Attribution of Extreme Precipitation Events in the Mediterranean Region Using High-Resolution COREX Ensemble

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1. Introduction

- One of the major challenges faced by event-based attribution is the short observational record, particularly under non-stationary conditions where the extremity of the event can be so high that the statistical model suggests a near-zero probability of occurrence.
- Utilizing such an insufficient record under changing climate conditions can lead to an underestimation of the return level and an overestimation of the return period [1].
- In this study, the long-term simulations of the high-resolution (0.11°) COREX ensemble over the Mediterranean region are employed to tackle this issue.

2. Data and Methodology

2.1 Data

- Daily precipitation from the E-OBS gridded dataset.
- Nine members of CORDEX EUR-11 ensemble that has the historical and RCP4.5 scenarios.

2.2 Methodology

- Quantile mapping is used to bias correct the model-simulated daily precipitation.
- Probability-based attribution is then undertaken on both observed and modeled data.

3. Bias-Corrected CORDEX data

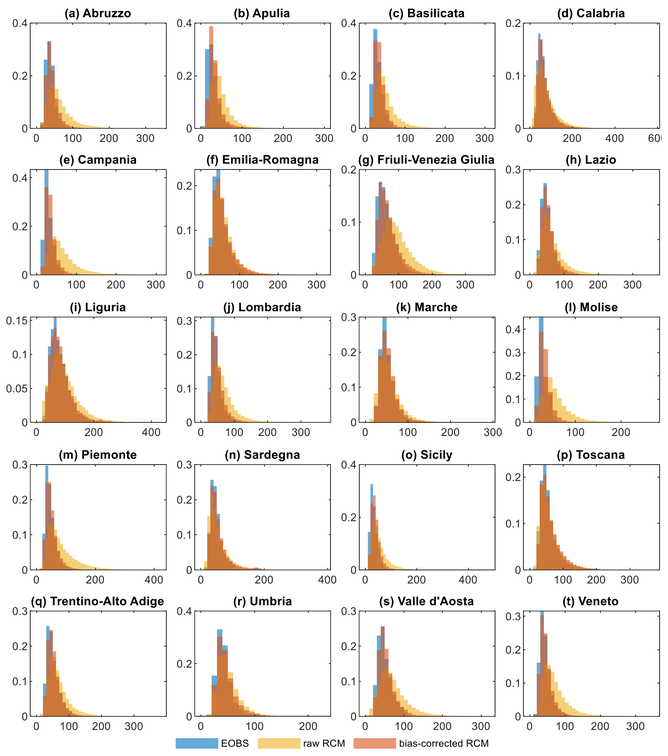

Figure 1. Normalized histogram for annual maximum precipitation of the observation, raw RCM, and bias-corrected RCM. For each region, the grids and RCMs are pooled to produce the distribution.

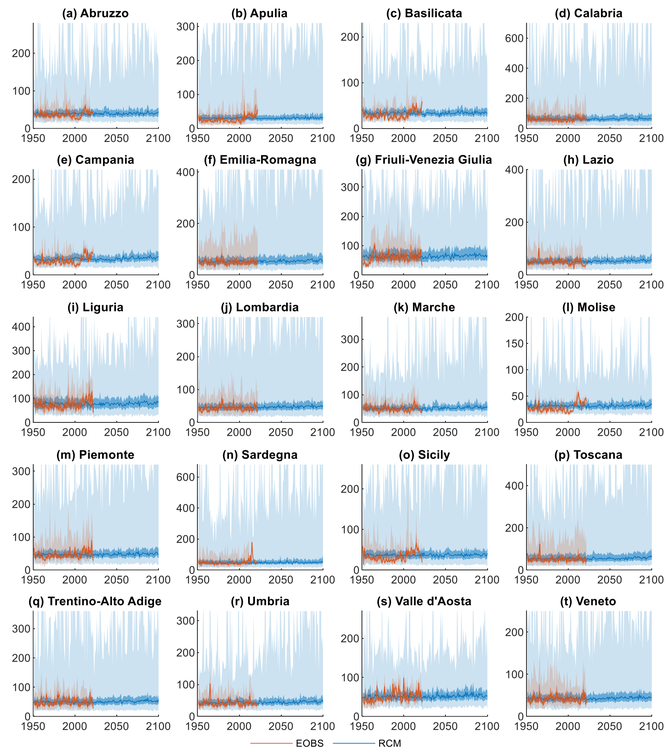

Figure 2. Annual maximum precipitation time series for the observation and bias-corrected RCM, where lines are for the median, darker shades are for the 25th to 75th percentile range, and the lighter shades are for the overall range.

4. Probability-Based Attribution

- The historical period is separated into two (1951 to 1986, and 1987 to 2022), with the former representing the counterfactual world, and the latter the factual one. Annual maximum precipitation of each period is used to fit the generalized extreme value (GEV) distribution.
- For the projection of the change in the risk of extreme precipitation events, the period is separated into three (1951 to 2000, 2001 to 2050, and 2051 to 2100).
- A series of extremely rare precipitation events is defined by multiplying the historical maximum precipitation of EOBS by coefficients from 1.0 to 5.0 in steps of 0.5. The probability of extreme events is evaluated at these levels.

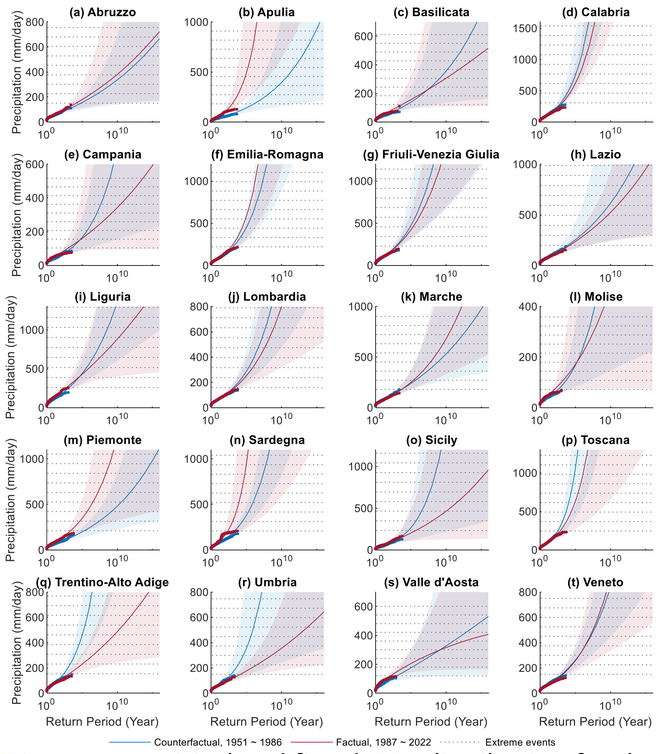

Figure 3. Empirical and fitted GEV distribution for the historical period based on EOBS data.

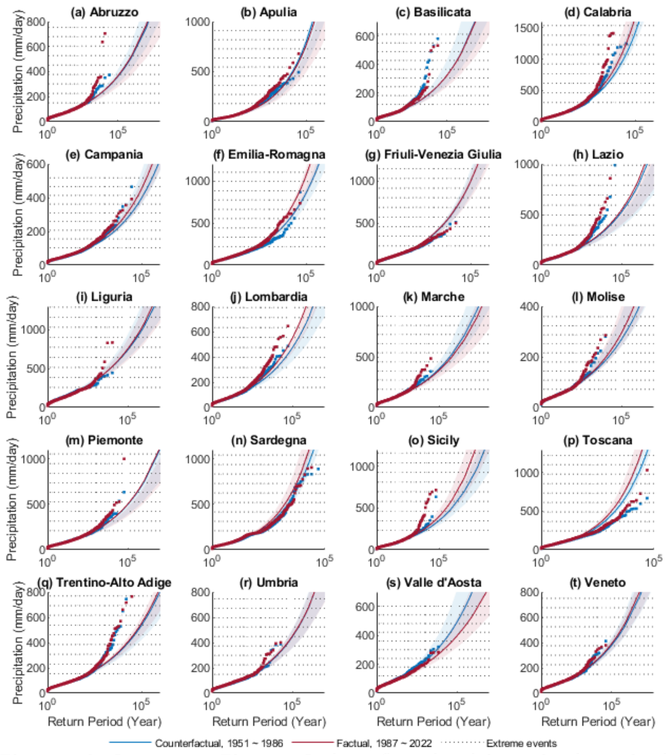

Figure 4. Same as Figure 3, but for the historical period of the bias-corrected CORDEX data.

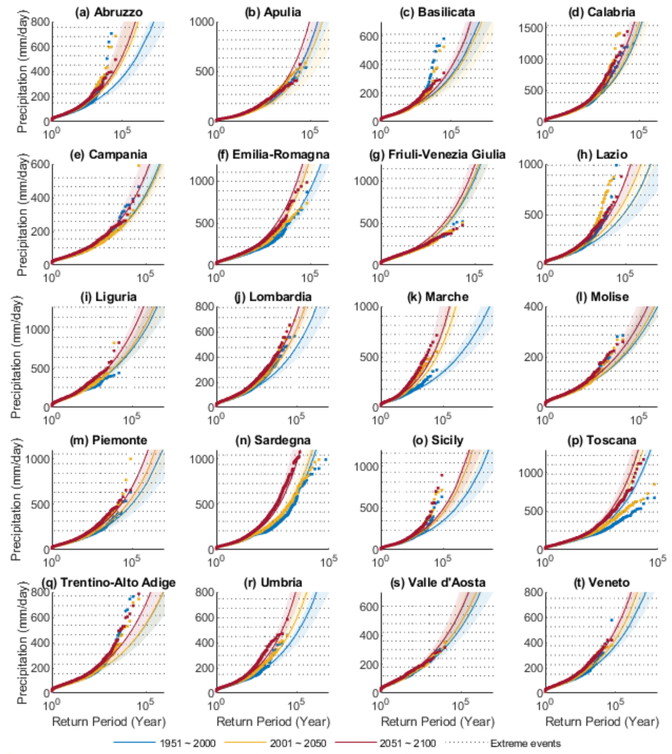

Figure 5. Same as Figure 3, but for the historical and future periods of the bias-corrected CORDEX data.

5. Probability Ratio

- Defined as the ratio of the probability of the extreme event in the factual world and that of the counterfactual world (PR = P1/P0).
- Indicates if the probability of extreme event of a given intensity has increased in the past or if it will increase in the future.

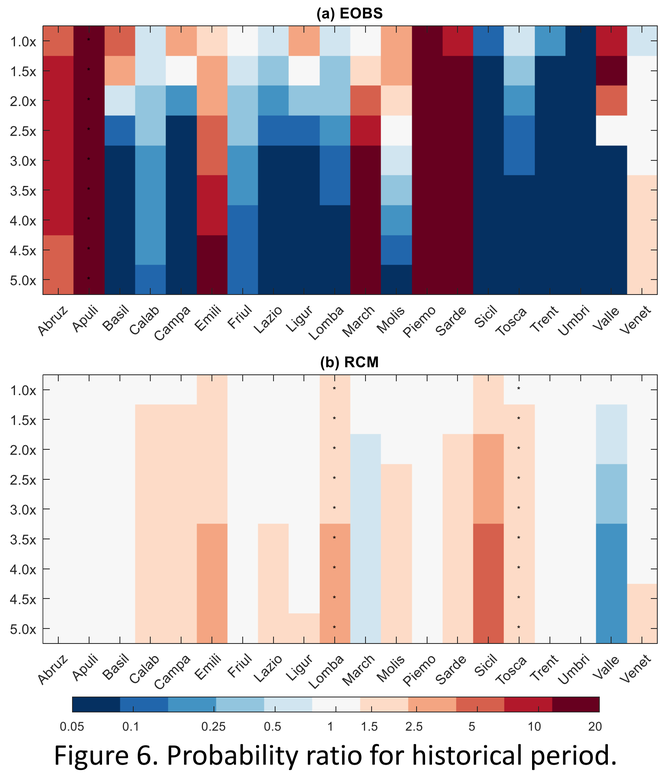

Figure 6. Probability ratio for historical period.

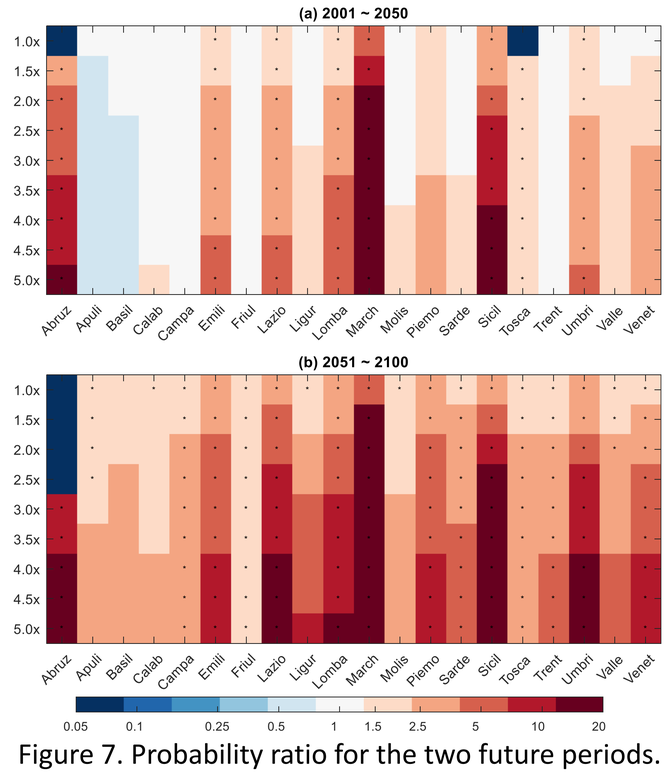

Figure 7. Probability ratio for the two future periods.

6. Summary

- For EOBS, extremely rare events are estimated with very large return periods due to insufficient record.
- In comparison, extremely rare events of a comparable intensity are occasionally generated in the CORDEX ensemble, providing samples to support a more reliable fitting of the distribution and thus a better estimate of the probability.
- The probability ratio based on EOBS shows a mixed change in the risk of extremely rare events in the past, while the CORDEX ensemble suggests increased risks in many regions.
- In the mid-21st century, nearly half of the regions are projected with statistically significantly increased risks in extremely rare events, and nearly all regions are affected at the end of the 21st century.

Reference

[1] J. Zeder, S. Sippel, O. C. Pasche, S. Engelke, E. M. Fischer. The effect of a short observational record on the statistics of temperature extremes. ESS Open Archive. (April 16, 2023). DOI: 10.22541/essoar.168167197.74742164/v1

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