A new framework for identifying and investigating seasonal climate extremes

Matthias Röthlisberger¹, Mauro Hermann¹, Christoph Frei², Flavio Lehner¹,³,⁴, Erich M. Fischer¹, Reto Knutti¹, and Heini Wernli¹
¹ETH Zürich, Institute for Atmospheric and Climate Science, Environmental Systems Science, Zürich, Switzerland (matthias.roethlisberger@env.ethz.ch)
²Federal Office of Meteorology and Climatology MeteoSwiss, Zürich, Switzerland
³Department of Earth and Atmospheric Sciences, Cornell University, Ithaca, New York, USA
⁴National Center for Atmospheric Research, Boulder, Colorado, USA

Previous studies have recognized the societal relevance of climatic extremes on the seasonal timescale and examined physical processes leading to individual high-impact extreme seasons (e.g., extremely wet or warm seasons). However, these findings have not yet been generalizing beyond individual case studies since at any specific location only very few seasonal events of such rarity occurred in the observational record. In this concept paper, a pragmatic approach to pool seasonal extremes across space is developed and applied to investigate hot summers and cold winters in ERA-Interim and the Community Earth System Model Large Ensemble (CESM-LENS). We identify spatial extreme season objects as contiguous regions of extreme seasonal mean temperatures based on statistical modeling. Regional pooling of extreme season objects in CESM-LENS then yields considerable samples of analogues to even the most extreme ERA-Interim events, which allow for climatological analyses of their statistical and physical characteristics.

This approach offers numerous opportunities for analyzing large samples of extreme seasons across regions, and several such analyses are illustrated exemplarily. We perform a climate model evaluation with regard to extreme season size and intensity measures and estimate how often an extreme winter like the cold North American 2013/14 winter is expected anywhere in mid-latitude regions. Moreover, we present a large set of simulated spatial analogues to this event, which allows to study commonalities and differences of their underlying physical processes. Finally, substantial but spatially varying climatological differences in the size of extreme summer and extreme winter objects are identified.