CAPI Science Plan

Steve Ghan, Rob Wood, Graham Feingold, Hugh Morrison, Xiaohong Liu, Laura Riihikmaki

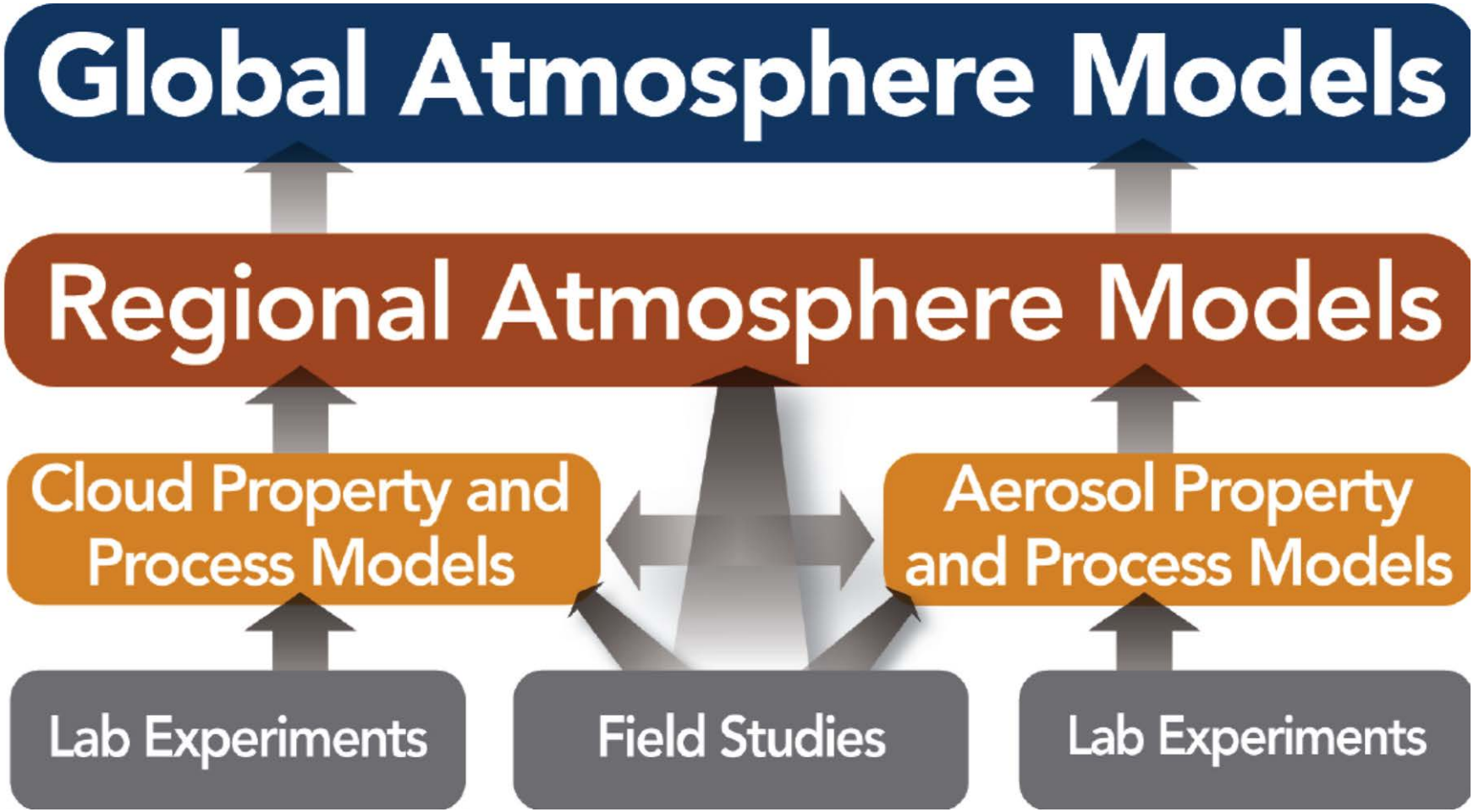
CAPI Science Questions

1. What processes control diversity in the sensitivity of warm low clouds to aerosol perturbations, and why do GCMs seem to overestimate the sensitivity?
2. What aerosol-related processes control deep convective cloud properties relevant to climate?
3. What processes control ice nucleation and its impact on ice-containing clouds?

CAPI Objectives

A. Build measurement and modeling capacity to answer the questions
B. Improve understanding of microphysical processes
C. Improve understanding of the sensitivity of cloud systems to aerosol perturbations

Approach


Global Atmosphere Models
Regional Atmosphere Models
Cloud Property and Process Models
Aerosol Property and Process Models
Lab Experiments
Field Studies
Lab Experiments

Building Measurements

- In situ
- Retrievals
- Field experiments

New in situ Measurements

- Vertical velocity profiles through deep cumulus
- IN measurements at base of deep convection
- IN measurements that more clearly identify mode of ice nucleation
- Lab measurements of ice nucleation on anthropogenic aerosol
- *In situ* ice number with new probes
- CVI that distinguishes between droplets and ice crystals
- Single-particle mass spectrometer behind such a CVI in lab and in field

New Retrievals

- LWP under drizzling conditions
- Light drizzle
- Ice number concentration

New Field Experiments

- SOCRATES to characterize pre-industrial aerosol
- CORMORANT to investigate the relationship between clouds, aerosols, air-sea fluxes and upper ocean properties around the Galapagos Islands
- Aircraft campaign over Azores to validate microphysics, vertical velocity, entrainment retrievals

Building Modeling

- Add subgrid covariance between cloud water and rain to cloud microphysics in global models
- Add prognostic precipitation to global models
- Represent aerosol effects on shallow cumulus clouds in CAM5, including dependence on entrainment
- Improve representation of microphysics in cumulus parameterizations
- Relate all ice nucleation mechanisms to aerosol properties
- Dedicated modeling at SGP

Improving Understanding of Microphysical Processes

- Influence of turbulent mixing/entrainment on droplet number
- Cloud processing of the aerosol through activation, collision-coalescence, aqueous chemistry, and resuspension or removal
- Relative contributions of autoconversion and collection to precipitation
- Role of aerosol effects on condensation in invigoration
- Importance of secondary droplet nucleation in the interior of deep clouds
- Dependence of condensate detrainment on aerosol in deep convective clouds
- Dependence of ice nucleation on
  - updraft velocity
  - anthropogenic aerosol
  - existing cloud ice

Improving Understanding of the Sensitivity of Cloud Systems to Aerosol Perturbations

- Resilience of different cloud regimes to aerosol
- Role of subgrid variability in limiting sensitivity of cloud to aerosol
- Dependence of measured and modeled sensitivity on spatial scale
- Role of cloud processing of aerosol on resilience of cloud-aerosol system
- Influence of hygroscopic and/or ice nucleating aerosol on cloud radiative forcing from deep convective cloud system
- Aerosol influence on precipitation probability and rate
- Role of large-scale constraints on sensitivity of precipitation to aerosol
- Influence of anthropogenic aerosol on glaciation of cloud systems

CAPI presentations

- This session
  - Z Li: Aerosol-Deep-Convection Interactions focus group proposal
  - X. Liu: Ice nucleation focus group proposal
  - L. Riihimaki: VAP update
  - S. van den Heever: aerosol impacts on convection
  - D. Rosenfeld: satellite retrieval of CCN
- CAPI warm clouds
- CAPI deep convective clouds
- CAPI ice nucleation

Invited Presentations: Key Challenges

- Graham Feingold: What processes control diversity in the sensitivity of warm low clouds to aerosol perturbations, and why do GCMs seem to overestimate the sensitivity?
- Jiwen Fan: What aerosol-related processes control deep convective cloud properties relevant to climate?
- Ray Shaw: What processes control ice nucleation and its impact on ice-containing clouds?

Breakout Sessions

- Warm low clouds
  - Joyce Penner: Do GCMs overestimate the warm cloud aerosol indirect effect?
  - Cheng Zhou: Comparison of CAM5 with a cloud resolving model
  - Xiquan Dong: Marine and continental low-level cloud processes and properties, based on ARM SGP and Azores results
  - Jim Hudson: Relationships among CCN spectra, vertical velocity and cloud microphysics in clean and polluted low stratus and cumuli (MASE, POST, RICO, ICE-T)
  - Alexander Marshak: Towards understanding of the transition zone between warm low clouds and clear air
  - Greg McFarquhar: Cloud microphysics analysis from RACORO: How indirect effects and mixing mechanisms impact cloud properties
  - Yangang Liu: : Consideration of interactive influences of aerosol size distribution and updraft to reconcile different dispersion effects
  - Jan Kazil: On the interaction between marine boundary layer cellular cloudiness and surface heat fluxes

- Deep convective clouds (DCC)
  - Jiwen Fan: A new mechanism of aerosol ‘s impact on DCC
  - Zhanqing Li: Estimation of ADCI-induced changes in cloud radiative forcing of DCCs
  - Susan van den Heever: The impacts of aerosols on MCSs observed during MC3E
  - Guang Zhang: Aerosol effects on convection in NCAR CAM5
  - Marcus van Lier-Walqui: Analysis of storm-to-storm and within-storm variability of C-band and S-band polarimetric signatures in MC3E deep convection updrafts
  - Danny Rosenfeld: Satellite retrieval of vertical microphysical profile of convective clouds and retrieving their cloud drop number concentrations
  - Xiquan Dong: Diurnal and life cycles of DCS and associated precipitation and TOA CRFs.
  - Pierre Gentine: Representing the diurnal cycle of continental convection with an ensemble of plumes
  - Virendra Ghate or Jennifer Comstock: Overview and update of the vertical velocity products for studying DCCs
  - M.G. Manoj: Aerosol effects on deep convection over the Indian region during ARM GVAX Campaign
  - Tim Logan: DCS interaction with biomass burning

- Ice clouds
  - P. DeMott: Investigations of ice nucleating particles from sea spray
  - G. Kulkarni: Ice nucleation properties of coated and uncoated dust particles
  - Gijs de Boer: Influence of aerosols on the liquid component of thin mixed-phase clouds
  - Z. Wang: The aerosol dependence of ice generation in stratiform mixed-phase cloud as observed from remote sensing
  - D. Mitchell: Microphysical and radiative impacts of the cirrus cloud negative Twomey effect in two GCMs based on SPARTICUS data
  - X. Liu: Effect of dust speciation on ice nucleation in mixed-phase clouds
  - J. Fan: Evaluation of ice nucleation parameterizations in a storm case from the DC3 field campaign
  - J. Penner: Climate effect of aircraft soot as ice nuclei

Charge for Breakout Sessions

- Show your stuff
- Explore collaborations on analysis
- Identify unmet measurement/retrieval needs
- Discuss potential new field experiments
- Discuss dependencies on / interactions with other ASR groups
- Consider incorporation as a focus group
- Prepare report for plenary tomorrow