The following information on expected future climate in the Pacific Northwest has been excerpted from: Ch. 27. Northwest. In: *Fifth National Climate Assessment*. Crimmins, A.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, B.C. Stewart, and T.K. Maycock, Eds. U.S. Global Change Research Program, Washington, DC, USA. https://doi.org/10.7930/NCA5.2023.CH27

The Northwest—Washington, Oregon, and Idaho—encompasses diverse communities, economies, and ecosystems, with almost 14 million residents.[1] From western coastal regions to forested mountains to arid shrub-steppe, the Northwest is home to numerous culturally and economically important native plants and animals. Northwest ecosystems provide housing, recreation, food, and income that support the collective health and well-being of the region's communities and economies. The 43 Federally Recognized Tribes in the Northwest also rely on the region's ecosystems to sustain their livelihoods. Climate change has already affected all areas in the Northwest and will continue transforming the region in consequential ways. Northwest communities are employing a variety of strategies to adapt to and prepare for climate change; however, there are limits to the long-term effectiveness of adaptation actions without comparable investments to mitigate climate change (KM 31.1).[2,3]

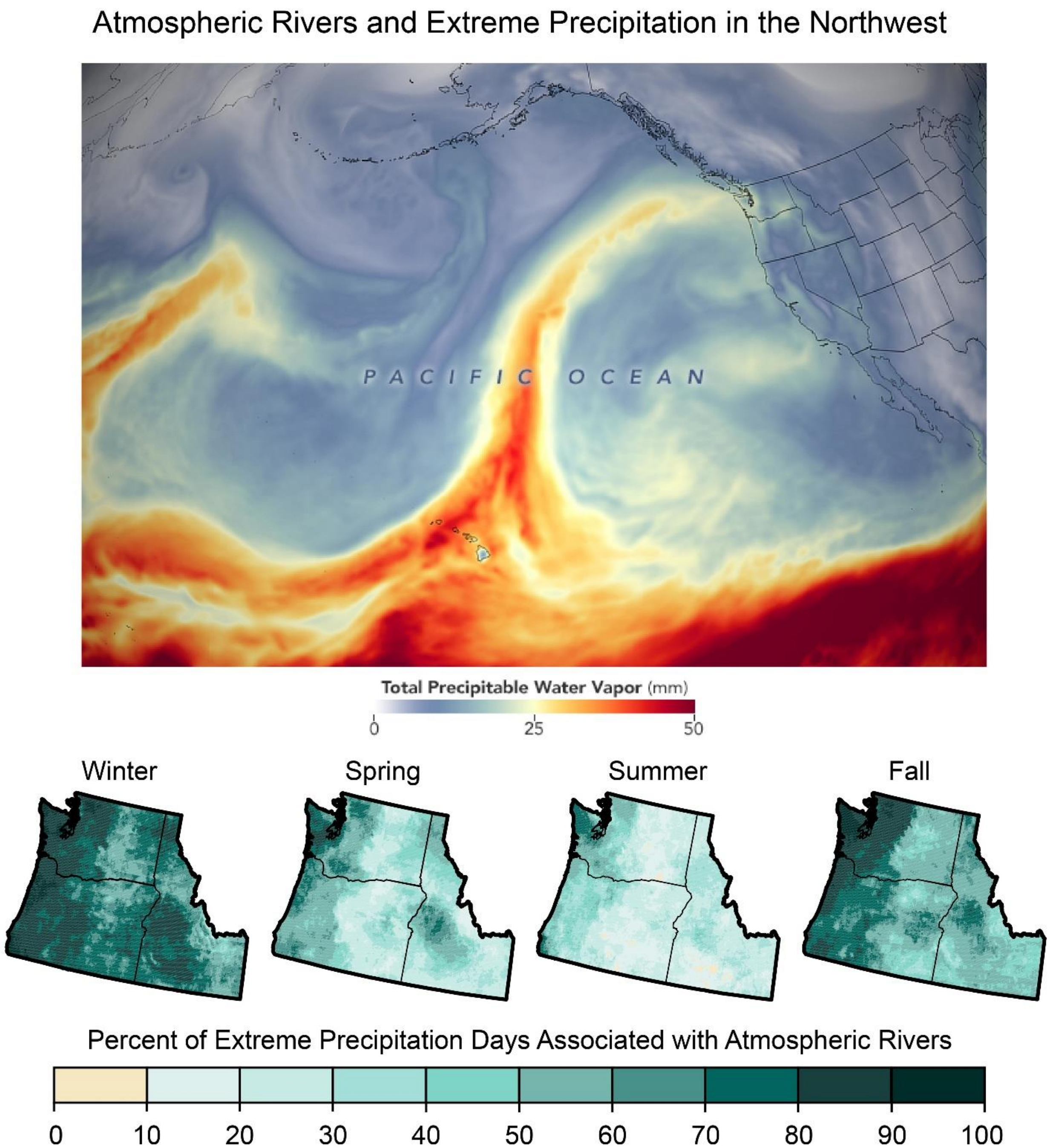
Climate change observations in the Northwest are consistent with projections from previous National Climate Assessments.[4,5,6] Annual average air temperatures in the region have risen by almost 2°F since 1900. Washington and Idaho have warmed by nearly 2°F, and Oregon has warmed by 2.5°F. Relative to 1900–2020, the annual number of extremely hot days and warm nights in the Northwest has been above the long-term average over the past decade, and the annual number of extremely cold nights over the same period has been below the long-term average.[7,8] By the 2080s, annual average temperatures in the Northwest are projected to increase by an average of 4.7°F under a low scenario (SSP1-2.6) and by an average of 10.0°F under a very high scenario (SSP5-8.5) relative to the period 1950–1999.[9] Future warming in the region is expected to exacerbate regional heatwave intensities (KM 27.5).[8,10]

Warmer winter temperatures have led to declines in mountain snowpack, particularly in areas with warm maritime climates.[11,12,13,14] A greater proportion of winter precipitation is projected to fall as rain rather than snow.[15] Warmer winter temperatures are expected to increase snow-line elevation, contributing to snow-dominated watersheds transitioning to mixed rain-and-snow watersheds and mixed rain-and-snow watersheds transitioning to rain-dominated watersheds.[16,17] Summer precipitation is projected to decline under all scenarios, although it will be variable,[9] contributing to more frequent, longer, and more severe regional drought conditions that increase wildfire risk and decrease water availability (KMs 27.2, 27.3).

Interannual variability in precipitation is projected to persist, and observed lower streamflows in summer are expected to decrease even further due to reduced snow storage, increased evapotranspiration, and longer lags between summer precipitation events.[18,19,20] Increasingly low precipitation in drought years has driven extremely low streamflows.[20] Some currently permanent streams will transition to ephemeral streams, affecting aquatic species and regional water supply (KMs 27.2, 27.4).

Decreased snow accumulation and increasing melt are raising the elevation of the snow line, or the point at which annual accumulation and melt of snow are equal, which is causing Northwest glaciers to recede,[21,22] affecting recreation industries and regional water systems (KMs 27.3, 27.4, 27.6). Over the long term, streamflow reductions are expected in basins historically fed by glaciers.[23] Debris flows and landslides are expected to become more frequent as glacial recessions leave more bare land exposed to direct precipitation and the steep sideslopes of glaciated valleys are left unbuttressed by ice.[24]

The frequency and intensity of extreme precipitation events are projected to increase across the region.[7,8,25] Long, narrow bands of atmospheric water vapor transport, commonly known as atmospheric rivers (ARs), are associated with extreme precipitation in the western United States, where they contribute an average of 30%–45% of total winter precipitation (Figure 27.1).[26,27,28] ARs can cause severe damages,[29] such as the widespread damage resulting from ARs witnessed in western Washington in November 2021 (KM 27.4). A greater number of strong AR events and fewer moderate and weak events are projected to occur,[30] although the changes in the frequency of landfalling ARs vary across climate models.[31,32] While the average contribution of ARs to annual precipitation in coastal areas is 50% or greater,[33] ARs are projected to reach farther inland.[34,35,36,37,38] Understanding how climate change affects ARs is critical to estimating how the region's water supply will change (KM 27.4).



Extreme precipitation days are closely associated with atmospheric rivers, which are projected to be more frequent and intense and to reach farther inland.

A satellite image and four maps illustrate the connection between atmospheric rivers and extreme precipitation events in the Northwest. The satellite image at the top is centered on the northern Pacific Ocean with the eastern half of North America visible at the right. A legend shows total precipitable water vapor in millimeters, ranging from 0 to 50, with colors ranging from white through blues, greens, yellows, oranges, and reds. Most of the northern Pacific shows values less than 25, but there are values near 50 across the tropics. An atmospheric river of high precipitable water values extends north from the Hawaiian islands and then bends to the east, nearly reaching the North American coast at the US and Canada border. A second band of high precipitable water extends northwest along the far western edge of the image. Four maps of the Northwest at the bottom show the percent of extreme precipitation days that are associated with atmospheric rivers, for winter, spring, summer, and fall, respectively. A legend ranges from 0 to 100 percent. Winter shows high percentages across most of the region. In spring, percentages are generally 30 or less across much of the region, but are above 50 in coastal areas, particularly to the north. Summer shows 20 percent or less across most of the region, with somewhat higher values along the coast. Fall percentages are above 40 for much of the region, with values of 60 or more across much of the western halves of Washington and Oregon.

Seasonal coastal upwelling causes nearshore sea surface temperatures off the Washington and Oregon coasts to be cooler than offshore surface temperatures, tracking temperature trends in the slower-warming deep water.[39] Nonetheless, annual average coastal sea surface temperatures in the Northwest have warmed approximately 1.2°F since 1900, and the northern California Current is projected to warm by an additional 4.6°–7.3°F by the end of the century under a very high scenario (RCP8.5), affecting marine species in a variety of ways (KM 27.2).[39,40,41,42] Human-caused carbon emissions have already driven ocean acidification of surface and subsurface waters off Oregon and Washington.[43] Synergies among ocean acidification, hypoxia, and human-caused nutrient inputs negatively affect many species, with cascading effects on food webs and human communities (KMs 27.2, 27.6).[44,45,46]

Two recent periods of widespread and persistent high sea surface temperatures in 2014–2016 and in 2019, known as marine heatwaves (and informally as the “Blob” and “Blob 2.0”), temporarily increased onshore temperatures by up to 11°F above regional averages,[47] resulting in short-term shifts in species distributions and mortality of many seabirds[48] and marine mammals (KMs 10.1, 27.2).[49] These heatwaves increased the toxicity of harmful algal blooms to marine mammals and humans who consume crabs and other shellfish (KM 27.6).[50,51,52,53,54]

Sea level is projected to increase across the Northwest under all scenarios (App. 3.3).[55] Net sea level changes vary by location in response to rising sea levels and vertical land motion, which is the long-term change in land surface elevation from processes such as tectonic forces (Table 27.1).[56] Sea levels are further affected by climate cycles, such as El Niño, which can raise sea levels up to another 7.9 inches for several months. Relative to the 1991–2009 average, relative sea levels in the Northwest are projected to rise 0.6 to 1.0 feet by 2050 for the Intermediate and High scenarios, respectively (Table 27.1),[55] placing physical structures and communities at risk (KMs 27.1, 27.4).[57] In Puget Sound, where most land is subsiding, sea levels are expected to rise 0.9 to 1.6 feet by 2050 and 3.2 to 10.2 feet by 2150 under a very high scenario (RCP8.5), relative to the reference period. On Washington’s outer coast, sea level rise is anticipated to range from 0.1 to 0.8 feet by 2050 in Neah Bay, where land is rising, and 0.5 to 1.2 feet by 2050 in Tahola, where land is subsiding, under a very high scenario (RCP8.5).[58]

Sea level rise is projected to increase across the Northwest under all sea level rise scenarios. This table illustrates the variability of sea level rise projections for 2050, 2100, and 2150 across the Northwest under the Intermediate and High sea level scenarios[55] and for specific locations under comparable scenarios (50% likelihood of exceedance and 1% likelihood of exceedance, respectively) for downscaled sea level rise projections for Washington State under a very high scenario (RCP8.5).[58] The changes are increases in feet, relative to the 1991–2009 average. See Appendix 3 for associated information on scenarios.

Location	2050	2100	2150
Northwest Region	0.60–1.03	2.64–5.98	5.40–10.86
Tacoma, WA	0.9–1.6	2.5–5.3	4.2–10.7
Neah Bay, WA	0.1–0.8	1.0–3.8	1.8–8.4
Tahola, WA	0.5–1.2	1.7–4.5	3.0–9.5