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High-resolution climate and land surface interactions modeling over Belgium: current state and decennial scale projections

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The interactions between land surface and climate are complex. Climate changes can affect ecosystem structure and functions, by altering photosynthesis and productivity or inducing thermal and hydric stresses on plant species. These changes then impact socio-economic systems, through e.g., lower farming or forestry incomes. Ultimately, it can lead to permanent changes in land use structure, especially when associated with other non-climatic factors, such as urbanization pressure. These interactions and changes have feedbacks on the climate systems, in terms of changing: (1) surface properties (albedo, roughness, evapotranspiration, etc.) and (2) greenhouse gas emissions (mainly CO_2, CH4, N2O).

In the framework of the MASC project (« Modelling and Assessing Surface Change impacts on Belgian and Western European climate »), we aim at improving regional climate model projections at the decennial scale over Belgium and Western Europe by combining high-resolution models of climate, land surface dynamics and socio-economic processes. The land surface dynamics (LSD) module is composed of a dynamic vegetation model (CARAIB) calculating the productivity and growth of natural and managed vegetation, and an agent-based model (CRAFTY), determining the shifts in land use and land cover. This up-scaled LSD module is made consistent with the surface scheme of the regional climate model (RCM: ALARO) to allow simulations of the RCM with a fully dynamic land surface for the recent past and the period 2000-2030.

In this contribution, we analyze the results of the first simulations performed with the CARAIB dynamic vegetation model over Belgium at a resolution of 1km. This analysis is performed at the species level, using a set of 17 species for natural vegetation (trees and grasses) and 10 crops, especially designed to represent the Belgian vegetation. The CARAIB model is forced with surface atmospheric variables derived from the monthly global CRU climatology or ALARO outputs (from a 4 km resolution simulation) for the recent past and the decennial projections. Evidently, these simulations lead to a first analysis of the impact of climate change on carbon stocks (e.g., biomass, soil carbon) and fluxes (e.g., gross and net primary productivities (GPP and NPP) and net ecosystem production (NEP)). The surface scheme is based on two land use/land cover databases, ECOPLAN for the Flemish region and, for the Walloon region, the COS-Wallonia database and the Belgian agricultural statistics for agricultural land. Land use and land cover are fixed through time (reference year: 2007) in these simulations, but a first attempt of coupling between CARAIB and CRAFTY will be made to establish dynamic land use change scenarios for the next decades. A simulation with variable land use would allow an analysis of land use change impacts not only on crop yields and the land carbon budget, but also on climate relevant parameters, such as surface albedo, roughness length and evapotranspiration towards a coupling with the RCM.