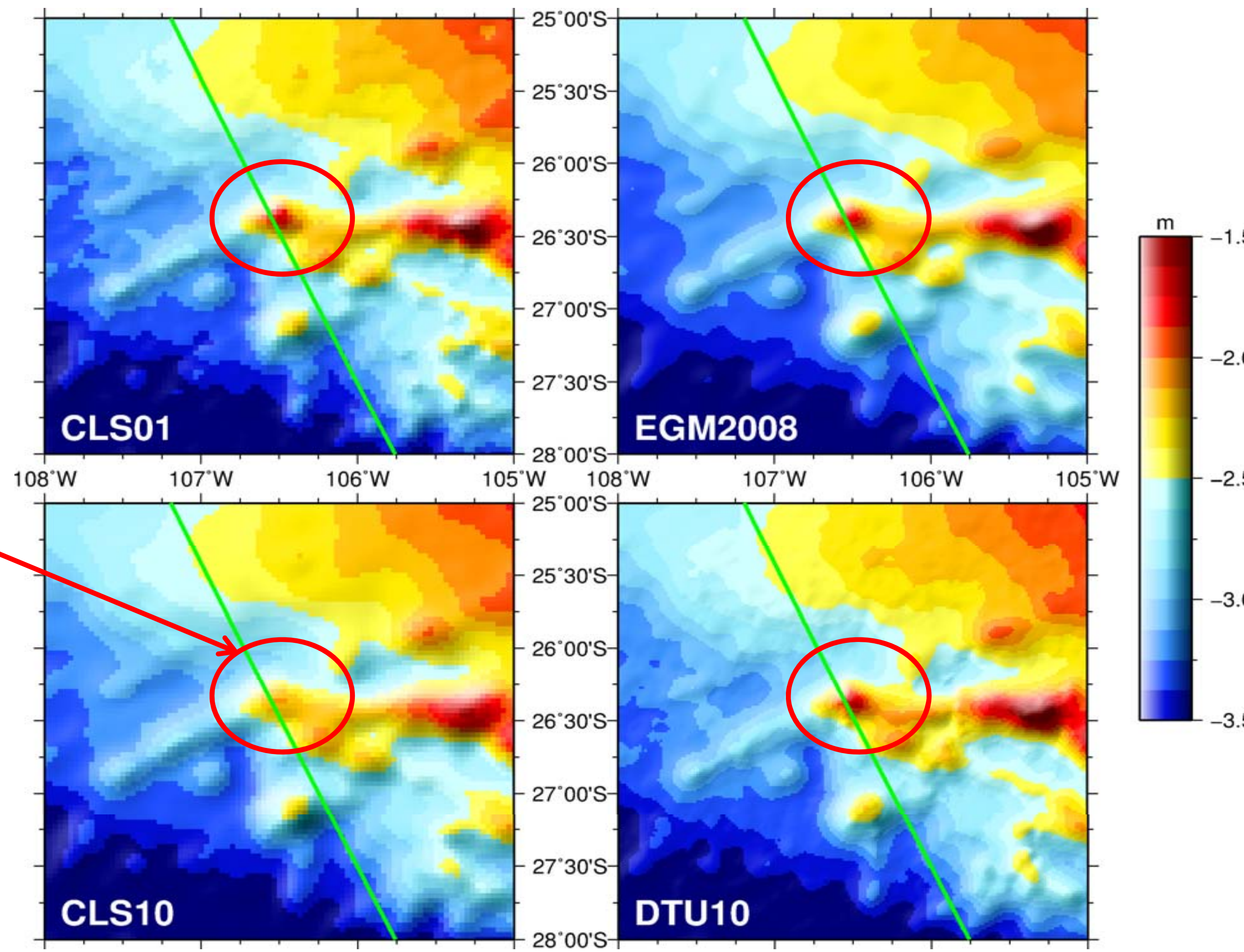
The CNES/CLS 10 MSS
Comparisons between MSS at the shortest wavelengths.

By Walter H. F. Smith & Remko Scharroo

A seamount is strongly smoothed in CNES_CLS10 !

what was happening !

Is it just data, or OI, or both?



The 2010 Phil's BUG!
Comparisons between data &
CNES/CLS10 MSS

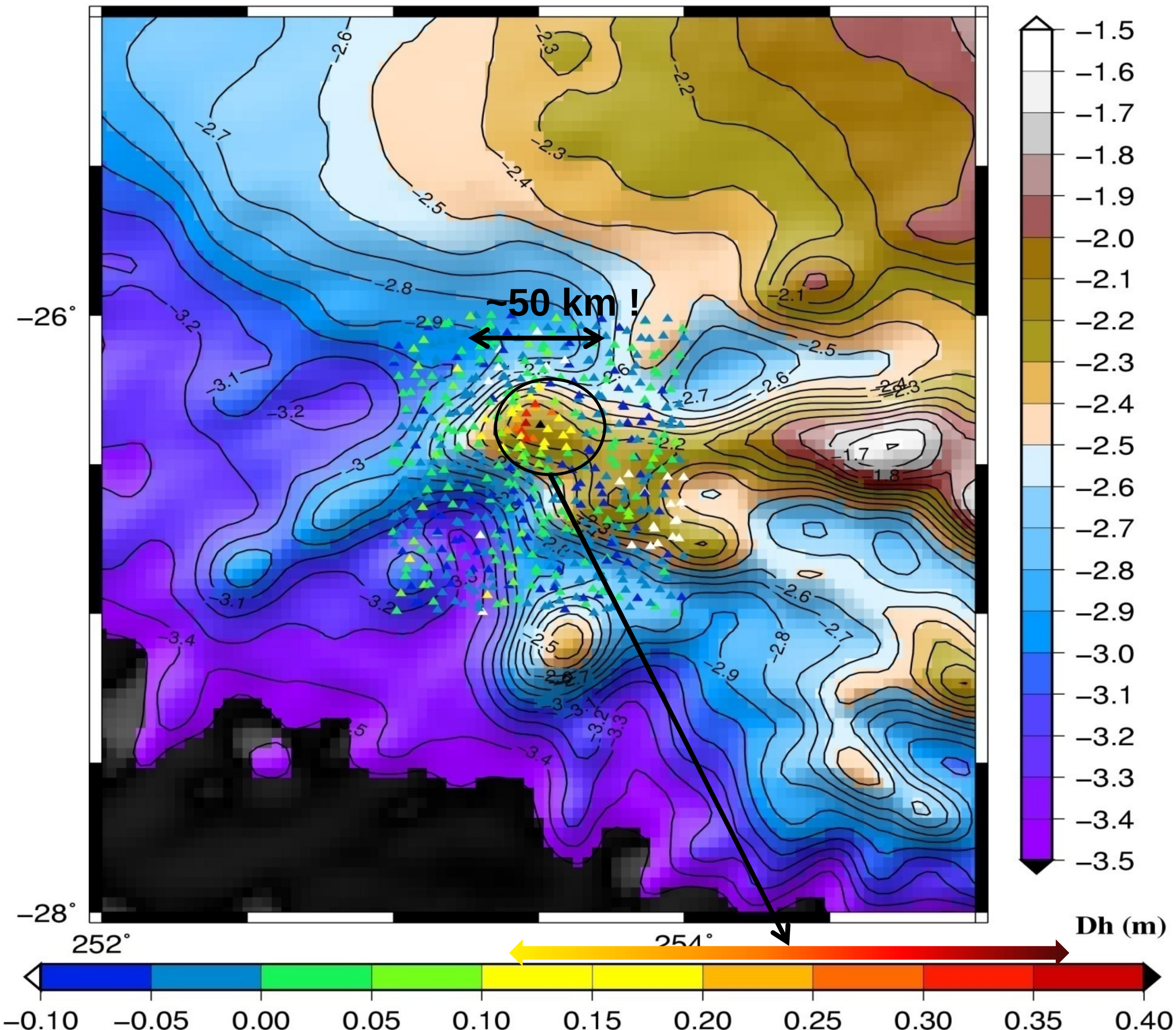
MSS CNES/CLS 2010

Prf – MSS

what has been happening?

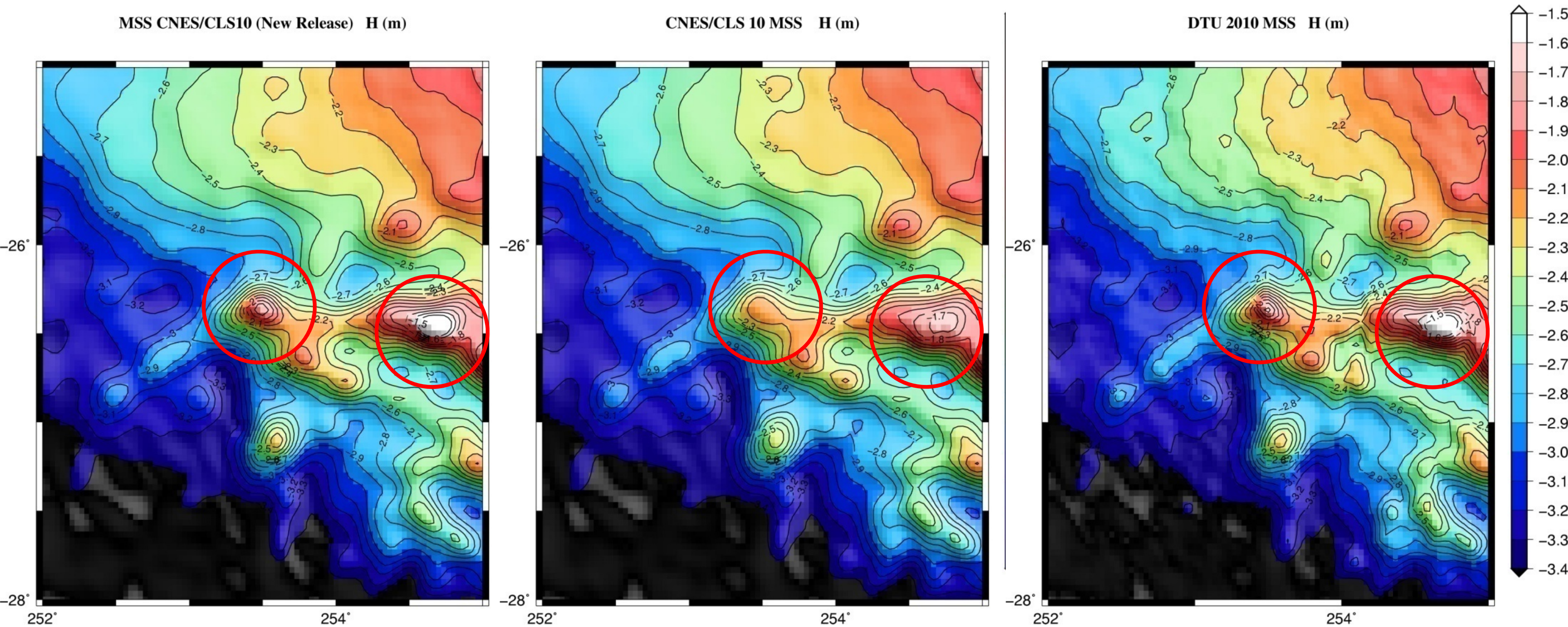
The data in red (E1-GM) were excluded because they are potentially "considered" by the algorithm as an eddy !

On the point of view of my first modeling, the removing of this potential eddy takes over topography.



CNES/CLS 10 & DTU 10 MSS
Comparisons between MSS at the shortest wavelengths.

The bug is been corrected by changing the behavior of the algorithm…



… without altering its ability to remove residues of variability !

The CNES/CLS 10 MSS
Differences between data and MSS.
ERS-1 GM & Mean Profiles

Global grid represent ≈ 40 10^6 points. Data represent ≈ 18 10^6 observations

[Dh > 20 cm] → 0.2 %

Include E1-GM data with bias (not only the "bug")

[Dh > 30 cm] → 0.05 %

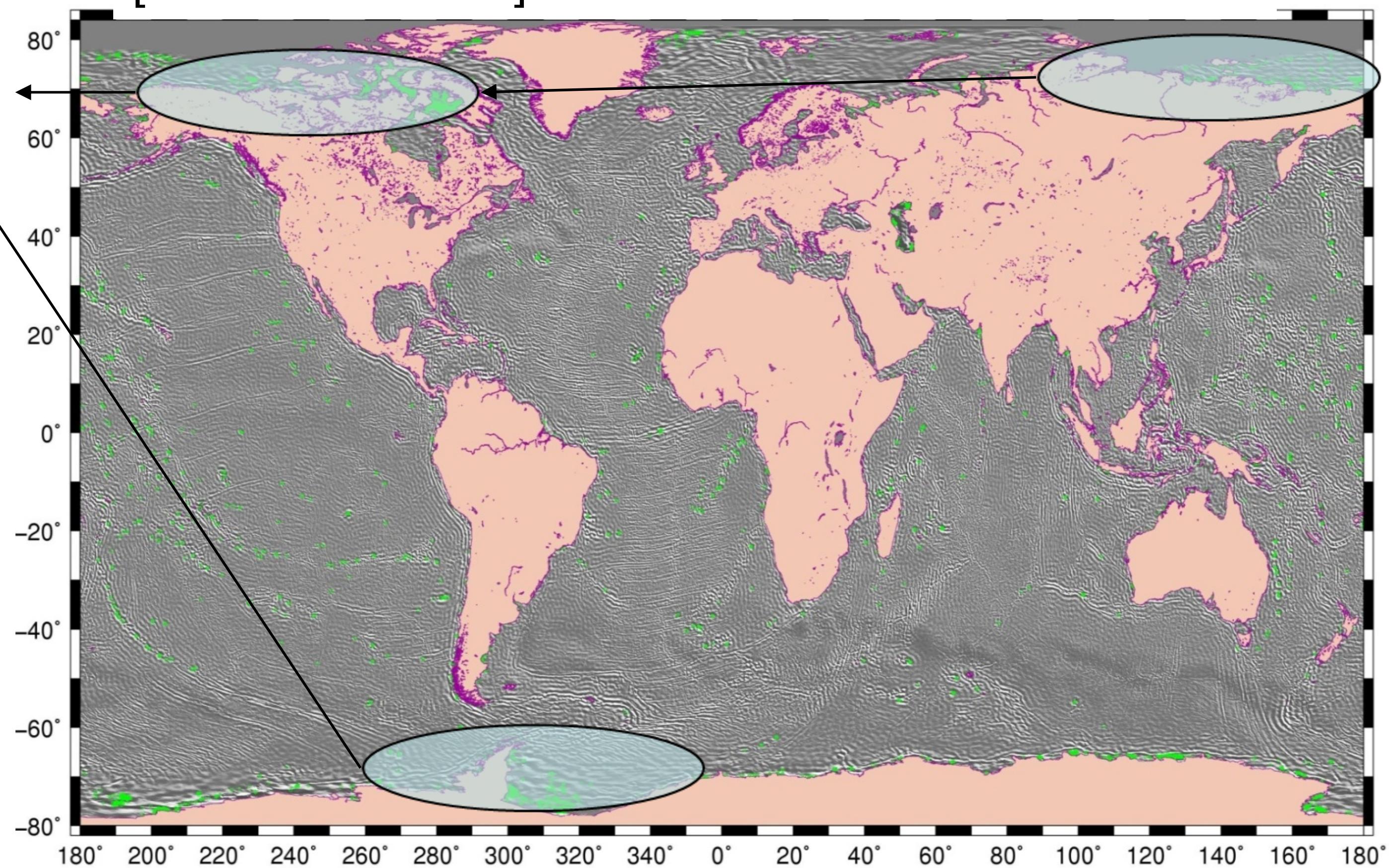
[Dh > 30 cm] < 0.01 %

[Dh > 40 cm] → 0.01 %

[Dh > 50 cm] = 0

The problem to be corrected !

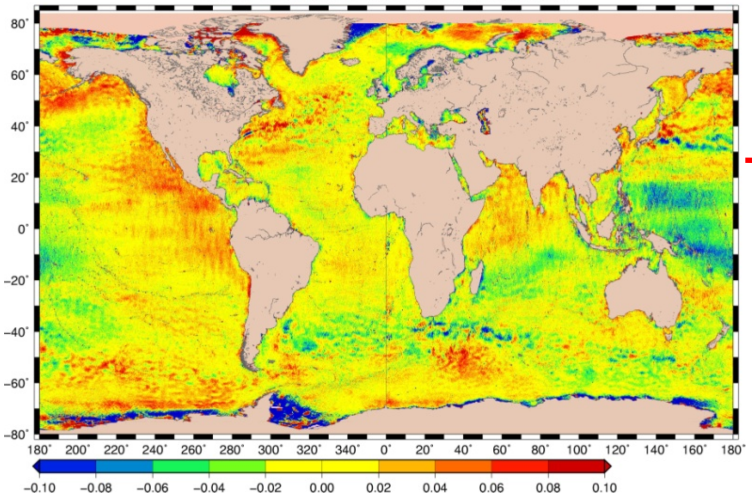
[MP + ERS-1 GM] – MSS CNES/CLS10 Dh > 20 cm



Areas where there is a problem with seasonal variability (poorly defined).

The CNES/CLS 10 MSS Comparisons with DTU10 MSS

CNES/CLS10 – DTU10



Difference is dominated by interannual variability.

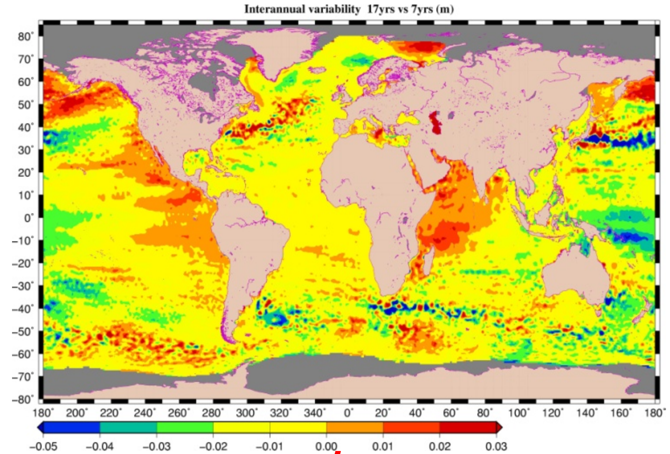
Impact of the reference period

17 yrs (DTU)

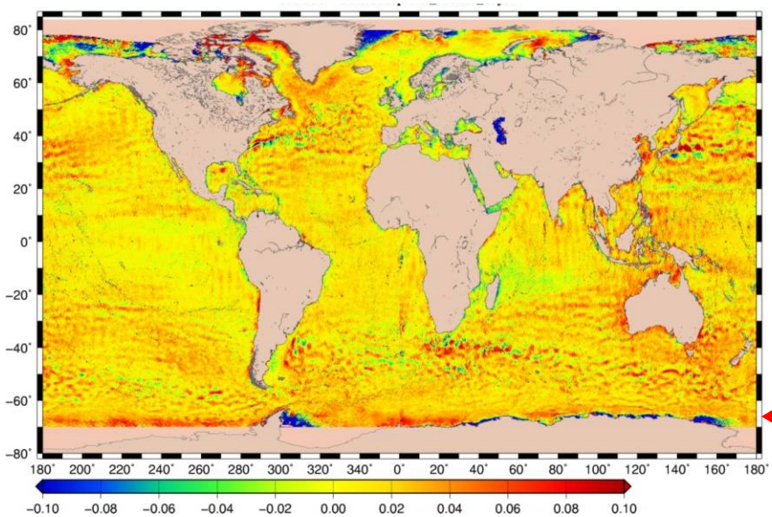
vs.

7 yrs (CLS/CNES)

Interannual Variabilty (17yrs vs 7yrs)



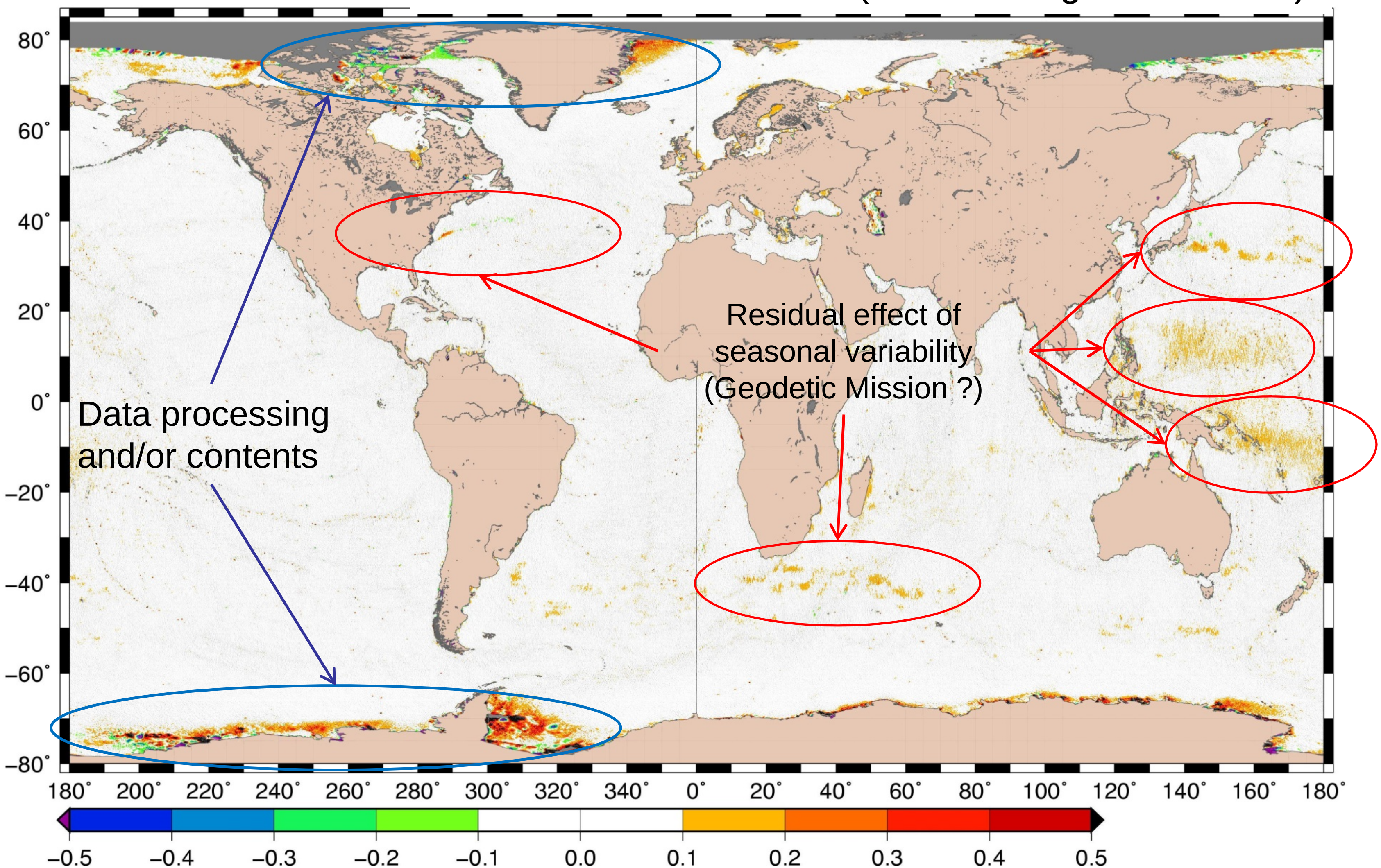
CNES/CLS10 – DTU10 (IntVar removed)



On the difference between the two MSS, we find that there is a residue of ocean variability.

The CNES/CLS 10 MSS
Comparisons with DTU10 MSS

DTU 10 – CNES/CLS10 (considering Dh > 10 cm)



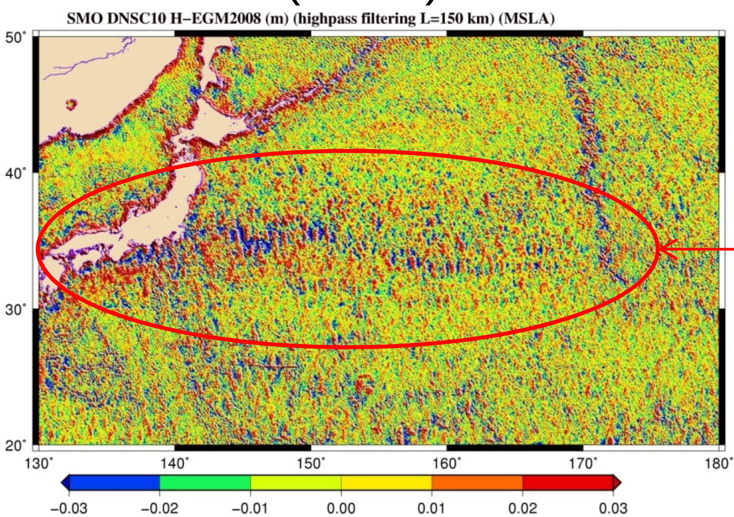
It is particularly difficult to remove the seasonal variability of the geodetic data (no averaging process).

CNES/CLS 10 & DTU 10 MSS

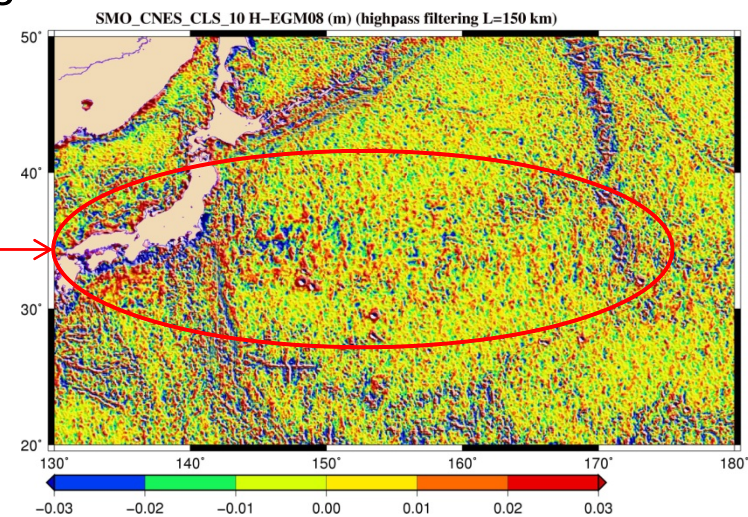
Comparisons with EGM2008

By definition and by construction, the geoid does not contain variability.

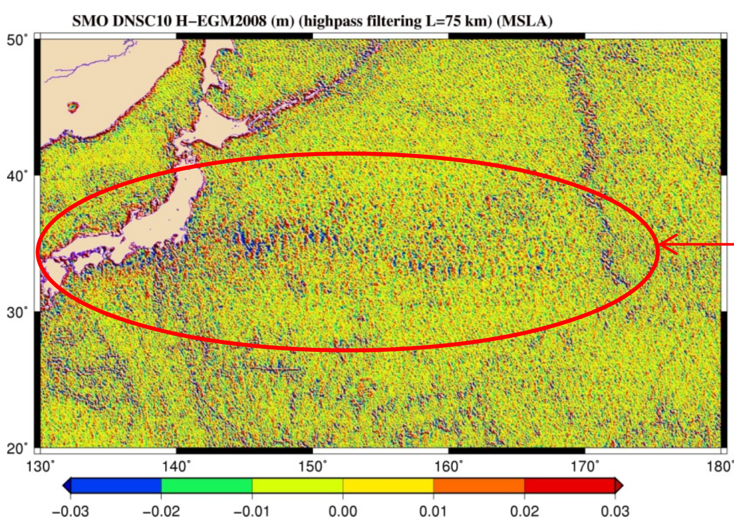
DTU10(IntVar) –EGM2008 Highpass filtering CNES/CLS 10 –EGM2008



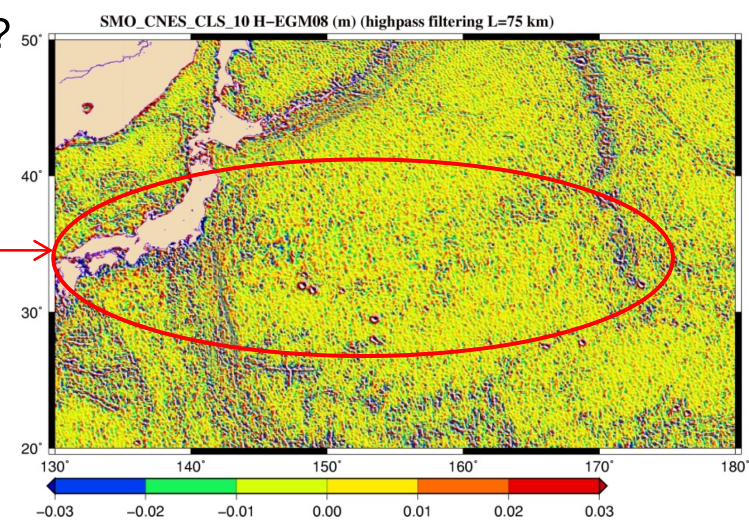
λ < 150 km



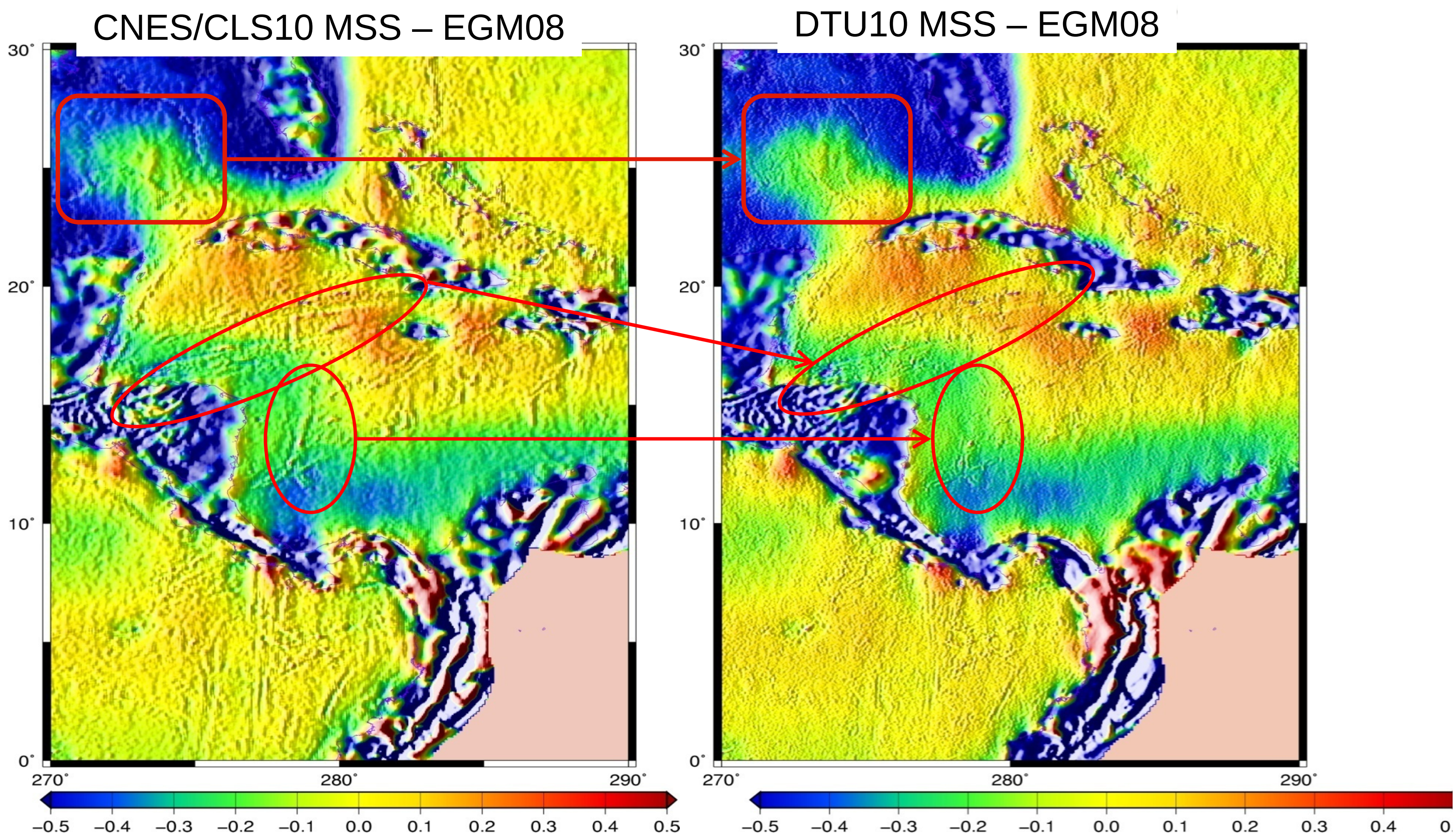
Residual effect of the oceanic variability ?



λ < 75 km



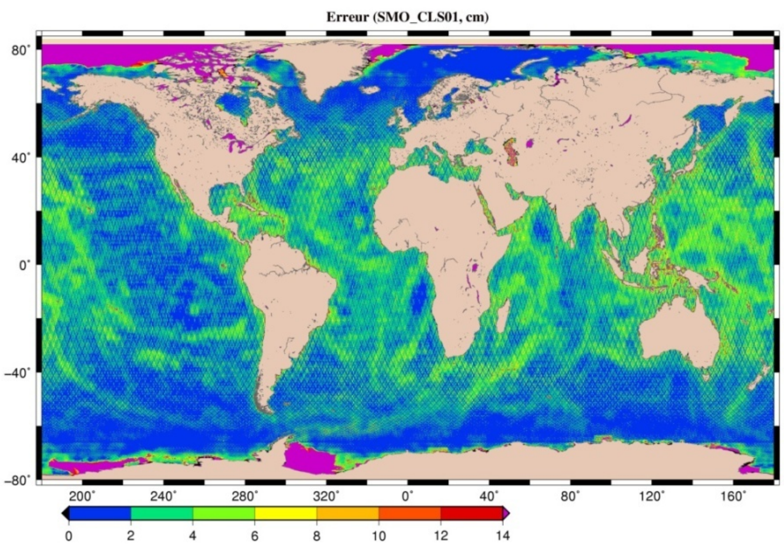
CNES/CLS 10 & DTU 10 MSS
Difference with EGM2008
MSS show a better resolution of the finest structures than EGM2008 !

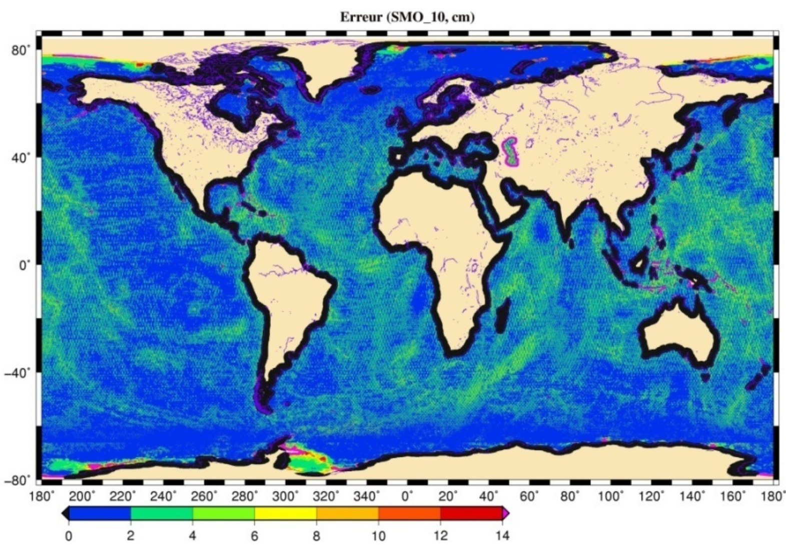


In comparison with EGM08, the two MSS do not have the same content !

The CNES/CLS 10 MSS
Improvement

Improving the accuracies





Error (cm)	Average	Standard deviation	Min/Max
MSS CNES-CLS 2010	**1.9**	**2.1**	**0.2 / 59.0**
MSS CLS 2001	**2.9**	**3.7**	**0.2 / 539.7**

In comparison with the CLS01 MSS : the error of the new MSS is reduced by 50% and the diminution of the standard deviation tends to demonstrate that this new MSS is more homogeneous than the previous one !

The CNES/CLS 10 MSS Improvement

Improving the MSS near the coast:

Mean **P**rofile cm (mm/km)	**MP-CLS01** RMS Dh (std Dh/ds)	**MP-CNES_CLS_10** RMS Dh (std Dh/ds)
T/P + Jason-1	6.4 (2.1)	2.7 (1.2)
Ers2 + EnviSat	6.9 (2.2)	4.6 (1.8)
GFO	9.8 (2.5)	4.7 (1.5)
T/P tandem	7.0 (2.8)	3.5 (1.4)

This table show statistics of along track differences, and gradient differences between the mean profiles and MSS. Results presented here are calculated for the bathymetry lower than 100 m. In comparison with the MSS CLS01: the results obtained with the new MSS CLS_CNES_10 show a great improvement. It is also an indication that the shortest wavelengths are better reproduced.

MSS and GOCE
Comparisons with in situ data (drifter)
MSS – GEOID = MDT

Differences of velocity calculated from the MDT (MSS-GEOID) and in situ data at different wavelengths.

- Red curve is the standard deviation of in situ data.

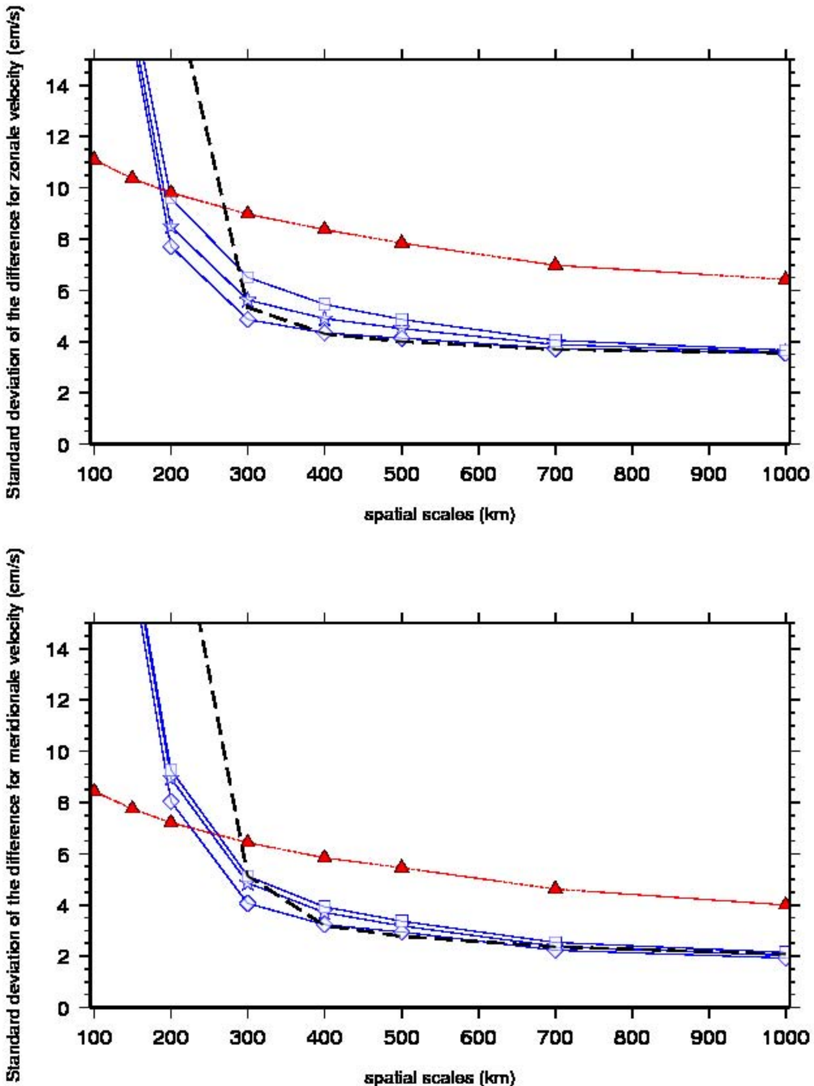
- blue curves are velocity calculated from the difference between the new GOCE model (direct method) respectively with:
  - DNSC08 (blue square),
  - CLS01 (blue star),
  - and CNES/CLS10 (blue diamond),

- black curve is the velocity calculated from CNES/CLS10 and EIGEN_6 geoid model.

Compared to the GRACE results the new results obtained from GOCE show a significant improvement!
Note that result obtained with CNES/CLS10 shows the smallest differences.

By S Mulet (in PhD GOCE/MDT).

GLOBAL ; rouge: EctTyp obs
Ecart type des différences par rayon de filtrage pour les MDT
MSS_CLS01–GOCEdir_L210(étoile bleu),MSS_CNES_CLS10–GOCEdir_L210(losange bleu),
MSS_DNSC08–GOCEdir_L210(carre bleu),MSS_CNES_CLS10–Eigen6(pointillés noirs)



The CNES/CLS 10 MSS
Conclusion

Remember that it is important to remove properly the ocean variability.
It is essential for geodetic data but also for mean profiles!

MSS CNES/CLS10 will be corrected from the « 2010 » bug…

Opportunely we have two MSS for intercomparisons (remark we have only 2 MSS solutions to compare, while there is 6 “GRACE” geoid models and 3 GOCE geoid models).

CNES/CLS 10 MSS is probably the better corrected from oceanic variability.
Thus CNES/CLS10 (after correction) is certainly better suited for oceanographic studies (SLA production and MDT determination for which oceanic contents is the most important).

DTU10 is probably the most precise in high latitude !

The future of the MSS ?

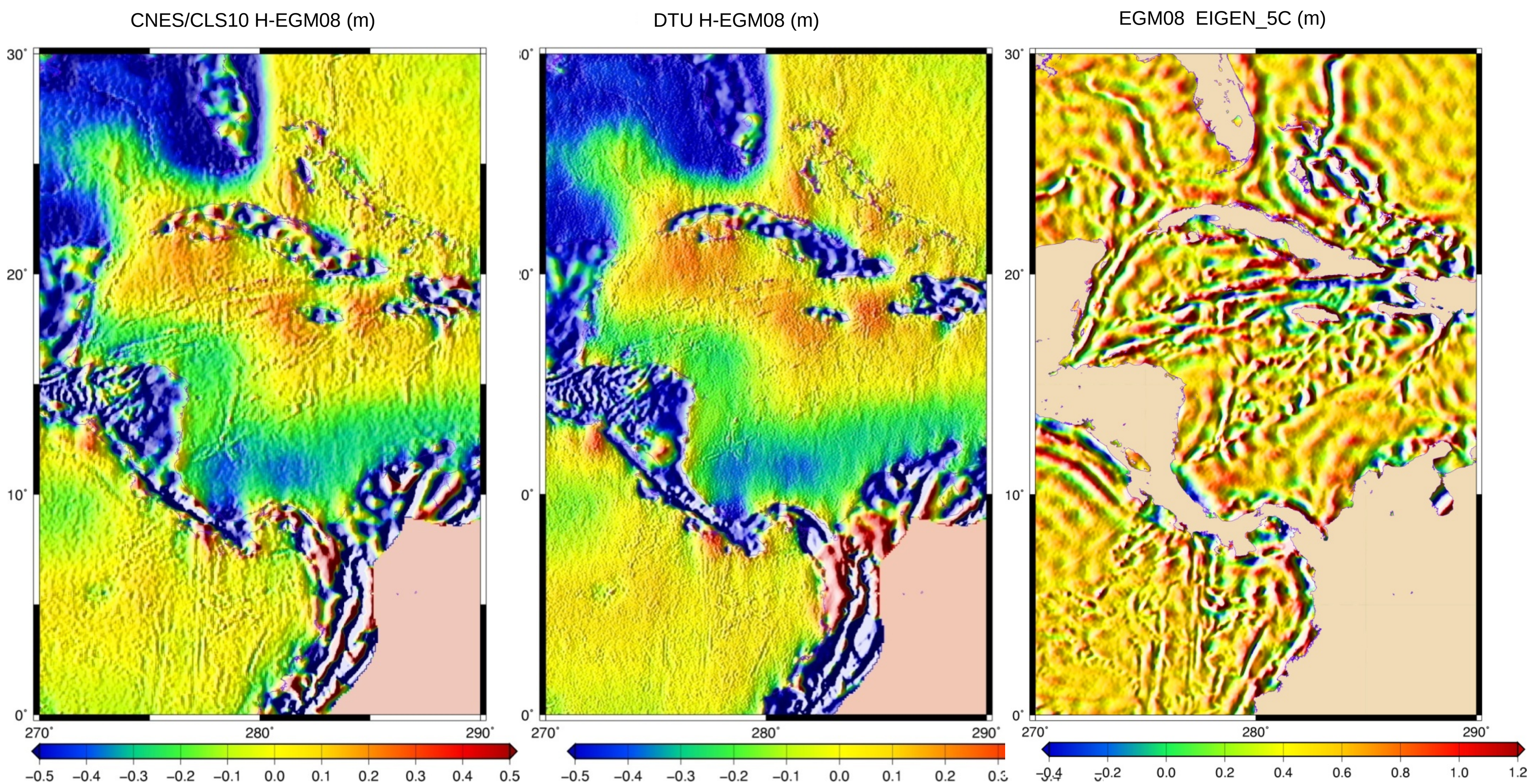
Improve the spatial resolution with:

- retracked ERS-1 GM (10 Hz)
- retracked GEOSAT–GM (10 Hz)

- “retracked” MP (> 5 Hz)

MSS connected with new geoid model like EGM08
(high resolution of geophysical structures)

CNES/CLS 10 & DTU 10 MSS
Comparisons with EGM2008



Differences between MSS and EGM08 show geophysical structures.
We can suppose here that MSS present a higher resolution than EGM2008 (it is wanted).