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Model intercomparison to explore catchment functioning: Results from a remote montane tropical rainforest

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ABSTRACT

Catchment-scale runoff generation involves a complex interaction of physical and chemical processes operating over a wide distribution of spatial and temporal scales. Understanding runoff generation is challenged by this inherent complexity – the more uncertain step of predicting the hydrologic response of catchments is that much more challenging. Many different hypotheses have been implemented in hydrological models to capture runoff generation processes and provide hydrologic predictions. These concepts have been developed based on extended field observations. Here we propose inferring water flux understanding and catchment exploring through the application of a variety of available hydrological models as a mechanism to build upon and extend models that have been developed to capture particular hydrological processes. We view this ensemble modeling strategy as particularly appropriate in ungauged catchments. The study is carried out in a tropical montane rainforest catchment in Southern Ecuador. The catchment is 75 km^2 and is covered by forest in the south, while the northern slopes have been partly deforested for grazing. Annual rainfall is highly variable, reaching up to 5700 mm per year in the upper parts of the catchment. To explore the dominating runoff processes, an ensemble of 6 hydrological models with different structures applied over different levels of both spatial and temporal detail was developed. The ensemble includes spatially lumped (HBV-light), semi-distributed (HEC-HMS, CHIMP, SWAT, LASCAM) and a fully distributed model (HBV-N-D). The hydro-statistical toolkit WETSPRO was used to characterize simulated and observed hydrographs. Estimated baseflow indices, flow minima and maxima, flow duration curves and cumulative errors were generated and compared among the ensemble of models. This process facilitated the exploration of processes controlling runoff generation, enabled an evaluation of the applicability of the screened models to tropical montane rainforests, and provided the capacity to evaluate and explain where different models failed.

1. Introduction

Water is a key component of ecosystems that facilitates energy transfers, triggers erosion, drives patterns of biodiversity and acts as a key agent of lateral transport for particulate and dissolved nutrients. A variety of environmental models have been developed to evaluate ecosystem function, including issues related to climate, land-use change and water quality (Cook and Vizy, 2008; Krysanova et al., 1998; Riley and Stefan, 1988; Veldkamp and Lambin, 2001). These models are generally coupled with existing concepts defining the hydrological flow response. The combination of field and modeling studies has contributed to a more complete understanding of the hydro-ecological cycle, and is crucial in the investigation of how future land use and climate change will alter water and solute fluxes. These fluxes influence a wide variety of ecosystem services, including nutrient storage, erosion reduction, water supply, potential hydroelectric production and the management of ecological resources (Caballero et al., 2004; Vanacker et al., 2007; Célleri and Feyen, 2009).

Increasingly, attention is focused on tropical regions to better understand hydrological fluxes and processes, as well as interactions between biogeochemical and ecological processes (Bruijnzeel, 2004; Hilton et al., 2008; Guardiola Claramonte et al., 2010; Figueiredo et al., 2010). These types of studies approach fundamental issues faced by those living in tropical areas: as demand

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