Three Decades of Thunderstorm Environments Reflected in the PERUN Reanalysis

1 Faculty of Science, Charles University

Robert Kvak[1,2] and **Petr Zacharov**[2]

(kvakr@natur.cuni.cz) *(petas@ufa.cas.cz)*

2 INSTITUTE OF ATMOSPHERIC PHYSICS CAS

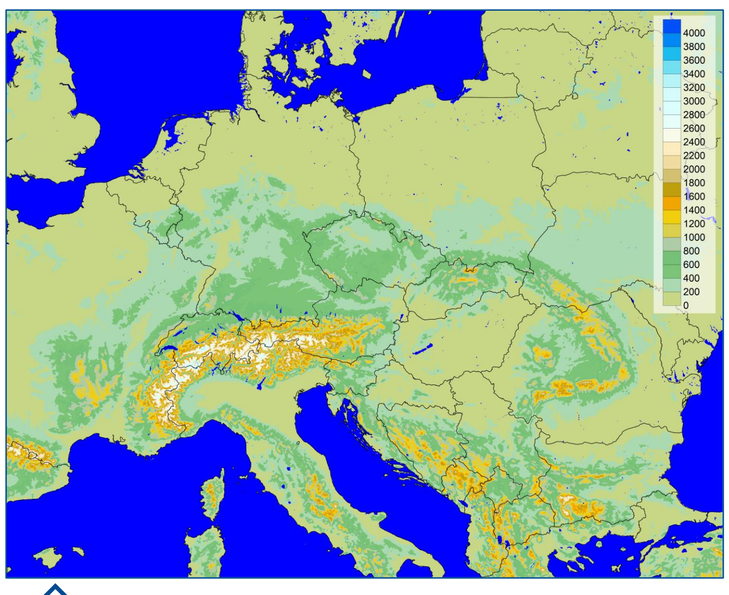


FIG. 1. The domain of the ALADIN/Reanalysis.

PERUN Reanalysis

NWP Model: ALADIN
Initial Conditions: ERA5
Data Assimilation: Included
Resolution: 2.3 km; 1-hour time step
Period: 1990–2021 (Spin-up: 1989)
Domain: "Central" Europe

Environmental Parameters

1. Most Unstable *Convective Available Potential Energy* **(MUCAPE)**
2. vertical *wind shear* 0–6 km AGL **(SHEAR)**

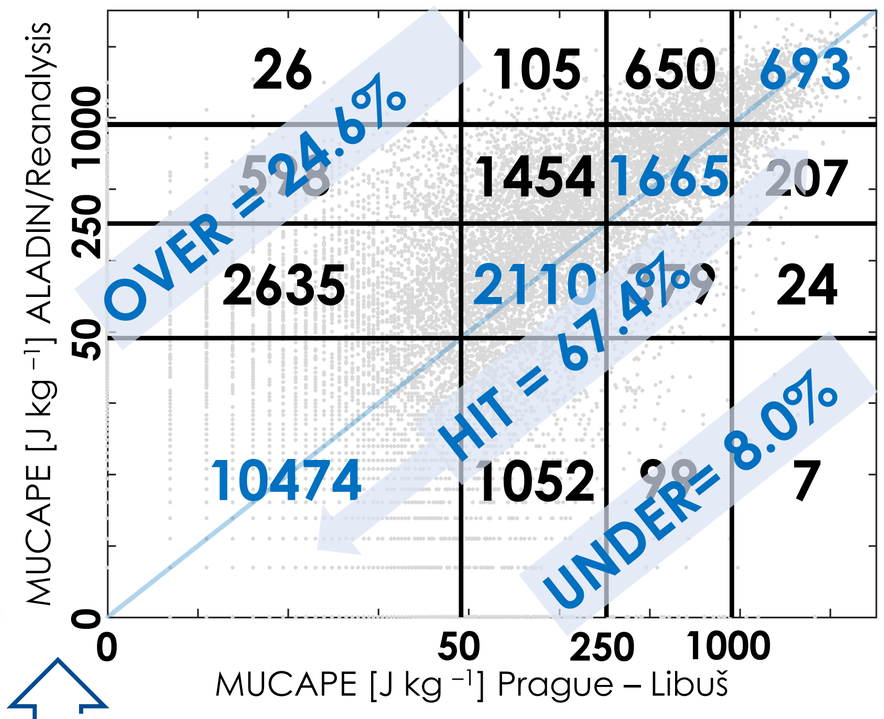


FIG. 2. Contingency table of MUCAPE from sounding measurements at the Prague – Libuš station and the PERUN reanalysis. The percentage of successfully reanalyzed values (**67.4%**), overestimated values (**OVER = 24.6%**), and underestimated values (**UNDER = 8%**) is shown in the table.

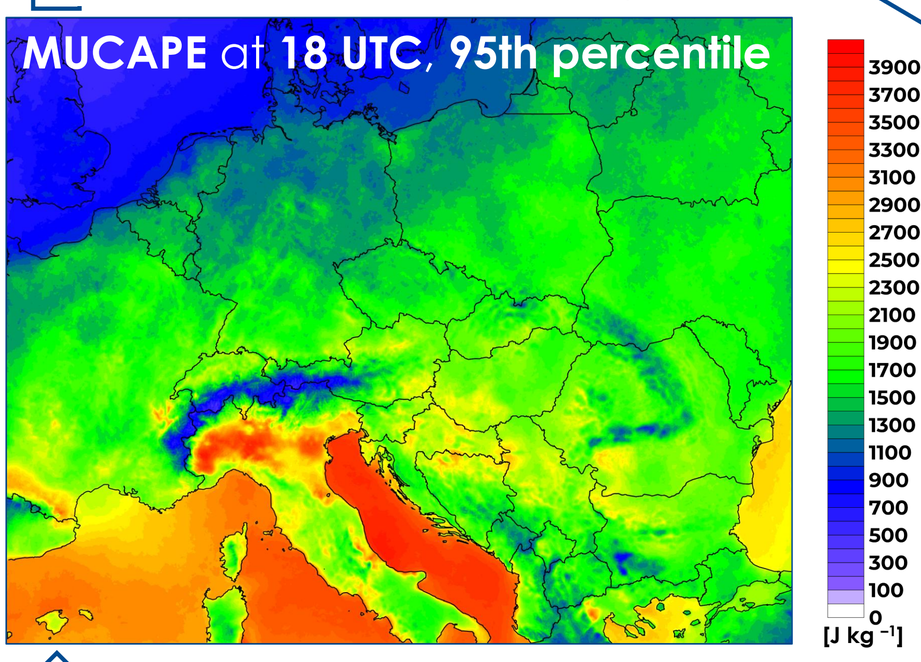


FIG. 3. The spatial distribution of the 95th percentile of MUCAPE at 18 UTC in 'Central' Europe highlights distinct regional influences. The warming effects of warm seas and lowlands, particularly over the Po Plain, contribute to higher MUCAPE values, whereas mountain barriers such as the Alps, Carpathian Arc, and Pyrenees induce a cooling effect, limiting convective potential. These geographical contrasts play a crucial role in shaping the local storm environment and convective storm initiation.

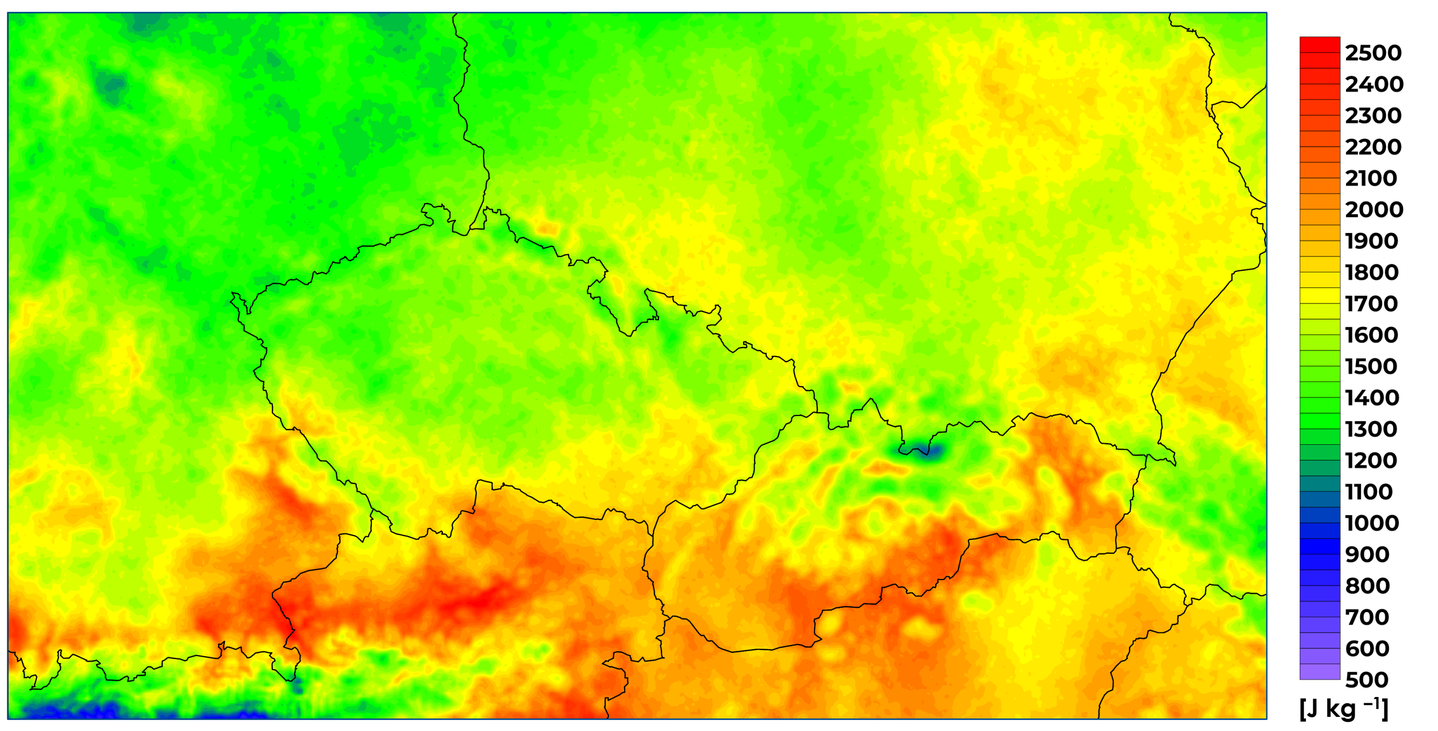
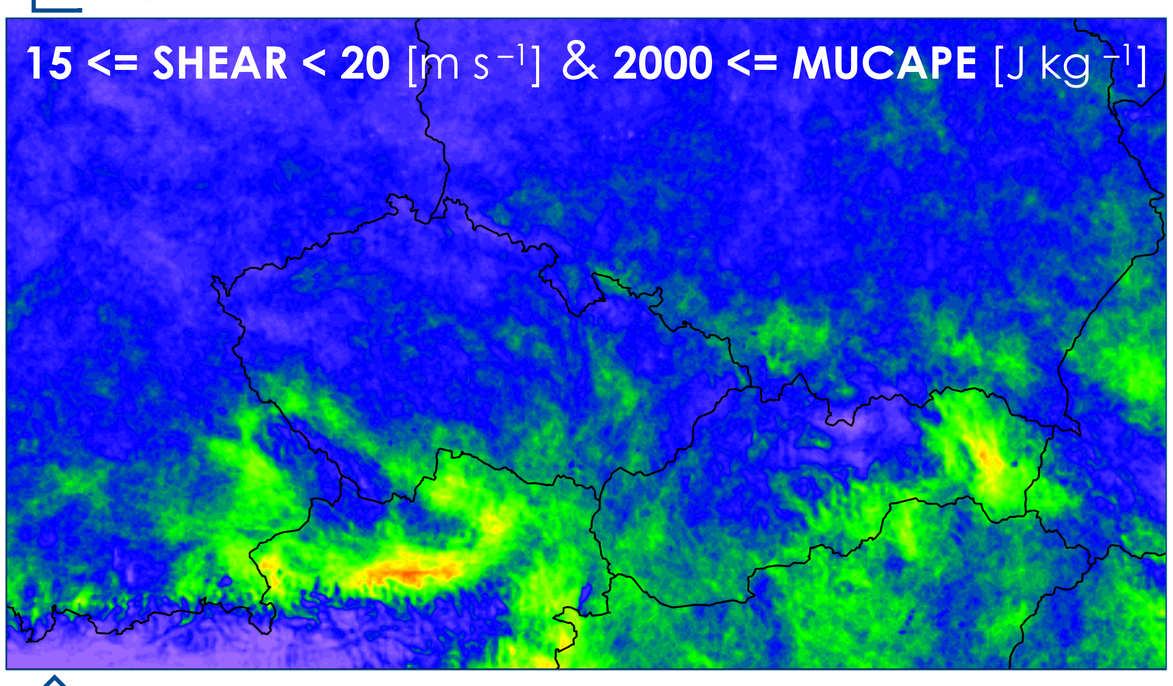
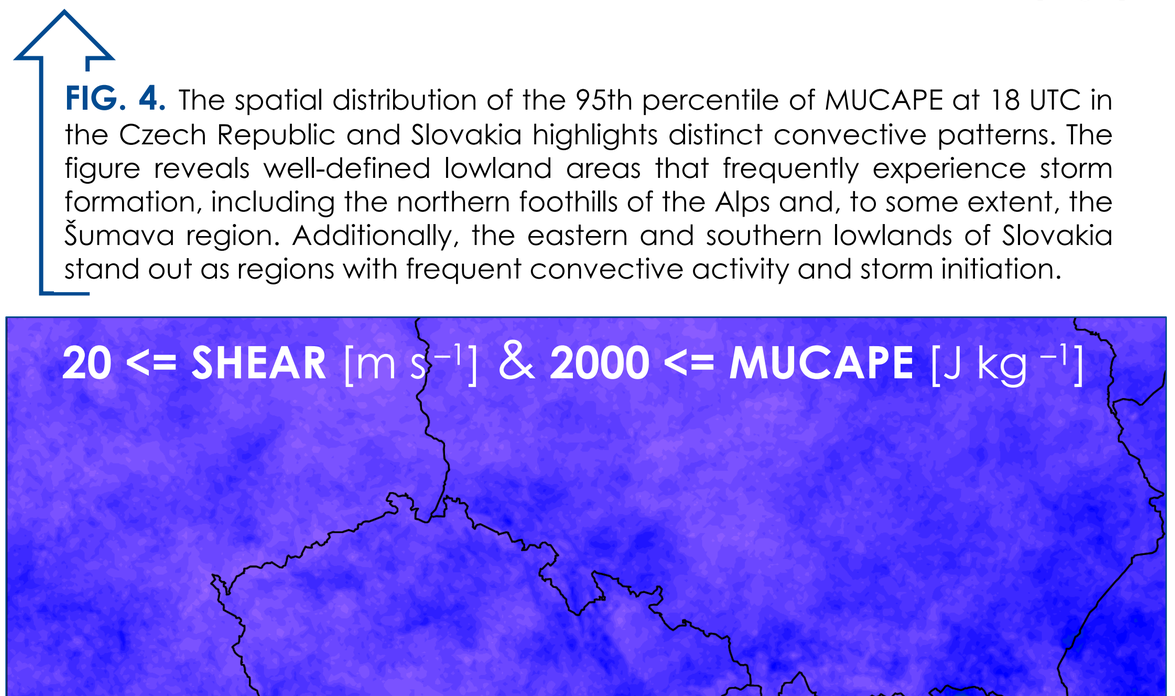
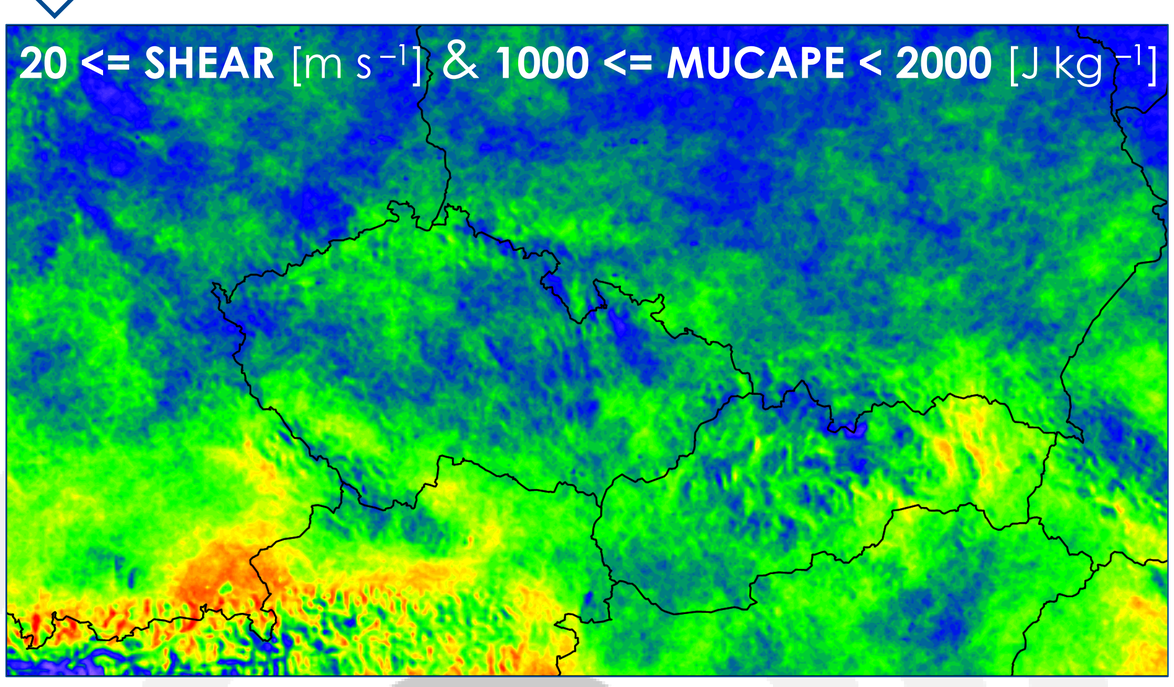


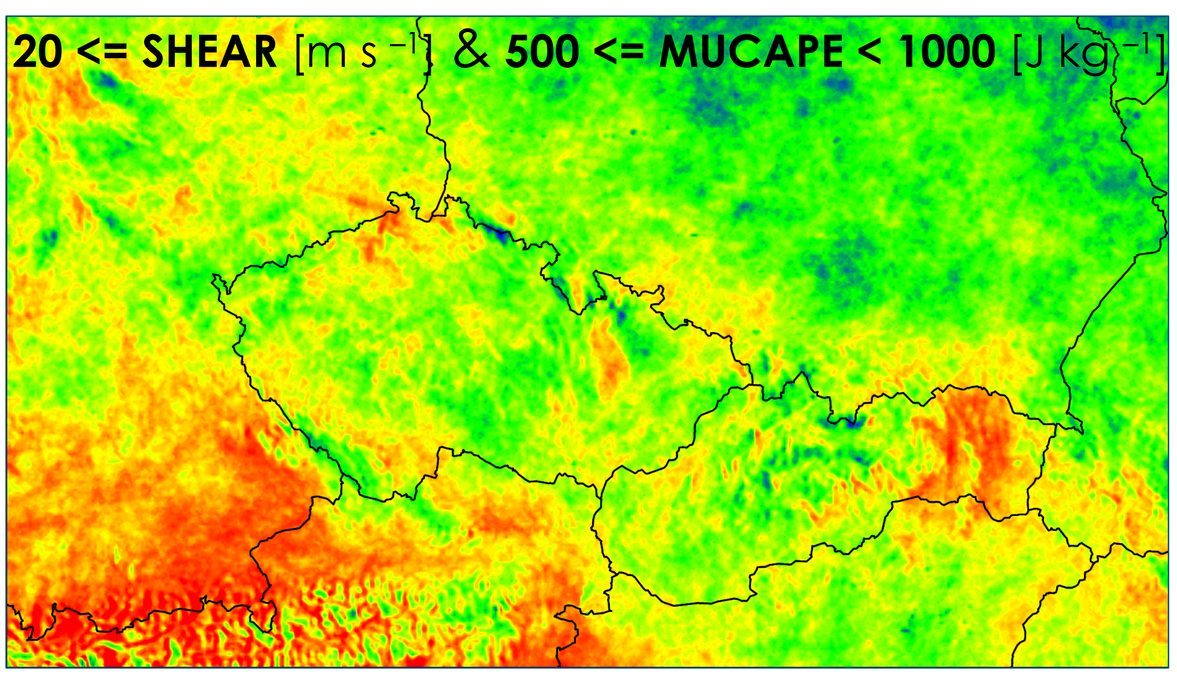
FIG. 4. The spatial distribution of the 95th percentile of MUCAPE at 18 UTC in the Czech Republic and Slovakia highlights distinct convective patterns. The figure reveals well-defined lowland areas that frequently experience storm formation, including the northern foothills of the Alps and, to some extent, the Šumava region. Additionally, the eastern and southern lowlands of Slovakia stand out as regions with frequent convective activity and storm initiation.





FIGs. 5–8. The spatial distribution of the number of days with SHEAR and MUCAPE within selected ranges (see the title of each figure). Areas where both high SHEAR and elevated MUCAPE values frequently coincide are particularly evident in the foothills of the Alps, Šumava, and Eastern Slovakia. These regions exhibit favorable conditions for the development of severe convective storms, influenced by local topography.





Essential Insights

- severe storm precursors derived from a 30-year model reanalysis
- strong agreement in MUCAPE values between reanalysis and observations
- regions with higher MUCAPE values:
  - Europe – the Po Valley and the foothills of the Alps and Pyrenees
  - The Czech Republic – the foothills of Šumava and the pre-Alpine region
  - Slovakia – the lowlands of Eastern Slovakia and the Lučenec-Košice Depression
- combination of SHEAR (0–6 km AGL) and MUCAPE; extensive regions with elevated values:
  - Europe – the Po Valley and the eastern coast of Italy
  - The Czech Republic – the foothills of Šumava and the pre-Alpine region
  - Slovakia – the lowlands of Eastern Slovakia and the Lučenec-Košice Depression

Looking Ahead

- ALADIN-CLIMATE (nested in CNRM–ESM2–1):
  - A/Hist – historical run 1900–2014
  - A/C – climate run 2015-2100 as follows:
  - A/C–8.5 nested in CNRM–ESM2–1 with SSP5–8.5
  - A/C–4.5 nested in CNRM–ESM2–1 with SSP5–4.5
- ➢ temporal and regional changes in environmental parameters of severe convective storms under a changing climate, based on the evolution of emission scenarios until 2100

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