ClimateWNA v5.30

A program to generate climate normal, annual, seasonal and monthly data for historical and future periods in western North America

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About this program

ClimateWNA is a standalone MS Windows® application written in Visual Basic 6.0. It extracts and downscales 1961-1990 monthly climate normal data and monthly solar radiation normal data from a moderate spatial resolution (4 x 4 km) to scale-free point locations, and calculates many (>200) monthly, seasonal and annual climate variables for specific locations based on latitude, longitude and elevation (optional). The downscaling is achieved through a combination of bilinear interpolation and dynamic local elevational adjustment. ClimateWNA also uses the scale-free data as baseline to downscale historical and future climate variables for individual years and periods between 1901 and 2100. A time-series function is available to generate climate variables for multiple years. The coverage of the program is shown in Figure 1.

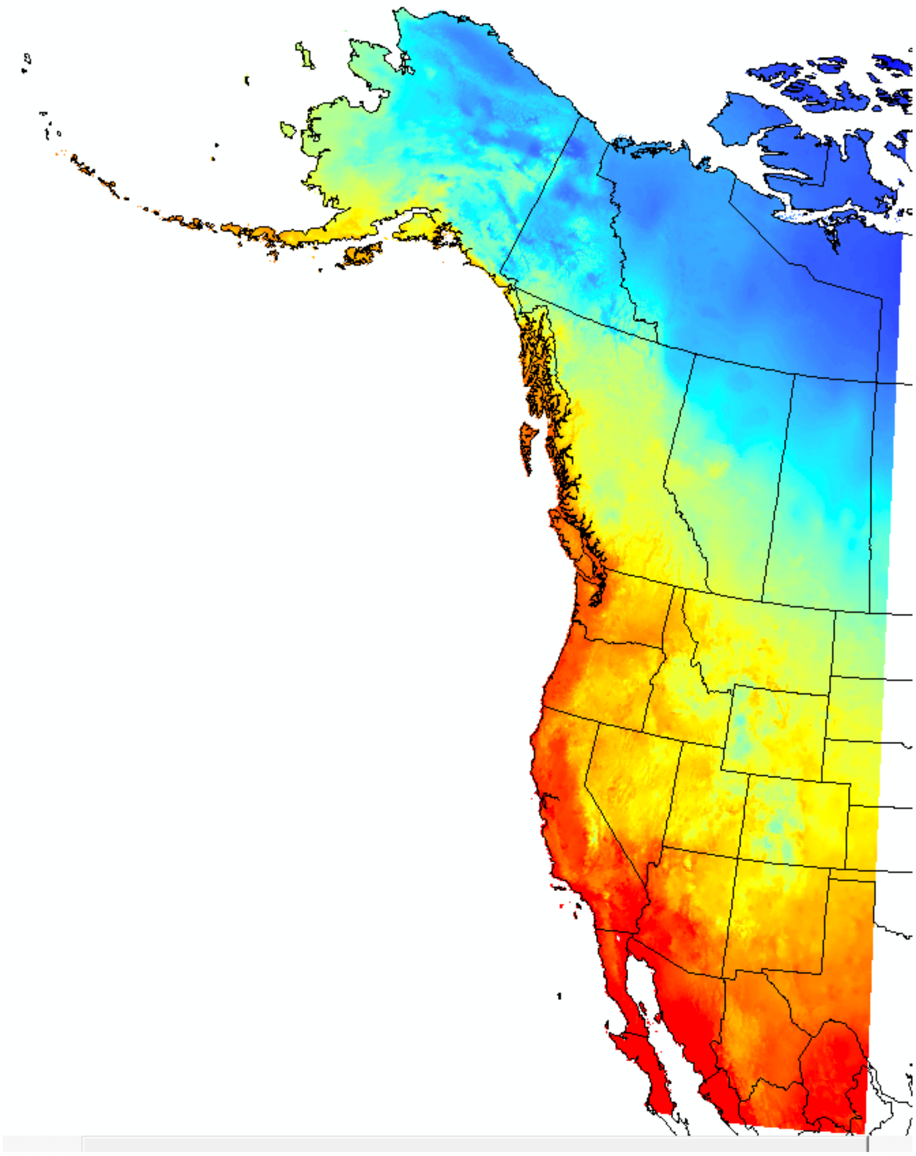


Figure 1. The coverage of ClimateWNA. The extent of the coverage: longitude = -179.167 ~ -100.000°; latitude = 24.494 ~ 79.994°.

Data sources

Baseline data

The monthly baseline data for 1961-1990 normals were compiled from the following sources and unified at 4 x 4 km spatial resolution:

1. British Columbia: PRISM at 800 x 800 m from Pacific Climate Impact Consortium;
2. Parries provinces: PRISM at 4 x 4 km from the PRISM Climate Group (http://www.prism.oregonstate.edu/);
3. United States: PRISM at 800 x 800 m from the PRISM Climate Group (Daly *et al*. 2008);
4. The rest: ANUSPLIN at 4 x 4 km
5. The monthly solar radiation data were provided by Dr. Robbie Hember at University of British Columbia.

Historical data

Historical monthly data were obtained from Climate Research Unit (CRU) (Harris et al 2014). The data version is CRU TS 3.23. The spatial resolution is 0.5 x 0.5° and covers the period of 1901-2014. Anomalies were calculated for each year and period relative to the 1961-1990 normals.

Future climate data

The climate data for future periods, including 2020s (2010-2039), 2050s (2040-69) and 2080s (2070-2100), were from General Circulation Models (GCMs) of the Coupled Model Intercomparison Project (CMIP5) included in the IPCC Fifth Assessment Report (IPCC 2014). Fifteen GCMs were selected for two greenhouse gas emission scenarios (RCP 4.5 and RCP 8.5). When multiple ensembles are available for each GCM, an average was taken over the available (up to five) ensembles. Ensembles among the 15 GCMs are also available.

Time-series of monthly projections are provided for the years between 2011-2100 for RCP 4.5 and RCP 8.5 of six GCMs. A time-series function is available for users to generate time series data for multiple years with a single run.

Paleoclimate data

Monthly paleoclimate data were from four GCMs of the CMIP5. The paleo periods covered: 1) Last Millennium or past 1000 years, starting on January 01, 0850; 2) MidHolocene (6,000 years ago); and 3) Last Glacial Maximum (21,000 kyrs ago). Monthly averages were taken over the first 50 years of each period, which is the minimum period available in among the four GCMs.

How to add climate data from additional GCMs

The coordinate file "ClimateNA_GCM_coord_vID.csv" included in the "Reference" folder can be used as template to add additional GCM data to the package by users. After the monthly climate data are added to the template, remove the first three columns and save it to the GCMdat folder with the extension name ".gcm". This applies to GCM time series data as well.

Climate variables predicted

1) Annual variables:

Directly calculated annual variables:

MAT	mean annual temperature (°C),
MWMT	mean warmest month temperature (°C),
MCMT	mean coldest month temperature (°C),
TD	temperature difference between MWMT and MCMT, or continentality (°C),
MAP	mean annual precipitation (mm),
MSP	mean annual summer (May to Sept.) precipitation (mm),
AHM	annual heat-moisture index (MAT+10)/(MAP/1000))
SHM	summer heat-moisture index ((MWMT)/(MSP/1000))

Derived annual variables:

DD<0	degree-days below 0°C, chilling degree-days
DD>5	degree-days above 5°C, growing degree-days
DD<18	degree-days below 18°C, heating degree-days
DD>18	degree-days above 18°C, cooling degree-days
NFFD	the number of frost-free days
FFP	frost-free period
bFFP	the day of the year on which FFP begins
eFFP	the day of the year on which FFP ends
PAS	precipitation as snow (mm) between August in previous year and July in current year
EMT	extreme minimum temperature over 30 years
EXT	extreme maximum temperature over 30 years
Eref	Hargreaves reference evaporation (mm)
CMD	Hargreaves climatic moisture deficit (mm)
MAR	mean annual solar radiation (MJ m^{-2} d^{-1})
RH	mean annual relative humidity (%)

2) Seasonal variables:

Seasons:

Winter (_wt): Dec. (prev. yr) - Feb for annual, Jan, Feb, Dec for normals

Spring (_sp): March, April and May

Summer (_sm): June, July and August

Autumn (_at): September, October and November

Directly calculated seasonal variables:

Tave_wt	winter mean temperature (°C)

Tave_sp	spring mean temperature (°C)
Tave_sm	summer mean temperature (°C)
Tave_at	autumn mean temperature (°C)
Tmax_wt	winter mean maximum temperature (°C)
Tmax_sp	spring mean maximum temperature (°C)
Tmax_sm	summer mean maximum temperature (°C)
Tmax_at	autumn mean maximum temperature (°C)
Tmin_wt	winter mean minimum temperature (°C)
Tmin_sp	spring mean minimum temperature (°C)
Tmin_sm	summer mean minimum temperature (°C)
Tmin_at	autumn mean minimum temperature (°C)
PPT_wt	winter precipitation (mm)
PPT_sp	spring precipitation (mm)
PPT_sm	summer precipitation (mm)
PPT_at	autumn precipitation (mm)
RAD_wt	winter solar radiation (MJ m^{-2} d^{-1})
RAD_sp	spring solar radiation (MJ m^{-2} d^{-1})
RAD_sm	summer solar radiation (MJ m^{-2} d^{-1})
RAD_at	autumn solar radiation (MJ m^{-2} d^{-1})

Derived seasonal variables:

DD_0_wt	winter degree-days below 0°C
DD_0_sp	spring degree-days below 0°C
DD_0_sm	summer degree-days below 0°C
DD_0_at	autumn degree-days below 0°C
DD5_wt	winter degree-days below 5°C
DD5_sp	spring degree-days above 5°C
DD5_sm	summer degree-days above 5°C
DD5_at	autumn degree-days above 5°C
DD_18_wt	winter degree-days below 18°C
DD_18_sp	spring degree-days below 18°C
DD_18_sm	summer degree-days below 18°C

DD_18_at autumn degree-days below 18°C

DD18_wt winter degree-days below 18°C
DD18_sp spring degree-days above 18°C
DD18_sm summer degree-days above 18°C
DD18_at autumn degree-days above 18°C

NFFD_wt winter number of frost-free days
NFFD_sp spring number of frost-free days
NFFD_sm summer number of frost-free days
NFFD_at autumn number of frost-free days

PAS_wt winter precipitation as snow (mm)
PAS_sp spring precipitation as snow (mm)
PAS_sm summer precipitation as snow (mm)
PAS_at autumn precipitation as snow (mm)

Eref_wt winter Hargreaves reference evaporation (mm)
Eref_sp spring Hargreaves reference evaporation (mm)
Eref_sm summer Hargreaves reference evaporation (mm)
Eref_at autumn Hargreaves reference evaporation (mm)

CMD_wt winter Hargreaves climatic moisture deficit (mm)
CMD_sp spring Hargreaves climatic moisture deficit (mm)
CMD_sm summer Hargreaves climatic moisture deficit (mm)
CMD_at autumn Hargreaves climatic moisture deficit (mm)

RH_wt winter relative humidity (%)
RH_sp winter relative humidity (%)
RH_sm winter relative humidity (%)
RH_at winter relative humidity (%)

3) Monthly variables

Primary monthly variables:

Tave01 – Tave12 January - December mean temperatures (°C)
TMX01 – TMX12 January - December maximum mean temperatures (°C)
TMN01 – TMN12 January - December minimum mean temperatures (°C)

PPT01 – PPT12 January - December precipitation (mm)
RAD01 – RAD12 January - December solar radiation (MJ m^{-2} d^{-1})

Derived monthly variables:
DD_0_01 – DD_0_12 January - December degree-days below 0°C
DD5_01 – DD5_12 January - December degree-days above 5°C
DD_18_01 – DD_18_12 January - December degree-days below 18°C
DD18_01 – DD18_12 January - December degree-days above 18°C
NFFD01 – NFFD12 January - December number of frost-free days
PAS01 – PAS12 January – December precipitation as snow (mm)
Eref01 – Eref12 January – December Hargreaves reference evaporation (mm)
CMD01 – CMD12 January – December Hargreaves climatic moisture deficit (mm)
RH01 – RH12 January – December relative humidity (%)

How to install

No installation is required. Simply unzip all the files and subfolders into a folder on your hard disk and double click the file ClimateNA _v5.**.exe".

How to use

1) Use the program interactively

Latitude and longitude can be entered in either decimal degrees (e.g. Lat: 51.542, Long: 129.333) or degree, minute and second (e.g., 51°30'15"N, 129°15'30'W). Longitude information is accepted either in positive or negative values. Elevation has to be entered in meters, or empty if no elevation data available. If "Monthly variables", "Seasonal variables" or "All variables" output variables was selected, an additional output sheet appears and annual climate variables are still calculated.

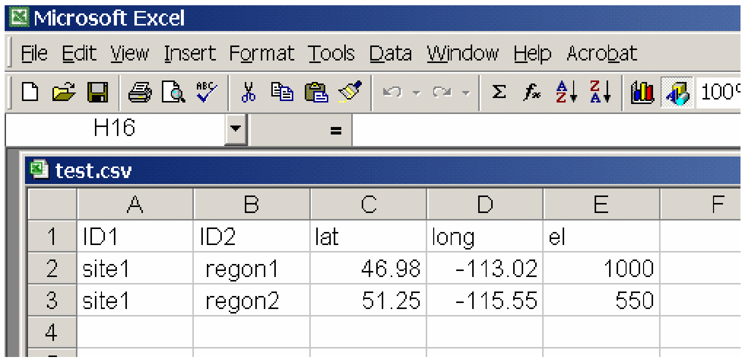
Output data can be saved as text file and imported to spreadsheet file using space-delimitated option.

2) For multi-location process

- Most users will have their sample data information in an Excel spreadsheet or in a text file. To make it possible for the program to read this data it must first be modified to a standard format.

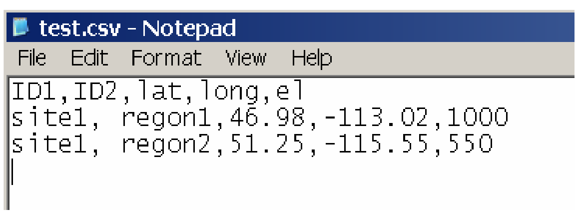
- Create a spreadsheet with the headers "ID1, ID2, lat, long, el" as shown in the example below. ID1 and ID2 can be "Location", "Region" or whatever. The file must have the title row and all variables in exactly the same order as shown. If you don't have elevation information or a second ID, you have to put in "." in the columns. If you have more information columns in your original file, you have to remove them.

- If you use a GPS or GIS software to obtain your location information for many samples latitude values in the western hemisphere will be negative. For convenience, you can use either positive or negative values and the program will automatically convert the data.



- After the spreadsheet is prepared as shown, save it as "comma delimited text file" by choosing "Save as …" form the file menu, and then specifying (*.csv) from the "Save as type …" drop down menu.

- You can also directly create a comma delimited text file in any text editor such as Notepad. If there is a missing value, you need to enter a "." between two commas.



- Save this text file with a .csv extension by writing out the full file name with extension in parenthesis when saving, e. g. "test.csv" instead of test.csv or test.

- Now you are ready for processing: Click on Select input file to read your spreadsheet and on Specify output file to specify your output file folder and file. Then, click the Start button. Climate variable information will be appended as additional columns to your input file. If elevation information is provided the climate variables will be elevation adjusted.

3) For Time Series

Time Series function works only for multi-location process. Here are the steps to follow:

1. Select "Time Series" (for historical years) or a future time series in the period section drop box;
2. Select a variable category (monthly, seasonal, annual or all variables);

3. Input the starting and ending years in the pop-up boxes;
4. Specify input and output files, and click the “Calculate TS” button.

4) How to generate climate surfaces

1. Have a DEM raster for the area of interest at the resolution you want;
2. Convert DEM raster to a feature in ArcGIS (or other programs);
3. Add XY (lat/long) to the feature;
4. Use SAS or R to manipulate the dbf file of the feature to generate an input file for ClimateBC;
5. Import csv output of climate variables into ArcGIS (or other programs) to generate the surfaces.

How to refer

Wang, T., Hamann, A. Spittlehouse, D.L. and Murdock, T.Q. 2012. ClimateWNA – High-resolution spatial climate data for western North America. *Journal of Applied Meteorology and Climatology* **51**:16-29.

References

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Harris, I., Jones, P.D., Osborn, T.J. and Lister, D.H. (2014), Updated high-resolution grids of monthly climatic observations - the CRU TS3.10 Dataset. International Journal of Climatology, 34. pp. 623-642.