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Integrated approach to estimate the ocean's time variable dynamic topography including its covariance matrix

Silvia Müller, Jan Martin Brockmann, and Wolf-Dieter Schuh
University of Bonn, Institute of Geodesy and Geoinformation, Germany (silvia.mueller@geod.uni-bonn.de)

The ocean's dynamic topography as the difference between the sea surface and the geoid reflects many characteristics of the general ocean circulation. Consequently, it provides valuable information for evaluating or tuning ocean circulation models. The sea surface is directly observed by satellite radar altimetry while the geoid cannot be observed directly. The satellite-based gravity field determination requires different measurement principles (satellite-to-satellite tracking (e.g. GRACE), satellite-gravity-gradiometry (GOCE)). In addition, hydrographic measurements (salinity, temperature and pressure; near-surface velocities) provide information on the dynamic topography. The observation types have different representations and spatial as well as temporal resolutions. Therefore, the determination of the dynamic topography is not straightforward. Furthermore, the integration of the dynamic topography into ocean circulation models requires not only the dynamic topography itself but also its inverse covariance matrix on the ocean model grid.

We developed a rigorous combination method in which the dynamic topography is parameterized in space as well as in time. The altimetric sea surface heights are expressed as a sum of geoid heights represented in terms of spherical harmonics and the dynamic topography parameterized by a finite element method which can be directly related to the particular ocean model grid. Besides the difficult task of combining altimetry data with a gravity field model, a major aspect is the consistent combination of satellite data and in-situ observations. The particular characteristics and the signal content of the different observations must be adequately considered requiring the introduction of auxiliary parameters. Within our model the individual observation groups are combined in terms of normal equations considering their full covariance information; i.e. a rigorous variance/covariance propagation from the original measurements to the final product is accomplished. In conclusion, the developed integrated approach allows for estimating the dynamic topography and its inverse covariance matrix on arbitrary grids in space and time. The inverse covariance matrix contains the appropriate weights for model-data misfits in least-squares ocean model inversions.

The focus of this study is on the North Atlantic Ocean. We will present the conceptual design and dynamic topography estimates based on time variable data from seven satellite altimeter missions (Jason-1, Jason-2, Topex/Poseidon, Envisat, ERS-2, GFO, Cryosat2) in combination with the latest GOCE gravity field model and in-situ data from the Argo floats and near-surface drifting buoys.