RUTGERS

A Large Eddy-Based Simulation of Scanning Cloud Radar Observations

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Why simulate cloud radar echoes and Doppler velocities using structure predicted by a Large Eddy Simulation (LES)?

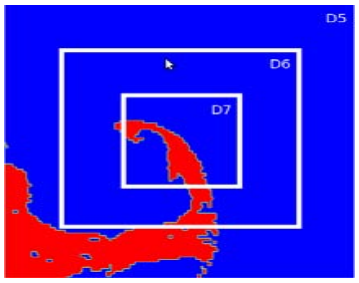
1) **Optimal scanning strategy** may vary according to cloud type and observation site.
2) **Along-beam attenuation** depends upon the 3-D water vapor distribution and cloud radar wavelength, but potential impacts have not been quantified.
3) **Detectability and echo smearing** are range dependent and must be considered when computing cloud fraction.
4) ***How do we interpret the radar signatures of critical cloud life cycle parameters like entrainment and precipitation?***

What LES model is used?

- Weather Research and Forecasting Model Large Eddy Simulation (WRF-LES) Ver. 3.4
  - ❖ **Seven nested domains** 36.45 km to 50 m horizontal resolution (30 m in near future)
  - ❖ **125 vertical levels** (10 m to 500 m) [never less than 20 m vertical resolution in the boundary layer]
  - ❖ **Setup**
    - ✓ Dudhia shortwave / RRTM longwave
    - ✓ NOAH Land Surface Model with Jimenez surface layer
    - ✓ WSM6 microphysics
    - ✓ Kane-Frisch cumulus scheme on two outermost domains
    - ✓ YSU PBL

Two Column Aerosol Project (TCAP) Cape Cod, Massachusetts

Three innermost domains



Cloud Radar Simulation Challenges

- Intersection of cloud radar beam and LES volumes
- Computation burden for 50-m resolution simulation requires supercomputer and massive data storage

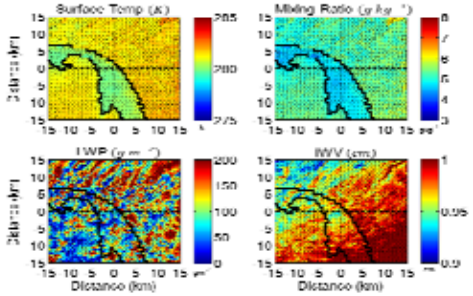


Figure 1. WRF LES simulation of stratocumulus at TCAP AMF#1 site (15 November 2012 at10:36 UTC)

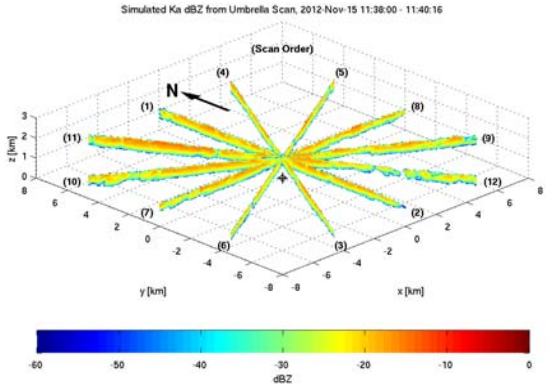


Figure 2. A 35-GHz cloud radar "umbrella" scan based upon WRF-LES simulations for November 15. 2012 at the AMF deployment location on the shore of Cape Cod in Massachusetts. Effective Reflectivity Factor is color-contoured.

- **SACR Simulations that follow use:**
- Morrison and Gettelman (2008) Two Moment Microphysics
- Lognormal Droplet Distribution
- Ulaby and Long Attenuation Model

SACR Simulations for Matched 0.32° Beamwidth

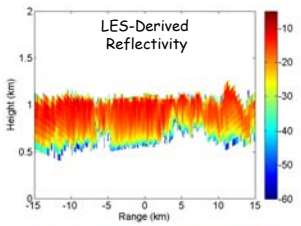
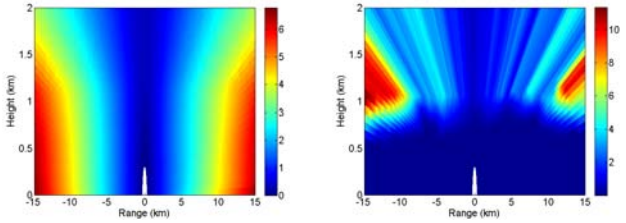
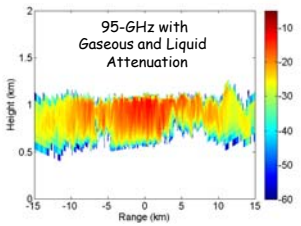


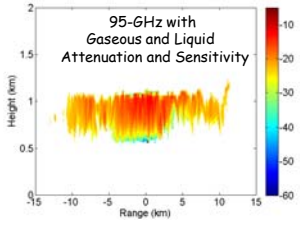
Figure 3 (a). Color contours of Effective Reflectivity Factor (dBZ) from a Range-Height Indicator (RHI) scan of WRF simulated coastal stratocumulus neglecting microwave gaseous and liquid absorption and radar sensitivity as a function of range.



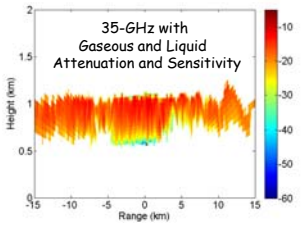
3(b) 95 GHz gaseous and (c) cloud liquid water attenuation (dB)



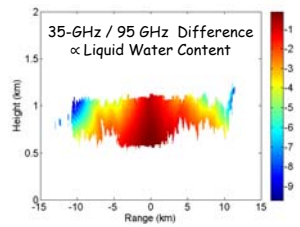
3(d) As in 3(a) but with attenuation (dBZ)



3(e) As in 3(d) but with radar range sensitivity included (dBZ)



3(f) As in 3(e) but for 35 GHz (dBZ)



3(g) 35 GHz / 95 GHz difference (dBZ)