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

P. J. DeMott, M. D. Branson, C. A. DeMott,

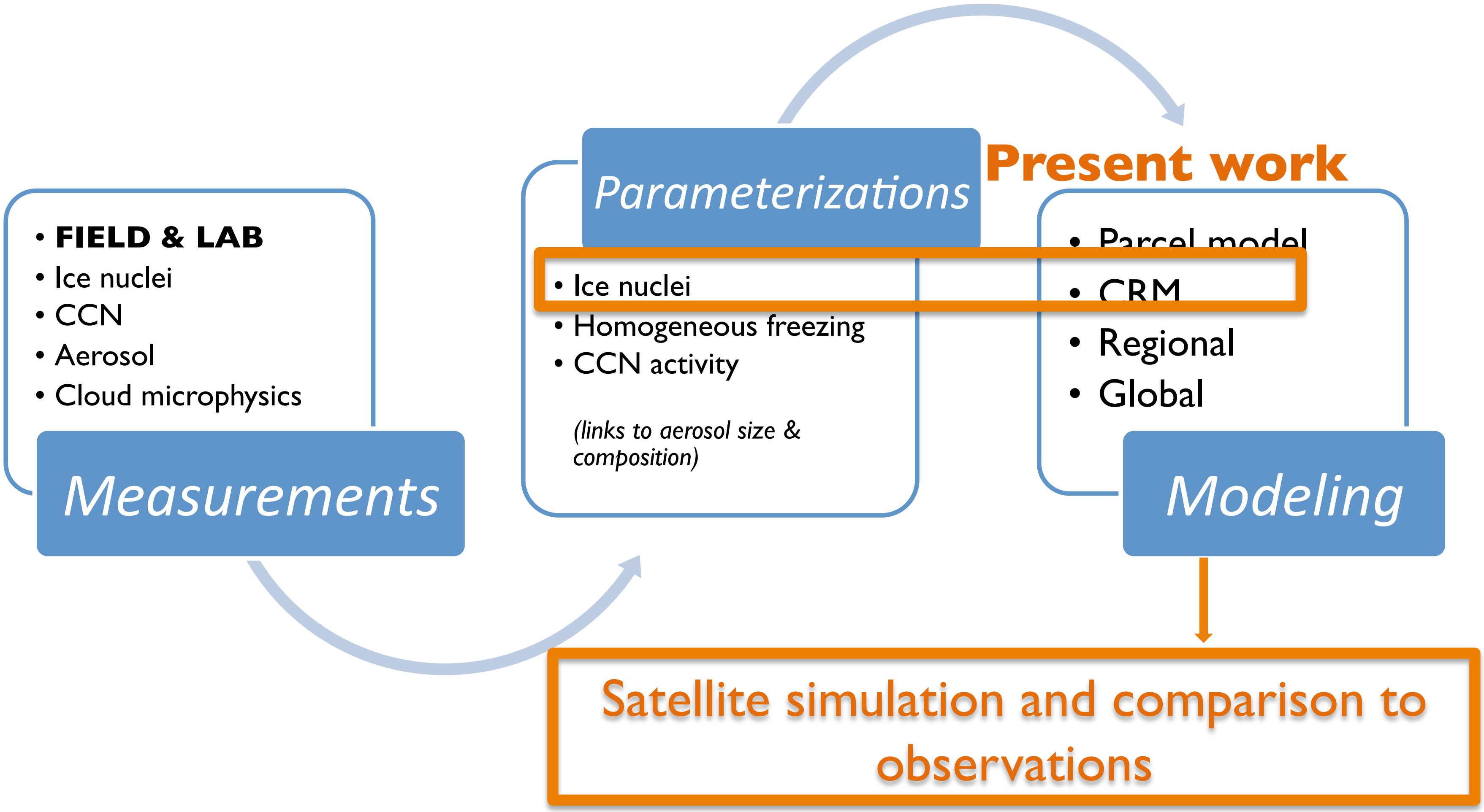
S. M. Kreidenweis, and H. Morrison

Acknowledgments:

DOE-ARM (Grant No. DE-FG02-09ER64772); NSF ATM0611936

National Science Foundation Science and Technology Center for Multi-Scale Modeling of Atmospheric Processes, managed by Colorado State University under cooperative agreement No. ATM-0425247.

Approach


Present work
Parameterizations
• Ice nuclei
• Homogeneous freezing
• CCN activity
(links to aerosol size & composition)
• FIELD & LAB
• Ice nuclei
• CCN
• Aerosol
• Cloud microphysics
Measurements
• Parcel model
• CRM
• Regional
• Global
Modeling
Satellite simulation and comparison to observations

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))

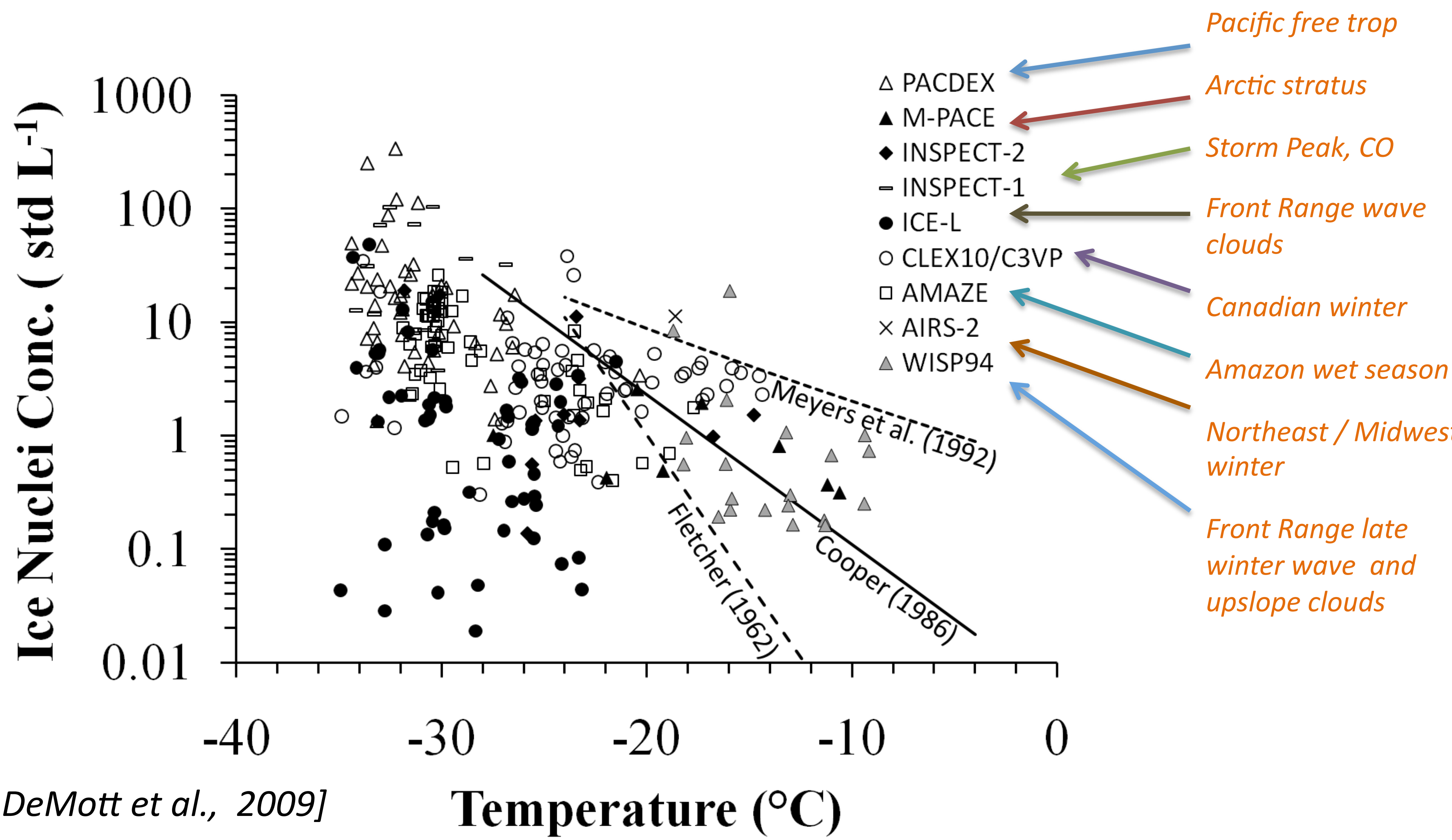
(All depend only on T or ice supersaturation - no links to aerosol properties)

- DeMott et al. (2009):

(T, n_{aer} > 0.5mm diameter)

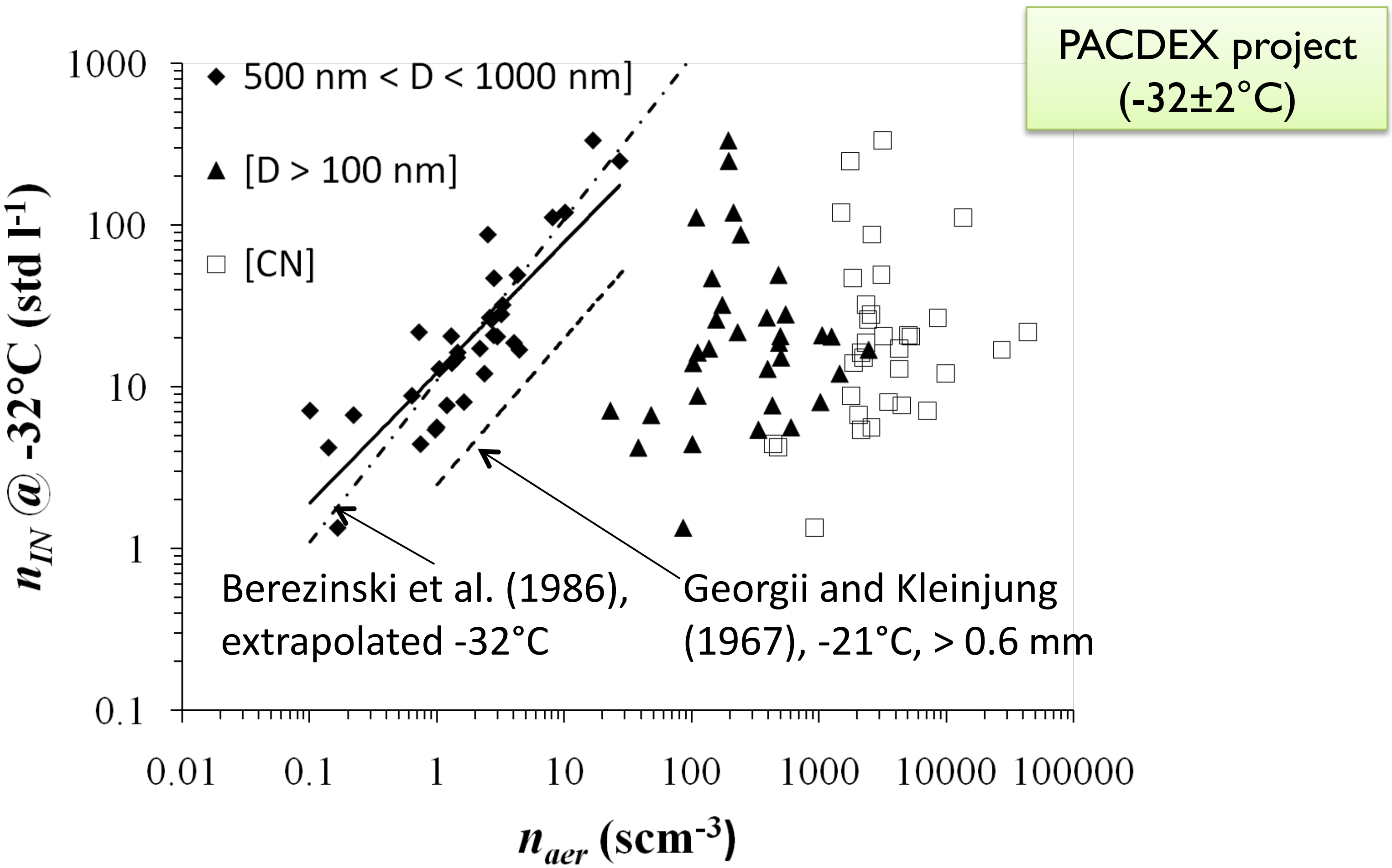
$$n_{in} = a(273.16 - T_k)^b (n_{aer,0.5})^{c(T_k)}$$

Ice nuclei concentrations over several projects (10-30 min. averages)



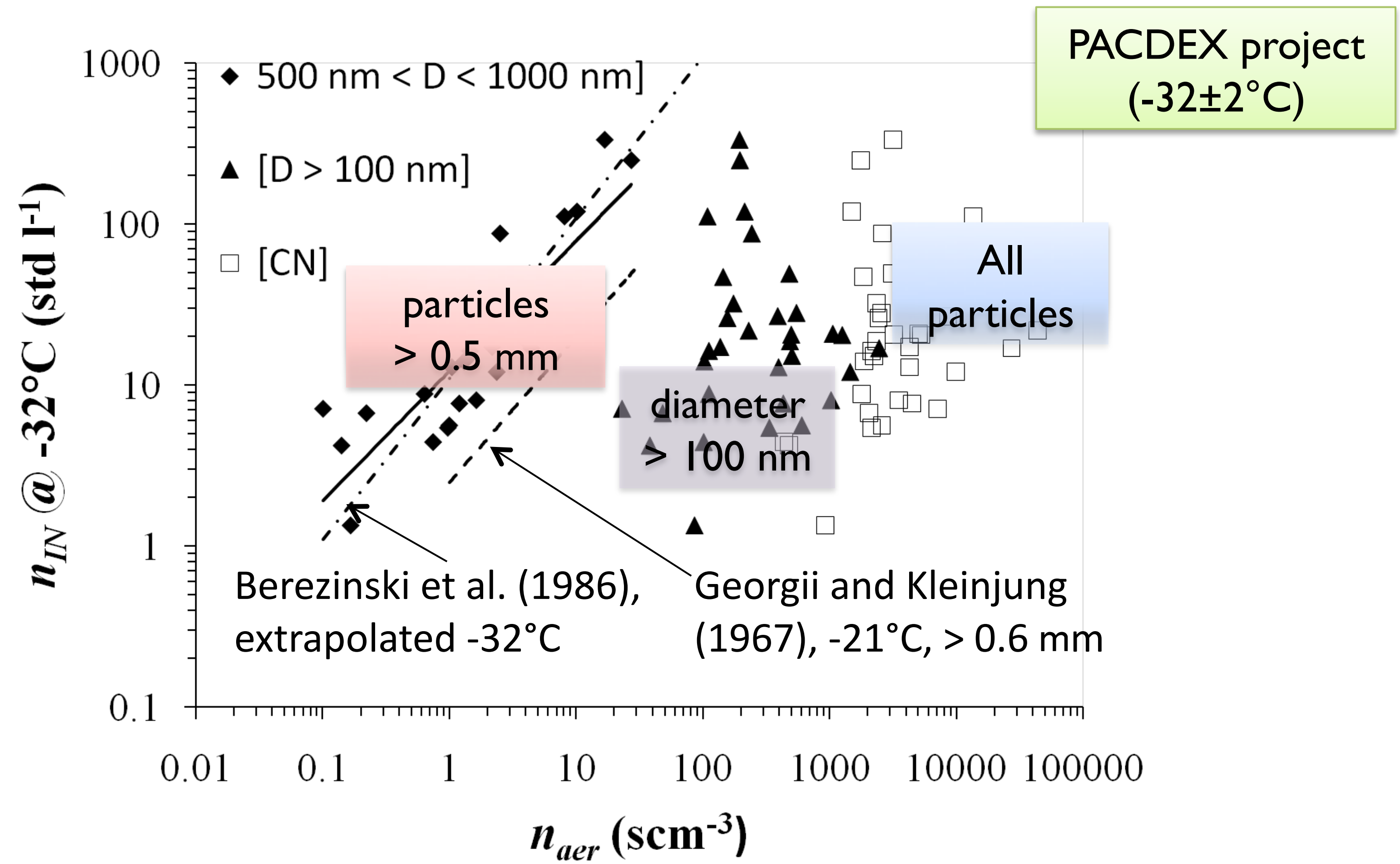
[DeMott et al., 2009]

Major source of IN variability: IN trend with aerosol concentrations when stratified by **size** and **temperature**



DeMott et al. (2009)

Major source of IN variability: IN trend with aerosol concentrations when stratified by **size** and **temperature**



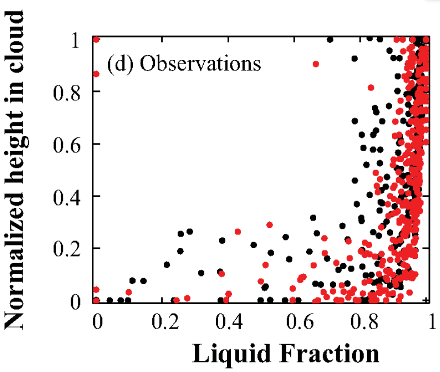
DeMott et al. (2009)

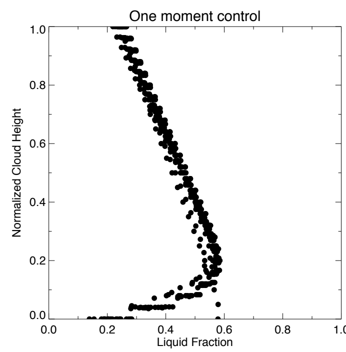
Mixed-Phase Arctic Cloud Experiment simulations with SAM (October 9-10, 2004 single layer cloud)

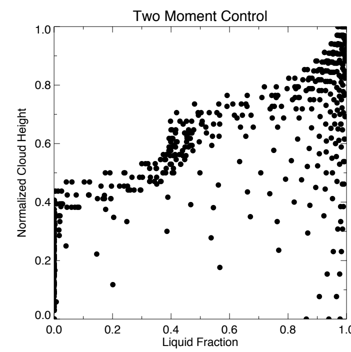
SAM6.8.1 with single-moment microphys. (n_{IN} = 0.16 per liter → observed)

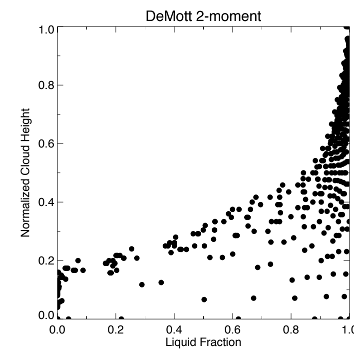
SAM6.8.1 with Morrison 2-moment microphys. (n_{IN} = 0.16 per liter → observed)

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

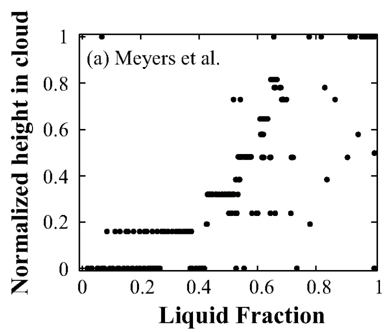




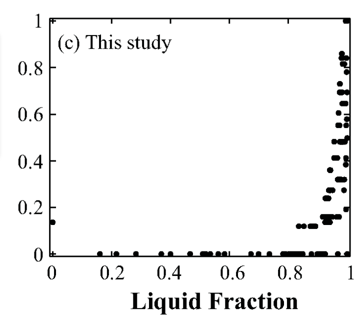




SCAM3 with Liu et al. 2-moment microphys. + Meyers et al. →

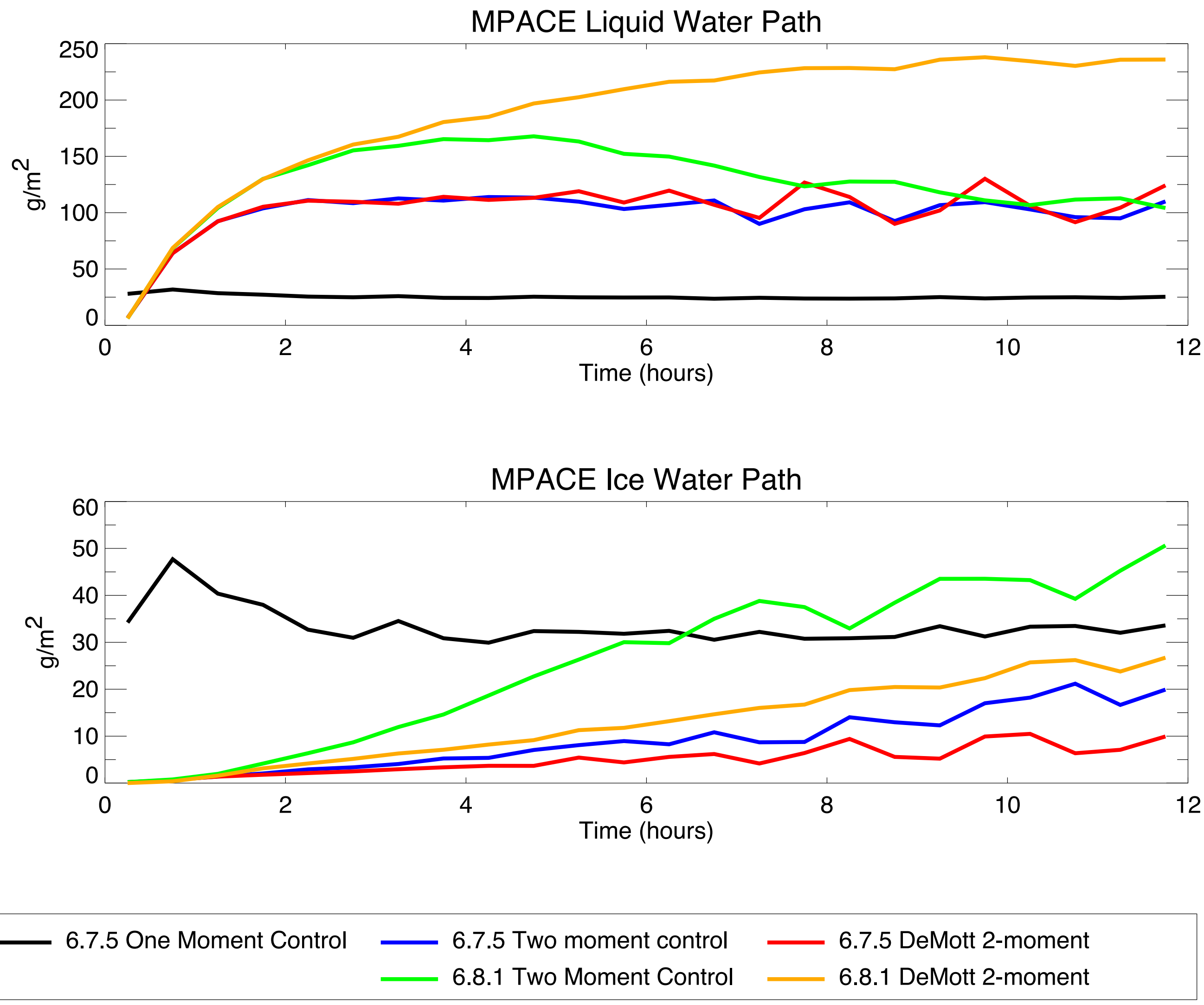


SCAM3 with DeMott IN param, clim. aerosols →

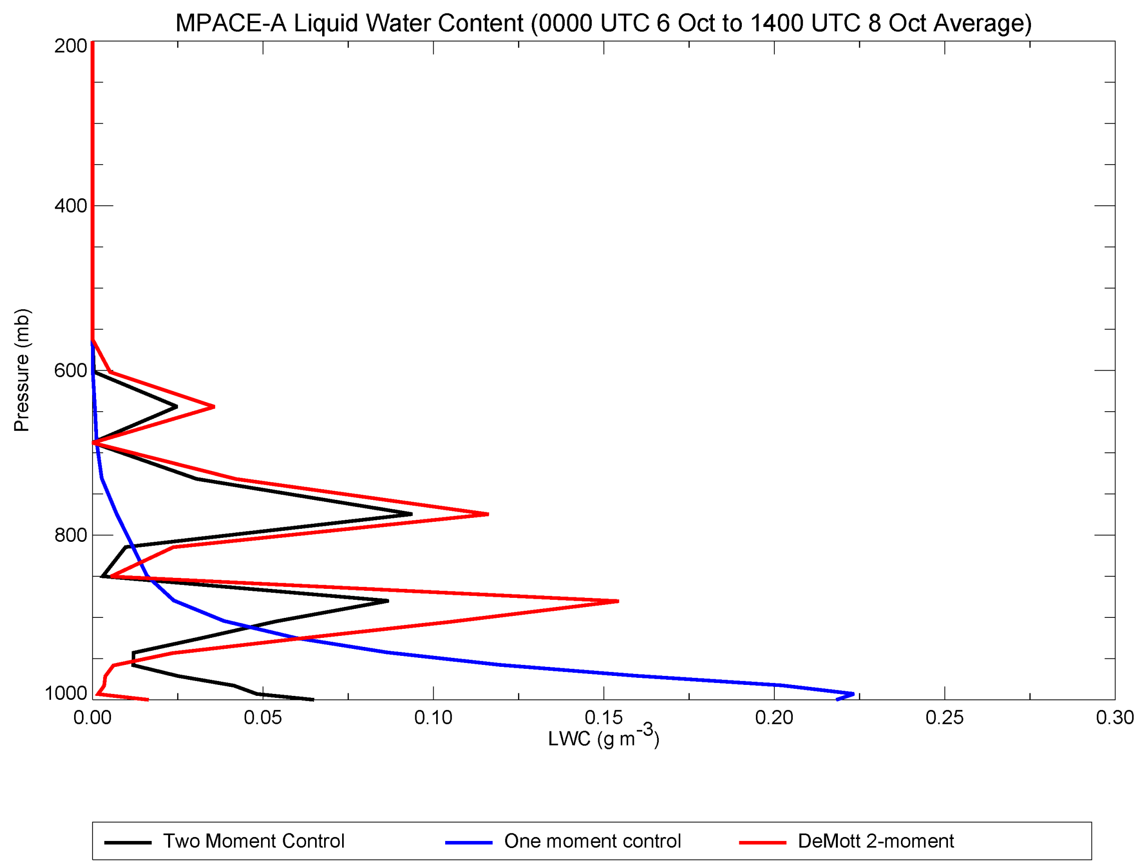


[*DeMott et al.*, 2009]

M-PACE single-layer cloud case



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