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Model comparison for climate change impact prediction: does complexity actually matter?

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Arid and semiarid areas cover one third of the Earth's surface and estimates for populations living in these regions varies between 1.4 to 2.1 Billions and are projected to rise to 3 Billions by 2080. Mountainous zones, hosting the headwaters of these arid and semiarid basins provide these populations with freshwater. However, these zones are very sensitive to changes in precipitation and in temperature. Consequently, shifts in the regional climate will possibly influence snowmelt processes or foster glacier retreat, and therefore durably introduce perturbation in the local hydrological processes.
However, despite their substantial socio-economic relevance, the influence of a changing climate in hydro-meteorological processes is poorly studied in drylands, and this although they are expected to be among the ecosystems most affected by Climate Change.

Understanding the underlying hydrological processes at stake in these regions will assist to design the best strategies to mitigate forthcoming climate induced impairments. However, at the catchment scale, these processes are only understood conceptually. To examine the applicability of conceptual hydrological models to the processes actually occurring, three precipitation-runoff models - the J2000 model, the Soil and Water Assessment Tool (SWAT), and a simple lumped model - were applied in the Central Andes.

This study explores whether the different assumptions in model structures, therefore modeling different physical processes, actually influence their prediction ability in a poorly gauged basin. Furthermore, given the relatively low availability of input data, the performance of the three models is discussed under the light of their respective conceptual complexity. Subsequently, the three different hydrological models are forced using downscaled climate data inputs from three different GCMs (tested for the region in a parallel study) and the different impact simulation compared at the 2060 time horizon.

The calibrated sets of input parameters for each model are discussed and compared based on several statistical performance indicators. The hydrologic processes represented in the parameter sets resulting from each model are comparable but varied in their importance and their spatial distribution. More interestingly, no notable differences in simulations of future river flows was determined between the three models, arguing for flow predictions overwhelmingly driven by downscaled datasets. This raises therefore the issue of the relevance of using complex conceptual hydrological model for climate impact studies in poorly gauged regions.