Recent trends in sounding-derived indices and thunderstorm-related observations: a wider perspective over the Po Valley

G. Fasano[1]*, L. Ferraro[2], E. Palazzi[2], L. Tomassone[1], A. Golzio[1], F. Sioni[3], A. Manzato[3,4]

1: Arpa Piemonte, Turin, Italy; 2: University of Turin, Italy; 3: ARPA Friuli Venezia Giulia, Italy; 4: CNR-ISAC, Bologna, Italy

1. MOTIVATIONS & GOALS

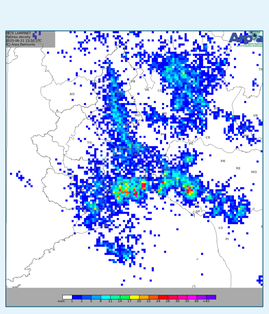
- Po Valley (N Italy) has experienced an increase in lightning activity and hail in the last decades, according to models based on reanalysis data[1]. With global warming, a higher frequency of severe thunderstorms is expected in the future[2].
- Assessing the actual trends of observed convective activity is difficult, due to the **limitations in observational records**. The assessment of convective indices as proxies of thunderstorm activity is often a more convenient way[3].
- Analyses of radiosounding data in the Eastern Po Valley have shown that atmospheric **instability** and **moisture** content have recently **increased**, whereas observed storm activity **has not** shown a comparable trend (except for hail size diameter).[4]
- This work presents new evidences coming from the **other side of the Po Valley** (Piedmont region, on its western side), to assess if these unexpected results are valid only on a limited region or they exhibit a more general validity.

2. DATA & METHODS

20 years (2005-2024) of high vertical resolution radiosounding data from Cuneo Levaldigi (only 12 UTC, April-September)

22 convective parameters from ThundeR package

11 years (2014-2024) of CG lightning data over Piedmont (LAMPINET network)

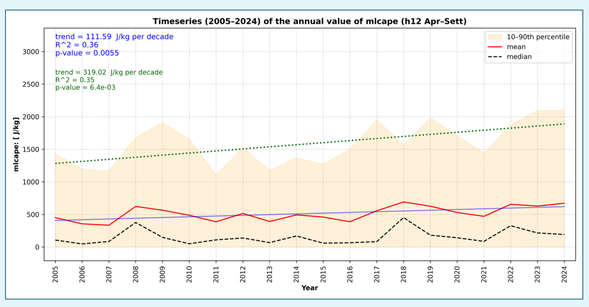


Comparison with indices available from ERA5

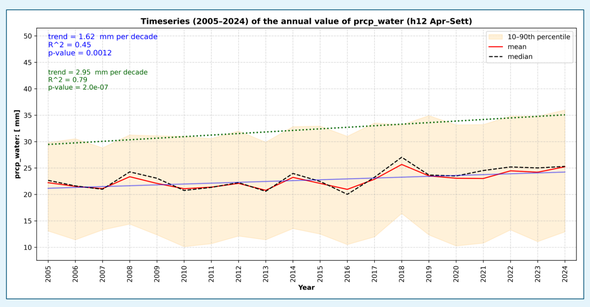
3. RESULTS

Convective parameters:

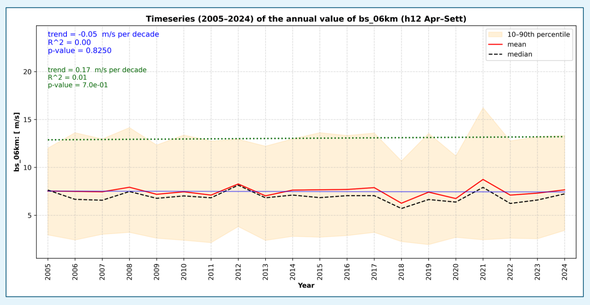
instability has significantly **increased** in the last 20 years, as shown for example by CAPE, Lifted Index, K Index. Atmospheric **moisture** has also **increased** a lot, as shown by precipitable water and mixing ratio of the most unstable particle. **Inhibition** and **wind parameters** have not changed.



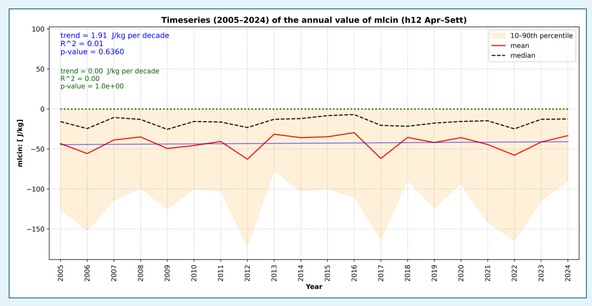
MLCAPE



PW



MLCIN



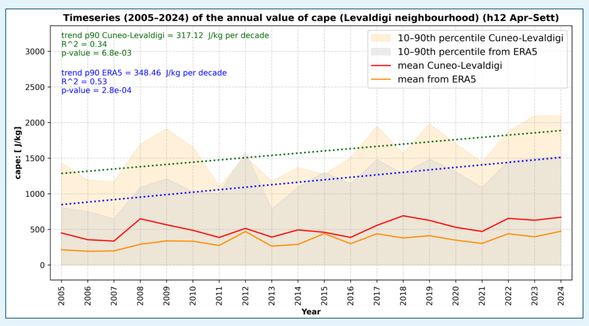
BULK SHEAR 0-6km

Comparison with ERA5:

ERA5 satisfactorily reproduces the magnitude and the trends of the convective parameters subject to comparison. The absolute values of CAPE are partially underestimated, but the increase in time is consistent. In the case of PW, the increase in time is slightly underestimated by ERA5.

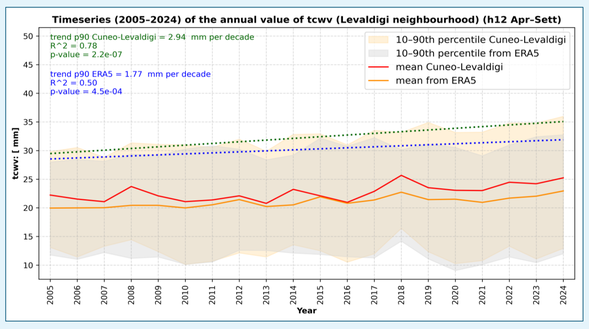
For example, trends of:

CAPE [J/kg per decade]	RDS	ERA5
Mean value	~ +100	~ +100
90th percentile	~ +300	~ +300



CAPE (RDS & ERA5)

PW [mm per decade]	RDS	ERA5
Mean value	~ +1.6	~ +1.3
90th percentile	~ +3	~ +1.8



PW (RDS & ERA5)

Comparison with the results in Udine Rivolto:

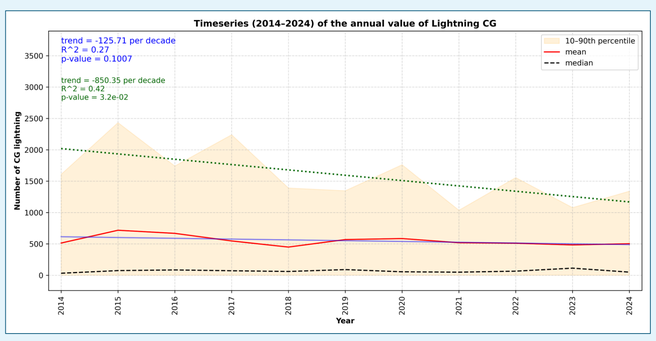
The instability and moisture parameters calculated in the two locations exhibit consistent trends: CAPE and PW increase at a similare pace (see tables below), CIN does not change significantly.

CAPE [J/kg per decade]	Cuneo	Udine
Mean value	~ +100	~ +100
90th percentile	~ +300	~ +300

PW [mm per decade]	Cuneo	Udine
Mean value	~ +1.6	~ +1.6
90th percentile	~ +3	~ +2.2

CG lightning:

the total number of **CG lightning** over Piedmont seems to be **decreasing** in the latest years. The data availability unfortunately covers only the last 11 years, so the robustness of this result is limited, but a signal can still be detected: both the mean annual value and the 90° percentile are decreasing, with p-values of the linear trends of 0.1 and 0.03 respectively.



4. CONCLUSIONS

- Atmospheric **instability** and **moisture** content are significantly **increasing** on the **western side of the Po Valley**.
- The rates **of increase match very well** those found on the **other side of the plain**, in Friuli Venezia Giulia, which is also very close to the Adriatic Sea (an importance source of moisture).
- In Friuli Venezia Giulia, the **observed convective activity is not increasing** (except for mean hail diameter). From the point of view of the lightning number, **it seems to be the same also for the Western Po Valley**.
- The analysis of thunderstorm-related observations is limited by the use of just **one relatively short dataset** (11 years of CG lightning). In the future, other observational datasets (e.g. weather radar products, short term rainfall from raingauge network) will be analyzed.
- It will be very interesting and useful to further extend the analysis over other regions in Italy.

REFERENCES

1. Battaglioli, F., et al.: «Modeled multidecadal trends of lightning and (very) large hail in Europe and North America (1950-2021)». *JAMC*, 62, 1627-1653 (2023).
2. Rädler, A. T., et al.: «Frequency of severe thunderstorms across Europe expected to increase in the 21° century due to rising instability». *Npj Clim. Atmos. Sci.*, 2, 30 (2019).
3. Taszarek, M., et al.: «Differing trends in United States and European severe thunderstorm environments in a warming climate». *BAMS*, 102, E296-E322 (2021).
4. Manzato, A., et al.: «Relationships between environmental parameter and storm observations in Po Valley: are they climate change invariant?». *JAMC*, 64, 267-298 (2025).

* corresponding author: gabriele.fasano@arpa.piemonte.it