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EXTREME TEMPERATURE IN FRANCE BY 2100

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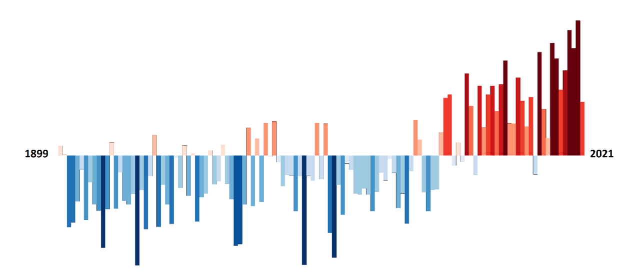
Climate Change

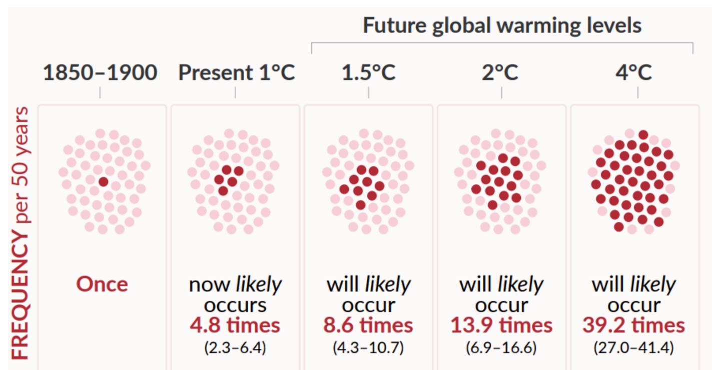
Increase in mean temperature.



Annual Average Temperature over France

Source: showyourstripes.info. Average 1971-2000, using the Berkeley Earth temperature dataset.

Increase **in Frequency, Severity** of Extreme temperature events.
Ex: 2003, 2006, 2019, 2022



Nuclear safety Issues: Jeopardy of Critical equipment, Constructions, Health.

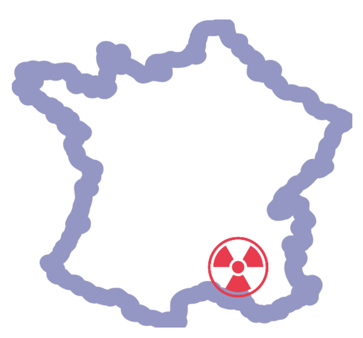
Our Aim

Quantify the probability of **extreme temperature** levels by horizon **2100** and **at a point of interest.**

Data

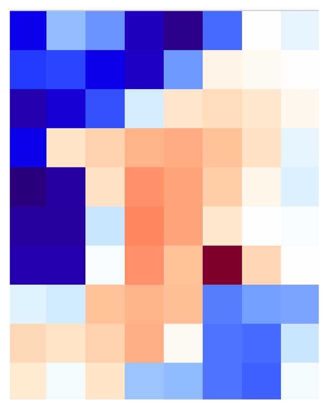
Application:

Tricastin Nuclear Site



EDF's Exceptional temperature level:
46° to 48°C

France on 26 August 2066



UKESM1.0-LL model output prepared for CMIP6 ScenarioMIP

Global Climate Models

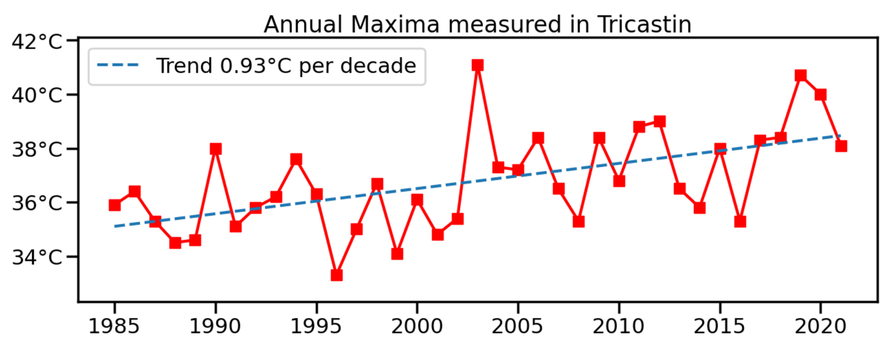
- *Physic based* modelization.
- Allow historical and scenario (future) runs.
- Large, discrete Grid.
- Using TX (Daily Maximal temperature) Annuel Maxima.

28 CMIP6 models with *SSP585 scenario.*

Local Observations

- Meteoriological data of TX (1985-2022)
- Local information
- *Limited depth* (37 years))
- No information on future

Météo France observations in Tricastin:



Statistical Model

Model

- **Annual Maxima** as a Generalized extreme value distribution (GEV)
- Non stationarity: **Time dependency** on a covariable

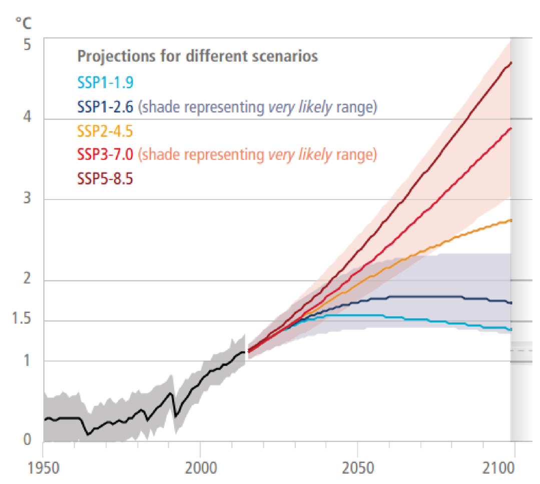
$$Y \sim \mathbb{P}_t = GEV(\mu_t, \sigma_t, \xi)$$

$$\mathbb{M}(t) = \begin{cases} \mu(t) & = \mu_0 + \mu_1 X_t \\ \sigma(t) & = exp(\sigma_0 + \sigma_1 X_t) \\ \xi(t) & = \xi_0 \end{cases}$$

Time dependency

Covariable is Global Mean Surface Temperature (GMST):

- **Proxy of climate change**
- Scenario Dependent
- **Relationship** with Time not linear



Quantity of Interest

Equivalent Reliability z^{ER}_{T2-T1} (Liang et al. 2016):

$$P[\bigcap_{t=T_1}^{T_2} (Y_t < z^{ER}_{T_2-T_1})] = (1 - \frac{1}{T})^{T_2 - T_1 + 1}$$

- Comparable to stationary return Level T
- **Cover a time period** T1 to T2

Our Method

From Robin 2020:

1. **GEV adjustment** on each Climate Model
2. **Multisynthesis**
3. **Observational constraint**

Step 1: Adjustments

Adjustment of Non-stationary Gev on **each Climate Model**

28 different distributions -> **28 sets** of GEV parameters.

Adjustments **differs** between models.

Step 2: Multisynthesis

Synthesis of 28 Climate models in one **single multimodel distribution.**

Model-truth exchangeability: Each model a realization.

Construction **of Bayesian Prior: Multivariate Gaussian law** of GEV parameters

Step 3: Bayesian Constraint

Using **observation data**
Bayesian Constraint in 2 steps:

$$\mathbb{P}(\theta | X^0)$$

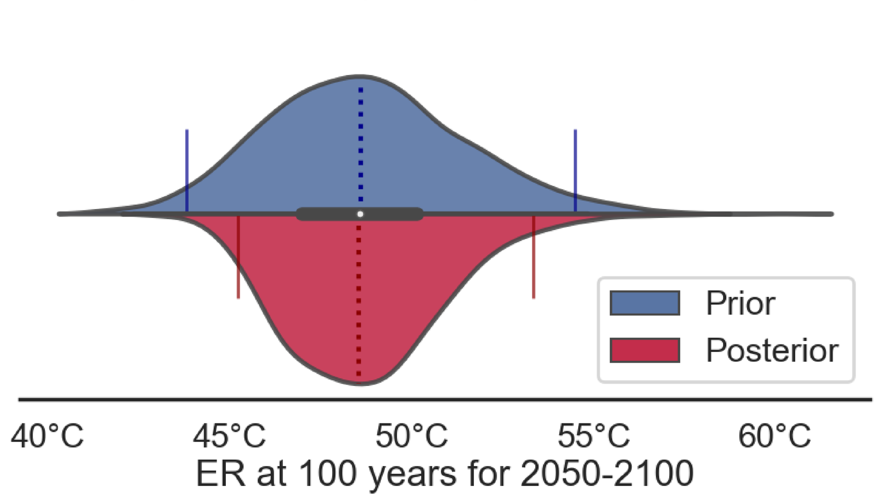
- **Explicit expression** for covariate constraint.

$$\mathbb{P}(\theta | Y^0 \cap X^0)$$

- **Markov chain Monte Carlo Algorithm** for Maxima constraint.

Results

Equivalent Reliability of 100 years over 2050-2100



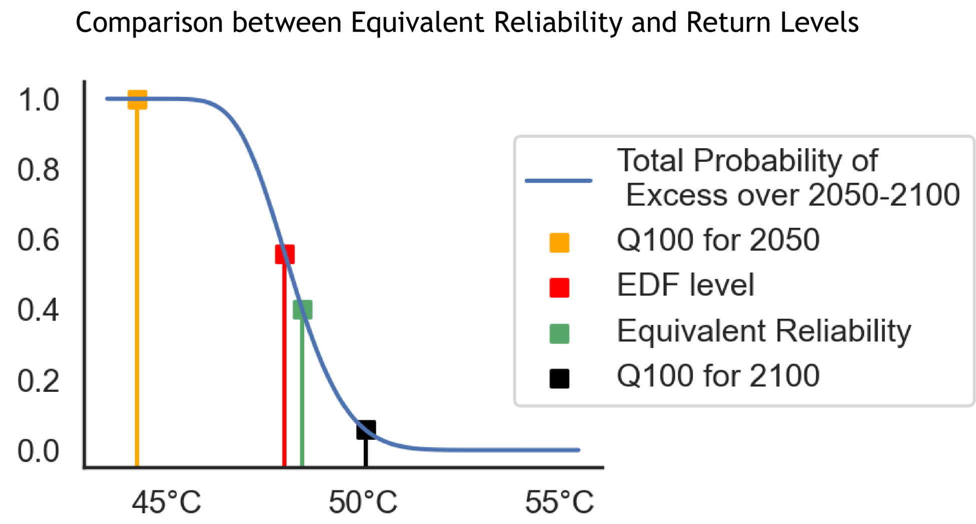
Constraint creates **narrower distribution.**

Quantile 5% from 43.7°C to 45.2°C
Quantile 95% from 54.4°C to 53.3°C

Median value of 48.6°C
Do not vary much, only 0.1°C.

Over 50 years, an event of Annual probability of 1/100 is **no longer rare.**
Around 41%

Comparison between Equivalent Reliability and Return Levels



Further Devellopments

For Algorithm

- M-H + Gibbs hybrid: Perturbation and acceptation on each parameters individually
- Sensibility simulations
- Hierarchical Bayesian representation
- Construction of the prior
- MCMC alternatives such as INLA (Integrated Nested Laplace Approximations)

Others Possibilities

- Use of Regional Climate Model
- Other methods like Statistical downscaling
- Bias correction of observations
- Using geostatistics / krigeage to sample local observations using several meteorological stations

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IRSN/FRM-605 ind. 2

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