**Using PPE simulations and parametric sensitivity analysis to better understand model physics and parameterization in E3SM atmosphere model over different cloud regimes**

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**Abstract**

DOE Energy Exascale Earth System Model (E3SM), including its atmospheric model (EAM) component, has been added many new features and modifications. In our previous study we conducted a systematic parametric sensitivity analysis for EAM based on short parameter-perturbed ensemble simulations (PPE), but mainly focusing on global mean features and quantities. While the parameters values in conventional global climate model are usually temporally and spatially constant, model response to parameters perturbation may vary across different regions and cloud regimes, which motivates a need to better understand the model behaviors and physics at regional scale and process level. In this study, using the same set of PPE simulations and similar sensitivity analysis framework, we identify what parameters are most sensitive over different regions and compare how the model respond to the parameters for several important fidelity metrics related to cloud across different cloud regimes. We find the cloud forcing has opposite response to some parameters over mid-latitude vs. tropical land. We analyze how parametric sensitivity changes from stratocumulus to shallow convection to deep convection system over ocean along GPCI cross section. Low cloud and SWCF in the subtropical eastern Pacific seem most sensitive to gamma and c8 near the coast but becomes more sensitive to c1 further offshore. We also investigate how parametric sensitivity evolve with prediction lengthy. This study improves our process-level understanding on cloud physics and parameterization and provides insights for developing more advanced space-awareness parameterization schemes.