Tracing Tornadoes Through Time: Enhancing Tornado Climatology in Romania with Historical Data and Modern Analysis

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Abstract

This study delivers the most comprehensive **tornado and waterspout climatology for Romania** to date, substantially increasing the known record of events and revealing new insights into their spatial, temporal, and environmental patterns. By integrating previously overlooked **archival data** with **modern database entries** and **state-of-the-art meteorological reanalysis**, the research not only uncovered historic, deadly tornadoes but also provided insights into the environments in which Romanian tornadoes form. These findings enhance the understanding of regional tornado risk and provide valuable guidance for disaster preparedness in Romania and neighboring regions.

Data and Methods

Based on keyword search, we retrieved 216 potential new tornado and waterspout reports. Because different terms have been used over time to describe tornadoes and waterspouts in Romania, it was not possible to definitively identify the event as a tornado or waterspout based solely on the terminology used in historical records.

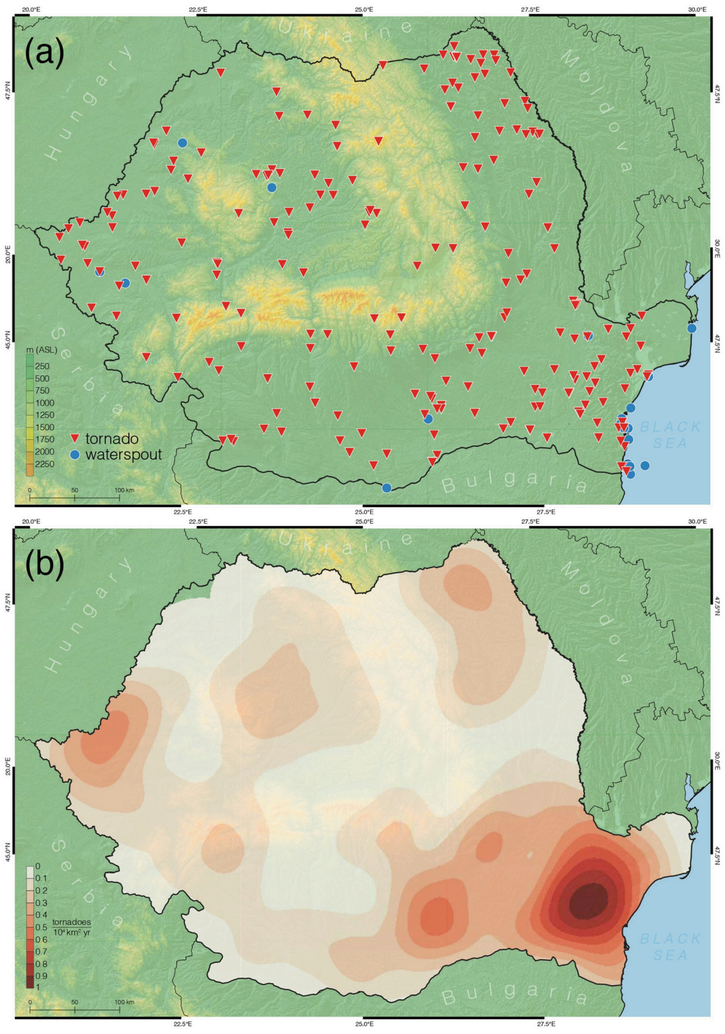


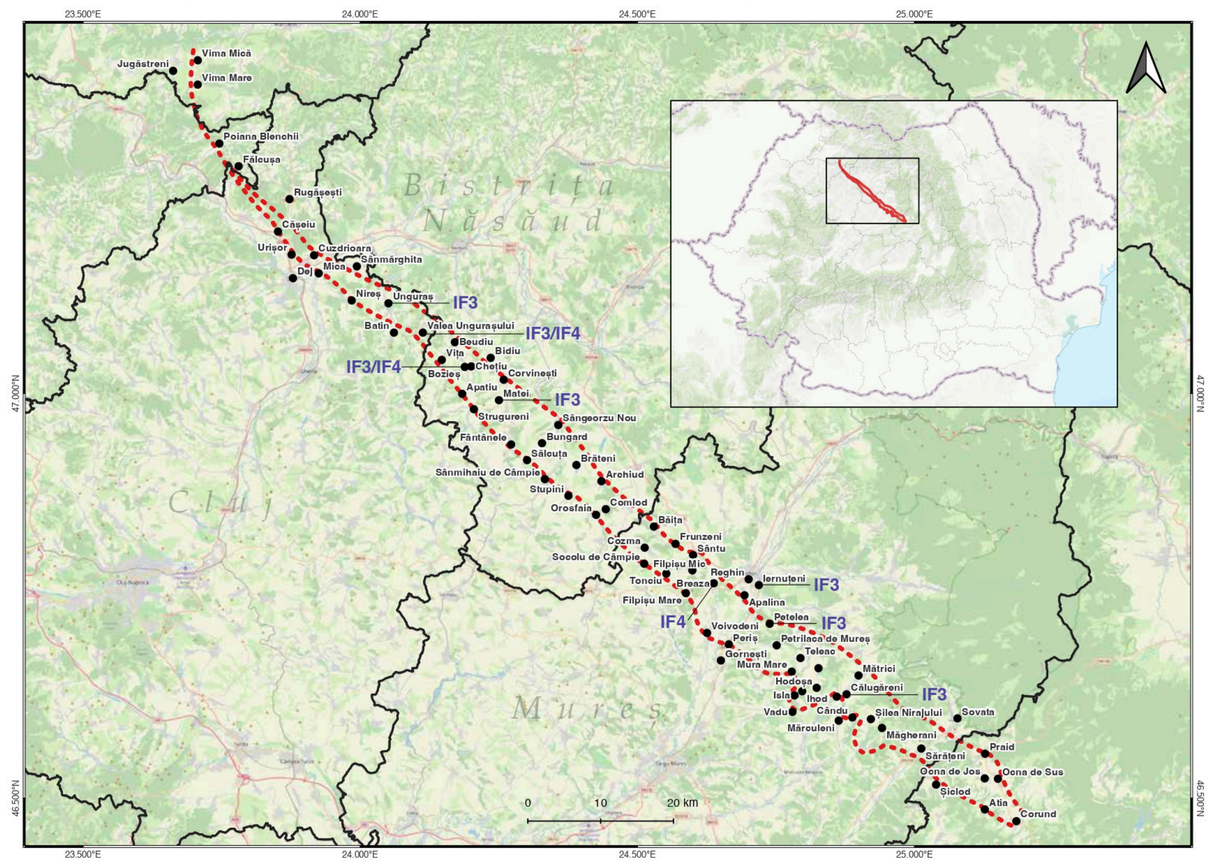
Fig. 1 (a) Spatial distribution of the 245 tornadoes and waterspout reported in Romania between 1634 and 2024. (b) Kernel Density Estimation (KDE) analysis only for the tornadoes reported between 2000–2024 (i.e., 131 reports) showing the annual average number of tornado reports.

To examine atmospheric environments, we used hourly ERA5 reanalysis data (1990–2024) at 0.25° resolution. For each event, key parameters such as MLCAPE, BS 0–1 km, SRH, RH SHERBE, and STP were extracted within a 48-hour window before and 24 hours after occurrence (fig. 5).
Spatial patterns were analyzed using kernel density estimation to locate high-risk areas, while seasonal and diurnal cycles were assessed to identify peak activity periods. Composite time series and trend analysis (Theil–Sen and Mann–Kendall tests) were applied to investigate environmental evolution (fig. 6) and long-term changes.

Results

Archival research conducted in this study has uncovered evidence of three deadly tornadoes. the largest number of fatalities (i.e., 23–27 fatalities) and also of injuries (i.e., more than 150 injuries) was produced by the 13 May 1912 Transylvania tornado (Fig. 2), considered **the most impactful tornado in the history of Romania**. The damage path was approximately 150 km long, stretching northwest to southeast, starting near Vima Mare (Maramures, County) and ending near Corund (Harghita County).

Fig. 2 Map showing the tornado track of the 13 May 1912 tornado



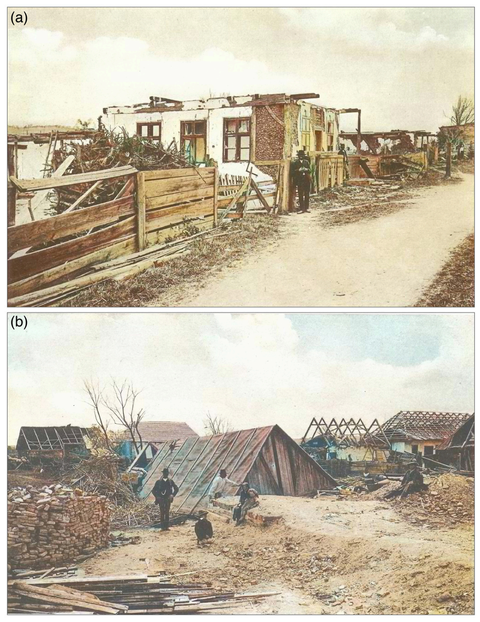


Fig. 3 Damages produced by the 13 May 1912 Transylvania tornado at Unguras

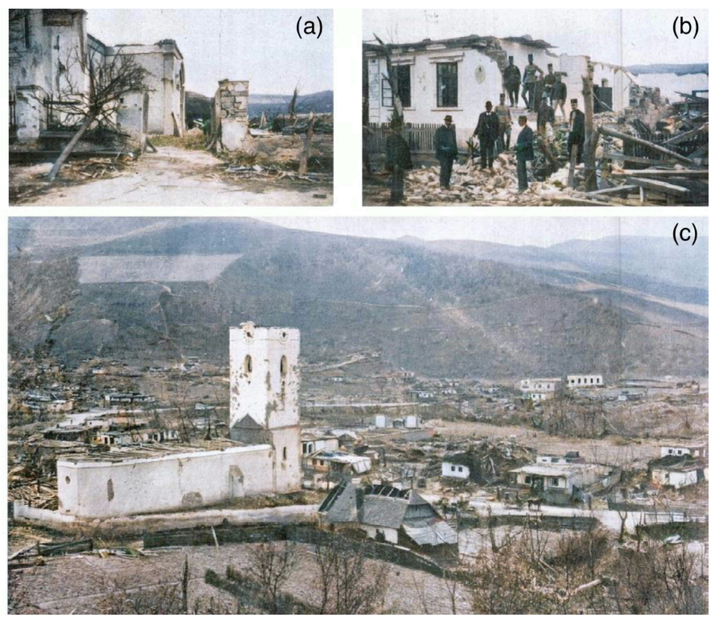


Fig. 4 Damages produced by the 13 May 1912 Transylvania tornado at Breaza

Conclusions

- There is a higher frequency of reports from the plain regions in northeastern and southeastern Romania.
- Tornadoes in Romania occur mainly from May to July, with most events weak (IF1), but occasional IF2+ cases causing severe impacts.
- Composite ERA5 environments show that Romanian tornadoes typically form in rapidly evolving high-shear/low-CAPE (HSLC) regimes.
- Although tornadoes will remain climatologically infrequent in Romania, the tail risk of IF2–IF3 (or stronger) events is non-zero.

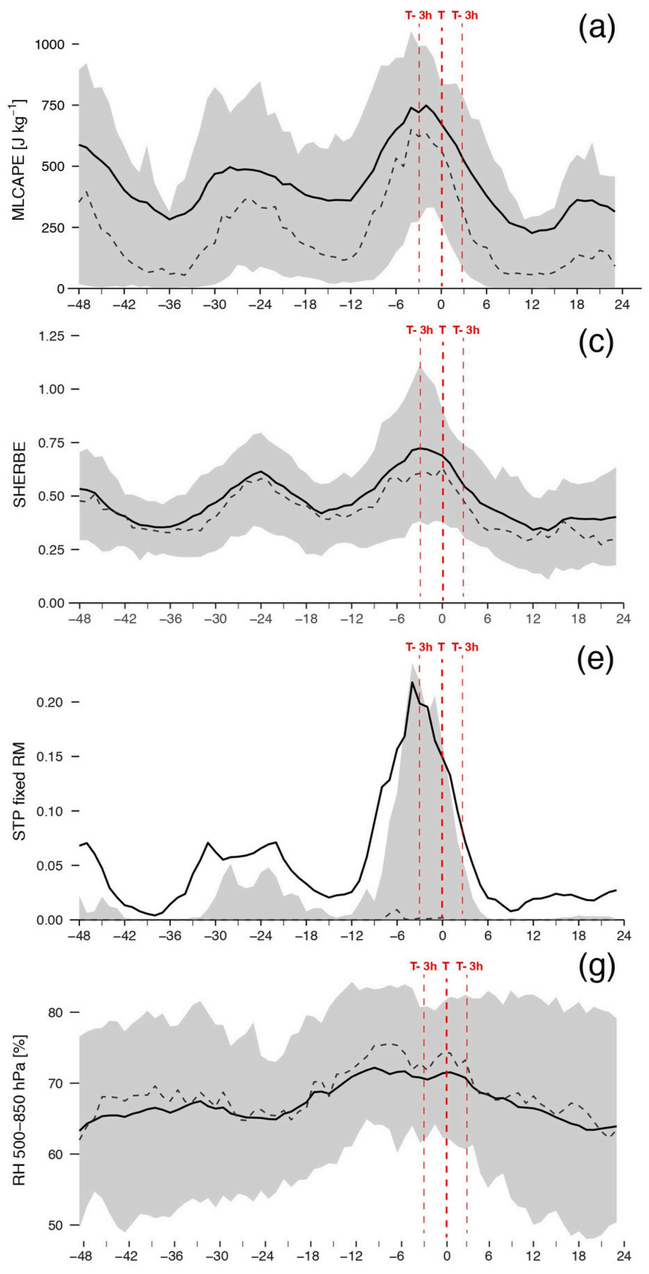


Fig. 5 Time evolution for 48h prior and 24h after the event. The grey area represents the interquartile range (IQR), the black solid line is represented by the mean and the black dashed line is the median.

References

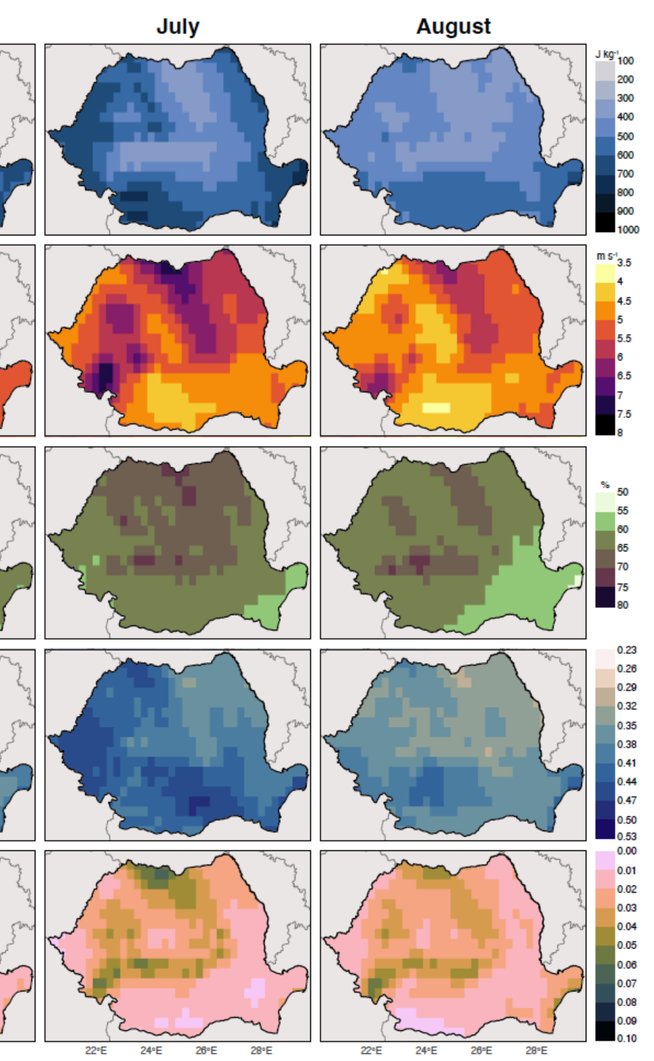


Fig. 6 The 95th percentile of monthly mean values for the parameters (1990–2024). For each calendar month, the plotted values represent the threshold above which only the highest 5% of monthly mean values occur within the 1990–2024 period.