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Uncertainties of TWS Time Series for Arbitrary Regions - Modelled vs. Formal Covariances

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Knowledge of the variances and covariances of gridded terrestrial water storage anomalies (TWS) as observed with GRACE and GRACE-FO is crucial for many applications thereof. For example, data assimilation into different models, trend estimations, or combinations with other data set require reliable estimations of the variances and covariances. Today, the Level-2 Stokes coefficients are provided with formal variance-covariance matrices which can yield variance-covariance matrices of the gridded data after a labourious variance propagation through all post-processing steps, including filtering and spherical harmonic synthesis. Unfortunately, this is beyond the capabilities of many, if not most, users.

This is why, we developed a spatial covariance model for gridded TWS data. The covariance model results in non-homogeneous, non-stationary, and anisotropic covariances. This model also accommodates a wave-like behaviour in latitudinal-directed correlations caused by residual striping errors. The model is applied to both VDK3 filtered GFZ RL06 and ITSG-Grace2018 TWS data.

With thus derived covariances it is possible to estimate the uncertainties of mean TWS time series for any arbitrary region such as river basins. On the other hand, such time series uncertainties can also be derived from the afore mentioned formal covariance matrices. Here, only the formal covariance matrices of ITSG-Grace2018 are used which are also filtered with the VDK3 filter. All together, we are able to compare globally the time series uncertainties of both the modelled and formal approach. Further, the modelled uncertainties are compared to empirical standard deviations in arid regions in the Arabian, Sahara, and Gobi desert where residual hydrological signal can be neglected. Both in the temporal and spatial domain they show a very satisfying agreement proving the usefulness of the covariance model for the users.