Use of Reanalyses to Examine Climate Model Errors in Short Forecasts

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Short forecasts made with climate models initialized from reanalyses are an effective method to diagnose parameterization errors. This approach is most powerful when paired with field campaign observations of parameterized variables. However the approach can also be applied to examine errors and to test hypotheses associated with those errors by using the reanalyses for verification of state variables as well as for initial conditions. Reanalyses based on high resolution Numerical Weather Prediction models are advantageous over native analyses based on the modest resolution climate model because the model biases, which are likely to be present in a native analysis, diminish the apparent forecast errors and bias the results. The use of several different but of similar quality reanalyses for the initial conditions and verification provides an indication of the robustness of the climate model error signal. Careful interpolation from the high resolution reanalysis native grid to the modest resolution climate model grid is essential to maintain structures that might be important to the parameterizations, in particular vertical structures, and to prevent dynamical noise by accounting for different vertical transform coordinates based on different surface orographies.

We apply this forecast approach to examine errors in the Eastern Tropical Pacific in the 0.25 degree Community Atmosphere Model Version 5 (CAM5). These errors are not well understood and have been very difficult to reduce during the tuning phase of development. Several ensembles of short (5 day) forecasts based on different reanalyses provide a much more economical way to study these errors than multi-year climate simulations. In addition, the short forecasts capture the first-order errors before significant compensation sets in and masks the primary cause. The forecast errors considered here rapidly evolve toward the model climate errors in the 5 days. The dominant CAM5 error in the Eastern Tropical Pacific in January is a too strong and too narrow ITCZ in the Northern Hemisphere and a weaker fictitious or double structure which forms in the Southern Hemisphere. These errors are less severe at lower resolutions. We examine the five-day evolution of the precipitation error based on 3-hourly TRMM data. This includes the evolution of geographical distributions, frequency distributions, and tropical propagation characteristics. We examine the evolution of vertical profiles of temperature and specific humidity errors based on the reanalyses, and the evolution of vertical profiles of the terms in the temperature and specific humidity budgets. These include the tight linkages between the resolved dynamics and the parameterizations. In general we consider conditionally averaged vertical profiles based on characteristics of the precipitation and precipitation error. This yields a stronger, more consistent signal. We compare the 0.25 degree model with the 1 degree model in an attempt to determine why the 0.25 degree model errors are larger than the 1 degree model errors. We also examine the sensitivity to changes in free constants in the parameterizations.

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