Identifying drivers behind future changes in supercell occurrence in Europe

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OESCHGER CENTRE CLIMATE CHANGE RESEARCH

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Research question:

To what extent does a +3°C increase in mean surface temperature until the end of the twenty-first century, simulated by a km-scale regional climate model, alter the environmental conditions for supercell thunderstorms in Europe?

Introduction:

- Supercells are the **largest** and **most dangerous thunderstorm formations**.
- Characterized by mid-level rotating updraft (Markowski and Richardson, 2010).
- Originate from **deep moist convection**.
- Require three necessary environmental conditions (sufficient boundary layer moisture, steep temperature lapse rate and trigger for convective initiation) (Johns and Doswell, 1992).

Motivation:

- **Alpine Region** is a **hot spot** for **severe thunderstorms** (Taszarek et al., 2019).
- Various impacts on human life and infrastructure.
- Loss amount of 60 million Swiss francs solely for the canton of Lucerne from supercell on 06/28/2021.
- Anthropogenic climate change affects the environmental conditions that favor supercell formation.

State of research:

- **Research** on supercells has predominantly **focused** on the Great Plains and the southeastern United States, **where the terrain is flat**. A recent study has investigated the effects of complex topography on supercell evolution (Feldmann et. al, 2024).
- **Long term trends for severe convection remain unclear** due to unequivocal changes in the environmental ingredients (Taszarek et. al, 2021).

Case study of week with supercells

- Multiple severe convective events occurred in week from 06/21/2021 to 06/28/2021.
- The goal is to **identify how** the **environmental conditions** that lead to those events might **change in a future climate** projection (2085-2095).
- Start by summarizing daily synoptic weather conditions to incorporate their effects on meso-scale deep moist convection.
- Finish by **comparing** a set of **thermodynamical and kinematic parameters** (CAPE, CIN, θ_E, specific humidity, lapse rates, vertical wind shear).

Analyze supercell tracks, present vs. future

- The aim of this stage is to **detect changes in the supercell tracks** (see in box on data) between the present-day and future climate .
- Set up a map for the supercell frequency to capture shifts in regional occurrence.
- Compare the mean storm area, track length and storm lifespan.
- Identify shifts in intensity by comparing integrated updraft helicity, rain rate, hail diameter and wind speed on 10 m.
- Investigate on seasonal and diurnal cycles of supercell occurrence.

Tag each supercell track with environmental fingerprint

- The goal of the last stage is to establish an **automated procedure** which **assigns** a set of thermodynamical and kinematic parameters **(fingerprint)** to **each supercell trajectory.**
- This allows to statistically analyze the distributions of these parameters in the present-day and future climate.

Data:

- Simulation output from the **COSMO** regional climate **model** is used.
- Model is employed in a **convection-permitting** mode with 2.2 km horizontal grid spacing.
- First simulation scenario spans the present-day climate from 2011-2021.
- Second simulation scenario is for a future projection from 2085-2095.
- Pseudo-global-warming approach with +3°C for second scenario.
- **Blanc (2024) provides** a dataset where he assembled all **supercell trajectories** within the simulation output with his custom-designed supercell tracking algorithm.

Take home messages:

- The data analysis in this thesis aims to identify changes in supercell tracks and explain their underlying drivers.

Contact me via E-Mail!

Link to scClim project

References:

Blanc M. (2024), Supercells in European Climate Simulations; **Feldmann M. et al. (2024),** Supercell Thunderstorms in Complex Topography – How Mountain Valleys with Lakes Can Increase Occurrence Frequency, Monthly Weather Review 152.2, pp. 471-489, DOI: 10.1175/MWR-D-22-0350.1; **Johns R. H. and Doswell C. A. (1992),** Severe Local Storms Forecasting, Weather and Forecasting 7.4, pp. 588-612, DOI: 10.1175/1520-0434(1992)007<0588:SLSF>2.0.CO;2; **Markowski P. and Richardson Y. (2010),** Mesoscale Meteorology in Midlatitudes, 1st ed. Wiley, DOI: 10.1002/9780470682104; **Taszarek M. et al. (2019),** A Climatology of Thunderstorms across Europe from a Synthesis of Multiple Data Sources, Journal of Climate 32.6, pp. 1813-1837, DOI: 10.1175/JCLI-D-18-0372.1; **Taszarek M. et al. (2021),** Differing Trends in United States and European Severe Thunderstorm Environments in a Warming Climate, Bulletin of the American Meteorological Society 102.2, E296-E322, DOI: 10.1175/BAMS-D-20-0004.1