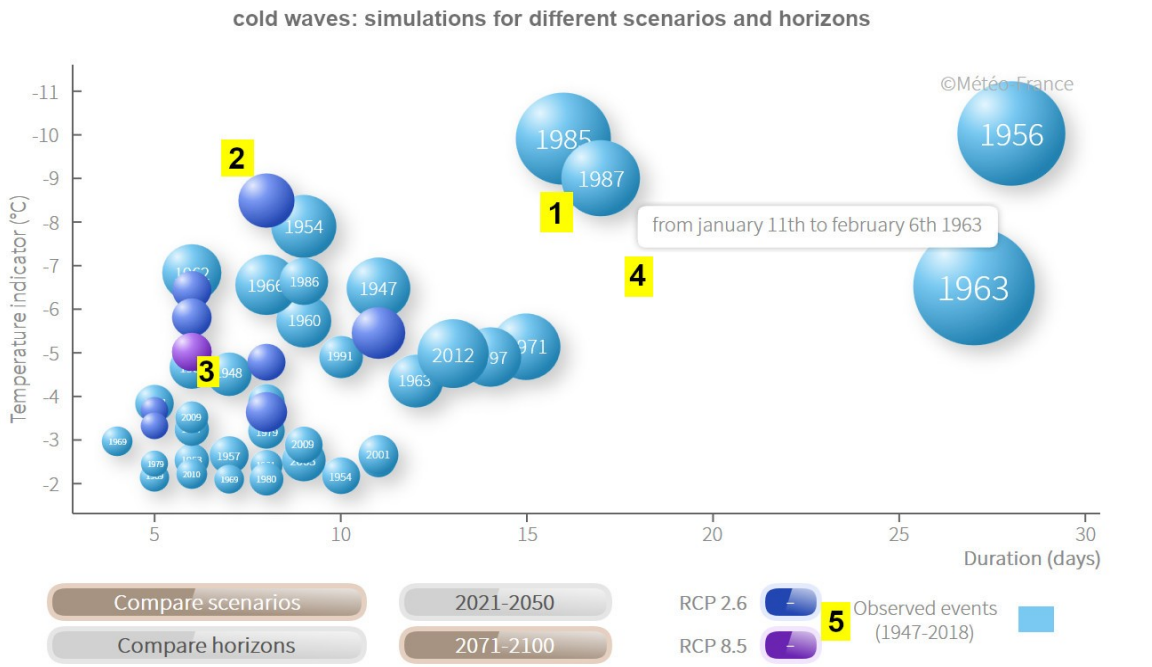
Evolution of cold waves
Past and future climate – metropolitan France

1. Graph readind aid

This graph shows the evolution of cold waves in future climate compared to that observed in past climate. It offers several display options, including :

- compare two greenhouse gas emission scenarios (RCP 2.6 and RCP 8.5) for a given time horizon (2021 – 2050 or 2071 – 2100) ;
- compare two time horizons (2021 – 2050 and 2071 – 2100) for a given greenhouse gas emission scenario (RCP2.6 or RCP8.5).

1.1 Compare the RCP 2.6 and RCP 8.5 scenarios



On this graph we find :

- the cold waves observed in metropolitan France since 1947 (blue bubbles [1]) ;
- for the selected time horizon (2021 – 2050 or 2071 – 2100) the cold waves simulated for RCP 2.6 (dark blue bubbles [2]) and for RCP 8.5 (violet bubbles [3]).

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Each episode is represented by a bubble. Its position and size indicate the characteristics of the cold wave :

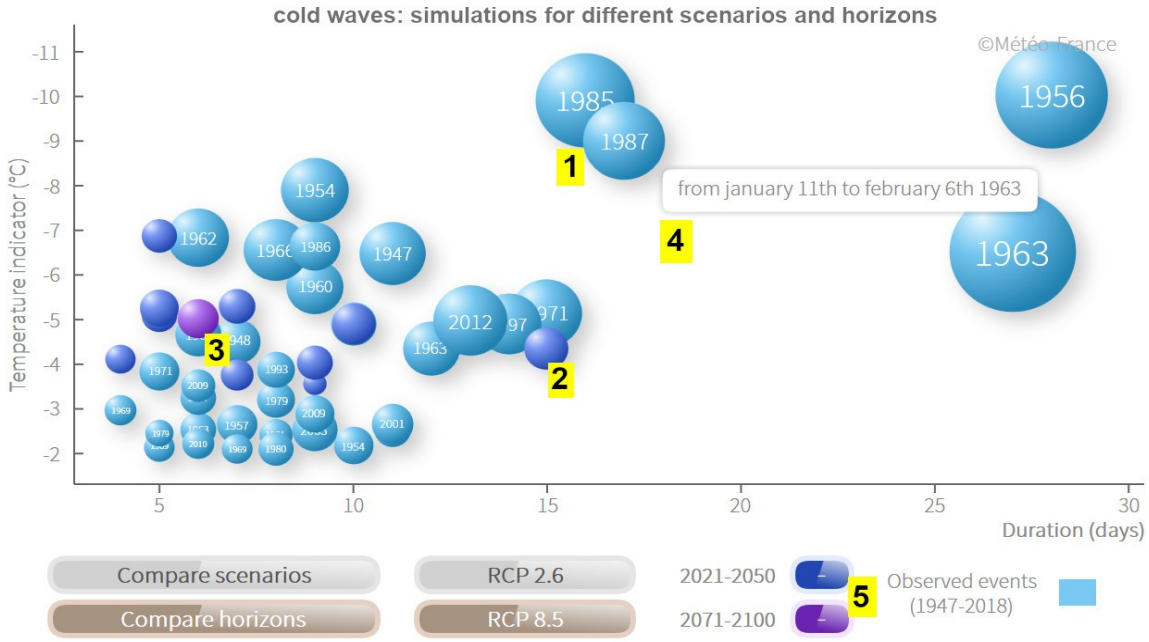
- The horizontal position indicates the duration (in days) of the episode.
- The vertical position indicates the intensity of the cold wave. It is the minimum value of the daily national thermal indicator reached during the episode.
- Size indicates the severity of the cold wave. It is proportional to the cumulative cold during the episode.

For the observed cold waves, the dates of their occurrence appear when the mouse moves over them [4].

The [5] buttons are used to activate the display of the corresponding RCP scenarios.

Note : only cold spells of 4 days or more are shown

1.2 Compare the time horizons 2021 – 2050 and 2071 – 2100



On this graph we find :

- the cold waves observed in metropolitan France since 1947 (blue bubbles [1]) ;
- for the selected RCP scenario (RCP 2.6 or RCP 8.5), the simulated cold waves for the 2021 – 2050 horizon (dark blue bubbles [2]) and for the 2071 – 2100 horizon (violet bubbles [3]).

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2. Definitions

Average daily temperature :

- Daily minimum temperature (TNq) = minimum temperature observed between D-1 to 18 UTC and D to 18 UTC.
- Daily maximum temperature (TXq) = maximum temperature observed between D at 06 UTC and D+1 at 06 UTC.
- Average daily temperature (TMq) = (TNq + Txq)/2.

3. Data and methods

3.1 Observed data

For the past climate, we use the national thermal indicator, calculated over the period from 1947 to the present.

National thermal indicator

The national thermal indicator is defined as the average of daily average air temperature measurements at 30 weather stations distributed in a balanced way over the metropolitan territory and selected from the work on homogenization.

3.2 Simulated data

For the future climate, we rely on the regionalized climate projections of the Aladin-Climat model of Météo-France, for the emission scenarios RCP 2.6 and RCP8.5. These projections provide, in grid points, a daily simulation of temperatures over France. For each day, a national thermal indicator is simulated by averaging the 30 grid points closest to the 30 stations used to develop the observed indicator. This national thermal indicator is then simulated over two 30-year periods: 2021 – 2050 (near horizon) and 2071 – 2100 (far horizon).

Climate modelling

Climate simulations are carried out using general circulation models, which take into account different reference scenarios of the evolution of radiative forcing called RCP (Representative Concentration Pathway). Compared to forecasting models, an essential feature of climate models is that they are not

at all adjusted to observations. The climate system evolves completely freely; it receives energy in the form of solar radiation and loses energy in the form of infrared radiation emitted into space. The simulated climate (temperature, precipitation, etc.) is the result of this adjustment between received and lost energy. These models make it possible to develop climate projections that are representative of different possible scenarios of climate change.

RCP scenarios

Two RCP scenarios are proposed :

- RCP 8.5, corresponding to a scenario without climate policy.
- RCP 2.6, corresponding to a scenario with climate policies aimed at reducing CO2 concentrations.

3.3 Identification of cold waves

Cold waves are identified from the thermal indicator observed over the period 1947 to the present day and from the simulated thermal indicator over both near and far horizons. Several criteria based on the annual statistical distribution (calculated over the period 1981 – 2010) are applied:

- An episode is detected when a daily value of the thermal indicator reaches or falls below the 0.05 percentile.
- The episode includes days adjacent to the day(s) previously detected for which :
  - the daily thermal indicator does not permanently exceed the 2.5 percentile (referred to as the S threshold in the figure below). By durably means three days or more.
  - the daily thermal indicator does not exceed the 5.0 percentile.
- The severity of the episode corresponds to the intensity integrated over the duration of the episode.