(1) Politecnico di Milano, Italy
(2) Aristotle University of Thessaloniki, Greece
(3) CNES, Toulouse, France
(4) OMP/GET, Toulouse, France
(5) SHOM, Brest, France
(6) DTU Space, Kopenhagen, Denmark
(7) University of Zagreb, Croatia
(8) General Command of Mapping, Ankara, Turkey
(9) Observatoire de Paris, France
(10) University of Jaén, Spain

The GEOMED2 project: Geoid estimation of the Mediterranean Area

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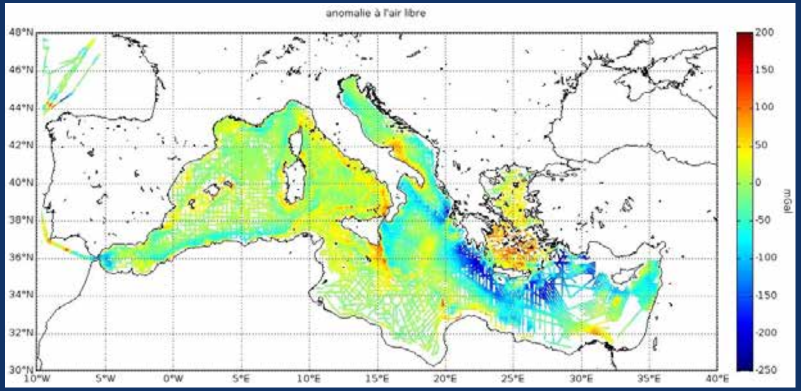
2. Georgios Vergos, Ilias Tziavos, Vassilios Grigoriadis, Dimitrios Natsiopoulos
3. **Sean Bruinsma**, Franck Reinquin
4. Lucia Seoane, Sylvain Bonvalot
5. Marie-Françoise Lequentrec-Lalancette, Corinne Salaun
6. Per Knudsen, Ole Andersen
7. Tomislav Basic, Matej Varga, Olga Bjelotomic
8. Mehmet Simav, Hasan Yildiz
9. Pascal Bonnefond
10. Antonio J. Gil

The preliminary computation over the Mediterranean area

- Gravity data selected with a mean spacing of 1’×1’ from the following databases:
  - i) BGI
  - ii) SHOM
  - iii) Croatia
  - iv) Greece
  - v) Italy
  - vi) Turkey
  - vii) EIGEN6-c4 (void areas)



- The computation area : $36 < \varphi < 48$ $-10 < \lambda < 40$

- Geoid estimate based on the Remove-Compute-Restore method (***ship gravity data only are used in this computation)***

- Methods applied for geoid computation:
  - i) Fast-Collocation
  - ii) Stokes-FFT (WG kernel modification)

THE GGM AND DTM/BATHYMETRY IN THE REMOVE-RESTORE

- The GGM used in modelling the low-frequencies was **EIGEN-6c4** (d/o **1000)**
(test computations have been also performed using **GOCE-DIR5** to d/o **230;** *not successful*)

- On land areas, SRTM3 was used as the detailed DTM ($28 < \varphi < 50$ $-12 < \lambda < 42$)

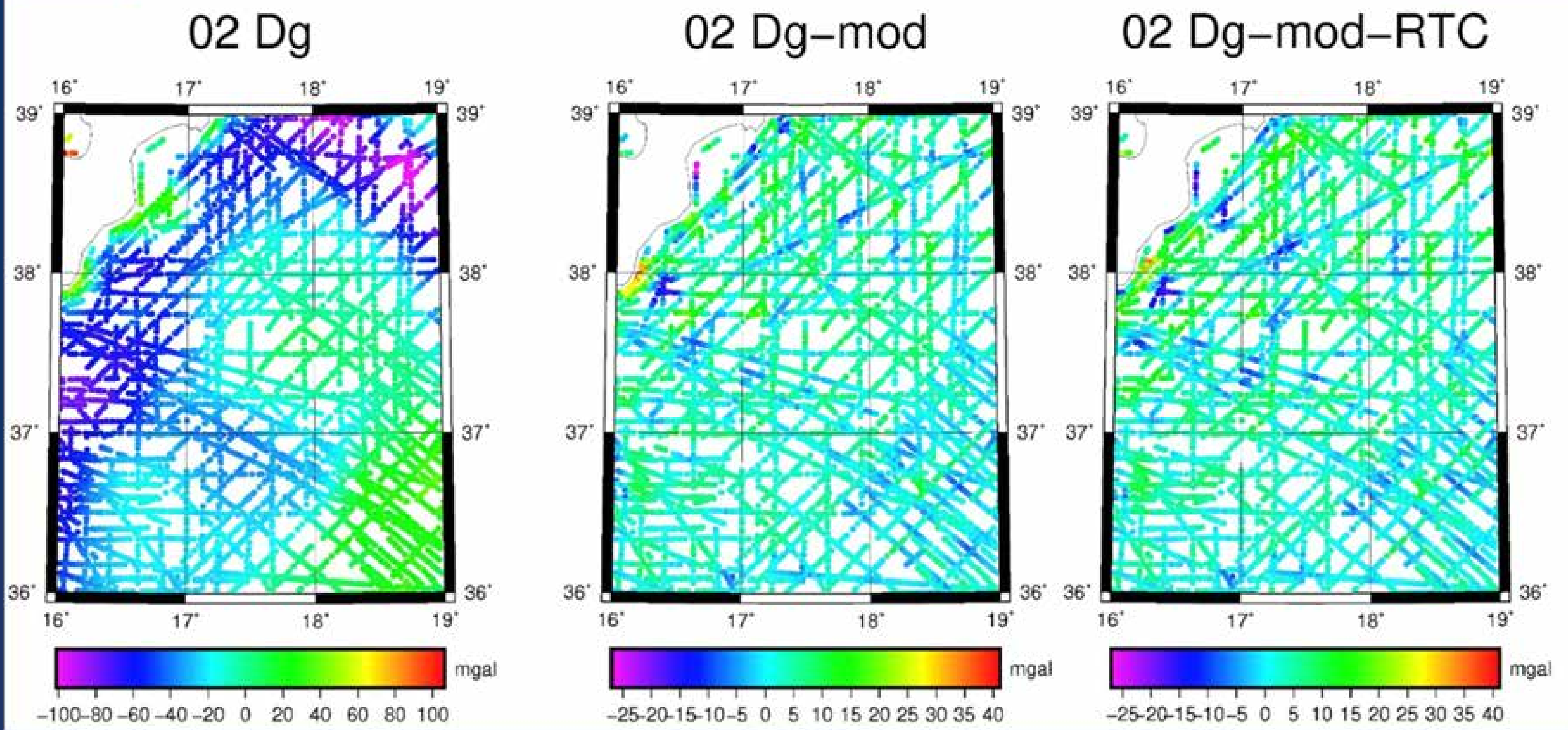
- RTC effect computed up to 100km using TC (GRAVSOFT) and a reference DTM
estimated by smoothing the detailed one (based on a 8' moving average)

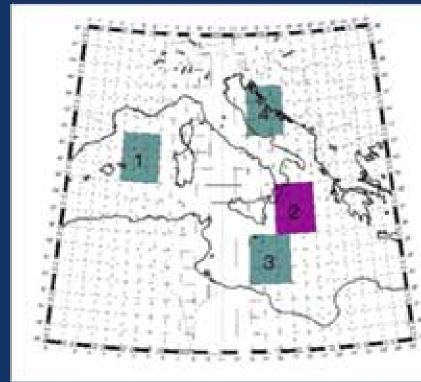
- Different DBMs have been re-gridded and merged with SRTM3 over the entire Mediterranean: DTU10 (1'x1'), SRTM-PLUS15 (15"x15"), EMODNET (7.5"x7.5")

These tests proved that the three DBMs are practically equivalent, and that they do not reduce the gravity residuals

→ *no bathymetry correction was applied*

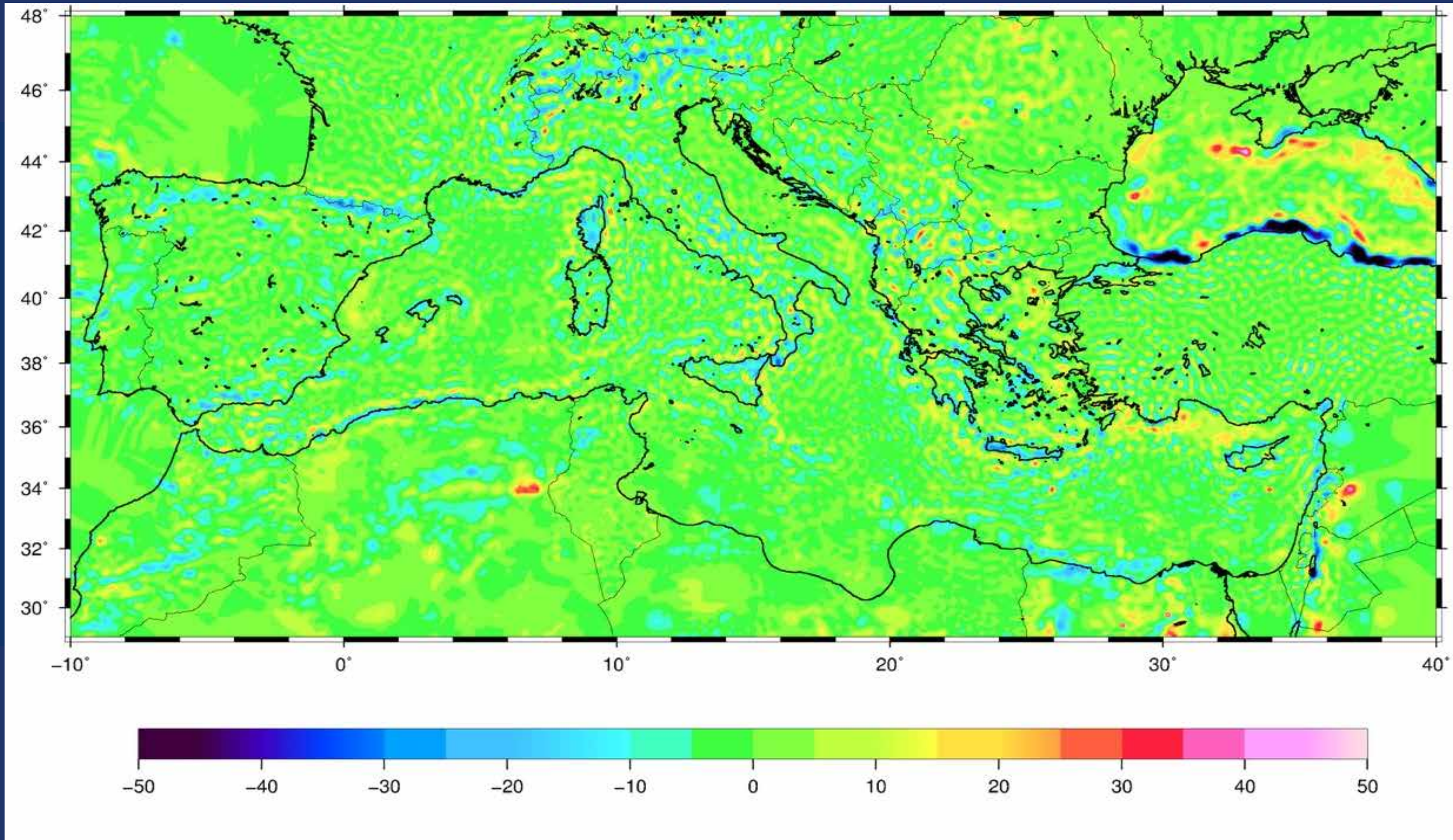
	02 Dg	02 Dg–mod	02 Dg–mod–RTC
#	4291	4291	4291
Mean	–24.127	2.989	3.310
St.Dev	29.404	4.930	5.161
Min	–101.200	-26.913	–18.987
Max	106.540	41.188	36.219
RMS	38.036	5.765	6.131





Only area 3 was slightly better after RTC

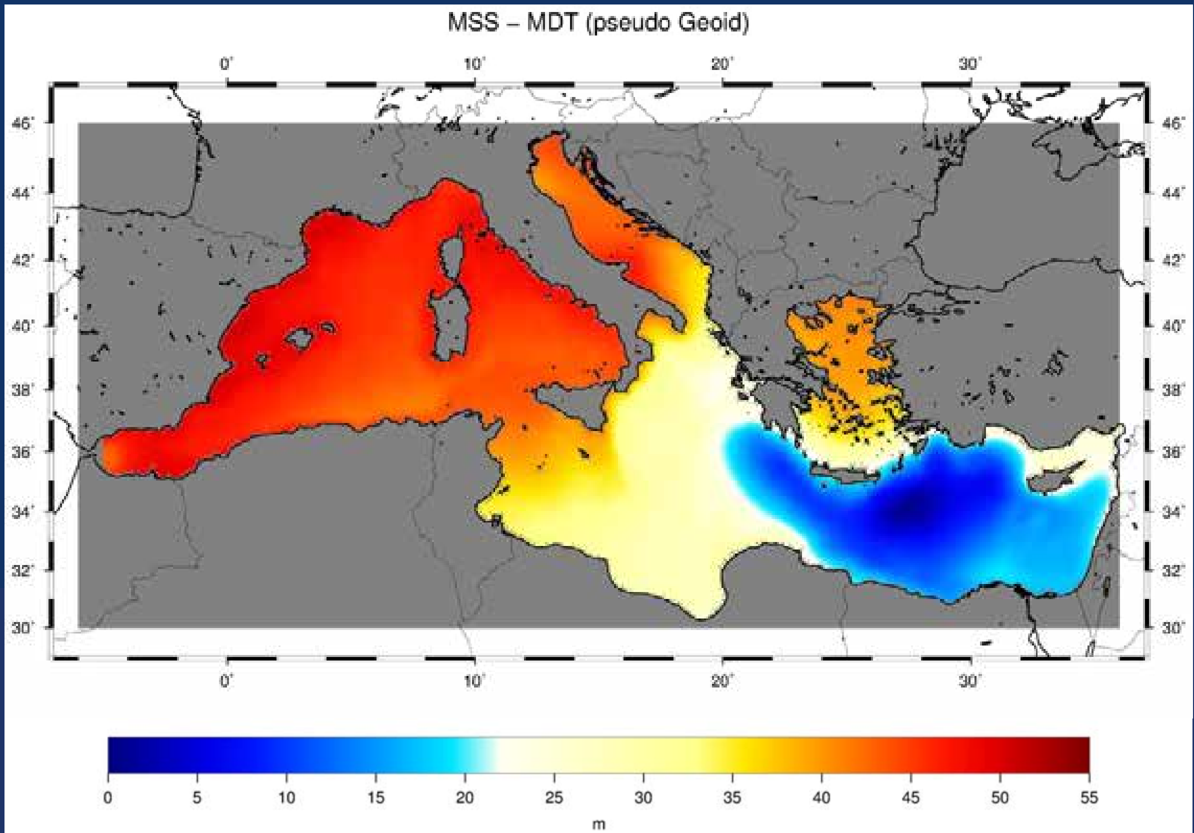
THE REMOVE STEP: RESIDUAL GRAVITIES

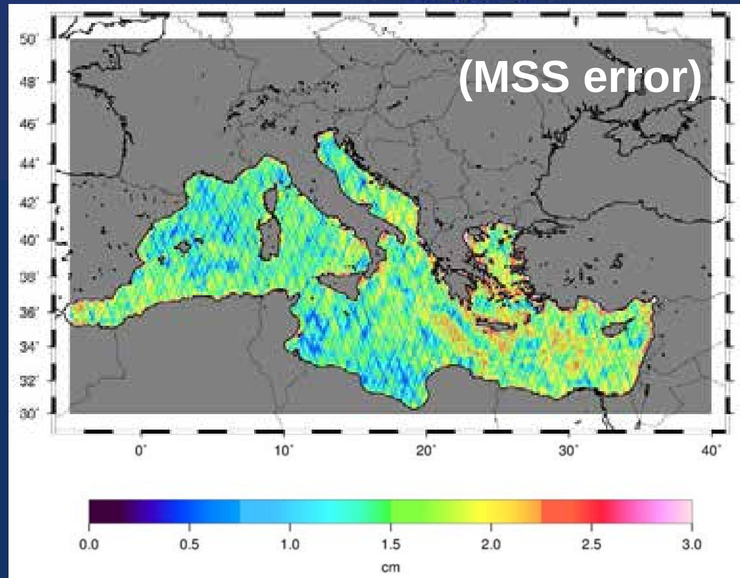


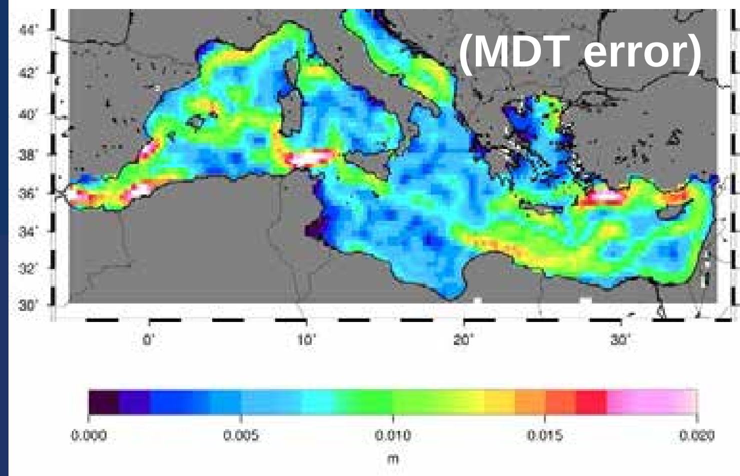
COMPARISON WITH AN 'OCEANOGRAPHIC' GEOID

The geoid model is compared with an independent marine geoid:

'CLS' geoid = MSS(CNES-CLS15) – MDT(SOCIB-CLS)



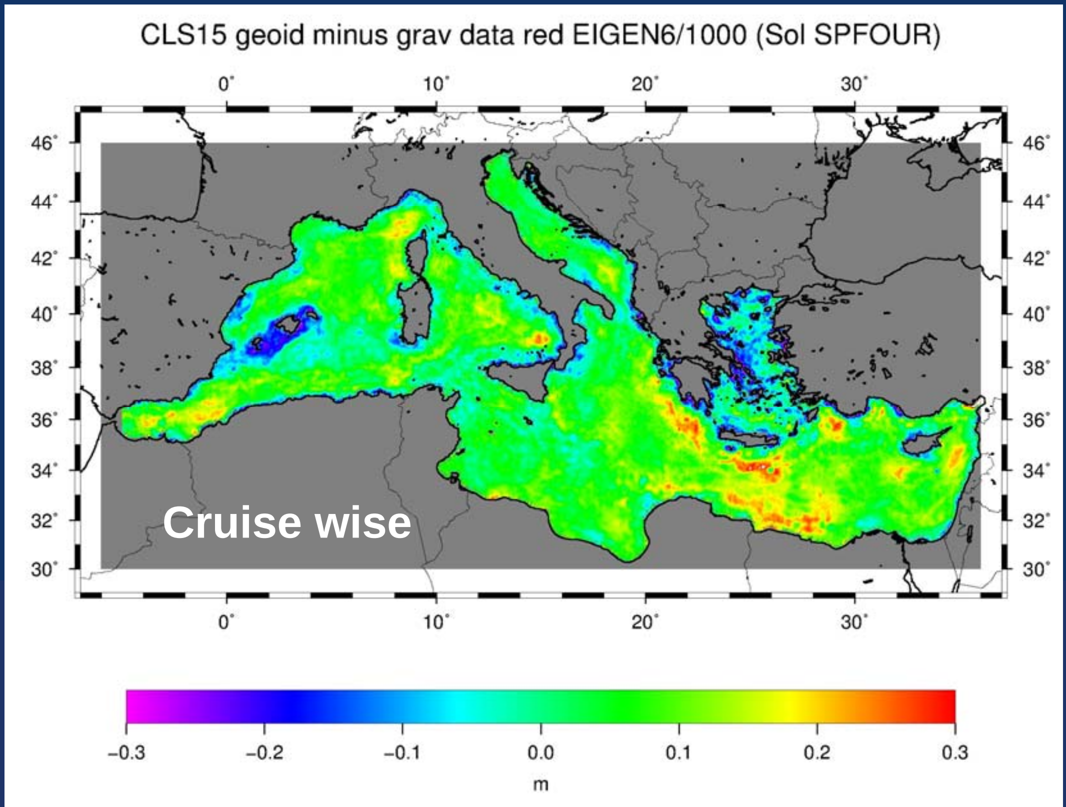




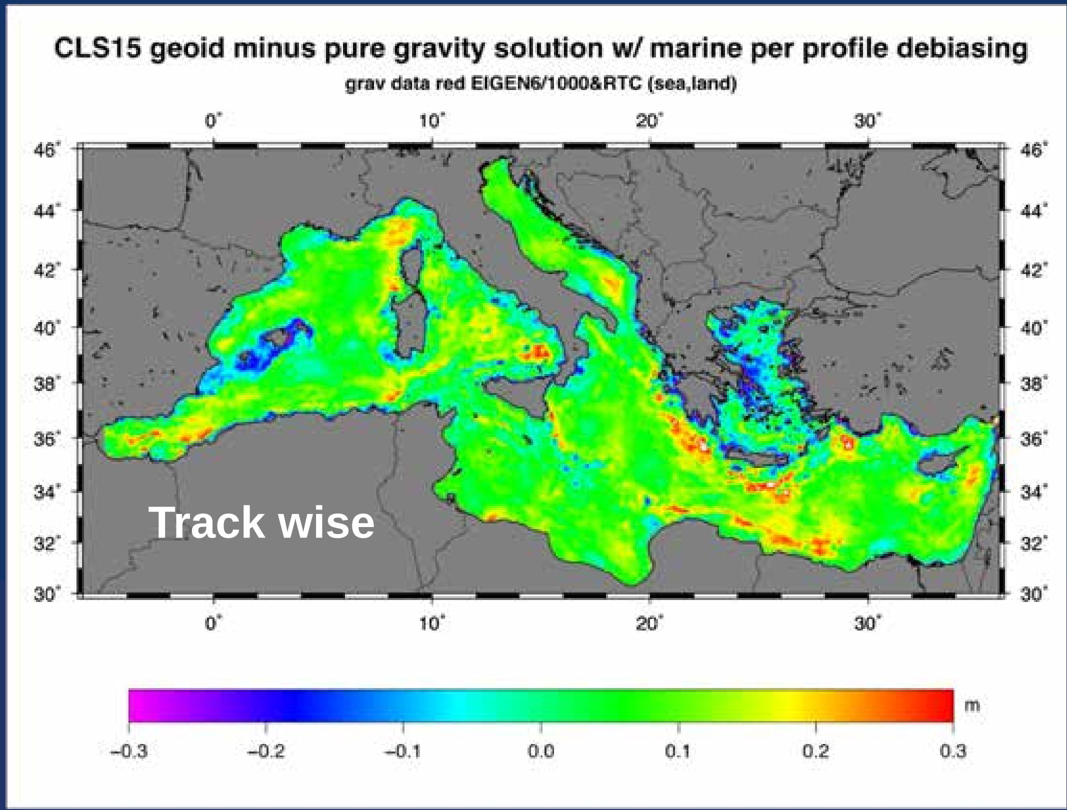
RESULTS: PRELIMINARY GEOID ESTIMATES

SPFOUR solutions compared to 'CLS' geoid: effect of debiasing method

StD=8.3 cm (*July*)



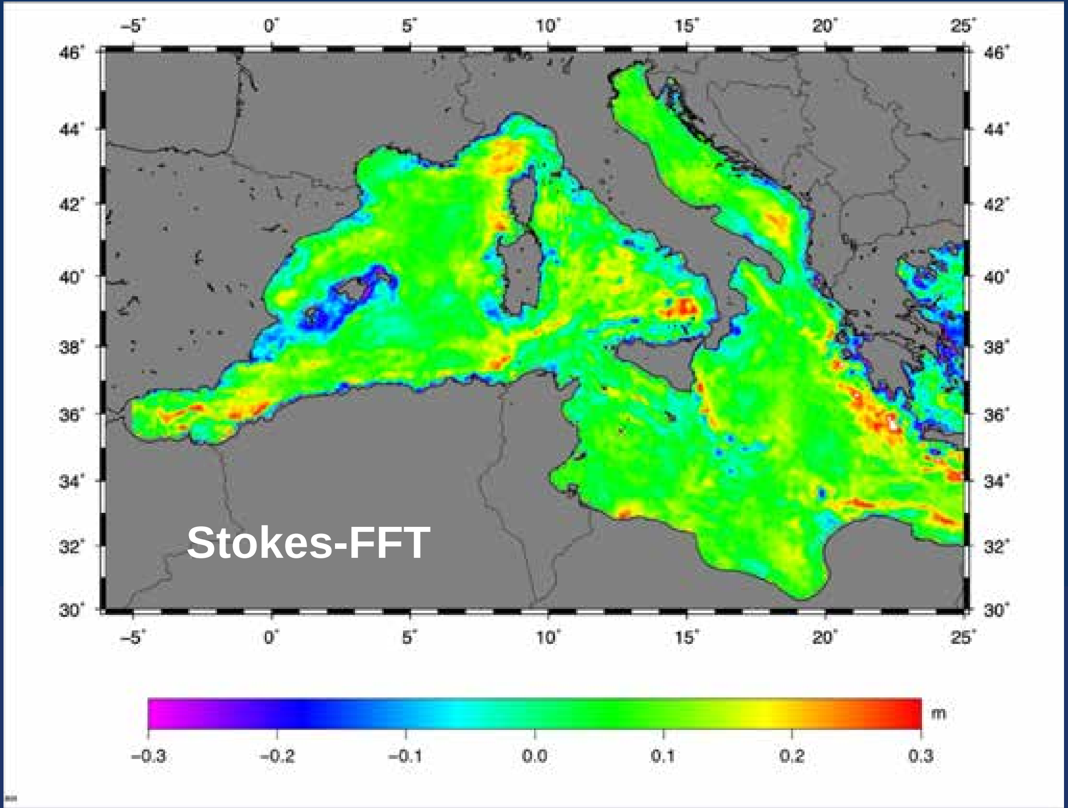
StD=8.4 cm (*September*)



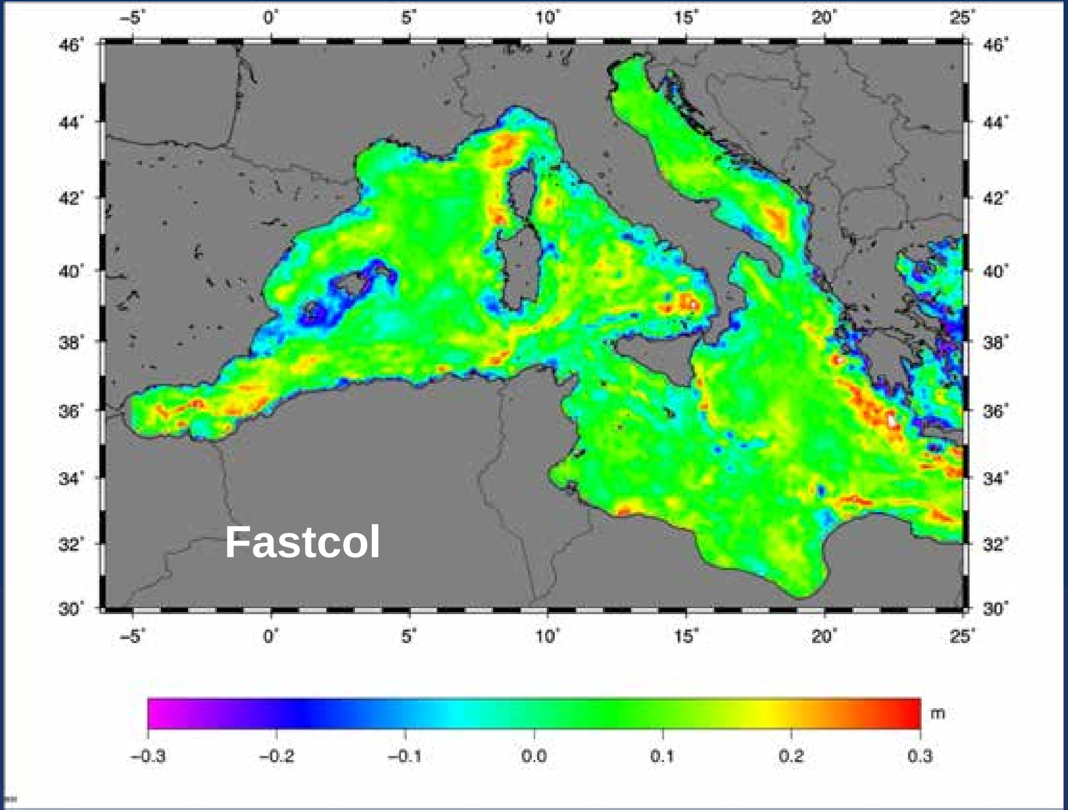
RESULTS: PRELIMINARY GEOID ESTIMATES

Solutions obtained through different methods (track wise debiasing) compared to ‘CLS’ geoid

StD=8.1 cm

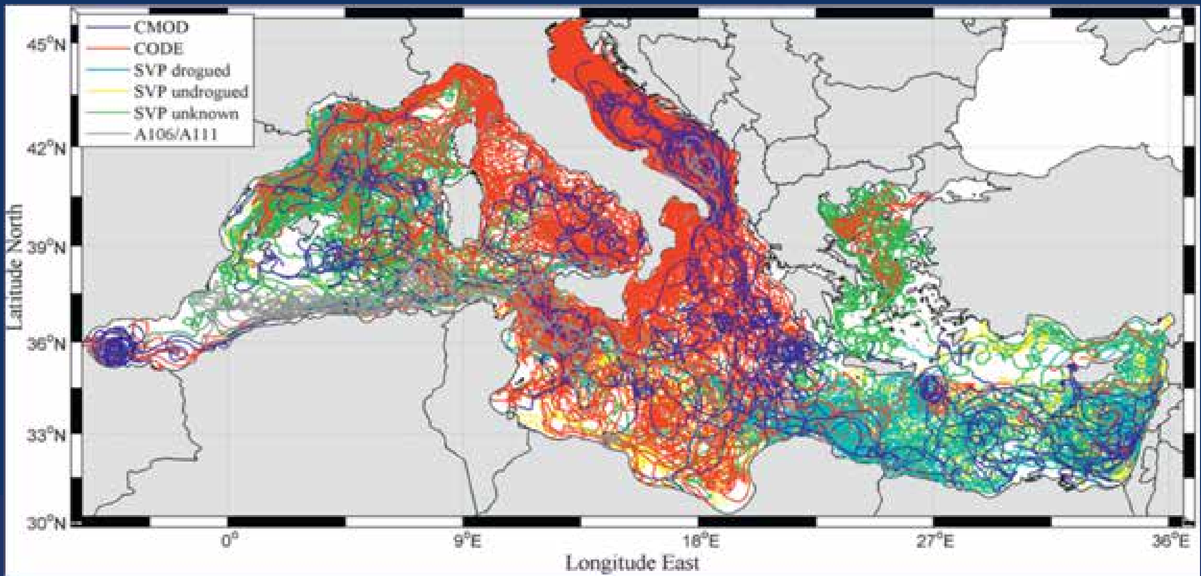


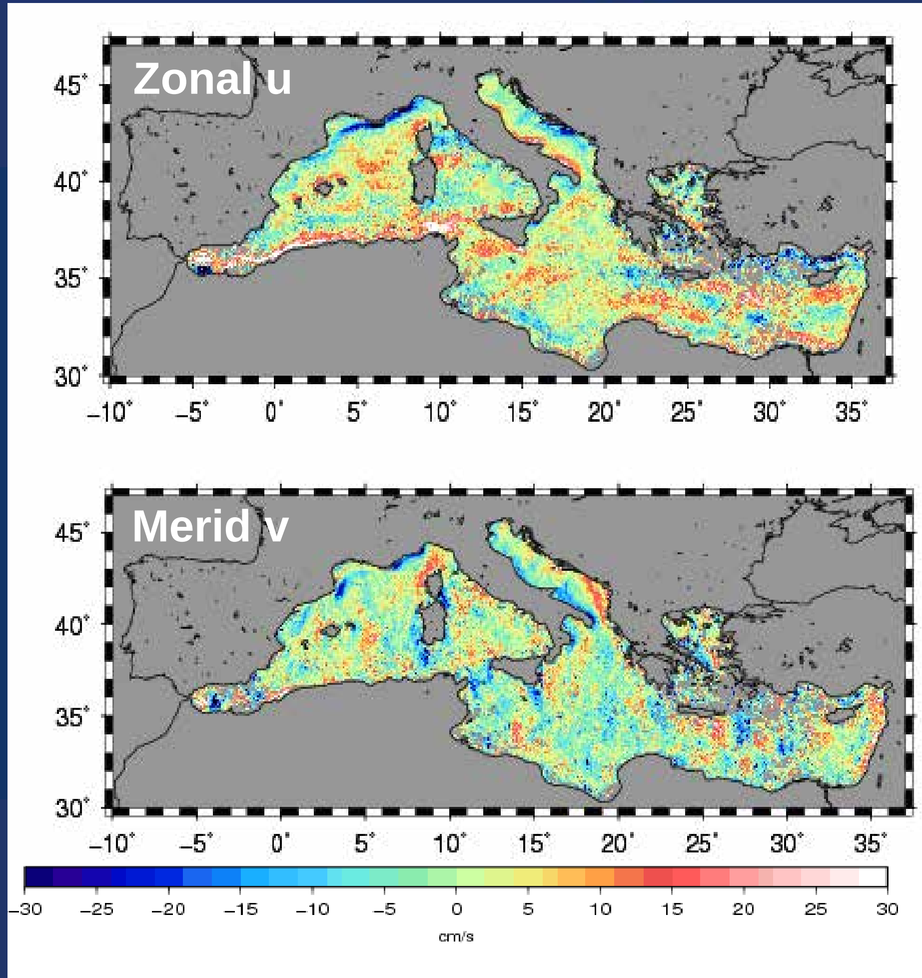
StD=8.5 cm



COMPARISON WITH DRIFTER DATA (I.E. GEOSTROPHIC CURRENT)

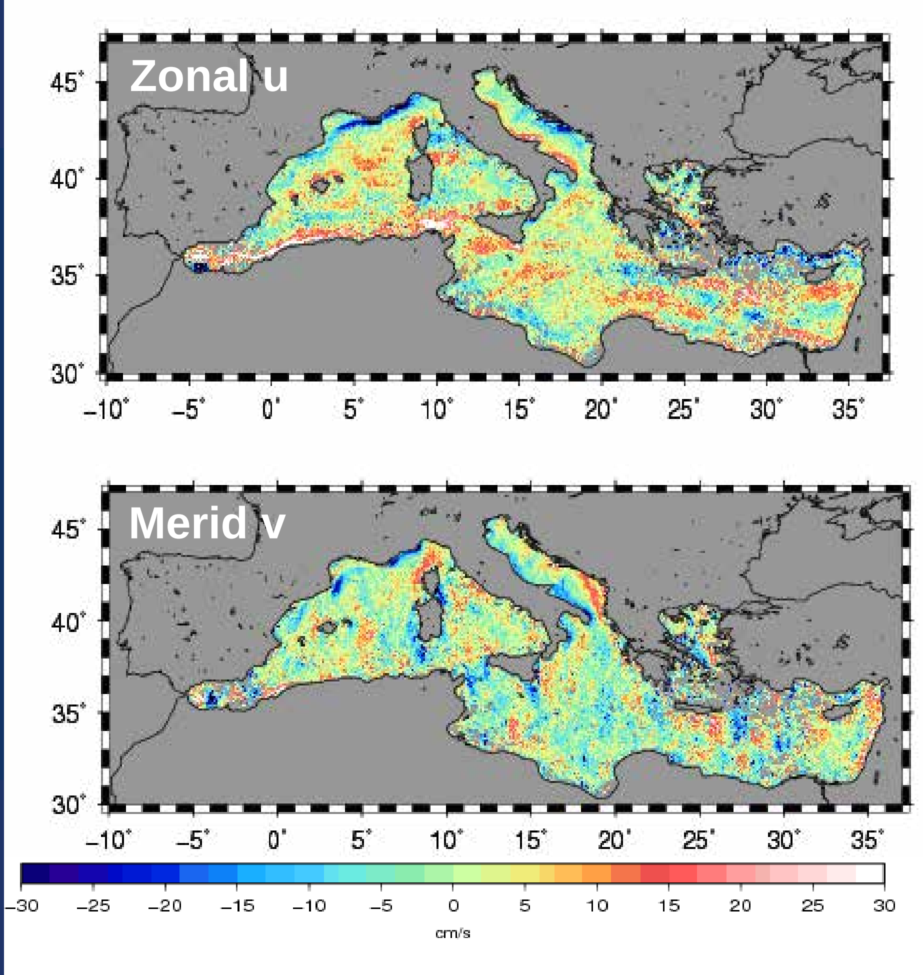
Updated synthetic mean velocities dataset (1993-2016) + Specific regional processing of the drifting buoys (regional Ekman model), accurate error assessment





***Observed* mean velocities**

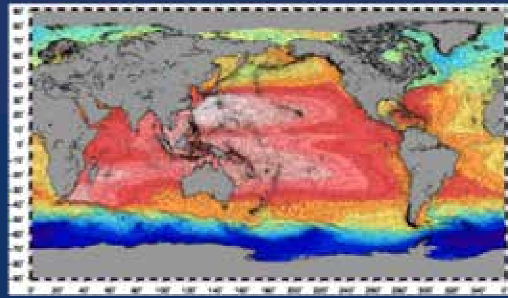
COMPARISON WITH DRIFTER DATA (I.E. GEOSTROPHIC CURRENT)



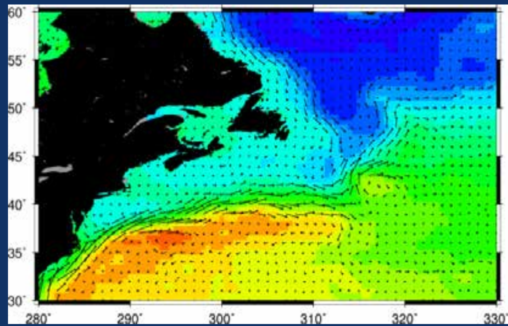
Observed mean velocities

MDT=MSS – Geoid

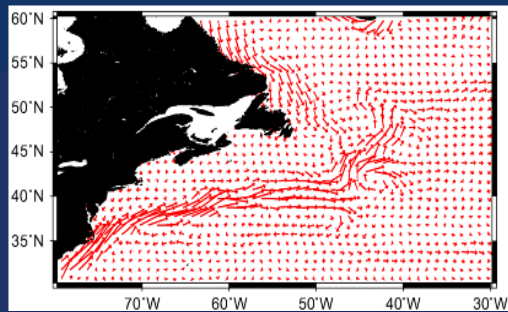
Filtering of the MDT with a gaussian filter



Computation of the mean geostrophic currents

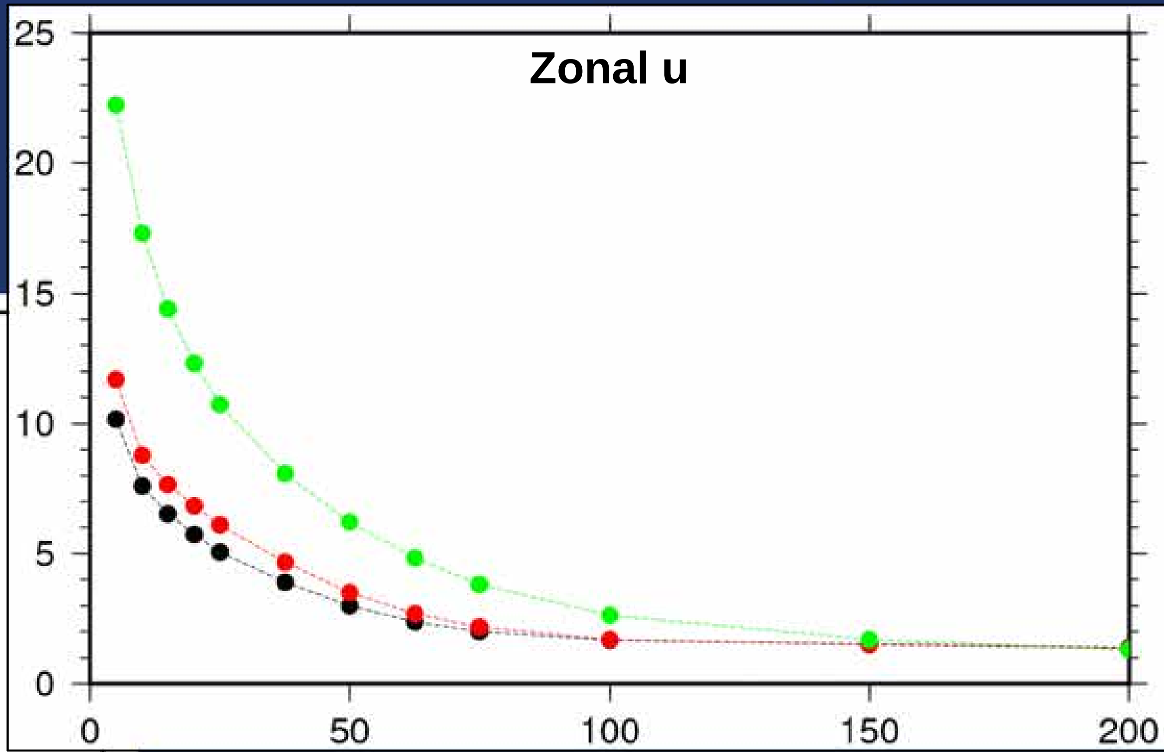


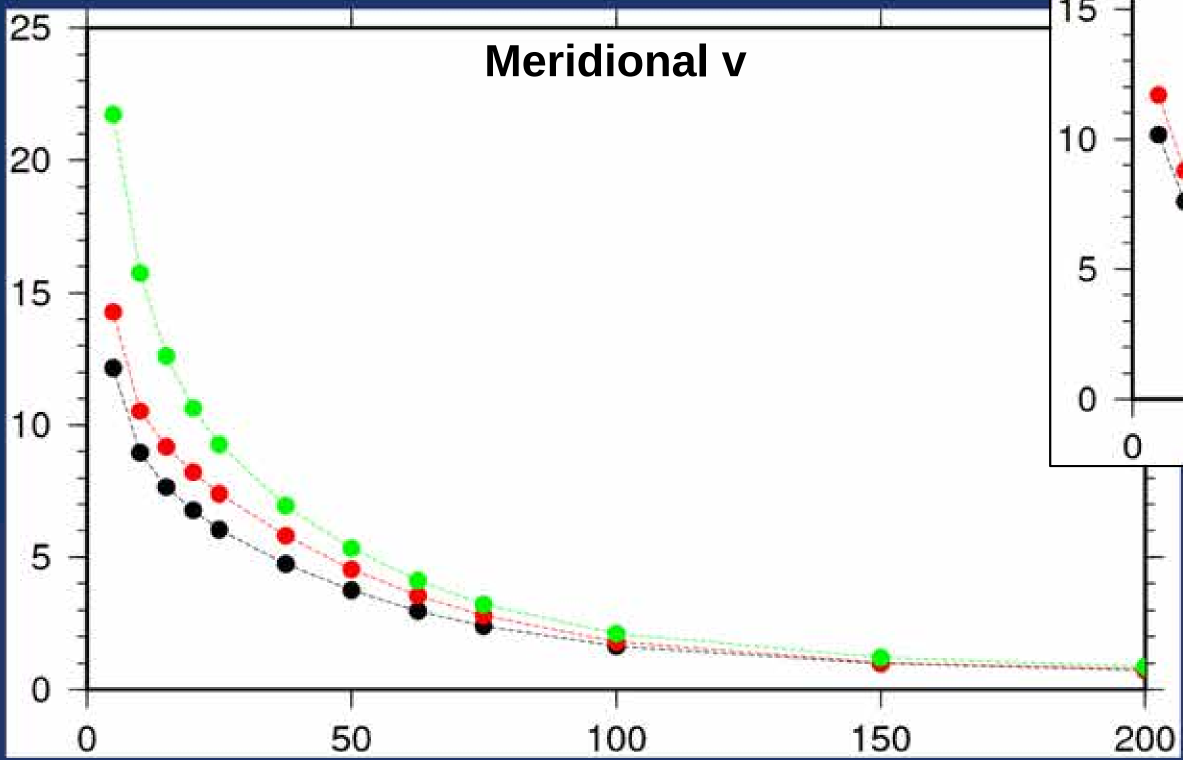
Computation of mean geostrophic velocities from in-situ oceanographic measurements and altimetry; filtering



COMPARISON WITH DRIFTER DATA (I.E. GEOSTROPHIC CURRENT)

RMS of the difference (in cm/s) over the entire Mediterranean basin as a function of spatial scale (km)



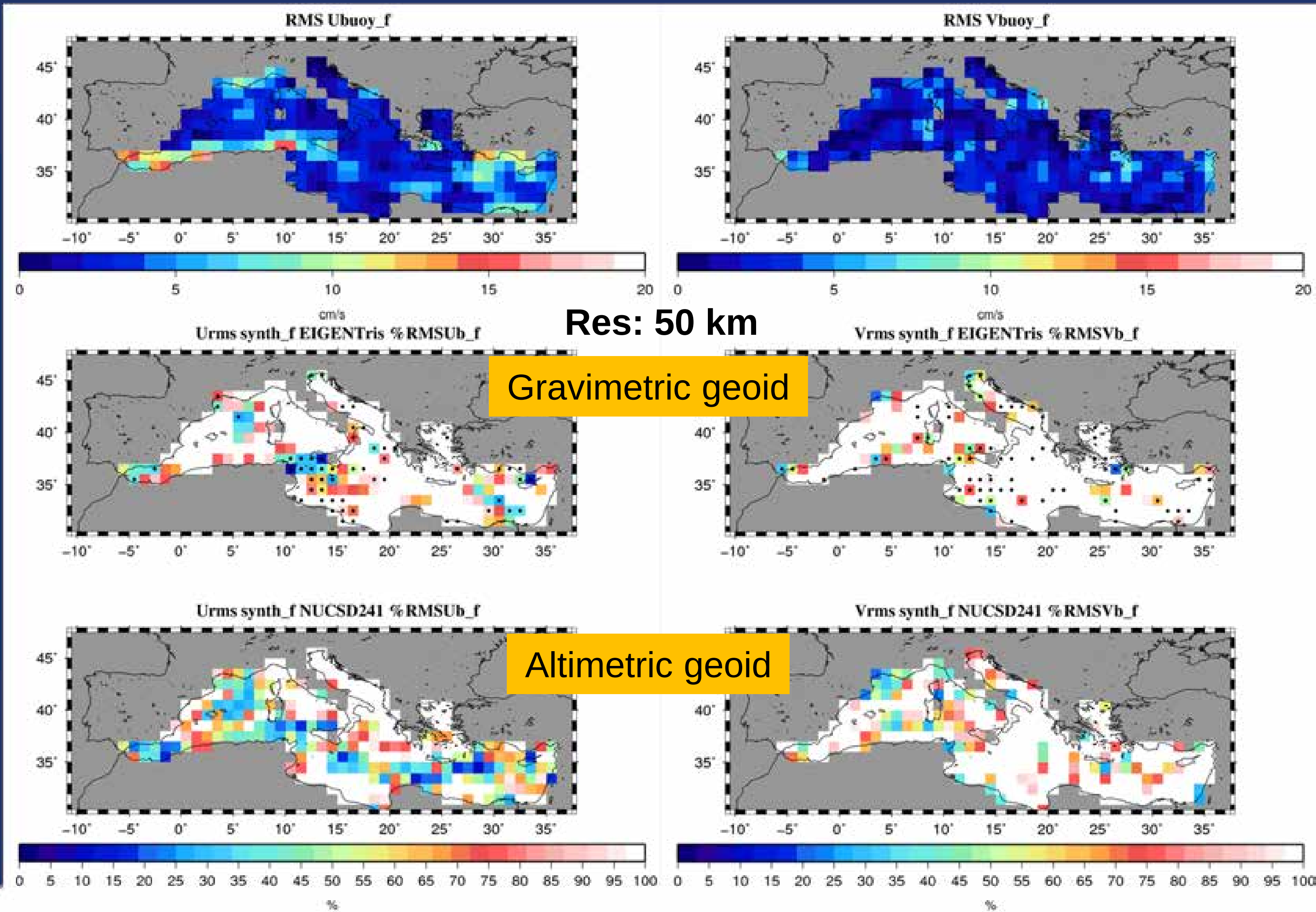


Gravimetric geoid

EIGEN6C4 geoid

Altimetric geoid (with UCSD V24.1)

COMPARISON WITH DRIFTER DATA (I.E. GEOSTROPHIC CURRENT)



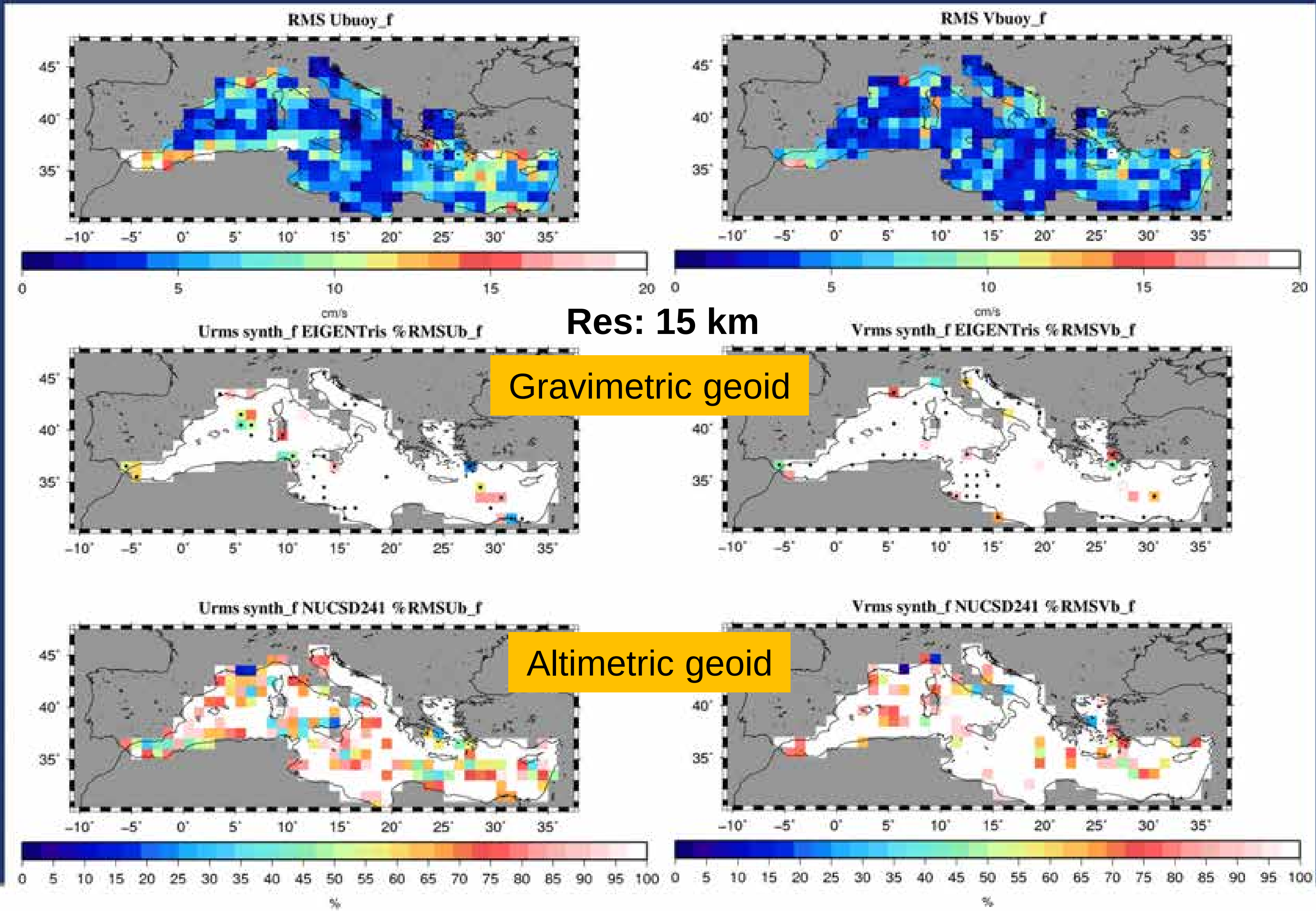
RMS of the filtered measured current speed in 1°x1° bins

Difference with the measured currents in 1°x1° bins presented as a percentage of the total signal.

White bins indicate that the error is larger than 100%

Black dots indicate bins for which the gravimetric geoid gives better results

COMPARISON WITH DRIFTER DATA (I.E. GEOSTROPHIC CURRENT)



RMS of the filtered measured current speed in 1°x1° bins

Difference with the measured currents in 1°x1° bins presented as a percentage of the total signal.

White bins indicate that the error is larger than 100%

Black dots indicate bins for which the gravimetric geoid gives better results

CONLUSIONS AND REMAINING WORK

- Modeling RTC over sea does not reduce the gravity residuals; it was abandoned;
- The gravimetric geoid is overall less accurate than a geoid computed using altimetry-inferred gravity; locally (drifter evaluation) it can be more accurate, but it is not clear why;
- The ship gravity data (gravimetric geoid) seems to be affected by small-scale noise;
- The available data (quality and distribution) may not allow a more accurate gravimetric geoid;

➢ Fast collocation and Stokes-FFT are presently at the same level, after data debiasing and better tuning of the covariance function – *but not optimum yet*;

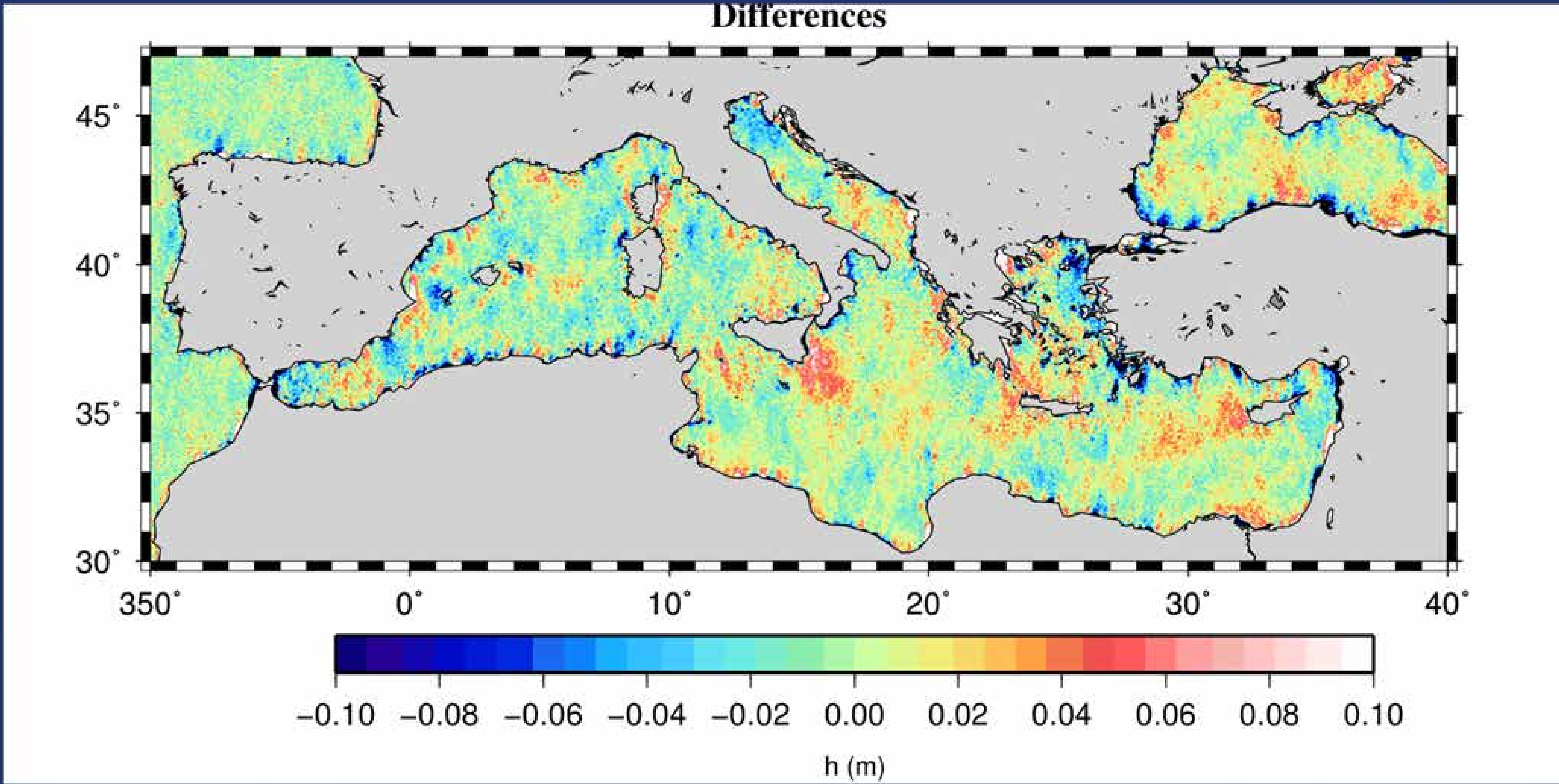
➢ Not all marine data have been used yet - *debiasing required first;*

➢ Land areas with bad data, or poor coverage (*compatibility!*), *must be filled in;*

➢ The data interpolation (gridding) and smoothing is not optimum, *and more tests are necessary.*

BACKUP

DIFFERENCE OF MEAN SEA SURFACES: CNES-CLS15 – DTU15



BATHYMETRIE: GEBCO 2014