



National Climate Change Viewer for visualizing, summarizing and accessing CMIP5/IPCC AR5 climate model output and water-balance modeling

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Development**

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Oregon State University**

Motivation

- **Synthesize and translate huge volumes of climate model output into a form that is understandable, informative, and accessible to a wide range of users**
- **Model CONUS water balance**
- **Average data into tangible geographic units: states, counties, USGS hydrologic units**
- **Provide web applications for viewing, interrogating and accessing data**
- **Apply data to address climate related research**

State, county and HUC viewer

(http://www.usgs.gov/climate_landuse/clu_rd/nccv.asp; doi:10.5066/F7W9575T)

- 30 CMIP5/IPCC models
- Temperature and precipitation statistically downscaled to 800 m by NASA using BCSD
- Middle (RCP4.5, ~650 ppm CO₂) and high (RCP8.5, 1370 ppm CO₂) IPCC emissions scenarios
- Historical (1950-2005) and future 25-yr averaging periods (2025-2049, 2050-2074, and 2075-2099)
- Water balance modeling at 800 m
- Averaged over US, states, counties and USGS HUCs

USGS
science for a changing world

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R&D HOME

CURRENT RESEARCH THEMES:

- Abrupt Climate Change
- Carbon Cycle - Processes Influencing Carbon Flux
- Climate Data and Model Integration
- Distinguishing Natural Climate Variability from Anthropogenic Climate Change
- Hydrologic Extremes: Patterns, Causes, and Impacts
- Impacts of Climate and Land Use Change on Terrestrial and Marine Systems
- Rates, Causes, and Consequences of Land Use and Land Cover Change
- Sea Level Rise and Coastal Regions

PROJECTS

PUBLICATIONS

APPLICATIONS

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National Climate Change Viewer (NCCV) Home

[Home](#) | [Viewer](#) | [Tutorial \(PDF\)](#) | [Updates](#)

05-05-2014: The application now includes watersheds and new water-balance variables (snow water equivalent, runoff, soil water storage and evaporative deficit)

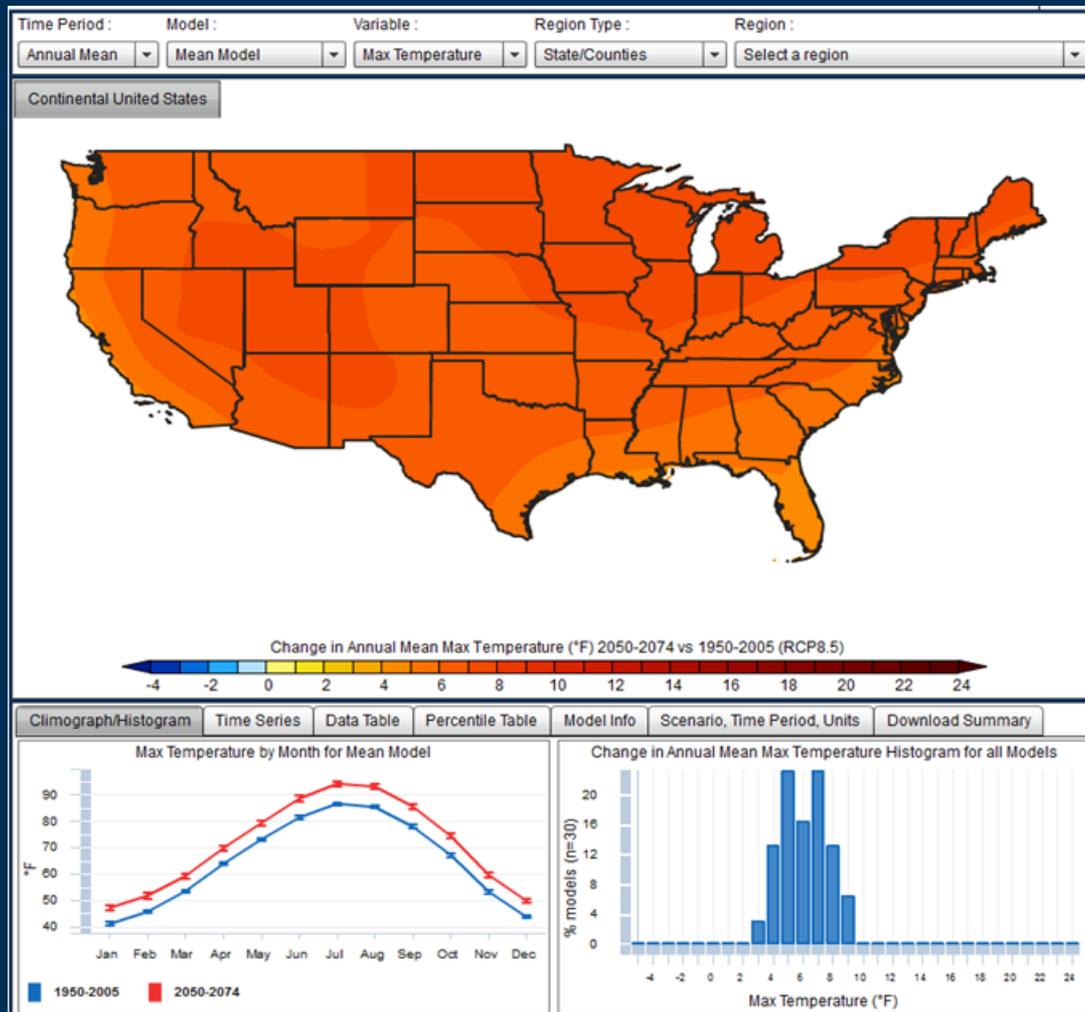
Worldwide climate modeling centers participating in the 5th Climate Model Intercomparison Program (CMIP5) are providing climate information for the ongoing Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC). The output from the CMIP5 models is typically provided on grids of ~1 to 3 degrees in latitude and longitude (roughly 80 to 230 km at 45° latitude). To derive higher resolution data for regional climate change assessments, NASA applied a statistical technique to downscale maximum and minimum air temperature and precipitation from 33 of the CMIP5 climate models to a very fine, 800-m grid over the continental United States (CONUS). The full NEX-DCP30 dataset covers the historical period (1950-2005) and 21st century (2006-2099) under four Representative Concentration Pathways (RCP) emission scenarios developed for AR5.

The USGS National Climate Change Viewer (NCCV) includes the historical and future climate projections from 30 of the downscaled models for two of the RCP emission scenarios, RCP4.5 and RCP8.5. RCP4.5 is one of the possible emissions scenarios in which atmospheric GHG concentrations are stabilized so as not to exceed a radiative equivalent of 4.5 Wm⁻² after 2100, about 650 ppm CO₂ equivalent. RCP8.5 is the most aggressive emissions scenario in which GHGs continue to rise unchecked through the end of the century leading to an equivalent radiative forcing of 8.5 Wm⁻², about 1370 ppm CO₂ equivalent. To create a manageable number of permutations for the viewer, we averaged the climate and water balance data into four climatology periods: 1950-2005, 2025-2049, 2050-2074, and 2075-2099.

We have used the air temperature and precipitation data from the 30 CMIP5 models as input to a simple water-balance model to simulate changes in the surface water balance over the historical and future time periods on the 800-m CONUS grid. Combining the climate data with the water balance data in the NCCV provides further insights into the potential for climate-driven change in water resources.

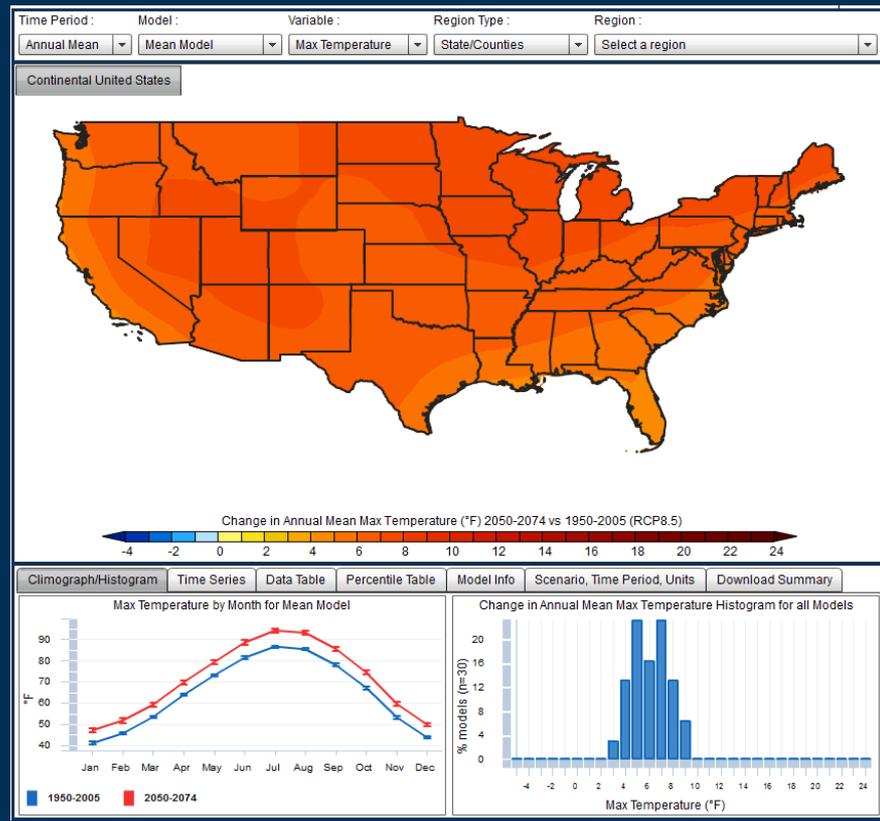
Design

- Simple user interface
- Tutorial (PDF)
- Maps, graphs charts
- Summaries (PDF)
- Data (spreadsheet)

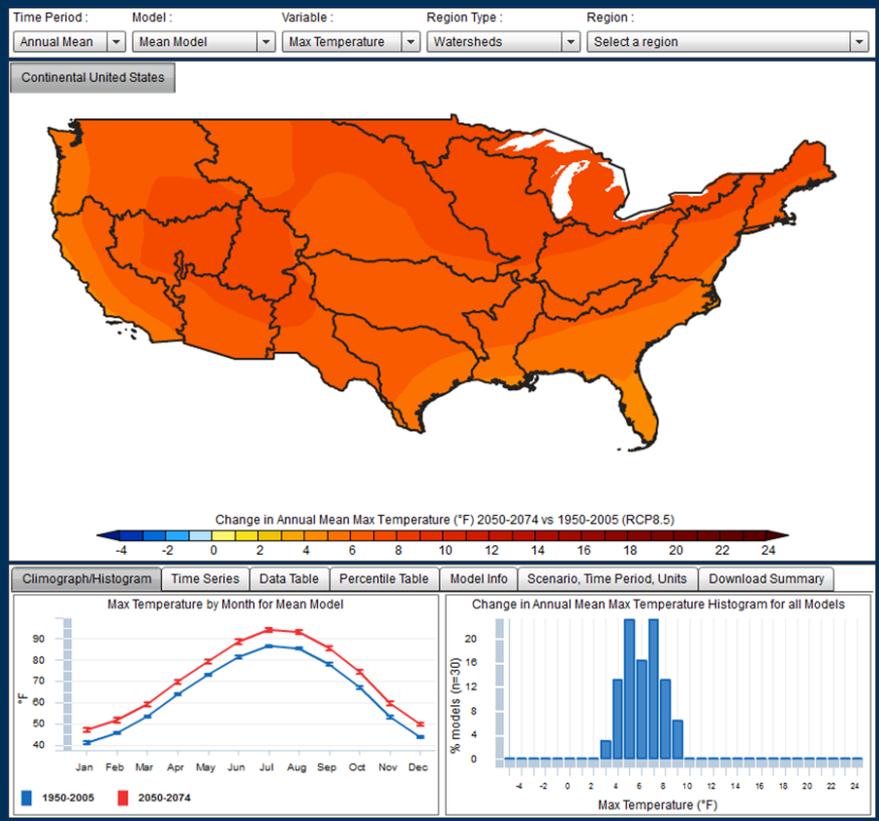


CONUS (2050-2074)

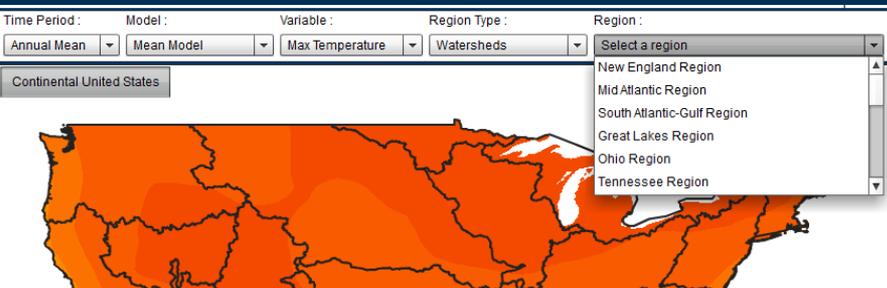
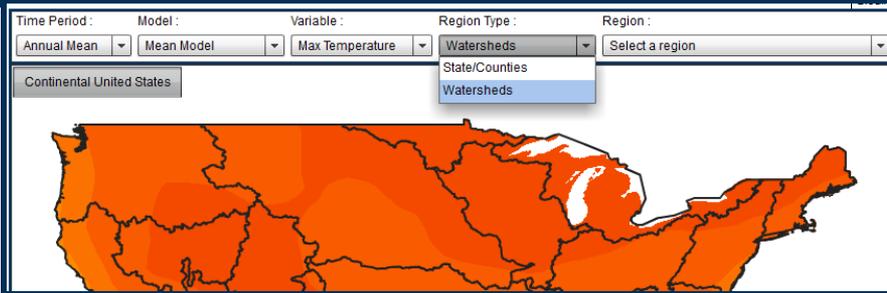
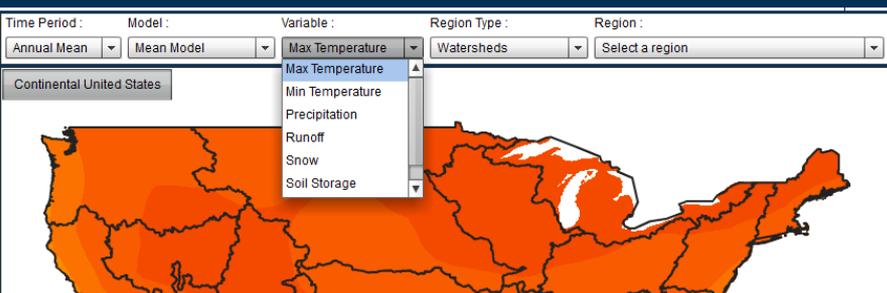
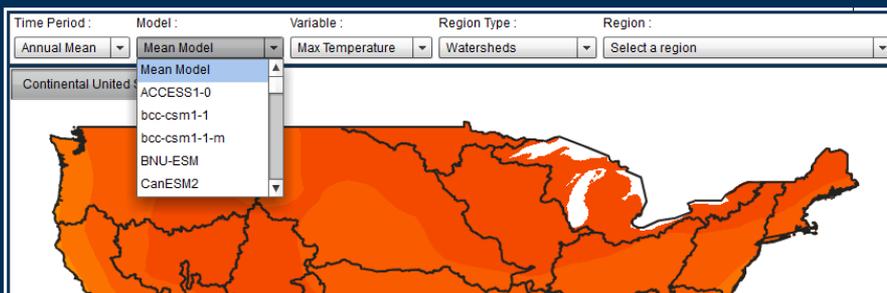
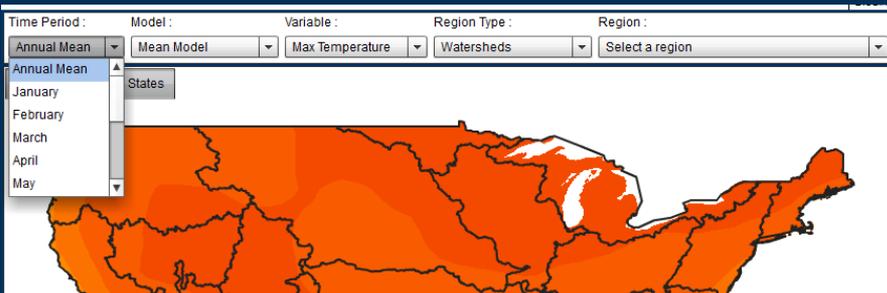
States/counties



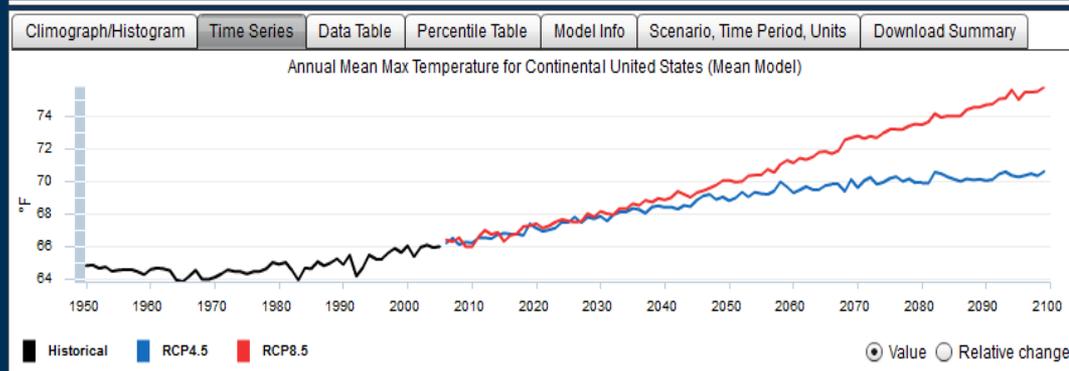
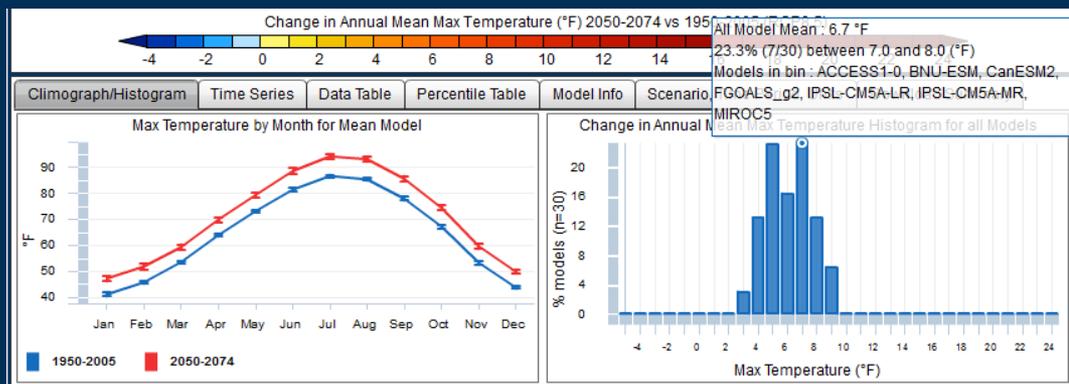
USGS HUCs



Viewer settings



Viewer settings



Climograph/Histogram Time Series Data Table Percentile Table Model Info Scenario, Time Period, Units Download Summary

Scenario:

Time Period:

Units: English Metric

Climograph/Histogram Time Series Data Table Percentile Table Model Info Scenario, Time Period, Units Download Summary

Location: Continental United States

Model: Mean Model

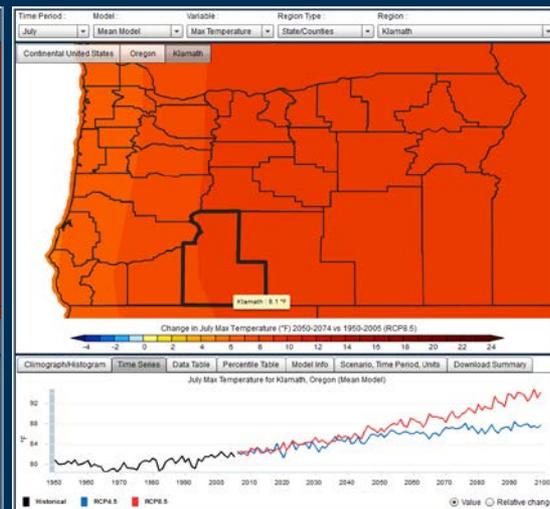
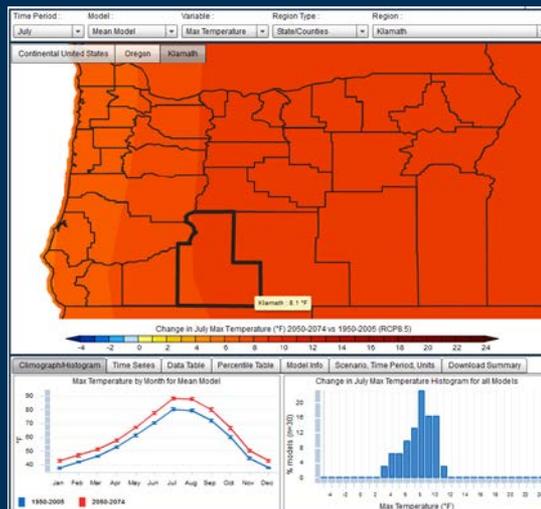
Time Period: Annual Mean

Klamath County, Oregon (2050-2074)

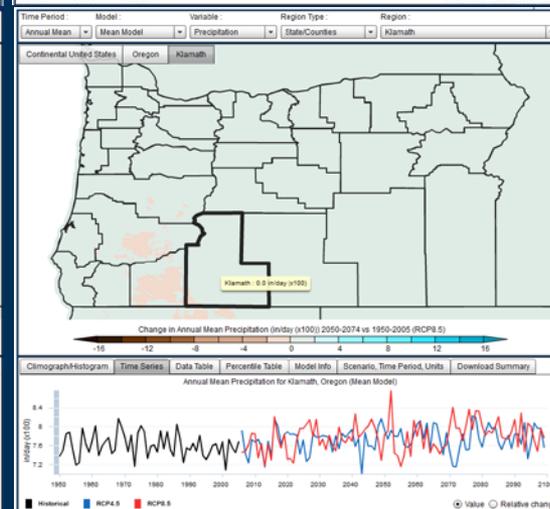
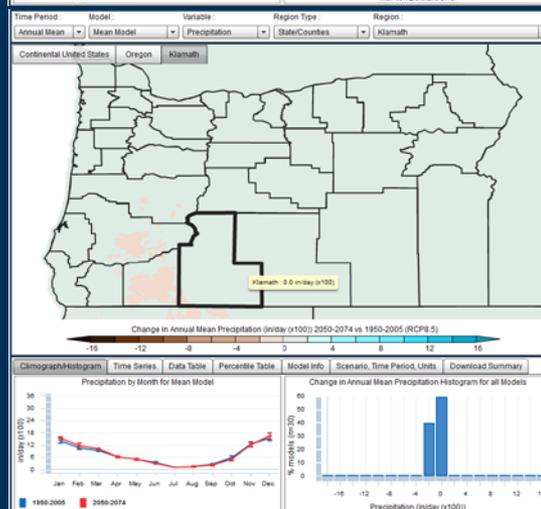
Climatology

Time series

Change in July maximum air temperature



Change in annual precipitation



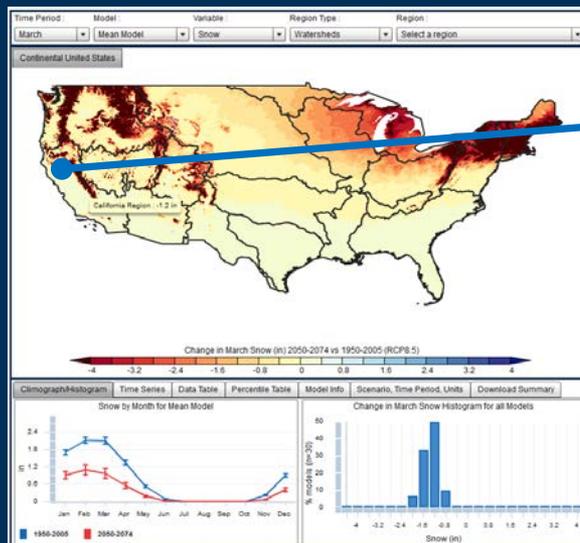
Telescoping USGS Hydrologic Units

Change in March snow water equivalent (mean model)

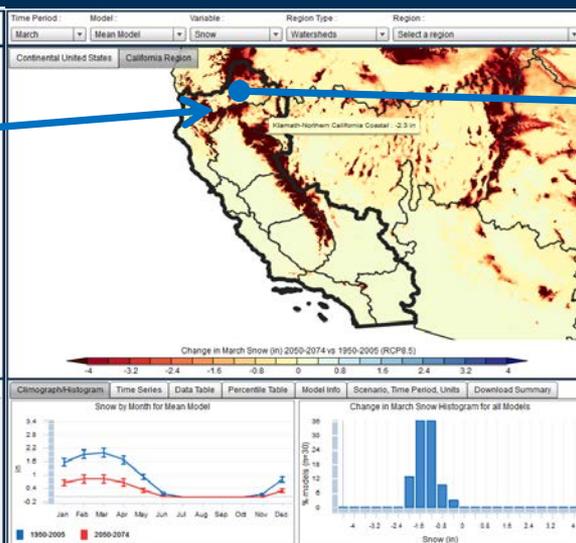
HUC2
21 ~460,000 km²

HUC4
222 ~43,500 km²

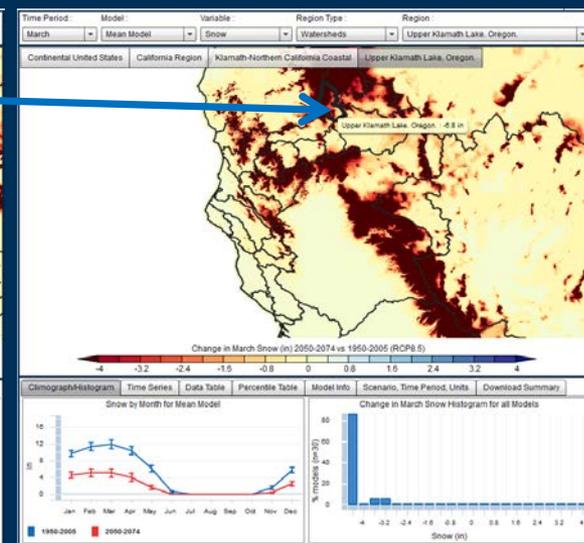
HUC8
2,200 ~1,800 km²



California Region



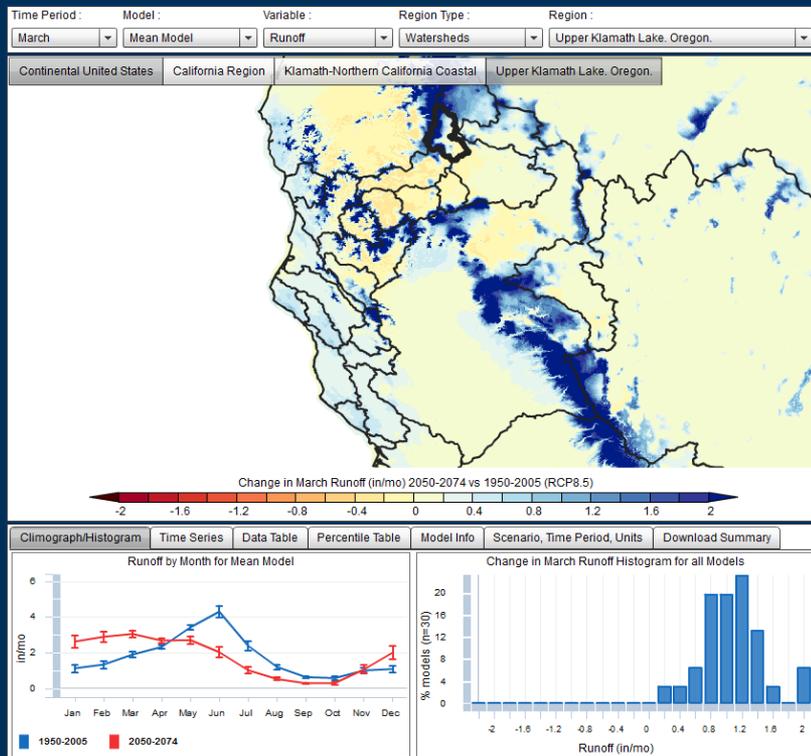
**Klamath-Northern
California Coastal**



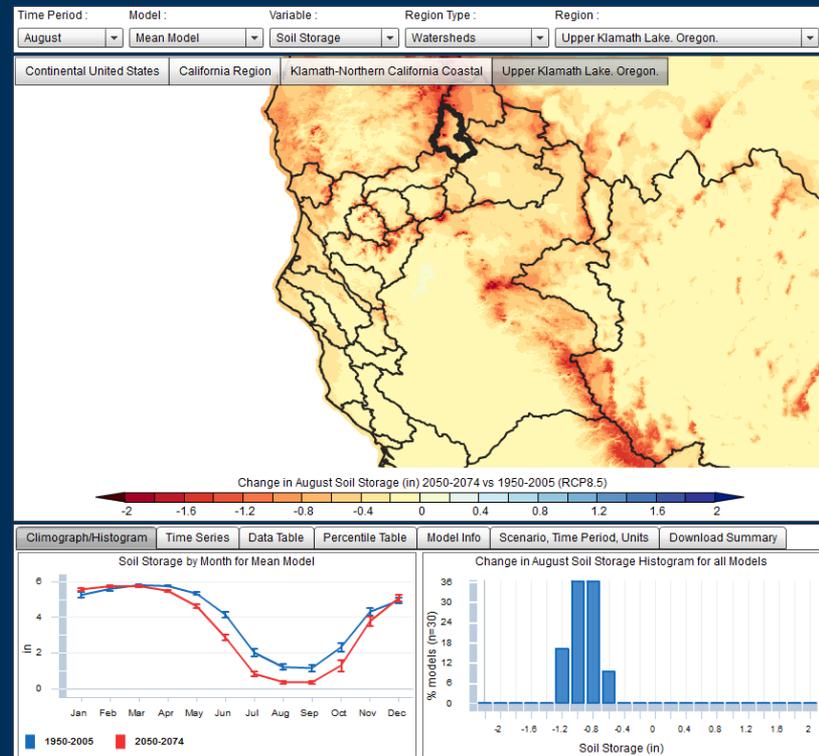
**Upper Klamath Lake,
Oregon**

Upper Klamath Lake, OR (HUC8) water balance components

Change in March runoff



Change in August soil moisture



Documentation, summaries, data

Tutorial

Summary

CSV files

USGS
U.S. Geological Survey - National Climate Change Viewer
Tutorial and Documentation

1 Introduction

Worldwide climate modeling centers participating in the 5th Co-ordinated Downscaling Experiment (CDEX) are providing climate model information for the ongoing 5th Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC). USGS Hydrologic Unit Maps (HUMs) are hierarchical units derived from the CMIP5 models typically provided on a 30 arc-minute (30 min) to 1-degree latitude and longitude (roughly 300 to 360 km) scale. Larger HUCs span multistate areas such as the California Inyo-Nevada (CA-NV) region, average area of 45,000 km² and reference down to smaller subregions such as the California Northern Klamath-... 30,000 km².

4 Water-Balance Modeling

In addition to information about temperature and precipitation, related parameters of future change in the seasonal hydrological cycle are of interest. We applied a simple water-balance model driven by the NEX-CO2Rc temperature and precipitation data from all the included CMIP5 models to simulate the monthly water balance through the 21st century. In the water, we include snow water equivalent (the amount of liquid water in the snowpack), soil water storage, runoff and evaporation deficit (the difference between potential evaporation and actual evaporation) averaged over states, counties and USGS HUCs.

4.1 Overview and limitations of the Water-Balance model

The water-balance model (WBM) was developed by McCabe and Wolock (J. Adv. Water Resour., Abstr. 30, 1990, doi:10.1111/j.1753-3187.1990.tb04231.x) and has been applied to investigate the surface water balance and climate change over the US and globally (McCabe and Wolock, Clim. Change 2016, doi:10.1007/s10584-016-0975-2; Palumbo et al., Geophys. Res. Lett., 2013, doi:10.1002/glt.2013. The model accounts for the partitioning of water through the spatial components of the hydrological system (Figure 20) embodied by:

$$P = ET + R + \Delta S$$

where P is precipitation, ET is evapotranspiration, R is runoff and ΔS is soil moisture storage. As temperature determines the partition of precipitation that falls as rain or snow, evaporation and melting of the snowpack and potential evaporation, rain and melting snow are partitioned into runoff and soil moisture; surplus rainfall that occurs when soil moisture capacity is at 100% and evapotranspiration. A few parameters are specified in the model. We use the values of McCabe and Wolock (et al., Climate, 11, 2011, doi: 10.1002/clm.1200). With the exception of introducing a time-dependent snowmelt coefficient in order to best year-round snow or high elevation sites and provide a better match of simulated snowpack and observations.

The simplicity of the WBM facilitates the computational performance needed to run 30 models for 100 years over the 12-million NEX-CO2Rc grid cells across the US. An additional strength of the WBM is that it provides a common method for analyzing change in the water balance as driven by temperature and precipitation from the CMIP5 models, thereby producing data that are directly comparable across all models as opposed to comparing the water balance data from the individual climate models which employ a wide range of hydrologic models and parameterizations.

There are tradeoffs, however, in using the simple WBM instead of more complex watershed models and the WBM has limitations

Miller and Harewood, USGS

USGS
U.S. Geological Survey - National Climate Change Viewer
Summary of Klamath County, Oregon

SUMMARY OF KLAMATH COUNTY, OREGON

1 Maximum 2-m Air Temperature

5 Runoff

Figure 1. Seasonal average time series of maximum 2-m air temperature (°C) for historical period (1950-2005) and 30 CMIP5 models (2005-2100). The historical period ends in 2005, and the future periods begin in 2005. The average of 30 CMIP5 models is indicated by the solid line and their standard deviations are indicated by the respective shaded envelopes.

Figure 2. Monthly average of maximum 2-m air temperature (°C) for historical period (1950-2005) and 30 CMIP5 models (2005-2100). The historical period ends in 2005, and the future periods begin in 2005. The average of 30 CMIP5 models is indicated by the solid line and their standard deviations are indicated by the respective shaded envelopes.

Figure 3. Seasonal average time series of runoff (mm) for historical period (1950-2005) and 30 CMIP5 models (2005-2100). The historical period ends in 2005, and the future periods begin in 2005. The average of 30 CMIP5 models is indicated by the solid line and their standard deviations are indicated by the respective shaded envelopes.

Figure 4. Monthly average of runoff (mm) for historical period (1950-2005) and 30 CMIP5 models (2005-2100). The historical period ends in 2005, and the future periods begin in 2005. The average of 30 CMIP5 models is indicated by the solid line and their standard deviations are indicated by the respective shaded envelopes.

Miller and Harewood, USGS

CSV file showing climate data for Klamath County, Oregon. The data includes columns for Year, Maximum 2-m Air Temperature (°C), and Runoff (mm). The data is organized into sections for historical periods (1950-2005) and future periods (2005-2100) for various CMIP5 models.

Year	Maximum 2-m Air Temperature (°C)	Runoff (mm)
1950	10.8677	10.8677
1951	10.8677	10.8677
1952	10.8677	10.8677
1953	10.8677	10.8677
1954	10.8677	10.8677
1955	10.8677	10.8677
1956	10.8677	10.8677
1957	10.8677	10.8677
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2093	10.8677	10.8677
2094	10.8677	10.8677
2095	10.8677	10.8677
2096	10.8677	10.8677
2097	10.8677	10.8677
2098	10.8677	10.8677
2099	10.8677	10.8677
2100	10.8677	10.8677

Model agreement/spread

At a place (HUC8)

Nationwide (HUC8)

5 Runoff

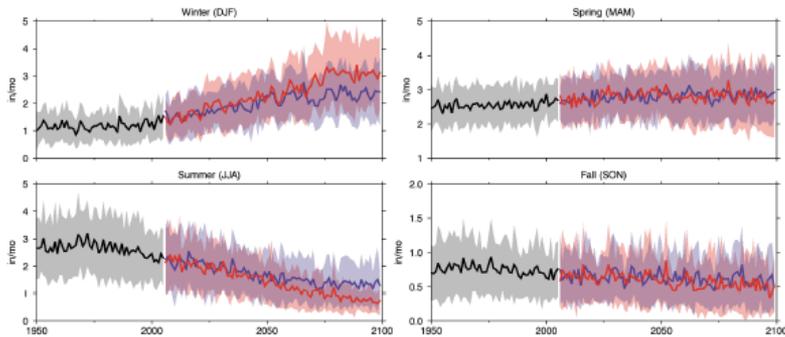


Figure 9: Seasonal average time series of runoff for historical (black), RCP4.5 (blue) and RCP8.5 (red). The historical period ends in 2005 and the future periods begin in 2006. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.

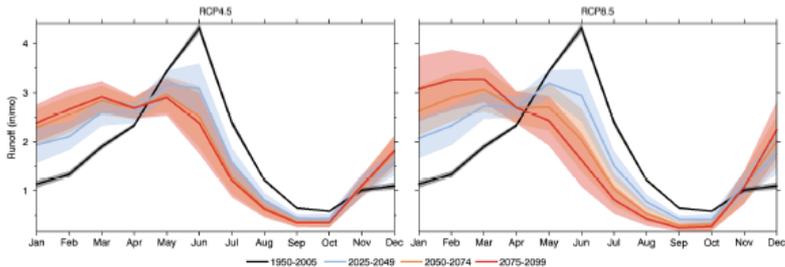
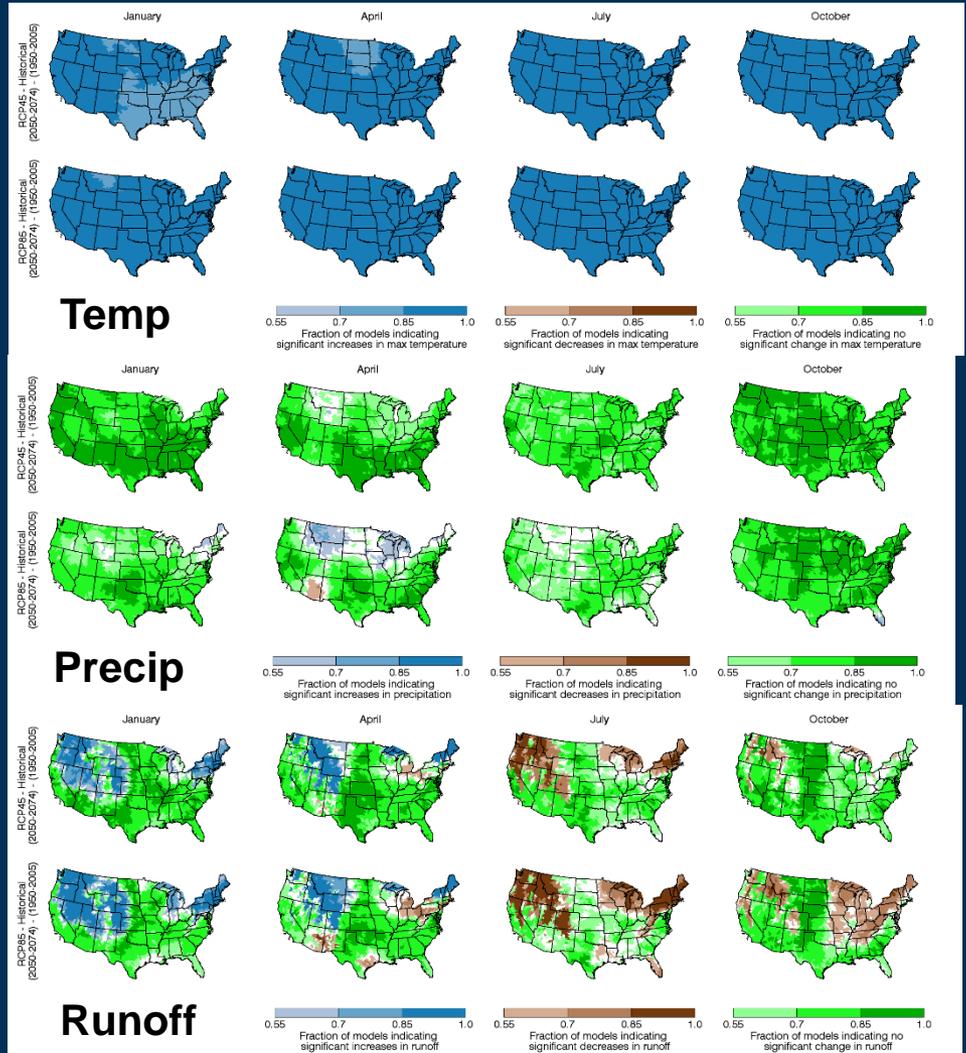


Figure 10: Monthly averages of runoff for four time periods for the RCP4.5 (left) and RCP8.5 (right) simulations. The average of 30 CMIP5 models is indicated by the solid lines and their standard deviations are indicated by the respective shaded envelopes.



Summary

- **NCCV provides simplified access to a maze and volume of CMIP5/IPCC climate data**
- **Entry point for understanding climate modeling in the context of climate change e.g., the average and spread in model results**
- **Starting point for investigating potential future change at local scales**
- **Only one type of downscaling (BCSD) used**
- **Simple water balance model**
- **Monthly time scales do not capture shorter term events e.g., rain on snow flooding, storms**