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Towards validation of GRACE/-FO gravity fields and background models using GNSS position time series

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Precise positioning of terrestrial stations with Global Navigation Satellite Systems (GNSSs) constitutes a rich data source for studying the Earth's deformations due to large-scale and local phenomena. When looking at the explained root-mean-square values of the GNSS position time series for stations located in Europe, the Baltic Sea coasts are predominantly affected by non-tidal atmospheric loading, non-tidal ocean loading prevails for the North Sea coast, while central Europe is strongly affected by loading due to storage changes in the continental hydrosphere. Furthermore, the GNSS observations have been used for comparing to, and validating, position time series derived from monthly GRACE (Gravity Recovery and Climate Experiment) gravity models. In the context of the newly established research unit NEROGRAV, funded by the Deutsche Forschungsgemeinschaft (DFG), we propose to validate gravity fields from GRACE/GRACE-FO and (combinations of) the various background models (e.g. non-tidal oceanic and atmospheric models) used in processing of GRACE/GRACE-FO data through cross-checking their predicted vertical and horizontal load-induced displacements against position time series of the European GNSS stations. A global set of about 17000 GNSS permanent stations, 4500 of which are located in Europe, provides a wide range of opportunities to gather and interpret independent data for validation purposes. In this presentation, we will focus on the requirements that GNSS permanent stations need to fulfill to be employed for this task. Obviously, stations should be evenly distributed over the entire area of interest to assess load-induced phenomena in a representative way. To properly analyze and interpret loading-related effects, long time series are indispensable, covering at least a 5-year time span with the lowest possible number of missing values. As we aim to evaluate load-induced displacements from GRACE-FO and from GRACE/-FO gap filling approaches, the permanent stations we chose should still be operating. Another problem is that while GNSS point measurements detect signals over the entire spatial spectrum of the surface load redistribution (although at short spatial scales the Love numbers drop quickly), GRACE-predicted loads and deformations are limited to the GRACE product's spectral resolution, typically between degree 50 or 90, and model-predicted deformations are limited by the model's spatial resolution, often 50 km. In other words, small-scale loading may be present in GNSS station motion. Also, GRACE data are typically spatially smoothed in order to reduce correlated noise. We therefore discuss to what extent GRACE, GNSS and model data sets are consistent with each other.