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A new method of coupling distributed hydrology into dynamic ecosystem modeling, LPJ-GUESS

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The dynamic vegetation model LPJ-GUESS combines complex plant physiological and biogeochemical processes with detailed plant vegetation dynamics. It has been successfully used in predicting the vegetation structure and biomass at both local and global scale. However, the water cycling in LPJ-GUESS is only considering the vertical water movement between atmosphere, plants and soil, ignoring the lateral water interactions between grid cells. Topographic indices based on Digital Elevation Models (DEM) have been widely used to describe water movement as well as spatial patterns of soil moisture. Those indices are assuming steady-state conditions and can describe the spatial characteristics based on DEMs. In order to better predict the spatial pattern of vegetation, we have developed a new method by adding topographic indices into LPJ-GUESS, which we name LPJ-DH. Those indices were utilized to redistribute surface runoff at the simulating iteration. The generated surface runoff was transported downslope following the draining connection and direction. The coming water from the upslope area was added to the next iteration simulation which affected the vegetation dynamics. Thus, the water balance was kept within the catchment. We tested LPJ-DH in the Stordalen catchment (in northern Sweden) and implemented climate driven data at 50m resolution. The modeled runoff was evaluated by the observed runoff from the year 2007 and 2009. We demonstrated that the computed runoff by LPJ-DH were in well agreement with the measured data at annual, monthly and weekly time scales. Furthermore, we compared the correlations between the modeled monthly runoff with observations for LPJ-DH and LPJ-GUESS. The results showed higher values for LPJ-DH (R2=0.90198) than LPJ-GUESS (R2=0.69042), although with some bias for underestimation during the low runoff periods. The spatial pattern computed by LPJ-DH differed from the LPJ-GUESS and showed a more realistic drainage network. We also evaluated our modeled evapotranspiration (ET) with 2 years (1988-1989) observations and showed annual ET by LPJ-DH lying within the range of observed data, with less than 5mm deviation. Overall, the study justifies the feasibility and advantages of incorporating distributed topographic indices into the LPJ-GUESS.