

Impacts of Ice Nucleation Parameterizations of Dust on Deep Convective Clouds and Precipitation with CAM5 physics in the WRF model



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INTRODUCTION

- Ice nucleation plays a critical role in forming ice in clouds and converting liquid to ice in mixed-phase clouds, which, in turn, have important climate consequence.
- Many past heterogeneous ice nucleation parameterizations were developed based on field measurements with the artifacts of shattering, and also not connected with aerosol particles.
- Recent lab and field measurements led to a few new ice nucleation parameterizations connecting with aerosols, which should be implemented to models and evaluated by observations.

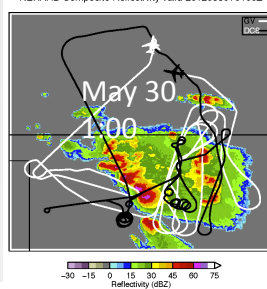
EXPERIMENT DESIGN

- WRF with CAM5 physics package
- 4-km resolution. NARR to provide initial and boundary conditions.
- CBMZ and MAM3; NEI05 emission data.

Ice nucleation parameterizations

- Meyers1992 (Meyers et al. 1992): T-dependent.
- Demott2013 (DeMott et al., 2013): connects with dust number concentrations with size >0.5 microns.
- Niemand2012 (Niemand et al. 2012,): number and surface area of dust
- Phillips2013 (Phillips et al., 2013): number and surface area of dust.

NEXRAD Composite Reflectivity valid 20120530T0100Z



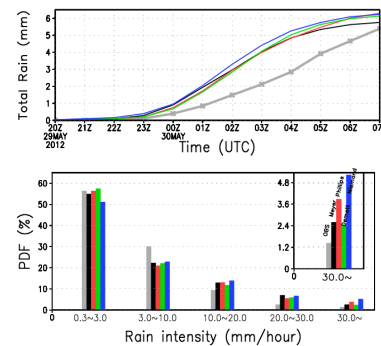
A storm case on May 29-30 from the DC3 campaign



RESULTS

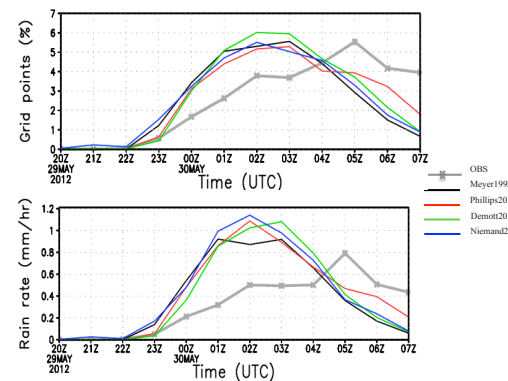
Comparison with observations

Comparison of precipitation

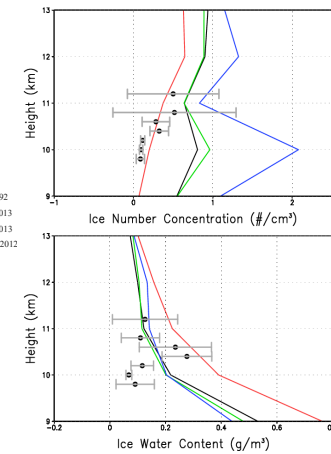


- The simulated storm peaks a few hours earlier than observed.
- Different ice nucleation schemes do not produce significant impacts on total rain, but they impact the rain rate PDF.
- Phillips2013 predicts the lowest Ni in the anvil area, agreeing the best with obs.

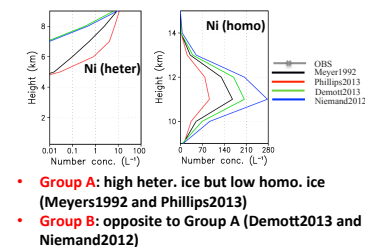
Convection evolution with time



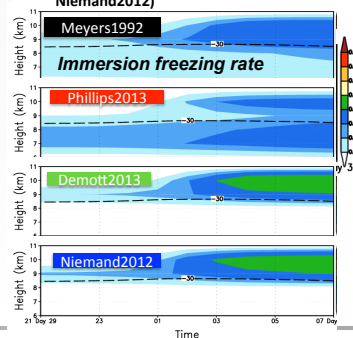
Aircraft Measurements



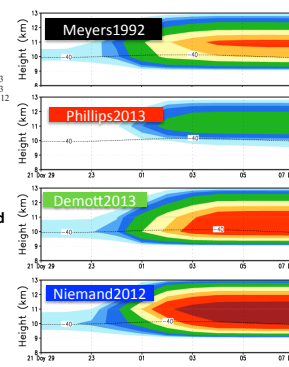
Impacts on cloud properties



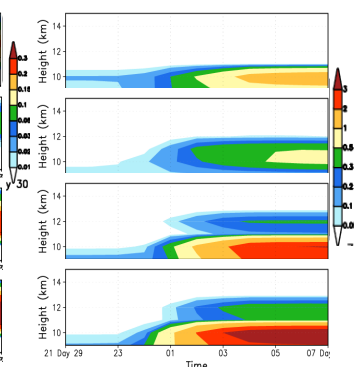
- Group A: high heter. ice but low homo. ice (Meyers1992 and Phillips2013)
- Group B: opposite to Group A (Demott2013 and Niemand2012)



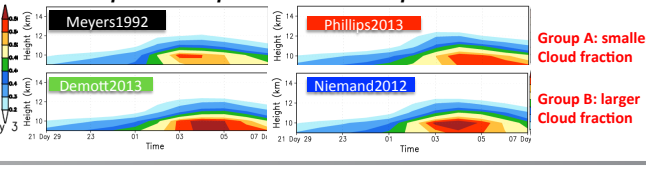
Droplet homo. freezing rate



Droplet nucleation in the upper levels



Cloud expansion explains different droplet nucleation



CONCLUSIONS

- The simulated storm by all ice nucleation schemes peaks earlier and produces too much heavy rain.
- Meyers1992 and Phillips2013 predict much higher Ni at warm T (5-9 km) than Demott2013 and Niemand2012, leading to much smaller ice formation in the upper levels, because higher Ni in the mixed-phase regime leads to smaller detrainment of water vapor, forming less cloud, which reduces droplet nucleation and then droplet freezing to form ice.
- Cloud micro- and macro-properties in the upper levels of storm are significantly impacted by ice nucleation in mixed-phase regime.

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