A Radar Network Approach to Characterize Shallow Convection at the SGP Mega Site to Support the LASSO Activity

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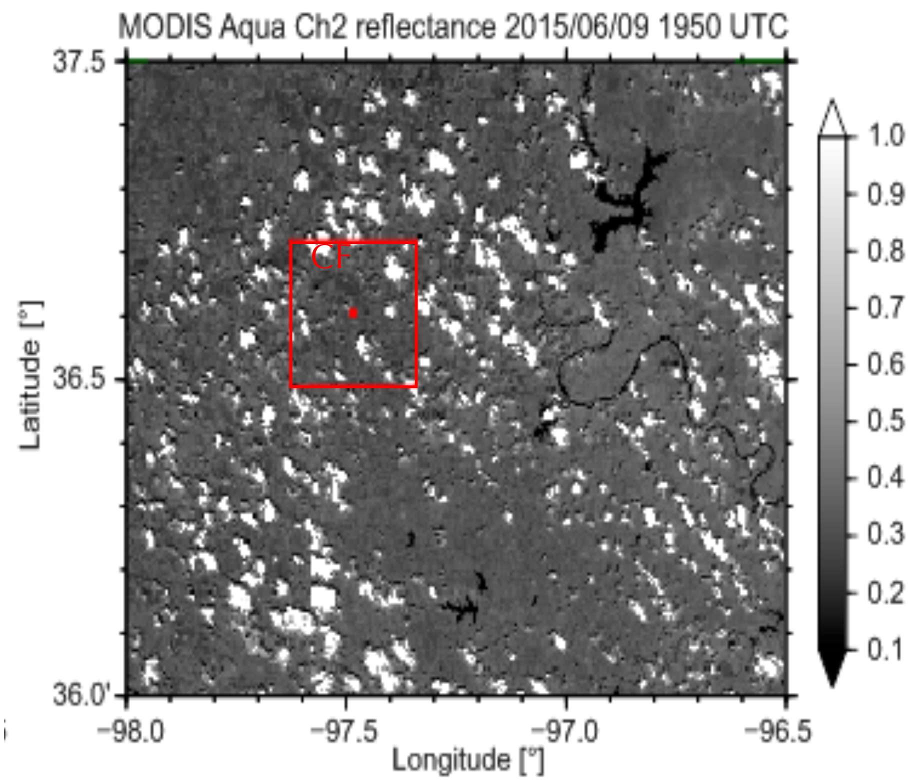
Motivation



Shallow convection is characterized by large inhomogeneity in cloud properties

Shallow clouds at the SGP pose detection challenges to radars due their weak reflectivity and small size (Lamer and Kollias, 2015).

How well profiling observations of shallow convection capture these properties?

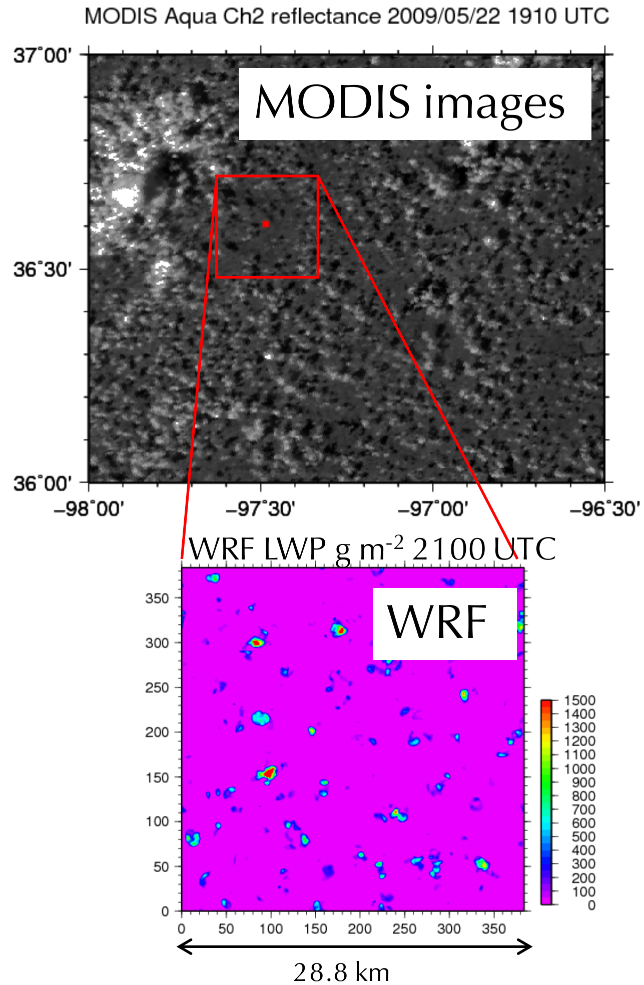
How best to compare domain-average model output with profiling observations?

Methodology

- Use WRF to simulate two cumulus cloud cases over the SGP:
  1. Shallow case on 22 May, 2009 (RACORO campaign)
  2. Deep case on 9 June 2015 (Endo et al., 2015)

http://radarscience.weebly.com/radar-simulators.html

Shallow case 2009/05/22



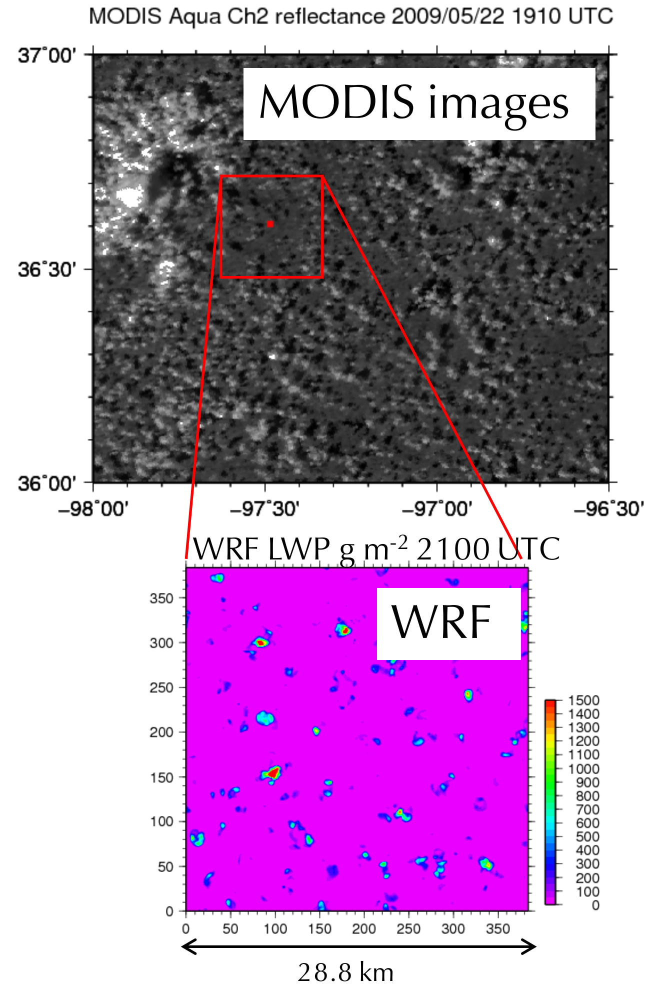
Methodology

- Use WRF to simulate two cumulus cloud cases over the SGP:
  1. Shallow case on 22 May, 2009 (RACORO campaign)
  2. Deep case on 9 June 2015 (Endo et al., 2015)

- Use Cloud Radar – SIMulator (CR-SIM) to emulate the Scanning ARM Cloud Radar observations
  - A simulated ceilometer lidar is also generated by CR-SIM

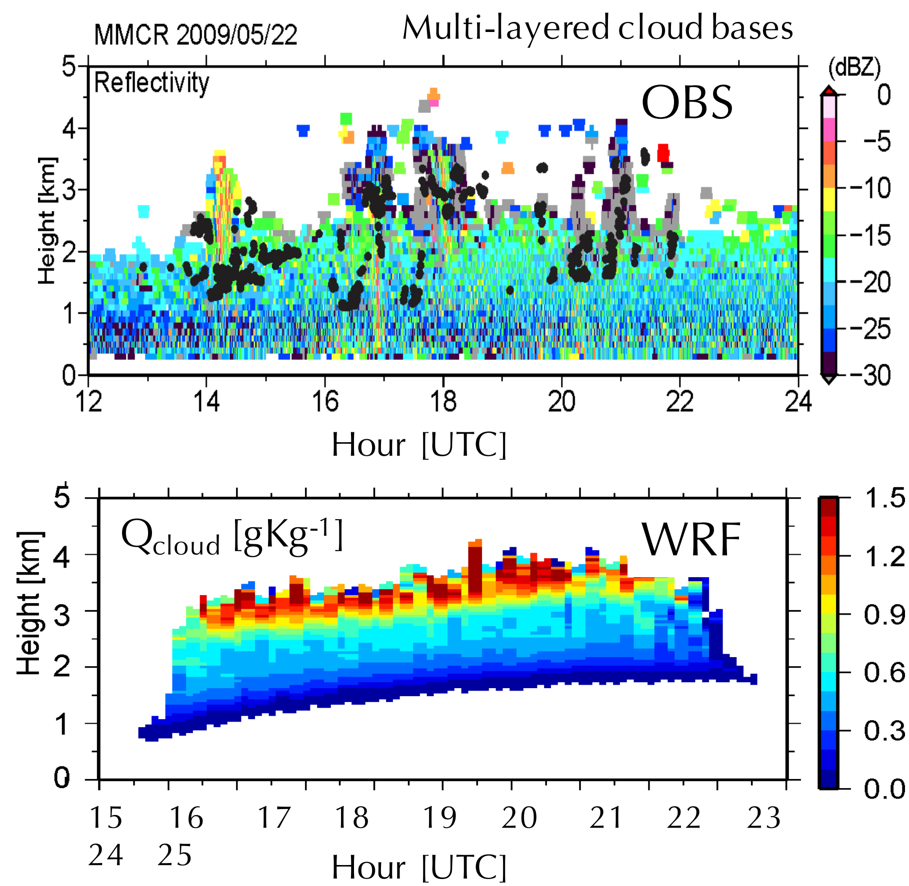
➢ *Source code and user manual are available at http://radarscience.weebly.com/radar-simulators.html*
➢ *Support for interfacing models is available*

Shallow case 2009/05/22



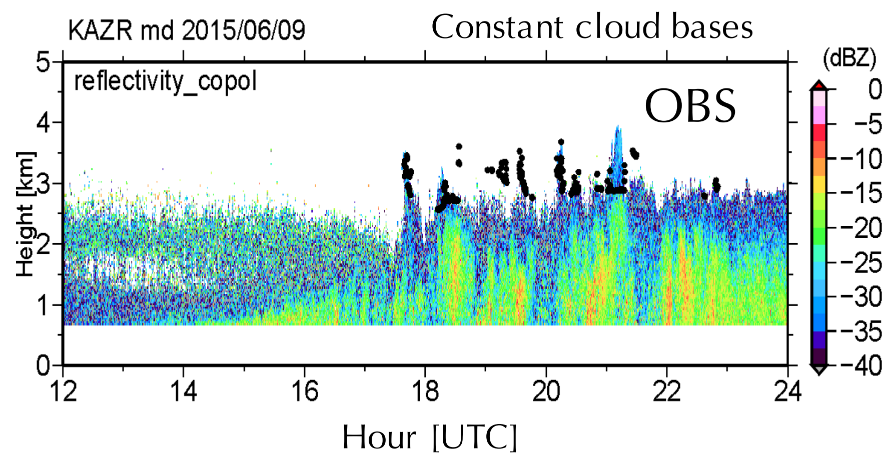
Profiling Observations vs domain-averaged WRF output

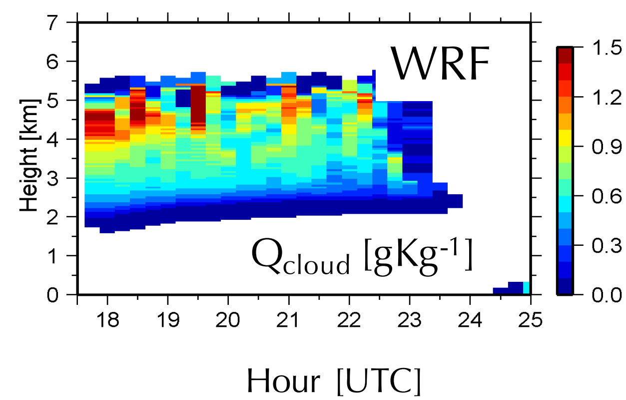
- When deep clouds overpass the radar the comparison seems fair



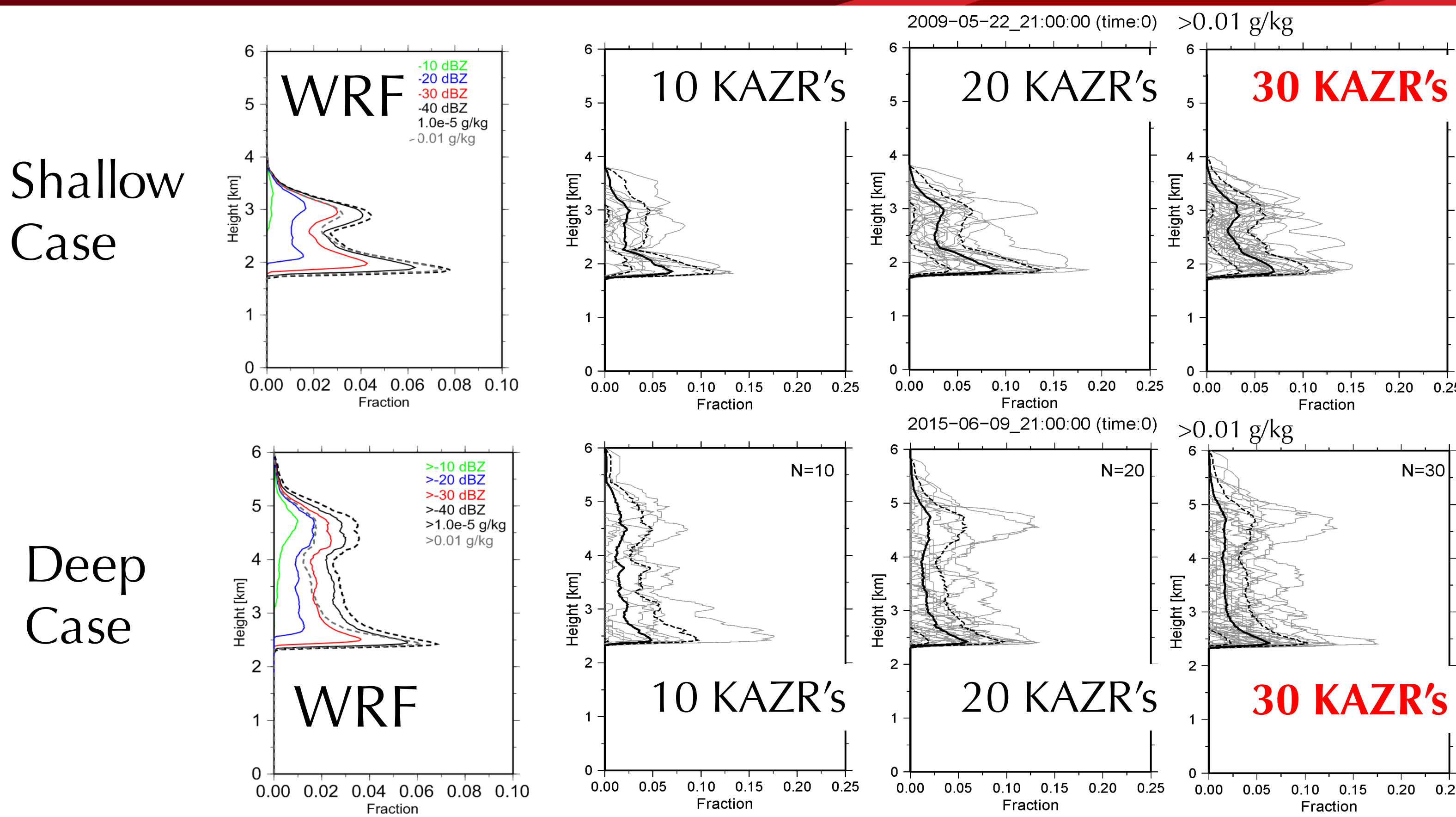
Profiling Observations vs domain-averaged WRF output

- If only shallow clouds overpass the radar then it is a bad model





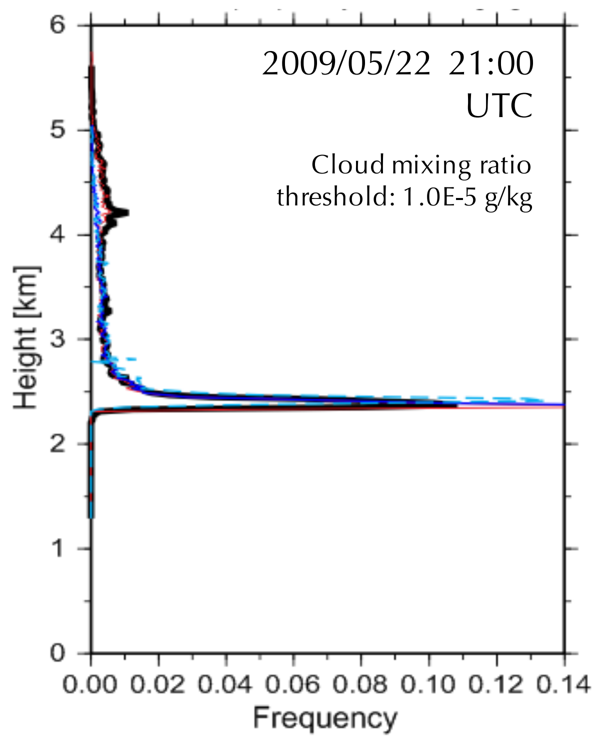
How many KAZR's we need to estimate the CF profile?



Cloud Fraction at the cloud base height – KAZR + CEILOMETER

Assuming we have vertically-pointing radar and lidar everywhere

- KAZR cannot capture all cloud bases
- Ceilometer is necessary to capture the base of shallow clouds

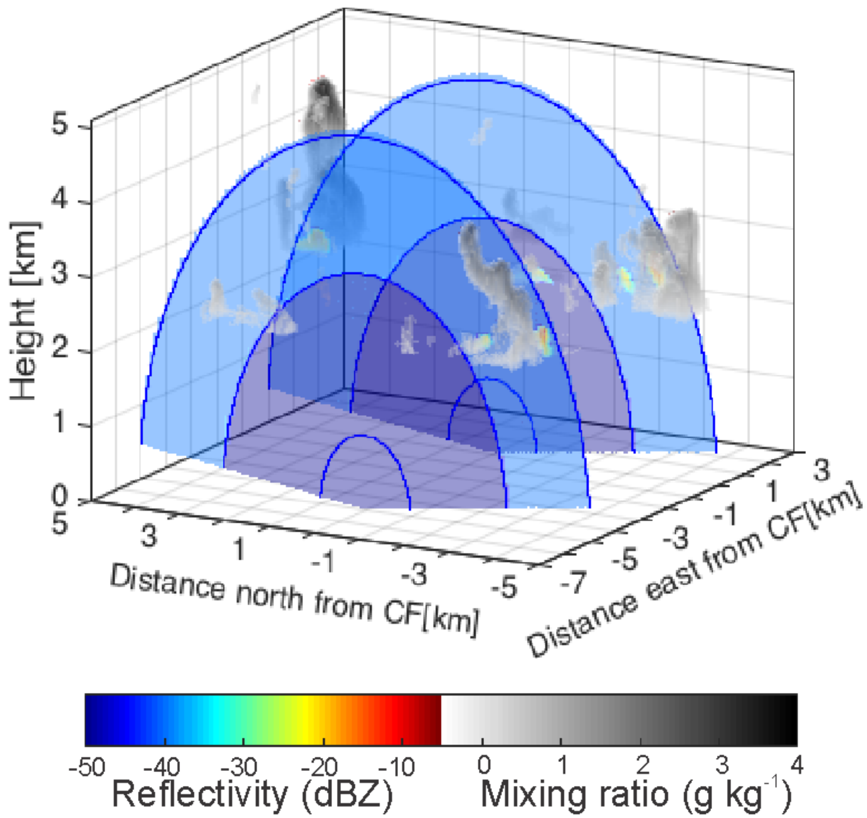


Red: WRF hydrometeor mixing ratio > 0.01 g/kg

Blue: Lowest height of lidar (ceilometer) backscatter (> 10^{-4} sr^{-1} m^{-1})

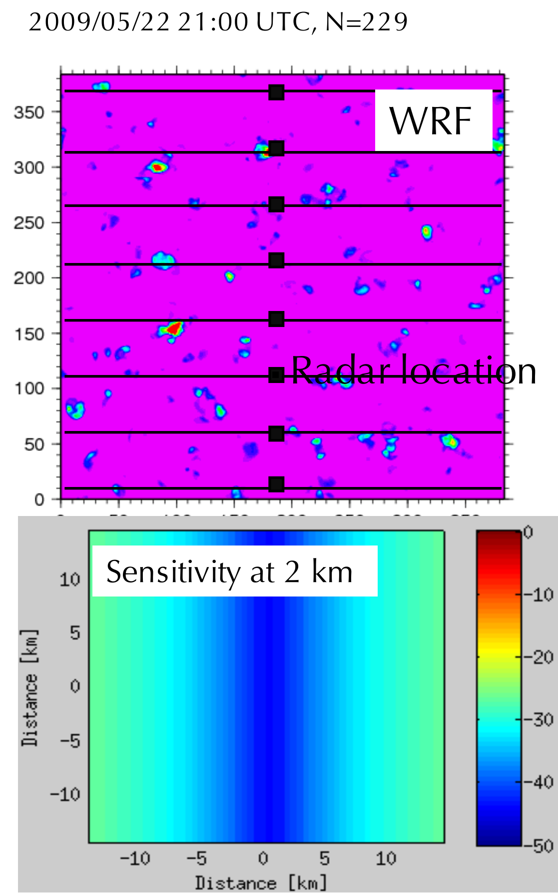
Black: Lowest height of Ka-band Zhh (-50+20log10(R) dBZ is applied)

Use of Scanning ARM Cloud Radar Observations



Oue et al., 2016

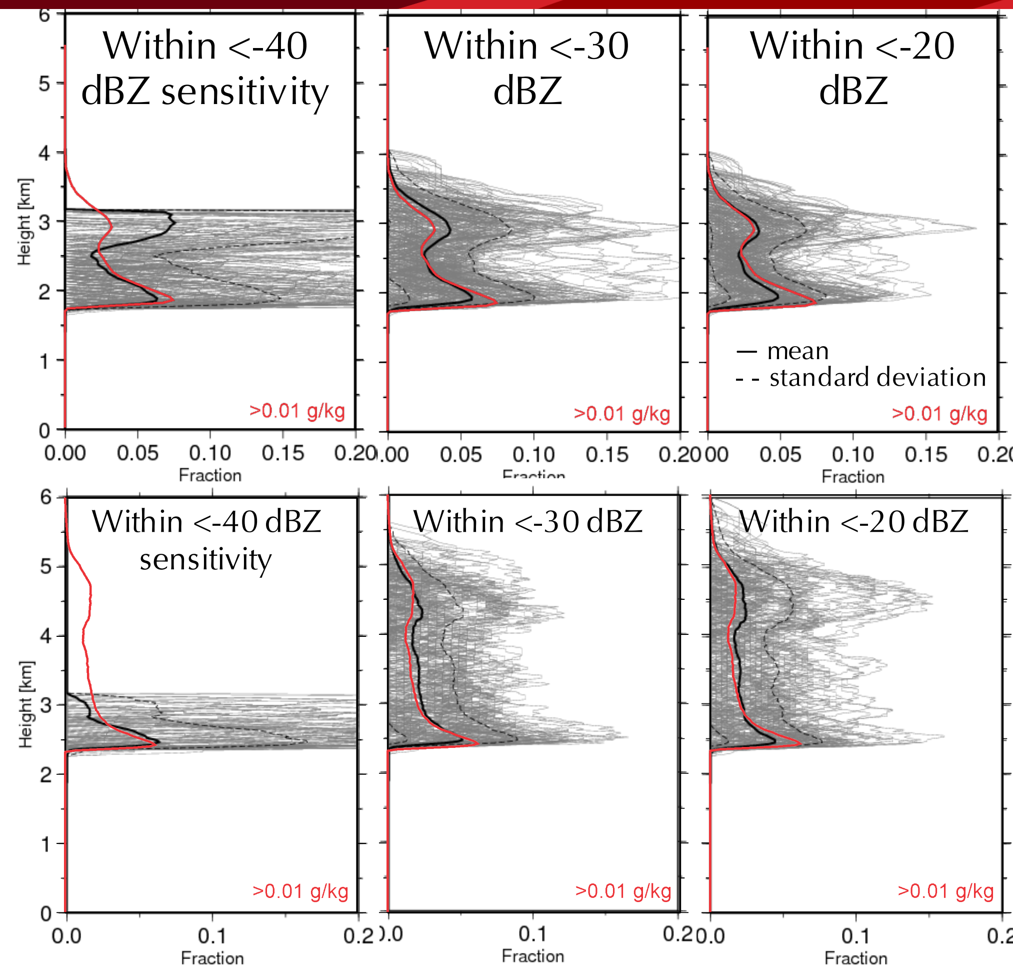
Scanning cloud radar simulations – How to exploit the dilema between sensitivity and domain size



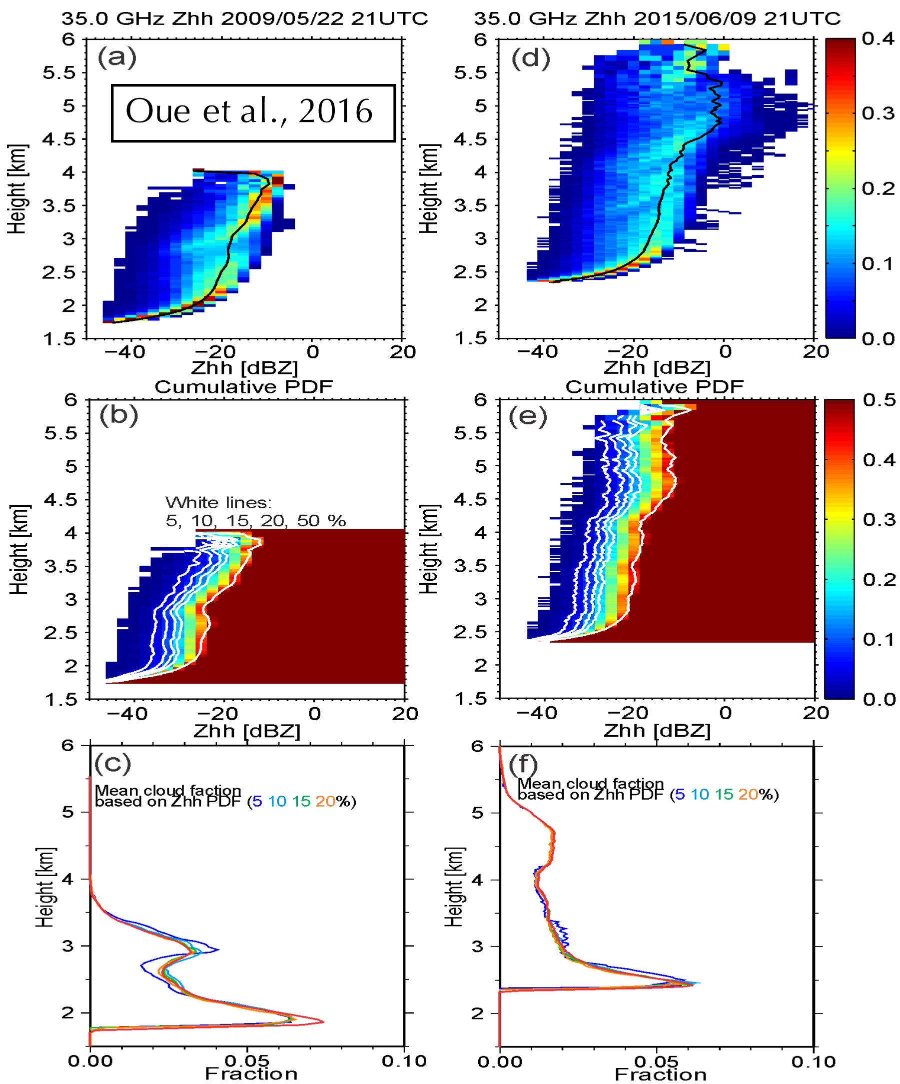
- Assuming CWRHI scans every 30 sec (clouds moving along N-S direction)
- Note how Ka-band SACR sensitivity decreases with distance away from the radar

Cloud fraction estimate from "observation"

- High sensitivity => Small domain
  - Captures the shallow mode
- Low sensitivity => Better coverage, large domain
  - Captures the deep mode
- Combined
  - Capture best estimate of all clouds



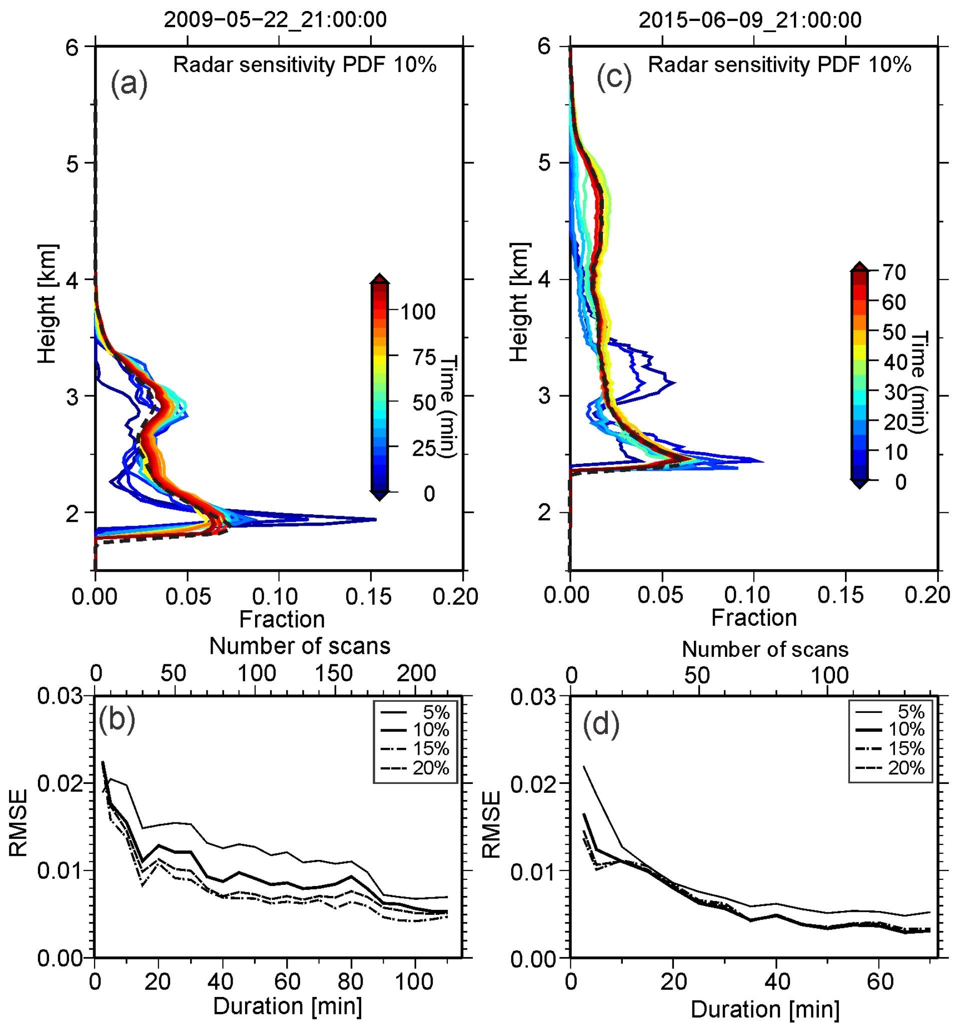
Cloud fractions from WRF mixing ratio greater than 0.01 g kg^{-1} (red) and CWRHI scans (gray line), mean cloud fraction (black solid line), and standard deviation (dashed lines) for sensitivity regions of -40 dBZ, -30 dBZ, and -20 dBZ



Contoured frequency by altitude diagram (CFAD) of radar reflectivity observed by the SACR (CR-SIM) with hydrometeor mixing ratios > 0.01 g/kg. Black line represents mean profile.

Cumulative probability density of the SACR observed reflectivity as a function of height. [5, 10, 15, 20 and 50%]

Mean cloud fractions from CWRHI scans with sensitivities according to 5% (blue), 10% (light blue), 15% (green), and 20% (orange) CDF isolines and cloud fraction from WRF mixing ratio > 0.01 g kg^{-1} (red).



Time duration of the SACR scan?

40-60 min

Cloud fraction profiles according to 10% PDF isoline with changing duration time of scans (hence number of scans). Black dashed line represents the CF profile from WRF mixing ratio > 0.01 g kg^{-1}.

The RMSE from the WRF CF profile according to 5, 10, 15, and 20% as a function of duration time

Oue et al., 2016

Summary

- Profiling radar/lidar observations are not adequate to characterize cloud field properties in shallow convection.
- A methodology for the objective determination of the cloud fraction profile in shallow convection using a scanning cloud radar has been developed.
- The RMSE in the cloud fraction estimation is ~1% and the minimum time of scanning cloud radar observations is 40-60 min.