Submitted Abstract

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Abstract

Tropical high-Andean wetlands, locally called bofedales, represent key ecosystems sustaining biodiversity, carbon sequestration, water provision and livestock farming. They are highly sensitive to climatic and anthropogenic disturbances, such as changes in precipitation patterns, glacier retreat and peat extraction, and are thus of major concern for watershed management. However, the eco-hydrological dynamics and responses of bofedales to impacts from global change are little explored.

In this study we map seasonal bofedales extent in the glaciated Vilcanota-Urubamba basin (Southern Peru) at unprecedented spatial resolution in the region. Therefore, we developed a supervised classification based on the Machine Learning algorithm Random Forest in Google Earth Engine. A total of 27 vegetation and topographic indices were computed and iteratively selected with cross-validated feature selection. We identify a total wetland area of 282 km^2 (630 km^2) at the end of the dry (wet) season in 2020 (2021). The observed high seasonal variability in bofedales extent within the study region suggests the presence of a pronounced intra-annual hydrological regime of drying, soaking and wetting.

For a more thorough assessment of the suggested pattern, we combined borehole water level and outlet river stage data from an arduino sensor network covering five bofedales sites in two micro-watersheds. These confirmed distinct wetting and drying regimes, indicating a strong relationship between wetland area extent and water table levels. Based on these findings and a scoping review, a conceptual hydrological model has been proposed. As an initial attempt for model parameterisation, we undertook a statistical analysis, cross-correlating borehole levels, river stage and precipitation inputs. We identified lag-time responses to precipitation from 1 to 46 days, likely owing to the complex topography, hydrogeology and eco-hydrological processes controlling intra-annual storage dynamics of the bofedales.

Our proposed conceptual model offers a framework to further assess the water storage capacity and residence times of bofedales that can support local decision-making. In view of severe impacts from climate and land use changes, locally tailored conservation and adaptation practices are urgently needed including innovative water storage enhancement interventions. These can be combined with traditional bofedales management by local, native livestock herders. In this regard, nature-based solutions, such as headwater and wetland protection and the implementation of additional water storage, can provide a cost-effective and flexible solution. These interventions leverage natural processes that sustain ecosystem services and increase the buffer function of bofedales to water loss from e.g. glacier shrinkage in headwaters and increasing water demand further downstream.