May 31, 2019

National Forest Climate Change Maps Metadata

https://www.fs.usda.gov/rm/boise/AWAE/projects/national-forest-climate-change-maps.html

Introduction:

The National Forest Climate Change Maps project was developed to meet the need of National Forest managers for information on projected climate changes at a scale relevant to decision making processes, including Forest Plans. The maps use state-of-the-art science and are available for every National Forest in the contiguous United States with relevant data coverage. Currently, the map sets include variables related to precipitation, air temperature, snow (including April 1 snow water equivalent (SWE), and snow residence time), and stream flow.

In addition to the datasets provided for the contiguous U.S., temperature and precipitation maps were produced for the state of Alaska, using datasets developed by SNAP (the Scenarios Network for Alaska and Arctic Planning, https://snap.uaf.edu). These datasets have several important differences from the MACAv2-Metdata, used in the contiguous U.S. They were developed using different global circulation models and different downscaling methods, and were downscaled to a different scale. While they cover the same time periods, and represent the best available science for each portion of the country, caution should be used when directly comparing values between Alaska and the contiguous United States. Additional information on sources and methods for the Alaskan datasets is provided in the environmental data section below.

Data:

GIS Data:

- Terrain base maps were retrieved from maps.stamen.com and converted to grayscale in R.
- Waterbody and stream layers are from the National Hydrography Dataset Plus version 2, and are available at http://www.horizon-systems.com/NHDPlus/NHDPlusV2_home.php.

Environmental Data (Contiguous United States):

- Historical and future precipitation and temperature data are ensemble mean values across 20 global climate models from the CMIP5 experiment (Taylor, Stouffer, & Meehl, 2012), downscaled to a 4km grid. For more information on the downscaling method and to access the data, please see Abatzoglou and Brown (2012) and http://maca.northwestknowledge.net/. We used the MACAv2-Metdata monthly dataset. Monthly precipitation values were summed over the season of interest (annual, winter, or summer). Average temperature values were calculated as the mean of monthly minimum and maximum air temperature values, averaged over the season of interest. We used the time period 1975-2005 to represent the historical period and 2071-2090 under scenario representative concentration pathway (RCP) 8.5 to represent the 2080s.
- April 1 SWE and snow residence time were modeled using the spatial analog models of Luce, Lopez-Burgos, and Holden (2014) (see also Lute and Luce (2017)). These models are built on precipitation and snow data from Snowpack Telemetry (SNOTEL) stations across the western United States and temperature data from the TopoWx dataset (Oyler, Ballantyne, Jencso, Sweet, & Running, 2015). To simulate historical and future gridded snow, the models ingest gridded winter cumulative

precipitation and winter average temperature (from the MACAv2-Metdata dataset described above). While the snow models have been rigorously validated (Lute & Luce, 2017), their application to gridded climate model data has not been evaluated.

- Daily runoff and baseflow from the Variable Infiltration Capacity (VIC) macroscale hydrologic model were used to estimate historical and projected future stream flow metrics for stream segments in the Western U.S. Projections were based on an ensemble of ten global climate models from CMIP3 using the A1B emissions scenario. For each stream segment in the National Hydrography Dataset Plus Version 2 (NHDPlusV2) in the Western U.S. we estimated hydrographs for the historical period (1915-2006), the 2040s (2030-2059), and the 2080s (2070-2099). From these we calculated summary flow metrics to describe flow regimes for each stream segment and each time period. Note that the climate scenarios and time periods used for the stream flow metrics are not the same as those used for precipitation, temperature, and snow. Stream flow metrics data can be found here: https://www.fs.usda.gov/rm/boise/AWAE/projects/modeled_stream_flow_metrics.shtml and more information on the methods used can be found in the associated user guide: https://www.fs.usda.gov/rm/boise/AWAE/projects/VIC_streamflowmetrics/downloads/WUS_VIC_Metrics_UserGuide.pdf.

Environmental Data (Alaska):
The information below is based upon metadata provided by SNAP (https://snap.uaf.edu).

Historical temperature:
  - This set of files includes downscaled projections of monthly totals, and derived annual, seasonal, and decadal means of monthly average temperature (in degrees Celsius, no unit conversion necessary) from 1901 - 2009 (CRU TS 3.1) at 771 x 771 meter spatial resolution. The downscaling process utilizes PRISM climatological datasets from 1971-2000.
  - These data were modified as follows from the original:
    - Annual: all months were averaged together, for the years 1975-2005.
    - Summer: The months of June-August were averaged together, for the years 1975-2005.
    - Winter: The months of November-March were averaged together, for the years 1975-2005.

Projected temperature:
- This set of files includes downscaled projections (RCP 8.5) of monthly means, and derived annual, seasonal, and decadal means of monthly mean temperatures (in degrees Celsius, no unit conversion necessary) from Jan 2006 - Dec 2100 at 771x771 meter spatial resolution. The downscaling process utilizes PRISM climatological datasets from 1971-2000. Each set of files originates from the five top ranked global circulation models from the CMIP5/AR5 models and RCPs (NCAR-CCSM4, GFDL-CM3, GISS-E2-R, IPSL-CM5A-LR, MRI-CGCM3), calculated as a 5-Model Average.
- These data were modified as follows from the original:
  - Annual: all months were averaged together, for the years 2071-2090.
  - Summer: The months of June-August were averaged together, for the years 2071-2090.
  - Winter: The months of November-March were averaged together, for the years 2071-2090.

Absolute change in temperature:

- Projected minus historical temperature values, annually and for each season.

Historical precipitation:

- This set of files includes downscaled historical estimates of monthly totals, and derived annual, seasonal, and decadal means of monthly total precipitation (in millimeters, no unit conversion necessary) from 1901 - 2009 (CRU TS 3.1) at 771 x 771 meter spatial resolution. The downscaling process utilizes PRISM climatological datasets from 1961-1990.
- These data were modified as follows from the original:
  - Annual: for each month, the values were averaged for the years 1975-2005, then these values were summed to give the annual total.
  - Summer: for the months of June-August, the values were averaged for the years 1975-2005, then these values were summed to give the annual total.
  - Winter: for the months of November-March, the values were averaged for the years 1975-2005, then these values were summed to give the annual total.

Projected precipitation:

- This set of files includes downscaled projections (RCP 8.5) of monthly totals, and derived annual, seasonal, and decadal means of monthly total precipitation (in millimeters, no unit conversion necessary) from Jan 2006 - Dec 2100 at 771x771 meter spatial resolution. Each set of files originates the five top ranked global circulation models from the CMIP5/AR5 models and RCPs (NCAR-CCSM4, GFDL-CM3, GISS-E2-R, IPSL-CM5A-LR, MRI-CGCM3), calculated as a 5-Model Average. The downscaling process utilizes PRISM climatological datasets from 1971-2000.
- These data were modified as follows from the original:
  - Annual: for each month, the values were averaged for the years 2071-2090, then these values were summed to give the annual total.
  - Summer: for the months of June-August, the values were averaged for the years 2071-2090, then these values were summed to give the annual total.
  - Winter: for the months of November-March, the values were averaged for the years 2071-2090, then these values were summed to give the annual total.

Absolute change in precipitation:

- Projected minus historical precipitation values, annually and for each season.

Percent change in precipitation:

- Projected minus historical precipitation values, annually and for each season, converted to a percent change from the historical precipitation.

Mapping Method:

All data processing and map making was done in R (https://www.r-project.org/). Map making was automated to run over all National Forests and to be able to map other areas as well.

Colorbars were kept consistent across historical and future maps of the same variable in the same location to facilitate detecting change.

Gridded datasets are displayed as semi-transparent layers, therefor some discoloration due to topographic or forested/non-forested shading on the underlying base map layer may be visible.

Streamflow layers were restricted to only display stream segments with mean annual flow greater than the 80th percentile of mean annual flow values in the mapped area. Historical and future mean annual, mean summer, mean August, and 1.5 year flood maps use log colorbars. For percent changes in streamflow metrics, if the historical value was zero, the percent change value was set to NA and is displayed as gray on the maps.

File Naming Structure:

Maps are provided as pdfs and follow the naming structure:
'*Forest_name*'_'*season*'_'*variable*'_'*timeperiod*'.pdf

'*season*' options:

- Annual (water year summary)
- Winter (November through March summary)
- Summer (June through August summary)

'*variable*' options:

- ppt (precipitation)
- tavg (average temperature)
- A1SWE (April 1 SWE)
- SRT (snow residence time)
- MA (mean annual flow)
- MS (mean summer flow)
- MAug (mean August flow)
- W95 (number of 95th percentile winter floods)
- W99 (number of 99th percentile winter floods)
- Q1_5 (1.5 year flood magnitude)
- CFM (center of flow mass)

'*timeperiod*' options:

- Historical
- RCP85_2080s
- A1B_2040s
- A1B_2080s
- abschange (absolute change)
  - H40 (historical to 2040s for streamflow only)
  - H80 (historical to 2080s for streamflow only)
  - For temperature, precipitation and snow variables, the absolute change is between historical and 2080s since those are the only two time periods available. No suffix is included.
- percentchange (percent change)
  - H40 (historical to 2040s for streamflow only)
  - H80 (historical to 2080s for streamflow only)
  - For temperature, precipitation and snow variables, the percent change is between historical and 2080s since those are the only two time periods available. No suffix is

included.

Available Maps:

Currently, the map sets include variables related to precipitation, air temperature, snow (including April 1 snow water equivalent (SWE), and snow residence time), and stream flow. There are several map types available within each of these categories, listed below. Not all maps are available for every forest due to lack of input data coverage in some areas. Maps are not yet available for Alaskan forests, or for the summer analyses in the contiguous United States.

- Precipitation
  - Historical annual precipitation (1975-2005)
  - Future annual precipitation (2080s, RCP 8.5)
  - Absolute change in annual precipitation (historical to future)
  - Percent change in annual precipitation (historical to future)
  - Historical winter precipitation (1975-2005)
  - Future winter precipitation (2080s, RCP 8.5)
  - Absolute change in winter precipitation (historical to future)
  - Percent change in winter precipitation (historical to future)
- Air Temperature
  - Historical annual average temperature (1975-2005)
  - Future annual average temperature (2080s, RCP 8.5)
  - Absolute change in annual average temperature (historical to future)
  - Historical winter average temperature (1975-2005)
  - Future winter average temperature (2080s, RCP 8.5)
  - Absolute change in winter average temperature (historical to future)
- Snow
  - Historical April 1 SWE (1975-2005)
  - Future April 1 SWE (2080s, RCP8.5)
  - Absolute change in April 1 SWE (historical to future)
  - Percent change in April 1 SWE (historical to future)
  - Historical snow residence time (1975-2005)
  - Future snow residence time (2080s, RCP8.5)
  - Absolute change in snow residence time (historical to future)
  - Percent change in snow residence time (historical to future)
- Stream flow
  - For each of the following stream flow metrics, we provide historical, 2040s, and 2080s maps, plus absolute and percent change maps between historical and 2040s and historical and 2080s:
  - Mean annual flow
  - Mean summer flow
  - Mean August flow
  - Number of 95th percentile winter floods
  - Number of 99th percentile winter floods
  - 1.5 year flood
  - Center of flow mass

Contact Information:

To access maps and data, please visit the project website:

https://www.fs.usda.gov/rm/boise/AWAE/projects/national-forest-climate-change-maps.html

- For map and data questions in the contiguous United States, contact Charles Luce: Charles.Luce@usda.gov or (208) 373-4382
- For website questions, contact Sharon Parkes: Sharon.L.Payne@usda.gov or (208)373-4356
- For questions about the SNAP data, contact Tom Kurkowski (takurkowski@alaska.edu).
- For questions about the Alaskan datasets derived from these data, contact Nathan Walker (nathan.walker1@usda.gov) or Erik Johnson (erik.johnson2@usda.gov) at the USDA Office of Sustainability and Climate.

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