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An Advanced Formulation of Kalman Filter Time Series Reference Frame Realization for Geophysical Applications

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A Kalman filter and time series approach to the International Terrestrial Reference Frame (ITRF) realization (KALREF) has been developed and used in JPL. KALREF combines weekly or daily SLR, VLBI, GNSS and DORIS data and realizes a terrestrial reference frame in the form of time-variable geocentric station coordinate time series. The origin is defined at nearly instantaneous Center-of-Mass of the Earth system (CM) sensed by weekly SLR data and the scale is implicitly defined by the weighted averages of those of weekly SLR and daily VLBI data. The standard KALREF formulation describes the state vector in terms of time variable station coordinates and other constant parameters. Such a formulation is fine for station positions and their uncertainties or covariance matrices at individual epochs. However, coordinate errors are strongly correlated over time given KALREF's unique nature of combining different technique data with various frame strengths through local tie measurements and co-motion constraints and its use of random walk processes. For long time series and large space geodetic networks in the ITRF, KALREF cannot keep track of such correlations over time. If they are ignored when forming geocentric displacements for geophysical inverse or network shift geocenter motion studies, the covariance matrices of coordinate differences cannot adequately represent those of displacements. Consequently, significant non-uniqueness and inaccuracies would occur in the results of studies using such matrices. To overcome this difficulty, an advanced KALREF formulation is implemented that features explicit displacement parameters in the state vector that would allow the Kalman filter and smoother to compute and return covariance matrices of displacements. The use of displacement covariance matrices reduces the impact of time correlated errors and completely solves the non-uniqueness problem. However, errors in the displacements are still correlated in time. Further calibrations are needed to accurately assess covariance matrices of derivative quantities such as averages, velocities and accelerations during various time periods. We will present KALREF results of the new formulation and their use along with newly reprocessed RL06 GRACE gravity data in a new unified inversion for geocenter motion.