Establishment of a climatological frame of reference of cold weather for gas transporters

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Objective & Background

Gas transporters regularly have to deal with the increase in energy demand during cold spells in winter to guarantee the continuity and safety of gas supply in France and Europe.

On one hand, they need to ensure that the gas transport network and storage tanks dimensions will be sufficient to handle extreme cold weather, defined as a 50-year return level event, within the next few years, and on the other hand, they need a climatological reference to contextualise the weather and associated gas demand for operational decision making.

GRTgaz, the main French gas transporter, therefore requested Météo-France's expertise to address both needs by first estimating the magnitude of a yearly and month by month 50-year (and 20, 10 and 2-year) return level cold spell (defined using a daily mean temperature smoothed over 3 days) in the current climatic context, based on historical measurements from 1949 to 2021 on weather stations in France, and then by establishing a climatological reference on this perimeter by calculating cumulated heating degree days for cold spells (3, 7 or 14 days periods), each winter month, and the whole winter, as well as their associated return periods in the current climatic context.

Method

Both questions were handled using a similar methodology to ensure consistency within the results.

The studied variables are computed from time series of measured 2-meter air temperature on a selection of weather stations in France over the 1949-2021 period.

An adequate statistical model is chosen to represent the distribution of the variables: a Generalized Extreme Value [GEV] distribution for the cold spells, and a Gaussian distribution for the monthly or winterly cumulated heating degree days.

A dependence on a proxy of the climate change in France (Ribes et al., 2022) is introduced as a covariate in the parameters of each distribution to better fit the measurements, since they can not be considered stationary due to the influence of climate change over the studied period (Robin and Ribes, 2020).

Different versions of the models are then compared using a likelihood-ratio test and further assessed with fitting validation plots.

Finally, the return levels or periods are computed using the best statistical model previously established. Associated confidence intervals are issued from an ensemble of values obtained from a bootstrapping procedure.

Principal Findings

In both investigations, the temporal evolution of the return levels and periods on the 1949-2021 period follows the evolution of the covariate and the tendencies are similar to those of the already documented evolution of the near surface temperature in France (stable between 1950 and 1970, then increasing between 1970 and 1990, and accelerating from 1990 to 2020).

The statistical models used to compute these results seem robust for the yearly and winterly time steps and for short return period events. They might be less reliable for the monthly and for the 20 and 50-year return period results because of the reduced size of the sample (73 years), which highlights the necessity of exploiting confidence intervals alongside the centre values.

1. ROBIN Y. and RIBES A., 2020: Nonstationary extreme value analysis for event attribution combining climate models and observations. Adv. Stat. Clim. Meteorol. Oceanogr., 6, 205–221, (https://doi.org/10.5194/ascmo-6-205-2020)
2. RIBES A. et al., 2022: An updated assessment of past and future warming over France based on a regional observational constraint. Earth System Dynamics, 2022, 13, pp.1397-1415 (https://doi.org/10.5194/esd-13-1397-2022)