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On the long-term stability of Kalman filter terrestrial reference frame solutions

Benedikt Soja (1), Richard Gross (1), Claudio Abbondanza (1), Toshio Chin (1), Michael Heflin (1), Xiaoping Wu (1), Tobias Nilsson (2), Susanne Glaser (3), Kyriakos Balidakis (3), Maria Karbon (3), Robert Heinkelmann (2), Harald Schuh (2,3)

(1) Jet Propulsion Laboratory, California Institute of Technology, Pasadena, United States, (2) GFZ German Research Centre for Geosciences, Potsdam, Germany, (3) Technische Universität Berlin, Institute for Geodesy and Geoinformation Science, Berlin, Germany

The Global Geodetic Observing System (GGOS) requirement for the long-term stability of the International Terrestrial Reference Frame (ITRF) is 0.1 mm/yr, motivated by rigorous sea level studies. Furthermore, high-quality station velocities are of great importance for the prediction of future station coordinates, which are fundamental for several geodetic applications. In this study, we investigate the performance of predictions from terrestrial reference frames (TRFs) based on Kalman filtering. The predictions are computed by extrapolating the deterministic part of the coordinate model, which is linear. As input data, we used over 4000 very long baseline interferometry (VLBI) sessions between 1980 and the mid of 2016. In order to study the predictions, we computed VLBI TRF solutions only from the data until the end of 2013. The period of 2014 until 2016.5 was used to validate the predictions of the TRF solutions against the measured VLBI station coordinates. To assess the quality, we computed average RMS and WRMS values from the coordinate differences as well as from estimated Helmert transformation parameters, in particular, the scale. We found that the results significantly depend on the level of process noise used in the filter. While larger values of process noise allow the TRF station coordinates to more closely follow the input data, the TRF predictions exhibit larger deviations from the VLBI station coordinates after 2014. On the other hand, lower levels of process noise improve the predictions, making them more similar to those of deterministic solutions, however, at the cost of degrading the agreement with the input data. Furthermore, our investigations show that additionally estimating annual signals in the coordinates does not significantly impact the results. Finally, we computed a TRF solution mimicking a potential real time TRF, for which the data after 2014 was sequentially fed into a Kalman filter solely running forward. Here, we found significant improvements over the other investigated solutions, all of which rely on extrapolating the coordinate model for their predictions, with RMS reductions of more than 20 %.