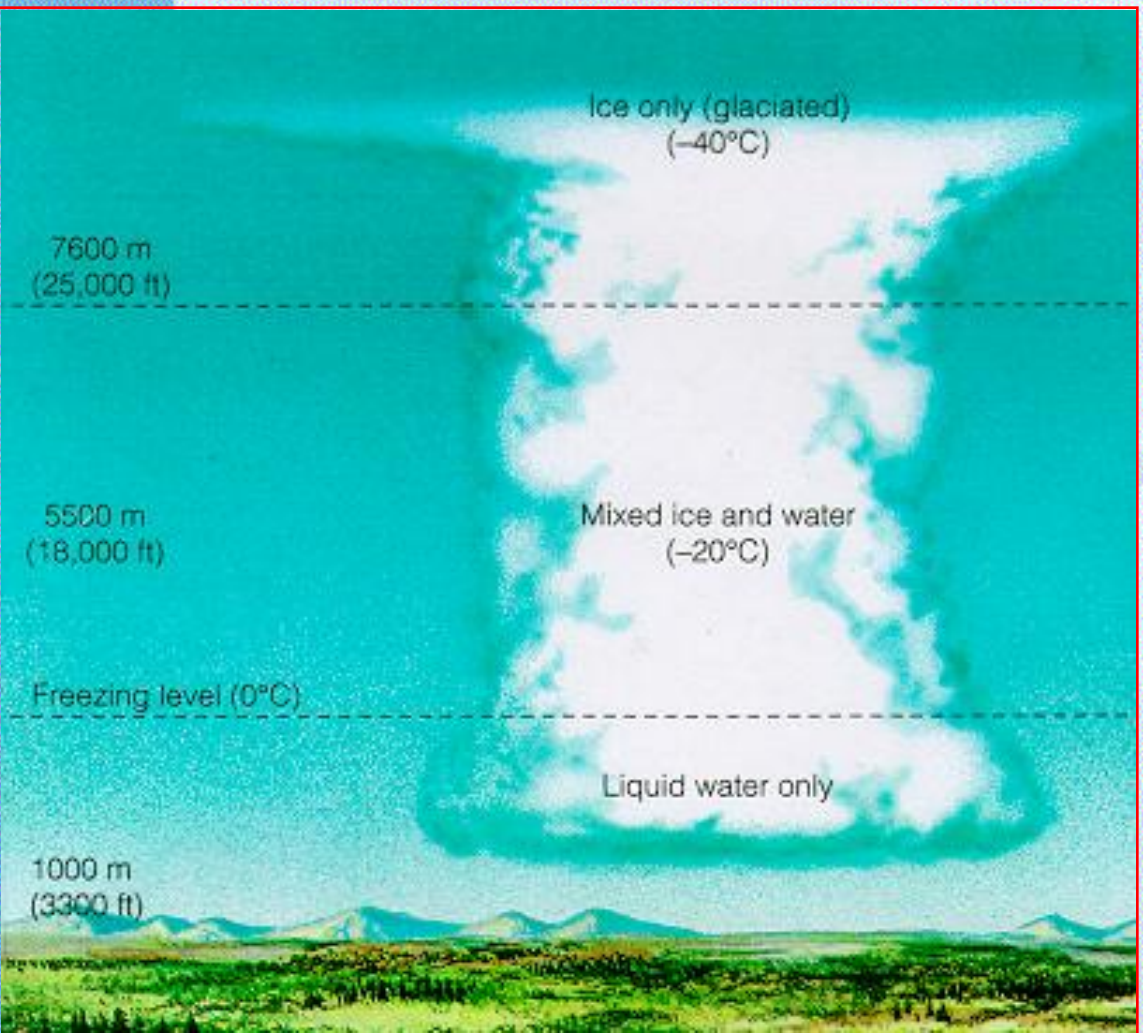
ICE IN CONVECTIVE CLOUDS

Boulder, Colorado

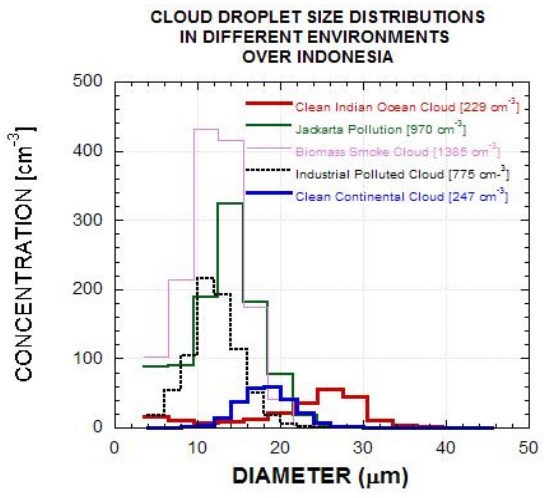
Distribution of Ice and Water in a Convective Cloud



- In the atmosphere temperature decreases 10^{o}C per km with height in a dry environment and about 6^{o}C per km in a cloud

Contrasts in Indonesia 1997-1998 and 2005 Studies

NCAR

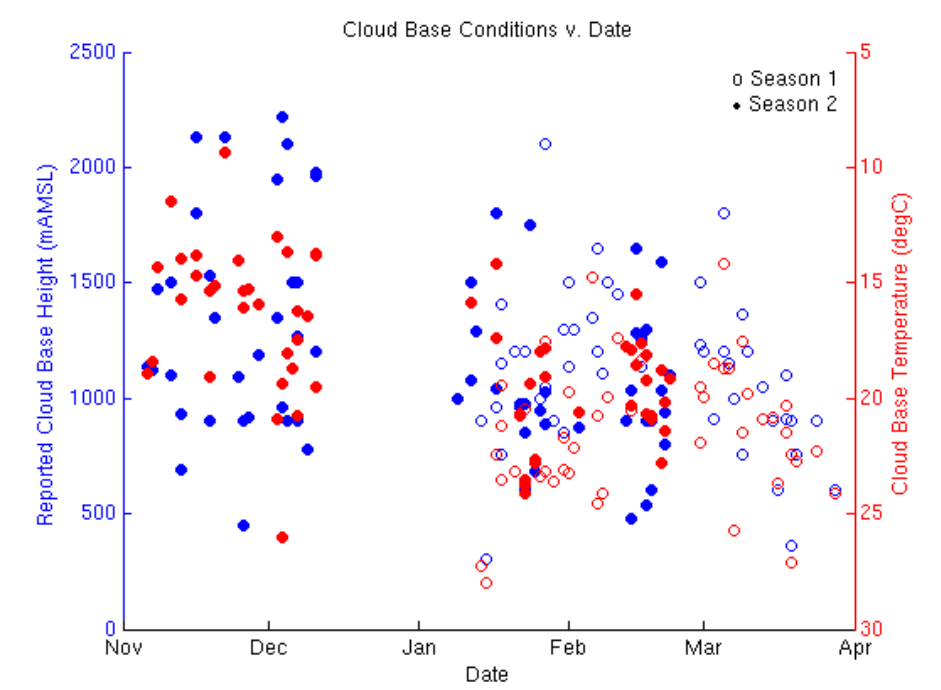


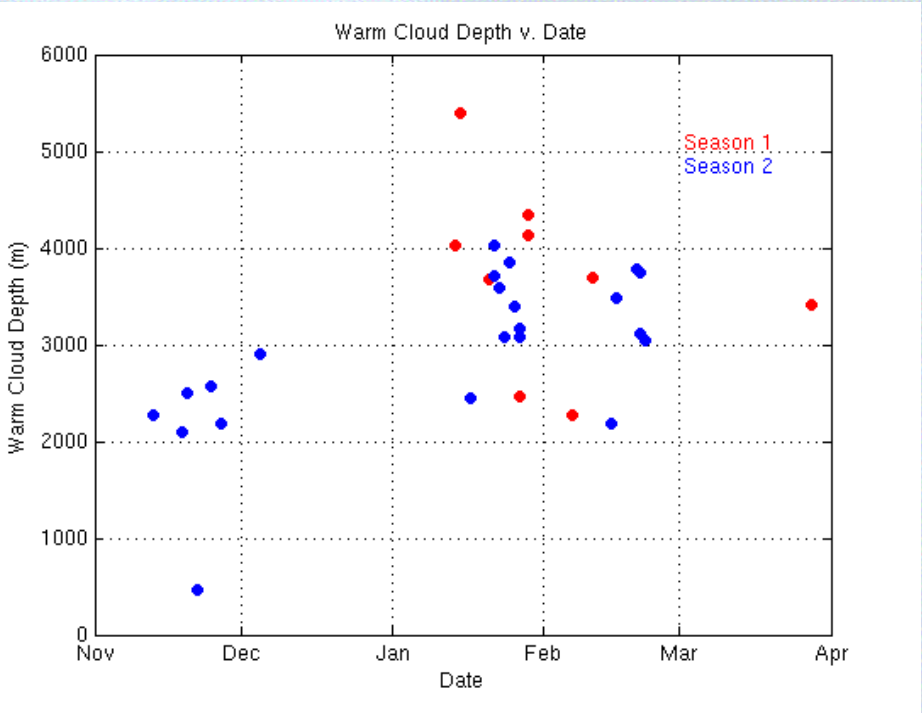
Measured cloud base cloud droplet size distributions in different environments over Indonesia.

Biomass smoke at an airport in Sumatra during the peak of the forest fires in Southeast Asia during the 1997/98 biomass smoke event.

Cloud base heights

- Cloud base heights generally got lower as the wet season progressed, leading to deeper warm cloud depths in Feb compared to Nov
  - This may affect the mixed phase microphysics



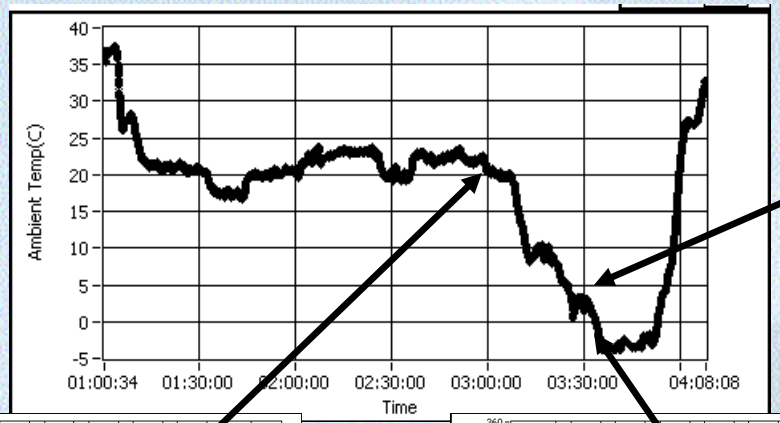


Precipitation Processes: QLD example (22 Jan. 2009)

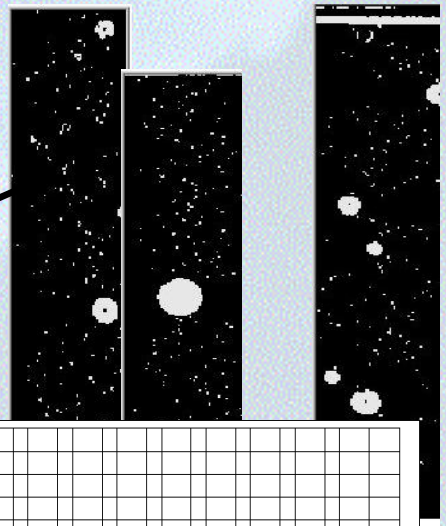
NCAR

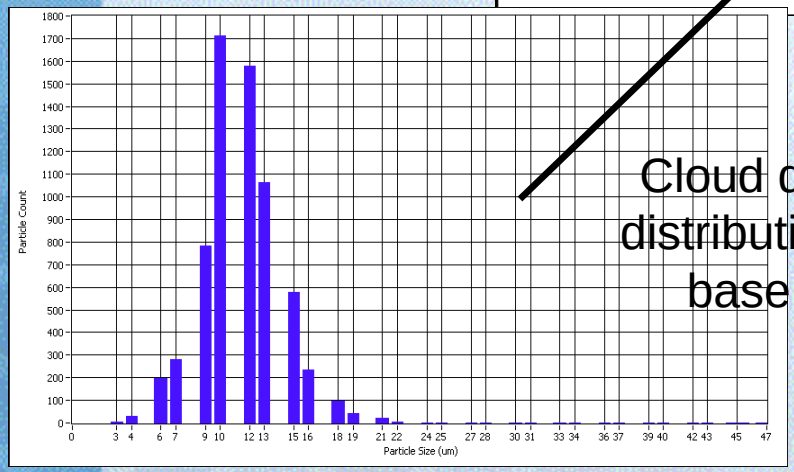
- Continental cloud droplet spectra at cloud base
- Coalescence initiates before cloud top reaches 0ºC
- Drizzle/rain drops present as cloud rises through 0ºC level

Temperature versus time
22 January 2009

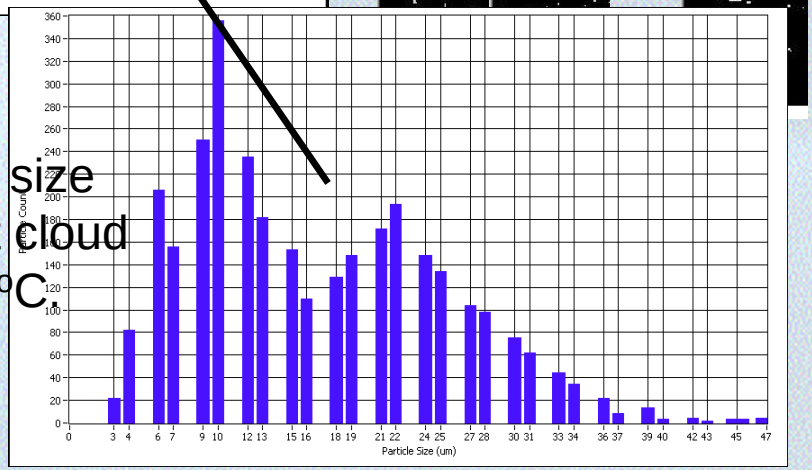


Images of cloud droplets and drizzle/rain drops



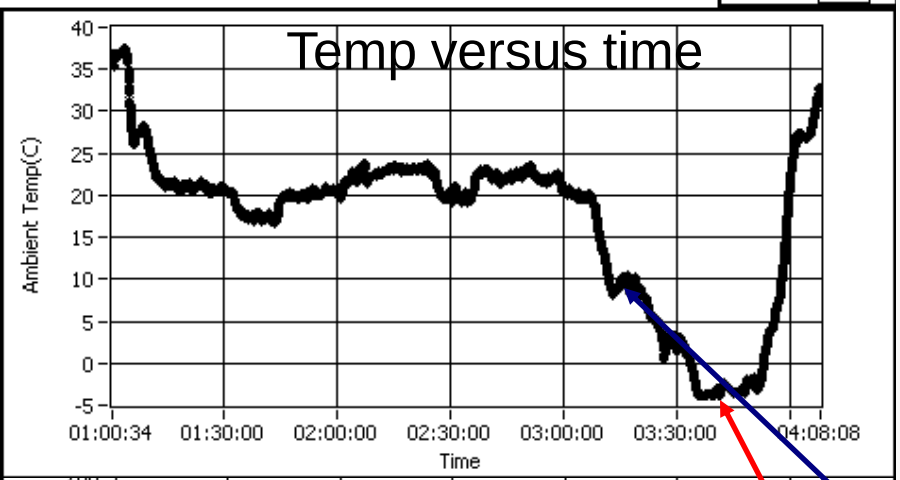


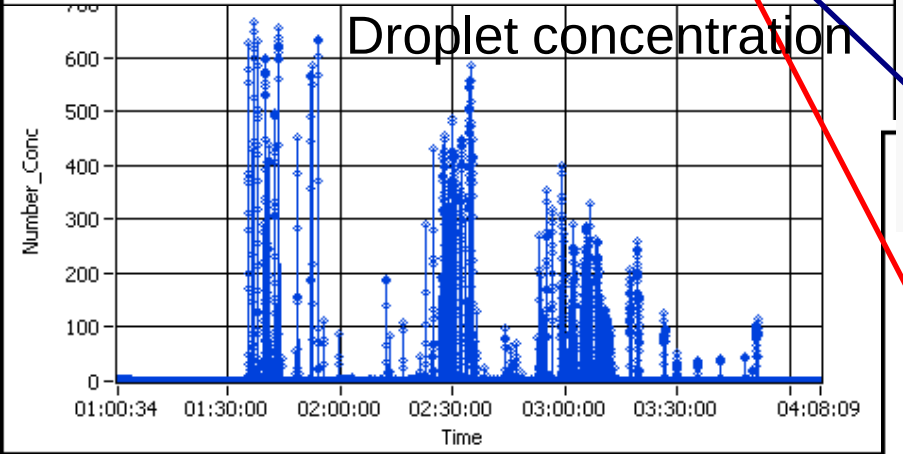
Cloud droplet size distributions at cloud base and 0ºC.

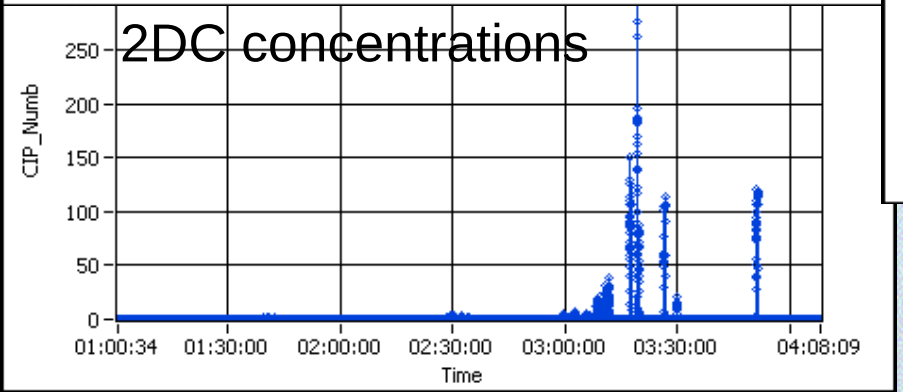


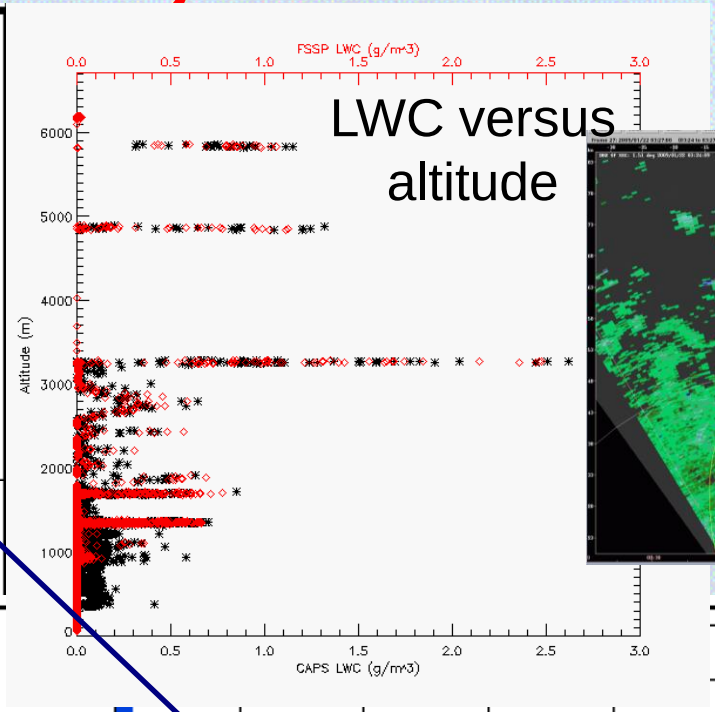
Due to warm cloud bases (~20ºC) clouds initially develop warm rain process

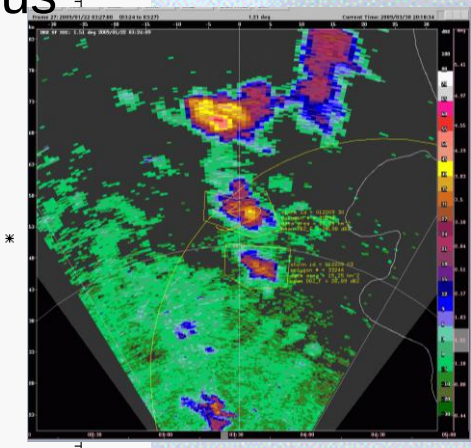
22 January 2009

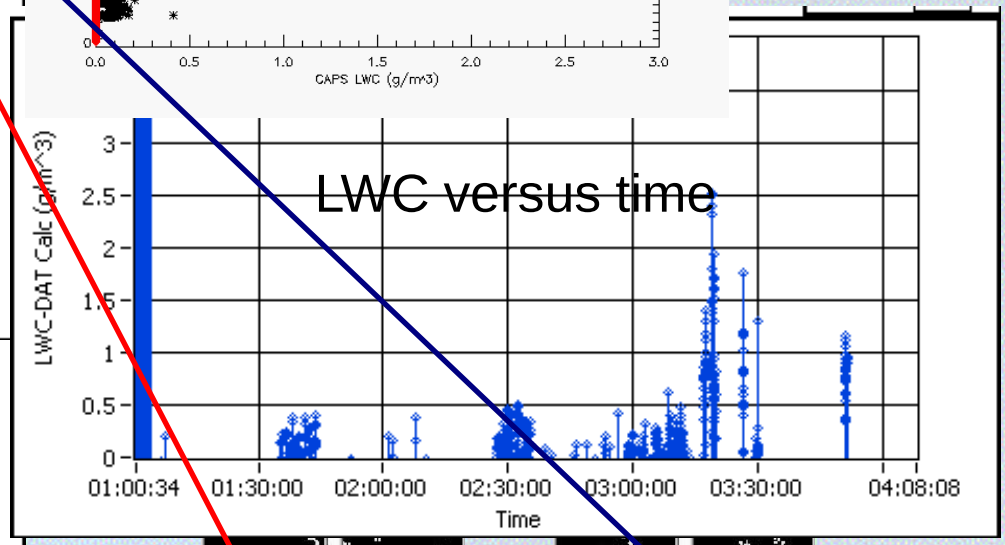


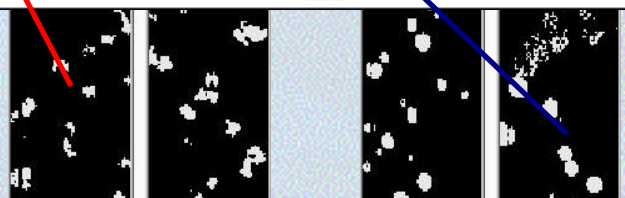




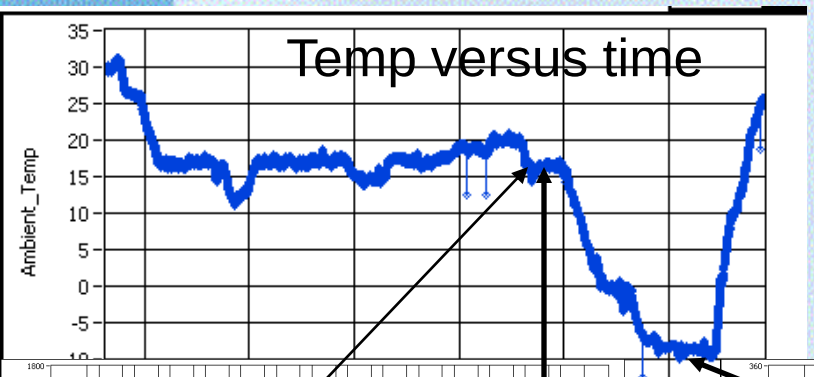


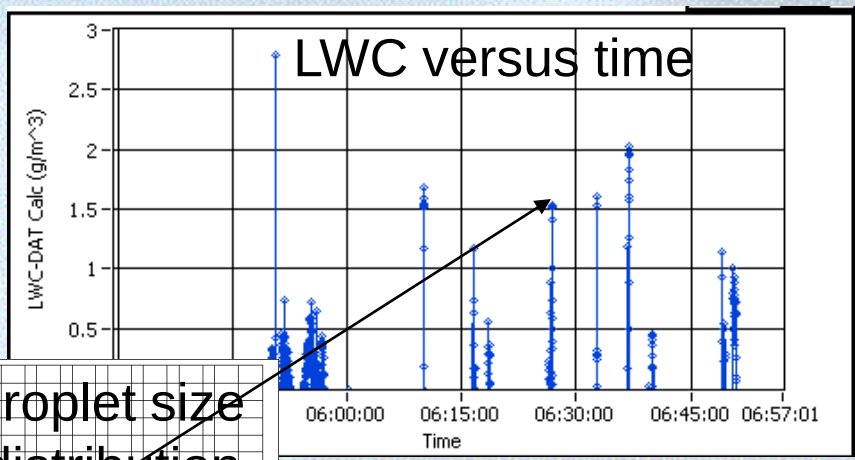


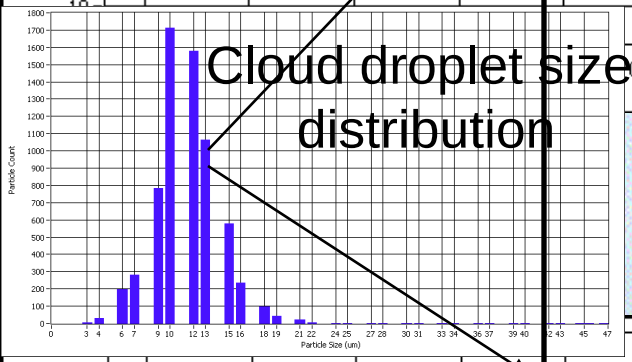


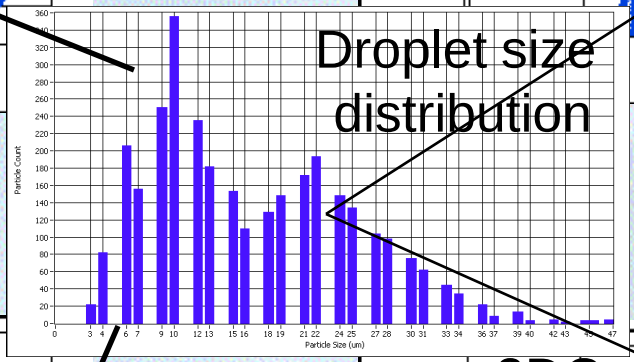


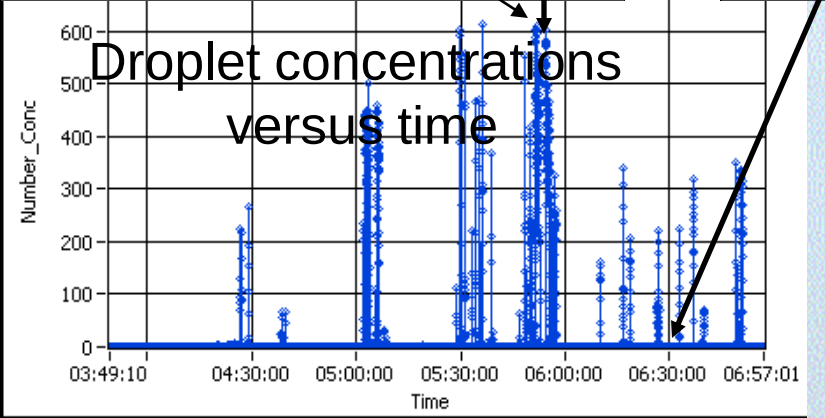
Queensland, Australia
Microphysical data16 February 2008

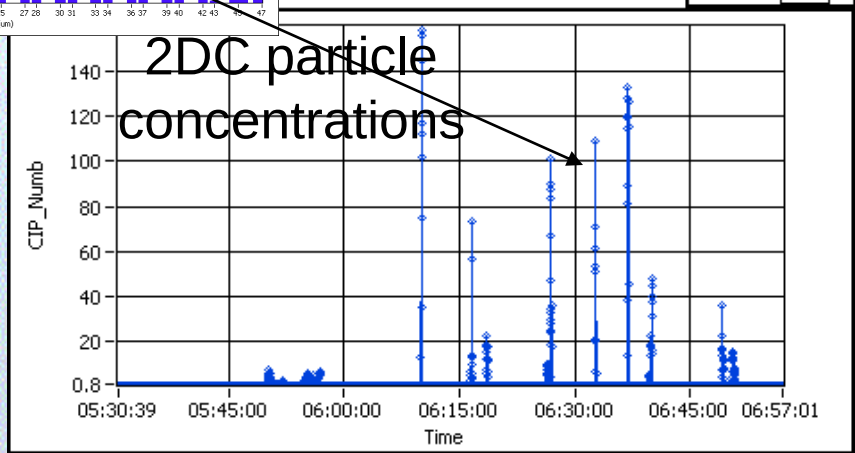




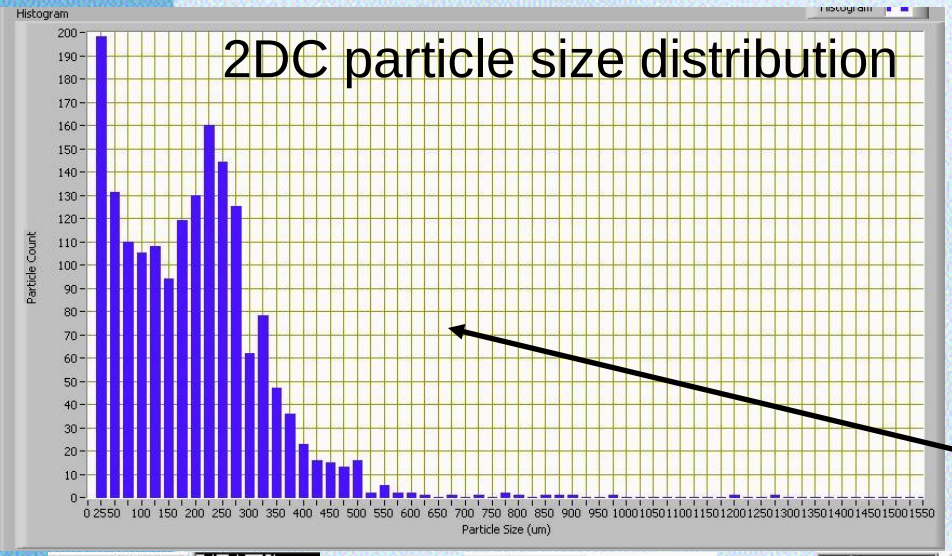


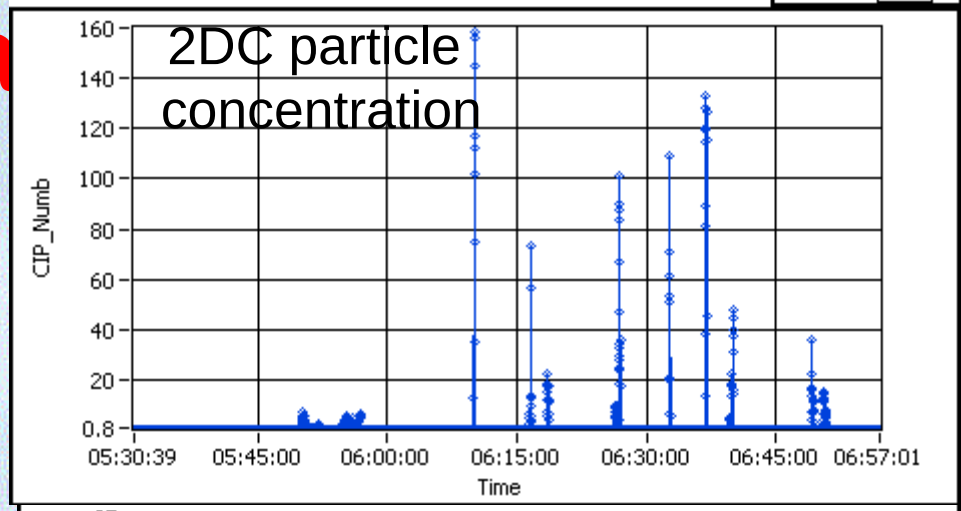


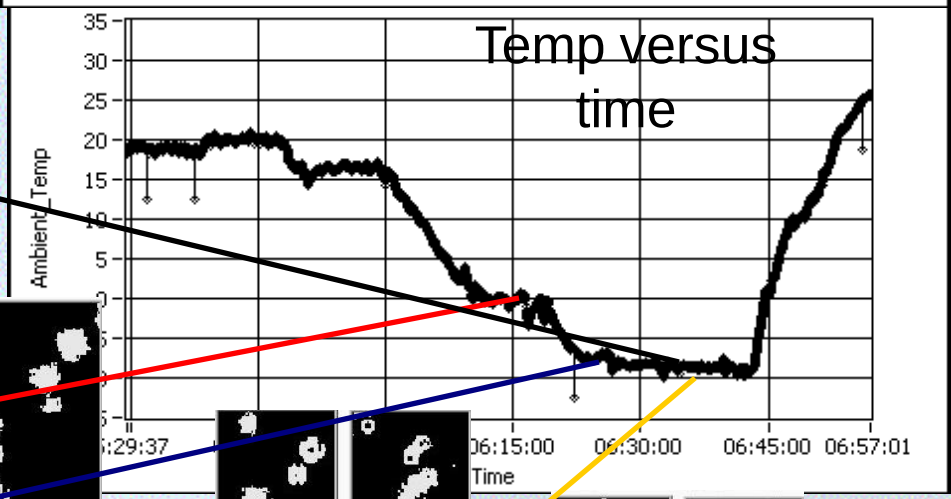


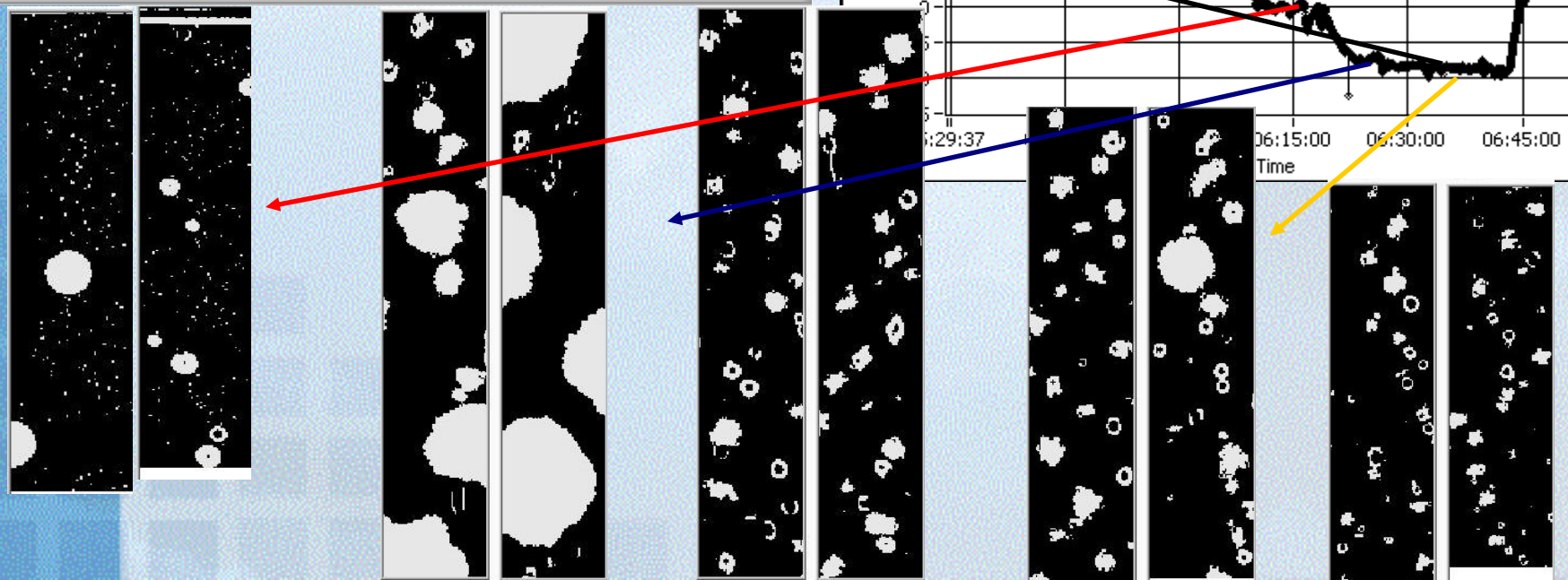


Microphysical data 16 February 2008







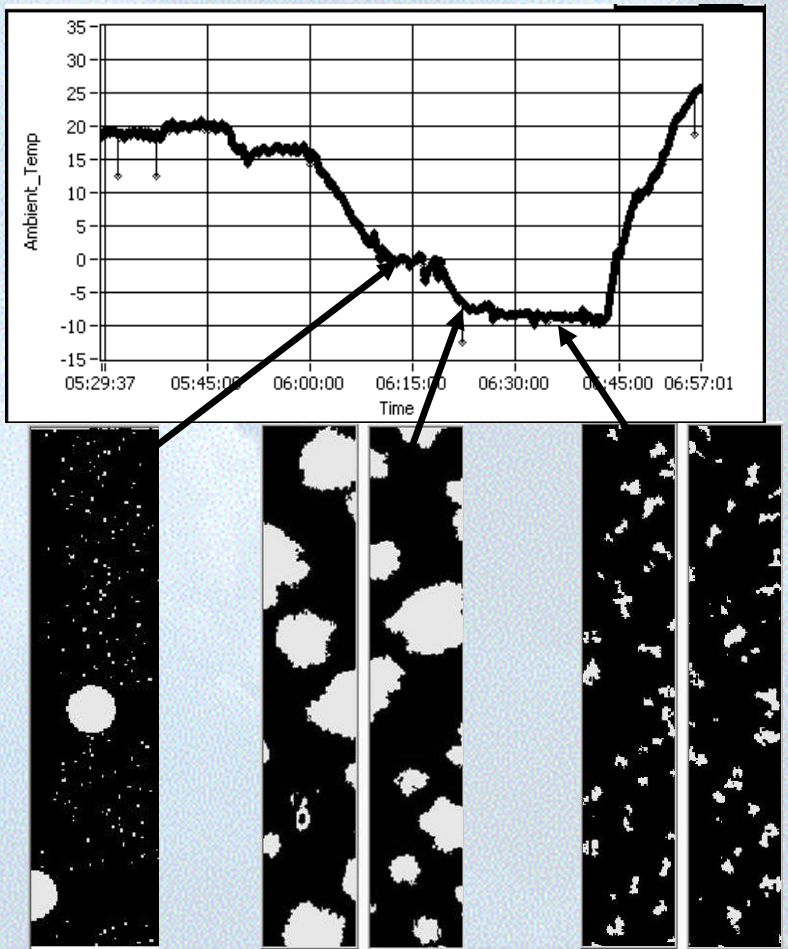


Precipitation Processes:

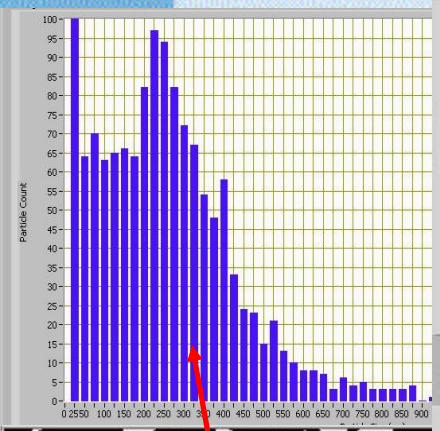
Mixed-phase/ice processes initiated by freezing of large drizzle/rain drops and subsequent initiation of natural seeding (ice splintering) process rapidly depleting cloud liquid water content

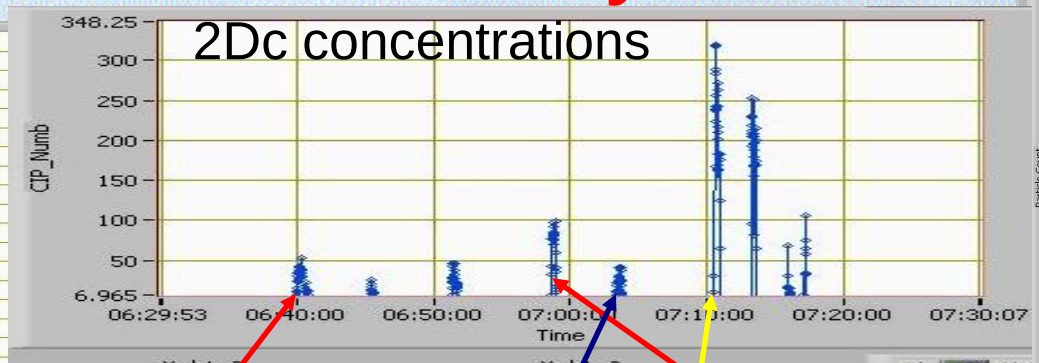
- Large drop freezing at ~-5ºC
- Initiation of ice splintering process
- Rapid conversion of LWC to ice
- Rapid depletion of LWC inhibiting lightning in these cases

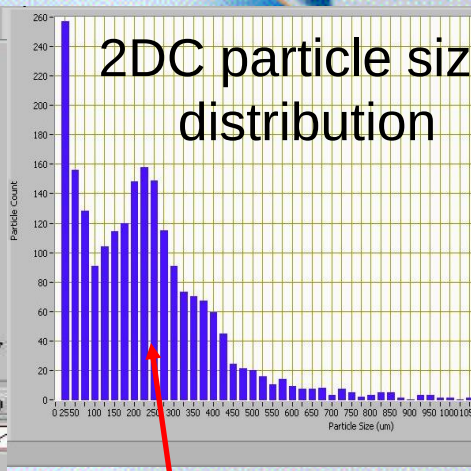
Temperature versus time
27 January 2009

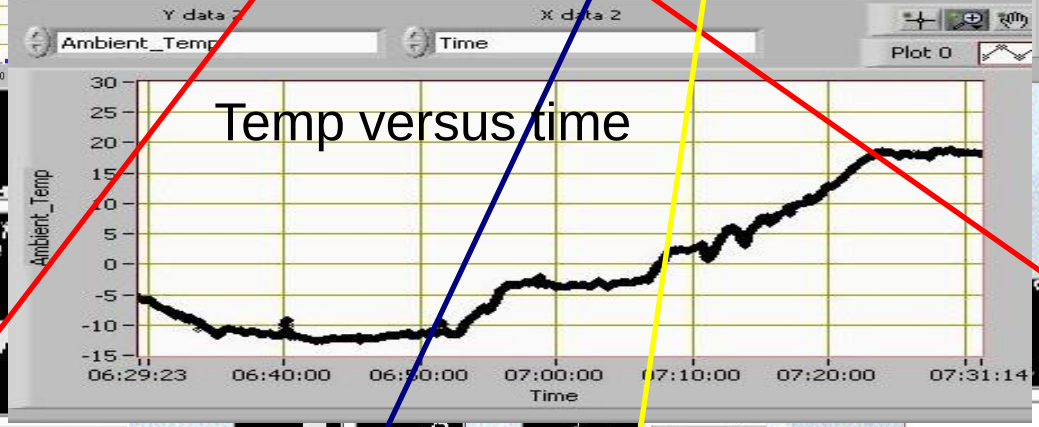


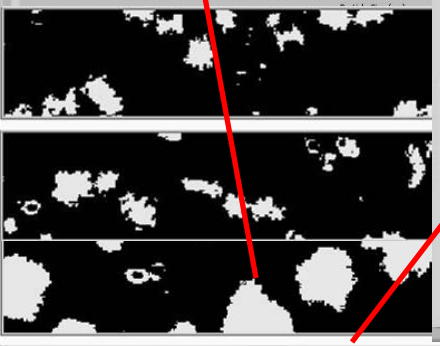
27 January 2009

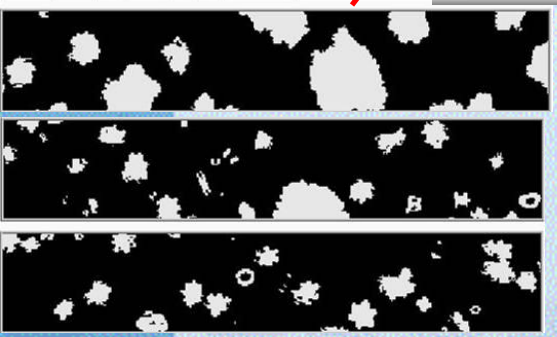


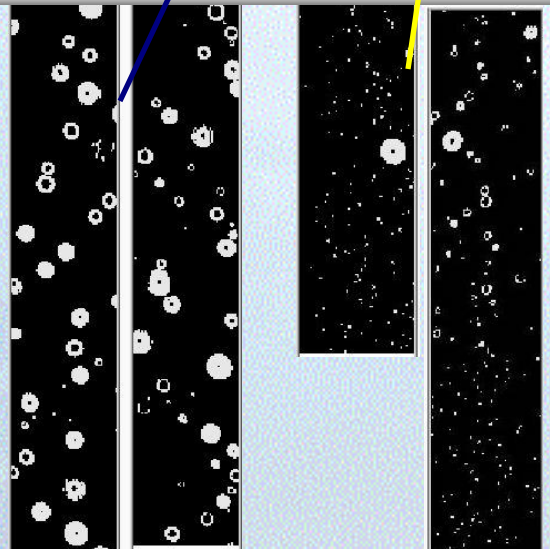


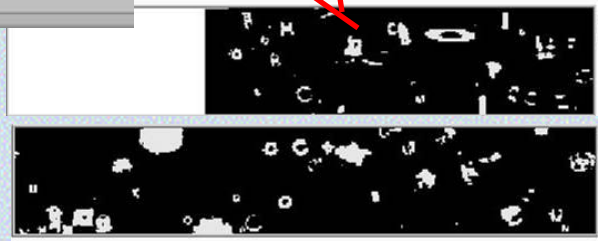




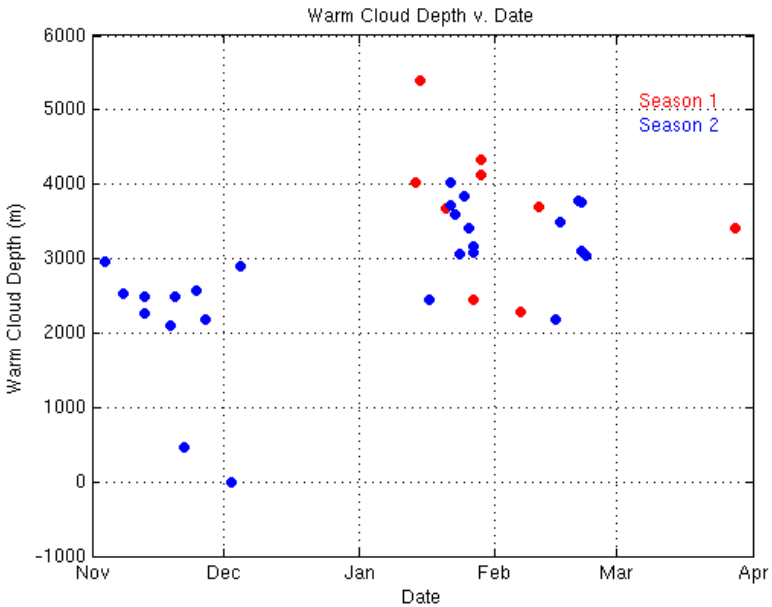


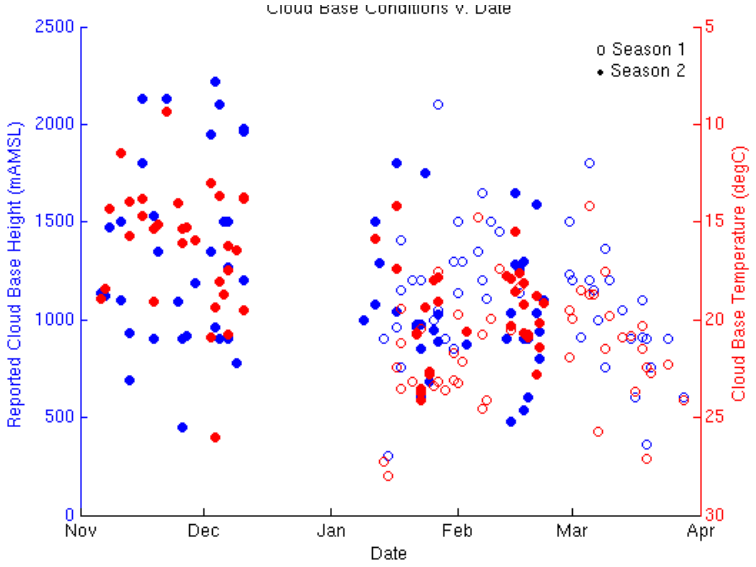


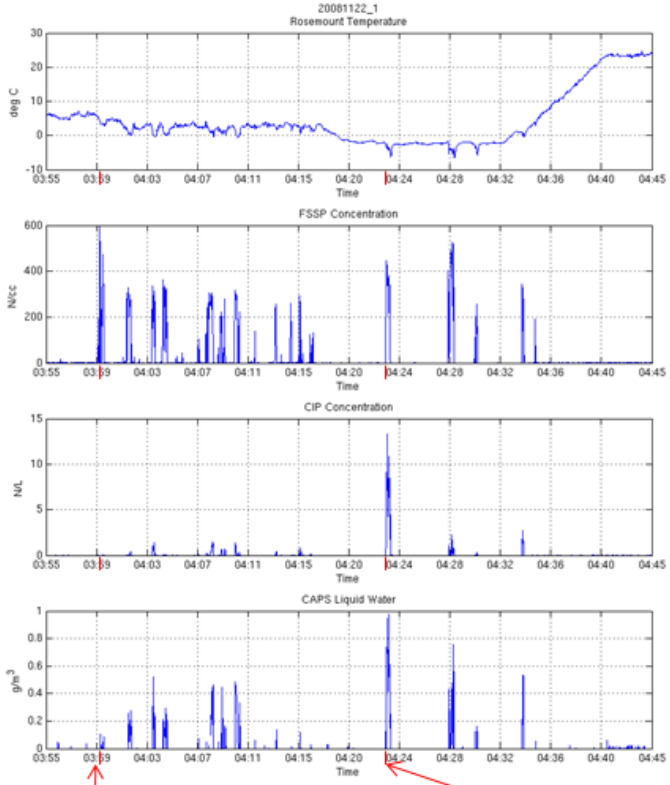


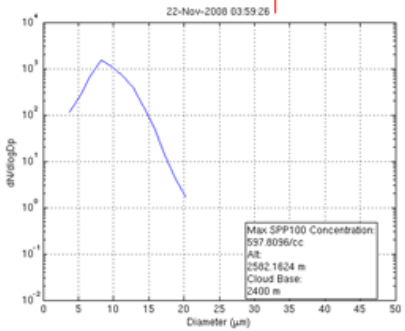


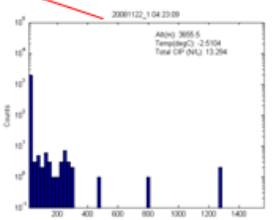
Cloud base heights and warm cloud depths during Queensland project





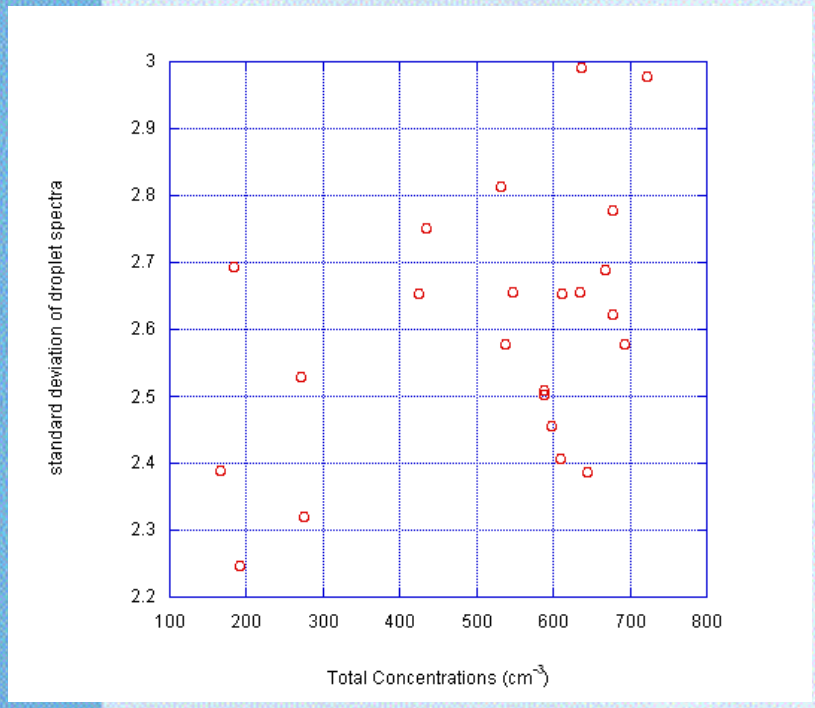




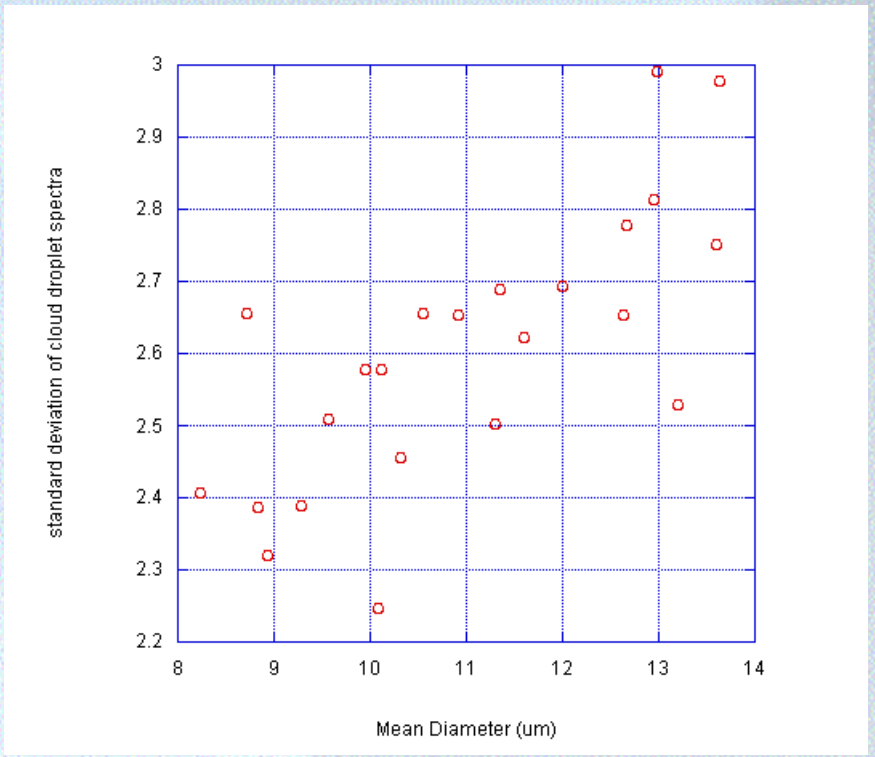


22 November 2008
High cloud base
No large drops at 0C
First ice below -12C

Microphysical relationships



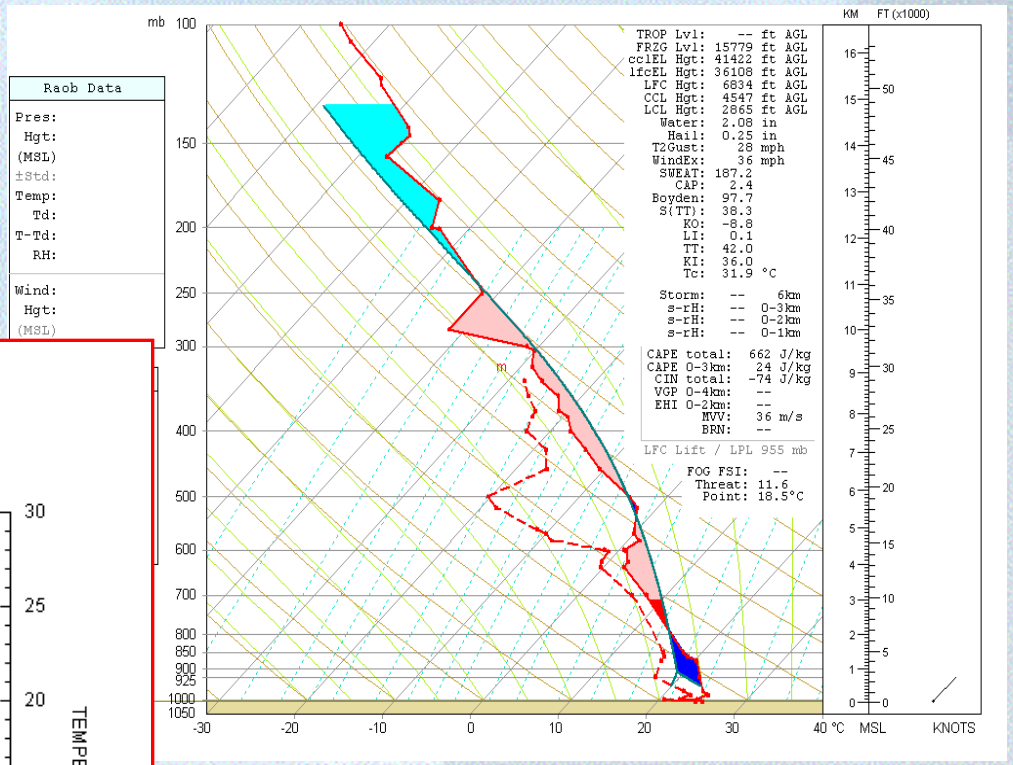
Total peak droplet concentrations (cm^{-3}) as a function of standard deviation of the cloud droplet spectra for the 22 cases when penetrations were conducted in deep convection near cloud base in growing non-precipitating parts of the cloud.

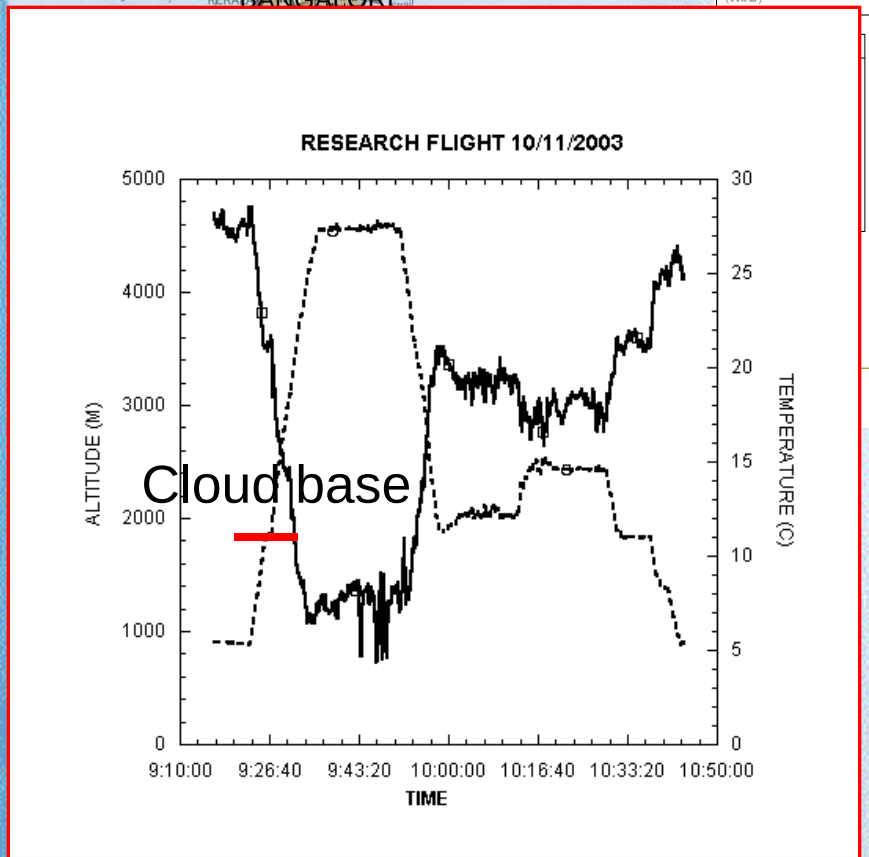


Mean diameter of the cloud base doplet spectra as a function of standard deviation of the cloud droplet spectra for the 22 cases when penetrations were conducted in deep convection near cloud base in growing non-precipitating parts of the cloud.

Aerosol-cloud interactions India

NCAR

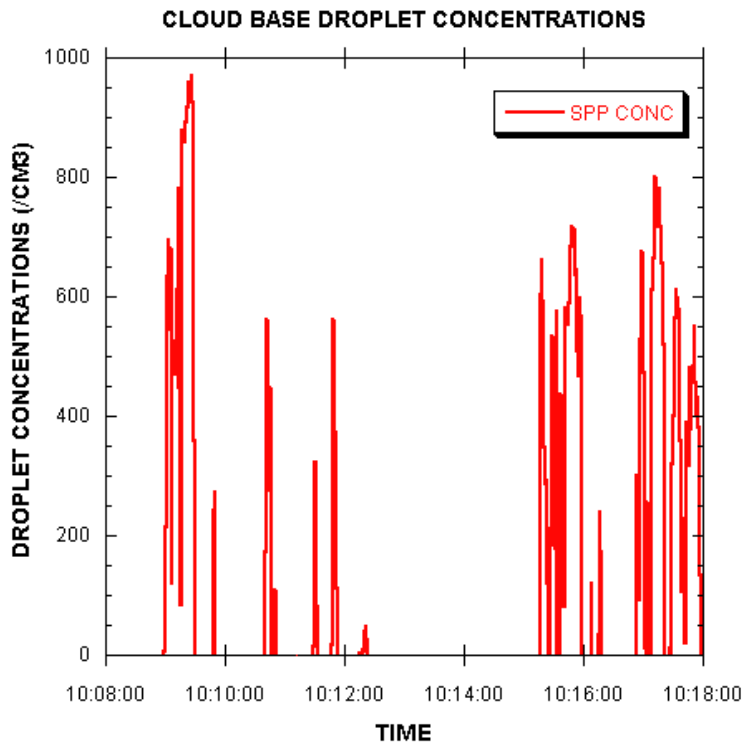




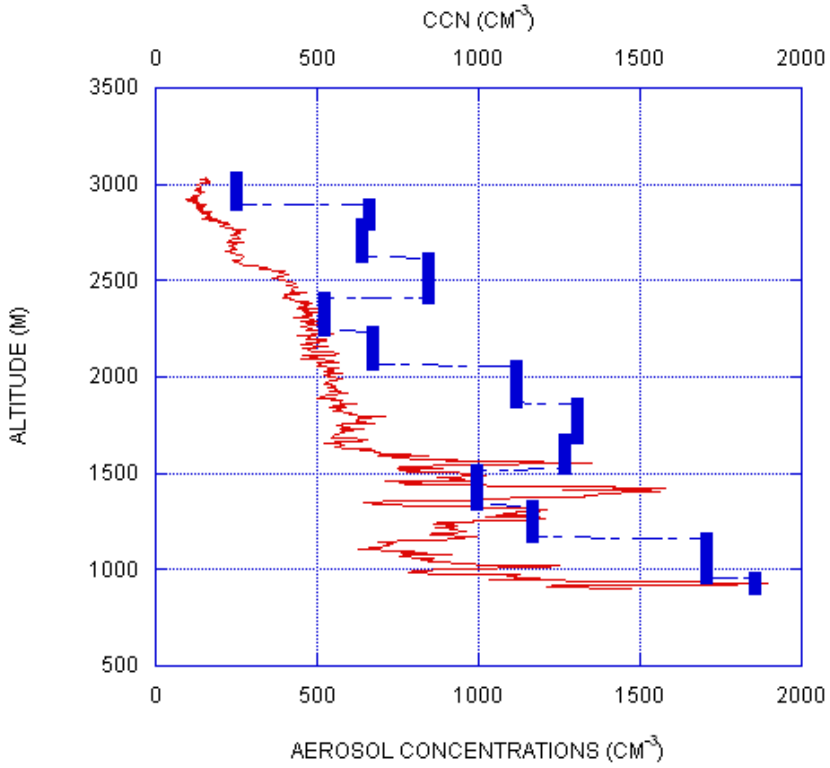
Aerosols, CCN and Cloud droplet concentrations (India)

NCAR

High concentrations of droplets due to pollution

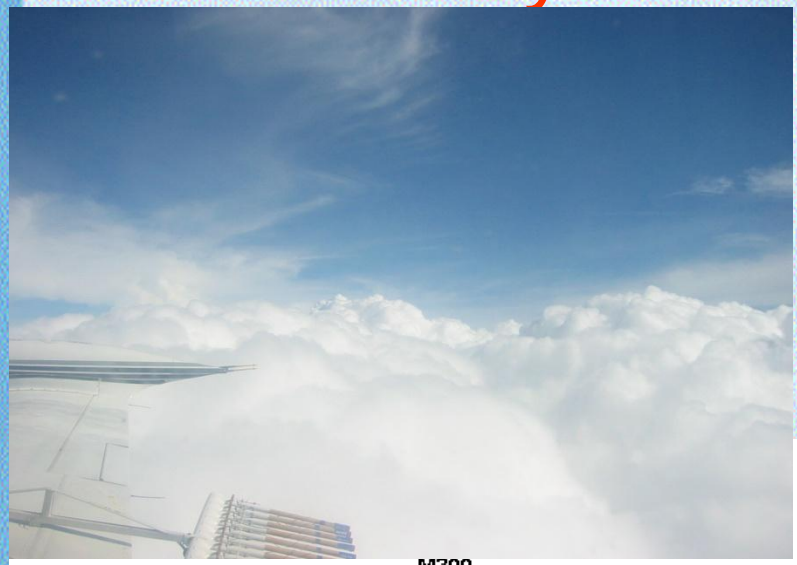


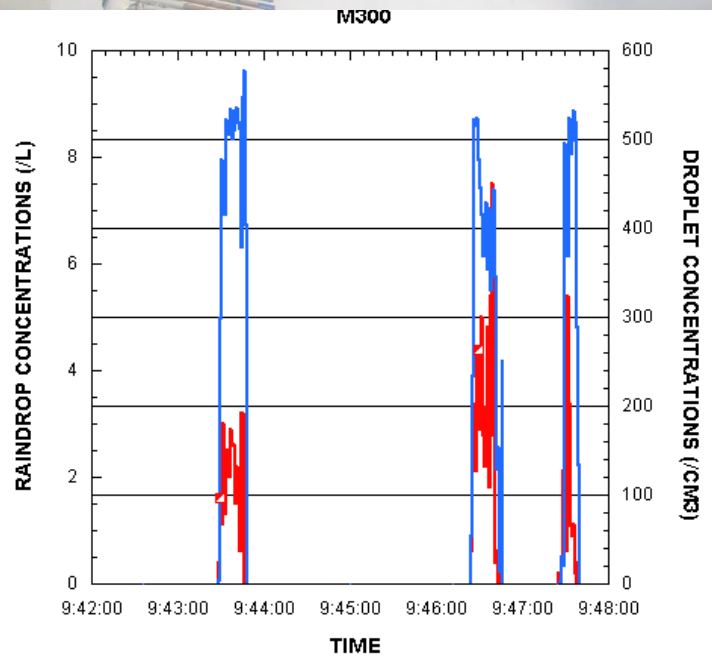
CCN and aerosol conc.

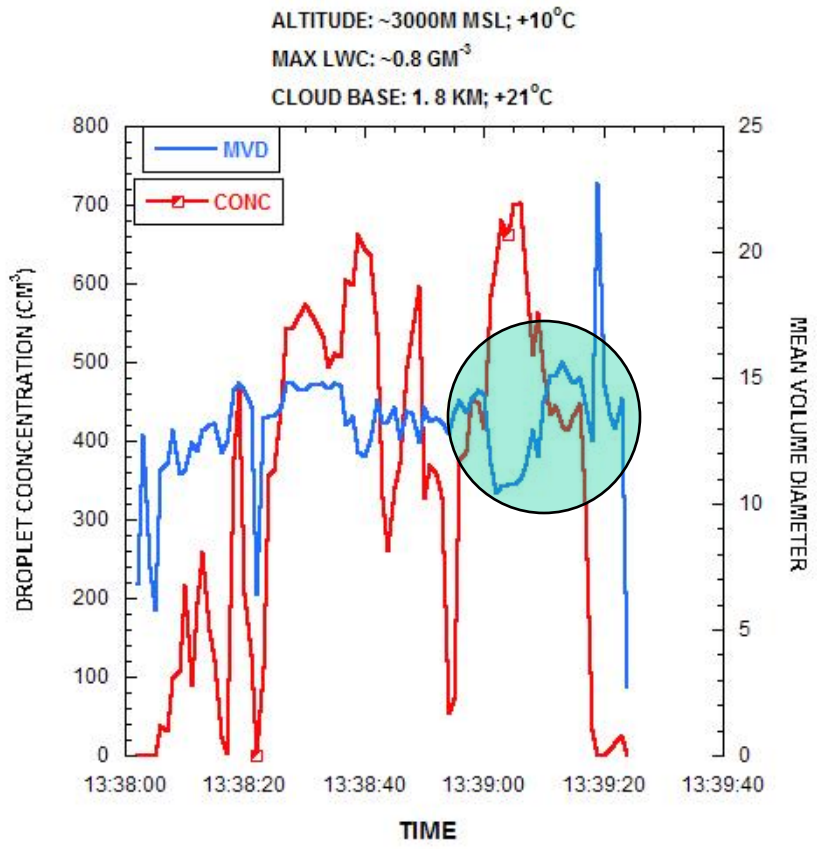


Broadening of cloud droplet spectra by re-circulation

NCAR





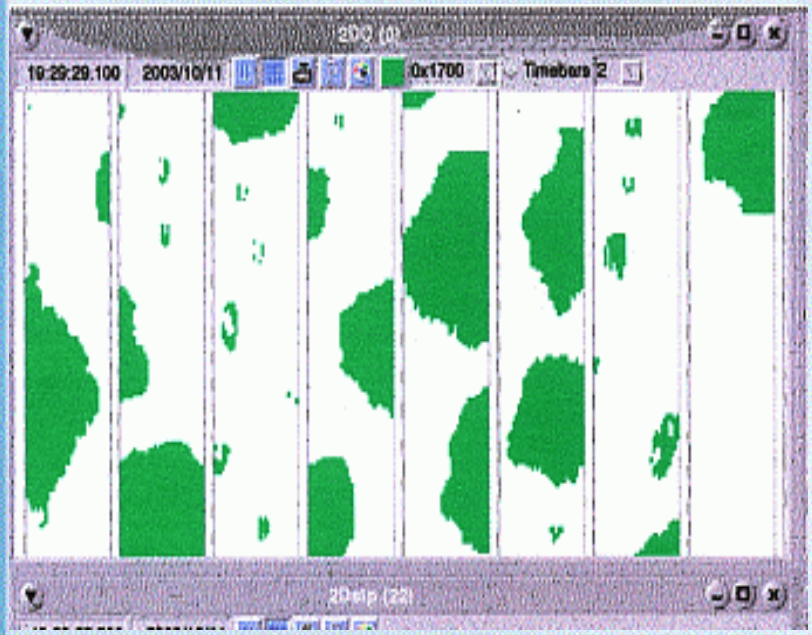


CCN effect: Difficult to form rain in clouds

Effects on Ice Processes

NCAR

Large drops freezing

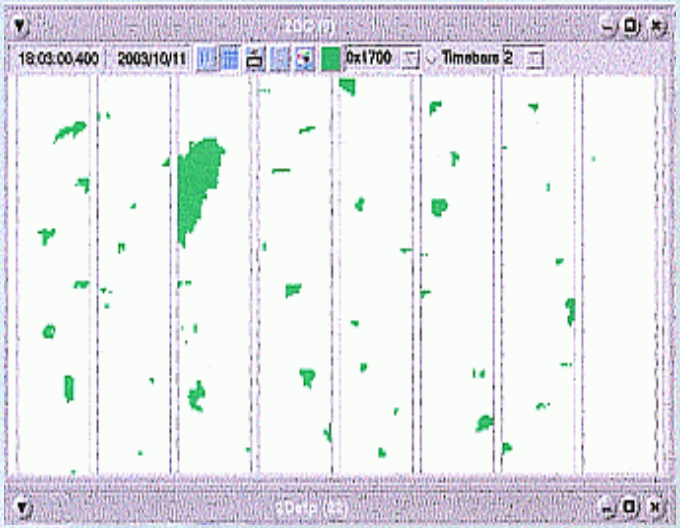


Concentrations: ~5-10L^{-1}

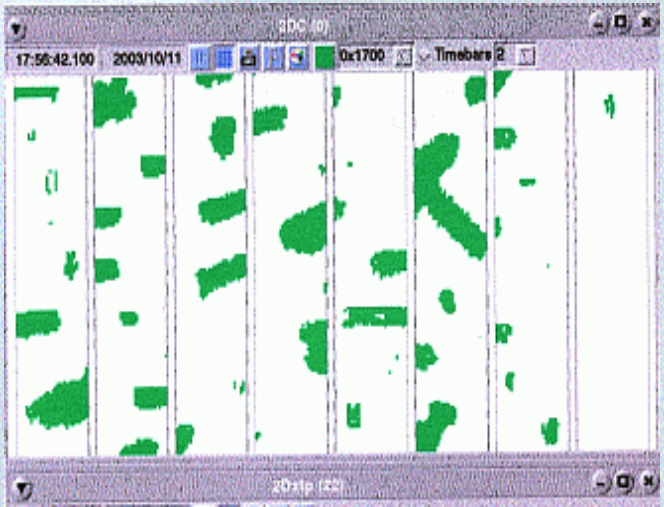
Similar to concentrations of observed large drops

POTENTIAL INVIGORATION OF CLOUD GROWTH DUE TO LATENT HEAT OF FREEZING

Secondary Ice Formation

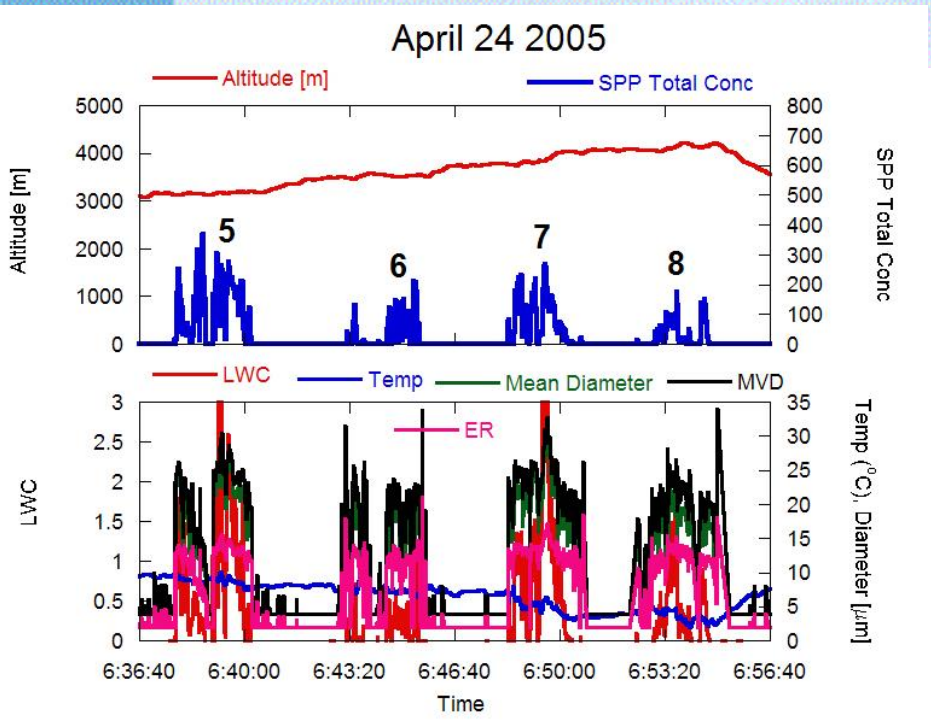


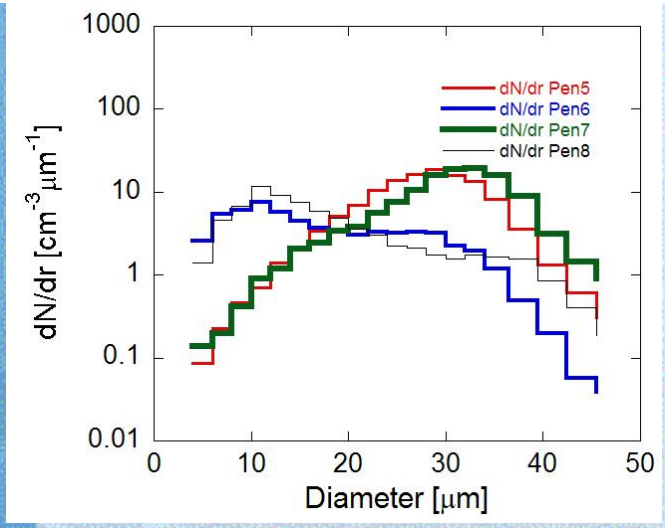
Concentrations between 200 to 400L^{-1}

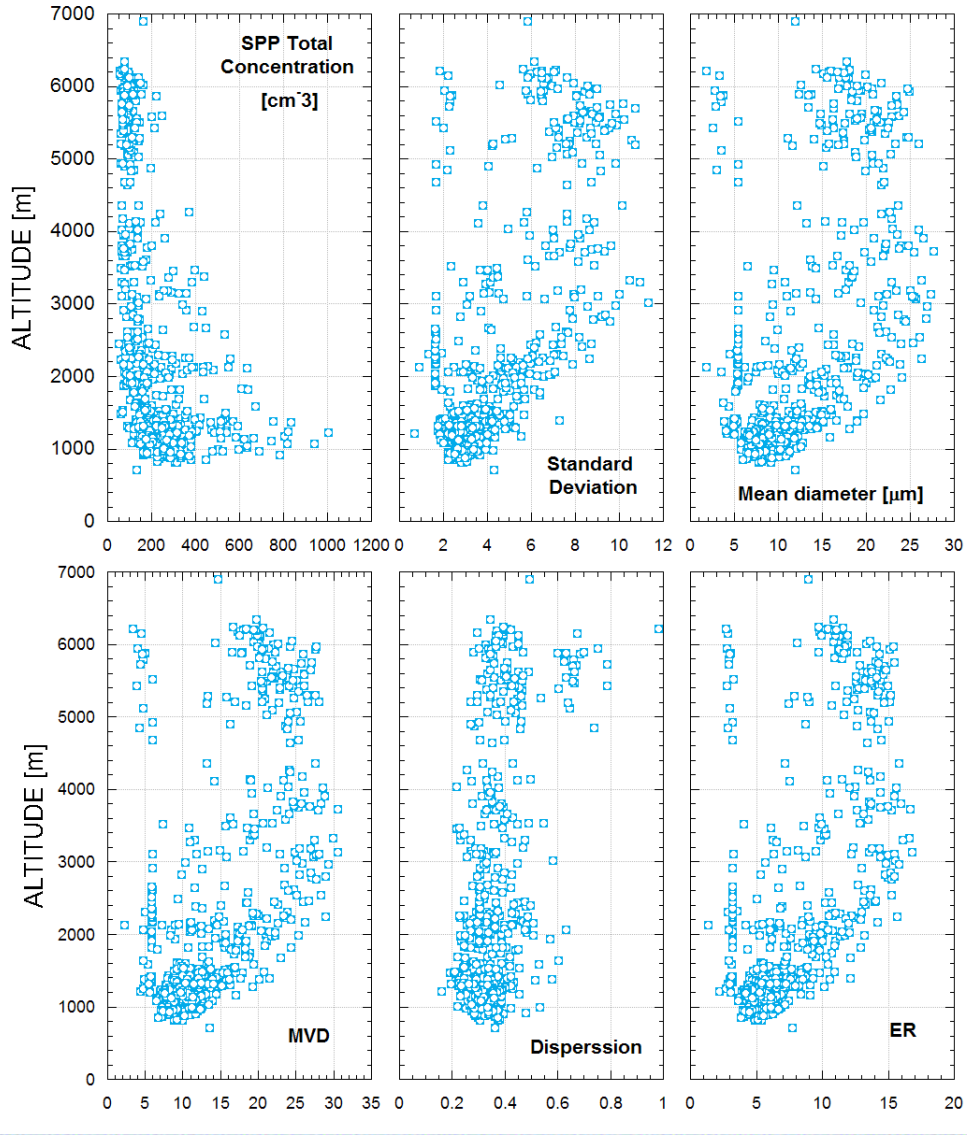


Sulawesi microphysical measurements

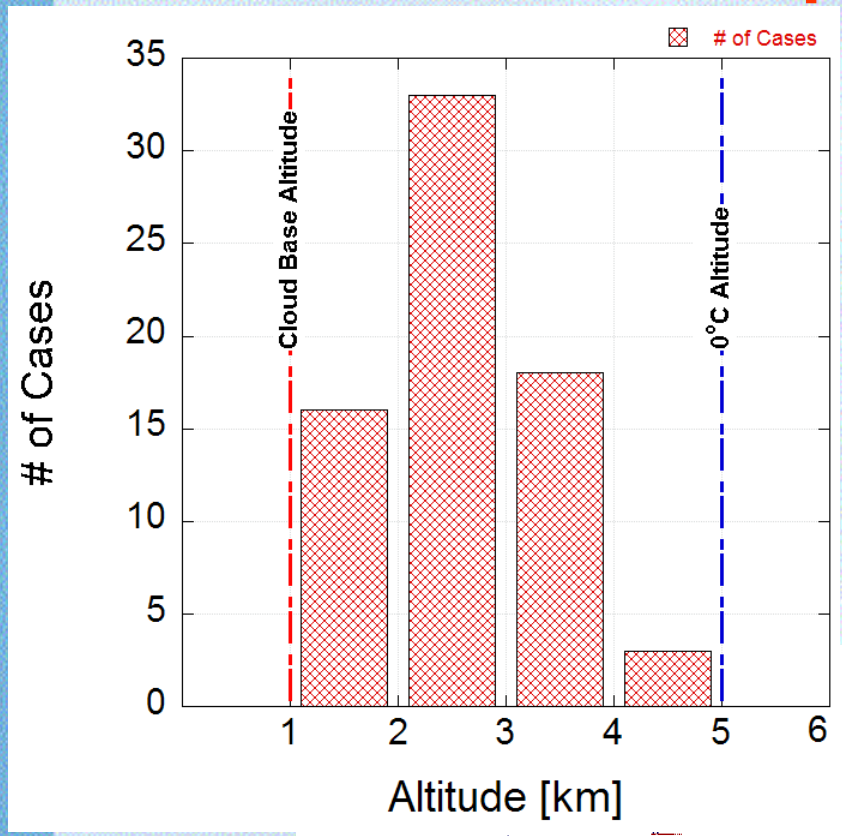
NCAR

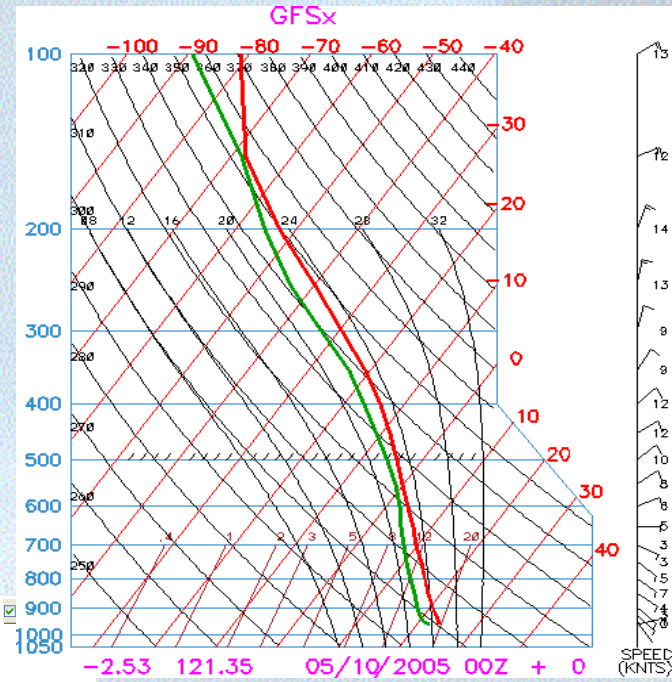


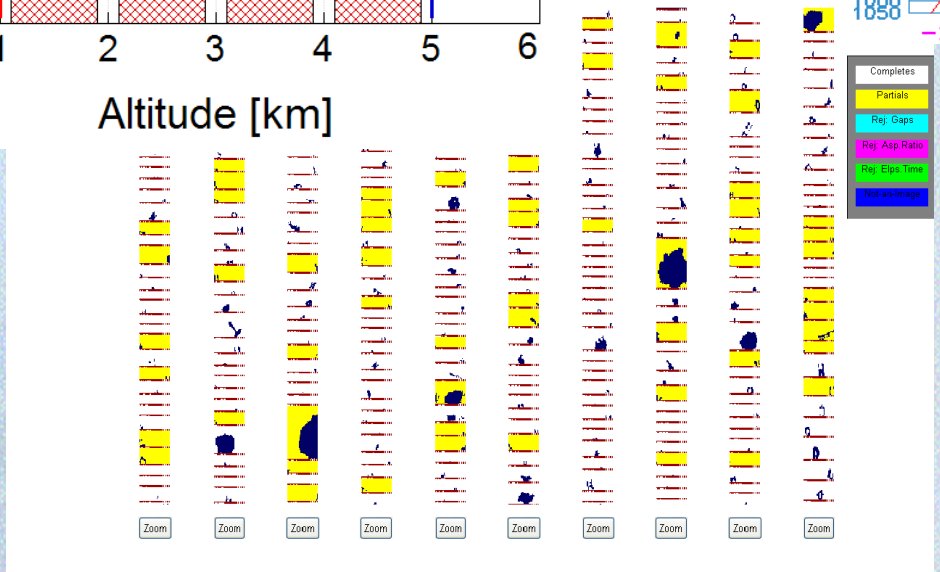




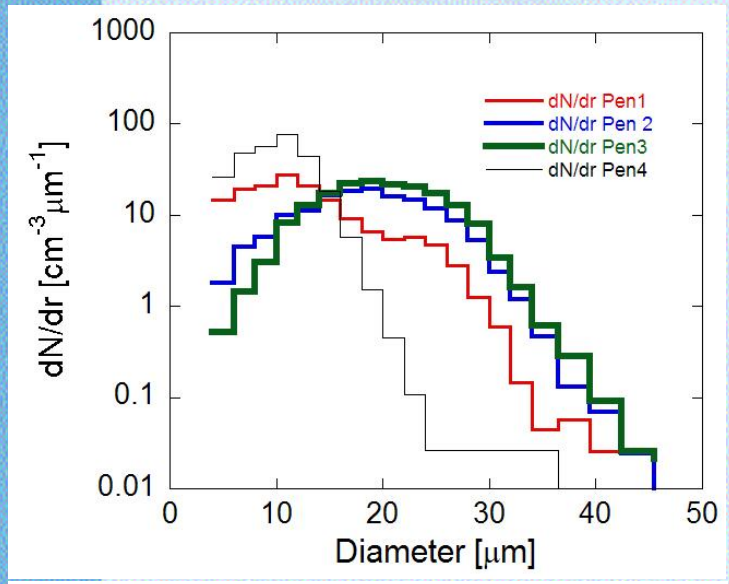
Sulawesi Precipitation process

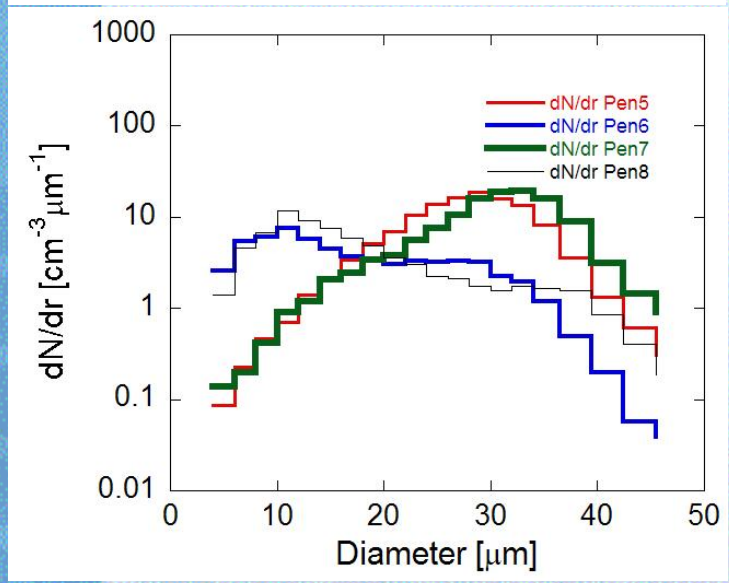


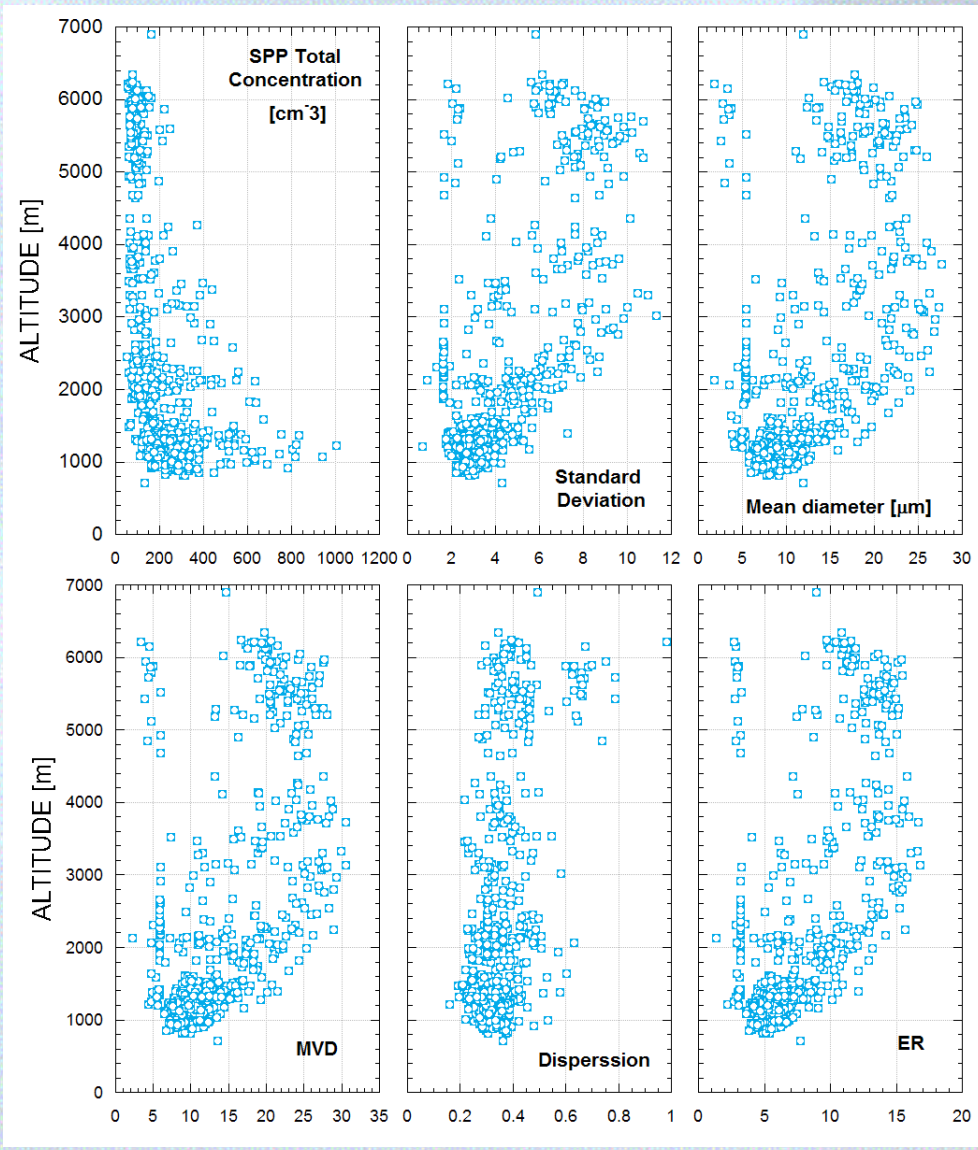


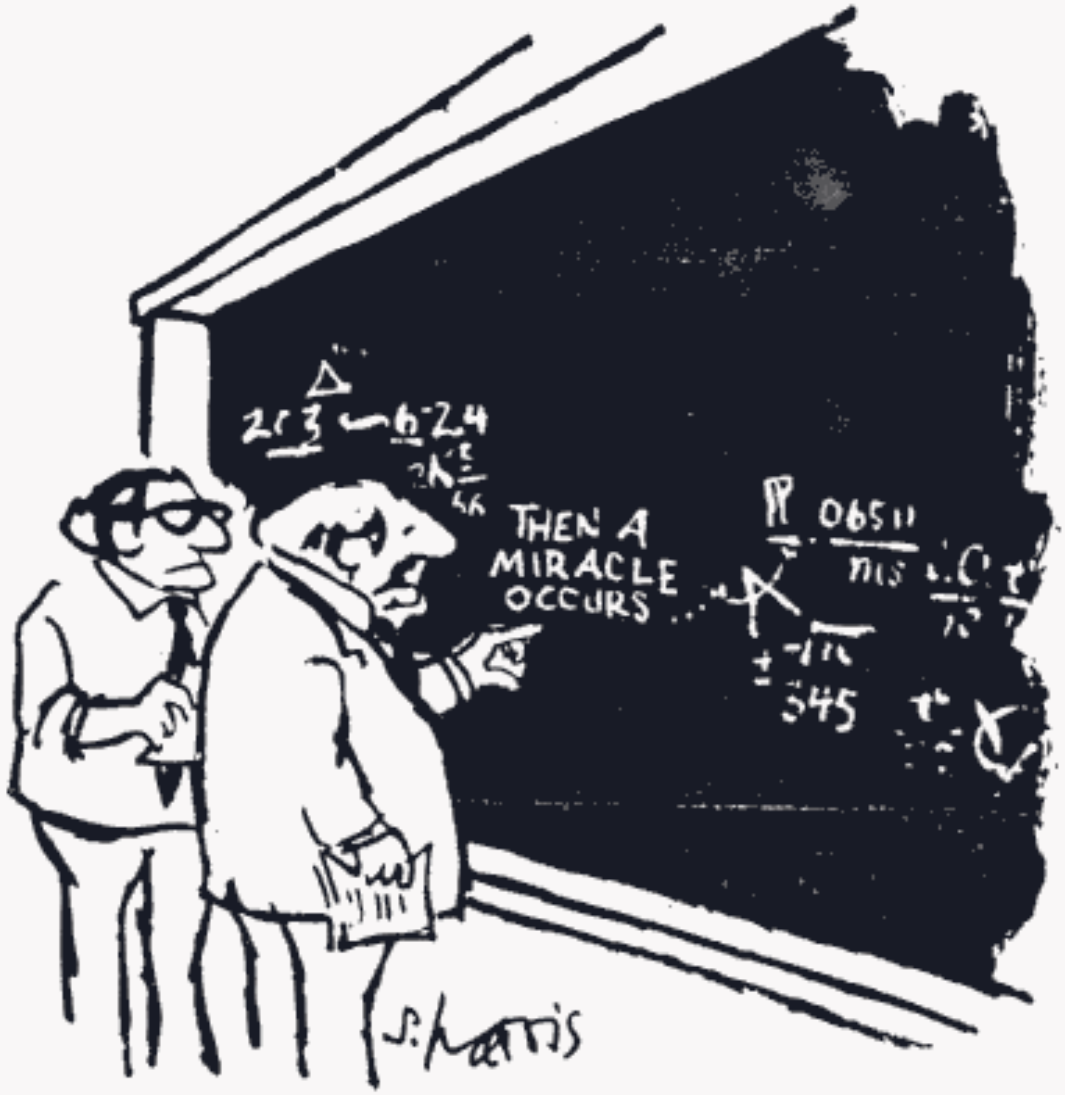


Sulawesi microphysical measurements and precipitation processes









"I THINK YOU SHOULD BE MORE EXPLICIT HERE IN STEP TWO."