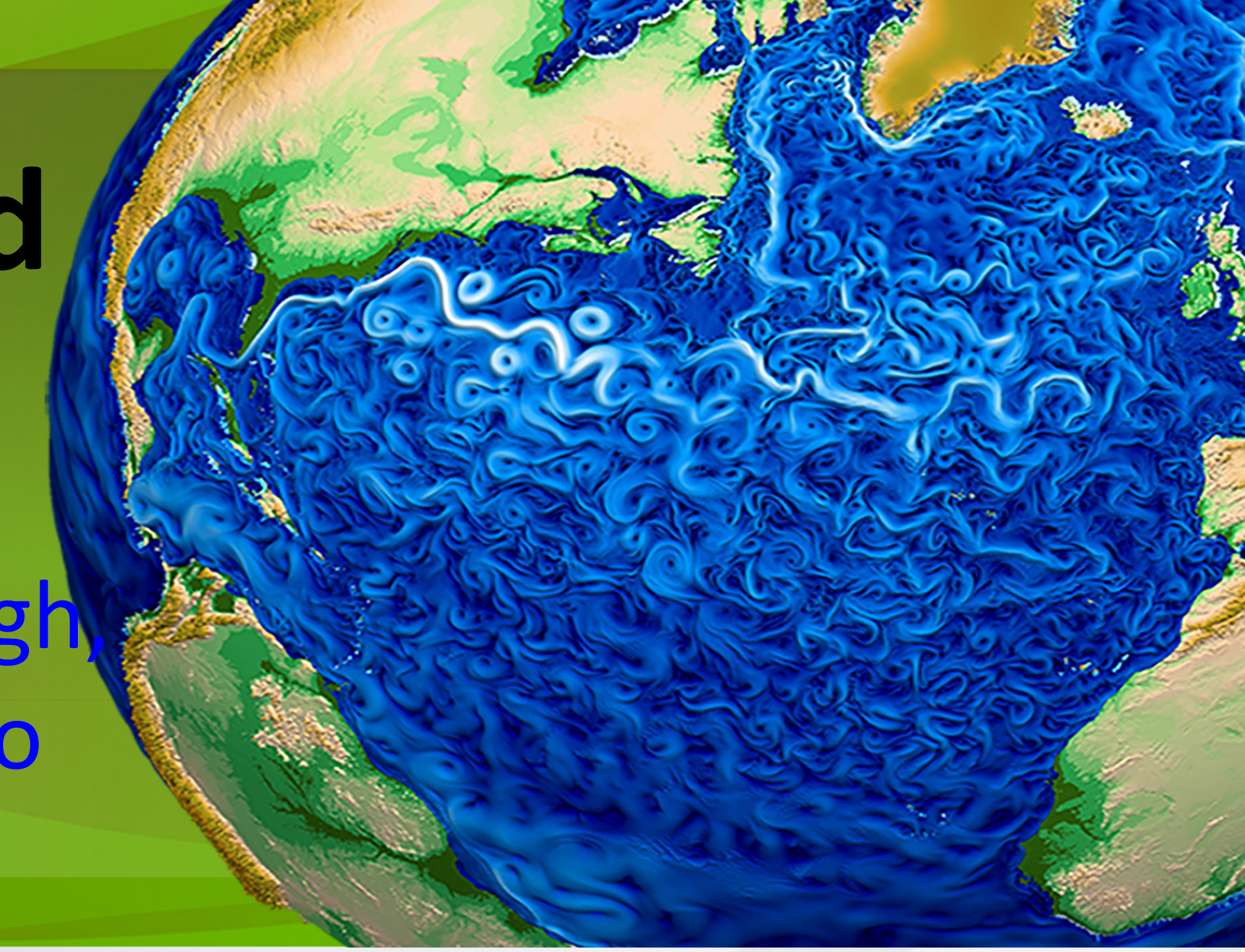


# Parametric sensitivity in ACME-V1 atmosphere model revealed

## by short Perturbed Parameters Ensemble (PPE) simulations

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### Motivation

In one-at-a-time model tuning we often encounter

- (1) the tuning of one parameter leads to an offset of the accomplishment from the tuning of another parameter;
- (2) the improvement in one target variable leads to degradation of model fidelity in another target variable.

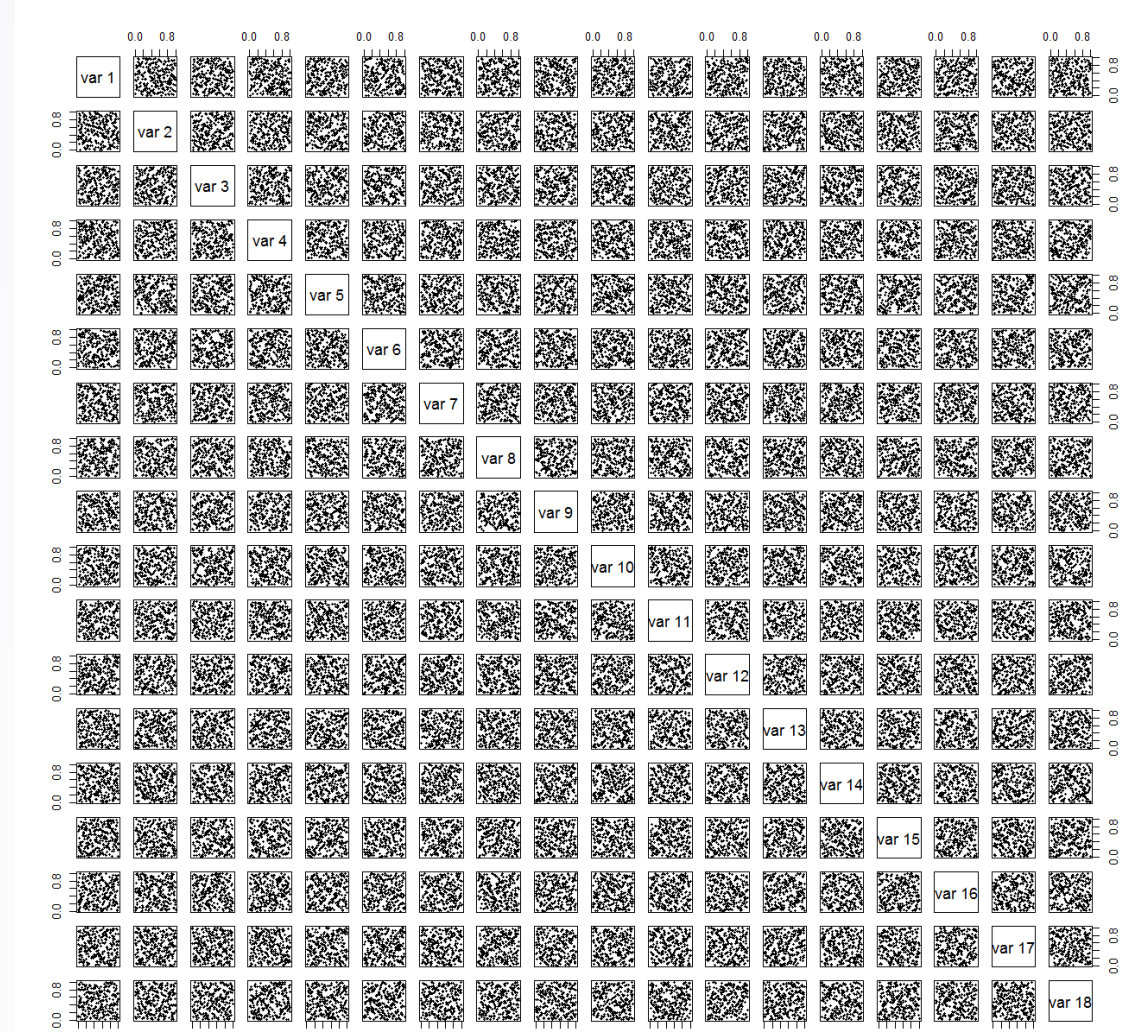
### Approach

- 18 perturbed parameters.
- 256 sampling points from the parameter space.
- Latin Hypercube sampling method.
- 12 ensemble members corresponding to 12 months for each sampling point.
- 3-day long simulation and day-3 results analyzed.
- Finished 256x12 ensemble simulations at a rather modest cost and within 5 days of wall clock time.

18 perturbed parameters in ACME-V1-ne30L72 PPE simulations

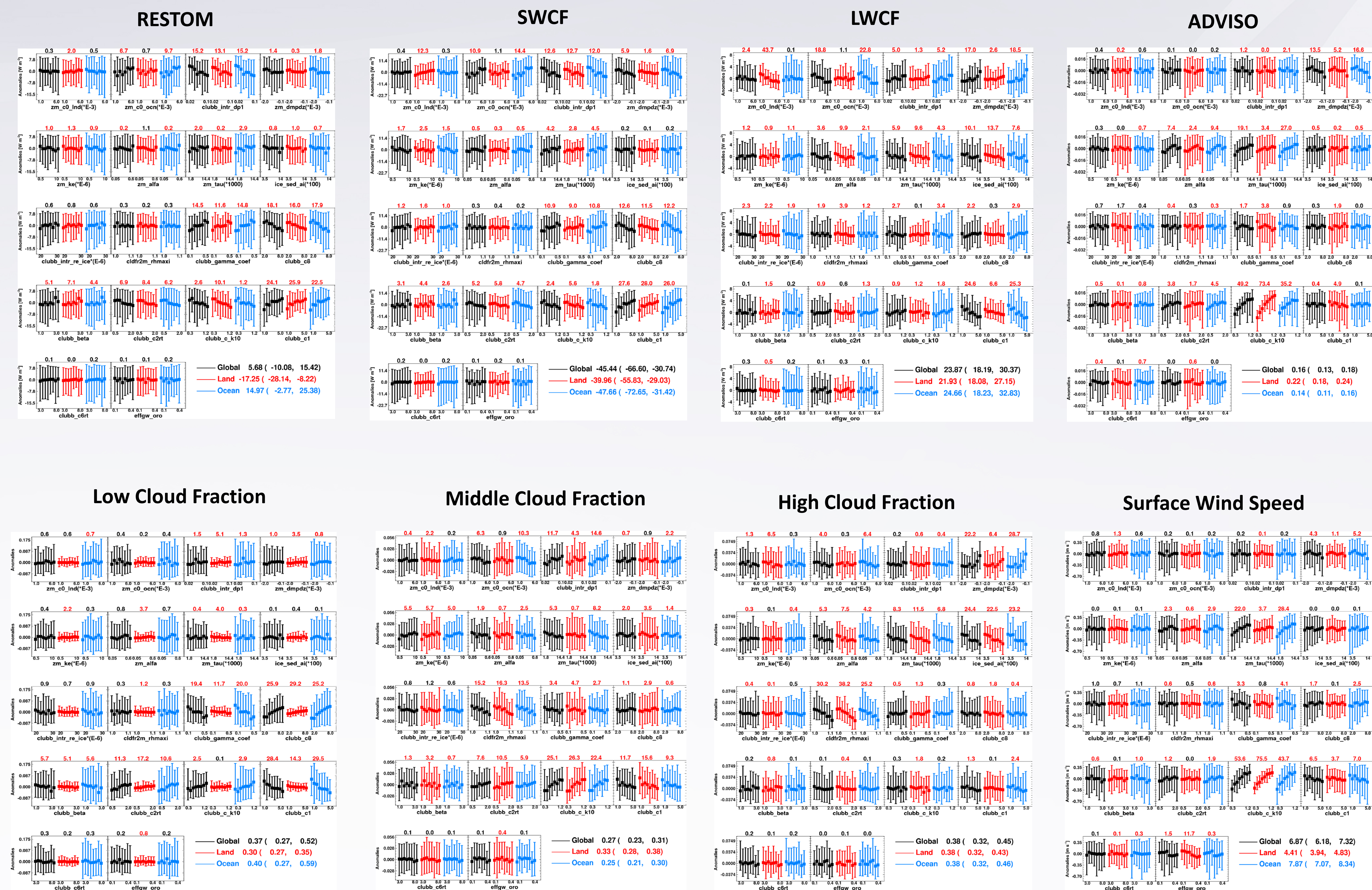
#	Parameter Name	Min	Default	Max	Description	Namelist Prefix	File Name (PPE)	Reference
1	cl_bnd	0.001	0.002	0.006	Deep convection precipitation efficiency over land	zmcovc	zmcovc	Qian15/Ma
2	cl_oce	0.001	0.002	0.006	Deep convection precipitation efficiency over ocean	zmcovc	zmcovc	Qian15/Ma
3	dp1	0.02	0.1	0.1	Deep convection cloud fraction parameter	---	clubb_int1	Ma
4	empr2	2.0e-3	0.5e-3	0.3e-3	Parcel fractional mass entrainment rate	zmcovc	zmcovc	Qian15/Neale
5	ev	0.5e-6	1.0e-6	10.0e-6	Evaporation efficiency of precipitation	zmcovc	zmcovc	Qian15
6	flw	0.05	0.10	0.50	Maximum cloud downdraft mass flux fraction	zmcovc	zmcovc	Qian15
7	tau	1800.0	3600.0	36000.0	Time scale for consumption rate deep CAPE	zmcovc	zmcovc	Qian15/Neale
8	ic	190.0	700.0	2400.0	Fall speed parameter for cloud ice	cloud_ic	cloud_ic	Ma/Zhang
9	ic_sca	20	25	30	Effective radius of detrainment ice crystals from deep convective clouds	cloud_ic	cloud_ic	Ma/Zhang
10	rhmax	1.00	1.0	1.30	Max relative humidity threshold for ice cloud	cloud_ic	cloud_ic	Ma/Zhang
11	gamma_coef	0.1	0.32	0.5	Constant of the width of PDF in w-coordinate	Clubb_parameters_tunable	Clubb_parameters_tunable	Guo15/Ma
12	cl	2.0	4.2	8.0	Constant associated with Newtonian damping of $\omega$	Clubb_parameters_tunable	Clubb_parameters_tunable	Guo15/Ma
13	beta	1.0	2.4	3.0	Constant related to skewness of $\omega$	Clubb_parameters_tunable	Clubb_parameters_tunable	Guo15/Ma
14	clm	0.5	1.0	1.0	Constant with dissipation of variance of total water	Clubb_parameters_tunable	Clubb_parameters_tunable	Guo15/Ma
15	cl310	0.3	0.6	1.2	Momentum diffusion factor	Clubb_parameters_tunable	Clubb_parameters_tunable	Ma
16	cl1	1.0	1.0	5.0	Constant associated with dissipation of variance of $\omega$	Clubb_parameters_tunable	Clubb_parameters_tunable	Ma
17	clm1	3.0	4.0	8.0	Low skewness of Newtonian damping of variance of $\omega$	Clubb_parameters_tunable	Clubb_parameters_tunable	Qian
18	eflge_ave	0.1	0.3	0.4	Gravity wave drag intensity	---	gw_drag_P90	Ma

Latin Hypercube Sampling of the 18D parameter space. 256 sampling points are shown in the figure



### Results

Anomalies of variation of global (black), land (red), and ocean (blue) averaged quantities in response to the perturbations of parameters from PPE short simulations. The mean, minimum, and maximum precipitation in the 256 simulations for global, land, and ocean average, respectively, are also presented at the bottom-right corner of each plot. The numbers above each plot box represent the relative contribution (%) of each input parameter perturbation to the overall variable variations. Red indicates that the contribution has 95% statistical significance.



### Impact

- Identified the most influential parameters and quantified the model response to these parameters for a number of important fidelity metrics.
- Provided a more complete picture of the ACME-V1 model behavior and information on the tuning potential of different parameters, thus can help guide the tuning activities.