Focus Group: Aerosol Deep Convection/Cloud Interaction

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Overarching Question

What aerosol-related processes influence deep convection cloud properties relevant to climate (precipitation, cloud radiative forcing, latent heating profiles)?

Aerosol Effects on Deep Convection

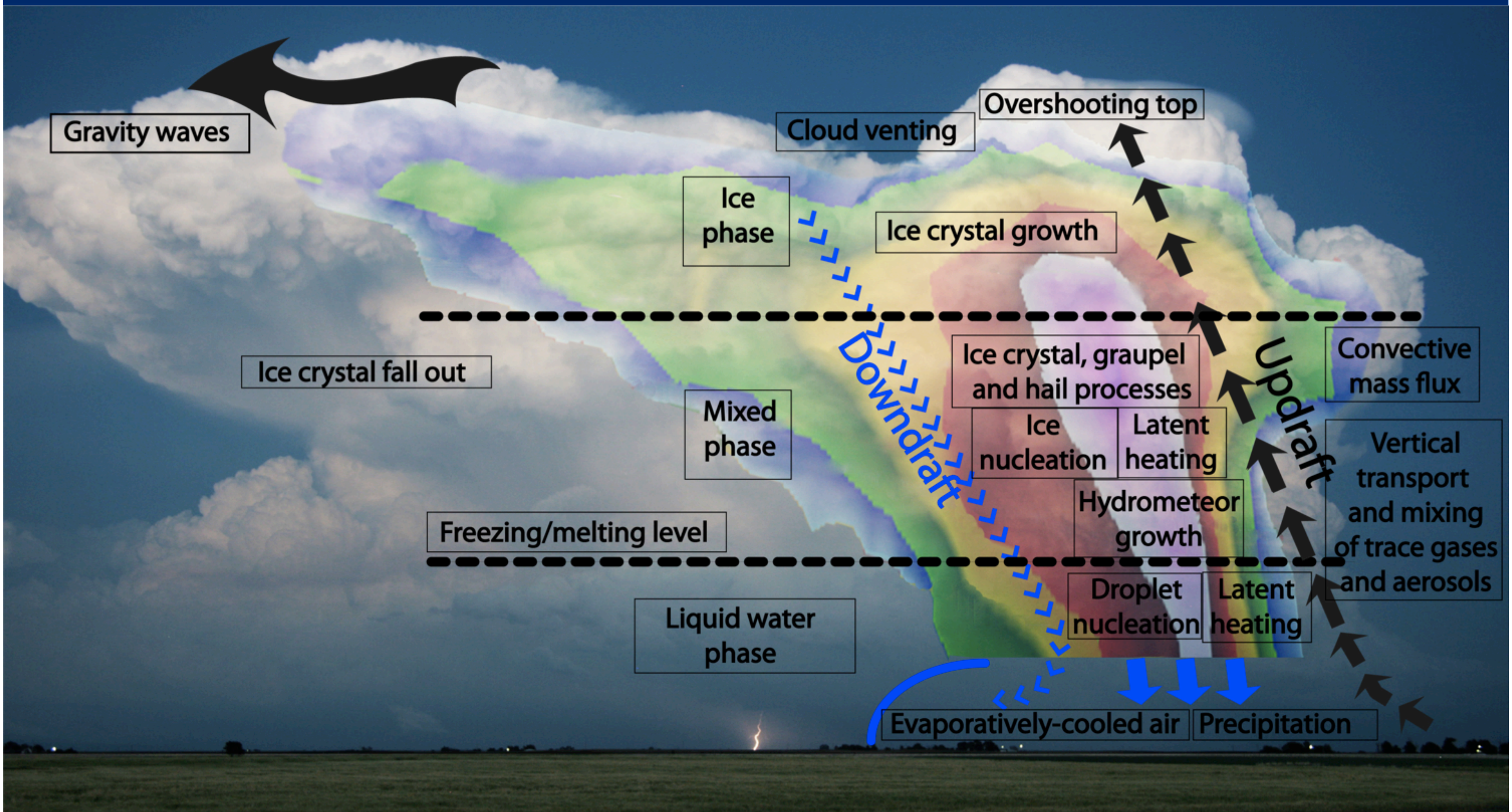


Image: Rob Seigel

Aerosol Effects on Deep Convection

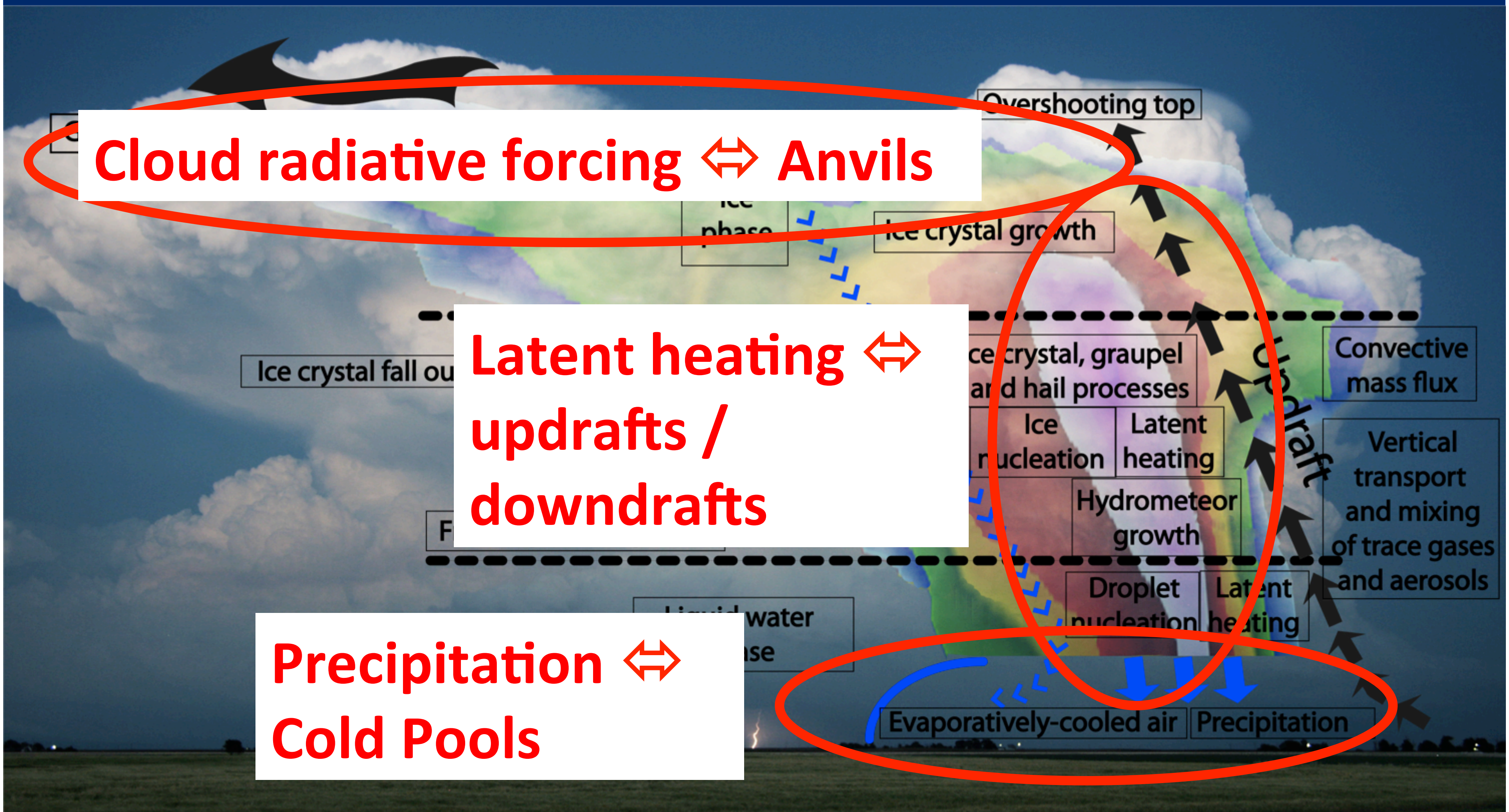


Image: Rob Seigel, Modified by Heever

Objectives

- To find and reinforce key factors determining if aerosol suppresses or invigorates convection by rigorous and insightful analysis of **observations** from both ARM data and other datasets
- To improve our understanding of the mechanisms governing aerosol-deep convection interactions by means of **modeling** with incorporation of observation data.
- Identify differences in aerosol impacts on convection across **models and observations**, and understand specific processes responsible for explaining these differences.

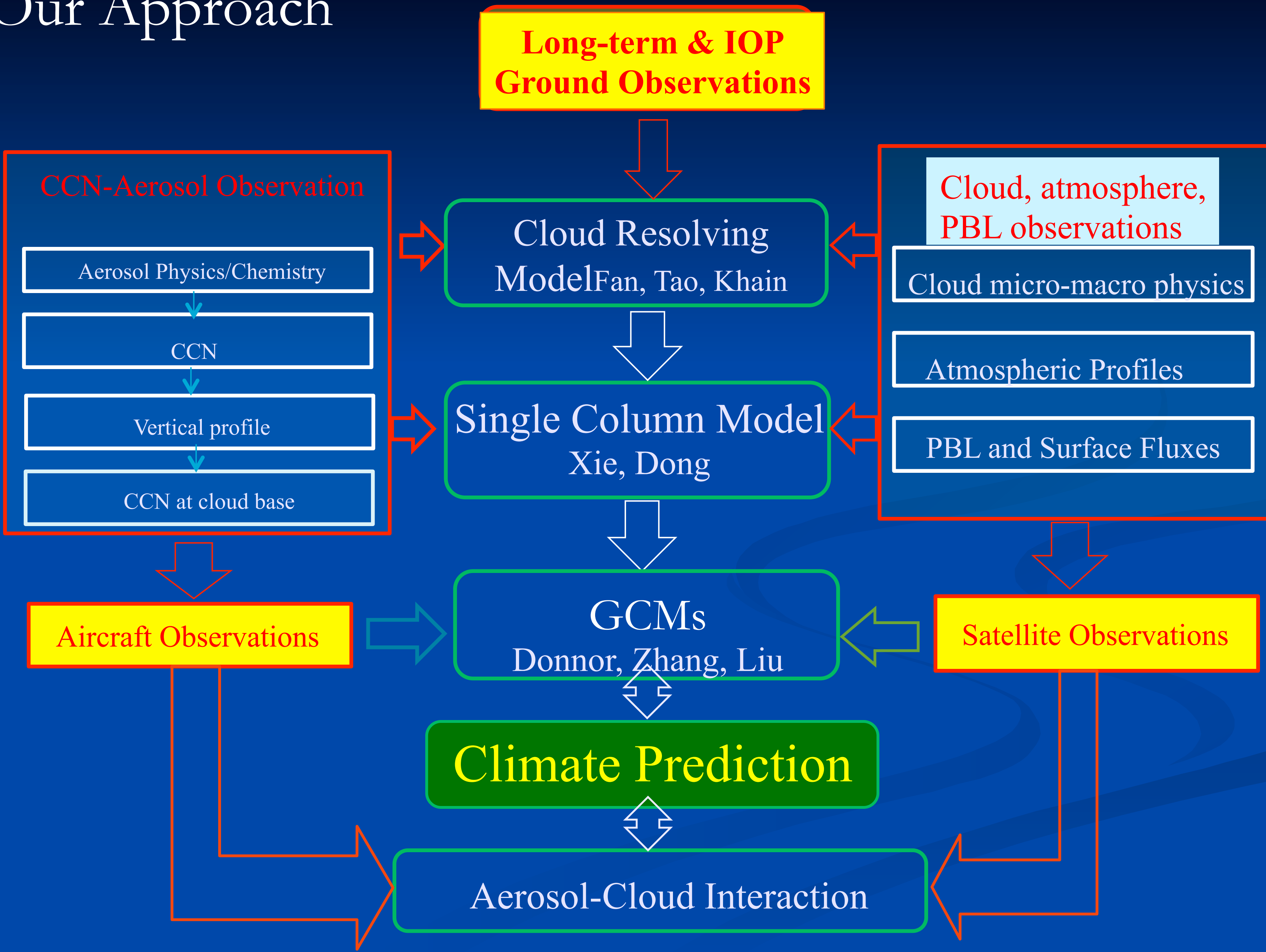
Key Issues & Uncertainties

- Latent heating & vertical velocity:
  - Cloud base height & mixed-phase microphysical processes
  - Vertical velocity
  - Feedbacks between latent heating and vertical motion
- Precipitation

  "Among these modeling studies, the most striking difference is that cumulative precipitation can either increase or decrease in response to higher concentrations of CCN." (Tao et al 2012, Rev. of Geophy.). For CAPI, both rain amount and PDF matter !
- Cloud radiative forcing

  Responses vary from negative to positive responses in recent observational, CRM and conceptual studies

Our Approach

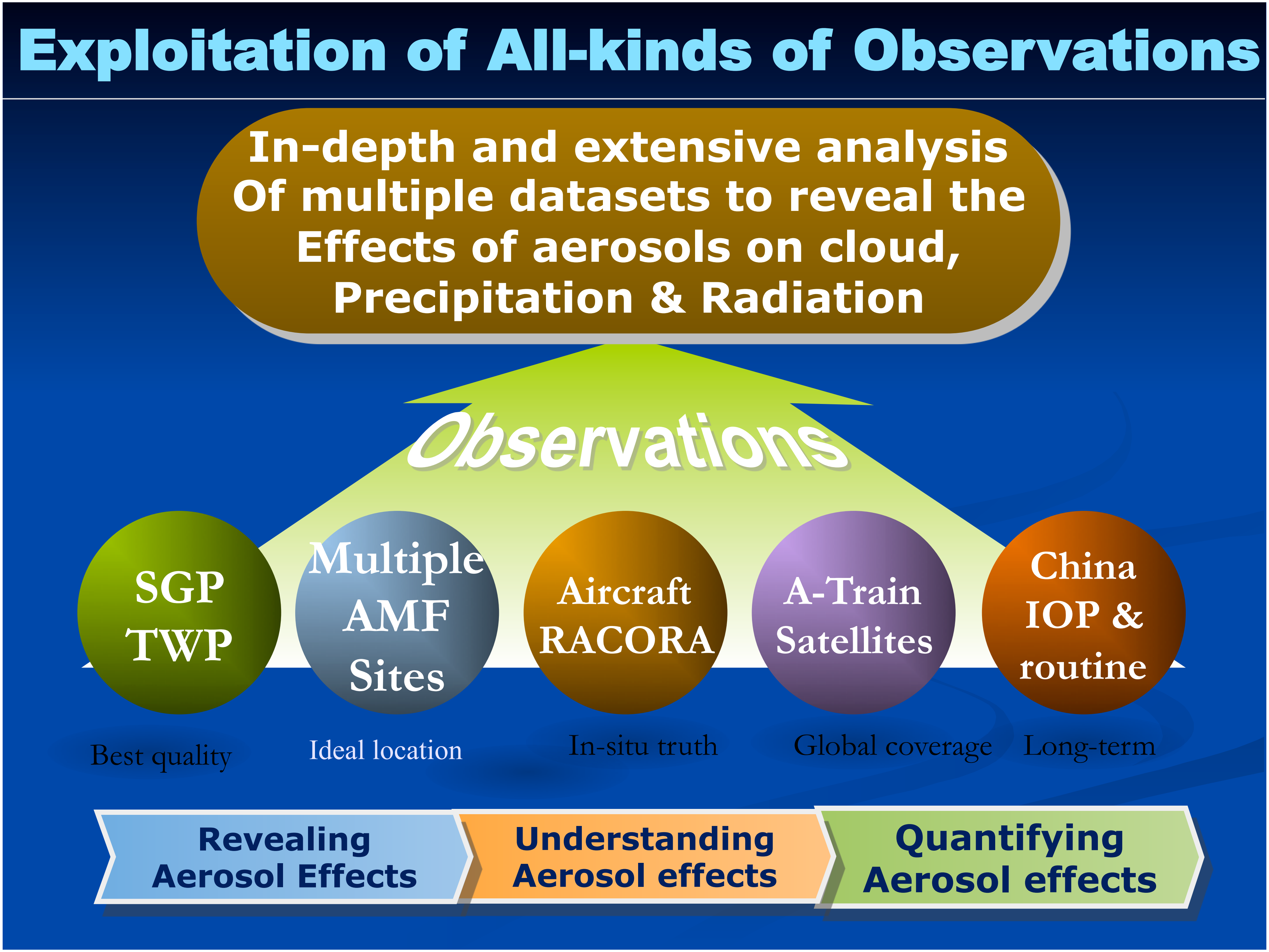


Observation
Needed & Challenges

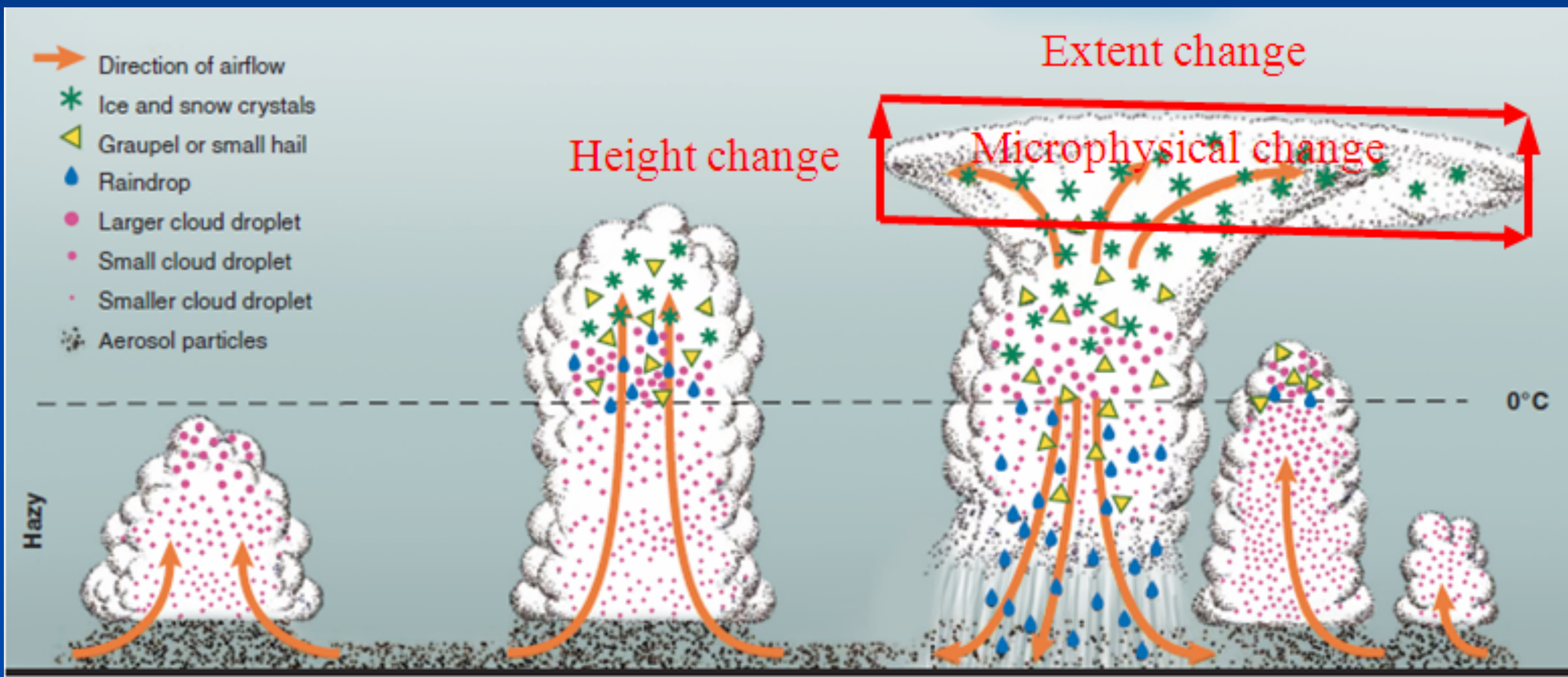
- **CCN near cloud base and IN inside clouds**
- **Vertical velocity through the depth of deep convective systems**
- Latent heat profiles
- Large spatial domain measurements to monitor evolution of cloud system
- Continuous coverage of diurnal variation
- Diverse environmental conditions

Reality Check How We Are Doing

1. Z. Li, Observation data available for our studies
2. D. Rosenfeld, Estimation of CCN at cloud base
3. Kirk North and Scott Collis, 3-D wind
4. X. Dong, Selected cases of DC system
5. Susan Heever, aerosol effect on deep convection
6. J. Fan, Real case simulations.
7. G. Zhang Convective Microphysics Parameterization
8. Leo Donner (GFDL), Aerosol-Deep Convective Coupling in GFDL AM3
9. Ann Fridlind, Combining observations and CRM simulations to constrain aerosol-cloud interaction


Exploitation of All-kinds of Observations
In-depth and extensive analysis
Of multiple datasets to reveal the
Effects of aerosols on cloud,
Precipitation & Radiation
Observations
SGP
TWP
Multiple
AMF
Sites
Aircraft
RACORA
A-Train
Satellites
China
IOP &
routine
Best quality
Ideal location
In-situ truth
Global coverage
Long-term
Revealing
Aerosol Effects
Understanding
Aerosol effects
Quantifying
Aerosol effects

Impact of aerosols on cloud radiative forcing (Aerosol-Mediated CRF)



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Modeling Challenges

What can explain large differences among different modeling studies?

- - different cases (sensitivity to environment, e.g., shear, RH, CAPE)
- - differences in models and model parameterizations (e.g., bulk vs. bin microphysics)
- - different spatial and temporal scales
- How can we best use ARM observations (and other datasets) to constrain models?

What collaborative activities can we focus on to address these issues?

- - e.g., systematic modeling studies to address differences for observationally based cases a la GCSS/GASS???

Reality Check How We Are Doing

1. Z. Li, Overall observation data available for our studies
2. D. Rosenfeld, Estimation of CCN at cloudbase
3. Kirk North and Scott Collis, 3-D wind
4. X. Dong, Datasets tailored for DCS.
5. Ann Fridlind, Combining observations and CRM simulations to constrain aerosol-cloud interaction
6. J. Fan, Real case simulations.
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Recommendation for Observation

1. To continue the pursuit of challenging quantities as identified above

2. To exploit extensive measurements from ground-based (all ARM fixed sites and AMF sites), air-borne (ARM campaigns) and space-borne measurements to attempt to identify and quantify different types of AIEs

3. To provide metrics of the estimates of AIEs from a variety of observation platforms for validation and improvement of a hierarchy of models

Recommendation for Modeling

1. **To continue process-oriented modeling exercises to tackle with outstanding issues identified**

2. **To run LES, CRM, SCM and GCM models to try to simulate observed cloud scenes with diverse aerosol inputs and meteorological settings.**

3. **To analyze modeled quantities in the similar manner as the analyses of observations to examine various relationships as revealed from observations concerning different types of AIEs.**

Recommendation for Observers & Modelers

1. Identify deficiencies in both modeling and observations regarding their validity in studying the AIE.

2. Sort out true effects from false appearance.

3. Evaluation of model's performance in simulating the AIEs from local to global scales