

EGU21-1505

<https://doi.org/10.5194/egusphere-egu21-1505>

EGU General Assembly 2021

© Author(s) 2022. This work is distributed under the Creative Commons Attribution 4.0 License.



Drought spatiotemporal propagation via land feedbacks

Diego G. Miralles¹, Dominik L. Schumacher¹, Jessica Keune¹, and Paul A. Dirmeyer²

¹Hydro-Climate Extremes Lab (H-CEL), Ghent University, Ghent, Belgium (diego.miralles@ugent.be)

²Department of Atmospheric, Oceanic and Earth Sciences, George Mason University, Virginia, USA

The predicted increase in drought occurrence and intensity will pose serious threats to global future water and food security. This was hinted by several historically unprecedented droughts over the last two decades, taking place in Europe, Australia, Amazonia or the USA. It has been hypothesised that the strength of these events responded to self-reinforcement processes related to land–atmospheric feedbacks: as rainfall deficits dry out soil and vegetation, the evaporation of land water is reduced, then the local air becomes too dry to yield rainfall, which further enhances drought conditions. Despite the 'local' nature of these feedbacks, their consequences can be remote, as downwind regions may rely on evaporated water transported by winds from drought-affected locations. Following this rationale, droughts may not only self-reinforce locally, due to land atmospheric feedbacks, but *self-propagate* in the downwind direction, always conditioned on atmospheric circulation. This propagation is not only meteorological but relies on soil moisture drought, and may lead to a downwind cascading of impacts on water resources. However, a global capacity to observe these processes is lacking, and thus our knowledge of how droughts start and evolve, and how this may change as climate changes, remains limited. Furthermore, climate and forecast models are still immature when it comes to representing the influences of land on rainfall.

Here, the largest global drought events are studied to unravel the role of land–atmosphere feedbacks during the spatiotemporal propagation of these events. We based our study on satellite and reanalysis records of soil moisture, evaporation, air humidity, winds and precipitation, in combination with a Lagrangian framework that can map water vapor trajectories and explore multi-dimensional feedbacks. We estimate the reduction in precipitation in the direction of drought propagation that is caused by the upwind soil moisture drought, and isolate this effect from the influence of potential evaporation and circulation changes. By doing so, the downwind lack of precipitation caused by upwind soil drought via water vapor deficits, and hence the impact of drought self-propagation, is determined. We show that droughts occurring in dryland regions are particularly prone to self-propagate, as evaporation there tends to respond strongly to enhanced soil stress and precipitation is frequently convective. This kind of knowledge may be used to improve climate and forecast models and can be exploited to develop geo-engineering mitigation strategies to help prevent drought events from aggravating during their early stages.