# Dual-polarization phase shift processing with the Python ARM Radar Toolkit

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ARM C-Band


ARM 2D Disdrometer


ARM SGP/MC3E

## The Python ARM Radar Toolkit

github.com/ARM-DOE/pyart

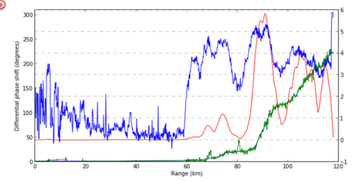
- Py-ART (Helmus and Collis 2016) uses a moderately complex data model which closely mirrors the CF-Radial community file format.
- It makes heavy use of Python dictionaries to form a self –describing radar object.
- Community codebase on GitHub, main fork is DoE maintained and moderated.

## Specific Differential Phase, Why So Special?

- **From a measurement perspective** Specific differential phase ($K_{DP}$) is the rate of change of phase lag between the horizontal and vertical polarized pulses.
- **From a microphysical perspective** it is the phase lag between the propagating waves due to the anisotropy of the refractive index of the medium.
- It is a measure of RWC that is robust to calibration and liquid path attenuation.
- However, careful processing is required as $K_{DP}$ is not measured, rather its integral, $\Psi_{DP}$ which includes artifacts.

$$\Psi_{DP} = \Phi_{DP} + \delta + NBF$$

Notebooks And more




The Py-ART ecosystem has three Open Source $K_{DP}$ retrieval techniques
One site for disdrometric measurements is never enough
Tests which were performed with "out of the box" configuration and result are initial.
The FIR Bringi technique is the quickest and easiest. Performs well at $K_{DP} > 0.5$.
The fully variational Maesaka technique works well but shows some stability issues.
The LP method is computationally costly and is difficult to install but shows great promise at low $K_{DP}$

## CSU/Bringi:

- Lang et al 2007. Based on a finite impulse response filter. applied to dif. phase. in a moving adjustable-length window.
- $K_{DP}$ calculated using moving linear fit. Length based on $Z_e$
- Part of the CSU_RadarTools package.
- Big thanks to Brenda Dolan, Paul Hein and Brody Fuchs!

## Maesaka:

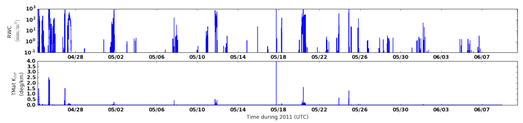
- Variational technique based on Maesaka (2012) which uses a cost function involving the square of the $K_{DP}$ thus ensuring monotonicity.
- Cost function is minimized using a nonlinear conjugate gradient algorithm.
- Many options, comes default in Py-ART, easy to use.

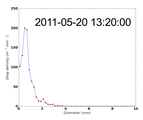
## Giangrande LP:

- Uses Linear Programming to ensure monotonicity over a range of gates via a upwards bound, Giangrande et al (2013). Thanks to Scott for all his help!
- Uses reflectivity to force increase gradient.
- Originally used PyGLPK, now CyLP (20x improvement in speed). Involves poorly supported 3rd party dependencies.
- $K_{DP}$ calculated from processed phase using a constant length sobel filter.

## T-Matrix

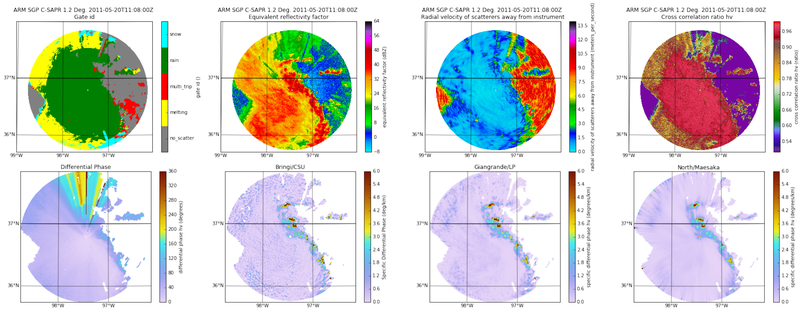
- $Z_e$ $K_{DP}$ A and $Z_{DR}$ were calculated using PyTMatrix from 2DVD data collected during MC3E. Leinonen 2014.
- 72,000 DSDs used AR(D) from Thurai et al 2007




## Processing

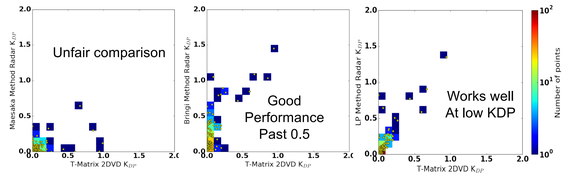
4218 volumes.. Only 221 matches

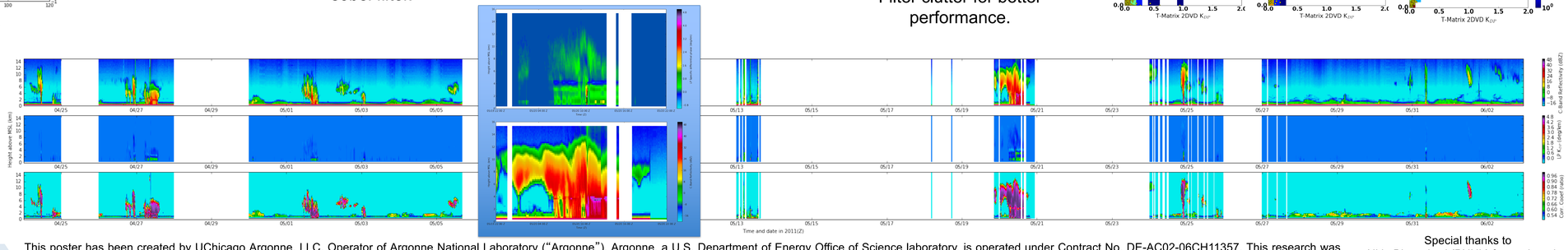



## Future Work

Use 2DVD AR(D)
MORE Disdrometers! Use NASA P2s.
Better configuration for Maesaka.
Filter clutter for better performance.

## Very Initial Results

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