



Long-term drought variability over North America and its connection to global and tropical Pacific SST forcing

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Gridded summer Palmer Drought Severity Index (PDSI) reconstructions have been developed for most of North America using a network of centuries-long annual tree-ring chronologies. Many of the reconstructions extend back 1,000 years or more, especially in the western United States. To examine some of the physical mechanisms that are likely to be behind notable large-scale, multi-year droughts found in the reconstructions, an atmospheric general circulation (AGCM) is forced with the observed (1856-2001) history of global SSTs (the GOGA experiment) and with only with tropical Pacific SSTs, with the AGCM in this case being coupled to a two-layer entraining mixed layer (ML) ocean elsewhere (the POGA-ML experiment). A comparison of modeled soil moisture with reconstructed PDSI, a reasonable proxy for soil moisture, reveals that the POGA-ML and GOGA ensemble means capture the spatial patterns of the multi-year droughts well, indicating that large-scale, multi-year droughts over North America are mostly SST forced. The similarity of the POGA-ML and GOGA simulations also implies that the drought signal being forced by SSTs is driven mainly by La Nina-like SST anomalies of the tropical Pacific. On longer time scales, when the Zebiak-Cane (Z-C) ENSO model is radiatively forced by changing solar irradiance and explosive volcanism over the past 1000 years, persistent La Niña-like SSTs in the eastern equatorial Pacific are produced during the first 200-300 years of the Z-C ensemble mean when volcanic forcing is low and solar forcing high in the model. This modeled La Niña-like interval agrees well with below average, eastern equatorial Pacific SSTs indicated by fossil corals, a severe long-term drought in Peru (indicating persistent La Niña-like conditions), and a prolonged period of drought reconstructed for the western United States over the AD 900-1300 period. Thus, tropical Pacific SSTs have played a key role in the development of North American droughts over the

past 1000 years, with volcanic and solar forcing suggested as contributors as well.