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Nonlinearities and uncertainties in extreme precipitation for observed and simulated future climates

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Recent hydro-meteorological time series analyses have systematically supported the complex and nonstationary nature of precipitation patterns. However, these have failed to provide a comprehensive statistical characterization of both temporal evolution and observed transitions, which is necessary for model selection and prediction. In this respect, a novel statistical framework based on nonlinear dynamics theory and recurrence analysis of dynamical systems is proposed in order to quantitatively identify the temporal characteristics of extreme (maximum) daily precipitation series. Methodologically, the series are embedded in the Phase-Space; a pattern of a sliding window for extreme precipitation is defined and its recurrent behaviour and the manner it evolves in time are further analyzed. Analyses of a set of statistical measures are employed to identify the evolution of the deterministic, nonlinear and entropy features of the extreme precipitation patterns. The analyses are conducted for both historical and simulated future climates. The available data include historical daily precipitation time series conditioned on observed and ECHAM4 GCM-generated circulation patterns for 1xCO_2 and 2xCO_2 climates over the medium-sized mountainous Mesochora catchment in Central-Western Greece (Panagoulia et al. 2006). Results reveal substantial differences between the extreme (maximum) daily precipitation statistical patterns for historical and two climate scenarios (Panagoulia and Vlahogianni 2013). The historical precipitation patterns exhibit decreasing recurrence with time while the recurrence of two climate scenarios is cyclic. Moreover, a variable nonlinear determinism exists in all climates and especially for 1xCO_2 and 2xCO_2 scenarios. Periodic-to-chaotic and chaotic-to-chaotic transitions ’patterns are evident in all climates which though differ in terms of duration and intensity. The 2xCO_2 scenario contains the strongest transitions. The mentioned characteristics of time series evolution may have significant implications to future water resources systems design and planning underling an extraordinary

situation of shifts between droughts and floods. From the methodological standpoint, the analysis presented helps to statistically discern the temporal patterns of the precipitation phenomena under investigation and characterize the transitions observed. These aspects of time series analysis are essential in the process of prediction and could be used to detect basic statistical characteristics of the time series, such as on which time period the near past information losses its criticality on the manner the system evolves in time, and, consequently help towards proper selection of a prediction model.

References

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