Explanation of the climate surfaces for the PIER 2010 Vulnerability and Adaption (V&A) study

Primary Contact: Jim Thorne (jhthorne@ucdavis.edu) 530-752-4389
Secondary Contact: Ryan Boynton (rmboynton@ucdavis.edu) 530-752-9614

Background

For the V&A study, the Flints (USGS) and Jim Thorne (UC Davis) have further downscaled and bias corrected a *subset* of four of the "standard" climate scenarios provided by Dan Cayan et al. This subset of downscaled standard future climates as well as historical data based on the 4km PRISM climate surfaces was created using a method developed by Drs. Lorrie and Alan Flint, for the A2 and B1scenarios of the PCM and GFDL GCMs to a 270m horizontal resolution. The Flints have been coordinating with the PRISM group, and Scripps to develop these high resolution products for the state of California and its connecting watersheds.

For this California domain, we produced 270m grids to represent historic and future climates from 1900 to 2100, resulting in 6,594,862 grid cells. Since retaining yearly values for this region results in unwieldy large files, we have reduced the data size for distribution to 30-year means, providing monthly blocks of variables historically for 1911-1940, 1941-1970, 1971-2000. Future climate values are based off 100 year simulations, with 2010-2039, 2040-2069, and 2070-2099 time slices produced. ASCII or ArcGRID files are available for each of the time slices, with an average size of 151 MB per ASCII file and 58 MB per ArcGRID file.

Using a regional water balance model, the Basin Characterization Model (BCM), driven by the high resolution downscaled precipitation and temperature, the Flints developed a program to calculate and portray several other derivative measures, which are associated with the water balance at the land surface. Calculation of these items required some static inputs as well as time varying measures derived from the RCMs provided by Scripps. The static inputs include: 1) DEM, 2) geology, 3) soil water content at field capacity, 4) soil porosity, 5) bulk bedrock permeability, 6) soil thickness, and 7) soil water content at wilting point. We used the BCM to produce an additional suite of variables state-wide at the 270m grid scale.

These data are intended to be available for any members of the PIER V&A study who would like to use them. The advantage in using them is that results will cross-comparable with other studies that also use them. To get a copy please contact Ryan or Jim above. You will need to send a portable hard drive to us, and we will copy the files for you. Please contact us first to specify what file formats you desire. Some limited additional processing may be conducted, so if a variable you need is not there (but you can give us the equation and the citation), or you have some other request, feel free to let us know. We are in the final steps of processing now, so will be considering future steps in the near future.

These are 14 variables processed.

Variable	Code	Creation Method	Units	Equation/model	Description
Maximum Temperature	tmax	downscaled	degree C	Model input	The maximum monthly temperature averaged annually
Minimum Temperature	tmin	downscaled	degree C	Model input	The minimum monthly temperature averaged annually
Precipitation	ppt	downscaled	mm	Model input	Total monthly precipitation (rain or snow) summed annually
Potential Evapotranspiration	pet	Modeled/ pre-processing input for BCM	mm	Modeled* on an hourly basis from solar radiation that is modeled using topographic shading, corrected for cloudiness, and partitioned on the basis of vegetation cover to represent bare-soil evaporation and evapotranspiration due to vegetation	Total amount of water that can evaporate from the ground surface or be transpired by plants summed annually
Runoff	run	BCM	mm	Amount of water that exceeds total soil storage + rejected recharge	Amount of water that becomes stream flow, summed annually
Recharge	rch	BCM	mm	Amount of water exceeding field capacity that enters bedrock, occurs at a rate determined by the hydraulic conductivity of the	Amount of water that penetrates below the root zone, summed annually

				underlying materials, excess water (rejected recharge) is added to runoff	
Climatic Water Deficit	cwd	BCM	mm	pet-aet	Annual evaporative demand that exceeds available water, summed annually
Actual Evapotranspiration	aet	BCM	mm	pet calculated* when soil water content is above wilting point	Amount of water that evaporates from the surface and is transpired by plants if the total amount of water is not limited, summed annually
Sublimation	subl	BCM	mm	Calculated*, applied to pck	Amount of snow lost to sublimation (snow to water vapor) summed annually
Soil Water Storage	stor	BCM	mm	ppt + melt – aet – rch - run	Average amount of water stored in the soil annually
Snowfall	snow	BCM	mm	precipitation if air temperature below 1.5 degrees C (calibrated)	Amount of snow that fell summed annually
Snowpack	pck	BCM	mm	Prior month pck + snow – subl - melt	Amount of snow that accumulated per month summed annually (if divided by 12 would be average monthly snowpack)
Snowmelt	melt	BCM	mm	Calculated*, applied to pck	Amount of snow that melted summed annually (snow to liquid water)
Excess Water	exc	BCM	mm	ppt – pet	Amount of water that remains in the system, assuming evapotranspiration consumes the maximum possible amount of water, summed annually for positive months only

Table 1 – Description of the 14 variables available

*the equation or model for these variables is available from the following publications:

Flint, A.L., Flint, L.E., Hevesi, J.A., and Blainey, J.M., 2004, Fundamental concepts of recharge in the Desert Southwest: a regional modeling perspective, in *Groundwater Recharge in a Desert Environment: The Southwestern United States,* edited by J.F. Hogan, F.M. Phillips, and B.R. Scanlon, Water Science and Applications Series, vol. 9, American Geophysical Union, Washington, D.C., 159-184.

Flint, L.E., and Flint, A.L., 2007, Regional analysis of ground-water recharge, *in* Stonestrom, D.A., Constantz, J., Ferré, T.P.A., and Leake, S.A., eds., Ground-water recharge in the arid and semiarid southwestern United States: U.S. Geological Survey Professional Paper 1703, p. 29-59. http://pubs.usgs.gov/pp/pp1703/ http://pubs.usgs.gov/pp/pp1703/b/

Flint, A.L., and Flint, L.E., 2007, Application of the basin characterization model to estimate in-place recharge and runoff potential in the Basin and Range carbonate-rock aquifer system, White Pine County, Nevada, and adjacent areas in Nevada and Utah: U.S. Geological Survey Scientific Investigations Report 2007-5099, 20 p. http://pubs.usgs.gov/sir/2007/5099/

Currently, we have the data in 3 groups as explained below.

1. Monthly values
   a. A value for every month of every year modeled.
2. 30y Monthly Summary
   a. Summaries of monthly values were calculated for 30 year intervals. For each month all 30 years in the sequence were fed into a linear regression model. The historic time frames supplied are: 1911-1940, 1941-1970 and 1971-2000. The future scenarios provided are for: 2010-2039, 2040-2069, 2070-2099.
3. 30y Water Year Summary
   a. The same time frames are provided for water years. Water year summaries were done by either averaging or adding the values from all 12 months for each water year. Water years start in October and end in September, therefore water year 2000 is from October 1999 to September 2000. Table 2 displays the method used for each variable.
   b. 30 year water year summaries were then calculated by running a linear regression model on a sequence of 30 water years.

Variable	Code	Calculation Method
Maximum Temperature	tmax	average
Minimum Temperature	tmin	average
Precipitation	ppt	total
Potential Evapotranspiration	pet	total
Runoff	run	total
Recharge	rch	total
Climatic Water Deficit	cwd	total
Actual Evapotranspiration	aet	total
Sublimation	subl	total

Soil Water Storage	stor	total
Snowfall	snow	total
Snowpack	pck	total
Snowmelt	melt	total
Excess Water	exc	total

Table 2 – Combining method used for Water Year Summaries

In addition to the averages (ave), we also produced the following statistics for the 30 year summaries:

Average	ave
Standard Deviation	std
Coefficient of Variation	cov
Variance	var
Coefficient of Determination	rsq
Slope	slp
Intercept	int

Table 3 – Other statistics available for the summaries

Equations used were from: Zar, Jerrold H., 1999, Biostatistical Analysis - 4th Edition, Prentice-Hall, New Jersey
Data from all 3 of these groups are available in either ASCII text file or ArcGRID or both. We do not plan to distribute the raw monthly files as they comprise some 11 TB. Here is a breakdown of data availability:

		Monthly		30y Water Year Summary		30y Monthly Summary	
		ASCII	GRID	ASCII	GRID	ASCII	GRID
Maximum Temperature	tmax	yes	no	yes	yes	yes	yes
Minimum Temperature	tmin	yes	no	yes	yes	yes	yes
Precipitation	ppt	yes	no	yes	yes	yes	yes
Potential Evapotranspiration	pet	yes	no	yes	yes	yes	yes
Runoff	run	yes	no	yes	yes	yes	yes
Recharge	rch	yes	no	yes	yes	yes	yes
Climatic Water Deficit	cwd	yes	no	yes	yes	yes	yes
Actual Evapotranspiration	aet	yes	no	yes	yes	yes	yes
Sublimation	subl	yes	no	yes	yes	yes	yes
Soil Water Storage	stor	yes	no	yes	yes	yes	yes
Snowfall	snow	yes	no	yes	yes	yes	yes
Snowpack	pck	yes	no	yes	yes	yes	yes
Melt	melt	yes	no	yes	yes	yes	yes

Excess Water	exc	yes	no	yes	yes	yes	yes
Approx size (all variables, 1 scenario, uncompressed)		2.3TB		47GB	16GB	525GB	200GB
Approx size (all variables, 1 scenario, compressed)				3.17GB	2.85GB	19.8GB	18.1GB

Table 4 – Available formats for the 14 variables

File naming convention

1. Summary Data
    a. ASCII
        i. VariableYear1_Year2Month_Statistic_Scenario
            1. Variable = the 3-4 letter code for the variable
                a. See Table 1
            2. Year1 = The first year of the summary
            3. Year2 = The last year of the summary
            4. Month = 3 letter code for the month
                a. If there is no Month in the file name, it is a water year summary
                b. jan,feb,mar,apr,may,jun,jul,aug,sep,oct,nov,dec
            5. Statistic = the 3 letter code for the statistic
                a. See Table 3
            6. Scenario = thee 3 letter code for the scenario
                a. HST = Historic (PRISM) data
                b. PA2 = PCM A2
                c. PB1 = PCM B1
                d. GA2 = GFDL A2
                e. GB1 = GFDL B1
        ii. Example1: pck1971_2000jan_ave_HST

            1. This is the average snow pack in January for the 30 years between 1971 and 2000 within the Historic (PRISM) scenario
        iii. Example2: ppt2070_2099_var_PA2
            1. This is the variance of the total precipitation for the 30 water years between 2070 and 2099 within the PCM A2 scenario
            2. I know that this is total precipitation for the water year (and not the monthly average) by looking at Table 2
    b. ArcGRID
        i. VariableYear1Year2WYMonthStatistic
            1. Variable = the 3-4 letter code for the variable
                a. See Table 1
            2. Year1 = The last 2 digits of the first year of the summary
            3. Year2 = The last 2 digits of the last year of the summary
            4. WYMonth = 2 digit code for the water year month
                a. If there is no Month in the file name, it is a water year summary
                b. Reminder: Water years start in October and end in November
                    i. The 01 month of the 2000 water year = October 1999
                    ii. The 06 month of the 2000 water year = March 2000
            5. Statistic = the 3 letter code for the statistic
                a. See Table 3
            6. Scenario – The scenario is not part of the file name. This is because ArcGRIDs have a maximum length of 13 characters. Therefore, we suggest you store these files in a folder that contains the scenario name.
        ii. Example1: pck710004ave (within the Historic folder).
            1. This is the average snow pack in January for the 30 years between 1971 and 2000 within the Historic (PRISM) scenario
        iii. Example2: ppt7099var (within the PCM A2 folder)
            1. This is the variance of the total precipitation for the 30 water years between 2070 and 2099 within the PCM A2 scenario
2. Monthly Data
    a. Only available in ASCII format
    b. The data format is not consistent across variables. This is due to these files being an output of the BCM model. Table 5 displays the format for each Variable.
        i. Month = 3 letter code for the month
            1. jan,feb,mar,apr,may,jun,jul,aug,sep,oct,nov,dec
        ii. Year = 4 digits for the year
            1. 2000, 2001, 2002, etc.

Variable	Data Format
Maximum Temperature	tmaxYearMonth
Minimum Temperature	tminYearMonth
Precipitation	pptYearMonth
Potentail Evapotranspiration	petYearMonth
Runoff	run2MonthYear
Recharge	rch3MonthYear
Climatic Water Deficit	cwd1MonthYear
Actual Evapotranspiration	aetMonthYear
Sublimation	sublYearMonth
Soil Water Storage	storYearMonth

Snowfall	snowYearMonth
Snowpack	pckYearMonth
Melt	meltYearMonth
Excess Water	exc1MonthYear

Table 5 – Data format for the Monthly ASCII data