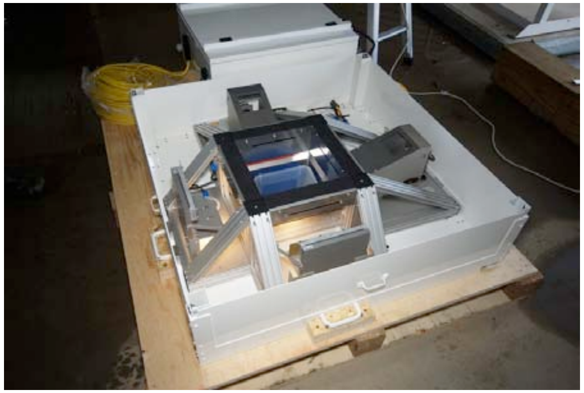
# Geophysical retrievals from scanning precipitation radar measurements

From “out of the box” data to fully fledged and verified VAPS

# Why are scanning radars a special challenge?




$N(D)$

$\mathbf{w_t}$

$$Z = \int N(D) D^6 dD$$

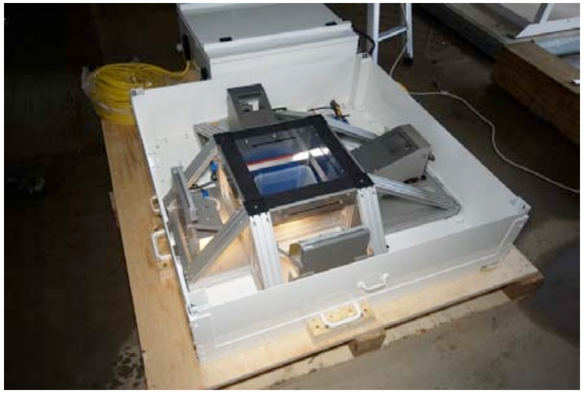
$$v_r = \overline{\mathbf{u}} \cdot i + \overline{\mathbf{v}} \cdot j + \overline{(\mathbf{w} - \mathbf{w_t})} \cdot k$$

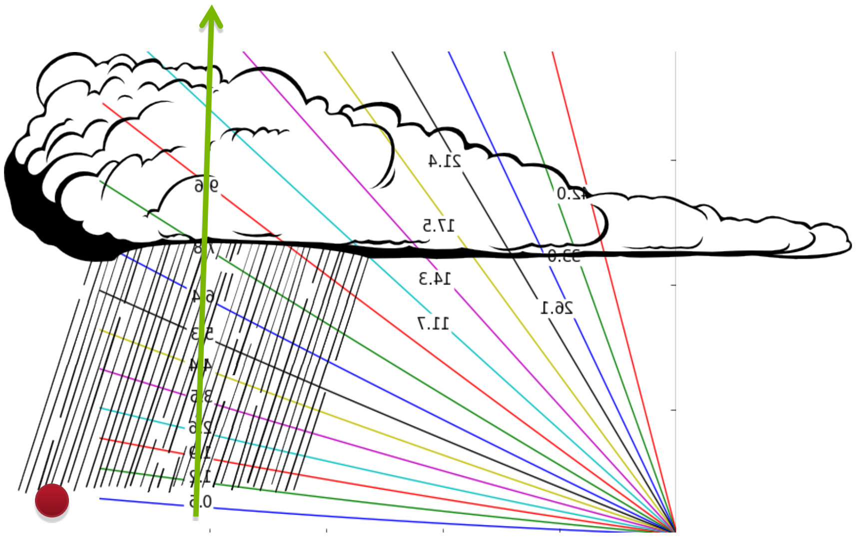
$$Z_{DR} = 10 \log\left(\frac{Z_H}{Z_V}\right)$$

+ ……

* Image courtesy Kevin Widener

# The remote sensing problem





* Image courtesy Kevin Widener

# What retrievals?

- New territory, unlike the cloud radars there exists no similar 2D product for the precipitation radars.
- Priority will be driven by demand from the working groups.
- Implementation will be two phase.
- Phase 1: Off the shelf or Vendor retrievals will be implemented to generate products for evaluation. The output of these will not have undergone rigorous testing nor will have a long climatology.
- Phase two: Implementation and verification of “Best Practice” algorithms. This process will by submission of PI algorithms, adaptation of algorithms existing in the literature or, in some cases, research into new retrieval techniques.

# Demand from the CAPI and CLC Working groups for evaluation (vendor) products

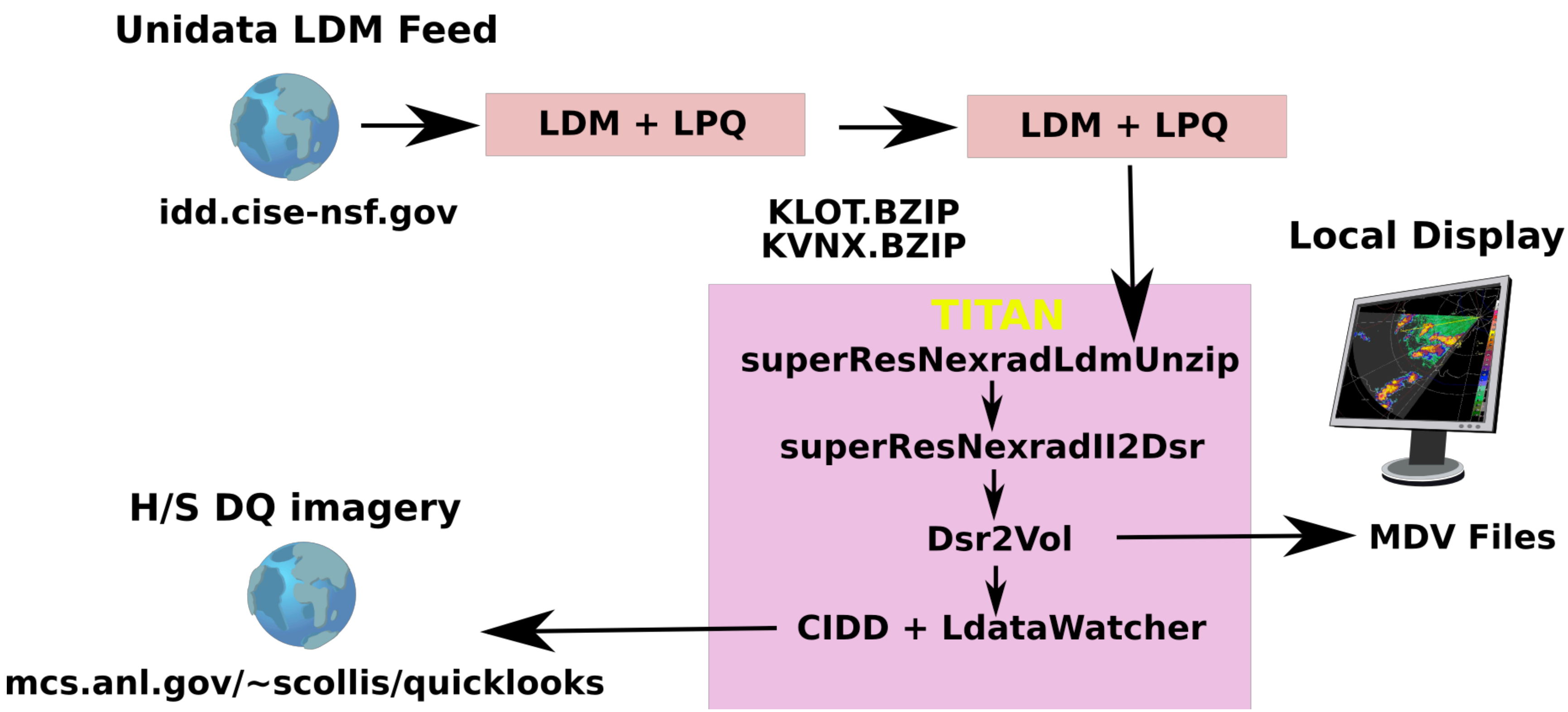
| Product | Dimensions | Priority | Difficulty | Notes |
|---|---|---|---|---|
| Moments from the lowest tilt | R,AZ | 1 | 1 | |
| Rainfall QPE | X,Y | 2 | 3 | |
| Constant height interpolation of Z,Vr | X,Y | 3 | 2 | |
| Convective stratiform mask | X,Y | 4 | 2 | 1 |
| Moments from RHIs over CF | R,ELE | 5 | 1 | |
| Echo tops | X,Y | 6 | 2 | 1 |
| Hydrometeor classification | R,AZ (or X,Y) | 7 | 2 | |
| Merged reflectivity | X,Y | 8 | 1 | |

1: May not be a vendor product

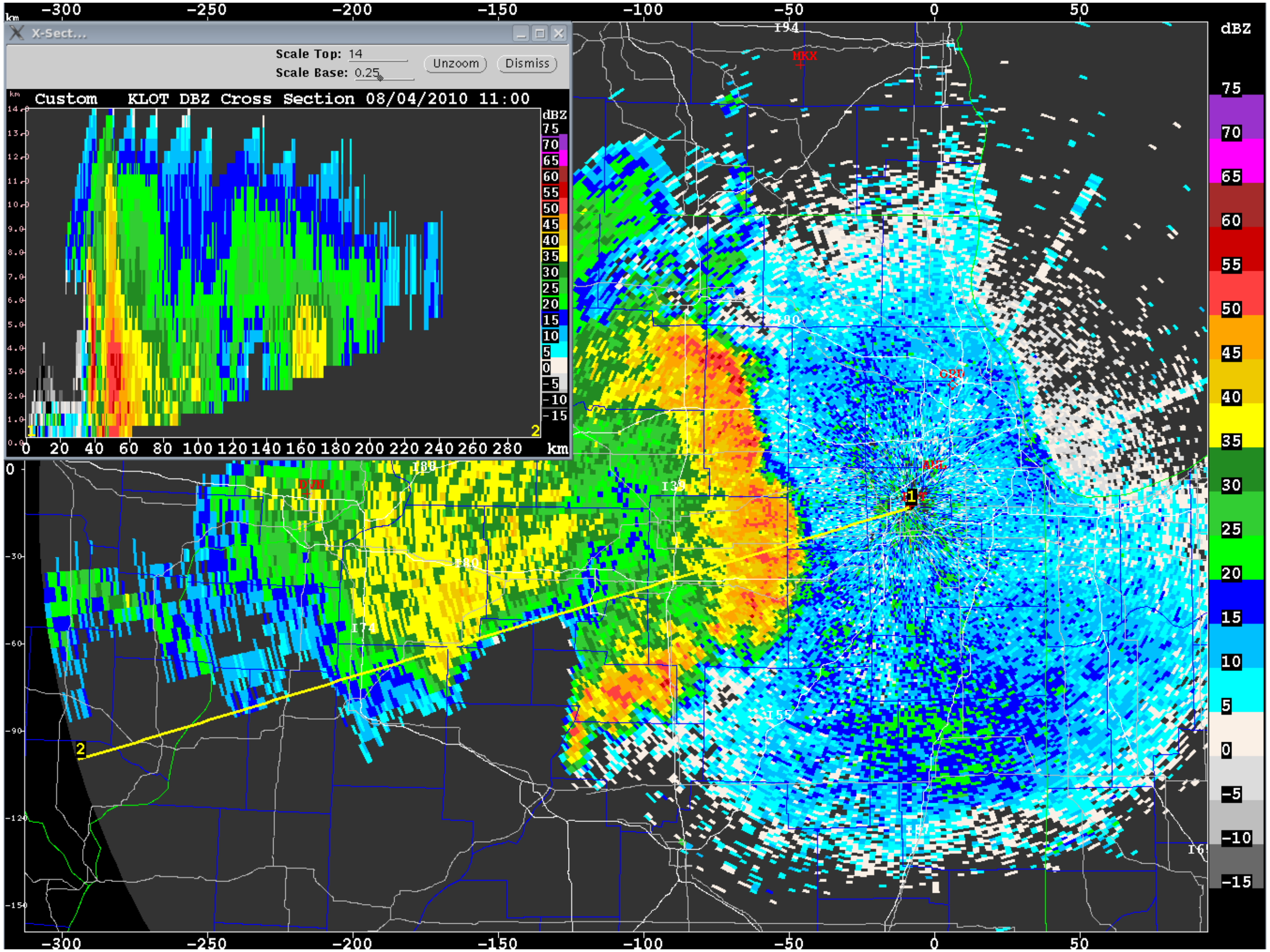
# Preparing for the deluge

- We have set up a test system at Argonne ingesting NWS radar data and observations.
- This system takes in the Chicago (KLOT, KILX) and Vance, OK (KVNX) radars and saves them in the same format as the C-SAPRs will be producing
- This allows some development of processing infrastructure and real time load testing before data from ACRF systems flow
- Uses the NCAR's TITAN and Unidata's LDM software, both open source.
- Also allows test data quality and health and status feeds to be explored as well as giving an insight into metadata handling issues.

# anl-titan.mcs.anl.gov

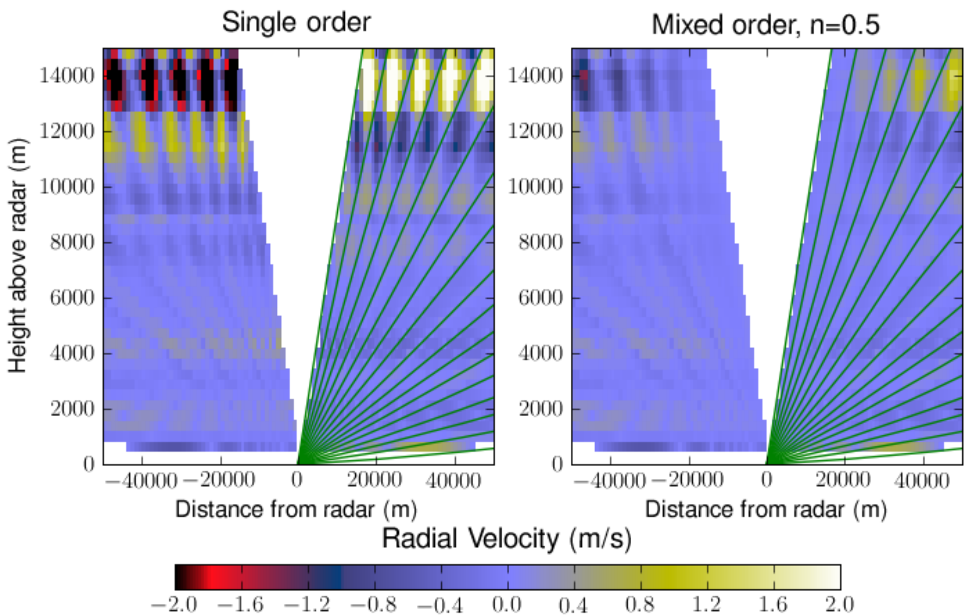


# Example display

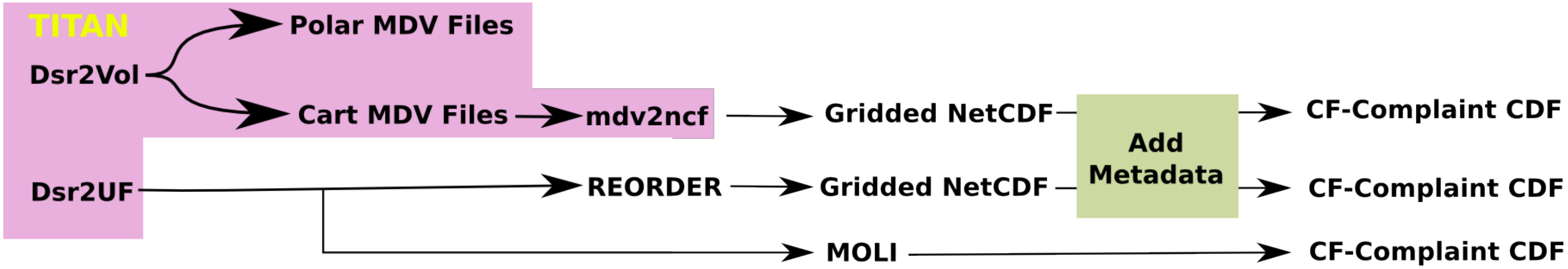


# Mapping to a Cartesian grid

- Many data products will require data mapped to a regularly spaced X,Y,Z grid. Models generally do not produce results in polar coordinates
- Artifacts can be generated depending on estimation technique, scanning strategy and vertical gradients of remotely sensed measurements.
- There is a need to evaluate techniques and off the shelf mapping packages for suitability.
- Also highlights the need for a scanning strategy appropriate for the expected vertical gradients in observables.



# Cartesian mapping testbed



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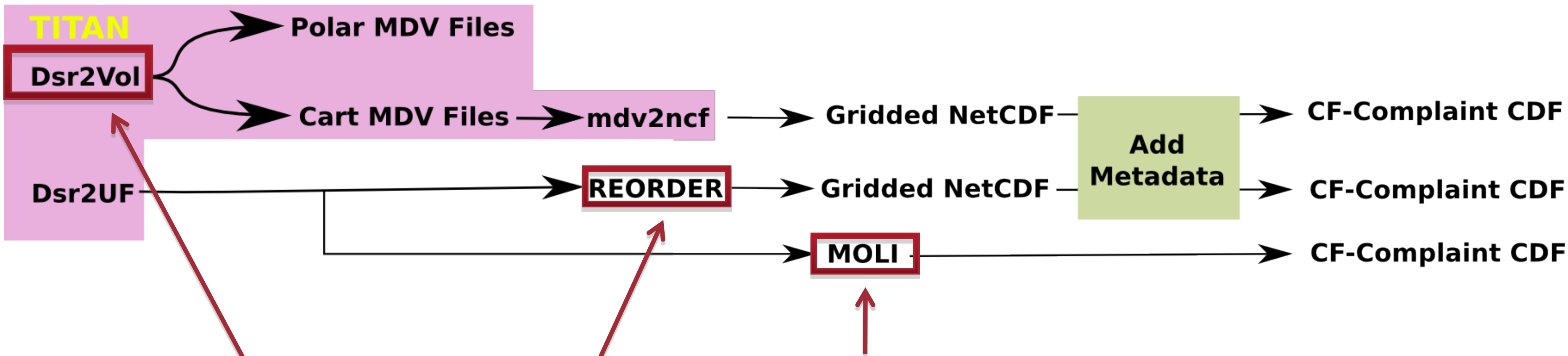
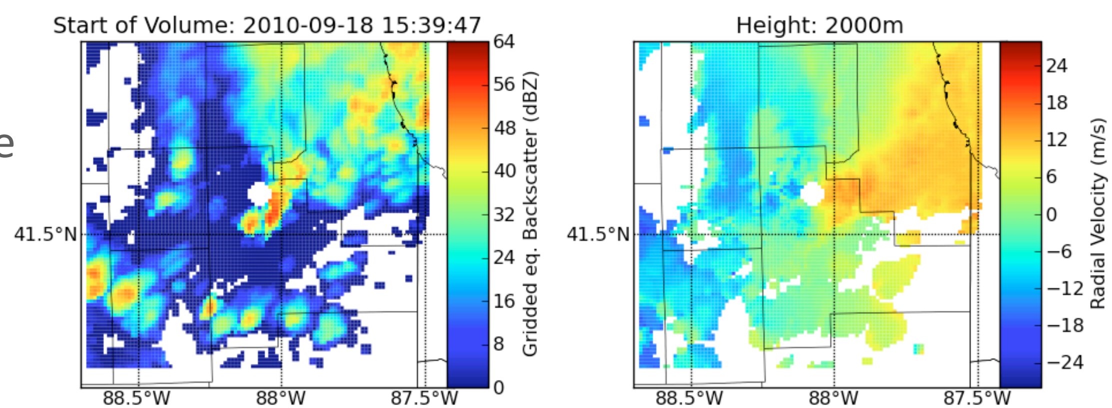



Tri-linear interpolation with blended orders for artifact suppression

Tri-linear ordered interpolation

- Tri-linear interpolation
- Constant radius of influence
- Distance weighted average (eg Cressman)
- Variable radius of influence
- Nearest neighbor




ARM CLIMATE RESEARCH FACILITY

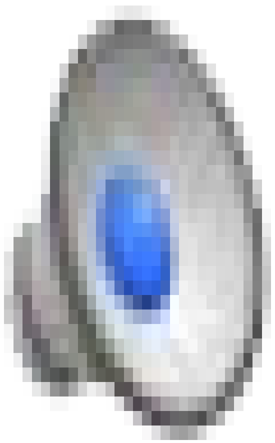
U.S. DEPARTMENT OF ENERGY

# Why CF Complaint??

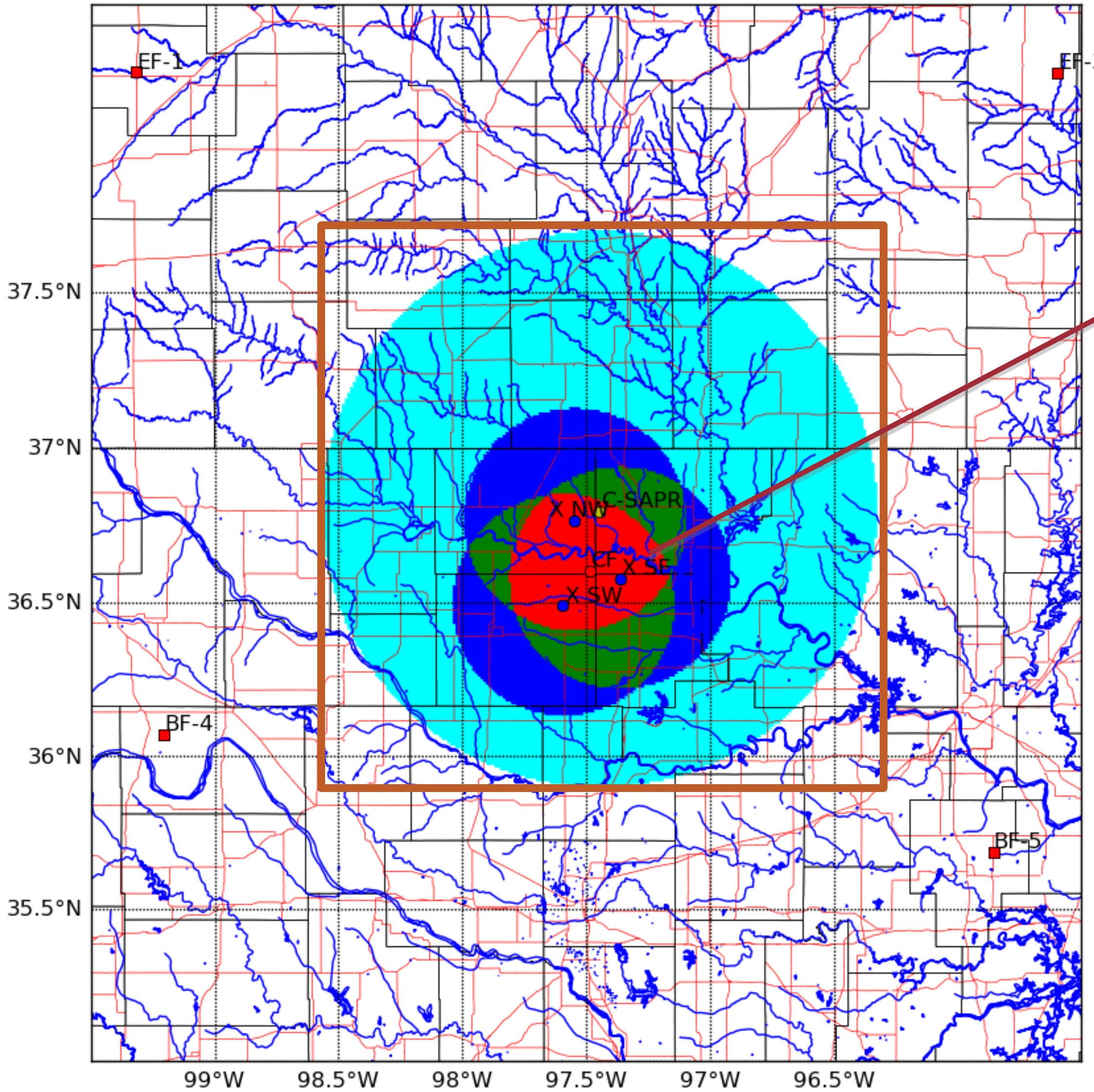
http://cf-pcmdi.llnl.gov/

http://www.unidata.ucar.edu/software/idv/

- The climate forecasting conventions mandate a minimal set of metadata and the use of a standard set of names for geophysical parameters
- Creates self describing data sets.
- Allows for interactive data discovery in “off the shelf” applications (eg Unidata’s IDV)



# "Model like" domains for co-mapping




CZ_X1
CZ_X2
CZ_X3
CZ_C
..
..
..

# Radar derivable geophysical parameters fall into three categories

1. Parameters where there exist many techniques for retrieval. In these cases the main task will be to contrast the techniques and implement “best practice”. QPE liquid phase is a good example.
2. Parameters where there is only one mature retrieval technique (or one mature technique with minor variations). In these cases the main task will be to implement and verify the performance of the algorithm using an independent data set. Not many parameters fall into this set.
3. Parameters where research is still required to design a dependable retrieval technique. In this case development needs to be carried out by PIs in tandem with the data lead. Most parameters dealing with ice phase processes fall into this category (QPE at Barrow!)

## Raw remotely Sensed

## Dynamics retrievals

## Echo/mask characterization

## Microphysical

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Radar coord. Moments (r,ϕ,θ)

Mapped (x,y,z) moments

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Storm top heights

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Quantitative Precipitation Estimates

Drop size distribution parameters

LWC/IWC

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Vertical velocities

Wind profiles (VAD)

Storm motions

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# Quantitative estimates of precipitation

- Many techniques and algorithms exist. There is already a product that exists at the SGP (Arkansas river basin product)
- Techniques will be contrasted, MC3E will provide some very good verifying data sets via the distrometer network
- In collaboration with Scott Giangrande and Peter May investigate seasonal effects in TWP
- In collaboration with anyone who offers look at relations between moments and ice shapes (2DVD) in NSA (hard!)

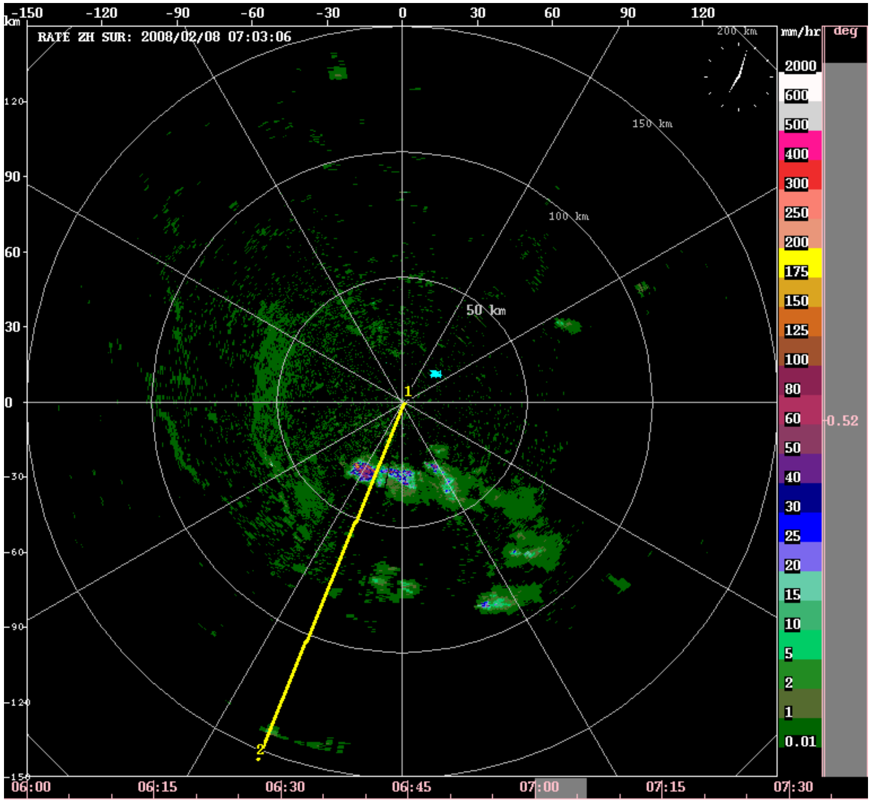
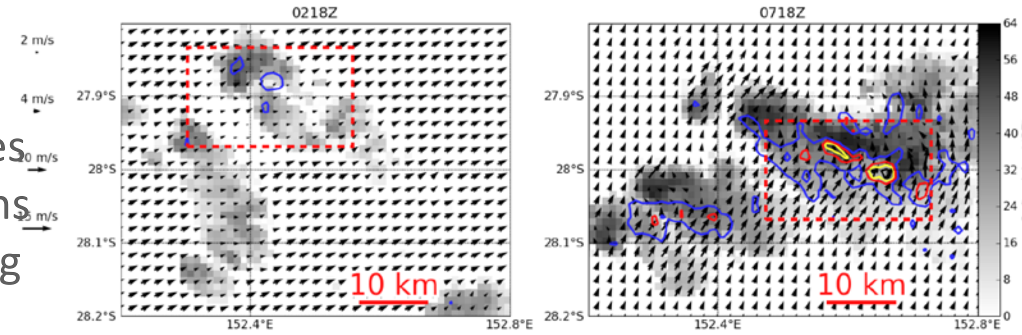
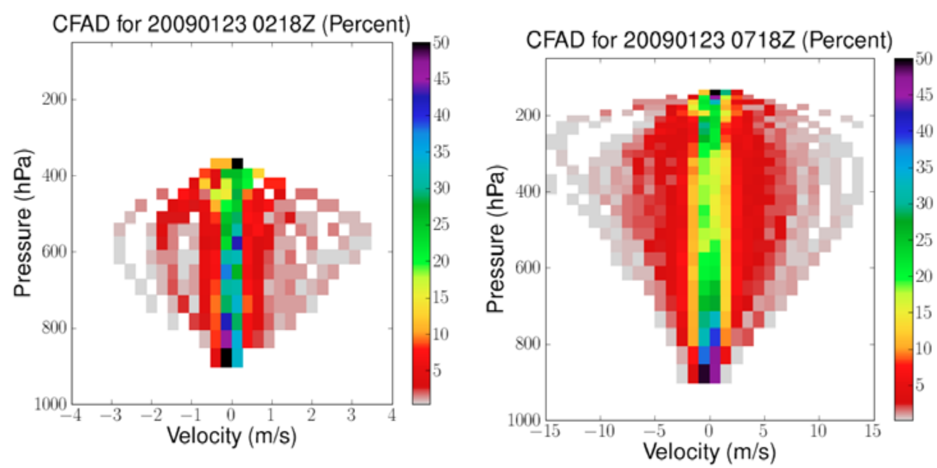



Image courtesy Frank Hage, ARC

# Gridded radar derived vertical velocities

- Uses radial velocity measured by several radars
- Variational analysis which minimizes disagreement between observations and constraining functions including anelastic mass continuity and smoothness
- Likely to implement the system used in Darwin but will use best practice
- SGP network is well set up for retrievals, other sites will need more constraints
- Verification essential, again MC3E provides an excellent source of co-located vertically profiling data



# Take home messages

- While radar savvy scientists can and will use raw moments retrieving geophysical parameters on a Cartesian grid will increase the impact of the precipitation radars on ASR science.
- Vendor products -> PI like products -> VAPS
- Moments and precipitation the first vendor products
- Long term development will focus on vertical velocity and QPE
- Best practice retrievals. If a better algorithm exists we will verify it and implement it!

# Thank you

# Any questions?

Data feed supplied courtesy of Unidata

Special thanks to Eric Nelson and Mike Dixon (NCAR) for all their TITAN help!