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The Angular Momentum Budget of ENSO in the Community Earth System Model

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ENSO is a global phenomenon that appears on interannual timescales and influences the whole Earth system, including the atmosphere, ocean and continental hydrosphere. It is characterized by changes in atmospheric and oceanic dynamics especially in the Pacific regions, along with atmospheric mass redistribution over the continents, leading to floods and droughts. Mass redistribution and dynamical variations within the Earth system lead to changes of the angular momentum of each Earth subsystem. The thereby induced variation in the Earth's angular momentum causes changes in the Earth rotation parameters, including the length of day and polar motion, which are observed with high precision. These parameters therefore represent integral measures of the Earth system state. However, it is difficult to balance the excitation of Earth rotation from individual subsystems in a model and compare it to observations since net effects of all subsystems are incorporated and difficult to separate.
In order to understand the ENSO contribution to Earth rotation variations, we compute angular momentum excitation from the atmosphere, ocean, and continental hydrosphere from a 140-year simulation of NCAR's coupled Community Earth System Model (CESM), a physically consistent model conserving total angular momentum, energy and mass. The atmospheric component of CESM we use is the Whole Atmosphere Community Climate Model (WACCM), which includes middle atmosphere dynamics, physics and chemistry, up to the thermosphere (140km). CESM also includes an interactive ocean (POP2), land (CLM4) and sea ice (CICE4) components.
We analyze the modeled angular momentum transfer between atmosphere, ocean and the continental hydrosphere on ENSO timescales, and compare this with observations from the International Earth Rotation and Reference Systems Service (IERS). We show regional patterns of Earth rotation excitation for all modeled subsystems, and the net impact on the length of day and polar motion. Regional ENSO effects are determined by computing the correlation between regional Earth rotation excitation and the $NINO_3.4$ index.