Aerosol-linked ice nuclei prediction in the two-moment SAM and future plans

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Approach

Measurements

- FIELD & LAB
  - Ice nuclei
  - CCN
  - Aerosol
  - Cloud microphysics

Parameterizations

- Ice nuclei
- Homogeneous freezing
- CCN activity
  (links to aerosol size & composition)

Modeling

- Parcel model
- CRM
- Regional
- Global

Present work

Satellite simulation and comparison to observations

January 2010
La Jolla, CA
Simple ice nucleation parameterizations for use in global model predictions of mixed phase clouds

• Meyers et al. (1992): \( n_{in} = \exp(12.96(S_i - 1) - 0.639) \)

• Fletcher (1962): \( n_{in} = a \exp(bT_C) \)

• Cooper (1986): \( n_{ice} = a \exp(b(273.16 - T_k)) \)

(All depend only on T or ice supersaturation - no links to aerosol properties)

• DeMott et al. (2009):
  \( n_{in} = a(273.16 - T_k)^b(n_{aer,0.5})^c(T_k) \)

(T, \( n_{aer} > 0.5\text{mm diameter} \))
Ice nuclei concentrations over several projects (10-30 min. averages)

- PACDEX
- M-PACE
- INSPECT-2
- INSPECT-1
- ICE-L
- CLEX10/C3VP
- AMAZE
- AIRS-2
- WISP94

Temperature (°C)

Ice Nuclei Conc. (std L⁻¹)

[DeMott et al., 2009]

January 2010

CMMAP Meeting

La Jolla, CA
Major source of IN variability: IN trend with aerosol concentrations when stratified by size and temperature

Berezinski et al. (1986), extrapolated -32°C
Georgii and Kleinjung (1967), -21°C, > 0.6 mm

PACDEX project (-32±2°C)

DeMott et al. (2009)
Major source of IN variability: IN trend with aerosol concentrations when stratified by size and temperature

Berezinski et al. (1986), extrapolated -32°C
Georgii and Kleinjung (1967), -21°C, > 0.6 mm

DeMott et al. (2009)
CMMAP Meeting
La Jolla, CA
Mixed-Phase Arctic Cloud Experiment simulations with SAM (October 9-10, 2004 single layer cloud)

SCAM3 with Liu et al. 2-moment microphys. + Meyers et al. →

SAM6.8.1 with single-moment microphys. ($n_{IN} = 0.16$ per liter → observed)

SAM6.8.1 with Morrison 2-moment microphys. ($n_{IN} = 0.16$ per liter → observed)

SAM6.8.1, Morrison 2-moment microphys. ($n_{IN}$ via DeMott, based on observed aerosols)

SCAM3 with DeMott IN param, clim. aerosols →

[DeMott et al., 2009]
M-PACE single-layer cloud case

MPACE Liquid Water Path

MPACE Ice Water Path

- 6.7.5 One Moment Control
- 6.7.5 Two moment control
- 6.7.5 DeMott 2-moment
- 6.8.1 Two Moment Control
- 6.8.1 DeMott 2-moment
M-PACE multilayer cloud case (October 6-8, 2004)
Summary

• IN concentrations in mixed-phase cloud T regime can to first order be related to the number concentrations of particles larger than ~0.5 mm and temperature
  → useful in models that carry some information on particle size, eventually particle type (composition)

• SAM implementation gives reasonable results for two Arctic case studies
  → new parameterization using observed aerosols as input and two-moment microphysics yields water mass/phase distribution that agrees reasonably well with observations.
Future work

• Seek new case studies for SAM
  – Identified two NAMMA study cases with strong differences in aerosol (dust) impacts.
  – CloudSat data available for comparison to model results using simulator

• Implementation in the MMF
  – Work with those implementing aerosols