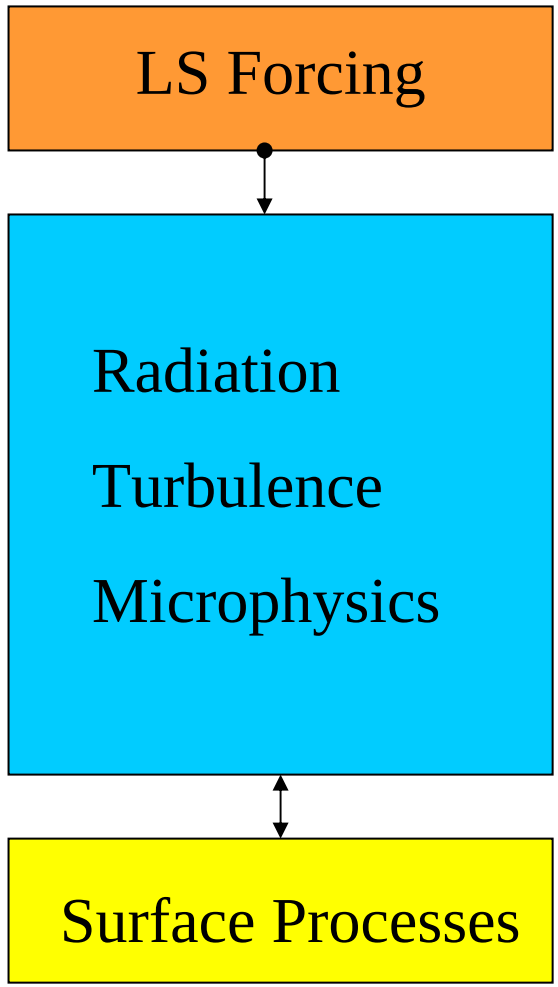
ARM Boundary Layer Clouds

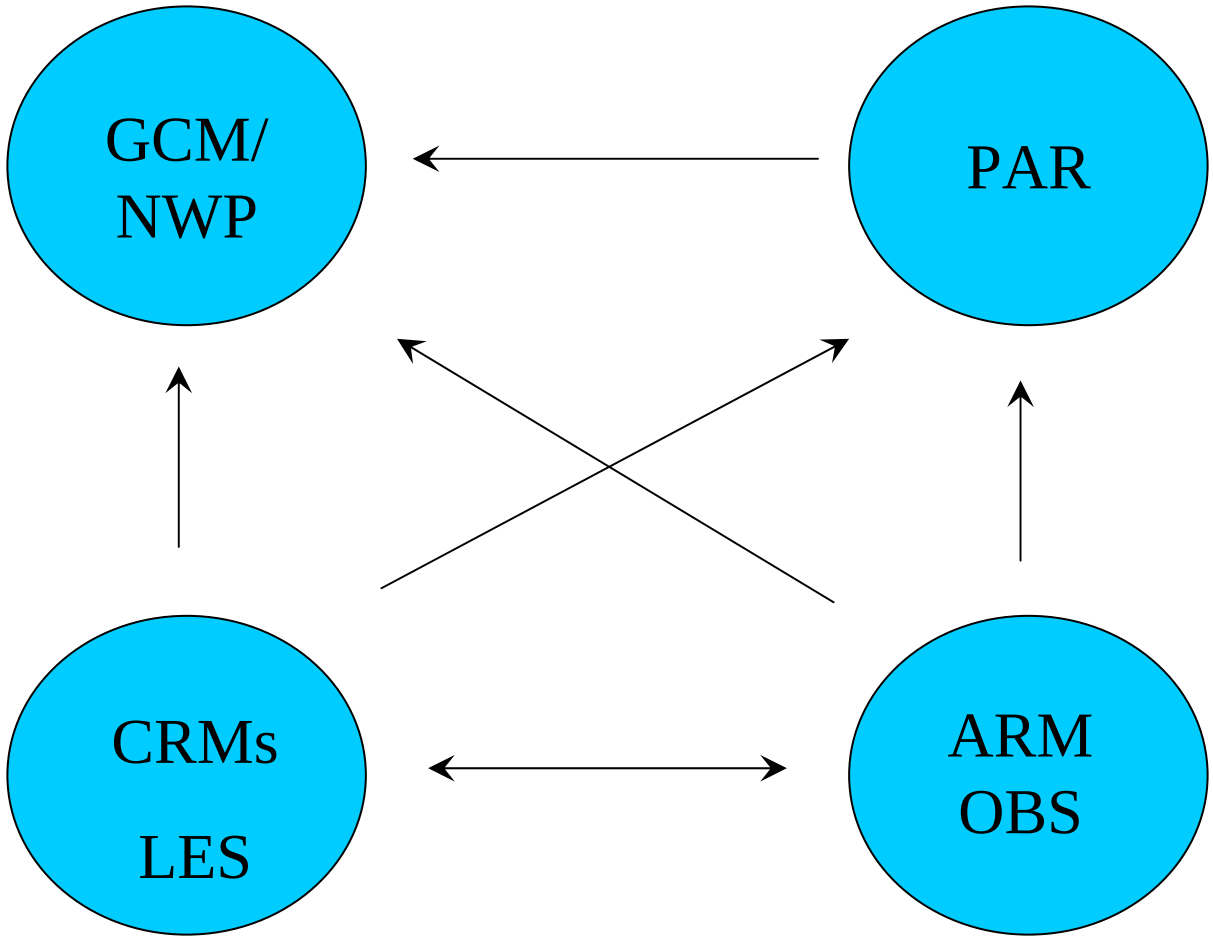
- Continental Stratus/Stratocumulus
- Continental Fair-Weather Cu
- Marine Fair-Weather Cu

Issues

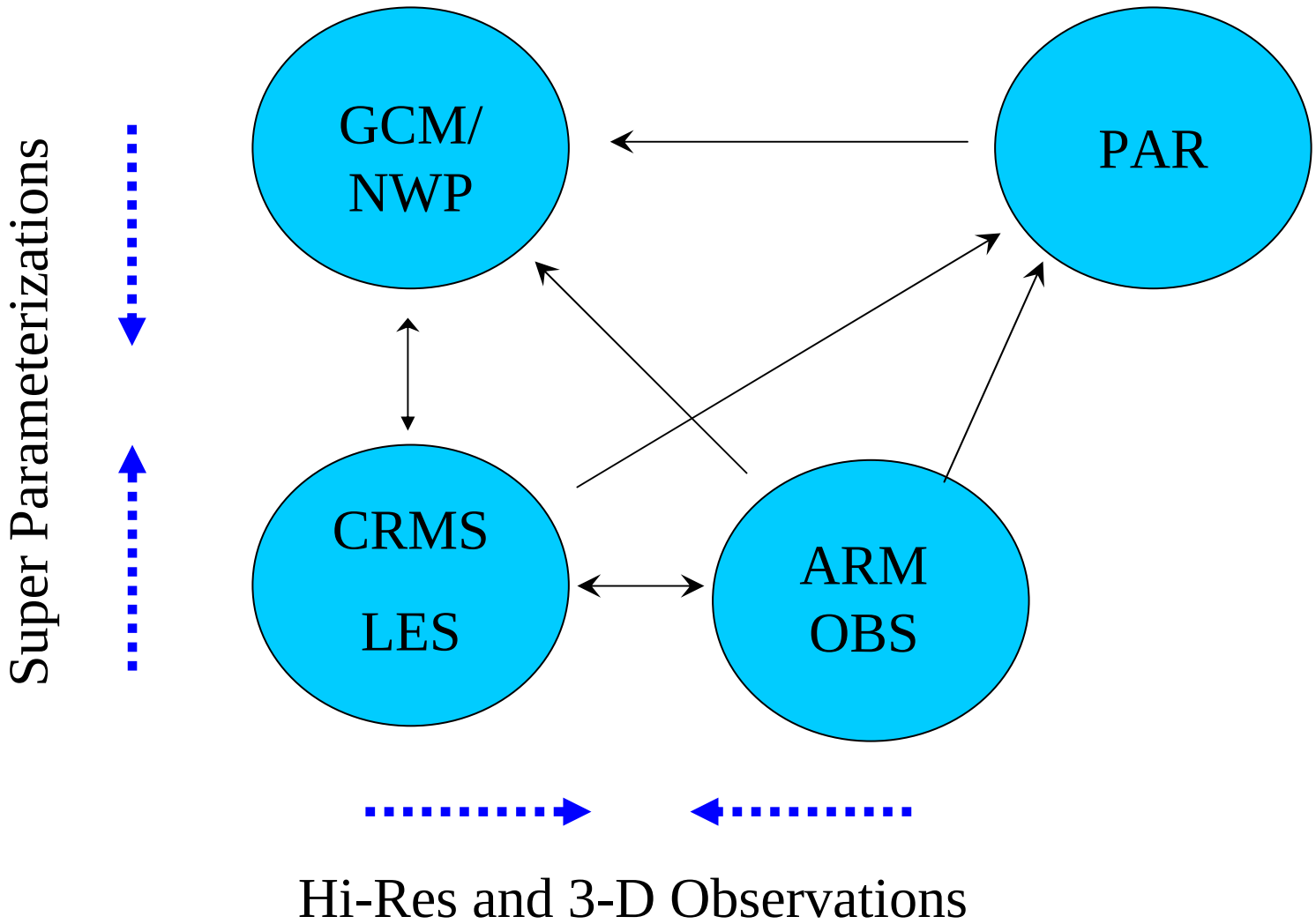
- Cloud Evolution and Maintenance
- Cloudiness (Radiation)
- Radiative and Microphysical Properties
- Cloud-Aerosol-Drizzle Interactions
- Mass Transports
- Surface Interactions



Parameterization Development and Testing Strategy



Parameterization Development and Testing Strategy

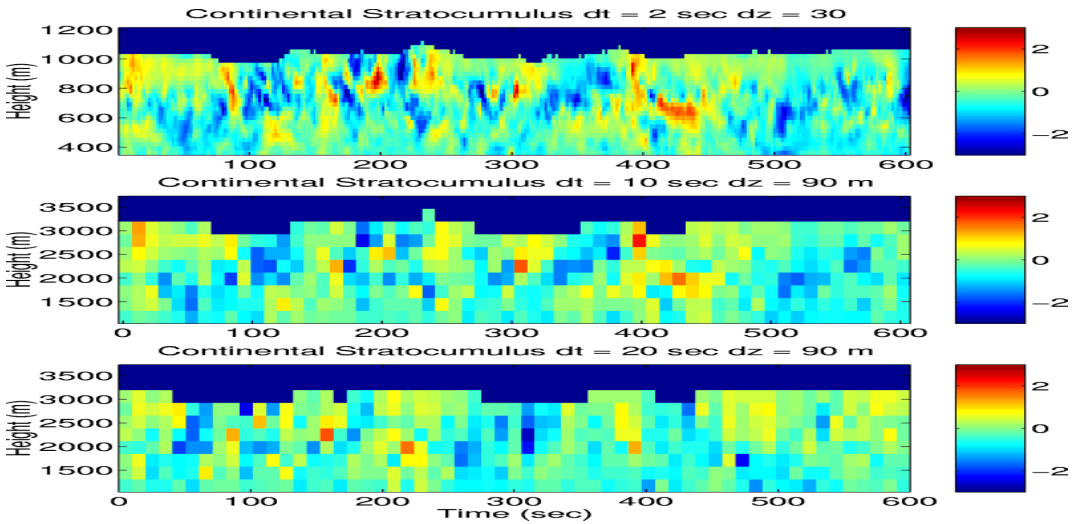


Enabling Technology—

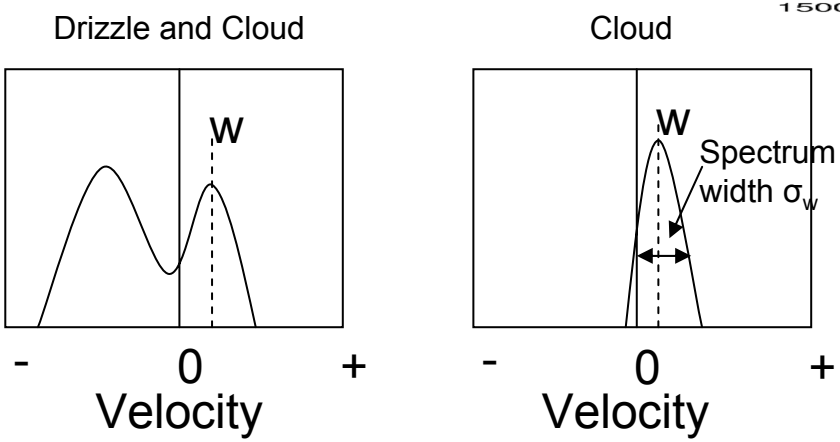
High resolution MMCR and 95 GHz spectra and moments provide in-cloud turbulence

Scanning?

Doppler Vertical Velocities from Continental Stratus



BLC Doppler Spectra



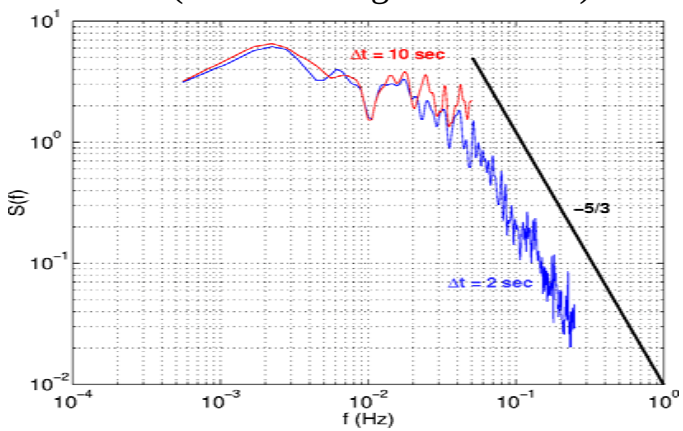
Doppler Spectrum Variance

$$\sigma_w^2 = \sigma_d^2 + \sigma_s^2 + \sigma_t^2$$

drop shear turb

In-Cloud w Spectra

(2-sec and degraded 10-sec)



New Thrust–ARM LES Testbed (ALT)

Motivation:

--New high resolution radar and MWR observations

--Prospects of 3-D cloud characterizations (AVA)

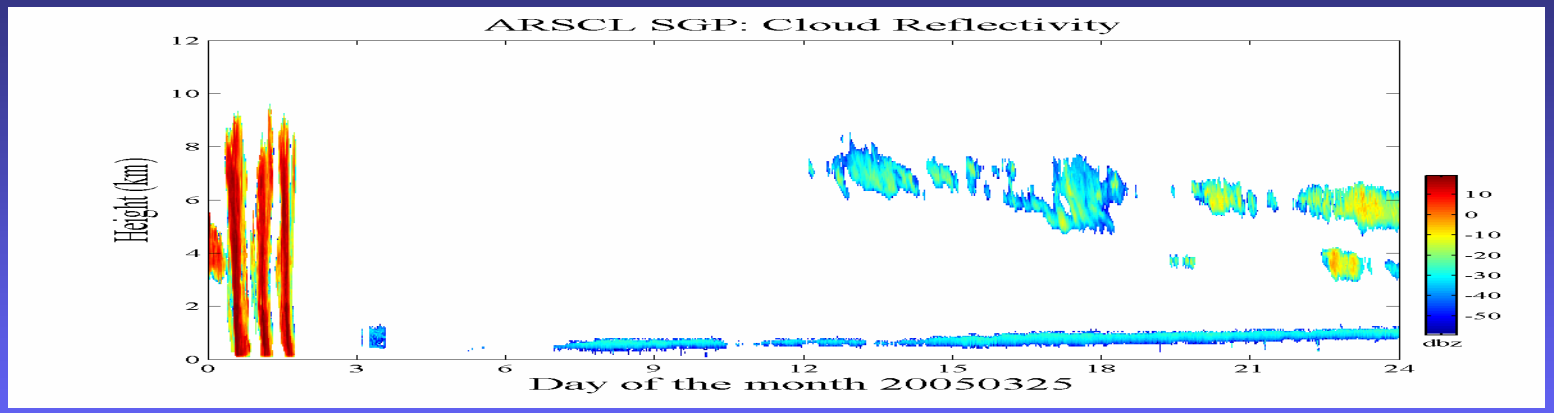
--A framework for organizing observations

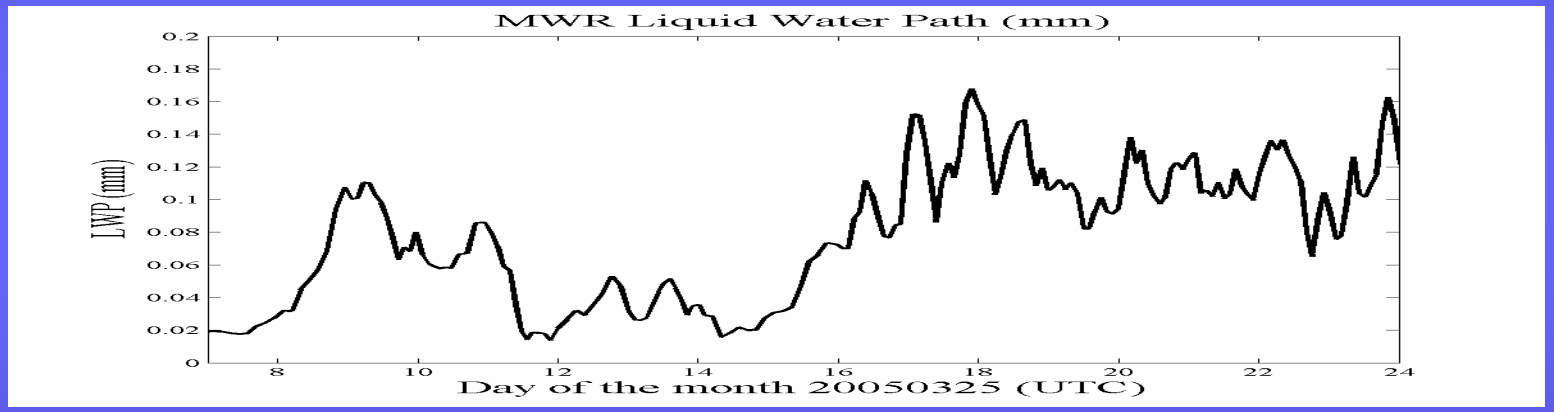
- ARM LES Evaluator (ALE)
  - Develop BL Data Sets—Single layered, uniform, cloud fields (stratocumulus; fair-weather cumulus)
  - BCs from ARM Obs, VAPS, NWP analyses…….
  - Evaluation/Tuning
    - Radar Doppler Spectra; LEO for LES
    - Liquid Water Path, Cloudbase, Surface Rad, 3-D cloud fields, e.g.
    - Establish Model Sensitivity to Forcing and Tunable Parameters
- ARM BLC Simulator (ABS) (20 kmx20 km domain?)
  - Near real time LES (1-hour statistics)
  - Assimilation/Nudging/Iteration/Neural Network Tuning?
  - Output --domain cloud, boundary layer, and radiation characteristics/statistics

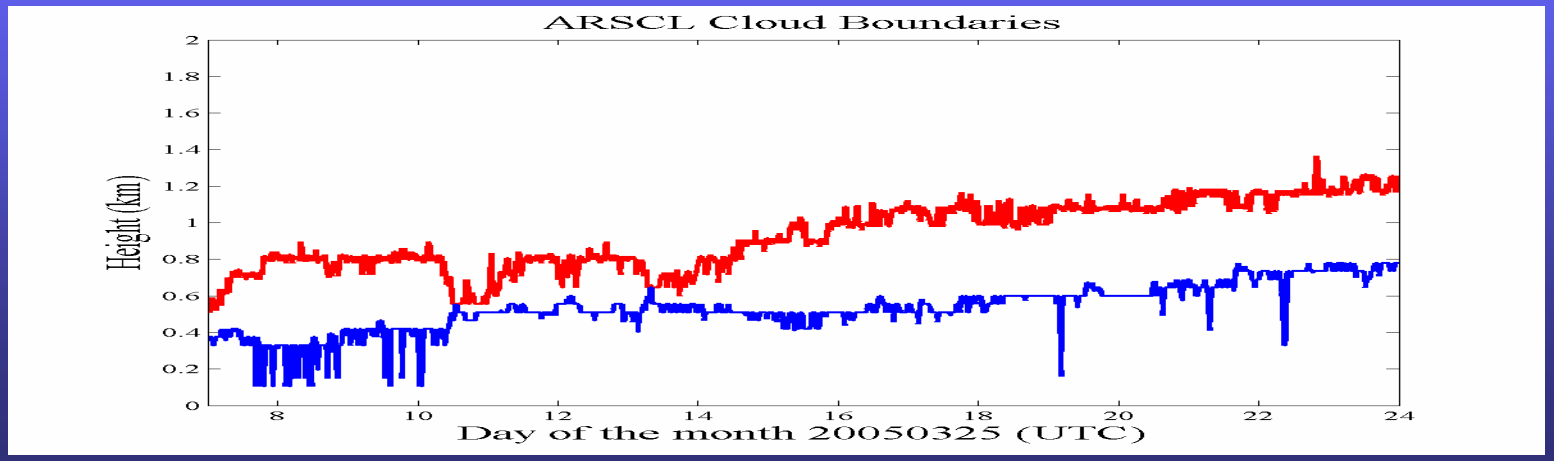
Pre-ALT Feasibility Demo

- SGP Stratocumulus Case Study (March 25, 2005)
- Hi-Res Radar Observations (P. Kollias; BNL)
- Hi-Res (WRF) Modeling (P. Zhu; FIU)

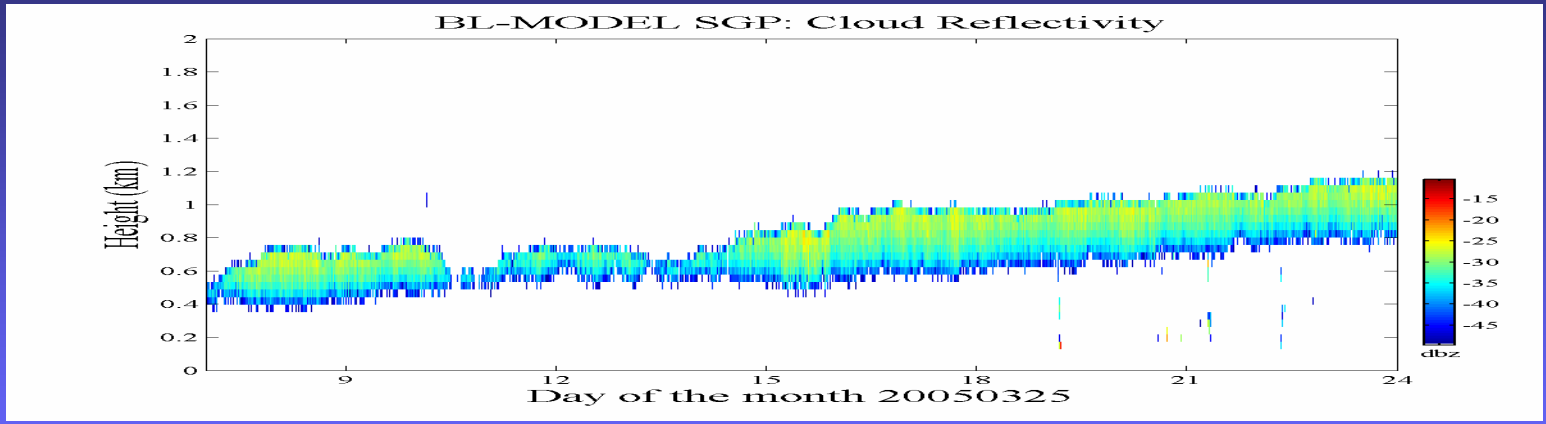
ARSCL View of the Stratus

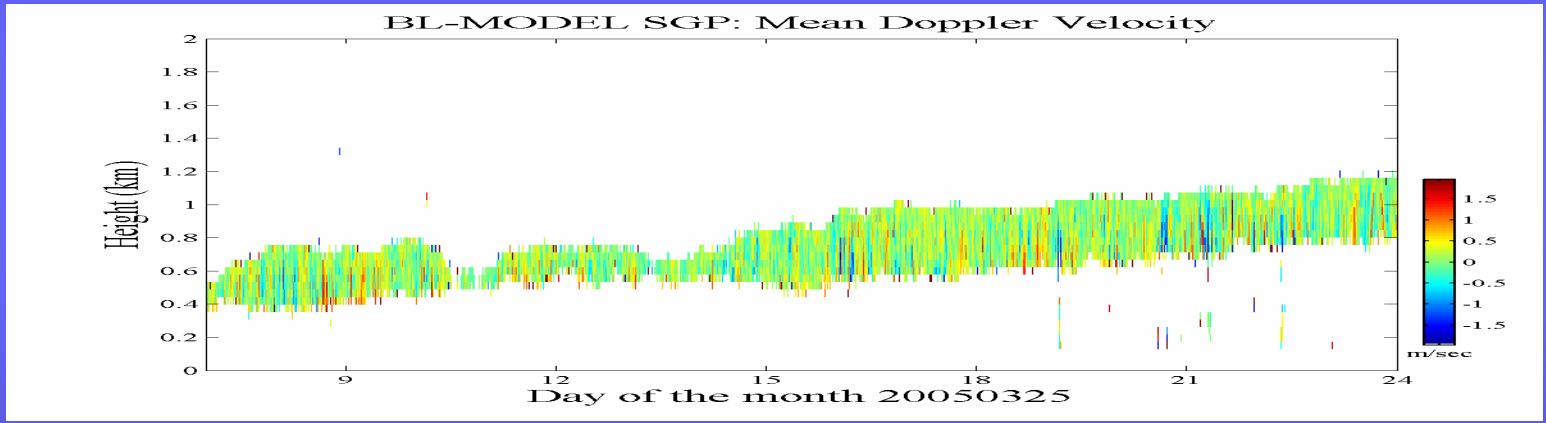


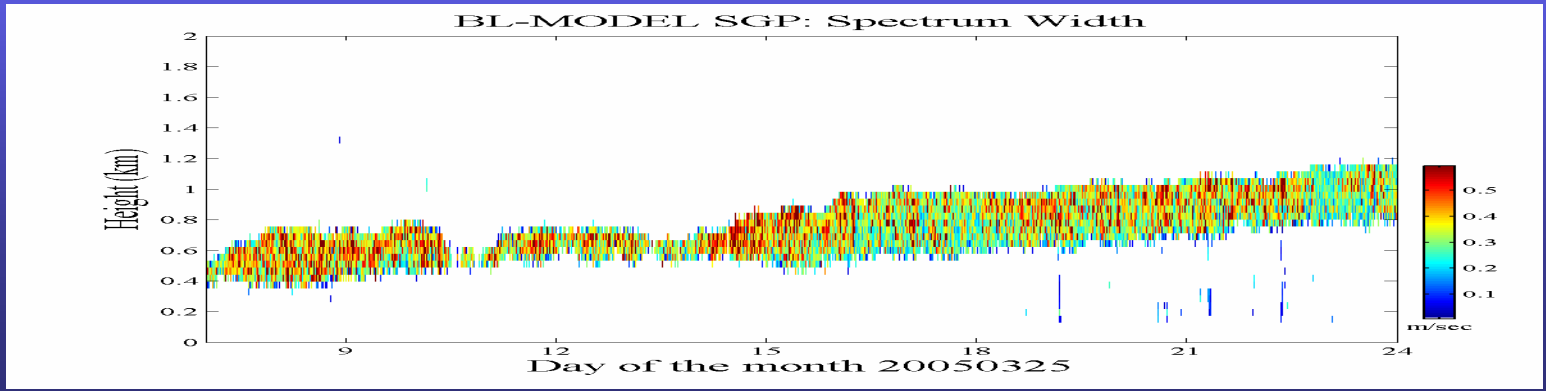




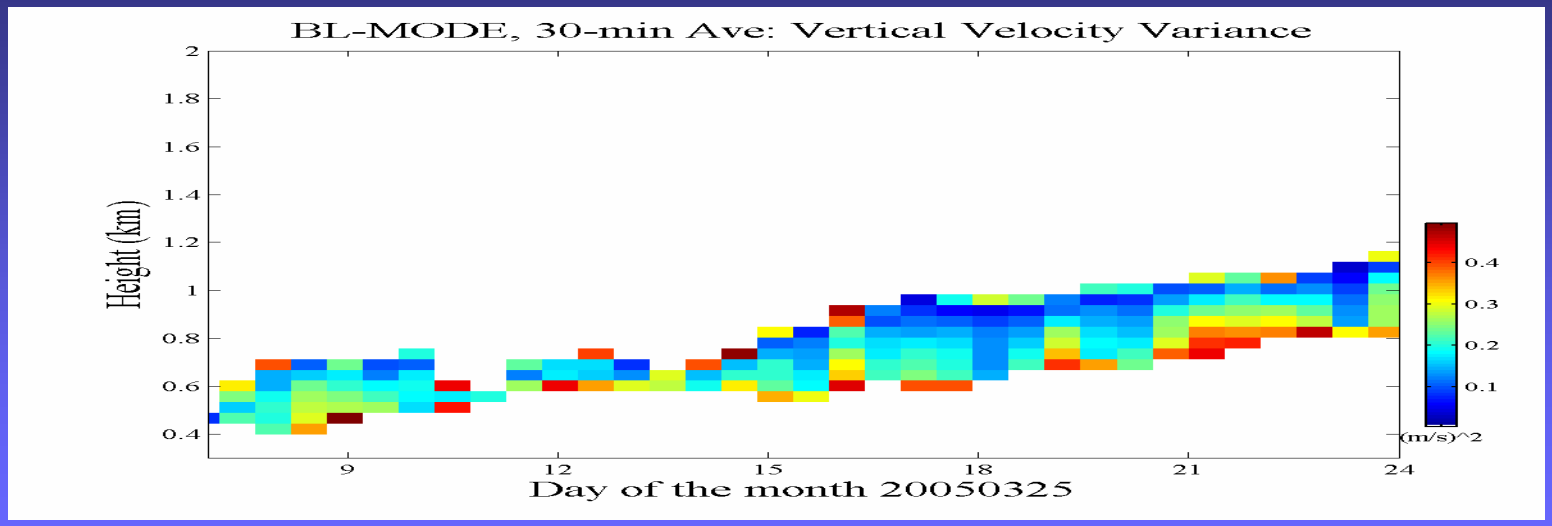
BL Mode Radar Moments

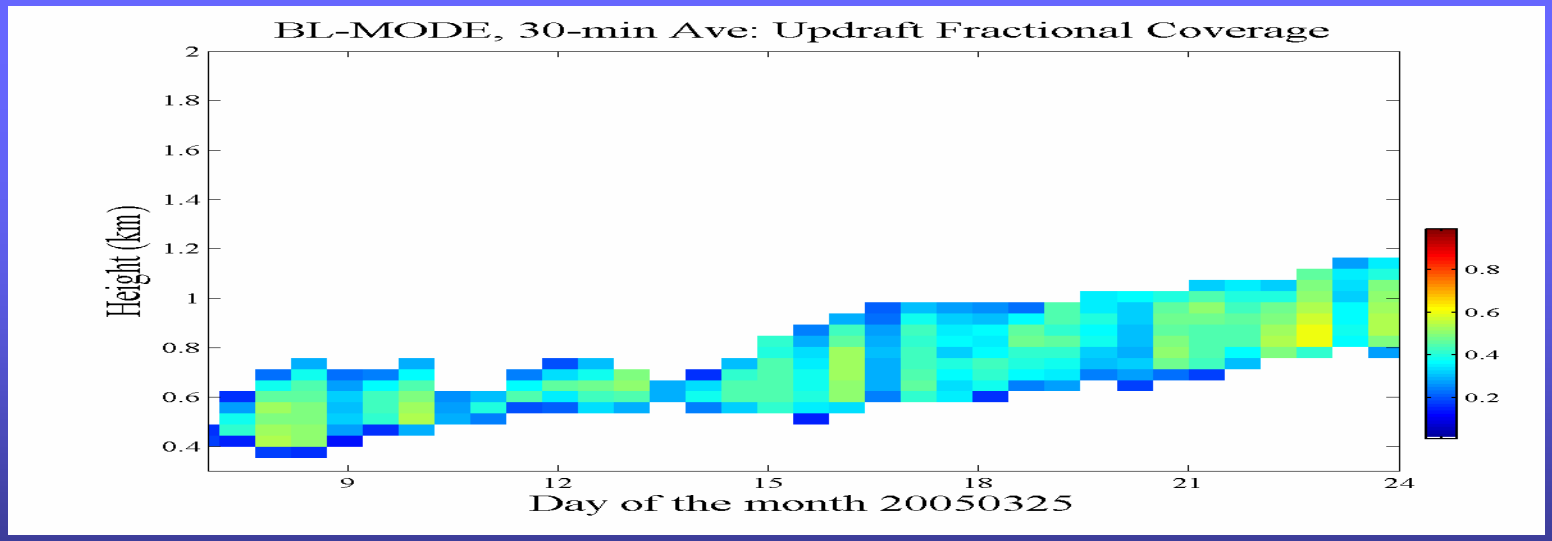






30-min Averages





Multi-nested WRF simulation

1. Configuration.

a) 5 domain with 4 two-way nests.

b) Domain - 1: $121 \times 101 \times 54, \quad \Delta x = 8100\ \text{m}$

Domain - 2: $103 \times 103 \times 54, \quad \Delta x = 2700\ \text{m}$

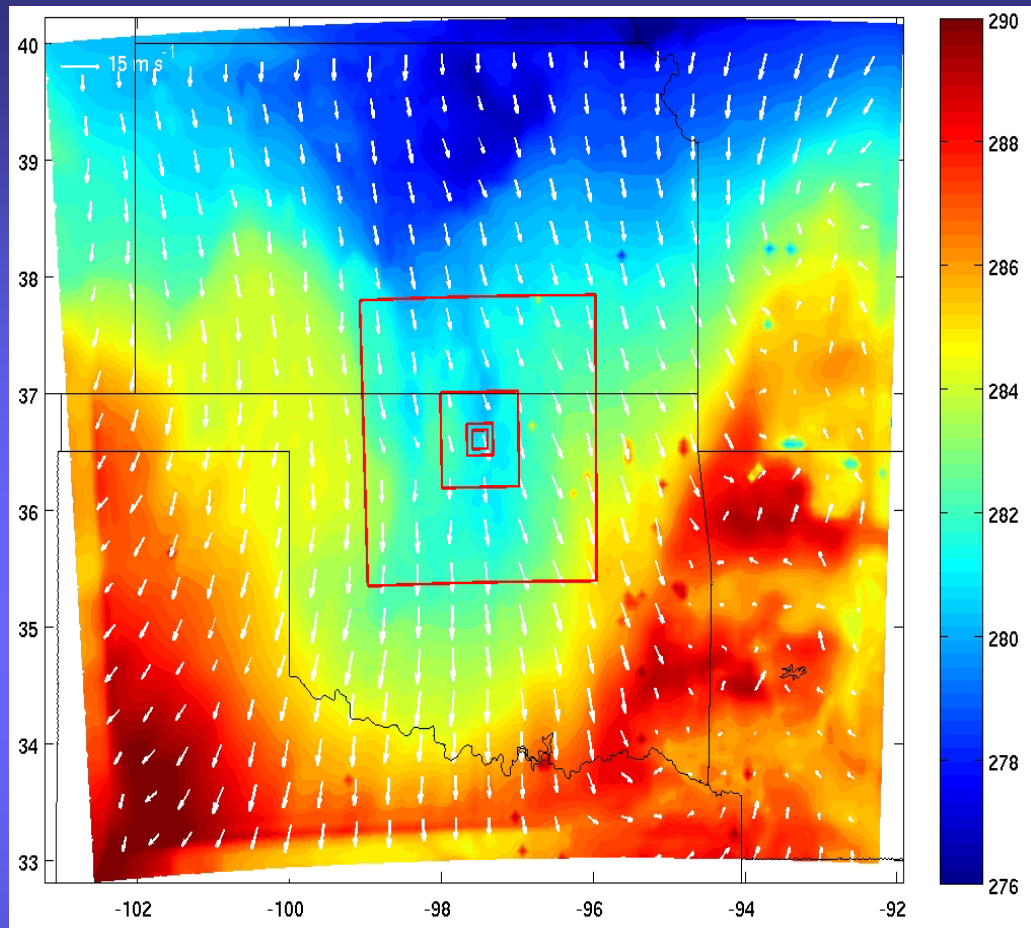
Domain - 3: $103 \times 103 \times 54, \quad \Delta x = 900\ \text{m}$

Domain - 4: $103 \times 103 \times 54, \quad \Delta x = 300\ \text{m}$

Domain - 5: $181 \times 181 \times 54, \quad \Delta x = 100\ \text{m}$

c) All 5 domains use same vertical resolution varying from 24.0 m to 55.7 m below 1845 m.

d) Simulation (domain-1) started at Mar. 25 2005 00:00 UTC. Four two-way nests were activated 6 hours later at 06:00 UTC.



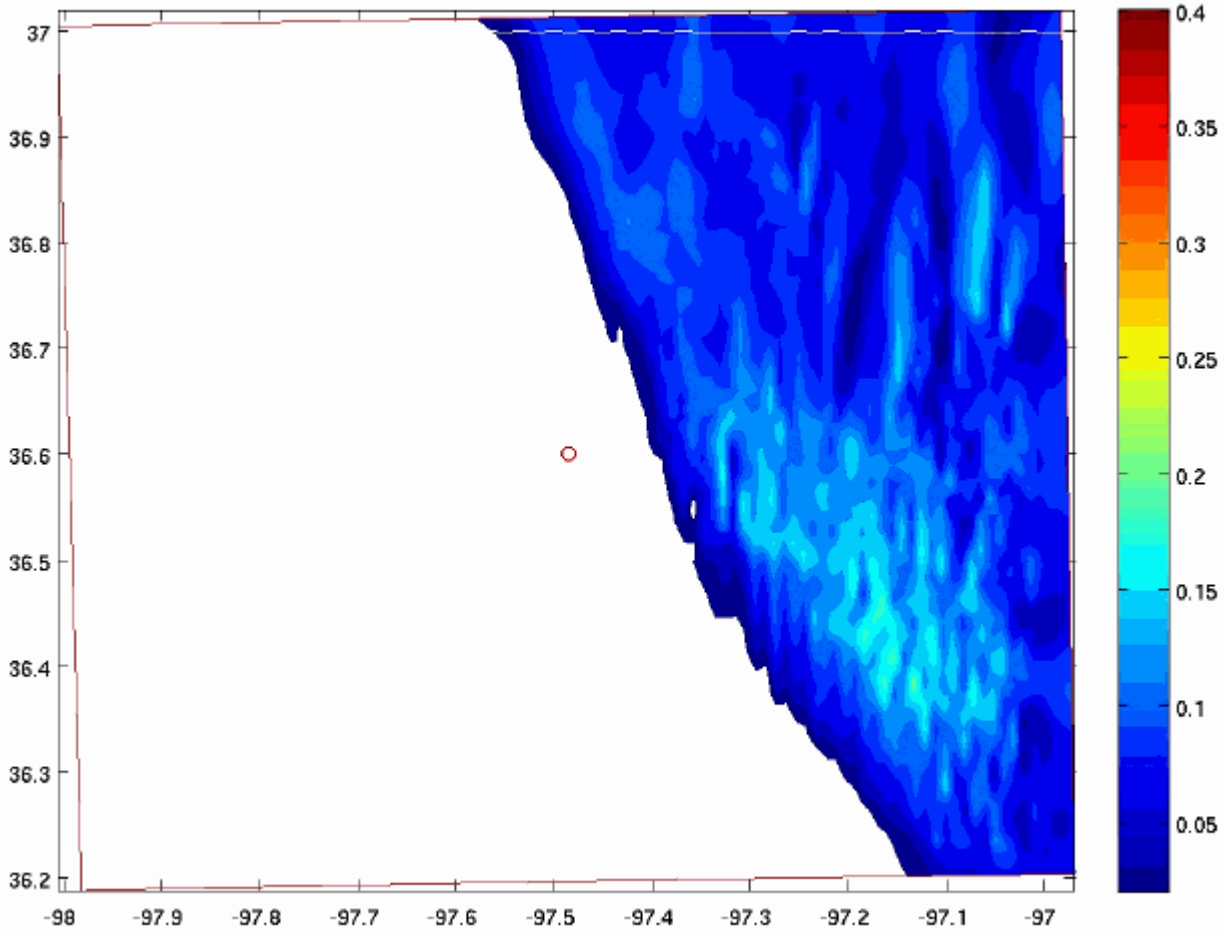
Background: 2 m high potential temperature with 10 m high wind vectors

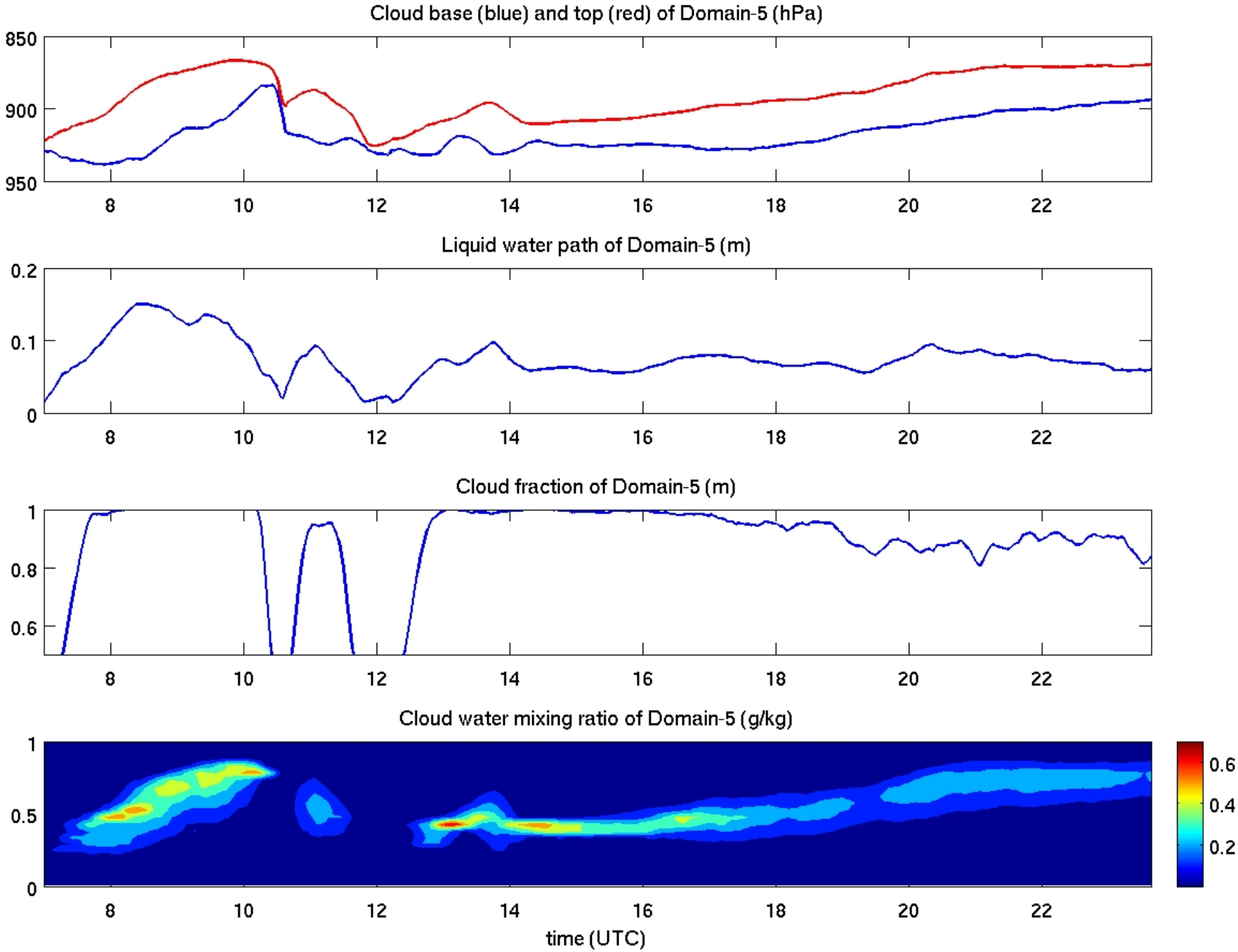
2. Initialization.

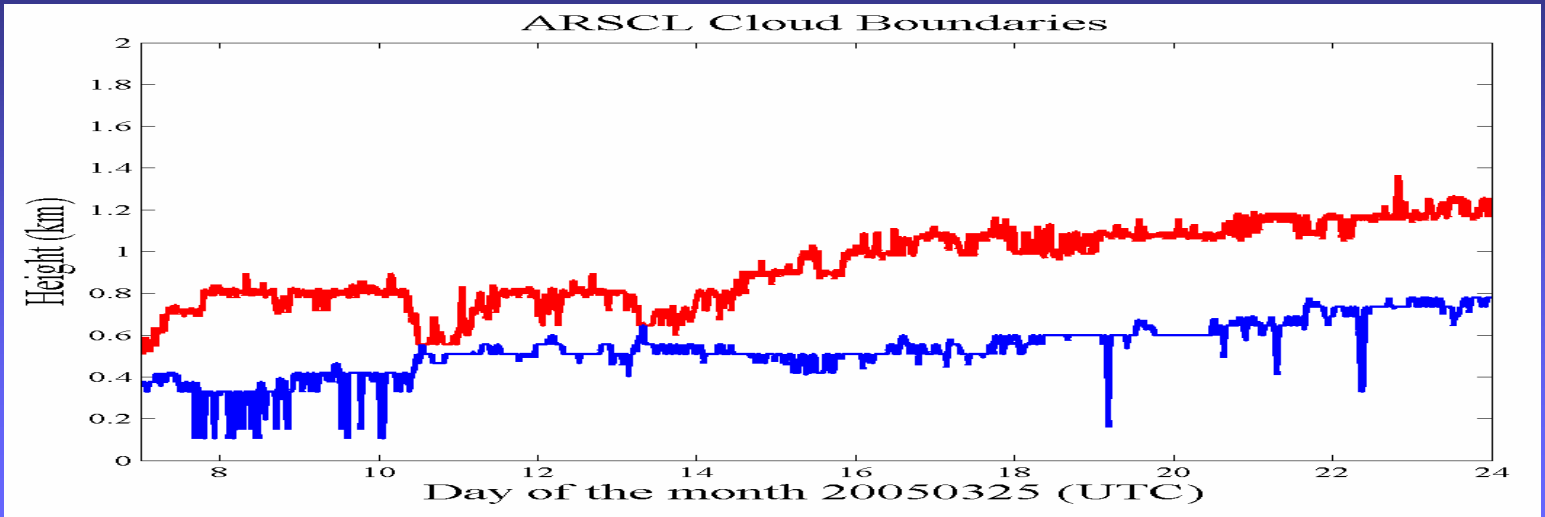
Initial and boundary conditions are supplied with NCEP Global Tropospheric Analyses data with resolution 1x1 degree.

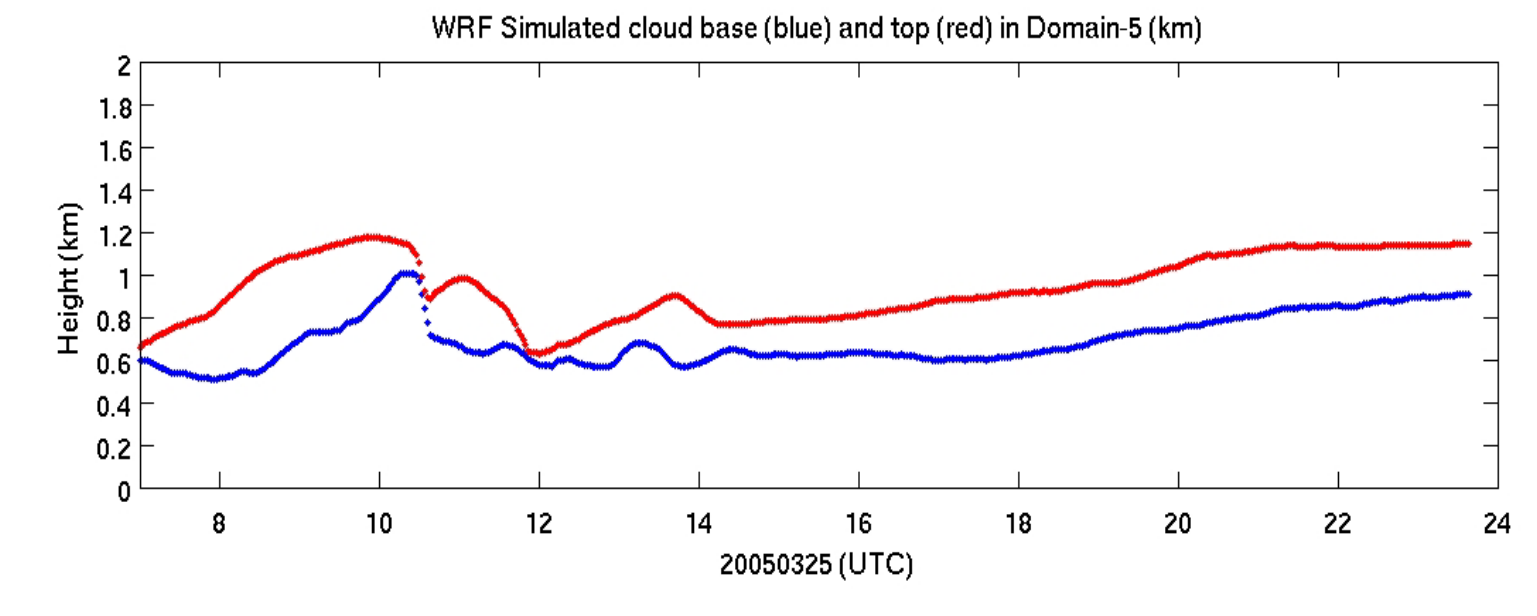
3. Model physics

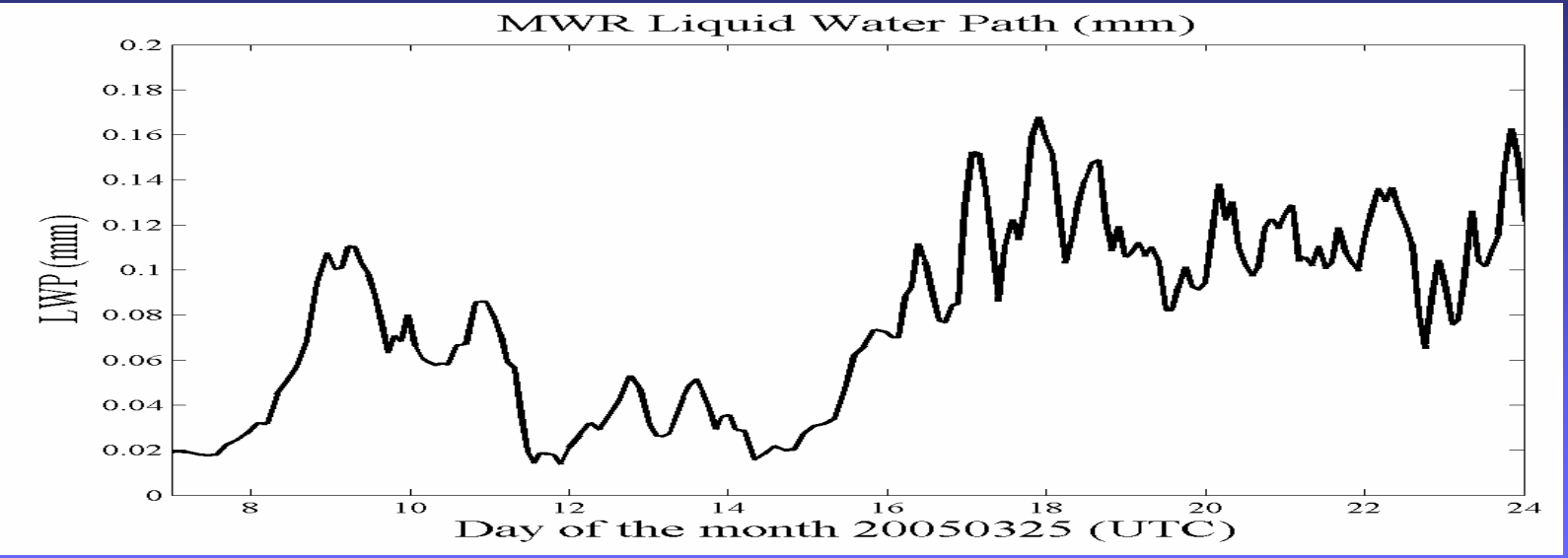
a) Microphysics: Thompson et al. (2004) graupel scheme.
b) Radiation: rrtm longwave, Dudhia shortwave schemes.
c) Boundary layer: Mellor-Yamada-Janjic TKE scheme, Monin-Obukhov scheme.
d) Cumulus: Kain-Fritsch scheme (domains 1 and 2).
e) Soil model: Noah land-surface model, thermal diffusion scheme for temp only.

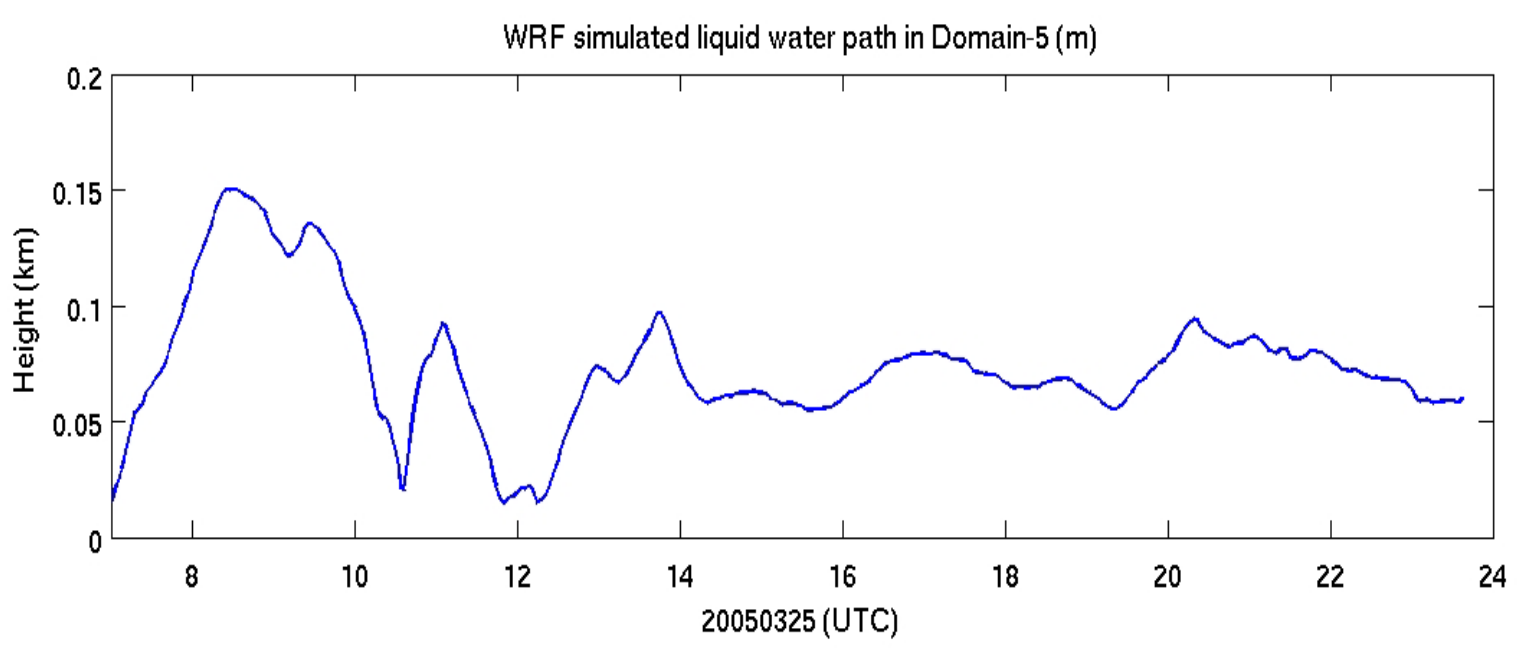

37
36.9
36.8
36.7
36.6
36.5
36.4
36.3
36.2
-98
-97.9
-97.8
-97.7
-97.6
-97.5
-97.4
-97.3
-97.2
-97.1
-97
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05


Cloud base (blue) and top (red) of Domain-5 (hPa)
850
900
950
8
10
12
14
16
18
20
22
Liquid water path of Domain-5 (m)
0.2
0.1
0
Cloud fraction of Domain-5 (m)
1
0.8
0.6
Cloud water mixing ratio of Domain-5 (g/kg)
1
0.5
0
0.6
0.4
0.2
time (UTC)

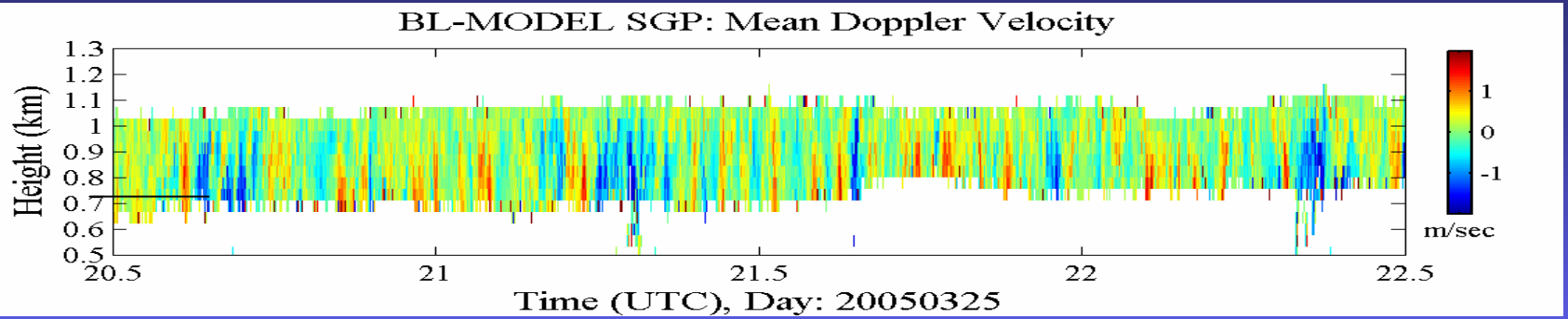

ARSCL Cloud Boundaries
Height (km)
Day of the month 20050325 (UTC)

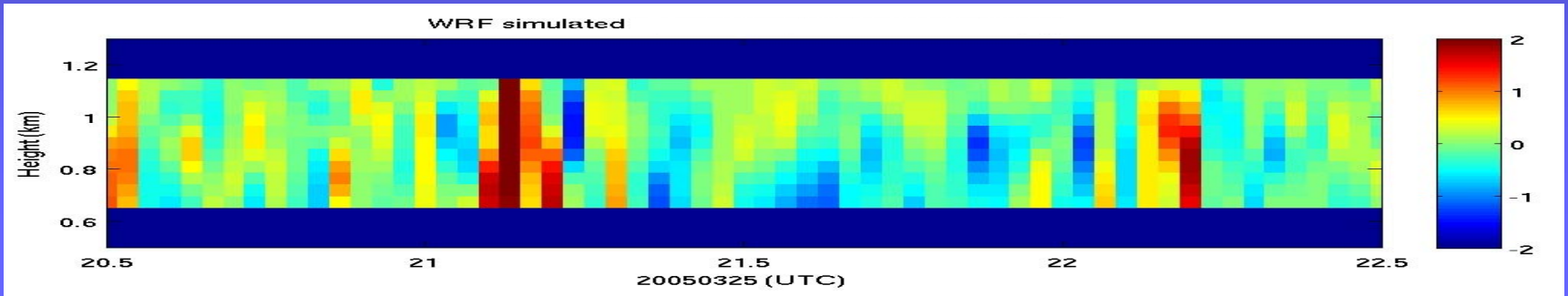

WRF Simulated cloud base (blue) and top (red) in Domain-5 (km)
Height (km)
20050325 (UTC)

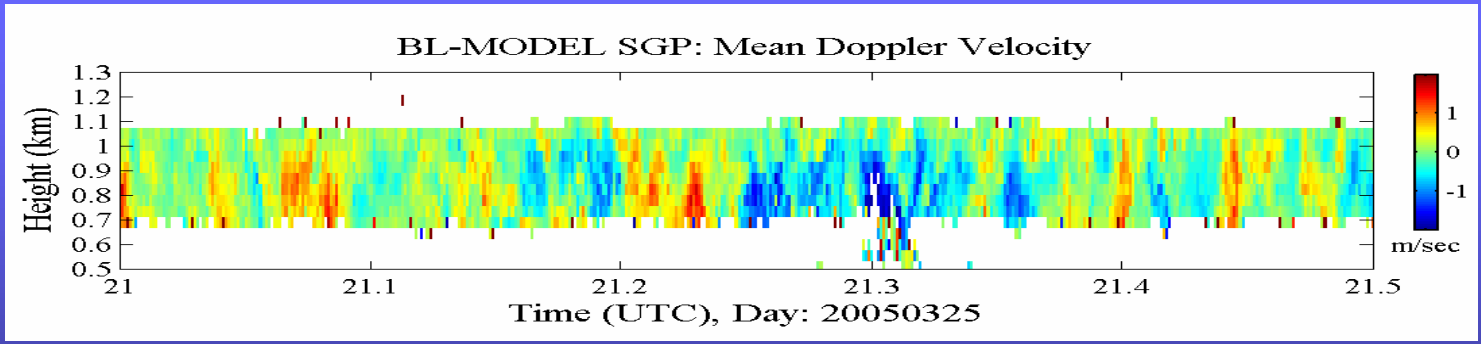

MWR Liquid Water Path (mm)
LWP (mm)
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
8
10
12
14
16
18
20
22
24
Day of the month 20050325 (UTC)

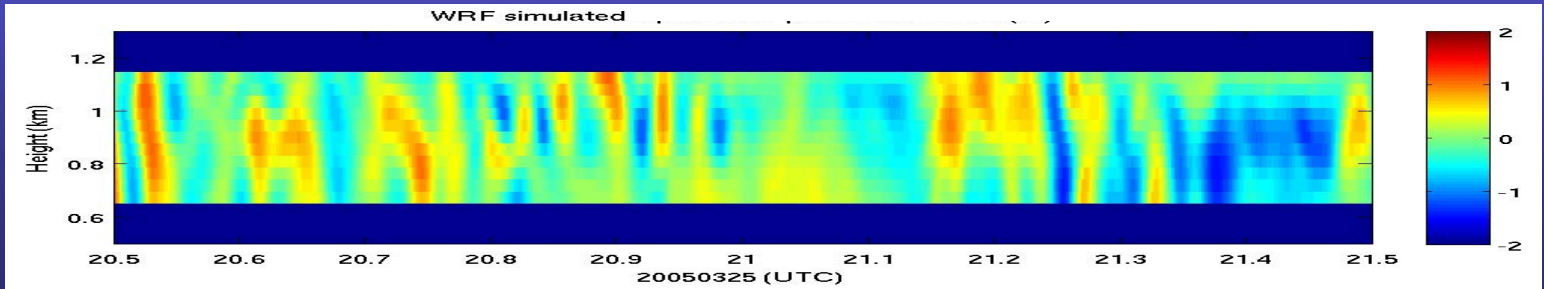

WRF simulated liquid water path in Domain-5 (m)
Height (km)
0.2
0.15
0.1
0.05
0
8
10
12
14
16
18
20
22
24
20050325 (UTC)

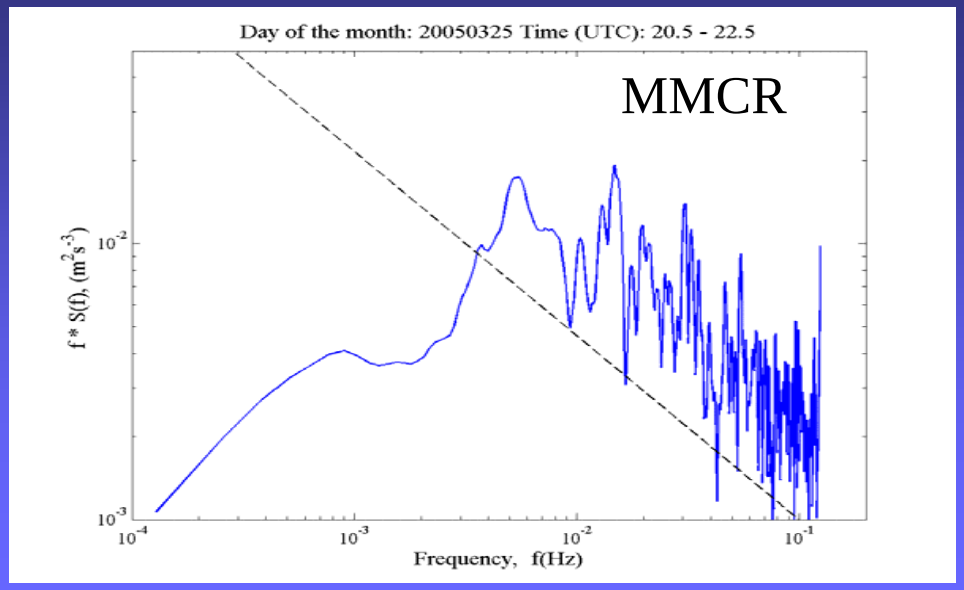
Up- and Downdraft Structures

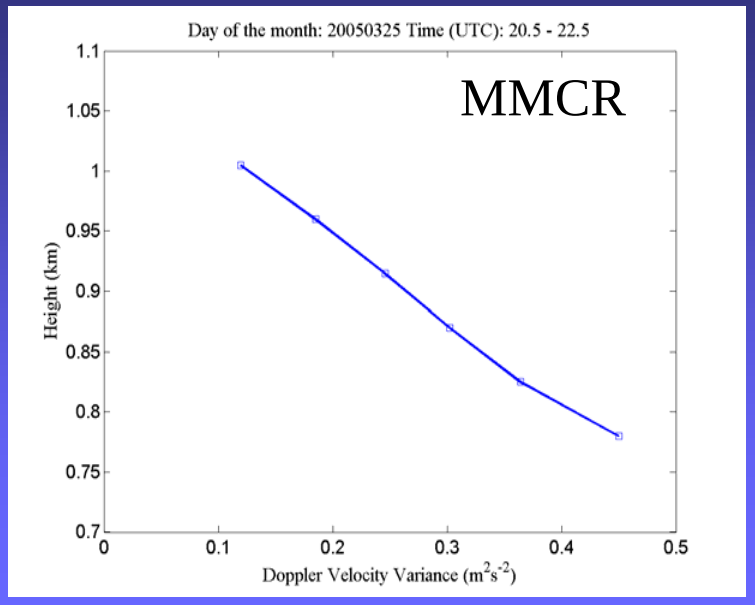


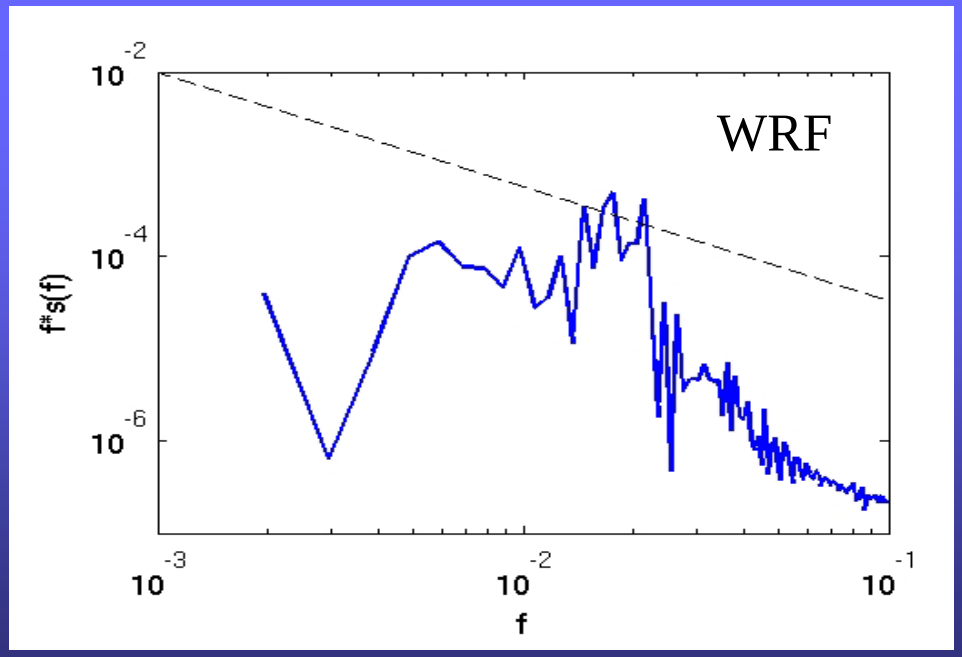


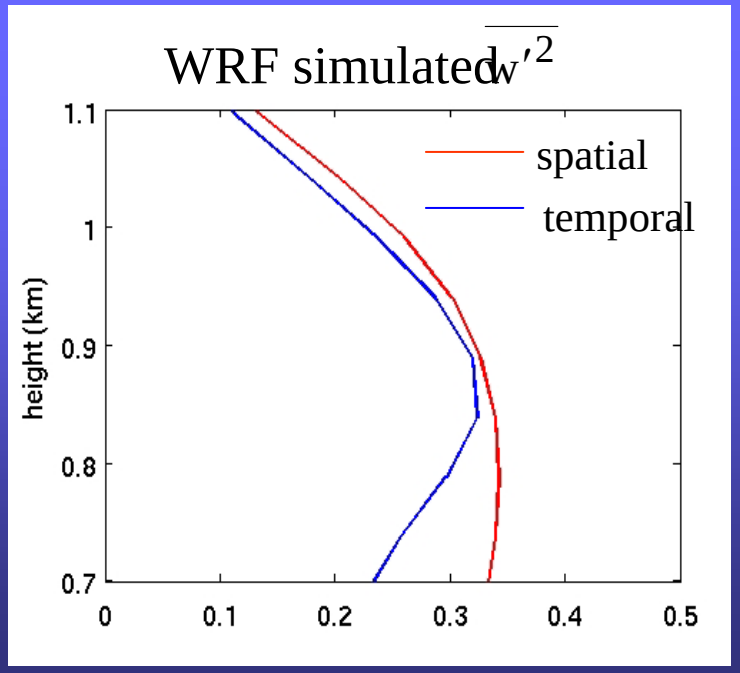





Day of the month: 20050325 Time (UTC): 20.5 - 22.5
MMCR
f * S(f), (m2s-3)
Frequency, f(Hz)


Day of the month: 20050325 Time (UTC): 20.5 - 22.5
MMCR
Height (km)
Doppler Velocity Variance (m2s-2)


WRF
f*s(f)
f


WRF simulated $\overline{w'^2}$
spatial
temporal
height (km)

Activating ALT

- Identify and Entrain Modelers
- Develop a Plan
- Establish Initial Data Sets and Approaches
- Identify New Observational Needs
- Integrate ALE Activities with Appropriate IOPs (e.g. CLASIC)

New Thrust—ARM LES Testbed (ALT)

Motivated by new high resolution radar and MWR observations;
Prospects of 3-D cloud characterizations
Mostly an observational perspective

- ARM LES Evaluator (ALE)
  - Develop BL Data Sets—Single layered, uniform, cloud fields (stratocumulus; fair-weather cumulus)
  - BCs from ARM Obs, VAPS, NWP analyses…….
  - Evaluation/Tuning
    - Radar Doppler Spectra; LEO for LES
    - Liquid Water Path, Cloudbase, Surface Rad, 3-D cloud fields, e.g.
    - Establish Model Sensitivity to Forcing and Tunable Parameters
- ARM BLC Simulator (ABS) (20 kmx20 km domain?)
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  - Output --domain cloud, boundary layer, and radiation characteristics/statistics