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Influence of El Niño Southern Oscillation on global hydropower production

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Hydropower contributes significantly to meeting the world's energy demand, accounting for at least 16% of total electrical output. Its role as a mature and cost competitive renewable energy source is expected to become increasingly important as the world transits to a low-carbon economy. A key component of hydropower production is runoff, which is highly dependent on precipitation and other climate variables. As such, it becomes critical to understand how the drivers of climate variability impact hydropower production. One globally-important driver is the El Niño Southern Oscillation (ENSO). While it is known that ENSO influences hydrological processes, the potential value of its associated teleconnection in design related tasks has yet to be explored at the global scale. Our work seeks to characterize the impact of ENSO on global hydropower production so as to quantify the potential for increased production brought about by incorporating climate information within reservoir operating models. We study over 1,500 hydropower reservoirs—representing more than half the world's hydropower capacity. A historical monthly reservoir inflow time series is assigned to each reservoir from a 0.5 degree gridded global runoff dataset. Reservoir operating rules are designed using stochastic dynamic programming, and storage dynamics are simulated to assess performance under the climate conditions of the 20th century. Results show that hydropower reservoirs in the United States, Brazil, Argentina, Australia, and Eastern China are strongly influenced by ENSO episodes. Statistically significant lag correlations between ENSO indicators and hydropower production demonstrate predictive skill with lead times up to several months. Our work highlights the potential for using these indicators to increase the contribution of existing hydropower plants to global energy supplies.