Evaluation of Cloud Microphysical Parameterizations in Cloud-resolving Model Simulations Using the ARM Observations
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Motivation
- Cloud resolving model (CRM) is a convenient platform to test parameterizations used in the multiscale modeling framework (MMF).
- MMF simulations produce too much high-level cloud with high optical depth.
- Investigation of the microphysics parameterizations in the embedded CRM can provide insight for the cause of these issues.

Model Setup
- CRM: System for Atmospheric Modeling (SAM) is the embedded CRM in the Colorado State University MMF.
- Radiation scheme: CAM3 radiation.
- Microphysics: Morrison et al (2005) two-moment schemes and the default one-moment schemes in SAM.
- Domain size (2D): 1024 km x 27 km.
- Resolution: Δx = 1 km, Δz = 75 m ~ 500m, Δt = 10 s.
- Radar simulator: Quickbeam (Hagyes et al,2007) using size distribution consistent with microphysics.

Results
- Two-moment microphysics better reproduce the observed reflectivity histograms compared to one-moment microphysics.
- Two-moment microphysics generates significantly more cloud than the ARM MMCR observations and one-moment microphysics has much less cloud cover.
- The periodic lateral boundary conditions play an important role in the positive bias of cloud occurrence by artificially maintaining residual cloud after convection, in both microphysics schemes.
- N_i is too high in two-moment microphysics; improvements in ice nucleation schemes may better represent convective clouds.

Other tests showing little improvement
- Use prescribed radiative forcing.
- Apply large scale subsidence to vertical velocity and hydrometeors.
- Increase terminal fall speed for ice, V_Ti, by 50%.
- Use thermodynamic nudging with τ = 2 hr. ~ 50 hr.
- Switch to 3D, higher resolution, different domain size.

ARM9707: month-long simulations
- CNTL: 2-moment
- SAM1MOM: 1-moment
- ARM: observations
- precipitation events are well reproduced.
- OLR from both schemes are too low.

Cloud occurrence

Issues with periodic lateral boundary condition: An example

Ice nucleation schemes
- ΔN_i in current ice nucleation schemes is dependent exponentially on T_{abs}.
- Modeled N_i peaks at values about one order of magnitude larger than observations.
- Modeled N_i has a much narrower peak than the observed distribution.
- Meyers et al (1992) scheme for condensation/deposition freezing can decrease cloud cover (left), and improve OLR histograms (not shown).
- N_i is also decreased, but too aggressively. Need more subtle treatment on ice nucleation.