Atmospheric Rivers observed during the Olympic Mountains Experiment (OLYMPEX)

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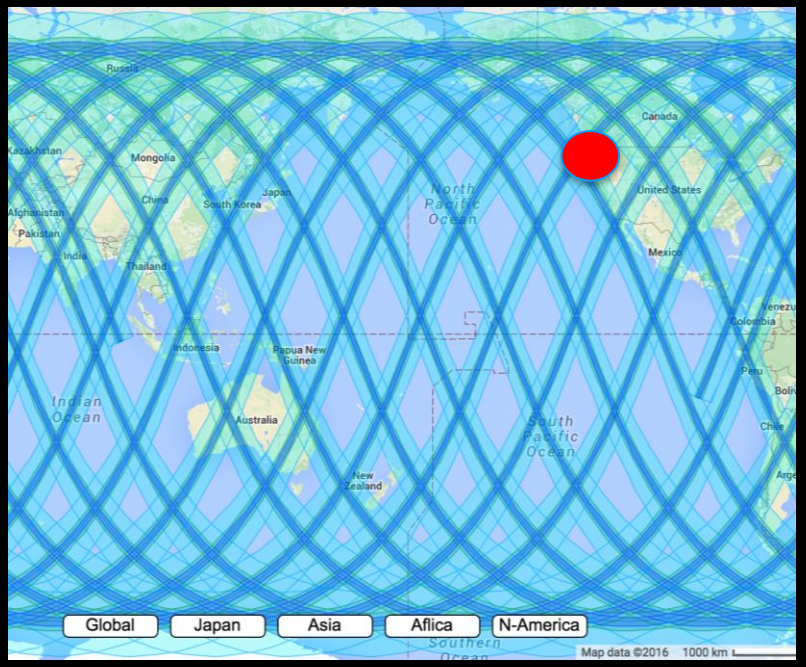
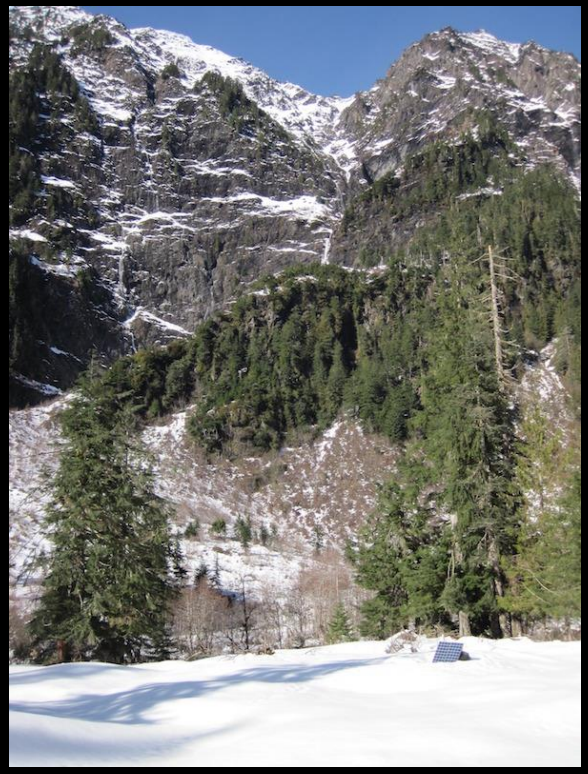
Goals of OLYMPEX

- Validate GPM satellite radar and passive microwave instruments measurements of precipitation

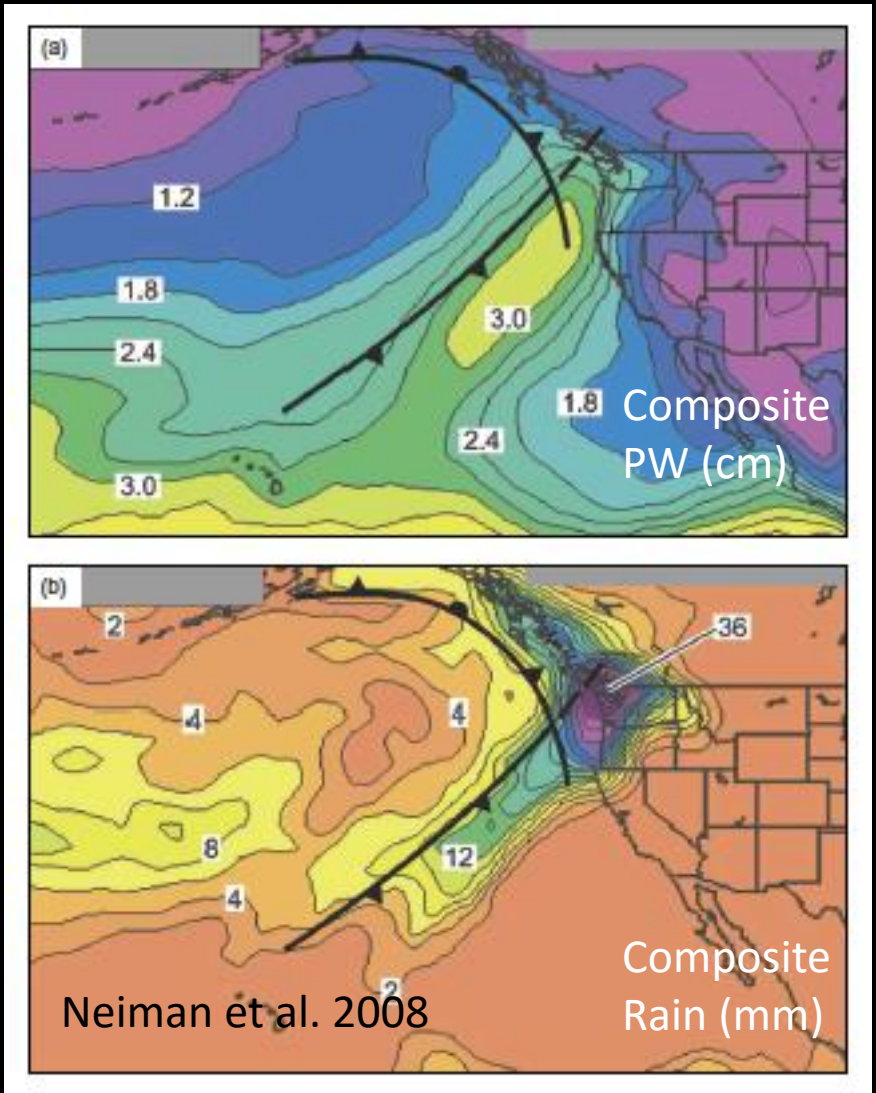


Goals of OLYMPEX

- Determine the orographic effects on precipitation processes

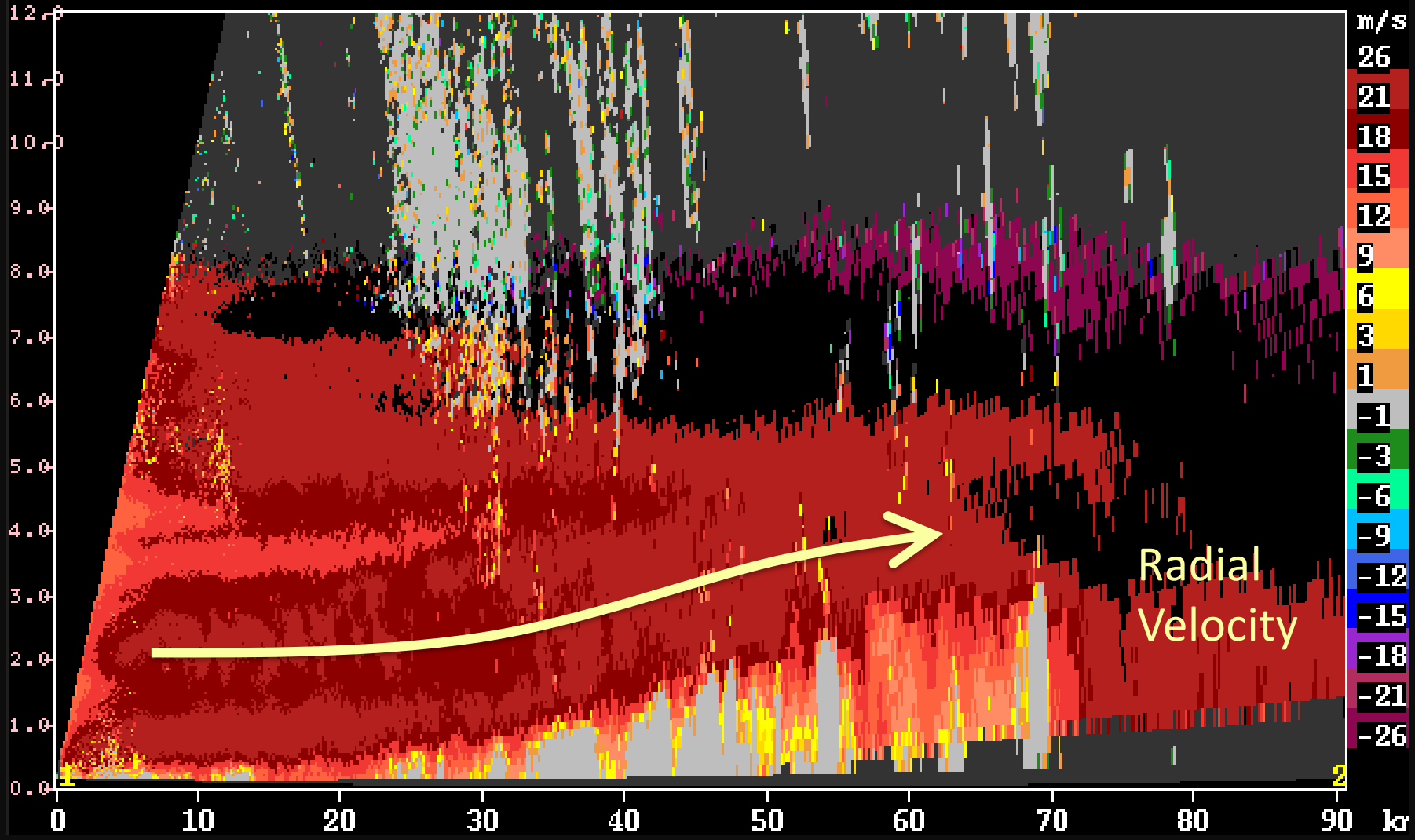


What are the mechanisms of enhancement of Atmospheric Rivers and other frontal precipitation over coastal mountains?

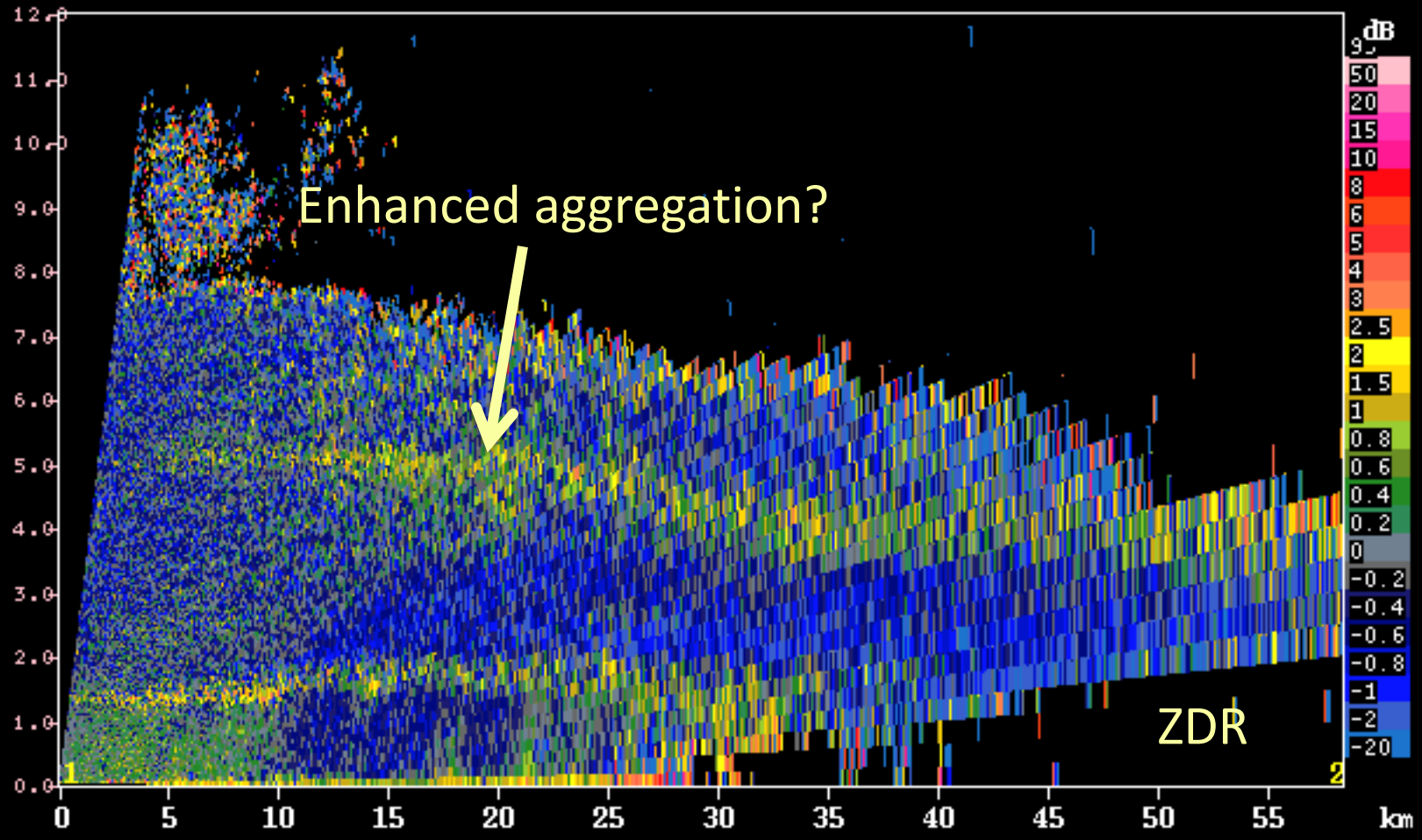


Results addressing this question can inform the PMP (Larry Schick's talk)

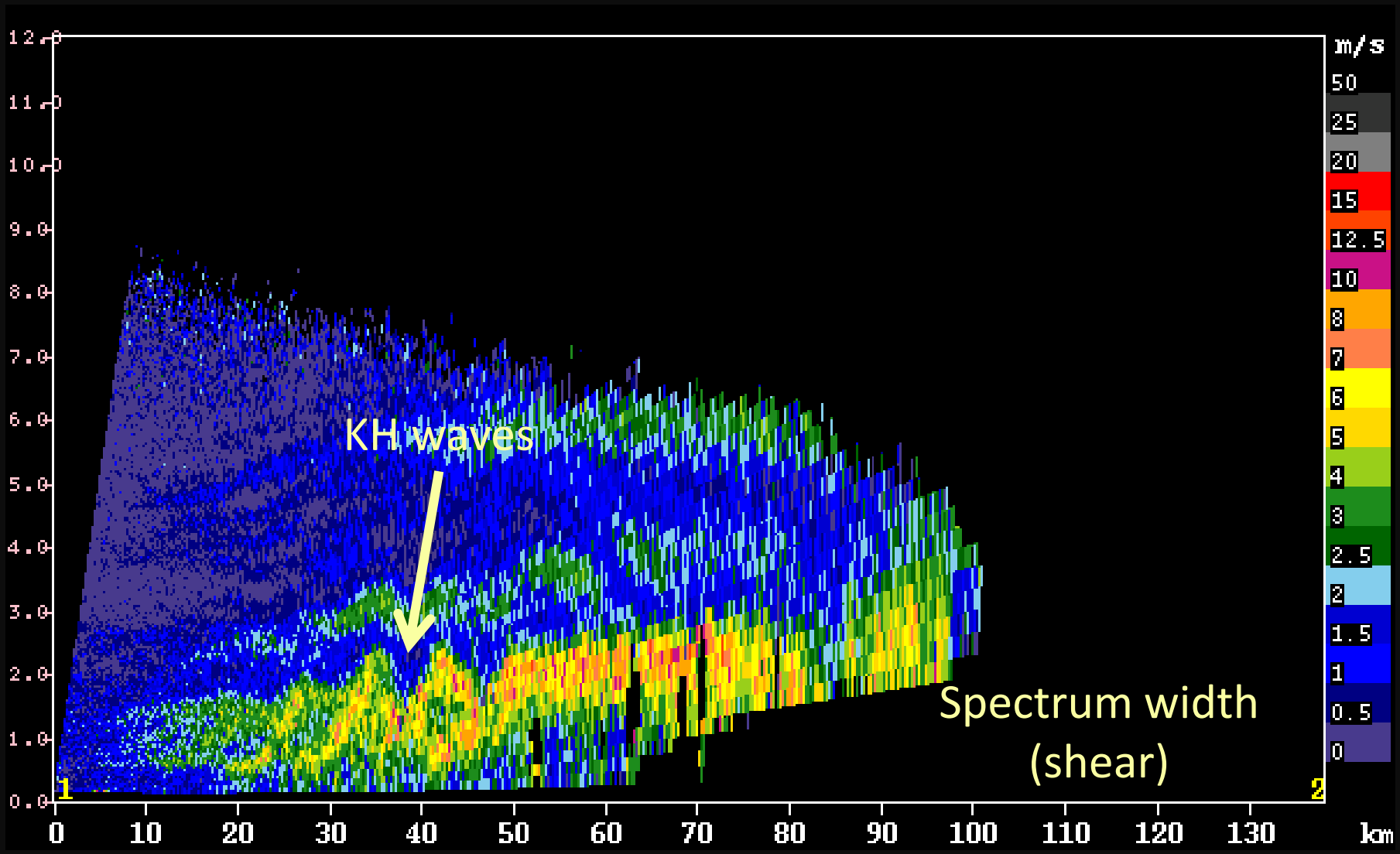
Layer lifting of low-level warm moist jet?



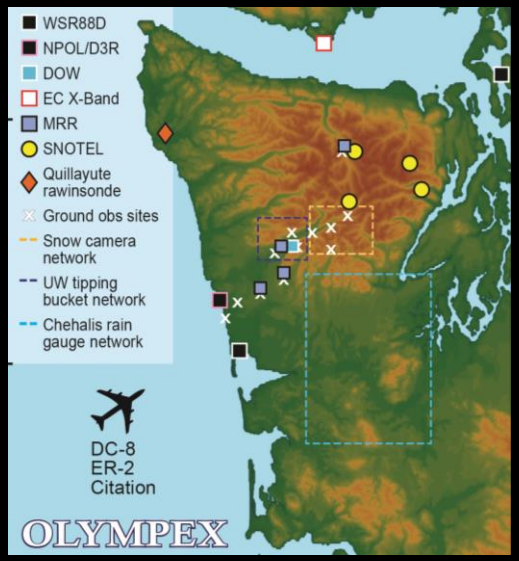
Enhancement of ice-phase processes?

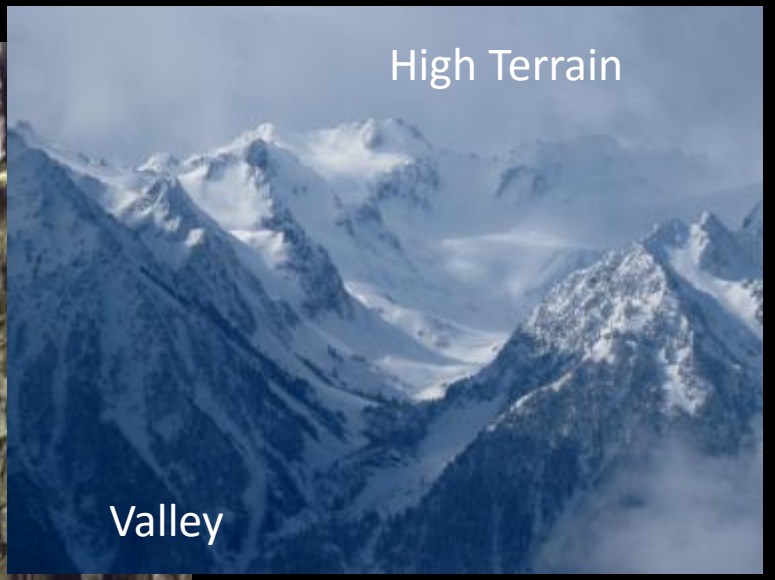


Cellularity in the upslope flow?

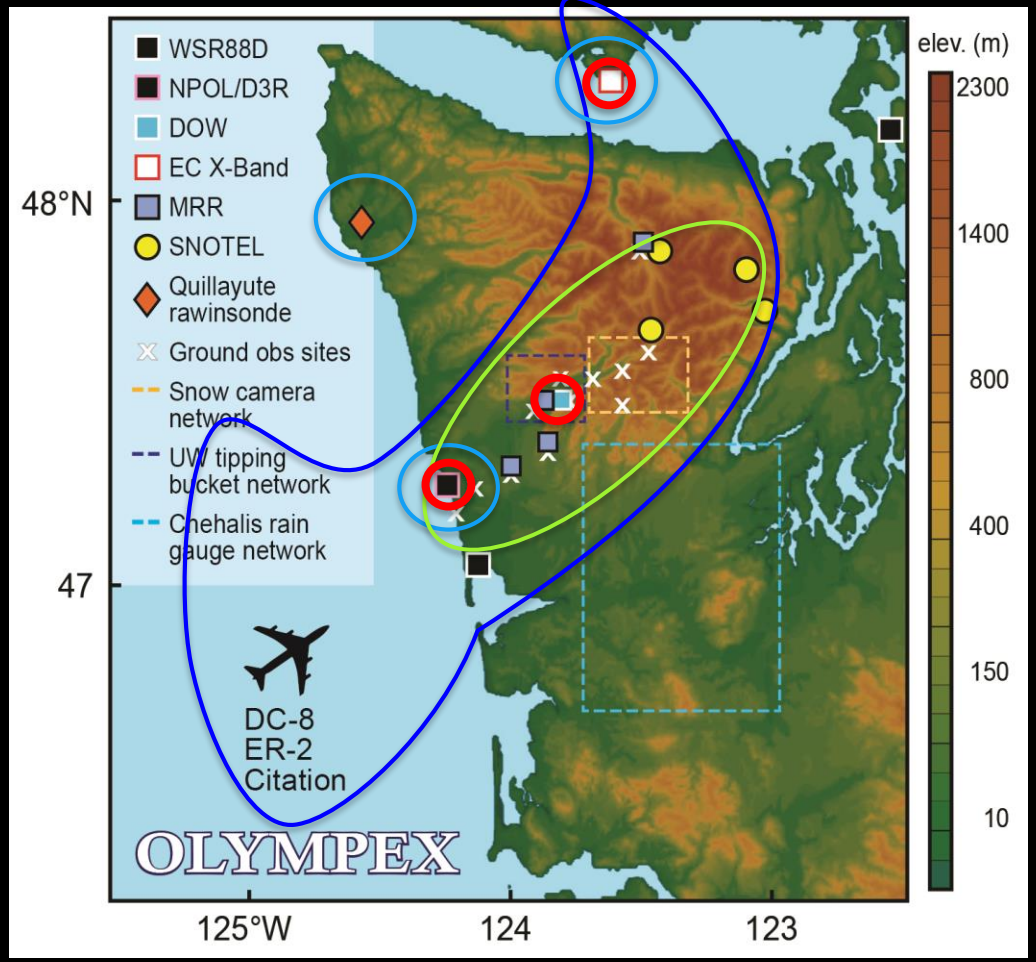


The Olympic Peninsula





The OLYMPEX Strategy



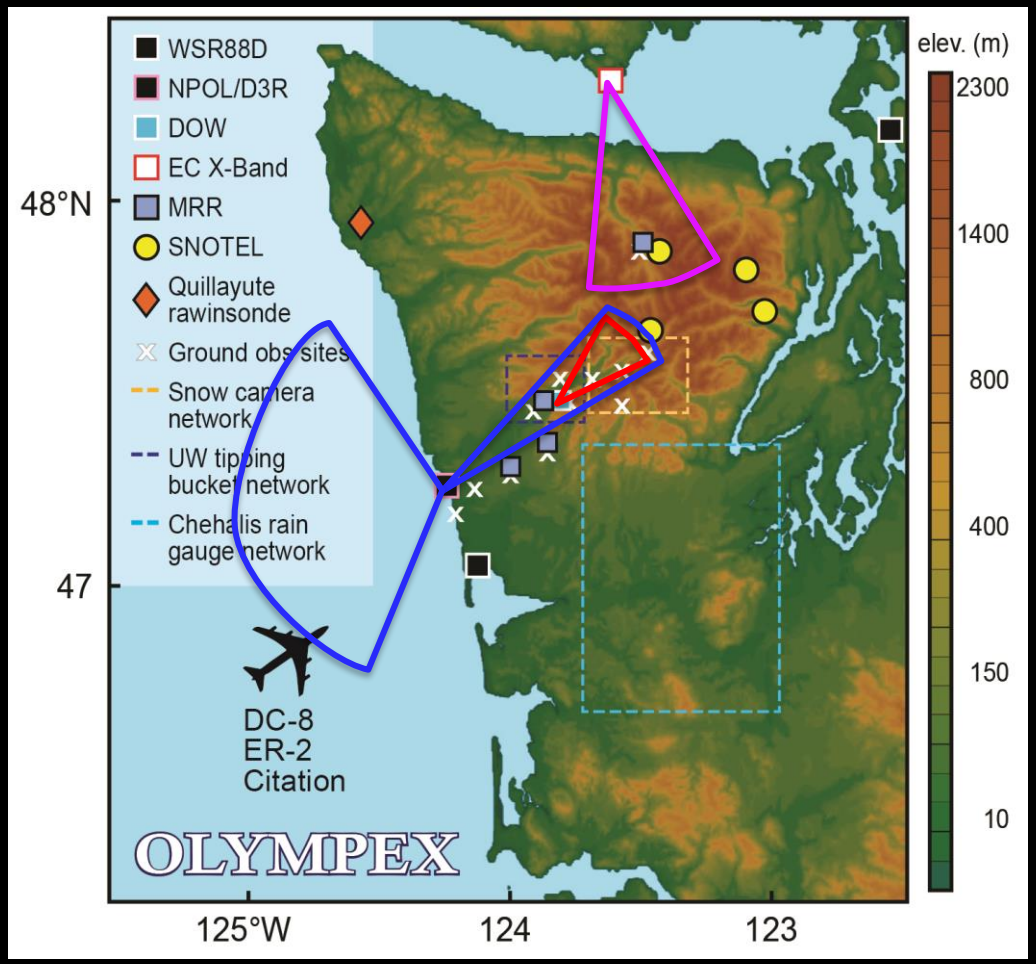
Aircraft
- ER2 & DC8—over the top
- Citation—through the clouds

Surface
- Particle sizes and fallspeeds
- Rain and snow amounts
- Snow cameras

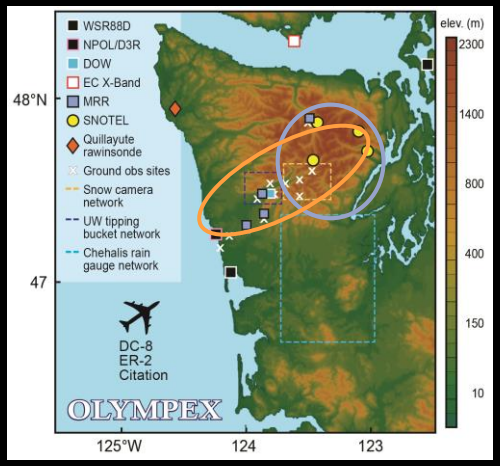
Upper air
- Supplemental soundings in events
- Windward and leeside stations

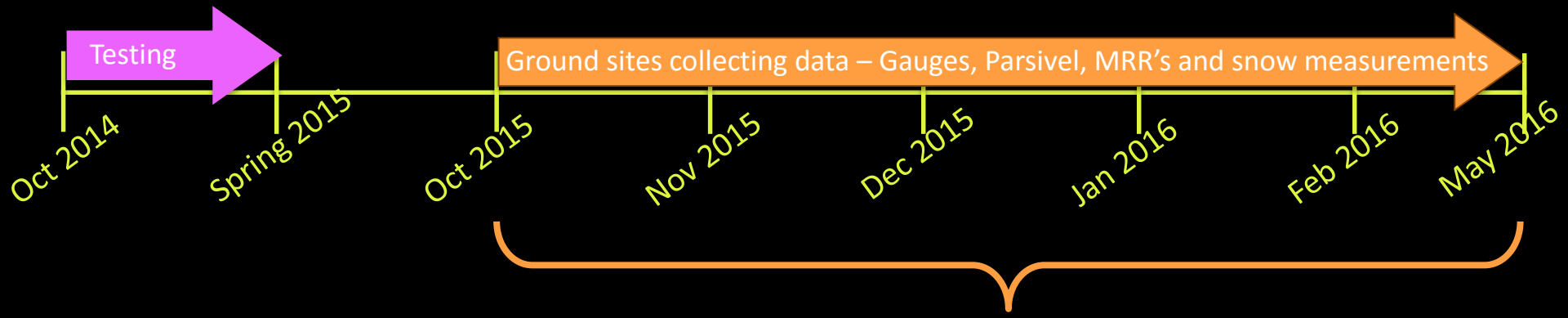
Radars for 3D structure
- RHI sectors at 4 different wavelengths
- Dual polarization
- Doppler

RHI sectors


WSR88D
NPOL/D3R
DOW
EC X-Band
MRR
SNOTEL
Quillayute rawinsonde
Ground obs sites
Snow camera network
UW tipping bucket network
Chehalis rain gauge network
DC-8
ER-2
Citation
OLYMPEX
48°N
47
125°W
124
123
elev. (m)
2300
1400
800
400
150
10

Timeline of Operations





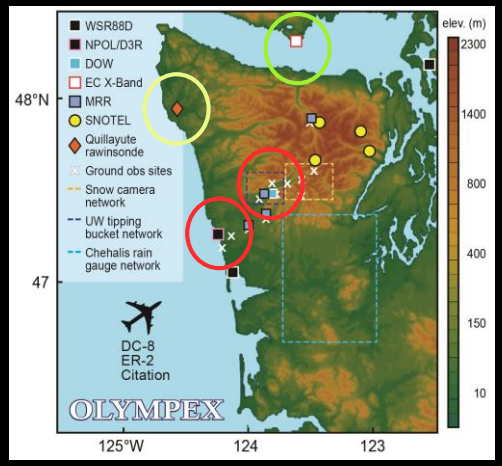
Ground Sites

Rain gauges, disdrometers, MRR's

Snow Measurements

Trailer, Hurricane Ridge, Snow Poles, Snow Survey, Lidar Flights

Timeline of Operations



Aircraft

Soundings

Soundings

EC X-band Operations

NPOL and DOW Operations

NPOL,DOW

Testing

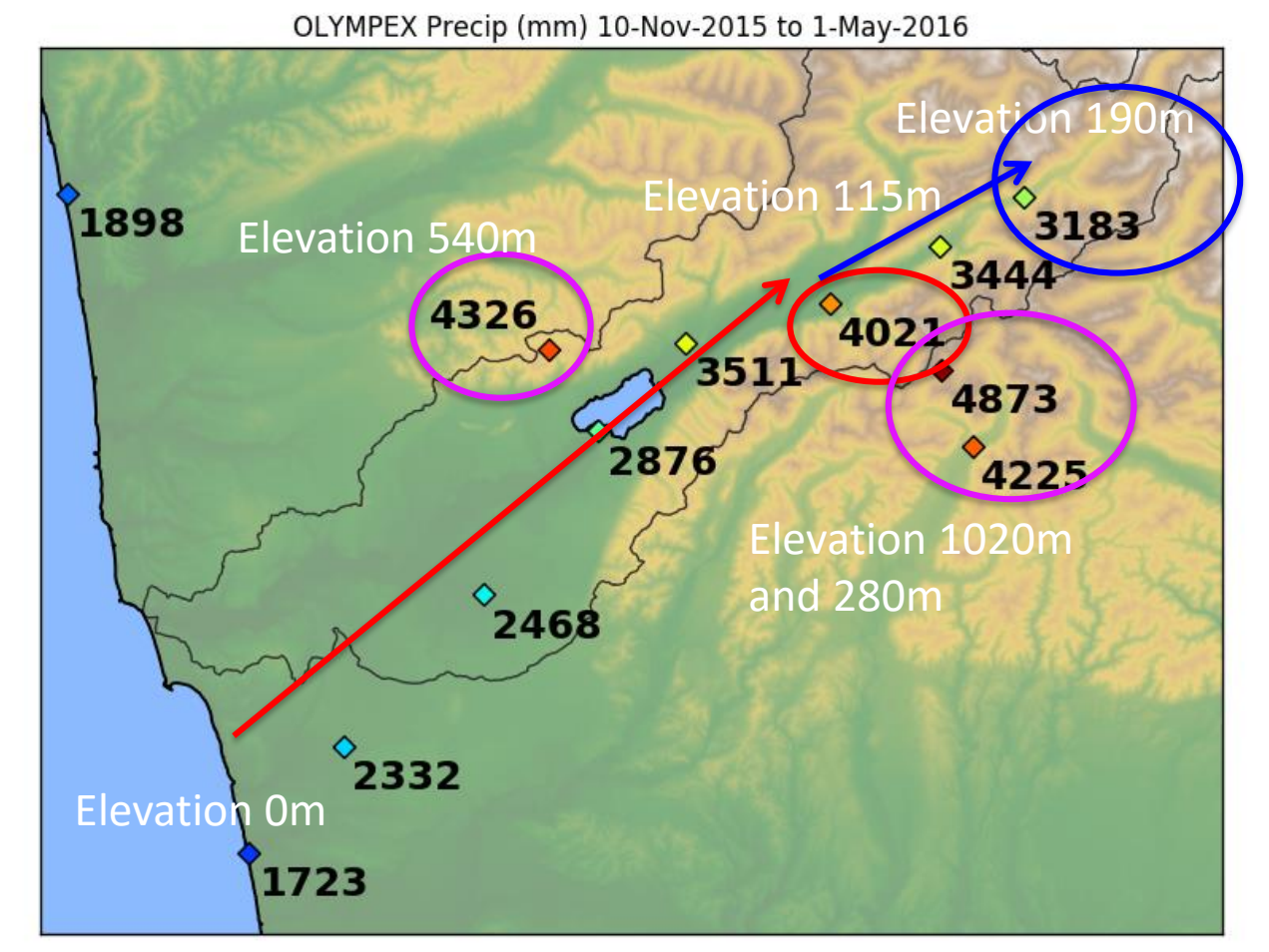
Ground sites collecting data – Raingauge and Parsivel and MRR's

Oct 2014 | Spring 2015 | Oct 2015 | Nov 2015 | Dec 2015 | Jan 2016 | Feb 2016 | May 2016

Aircraft
Radars
Soundings

Radars
Soundings

What did we observe?



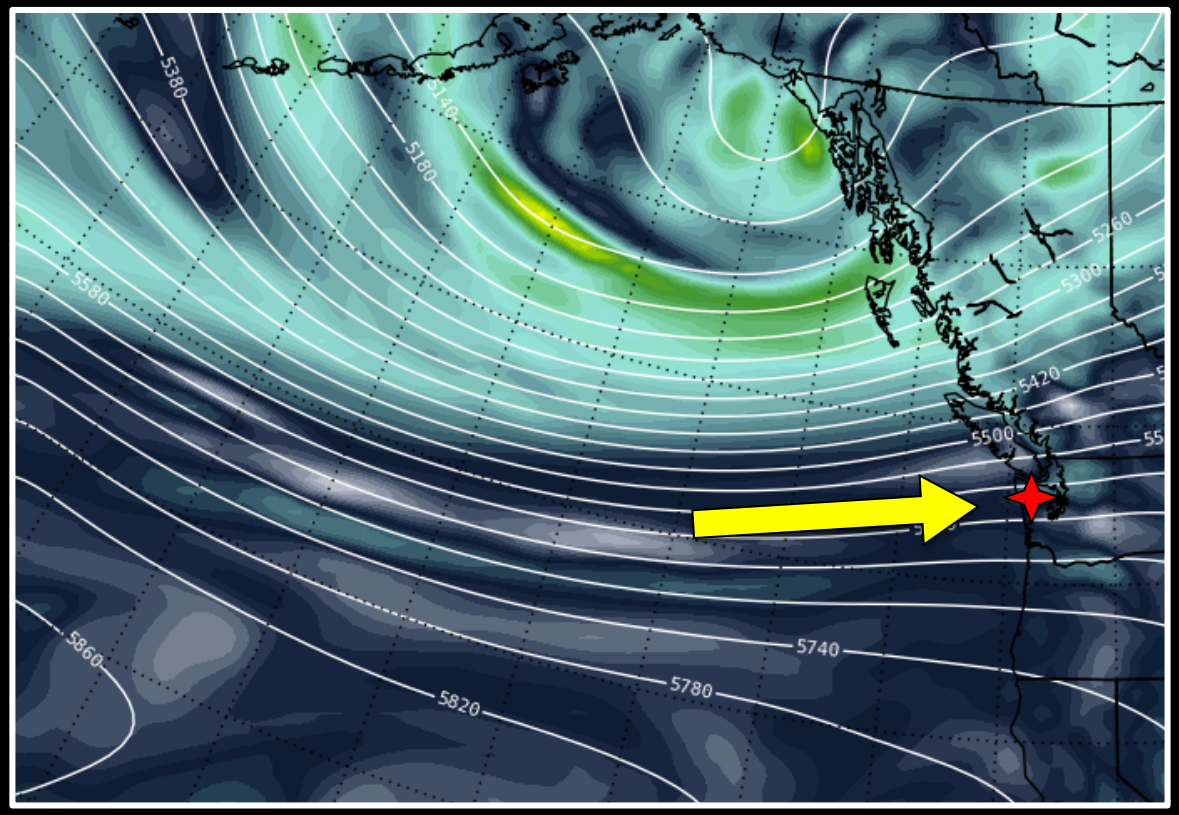
A lot of precipitation

Our criteria for Atmospheric River events

- High Melting level (> 2 km)
- High Precipitable water (>25mm)
- Strong cross-barrier flow (>40 kts at 925 hPa)
- Long period of precipitation/ orographic enhancement of precipitation (in our cases)

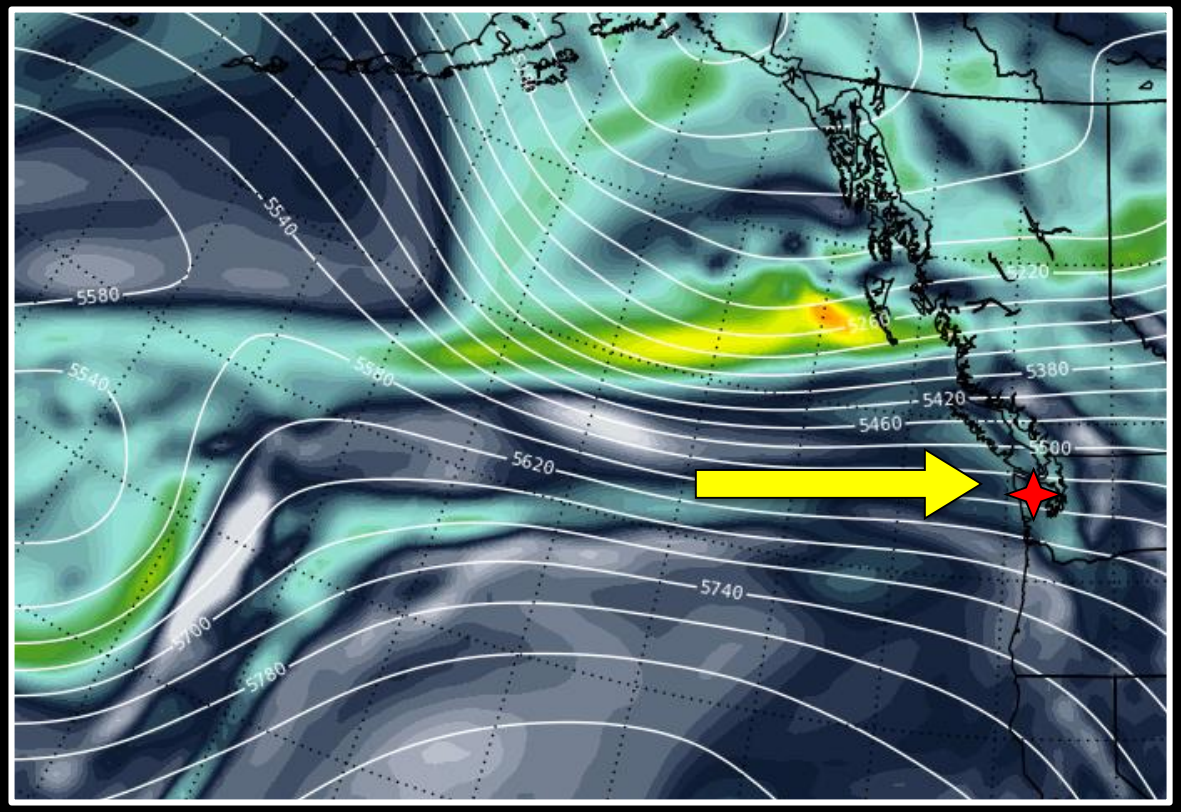
At least 6 Atmospheric River Events during OLYMPEX

- 12 – 13 November – First day of full operations
- 16 – 17 November – no aircraft flights – strong cross winds
- 3 – 4 December
- 8 – 9 December
- 21 – 22 January 2016 –observed by ground network only
- 14 – 16 February 2016 – observed by ground network only



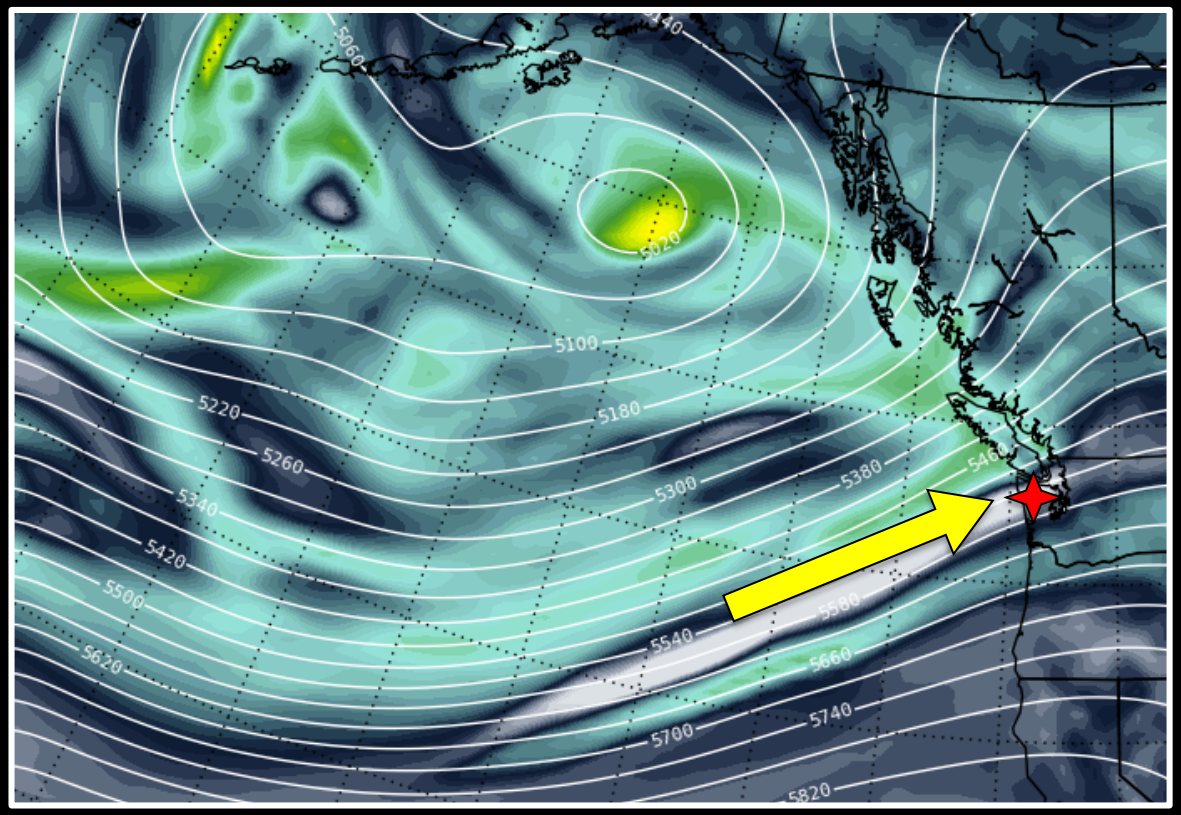
WSW Flow
Strong Jet
across Pacific

0600 UTC 13 November
500 hPa Heights and Vorticity



WSW Flow
Even stronger
Jet across
Pacific

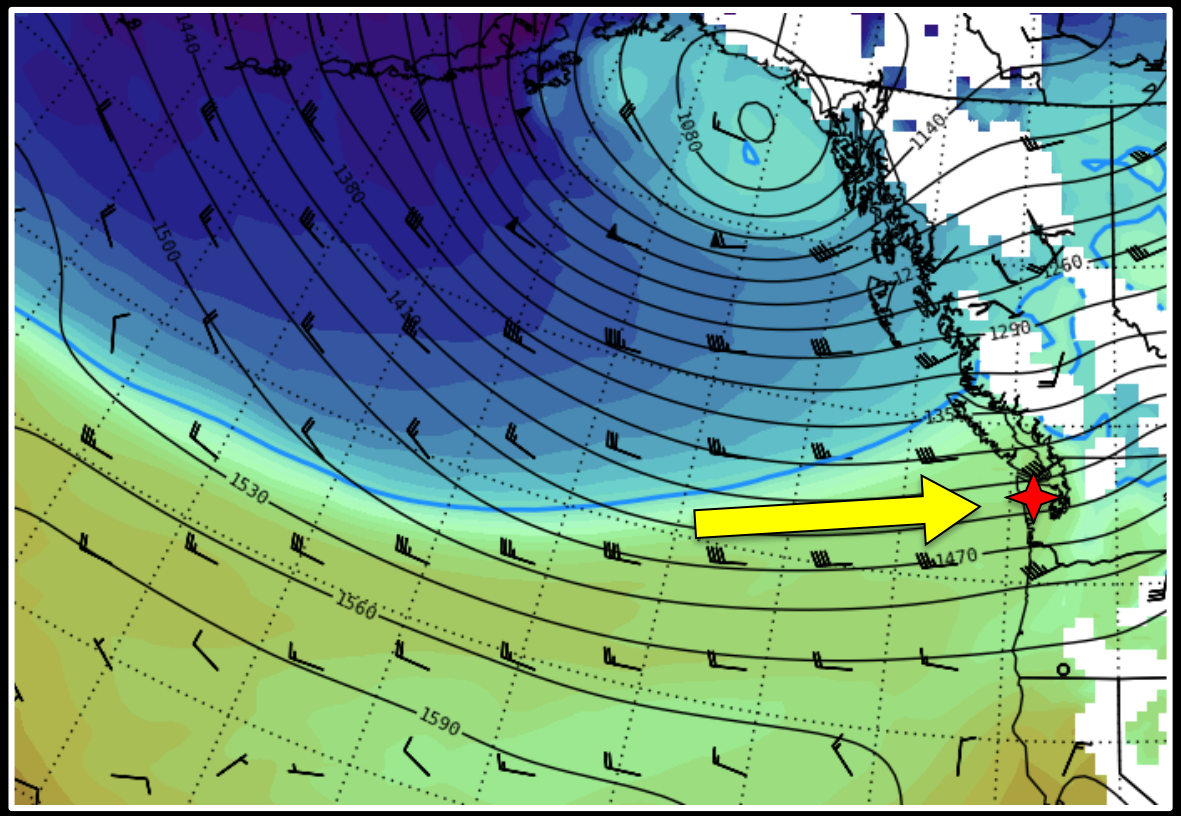
1200 UTC 17 November
500 hPa Heights and Vorticity



SW Flow
Strong Jet
across Pacific

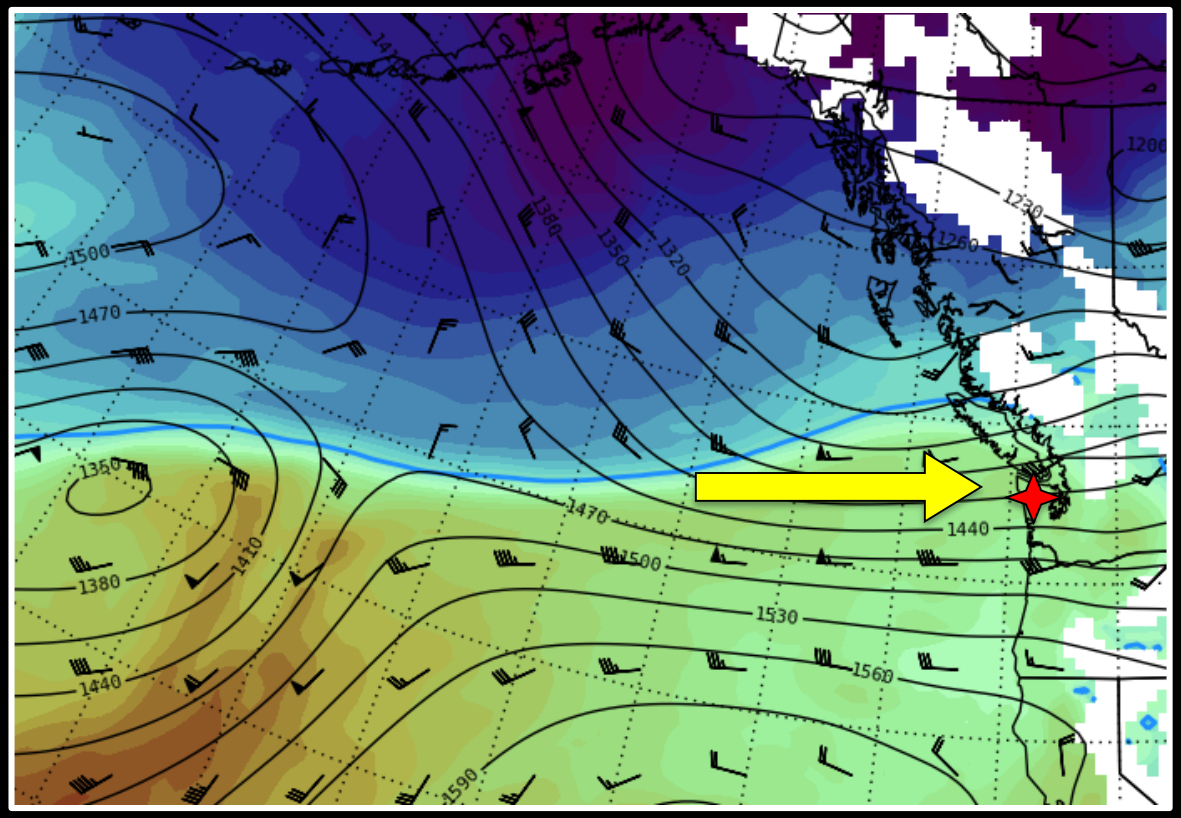
1800 UTC 8 December
500 hPa Heights and Vorticity

All 3 cases had strong ~(south)westerly jet aimed straight towards Olympic Peninsula



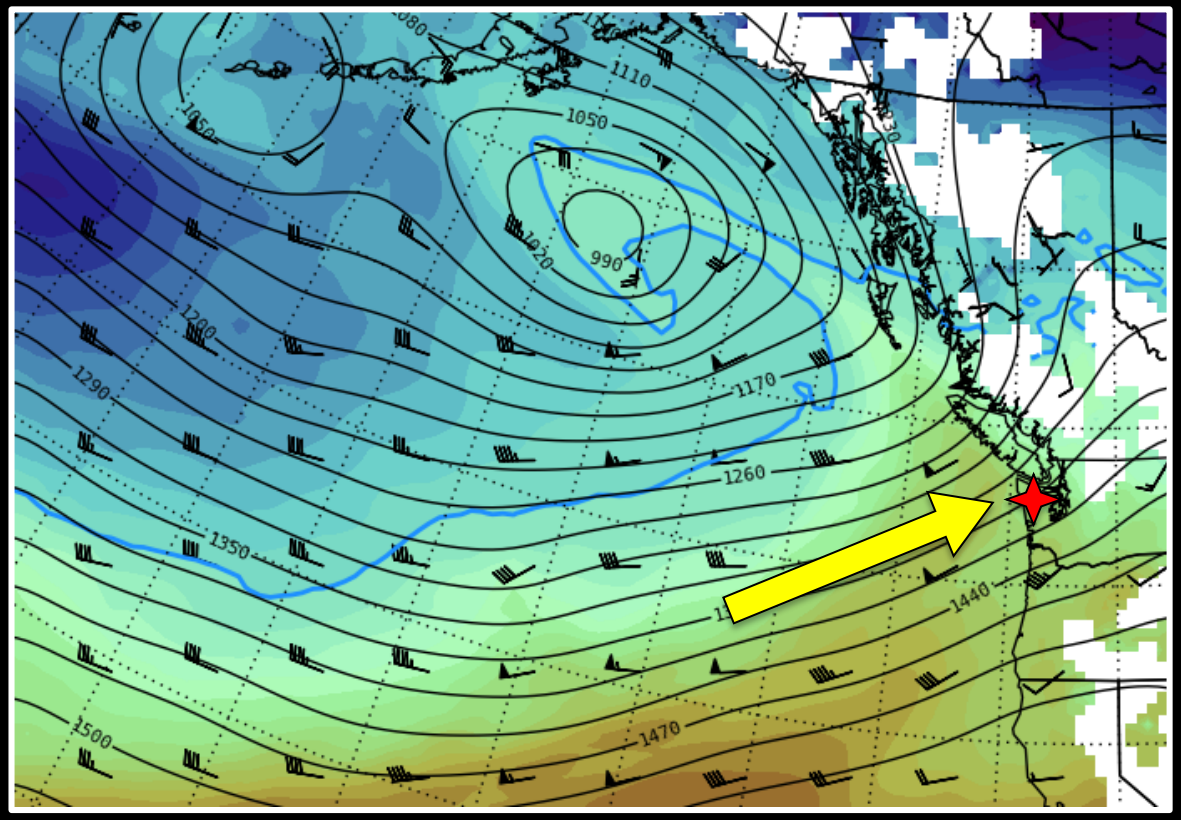
Strong onshore flow at 850hPa. Very warm airmass

0600 UTC 13 November
850 hPa Heights and Temperature



Strong onshore flow at 850hPa. Very warm airmass

1200 UTC 17 November
850 hPa Heights and Temperature

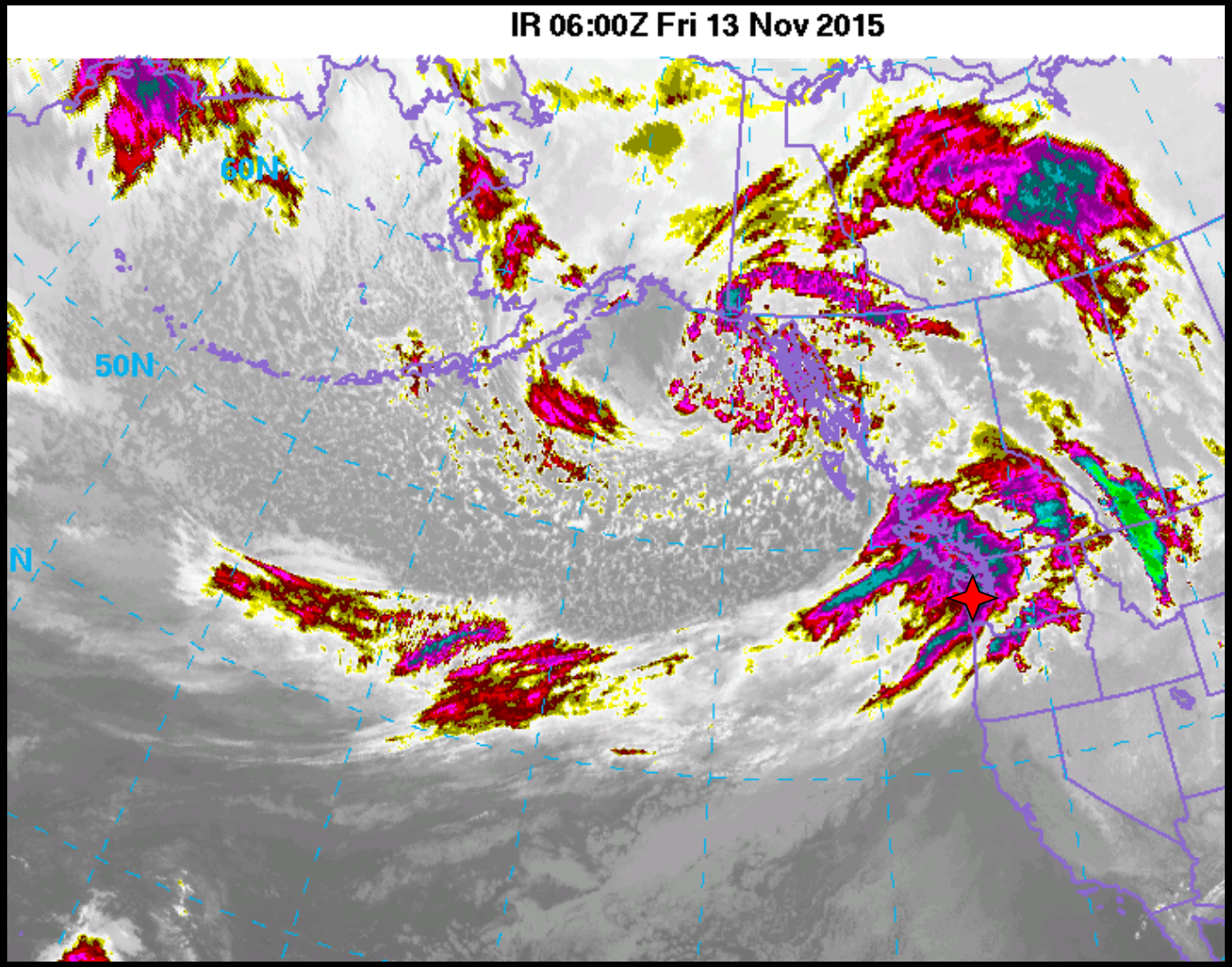


SW Flow
Strong Jet
across Pacific

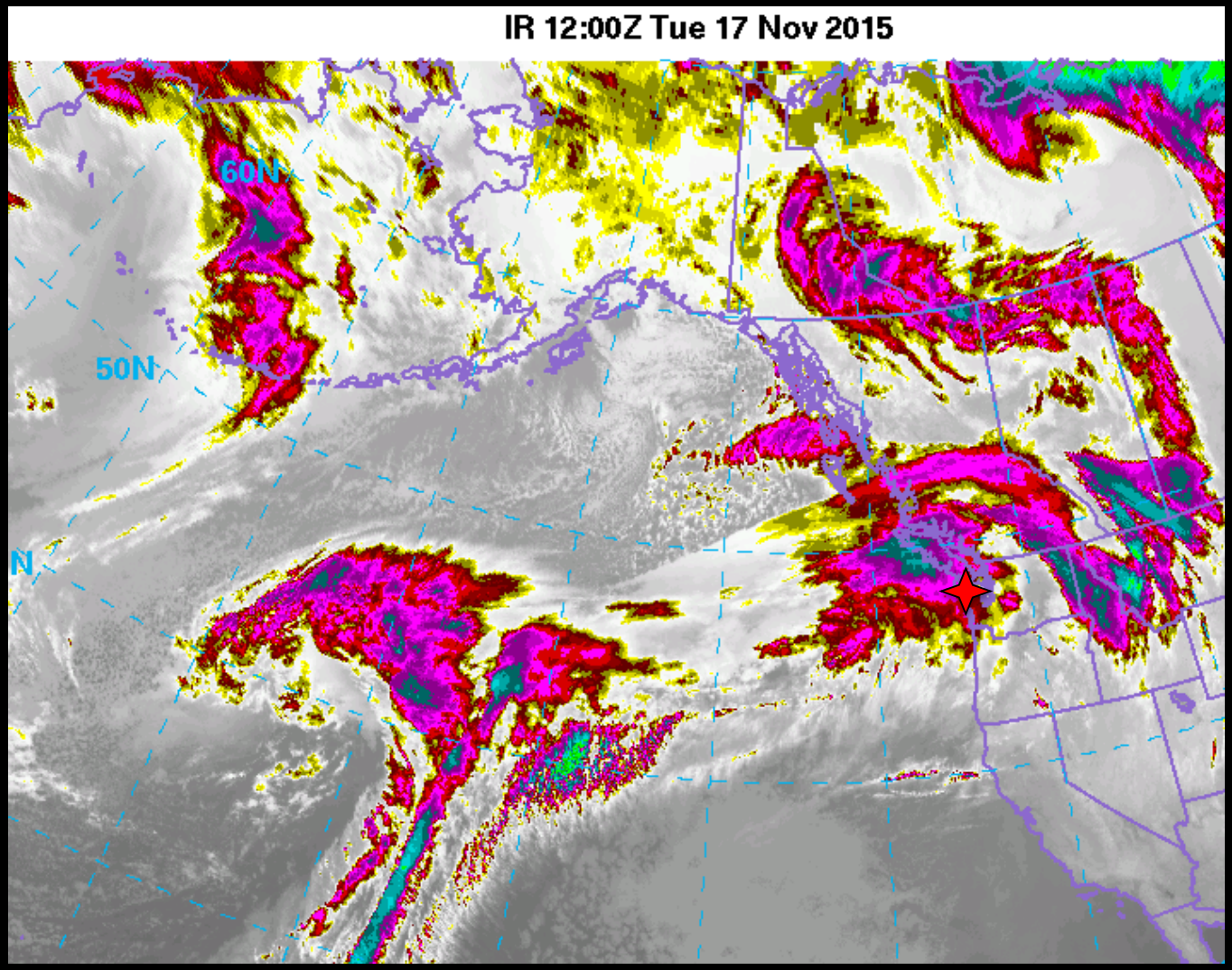
1800 UTC 8 December
850 hPa Heights and Temperature

All 3 cases had warm, strong low level flow. Nov 13 and 17 events had NCFR passage at end of event

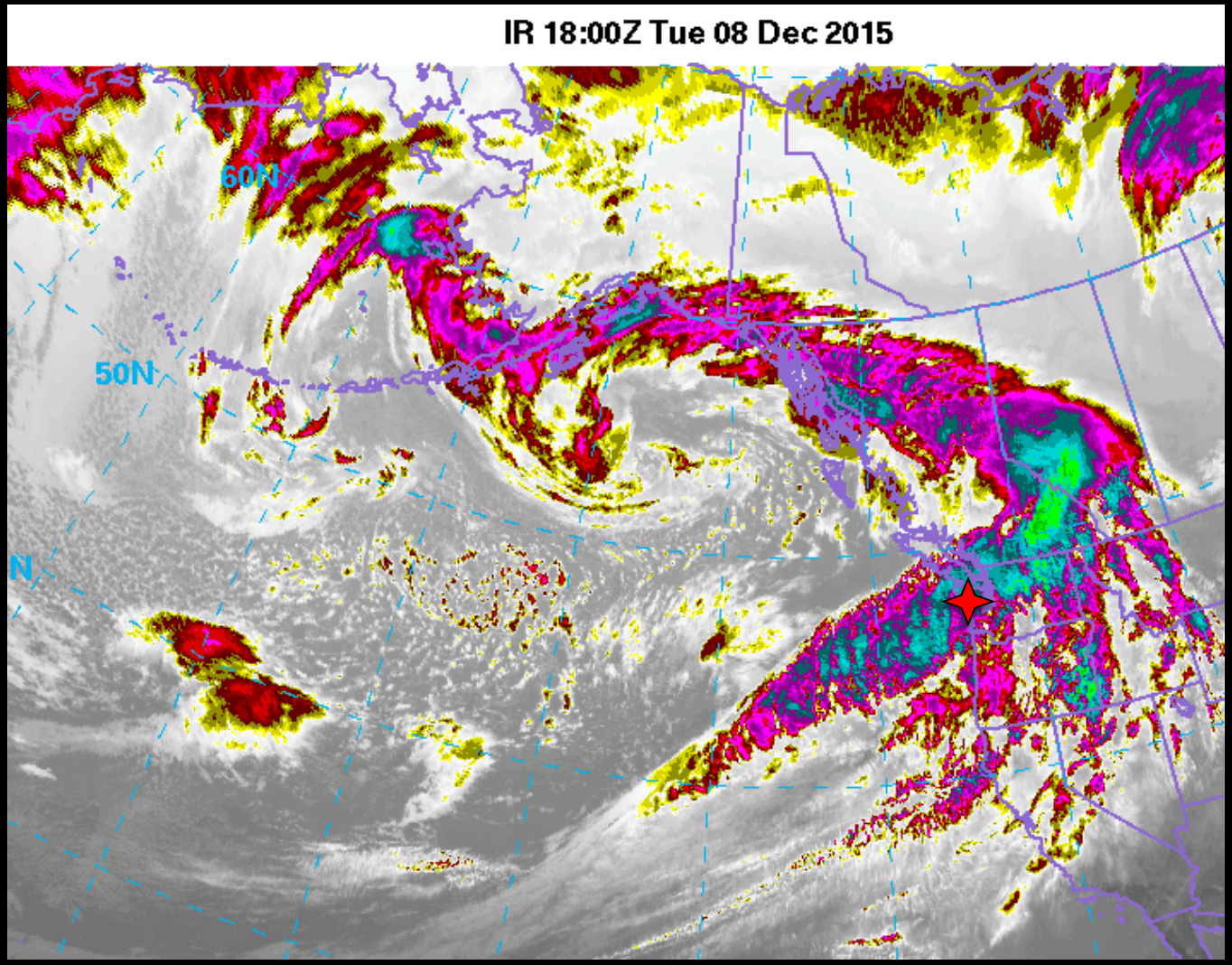
12 – 13 November Atmospheric River

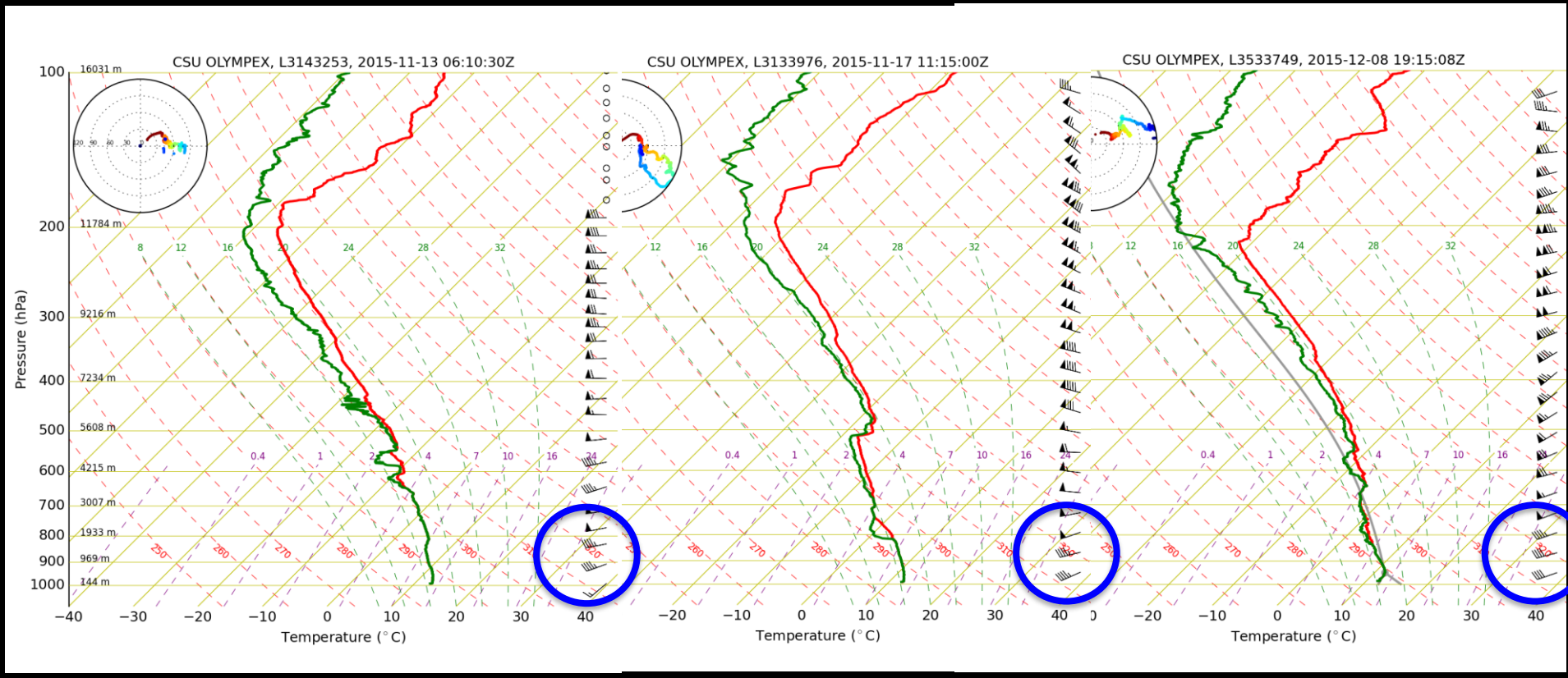


16 – 17 November Atmospheric River



8 – 9 December Atmospheric River



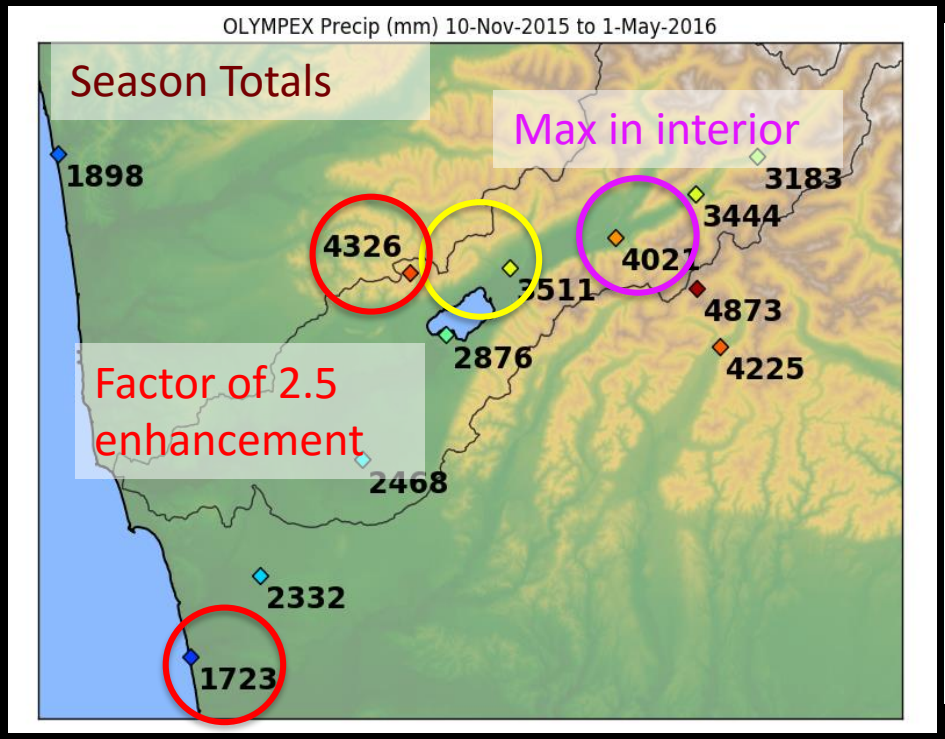


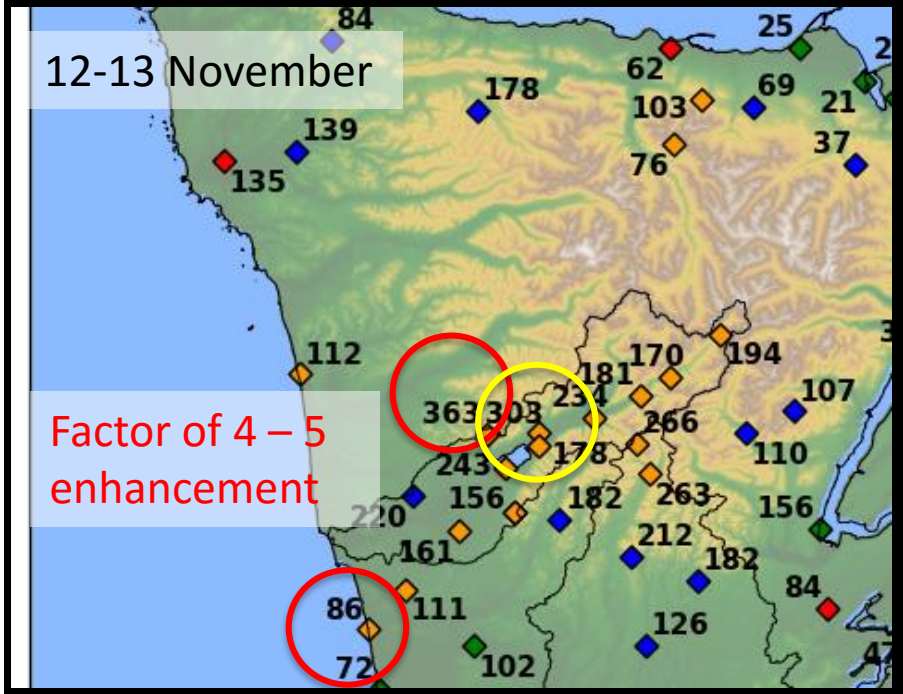
0600 UTC 13 Nov
PW = 29.3 mm
0°C = 2680 m

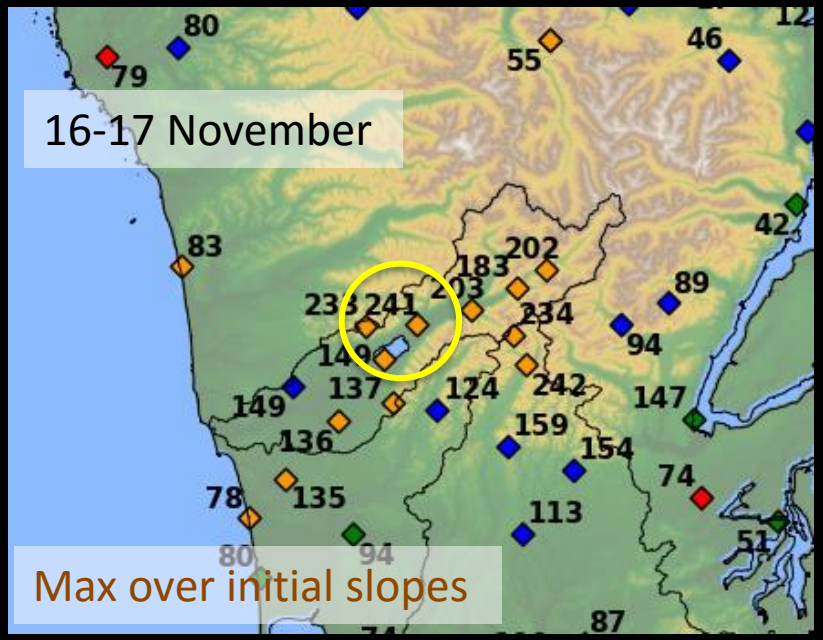
1200 UTC 17 Nov
PW = 27.1 mm
0°C = 2276 m

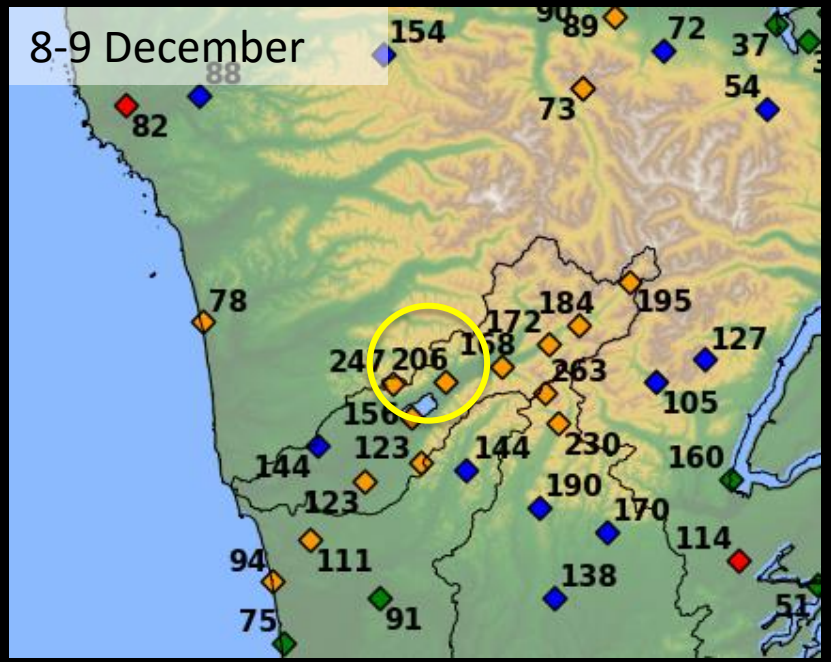
1800 UTC 8 Dec
PW = 28.8 mm
0°C = 2488 m

All 3 cases had high melting levels and large precipitable water and strong 40kt jet at 925 hPa with little turning


OLYMPEX Precip (mm) 10-Nov-2015 to 1-May-2016
Season Totals
Max in interior
Factor of 2.5 enhancement
1898
3183
3444
4326
4027
3511
4873
2876
4225
2468
2332
1723

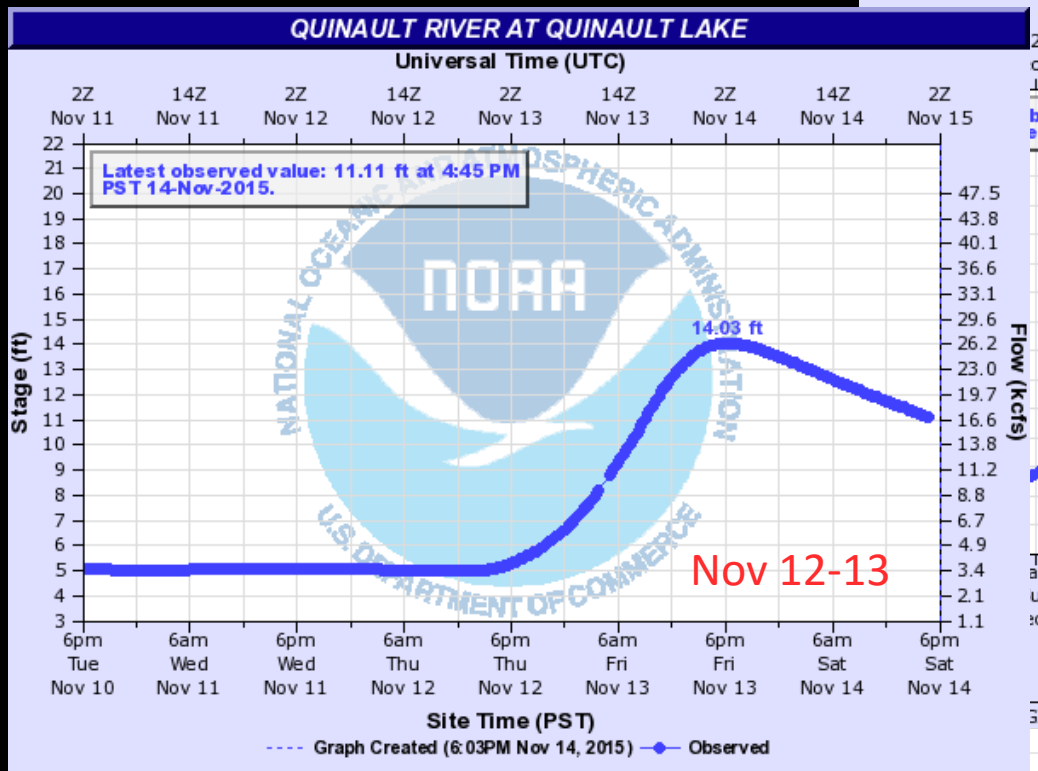

12-13 November
Factor of 4 – 5 enhancement
84
25
178
62
103
69
21
139
37
76
135
112
170
194
181
107
266
110
156
182
263
212
161
182
84
86
111
126
72
102


16-17 November
Max over initial slopes
80
79
55
46
83
202
183
89
234
94
137
124
242
147
149
136
159
154
74
78
135
113
51
94
87


8-9 December
154
89
72
37
82
73
54
78
184
195
172
127
206
263
105
123
144
230
160
190
170
114
94
111
138
75
91
51

Hydrological Impacts

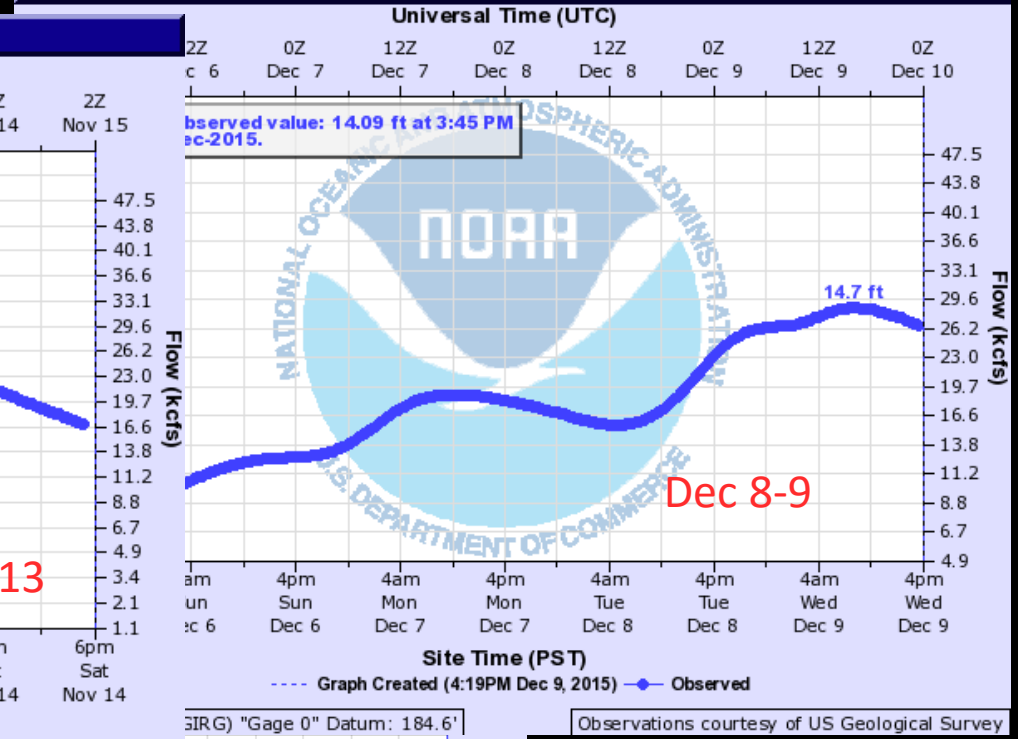
QUINAULT RIVER AT QUINAULT LAKE



QLTW1(plotting HGIRG) "Gage 0" Datum: 184.6'

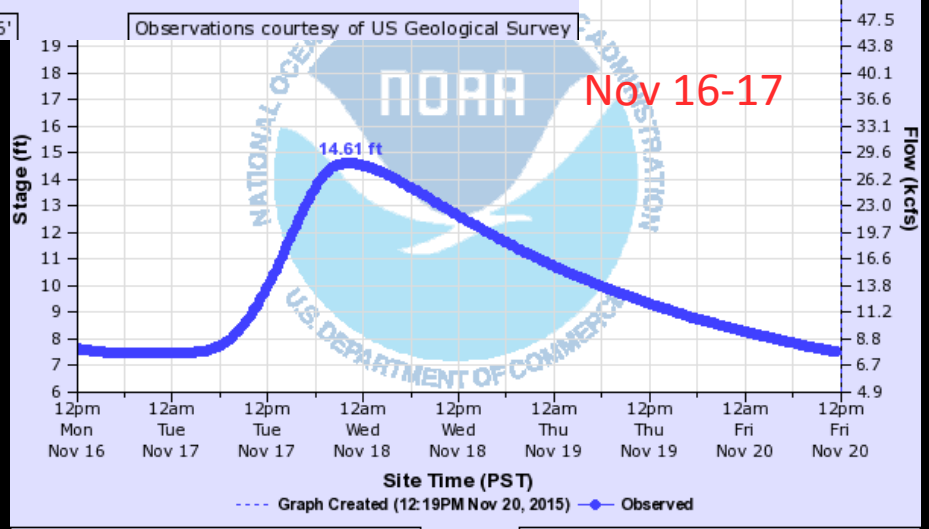
Observations courtesy of US Geological Survey

QUINAULT RIVER AT QUINAULT LAKE



GIRG) "Gage 0" Datum: 184.6'

Observations courtesy of US Geological Survey



QLTW1(plotting HGIRG) "Gage 0" Datum: 184.6'

Observations courtesy of US Geological Survey

16 – 17 November Atmospheric River

The Doppler on ~~Wheels~~ Water (DOW)

Common Features of these 3 Events (warm sector period)

- Strong, moist WSW flow towards the Olympic Mountains with high melting levels
- Precipitation patterns differ from seasonal climatology including stronger than average orographic enhancement
- Large hydrologic impact
- Next talk: What is role of warm rain and ice-processes in contributing to orographic enhancement?

Now for some preliminary results from Joe…