Translating the Physics of Snowfall to Radar-Based Validation of GPM

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Objective: Validate GPM estimates of Snow Water Equivalent Rate (SWER)

- Original GPM requirement is for “detection” of falling snow rates, but desire is to reliably estimate SWER
- Reliable satellite-based remote sensing of SWER is hard- but also the case for ground-based instrumentation (a “validation” source)
- How do we assess agreement between distributed (i.e., multiple footprints) GV-radar and near instantaneous satellite-based SWER estimates?

Approach(es)

Construct deterministic (e.g., S(Z), S (KDP,Z), etc.) and probabilistic (POPE) radar-based SWER with minimum bias (random error accepted for large sample).
- Use multi-radar “reference” networks to obtain “best” footprint area estimators;
- Assess/correct radar SWER biases relative to reference network and physical character of snowfall
- Compare reference-based radar-diagnosed SWER to GPM satellite DPR and GMI estimates.

Results

1. Example GPM SWER Comparisons over Hyytiala Finland

- GMI-GPROF (VS) SWER (y-axis) vs. IKA Radar SWER (x-axis) Winter 2014/15, 17/18
- SEV PQPE 25th% vs. DPR NS product (left) and DPR MS product (right) - DPR Ku similar
- As in figure for GMI-GPROF but DPR GPROF MS product (left) and DPR NS product (right)

2. Marquette

- Pluvio “reference” at NWS Site, single Alter shield, compares reasonably well with observer SWE (manual core)
- DPR matched swath (MS) product: 625% and SEV Z-S plotted against RPN (lowest 3-tails of KMQT volume scan- heights 100m - 700m above RPN)
- GMI SEV (similar to MRMS): ~85%, GMI 75% and polarimetric estimator (S(Z), KDP, not shown) are biased ~100% high.
- Local KMQT (not shown) Z-S, SMQT: ~4% - POPE 25th%: ~23%

3. VN and GPM

- The POPE 25th% and KMQT Z-S relationships are the “best” for the MQT network (from a purely bias perspective). How well do DPR-estimated SWERs compare to these estimates in the KMQT radar domain and subsequently over the Continental U.S. (CONUS) when using WSR-88 radars in the VN architecture?
- DPR matched swath (MS) product: only slightly lower than “best” relationships (POPE 25% and KMQT Z-S in the KMQT radar domain. [Combined algorithm, similar, not shown])
- DMR Markedly lower for POPE SEV and dual-pol KMQT (as expected based on RPN comparisons).

Summary

- We have developed an ensemble of tools/approaches designed to provide physically-tuned/consistent and/or statistically optimal radar-based SWER estimates to validate instantaneous GPM estimates of SWER from the pixel to swath scale.
- Comparison of the GPM products to reference radar-based SWER estimates over Finland and the U.S. suggest that GPM GMI-GPROF and DPR SWER estimates may be biased low.
- Ongoing and future analysis will include expansion of the case database in Finland and Canada, continued evaluation of snow physical properties defining regime Z-S behavior, examination of footprint to sub-footprint scale SWER variability.

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