# Northwest Windstorms

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Although the Pacific Northwest escapes the threat of hurricanes, the region is no stranger to strong, damaging winds. Each winter season, several Pacific low pressure centers (or cyclones) make landfall upon the Northwest and British Columbia coasts, resulting in winds strong enough (40 to 60 mph) to produce power failures and modest damage west of the Cascades. Less frequently, perhaps two or three times a decade, windstorms of considerably greater magnitude occur, with winds gusting to 70 mph or more, massive power failures affecting hundreds of thousands of homes, and damage reaching the tens or hundreds of millions of dollars.

Most windstorm damage in the Northwest results from fallen trees, as illustrated by this photo of a home in north Seattle after the relatively weak windstorm of 30 March 1997

Along the coast, winds exceeding 100 mph have accompanied these major storms, particularly on exposed headlands such as Cape Blanco, on the Oregon Coast, and North Head, just north of the Columbia River.

## Major Northwest Windstorms of the Past

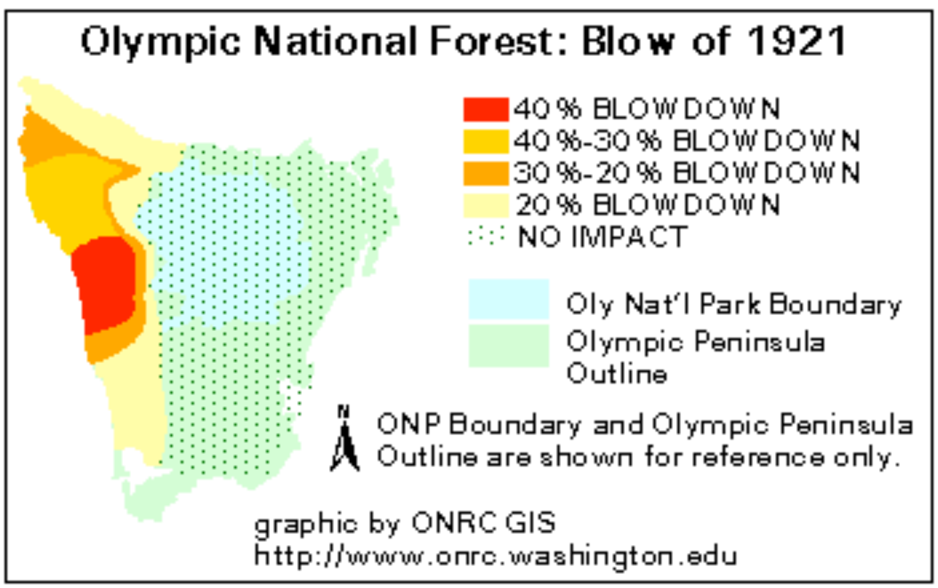
Native American legends recognized the occurrence of strong coastal winds and provided explanations of their origin. For example, the Quillayute tribe, which lived along the Quillayute River of the western Olympic Peninsula, told stories about the Thunderbird, a giant bird with wings twice as long as a war canoe. As he flapped his wings great winds were produced. The Quillayutes, like other coastal tribes, were aware that winter windstorms were more intense near the coast, and generally moved to more protected inland camps during the stormy winter months.

Northwest Indian graphic depicting the giant thunderbird carrying off a killer whale.

As non-Indian settlers moved into the Northwest during the later half of the nineteenth century, they learned that Northwest windstorms were a force to be reckoned with. In his memoir "Pioneer Days on Puget Sound" written in 1888, Seattle pioneer Arthur Denny noted that "the heaviest windstorm since the settlement of the country" occurred on 16 November 1875. Denny described the storm as "a strong gale which threw down considerable timber and overturned light structures, such as sheds and outbuildings."

An even stronger storm stuck the region on 9 January 1880. Regarded by the Portland Oregonian as "the most violent storm ...since its occupation by white men", the cyclone swept through northern Oregon and southern Washington toppling thousands of trees, many 5-8 ft in diameter. Winds gusting to 73 mph begin in Portland during the early afternoon, demolishing and unroofing many buildings, uprooting trees, felling telegraph wires, and killing one person. Scores of buildings throughout the Willamette Valley were destroyed and hundreds more, including large public buildings, were damaged. Part of the roof of the Oregon State Capital in Salem was blown off, allowing snow to accumulate inside the building. Rail traffic was halted in most of northwest Oregon, virtually all fences in the Willamette Valley that were aligned east-west were downed, and every barn near the coastal town of Newport, Oregon was destroyed. Wind gusts on the coast were estimated to reach 138 mph.

The "Great Olympic Blowdown" of 29 January 1921 produced hurricane-force winds along the northern Oregon and Washington coastlines and an extraordinary loss of timber on the Olympic Peninsula. Southwest of the Olympic Mountains over 40% of the trees were blown down, with at least 20% loss along the entire Olympic coastline (see graphic). Billions of board feet of timber were uprooted, much of it in remote regions that made salvage impossible. An official report at North Head, on the north side of the mouth of the Columbia River, indicated a sustained wind[1] of 113 mph, with estimated gusts to 150 mph before the instrument was carried away by the wind. Although the coastal bluff seaward of the North Head observation site may have accelerated the winds above those observed over the nearby Pacific, the huge loss of timber along the Washington coast (eight times more than felled by the eruption of Mt. St. Helens in 1980) is consistent with a singular event. Very strong, but lesser, winds were observed over Oregon's Willamette Valley and Puget Sound, with maximum gusts ranging from 50 to 60 mph. In Seattle's Elliott Bay twenty-one barges broke their mooring lines and were driven into Puget Sound, while on land a number of greenhouses were destroyed and several dozen fires were ignited as a result of the strong winds. Powerlines and telephone lines were downed across western Washington.




The windstorm of January 1921 produced a devastating loss of timber along the coast of the Olympic Peninsula, but only minor damage in the interior of western Washington.

*12 October 1962: The Columbus Day Storm*

By all accounts, the Columbus Day Storm was the most damaging windstorm to strike the Pacific Northwest in 150 years. An extensive area, stretching from northern California to southern British Columbia experienced hurricane-force winds, massive treefalls, and power outages. In Oregon and Washington, 46 died and 317 required hospitalization as a result of the storm. Fifteen billion board feet of timber worth 750 million (more than a year's annual cut) were downed, 53,000 homes were damaged, thousands of utility poles were toppled, part of the roof of Portland's Multnomah stadium was torn off, and the twin 520 ft steel towers that carried the main power lines of Portland were crumpled. At the height of the storm approximately one million homes were without power in the two states, and total damage was conservatively estimated at a quarter of a billion (1962) dollars.

The Tower on Campbell Hall of Western Oregon State College collapsed during the height of the Columbus Day windstorm

The Columbus Day Storm began east of the Philippines as a tropical storm--Typhoon Freda. As it moved eastward into the mid-Pacific on 8-10 October, the storm transitioned into an extratropical (midlatitude) cyclone. Twelve hundred miles west of Los Angeles, the storm abruptly turned northward and began to deepen rapidly, reaching its lowest pressure approximately 300 miles southwest of

[1] This sustained wind report is actually the "fastest mile," which is the wind speed associated withthe period in which a mile of air moved past the anemometer most rapidly. With a fastest mile win speed of 113 mph, this implies a period of approximately 30 seconds.

Brookings, Oregon at around 7 A.M. on 12 October. Maintaining its intensity, the cyclone paralleled the coast for the next twelve hours, reached the Columbia River at approximately 5 P.M. and crossed the northwestern tip of the Olympic Peninsula just before midnight.

Over coastal regions and the offshore waters the winds gusted well over 100 mph, with 60-90 mph gusts over the western interiors of Oregon and Washington. At the Cape Blanco Loran Station sustained winds were estimated to reach 150 mph with gusts to 179 mph, at the Naselle radar site in the coastal mountains of southwest Washington gusts reached 160 mph, and a 131 mph gust was observed at Oregon's Mount Hebo Air Force Station. The winds at these three locations are undoubtedly enhanced by local terrain features. Away from the coast, winds gusted to 116 mph at Portland's Morrison Street Bridge, 90 mph in Salem OR, 100 mph at Renton WA, 80 mph at Whidbey Island Naval Air Station, 80 mph at Paine Field, 113 mph in Bellingham, 88 mph in Tacoma, 89 mph at Toledo WA, and 83 mph at West Point in Seattle. Even in California fierce winds were observed, with sustained winds of 68 mph in Red Bluff, in the Central Valley, and gusts of 120 mph at Mt. Tamalpais, just north of California. As is characteristic of most Northwest windstorms, both the storm and its associated winds weakened rapidly after landfall as the low center moved into British Columbia.

*13 February 1979: The Hood Canal Storm*

Due to its offshore track, this storm caused less widespread damage over the Northwest than most events reviewed in this chapter. However, the interaction of strong southwesterly coastal winds with the high terrain of the Olympic Peninsula produced a small, but intense, low-pressure area to the northeast of the Olympics that accelerated southerly winds near the Hood Canal to over 100 mph. The result was the loss of the 3200 ft western section of the floating Hood Canal Bridge and a massive blowdown of timber that was surpassed only by the great storm of 1921. In some areas surrounding the Hood Canal Bridge over 80% of the trees were downed. For example, on the nearby Pope and Talbot tree farm, 26 million board feet were blown down, four to five times the amount that fell during the Columbus Day storm of 1962—the most destructive storm of modern times.

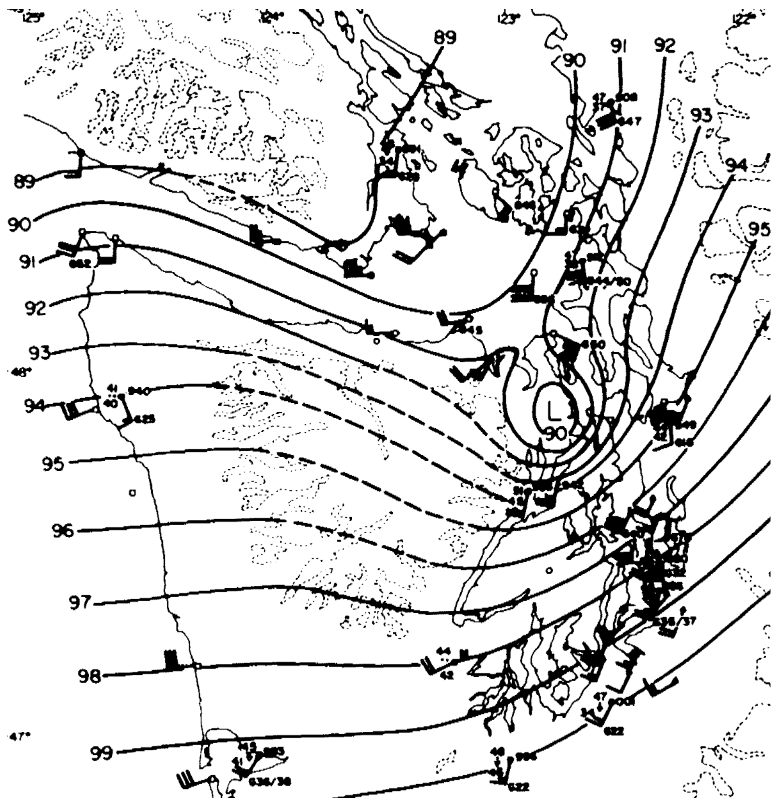
Winds of over 100 mph resulted in the failure of the western section of the Hood Canal Bridge on 13 February 1979.

Over most of western Washington, the wind speeds associated with this event were not extraordinary for a winter windstorm. Maximum sustained (one-minute average) winds at most locations were around 40 mph with gusts under 75 mph. On the coast the winds were somewhat higher, with the Cape Flattery Coast Guard Station experiencing a maximum sustained wind of 56 mph, with a peak gust of 98 mph.

In a detailed study of the storm, Professor Richard Reed of the University of showed that the extraordinary high winds near the Hood Canal bridge were associated with a very small low pressure center---termed a mesolow-- to the lee (northeast) of the Olympic Mountains (see Figure). Just as water passing over a large rock in a stream often produces a downward plunge of the water surface--with associated vortices and eddies--immediately downstream of the rock, a similar phenomenon can occur in the atmosphere when the conditions are right. Specifically, when the winds approaching the crest of the Olympics are strong enough and the vertical stability of the air (the tendency for the air to return to its initial altitude when displaced vertically) is relatively low, an intense, but small (20-40 miles in width) low center forms downstream of the barrier. From theoretical studies, it appears that the conditions on 13 February 1979 were ideal for such a leeside eddy to form.

Air increases in speed as it moves from higher to lower pressure (as does toothpaste when one squeezes the tube). Thus, already strong (30-40 mph) winds over southern Puget Sound accelerated rapidly over the Hood Canal area as they approached the small low center, which was centered near Port

Townsend. Although the anemometer on the bridge was eventually lost, bridge tenders reported that wind gusts repeatedly attained their instrument's maximum reading (100 mph) before they were forced to abandon their station. They also noted that sustained winds of 80 mph were observed for the two hours before the bridge failed. The Hood Canal Bridge was later replaced at a cost of over 140 million dollars.

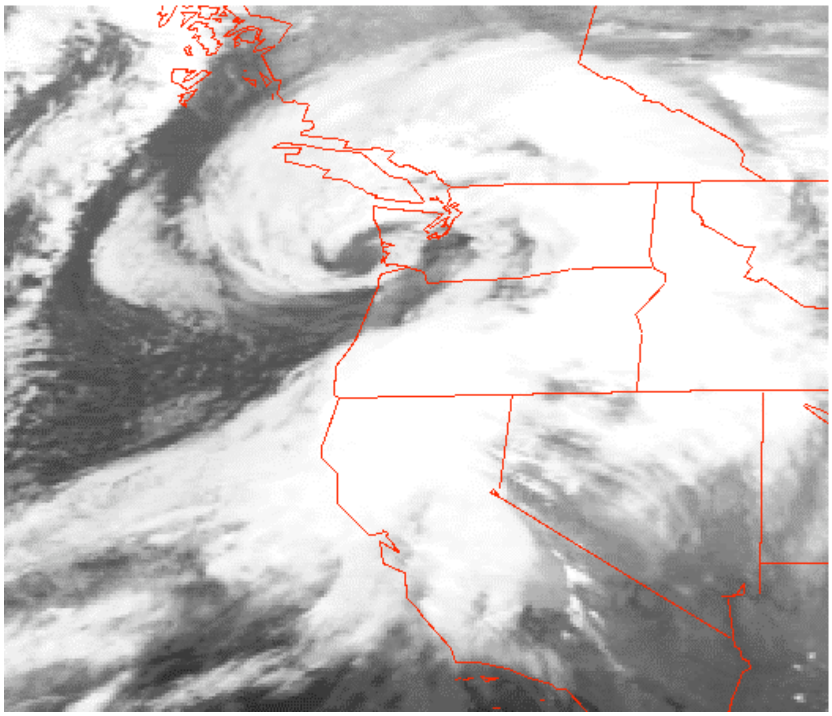



Sea-level pressure analysis at 7 A.M. PST 13 February 1979. An intense small-scale low pressure center is apparent to the northeast of the Olympics. The intense pressure change south of the low produced winds exceeding 100 mph over the Hood Canal. Analysis is from Reed (1980).

*20 January 1993: The Inauguration Day Windstorm*

Probably the second most damaging storm during the past 50 years (with the Columbus Day Storm being number one) struck the Northwest on the Inauguration Day of President Bill Clinton (20 January 1993). Winds of over 100 mph were observed at exposed sites in the coastal mountains and the Cascades, with speeds exceeding 80 mph along the coast and in the interior of western Washington. In Washington State six people died, approximately 870,000 customers lost power, 79 homes and 4 apartment buildings were destroyed, 581 dwellings sustained major damage, and insured damage was estimated at 159 million.

The Inauguration Day Storm rapidly intensified in the day preceding landfall on the northern Washington coastline. At 4 P.M. PST on January 19th, the low-pressure center was approximately 600 miles east of the northern California coast. The storm then entered a period of rapid intensification, with the central pressure reaching its lowest at 7 A.M. on January 20th, when it was located about 20 miles east of the outlet of the Columbia River. A secondary trough of low pressure extended south of the low center, and within this trough the pressure differences (horizontal pressure gradients) and associated winds were very large. During the next six hours, as the low center passed west and north of the Puget Sound area, the secondary trough moved northwestward across northwest Oregon and western Washington, bringing hurricane force winds and considerable destruction.



5.8 Infrared satellite picture at 7 A.M. PST 20 January 1993 showing the low center (in the middle of the circular swirl of clouds) making landfall upon the Washington coast. In infrared pictures whiter (darker) clouds are higher (lower)

As the storm moved along the Oregon coast, winds gusted to 86 mph at Cape Blanco and 84 mph at Arch Cape, with unofficial reports of gusts in excess of 100 mph over northwest Oregon. These hurricane-force winds produced widespread power outages over coastal Oregon and the loss of millions of dollars of timber within the coastal mountains southeast of Astoria. As the storm moved northward along the Washington coast, winds gusted to 98 mph at Cape Disappointment along the northern terminus of the Columbia River, 94 mph at the Hood Canal Bridge, 75 mph at Alki Point, 80 mph at Enunclaw near the Cascade foothills, and a record 88 mph on the roof of the Atmospheric Sciences building at the University of Washington (Seattle). The 64 mph gust at Seattle-Tacoma Airport was the second strongest in 50 years (the record was 67 mph during the 14 November 1981 storm). Near the Cascade crest, winds exceeded

100 mph several times over a two-hour period at Stampede Pass and reached 116 mph at the Alpental ski area in Snoqualmie Pass. For the first time ever, both floating bridges across Lake Washington were closed, as was the Tacoma Narrows suspension bridge. The massive power outages accompanying the storm caused businesses and schools throughout western Washington to close midday; with some schools sending children home when dangerous winds were still pummeling the region (a big mistake). A power outage north of Seattle in Edmonds resulted in nine million gallons of raw sewage inundating city streets, while near Toledo, Interstate 5 was closed when power lines were downed over four of the lanes.

Official National Weather Service forecasts were generally quite good, with the release of a high wind watch at 1:30 PM PST and a high wind warning at 10 P.M. the day before (19 January). These excellent forecasts were generally ignored by media, which were busy covering Clinton's Inaugural. The skillful forecast of this event reflected the substantial improvement in numerical weather prediction that had occurred during the previous ten years. While nearly every major windstorm was poorly predicted prior to 1990, advances in observations, data assimilation, and numerical modeling have resulted in consistently better forecasts of major storm systems in recent years.

*12 December 1995*

Of all the major windstorms to strike the Pacific Northwest, none was better forecast nor more intensively studied than the 12 December 1995 event. Hurricane-force gusts and substantial damage covered an extraordinarily large area from San Francisco Bay to southern British Columbia, resulting in five fatalities and over 200 millions dollars damage. Early in the day, the storm struck northern California with gusts of 103 mph at San Francisco, 75 mph at Eureka, and 75 mph in Oakland, resulting in numerous tree falls and three deaths. In Oregon, winds at Sea Lion Caves near Florence reached 119 mph before the anemometer failed, at North Bend winds gusted to 86 mph, Newport winds attained 107 mph, and both Cape Blanco and Astoria had maximum winds that just exceeded 100 mph. Sea level pressure at Astoria dropped to 28.51 inches (965 mb), an all-time record low for that observing site. Winds within the Willamette Valley surpassed 60 mph at several locations, and with very wet soil from an unusually rainy fall, many large trees were uprooted.

Throughout Oregon and Washington thousands of trees were toppled during the
12 December 1995 storm. This picture was taken in Salem, Oregon.

Over western Washington sustained winds reached 30-50 mph, with gusts of 50-80 mph. North Bend and Seattle experienced maximum gusts of 78 mph and 59 mph, respectively, with the latter location experienced its all-time record low pressure (970 mb, 28.65 mb). Over the waters of Puget Sound the winds were greatly enhanced compared to land values: a ship just outside of Elliott Bay reported sustained winds of 60-70 mph with gusts to 90 mph, the ferry terminal at Mukilteo reported sustained winds of 60-70 mph with a gust to 86 mph, and gusts attained 76 mph on the Hood Canal Bridge. Approximately 400,000 homes lost power in western Washington, with nearly complete blackouts on Bainbridge, Vashon, and Mercer Islands. To the south, 205,000 customers lost power in Oregon while in northern California the total was 714,000.

The 12 December 1995 event was the most skillfully forecast windstorm in Northwest history. The computer weather models began predicting an intense event 3-4 days ahead of time, and the day before it struck the National Weather Service provided a strongly worded warning for a powerful, damaging windstorm. The media went wild, with television reporters reporting live from seemingly dozens of locations. Government, educational institutions, and businesses took the warnings seriously, protecting property and closing down early. The forecasts released the morning of 12 December not only correctly predicted storm strength, but provided timing that was accurate to within an hour.

**Major Northwest Windstorms, El Nino, and La Nina**

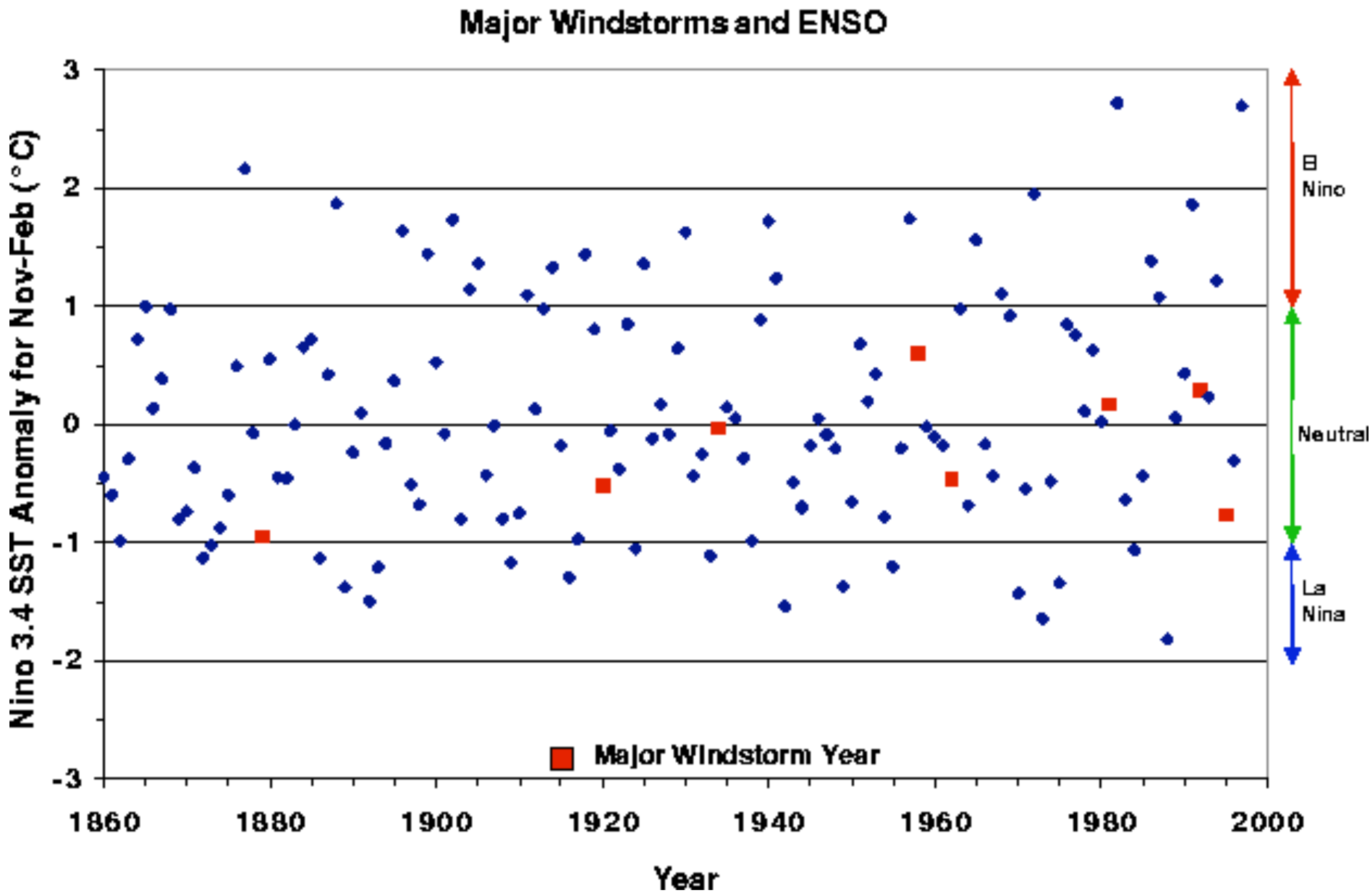
Recent research has revealed a connection between the surface temperatures of the tropical Pacific and weather over the western U.S. When tropical sea surface temperatures (SSTs) are warmer than normal (El Nino periods), the Northwest tends to be warmer and drier than usual during the winter, while cooler tropical SSTs (associated with La Nina conditions) bring wetter than normal winters, with somewhat cooler and snowier conditions during the latter half of the winter. The tendency to alternate between El Nino and La Nina conditions over a period of three to seven years is termed the El Nino Southern Oscillation (ENSO), with the intervening "neutral" years having near-normal SST conditions.

ENSO appears to influence the frequency of major Northwest windstorms, with the greatest windstorms occurring in neutral (neither El Nino nor La Nina) years. To illustrate this fact, the figure below shows the variation of sea surface temperature for November through February for a region in the eastern tropical Pacific (called the Nino 3.4 area). Temperatures are shown as anomalies (or differences) from average temperature over the period (1856-1997). El Nino (La Nina) years are associated with warm (cold) anomalies of approximately 1°C or more. The temperature anomalies are indicated by blue diamonds except for the temperatures of major windstorm[2] years, which are indicated by red squares. Clearly, the major windstorms are all in neutral years. Since there were only a small number of major windstorms during the past century our sample size is relatively small; thus, this ENSO/windstorm relationship should be considered suggestive, but not definitive.

The lack of major windstorms in El Nino years is not surprising, since a number of researchers have found that El Nino periods are often associated with "split flow" over the eastern Pacific, with the Pacific jet stream dividing, with one portion going into Alaska and the other heading towards California. Such conditions tend to shear weather systems apart as they approach the Northwest--which lessens the chance for strong windstorm development. La Nina years often have periods with enhanced high pressure in the eastern Pacific (termed "ridging") that produces enhanced cool, northerly (from the north) flow that is quite different than the typical windstorm pattern in which strong southwesterly flow heads directly into the Pacific Northwest.

Since the transition between El Nino to La Nino occurs relatively slowly and can often be predicted at least six months in advance, the connection between ENSO and major windstorms provides a several month "heads up" regarding the probability of a significant wind event.

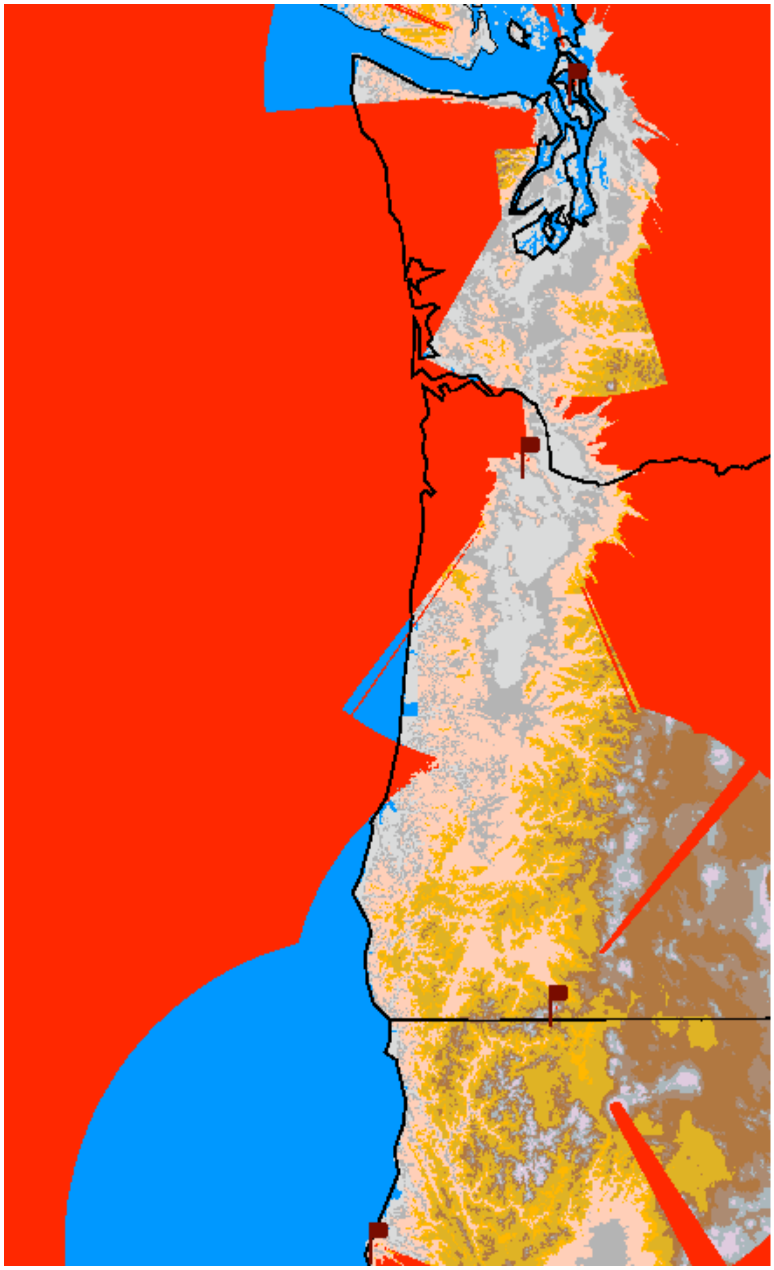
[2] The major windstorms that were selected all produced massive damage over the Northwest with winds of 60 mph and greater. The storms were 9 January 1921, 29 January 1921, 21 October 1934, 3-4 November 1958, 12 October 1962, 13-15 November 1981, 20 January 1993, and 12 December 1995.




Sea-surface temperature anomalies over an area of the eastern tropical Pacific (Nino 3.4 region) for November through February. Years with major windstorms are indicated by red squares, with non-windstorm years shown by blue diamonds. It appears that major windstorms avoid El Nino and La Nina years.

**A Major Problem In Forecasting Northwest Windstorms**

Although research at the University of Washington and elsewhere has revealed a great deal about the nature of these storms, the ability to predict them is undermined by a lack of a coastal weather radar. Over the eastern U.S an offshore storm, such as a hurricane is clearly seen hours before landfall by the coastal weather radars owned by the National Weather Service. In contrast, the Northwest U.S. has virtually no coastal radar coverage and thus local forecasters are often unsure exactly where an approaching storm is located (see figure). With the acquisition of coastal radars and continuing improvement in computer forecast models, there is no reason that the Northwest should ever be surprised by one of these great storms.



Current Northwest Weather Radar Coverage.  Red areas indicate no coverage.