Geophysical Research Abstracts,
Vol. 10, EGU2008-A-10354, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-10354
EGU General Assembly 2008

Assessing the disproportionate response rates observed in extreme precipitation indices

J. Abaurrea, J. Asín, A.C. Cebrián and Z. Gracia
Statistical Methods Dpt., Zaragoza University, Spain (abaurrea@unizar.es)

According to the recent research revision by Meehl et al. in the 10th chapter of the Contribution of Working Group I to the 4AR of the IPCC (2007), in a future climate, precipitation intensity is projected to increase over most regions and the increase in precipitation extremes is greater than changes in mean precipitation.

Research on current climate has searched for evidences of this behaviour in observed precipitation. Data availability makes very difficult the detection of changes in extreme events, by fitting extreme value models to daily data; so, the usual approach is to analyse the temporal evolution of selected indices related to extreme behaviour. In general, these studies, see for example Klein Tank & Konnen (2003) or Groisman et al. (2005), find a "disproportionate" or "extraordinary" response in extreme precipitation events, in comparison with the change observed in total precipitation. This behaviour is evaluated by analysing, in particular, the proportion of extreme precipitation, i.e. total precipitation gathered in the events over an extreme percentile, 90th, 95th or 99th, in total precipitation.

Given the interest of discriminating between climate change evidences and other effects not necessarily linked to that change, our aim in this work is to show that this extraordinary response can occur, without any change taking place in the precipitation process. As it is known, the extreme values in a random sample are related to the sample size: if total precipitation increases, this will entail a frequency increase; so, more and more intense extreme events have to be expected. Moreover, as we shall see, the relationship between changes in global and extreme precipitation, under stationary conditions, is not linear.

This is a simulation study based on daily precipitation models fitted to data from locations sited in different climatic regions. We took as reference the updated world map of the Köppen-Geiger climate classification, see Kottek et al. (2006), and we selected from available datasets, GDCNv1.0, ECA project, Australian BOM, etc., meteorological stations with long daily precipitation series of verified homogeneity and quality. They are sited mainly in Eurasia, North America and Australia.

Our model combines a Gamma distribution, for describing the daily amount, and a Poisson or Negative Binomial distribution, for the number of rainfall days. The model is fitted to daily data, in two-month long intervals, i.e. April-May, November-December, where the homogeneity of rainfall characteristics has been previously assessed; the considered time period is 1961-90. For the simulation analysis, we select models fitting successfully the precipitation process; the locations and intervals for which this occurs, cover quite satisfactorily the different seasons, climates and precipitation modes of the Köppen-Geiger classification.

The results of our simulation experiment allow us to assert that most of the disproportionate rates reported in previously refered works, could have been observed without the intervention of any change in the precipitation process.

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