Dual-Polarization Radar Observations of Precipitation Processes in Complex Terrain during OLYMPEX

Angela K. Rowe[1], Megan M. Chaplin[1], and Robert A. Houze, Jr.[1,2]

[1]University of Washington, Seattle, WA; [2]PNNL, Richland, WA

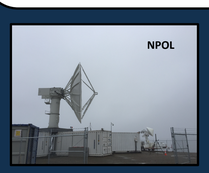
1. Introduction

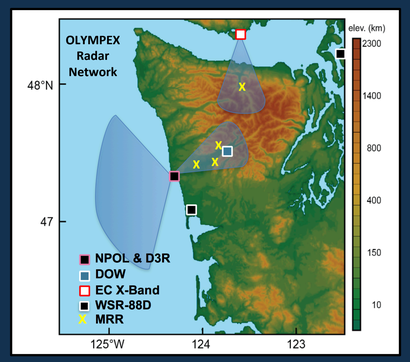
The Olympic Mountains Experiment (OLYMPEX), a NASA GPM ground validation project occurring fall 2015 – winter 2016, provided a unique opportunity to investigate precipitation processes as wintertime mid-latitude cyclones encounter complex terrain. The extensive instrument assets deployed during the field campaign upstream and across a range of elevations of the Olympic Mountains allowed for documentation of orographic enhancement of precipitation in a variety of synoptic events. As part of this observational network, ground-based dual-polarization Doppler radars operated nearly continuously on the coast, windward interior valley, and leeside of the mountains. ***These data provided unprecedented detail to illuminate the role of terrain on microphysical and dynamical processes associated with this precipitation enhancement.*** Additional details on microphysical processes are available through in situ aircraft data, including spirals through the radar sectors.

2. OLYMPEX Data

NPOL

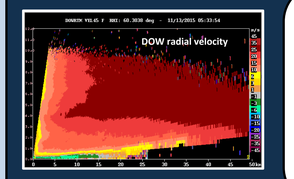
- NASA's S-band dual-polarization, Doppler radar
- Operated from coast (Quinault Nation)
- Collected high-resolution RHIs over ocean and inland over Quinault Valley





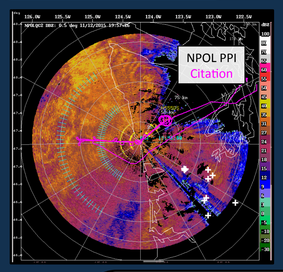
DOW

- CSWR's X-band, dual-polarization, Doppler on Wheels radar
- Located at Lake Quinault beneath NPOL beam
- Collected high-resolution RHIs in Quinault Valley and over windward slopes

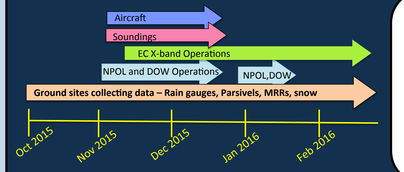


UND Citation

- LWC (King Hot Wire Probe)
- CWC (CSI)
- TWC (Nevzorov)
- Cloud DSD (CDP)
- Particle images (2D-S, HVPS-3, CPII, 2DC)
- Supercooled water (Rosemount icing probe)
- Up to 7.5 km



Focus on Citation spirals in DOW and NPOL RHI sectors

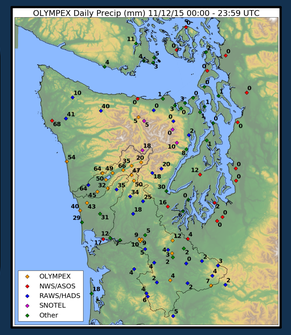


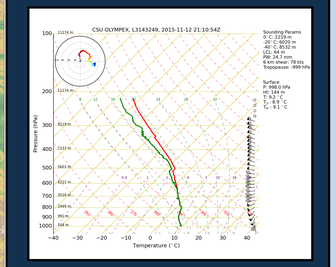
OBJECTIVE

Collocate in situ data from Citation spirals with DOW and NPOL RHIs to validate microphysical inferences from radar data and *to investigate precipitation processes* with respect to different environmental conditions and terrain.

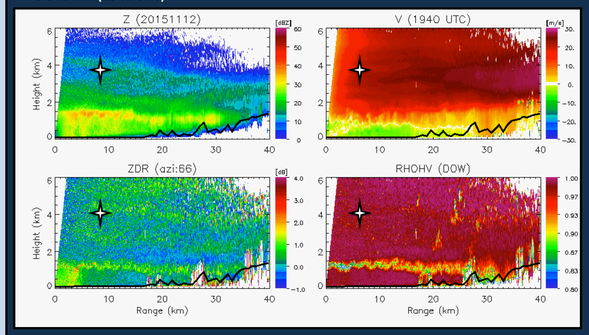
3. 12 November 2015 Case Study

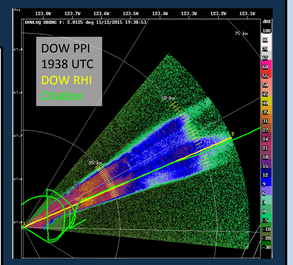
- Warm prefrontal flow impinging on mountains (W at 500 hPa, SW at 850 hPa)
- Deep, moist, stable layer
- Pronounced leeside rain shadow
- Coordinated flights with GPM overpass, including Citation spirals over NPOL and DOW sectors

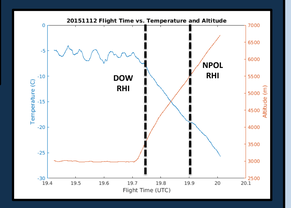


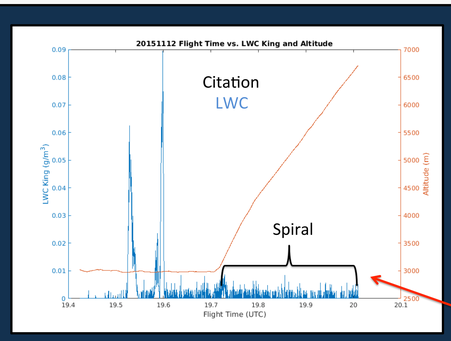


DOW RHI (1945 UTC)

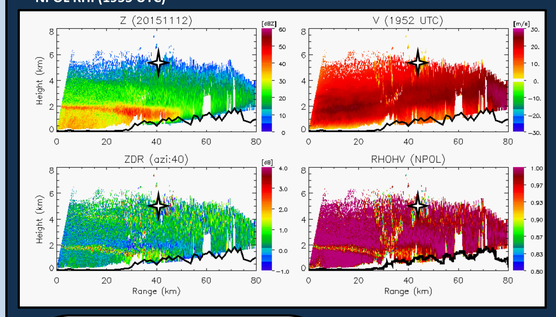








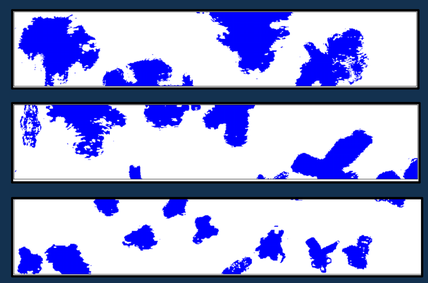
NPOL RHI (1955 UTC)



- Upstream influence of mountains (air rising before mountain, NPOL)
- Shallow down-valley flow (DOW)
- Bending of brightband toward terrain
- Very little to no liquid water or rime ice encountered
- Secondary maxima in ZDR aloft with increasing reflectivity below
- Rise in melting level with time, increasing enhancement and role of warm-rain processes (see Joe Zagrodnik's poster)

- 1945 UTC: Time of DOW RHI above, ~3.5 km, -7°C, large aggregates (increase Z, decreasing ZDR)
- 1949 UTC: In between DOW and NPOL RHIs above, ~5 km, -13°C, aggregates, pristine stellars, sectored plate (in region of locally enhanced ZDR aloft)
- 1955 UTC: Time of NPOL RHI above, ~5 km, -20°C, smaller, irregular (low Z)

2DS_H Probe
Buffer width=1280 microns
Resolution: 10 microns



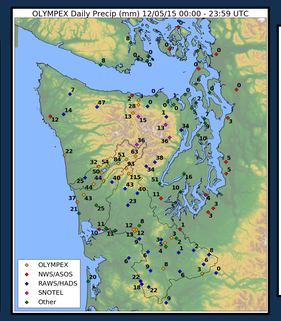
1945 UTC

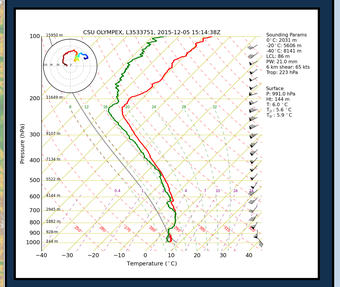
1949 UTC

1955 UTC

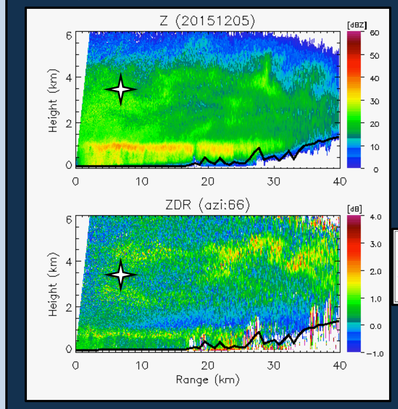
4. 5 December 2015 Case Study

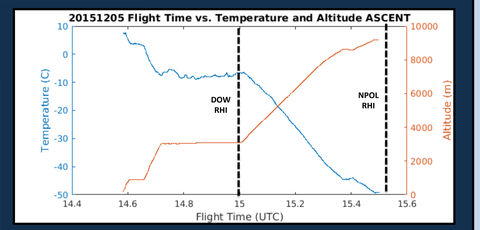
- Occluded frontal system with strong wind shear
- Strong southwesterly winds at and above 900 hPa with slightly weaker southeasterly flow below
- Large drops (compared to 12 Nov period) observed along western slopes suggesting greater contribution from melting snow
- Shear-induced Kelvin-Helmholtz waves developing during time of Citation spirals





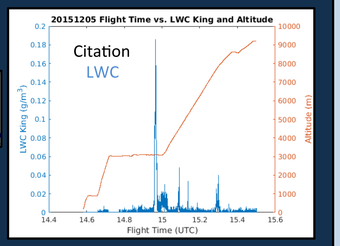
DOW (1505 UTC)





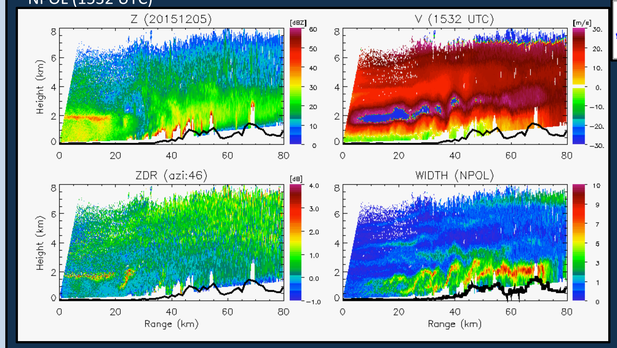
2DS_H
1505 UTC

Large aggregates where Z increasing, ZDR decreasing with height



1508 UTC

NPOL (1532 UTC)



- Small spikes in LWC as ascends through stratiform ice region
- 1454 UTC: Large aggregates just before spiral near 3 km (no supercooled water)
- 1505 UTC: large aggregates (~3.5 km)
- 1508 UTC: bullet rosettes, capped columns (~4.5 km)
- 5.5-6.5 km: irregulars
- > 6.5 km: column aggregates, small crystals

Microphysical impact of K-H waves seen in NPOL with increased and deeper high reflectivity over terrain; occurring under relatively higher ZDR aloft

5. Conclusions

- Two cases with different synoptic/environmental conditions, varying melting levels with respect to time and distance to terrain, upper-level enhancement over mountains (waves in 5 Dec case), little to no liquid water observed in spirals
- Observations of dendrites and capped columns in region of upper-level ZDR enhancement, with large aggregates observed below as ZDR decreases/Z, increase providing confidence in microphysical inferences from radar when in situ data not available
- Future work to investigate dynamical processes related to upper-level enhancement, role of K-H waves in modification of microphysics, further classification of Citation data (e.g., LWC) as a function of T for additional cases

E-mail: akrowe@atmos.uw.edu

Funded by NSF Grant # AGS-1503155 and NASA Grants # NNX16AD75G, NNX15AL38G
AMS Annual Meeting, January 2017, Seattle, WA