R: Ice Cloud Representation in ACME V1 and Its Sensitivity to Uncertain Parameters

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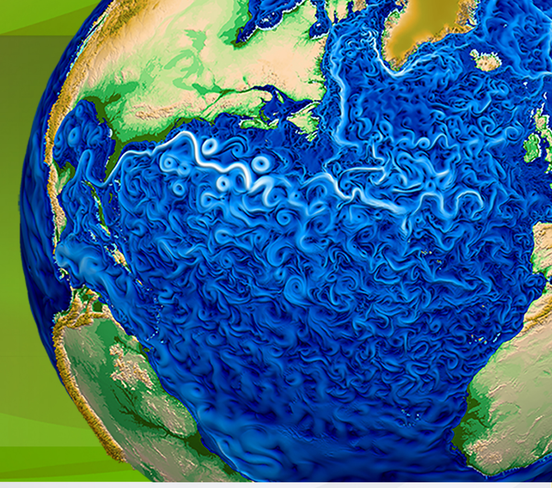

Objective and Progress

Microphysical processes happening in ice clouds and mixed-phase clouds have significant impacts on cloud properties and radiative effects.

Several new parameterizations have been implemented into ACME in order to improve the representation of ice clouds. However, it was unclear whether these more physically-based parameterizations would perform well in the new model, because many other changes (e.g. cloud micro- and macrophysics, turbulence, aerosol representation) and tunings had been made at the same time.

Ice cloud properties simulated in the **ACME V1 ne30 L72** configuration are compared to previous model versions and evaluated against observations. The **impacts of individual model improvements** are investigated.

Using results from the Short Simulations team, we also investigated the **sensitivity** of ice cloud properties **to** a set of **uncertain physical parameters**.

Performance of Current ACME (V1-03)

Longwave cloud forcing (LWCF) in the mid-latitudes is improved in ACME V1 compared to CAM5.3. In the tropics, current model has a significant negative bias compared to satellite retrievals (CERES-EBAF).

High cloud fraction is slightly improved in ACME V1, especially in mid- and high latitudes.

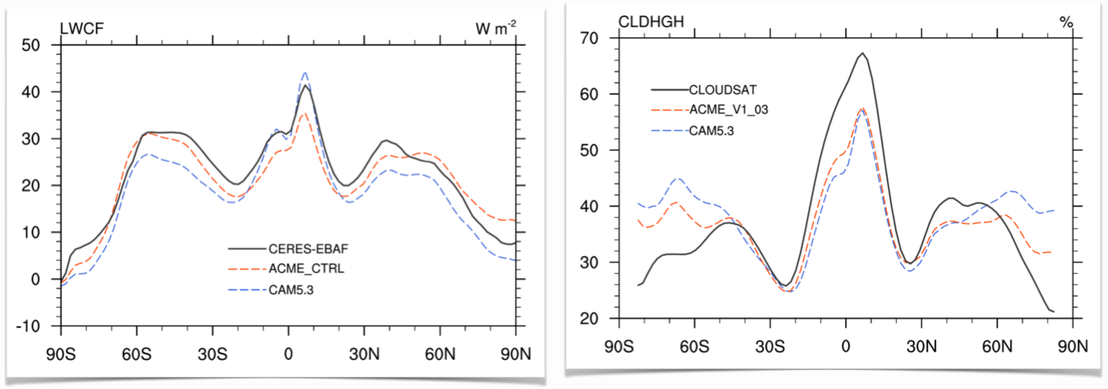

Fig 1. Simulated longwave cloud forcing (LWCF) and high cloud fraction (CLDHGH) in ACME (V1-03) and CAM5.3. Also shown are satellite retrievals from CERES-EBAF and CLOUDSAT.

Sensitivity to Parameterization Changes

It is understood that more physically-based parameterizations will not always lead to better results, and the interactions with other model changes might cause problems. It was found that the pre-existing ice treatment for cirrus clouds does not work well with CLUBB. Some further tuning of current schemes can lead to better simulations (e.g. adjustment of **DCST**).

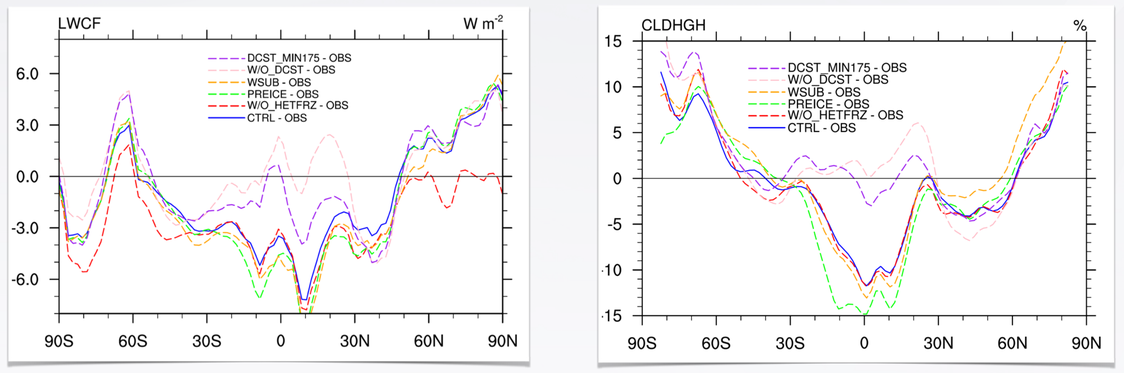

Fig 2. Zonal mean bias of simulated longwave cloud forcing (LWCF) and high cloud fraction (CLDHGH) in ACME CTRL and sensitivity simulations (**PREICE**: pre-existing ice for cirrus; **HETFRZ**: new heterogeneous ice nucleation treatment; **WSUB**: updraft velocity treatment; **DCST**: temperature dependent threshold size for auto-conversion of ice to snow. Note that w/o the DCST treatment, IWP is very small (6gm^{-2}) and LWCF/ CLDHGH have a positive bias in the tropics.

Sensitivity to Uncertain Parameters

Short Perturbed Parameters Ensemble (PPE) simulations were performed using the V1-02 model. 18 parameters related to convection and cloud physics were perturbed simultaneously. The simulations were 3-day long, initialized from 12 different initial conditions.

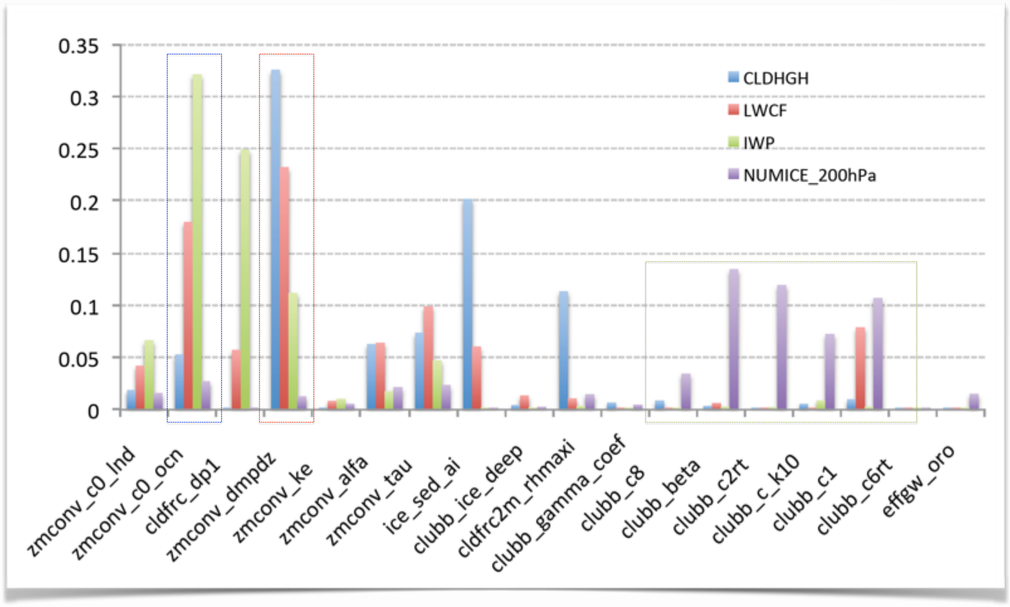

Fig 3. Relative contribution of individual parameters to the total variance caused by parameter perturbation. The variance analysis is carried out with tropical averages. LWCF, IWP, and CLDHGH are all sensitive to a parameter related to convection (**dmpdz**, parcel fractional mass entrainment rate). Ice crystal number is more sensitive to CLUBB parameters that affect water vapor in the upper troposphere.

ACME Accelerated Climate Modeling for Energy

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