Office of the Washington State Climatologist

January 5, 2011

December Event Summary

For most of the state, December, on average, was warmer and wetter than normal. The weather started out rather calm for the first few days of the month, except for some snow in the Blue Mountains of southeast WA. The rain finally started on the west side of the Cascades on the 6th and fell scattered as snow east of the Cascades on the 7th. The precipitation continued for most of the state, and heavy rain and thunder were experienced in western WA on the morning of the 8th. The Seattle Weather Forecasting Office (WFO) recorded rainfall of 0.85" on that day, which is a record for the date.

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The really heavy precipitation started on the 11th, however, falling as rain in western WA and as snow east of the Cascades. Flooding and landslides occurred in western WA, and the state emergency operations center set up county emergency operation centers in Snohomish, Pierce, and Skagit Counties. Maximum daily rainfall records were broken on the 11th (SeaTac; 1.42", Quillayute; 2.17", Moses Lake; 0.35") and a maximum daily snowfall record was set at Yakima (5.9"). More maximum daily rainfall records were broken on the 12th (Table 1), and maximum daily snowfall records were set as well on the east slopes of the North Cascades: Mazama (21.0"), Holden Village (18.9"), and Winthrop (17.0").

Station	Dec 12 Rainfall Record (inches)
Shelton	3.10
Seattle WFO	2.25
Boeing Field	2.21
SeaTac	2.19
Renton	1.92
Olympia	1.80
Bellingham	1.61
Port Angeles	1.18
Everett Paine Field	0.96

Table 1: Daily rainfall records set on December 12.

The cold front moved through western WA in the early morning hours of the 14th, bringing thunderstorms, heavy rain, wind, and even some hail to parts of the state. This combined with the previous days of rain caused havoc in western WA; mudslides stalled Amtrak service and many trees fell, even on houses (Seattle Times; 12/13 and 12/14).

The state dried out starting on the 15th and 16th, but it didn't last long. Strong winds off the Cascades impacted the eastern Puget Sound area on the morning of the 18th, and was followed by more rain on the west side and snow east of the Cascades. The spigot was effectively turned on again on the 23rd, and western WA had a wet Christmas while some locations east of the Cascades received snow on Christmas Day. A final snowfall wallop was given to the furthest eastern locations of the state, where 5-15" of snow fell on the 28th and 29th. Some isolated snow showers occurred in western WA on the 29th as well. The state did finally dry out for the last two days of the year, due to a ridge aloft to the west which brought clear skies and much colder than normal temperatures.

Snowpack

The wet month benefited snowpack in the mountains across the state. Figure 1 shows the snow water equivalent (SWE) percent of normal for 11 basins from the National Resources Conservation Service. The Olympic Mountains have much more snow than usual for this time of year at 163% of normal. The Lower Columbia basin also has above normal SWE. Several other basins have near-normal SWE (Lower Yakima, Lower Snake, and Upper Columbia). The remaining basins have below normal SWE, falling between 77 and 86% of normal.

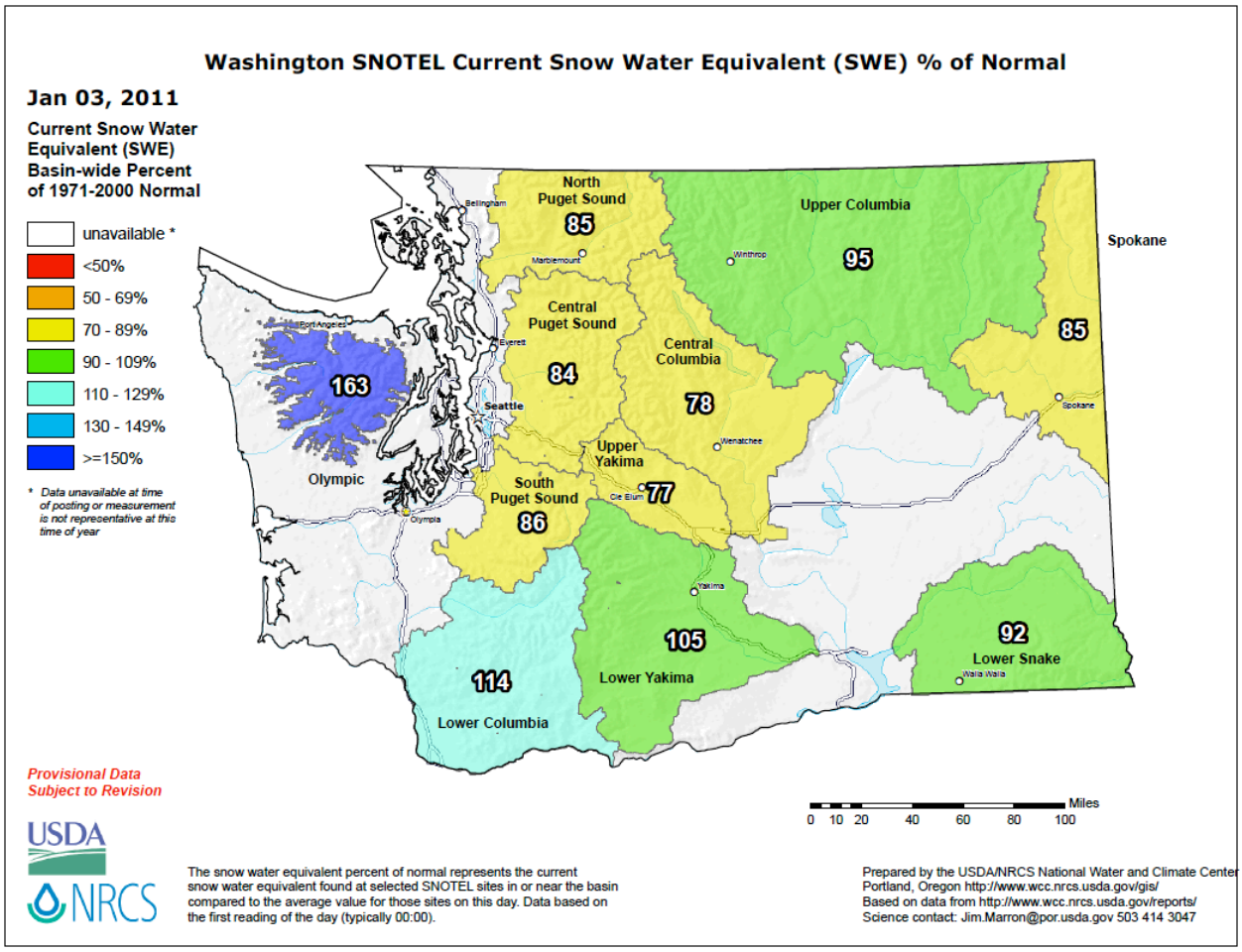
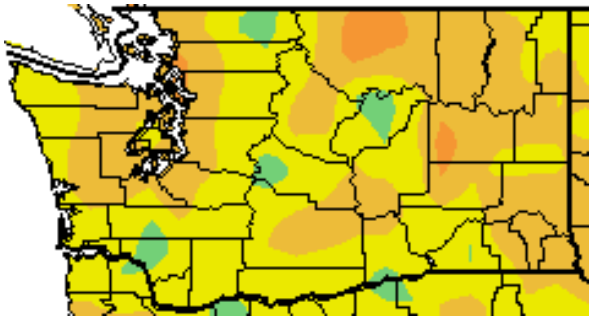


Figure 1: Snowpack (in terms of snow water equivalent) percent of normal for Washington as of January 3, 2011. Image is from the National Resources Conservation Service.

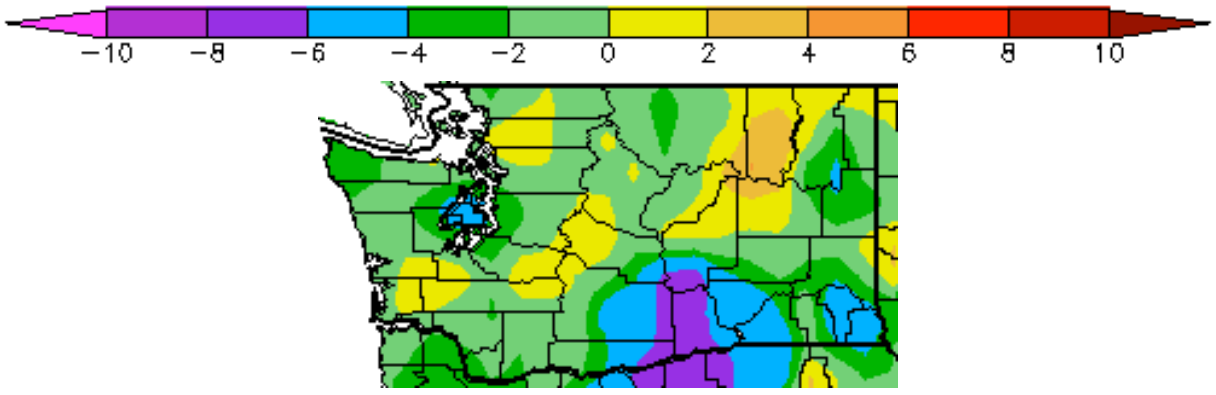
Climate Summary

Temperatures around the state were generally above normal for December, as shown in the High Plains Regional Climate Center (HPRCC) map displayed below. The Puget Sound region and portions of north and southeastern WA were the warmest with temperatures between 2°F and 4°F above normal. Some central WA locations had temperatures closer to those expected for December. Ephrata and Wenatchee, for example, were only 0.2°F and 0.7°F above normal, respectively (Table 2).

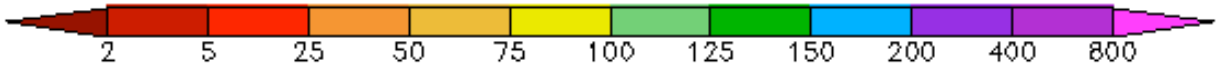
Total precipitation for December was above normal for most of the state, with the wettest locations, south central WA, receiving between 150 and 200% of normal precipitation. The rest of the state mostly had between 100 and 125% of normal precipitation as shown in Table 2. One dry station resulted in the dry bull's eye in northeastern WA: Coulee Dam. This location received 0.94" of precipitation in December, about 64% of normal.



Temperature (°F)



Precipitation (%)



December temperature (°F) departure from normal (top) and December precipitation % of normal (bottom). Source: High Plains Regional Climate Center (http://www.hprcc.unl.edu).

	Mean Temperature (°F)			Precipitation (inches)			Snowfall (inches)		
	Avg	Norm	Departure from Normal	Total	Norm	% of Norm	Total	Norm	% of Norm
Western Washington									
Olympia	40.5	38.0	2.5	9.35	7.89	119	M	3.8	M
Seattle	43.9	40.7	3.2	7.94	5.45	146	0.0	M	M
Sea-Tac	43.2	40.7	2.5	8.69	5.62	155	0.0	2.5	0
Quillayute	42.2	40.1	2.1	19.02	14.50	131	M	2.7	M
Vancouver	42.8	40.7	2.1	8.23	6.10	135	M	M	M
Eastern Washington									
Spokane	29.4	27.2	2.2	3.19	2.25	142	17.4	13.7	127
Wenatchee	28.9	28.2	0.7	1.57	1.43	110	M	12.1	M
Omak	28.5	25.0	3.5	2.02	1.82	111	M	7.9	M
Ephrata	28.7	28.5	0.2	1.27	1.19	107	M	7.7	M
Yakima	31.9	28.8	3.1	2.38	1.38	172	13.4	9.5	141

Table 2 - December climate summaries for locations around Washington. The climate normal baseline is 1971-2000 except for Seattle WFO (1986-2000) and Vancouver (1998-2009). Please be aware that the Seattle WFO and Vancouver climate normal periods are shorter than the 30-year period that is typically used for climatology.

CoCoRaHS

Thanks for your measurements, CoCoRaHS observers! They proved valuable during the frequent rains of December, as usual. A reminder that WeatherFest, an interactive science and weather fair held by the American Meteorological Society, will be held from noon-4 pm on Sunday, January 23, 2011 at the Washington State Convention Center in Seattle. OWSC staff will be in attendance and be pleased to meet you. More information on the event can be found here: http://www.ametsoc.org/meet/annual/weatherfest.html.

Thanks for your interest in a CoCoRaHS volunteer meet-and-greet after WeatherFest. We WILL be hosting an event at the end of WeatherFest, but are still ironing out details. Look for updates on the CoCoRaHS page (http://www.cocorahs.org/state.aspx?state=wa) or on the OWSC home page (http://www.climate.washington.edu/).

Pollution due to Wood Smoke and the Weather of Washington State

Air quality is often good in the Pacific Northwest due to the prevailing west to east winds off the North Pacific. There are exceptions to this situation, of course, during which residents of Washington are exposed to hazardous levels of air pollution. The primary pollution problem during the fall and winter is high concentrations of the small particulates less than 2.5 microns in diameter ($PM_{2.5}$) associated with wood smoke. While the aroma of wood smoke is not necessarily unpleasant, and can have favorable connotations such as cozy evenings around the fireplace, the health impacts of this smoke are definitely negative. For example, University of Washington scientists Jane Koenig and Timothy Larson, along with collaborators, have found that children are more prone to asthma attacks and other respiratory problems in Puget Sound neighborhoods where wood smoke is prevalent. The issue is not just limited to the regions of high population density in Washington State. Following is a brief review of the weather conditions that promote the buildup of $PM_{2.5}$, and what folks can do about it.

High concentrations of $PM_{2.5}$ generally occur during periods of calm weather during the cool season. These periods feature a prominent ridge aloft, relatively high values of sea level pressure, and light winds. Their onset typically begins with clear skies followed by nighttime fog that may burn off during the day. During extended episodes of this kind of weather, the fog tends to persist through the day. Less frequently, the humidity is low enough such that fog is only in patches or absent, even at night. From an air quality point of view, the main problem is associated with the temperature inversion, i.e., a layer of air in which the temperature is increasing with height, that develops near the surface. This kind of temperature profile inhibits vertical mixing of air, resulting in trapping pollutants near the ground, thereby allowing their concentrations to increase to unhealthful levels. The extent to which this occurs varies substantially from place to place. In general, lower elevation regions such as the Puget Sound lowlands and the Columbia basin of eastern Washington are subject to stronger low-level inversions than higher elevations. A particularly striking example of this effect is illustrated by time series of daily maximum air temperature from SeaTac, Spokane, and Paradise Ranger Station on Mount Rainier for the month of January 2009 (Figure 2). A major air-stagnation event developed during the middle of the month and at its peak, the daytime high temperature at Paradise at about 5500 ft elevation was more than 20 and 30 degrees F warmer than at SeaTac and Spokane, respectively. There are also much smaller-scale effects. Surveys carried out by the Puget Sound Clear Air Agency and others have revealed that local valleys, especially away from the water, are colder and experience much greater smoke concentrations than nearby areas. Fortunately, there are resources for monitoring the development of these events. Specifically, the wind profiler on the NOAA Sandpoint campus in Seattle, and the twice-daily rawinsonde soundings taken at Geiger Field outside Spokane provide measurements of the vertical profiles of the temperature and wind. With the help of these and other observations, we can track the development of these episodes, but can we anticipate them in the first place?

The overall weather pattern favoring stagnant conditions and poor air quality in the cool season can be predicted quite reliably on time horizons of a week or so. Current numerical

weather prediction (NWP) models still do not get the details exactly right, but on these time scales are actually quite remarkable in their ability to project major transitions in the weather. On seasonal and longer time scales it is a different matter. Presumably the large-scale atmospheric circulation on these time scales relates to the frequency and severity of these events, but the relationship(s) here are unknown (and arguably something we should figure out). Moreover, we have only modest ability to project seasonal weather anomalies in the first place. It bears emphasizing that virtually every cool season includes some events, and so it is worthwhile to consider what actions can be taken as individuals.

First and foremost, we can all do our part to reduce wood smoke in the first place. It is best to have small and hot fires with seasoned wood. Certified wood stoves tend to be both more efficient and produce less smoke than older models. In general, highly visible smoke out of the chimney is a bad sign. A single smoky fire can pollute an entire neighborhood in certain conditions. It is especially important to limit burning to the extent possible when local authorities raise warnings or burn bans. These notices are now being included in forecasts available from the National Weather Service and are being better communicated by the media. For those with special interest in short-term forecasts of air quality in the Pacific Northwest, Washington State University provides a web site (http://lar.wsu.edu/airpact-3/) with predictions using state-of-the-art atmospheric and chemical models. This information may be especially relevant to those with compromised respiratory systems in that it can be used to help limit the exposure to air pollution.

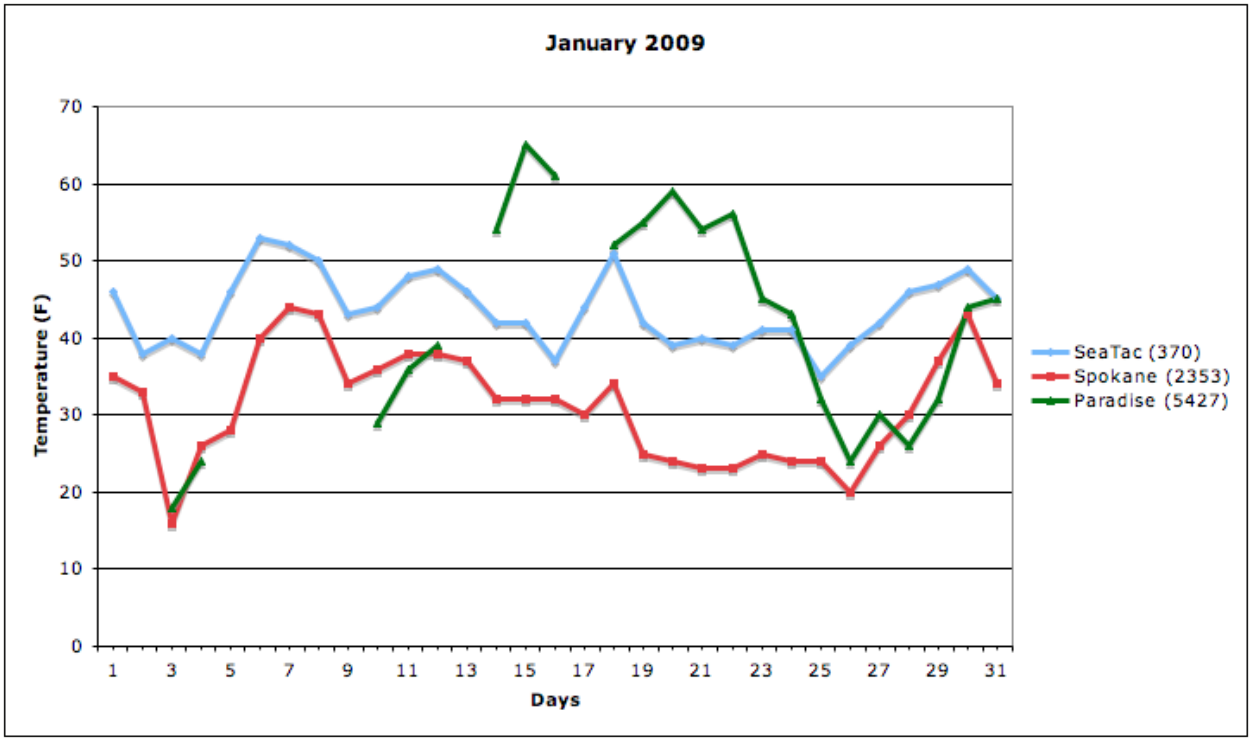


Figure 2: Daily maximum temperatures at SeaTac, Spokane, and Paradise Rainier during January 2009. The elevation of each station is shown in parenthesis in the legend.

Climate Outlook

La Niña conditions are still present across the equatorial Pacific according to the Climate Prediction Center (http://www.cpc.noaa.gov/products/precip/CWlink/MJO/enso.shtml), and is expected to last through spring. The La Niña is reflected in the CPC seasonal outlooks featured below.

The January-February-March (JFM) three-class outlook calls for colder than normal temperatures for the entire state. The western half of the state has higher chances of below normal temperature (exceeding 50% on the three-class system) than the eastern half (exceeds 40%). With regards to precipitation, the entire state is relatively likely to be significantly wetter than normal (i.e., at least a 40% chance using the three-class system).

The February-March-April CPC three-class outlook is essentially the same as the JFM outlook. Below normal temperatures are expected for the entire state (chances exceeding 50%). The precipitation outlook has higher odds than usual for above normal precipitation for the entire state (i.e., at least 40%).

January-February-March outlook for temperature (left) and precipitation (right) from the CPC.

February-March-April outlook for temperature (left) and precipitation (right) from the CPC.

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