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A statistical approach for capturing the synergistic temporally distributed effects from environmental stressors on health outcomes

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The adverse effects of heat and cold extremes on human health have been well-documented. It is imperative however to understand the possible synergistic effects of thermal stress and other potentially harmfull exposures such as low ambient air quality. The statistical modelling framework of Distributed Lag Models (DLMs) is a ubiquitous tool used to estimate the temporally distributed effects of thermal stress on health metrics such as mortality.

In this work, we show how to use of Generalized Additive Models with penalised regression splines to fit DLMs in order to capture the synergistic effects of temperature extremes and other harmful factors. Implementation in the R package `mgcv' offers a practically straightforward way of training the models to health and exposure data. Synergistic effects from both continuous exposures such as air pollutants' concentrations or categorical metrics such as presence or absence of heat-waves can be incorporated via the concept of hierarchical structures.

We illustrate the approach to tackle various research challenges. Specifically, we present heat-risk and cold-risk for the Mediterranean island of Cyprus, and how the risk is modified during heat-waves and cold-waves. In addition, we demonstrate the quantification of the synergistic effect of temperature and air pollution on mortality for the city of Chicago, while exploring the option to consider different lag-periods for temperature and PM10.