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A national perspective on paleoclimate streamflow and water storage infrastructure in the conterminous United States

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Large-scale water storage infrastructure in the Conterminous United States (CONUS) provides a means of regulating the temporal variability in water supply with storage capacities ranging from seasonal storage in the wetter east to multi-annual and decadal-scale storage in the drier west. Regional differences in water availability across the CONUS provides opportunities for optimizing water dependent economic activities, such as food and energy production, through storage and transportation. However, the ability to sufficiently regulate water supplies into the future is compromised by inadequate monitoring of non-federally-owned dams that make up around 97% of all dams. Furthermore, many of these dams are reaching or have exceeded their economic design life.

Understanding the role of dams in the current and future landscape of water requirements in the CONUS is needed to prioritize dam safety remediation or identify where redundant dams may be removed. A national water assessment and planning process is needed for addressing water requirements, accounting for regional differences in water supply and demand, and the role of dams in such a landscape.

Most dams in the CONUS were designed without knowledge of devastating floods and prolonged droughts detected in multi-centennial paleoclimate records, consideration of projected climate change, nor consideration of optimal operation across large-scale regions. As a step towards informing water supply across the CONUS we present a paleoclimate reconstruction of annual streamflow across the CONUS over the past 555 years using a spatially and temporally complete paleoclimate record of summer drought across the CONUS targeting a set of US Geological Survey streamflow sites. The spatial and temporal structures of national streamflow variability are analyzed using hierarchical clustering, principal component analysis, and wavelet analyses. The reconstructions show signals of contemporary droughts such as the Dust Bowl (1930s) and 1950s droughts. Decadal-scale variability was detected in the late 1900s in the western US, however, similar modes of temporal variability were rarely present prior to the 1950s. The 20th century featured longer wet spells and shorter dry spells compared with the preceding 450 years. Streamflow in the Pacific Northwest and Northeast are negatively correlated with the central US suggesting the potential to mitigate some drought impacts by balancing economic activities and insurance pools across these regions during major droughts.

The converging issues of a slowly growing US population, evolving demands for food, energy, and water, aging dams, and reduced water storage capacity through decommissioning and sedimentation highlights the pressing need for a national water assessment and a subsequent national water plan. There are many factors that need to be understood in order to appropriately assess dam and reservoir requirements across the CONUS and to improve water use and flood protection efficiency. In addition to historical and paleoclimate-informed surface water supply, factors requiring consideration in planning for future dam and reservoir infrastructure include:

-the role of conjunctive surface and groundwater storage and use;
-basin-scale operational strategies to balance sectoral water demand;
-projections of surface water supply;
-projections of regional water demands;
-impacts of water conservation; and
-the influence of water policy and financial instruments.