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Terrestrial Reference Frame from GPS, TOPEX, Jason, and GRACE

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We present terrestrial reference frame (TRF) realizations based on precise orbit determination of the GPS constellation and low-Earth orbiters (LEOs). Our solutions rely on accurate and consistent GPS orbit determination tuned for reference frame realization: we use multi-day orbit arcs to capitalize on the spacecraft dynamics, estimate once- and twice-per-revolution accelerations in the spacecraft-sun coordinate system, utilize a homogeneous network of ground stations equipped with choke-ring antennas, and apply 1-km a priori constraints to the station positions. Receiver and transmitter antenna phase variation (APV) calibrations are derived from test range measurements and LEO data processed with a fiducial-free network. The resulting TRF is therefore realized without a priori ties to the International Terrestrial Reference Frame (ITRF).

Our orbit solutions and reference frame realizations span 20 years, from 1993-2012. The baseline solution includes only the ground network and GPS constellation. Relative to ITRF2008, this solution yields a 3D origin offset and rate of 9 mm and 0.7 mm/yr, respectively, and scale bias and rate of 2 ppb and 0.03 ppb/yr. Next, we include GRACE from 2002 onwards. The spacecraft's polar orbit greatly improves the spatio-temporal distribution of the observations over the oceans and in the north-south direction – and further reduces the Z-origin bias and scatter relative to ITRF2008 by 20% and 30%, respectively. We then add Jason-1 to the solutions from 2002-2006. The Jason-1 orbit inclination is 66 deg, so its improvements to the observation geometry are more pronounced in the origin X- and Y-components, where both bias and scatter are reduced by approximately 10% versus the GPS-only solution. Finally, we add dual-frequency TOPEX/Poseidon data in 1993. Preliminary results indicate that significant improvements to the origin scatter are realized in this time frame relative to using the ground network and GPS alone, chiefly due to poor station geometry in the southern hemisphere in this timeframe. Our presentation will provide detailed results for TRF origin and scale, discuss impacts of antenna models on scale, and explore strategies for tuning LEO orbit estimation in the context of TRF realization.