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Assessment of water yield under global change scenarios in a Mediterranean rainfed watershed dominated by exotic tree plantations

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In forest plantations, management decisions to increase the productivity and the economic benefit of biomass production can notably affect ecosystem functioning. In particular, water yield which is an ecosystem service that depends on the hydrological processes occurring at the watershed scale. The consequences of the current and future landscape configuration mainly driven by forest plantations, can be especially severe under scarce water availability scenarios due to climate and Land Use and Land Cover Changes (LULCC). The general goal of this research is to assess the impacts of global change on water yield in a Mediterranean rainfed watershed dominated by exotic tree plantations.

The Cauquenes watershed is located in South-Central Chile (36°S) with 800 mm annual rainfall, mean annual streamflow of 5 m3 s-1 and elevations ranging from 150 to 750 m asl. The main land cover classes were identified with a supervised classification using a Landsat OLI scene with an overall accuracy of 86.5%. The corresponding land cover classes were as follows: forest evergreen (43%), shrubland (43%), barren land (10%), native forest (3%) and agriculture (1%). We first calibrated and validated the Soil and Water Assessment Tool (SWAT) based on the results of a sensitivity analysis (Latin Hypercube one-factor-at-a-time) included in the hydroPSO R package. The calibration was done at daily and monthly scale considering years 2009 to 2016. We then analyzed the changes in the streamflows obtained by the SWAT simulations for different land use and climate change scenarios for the years 2015-2035. We proposed two land use scenarios, the first following the most conservative forestry policy guidelines (CUS1), and the second considering a total replacement of non-profitable land use (CUS2). A single climate change scenario (MIROC_ESM) was selected from an ensemble of 26 GCM CMIP5 models (RCP 8.5), downscaled and bias corrected for the region.

Satisfactory calibrations were obtained for daily and monthly simulations with a NSE of 0.6 and 0.74 respectively and a PBIAS of -9.8% to -9.5%. Validations produced lower accuracies with 0.41 and 0.65 NSE and -8.5% and 8.5% PBIAS at daily and monthly scale respectively. Future scenarios CUS1 and CUS2 were then assessed only at monthly scale, showing an increment of 9.8% and 42.6% of total forest plantation areas, resulting in an increment of 0.6% and 4.1% of annual streamflows, respectively. The maximum difference was observed in October, probably due to more intense physiological activity of pines during spring. Climate change reduced in 30% the annual streamflow, and the most affected months were April, November and February with -76.5%, -67.5% and -65.5% of streamflow reduction respectively. The combined effect of LULCC and Climate Change produced a reduction of 30.6% and 33.6% of the annual streamflows. April, November and February were the most affected months with a reduction in streamflows ranging from -65.5 to -78.1%.

Streamflow simulations were strongly affected by Climate Change in comparison to LULCC, however a more detailed local parameterization of local vegetation water consumption should be implemented to have an adequate LULCC assessment.