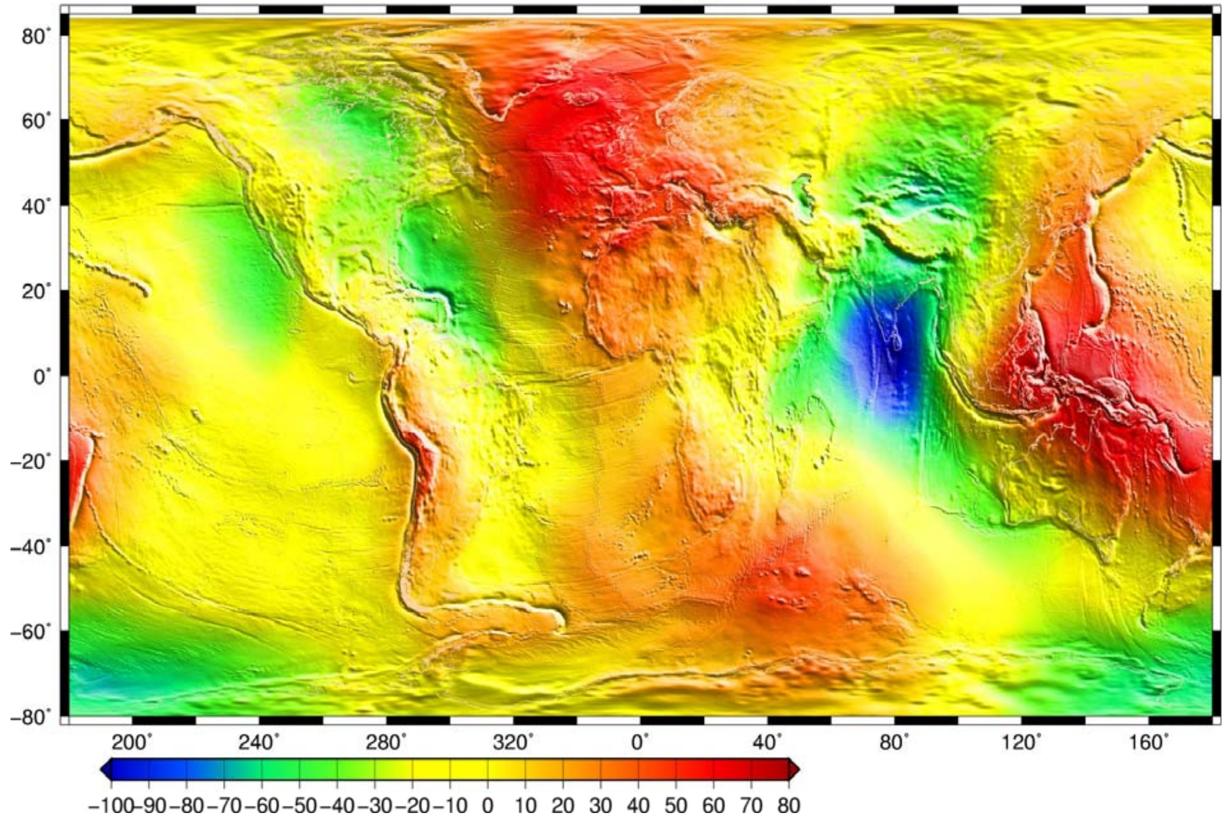
P. Schaeffer, Y. Faugere, JF Legeais (CLS),
N. Picot (CNES).
with validation material kindly provided by Remko Scharroo (Altimetrics) and data provided by Pascal Bonnefond (CERGA)

The CNES CLS 2011 Global Mean Sea surface



OST-ST, San-Diego, October 2011.

Plan

•Data & Processing

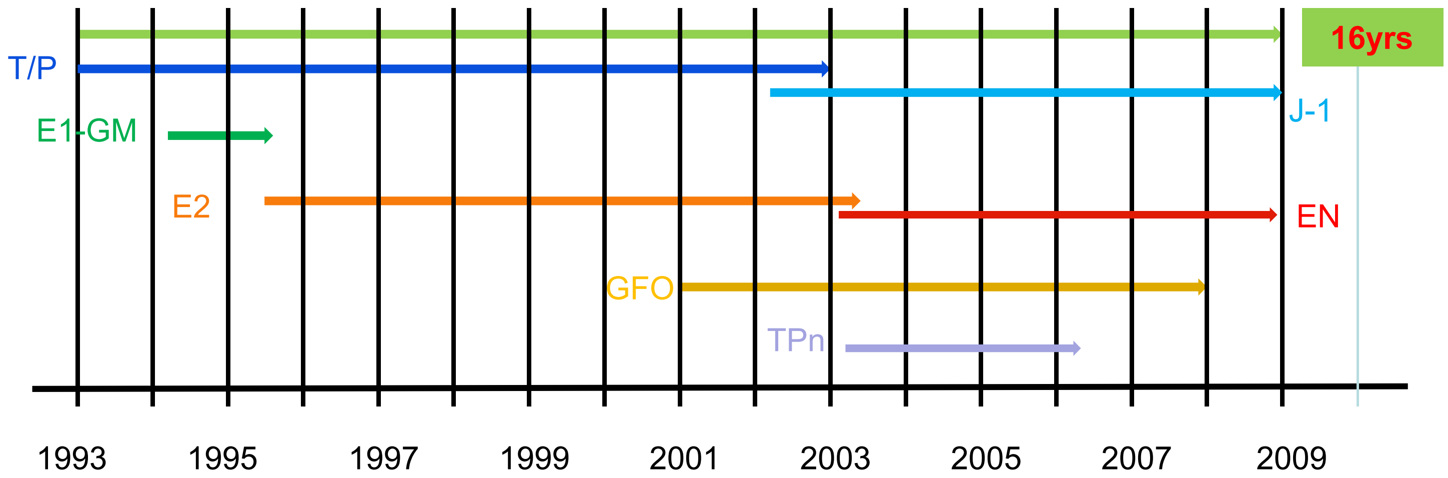
•Comparison to CLS01

•Comparison to DTU10
  ✓Interannual content differences
  ✓Differences at short scales

•Comparison to Regional GPS based MSS

Data & Processing

<u>Dataset</u>: using a total of 16 years of altimetric data (Mean Profiles, SLA, Geodetic Mission)



Reference: 1993-1999 period

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

oceanic contents = 7 yrs (based on MSLA/DUACS)

- **Mean Profiles & E1-GM.**

	TimePeriod	Number of Years	Nb cycles	Std/√2 (Xover)
T/P + Jason-1	1993-2008	16	11-343 + 11-250	0.8
ERS-2 + EnviSat	1995-2008	14	1-85 + 22-72	2.5
GFO	2001-2007	7	37-187	1.4
T/P interlaced	2003-2006	3	369-479	1.4
ERS-1 GM	1994-1995	2*168 days	No cycle	4.4

Unit cm

Xover are used for calibrating the error of the MSS

Data & Processing

- **Computation of Mean Profiles & ERS-1 GM:**
  - ➢ interannual & seasonal oceanic variability corrected from Optimal Analysis of SLA (Le Traon et al, 1998) >>> $\mathbf{SSH_{cor}(t,\lambda,\varphi) = SSH(t,\lambda,\varphi) - OA[SLA^{i}_{(t,\lambda,\varphi)}]}$; i=(1,N) defines a set of SLA surrounding the SSH in a space-time bubble.

- **Computation of the MSS:** Optimal Interpolation (Bretherton et al, 1976)

  - ➢Anisotropic covariance model.
  - ➢ Noise budget (3 components: instrumental, residual effect of the seasonal variability, long wavelength bias).
  - ➢ Calibrated error (Xover).
  - ➢ Over Continents (80/100 km inland) : MSS is connected to the EIGEN_GRACE_5C Geoid model *(Foerste et all, 2008).*
  - ➢ Spatial coverage 80°S / 84°N.
  - ➢Cartesian grid with a step of 2 minutes.

  - ➢Changes for 2011 version versus 2010 version
    - ➢Us of new parameters for inversion
    - ➢Refinement of priori error budgets for geodesic mission

Comparison to CLS01

• **Improvement of the shortest wavelengths (λ<20 km):**
analysis based on the gradient differences between the mean profiles and MSS (RMS in mm/km)

MeanProfil: **TP/J1**

Bathy criteria	CLS01	CNES_CLS10	CNES_CLS11
> 0 m	*0.7*	*0.7*	*0.4*
0-100 m	*2.1*	*1.2*	*1.0*
> 500 m	*0.6*	*0.6*	*0.4*

MeanProfil: **ERS-2/EnviSat**

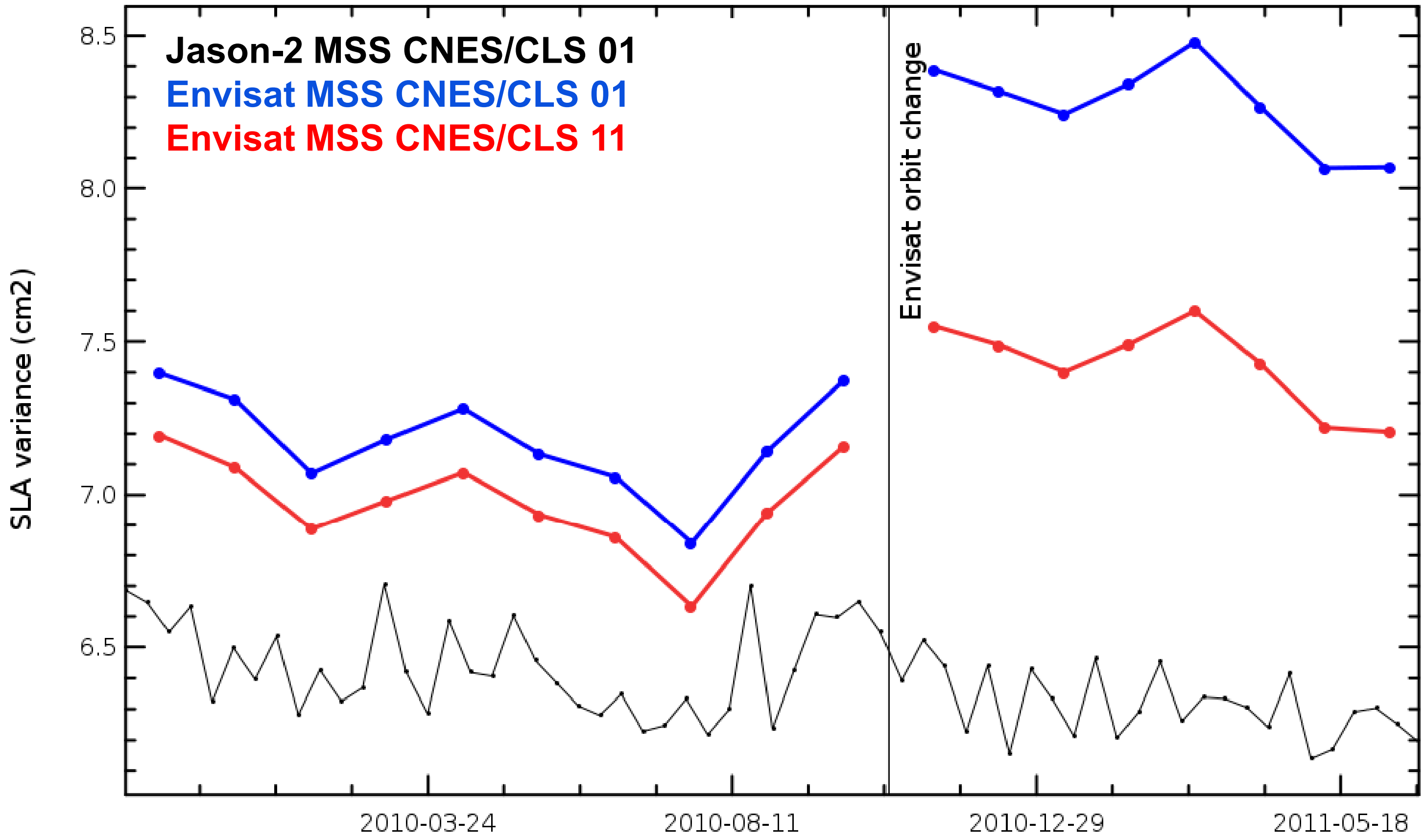
Bathy criteria	CLS01	CNES_CLS10	CNES_CLS11
> 0 m	*1.0*	*1.0*	*0.7*
0-100 m	*2.2*	*1.8*	*1.6*
> 500 m	*0.9*	*0.9*	*0.6*

•Concerning global ocean (B>0 m) and open ocean (B> 500 m) : these statistics shows an improvement of about 50%.

•Concerning areas near the coast (B<100 m): improvement of 30 % for E2/En and 50% for TP/J1.

Comparison to CLS01

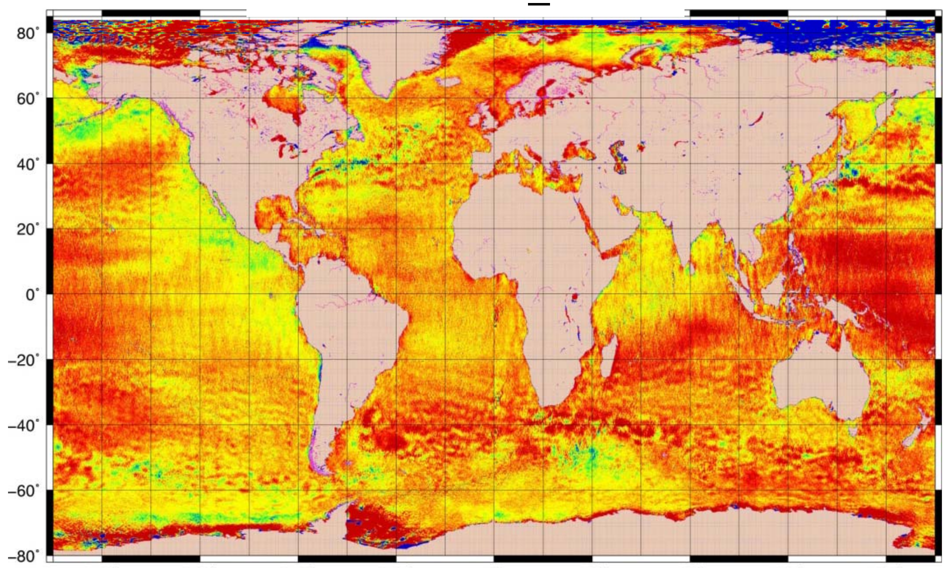
•Computation of SLA variance on Envisat data.
•New ground track from October 2012 => independant dataset for MSS performance assessment.
•Variance of SLA filtered: wavelength <50km and >500km are removed



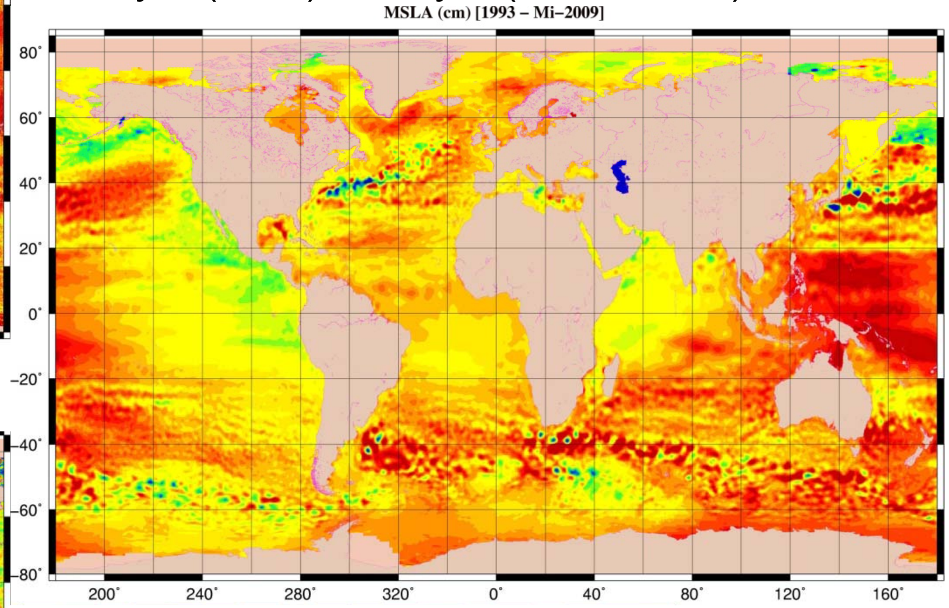
•Degradation on the new ground track strongly reduced when using CNES/CLS11

Comparison to DTU10

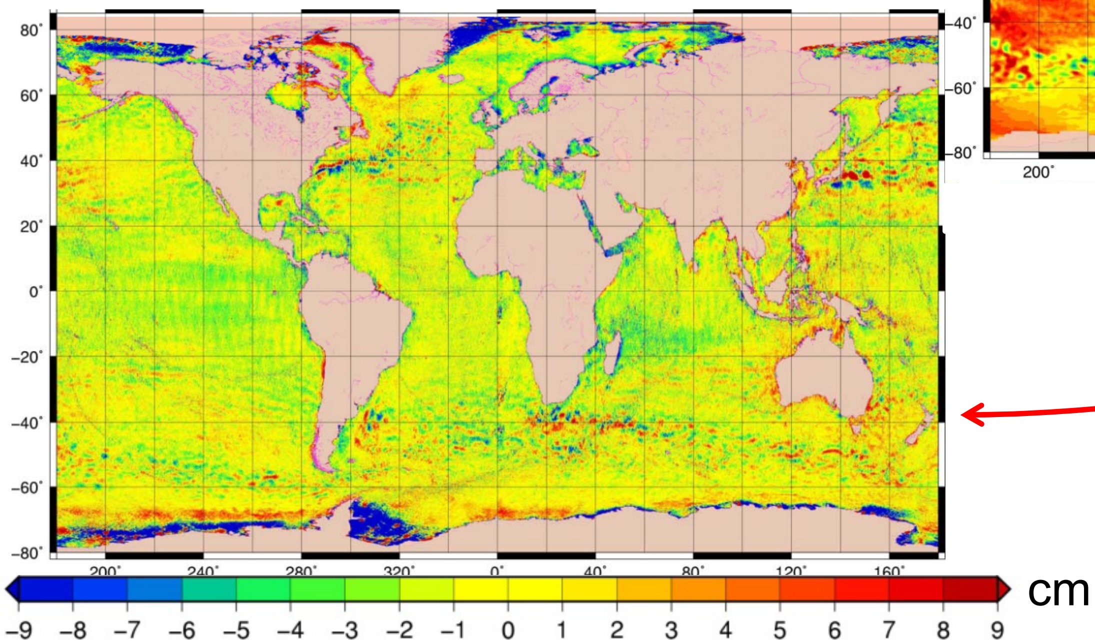
DTU10 – CNES_CLS11



Map of SLA
17 yrs (DTU) vs. 7 yrs (CLS/CNES)

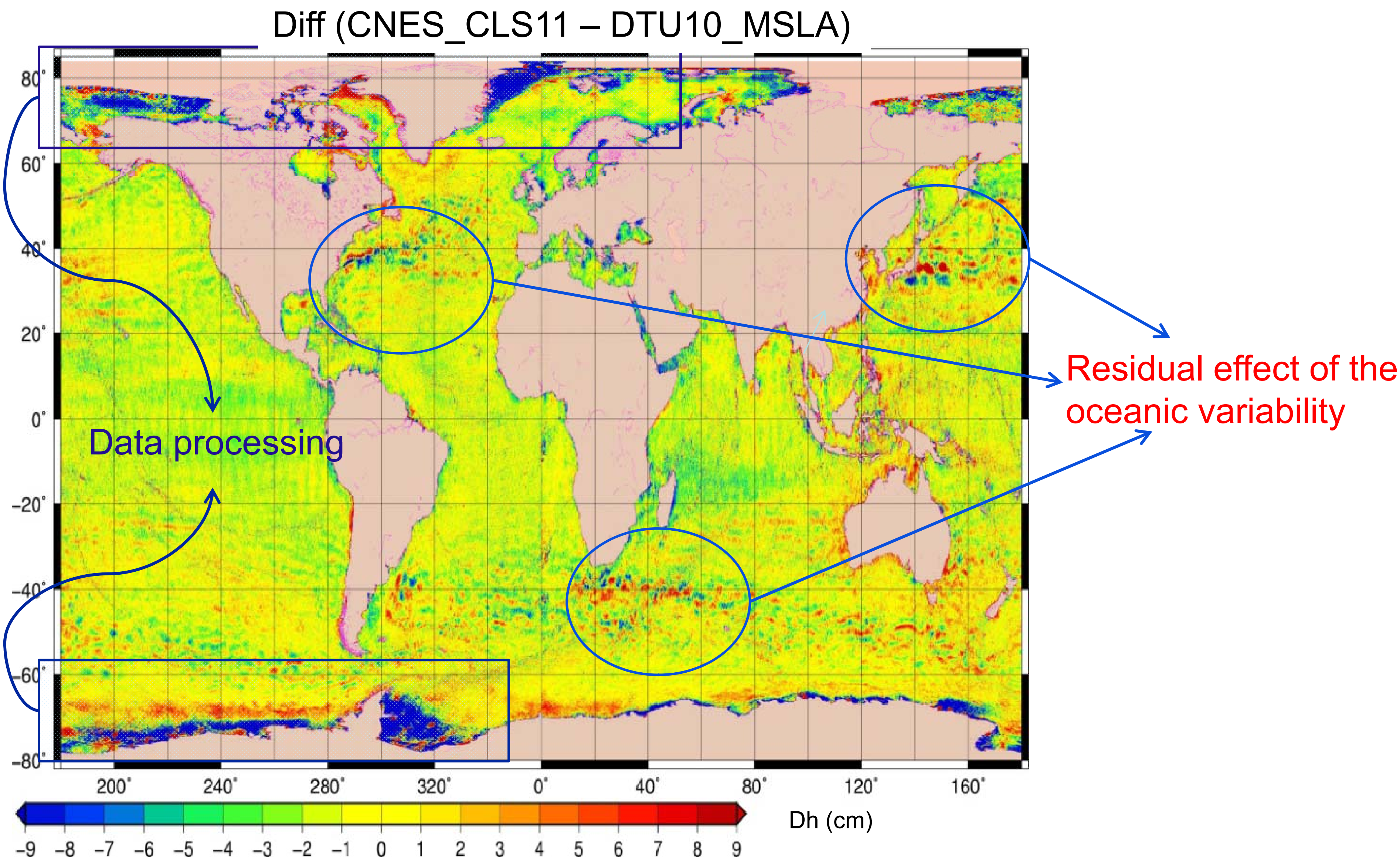


DTU10_MSLA – CNES_CLS11



Difference between MSS (i.e.DTU10 & CNES_CLS11) is dominated by interannual variability.

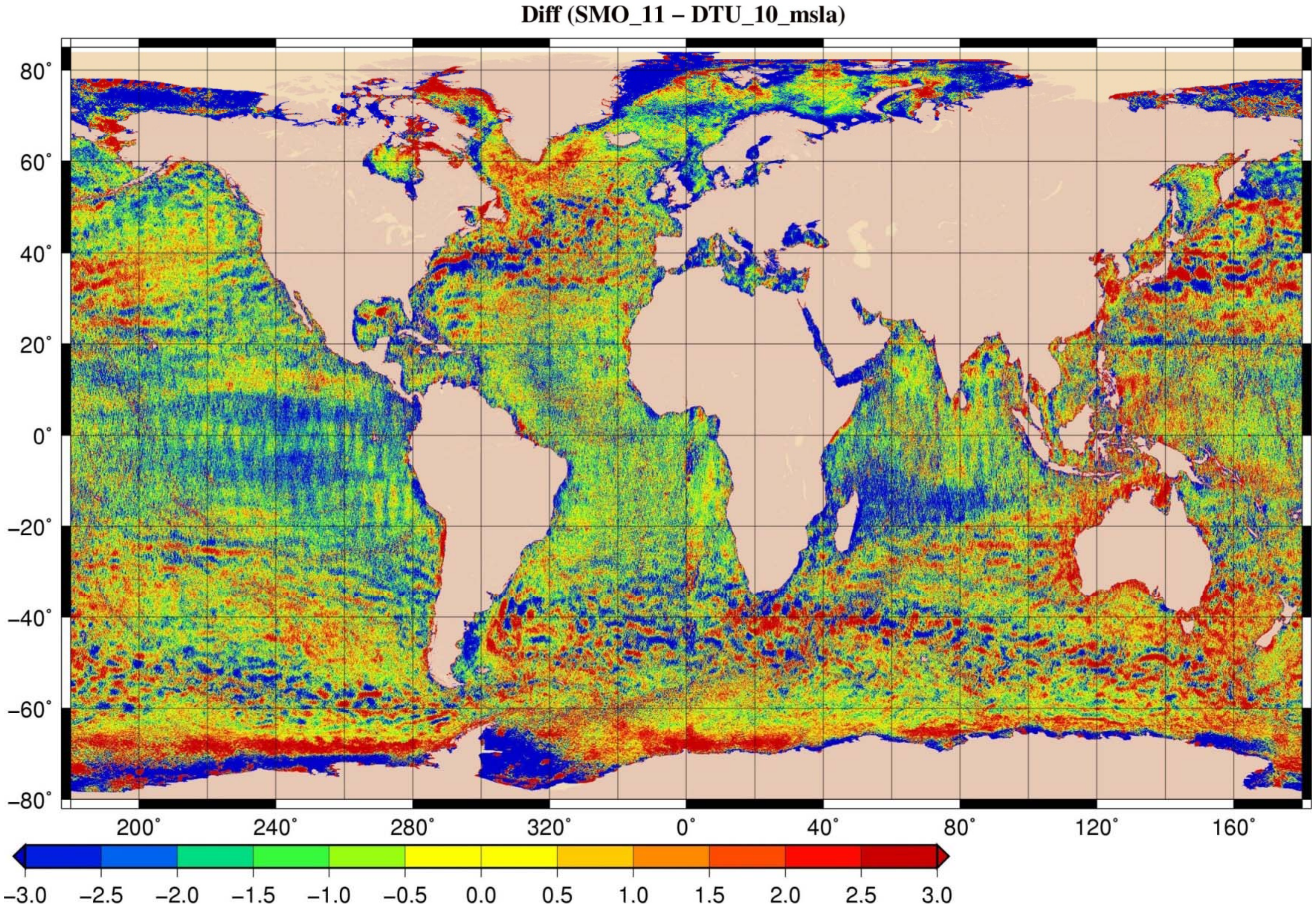
Comparison to DTU10



The difference between the two MSS contains residue of ocean variability and also shows differences concerning the data processing at high latitude.

Comparison to DTU10

Changing the color scale between +/- 3 cm

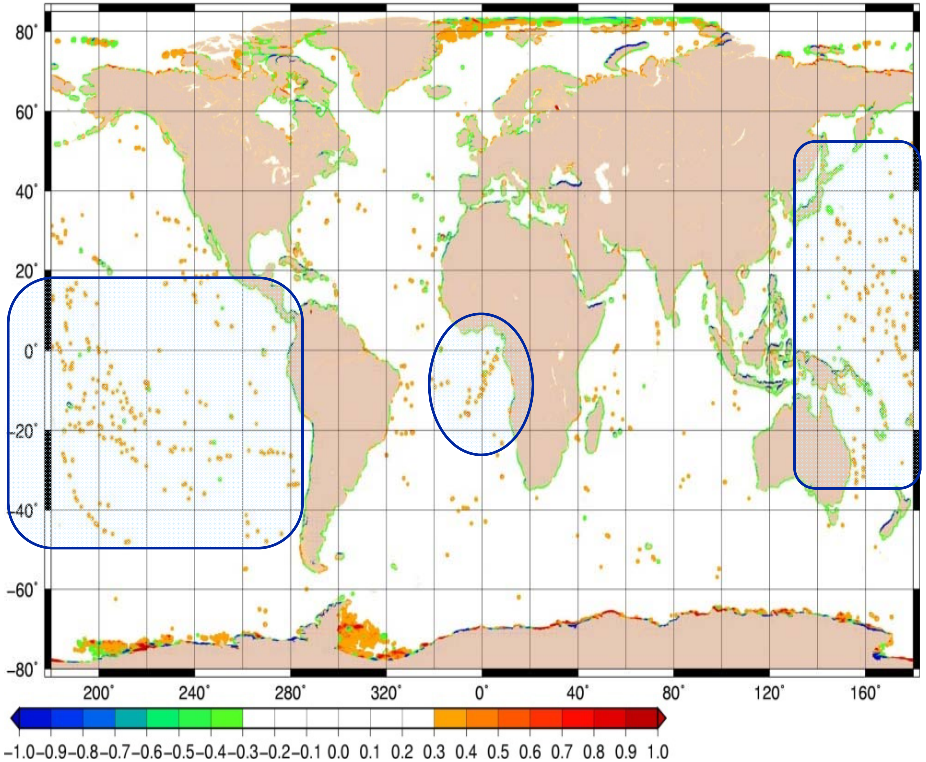


We see the differences in geophysical contents that must be further understand

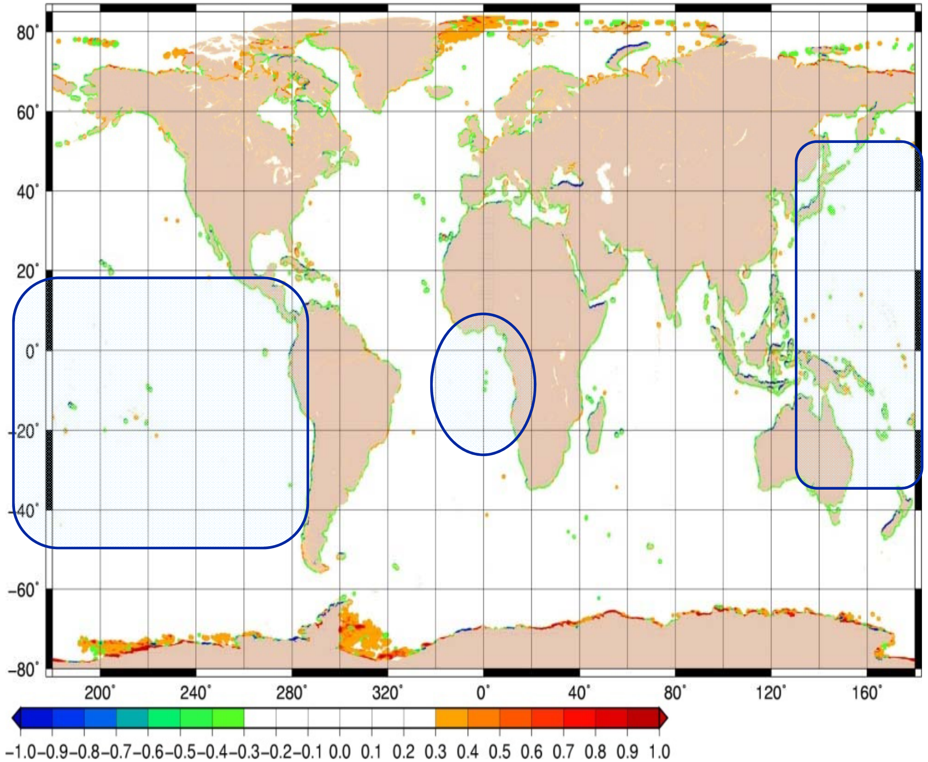
Comparison to DTU10

• **<u>Focusing on specific differences greater than 30 cm:</u>** some seamounts (200-300) were smoothed in the CNES_CLS10 MSS.

MSS CNES_CLS_10 – DTU_10



MSS CNES_CLS_11 – DTU_10

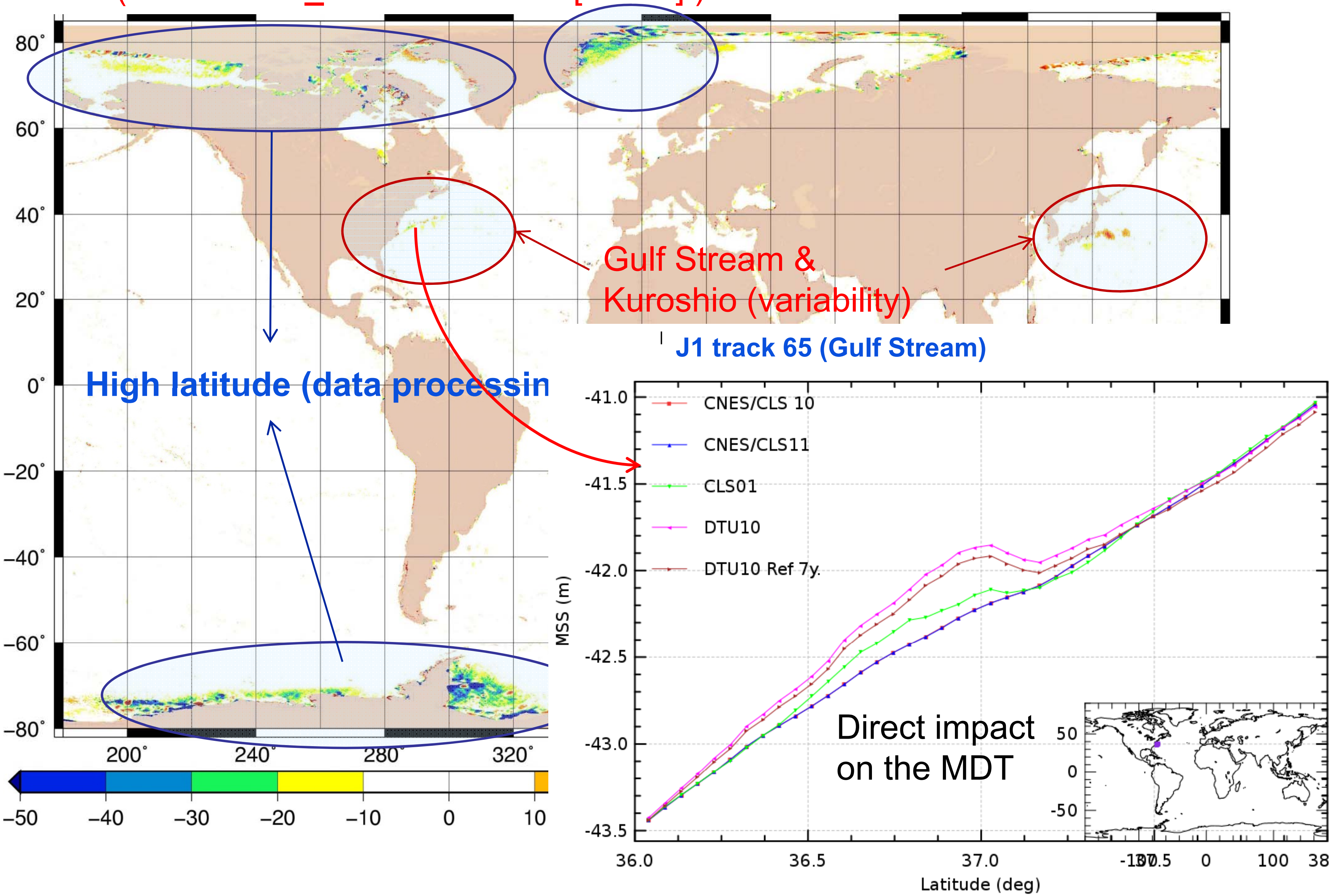


•This issue is corrected in CNES_CLS11.

• remaining differences (Dh>30 cm) are located on the coast (islands and continents). This is due to the difference in the OI (extrapolation of altimetric slope in coastal area, geoids connection, …).

Comparison to DTU10C

Dif (MSS **CNES_CLS11** – **DTU10**[MSLA]) **> 10 cm**



Impact on Sea Level Anomalies

We compute SLA statistics over 1 cycle of Jason-1 data (cy 286) and 1 cycle of Envisat data (cy 96), over its new drifting orbit

Jason-1 SLA statistics, cycle 286 (without Caspian sea)			
MSS	**Selection**	**Standard deviation**	**Rms difference with DTU10**
CNES/CLS 11 (Ref DTU10)	No selection	10.85	-2.04
DTU10		11.04	
CNES/CLS 11 (Ref DTU10)	Bathymetry < -1000m & -50° < Latitude < 50° & Ocean variability < 20cm	10.27	-1.51
DTU10		10.38	
CNES/CLS 11 (Ref DTU10)	-100 m< bathymetry < 0m	18.47	-5.84
DTU10		19.37	
CNES/CLS 11 (Ref DTU10)	Latitude < -50° & Latitude > 50°	11.89	0.84
DTU10		11.86	

* The global difference between SLA computed with CNES/CLS11 referenced to the content of DTU10 and DTU10 is of -2 cm rms (in favor of CNES/CLS11).
* It is reduced to -1.5 cm rms in regions of low latitudes, deep waters and low ocean variability.
* This difference is increased to -5.8 cm rms in shallow waters.
* It is degraded to +0.8 cm rms when limited to high latitudes.

Envisat SLA statistics, drifting cycle 96 (without Caspian sea)			
Difference	**Selection**	**Standard deviation**	**Rms difference with DTU10**
CNES/CLS 11 (Ref DTU10)	No selection	10.56	-2.26
DTU10		10.80	
CNES/CLS 11 (Ref DTU10)	Bathymetry < -1000m & -50° < Latitude < 50° & Ocean variability < 20cm	9.37	-1.79
DTU10		9.54	
CNES/CLS 11 (Ref DTU10)	Lat < -50 or Lat > +50	10.21	-1.20
DTU10		10.28	

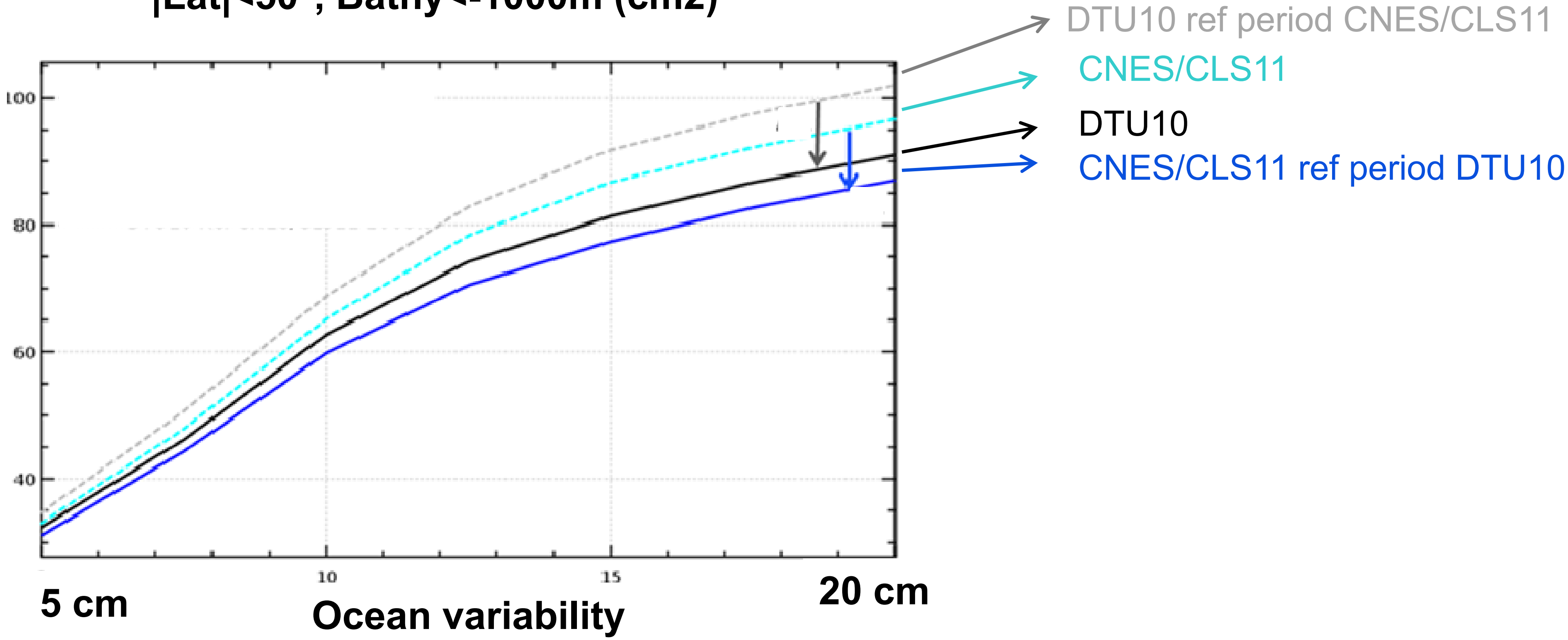
* The global difference between SLA computed with CNES/CLS11 referenced to the content of DTU10 and DTU10 is of -2.3 cm rms
* It is reduced to -1.8 cm rms in regions of low latitudes, deep waters and low ocean variability.

The processing of inter annual ocean variability in MSS computation is at the origin of major differences between surfaces and has to be handled with care!

Comparison to DTU10C

Impact on Sea Level Anomalies Statistics: SLA statistics are computed over 1 cycle of Envisat data on its new orbit

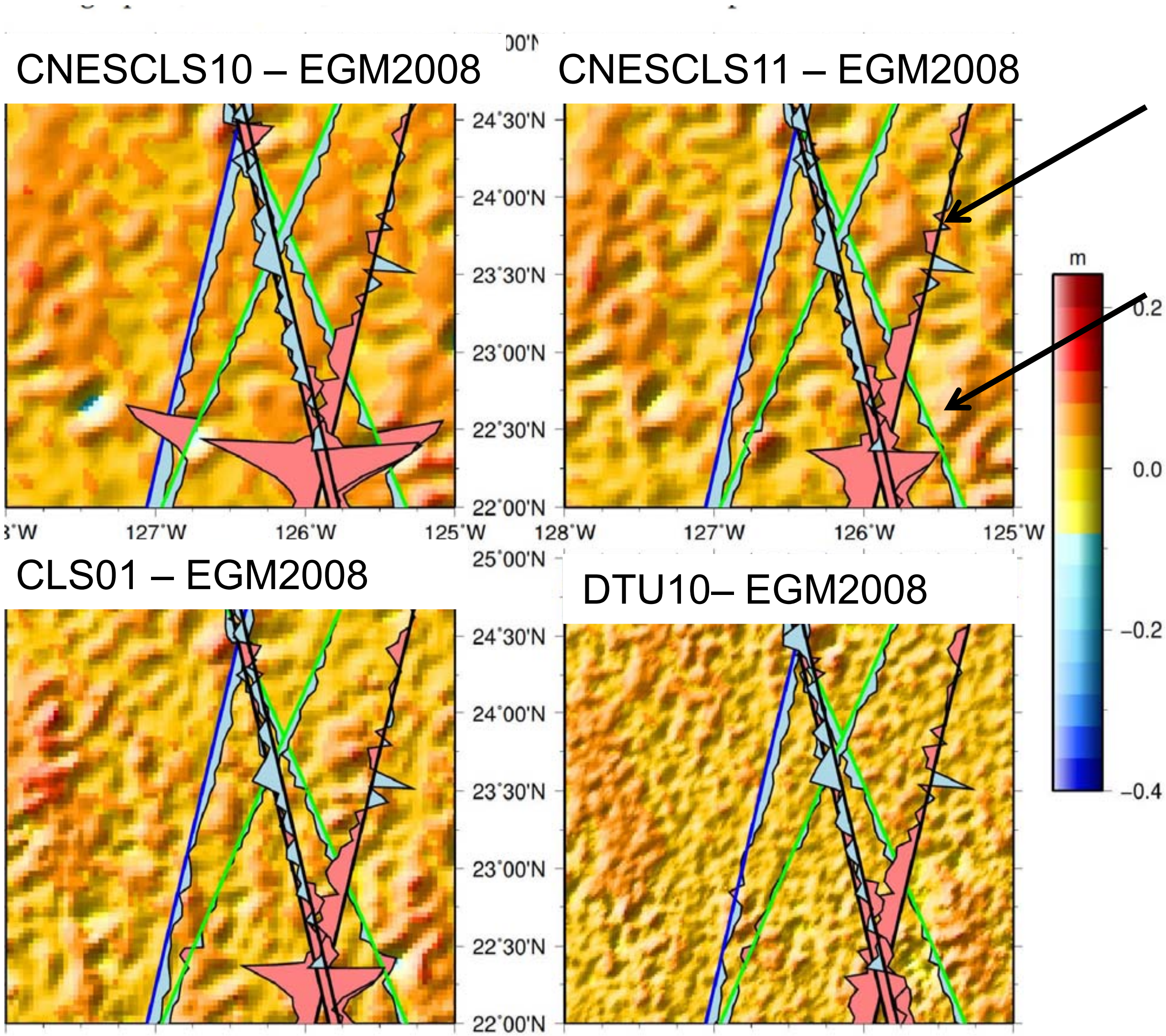
SLA variance on Envisat Cycle 96
|Lat|<50°, Bathy<-1000m (cm2)



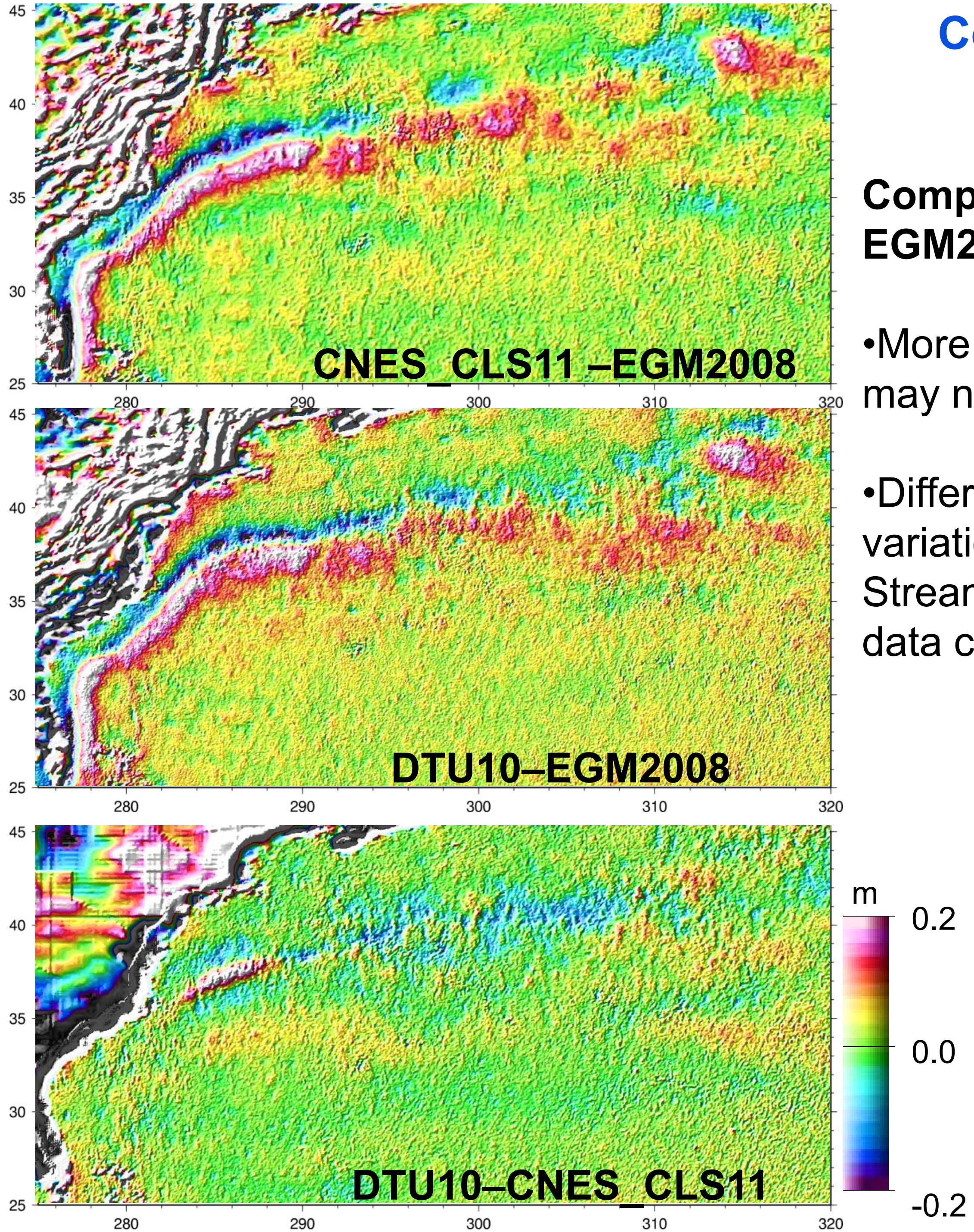
- It iss crucial to compare MSS performances on the same reference period
- CNESCLS11/DTU10 variance difference is quite consistent whatever the reference period chosen

Comparison to DTU10

Comparison between MSS & ERS-1 GM profiles
- *courtesy Remko Scharroo*



- Comparison between MSS & EGM2008 over 1 ERS-1 during geodetic phase
- 1 exemple of high differences between the two MSS
- A sea mount is probably underestimated in CNES-CLS11.



Comparison to DTU10

Comparison between MSS & EGM2008 - *courtesy Remko Scharroo*

•More small scales in DTU10, which may not constitute true features

•Differences are largely correlated with variations in the location of the Gulf Stream and may indicate differences in data coverage or analysis period.

Comparisons with Local GPS MSS

Comparison between altimetry MSS & CERGA GPD based MSS

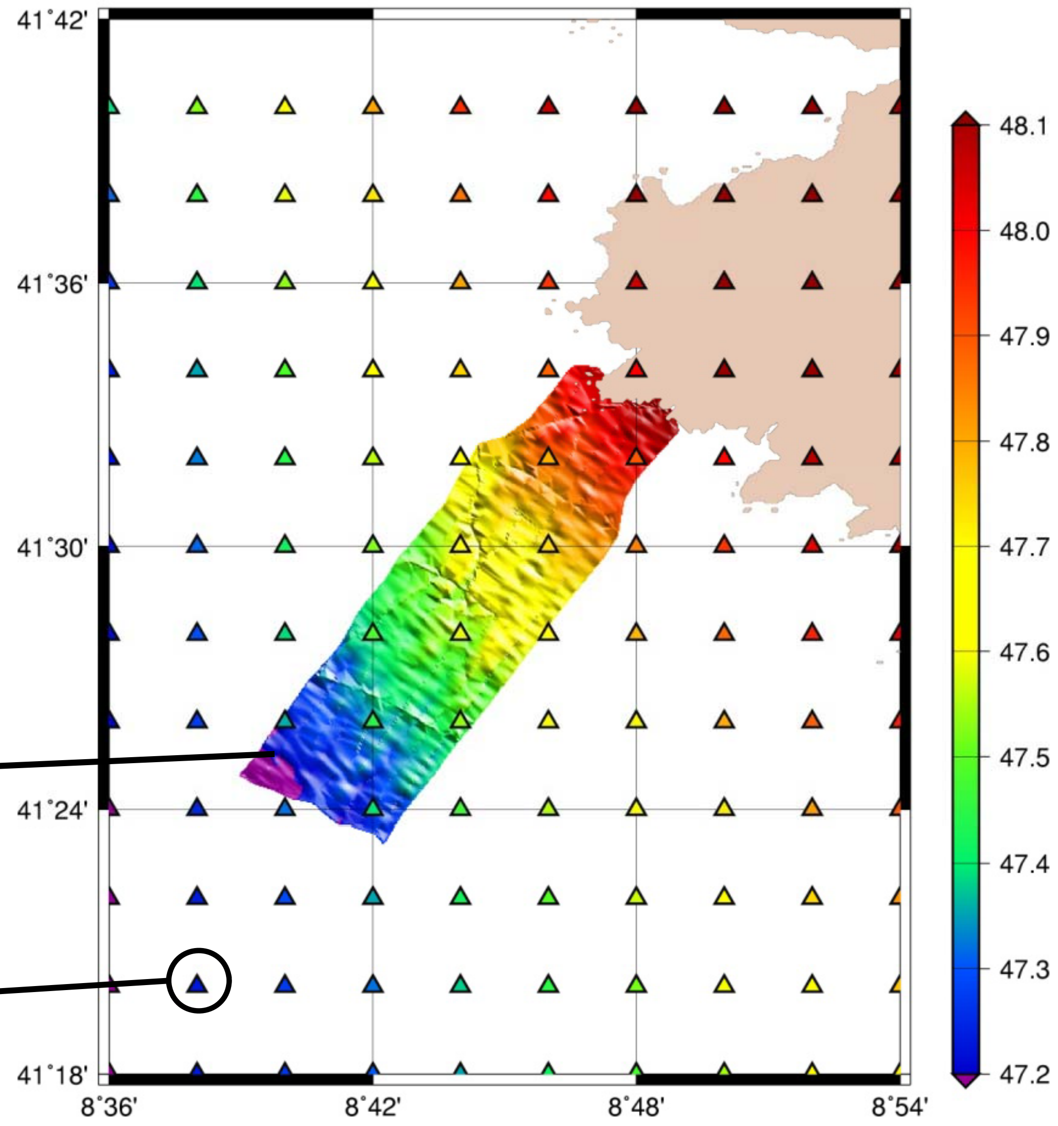
•Methodology described in P. Bonnefond et al., "Leveling the sea surface using a GPS catamaran,“

•Several comparison performed:
- •Corsica (2 sites)
- •Ibiza

CERGA MSS
(resolution <100m)

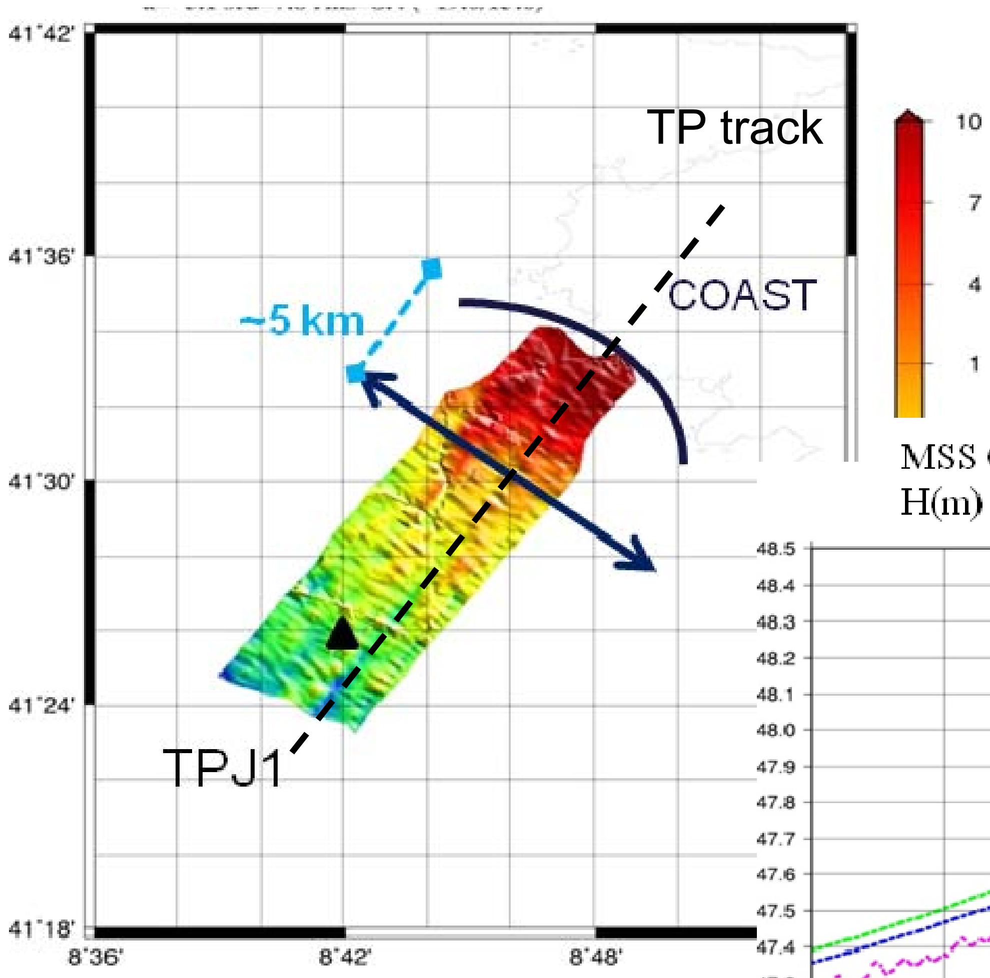
CNES/CLS 11 MSS
(resolution 3 km)

Senetosa T/P & Janson-1/2 CalVal area

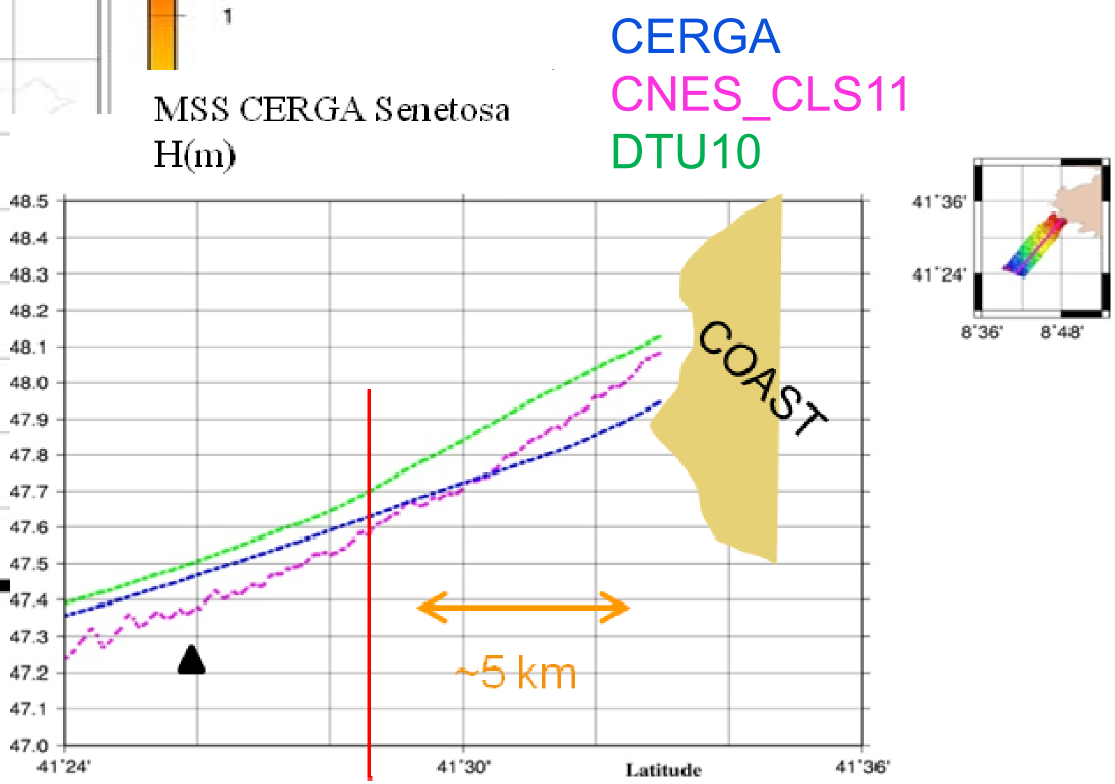


Comparisons with Local GPS MSS

MSS CERGA –CNES_CLS11 (cm)



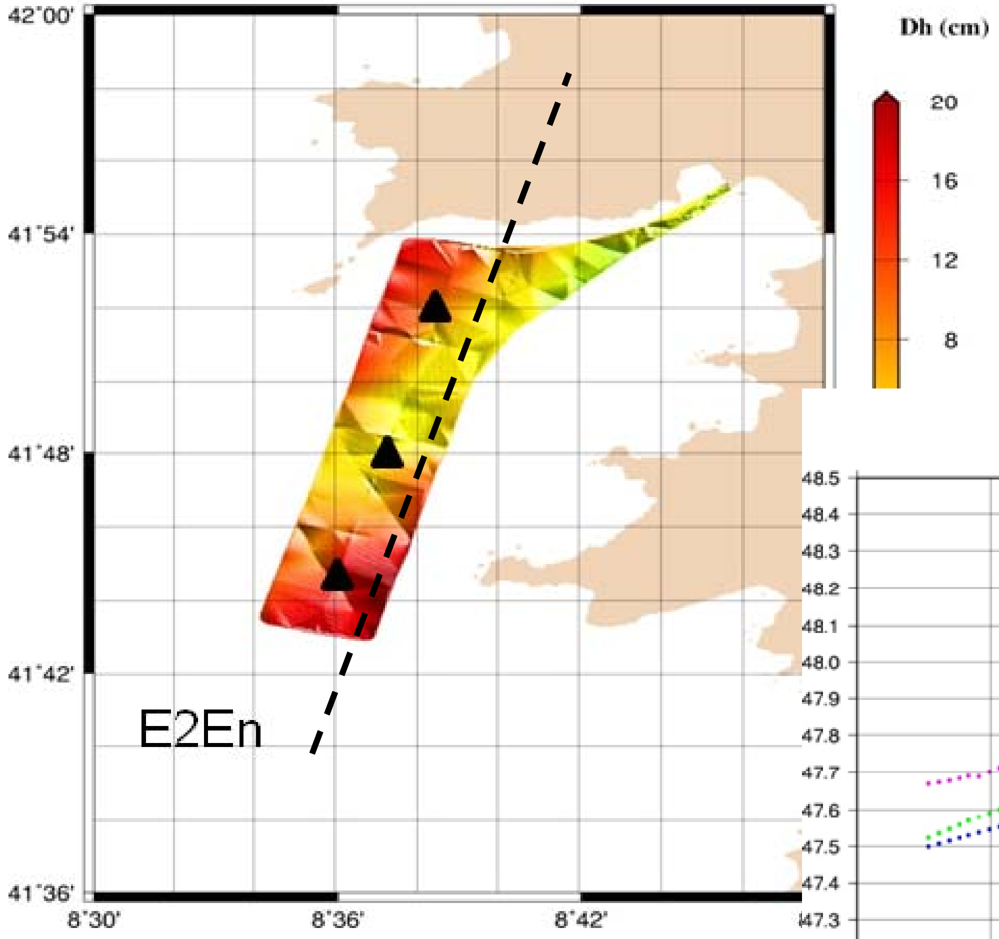
- •Centimetric differences between CNES-CLS 11 and local MSS at large scale and very small scales
- •On this exemple better correlation between DTU10 and CERGA



Change in slope

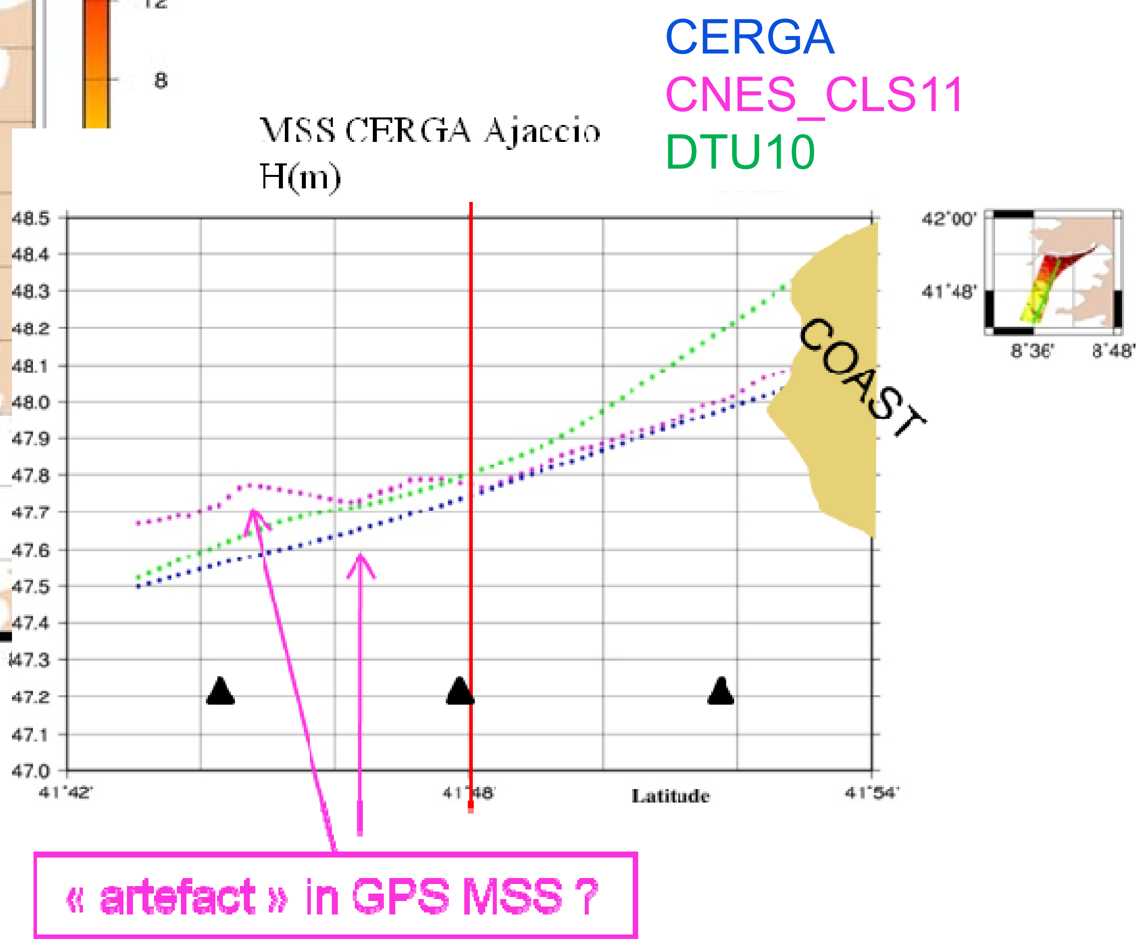
Comparisons with Local GPS MSS

MSS CERGA –CNES_CLS11 (cm)

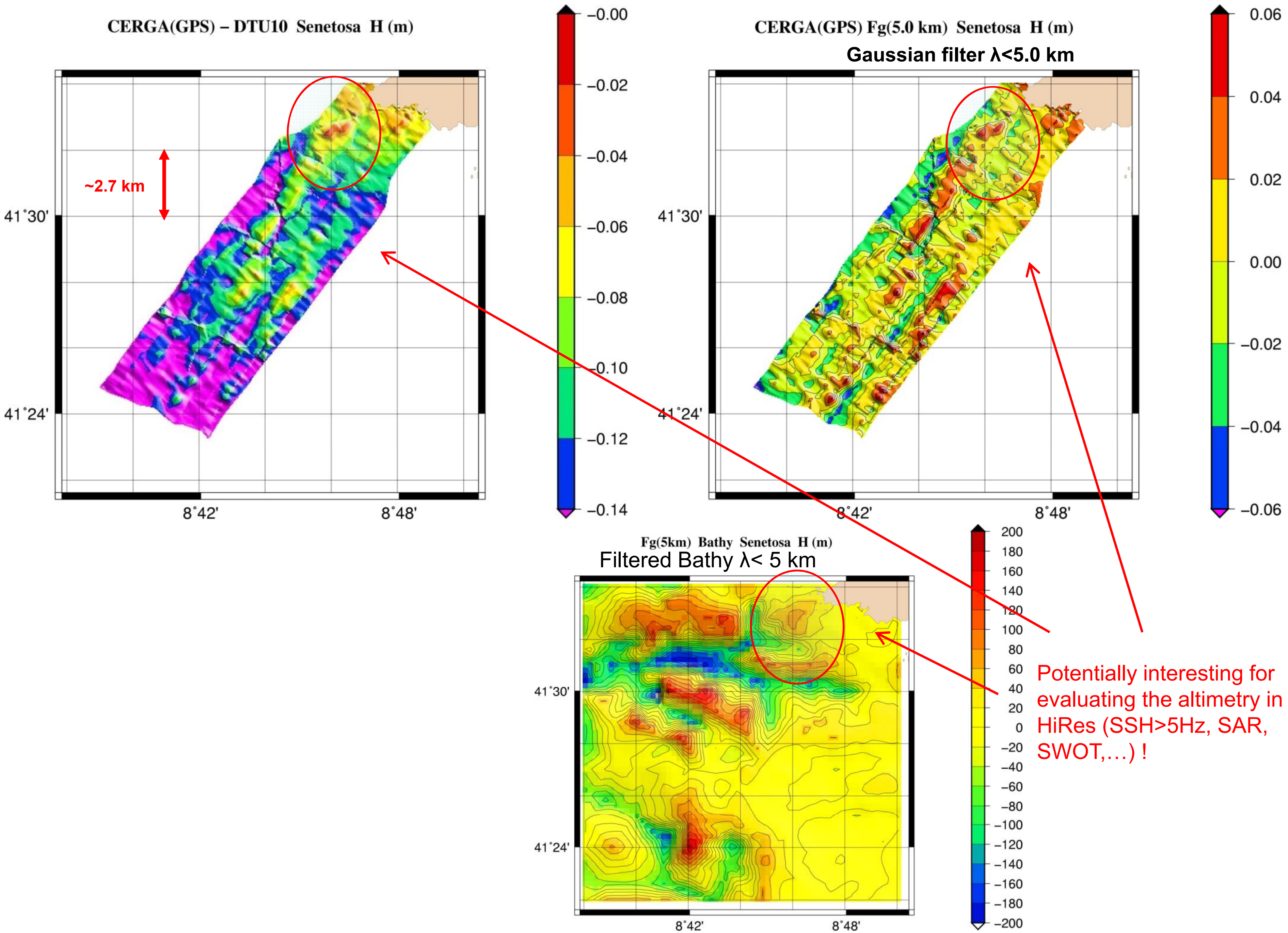


•Behaviour different on this exemple. difference in the average is due to the interannual variabilité (Ajaccion=2009 / Senetosa=1999)

•On this exemple better correlation between CNES_CLS11 and CERGA



GPS/CERGA MSS reveals structures at very short wavelengths ! (is it realistics ?)



Conclusion

•A new MSS, MSS CNES_CLS11 is available to user since summer at http://www.aviso.oceanobs.com/en/data/products/auxiliary-products/mss/index.html (netcdf format)

•Good performances in open ocean,

✓drastic improvement of short wavelengths of MSS CNES_CLS11.

✓Reduced degradation of Envisat SLA after the orbit change

• Homogenization of interannual signal : crucial to reference the MSS on the same period for intercomparison

• Comparison to GPS High Resolution MSS: interesting exercise and interesting to extend comparisons over largest areas.

•Perspectives

✓Data of missions with new Ground track, not included in this version are or will be available in 2012: Envisat drifting Phase, Cryosat, HY2

✓Reprocessed dataset with recent standard will also be released: Envisat, Reaper, GDRD CNES Orbits, …

=> Very good perspectives to improve the quality and resolution of MSS