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Basin-scale assessment of water resource availability in climate change scenarios through a grid-based approach: an application to Sicily

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Climate change resulting from the enhanced greenhouse effect is expected to have great implications for hydrological cycle and for existing surface and groundwater resources systems. The effects of climate variability and climate change have to be fully considered in current water management and planning, since water availability, quality and streamflow are sensitive to changes in temperature and precipitation regimes. Since hydrological models are an important tool in the study and analysis of the hydrological processes and in water resources management, international literature proposes several models, that attempt to assess accurately the available water resources under stationary and changing climatic conditions at different spatial and temporal scales.

In order to assess the potential impacts of climate change on surface and groundwater resources water availability in a Southern area of Italy, a conceptual model was applied to simulate the hydrological processes in the Belice river basin, located in Sicily. A trend analysis, carried out using non-parametric techniques, highlighted a decrease of precipitation and an increase of temperature for the area of study over the last 80 years. The model was applied for current conditions of precipitation and temperature as well as under the hypothesis of climate variations, as represented by scenarios consistent with the climate trend analysis. The analysis of the climatic forcing trend provided the parameters needed in order to generate synthetic climate forcing series through the use of stochastic approaches.

The conceptual model, developed and applied in this study, is the TOpography based Probability Distributed Model, indicated as TOPDM, resulting from the combination and integration of TOPMODEL into a probability distributed model. Through a relationship between topographic index and storage capacity, this model reflects adequately the influence of basin topography in the hydrological process of runoff generation. The direct runoff occurs according two different mechanism, the Dunnian mechanism and the hortonian mechanism; vertical drainage to groundwater, represented as a storage with unlimited capacity, is simulated as well. This storage, which does not exchange water with the sub-surface system, generates the slow response of the basin. The inclusion of groundwater resources in the model is particularly important since most of the population in the Mediterranean areas relies on groundwater as its primary water resource. The model simulates hydrological processes at two time scales, daily and hourly; here, since the aim of this study is the assessment of climate change effects on water resources, a daily scale application of the model has been considered appropriate.

The model has been used to estimate the basin water balance components and the surface and groundwater availability in a no trend scenario, representing the current climate conditions, and in three different groups of scenarios, in which a decrease of precipitation, an increase of temperature, and a combination of these effect were reproduced. The application of TOPDM to the test basins provided some important conclusions about the implications of climate change in the Southern part of Italy. Results show that runoff and evapotranspiration reflect variations in precipitation and in temperature, in particular the negative trend in precipitation determines a decrease in surface and groundwater resources, and this effect is intensified in the scenarios that include a temperature trend as well. Therefore the climate change, occurring as precipitation amount reduction and temperature rise, could exacerbate the water resources stresses in the area of study, in which water scarcity is already an important issue for water resource management.