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Identification of Tropical-Extratropical Interactions and Extreme Precipitation Events in the Middle East based on Potential Vorticity and Moisture Transport

Andries Jan De Vries (1), Huug G. Ouwersloot (1), Steven B. Feldstein (2), Michael Riemer (3), Ahmed M. El Kenawy (4), Matthew F. McCabe (5), Jos Lelieveld (1,6)

(1) Max Planck Institute for Chemistry, Atmospheric Chemistry Department, Mainz, Germany (a.devries@mpic.de), (2) Department of Meteorology, The Pennsylvania State University, University Park, USA, (3) Institut für Physik der Atmosphäre, University of Mainz, Germany, (4) Department of Geography, Mansoura University, Egypt, (5) Water Desalination and Reuse Center, Division of Biological and Environmental Sciences and Engineering, King Abdullah University of Science and Technology, Jeddah, Saudi Arabia, (6) Energy, Environment and Water Research Center, The Cyprus Institute, Nicosia, Cyprus

Extreme precipitation events in the otherwise arid Middle East can cause flooding with dramatic socioeconomic impacts. Most of these events are associated with tropical-extratropical interactions, whereby a stratospheric potential vorticity (PV) intrusion reaches deep into the subtropics and forces an incursion of high poleward vertically integrated water vapor transport (IVT) into the Middle East. This study presents an object-based identification method for extreme precipitation events based on the combination of these two larger-scale meteorological features. The general motivation for this approach is that precipitation is often poorly simulated in relatively coarse weather and climate models, whereas the synoptic-scale circulation is much better represented. The algorithm is applied to ERA-Interim reanalysis data (1979-2015) and detects 90% (83%) of the 99th (97.5th) percentile of extreme precipitation days in the region of interest. Our results show that stratospheric PV intrusions and IVT structures are intimately connected to extreme precipitation intensity and seasonality. The farther south a stratospheric PV intrusion reaches, the larger the IVT magnitude, and the longer the duration of their combined occurrence, the more extreme the precipitation. Our algorithm detects a large fraction of the climatological rainfall amounts (40-70%), heavy precipitation days (50-80%), and the top 10 extreme precipitation days (60-90%) at many sites in southern Israel and the northern and western parts of Saudi Arabia. This identification method provides a new tool for future work to disentangle teleconnections, assess medium-range predictability and improve understanding of climatic changes of extreme precipitation in the Middle East and elsewhere.