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Bridging the gap between policy-driven land use changes and regional climate projections

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The biogeochemical effect of the land use and land cover changes (LULCC) is incorporated by the Radiative Concentration Pathways (RCPs). However, they do not represent the biogeophysical effect of LULCC that can have a significant impact on the local and regional climate. This study presents a novel modelling approach for a better prediction of the future climate under changing land surface.

Modelling the LULCC impact on the regional climate can be achieved by using LULCC scenarios that represent storylines of future land cover. Due to the large variety of small changes in the landscape of Western Europe, the small-scale climate impact by the LULCC can be achieved using high-resolution scenarios. Besides, the small-scale changes in the landscape impose a challenge to the climate model community to parameterise this subgrid-scale variability. Different spatial patterns of LULCC have been modelled among different scenarios within the European "Assessing LArge-scale environmental Risks for biodiversity with tested Methods" (ALARM) project, governed by the European Commission. This ambitious project generated LULCC scenarios on a resolution of 1x1 km and they were further downscaled to a higher resolution of 250x250 m for three years in the future: 2020, 2050 and 2080. The scenario selected within this study is a policy-driven scenario for 2020 that follows current and expected trends in EU policies and includes mitigation and adaptation strategies. The largest changes involve the abandonment of both cropland and grassland, compensated by an increase in forests and urban areas.

Meanwhile, the use of the high-resolution land surface model SURFace Externalisée (SURFEX) with its tiling approach allows us to accurately represent the small-scale changes in the landscape. The CNRM-CM5.1 global climate model coupled to RCP8.5 has been downscaled to perform simulations with the regional climate model ALARO coupled to SURFEX for a 30-yr period in the near future. Both climate changes and LULCC have been assessed based on the RCP and ALARM scenario.

Our results indicated a significant impact of LULCC on the near-surface temperature and to a lesser extent the precipitation. The changes of radiative forcing led to temperature increases in the near future of about 0.5 °C which were quite uniform in space. This was in contrast to the LULCC that led to temperature changes of -0.4 °C to 0.6 °C with large standard deviations. Therefore, the impacts of LULCC were much more geographically isolated with respect to changes in the radiative forcing. The regions with afforestation illustrated increases in minimum temperature of 0.5 °C and neutral changes in maximum temperature. On the other hand, urbanisation intensified the warming effect with 0.5 °C during day and night. Consequently, LULCC have a significant impact compared to climate changes for the near future. They provide valuable information for policy makers to apply strategies for adapting and mitigating to climate change. Finally, the strength of this study is the use of policy-driven LULCC data combined with an accurate representation of the land surface by the climate model.