Climate Variables Impacting Water Supply of the Colorado River Basin in the Upper Yampa and Roaring Fork Watersheds

By Rachael Jones, Summer 2021 intern, AGCI, CW3E, SIO

Mentors: Elise Osenga, Julie Vano, Nathan Stewart, Michelle Stewart, Nicole Pepper

Introduction and Research Question

Aspen Global Change Institute (AGCI) is a non-profit organization in the town of Aspen Colorado, within the Roaring Fork Watershed of the Upper Colorado River Basin (UCRB). This organization maintains a network of soil moisture monitoring stations spanning from 6,000 to 12,000 feet above sea level. The Yampa Valley Sustainability Council (YVSC) in The Upper Yampa Watershed, another high mountain basin within the UCRB, is working to install a similar network. With consideration of the collaborative nature between AGCI and YVSC, my goal this summer was to analyse the available climate data within both watersheds and identify the most significant climate variables within these high-impact watersheds that are affecting the water supply of the Colorado River Basin. While small, both watersheds contribute a sizable portion of the annual flow of the Colorado River (between 5% and 12% respectively), and any shifts in the local climate has a direct impact on the Colorado River Basin.

Methods

I began with a review of the literature and gathered abundant information on the topic. This research mostly consisted of peer-reviewed journal articles, State of the Science reports for both basins, as well as recordings of presentations and discussions on the topic. Other helpful sources were websites devoted to high-impact variables (for example, codos.org, a website devoted to dust on snow research), in-person interviews with professionals in relevant fields, and field days in which I tested soils in both watersheds. After the most significant variables were identified, I decided on methods for visualizing my findings. I used GIS and gridded Prism data to display temperatures over the last four decades (1981-2020) in each watershed, as well as Excel and SNOTEL data for creating graphs of precipitation and snowmelt trends in each watershed.

Results (Variables Identified)

The most significant variable identified was warming temperatures in both basins (and in the UCRB as a whole): a full 2 degrees Fahrenheit warming from 1980 to 2019 (Lukas, et al. 2020). It is estimated that ⅓ or more of the recent Colorado River flow reduction is most likely a result of record-setting warmth (Udall, Overpeck, 2017). This variable contributes toward an earlier date of snowmelt (specifically verified at two SNOTEL sites in each watershed, the Tower site on Buffalo Pass, and the Independence Pass site) across the region, more annual precipitation falling as rain rather than snow (Brekke, et al.), an earlier and more intense runoff pattern in the spring, higher rates of evapotranspiration (Milly, Dunne, 2020) leading to decreased runoff and streamflow, and general drying of the vegetation and soils (Udall, Overpeck, 2017). While precipitation fluctuates widely on an interannual basis, the recent drought is worsened by the higher temperatures, a phenomenon known as “hot drought” (Udall, Overpeck, 2017). Another interesting and relevant variable is dust on snow events, when dust primarily from the Colorado plateau is deposited by wet or dry storms onto Colorado’s snowpack. This dust significantly decreases the albedo of the snow and enhances the timing and intensity of snowmelt by as much as fifty-one days, a much greater impact than warming temperatures (Skiles, et al. 2012). While not a climate variable, dust on snow events have intensified in recent decades due to increased disturbance in the southwest region of the United States, from both recreation, grazing, and general erosion due to drying soils and vegetation (Skiles, et al. 2012).

Other interesting findings included the variation in topography between the two basins: specifically the more homogeneous nature of the landscape in the Upper Yampa, and more variation in the Roaring Fork. The temperature overlay on the GIS maps made this difference quite apparent. Additionally, the amount of precipitation and date of snowmelt varies significantly, not only year to year, but between basins as well.

Conclusion

Variability between the watersheds was expected, specifically annual precipitation totals and temperature. The trend towards an earlier date of snowmelt is stronger in the Upper Yampa, and only slightly noticeable in the Roaring Fork. Findings in regards to general trends were similar in both watersheds, most notably the significant increase in temperatures over the last few decades. Despite the variations, both watersheds are experiencing impacts from the climate variables, which have and will continue to have a significant impact on annual flows of the Colorado river, and availability of water in the southwest region of the United States in the future (Udall, Overpeck, 2017).

Figures

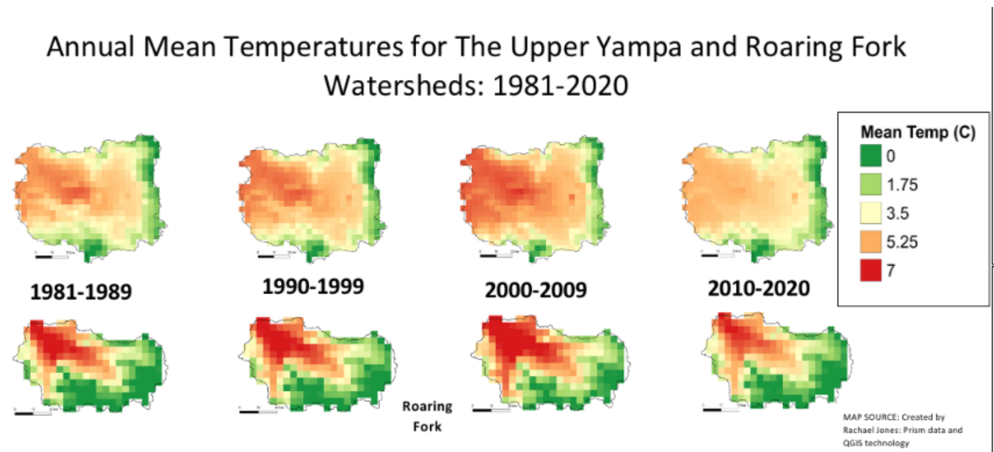

Figure 1. GIS maps representing annual mean temperatures, 1981-2020. Upper Yampa and Roaring Fork Watersheds

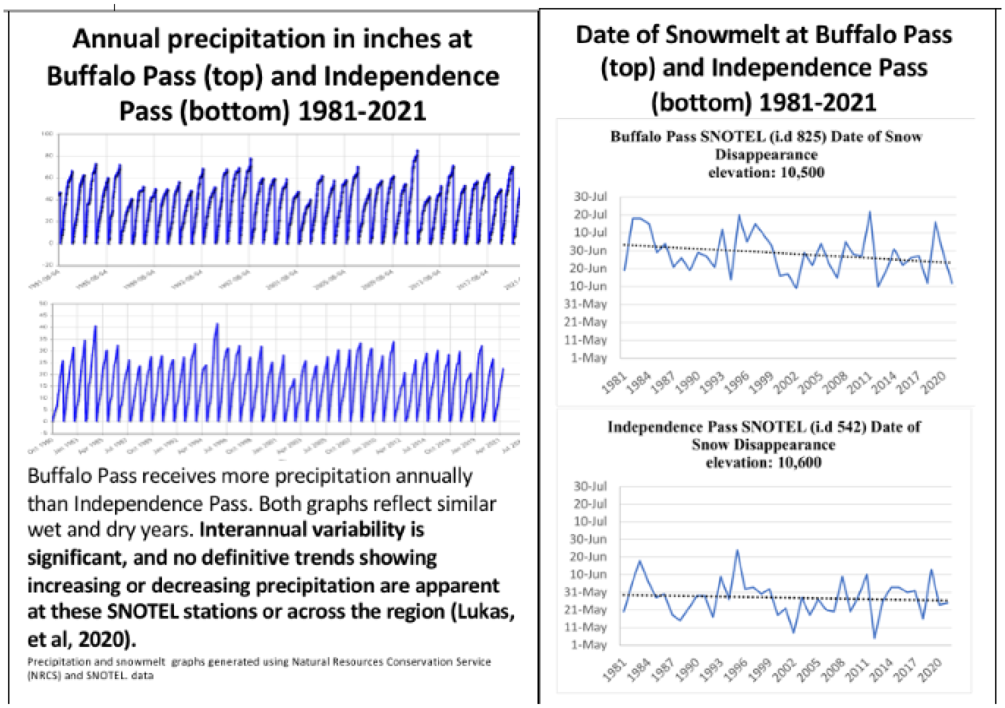

Figure 2. Annual precipitation and date of snowmelt at Buffalo Pass and Independence Pass, 1981-2021.

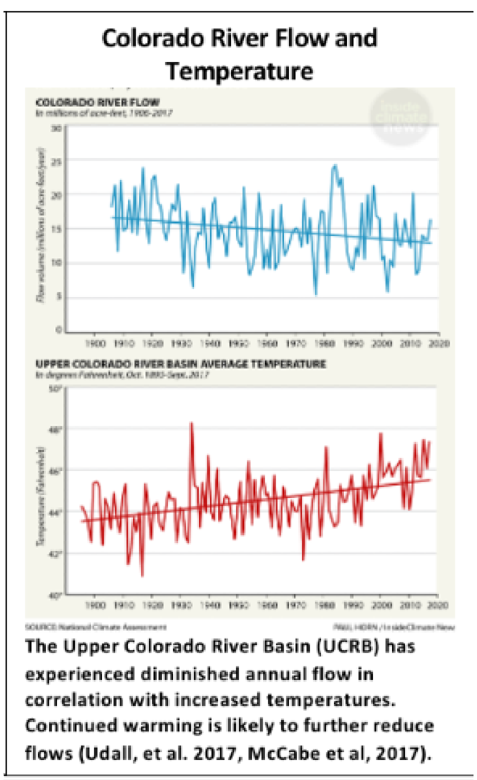

Figure 3. Colorado River flow and temperature relationship, 1900-2020

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