An Update from the ARM Cloud and Precipitation Measurements and Science Group

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- convened in February 2019
- presented preliminary findings to PI Meeting in June 2019 (‘listening tour’)
- drafted six general recommendations
- virtual workshop to review and flesh out in March 2020 (thanks to attendees!)
- report due circa October 2020

What is the CPMSG?

- ARM Cloud and Precipitation Measurements and Science Group
  - The CPMSG … is charged with working together to provide constructive recommendations regarding the operation, characterization, and development of instruments providing cloud and precipitation measurements along with the development of data products derived from these instruments and the identification of measurement gaps
  - A driving consideration for the group should be how resources can best be applied to measurements of cloud and precipitation properties and the development of associated data products to increase the scientific impact of these measurements
- Starting point
  - Given scientific focus areas that are important to DOE objectives and relevant to ARM measurements, are there subtopics where ARM has strong potential to contribute but is not reaching that potential for various possible reasons?

Enabling Program Capacity, Existing Data Usage

- Create a “short-term measurement” designation and strategy for instrument and data product streams that are too resource-intensive to bring into ARM’s legacy, long-term measurement paradigm with sufficient consistency
- Develop and maintain a public list of measurements or value-added products (VAPs) that are getting insufficient use to warrant further investment
- Develop and implement a plan to reduce particularly high-volume data streams while maintaining scientific value
- Develop and support an open source and community code paradigm for existing and future data products and tools
- Develop and maintain a system of regime classification for long-term data sets and deployments of ARM mobile facilities
- Seek and support frameworks that bring individuals and groups together for limited joint exercises
- Develop and maintain a public list of measurement or analysis gaps that require either specific additional investments or integration of PI or external data sets or codes, as well as a method for gauging community support

Science Question	Problems & Roadblocks	Impact	Research Elements	Maturity/ Confidence	Solution/ Recommendation
How do ice microphysical processes and their interactions with radiation and dynamics determine the structure, evolution, lifecycle, and precipitation of cold clouds?	There is a significant challenge in robustly quantifying the complexities of ice particle physical properties with existing instrumentation --- Key instrumentation or observations for optimal/robust analyses has not been collocated ---	Most models and forward operators are plagued by dramatic oversimplifications of particle properties, which are known to substantially affect cloud macrophysical properties. This is a significant shortcoming for interpreting both observations and model simulations. _____ Incomplete datasets produce large uncertainties in quantitative analyses. Combined datasets will pin down uncertainties and lead to improved understanding	Multi-wavelength radar observations (VPT, scanning, polarimetric, spectral); profiling instruments (radiometer/ceilometer/lidar)	Research platforms are mature, but continuous operation remains a challenge.	Maintain radar data streams; perhaps dedicated IOPs? Co-locate instrumentation for comprehensive datasets Determine the minimum level of complexity needed in retrievals/models to accurately characterize clouds and feedbacks.
			Surface instrumentation for characterization of snow/ice properties	MASC has been available, but often not collocated with other instruments. Concerns over MASC retrieval accuracy/uncertainty. Challenges in quantifying ice particle morphology and properties. Validation difficult.	Additional ground instrumentation for redundant measurements to reduce uncertainties (e.g., NASA PIPs, additional snow cameras, gauges; manual observations during IOPs); improved MASC design like CSU's multiple extra cameras Co-locate instrumentation for comprehensive datasets
			Retrievals of cloud and precipitation microphysics	Historical methods (e.g., HID) are "mature" but have uncertainties that are too large for target process studies. Evolving polarimetric, multifrequency, and spectral radar techniques are promising but need more validation, which is difficult.	Surface and in-situ validation for dedicated periods; confidence flag would be valuable for ice cloud retrievals; discouragement of "re-inventing" the wheel on older techniques that are not useful for advancing science

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How do ice microphysical processes and their interactions with radiation and dynamics determine the structure, evolution, lifecycle, and precipitation of cold clouds? (2)	Comparison of aircraft/in situ data with remote sensing and surface observations is challenging to do robustly (most 2D imaging from aircraft insufficient for characterizing shapes/mass accurately)	In situ measurements are critical for improving remote retrievals and validating model simulations. Improving such comparisons will make substantial reductions to uncertainties.	Aircraft or other in situ measurements.	Few options for aircraft sampling of cold clouds in Arctic; tethersonde measurements in development?	Pursue targeted aircraft campaigns, explore tethersondes or UAV/cheaper approaches to in situ microphysics characterization.
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