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Analyses of Regional Patterns of Rapid Temperature Change in the Middle East, North Africa, and the Mediterranean

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The arid climates of the Middle East, Northern Africa, and the Mediterranean are controlled by downward flow in the Hadley cell. They share the common feature of variability. We analyze the spatial and temporal changes in seasonal temperature in these regions by using surface station data, Microwave Sounding Unit (MSU) observations, European Center for medium Weather Forecast (ECMWF) and National Center for Environmental protection (NCEP) reanalysis, and simulation data from a fine-resolution global model (HIRAM) with prescribed Sea Surface Temperature (SST) developed at the Geophysical Fluid Dynamics Laboratory (GFDL). For the period since the early 1980s, the station data indicate an increase in the surface temperature (most pronounced in the summer) of the order of 1 K/decade with a complex spatial structure that is better captured by the model than by reanalysis. Contrary to the surface temperature trends, the upper air trends (lower and middle troposphere) calculated using MSU observations are better replicated by reanalysis then by the model. This is as expected because both NCEP and ECMWF reanalysis assimilate the MSU data and do not assimilate surface observations.

The amplitude of the seasonal cycle calculated as the difference between the summer and winter seasons is remarkably consistent between the model, reanalysis, and observations, probably because the unconstrained low-frequency variability is removed. There was a decreasing seasonal variation in the African Sahel and an increasing seasonal variation in the Eastern Mediterranean. In the upper troposphere, we observe the opposite pattern in the Sahel due to an increase in moist convection in the summer.

Our observations indicate the occurrence of rapid climate change in the Middle East, North Africa, and the Mediterranean since the early 1980s until the present. Model simulations appear to capture this trend well and provide a new method to understand the mechanisms of regional variability. Long-term surface temperature records, however, show multi-decadal oscillations presumably associated with the SST variability in the North Atlantic. This suggests that the observed trends cannot be easily extrapolated beyond the period of observation.