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The Seasonal Effects of ENSO on Western European Precipitation: Observational Analyses and Model Simulations

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Analysis and characterization of seasonal changes in the teleconnection between ENSO and western European reveal that precipitation is significantly associated with coincident ENSO conditions during boreal spring, summer and fall. This association is strongest and most geographically pervasive during boreal autumn. Strong negative precipitation anomalies also manifest during summer over northern Europe. Observational analyses indicate that these seasonal teleconnections are mediated by changes in upper tropospheric conditions along the coast of Europe that project down to the lower troposphere and produce onshore or offshore moisture flux anomalies, depending on the season. Analyses during boreal winter reveal little effect of coincident ENSO conditions on either European precipitation or upper tropopsheric conditions over Europe. Rather, wintertime ENSO variability excites a Rossby wave train that passes over the north Atlantic to the west of Europe and fails to affect European conditions.

These seasonal upper tropospheric teleconnections are further explored through a series of model experiments. Simulations with a linearized barotropic vorticity equation model indicate that divergence forcing associated with convective activity over the eastern equatorial Pacific excites a northeastward propagating stationary barotropic Rossby wave train, which extends across the north Atlantic to the European coast during boreal fall, winter and spring. Strong vorticity anomalies develop over the British Isles in the vicinity of the North Atlantic jet exit, as seen in observations during spring and fall. Solutions during boreal summer produce no clear wave train; however, evidence exists for a north Atlantic response due to both eastward and westward propagating signals.

Further experiments with the vorticity equation model using full Rossby wave source forcing, as well as experiments with the Community Atmospheric Model (CAM) 4.0, reveal that the basic wave train response is modulated by downstream effects, including vorticity advection. These changes are most profound during boreal winter and engender an arching wave train pattern that reflects off the North American jet over North America, propagates southeastward over the north Atlantic and fails to reach the European coast. Simulations with CAM correctly depict observed seasonal changes in the magnitude of the ENSO-north Atlantic/European teleconnection by producing a strong fall and winter response but a weaker spring and summer response.