ARM LES Testbed Prototype:
Multi-Scale WRF Simulations of Boundary Layer Clouds

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What is ARM-LES-Testbed ?

It is structured to provide a framework for effectively organizing and using the extensive data generated by the ARM radars and other ARM observing systems for boundary layer cloud studies and for evaluating high resolution simulations.

Parameterization Development and Testing Strategy

Super Parameterizations

GCM/NWP

PAR

CRMS LES

ARM OBS

ARM-LES-Testbed
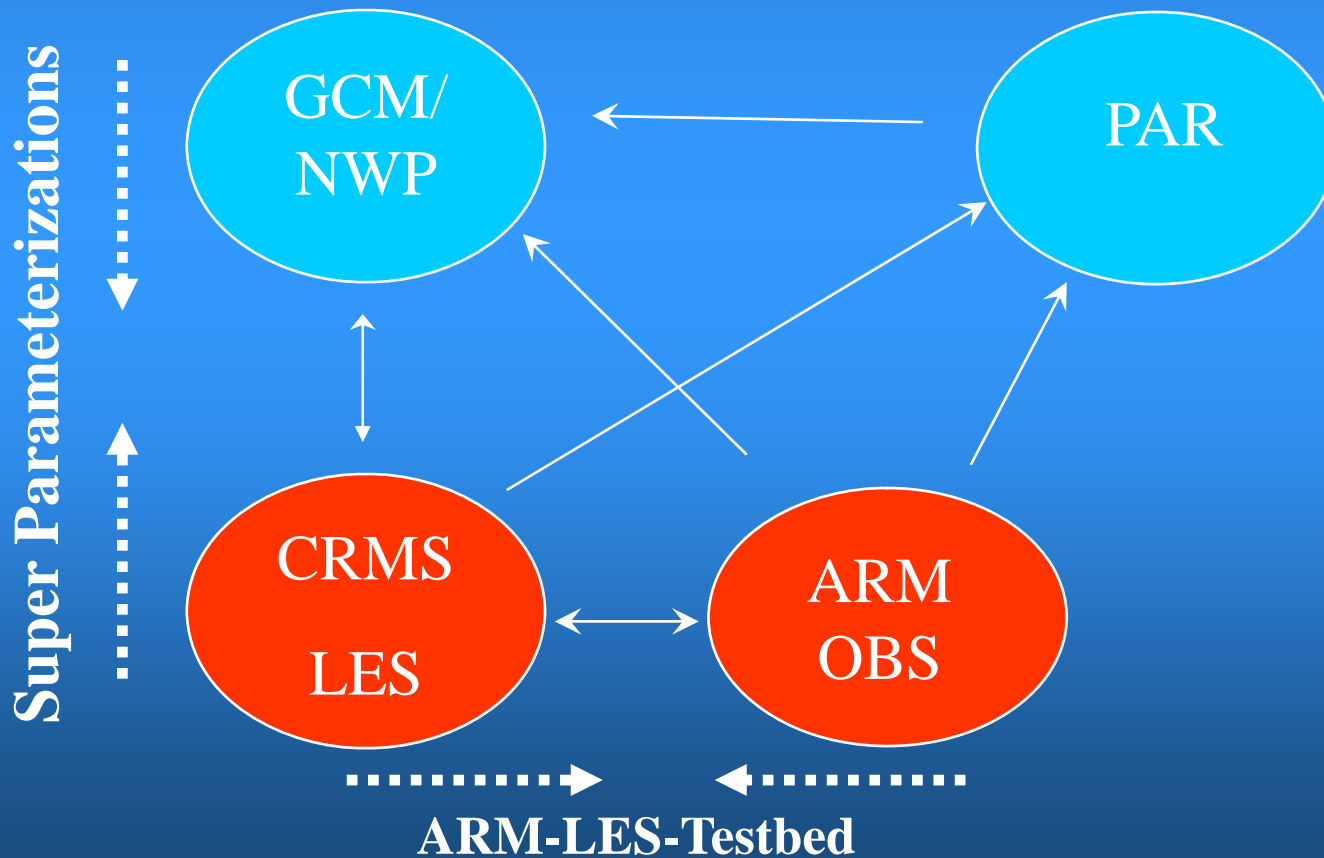
ARM Hi-Res and 3-D Observations (e.g. MMCR and WACR)

➢ In-cloud turbulence, large-eddy circulations, and high resolution cloud structures.
➢ Possibility of combining the liquid water estimates with the vertical velocities to obtain liquid water fluxes.
➢ ARM Radar simulator.

Classic LES framework

➢ Idealized initial conditions
➢ Homogeneous large-scale forcings

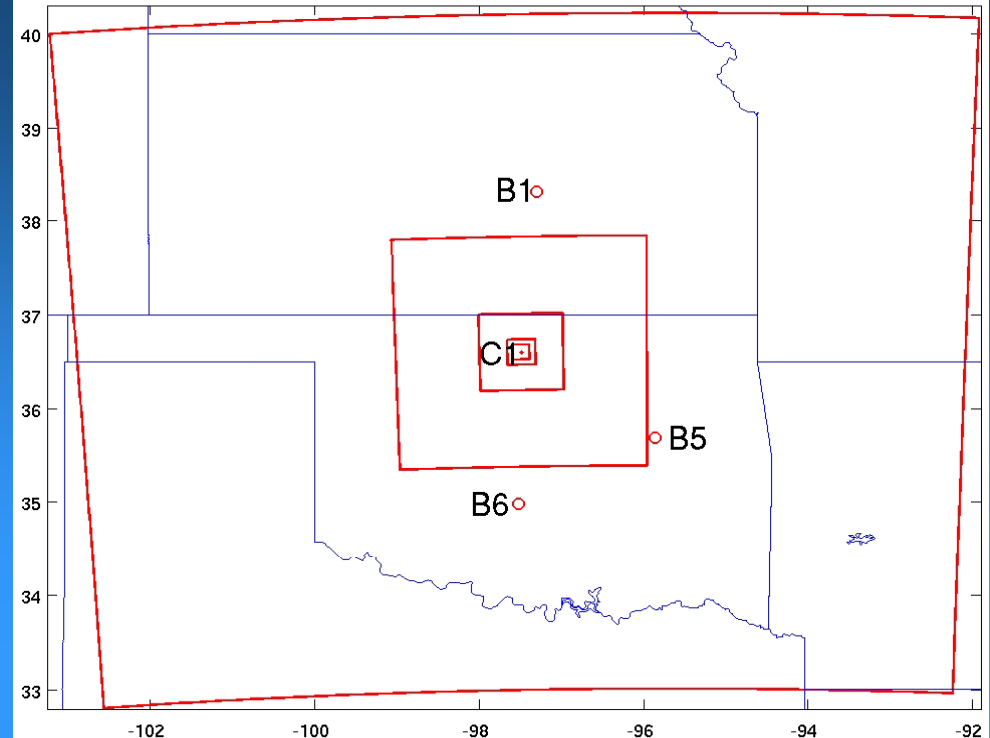(e.g., BOMEX, ATEX, DYCOM, ARM-SGP)

A New LES Framework:

A multiple two-way nested model to explicitly simulate a spectrum of scales from synoptic scale flow, meso-scale organizations, down to fine scale turbulent eddies in a unified system.


WRF nested domain over SGP site

WRF-LES

➢Nested within WRF mesoscale simulations to ensure robust up-scale and down-scale interactions across a spectrum of scales.

➢Potential to be executed at regular bases in parallel with MMCR and WACR observations.

➢Initialized with forecast or reanalyses data. Initialization can be improved through assimilating ARM observations.

➢Generating forcing data to drive various existing LES models in the community.

Stratocumulus case, March 25, 2005

2 m high potential temperature with 10 m high wind vectors at 11:30 UTC
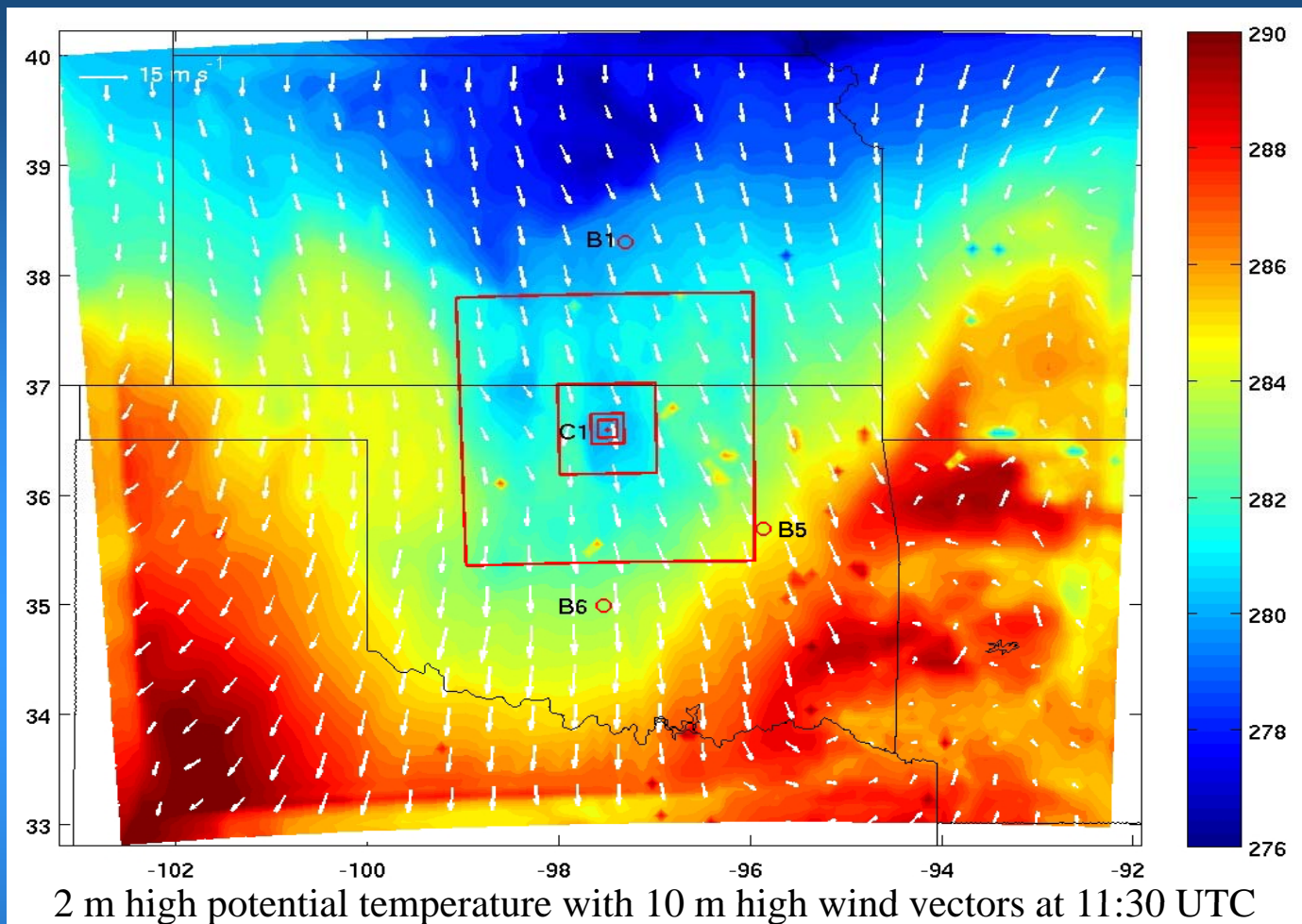
5 domains with 4 two-way nests.

Vertical resolution varying from 24.0 m to 55.7 m below 1845 m.

Domain - 1: $121 \times 101 \times 54$, $\Delta x = 8100$ m

Domain - 2: $103 \times 103 \times 54$, $\Delta x = 2700$ m

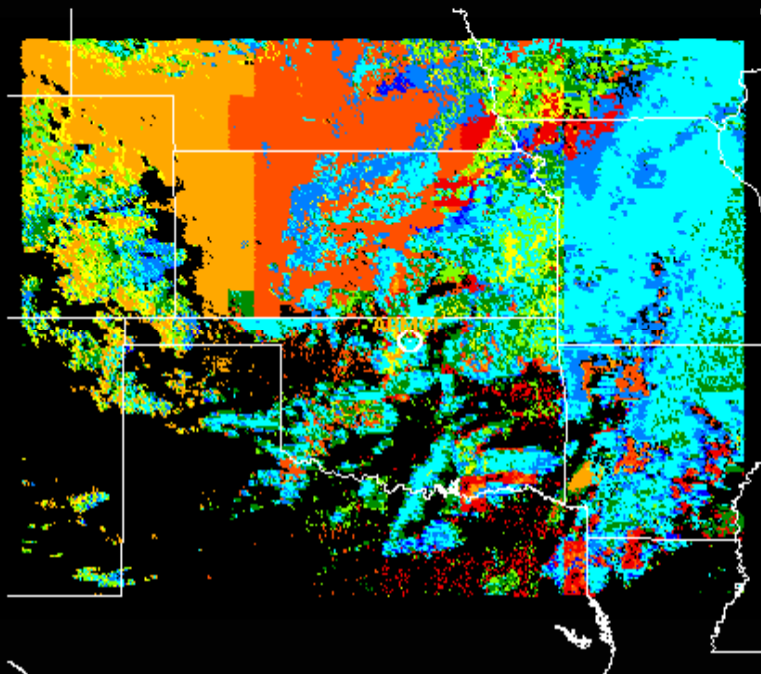Domain - 3: $103 \times 103 \times 54$, $\Delta x = 900$ m

Domain - 4: $103 \times 103 \times 54$, $\Delta x = 300$ m

Domain - 5: $181 \times 181 \times 54$, $\Delta x = 100$ m

CLOUD-BASE PRESSURE

NASA Langley (M02.1)

PBOT (mb)

1050
1000
950
900
800
700
600
500
400
300
200
100

GOES-12   MAR 25, 2005 00:15Z   NASA LARC

CLOUD-TOP PRESSURE

NASA Langley (M02.1)

PTOP (mb)

1050
1000
950
900
800
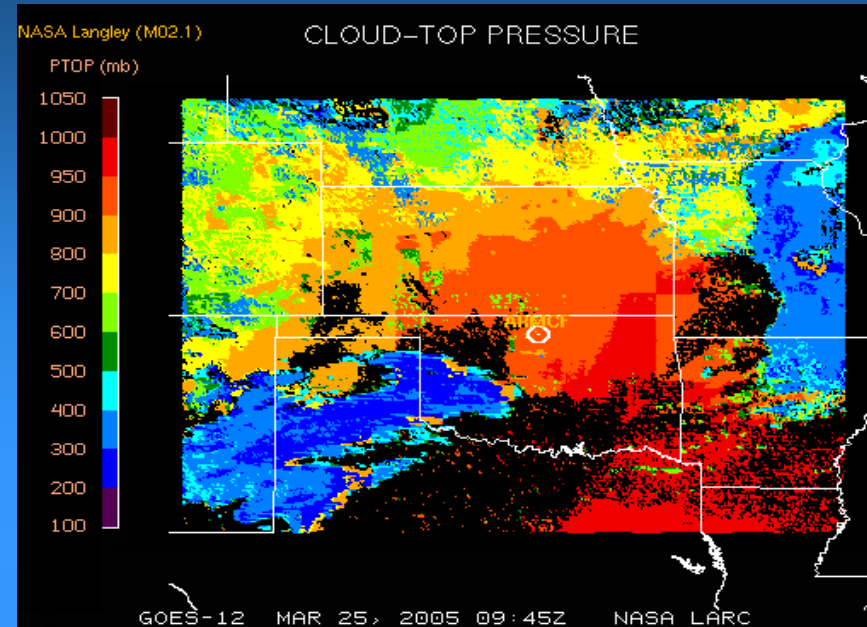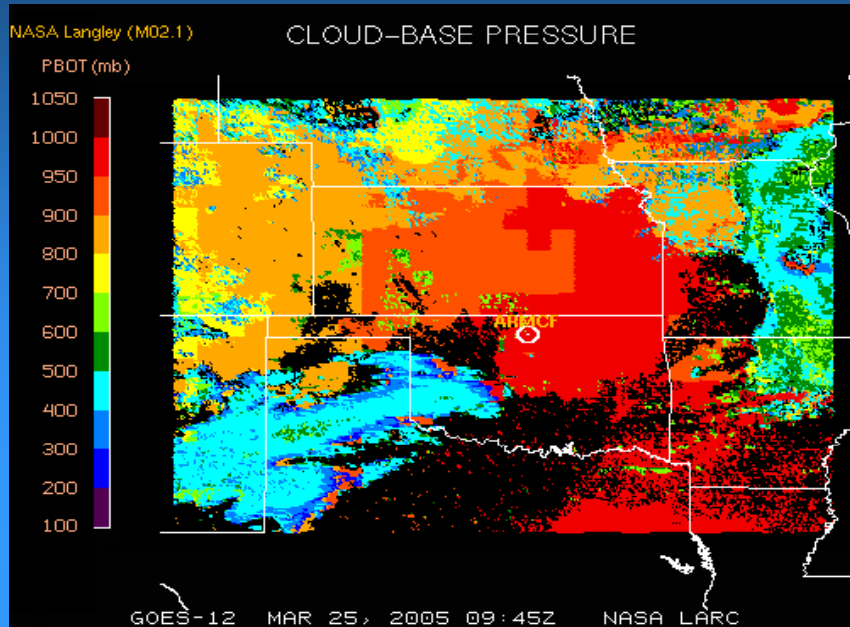700
600
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400
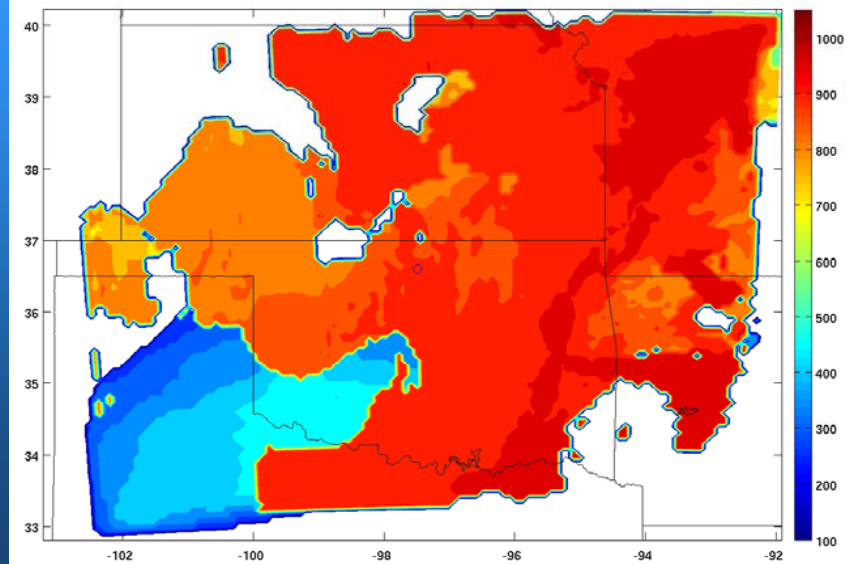300
200
100
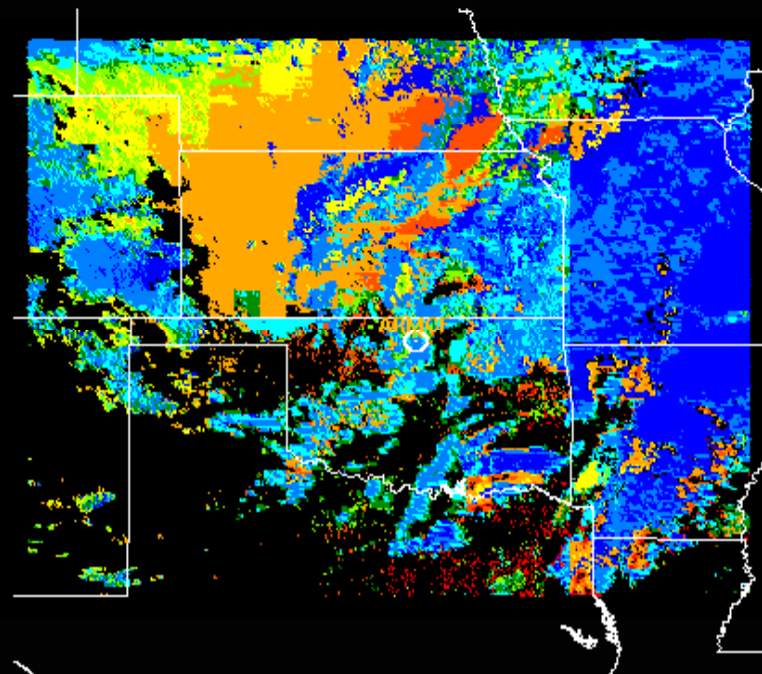
GOES-12   MAR 25, 2005 00:15Z   NASA LARC

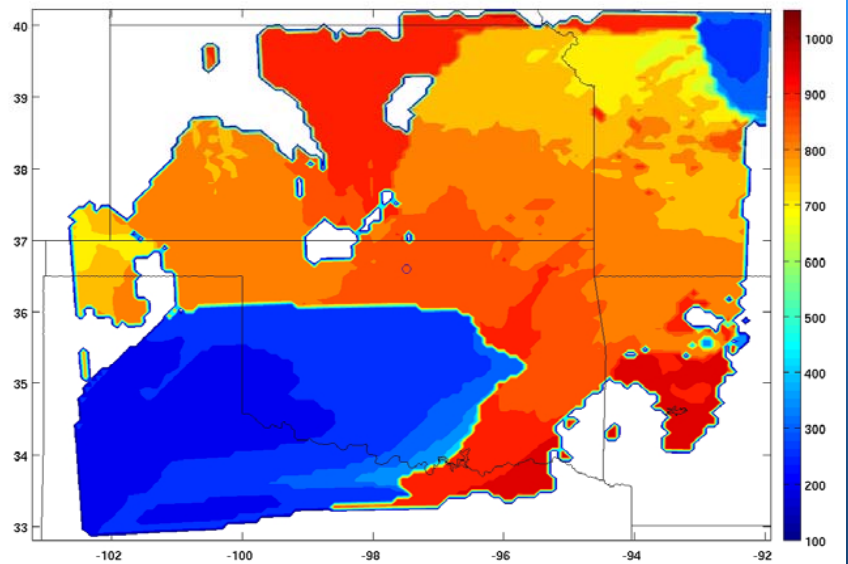MWR observed liquid water path (mm) at different facilities at SGP site
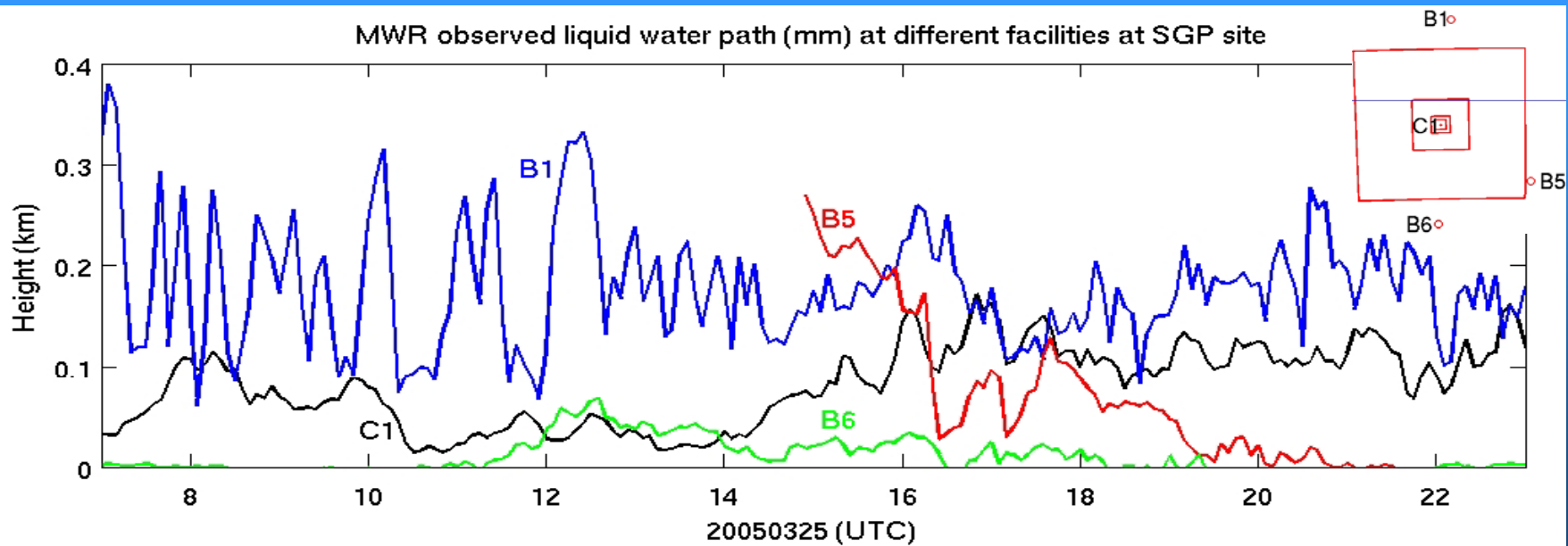
NCEP Global Tropospheric Analyses (1 X 1).
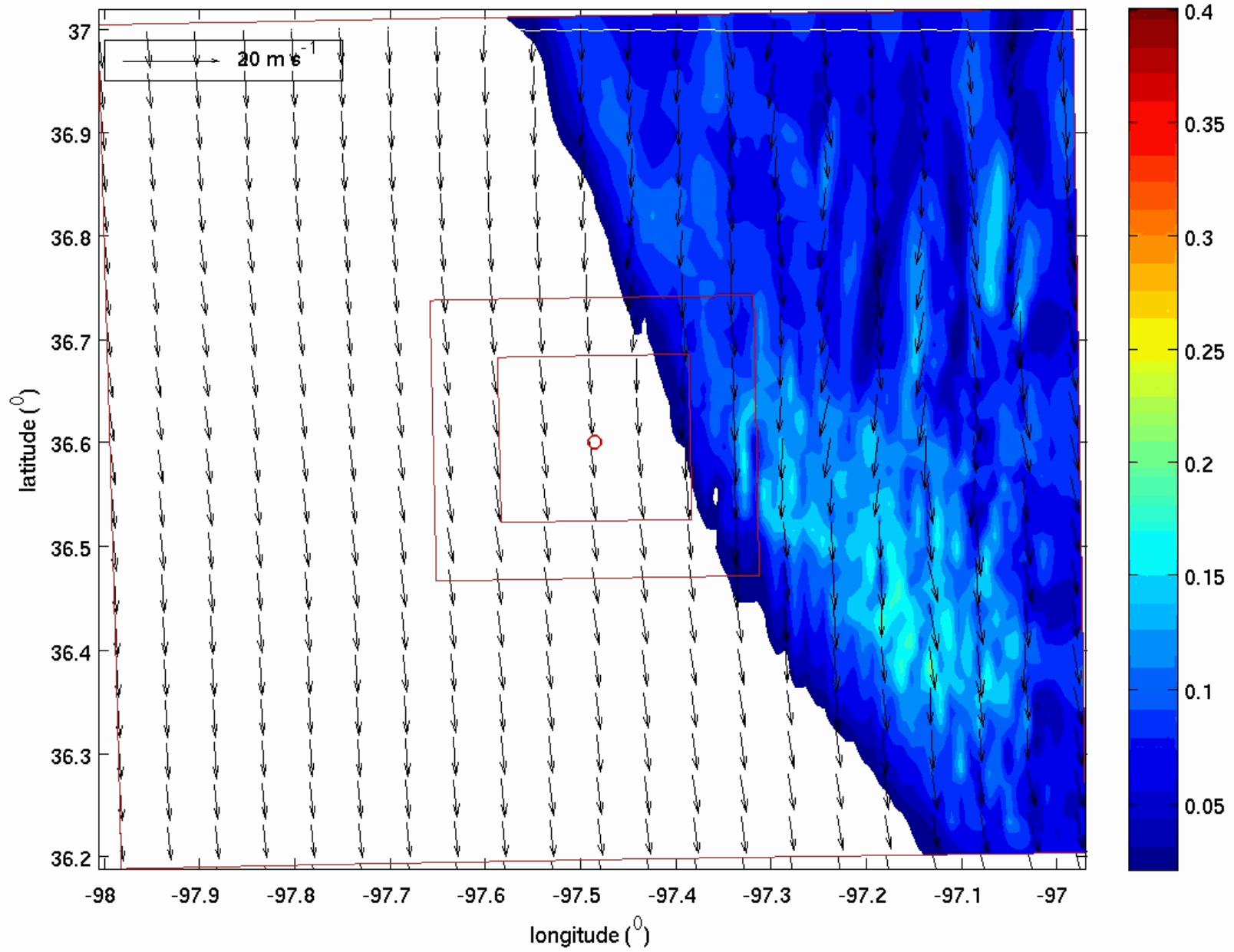## NCEP reanalysis and ARM sounding
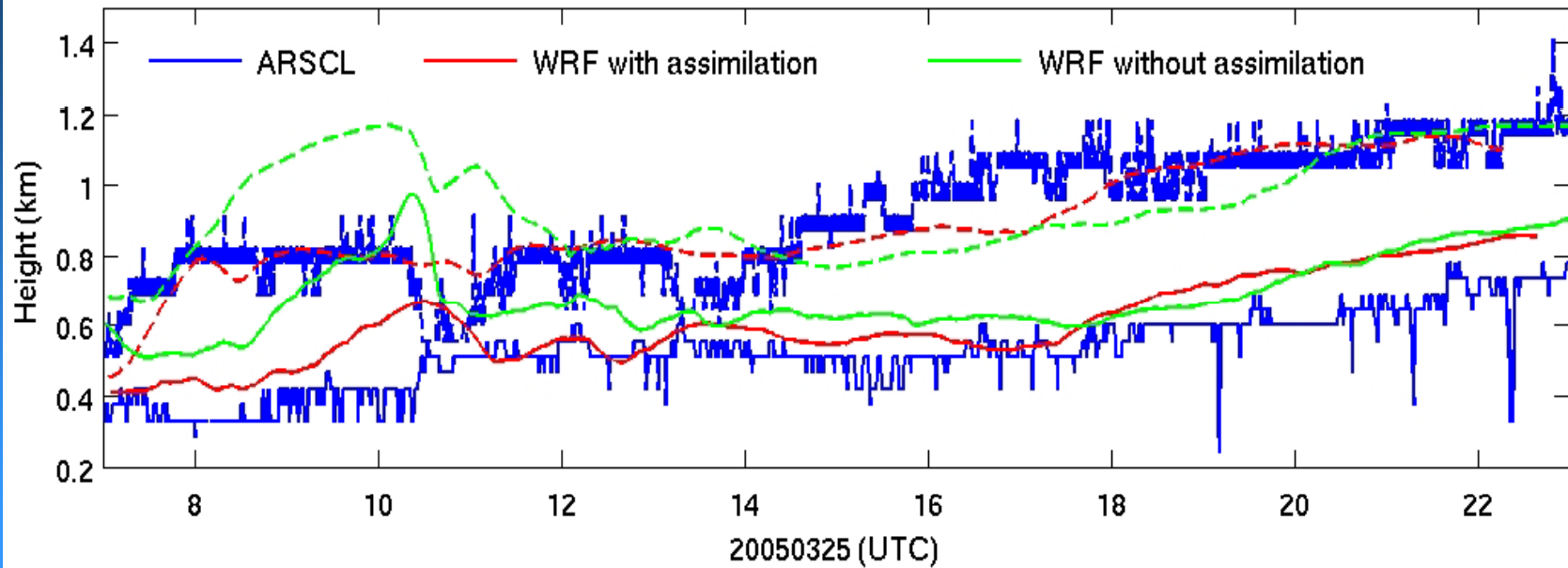

SIMULATED DOMAIN-1 CLOUD-BASE PRESSURE MAR 25 09:45Z
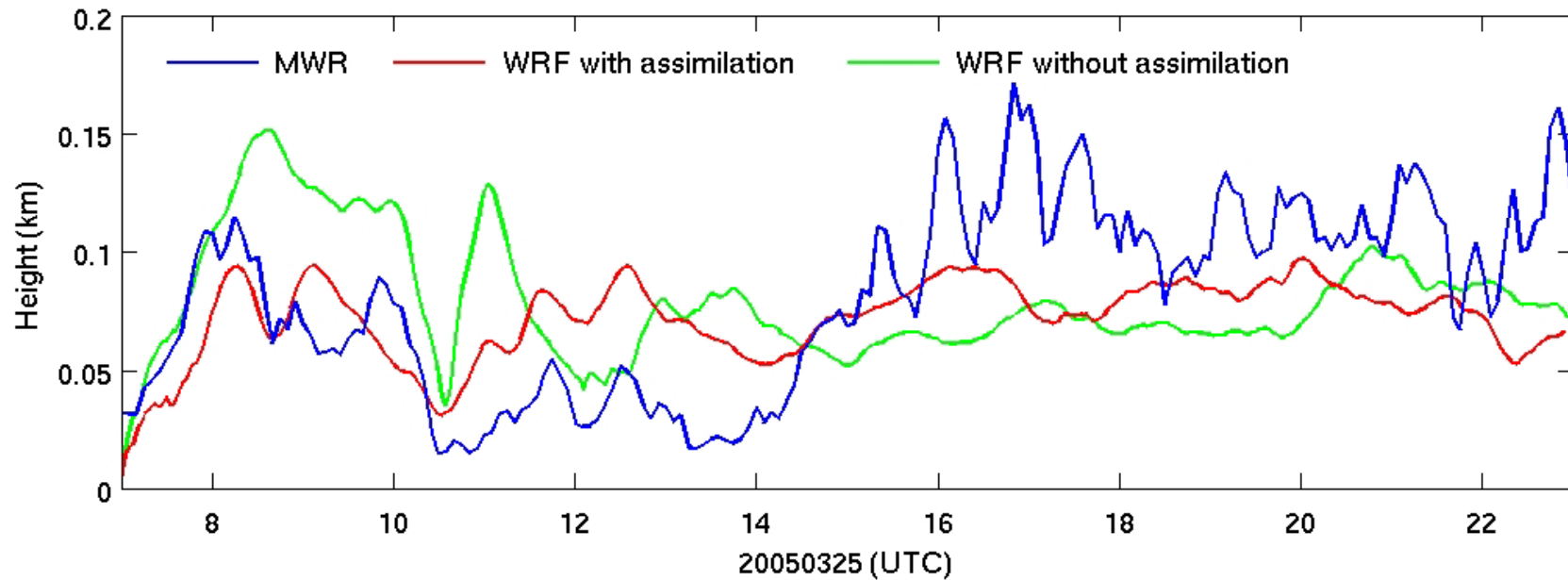
SIMULATED DOMAIN-1 CLOUD-TOP PRESSURE MAR 25 09:45Z
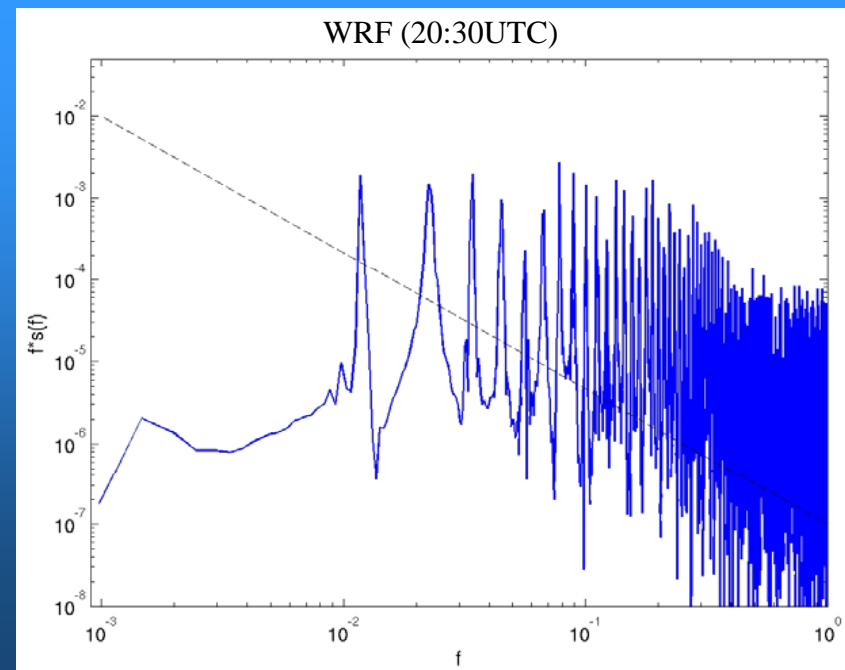
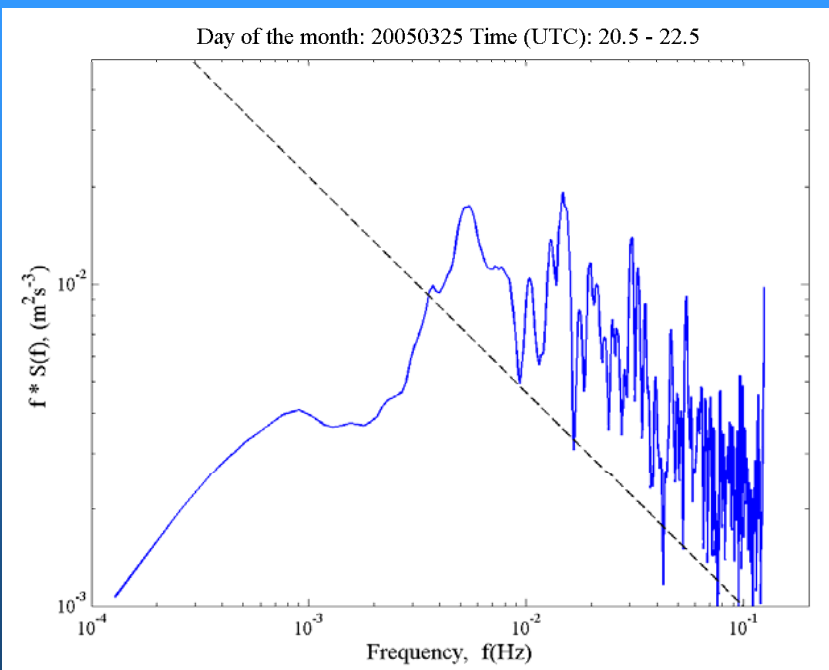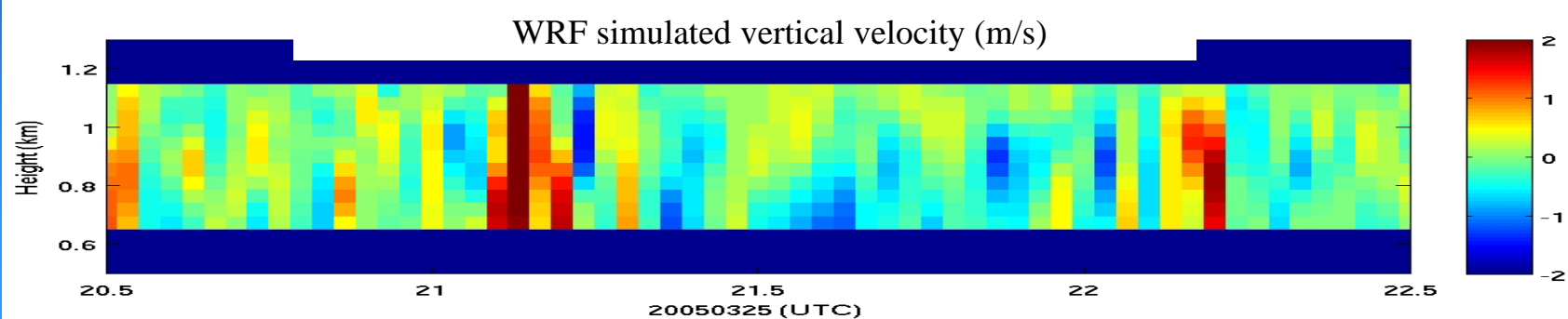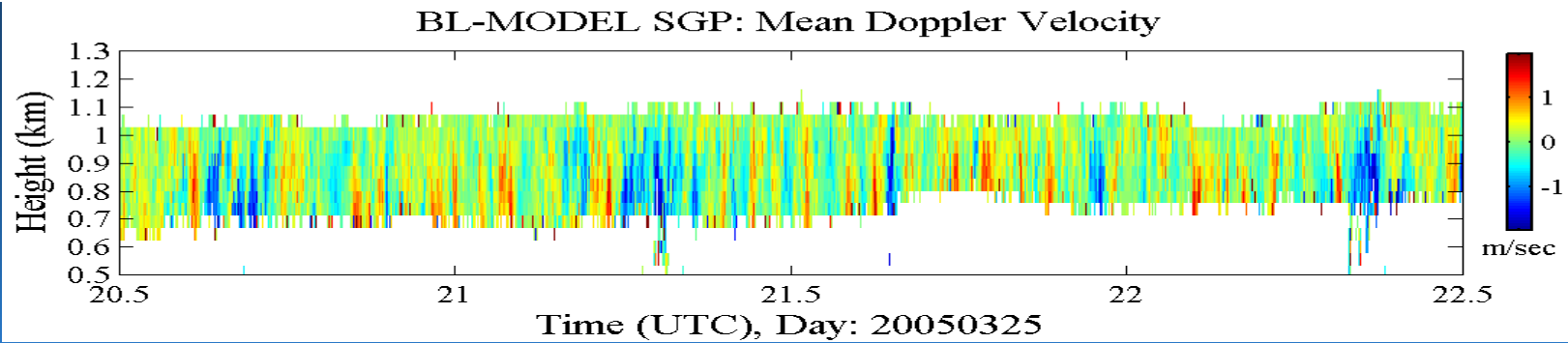Cloud water path (mm), 10 m winds, 2005-03-25-07:00:00

ARSCL observed and WRF Simulated (Domain-5-averaged) cloud base and cloud top (km)

MWR observed and WRF simulated (Domain-5-averaged) liquid water path (mm)

BL-MODEL SGP: Mean Doppler Velocity

WRF simulated vertical velocity (m/s)

Day of the month: 20050325 Time (UTC): 20.5 - 22.5

WRF (20:30UTC)

WRF-LES: ➤ Simulating the cloud cases that are strongly affected by the interaction across scales.

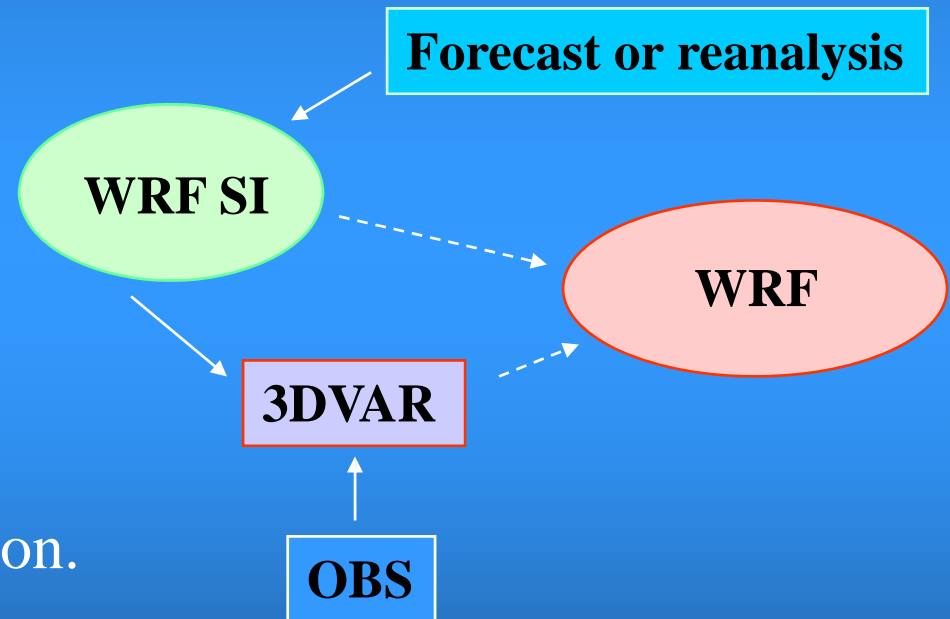➤ Providing forcing data to drive various LES models and 3-D dataset for analyses.

Data assimilation of ARM observations.

Data can be assimilated:
1. sounding data
2. surface observations
3. radar radial velocities
4. radar reflectivity

Improvement of 3DVAR
1. wind profile data assimilation.
2. precipitation assimilation.

Forecast or reanalysis

WRF SI

WRF

3DVAR

OBS

Conclusion:

WRF-LES could be served as an appropriate modeling platform to fulfill the primary goal of ARM-LES-Testbed.

Model physics

- Microphysics: Thompson et al. (2004) graupel scheme.

- Radiation: RRTM (Rapid Radiative Transfer Model) longwave scheme, Dudhia shortwave scheme.

- Boundary layer: Mellor-Yamada-Janjic TKE scheme, Monin-Obukhov scheme.

- Cumulus: Kain-Fritsch scheme (domains 1 and 2).

- Soil model: Noah land-surface model, thermal diffusion scheme for temp only.