# Extreme events of perceived temperature over Europe: a projected northward extension of dangerous area


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## Abstract

An increase of temperature over Europe, both in terms of averages and extremes is expected within the current century. In order to consider **health impacts under warm conditions**, it is important to **take into account** also **the combined effect of temperature and humidity on the human body**. To this aim projections of a basic index – the **humindex - representative of the perceived temperature**, **under different scenarios** and periods, **has been investigated** in this study. **A very low concomitance of observed extreme temperature events and extreme perceived temperature events is found over the present climate (Fig.1)**, reinforcing the importance to investigate not only future projections of temperature and humidity, but also the combination of the two fields. A set of **10-km resolution climate simulations**, provided within the **EURO-CORDEX** multi-model effort, **demonstrates ability in representing the intense and extreme events of perceived temperature** over the present climate (**Fig.2**) and to be eligible as a tool to quantify future changes in geographical patterns of exposed areas over Europe. Following the worst (RCP8.5) climate scenario, **an enlargement of the domain subject to dangerous conditions is expected since the middle of the current century**, reaching 60 degrees North when considering really extreme events (**Fig. 3**). The most significant increase of extreme events is found when comparing the 2066-2095 projections, to the 1966-2005 period: bearing in mind that changes in relative humidity may either amplify or offset the health effects of temperature extremes, **a less pronounced projected reduction of relative humidity in the north-eastern part of the European domain – due to an increase of specific humidity over the region (Fig.4) - makes north-eastern Europe the most prone region to an increase of intense to really extreme values of perceived temperature.**


## Data and Methods

The **PERCEIVED TEMPERATURE** index is defined based on 2 meter air Temperature (**TAS**) and Relative Humidity (**RH**)as:

**HUMINDEX** = **TAS** + 5/9 x (e-10)

where:

e ={6,112x10^(7.5x**TAS**/[237,7+**TAS**])x**RH**/100}

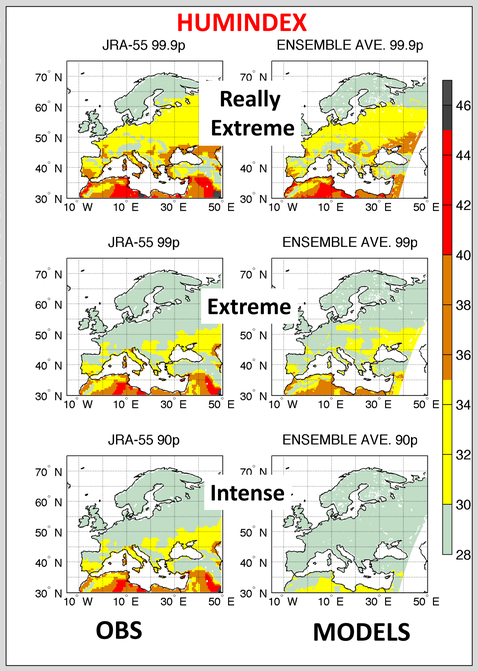
Five main **HUMINDEX** categories are defined to represent different level of ***heat disease***:

- ***I)*** ***HUMINDEX*** >= 45 Really Dangerous, Heat Stroke possible
- **II)** 40 <= ***HUMINDEX*** < 45 Huge Disconfort, avoid exertion
- **III)** 35 <= ***HUMINDEX*** < 40 Great Disconfort
- **IV)** 30 <= ***HUMINDEX*** < 35 Some Disconfort
- **V)** ***HUMINDEX***< 30 No Disconfort

**Intense/Extreme/Really Extreme events**
**(90th/99th/99.9th percentiles [90p/99p/99.9p])**
are computed based on daily time series over the **HISTORICAL** (**1976-2005**) and **FUTURE** (**2066-2095**) period under the CMIP5 **RCP8.5** scenario (worst case in terms of emissions).
The analysis is based on **multi-model EURO-CORDEX** (Tab.1) results having a horizontal resolution of **about 10 km**.

## HISTORICAL (1976:2005)

**Fig.2 Intense (90p, lower panels), Extreme (99p, central panels) and Really Extreme (99.9, upper panels) HUMINDEX values over the HISTORICAL period (1976-2005) as represented by the EURO-CORDEX ensemble average (right panels) compared to observations (left panels). The five colors (gray/yellow/orange/red/brown) indicate No discomfort/ Some discomfort/ Great discomfort/ Huge discomfort/ Really dangerous conditions, respectively.**



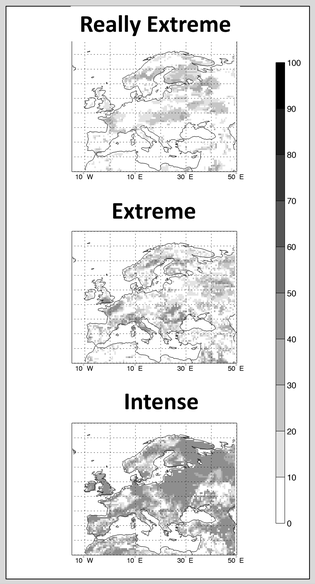




**Fig.1 Observed fraction of intense/extreme/really-extreme (greater than 90p/99p/99.9p) HUMINDEX events (lower/central/upper panel) contemporaneous to intense/extreme/really-extreme temperature events during 1976-2005. Units are [%].**

## FUTURE (RCP8.5 2066:2095)

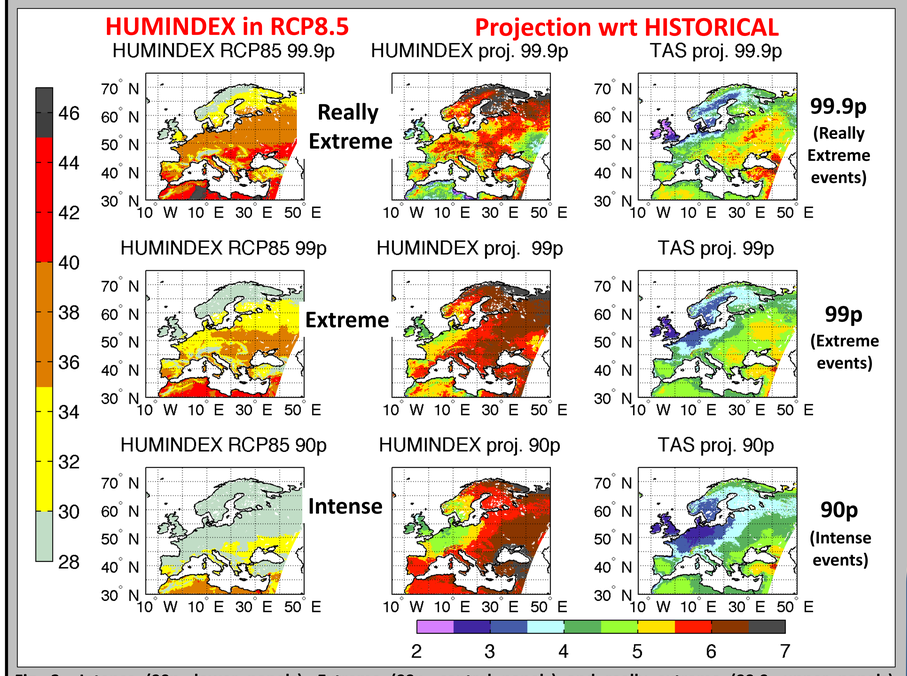



**Fig. 3 Intense (90p, lower panels), Extreme (99p, central panels) and really extreme (99.9, upper panels) HUMINDEX RCP85 far future (2066-2095) values (left panels) and HUMINDEX increase (central panels) compared to TAS increase (right panels). Projections refer to the HISTORICAL period (1976-2005). Units are [°C].**

| Model name | Driving GCM | Institute |
|---|---|---|
| SMHI-RCA4 | CNRM-CM5 | Swedish Meteorological and Hydrological Institute, Rossby Centre |
| KNMI-RACMO22E | ICHEC-EC-EARTH | Royal Netherlands Meteorological Institute |
| INERIS-WRF331F | IPSL-CM5A-MR | IPSL (Institut Pierre Simon Laplace) and INERIS (Institut National de l Environnement industriel et des RISques) |
| CNRM-ALADIN53 | CNRM-CM5 | Centre National de Recherches Meteorologiques |

**Tab. 1 Involved EURO-CORDEX EUR-11 Regional Climate Models (RCM). GCM column indicate the General Circulation Model used to force the RCM.**

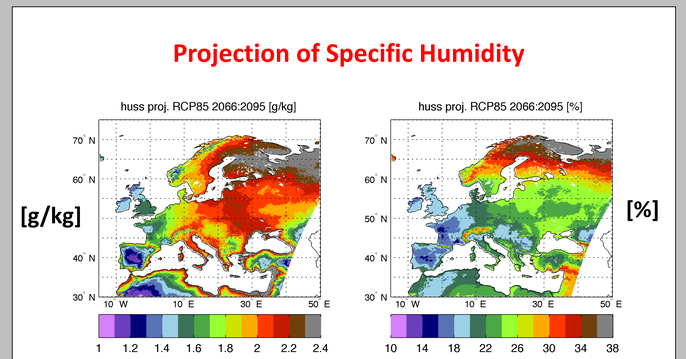



**Fig.4 Projections of summer (June-August) averaged 2 meter specific humidity in RCP85 far future (2066-2095). Left panel shows absolute value increase [g/kg]. Right panel shows relative increase [%]. Projections refer to the HISTORICAL period (1976-2005).**

## CONCLUSIONS:

- Extreme Events of ***Temperature*** *and* Extreme Events of ***perceived Temperature (HUMINDEX)*** are **not synchronous** (**Fig.1**)
- EURO-CORDEX EUR-11 RCM **models are able to represent** intense to really extreme **HUMINDEX** patterns (**Fig.2**)
- When focusing on Extreme Events, projections on ***perceived temperature*** (**HUMINDEX**) over north-eastern Europe are more pronounced than projections of **temperature** (**TAS**) only (**Fig.3**) .
- The Relative Humidity under warmer conditions tends to decrease, but less over the north-eastern Europe, due to the **pronounced projected increase of *Specific Humidity*** over the region (**Fig.4**)