



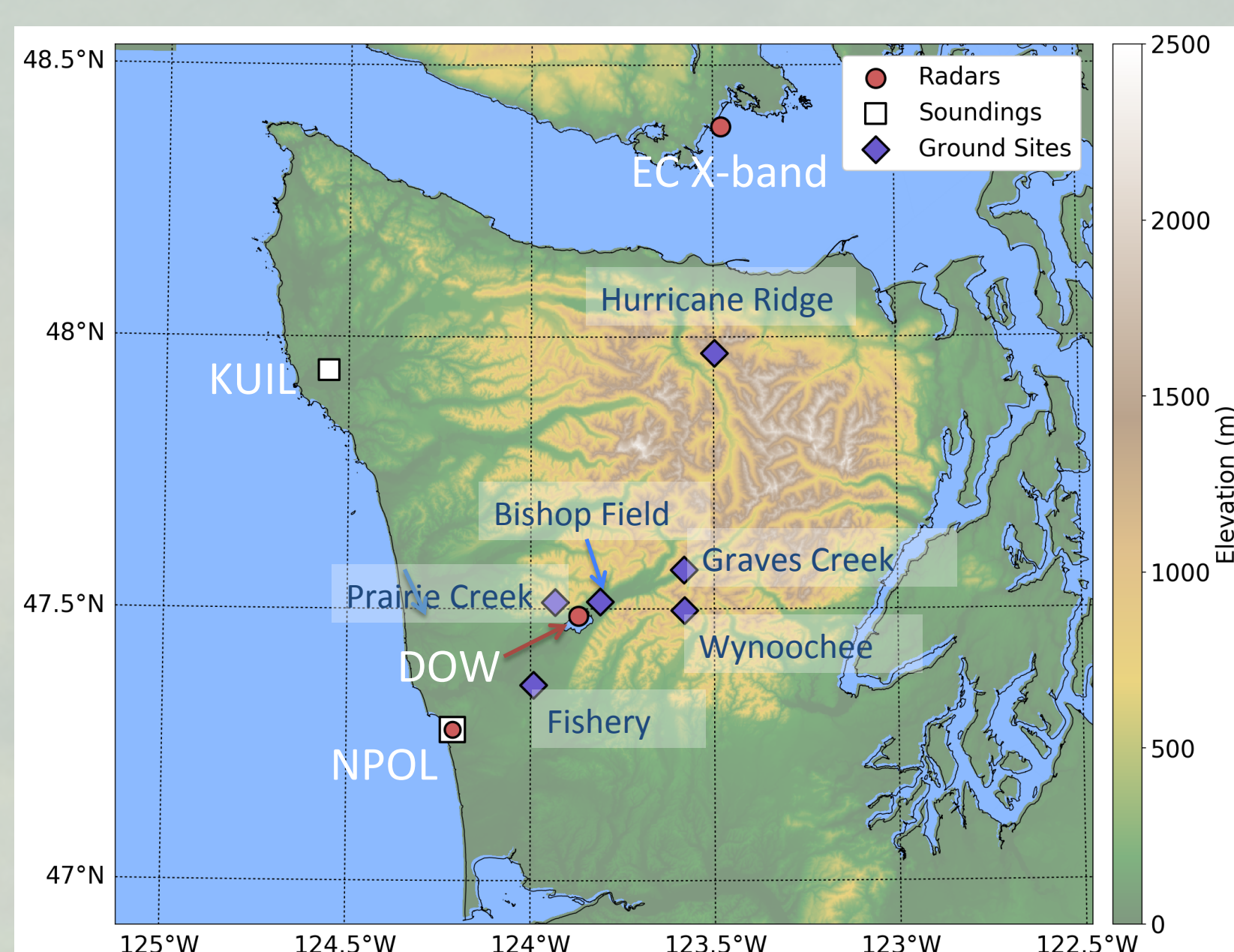
225: Verification of the GPM Satellite by the Olympic Mountains Experiment (OLYMPEX)

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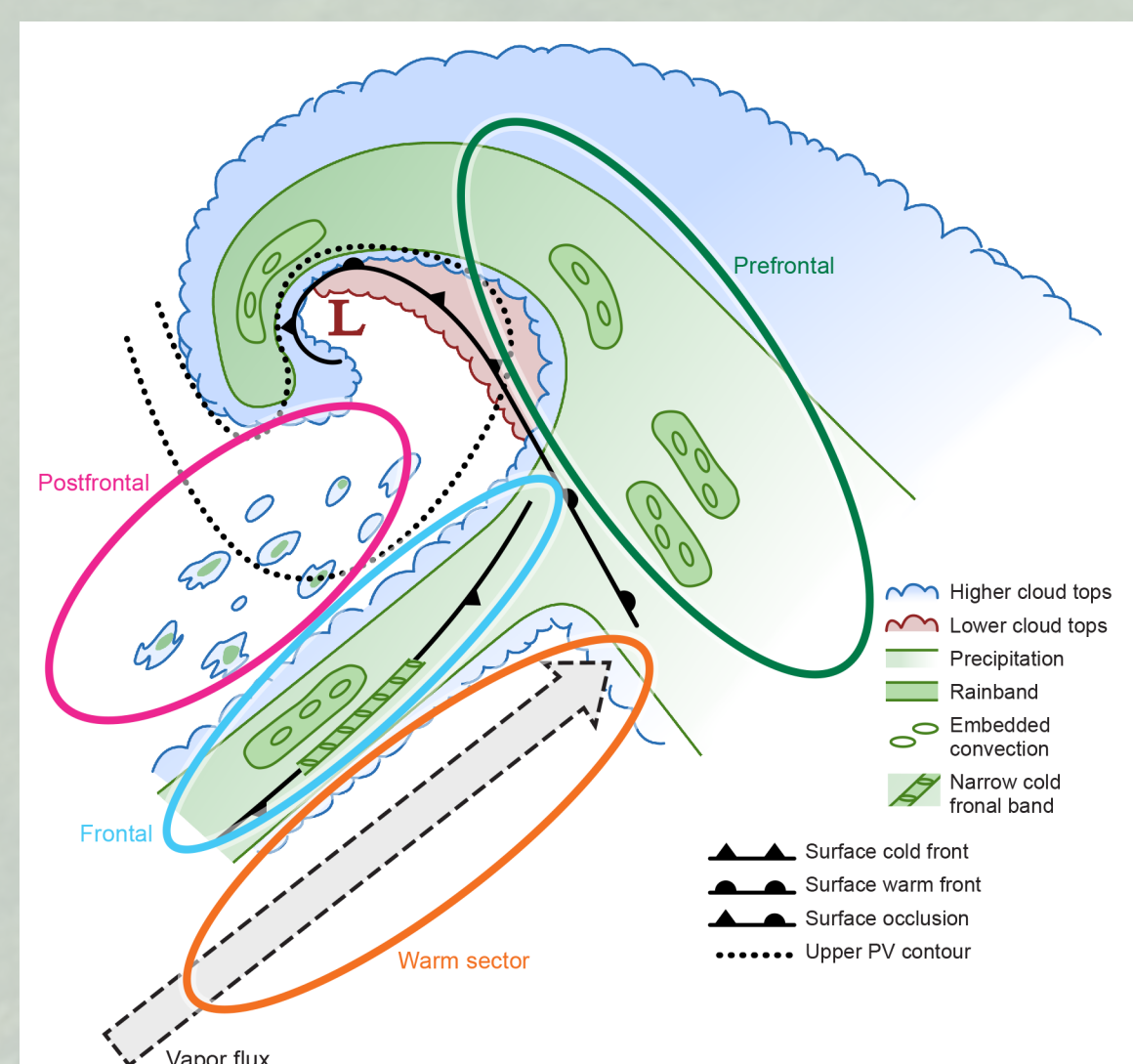
OLYMPEX - Goals

- 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 stability
- Low-level SW flow
- IVT High
- High melting level height

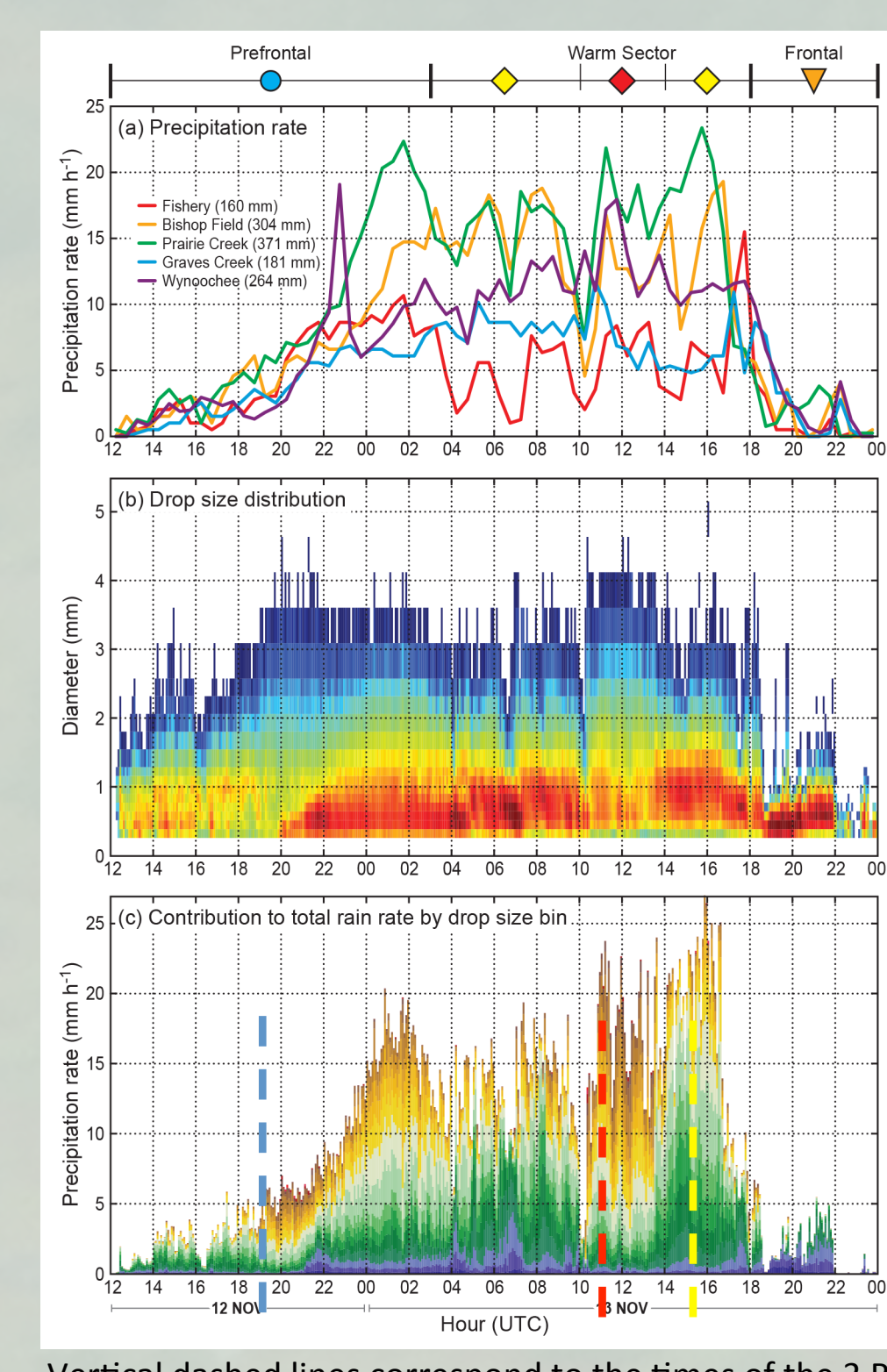
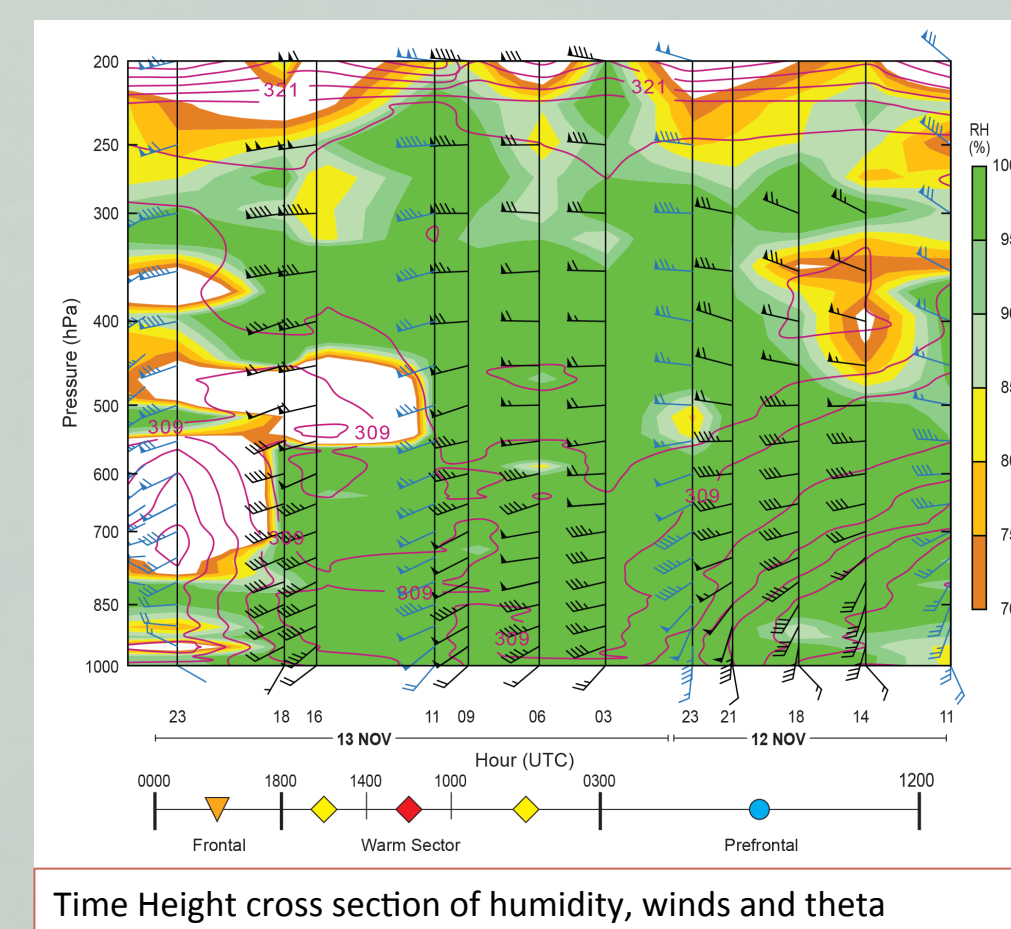
Frontal

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

Cold Sector

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

12—13 November 2015 Atmospheric River Event Ground Network – Disdrometer and Gauge Results

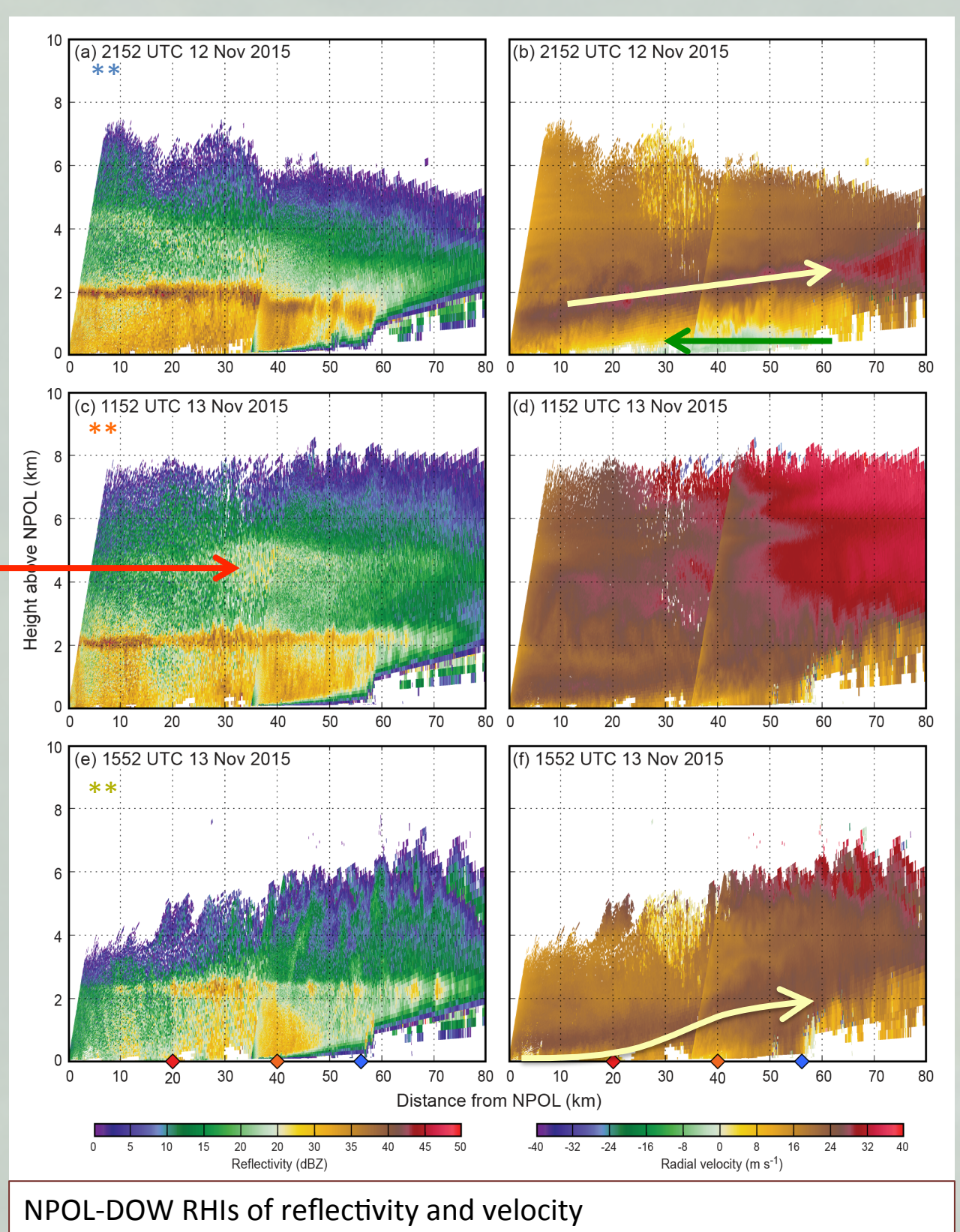
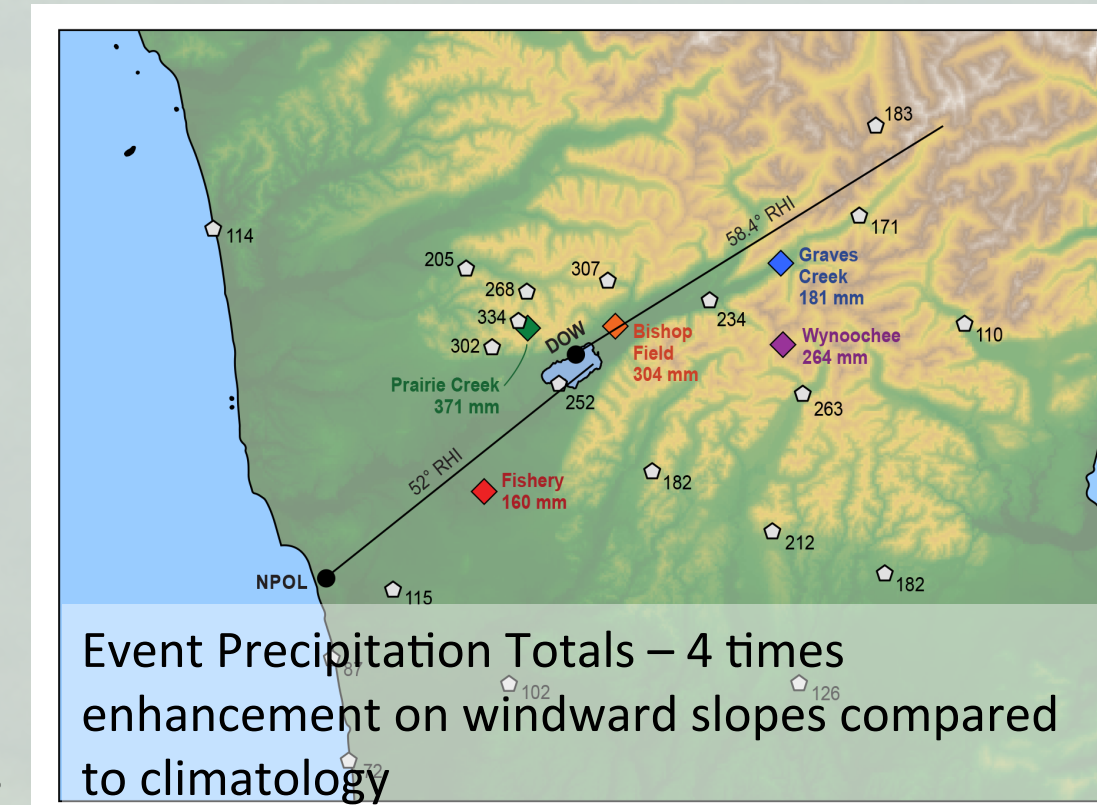


- Precipitation totals demonstrate extreme orographic enhancement with more precip on the windward slopes than high terrain sites
- During prefrontal period all stations experience similar rain rates and there is weak down valley flow (green arrow)
- As warm front approaches big ramp up of precipitation rates especially Prairie Creek

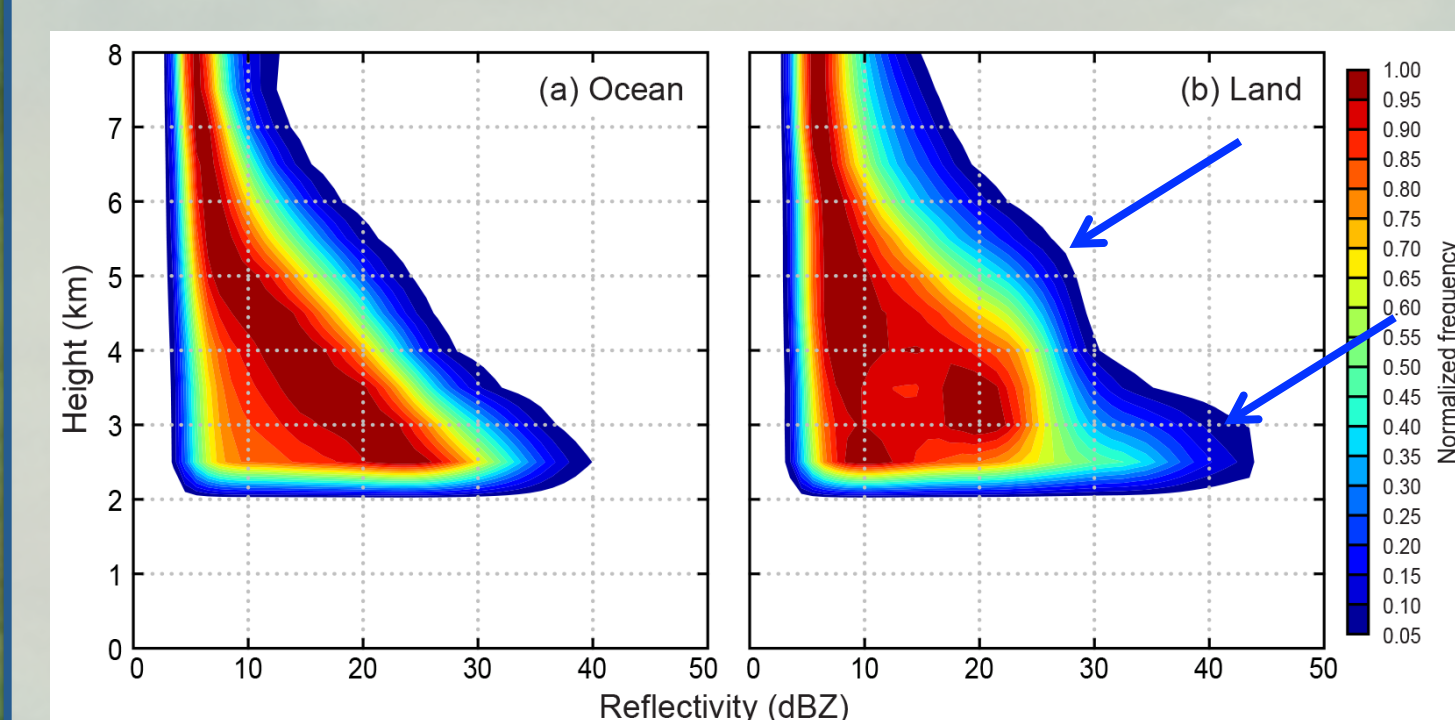
- Increase of precipitation at Prairie Creek due to small drops
- Small drops contribute to ~1/2 of total rain rate in warm sector due to lifting of low level jet
- Secondary enhancement aloft during middle RHI period with large drops due to mesoscale feature aloft (red arrow)

Message for GPM

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



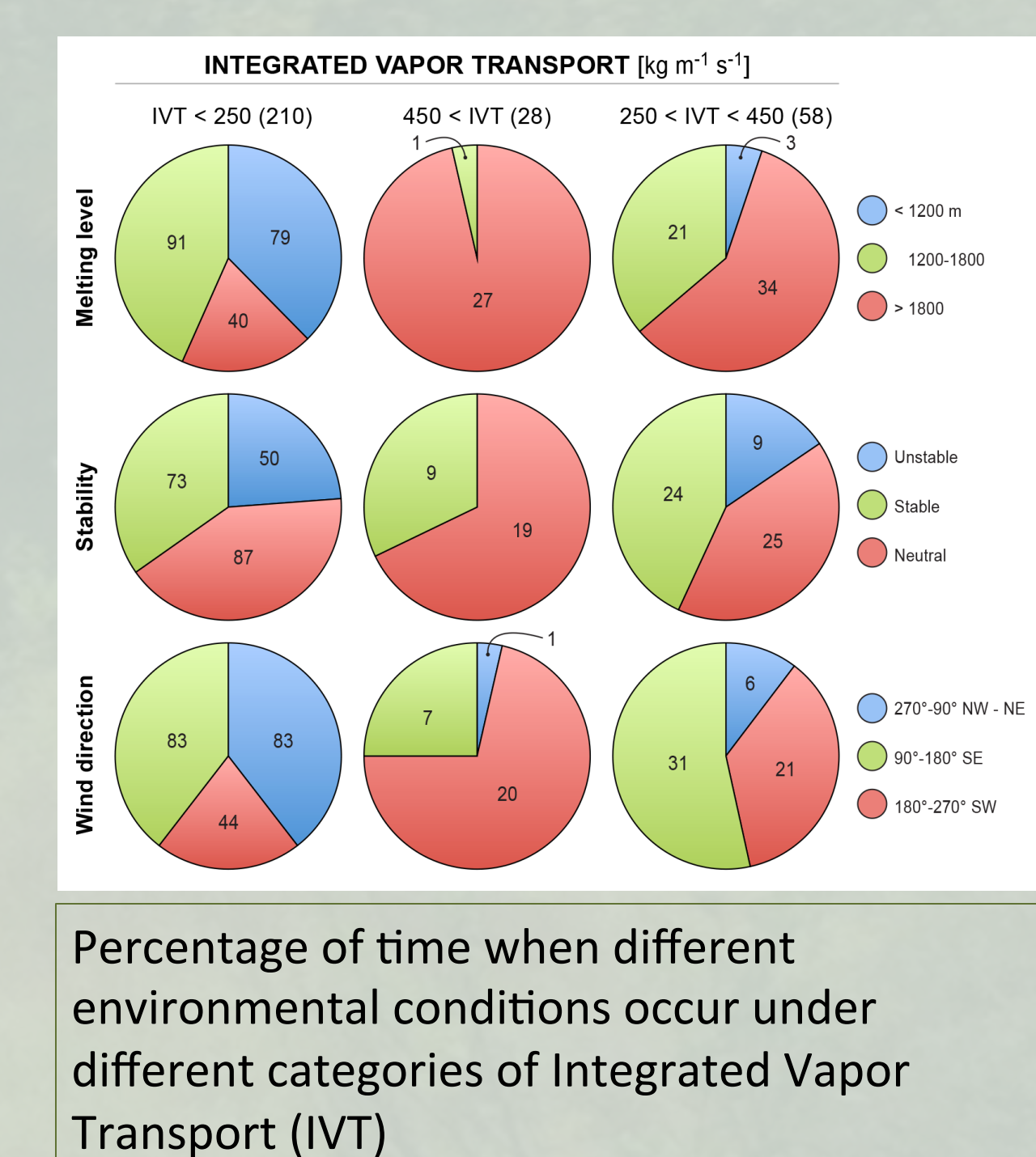
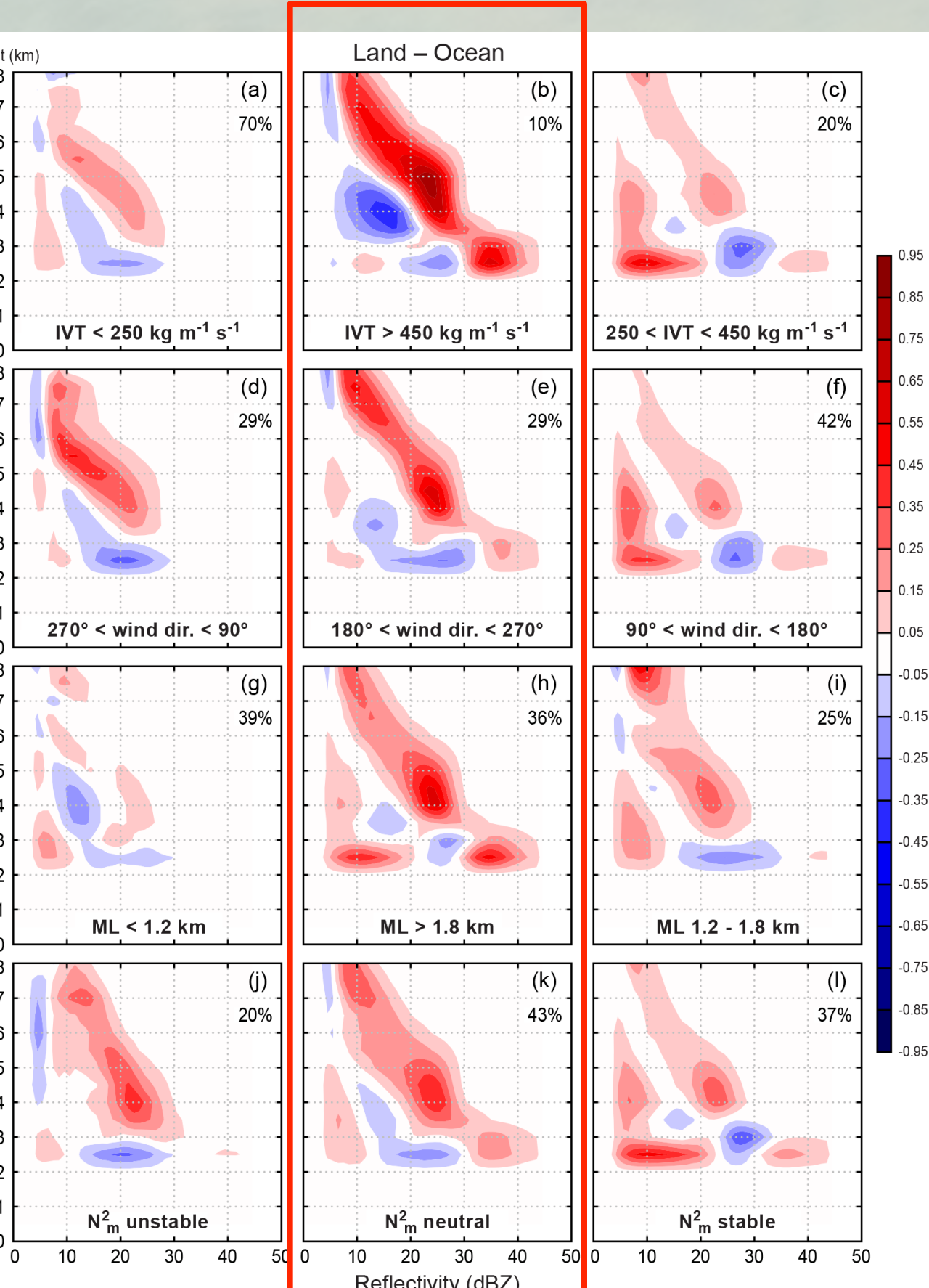
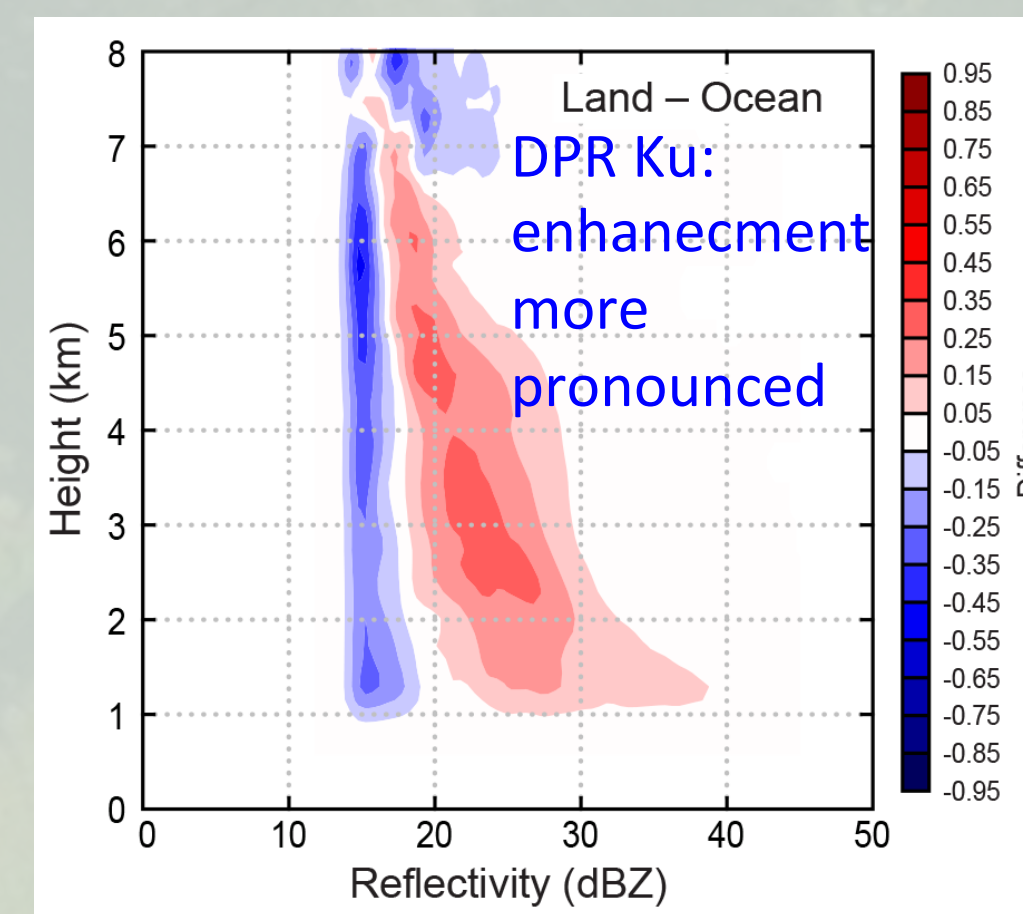
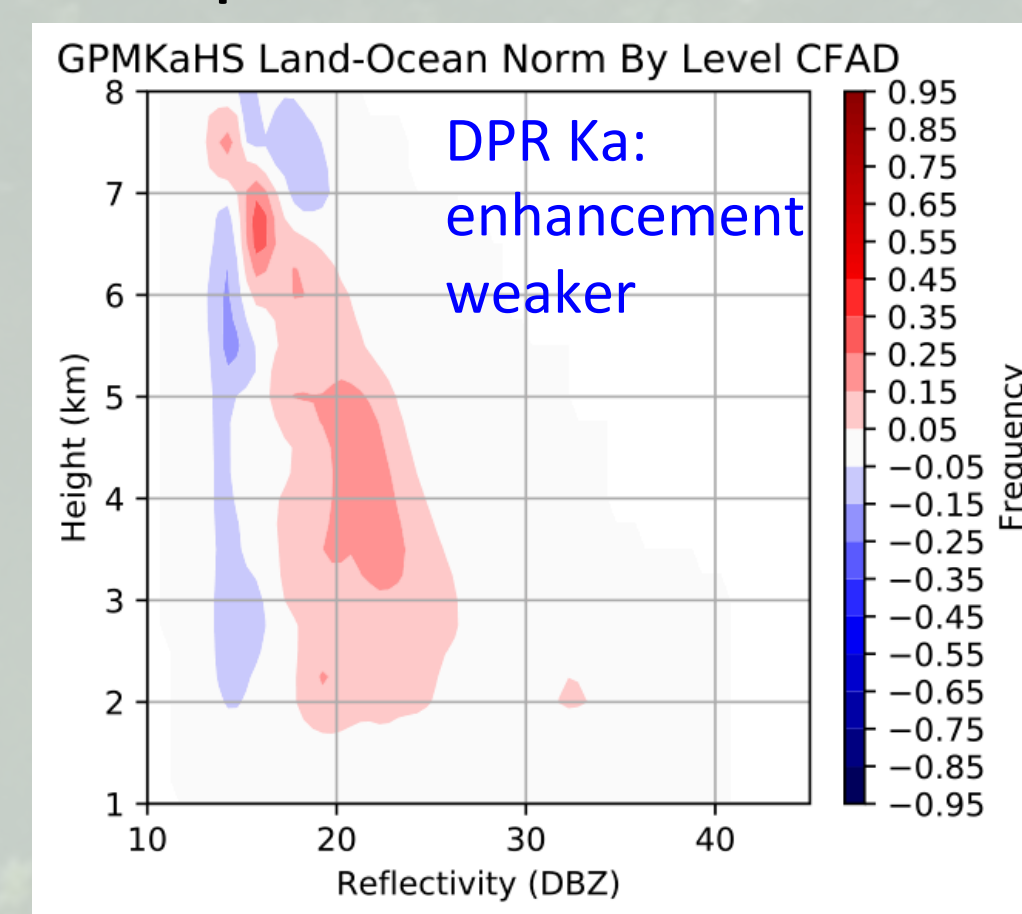
Terrain-Enhanced Precipitation Processes above the Melting Layer



- 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.

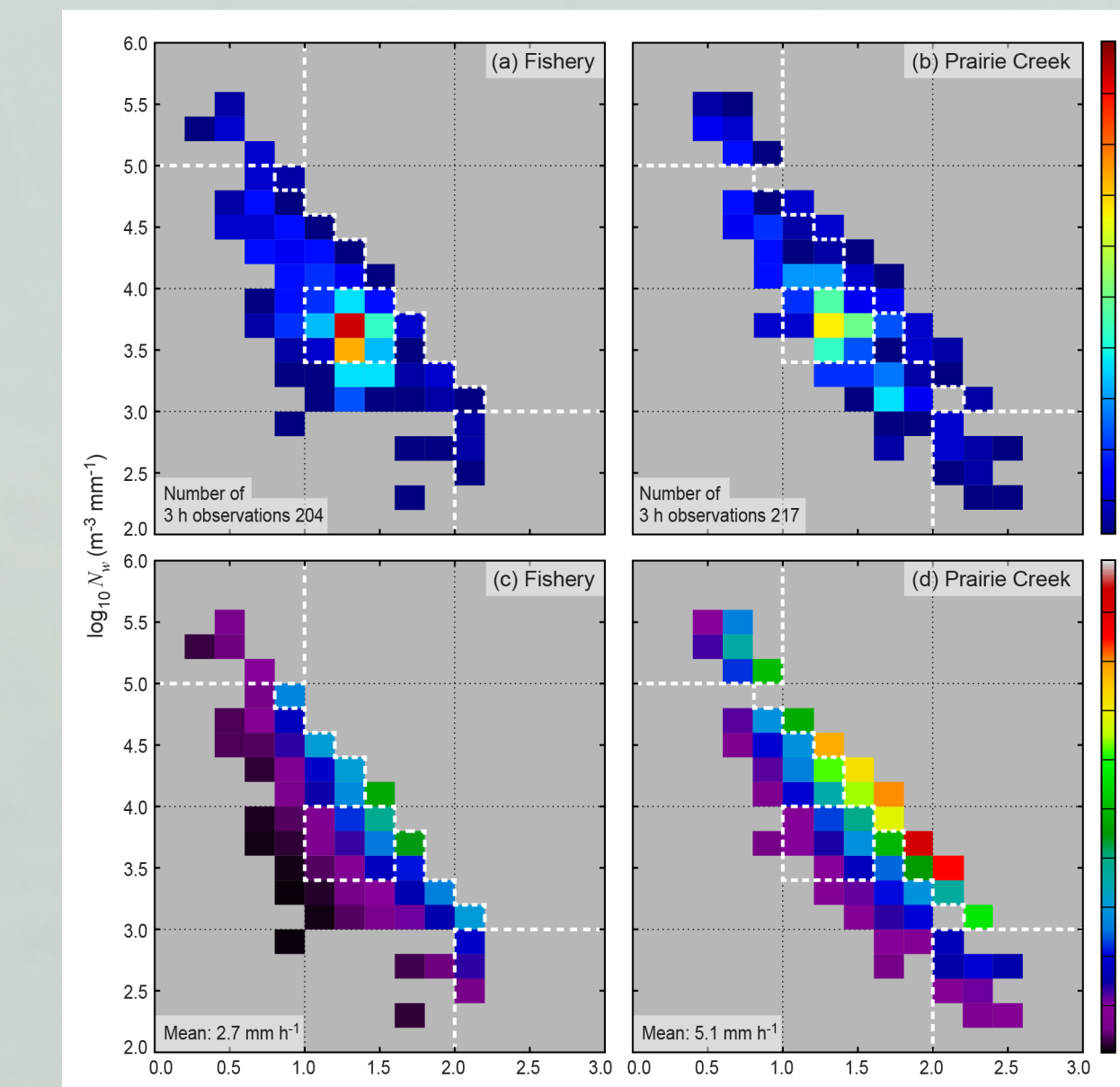
Message for GPM

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



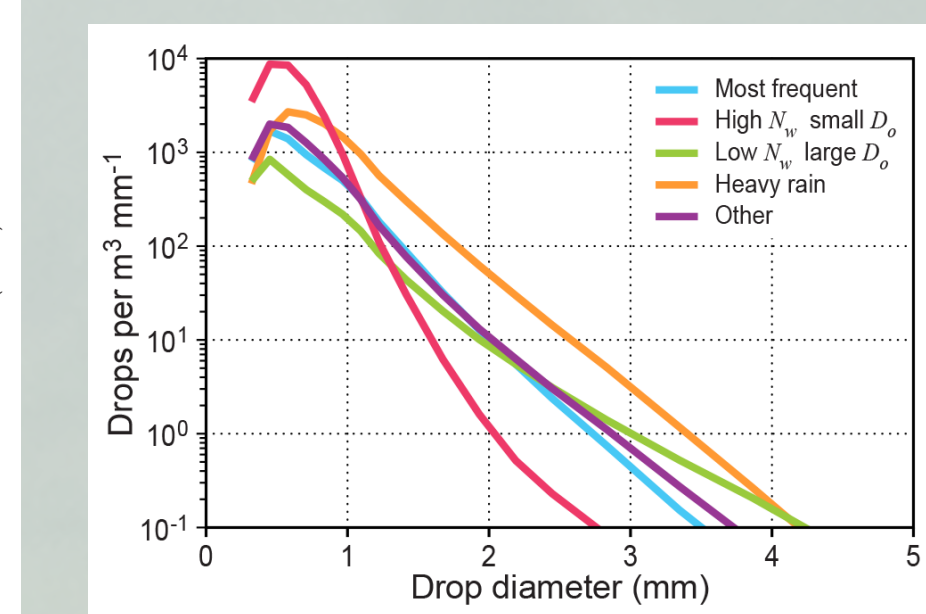
Acknowledgments: Work supported by NASA grants NNX16AK05G, NNX16AD75G, and 80NSSC17K0279. See Houze et al., 2017, BAMS and Zagrodnik et al., 2018, JAS, McMurdie et al. 2018, JGR and Zagrodnik et al., 2018, JAS, all available at olympex.atmos.washington.edu, for more information.

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

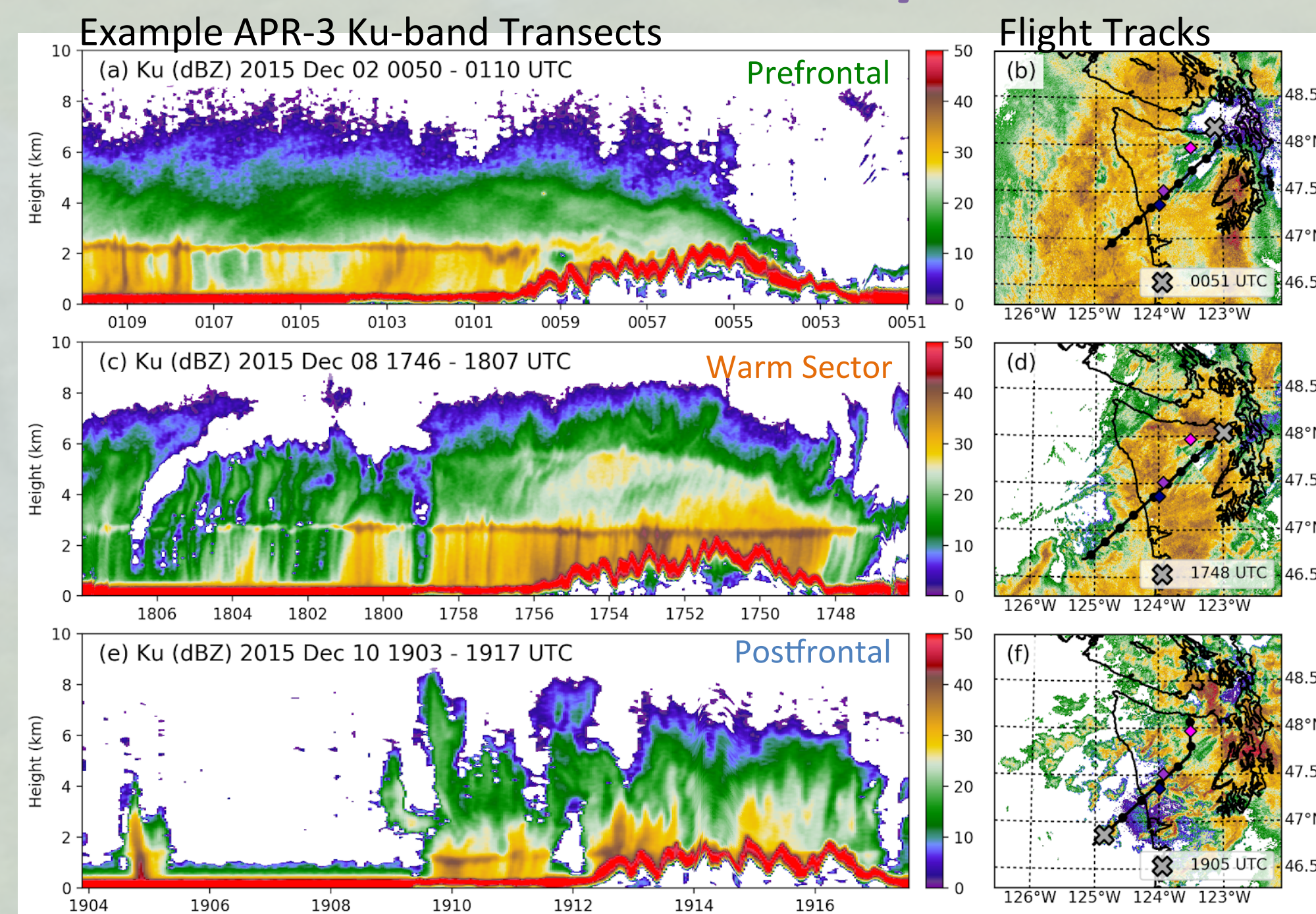
DSD variability with environmental conditions

- 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

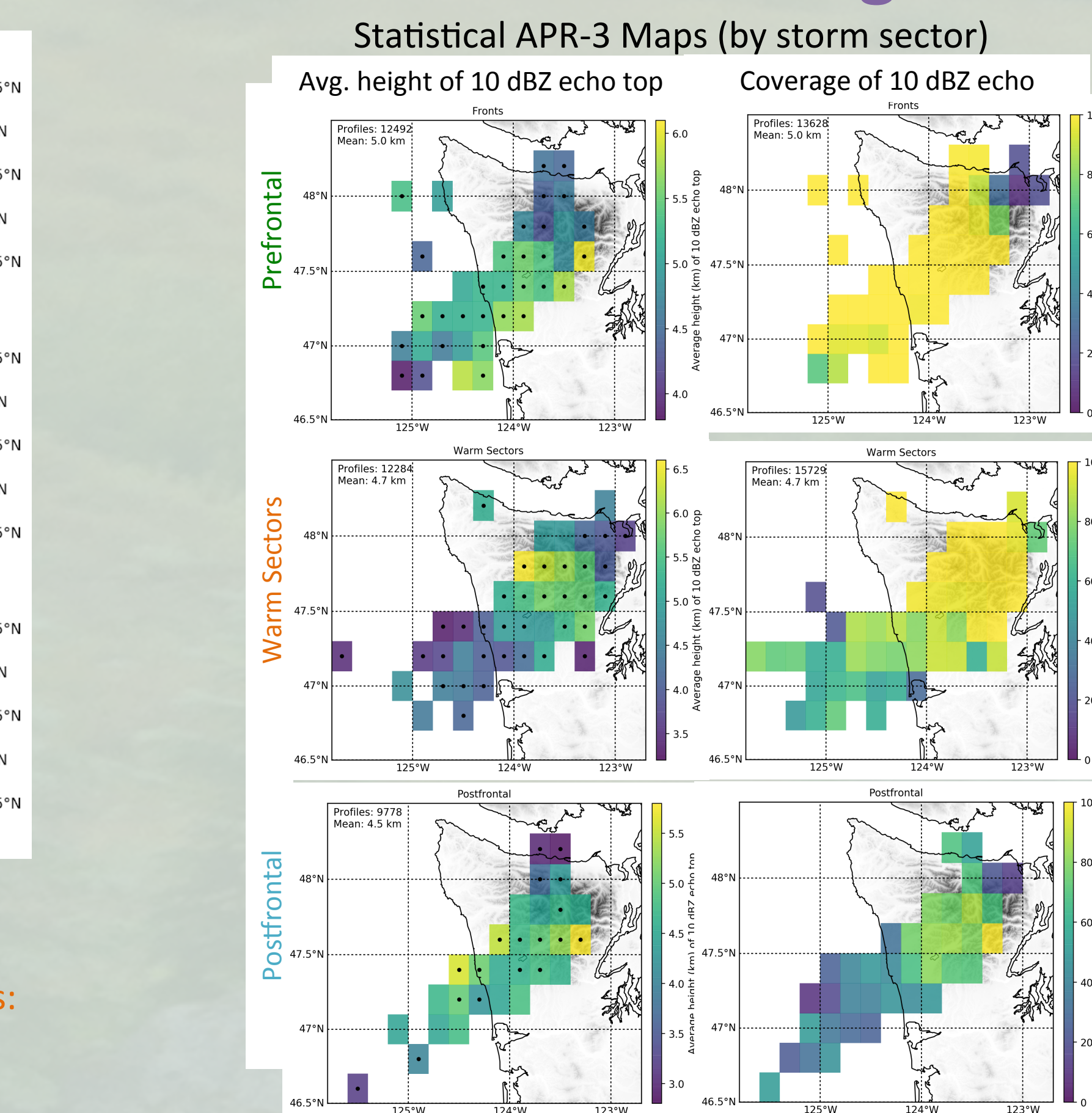
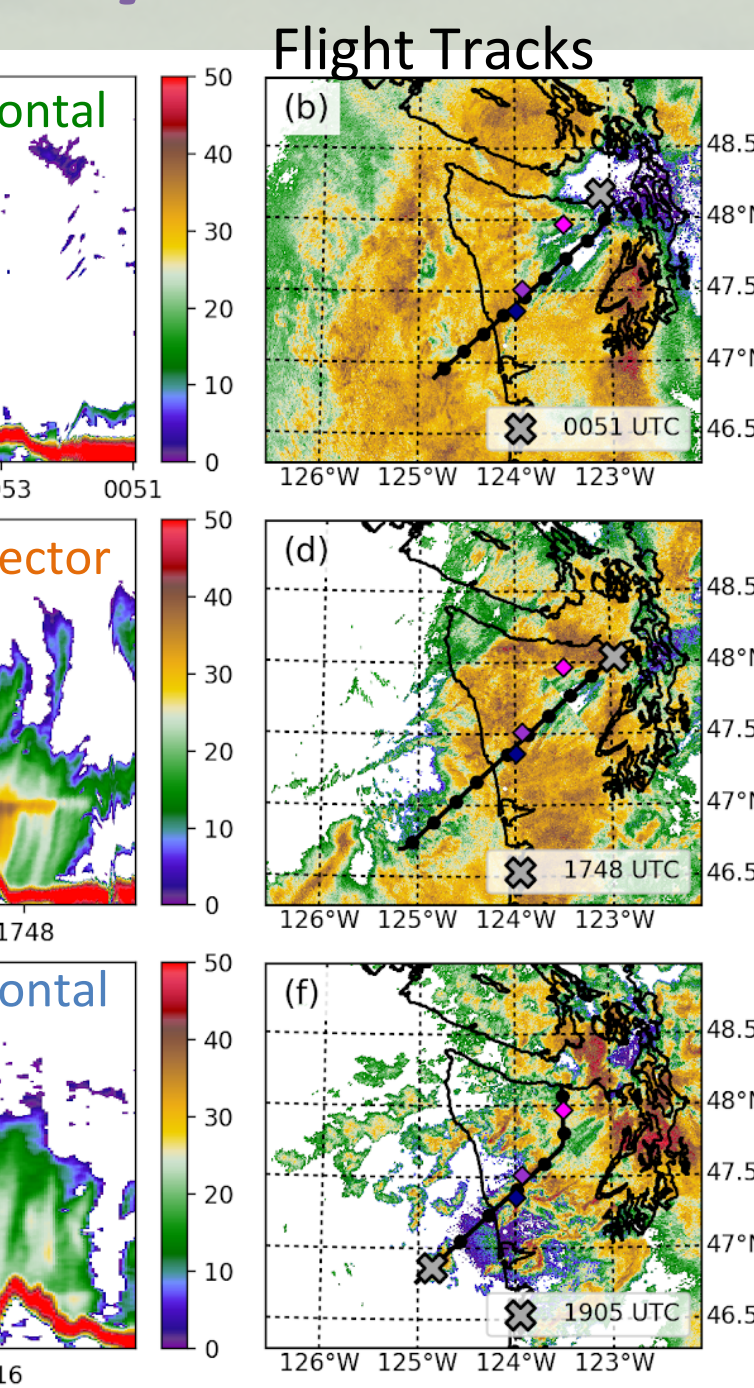
- Modest enhancement on windward slopes similar to overall CFAD from NPOL
- Significant diminishment on lee side at low levels
- Strong rain shadow.

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



Difference CFADS between Region - Ocean

