Implementing and improving convective microphysics parameterization in E3SMv1

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Motivation

- Improve the representation of microphysical and precipitation processes in convective clouds in E3SM
- Represent the effect aerosol on convective clouds
- Improve the representation of interactions between convective and stratiform clouds in E3SM

Two-moment microphysics scheme for convective clouds



Song and Zhang, 2011, J. Geophys. Res.

New improvements (graupel, snow detrainment)

Implementation of convective microphysics scheme in E3SMv1



New implemented and modified processes:

- Droplet activation and ice nucleation in convective cloud,
- Interaction between microphysics and cumulus thermodynamics,
- Detrainment of snow and hydrometeor number concentration.

Experimental design

Two 5-yr E3SM v1 simulations are conducted:
CTL: standard E3SM
MPSZ: with convective microphysics scheme
Results from the last 4-year simulations are presented here

- Resolution: NE30, 72 layers
- Compset: F2010C5-CMIP6_LR + COSP.
- Evaluation dataset:

ERA40, CloudSat, CALIPSO-GOCCP, MODIS, CERES-EBAF, UWisc(v3)

Evaluation of the microphysics scheme with observations

Cloud liquid water content (LWC)



Cloud Aerosol Interaction and Precipitation Enhancement EXperiment (CAIPEEX) (Adopted from Prabha et al., 2012, J. Geophys. Res.)



Cloud ice water content (IWC)



CTL simulation tends to underestimate the LWC and IWC in convective clouds. The new convective microphysics scheme increases both convective LWC and IWC. It produces higher IWC in upper troposphere in mid-latitude land convection than tropical ocean convection, which is observed in CloudSat observation.

Impacts on global climate simulation

Annual-mean moisture bias



Annual-mean temperature bias



Cloud properties and cloud radiative forcing-Annual cycle global mean climatology

Cloud fraction

Cloud LWP

Cloud radiative forcing



Conclusions

- A two-moment microphysics scheme for convective clouds is implemented in the E3SMv1. This scheme improves the representation of convective clouds and their interaction with large-scale clouds and aerosols in the E3SM.
- Convective cloud microphysical properties simulated by the new scheme are generally in good agreement with available observations.
- The cold and dry biases in tropical troposphere are mitigated with the new convective microphysics scheme
- The biases in cloud water path, high-level cloud fraction, low-level cloud fraction, and LWCF are reduced.