



# **The Olympic Mountains Experiment (OLYMPEX)**

## **An Opportunity to Explore Terrain- Influenced Precipitation Processes in Mid-Latitude Cyclones**

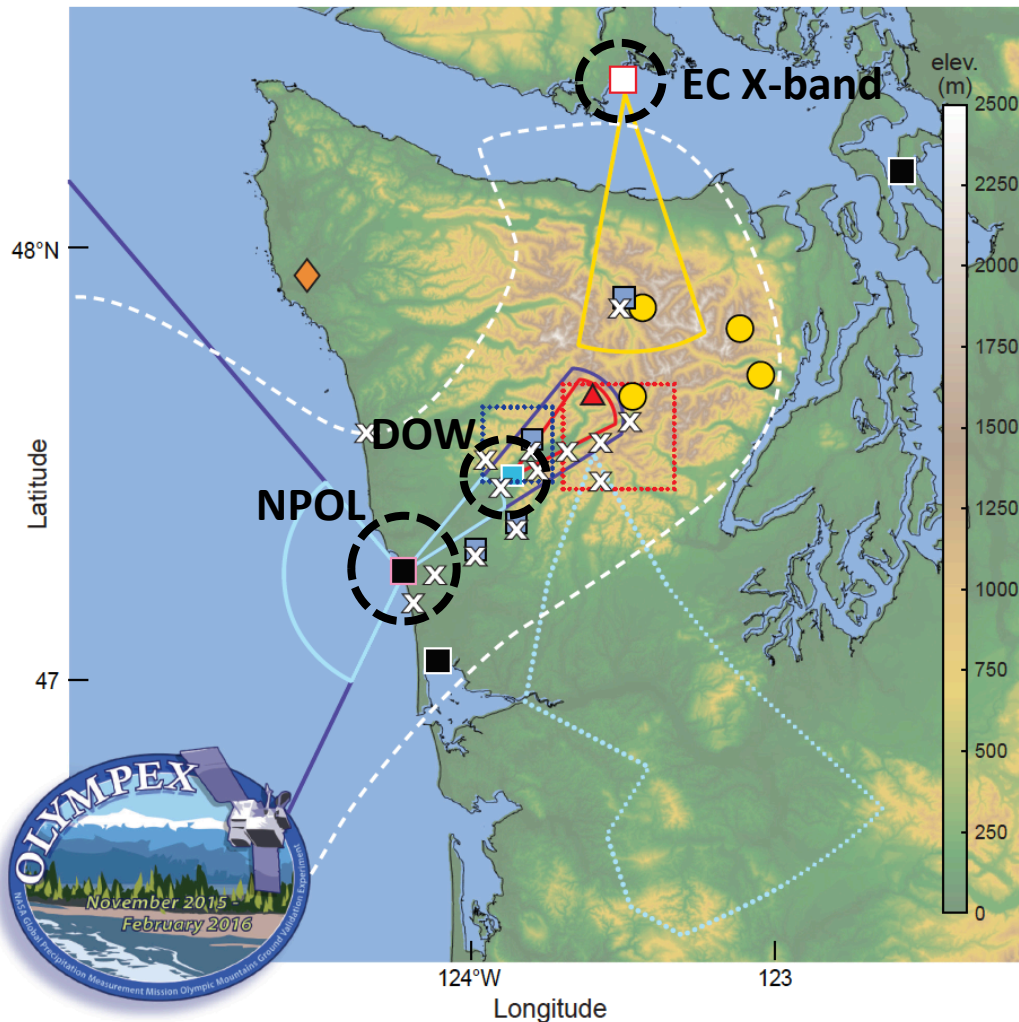
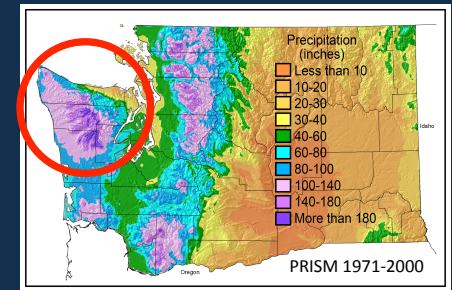
**Angela Rowe**

**Megan Chaplin, Thomas Schuldt, Joe Zagrodnik,  
Robert A. Houze, Jr., Lynn McMurdie**  
*University of Washington, Seattle, WA*

AMS 38<sup>th</sup> Conference on Radar Meteorology  
Chicago, IL  
31 August 2017



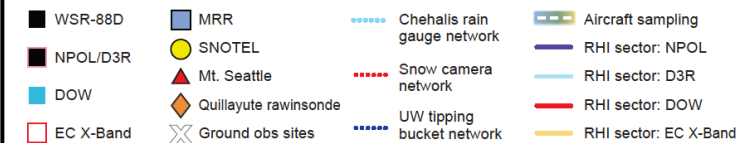
# OLYMPEX



**October 2015 – April 2016**

- Ground sites (snow, rain)
- Soundings
- Aircraft
- Ground-based radars (NPOL, DOW6, EC)

**Windward, high terrain,  
leeside**



Houze et al. (2017), in press



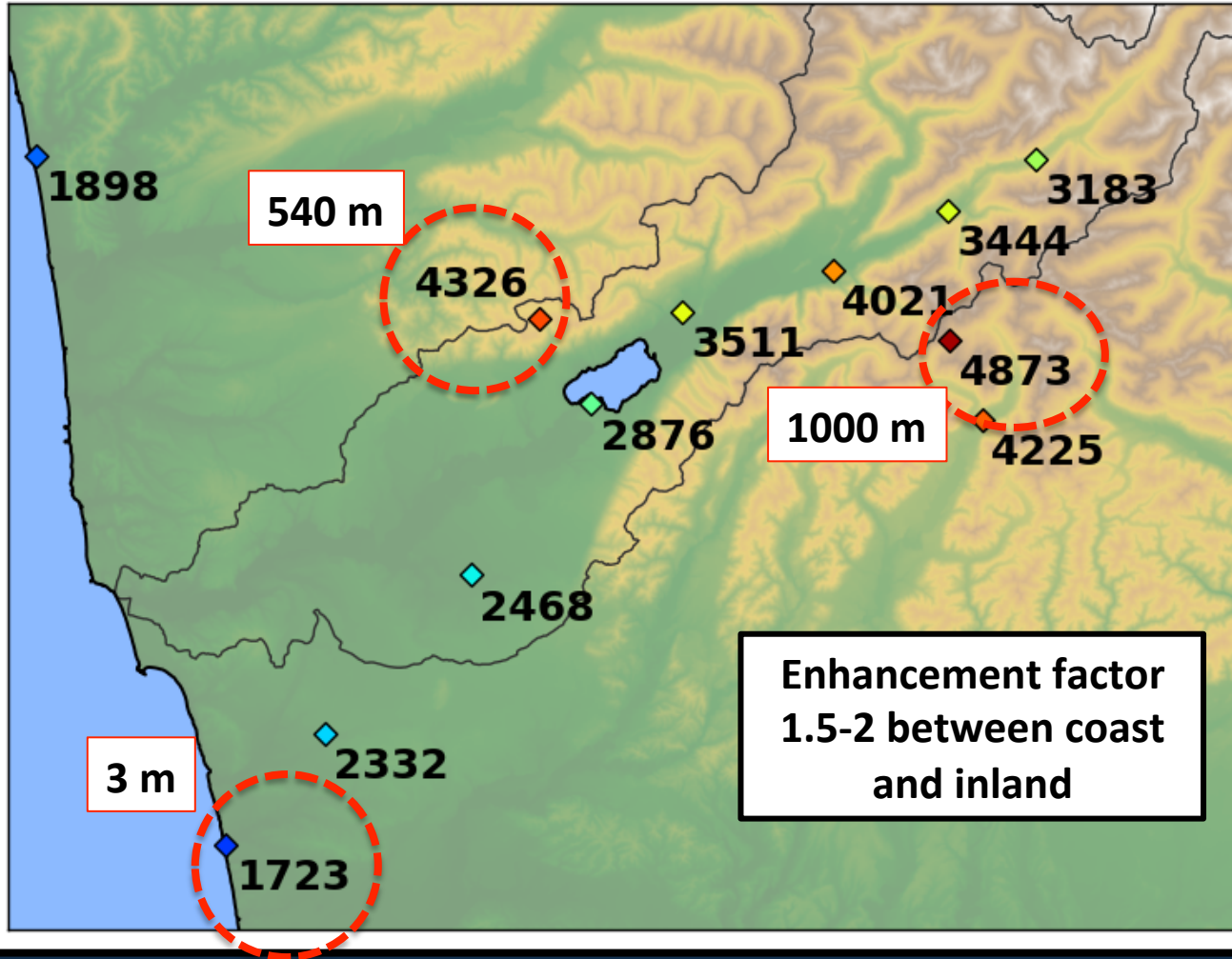
# Doppler on Wheels ~~Water~~ Water





# OLYMPEX Precipitation

OLYMPEX Precip (mm) 10-Nov-2015 to 1-May-2016



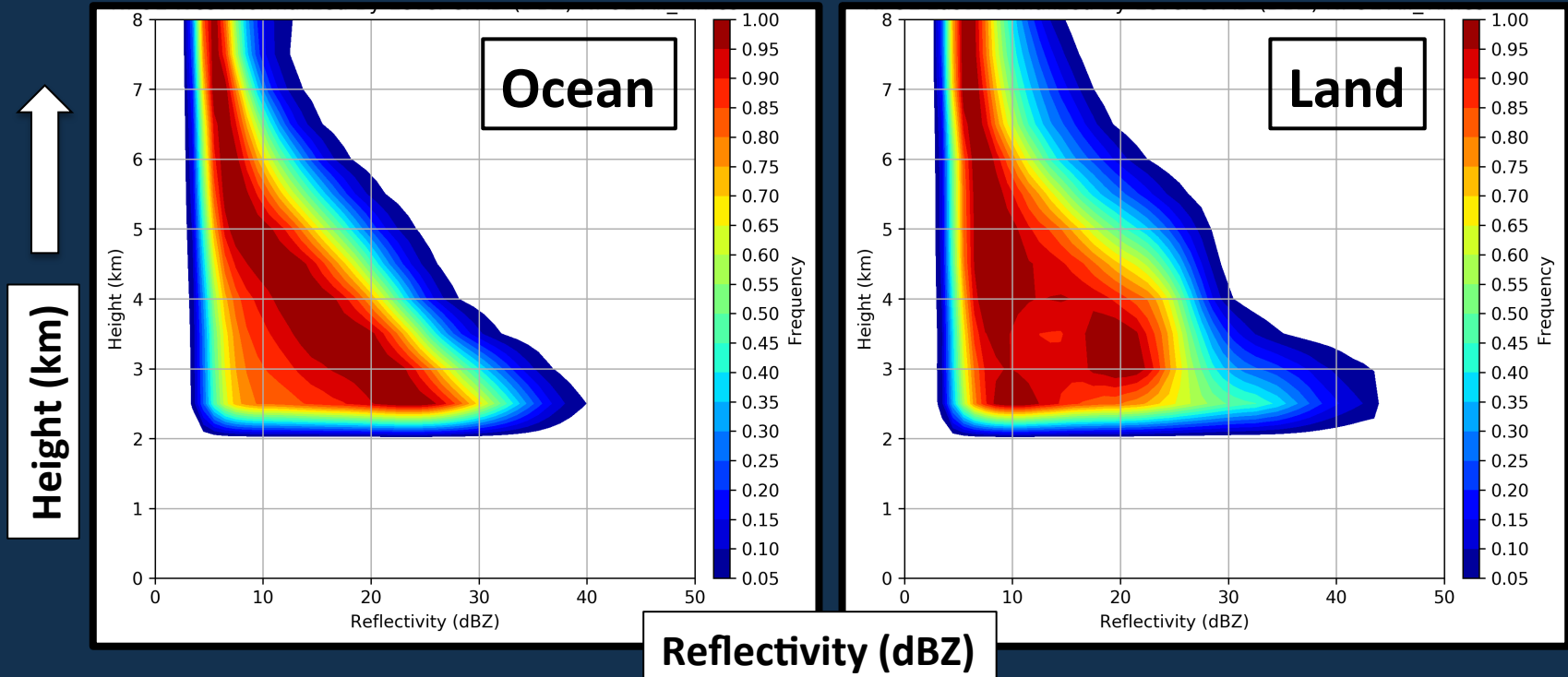
~65 frontal systems  
(warm/cold, sectors, degrees of enhancement)

What can radar tell us about precipitation processes leading to enhancement?

Houze et al.  
(2017), in press



# NPOL – Ocean vs. Land



12 Nov – 18 Dec, 3-15 Jan

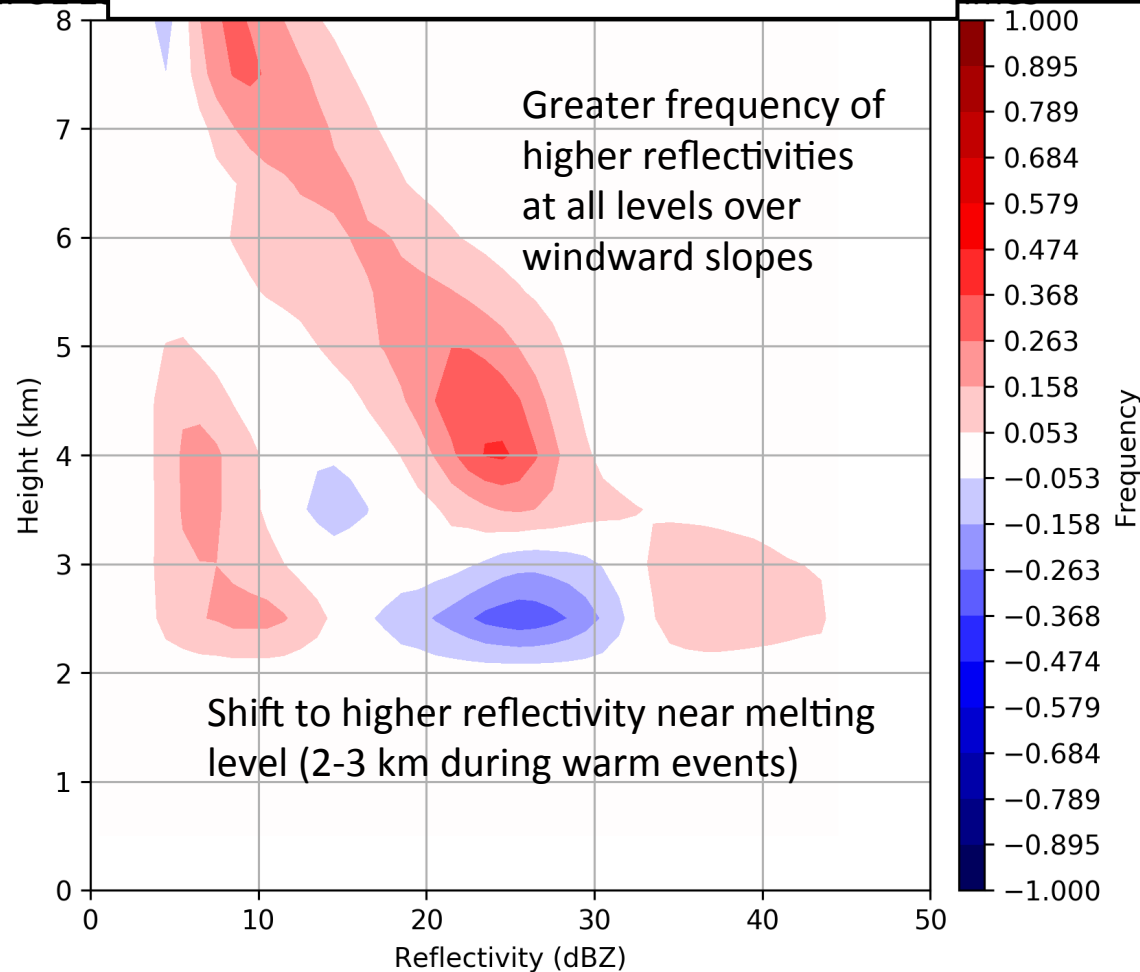
## Contoured Frequency by Altitude Diagrams

Frequencies normalized by level for all NPOL RHI data over ocean and land above 2 km height



# Orographic enhancement

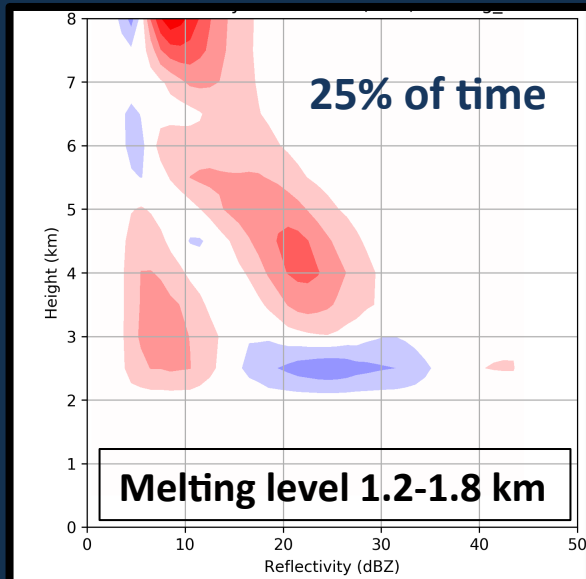
## Land – Ocean Difference CFAD



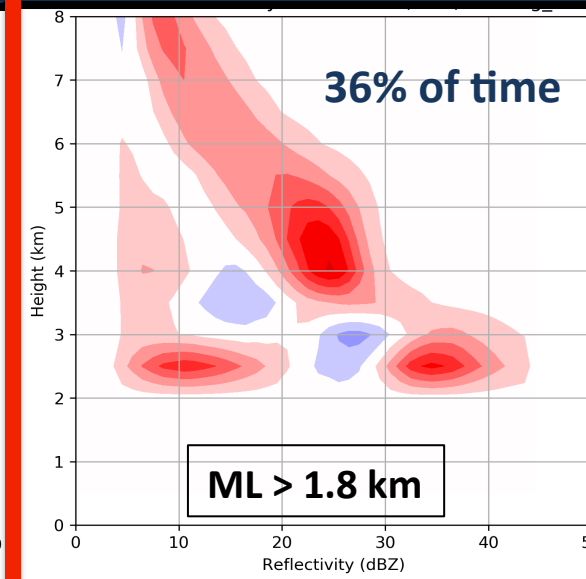
- Dominated by certain events? Dependence on environmental conditions?
- Partition NPOL data by environmental parameters from NARR at NPOL site
  - Melting level height
  - Moist static stability
  - Integrated vapor transport
  - Wind direction



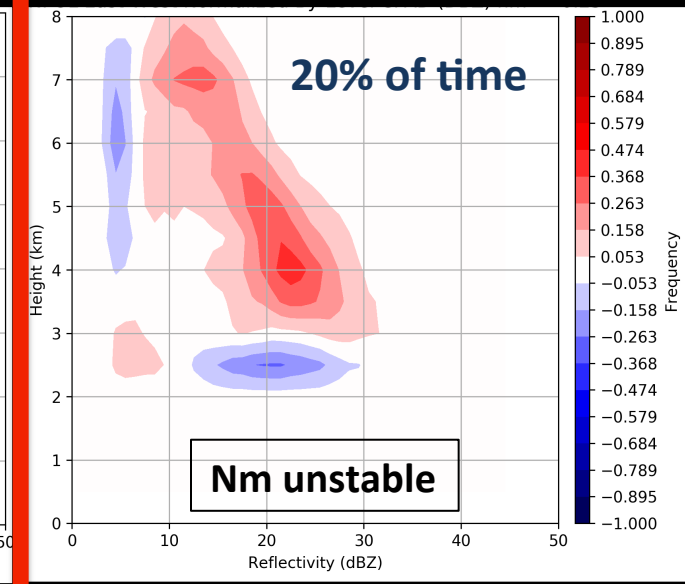
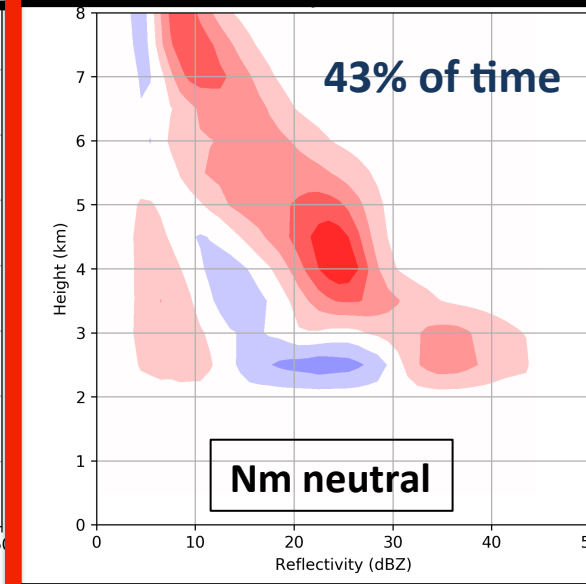
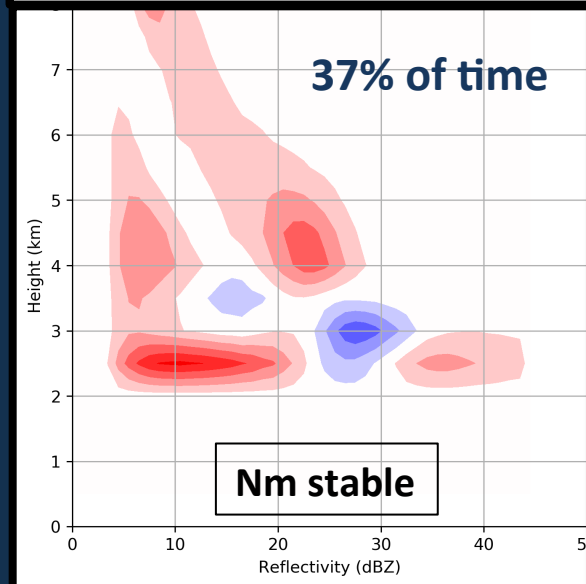
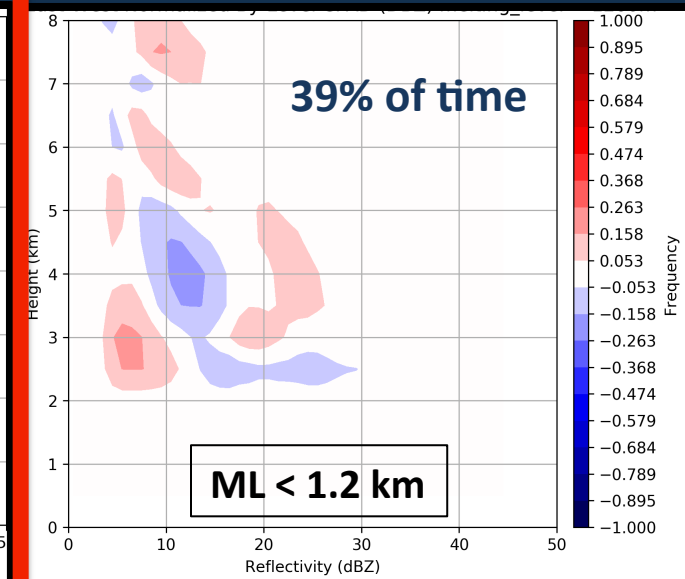
## ~Pre-frontal



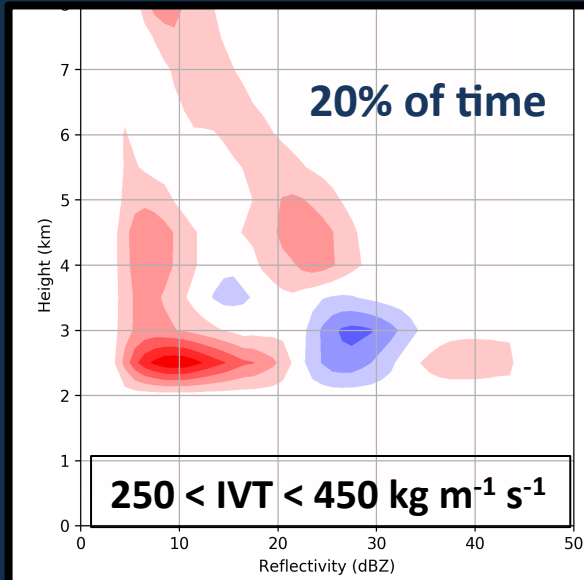
## ~Warm sector



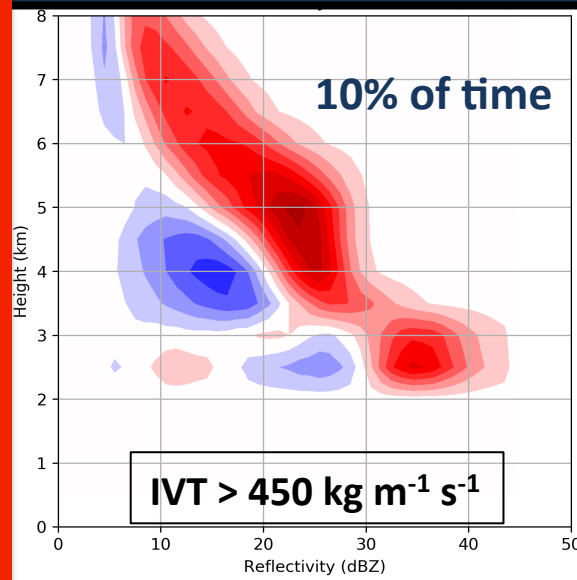
## ~Post frontal



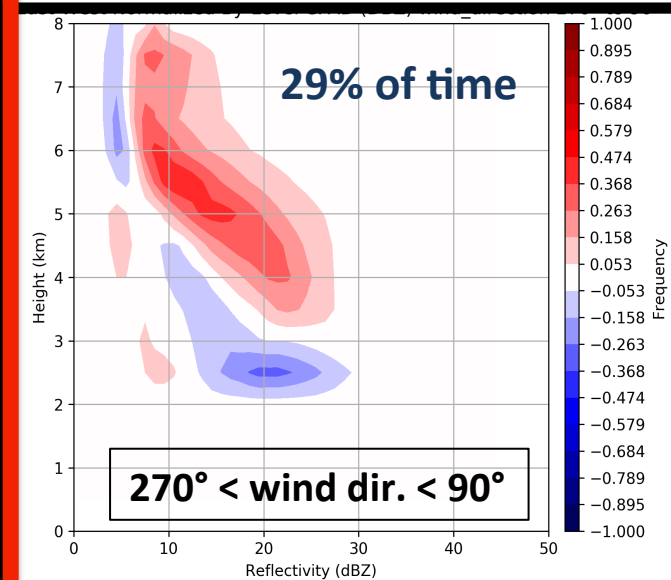
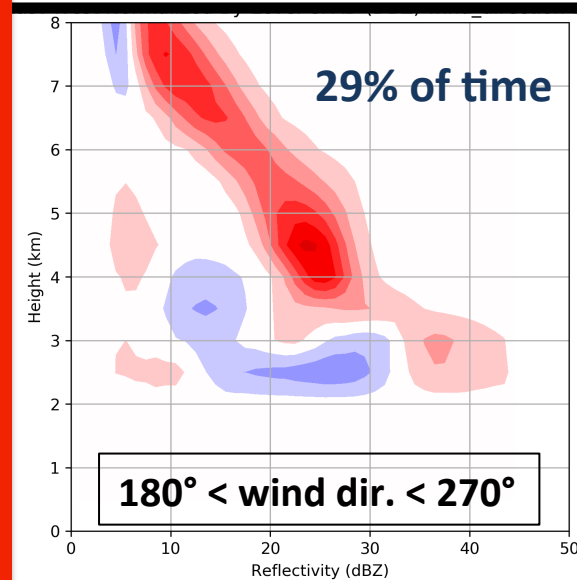
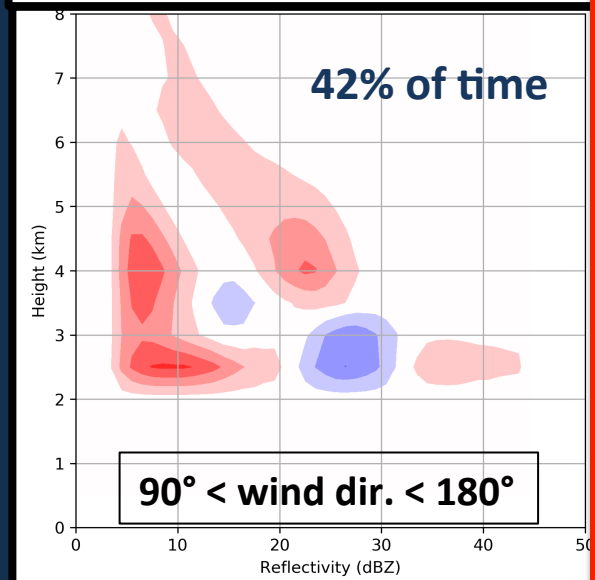
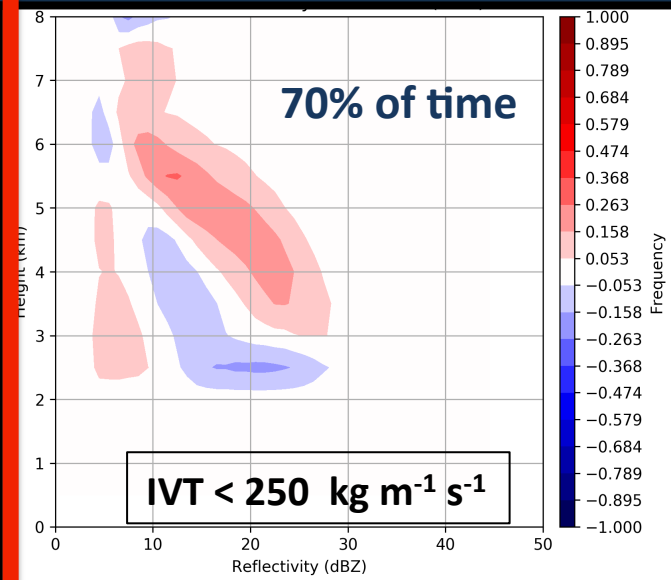
## ~Pre-frontal



## ~Warm sector

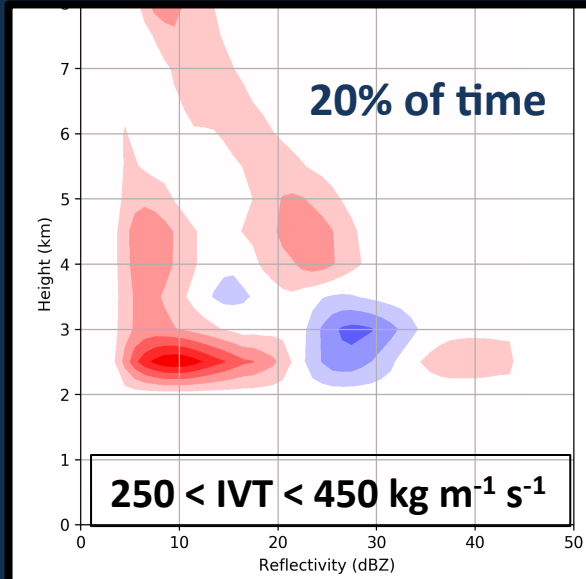


## ~Post frontal

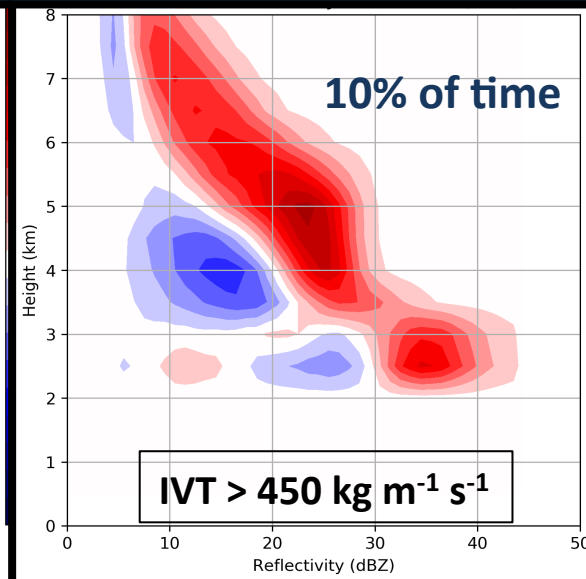




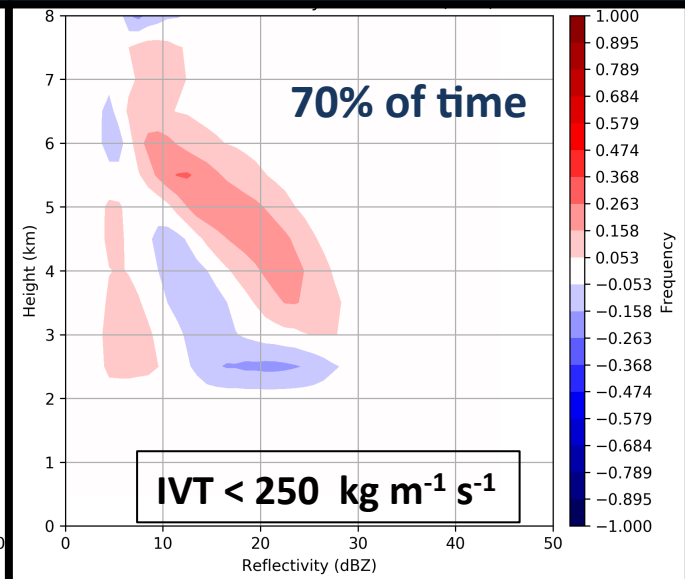
~Pre-frontal



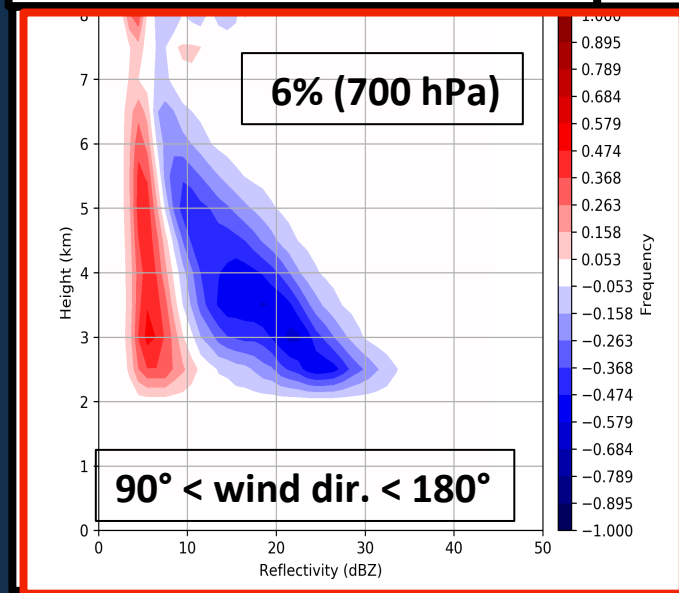
~Warm sector



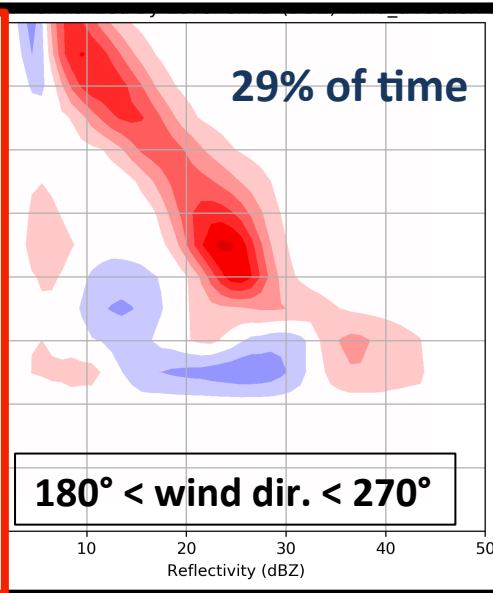
~Post frontal



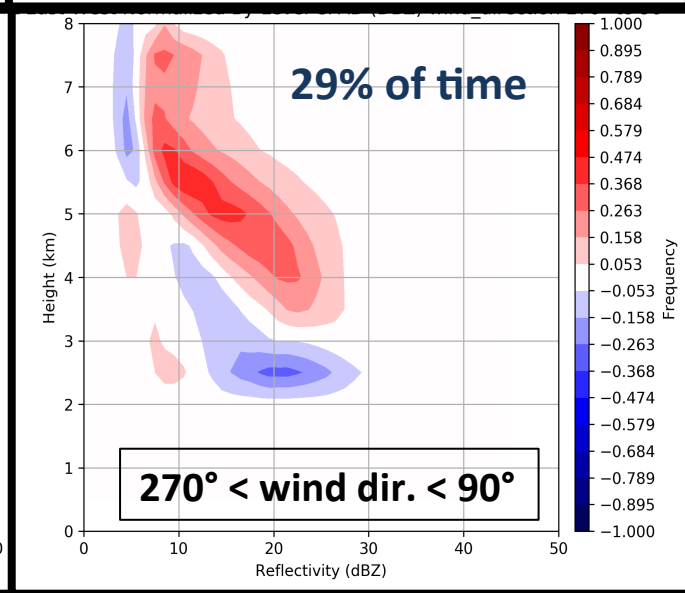
6% (700 hPa)



29% of time

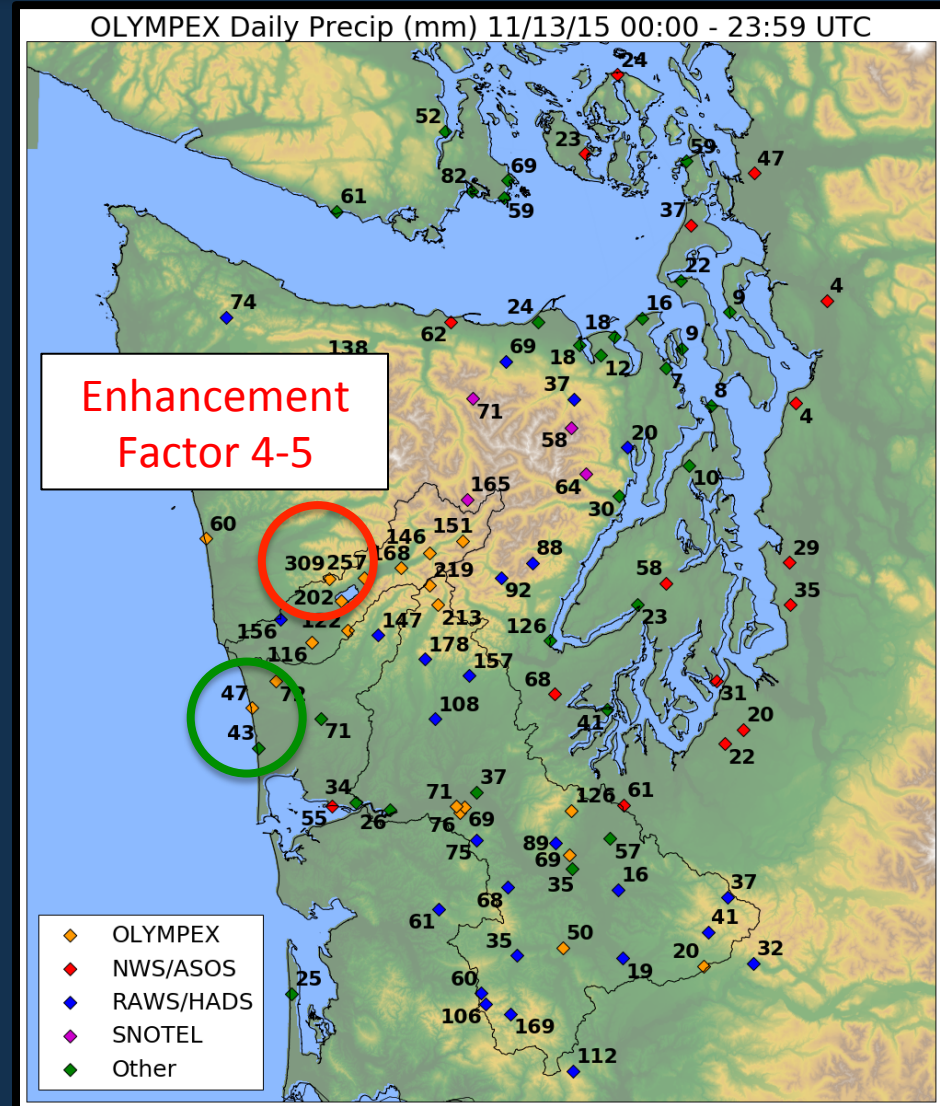
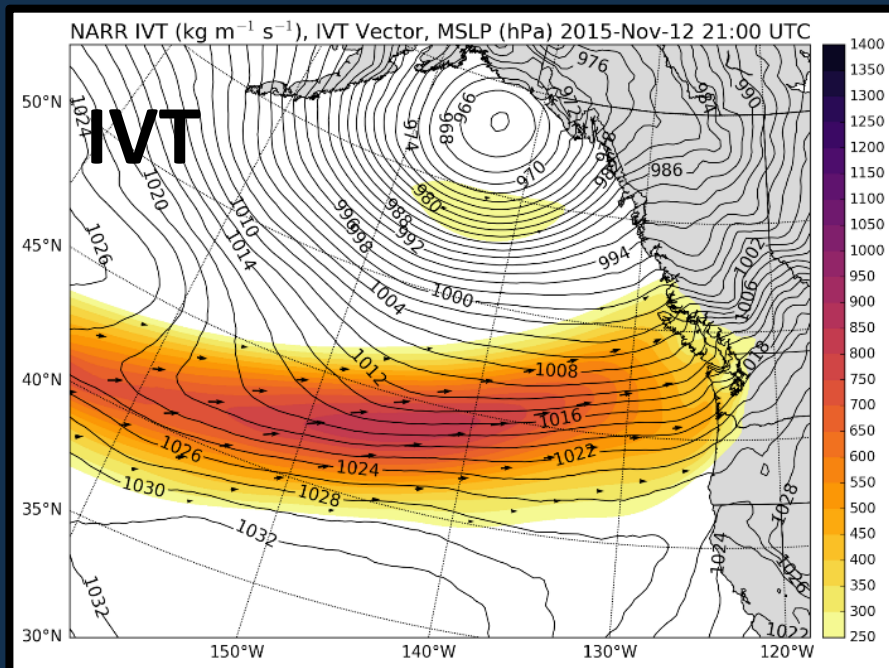


29% of time



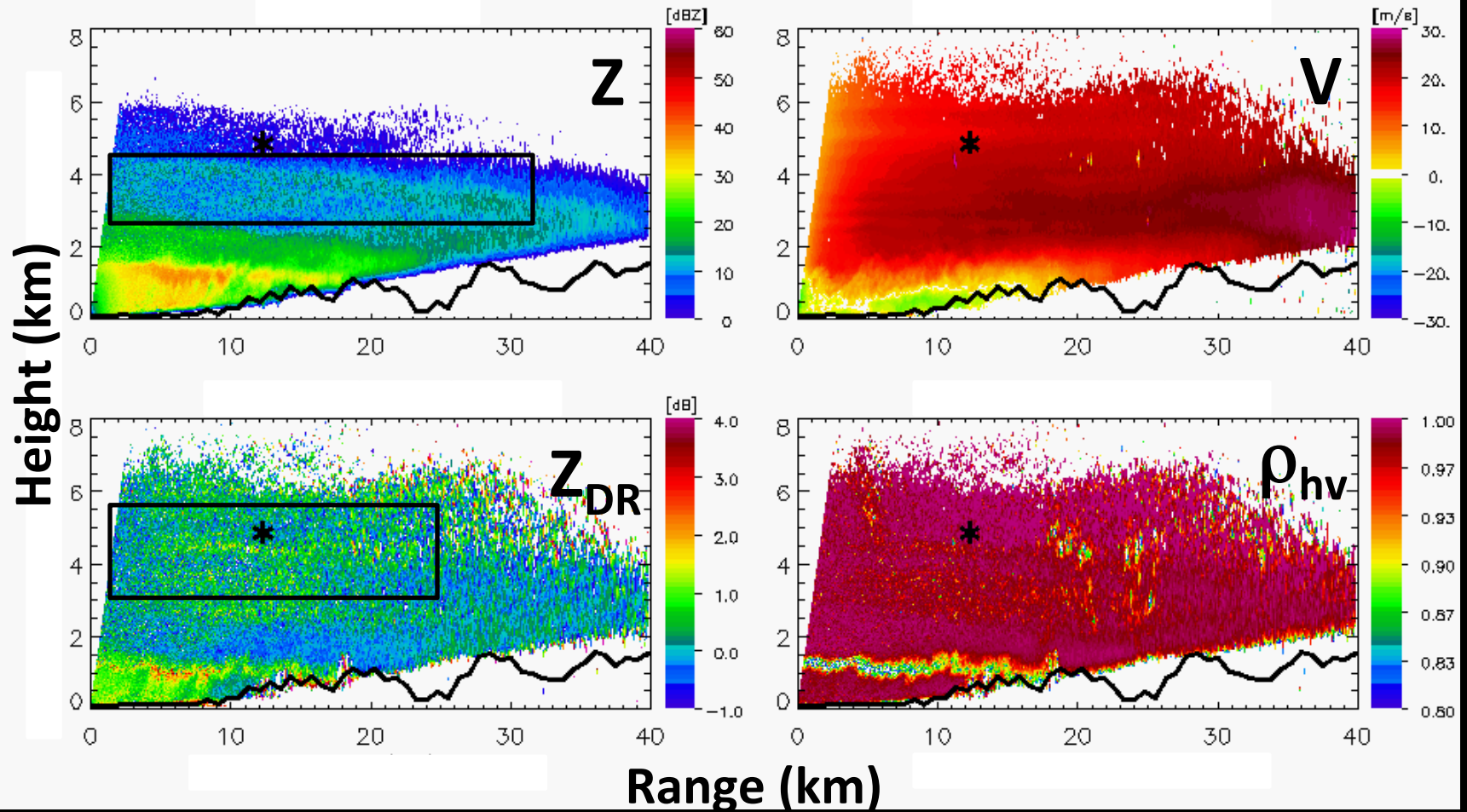
- Upper-level enhancement in reflectivity in almost all scenarios, with greatest enhancement associated with:
  - ✓ **Large IVT**
  - ✓ **High melting level**
  - ✓ **Neutral moist stability**
  - ✓ **Strong low-level southwesterly winds**
- Warm sector (Atmospheric River)
  - Also highest rain rates (Zagrodnik et al. 2017)

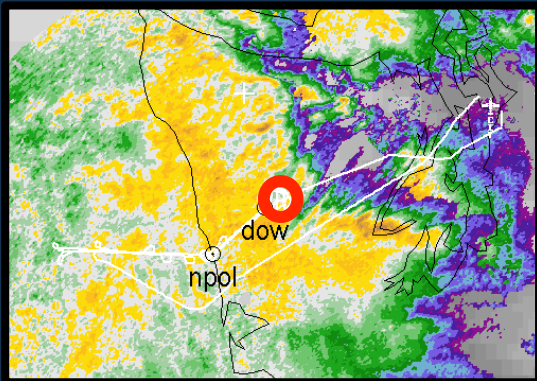
# 12- 13 November 2015



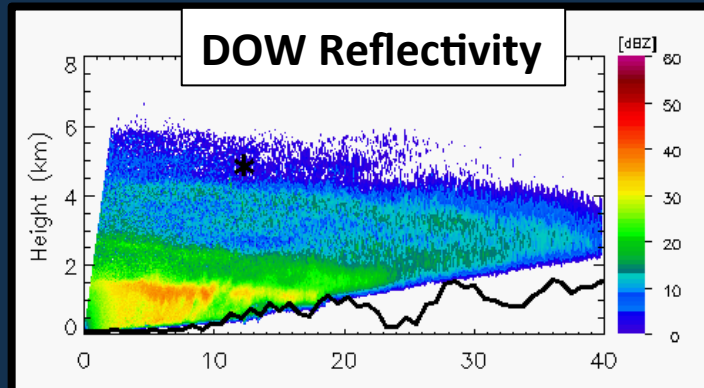


# 1948 UTC 12 Nov 2015 - DOW





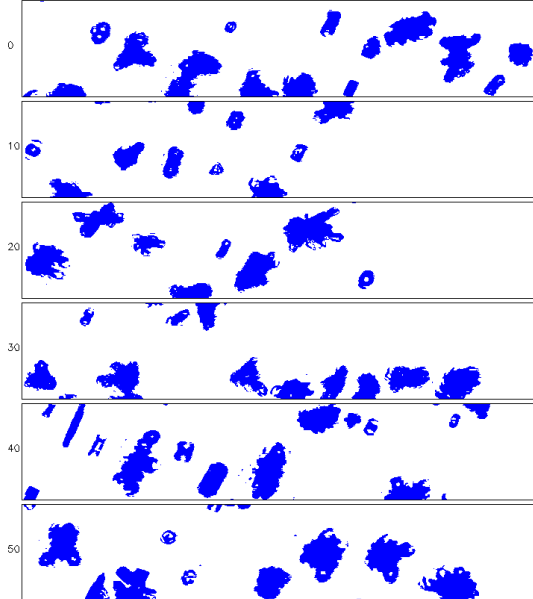
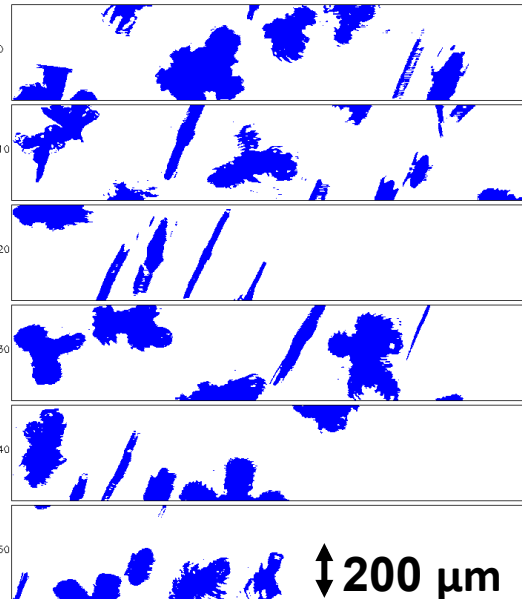
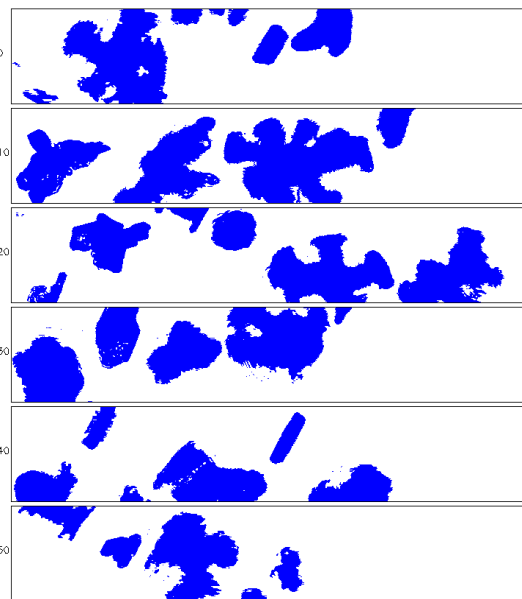
12 Nov 2015  
Citation



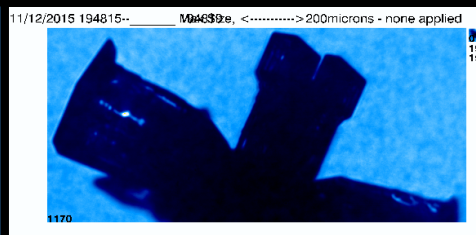
$-9^{\circ}\text{C}$  (4 km)

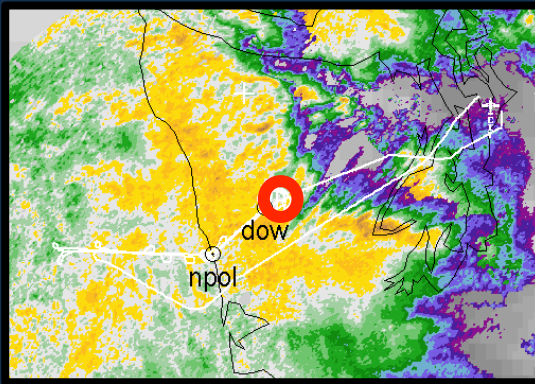
$-17^{\circ}\text{C}$  (5 km)

$-26^{\circ}\text{C}$  (6 km)

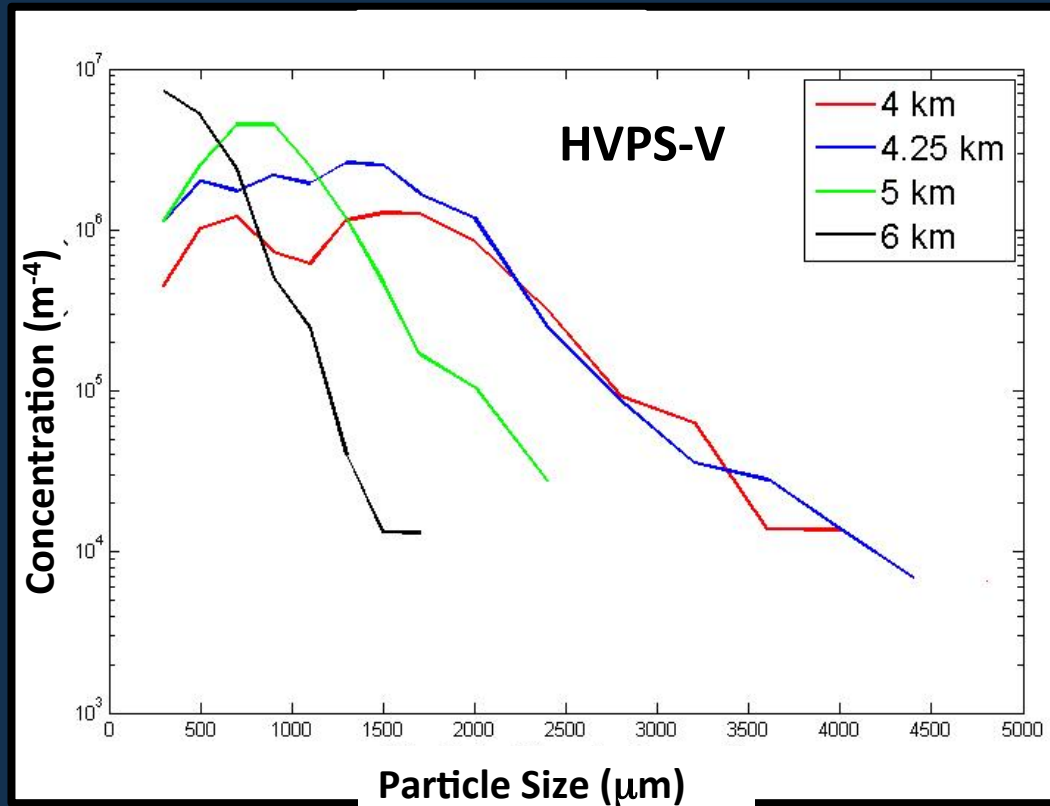
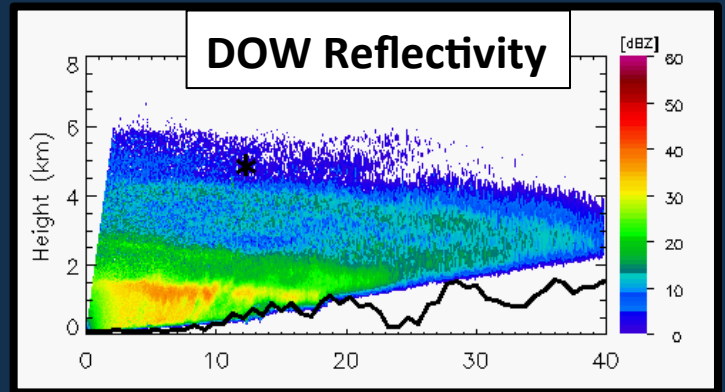


2DSV: 10–1280  $\mu\text{m}$





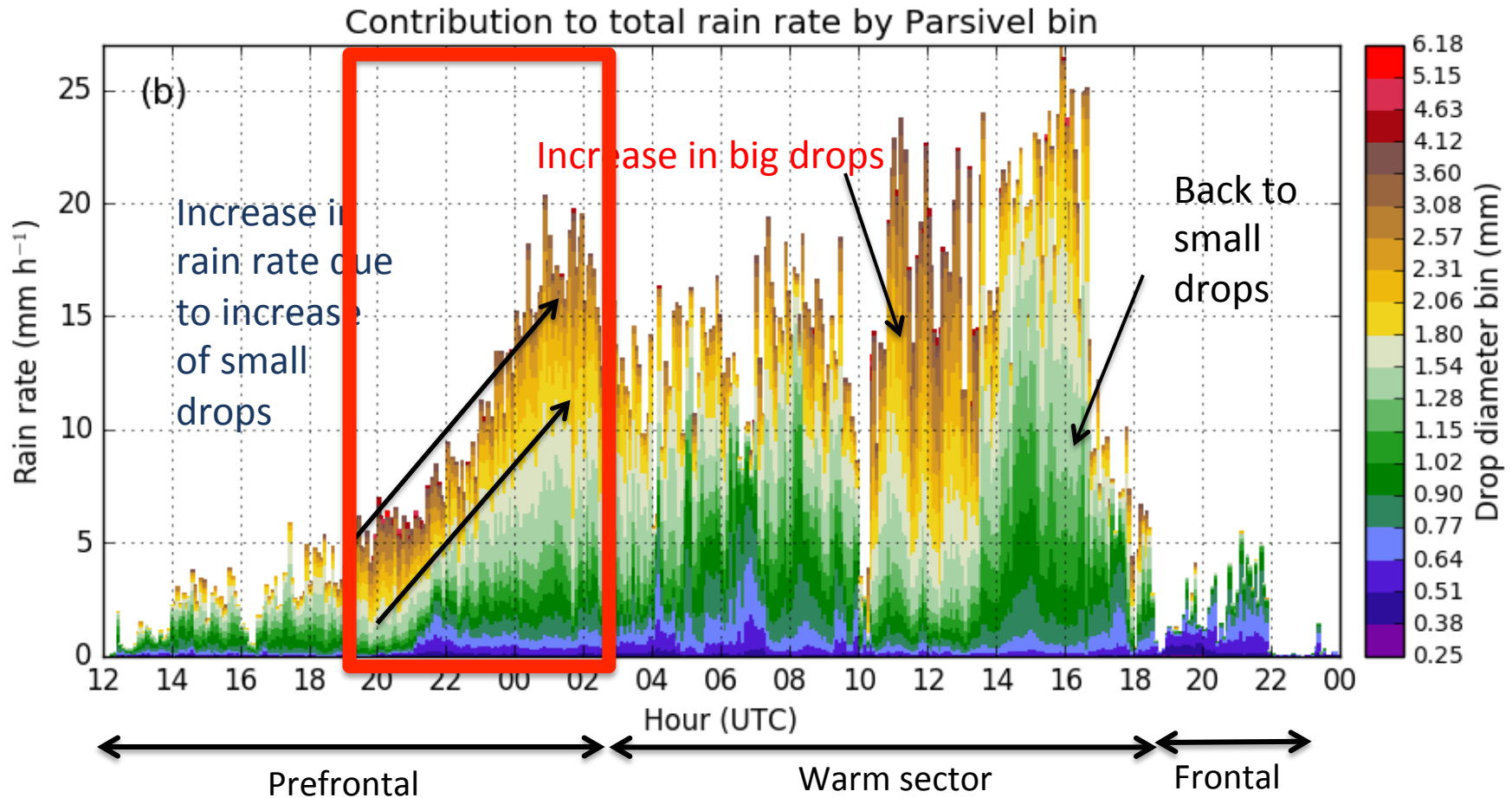
**12 Nov 2015  
Citation**

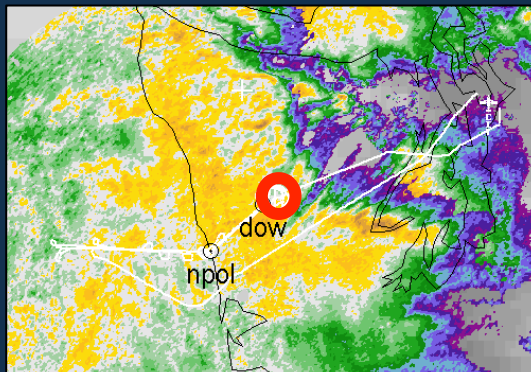


- Greater reflectivity
- Larger particles
- Many bullet rosettes
- Some aggregating

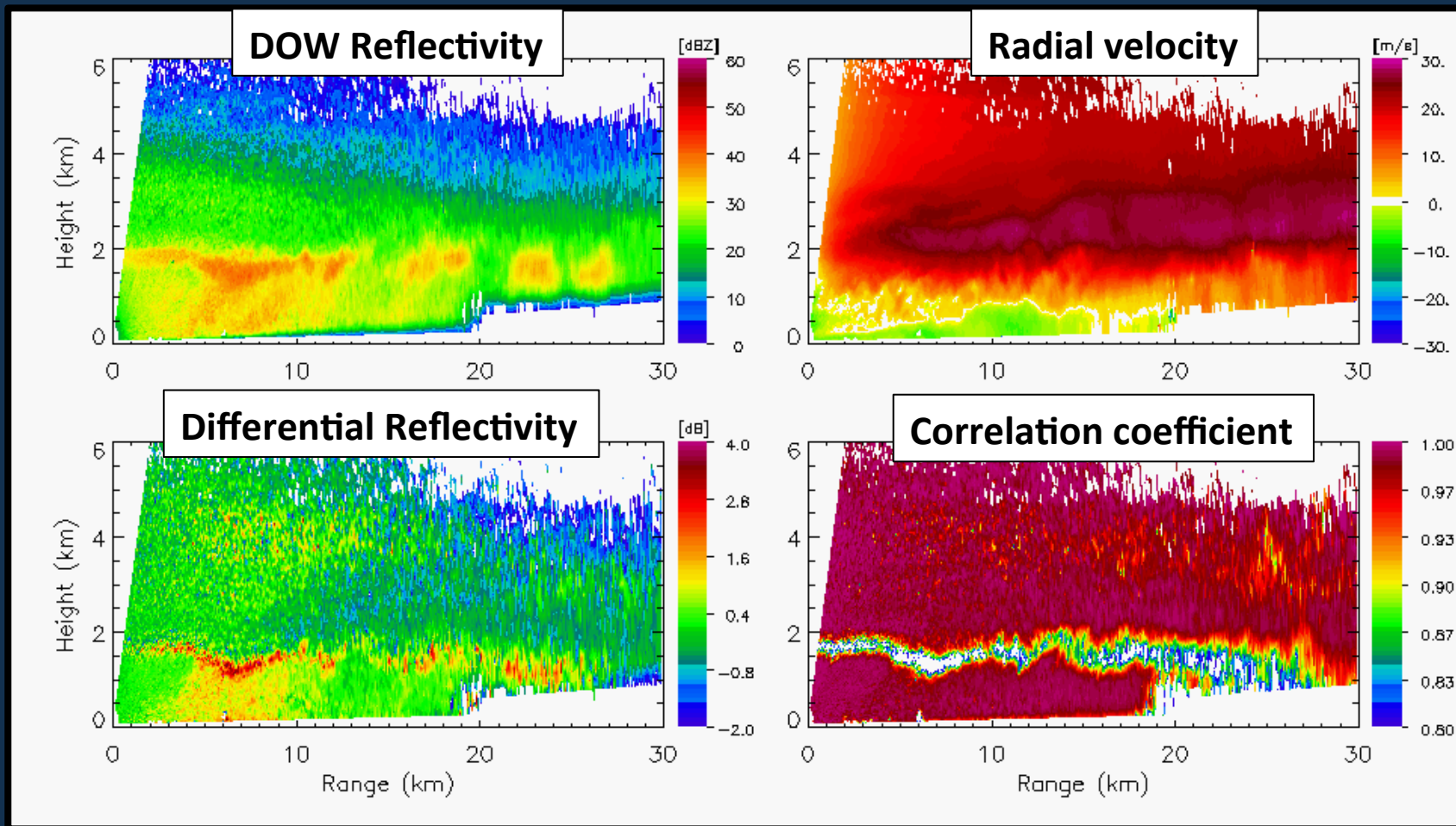
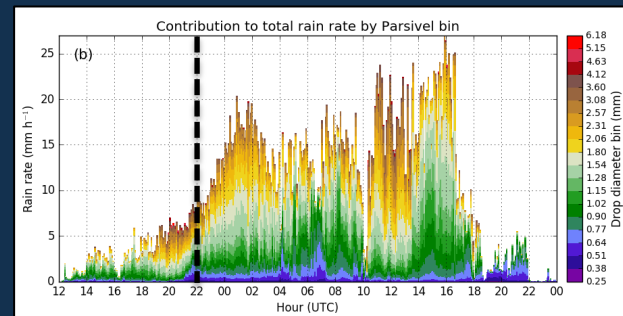


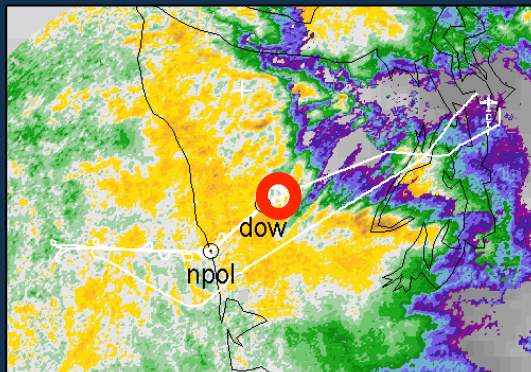
# 12-13 November 2015 – 540 m



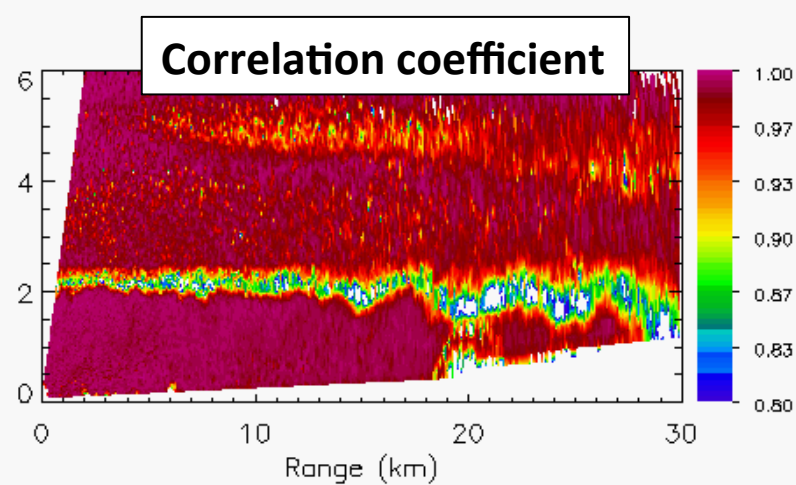
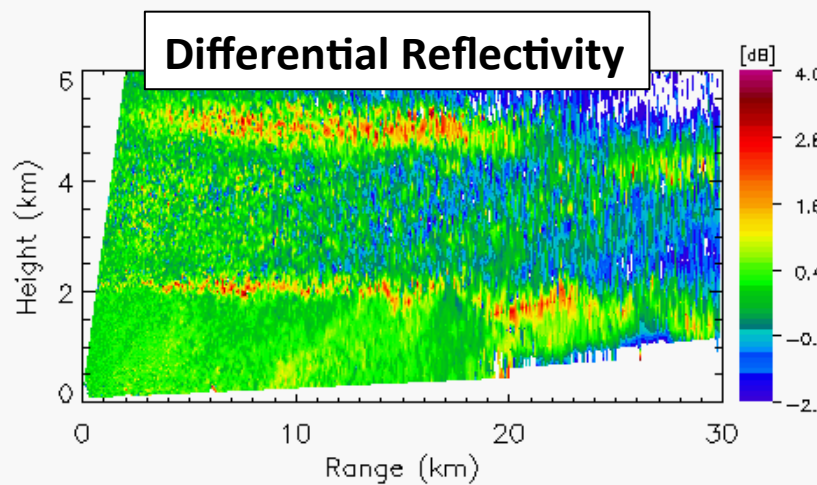
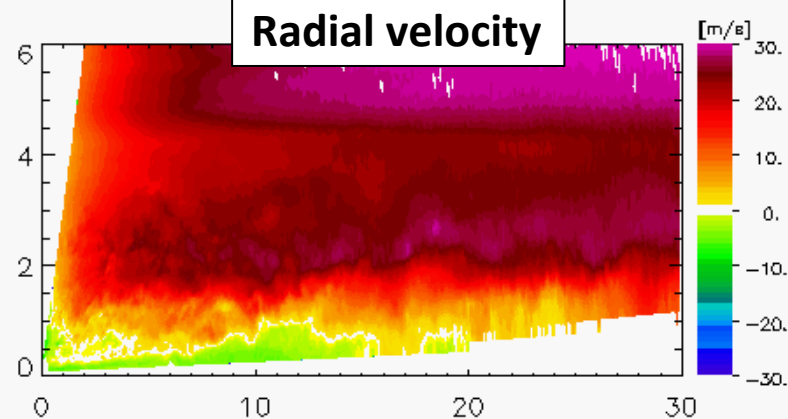
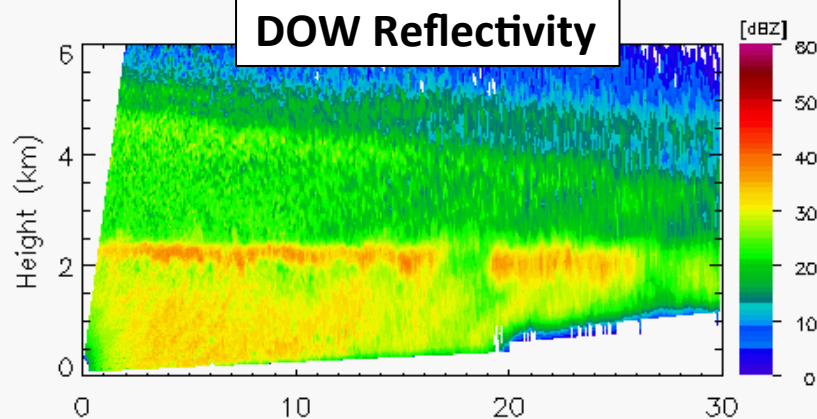


**12 Nov 2015  
2210 UTC  
(prefrontal)**

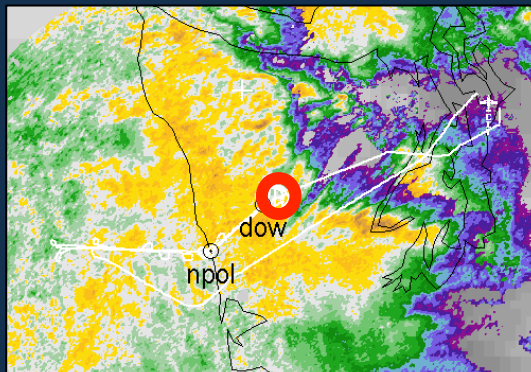




**13 Nov 2015  
0110 UTC  
(prefrontal)**

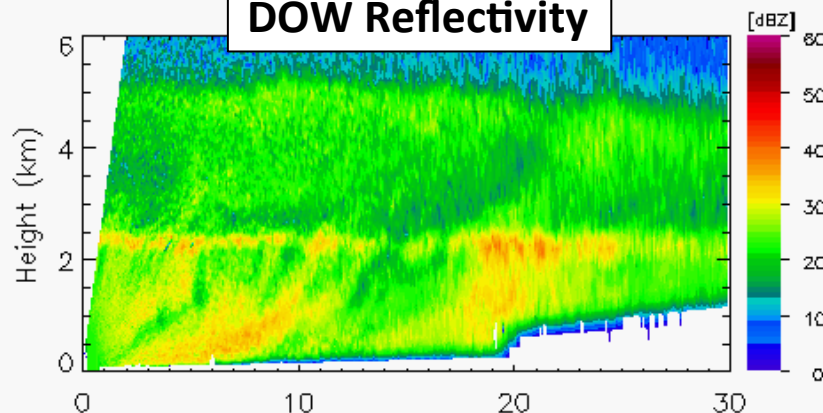




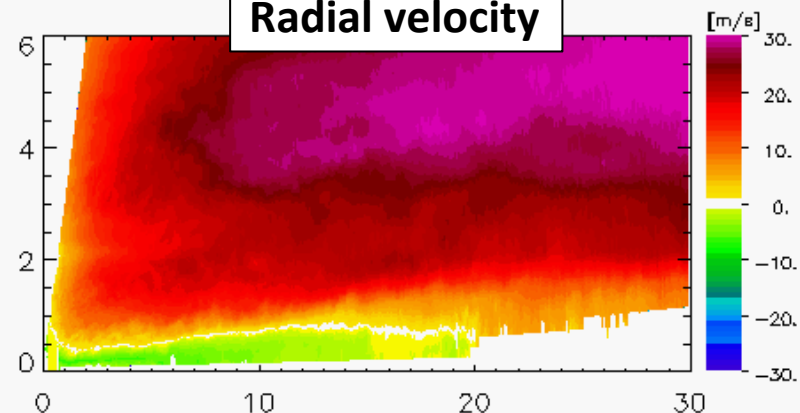


**13 Nov 2015  
0350 UTC  
(warm sector)**

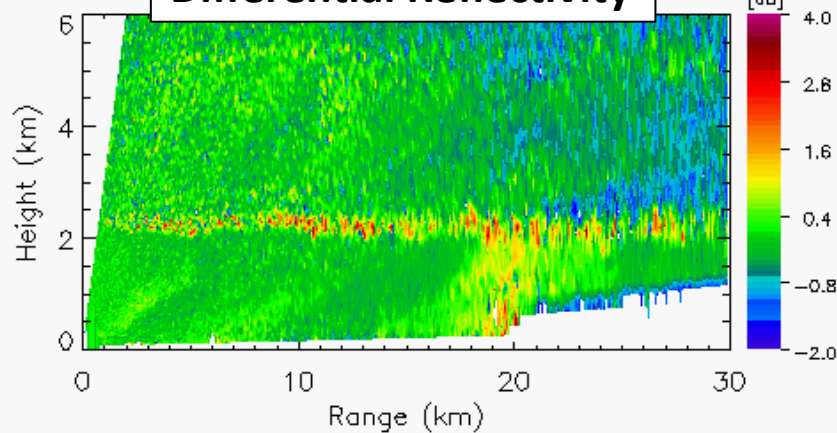
**DOW Reflectivity**



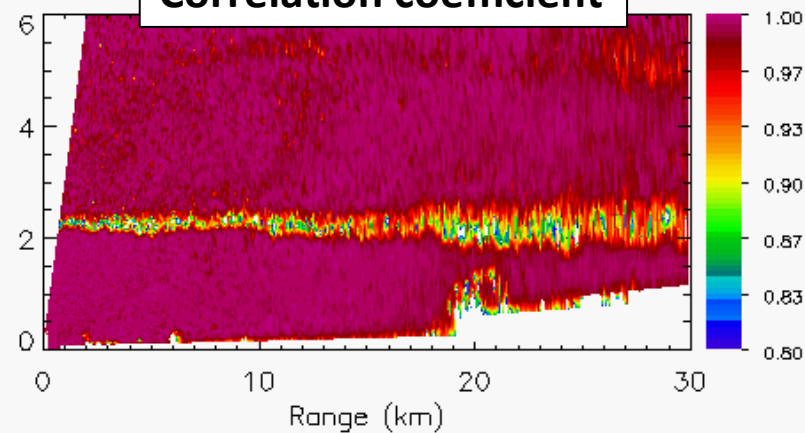
**Radial velocity**

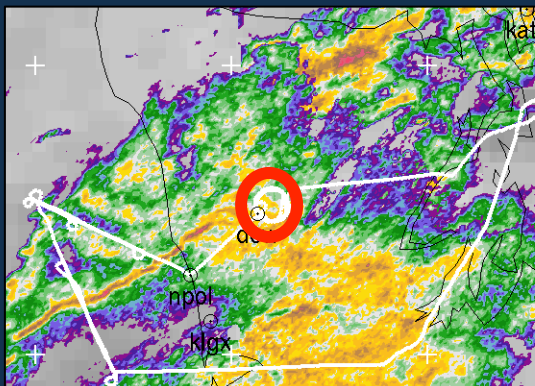


**Differential Reflectivity**

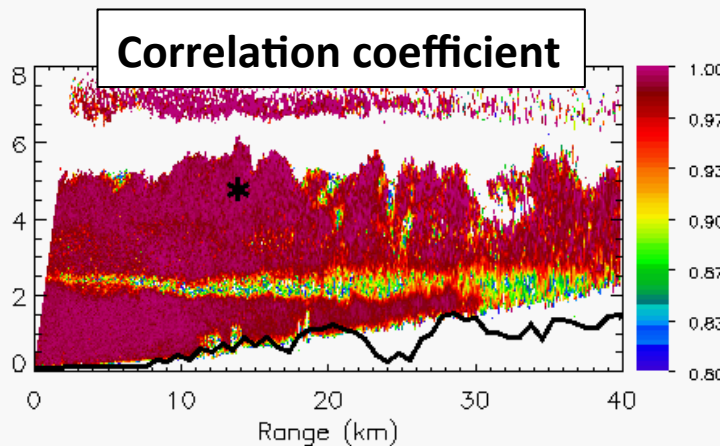
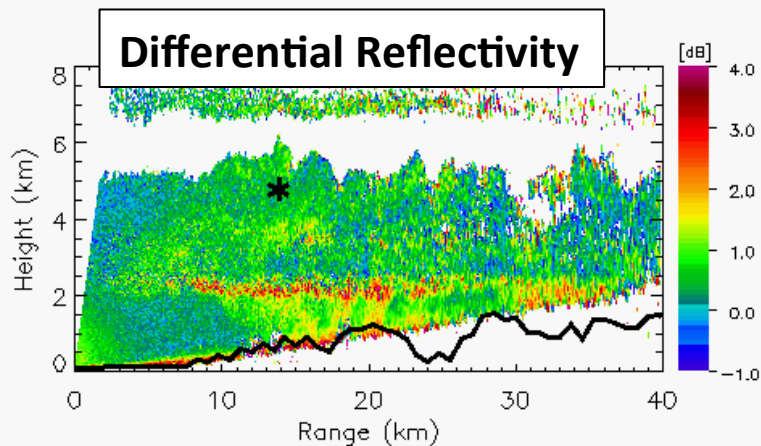
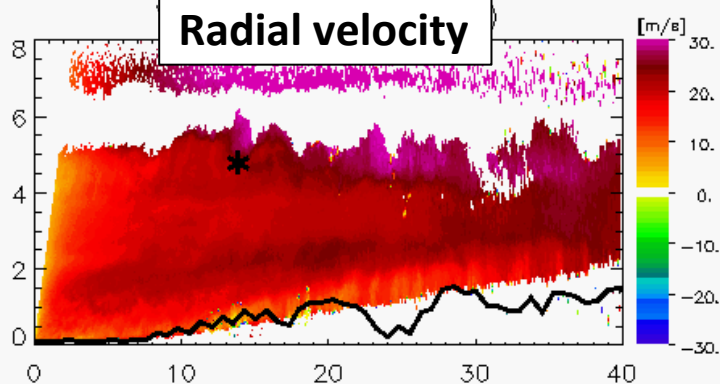
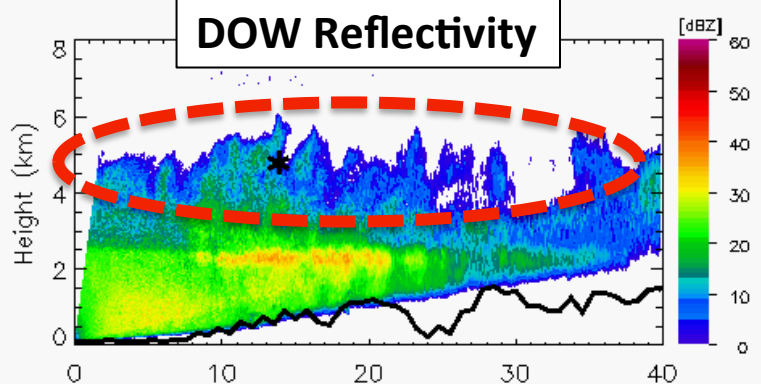
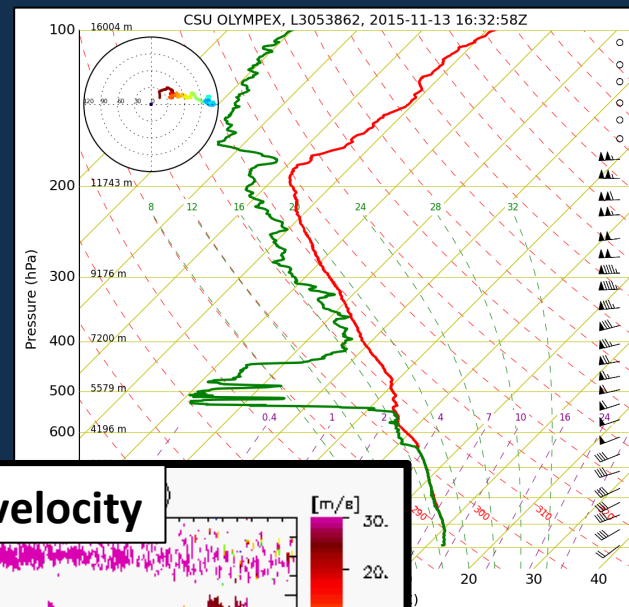


**Correlation coefficient**

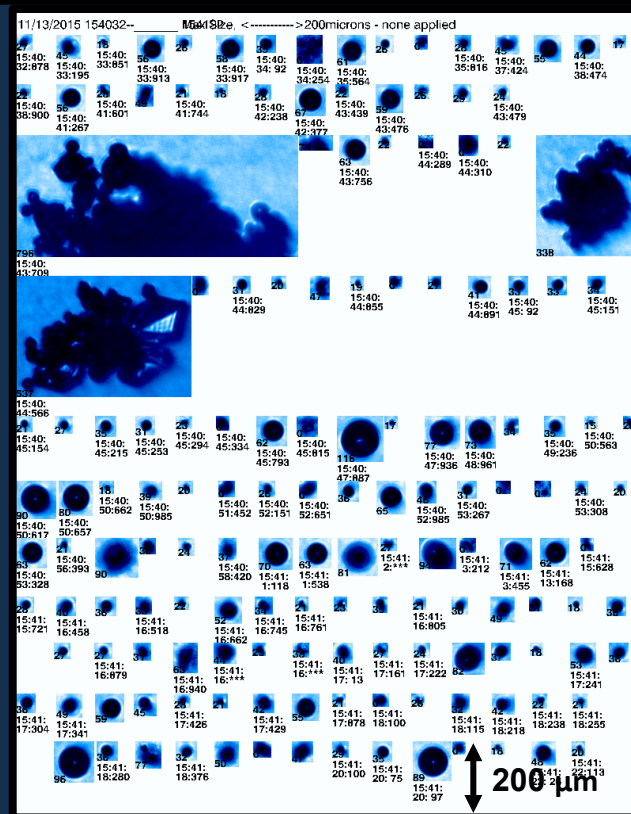
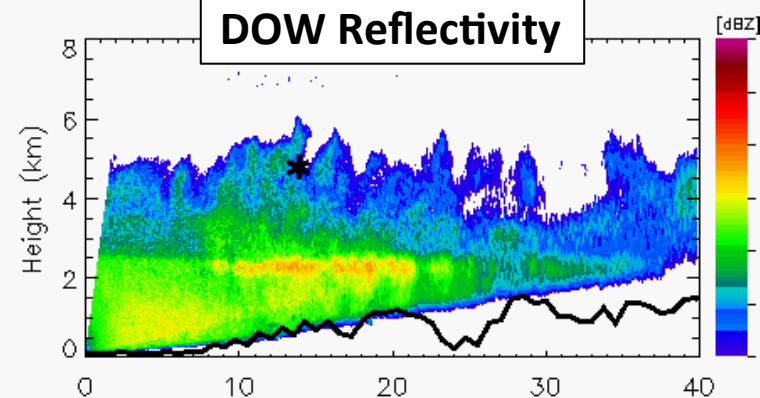
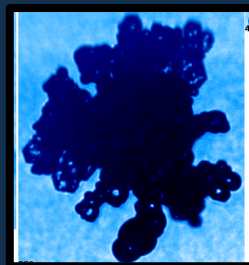
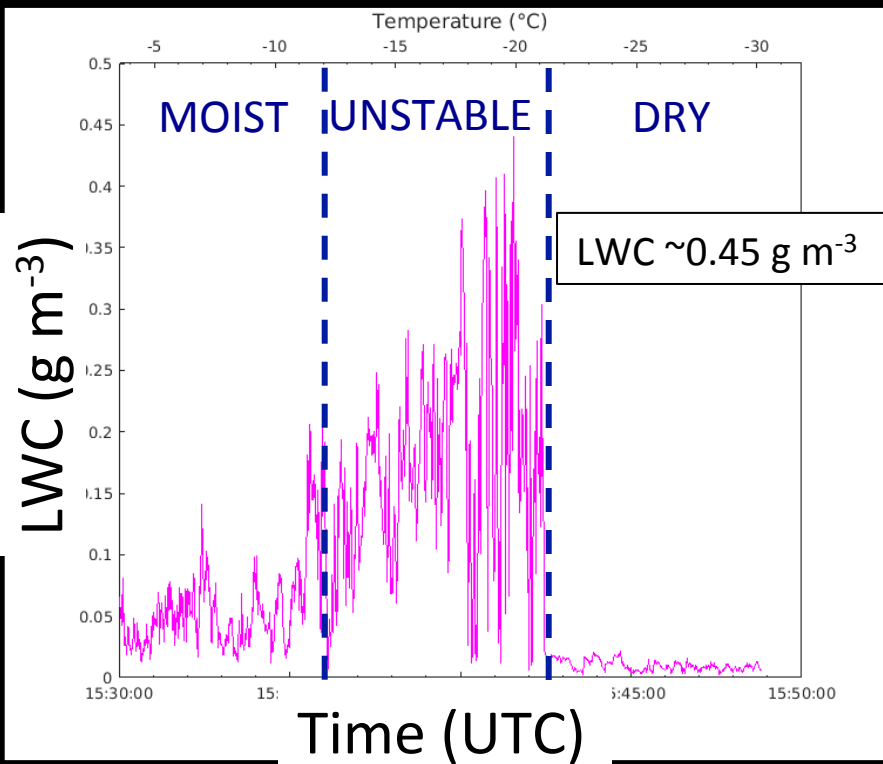




**13 Nov 2015  
1536 UTC  
(warm sector)**



# 13 Nov 2015 Citation



CPI: 15–2500  $\mu\text{m}$

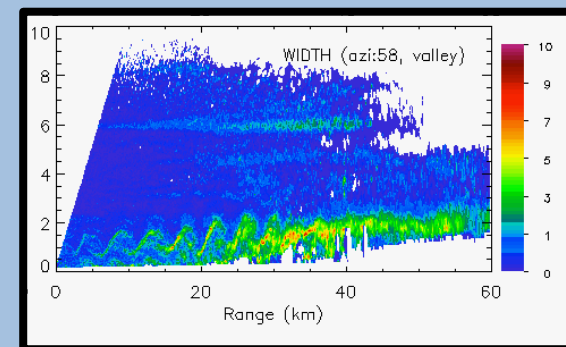
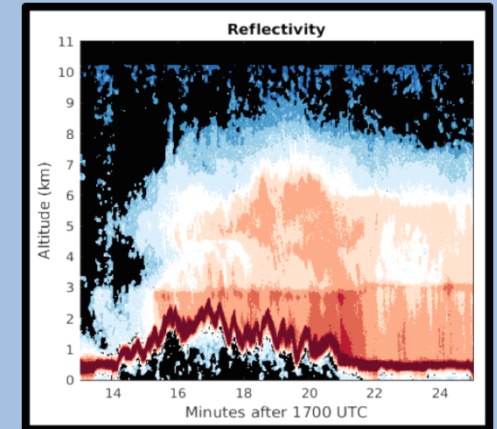


# Conclusions

- **Upper-level enhancement in reflectivity over windward slopes**
  - Strongest in warm sector/atmospheric river scenarios, but a persistent feature
  - Case of larger (some aggregated) bullet rosettes in reflectivity max aloft
- **DSD variability within storm sector, location**
  - Varying relative roles of warm-rain and ice-based processes
  - Transient upper-level Z and ZDR maxima
- **Generating cells producing high liquid water content aloft**
  - Presence of rimed plates below peak in LWC

# Looking forward

- **Additional cases with coincident in situ data**
  - Upper-level Z and ZDR maxima
- **Extending to high terrain/leeside**
  - APR3 (DC8)
  - EC X-band
- **Influence of K-H waves**
  - Barnes et al., in prep
  - Above, within, and below ML



# Thank you!

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Grants #NNX13AG71G,  
#NNX15AL38G, #NNX16AD75G,  
and NSF Grant #AGS-1503155

