# 225: Verification of the GPM Satellite by the Olympic Mountains Experiment (OLYMPEX)

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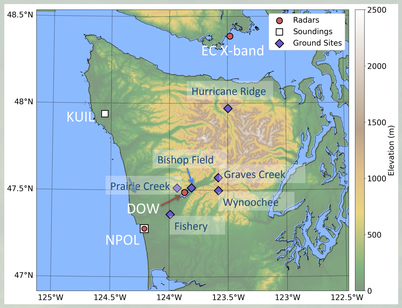
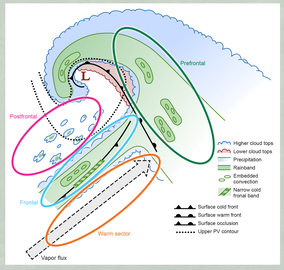
## OLYMPEX - Goals

- 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 and leeward side of the Olympic Mountains and the Quinault and Chehalis river basins
- **Radars**: S-Band (NPOL) and Ka- Ku-Band (D3R) X-band (DOW, EC-Xband)
- **Ground Network:** Parsivels, dual-tipping buckets, Pluvios, MRRs, Soundings
- **Aircraft:** DC-8 , ER-2 with satellite simulating instruments, Citation with microphysics
- **Snow Measurement:** SNOTEL and snow cameras, 2 lidar flights, PIP disdrometer at Hurricane Ridge.




## Storm Sectors

### Prefrontal

- Warm advection
- Stable
- Low-level SE flow
- IVT variable (can be high)
- Increasing melting level height

### Warm Sector

- No advection
- Neutral stablity
- Low-level SW flow
- IVT High
- High melting level height

### Cold Sector

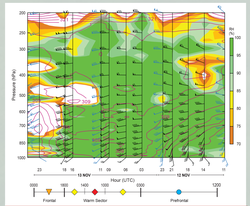
- Cold advection
- Unstable
- Low-level W or NW flow
- IVT Low
- Low melting level height

### Frontal

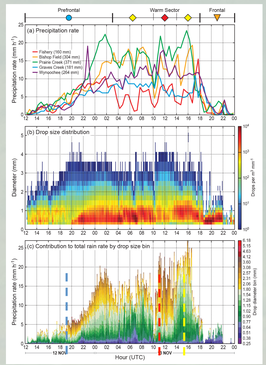
- Cold front passage
- Can have embedded convection along the front (NCFR)
- Abrupt changes in environmental conditions

## 12—13 November 2015 Atmospheric River Event

### Ground Network – Disdrometer and Gauge Results

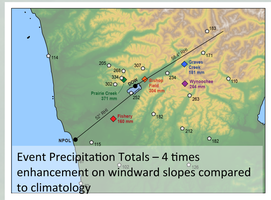


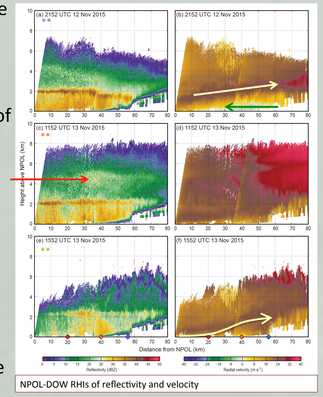
Time Height cross section of humidity, winds and theta




Vertical dashed lines correspond to the times of the 3 RHIs to the right →

- Precipitation totals demonstrate extreme orographic enhancement with more precip on the windward slopes than high terrain sites
- During prefrontal period all stations experience similar rain rates and there is weak down valley flow (green arrow)
- As warm front approaches big ramp up of precipitation rates especially Prairie Creek
- Increase of precipitation at Prairie Creek due to small drops
- Small drops contribute to ~1/2 of total rain rate in warm sector due to lifting of low level jet
- Secondary enhancement aloft during middle RHI period with large drops due to mesoscale feature aloft (red arrow)



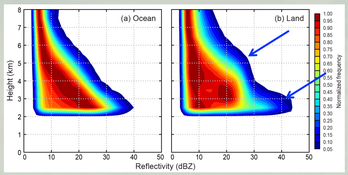



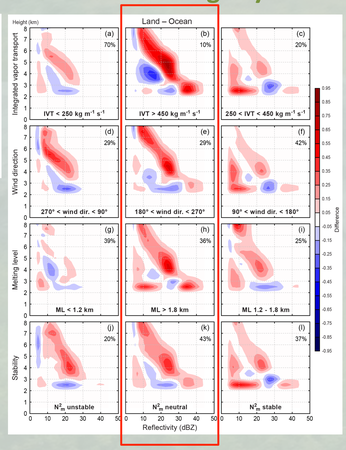

NPOL-DOW RHIs of reflectivity and velocity

### Message for GPM

- Warm rain processes important
- May be difficult to observe since these are low level processes

## Terrain-Enhanced Precipitation Processes above the Melting Layer

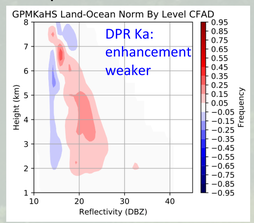


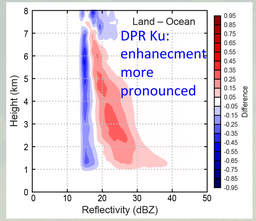



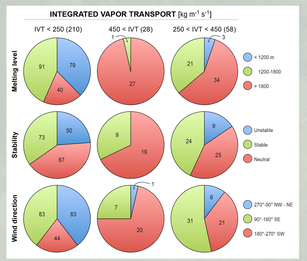

- Contoured Frequency by Altitude Diagrams (CFADs) were made from all NPOL RHI scans over the ocean and over the land (complex terrain)
- There is a clear signature of enhancement over the land at all altitudes, especially between 4-6 km and a shift towards higher reflectivity at 2-3 km associated with a more intense brightband.
- These signatures are most prevalent under environmental conditions commonly found in warm sectors or atmospheric rivers.
- CFADS constructed from the Ka and Ku bands from DPR also show similar enhancement.

### Message for GPM

- GPM can sample this upper-level enhancement over complex terrain




Percentage of time when different environmental conditions occur under different categories of Integrated Vapor Transport (IVT)

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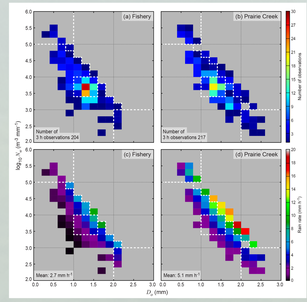
See Houze et al., 2017, BAMS and Zagrodnik et al., 2018, JAS, McMurdie et al. 2018, JGR and Zagrodnik et al., 2018, JAS, all available at olympex.atmos.washington.edu, for more information.

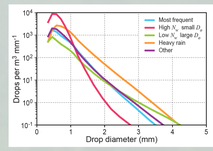
## Surface Precipitation Characteristics – DSDs

### Stratiform Precipitation



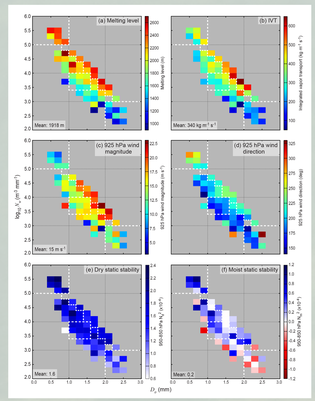

#### Four DSD regimes from Parsivel observations

- Most frequently occurring: Moderate $N_w$ and $D_o$
- High concentrations of small drops, high $N_w$ and small $D_o$
- Low concentrations of big drops, low $N_w$ and large $D_o$
- Heaviest rain: High $N_w$ and large $D_o$
- Fishery exhibits less variability in DSD than Prairie Creek




Overall DSDs at Prairie Creek (left)

- The high concentrations of small drops has a much different distributions than the others
- Heavy rain regime exhibits more drops of all sizes



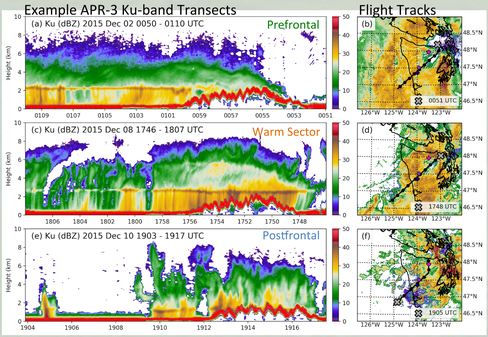

#### DSD variability with environmental conditions

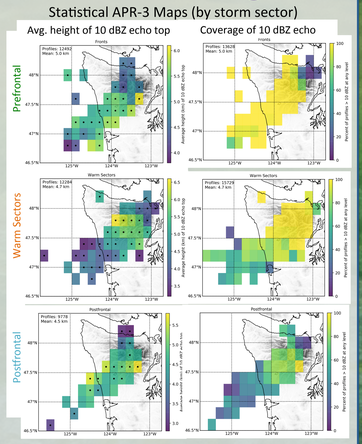
- The most frequently occurring regime has average melting level, average IVT, moderate low-level winds, generally from SW and mostly stable conditions
- The high concentrations of small drops regime has high melting level, moderate to low IVT, weak low-level winds from various directions.
- The low concentrations of big drops regime has low melting level, low IVT, winds with variety of strengths from generally westerly direction and unstable conditions
- The heavy rain regime has high melting level, high IVT, strong low-level winds from the SW and near-neutral stability

#### Message for GPM

- The most frequent PSD will be appropriate for most circumstances, but in heavy rain during orographic enhancement , the PSD shifts to larger numbers of all drops

## Windward Enhancement/Lee Side Diminishment from APR-3 flights




### Prefrontal

- Modest enhancement on windward slopes similar to overall CFAD from NPOL
- Significant diminishment on lee side at low levels
- Strong rain shadow.

### Warm sectors

- Strong enhancement on windward slopes at all elevations.
- Enhancement on lee side, especially at low levels implying spill over from windward slopes
- Weak rain shadow

### Postfrontal

- Deep enhancement on windward slopes and CFAD more convective
- Modest to no enhancement at low levels on lee side
- Some diminishment at upper levels on lee side.
- Rain shadow minimal

Three Prefrontal Flights:
- 01, 05 and 12 Dec

Three Warm Sector Flights:
- 13 Nov, 03 and 08 Dec

Three Postfrontal Flights:
- 04, 10, and 13 Dec

Difference CFADS between Region - Ocean