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ITCZ migration effects in the Middle East, Northern Africa and Eastern Mediterranean

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It was argued that expansion of tropics and shift of Intertropical Convergence Zone (ITCZ) might affect regional and global climate. In this paper, observations, National Center for Environmental Protection (NCEP) and European Center for Medium Weather Forecast (ECMWF) reanalyses, and fine-resolution simulations from the Geophysical Fluid Dynamics Laboratory (GFDL) General Circulation Model (HIRAM) are used to analyze the regional surface temperature trends in Northern Africa, the Middle East and the Mediterranean regions over the last 30 years. The data indicate that the trends are especially large over the Balkan and Anatolia peninsulas and in the Middle East, where the magnitude exceeds 1K/decade. The African Sahel region and south of the Arabian Peninsula experience negative temperature trends, although they are not always statistically significant. The observed trends have a pronounced seasonal structure maximizing in the summer (June-July-August) and becoming less pronounced in the winter (December-January-February). Although the reanalyses and the simulation data qualitatively reproduce the observed surface temperature trends, their spatial patterns and magnitude differ in the various data sets with the simulation trends closer to observations than either the NCEP or the ECMWF reanalysis.

By considering the evolution of the seasonal cycle, defined as the difference between summer and winter temperatures, we found a remarkably consistent picture of seasonality change among all data sets. In particular, the seasonal variability increases in the Eastern Mediterranean, while it decreases in the Sahel. The consistency between the data sets increased when a low frequency bias present both in the winter and the summer series was removed. This regional low frequency variability may be caused by remote Sea Surface Temperature (SST) changes and global warming. The seasonal cycle appears to be significantly affected by processes acting on the regional scale. Because the simulation captures the observed changes, we used simulation data to conduct a process analysis. We found that changes in the temperature and in the annual cycle in the Sahel and southern part of the Arabian Peninsula can be attributed to an increase in cloudiness in the Sahel region associated with a 0.5-degree northward shift of the summer ITCZ. The corresponding shift in the mean latitude of the inter-tropical convergence front and the tropical rain belt affect the surface temperature. In the Eastern Mediterranean, the increase in amplitude of the annual temperature cycle results from the fair weather conditions and associated dryness due to decreases in precipitation and cloudiness, which strongly affect the surface temperature in the summer. The center of the subsidence in the Eastern Mediterranean during the summer correlates with the ITCZ latitude. Moreover, as a result of the decreasing surface pressure in the Eastern Mediterranean, the return flow of the Hadley cell feeding the ITCZ south of the Arabian Peninsula weakens. The increase of 600 hPa geopotential height in the Eastern Mediterranean, the Sahara and the Middle East strengthens the African Easterly Jet. Thus, we observe an expansion of the tropics in Northern Africa and a trend toward more continental climate conditions in the Eastern Mediterranean. These observations are consistent among observations, reanalyses and the fine-resolution model simulations.