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Interannual variation of snowmelt runoff hydrographs in the Eastern Colorado River Basin controlled by dust radiative forcing

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Common practice and conventional wisdom hold that fluctuations in air temperature control interannual variability in snowmelt and subsequent river runoff. However, recent observations in the Upper Colorado River Basin confirm that net solar radiation and by extension radiative forcing by dust deposited on snow cover exerts the primary forcing on snowmelt.

Here we investigate the basin-scale controls on the shape of the rising limb of the runoff hydrograph of rivers in the San Juan Mountains, Colorado. The rate at which the river rises from baseflow to its peak discharge varies from year to year, driven by energy-balance controlled snowmelt rates. Our physical understanding of snowmelt processes suggests that the slope of the hydrograph rising limb should therefore be determined primarily by net solar input, and by air temperature to a much lesser degree. In this paper we test this assertion; to what degree is interannual variability in steepness of the rising limb of these hydrographs controlled by (i) variability in winter and spring air temperature, and (ii) variability in dust radiative forcing in snow.

We show that the variation in the shape of the rising limb of the annual hydrograph is controlled by variability in dust radiative forcing and surprisingly is independent of variations in winter and spring air temperatures. These observations suggest that hydroclimatic modeling must be improved to account for aerosol forcings of the water cycle. These results also reinforce that atmosphere/cryosphere interactions such as dust and black carbon transport to snow have marked impact on the regional to global water cycles.

Anthropogenic climate change will likely reduce total snow accumulations and cause snowmelt runoff to occur earlier. However, dust radiative forcing of snowmelt is likely consuming important adaptive capacity that would allow human and natural systems to be more resilient to changing hydroclimatic conditions.