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Changing Snowpack-streamflow Relationships in the Rio Grande Headwaters

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ABSTRACT

Surface water supplies in most areas of western North America are derived principally from snowmelt runoff from high elevation watersheds. We document the changing relationship over the past half-century between snowpack, total precipitation, and snowmelt runoff in one such watershed, the Upper Rio Grande basin (Fig. 1). Snowpack is significantly declining in this watershed, while streamflow out of the basin is also declining but proportionately much less. We diagnose these changes in terms of runoff ratios of streamflow/snowpack or streamflow/precipitation, as well as the runoff sensitivity d(streamflow)/ d(snowpack). We find that changes to runoff sensitivity are broadly in agreement with expectations from global climate change models, but the runoff ratio based on precipitation has not changed as much due to the increasing importance of spring season precipitation during the snow ablation season. These hydrologic changes have immediate practical consequences for seasonal streamflow forecasting, because the signal/noise ratio for such forecasts is declining rapidly as the direct correlation between snowpack (the principal source of seasonal prediction skill) and subsequent streamflow becomes smaller as snowpack declines.

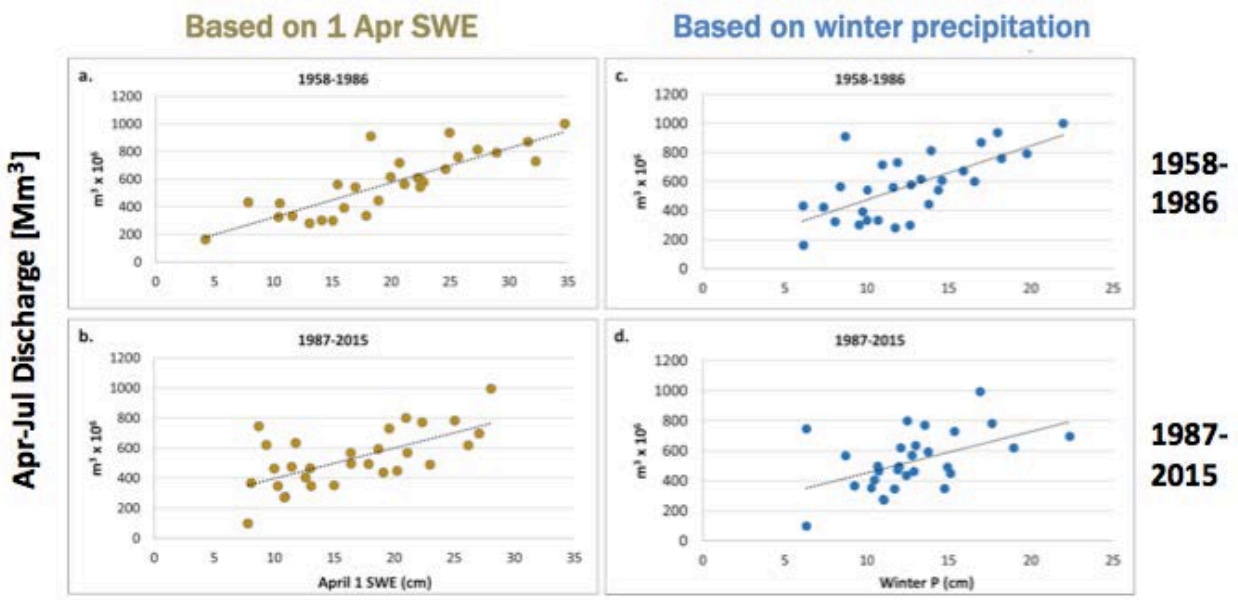

Fig. 1 Runoff ratios of streamflow/snowpack (left column) and streamflow/winter precipitation (right column) at the Del Norte gage for 1958-1986 (top row) and 1987-2015 (bottom row). In later epoch, much worse linear fit (streamflow depends less directly on snow water equivalent (SWE) or precipitation (P)) and shallower regression slope (reduced sensitivity of streamflow to SWE or P) are found due to warmer temperatures, less snow, and more variable post-snow precipitation.

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References

Chavarria, S. B., and D. S. Gutzler, 2018: Observed changes in climate and streamflow in the upper Rio Grande Basin. *J. Amer. Water Resour. Assoc. (JAWRA)* 1–16, https://doi.org/10.1111/1752-1688.12640

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