August 27-31, 2023
FLORENCE - ITALY
ICWE 16
16th International Conference on Wind Engineering

Similarities and differences between thunderstorm outflows measured in Italy and Romania

Ileana Calotescu [1], Federico Canepa [2], Maria-Pia Repetto[3], Massimiliano Burlando [4]

[1]*Technical University of Civil Engineering Bucharest, Bucharest, Romania, ileana.calotescu@utcb.ro*
[2]*Genoa University, Genoa, Italy, federico.canepa@edu.unige.it*
[3]*Genoa University, Genoa, Italy, repetto@dicca.unige.it*
[4]*Genoa University, Genoa, Italy, massimiliano.burlando@unige.it*

SUMMARY:
Do thunderstorms that occur in different parts of the world possess similar characteristics? The answer to this question will have great significance on the design of structures exposed to thunderstorm winds, as well as on the understanding of the atmospheric variability of the phenomenon based on the location of occurrence. This abstract is an initial attempt to clarify aspects related to similarities and differences between thunderstorm outflows measured in Italy and Romania. For this a dataset of 29 Italian and 18 Romanian records are used. Comparison is made in terms of visual resemblance of velocity time-series, outflow characteristics and noteworthy velocity ratios. Results show striking resemblances of 10-min, 1-hour and 10-hours thunderstorm records measured in the two different sites, which seems to suggest that thunderstorm outflow characteristics can be the same at least in the Mediterranean and continental part of Europe. This is clearly noteworthy in the perspective of assuming a standard model of thunderstorm outflows for civil engineering purposes.

Keywords: dataset, thunderstorm outflows, geographical comparison

1. INTRODUCTION

This abstract presents a comparison of two datasets of thunderstorm records registered in Italy and Romania with the aim of emphasizing similarities and differences between them. The Italian dataset consists of 29 verified thunderstorm records (Canepa et. al, 2023) that were recorded in three port areas of the Northern Tyrrhenian Sea (Genoa, Livorno, and La Spezia) during the “Wind and Ports” (Solari et. al, 2012) and “Wind, Ports and Sea” (Repetto et. al, 2018) European Projects. The Romanian dataset consists of 18 thunderstorm outflows recorded throughout 2021 and 2022 by a monitoring system located in Sânnicolau Mare, Romania (Calotescu et al., 2023).

2. DATASETS OF WIND RECORDS

The two datasets used within this study were obtained according to the separation and classification methodology of extreme wind events from anemometric records presented by De Gaetano et al. (2014) and further improved by Burlando et al. (2018) who suggested separating thunderstorm outflows into three categories, i.e. 10-min, 1-h and 10-h records, depending on the time interval where the presence of a ramp-up and transient peak are clearly detectable. Out of the 29 Italian records, only 27 were considered for this analysis, 15 belonging to the 10-min category, 10 to the 1-hr category and 2 to the 10-h category. On the other hand, only 4 out of 18 Romanian records belong to the 10-min category whereas 7 belong to the 1-hr category and 7 to the 10-h category. Figures 1-3 present samples of thunderstorm outflows recorded in Genova (GE) and Livorno (LI), Italy and in Sânnicolau Mare (SM), Romania, each record being identified by the station name, port code (Italian records) and date.

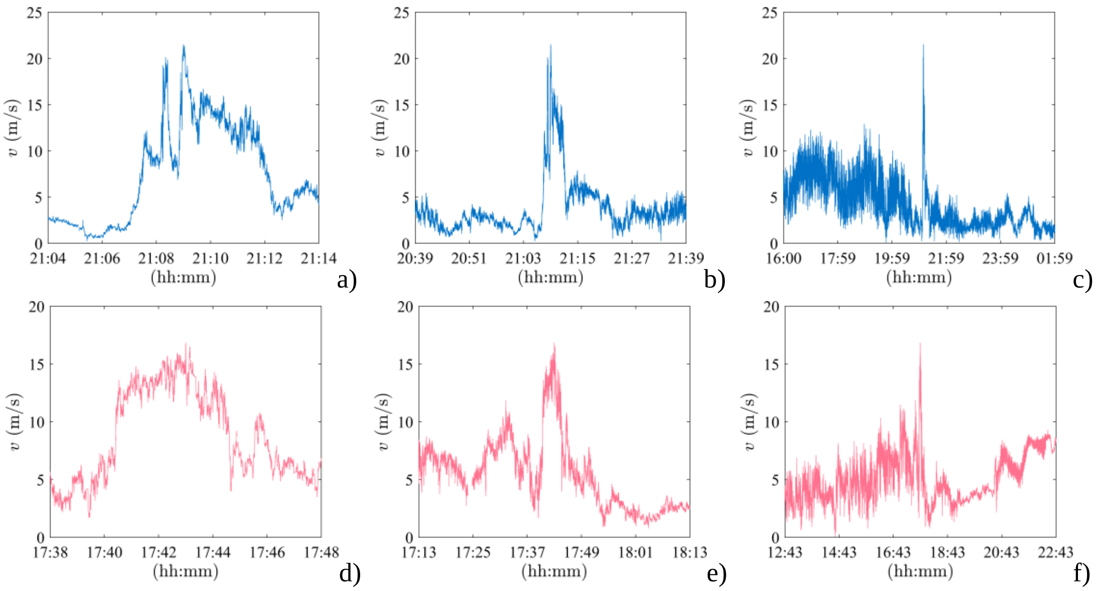

Figure 1. “10-min” thunderstorm outflow record: GE02_2012-09-30 wind speed in 10-min (a), 1-h (b) and 10-h (c) and SM_2021-04-21 wind speed in 10-min (d), 1-h (e) and 10-h (f)

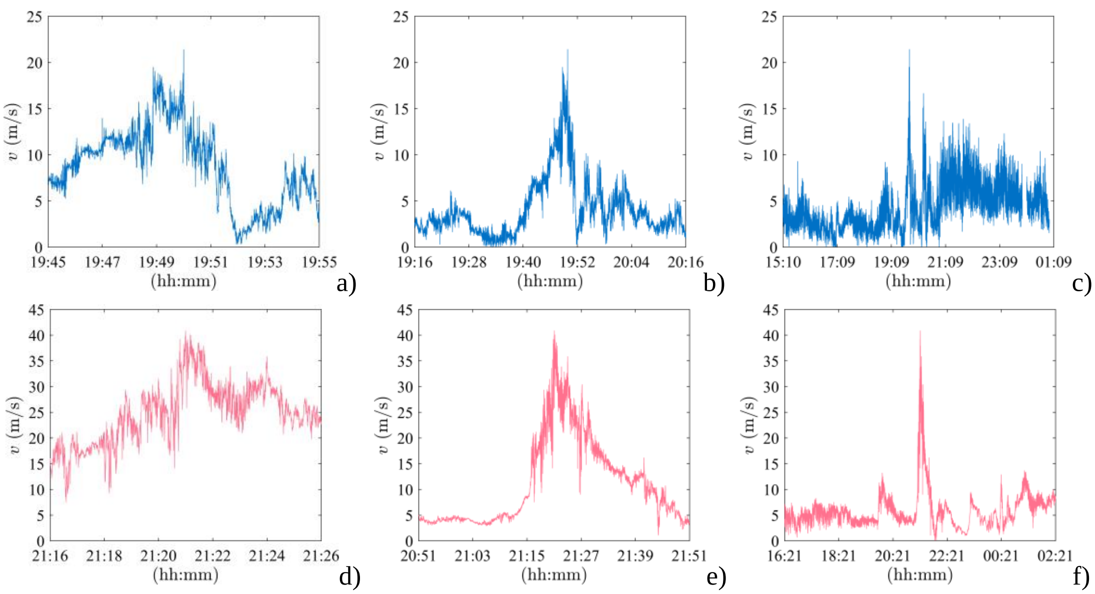

Figure 2. “1-h” thunderstorm outflow record: LI01_2014-01-18 wind speed in 10-min (a), 1-h (b) and 10-h (c) and SM_2021-06-25 wind speed in 10-min (d), 1-h (e) and 10-h (f)

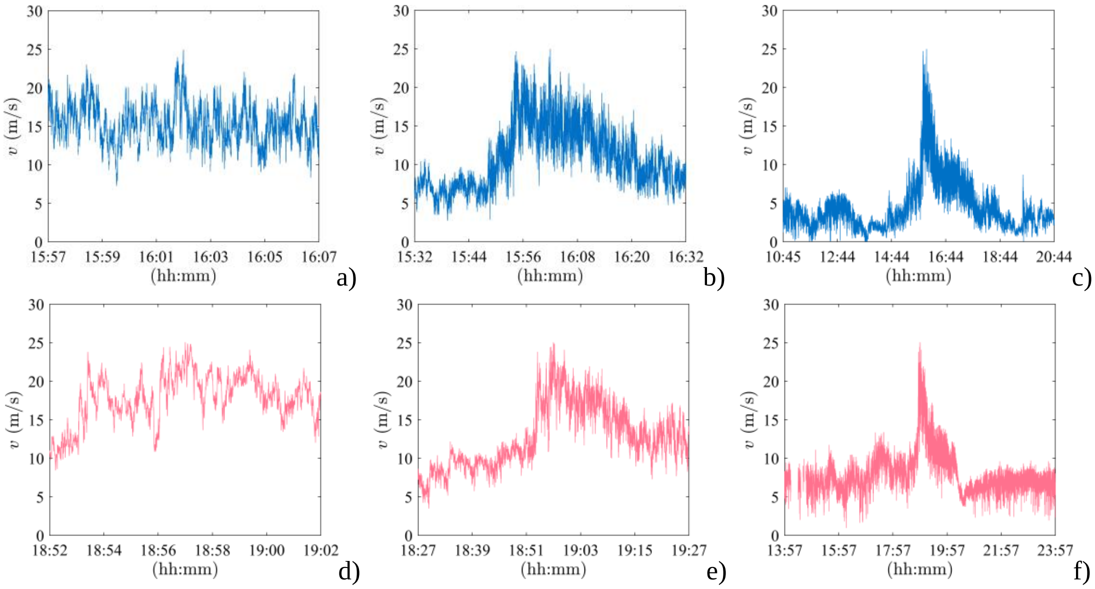

Figure 3. "10-h" thunderstorm outflow record: LI02_2011-09-04 wind speed in 10-min (a), 1-h (b) and 10-h (c) and SM_ 2021-05-31 wind speed in 10-min (d), 1-h (e) and 10-h (f)

The striking resemblance between times-histories belonging to each of the three families of records may suggest that the decomposition of wind velocity signals may be applied similarly to both sets by considering the same moving average period suggested by Solari et al. (2015).

3. THUNDERSTORM OUTFLOW CHARACTERISTICS

The wind velocity in thunderstorms is usually expressed by (Solari et al., 2015):

$$v(t) = \bar{v}(t) + v'(t) \tag{1}$$

where t is the time, $\bar{v}$ is the slowly-varying mean wind velocity, related to the low frequency content of v, $v'(t)$ is the residual fluctuation, related to the high frequency content of v. One of the most relevant characteristics of thunderstorm outflows is the time period over which thunderstorms develop their own maximum intensity. It may be defined by (Solari et al., 2015):

$$\gamma(t) = \frac{\bar{v}(t)}{\bar{v}_{\max}} \tag{2}$$

where $\bar{v}_{\max}$ is the maximum value of the slowly-varying mean wind velocity $\bar{v}$.

Figure 4 shows the ensemble of γ diagrams for the 10-min and 1-h records. Biased by the larger number of events collected, the γ diagrams for both categories of records show a much larger variability for the Italian dataset as they do for the Romanian dataset, especially for the 1-h category. Romanian 1-h records seem to be much similar to each other resulting in a smoother γ mean value. Note that, due to the small number (4) of Romanian 10-min records used within this analysis, the corresponding γ diagram has to be considered at this stage as purely indicative.

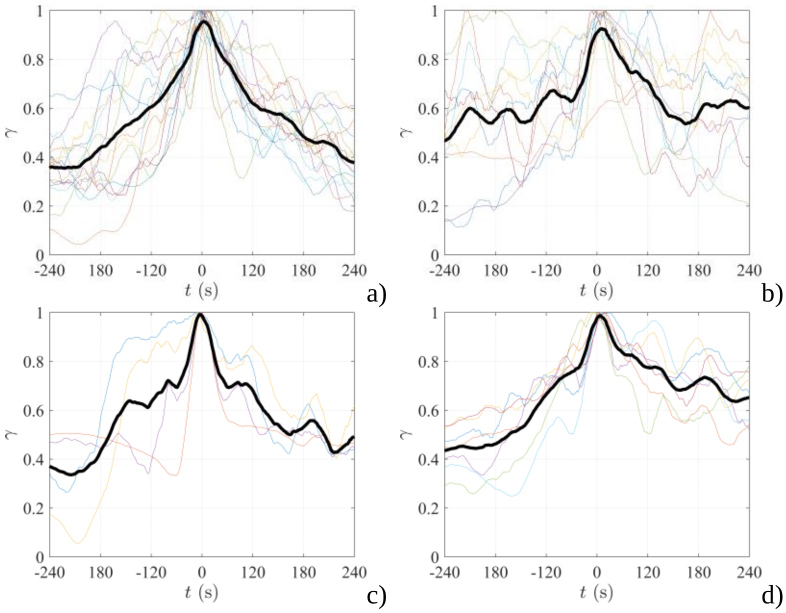

Figure 4. Ensemble of the diagrams of γ for thunderstorm records: Italian dataset (a) 10-min records (b) 1-h records and Romanian dataset (c) 10-min records (d) 1-h records and their mean values (thick lines)

4. CONCLUSIONS

This abstract presented a comparison between thunderstorm outflows registered in Italy and Romania. Inspection of velocity time-series corresponding to the 10-min, 1-h and 10-h categories of records show great similarity in each case. Some discrepancy is observed between γ diagrams corresponding to the two datasets, with the Romanian records showing less variability in respect to the Italian ones. The comparison performed within this study shows promising results which will be further investigated in future studies.

ACKNOWLEDGEMENTS

The research carried out for this paper by F. Canepa, M. Burlando and M.P. Repetto was supported by the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation program (grant agreement No. 741273) for the Project THUNDERR - Detection, simulation, modelling and loading of thunderstorm outflows to design wind-safer and cost-efficient structures – supported by an Advanced Grant (AdG) 2016.

REFERENCES

Burlando M., Zhang, S. and Solari G., 2018. Monitoring, cataloguing, and weather scenarios of thunderstorm outflows in the northern Mediterranean. Nat. Hazards Earth Syst. Sci. 18, 2309–2330.

Calotescu I., Bîtcă D and Repetto M.P., 2023. Wind and structural monitoring system for a telecommunication lattice tower, under review.

Canepa F., Burlando M. and Repetto M.P., 2023. Thunderstorm outflows in the Mediterranean Sea area [Data set]. Zenodo. https://doi.org/10.5281/zenodo.7495115

De Gaetano, P., Repetto, M.P., Repetto, T. and Solari, G., 2014. Separation and classification of extreme wind events from anemometric records. J. Wind Eng. Ind. Aerodyn. 126, 132–143.

Repetto M.P., Burlando M., Solari G., De Gaetano P., Pizzo M. and Tizzi M., 2018. A GIS-based platform for the risk assessment of structures and infrastructures exposed to wind. Adv. Eng. Softw. 117, 29-45.

Solari G., Repetto M.P., Burlando M., De Gaetano P., Pizzo M., Tizzi M. and Parodi M., 2012. The wind forecast for safety and management of port areas. J. Wind Eng. Ind. Aerodyn. 104, 266-277.

Solari, G., Burlando, M., De Gaetano, P., and Repetto, M.P., 2015. Characteristics of thunderstorms relevant to the wind loading of structures. Wind and Structures, 20(6), 763–791.