DETERMINATION OF SEASONAL GEOCENTER VARIATIONS FROM DORIS, GPS AND SLR DATA

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The gravitational center of the Earth plays a crucial role as the origin of the terrestrial reference system and should be determined and monitored with highest accuracy.

Physically, the geocenter is defined as center of mass (CM) of the whole Earth, including oceans, atmosphere and surface groundwater.

Practically, the geocenter is realized by the coordinates of the tracking network on the solid Earth. If a set of tracking stations has sufficient global coverage, the variations of the center of network (CN) will be a good representation of the geocenter variations [Dong et al., 2003].

Geocenter variations caused both surface and internal mass redistribution. Theoretically the spectrum of the geocenter oscillations is a sum of spectra from all geophysical processes capable of causing mass redistribution. In this investigation we pay our attention on seasonal geocenter variations (annual and semiannual) as the most significant compare with other periods [Montag, 1999].

5 time series of geocenter solutions were used for comparison:

- two DORIS solutions using data on SPOT2, SPOT3, SPOT4, SPOT5, TOPEX-POSEIDON and ENVISAT satellites;
- one GPS global solution;
- two SLR solutions.

The seasonal geocenter variations were derived by least squares method using the next approximation:

$$J(t) = a_0 + b_0 t + A_0 \sin\left[\frac{2\pi(t - t_0)}{P} + \varphi_0\right], \tag{1}$$

A_0 - amplitude of the signal;
P - period of the signal (in years);
φ_0 - initial phase of the signal;
a_0 - offset;
b_0 - trend;
t - time;
t_0 - arbitrary initial time (we take t_0 - 1st January).

Table 1 shows the seasonal geocenter variations derived from Doris, GPS and SLR data and predicted values from surface mass redistribution (atmosphere, oceans, continental hydrology). The SLR solutions (Lageos1,2 and Topex/Doris) are in good agreement with the geophysical predictions for amplitudes. The phases are mainly different. The amplitudes of the Doris and GPS x and y components are a bit larger compare with the SLR and predicted solutions. The phases again are different. The amplitudes of z component for Doris and GPS geocenter variations are significantly bigger (4-7 times) then in the mean SLR solutions.

For IGN/JPL DORIS geocenter time series, the biases and trends are 2.7±0.6, 9.4±0.6, -35.4±3.3 mm, -1.9±0.1, 0.1±0.1, 5.1±0.4 mm/yr, for x, y and z, respectively. For INASAN DORIS geocenter time series, the biases and trends are 2.9±0.5, 11.5±0.5, -32.4±2.4 mm, -1.2±0.1, -0.4±0.1, 3.7±0.5 mm/yr, for x, y and z, respectively. For JPL GPS geocenter time series, the biases and trends are 5.4±0.6, 13.5±0.5, -37.1±1.3 mm, -0.2±0.1, -1.6±0.1, 3.8±0.2 mm/yr, for x, y and z, respectively. For CSR SLR (Lageos1,2) geocenter time series, the biases and trends are -0.7±0.5, -0.9±0.5, -6.8±0.6 mm, -0.2±0.1, 0.7±0.1, 1.2±0.2 mm/yr, for x, y and z, respectively. For CSR SLR (Topex/Doris) geocenter time series, the biases and trends are -0.4±0.3, 0.5±0.3, -2.2±0.9 mm, 0.1±0.1, 0.2±0.1, 0.6±0.2 mm/yr, for x, y and z, respectively.

Table 1: Measured and predicted seasonal variations of geocenter motion

MEASURED

SOLUTION		Span	X				Y				Z			
			Annual		Semiannual		Annual		Semiannual		Annual		Semiannual	
			A, mm	Ph, deg	A, mm	Ph, deg	A, mm	Ph, deg	A, mm	Ph, deg	A, mm	Ph, deg	A, mm	Ph, deg
DORIS	IGN/JPL (weekly)	1993.0-2005.4	6.2 ±0.3	91.6 ±3.2	1.2 ±0.3	1.8 ±15.2	5.5 ±0.1	314.9 ±5.3	4.4 ±0.5	199.4 ±2.9	30.6 ±1.2	288.8 ±4.7	18.4 ±1.5	347.8 ±7.3
	INASAN (weekly)	1993.0-2004.5	5.5 ±0.3	104.9 ±5.1	2.0 ±0.4	5.1 ±10.4	4.3 ±0.3	352.6 ±6.0	1.9 ±0.5	205.2 ±5.7	23.7 ±1.2	286.8 ±5.6	11.0 ±1.6	353.7 ±10.7
GPS	JPL (daily)	1993.0-2004.7	3.0 ±0.1	302.5 ±7.1	14.1 ±0.2	354.9 ±1.2	5.0 ±0.1	288.8 ±3.8	3.3 ±0.3	12.0 ±3.2	13.2 ±0.4	109.5 ±3.4	6.0 ±0.4	106.8 ±7.2
SLR	CSR-Lag1,2 (monthly)	1993.0-2000.2	3.1 ±0.5	17.6 ±4.9	1.1 ±0.5	19.2 ±13.2	5.5 ±0.5	197.9 ±2.6	0.8 ±0.5	16.0 ±18.5	3.6 ±0.5	82.8 ±6.5	1.4 ±0.6	197.1 ±12.2
	CSR-T/P (monthly)	1993.0-2000.1	1.8 ±0.4	47.8 ±0.5	1.5 ±0.2	170.7 ±11.7	2.8 ±0.1	130.3 ±6.1	0.4 ±0.1	295.1 ±38.0	2.3 ±0.8	66.0 ±8.0	3.8 ±0.8	195.4 ±6.8
PREDICTED														
Dong et al.[1997]			4.2	224	0.83	30	3.2	339	0.43	26	3.5	235	1.1	313
Chen et al.[1999]			2.4	244	0.75	181	2.0	270	0.89	221	4.1	228	0.5	238
Bouille et al.[2000]			1.6	236			1.8	309			3.1	254		

CONCLUSIONS

SLR, Doris and GPS space geodesy techniques are sensitive to the variations of geocenter in different degree. The SLR solution has results the closest compare with the predicted solutions. GPS and Doris solutions have a slightly higher amplitudes for x and y components compare with the SLR and considerably higher for z component. It is confirm the lower quality geocenter determination from the geometric method, though degree-1 deformation approach gives more reasonable estimates for amplitudes and phases of GPS geocenter time series, which are consistent with SLR results and geophysical predictions [Dong et al., 2003].

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