Moments to Models: Analyzing the data from the ARM Precipitation sensitive radars.

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This time last year...
What are we seeing from the radars?

- Good high resolution data.
- Good vertical coverage from the agile X-SAPR systems.
- Working at high frequencies has meant nice KDP but issues with attenuation and differential attenuation.
- I have concerns using ZDR in OK, less in the tropics.
Corrections in antenna co-ordinates

- The university of Washington 4DD code has been adapted to work in a Python environment.
- ARM soundings used to generate a first guess. Dealiasing works well most of the times. Issues with clutter.
- Using a Z-PHI like method to correct for attenuation at C-Band. This is very sensitive and we need to improve processing.
- Work by Brenda and Angela from CSU on X-Band attenuation correction.
A VAP for radar folk

- Corrected Moments in Antenna Coordinates (CMAC) will be providing moment data in radial co-ordinates including any processing which has been done.
- The data format will be NetCDF adhering to the CF-Radial convections.
- This allows for very easy manipulation and plotting and ensured compatibility with a wide range of platforms.
- Will look very similar to ingested SACR data.

From the format document by Dixon et al.
Objective analysis, to reinvent the wheel?

- To increase the impact of the data we need it mapped to a model like grid.
- We tried to work with NCAR’s Reorder as it is fast. We ran into issues with the inflexibility of the radius of influence.
- Need to have a formulation for ROI(r) that preserves low elevation detail and suppresses high elevation artifacts.
- We ended up writing our own code in a mix of C and Python. It is not as fast (we are optimizing!) but has a fully flexible formulation for ROI.
Mapped Moments to a Cartesian Grid (MMCG)

- First VAP from the ARM radars.
- CSAPR data from MC3E is in the development section (V0.1E) of the Archive AMIE Manus data soon to follow as well as X-SAPR data.

<table>
<thead>
<tr>
<th>Site</th>
<th>Radar</th>
<th>Domain, resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>SGP</td>
<td>CSAPR</td>
<td>240x240x17km, 1x1x0.5km</td>
</tr>
<tr>
<td></td>
<td>CSAPR</td>
<td>100x100x17km, 0.5x0.5x0.5km</td>
</tr>
<tr>
<td></td>
<td>XSAPR (x3)</td>
<td>100x100x17km, 0.5x0.5x0.5km</td>
</tr>
<tr>
<td>TWP Manus</td>
<td>CSAPR</td>
<td>240x240x18km, 1x1x0.5km</td>
</tr>
<tr>
<td>NSA Barrow</td>
<td></td>
<td>120x120x10km, 0.5x0.5x0.5km</td>
</tr>
</tbody>
</table>
Three dimension storm structure
Retrievals

- Much of the work to date has been on QC and objective analysis.
- Much of the work on retrievals has been led by collaborators.
- Highlights include successful QPE retrievals for Oklahoma, first tri-doppler retrievals, great work by the CSU crew on X-Band particle ID.
Python-ARM Radar Toolkit

What is Py-ART

- Code used to produce VAPs from the precipitation radars released as an open source toolkit.
- Freely available and suited to working with the formats that ARM radars produce.
- Released under nonrestrictive licenses

We not only provide data streams and VAPS but the tools to work with the data.

Why Python?

- Easy to prototype (easier to debug!).
- Open source by nature.
- Extensible, good success wrapping in existing radar codes into Python using Ctypes, Cython, SWIG et al.
- Great set of existing libraries.

Most importantly: A vibrant and engaged community!
Operational modes of the radars conducive to retrievals.

- Initial work with the radars has helped shown how the facilities can be run to make our job “easier”.
- Timing: Having the radars synchronized greatly helps in multi-Doppler and multi-frequency retrievals.
- Timing: Having the radars start at predictable times (ie so you always get a scan that starts on the hour) helps with precipitation accumulations.
- Predictable mode changes.
- Also: The NW X-Band sees essentially the same as the CSAPR... Should we keep this is HSRHI mode?
HSRHIs?

- Amazing detail.
- X-Band sensitivity shows how we may use these instruments to “bridge the gap”.
- Over the top scans give a great recording of tops.

**Question is:** What to do with them?