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The Velocity and Annual Oscillation Between the Mass Center and Surface of Earth: Implications for Continental–Scale Seasonal Fluctuations of Water, Snow, and Ice

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To assess uncertainty in the definition of Earth's reference frame, we evaluate GPS, SLR, and VLBI estimates of scale and CM as a function of time using data decimation and spectral analysis following Argus (JGR 2012).

We find JPL's GPS series for scale, determined by Desai et al. (AGU 2012), to be straighter (more linear) than in prior GPS solutions. This is due to the use of new satellite phase center variation models (Schmid et al. IGS 2010) and solar radiation pressure models (Sibthorpe AGU 2012). We estimate uncertainty in JPL's GPS scale rate to be half that of either VLBI or SLR. While GPS scale depends on VLBI and SLR, this small GPS scale rate uncertainty suggests GPS velocities are now unbiased by changing satellite Block types.

We estimate the uncertainty in the SLR estimate of the Z component of CM to be $\pm$0.9 mm/yr (95% conf. limits). The velocity of CM in Z estimated from SLR data from 1993–2000 differs by 1.15 mm/yr from that estimate from SLR data from 2001–2008. Therefore interpretation of space geodetic velocities in terms of postglacial rebound, sea level, and plate motion must account for uncertainty in CM. We nevertheless advocate that the next ITRF be defined using the velocity of CM.

We assess SLR and GPS estimates of the annual oscillation of CM (the geocenter) and examine implications for GRACE gravity estimates of seasonal mass fluctuations. SLR and GPS exhibit an annual oscillation in the Y component of CM of 3.5 mm with a maximum in November. This observation is consistent in phase with heavy rainfall in the Amazon basin in April and monsoon rains in southeast Asia in September. The observed amplitude is, however, nearly twice that either predicted by loading models or inferred from GRACE. SLR exhibits an annual oscillation of the Z component of CM of 5 mm with a maximum in January, whereas GPS suggests the annual oscillation in Z to be just 1 mm. Loading models predict the amplitude, which is proportional to the Winter accumulation of snow in Europe and North America, to be partway between the SLR and GPS estimates.