2. Definitions + Methodology

Here we define geocenter motion to be the vector displacement \( \Delta \text{CM} \) of the geometrical center of figure of the Earth (CF) from the Center of Mass of the entire Earth system (solid Earth+oceans+atmosphere). Note this definition is not unique; its opposite in sign is as common in the literature. There are essentially two styles of method to estimate geocenter motion from satellite techniques:

**Network shift (GPS/SLR/DORIS):** Satellite techniques give us site displacements \( \Delta \text{CM} \) in the CM frame, the average of these site displacements gives an estimate of geocenter motion. Since site displacements due to loading are not a pure translation (see box 3.), this method can suffer from aliasing due to a poorly distributed network. This method is favoured for SLR since the orbit errors are smaller than GPS and the network is too poor for inversion methods.

**Inversion Methods (GPS):** The site displacements \( \Delta \text{CM} \) in the CM frame are not a pure translation (see box 3.), the actual displacements due to loading can be modeled in the CM or CF frame using elastic loading theory. A dense global site coverage is required for inversion, limiting this method to GPS. Even with GPS the problem is not solved and requires regularization or physically motivated constraints. Inversion results rely more heavily on inter-site deformation observed by GPS which is generally thought to be inherently less sensitive to translational orbit modeling errors.

8. Reprocessed GPS-inversion and SLR Geocenter Motion Estimates

We estimate Geocenter motion from 12 years of weekly reprocessed GPS and SLR solutions 1999-2008.

**GPS:** We use an Inversion approach for GPS displacements in the CM frame (see box 2.) with mass conserving, land/ocean partitioned basis functions (Clarke et al., 2007). We use a higher-order ionospheric model (see box 7.) and arctic ionosphere phase center models in the GARET reprocessing.

**SLR:** Network shift approach from loosely constrained weekly solutions from LAGEOS 1 & 2.

7. Higher Order Ionosphere effects on GPS and GPS-inversion

Neglecting higher order ionospheric effects in the GPS processing will affect geocenter motion estimated by the Network shift approach (Puchalski et al., 2005) and may affect an inversion approach. We compare geocenter estimates from corrected and uncorrected GPS solutions for both approaches. The largest effects (\( E \)) are 1.3mm RMS and 6.8 mm RMS for the inversion and Network shift approaches respectively. The effect on the estimated annual amplitude and phase is < 0.01 mm and < 5 degrees for the inversion approach and < 0.3 mm and < 6 degrees for the Network shift approach.

6. Seasonal Geocenter Motion from GRACE

Preliminary geocenter motion estimates from GPS tracking of GRACE do exist (King et al., 2005, Zhu et al., 2004) but full results have yet to be published.

An alternative has been developed by Swenson & Wahr (2005) by combining GRACE and ocean model output. Here we try a similarly motivated approach. We fit the GRACE degree 2-30 total load with a robust 2-20 degree modified basis function (Clarke et al., 2007) via least squares. This basis parameterizes a degree 3-30 load on land plus it’s corresponding 0.30 degree equivalent load. Mass conservation is maintained in the ocean. Release 4 GSM and GAC products after December 2005. These preliminary results are plotted alongside GPS and SLR (Figures 6 and 7 box 8).

5. Comparison of Published Geocenter Motion Annual Signal

Figure 3 compares all published annual amplitudes and phases found by the authors (see separate table for references). We note the following:

- We know of a likely systematic error source in almost every result plotted in Figure 3. See Clarke et al., 2007, Lenczows et al., 2005, Tregoning & van Dam, 2005, Wu et al., 2002, Willis, 2006, box 4 and box 7 for details, not all errors are visible in future estimations.

Values from common techniques are not independent, mostly sharing the low model values, they too have common parts. There is some overlap between some GRACE, GPS inversion and loading models (e.g. ECOO)

There are few published results for GPS via the Network shift approach but 3 of the 4 available are estimated from < 3 yrs of data.

4. Suitability of Annual+Semi-Annual model

To gauge accuracy we wish to compare estimates from different techniques and to different loading models. Comparison between different published estimates is usually via annual+semi annual fits.

The annual+semi annual reliable model for this comparison! Different published estimates are estimated from different windows of data (3-11 yrs) and at different epochs in time.

Our results suggest that we should expect significant variation due to estimation over different data windows, even with 5 years of data we can expect variation in annual amplitude up to 2mm and 10 degrees in phase on top of any model differences or technique/method specific measurement errors.

1. Introduction

It is ten years since the IERS Campaign to investigate motion of the geocenter. One conclusion from that campaign was ‘It appears that even if GPS/Goddard geocenter estimates are sensitive to seasonal variations, the determinations are not yet accurate and reliable enough to adopt an empirical model to correct for dynamical motion. Since site displacements due to loading are not a pure translation (see box 3.), this method can suffer from aliasing due to a poorly distributed network. This method is favoured for SLR since the orbit errors are smaller than GPS and the network is too poor for inversion methods.

2. Definitions + Methodology

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3. Network Shift Versus Inversion methods

Table 1 shows some critical properties of the two methods. Both time series show a clear annual component but the GPS results are 2.5 times larger than the SLR results and the GPS results are significantly less noisy. In addition GPS results are only available since 1999 and even with 5 years of data we see significant variation in annual amplitude up to 2mm and 10 degrees in phase on top of any model differences or technique/method specific measurement errors.

References


