Assimilation of geodetic dynamical ocean topography data

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Motivation

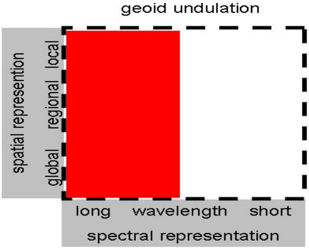
- Determination of the absolute, temporally changing ocean circulation flow field and its mass and heat transport by assimilating geodetic estimates of the dynamic sea surface topography.
- Both, gravity from GRACE, and altimetry are used to estimate geodetic ocean topography which is assimilated into a numerical model.
- The ocean model returns an optimized mean dynamical ocean topography (MDT).

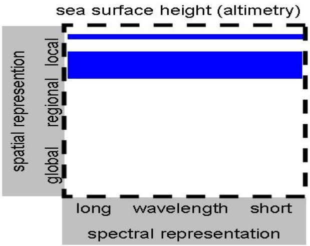
Outline:

- Data set
- Model configuration
- Data assimilation method
- Results

Assimilated Data Set

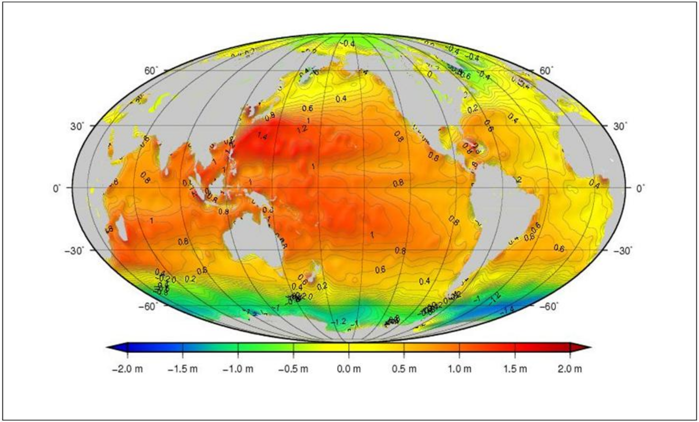
- The DOT was obtained by means of geodetic approach from carefully cross-calibrated multi-mission-altimeter data and GRACE gravity fields.





- Spectral consistency is achieved by applying a Gauss-type filter (Jekeli/Wahr) on sea surface and geoid.
- The filter length is driven by the spectral resolution of the gravity field. It is set to 241km (corresponding to harmonic degree 60).

Geodetic DOT



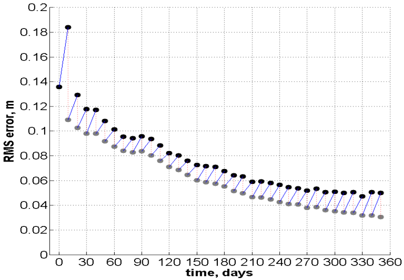
Global approach DOT (Albertella and Rummel, 2009).

Model configuration used for data assimilation

- Finite Element Ocean Model (FEOM) developed at the Alfred-Wegener Institut (AWI).
- This model solves the standard set of hydrostatic ocean dynamic primitive equations (Wang et al 2008).
- Prismatic mesh.
- 1^o resolution global ocean model.
- 25 levels.
- Monthly forcing is used.

Data assimilation method

- Satellite data is assimilated sequentially every 10 days.
- A series of correction/prediction producing analysis/forecast is carried out to fit the model trajectory to the data.

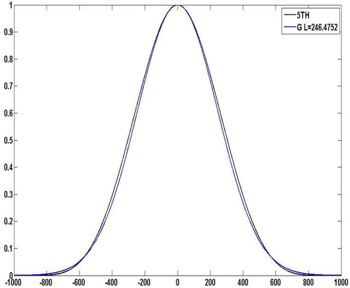


RMS error calculated with respect to assimilated data every 10 days for analysis and forecast.

Data assimilation method

- Ensemble based Kalman filter is used for assimilation.
- Corrections are made to all model variables, i.e. T,S, SSH, velocities.
- Corrections are based on time evolving error covariance matrix, derived from ensemble of model states.
- These covariances are multivariate, nonstationary, nonisotropic.
- 13 ensemble members.
- Localization is applied by modifying observational error covariance matrix (Hunt et al. 2007).
- In our previous studies, Janjic et al. (2009,2010), we showed sensitivities to the specifications of observational error covariance used in this setting.

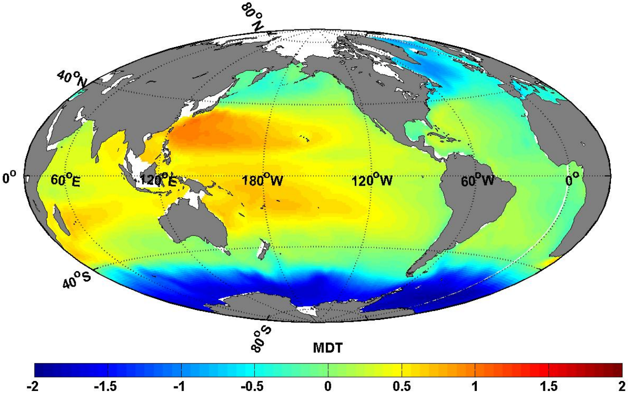
Data assimilation method



Correlation function used for localization.

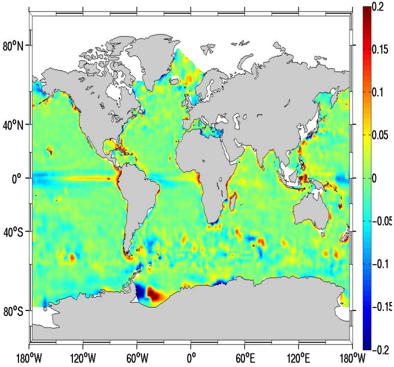
- Assimilation is performed for each column of model separately (Nerger et al. 2005,2006) using the observations within radius of 900 km.
- 5TH order polynomial correlation function is used (Gaspari and Cohn 1999).
- The observational error standard deviation is 5 cm. It accounts for the error of altimetry and gravity data, mapping errors, as well as the effects of cross-correlations introduced by interpolation.

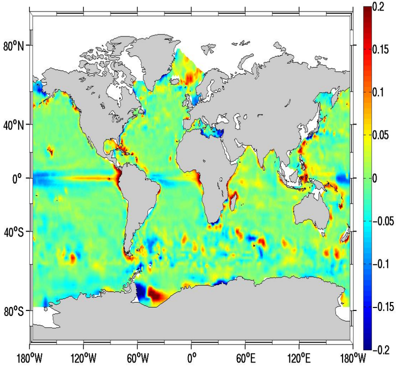
Results



MDT as result of data assimilation. It reflect the influence of the geodetic DOT data used, forcing, and ocean model parameterizations. In addition results are temperature, salinity and velocity fields corresponding to this MDT.

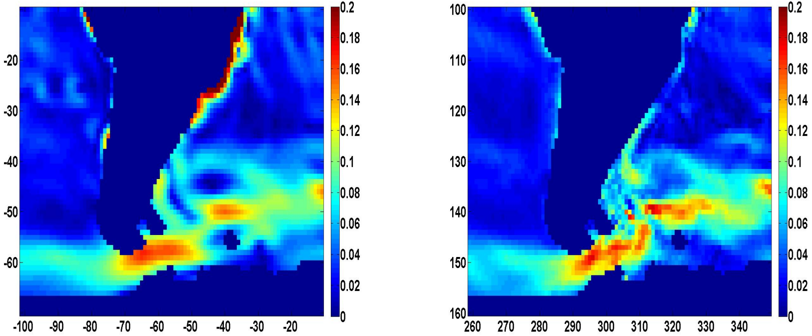
Results with respect to assimilated data





Difference between the MDT from observations and MDT from analysis (left). Difference between the MDT from observations and predicted MDT (right).

Results with respect to assimilated data



Mean geostrophic velocities calculated from geodetic DOT (left) and as result of assimilation (right).

Transport estimates

Location	M	5TH	5TH3cm	5THplGr	Obs
43S 140.25E to 45 S 140.25 E	0.88	-2.7	-3.2417	-5.8	-8 ± 13 Sv
48S 147.25E to 55.5S 140.25E	127.97	119.95	121.97	129.47	110 ± 12 Sv
66.5S 140.25E to 55.5S 140.25E	42.43	54.94	46.3	73	56.5 ± 5 Sv
Drake Passage	146	147.9	148.2	149.17	134 ± 13 Sv

Summary of the transport results for WOCE SR3 section and four different data assimilation experiments. Observational values are taken from (Rintoul and Sokolov 2001).

Conclusion/Future work

- We were able to adjust the DOT of a global ocean circulation model by data assimilation and reduce the misfit to measurements to less than 5cm RMSE.
- In addition, this result is accompanied with a number of localized high amplitude differences between observed and the estimated DOT of a global ocean circulation model.
- The discrepancies cannot be simply explained by error models or by the assimilation technique.
- Improve the filtering, specially along the coastline for geodetic DOT.
- Spectral consistency of geodetic DOT and ocean model
- Comparative analysis of geodetic and oceanographic mean dynamic ocean topography