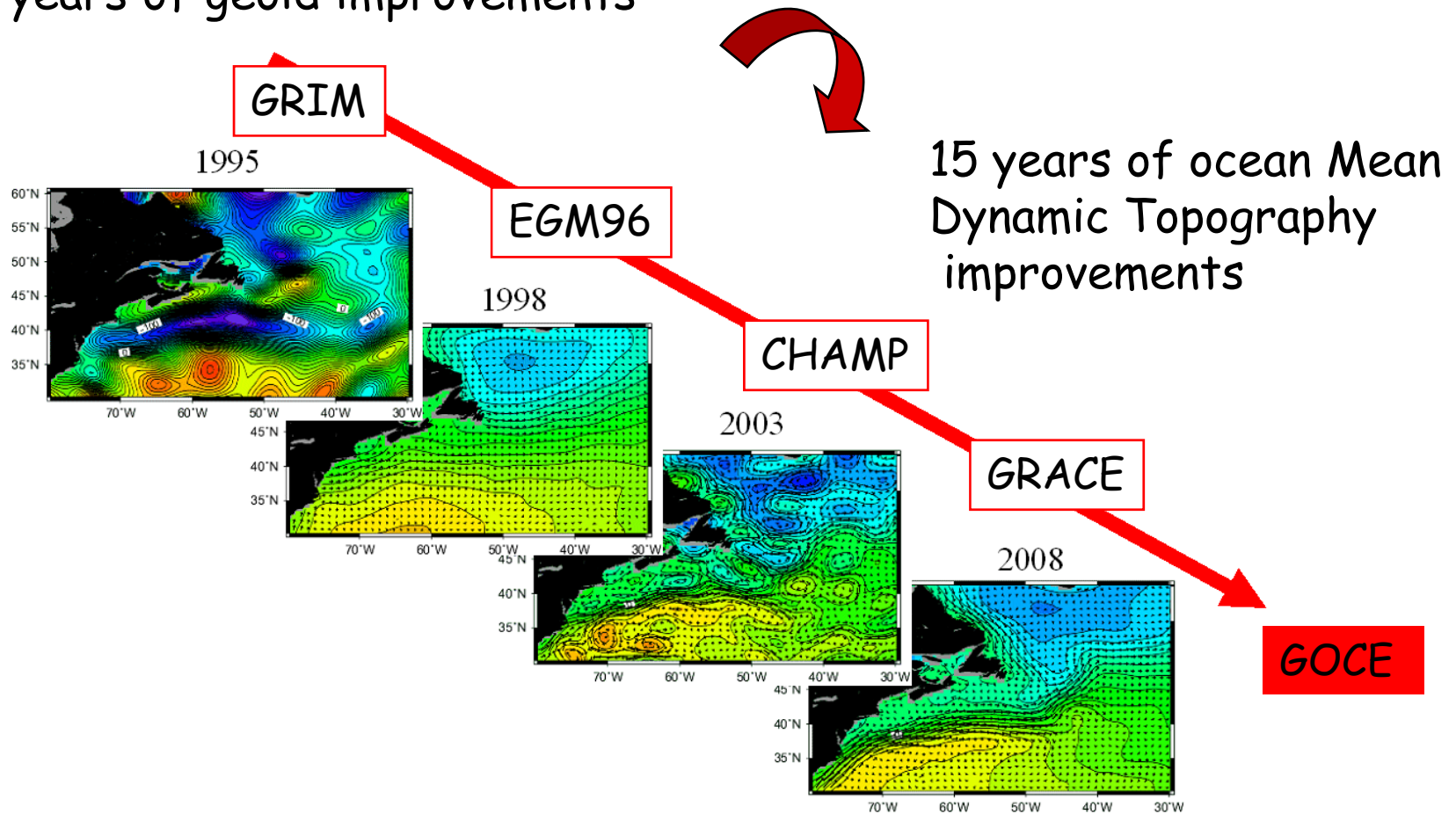


# Use of oceanographic in-situ measurements and altimetry to assess the accuracy of the latest geoid models



M.-H. Rio, P. Schaeffer, M.F. Lequentrec-Lalancette

## 15 years of geoid improvements

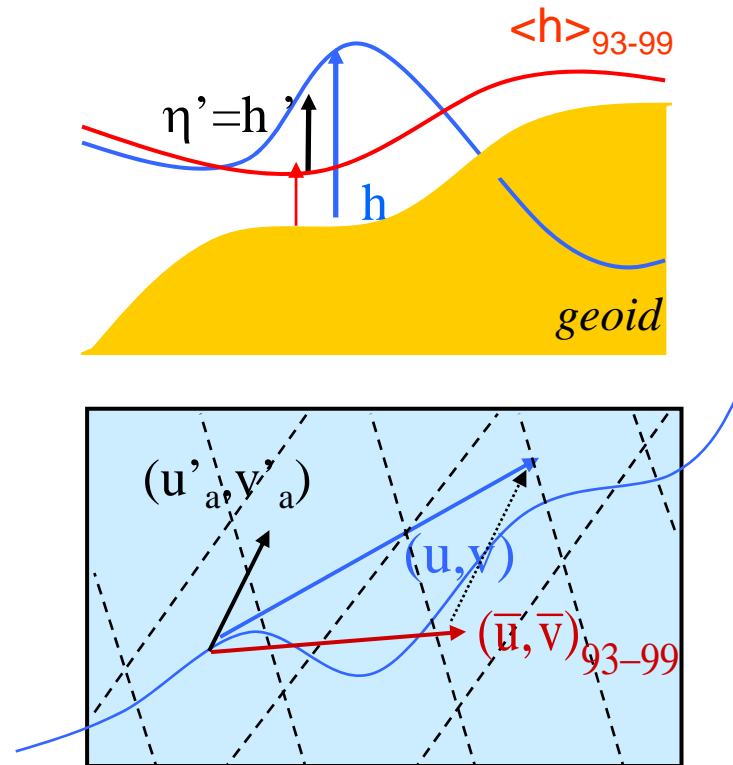
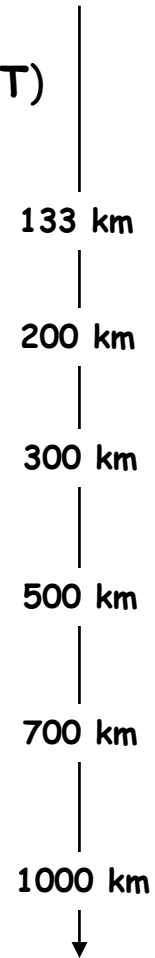
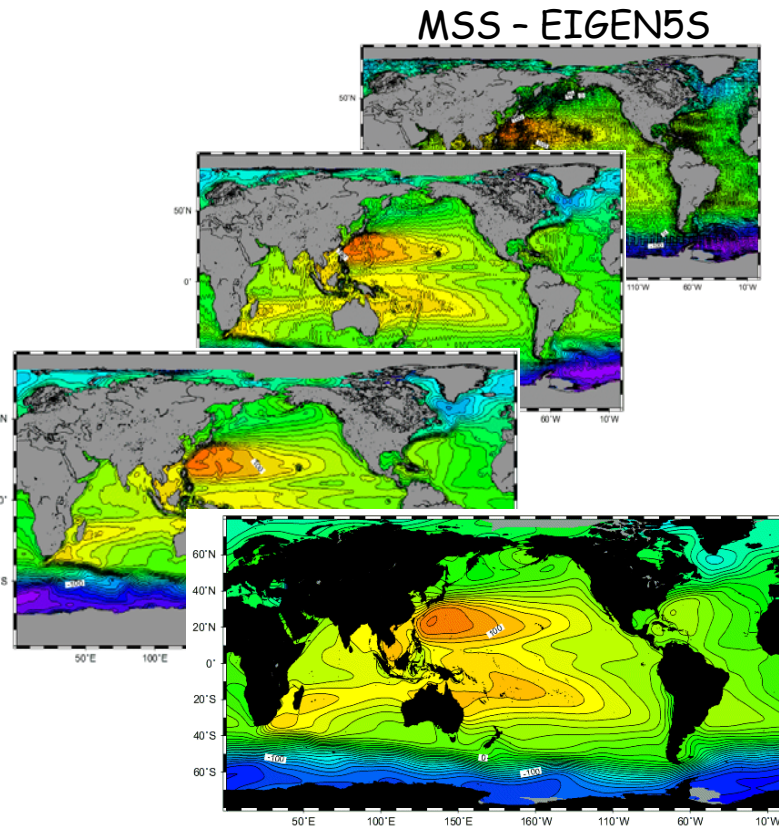


OSTST, November 2008, Nice

# Method

Computation of the ocean Mean Dynamic Topography from filtered altimetric MSS - Geoid (**direct MDT**)

Use of in-situ oceanographic measurements and altimetry to compute **synthetic estimates of the MDT (and mean velocities)**



+ *geostrophic mean surface currents*

$$\text{RMS}^2_{\text{diff}} = \text{Err}^2_{\text{synth}} + \text{Err}^2_{\text{MSS}} + \text{Err}^2_{\text{Geoid/om}} + \text{Err}^2_{\text{Geoid/com}}$$

# Data used

## 8 different geoid models

Model	Year	SH	Data
EGM96	1996	360	S/G/A
EGM08	2008	360	S/G/A
EIGEN3S	2005	150	GRACE (1 an)
EIGEN3C	2005	360	GRACE/G/A
GGM02S	2005	160	GRACE (1 an)
GGM02C	2005	200	GRACE (1 an)/G/A
EIGENGL05S	2008	150	5 ans GRACE + LAGEOS
EIGENGL05C	2008	360	GRACE/G/A

## Altimetric data

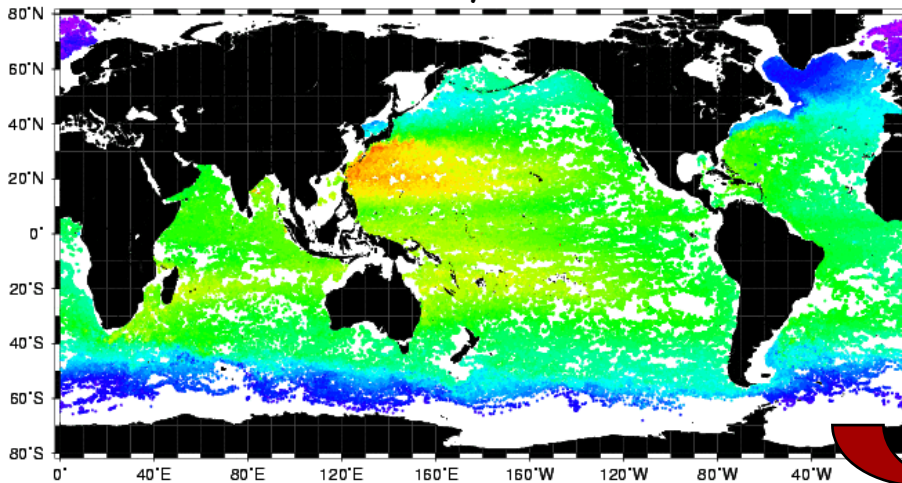
Altimetric Mean Sea Surface CLS01 (mean over 1993-1999)  
Altimetric Sea Level Anomalies from Aviso for the 1993-2007 period

# Data used

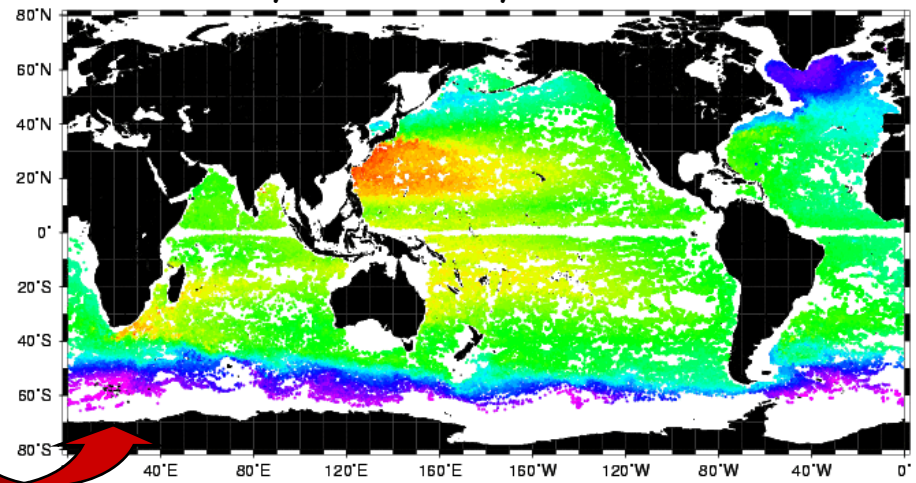
## In-Situ oceanographic data

T/S profiles distributed via Coriolis for the 1993-2007 period  
Used to compute dynamic heights relative to 1000m

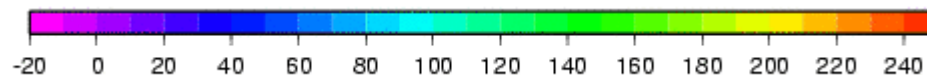
Hsynth



Hsynthtot=Hsynth+h1000

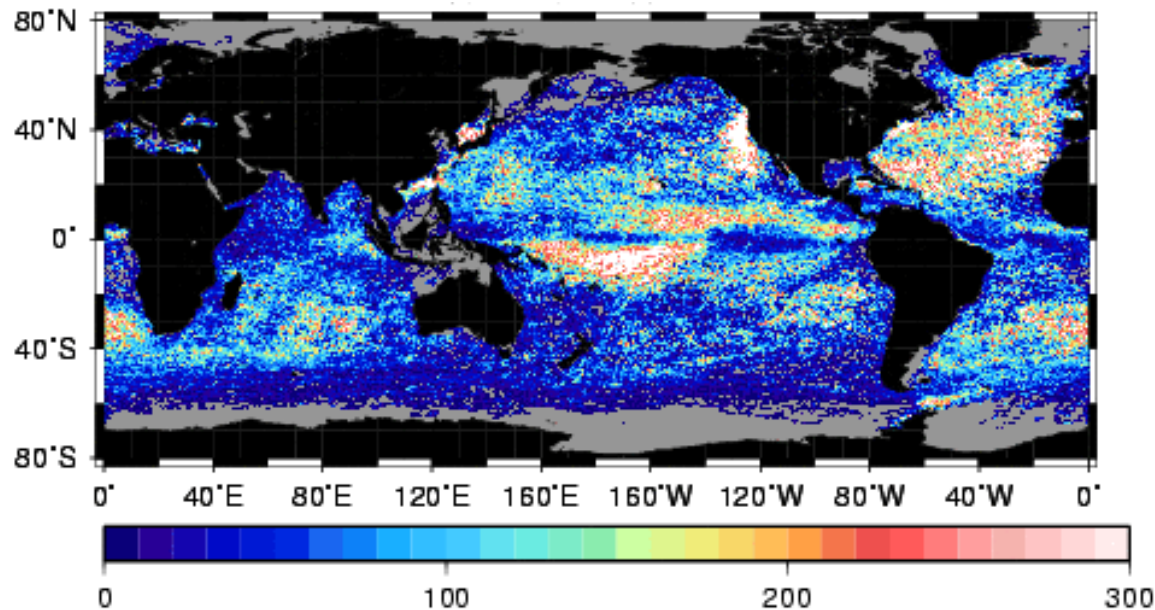


An estimate of the mean dynamic height at 1000m (Willis et al, 2006) is added to the dynamic heights relative to 1000m



## Data used

Surface current velocities measured by SVP type drifting buoys and distributed by AOML over the 1993-2007 period

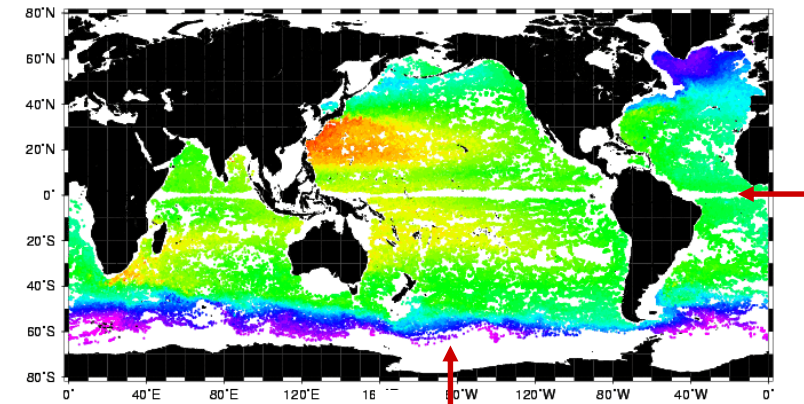


Drifter velocities are processed to extract the only-geostrophic component:  
-Ekman currents are modeled (Rio et al, 2003) and subtracted  
-A 3 days low pass filter is applied along the drifter trajectories

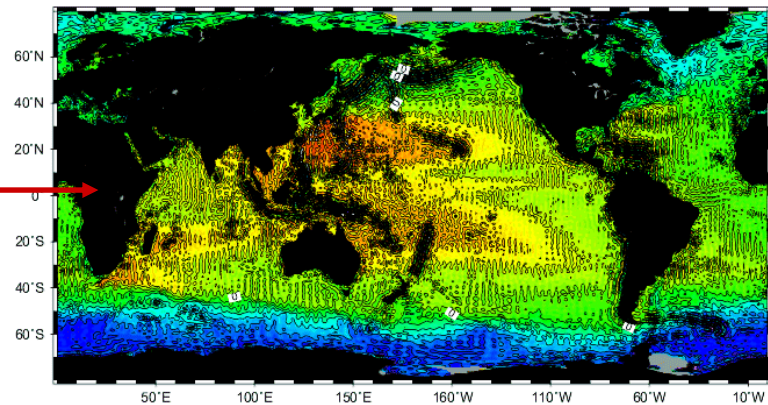


# Results

MDTsynth



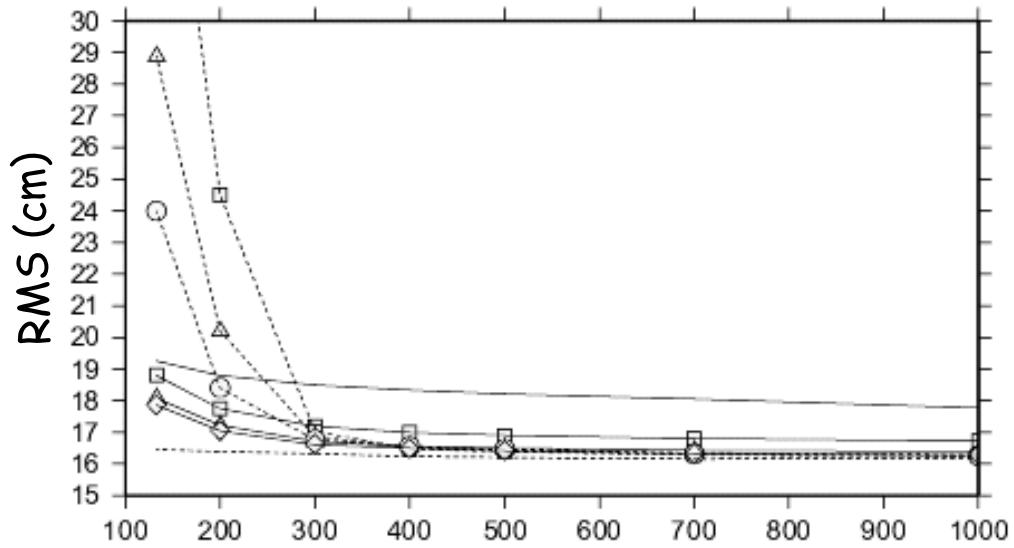
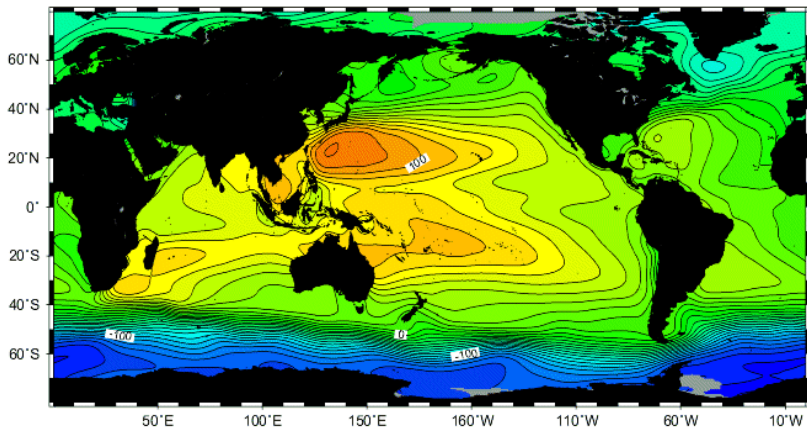
MDT 133 km (MSS-EIGEN5S)



versus

versus

MDT 1000 km (MSS-EIGEN5S)

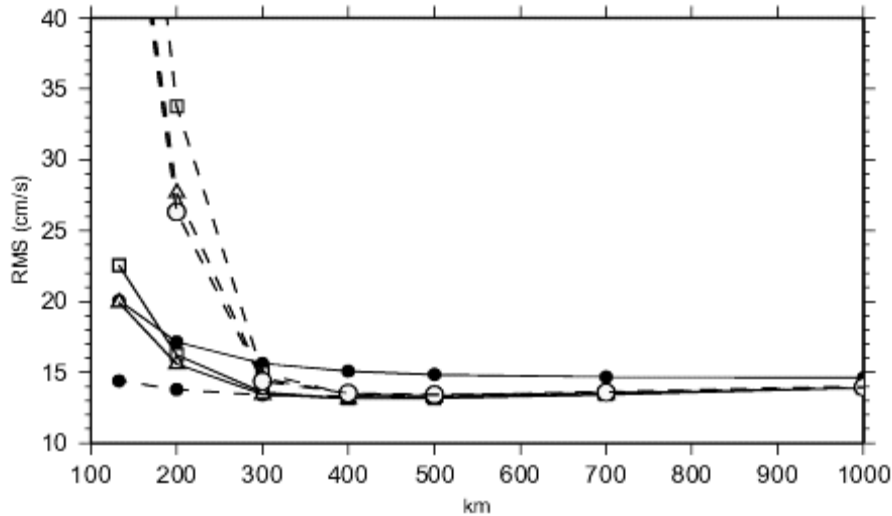


- EIGENGL05C
- △ EIGEN3C
- GGM02S
- EGM96
- GGM02C
- ⊙ EIGENGL05S
- △ EIGEN3S
- - - EGM08

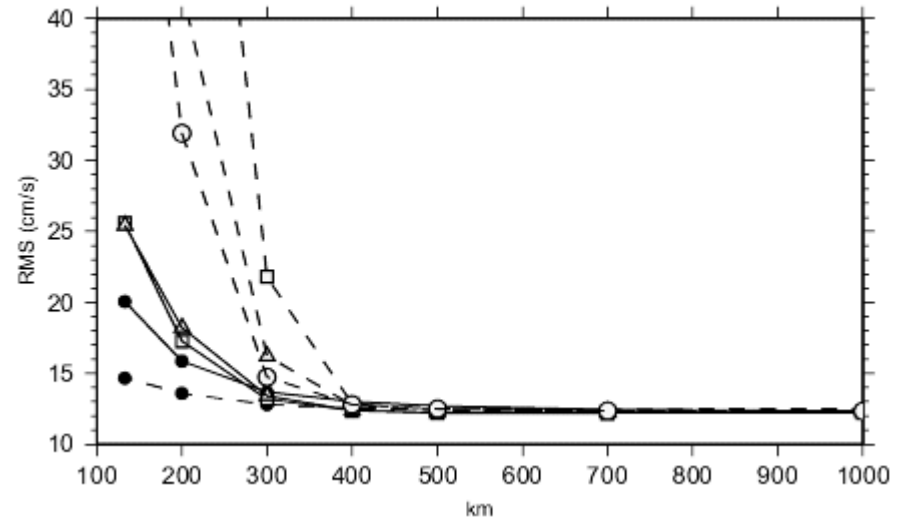
# Results

## Comparison to synthetic mean velocities

### RMS U



### RMS V



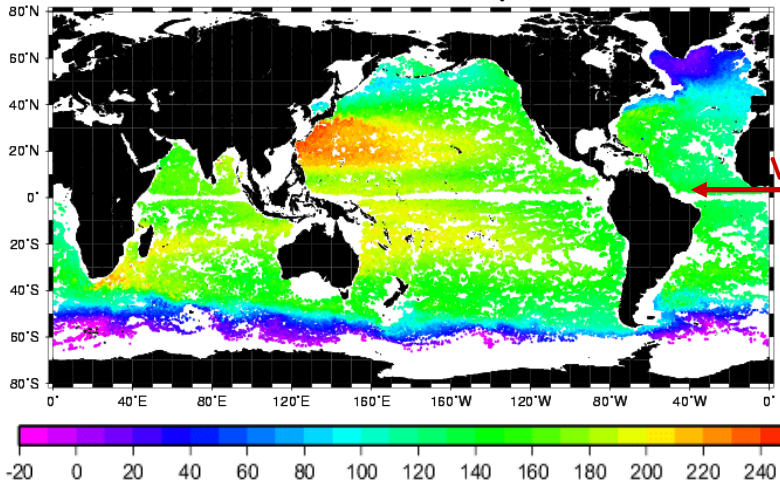
- |     |            |       |            |       |         |       |       |
|-----|------------|-------|------------|-------|---------|-------|-------|
| —○— | EIGENGL05C | —△—   | EIGEN3C    | --□-- | GGM02S  | —●—   | EGM96 |
| —□— | GGM02C     | --○-- | EIGENGL05S | --△-- | EIGEN3S | --●-- | EGM08 |

# Results

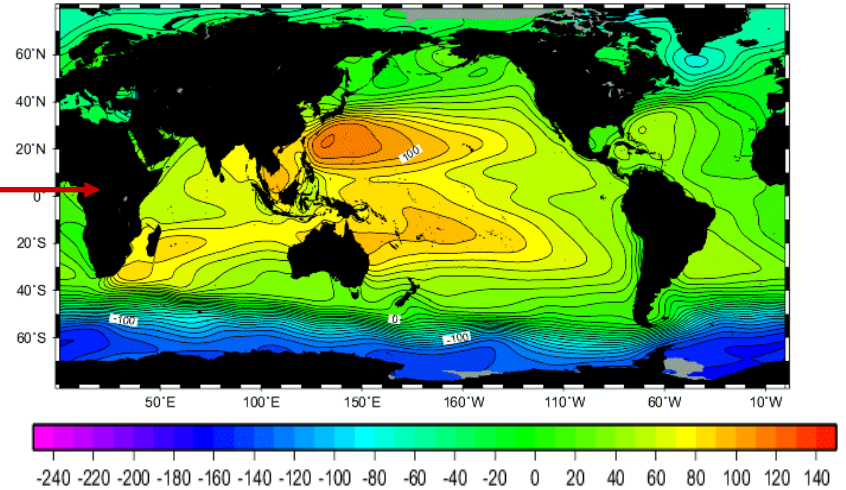
$$RMS^2_{diff} = Err^2_{synth} + Err^2_{MSS} + Err^2_{Geoid/com} + Err^2_{Geoid/om}$$

MDT synth

MDT 1000 km (MSS-EIGEN5S)



versus

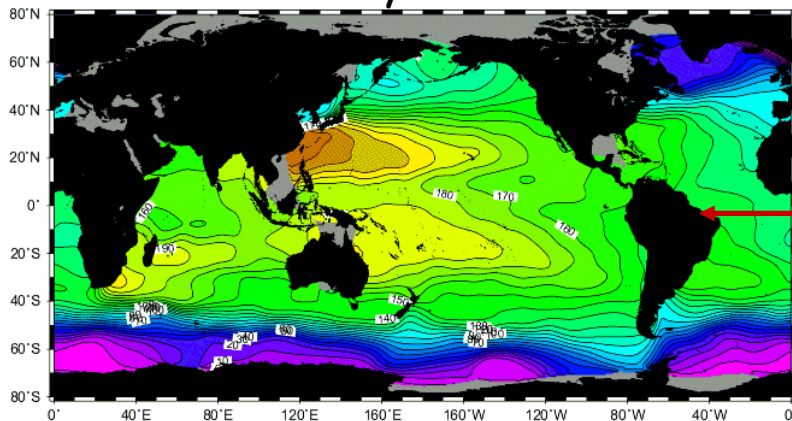


If synthetic estimates are also filtered at the same resolution than the direct estimates

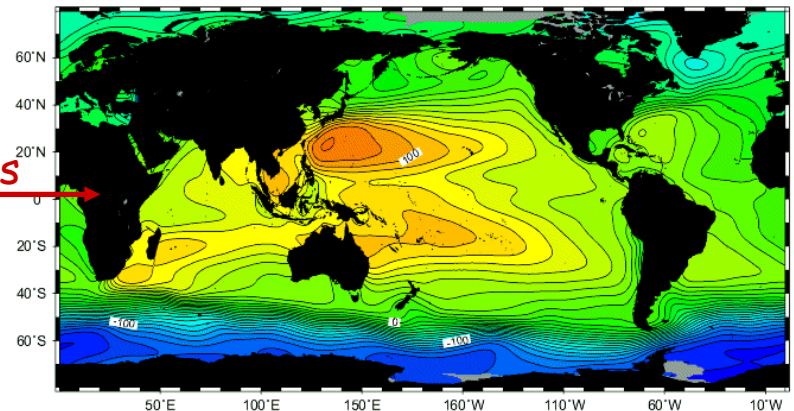
$$RMS_f^2_{diff} = Err^2_{synth} + Err^2_{MSS} + Err^2_{Geoid/com} + \cancel{Err^2_{Geoid/om}}$$

MDT synth 1000km

MDT 1000 km (MSS-EIGEN5S)



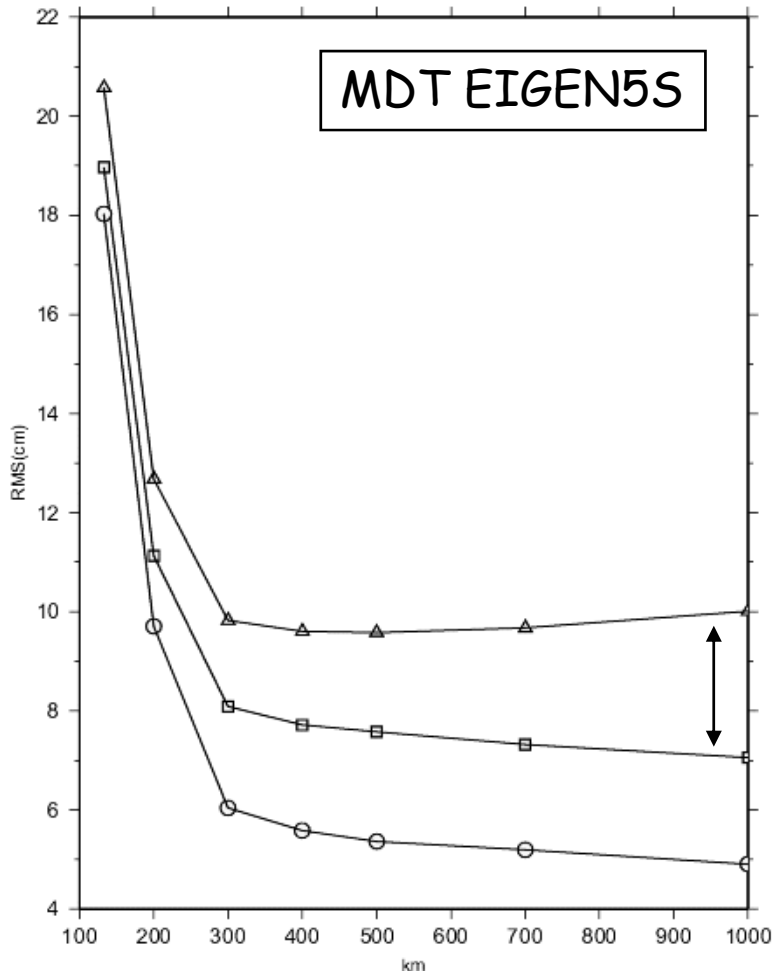
versus





# Results

## Comparison to filtered / unfiltered synthetic heights



- △ Comparison to unfiltered synthetic heights (relative to 1000m)
- Comparison to filtered synthetic heights (relative to 1000m)
- Comparison to filtered synthetic heights (total)

$$\approx \text{Err}^2_{\text{Geoid/om}}$$



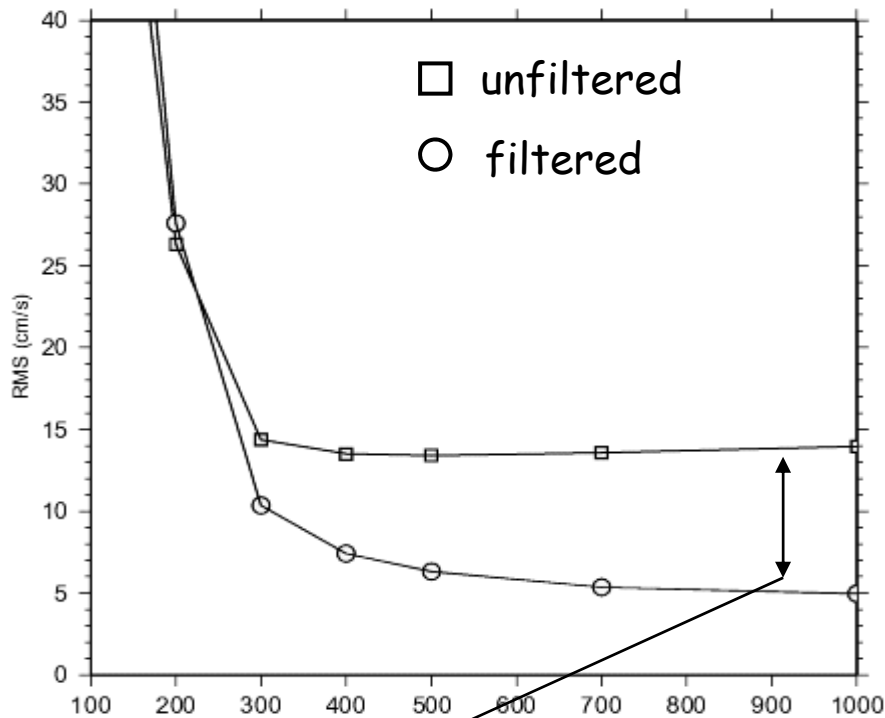
Short scales resolved by the synthetic estimates and not resolved by the filtered geoid-based MDTs

# Results

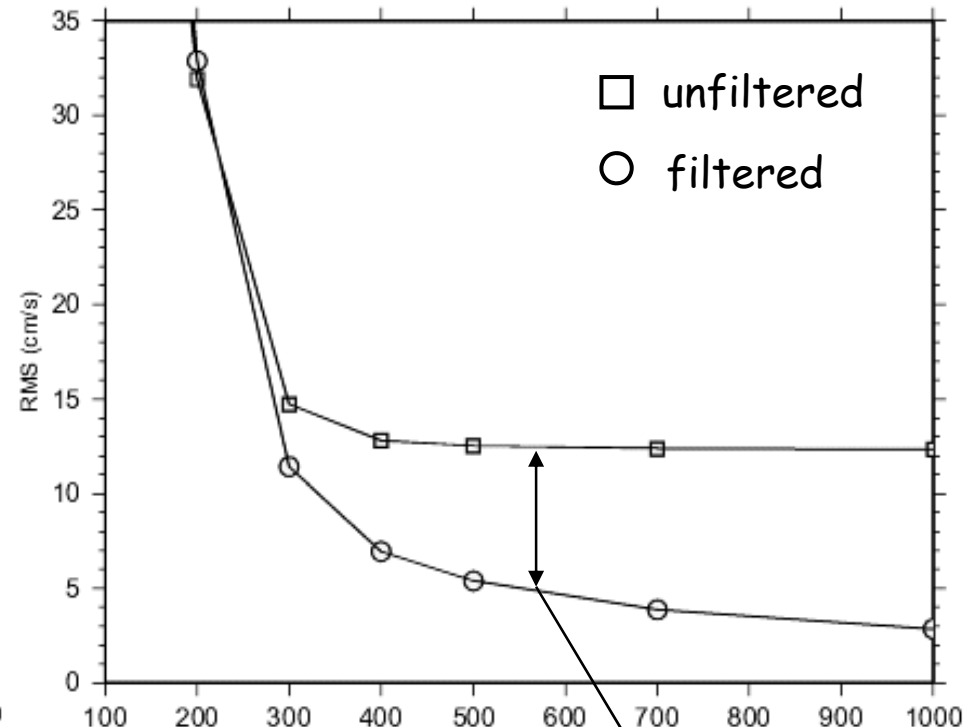
Comparison to filtered / unfiltered synthetic velocities

MDT EIGEN5S

RMS U



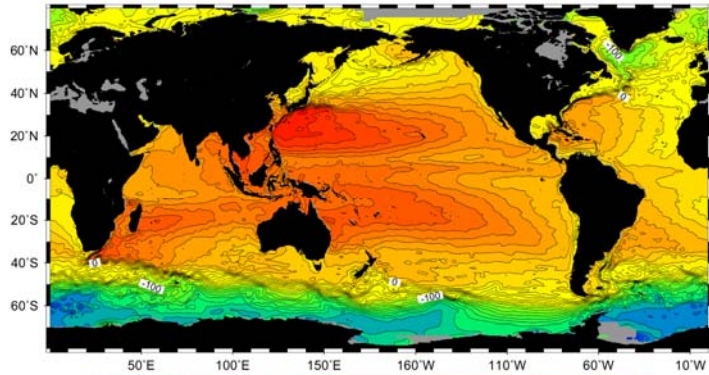
RMS V



Short scales resolved by the synthetic estimates and not resolved by the filtered geoid-based MDTs

# Application of the synergy btw direct /synthetic estimates

CMDT RIO05

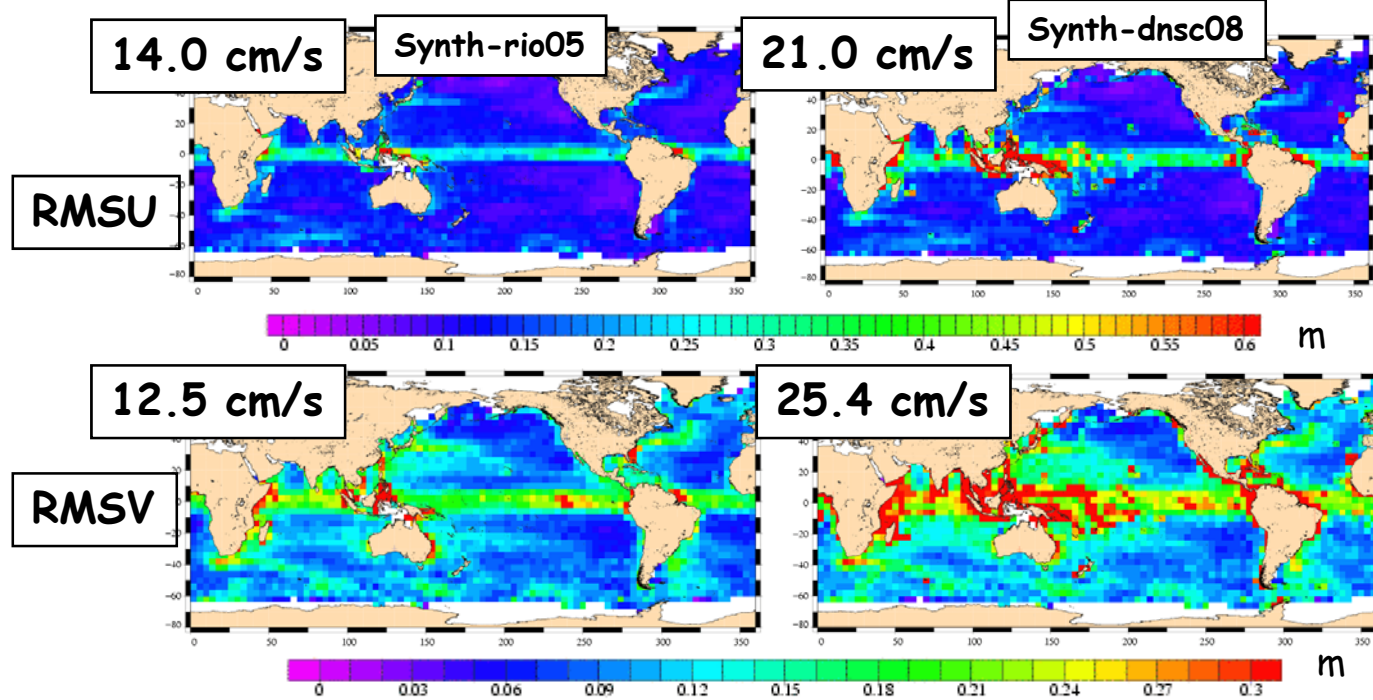


Combination of satellite only geoid-based MDT and synthetic height and velocity estimates to compute high resolution MDT (Rio et al, 2005 based on EIGEN3S MDT + in-situ-altimetric data from 1993 to 2003)

How does it compare to high resolution combined geoid-based MDTs?

MDT from MSS - EGM08 (O. Andersen, DNSC)

RMS differences with synthetic velocities based on altimetry and drifter velocities (2004-2008) NOT used in the CMDT RIO05 computation



## Conclusions

- **Method routinely used to assess the accuracy of new geoid models**  
Based on the comparison, at different space scales, between direct and synthetic estimates of the Mean Dynamic Topography
- **Satellite only geoids:** Significant improvement of EIGEN5S compared to previous models (EIGEN3S-GGM02S)  
=> Same accuracy than combined models at scales larger than 300km
- **Combined geoids:** Very good performance of new EGM08
- Synthetic estimates contain much shorter scales than direct MDT based on Satellite-only solutions => **combination with synthetic estimates needed to compute high resolution MDT solutions** (Rio et al, 2004,2005,2007 + updated solution for 2009 - see poster SF.8 -127 about the SLOOP project)
- Such combined MDTs perform better than direct MDTs based on MSS minus combined geoid (e.g. EGM08)