Geophysical Research Abstracts
Vol. 14, EGU2012-8227, 2012
EGU General Assembly 2012

Characterising the hydrological response to climate change of a remote tropical mountainous catchment: a multi-model approach

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Process-based conceptual rainfall-runoff models are useful to understand runoff generation at different time and spatial resolutions. Contrary to physically-based models, they do not rely much on field observations (e.g. soil physical properties) which may not be available everywhere. Instead, these mathematical tools close the water balance and predict runoff as a function of some empirical parameters. Since corresponding values are hardly measurable, modellers usually proceed to a calibration against available observations to obtain an acceptable match between observations and predictions.

However, in the case of poorly monitored areas such as elevated catchments in the Andean Cordillera, good high frequency calibration data available over a long time span are scarce. Therefore, in spite of the development of multiple effective automatized calibration techniques in recent years, results remain uncertain because of the non-uniqueness of optimal parameter sets. A state-of-the-art option to cope with this predictive uncertainty is to consider ensembles of predictions rather than single ones. Furthermore, by gathering more independent parameterisations of the same processes, multi-model approaches allow a better representation of the uncertainty than multiple realisations of the same, eventually biased, model structure subjectively chosen by the modeller based on previous experience or project requirements.

As a demonstration of the usefulness of this approach in scarcely-monitored areas, we present here results of an ensemble of heterogeneous rainfall-runoff models applied to the remote San Francisco (75 km^2) tropical montane forest catchment, located in the southern part of Ecuador. Each of the 7 models (CHIMP, HBV-D, HBV-light, HMS, LASCAM, NAM, SWAT) is applied to simulate runoff whilst being forced by 6 increasingly uncertain meteorological data: on-site precipitation gauges record (also used for calibration), bias-corrected downscaled re-analysis (SDSM) output of the CCSM Regional Climate Model (RCM) over the first decade of the 21st century, and output of the same RCM forced by two different IPCC emission scenarios (A1B, B1) for two decades of the middle (2050-2059) and the end of the current century (2090-2099).

Results show that the annual cumulative runoff and maximum flows should increase in this area during the 21st century. Furthermore, in spite of a good agreement in the timing of seasonal runoff patterns between rainfall-runoff models forced by the same input data, there is a great variability in the magnitude of predicted extreme values. The uncertainty in the RCM emission scenarios is not greater than the uncertainty between hydrological model predictions but the ensemble still allows targeting the most probable future.