Atmospheric Predictability of Seasonal, Annual and Decadal Climate Means and the Role of the ENSO Cycle : a Model Study

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ABSTRACT

The characteristics of extratropical low frequency variability is examined using a comprehensive atmospheric general circulation model. A large experiment consisting of 13 45-year long integrations forced by prescribed sea surface temperature (SST) variations is analyzed. The predictability on time scales of seasonal to decadal averages are evaluated. The variability of a climate mean contains not only climate signal arising from external boundary forcing but also climate noise due to the internal dynamics of the climate system, resulting in various levels of predictability that are dependent on the forcing boundary conditions and averaging time scales. The focus of this study deviates from the classical predictability study of Lorenz, which is essentially initial condition sensitive. This study can be considered to be a model counterpart of Madden's 'potential' predictability study.

The tropical SST anomalies impact more on the predictability over the Pacific North America sector than the Atlantic Eurasia sector. In the former sector, significant and positive impacts are found during El Niño and La Niña phases of the ENSO cycle than during ENSO inactive period of time. Furthermore, the predictability is significantly higher during El Niño than La Niña phases of the ENSO cycle. The predictability of seasonal means exhibits large seasonality for both warm and cold phases of the ENSO cycle. During the warm phases, a high level of predictability is observed from December to April. During the cool phases, the predictability rapidly drops to below normal from November to March. The spring barrier in the atmospheric predictability is therefore a distinct phenomenon for the cold phase, not the warm phase, of the ENSO cycle. The cause of the barrier can be traced to the smaller climate signal and larger climate noise generated during cold events, which in turn can be traced back to the rapidly weakening negative SST anomalies in the tropical Pacific east of the dateline.

Due to the fact that the signal to noise ratio of this model climate system is very small, an upper bound in atmospheric predictability is present, even when a perfect model atmosphere is considered and large ensemble mean predictions are exploited. The outstanding issues of the dynamical short-term climate prediction employing an atmospheric general circulation model are examined, the current model deficiencies identified and continuing efforts in model development addressed.