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Moisture sources associated with the 2010 mega-heatwave in Russia

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The European heatwave in the summer of 2003 caused air temperatures to soar unprecedentedly in late modern history, resulting in numerous local weather records. Bafflingly and largely unnoticed by the European public, yet another mega-heatwave followed only seven years later in Russia. Estimates on the socio-economic impact of these two extreme events vary largely, but it is undisputed that the unusual and persistent heat lead to an increase of the respective death tolls by tens of thousands. While it is difficult to link such individual events to anthropogenic climate change, the mere occurrence of heatwaves raises questions about their genesis.

It has been established that hot extreme events require suitable synoptic conditions to occur, e.g. the presence of an atmospheric blocking. Moreover, anomalously dry soils have been shown to intensify local land–atmosphere feedbacks that allow for even higher air temperatures. Clearly, moisture plays an important factor, as its scarcity may strengthen sensible heat fluxes, allowing for a progressive heat buildup and thus further escalation of air temperatures. In light of heatwaves becoming increasingly likely due to climate change, an investigation of the anomalies in the long-range moisture transport associated with these events, rather than solely focusing on local (soil) moisture anomalies, might contribute to a better overall understanding of these extreme events.

Here, a case study of the Russian heatwave in 2010 aims to shed light on this issue by first identifying the origins of moisture during the event, and then by comparing those to climatological moisture sources. The analysis relies on a state-of-the-art Lagrangian model, FLEXPART, run globally and driven by ERA-Interim data. The trajectories obtained from FLEXPART allow us to track changes in moisture backward in time, and hence, based on assumptions on the atmospheric residence time of water, to identify source regions. Did the origins of moisture in the region of interest during and prior to the heatwave clearly differ from ‘ordinary’ summers, and if so, how?

It is plausible to assume that during the mega-heatwave in 2010, moisture advection towards the affected region during the months prior to the event was diminished, and that this contributed to the negative anomaly in soil moisture that increased the escalation of temperatures during the summer. Therefore, the occurrence of such an extreme event could be viewed from a different perspective: by considering not only the local soil moisture deficit, but possibly also anomalous soil dryness in the moisture source region during the months preceding the hot event.