Investigating high cloud response to aerosols in a **Perturbed Parameter** Ensemble

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PPE Overview

CAM6.3

19 Parameters

- Aerosols
- Microphysics

162 parameter sets for simulation using Latin Hypercube Sampling

Almost all parameter ranges inherited from Eidhammer et al. (2024)

Parameters micro_mg_accre_enhan_fact micro mg autocon fact micro_mg_autocon_lwp_exp micro mg autocon nd exp micro_mg_berg_eff_factor micro mg dcs micro_mg_effi_factor micro_mg_homog_size micro_mg_iaccr_factor micro_mg_max_nicons micro_mg_vtrmi_factor seasalt_emis_scale microp_aero_npccn_scale microp_aero_wsub_min microp_aero_wsub_scale microp_aero_wsubi_min microp_aero_wsubi_scale dust emis fact Sol_facti_cloud_borne

New parameter Modified parameter range

Experiment Setup

Two types of simulation (2 years), all fixed SST:

- PI: preindustrial (1850) aerosol emissions
- **PD:** present day forcing & SSTs (2010)

Winds nudged to MERRA2 reanalysis over 2010-2011 period



How to diagnose ERFaci

Double-call (Ghan, 2013)

Uses extra aerosol-free radiative fluxes under clear- and all-sky conditions APRP (Taylor et al., 2007)

Simplified 1-layer model of the atmosphere

Partition cloud changes into amount, scattering, and absorbing components MODIS cloud radiative kernel (Duran et al., 2025) Uses MODIS satellite simulator output and cloud radiative kernels

Phase-distinction enables separation of liquid and ice cloud changes!

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New MODIS CRK method for diagnosing ERFaci



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ERFaci from ice clouds

(Ensemble mean)



Ice cloud response to aerosols is heterogeneous!



(whereas aerosols induce much more broad increases in liquid clouds)

(a)



 Wm^{-2}

Warming effect is robust across ERFaci estimates (magnitude differs across methods)



Tropical Ice Cloud Response - Micro or Macro?



Cloud loss confined to upper troposphere (150-250E)

Tropical Ice Cloud Response - Micro or Macro?



Strong decrease in cloud ice number, associated with diminished homogeneous nucleation

Tropical Ice Cloud Response - Micro or Macro?



Increase in heterogeneous nucleation reflective of intensified competition between homogeneous and heterogeneous nucleation? 15

Conclusions & paths forward

Aerosols generate counteracting ice clouds changes (compared to near-uniform $\Delta C > 0$ for liquid)

Default CAM6 ERFaci_{ice} (-0.3 Wm⁻²) is substantially weaker than ERFaci_{liq} (-1.5 Wm⁻²)

Tropical ice clouds loss may be governed by competition between homogeneous and heterogeneous ice nucleation!

SW ERFaci diagnosis



Ice crystal shape parameterization matters!



Residual for our decomposition is small



Satellite simulator cloud changes don't always

line up with model-native cloud changes

(a)



This is an inherent limitation of cloud radiative kernel methods

(whereas aerosols induce

