An Application of Linear Programming Techniques to ARM Polarimetric Radar Processing

Research Highlight

Detailed microphysical insights from weather radar systems are in demand within weather and climate agencies for the evaluation of numerical weather and climate prediction models. In particular, polarimetric radar systems allow for more robust precipitation products over conventional weather radar systems since including polarimetry promises improved data quality and reduced uncertainty for applications including hydrometeor classification, rainfall estimation, and drop-size distribution retrievals. The Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) Climate Research Facility recently installed several polarimetric weather radar platforms operating at C-band (5-cm wavelength) and X-band (3-cm wavelength) to bolster cloud and precipitation life cycle monitoring capabilities and further support studies into cloud-aerosol-precipitation interactions.

Despite the attractive qualities of these polarimetric radar measurements, the usefulness of these measurements in precipitation is potentially undermined as a consequence of measurement fluctuations as well as physical process noises, attenuation in rain, and beam geometry artifacts. The challenge for eventual ARM radar data interpretation and usefulness in product development is exacerbated for the shorter radar wavelengths that include these newer ARM C-band and X-band weather radar systems. These wavelengths in particular are susceptible to significant attenuation in rain, especially for deep convective environments typical for the warm season over the ARM Southern Great Plains (SGP) Oklahoma facility. The particular demand to provide useful radar observations in the presence of partial attenuation in rain highlights the need to exploit polarimetric differential phase measurements that offer significant insights into precipitation microphysics and are the only quantitative radar measurements immune to partial beam blockages and attenuation in rain. However, unlike conventional radar fields such as the radar reflectivity factor Z, differential phase measurements are considerably noisy and demanding data fields that hinder simple ability to extract usable precipitation information through many critical deep convective storm conditions.

Here, we sought to assist Atmospheric System Research (ASR) scientists and others overcome many challenges associated with differential phase measurements through an application of linear programming. This retrieval was designed to improve estimates from these radar differential phase fields by allowing realistic physical constraints of monotonicity and polarimetric radar measurement self-consistency ideas popular in the radar community. By improving the reliability of these radar differential phase measurements, there is an immediate and cascading benefit towards improved estimates of rainfall accumulation as well as critical improvements to data quality of convectional radar fields including reflectivity factor Z.

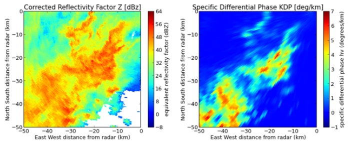
For the ARM systems, there was an additional demand for open and free source radar processing codes and community data formats that further encourage use and visualization of DOE ARM radar data sets within ASR and other communities. Therefore, development activities were simultaneously conscious of supporting ARM radar infrastructure efforts, allowing quick integration of these new processing methods into the open-source Python-ARM Radar Toolkit (PyART) as one standard radar phase-processing module option for future ARM product development.

Reference(s)

Giangrande SE, R McGraw, and L Lei. 2013. "An application of linear programming to polarimetric radar differential phase processing." Journal of Atmospheric and Oceanic Technology, , . ACCEPTED.

Contributors

Scott Giangrande, *Brookhaven National Laboratory*



C-band scanning ARM precipitation radar fields of radar reflectivity factor Z and processed specific differential phase KDP for a section of a Midlatitude Continental Convective Clouds Experiment (MC3E) convective event as output from LP methods implemented for the ARM PyART processing suite.

Working Group(s)
Cloud Life Cycle