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Identification of the dominant runoff generating processes in a tropical catchment by means of physically based hydrological modelling

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The aim of this paper is to identify the dominant runoff-generating processes in a tropical catchment for which limited hydrological information is available. The analysis follows a pragmatic downward approach that involves physically-based hydrological models of increasing complexity. The optimal model complexity is identified through testing the model predictions against signatures of observed runoff variability. The aim is to explore and explain the main processes that may be responsible for the observed catchment streamflow response in the monsoonal climate basins of the Northern Territory, Australia. Seventeen Mile Creek basin has been chosen for this study because of the availability of stream flow, rainfall and potential evapotranspiration data. The catchment area at Waterfall View is 690 km2; two rainfall gauges and one stream flow gauge are deployed in the area, while potential evapotranspiration values are obtained from three stations close to the area of study. Streamflow variability is analyzed at various timescales, which reveals a high variability of runoff, both at the inter-annual and at the intra-annual timescales. These are interpreted in terms of the underlying climatic and landscape characteristics, based on qualitative as well as available quantitative descriptions of soil characteristics, hydrogeology and vegetation. In order to further explore the causes of the observed variability, a multiple bucket model is developed and run using data at the hourly time step. The model parameters are directly extrapolated from the physical properties of the catchment, without requiring calibration. The final chosen model consists of four parallel buckets, with depths and porosities carefully chosen to represent the soil characteristics of the area. The model takes into

account saturation excess overland flow, nonlinear delayed runoff and linear groundwater flow. Moreover, according to the knowledge of the vegetation cover, the total evapotranspiration is divided into bare soil evaporation and transpiration. The results are presented by means of three key signatures: the inter-annual variability of runoff, the intra-annual (mean monthly) variation of runoff, and the flow duration curve, each of which is estimate for the total runoff and for the three constituent components. In particular, we found that the delayed runoff is the most dominant process in this catchment, due to the presence of local aquifers and the infiltration between the soil and the rocky landscape, whereas saturation excess overland flow occurs only after high rainfall events during the wet season. In contrast, groundwater flow is produced by the underlying cretaceous aquifer and found to last for the whole dry season. As the main waterbodies are confined to the watercourses and the streamflow in the river is fast, no routing computations were required. Once the hydrological processes have been determined, a sensitivity analysis is conducted by applying the model to the catchment at different timescales, to obtain a more complete understanding of the runoff generation processes. Following this, a detailed investigation is conducted to determine the effects of the soil heterogeneity, the variation in the soil depth and rainfall depth. The proposed modelling approach opens interesting insights into the relationships between catchment properties, dominant hydrological processes and model concepts.