Geophysical Research Abstracts
Vol. 14, EGU2012-3741, 2012
EGU General Assembly 2012
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Global Tropical Moisture Exports and their Influence on Extratropical Cyclone Activity

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Many case studies have shown that heavy precipitation events and rapid cyclogenesis in the extratropics can be fuelled by moist and warm tropical air masses. Often the tropical moisture export (TME) occurs through a longitudinally confined region in the subtropics. Here a climatology of TMEs to both hemispheres is constructed on the basis of seven-day forward trajectories, which were started daily from the tropical lower troposphere and which were required to reach a water vapour flux of at least 100 g kg–1 m s–1 somewhere poleward of 35 degrees. For this analysis 6-hourly European Centre for Medium-Range Weather Forecasts (ECMWF) ERA-Interim re-analysis data have been used for the 32-year period 1979–2010. A comparison with a TME climatology based upon the older ERA-40 re-analysis shows little sensitivity. The results are then related to the deepening of objectively identified (extratropical) cyclones in both hemispheres.

On average TME trajectories move upwards and eastwards on their way across the subtropics in both hemispheres and are associated with both moisture and meridional-wind anomalies. TME shows four main regions of activity in both hemispheres: In the northern hemisphere these are the eastern Pacific ("Pineapple Express" region) with a marked activity maximum in boreal winter, the West Pacific with maximum activity in summer and autumn associated with the Asian monsoon, the narrow Great Plains region with a maximum in spring and summer associated with the North American monsoon and the western Atlantic or Gulf Stream region with a rather flat seasonal cycle. In the southern hemisphere activity peaks over the central and eastern Pacific, eastern South America and the adjacent Atlantic, the western Indian Ocean, and western Australia. Southern hemisphere TME activity peaks in boreal winter, particularly over the Atlantic and Pacific Oceans, which suggests a significant influence of northern hemispheric Rossby wave energy propagation across the equator. The interannual variability in several regions is significantly modulated by El Niño. A detailed analysis of TME encounters along individual extratropical cyclone tracks reveals several extraordinary cyclone-deepening events associated with TME trajectories (e.g. storm "Klaus" in January 2009). A statistical analysis quantifies the fraction of explosively deepening cyclones that occur with and without a TME influence.