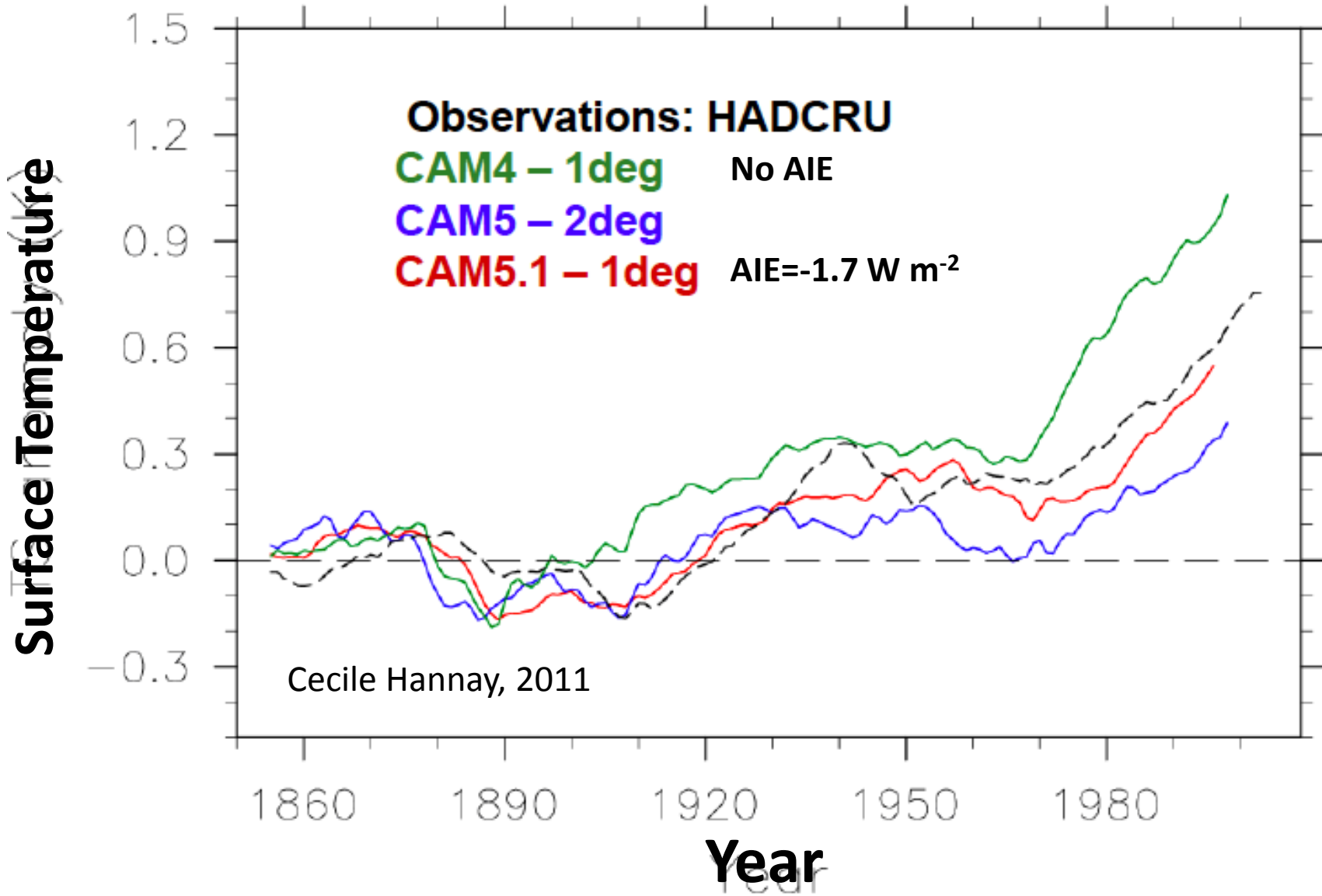


CAPI Challenges

Steve Ghan

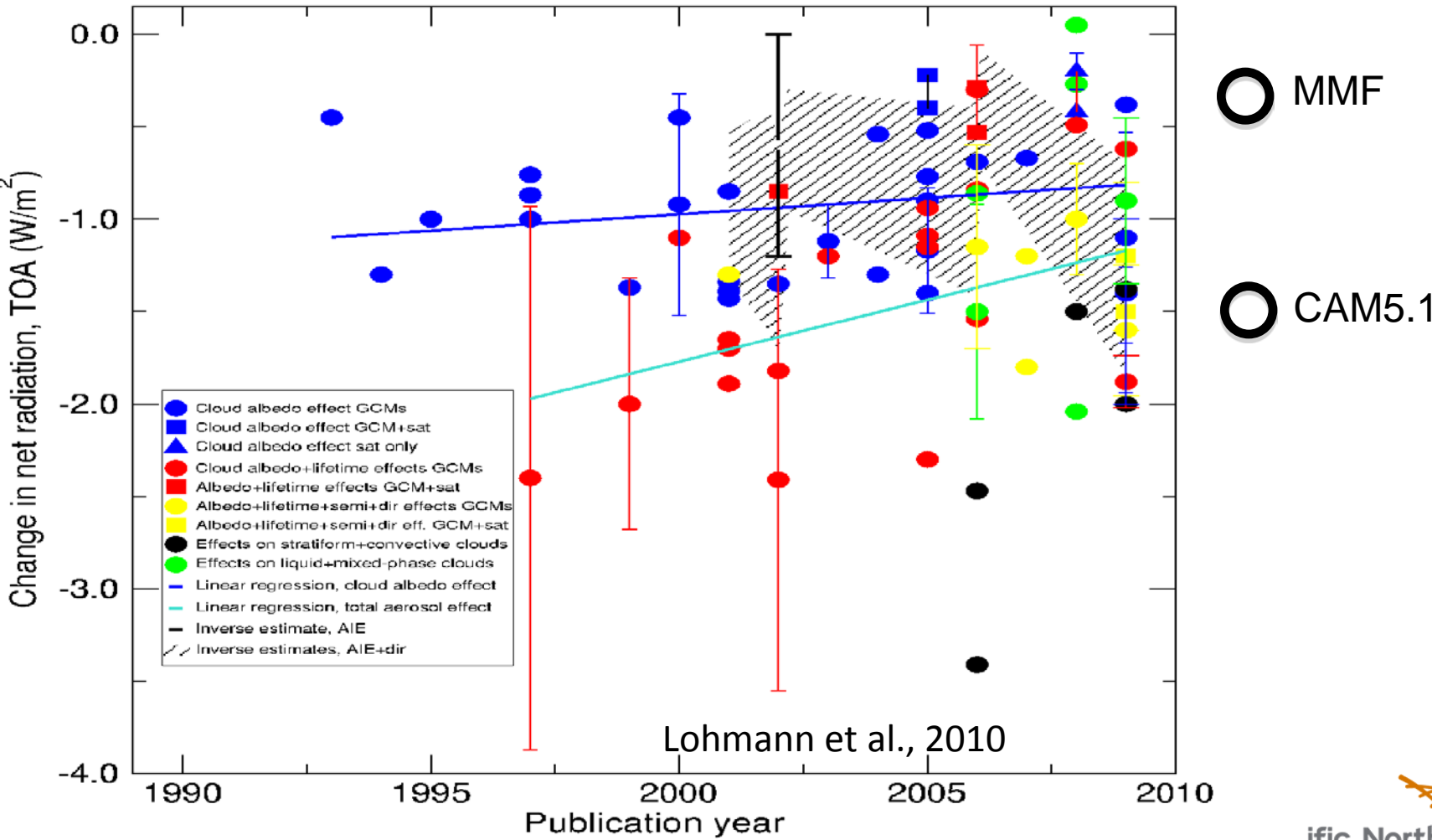
- ▶ Explain why climate models produce large AIE
- ▶ Understand aerosol effects on precipitation
- ▶ Understand the catastrophic collapse of the CAPI system in boundary layer clouds
- ▶ Understand ice nucleation and its impact on mixed-phase clouds

Explain why climate models produce large AIE



Explain why climate models produce large AIE

Published estimates of the aerosol indirect effect
Anthropogenic changes in net radiation at the TOA



Explain why climate models produce large AIE

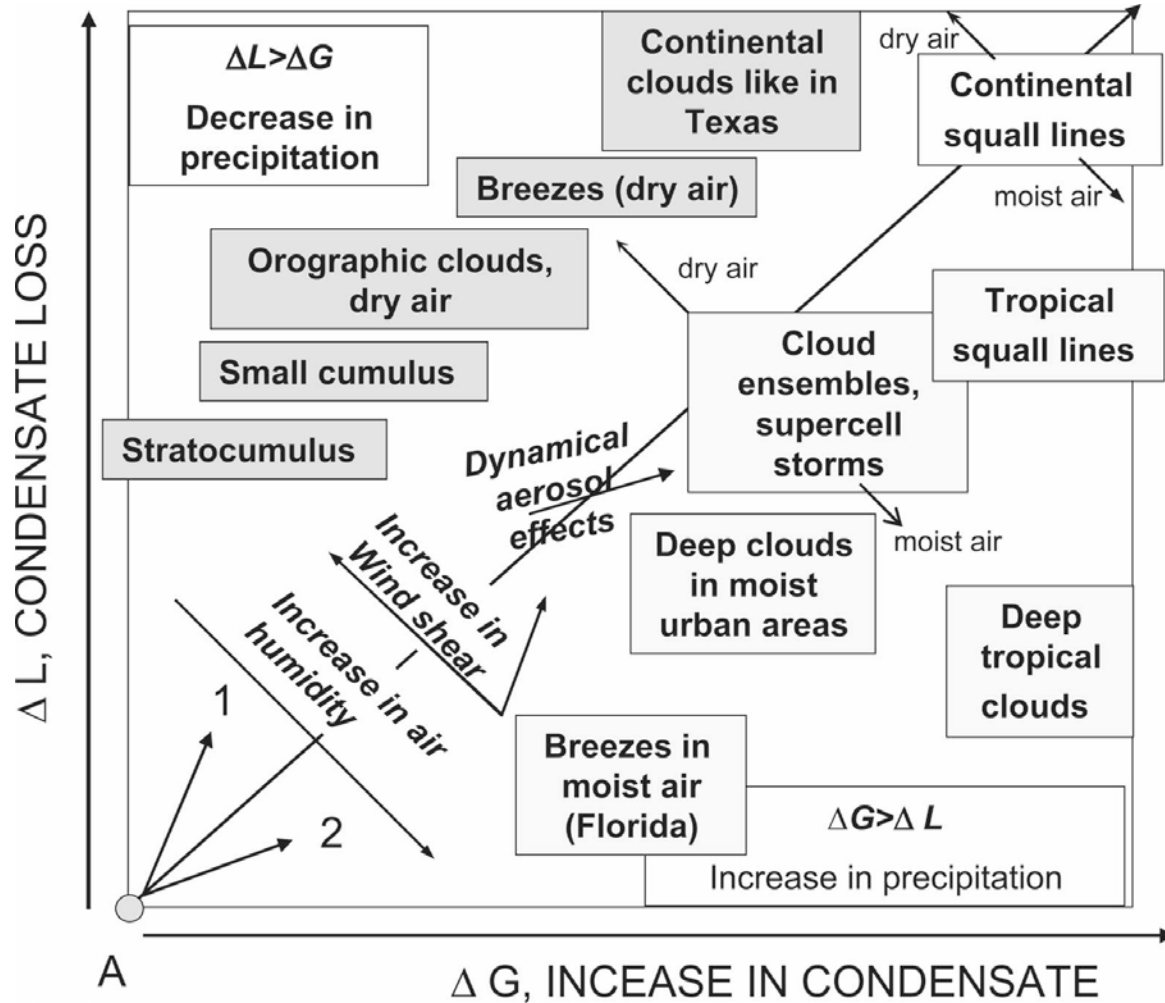
- ▶ Excessive anthropogenic increase in CCN
- ▶ Inaccurate estimate of supersaturation
- ▶ Neglect of influence of entrainment or kinetic limitations on aerosol activation
- ▶ Poor representation of sedimentation effects on liquid water path
- ▶ Inadequate resolution of radiative cooling in thin clouds
- ▶ Excessive influence of droplet number on autoconversion and liquid water path
- ▶ Excessive depletion of CCN concentration by clouds

Yang talk

Earle talk

Wang talk

Understand aerosol effects on precipitation



Khain et al., JAS, 2008

Understand aerosol effects on precipitation

- ▶ Distinction between influence due to activation (indirect effects) vs absorption (semi-direct effects).
- ▶ Understand liquid water path dependence of aerosol effects on precipitation.
- ▶ Separation of aerosol effects from circulation effects.
- ▶ Understand role of atmospheric circulation as a function of spatial and temporal scale.
 - Global equilibrium vs local single cloud lifetime
 - Global versus regional equilibrium
 - Ocean feedback effects

Lee talk

Wang talk

Morrison talk

Understand the catastrophic collapse of the CAPI system in boundary layer clouds

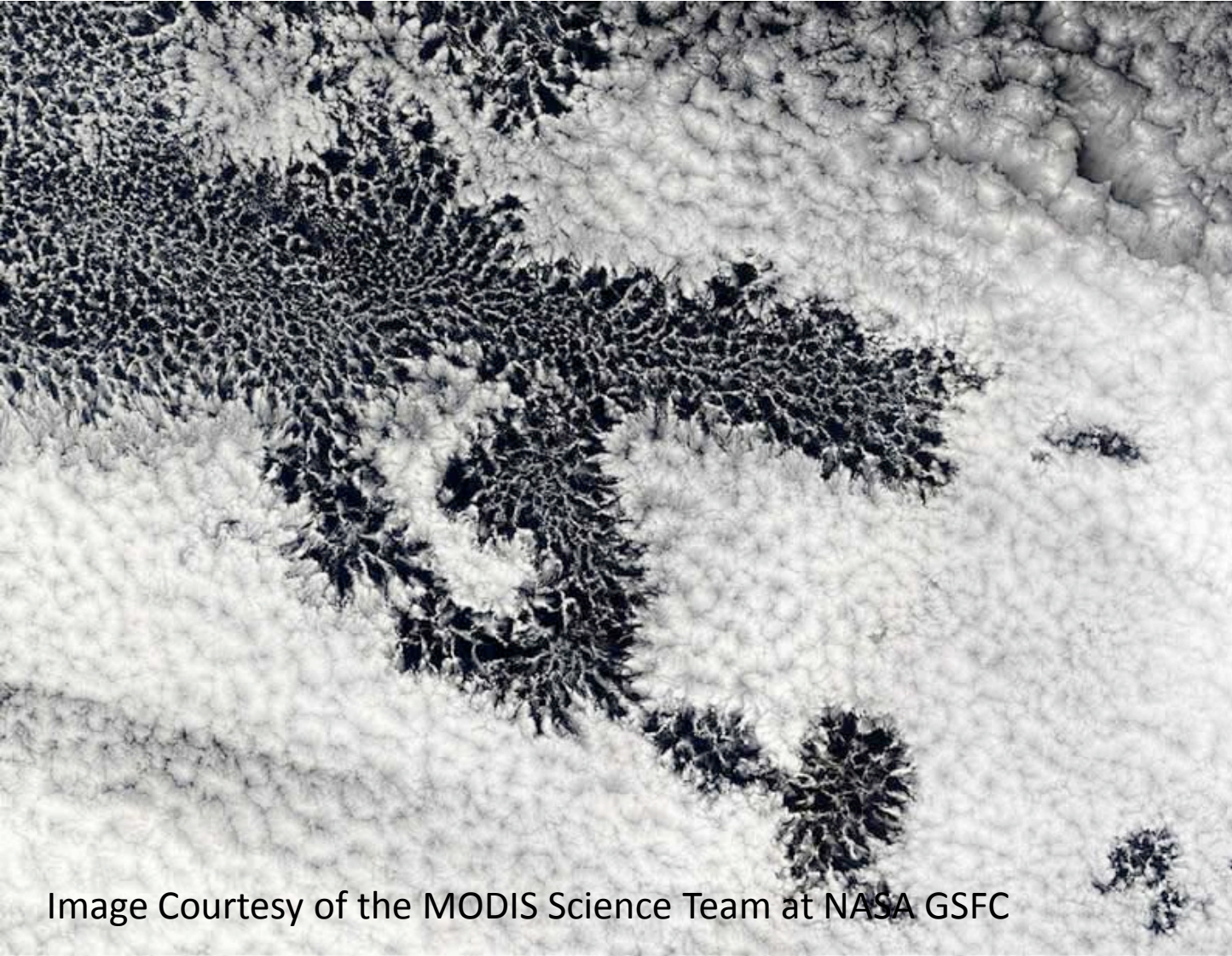


Image Courtesy of the MODIS Science Team at NASA GSFC

Understand the catastrophic collapse of the CAPI system in boundary layer clouds

- ▶ Can this transition be simulated by cloud-resolving models with full cloud-aerosol-precipitation interactions?
- ▶ Can this transition be simulated by a single-column version of a GCM with full CAPI physics?
- ▶ If not, what physics is missing or inaccurate?
- ▶ If the transition can be simulated, was the open cell regime much larger before human emissions?

Yum poster

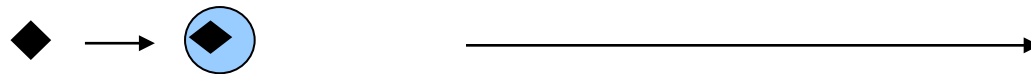
Wyant poster

Baker and Charlson, Nature, 1990

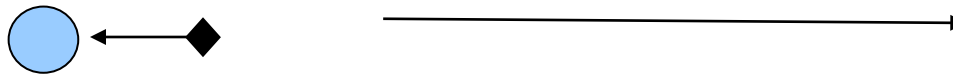
Wood et al., ACP, 2011

Understand ice nucleation and its impact on mixed-phase clouds

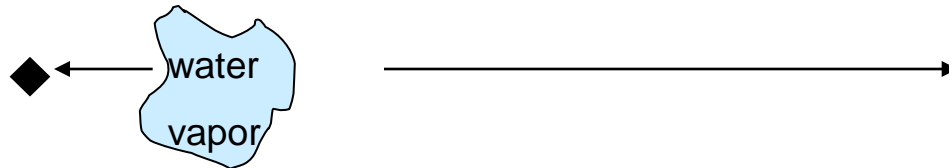
Heterogeneous Nucleation



condensation, immersion $T < 0^\circ$, $RH \sim 100\%$



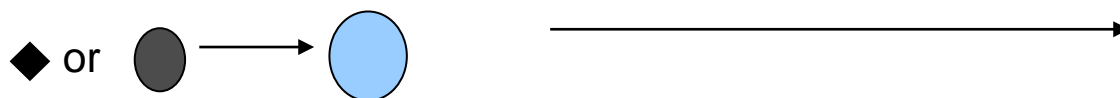
contact $T < 0^\circ$, $RH < 100\%$



deposition $T < 0^\circ$, $RH < 100\%$



Homogeneous Nucleation



condensation, growth $T < -40^\circ$, $RH_{ice} > 100\%$



Understand ice nucleation and its impact on mixed-phase clouds

- ▶ Reconcile the laboratory evidence for inefficient ice activation of soot with field measurements showing soot in cloud ice. Are the ice nucleation chambers missing important nucleation mechanisms?
- ▶ Understand and model the influence of mineral type on activation of dust as an ice nuclei.
- ▶ Understand and model the influence of dust coating by sulfate and organic on ice nucleation.
- ▶ How can the subgrid distribution of ice supersaturation be represented in global models?

DeMott talk
Jouan poster

CAPI PI Talks

- ▶ **Hee Jung Yang** Effect of aerosols on shallow cumuli sampled during RACORO
- ▶ **Seung-Soo Lee** Precipitating cloud-system response to aerosol perturbations
- ▶ **Mike Earle** Indirect effects in Arctic liquid-phase clouds during ISDAC
- ▶ **Paul DeMott** Testing a new aerosol-dependent ice nucleation parameterization for predicting ice nuclei and simulating mixed-phase clouds during ISDAC
- ▶ **Hugh Morrison** Impacts of aerosols on cloud system-resolving model simulations of tropical deep convection during TWP-ICE
- ▶ **Minghuai Wang** Aerosol indirect effects in the PNNL-MMF multi-scale aerosol-climate model