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Land-atmospheric feedbacks during droughts and heatwaves (EMS Tromp Award Lecture)

Diego G. Miralles (1), Dominik Schumacher (1), Jessica Keune (1), Chiel van Heerwarden (2), Jordi Vila (2), Sonia I. Seneviratne (3), Pierre Gentine (4), and Adriaan J. Teuling (5)

(1) Laboratory of Hydrology and Water Management, Ghent University, Ghent, Belgium, (2) Meteorology and Air Quality Group, Wageningen University and Research, Wageningen, The Netherlands, (3) Institute for Atmospheric and Climate Science, ETH Zurich, Zurich, Switzerland, (4) Department of Earth and Environmental Engineering, Columbia University, New York, USA, (5) Hydrology and Quantitative Water Management Group, Wageningen University and Research, Wageningen, The Netherlands

Droughts and heatwaves cause agricultural loss, forest mortality, and drinking water scarcity, especially when they occur simultaneously as compound events. Their predicted increase in recurrence and intensity poses serious threats to future food security. Moreover, both events have been suggested to reinforce each other. However, a global capacity to observe these processes is still lacking, and climate and forecast models are immature when it comes to representing the influences of land on temperature and rainfall. Key open questions remain in our goal to uncover the real importance of these feedbacks: What is the impact of the extreme meteorological conditions on ecosystem evaporation? How do these anomalies regulate the atmospheric boundary layer state (potential event *self-intensification*) and contribute to the inflow of heat and moisture to other regions (potential event *self-propagation*)? The goal of this presentation is not to present a convincing answer to these questions, but to assess the scientific progress to date, while highlighting new results that may help us advance our understanding of these processes.

The exceptional event of 2010 in Eastern Europe will be used as a test case to study the role of land– atmosphere feedbacks during compound dry–hot events. Results will highlight the role of heat advection and its dependency on upwind drought conditions. During the peak of the 2010 event, the heatwave region received anomalously high contributions of heat from east and southeast, while westerly contributions were limited due to the presence of a persistent anticyclone. As the soils in the eastern upwind areas were anomalously dry, evaporation was heavily constrained there, and sensible heat was unusually high. This hot and dry air was continuously advected into the heatwave region, altering the atmospheric boundary layer and further accelerating soil desiccation in that region. These findings highlight the dependency of heatwaves on upstream land surface conditions via heat advection. This kind of knowledge may be exploited to develop geo-engineering mitigation strategies that can help prevent events from aggravating during their early stages or even propagating to other regions.