Preliminary results on impact of combining GRACE and GOCE data on ocean circulation estimates

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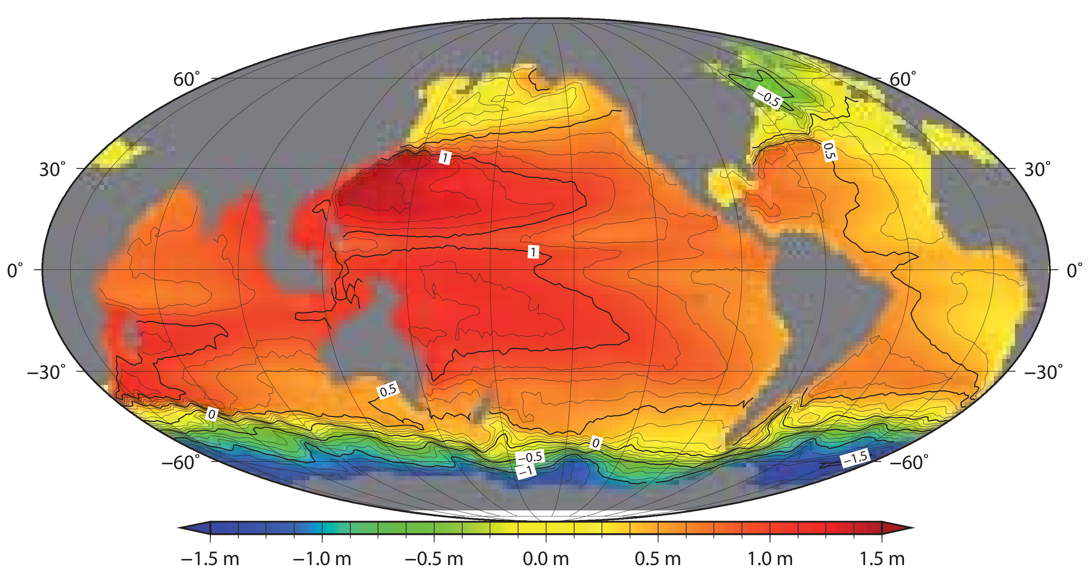
1 Introduction

The geodetic approach for obtaining the dynamical ocean topography (DOT), that combines the multi-mission-altimeter data and the GRACE/GOCE gravity fields, requires that both fields be spectrally consistent. The spectral consistency is achieved by filtering applied to the sea surface and the geoid. Combining the GRACE and GOCE data, considerably shorter filter length resolving more DOT details can be used.

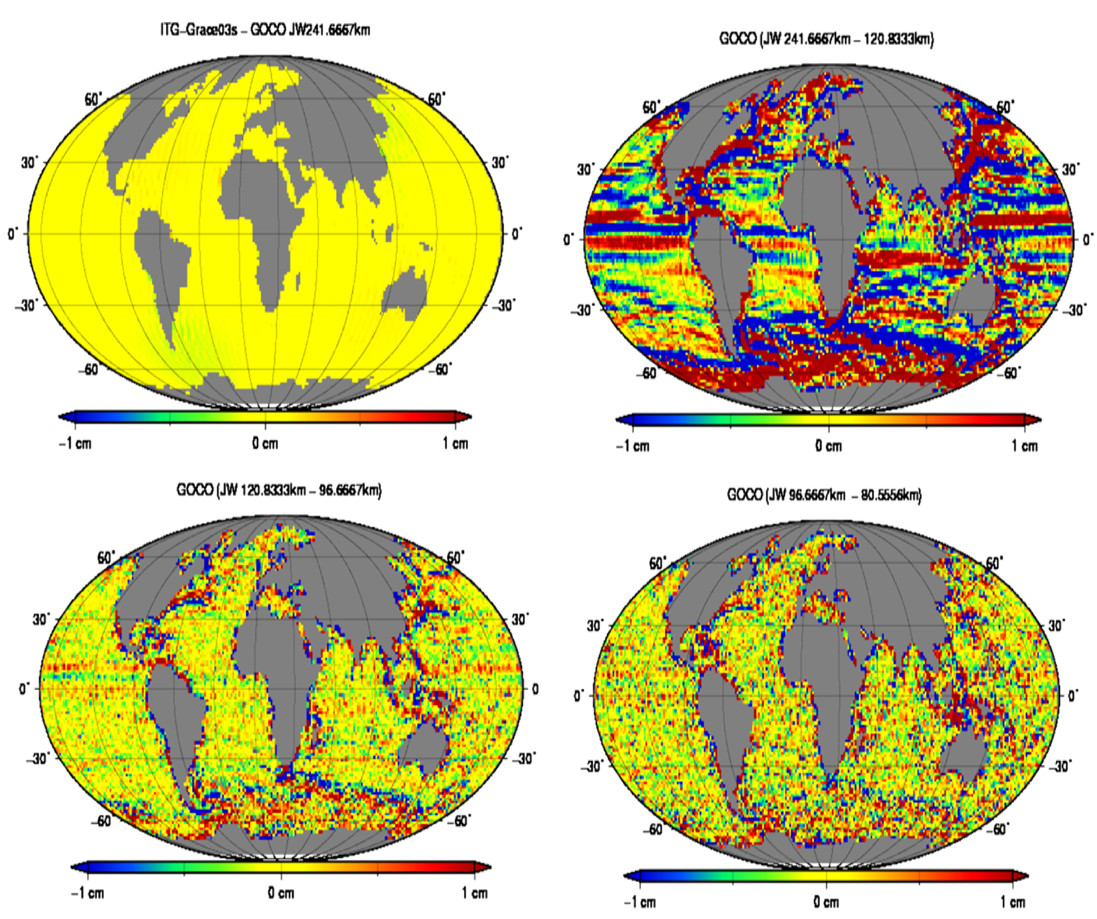
In this work we present the geodetic DOT obtained by using Jekeli-Wahr filter corresponding to 241 km, 121 km, 97 km and 81 km halfwidths for the GRACE/GOCE based gravity field model GOCO01S [5]. Further we assimilate satellite measurements of DOT into the global finite-element ocean model (FEOM) corresponding to 241 km, 121 km and 97 km halfwidths. The effects of gained resolution in the data fields are investigated as well as the effects on other ocean fields obtained as the result of the assimilation of these data.

2 Geodetic DOT



Mean DOT obtained using Jekeli-Wahr filter with half width of 121 km and by combining GRACE and GOCE gravity data.

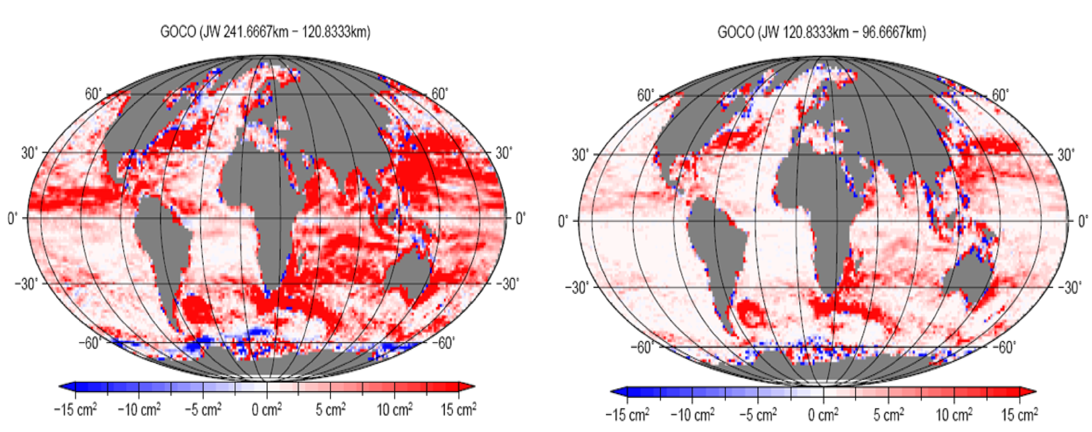
3 Increase in resolution of geodetic DOT



The difference between geodetic DOTs. Left upper: obtained form GRACE data only and by combining GRACE and GOCE gravity data. Both filtered using Jekeli-Wahr filter with half width of 241 km. Right upper: Filtered up to degree 241 km and 121 km. Left lower: Filtered up to degree 121 km and 97 km. Right lower: Filtered up to degree 97 km and 81 km.

4 Increase in variability of DOT

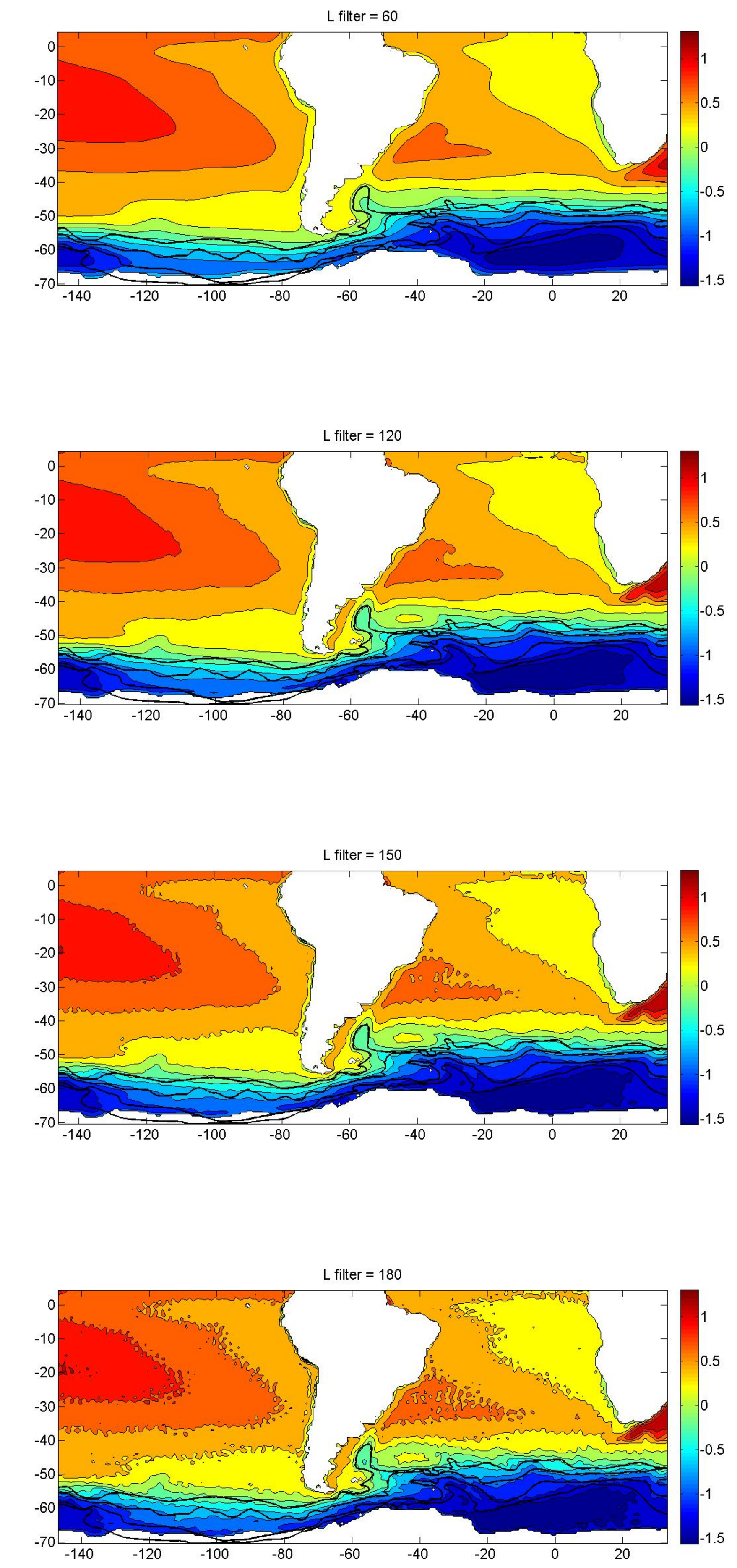
Time varying DOT data are assimilated every 10 days. The temporal variability of this data set clearly shows all major eddy fields.



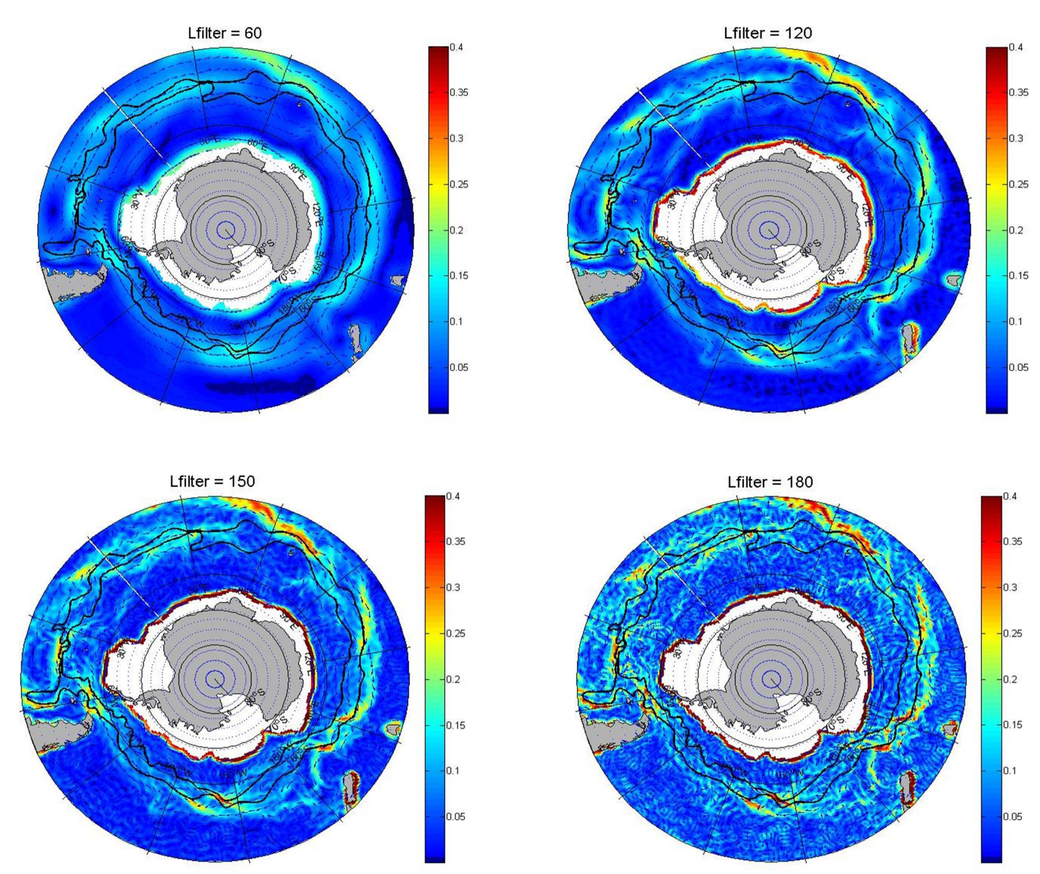
Left: Difference in variance between half width 241 km and 121 km filtering, Right: between half width 121 km and 97 km.

5 Better resolved South Atlantic

The use of only satellite data starting with half width of 121 km show fine space scales that were previously poorly resolved with half width of 241 km. On the mean DOT as well on velocities figures below superimposed are location of the fronts from [4].



6 Geostrophic velocities in Southern Ocean

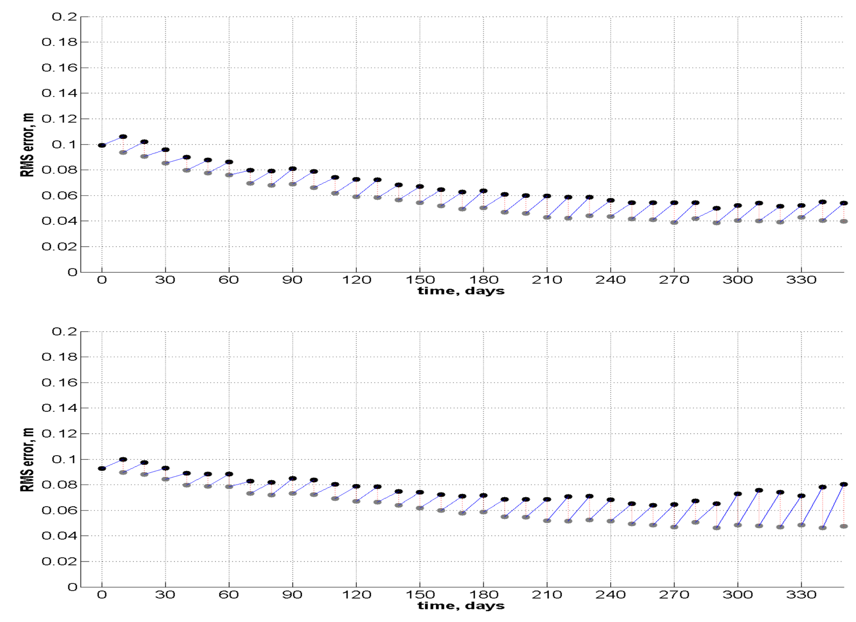


Geostrophic velocities calculated from DOT filtered to Left upper: half width of 241 km. Right upper: 121 km. Left lower: 97 km. Right lower: 81 km.

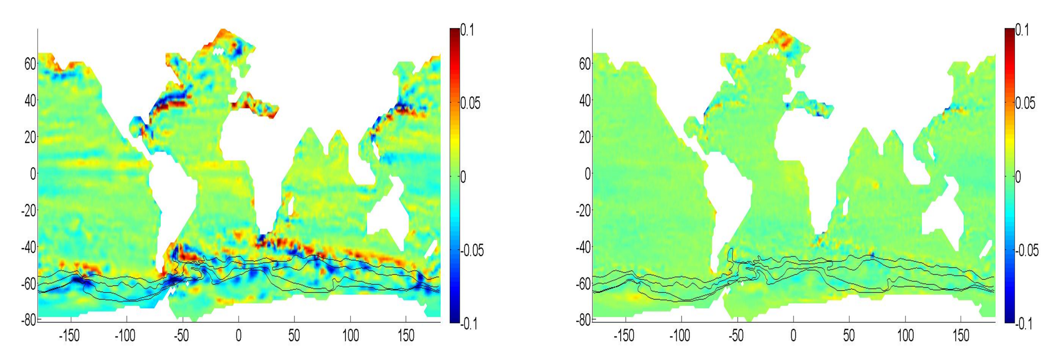
7 Assimilation of data

The study was performed by the Finite-Element Ocean circulation Model (FEOM) [6, 1] configured on a global almost regular triangular mesh with the spatial resolution of 1.5°. Details of the data assimilation algorithm are described in [2] for assimilation of the geodetic DOT using GRACE data only.

Here we focus only on modifications to the algorithm that need to be done in order to take into account higher resolution data. In [2] it was shown that the optimal influence region is a circle with a radius of 900 km (cutoff length) for observations that are filtered to half width 241 km and that optimal covariance for localization of ensemble Kalman filter algorithm approximates well a Gaussian with length scale of 246 km. For the data filtered up to 121 km experiments were performed using same specification, as well as a localization function with length scale of 123 km (450 km cutoff).

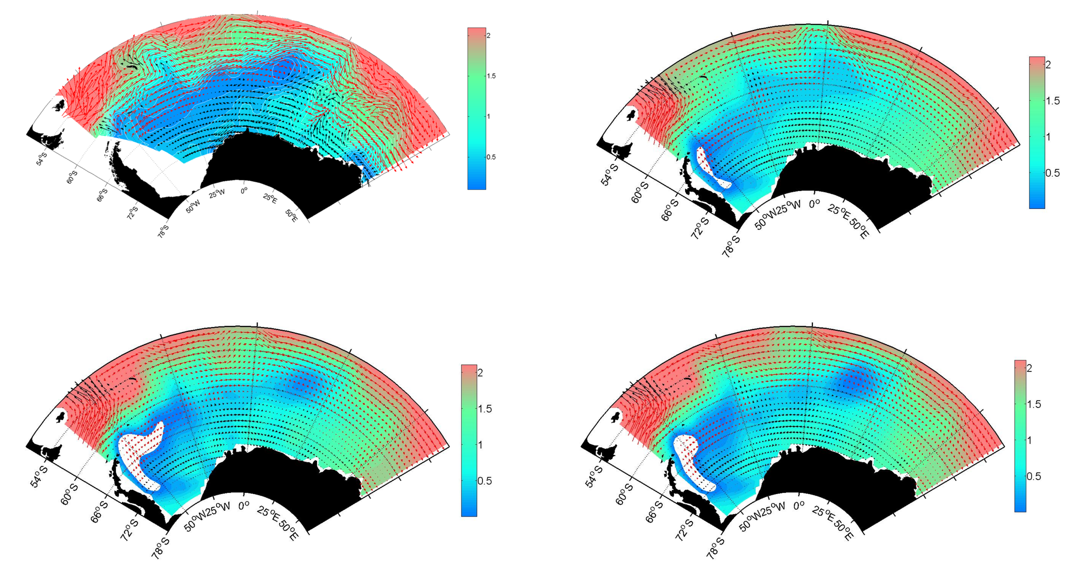


Evolution of RMS error of SSH for the world ocean. The black lines with bullets represent the 10-day model forecasts, while the dotted gray lines correspond to the analysis. Upper: RMS error for assimilation of data filtered up to half width of 121 km and localization function that correspond to Gaussian with length scale 123 km (450 km cutoff). Lower: Localization function corresponds to Gaussian with length scale 246 km (900 km cutoff).



The difference between geodetic DOTs as a result of assimilation, Left: for assimilation of data with the half width of 241 and 121 km. Right: and the difference in results for assimilation of data with 121 km and 97 km.

Data assimilation scheme corrects all the ocean fields, although only geodetic DOT is assimilated. Radar altimetry cannot be used for those regions where the sea-ice coverage exceeds a certain percentage during the entire year, as well as for ice shelves and near-coastal zones. Therefore it is interesting to compare the assimilation results in the area which is not well observed.



Temperature and velocity at 800 m depth. Left Upper: Composite of ARGO data from 1999 to 2009 is used (courtesy of Dr.O.Klatt, AWI). Right Upper: For model only without data assimilation. Left Lower: As result of assimilation of geodetic DOT filtered up to 241 km Right Lower: As result of assimilation of geodetic DOT filtered up to 121 km.

8 Conclusion

- DOT with much finer space scales, that were previously poorly resolved, is obtained by combining GRACE and GOCE gravity field data.
- Fine space scale structures are particularly visible in the areas of strong currents. Here we show South Atlantic and Southern Ocean example only.
- Results of assimilation into the global finite element ocean model, shows similar increase in the resolution of DOT obtained as seen in the data.
- Further comparison of the results with independent ARGO data set shows positive impact of increased resolution in Weddell Sea area.

References

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