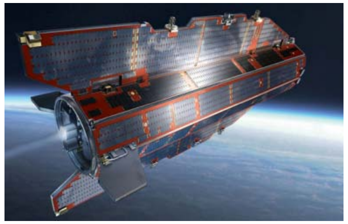

High resolution Mean Dynamic Topography in the Kerguelen area from altimetry, GOCE data and oceanographic in-situ measurements.

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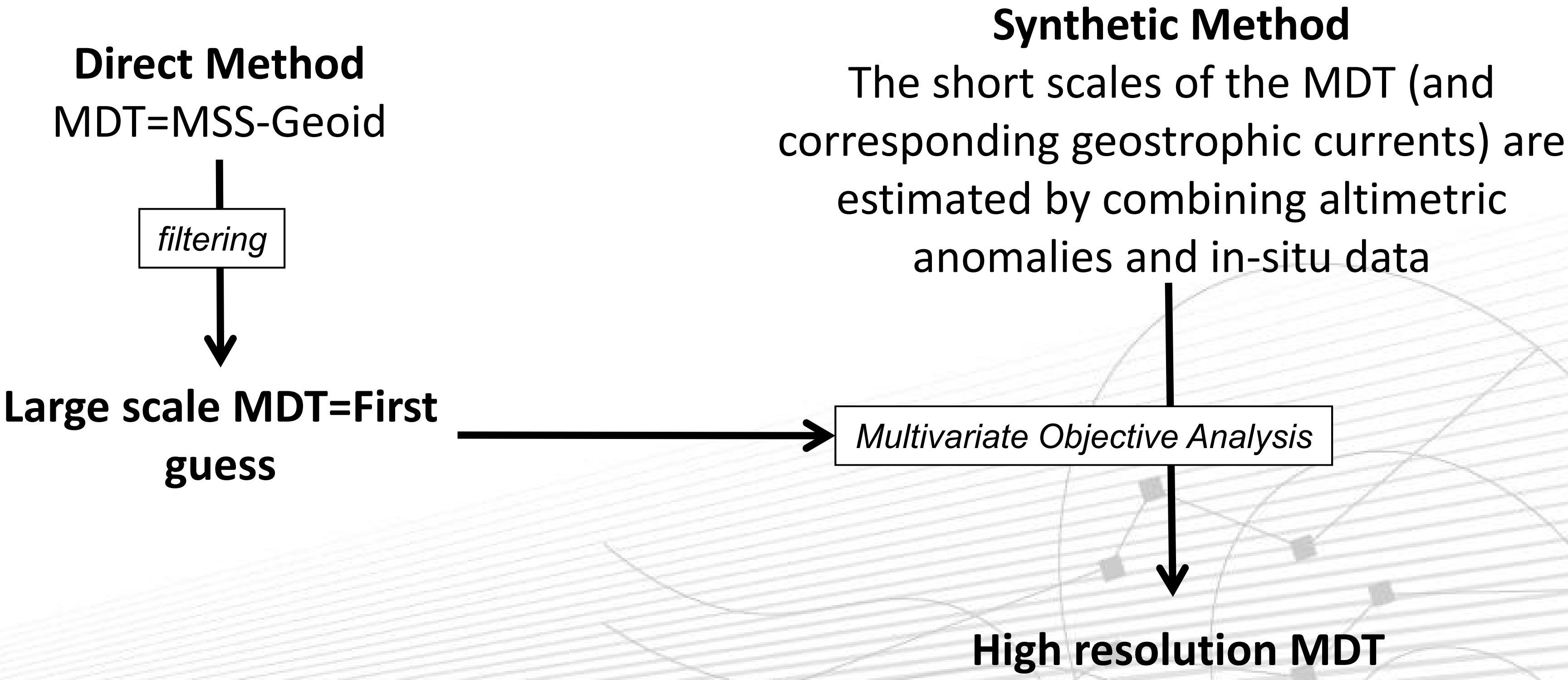
INTRODUCTION

The KEOPS-2 project:

- the KEOPS2 project is dedicated to investigating the impact of natural iron fertilization on the biogeochemical cycles in the Southern Ocean
- a sea campaign is currently taking place in the Kerguelen island area.
- For the full duration of the campaign, CLS will provide in real time regional altimetric maps of the absolute dynamic topography and the ocean currents of the region
- See Poster from Isabelle Pujol et al. in the Near real time products and application session: A Kerguelen regional Sea Level product to support the KEOPS2 experiment
- To improve regionally the altimetric maps of absolute dynamic topography and geostrophic currents, a specific Mean Dynamic Topography has been computed.

High resolution Mean Dynamic Topography in the Kerguelen area from altimetry, GOCE data and oceanographic in-situ measurements

Method (Rio et al, 2004,2005,2007,2011)



Direct Method

MDT=MSS-Geoid

filtering

Large scale MDT=First guess

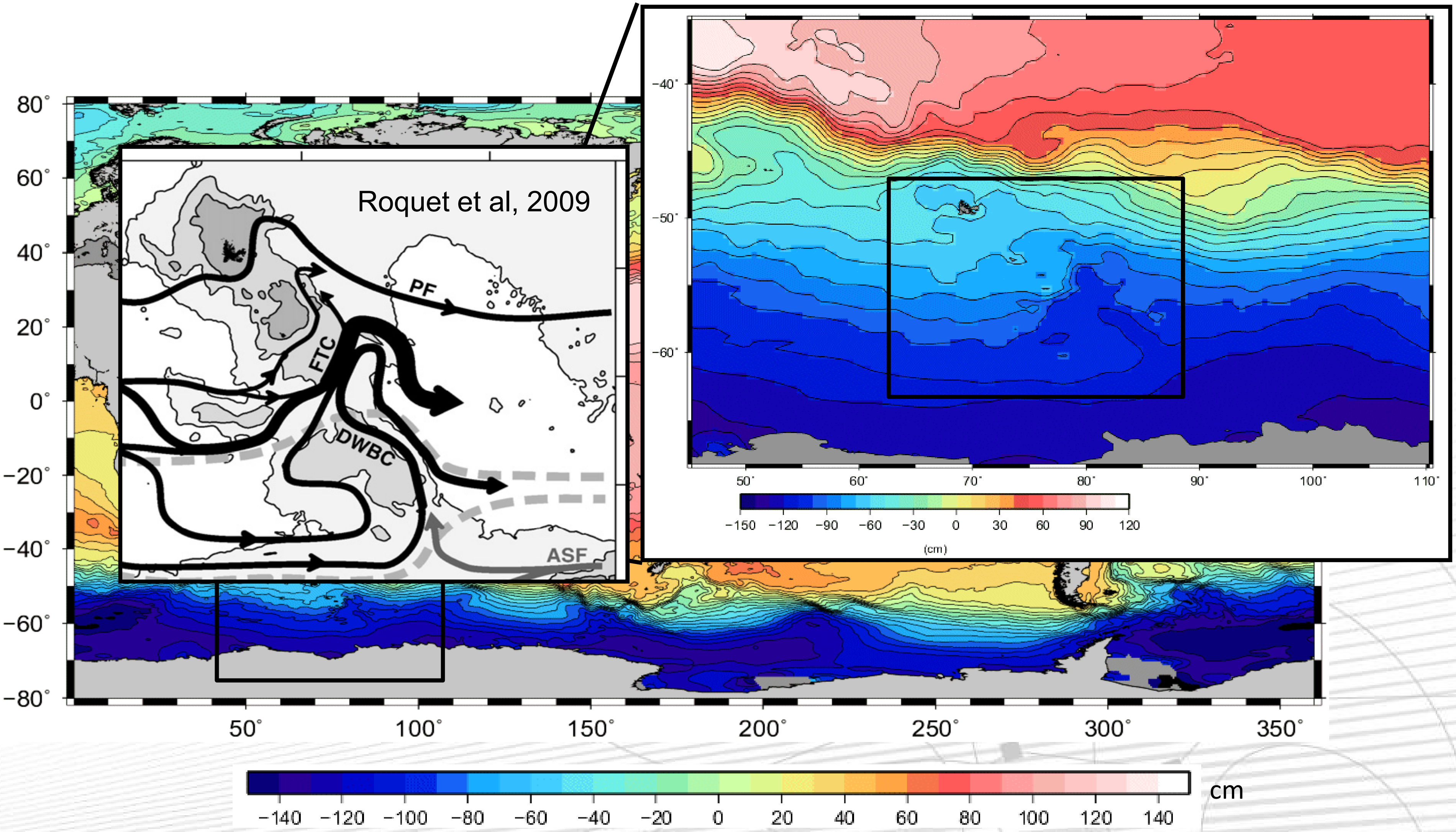
Synthetic Method

The short scales of the MDT (and corresponding geostrophic currents) are estimated by combining altimetric anomalies and in-situ data

Multivariate Objective Analysis

High resolution MDT

The global CNES-CLS09 MDT

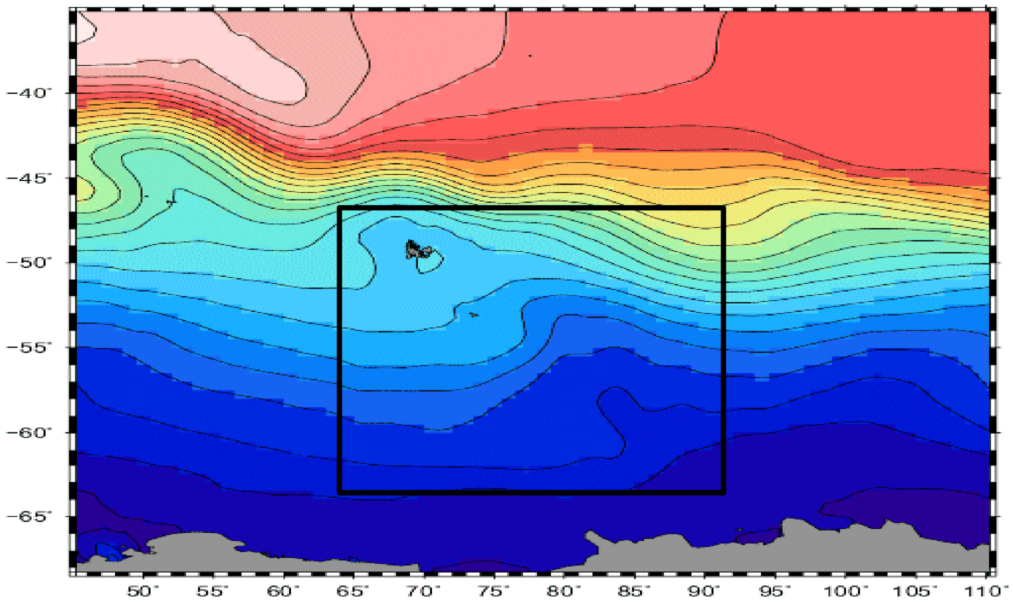


Main improvements relative to the globale CNES-CLS09 solution

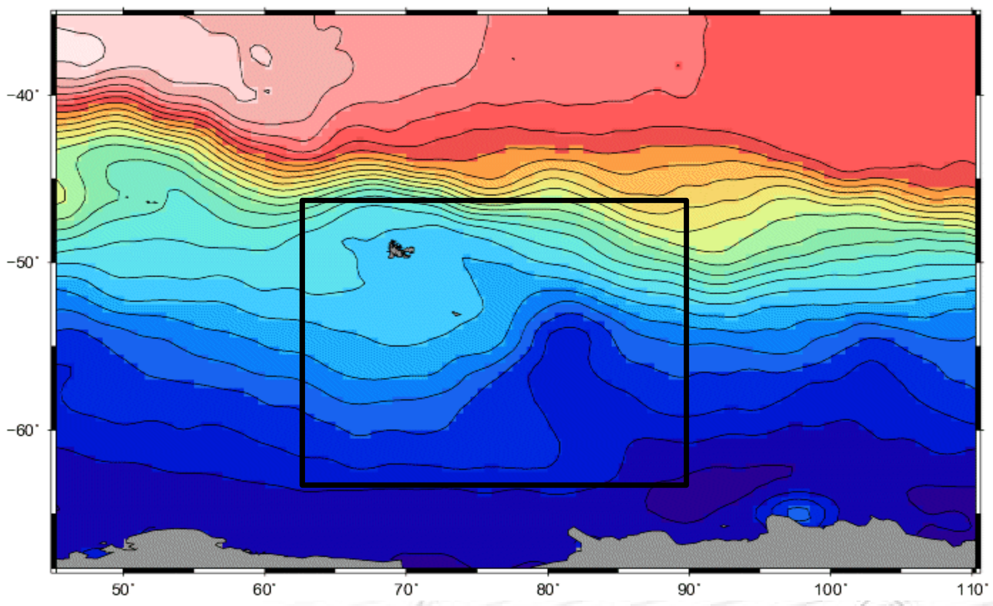
	CMDT CNES-CLS09 →	**CMDT KEOPS V1.0**
MSS used for first guess computation Geoid model used for First Guess computation:	MSS CLS01 EIGEN-GRGS.RL02.MEAN based on $4^{1/2}$ years of GRACE data	MSS CLS11 GOCO02S based on 7 years of GRACE data and 8 months of GOCE data
Filtering used for First Guess computation:	Optimal filter (~400 km)	Gaussian filter 250km
Buoy velocities dataset	SVP à 15m, Period 1993-2008	SVP at 15m, Period 1993-2010 Corrected for Wind slippage in case of drogue loss
Ekman model	Parameters fitted over the 1993-2008 period, by latitude, year, and month (3 months moving window)	Parameters fitted over the 1993-2010 period, by latitude and month (3 months moving window)
T/S data	CTD, ARGO Pref variable 200/400/900/1200/1900 Period 1993-2008	CTD (Cora3.2), ARGO Pref variable 200/400/900/1200/1900 Period 1993-2010
Resolution	Global, ¼° (no Méditerranean)	Regional 1/8°

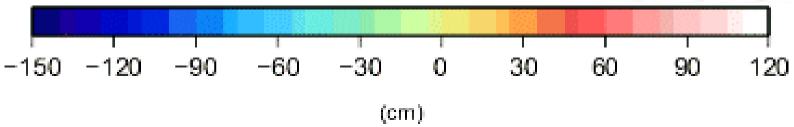
First guess

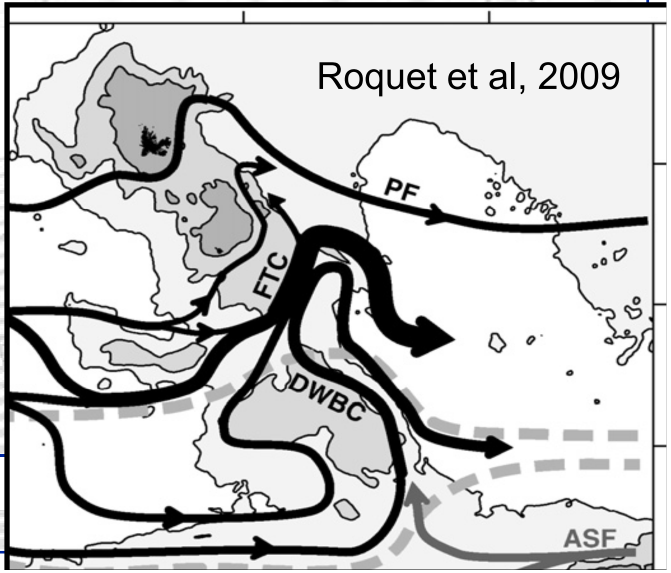
MSS CLS01-GRACE 400km



MSS CLS11-GOCO02S 250km






Roquet et al, 2009

Estimation of synthetic mean velocities

$$\langle u_g(x,y)\rangle_{93\text{-}99} = u_g(x,y,t) - u_g'(x,y,t)$$

$$\langle v_g(x,y)\rangle_{93\text{-}99} = v_g(x,y,t) - v_g'(x,y,t)$$

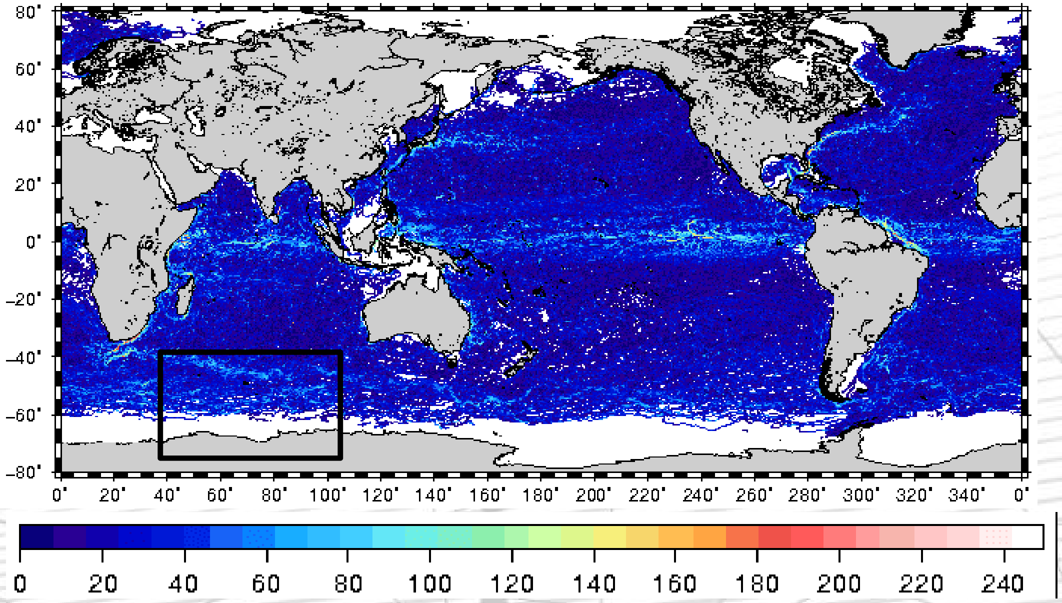
From altimetry

Deduced from drifting buoy trajectories after

✓Substraction of Ekman component

✓3 days low-pass filtering

15m-drogued drifting buoy velocities distributed by AOML for the period 1993-2010



cm/s

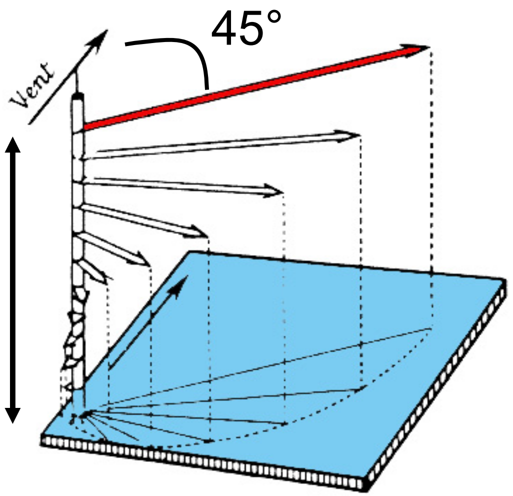
Modelling Ekman currents

Ekman theory

$$u_e = \pm \frac{\pi\sqrt{2}}{\rho f D_e} e^{\frac{\pi}{D_e}z} * \tau * \cos(\frac{\pi}{4} + \frac{\pi}{D_e} z)$$

$$v_e = \frac{\pi\sqrt{2}}{\rho f D_e} e^{\frac{\pi}{D_e}z} * \tau * \sin(\frac{\pi}{4} + \frac{\pi}{D_e} z)$$

β θ



Model

Rio and Hernandez, 2003

$$\vec{u}_e = \beta \vec{\tau} e^{i\theta}$$

$\vec{u}_{buoy} - \vec{u}_{alti}$

Wind stress from ERA INTERIM

Band pass filtered 30 hours – 20 days

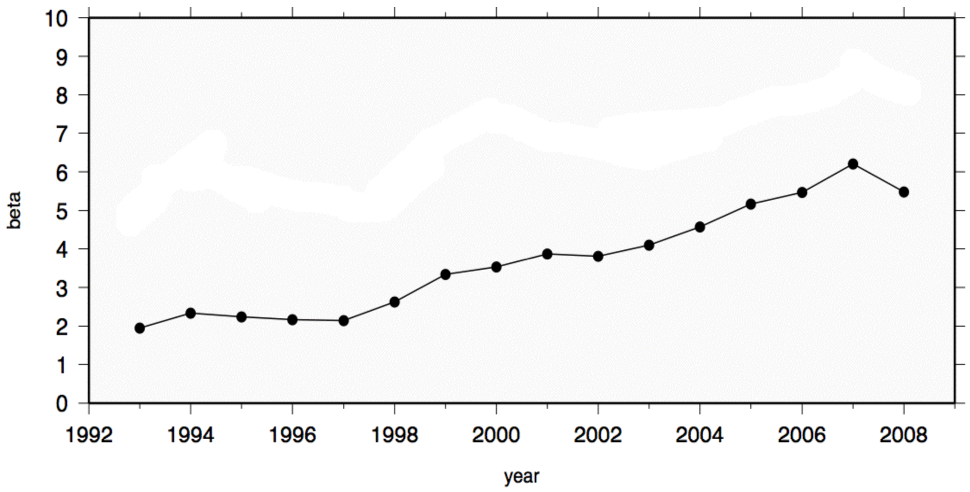
β and θ are estimated through least square fit

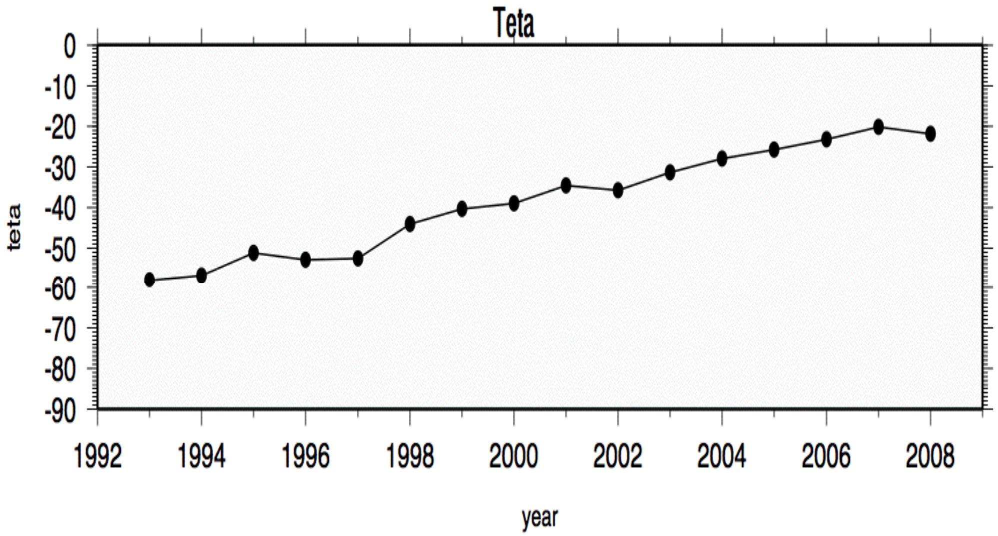
Dataset used for the CNES-CLS09 MDT computation: Drifting buoys from AOML for the period **1993-2008**

Modelling Ekman currents

β and θ computed over the global ocean by year

β



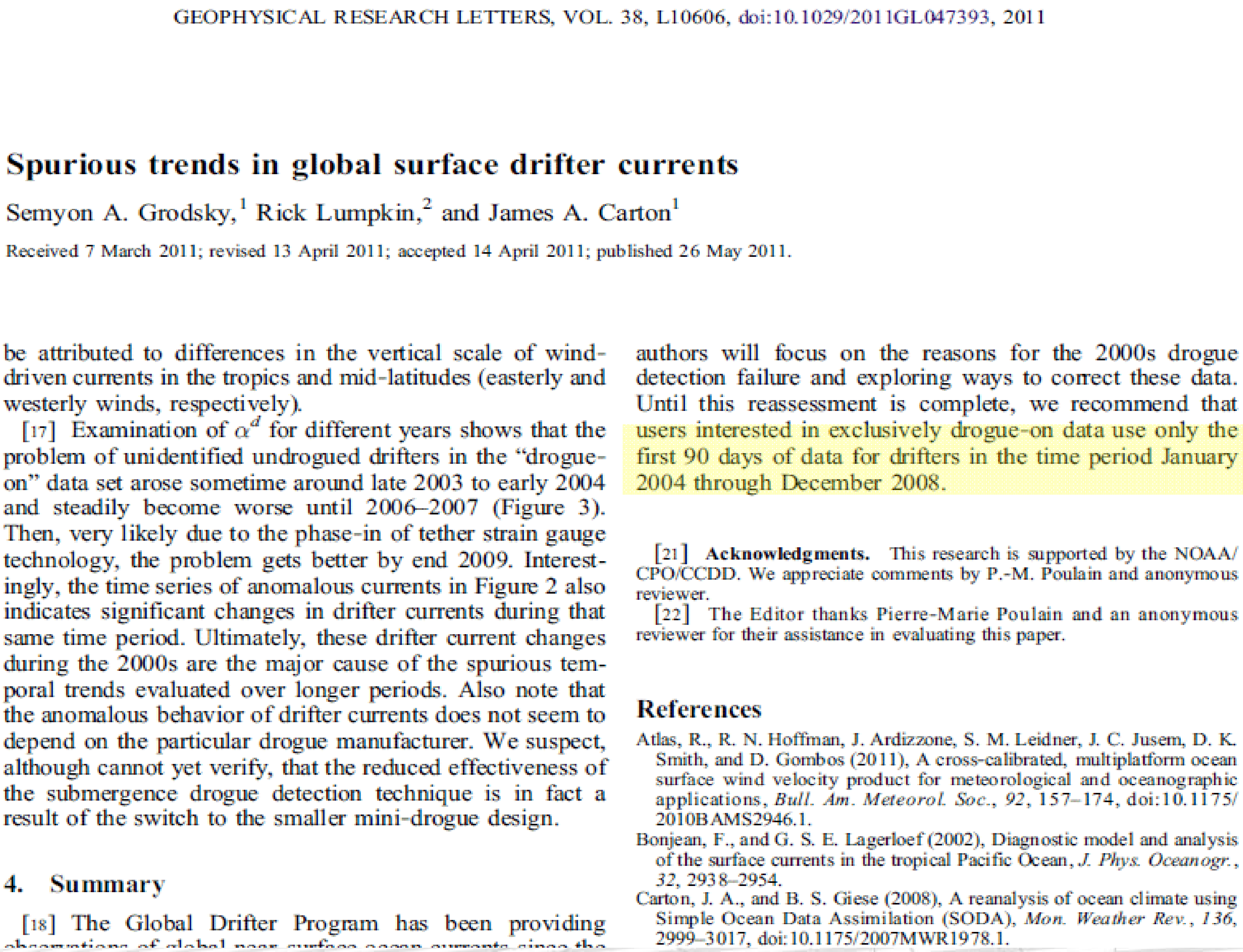


Strong dependency of β and θ parameters with time

✓ Increase with time of parameter β

✓ Decrease with time of |θ| - Direction of Ekman currents closer to wind direction

Rio et al, 2011



GEOPHYSICAL RESEARCH LETTERS, VOL. 38, L10606, doi:10.1029/2011GL047393, 2011

Spurious trends in global surface drifter currents

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be attributed to differences in the vertical scale of wind-driven currents in the tropics and mid-latitudes (easterly and westerly winds, respectively).

[17] Examination of α^d for different years shows that the problem of unidentified undrogued drifters in the “drogue-on” data set arose sometime around late 2003 to early 2004 and steadily become worse until 2006–2007 (Figure 3). Then, very likely due to the phase-in of tether strain gauge technology, the problem gets better by end 2009. Interestingly, the time series of anomalous currents in Figure 2 also indicates significant changes in drifter currents during that same time period. Ultimately, these drifter current changes during the 2000s are the major cause of the spurious temporal trends evaluated over longer periods. Also note that the anomalous behavior of drifter currents does not seem to depend on the particular drogue manufacturer. We suspect, although cannot yet verify, that the reduced effectiveness of the submergence drogue detection technique is in fact a result of the switch to the smaller mini-drogue design.

4. Summary

[18] The Global Drifter Program has been providing

authors will focus on the reasons for the 2000s drogue detection failure and exploring ways to correct these data. Until this reassessment is complete, we recommend that users interested in exclusively drogue-on data use only the first 90 days of data for drifters in the time period January 2004 through December 2008.

[21] **Acknowledgments.** This research is supported by the NOAA/CPO/CCDD. We appreciate comments by P.-M. Poulain and anonymous reviewer.

[22] The Editor thanks Pierre-Marie Poulain and an anonymous reviewer for their assistance in evaluating this paper.

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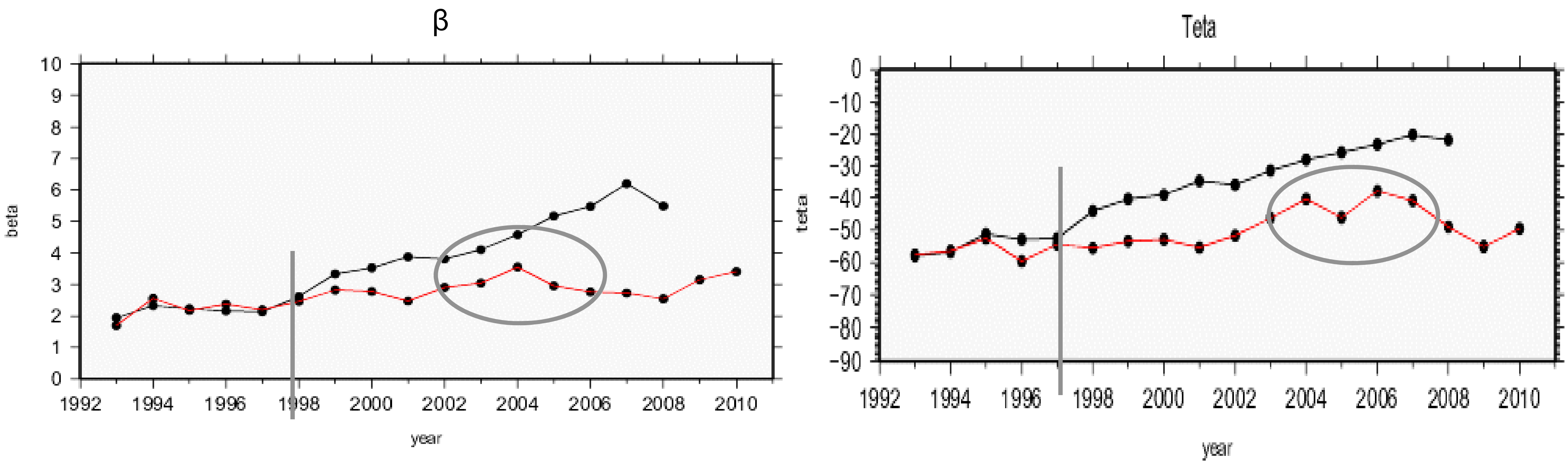
Bonjean, F., and G. S. E. Lagerloef (2002), Diagnostic model and analysis of the surface currents in the tropical Pacific Ocean, *J. Phys. Oceanogr.*, *32*, 2938–2954.

Carton, J. A., and B. S. Giese (2008), A reanalysis of ocean climate using Simple Ocean Data Assimilation (SODA), *Mon. Weather Rev.*, *136*, 2999–3017, doi:10.1175/2007MWR1978.1.

Modelling Ekman currents

β and θ computed over the global ocean by year



― ALL

― First three months of each trajectory only (Grodsky et al, 2011)

11 000 703 data

1 107 262 data

Only 10% of the data kept!

Need for cleaning the AOML drifting buoy dataset for undetected undrogued drifter

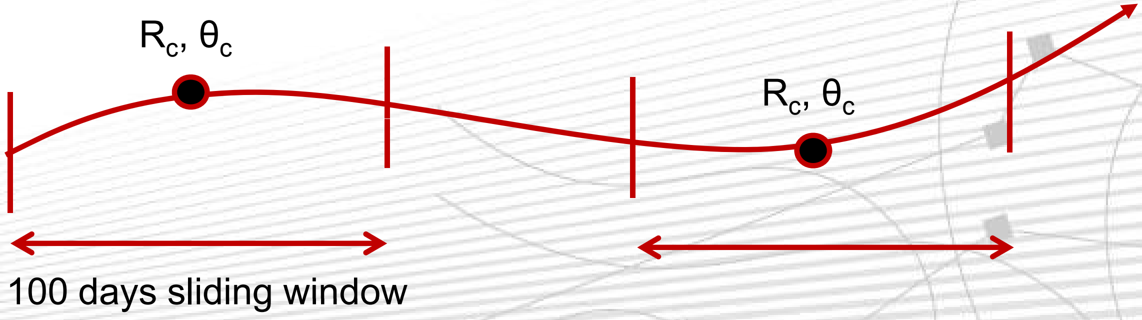
Detecting the drogue loss: Method

✓A new Ekman model is computed based on the first three months of the AOML drifter trajectories (by latitudinal band and by month to take into account the spatial and seasonal change in stratification)

✓Altimetric geostrophic currents (AVISO) are subtracted from the drifter velocity
-> 'Ageostrophic' drifter velocity

✓Ekman currents are subtracted fom the drifter currents -> 'residual' drifter velocity

✓Vectorial correlation between the 'residual' drifter velocity and the wind is computed along the drifter trajectories (only trajectories longer than 200 days are considered)



Detecting the drogue loss: Example

— ‘Ageostrophic’ drifter velocity vs Wind

‘Ageostrophic’ velocities = Vbuoy-Valti

P1-P2: Correlation > 0.3

Ekman angle ~60°

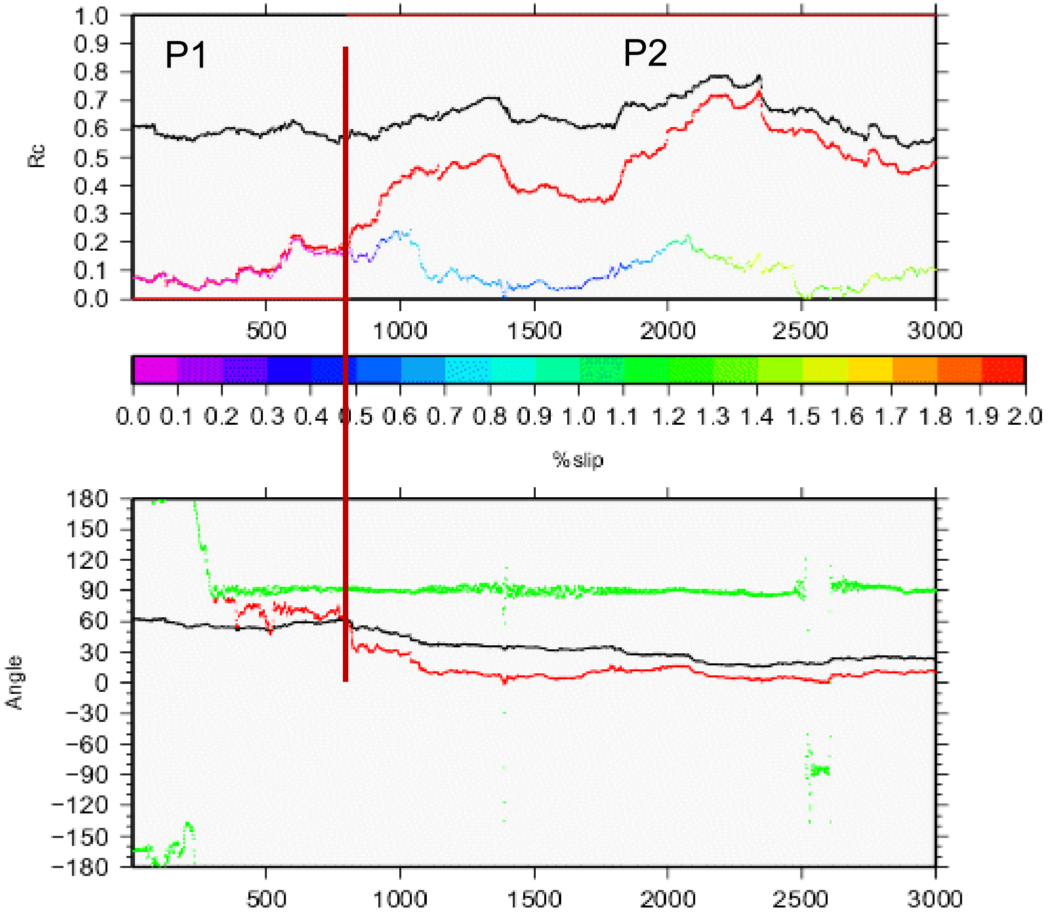
— ‘Residual’ drifter velocity vs Wind

‘Residual’ velocities = Vbuoy-Valti-Vekman

P1: Correlation coefficient low(<0.3)
Correlation angle uncoherent

P2: Correlation coefficient increases
Correlation angle nearly 0

We are confident that the drogue is ON during P1 and is off during P2



‘Residual’ velocities = Vbuoy-Valti-Vekman-αWind

α ranging from 0% to 2%

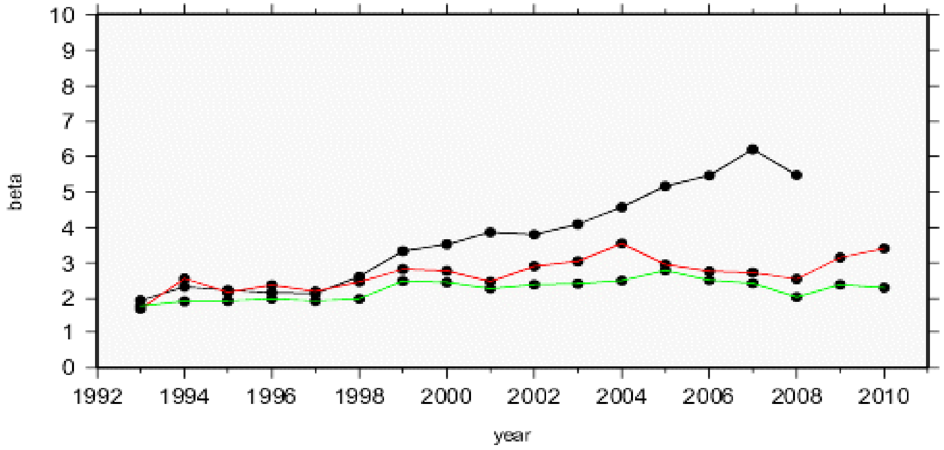
— Vbuoy-Valti-Vekman-α_{best}Wind vs Wind

We determine α= α_{best} that minimizes the vectorial correlation between the ‘residual’ velocity and the wind.

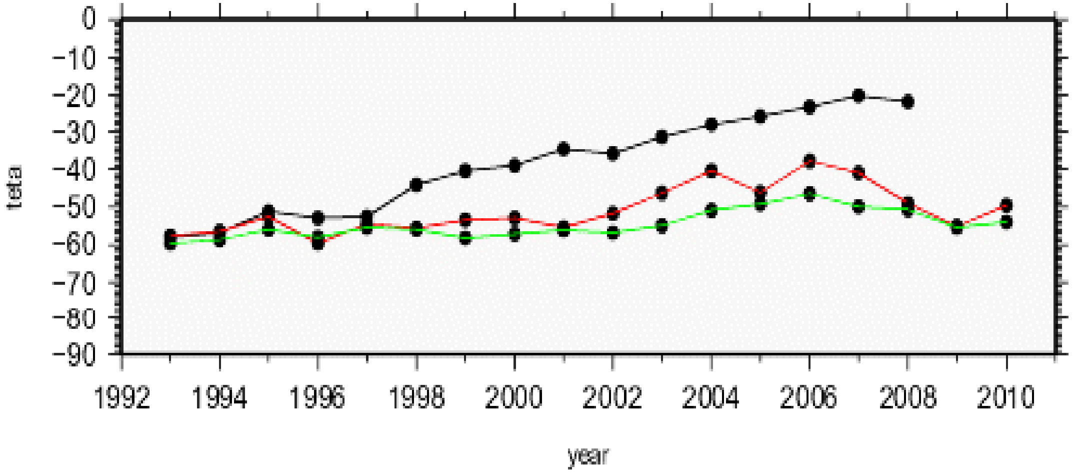
Modelling Ekman currents

β and θ computed over the global ocean by year

β



θ



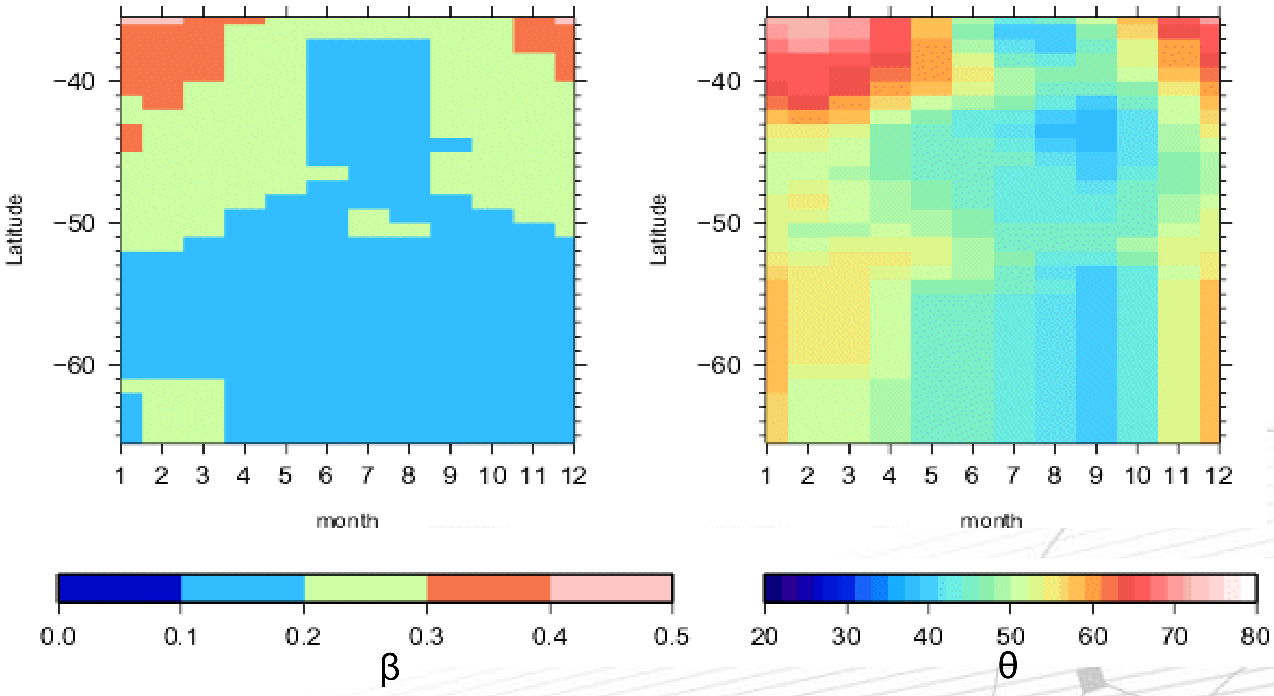
— ALL

— First three months of each trajectory only (Grodsky et al, 2011)

— Only drogued drifters

Modelling Ekman currents

Final model for the KEOPS project:
β and θ computed by latitude and month over the longitudinal band [45°E-110°E]



In Summer stratification increases
=> De decreases =>

$$\beta = \frac{\pi\sqrt{2}}{\rho f D_E} e^{\frac{\pi}{D_E} z}$$

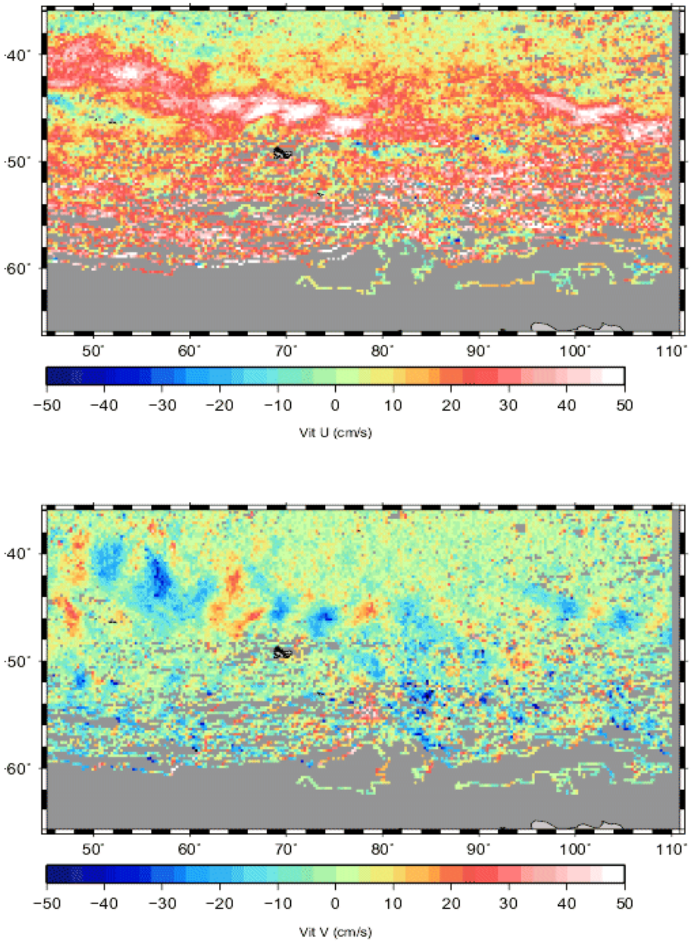
increases

$$|\theta| = \left(\frac{\pi}{4} + \frac{15}{D_e} \right)$$

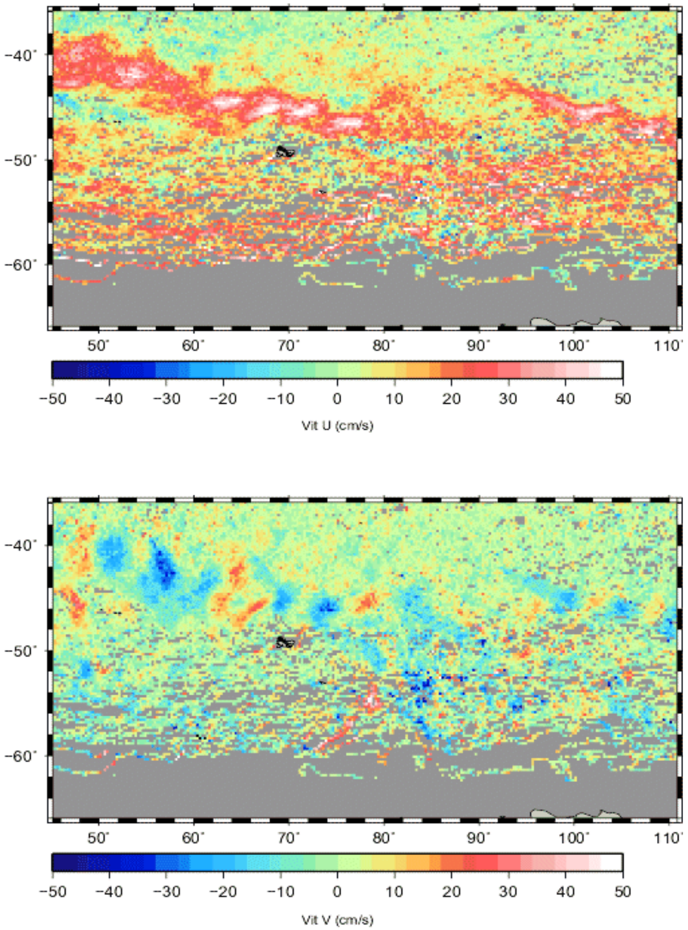
increases

Final set of mean Synthetic velocity estimates

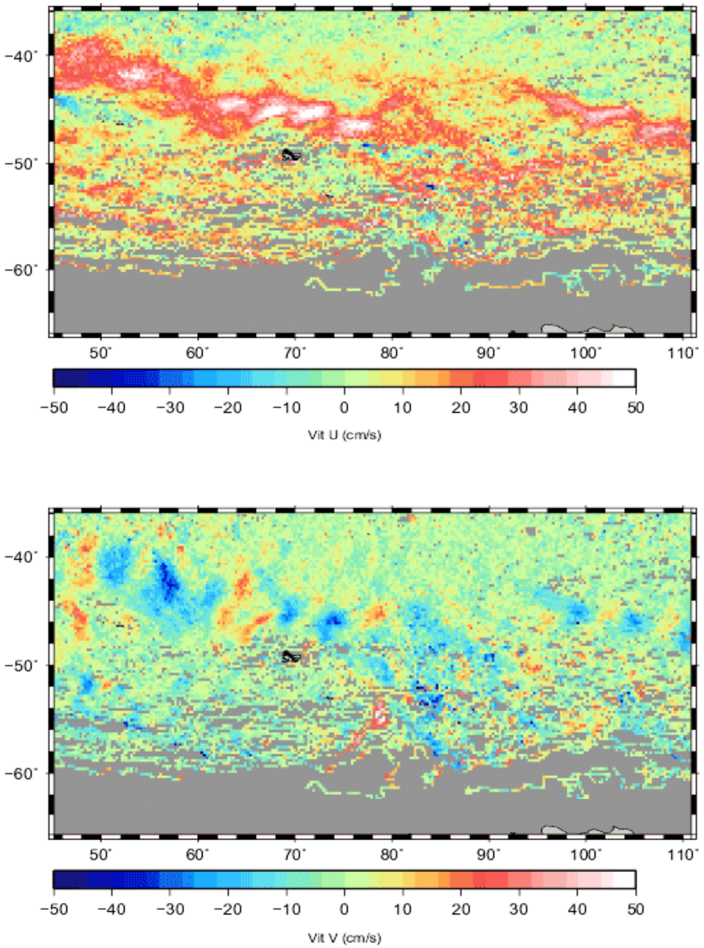
New Ekman model
ALL BUOY (drog ON and OFF)



CNES-CLS09

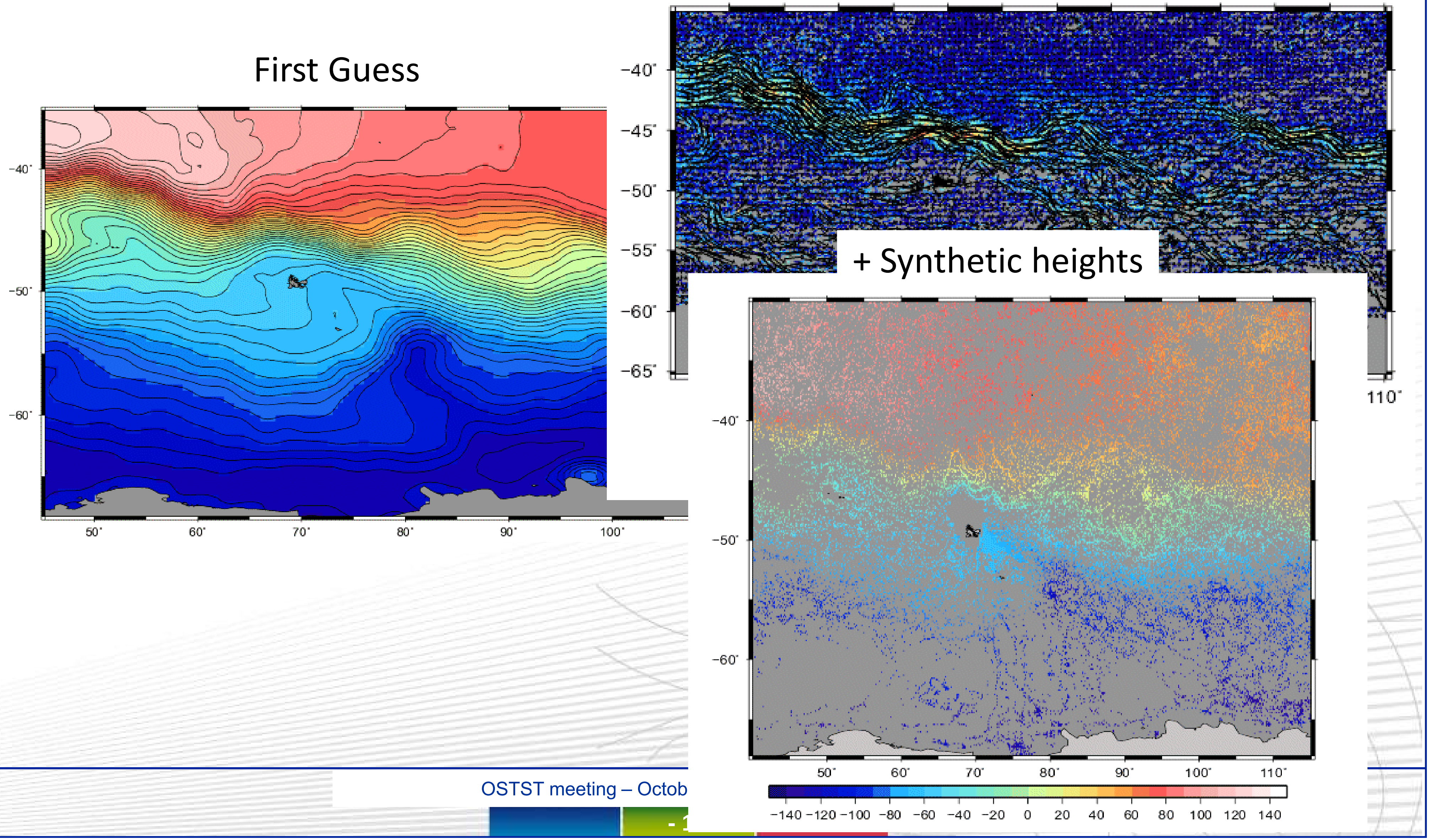


New Ekman model
+ Slip correction
ALL BUOY (drog ON and OFF)



In the CNES-CLS09 MDT the 'drog' issue is partially solved thanks to the yearly varying component of the Ekman model

Regional MDT KEOPS V1.0

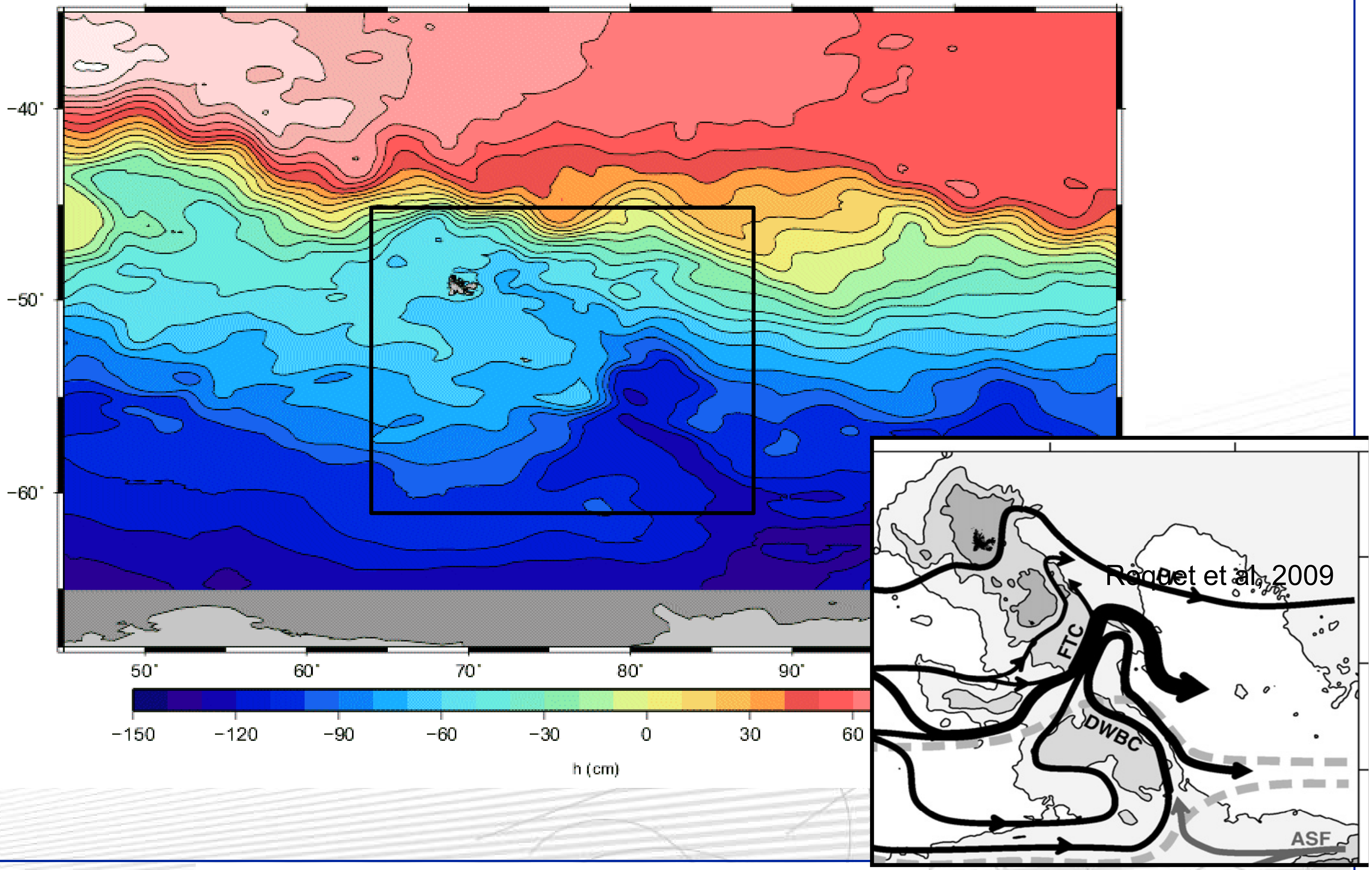


First Guess

+ Synthetic velocities

+ Synthetic heights

= Regional MDT KEOPS V1.0



Roquet et al, 2009

Conclusion

A regional 1/8° MDT has been computed dedicated to the KEOPS-2 campaign
Compared to the global CNES-CLS09 solution, the following improvements have been made:

✓Update of the in-situ datasets: 1993-2008 -> 1993-2010

✓Use of the latest geoid model including GOCE data (instead of only GRACE data)

✓Correction of the drifting buoy dataset for the direct action of the wind on undrogued drifters

The KEOPS regional MDT was used together with the KEOPS regional SLA to compute improved maps of absolute dynamic topography that are currently delivered to the KEOPS-2 scientists in real time

The regional product has already proven to be very useful for the campaign

Perspectives

✓Validation:

The KEOPS-V1 MDT will be validated using in-situ data from the KEOPS2 campaign (independent drifter velocities, and hydrological profiles)

A new version (V2) will be computed in 2012 including:

new GOCE model (1 year of data instead of 8 months)

in-situ data from the KEOPS2 campaign

Correlation coefficients fitted for the area (needed in the multivariate objective analysis – here we used those from the CNES-CLS09 solution)

✓Need for updating the global MDT taking into account:

The GOCE geoid model

The cleaned drifting buoy dataset