A 33 Year Time History of the Earth Dynamic Oblateness changes from SLR data

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Abstract

Satellite Laser Ranging (SLR) data tracked by the ILRS network have recorded the global nature of long-wavelength mass redistribution occurring within the Earth system for more than three decades. The second degree zonal harmonics of the Earth's gravity field, or the J2 coefficient is directly related to the Earth dynamic oblateness, or the dynamic shape factor, which represents how much its rounded shape flattens at the poles and widens at the equator. The variations in J2 are the results of imbalance of the climate induced mass changes between the tropical' area (in the range of the north and south 35 degree latitude) and the extra tropical area. Studying the variations in J2 has provided a clear vision of the large-scale mass redistribution with a long-term signature within the Earth system from analysis of SLR data. Early analysis of 28-year time series of monthly SLR estimates of J2 [Cheng and Tapley, 2004] has indicated that in addition to the secular, 18.6 year tidal and seasonal variations, the J2 has undergone significant interannual variations with time scales of ~4-6 years and a decadal variation with a period of ~21 years. Two large interannual variations are related to the strong El Ninio-Southern Oscillation (ENSO) events during the periods of 1986-1991 and 1996-2002. Recent analysis including an additional five years of data suggests that the Earth has undergone another 3 fluctuations cycles starting from middle of 2002.

Because of the significant aliasing effects in the GRACE data derived J2 coefficient and the J2 variations from SLR data is the most accurate measurement for the application of GRACE product to extract the signal of mass variations in ocean and hydrological. This paper presents detail analysis for the variations in J2 from analysis of multiple geodetic satellites over the period from 1976 to 2008, and a comparison with the monthly solutions from GRACE measurements.