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Variability of the Azores High and regional hydroclimate over the past millennium

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The subtropical dry zones, including the broader Mediterranean region, are likely to experience considerable changes in hydroclimate in a warming climate. An expansion of the atmosphere's meridional overturning circulation, the Hadley circulation, over recent decades has been reported, with implications for regional hydroclimate. Yet, there exists considerable disagreement in magnitude and even sign of these trends among different metrics that measure various aspects of the Hadley circulation, as well as discrepancies in trends between different analysis periods and reanalysis products during the 20th century. In light of these uncertainties, it is therefore of interest to explore variability and trends in subtropical hydroclimate and its dominant driver, the Hadley Circulation. We focus on the North Atlantic sector and explore variability in the Azores High, the manifestation of the Hadley Circulation's downward branch, and hydroclimate across the Iberian Peninsula using a combination of observational/reanalysis products, state-of-the-art climate model simulations, and hydroclimatically-sensitive stalagmite records over the past 1200 yr. The Last Millennium Ensemble (LME) with the Community Earth System Model provides thirteen transient simulations covering the period 850 to 2005 A.D. with prescribed external forcing (e.g. greenhouse gas, solar, volcanic, land use, orbital, and aerosol) and smaller subsets with individual forcing only. The LME is shown to accurately simulate the variability and trends in the Azores High when compared to observational records from the 20th century. We evaluate variability in the Azores High (e.g., size, intensity, position) in relation to other key metrics that measure different aspects of the Hadley circulation throughout the course of the last millennium, as well as during key periods, such as the Little Ice Age or Medieval Climate Anomaly. The smaller subsets of LME simulations with individual forcing factors (e.g., solar, volcanic) allow for an attribution of past changes in regional hydroclimate to external drivers. Results from the climate model simulations are compared with hydroclimate reconstructed from stalagmites from Portuguese caves.