Non-uniform Beamfilling Effects Based on Direct Comparison of GPM DPR and Airborne Radar Observations in OLYMPEX

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Overview

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- OLYMPEX in 2015 provided two cases in which GPM was under-flown by the APR3 airborne precipitation radar
- Direct comparison of the DPR and APR3 data provides opportunities to assess effects of resolution on DPR observations and retrievals
- DPR horizontal resolution ~5 km; APR3 horizontal resolution better than 1 km
- Previous studies have shown that non-uniform beam-filling (NUBF) can cause underestimation of the path-integrated attenuation PIA
- PIA and Z errors result in errors in retrieved rainfall

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- The first DPR under flight case was December 3, 2015 at 15:22 UTC mostly over land.
  - Prefrontal precipitation ahead of an approaching front, enhanced by the topography of the Olympic Mountains.
- The second case occurred on December 19 at 02:55 UTC, mostly over ocean and was postfrontal.
  - There were a few small, isolated convective cells during the GPM overpass.

Dec 3 Flight Tracks

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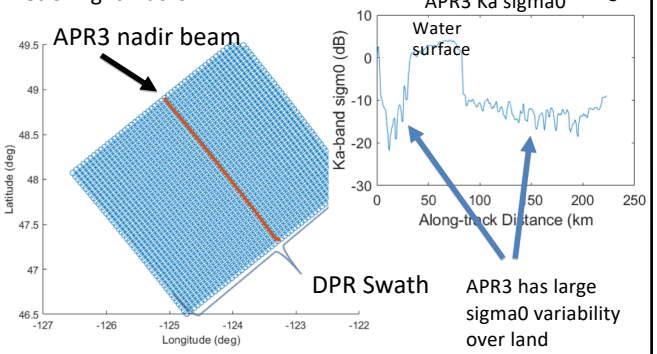

APR3 has large sigma0 variability over land

Dec 19 Flight Tracks

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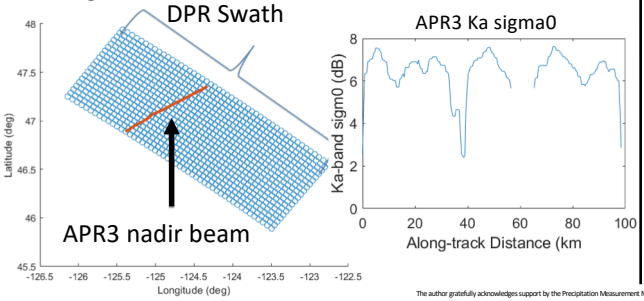

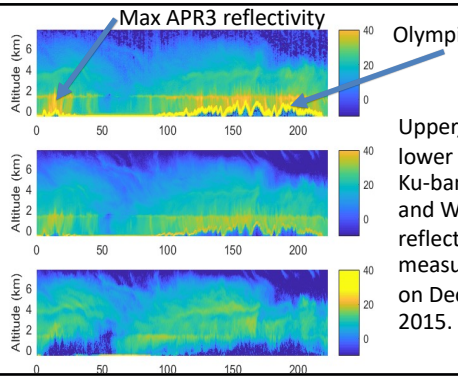

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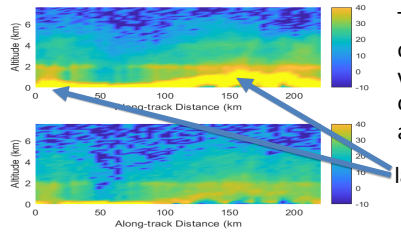
Upper, middle, and lower panels are Ku-band, Ka-band, and W-band reflectivity measured by APR3 on December 3, 2015.



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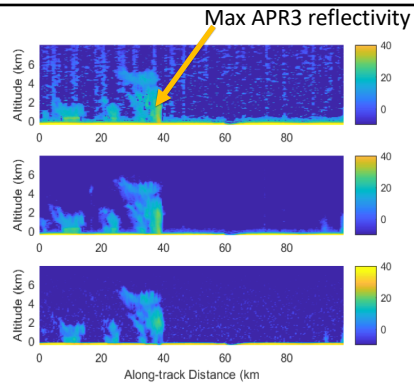
This case is complicated by varying rain types over orography and ocean

land

Upper and lower panels are Ku-band and Ka-band reflectivity measured by DPR on December 3, 2015.



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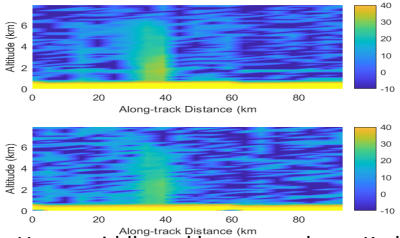
Upper middle and lower panels are Ku-band, Ka-band, and W-band reflectivity measured by APR3 on December 19, 2015.



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This case is dominated by a single, relatively weak cell over ocean

Upper middle and lower panels are Ku-band, Ka-band, and W-band reflectivity measured by APR3 on December 19, 2015.

Comparison of APR3 and DPR Statistics for Dec 3 case

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Case	Max PIA (dB)	Max rain Z (dBZ)	Max BB Z (dBZ)	Max SRR (mm/h)	Avg SRR (mm/h)
APR3 Ku	2.8	48	43	29	8
DPR Ku	11.0	37	40	-	8
APR3 Ka	17.0	37	36	30	7
DPR Ka	11.5	33	35	-	5

- APR3 reflectivity was adjusted upward to match DPR; values at location of APR3 max
- DPR RR values in table based on averaging APR3 measurements over DPR resolution volume and use of simple SRT method
- Maximum surface precipitation rate in DPR L2 product is 9.3 mm/h; Ku RR is 4.6 mm/h and Ka RR is 10.4 mm/h

Comparison of APR3 and DPR Statistics for Dec 19 case

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Case	Max PIA (dB)	Max rain Z (dBZ)	Max SRR (mm/h)	Avg SRR (mm/h)
APR3 Ku	0.8	40	8.1	2.3
DPR Ku	1.2	33	-	3.3
APR3 Ka	5.8	36	5.3	2.0
DPR Ka	3.0	29	-	1.4

- Same assumptions and method as above
- Maximum precipitation rate in DPR L2 product is 2.6 mm/h; Ku RR is 2.1 mm/h, Ka RR is 1.6 mm/h,
- DPR estimated from low-res APR3 allows comparisons with same retrieval algorithm

Results and Analysis I

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- Both cases have variation in PIA and Z at the DPR sub-pixel scale (NUBF), based on comparison with high-res APR3 data
- Z and RR at 5 km resolution significantly smaller than 1 km resolution values
- Comparison of average RR over 5 km with RR retrieved from Z over 5 km shows
  - Ku-band very similar Dec 3, overestimate Dec 19
  - Ka-band RR from low-res Z smaller than low-res RR
- For DPR to detect NUBF it can only access beam-to-beam standard deviation σ, ratio of Ka-band to Ku-band PIA ρ
- Analyses of DPR data indicate large σ (a few dB) and small ρ (less than ~4) indicate NUBF (basis of "Trigger" Algorithm, Tanelli)

Results and Analysis II

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- For Dec 3 σ=3.6 dB, ρ=1.1; reliability for Ku PIA over land only 1.9, due to large variability (see plot of APR3 sigma0 at left)
  - Consistent with RR underestimate at Ka-band
- For Dec 19 σ=0.8 dB, ρ=2.4; reliability for Ku PIA 5.45, but PIA near 1 dB is difficult to measure w/SRT
  - Ka RR also slightly below average RR, suggesting NUBF
- Analysis of Dec 3 case will be expanded to other locations in overpass
- Averaging APR3 Z and RR allows NUBF details to be examined without DPR data; will apply to other cases, especially over land

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