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Application of Kalman filtering for the determination of a VLBI terrestrial reference frame

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Terrestrial reference frames (TRF) of high quality are indispensable for many geoscientific and geodetic applications including very long baseline interferometry (VLBI) data analysis. While secular station coordinate changes, e.g. due to tectonic plate motion, can be well represented by a linear model, current accuracy requirements also demand modeling of non-linear signals such as surface deformations due to mass loading or post-seismic deformations. The ITRF2014, for instance, includes coefficients for exponential and logarithmic functions after major earthquakes. Another approach, used for the determination of JTRF2014, is the application of Kalman filtering that allows post-seismic displacements to be accounted for in a non-parametric manner.

In this paper, we portray a TRF solution solely based on VLBI data, employing Kalman filtering and smoothing for the computation of session-wise coordinates of more than hundred VLBI radio telescopes over more than 30 years. By using a random walk process, non-linear coordinate changes are modeled stochastically. The noise model is derived from loading deformation time series that are not included in the model for the station motion (i.e., non-tidal atmosphere, non-tidal ocean, and continental water storage loading). This stochastic model alone is not able to adapt to the large coordinate variations that can happen after major earthquakes. Therefore, we additionally increase the process noise in the periods following earthquakes based on the amplitude of the estimated coordinate jumps, introducing the epochs of the seismic events as prior information.

We compare our Kalman filtered and smoothed VLBI-TRF to a classical least squares VLBI solution calculated by the VieVS@GFZ software, based on linear segments between episodic events. Additionally, multi-technique TRF, such as the ITRF2014 and JTRF2014, are included in the comparisons, especially for assessing the different approaches of modeling post-seismic deformations.

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