Breakout Session Report
ARM/ASR User and PI Meeting
March 16-20, 2015

Session Title: Precipitation Measurements for ARM
Session Date: Thursday, March 19, 2015
Session Time: 10:30 a.m.–12:30 p.m.
Summary Authors: Scott Collis, Mary-Jane Bartholomew, Jessica Cherry, Christopher Williams, and Scott Giangrande

Description

Aim: To solicit discussion and recommendations on an "All of the above" precipitation measurement strategy for warm climate and cold climate precipitation.

ARM is reorganizing around two mega sites in Oklahoma (SGP) and Alaska (NSA), as well as continued operation of three mobile facilities and a new deployment in the Azores (ENA). An important measurement across all sites is the quantity and characterization (e.g., drop size distributions, type) of precipitation. The activity scales from point precipitation measurements to areal-averaged domain (GCM) means available from remote sensing platforms.

This session will provide two specific use cases from within the science community (warm and cold climates) and "straw man" sensor packages to solicit discussion for improved point sensor configurations in support of ARM stakeholder science and precipitation (rate) retrievals from remote sensing data.

Agenda:

10:30 Intro (Collis)
10:35 User needs of data from precipitation sensors in warm climates (Giangrande)
10:50 Strawman configuration of sensor suite for SGP precipitation (Bartholomew)
11:00 Discussion (all)
11:30 User needs of data from precipitation sensors in cold climates (Williams)
11:45 Strawman configuration of a sensor suite for NSA precipitation (Cherry)
11:55 Discussion (all)
12:25 Summary and Finish

Warm Climates Precipitation

Scott Giangrande presented a science needs viewpoint of warm climate precipitation. He highlighted the multi-year analysis carried out using distrometer data from Darwin, long term wind profiler data sets (using the 915 MHz systems as UHF profiling radars), he mentioned the importance of PI submitted products and that ARM needs to be committed to long term data Quality Control (including radar calibration). Scott also highlighted several other remote sensing techniques for precipitation insights including using W band spectra and merging KAZR data with scans from centimeter wavelength radars. Scott also presented a slide that specifically spelled out a few user needs including: Working systems with more eyes on the data to diagnose when systems go awry, calibration (Scott is leading a whitepaper effort for the calibration of the radars) and the need for basic level processing including the calculation of radar moments from collected DSDs.

Mary-Jane Bartholomew, the mentor for ARMs DSD measurement systems, gave a presentation outlining infrastructure's plans for meeting user needs. She outlined the spectrum of instruments ARM currently

uses and showed a study by Adam Theisen that examined the rainfall intensity dependent performance of each instrument. Mary-Jane then proceeded to outline proposed changes site by site. Taken directly from her slides:

SGP Central Facility

- Pluvio weighing bucket replacing Belfort unit
- Serial Optical Rain Gauge replacing analog ORG
- 2DVD + one additional 2DVD
- Two Parsivel2s
- MET – tipping bucket, PWD

SGP at the 4 radar wind profiler sites

- Tipping bucket
- Two Parsivel2s
- Mini-MET system (temperature, pressure and winds)

Eastern North Atlantic

- Pluvio weighing bucket replacing Belfort
- Parsivel2
- 2DVD
- PWD
- MET - Serial Optical Rain Gauge
- AOSMET Vaisala impact gauge
- MWR3C Vaisala impact gauge

AMF1

- RAIN tipping bucket
- MET serial optical rain gauge
- Parsivel2 + one additional Parsivel2
- PWD
- AOSMET Vaisala impact rain gauge
- MWR3C Vaisala impact rain gauge

AMF2

- Pluvio weighing bucket replacing Belfort unit

- 2DVD
- 2 Parsivel2s
- PWD
- MET serial optical rain gauge
- AOSMET Vaisala impact rain gauge

Mary-Jane concluded by proposing a VAP effort to merge datastreams from precipitation systems.

Warm Climates Precipitation Discussion

Discussion began with attendees giving strong support to Mary-Jane's proposal of a precipitation VAP. There was a strong desire from the modelling community for calculated radar moments to be included as well as an eventual "Best datastream" product that followed on from Adam's work and made clear to the user which precipitation rate (from which instrument) is the best to use. There was a caution however that to automate such a VAP would take some effort.

We then proceeded to go through each site and the instruments to solicit feedback. One clear recommendation stood out: A single rain gauge was of questionable use. Only when two or more are combined can we get a measure on data quality. Issues were discussed about how these would be sited within a shield.

The need for supporting instrumentation for the deployable CSAPR2 was raised. It was recommended that the CSAPR2 should have at least one system similar to what will be deployed at the RWP sites. We were cautioned, however, that deploying these remote from the site could cause logistical issues.

The need for a 2DVD at ENA was raised and if the unit would be more useful being assigned to CSAPR2. It will be very important to investigate methods, including using aircraft probes, tethered balloons, to measure drizzle at ENA to underpin remote sensing retrievals.

Recommendations

1. The group considered the proposed DROPS VAP to be of great importance and should be a priority for development. It could be developed in stages with the merged datastream plus calculated radar measurements first followed by work on a best estimate datastream.
2. All rain gauges should come in co-located pairs.
3. The CSAPR2 should be deployed with at least one instrument package, perhaps with two Parsivels and/or two tipping bucket rain gauges.
4. Relocate ENA or 2nd SGP 2DVD to CSAPR2.

Cold Climates Precipitation

Christopher Williams presented a science needs based overview. He began by highlighting the success of the measurement strategy at the BAECC campaign showing some great multi-frequency measurements of snowfall and how well aligned and calibrated radars, due to the size dependence of the backscatter cross section, can help determine particle habit and make quantitative retrievals in the profile possible.

Christopher also highlighted work by Mariko Oue and Tim Garrett using the Multi-Angle Snowflake Camera and comparing to radar spectra observations. Christopher also highlighted the need for tower mounted observations to understand the variation with height and help separate falling from blowing snow.

The idea of tethered balloon observations was also covered with a proposed instrument package from SPEC being outlined. Christopher finished by outlining some priorities and keywords to be used in the discussion.

Jessica Cherry gave an overview of ARM's measurement strategy in colder climates. She began by clearly outlining some of the challenges of working in the Arctic including icing of instrumentation (or plain outright destruction) siting challenges on the tundra and the issue of blowing and drifting snow. A continual issue was the idea of flow around gauges and if snow would actually fall in. Also mentioned was the non-predictable performance of the heated plate based total precipitation sensor. The Geonor DFIR sensor was discussed as a well performing system but without the time resolution of the TPS. And again the need for tower measurements was raised.

Cold Climates Precipitation Discussion

Ensuing conversation initially focused on the issues surrounding the TPS and if ARM could develop new software or if the vendor could deliver an improved system. This seemed problematic due to software proprietary issues. It was mentioned that accurate snowfall rate measurements could be a very good topic for a SBIR/STTR call/proposal. What was clear was there was no "One sensor to rule them all" and an all of the above strategy must be taken. It was also debated if the redundant gauge approach used in the warm climate session was valid for snow which is much more of a passive tracer in the flow field and two gauges in a shield may create flow issues which would mean they are not comparable. Further reading indicates that the Double Fence Intercomparison Reference (DFIR) is designed with only one sensor in the middle of the structure. Adding more sensors may discredit the reference aspect of the DFIR.

One interesting path of discussion was the measurement of snow depth. There already exist instruments using ultrasonics and it was suggested a scanning LIDAR package mounted on a tower could create a 2D map of snowfall depth and rates, compaction, sublimation, etc., could be backed out with assistance from other datastreams.

Talk then moved onto the need for profiles both tower and balloon based. Barrow has a 40m tower which "objects up to a certain weight and power requirement" could be mounted. OLI has a 10 meter wind up tower and due to site requirements no larger installation could be used. Aircraft/UAV campaigns were discussed on a way to gauge the depth of the blowing snow layer. Also discussed was a role for the DQ office to look at web cameras and other datastreams to assess if there is blowing snow or not to allow a weather state datastream allowing conditional sampling. In addition it was raised there is a NWS observational site nearby and there are site operational personnel who could, with some instruction, log the existence of blowing snow.

Discussion then turned to the particle resolved sensors. The 2DVDs used for warm climate precipitation were unreliable; the temperatures present were outside its operating range. ARM is deploying a MASC to OLI. It was brought up that software for retrieving PSDs from the MASC was still under development by Tim Garrett and this is a highly developmental project with (as yet, to the knowledge of the group) no

validation or understanding of limitations. It was proposed a better solution to get at quantitative PSD measurements was the installation of aircraft microphysical probes and using a wind vane to orient into the wind. This would allow the use of long developed and vetted analysis techniques and that the MASC was more suited to habit determination.

Recommendations

1. A system for diagnosing the existence of blowing snow is required.
2. The TPS is not reliable. If used a TPS should be paired with a DFIR. The TPS should always be outside of the double fence. Improving TPS processing would be of great value to the community.
3. Tower mounted measurements are desired at multiple heights.
4. The MASC, while great for habit determinate has a “not yet known” and therefore questionable ability for quantitative PSD estimation. Therefore a good combination would be the MASC with a modified aircraft microphysical probe (for example a High Volume Precipitation Sensor, HVPS, or a 2 Dimensional Stereo probe, 2DS).

Acronyms

2DVD: Two Dimensional Video Distrometer (http://www.distrometer.at/)

2DS: Two Dimensional Stereo Probe (http://www.specinc.com/2d-s-stereo-probe-operation)

BAECC: Biogenic Aerosols – Effects on Clouds and Climate

CSAPR2: C-band Scanning Arm Precipitation Radar version 2

DFIR: Double Fence Intercomparison Reference. A Geonor T-200B weighing gauge in a Double Fence.

DSD: Drop Size Distribution

HVPS: High Volume Precipitation Sensor (http://www.specinc.com/high-volumne-precipitation-spectrometer)

KAZR: Ka-band Zenith pointing Radar (http://www.arm.gov/instruments/kazr)

MASC: Multi-Angle Snowflake Camera (http://www.inscc.utah.edu/~tgarrett/Snowflakes/MASC.html)

PSD: Particle Size Distribution

TPS: Total Precipitation Sensor (http://www.esrl.noaa.gov/psd/data/obs/instruments/HotPlate.pdf)

SBIR: Small Business Innovation Research

STTR: Small Business Technology Transfer (http://science.energy.gov/sbir/)

VAP: Value-Added Product (http://www.arm.gov/data/vaps)