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Northern Hemisphere hydroclimate patterns in the last 12 centuries

Fredrik Charpentier Ljungqvist (1,2), Paul J. Krusic (3,4), Hanna S. Sundqvist (4), Eduardo Zorita (5), Gudrun Brattström (2,6), and David Frank (7)

(1) Department of History, Stockholm University, 10691 Stockholm, Sweden, (2) Bolin Centre for Climate Research, Stockholm University, 10691 Stockholm, Sweden, (3) Navarino Environmental Observatory, 24001 Messinia, Greece, (4) Department of Physical Geography and Quaternary Geology, Stockholm University, 10691 Stockholm, Sweden, (5) Helmholtz-Zentrum Geesthacht, Institute for Coastal Research, Geesthacht, Germany, (6) Department of Mathematics, Stockholm University, 10691 Stockholm, Sweden, (7) Swiss Federal Research Institute WSL, 8903 Birmensdorf, Switzerland

Variations in local to continental-scale hydroclimate have a strong impact on ecosystem functioning, crop yields, and society's water resources. Consequently, the ability to model and predict with reasonable certainty the dynamic and spatial response of precipitation to global warming is essential. The uncertainty in hydroclimate projections from model simulations remains large as a consequence of significant gaps in our knowledge of preindustrial boundary conditions due to the short length of instrumental measurements of precipitation.

In this study, we assembled an unprecedentedly large network of 196 records hydroclimatic records from the Northern Hemisphere (NH) to place recent hydrological changes and future precipitation scenarios in the context of spatially resolved and temporally persistent hydroclimatic variations over the last twelve centuries. The data from grid cells corresponding to the proxy locations were obtained from six CMIP5 last millennium simulations and treated in a similar way as the proxy data in order to facilitate a model–proxy comparison.

The most extensive areas of low moisture availability are found during the 12th and 15th centuries. It is notable that the intensification of wet and dry anomalies during the 20th century shown in coupled atmosphere-ocean model simulations is not supported by empirical evidence. Our results reveals that prominent hydroclimatic see-saw patterns, also observed in instrumental data, of alternating moisture regimes between the east and west Mediterranean, southwest vs. northwest United States, east vs. west China have been operating consistently during the past millennium.

Key findings:
– Dry as well as wet conditions can prevail under both warm and cold climate states in most regions.
– In some regions a tendency can be seen for either increased aridity or wetness with increasing or decreasing temperatures.
– Such changes can be expressed in localized wet–dry seesaw patterns that climate models seems unable to simulate.
– The extreme hydrological model anomalies in the 20th century, compared to earlier centuries, are not at all supported by the available proxy evidence.
– With a continuously expanding proxy network it will be increasingly possible to place present and predicted future hydrological changes, over larger parts of the globe, into a long-term perspective and to test the ability of climate models to simulate hydrological variability over centennial to millennial time-scales.