Evolution and predictability of temperature and hydrological extremes connected to atmospheric blocking under climate change

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Research field "Physical climate science: Uncertainties in atmospheric processes in a changing climate"
Research question 2 | Cluster 2
Links to showcases Bednar-Friedl 1, Birk 2, Kirchengast 2, Maraun

Background: European weather and climate is dominated by westerly winds. Blocking of the westerly flow can cause extreme events such as winter cold spells, summer heat waves, droughts and flooding (e.g., Sillmann et al., 2011), causing damages and posing health and life risks. The recent warming in the Arctic influences the circulation at mid-latitudes, coinciding with more frequent extreme weather (Cohen et al., 2014). But changes in blocking frequency and driving processes are unclear due to limitations of models and data sets (Barnes et al., 2014). Progress can be made by combining observational diagnosis and model simulations. In phase 1 of the DK, Brunner et al. (2016) demonstrated the detection of blocking in new observations from GPS radio occultation. Focusing on the spring season, Brunner et al. (2017) found a highly significant link between blocking and the occurrence of temperature extremes in Europe. A warming climate holds the potential for even higher vulnerability to extremes. Predictability of extreme events is thus crucial to possibly mitigate or even avoid some of the impacts.

Goal: The goal is to investigate the evolution of temperature and hydrological extremes, their connection to atmospheric processes, and to identify possible predictive capabilities. We will analyse the vertical structure of meridional temperature gradients and the links to blocking and jet stream variability. We will investigate the evolution and possible predictability of extreme events connected with atmospheric blocking—cold spells in spring and heat waves/ drought in summer—and impacts on agriculture, economy, and society in Europe, and in the focus region South East Styria. The leading question is if we can identify indicators and early warnings for extreme events to mitigate impacts and to develop adaptation strategies.

Methods and disciplinary background: Building on our expertise from phase 1 (Brunner et al., 2016; 2017; Brunner and Steiner, 2017), and having implemented a scheme for the dectection of blocking and extremes, we will analyse observational data sets, surface (EOBS, Spartacus) and vertically high resolved atmospheric data (GPS RO), complemented by novel reanalyses (ERA-5) and model simulations.

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Attribution of temperature and hydrological extreme events to human-induced climate change

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Research question 2 | Cluster 1
Links to showcases Bednar-Friedl 2, Birk 1, Foelsche, Maraun, Meyer 1

Background: The attribution of extreme events to human-induced climate change is of particular interest and has been demonstrated for record hot seasons (e.g., King et al., 2016). It is challenging since changes in circulation are uncertain. Forced circulation changes are not well established in current climate models, and it is difficult to detect changes in circulation-related extremes in observations because of small signal-to-noise ratios. Sensitivity experiments show a decrease in blocking occurrence and shifts eastward over Europe due to a projected eastward extension of the jet and storm track (Kennedy et al., 2016), whereas Arctic sea ice observations point to an increase of blocking occurrence (e.g., Francis and Skific, 2015). A robust approach to climate extreme-event attribution is needed.

Goal: The attribution of temperature and hydrological extreme events to human-induced climate change, in particular of heat waves and drought in Europe (with the DK focus region South East Styria), as well as in drought prone region in Africa. Given a disruption in atmospheric circulation, such as blocking, that caused an event, how did climate change alter its impacts? Why and what kind of changes can be expected in the future? This will be investigated using high quality observations and selected climate models with good blocking representation (Davini and D'Andrea, 2016; Mitchell et al., 2016).

Methods and disciplinary background: For investigating the influence of anthropogenic forcings on extreme heat events, we will use the fractional attributable risk framework (Hegerl et al., 1996; Stott et al., 2004; King et al., 2016). It compares the probability of such events between climate model simulations with both natural and anthropogenic forcings and those with natural forcings only. We further consider the approach of Trenberth et al. (2015) to climate extreme-event attribution. They regard the circulation regime or weather event as a conditional state and ask whether the impact of the particular event was affected by known changes in the climate system's thermodynamic state (e.g., temperature or atmospheric moisture content).

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