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Long-term ERP time series as indicators for global climate variability and climate change

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This study assesses whether variations in observed Earth orientation parameters (EOPs, IERS) such as length-of day (LOD EOP C04) and polar motion (PM EOP C04) can be applied as climate indicators. Data analyses suggest that observed EOPs are differently affected by parameters associated with the atmosphere and ocean. On interannual time scales the varying ocean-atmosphere effects on EOPs are in particular pronounced during episodes of the coupled ocean-atmosphere phenomenon El Niño–Southern Oscillation (ENSO). Observed ENSO anomalies of spatial patterns of parameters affected by atmosphere and ocean (climate indices and sea surface temperatures) are related to LOD and PM variability and associated with possible physical background processes.

Present time analyses (1962 – 2000) indicate that the main source of the varying ENSO signal on observed LOD can be associated with anomalies of the relative angular momentum (AAM) related to variations in location and strength of jet streams of the upper troposphere. While on interannual time scales observed LOD and AAM are highly correlated (r=0.75), results suggest that strong El Niño events affect the observed LOD – AAM relation differently strong (explained variance 71%- 98%). Accordingly, the relation between AAM and ocean sea surface temperatures (SST) in the NIÑO 3.4 region differs (explained variances 15%-73%). Corresponding analysis is conducted on modelled EOPs (ERA40 reanalysis, ECHAM5-OM1) to obtain Earth rotation parameters undisturbed by core-mantle activities, and to study rotational variations under climate variability and change. A total of 91 strong El Niño events are analysed in coupled ocean-atmosphere ECHAM5-OM1 scenarios concerning the 20th century (20C), climate warming (A1B) and pre-industrial climate variability. Analyses on a total of 61 strong El Niño events covering a time period of 505 simulation years under pre-industrial climate conditions indicate a range of El Niño events with a strong or smaller effect on the AAM-SST relation corresponding to analyses on the 20th century (20C) (explained variance 19%-76%).

The excitation of LOD and polar motion by the oceanic angular momentum (OAM) is assessed by applying the Ocean Model for Circulation and Tides (OMCT). While changes in atmospheric patterns dominate variations in observed LOD, the ocean mainly affects polar motion and the non-atmospheric LOD residual. Comparing the mean annual cycle of the non-atmospheric observed LOD and OMCT simulated OAMmass (IB) reveals a close similarity between their amplitudes. On interannual time scales OMCT simulated OAM time series correlates well with observed rotational variations corrected for atmospheric and hydrological effects with 82% with respect to polar motion. The OMCT modell is also able to reproduce with high accuracy Niño 3.4 SSTs close to observations on interannual time scales. Variations in simulated SSTs indicate a significant relation to changes in polar motion due to the excitation by the ocean.

The second project phase will build on results from this study assessing LOD and PM interconnections concerning joint atmosphere-ocean-hydrosphere modes.