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Using PRISM Climate Grids and GIS for Extreme Precipitation Mapping

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Extreme precipitation information is of interest for a variety of purposes, including public safety, water supply, dam design and operation, and transportation planning. Two common parameters calculated for extreme precipitation purposes are probable maximum precipitation (PMP) and intensity-duration-frequency (IDF). The definition of PMP is “theoretically, the greatest depth of precipitation for a given duration that is physically possible over a given area at a particular geographical location at a certain time of the year.” PMP estimates are used to calculate the probable maximum flood (PMF), which in turn is used to evaluate the adequacy of hydraulic structures. IDF calculations are used in a variety of precipitation-related tasks, including PMP. The primary agency responsible for establishing standards for PMP and IDF has been the National Oceanic and Atmospheric Administration (NOAA) – see, for example, U.S. Department of Commerce(1994). Specific regional and local analyses have generally been performed by local agencies or private contractors.

Historically, computations of these parameters have been accomplished using mostly manual techniques (e.g., hand-drawn maps). Advances in spatial climate mapping and geographical information systems (GIS) technology have created new opportunities for mapping extreme precipitation. Using GIS software and climate grids created using PRISM, new approaches to extreme precipitation mapping have been applied to specific locations with good success. In addition to automating analytical processes, thereby saving time, the new techniques have been shown to produce more consistent and defensible coverages (digital map layers) than those of previous analyses.

PRISM (Parameter-elevation Regressions on Independent Slopes Model) is an expert system that uses point data and a digital elevation model (DEM) to generate gridded estimates of climate parameters (Daly et al., 2002). Unlike other statistical methods in use today, PRISM was written by a meteorologist specifically to address climate. PRISM is well-suited to mountainous regions, because the effects of terrain on climate play a central role in the model's conceptual framework. We call it an expert system, because it attempts to mimic the process an expert would use to map climate parameters. The user interacts with the process through a graphical interface.

The general procedure for estimating 24-hour PMP includes the following steps:

1) Collect hourly and daily precipitation data for major historical storms and select major storms for analysis;
2) Obtain or develop station information representing computed or estimated 100-year 24-hour (or other averaging period) precipitation amounts (see Figure 1);

3) For each storm, calculate the percent of 100-year 24-hour precipitation observed at each available station
4) Create a GIS coverage representing the percentage of 100-year precipitation using the station data above (Figure 2);
5) Create isohyetal maps of maximum 24-hour precipitation for each selected historical storm using the coverages from 2) and 4) – Figure 3.
6) Estimate the 100-year convergence precipitation (defined as the maximum precipitation component operating independent of terrain influences) using a spatial grid and GIS (Figure 3);
7) Determine the convergence precipitation from significant historical storms;
8) Maximize the convergence component of historical storms using a set of maximization factors, particularly the ratio of maximum observed dew point to observed dew point during each storm;
9) Transpose maximized convergence from each storm across a spatial grid using variations in maximum persisting dew point applying both vertical and horizontal transposition limits;
10) Estimate the ratio of 100-year total precipitation to 100-year convergence precipitation (T/C) using the above data (Figure 4);
11) Estimate the variation in values of the storm intensity factor, M, to derive the orographic factor, K; and
11) Determine the total PMP by multiplying GIS coverage of convergence PMP by grid of K (Figure 5).

The figures shown were developed for two PMP projects in the Pacific Northwest: PMP for Southwestern British Columbia, for B.C. Hydro of Canada; and Extreme Precipitation (IDF) for Western Washington for the Washington Department of Transportation.

References

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100-year 24-hour Precipitation, Western Washington

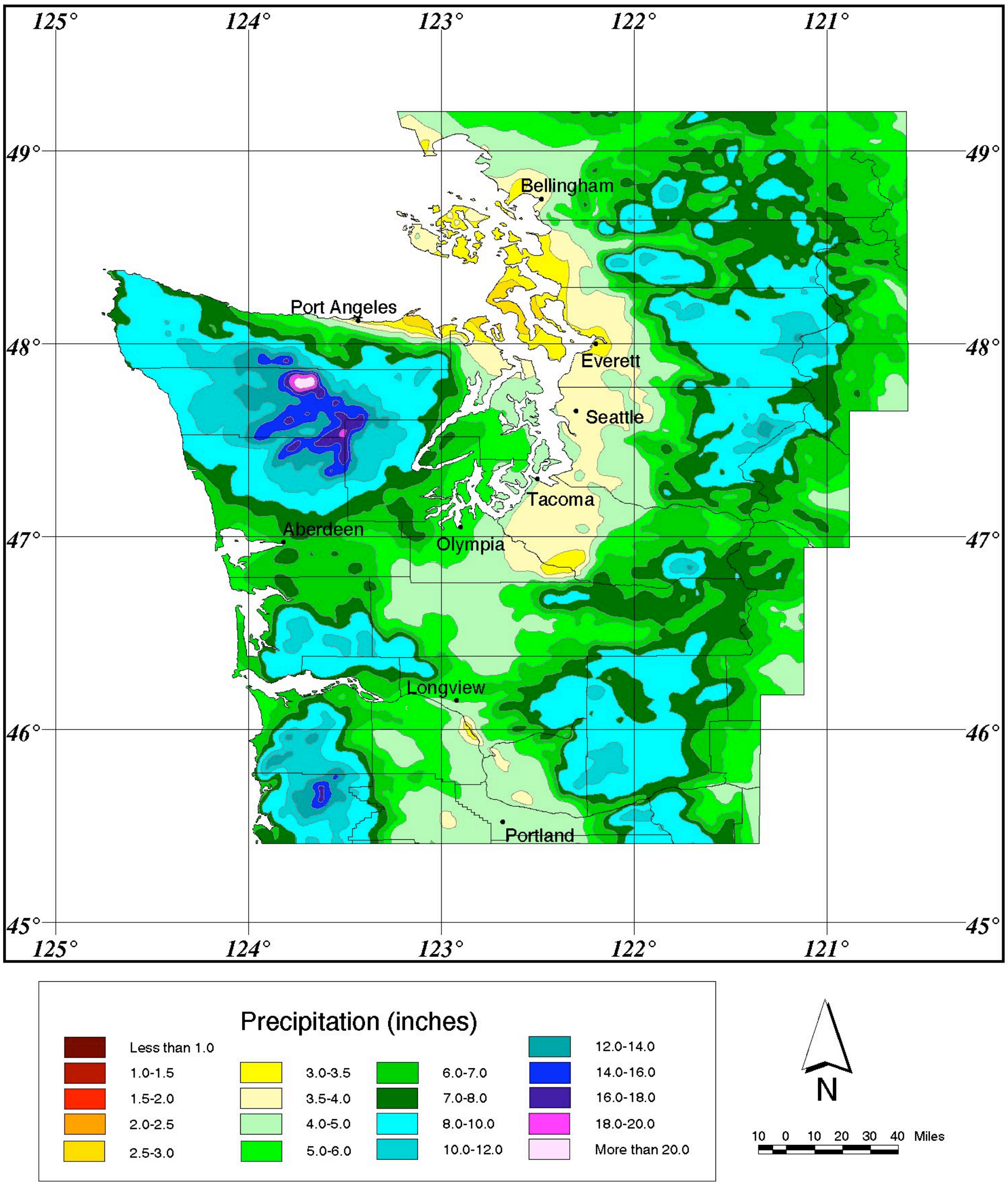

Figure 1. Example of a 100-year, 24-hour Maximum Precipitation Map

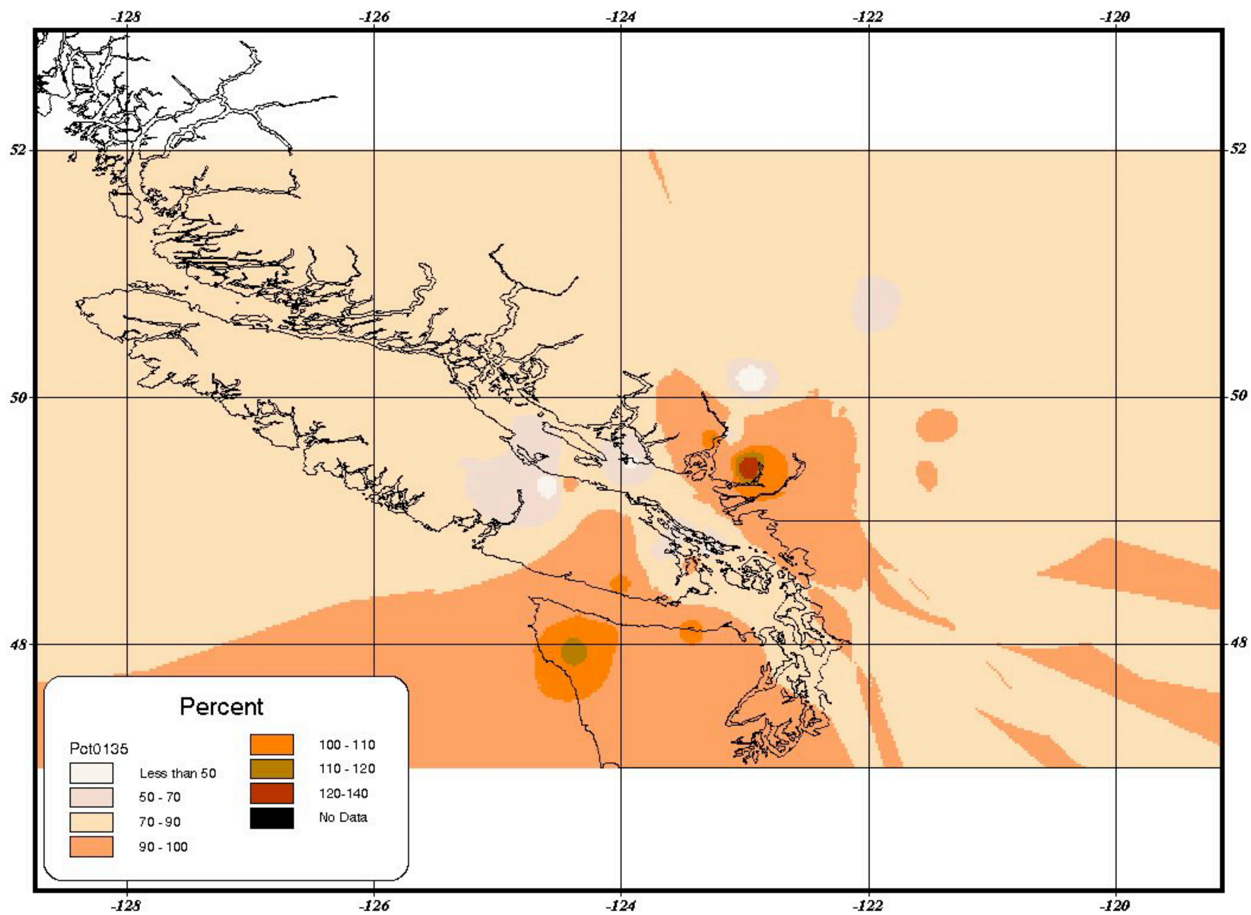

Figure 2. Estimated Percent of 100-year Precipitation Observed During a Storm

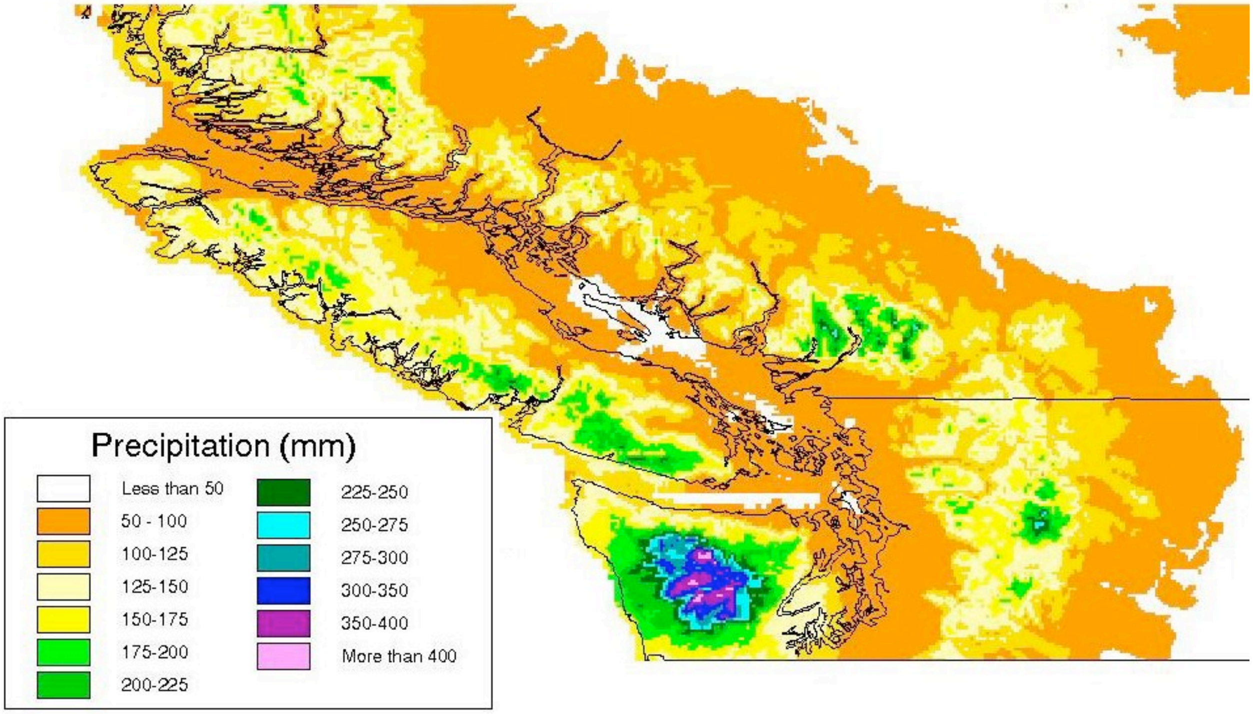

Figure 3. Estimated One-Day Precipitation for a Storm Event

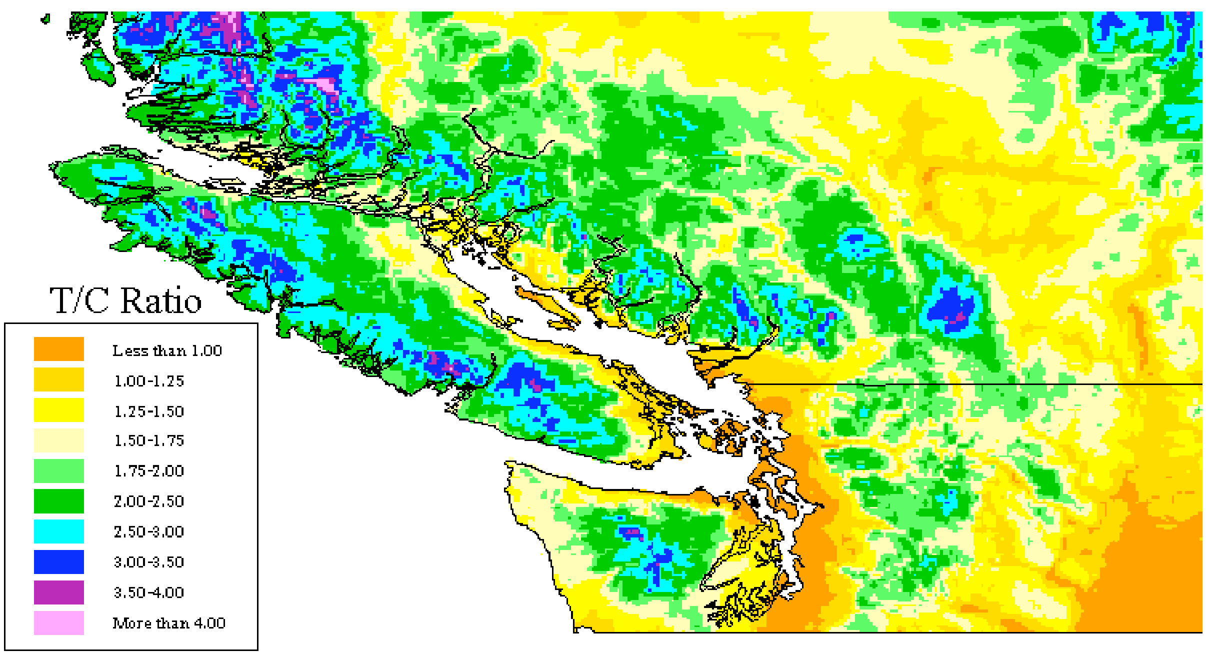

Figure 4. T over C (total to convergence precipitation) for Southwest British Columbia and Northwest Washington

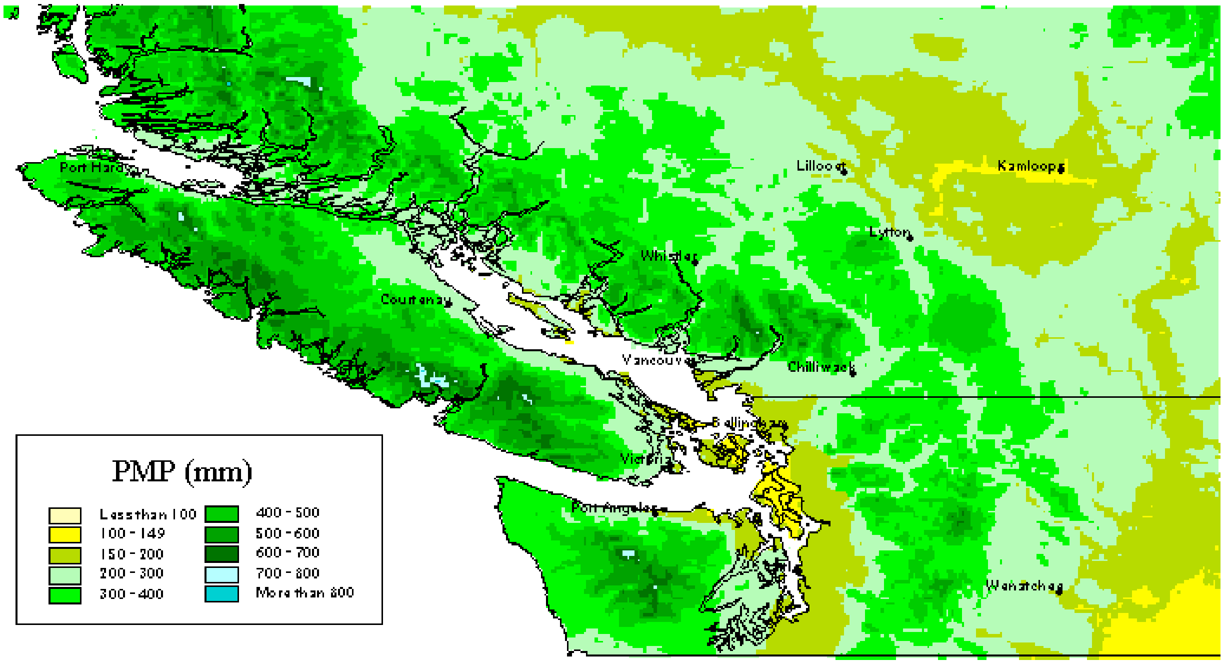

Figure 5. Probable maximum Precipitation (PMP) for Southwest British Columbia and Northwest Washington