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Updated Delft Mass Transport model DMT-2: computation and validation

Hassan Hashemi Farahani (1), Pavel Ditmar (1), Pedro Inacio (1), Roland Klees (1), Jing Guo (2), Xiang Guo (2), Xianglin Liu (3), Qile Zhao (2), Olga Didova (1), Jiangjun Ran (1), Yu Sun (1), Natthachet Tangdamrongsub (1), Brian Gunter (1), Ricardo Riva (1), and Susan Steele-Dunne (1)

(1) Delft University of Technology, Delft, The Netherlands, (2) Wuhan University, Wuhan, China, (3) Fugro Intersite B.V., Leidschendam, The Netherlands

A number of research centers compute models of mass transport in the Earth's system using primarily K-Band Ranging (KBR) data from the Gravity Recovery And Climate Experiment (GRACE) satellite mission. These models typically consist of a time series of monthly solutions, each of which is defined in terms of a set of spherical harmonic coefficients up to degree 60–120. One of such models, the Delft Mass Transport, release 2 (DMT-2), is computed at the Delft University of Technology (The Netherlands) in collaboration with Wuhan University. An updated variant of this model has been produced recently. A unique feature of the computational scheme designed to compute DMT-2 is the preparation of an accurate stochastic description of data noise in the frequency domain using an Auto-Regressive Moving-Average (ARMA) model, which is derived for each particular month. The benefits of such an approach are a proper frequency-dependent data weighting in the data inversion and an accurate variance-covariance matrix of noise in the estimated spherical harmonic coefficients. Furthermore, the data prior to the inversion are subject to an advanced high-pass filtering, which makes use of a spatially-dependent weighting scheme, so that noise is primarily estimated on the basis of data collected over areas with minor mass transport signals (e.g., oceans). On the one hand, this procedure efficiently suppresses noise, which are caused by inaccuracies in satellite orbits and, on the other hand, preserves mass transport signals in the data. Finally, the unconstrained monthly solutions are filtered using a Wiener filter, which is based on estimates of the signal and noise variance-covariance matrices. In combination with a proper data weighting, this noticeably improves the spatial resolution of the monthly gravity models and the associated mass transport models.. For instance, the computed solutions allow long-term negative trends to be clearly seen in sufficiently small regions notorious for rapid mass transport losses, such us the Kangerdlugssuaq and Jakobshavn glaciers in the Greenland ice sheet, as well as the Aral Sea in the Central Asia. The updated variant of DMT-2 has been extensively tested and compared with alternative models. A number of regions/processes have been considered for that purpose. In particular, this model has been applied to estimate mass variations in Greenland and Antarctica (both total and for individual ice drainage systems), as well as to improve a hydrological model of the Rhine River basin. Furthermore, a time-series of degree-1 coefficients has been derived from the DMT-2 model using the method of Swenson et al. (2008). The obtained results are in a good agreement both with alternative GRACE-based models and with independent data, which confirms a high quality of the updated variant of DMT-2.