Filtering of Altimetric Sea Surface Heights with local and global approaches

Alberta Albertella – Xinxing Wang - Reiner Rummel
Institut für Astronomische und Physikalische Geodäsie, Technische Universität München

Within the Priority Research programme "Mass Transport and Mass Distribution in the Earth System" of the German Research Foundation, the objective of the project **GEO-TOP** is the study of the Sea Surface Topography and Mass Transport of the Antarctic Circumpolar Current in a cooperation of **IAPG**, the Deutsches Geodätisches Forschungsinstitut München (**DGFI**) and the Alfred-Wegener-Institut für Polar und Meeresforschung Bremerhaven (**AWI**).

The absolute dynamic sea surface topography is determined from accurate geoids models combined with a mean ocean surface derived from long-term time series of sea surface heights from multi-mission satellite altimetry. This implies combination of data with fundamentally different characteristics and different spatial resolution. The sea surface height data contain information with higher spatial resolution than the one included in the geoid model.
These short scales features must be removed by filtering in order to provide a dynamic topography field that is consistent with the geoid field.

In this study we investigate different ways to carry out the filtering of the altimetric surface:

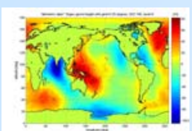
- the first one considers data from a "global" point of view, using a spherical harmonic representation;
- the second one considers the data from a "regional" point of view, using a bi-dimensional Fourier representation.

To check the filtering procedure the following steps are made:

- Simulation of a "spectrally known" sea surface height = geoid undulation up to degree 180 (from a known set of spherical harmonic coefficients)
- Filtering up to degree 60
- Comparison between the filtered N^F_{60} and the synthesized N^S_{60} ➔ ERRORS computation

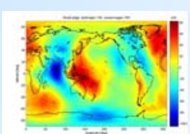
GLOBAL APPROACH (spherical harmonic representation)

This approach consists in the expansion of the global altimetric sea surface into spherical harmonic coefficients and then in the filtering to lower degree and order which is compatible with the geoid representation (60 in this example).



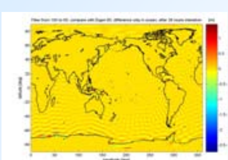
The problem is how to obtain a complete set of data, also in the land areas where no altimetric data exist.

To extend the data in the land areas we propose an "iterative procedure".
We start using EGM96 geoid to degree and order 180 on the land and EIGEN geoid to the same degree and order in the ocean. Next we perform spherical harmonics analysis to get harmonic coefficients, and then perform synthesis to come back to geoid. After this process, we get a new "mixed geoid" on the globe. Then, we will stick to EIGEN geoid to degree and order 180 in the ocean, but on land we will use the "mixed geoid". Then we repeat the process.
Because this "mixed geoid" on the land contains also data from ocean, it will merge the ocean and land data so that the edge between land and ocean will be smaller.



Two different filters are applied:

- direct cut-off filter
- Gauss filter

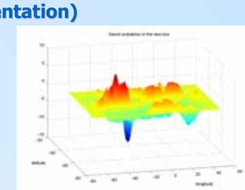


RESULTS (in the ocean areas)

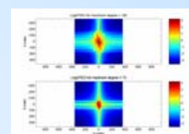
Statistical analysis	Max [m]	Min [m]	Mean [m]	Sigma [m]
Direct cut-off filter	1.501	-2.753	-5.6e-4	0.0711
Gauss filter	1.179	-0.580	-6.13e-5	**0.0244**

LOCAL APPROACH (Fourier representation)

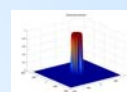
The considered area is an ocean box (lat = [-65°,-45°]; lon = [40°W, 20°E]), with a regular equiangular grid (0.5° x 0.5°). To avoid problems related to this spatial window, a larger (50%) area is taken into account with a transition zone smoothed by a Tukey windowing.



The shape of the Fourier spectrum (an ellipse) depends on the geographical extensions of the considered box and on the latitude (for the considered box $\varphi_M = -55°$).



The selected filter is a **2D Butterworth low pass filter**.



The two axes (in the spectral domain) are related to the position (φ_M) and to the dimensions ($\Delta\varphi$, $\Delta\lambda$) of the box containing the data, i.e.:

$$a = k0/2 * \Delta\varphi/\pi$$
$$b = k0/2 * \Delta\lambda/(2\pi) * \cos\varphi_M$$

The constant **k0** is the frequency threshold of the filter (60 in this example).

RESULTS

Max [m]	Min [m]	Mean [m]	Sigma [m]
0.0544	-0.0672	0.0004	**0.0188**

CONCLUSIONS: In both cases satisfactory results could be achieved. The procedures of filtering have an accuracy of **2 centimetres**, which is compatible with the precision of the altimetric data. However it turns out that the question of what consistency really is, is not so easy to answer.

Joint International GSTM and DFG SPP Symposium,
October 15-17, 2007 GFZ Potsdam