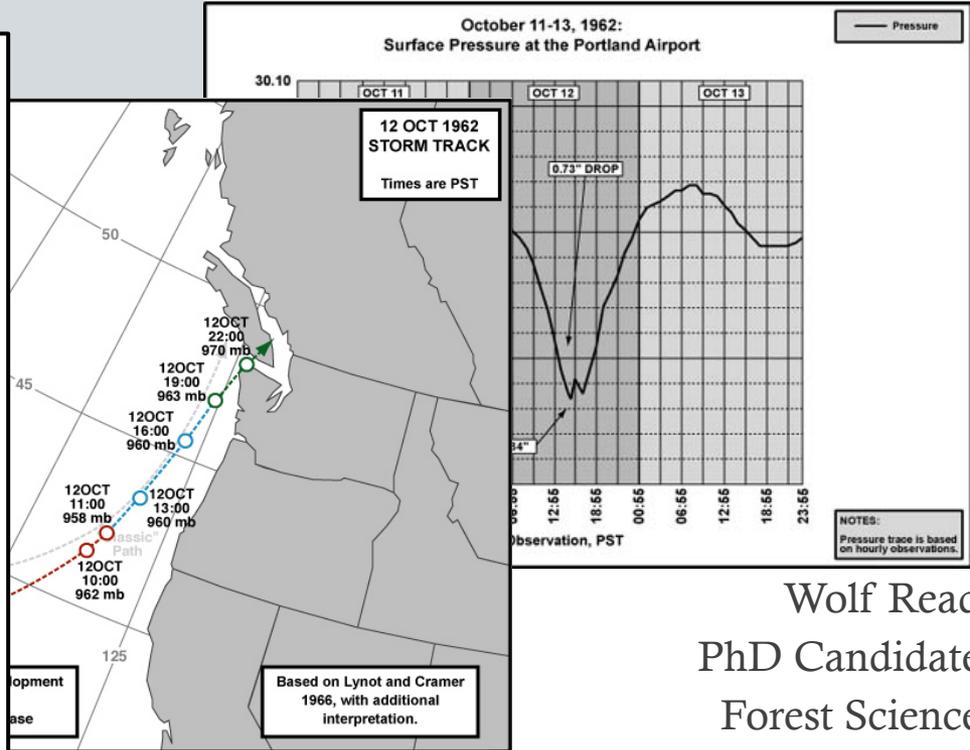
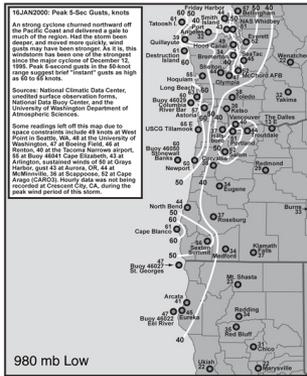
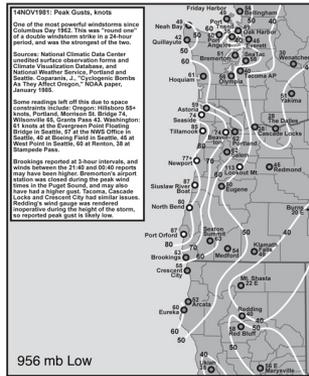
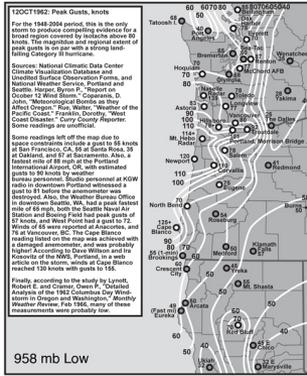
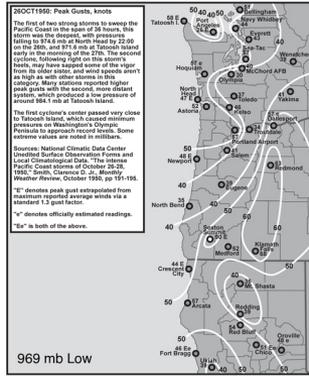


A Climatological Perspective of the 1962 Columbus Day Storm

Class 6 Storms: Peak gust distribution for some significant events, 1948-2004.



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 PhD Candidate
 Forest Science
 University of British Columbia
 wolfread@alumni.ubc.ca

Outline

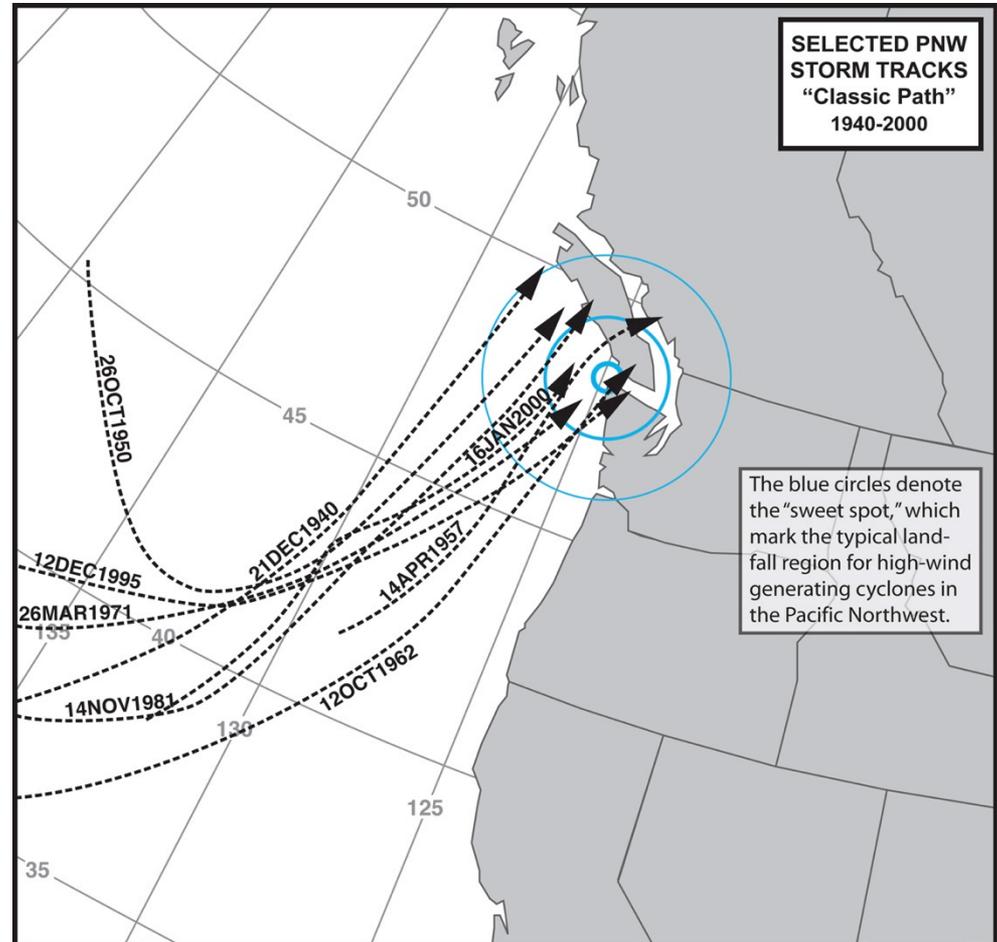
- The “Classic Path”: An examination of 9 significant events from 1940-2000
- Return intervals
- Columbus Day Storm (CDS) gust magnitude: Significance relative to other storms
- CDS pressure tendencies: Examination of a key reason for the extraordinary wind gusts



Photos courtesy of Oregon State University.

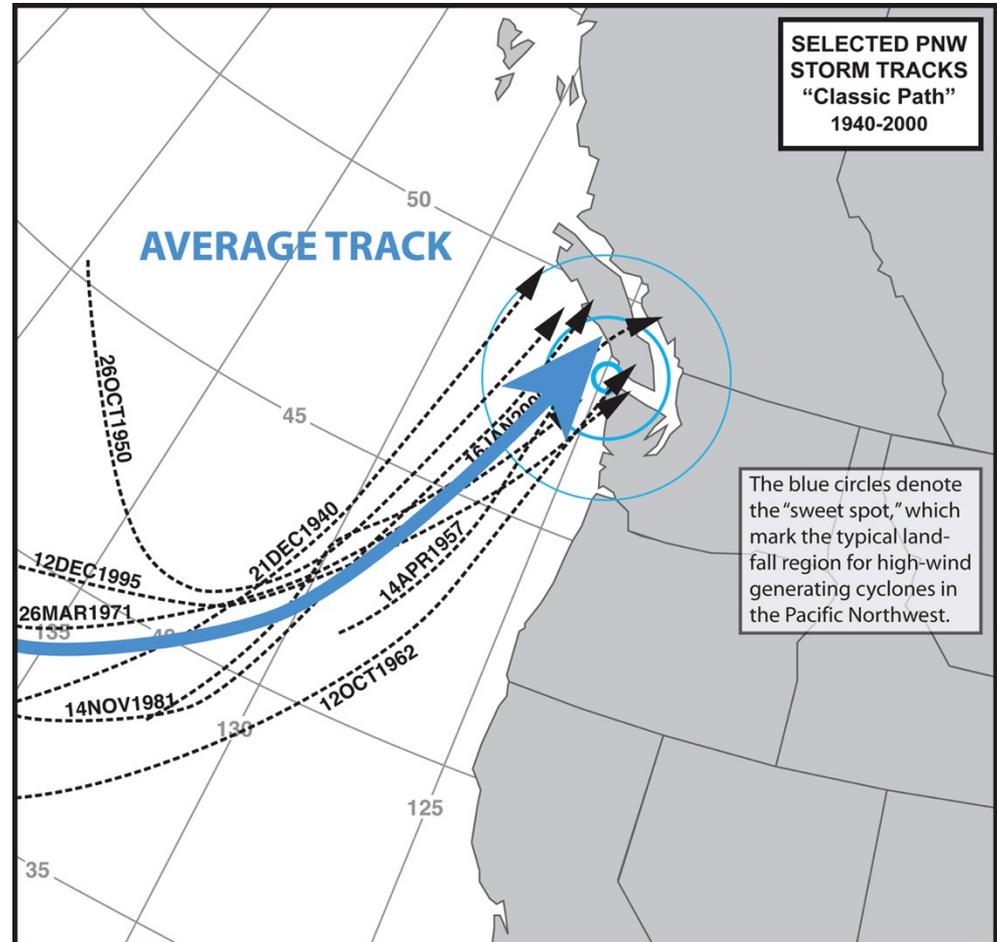
Classic Path: Storm Tracks

- These are the tracks of 8 (out of 9) significant extratropical cyclones that generated high-winds in the Pacific Northwest from 1940-2000



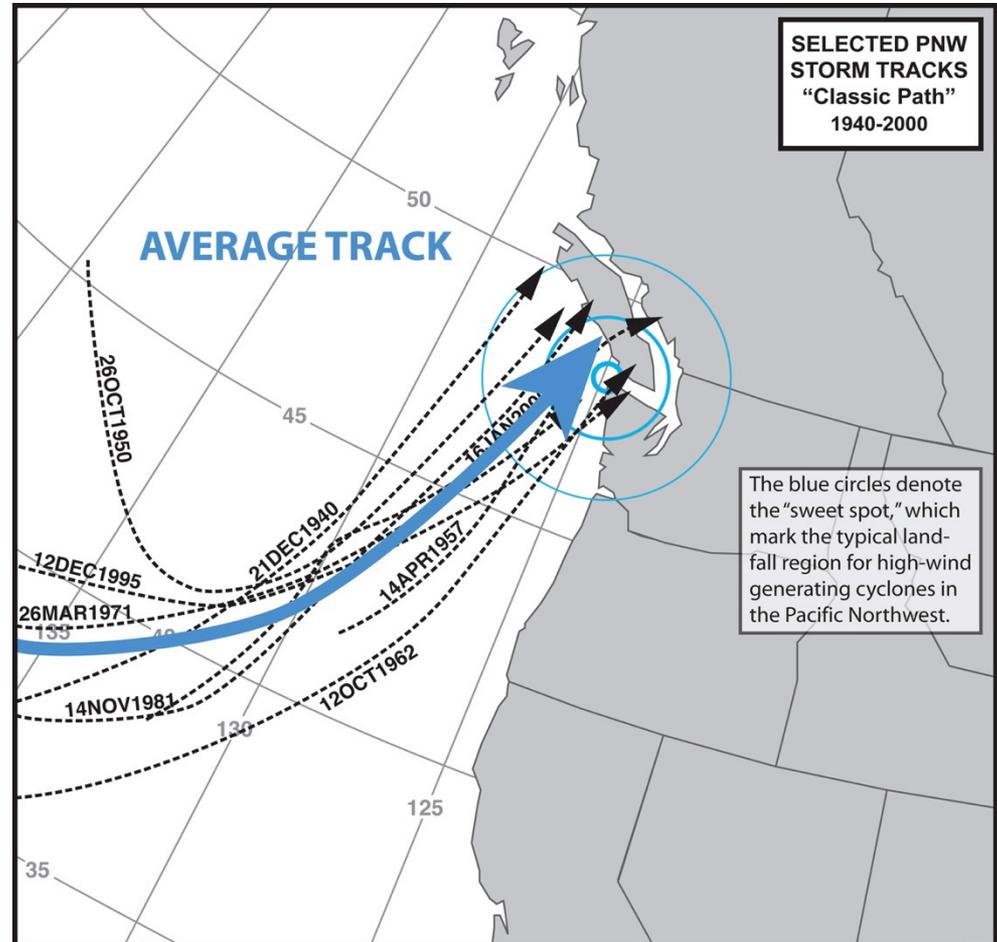
Classic Path: Storm Tracks

- These are the tracks of 8 (out of 9) significant extratropical cyclones that generated high-winds in the Pacific Northwest from 1940-2000
- The average of these tracks, with a strong northward direction just off the Pacific Coast, is sometimes called the “Classic Path”



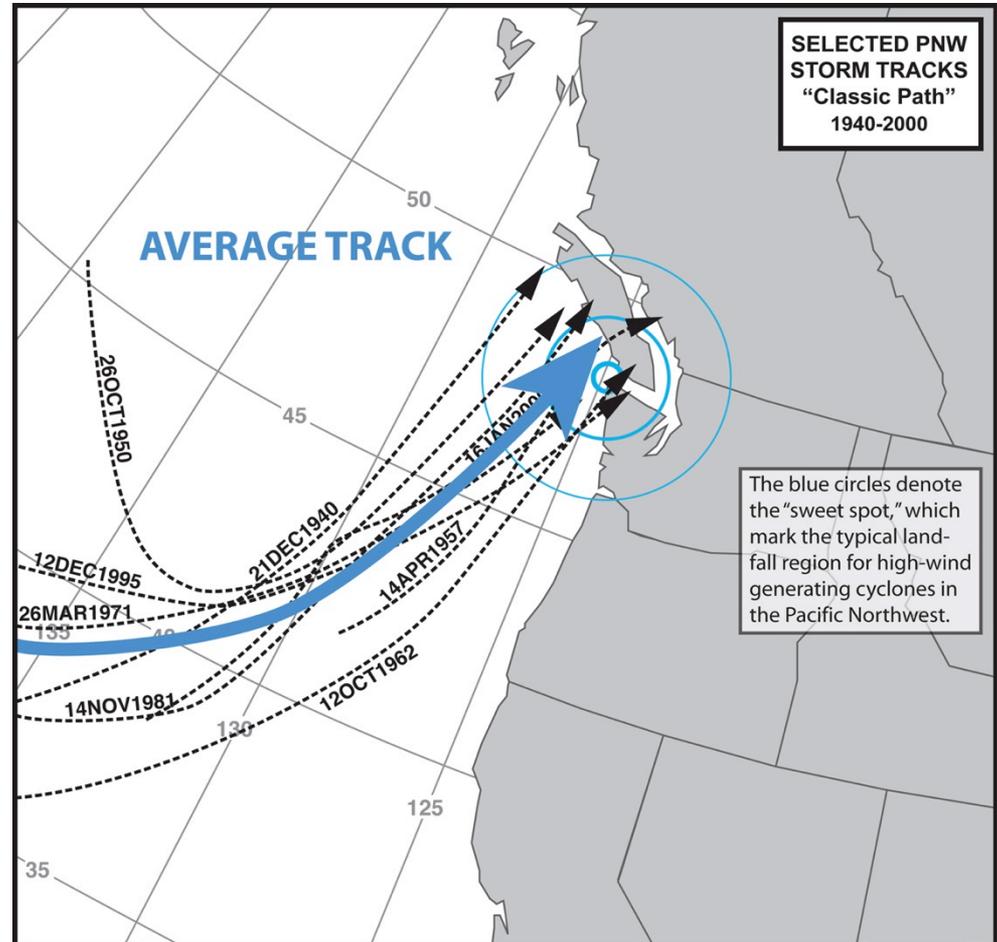
Classic Path: Storm Tracks

- The low center crosses inside of 130°W off the coast of Southwest OR, generally between 39° to 44°N
- Low then tracks NNE toward Vancouver Island, generally 10° to 20° (sometimes up to 30°) off of true N



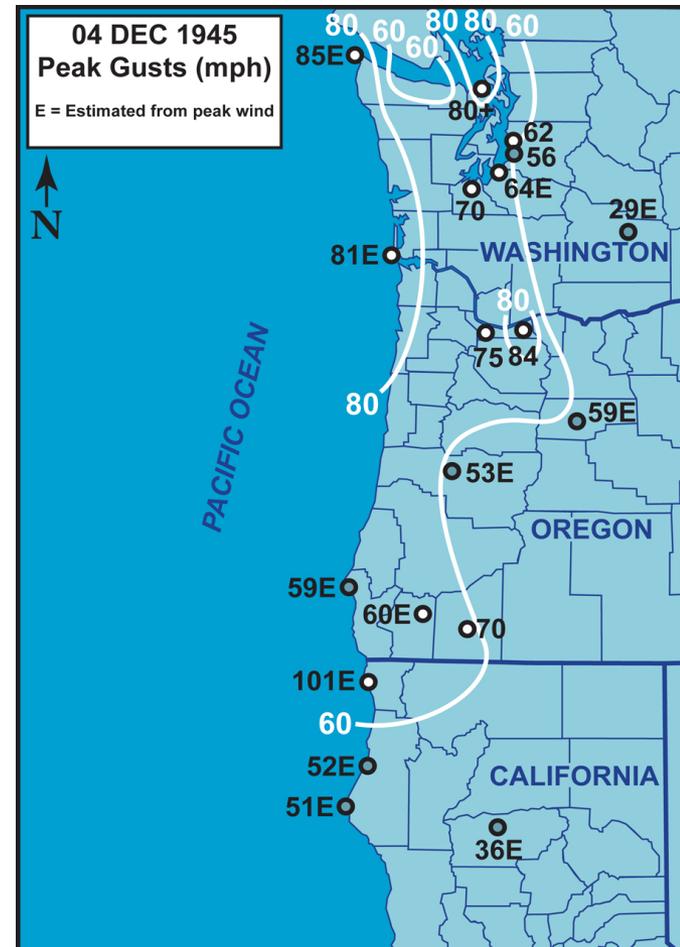
Classic Path: Storm Tracks

- The nearly due north track is probably a more important consideration for high-winds than exactly at what latitude the low center crosses the 130°W line
- The proximity of the low center to the Pacific coast is another consideration for high-wind potential



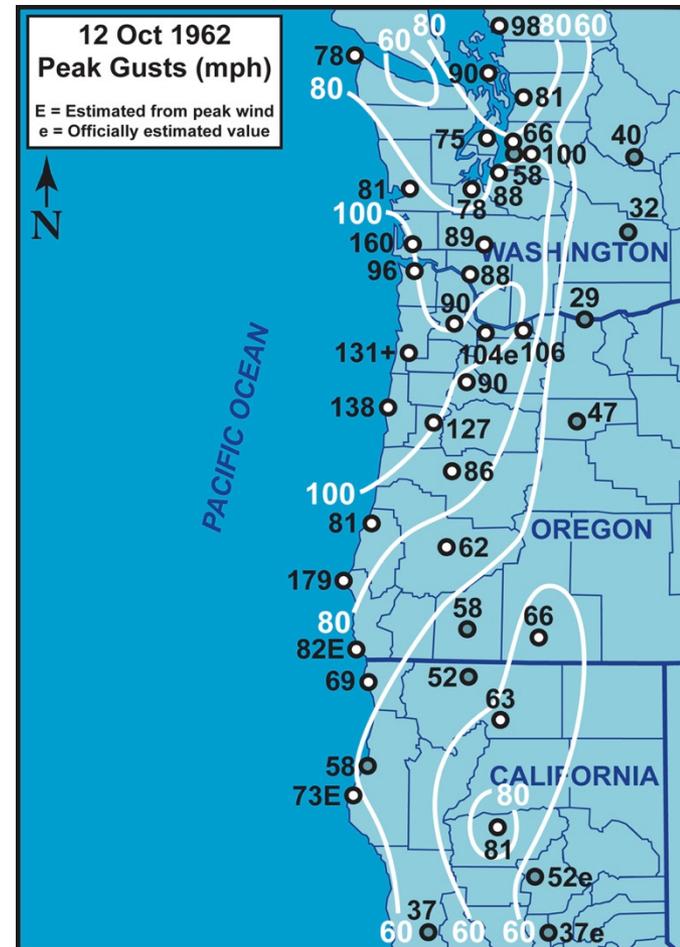
Classic Path: Historic Peak Gust Distributions

- Is there a pattern to peak gust distributions among classic path storms?
- Looking at the 4 strongest events 1940-2000:
- 04 Dec 1945: High winds occurred inland from Southwest OR northward
- Somewhat like the Columbus Day Storm distribution...



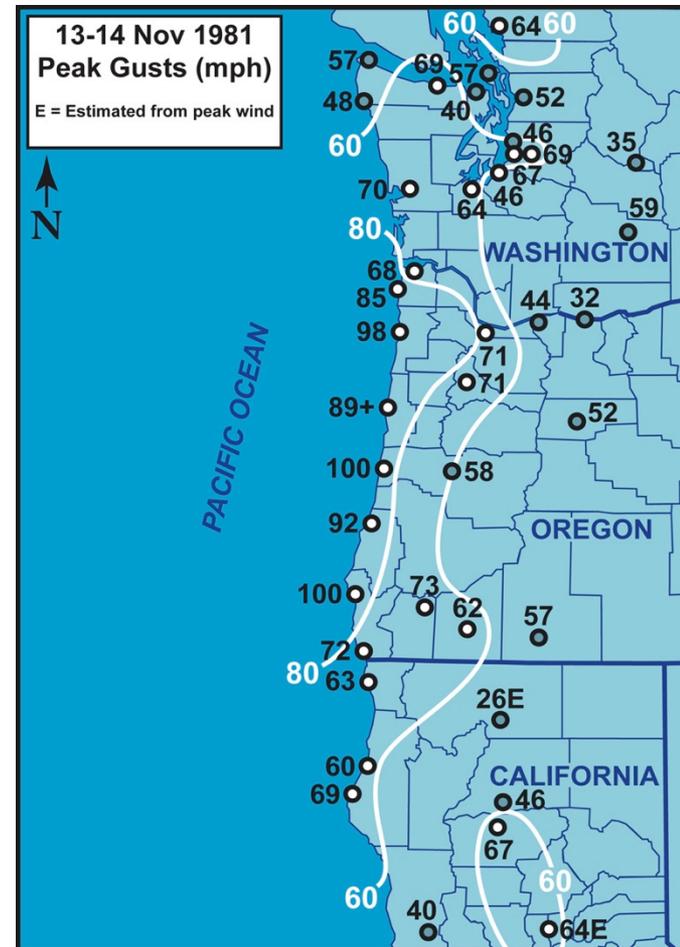
Classic Path: Historic Peak Gust Distributions

- 12 Oct 1962: The Columbus Day Storm
- Extreme gust speeds carried inland
- Gust speeds more typical of coastal headlands reach the interior



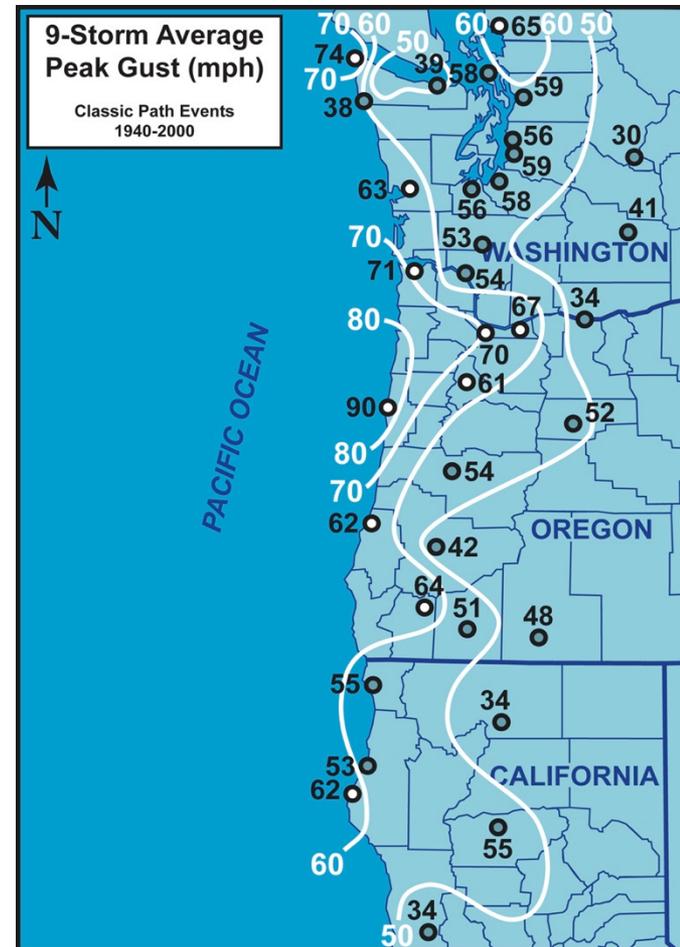
Classic Path: Historic Peak Gust Distributions

- 13-14 Nov 1981: Pattern quite similar to the Columbus Day Storm
- Exception: Strait of Juan de Fuca, where strong gusts occurred in locations that are typically spared (e.g. Port Angeles)
- Wind magnitude not as strong as CDS, save for a few stations (e.g. North Bend, OR, and Sea-Tac, WA)



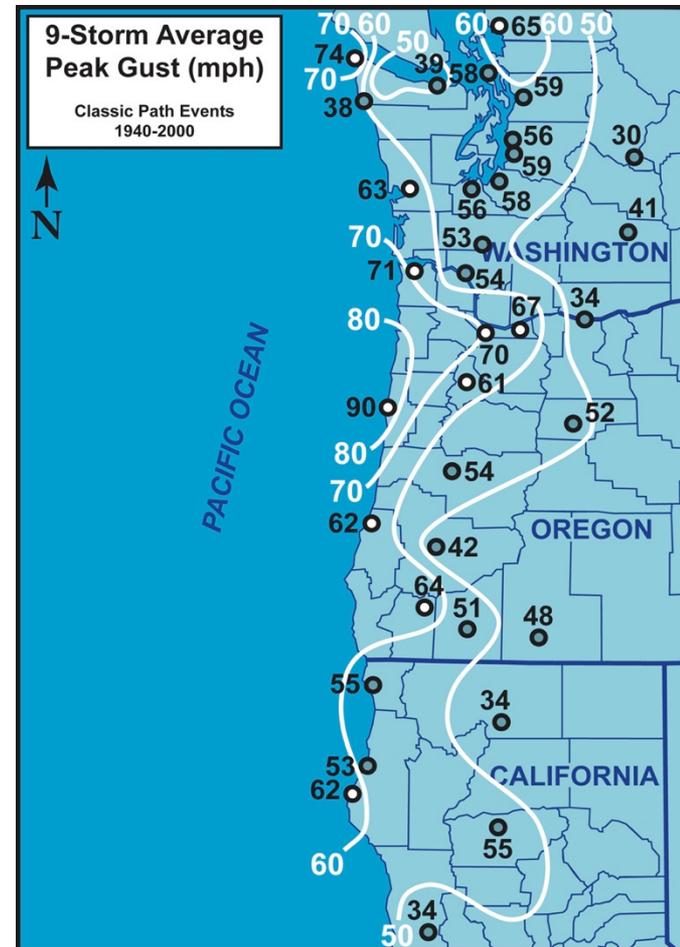
Classic Path: Average Peak Gust Distribution

- Average peak gust of 9 significant classic-path storms
- Caveats:
 - Only 9 samples, and most stations have missing data
 - Therefore statistical uncertainty is high
 - Much variance in spatial distribution (e.g. 26 Oct 1950)
 - Take this analysis with a grain of salt



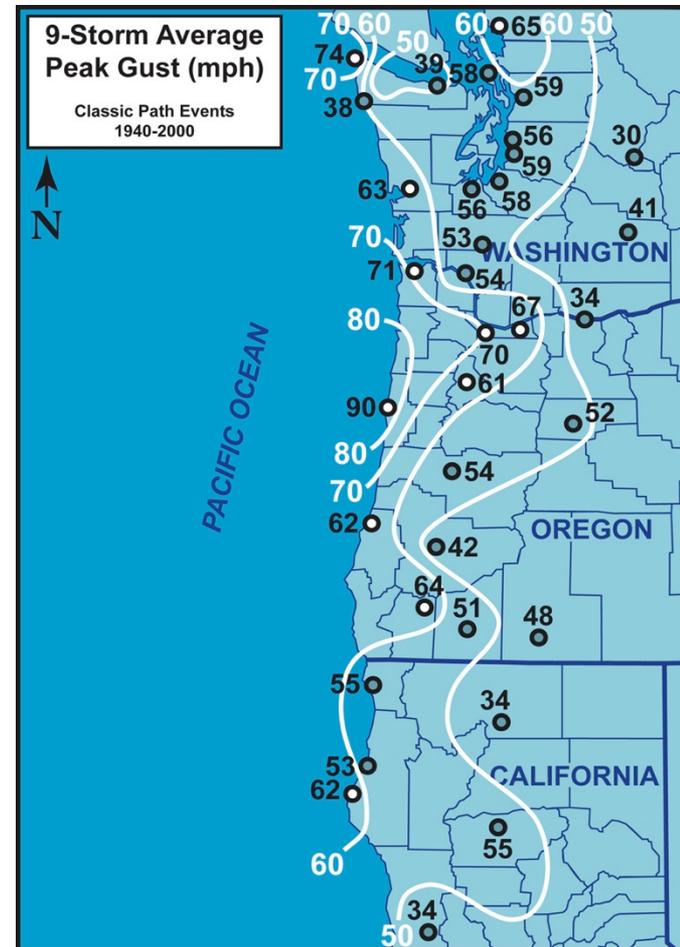
Classic Path: Average Peak Gust Distribution

- Average peak gust of 9 significant classic-path storms
- Strengths:
 - The strongest storms (1945, 1962, 1981 and 1995) have similar spatial patterns of gust-speed magnitude
 - This map is largely a reflection of the biggest storms



Classic Path: Average Peak Gust Distribution

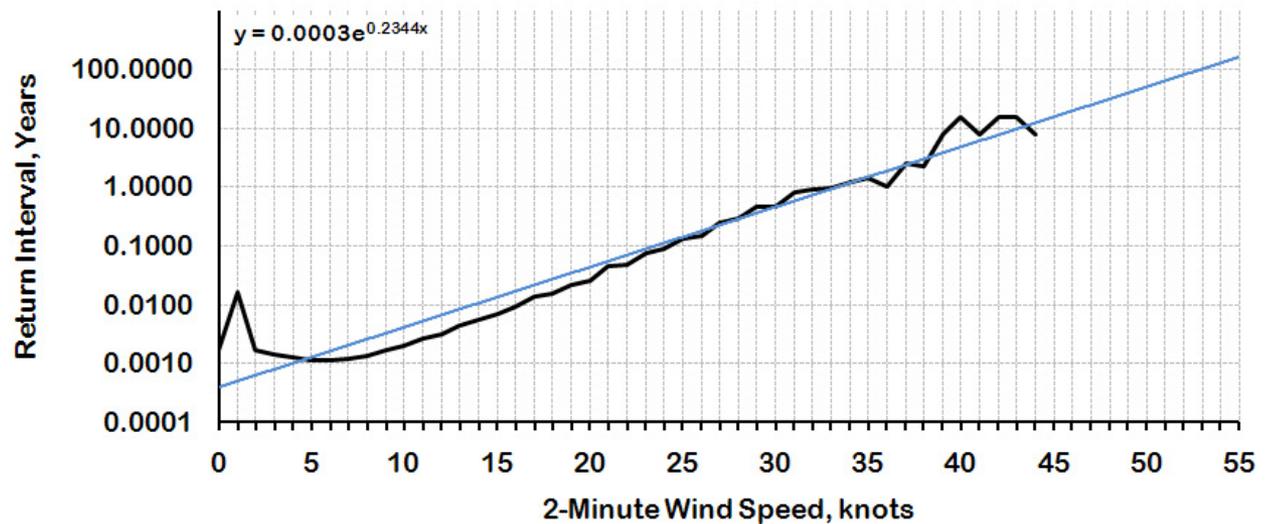
- The OR coast tends to receive the strongest gusts (>70 mph)
- The northern Willamette Valley of OR and Northwest Interior of WA also appear more prone to damaging gusts (>60 mph)
- High-wind gusts also tend to occur in the Puget Lowlands, but not quite with the intensity of locations S and N (55-60 mph)



Classic Path: Return Intervals

- There are a number of ways to compute return intervals
- Most methods utilize the wind speed record at a particular location

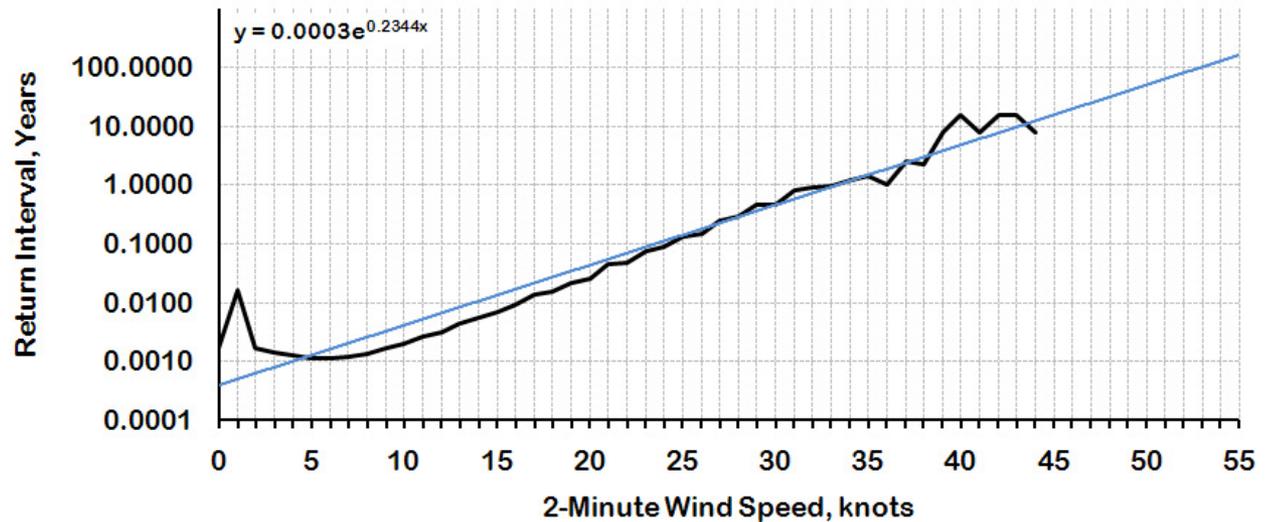
Return Interval for 2-Minute Wind in 1-kt Increments at CYVR, Based on 78D Data From Aug 1992-Jul 2008, With Prediction Beyond 44-kt



Classic Path: Return Intervals

- There are a number of ways to compute return intervals
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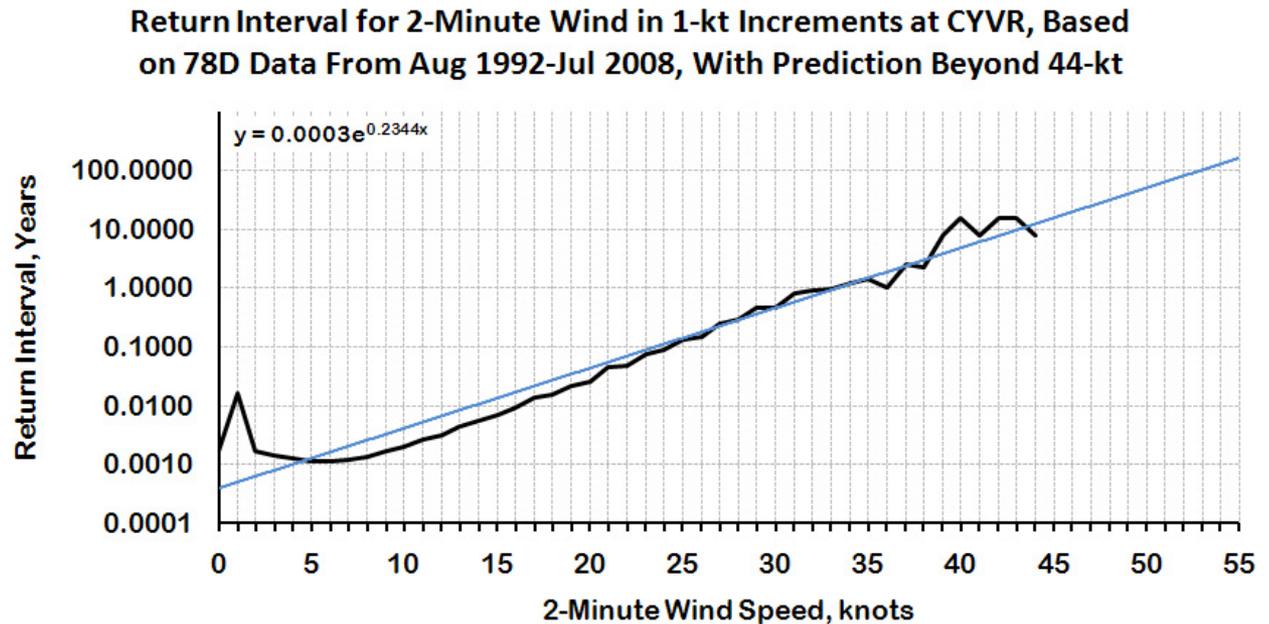
Return Interval for 2-Minute Wind in 1-kt Increments at CYVR, Based on 78D Data From Aug 1992-Jul 2008, With Prediction Beyond 44-kt



- The chart above is for Vancouver International Airport, BC

Classic Path: Return Intervals

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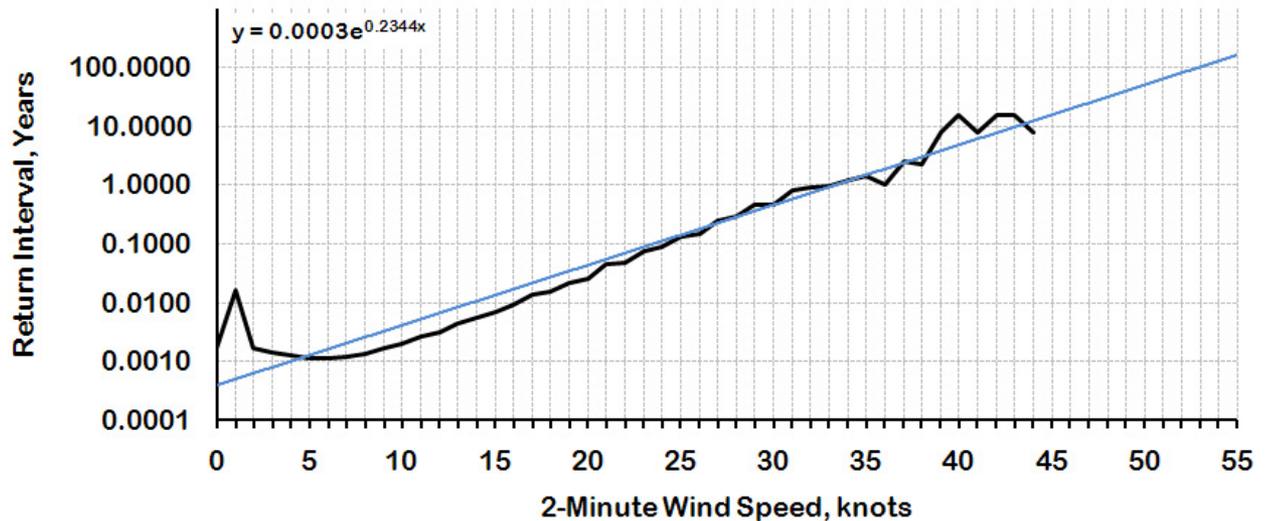


- The chart above is for Vancouver International Airport, BC
- Analyses such as this can be made for any location with a long-term wind record

Classic Path: Return Intervals

- There are a number of ways to compute return intervals
- Most methods utilize the wind speed record at a particular location
- For interior stations such as Portland and Seattle, the results would be similar

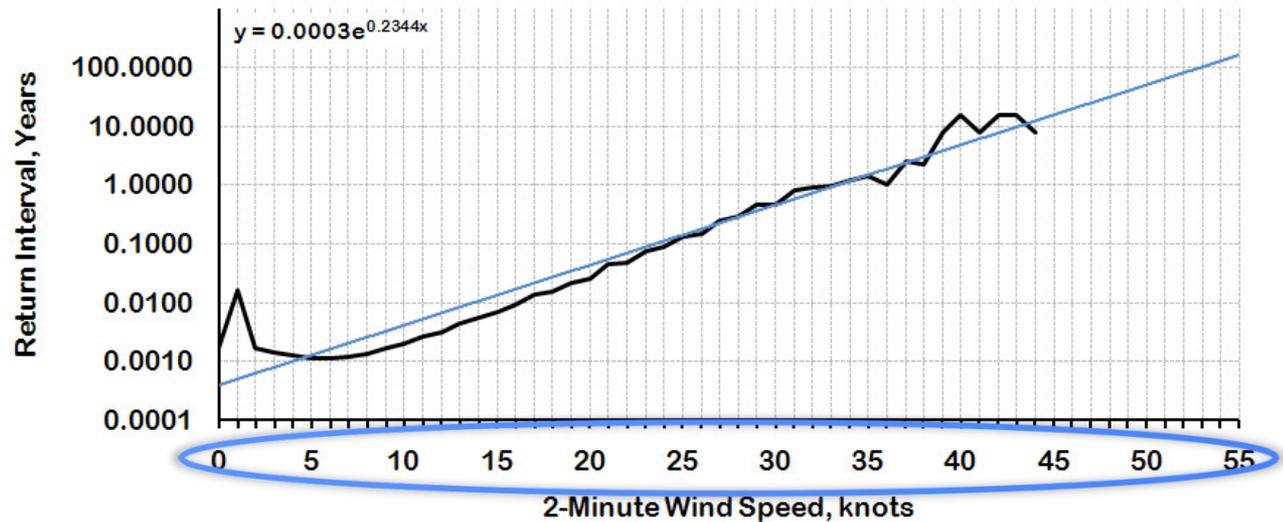
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Classic Path: Return Intervals

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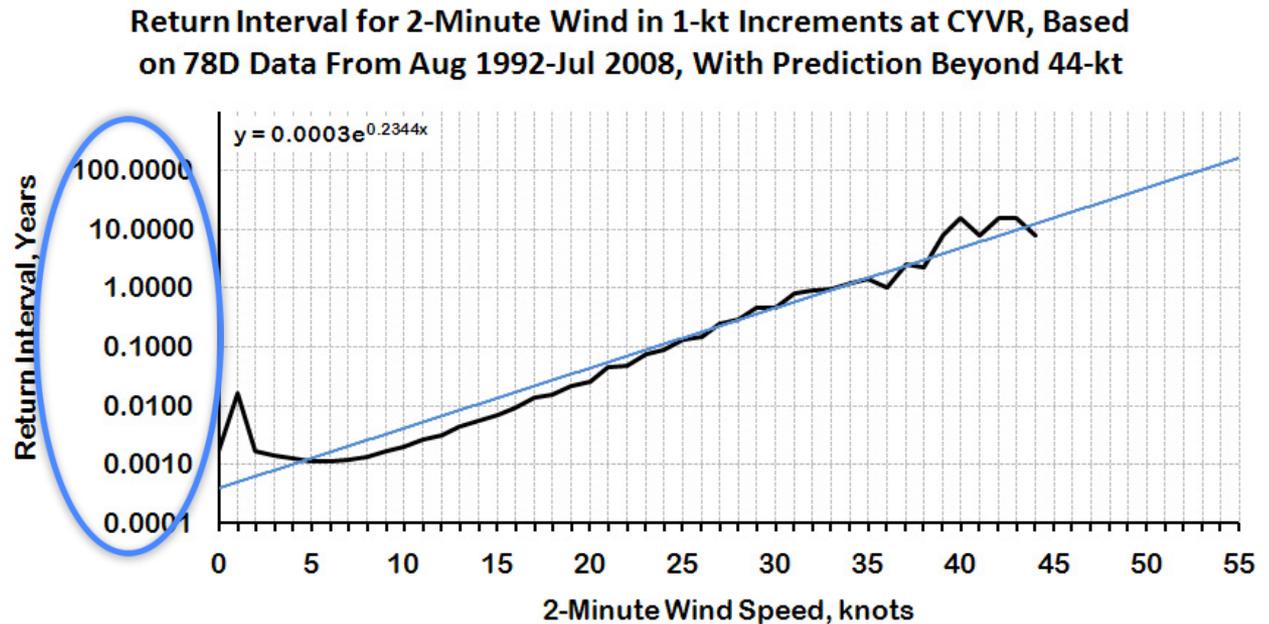
Return Interval for 2-Minute Wind in 1-kt Increments at CYVR, Based on 78D Data From Aug 1992-Jul 2008, With Prediction Beyond 44-kt



- 2-minute average wind speed is on this axis

Classic Path: Return Intervals

- There are a number of ways to compute return intervals
- Most methods utilize the wind speed record at a particular location

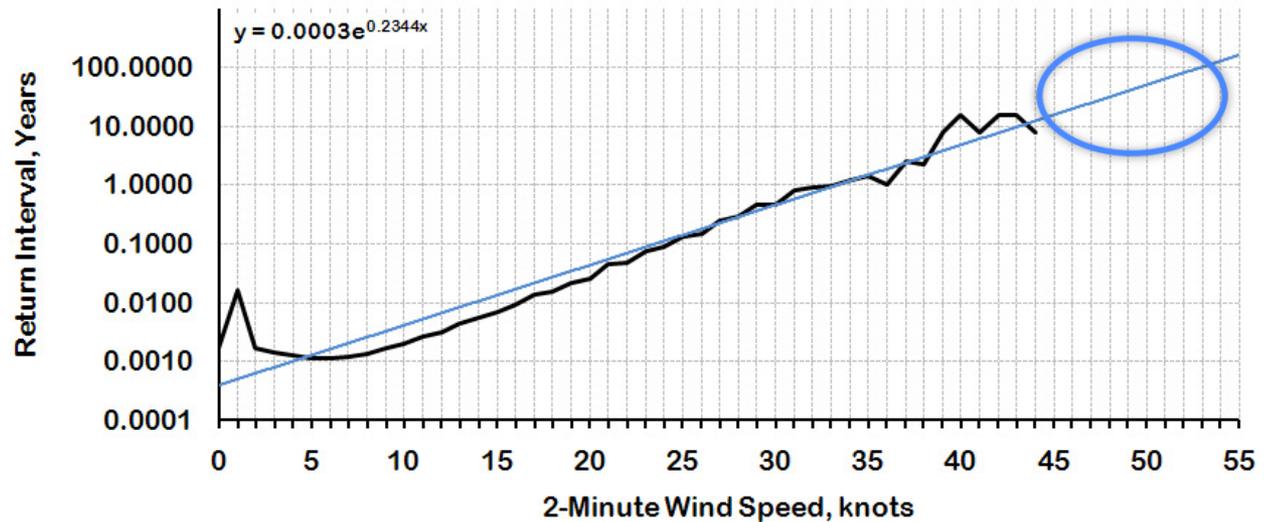


- The return interval, in years, for a particular speed is on this axis

Classic Path: Return Intervals

- There are a number of ways to compute return intervals
- Most methods utilize the wind speed record at a particular location

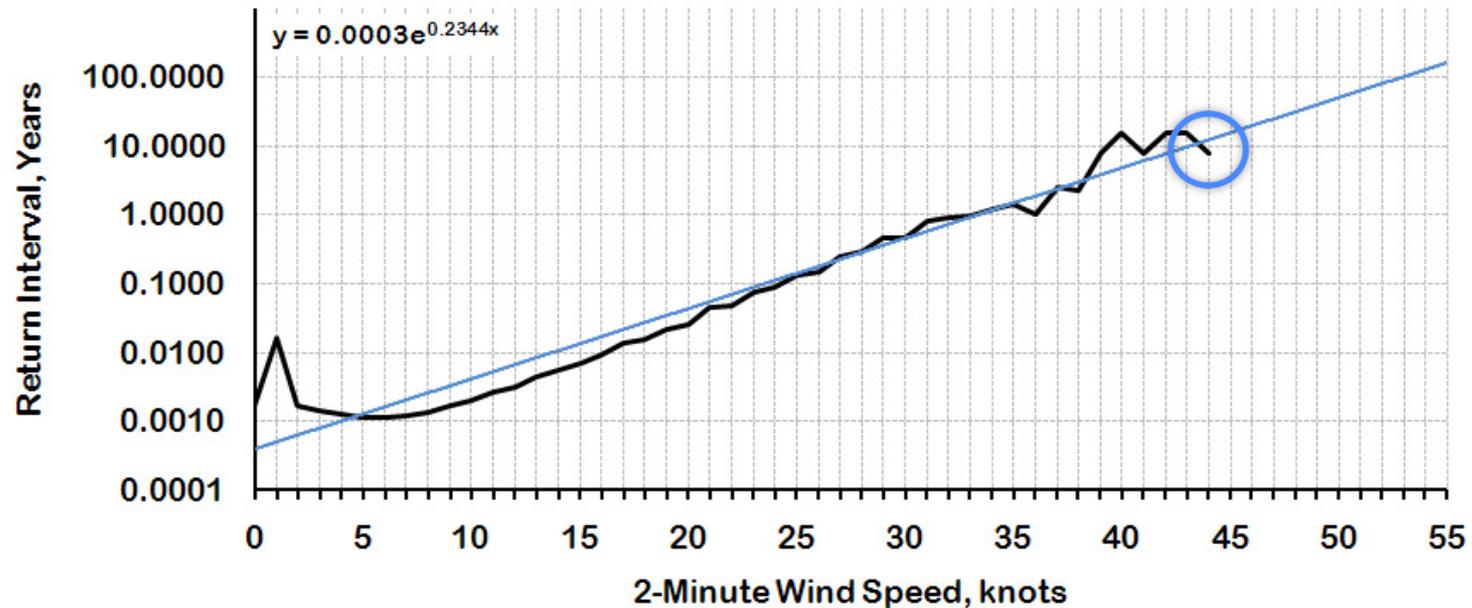
Return Interval for 2-Minute Wind in 1-kt Increments at CYVR, Based on 78D Data From Aug 1992-Jul 2008, With Prediction Beyond 44-kt



- The return interval, in years, for a particular speed is on this axis
- The prediction beyond 44 knots is a form of induction and therefore imperfect

Classic Path: Return Intervals

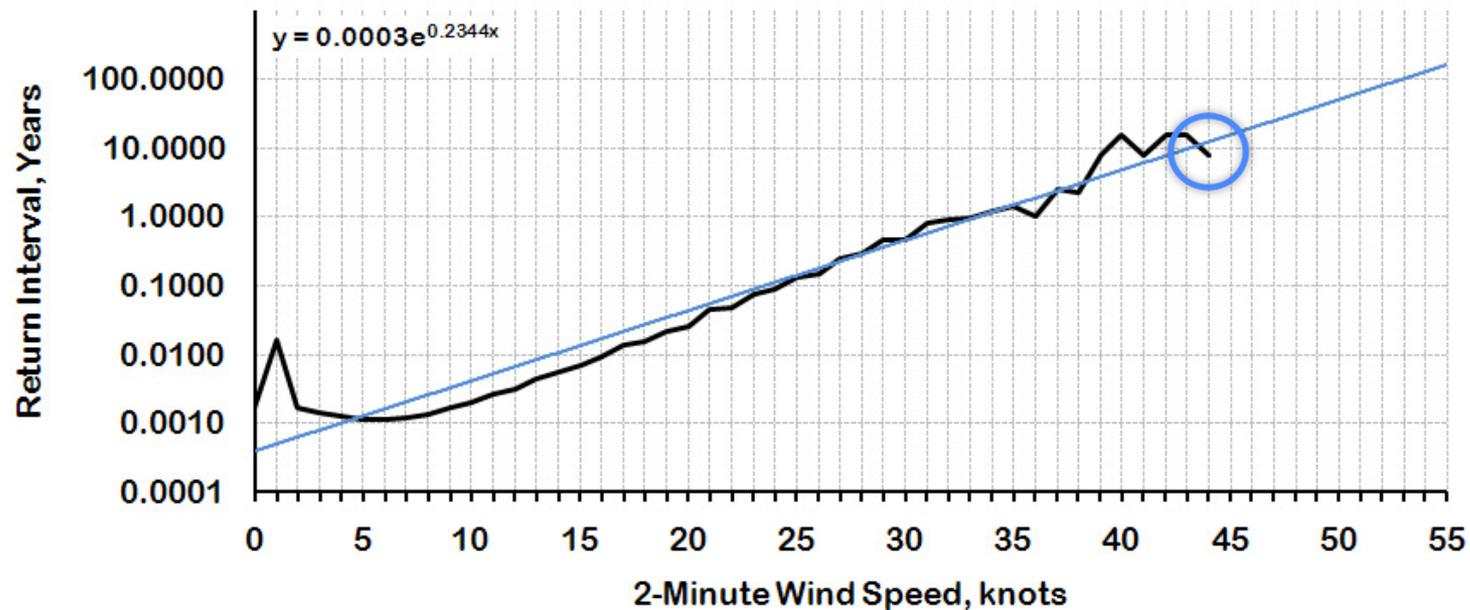
Return Interval for 2-Minute Wind in 1-kt Increments at CYVR, Based on 78D Data From Aug 1992-Jul 2008, With Prediction Beyond 44-kt



- A 45-knot (52 mph) wind can be expected about once a decade

Classic Path: Return Intervals

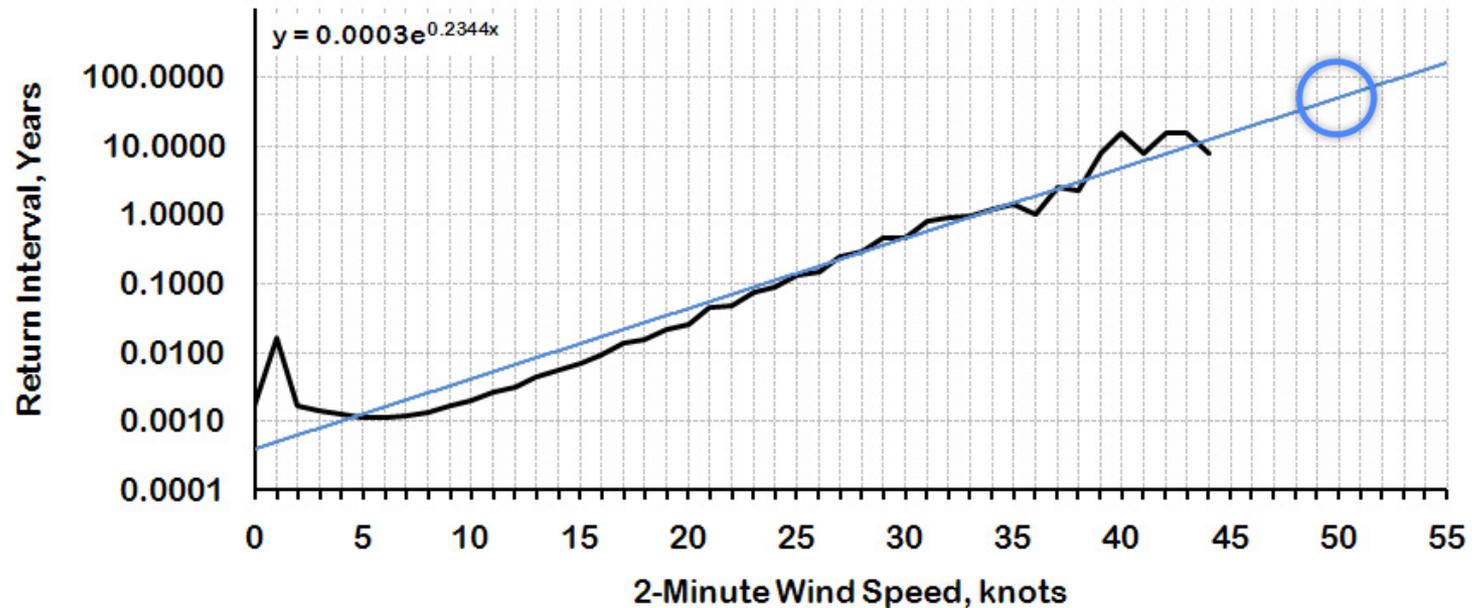
Return Interval for 2-Minute Wind in 1-kt Increments at CYVR, Based on 78D Data From Aug 1992-Jul 2008, With Prediction Beyond 44-kt



- A 45-knot (52 mph) wind can be expected about once a decade
- Gusts would be around $(45 * 1.3)$ 60 knots (~ 70 mph)

Classic Path: Return Intervals

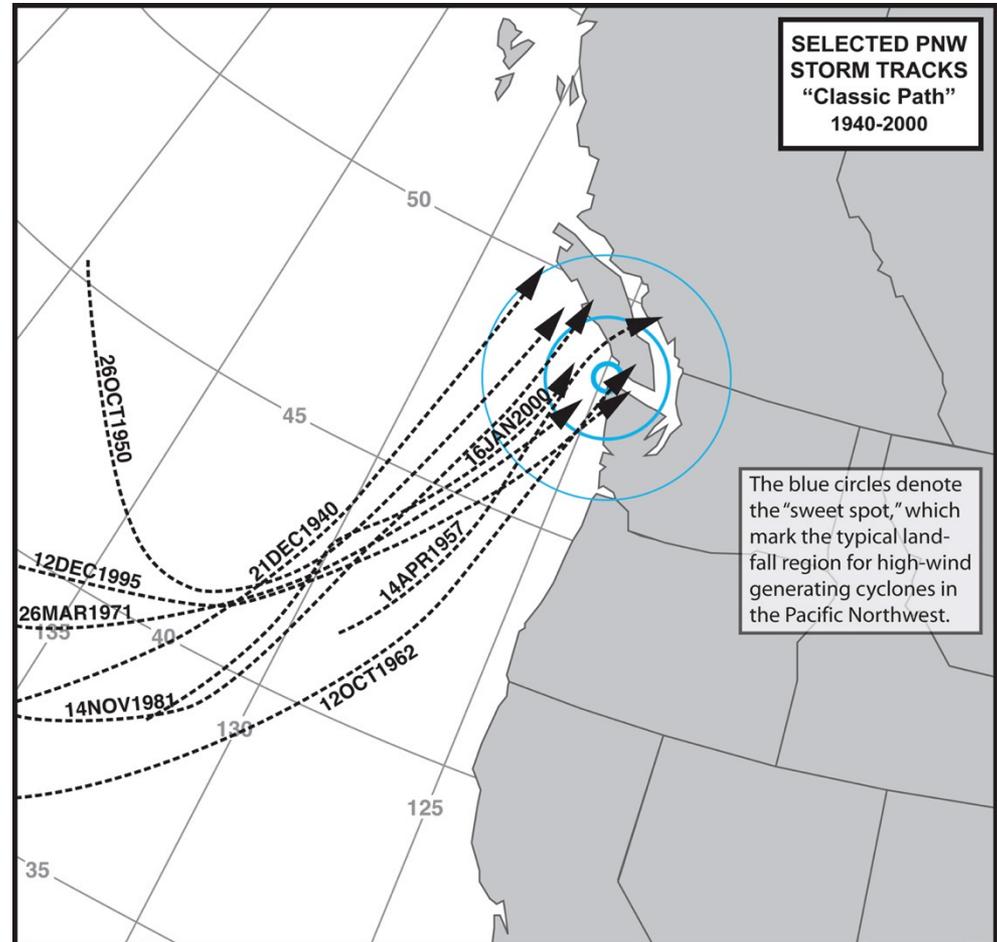
Return Interval for 2-Minute Wind in 1-kt Increments at CYVR, Based on 78D Data From Aug 1992-Jul 2008, With Prediction Beyond 44-kt



- A 50-knot (58 mph) wind can be expected about once every 40 years
- 50 knots is what occurred at CYVR during the Columbus Day Storm

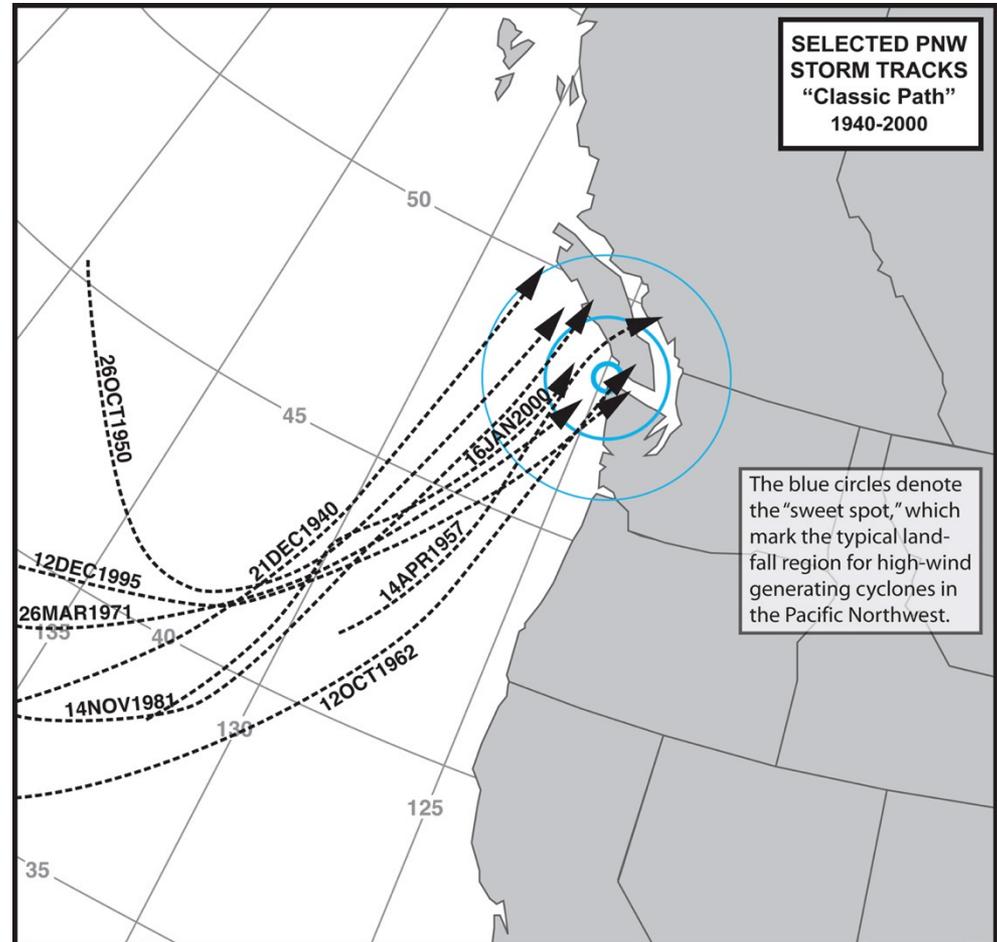
Classic Path: Return Intervals

- Another way of exploring return frequency:
 - 9 significant classic events from 1940-2000, or 61 years
 - Results in 1 significant classic event about every 7 years



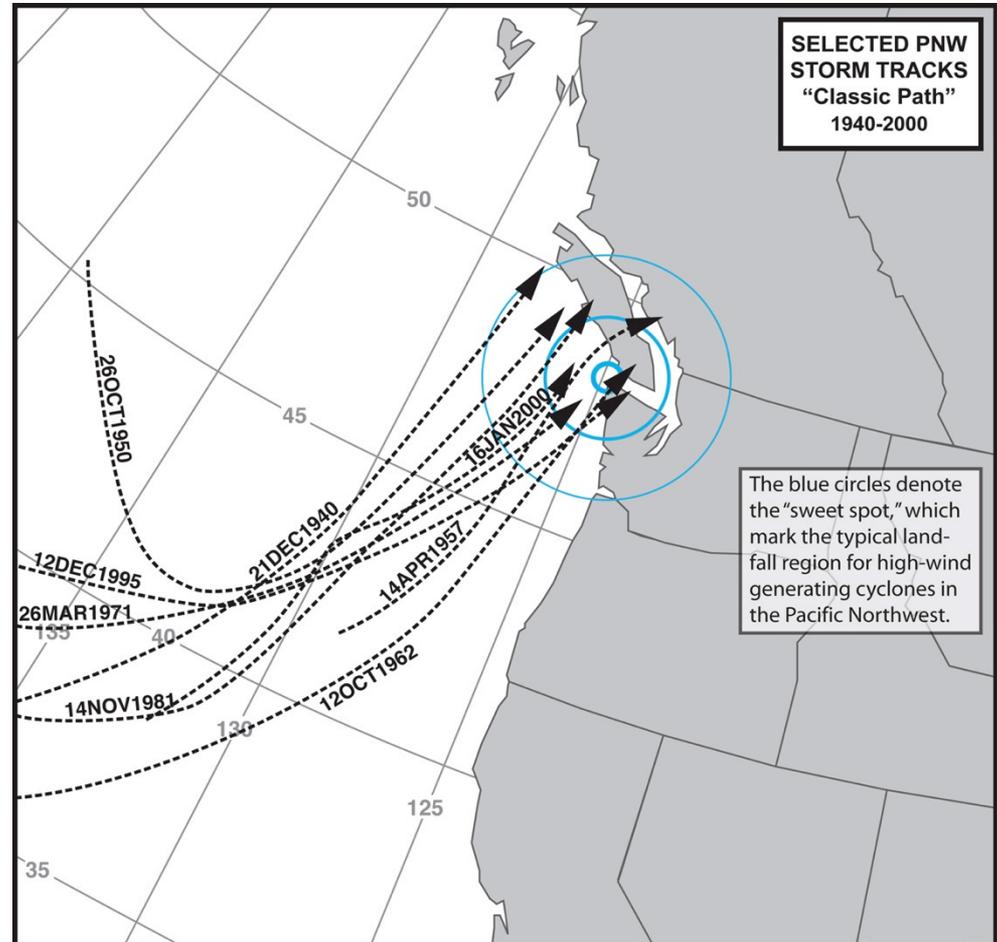
Classic Path: Return Intervals

- Another way of exploring return frequency:
 - 9 significant classic events from 1940-2000, or 61 years
 - Results in 1 significant classic event about every 7 years
 - 4 of these events were particularly strong: 1945, 1962, 1981 and 1995
 - Results in 1 strong event every 15 years



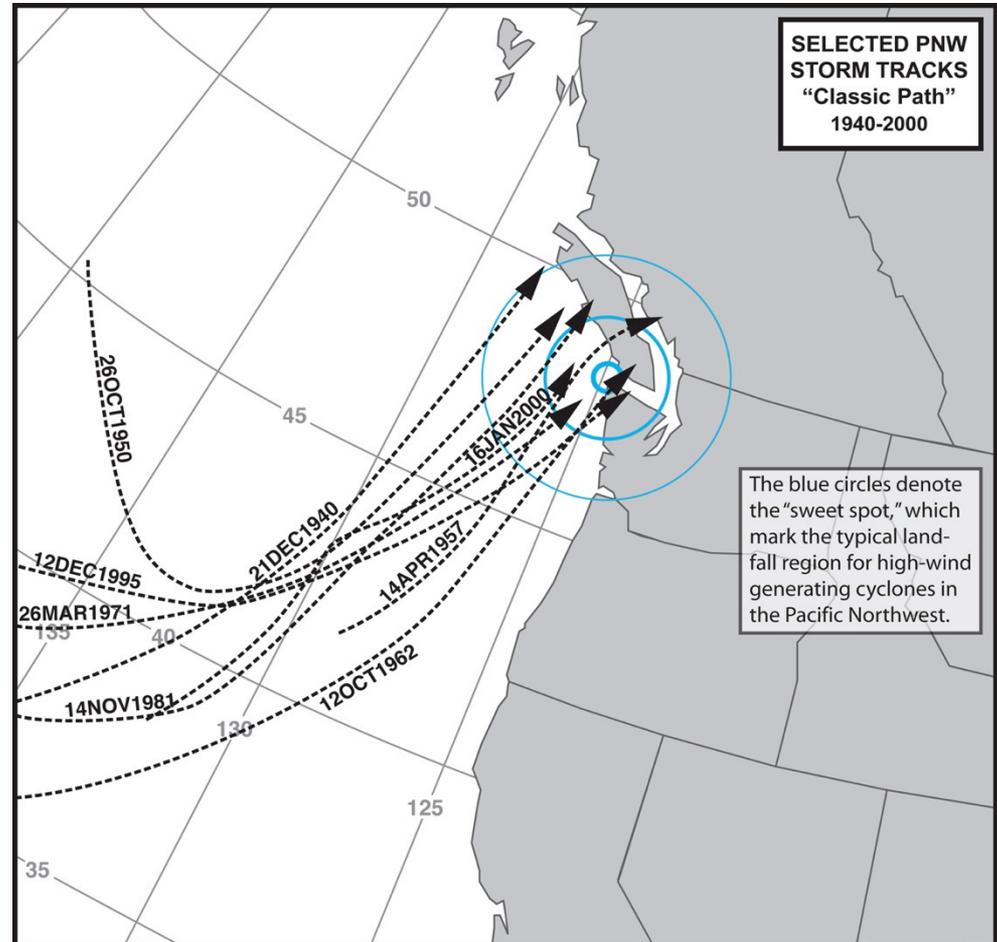
Classic Path: Return Intervals

- Another way of exploring return frequency:
 - 9 significant classic events from 1940-2000, or 61 years
 - Results in 1 significant classic event about every 7 years
 - 4 of these events were particularly strong: 1945, 1962, 1981 and 1995
 - Results in 1 strong event every 15 years
 - $2012 - 1995 = 17$ years



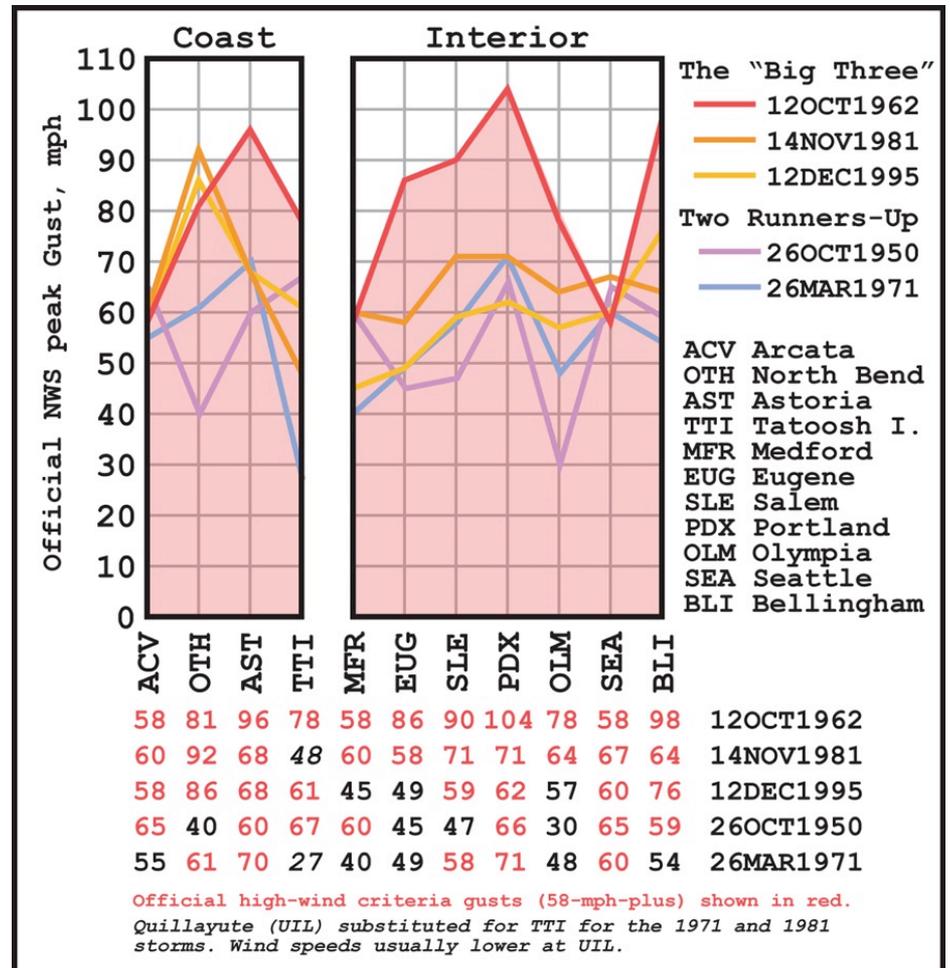
Classic Path: Return Intervals

- Another way of exploring return frequency:
 - 1 event produced widespread 80-110 mph gusts in the interior of OR and WA (the CDS)
 - Return interval could be interpreted—on very limited data—as being greater than 50 years
 - Remember the Vancouver, BC, data that suggested a 40 year return interval for CDS-magnitude winds



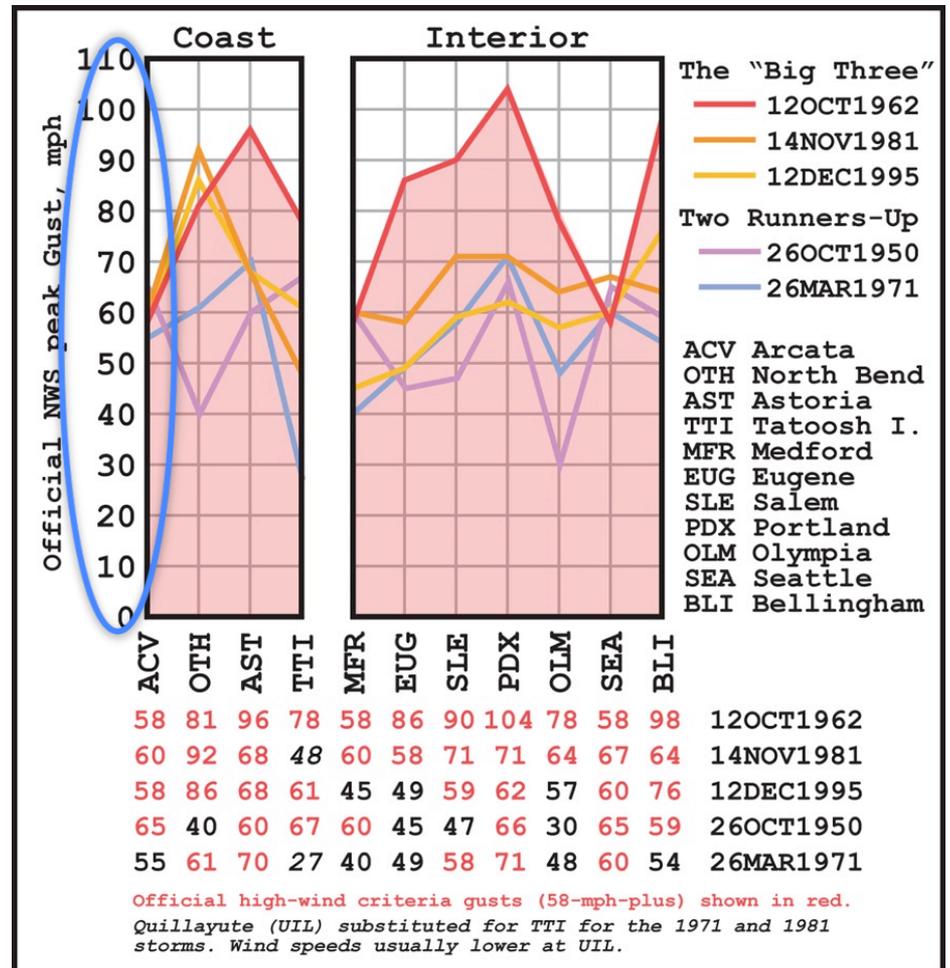
Significance of the Columbus Day Storm Peak Gust Magnitude

- Chart on the right compares the peak gusts from 5 of the 9 classic events from 1940-2000



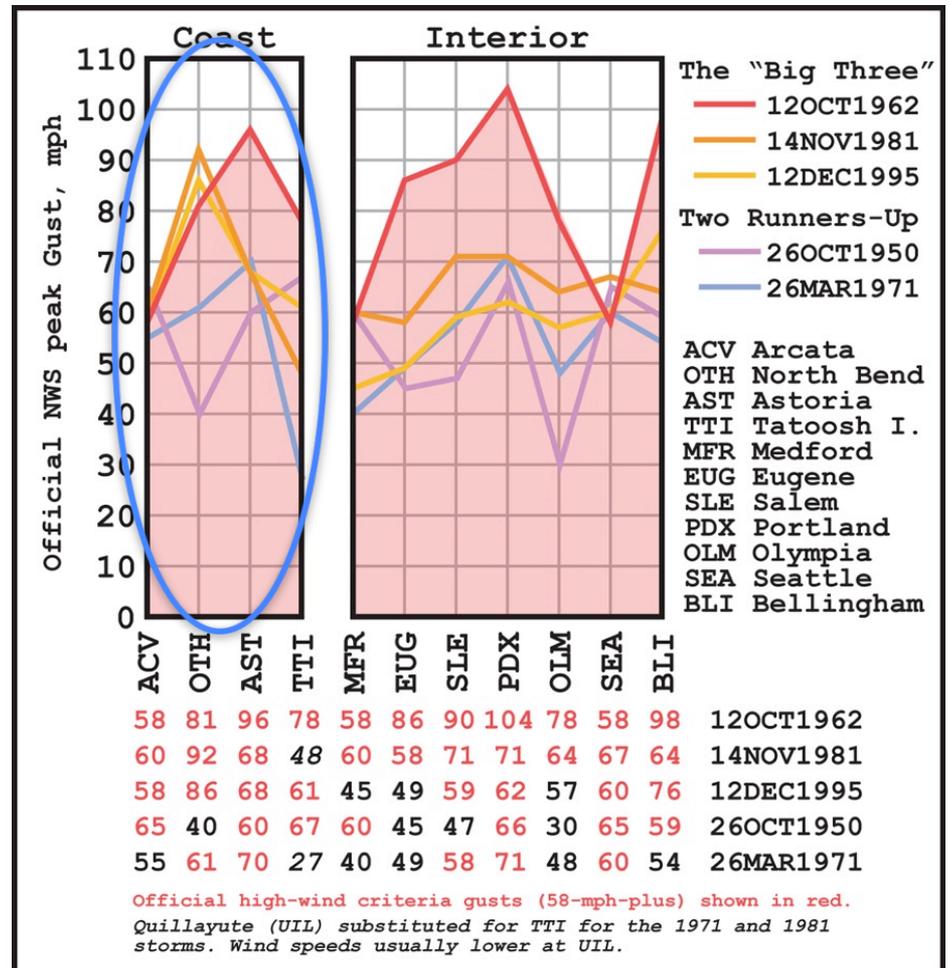
Significance of the Columbus Day Storm Peak Gust Magnitude

- Chart on the right compares the peak gusts from 5 of the 9 classic events from 1940-2000
- Peak gust speed in mph



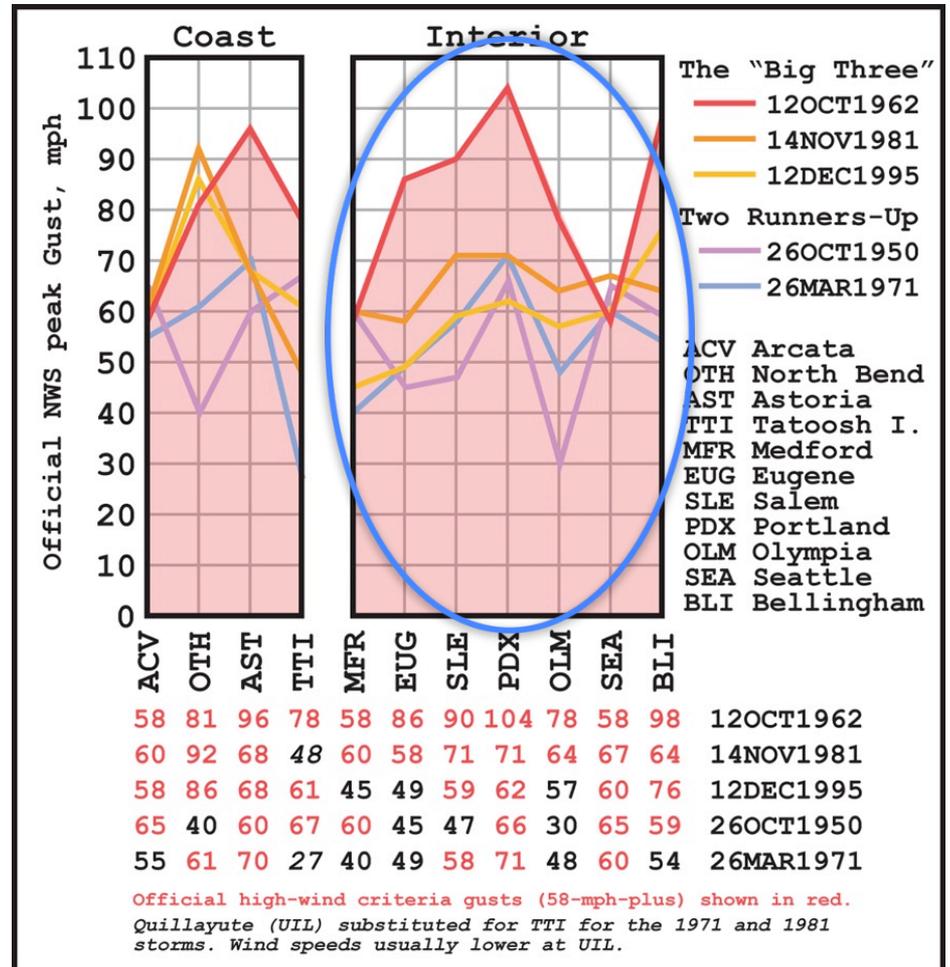
Significance of the Columbus Day Storm Peak Gust Magnitude

- Chart on the right compares the peak gusts from 5 of the 9 classic events from 1940-2000
- Peak gust speed in mph
- Coastal stations from S to N going left to right



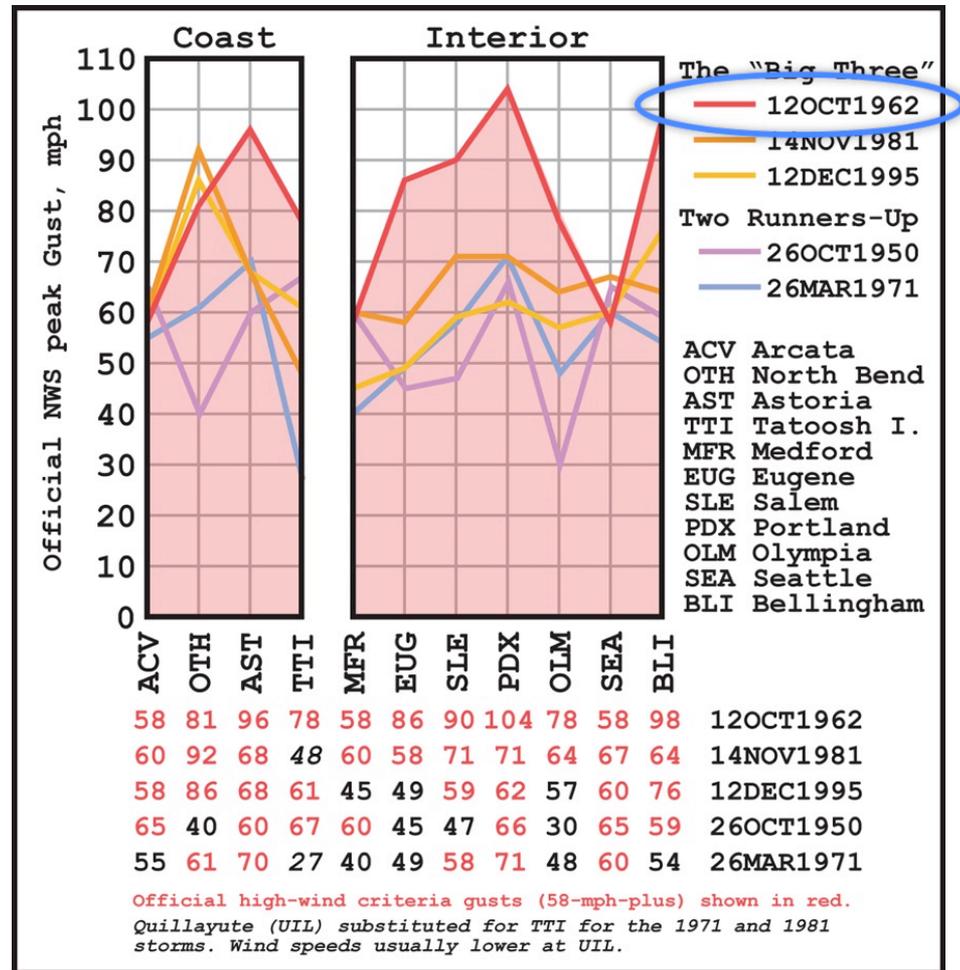
Significance of the Columbus Day Storm Peak Gust Magnitude

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- Peak gust speed in mph
- Coastal stations from S to N going left to right
- Interior stations from S to N going left to right



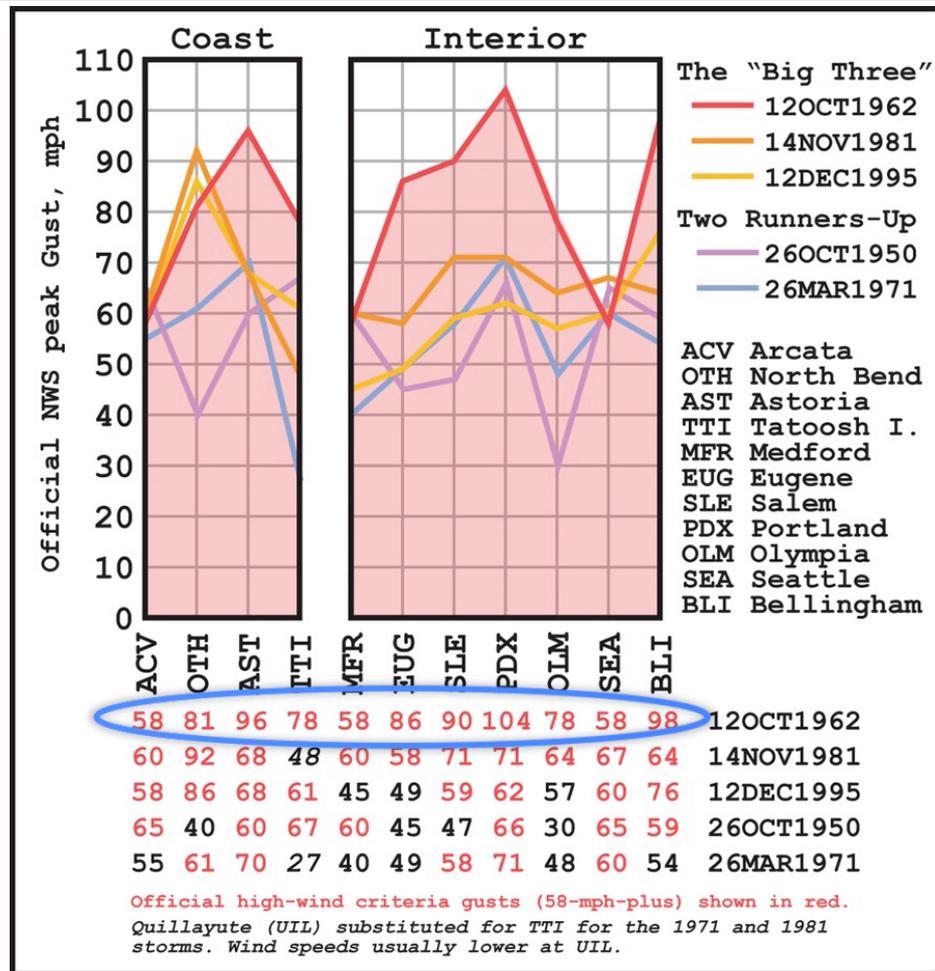
Significance of the Columbus Day Storm Peak Gust Magnitude

- Chart on the right compares the peak gusts from 5 of the 9 classic events from 1940-2000
- Peak gust speed in mph
- Coastal stations from S to N going left to right
- Interior stations from S to N going left to right
- Red line is the CDS



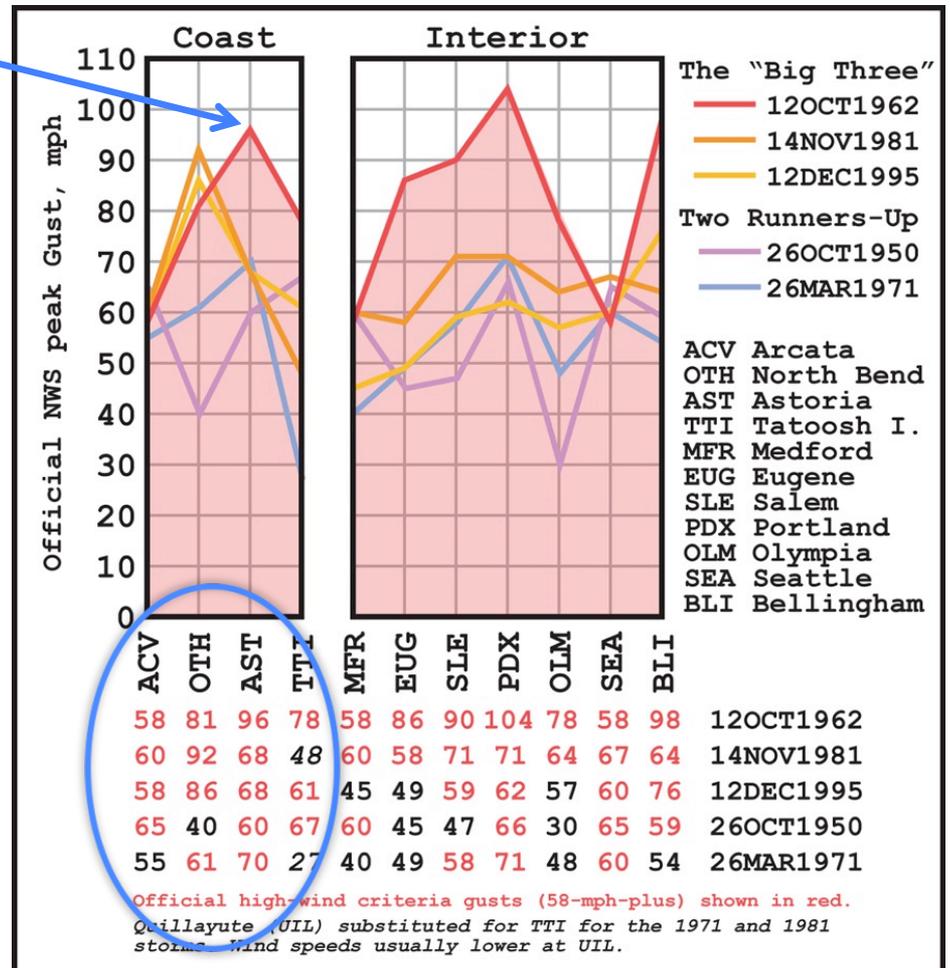
Significance of the Columbus Day Storm Peak Gust Magnitude

- The CDS is the only storm event to generate high-wind criteria gusts (50 knots, or 58 mph) at every one of these stations
- 14 Nov 1981 came close!



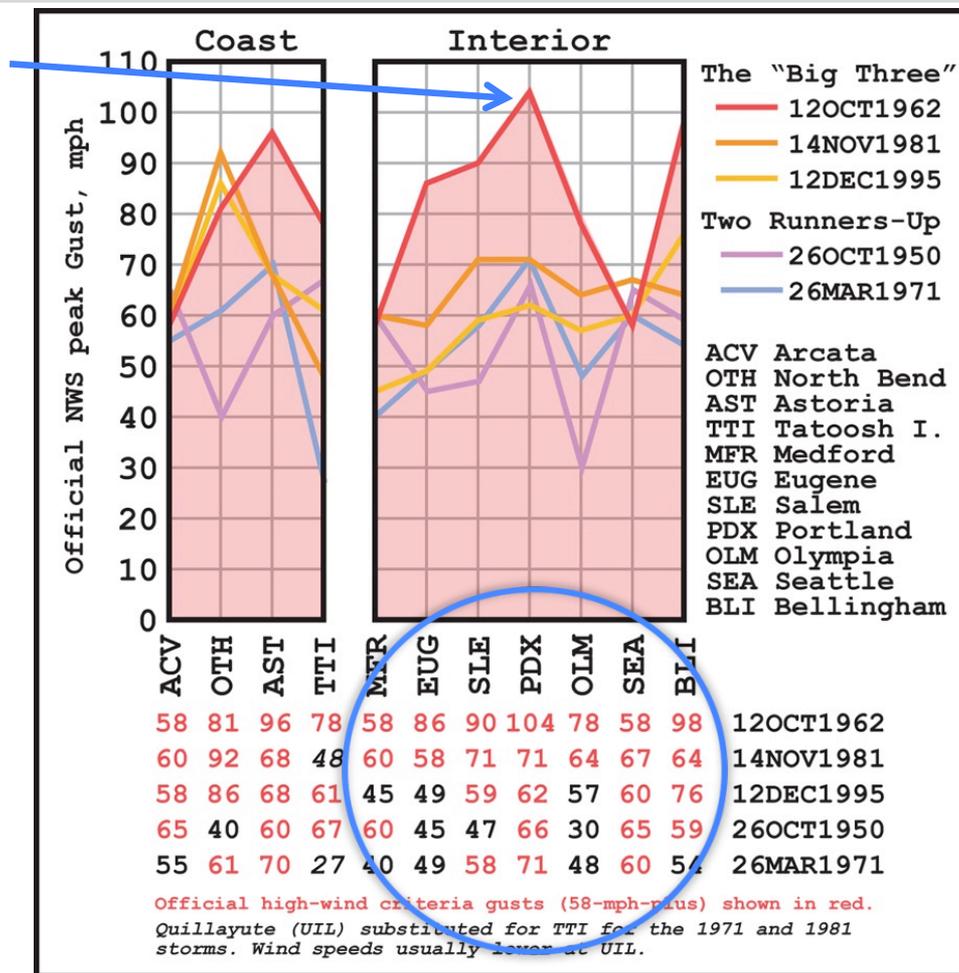
Significance of the Columbus Day Storm Peak Gust Magnitude

- Relative to the other storms, CDS coastal wind speeds were quite strong in areas, but not strikingly so, at long-term official stations
- Nov 1981 and Dec 1995 produced faster speeds at North Bend, OR



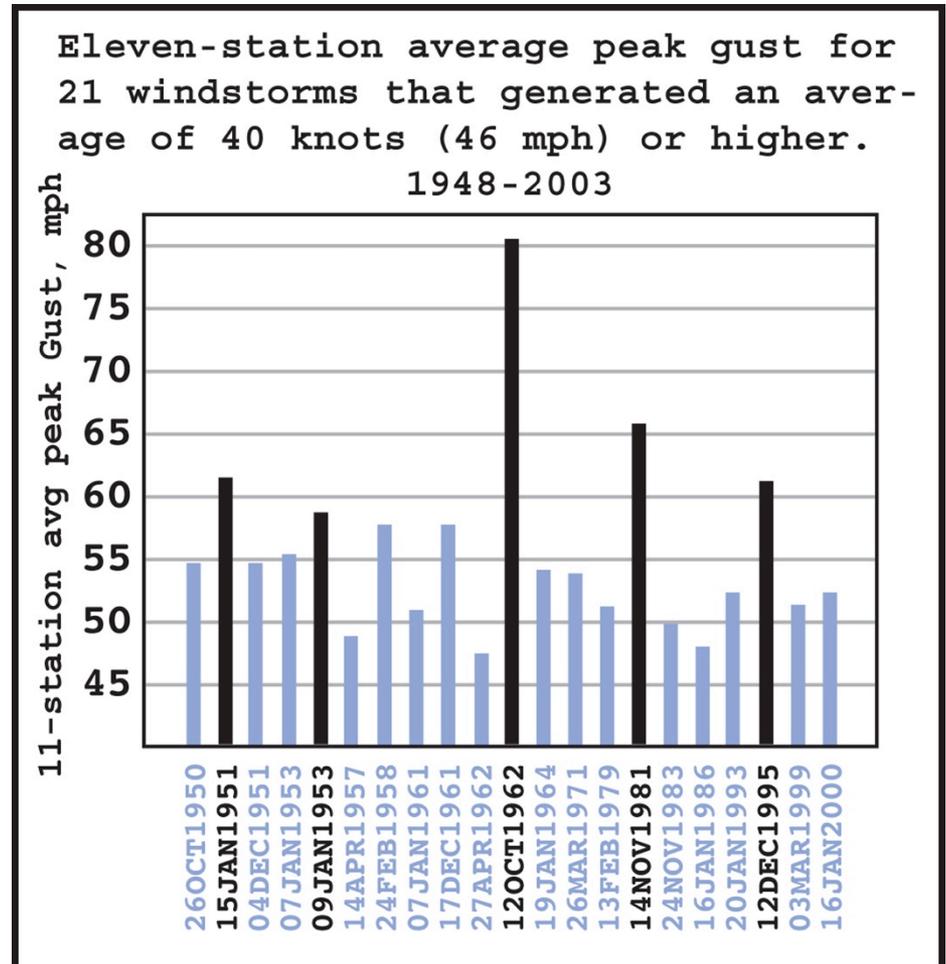
Significance of the Columbus Day Storm Peak Gust Magnitude

- Interior wind speeds for the CDS, however, were nearly off-scale relative to the other storms
- As noted earlier, CDS interior wind speeds matched and exceeded coastal wind speeds measured during Nov 1981 and Dec 1995, marking a truly unusual situation



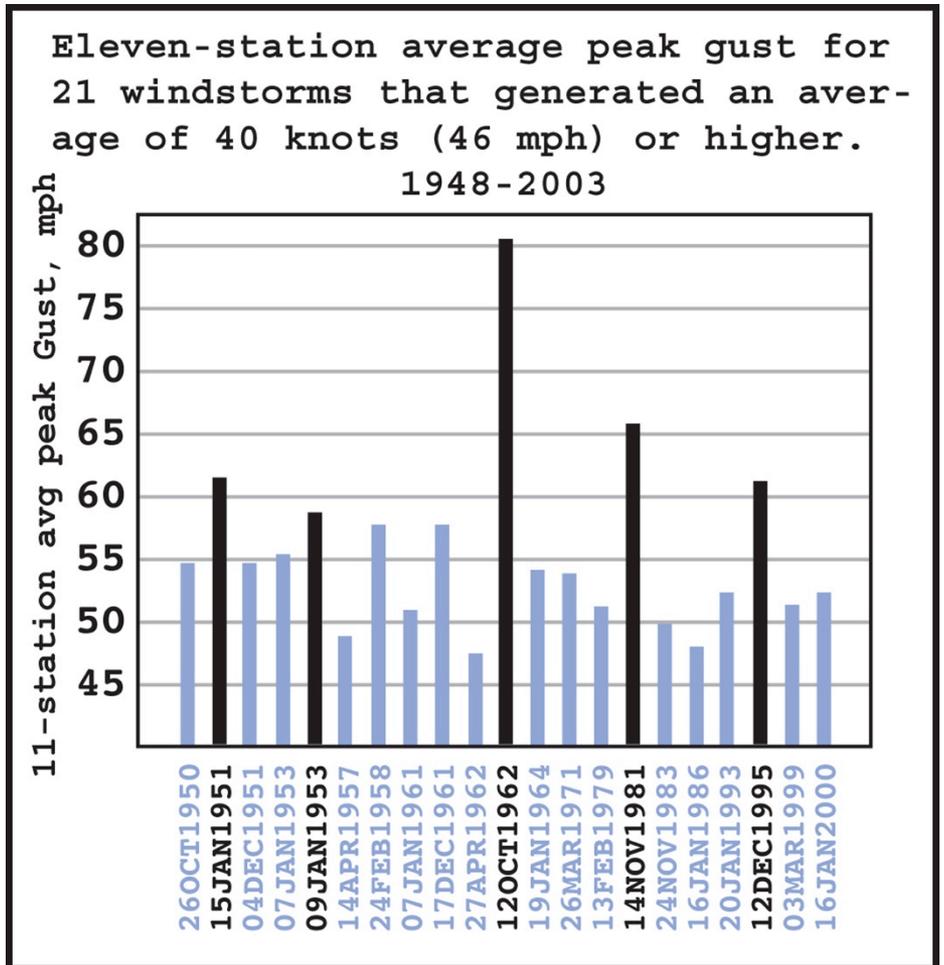
Significance of the Columbus Day Storm Peak Gust Magnitude

- Graph on left shows an average of the peak gusts from the same 11 stations used in the previous analysis
- Incorporates all windstorm events—*regardless of track type*—that produced a ≥ 40 -knot (46 mph) average peak gust from 1948-2003



Significance of the Columbus Day Storm Peak Gust Magnitude

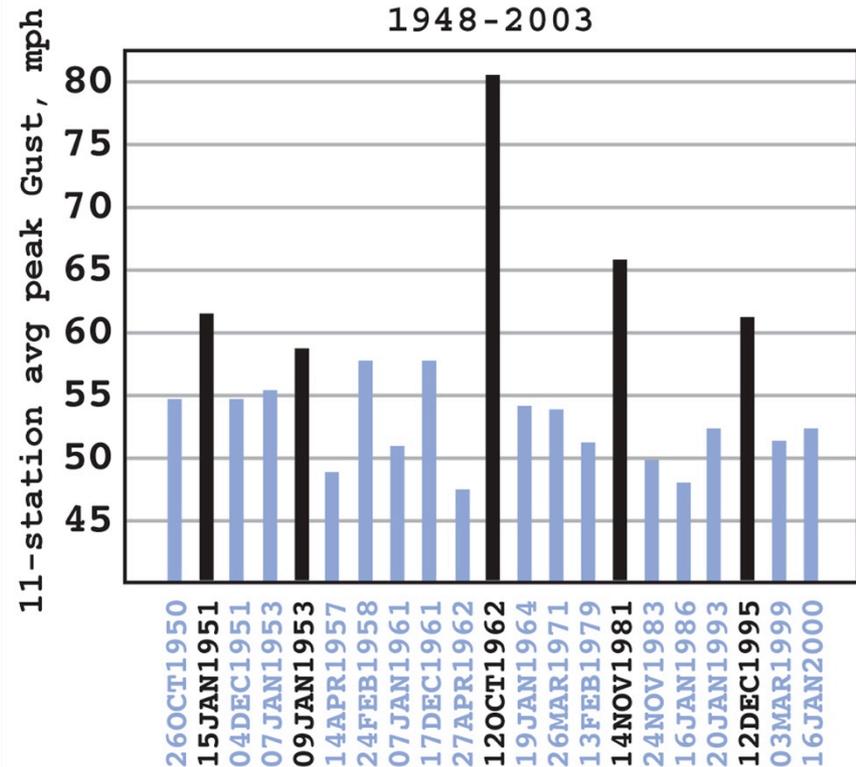
- Can you find the Columbus Day Storm?



Significance of the Columbus Day Storm Peak Gust Magnitude

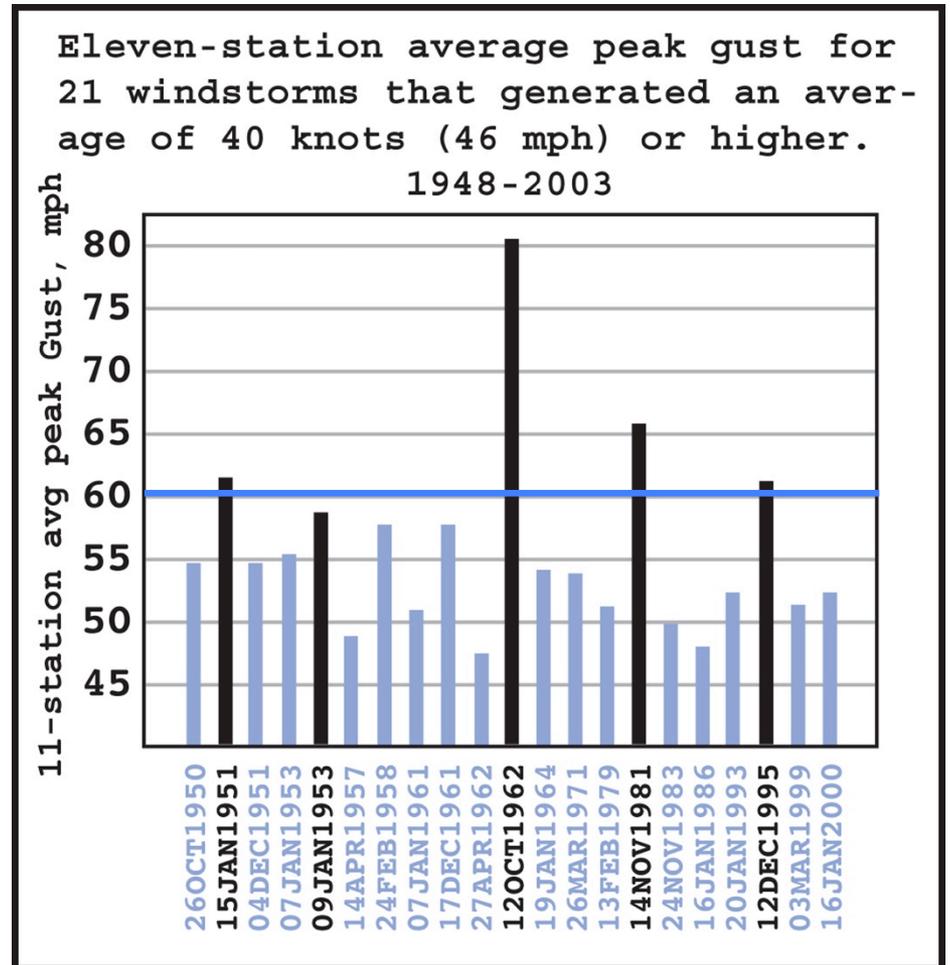
- Can you find the Columbus Day Storm?
- Are there any events that are even close to the CDS in average peak gust magnitude?

Eleven-station average peak gust for 21 windstorms that generated an average of 40 knots (46 mph) or higher. 1948-2003



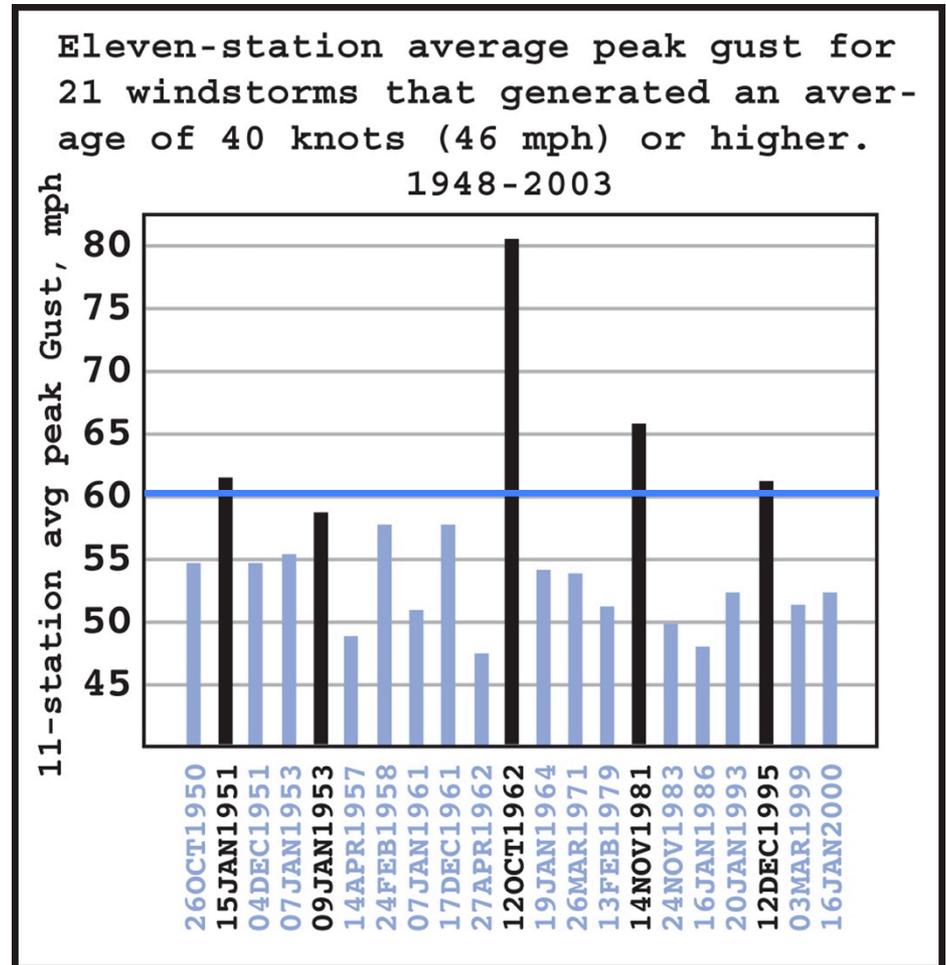
Significance of the Columbus Day Storm Peak Gust Magnitude

- Can you find the Columbus Day Storm?
- Are there any events that are even close to the CDS in average peak gust magnitude?
- Most of the these storms have an average peak gust below 60 mph

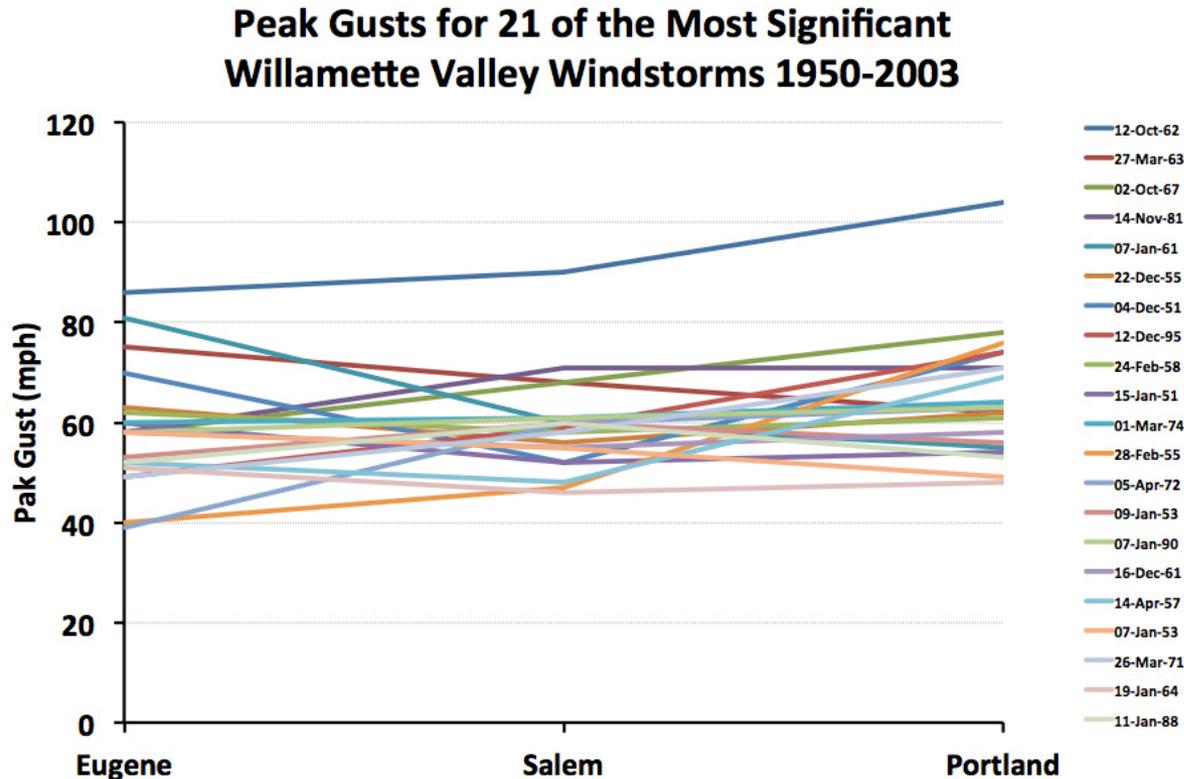


Significance of the Columbus Day Storm Peak Gust Magnitude

- Can you find the Columbus Day Storm?
- Are there any events that are even close to the CDS in average peak gust magnitude?
- Most of the these storms have an average peak gust below 60 mph
- The CDS produced about 2-times the wind-force of the more typical events

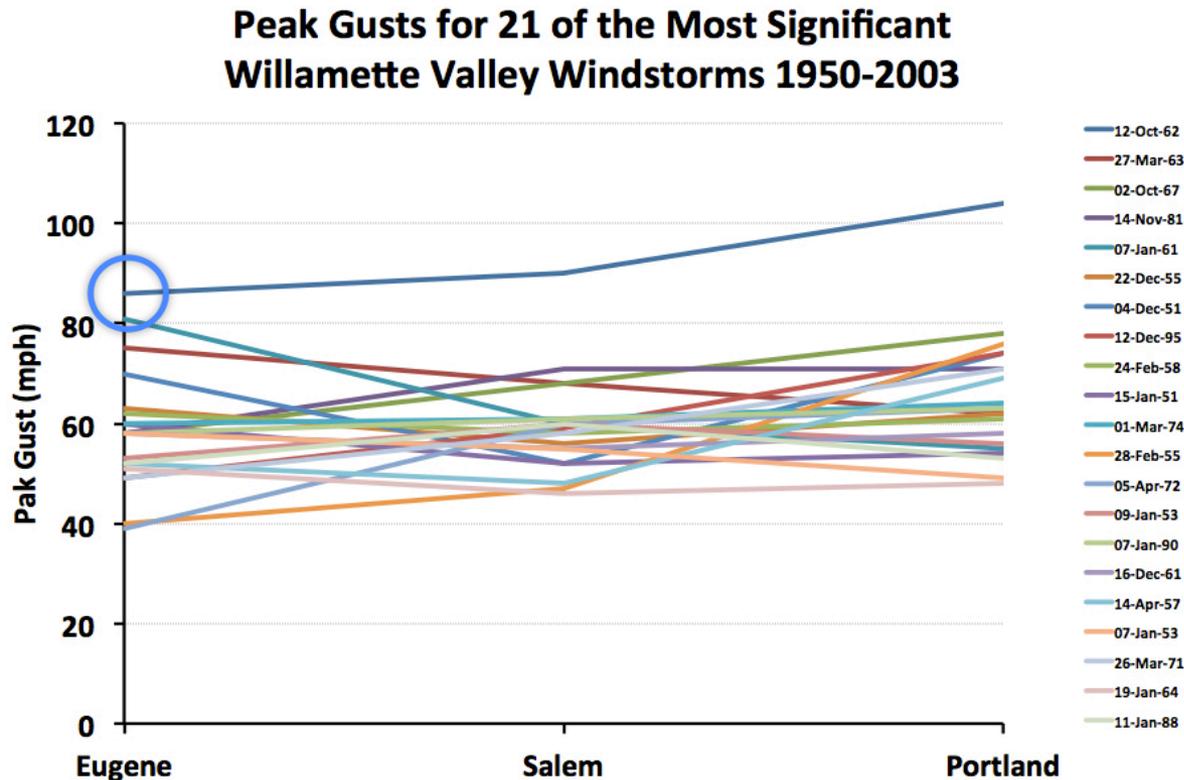


Significance of the Columbus Day Storm Peak Gust Magnitude



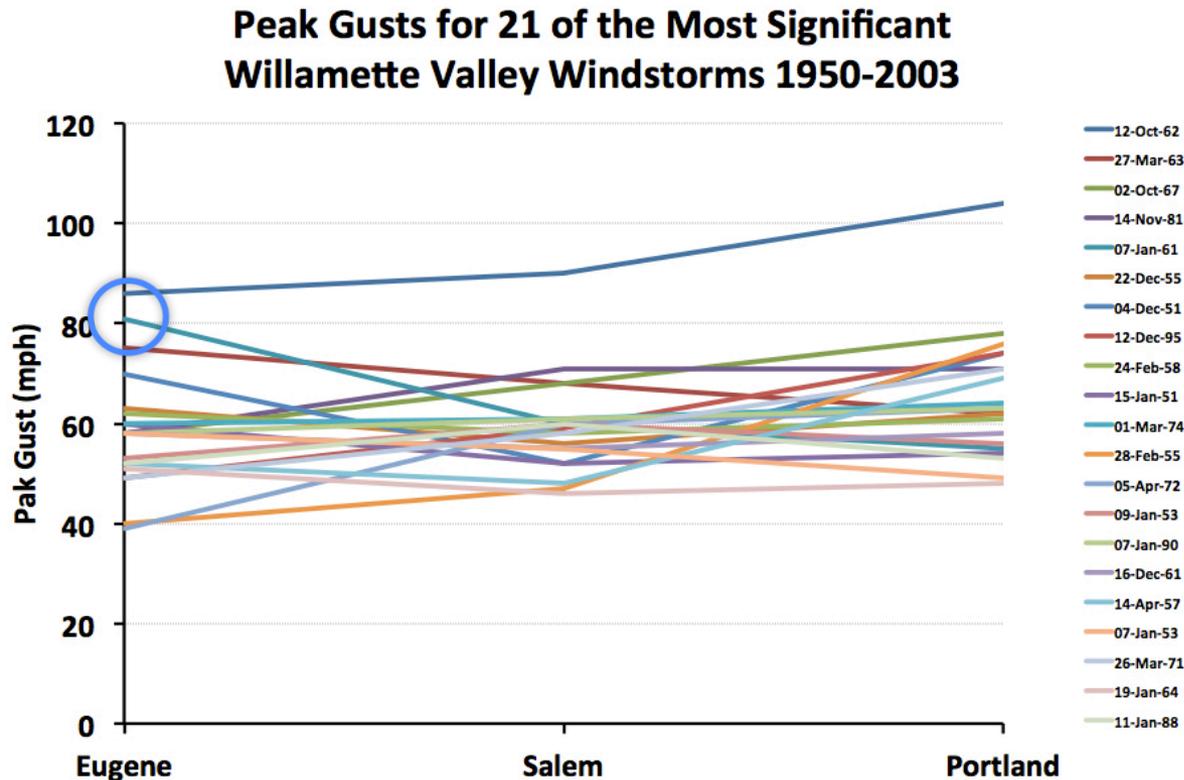
- One more way of looking at this: Peak gust response for 21 of the most significant windstorms in the Willamette Valley

Significance of the Columbus Day Storm Peak Gust Magnitude



- During the Columbus Day Storm, Eugene reported a peak gust of 86 mph, the lowest for any official station in the Valley

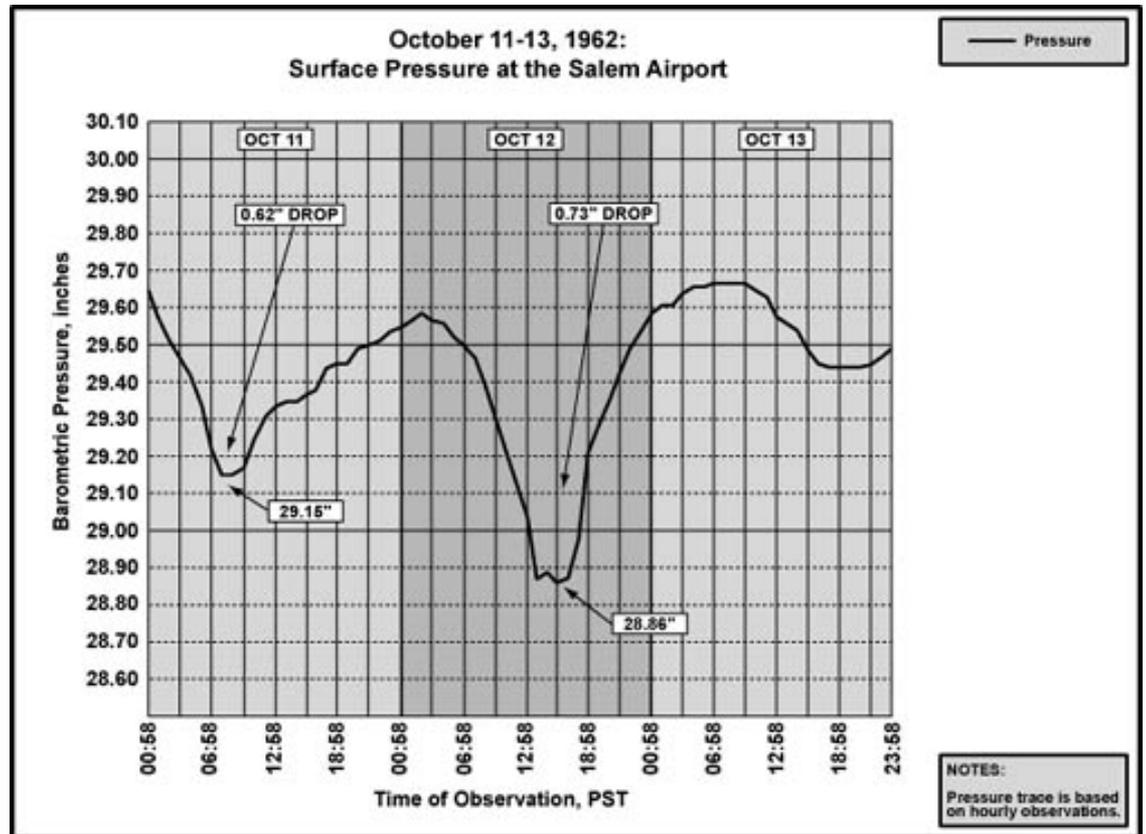
Significance of the Columbus Day Storm Peak Gust Magnitude



- The 86 mph *low* is *higher* than the highest Willamette Valley gust from any other windstorm (81 mph at Eugene 07 Jan 1961)

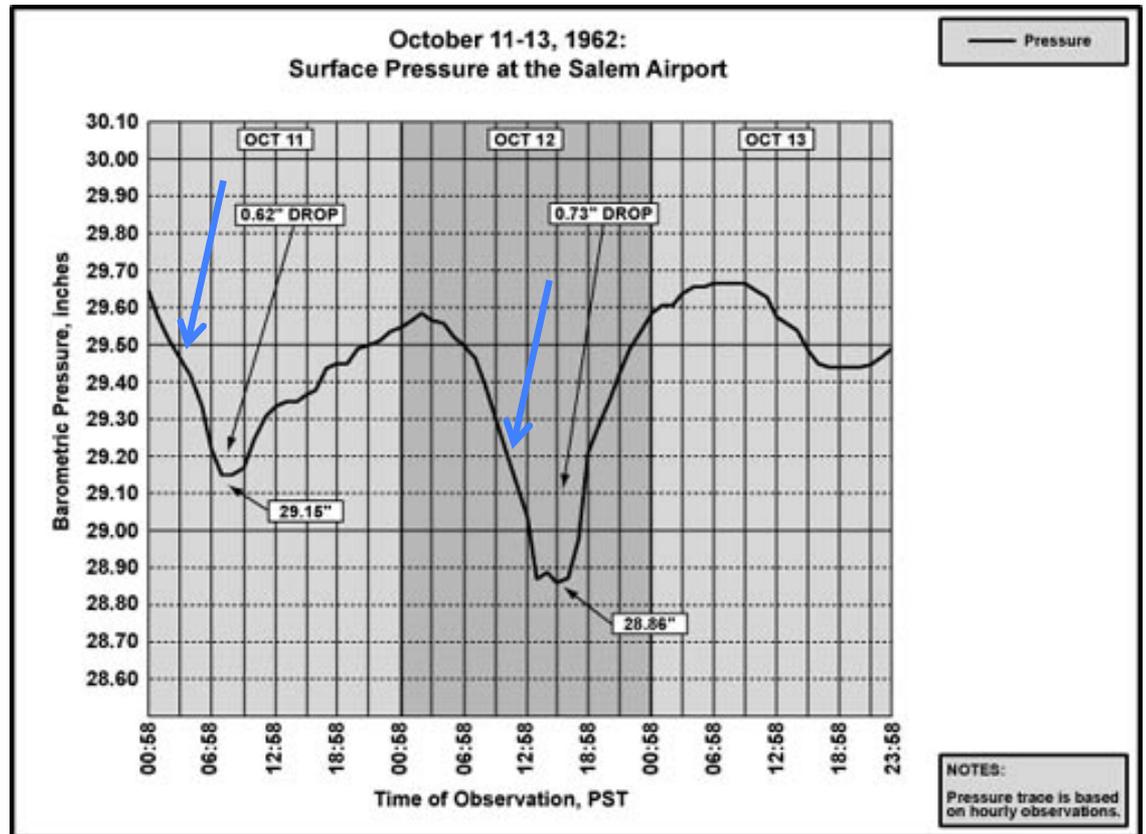
Pressure Tendencies: An Explanation for the Extraordinary CDS Winds

- Pressure tendency is (in part) the rate at which the pressure changes over a fixed unit of time



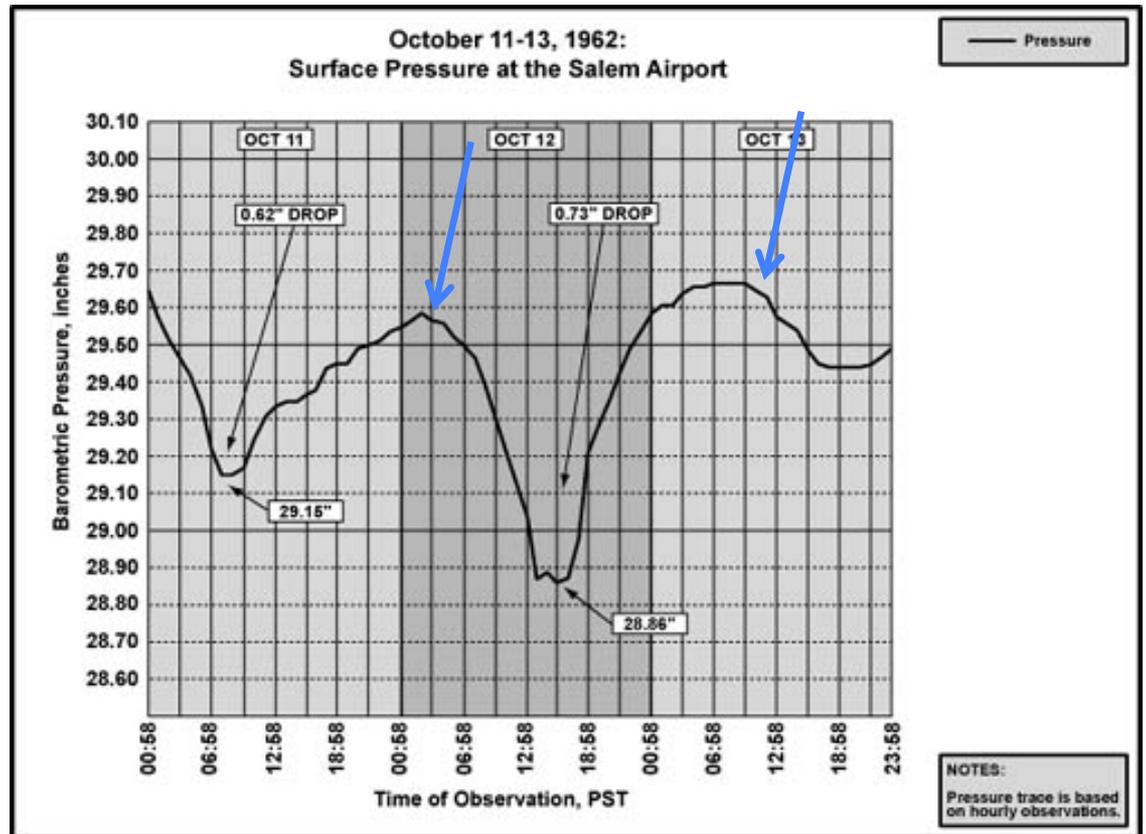
Pressure Tendencies: An Explanation for the Extraordinary CDS Winds

- Pressure tendency is (in part) the rate at which the pressure changes over a fixed unit of time
- Fast pressure drops



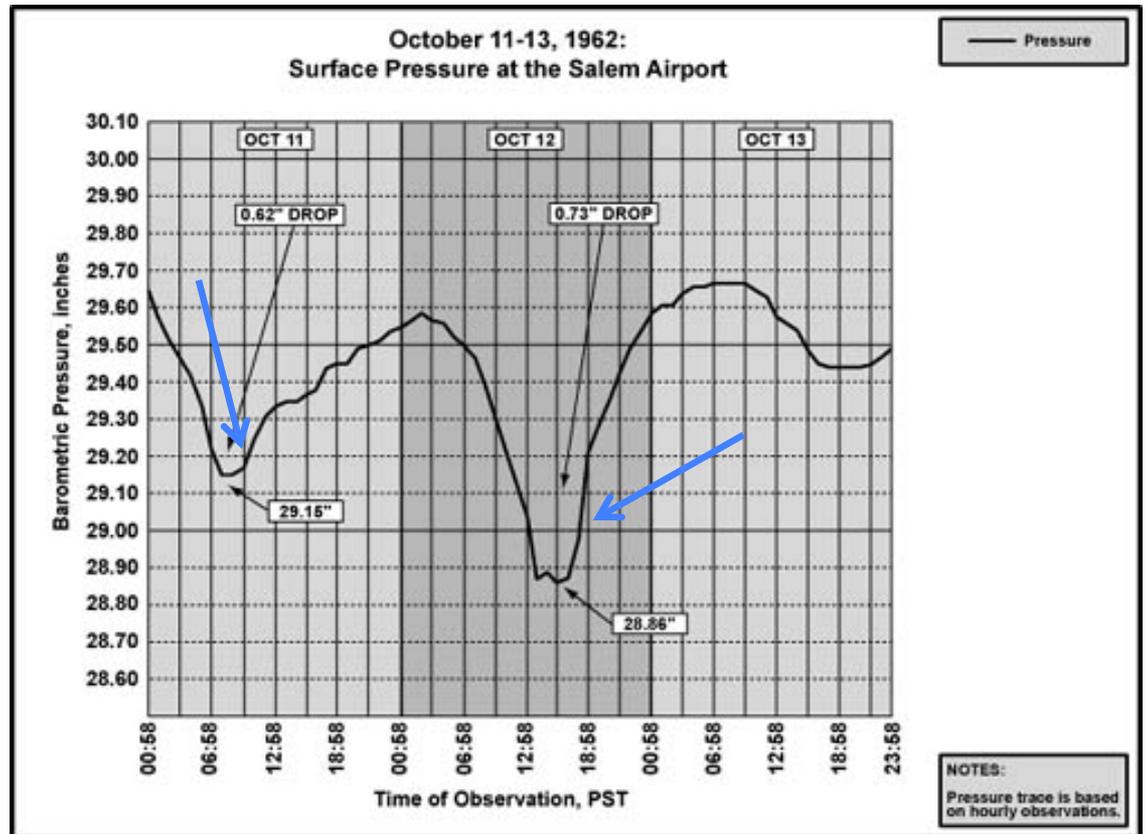
Pressure Tendencies: An Explanation for the Extraordinary CDS Winds

- Pressure tendency is (in part) the rate at which the pressure changes over a fixed unit of time
- Slow pressure drops



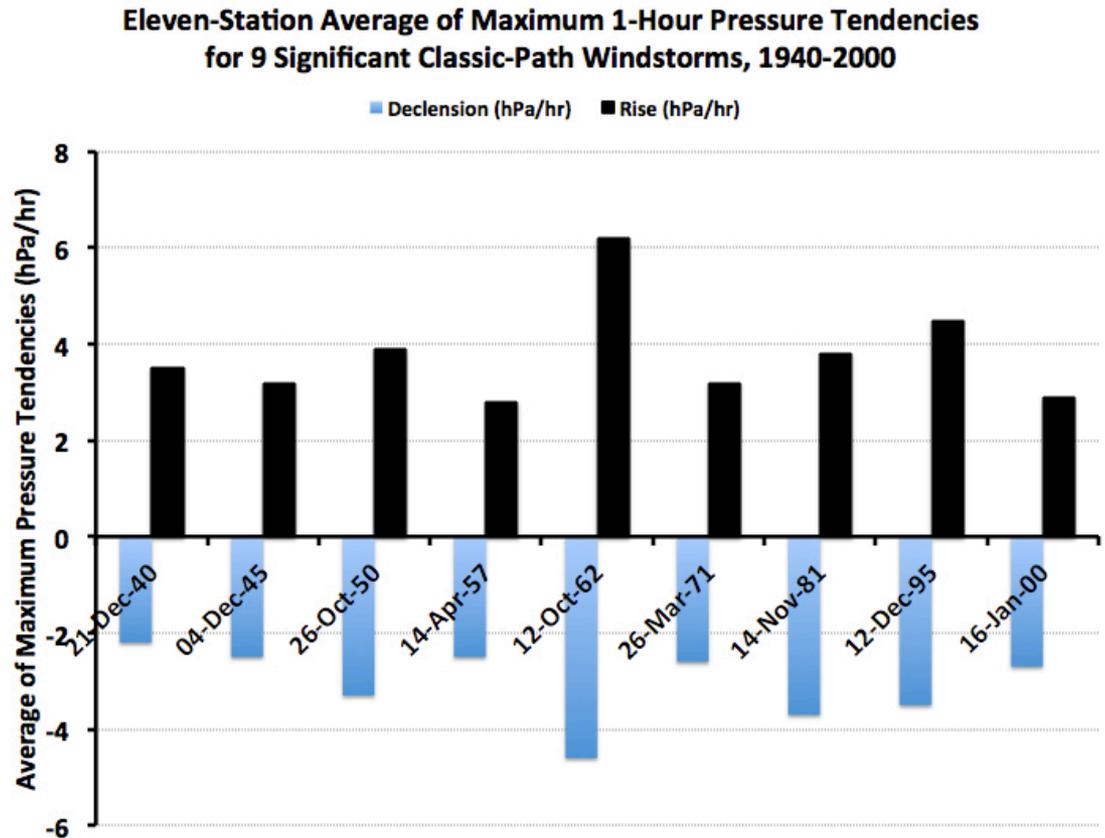
Pressure Tendencies: An Explanation for the Extraordinary CDS Winds

- Pressure tendency is (in part) the rate at which the pressure changes over a fixed unit of time
- Fast pressure rises



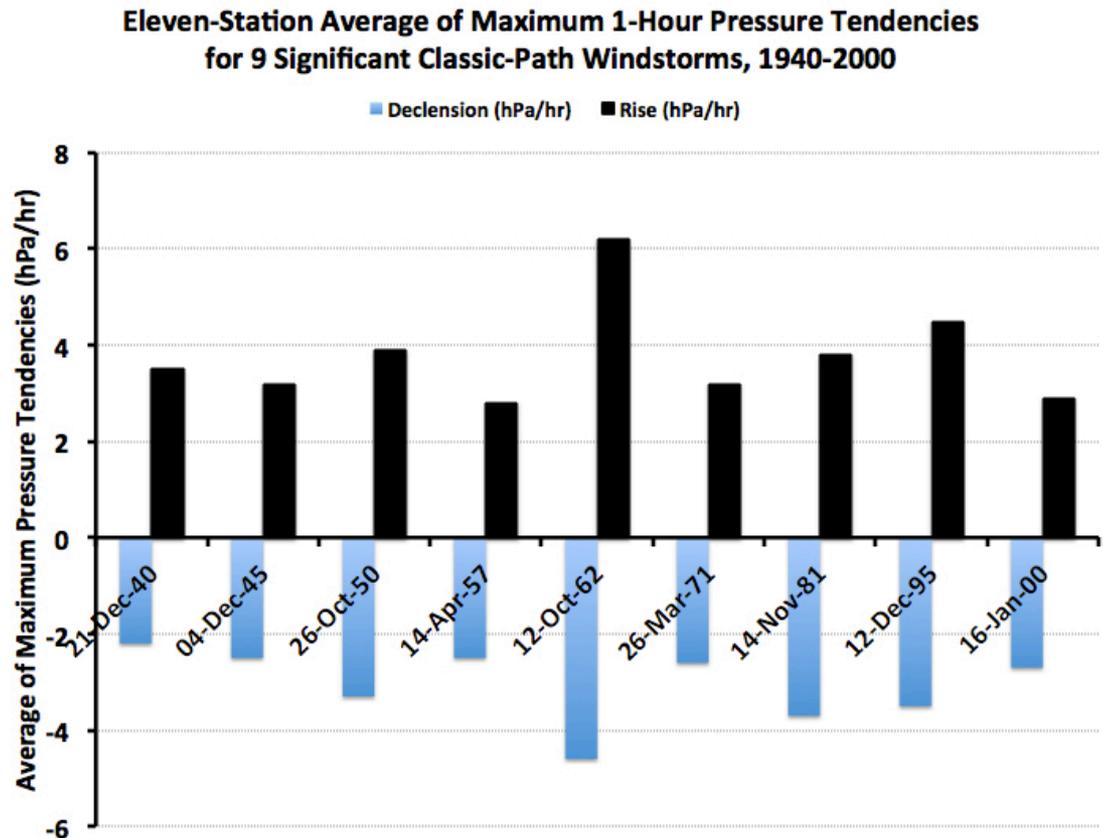
Pressure Tendencies: An Explanation for the Extraordinary CDS Winds

- The chart to the right depicts an 11-station average of maximum 1-hour pressure change for the 9 classic-path storms 1940-2000
- 1 hPa = 1 mb



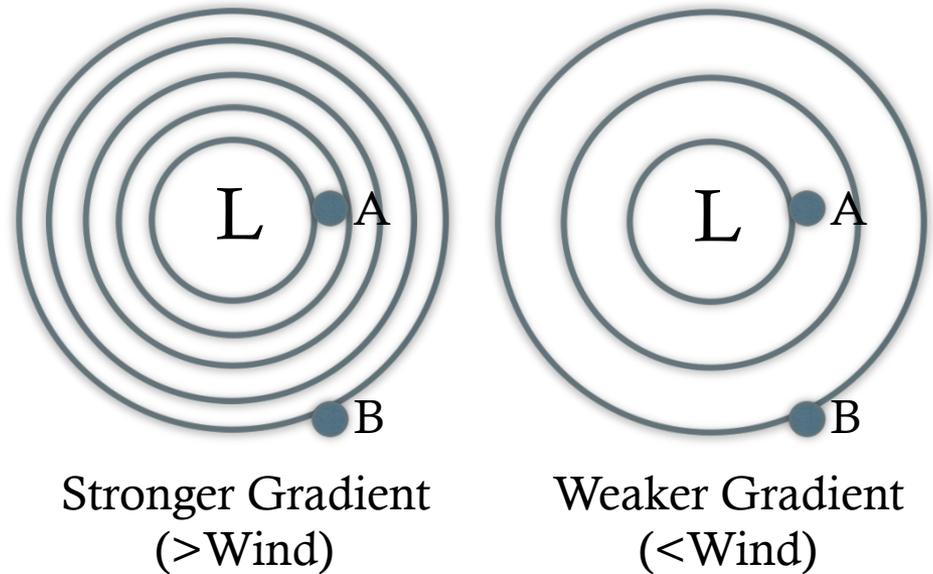
Pressure Tendencies: An Explanation for the Extraordinary CDS Winds

- The bars indicate the average of the maximum hourly pressure changes at 11 key stations



Pressure Tendencies: An Explanation for the Extraordinary CDS Winds

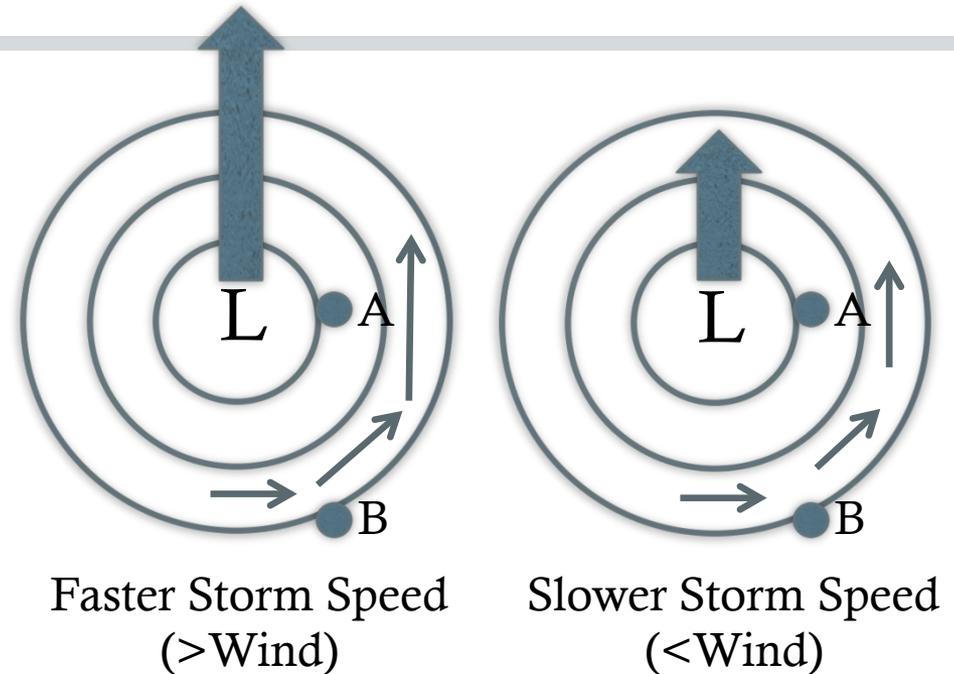
- Pressure tendencies integrate at least three variables:
 - 1) Pressure gradient: If two storms are moving at the same speed, the one with the stronger gradient is likely to produce faster pressure changes as a fixed point
 - Higher pressure gradients tend to result in higher wind speeds



Locations A & B are fixed points (e.g. weather stations)

Pressure Tendencies: An Explanation for the Extraordinary CDS Winds

- Pressure tendencies integrate at least three variables:
 - 2) Speed of storm motion
 - Given a similar pressure gradient, the faster the forward speed, the greater the potential wind speeds on the right side (or base if wind flow is ageostrophic) of the storm

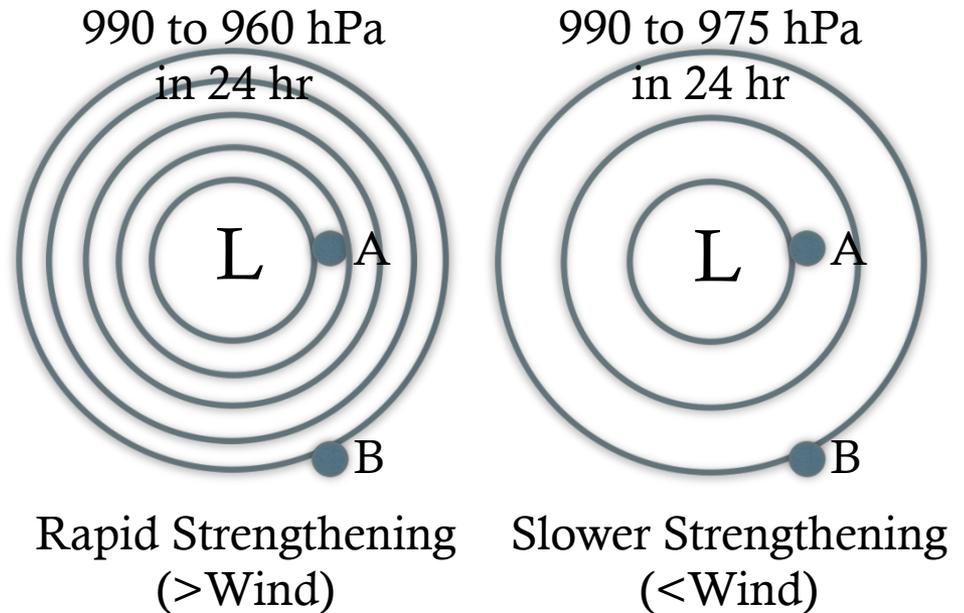


Locations A & B are fixed points (e.g. weather stations)

→
Wind Speed (longer arrows = faster speed)

Pressure Tendencies: An Explanation for the Extraordinary CDS Winds

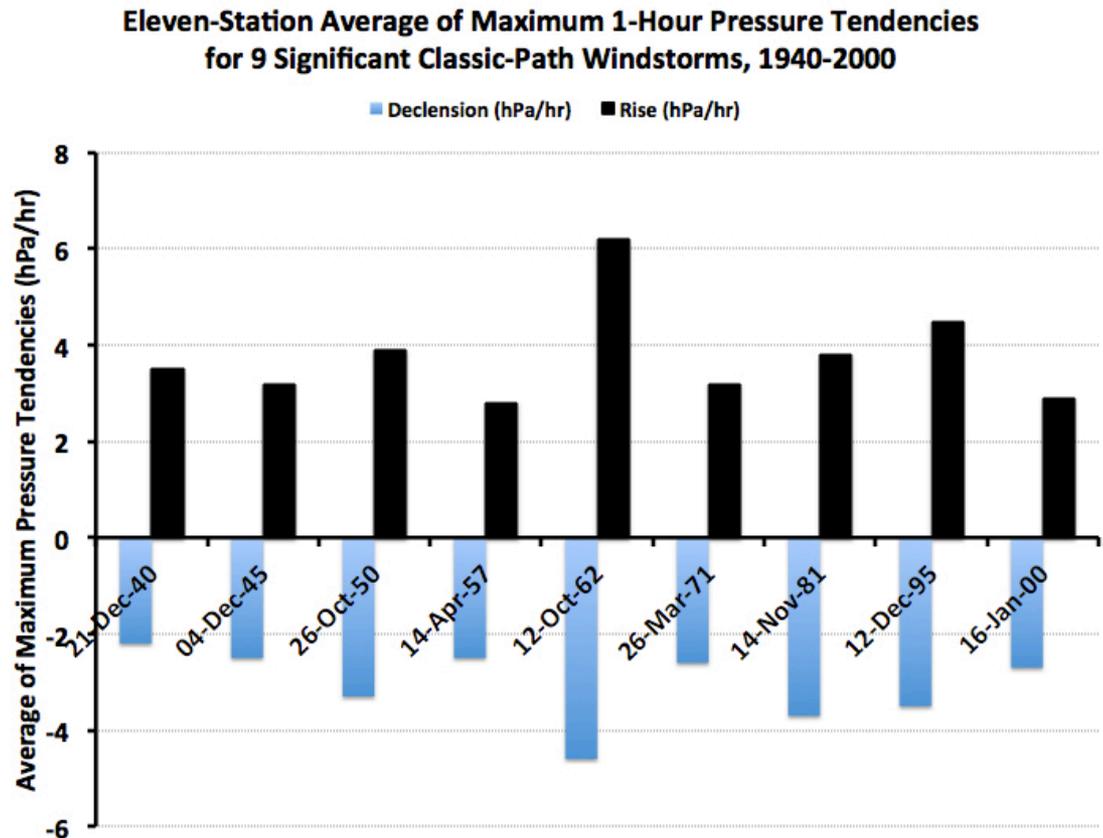
- Pressure tendencies integrate at least three variables:
 - 3) A rapidly deepening storm would tend to produce faster pressure falls than a slowly deepening storm
 - Rapidly intensifying storms are more likely to generate damaging winds (generally due to more intense pressure gradients)



Locations A & B are fixed points (e.g. weather stations)

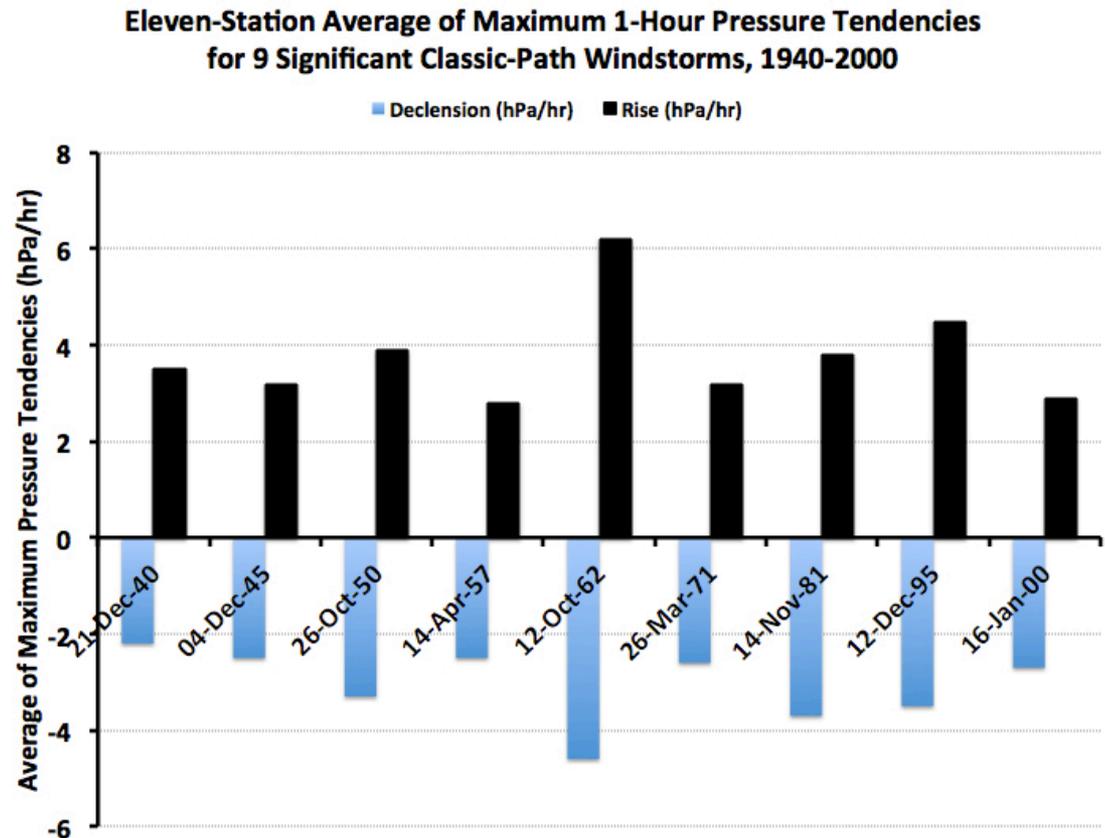
Pressure Tendencies: An Explanation for the Extraordinary CDS Winds

- The Columbus Day Storm had the strongest pressure changes out of any of the storms
- Rates of pressure fall and rise were 1.5 to 2 times higher than for any of the other classic windstorms



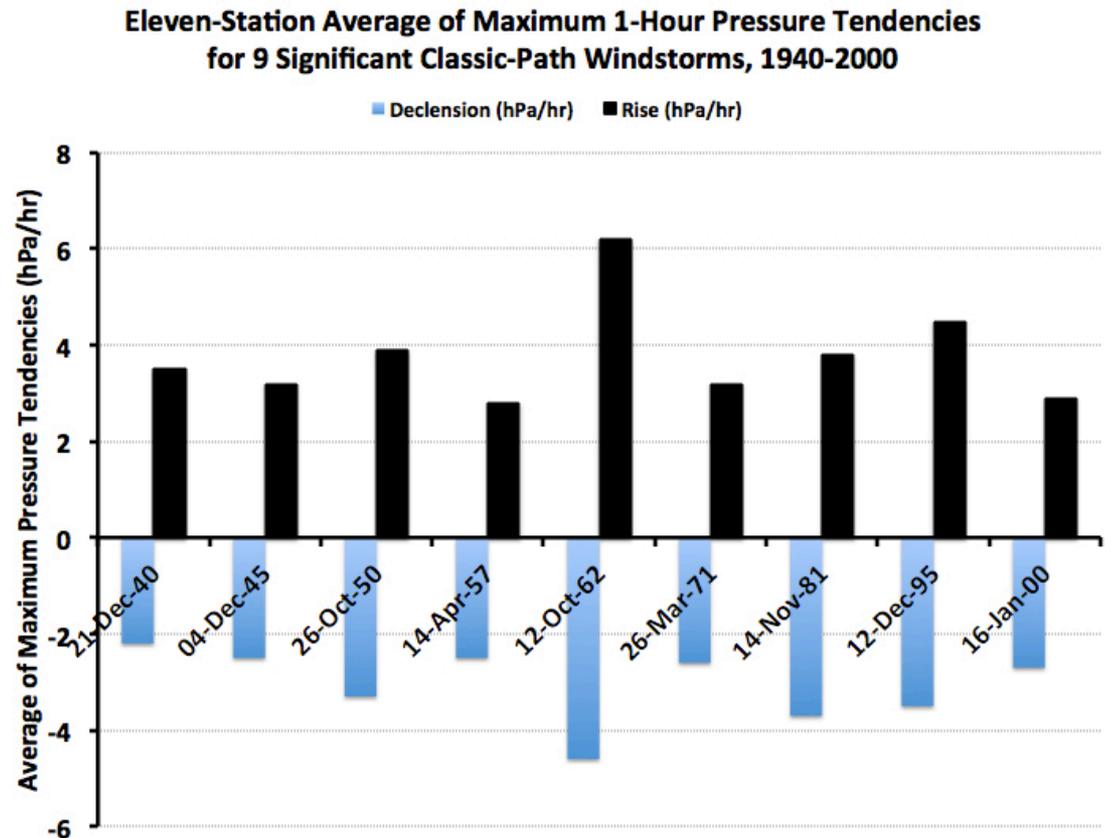
Pressure Tendencies: An Explanation for the Extraordinary CDS Winds

- Nov 1981 and Dec 1995 generated the next strongest rates-of-change in barometric pressure on average
- Oct 1950 is the outlier—one of the weaker classic storms, but with some fairly strong pressure tendencies



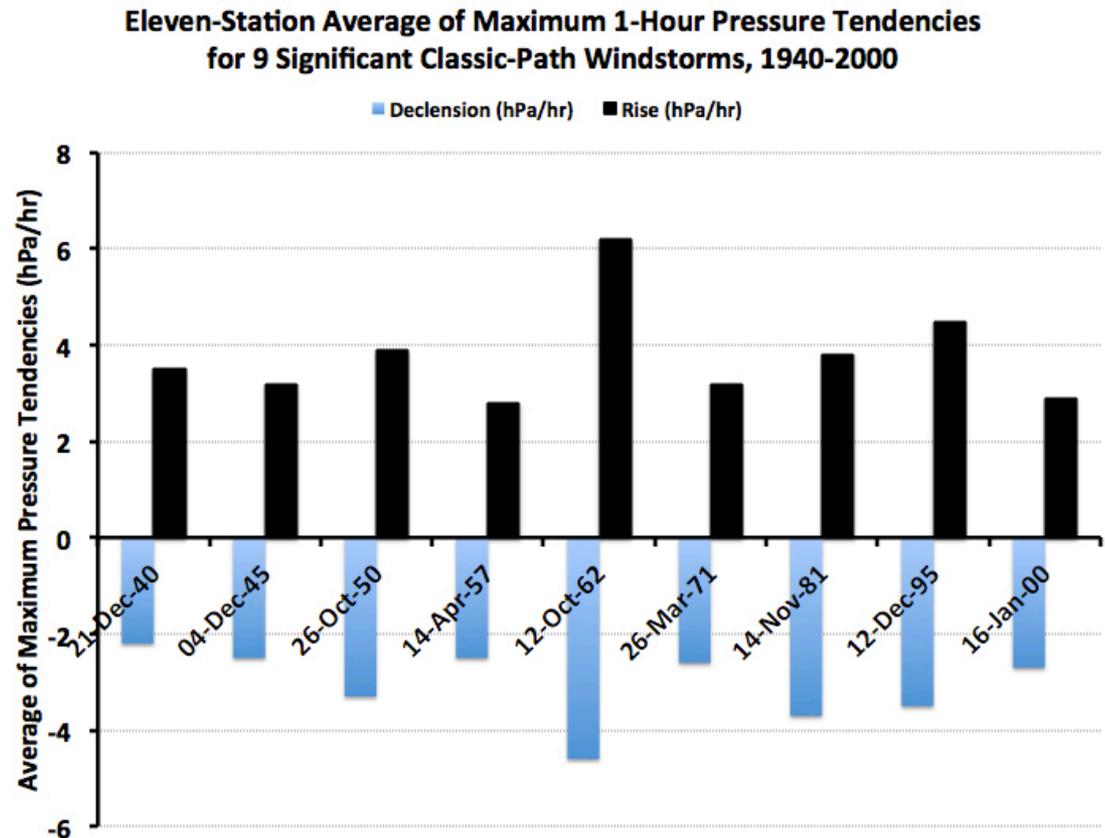
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- The pressure gradient magnitudes of Oct 1962, Nov 1981 and Dec 1995 were fairly similar



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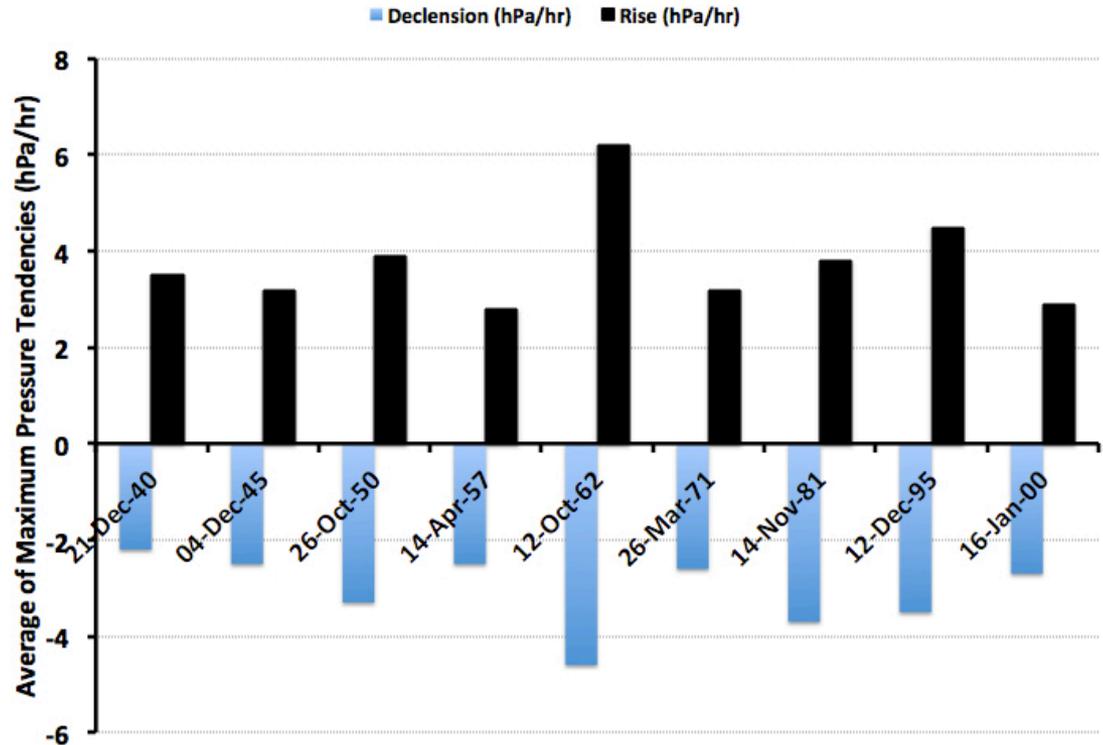
- The pressure gradient magnitudes of Oct 1962, Nov 1981 and Dec 1995 were fairly similar
- And all three storms reached peak intensity off of the OR coast, with similar minimum central pressures (~955 hPa give or take a few)



Pressure Tendencies: An Explanation for the Extraordinary CDS Winds

- This suggests that the Columbus Day Storm had a faster speed than the Nov 1981 and Dec 1995 storms
- Measurement from available surface maps suggests ~35-40 kt vs. ~25-30 kt
- This faster storm speed likely contributed to the higher surface wind gusts on the coast and in the interior

Eleven-Station Average of Maximum 1-Hour Pressure Tendencies for 9 Significant Classic-Path Windstorms, 1940-2000



Thank You

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