State of 3D Convective Vertical Velocity Retrievals at the ARM Sites: Application of Radar Simulator to Evaluation of Observation-Based Retrievals

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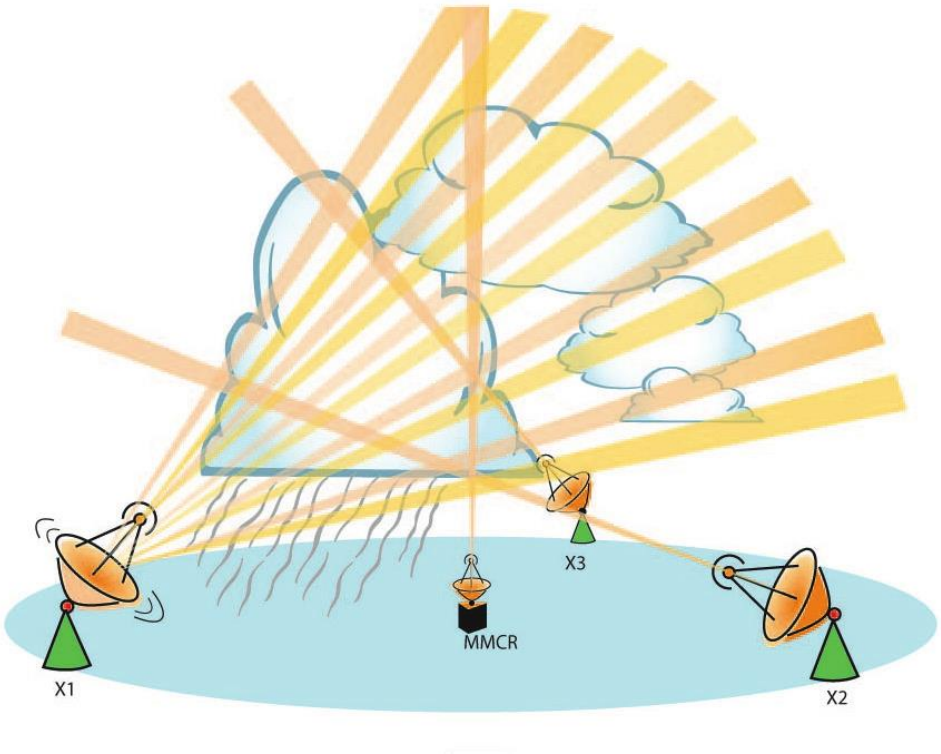
Multi-Doppler Radar Wind Retrieval



Potential sources of errors:

- 3DVAR algorithm
- Time differences amongst PPI scans
- Gridding (e.g. smoothing strength)
- Radar characteristics (e.g. wavelength, beam width)
- Volume Coverage Pattern (VCP, e.g., elevation angles, radar locations)
- Particle fall speed estimate

The objective of this study is to assess the impact of temporal/spatial sampling and retrieval assumptions on the quality and representativeness of the retrieved vertical velocity field against those derived directly from model output.

Application of Radar Forward Simulator to Evaluation of Observation-Based Retrievals

Input
WRF simulated **u, v, w, Q, N**
This study:
MC3E, dx=500,
20-sec outputs

Forward Model (CR-SIM)

Zhh, DV, SW, Zvv, Zdr, Kdp, Ah, Av, LDRh for each hydrometeor type, at each gridbox. Account for radar elevation angles.

Instrument Model (Convert to CFRadial)

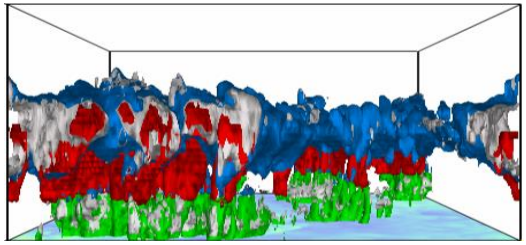
Sampling geometry, sampling volume, attenuation, and sensitivity.

Retrieval Model

Gridding using smoothing factor.
3DVAR multi-Doppler radar wind retrieval.

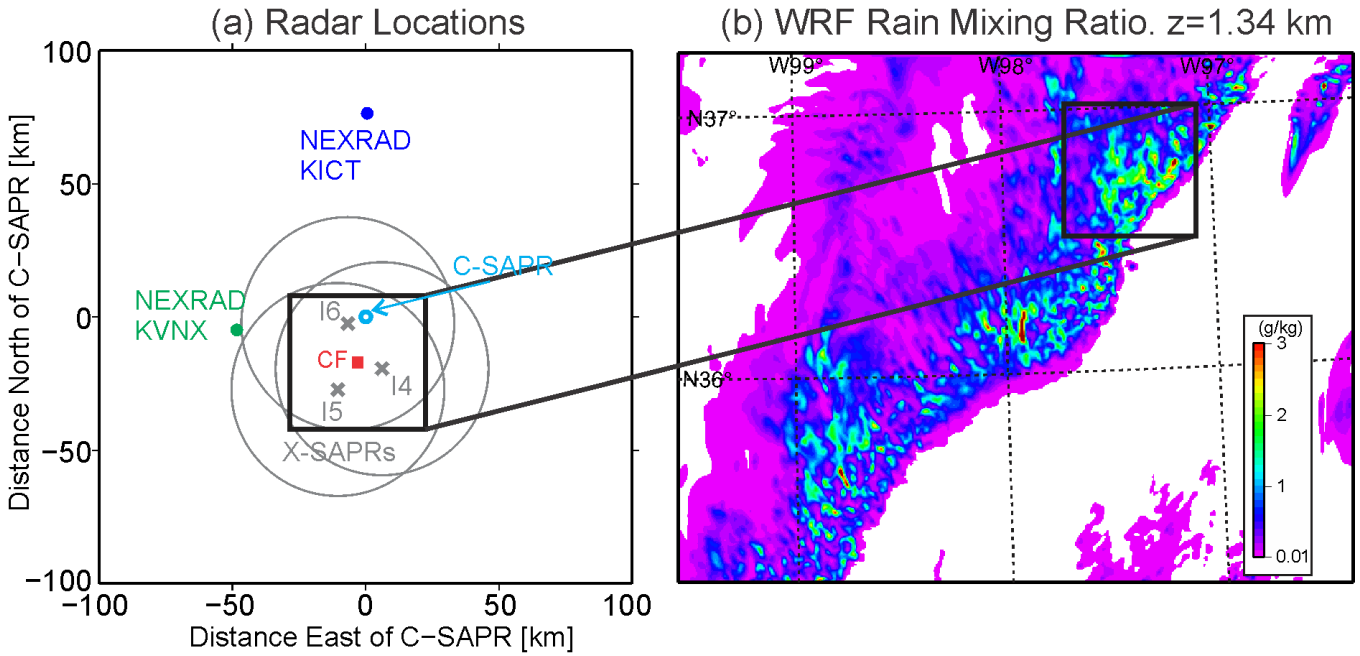
Output
Simulated retrieval parameters
This study:
multi-Doppler radar retrieved **w**

Compare and investigate uncertainties from error sources separately



Application to Multi-Doppler Radar Wind Retrievals for Mesoscale Convection

Mesoscale convective system (MC3E)



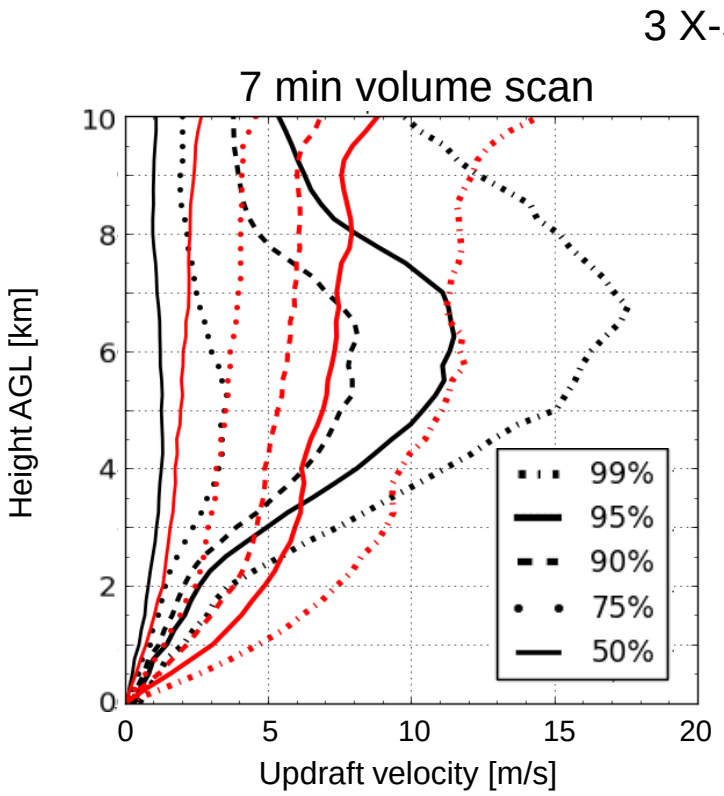
WRF: MC3E of 2011/05/20 12:18 – 12:25, DX=0.5 km, 20-sec outputs

Retrieval grid : 50 km x 50 km domain, DX,DY,DZ=250 m

Assess potential observation errors in wind retrievals:

1) Use of 3 X-SAPRs (near by the CF, dense data points)
2) Use of C-SAPR and 2 NEXRAD radars (far from the CF, sparse data points)

Results: Errors in Observational Retrievals



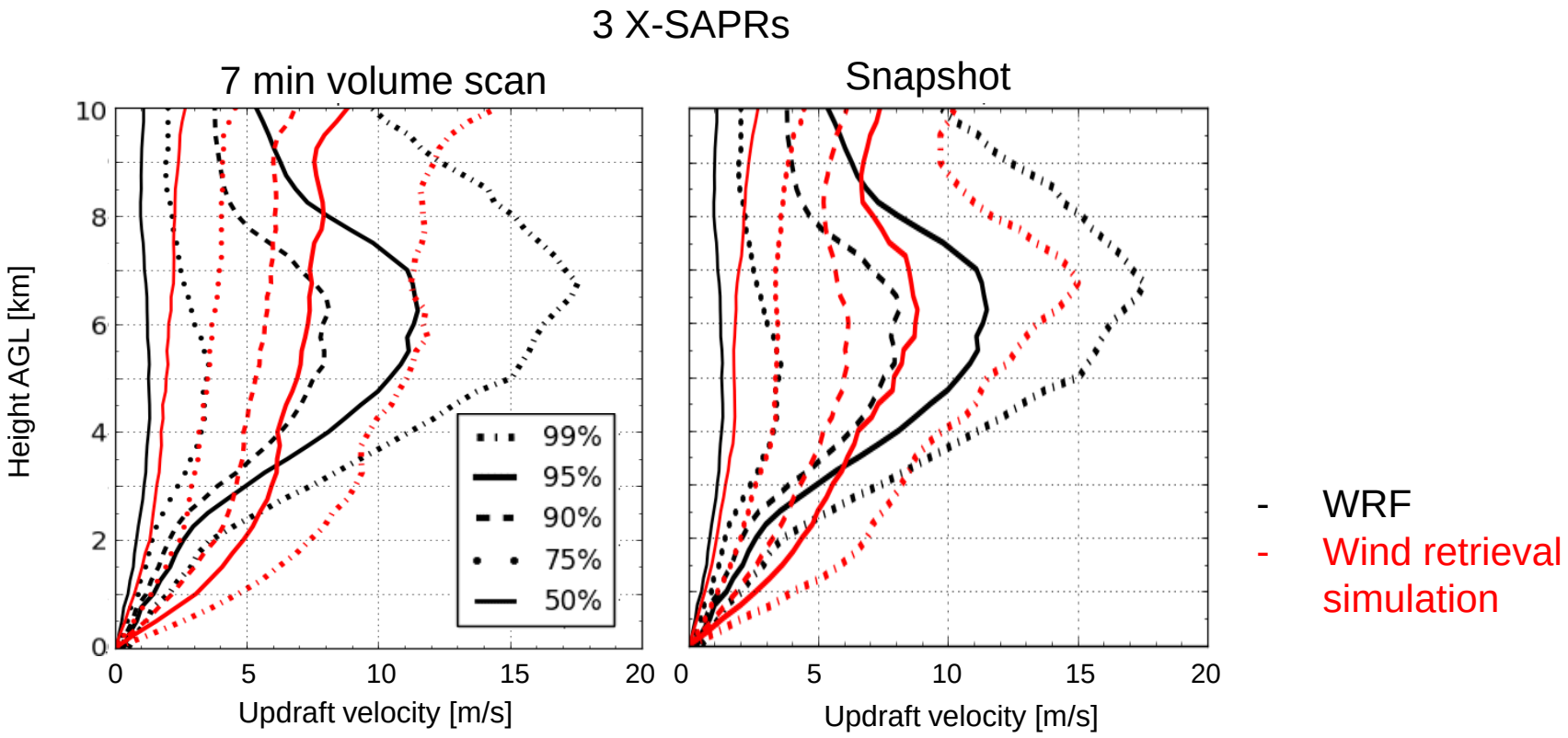
- WRF
- Wind retrieval simulation

Retrievals using simulated X-SAPR radar PPI measurements (20 sec/PPI).

Sources of the errors include:

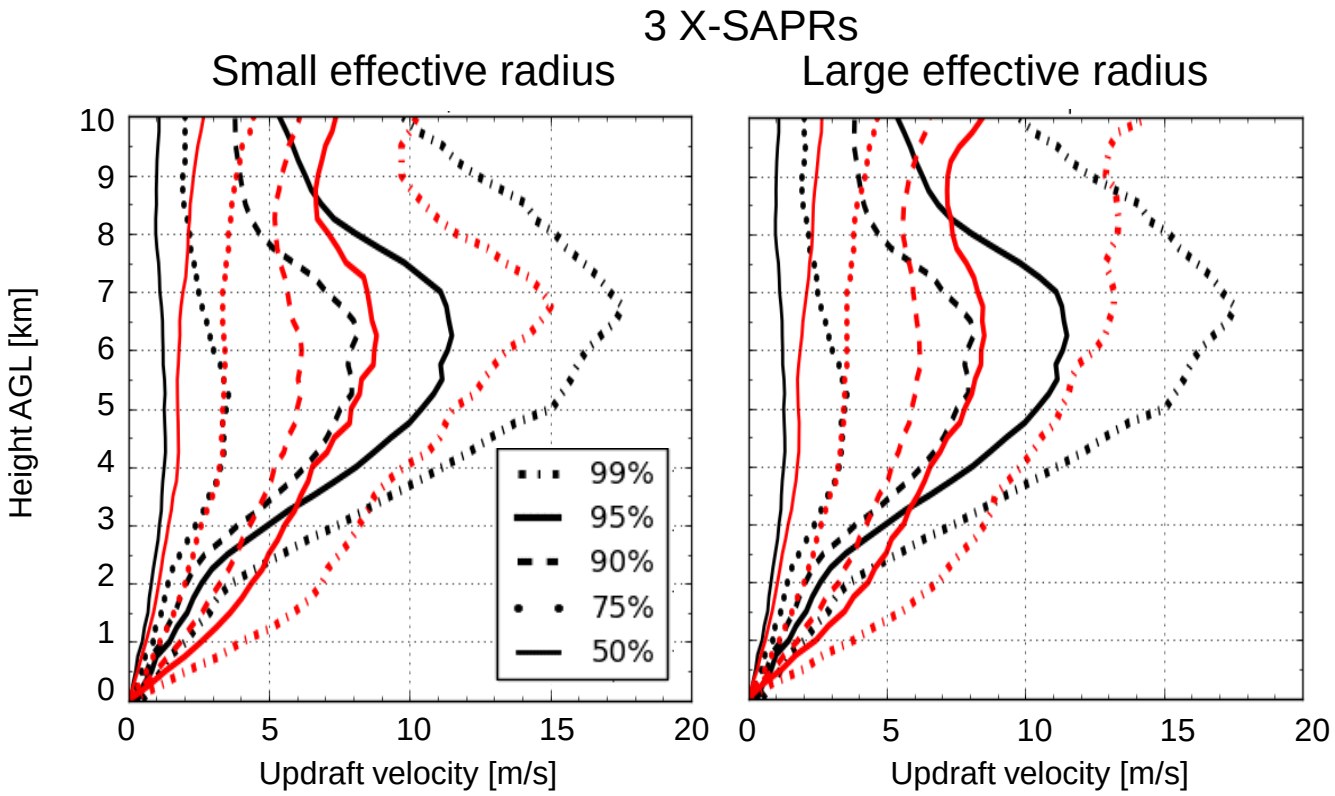
- Time differences amongst PPI scans
- Gridding (e.g. smoothing strength)
- Radar characteristics (e.g. beam width)
- VCP (e.g., elevation angles, radar locations)
- Particle fall speed estimate

Results: Errors from Volume Scan Time



- The 7 min volume scans cannot resolve cloud evolution.
- The snapshot retrievals using 3 X-SAPRs can capture the peak at ~7 km altitude, but underestimate larger updrafts at 4-9 km altitudes.

Results: Errors from Gridding Process

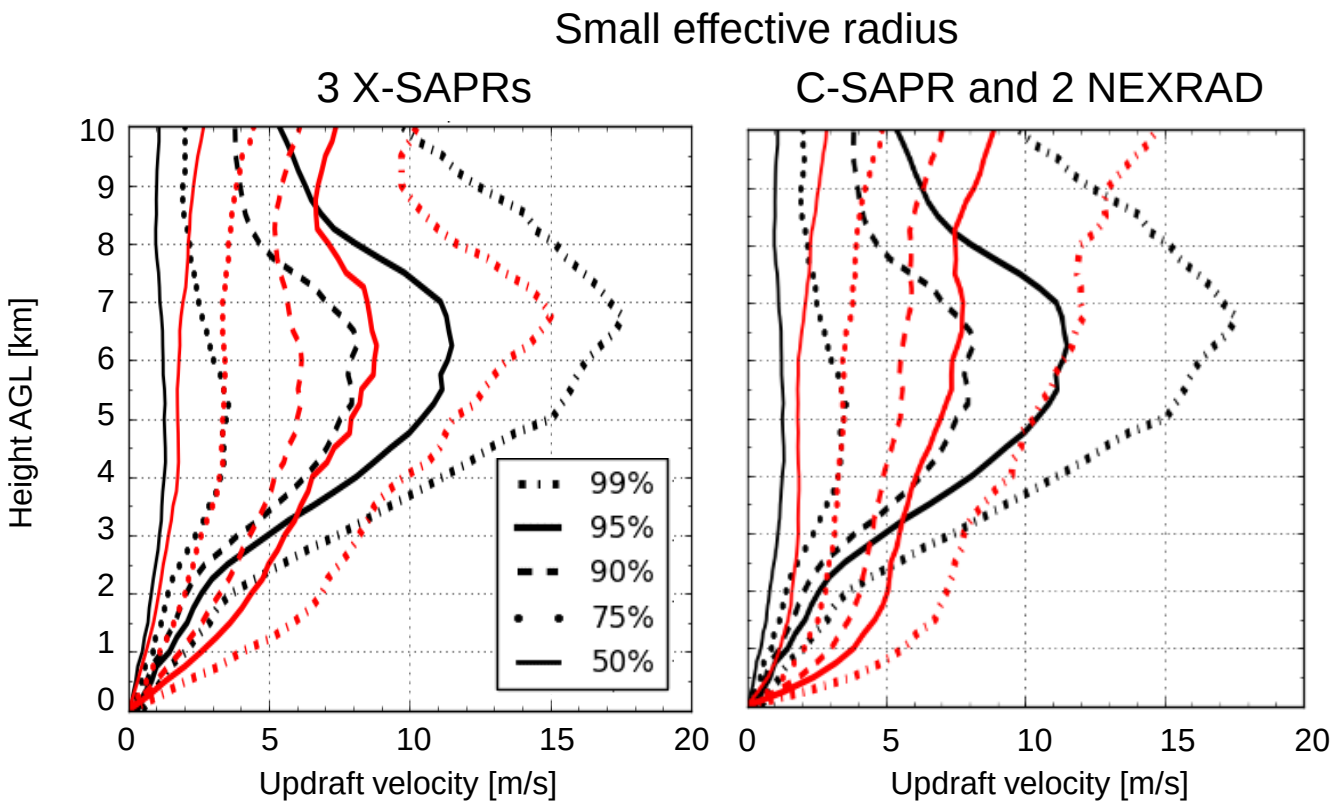


Retrievals using snapshot from the use of 3XSAPRs with different smoothing effects.

- WRF
- Wind retrieval simulation

- Using strong smoothness (larger effective radius) can cause underestimation of larger updrafts.

Results: Errors from VCP

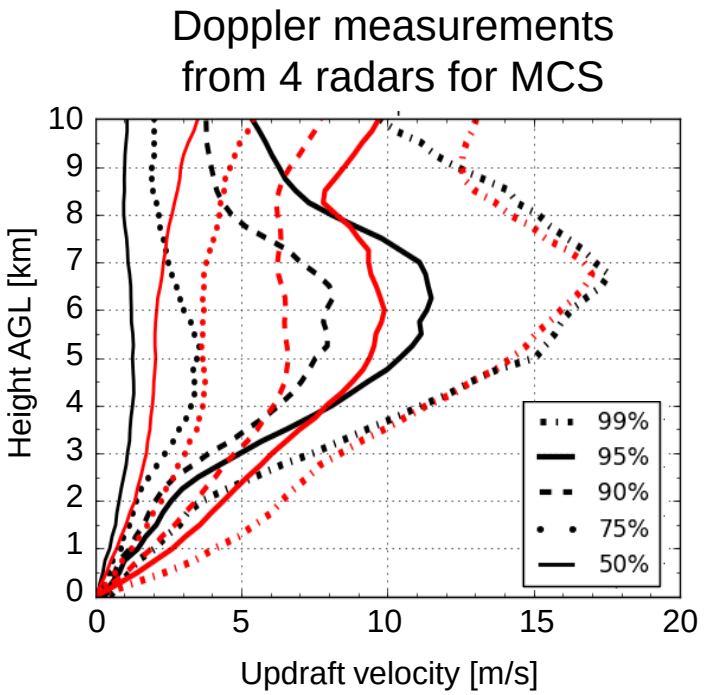


Retrievals using snapshot with the same parameters from the use of 3XSAPRs and the use of C-SAPR and 2 NEXRAD radars.

- WRF
- Wind retrieval simulation

- The use of NEXRAD radars seems to be difficult to capture the peak.
- The difference between the two retrievals can be caused by locations of radars.

Challenge and Recommendation



Retrievals for snapshot using Doppler radar measurements from 3 X-SAPRs and C-SAPR.

- WRF
- Wind retrieval simulation

- Fast volume scans (< 1 min) by more than 2 radars (e.g., sector scans, phased array radars) at high spatial resolution can provide best performance for 3D vertical velocity retrievals.
- Reflectivity without attenuation (e.g., NEXRAD) should be used to estimate particle fall speeds.

Summary and Updates of CR-SIM

CR-SIM package is a useful product to evaluate observation-based retrievals and determine the new observation strategy. The latest CR-SIM:

- Implements the P3 microphysics
- Accepts RAMS and ICON model inputs and their microphysics
- Is optimized for speed-up (e.g. using OpenMP)
- Implements automake configuration
- Latest packages are available at:
  https://www.bnl.gov/CMAS/cr-sim.php
  https://you.stonybrook.edu/radar/research/radar-simulators/