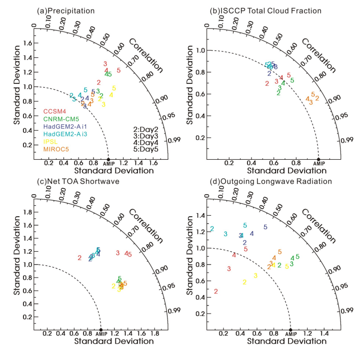
Most Systematic Errors in Climate Models Appear in Only a Few Days of Model Integration

Research Highlight

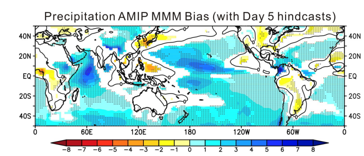
Better understanding of the systematic errors in climate models will improve their fidelity in simulating the mean state and variability of current and future climate. However, this is challenging because nonlinear feedback processes in the climate system make it difficult to unambiguously identify causal relationships.

Scientists at Lawrence Livermore National Laboratory and several modeling centers around the world, including the National Center for Atmospheric Research, U. K. Met Office, Institut Pierre Simon Laplace, Météo-France, and Atmosphere and Ocean Research Institute, University of Tokyo, examine the correspondence between short- and long-term systematic errors in five atmospheric models. They compare 16 five-day hindcast ensembles from the Transpose-AMIP II for July-August 2009 (short-term) to the climate simulations from the Coupled Model Intercomparison Project Phase 5 (CMIP5)/Atmospheric Model Intercomparison Project (AMIP) for the June-August 1979-2008 (long-term) mean conditions. Because the short-term hindcasts were conducted with identical climate models used in the CMIP5/AMIP simulations, one can diagnose what time-scale systematic errors in these climate simulations develop, thus yielding insights into their origin through a seamless modeling approach. Analysis suggests that most systematic errors in the long-term climate runs of precipitation, clouds, and radiation processes are present by Day 5 in ensemble average hindcasts for all models. Errors typically saturate after a few days of hindcasts, with amplitudes comparable to the climate errors, and the impacts of initial conditions on the simulated ensemble mean errors are relatively small. This robust bias correspondence suggests that these systematic errors across different models are likely initiated by model parameterizations since the atmospheric large-scale states remain close to observations in the first two to three days. However biases associated with model physics can have impacts on the large-scale states by Day 5, such as zonal winds, two-meter temperature and sea-level pressure. Analysis further indicates a good correspondence between short- and long-term biases for these large-scale states.

Improving individual model parameterizations in the hindcast mode could lead to improvement of most climate models, simulating their climate mean state and potentially their future projections.



Pattern statistics of (a) precipitation, (b) total cloud fraction from ISCCP simulator, (c) net shortwave flux at top of atmosphere, and (d) outgoing longwave radiation northern summer mean biases from the Transpose-AMIP II hindcasts. The reference fields are the corresponding biases in the CMIP5/AMIP runs. The data are analyzed over 0#–360#, 90#S–90#N.



June-August CMIP5/AMIP multi-model mean precipitation biases (mm day-1, color shades), and contours indicate zero bias. Regions where ensemble mean biases are statistically significant at the 95% confidence level are color shaded. The stippled regions are where more than four (including four) out of five transpose-AMIP II models have the same sign of biases on Day5 compared to CMIP5/AMIP multi-model mean biases.

Reference(s)

Ma H, S Xie, SA Klein, KD Williams, JS Boyle, S Bony, H Douville, S Fermepin, B Medeiros, S Tyteca, M Watanabe, and DL Williamson. 2014. "On the correspondence between mean forecast errors and climate errors in CMIP5 models." Journal of Climate, , . ACCEPTED.

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Cloud Life Cycle