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Diversity of seasonal cycle anomalies of surface air temperature in winter over China

Minjie Yu
National Institute of Natural Hazards, Beijing, China (minjieyu@ninhm.ac.cn)

The seasonal cycle (SC) anomalies of winter surface air temperature (SAT) over China mainly include three modes: consistent changes throughout the winter, inverse changes in the early and late winter, and opposite changes in the southern and northern China, respectively. The positive EOF1 phase (i.e., uniformly warming throughout winter) can be attributed to global warming, especially in the North Atlantic and tropical Pacific. The EOF2 is mainly related to the dipole sea surface temperature (SST) pattern in the North Atlantic. In the early winter, the Rossby wave originating from North Atlantic strengthens Ural blocking high (UBH) and Siberian high (SH) in the early winter, resulting in cold SAT anomalies in most of China. While the large-scale zonal circulation with weakened SH has transformed SAT over China into a warm state in the later winter. The EOF3 can be attributed to the tripole SST in the North Atlantic and El Niño-like SST pattern in the tropical Pacific. In December, the Rossby wave train originating from the mid-latitudes of the North Atlantic Ocean enhances cold air activity in the Northern Hemisphere, causing cold SAT anomalies in Northeast China, while the dominating southerly winds in southern China cause warm SAT anomalies. In the late winter, the large-scale circulation resembles negative AO phase, resulting in the northerly winds and cold SAT anomalies in the northern China. Meanwhile, the anomalous anticyclonic circulation in the Northwest Pacific causes warm SAT anomalies in southern China. Therefore, the combined effects of tropical and extratropical SST should be considered when predicting interannual variability of winter SAT anomalies over China.