# 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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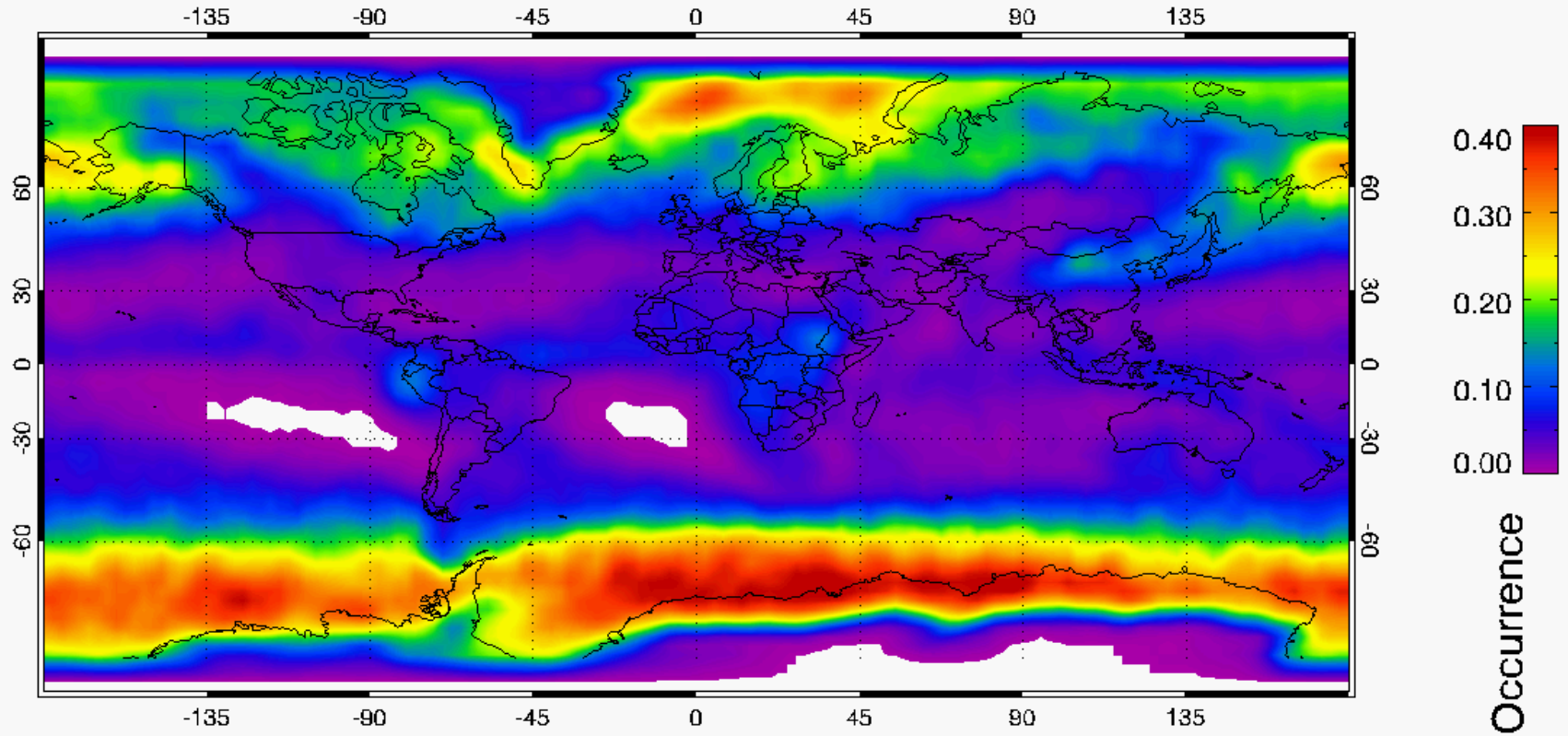
# Retrieving Precipitating Mixed-phase Cloud Properties

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: $r_{eff}$

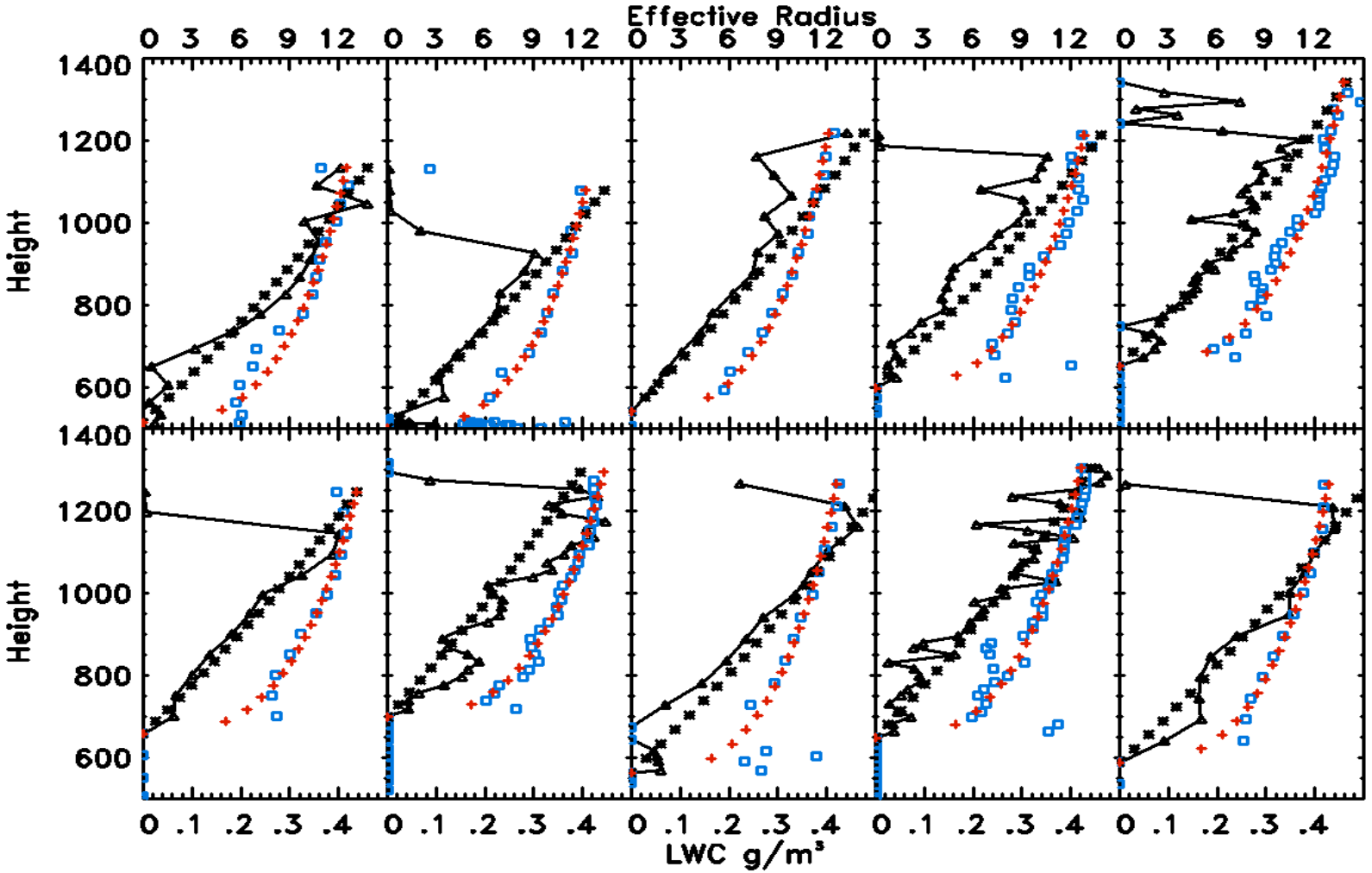
Ice phase:

MPL+MMCR

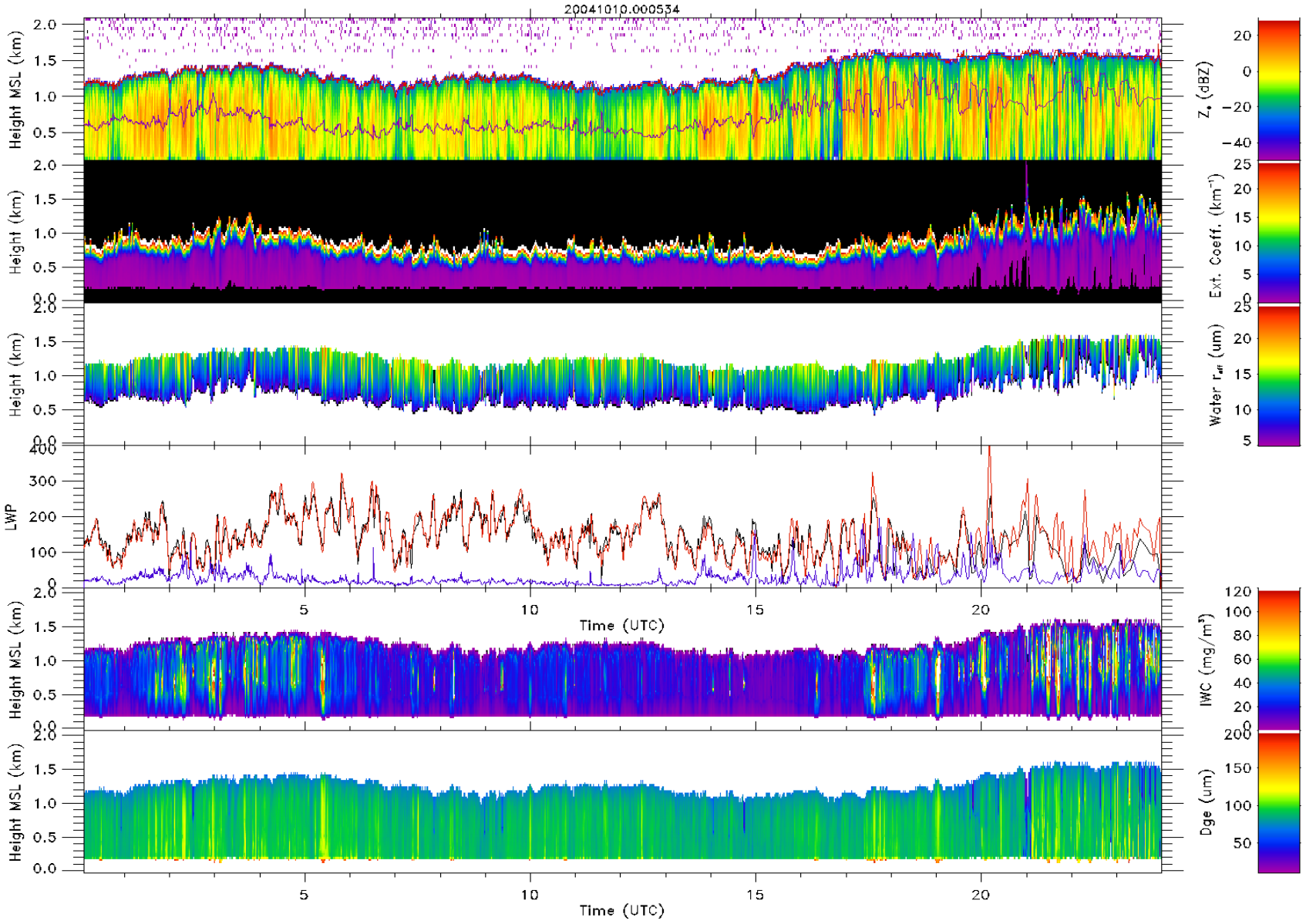
$$LWC = \frac{2}{3}\rho_w \sigma\, r_{eff}$$

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

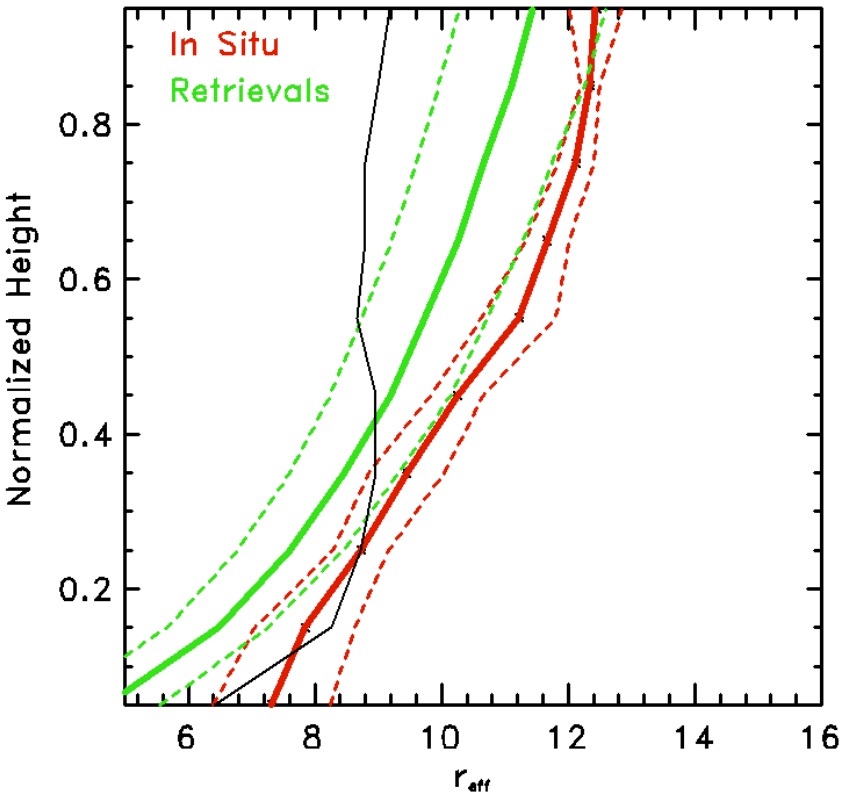
# How good the $r_{eff}$ fitted to adiabatic model?

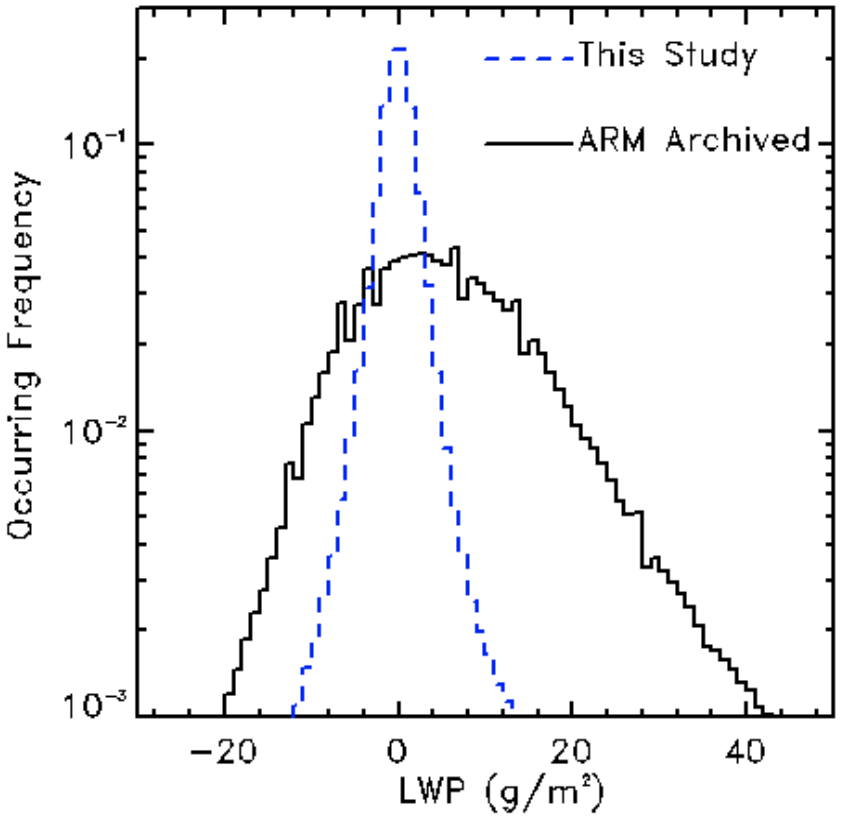


# An retrieval example



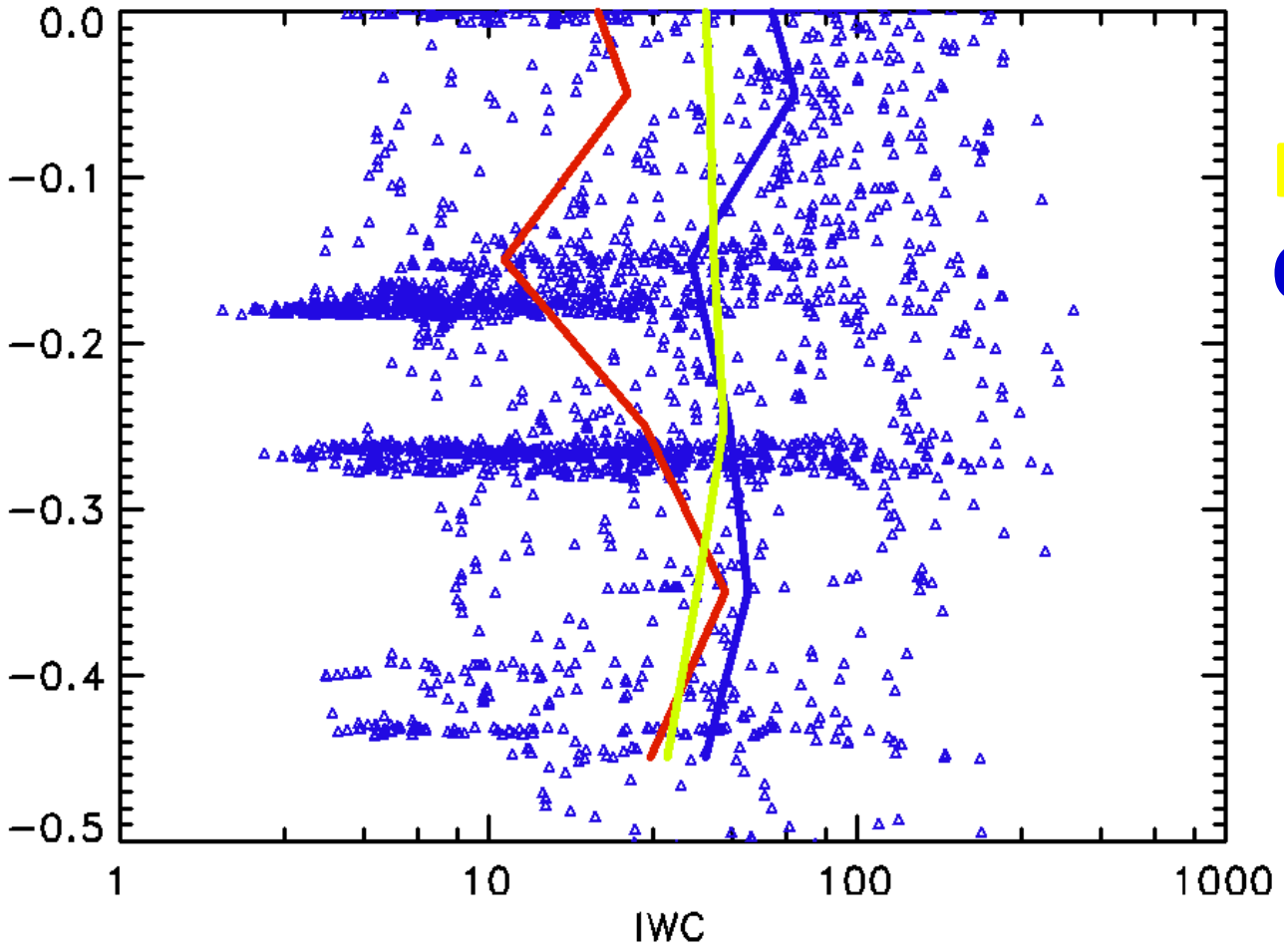
# Ballpark Uncertainties
# $r_{eff}$ < 15% and LWP <10%



# Ballpark uncertainties

## *IWC ~30%*

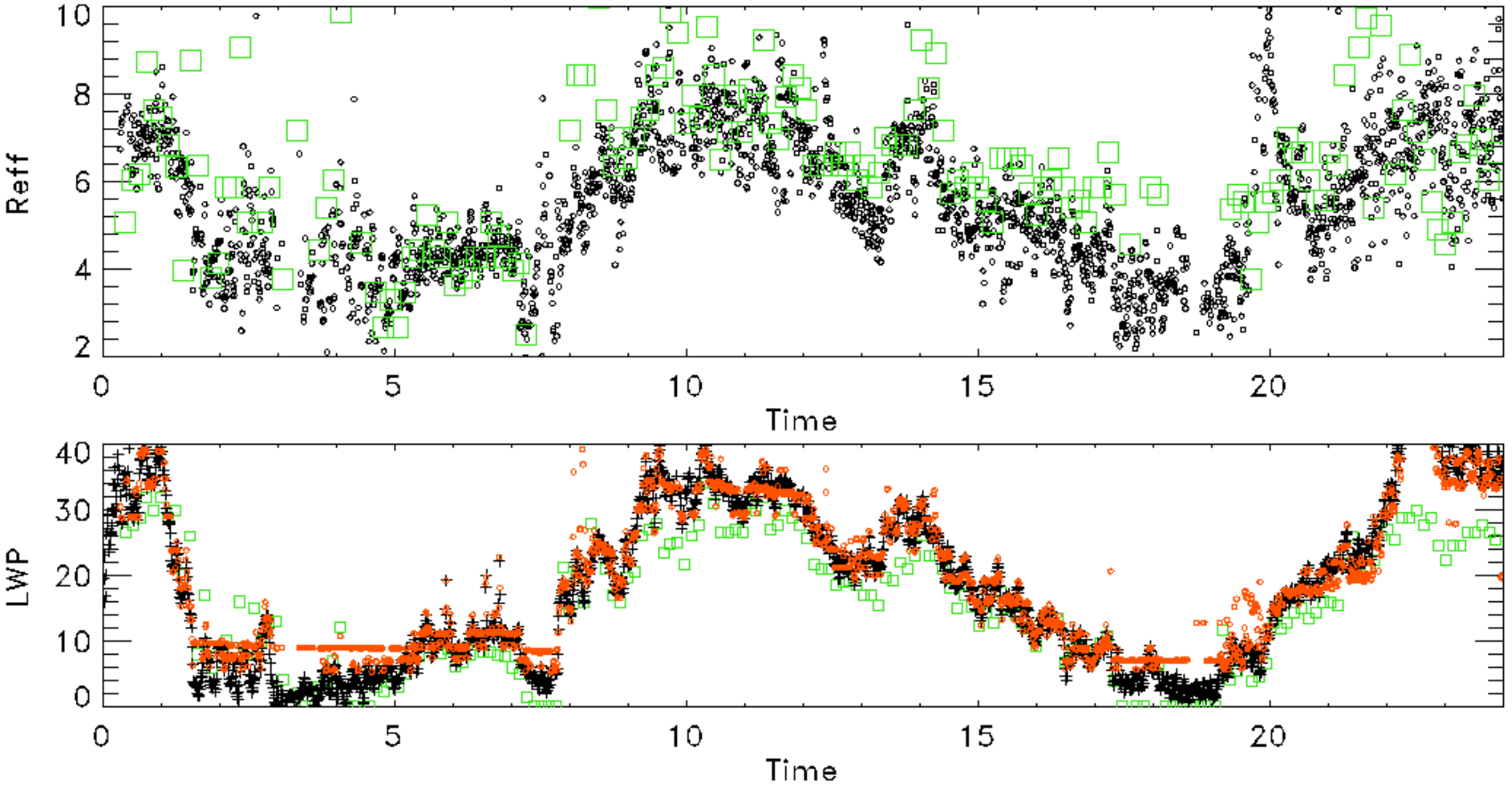



**Retrievals**

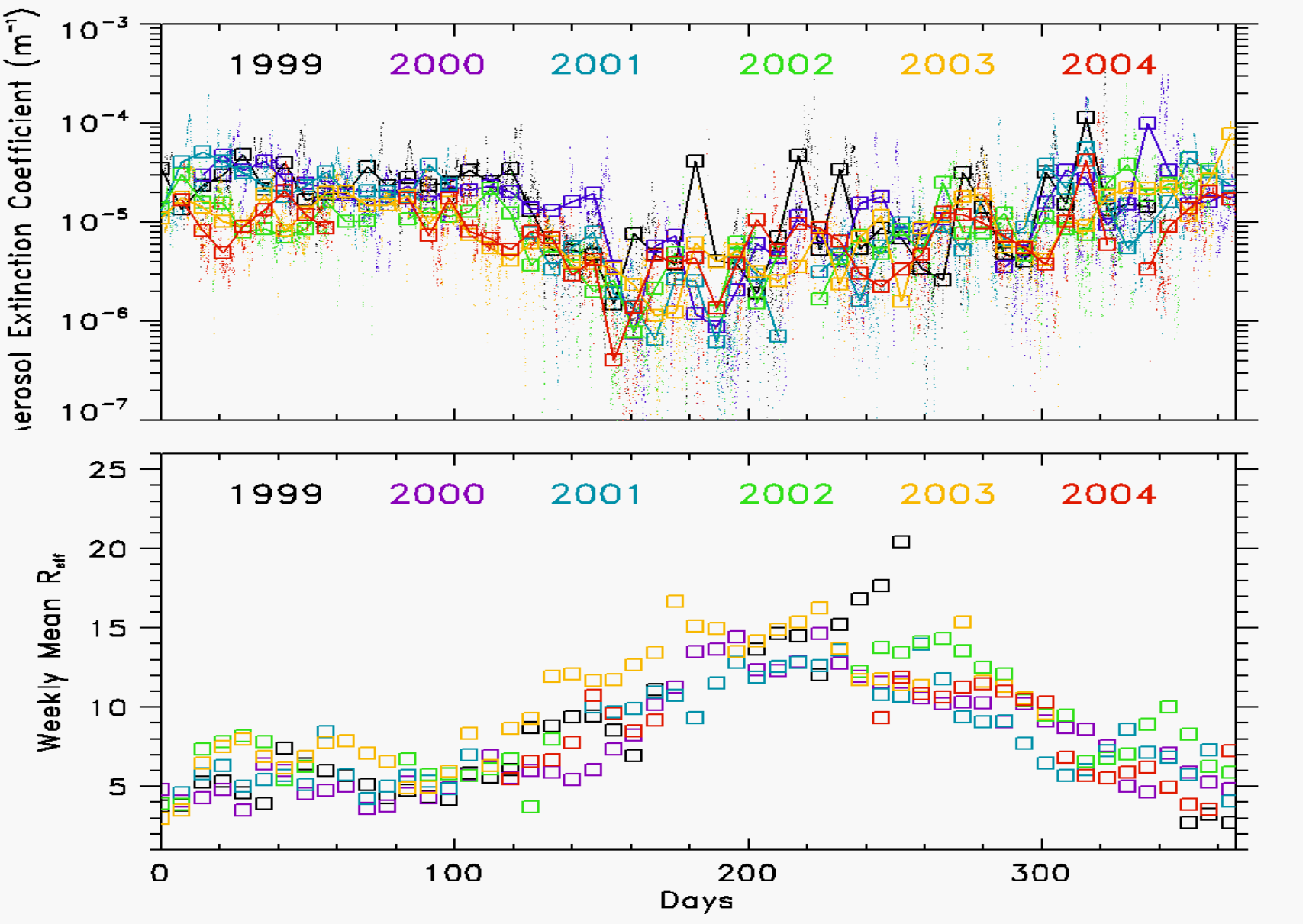
**CVI IWC**

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

# Covering Large LWP range!




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

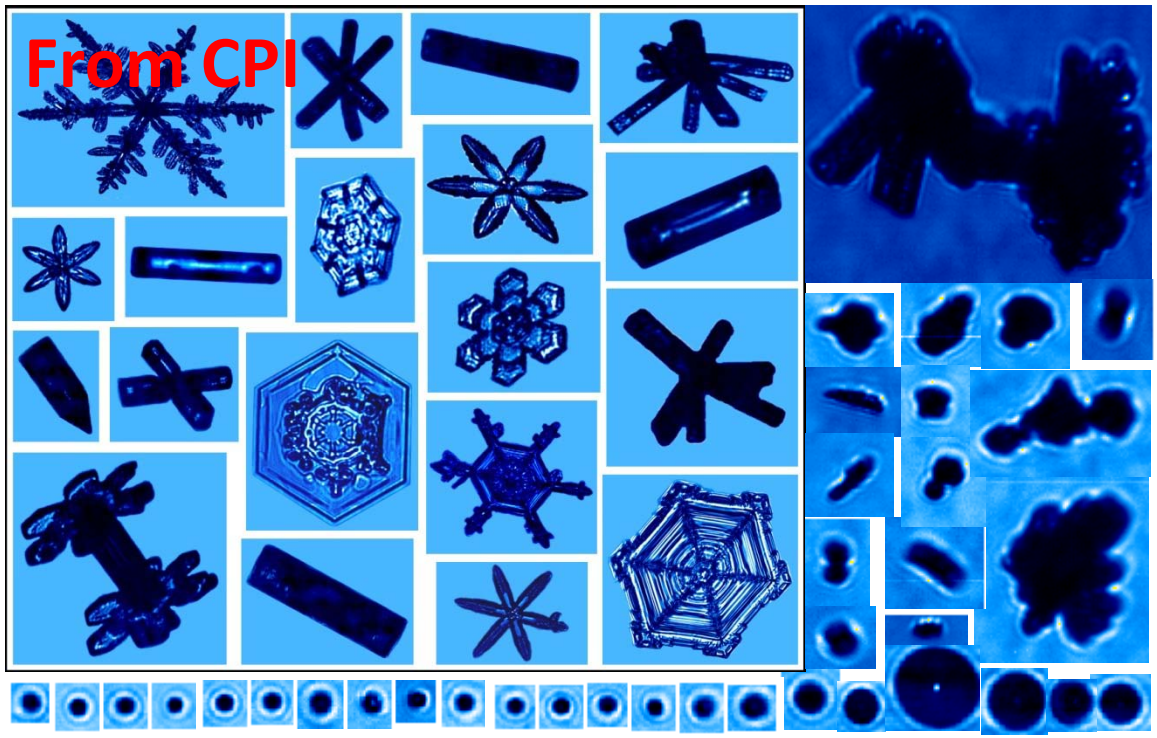



Will make above six year data available after further validation with ISDAC data.

# 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.

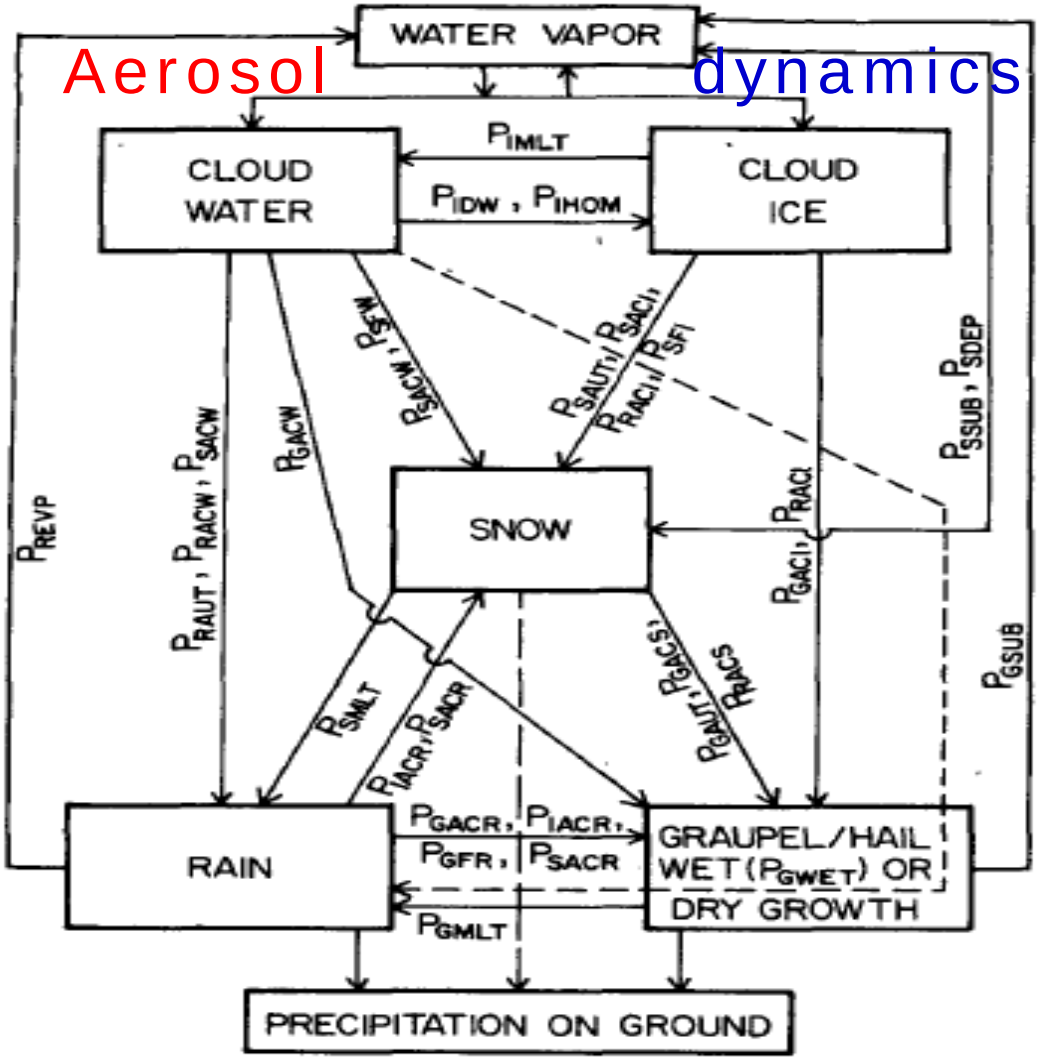



FIG. 1. Cloud physics processes simulated in the model with the snow field included. See Table 1 for an explanation of the symbols.

Lin et al. (1983)