1. Retrieving precipitating mixed-phase cloud properties

2. A suggestion for a new focus on cloud microphysical process study in the ARM program

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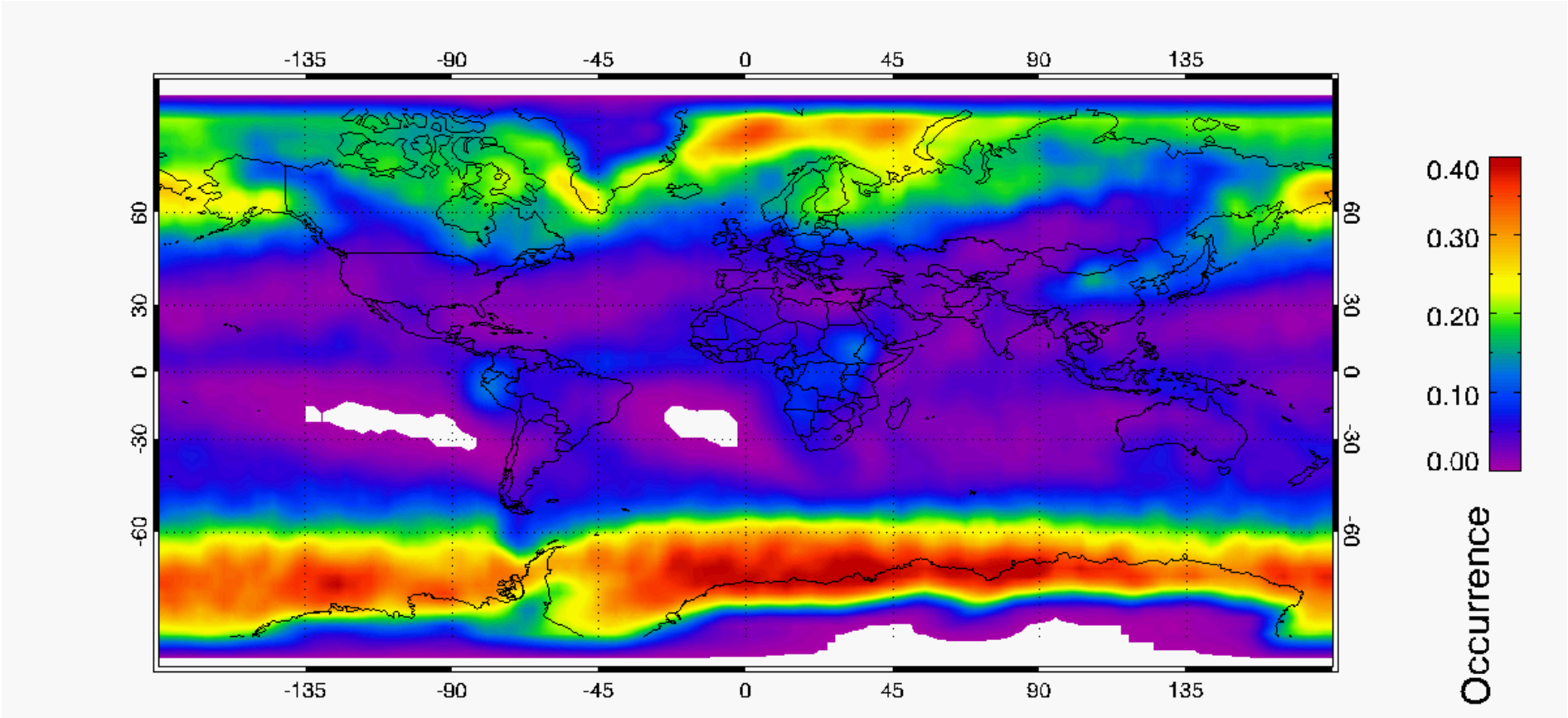
Retrieving Precipitating Mixed-phase Cloud Properties

Global distribution of supercooled water topped stratiform clouds (top > 1 km and length> 14km)

Most of them are mixed-phase with precipitation or virga



An multiple sensor based approach to provide water phase as well as ice phase properties

Measurements

- **MWR**
- **MPL or Raman lidar**
- **MMCR**

The approach

Water Phase:

MWR – LWP

MPL+ adiabatic cloud model: r_{eff}

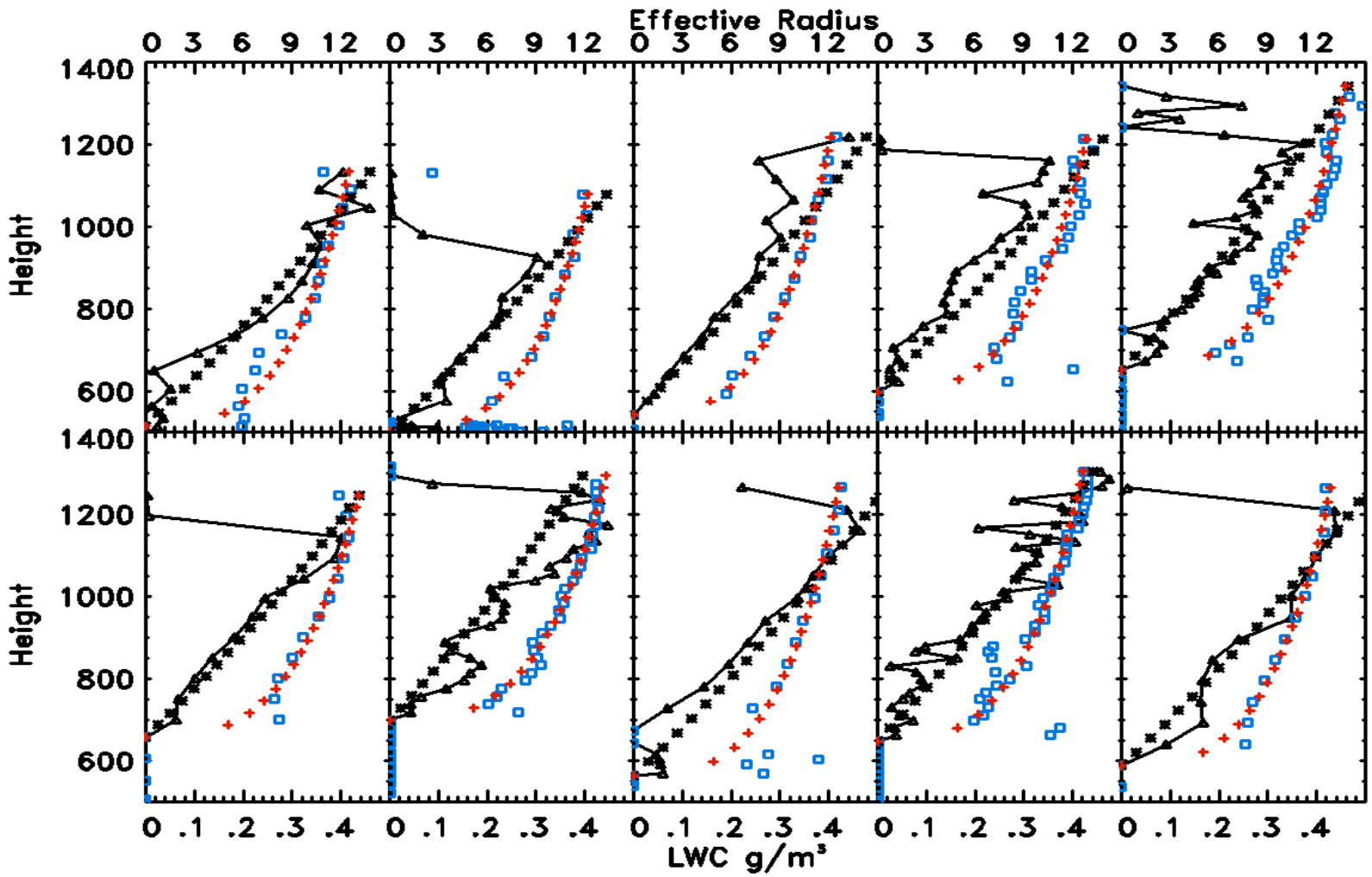
Ice phase:

MPL+MMCR

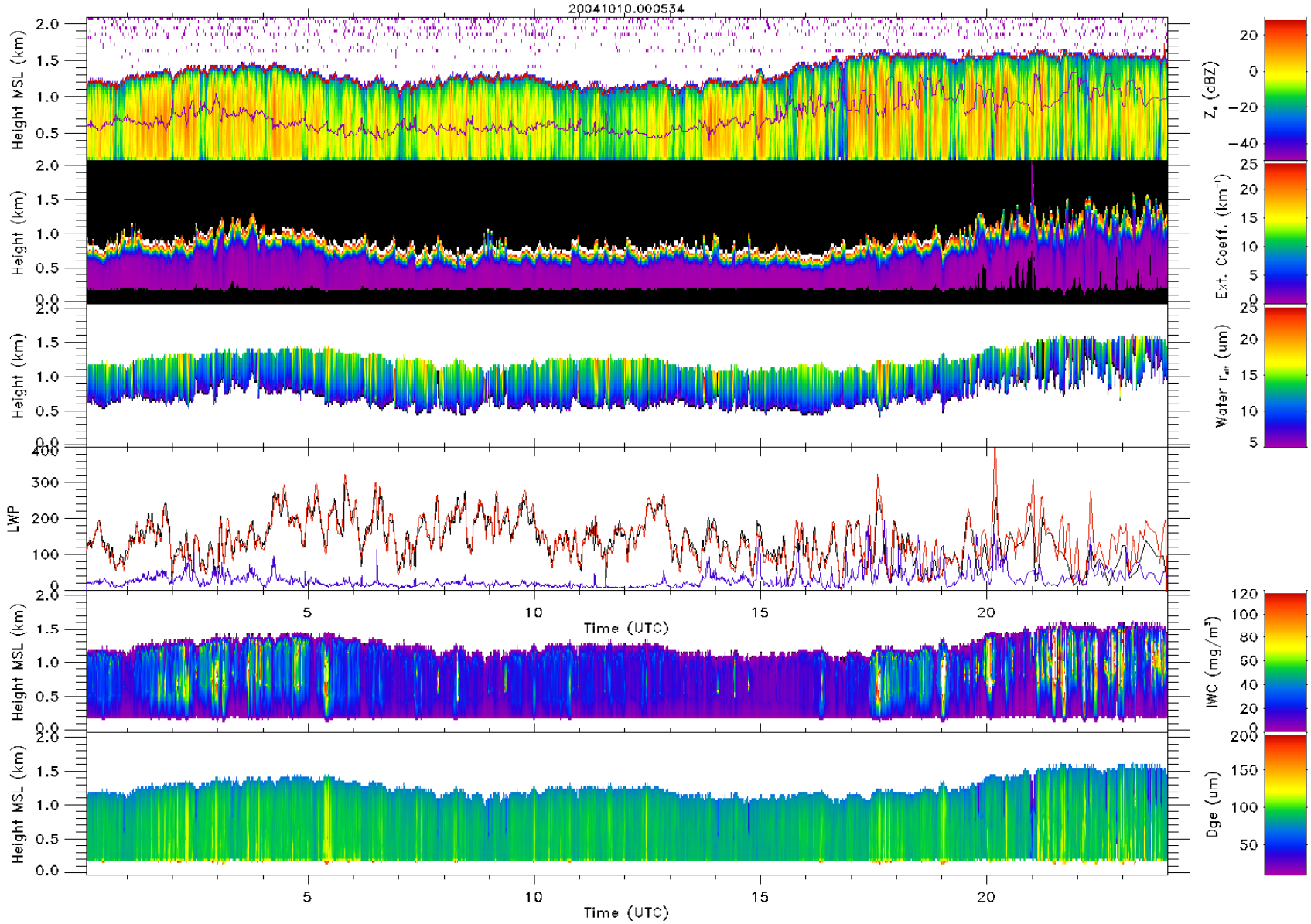
$$LWC = \frac{2}{3}\rho_w \sigma\, r_{eff}$$

$$\frac{LWC(z1)}{LWC(z2)} \approx \frac{r_{eff}(z1)^3}{r_{eff}(z2)^3}$$

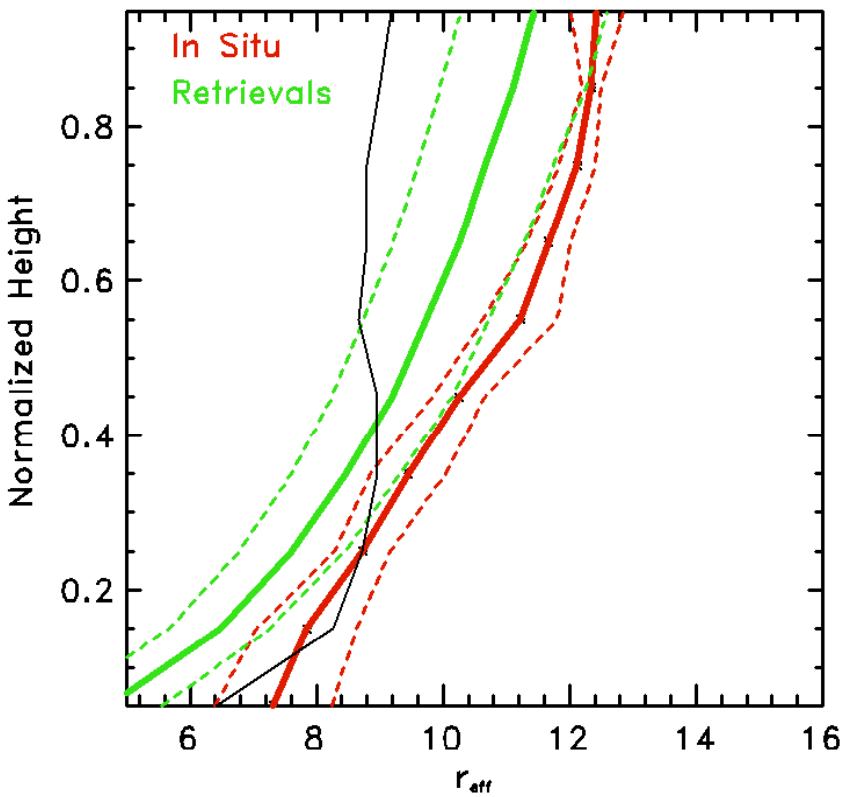
How good the r_{eff} fitted to adiabatic model?

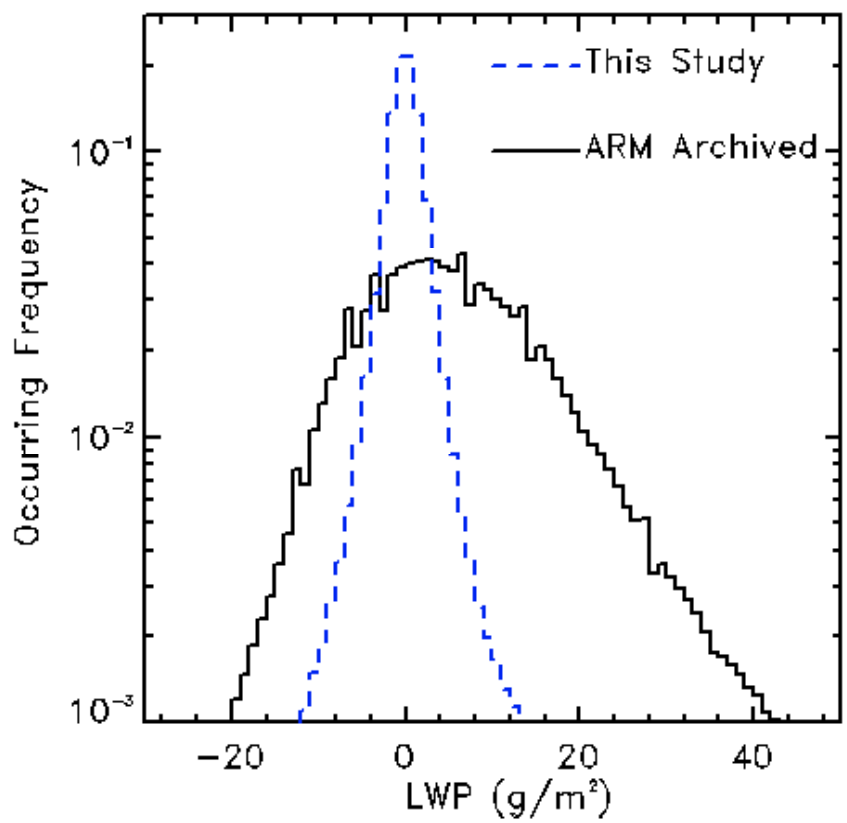


An retrieval example



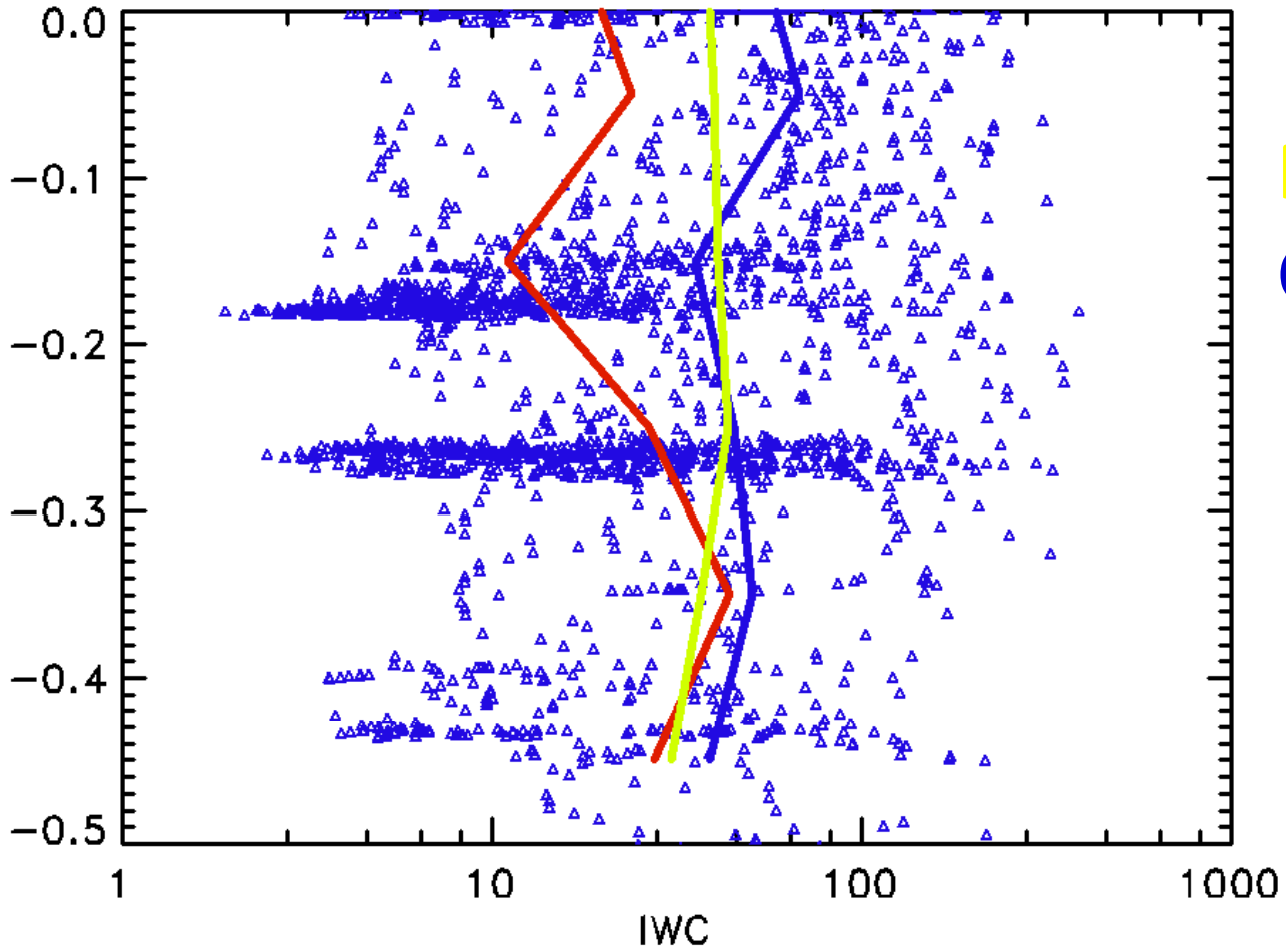
Ballpark Uncertainties
r_{eff} < 15% and LWP <10%





Ballpark uncertainties

IWC ~30%

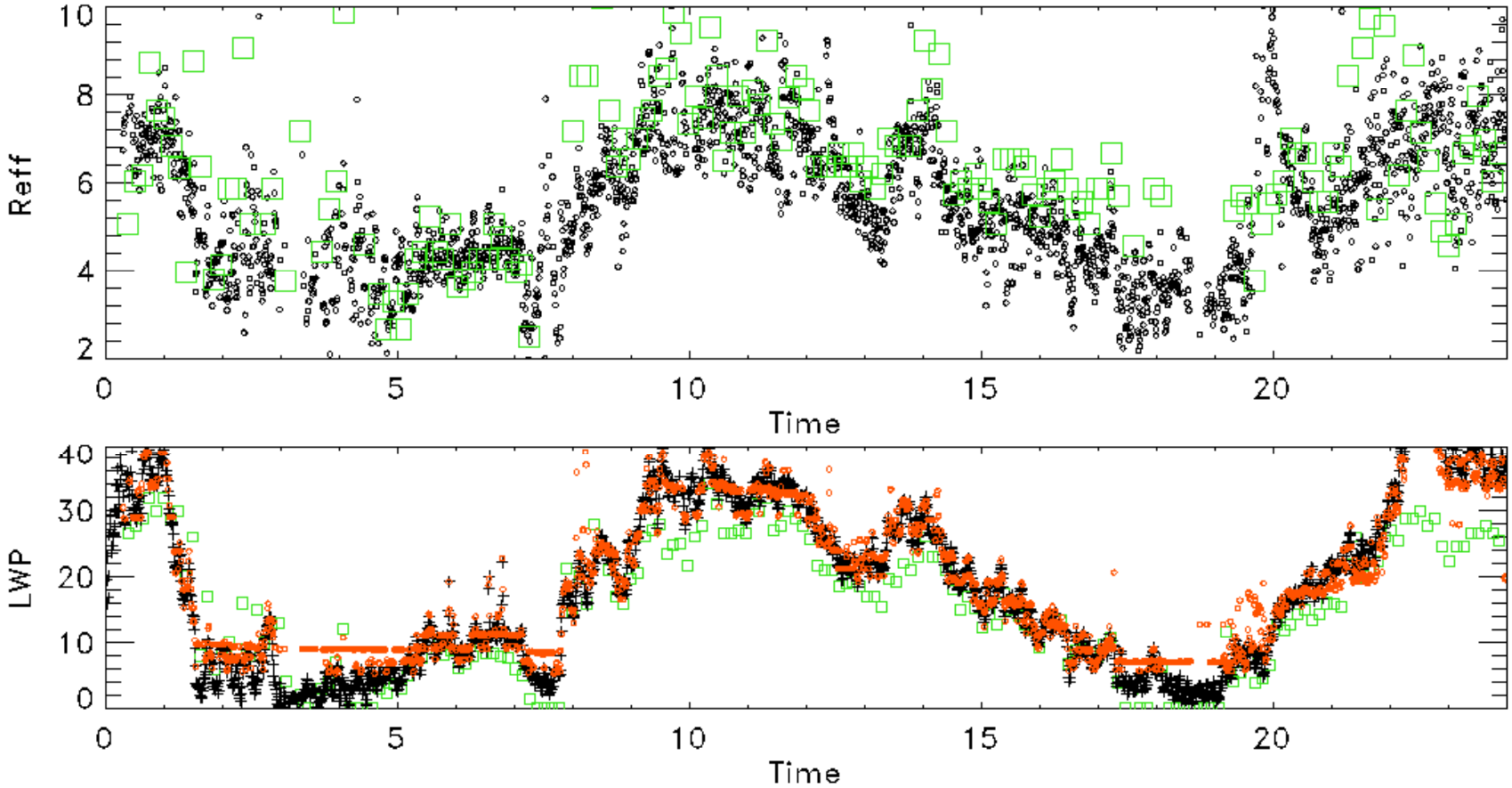


Retrievals

CVI IWC

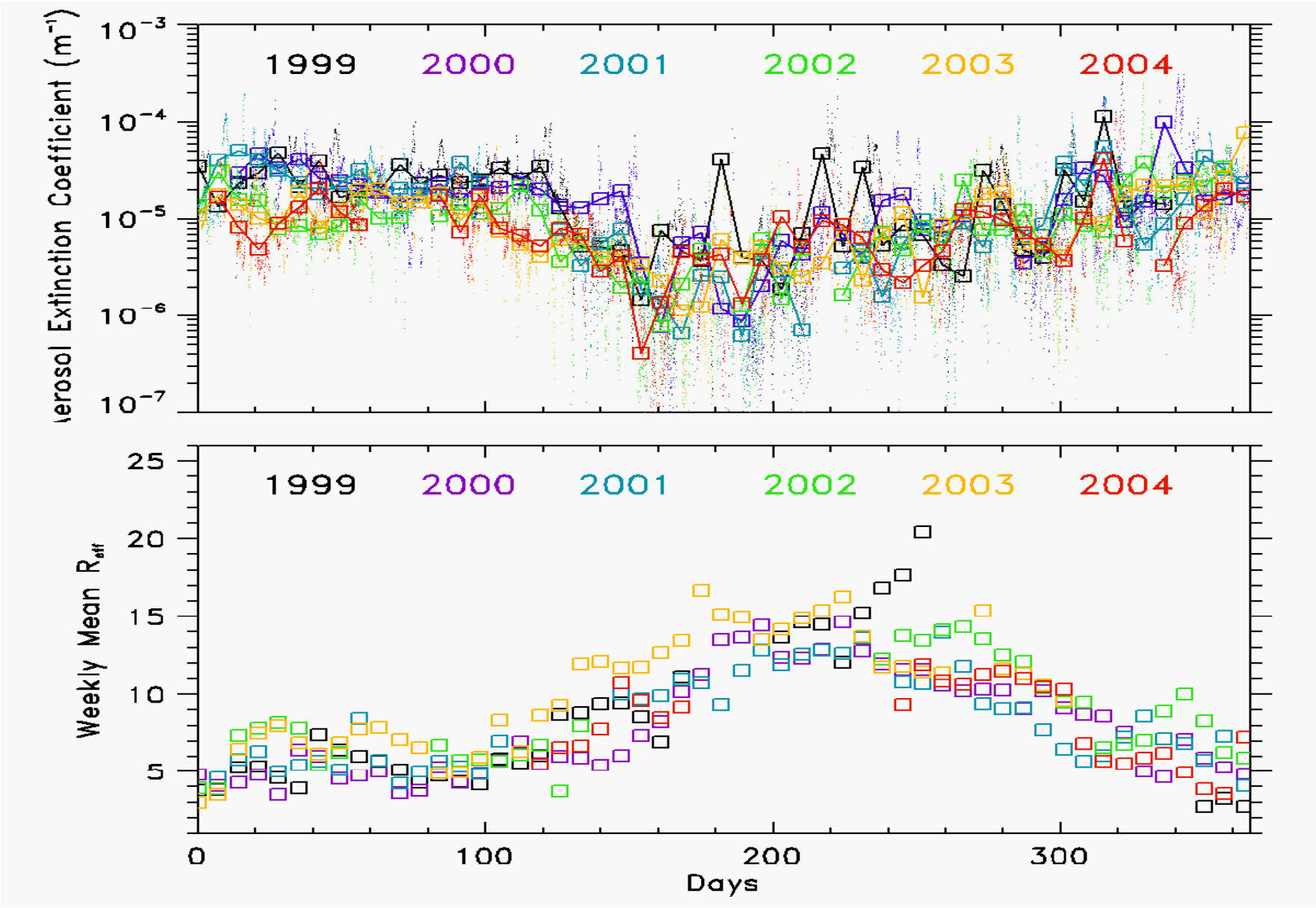
IWC (, mg/m^3) 10/10/2004

Covering Large LWP range!



Comparison with AERI-MMCR-MPL retrieval (*Wang et al. 2004*

squares)

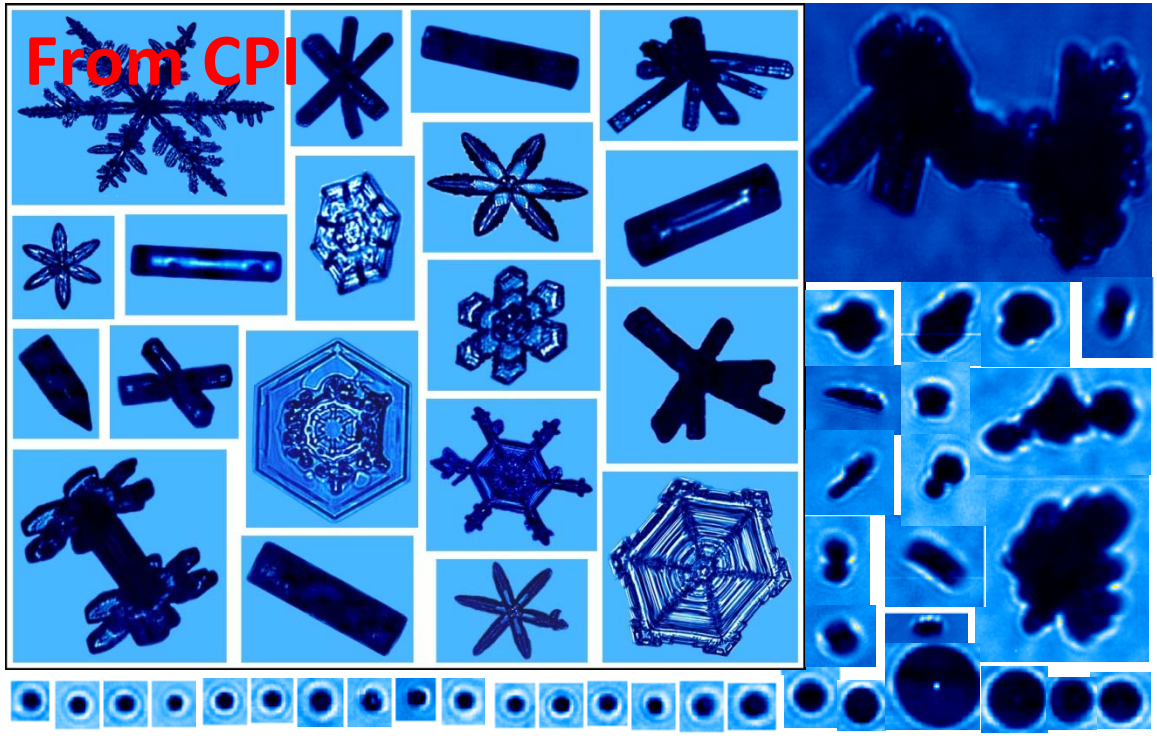


Will make above six year data available after further validation with ISDAC data.

A Focus on Advancing Our Understanding of

Cloud Microphysical Processes

Initializations, diffusion growths, and hydrometer interactions



Cloud Microphysical Processes –couple aerosol, dynamics, and the water and energy cycles in the atmosphere!

Where will we be in 30 years?

- Progress in computation
  - Moore's Law will give us a factor of about 10^6, we hope.
  - Global cloud-resolving models will be used in true climate simulations.
- Progress in understanding: Future parameterizations
  - A new focus on microphysical processes
  - How many clouds?

David Randall

There are large knowledge gaps in cloud microphysical processes, especially related ice.

- Very large differences between observed IN number concentration and ice concentration in a given clouds.
- Many ice nucleation modes are poorly understood or still unknown.
  - Heterogeneous freezing —two opposing views: **stochastic** versus **singular** behavior; Most of models still use **Bigg (1953**) formulation.
- Turbulence impacts on hydrometer interactions are not fully quantified.
- …

Cloud microphysical processes represented in current models are far from “accurate” !

The ARM program is in position to make a significant contribution in the future

- Laboratory studies are not enough.
  - Not capture all nature processes
  - Do can contribute to some processes study
- ARCF long-term ground-base observations and extensive airborne observations (AVP) are more suitable for process-oriented study compared with satellite observations and other field experiments.
- Time is right too.

Need a real collaboration between modeler and observer to move it forward !

- A small group of modelers and observers with focused goals.
- Have a strategy to attack problems.
- With a solid and stable funding behind it.
  - it takes time to make real improvements.
- ARM can do it.

Cloud Physics Processes In Numerical models

- Cloud physics processes are explicitly simulated or parameterized in models.
- Many cloud physics processes can't directly measured.

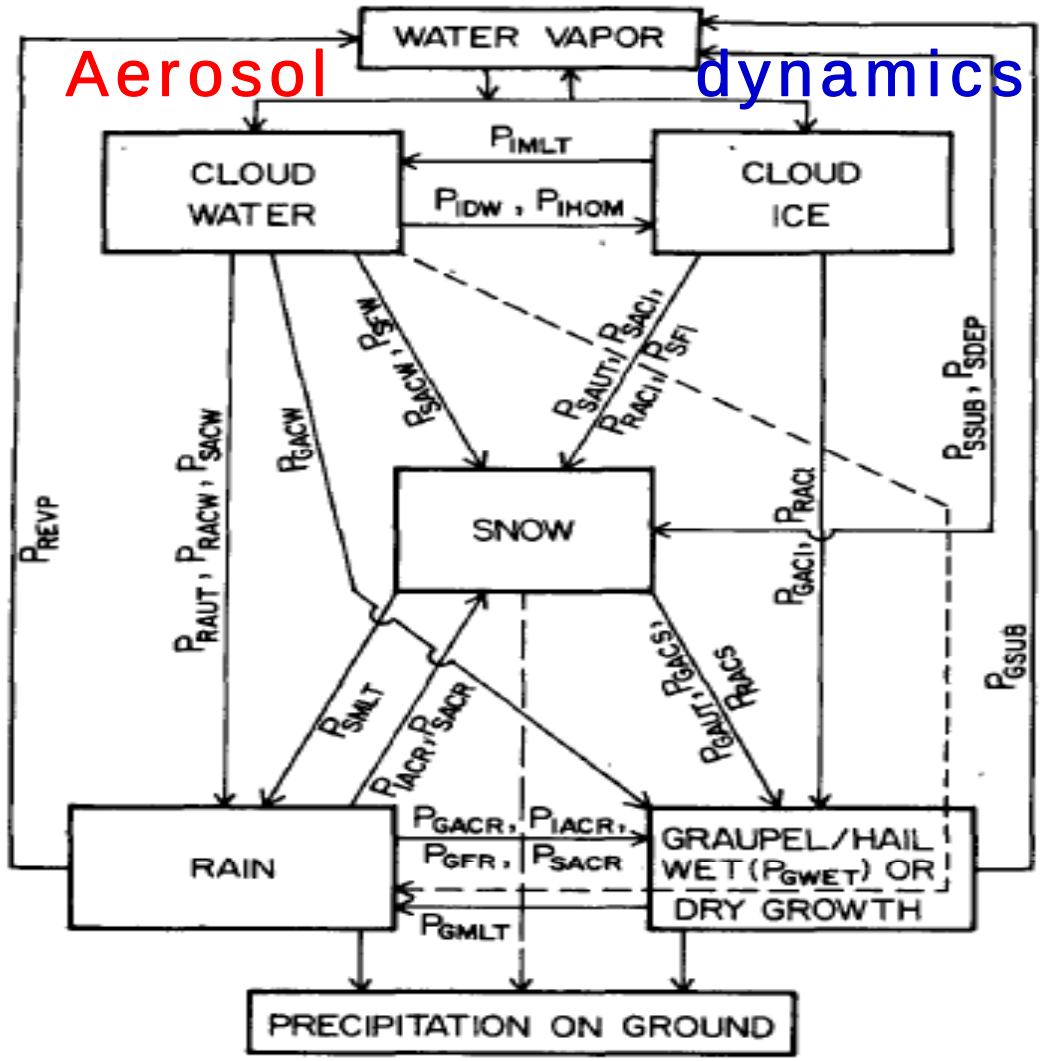


FIG. 1. Cloud physics processes simulated in the model with the snow field included. See Table 1 for an explanation of the symbols.

Lin et al. (1983)