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The Effect of Forests on the Amount of Incoming Precipitation over Europe

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Numerous studies have demonstrated that forests considerably alter temperatures at the land surface. These alterations vary in space and time due to a complex interplay of several modified energy fluxes at the land surface. The effect of forests on the amount and pattern of precipitation has gained less attention, despite its high socio-economic relevance. Previous work has demonstrated that the high precipitation amounts in tropical rain forests are self-sustained by the abundance of those forests itself. Yet, the impact of forests on precipitation in extra-tropical regions has gained only little attention. This study attempts to identify a relationship between the amount of precipitation and the abundance of forests over the European continent. Such a relationship can originate from two kinds of interactions: (1) The amount of precipitation can drive the abundance of forests, as water is a crucial resource for forests ecosystems. (2) The energy and water redistribution at the land surface associated with forests can alter processes in the atmospheric air column, which in term could affect the amount of precipitation at the location of the forest. Here, we aim to isolate the second kind of effects, as those are more relevant for human decision making.

Establishing a causal relationship between the abundance of forests and the amount of precipitation is complex due this two-way interaction. Hence, three different data sources are employed to advance our understanding of how forests influence precipitation patterns. Firstly, a geographically weighted regression is applied to the spatially-continuous, observation-based precipitation data set MSWEP2.2 (Beck et al., 2017). Besides the forest fraction, a number of topographical variables are considered as predictor variables to account for potential confounding factors (i.e, to assure that interactions of the first kind are not misinterpreted as interactions of the second kind). Secondly, closely-located, paired sites that resemble in topography, but differ in forest fraction are identified in the GHCN (Menne et al., 2012) and the GSDR (Lewis et al., 2019) rain gauge data sets. This allows to evaluate the results based on MSWEP2.2. Thirdly, the same geographically weighted regression is applied to convection-resolving regional climate simulations. By artificially defining the forest fraction distribution in model simulations, interactions of the first kind can be disabled, further fostering the understanding about the causality on the relations identified using the observations. Further sensitivity experiments could be conducted, to improve the process understanding on interactions of the second kind. Overall, our results indicate, that the abundance of a forest increases the amount of precipitation in the order of 100 mm/yr in many locations of Europe. This increased amount of precipitation is more pronounced during the

winter months, while the summer signal is more close to zero.