Hydrological excitation of the polar motion constrained from geodetic observation

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We estimated seasonal excitations of the Earth rotation by geophysical fluids other than the atmosphere or oceans. Hydrological excitation is expected to be large, however, currently available hydrological data sets still have problems in their quality. Both the geodetic seasonal excitation obtained by geodetic observation and modeled geophysical (atmospheric and oceanic) excitations are useful to constrain unmodeled geophysical excitations that are mainly due to the hydrosphere.

In this study, we used the International Earth rotation and reference systems service (IERS) C04 series for the observed Earth orientation parameters. The atmospheric excitations are calculated from meteorological reanalysis data sets. For the oceanic excitation, we used the ocean angular momentum data supplied by the IERS Global Geophysical Fluid Center (Gross et al. (2003, 2004)). We extracted seasonal signals from the observed and modeled excitations by fitting sinusoids by the least-squares method. Since the atmospheric excitations calculated from different meteorological data sets have different values, we compare three atmospheric excitation series based on the NCEP/NCAR, NCEP-DOE and ERA-40 reanalysis data, in advance. Then, we set the analysis period 1996 to 2001 in this study, because of small deviations between three atmospheric excitations.

The residual excitations (observed minus modeled excitations) are at the maximum in boreal summer in the direction of longitude from 90E to 120E (the polar motion projected onto the northern hemisphere). It requires that the positive mass anomaly should be distributed toward longitude 90E to 120E (if the mass is distributed in the northern hemisphere) or 60W to 90W (if the mass is distributed in the southern hemisphere) in boreal summer. Geophysical excitations of the Earth rotation are caused via two regimes; via mass redistribution of the geophysical fluids and via changes in the angular momentum of them. Since no other geophysical fluids than the atmosphere or oceans has large angular momentum, the residual excitations are due to mass redistribution of the geophysical fluids. Among such fluids, the hydrosphere (land water, glaciers, etc.) has largest contributions to the excitation of the Earth rotation, therefore, the residual excitations are expected to be attributed to the hydrosphere.

In recent years, the gravity observation satellites GRACE have detected large seasonal changes in gravity near the Amazon River (Tapley et al.(2004)). Moreover, the mass anomaly reaches the maximum in boreal summer. Our results are in harmony with the results of the satellite observation.