A probability model of three potential precursors during tornado occurrences: the Italian case.

R.Ingrosso[1], P. Lionello[2,3] , M. M. Miglietta[4], G. Salvadori[5]

[1] Department of Earth and Atmospheric Sciences, University of Quebec in Montreal (UQAM), 201, av. du President Kennedy, Montreal, QC, H2X 3Y7, Canada

[2] Dipartimento di Scienze Ambientali e Biologiche, Università del Salento, via per Monteroni 165, 73100 Lecce, Italy

[3] CMCC, Centro euro-Mediterraneo per i Cambiamenti Climatici (CMCC)

[4] ISAC-CNR, Istituto di Scienze dell'Atmosfera e del Clima-Consiglio Nazionale delle Ricerche, corso Stati Uniti 4, 35127 Padua, Italy

[5] Dipartimento di Matematica e Fisica, Università del Salento, Provinciale Lecce-Arnesano, P.O. Box 193, 73100 Lecce, Italy

Abstract

- 57 tornadoes with intensity Enhanced Fujita Scale 2 or larger that occurred in Italy in the period 2000–2018 are analysed in order to investigate the way two meteorological parameters, namely Wind Shear, low-level shear (LLS) and deep-level sheare (DLS) and CAPE, affect their development. For this purpose, a statistical analysis, by means of homogeneity tests, conditional probabilities and a multivariate analysis via copulas is performed, using two different re-analysis datasets (ERA-Interim and ERA-5). The study indicates that: (a) tornadoes occur mostly in correspondence with positive anomalies of both variables; (b) probability of occurrence is correlated with WS, and (c) is maximum when either WS or CAPE are large. Also, the probability does not increase significantly with CAPE, although sufficiently large values are needed for tornado occurrence. These results are similar for both re-analyses we used and suggest that the selected parameters are reliable precursors for Italian tornadoes.

Locations of EF2+ tornadoes occurred in Italy during the period 2000–2018.
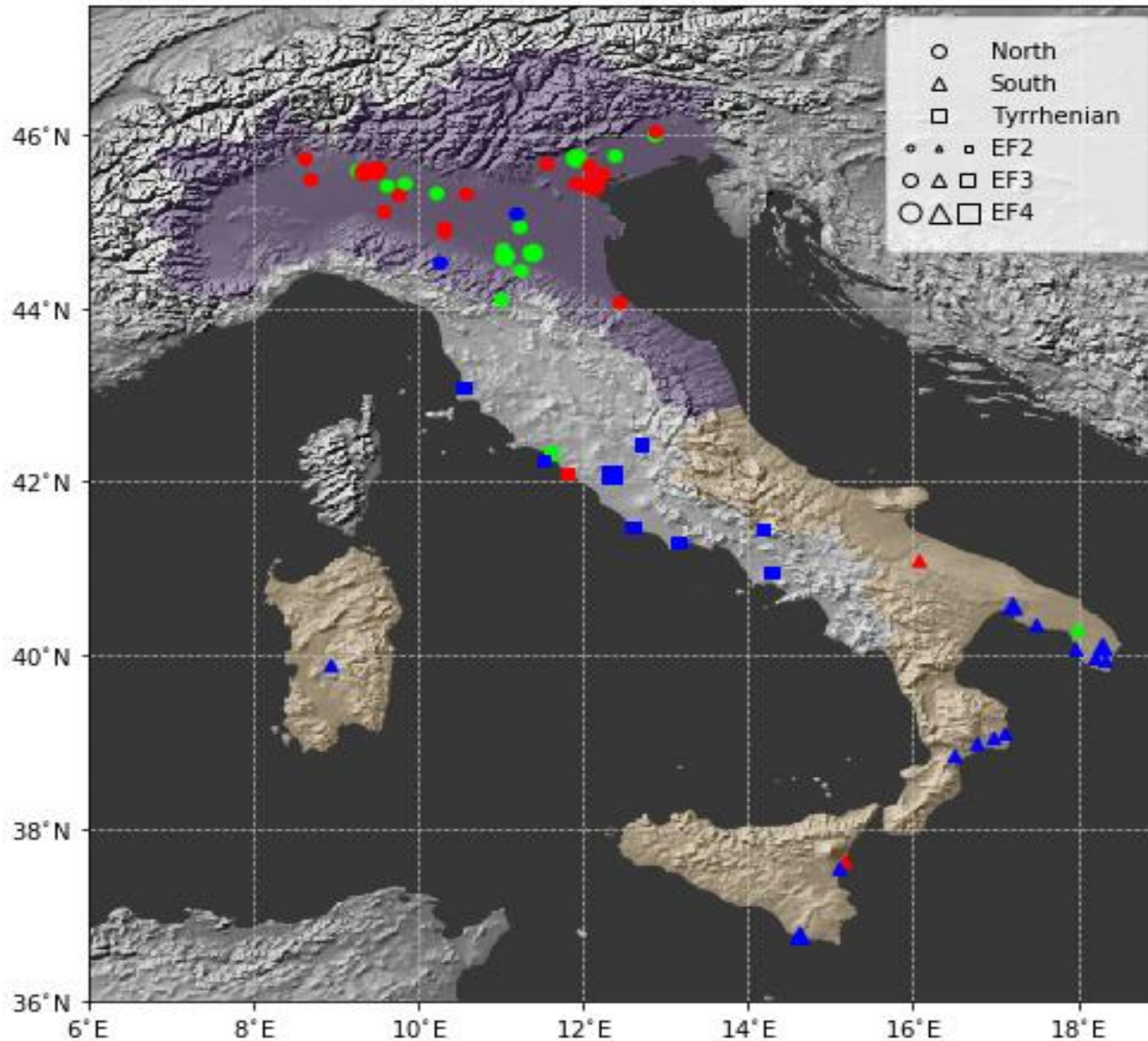

The colors indicate the seasons: spring (green), summer (red), and autumn (blue). Different markers represent three different regions: northern Italy (circles), the Tyrrhenian coast (squares), southern Italy (triangles). The increasing size of the markers denote stronger intensity of tornadoes (from EF2 to EF4)—see the corresponding legend.
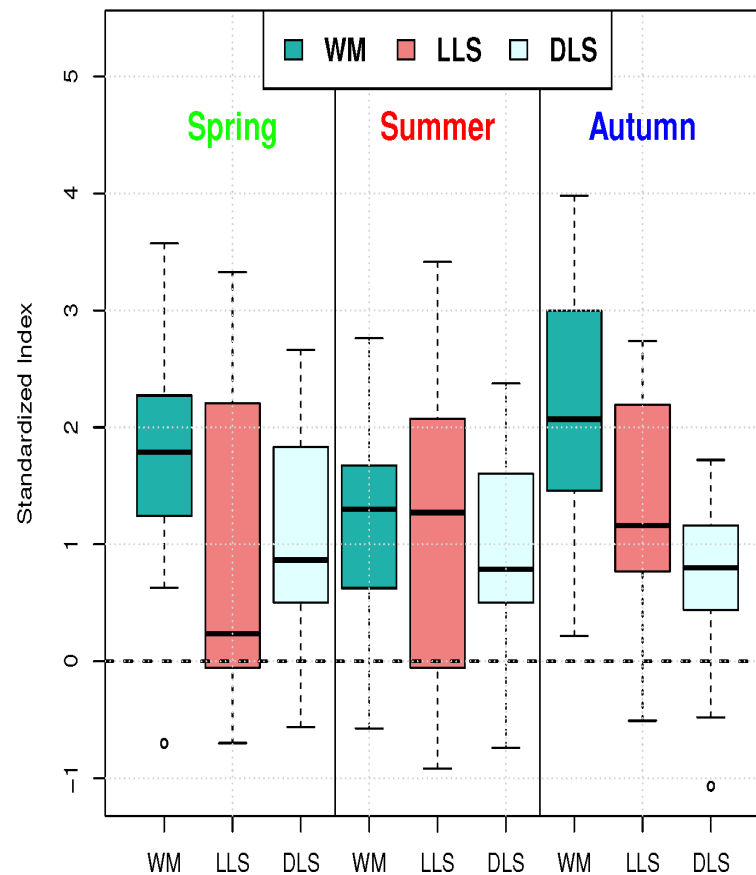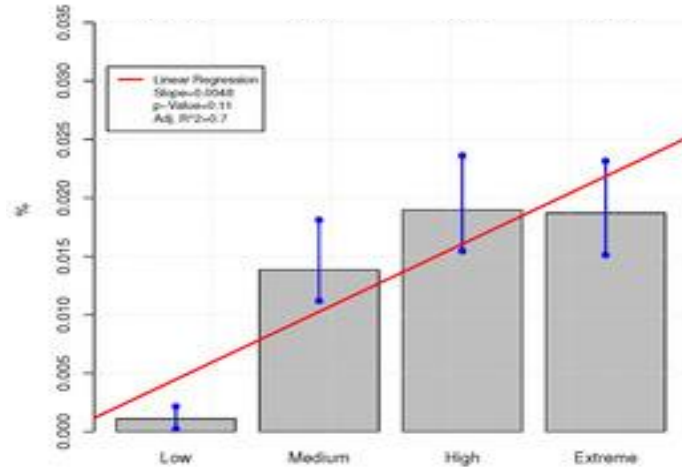
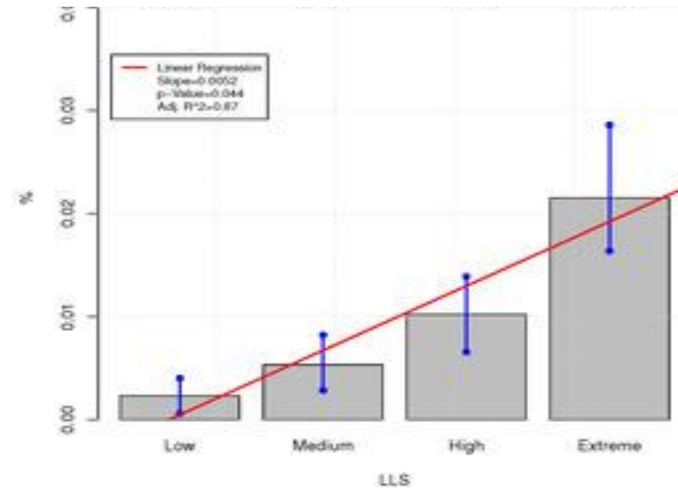# Boxplots of WM, LLS and DLS standardized indices
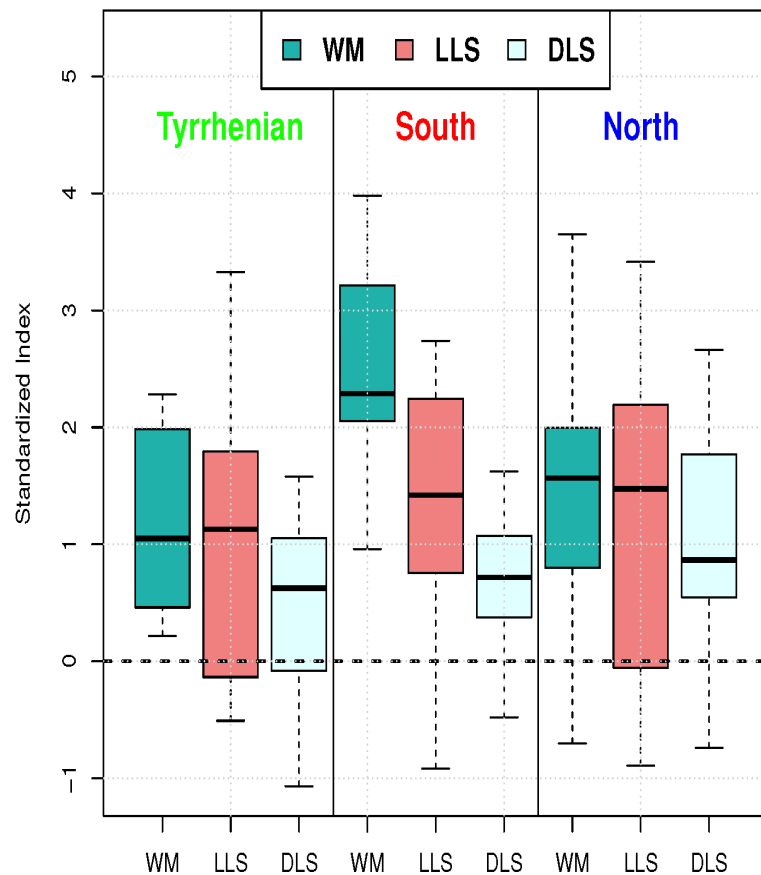
The horizontal black dashed line at zero corresponds to the mean climate condition.
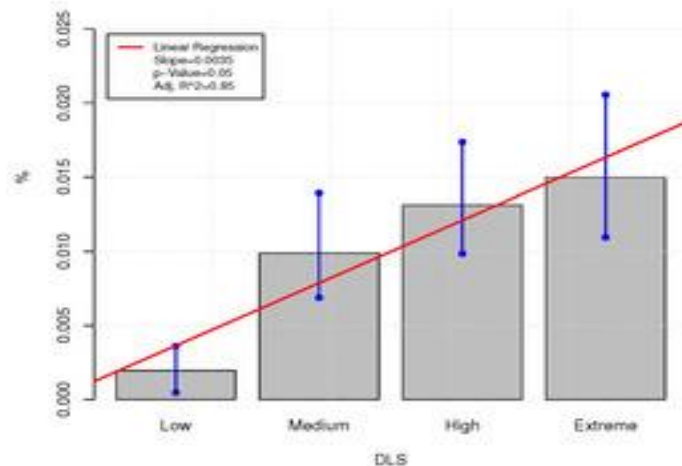
Probability of tornado occurrence

Tornado Probability conditional to WM bin

Tornado Probability conditional to LLS bin

Tornado Probability conditional to DLS bin

WM p-value ≈ 11%
LLS p-value ≈ 4.4 %
DLS p-value ≈ 5%

Estimates (bars) of the probability of tornado occurrence conditional to the fact that WM (**top-left**), or LLS (**top-right**), or DLS (**bottom-left**) takes on a value in a given bin at TS1 (ERA-5 dataset). The vertical blue lines correspond to 95% bootstrap Confidence Intervals. The red lines represent the outcome of the linear regression, and the legends report the main statistical results. The top labels show the conditional probabilities in each bin (% value). The bottom-right panel summarizes and compares the regression *p*-values.

Empirical copulas

Copulas
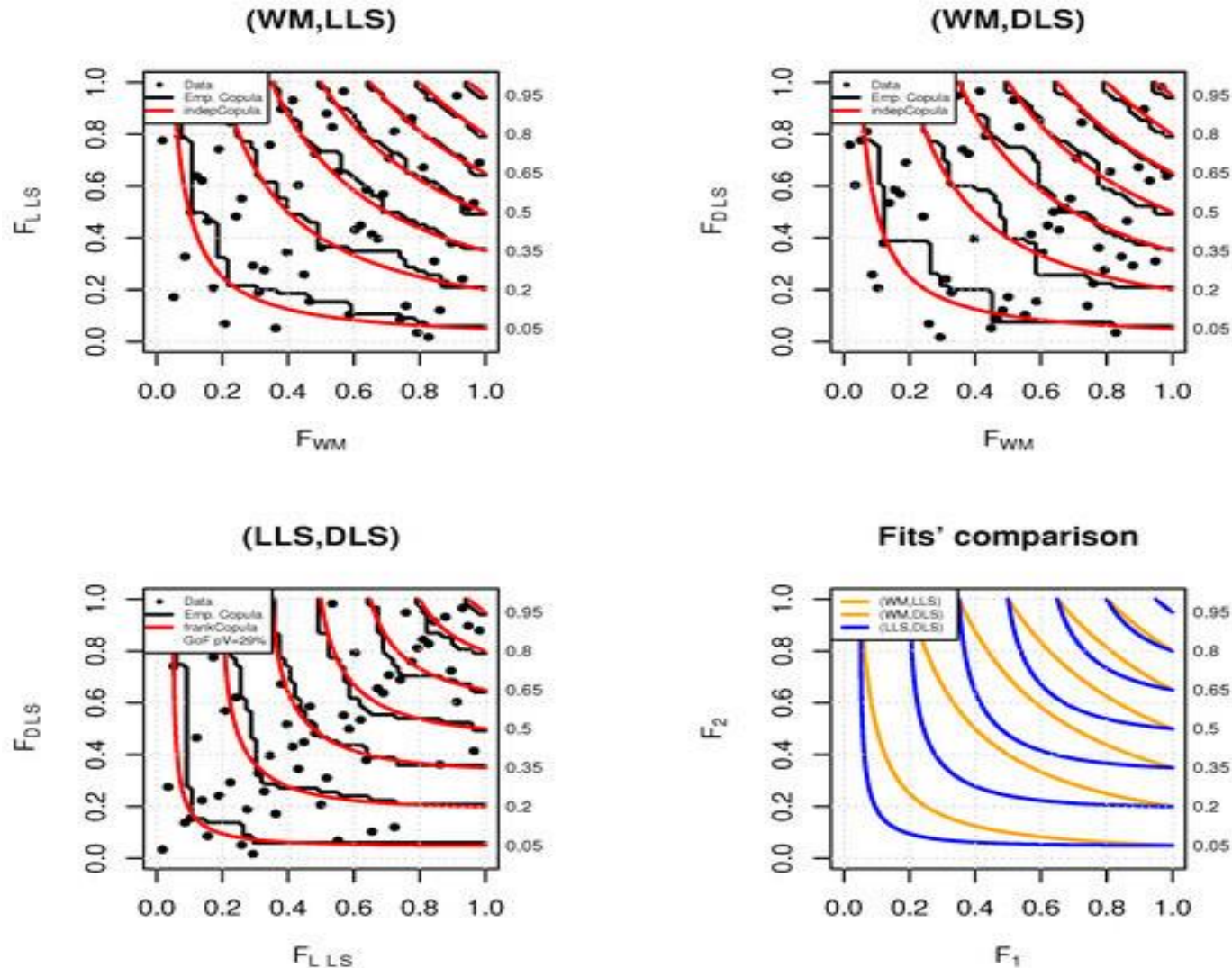
Isolines of the empirical copulas (black lines) of the pairs (**WM, LLS**), (**WM, DLS**), and (**LLS, DLS**) for the ERA-5 dataset, and of the corresponding fitted copulas (red lines). Also shown are the available data (markers). The bottom-right panel shows a comparison between the three fitted copulas