Why are European severe storms most frequent near mountains?

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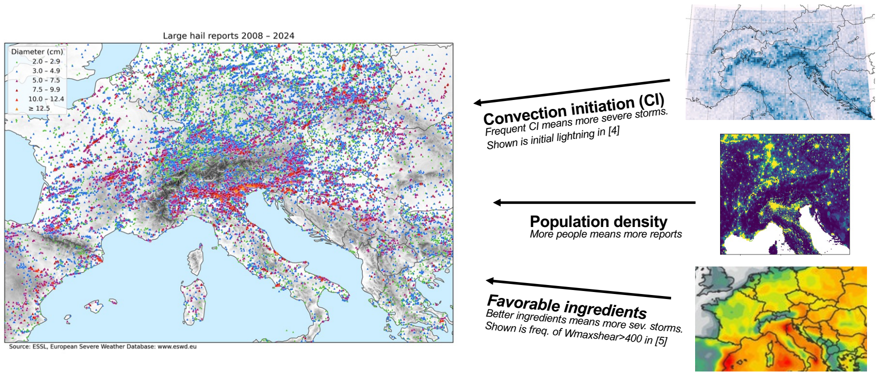
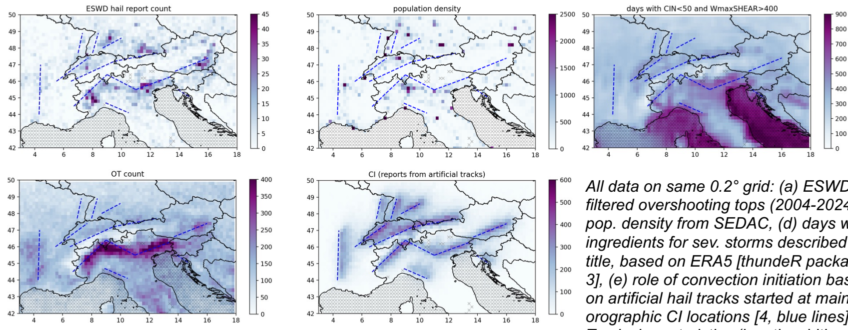
Motivation – one question of the **TIM** field campaign is why severe weather reports cluster near mountain ranges [1]
→ find relative influences of
(1) convection initiation, (2) population density, (3) convective ingredients

Methods – to independently compare these factors, each interpolated to same grid (see caption), then correlations among fields are calculated, with ESWD and OTs serving as "truth" for the severe storm distribution

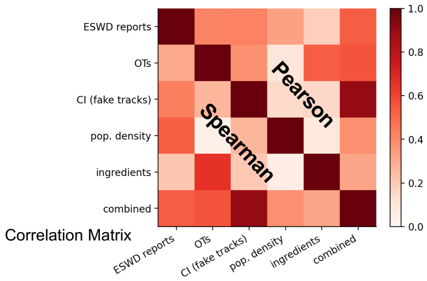
Results

- As expected, correlations and visible similarities in 2D distributions exist
- Best correlations when combining factors (1)-(3)
- **BUT correlation not large (<0.6)**
  → are there additional factors (e.g., local orographic processes [2]) or is the method just too simplified?
- Pop. density has impact on report distribution, especially using Spearman corr., likely because of nonlinear effect on report frequency

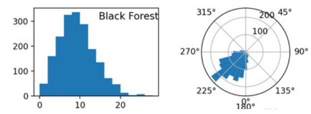




All data on same 0.2° grid: (a) ESWD, (b) filtered overshooting tops (2004-2024), (c) pop. density from SEDAC, (d) days with ingredients for sev. storms described in title, based on ERA5 [thundeR package, 3], (e) role of convection initiation based on artificial hail tracks started at main orographic CI locations [4, blue lines]. Track characteristics (length, width, lifetime) were stochastically generated from observed distributions like below found with ERA5 near ESWD reports



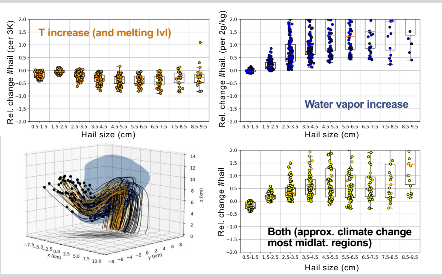
Correlation Matrix



Histograms of Bunkers mean wind speed (m/s) and direction

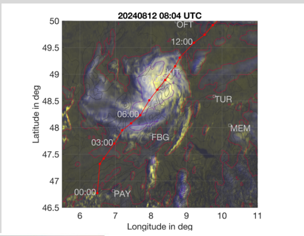
Other current projects I'm happy to discuss:

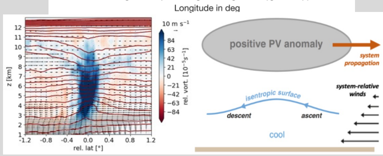
Hail trajectories in a changing climate (K.Lombardo, M.Kumjian)



3D hail trajectory simulations with varying updraft strengths and widths in [6] are used as ensemble to disentangle effects of climate change variables (melt lvl, water vapor). Figs. show delta hail count between 2 sims with only changing T or qv. → Combination of melting (T increase) and faster growth (cloud water increase) causes hail size dichotomy [7], but ~2 cm!

Two MCVs over central Europe (J. Quinting, A.Oertel, P.Gasch, B.Kirsch)

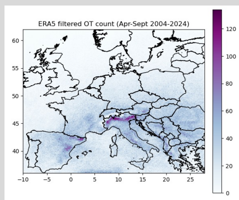


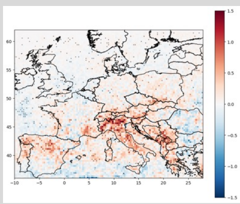


Track of mesoscale convective vortex (MCV) in satellite; sim. cross-section with isentropes and system-relative winds; illustration of matching MCV dynamics in [8]

Climatology and trend in hail based on overshooting tops

Number of OTs (new 2004-2024 data, summer half) after filtering for >50 J/kg MUCAPE and >1600 m melting lvl with ERA5 [3]





Trend in same data (OTs/yr); dots indicate sig.

References:
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[2] Feldmann, M., Rotunno, R., Germann, U., & Berne, A. (2024). Supercell Thunderstorms in Complex Topography—How Mountain Valleys with Lakes Can Increase Occurrence Frequency. Monthly Weather Review, 152(2), 471–489.
[3] Taszarek, M., Czernecki, B., and Szuster, P.: thundeR - a rawinsonde package for processing convective parameters and visualizing atmospheric profiles, 11th European Conference on Severe Storms, Bucharest, Romania, 8–12 May 2023
[4] Manzato, A., S. Serafin, M. M. Miglietta, D. Kirshbaum, and W. Schulz, 2022: A Pan-Alpine Climatology of Lightning and Convective Initiation. Mon. Wea. Rev., 150, 2213–2230,
[5] Taszarek, M., Allen, J., Púčik, T., Groenemeijer, P., Czernecki, B., Kolendowicz, L., … Schulz, W. (2019). A climatology of thunderstorms across Europe from a synthesis of multiple data sources. Journal of Climate, 32(6), 1813–1837.
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[7] Gensini, V. A., Ashley, W. S., Michaelis, A. C., Haberlie, A. M., Goodin, J., & Wallace, B. C. (2024). Hailstone size dichotomy in a warming climate. Npj Climate and Atmospheric Science, 7(1), 1–10.
[8] Markowski, P., & Richardson, Y. (2010). Mesoscale meteorology in midlatitudes (Vol. 2). John Wiley and Sons.