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Future Water Availability in the Central Andes under the Climate Change Hypothesis

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Arid and semiarid areas cover on third of the Earth's surface and estimates for populations living in these regions varies between 1.4 to 2.1 Billions. By 2080, the IPCC projects an addition three Billions of people living in such areas. 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. Specifically, in the Central Andes, additional characteristic traits such as the influence of El Niño and the Southern Oscillation (ENSO) phenomena, a low cover of vegetation, poor mineral soil and severe droughts, make the zone especially vulnerable to Climate Change. However, despite their substantial socio-economic relevance, variations in temperature, precipitation and discharge are poorly studied in drylands, and this despite they are expected to be among the ecosystems most affected by Climate Change.

The Upper Hurtado watershed – of interest in this study – shares all common characteristics of arid and semiarid mountainous zones, which makes this basin an ideal candidate for the investigation of the impacts of Climate Change on water resources. It covers a surface of 670km^2, and lies on the westerly slopes of the Central Andes, located within Northern Central Chile.

The objectives of this work are i) to project future scenarios in the region, and ii) to simulate future water availability in the Upper Hurtado catchment. Projections of future climate signal were obtained using two different downscaling techniques (statistical and delta method downscaling). Both methods were preliminary tested for their accuracy in the region. In order to reduce uncertainties, a set of four different GCMs (CGCM3, GDFL, HadCM3, and MRI) was used along with two different SRES scenarios (A2 and B1). Subsequently, the SWAT model was calibrated and validated for the Upper Hurtado Basins. SWAT performance statistics returned satisfactory to good results (ENS>0.71, d>0.89), showing a good agreement between observed and simulated discharge. This good agreement was confirmed by a residual analysis. However, biases in the simulation of peakflows were identified at the monthly level. The predictive uncertainty analysis confirmed these biases, which were identified as originating mainly from the baseflow component. Finally, downscaled variables (precipitation, Tmax and Tmin) using multi-GCMs signals were introduced in the hydrological model. Future streamflow regimes in the Upper Hurtado watershed were simulated at the time horizons 2050 (2046-2065) and 2090 (2081-2099).

Results show a general decrease of the annual water yield (between -10% to -17%), mainly due to a decrease in the baseflow contribution. Nevertheless, the relative percentage decrease in runoff returned worrisome value up to -50%, which will likely drive the local population to increase their already important downstream pumping outtakes. In the same vein, a one month shift perturbation in the catchment's hydrograph is projected at both time horizons. This indicates that water availability is expected to diminish in summer, when it is most needed. This shift in the monthly hydrograph is explained by both the projected decrease in precipitation and the rise of temperature at high altitudes. This, combined to diminishing precipitation volumes will reduce the snowpack buffer capacity during dry spell years, which explains also the important diminution in baseflow.

These conclusions, in agreement with observed long-term trends in the study area, confirm the already observed decrease in discharge in the Central Andes. Hence, under the assumptions of these scenarios and taking into account all sources of uncertainties, downstream catchments hosting the agricultural activities might be seriously challenged.