Challenges to Evaluate 3D LES Using Ground-Based Profiling Observations for Shallow Cumulus Clouds

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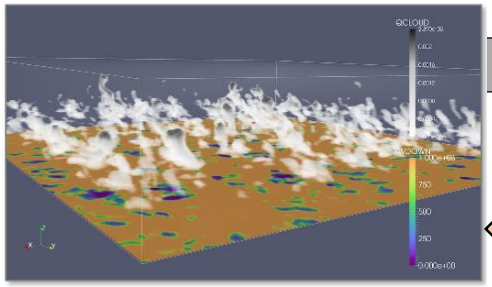
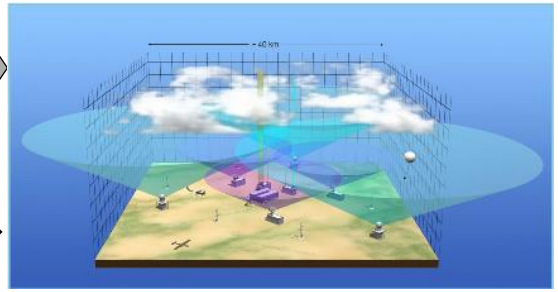
Cloud Model Simulations (LASSO)



Cloud Resolving Model Radar SIMulator (CR-SIM)

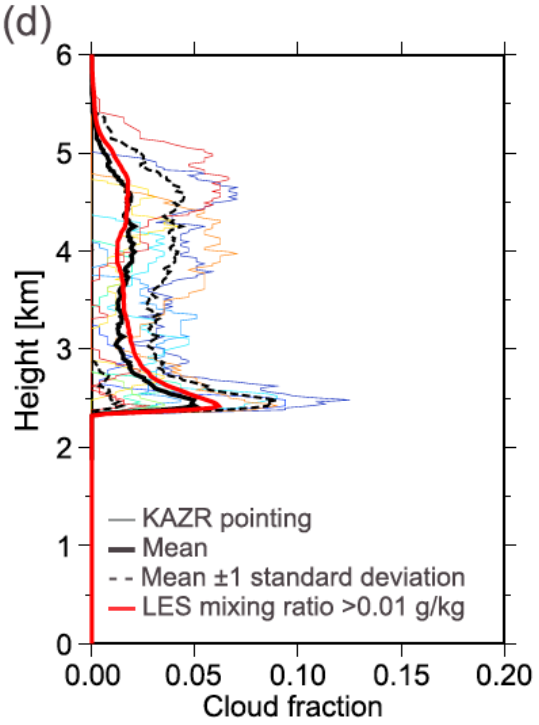
Virtual Observational Products



Compare simulated observational cloud field with the original model dataset to address potential uncertainties in observational products.

Motivation

Simulated Cloud Fraction Profiles



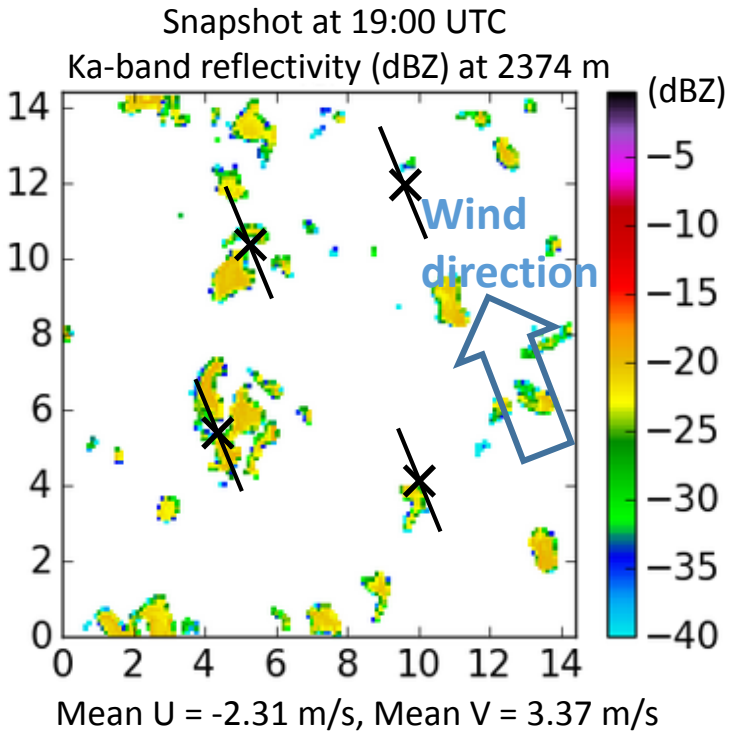
KAZR cloud fraction (colored lines)
Mean over 10 KAZRs (black line)
Model (red line)

(*Oue et al. 2016*)

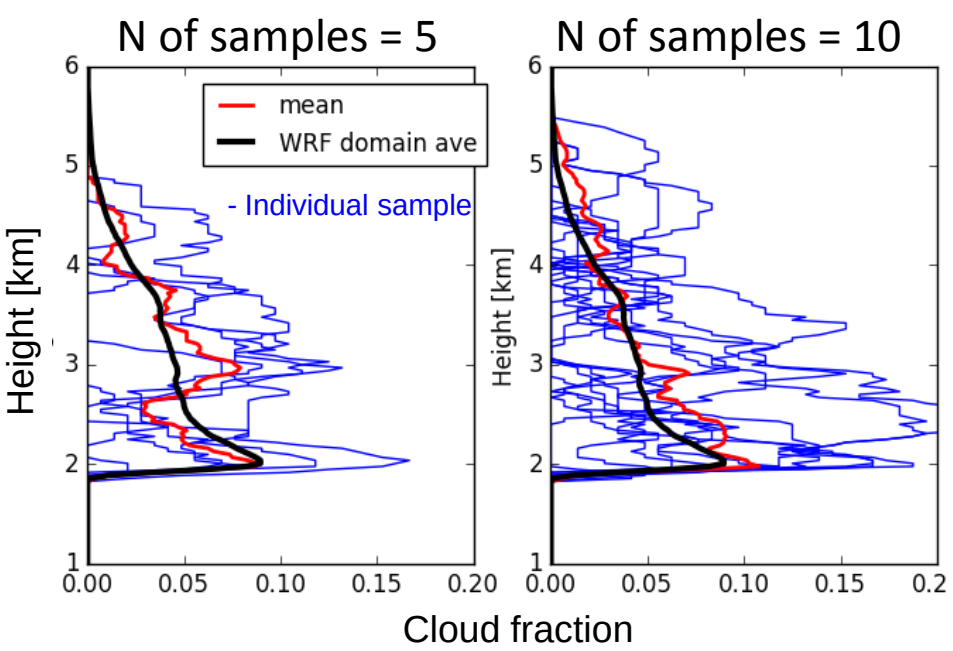
How many observation sites are needed to estimate the domain averages?

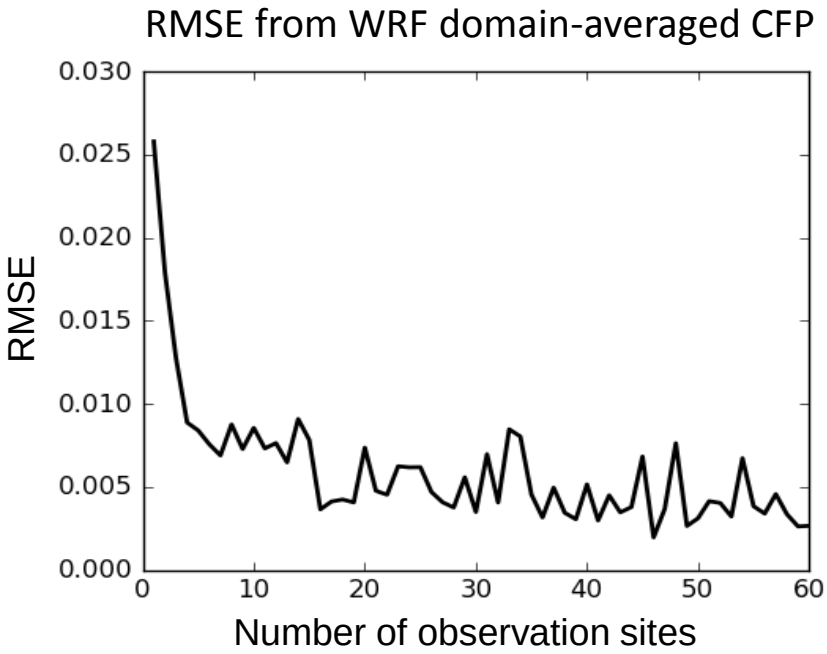
Methodology

- Sampling method
  - Randomly select observation site.
  - Assume no cloud evolution within 10 minutes.
  - Sample clouds moved by the mean horizontal wind within 10 min for each output.
  - Integrate an hour (6 outputs, 19:00-19:50 UTC).
  - Average over samples.



Cloud Fraction Profile





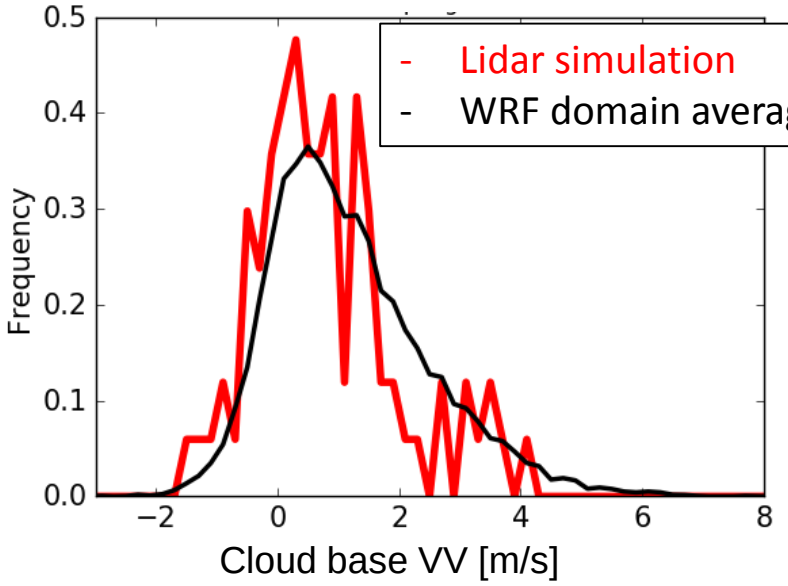
Each cloud fraction profile from single location has large variability, but the mean of them can be close to the domain average.

RMSE of cloud fraction profile quickly converges on 0.007 until the number of samples of 5-7.

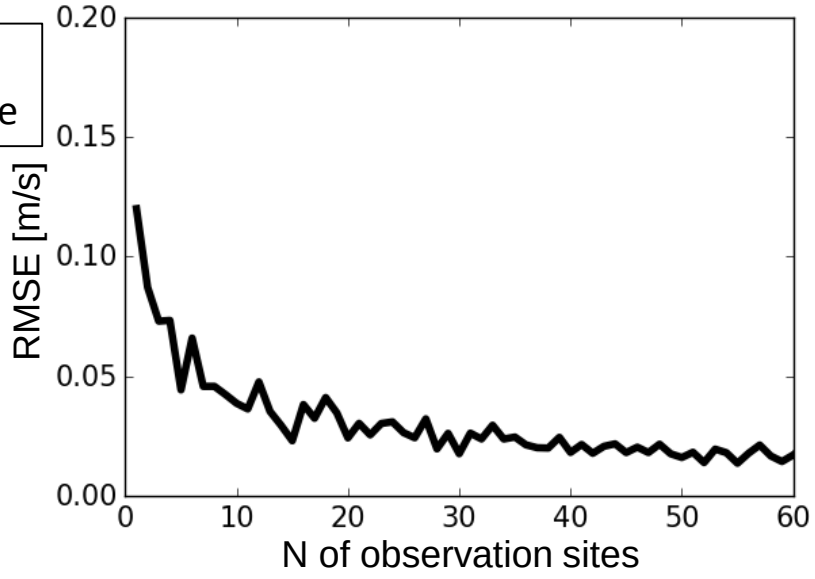
Cloud Base Vertical Velocity PDF

Cloud base = the micro pulse lidar (MPL) first echo (>10^{-5} $km^{-1}sr^{-1}$).
Cloud base from tilted clouds were excluded.

5 observation sites



RMSE from WRF PDF



RMSE of cloud fraction profile quickly decreases below 0.05 until the number of samples of 5-7.

Summary

How many observation sites are needed to estimate the domain (14x14km) averages from 1 hour integration?

- Cloud fraction profiles (CFP)
  - For profiling measurements (ARSCL), at least 5 observation sites would be needed to estimate the domain averaged CFPs with small errors.
- PDF of cloud base vertical velocity
  - For lidar measurements, 5 locations would be needed to estimate the domain averaged cloud base vertical velocity PDF with small errors.

Latest packages of the forward simulator are available at
https://www.bnl.gov/CMAS/cr-sim.php
https://you.stonybrook.edu/radar/research/radar-simulators/