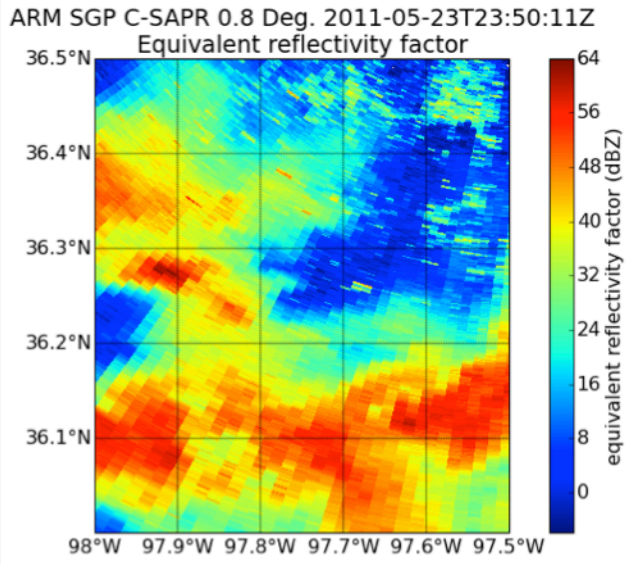
Prove it! ARM's Progress Towards a Suite of Verified Precipitating Cloud System Retrievals

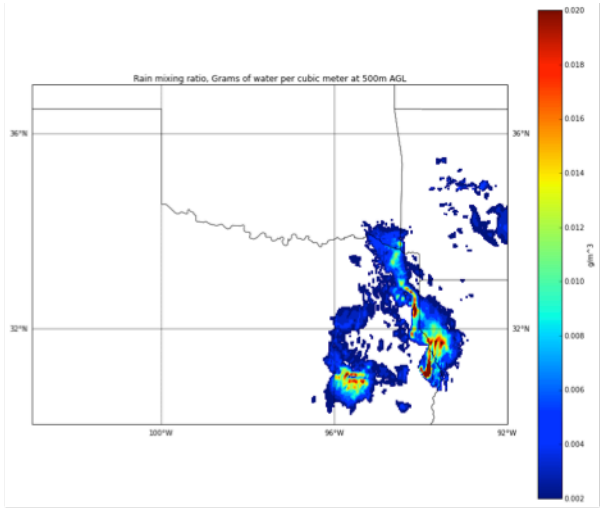
Scott Collis, Scott Giangrande, Jonathan Helmus, Kirk North, Christopher Williams, Virendra Ghate, Adam Theisen and Alain Protat

The Big Picture: Comparison Across Scales

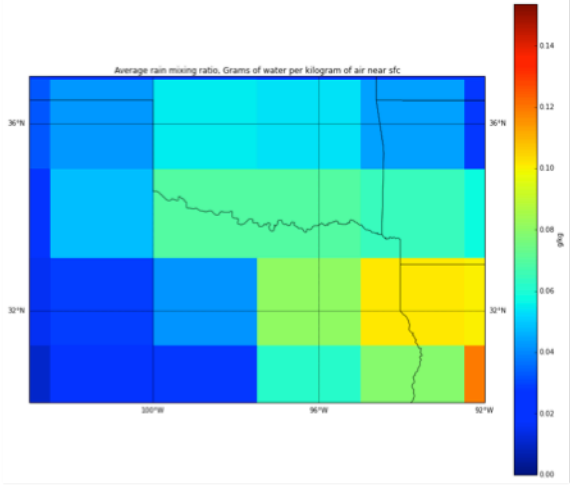
- ARM's programmatic objective is to improve the understanding and representation, in climate and earth system models, of clouds and aerosols as well as their interactions and coupling with the Earth's surface.
- Direct measurements are great but only remote sensing measurements come close to the domain of a ESM/GCM grid scale.



Gates of ARM C-Band Radar Reflectivity 117x100x100m



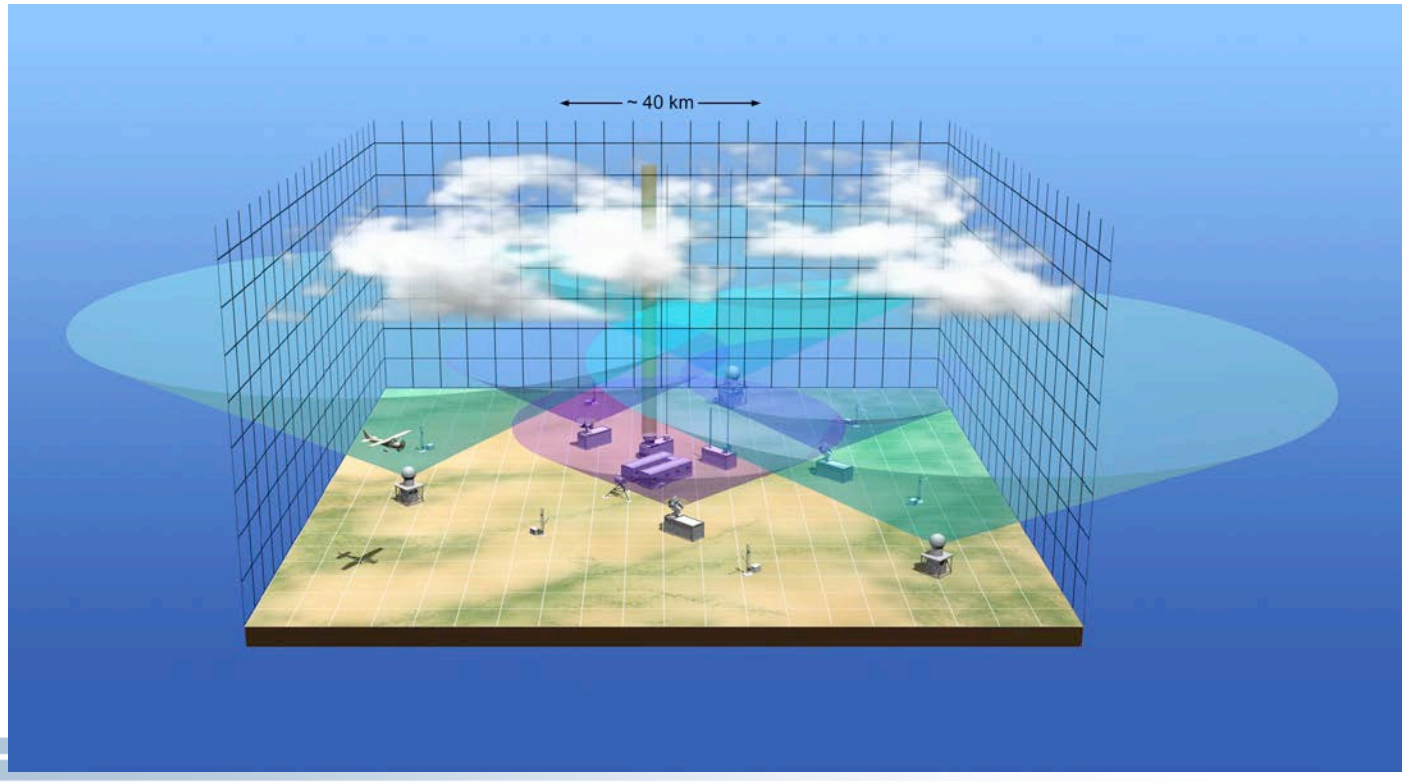
Grid cells of WRF Rain Mixing Ratio 0.5x3x3km



CAM5 Rain Mixing ratio, ~100's km

Our approach:

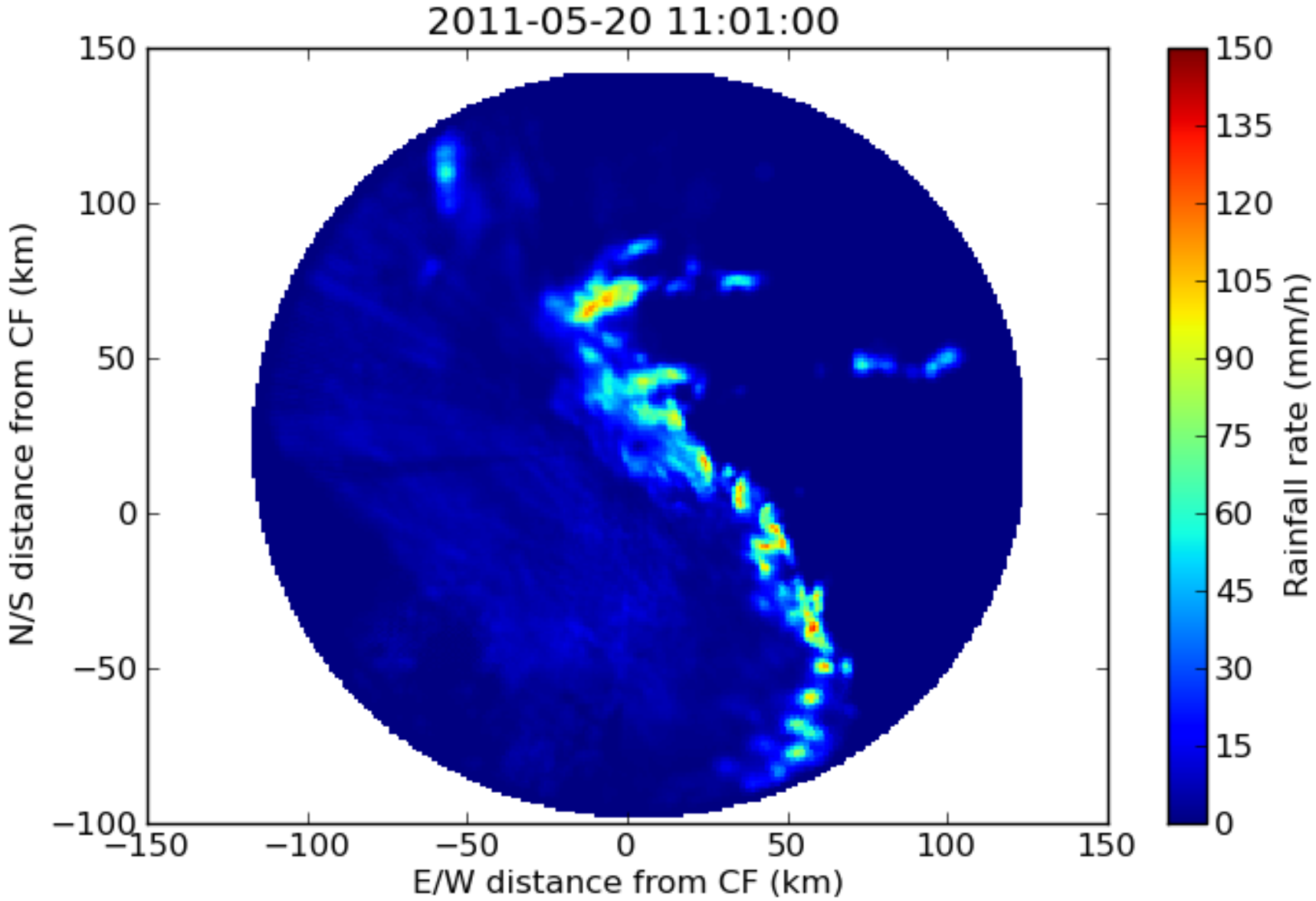
- Work with Pis and existing retrieval code if possible.
- Improve if needed. Make robust, make ubiquitous as possible.
- Build using common data models so no special cases
- **Prove it!** Do our retrievals make sense? How do they compare to **independent data sources.** Unproven retrievals can lead to Garbage in Garbage out.
- Of course we recognize comparing two retrievals is not a ground truth.. But it is a start, especially when different methodologies are used and assumptions made.
- ARM is IDEAL for this approach, we have **Multi-scale** independent measurements!



Case 1: Precipitation Rates at the Southern Great Plains

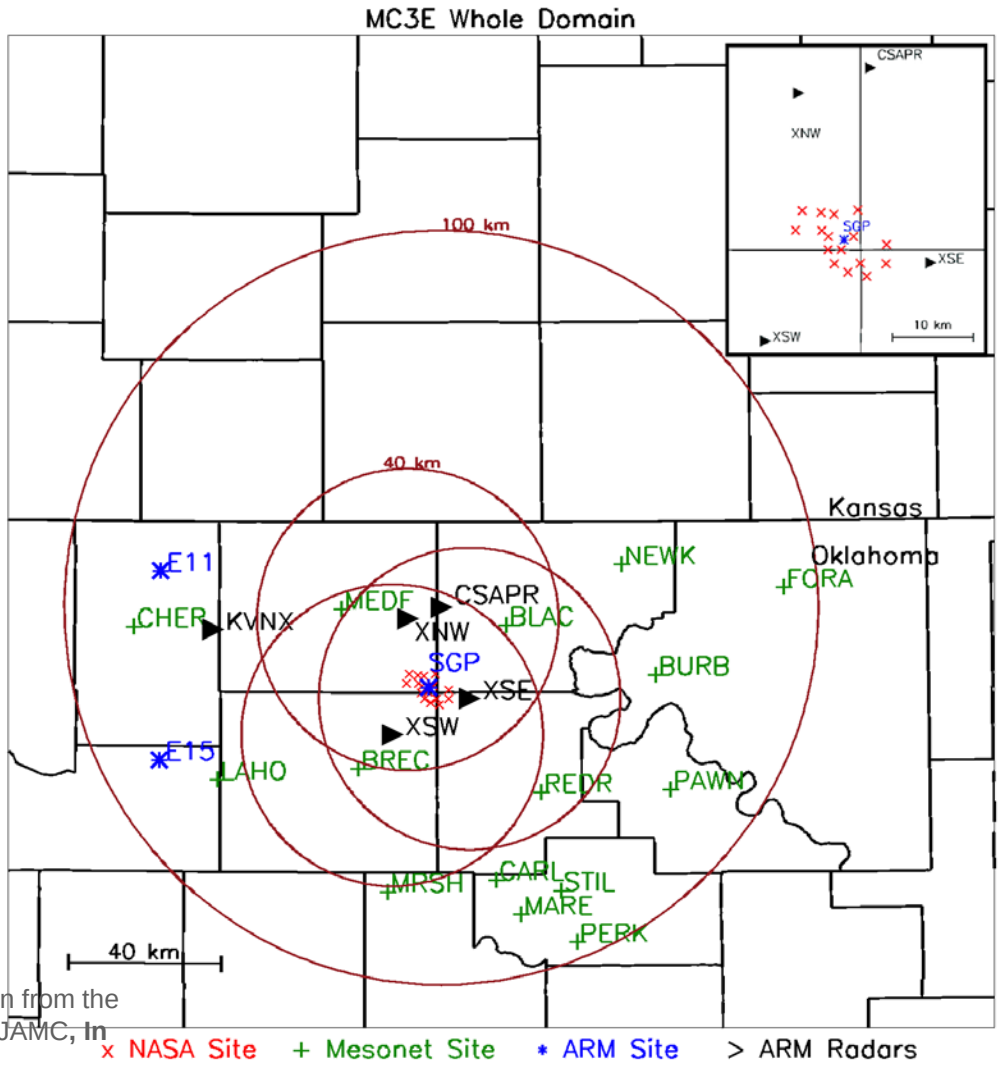
- The data source: Scanning 5cm and 3cm wavelength radars.
- The desired product: Rain rates in mm/h at the surface, resolving fine scale structure but covering a domain equivalent to a GCM grid cell on Process scale time scale.
- Method: Use Polarimetric phase information which is calibration robust and insensitive to atmospheric attenuation combined with highly sensitive reflectivity factor data to retrieve specific attenuation (dBZ/km) and use this to retrieve rain rates.

Giangrande, Collis, Theisen and Tokay, Precipitation Estimation from the ARM Distributed Radar Network During the MC3E Campaign, JAMC**, In Revision**


2011-05-20 11:01:00
N/S distance from CF (km)
E/W distance from CF (km)
Rainfall rate (mm/h)
150
100
50
0
−50
−100
−150
135
120
105
90
75
60
45
30
15

Prove it!

- In this case our independent data source is a very dense network of rain gauges and distrometers.
- We used the GPM-ARM MC3E IOP as our test data set as we had an additional array of NASA gauges and distrometers.
- Data set combines multiple systems across regiemes (Supercell, MCS, weak convection, cold front/low)



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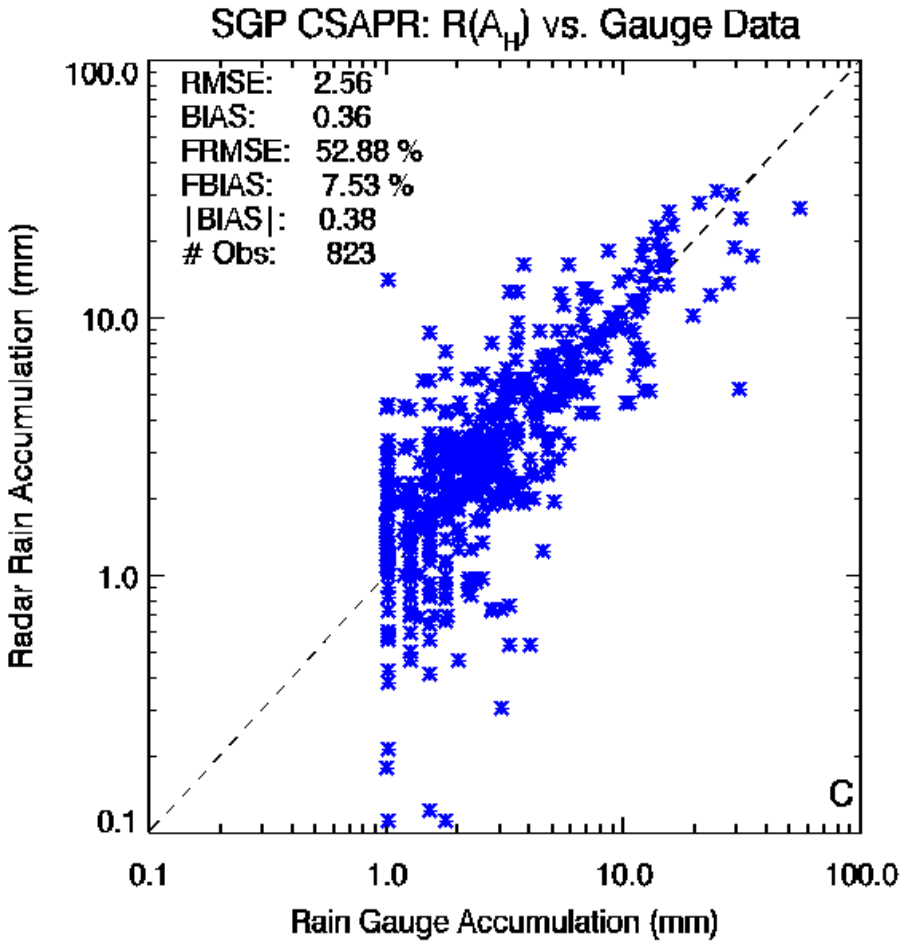

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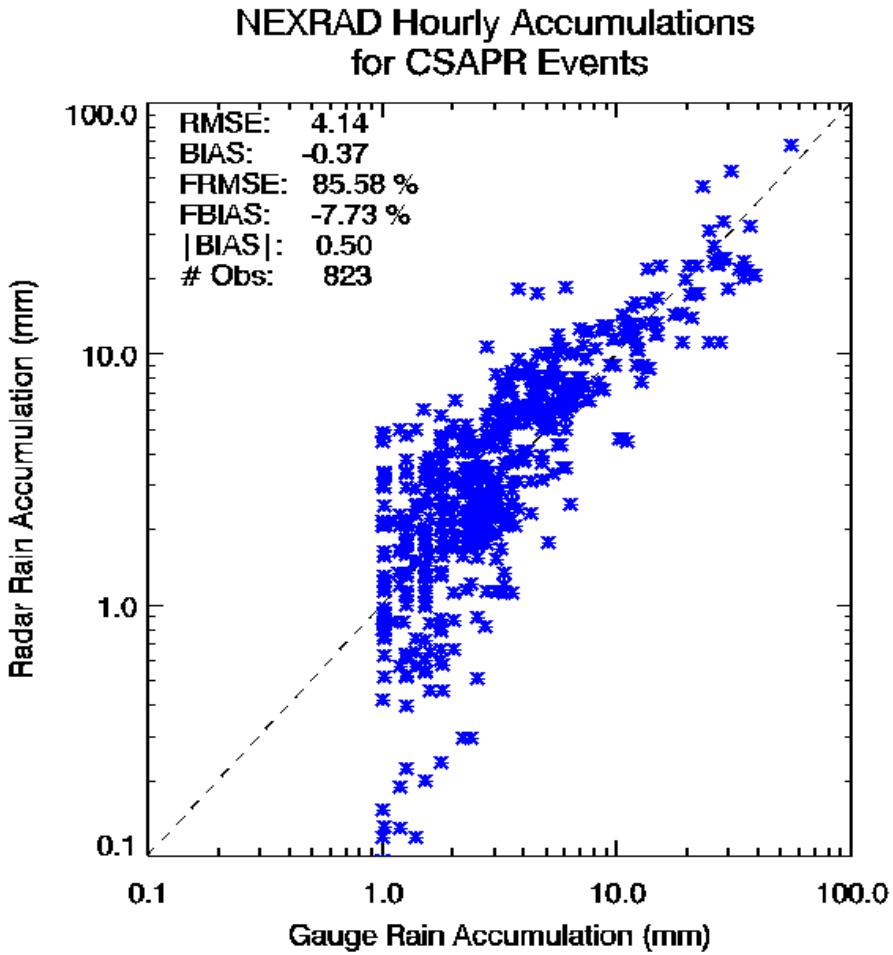

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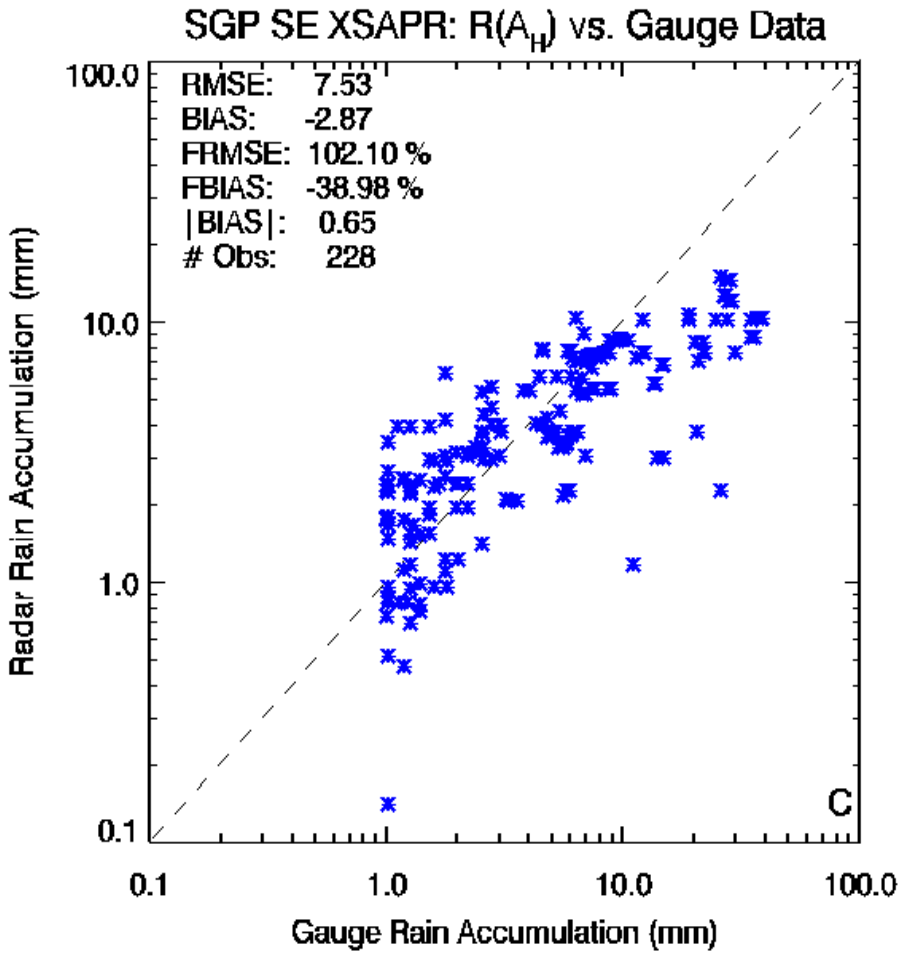

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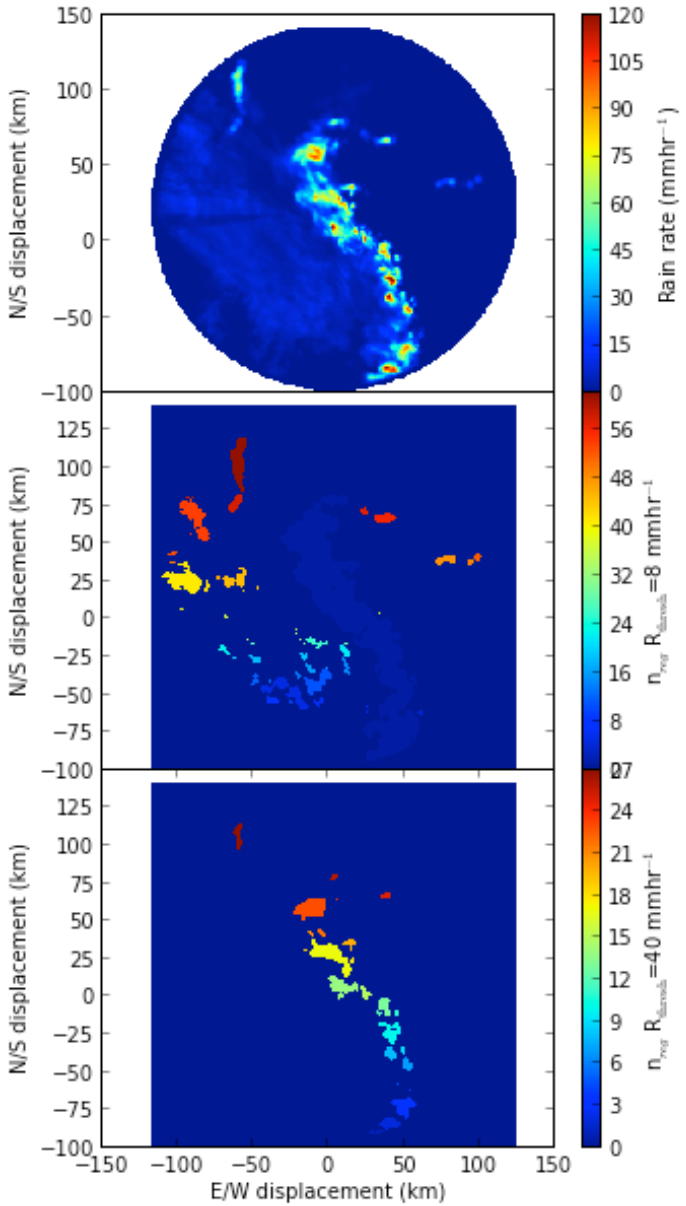
Now how can we use rain rates?

- Rain is what happens when we get a precipitating cloud system!
- The structure of the rain is dictated by the structure of the underlying system dynamics and microphysics, a MCS with defined convective, stratiform and transition elements produces a different rainfall “pattern” than isolated severe convection.
- So rainfall morphology can serve as a vital **metric** for if the structure in a LES or CRM model mirrors reality!



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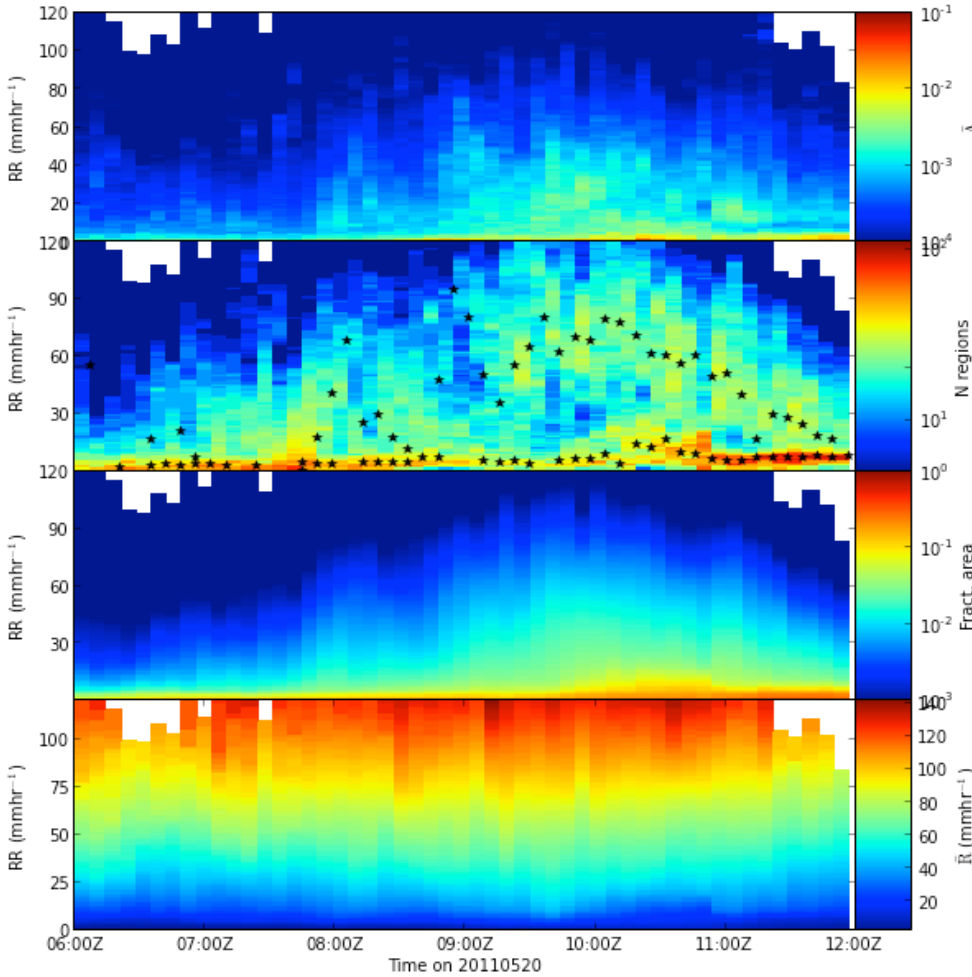

Case 2: Convective Vertical Velocities

- The data source: Networks of scanning Doppler radars
- The desired product: Three component three dimensional wind velocities in
- Method: Use the Doppler Velocities as a constraint in a cost based variational retrieval in tandem with the Anelastic Mass Continuity equation.
- Caveats: Lots of assumptions, W=0 at TOA and surface, do we adequately resolve convergence and divergence?

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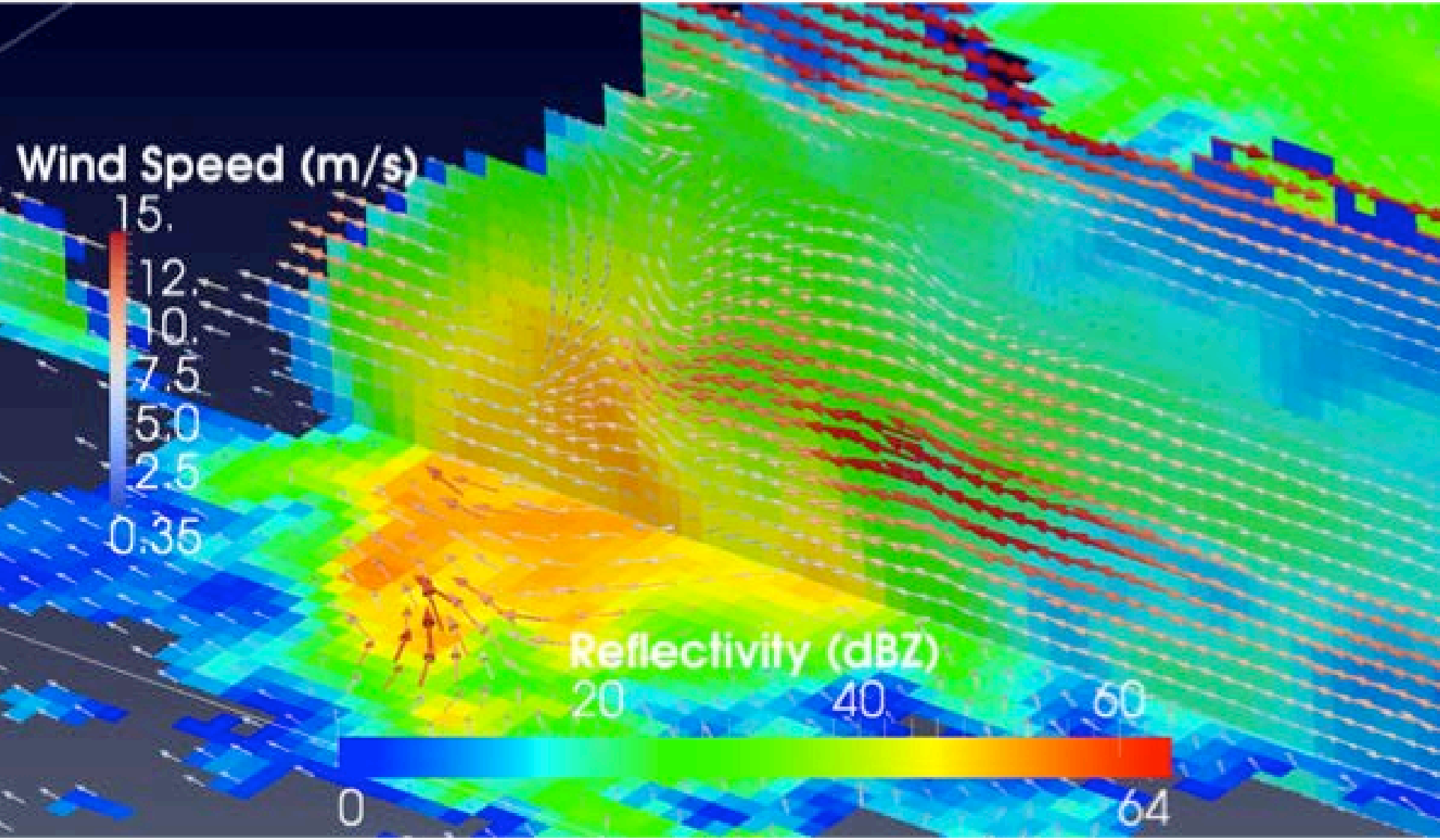
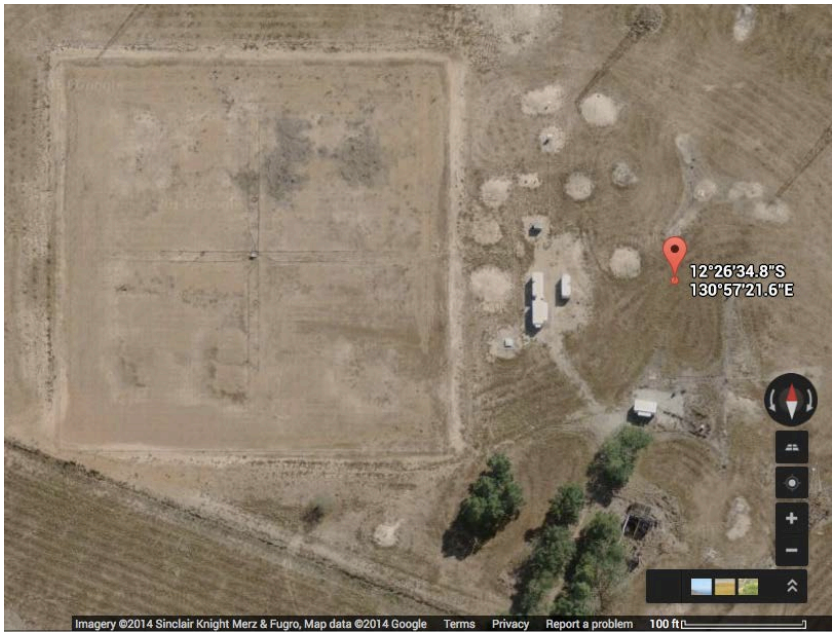

Wind Speed (m/s)
15.
12.5
10.
7.5
5.0
2.5
0.35
Reflectivity (dBZ)
20
40
60
0
64

Prove it!

- In this case our independent data source are profiling radars which more directly measure the vertical velocity.
- In Darwin this is a Dual Frequency (VHF/UHF, 915/50MHz) system. Non-ideal location.
- In the Southern Great Plains it is a network of UHF profiler systems ideally located at the multi-Doppler “sweet spots”
- Not a “direct measure” of vertical velocity by any means, but completely independent and more direct.



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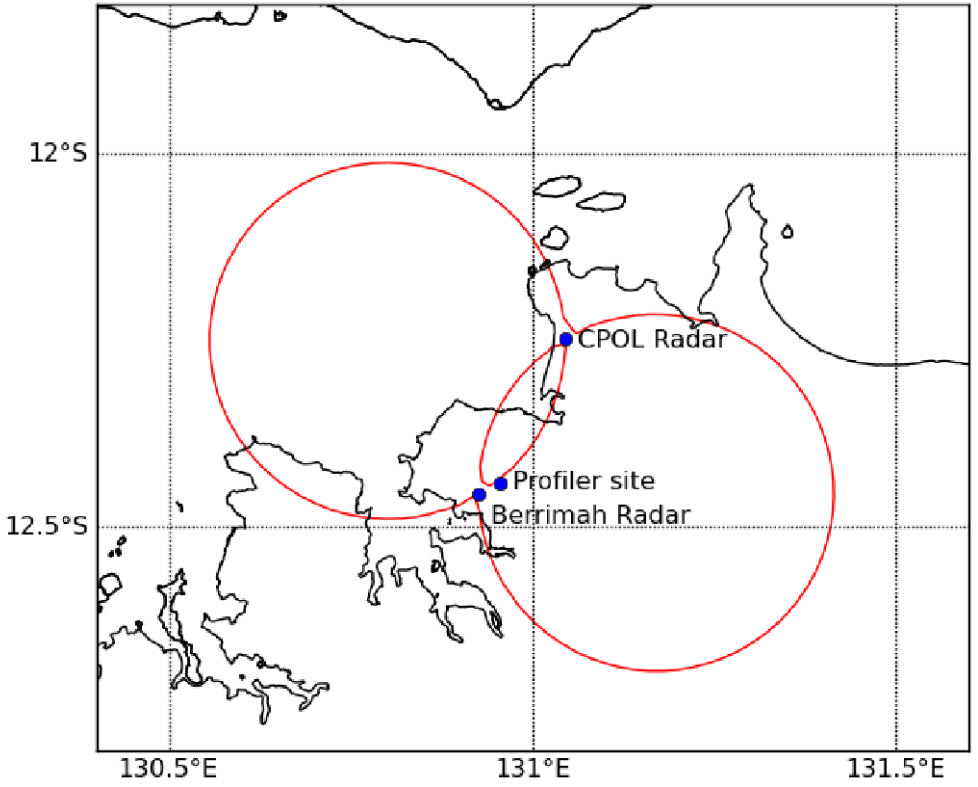

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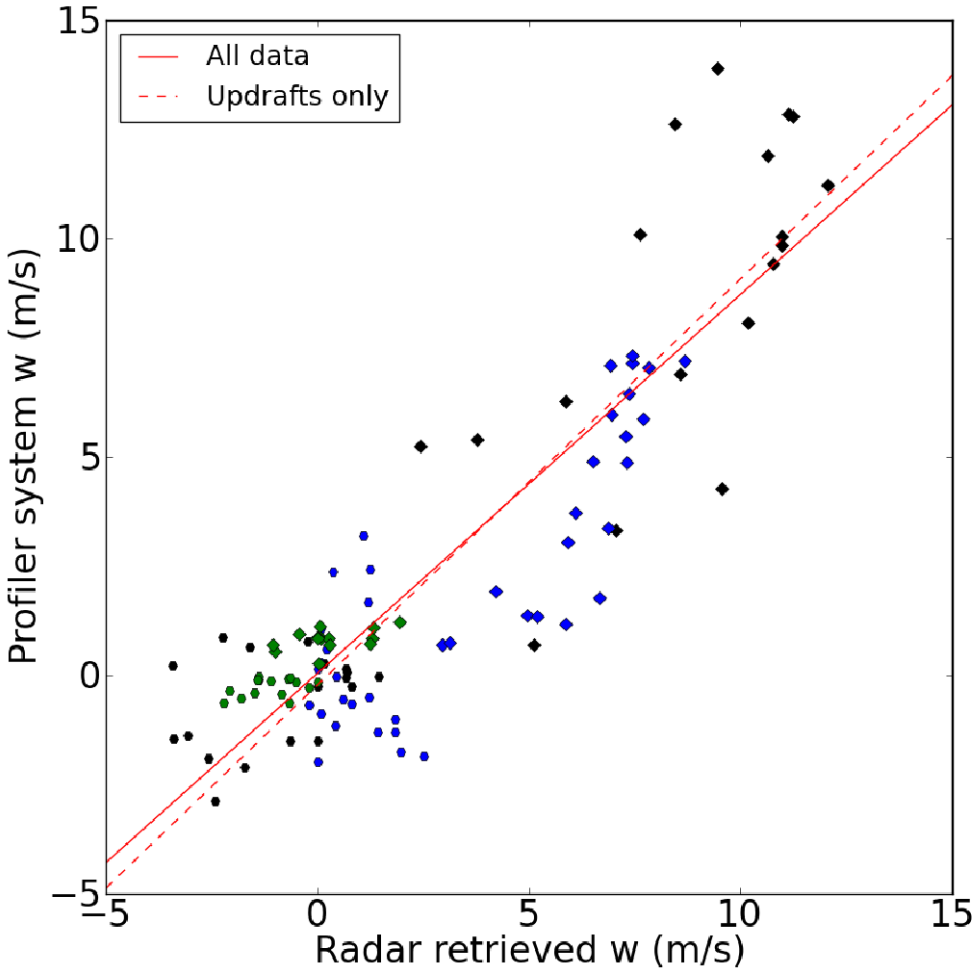

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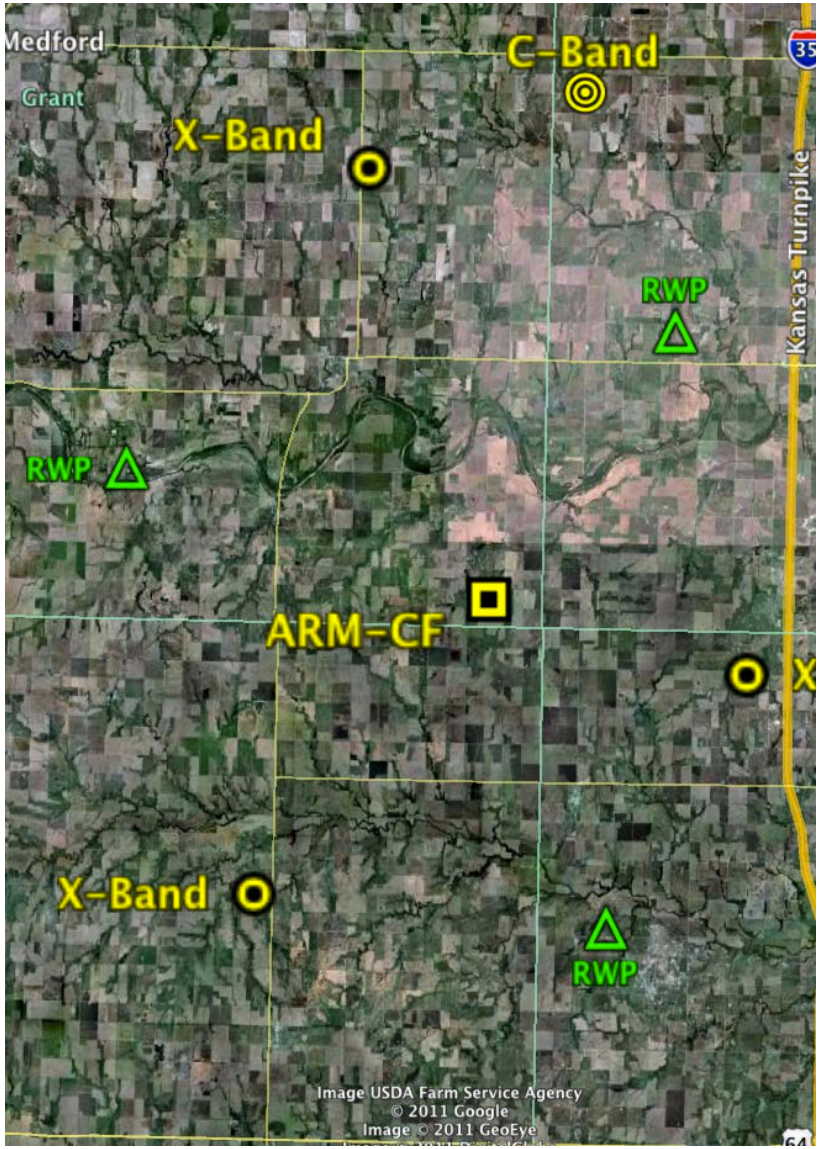

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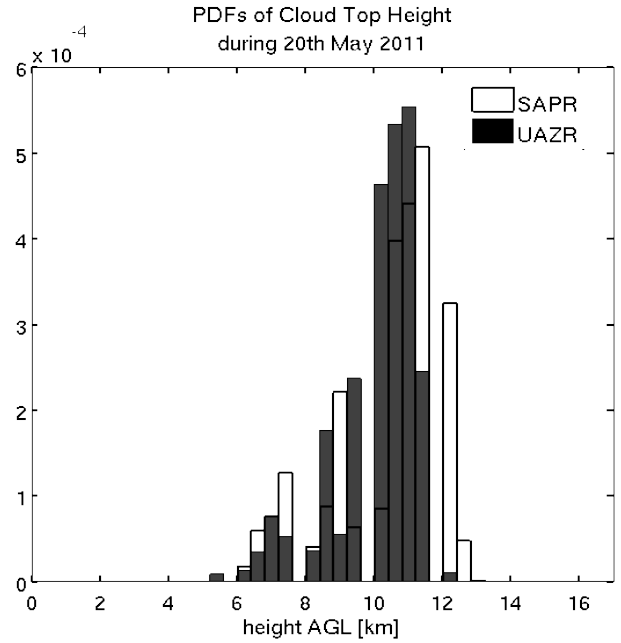
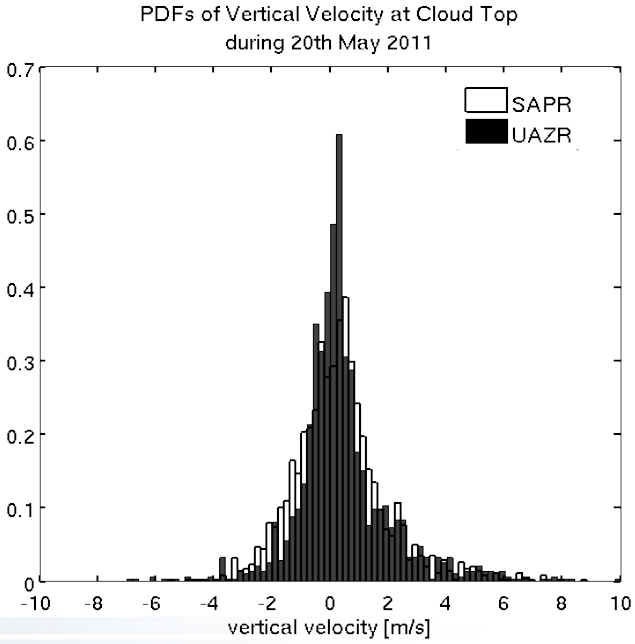


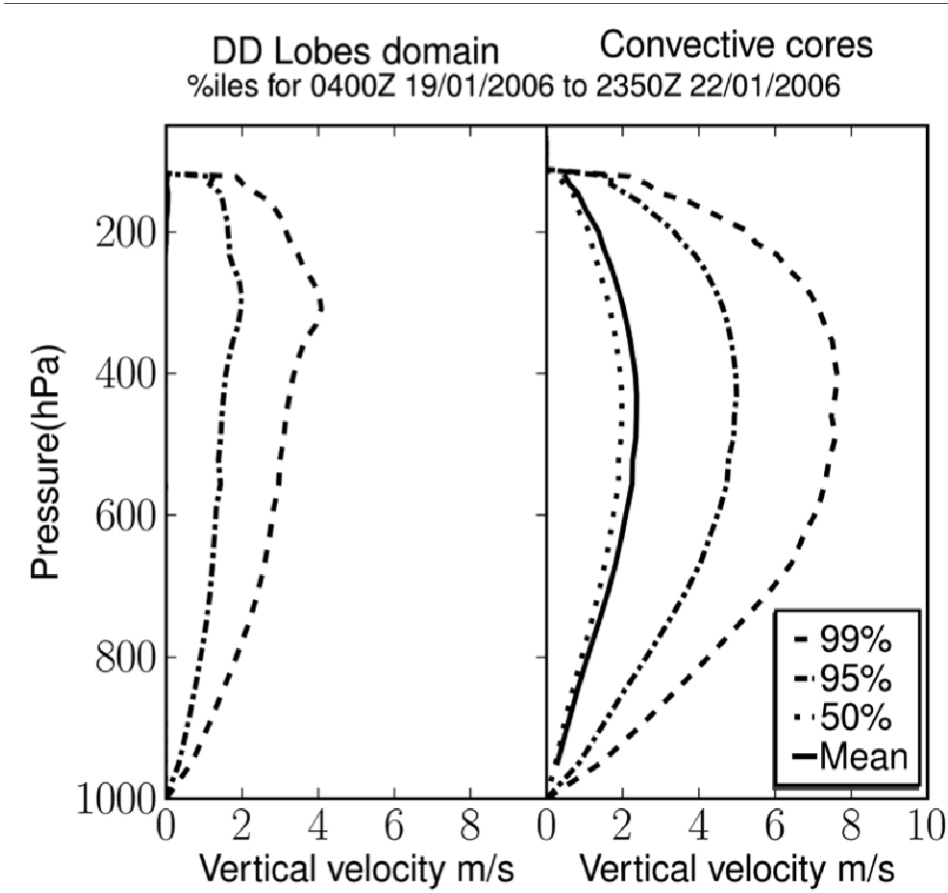


A taste of analysis

- For vertical velocities conditional sampling is **essential**.

Take home

- In our case we define deep convective cores to be 1m/s for at least 5km and contrast these DCCs to that reported in the literature from TWP-ICE using WRF.
- Yes.. You've heard this story before.. But we have finally actually published this!



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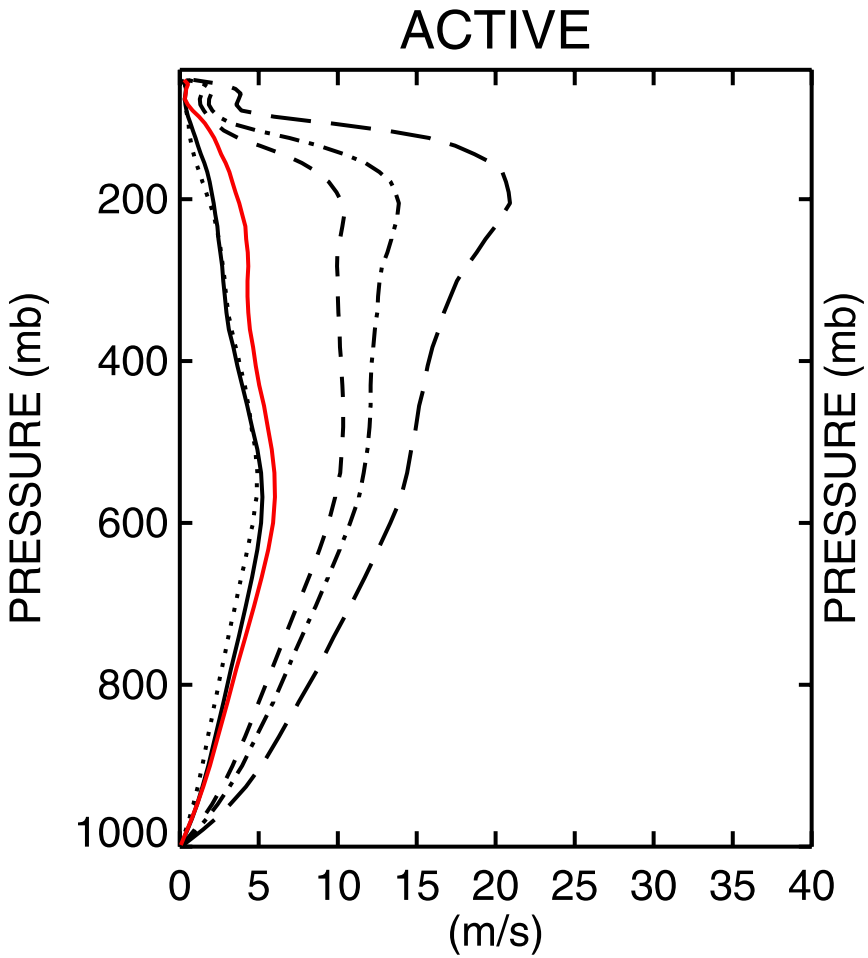

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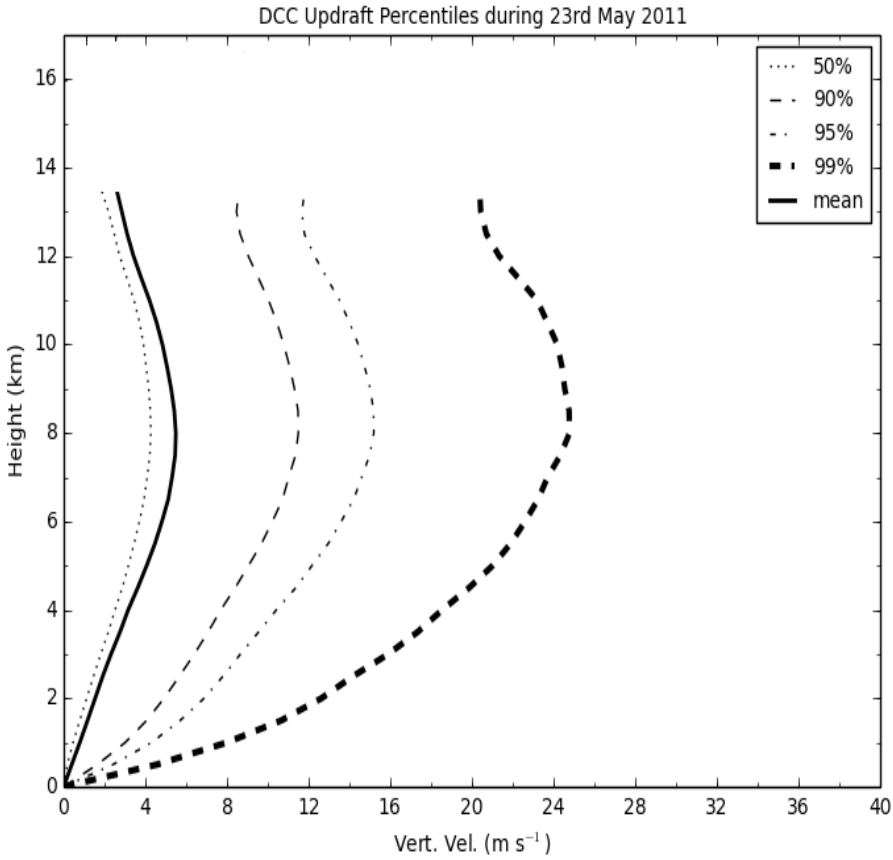
- Pleasingly the VERY strongly forced DCCs from a MC3E case are much stronger.



North, K., S. Collis, S. Giangrande, and P. Kollias, 2013: Vertical Velocity Retrievals in Convective Clouds using the ARM Heterogeneous Radar Network at SGP during MC3E Part I: Evaluation. **In preperation**.

Conclusions

- The key is microphysical and dynamical comparison across scales.
- Fine scale models are key, but these must be constrained using observations.
- Remote sensing retrievals provides a key tool to cross these scales but the techniques and assumptions in these retrievals must be vetted!

Products:

3D Vertical Velocity:	Profiles:	Rainfall:
SGP: Evaluation	SGP: Development	SGP: Evaluation
TWP: TB PI product	TWP: Development	TWP: Development
Scott Collis	Scott Giangrande	Scott Collis
Kirk North	Virendra Ghate	Scott Giangrande
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