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Optimal regularization/interpolation of mass anomaly time-series based on satellite gravimetry data

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The primary source of information about mass transport in the Earth's system is satellite gravimetry. The satellite mission that is mostly suited for mass transport monitoring is the Gravity Recovery And Climate Experiment (GRACE), which was launched in 2002. This mission delivers invaluable data to quantify mass transport associated with different processes,, including accumulation and depletion of continental water stocks, shrinking of ice sheets, megathrust earthquakes, glacial isostatic adjustment, and ocean circulation. The mass anomalies based on GRACE data are usually provided in terms of monthly solutions. Unfortunately, a degradation of the GRACE satellite systems causes gaps in GRACE data, the number of which keeps increasing. Furthermore, a termination of the GRACE mission in the near future cannot be excluded, which would inevitably result in an extended gap that will last until the GRACE Follow-On mission becomes fully operational (scheduled for launch in August 2017). There are on-going attempts to exploit alternative data (primarily, GPS data) that are delivered by other satellite missions in order to fill the gaps. However, the spatial resolution of mass anomaly time-series derived from the alternative data is by far lower. This means that the resulting total mass anomalies within a given region are known with a lower accuracy or even virtually unknown (depending on the region size), as compared to the months when the GRACE data are available. At the same time, many data processing and assimilation techniques require that mass anomalies form a gapless time-series of a (nearly) homogeneous quality. To meet this challenge, we propose a novel regularization technique. It is a variant of the classical Tikhonov regularization that takes into account (i) continuity and (ii) annual periodicity of mass anomaly time-series. The impact of the regularization is defined by a single regularization parameter, which is obtained using variance component estimation. The proposed approach may take into account non-stationary noise in the input time-series of mass anomalies. In the extreme case when a mass anomaly estimate is so uncertain that it can be considered as being absent, the proposed technique works as interpolation. An additional benefit of the proposed technique is its ability to scale the estimates of errors in the input data time-series (or to estimate the errors themselves if the quality of the input time-series is homogeneous). To demonstrate the performance of the proposed technique, we apply it to both synthetic and real (GRACE-based) time-series of mass anomalies. The obtained results are compared with those obtained with more traditional interpolation schemes.