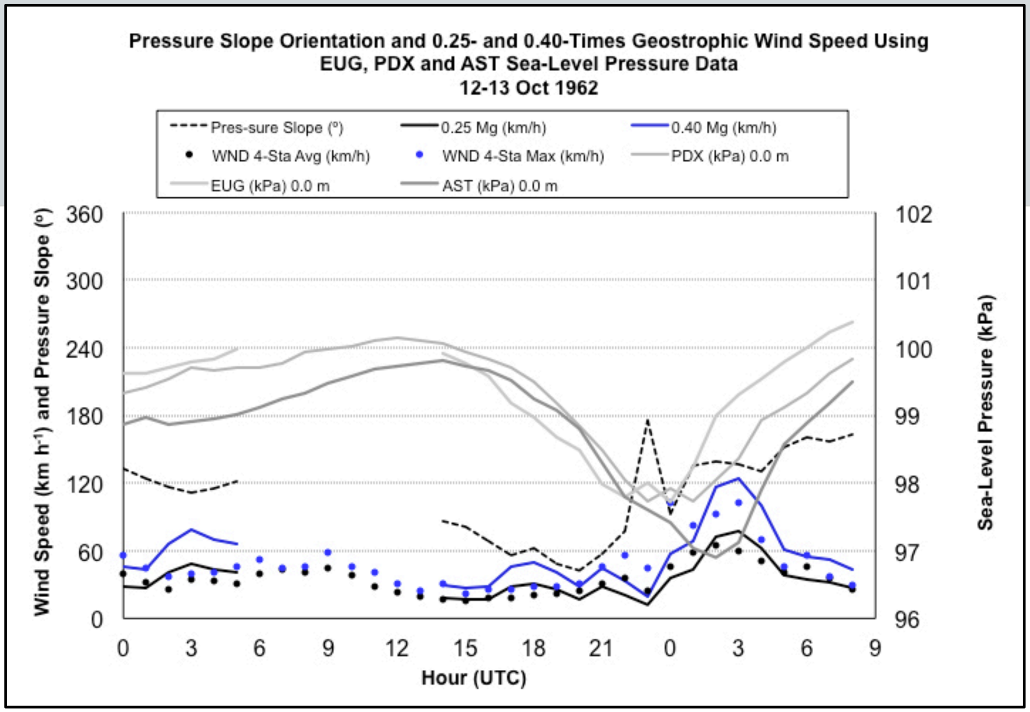
Detailed examination of 2-dimensional surface pressure gradients over Northwest Oregon for significant windstorms 1945-2012, with a focus on the 1962 Columbus Day Storm



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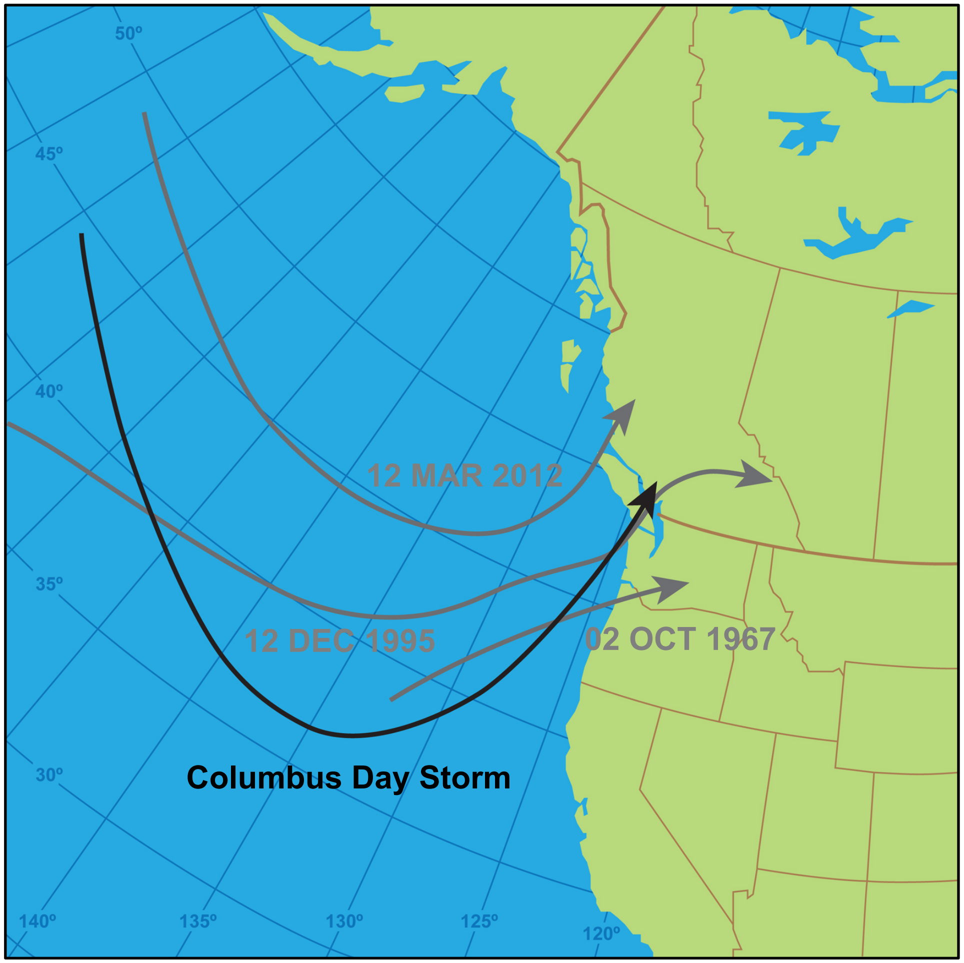
Overview

- The Columbus Day Storm
- The pressure triangle (2D gradients)
- Peak pressure gradient over Northwest Oregon during the 1962 windstorm
- Comparison of pressure gradient magnitude to other significant events
- Epilogue: A question to ponder

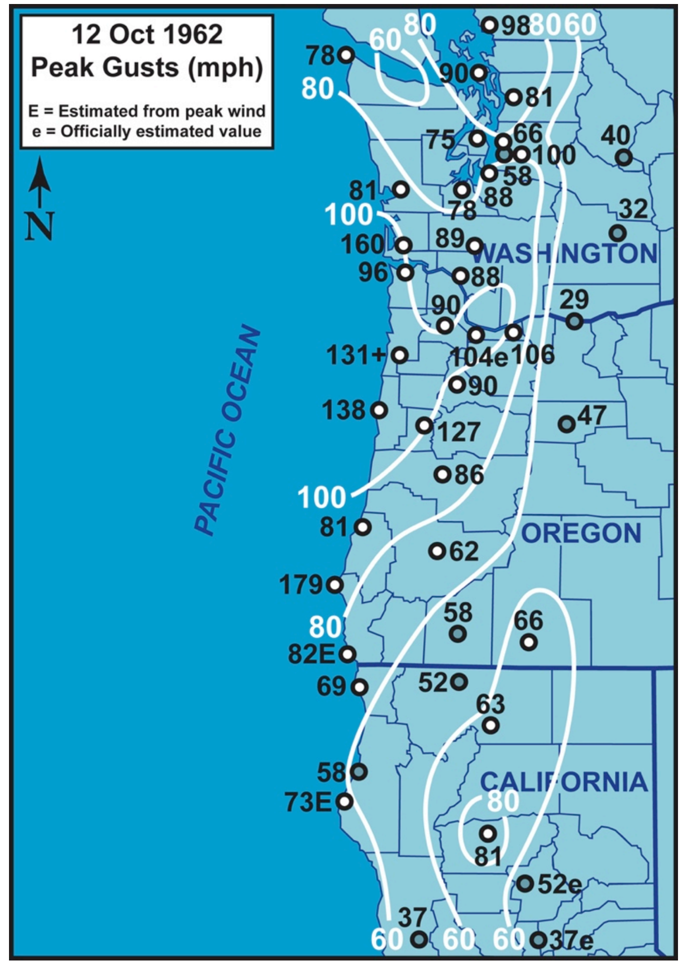
1962 Columbus Day Storm

- Columbus Day Storm tack (black)
- The other three tracks are important windstorms that will be referenced
- Recurvature to a nearly due north track near the coast puts the Columbus Day Storm in the rare category of "classic path" events



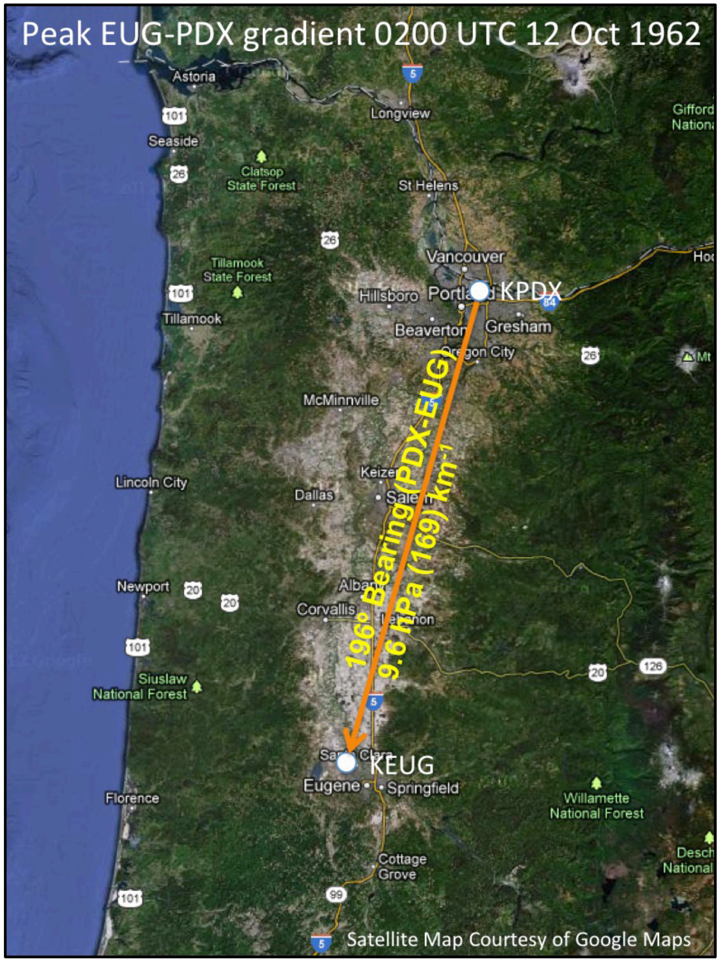
1962 Columbus Day Storm

- The cyclone's close passage to the coast contributed to extreme winds by bringing an intense pressure gradient over the region
- Gust speeds more typical of coastal headlands reached the interior
- Indeed, *interior* gust speeds were higher in places than *coastal* gust speeds for other major storms (e.g. Nov 1981, Dec 1995)



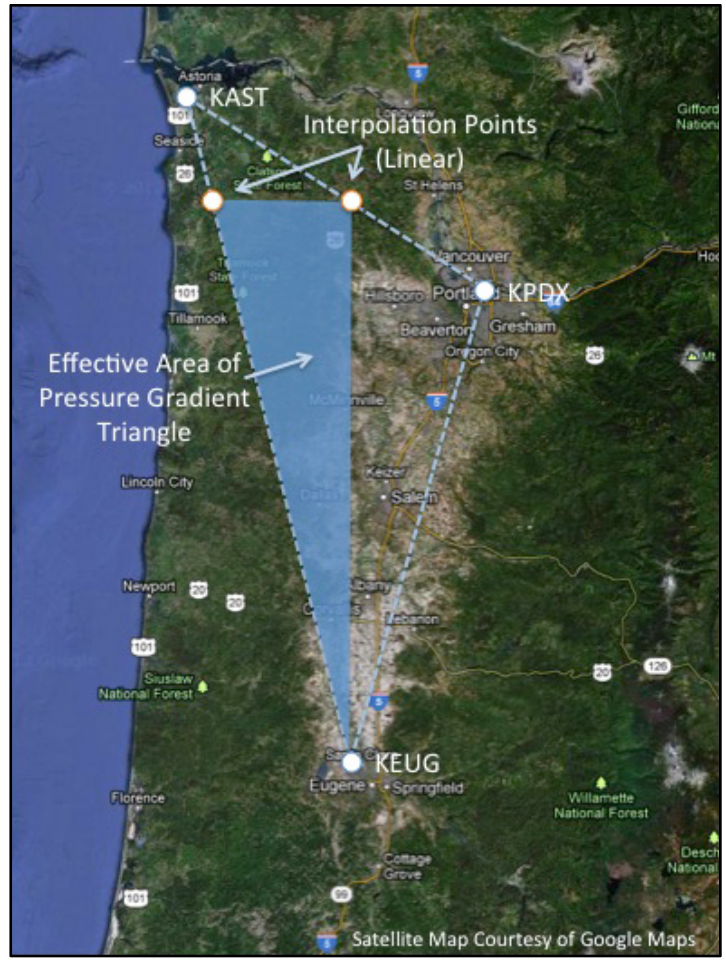
1962 Columbus Day Storm

- However, pressure gradients calculated on standard 1-D measures, such as EUG-PDX, were strong…
- But not exceptional
- 2-station or 1-D gradients are limited in that they only report a measure on a fixed bearing
- The pressure gradient orientation may not be on that bearing, resulting in under-reporting of true magnitude



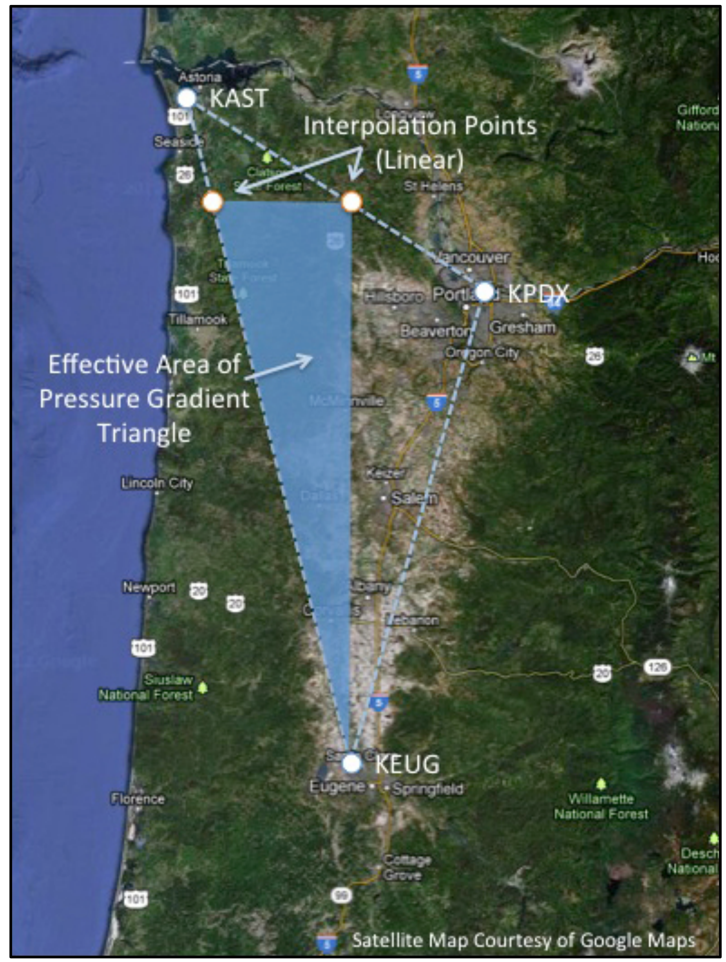
Pressure-Wind Triangle

- A 3-station, or 2-D, method provides more information about the surface pressure field
- Here EUG, PDX and AST are used as the basis of the station triad
- A right triangle is required for the calculations, so linear interpolation is used between stations (some station triads do not require this)



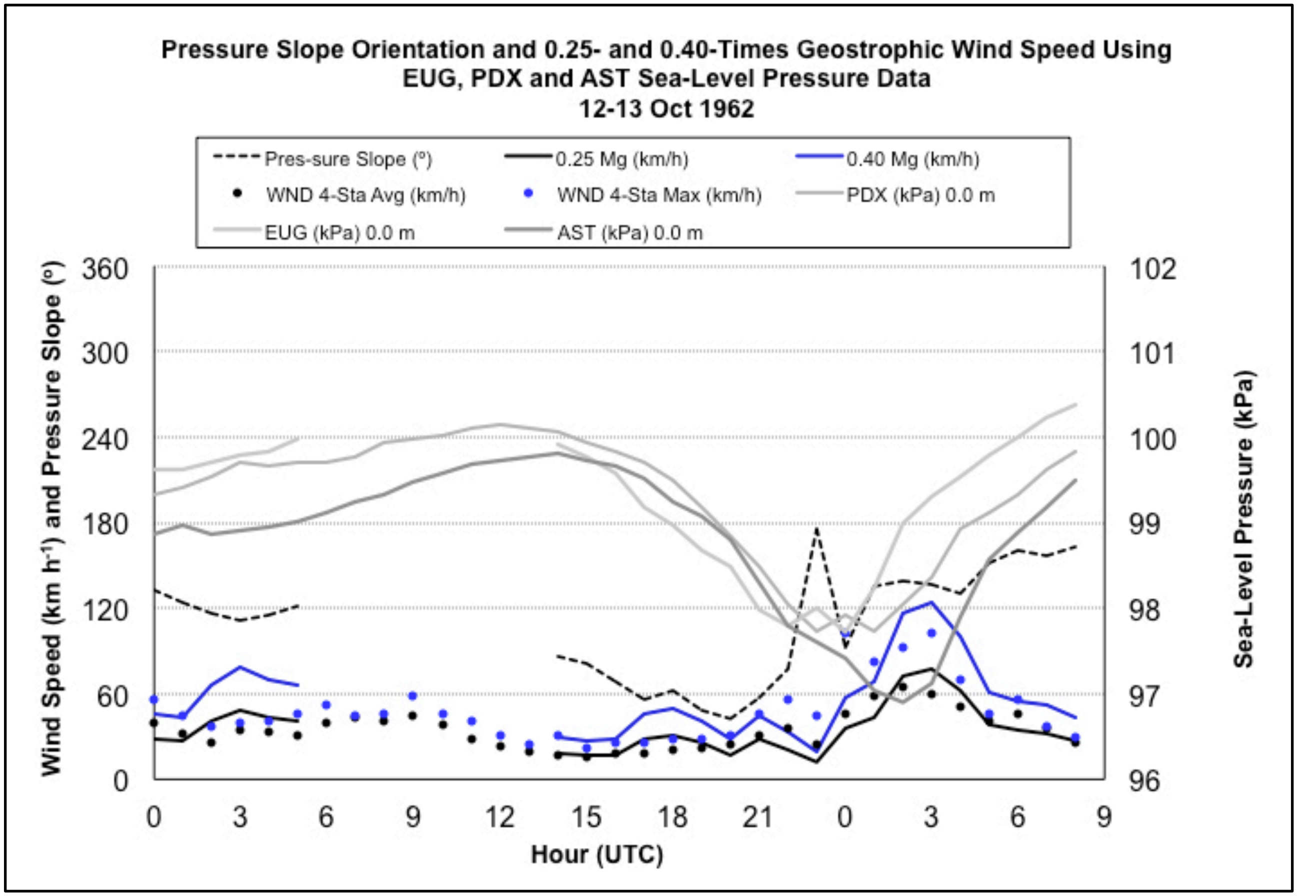
Pressure-Wind Triangle

- This method is often used to calculate the geostrophic wind between stations, hence the term pressure-wind triangle
- But it is mostly about determining pressure gradient, and the orientation of the gradient field (e.g. "pressure slope"[1])

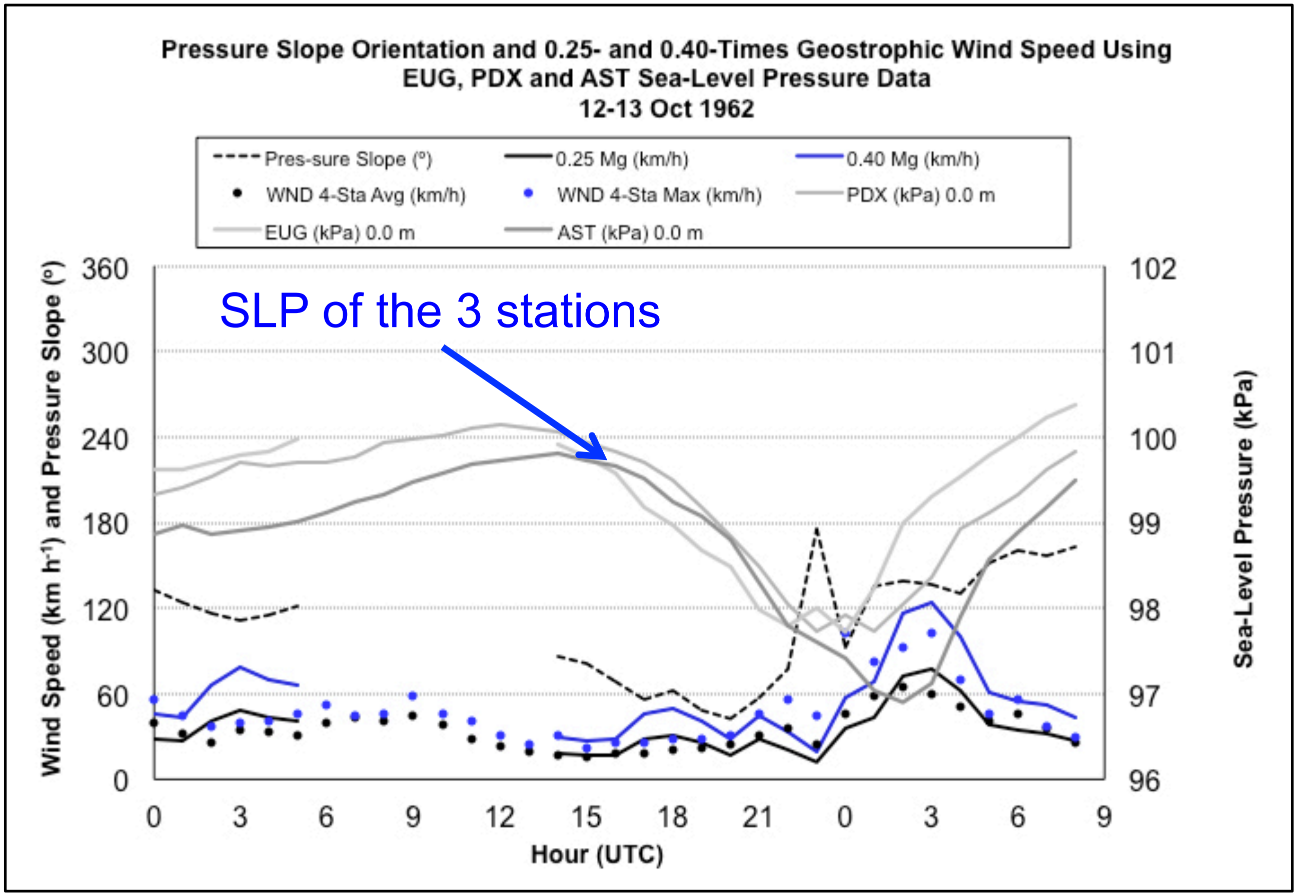


[1] The term "pressure slope" as presented in *The Wind Came All Ways* by Owen Lange (1998)

Pressure-Wind Triangle



Pressure-Wind Triangle



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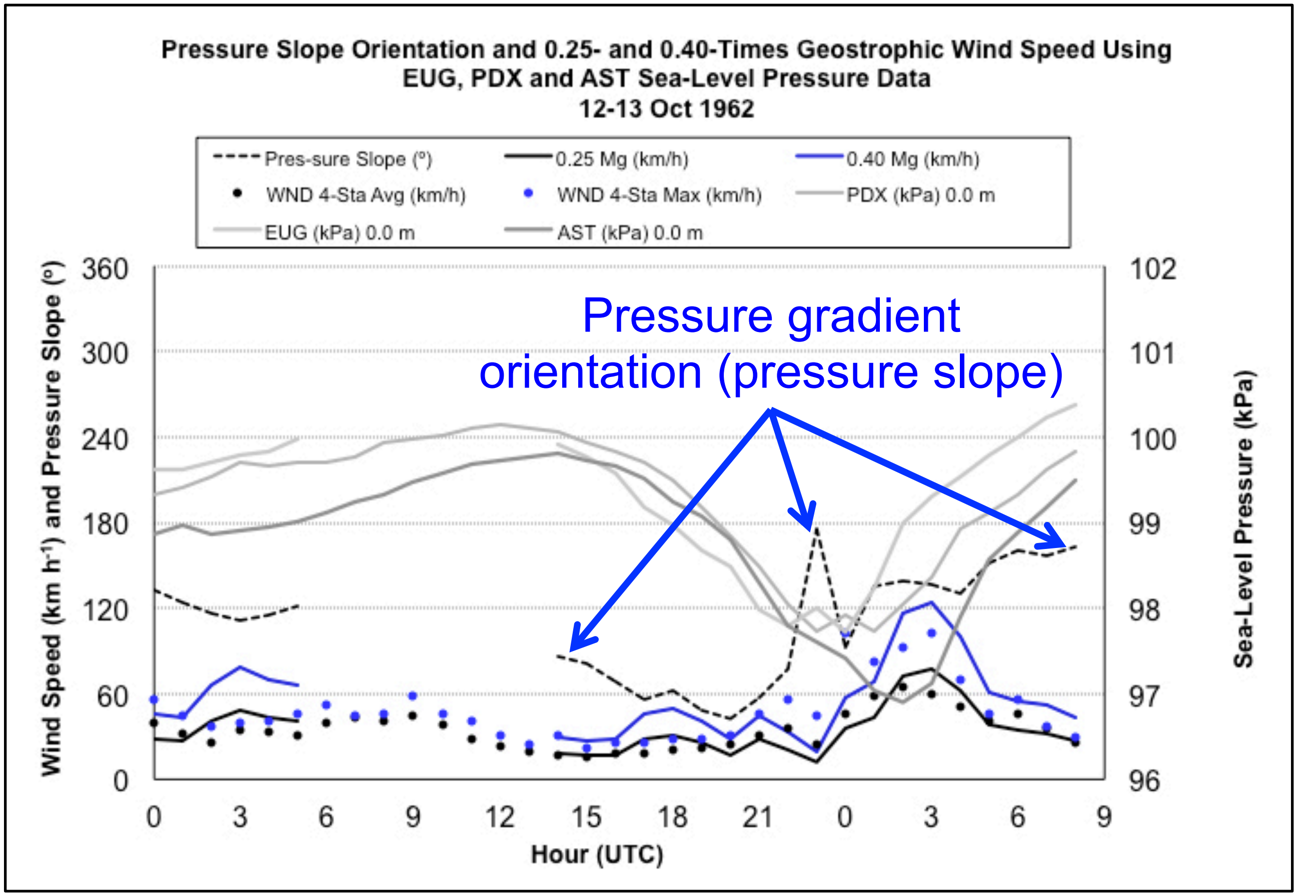
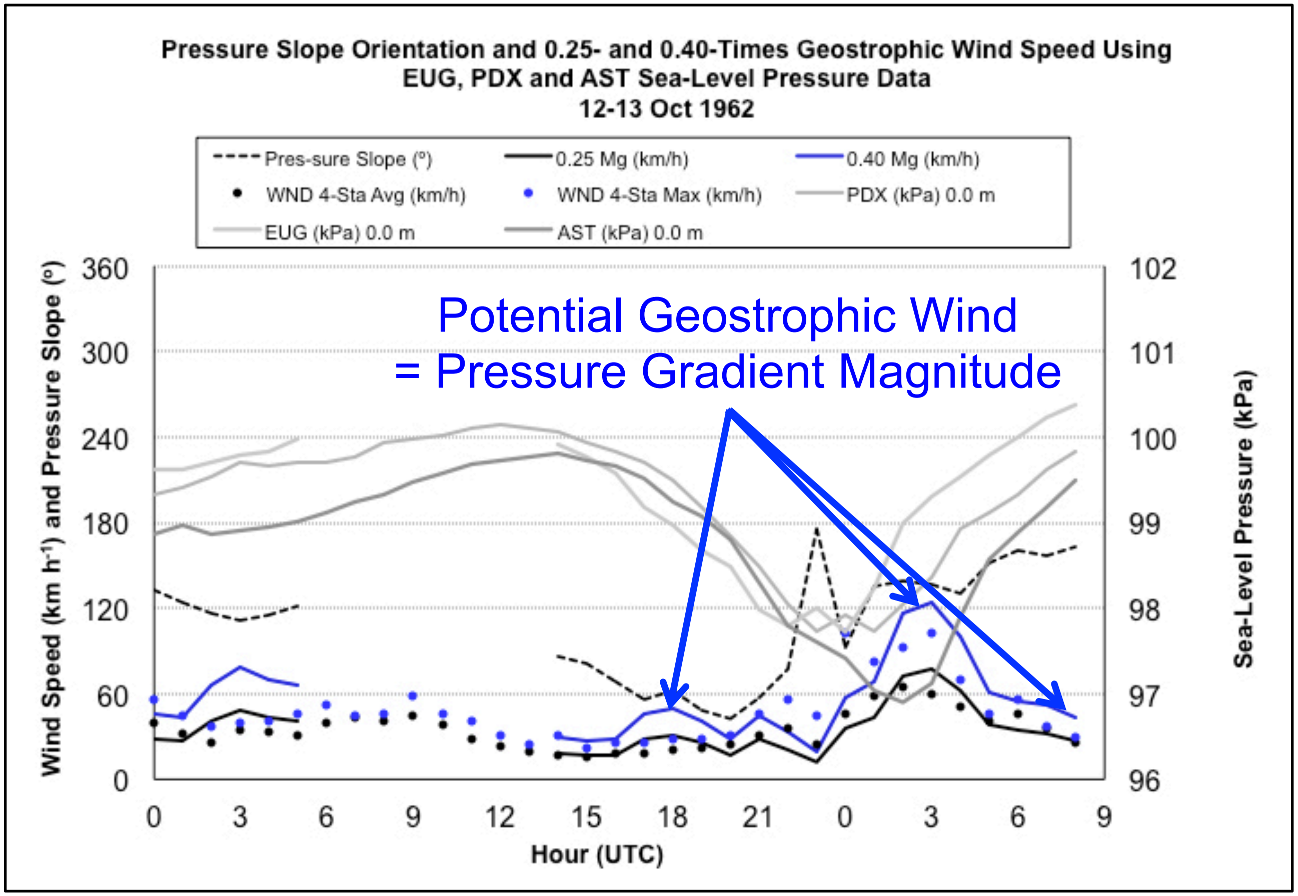
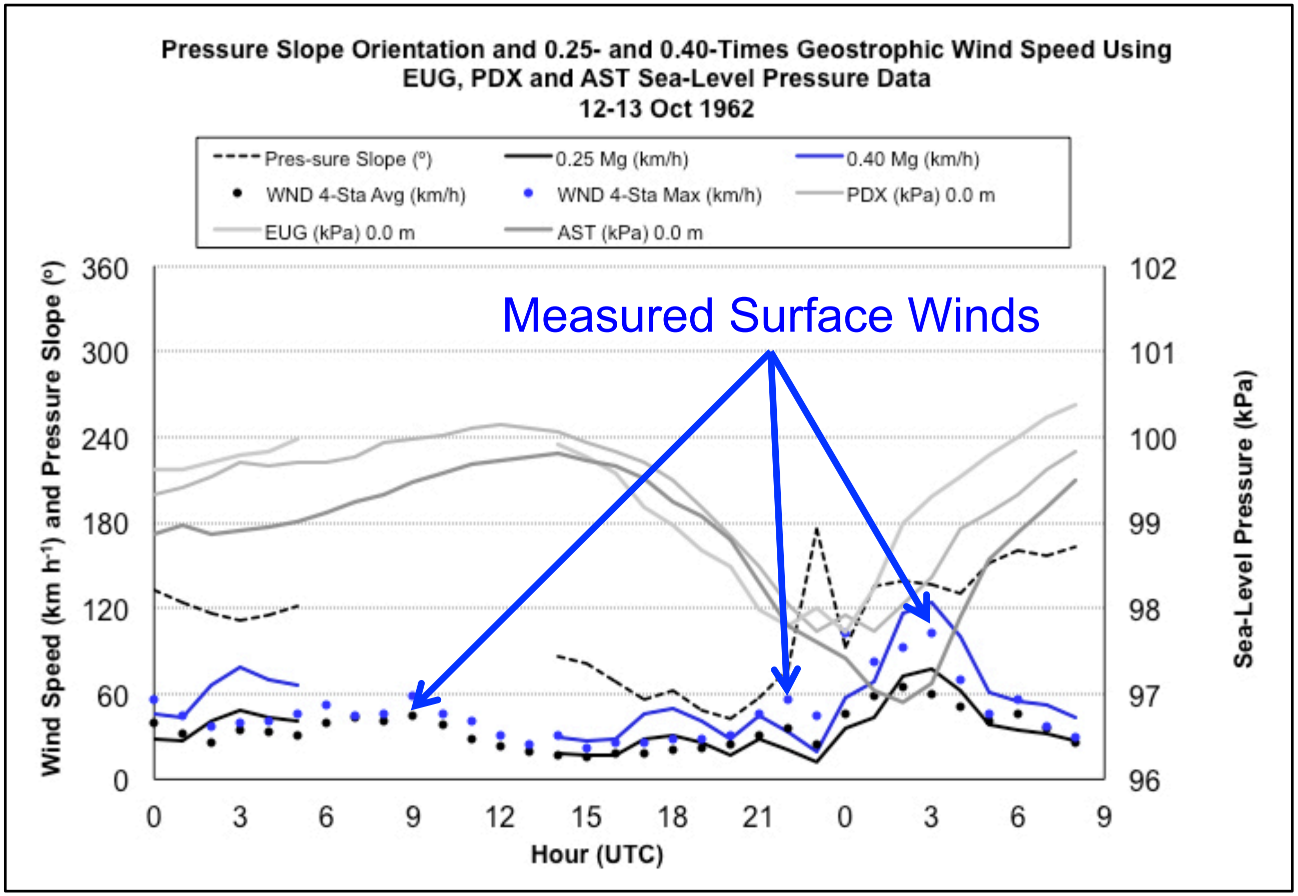


Pressure-Wind Triangle

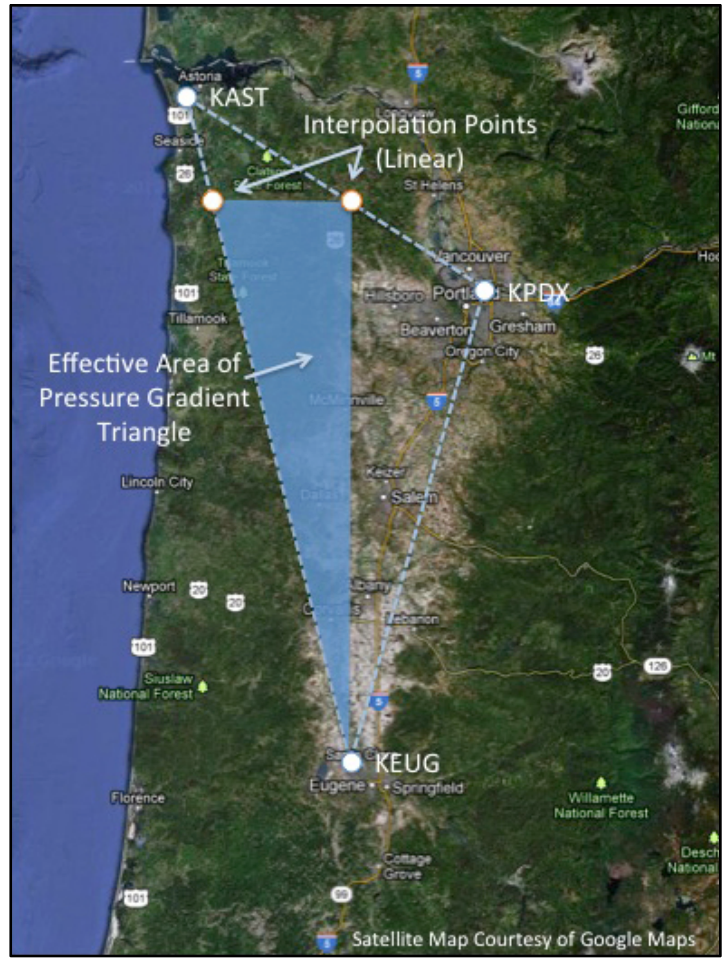


Pressure-Wind Triangle



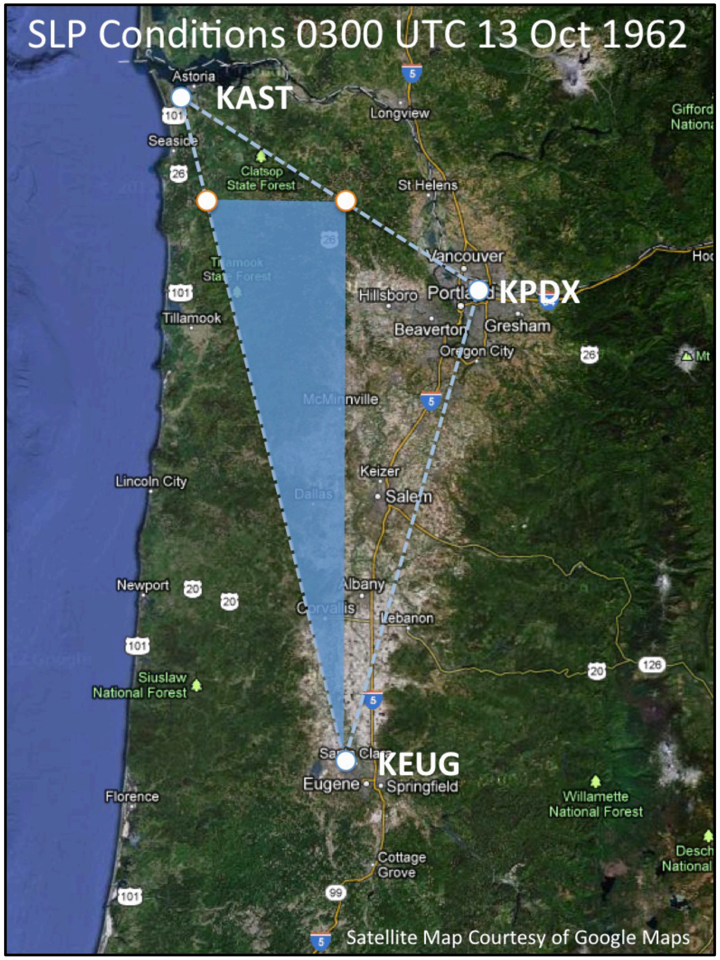
Pressure-Wind Triangle

- With the pressure-wind triangle approach, there are no negative gradients
- Gradients are positive, with the orientation derived from the gradient magnitude calculation
- I typically report pressure gradients in terms of hPa per 100 km, e.g. hPa (100) km^{-1}
- However, in this presentation I use hPa (169) km^{-1}, the EUG-PDX distance



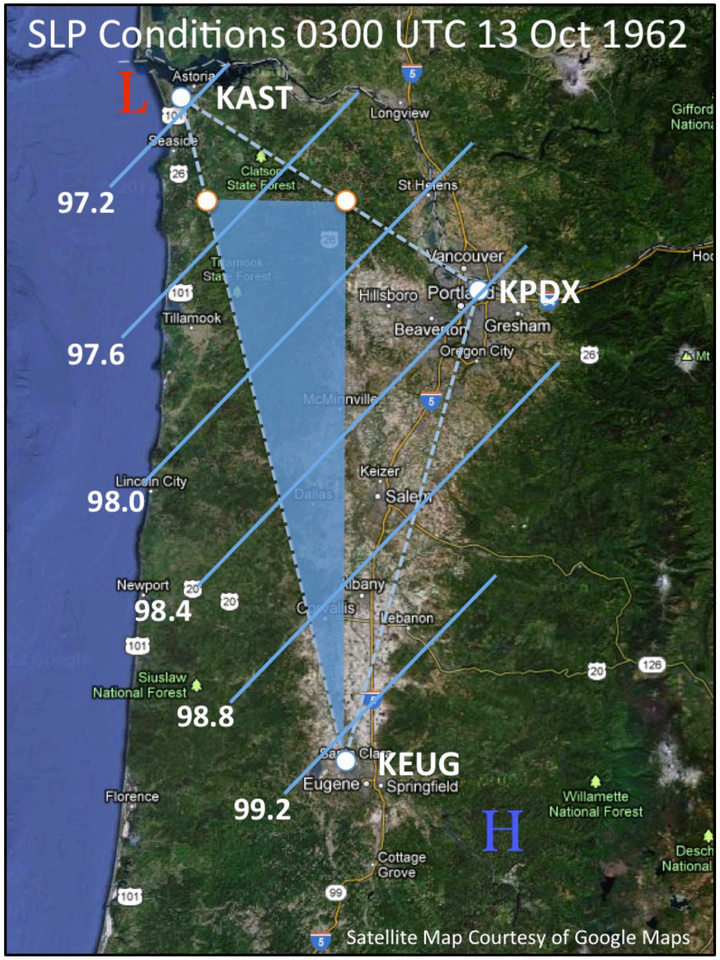
Pressure-Wind Triangle

- Looking at 0300 UTC 13 Oct 1962, the time of peak pressure gradient over Northwest Oregon



Pressure-Wind Triangle

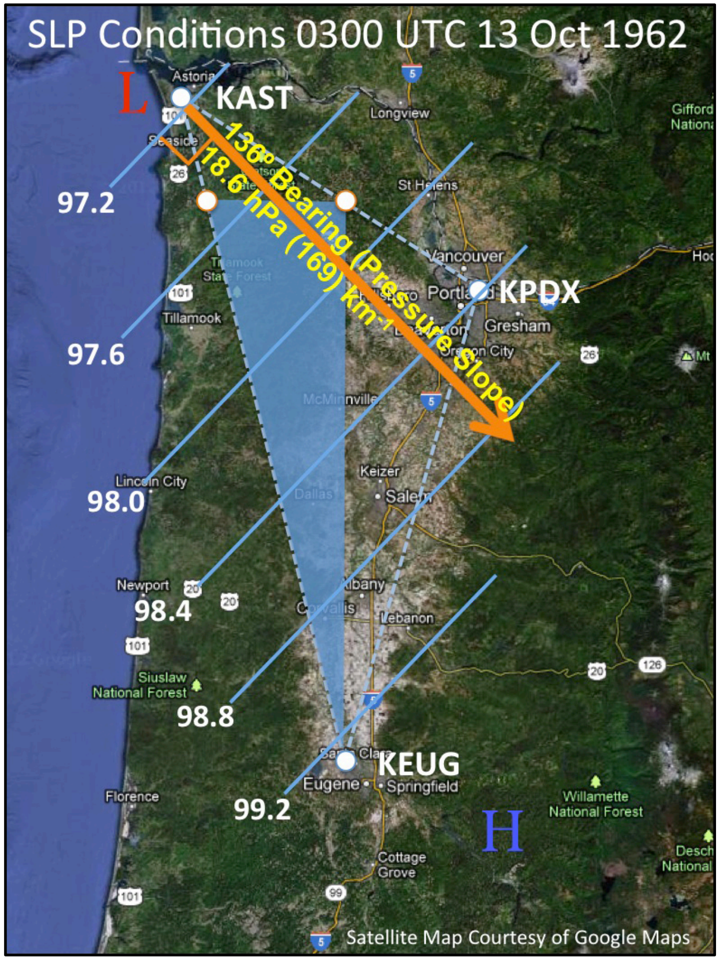
- Idealized isobars
- On a surface analysis map, the isobars would be curved around the low
- The "H" and "L" do not mark the actual centers but are there for a guide



Pressure-Wind Triangle

- The pressure slope is perpendicular to the isobars, pointing into the direction that ideal agoestrophic winds would be originating from
- This is the orientation that best measures the pressure gradient: the *absolute* gradient
- Gradient magnitude along the 136º (SE) bearing:

18.6 hPa (169) km^{-1}

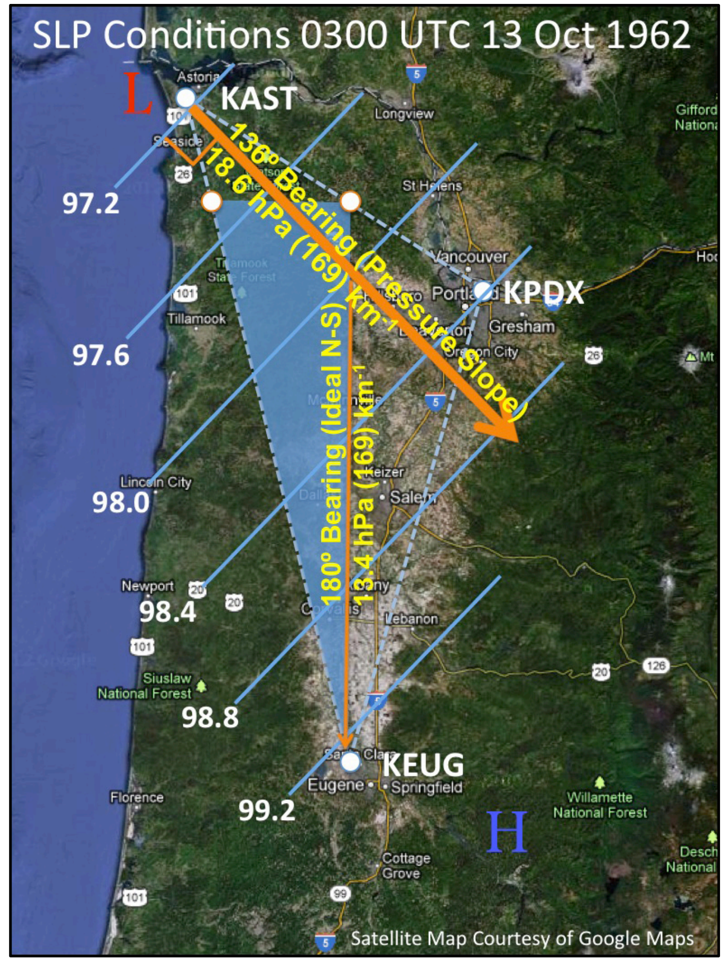


Pressure-Wind Triangle

- A 180º bearing is roughly the ideal direction for strong ageostrophic flow in the Willamette Valley given the orientation of local mountain ranges

- Gradient magnitude along the 180º (S) bearing:

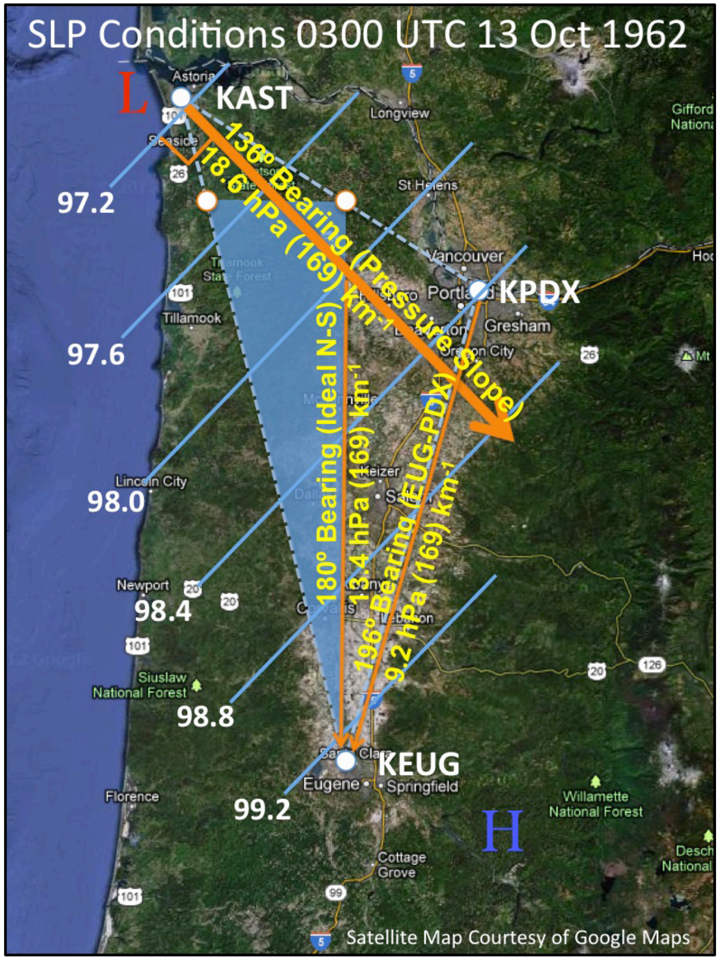
  13.4 hPa (169) km^{-1}



Pressure-Wind Triangle

- The bearing between PDX and EUG is 196º (SSW)
- Gradient magnitude along the 196º (S) bearing:

  9.2 hPa (169) km^{-1}



Peak Gradients of Historic Storms

Event	Peak Gradient hPa (169) km^{-1}	Peak-Gradient Pressure Slope ^{o}	Time of Peak Gradient UTC	Peak Gradient for 180^{o} Orientation hPa (169) km^{-1}
12 Oct 1962	18.6	136	03:00 13 Oct	13.4
08 Jan 1990	16.9	238	10:00 08 Jan	13.1
02 Oct 1967	16.2	228	05:00 02 Oct	10.8
24 Nov 1983	15.2	144	16:00 24 Nov	12.4
12 Dec 1995	15.0	144	00:00 13 Dec	12.0
14 Nov 1981	15.0	139	14:00 14 Nov	11.6

- Gradients were calculated for 27 significant storms 1945-2012
- Not all known windstorms included, mainly due to missing pressure data
- Here are the top five events after the CDS

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- The Columbus Day storm produced the strongest pressure gradient, both absolute and along a 180^{o} orientation

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- The next two strongest events tracked inland just north of Portland, the ideal arrangement for maximum pressure gradients within this station triad
- Note that with these two storms, the pressure slope is SW during the peak gradient, not the idealized S

Peak Gradients of Historic Storms

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- The SW orientation may be due to a tendency for the strongest gradient to be associated with the bent-back front in the SW quadrant of the low

Peak Gradients of Historic Storms

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- The next three storms followed tracks somewhat similar to the CDS (the 1983 Thanksgiving Day storm had the least similar path)
- Note that the pressure slope during peak gradient seems to have a tendency for a SE orientation, matching the CDS

Peak Gradients of Historic Storms

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- Among the 27 examined storm events, pressure slope very rarely falls within ± 25° of 180°
- The vast majority (~90%) of events have either SE or SW pressure slopes during the time of peak gradient, a tendency that likely mitigates peak wind speeds in the Willamette Valley to some extent

Peak Gradients of Historic Storms

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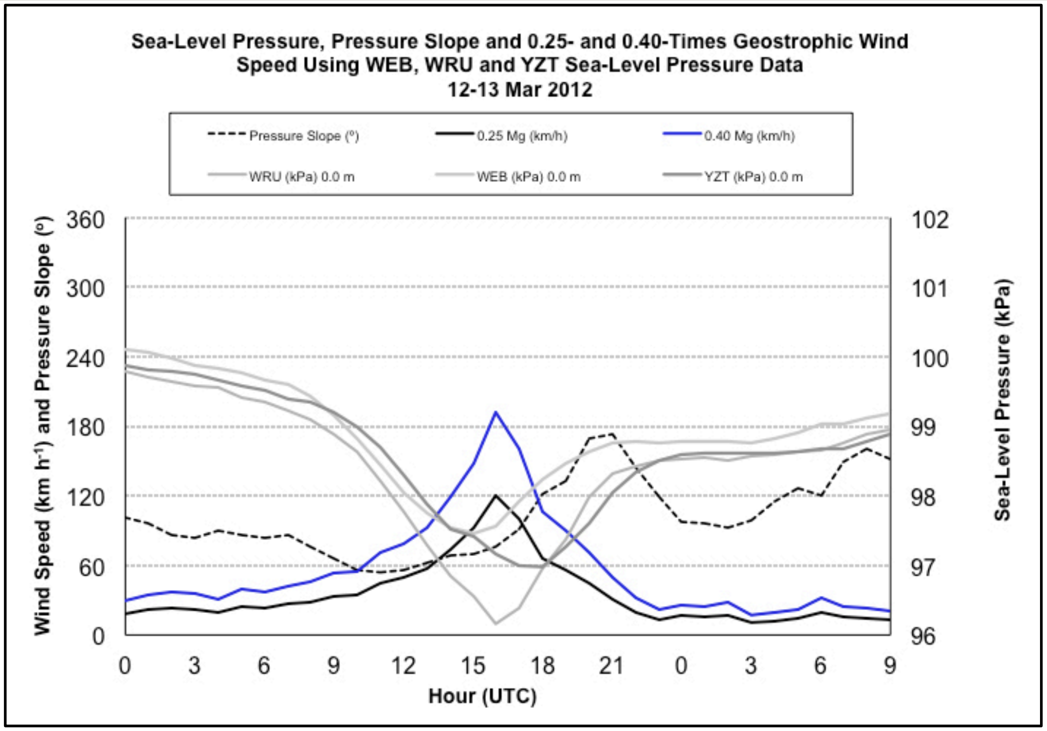
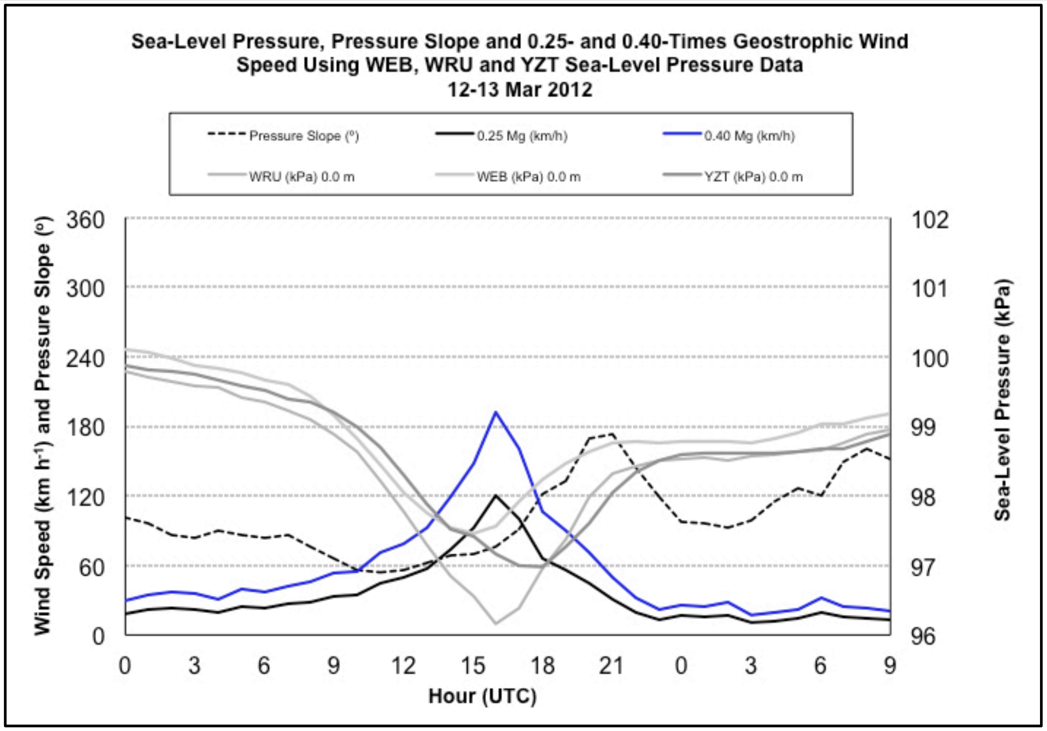
- In any event, what is evident here is that the CDS brought the strongest surface pressure gradient to Northwest OR among historical windstorms
- This fits well, as the CDS also brought with it the strongest measured surface wind speeds in the region of interest

Epilogue



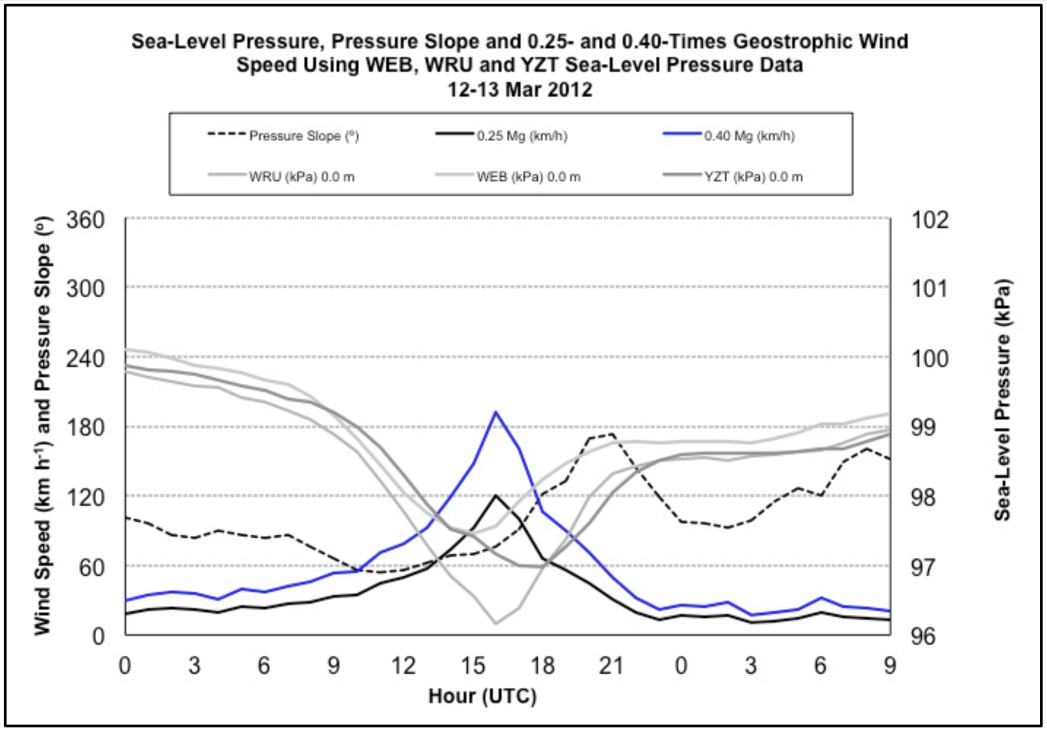
- On 12 Mar 2012, an intense extratropical cyclone brought a 30.9 hPa (169) km^{-1} gradient to northern Vancouver Island
- This is 1.66 times the peak Northwest Oregon gradient during the CDS

Epilogue



- If a future storm following a track similar to the CDS brought a 30.9 hPa (169) km^{-1} gradient to Northwest Oregon, might the surface wind speeds be even stronger than in 1962?

Thank You



Sea-Level Pressure, Pressure Slope and 0.25- and 0.40-Times Geostrophic Wind Speed Using WEB, WRU and YZT Sea-Level Pressure Data
12-13 Mar 2012
Pressure Slope (°)
0.25 Mg (km/h)
0.40 Mg (km/h)
WRU (kPa) 0.0 m
WEB (kPa) 0.0 m
YZT (kPa) 0.0 m
Wind Speed (km h⁻¹) and Pressure Slope (°)
Sea-Level Pressure (kPa)
Hour (UTC)
0 60 120 180 240 300 360
96 97 98 99 100 101 102
0 3 6 9 12 15 18 21 0 3 6 9