An Efficient Method for Discerning Climate-Relevant Sensitivities in Atmospheric General Circulation Models

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Motivation

Multiple simulation years are often required in sensitivity studies to overcome natural variability and separate signal from noise. This is inconveniently expensive at high resolutions.

We explored an alternative strategy using ensembles of shorter simulations, exploiting the important role of fast processes in determining model characteristics.

Example I:
Sensitivity of Cloud Cover to Model Time Step

Compared to 5-yr climate simulation:
Very similar results (see figure below), but with a factor of 15 reduction in CPU time and a factor of 300 reduction in turnaround time.
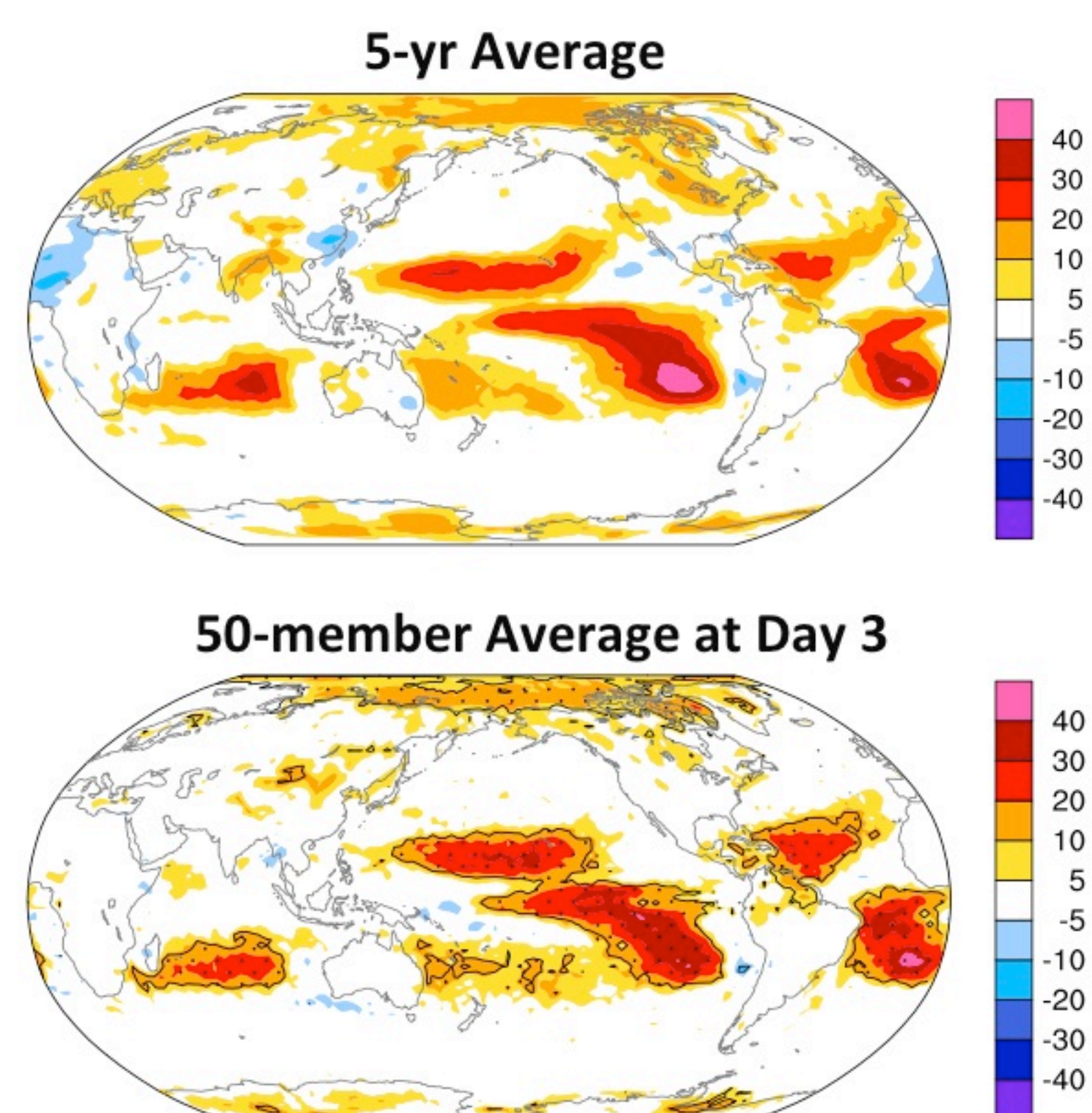

Figure shows total cloud cover difference (unit: %) between simulations conducted using 4-minute and 30-minute time steps. Stippling in the lower panel indicates statistical significance at 95% confidence level.

Conclusion and Implication

Ensembles of short simulations can correctly detect the main signals of model sensitivities revealed by long-term climate simulations, but at a fraction of total computation time and turnaround time. This provides a powerful tool to efficiently use leadership computing facilities and to speed up model development.

Ensemble Design

Different members start from different initial conditions sampled from a prior long-term simulations conducted using the standard model configuration. For further details, see Wan et al. (2014, GMDD, doi:10.5194/gmdd-7-2173-2014).

Climate model used in this study: CAM5 (Neale et al., 2010)

Example II:
Sensitivity of Global Mean TOA Net Radiation Flux to Cloud and Aerosol Related Model Parameters (UQ)

Compared to 4-yr climate simulation:
Very similar results (see figure below), but with a factor of 15 reduction in CPU time; 12x256 simulations finished within a few hours on Yellowstone at NCAR/CISL.

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