R: Short Simulations for Efficient Model Evaluation and Tuning : *Looking for robust sensitivities*

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Objectives

- **Determine the strengths and limitations of short simulations**
- **Gain experience to guide the experimental design of short-ensemble-based auto-tuning**

Approach

CAPT Hindcasts

- 10-day hindcasts in July 2008
- Initial conditions from ERA-Interim and nudged CAM-CLM simulations

Parametric Sensitivity Experiments

- 6 uncertain parameters related to shallow convection and turbulence were perturbed (see Table below)
- 128 points were sampled from the 6D parameter space for sensitivity analysis using the Quasi Monte Carlo method.
- A surrogate model, the generalized linear model, was used to analyze model's response to parameter perturbation
- The surrogate model was also used to adjust the 6 parameters so that the simulated July 2008 mean cloud liquid water content along the GPCI transect agree better with NASA's satellite product CCCM (Fig. 1a).

Comparison of Short Ensembles with AMIP Simulations

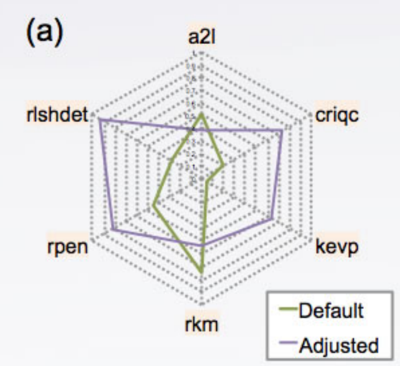
- The default and adjusted model parameters were used to conduct 10-day hindcasts and AMIP simulations.
- Differences between the two configurations in short and long simulations were compared to identify the agreements and disagreements between the hindcasts and climate simulations.

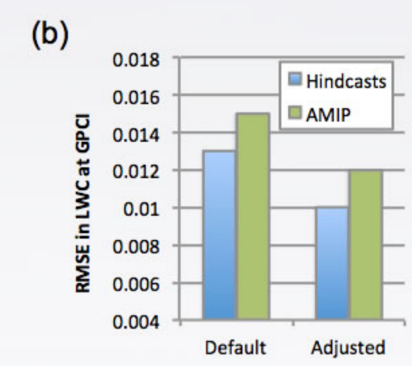
Table: List of uncertain parameters perturbed in the sensitivity experiments.

Index	Parameter	Lower bound	Default value	Higher bound	Notes
1	a2l	10	30	50	Moist entrainment enhancement parameter
2	criqc	0.5E-3	0.7E-3	1.5E-3	Maximum condensate mixing ratio in the updraft
3	kevp	1E-6	2E-6	20E-6	Evaporation efficiency
4	rkm	8	14	16	Fractional updraft mixing efficiency
5	rpen	1	5	10	Penetrative entraiment efficiency
6	rlshdet	6E-6	10E-6	10E-6	Radius (m) of cloud droplet detrained from shallow convection

Key Results

Along the GPCI transect, model parameters adjusted using short ensembles improve cloud liquid water content (LWC) in AMIP simulations





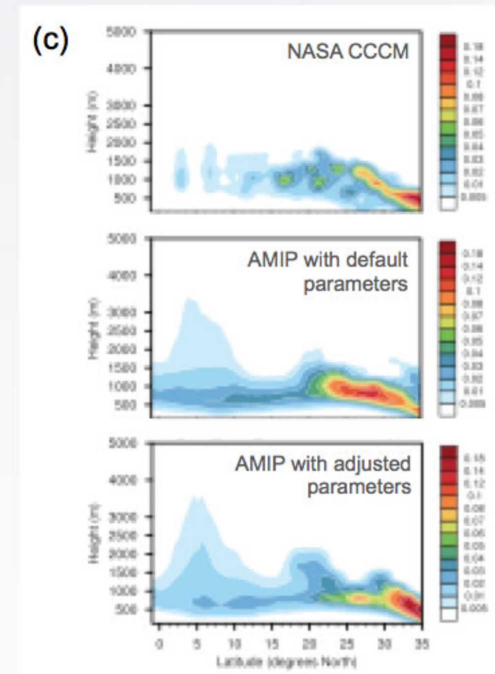


Figure 1: (a) Default and adjusted parameter values. (b) The corresponding RMSEs at the GPCI transect for monthly mean LWC of July 2008. (c) Latitude-height cross section of LWC (g/kg) at GPCI, from NASA's satellite product CCCM, and in AMIP simulations performed with the default and adjusted parameters.

Globally, cloud properties directly affected by the perturbed parameters can be very well captured by short ensembles. Short hindcast lead time helps to avoid noise associated with internal variability of the general circulation.

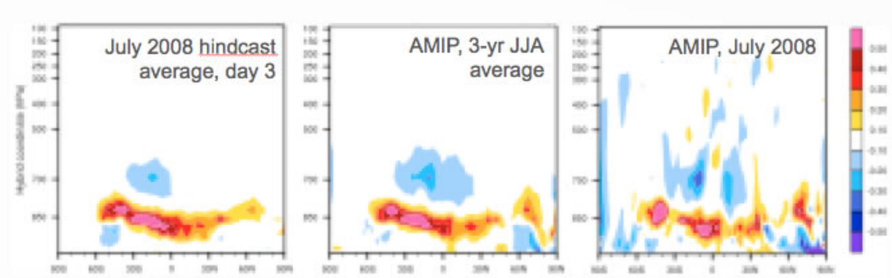


Figure 2: Zonal mean longwave heating rate differences (K/day) between simulations with default and adjusted parameters.

Model sensitivities very closely tied to circulation features (e.g., temperature and humidity responses), are not accurately characterized by short runs.

Issues needing further investigation

- Evolution of parametric sensitivity and drift of model state from reanalysis are convolved, especially for deep convection.
- It might be possible to further improve computational efficiency by optimizing hindcast frequency and time coverage.
- For the ensemble execution, job bundling has significant overhead. This is true for both the multi-instance runs and the job scheduler based bundling.

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