Lab 6 Assignment - Snowpack formation and melt

(Due Friday March 8 at 5:00pm)

Your consulting firm has been hired by the California Department of Water Resources (DWR) to develop a model of snowpack formation and melt in California. The overall aim is to help understand how changes in temperature during this century may affect the water supply of the region, with implications for both the surrounding ecosystems and the many aqueducts in the state.

The first part of this project is to demonstrate to the DWR the ability of your model to successfully predict historical observations (i.e. how good is your model?). Then you'll provide an initial evaluation of changes in water availability based on scenarios of future temperature change. Finally, you'll write a brief summary of your results.

Part 1 – Demonstration and evaluation of the model using data from Tuolumne Meadows, CA. Use your code from Lab 6 and data from **Lab 6 Data 2021.RData** to show the results of your model calibration. (These figures are also described in the lab handout.)

- **Figure 1**: An overlay of both modeled and observed snowpack SWE through time for the 2021 Water Year.

- **Figure 2**: A scatterplot of observed (X) vs. modeled (Y) snowpack SWE values at Tuolumne Meadows during the 2021 water year. Be sure to include the 1:1 line and the best fit line. Indicate the value for albedo that allows modeled SWE to more closely match the observed SWE.

Part 2 – Changes to the timing and magnitude of snowmelt and rainfall under climate change scenarios.

Approach for simulating different climate scenarios: As a first examination of future changes in temperature, we can implement "crude" climate simulations by modifying the object `Temp` prior to being used in your model. For example, `Temp <- Temp + 4` will increase each day's temperature by 4°C.

It's ultimately up to you to decide how you want to use/modify your code in order to create the figures and address the questions below, but I suggest that you look at *Lab 6 Assignment - Chunks Example.Rmd* (and corresponding PDF). This shows how to separate your model from inputs that you might want to vary, which can make it easier to run multiple scenarios and overlay the results.

- **Figure 3**: A plot (or plots) showing the cumulative sum of snowmelt for (1) the modeled 2021 water year, and (2) a scenario where the 2021 temperature values are increased by 4 ˚C.
  - You can do this by making two separate figures or making an overlay/panels plot. If you create two separate figures, be sure that the Y axis scaling on each is the same (for proper comparison) by using the `ylim` argument in weplot, e.g.:

    ```
    weplot(..., ylim = c(0, 500))
    ```

    This sets the Y axis minimum to 0 and the maximum to 500

- **Figure 4**: A plot (or plots) showing the cumulative sum of liquid water for (1) the modeled 2021 water year, and (2) a scenario where the 2021 temperature values are increased by 4 ˚C.
  - Liquid water in this case is rainfall plus snowmelt, which represents the maximum potential for runoff that could flow into the Los Angeles aqueduct. The *amount* and *timing* of this value is crucial for water managers.

For the following, you'll need to examine the change in final snowmelt dates across multiple years using data from **Lab 6 Data 2018-2021.RData**. (Note that there is no `SWE.Observed` object in this dataset)

- **Table 1:** Generate values for the table below that shows the range of final snow melt dates for three warming scenarios (+0˚C, +2˚C, +4˚C). In other words, when is the runoff from snowmelt expected to end?
  - Use the `melt.dates` function: `melt.dates(SWE, Date)`
  - Only include the final melt date for each year. In other words, don't include melt dates for a snowpack that forms and melts earlier in the season, but then reforms.)
  - Example range for final melt dates across four years: "5/3 - 6/14"

	Temperature Increase		
	0 ˚C	**2 ˚C**	**4 ˚C**
Final snow melt date range	? - ?	? - ?	? - ?

Part 3

- Write a brief report (one page maximum) that summarizes your results and explicitly refers to all your figures and tables. Be sure to consider both the strengths and potential limitations of your model. Also, be mindful of the *magnitude*, *variability*, and *timing* of your results as all of these are very important for water management.

- Be sure to think beyond “first-order” results such as “the snowpack will increase/decrease”. Really dig into the patterns observed. For example, what about water derived from rain versus snow melt water? Is the response to temperature nonlinear? There’s a lot in there that you can look at – don’t necessarily limit yourself to examining only the figures/table suggested here.

- Make sure that each figure and table has a proper caption and that all axes are labeled.