Preliminary Observations of Cloud and Precipitation Characteristics in the Brisbane, Australia Region

Sarah Tessendorf

April 23, 2008

R. Bruintjes, J. Wilson, R. Roberts, E. Brandes, P. May, J. Peter, I. Craig, R. Stone, S. Seims, M. Manton, and D. Axisa

Queensland Cloud Seeding Research Program

- In response to drought the area has experienced the past couple years
- December 2007-March 2008
- Southeast Queensland region, based in Brisbane

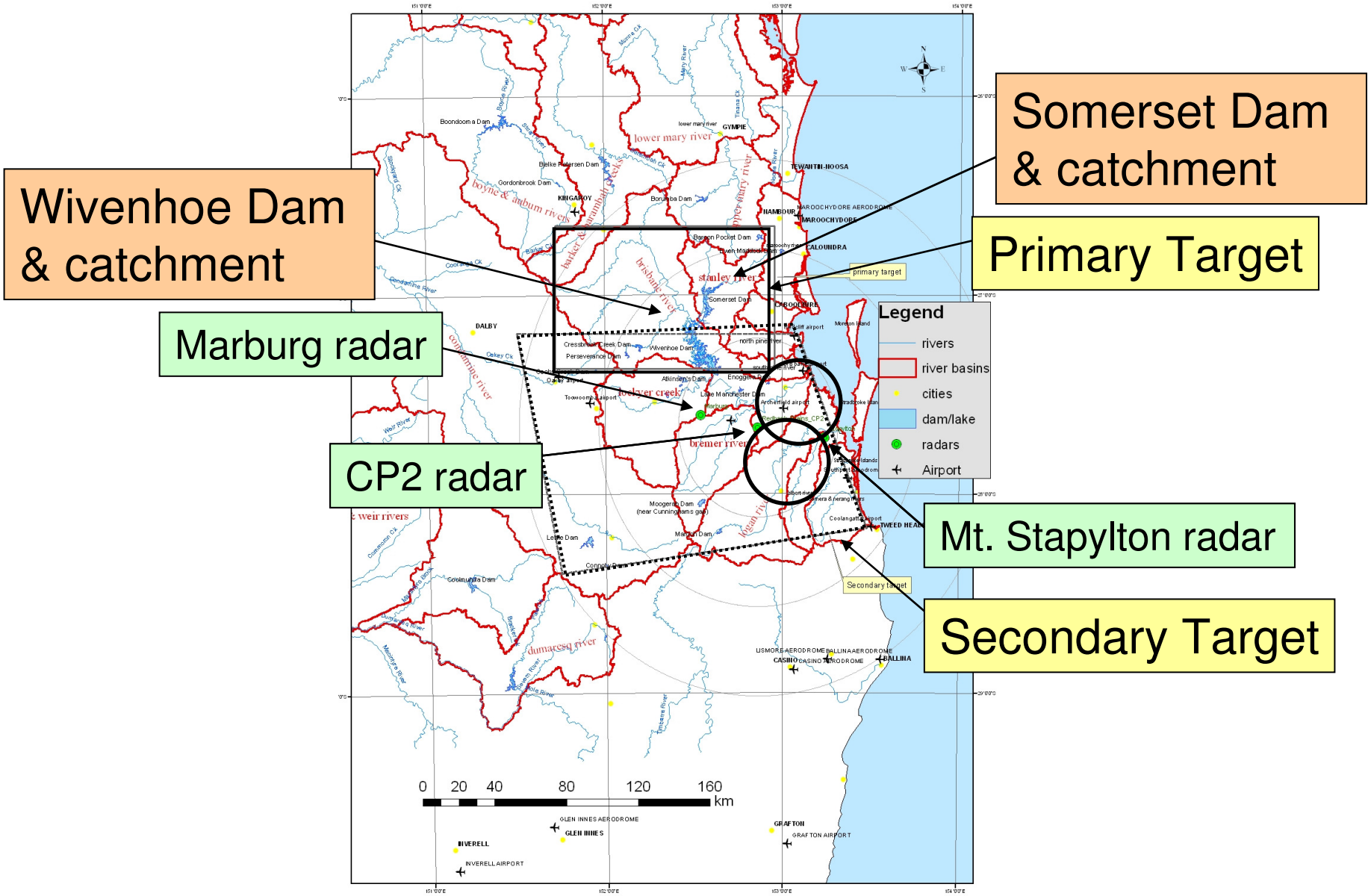
Program Objectives

- To make preliminary assessments of:
  - Climatological characteristics of precipitation, in particular, frequency of clouds suitable for seeding
  - Approaches necessary to make robust estimates of precipitation amount and retrieve microphysical properties of clouds
  - Effect of cloud seeding on storm microphysics and dynamics
  - Evidence from cloud seeding of increased secondary convection initiation
  - Evidence of precipitation enhancement from cloud seeding

Facilities

- CP2 dual-wavelength, dual-polarization radar
- Bureau of Meteorology radar network
- Two aircraft:
  - South African Weather Service (SAWS) Aerocommander (Research aircraft)
  - Weather Modification Inc (WMI) Piper Cheyenne II (Seeding aircraft)
- NCAR video disdrometer

Map of Southeast Queensland



CP2 radar

Research and Seeding Aircraft

Research aircraft instruments

- State parameters (temp, press, RH)
- AIMMS 3D winds
- Liquid water content
  - King hot wire, CAPS hot wire
- Aerosol
  - Fine mode (DMA)
  - Accumulation mode (PCASP)
  - CCN counter
  - Filter sampling
- Cloud droplet spectrometers
  - FSSP, SPP-100, CAS
- Cloud droplet imaging
  - 2DC, CIP
- Large drop imaging
  - 2DP
- Trace gases
  - SO2, NOx, O3, CO
- Wing flare racks
  - 20 burn in place (10 per wing)

Seeding aircraft features

- Wing flare racks
  - 24 burn in place (12 per wing)
  - Hygroscopic or Silver Iodide (AgI)
- Undercarriage flare rack
  - 306 ejectable AgI flares

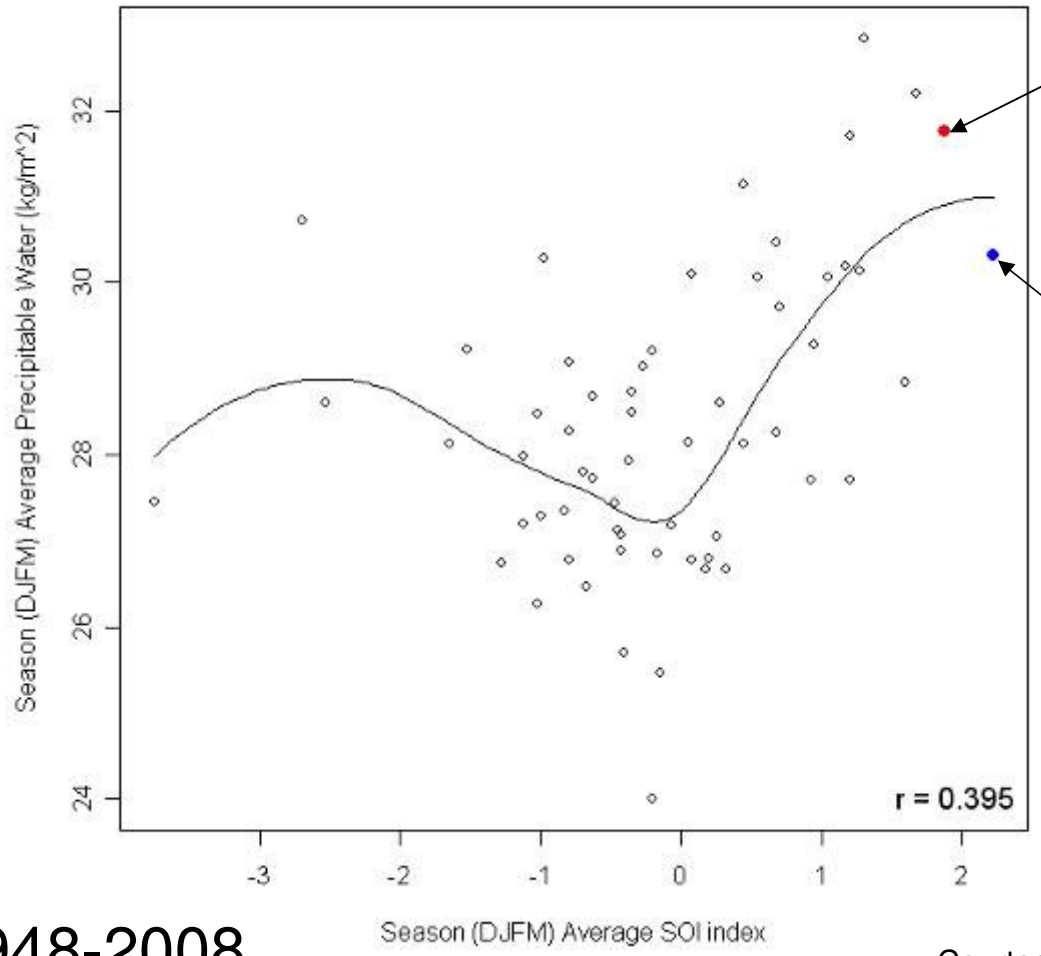
Goals of Aircraft Measurements

- Aerosol, CCN characterization
- Cloud droplet characterization
- Development of drizzle-sized drops
- Ice phase processes
- Drop size distributions in rain shafts

Flight strategies

- Ambient aerosol/sub-cloud surveys
- Cloud and aerosol microphysics flights
- Experimental seeding process studies
  - Primarily hygroscopic seeding
- Randomized seeding
  - Often, coordinated with in situ research aircraft measurements
  - CP2 polarimetric radar
  - Often, in southern dual-Doppler lobe
- Test and intercomparison flights

Context of 2008 DJFM season



2008 (3rd highest PW)

1974 (8th highest PW and highest SOI)

Data from 1948-2008

Courtesy Erin Towler, NCAR

Randomized Seeding Experiment

- 62 total cases
  - 10 deep convective with ice phase
  - 52 warm rain only
  - Hygroscopic seeding in all randomized seeded cases
- Statistical analysis of these cases with radar reflectivity, as well as polarimetric, estimates of rainfall will begin soon

13 Feb 2008

Highlights:

-4 seeded clouds

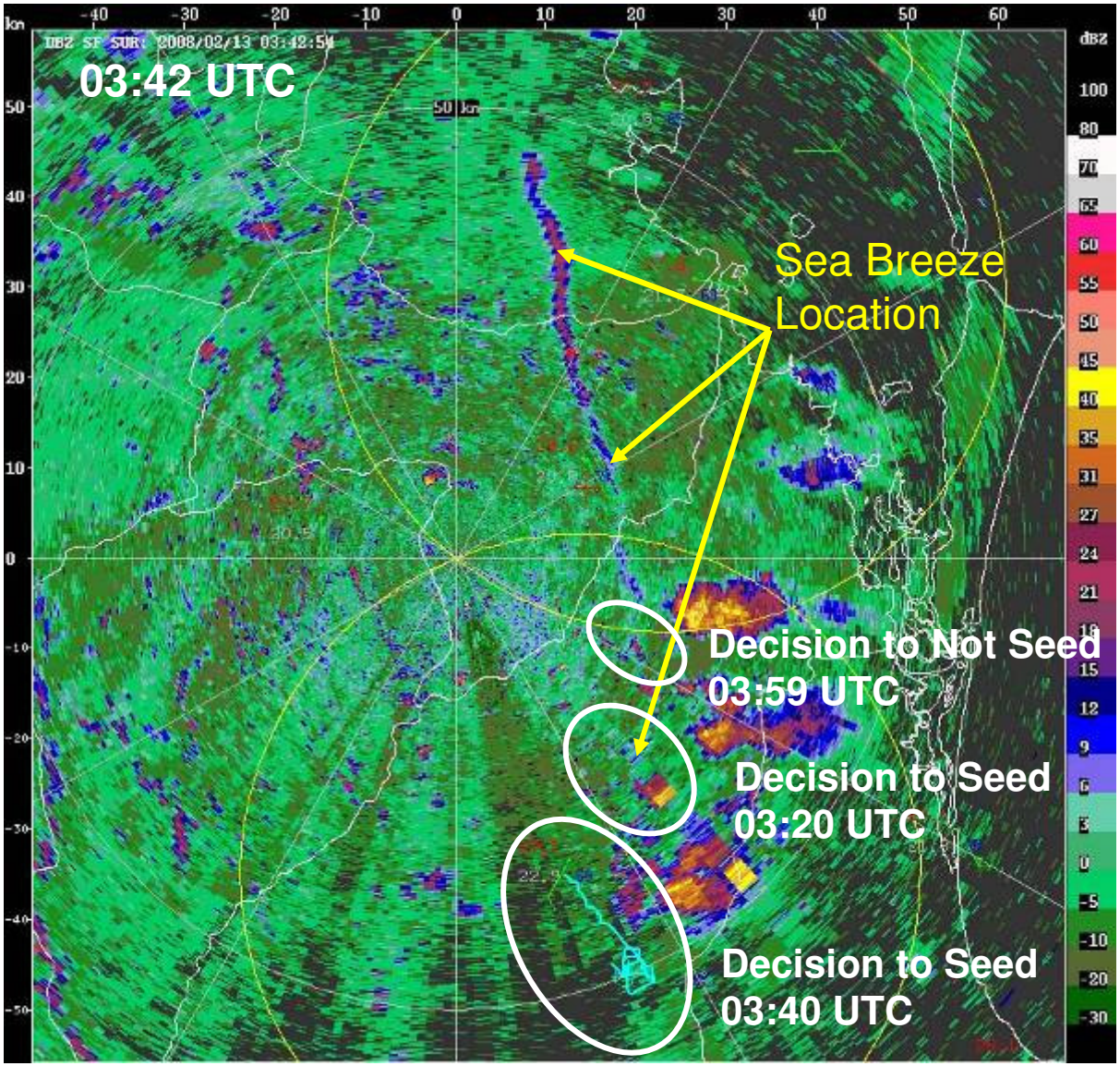
-2 not seeded clouds

-Several additional non-seeded cells formed along front

-All randomized seeding tests conducted within south or north dual-Doppler lobes (yellow circles).

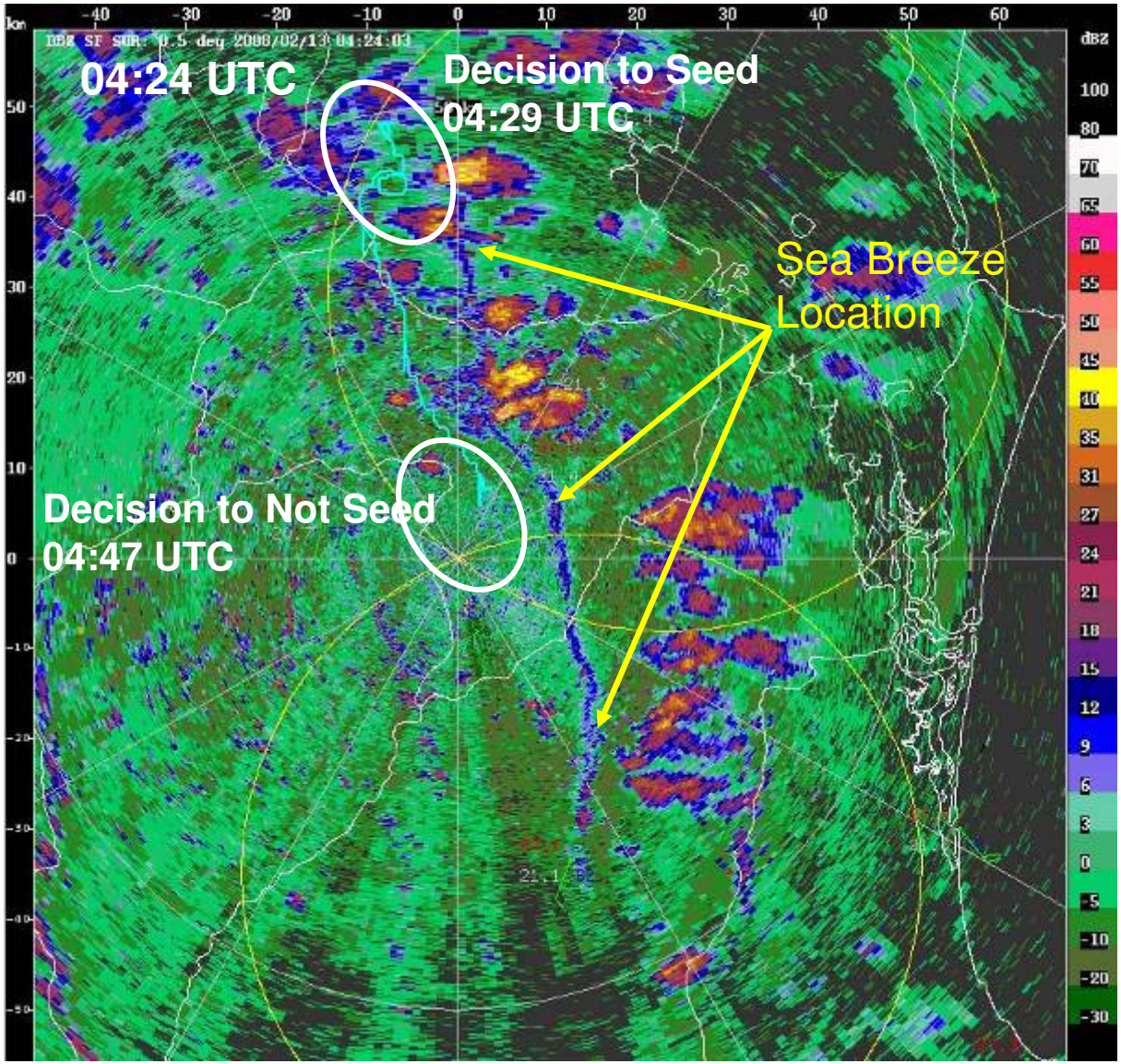
-Dynamics, kinematics and microphysical information possible from radar.

-Can examine impacts of seeding on downdraft production and outflows.

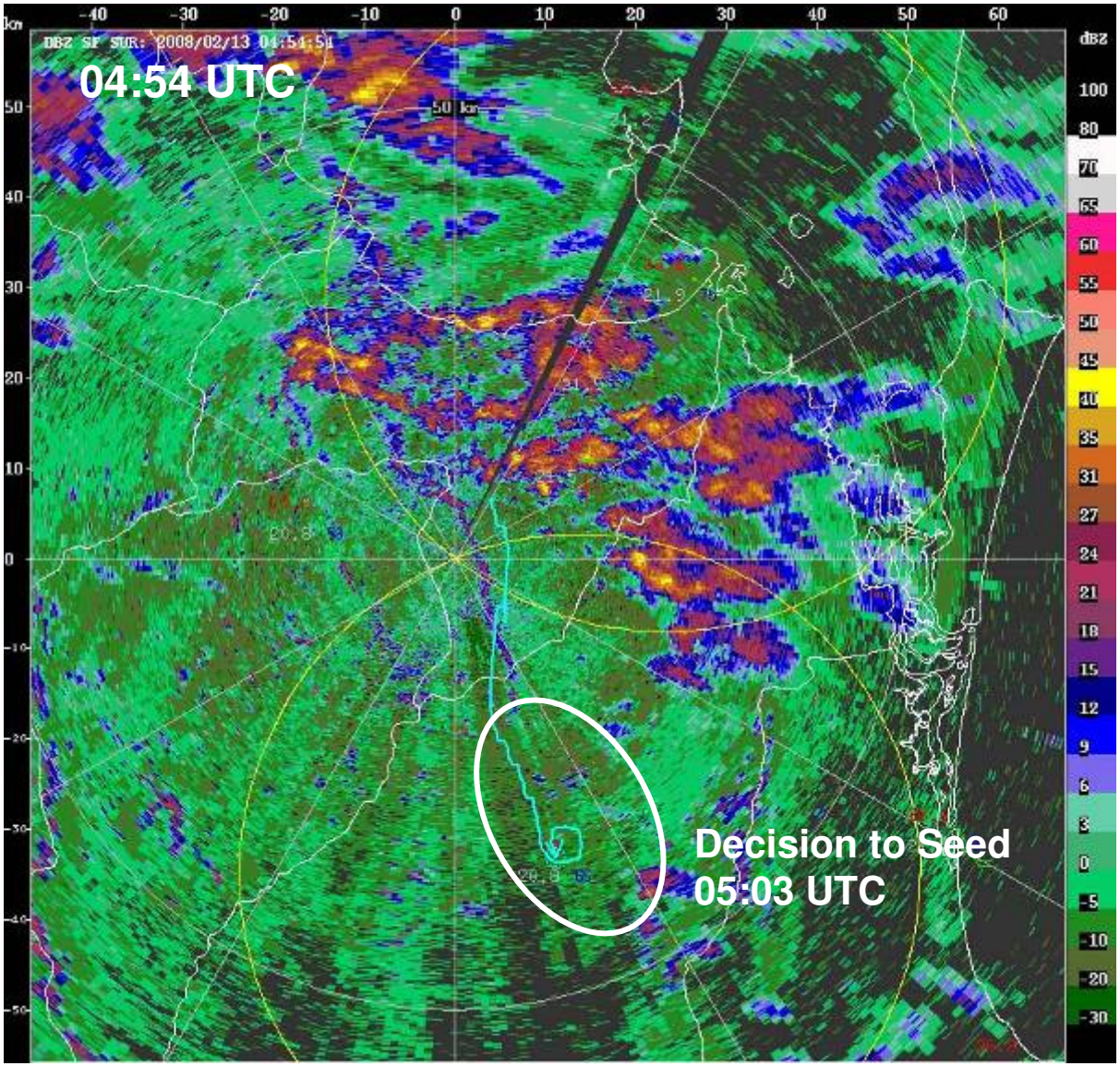


13 Feb 2008

- A few randomized cases in western side of north dual-Doppler lobe

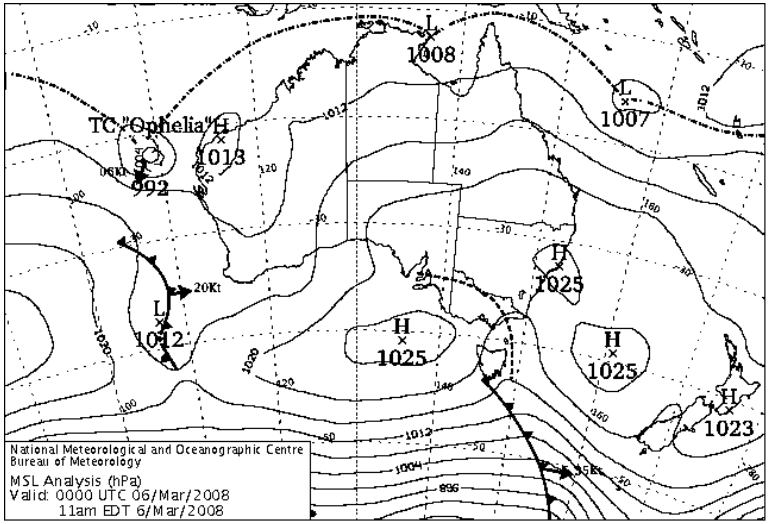


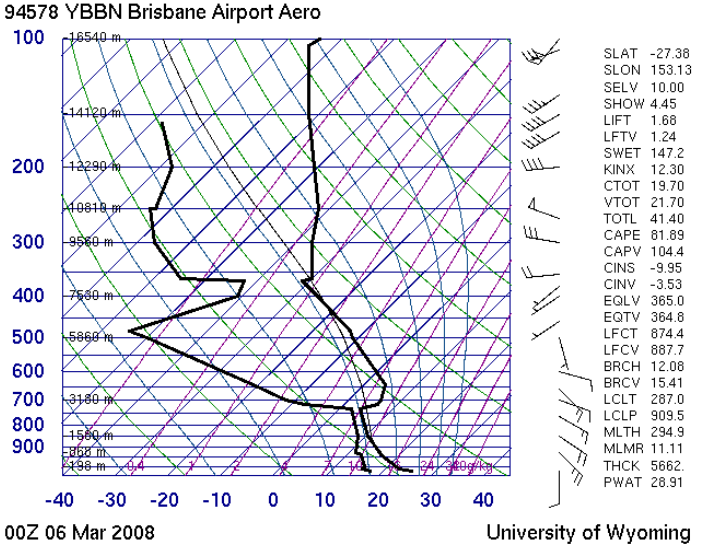
13 Feb 2008


DBZ SF SUR: 2008/02/13 04:54:54
04:54 UTC
Decision to Seed
05:03 UTC
dBZ

Warm rain processes

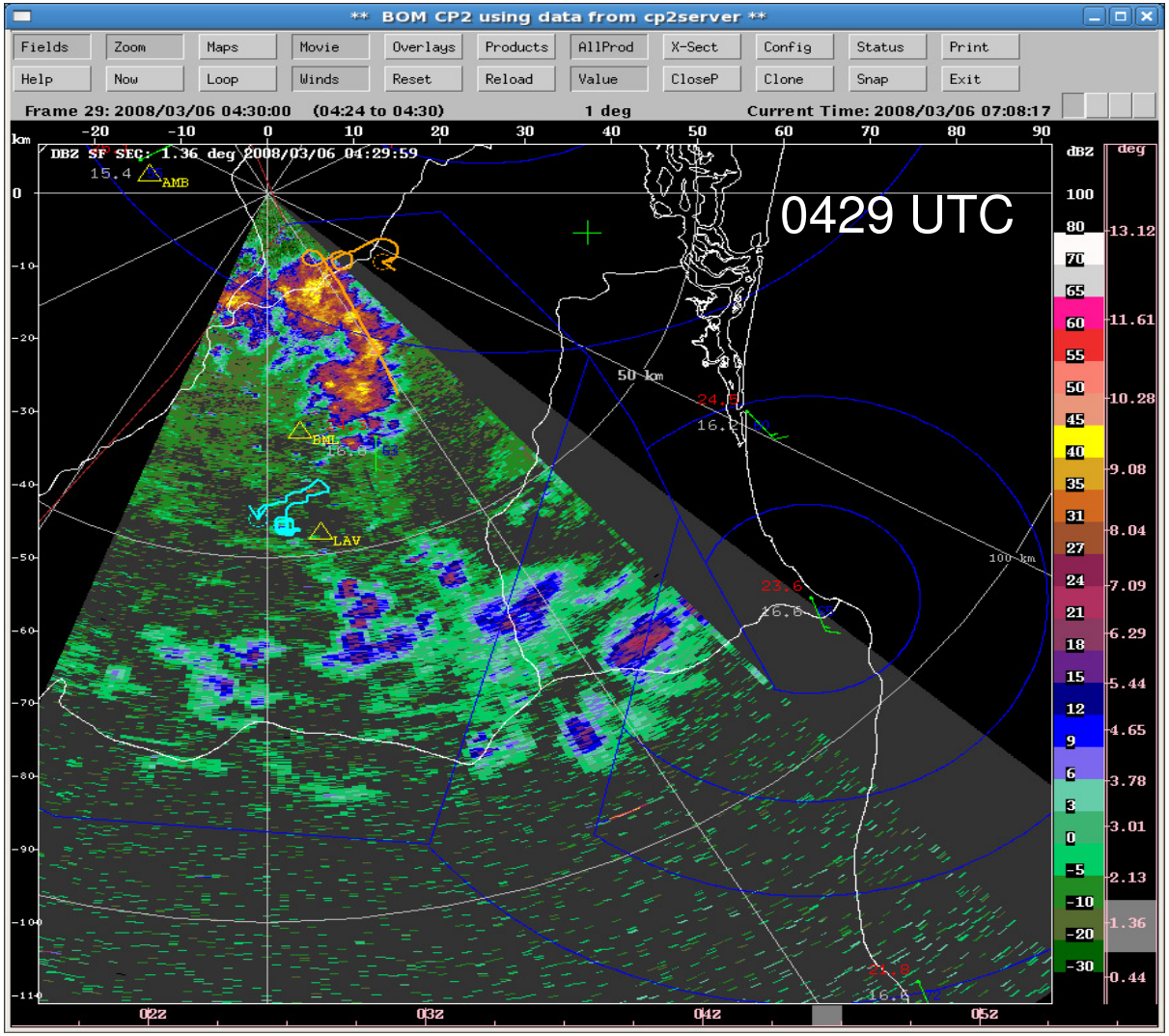
- Shallow trade wind cumulus clouds were very common
  - Dec: 2 days
  - Jan: 6 days
  - Feb: 10 days
  - Mar: 12 days
  - 64% of flight days





6 March 2008 Warm Clouds

- Bases: 4000 ft, tops: 9,000-10,000 ft



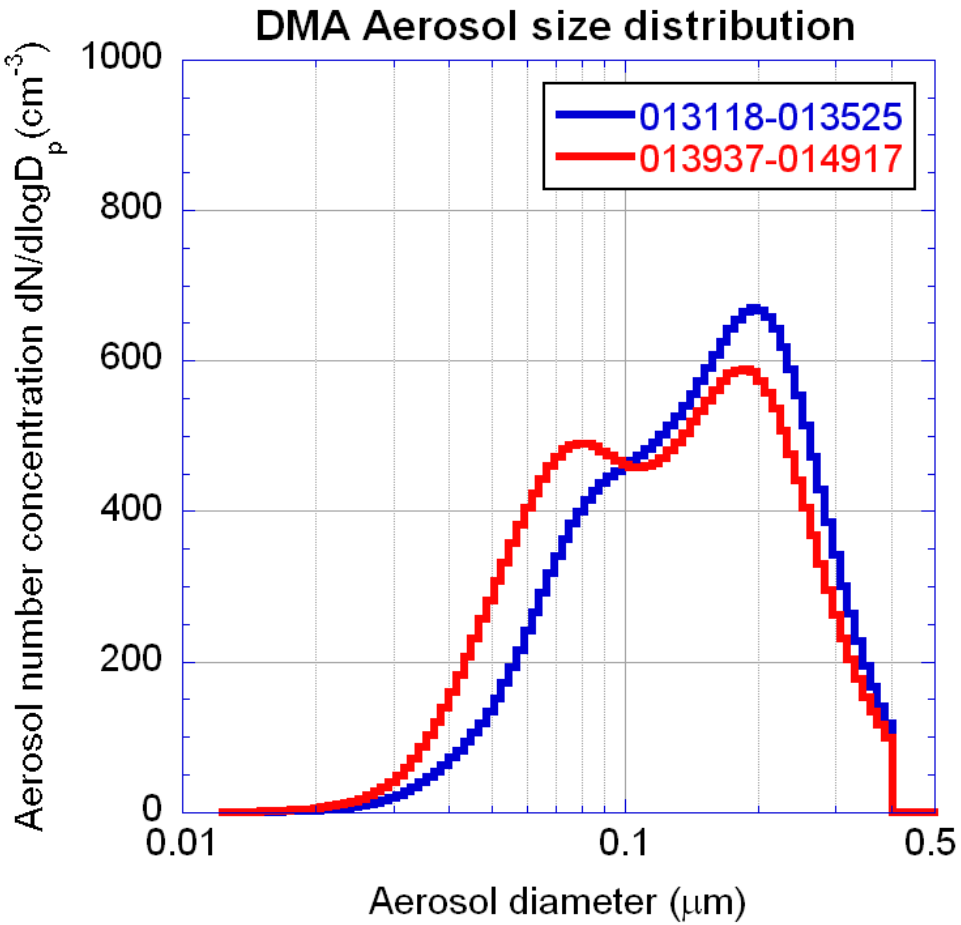
Randomized case #24

- Seeded
- Research aircraft penetrations at 9kft in cloud on route to base
- Passed through seeded cloud at 5, 8, 10 kft

Randomized case #32

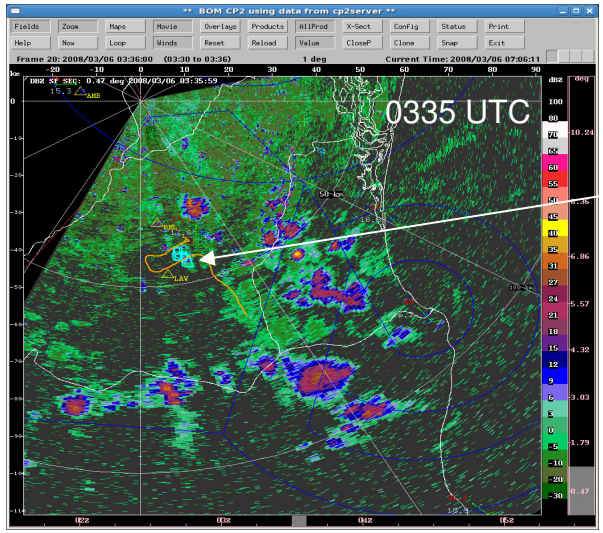
- Not seeded
- Research aircraft penetrations at 5000 ft in nearby clear measurements

6 March 2008 Subcloud Data

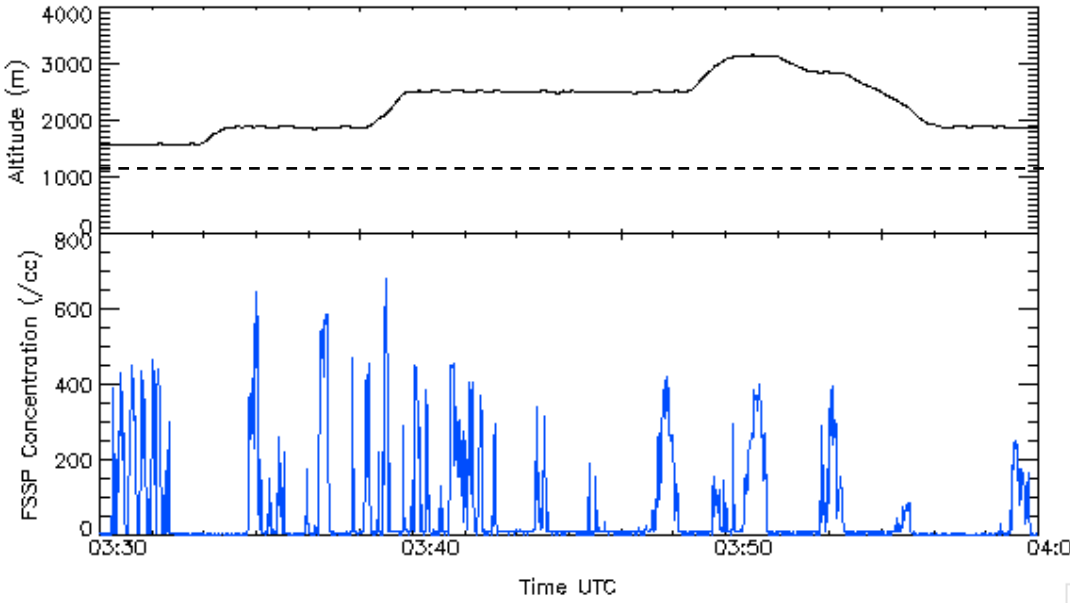


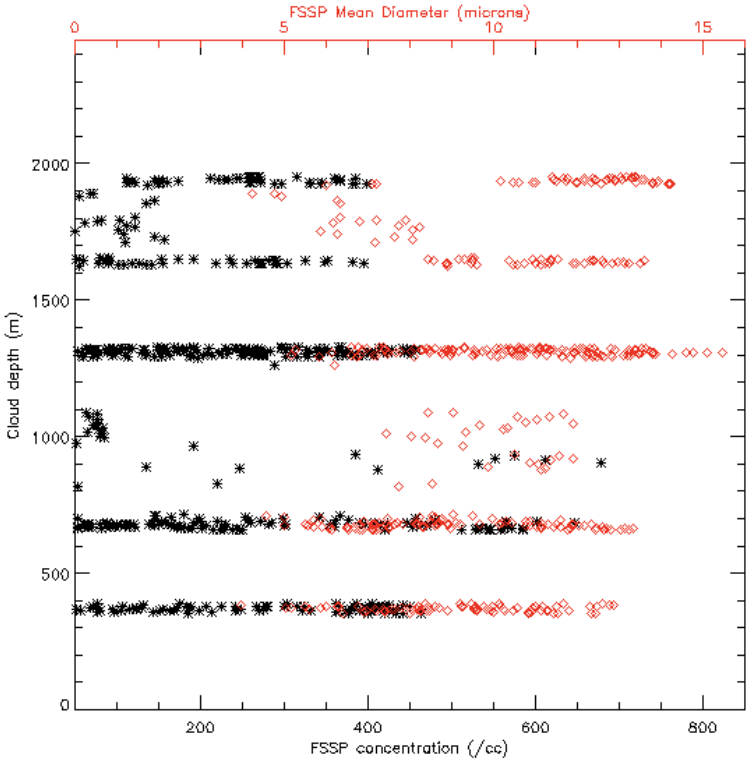
Taken just below cloud base at 1000-1200 m

6 March 2008 Cloud Penetrations



Randomized case #22



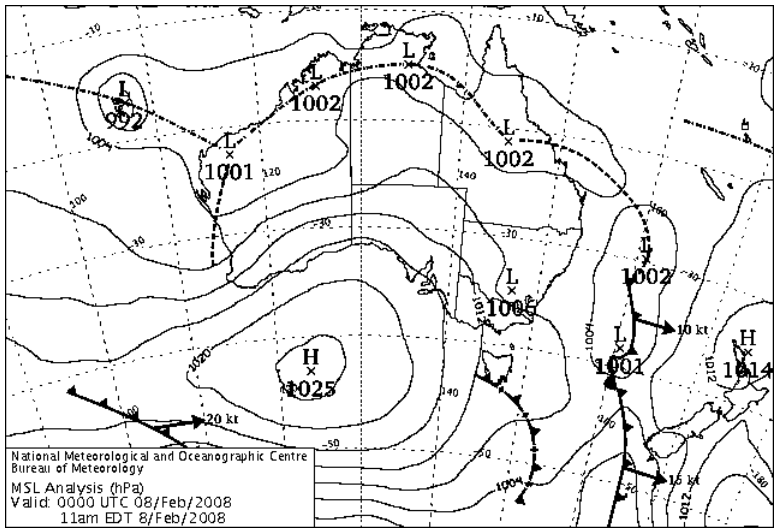


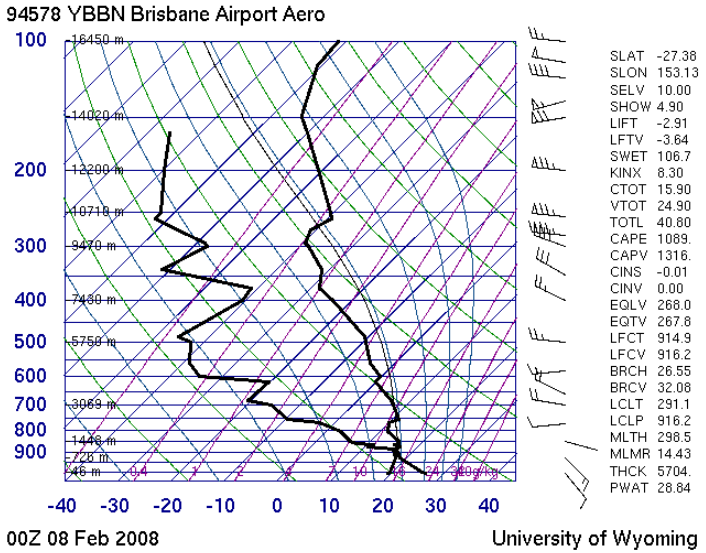
Cloud base: 1200 m

Cloud tops: ~ 3000 m

Deep convection

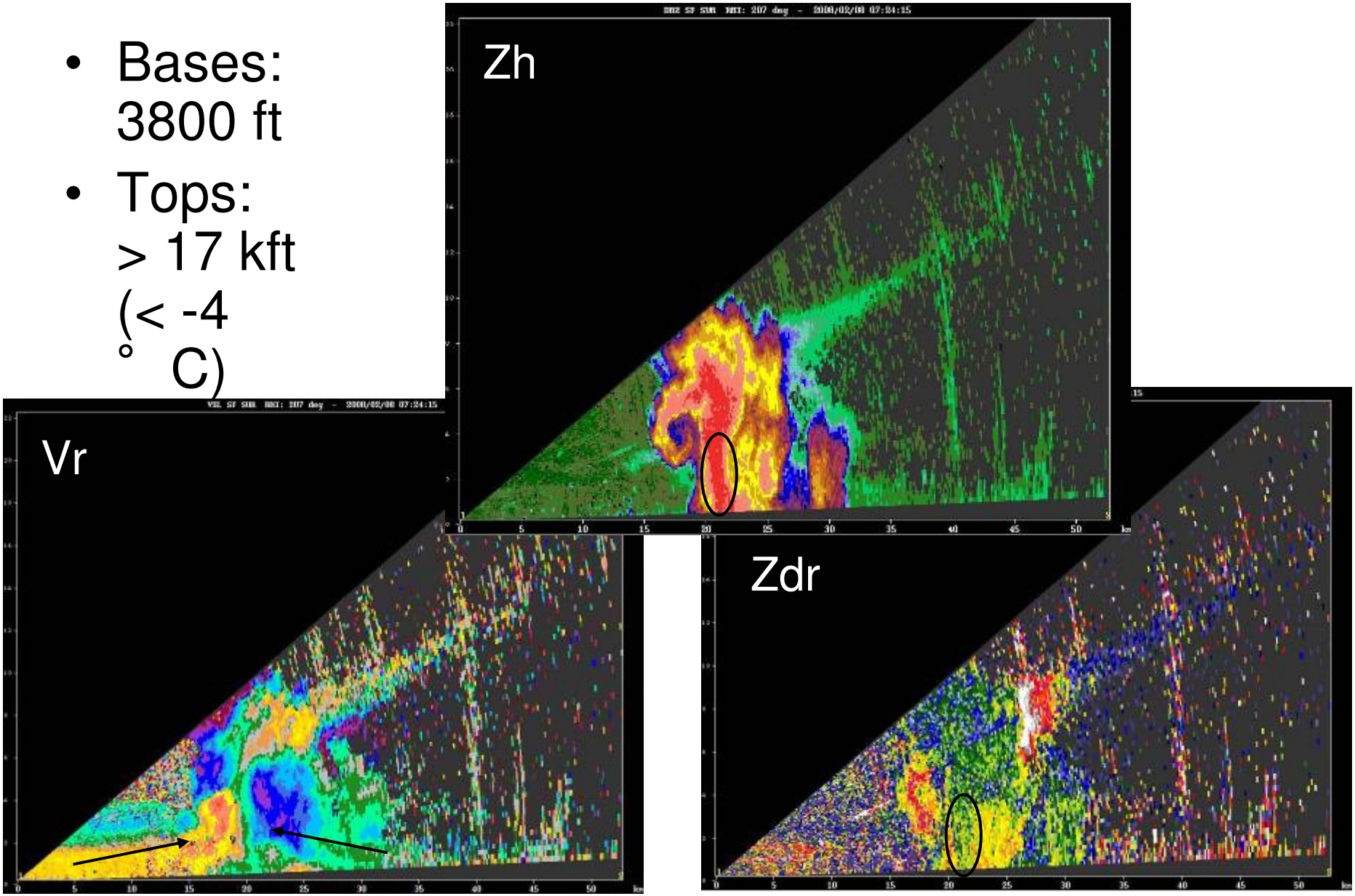
- Deep convective storms were usually associated with approaching troughs which helped destabilize the atmosphere
  - Jan: 6 days
  - Feb: 4 days
  - Mar: 3 days
  - 28% of flight days





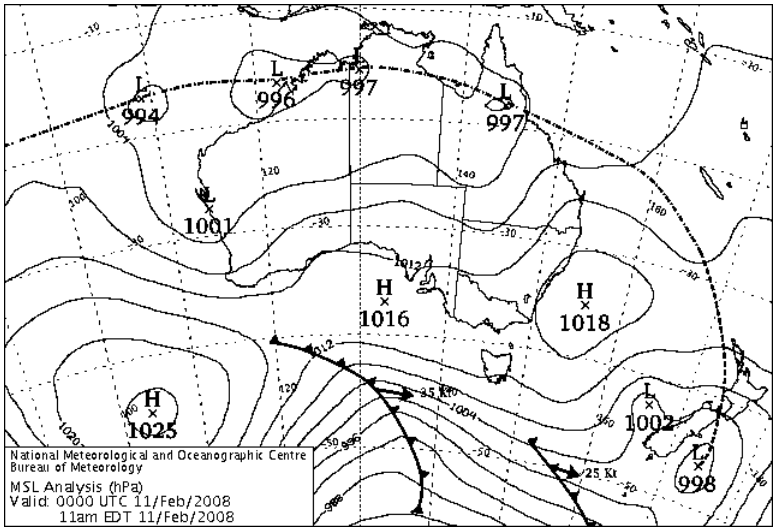
Feb 8 2008 Deep Convection

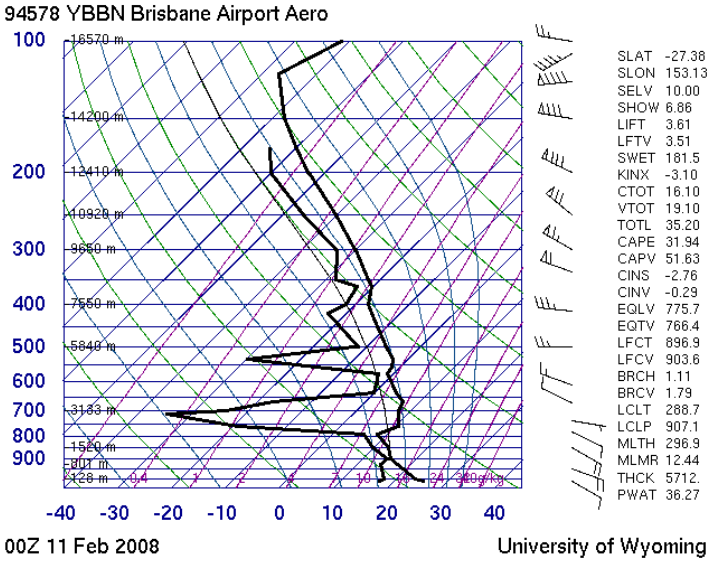
- Bases: 3800 ft
- Tops: > 17 kft (< -4 ° C)



Deep stratiform systems

- Nearby monsoon trough and moist adiabatic sounding profile
- First observed case (Jan 15) had liquid water at -5 C
- Later observed cases did not have supercooled LW
  - Jan: 1 day
  - Feb: 2 days
  - 6 % of flight days





Summary

- Good dataset of sub-cloud aerosol conditions
  - Were the observed clouds more maritime or continental? How does the Brisbane plume affect aerosol & CCN distributions?
- Good dataset of warm cloud (often very shallow) precipitation processes and a few good deep convective cases
  - How were shallow clouds such effective rain producers? How much rain did they produce? How common are they?
  - What is the effect of hygroscopic seeding?
- A few deep stratiform cases
  - Why such little supercooled liquid water in later season cases?

Future work

- Relate sub-cloud aerosol to CCN and cloud drop distributions
- Study effects of hygroscopic seeding
  - Experimental process studies with in situ measurements
  - Randomized study (will begin soon)
    - Including polarimetric and dual-Doppler radar analysis!
- Climatological analysis (underway)
- Case studies and associated research questions