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Surface Temperature Gradients and their relation to Mid-latitude Circulation Dynamics and inter-annual Precipitation variability: Trends and links to ENSO in Observations and Low-order Climate models.

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The evolution of hydroclimatic extremes in the mid-latitudes is influenced by low-frequency climate modes associated with ocean-atmosphere interactions. In this work, such influences are explored using observations and low-order models. First, the Lorenz-1984 model is considered for mid-latitude circulation, and its response to changes in the meridional and zonal thermal gradients is investigated, in order to gain a better understanding of how these dynamical factors may influence mid-latitude climate anomalies. The forcing terms and parameters of the low-order model are derived from analysis of the historic trends, variability and probability structure of the Northern Hemisphere Equator-to-Pole temperature Gradient (EPG) and the Ocean-Land temperature Contrast (OLC) over the 20th century. Different combinations of the meridional and zonal thermal gradients are shown to be associated with precipitation anomalies in the mid-latitudes. The Lorenz-1984 model is then coupled to a low-order ENSO model, in order to explore the effect of ENSO variability on the aforementioned thermal gradients, and, hence, on organizing mid-latitude circulation, and influencing hydroclimatic anomalies. The coupled model is used to assess how the probability distribution of circulation extremes evolves in such simple models, as the nature of interaction between the tropics and the mid-latitudes is varied. Under coupling to the ENSO model, especially when the ENSO state drives the eddies directly, the atmospheric model states get more organized with an increase in the mean eddy energy and a reduction in its spread. The resulting probability distributions forced by El Niño and La Niña conditions are indicative of the types of shifts in circulation and precipitation that can be expected in nature. While moist circulation is not explicitly modeled, the results from the model(s) can be interpreted in terms of the potential changes in the key modes of eddy transport of moisture and heat, and the resulting implications for the temporal structure of storminess. The simplicity of such models, and the ability to do extensive scenario analyses with them provides investigators a mechanism to sharpen and evaluate their intuition as to what could be expected under different scenarios put forth for changes in the boundary conditions to the atmosphere.