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A Piecewise Modeling Approach for Sensitivity Studies – Tests with WRF Model

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The model-based numerical sensitivity experiment is the basis for the attribution studies of the climate change and weather/climate anomalies. In order to reduce systematic errors and prevent model drift caused by accumulated model errors in the long-term simulations, a piecewise modeling approach that subdivides long integrations into a sequence of short ones is adopted for the sensitivity studies. For the control run with realistic external forcings to produce the reference state, it is similar to the common model reinitialization method in which the simulated state is updated periodically with available analysis data or observations at the end of each segment. For the perturbation run with some modified external forcings to produce perturbed states, no analysis data or observation is available. In this case, we update the simulated perturbed states with the sum of the analysis and the difference fields between two simulated states. An idealized twin sensitivity experiment was conducted with the Weather Research and Forecasting model (WRF) to evaluate the advantages of the piecewise approach over the conventional continuous modeling approach. The sensitivity experiment is designed to assess the effect of anomalous snow depth over the Tibetan Plateau in the preceding winter on East Asian summer climate, which consists of one conventional continuous run and eight piecewise runs with different segment length and error size in the analysis data. The results show that the piecewise approach can improve the credibility of the modeled sensitivity experiment and all eight piecewise runs perform significantly better than the continuous run. Compared with the continuous run, the mean absolute errors in summer 2-m temperature difference field and precipitation difference field over East Asia can be reduced by 36.9% and 16.3% by using the piecewise approach, respectively. The spatial correlation coefficient between the true and simulated state increases from 0.26 (for continuous run) to 0.66 (for piecewise run) for 2-m temperature difference field, and from 0.06 to 0.40 for the precipitation difference fields.

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