



Geocenter Variations Derived from GRACE Data

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Background and Motivations

- Since the launch of GRACE satellite in March 2002, data quality and mean gravity model as well as background models have been improved significantly.
- This has resulted in significant improvements to both orbit and other parameter (such as geocenter) determination accuracies.
- Is it possible to well determine the geocenter variation parameters using GRACE daily GPS data?

Objectives

- **Study how to determine geocenter variations from GRACE data**
- **Find which components and how well can be determined from GRACE daily geocenter solution**
- **Access the results through internal comparison between GRACE-A and GRACE-B, external comparison between different techniques SLR, DORIS, ground GPS, GPS-LEO, and between observed and predicated variations from geophysical models**

Methods for determination of geocenter motion (1)

- **Geometric method** (network shift method) obtains a **free-network solution** in a CM (Center of Mass) frame, and performs a seven-parameter transformation. The estimated translation parameters represent the geocenter motion and systematic error in GPS data analysis. This method mainly depends on the data quality and station distribution, and is more sensitive to orbit systematic errors.
- **Dynamic method** uses the reference frame to directly estimate **degree one coefficients**. If tracking data just from one satellite are used, estimates for geocenter motions represent linear combinations of several low degree and order coefficients, not just the degree one coefficients. Therefore, it is better to use the tracking data from different types of satellites for this method.

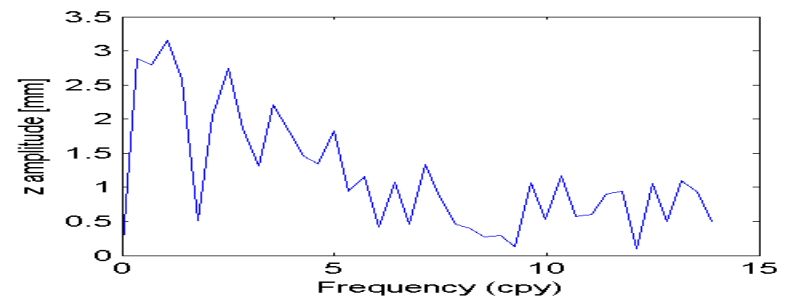
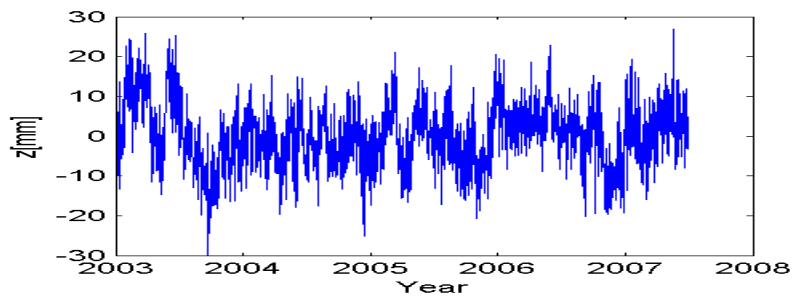
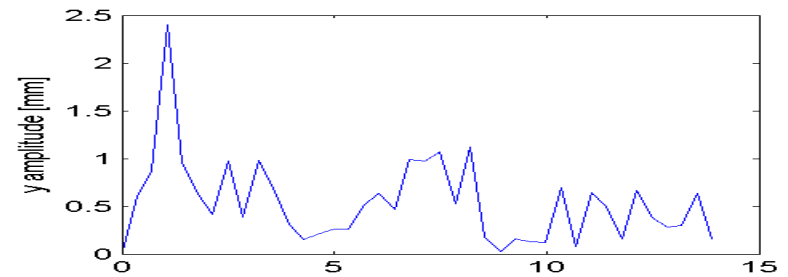
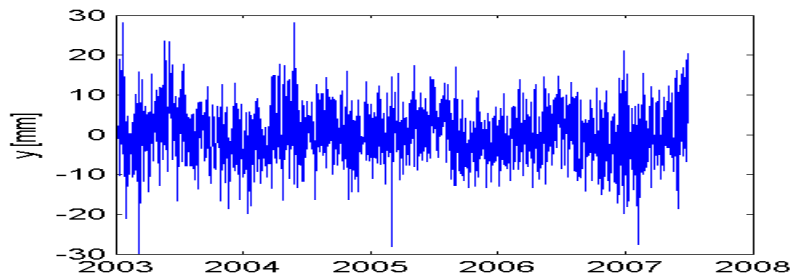
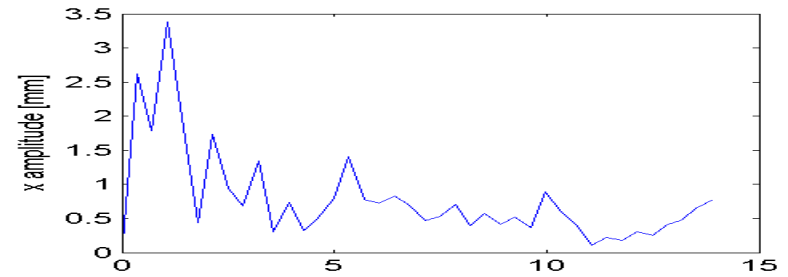
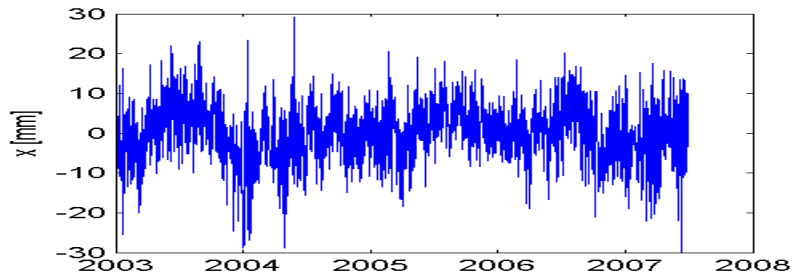
Methods for determination of geocenter motion (2)

- **Kinematic method** directly estimates **geocenter vector offset** between the CM and CF (center of Frame) origins using satellite tracking data. Similar to the geometric method, this method also depends the data quality and station distribution, and is sensitive to orbit systematic errors. In addition, the un- or mis-modeled station corrections have effects on the solutions, because the station coordinates are fixed using this method. However, this method estimates only **three geocenter coordinates**, not a whole network of station coordinates. For our investigation, we have used the kinematic method.

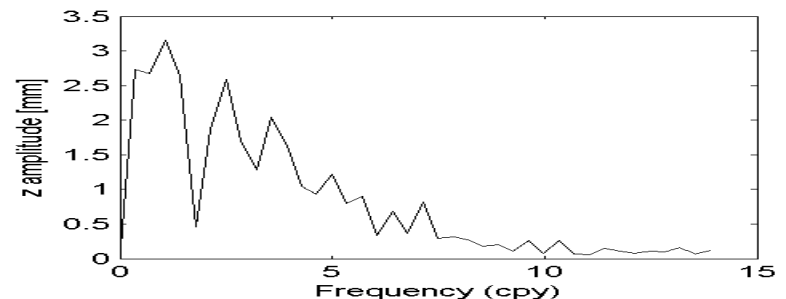
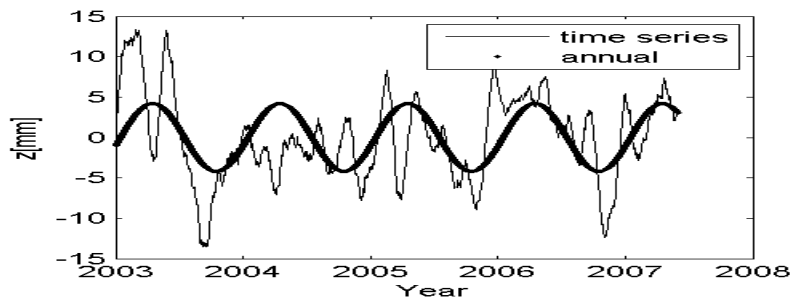
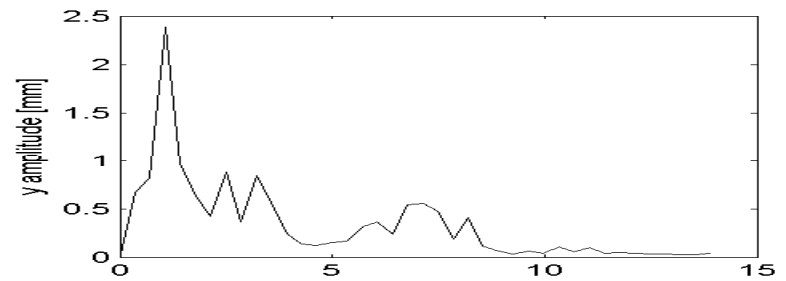
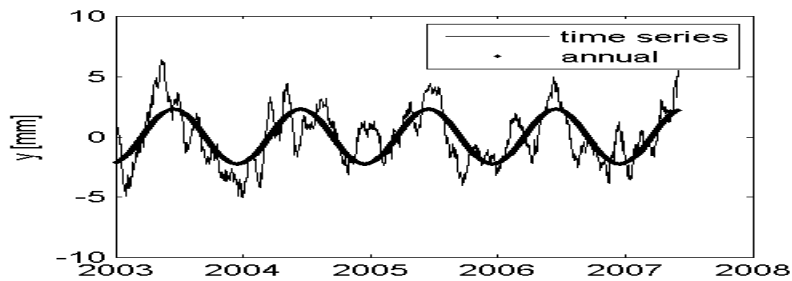
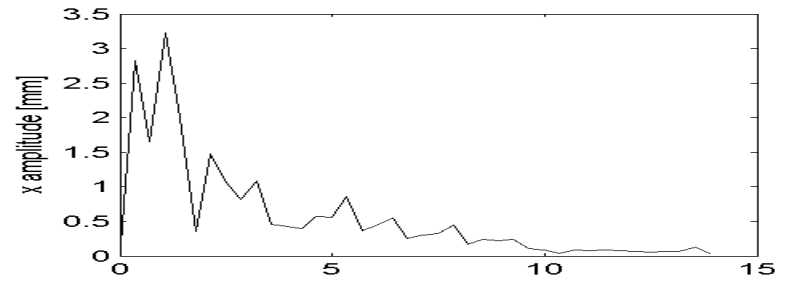
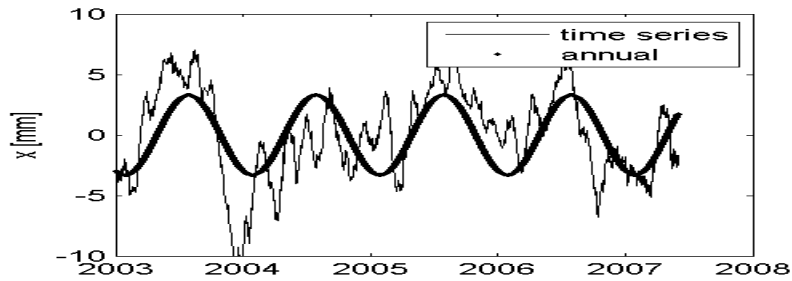
Data processing and Test data

- **Orbit determination method:** dynamic orbit determination
- **Observation type:** GPS double-differenced (DD) carrier-phase
- **Arc length:** one day (daily geocenter solution)
- **Test data:** four-and-a-half-year (January 1, 2003 – June 30, 2007) GRACE GPS Data

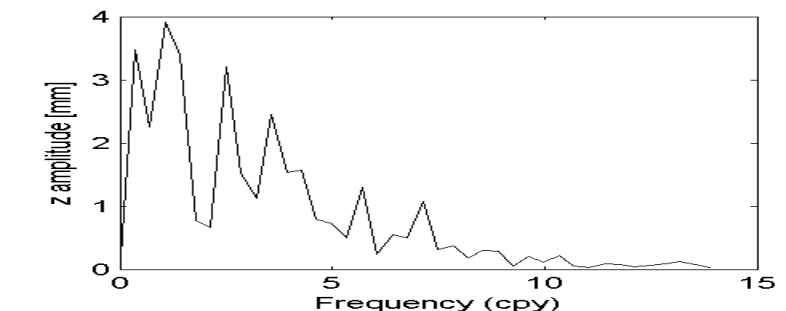
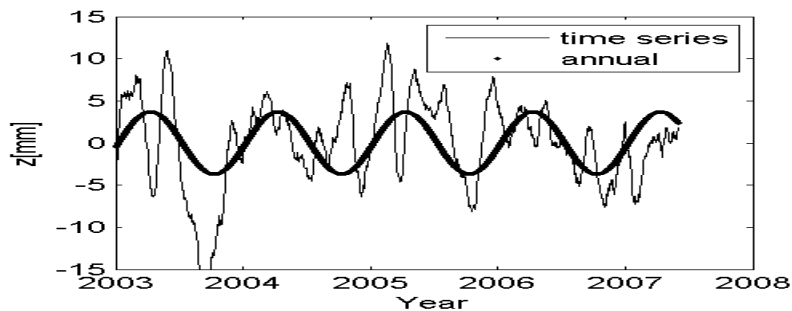
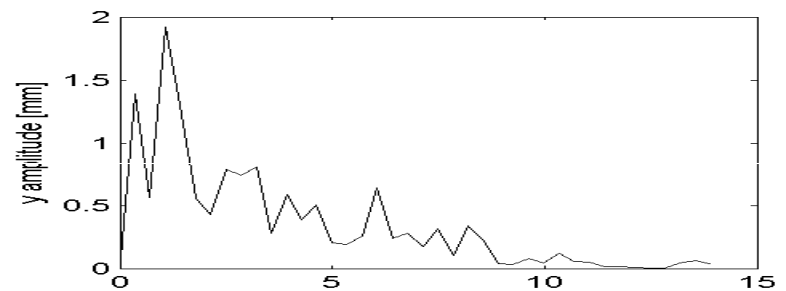
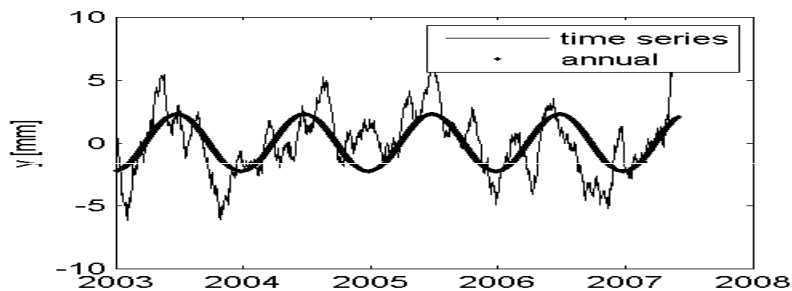
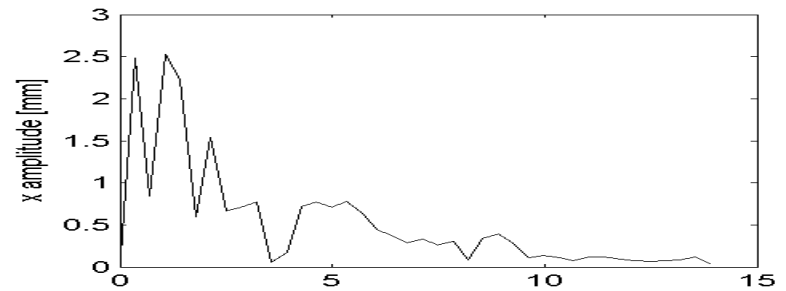
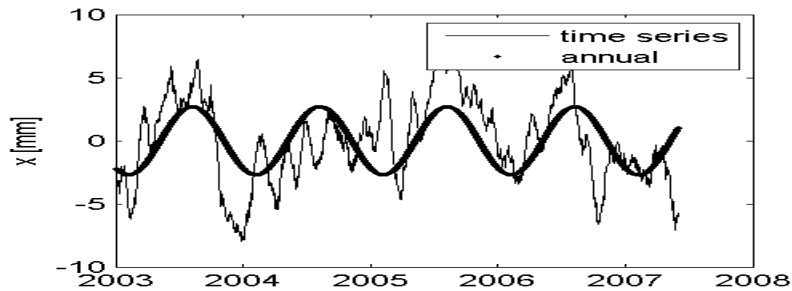
Daily geocenter time series and spectrums derived from GRACE-A



Monthly average geocenter time series, annual curve and spectrums derived from GRACE-A



Monthly average geocenter time series, annual curve and spectrums derived from GRACE-B



Observed annual variations of geocenter motion derived from GRACE for different time series

| | x | | y | | z | |
|------------------------------------|---------------------------------|--------------------------------|---------------------------------|--------------------------------|---------------------------------|--------------------------------|
| | Amp., [mm] | Phase [deg] | Amp. [mm] | Phase [deg] | Amp. [mm] | Phase [deg] |
| GPS-LEO GRACE-A^a | 3.3 ± 0.2 | 244 ± 14 | 2.4 ± 0.2 | 286 ± 14 | 4.2 ± 0.3 | 344 ± 16 |
| GPS-LEO GRACE-A^b | 3.3 ± 0.1 | 244 ± 6 | 2.3 ± 0.1 | 287 ± 4 | 4.2 ± 0.2 | 346 ± 10 |
| GPS-LEO GRACE-B^a | 2.7 ± 0.3 | 232 ± 14 | 2.3 ± 0.2 | 277 ± 14 | 3.7 ± 0.3 | 349 ± 16 |
| GPS-LEO GRACE-B^b | 2.7 ± 0.1 | 234 ± 6 | 2.2 ± 0.1 | 277 ± 4 | 3.7 ± 0.3 | 352 ± 10 |

^aValues from daily time series

^bValues from monthly average time series

Observed and predicted annual variations of geocenter motion

| | x | | y | | z | |
|------------------------------------|-----------|------------|-----------|------------|-----------|------------|
| | Amp., mm | Phase, deg | Amp., mm | Phase, deg | Amp., mm | Phase, deg |
| Lageos 1 & 2 (Eanes et al. 1997) | 2.2 | 211 | 3.2 | 331 | 2.8 | 225 |
| Lageos 1 & 2 (Bouille et al. 2000) | 2.1 | 223 | 2.0 | 308 | 3.5 | 228 |
| DORIS (Bouille et al. 2000) | 1.8 | 205 | 5.0 | 349 | 3.0 | 298 |
| GPS/OBP (Wu et al. 2006) | 1.7 | 274 | 3.8 | 285 | 4.5 | 249 |
| GPS (Blewitt et al. 2001) | 3.3 | 184 | 4.8 | 285 | 11.0 | 214 |
| GPS (Dong et al. 2003) | 4.8 | 220 | 3.6 | 320 | 9.4 | 105 |
| GPS-LEO ^a | 3.3 ± 0.2 | 244 ± 14 | 2.4 ± 0.2 | 286 ± 14 | 4.2 ± 0.3 | 344 ± 16 |
| GPS-LEO ^b | 2.7 ± 0.2 | 232 ± 14 | 2.3 ± 0.2 | 277 ± 14 | 3.7 ± 0.3 | 349 ± 16 |
| Dong et al. 1997 | 4.2 | 224 | 3.2 | 339 | 3.5 | 235 |
| Chen et al. 1999 | 2.4 | 244 | 2.0 | 270 | 4.1 | 228 |
| Bouille et al. 2000 | 1.6 | 236 | 1.8 | 309 | 3.1 | 254 |

^aValues from daily time series using GRACE-A GPS data

^bValues from daily time series using GRACE-B GPS data

Observed and predicted semiannual variations of geocenter motion

| | x | | y | | z | |
|----------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|
| | Amp., mm | Phase, deg | Amp., mm | Phase, deg | Amp., mm | Phase, deg |
| Lageos 1 & 2 (Eanes et al. 1997) | 1.1 | 164 | 0.8 | 213 | 0.4 | 13 |
| GPS-LEO ^a | 0.6 ± 0.3 | 170 ± 8 | 0.7 ± 0.2 | 297 ± 8 | 1.6 ± 0.3 | 232 ± 8 |
| GPS-LEO ^b | 1.0 ± 0.3 | 172 ± 8 | 0.7 ± 0.2 | 267 ± 8 | 1.3 ± 0.3 | 254 ± 8 |
| Dong et al. 1997 | 0.8 | 30 | 0.4 | 26 | 1.1 | 313 |
| Chen et al. 1999 | 0.7 | 181 | 0.9 | 221 | 0.5 | 238 |

Summary and Conclusions

- Our main goal is to investigate how well geocenter variation parameters can be determined using **GPS-LEO GRACE** data.
- **The proper assessments** (internal comparison between GRACE-A and GRACE-B, external comparison between different techniques SLR, DORIS, ground GPS, GPS-LEO, and between observed and predicated variations) have been carried out.
- Based on the **internal and various external comparisons**, the annual and semiannual variations of geocenter motion derived from GPS-LEO GRACE data are in a good agreement with the SLR solution and predicted values from geophysical models except the phase for the z-component.
- Generally, the results from the **GPS-LEO GRACE** are **better** than that from the ground GPS and DORIS.

Summary and Conclusions (cont.)

- **Daily and averaged time series of geocenter motion can be used for investigating the **short-periodic signals** with the accuracy improvement in the future.**
- **In the future, longer GPS-LEO data from **multi-satellites** may further improve the accuracy for the geocenter variation determination in the z-component.**