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Resolution and significant contributions of tidal forcing in flexible harmonic grouping computed using Singular Value Decomposition

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We present the results of our studies of singular value decomposition (SVD) of the forward operator in tidal analysis. Using the resolution matrix and the ratio between singular values, we distinguish significant contributions that compose the tidal signal and we study cross-talk within and between tidal groups. Using all harmonics from the tidal catalogue we investigate the resolution matrix properties with decreasing amplitude of harmonics. We demonstrate the loss of resolution even for harmonics of large amplitude with decreasing time-series length. Our further investigation shows the cross-talk from atmospherically induced gravity variation into a tidal signal (expected and unexpected, e.g. S1, Fi1, Sig1). We investigate the ability to determine the ratio of gravimetric factors of degree 2 and degree 3 tides from the specific tidal gravity signal recordings.

The main interest of tidal analysis is the accurate and precise determination of tidal parameters, which are amplitude (gravimetric) factor and phase lag, the quantities describing the Earth response to the tidal forcing. Tidal catalogues define the tide generating potential in terms of harmonics. Widely used software, like ETERNA or Baytap-G, uses a-priori grouping of harmonics which is based on reasonable considerations like the Rayleigh criterion of spectral resolution. Wave grouping is a model parameterisation used to make the analysis problem overdetermined by using assumptions regarding the model parameters (e.g. credo of smoothness, known free-core resonance parameters, known ratio between response to degree 2 and degree 3 forcing). If those assumptions are incorrect, this can lead to artefacts which might go unnoticed. This presents a limitation for example in the search for causes of temporal variation of tidal parameters, as reported recently. SVD of the unparameterised problem allows us to investigate these limitations.

In our analysis, SVD is a factorisation of a linear regression matrix. The regression matrix consists of tidal harmonics in-phase and quadrature signal for rigid Earth tide (tidal forcing to Earth surface). We compute time series for each harmonic present in Tamura tidal catalogue by using a modified version of "Predict" (ETERNA package). Resulting values can be, but do not need to be, grouped prior to SVD analysis. Other than with conventional programs, wave groups can not only be defined along the frequency axis. They can as well be used to separate harmonics of degree 2 and degree 3. SVD allows us to study the significance of tidal harmonics, cross-talk between

harmonics or groups and matrix null space. Thus, we can discriminate the parameters with small singular value, which do not significantly contribute to the predicted tidal data or are noise-sensitive.

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