Le réseau de transport d'électricité

icem 2023

Adaptation of the French Transmission Network to Climate Change

Underground Lines Resilience

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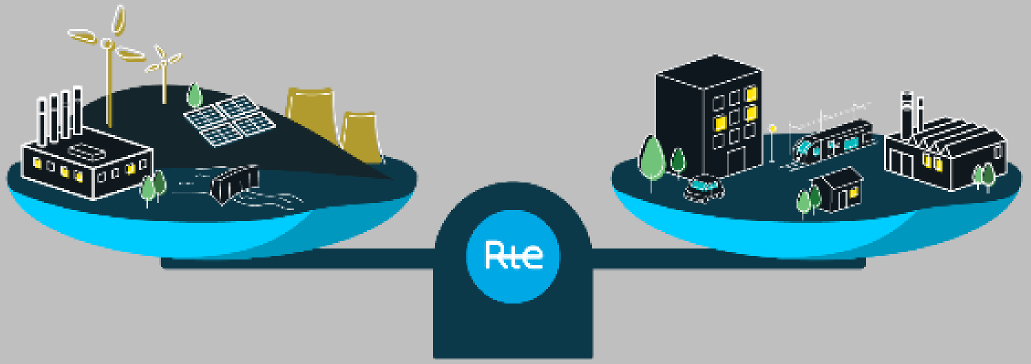
SOMMAIRE

Outline

The power network is dependent on weather and climate …

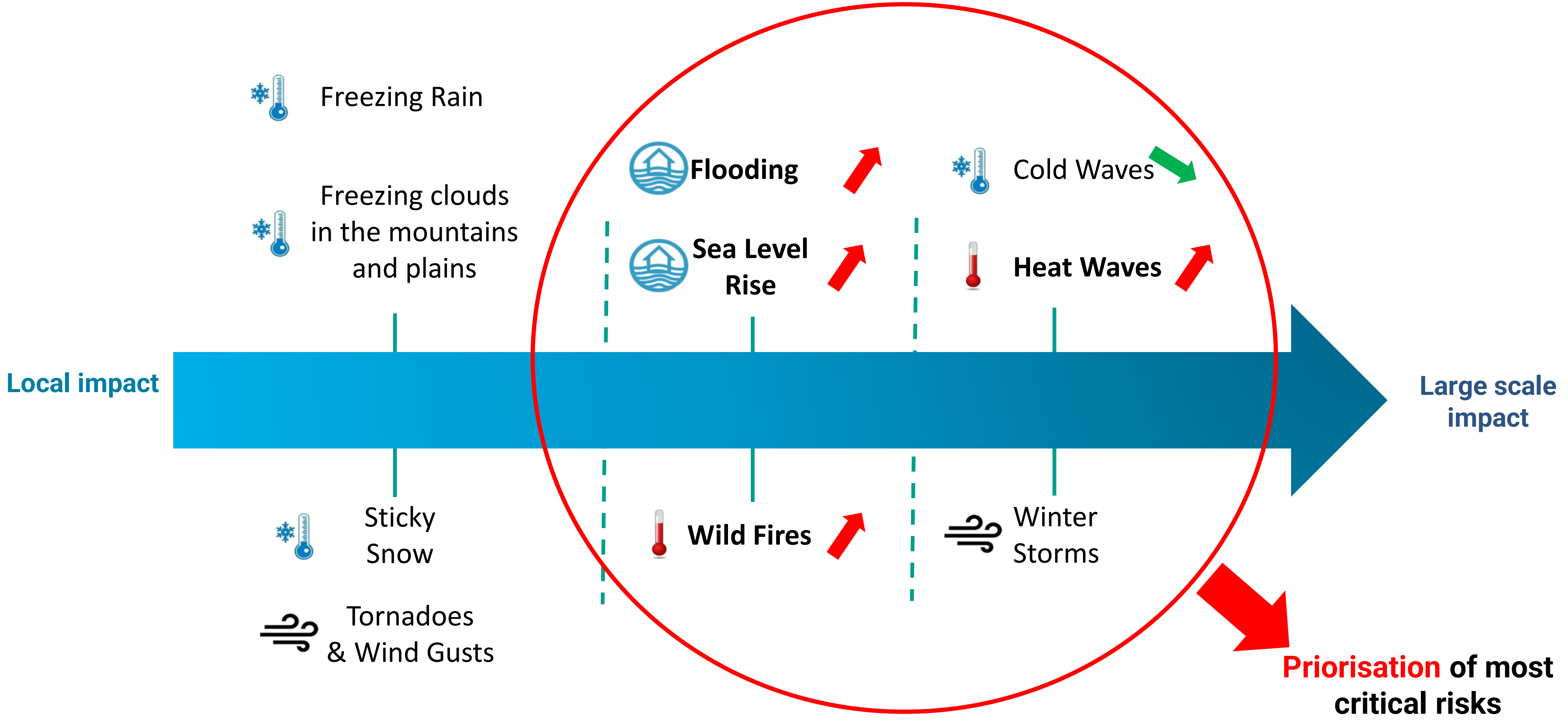
Supply / Demand Balance
Resource Adequacy Assessment



… at all time scales

Climate Change & REs Development will increase the dependance
➔ Weather & Climate Services are a critical ingredient of the energy transition

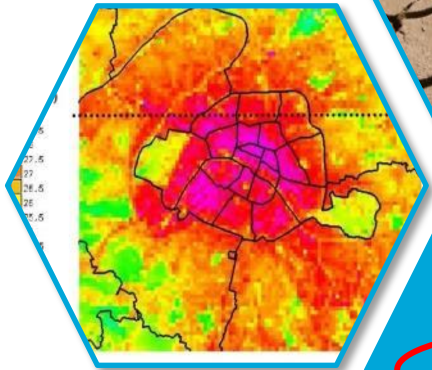
First step: identification and classification of risks



Addressing most critical risks

Overhead Lines & Pylons
Underground Lines
Power stations

Soil Wetness / Droughts



Heat waves

Flooding (sea level rise & marine submersion)

Flooding (rivers)

Climate data under consideration: 1- Current climate

ERA5-land

- 2001-2022
- 0.2° resolution, daily average
- T2m + average Soil temperature in Layer 1 [0.3-1m] and Layer 2 [1-2.9m]

HIRLAM

- 2001-2014
- 0.2° resolution, daily average
- Computation of mean temperature in the same layers

Climate data under consideration: 2-Reference Projections

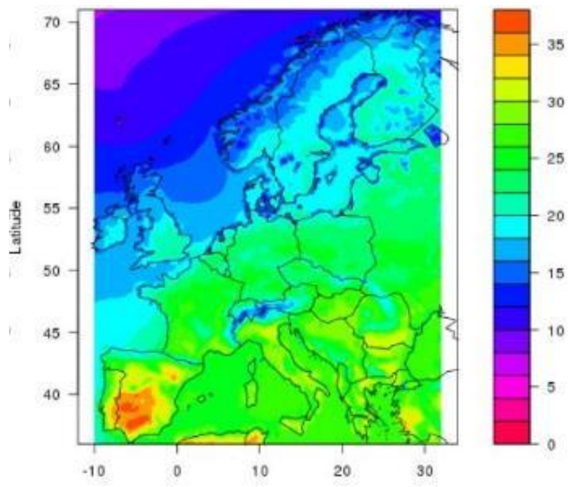
Simulated data : (Météo-France)

<u>Adjusted against HIRLAM 1985-2014</u>

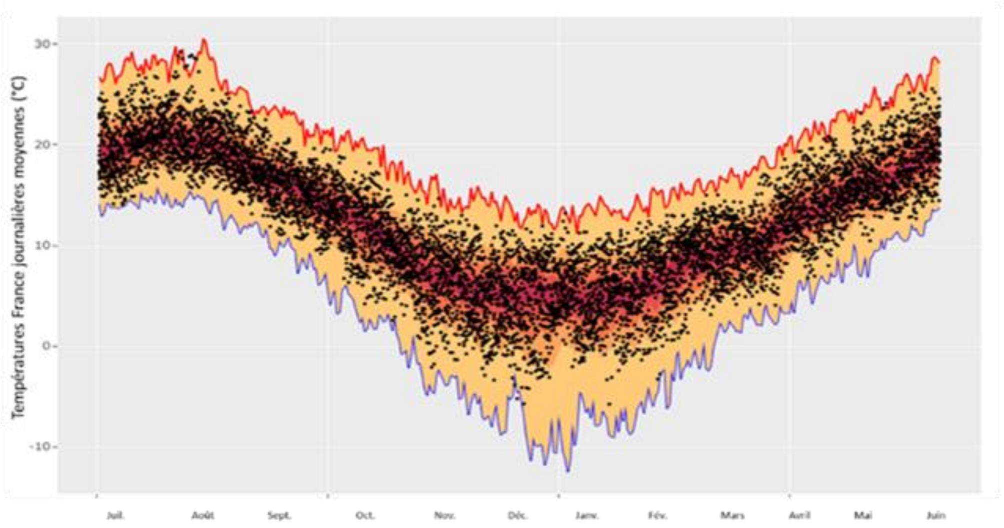
3 simulations sets with « constant climate » (constant CO_2 levels)

- 200 years « climate 2000 »
- 200 years « climate 2050 » RCP4.5
- 200 years « climate 2050 » RCP8.5

Data on more than 37,000 grid points over Europe



Source Météo-France



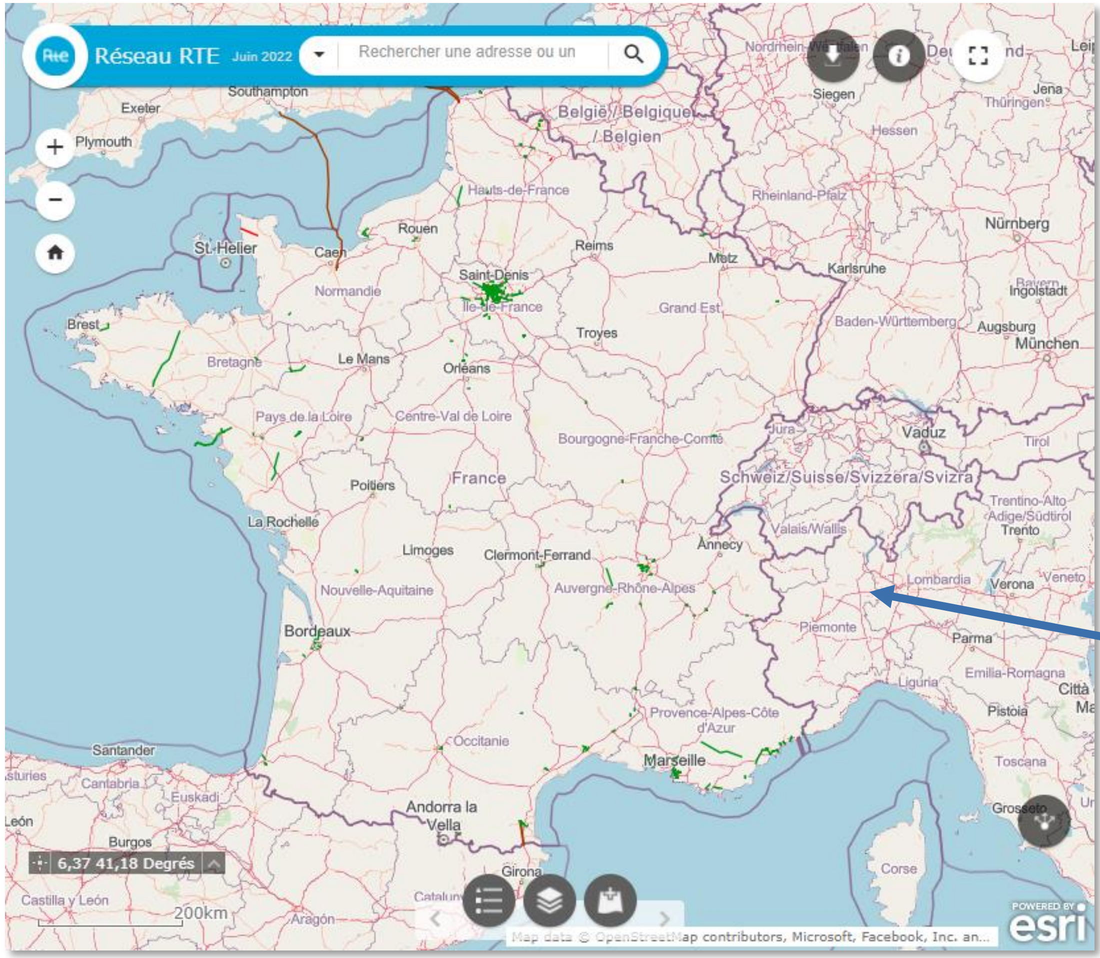
Black dots represent the actual observations over the last 33 years
Bias correction with Hirlam Reanalysis
Extrapolation of extreme temperature values

Available data

- **Temperature T2m and -1m**
- Cloud Cover
- Wind Speed
- Solaire Irradiance
- Precipitation & river flow

200 years, hourly time resolution
37 000 points over Europe

Our network (63 kV to 400 kV)



>106,000 km
of power lines
and 2 783 substations
currently in operation

22,750 km
of optical fibres

Of which underground lines (mainly 63-90 kV) represent:

> 7,000 km (2022), likely to increase significantly in the next decades

Mainly in urban and protected areas and for offshore wind farms connections landing

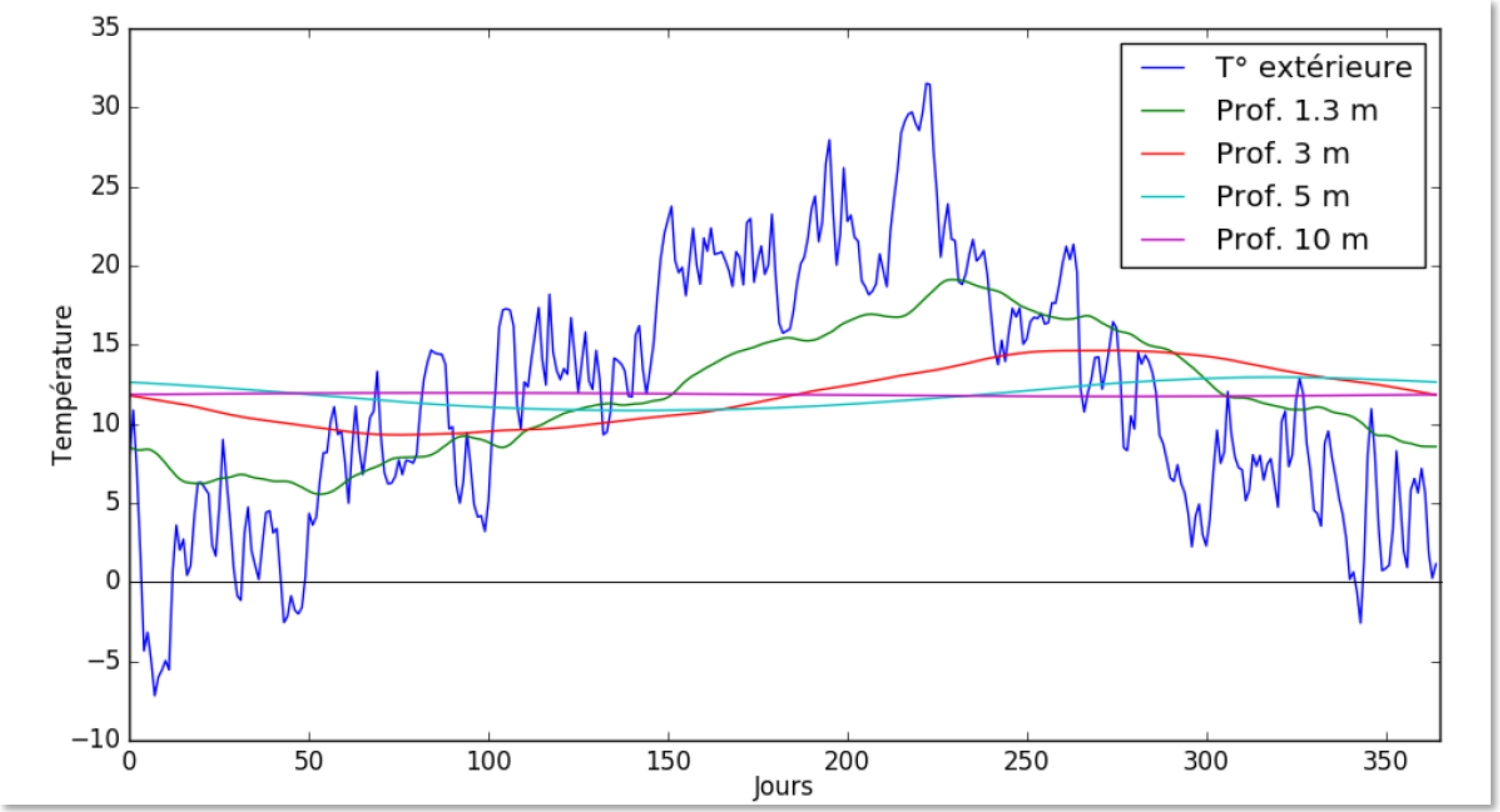
The dimensioning requires the max temperature in the ground

Current heat transfer model

$$\theta(y,t) = \theta_0 + \theta_1 \times e^{-y/\delta} \times \cos\left(\omega t + \varphi - \frac{y}{\delta}\right)$$

$$\delta = \sqrt{\frac{2\lambda}{\mu c \omega}} = \sqrt{\frac{2a}{\omega}} \qquad a = \frac{\lambda}{\mu c}$$

λ : soil thermal conductivity (in W/m/K)
μ : soil density (in kg/m3)
c : soil specific heat capacity (in J/kg/°C)
a : soil thermal diffusivity (in m²/s)

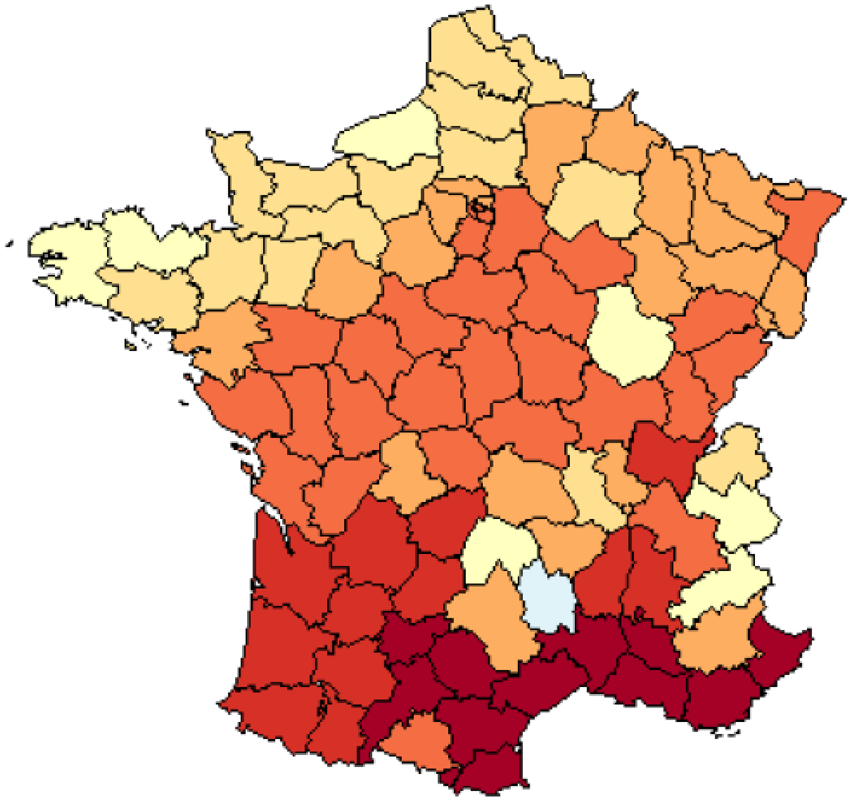


NUTS2 resolution, 2 values per zone (1 for winter, 1 for summer) max of the NUTS2 grid points daily average temperature (rounded to the upper integer value)

Current heat transfer model - Maps

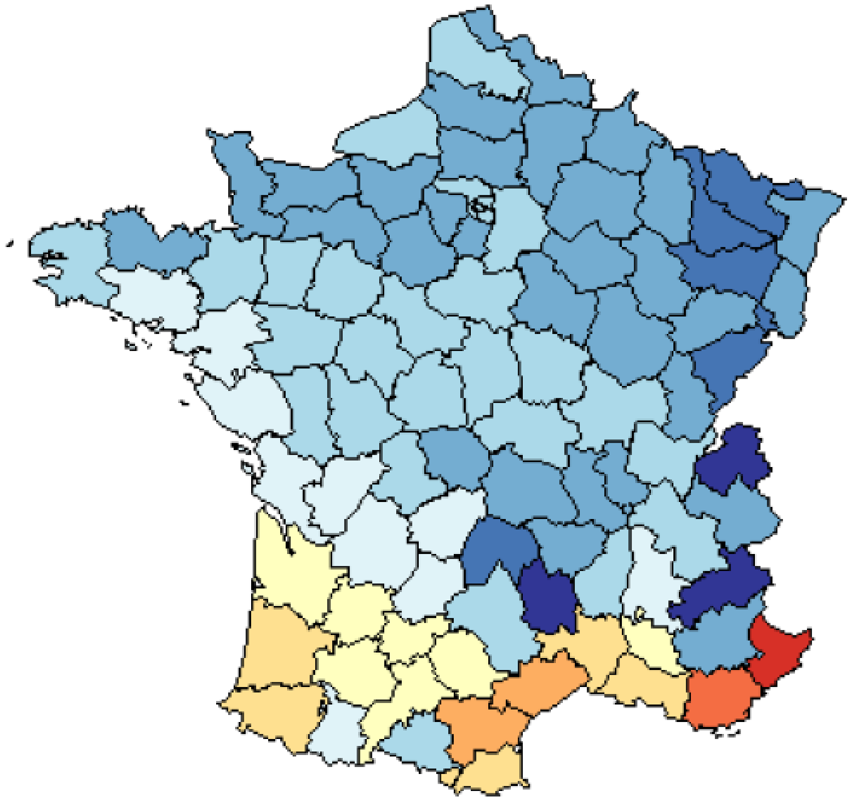
Depth = 3m

Summer



T° min :	16°C
T° max :	24°C

Winter



T° min :	12°C
T° max :	21°C

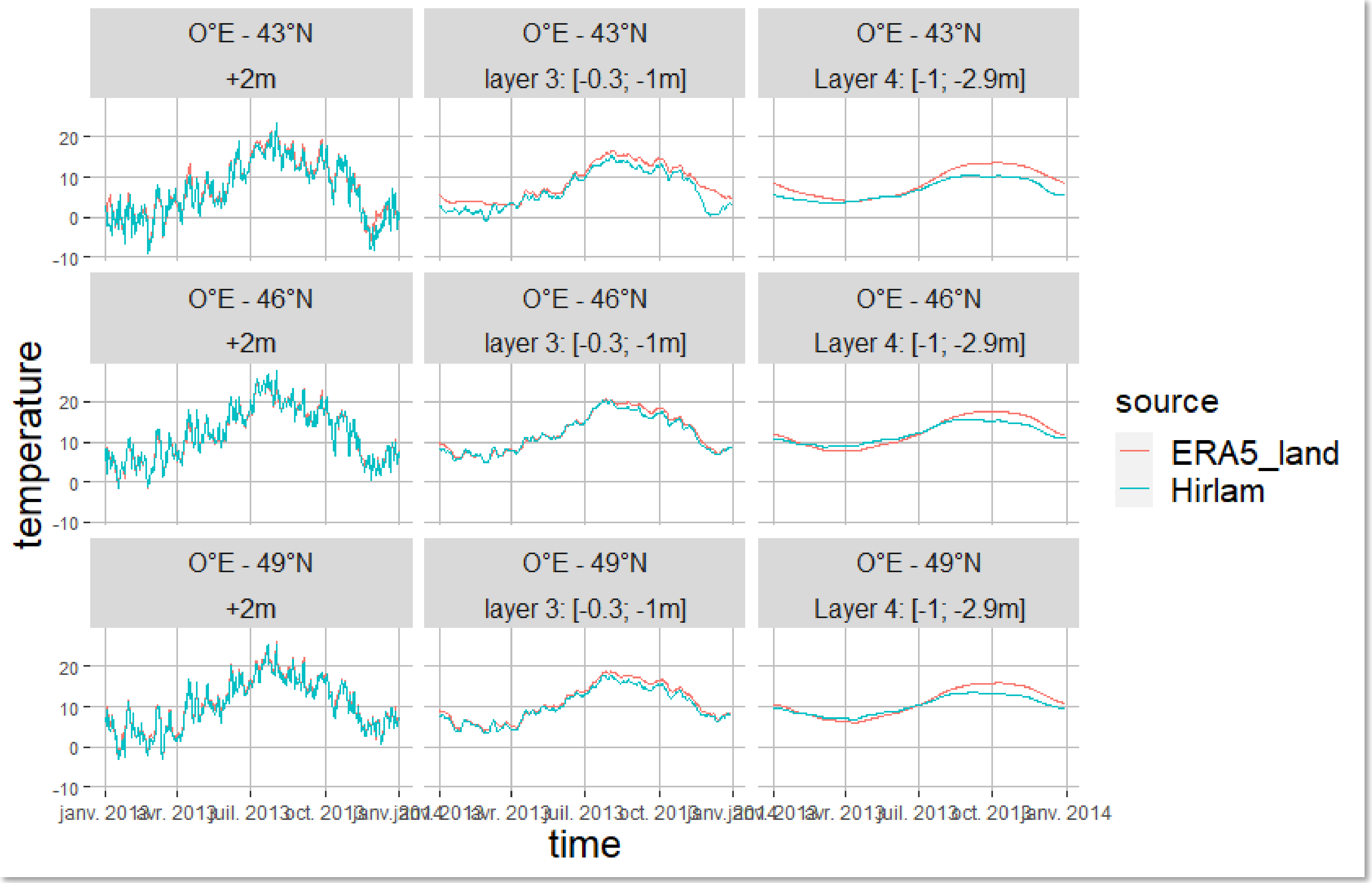
What will be the impact of climate change ?

Soil temperature uncertainties

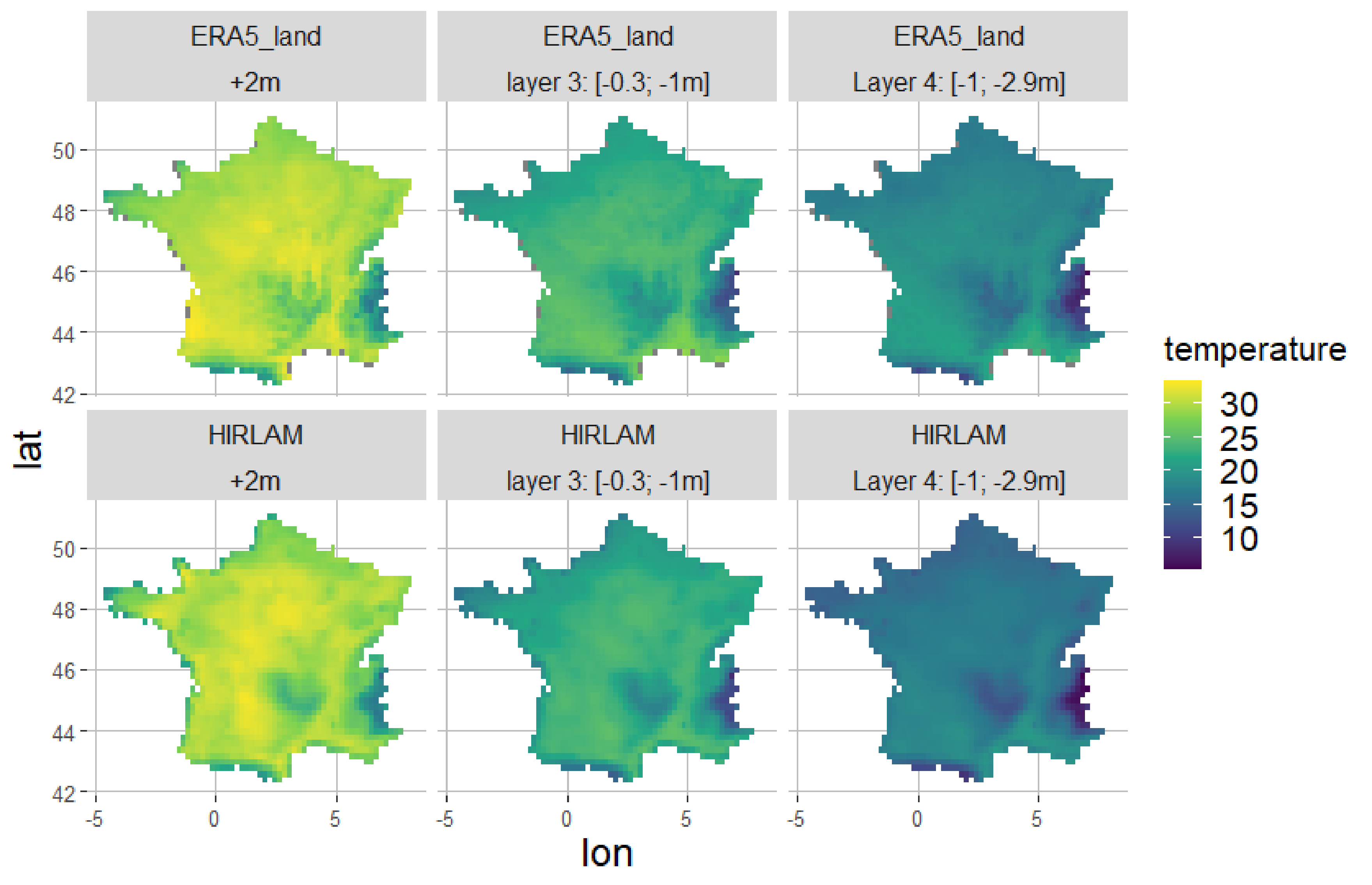
Comparison of the soil temperature obtained with 2 different approaches:

ERA5-Land: direct model output
HIRLAM: T2m + diffusion model

Temperature from both reanalysis are very close at the surface

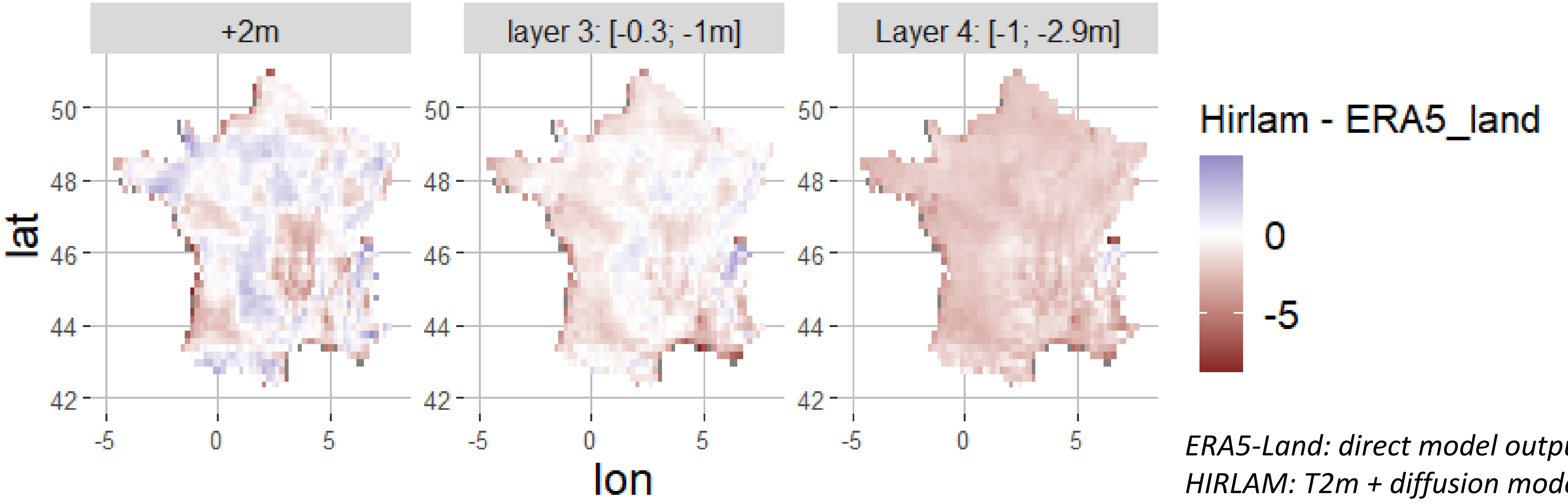


Temperature diffusion model into the ground



ERA5-Land: direct model output
HIRLAM: T2m + diffusion model

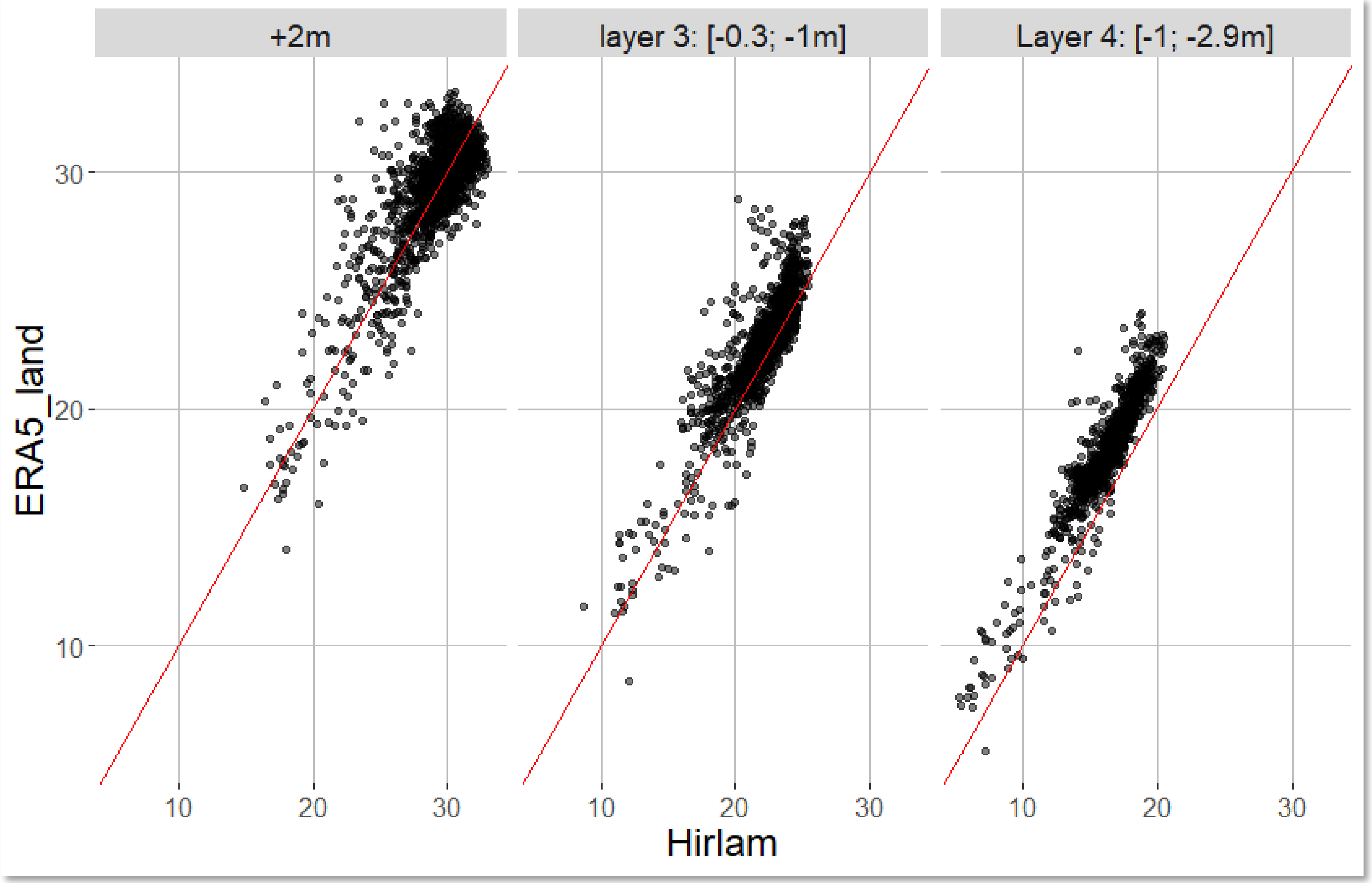
Soil temperature uncertainties



ERA5-Land: direct model output
HIRLAM: T2m + diffusion model

HIRLAM ~ERA5-land at the surface but significantly cooler with increasing depth

Differences increase with depth

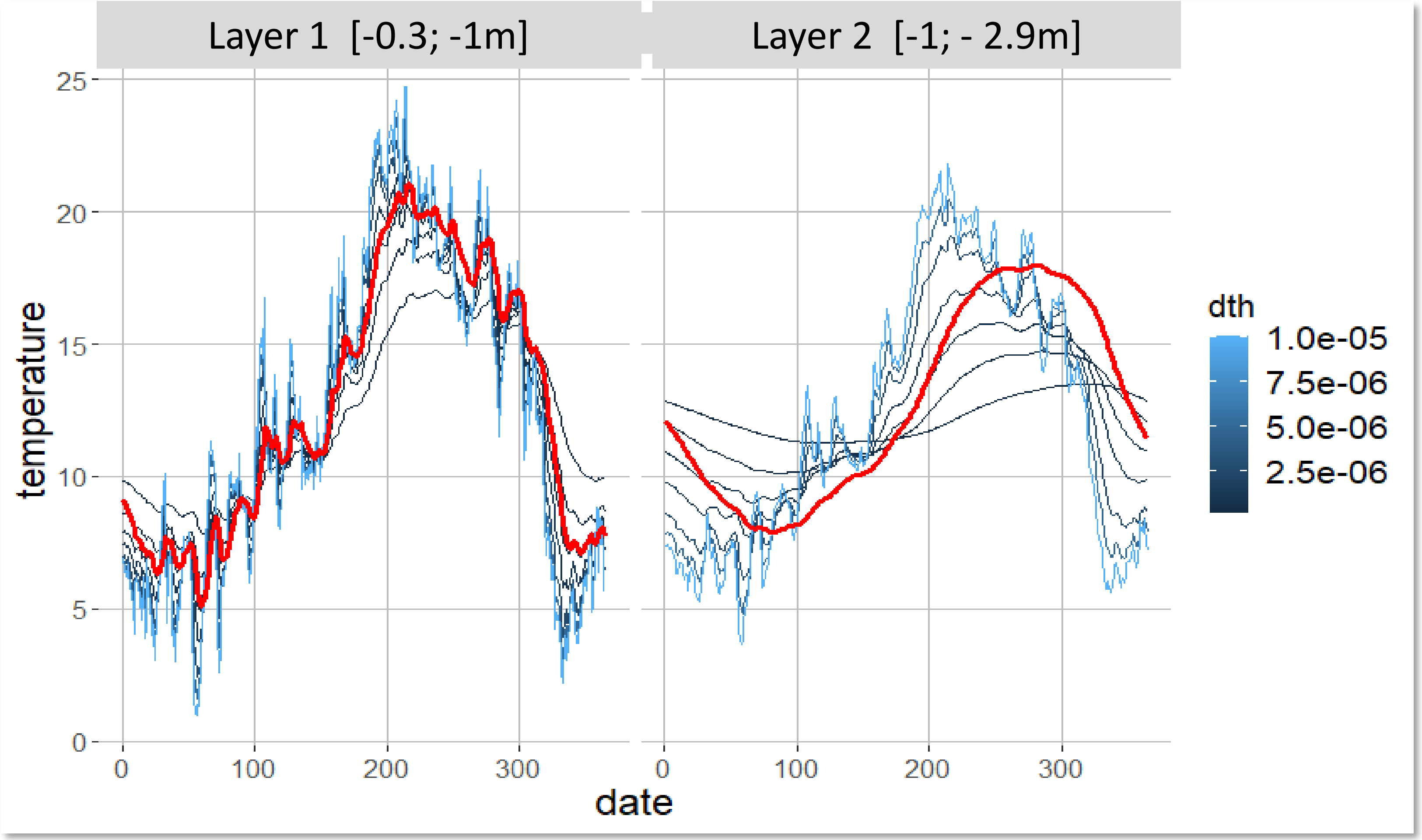


HIRLAM ~ERA5-land at the surface but significantly cooler with increasing depth

(200 points chosen randomly)

Results

Impact of soil thermal resistivity ?

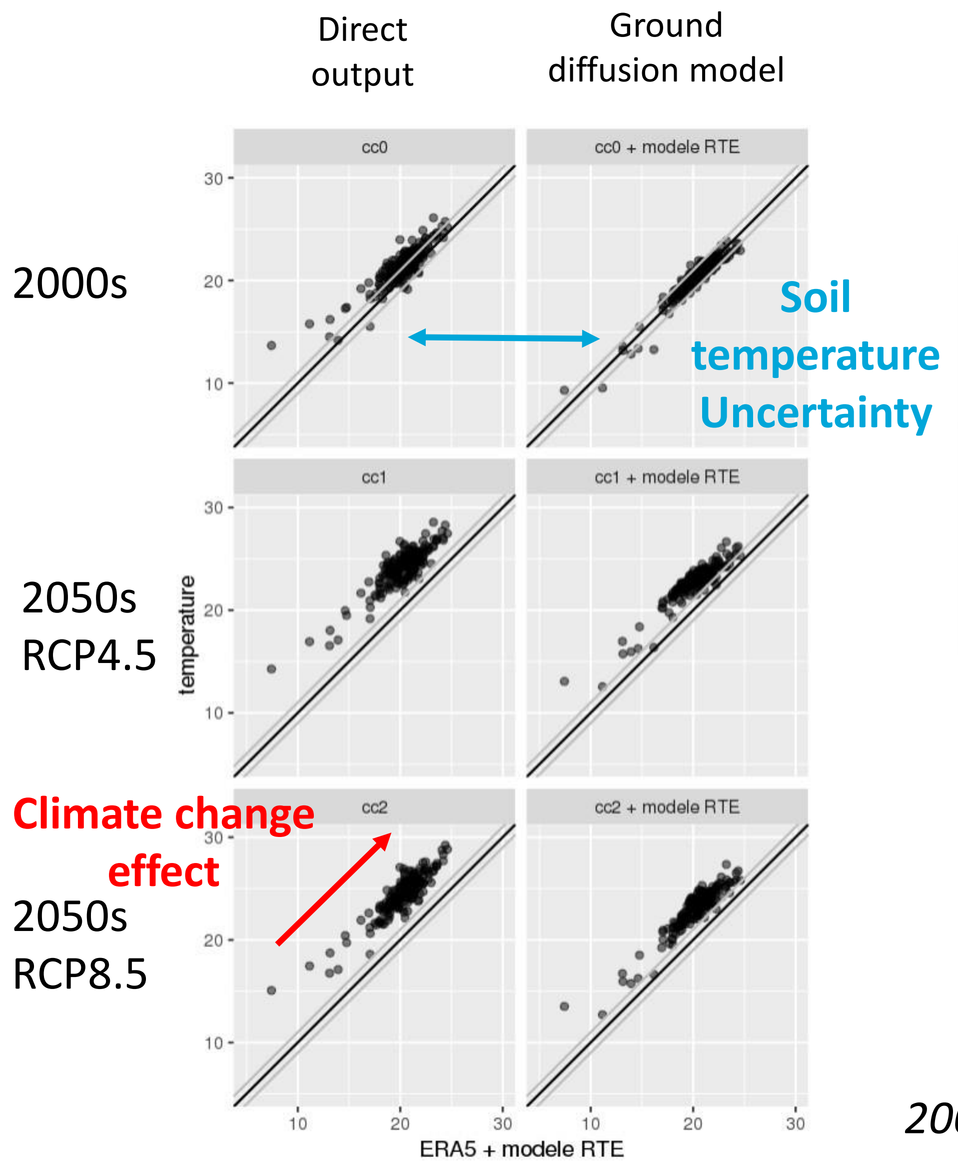


T2m from ERA5-land + ground thermal diffusion model, with different soil thermal resistivity values

T2m from ERA5-land + ground thermal diffusion model, with default value= 5.10^{-6} m².K/W

ERA5-land soil temperature

What about projected values?



Percentile	ERA5-land + ground diffusion model	2050 RCP4.5 + ground diffusion model	2050 RCP4.5 direct model output
Mean	0.0	+2.5	+3.9
75%	0.0	+3.2	+4.5
Max	0.0	+5.6	+6.8

+1°C corresponds to a transit loss of 1-2%

200 randomly chosen points over France, depth = 1m

Take away messages

- Significant **uncertainties** depending on data source
- The current cables’ design model has **comfortable margins**…
- … but it doesn’t take **soil wetness** and **soil’s nature properly** into account…
- With **Climate Change**, **soil humidity** may become critical and the model needs to be improved
- **Observations** of soil temperature and humidity are scarce!
- No assimilation of such data in reanalysis products? … and what about the **quality in climate projections**?

➔ **Some research & work is needed here !**

Le réseau
de transport
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Thank you

Contact: laurent.dubus@rte-france.com

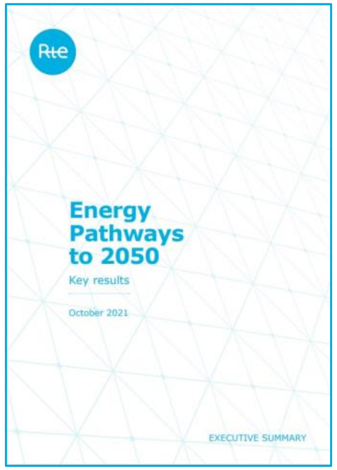
RTE : France’s Transmission System Operator for Electricity

RTE operates and maintains >106,000 km of power **lines**

RTE **enlightens** the public and decision makers

>9,000 employees

RTE maintains a constant **balance** between power **supply and demand** 24/7



In compliance with its legal obligations (Generation Adequacy Report) and at the request of the French government, in 2019, RTE launched a wide-ranging **study on the evolution of the power system** called “Energy Pathways to 2050”.

https://www.rte-france.com/en/home