Sixth Oregon Climate Assessment

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Acknowledgments

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The PRISM Climate Mapping System and CoCoRaHS Community Observer Network

Christopher Daly and Noah Newman

Spatially explicit data on weather and climate, usually in the form of continuous grids of pixels, often are key inputs to decision-support systems and tools that require environmental data. These grids typically describe conditions at monthly or daily resolution, and are especially useful because their wall-to-wall estimates of weather and climate encompass areas where weather stations do not currently exist. The most widely used spatial climate data in the United States are those developed by Oregon State University's PRISM Climate Group, which is named for the PRISM (Parameter-elevation Regressions on Independent Slopes Model) climate mapping system. The PRISM Climate Group is part of the Northwest Alliance for Computational Science and Engineering (NACSE) within the university's College of Engineering.

The PRISM approach to computerized climate mapping was first developed by Christopher Daly in 1991. The PRISM algorithm was written to mimic the decisions an expert climatologist makes while mapping long-term average temperature and precipitation (Daly et al. 1994). In computer science, this kind of model is called an "expert system" (Daly et al. 2002). Since its inception, PRISM has undergone nearly constant development, and has been operationalized to produce monthly and daily time series of an expanding list of meteorological variables, including precipitation, temperature, dew point, vapor pressure deficit, and solar radiation (Daly et al. 2021, Rupp et al. 2022). PRISM simulates how weather and climate vary spatially as a function of the physiography of Earth's surface, such as elevation and coastlines, and uses novel topographic indices to identify areas that are subject to temperature inversions and rain shadows (Daly et al. 2008). Each PRISM grid covers the conterminous United States with millions of grid cells, each

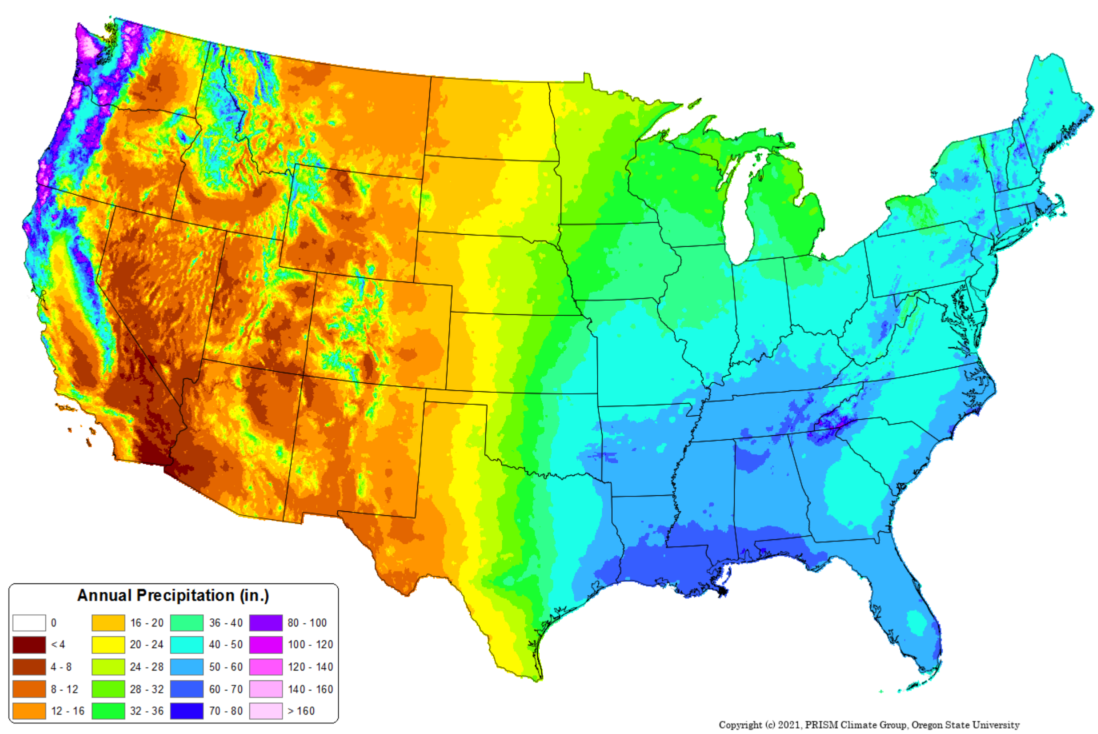

Figure 1. PRISM 1991–2020 normal annual precipitation for the conterminous United States.

approximately 800 x 800 m (1/2 x 1/2 mile), and also at 4 x 4 km (2.5 x 2.5 mile) resolution (prism.oregonstate.edu; Figures 1 and 2).

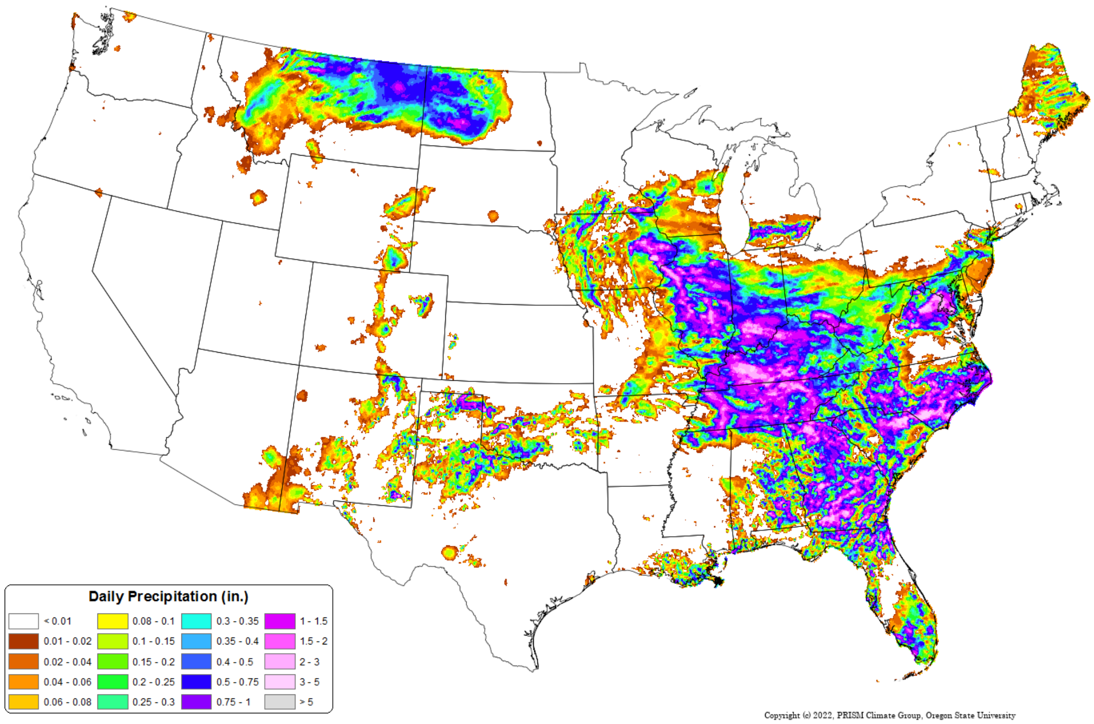

Figure 2. PRISM total daily precipitation on 9 July, 2022, for the conterminous United States.

Users download approximately one million PRISM spatial datasets each month from PRISM's public website (prism.oregonstate.edu). Nearly all U.S. government agencies use PRISM data. Furthermore, the private sector applies PRISM data to agriculture, hydrology, engineering, ecology, economics, and retail. The PRISM Climate Group developed the 2012 U.S. Department of Agriculture Plant Hardiness Zone map, which has been accessed millions of times by gardeners, farmers, horticulturists, and others (Daly et al. 2012). Moreover, the U.S. National Weather Service (NWS) and The Weather Channel have used PRISM data to guide the spatial patterns of their weather forecasts. Peer-reviewed scientific papers on PRISM have been cited in over 14,000 publications.

Contributions of the CoCoRaHS Community Network

Development of accurate, detailed, spatially explicit weather and climate data relies on a large quantity of high-quality station data. Each day, the PRISM Climate Group compiles data from more than 20,000 precipitation and 10,000 temperature stations that are members of federal, state, or regional networks. Because precipitation is sporadic and highly variable, particularly dense data are necessary to accurately quantify precipitation across large or topographically complex areas. Nearly 90 percent of the precipitation stations that contribute to the PRISM datasets are operated by community scientists, and are essential for filling gaps between automated weather stations. The largest of these community science networks is the Community Collaborative Rain, Hail and Snow network (CoCoRaHS; www.cocorahs.org), operated by the Colorado Climate Center.

CoCoRaHS's 25,000 active volunteers in all states, territories, and provinces in the United States and Canada measure and report precipitation from their selected locations, primarily residences but increasingly schools, libraries, public parks, and workplaces. The network documents approximately 14,000 observations of precipitation or its absence each day, including more than 400 in Oregon (Figure 3). CoCoRaHS has grown from a local community project in Colorado, which began after a flash flood in 1997, to the largest source of daily, manual precipitation measurements in the United States (Reges 2016). With the goal of creating a dense network of high-quality precipitation data, CoCoRaHS volunteers have now submitted over 55 million daily reports that are used by the National Oceanic Atmospheric Administration (NOAA) and its many entities (NOAA 2021). For example, NWS incorporates CoCoRaHS data into daily operational products, and the National

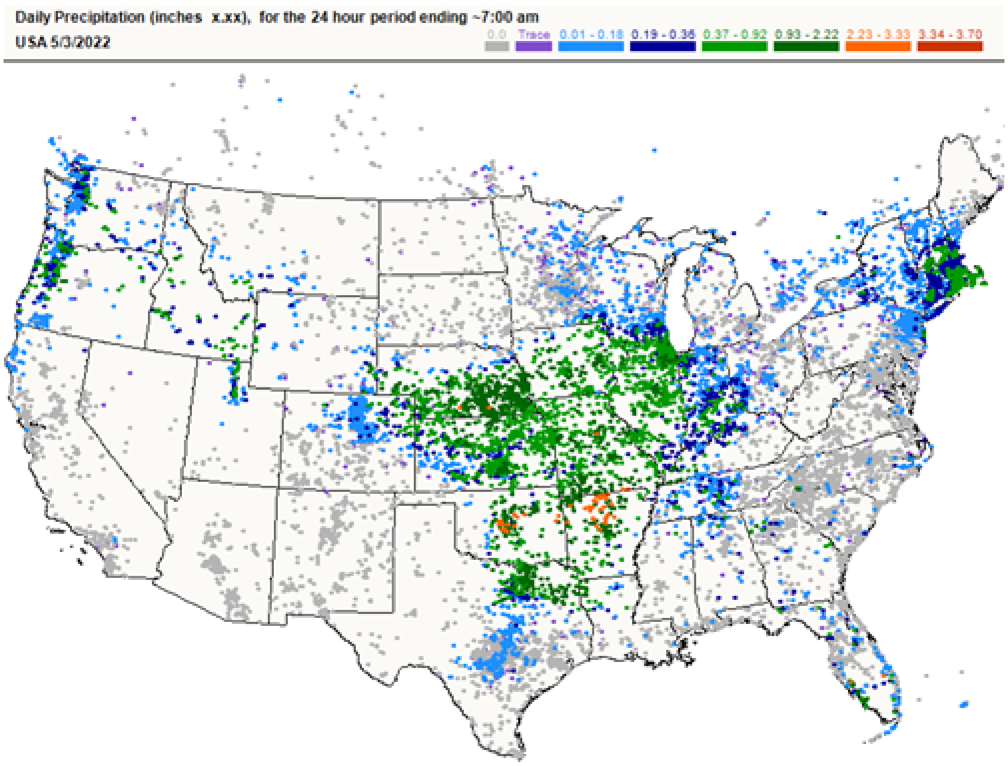

Figure 3. Data from CoCoRaHS observers documented the 24-hour precipitation totals ending at 7:00 a.m. local time on 3 May, 2022.

Centers for Environmental Information (NCEI) uses CoCoRaHS data in its climate research. CoCoRaHS also provides tools that enable volunteers to perform their own analyses, such as comparing monthly precipitation totals to 30-year PRISM averages for their locations (Figure 4).

CoCoRaHS observers measure not only rain but snowfall, snow depth, snow water equivalent (SWE; the amount of water in the snowpack), and hail size and amount. These measurements of SWE account for more than half of the ground-based observations used by NWS for its hydrologic models and predictions. Additionally, many observers submit notes with their observations, which can help to confirm an unusual rainfall or snowfall report during the quality assurance process. If a question about an observation remains, the CoCoRaHS quality control meteorologist is able to contact the observer directly to confirm the observation. This level of validation rarely is possible when data are gathered by automated weather stations rather than stations staffed by people.

CoCoRaHS requires volunteers to use a particular manual gauge that meets NWS standards and conducts extensive quality control and quality assurance processes, both automated and manual.

The CoCoRaHS leadership provides numerous engaging slideshows and videos that train observers on best practices, which helps to ensure that the measurements and reporting are consistent. Furthermore, NCEI performs their own quality assurance processes before data are disseminated to the NWS.

In 2021, NCEI completed their scheduled, decadal update of 30-year climate normals to cover the years 1991–2020. Although no CoCoRaHS station has been operating for 30 years yet, NCEI uses alternative methods to calculate normals on the basis of shorter periods of data. For the first time, data from CoCoRaHS stations were included in the updated normals; NCEI classified 4688 stations as pseudo-normal and 760 as provisional normal. To qualify for pseudo-normal status, data for every day in a given month in at least two years must be available. To qualify for provisional normal status, data for every day in a given month in at least ten years must be available. For data users, the updated normals are analogous to U.S. Census data. In the development of PRISM gridded normals for 1991–2020 (e.g., Figure 5), an activity separate from that of NCEI, 5419 CoCoRaHS stations qualified for inclusion for at least one month of the year. For a given month to be included in the PRISM normals, at least ten years or five years of complete data (for stations in the eastern and western United States, respectively) must be available. Inclusion of the CoCoRaHS data in the NCEI station normals and the PRISM gridded normals allows users to compare present-day conditions to long-term averages more thoroughly (Figure 4).

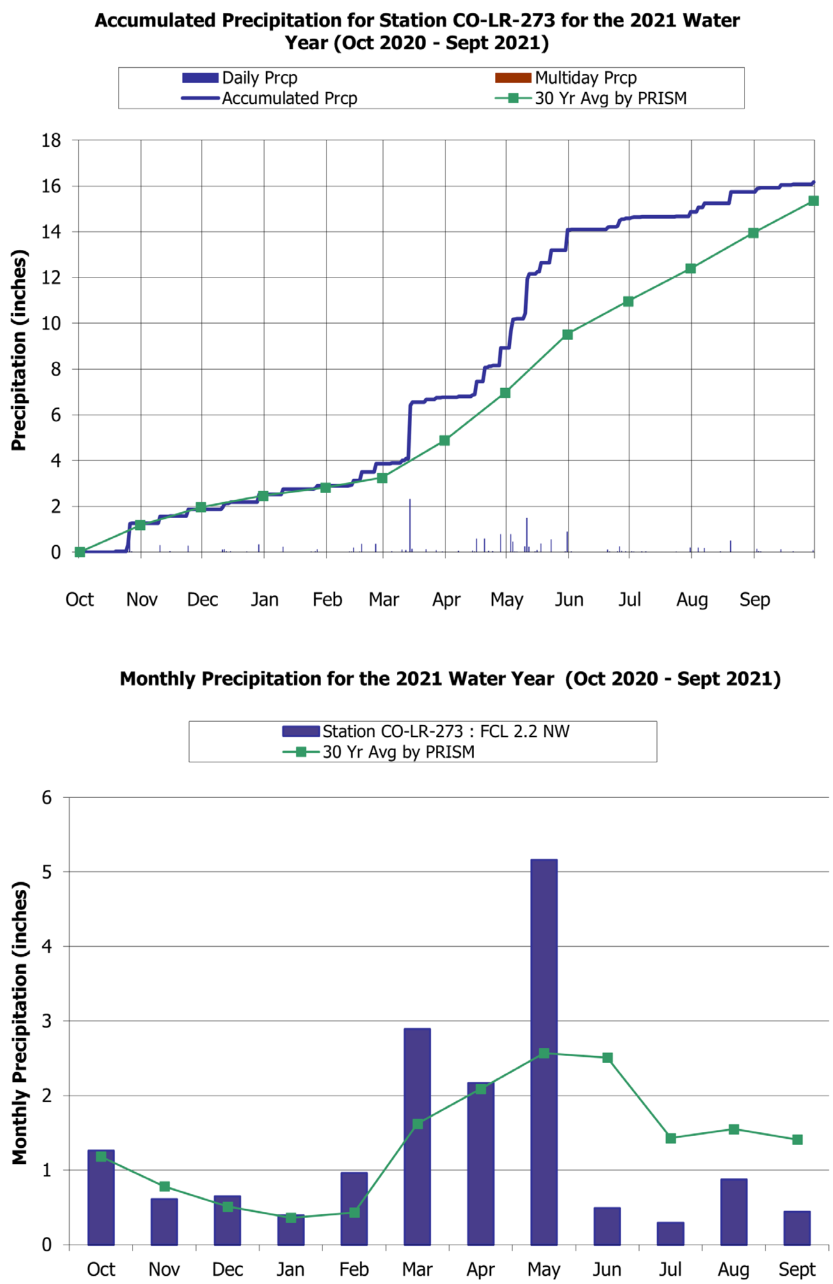

Figure 4. CoCoRaHS observers have immediate access to data analysis tools that are also available publicly, such as tools for summarizing total monthly precipitation (top) and long-term modeled average precipitation (bottom) for a given location.

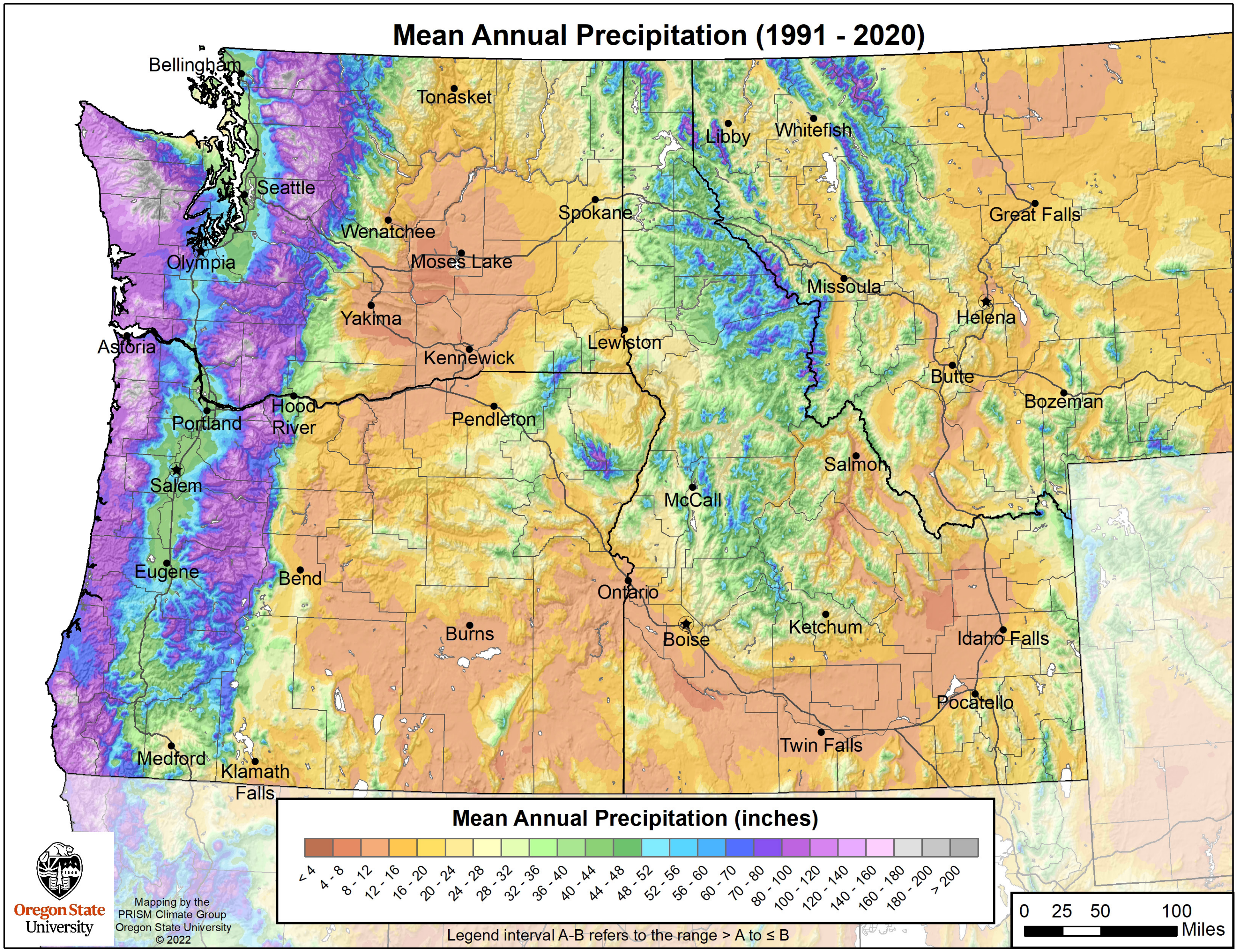

Figure 5. PRISM 1991–2020 normal annual precipitation across the Northwest.

After 24 years, the CoCoRaHS network of dedicated, volunteer observers has contributed to remarkable advances in understanding and application of meteorology and climatology. Municipal water managers use CoCoRaHS daily reports to assess supply and demand, while NWS River Forecast Centers use the daily reports as inputs to their flow prediction models. Stations with complete data over weeks, month, seasons, or years are of considerable value for agricultural applications such as the U.S. Drought Monitor, and for research on tropical storms and atmospheric rivers. The role of community science networks such as CoCoRaHS in improving the quality and detail of PRISM data cannot be overstated. Given the diverse use of PRISM data, community science weather networks have extraordinary, positive impacts throughout science and industry.

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