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Singular value decomposition of tidal harmonics on a rigid Earth

Adam Ciesielski (1) and Thomas Forbriger (1,2)

(1) Karlsruhe Institute of Technology, Geophysical Institute, Department of Physics, Karlsruhe, Germany (adam.ciesielski@kit.edu), (2) Black Forest Observatory (BFO), Schiltach, Germany

Temporal variations of tidal parameters have been recently reported in moving window analysis of superconducting gravimeter data. Tidal parameters are the quantities describing the Earth's response to tidal forcing. Since the admittance of Earth's body is not expected to vary rapidly, the cause may lay in non-stationary ocean loading or in deficiencies of the analysis method. The method uses a harmonic development expressed in tidal catalogues. Tidal harmonics are arranged in wave groups and parameters are kept constant within each group. This may be at variance with the actually recorded signal. For this reason we develop a new approach to tidal analysis which abandons wave grouping and replaces this a-priori model constraint by additional penalty terms in the inverse problem. Singular value decomposition (SVD) can help to distinguish parameter combinations of significance from neglectable ones. This shall allow the investigation of different causes of non-stationarity. Before setting the inverse problem, we study the properties of the forward problem.

We compute the SVD for the forward problem of synthetic gravity time series without phase shift. Model parameters are amplitude factors (gravimetric factor) applied to time series of individual tidal harmonics, which we compute with Eterna 3.40 for a rigid Earth. SVD allows to discriminate combinations of harmonics with small singular value, which do not significantly contribute to the predicted tidal data in the given time window and therefore would be prone to noise in the inversion. Singular vectors specify the corresponding linear combination of tidal harmonics.

We investigate the contribution of a set of selected tidal harmonics to the predicted data using SVD and focus on the most significant harmonics (in terms of the absolute catalogue amplitude) and S1 and $\psi 1$ (in group K1), additionally. The group K1 is of special interest because it contains harmonics with frequencies close to the free core nutation resonance. Moreover, the S1 signal in measured data would be strongly affected by radiative forcing. We examine their significance depending on the duration and sampling of the data. As expected, for time series long enough (corresponding to the smallest frequency distance between the used harmonics), there exists a one-to-one correspondence between singular value and tidal harmonic. For shorter records some linear combinations of tidal harmonics become insignificant with respect to the total time series. As a consequence for the corresponding inverse problem, only tidal parameters for those linear combinations which contribute significantly to the synthetic data could be determined. We will present the nature of significant and insignificant linear combinations and their dependency on data time window.