117 UW Preliminary Results from the Olympic Mountains Experiment (OLYMPEX)

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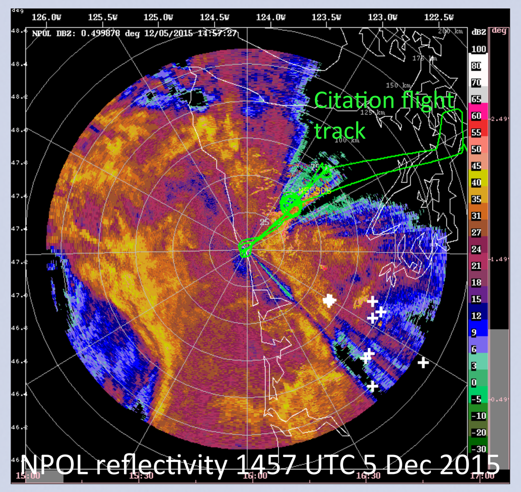
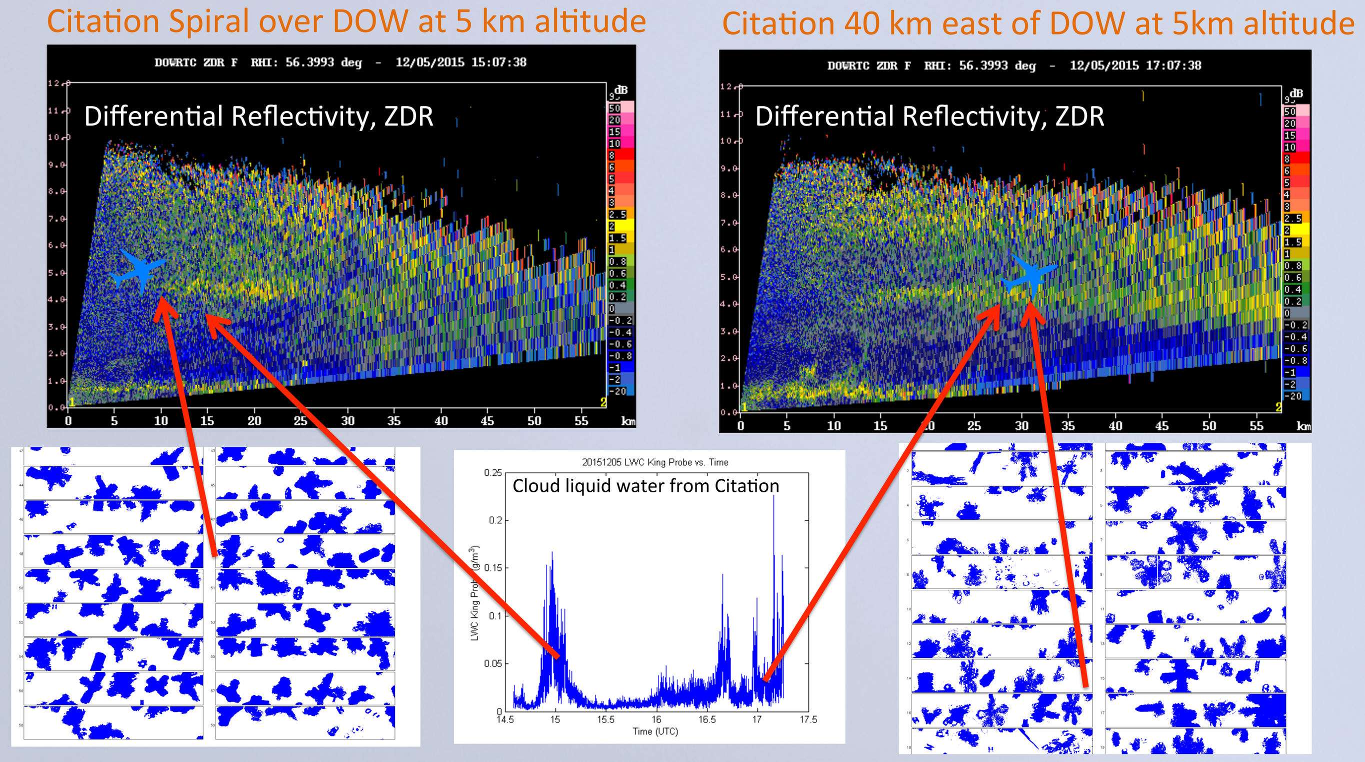
Secondary enhancement in ZDR

- Relate microphysical measurements by Citation to DOW radar measurements. Using times when Citation performed spirals over the DOW
- Looking at events where a secondary enhancement in ZDR above the melting level is observed in the DOW RHI sectors
- This example: 1500 – 1700 UTC 05 December 2015



1507 UTC 5 December 2015
Citation Spiral over DOW at 5 km altitude

1708 UTC 5 December 2015
Citation 40 km east of DOW at 5km altitude

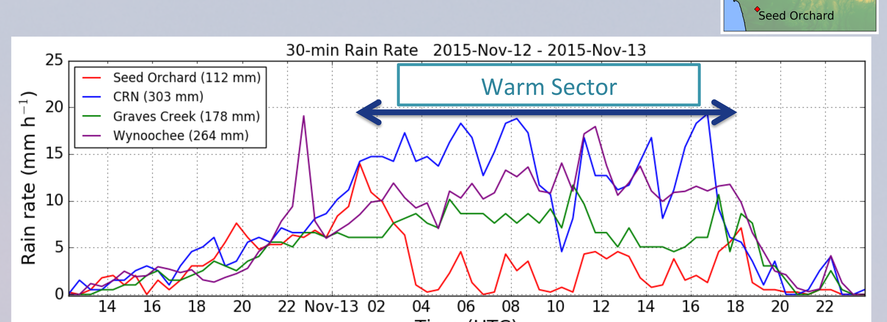


- More rimed particles
- Higher liquid water content
- Vertical velocity ~1-2 m s^{-1}
- Temp = -12°C
- Dendrites, aggregates, plates

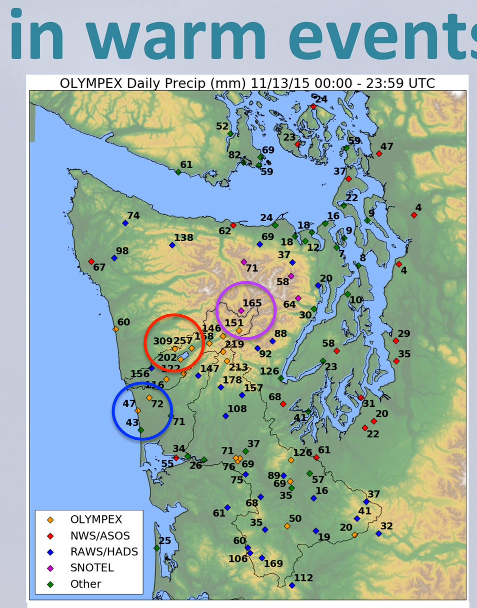
- Less rimed particles
- Lower liquid water content
- Vertical velocity ~10-50 cm s^{-1}
- Temp = -12°C
- More dendrites, some aggregates, and plates

Precipitation characteristics in warm events

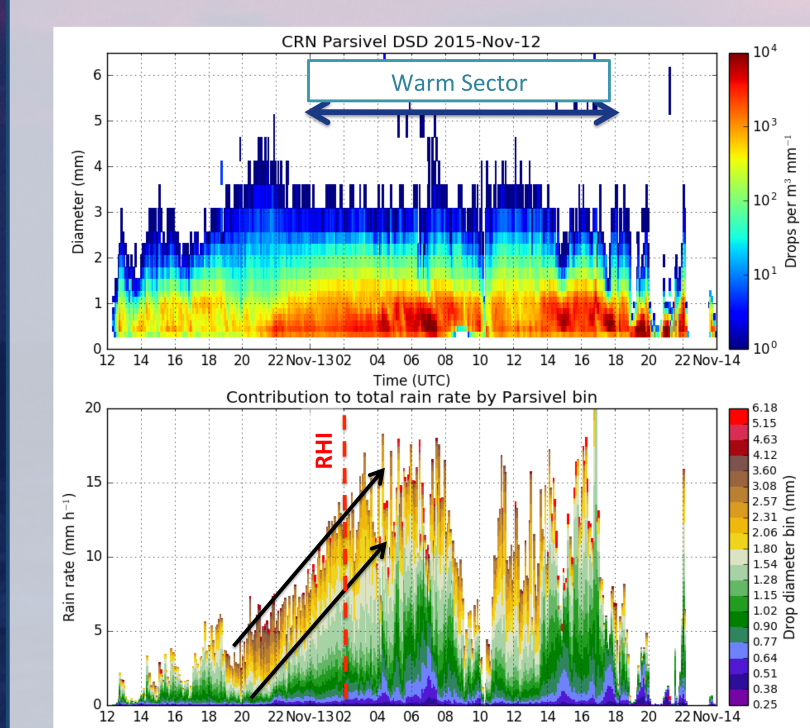
- Examining role of warm rain/ice processes in an atmospheric river event
- 12-13 November 2015



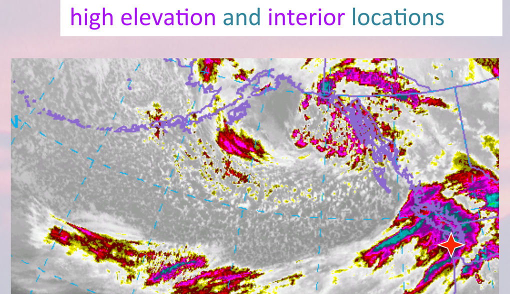
Strong orographic enhancement for 18 hours. More rain at CRN site compared to interior and higher elevation sites



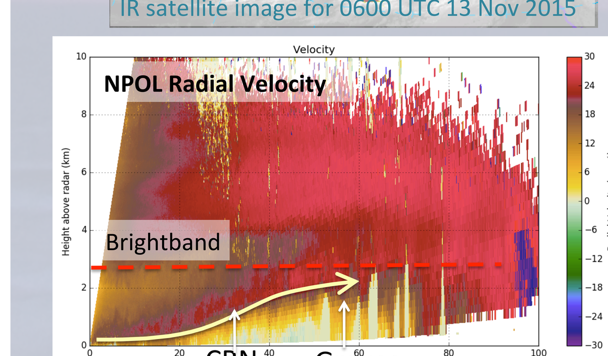
Factor of 4-5 enhancement between coast and inland sites. More precipitation at forward slopes than high elevation and interior locations



Orographic enhancement associated with large quantities of <1.5 mm drops. These drops are responsible for the majority of the increase in rain rate



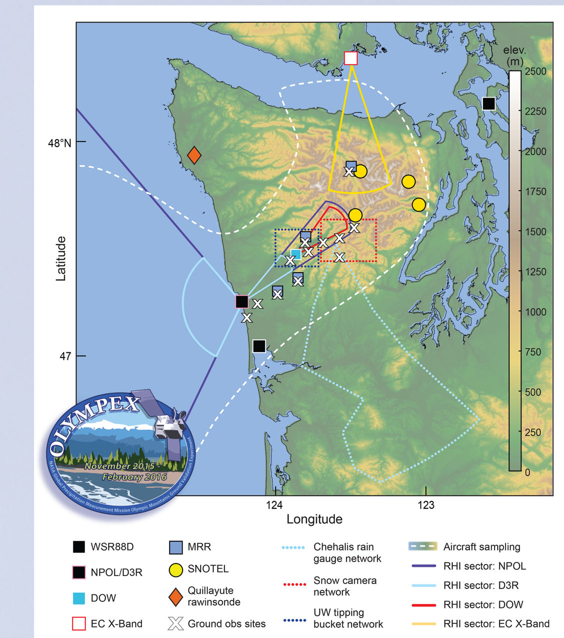
IR satellite image for 0600 UTC 13 Nov 2015



Low-level jet lifts at 20 km from NPOL. Drop formation and growth occurs below melting level ahead of terrain. Jet stops lifting at 50-60 km from NPOL

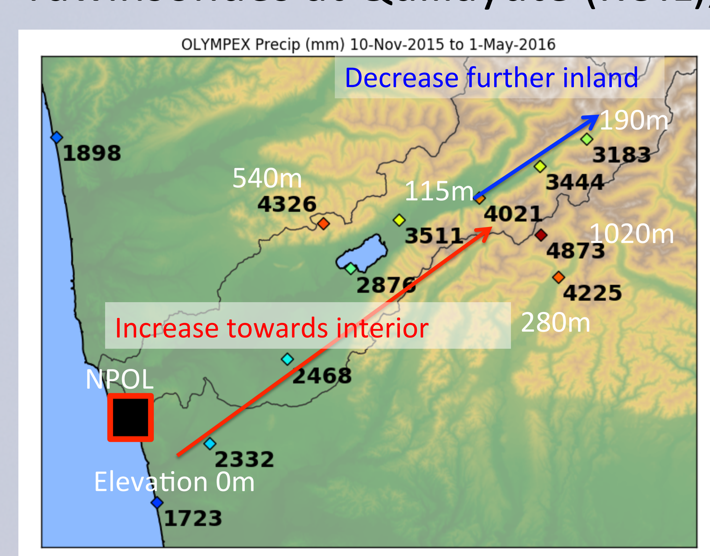
OLYMPEX - Goals

- Physical validation and verification of precipitation measurements by the GPM satellite
- Measure precipitation processes and their modulation by synoptic conditions and complex terrain

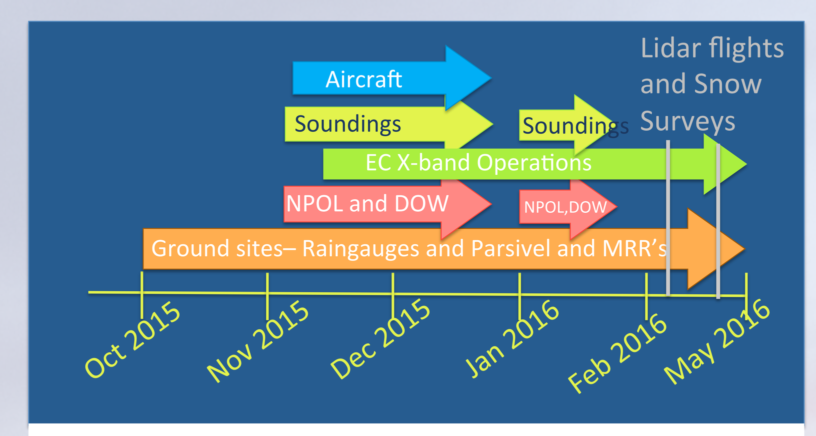


Field Campaign Overview

- OLYMPEX regions included ocean, windward side, high terrain and leeside and the Quinault and Chehalis river basins
- NPOL radar on coast sampled ocean and windward side, the Doppler on Wheels (DOW) sampled up the Quinault Valley. Both radars were supported by a ground network of disdrometers, rain gauges and MRRs
- Seasonal accumulation of the snowpack from SNOTEL and snow cameras, 2 lidar Airborne Snow Observatory (ASO) flights and snow surveys.
- Environment Canada (EC) X-band radar on Vancouver sampled the leeside, supported by disdrometers and rain gauges
- Raingauge network in Chehalis river basin
- Aircraft measurements by DC-8, ER-2 and Citation over all regions
- Environmental characteristics documented by dropsondes (DC-8) and rawinsondes at Quillayute (KUIL), NPOL and EC X-band locations



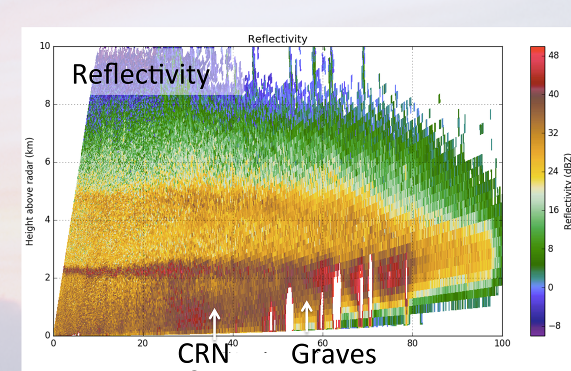
Seasonal precipitation totals observed during OLYMPEX in mm



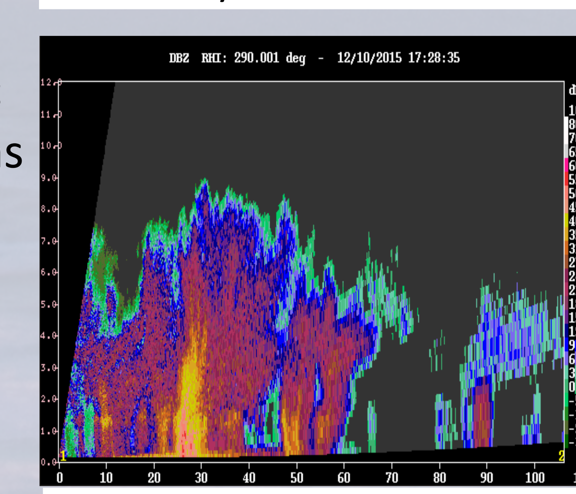
Timeline of instrument operations

What we observed during the intensive observation period

- 15 frontal systems, 10 prefrontal and warm sectors, 6 postfrontal sectors sampled by aircraft
- 3 major flooding events from atmospheric river type storms, several moderate storms and 3 weak storms
- 3 occluded fronts and 2 cold fronts sampled by aircraft
- Many more sampled by ground network and radars

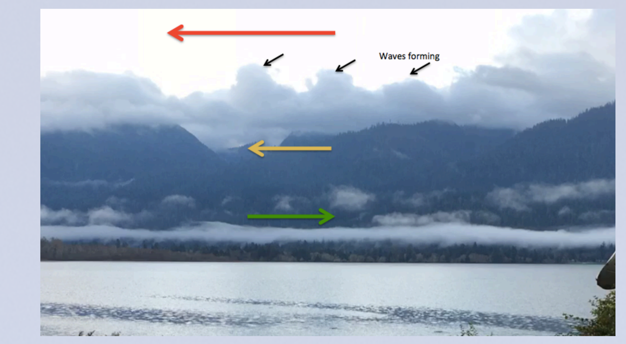


RHI Scan from NPOL
Reflectivity at 0600 UTC 13 Nov.

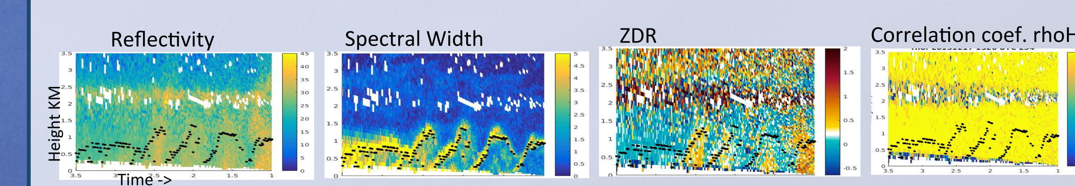


Postfrontal shower example NPOL

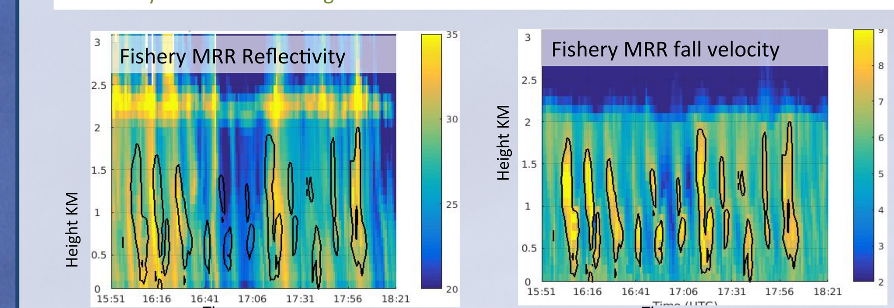
KH Waves observed at DOW and NPOL



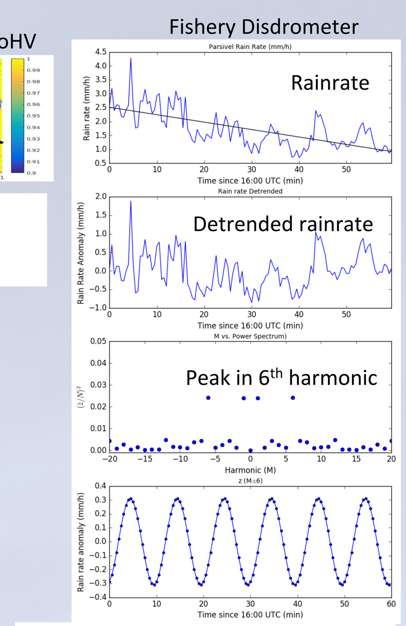
- Shallow Kelvin-Helmholtz waves were frequently seen at the DOW due to persistent easterly, shallow down-valley flow.
- More widespread KH waves were associated with stable frontal layers when significant shear was present.
- They are not fundamentally related to orography, but can be modified by orography
- They are most identifiable in radar data when they disturb the brightband
- They do not significantly impact rainfall rates, but some evidence of microphysical enhancement (~ 0.5 mm hr^{-1}) in particular events.



KH waves observed in reflectivity, spectral width, ZDR and rhoHV at the DOW 16 UTC 17 Dec 2015. Black dots show position of the wave as determined from the spectral width. The waves aren't seen in rhoHV since they are below the brightband in this case.

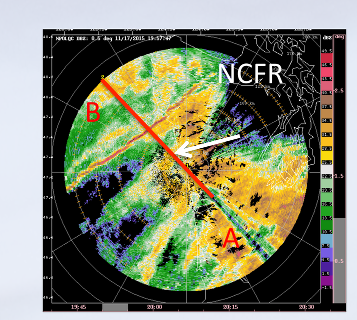


Similar 'waviness' seen in the reflectivity and fall velocity observed by the MRR at the Fishery (10 km west of DOW). The disdrometer at the Fisheries also sees a peak in the wave spectra at ~10min, same frequency as the waves seen by the MRR and the KH waves at the DOW.

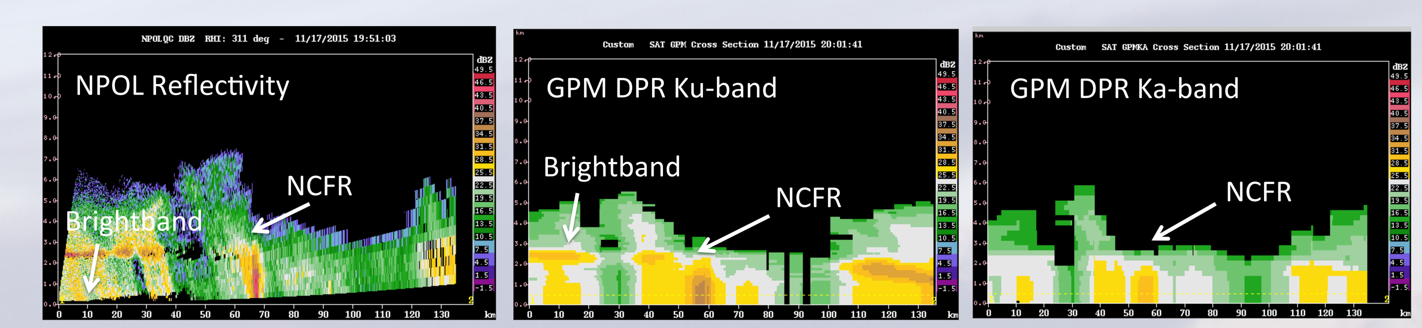


Power spectra with peak at 10 min – nearly the same freq. as KH waves

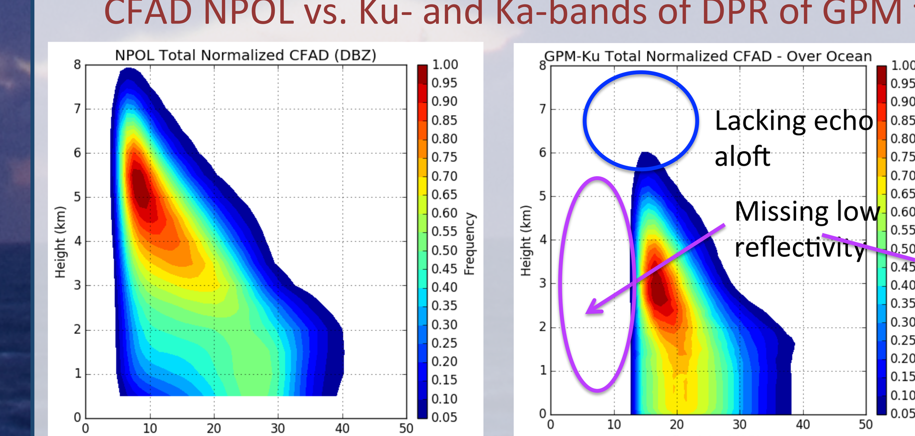
Comparison of NPOL to GPM



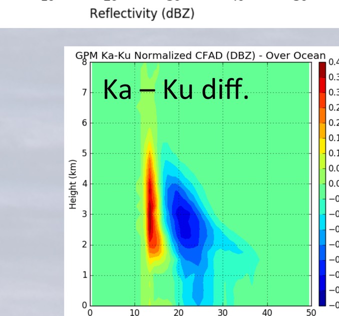
- Comparing NPOL reflectivity to the DPR on GPM
- This case on 17 Nov 2015 had a passage of a narrow cold frontal rainband (NCFR).
- The RHIs below show the intense rainfall associated with the NCFR by NPOL and GPM, however GPM reflectivity echos are lower and the Ka-band does not show cloud echoes aloft.



CFAD NPOL vs. Ku- and Ka-bands of DPR of GPM for ocean region only



The lack of echo aloft and reflectivity below 12 DBZ is most likely due to expected minimum sensitivity thresholds. But the GPM Ka-band has only slightly more sensitivity than the Ku-band (see right) and shows attenuation at higher reflectivity. Explanations are being investigated by our team and other groups.



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