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Modeling complex snow-vegetation-topography patterns with a physically-based approach

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In mountainous catchments or basins located at higher latitudes, the effects of snow, vegetation and topography can exert an important control on the hydrological response of a watershed. Snow accumulation and melt are mediated by the processes influenced by vegetation, such as snow interception, net radiation modifications, albedo changes, and shadow effects. Furthermore, a complex landscape alters the incoming shortwave radiation through local and remote topographic effects that lead to uneven distribution of energy. Consequently, the partition of hydrological budget components at any given location is a result of these complex interactions and can be rather different for various vegetation types or watershed exposures. The understanding and the quantitative evaluation of these processes are still an open research field that requires new tools and studies. In this work the investigation of hydrology-vegetation-topography linkages in a mountain environment is carried out using a physically based ecohydrological model, Tethys-Chloris. Tethys-Chloris reproduces essential components of hydrological cycle resolving the mass and energy budgets at the hourly scale; it includes energy and mass exchanges in the atmospheric boundary layer; a module of saturated and unsaturated soil water dynamics; two layers of vegetation, and a module of snowpack evolution. The vegetation component parameterizes essential plant life-cycle processes, including photosynthesis, phenology, carbon allocation, and tissue turnover. The mechanistic physically-based approach allows for quantitative evaluations of the influence of different vegetation types and topography on the snowpack dynamics and streamflow generation. This approach can help in formulating scientific hypotheses that can be tested with field experiments or distributed observations. The use of a physically-based model is regarded as a vital hypothesis-generating method for a highly complex systems, where simplified approaches are likely to fail because of multiple interacting non-linear processes and resulting feedbacks.