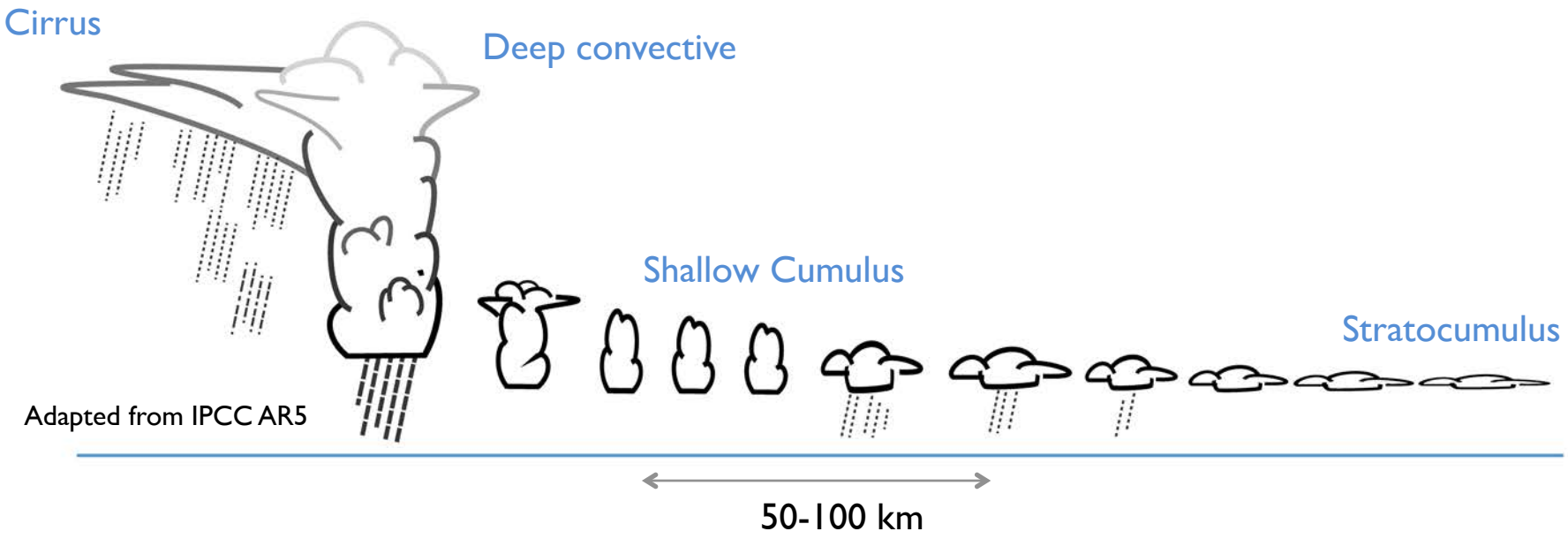
Aerosol, clouds, and precipitation in the climate system

Graham Feingold

Aerosol and Clouds are still a dominant source of uncertainty in Climate Change:
Aerosol-Radiation; Aerosol-Cloud; Cloud Feedbacks



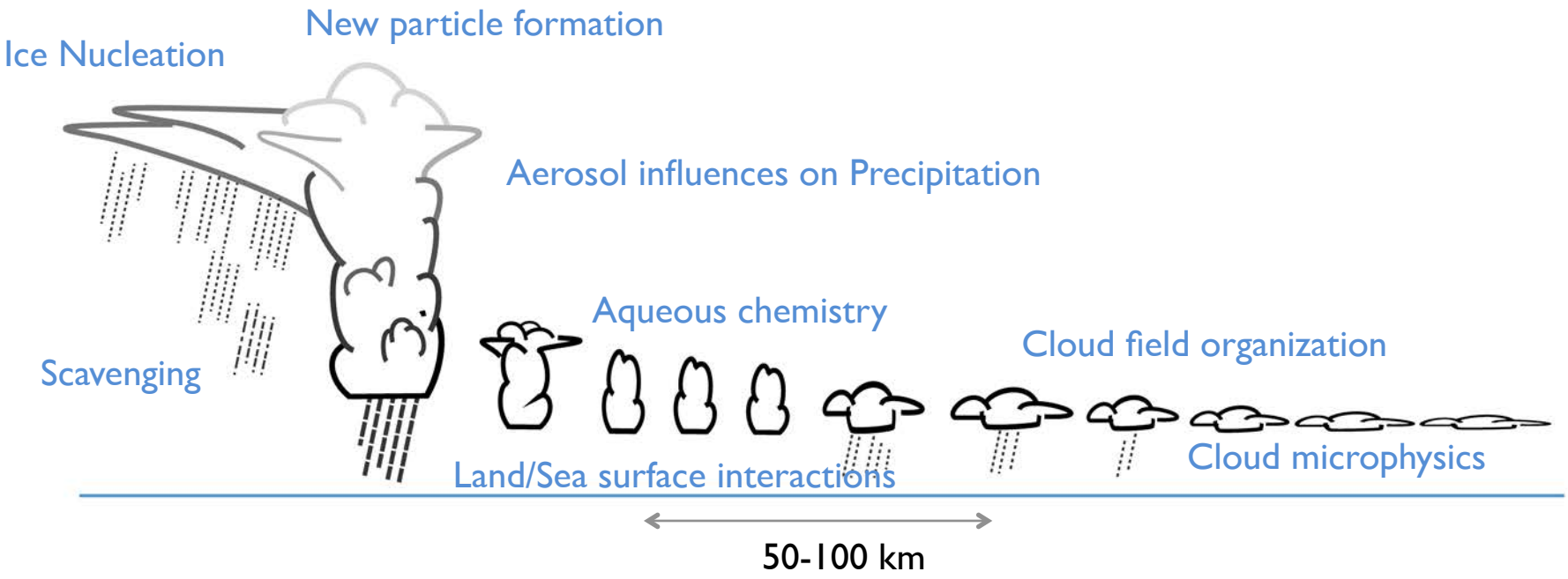
Blue text: Cloud regimes currently under investigation in CSD

Scales: Sub GCM Grid Scales/Seconds-to-Multi Day

Models: Heuristic Models, Parcel Models, Large Eddy Simulation, Cloud Resolving Models

Data: Remote Sensing, Aircraft In-situ, Lab.

Studies of Fundamental Cloud Processes



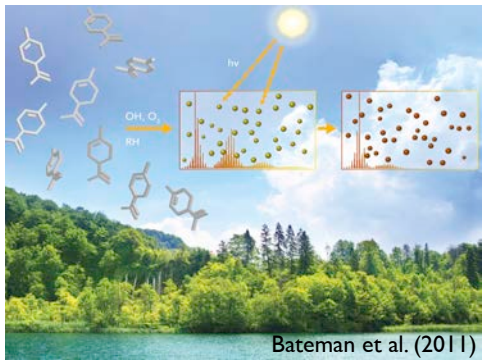
Blue text: Processes under study in CSD

Aerosol-Cloud-Precipitation Themes

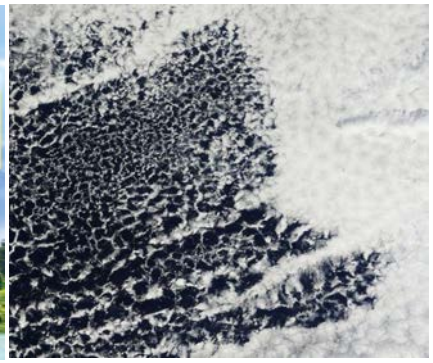
1. Fundamental Processes
2. Indirect Effects (Aerosol ←→ Cloud Interactions)
3. Cloud-Climate Feedbacks
4. Representation of Clouds and Indirect Effects in Climate Models (with GFDL, NCAR)

Process level understanding in support of climate prediction

NOAA Climate Goal: Understand Climate Variability and Change

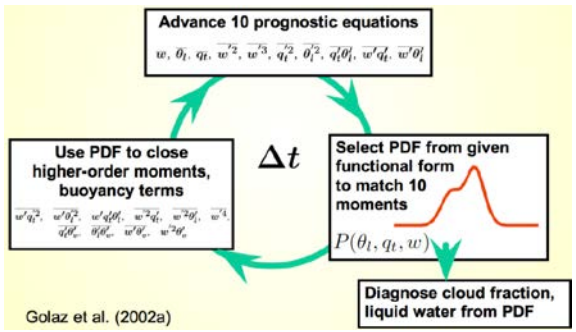


Nucleation (aerosol, ice), chemistry, entrainment



Closed/Open cell transition (aerosol controls)

Changes to clouds in a warmer world



Parameterization of turbulence, clouds, and ACI in GCMs

Key Accomplishments

Fundamental understanding of:

1. Aqueous production of organic aerosol
2. Ice nucleation
3. Marine boundary layer aerosol lifecycle
4. Closed – open cell transitions
5. Shallow cloud-climate feedbacks
6. Aerosol influences on deep convective cloud field organization
7. "Buffering" in the Aerosol-Cloud-Precipitation System

μphysical process level

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system behavior

NOAA Climate Goal: Understand Climate Variability and Change

Key Accomplishments

Fundamental understanding of:

1. Aqueous production of organic aerosol (Barbara Ervens)
2. Ice nucleation
3. Marine boundary layer aerosol lifecycle (Jan Kazil)
4. Closed – open cell transitions (Jan Kazil)
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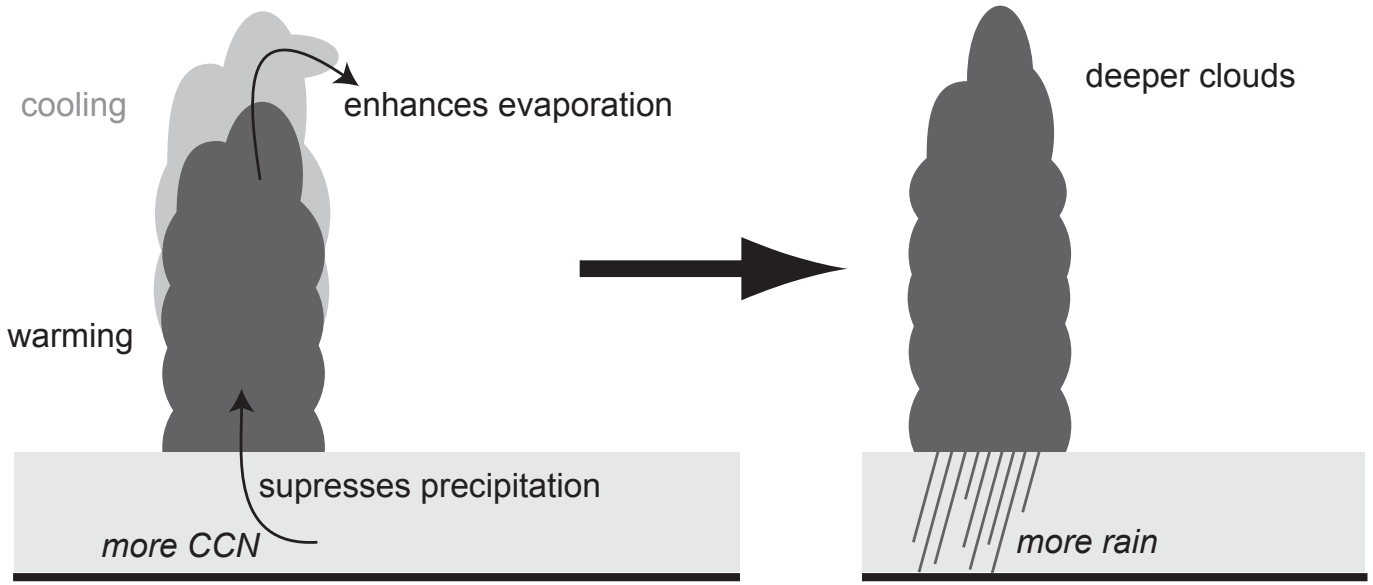
→ *NOAA Climate Goal: Understand Climate Variability and Change*

"Buffering" in the Aerosol-Cloud-Precipitation System

- Many studies suggest that the system is "buffered"
  - Responses to aerosol are smaller than one might have expected in the absence of meteorological adjustments



Stevens and Feingold (2009)

- Aerosol influences should not be considered in isolation!

- Identify conditions or regimes where the system is/is not sensitive to aerosol

Future Directions

Continue to pursue:

- Process level understanding of the aerosol-cloud-chemistry system in support of climate prediction
- More focus on
  - Cloud Feedbacks
  - Mixed-phase clouds and precipitation

- Enhance connections to climate modeling (with GFDL)