Heat/Cold wave Index (H/CWI)

Variable	Temporal scale	Spatial scale	Geographic coverage
Heat/Cold Wave index	Daily	¼ decimal degree	Europe

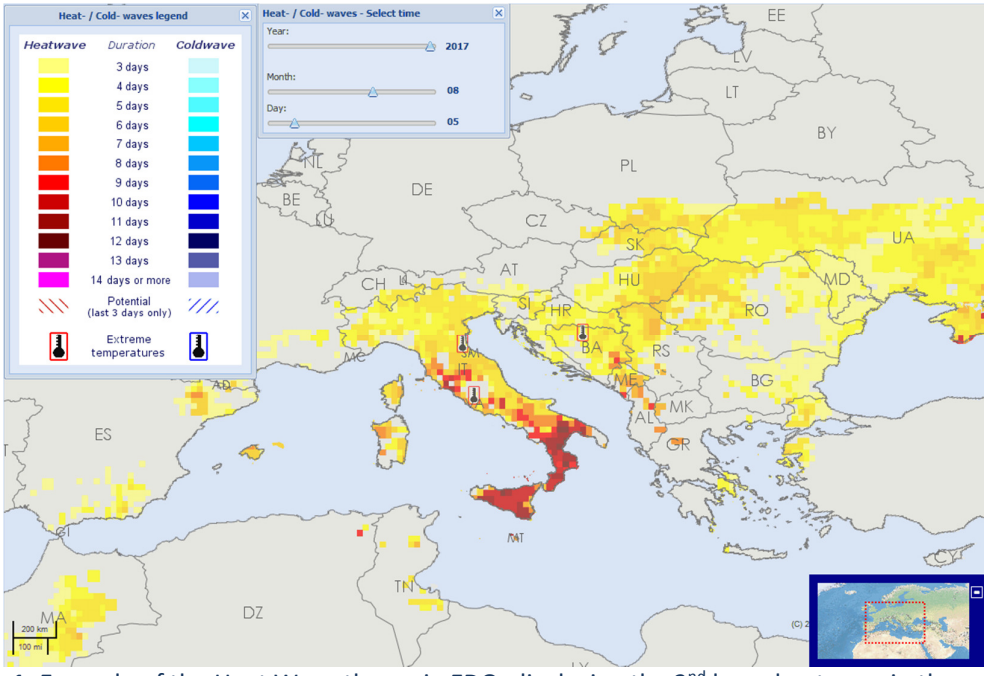


Figure 1: Example of the Heat Wave theme in EDO, displaying the 2nd large heatwave in the summer of 2017, with temperature surging over 40 °C in Italy and Bosnia.

1. Brief overview of the indicator

The heat/cold wave index is provided at grid level, with a spatial resolution of ¼ by ¼ decimal degrees, approximately 25 by 25 km, and indicates the duration (in days) or the intensity (in degrees) of a heat or cold wave that affects the grid cell during a specific day.

The methodology to detect and characterize these waves is introduced and validated in Lavaysse et al. (2017) and is an adaptation of the methodology developed in Russo et al. (2014). The method to detect heat waves (cold waves) is based on the persistency, at least 3 consecutive days, of the exceedance of quantiles Q90 (lower than Q10) of both daily minimum and maximum temperatures at grid point level.

2. What the indicator shows

The layer of Heat/Cold waves shows the duration (in days) of a heat (yellow to red colors) or a cold (blue to black colors) wave. As the minimum duration of a waves is 3 days, the scale starts at 3 and goes up to more than 25 days. For shorter durations (i.e. less than 3 days) of hot (cold) waves, the grid points are indicated with red (blue respectively) stripes.
Finally to highlight potential increase of the risks on human health, heat (cold) waves that occurred with temperature above 40 °C. (lower than -20 °C , respectively) are mentioned with red (blue) thermometer icons.

Additional indicators and layers are provided such as the daily maximum and minimum temperature (Tmax and Tmin), defined as the maximum and minimum temperature recorded during the 24-h of a chosen day. The daily amplitude of the diurnal cycle (defined as the difference in between Tmax and Tmin) is also available and provide information on the night cooling and is a proxy of cloud cover.

In addition to the layer of Heat/Cold waves, the daily maximum temperature anomaly is indicated (in °C), illustrating the temperature anomalies that are not necessary related to an extreme events. Finally, the daily calendar thresholds used to detect heat and cold waves (90^{th} and 10^{th} percentile respectively) are available and show the spatial variability of the temperature thresholds used.

For climatology purpose, the yearly strongest heatwave and the last heatwaves during the ongoing year are plotted. These heat waves are only calculated at station level with observed Tmax. The methodology of the calculation is derived from Russo et al. (2014) and focus only on the most extreme events.

3. How the indicator is calculated

3.1 Input data

The Heat/Cold wave index requires datasets of daily Tmin and Tmax.

- **Geographic coverage:** Extended Europe
- **Spatial scale:** ¼ by ¼ decimal degree
- **Temporal scale:** Daily
- **Data source:** MARS minimum and maximum observed temperature
- **Frequency of data collection:** Every day, with a 2-day lag for quality control

3.2 Methodology

First the temperatures are gridded using observed temperature at weather station of around 4000 stations in Europe and its surrounding area. The interpolation is done using an inverse distance algorithm considering up to 20 stations with a maximum search distance of 200 kilometers along the sphere. The temperature is corrected before interpolation for altitude using a factor 0.0065 °C per meter.
Note that, in the period 1992 to 1997 we have a lack of data around the Northern Baltic Sea. Data in the Middle East, Libya, Western Iceland, Madeira and the Azores are often not sufficient enough to create a reliable interpolation of historical data, in such cases the heat or cold waves will not be determined.

The methodology to detect heat and cold waves follows the requirement of WMO (2012) and it is developed in four steps :

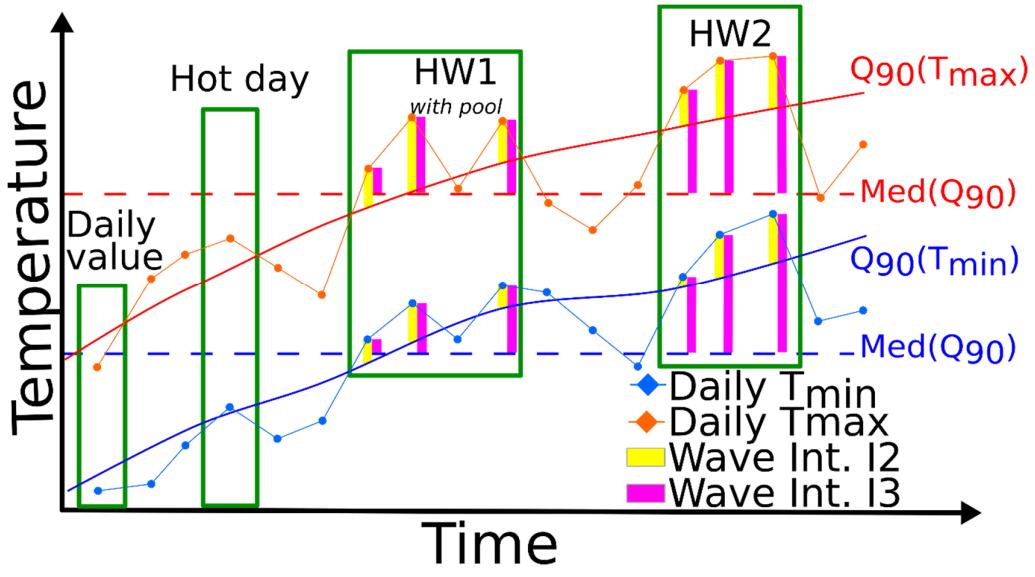
1- **The daily calendar thresholds are defined**: These thresholds are defined as the 90th and 10th percentile of Tmin and Tmax for every calendar days and are computed for the period of 1981 to 2010. A threshold for a calendar day is determined on the minimum or maximum temperatures of the day itself plus 5 days before and after the day. This results in 330 samples for each threshold. The threshold information is also made available as maps on the website.

2- **Definition of Hot/Cold days**: A hot (cold) day is defined when both Tmin and Tmax of the same day are above the 90th percentiles (lower the 10th percentiles respectively).

3- **Detection of the waves**: The waves are defined as a persistence of a minimum of 3 hot or cold consecutive days. Note that a pool is possible when a day without extreme values occurs during a wave.

4- **The intensity of the waves are calculated**: This last point is done using different methods. The first one is the anomaly of temperature above the calendar thresholds. The deviation regarding the long term climatology is used here as a proxy of the intensity of the waves and could be useful for agricultural purposes. The second method is based on the temperature difference with a constant yearly threshold that will take into account the seasonal cycle and so will increase the intensities of the waves when they occur during the peak of the season. This second indicator is useful to assess the potential risk for the human health. Finally, the last information provided relative to the danger level is provided by calculating the maximum (minimum) temperature recorded during the heat (cold respectively) wave. If the temperature exceeds 40 °C (lower than -20 °C, respectively) a symbol of thermometer is added. Note that this is added only when a wave is detected. A temperature above 40 °C or lower than -20 °C not in a detected waves will not be reported.

To illustrate the methodology employed in this study, the Fig. 1 from Lavaysse et al. (2017) presents the calculation of the indices.



4. How to use the indicator

The indicator indicates directly where and when a heat (cold) wave occurred. A long term climatology is also available and allows to monitor and validate past events.
The intensity of the waves is indicated following the duration and the temperature anomalies regarding the climatology. Finally an additional information is provided (small thermometer) when heat (cold) a wave occurred with a temperature above 40 °C (lower than -20 °C) that could be associated with a high risk for the population.
The thermometer is placed on the hottest location in a major CCM (Catchment Characterisation and Modelling, http://ccm.jrc.ec.europa.eu) Sea outlet (river basin).

5. Strengths and weaknesses of the indicator

[+] Indicator is easy to use and to understand.
[+] It is possible to assess the duration and the geographical propagation of heat- or cold waves over Europe day by day since 1980.
[+] The added symbol of a thermometer highlights regions where the risk for the population was high.
[+] Updated every day with a 2-day lag.

[-] The duration of the waves is mapped at daily basis, information if the chosen day is the beginning, central or at the end of the period requires the user to navigate to other days or to do an identify at the point of interest.
[-] The calculation of the waves that could have an impact on population is a key challenge. So far, we provide different indicators relative to the duration or to the temperature anomaly. Nevertheless, ongoing study will help us to increase the accuracy on monitoring the waves with human impacts.

References

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