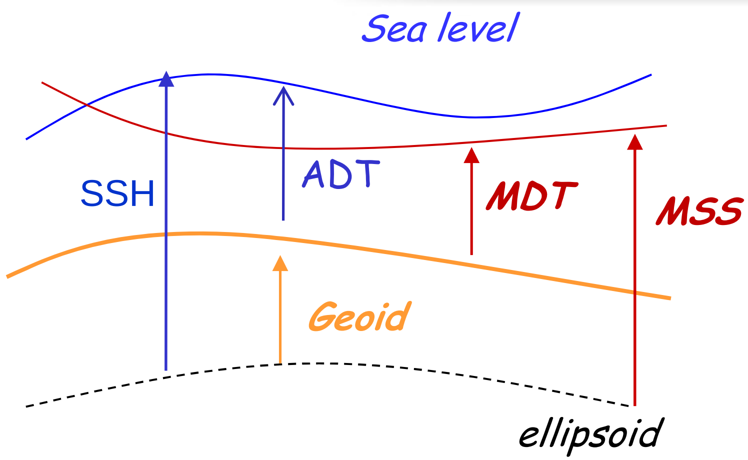
The New CNES-CLS09 global Mean Dynamic Topography computed from the combination of GRACE data, altimetry and in-situ measurements.

M.H. Rio (CLS), Y. Faugere (CLS), P. Schaeffer (CLS),
G. Moreaux (CLS), S. Bourgogne (Noveltis),
J.M. Lemoine (GRGS), E. Bronner, N. Picot (CNES)

Service Altimetrie & Localisation Precise

Reminder



Absolute Dynamic Topography
ADT=SSH-Geoid

Mean Dynamic Topography
MDT=MSS-Geoid

- Accurate knowledge of the ocean Mean Dynamic Topography at all spatial scales is mandatory for the full exploitation of altimeter measurements
  - compute the geostrophic current / ocean variability analysis
  - assimilation in monitoring and forecasting systems

- Preparation for future GOCE data, whose resolution will allow to estimate the ocean MDT with centimetric accuracy at 100km scales

→ A new high resolution MDT has been computed in the frame of the French CNES SLOOP project

Reminder

Direct Method

MDT=MSS-Geoid

↓

filtering

↓

Large scale
MDT=First Guess

→

Synthetic Method

Computation of the **MDT shortest scales** (heights and geostrophic velocities) combining altimetric anomalies and in-situ data

↓

Multivariate Objective Analysis

↓

High Resolution Mean Dynamic Topography

Rio and Hernandez, 2004
Rio et al, 2005

Main improvements relative to the previous RIO05 MDT

	MDT RIO05 →	**MDT CNES-CLS09**
Geoid model used for the first guess computation:	EIGEN3S based on **2 years of GRACE data** + Levitus/1500m climatology in the [-40,40] latitudinal band	EIGEN-GRGS.RL02.MEAN based on **$4^{1/2}$ years of GRACE data**
First Guess filtering method:	Gaussian filter 400 km	Optimal filter
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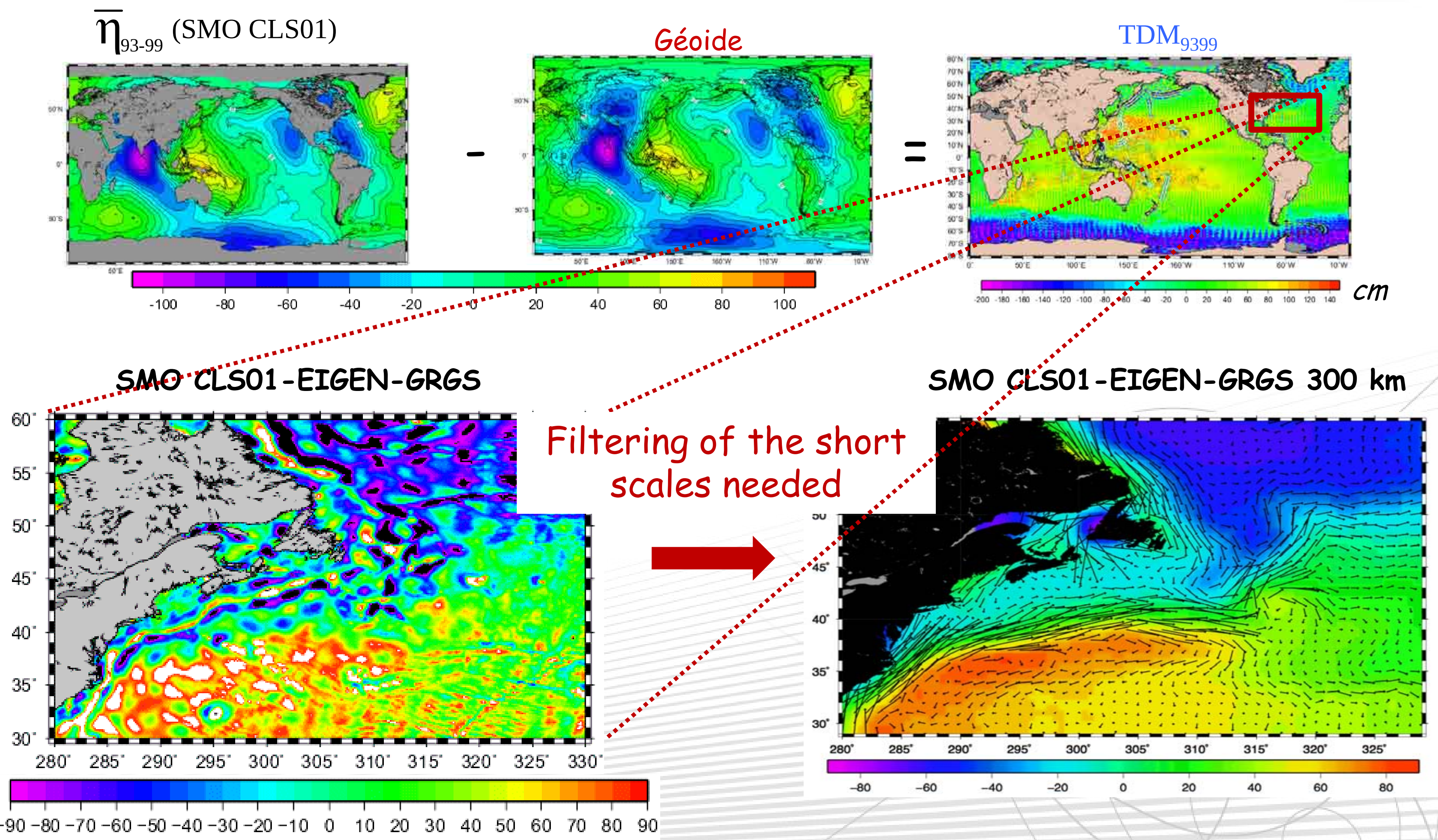
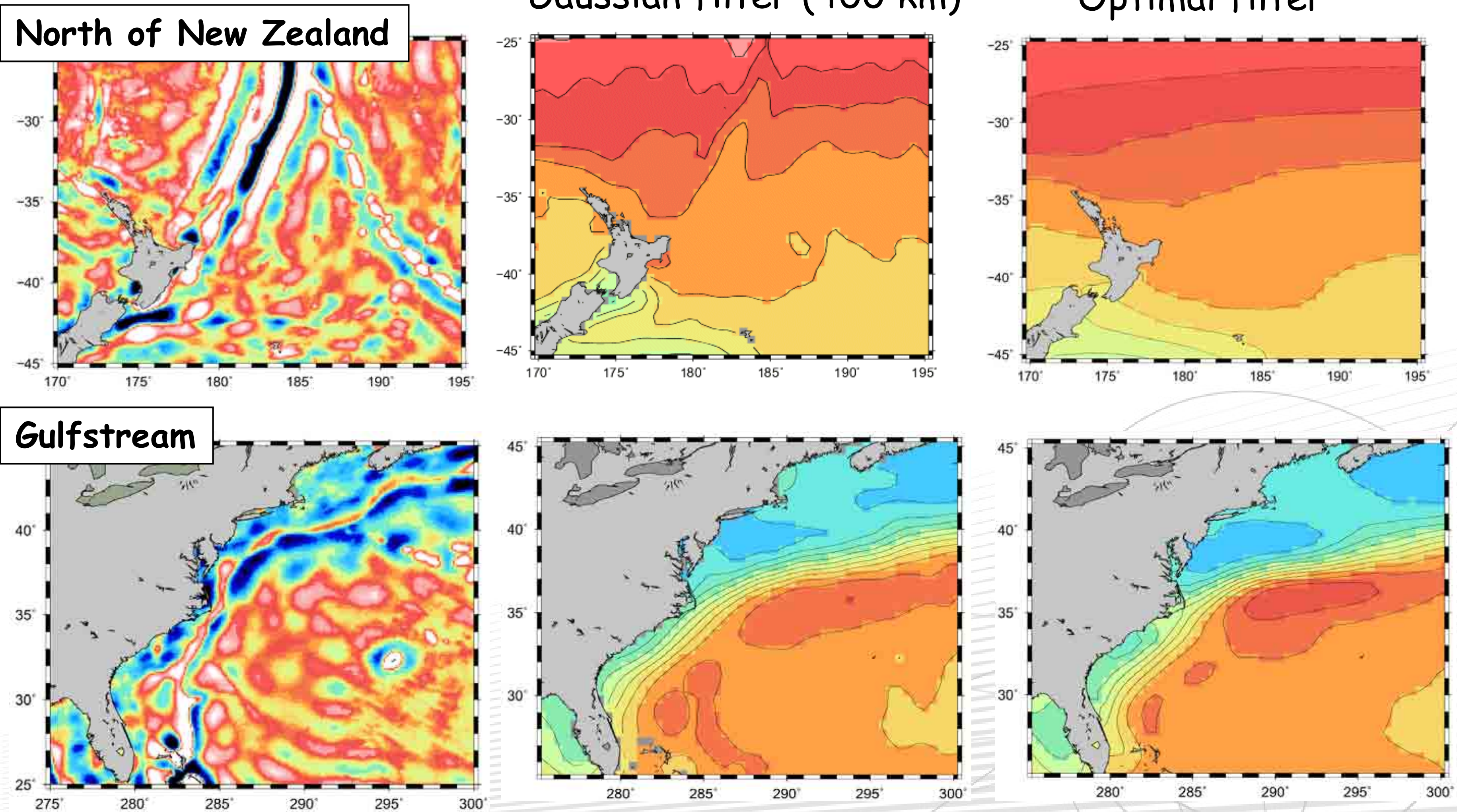
Optimal filtering of the direct MDT

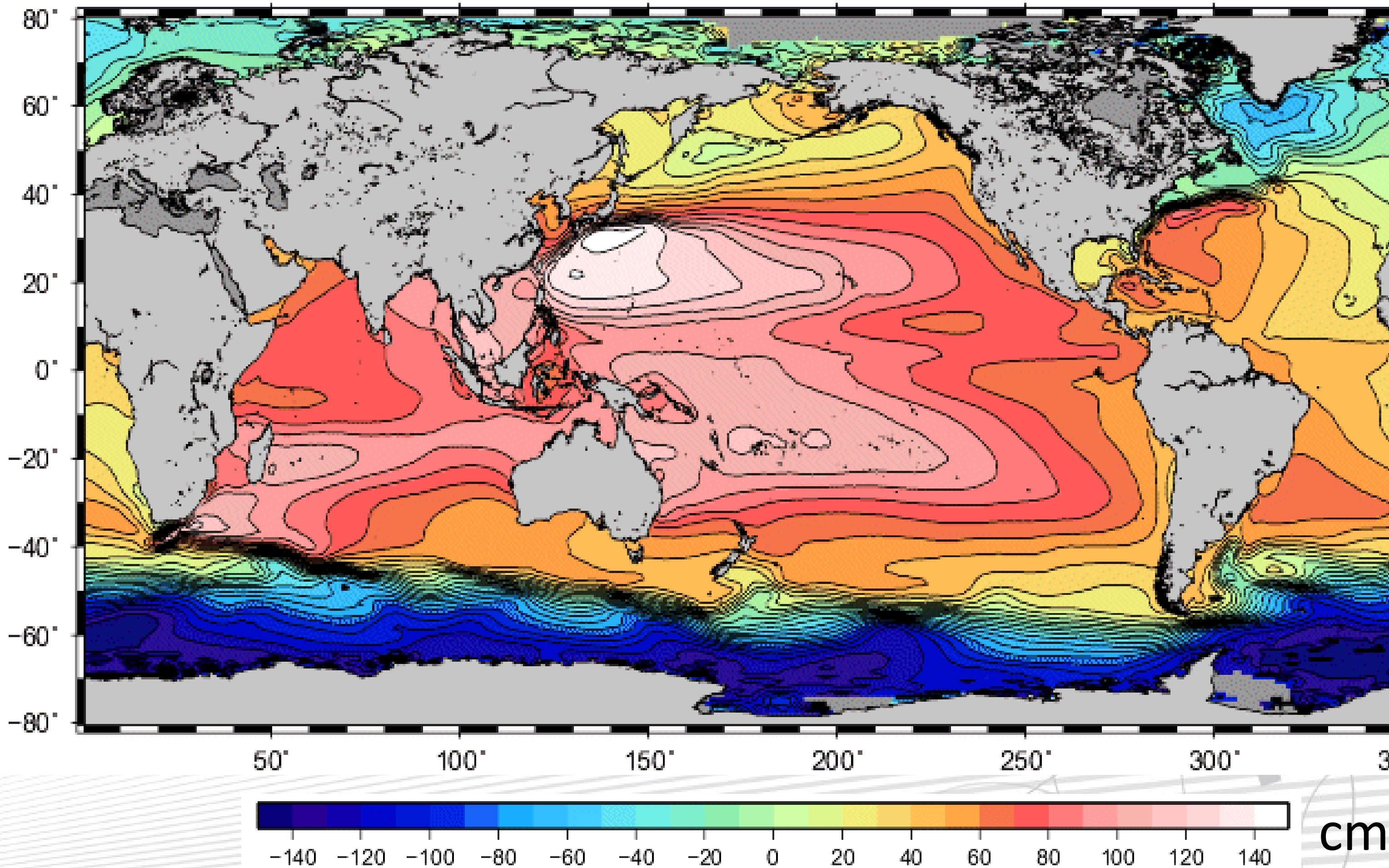


Optimal filtering vs gaussian filter

Raw MDT (MSS-Geoid) | Gaussian filter (400 km) | Optimal filter



Direct method → First Guess



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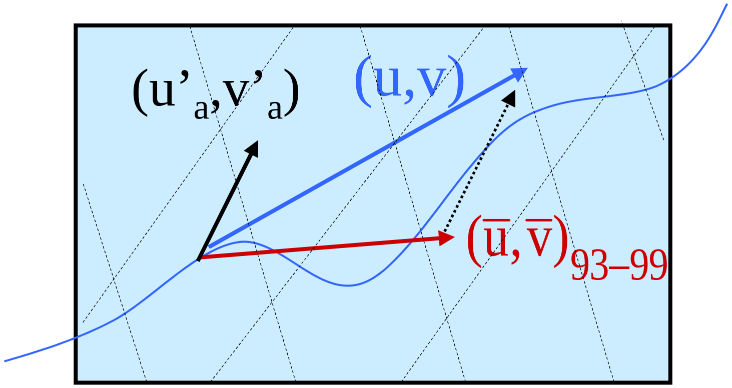
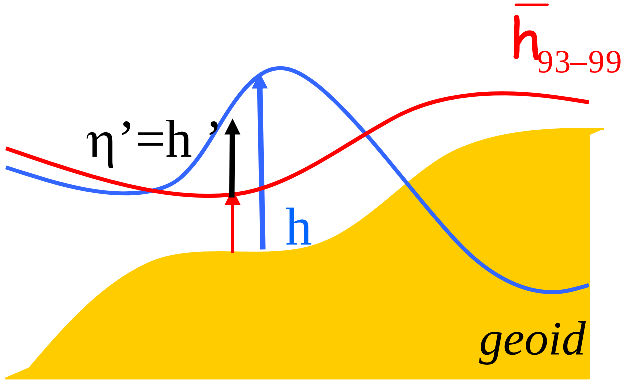
The synthetic method

Computation of the MDT synthetic estimates (heights and velocities)

Rio and Hernandez, 2004 - Rio et al, 2005





At each position r and time t for which an oceanographic in-situ measurement is available: dynamic height h (r,t) or surface velocity u(r,t),v(r,t)

- the in-situ data is processed to match the physical content of the altimetric measurement.
- the altimetric height/velocity anomaly is interpolated to the position/date of the in-situ data.
- the altimetric anomaly is subtracted from the in-situ height/velocity

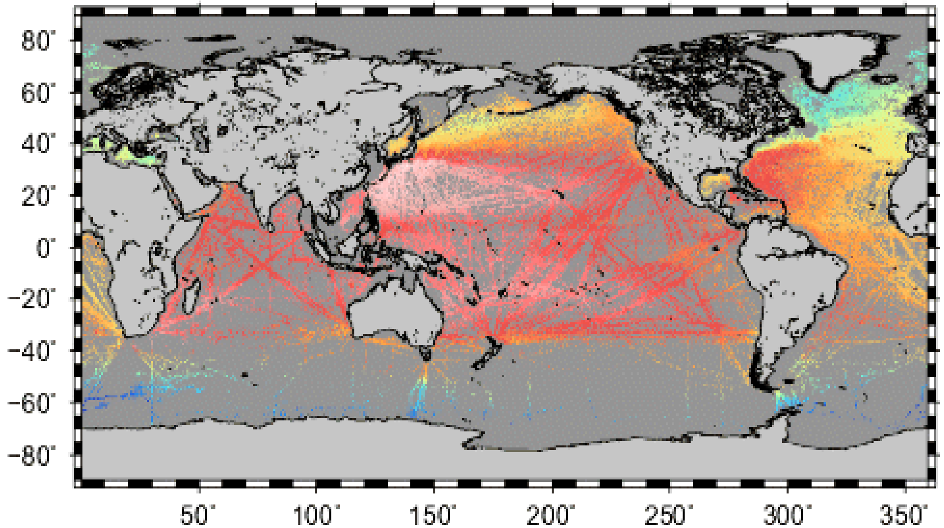
$$\overline{h}_{93-99} = h_{insitu} - h'_{93-99} \qquad \overline{u}_{93-99} = u_{insitu} - u'_{93-99} \qquad \overline{v}_{93-99} = v_{insitu} - v'_{93-99}$$

Updated in-situ measurement dataset

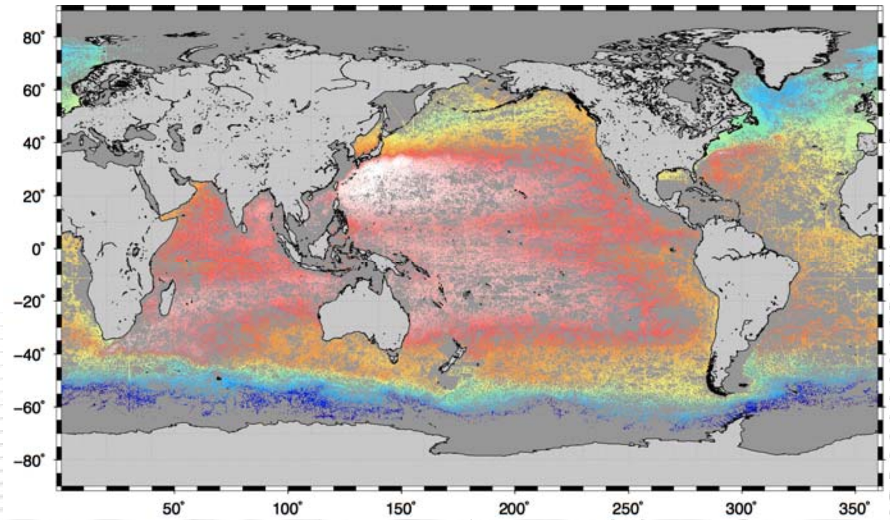
Mean synthetic heights averaged in ¼° boxes

Synthetic heights available for the RIO05 MDT computation

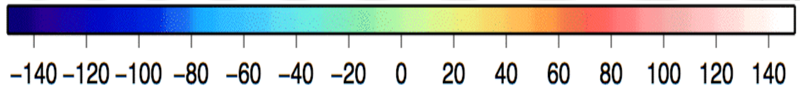
Synthetic heights used in the computation of the CNES-CLS09 MDT



1993-2002



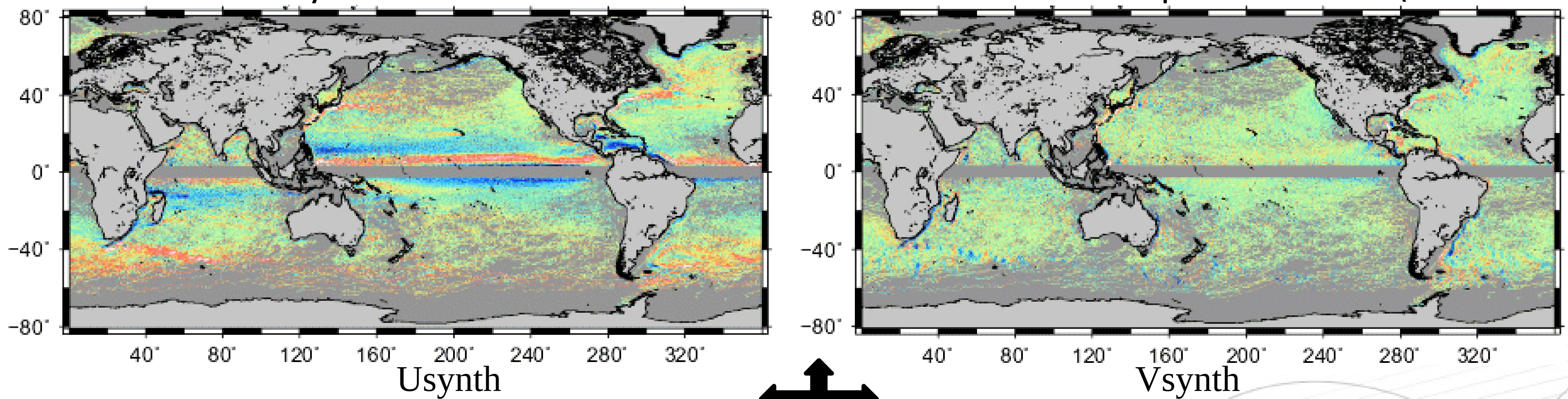
1993-2008



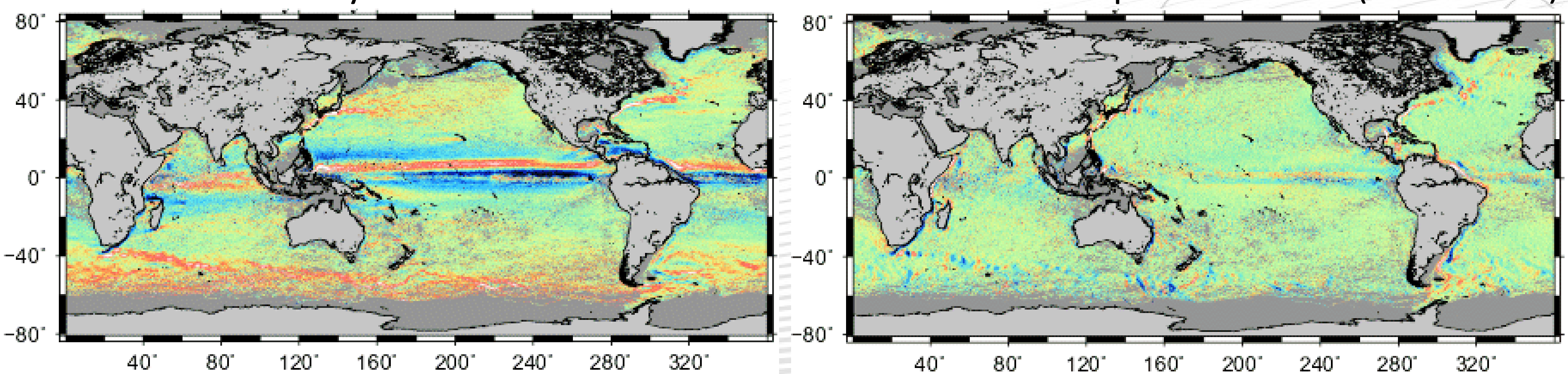
Updated in-situ measurement dataset

Mean synthetic velocities averaged in $\frac{1}{4}°$ boxes

Synthetic velocities available for the RIO05 MDT computation (1993-2002)



Synthetic velocities used for the new MDT computation (1993-2008)



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New Ekman model to correct the physical content of the drifters observations

(Rio and Hernandez, 2003)

$$\vec{u}_e = \frac{b}{\sqrt{f}} \vec{\tau} e^{i\theta}$$

$\vec{u}_{bouée} - \vec{u}_{alti}$

Filtered between 30 hours and 20 days

ERA-INTERIM wind stress every 3 hours

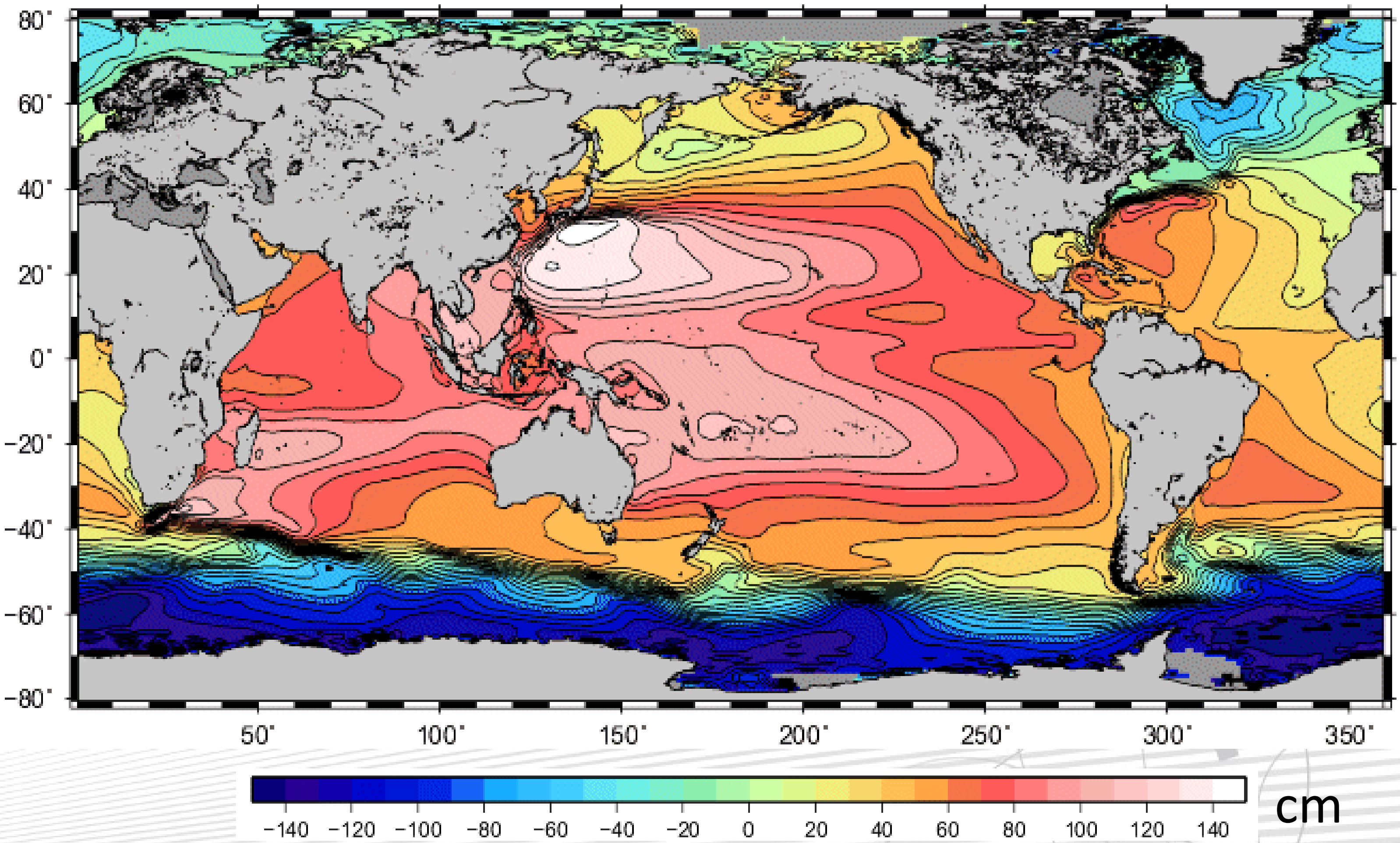
b and θ are estimated by least square minimization

- RIO05 MDT:
b and θ estimated by season (winter/automn/summer/spring) and by 4° boxes for the 1993-1999 time period

- New MDT CNES-CLS09
b and θ estimated by latitudinal band, by month (3 months sliping window) and by year for the 1993-2008 time period

The CNES-CLS09 MDT

Global, ¼° resolution grid of MDT, mean geostrophic velocities, and associated errors



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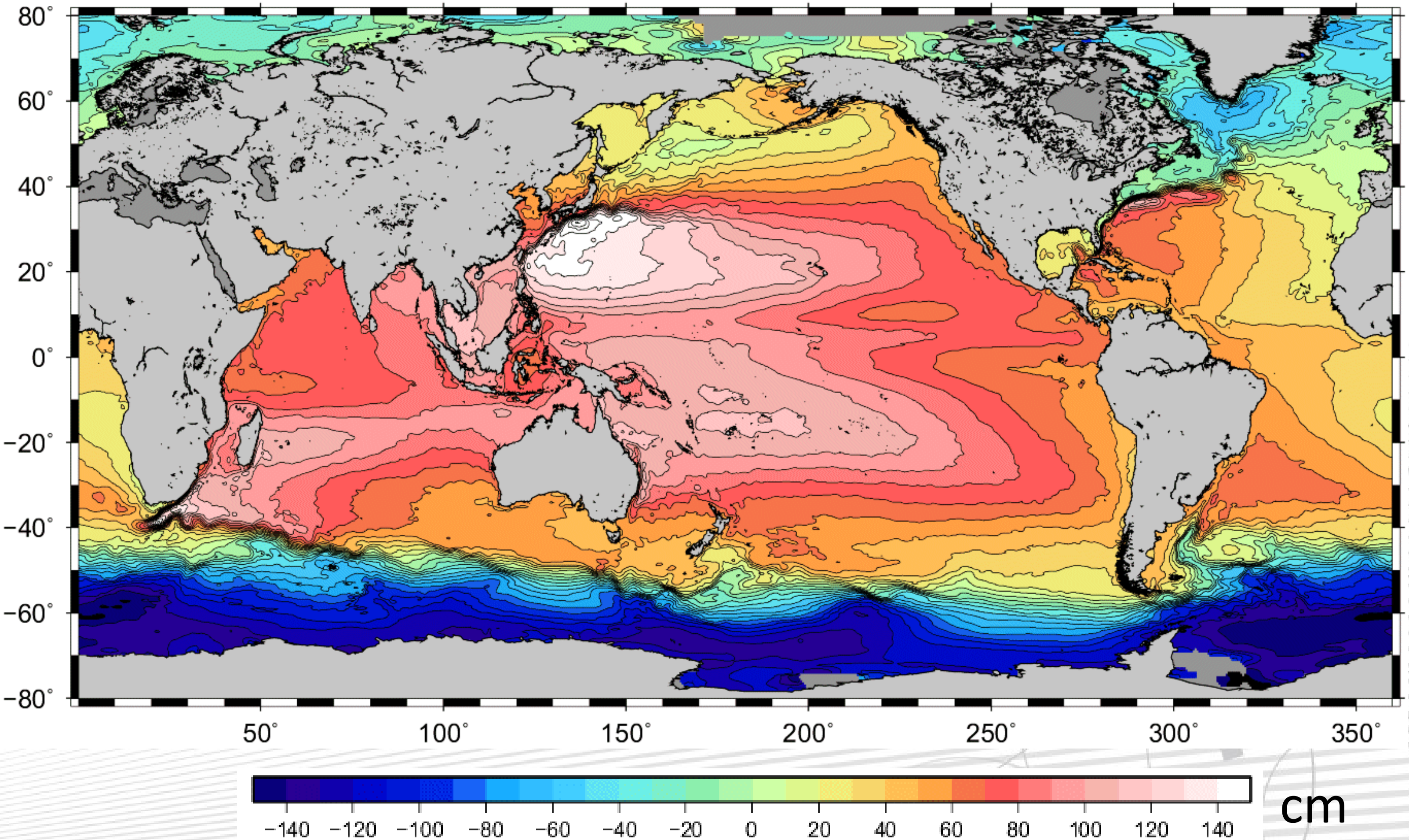
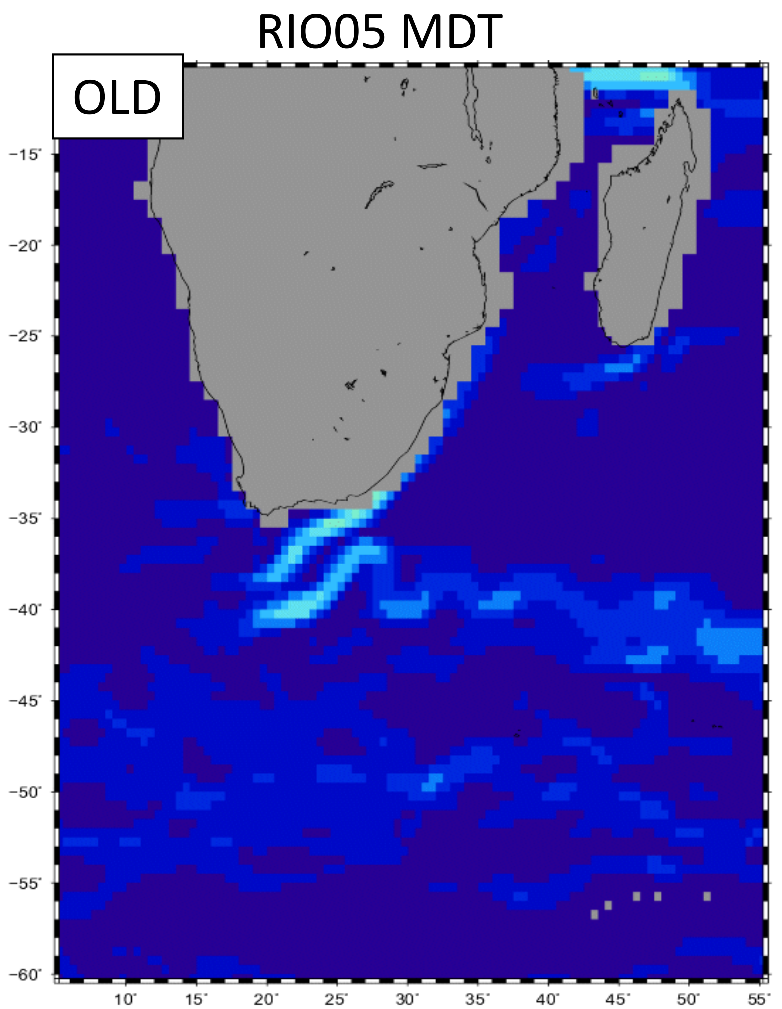
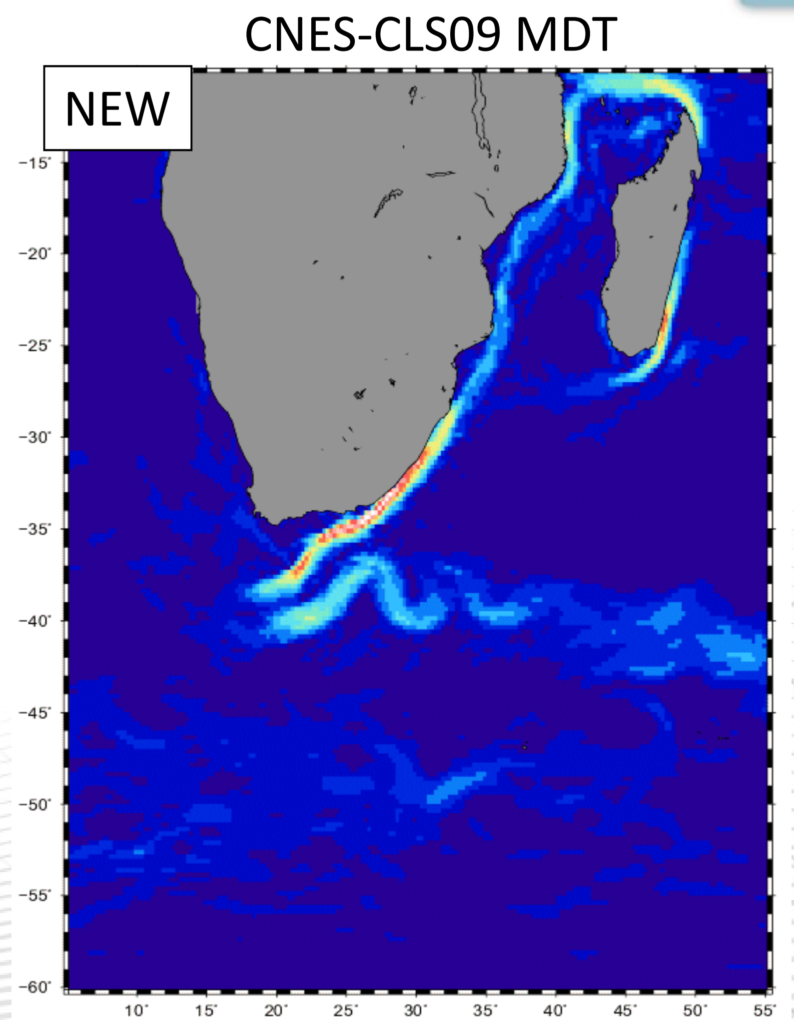
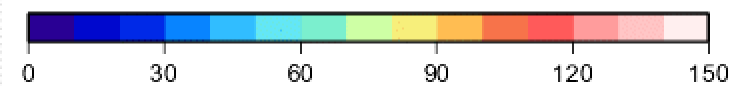


Rio et al, submitted to JGR

Aghulas Current



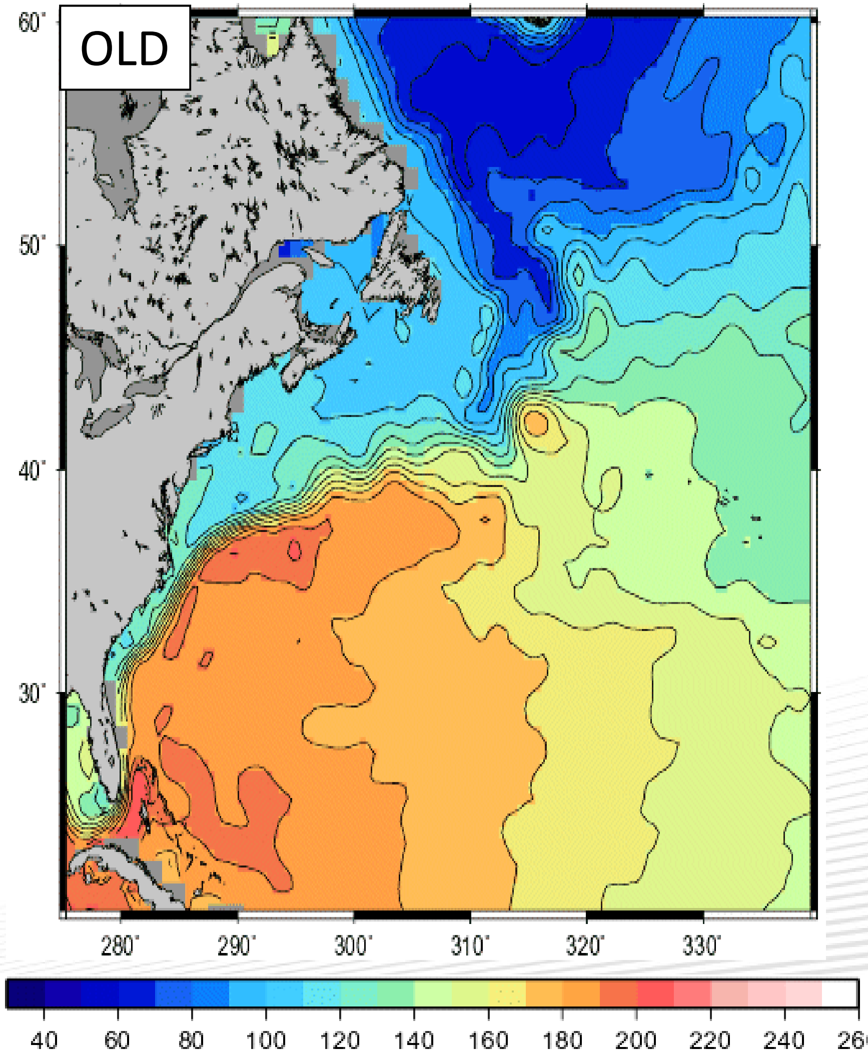




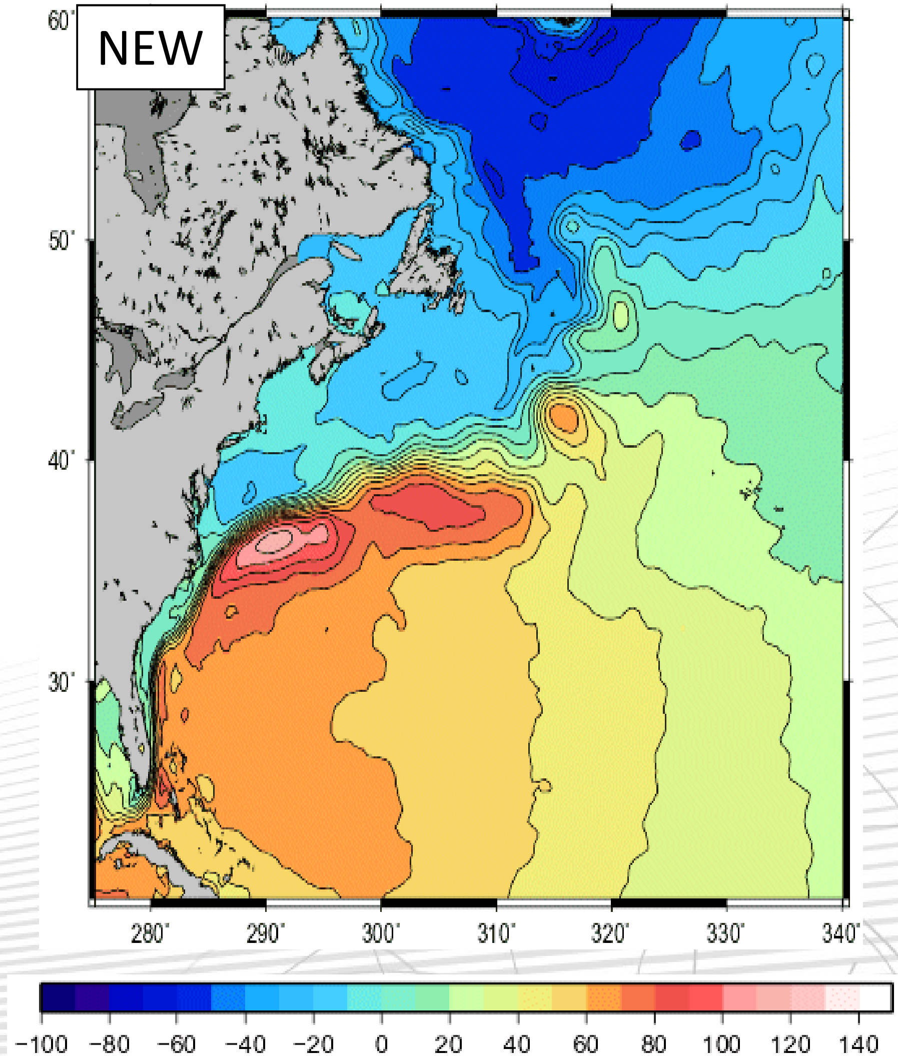
Geostrophic Velocity Amplitude (cm/s)

Gulfstream Current

RIO05 MDT



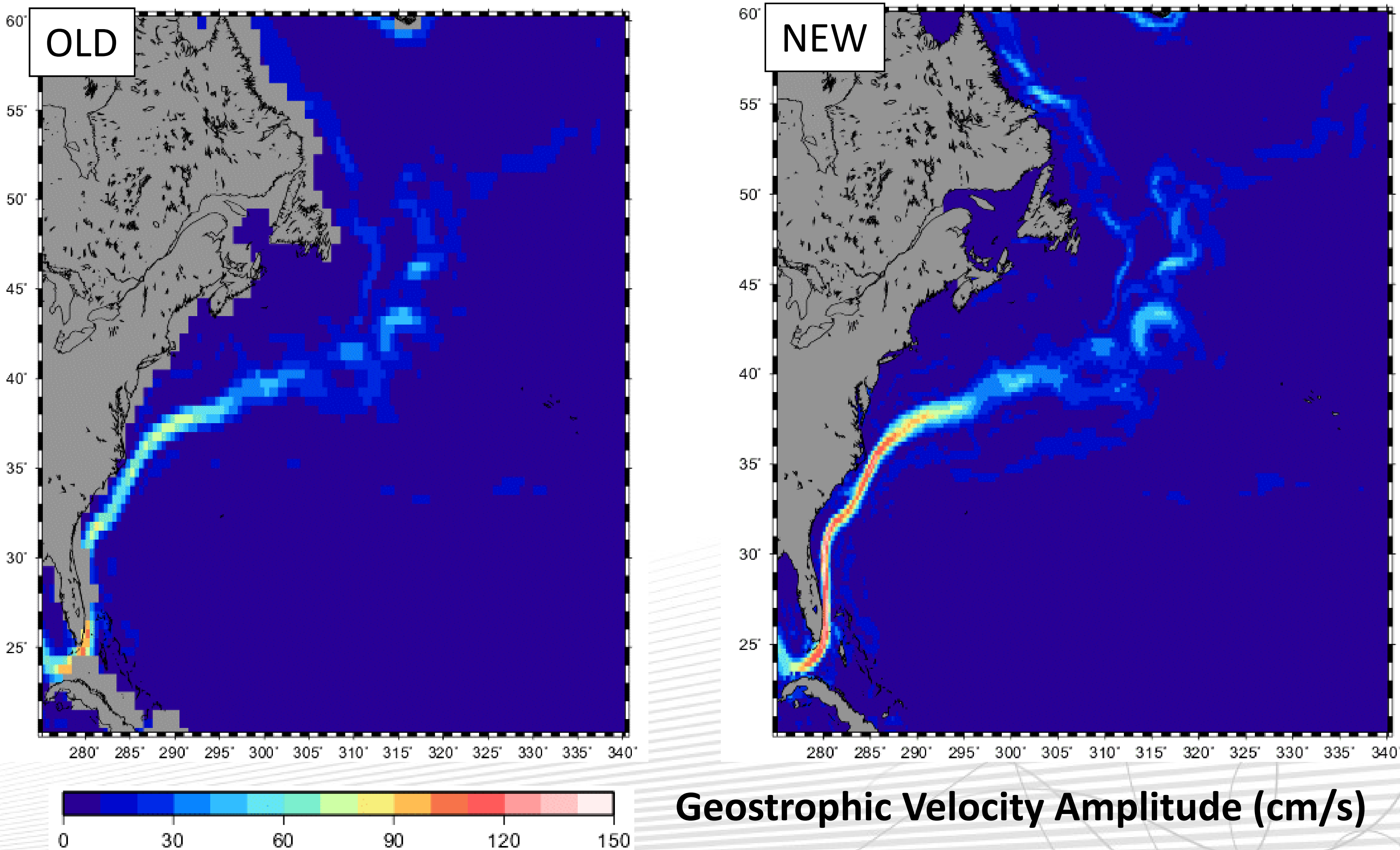
CNES-CLS09 MDT



Gulfstream Current

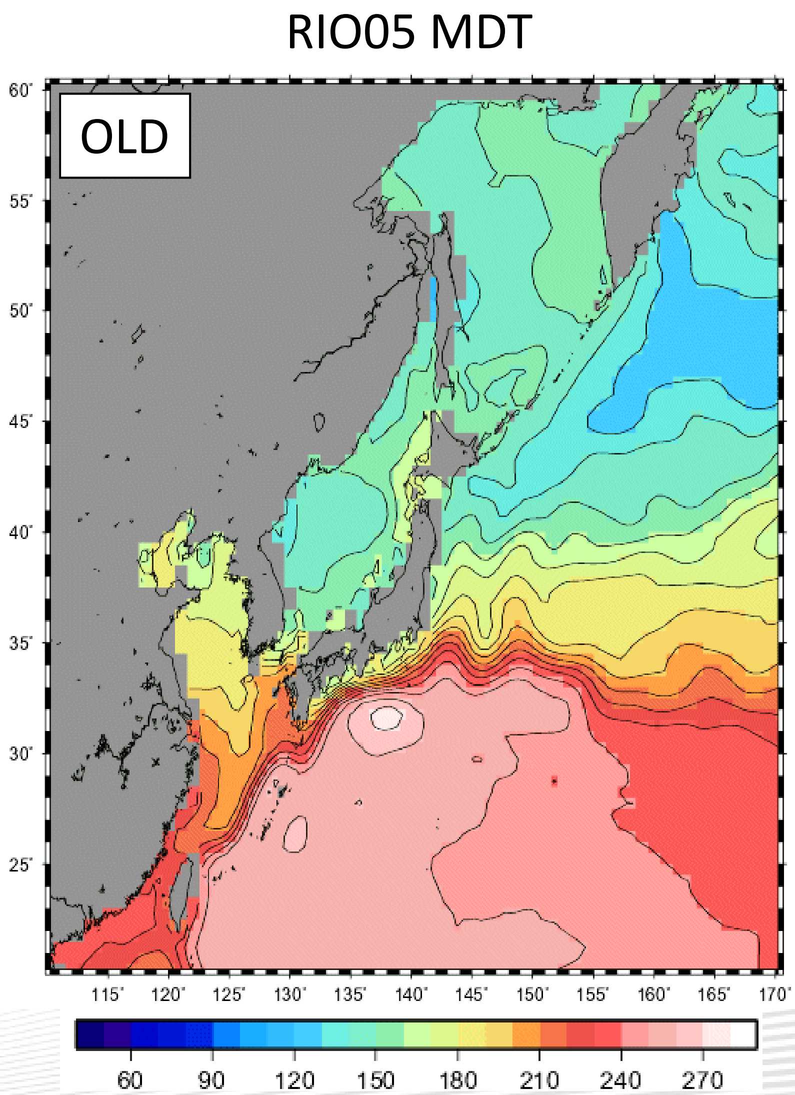
RIO05 MDT

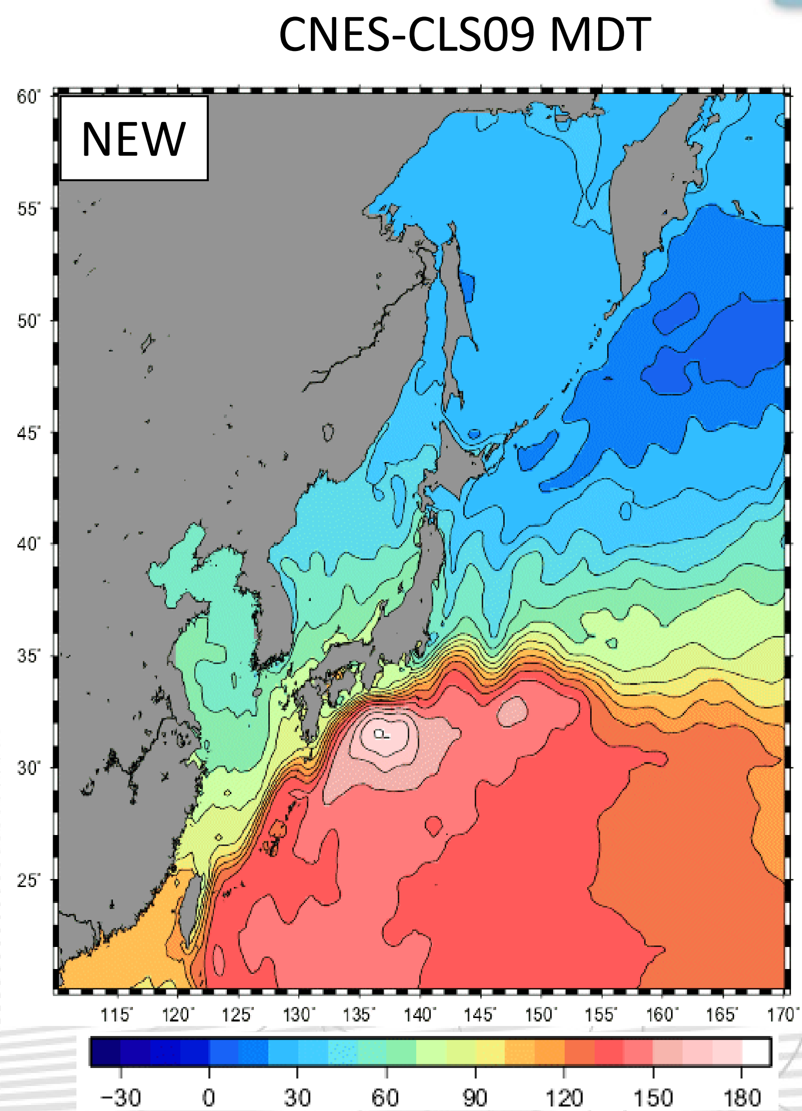
CNES-CLS09 MDT



Geostrophic Velocity Amplitude (cm/s)

Kuroshio Current





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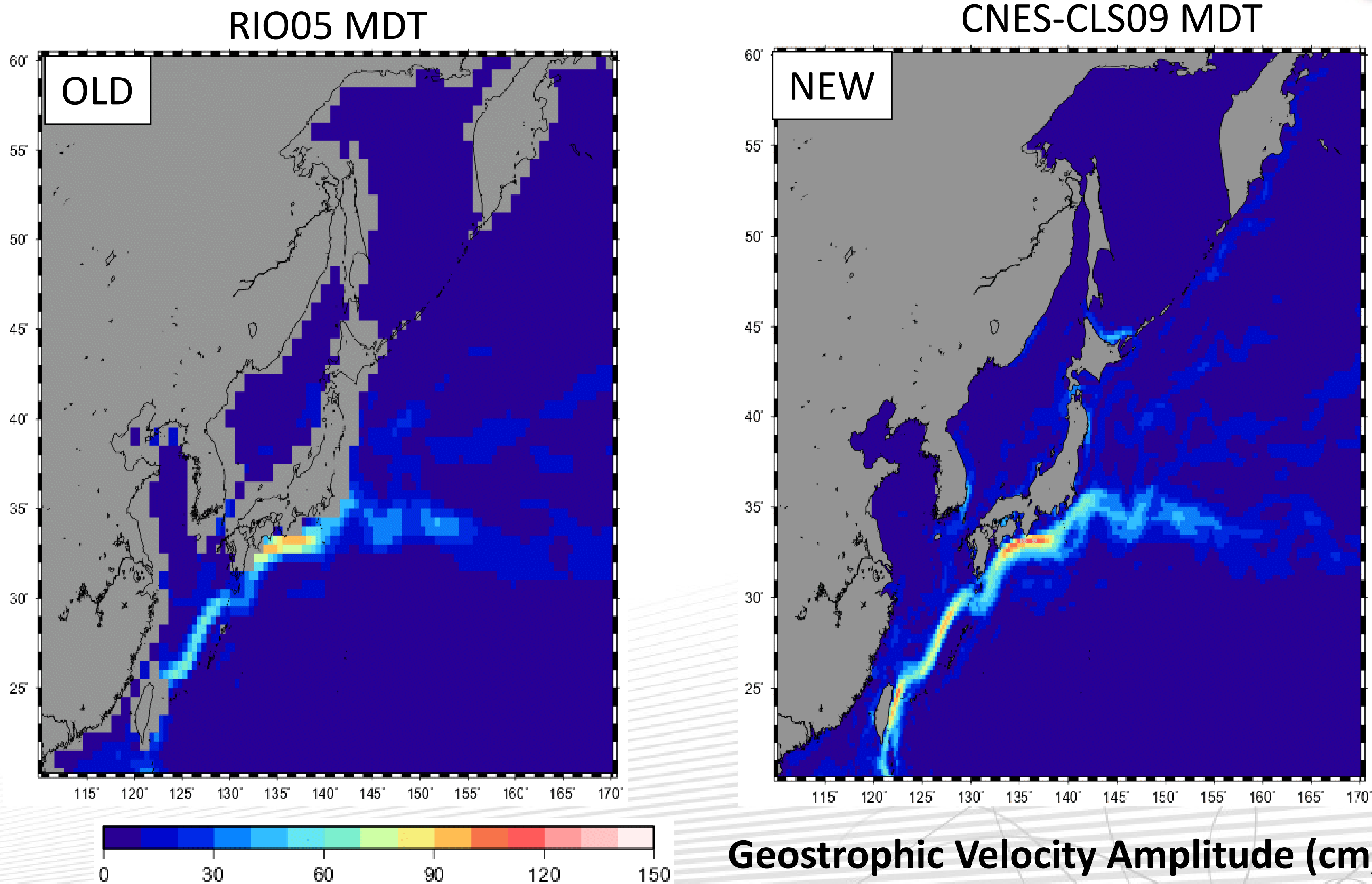


Geostrophic Velocity Amplitude (cm/s)

Conclusions

A new Mean Dynamic Topography is now available for the global ocean using:

✓ A recent GRACE geoid model computed from 4½ years of data

✓An updated dataset of drifting buoy velocities (1993 – 2008)

✓An updated dataset of dynamic heights (1993 – 2008, including all ARGO profiles)

✓An improved methodology

- o optimal filtering to compute the large scale first guess
- o new Ekman model to better process the drifting buoy velocities

✓The mean geostrophic currents associated to the CNES-CLS09 MDT are much more intense and realistic than the previous RIO05 MDT.

✓A specific work has been done to improve the mean currents in the equatorial band.

Download new MDT on AVISO :

www.aviso.oceanobs.com/fr/donnees/produits/produits-auxiliaires/mdt/index.html

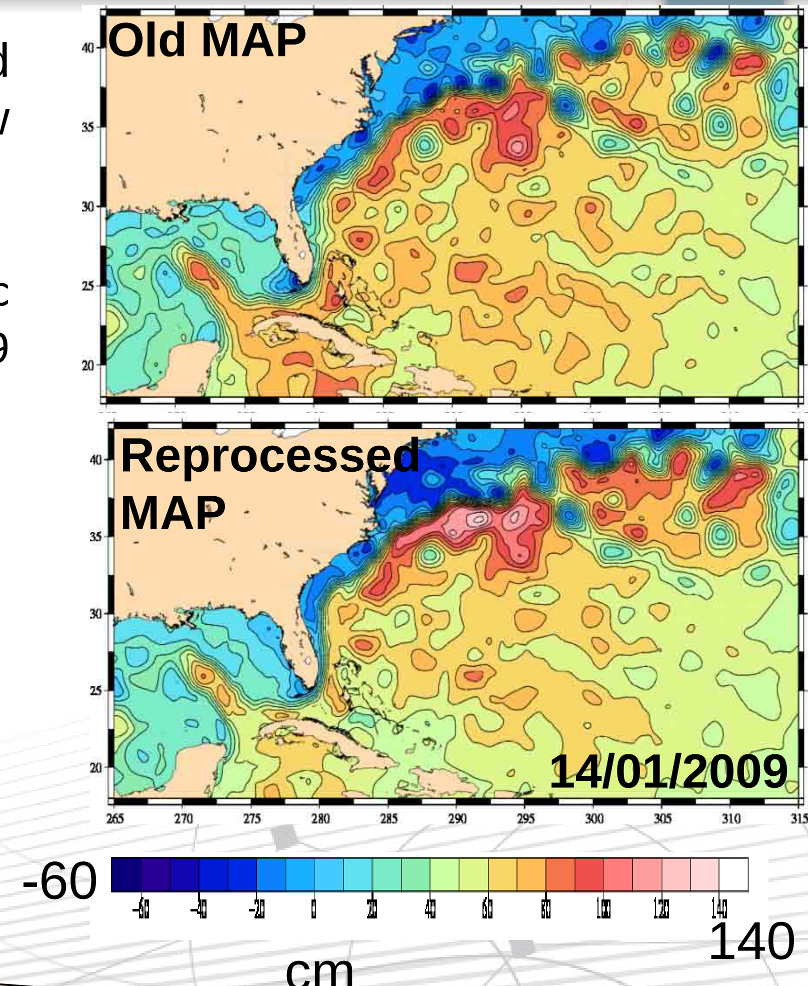
Conclusions

The AVISO multimission dataset (along track and gridded absolute dynamic height) is now distributed using this MDT:

1) The real-time AVISO altimetric absolute dynamic heights are now referenced to the new CNES-CLS09 MDT

2) The 1993-2009 recent reanalysis of altimetric ADT is also available

- referenced to the new CNES-CLS09 MDT
- Up to date standards (GDR-C or equivalent)
- Improved editing process, update mean profile
- Optimization of optimal interpolation parameterization



Download 1993-2009 SLA and ADT reanalysis on AVISO:
http://www.aviso.oceanobs.com/en/data/index.html

Perspectives

✓Assimilation in operational ocean forecasting systems (MERCATOR, FOAM, TOPAZ, ECMWF…)

✓Validation of GOCE data: Comparison between the CNES-CLS09 MDT and the GOCE MDT as soon as GOCE data are available (now!)

✓Further improvements (resolution and accuracy) of the ocean Mean Dynamic Topography will be made possible in the near future with the use of:

- ❑ A new geoid model based on the combination of GRACE data (for the long scales) and GOCE data (for the short scales, down to 100 km), when available (2011)

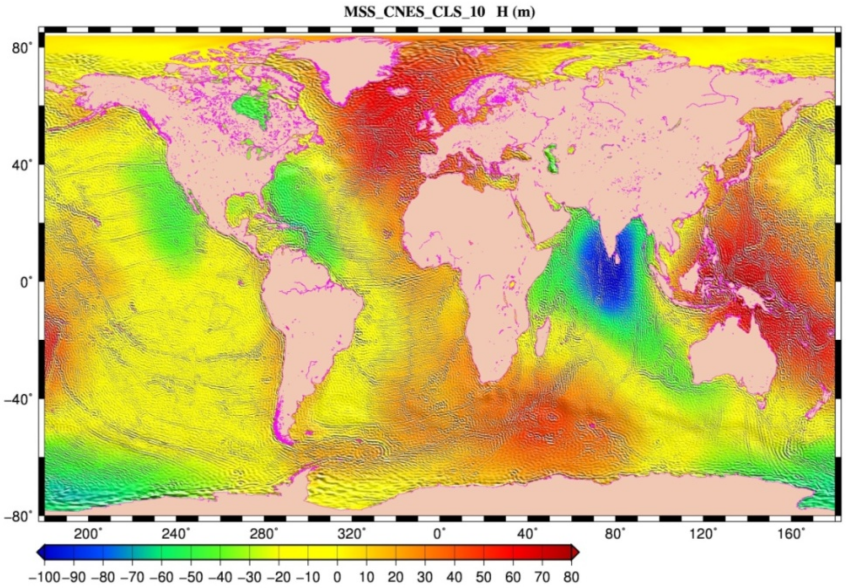
- ❑ A new altimetric Mean Sea Surface, that has been computed in the framework of the SLOOP project, the CNES-CLS10 MSS

Perspectives

The CNES_CLS_10 MSS has been computed from 15 yrs of altimetric data

The first validations results show improvements in different domains:

- the oceanic variability is better removed
- the accuracies is increased (by ~2),
- the shortest wavelengths are more powerful
- the MSS near the coast is more accurate,
- the oceanic mean contents is more realistic.



Download new MSS on AVISO :

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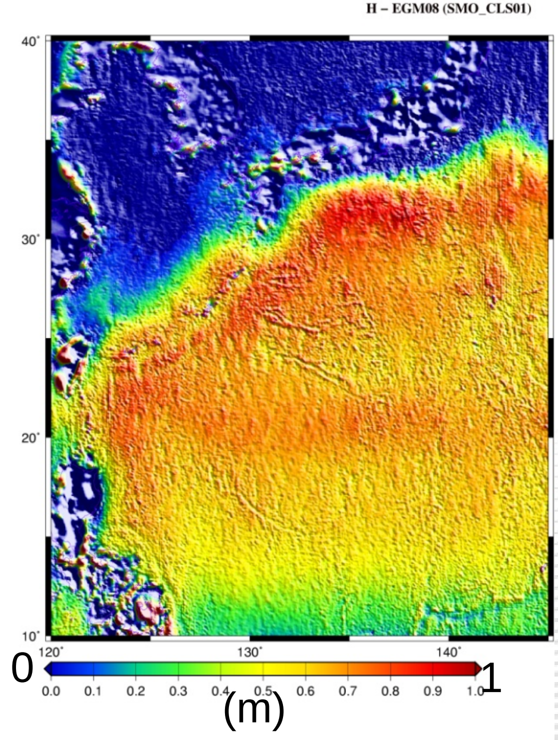
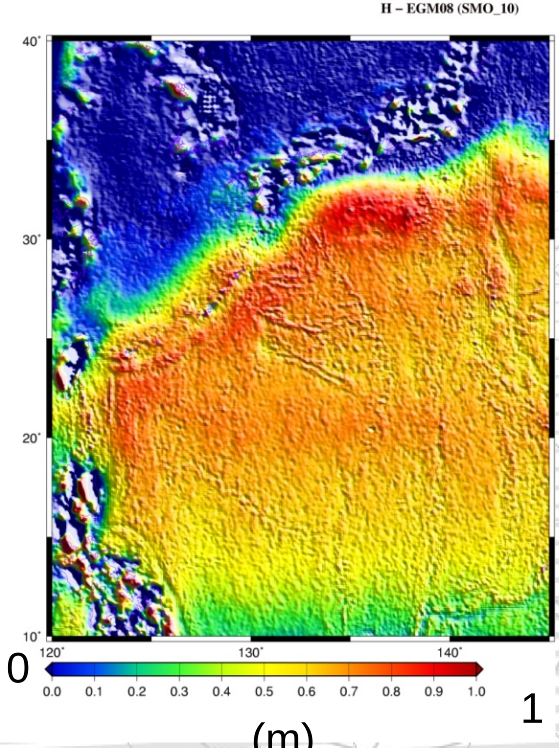
The oceanic variability is better removed: an example in the Kuroshio

MSS CLS01 –EGM08



MSS CNES_CLS10 –EGM08



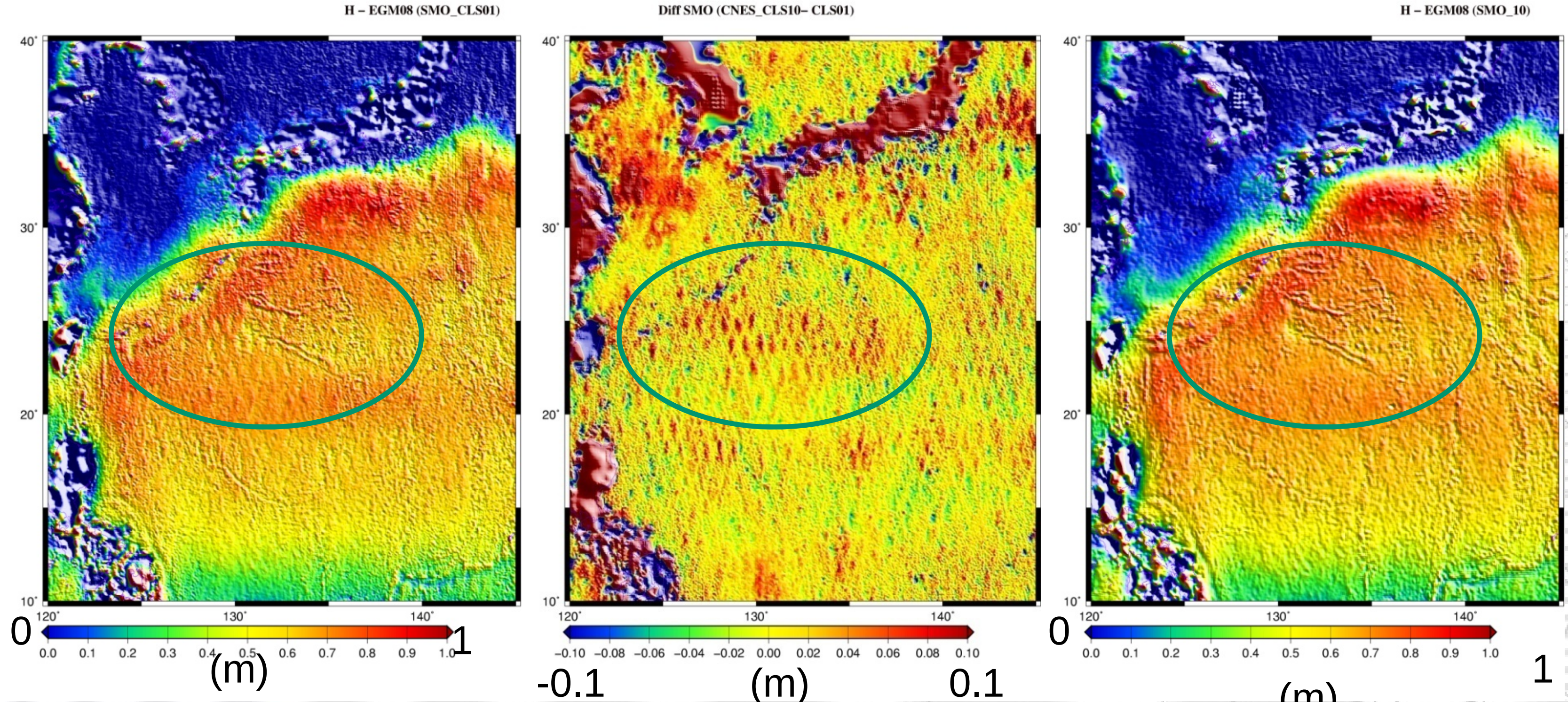
The oceanic variability is better removed: an example in the Kuroshio

✓The difference between MSS CLS01 & CNES_CLS10 shows

✓"small diamonds" on the difference => residual effect of the oceanic variability. Visible on MSS CLS01 –EGM08

✓Has disappeared with new MSS

MSS CLS01 –EGM08 | Difference (in meter) | MSS CNES_CLS10 –EGM08



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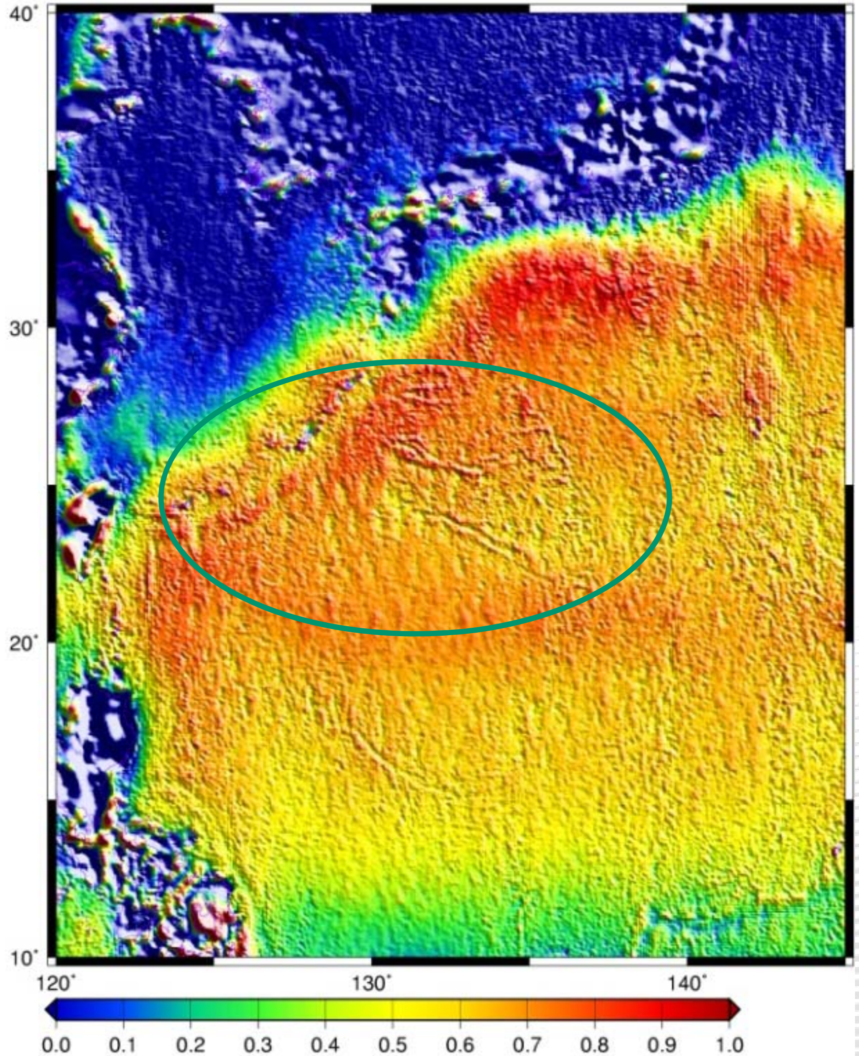

(m)

MSS CNES_CLS10–EGM08