Optimal Ocean Geoid as Reference Surface for Mean Ocean Circulation and Height Systems

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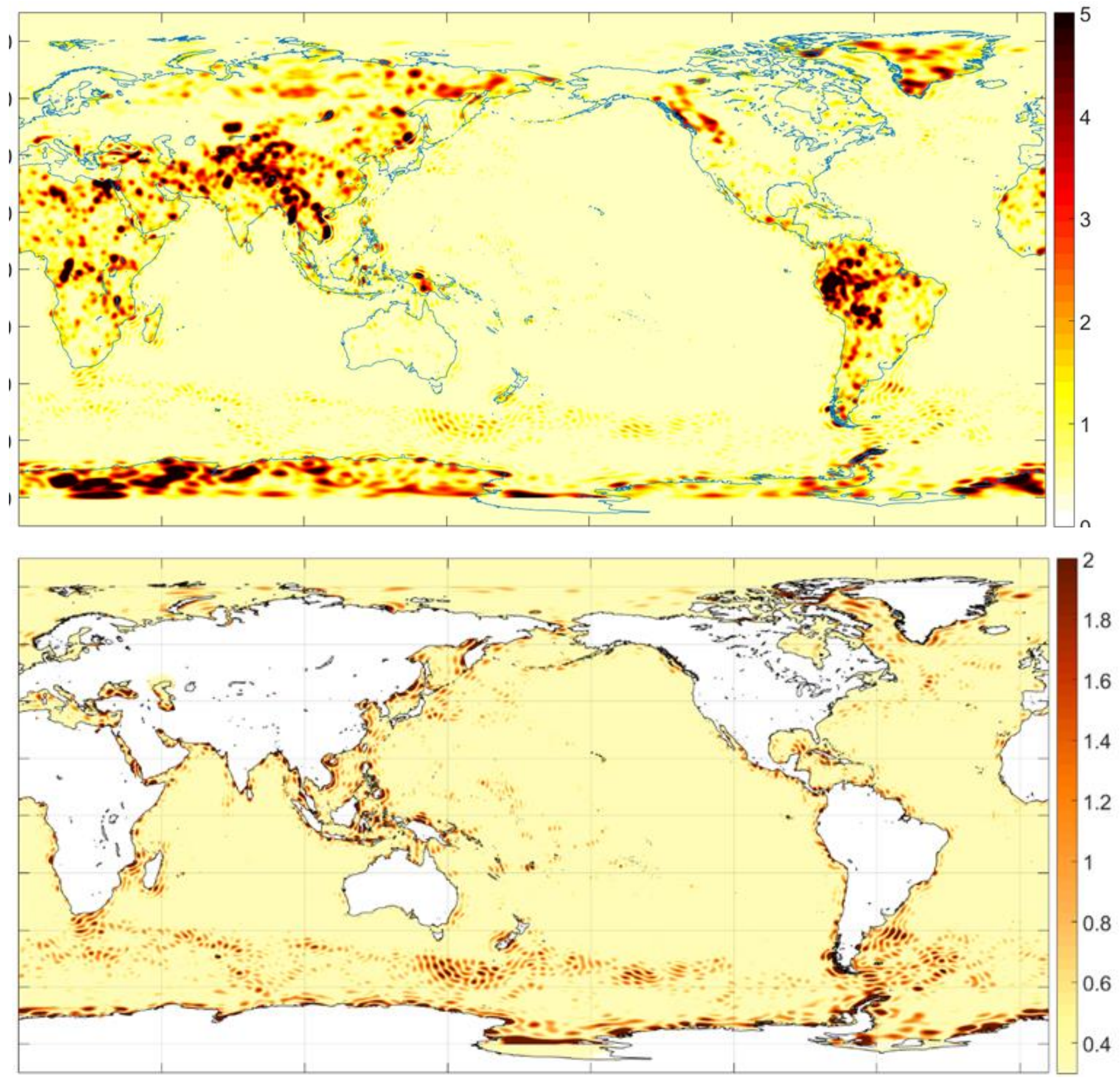
Introduction

The ocean geoid is the reference surface for mean ocean circulation and is needed for unification of height systems across the oceans. It is determined from a combination of satellite gravimetry for the long to medium wavelengths and from airborne, altimetric and shipborne gravimetry for the short wavelengths. Within a recently completed project of the European Space Agency named GOCE-OGMOC (Optimal Geoid Modelling based on GOCE and GRACE third-party mission data and merging with altimetric sea surface data to optimally determine Ocean Circulation) such an ocean geoid was computed by means of stochastically optimal combination of the various data sources.

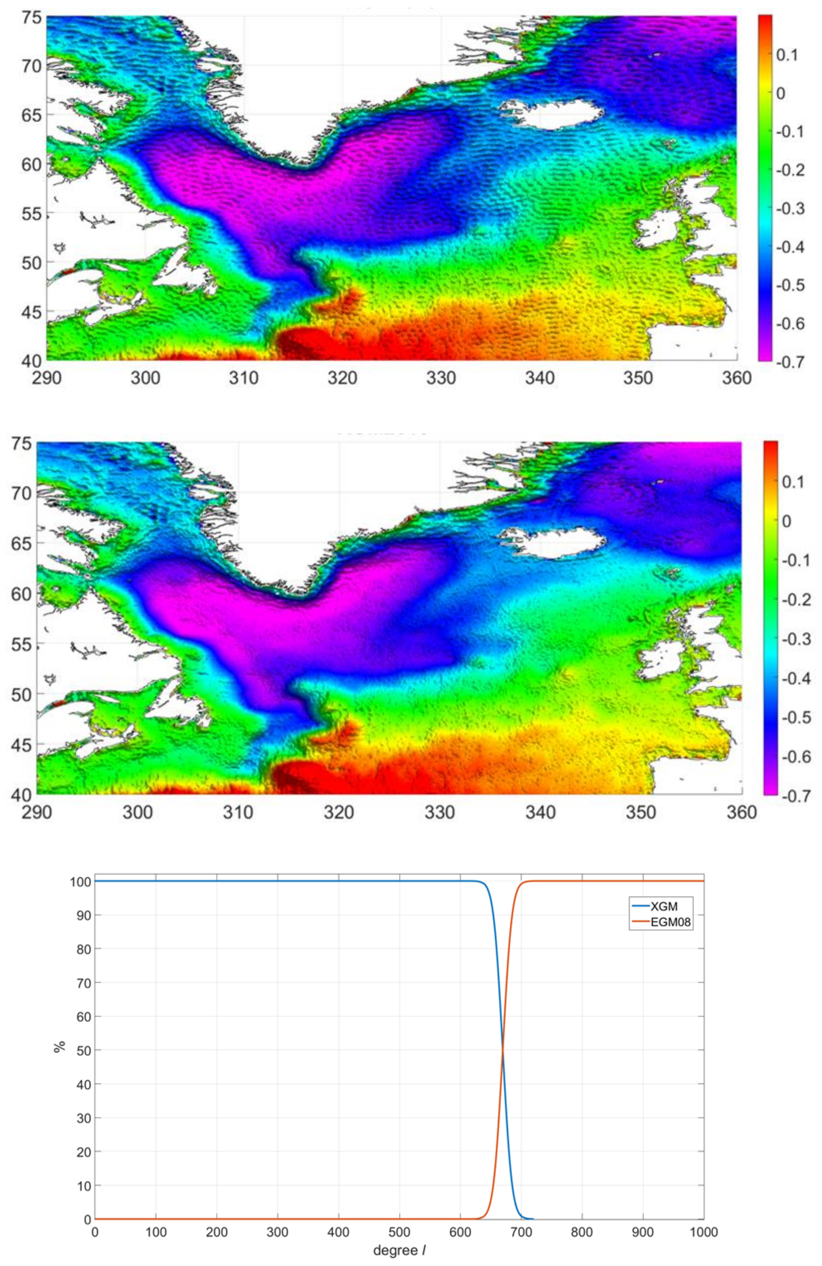
The ocean geoid model then was applied to compute an optimal geodetically derived mean dynamic topography (MDT) and related geostrophic current velocities by subtracting it from a recent mean sea surface and by applying dedicated filters. This MDT in detail was analysed with respect to its signal content and to its consistency over large areas and with respect to leakage of uncertain land gravimetric data into the oceans. In addition it was also investigated to what extent remaining dynamic ocean topography signal in altimetric gravity data is visible in the ocean geoid and/or the MDT solutions.



Gravity Field Modelling

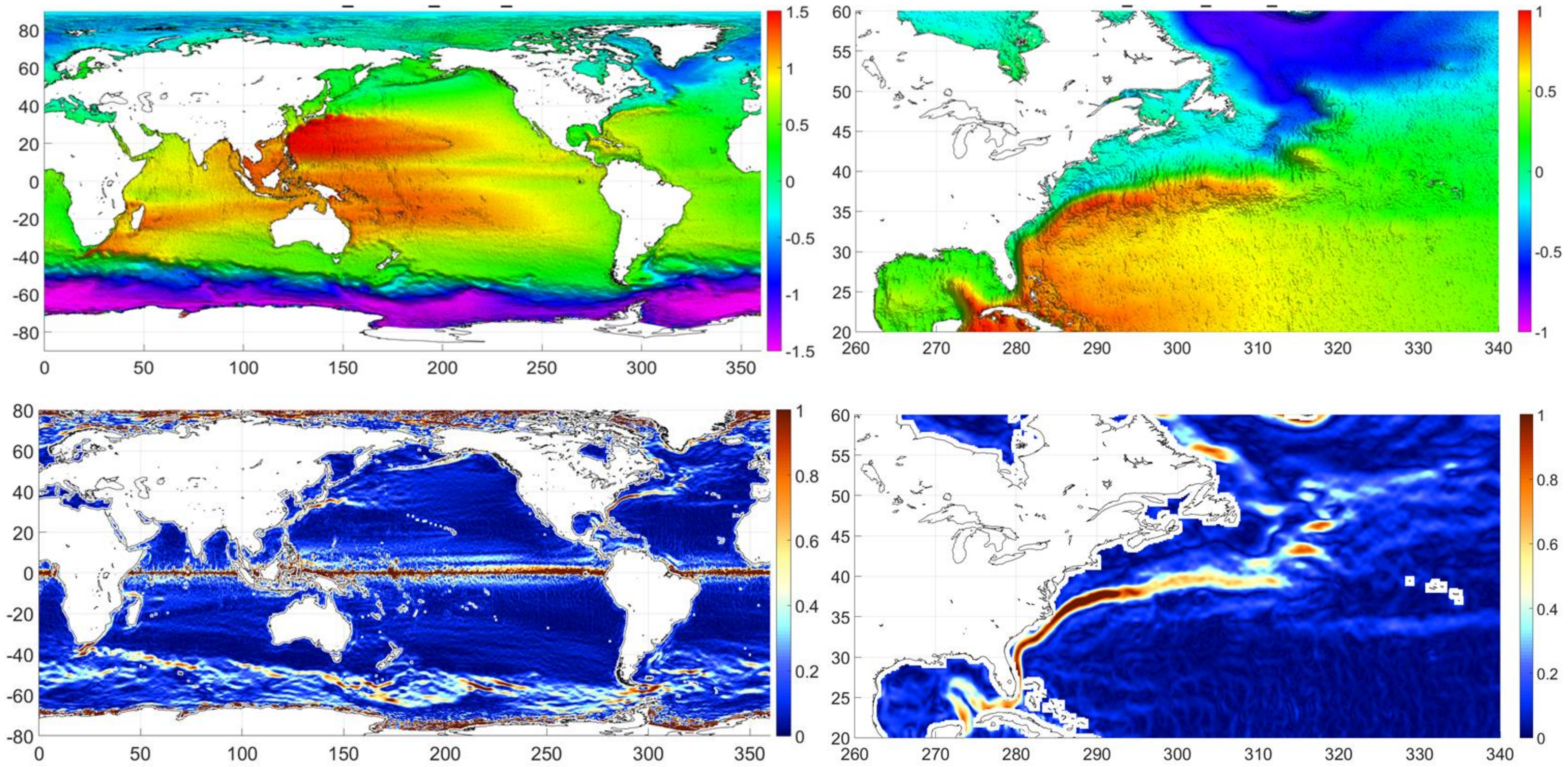
Appropriate relative weighting between the satellite and the ground data part by comparison with GOCO05S satellite-only model applying a tapering function between degree 75 and 225 is determined. Differences are converted to individual weights for ground data. Top left: Gravity anomaly weights for combined land and ocean data set, Bottom left: Gravity anomaly weights for altimetric gravity data (zoom-in) [mgal]. A model with full variance-covariance information up to d/ 719 is estimated = XGM2016 model.

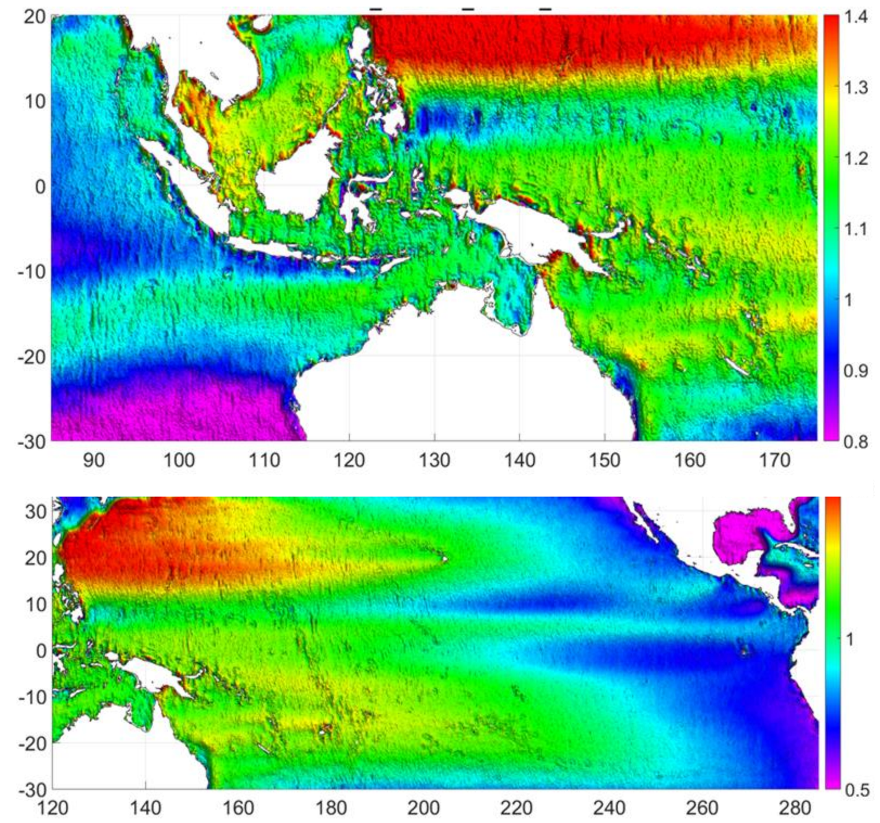
The model is further extended with EIGEN6-C4 coefficients by applying a tapering function between degree 620 and 719. EIGEN6-C4 uses the same DTU13 altimetric gravity anomalies as XGM2016. Tapering avoids artefacts by simply extending the model with EIGEN6-C4 coefficients. Bottom right: Tapering function; Top right: DTU13 MSS minus extended XGM2016 [m]; Mid right: DTU13 MSS minus extended XGM2016 applying tapering function [m].



Mean Dynamic Topography

The mean dynamic topography is computed by subtracting the ocean geoid from the DTU15 mean sea surface (spatial resolution 5'x5'). From the MDT also geostrophic current velocities are computed;

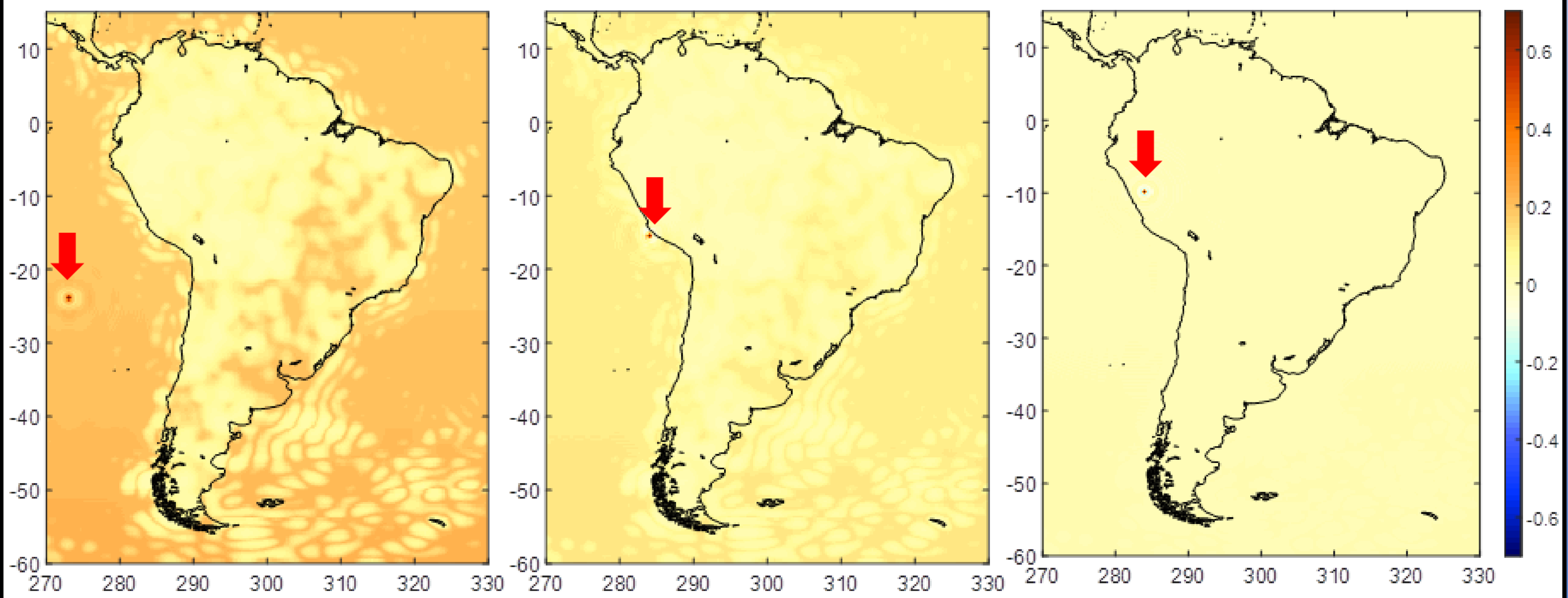




Top left: global MDT [m]; Bottom left: global geostrophic current velocities [m/s]; Top middle: MDT Gulf stream [m]; Bottom middle: Geostrophic current velocities Gulf stream [m/s]; Top right: MDT SE-Asia [m]; Bottom right: MDT Pacific [m].

Land & Coastal Impact to Ocean Geoid

A major issue in the determination of the geodetic MDT is its quality in coastal regions. These regions suffer from the limited quality of altimetry in coastal regions as well as from the influence of poor quality terrestrial data leaking into the oceans.



The variance covariance matrix of the gravity field is propagated to geoid heights and correlations are analysed for several points. They are compared for a point in the open ocean (left), for a point in a coastal region (middle) and for a point in a poor data quality region on land (right). The point in the open ocean is highly correlated with all other points of high accuracy. The correlations for the point in coastal region are much smaller. The point on land in a poor data quality region is mainly uncorrelated.

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