Synoptic and Orographic Control of Observed Drop Size Distribution Regimes in Atmospheric River events during the OLYMPEX Field Campaign

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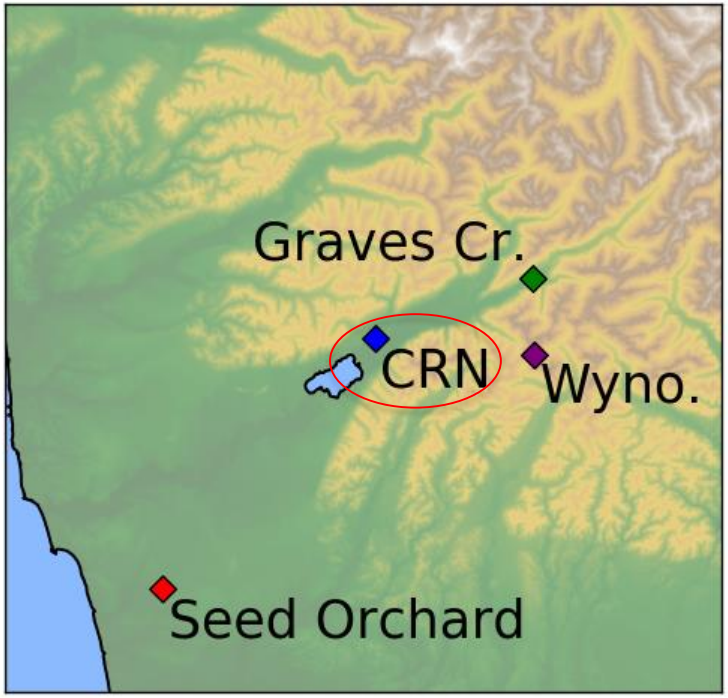
Overview

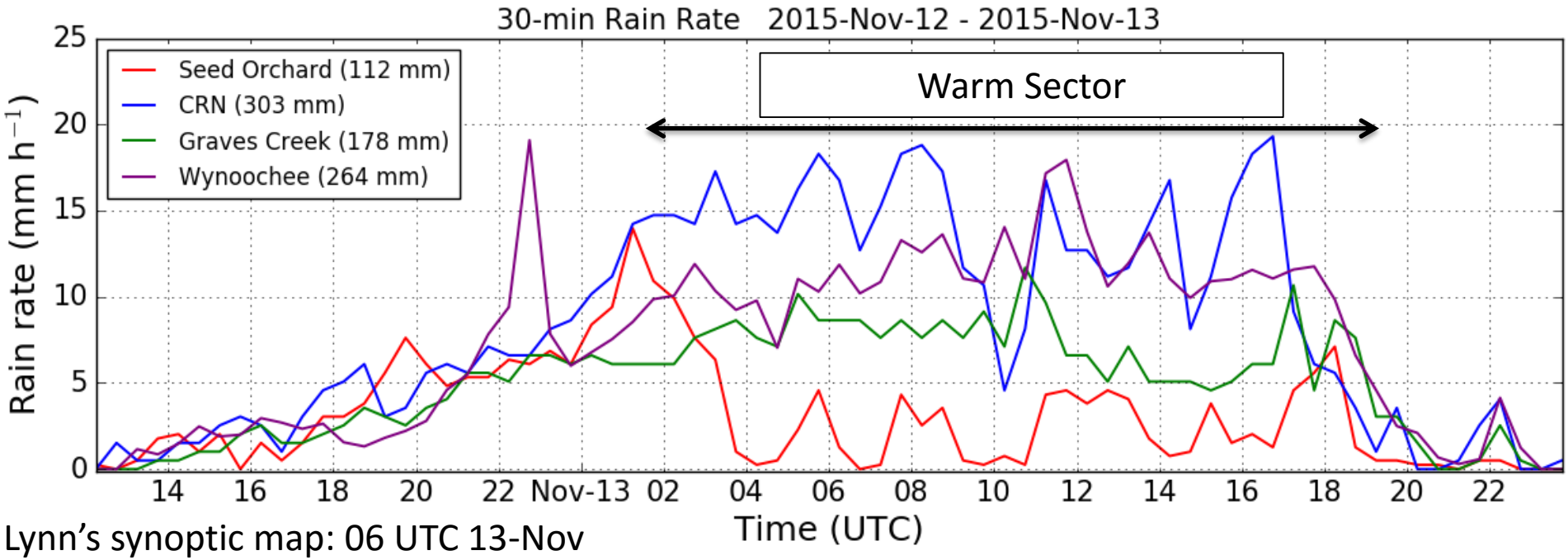
- Three *major* AR events observed during OLYMPEX IOP (Nov 12-13, Nov 16-17, Dec 8-9)
- What is the role of warm and cold microphysical processes in contributing to orographic enhancement in these events?
- OLYMPEX instruments:
  - Rain gauges
  - Micro Rain Radar (MRR)
  - Parsivel^2 Disdrometers
  - NPOL RHIs (from coast -> mountains)

Nov 12-13
Rain rates

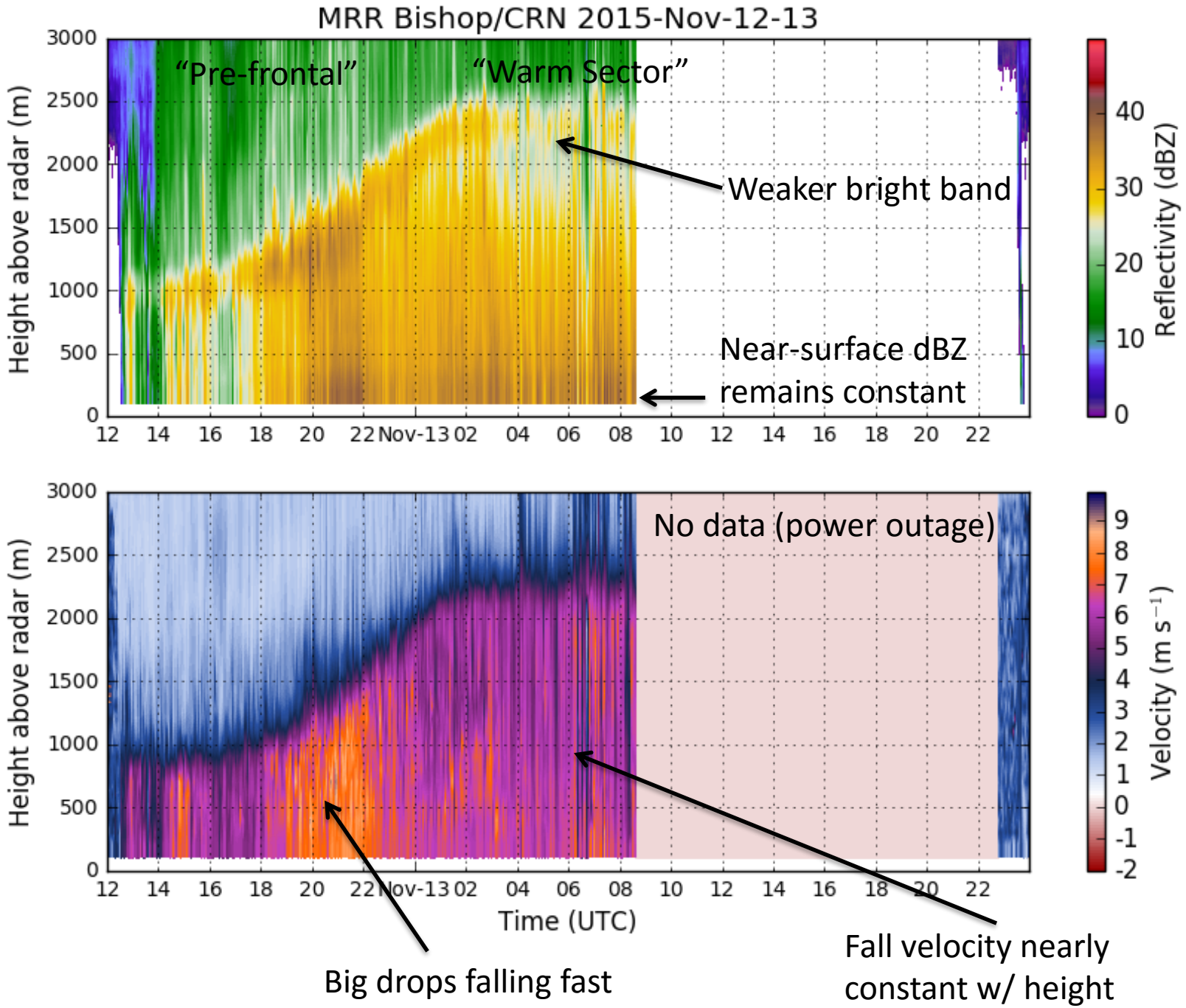
~18 hour period of orographic enhancement

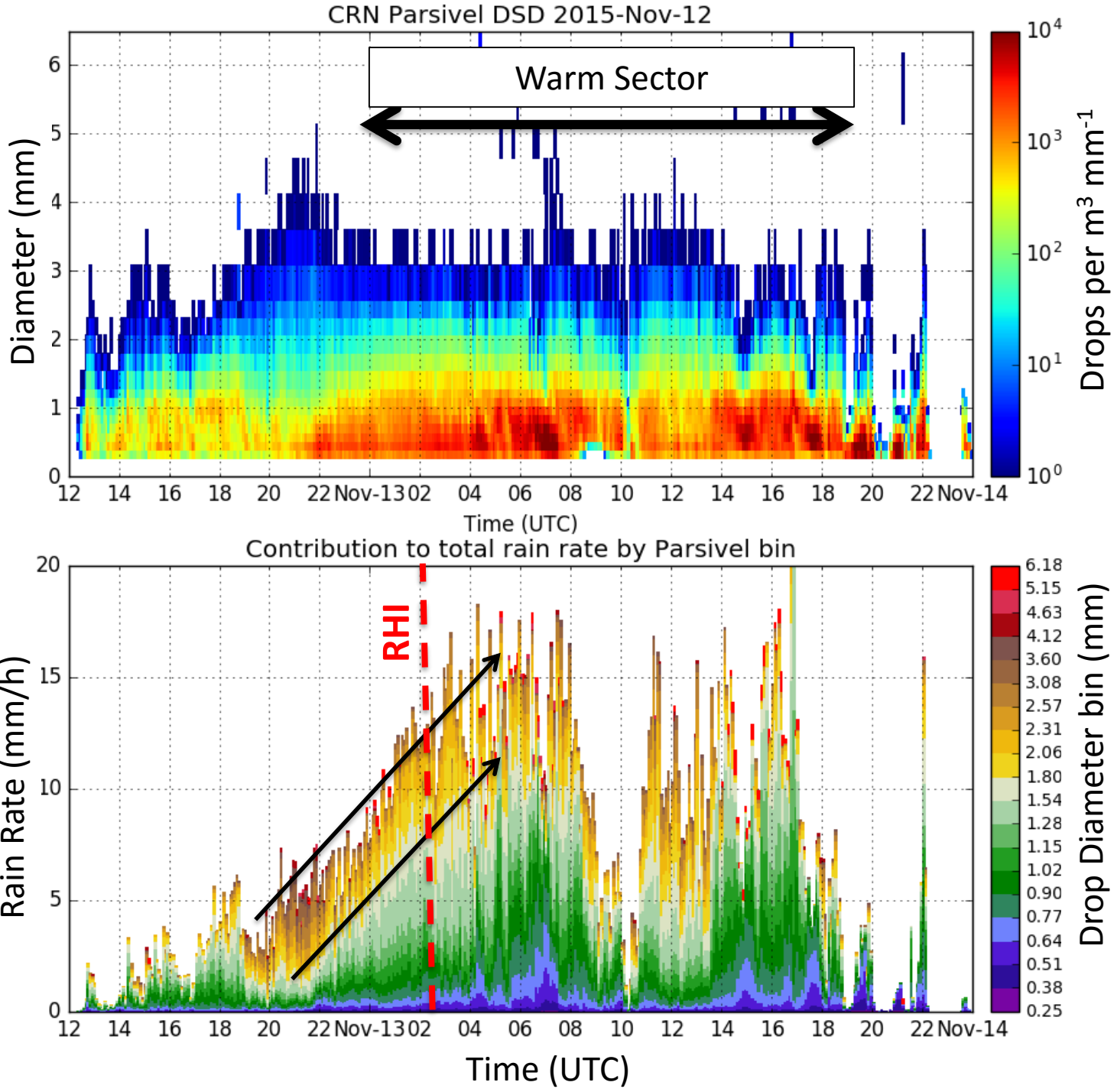
More rain at low-elevation CRN site compared with interior/higher elevation sites

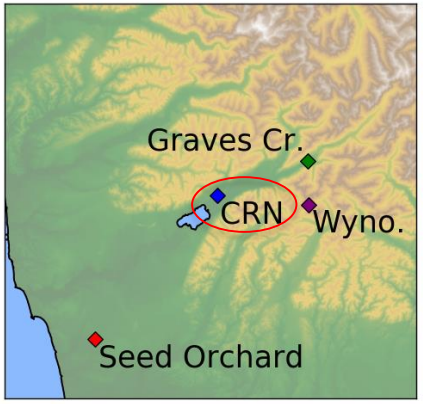




Lynn's synoptic map: 06 UTC 13-Nov


MRR Bishop/CRN 2015-Nov-12-13
"Pre-frontal"
"Warm Sector"
Weaker bright band
Near-surface dBZ
remains constant
Height above radar (m)
Reflectivity (dBZ)
No data (power outage)
Velocity (m s^{-1})
Time (UTC)
Big drops falling fast
Fall velocity nearly
constant w/ height

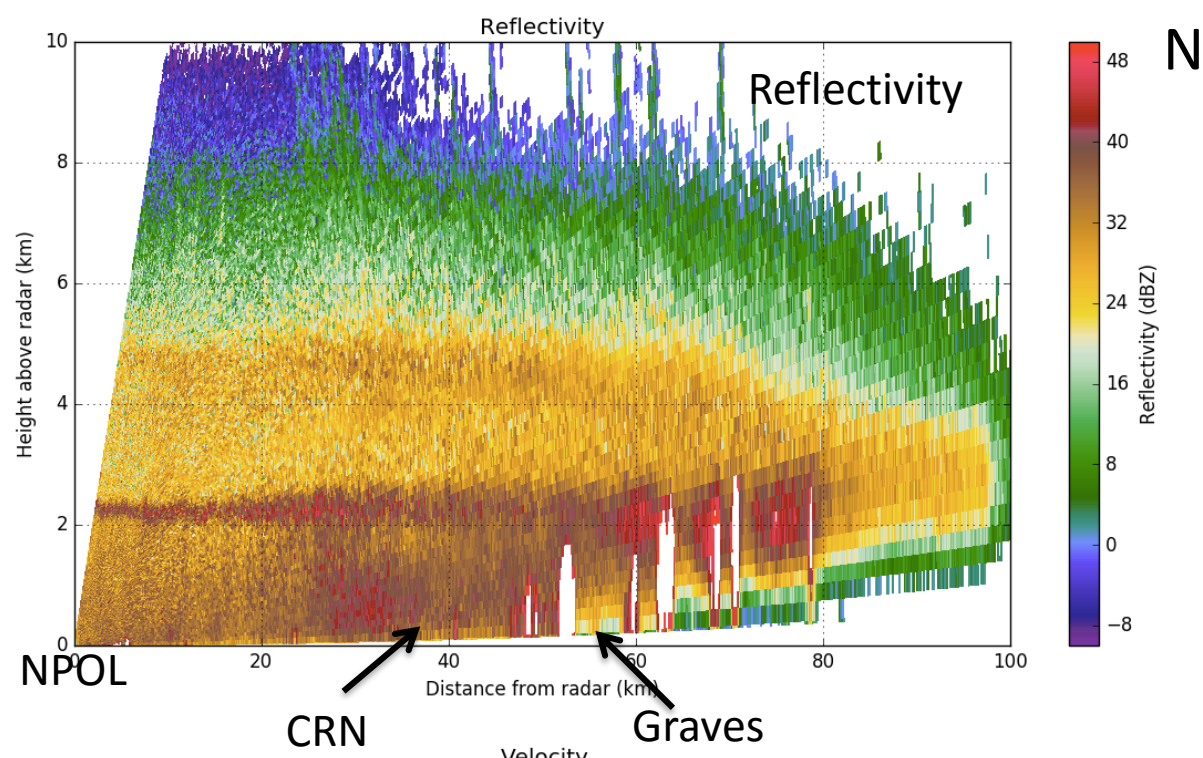


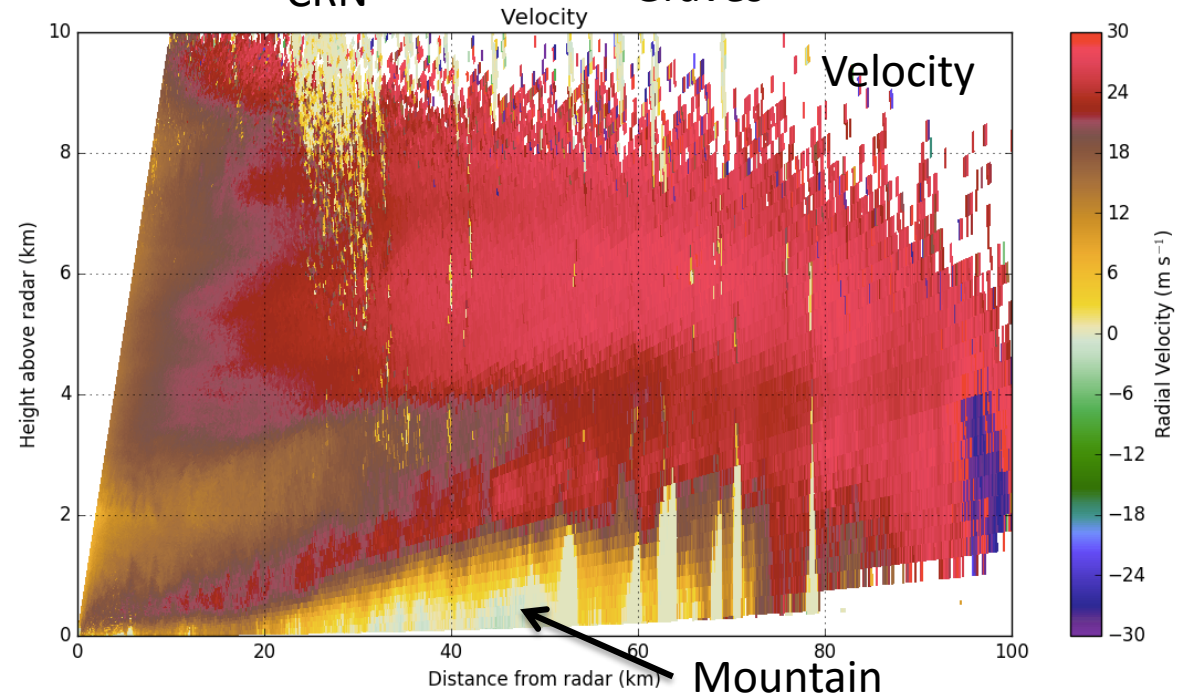


Orographic enhancement associated with large quantities of < 1.5 mm drops

These small-medium sized drops are responsible for the majority of the increase in rain rate

NPOL RHI 13-Nov 02:12 UTC 50° Azimuth

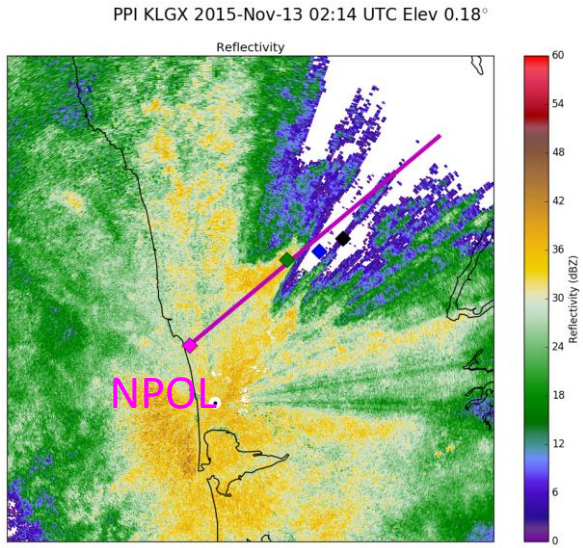




Low-level jet is within 1 km of the surface near NPOL and starts lifting around 20 km from radar.

Drop formation + growth occurs <u>below melting level</u> ahead of high terrain.

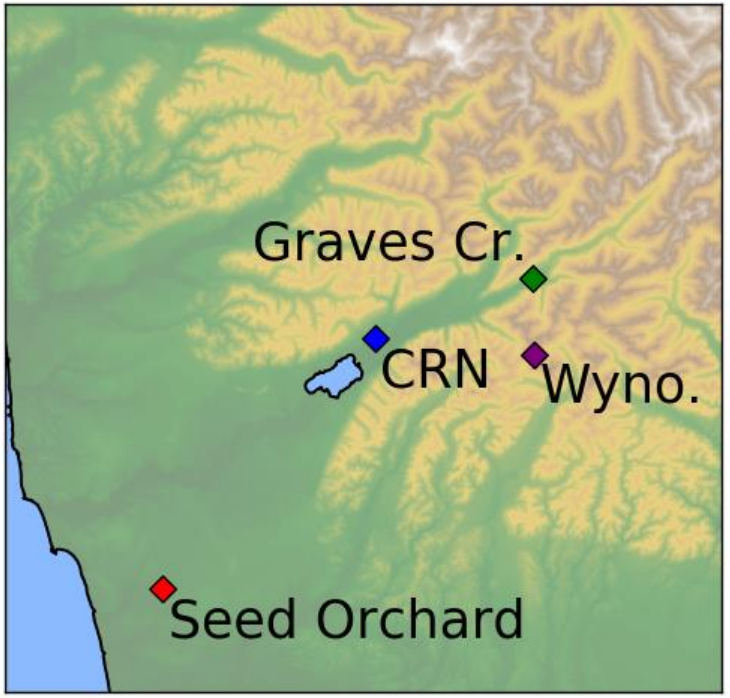
Jet lifting decreases 50-60 km from radar.

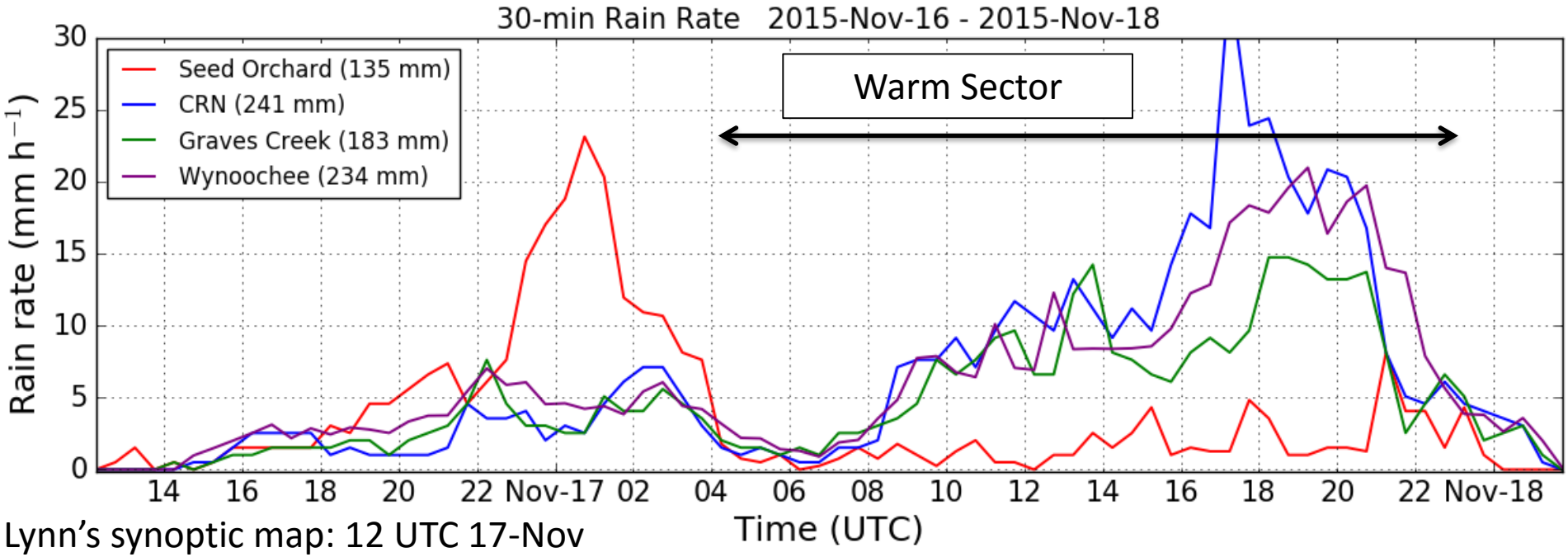


Nov 16-17
Rain rates

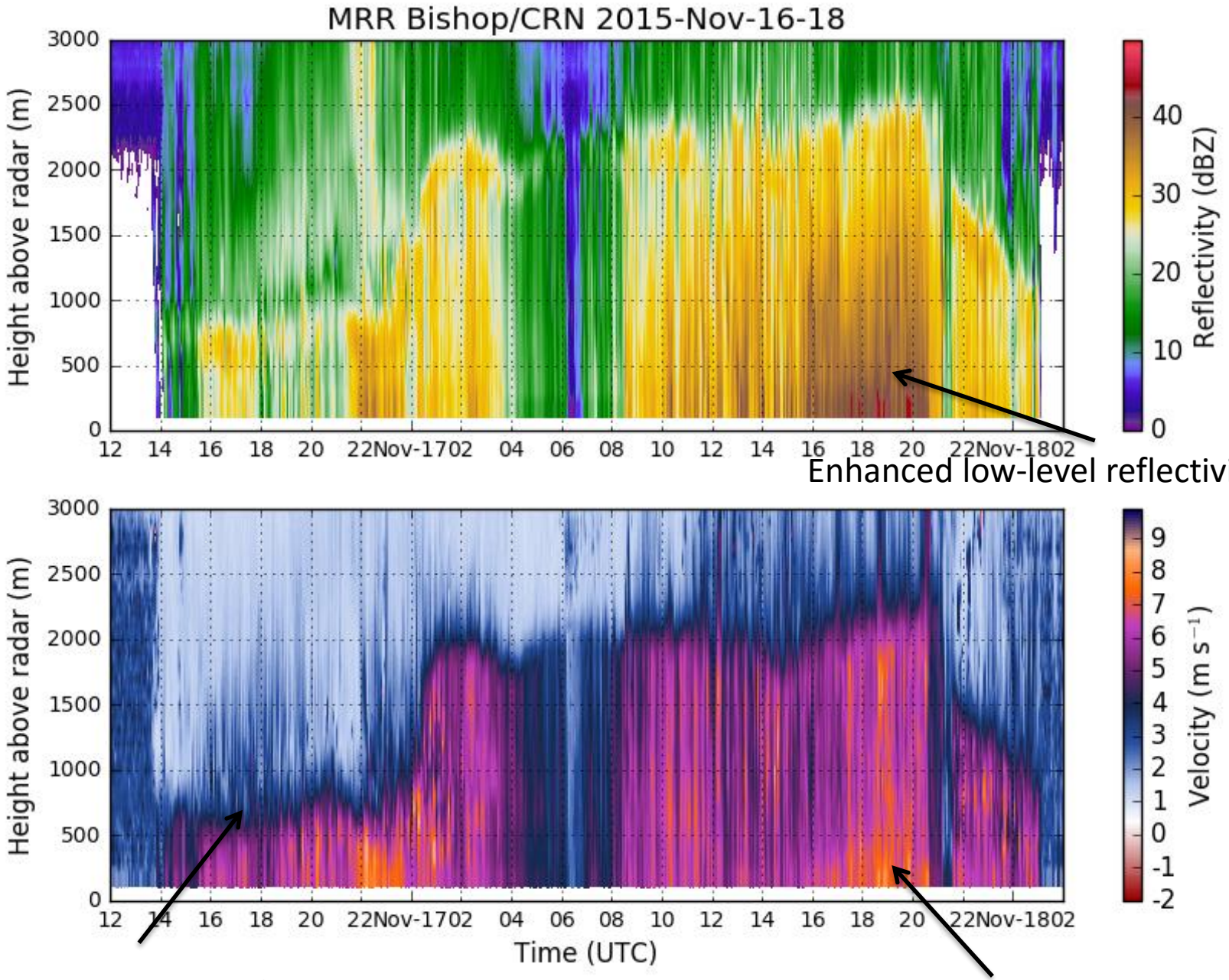
Spike in rainfall near coast in prefrontal sector

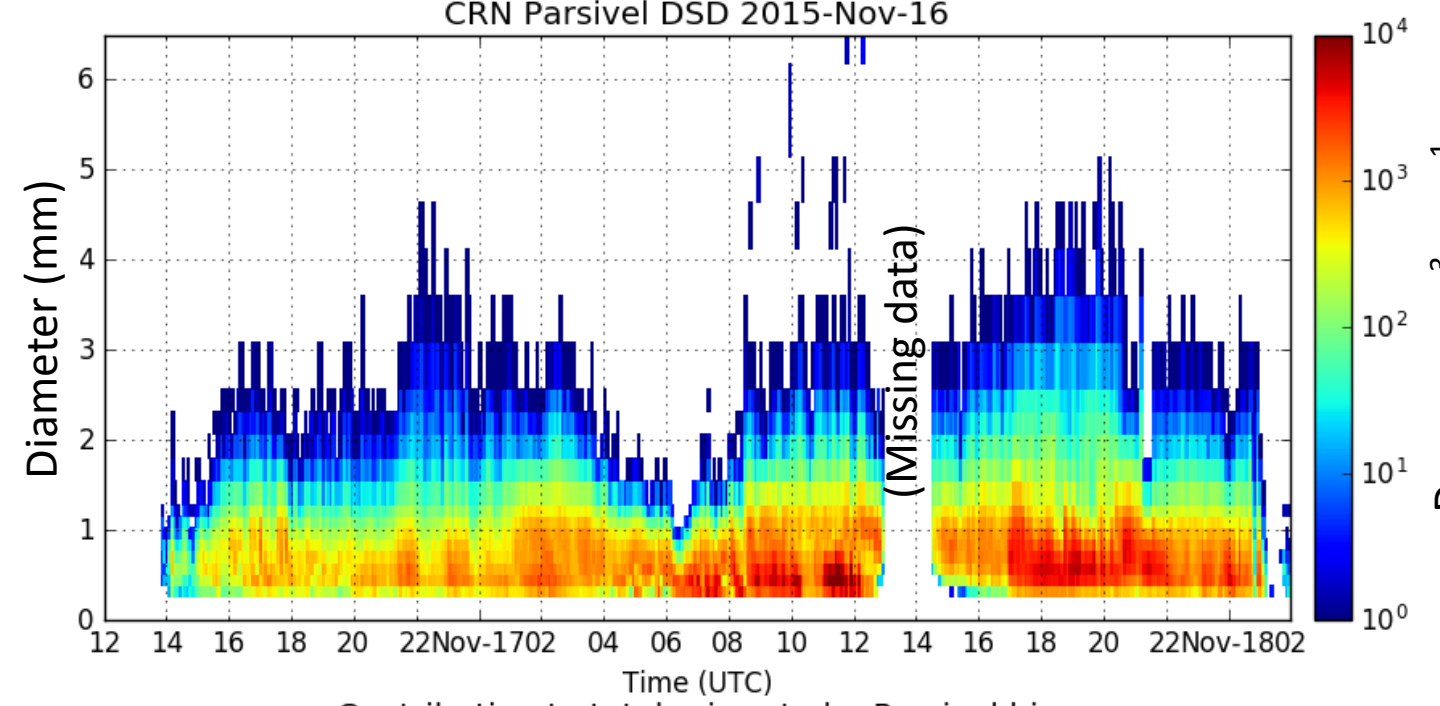
Extreme orographic enhancement in warm sector

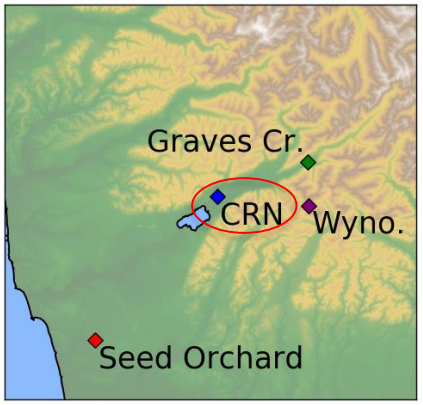


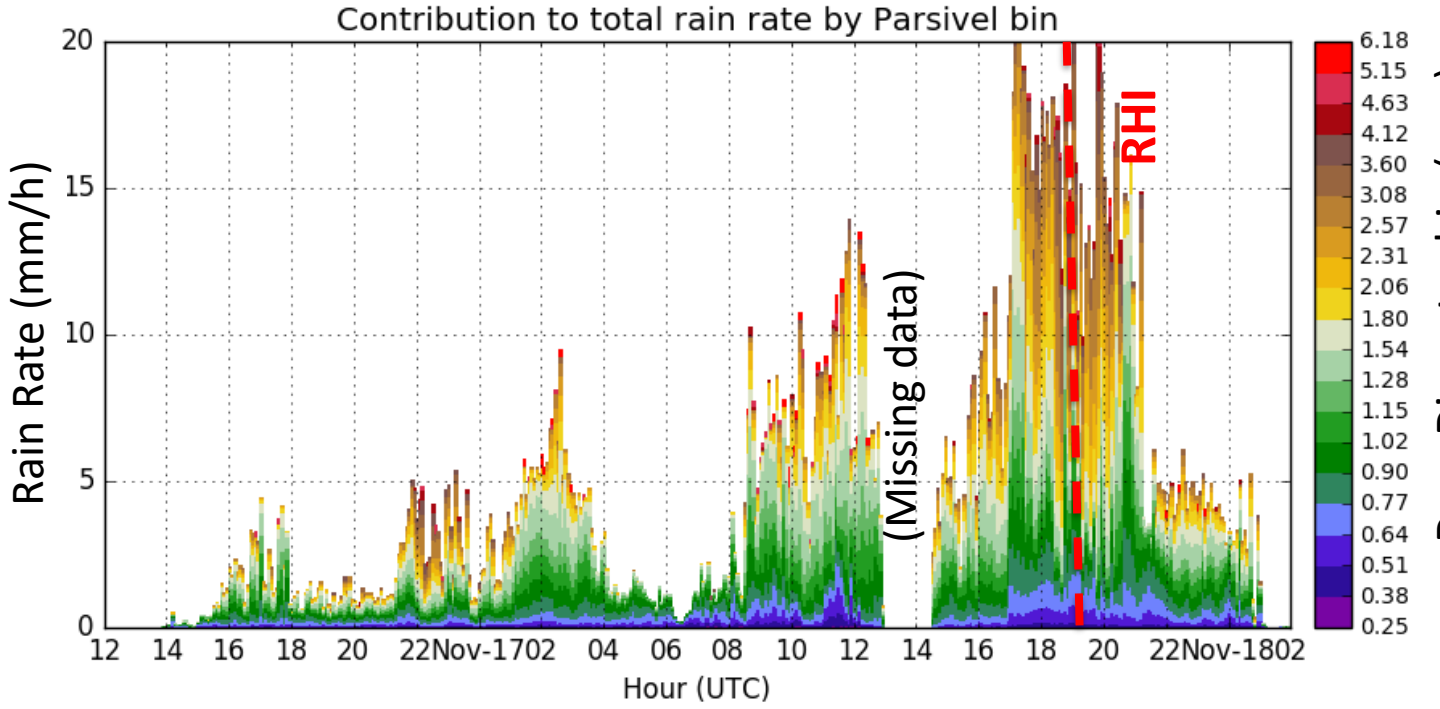


Lynn's synoptic map: 12 UTC 17-Nov


MRR Bishop/CRN 2015-Nov-16-18
Height above radar (m)
3000
2500
2000
1500
1000
500
0
12 14 16 18 20 22Nov-1702 04 06 08 10 12 14 16 18 20 22Nov-1802
Reflectivity (dBZ)
40
30
20
10
0
Enhanced low-level reflectivity
Height above radar (m)
Velocity (m s⁻¹)
9
8
7
6
5
4
3
2
1
0
-1
-2
Time (UTC)
Low melting level in prefrontal sector
Evidence of drop growth at low levels
during period of heaviest rain





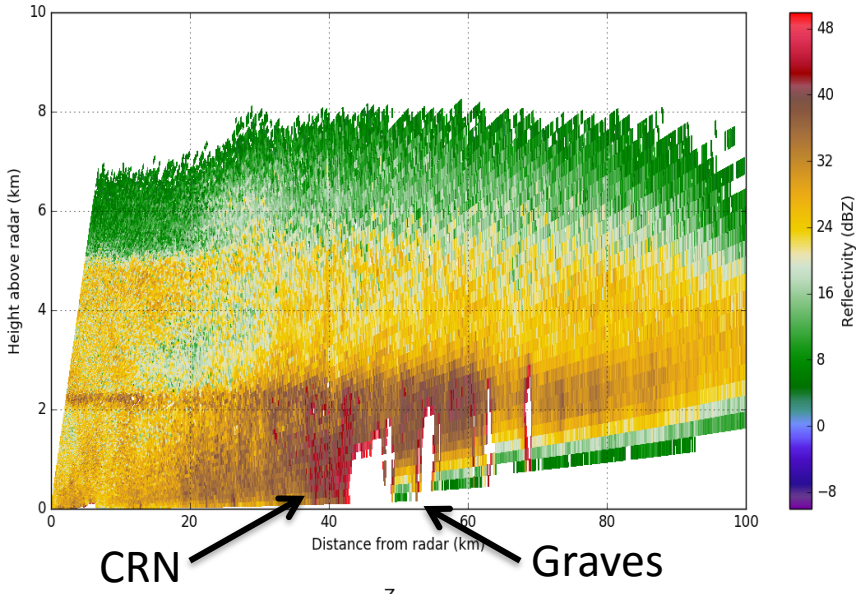


High drop concentrations of both small and large drops during period of heavy rainfall.

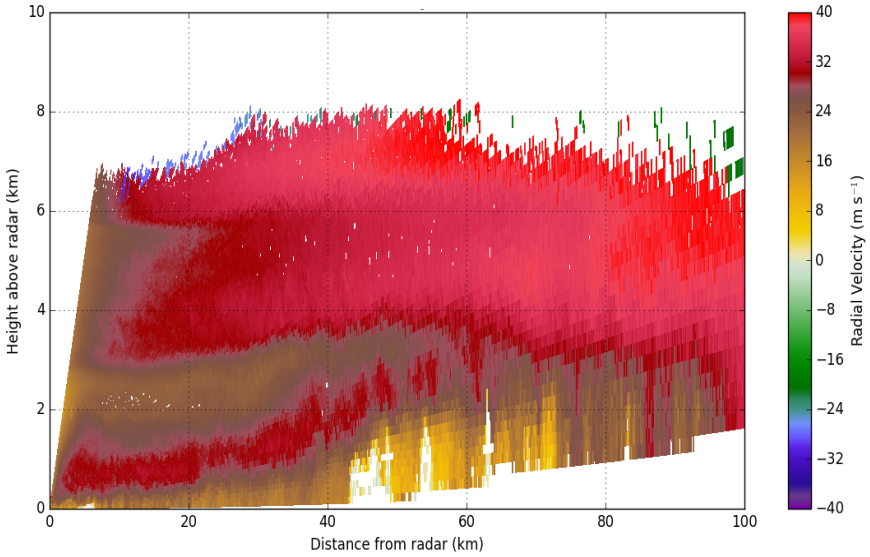
Otherwise, rain rates are relatively light.

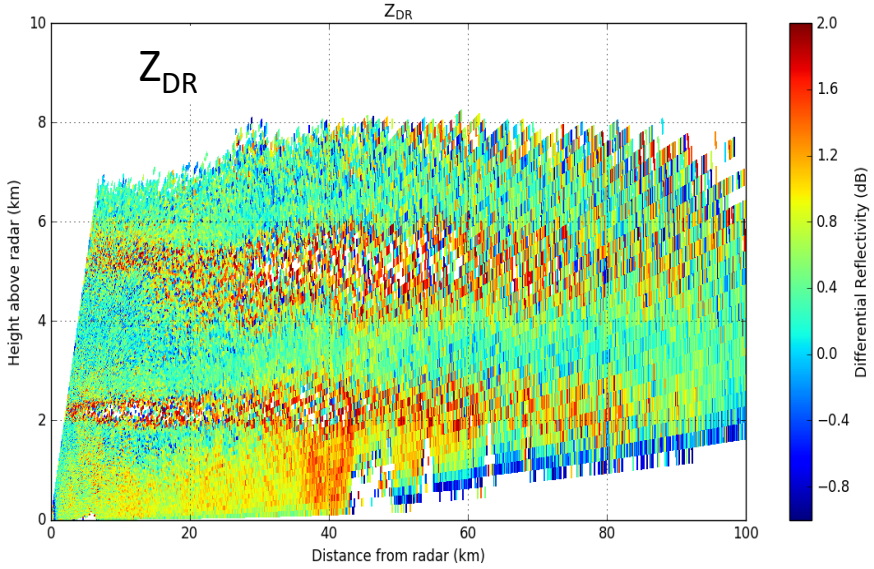
NPOL RHI 17-Nov 19:34 UTC 48° Azimuth

Reflectivity



Velocity





Both low and mid level jet appear to be lifting over terrain.

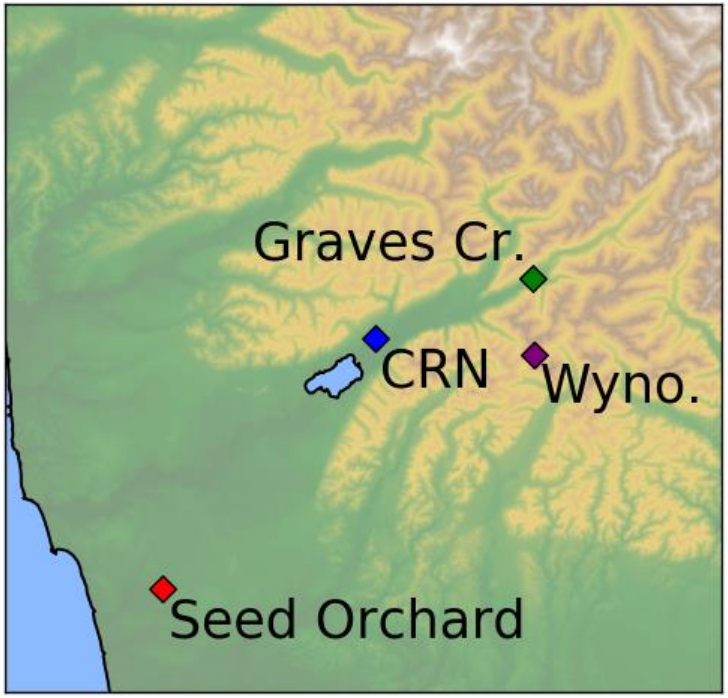
Enhanced reflectivity and higher Z_{DR} near surface. Indicates larger, more oblate drops.

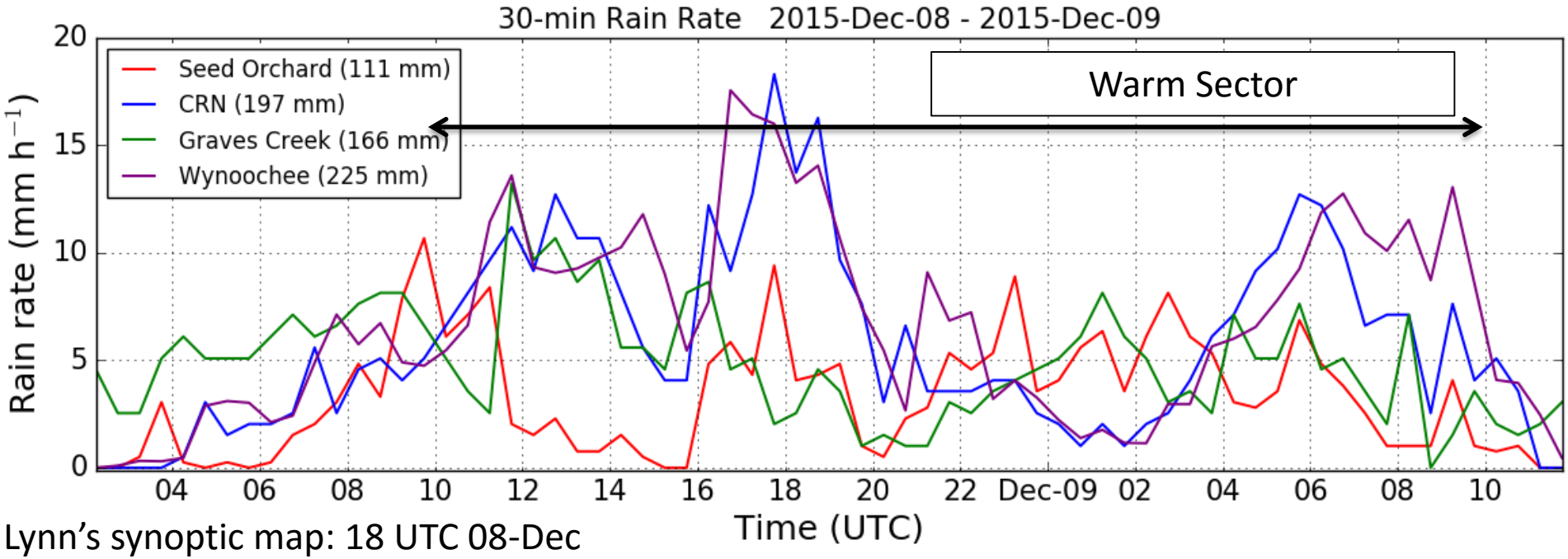
Secondary Z_{DR} max around 5 km. Suggests enhanced dendritic growth + aggregation.

Dec 08-09
Rain rates

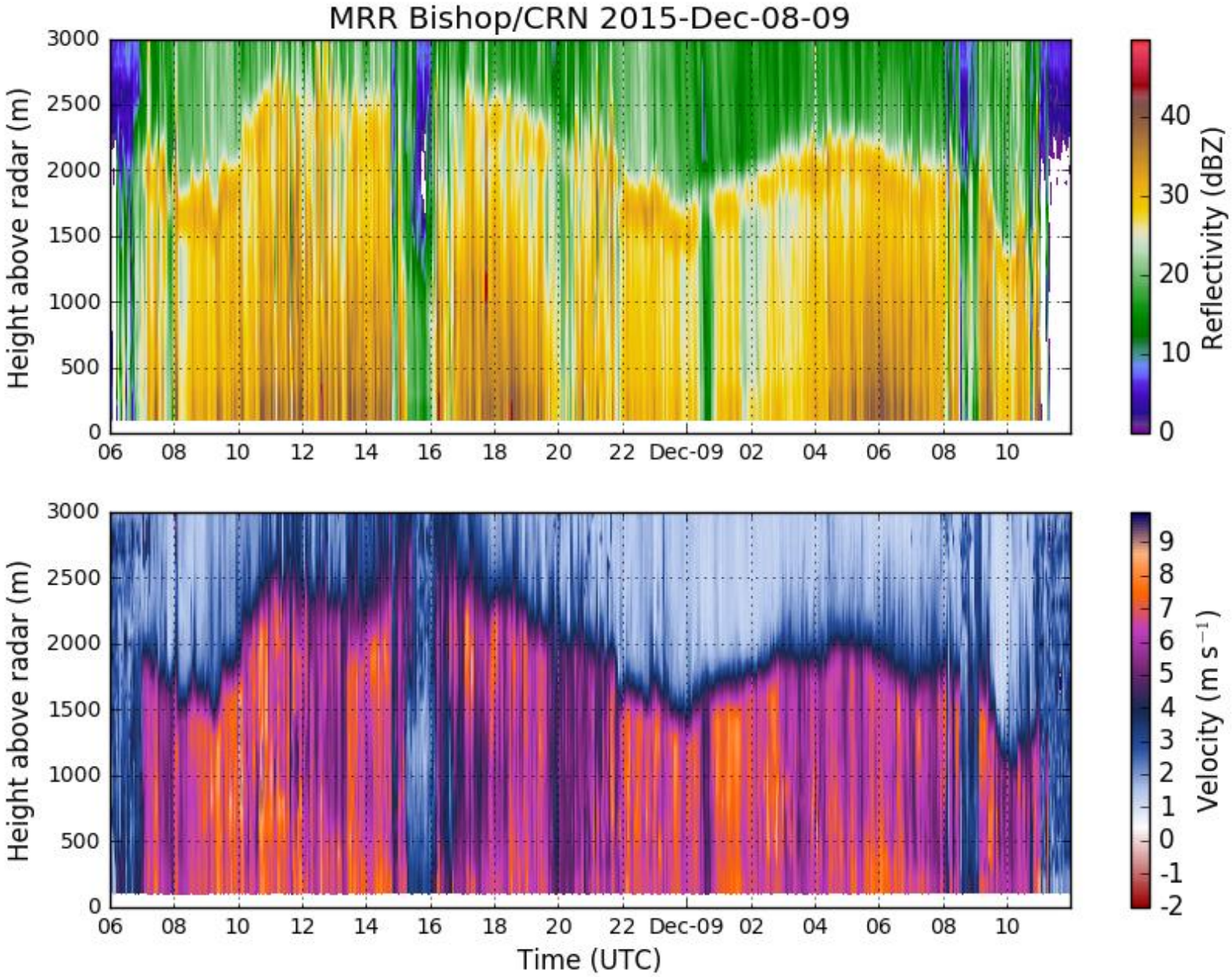
Long-duration warm sector with two separate shortwave passages

Both the maximum rain rate and the degree of orographic enhancement is less than other events.

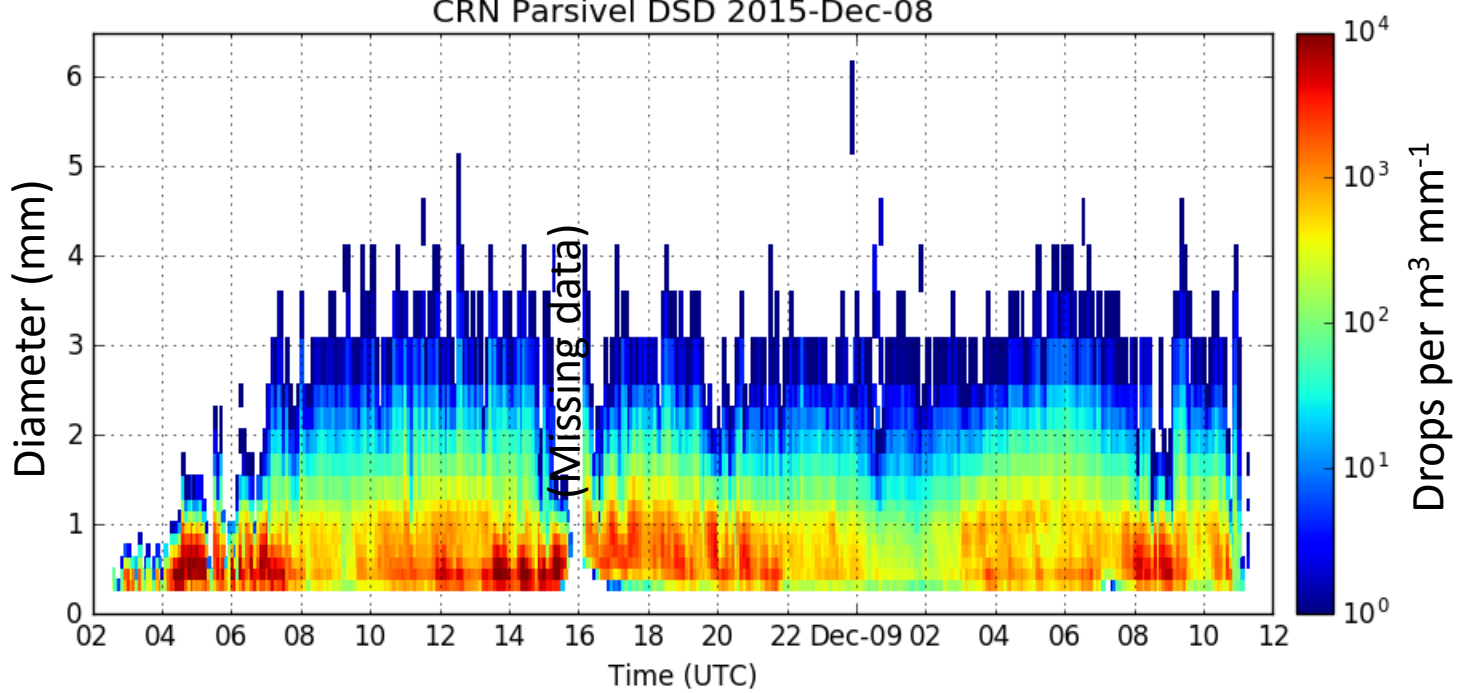


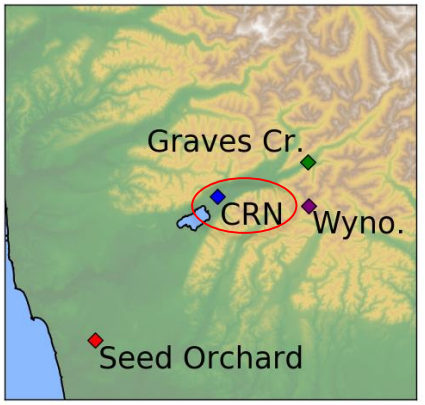


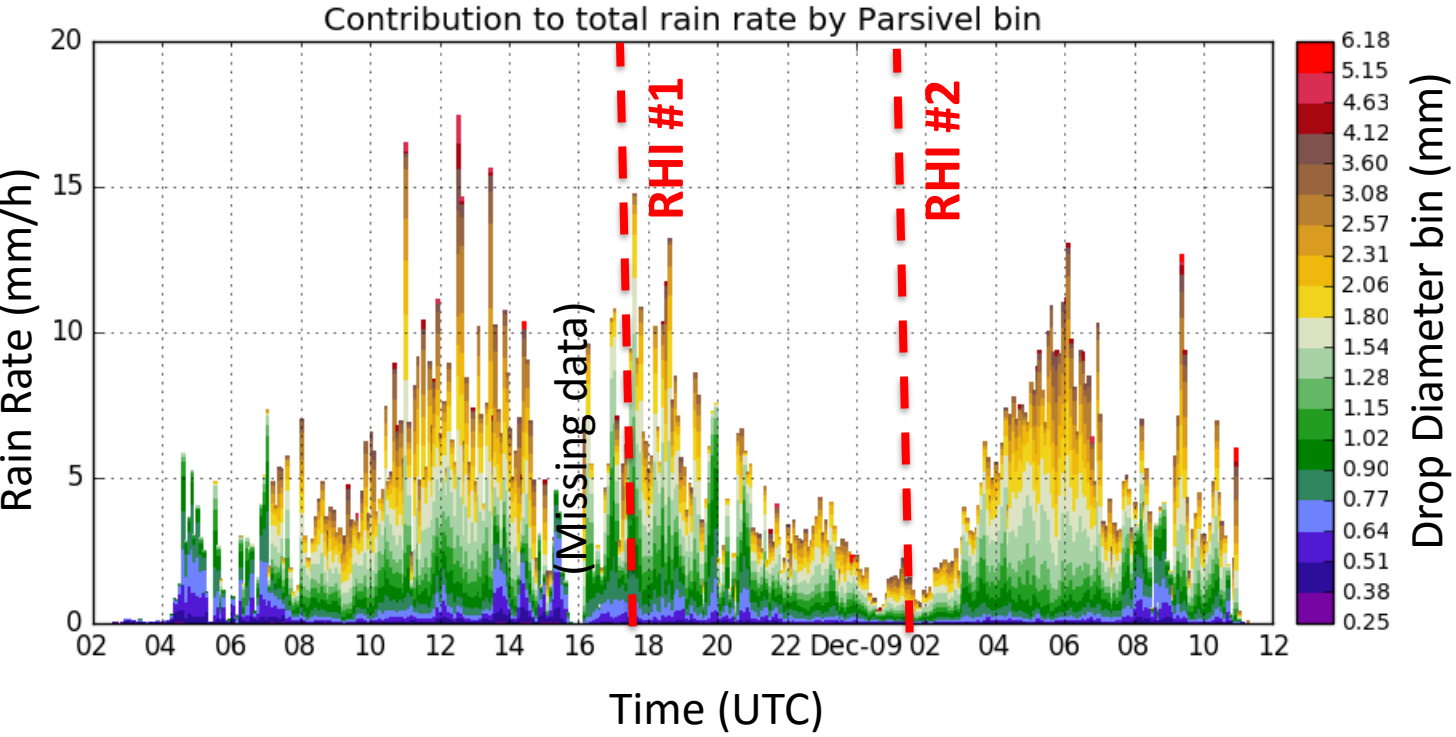
Lynn's synoptic map: 18 UTC 08-Dec



Two periods with high bright band. Reduction in low-level reflectivity enhancement when the bright band is lowered between the two waves.



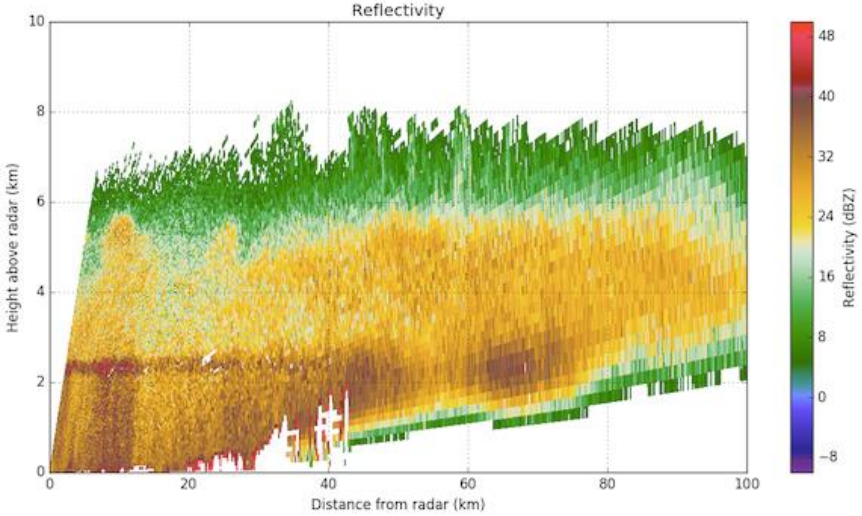


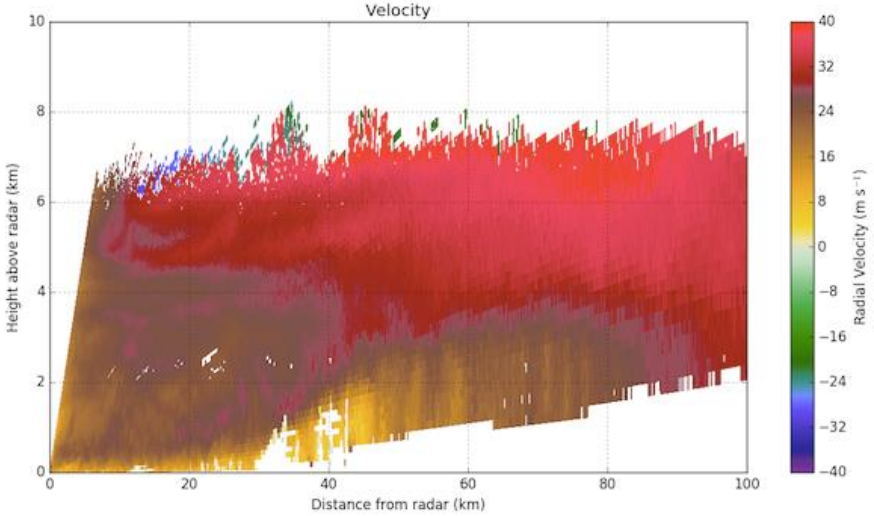


Similar DSD compared with other cases, just less intense

Small drop production goes away for about 6 hours starting 22 UTC 08-Dec

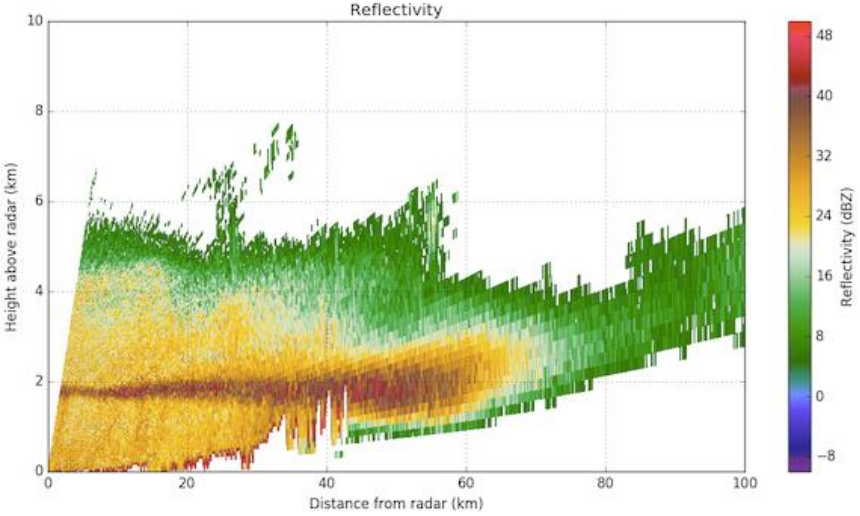
RHI #1: NPOL RHI 08-Dec 17:32 UTC 58° Azimuth

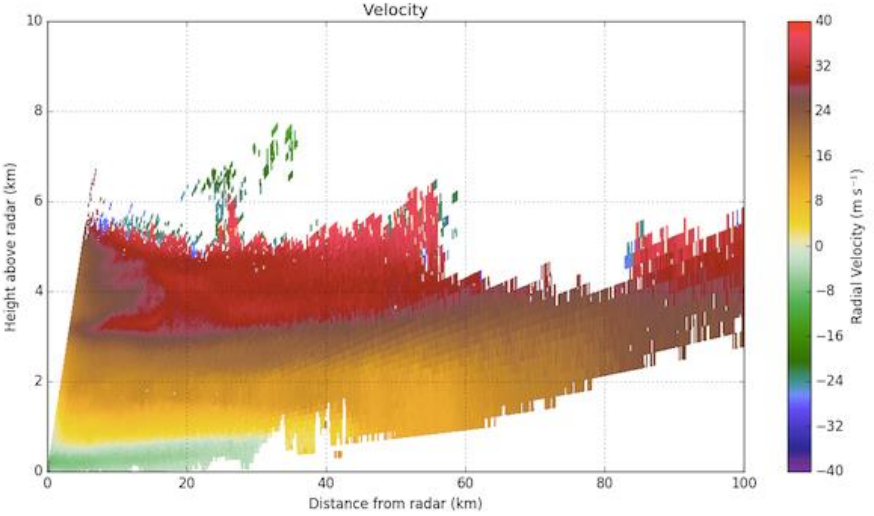




Unblocked flow, weaker LLJ than other cases. Low-level reflectivity enhancement is present.

RHI #2: NPOL RHI 08-Dec 01:52 UTC 58° Azimuth





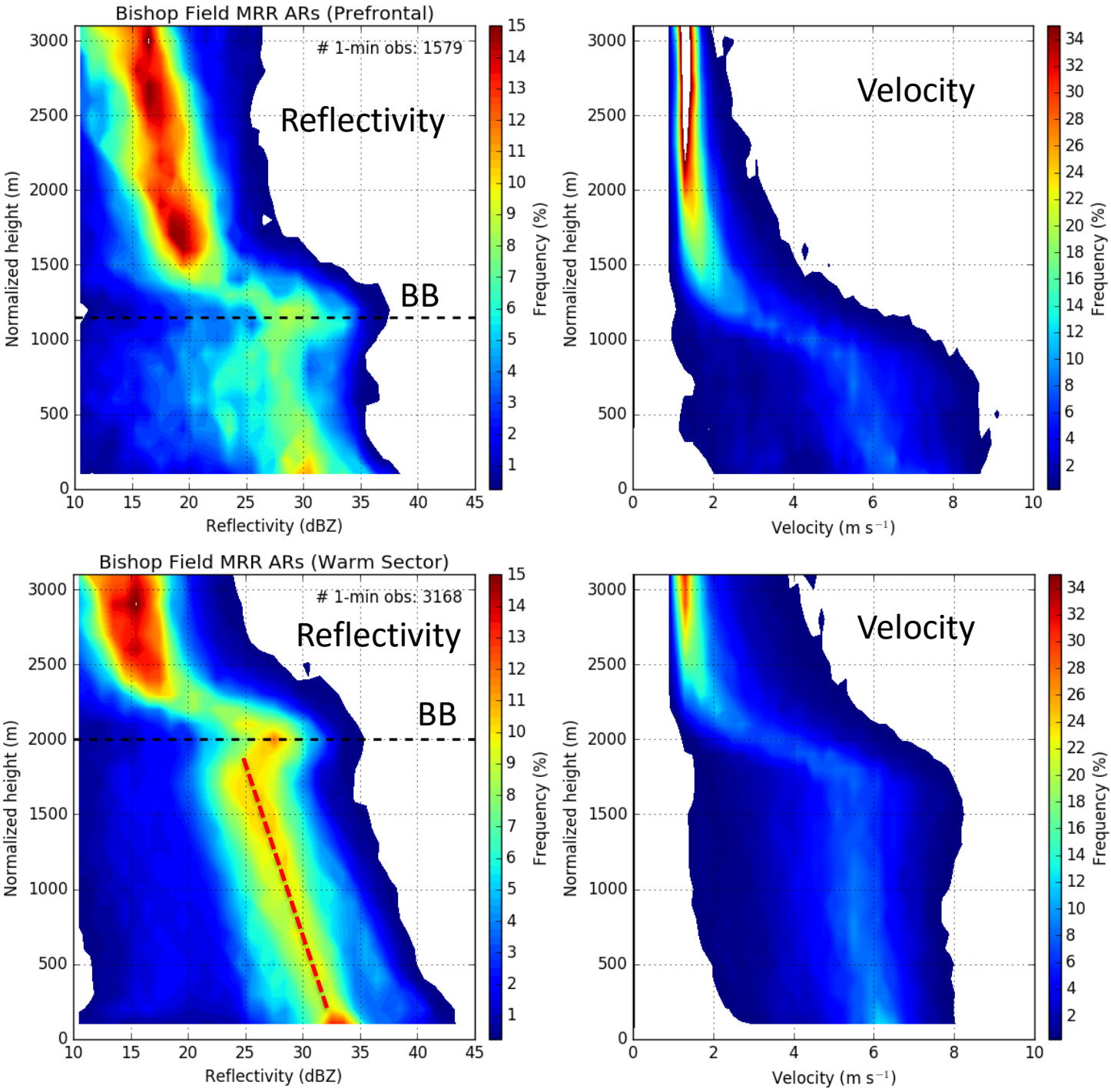
Blocked flow develops after passage of first wave. No low-level enhancement.

Prefrontal

MRR CFADs

(CRN site)

Warm Sector

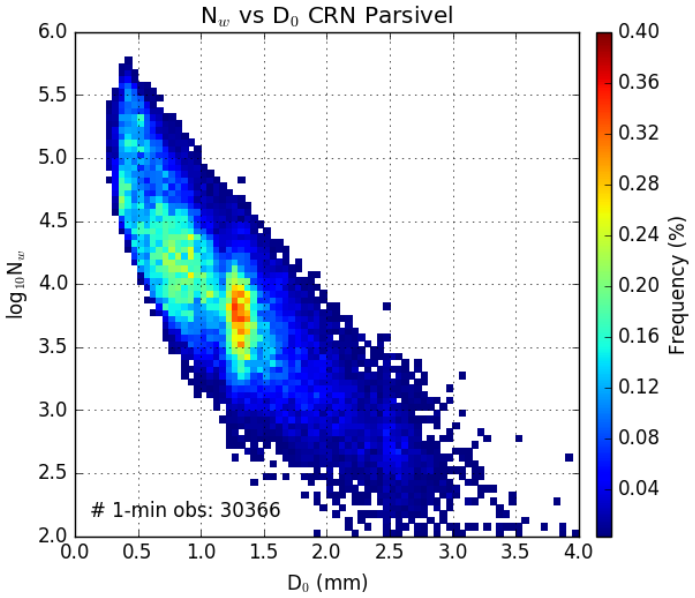


Summary

These three atmospheric river events contain:

- Deep, stratiform rain with high melting levels in the warm sector and a bright band present throughout the events.
- Greatest orographic enhancement produced by predominately warm rain processes (collision-coalescence) in association with low-level jet lifting over terrain at initial windward slopes.
- Occasional secondary reflectivity + Z_{DR} maxima indicating enhanced ice formation. Possibly associated with larger drops at the surface and heavier rain rates, but still being investigated.

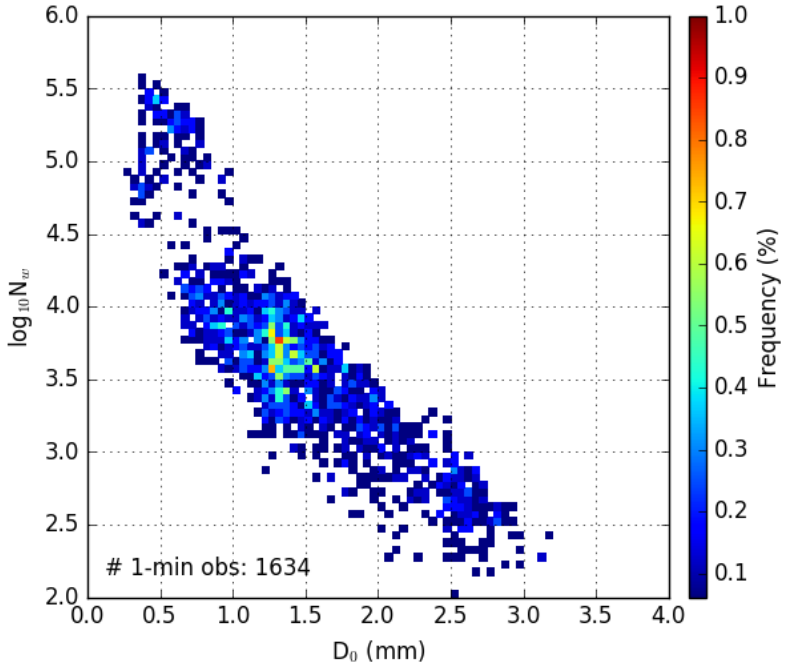
Normalized DSDs



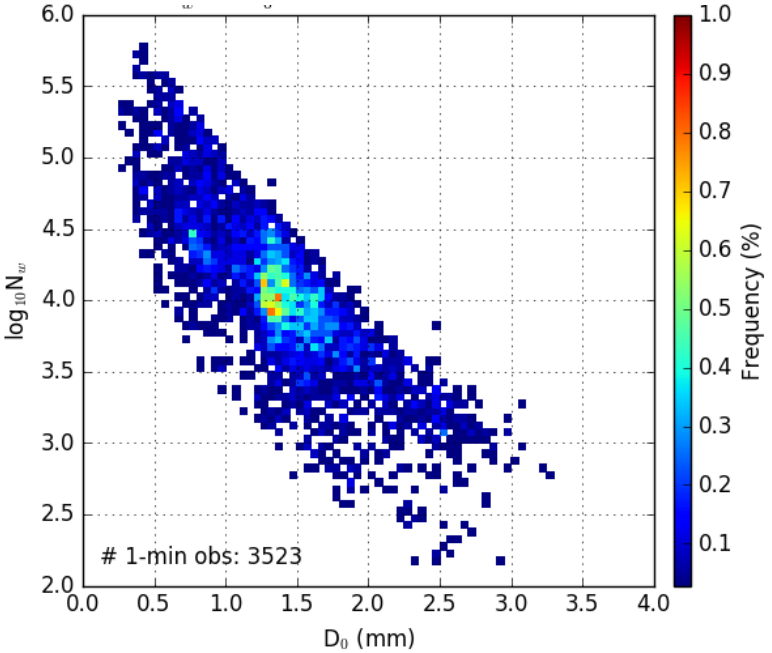
D_0 = Volume median diameter

N_w = "Normalized" intercept parameter (drop concentration)

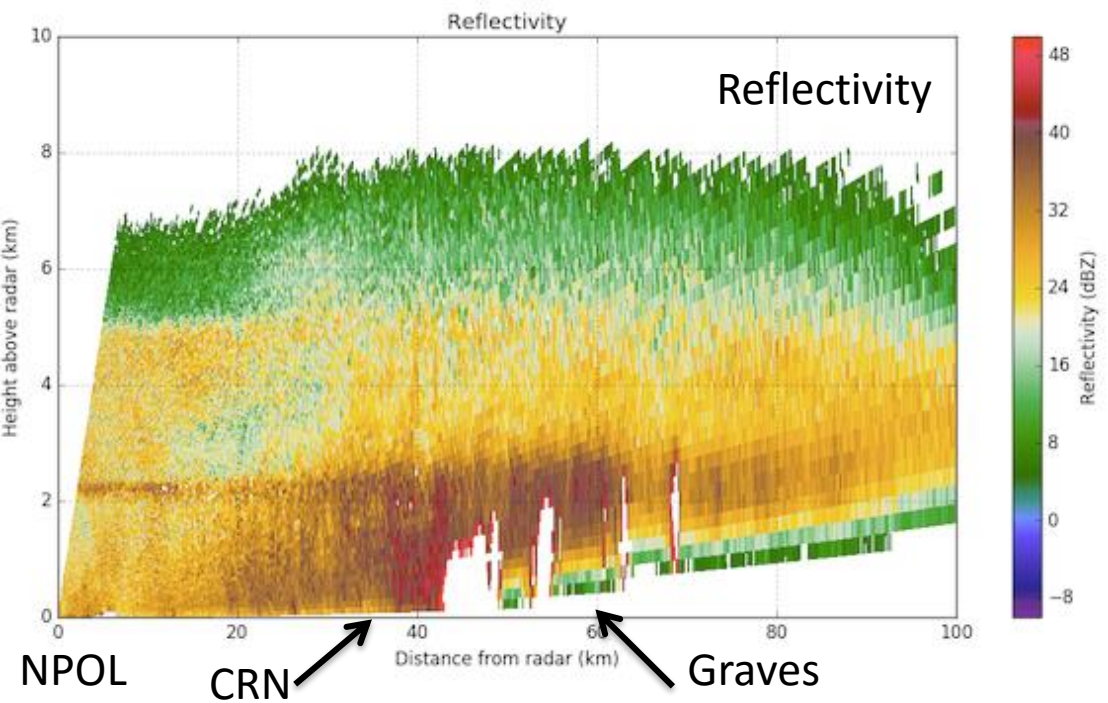
Atmos. Rivers -- Prefrontal

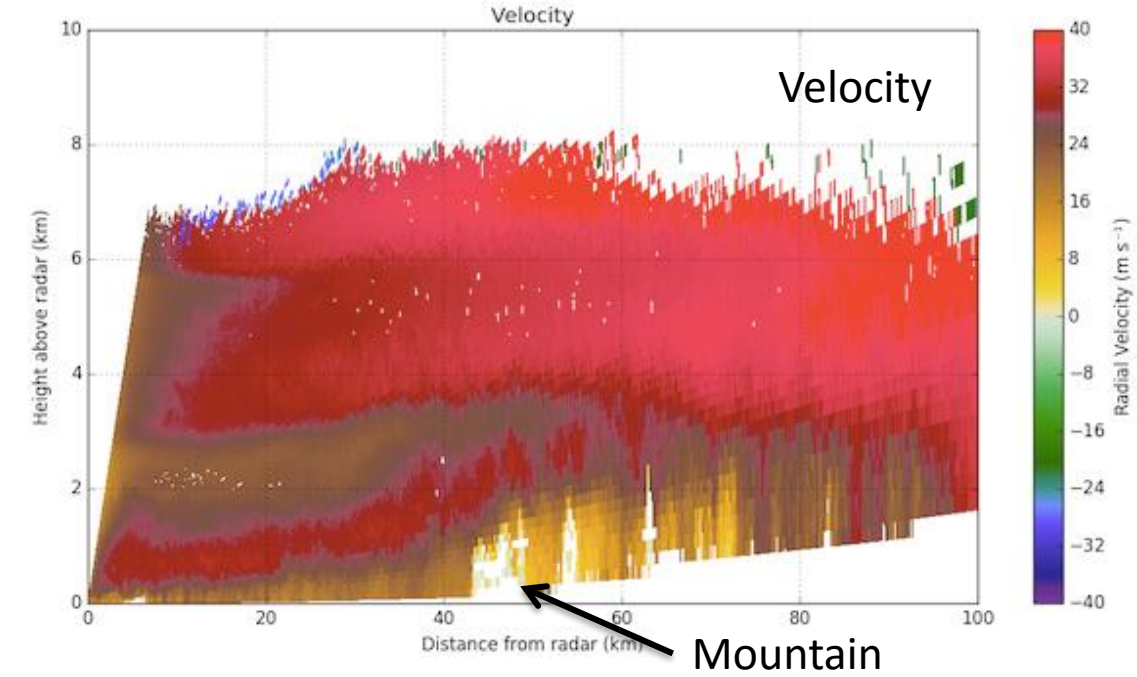


Atmos. Rivers –Warm Sector



NPOL RHI 17-Nov 19:34 UTC
48° Azimuth





Low-level jet again lifts over terrain, similar to 13-Nov. Very high reflectivity below bright band.

Mid-level flow may be lifted as well. Some enhanced reflectivity above bright band (and in dual-polarimetric variables).