Exploring an Ensemble-Based Approach to Atmospheric Climate Modeling and Testing at Scale

Objectives

- Evaluate a methodology to test Earth system models quickly on large scale computing systems
- Apply short (1-yr) simulation ensembles within a testing framework to ensure solution reproducibility following model development and/or software or hardware changes.

Impact

- Provide faster verification to model developers when developing at scale
- Illustrate the efficiency and utility of short simulation ensembles for testing as well as scientific applications.
- More effectively use multicore computing systems performing development model simulations

Accomplishments

- Developed and demonstrated the utility of a short simulation ensemble-based testing framework
- Demonstrated that running short simulation ensembles is more efficient than running a single long simulation
- Demonstrated that aggressive optimizations can lead to simulations with a statistically distinct model state.
- Averaged behavior of many single year runs of the atmosphere are statistically different than one long run, demonstrating atmosphere low-frequency variability

Mahajan S., A. L. Gaddis, K. J. Evans and M. R. Norman, 2017: Exploring an ensemble-based approach to atmospheric climate modeling and testing at scale, *Procedia Computer Science*, **108**, 735-744, doi: [10.1016/j.procs.2017.05.259](https://doi.org/10.1016/j.procs.2017.05.259)

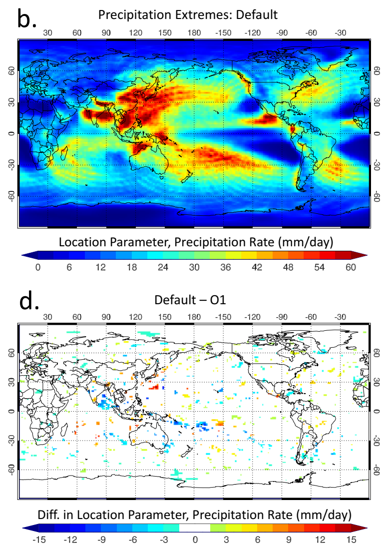

Figure showing difference in precipitation extremes between two short simulation ensembles

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Summary

A strict throughput requirement has placed a cap on the degree to which we can depend on the execution of single, long, fine spatial grid simulations to explore global atmospheric climate behavior. Whereas, running an ensemble of short simulations is computationally more efficient. We test the null hypothesis that the climate statistics of a full-complexity atmospheric model derived from an ensemble of independent short simulation is equivalent to that from an equilibrated long simulation. The climate of short simulation ensembles is statistically distinguishable from that of a long simulation in terms of the distribution of global annual means, largely due to the presence of low-frequency atmospheric intrinsic variability in the long simulation. We also find that model climate statistics of the simulation ensemble are sensitive to the choice of compiler optimizations. While some answer-changing optimization choices do not effect the climate state in terms of mean, variability and extremes, aggressive optimizations can result in significantly different climate states.

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