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Application of the Weather Research and Forecasting model to the investigation of the time evolution of outdoor thermo-hygrometric comfort in Italy

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Background and **aim** of the work

BACKGROUND

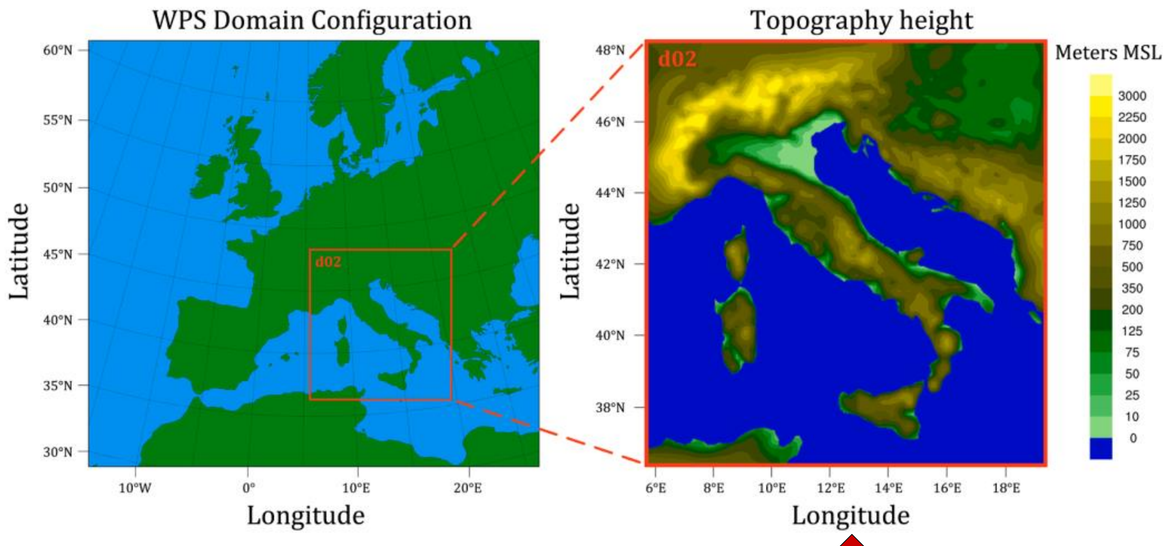
- ✓ The global warming trend is demonstrated by evident numerical and experimental evidence
- ✓ The Mediterranean basin is a hot-spot for climate change
- ✓ For Italy, these conditions appear especially crucial due to the high population density and high average age of the population
- ✓ Climate change significantly increases the frequency and intensity of extreme heat and consequently the human thermal stress
- ✓ The spatio-temporal evolution of human thermal conditions form the past to the future have been investigated by numerous scientific studies. However, these studies are based on data characterized by a coarse spatial resolution (e.g., 0.25° × 0.25°, Kyaw et al., 2023)

AIM OF THE WORK

- ✓ Studying at **high resolution** over Italy the **spatio-temporal evolution** of the biometeorological index named **MOCI** developed by F Salata et al., (2016) for the quantification of the thermal sensations of a Mediterranean normotype.

Methodology

The Weather Research and Forecasting (WRF) model



a) WRF domains configuration;
a) Topography height in the innermost domain.

Table: features of WRF simulations performed in this study, including the datasets providing the initial and boundary conditions

Year	Initial and boundary conditions	Future scenario
2000	GFS operational analyses of NCEP	None
2080	NCAR CESM Global Bias-Corrected CMIP5 Output	RCP4.5 RCP8.5

The Mediterranean Outdoor Thermal Comfort Index (MOCI)

The Mediterranean Outdoor Thermal Comfort Index (MOCI, Eq.1) is a thermo-hygrometric comfort index for outdoor environments and allows quantification of the thermal sensations of a Mediterranean normotype (Salata et al., 2016).

$$MOCI = -4.257 + 0.146 \cdot T_A + 0.325 \cdot I_{CL} + 0.005 \cdot RH + 0.001 \cdot I_S - 0.235 \cdot W_S \quad \text{(Eq. 1)}$$

T_A = air temperature [°C], RH = relative humidity [%]
I_S =solar radiation [Wm^{-2}], W_S =wind speed [ms^{-1}].
$I_{CL} = I_{CL} = 1.608 - 0.038 \cdot T_A$ thermal resistance of the clothing

The MOCI is an index based on an ASHRAE 7-point scale [-3; − 2; − 1; 0; +1; +2; +3].
MOCI categories:

- -0.5 and 0.5 comfort conditions.
- > 0.5 sensation of increasing heat
- < -0.5 sensation of increasing cold.

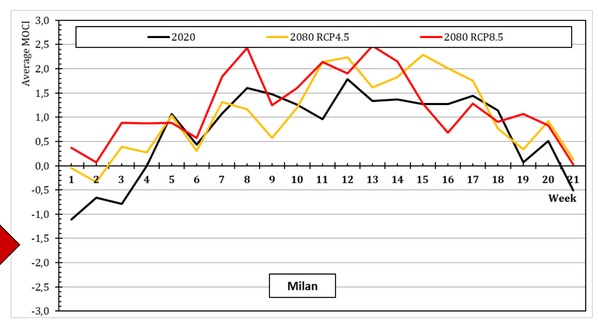
Hourly values of MOCI are computed here using weather variables simulated by the WRF model

Study period: May-September

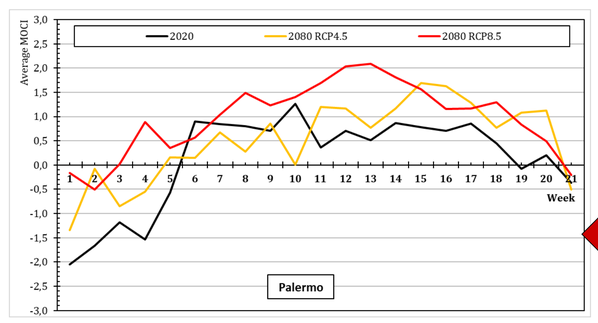
Results and conclusions

Local approach - Time evolution

Weekly averaged MOCI in Milan for the year 2020 (black line) and 2080 according to the IPCC RPC4.5 (orange line) and RCP8.5 (red line)



The time evolution of MOCI in Milan and Palermo is shown. Hourly values of quantities in (Eq. 1) have been extrapolated to compute the MOCI values, then averaged over each week of the May-September period.



Weekly averaged MOCI in Milan for the year 2020 (black line) and 2080 according to the IPCC RPC4.5 (orange line) and RCP8.5 (red line)

Conclusions

The results of the simulation of future scenarios prove the worsening of the outdoor thermo-hygrometric conditions (higher MOCI values) for the inhabitants of Milan and Palermo compared to the year 2000. As expected, this worsening is accentuated in the RCP8.5 scenario compared to the RCP4.5 scenario. These results also reveal that the city of Palermo, despite its lower latitude, has lower MOCI values thanks to its coastal location and the related beneficial effect of ventilation.

References

- Kyaw, A.K., Hamed, M.M., Shahid, S., 2023. Spatiotemporal changes in Universal Thermal Climate Index over South Asia. Atmospheric Research 292, 106838.
- Salata, F., Falasca, S., Ciancio, V., Curci, G., Grignaffini, S., De Wilde, P., 2022. Estimating building cooling energy demand through the Cooling Degree Hours in a changing climate: A modeling study. Sustainable Cities and Society 76, 103518.
- Salata, F., Golasi, I., De Lieto Vollaro, R., De Lieto Vollaro, A., 2016. Outdoor thermal comfort in the Mediterranean area. A transversal study in Rome, Italy. Building and Environment 96, 46–61.

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