Impact of temporal gravity field parameters determined from GNSS satellites on the estimated Earth rotation parameters

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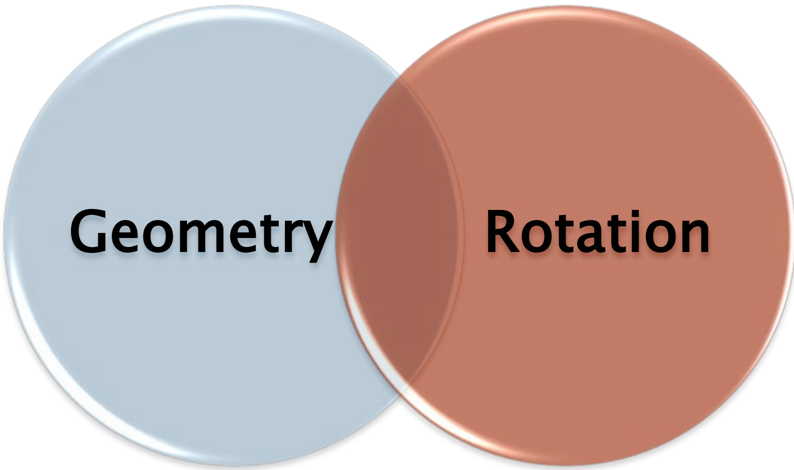
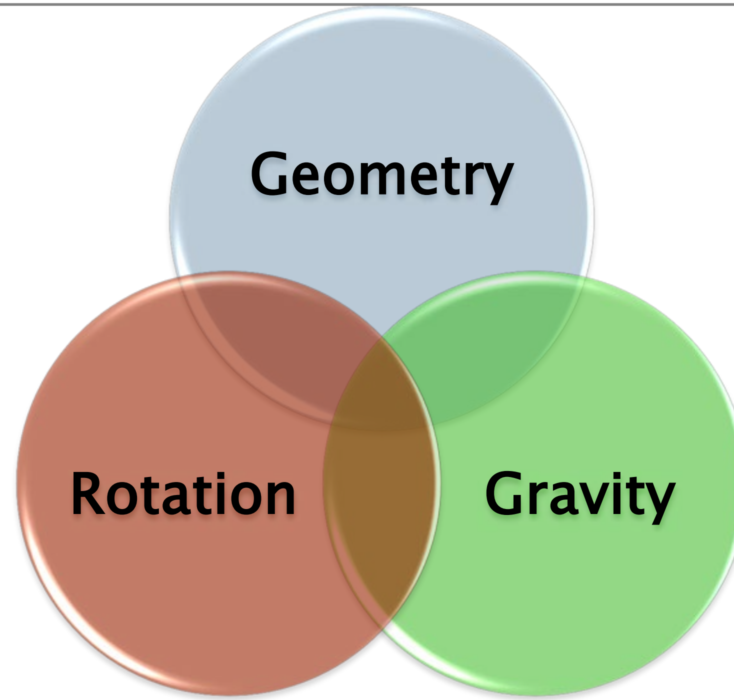
Three pillars of satellite geodesy





Current status:

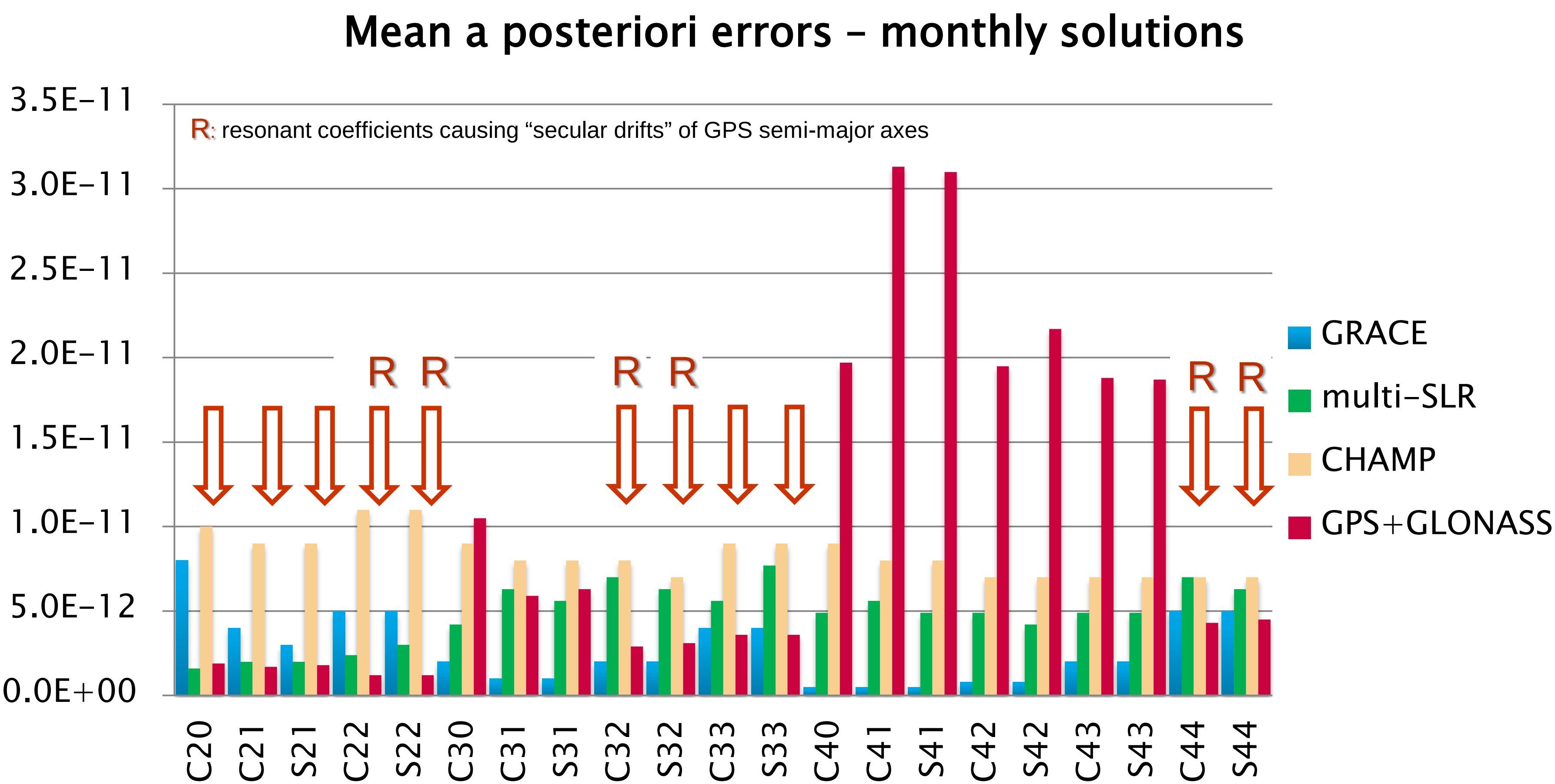
IGS provides products related to Geometry and Rotation, but not to temporal variations in the Earth's Gravity field.

This solution:

Parameters related to all three pillars are simultaneously estimated, because they are strongly dependent on each other.

Are GNSS satellites sufficiently sensitive to variations of gravity?

Sensitivity of GNSS solutions to low-degree gravity coeff.



GNSS satellites are very sensitive to gravity field coefficients of degree 2. For coefficients above degree 3, GNSS are typically very sensitive only to resonant gravity field coefficients.

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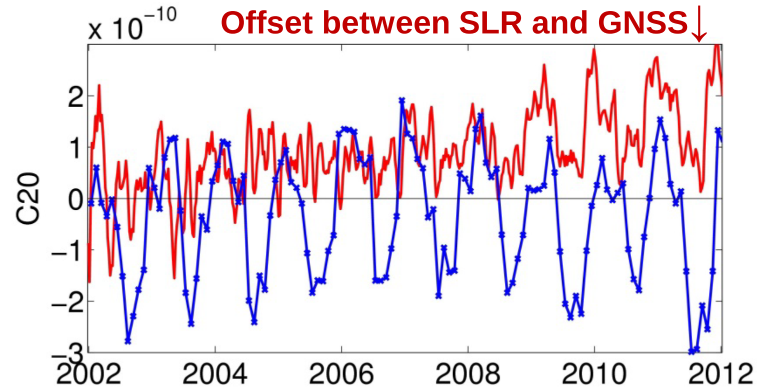
List of estimated parameters & solution set-up

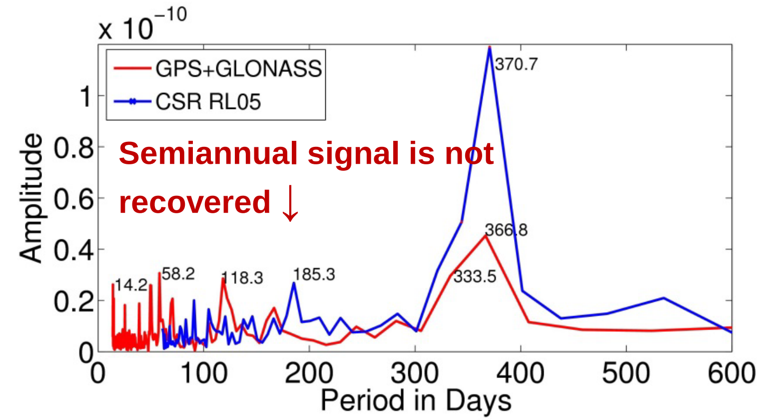
Estimated parameters		GNSS solutions
		up to 32 GPS and 24 GLONASS satellites
Orbits	Osculating elements	$a, e, i, \Omega, \omega, u_0$ (1 set per 3 days)
Orbits	Dynamical parameters	D_0, Y_0, X_0, X_S, X_C – unconstrained D_S, D_C, Y_S, Y_C – constrained at 10^{-12} (1 set per 3 days)
Orbits	Pseudo-stochastic pulses	R, S, W (constrained, estimated every 12^h)
Earth rotation parameters		X_P, Y_P, UT1-UTC (Piecewise linear, 1 set per day)
Geocenter coordinates		1 set per 7 days
Earth gravity field		**Estimated up to d/o 4/4** (1 set per 7 days)
Station coordinates		1 set per 7 days
Other parameters		Troposphere ZD (2h), gradients (24h) and ZTD biases

We processed 10 years of GPS and GLONASS data using the standard orbit modeling as from CODE with two major exceptions:

- 7-day solutions are generated instead of the 3-day long-arc solutions as for the IGS.
- The Earth's gravity field coefficients up to degree/order 4/4 and geocenter coordinates are simultaneously estimated along with other parameters.

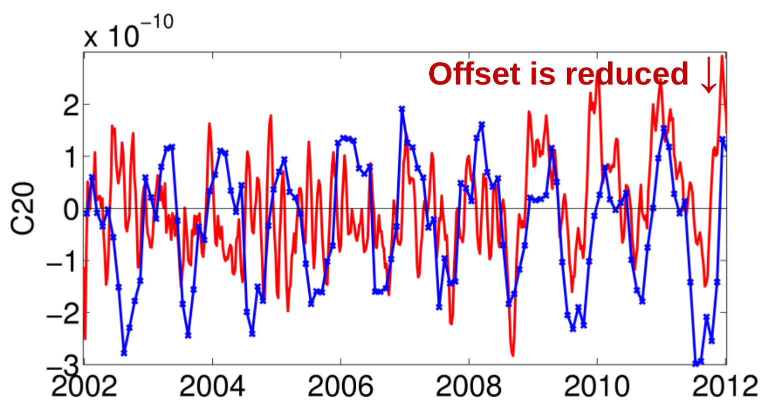
C_{20} from GPS+GLONASS

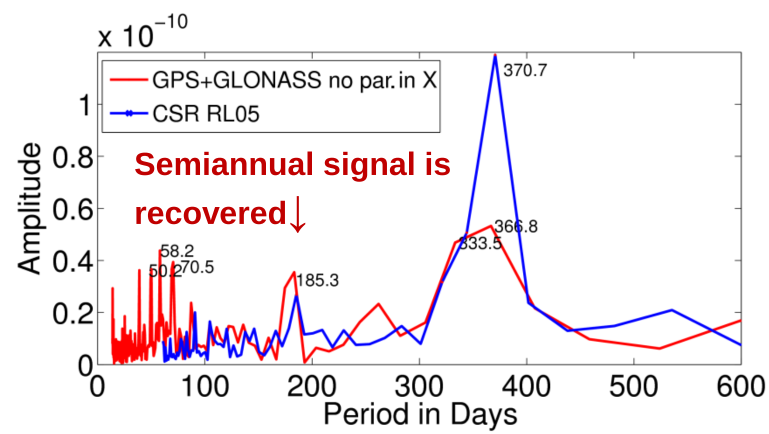




GNSS dynamic orbit parameters : D_0, Y_0, X_0, X_S, X_C

Orbit parameters in the X direction are correlated with C_{20}





GNSS dynamic orbit parameters : D_0, Y_0, ~~X_0, X_S, X_C~~

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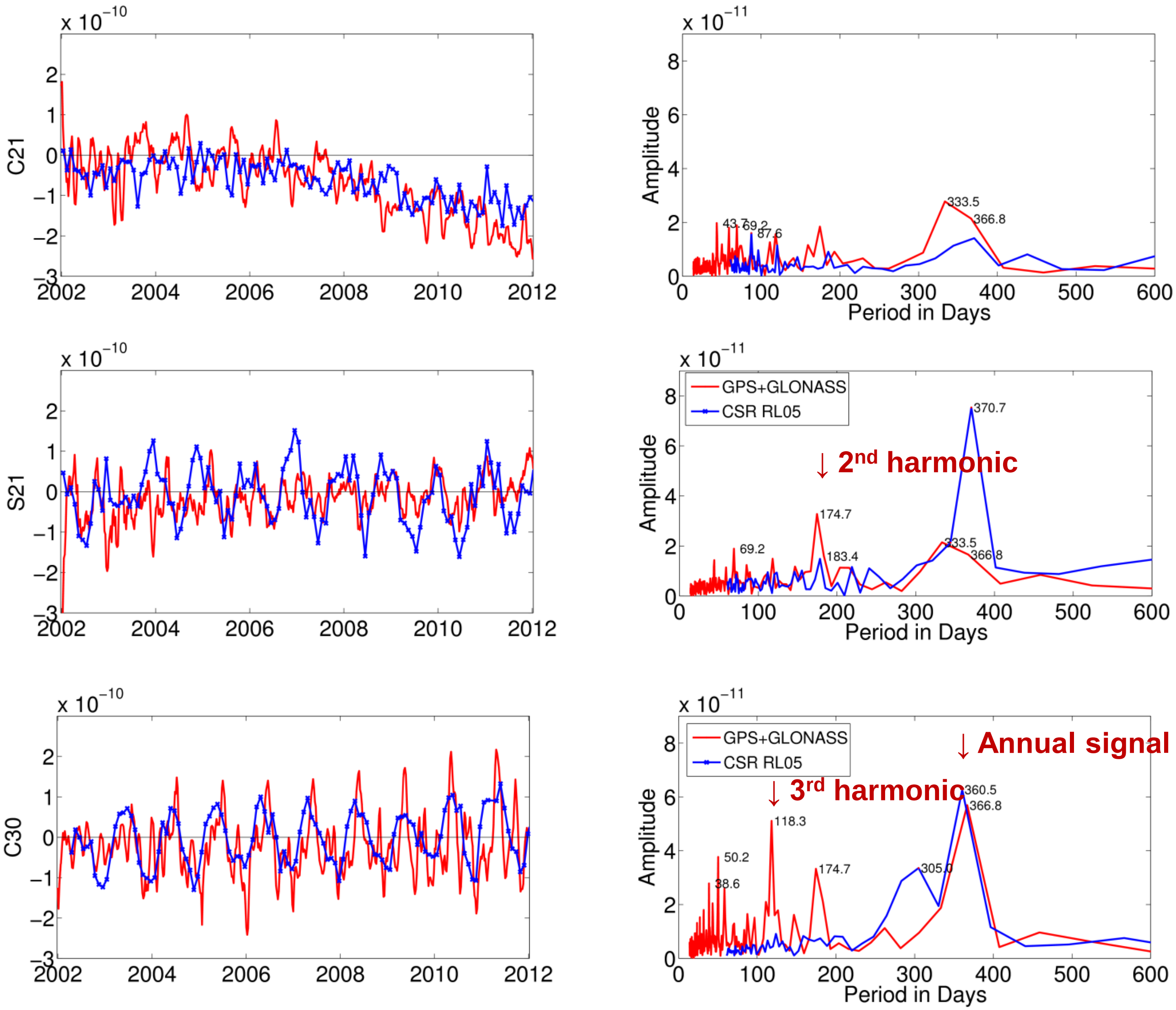
C_{21}, S_{21}, C_{30} from GPS+GLONASS



GNSS-derived gravity field parameters agree quite well with the CSR RL05 results (median difference of $8.2 \cdot 10^{-11}$), but:

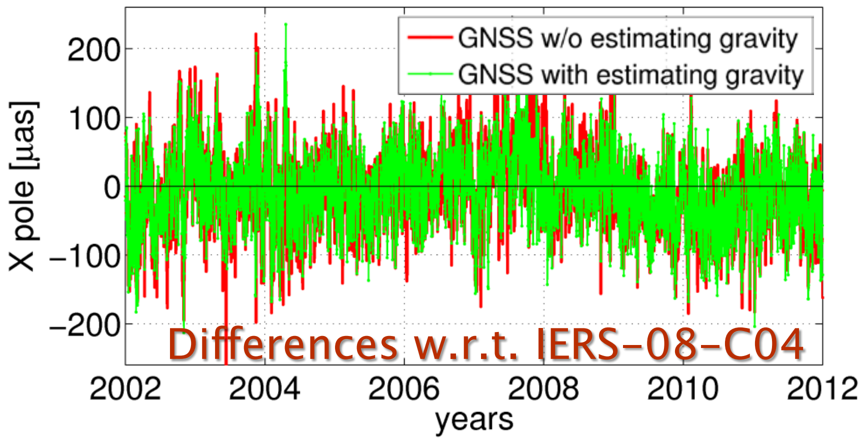
- GNSS-derived parameters show both: the seasonal signals as well as draconitic periods,
- C_{20} is correlated with orbit parameters in the X direction.

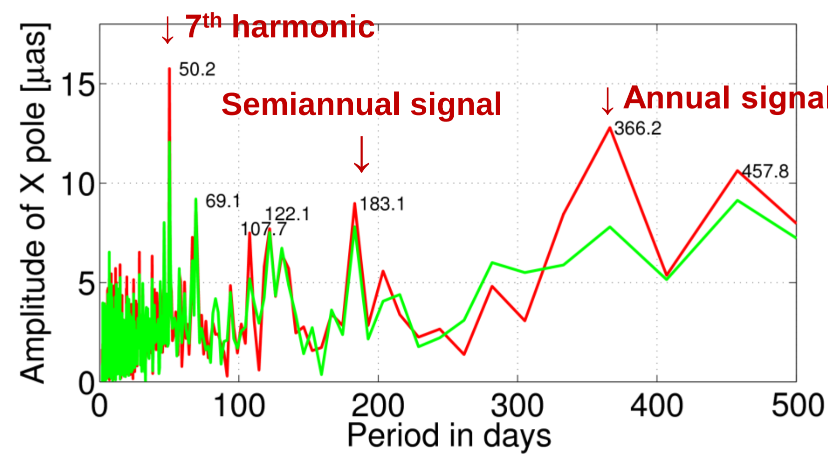
Gravity coefficients benefit from the contribution of GLONASS (after 2008, when the station coverage improves).

Question:

How much affected are the GNSS-derived parameters by neglecting the temporal gravity field variations, since GNSS satellites are sufficiently sensitive to recover the temporal variations of Earth's low-degree gravity field ?

X– pole coordinate



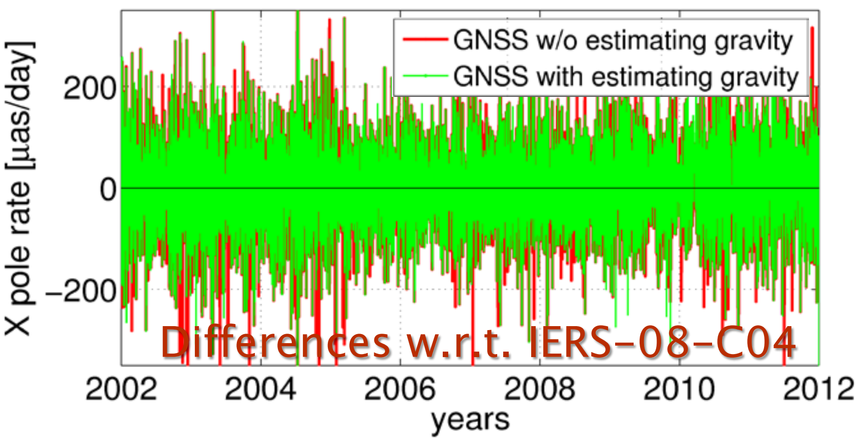


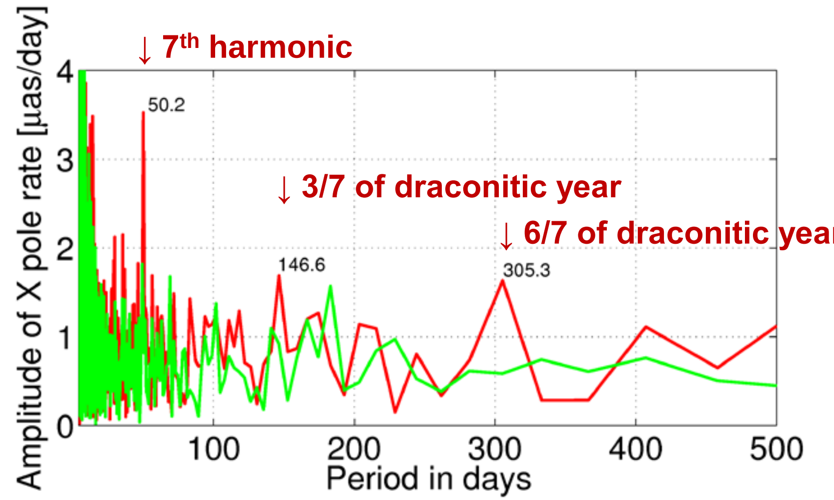
For the X pole coordinate:

- the amplitude of the 7th harmonic is reduced from 15.9 to 12.2 μas,
- the amplitude of the annual signal is reduced from 12.8 to 6.9 μas,
- the mean offset w.r.t. IERS−08−C04 is reduced from −10.5 to −9.9 μas,

for the solutions without and with estimating gravity field parameters, respectively.

X- pole rate



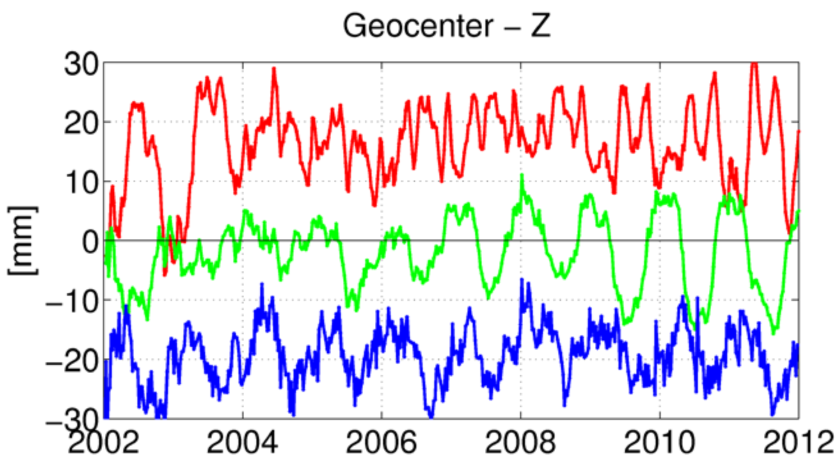


For the X pole rate:

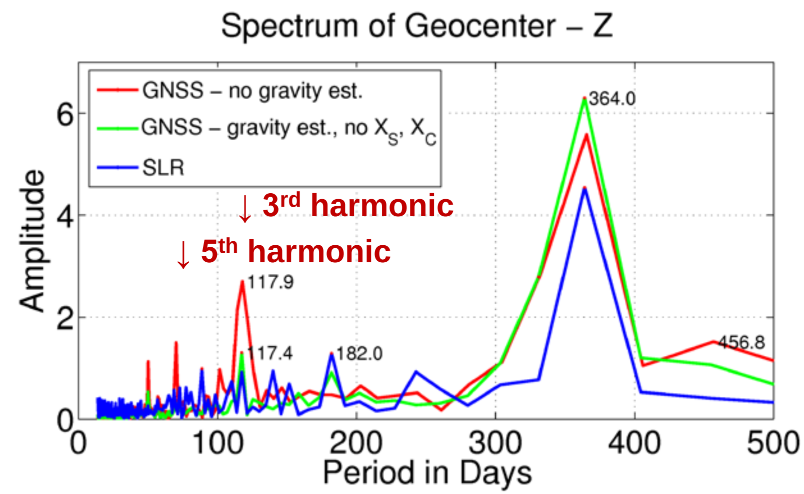
- the amplitude of the 7th harmonic is reduced from 3.5 to 1.8 µas/day,
- the mean offset w.r.t. IERS-08-C04 is reduced from 2.2 to 2.0 µas/day,

for the solutions without and with estimating gravity field parameters, respectively.

Z component of geocenter coordinates (C_{10})



Values shifted by +/−20 mm



When estimating the gravity field coefficients and heavily constraining once-per-revolution orbit parameters in the X direction, the Z geocenter coordinate from GNSS solutions (C_{10}):

- is by far less affected by solar radiation pressure modeling,
- is closer to the SLR results

as compared to GNSS solutions without estimating gravity field.

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Summary

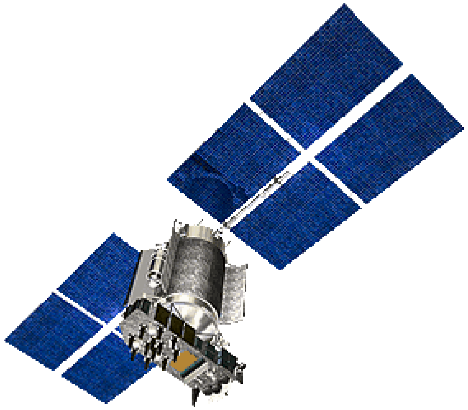
The GNSS satellites are sufficiently sensitive to low-degree gravity field parameters, to recover the temporal gravity field variations.

The simultaneous estimation of gravity field parameters along with ERPs, station coordinates, troposphere, and other GNSS parameters is feasible.

The empirical orbit parameters in the X direction are correlated with C_{20}, and thus, the X-parameters partly absorb the C_{20} variations. However, not all the gravity variations are absorbed by empirical parameters.

Unabsorbed gravity variations may contaminate the ERP estimates by introducing spurious peaks of seasonal and draconitic signals in the GNSS solutions when not estimating gravity field parameters.

Spurious seasonal and draconitic signals can be reduced by estimating the gravity field along with other GNSS parameters.



Thank you for your attention

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