

## Thesis Abstract

Extreme weather events like heatwaves and floods severely affect societies with impacts ranging from economic damages to losses in human lives. Global warming caused by anthropogenic greenhouse gas emissions is expected to increase their frequency and intensity, particularly in the warm season. Next to these thermodynamic changes, climate change might also impact the large scale atmospheric circulation. Such dynamic changes might additionally act on the occurrence of extreme weather events, but involved mechanisms are often highly non-linear. Therefore, large uncertainty exists on the exact nature of these changes and the related risks to society. Particularly in the densely populated mid-latitudes weather patterns are governed by the large scale circulation like the jet-streams and storm tracks. Extreme weather in this region is often related to persistent weather systems associated with a strongly meandering jet-stream. Such meanders are called Rossby waves. Under specific conditions they can become slow moving, stretched around the entire hemisphere and generate simultaneous heat- and rainfall extremes in far-away regions.

This thesis aims at enhancing the understanding of synoptic- scale, circumglobal Rossby waves and the associated risks of dynamical changes to society. More specific, the analyses investigate their relation to extreme weather, regions at risk, under which conditions they are generated, and the influence of anthropogenic climate change on those conditions now, in the past and in the future.

I find that circumglobal Rossby waves promoted simultaneous occurring weather extremes across the northern hemisphere in several recent summers. Further, I present evidence that they are often linked to quasiresonant-amplification of planetary waves. These events include the 2003 European heatwave and the Moscow heatwave of 2010. This non-linear mechanism acts on the upper level flow through trapping and amplification of stationary synoptic scale waves. I show that this resonance mechanism acts in both hemispheres and is related to extreme weather. A main finding is that circumglobal Rossby waves primarily occur as two specific teleconnection patterns associated with a wave 5 and wave 7 pattern in the northern hemisphere, likely due to the favourable longitudinal distance of prominent mountain ridges here. Furthermore, I identify those regions which are particularly at risk: The central United States, western Europe and the Ukraine/Russian region. Moreover, I present evidence that the wave 7 pattern has occurred more often in recent decades, explaining the observed increase of stationary and extreme weather in these regions. My results suggest that the increase in frequency can be linked to favourable changes in large scale temperature gradients, which I show to be largely underestimated by model simulations. Using surface temperature fingerprint as proxy for investigating historic and future model ensembles, evidence is presented that anthropogenic warming has likely increased the probability for the occurrence of circumglobal Rossby waves. Further it is shown that this might lead to a doubling of such events until the end of the century under a high-emission scenario.

Overall, this thesis establishes several atmosphere-dynamical pathways by which changes in large scale temperature gradients might link to persistent boreal summer weather. It highlights the societal risks associated with the increasing occurrence of a newly discovered Rossby wave teleconnection pattern, which has the potential to cause simultaneous heat-extremes in the mid-latitudinal bread-basket regions. In addition, it provides further evidence that the traditional picture by which quasi-stationary Rossby waves occur only in the low wavenumber regime, should be reconsidered.