Evidence of Post-frontal Mountain Wave Enhanced Wind Shear in Juneau, Alaska

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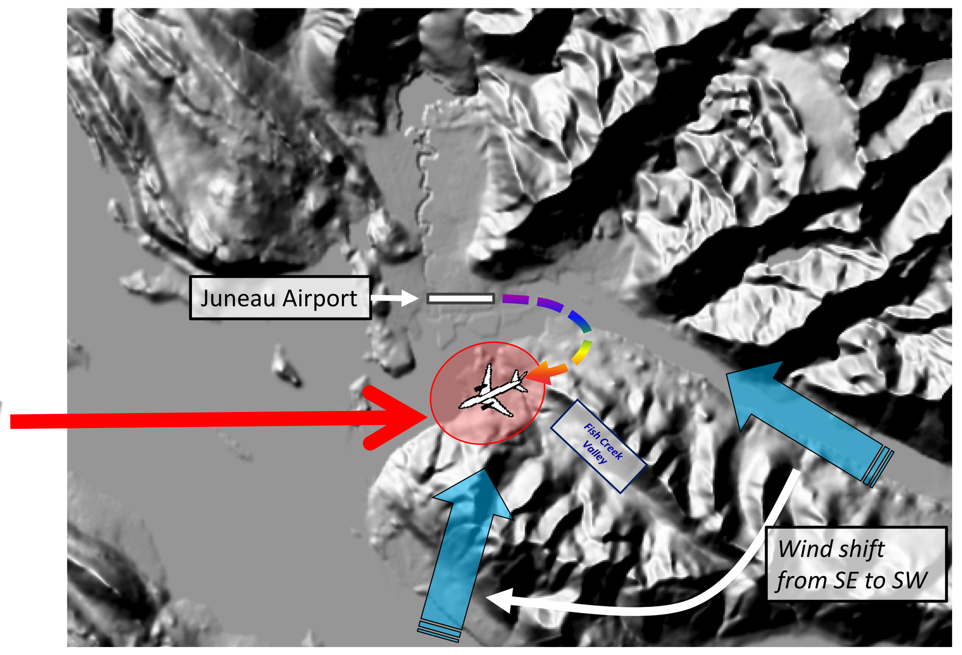
Aircraft Incident: 0315 UTC 30 Jan 1993

Over Fish Creek on FOX departure, at 900 ft AGL, 30 degree right bank, aircraft suddenly rolled to 60-90 degrees. Lost control and regained at 150 ft AGL.

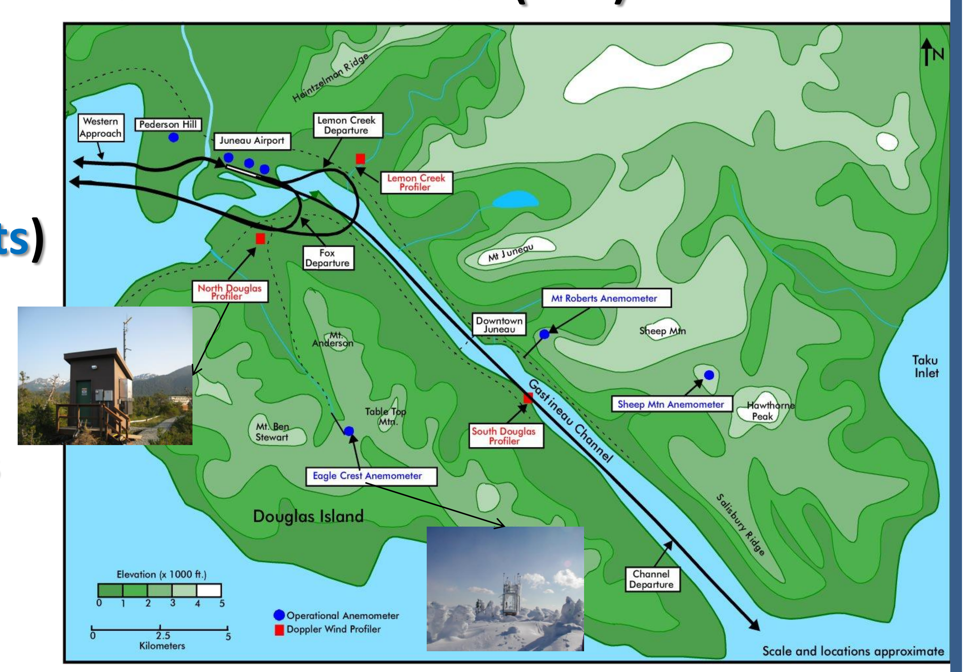


Juneau Airport Wind System (JAWS)

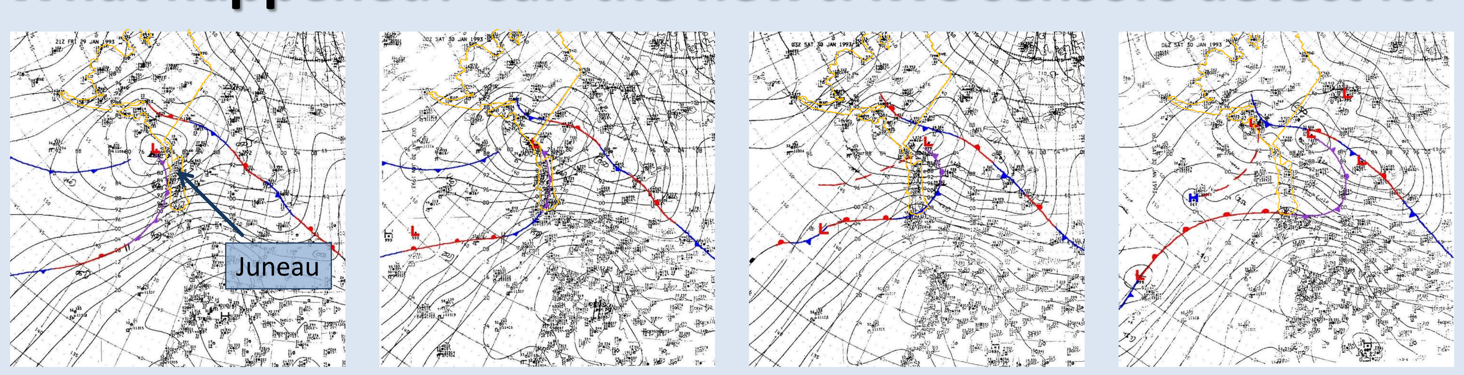
As a result of this incident and other wind shear problems, a wind hazard warning system for wind shear and turbulence was developed by the National Center for Atmospheric Research (NCAR) for the Federal Aviation Administration (FAA).

Sensors include:
- 7 mountain-top anemometers (blue dots)
- 3 boundary layer wind profilers (red squares)

Surface Station Identifiers
PAJN – Juneau Airport
NDIA2 – N. Douglas Profiler
JECA2 – Eaglecrest

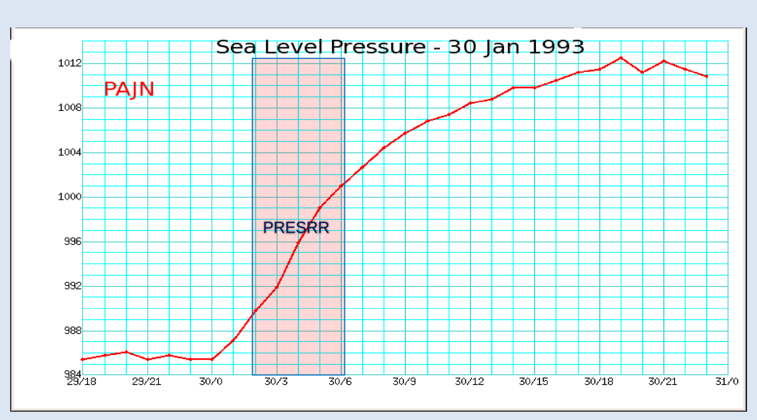


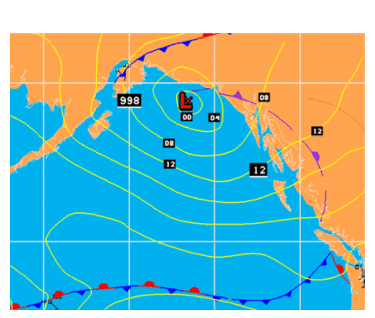
What happened? Can the new JAWS sensors detect it?



2100 UTC 29 Jan 1993 | 0000 UTC 30 Jan 1993 | 0300 UTC 30 Jan 1993 | 0600 UTC 30 Jan 1993

The aircraft took off immediately after passage of a strong front as pressures were rising rapidly and winds were in the process of shifting to the southwest. This type of dramatic post-frontal direction shift is rare for Juneau since flow is constrained by steep terrain and often a residual low remains in the Gulf of Alaska preventing significant pressure rises behind the front. (see below)





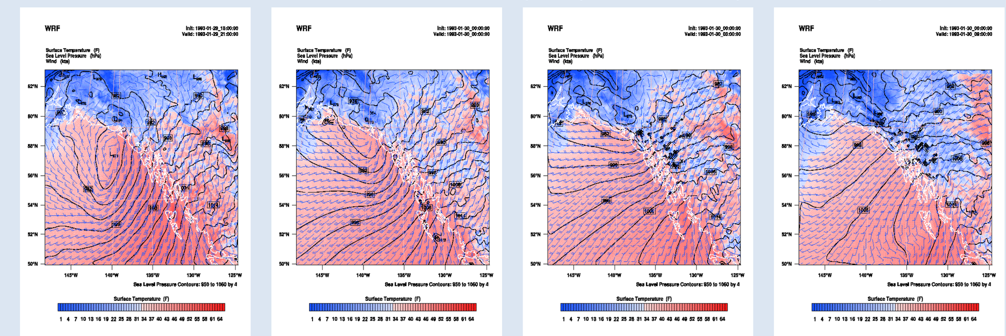
Typically, frontal passage in Juneau occurs while a residual low remains in the Gulf of Alaska. This prevents a significant shift in wind direction. On rare occasions a strong low making landfall northwest of Juneau that results in an abrupt wind shift from southeast to southwest.

WRF Simulation 30 Jan 1993

WRF initialized with North American Regional Reanalysis (NARR) data

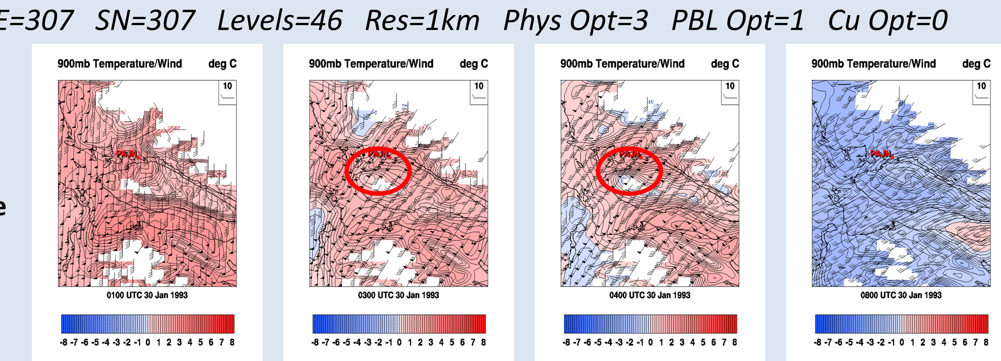
WRF V3.2 Domain 1: WE=189 SN=169 Levels=46 Res=9km Phys Opt=3 PBL Opt=1 Cu Opt=3

Synoptic Scale – the WRF simulation produced a low that was slightly weaker than the analysis in Gulf of Alaska but then deepened it more than the analysis when it moved inland.

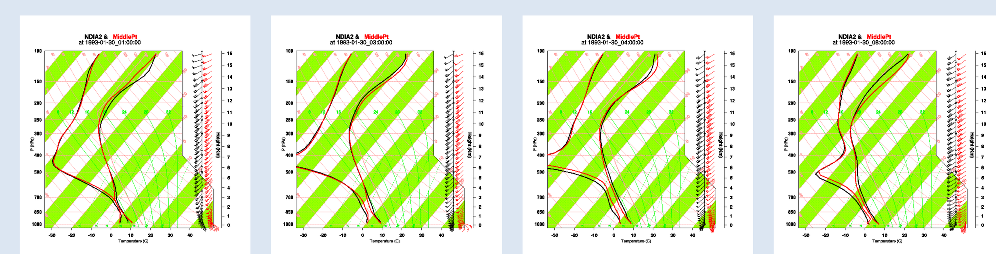


WRF V3.2 Domain 3: WE=307 SN=307 Levels=46 Res=1km Phys Opt=3 PBL Opt=1 Cu Opt=0

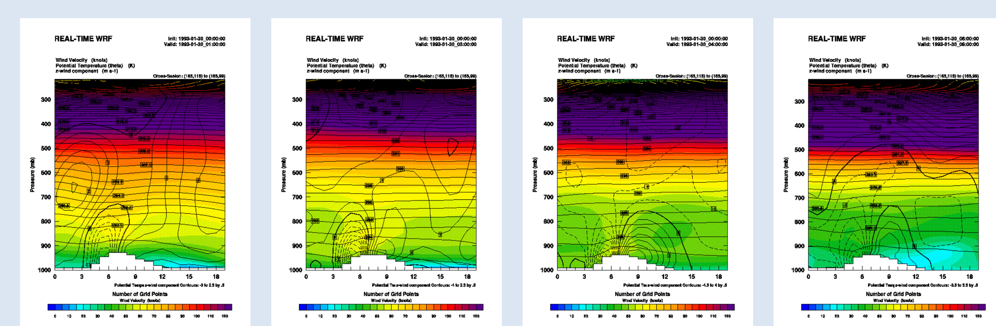
WRF 900mb temperatures show the influx of low level cold air behind the front which helped produce a stable layer just above mountains on Douglas Island, south of the Juneau airport.



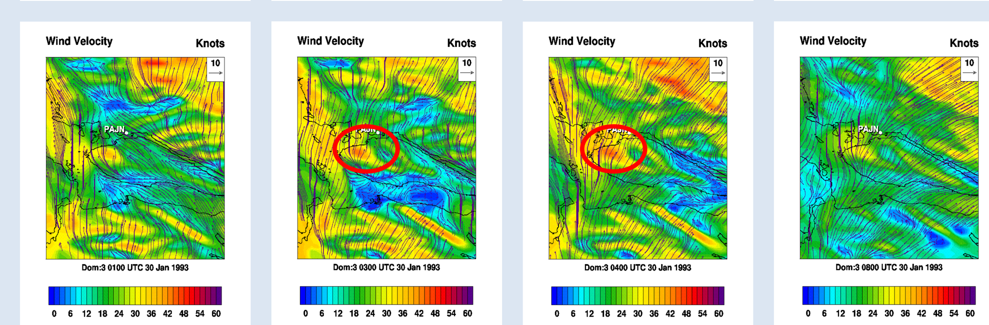
Soundings at Middle Point on the windward side of the Douglas mountain range show a stable layer that descends briefly and then elevates rapidly as the cold air behind the front deepens.



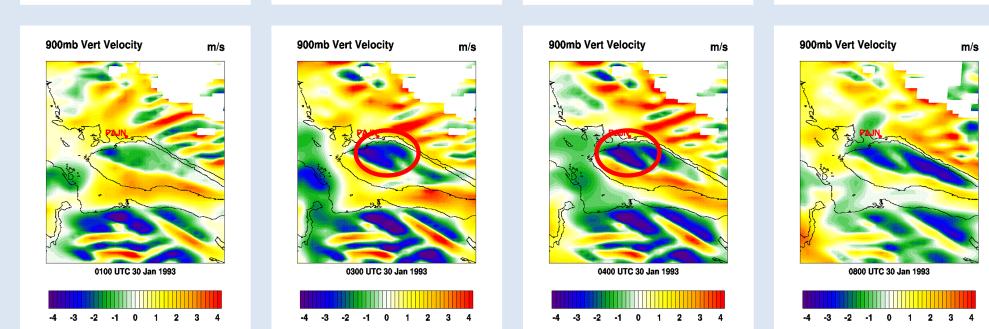
Cross-sections also depict a lee side bias in the stronger wind speeds and strong downward motion developing around the time of the frontal passage.



Surface wind velocities show a strong wind maximum on the lee side of the Douglas Island mountain range near the mouth of Fish Creek



Vertical velocities also show strong downward motion on the lee side of the mountain ridge near the mouth of Fish Creek



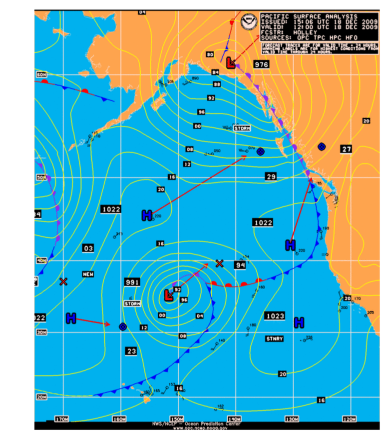
Conclusions

- **The 1993 strong wind shear event appears to be the result of mountain wave enhanced winds that occur immediately behind a strong front.**
- **As a result of the wave, in the Fish Creek valley, on the lee side of a mountain range, horizontal accelerations are accompanied by downward vertical velocities.**
- **A strong isallobaric ridge behind the front is needed to produce S-SW wind shifts at the Juneau airport.**
- **Although infrequent and short-lived, the impacts of this type of event can be significant due to its proximity to take-off and departure corridors at the Juneau airport.**
- **The JAWS observation network has proven to be a vital resource for improved understanding of mesoscale meteorological processes in the Juneau area.**
- **JAWS sensors are well placed to monitor turbulence and wind shear, but an understanding of the cause of this condition is essential for NWS forecasters to anticipate these events.**

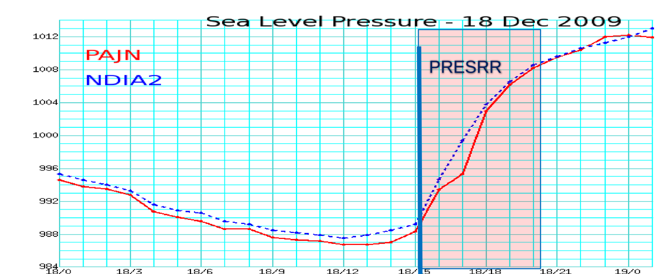
Similar Recent Events with JAWS Profiler/Anemometer Data

1500 UTC 18 Dec 2009

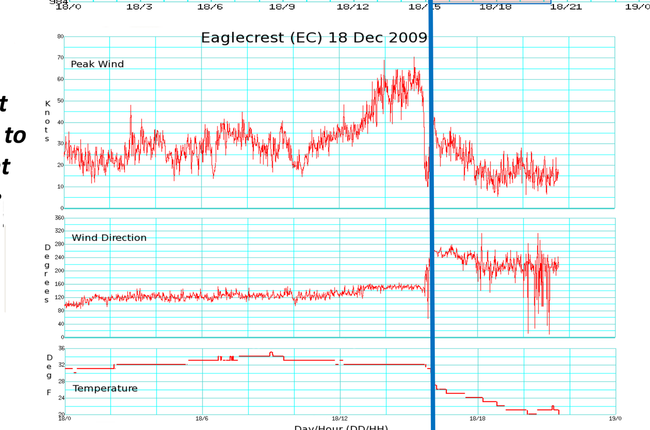
A 976 mb low moves inland north of Yakutat. Front through PAJN around 1545 UTC.



PAJN (ASOS) and NDIA2 (N. Douglas) detect PRESRR behind front.

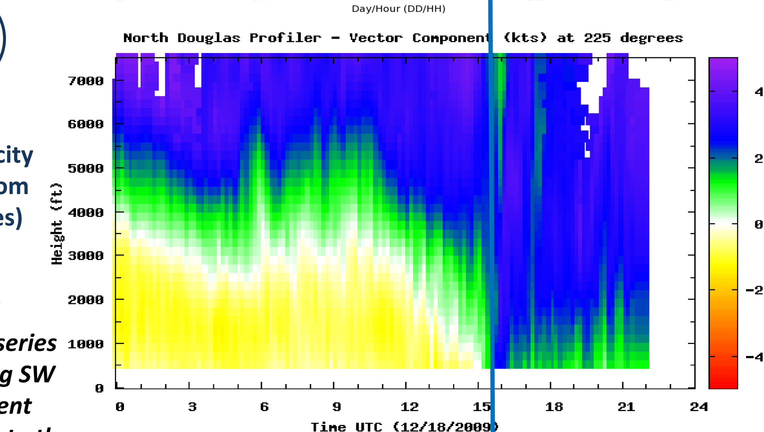


JECA2 (Eaglecrest) winds show abrupt wind shift from SE to SW with significant cooling behind the front.



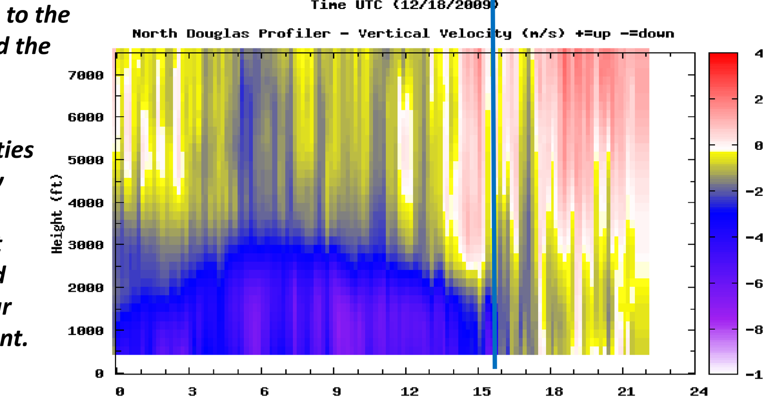
Profiler Radial Velocity (positive from 225 degrees)

Profiler radial velocity time series shows a strong SW wind component that descends to the surface behind the front.

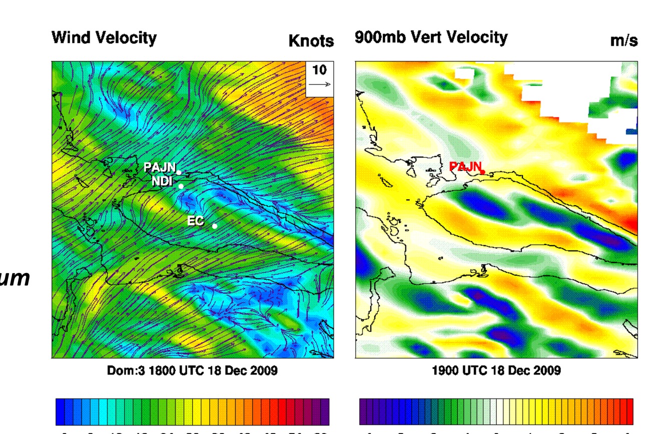


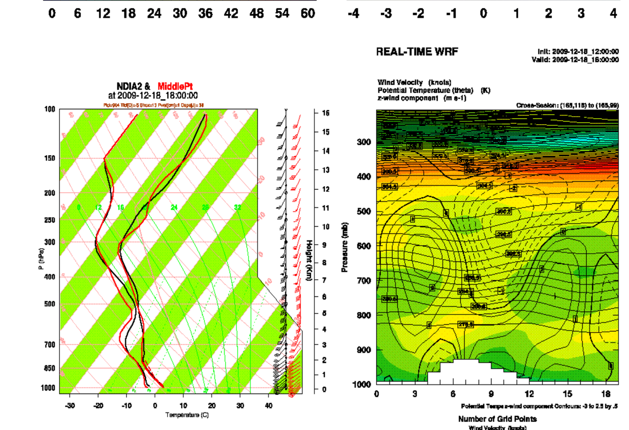
Atmospheric vertical velocities are masked by precipitation ahead of front but downward velocities occur behind the front.

Profiler Vertical Velocity
Rain >= 1.5 m/s
Snow ~ 1.0 m/s



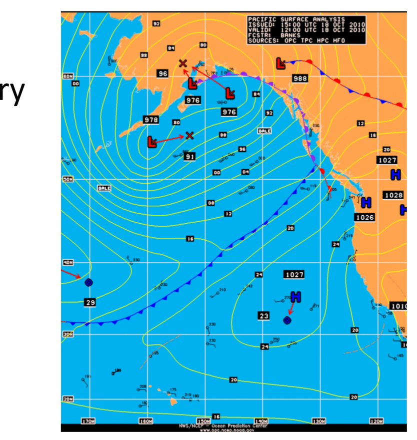
WRF model simulation shows characteristics similar to the 1993 event…
- *Surface wind maximum*
- *Negative vertical velocity maximum*
- *Stable layer above mountain-top*



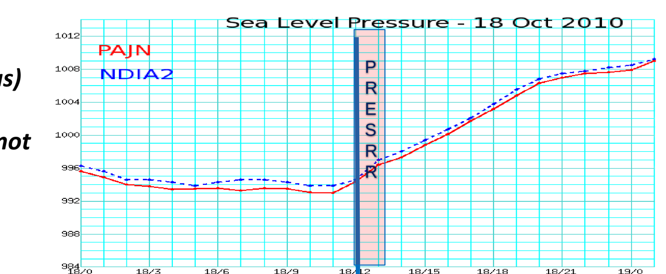


1200 UTC 18 Oct 2010

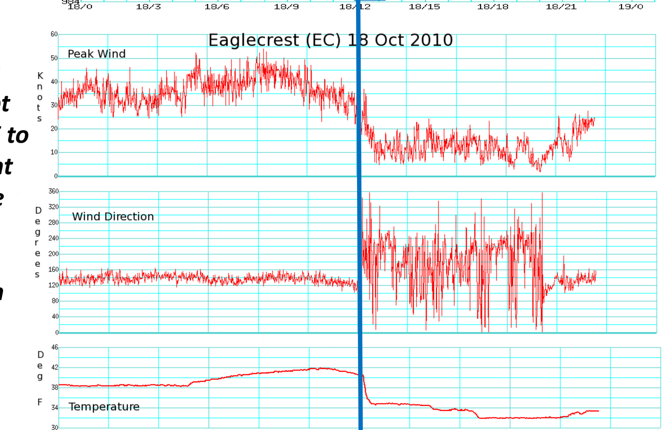
A 976 mb low is in the process of redeveloping in the Yukon Territory at the time of frontal passage at PAJN (around 1200 UTC).



PAJN (ASOS) and NDIA2 (N. Douglas) detect PRESRR behind front but not for as long as previous cases.



JECA2 (Eaglecrest) winds show abrupt wind shift from SE to SW with significant cooling behind the front. Strong southwest winds diminish within an hour.



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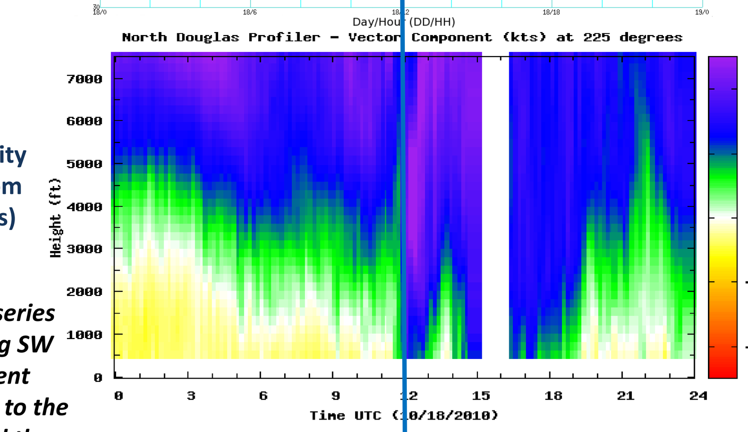

Downward velocities occur behind front but so does convective precipitation

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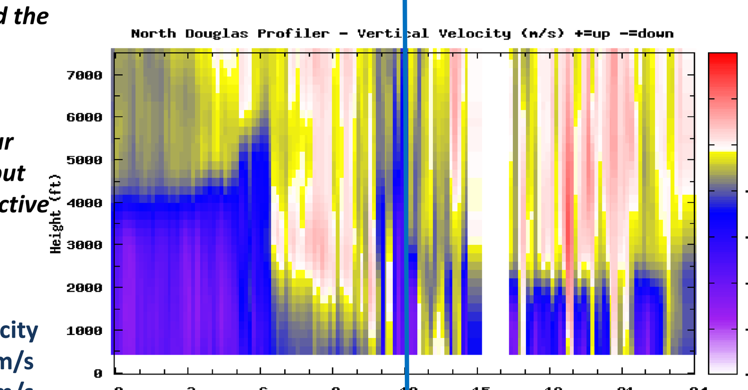
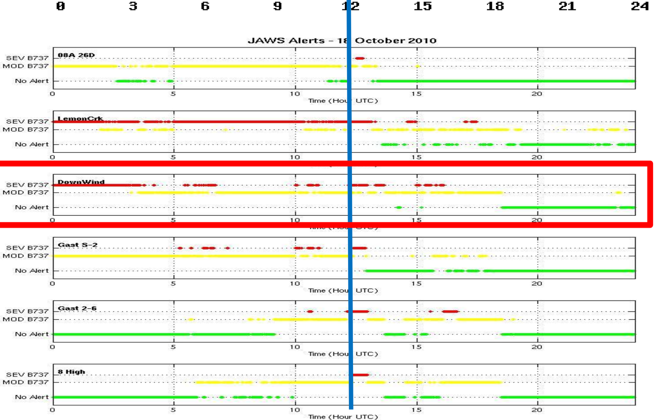


JAWS alerts for Juneau airport departure and arrival corridors. Red dots indicate severe turbulence or shear. The "DownWind" corridor includes the area near Fish Creek.



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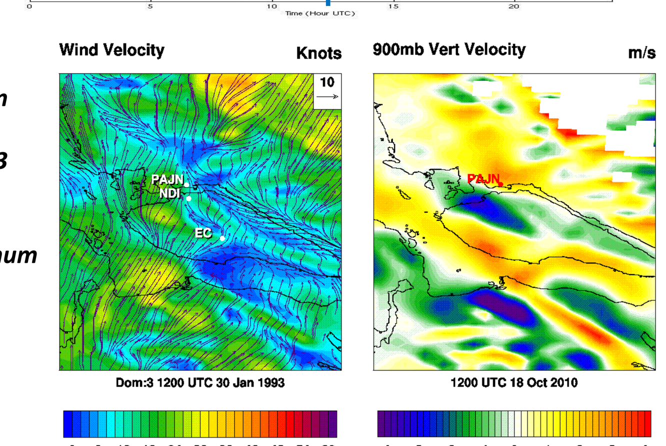

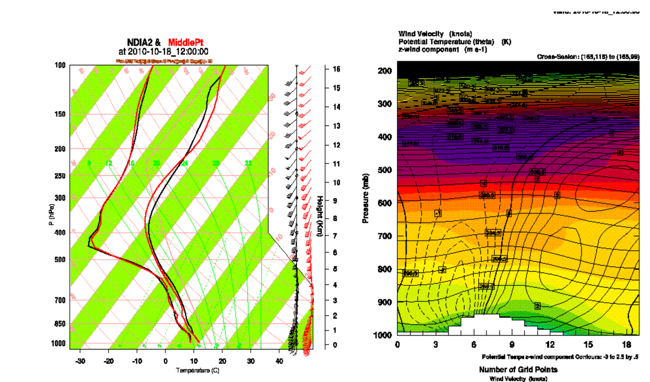

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Thanks to the Arctic Region Supercomputing Center (ARSC) at the University of Alaska Fairbanks (UAF) for WRF model access.

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