POLITECNICO MILANO 1863

ENVIRONMENTAL INTELLIGENCE LAB

Thesis title

Heatwaves and Warm Nights Detection via Machine Learning

Short description

Heatwaves are severely impacting events for ecosystems, human communities, and key socio-economic sectors(1). For example, in agriculture and food production(2), very hot daytime temperatures have a well-known effect on plants evapotranspiration, leading to water-stress conditions that may compromise yield, even in presence of established irrigation plans; on the other hand, recurrent episodes of elevated night temperatures (warm nights) may favor the proliferation of pests and/or the diffusion of diseases. Likewise, energy demand can be strongly affected by both conditions, since warm nights may prevent the expected night-time demand drop following the daily energy request peak. Moreover, the occurrence of both heatwaves and warm nights is projected to increase sharply even in a mitigated global warming scenario.

A large part of the recent literature(3) has focused on detecting heatwaves based on maximum temperatures or daily mean temperatures. However, these indices are defined at grid-point level and do not account for the areal extent, spatial structure, and time-evolving patterns of heatwave events, which are highly relevant to assess the affected areas and associated impacts. On the other hand, night-time temperature is likewise a crucial factor in determining heatwave magnitude(4), and its societal impact may be complementary to that of extremely high diurnal temperatures. Processes involved in the occurrence of night- and day-time extreme heat are not necessarily the same, since the highest maximum temperature generally occurs under dry air conditions, while the warmest nights are usually characterized by high relative humidity that does not allow heat dispersion and thus air cooling.

The aim of this thesis is to advance the detection of heatwaves and warm nights by using a data-driven approach that relies on advanced feature extraction algorithms to identify relevant precursors of these events from a pool of local and remote candidate predictors. The student is expected to carry out the following activities:

1. Literature review: reviewing the state of the art of existing indexes used for detecting heatwaves and warm nights
2. Data collection: acquisition of observed/reanalysis data (e.g. ERA5(5)) of relevant hydroclimatic variables
3. Computational experiments:
   - Data preprocessing and analysis of candidate precursors
   - Identification of the most relevant precursors using feature extraction algorithms (e.g., WQEISS())

Relevant courses and knowledge: Natural Resources Management

Number of Students: 1 or 2

Requisites*:* The student should be comfortable with data handling and programming skills (Matlab or Python).

References

(1) Stillman J.H. (2019), Heat waves, the new normal: summertime temperature extremes will impact animals, ecosystems, and human communities, *Physiology*

(2) Lobell et al. (2007), Historical effects of temperature and precipitation on California crop yields, *Climatic Change*

(3) Russo et al. (2015), Top ten European heatwaves since 1950 and their occurrence in the coming decades, *Environmental Research Letters*
(4) Perkins, S.E. and L.V. Alexander (2013), On the measurement of heat waves, *Journal of Climate*
(5) https://climate.copernicus.eu/climate-reanalysis