



North Coast and Cascades Network Climate Monitoring Report

Lewis and Clark National Historical Park; Water Year 2011

Natural Resource Data Series NPS/NCCN/NRDS—2013/537



ON THE COVER

Crescent Beach and rocky headlands south of Ecola Point, Ecola State Park, Lewis and Clark National Historic Park.
Photograph by: Bill Baccus

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The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Data Series is intended for the timely release of basic data sets and data summaries. Care has been taken to assure accuracy of raw data values, but a thorough analysis and interpretation of the data has not been completed. Consequently, the initial analyses of data in this report are provisional and subject to change.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner. This report received informal peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available from the North Coast and Cascades Network Inventory and Monitoring website (<http://science.nature.nps.gov/im/units/nccn/reportpubs.cfm>) and the Natural Resource Publications Management website (<http://www.nature.nps.gov/publications/nrpm/>). To receive this report in a format optimized for screen readers, please email irma@nps.gov.

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Contents

	Page
Contents	iii
Figures.....	v
Tables	vii
Executive Summary	ix
Acknowledgments.....	x
Acronyms.....	xi
Glossary	xii
Introduction.....	1
Methods.....	3
Station Locations	3
Weather Station Measurements	4
Data Quality Assurance and Control	5
<i>Water Year 2011 Data Quality</i>	5
Data Reporting.....	6
Results.....	7
Temperature.....	7
Precipitation.....	13
Wind	18
Literature Cited	19

Figures

	Page
Figure 1. North Coast and Cascades Network National Parks (NCCN).....	2
Figure 2. Location of weather stations referenced in this report.	4
Figure 3. Comparison of average monthly temperature (°F) for Astoria, OR (ASOS, COOP) in Water Year 2011 against monthly averages for the climatological normal 1971-2000.	9
Figure 4. Comparison of average monthly temperature (°F) for Long Beach, WA (COOP) in Water Year 2011 against monthly averages for the climatological normal 1971-2000.	9
Figure 5. Snow at Fort Clatsop, February 24, 2011.....	11
Figure 6. Daily average air temperature (°F) at Fort Clatsop, OR, Water Year 2011.	12
Figure 7. Daily average air temperature (°F) at Astoria, OR, Water Year 2011.	12
Figure 8. Daily average air temperature (°F) at Long Beach, WA, Water Year 2011.....	13
Figure 9. Comparison of total monthly precipitation (inches) as a percent of normal at Astoria, OR COOP in Water Year 2011 against the climatological normal 1971-2000.....	15
Figure 10. Comparison of total monthly precipitation (inches) as a percent of normal at the Long Beach, WA COOP Station in Water Year 2011 against the climatological normal 1971-2000.....	15
Figure 11. Comparison of monthly precipitation values for four stations within or adjacent to Lewis and Clark National Historical Park in Water Year 2011.	16
Figure 12. Daily precipitation (inches) at Fort Clatsop, OR, Water Year 2011.	16
Figure 13. Daily precipitation (inches) at Long Beach, WA, Water Year 2011.....	17
Figure 14. Daily precipitation (inches) at Astoria, OR, Water Year 2011.	17
Figure 15. Maximum daily wind speed (mph) at Astoria, OR, Water Year 2011.....	18

Tables

	Page
Table 1. Weather stations referenced in this report.....	3
Table 2. Parameters measured at weather stations included in this report.....	5
Table 3. Average monthly air temperatures (°F) from weather stations within or adjacent to Lewis and Clark National Historical Park in Water Year 2011.	8
Table 4. Air temperature extremes at Astoria, OR, Water Year 2011.	10
Table 5. Air temperature extremes at Fort Clatsop, OR, Water Year 2011.	10
Table 6. Air temperature extremes at Long Beach, OR, Water Year 2011.	10
Table 7. Average maximum and minimum daily air temperatures (°F) for each month from weather stations within or adjacent to Lewis and Clark National Historical Park in Water Year 2011.	11
Table 8. Total monthly precipitation (inches) from weather stations within or adjacent to Lewis and Clark National Historical Park in Water Year 2011.	14

Executive Summary

Climate and weather events define the ecological characteristics found in National Parks and are key to understanding and interpreting changes in natural resources. Everyday park operations including fire management, natural resource activities, maintenance of park infrastructure, and visitor use are influenced by weather. Monitoring weather and maintaining climate records provides essential information to support park operations and monitor park resources.

This report summarizes climate data collected at weather stations within and adjacent to Lewis and Clark National Historical Park from the 2011 water year. It is part of a set of climate summary reports from seven national and historic parks in the North Coast and Cascades Network. Published in the National Park Service's Natural Resource Data Series, annual climate summary reports are intended to provide basic data sets and data summaries in a timely manner, with minimal interpretation and analyses. We envision National Park staff, especially planners, scientists, and interpreters; partners; and interested public as the primary audience for these reports.

Temperature and precipitation data are presented from four weather stations located along the Pacific Coast from Northern Oregon to Southern Washington. Data were recorded using automated and manual instruments operated by the National Weather Service, Federal Aviation Administration, and National Park Service. For two stations with long term records, the Astoria Regional Airport Automated Surface Observing Systems (ASOS)/Cooperative Observer (COOP) Station and Long Beach COOP Station, monthly average temperatures and monthly total precipitation are reported and compared to the 30-year normal. For all stations, monthly temperature and precipitation data are displayed. Daily precipitation and average daily temperature are presented for three stations.

Water Year 2011 had near normal temperatures and slightly above normal precipitation. At Astoria and Long Beach, temperatures were -0.8 and -0.7°F cooler than normal, respectively. Total annual precipitation at Astoria was 81.5 inches, 121% of normal. Total annual precipitation at Long Beach was 90.0 inches, 111% of normal. Seasonal highlights include both a wetter and cooler than normal spring. The average total precipitation for Washington State for spring was the wettest in the 117-year record while Oregon State recorded the second wettest average total spring precipitation in the 117-year record (NOAA 2011).

Acknowledgments

The National Park Service relies on the National Weather Service Cooperative Observer Program and the Federal Aviation Administration and Department of Defense – Automated Surface Observing Systems to help support and maintain a long-term climate monitoring program as part of the North Coast and Cascades Network (NCCN) climate monitoring program.

Data management is critical to provide for the availability and analysis of climate data. We rely on the NCCN Data Managers, specifically John Boetsch and Bret Christoe; the Western Regional Climate Center; and the National Climate Data Center for climate data management.

Acronyms

ASOS	Automated Surface Observing Systems
COOP	Cooperative Observer Station
FAA	Federal Aviation Administration
I&M	Inventory and Monitoring
LEWI	Lewis and Clark National Historical Park
NCCN	North Coast and Cascades Network
NCDC	National Climatic Data Center
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NWS	National Weather Service
PNW	Pacific Northwest
WRCC	Western Regional Climate Center

Glossary

ASOS: The Automated Surface Observing Systems program is a joint effort of the National Weather Service, the Federal Aviation Administration and the Department of Defense. The program operates a network of automated weather stations at airports nationwide, for the purpose of supporting weather forecast activities and aviation operations.

Climate: Complete and entire ensemble of statistical descriptors of temporal and spatial properties comprising the behavior of the atmosphere. These descriptors include means, variances, frequency distributions, autocorrelations, spatial correlations and other patterns of association, temporal lags, and element-to-element relationships. The descriptors have a physical basis in flows and reservoirs of energy and mass. Climate and weather phenomena shade gradually into each other and are ultimately inseparable (Davey et al. 2006).

Climate Normals: A long-term average value of a meteorological parameter (i.e. temperature) for a certain area. For example, "temperatures are normal for this time of year" means that temperatures are at or near the average climatological value for a given time period. Normals are usually taken from data averaged over a 30-year period (e.g., 1971-2000 average), and are concerned with the distribution of data within limits of common occurrence.

Fall: the season of the year which is the transition period from summer to winter occurring as the sun approaches the winter solstice. Fall includes the months of September, October and November.

NWS-COOP: An extensive network of manually operated weather stations overseen by the National Weather Service. Many Cooperative Observer Program weather sites were established in the late 1800's and as such, provide the best long term data for understanding local climates. At each station, an observer records daily maximum and minimum temperature, as well as total rain and snowfall.

Period of Record: The total span of time that climate data have been collected at a specific location. The longer the period of record, the more likely the climate data will not be biased by singular weather events or cyclic climate anomalies such as those associated with the Pacific Decadal Oscillation.

Spring: The season of the year comprising the transition period from winter to summer occurring when the sun is approaching the summer solstice. Spring includes the months of March, April and May.

Summer: The warmest season of the year during which the sun is most nearly overhead. Summer includes the months of June, July, and August.

Water Year: The Water Year (or Hydrologic Year) is most often defined as the period from October 1st to September 30 of the following year. It is called by the calendar year in which it ends. Thus, Water Year 2011 is the 12-month period beginning October 1, 2010 and ending September 30, 2011. The period is chosen so as to encompass a full cycle of precipitation accumulation.

Weather: Instantaneous state of the atmosphere at any given time, mainly with respect to its effects on biological activities. As distinguished from climate, weather consists of the short-term (minutes to days) variations in the atmosphere. Popularly, weather is thought of in terms of temperature, precipitation, humidity, wind, sky condition, visibility, and cloud conditions (Davey et al. 2006).

Winter: Typically the coldest season of the year during which the sun is farthest from overhead. Winter includes the months of December, January and February.

Introduction

Climate is a dominant factor driving the physical and ecologic processes affecting the North Coast and Cascades Inventory and Monitoring Network (NCCN) (Davey et al. 2006). Trends in precipitation and temperature influence how an ecosystem and its organisms function. The quantity and timing of rainfall and snow can affect the productivity and health of forests (Nakawatase and Peterson 2006), the amount of water flowing in streams and rivers (Hamlet et al. 2007) or inundating wetlands. Likewise, temperature can influence many aspects of ecosystems, such as the quantity and timing of plant growth in forests and prairies (Cayan et al. 2001), distribution and migratory behavior of bird communities (Marra et al. 2005), or the thermal stress experienced by intertidal organisms along areas of rocky coastline (Tomanek and Helmuth 2002). Through direct and indirect methods, climate affects the behavior and reproduction of terrestrial and aquatic animal species (Crozier et al. 2008). Disturbance events such as forest fires, windstorms, and floods are strongly related to climate (Littell and Gwozdz 2011). These events have a major impact on park landscapes and their associated ecosystems.

Given the importance of climate, it has been identified as a primary vital sign by all 32 Inventory and Monitoring (I&M) networks within the National Park Service (Gray 2008). The NCCN specifically monitors climate in order to understand variations in other park resources being monitored, compare current and historic data to understand long-term trends, and provide data for modeling impacts to park facilities and resources in the future. Climate data, derived from the NCCN climate network will play an important role in understanding and interpreting the physical and ecological Vital Signs monitored within NCCN parks.

The NCCN climate monitoring program capitalizes on weather stations operated by partnering agencies. The NCCN climate monitoring program compiles data from over 60 weather stations in and adjacent to the parks, 15 of which are operated by the National Park Service. Although a wide variety of climate parameters are measured as part of the NCCN climate program, this report focuses on two key parameters: precipitation and air temperature.

This report summarizes climate data collected from four weather stations located in and adjacent to Lewis and Clark National Historical Park during the 2011 Water Year, and is part of a set of climate summary reports from six national and historic parks in the NCCN (Figure 1).

Annual climate summary reports are intended to provide basic data sets and data summaries in a timely manner, with minimal interpretation and analyses. National Park staff, especially park managers, scientists, and interpreters; partners; and interested public are the primary audience.



Figure 1. North Coast and Cascades Network National Parks (NCCN).

Methods

Station Locations

This report incorporates data collected from weather stations operated by the National Weather Service (COOP) and the Federal Aviation Administration (ASOS) (Table 1, Figure 2).

Table 1. Weather stations referenced in this report.

Station Name	Station Type	Location	Elevation (ft)	Forest Zone	Period of Record
Fort Clatsop	COOP	Fort Clatsop, OR	42	Coastal	1998 to Present
Astoria WSO Airport	ASOS, COOP ^a	Astoria, OR	9	Coastal	1953 to Present
Seaside	COOP	Seaside, OR	10	Coastal	1967 to Present
Long Beach Exp. Stn.	COOP	Long Beach, WA	30	Coastal	1930 to Present

^aAn ASOS was installed in March, 1993. Manual COOP observations continued until approximately 1998. Automated data from the ASOS station is used by the COOP network to continue the long term weather record.

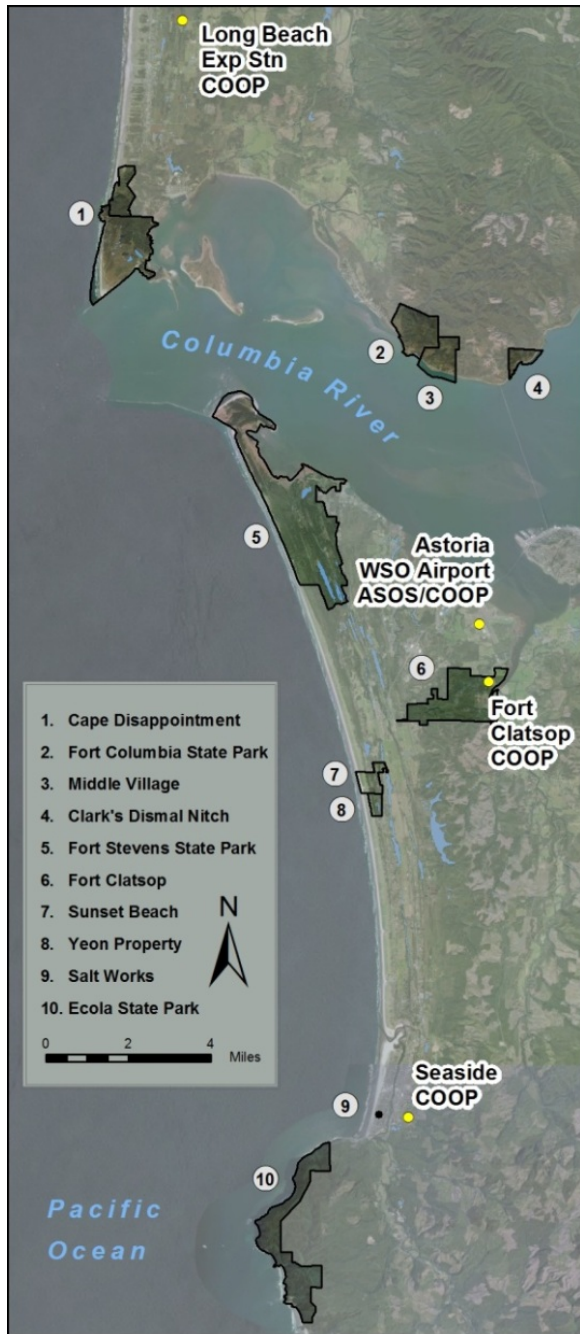


Figure 2. Location of weather stations referenced in this report.

Weather Station Measurements

Weather stations within or adjacent to LEWI are managed by several different agencies, each with a specific purpose. For this reason, instrumentation, method and period of collection vary between sites. Table 2 describes the parameters measured at each station, highlights the data which are presented in this report, and indicates which data are available by request from the NCCN.

Table 2. Parameters measured at weather stations included in this report. **X** indicates the parameter is measured and data are presented in this report; **X** indicates parameter is measured and data are available on request.

Station Name	Managing Agency - Station Type	Air Temp	Rh	Precipitation	Snow fall	Visibility/Sky Condition	Wind Speed & Direction
Fort Clatsop	NWS-COOP ¹	X		X	X		
Astoria WSO Airport ²	NWS-COOP ¹ FAA-ASOS ²	X	X	X	X	X	X
Seaside	NWS-COOP ¹	X		X	X		
Long Beach Exp Strn.	NWS-COOP ¹	X		X	X		

¹ National Weather Service Cooperative Stations (NWS COOP) stations rely on a standard array of manually operated weather instruments. Parameters are measured and recorded daily.

² An ASOS (Automated Surface Observing System) was added to the Astoria WSO Airport COOP in March, 1993. Wind speed and direction, visibility and sky condition are available after 1993. Manual observations continued to approximately 1998. Automated data from the ASOS station is used by the COOP network to continue the long term weather record. ASOS utilize a standard array of automated weather instruments in support of weather forecasting and aviation operations. Parameters are measured every 60 seconds, and output as hourly averages. These stations are managed and operated by the Federal Aviation Administration, National Weather Service and United States Department of Defense.

Data Quality Assurance and Control

The NWS COOP station data used in this report are acquired directly from the managing agencies. Quality assurance and control is provided by these agencies and is described in the NCCN Climate Monitoring Protocol (Lofgren et al. 2010).

Monthly values are generated and presented for stations where five or fewer daily values are missing. In the case of missing precipitation values, daily quantities may be substituted from another nearby weather station for the purposes of reporting monthly and annual totals. This will only occur when nearby data are available and a known correlation exists between these sites. In these cases where estimates are generated from nearby stations, data are footnoted and a description of the quantity and source of data replacement is given.

Water Year 2011 Data Quality

Seven days of temperature data are missing from the Fort Clatsop COOP in the month of June. Despite this, the average monthly temperature value for June is within 0.1°F of the adjacent Astoria station (Table 3). Due to this close correlation, we have included these data in the report summary. Months from November to July in 2011 from the Seaside COOP have varying degrees of data incompleteness, ranging from 7 to 14 days of missing temperature. Given the number of missing temperature data associated with the Seaside COOP, daily temperature graphs, air temperature extremes, and monthly average daily temperature maximums and minimums are not included in this report. Six days of precipitation data are missing from the Seaside COOP for the

month of September. Monthly precipitation data from the Seaside COOP are included in the report, but daily precipitation data are omitted.

Data Reporting

Data in this report are based on the hydrologic or water year and organized by month and seasons. Ecosystems in the Pacific Northwest are dominated by two distinct hydrological periods, a wet season generally beginning in late October and ending in June, and a drought season which extends from July to September. While a calendar year divides the wet winter season, the use of a water year (October 1 to September 30) closely reflects the timing and seasonality of many physical and ecological processes that are driven by climate, such as soil saturation, forest evapotranspiration, emergence and flowering of plants and the migratory timing of bird species.

Seasons in this report are distinguished based on National Weather Service (NWS) standards for the Northern Hemisphere. The NWS defines December, January, and February as winter; March, April, and May as spring; June, July, and August as summer; and September, October, and November as fall.

This report provides monthly averages of daily average temperatures and monthly total precipitation for four stations listed in Table 2. The data are presented in Fahrenheit and inches to easily facilitate use and interpretation by the public and park staff. Two stations with long term records: the Astoria WSO Airport ASOS/COOP located 2 miles north of Fort Clatsop, and the Long Beach Experimental Station COOP located 4 miles north of Camp Disappointment State Park are compared to the 30-year climate normal. Monthly averages of daily maximum and minimum temperatures, extreme daily maximum and minimum temperatures, and daily precipitation and temperature data are presented for the Astoria WSO Airport ASOS/COOP, Fort Clatsop COOP, and Long Beach Experimental Station COOP. Maximum daily wind speed is presented for the Astoria WSO Airport ASOS/COOP.

Results

Temperature

Mean annual temperatures were slightly below normal at weather stations adjacent to LEWI (Table 3). At Astoria, OR and Long Beach, WA temperatures were -0.8 and -0.7°F cooler than normal (1971-2000), respectively. Data collected at Fort Clatsop reflected mean annual temperatures -0.7°F cooler than the period of record (1998-2010).

Above normal temperatures were recorded at all stations in October. Overall, temperatures were colder than normal in November due to a cold air mass that arrived near the end of the month. Following a warmer than normal December (departures of +1.7° and +1.8°F at Astoria and Long Beach, respectively), cooler than normal temperatures dominated for the remainder of winter and all of spring. February had the highest observed deviation with a departure of -3.7°F at both Astoria and Long Beach (Figures 3 and 4). On average, the summer season was near normal. July was slightly cooler than normal. Temperatures in September ranged from near normal at Long Beach to slightly above normal at Astoria. Average monthly minimum and maximum daily air temperatures ranged from a low of 33.4°F in February at Fort Clatsop and Long Beach to a high of 70.9°F in August at Fort Clatsop (Table 7).

There were two prolonged cold periods in Water Year 2011, the most extreme in late November and a milder cold-event in late February (Figures 6-8). Fort Clatsop recorded an absolute low of 20°F on November 24 (Table 5) while Astoria recorded a low of 21°F (Table 4). On February 26, Long Beach recorded its absolute low of 20°F (Table 5). The cool February temperatures brought snow to the area (Figure 5). The date of absolute maximum temperatures were not associated with any particular summer period and varied between sites (Tables 4-6). The highest recorded temperature was 85°F at Fort Clatsop on August 20, 2011.

Table 3. Average monthly air temperatures (°F) from weather stations within or adjacent to Lewis and Clark National Historical Park in Water Year 2011.

Season	Month & Year	Astoria ASOS/COOP	Long Beach COOP	Fort Clatsop COOP	Seaside COOP
Fall	October 2010	53.1	52.1	53.4	52.5
	November 2010	44.7	44.6	44.7	---- ^b
Winter	December 2010	44.5	43.8	43.7	---- ^b
	January 2011	42.3	41.9	42.3	---- ^b
	February 2011	40.6	39.7	39.8	---- ^b
	March 2011	45.1	44.5	44.8	---- ^b
Spring	April 2011	44.9	44.9	45.7	---- ^b
	May 2011	50.2	50.2	49.8	---- ^b
Summer	June 2011	56.7	56.1	56.8 ^a	---- ^b
	July 2011	59.1	58.3	60.1	---- ^b
	August 2011	61.0	59.6	61.5	59.8
Fall	September 2011	59.7	57.3	60.5	57.6
Water Year		50.1	49.4	50.3	---- ^b
Period of Record 1971-2000		51.0	50.0	----	52.6

a Seven days of temperature data are missing from the Fort Clatsop COOP for the month of June.

b More than 5 days of temperature data from the Seaside COOP are missing from November-July.

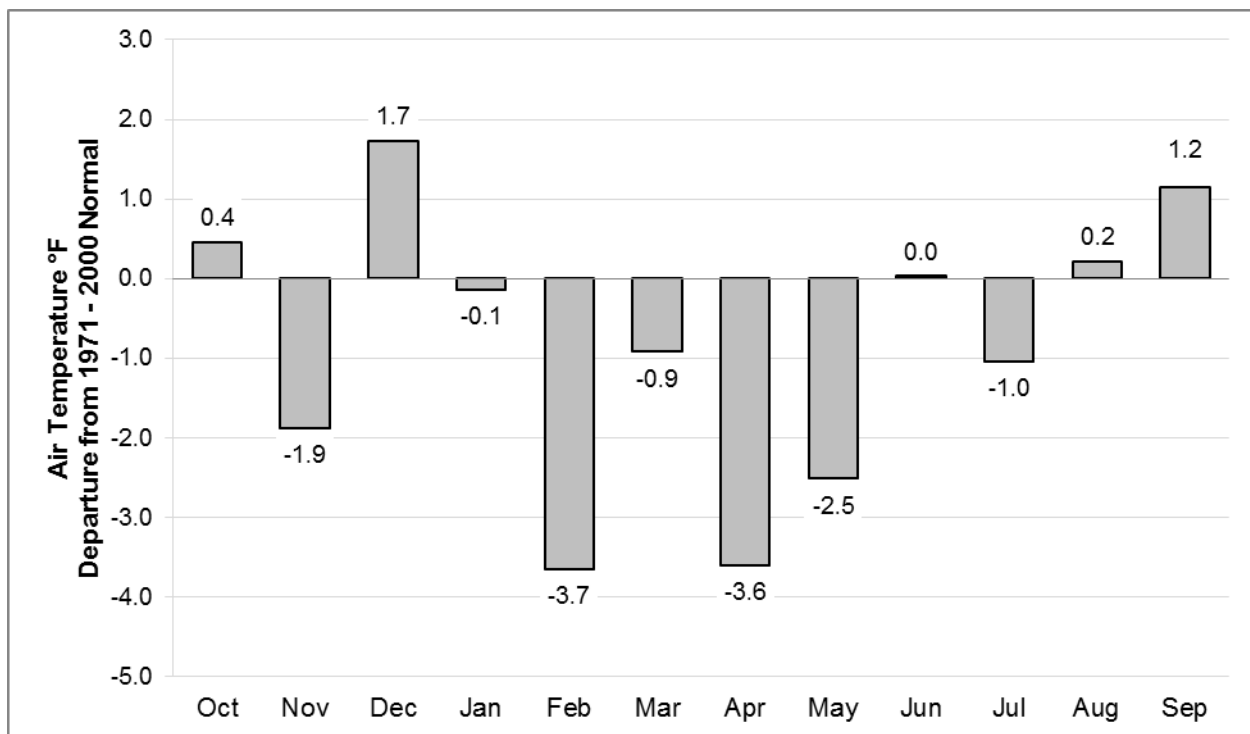


Figure 3. Comparison of average monthly temperature (°F) for Astoria, OR (ASOS, COOP) in Water Year 2011 against monthly averages for the climatological normal 1971-2000.

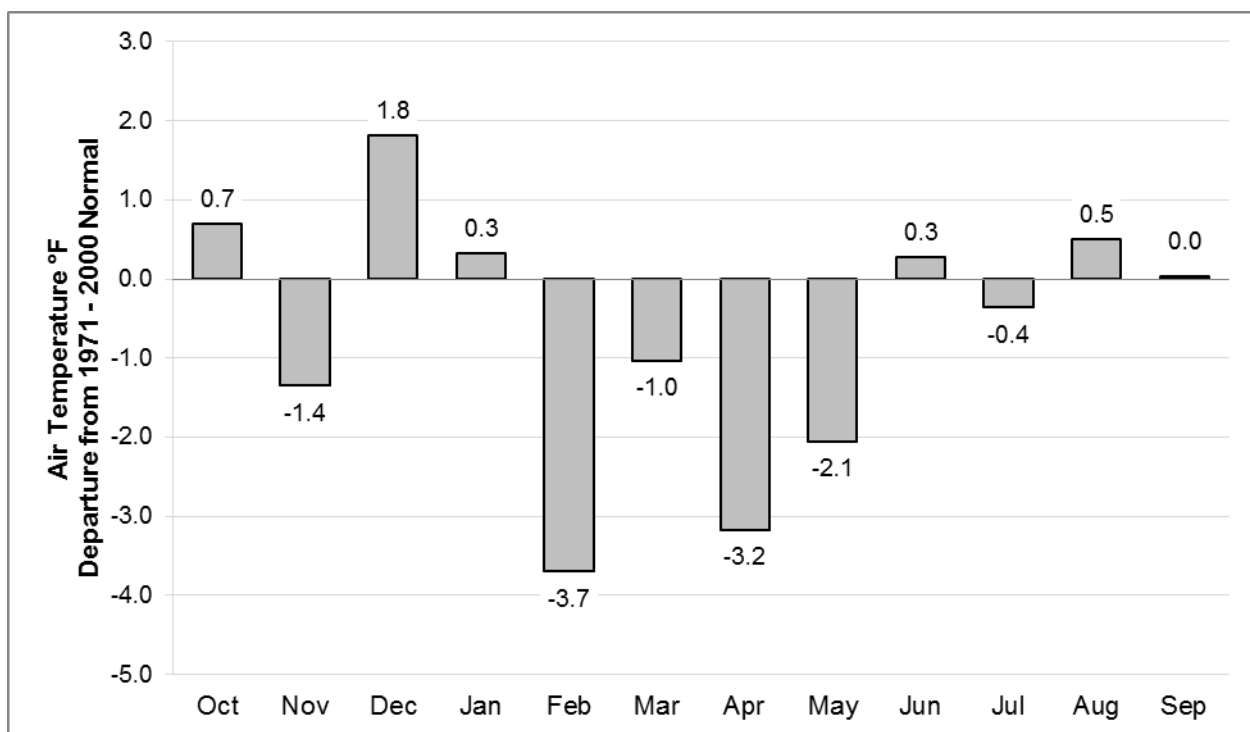


Figure 4. Comparison of average monthly temperature (°F) for Long Beach, WA (COOP) in Water Year 2011 against monthly averages for the climatological normal 1971-2000.

Table 4. Air temperature extremes at Astoria, OR, Water Year 2011.

Date	Max Air Temp °F	Date	Min Air Temp °F
September 3, 2011	84.0	November 24, 2010	21.0
August 20, 2011	82.0	February 26, 2011	21.0
September 10, 2011	82.0	November 23, 2010	23.0
September 29, 2011	79.0	January 4, 2011	25.0
June 4, 2011	78.1	February 20, 2011	25.0

Table 5. Air temperature extremes at Fort Clatsop, OR, Water Year 2011.

Date	Max Air Temp °F ^{1,2}	Date	Min Air Temp °F ¹
August 20, 2011	85	November 24, 2010	20
June 5, 2011	83	February 26, 2011	20
September 4, 2011	83	November 23, 2010	23
September 10, 2011	83	December 31, 2010	26
September 8, 2011	81	February 25, 2011	28

¹ Extreme temperatures at Fort Clatsop are presented in whole numbers due to the precision and recording practices at manually operated NWS COOP stations. Standard practice at these sites is to record daily temperatures to the nearest whole number.

² Seven days of temperature data are missing from the Fort Clatsop COOP for the month of June. Actual maximum air temperatures may have been missed.

Table 6. Air temperature extremes at Long Beach, OR, Water Year 2011.

Date	Max Air Temp °F ¹	Date	Min Air Temp °F ¹
October 1, 2010	82	February 26, 2011	20
September 4, 2011	80	November 24, 2010	22
October 7, 2011	76	November 23, 2010	23
June 5, 2011	75	December 31, 2011	23
September 30, 2011	75	January 3, 2011	24

¹ Extreme temperatures at Long Beach are presented in whole numbers due to the precision and recording practices at manually operated NWS COOP stations. Standard practice at these sites is to record daily temperatures to the nearest whole number.



Figure 5. Snow at Fort Clatsop, February 24, 2011.

Table 7. Average maximum and minimum daily air temperatures (°F) for each month from weather stations within or adjacent to Lewis and Clark National Historical Park in Water Year 2011.

Season	Month & Year	Fort Clatsop		Astoria		Long Beach	
		Average Daily Max Air Temp °F	Average Daily Min Air Temp °F	Average Daily Max Air Temp °F	Average Daily Min Air Temp °F	Average Daily Max Air Temp °F	Average Daily Min Air Temp °F
Fall	October 2010	61.8	45.0	61.2	44.9	60.5	43.7
	November 2010	50.9	38.2	50.3	39.1	50.1	39.0
Winter	December 2010	48.4	39.0	49.2	39.9	47.8	39.6
	January 2011	47.4	37.2	47.7	36.8	47.2	36.6
	February 2011	46.1	33.4	46.7	34.4	46.0	33.4
Spring	March 2011	50.8	38.9	50.7	39.5	50.2	38.8
	April 2011	52.8	37.9	51.6	38.2	51.8	38.1
	May 2011	59.3	40.3	57.2	43.2	56.7	43.7
Summer	June 2011	64.7 ^a	48.9 ^a	62.9	50.5	61.6	50.6
	July 2011	68.5	51.7	65.9	52.2	64.0	52.7
	August 2011	70.9	52.0	68.2	53.8	66.2	53.1
Fall	September 2011	70.3	50.7	68.3	51.0	65.9	48.7
Water Year		57.7	42.8	56.7	43.6	55.7	43.2

^a Seven days of temperature data are missing at the Fort Clatsop COOP for the month of June.

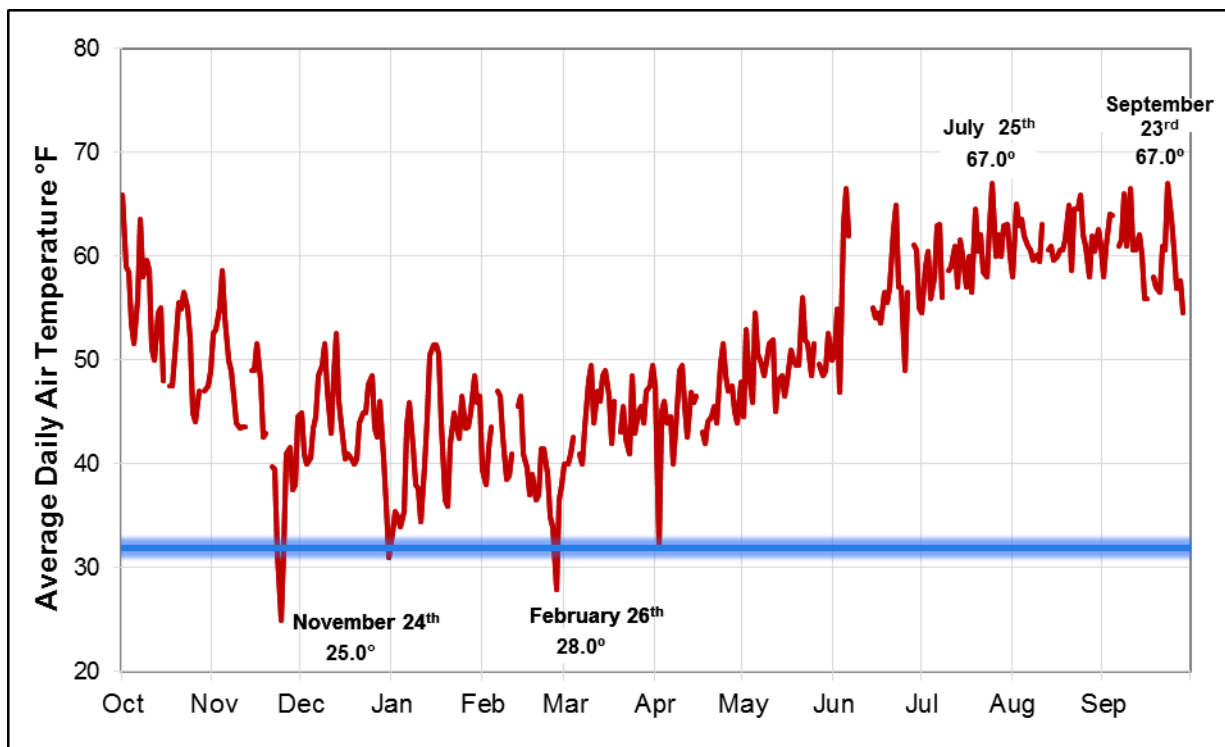


Figure 6. Daily average air temperature (°F) at Fort Clatsop, OR, Water Year 2011. Blue line indicates 32°F, the freezing point of water. Seven days of temperature data are missing for the month of June.

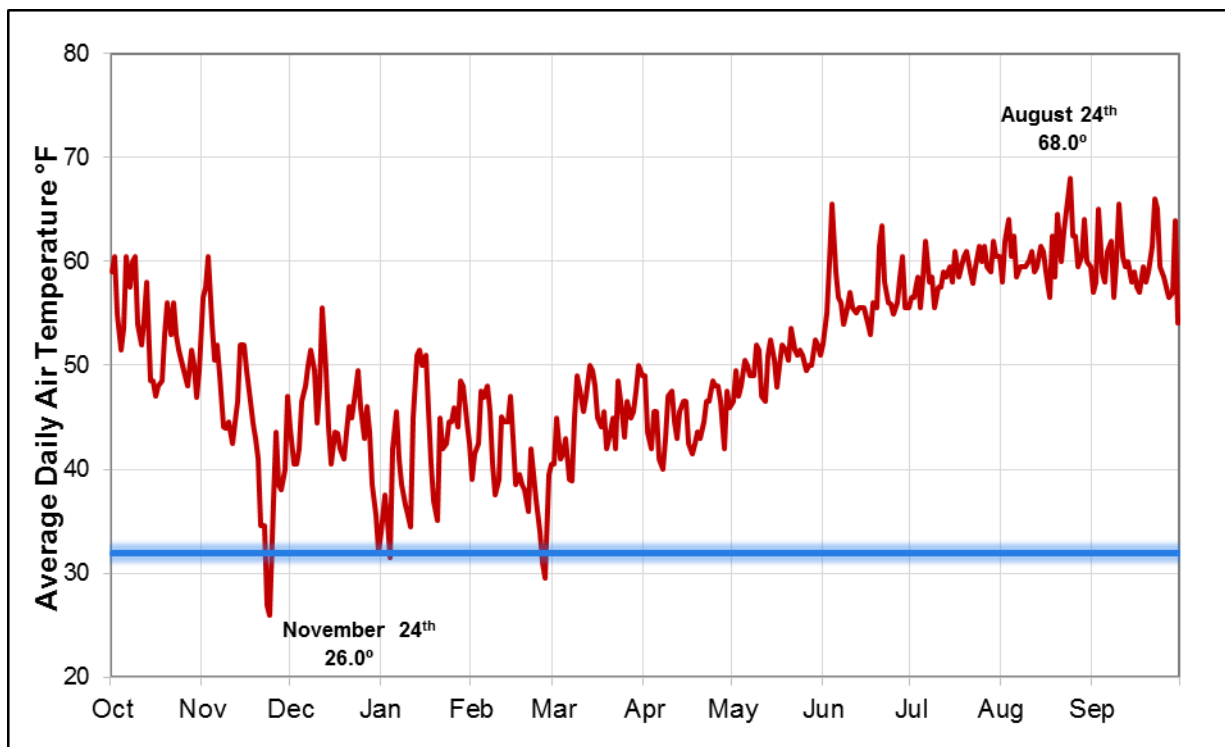


Figure 7. Daily average air temperature (°F) at Astoria, OR, Water Year 2011. Blue line indicates 32°F, the freezing point of water.

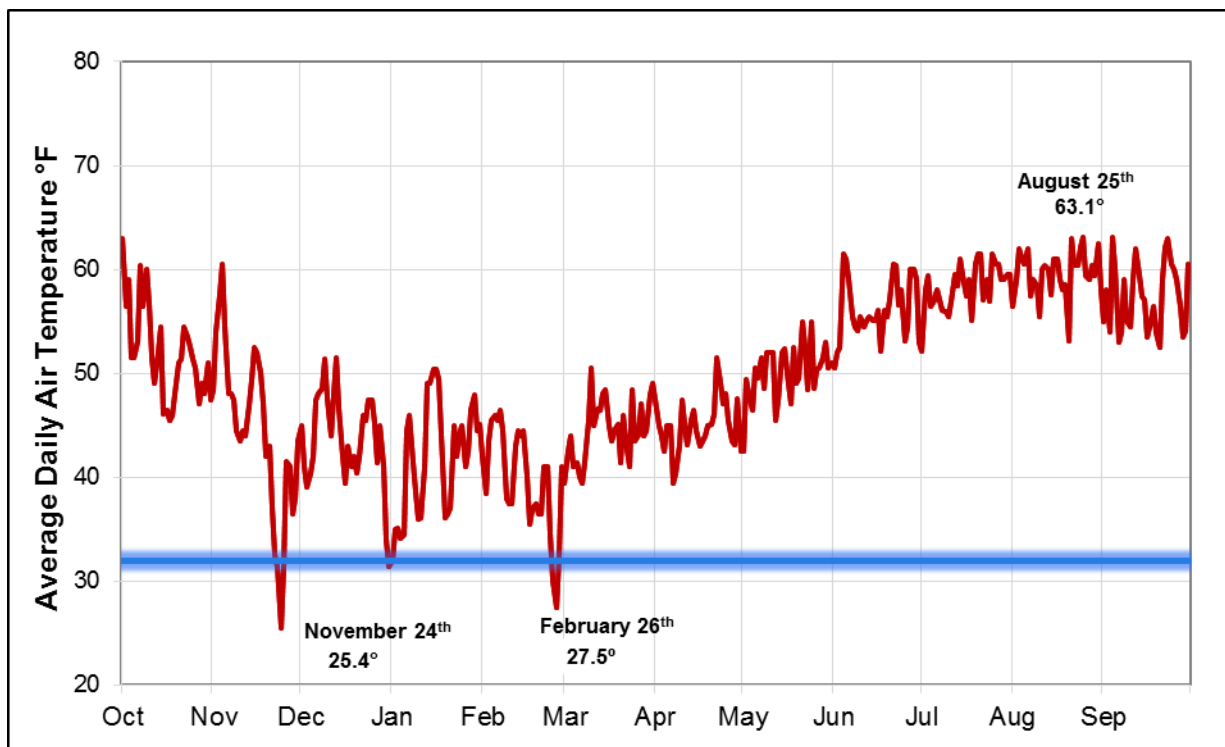


Figure 8. Daily average air temperature (°F) at Long Beach, WA, Water Year 2011. Blue line indicates 32°F, the freezing point of water.

Precipitation

Annual precipitation in Water Year 2011 was above normal at weather stations within and adjacent to LEWI: Astoria, OR received 81.5 inches, 121% of normal; Long Beach, WA received 90.0 inches, 111% of normal (1971-2000); and Fort Clatsop received 92.3 inches of precipitation, 116% compared to the period of record (1998-2010) (Table 8).

Above-normal precipitation persisted from October through May, with the exception of February when conditions were slightly below normal. Wet conditions dominated during the spring months (March, April, and May), with Astoria averaging 148% of normal and Long Beach averaging 145% of normal (Figures 9 and 10). This wet period paralleled statewide average precipitation totals in Washington and Oregon where the wettest and second wettest spring periods were recorded in 117-years, respectively (NOAA, 2011). Precipitation was slightly below normal in June followed by wetter than normal conditions in July. August brought the first extended period of dry weather for the area with no station receiving more than 0.4 inches of rain for the month. Precipitation this low is unusual for August; Astoria and Long Beach weather stations were 7% and 21% of normal for the month, respectively. Conditions in September ranged from near normal to slightly above normal. Monthly totals varied only slightly between weather stations; December had the largest difference in monthly precipitation (Figure 11).

The wettest day of the year occurred on January 16, 2011 when Fort Clatsop received 3.3 inches and Long Beach received 3.3 inches (Figures 12 and 13). Astoria Regional Airport received 3.6 inches over a two day period from January 15-16 (Figure 14). The difference in timing of total precipitation values between Astoria is likely due to the timing of data collection. Daily rainfall

totals are measured at midnight at the Astoria Regional Airport and at 10:00 am at the Fort Clatsop COOP.

Table 8. Total monthly precipitation (inches) from weather stations within or adjacent to Lewis and Clark National Historical Park in Water Year 2011.

Season	Month & Year	Astoria ASOS/ COOP	Long Beach COOP	Fort Clatsop COOP	Seaside COOP
Fall	October 2010	8.0	7.8	8.4	7.4
	November 2010	12.5	13.2	14.1	12.9
Winter	December 2010	11.4	14.7	12.8	15.9
	January 2011	12.2	12.2	13.3	13.3
	February 2011	7.4	7.8	7.6	7.8
	March 2011	11.9	13.3	13.9	10.7
Spring	April 2011	8.0	8.4	9.2	10.3
	May 2011	4.0	4.8	4.8	5.1
Summer	June 2011	1.7	1.9	2.3	2.3
	July 2011	1.4	2.3	2.1	1.8
	August 2011	0.1	0.4	0.2	0.1
Fall	September 2011	3.0	3.3	3.7	2.8 ^a
Water Year		81.5	90.0	92.3	90.4
Period of Record 1971-2000		67.1	81.2	----	75.8

^a Six days of precipitation data are missing from the Seaside COOP for the month of September.

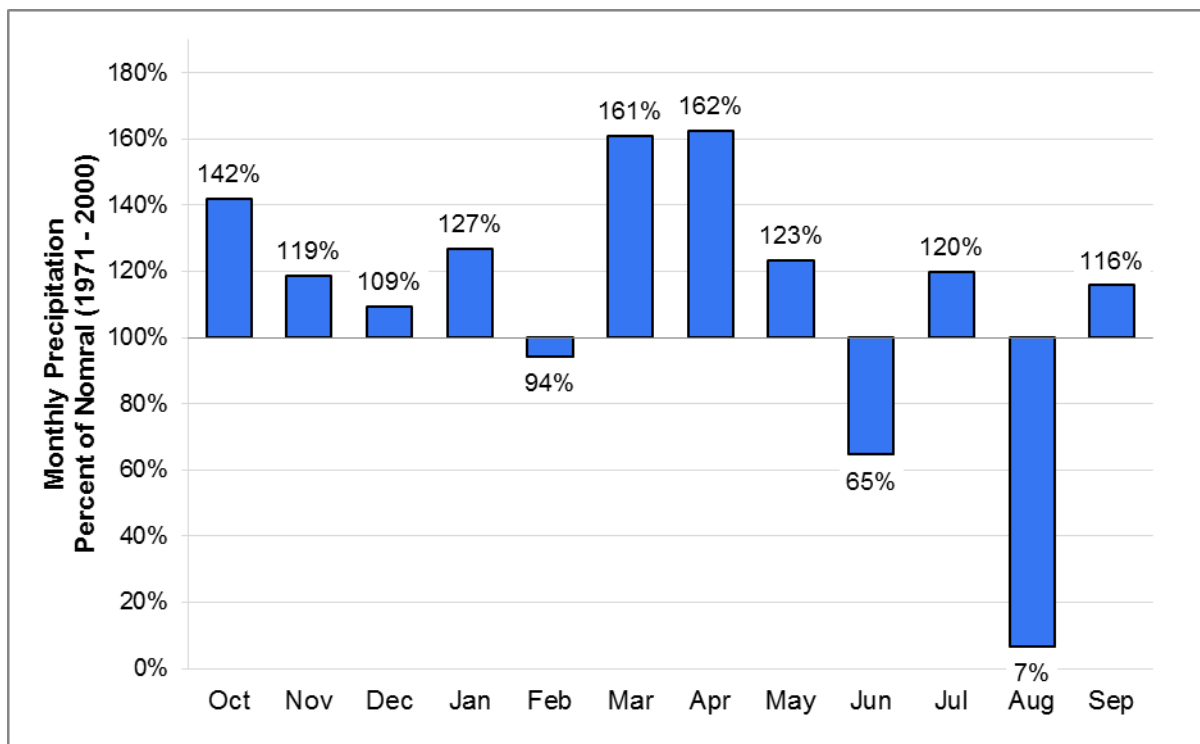


Figure 9. Comparison of total monthly precipitation (inches) as a percent of normal at Astoria, OR COOP in Water Year 2011 against the climatological normal 1971-2000.

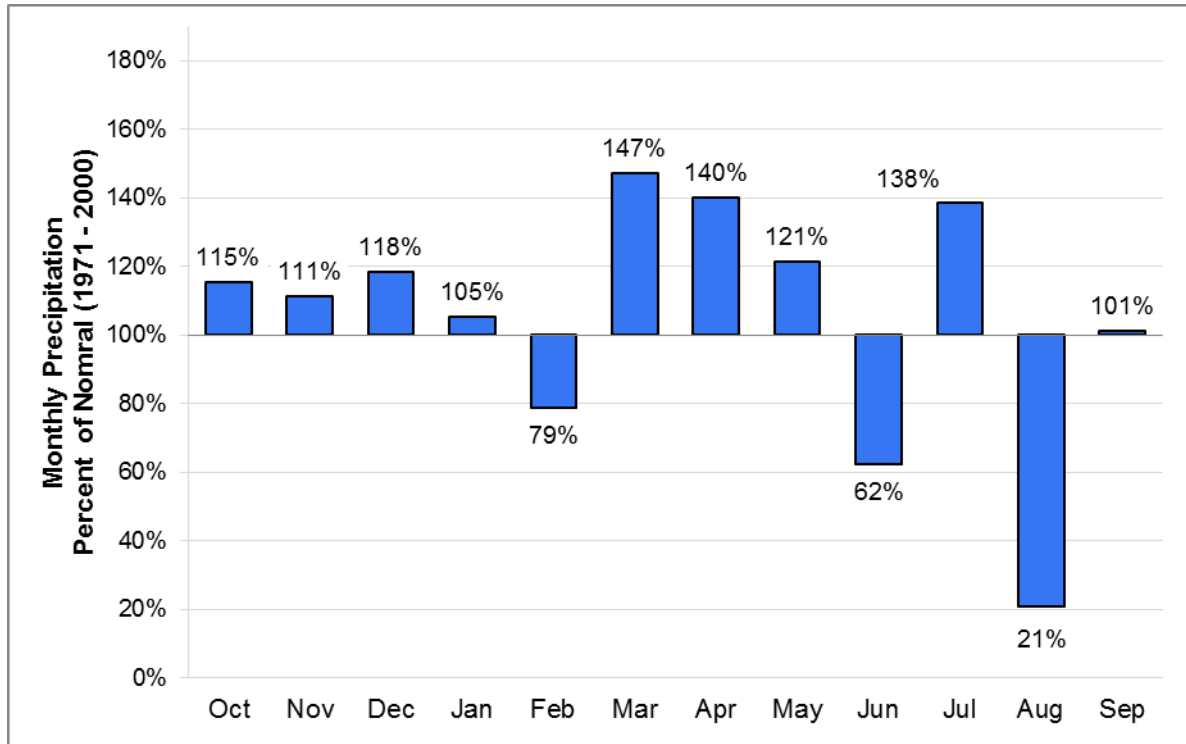


Figure 10. Comparison of total monthly precipitation (inches) as a percent of normal at the Long Beach, WA COOP Station in Water Year 2011 against the climatological normal 1971-2000.

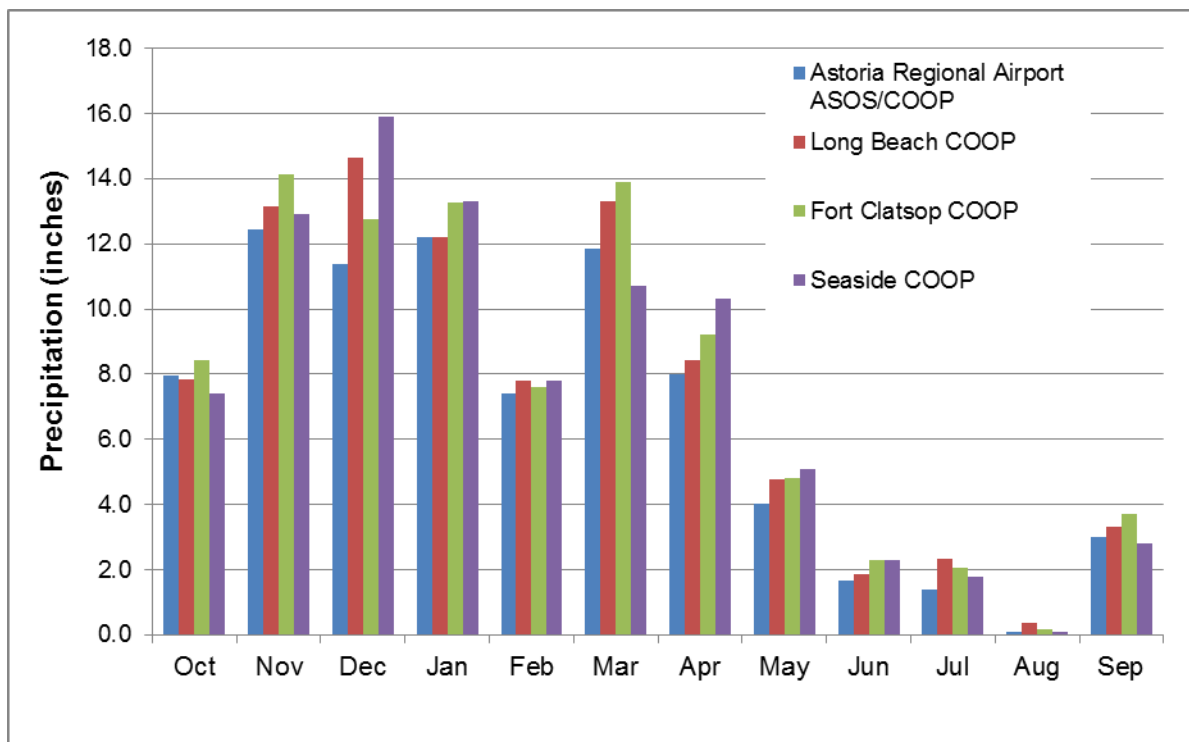


Figure 11. Comparison of monthly precipitation values for four stations within or adjacent to Lewis and Clark National Historical Park in Water Year 2011.

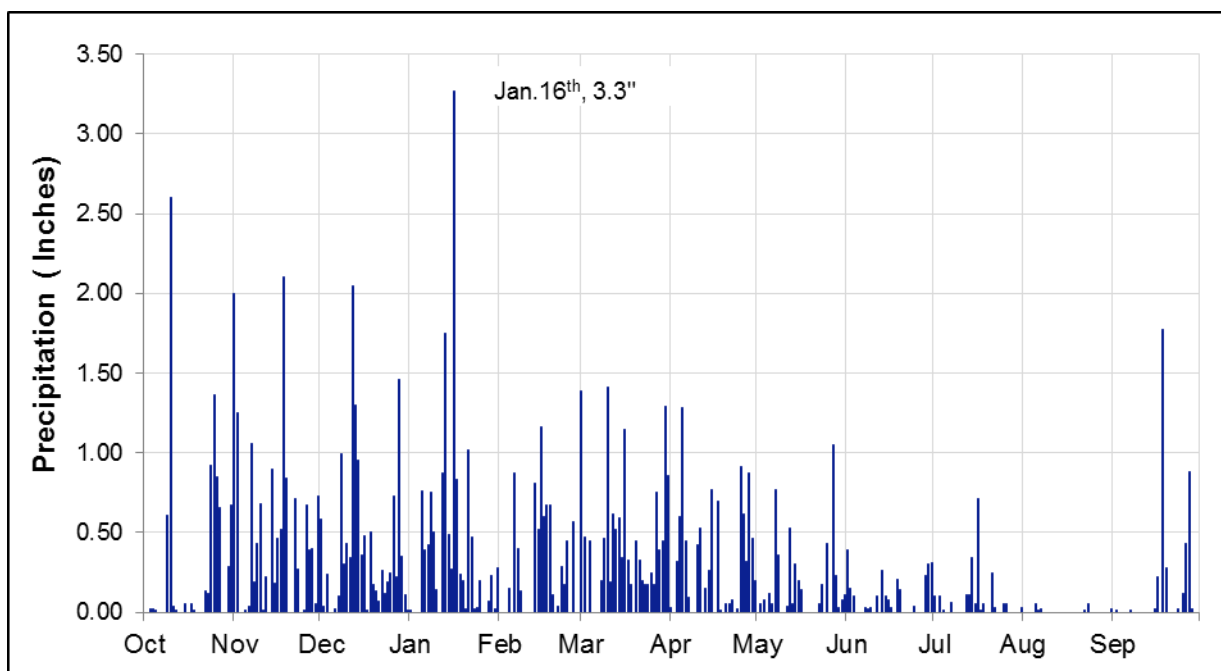


Figure 12. Daily precipitation (inches) at Fort Clatsop, OR, Water Year 2011. Daily rainfall totals are collected at 10am.

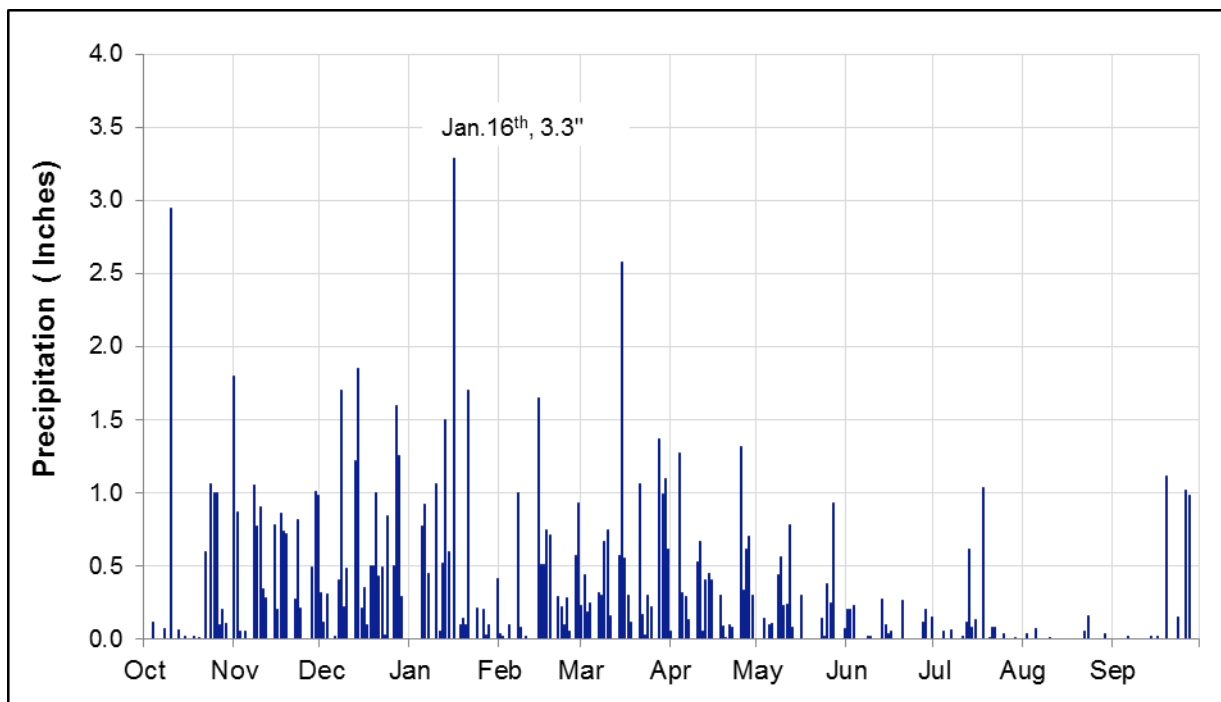


Figure 13. Daily precipitation (inches) at Long Beach, WA, Water Year 2011. Precipitation values are collected hourly.

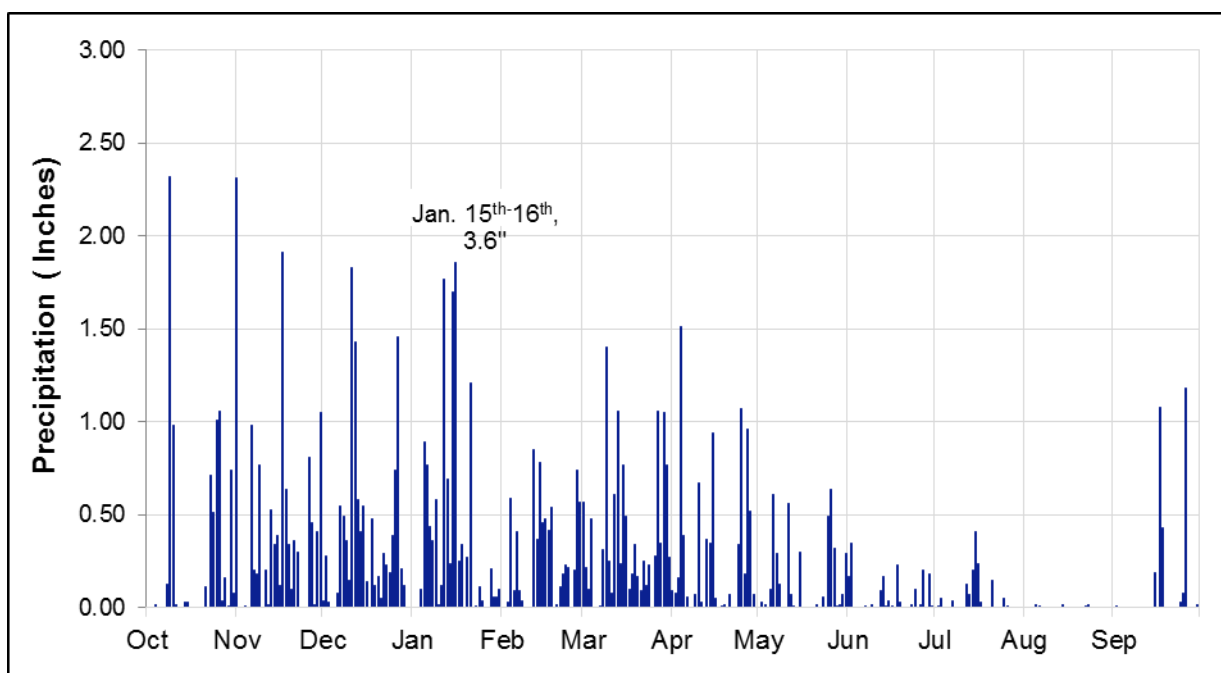


Figure 14. Daily precipitation (inches) at Astoria, OR, Water Year 2011. Daily rainfall totals are collected at midnight.

Wind

Maximum daily wind recorded at the Astoria Regional Airport in Water Year 2011 ranged from a low of 5.8 mph to a high of 41.4 mph recorded on February 14th (Figure 15). The strongest winds occurred from November to early March, with 16 days experiencing daily maximum winds >30 mph, whereas the daily maximum wind speed did not exceed >30 mph from mid-April through October.

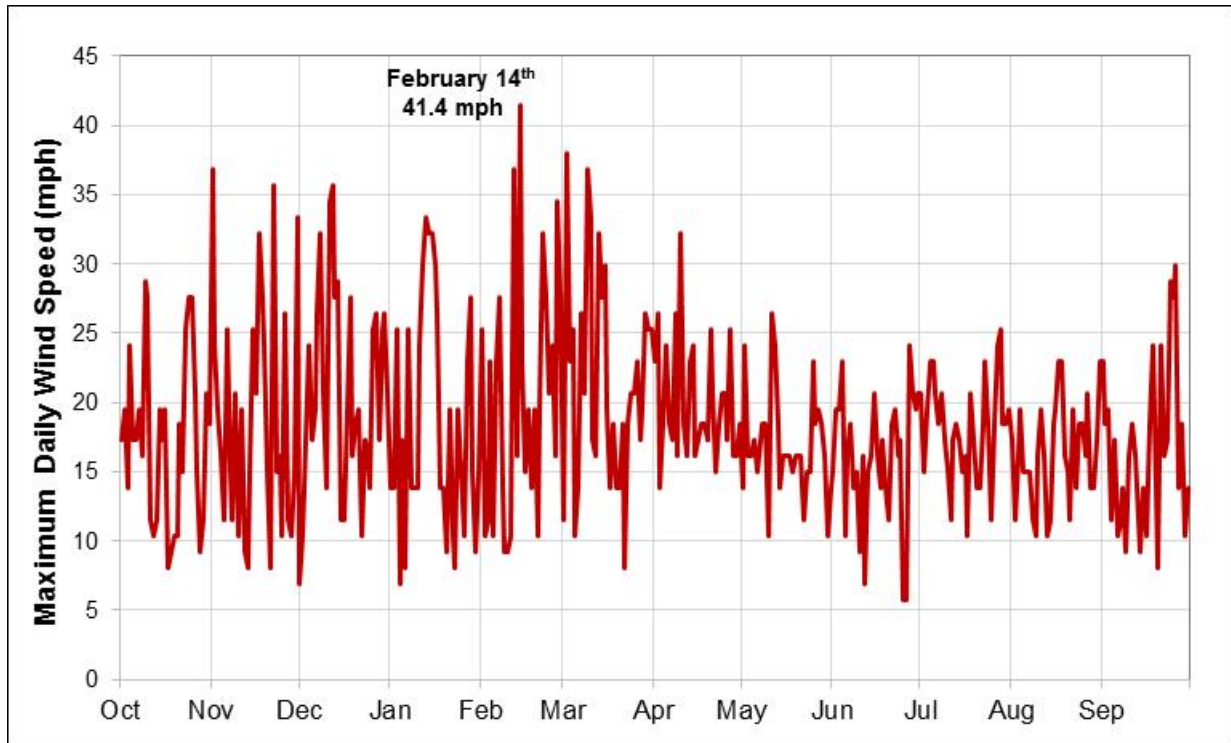


Figure 15. Maximum daily wind speed (mph) at Astoria, OR, Water Year 2011.

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