Variabilité spatio-temporelle des jours propices aux événements de pluie verglaçante et neige collante en Europe dans le contexte du changement climatique

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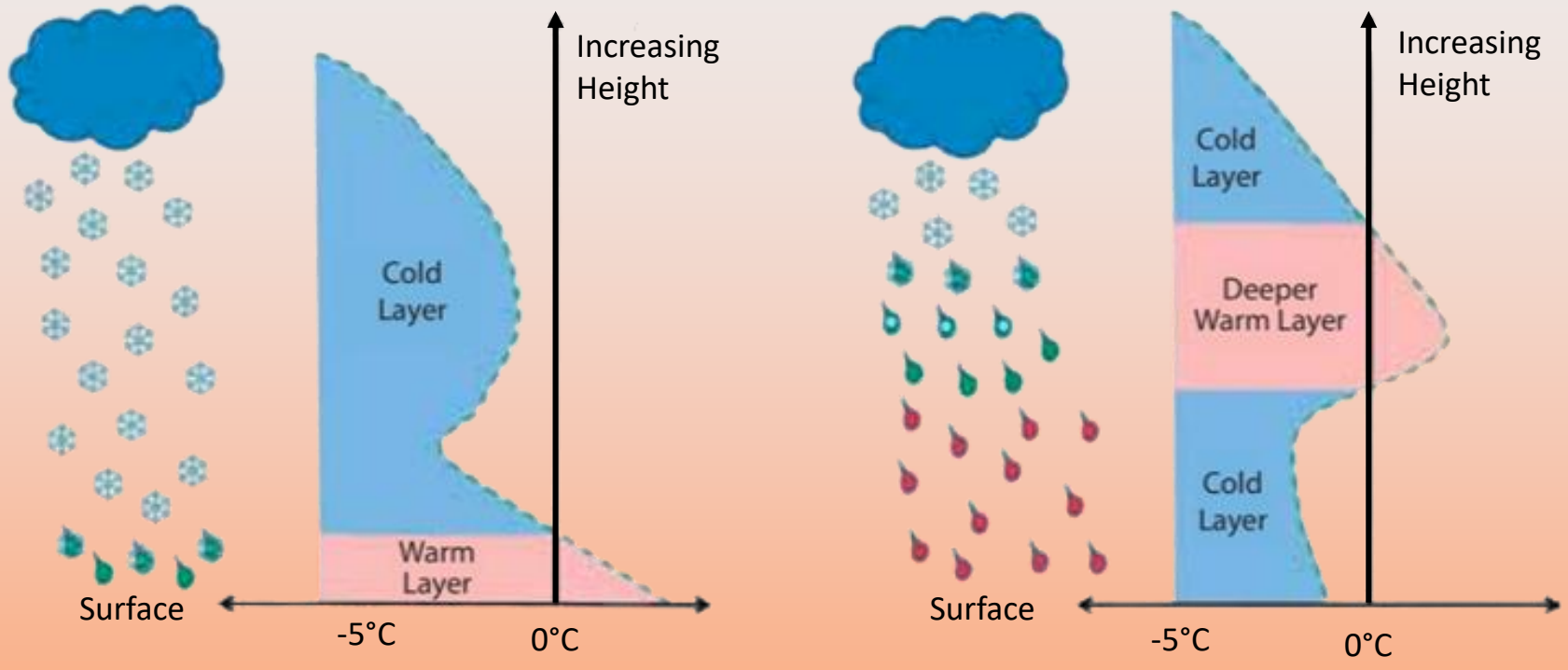
Wet snow and Freezing rain



Temperature of the atmosphere

Cold air layer(<0°C)

Warm air layer(>0°C)

Snow

Water drops

Supercooled water drops
(remains liquid despite negative temperatures)

Adapted from Forbes et al., 2014

Climatic events with impact

Damages following a freezing rain event in Slovenia, February 2014.
In Forbes et al., 2014. Photo credits : Srdjan Zivulovic/Reuters & Marko Korosec/Solent News.

> 30 km of power line destroyed, 174 km out of service.

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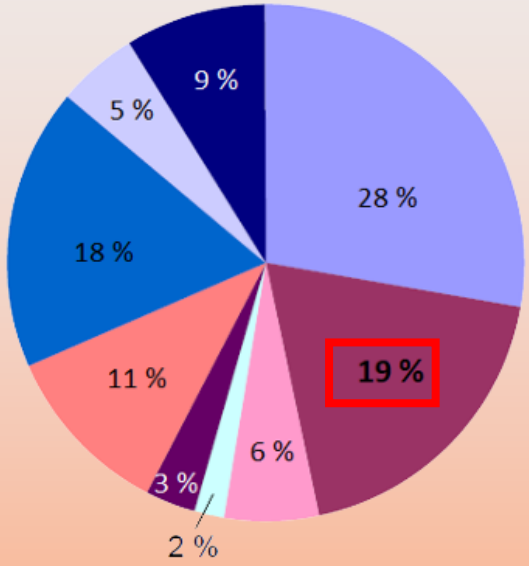
Causes of power system failure in Finland in 2006



- Wind and storm 28%
- Snow and ice load 19%
- Thunder 6%
- Other weather conditions 2%

55 %

- Animals 3%
- Structural or operational fault 11%
- Unknown 18%
- External reasons 5%
- Planned interruptions 9%

Martikainen et al., 2007

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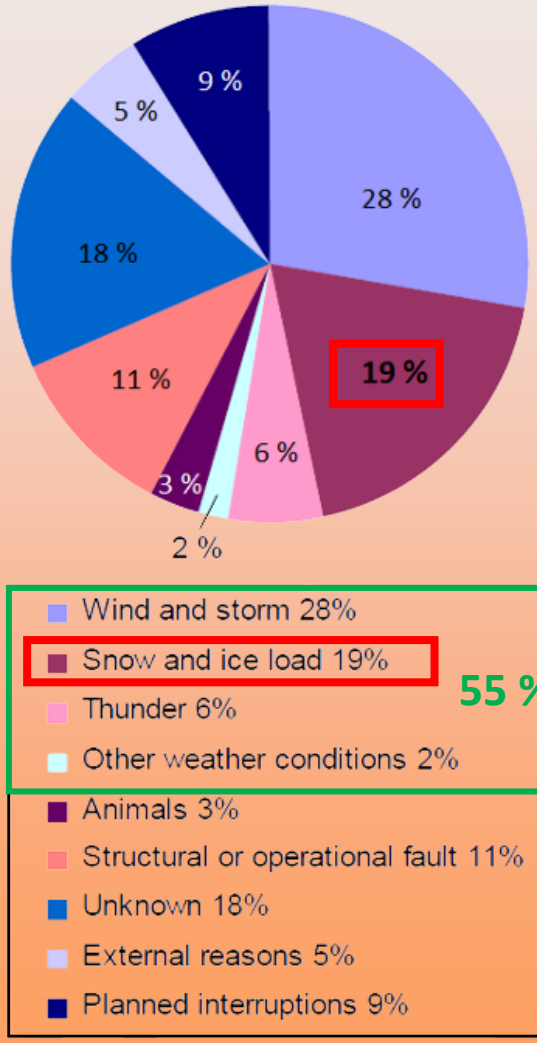
➢ **Only few studies in Europe, mainly in North America**

Causes of power system failure in Finland in 2006



Martikainen et al., 2007

- What would be the future trends of freezing rain/wet snow events in Europe?

- What is the dominating variable controlling these trends?

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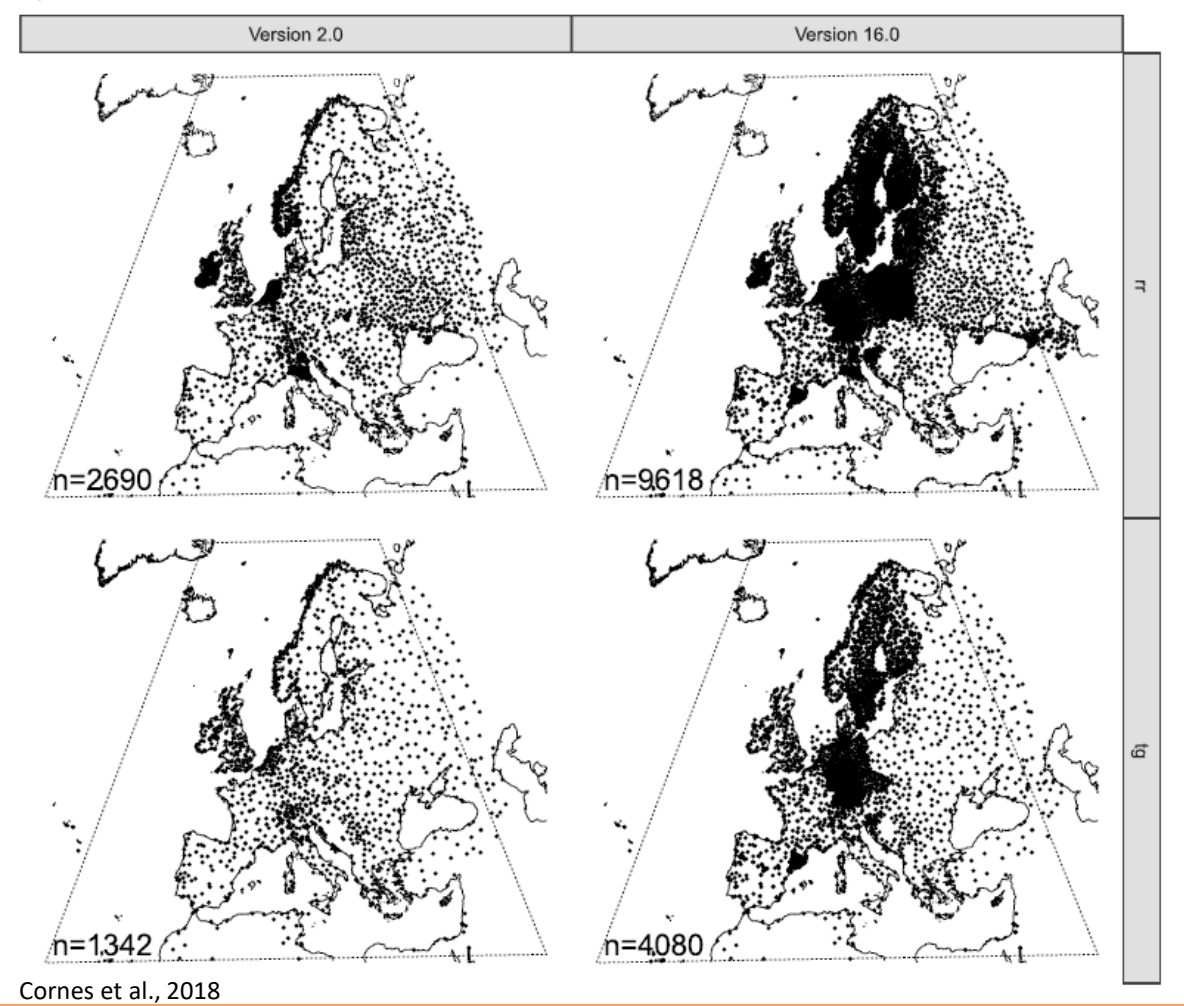
Historical period (1951-2018): E-OBS v22.0



Cornes et al., 2018

- Regular grid 0.25°x0.25°

Daily:

- Rain accumulation
- Minimum temperature
- Maximum temperature

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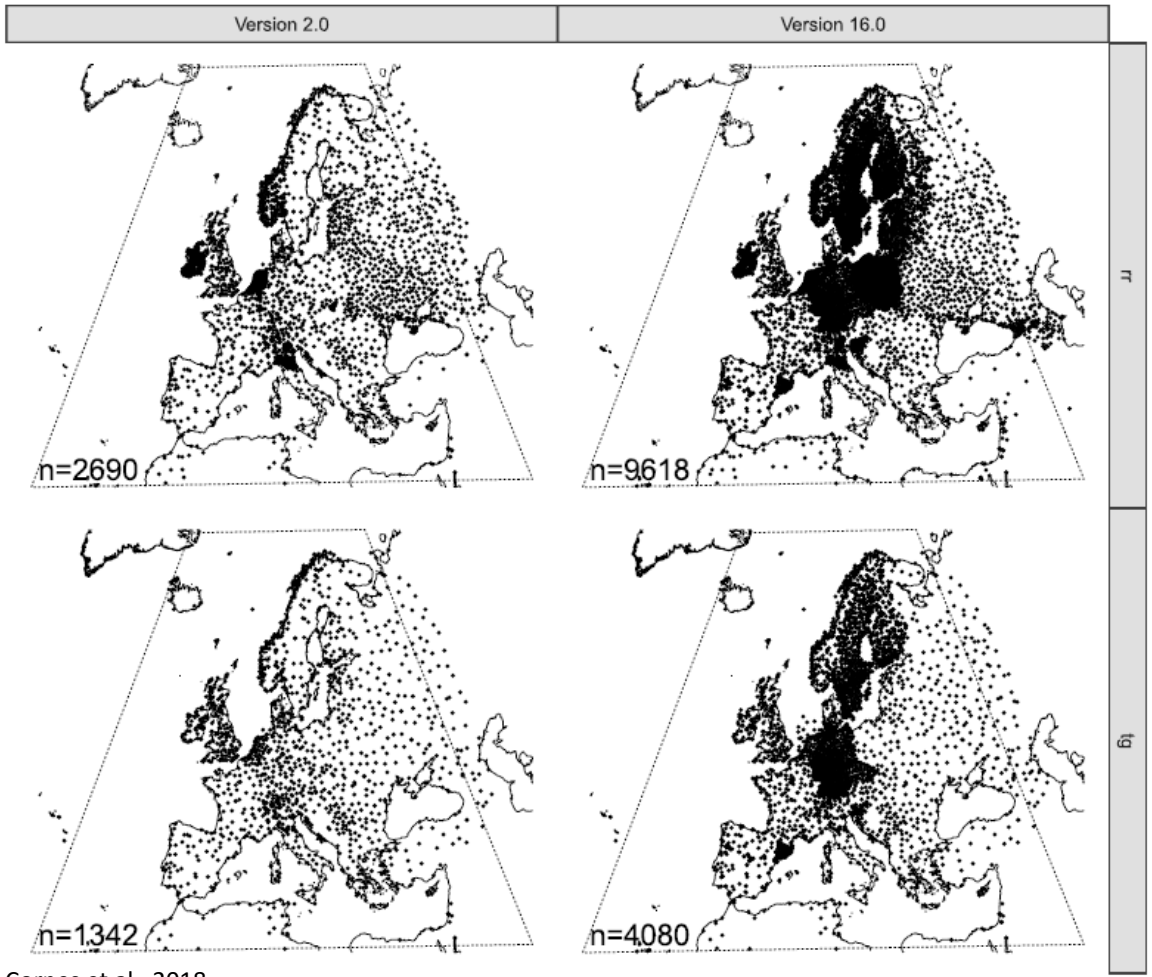

Cornes et al., 2018

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Daily:

- Rain accumulation
- Minimum temperature
- Maximum temperature

+ : Well reproduce spatio-temporal evolution of temperature and precipitation series

- : Density of the stations can have a strong impact on the extreme values of the distribution

Future period: Med/Euro CORDEX RCM

Institute (country)	Global model	Régional model	Covered period
IPSL (France)	CM5A-MR	WRF381P	1951-2100
KNMI (Netherlands)	EC-EARTH	RACMO22E	1950(1)-2100
SMHI (Sweden)	HadGEM2-ES	RCA4	1970-2098
CLMcom (Germany)	MPI-ESM-LR	CCLM4	1950-2100
DMI (Denmark)	NorESM1-M	HIRAM5	1951-2100

- 1972-2005 historical period

- 2026-2059 short-term horizon

- 2065-2098 long-term horizon

RCP4.5
RCP8.5

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How to reduce the uncertainty related to the different models (intern variability because of the parameterizations)?

➡ Bias correction with the CDF-t method (**C**umulative **D**ensity **F**onction-**t**ransform ; Michelangeli et al., 2009)

Objective: to make the statistical distribution simulated of daily variable identical to the distribution observed at each point.

Reference data: ERA5 reanalyses (0.25° x 0.25° resolution). Period used: 1980-2018.

	Historical	Future
RCM	F_{Gh} ↓	F_{Gf} ⇣
ERA5	F_{Sh} ↓	F_{sh}? ⇣

Detection of the “high-impact icing precipitation favourable day”

No information about the precise wet snow/freezing rain events: apprehend the days with favourable conditions to the occurrence of these impacting events.

➢ In the literature: wet snow (0°C to +2°C) and freezing rain (-5°C to +1°C); impact from 5 mm of accumulation.

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“Icing precipitation” as the generic term referring to both wet snow and freezing rain as their surface conditions of occurrence are rather similar

- Tmin ≥ −5°C and Tmax ≤ +2°C ⟶ Thermodynamical conditions day (TCD)

- RR ≥ 5 mm ⟶ Vulnerability conditions day (VCD)

➢ **Thermodynamical (TCD) + vulnerability conditions (VCD) = high-impact icing precipitation favourable day (IPD)**

The attributing process

Apprehend the respective contribution of the thermodynamical and vulnerability conditions

- perspective of uncertainty assessment

TCD (thermodynamical condition day)

VCD (vulnerability condition day)

IPD (high-impact icing precipitation favourable day)

The attributing process

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- perspective of uncertainty assessment

TCD (thermodynamical condition day)

VCD (vulnerability condition day)

IPD (high-impact icing precipitation favourable day)

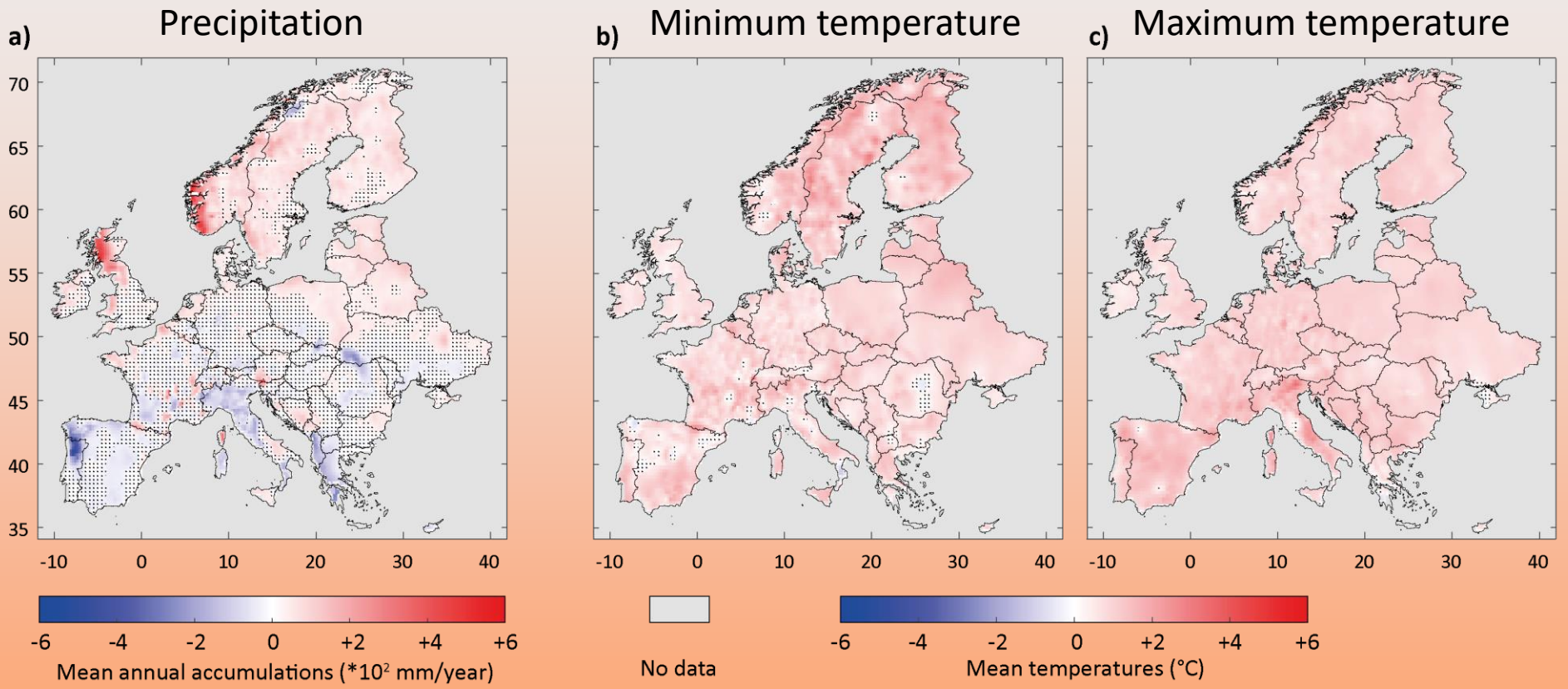
ΔP(IPD)= difference in the probability of occurrence between the 2 periods of 34 years

- If ΔP(IPD)>0, TCD dominantly controls the change of IPD occurrence if ΔP(TCD)/P(TCD) > ΔP(VCD)/P(VCD), otherwise it is VCD.

- If ΔP(IPD)<0, TCD dominantly controls the change of IPD occurrence if ΔP(TCD)/P(TCD) < ΔP(VCD)/P(VCD), otherwise it is VCD.

Historical trends of the climatic surface variables

1951-1984 vs 1985-2018

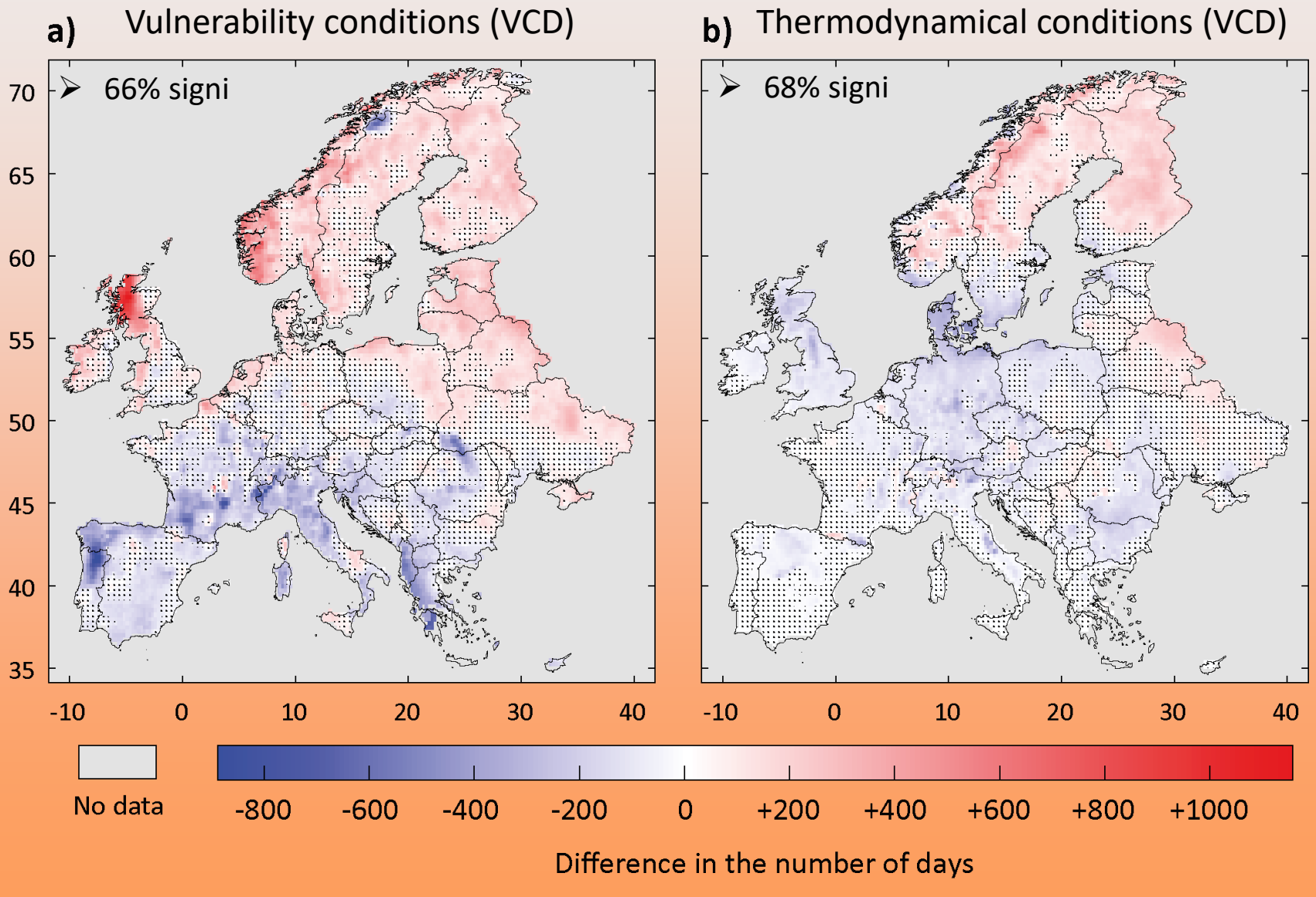


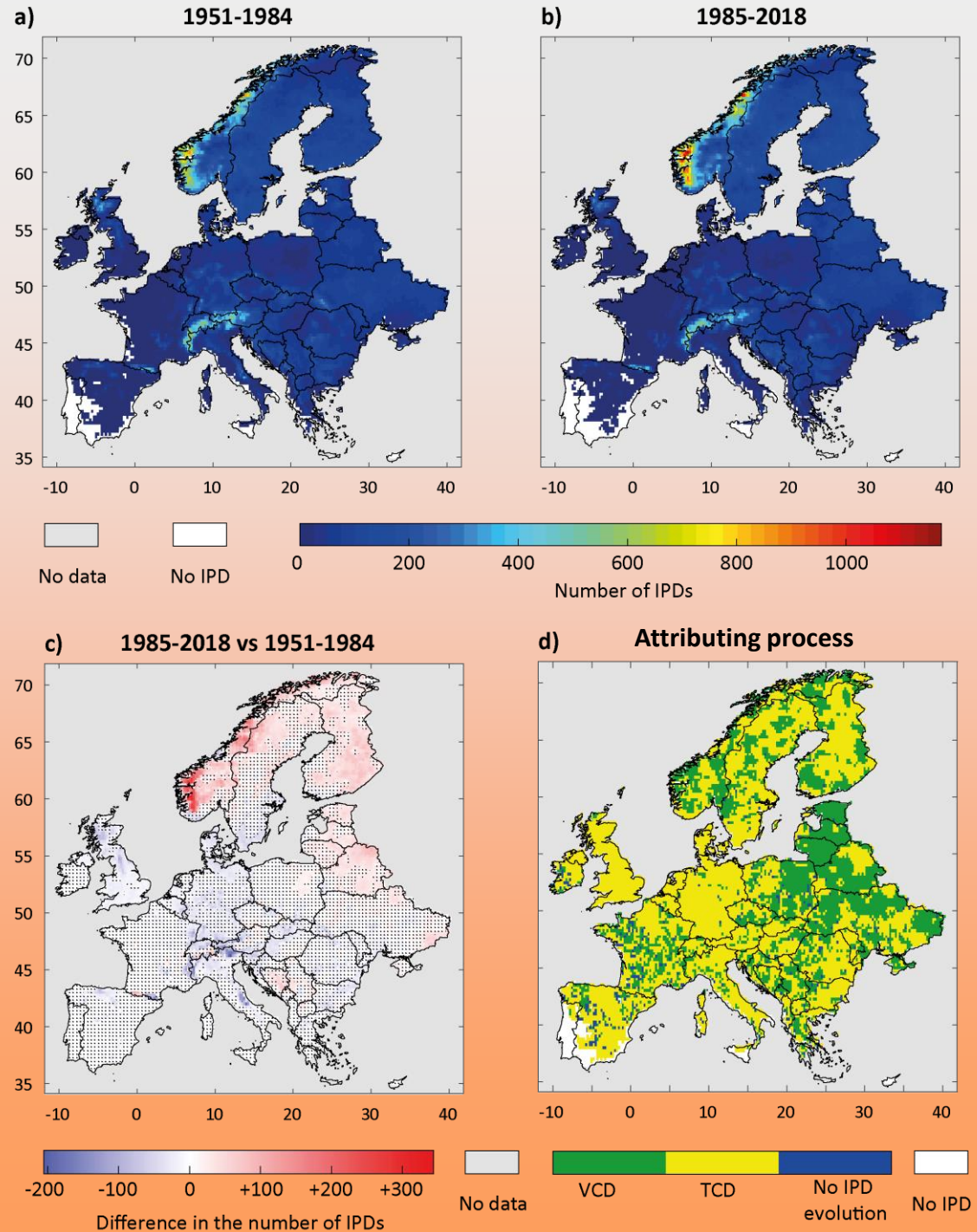
- 56% of significant trends
- 98% and 99% of significant trends

Climate change is affecting the temperatures in a more straightforward way over Europe than the precipitations, with less uncertainties

Historical trends of the Vulnerability/Thermodynamical conditions

1951-1984 vs 1985-2018





Historical trend in the High-impact icing precipitation favourable day (IPD), and attributing process

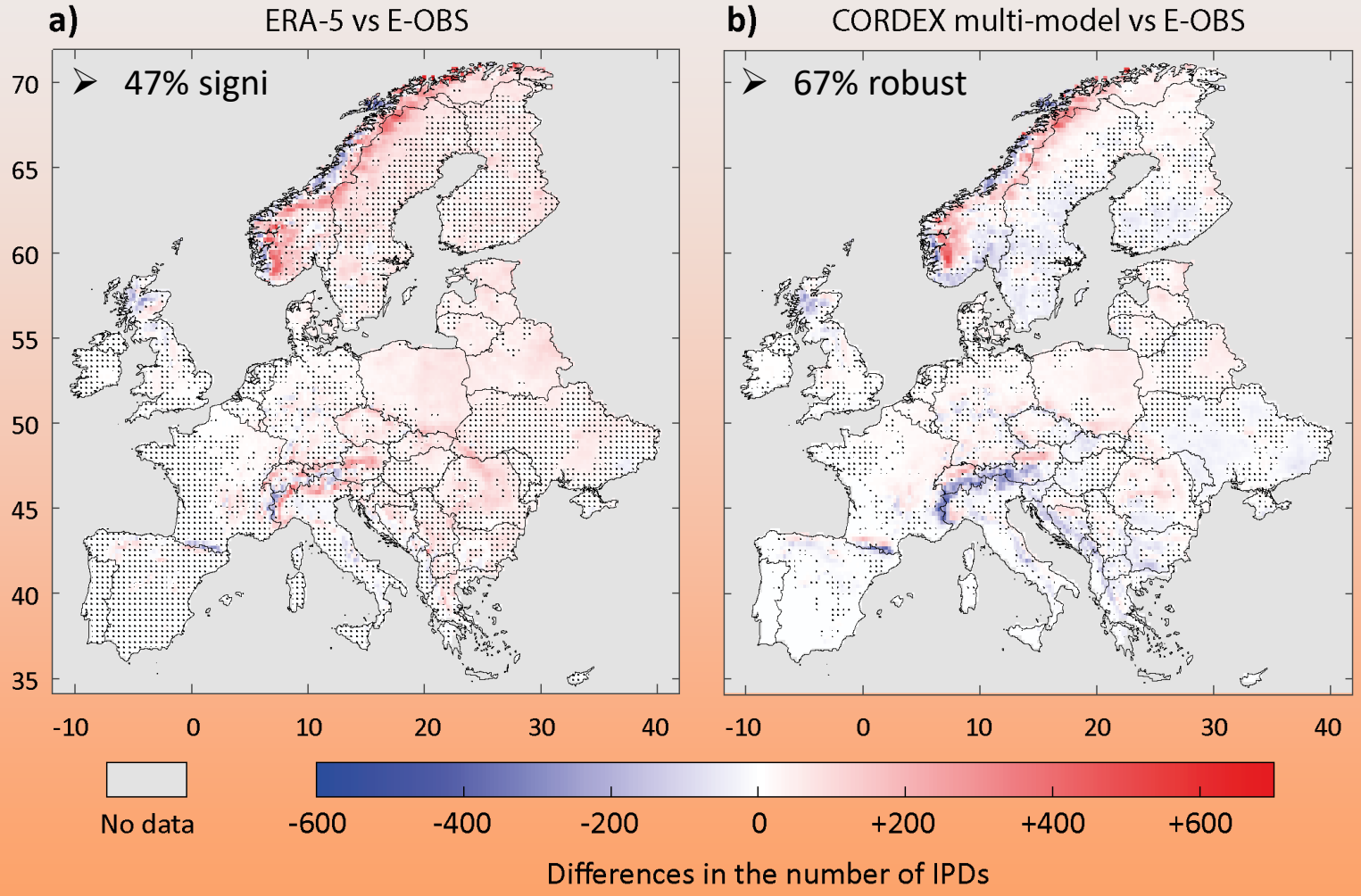
48% increase of IPD occurrence

47% decrease of IPD occurrence

(but only 35% of significant trends)

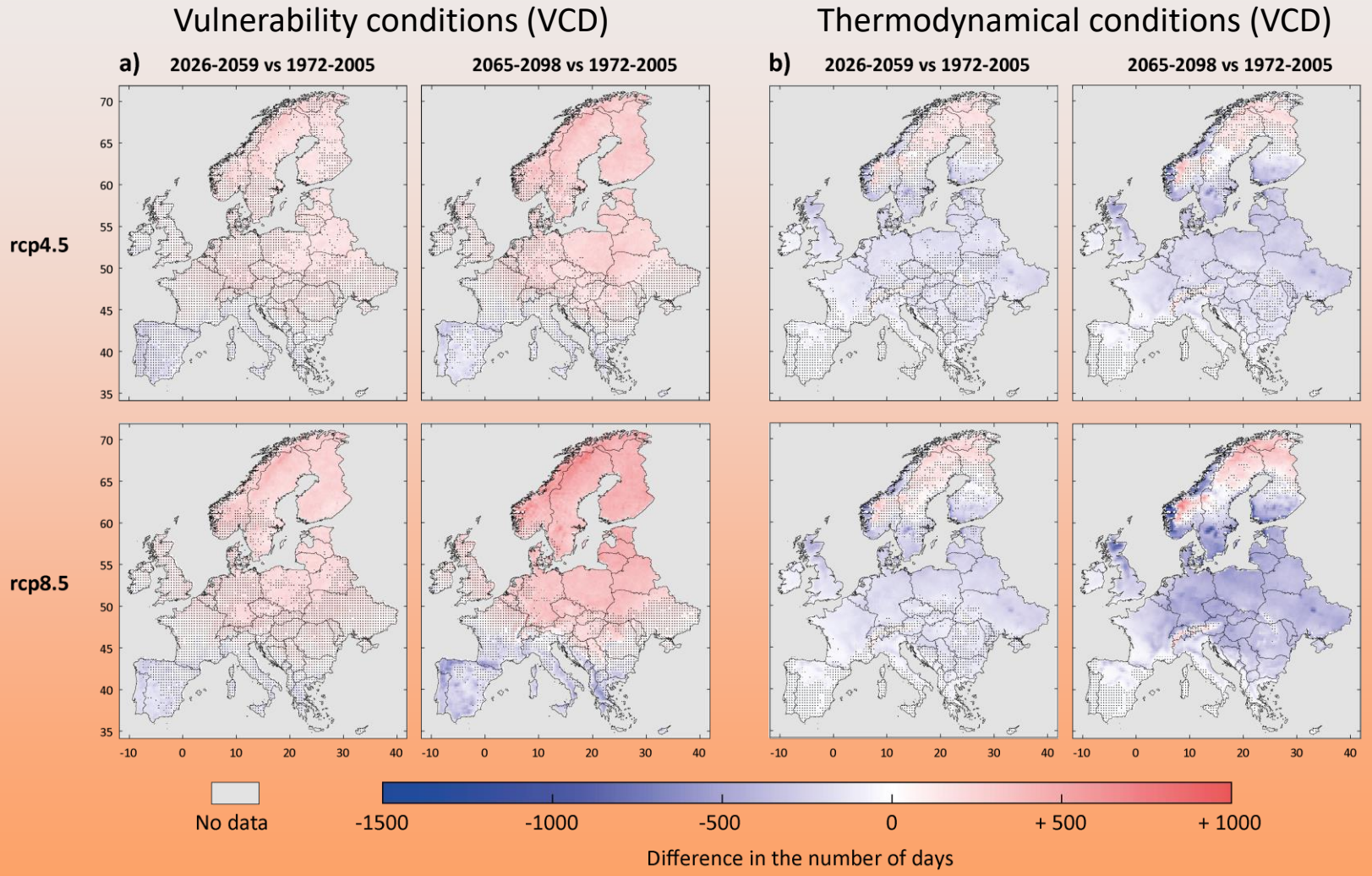
- No clear influencial conditions explaining the IPD trend

Ability of the ERA-5 and the Cordex models to reproduce the historical variability of IPDs (1972-2005)



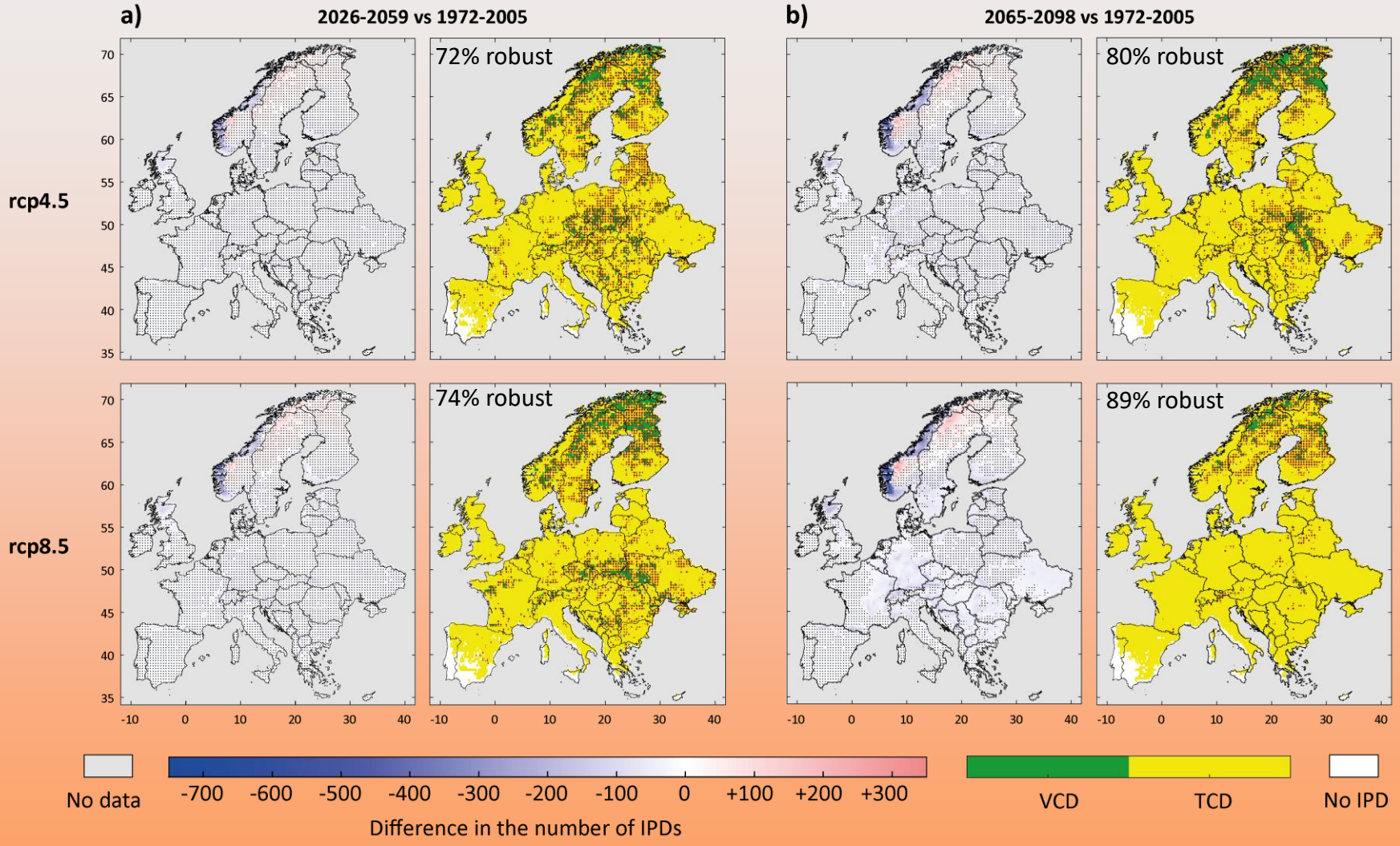
- Overestimation (83% of the domain) of the ERA-5 in the VCD occurrence, so in IPD occurrence
- Overestimation (60% of the domain) of the Cordex models in the IPD occurrence

Future multi-model mean spatiotemporal variability of the Vulnerability and Thermodynamical conditions



- Only from 27% to 67% of the grid points show robust future VCD trend: more uncertainties
- From 59% to 90% of the grid points show robust future TCD trend: less uncertainties

Future IPD spatiotemporal variability and attributing process



- From 8%(12%) to 18%(48%) show robust reduction in IPDs for RCP4.5 (RCP8.5)
- Strong contribution of the thermodynamical conditions (from 90% to 97%)

Conclusion

- IPDs occurrence should decrease in most of Europe during the 21st century.

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- Temperature projections display lower uncertainties than precipitation projections in regional climate simulations: confidence in our results.