Geophysical Research Abstracts,
Vol. 11, EGU2009-0, 2009
EGU General Assembly 2009

Assessing the effect of the relative atmospheric angular momentum (AAM) on length-of-day (LOD) variations under climate warming

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While most studies on model-projected future climate warming discuss climatological quantities, this study investigates the response of the relative atmospheric angular momentum (AAM) to climate warming for the 21th century and discusses its possible effects on future length-of-day variations.

Following the derivation of the dynamic relation between atmosphere and solid earth by Barnes et al. (Proc. Roy. Soc., 1985) this study relates the axial atmospheric excitation function X3 to changes in length-of-day that are proportional to variations in zonal winds. On interannual time scales changes in the relative AAM (ERA40 reanalyses) are well correlated with observed length-of-day (LOD, IERS EOP CO4) variability (r=0.75). The El Niño-Southern Oscillation (ENSO) is a prominent coupled ocean-atmosphere phenomenon to cause global climate variability on interannual time scales. Correspondingly, changes in observed LOD relate to ENSO due to observed strong wind anomalies.

This study investigates the varying effect of AAM anomalies on observed LOD by relating AAM to variations to ENSO teleconnections (sea surface temperatures, SSTs) and the Pacific North America (PNA) oscillation for the 20th and 21st century. The differently strong effect of strong El Niño events (explained variance 71%-98%) on present time (1962–2000) observed LOD-AAM relation can be associated to variations in location and strength of jet streams in the upper troposphere. Correspondingly, the relation between AAM and SSTs in the NIÑO 3.4 region also varies between explained variances of 15% to 73%.

Recent coupled ocean-atmosphere projections on future climate warming suggest changes in frequency and amplitude of ENSO events. Since changes in the relative AAM indicate shifts in large-scale atmospheric circulation patterns due to climate change, AAM - ENSO relations are assessed in coupled atmosphere-ocean (ECHAM5-OM1) climate warming projections (A1B) for the 21st century. A strong rise (+31%) in relative AAM is observed with major contributions in the upper troposphere where increased jet streams cause large AAM anomalies. Due to increasing westerly winds, an eastward shift can be observed during strong El Niño events for the Pacific and North America centers of the PNA while its southeast center is less pronounced and shifts to the West. As a result, the PNA region during strong 21th century El Niño events is closely located to the PNA region of mean atmospheric conditions of present time. Further analyses on the climate warming scenario (A1B) determined a total of 28 strong El Niño events suggesting a steady increase in ENSO events, magnitude and duration during the last decades of the 21st century. Rising Niño 3.4 SSTs exceed global increases by 15%. Correspondingly to present times, the AAM-SST relation also indicates a range of explained variances from 8% to 82%.

Ongoing analyses on 21st century climate warming relate zonal wind anomalies in the upper troposphere to SST patterns of individual strong El Niños to estimate a possible effect of the relative AAM on length-of-day variations.