Application of Uncertainty Quantification Techniques to Water Cycle Modeling

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Perturbed Parameter Techniques

- Modern moist physics parameterization suites contain a multitude of adjustable parameters
- Perturbed-parameter techniques explore the sensitivity of model results to plausible perturbation in these parameters

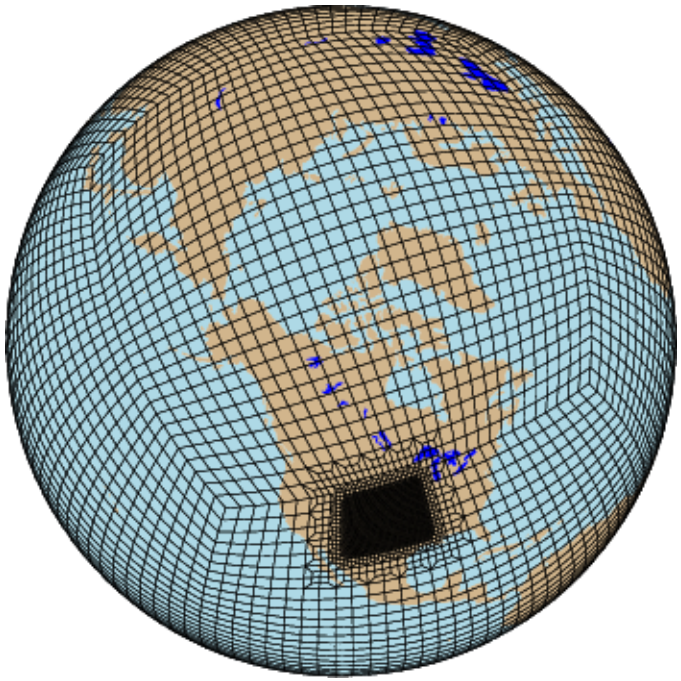
CSSEF CESM/CAM5 UQ Parameters of Interest (14)

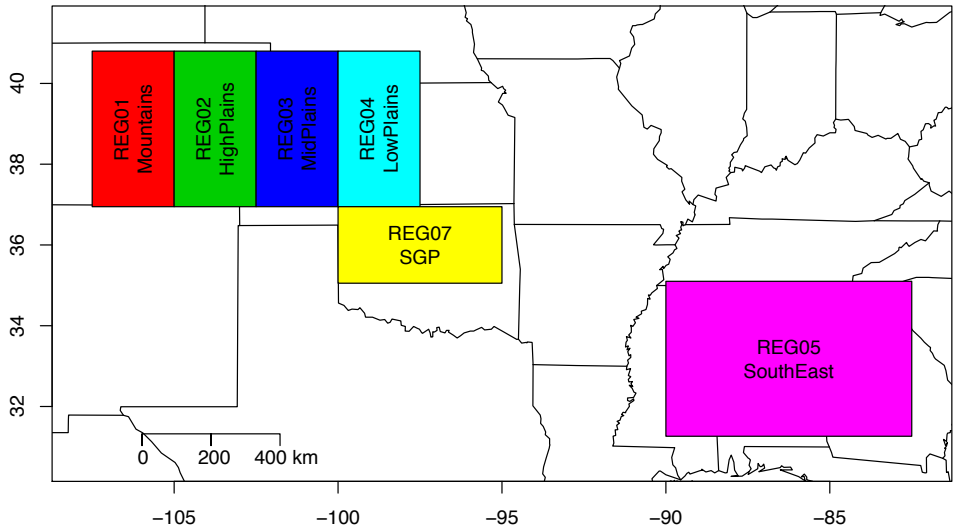
CESM 1.1.beta15; ne30xne30 resolution; CAM5 physics

#	Parameter Name	Range			Description	Namelist Prefix
		Low	Default	High		
1	rhminl*	0.80	0.8975	0.99	Threshold RH for fraction low stable clouds	cldfrc_
2	ai	350.0	700.0	1400.0	Fall speed parameter for cloud ice	micromg_
3	cdnl	0.0	0.0	10.0e+6	Cloud droplet number limiter	micromg_
4	dcs	100.0e-6	400.0e-6	500.0e-6	Autoconversion size threshold for ice to snow	micromg_
5	criqc	0.5e-3	0.7e-3	1.5e-3	Maximum updraft condensate	uwshcu_
6	kevp	1.0e-6	2.0e-6	20.0e-6	Evaporative efficiency	uwshcu_
7	rkm	8.0	14.0	16.0	Fractional updraft mixing efficiency	uwshcu_
8	alfa	0.05	0.10	0.60	Initial cloud downdraft mass flux	zmconv_
9	c0_lnd*	1.0e-3	5.9e-3	10.0e-3	Deep convection precipitation efficiency over land	zmconv_
10	c0_ocn*	1.0e-3	45.0e-3	100.0e-3	Deep convection precipitation efficiency over ocean	zmconv_
11	dmpdz	|0.2e-3|	|1.0e-3|	|2.0e-3|	Parcel fractional mass entrainment rate	zmconv_
12	ke*	0.5e-6	1.0e-6	10.0e-6	Evaporation efficiency parameter	zmconv_
13	tau	1800.0	3600.0	28800.0	Convective time scale	zmconv_
14	emiss_so2_fact	0.0	1.0	2.0	Factor to apply to specified variables in netcdf input file	N/A

Application to Water Cycle Quantities

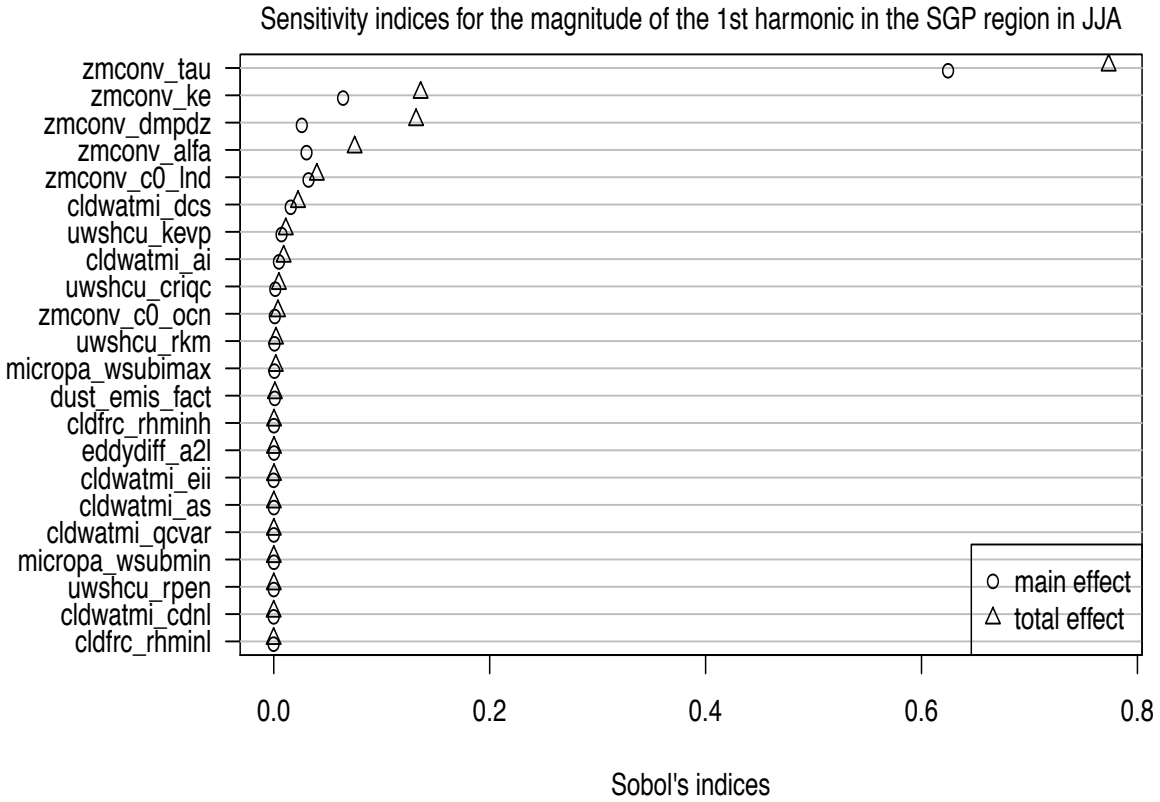
- DOE CSSEF Project is investigating the sensitivity to parameters of Community Atmosphere Model simulated precipitation intensity distributions and diurnal cycles of USA



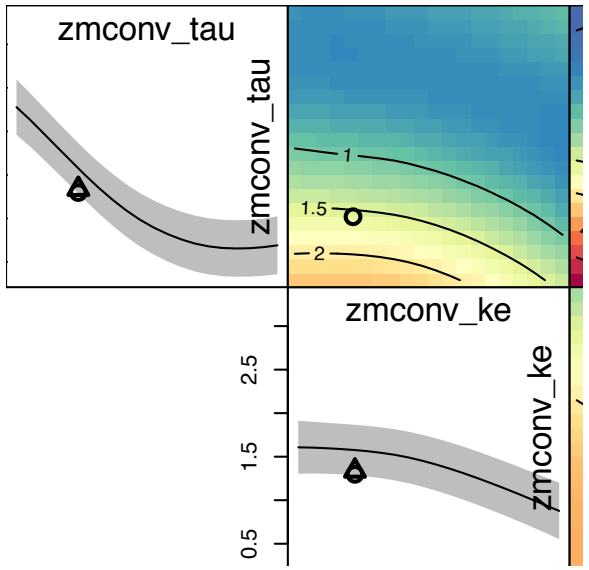


Sensitivity Analysis

- Magnitude of 1st Harmonic of the Diurnal Cycle of Precipitation in SGP during JJA

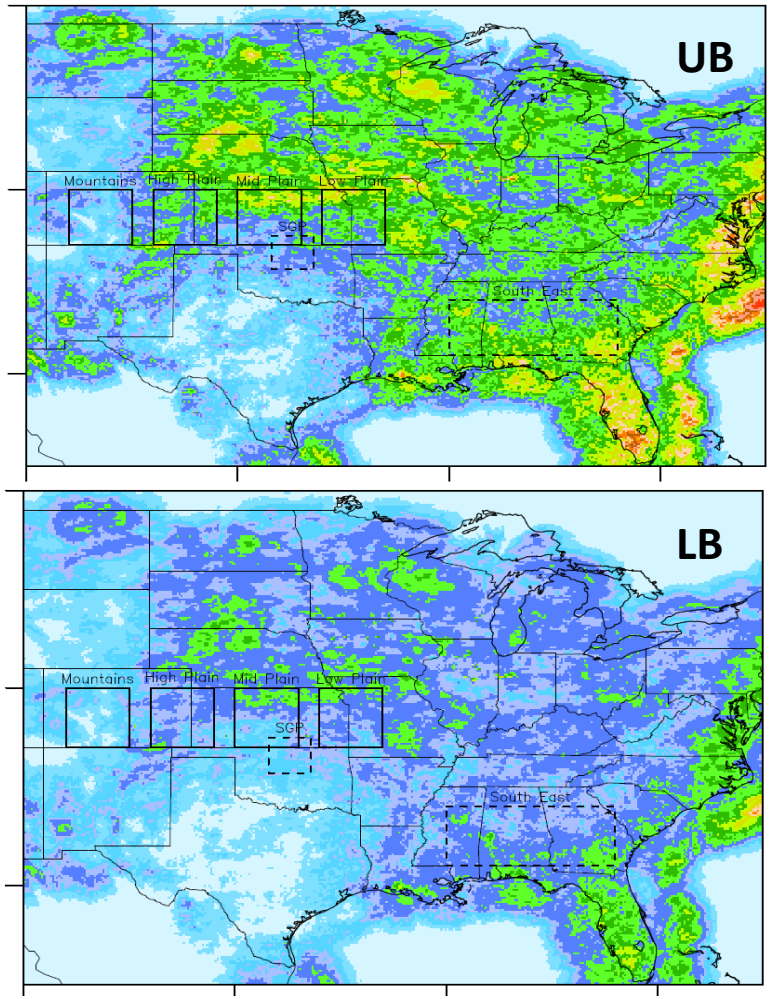


Amplitude as a function of the 2 parameters

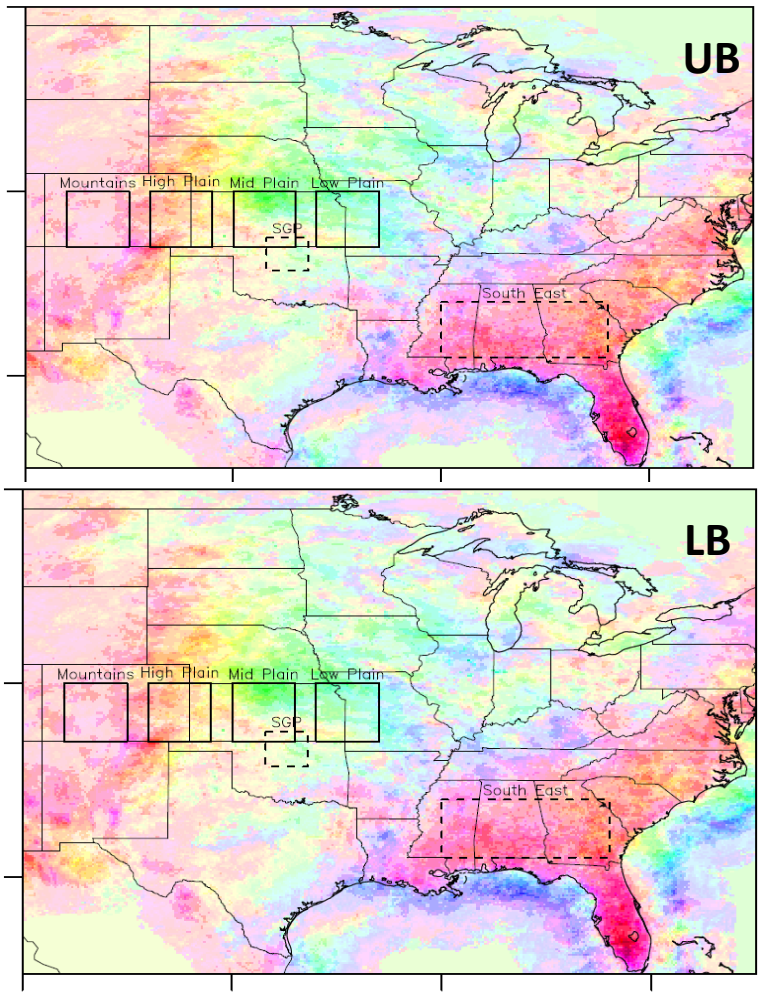


Observational Uncertainty is Important

NEXRAD 0.1 degree
JJA 2011, Mean Precipitation



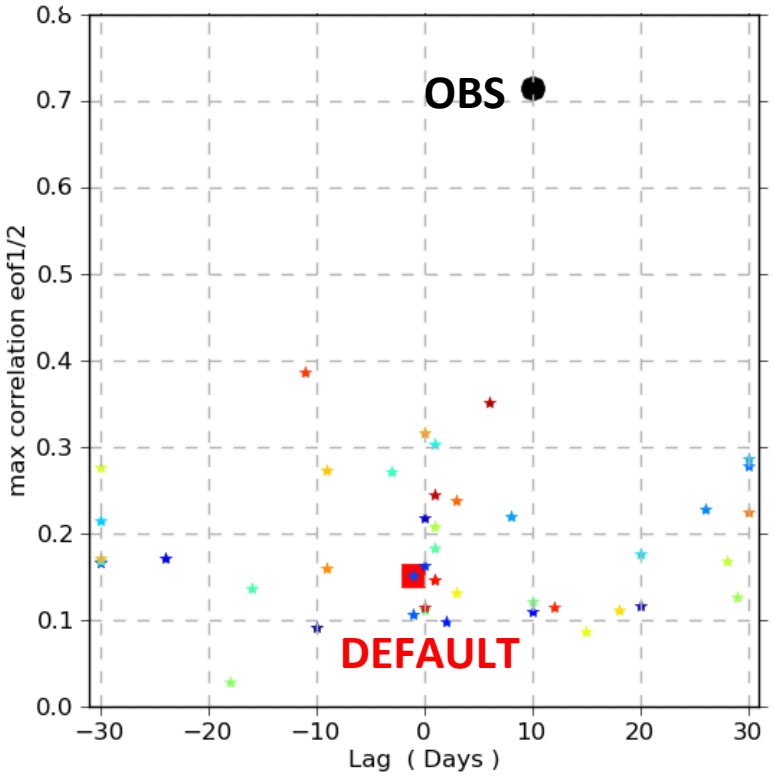
NEXRAD 0.1 degree
JJA 2011, phase of 1st diurnal harmonic



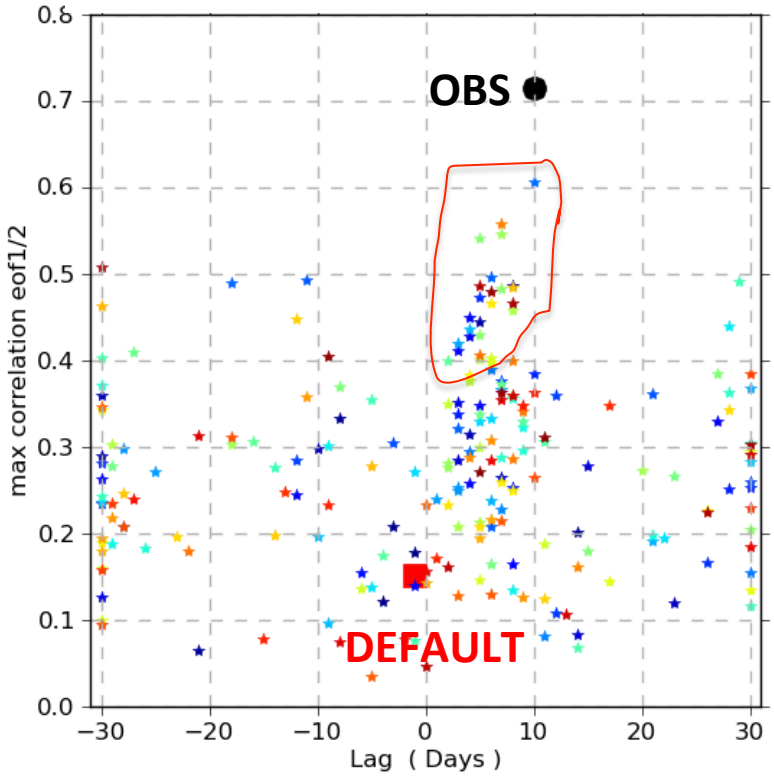
Systems Can Be Very Non-Linear

- Skill of CAM5 in simulating the Madden-Julian Oscillation of Tropical precipitation

One-At-A-Time Perturbations



Simultaneous Perturbations

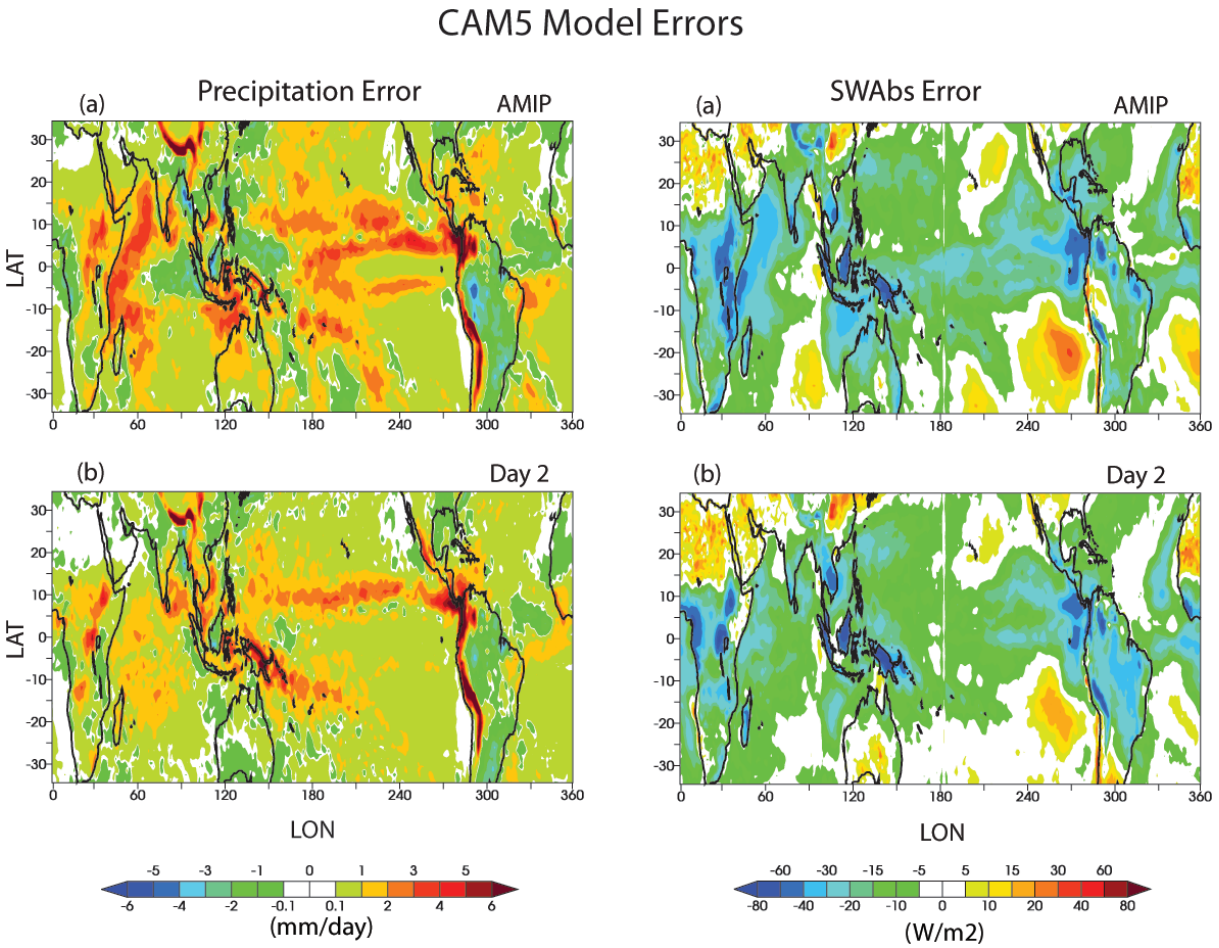


Take-home messages

- Perturbed parameter techniques can identify when the simulation of a phenomena can be achieved with plausible parameter perturbations
- When it cannot be, it indicates that a new model construction (i.e. parameterization) is necessary
- Systematic exploration of parameter space is better than ad-hoc exploration
- Multiple parameter perturbations can yield results not seen with one-at-a-time perturbations

Extra Slide

Correspondence between Annual Mean Forecast (1-2 day) Errors and Climate Errors



Xie, Ma, Boyle, Klein and Zhang (J. Climate, 2012)

Other Similarities

- The vertical profiles of temperature and water vapor biases in the tropical troposphere
- Warm biases of surface air temperature over land (cloud problem)
- Deficit of shortwave absorption near 60 S (cloud problem)

Differences

- Double ITCZ