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Comparing land use change and climate change as drivers of hydrological change in the Upper Ganges basin, India

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Quantifying how land use changes and climate change affect hydrological components is a challenge in hydrological science and especially in the tropics where many regions are considered data sparse. The Upper Ganges river basin (India) experiences almost every year monsoon flooding (for instance: summer 2013 floods over northern India). Studies have shown that there is evidence of strong coupling between the land surface (soil moisture) and atmosphere (precipitation) in North India which means that regional climate variations and changes in landscape are influencing the temporal dynamics of land-atmosphere interactions. This study aims to quantify how land use changes and climate change affect the hydrological response of the Upper Ganges (UG) river basin. High-resolution historic land cover maps for northern India were developed, based on satellite imagery, for the years from 1984 to 2010. Future scenarios of land cover were produced for year 2035 using Markov chain analysis. Climate change scenarios were derived from downscaled CIMP5 data from 16 participating models. The distributed version of the land surface model JULES was dynamically coupled with the crop model InfoCrop to allow for dynamic representation of crop growth. The coupled system was calibrated against measured daily stream flow data and run under different future land cover and climate change scenarios, to obtain hydrological projections for the UG basin.
We investigate the impact of seasonal and inter-annual land use changes as well as the impact of climate change by calculating annual variations in hydrological components (stream flow, evapotranspiration and soil moisture) during the simulation period. Significant differences on the long-term hydrologic fluxes arise under future land cover and climate change scenarios pointing towards a severe increase in high extremes of flow. The changes in all examined hydrological components are greater in the combined land use and climate change scenario compared to land use change and climate change scenarios individually. This work helps prioritizing adaptation strategies and regional land-use planning to improve Northern India's water resources.