Geophysical Research Abstracts
Vol. 14, EGU2012-5257, 2012
EGU General Assembly 2012

Quantifying the relevance of cyclones for precipitation extremes

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Precipitation extremes and associated floods may have a huge impact on society. It is thus important to better understand the mechanisms causing these events, also with regard to their variations in a changing climate. Here the importance of a particular category of weather systems, namely cyclones, for the occurrence of regional-scale precipitation extremes is quantified globally, based on the ERA-Interim reanalysis dataset for the period 1989-2009. Such an event-based climatological approach complements previous case studies, which established the physical relationship between cyclones and heavy precipitation.
Cyclones are identified from ERA-Interim sea level pressure fields as features with a finite size, determined by the outermost closed pressure contour comprising one or several pressure minima. At each grid point, the 99% percentile of six-hourly accumulated precipitation is calculated, and all dates with six-hourly precipitation larger than this percentile are identified as extreme events. A comparison with the satellite observation-based CMORPH dataset for the years 2003 to 2009 shows that ERA-Interim properly captures the timing of the extreme events in the major parts of the extratropics.
A cyclone is assumed to induce a precipitation extreme if both occur simultaneously at the same grid point. The percentage of extreme precipitation events coinciding with a cyclone is then quantified at every grid point. This percentage strongly exceeds the climatological cyclone frequency in many regions. It reaches maxima of more than 80%, e.g., in the main North Atlantic, North Pacific and Southern Ocean storm track areas. Other regional hot spots of cyclone-induced precipitation extremes are found in areas with very low climatological cyclone frequencies, in particular around the Mediterranean Sea, in eastern China, over the Philippines and the southeastern United States. Our results suggest that in these hot spot regions changes of precipitation extremes with global warming are specifically sensitive to variations in the dynamical forcing, e.g., related to shifts of the storm tracks.
Finally, properties of cyclones causing extreme precipitation are investigated. In the exit regions of the Northern Hemisphere storm tracks, these cyclones are on average slightly more intense than low-pressure systems not associated with extreme precipitation events, but no differences with respect to minimum core pressure are found in most other parts of the midlatitudes. The fundamental linkage between cyclones and precipitation extremes may thus provide guidance to forecasters involved in flood prediction, but it is unlikely that forecasting rules based on simple cyclone properties can be established.