Heat waves analysis based on temperature and UTCI from regional climate projections for German cities

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Motivation

Cities face rising heat-related health risks due to climate change[1]. But the stress could come from heat waves or a combined effect of many variables (like UTCI)[2]. To address this, we need downscaling methods and high-resolution climate data for urban planning and heat-stress reduction[2,3].

Research questions

- What are the differences between heat waves based on air temperature and thermal comfort for different German cities?
- How does the number of days and magnitude of these heat waves changes for the mid- and far future?

Data and Methods

Heat waves[4]: three or more consecutive "hot days" (temperature above a daily threshold)

UTCI[5]: Combination of temperature, humidity, radiation, and wind

Reference: ERA5[6] (near-surf. temperature) and ERA5-HEAT[7] (UTCI)

EURO-CORDEX experiments (EUR-11) [5,8]:

- Historical: 1971 – 2005
- Near future (RCP8.5): 2021 – 2050
- Far future (RCP8.5): 2070 – 2099

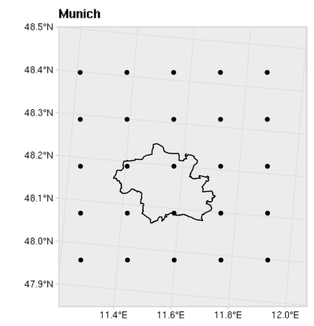

Fig. 1: Example of selected grids for Munich from the REMO 2015 – MPI-ESM-LR

ERA5

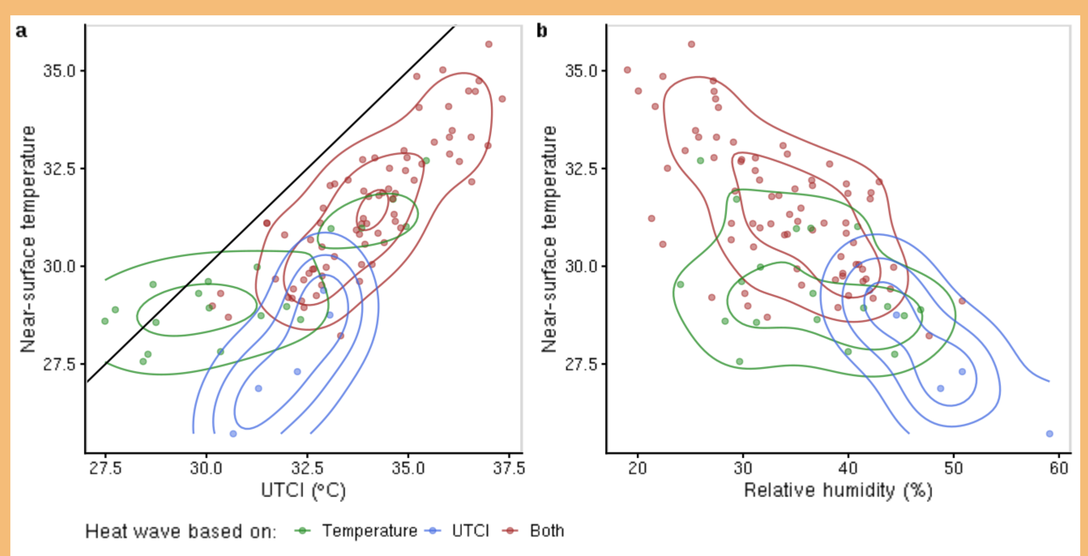

Fig. 2: (a) UTCI and (b) relative humidity against near-surface temperature. Dots and lines indicate the heat wave days and their probability density, respectively, using different heat wave computation (colors).

- On average, UTCI is ~3°C higher than near-surface temperature
- Extreme hot days can be identified with either temperature or UTCI
- Heat wave days with only UTCI have lower temperatures (and vice versa)
- UTCI only days have high relative humidity (>40%)

EURO-CORDEX historical simulations

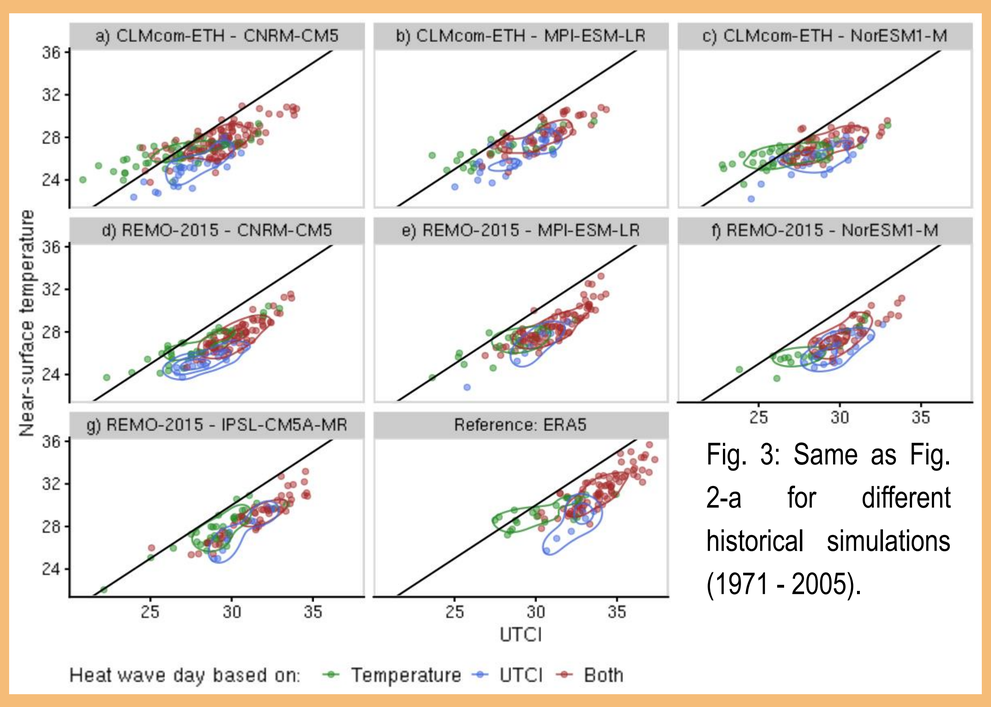

Fig. 3: Same as Fig. 2-a for different historical simulations (1971 - 2005).

Compared to ERA5 (Fig. 2-a):

- General near-surface temperature cold bias (~2-3°C)
- REMO-2015 (d-g) represents the temperature distribution well (below 1-1 line), while CLMcom (a-c) has higher temperature for lower UTCI
- Overall the heat wave characteristics are represented by most of the simulations

EURO-CORDEX projections

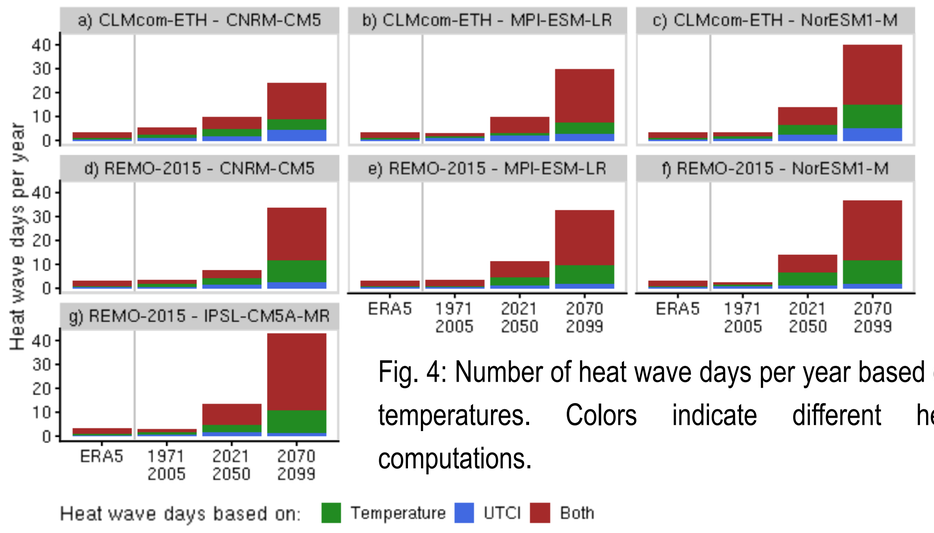

Fig. 4: Number of heat wave days per year based on different temperatures. Colors indicate different heat wave computations.

- **Historical (1971 – 2005):** Simulations accurately represent the amount of heat wave days per year compared to ERA5 (~4 days per year)
- **Near future (2021 – 2050):** Approximately, the number of heat wave days is double (~10 days per year)
- **Far future (2070 – 2099):** The increase in heat wave days is much higher (from 30 to 40 days per year)

Conclusions and Outlook:

- ERA5: strongest heat waves are identified with both variables; however, using only temperature misses potential moderate heat-stress days
- ERA5: UTCI-only heat waves characterized by relative high humidity
- EURO-CORDEX: historical simulations perform well with a cold bias
- EURO-CORDEX: RCP8.5 projections indicate a doubling of heat wave days in the near future and up to 10 times in the far future (similar with other German cities)
- **NEXT: analysis of future heat waves biometeorological characteristics (like wind and relative humidity) in other cities**

Acknowledgements

This work was carried out in the BMBF junior research group "Conflicts and Synergies between carbon-neutral and healthy City Scenarios" (CoSynHealth). We would like to thank the German Federal Ministry of Education and Research (BMBF) for the funding and the German Aerospace Center (DLR) for the project management support.

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