Error Budget analysis of a Mean Dynamic Topography

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Introduction: Knowledge of the overall error budget and accuracy of a Mean Dynamic Topography and subsequently derived Geostrophic Velocities is important information for ocean studies. Following the basic equation MDT = MSS - N with the Mean Dynamic Topography (MDT), a Mean Sea Surface (MSS) and the Geoid Height (N), one can clearly see that the MDT is composed of two entities derived from different measurement types and hence different error budgets. They can be considered as uncorrelated as they are in our case derived by different and independent techniques. The Error Budget of the MDT has therefore two contributions, the Geoid error and the MSS error. They both simply sum up to the overall MDT error.

In order to ensure spectral consistency between the two entities, the implementation of filters is an essential step for the MDT computation. For this reason, the behavior of two different filter types, anisotropic diffusive and Gaussian type filter, is investigated both, in terms of the MDT results and their covariances.

Data used

-The GOCO03s geoid model consisting of 18 months of GOCE data and CHAMP, GRACE and SLR data with its associated full covariance matrix is used for the geoid part.

-The DTU10 MSS with 5 minute resolution and its associated DTU10 ERR error file are used for the Mean Sea Surface part.

-A synthetic test field in order to better demonstrate the behavior of the filters applied.

Gaussian Filter

The Gaussian type filter is a standard isotropic smoothing operator whose design parameters have been chosen to closely match the anisotropic filter in order to allow comparison between the two filter types.

Anisotropic Filtering/Diffusive Smoothing

The anisotropic or diffusive filtering is based on the work by Perona and Malik (1990) and its application to MDT computation by Bingham (2010).

The degree of smoothing depends on the magnitude of the MDT gradient, with the idea to preserve edges and thus to enhance the spatial resolution of features such as geostrophic currents.

A rigorous error propagation was formulated allowing a better understanding of the smoothing process and its applicability for MDT computations.

Synthetic Case study

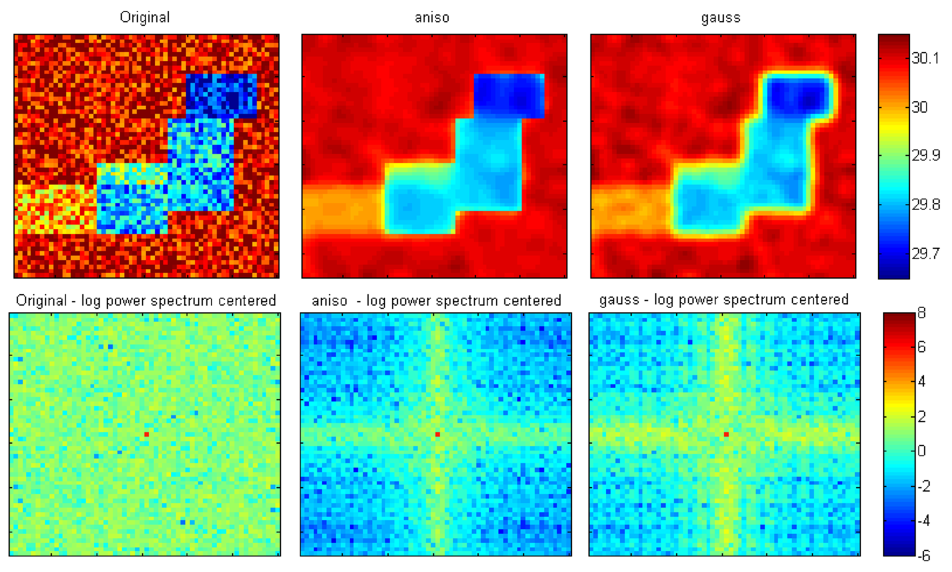

Fig.1: Original test field and test field with filters applied (upper row) and centered power spectrum density of the test field and the filtered fields

Fig. 1 shows the test field (upper left), the result of the anisotropic (upper middle) and Gaussian (upper right) filter. The resulting power spectrum density after subtraction of the original signal without noise is shown for the original (lower left), the anisotropic (lower middle) and Gaussian (lower right) case.

Conclusion/Outlook

From the results shown in Fig 2-13 it can be concluded that Anisotropic Filtering shows better performance with respect to a Gaussian Type filter with similar parameters, in order to evaluate geostrophic currents. Although one should note that the error propagation of the covariance matrix shows very high damping for the original errors applying the anisotropic/diffusive filter.

Computations on a larger scale and with higher resolution are currently under preparation.

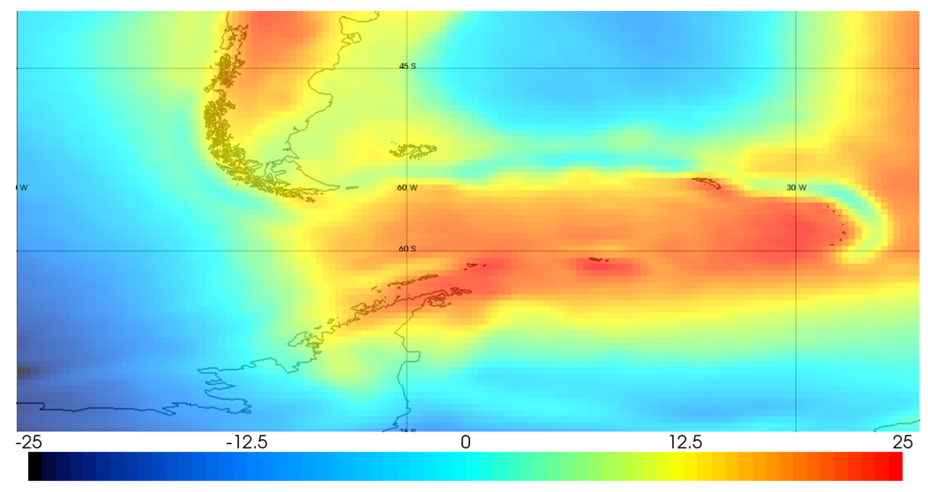

Fig. 2 **Mean Sea Surface** height from DTU10MSS on a 30min grid in meters

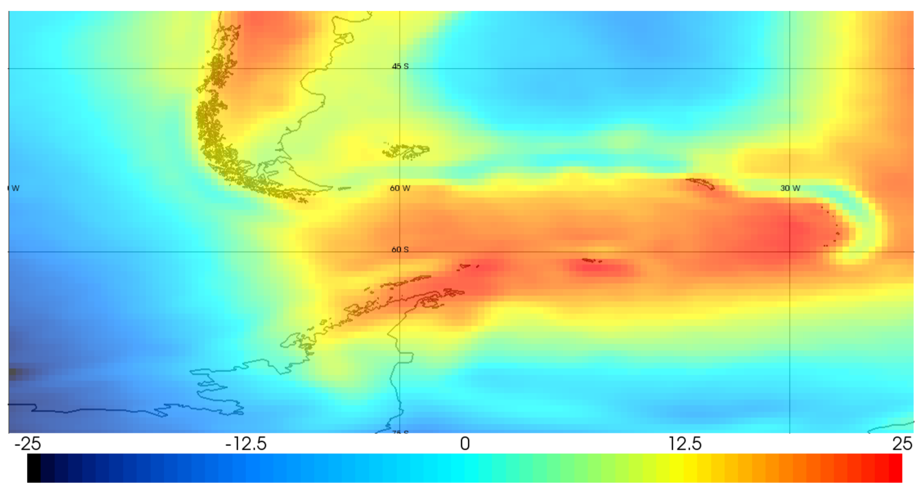

Fig. 3 **Geoid height** from GOCO03s developed to d/o 250 on a 30min grid im meters

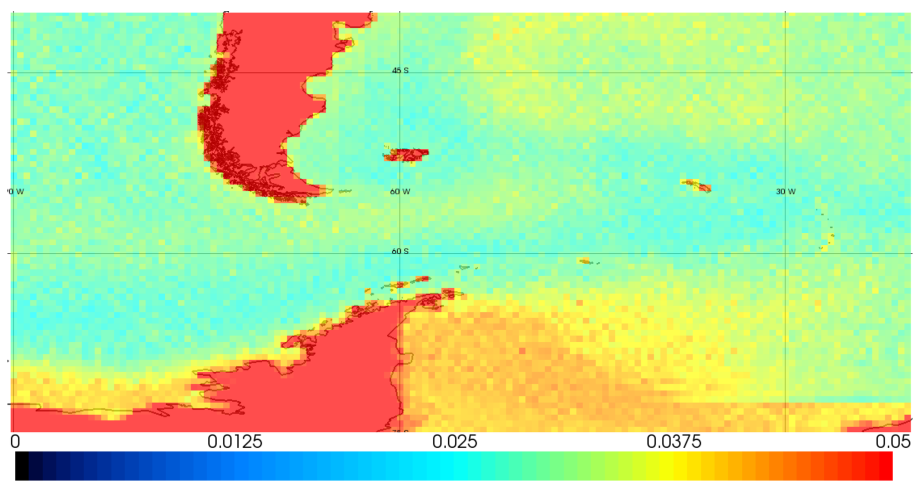

Fig. 4 **Error of the Mean Sea Surface** heights from DTU10ERR_5min file on a 30min grid in meters

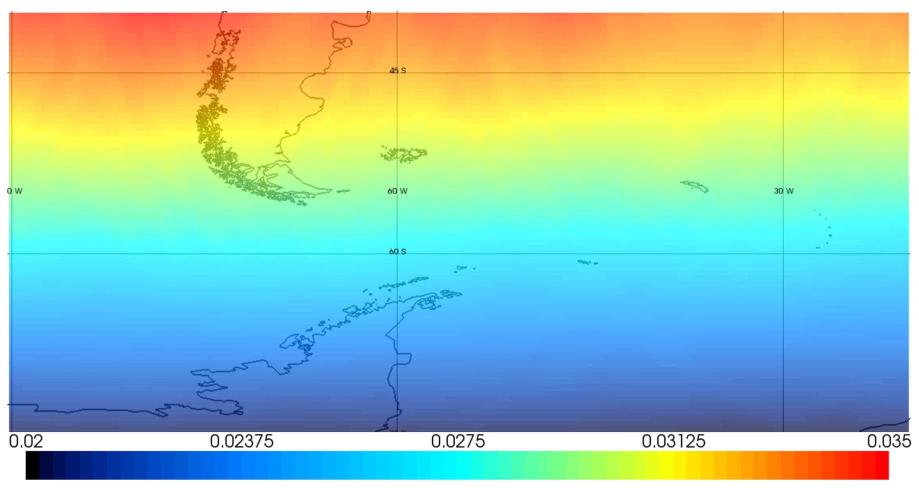

Fig. 5 **Error of the Geoid Height** from the full covariance matrix on a 30min grid in meters

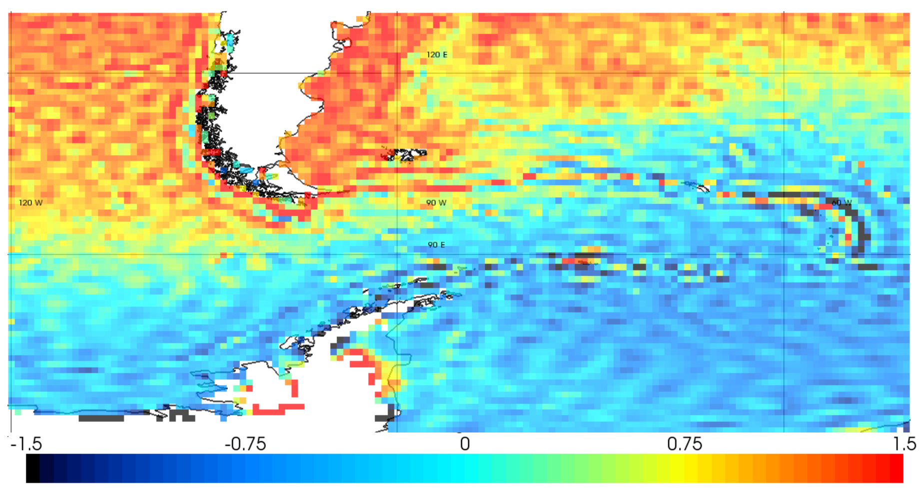

Fig. 6 unfiltered **Mean Dynamic Topography** on a 30min grid in meters

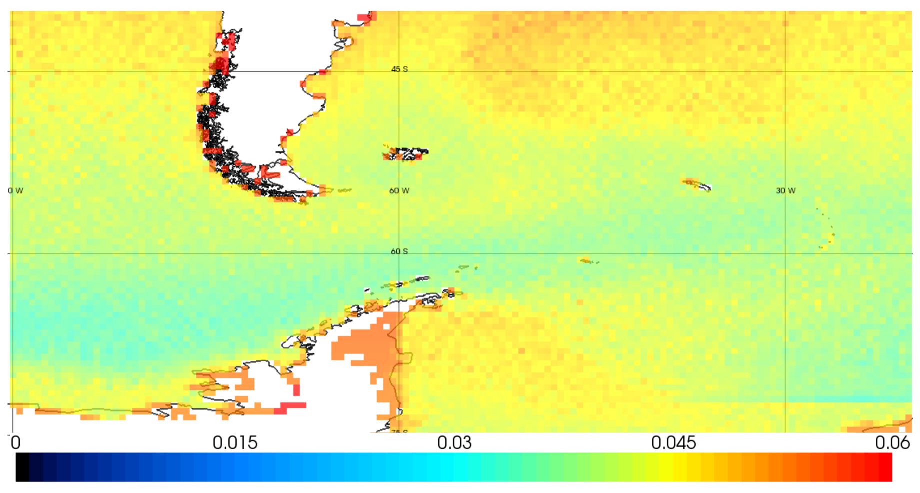

Fig. 7 **Error of the Mean Dynamic Togopraphy** on a 30 minute grid in meters

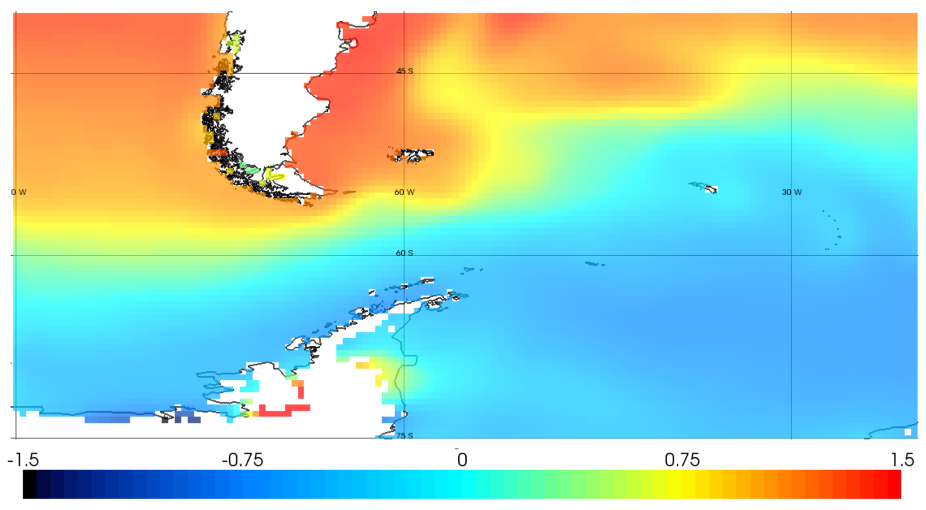

Fig. 8 Mean Dynamic Topography filtered with **Anisotropic Filter** on a 30min grid in meters

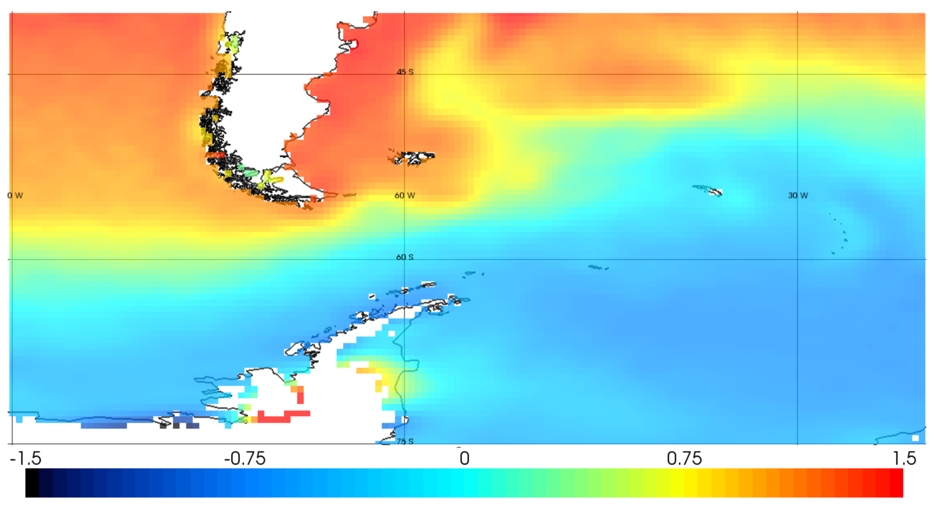

Fig. 9 Mean Dynamic Topography filtered with **Gaussian Filter** on a 30min grid in meters

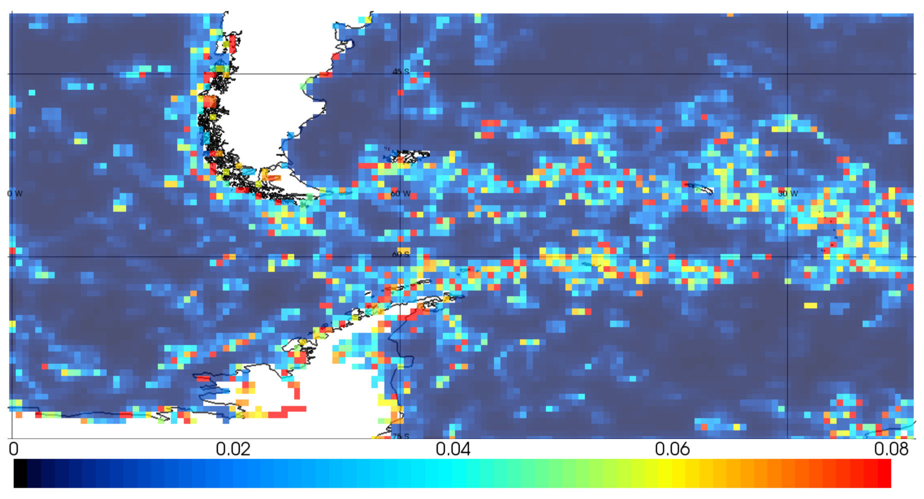

Fig. 10 **Error** of the **Anisotropic filtered MDT** on a 30min grid in meters

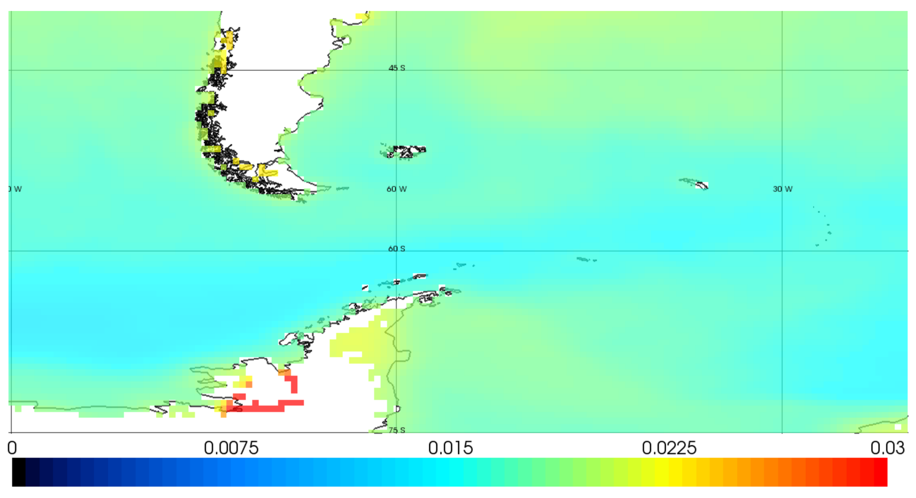

Fig. 11 **Error** of the **Gaussian filtered MDT** on a 30min grid in meters

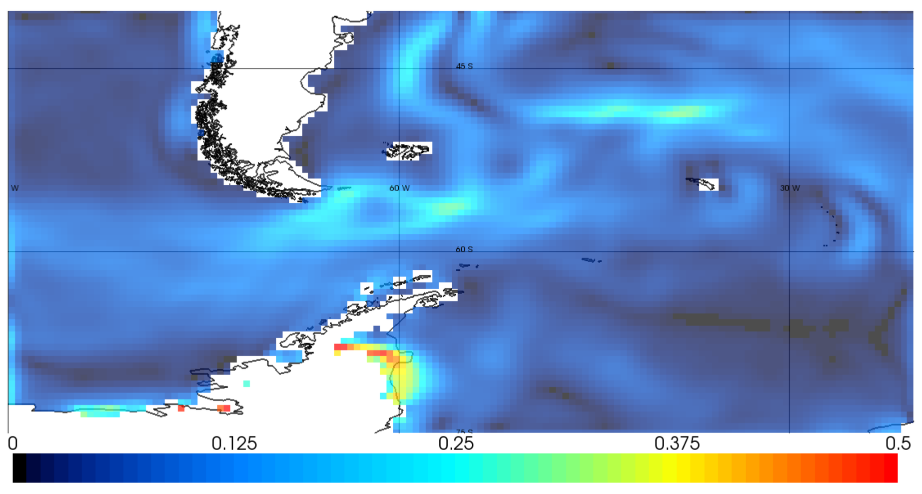

Fig. 12 **Geostrophic velocity** of the **Anisotropic filtered MDT** on a 30min grid in meters/second

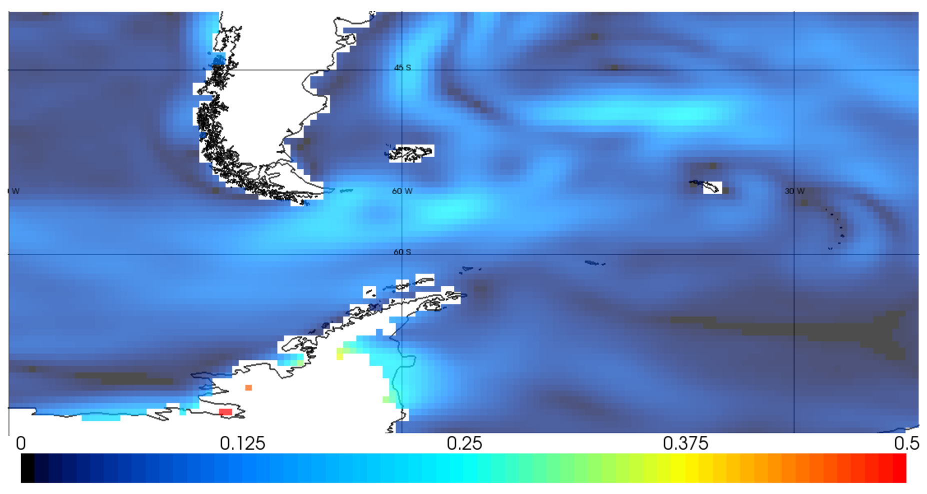

Fig. 13 **Geostrophic velocity** of the **Gaussian filtered MDT** on a 30min grid in meters/second

References:

Andersen, O. B., The DTU10 Gravity field and Mean sea surface (2010) Second international symposium of the gravity field of the Earth (IGFS2), Fairbanks, Alaska.

Bingham R.J. (2010): Nonlinear anisotropic diffusive filtering applied to the ocean's mean dynamic topography, Remote Sensing Letters, 1:4, 205-212

Mayer-Gürr T. et al. (2012): The new combined satellite only model GOCO03s. Abstract submitted to GGHS2012, Venice (Poster).

Perona, P. and Malik, J., 1990, Scale-space and edge detection using anisotropic diffusion. IEEE Transactions on Pattern Analysis and Machine Intelligence, 12, pp. 629–639.

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