1. **Data Set Title**: Maplots and Cascade Plots for Willamette Water 2100 Modeling Scenarios, Output Version 3.0

2. **Abstract**: Maplots and graphs summarizing output from Willamette Water 2100 project modeling scenarios. The output was generated by Willamette Envision, a computer model developed to explore future water supply and demand under different trajectories of climate change, demographic change and water management. Output is called WW2100 3.0 and was generated by Willamette Envision code version 330 and 331 as archived in the WW2100svn repository (https://freshwater.ceoas.oregonstate.edu:8443/svn/WW2100svn). These cascade plots were generated with python scripts, using tabular output from Willamette Envision runs for the period 2010-2099. The annotation on each plot indicates the source of data and the date the plot was generated. Python scripts are stored on GitHub (https://github.com/marathanman4202). Refer to the scenario table (PDF) and Willamette Water 2100 web page (http://inr.oregonstate.edu/ww2100/model-overview/scenarios) for a description of each scenario.

3. **Recommended data citation**: Haggerty, Roy. 2016. Maplots and Cascade Plots for Willamette Water 2100 Modeling Scenarios, Output Version 3.0. Oregon Hydrologic Information Server.

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5. **Related publications**
    a. http://inr.oregonstate.edu/ww2100/publications

6. **Methods**:

Maplots are used to show both spatial and temporal changes on the same figure [*Andrienko and Andrienko*, 2005]. In our case, we show a map of the Willamette River Basin (WRB) in the background. In general, the background is colored either by elevation (as in Figure RDH1) or by geology. Superimposed on that map are a number of 'sparklines' [*Tufte*, 2006]. To keep the maplot as uncluttered as possible, the vertical and horizontal axes are generally removed. A reference plot, for the entire basin, is placed in the upper left of the figure. That reference plot is labeled and has a vertical axis. Unless otherwise stated, all plots use the same scale.

The line in the maplots indicate simulated change over the 21st century relative to the simulated historical (1950 - 2010). The line is colored blue when the model variable indicates conditions are either wetter or cooler, or unchanged.The line is colored red when the model variable indicates conditions are either drier or warmer.

Shading is placed behind the lines in the maplots. The shading shows the range of model variable for the simulated period. Check the figure caption for the specific scenarios indicated by the shading.

Figure 1 shows an example maplot. In this case, the maplot shows change in snow water equivalent (SWE) simulated over the 21st century. Individual plots show changes in SWE for the sub-basins (e.g., McKenzie, Marys, etc.) The graph in the upper left (legend) shows changes in SWE for the whole WRB. The shading shows the range of SWE for all scenarios except Stationary Climate.

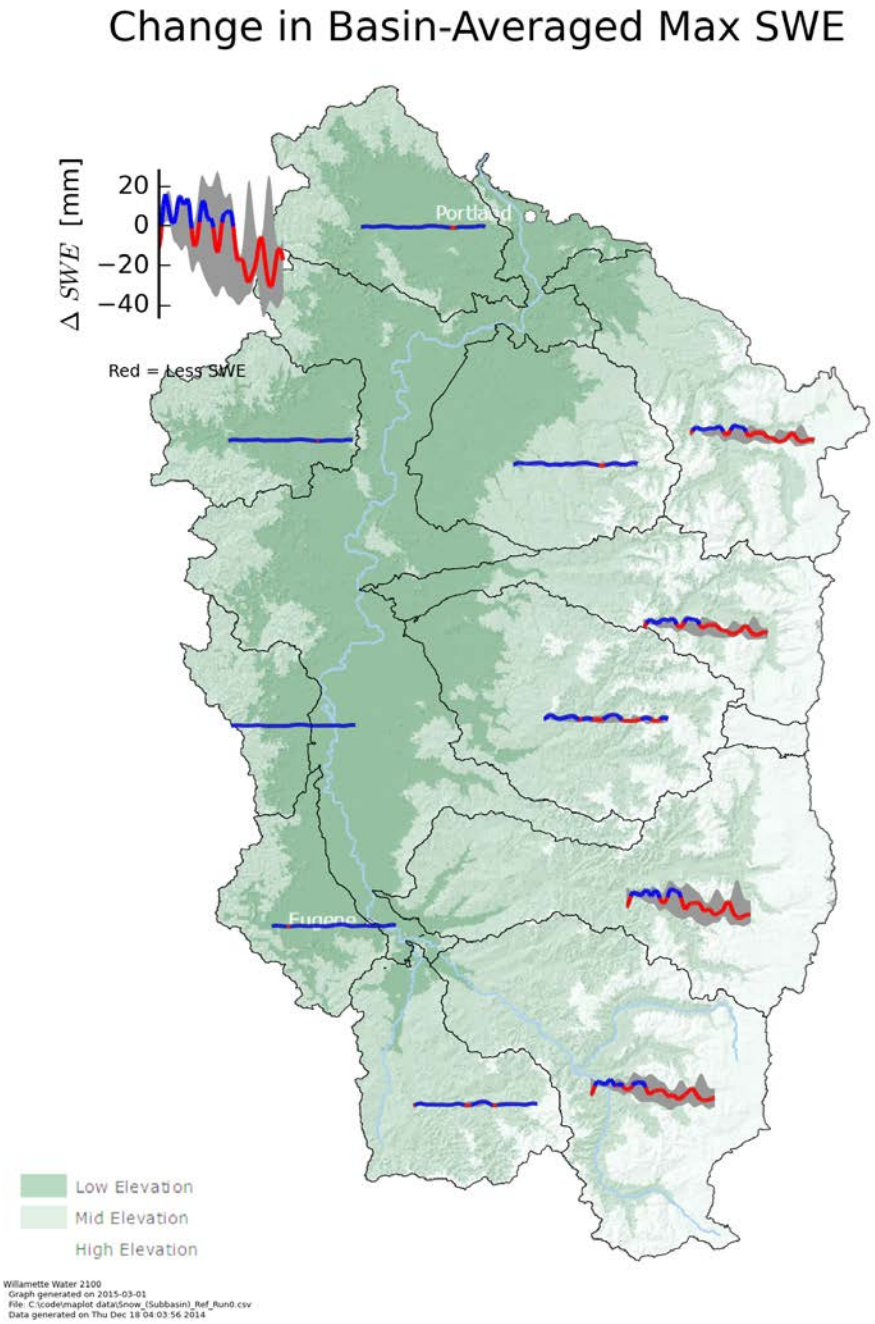

Figure 1. Example of a maplot. The base map shows the Willamette River Basin. Superimposed are plots for particular parts of the WRB, roughly corresponding to the location of the plots. In the maplots used in this report, blue means no change or more favorable conditions for the variable (typically wetter, cooler, or more snow) relative to the historical period 1950-2010. Red means less favorable conditions for the variable (typically drier, hotter, or less snow) relative to the historical period 1950-2010. The example shown is the change in maximum snow water equivalent (SWE) over the 21st century averaged over the entire WRB. The line plotted is the Reference scenario, and the shading is the range of other scenarios.

Cascade plots show the daily values for 2010 - 2099. Figure 2 shows an example for the average daily temperature of the WRB. The cascade plot begins on Oct. 1, 2010 (first day of water year (WY)) and goes through Sep. 30, 2099 (last day of water year). The values are represented by color intensity, in this case on a white (cold) to red (hot) scale, indicated by the scale bar on the right. Days of the year are read horizontally across the cascade plot, and years of the century are read vertically.

Below the cascade plot, a graph shows the average values through the year. Three lines indicate the averages for WY2010 - 2039, WY2040 - 2069, and WY2070 - 2099. Colored shading indicates the range of values for WY2070 - 2099 for alternative scenarios. Shading in each plot identifies the range of values from multiple scenarios. Blue shading = climate effects (Ref, HighClim, LowClim, StationaryClim); red shading = human effects (Ref, EconExtreme, FireSuppress, UrbExpand, LateRefill, LowIrrig, HighIrrig, NewIrrig, NewInstream, NoGrow, NoPopGrowth, NoIncGrowth, NoReservoirs, AllFallow); green shading = all possible scenarios (Ref, LowClim, HighClim, HighPop, FireSuppress, UrbExpand, LateRefill, LowIrrig, HighIrrig, NewIrrig, NewInstream, EconExtreme, Extreme, Managed). Refer to the scenario table (PDF) and Willamette Water 2100 web page (http://inr.oregonstate.edu/ww2100/model-overview/scenarios) for a description of each scenario.

To the right of the cascade plot are the maximum and minimum annual temperatures, indicated by box-and-whisker plots. In the box-and-whisker plots, the vertical line is the median. The box extends to the upper and lower quartile of data, and the whisker covers the extent of the data. In some cases, only one box-and-whisker plot is produced. To the right of the box-and-whisker plot(s) is a graph showing an annual value. Typically, the annual value is the mean, a maximum, or a minimum, depending on the variable. The data are smoothed interannually using a Gaussian filter with a standard deviation of 1.67 years.

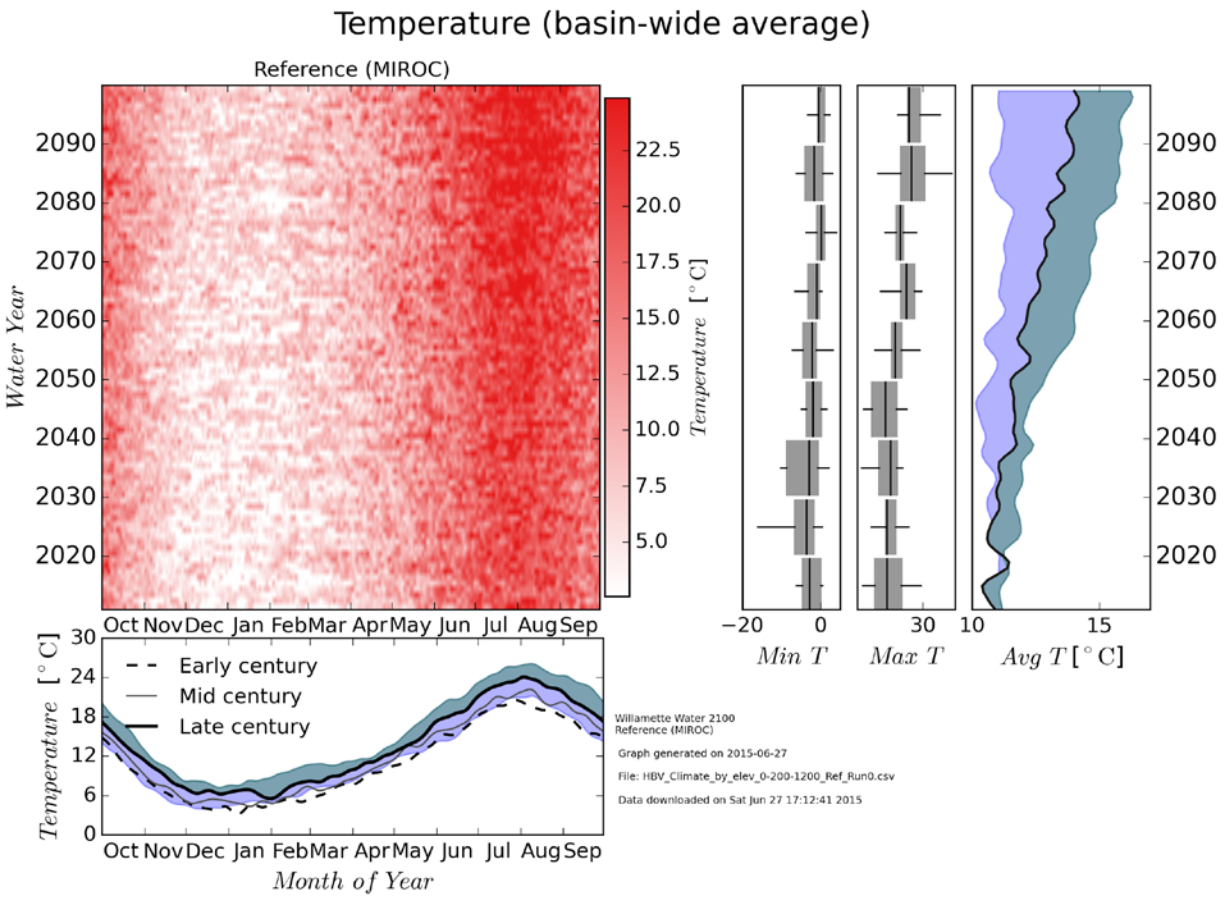

Figure 2. Example of a cascade plot showing temperature over the century for the Reference scenario. Cascade plots are used in several of the results sections for different kinds of data and analyses. The cascade plot shows daily values of temperature for the Willamette River Basin. The graph at the bottom shows the average temperature for different days of the year in the early century (2010 - 2039), mid-century (2040 - 2069), and late-century (2070 - 2099). The graphs on the right show min, max, and average annual temperatures through the century.

References

Andrienko, G., and N. Andrienko (2005), Visual exploration of the spatial distribution of temporal behaviors, paper presented at Information Visualisation, 2005. Proceedings. Ninth International Conference on, 6-8 July 2005.

Tufte, E. (2006), *Beautiful Evidence*, Cheshire, CT, Graphics Press.

7. **Location:** Willamette River Basin, Oregon, USA; Hydrologic Unit Code: 170900

8. **File format:** All files are .png image files

9. **Related documentation**:
   CascadePlotsShadingNotes.pdf - legend for interpreting shading in Cascade plots

List_of_CascadeMaplots.csv
WW2100_ScenarioTable.pdf
Notes.pdf - notes on how this version of code differs from previous versions
Scenario_Comparison.xlsx - comparison of how model output differs from output from earlier code versions

10. **Sponsorship**: Generation of this data set was supported by the National Science Foundation under Grants No. 1039192 (OSU), 1038925 (PSU) and 1038899 (UO).

11. **Overview of project and disclaimer**: The Willamette Water 2100 project was a six year collaborative research effort by Oregon State University, Portland State University and the University of Oregon to evaluate how climate change, population growth, and economic growth will alter the availability and the use of water in the Willamette River Basin on a decadal to centennial timescale. The project team developed a computer model, called Willamette Envision, that integrates aspects of hydrology, ecology, and human systems, and allows scientists and stakeholders to explore the interaction between land and water management policies, economics, climate, and ecology. The project was supported by grants from the National Science Foundation and was carried out between 2010 and 2016. Any opinions, findings, and conclusions or recommendations expressed by this work are those of the authors and do not necessarily reflect the views of the National Science Foundation.

12. **Keywords**: Envision, Water Sustainability and Climate, water scarcity, Willamette River Basin