

Low Level Wind Shear at KRNO (Reno, NV)

How to better forecast and detect

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Why...

- LLWS is a huge impact to aviation at KRNO
- Misunderstood forecasting
- Original idea: High wind days brought shear
- *Goal: To see if there are any patterns that would generate LLWS at KRNO → Ultimately forecast it better*

Actual PIREPs from 12/15/16

RNO UUA /OV RNO 5NW/TM 1855/FL085/TP DH8D/RM
LLWS +/- 10KTS ON SHORT FINAL 085-SFC DURD. ROTOR
ACTION. AIRCRAFT ALMOST ROLLED AT 085

RNO UA /OV RNO001001/TM 1737/FL010/TP DH8D/RM
WINDSHEAR +/- 30-40KTS UP DRAFT 1500-2000 FEET

RNO UUA /OV RNO/TM 1556/FL110/TP B737/TB MOD BLO
110/RM LLWS +/- 30-40KTS. MANY DIVERTS AND GO
AROUNDS. ZOA CWSU



Left: 737, Right: Dash 8



Impacts at KRNO



A photograph of a departure board at KRNO. The board lists flights to various destinations including Salt Lake, San Francisco, Dallas/Ft. Worth, St. Louis, Los Angeles, Albuquerque, Chicago O'Hare, Seattle, Phoenix, Las Vegas, San Francisco, Portland, and Seattle. The status column shows various outcomes: 'Departed', 'Cancelled', 'On Time', and 'Delayed Until 10:47'. The board is titled 'DEPARTURES' and includes a logo for 'KRNO'.

TO	TIME	AIRLINE	FLIGHT	GATE	STATUS
SALT LAKE	6:25 A	DELTA	1421	B10	Departed
SAN FRANCISCO	6:30 A	UNITED	5628		Cancelled
DALLAS/FT. WORTH	7:00 A		1174	C10	On Time
ST. LOUIS	7:00 A		209	B5	Cancelled
LOS ANGELES	7:25 A		36	B7	Cancelled
ALBUQUERQUE	8:25 A		559	B1	Cancelled
CHICAGO O'HARE	8:40 A		2360	C12	On Time
SEATTLE	9:15 A		2250	C6	Delayed Until 10:47
PHOENIX	9:30 A		536	B3	Cancelled
LAS VEGAS	9:30 A		648	B1	Cancelled
PHOENIX	9:30 A		416	C9	On Time
SAN FRANCISCO	9:32 A	UNITED	6484		Cancelled
PORTLAND	10:05 A		2150	C6	On Time
LAS VEGAS	10:20 A		2243	B3	Cancelled
SEATTLE	10:50 A		2442	C6	On Time
SAN FRANCISCO	11:00 A	UNITED	6336	C5	Cancelled
LOS ANGELES	11:25 A		123	B1	Cancelled

All Flight Data Provided by Respective Airlines

A sample of the number of flights cancelled or diverted* due to wind and LLWS:

10/14/16: 16 flights, 15%**

10/15/15: 22 flights, 20%**

12/15/16: 25 flights, 23%**

*does not include GA

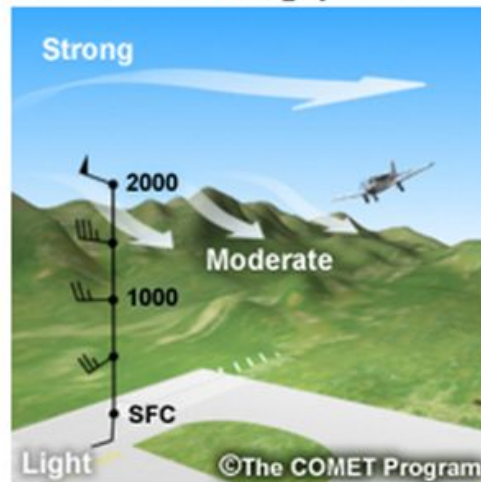
** % is an estimate based on 110 commercial flights per day

Common Causes of LLWS

Mountain/valley effects

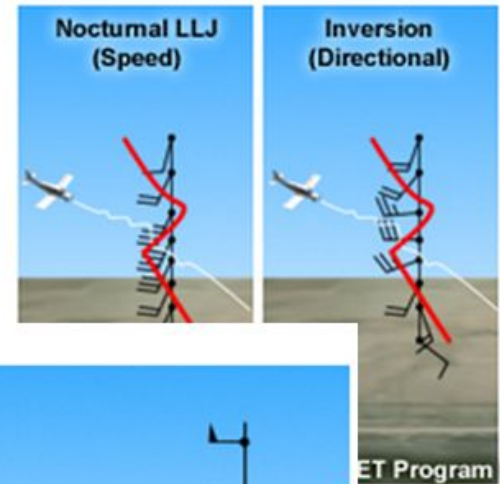


Lee-side effects/gap winds

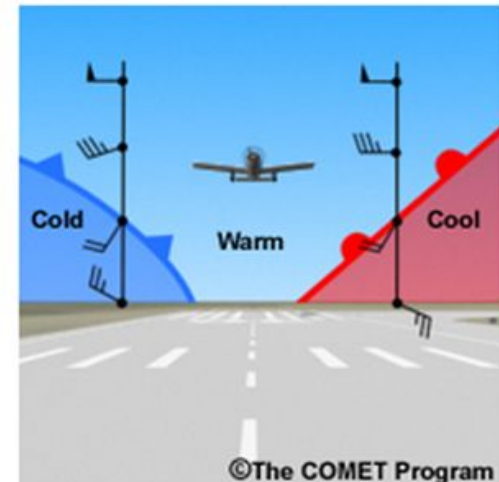


Low-level jet streams

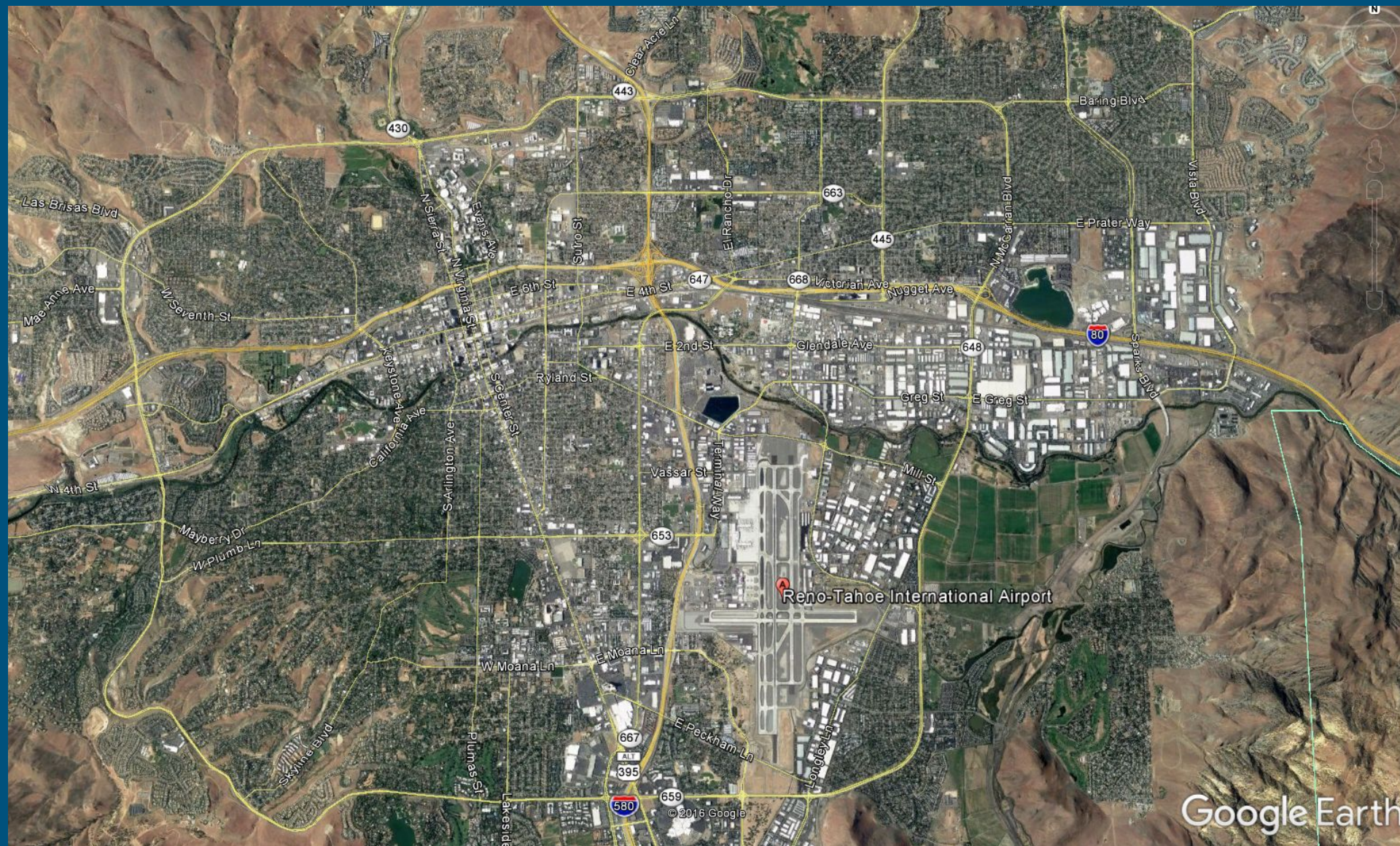
Inversions



Fronts



The Reno Airport



Terrain Viewed From the South



Terrain Viewed From the West

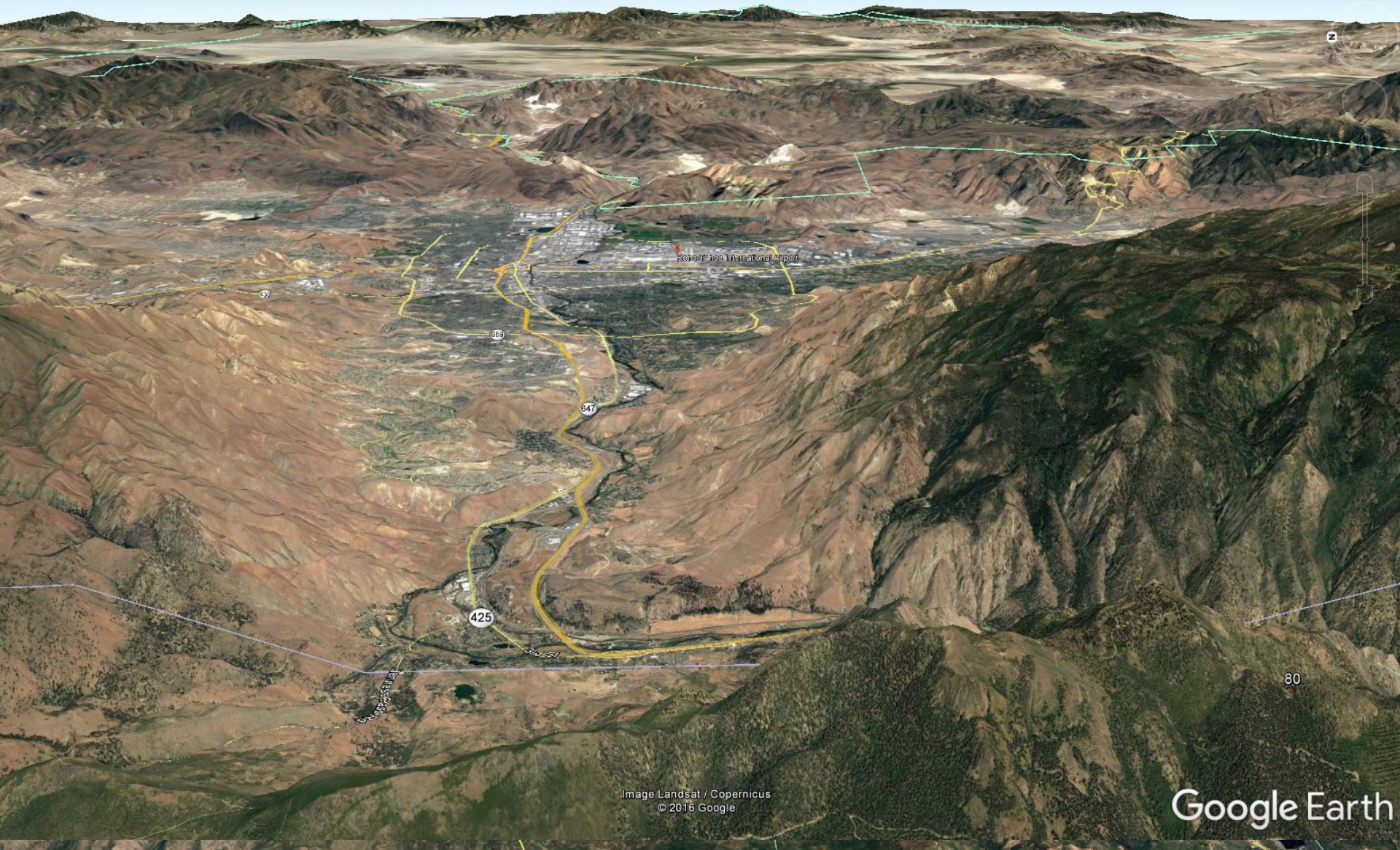


Image Landsat / Copernicus
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Google Earth

Terrain Viewed From the East



Terrain Viewed From the North



Methodology - The beginning

Finding archived PIREPs - Iowa State started Jan 20, 2015

Complications:

- PIREPs do not need to fit a strict format specification, so reports may be unparsable and therefore the data set is possibly incomplete.
- Limited to actual reports
- You can't search for a particular airport within the data set

Only interested in LLWS outside of summer months -- didn't want convective LLWS

After All That

- Ended up with 48 days there was at least one LLWS PIREP report at KRNO from Jan 20, 2015-Dec 15, 2016 (excluding the months of June/July/August to avoid tstorms)
- Wanted to focus on “big” days since the terrain and localized flow can easily cause LLWS at random times.
- Decided to use days that had 3 or more LLWS reports
 - ◆ This took it down to 19 days

Areas That Were Explored

- Observations at KRNO for the days of the study focused +/- 3 hours of the LLWS report timing
- Mesowest data - to explore lower level obs within the valley
- Ridge level wind data - winds aloft (approx 700 mb)
- Archived surface analysis (fronts, etc), soundings for KREV
- Winds (zonal and meridional components)
 - Jet position and anomalies
 - 700 mb anomalies
 - 850 anomalies (translates to near surface)
- 500 mb height anomalies - approaching systems, frontal boundaries

Speed Isn't What You Think

- There was **no direct correlation between higher averaged sustained wind speeds and greater number of LLWS reports**
- The difference between sustained speeds and the speed/gust spread also had no correlation



Peak Gust Stats

- 58% - 50 mph or greater

**** Note this leaves 42% of cases below advisory criteria!****

- 26% - 55 mph or greater, 0.05% - 60 mph or greater

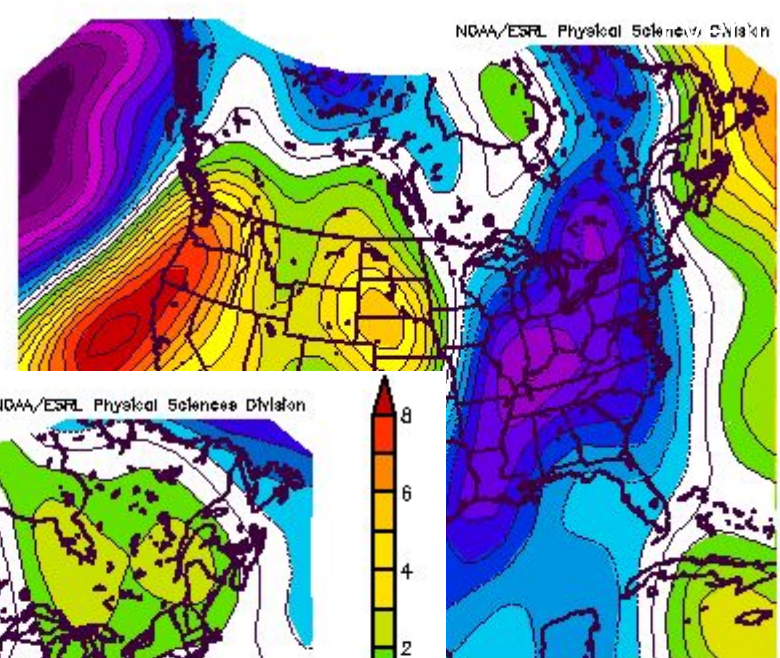
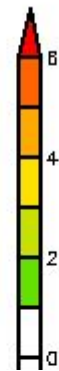
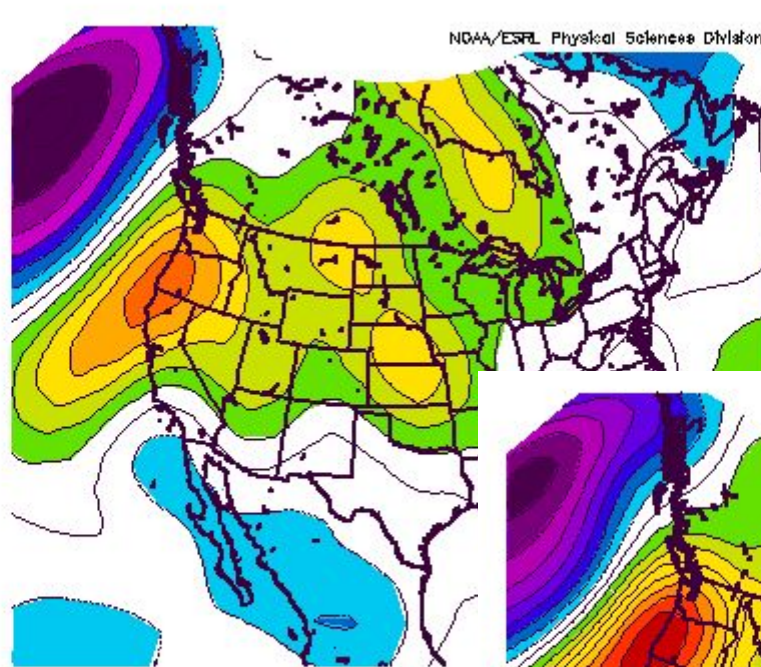


All west wind events had peak gusts less than 40 mph

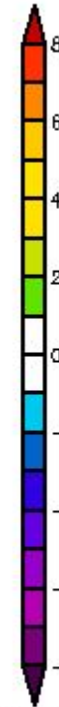
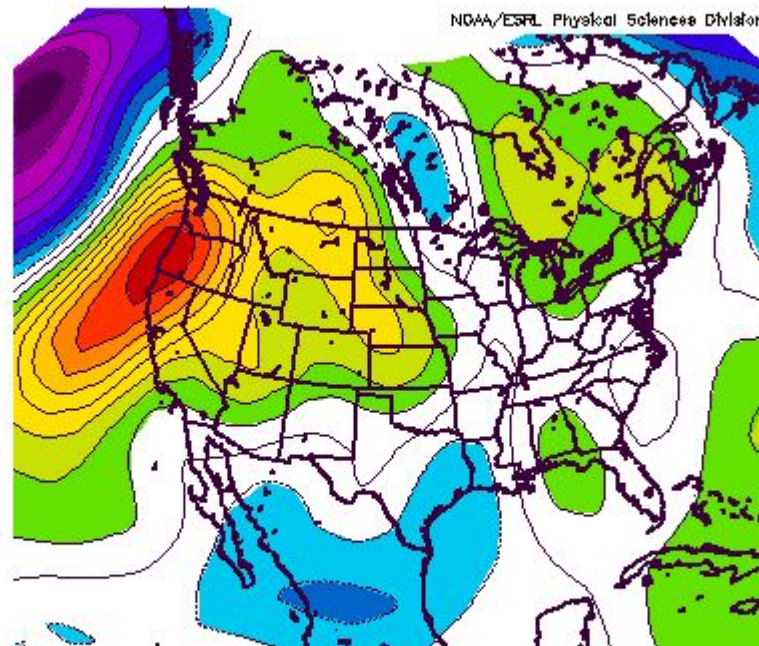
850 mb Meridional Anomalies

All Events

Top 3



850mb Meridional Wind (m/s) Composite Anom
18 02/08/18 01/29/18 12/15/18 03/21/18 04
NCEP/NCAR Reanalysis



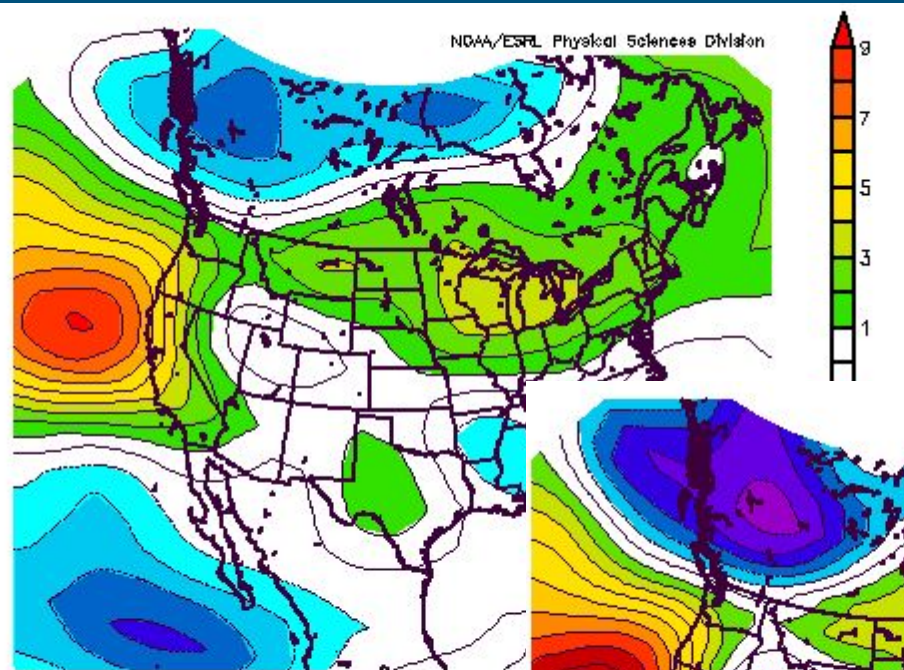
850mb Meridional Wind (m/s) Composite Anomaly (1981-2010 Climatology)
5 12/21/15 10/14/16 03/12/16 12/15/16 03/21/16 11/01/15 10/15/16 12/06/15
NCEP/NCAR Reanalysis

Top 11
Events

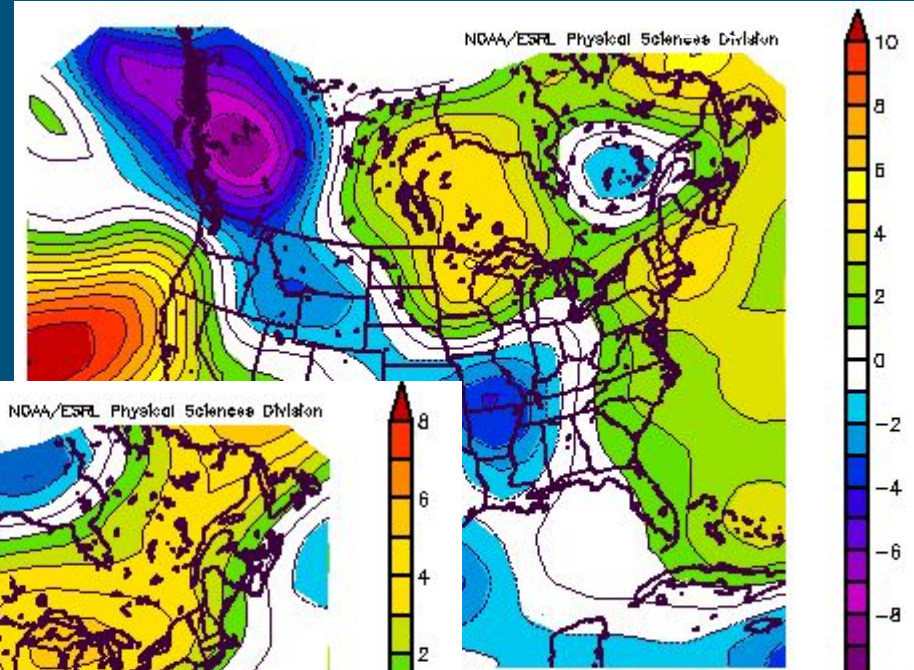
850 mb Zonal Anomalies

All Events

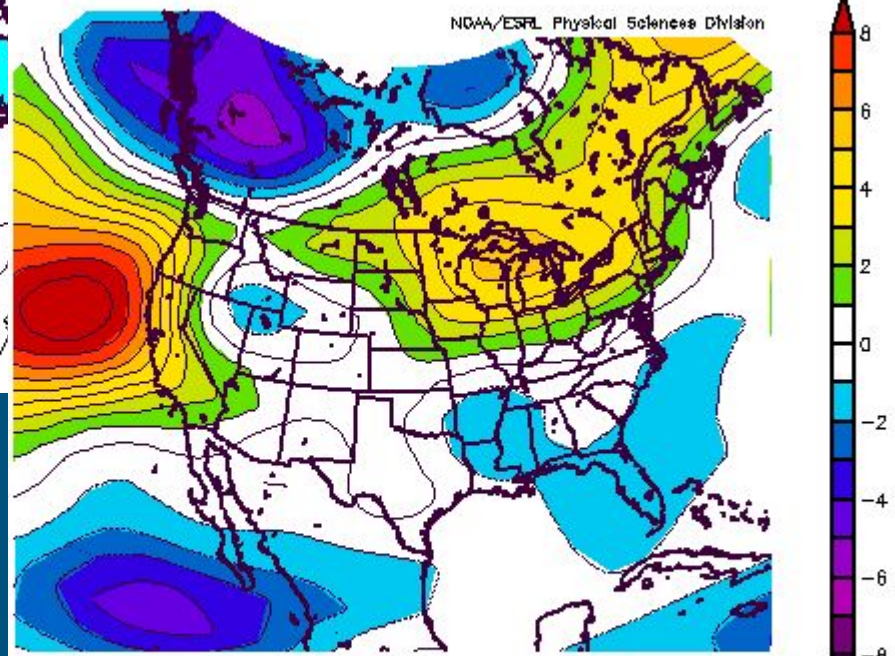
Top 3



850mb Zonal Wind (m/s) Composite Anomaly (1902/08/16 01/29/16 12/15/16 03/21/16 04/04/16)
NCEP/NCAR Reanalysis



850mb Zonal Wind (m/s) Composite Anomaly (1902/08/16 01/29/16 12/15/16 03/21/16 04/04/16)
NCEP/NCAR Reanalysis



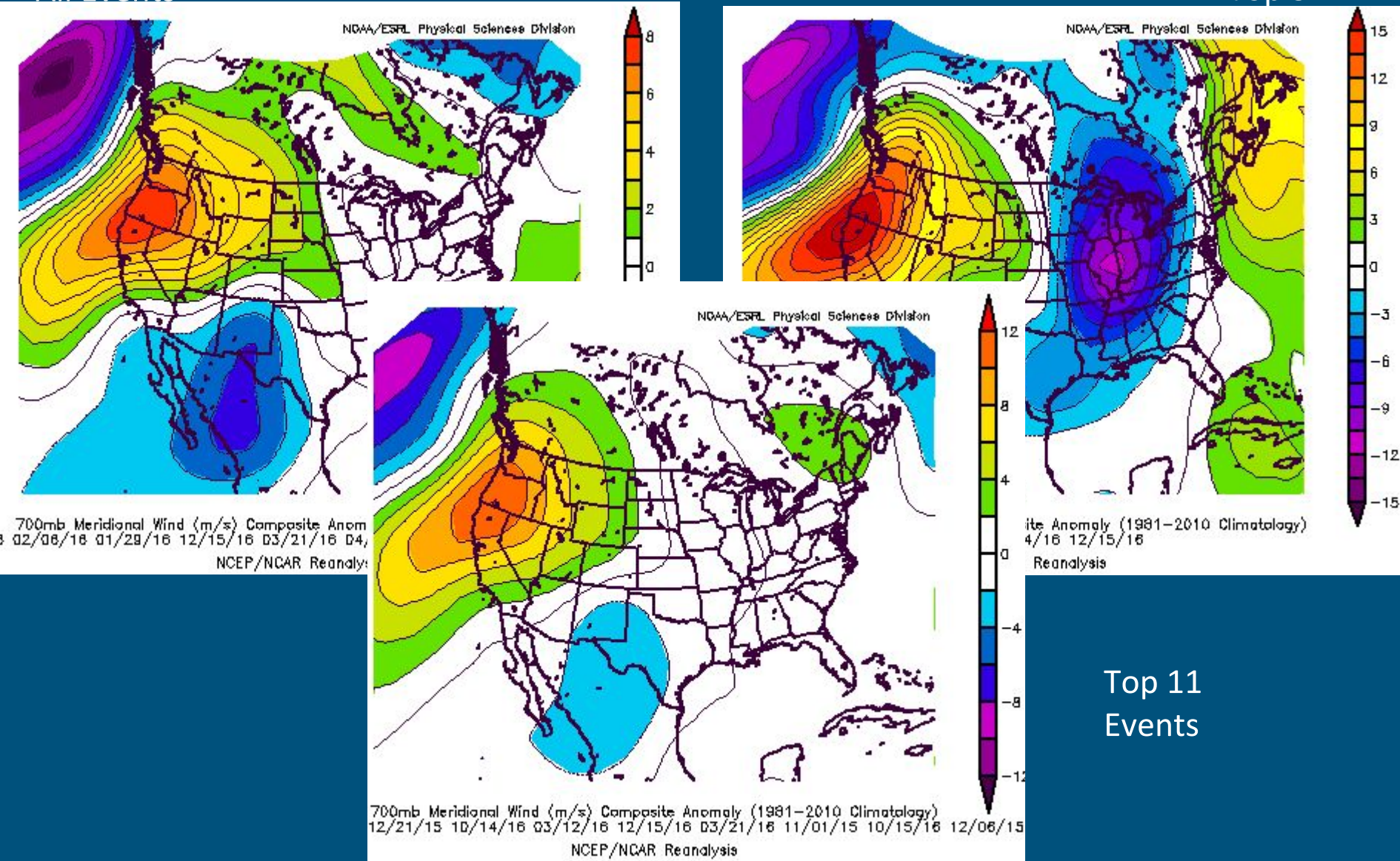
850mb Zonal Wind (m/s) Composite Anomaly (1981-2010 Climatology) 12/15/16
NCEP/NCAR Reanalysis

Top 11
Events

700 mb Meridional Anomalies

All Events

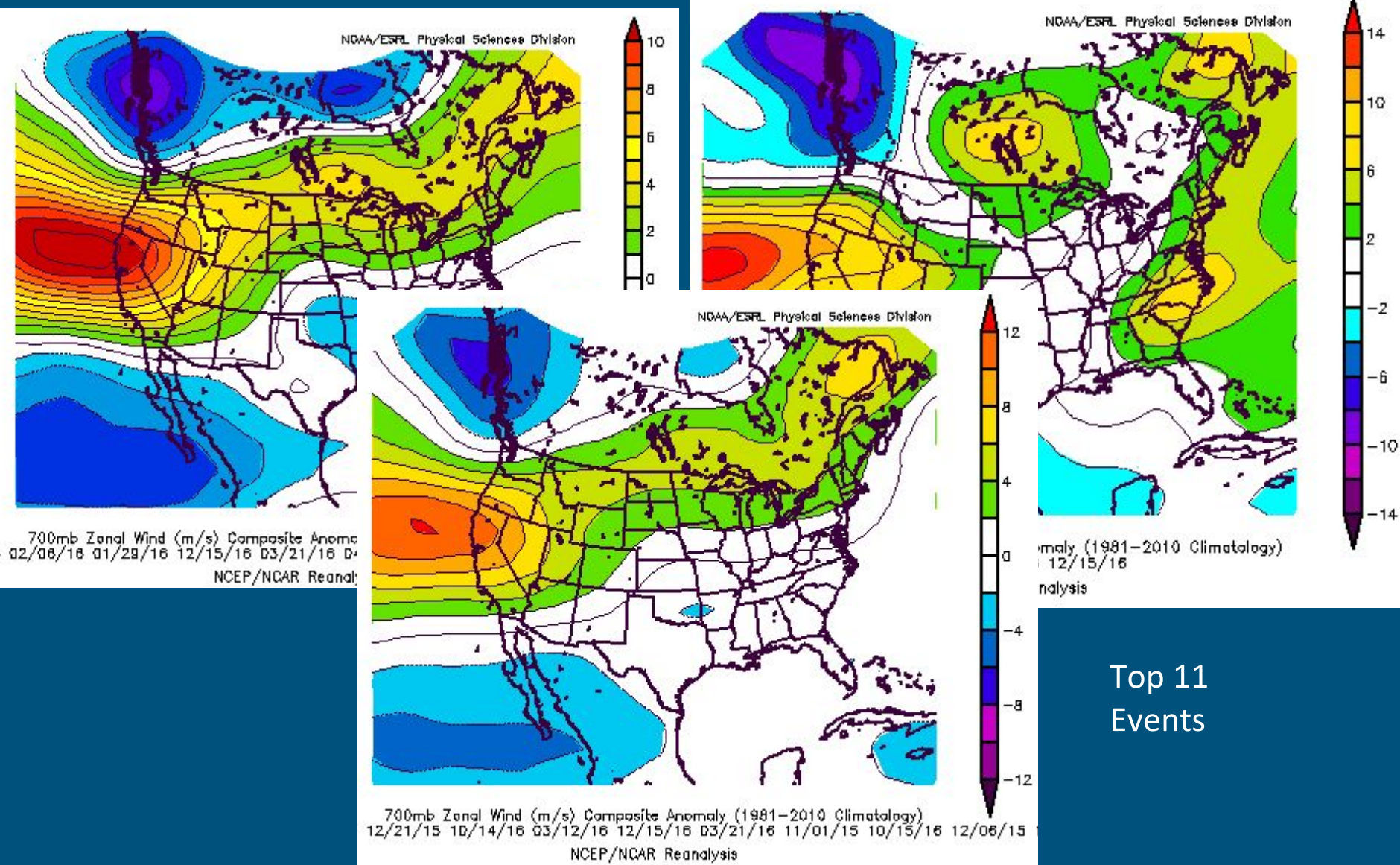
Top 3



700 mb Zonal Anomalies

All Events

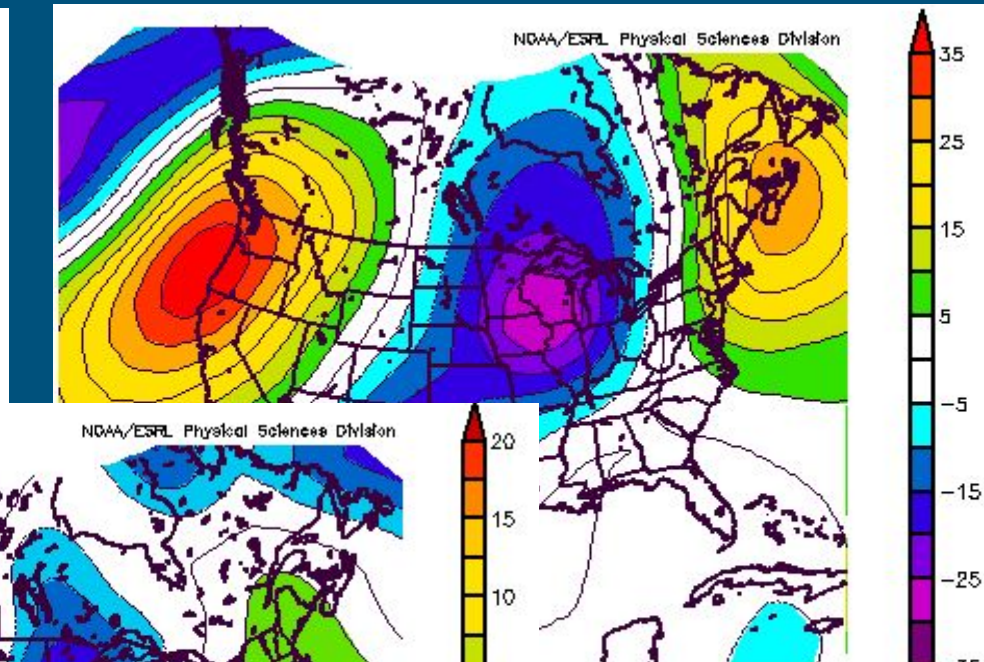
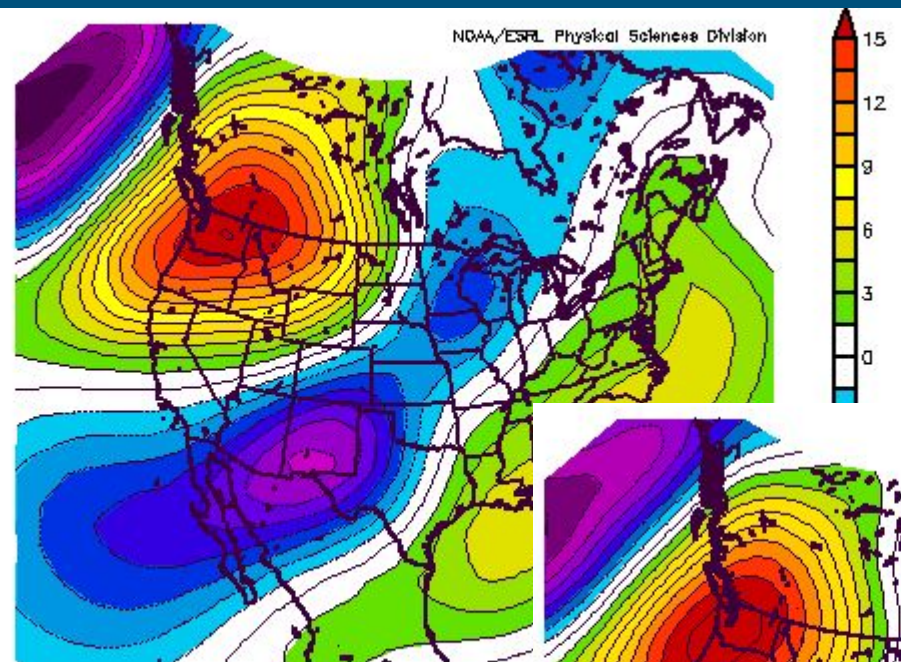
Top 3



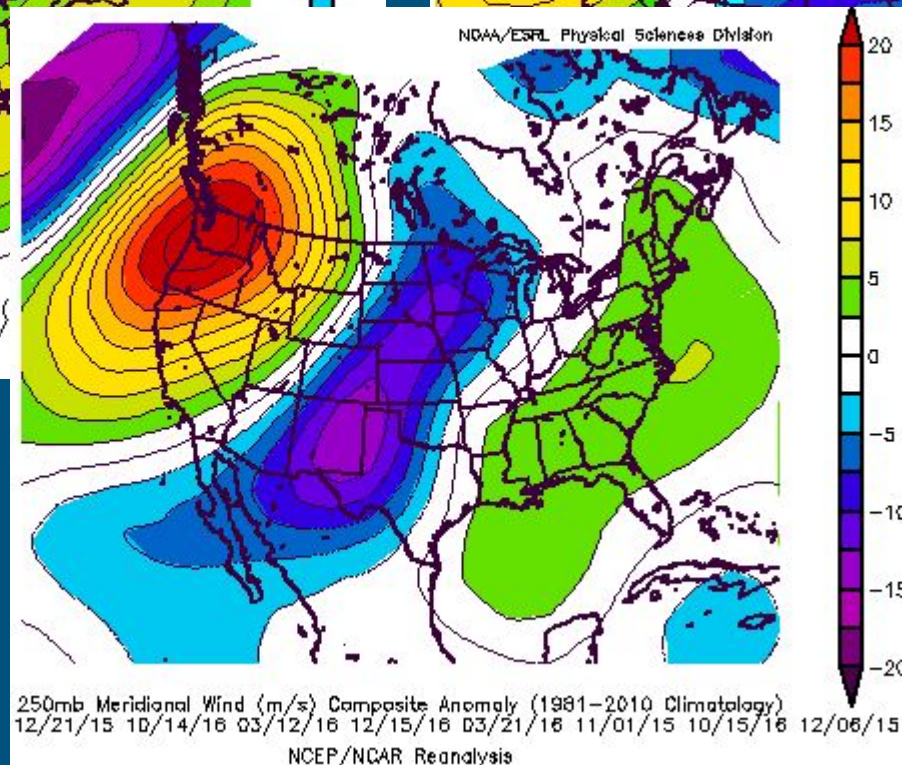
250 mb Meridional Anomalies

All Events

Top 3



250mb Meridional Wind (m/s) Composite Anomaly (02/08/16 01/29/16 12/15/16 03/21/16 04/04/16)
NCEP/NCAR Reanalysis



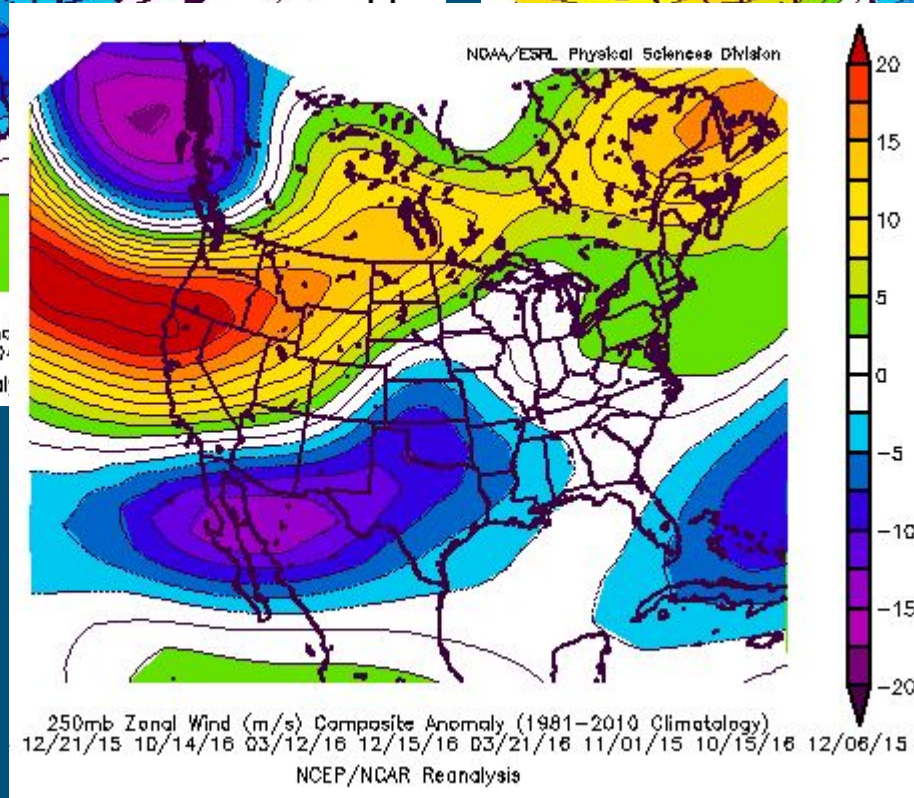
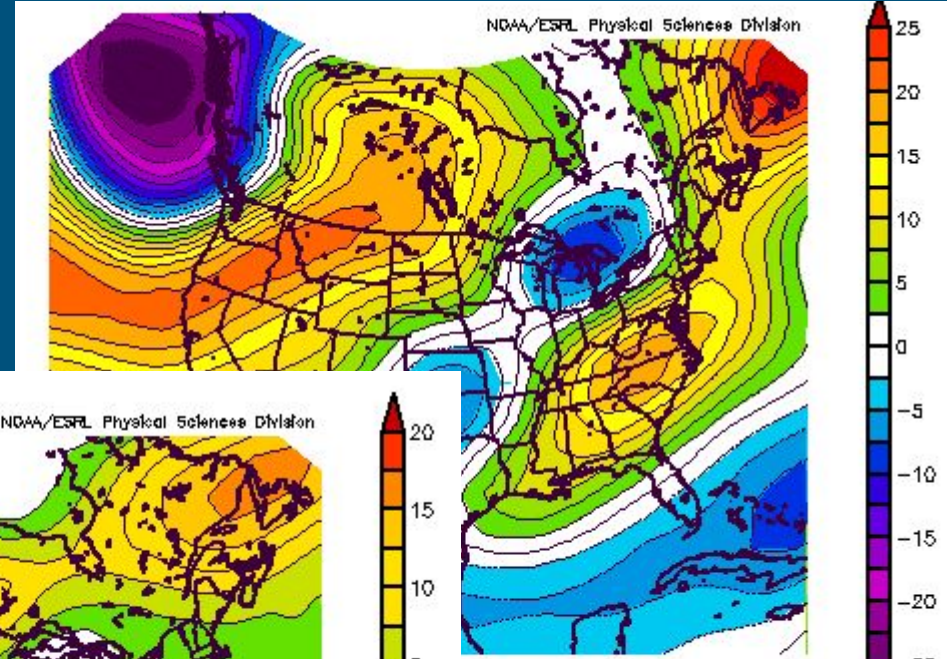
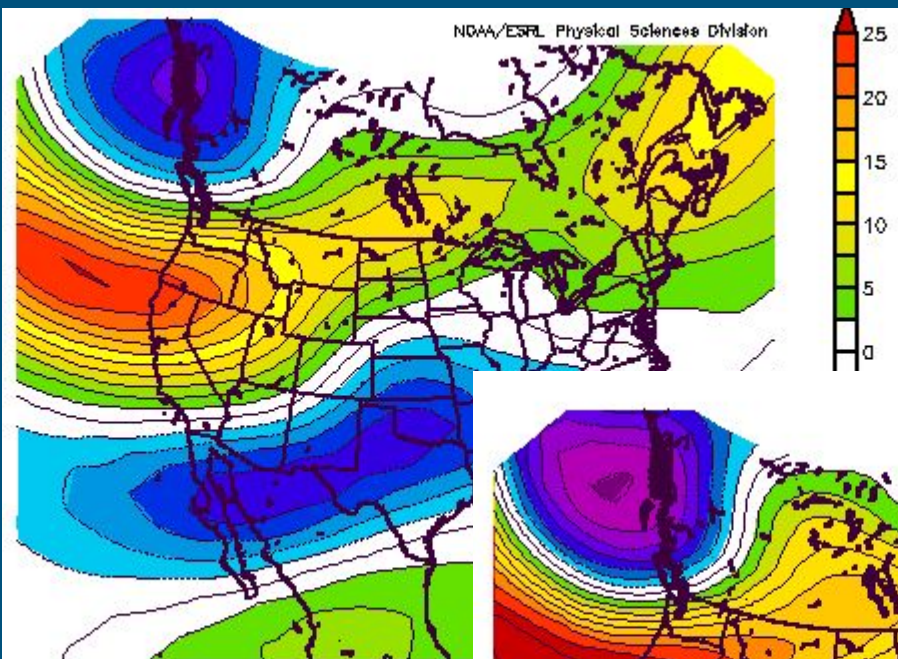
Top 11
Events

250mb Meridional Wind (m/s) Composite Anomaly (12/21/15 10/14/16 03/12/16 12/15/16 03/21/16 11/01/15 10/15/16 12/06/15)
NCEP/NCAR Reanalysis

250 mb Zonal Anomalies

All Events

Top 3



Top 11 Events

Other Findings

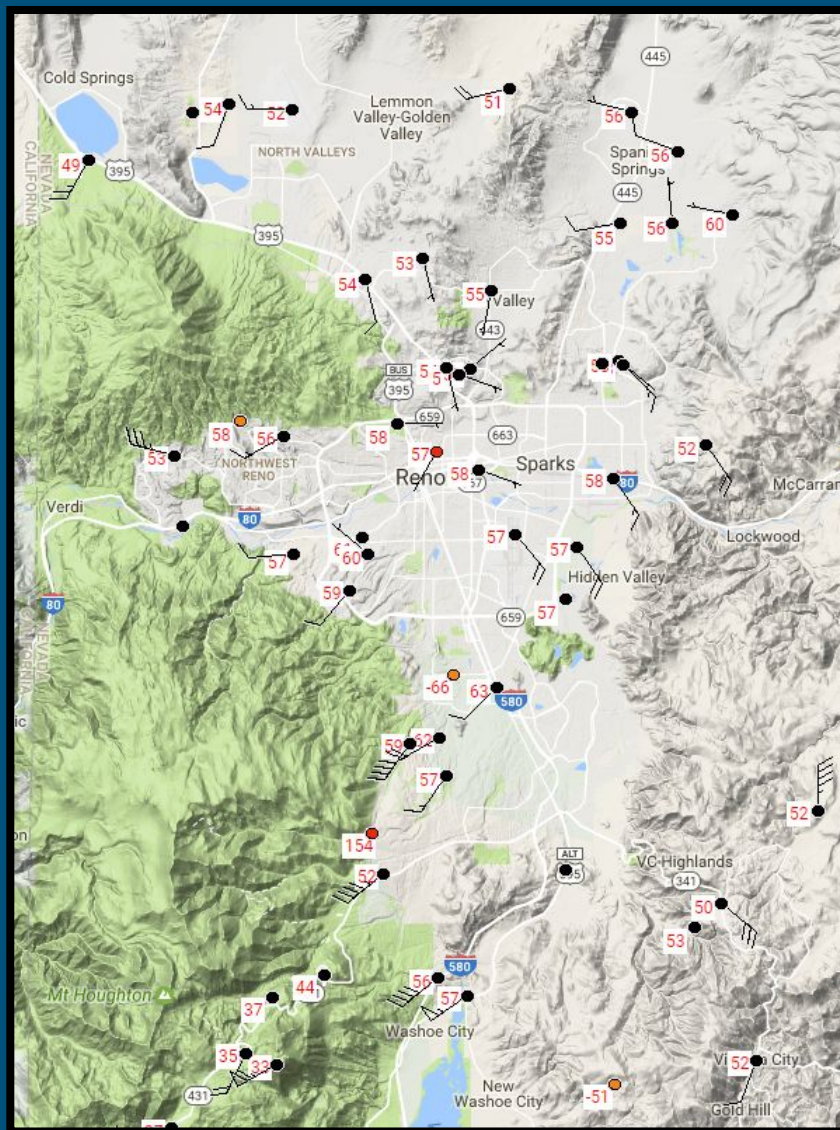
- **Southerly winds** at KRNO accounted for **84%** of the events
- 52% of the events had clear cases of **rotors** present
- 42% of the events the winds went from calm or nearly calm to howling quickly (**sudden inversion break**)
- Only 2 events had a clear wind shift from south to west
- Only 1 event featured west winds
 - Also a day with a clear wind shift from a cold frontal passage

Rotors Ahead!

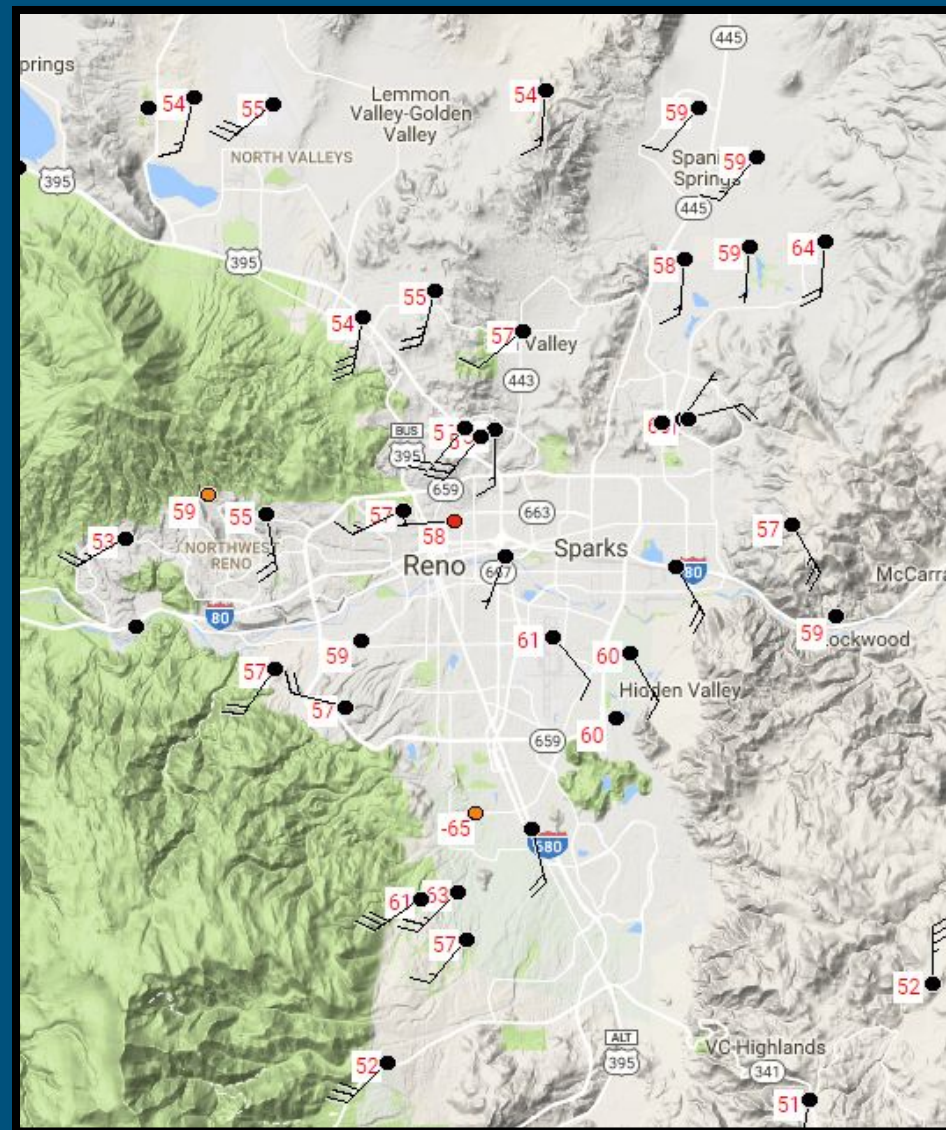


<https://business.facebook.com/NWSReno/videos/534104630570154/>

It's All About Direction

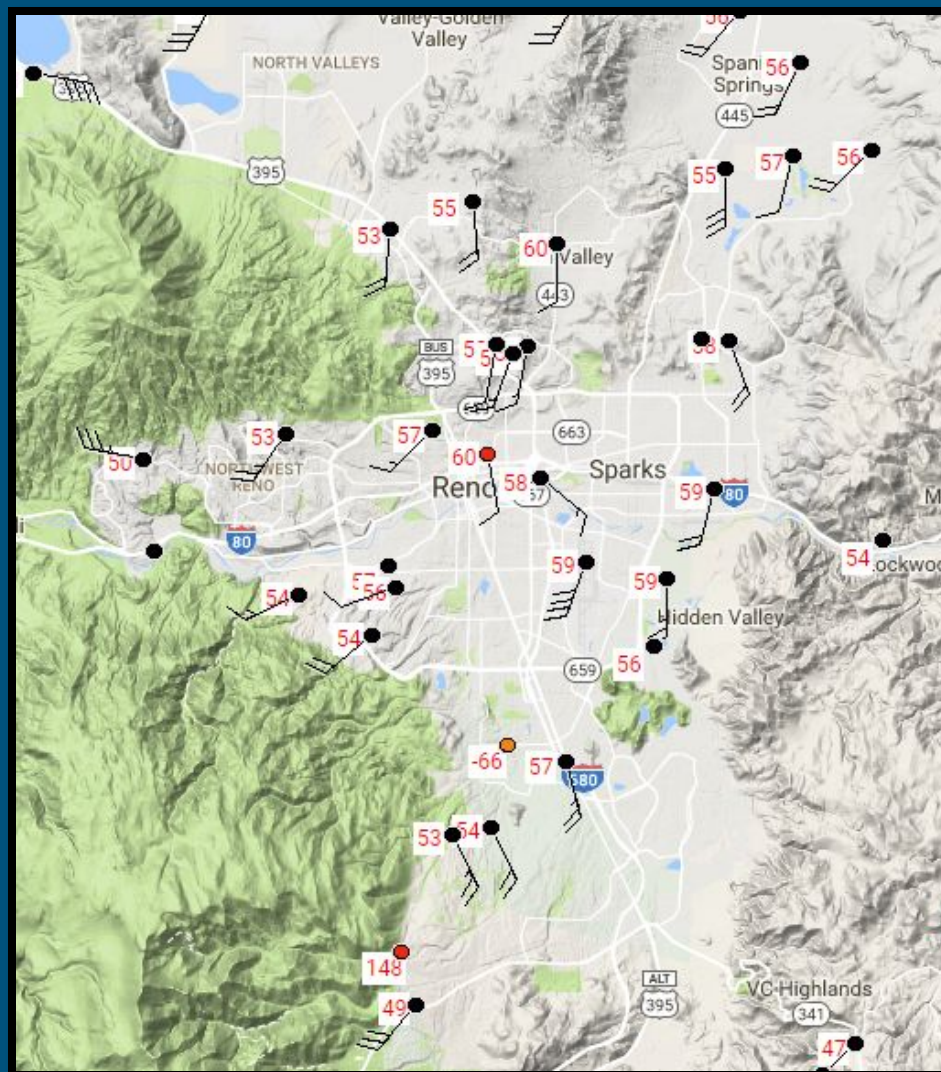


Dec 15, 2016 - 20z

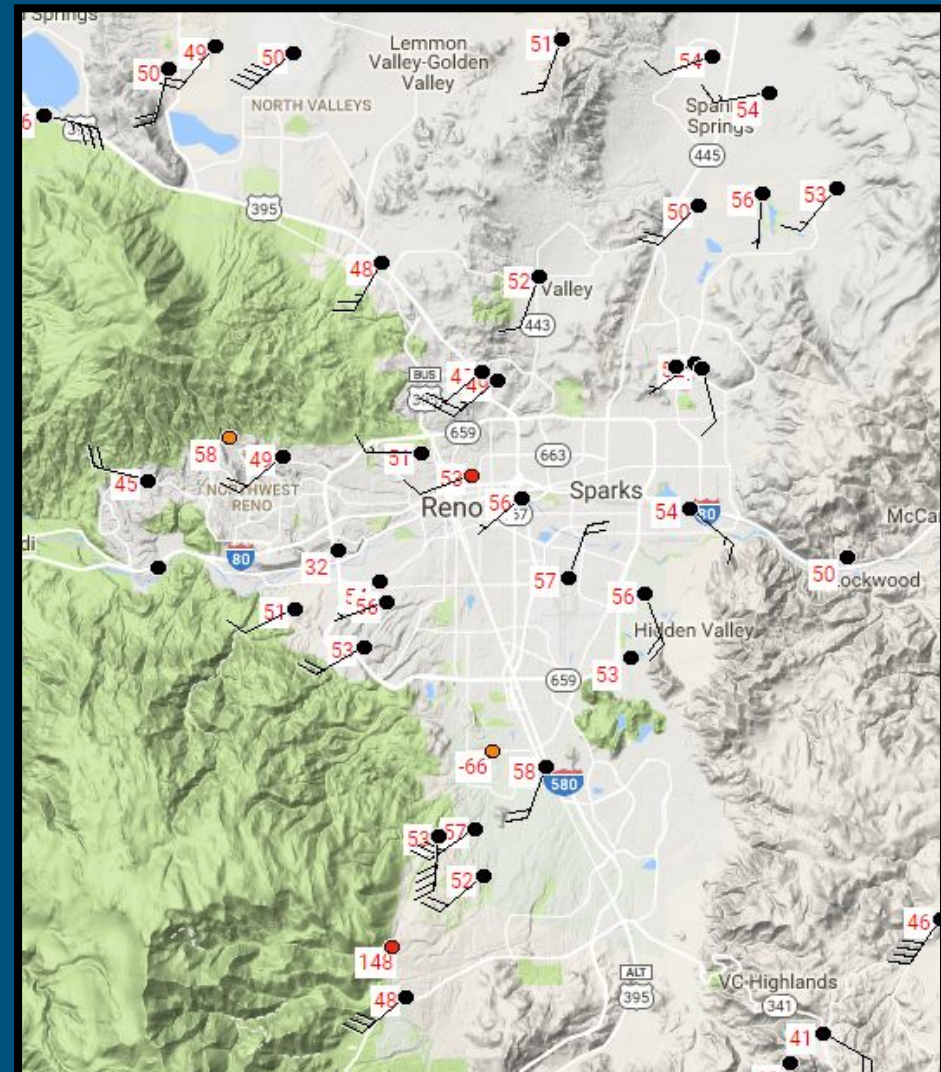


Oct 14, 2016 - 13z

It's All About Direction



Dec 3, 2015 – 22z



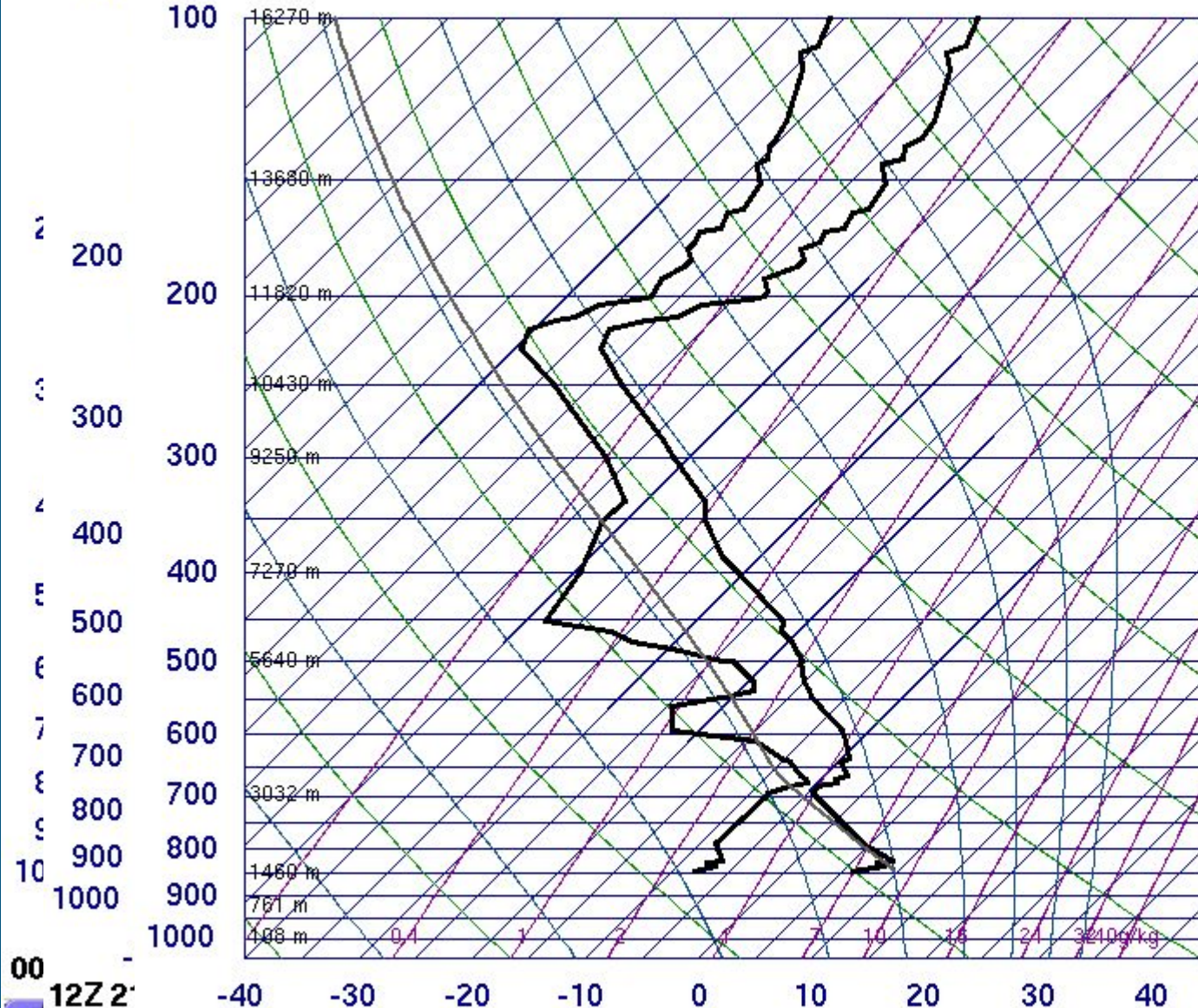
Mar 21, 2016 – 19z

72489 REV Reno

72489 REV Reno

100 72489 REV Reno

100



SLAT 39.56
 SLON -119.80
 SELV 1516.
 SHOW -9999
 LIFT 8.29
 LFTV 8.33
 SWET -9999
 KINX -9999
 CTOT -9999
 VTOT -9999
 TOTL -9999
 CAPE 0.00
 CAPV 0.00
 CINS 0.00
 CINV 0.00
 EQLV -9999
 EQTV -9999
 LFCT -9999
 LFCV -9999
 BRCH 0.00
 BRCV 0.00
 LCLT 263.0
 LCLP 655.1
 MLTH 296.8
 MLMR 2.73
 THCK 5532.
 PWAT 8.86

University of Wyoming

Prev

Next

Stop

Start

Slower

Faster

Delete

Best Practices

- **Key in on south wind events**
- Look at the anomalies and how they might line up compared to the previous events
- Focus in on the flow through the valley (West, South southwest, South or SE variations, rotors, etc)
- **If rotors are present, so is LLWS!**
- Be aware of frontal passages – often LLWS along the front



But Wait...There's More!



Heavy snow for the Sierra: 2-4ft Lake Tahoe and Mammoth; 4-8ft above 7500ft

Nuisance snow for the Sierra Front

Tahoe, Northern Sierra 80 50, NE California, Mammoth 395



W Nevada: Reno, Carson City, Fallon, Yerington 80



Dangerously strong winds likely to affect travel for high profile vehicles and to impact aviation today.

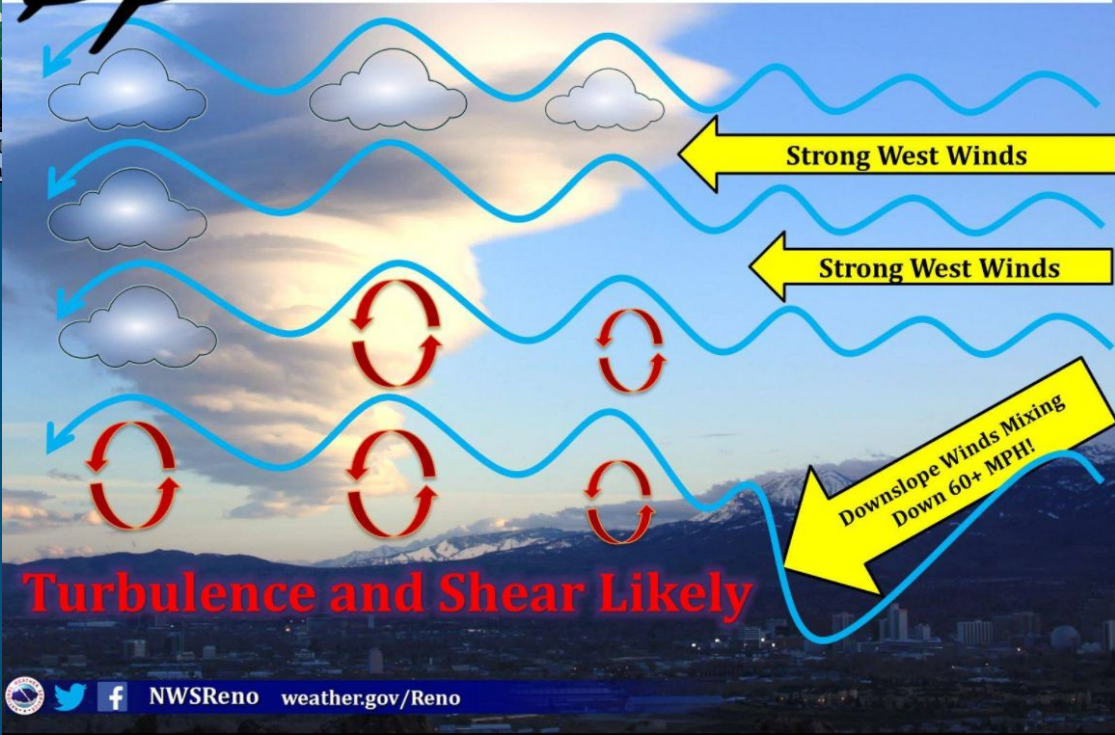


Credit: KTVN

Messaging and Future Work...



Aviation Impacts → Wednesday Morning to Thursday Night
Sierra Ridge Wind Gusts 100+ MPH with surface winds 60+ MPH.



NWSReno weather.gov/Reno

Questions?

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