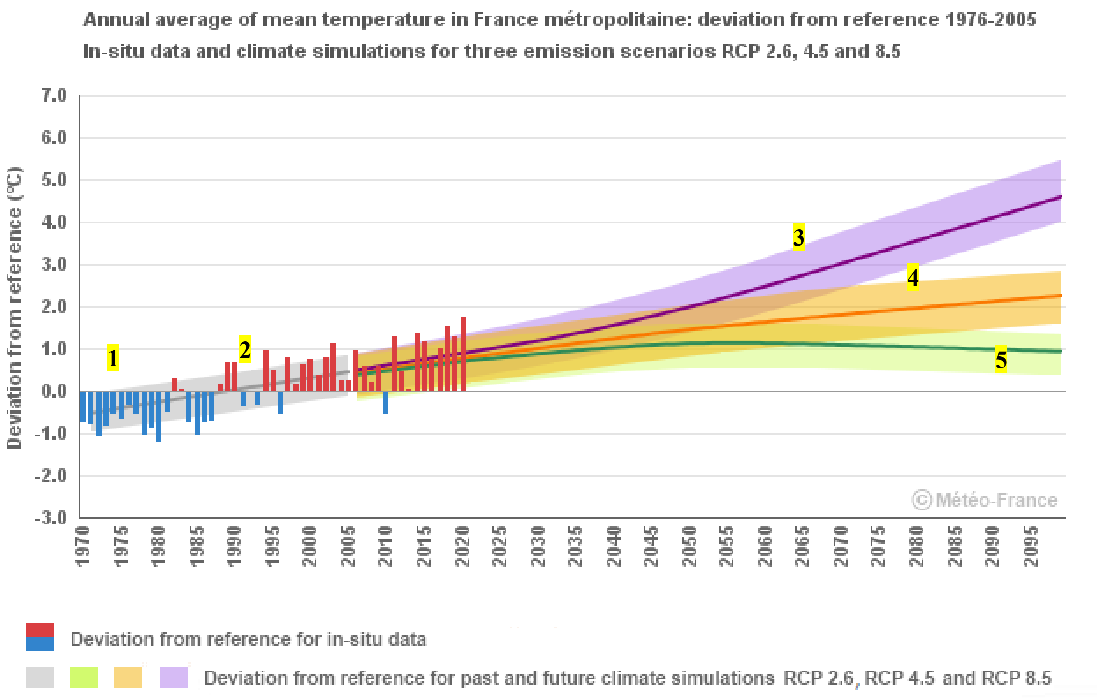
Evolution of annual / seasonal temperatures
Past and future climate – metropolitan France

1. Graph reading aid



5 data sequences are shown in the graph:

Sequence 1 'histogram in blue and red':
Deviation from the reference (average across the period 1976-2005) of the mean annual / seasonal temperature observed (national thermal indicator cf. §3.1 Observed data).
The values lower than the mean value established across the period 1976-2005 (the reference) are represented in blue, the higher values in red.

Sequence 2 'grey streak':
Deviation from the reference (average across the period 1976-2005) of the mean annual/seasonal temperature simulated by a set of models (DRIAS 2020) across the period 1970 – 2005.
The streak corresponds to the interval of the greatest probability (between the percentiles 17% and 83%)

Sequence 3 'purple streak':
Deviation from the reference (average across the period 1976-2005) of the average annual / seasonal temperature simulated by a set of models (DRIAS 2020) for the high emissions scenario (RCP 8.5) across the period 2006-2100.
The streak corresponds to the interval of the greatest probability (between the percentiles 17% and 83%)

Sequence 4 'orange streak':
Deviation from the reference (average across the period 1976-2005) of the average annual / seasonal temperature simulated by a set of models (DRIAS 2020) for the moderate emissions scenario (RCP 4.5) across the 2006-2100.
The streak corresponds to the interval of the greatest probability (between the percentiles 17% and 83%)

Sequence 5 'green streak':
Deviation from the reference (average across the period 1976-2005) of the average annual /seasonal temperature simulated by a set of models (DRIAS 2020) for the low emissions scenario (RCP 2.6) across the 2006-2100.
The streak corresponds to the interval of the greatest possibility (between the percentiles 17% and 83%).

2. Definitions

Meteorological seasons :
- Winter of the year A : December of the year A-1 to February of the year A
- Spring: March to May
- Summer : June to August
- Autumn : September to November

Daily mean temperature:
- Daily minimum temperature (TNq) = minimum temperature observed between J-1 at 18:00 UTC and J at 18:00 UTC
- Daily maximum temperature (TXq) = maximum temperature observed between J at 06:00 UTC and J+1 at 06:00 UTC
- Daily mean temperature (TMq) = (TNq + TXq)/2

Deviation from the reference of the annual / seasonal mean temperature (observed or simulated):
- Mean annual / seasonal TMs of daily average temperatures = Average across the year / the season of daily mean temperatures TMq
- Reference average across the period 1976- 2005 (Ref TMs) = average of 30 values of TMs
- Deviation from the reference = difference between the annual / seasonal average (TMs) and the reference average (Ref TMs)

3. Data and methods

3.1Observed data

National thermal indicator:
The national thermal indicator (daily) is defined as the average of daily measures of the mean air temperature in 30 weather stations distributed equally throughout the metropolitan territory and selected from work on homogenisation.

Homogenised sequences:
The sequences of measures are not immediately usable for the analysis of climate evolutions. They are affected by changes in measurement conditions over the course of time, such as alterations in the position of the measuring station, or sensor changes. These changes can cause breaks, which can be in the same order of magnitude as the climatic signal. Homogenisation is a statistical treatment the aim of which is to detect and correct breaks in the raw sequences, so as to produce reference sequences adapted to quantify climate change.

3.2 Simulated Data

Climatic modelling:
Climate simulations are created from general circulation models, which take into account different reference scenarios of the evolution of radiative forcing known as RCP (Representative Concentration Pathway). With respect to forecasting models, one essential feature of climatic models is that they are not drawn towards observations. The simulated climatic system evolves unhindered; it receives energy from sun rays and loses it in the form of infra red radiation emitted towards space. The simulated climate (temperature, precipitations, etc.) is the result of this adjustment between received energy and lost energy.
Energy conservation and more generally energy exchanges are therefore fundamental to a climatic model, and their modelling is a climatologist's prime concern.
These models allow the elaboration of climatic projections representative of various possible scenarios of climate evolution.

The RCP scenarios:
3 RCP scenarios are considered:
RCP 8.5, corresponding to a scenario with high greenhouse gas (GHG) emissions.
RCP 4.5, corresponding to a scenario with moderate greenhouse gas (GHG) emissions.
RCP 2.6, corresponding to a scenario with low greenhouse gas (GHG) emissions.
The number which follows the acronym RCP is the radiative forcing for the year 2100 in Watts per square metre.

The climatic projections used:
1. The DRIAS 2020 set, consisting of a multi-model ensemble (12 GCM/RCM pairs) derived from Euro-Cordex modelling, then corrected by the Adamont method (Météo-France) :
The main deliverable of the project Euro-Cordex is the availability across Europe of a set of climate simulations based on different models using statistical and dynamical down-scaling methods, forced by global methods used in the last report of the IPCC.
From this dataset a selection was made in order to determine a subset, allowing the best coverage of the range of future changes in temperature and precipitation over the territory of metropolitan France. This dataset was then reprocessed for the French territory by applying a correction method (Adamont) using the Safran reanalysis (this 1959-2013 reanalysis constitutes the reference for the observed climate). The resulting multi-model set is composed of 12 models for climate projections associated with RCP8.5, 10 models for RCP4.5, 8 models for RCP2.6 and 12 models for past climate simulations.

2. The statistical products elaborated from the multi-model set DRIAS 2020: the percentiles
The multi-model approach allows the representation of the dispersion of models, that is to say the set of values that can take a given parameter, and therefore take into account the uncertainty linked to the modelling. The percentile is each of the 99 values which divides the given data into 100 equal parts, so that each part represents 1/100 of the sample of the population.
For example, the median, which corresponds to the percentile 50%, is the threshold value for which 50% of the distribution values are higher.
These percentiles can be represented in the form of streaks for the time sequences, or of maps representing the values of percentiles in each grid point of the modelled surface.
In the DRIAS 2020 dataset, several percentiles and extreme values are available; the temperature evolutions presented here are based on the 17 and 83% quantiles which constitute the plume envelopes associated with each scenario.

4. References

Drias, climate futures
www.drias-climat.fr

Observatoire National sur les Effets du Réchauffement Climatique (National observatory for the effects of global warming): **French climate reports in the 21st century**
http://www.developpement-durable.gouv.fr/Volume-4-Scenarios-regionalises.html

Euro-Cordex
http://www.euro-cordex.net