# Project WORKLIMATE

*https://www.worklimate.it/*

**In-depth analysis and limits of the WORKLIMATE 2.0 forecasting system**

The prototype forecasting system developed as part of the WORKLIMATE 2.0 experimental activity, in its current form, includes three sections of forecasts:

1. Heat risk forecast for different worker profiles
2. Forecast of heat risk based on the "anti-heat" ordinance in force in some Italian regions
3. Forecast of areas where a maximum daily temperature of 35 °C may be exceeded.

The first two types of forecast use an indicator widely used in the employment sector at an international level for an initial assessment (first screening) of heat stress. The chosen indicator, the Wet Bulb Globe Temperature (WBGT), come out from a review of the literature whose results are available in a "Report" which can be consulted on the project website in the "Publications" section (https://www.worklimate.it/en/primo-report-di-attivita-su-revisione-dei-sistemi-di-allerta-da-caldo-e-selezione-degli-indicatori-da-utilizzare-per-valutare-limpatto-sui-lavoratori-2/).

The empirical measure called the WBGT (UNI EN ISO 7243:2017) was developed in the 1950s to monitor heat stress in US military training facilities. Later applications have made it possible to broaden its application, accounting for essential elements in the field of work, like personal protective equipment, in addition to the subject's degree of acclimation and the activity level (metabolic rate).
To date it represents the most common thermal stress indicator used in working environments to ensure that a worker's average body temperature does not exceed 38°C. The Physical Agents Portal (PAF) website (https://www.portaleagentifisici.it/fo_microclima_metodiche.php?lg=IT) has a thorough explanation of the indicator.
This index is used for the prevention of thermal effects on healthy subjects in the absence of individual thermal susceptibility conditions (https://www.portaleagentifisici.it/fo_microclima_index.php?lg=IT).
The WBGT was also chosen as an indicator in the prototype forecasting system (probabilistic forecasts with low spatial resolution and without any intra-day detail) dedicated to the employment sector, developed within the European project (H2020) HEAT-SHIELD (https ://www.heat-shield.eu/).
The WORKLIMATE 2.0 forecasting prototype forecasts is based on the input meteorological parameters of the deterministic model MOLOCH initialized on the global GFS (Global Forecasting System) model (http://www.lamma.rete.toscana.it/modelli/atmo/bolam-e-moloch-info-sui-modelli); it is a mesoscale model (a geographical dimension of meteorological systems, intermediate between the synoptic scale and the microscale) with a spatial resolution of approximately 2 km and an hourly temporal resolution with a 72-hour horizon. This model was recently implemented in the operational chain, replacing the BOLAM model which had a lower spatial resolution (7 km) and greater forecast uncertainty especially in geographical areas with complex morphology. For details

you can read the publication at the following link: https://www.mdpi.com/1660-4601/18/18/9940.

However, it should be remembered that weather forecasts (even more those automatic from meteorological models) are always affected, by their nature, by an intrinsic uncertainty and can be significantly different from the actual conditions observed; therefore the information obtained can be only considered as a support tool for the implementation of prevention and safety measures in the various operational contexts, to be provide during the risk assessment pursuant to the Legislative Decree. 81/08, which cannot ignore direct observation in the workplace.

The uncertainty of the forecasts depends on various factors such as the quality of the data used for the initialization of the MOLOCH model (the so-called "initial conditions", derived in this specific case from the global GFS model), the characteristics of the territory, the meteorological situation present, from the season, the spatial resolution of the model, and from the type of meteorological parameter.

In meteorological models, a series of simplifications regarding both the atmosphere and the Earth's surface are made. The dynamic-physical processes involved in the atmosphere are simulated using equations which, having to be applied to a particularly complex system such as the atmosphere-globe one, are based on a series of approximations and parameterizations. For example, the atmosphere is schematized in a series of vertical levels, which if more numerous (higher vertical resolution) better describe the real conditions.

The earth's surface is further divided into grid points, which are regular points whose distances represent the horizontal resolution of the model (for example, in the case of a model with 2 km resolution, these points will be 2 km apart from each other). The spatial resolution directly influences the correct representation of surface characteristics such as the orography and morphology of the territory (altitude, coastline, etc.) or the use and characteristics of the land (forest use, agricultural use, urban use, soil humidity, type of soil, etc.)

For example, in low horizontal resolution models, valley floors in mountainous areas will generally be represented at an altitude significantly higher than the real one, while on the contrary mountain peaks at a lower altitude, with consequent effects on the prediction of the meteorological parameters used for the calculation of the WBGT index (for example underestimation and overestimation of temperatures in the valley bottoms and mountain peaks respectively, unless conditions favorable to thermal inversion are present).

However, it should be remembered that even in the case of a high-detail horizontal resolution it will not be possible to predict the existence of local microclimates, also because, in the model, many of the characteristics characterizing the surface and soil refer to databases updated only periodically (in the case, for example, of the prediction for a given grid point the model does not allow you to distinguish whether you are on a lawn, on the roof of a building, on an asphalted square, etc.).

As already explain, the forecast will be more faithful to the characteristics of the territory, even if all the other sources of uncertainty in the forecast may persist, including the approximations present in the simulation of the dynamic-physical processes in the atmosphere and in its interaction with the earth's surface. In particular, the occurrence of precipitation, winds, cloud cover, etc. not predicted by the model could determine significant differences between the predicted and observed values of the meteorological parameters on the ground (temperature, humidity, etc.), regardless of the resolution of the model; the same applies if such phenomena are predicted by the model, but do not occur.

Figure 1 describes the differences in altitude of the two meteorological models used in the WORKLIMATE and WORKLIMATE 2.0 projects (initially the BOLAM and subsequently the MOLOCH) compared to the higher resolution model obtained from the "Shuttle Radar Topography Mission (SRTM)".

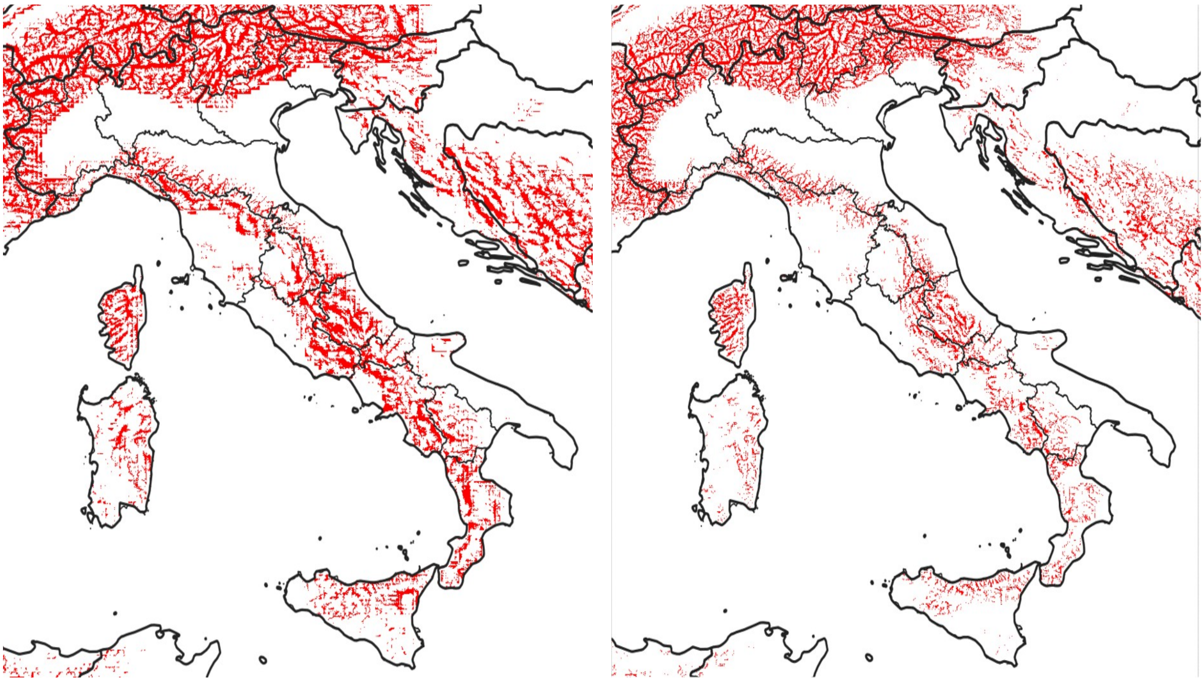

Figure 1: Difference in altitude between the DEM (Digital Elevation Model) of the BOLAM (7 km) and MOLOCH (2.5 km) meteorological models and the DEM at 90 m resolution (https://portal.opentopography.org/raster?opentopoID=OTSRTM.042013.4326.1). The areas in which the difference in altitude is greater than 200 m are indicated in red, i.e. those areas for which the BOLAM and MOLOCH models consider an altitude at least 200 m higher than the real one.

The areas in red in Fig. 1 (mainly deep valley in areas with complex orography) represent the areas where the altitude of the model's DTM is at least 200 meters higher than that of the high resolution DTM (90 m).

It is quite evident that going from a model at 7 km to one at 2.5 km the red areas are less large, demonstrating how much the model's DTM becomes more faithful to the real orography. Similar maps could be developed for the areas where the model altitude is lower than the real one (mainly ridges and areas above a certain altitude).

Even a wrong orographic and morphological depiction of the coastline could result in an underestimation of the daytime heat risk close to the shore, particularly if the model grid point is located at the interface between land and water. When interpreting and assessing the risk in light of the other indicated uncertainties, these are the kinds of situations that need to be taken seriously.

The personalized risk calculation procedure used in the WORKLIMATE forecasting system starting from forecast meteorological data can be consulted in a 2019 publication (https://www.mdpi.com/1660-4601/16/16/2890). This phase can also be a source of further forecast uncertainty.

The standard worker profile (175 cm tall, 75 kg weight), who is not acclimated to the heat and engages in moderate to severe activities directly exposed to sunlight or shade, is used to customise the heat risk forecast. A typical worker doesn't wear personal protective equipment (PPE) or in any case wear clothing that does not cause a further increase in risk.

The percentage ratio between the forecasted WBGT and the above-discussed standard worker's customised WBGT defines the heat risk level forecast. The forecasted risk level will be null (green) if the forecasted WBGT is less than 80% of the personal customised WBGT; if it is between 80% and 100%, the heat risk level will be low (yellow). The heat risk level can be classified as moderate (between 100 and 120%, orange) or high (over 120%, red) if the forecasted WBGT exceeds the customised WBGT threshold.

Conditions classified as moderate or high heat risk involve WBGT values that are higher than the customized WBGT threshold and necessitate significant actions. These conditions will be taken into account in a preventive system designed to offer behavioural or organisational solutions to safeguard employees from the impacts of environmental heat.

It is crucial to keep in mind that even low heat risk conditions - which indicate circumstances in which the forecast WBGT value is lower than the customized WBGT threshold - represent circumstances that should not be underestimated, particularly if they last for several hours or days or involve procedures that call for the use of bulky work clothes or waterproof personal protective equipment.

We must plan and execute ad hoc protective measures for workers who are thermally vulnerable, even in the presence of low risk areas (yellow areas).

Even the heat risk forecast provided on the basis of the "anti-heat" ordinance in force in some Italian regions is always based on the WBGT indicator calculated using the data provided by the MOLOCH meteorological model. In this case the heat risk is calculated considering the situation expected at 12:00 based on the worker profile indicated in the regional ordinance, so this also in the case of a healthy worker (without individual conditions of thermal susceptibility), not acclimatized to the heat, exposed to sun at 12:00 and engaged in intense physical activity. Below are the regional "anti-heat" ordinances issued from 2021 based on the forecasts provided by the WORKLIMATE forecasting system:

- 2021
  - Regione Puglia, Ord. N. 182 del 26/06/2021
  - Regione Basilicata, Ord. N. 33 del 01/07/2021
  - Regione Calabria, Ord. N. 44 del 30/06/2021
  - Regione Molise, Ord. N. 38 del 29/06/2021
- 2022
  - Regione Puglia, Ord. N. 69 del 21/06/2022
  - Regione Basilicata, Ord. N. 28 del 23/06/2022
  - Regione Calabria, Ord. N. 11 del 13/07/2022
- 2023
  - Regione Puglia, Ord. N. 60 del 24/06/2023
  - Regione Basilicata, Ord. 7 del 29/06/2023
  - Regione Calabria, Ord. N. 2 del 11/07/2023
  - Regione Campania, Ord. N. 2 del 20/07/2023
  - Regione Calabria, Ord. N. 3 del 21/07/2022

An example of an "anti-heat" ordinance in force in 2023 in the Puglia region can be consulted at the following address (https://press.regione.puglia.it/documents/65725/0/ordine+258_caldo+agricoltura+20

22_signed.pdf/fba44af6-7ea2-3aab-8e2c-01a35eb6a7fa?t=1655813235905), while a project publication on health prevention policies for occupational exposure to heat implemented in Italy can be consulted at this address (https://oem.bmj.com/content/79/3/215).

The third section of the WORKLIMATE forecasting system prototype, therefore the forecast of the areas in which it is possible to exceed the maximum daily temperature of 35 °C, uses the forecast of the maximum daily air temperature forecasted on the basis of the MOLOCH meteorological model, with a 2.5 km resolution.

The legend of the three forecast maps (today, tomorrow and the day after tomorrow) indicates the possible exceeding (in red) or not exceeding (in white) of the maximum daily air temperature threshold of 35 °C. This information is provided in support of the joint INAIL-INPS press release (https://www.inps.it/content/dam/inps-site/it/scorporati/comunicati-stampa/ 2022/07/Allegati/3153_CS-Inps- Inail-.pdf) and which provides instructions for ordinary layoffs in the event of suspension or reduction of work activity due to high temperatures.

The WORKLIMATE 2.0 forecasting system represents in this prototype phase a first orientation tool available to public health authorities and prevention operators: until today the prototype of the heat warning system that is available on the project website allows information to be displayed with a graphic detail at regional level and the extraction of some forecast information also at local (city) level. A Web App for the customized forecasting of various WORKLIMATE 2.0 products is also being tested and is dedicated to the employment sector.