Ministero dell'Università e della Ricerca

PRIN
PROGETTI DI RICERCA DI RILEVANTE INTERESSE NAZIONALE

CNR ISAC

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TRANSDISCIPLINARY NETWORK

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EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY
COST is supported by the EU Framework Programme Horizon 2020

Towards and impact-based approach to the detection of analogues:

the case-study of Emilia-Romagna floods in May 2023

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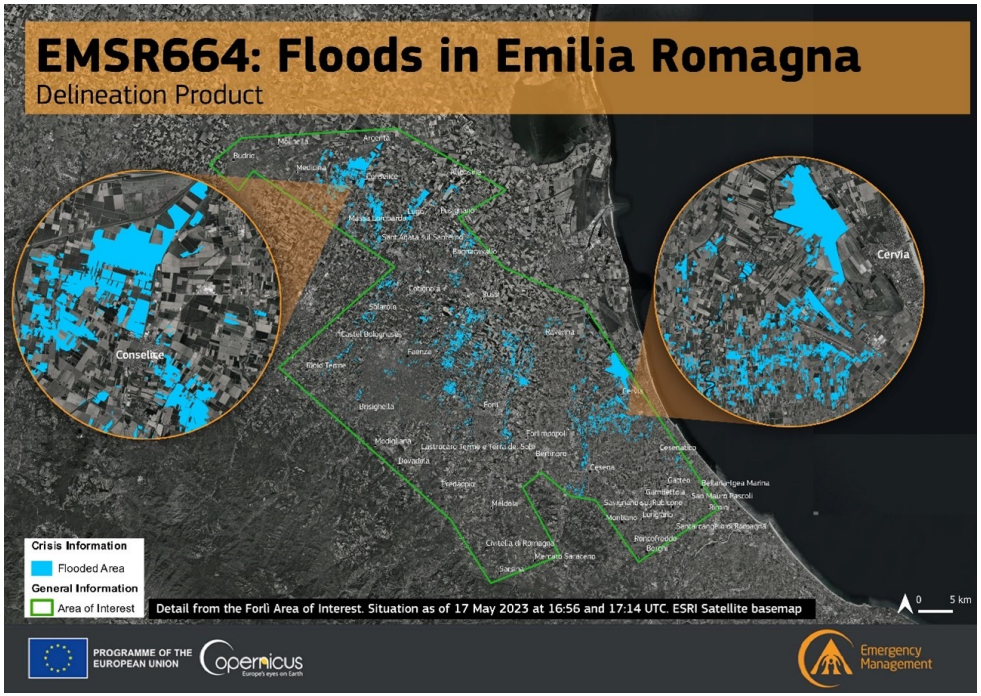
A temporally compound exceptional extreme event

- In May 2023, a series of deep low pressure systems affected the Italian Peninsula;
- The Emilia-Romagna region was particularly affected, due to the disposition of fronts and of the underlying topography;
- Floods covered a substantial part of the region's lowlands for several weeks;



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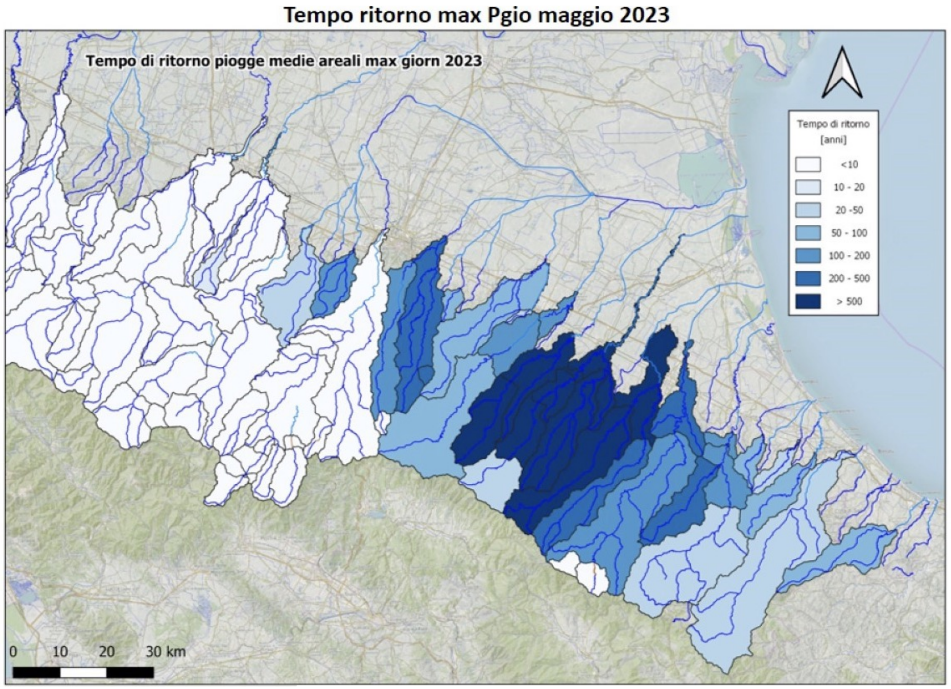
- The Emilia-Romagna region was particularly affected, due to the disposition of fronts and of the underlying topography;
- Floods covered a substantial part of the region's lowlands for several weeks;
- Return times have been computed to be far exceeding the century in some basins;



(Brath et al. 2023)

The challenge of attribution

The climate attribution of such event is challenged by several factors:

- The spatio-temporal resolution of the event (subdaily rainfall extreme, submonthly compounded duration, the surface area spanned)

→ WWA preliminary report did not capture a clear Climate Change footprint;

During May, three rainfall events caused severe flooding in Emilia-Romagna. Image by Red Cross Italy.

Home > Extreme rainfall > Limited net role for climate change in heavy spring rainfall in Emilia-Romagna

Limited net role for climate change in heavy spring rainfall in Emilia-Romagna

31 May, 2023

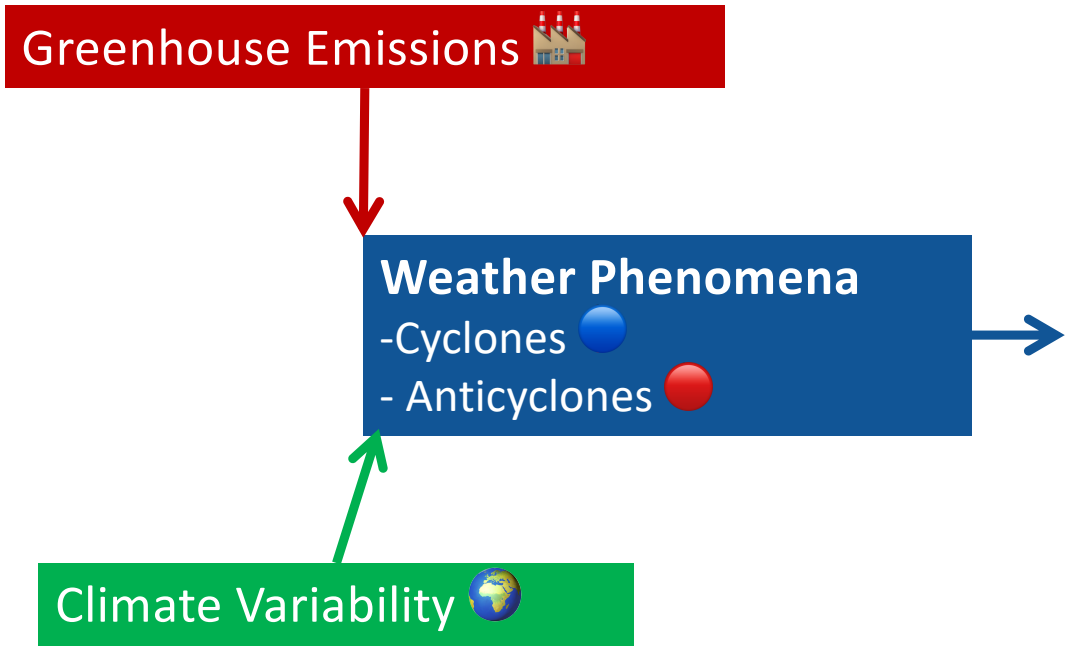
During May 2023, the North Italian region of Emilia-Romagna, particularly the provinces of Bologna, Ravenna, Forlì-Cesena, Rimini, experienced severe

Full study

Download the full study: Limited net role for climate change in heavy spring rainfall in Emilia-Romagna (21 pages, 991.85 kB)

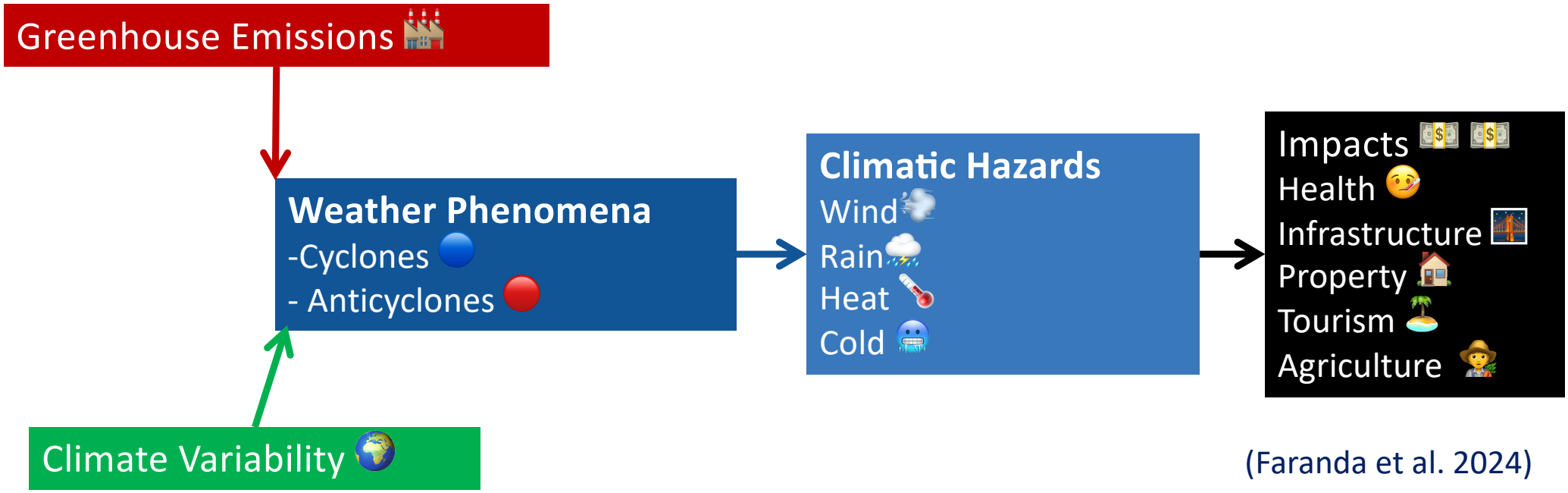
(Barnes et al. 2023)

ClimaMeter approach…



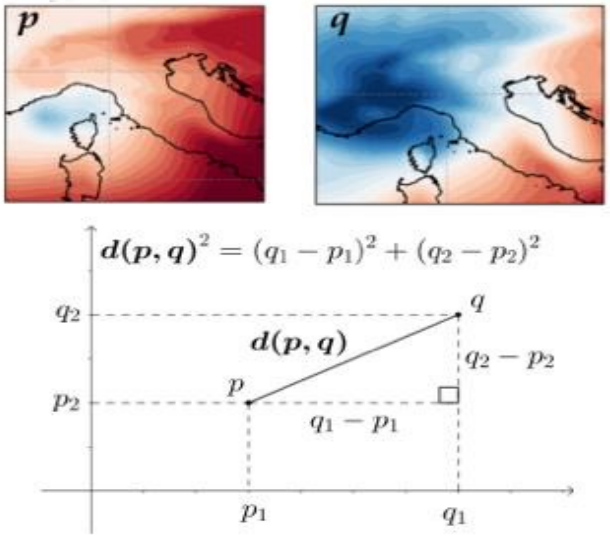
(Faranda et al. 2024)

ClimaMeter approach… and beyond



(Faranda et al. 2024)

ClimaMeter and beyond: from univariate to multivariate analogues approach



Novelties:
(i) trends of similar SLP patterns
(ii) SLP (pattern) leading EDR (impact)

We look for dates ti in which the Euclidean distance between the relevant event and the pattern at time ti is minimized, i.e.:

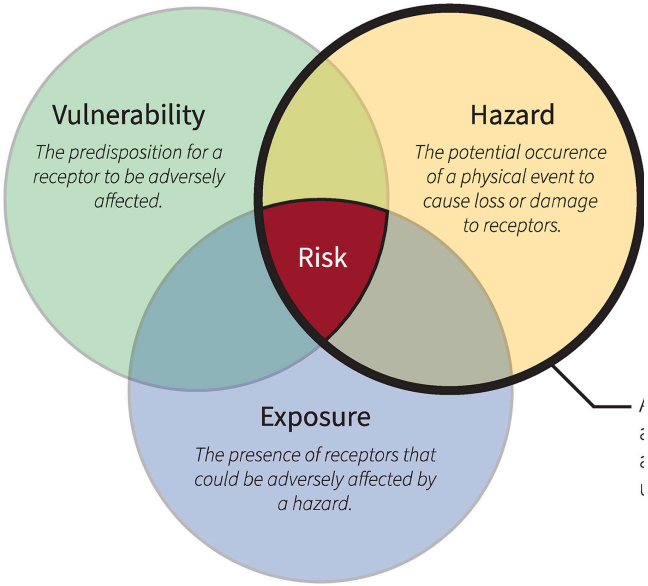
$$t_i = \arg min_{j \in R} dist(X_i^{(T)}, X_j^{(R)})$$

Where X is a multidimensional observable (or a set of observables) that are present in the reference (R) and target (T) databases

Towards an impact-based attribution

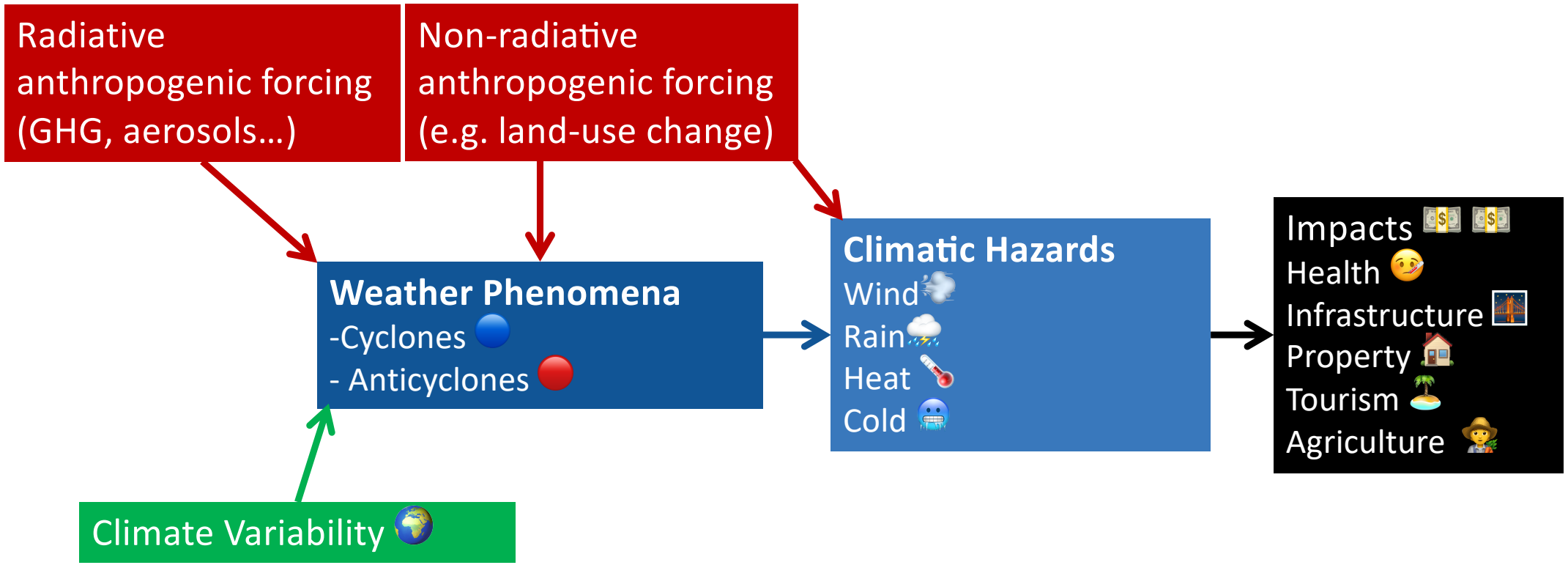
The assessment of the impact of such events in a changing climate has to address:

- Exposure (largely industrialized area with intensive farming and high population density);
- Vulnerability (several river basins with irregular flow, landslide potential);



(Leaman et al. 2021)

Towards an impact-based attribution

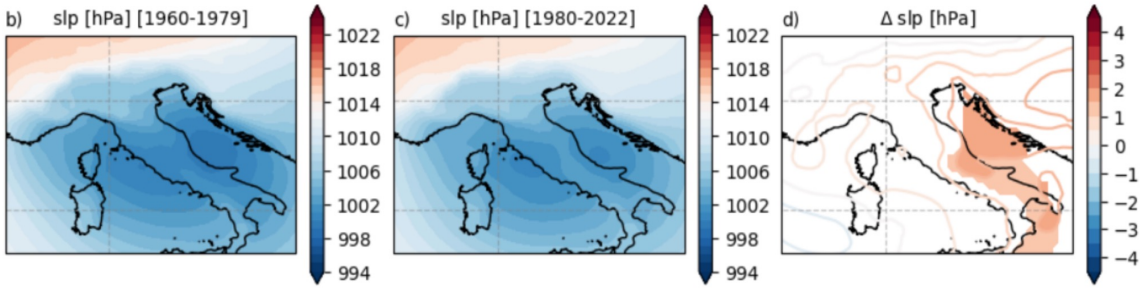


The challenge of attribution

The climate attribution of such event is challenged by several factors:

- It's not only about atmospheric dynamics!

→ Univariate analogues detection solely based on dynamical quantities indicative of the event can be insufficient

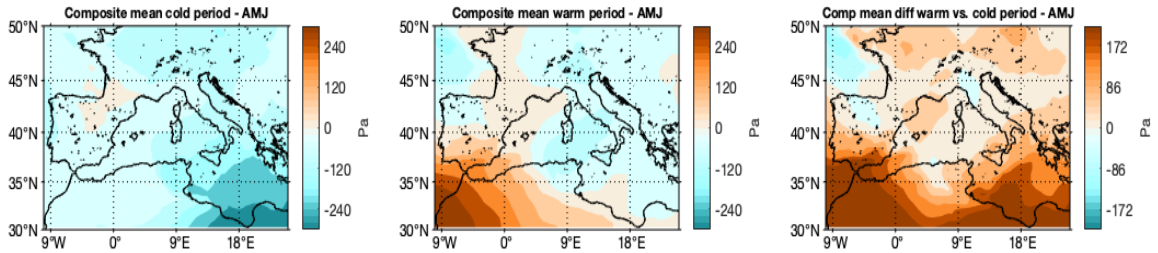


(Courtesy of M. Ginesta)

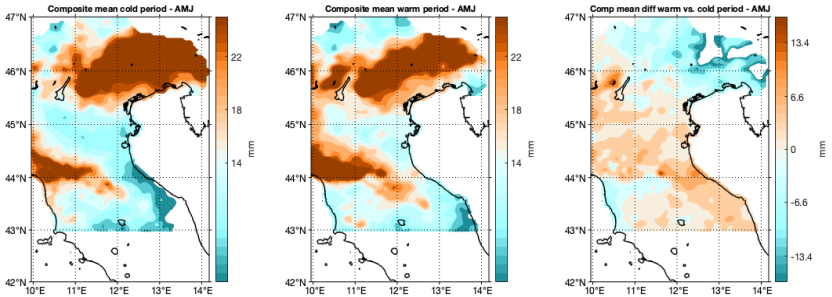
Univariate attribution – 02/05/2023

Cold Period: 1961-1990
Warm Period: 1991-2021

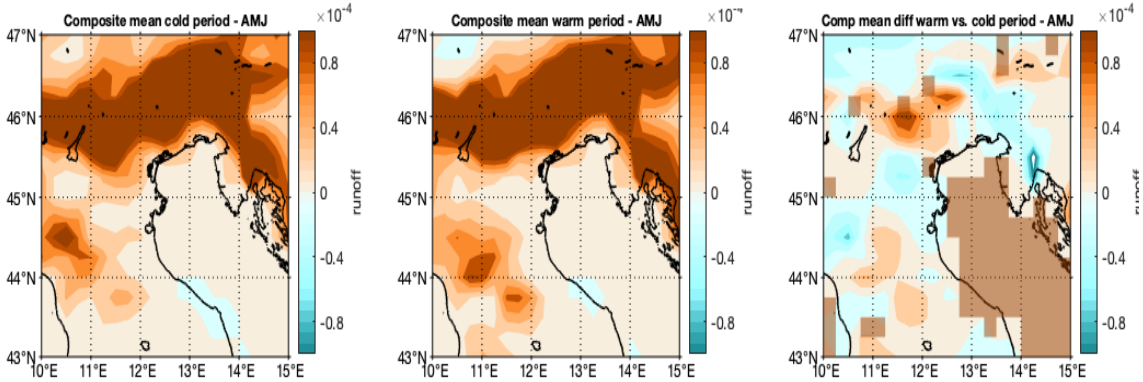
SLP (AMJ; from ERA5)



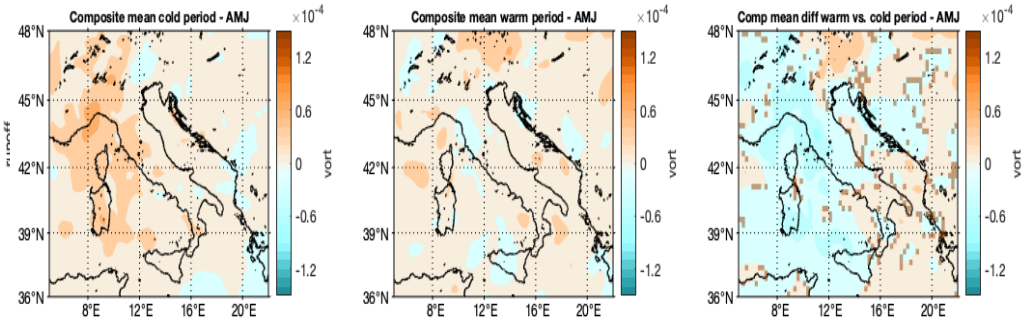
Precipitation (AMJ; from ArCIS)



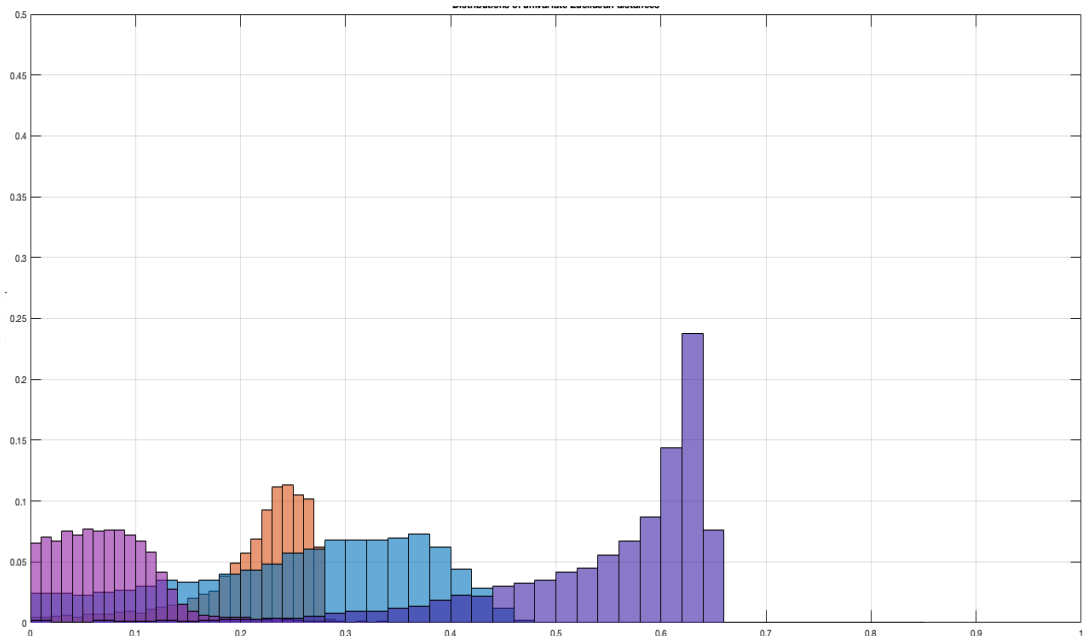
Runoff (AMJ; from ERA5)



Vorticity (AMJ; from ERA5)



The multivariate analogues approach (ClimaMeter and beyond)



- (orange) runoff, (blue) vorticity, (purple) sea-level pressure, (violet) precipitation;
- Depending on the level of «independence» it is more informative to use this approach:

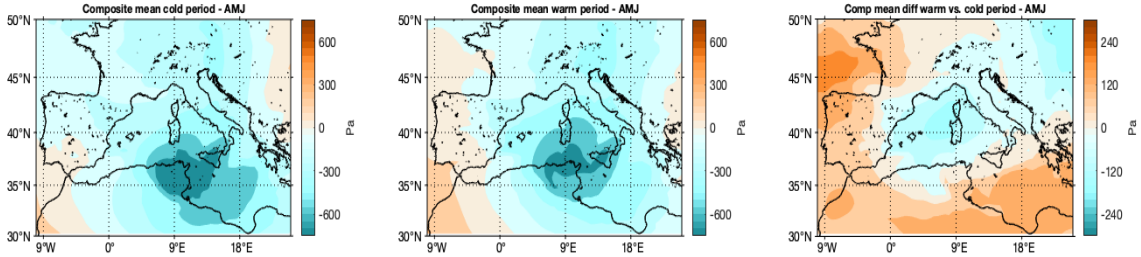
$$d(p,q)^2 = (q_1 - p_1)^2 + (q_2 - p_2)^2$$

or this approach:

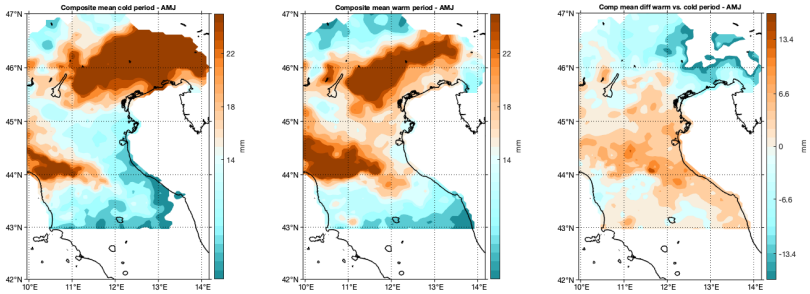
$$d(p)^2 + d(q)^2 = (q_1 - q_2)^2 + (p_1 - p_2)^2$$

Multivariate attribution (SLP, precip, runoff) – 02/05/2023

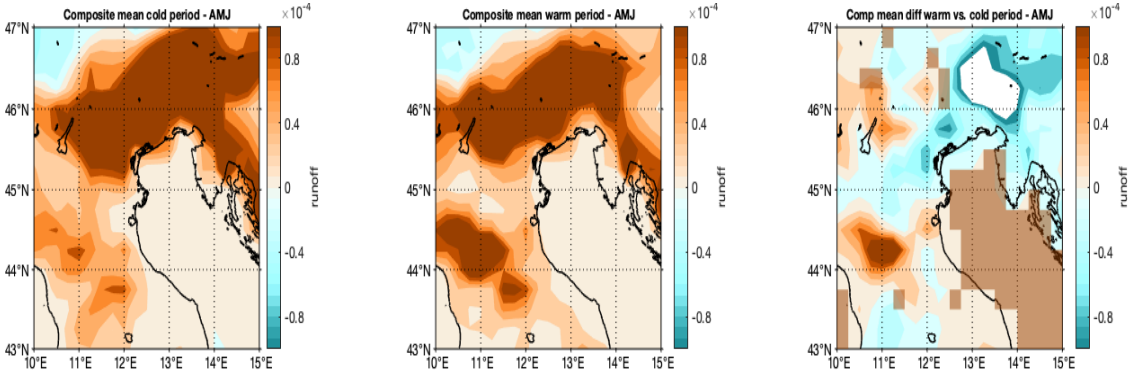
SLP (AMJ; from ERA5)



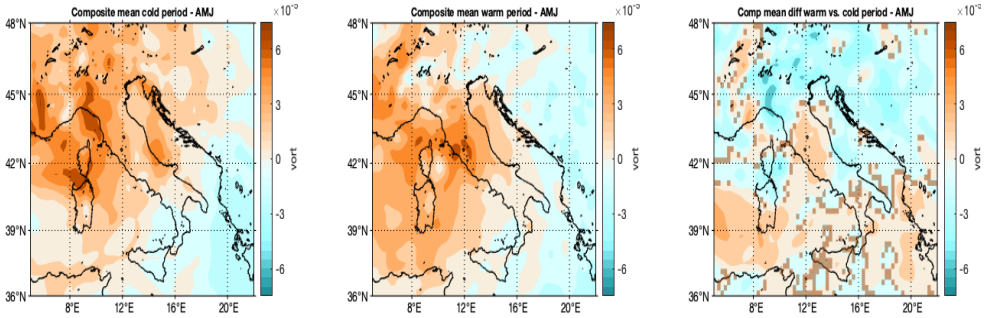
Precipitation (AMJ; from ArCIS)



Runoff (AMJ; from ERA5)



Vorticity (AMJ; from ERA5)



Summary

- Methodology of climate attribution with analogues is revised in a multivariate analogues employing high resolution precipitation datasets and runoff;
- Runoff, sea-level pressure and precipitation are combined to consider the changes in occurrence of analogues of the Emilia-Romagna floods in May 2023;
- Overall, the combination of these three observables provides a better characterization of the climate change fingerprint on these events than the univariate analysis;

Take-home messages

- Univariate approach for attribution of hazards and impacts related to extreme weather phenomena is not efficient;
- We need to take into account non-radiative anthropogenic factors;
- We need good data and good model simulations
  - ➔ Satellite coverage/gridded observational datasets;
  - ➔ High resolution models/impact models;

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Thank you for the attention!

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