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Understanding and predicting climate extremes on land: The new frontier

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We live on land and are daily affected by land climate variations, but early climate pioneers often focused on ocean-climate interactions and ice-covered regions. With good reasons, since oceans cover two third of the Earth and are thus critical for the global climate, and because ice sheets have strongly varied over millennia and include key indices on past climate. However, recent research has increasingly shown that land climate, where we live, displays specific climate characteristics, which cannot be simply inferred from global climate responses. This is particularly the case for climate extremes, such as heatwaves and droughts. I will present recent evidence for these properties and some avenues for future research.

Land-climate interactions, which are modulated by vegetation, play a key role for climate variability on continents. This implies a fascinating interface between biological processes and climate physics. The limitation of water on continents, and the role of vegetation in the land water input to the atmosphere, implies very different water-cycle responses compared to what is seen on oceans: For instance, dry regions do not necessarily get drier, nor wet regions wetter under increasing greenhouse gas forcing. In addition, land climate can strongly deviate from global climate in other ways: During the so-called “hiatus period” in the early 2000s, changes in temperature extremes on land actually showed an amplified increase. Furthermore, key land processes are still insufficiently captured in state-of-the art Earth System Models (ESMs), such as land water effects on the global carbon cycle, and climate response to irrigation or land management.

Land processes are playing an increasingly central role in the development of pathways for climate mitigation consistent with the aims of the Paris Agreement, for instance related to afforestation or the development of bioenergy use in combination with carbon capture and storage. However, these scenarios often overlook biological and physical constraints for these land cover and land use changes, such as risks from climate extremes, including fire, in a warming world. ESM emulators for grid-cell responses may help to proof such scenarios in the needed rapid and safe transition to a net-zero CO_2 world.