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Land-atmosphere coupling during compound extreme heat and drought events in the LUCAS experiment: a new coupling metric for climate extremes

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Land-atmosphere energy and water exchanges are fundamentally linked to soil-moisture. The distribution of the planets' biomes hinges on the surface-atmosphere coupling since soil moisture and temperature feedbacks have a strong influence on plant transpiration and photosynthesis. Land use/land cover changes (LUC) modify locally land surface properties that control the land-atmosphere mass, energy, and momentum exchanges. The impact of these changes depends on the scale and nature of land cover modifications and is very difficult to quantify. However, large inconsistencies in the LUC impacts are observed between models, highlighting the need for common LUC across a large ensemble of models. The Flagship Pilot Study LUCAS (Land Use & Climate Across Scales) provides a coordinated effort to study LUC using an ensemble of regional climate models (RCMs). In the first phase of the project 3 experiments were performed for continental Europe: EVAL (current climate); GRASS (trees replaced by grassland) and FOREST (grasses and shrubs replaced by trees). An analysis of the energy and moisture balance for the three experiments is performed, focusing on the relationship between the fluxes partitioning, heat waves and droughts. To better asses the link between extreme temperatures and soil moisture or evapotranspiration, a new coupling metric for short time scales is proposed, the Latent Heat Flux-Temperature Coupling Magnitude (LETCM). This new metric is computed for a specific period, considering the positive temperature extremes and the negative latent heat flux extremes. Areas with positive magnitude values imply higher temperature anomaly, due to a negative latent heat

flux anomaly. This new metric only considers periods of strong coupling, with positive signals in areas of high temperatures and evaporative stress, allowing for the detection of events that are extreme for energy and water cycle. Concurrently, a new decile based normalised drought index is used to examine the concurrent heat extremes and droughts. The analysis focuses on the three experiments revealing that the number, amplitude and spatial distribution of compound extreme heat and drought is highly model dependant. The impact of afforestation or deforestation is not consistent across models.

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