Project: **1147**

Project title: **LAnd MAnagement for CLImate Mitigation and Adaptation**

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Report period: **2023-11-01 to 2024-10-31**

During the report period we published two papers and submitted another two papers, which are currently in their second phase of review. The origin of all these papers was only possible by making use of the DKRZ computation and storage infrastructure. We will briefly report about the content of the two published and one submitted papers here.

1. Effects of idealized land cover and land management changes on the atmospheric water cycle (doi: 10.5194/esd-15-265-2024)

This study investigates the impact of idealized land cover and land management changes (LCLMC) on the atmospheric water cycle, particularly focusing on moisture fluxes and recycling. Using three Earth system models (ESMs), MPI-ESM, CESM and EC-EARTH, we simulate three distinct scenarios: global cropland expansion, global cropland expansion with irrigation, and global afforestation. We applied a moisture tracking algorithm to assess the localized and global moisture recycling changes under each scenario. The cropland expansion tends to decrease local moisture recycling and leads to a generally drier atmospheric environment, while afforestation and irrigation typically enhance local moisture recycling and increase moisture availability. However, the strength and spatial distribution of these effects vary significantly across the models due to differences in parameterization and scale. Notably, CESM displays pronounced atmospheric circulation shifts, while EC-EARTH shows stronger mesoscale and localized effects. Figure 1 shows how the models capture for example the non-local (circulation) versus local effects, highlighting CESM's strong circulation changes versus MPI-ESM's more local focus.

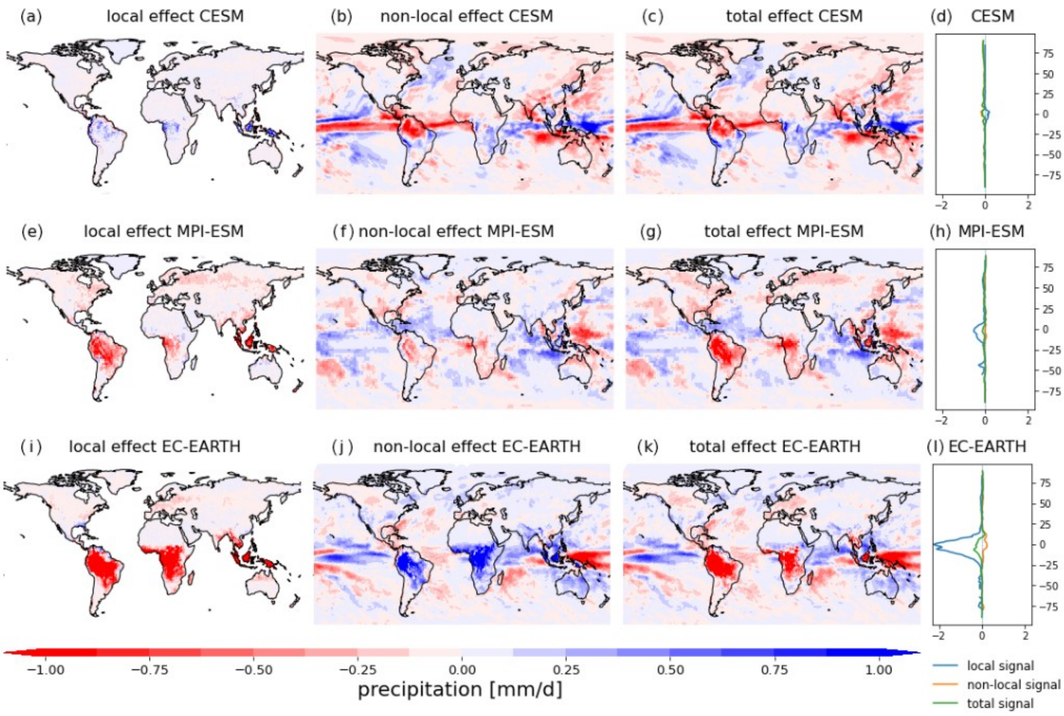

Figure 1: Annual mean precipitation response (local, non-local, and total effect) to cropland expansion.

Overall, we highlight that LCLMC strategies can drive substantial atmospheric water cycle shifts, underlining the necessity of incorporating these factors into climate mitigation and land management planning. Further, the variability among ESMs emphasizes the need for continued multi-model assessments to reduce uncertainties in LCLMC impacts on the water cycle. Our research contributes crucial insights for the development of sustainable, land-based climate mitigation strategies and underscores the importance of model diversity in evaluating environmental interventions.

2. Remote carbon cycle changes are overlooked impacts of land-cover and land management changes (doi: 10.5194/egusphere-2024-2387)

We investigate the overlooked impacts of land-cover and land management changes (LCLMCs) on the global carbon cycle, particularly focusing on nonlocal biogeochemical (BGC) effects that arise from these changes. While LCLMCs are known to influence the global carbon budget and climate through biogeophysical (BGP) effects, our research highlights their potential to trigger significant remote changes in carbon dynamics, which are typically not considered in current assessments. Using sensitivity simulations from the three ESMs, we examine again the three hypothetical large-scale LCLMC scenarios: global cropland expansion, global cropland expansion with irrigation, and global afforestation. Our findings reveal that nonlocal BGC effects on vegetation and soil carbon pools can accumulate over time, often becoming detectable within the first 40 years post-LCLMCs, and showing substantial changes by the end of a 160-year simulation period. Specifically, these effects can lead to variations in global terrestrial carbon stock ranging from 1 to 37 GtC, with pronounced changes observed in the densely forested Amazon and Congo regions. We underscore the necessity of including these nonlocal BGC effects in climate impact assessments and policymaking, particularly as LCLMCs play a crucial role in efforts to meet the Paris Agreement's targets for limiting global warming. We call for a re-evaluation of land-use emissions definitions to incorporate these significant, albeit often neglected, nonlocal effects.

3. Impacts of land-use and land-cover changes on temperature-related mortality (doi: 10.1097/EE9.0000000000000337)

Here, we explore how land-use and land-cover changes (LULCC) affect temperature-related mortality under two contrasting global scenarios of socio-economic development and land use: one sustainable (global implementation) and one unequal (limited to OECD countries) scenario. Using temperature data from the same three ESMs as before and mortality data from 823 locations across 52 countries, our study applies exposure-response functions to project mortality changes under the low warming scenario RCP1.9 through 2099. Our results show that globally sustainable LULCC can mitigate heat-related mortality in certain regions by reducing extreme temperatures, while unsustainable, unequal development may exacerbate temperature-related mortality, particularly in developing regions. However, significant variability exists across models and regions due to local climate differences and model sensitivity. Our findings underscore that sustainable land use could reduce temperature-induced mortality in key regions, contributing to healthier futures under Paris Agreement goals. We emphasize the importance of multi-model analyses and local adaptations in crafting effective climate policies.