EDO - European Drought Observatory
Emergency Management Service

Copernicus
Europe's eyes on Earth

European Commission

EDO INDICATOR FACTSHEET

Heat and Cold Wave Index (HCWI)

This Factsheet provides a detailed technical description of the indicator Heat and Cold Wave Index (HCWI), which is implemented in the Copernicus European Drought Observatory (EDO), and which is used for detecting and characterizing periods of extreme-temperature anomalies (i.e. heat and cold waves). The meteorological variables upon which the HCWI indicator produced by EDO is based, as well as the indicator's temporal and spatial scales and geographic coverage, are summarized below. An example of the HCWI indicator in EDO, is shown in Figure 1.

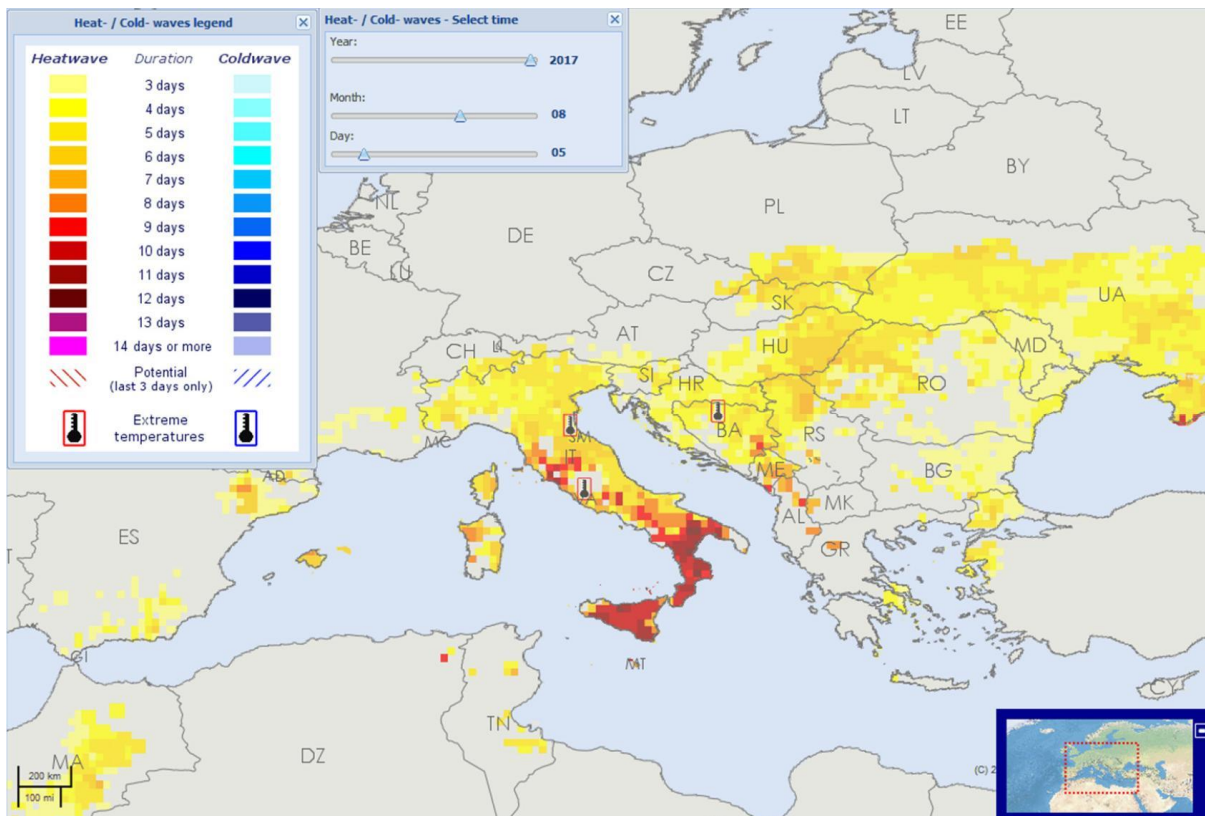| Variables	Temporal scale	Spatial scale	Coverage
Daily minimum and maximum temperatures	Daily	0.25 degrees (~ 25 km)	Europe

***Figure 1**: Example of the continuously updated HCWI indicator, produced by the Copernicus European Drought Observatory (EDO), showing the second major heat wave of the summer of 2017, with extreme temperatures of over 40°C (shown by the thermometer symbols) in Italy and Bosnia.*

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1. Brief overview of the indicator

The Heat and Cold Wave Index (HCWI) that is implemented in the Copernicus European Drought Observatory (EDO) is used to detect and monitor periods of extreme-temperature anomalies (i.e. heat and cold waves) that can have strong impacts on human activities and health. The HCWI indicator is computed for each location (grid-cell), using the methodology developed by Lavaysse et al. (2018), based on the persistence for at least three consecutive days of events with both daily minimum and maximum temperatures (Tmin and Tmax) above the 90th percentile daily threshold (for heat waves) or below the 10th percentile daily threshold (for cold waves). For each location, the daily threshold values for Tmin and Tmax are derived from a 30-year climatological baseline period (1981-2010), using the JRC's MARS AGRI4CAST database of daily meteorological observations. In order to highlight the events with the most potential human impact, heat waves are detected during the "extended summer" period (i.e. April to September, the six hottest months over Europe), while cold waves are detected during the "extended winter" period (i.e. October to March, the six coldest months over Europe).

2. What the indicator shows

The HCWI indicator that is implemented in EDO shows the duration in days of detected heat waves - defined as events of at least three consecutive "hot" days - and detected cold waves - defined as events of at least three consecutive "cold" days. In this context, a "hot day" is a day with both daily minimum and maximum temperatures (Tmin and Tmax) above their daily threshold values, calculated as the 90th percentile values of Tmin and Tmax for that calendar day during the climatological baseline period (1981-2010). Similarly, a "cold day" is a day with both Tmin and Tmax below their daily threshold values, calculated as the 10th percentile values of Tmin and Tmax for that calendar day during 1981-2010.

The following heat and cold wave-related data layers are also available via the EDO interface:

- Daily minimum and maximum temperatures (Tmin and Tmax) during a selected day.

- Daily amplitude of the diurnal temperature cycle, defined as the difference in between Tmax and Tmin, which provides information on night-time cooling, and is a proxy for cloud-cover.

- Daily maximum temperature anomaly, not necessarily related to extreme events.

- The daily calendar thresholds used in the HCWI indicator to detect heat and cold waves, showing the spatial variability of these thresholds.

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3. How the indicator is calculated

The HCWI indicator is computed from daily minimum and maximum temperature values, which are obtained from the JRC's MARS AGRI4CAST database containing daily meteorological observations from 1975 to the present day, interpolated onto a 25x25 km grid for all of continental Europe and some neighbouring countries[1], in two main steps, as is described below and illustrated in Figure 2.

1. Definition of the daily threshold values for heat and cold waves:

The threshold values of daily minimum and maximum temperature (Tmin and Tmax) that characterize a heat or cold wave are computed from the observed Tmin and Tmax for that calendar day during a 30-year baseline period (1981-2010). For heat waves, the daily threshold values for Tmin and Tmax are defined as the 90th percentile ("Q90") of the 330 respective temperature values in an 11-day window centred on that day, for all years in the baseline period. For cold waves, the daily threshold values for Tmin and Tmax are defined as the 10th percentile ("Q10") of the 330 temperature values in an 11-day window centred on that day, for all years in the baseline period.

2. Calculation of the duration of detected heat or cold waves:

A heat or cold wave is detected when there are at least three consecutive days with both Tmin and Tmax above (for heatwaves) or below (for cold waves) their daily threshold values (defined as described previously). When two successive heat or cold waves are separated in time by one day, these are considered to be mutually dependent events, and so are merged ("pooled") as a single event. The duration (in days, not counting "pool" days) of the detected waves, is then computed.
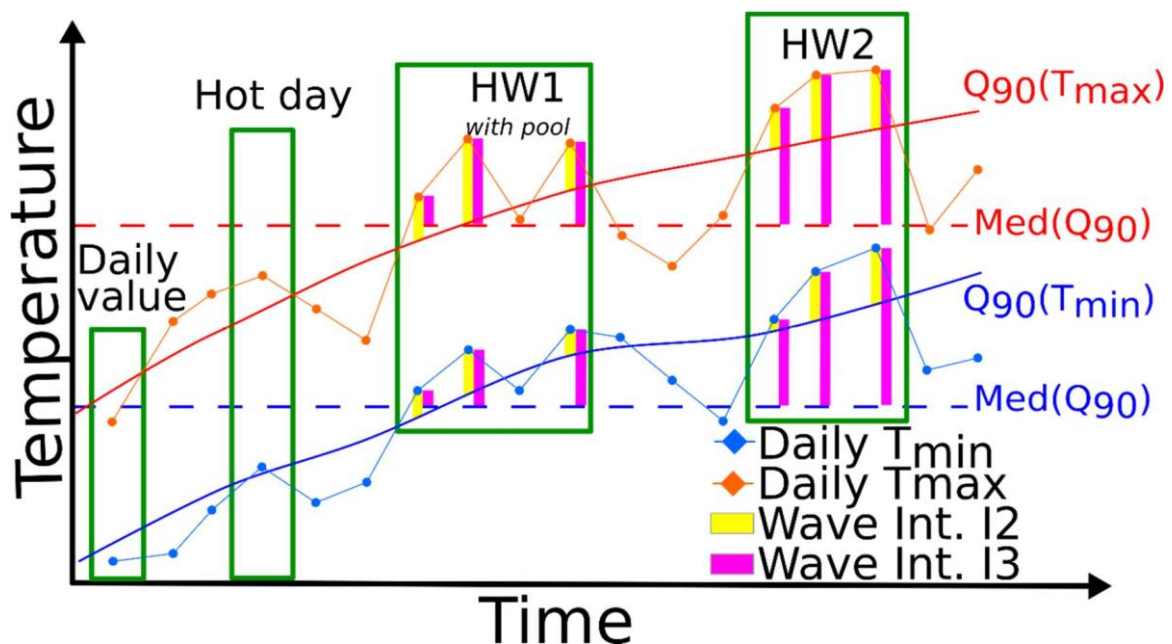

*Figure 2. Illustration of the calculation of the HCWI indicator, for two heatwaves (HW1 and HW2). Note that while only the **duration** of heat (and cold) waves is displayed in EDO, as can be seen their **intensity** ("I2" or "I3") can also be quantified, based on anomalies of Tmin and Tmax from calendar day ("Q90") or constant yearly ("Med(Q90)") threshold values. From: Lavaysse et al. (2018).*

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[1] http://agri4cast.jrc.ec.europa.eu/DataPortal/

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4. How to use the indicator

The HCWI indicator that is implemented in EDO, indicates directly where and when a heat or cold wave has occurred, while the long term climatology that is also available can be used for monitoring and validating past events. As can be seen in Figure 1 above, the HCWI indicator displays the duration of a heat or cold wave in order of increasing magnitude, with colour scales ranging from yellow to red (for heat waves) and blue to black (for cold waves). By definition, the minimum duration of a wave is three days, increasing to fourteen days and longer. For durations under three days, the affected grid-cells are indicated with red stripes (for heat waves) and blue stripes (for cold waves), in order to flag areas where waves may potentially be starting. Finally, waves that include daily temperatures above 40°C (for heat waves) or below minus 20°C (for cold waves), are higlighted by thermometer icons coloured red or blue, respectively, in order to highlight the potential increased risks for human health.

5. Strengths and weaknesses of the indicator

Strengths:

▪ The HCWI indicator that is implemented in EDO is updated on a daily basis (with a two-day delay), and provides a conceptually simple and easy-to-use method for assessing the duration and geographical distribution of sustained temperature anomalies (i.e. heat and cold waves) over Europe, for any given day from 1980 onwards.

▪ The use of calendar day percentile-based threshold values to determine hot and cold days means that the temperature anomalies that are detected are specific for the time of year, and for the geographic location.

▪ Furthermore, because it uses both daily minimum and maximum temperatures (Tmin and Tmax), the HCWI indicator takes account of the strong human impacts of nighttime temperatures (i.e. Tmin) during a heatwave, as recommended by WMO (2015). This contrasts with commonly used methods for measuring heat waves, which only use Tmax.

▪ The HCWI indicator highlights heat or cold wave events that have the highest potential human impact, by splitting the year into two periods: the extended summer period, when heat waves have the stronger impacts, and the extended winter, when cold waves have the stronger impacts. In addition, a thermometer icon is displayed to highlight regions where the detected heat or cold waves pose a particularly high risk for human health.

Weaknesses:

▪ The HCWI indicator shows the duration of the heat or cold wave on a selected day. However, in order to determine if this is towards the beginning, middle or end of the wave, the user may have to navigate to other days.

▪ Due to the different methods that are used, for example, in different countries to measure daily minimum and maximum temperatures, the HCWI indicator might not be exactly comparable with similar indicators that are available at national or regional levels.

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References

o Lavaysse, C., C. Cammalleri, A. Dosio, G. van der Schrier, A. Toreti, and J. Vogt. 2018. Towards a monitoring system of temperature extremes in Europe. Natural Hazards and Earth System Sciences, 18, 91-104. https://doi.org/10.5194/nhess-18-91-2018

o World Meteorological Organization and World Health Organization. 2015. Heatwaves and Health: Guidance on Warning-System Development. McGregor, G.R., P.Bessemoulin, K. Ebi and B. Menne (eds.). WMO-No. 1142. WMO, Geneva. 96 pp. ISBN 978-92-63-11142-5.

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