Geophysical Research Abstracts
Vol. 15, EGU2013-6198, 2013
EGU General Assembly 2013

Modeling Daily Rainfall Conditional on Atmospheric Predictors: An application to Western Greece

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Due to its intermittent and highly variable character, daily precipitation is the least well reproduced hydrologic variable by both General Circulation Models (GCMs) and Limited Area Models (LAMs). To that extent, several statistical procedures (usually referred to as downscaling schemes) have been suggested to generate synthetic rainfall time series conditional on predictor variables that are descriptive of the atmospheric circulation at the mesoscale. In addition to be more accurately simulated by GCMs and LAMs, large-scale atmospheric predictors are important indicators of the local weather.

Currently used downscaling methods simulate rainfall series using either stable statistical relationships (usually referred to as transfer functions) between certain characteristics of the rainfall process and mesoscale atmospheric predictor variables, or simple stochastic schemes (e.g. properly transformed autoregressive models) with parameters that depend on the large-scale atmospheric conditions. The latter are determined by classifying large-scale circulation patterns into broad categories of weather states, using empirical or theoretically based classification schemes, and modeled by resampling from those categories; a process usually referred to as weather generation.

In this work we propose a statistical framework to generate synthetic rainfall timeseries at a daily level, conditional on large scale atmospheric predictors. The latter include the mean sea level pressure (MSLP), the magnitude and direction of upper level geostrophic winds, and the 500 hPa geopotential height, relative vorticity and divergence. The suggested framework operates in continuous time, avoiding the use of transfer functions, and weather classification schemes.

The suggested downscaling approach is validated using atmospheric data from the ERA-Interim archive (see http://www.ecmwf.int/research/era/do/get/index), and daily rainfall data from Western Greece, for the 14-year period from 01 October 1979 - 30 September 1993. The developed model is found to accurately reproduce several statistics of actual rainfall timeseries, including the distribution of annual rainfall totals, the seasonal means, variances and wet-day fractions (i.e. seasonality), the alternation of wet and dry intervals (i.e. rainfall intermittency), and the empirical distribution of dry and wet spell lengths (i.e. the clustered nature of rainfall).

The suggested approach is expected to serve as a useful tool for the stochastic simulation of rainfall time-series conditional on GCM outputs, at a regional level, and at temporal scales suitable to run hydrological models and perform hydrologic impact studies.

Acknowledgments:
The research project is implemented within the framework of the Action «Supporting Postdoctoral Researchers» of the Operational Program "Education and Lifelong Learning" (Action's Beneficiary: General Secretariat for Research and Technology), and is co-financed by the European Social Fund (ESF) and the Greek State.