3.6.3 Jet Propulsion Laboratory (JPL)

Introduction

The Jet Propulsion Laboratory is continuing to develop an approach to determining ITRF-like terrestrial reference frames based upon the use of a sequential filter/smoother. Sequential filters are commonly used to estimate the parameters of some system when a stochastic model of the system is available and when the data contain noise. For the purpose of determining a terrestrial reference frame, the system consists of the positions and velocities of geodetic observing stations and associated EOPs along with their full covariance matrices. The data consist of time series of observed VLBI, SLR, GNSS, and DORIS station positions and EOPs along with the data measurement covariance matrices. In addition, measurements from ground surveys of the positions of reference marks of co-located stations are used to tie the technique-specific station networks to each other. The sequential filter/smoother software being developed at JPL combines these measurements to determine ITRF-like reference frames subject to constraints imposed on the allowed evolution of the station positions. The sequential filter/smoother includes options for constraining the stations to move linearly or to move linearly and seasonally. Through the use of stochastic models for the process noise, the station positions can be constrained to exactly follow this linear or linear and seasonal motion (by setting the process noise to zero), to exactly recover the observed station positions (by setting the process noise to a large value), or to follow a smoothed path (by setting the process noise to some intermediate value).

The first generation sequential filter/smoother software developed at JPL was based upon the use of a Kalman filter and had a fixed time step of one week (Wu et al., 2015). This Kalman filter and smoother for reference frame determination (KALREF) software was used to determine JTRF2014, JPL's realization of a terrestrial reference frame using the ITRF2014 input data sets (Abbondanza et al., 2017). During 2019, besides continuing to analyze the JTRF2014 solution, JPL also started to develop a second generation version of our sequential filter/smoother software. The new software, known as SREF (Square-root Reference Frame filter), is based upon a square-root information filter and has a variable time step. The variable time step will allow input data to be processed at its observation epoch without the need to first compute weekly averages of it.

JTRF2014 Analysis

An article for IERS Technical Note 40 "Description and Evaluation of DTRF2014, JTRF2014 and ITRF2014" was written (Abbondanza et al., 2020). The article reviews the main steps that led to the construction of JTRF2014. The first part of the article recalls the main concepts underlying the determination of terrestrial reference frames through

Kalman Filtering and Rauch-Tung-Striebel smoothing as implemented in JPL's KALREF software. The second part of the article adopts a comparative approach and, elaborating on metrics associated with Earth orientation and Helmert transformation parameters, analyzes JTRF2014 in relation to ITRF2014 and DTRF2014.

JTRF2020 Preparations

Much of 2019 was spent developing SREF, JPL's second generation sequential filter/smoother software. SREF is based on a more flexible and numerically stabler square-root information filter with a time-variable step. In addition, unlike KALREF, SREF includes a full process noise covariance matrix which will allow stochastic models of regional crustal deformation to be optionally included in the process noise model. And SREF includes the ability to optionally process radio source coordinates and precession/nutation parameters which will allow joint terrestrial/celestial reference frames to be determined. In the future, JPL plans to implement a dynamical model for daily EOPs as well as a postseismic displacement model for stations affected by great earthquakes. These future improvements will allow SREF to more accurately predict EOPs and station positions when observations of them are not available.

References

Abbondanza, C., T. M. Chin, R. S. Gross, M. B. Heflin, J. W. Parker, B. S. Soja, T. van Dam, and X. Wu (2017), JTRF2014, the JPL Kalman filter and smoother realization of the International Terrestrial Reference System, J. Geophys. Res., 122, 8474–8510, doi: 10.1002/2017/ JB014360.

Abbondanza, C., T. M. Chin, R. S. Gross, M. B. Heflin, J. W. Parker, B. S. Soja, T. M. van Dam, and X. Wu (2020), JTRF2014: Analysis, results and comparisons to ITRF2014 and DTRF2014, in: Altamimi, Z. and W. R. Dick (Eds.), Description and evaluation of DTRF2014, JTRF2014 and ITRF2014, IERS Technical Note No. 40, Frankfurt am Main: Verlag des Bundesamts für Kartographie und Geodäsie, pp. 17–69.

Wu, X., C. Abbondanza, Z. Altamimi, T. M. Chin, X. Collilieux, R. S. Gross, M. B. Heflin, Y. Jiang, and J. W. Parker (2015), KALREF–A Kalman filter and time series approach to the International Terrestrial Reference Frame realization, J. Geophys. Res. Solid Earth, 120(5), 3775–3802, doi: 10.1002/2014JB011622.

Richard Gross, Claudio Abbondanza, T. Mike Chin,
Mike Heflin, Jay Parker, Benedikt Soja