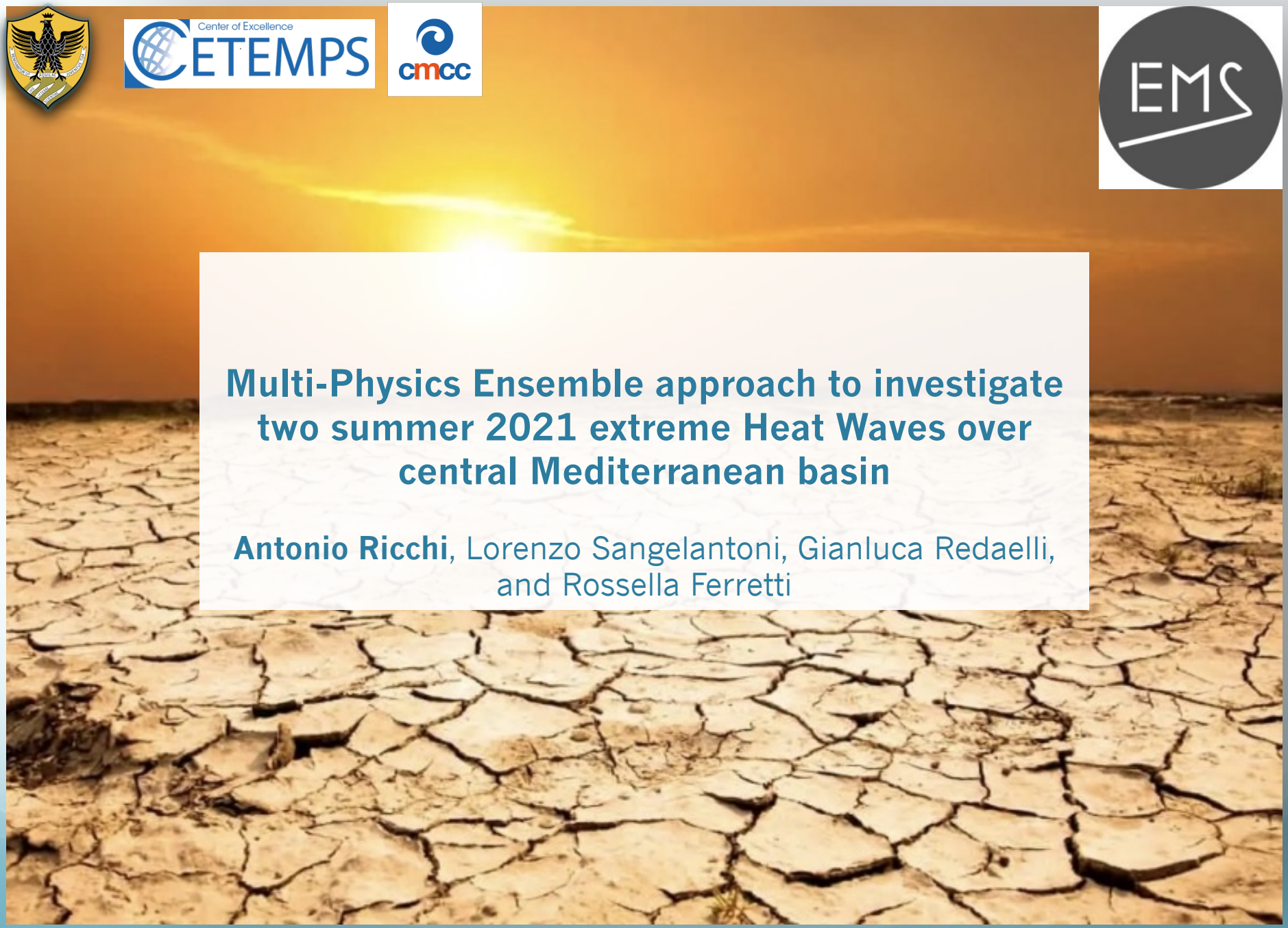


Multi-Physics Ensemble approach to investigate two summer 2021 extreme Heat Waves over central Mediterranean basin

Antonio Ricchi, Lorenzo Sangelantoni, Gianluca Redaelli, and Rossella Ferretti

Overview

1. Study motivation
2. Case studies and heat waves characterization
3. Numerical approach
4. Multi-pysics ensemble approach
5. Observations
6. Results
7. Conclusions

Study motivation

1. The Heat Waves (HWs) are among the most impacting weather phenomena. An exacerbation of this type of extreme is already ongoing. Predicting HWs is crucial for both societies and ecosystems.

2. HWs cause thousands of casualties in Europe every year, and economic damages for billion of euros.

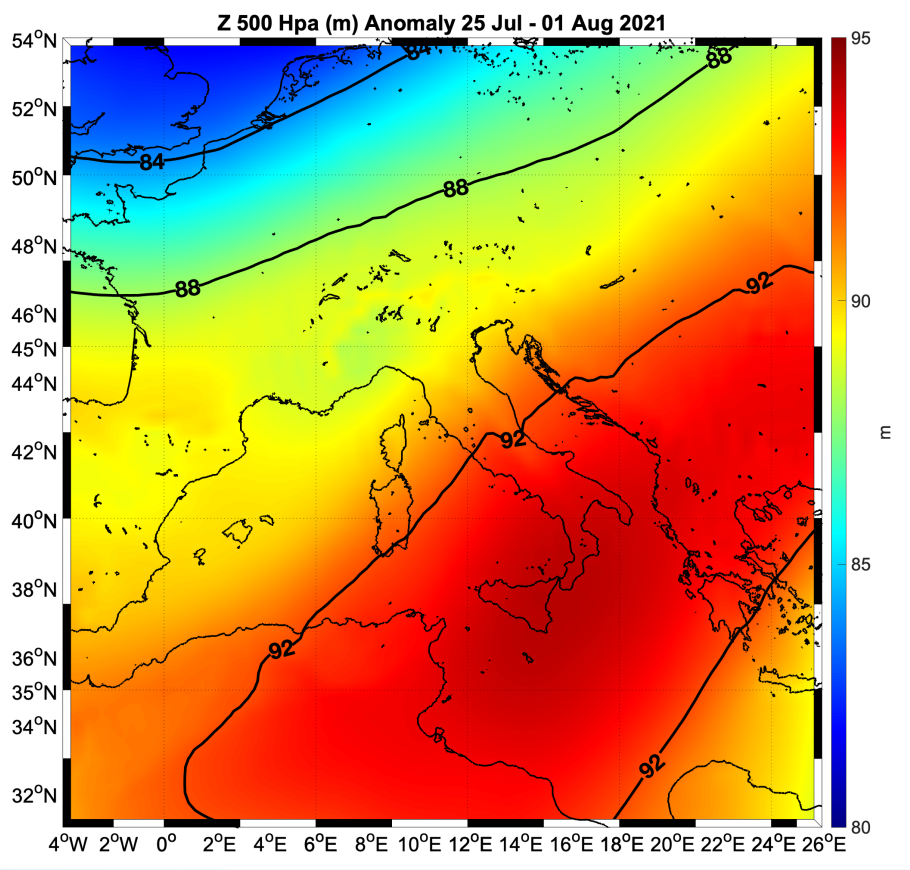
3. Although they are “easily” predictable on a synoptic scale, local-scale forcing can play a crucial role and affecting predictability.

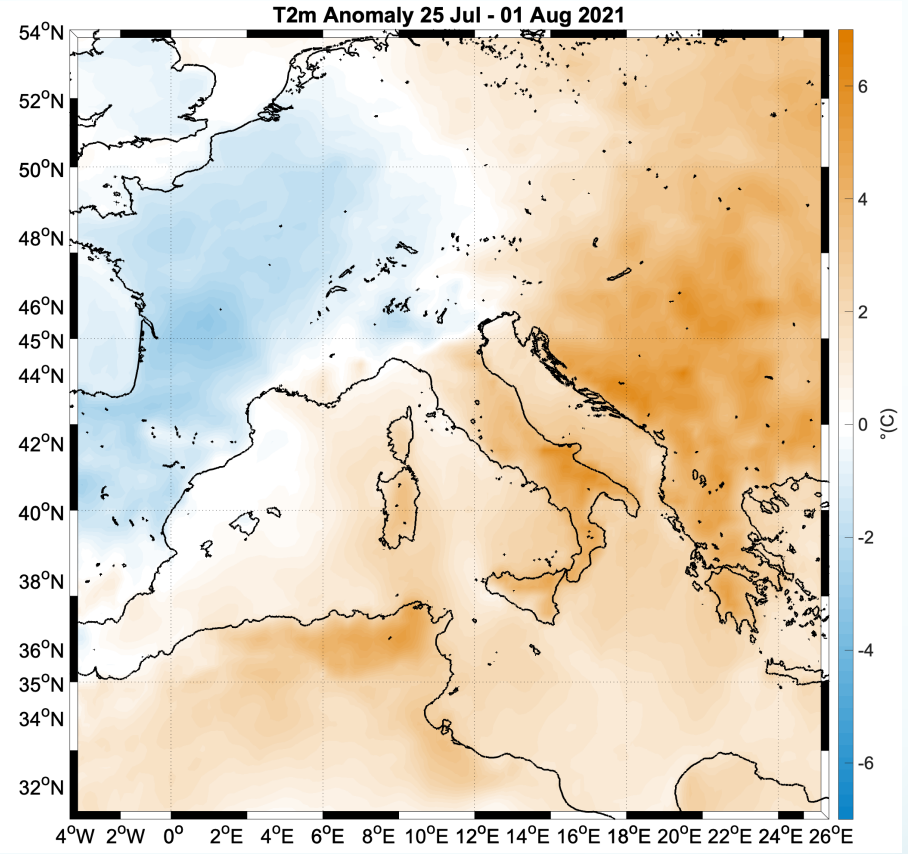
4. In this study we investigate two intense HW events occurred in July and August 2021.

5. Studied HWs, are substantially different from each other, from both a synoptic and local-scale forcing perspectives.

6. A Multi-Physics Ensemble (MPE) approach is here adopted to explore impacts of numerical schemes choice, and of the physical variables that invalidate the forecast, with a modulation up to 10-15% HWs maximum and minimum temperatures.

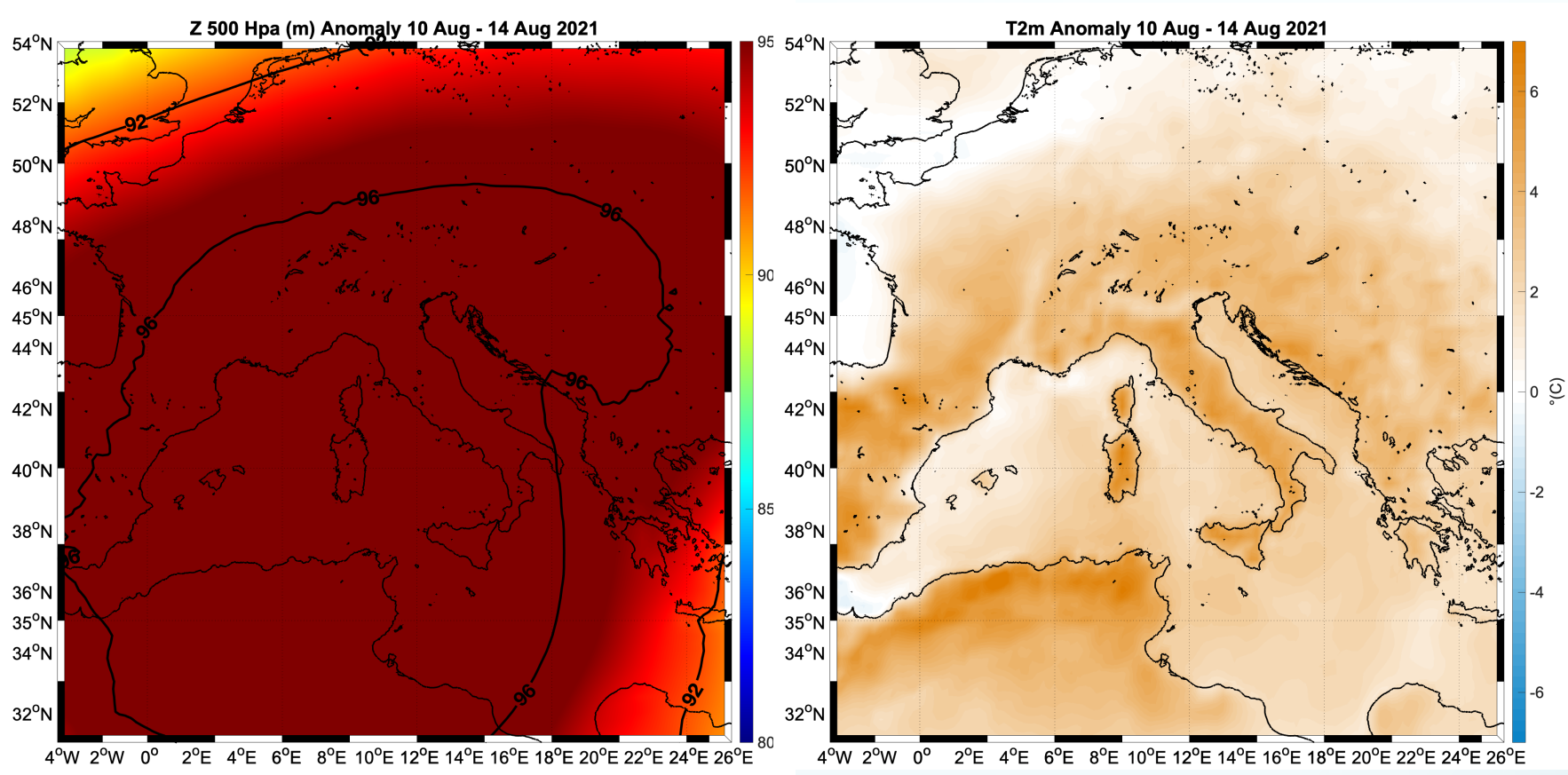
Heat Wave 25 July – 01 August 2021





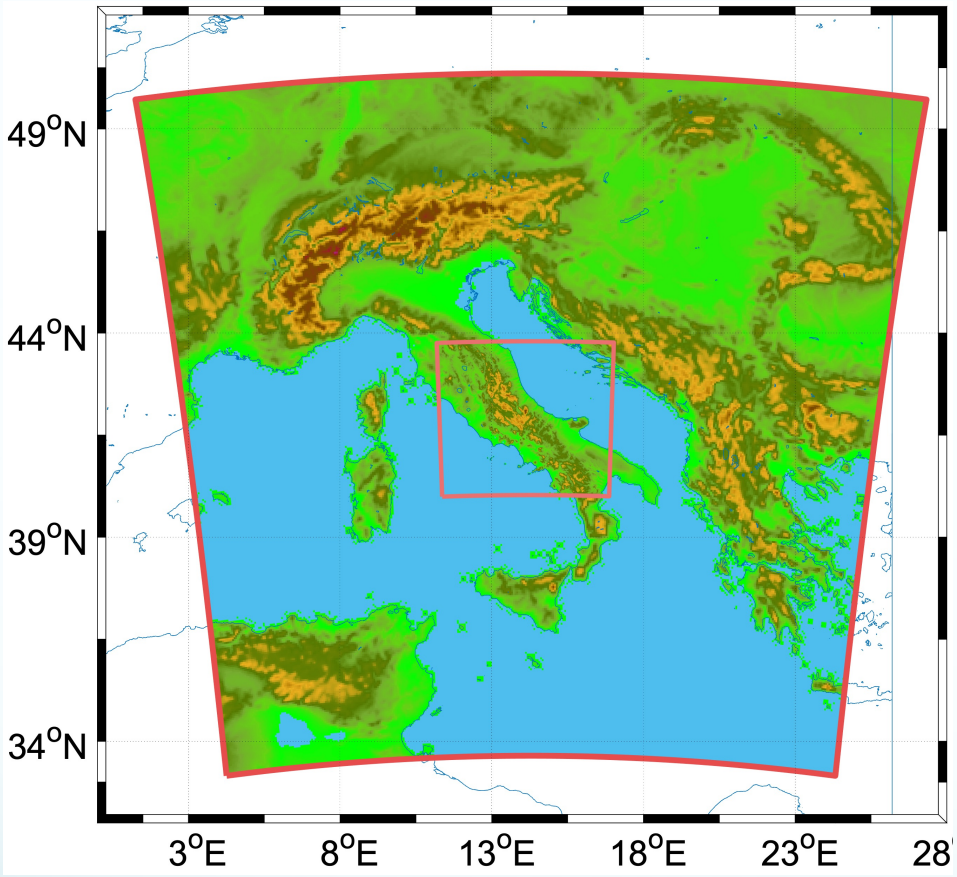
- Caused by a strong pressure anomaly (and geopotential at 500 hpa), with a rapid advection of hot and dry air coming from Tunisia.
- This configuration has particularly affected southern Italy, with intense winds coming from the SW.
- Interacting with the Apennines, the air mass generated the Fohen effect on the leeward side (Adriatic coast), where they
  record temperatures above 47 °C and an anomaly above 7 °C for 2 days.
- The HW was not particularly intense, but the topographic effect (katabatic compression) driven a strong temperature increase. this HW is not caused by the synoptic scale, but mainly by local factors, which are often complex to predict.

Heat Wave 11-14 August 2021

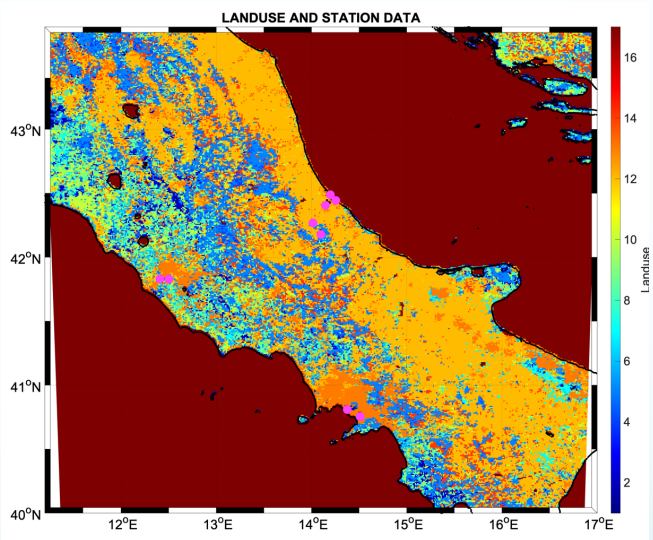


- Caused by a strong geopotential anomaly at 850 hpa and temperature at 850 hpa (30-32 ° C at 850 over south Italy).
- This HW has a very wide extension, entirely affecting central-western Mediterranean.
- It shows anomalies of temperatures above 5-6 °C in central and southern Italy, in particular the basins facing west.
- The dynamical characteristics are much less impulsive than the previous HW, in fact the atmospheric circulation is less dynamic, resulting from a very stable, structured, and intense high pressure field at all altitudes, with anomalies at 500 hPa higher than 9-10 DAM

Numerical Model Approach



WRF-ARW model
SST CMEMS 4.5 km
H. Resolution 5-1 km
75 Vert. Levels
1° level 15 mt above ground



IMPORTANT REMARKS: The simulations were done with the soil hot-start technique. 3 runs were done, 3 days long. The soil (output) variables were taken from each run and entered in the initialization of the next run. In this way the soil contains energy information from the previous days.

Multi-Physics approach

With the aim of studying the effects of model physical configurations on events predictability, we used a multi-physics ensemble approach.
We chose a control configuration (CTL) and modified:
1) PBL schemes;
2) For each PBL schemes we tested different surface schemes;
3) Soil schemes;
4) Radiation schemes

	Pbl 2-CTL	pbl 1	Pbl5-1	Pbl5-2	Pbl5-5	Pbl6-1	PBL 6-2	PBL 6-5	PBL 7-1	PBL 8-1	PBL 8	PBL 9-2	PBL 2-rad12	PBL 2-rad44	PBL 2-sfc1	PBL 2-sfc3	PBL 2-sfc4-opt3	PBL — sfc4
PBL	2	1	5	5	5	6	6	6	7	8	8	9	2	2	1	3	4	4
SOIL	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
SOIL OPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1
SURF	2	1	1	2	5	1	2	5	1	1	2	2	2	2	2	2	2	2
RADLW	1	1	1	1	1	1	1	1	1	1	1	1	1	4				
RADSW	1	1	1	1	1	1	1	1	1	1	1	1	2	4	1	1	1	1
CU	1-0	1-0	1-0	1-0	1-0	1-0	1-0	1-0	1-0	1-0	1-0	1-0	1-0	1-0	1-0	1-0	1-0	1-0

Observations

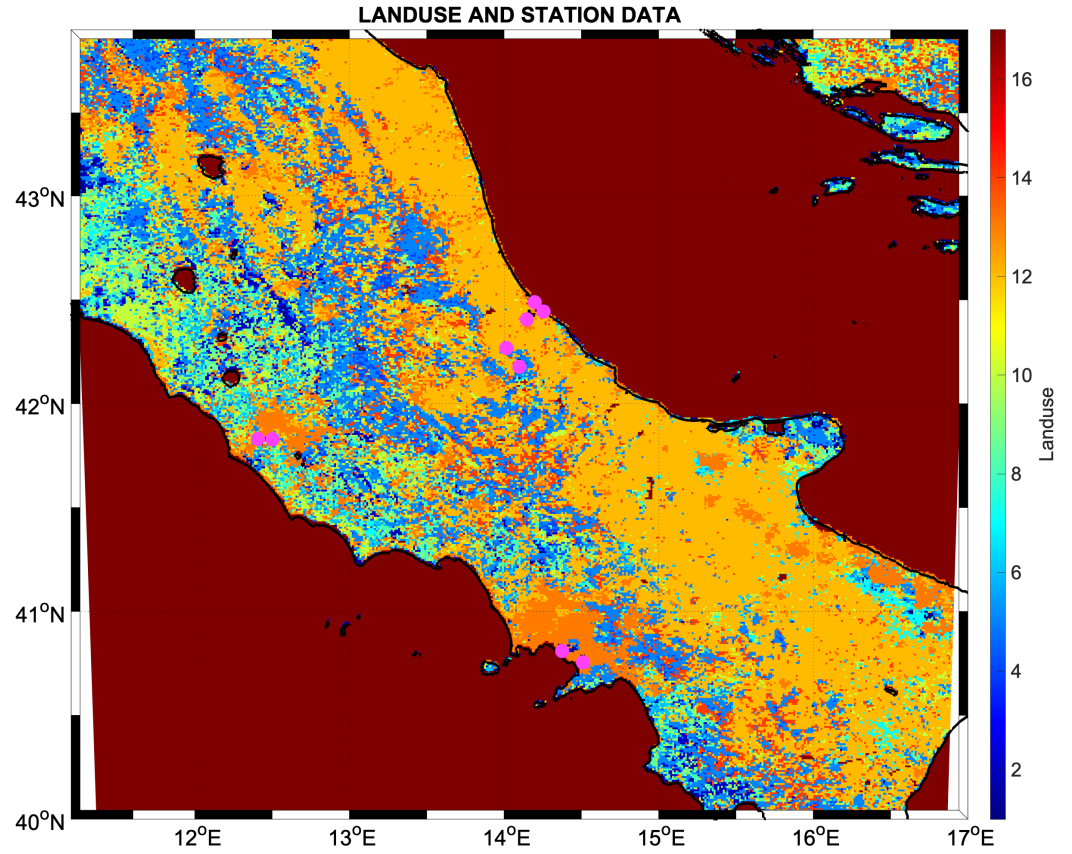
This is a preliminary phase of the study and we only evaluated the temperature at 2m variable. We have selected stations complete with all the main sensors, therefore the selection, on the territory, has been quite limited to a few stations (at the moment).

3 types of urban areas were investigated

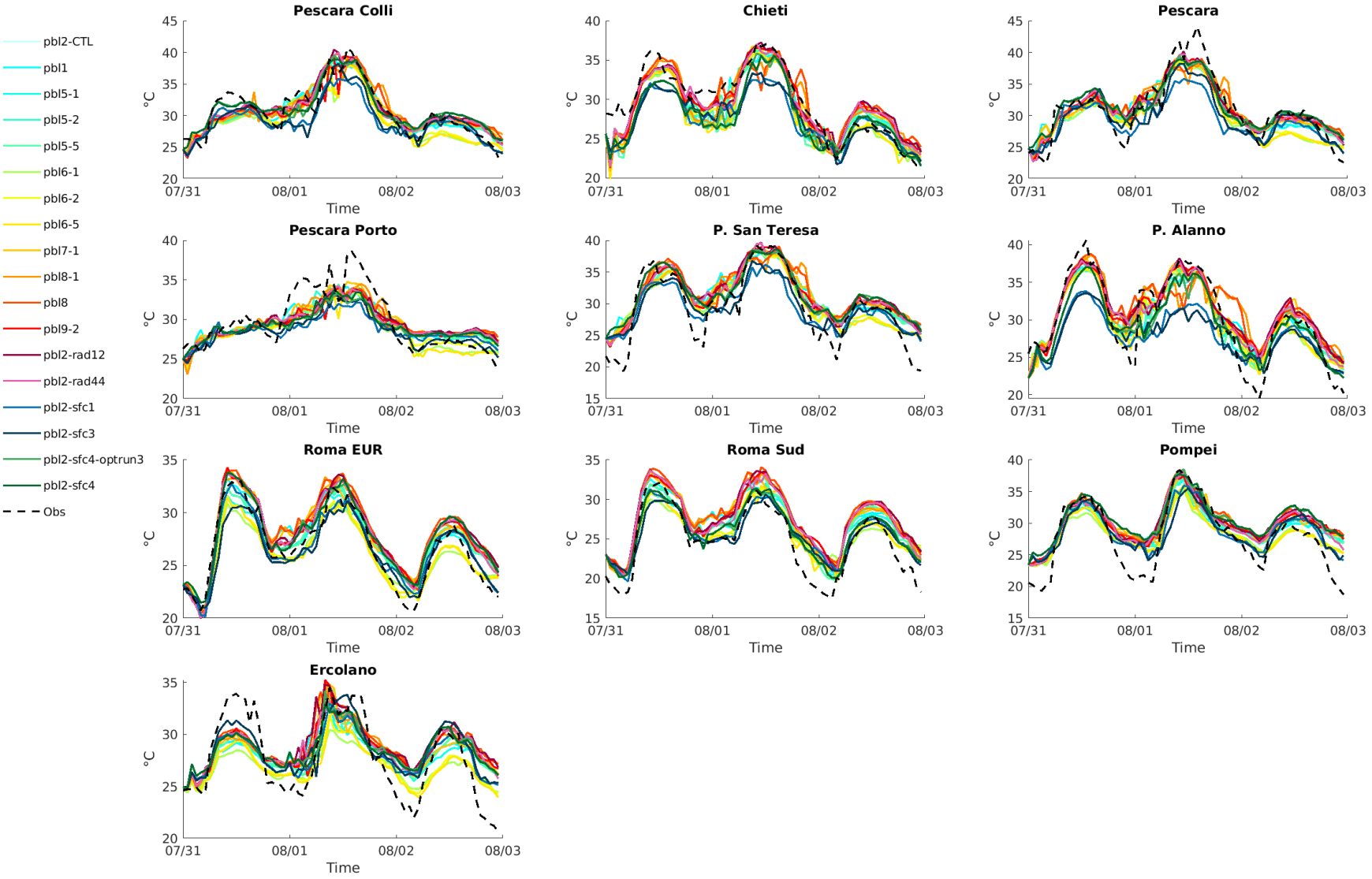
a) Small/medium city and extra-urban area (PESCARA);

b) Metropolis (ROME);

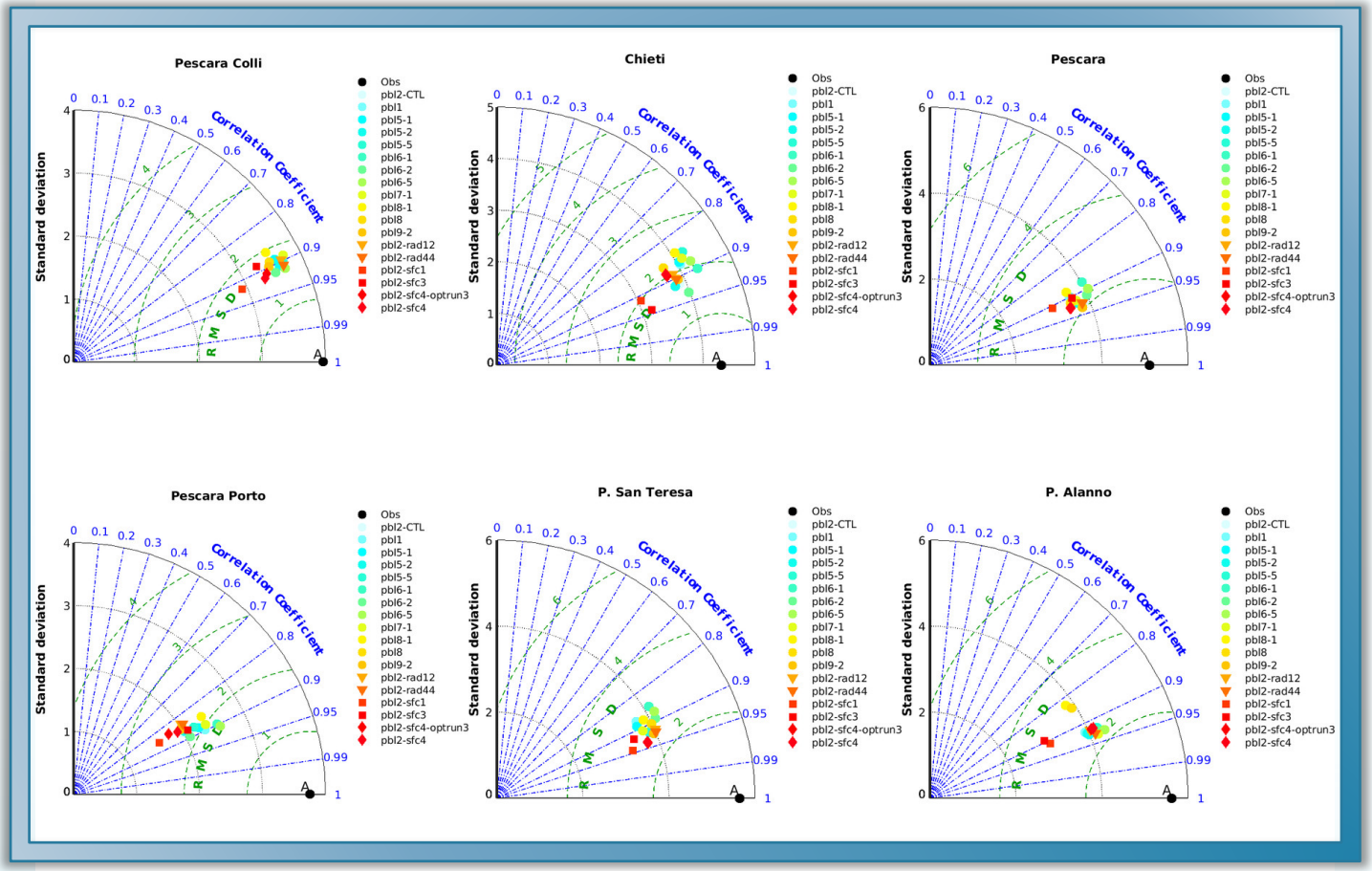
c) Most urbanized area in Europe, near the sea (NEAPOLITAN INTERLAND).



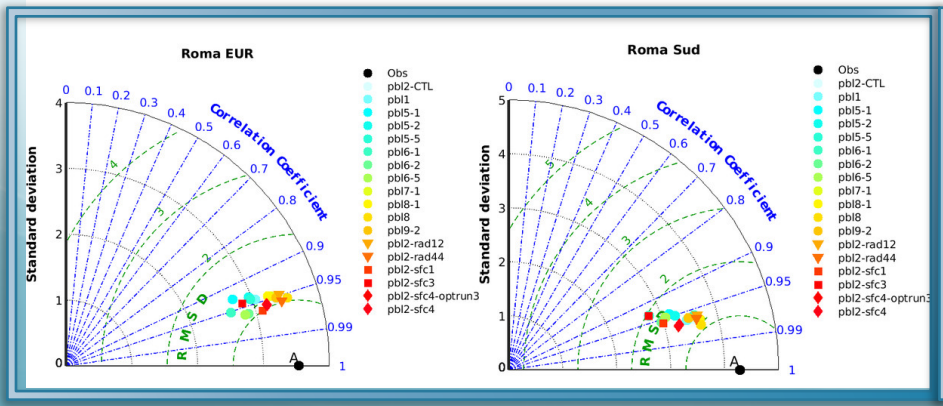
Heat Wave 25 July – 01 August 2021

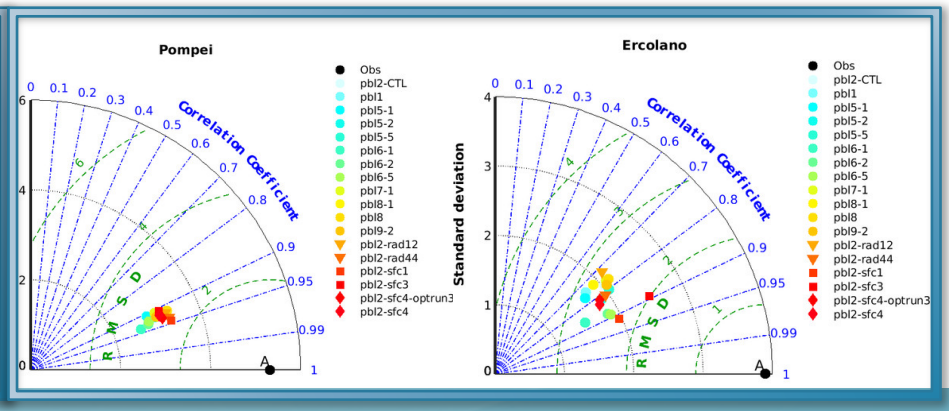


Heat Wave 25 July – 01 August 2021

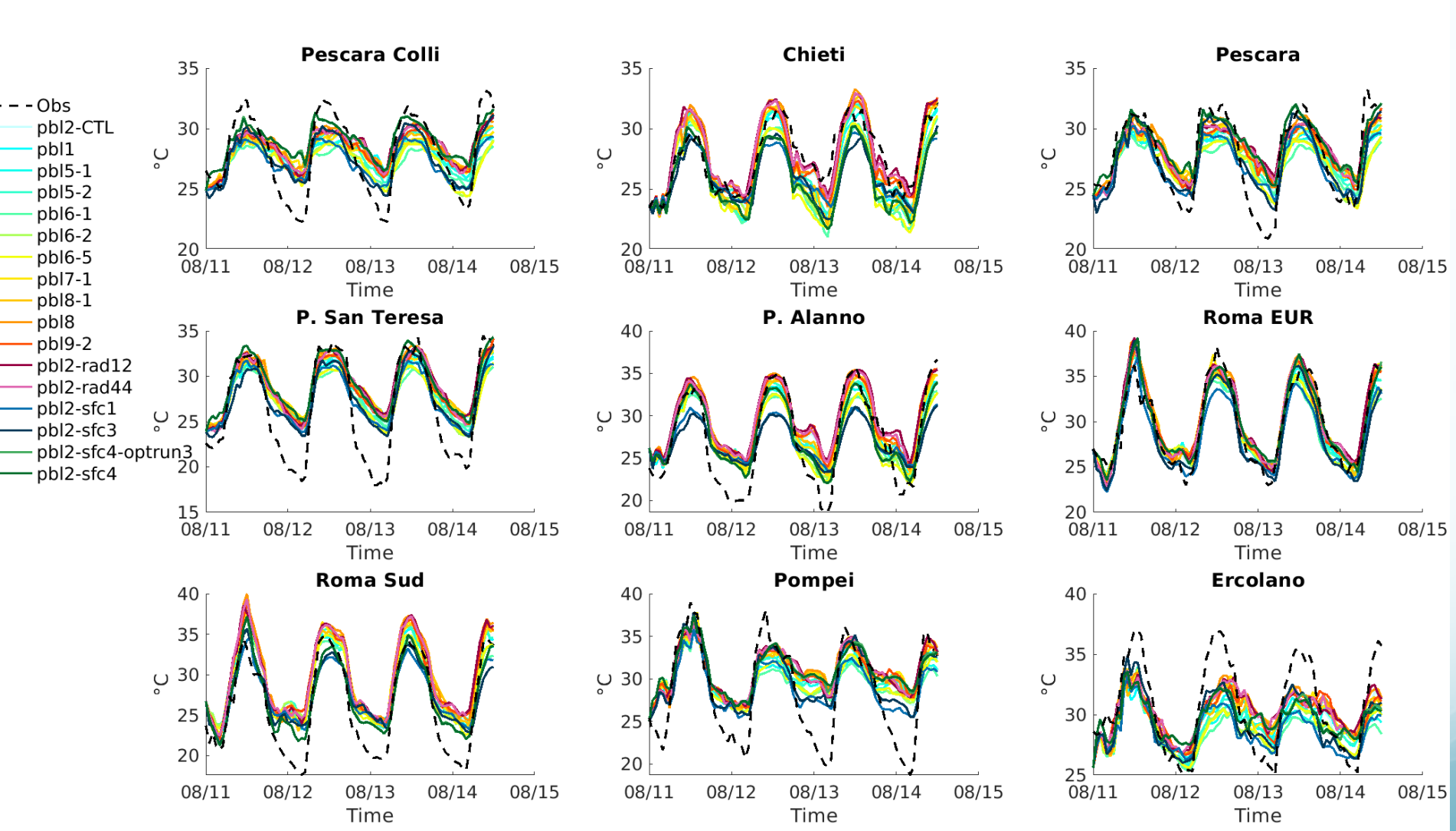


PESCARA, zona
dove osserviamo
la Heat Wave catabatica

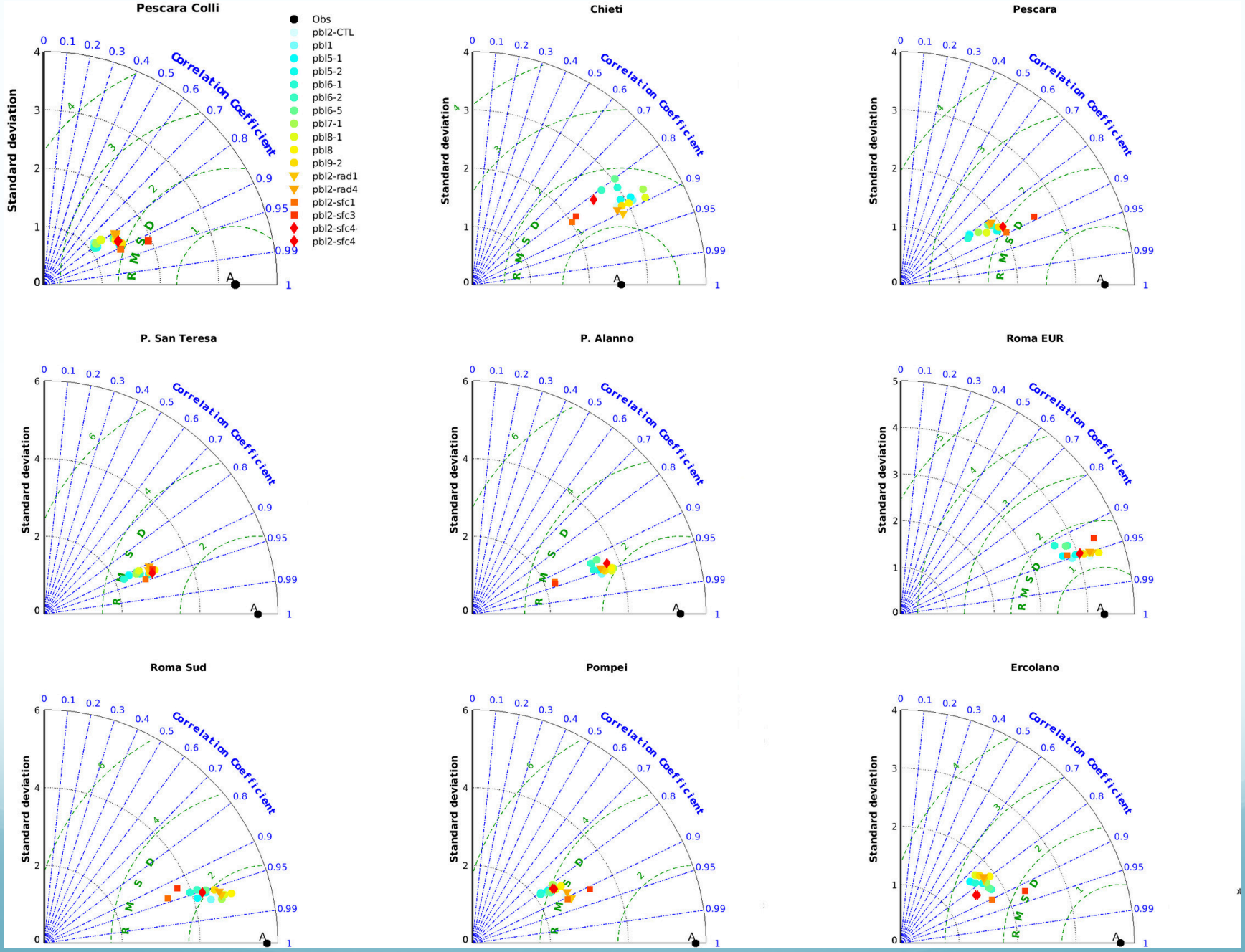




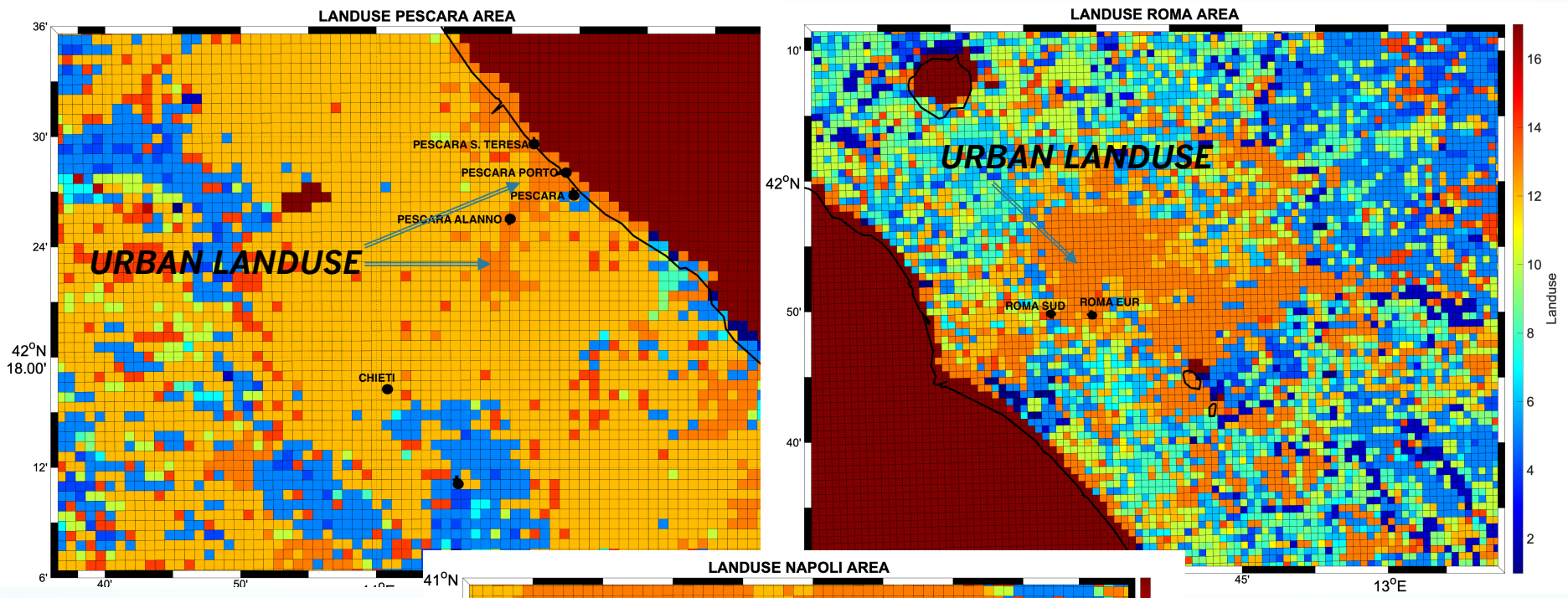
Heat Wave 25 July – 01 August 2021



Heat Wave 11-14 August 2021



Results – Potential impact of physics and landuse



Conclusion

- The results underline how multi-physics ensemble approach is essential for considering the physics and the type of the territory, and the local effects, but above for identifying the most impacting numerical component modulating events representation prediction.
- HWs can be very different from each other, and this is driven by the orography and morphology of the territory and the proximity of water basins (and their temperature).
- The distribution of land use is fundamental, because it significantly impacts the results in highly urbanized areas, especially after prolonged mild periods, in which the soil accumulates heat.