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MESOSCALE MODELLING OF INTERACTIONS BETWEEN RAINFALL AND THE LAND SURFACE IN WEST AFRICA

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ABSTRACT: Within the joint research project IMPETUS (An integrated approach to the efficient management of scarce water resources in West Africa), the effect of interactions between the earth's surface and the atmosphere on fresh water availability is investigated. Explorations are conducted for a river catchment in Benin by means of simulations with a non-hydrostatic mesoscale meteorological model. A combination of idealised ensemble simulations with a column version of the model and 3-D modelling of real precipitation events is employed to assess the sensitivity of precipitation to variations in the land surface. Simplified ensemble studies exhibit a dominant influence of initial soil water content and an enhanced dependence of precipitation on vegetation when soil water availability is reduced. For wet soils, the influence of parameters that determine the intensity of near-surface turbulence is dominant. 3-D modelling confirms that these relationships are useful to identify critical land use changes in realistic settings, but do not comprehensively account for the effect of heterogeneous land surface changes on regional precipitation. Instead, the interplay between surface properties, atmospheric dynamics and precipitation systems can generate intrinsic precipitation anomaly patterns that are incongruent with the imposed surface anomalies. Hence, assessments of land use change effects on precipitation for a specific region should be based on an integrated consideration of the interactions between surface processes, atmospheric forcing and precipitation systems. Based on these findings, possible effects of successive land degradation are investigated by sensitivity studies of land surface and rainfall system interaction for the Haute Vallée de l'Ouémé (HVO). In a first series of 3-D model simulations, a successive increase of the surface fraction with adverse conditions for the development of precipitation systems is performed. Within the scope of a second series a successive reduction of surface vegetation and soil water at randomly distributed areas that cover half of the simulation domain is carried out. Basically, a uniform decrease of average precipitation forced by changing conditions and a strong reduction of rainfall in some parts of the HVO are found. As a whole, the results strongly support the hypothesis of a growing risk of rainfall decrease as a result of land use changes.