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Eco-hydrological Modeling in the Framework of Climate Change

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A blueprint methodology for studying climate change impacts, as inferred from climate models, on eco-hydrological dynamics at the plot and small catchment scale is presented. Input hydro-meteorological variables for hydrological and eco-hydrological models for present and future climates are reproduced using a stochastic downscaling technique and a weather generator, "AWE-GEN". The generated time series of meteorological variables for the present climate and an ensemble of possible future climates serve as input to a newly developed physically-based eco-hydrological model "Tethys-Chloris". An application of the proposed methodology is realized reproducing the current (1961-2000) and multiple future (2081-2100) climates for the location of Tucson (Arizona). A general reduction of precipitation and a significant increase of air temperature are inferred. The eco-hydrological model is successively applied to detect changes in water recharge and vegetation dynamics for a desert shrub ecosystem, typical of the semi-arid climate of south Arizona. Results for the future climate account for uncertainties in the downscaling and are produced in terms of probability density functions. A comparison of control and future scenarios is discussed in terms of changes in the hydrological balance components, energy fluxes, and indices of vegetation productivity. An appreciable effect of climate change can be observed in metrics of vegetation performance. The negative impact on vegetation due to amplification of water stress in a warmer and dryer climate is offset by a positive effect of carbon dioxide augment. This implies a positive shift in plant capabilities to exploit water. Consequently, the plant water use efficiency and rain use efficiency are expected to increase. Interesting differences in the long-term vegetation productivity are also observed for the ensemble of future climates. The reduction of precipitation and the substantial maintenance of vegetation cover ultimately leads to the depletion of soil moisture and recharge to deeper layers. Such an outcome can affect the long-tem water availability in semi-arid systems and expose plants to more severe and frequent periods of stress.