Assimilating Observations of Atmospheric Angular Momentum: Synthetic-Observation Experiments with NCAR's Community Atmosphere Model

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Exchange of angular momentum between the atmosphere and the solid Earth excites changes in the rotation of the Earth, that is, wobbles of the rotational pole (polar motion) and small fluctuations in the rate of rotation of the Earth (i.e. in the length-of-day, or LOD). These changes range from subdaily to decadal, and while very small, can be observed at high precision by space geodetic techniques. Observations of polar motion and LOD reflect the atmosphere's total angular momentum, and thus represent an integral measure of the atmospheric state. They can therefore be used to observationally constrain atmospheric models.

We apply this constraint to NCAR's Community Climate Model 5 (CAM5) using an Ensemble Square Root Filter within the Data Assimilation Research Testbed (DART). We present a set of perfect-model experiments wherein observations of three atmospheric angular momentum (AAM) components are assimilated daily over several months. The effects of localization, inflation, and observation frequency restoration are tested. These experiments allow us to asses the amount of information gained from the observations, relative to concomitant runs with either no assimilation or using a set of more traditional meteorological observations.A major challenge of this approach is that the AAM observations represent spatial integrals, meaning that a set of observations does not correspond to a unique state-space solution. We show that information about the true state can nevertheless be gained from this assimilation, despite the integral nature of the observations, and discuss the complementarity of these observations to more spatially-localized observations.