

# The impact of climate change on PV power generation in Europe

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*Jerez et al., Nat. Comms. 2015*



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# How climate change could affect the future of the PV sector in Europe?

- By altering socio-economic factors, including energy demand
- By altering the PV power generation potential (PVpot)

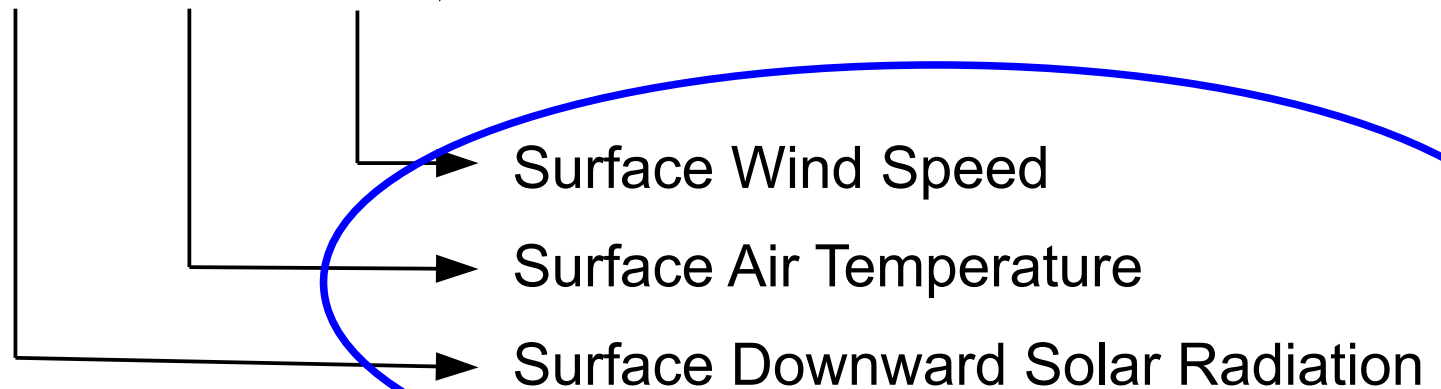
# How climate change could affect the future of the PV sector in Europe?

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- By altering the **PV power generation potential (PVpot)**

$$\text{PVpot} \propto \text{RSDS} \cdot P_R$$

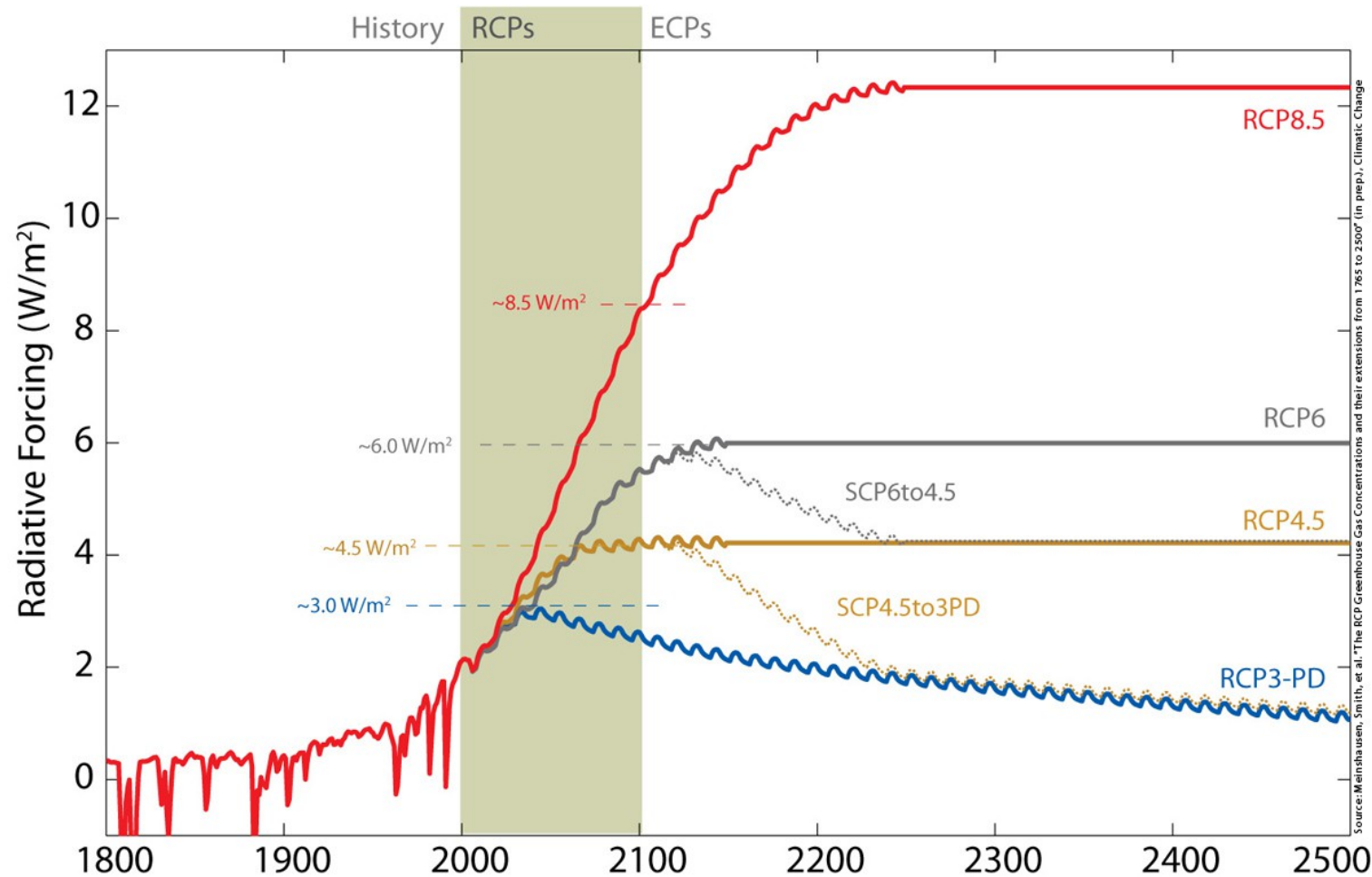
└─→ Performance ratio

$$P_R = f(\text{RSDS}, \text{TAS}, \text{VWS})$$



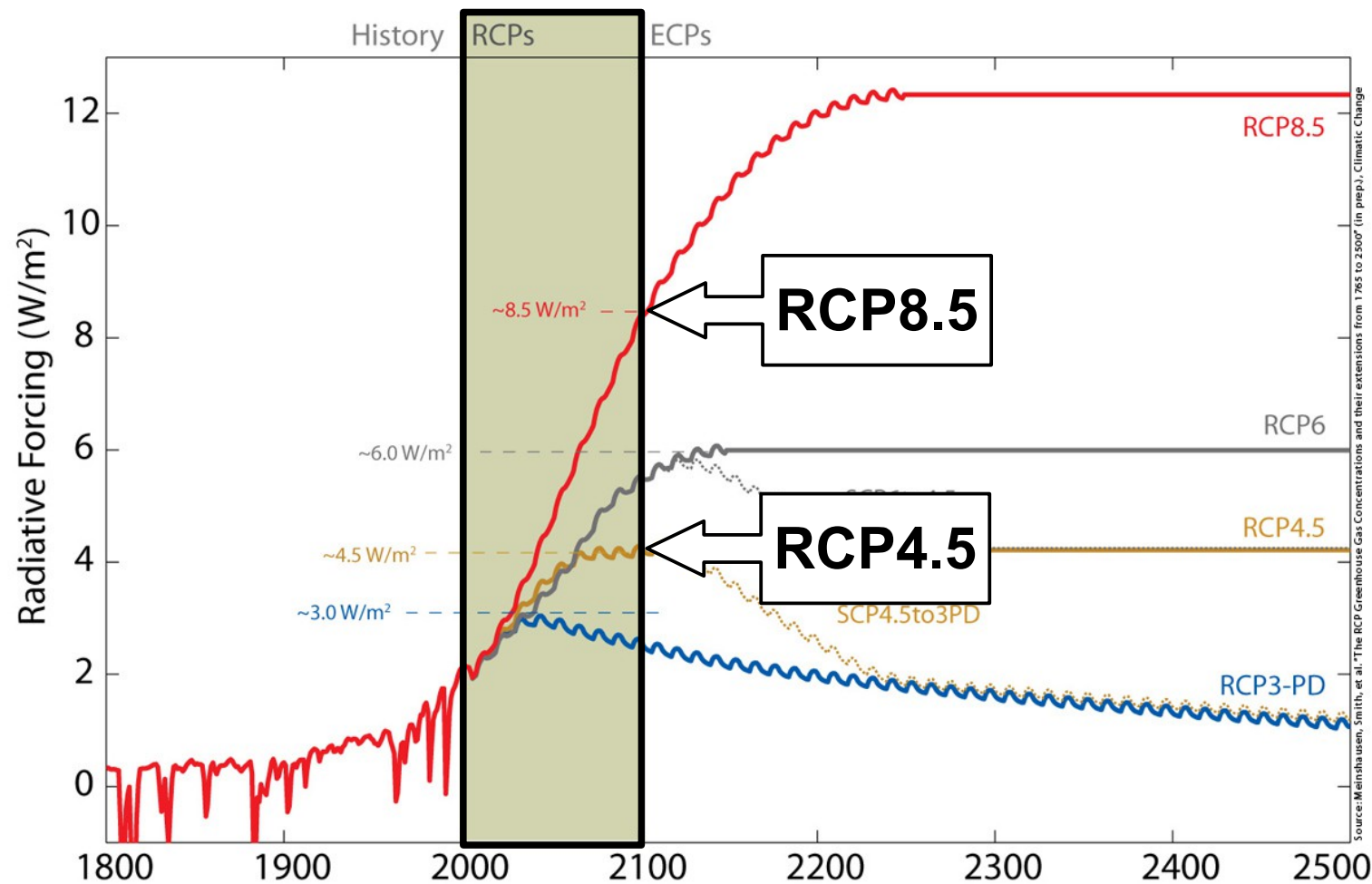
# What can we know about future climate conditions in Europe?

**Representative Concentration Pathways (RCPs)** provide estimations of the future radiative forcing under diverse socio-economic assumptions



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# What can we know about future climate conditions in Europe?

**Climate simulation models** provide non-uncertainty-free, physically consistent estimations of future climate conditions under the RCPs

→ **MULTI-MODEL ENSEMBLES** to deal with model uncertainty

Here we use a 10-member **EURO-CORDEX** ensemble of high-resolution (~12 km) climate simulations that cover the period 1970-2100

**ETH** Zürich



**SMHI**

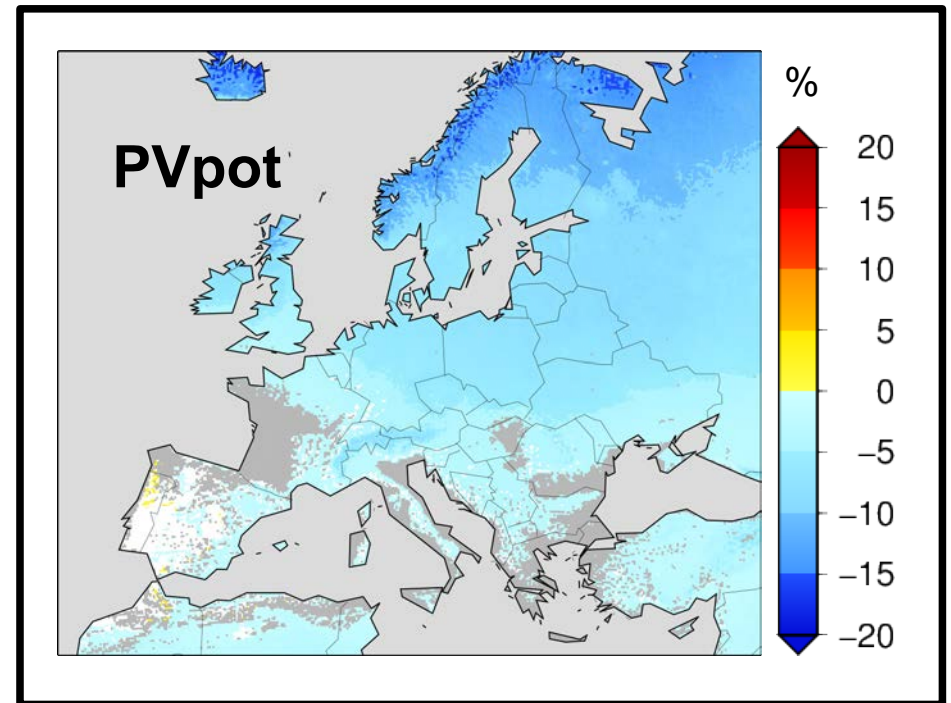
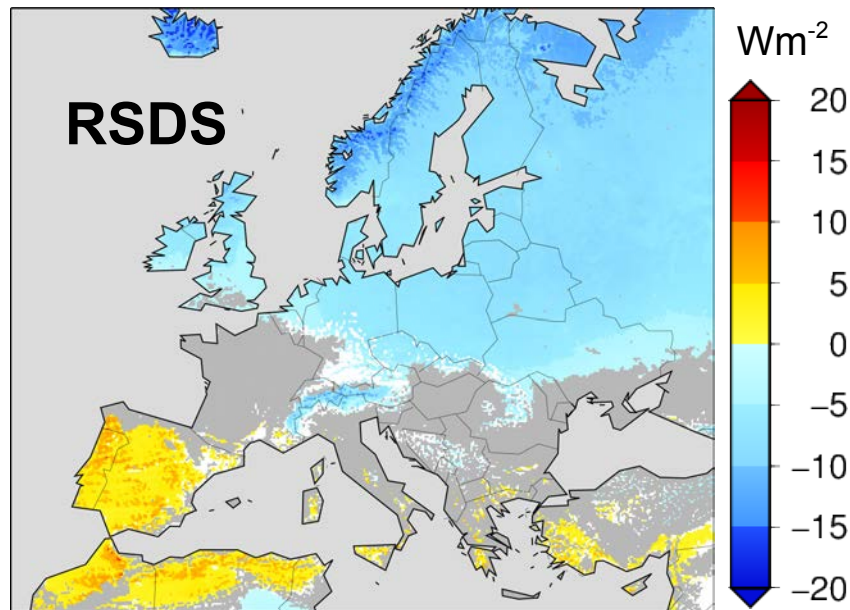
Climate Service Center  
Germany **2.**  
Eine Einrichtung des Helmholtz-Zentrums Geesthacht

**INERIS**



# Climate change projections

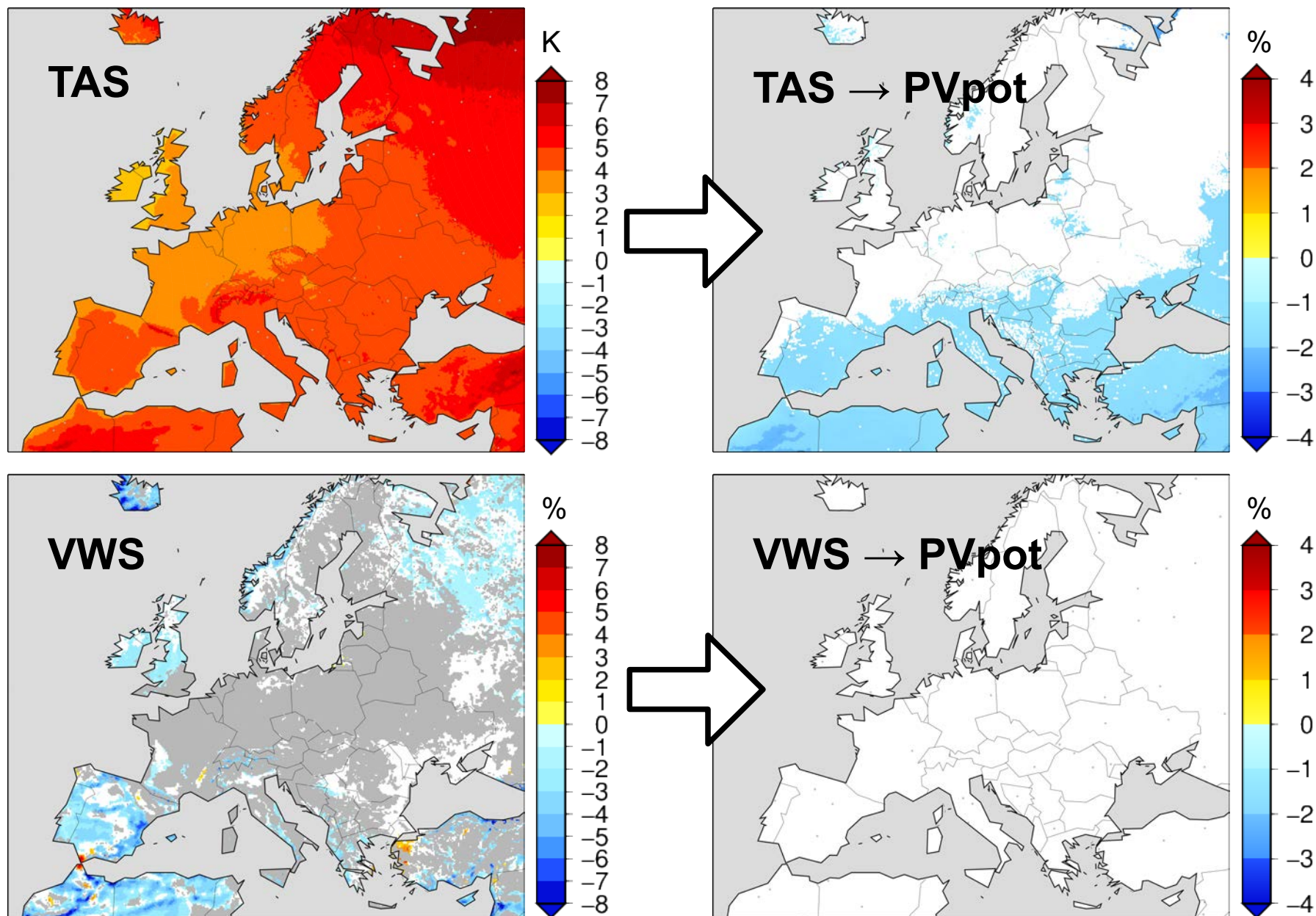
RCP8.5 – 2070-2099 vs 1970-1999 – Ensemble mean signals





# Climate change projections

RCP8.5 – 2070-2099 vs 1970-1999 – Ensemble mean signals

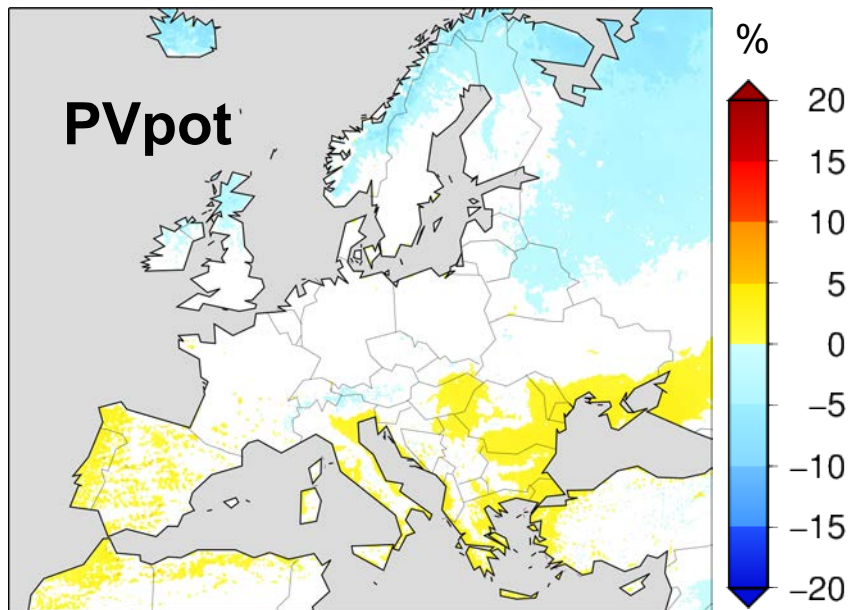




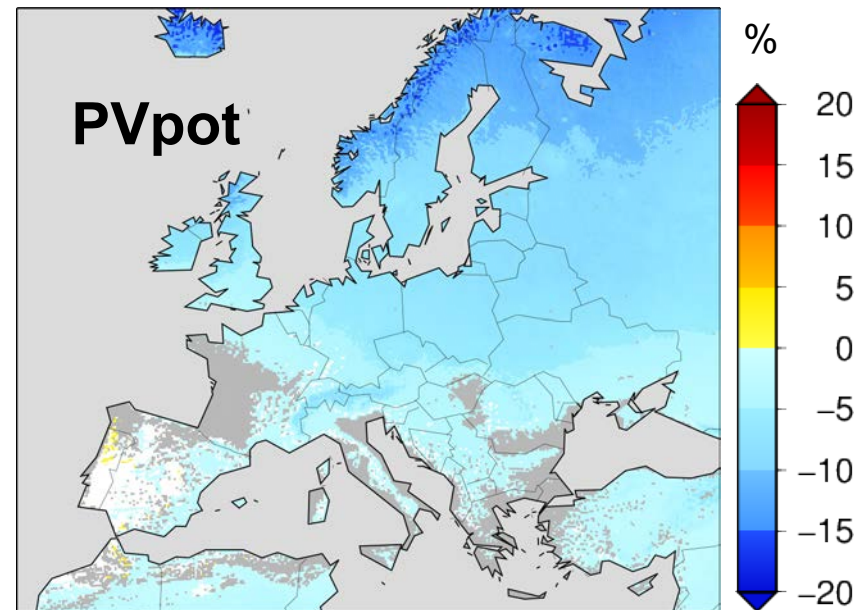
# Climate change projections

2070-2099 vs 1970-1999 – Ensemble mean signals

**RCP4.5**



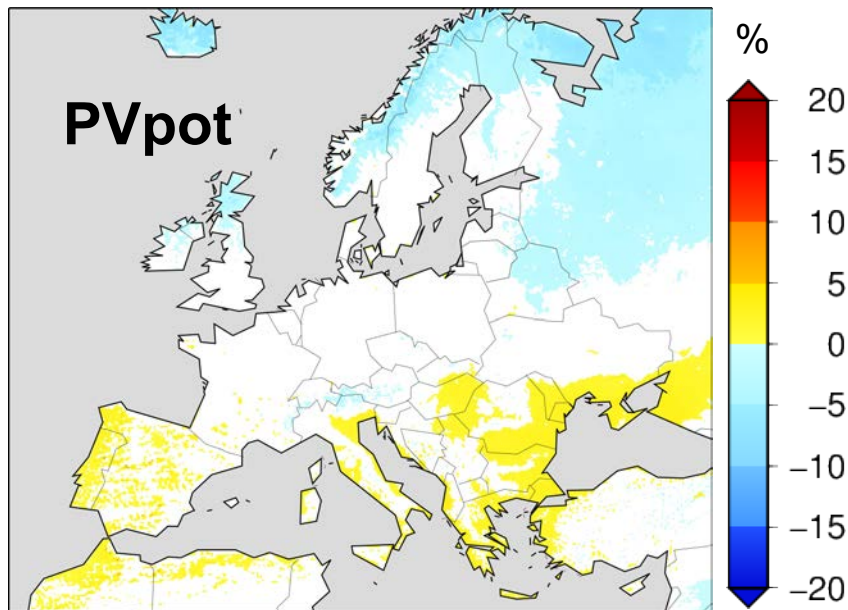
**RCP8.5**



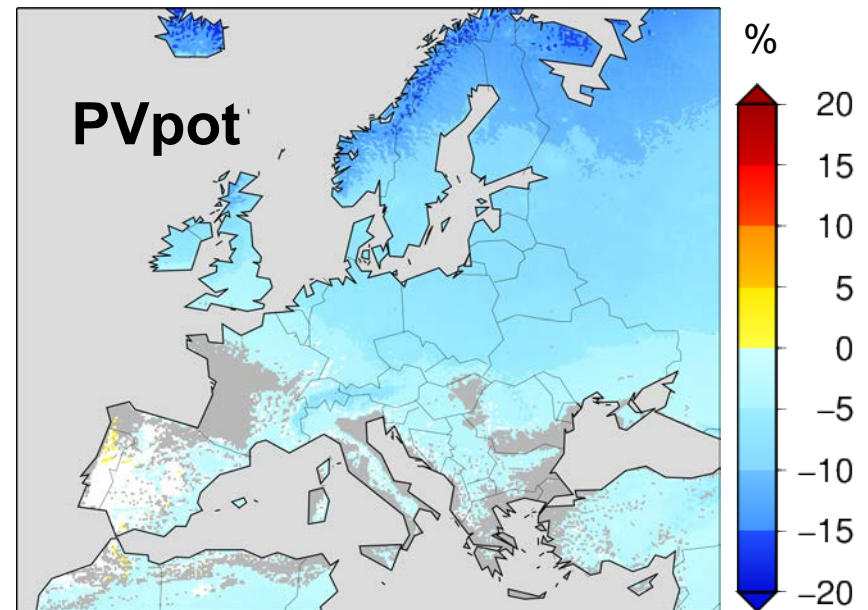
# Climate change projections

2070-2099 vs 1970-1999 – Ensemble mean signals

**RCP4.5**



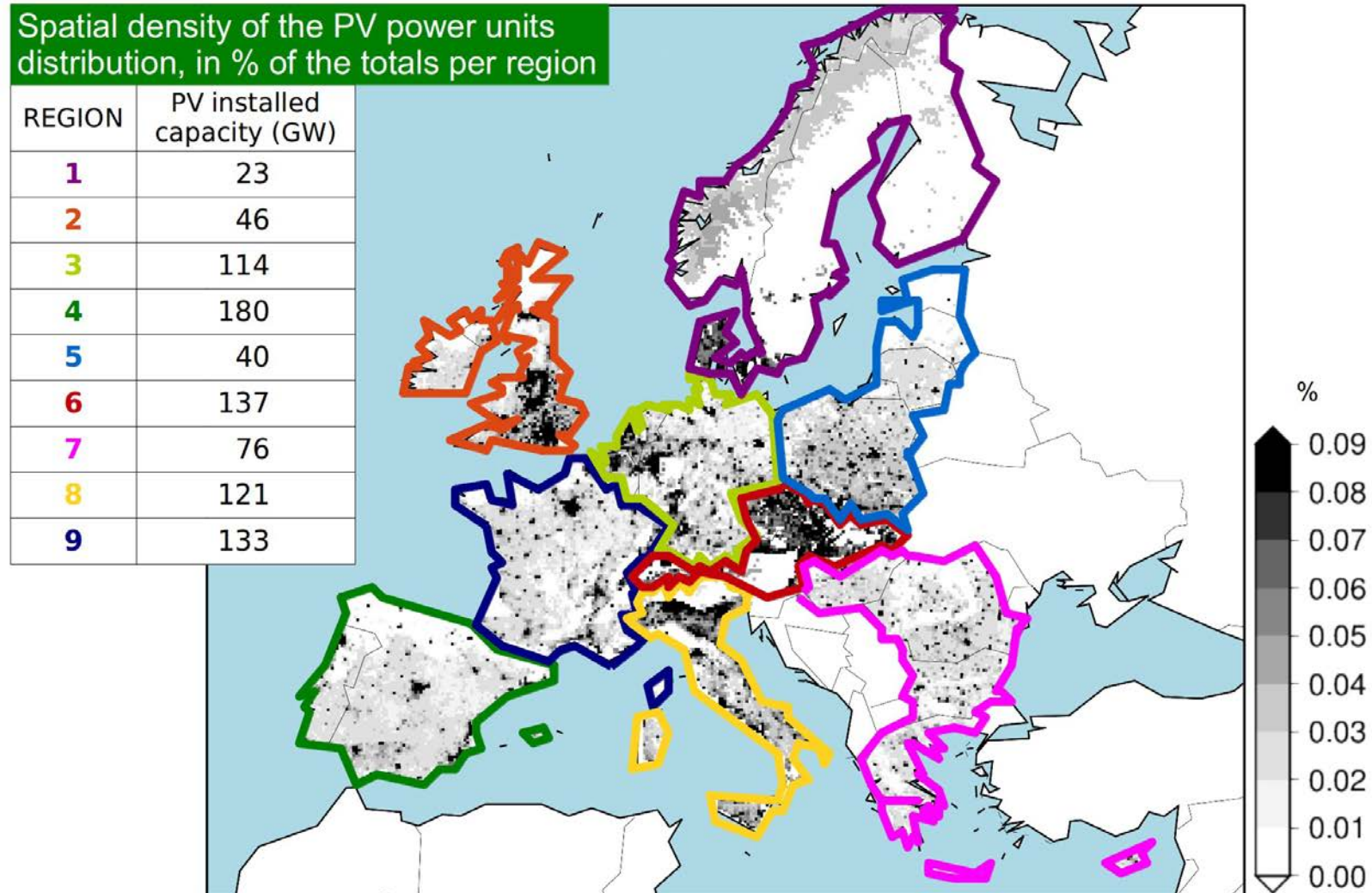
**RCP8.5**



**Do these projections for PVpot actually impact PV power generation?**

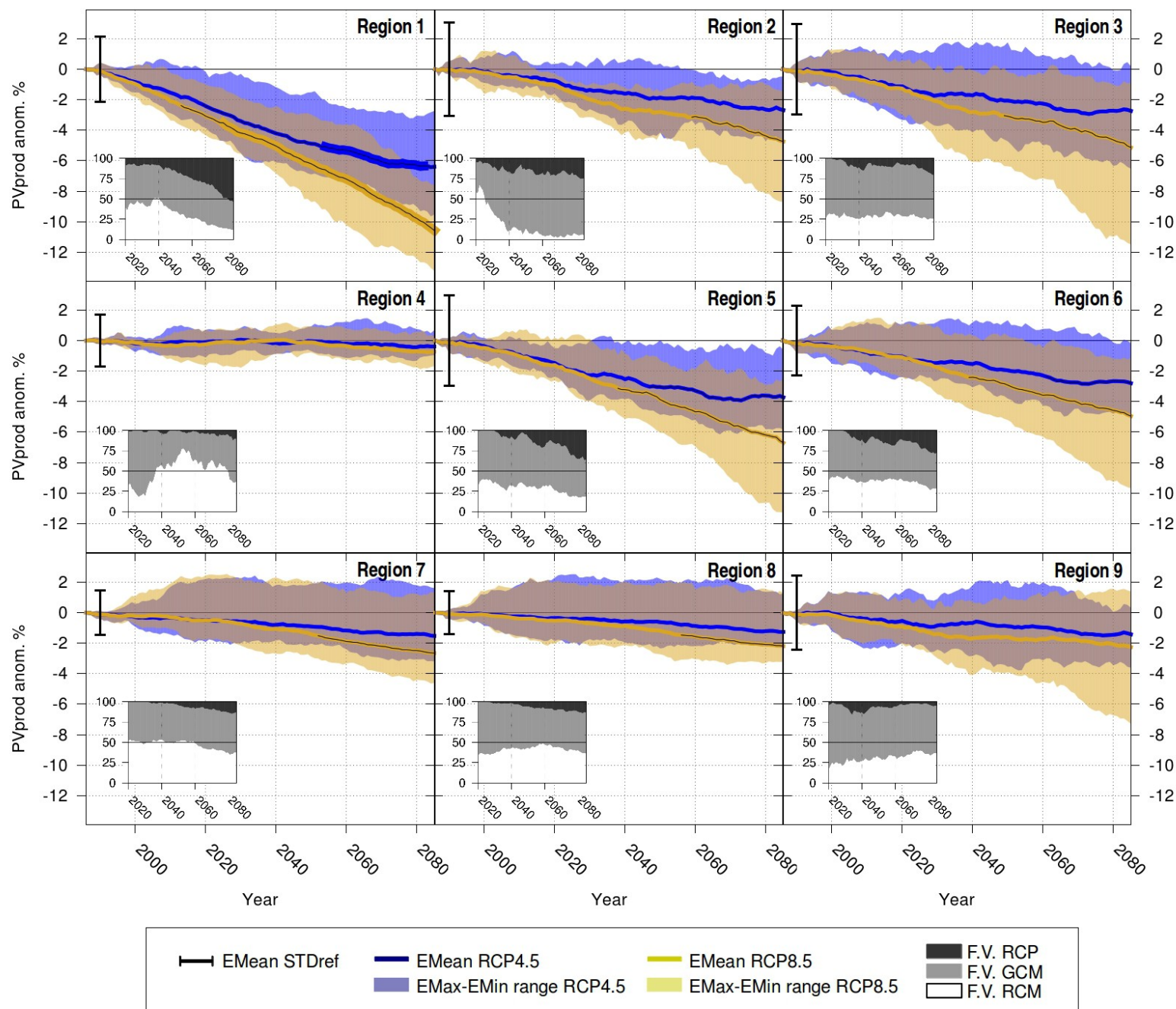
# Where are the PV units located?

We use the CLIMIX model to 'spatialize' the targets proposed by the European Climate Foundation in its **80% Renewable Energy Supply pathway**





# CC impact on PV generation

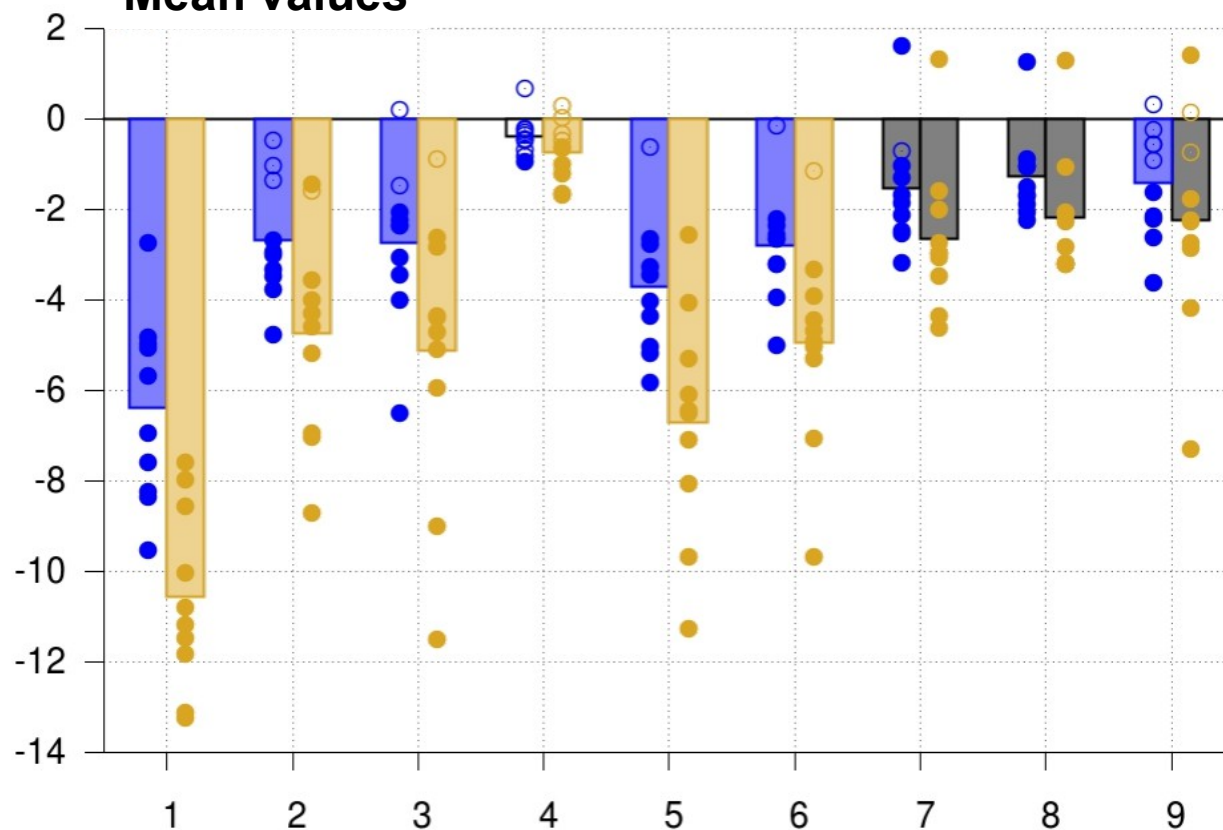


# CC impact on PV generation

(2070-2099 vs 1970-1999)



Mean values

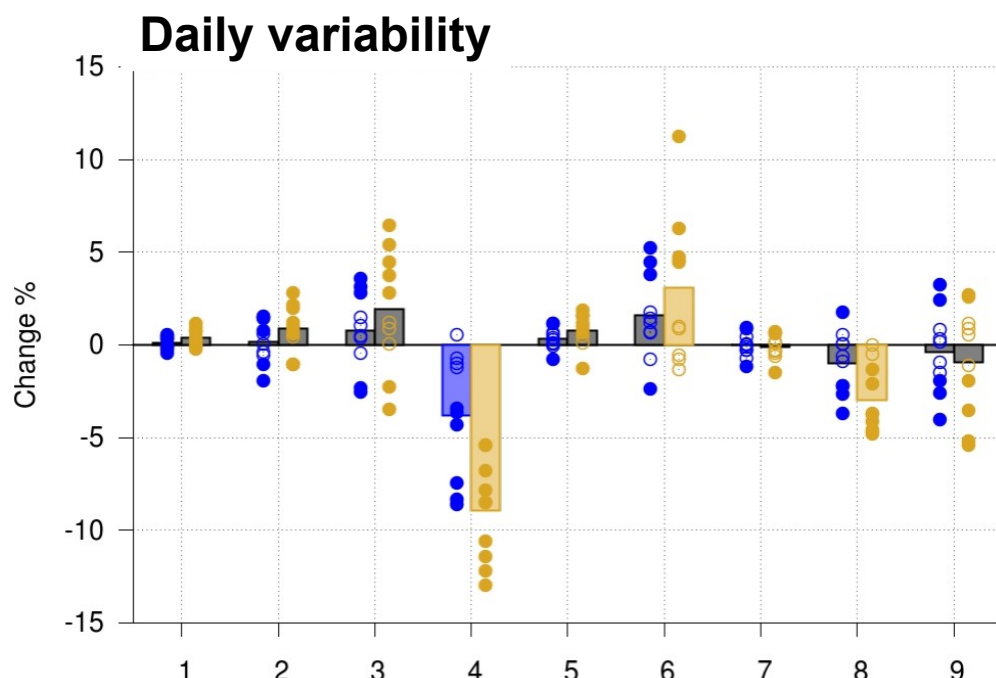
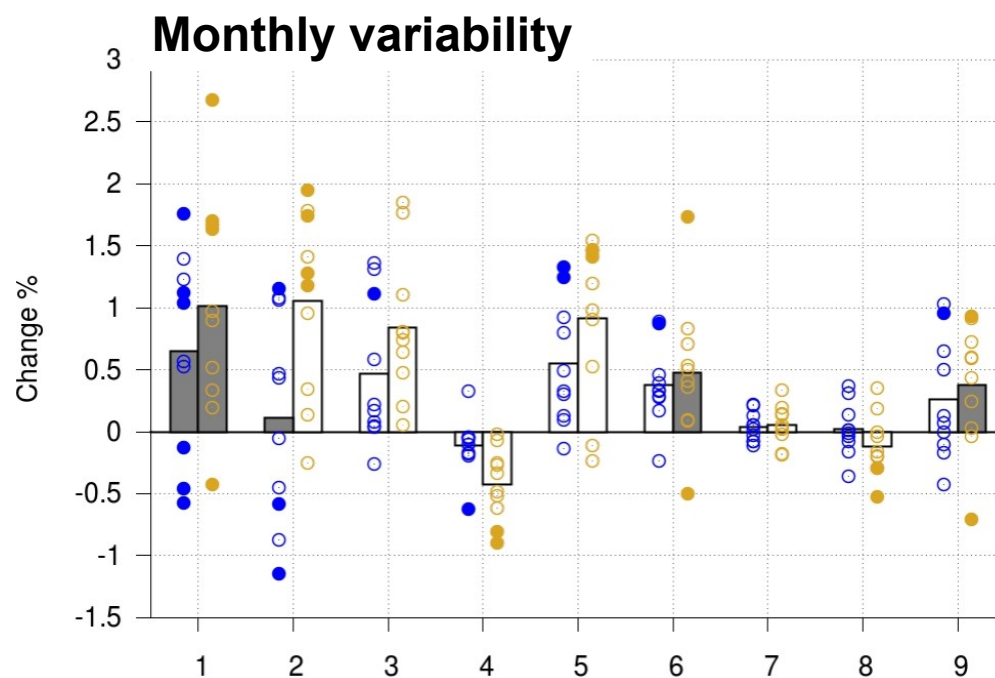
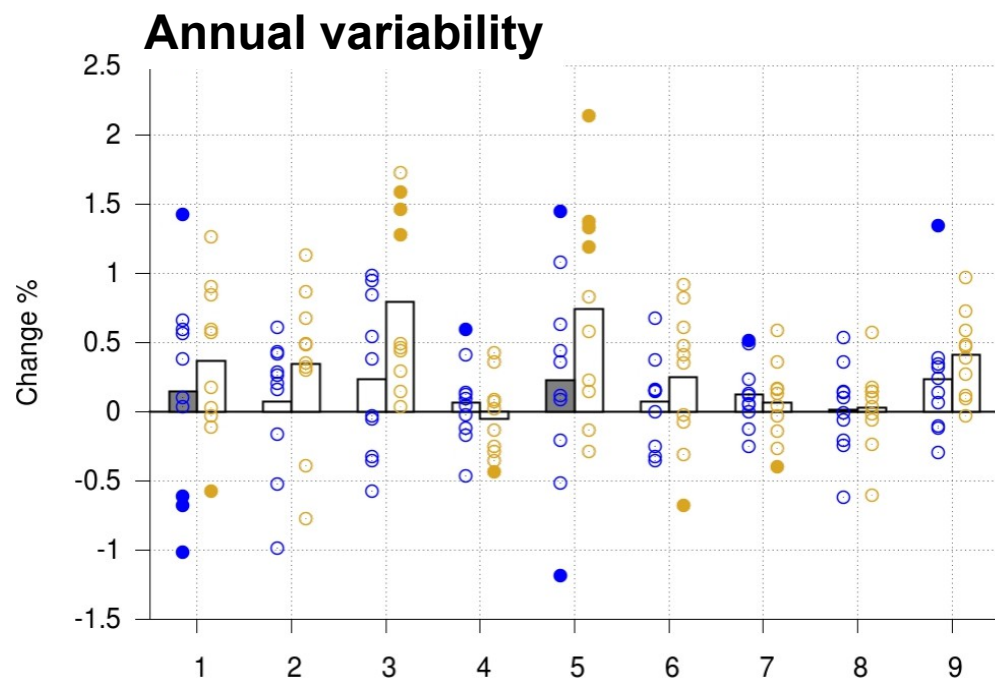


RCP4.5 RCP8.5

● ● Sig. individual signals  
○ ○ Non-sig. individual signals

□ Negligible EMean signal  
■ Uncertain EMean signal  
■ Robust EMean signal

# CC impact on PV generation





# Concluding...

## Does climate change threaten the future of the PV sector in Europe?

1. Overall mean PV supply will undergo slight decreases, the largest in Northern countries, where hardly overpass 15%
2. Time variability of PV supply does not appear as strongly affected, showing even a slightly higher temporal stability in Southern countries
3. Other studies also did not identify strong changes

Crook et al., *Energ. Environ. Sci.* 2011 & Wild et al., *Sol. Energy* 2015

**Therefore, climate change is unlikely to compromise the European development of photovoltaics**

### **But uncertainties still remain:**

- Different models provide different results (in particular GCMs vs RCMs)
- Indirect effects of aerosols and land use changes were not considered
- The tilt of PV panels was ignored

## Reference:

Jerez, S. et al. The impact of climate change on photovoltaic power generation in Europe. *Nature Communications* **6**, 10014, 2015.

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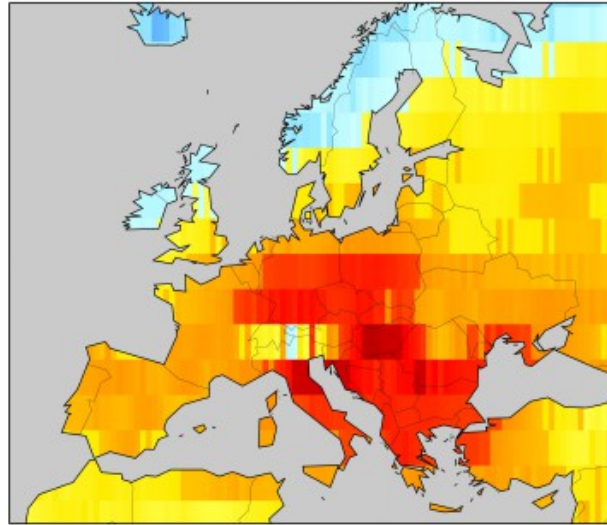
# Thank you for your attention!

**Supplementary Table 1.** Overview of the analyzed EURO-CORDEX experiments.

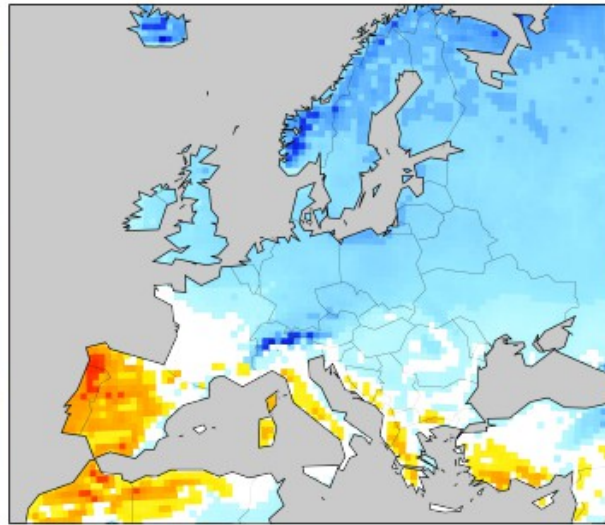
Exp. ID	Forcing GCM run	RCM	Institution (abbreviation)	Land-surface scheme	Planetary boundary layer scheme	Convection scheme	Microphysics scheme	Radiation scheme	No. of vertical levels
1	ICHEC-EC-EARTH-r3i1p1	HIRHAM 5	Danish Meteorological Institute (DMI)	[1]	[8]	[13]	[20]	[28] [29]	31
2	MOHC-HadGEM2-ES-01	CCLM 4.8.17	CLM Community (CLMCOM)	TERRA-ML [2]	[8]	[13]	[2] [21]	[30]	40
3	IPSL-CM5A-MR-r1i1p1	WRF 3.3.1	Institute Pierre Simon Laplace / Institut National de l'Environnement Industriel et des Risques (IPSL-IPERIS)	NOAH [3]	YSU [9]	[14]	[22]	RRTMG [31]	32
4	ICHEC-EC-EARTH-r1i1p1	RACMO 2.2	Royal Netherlands Meteorological Institute (KNMI)	[4] [5]	[10] [11]	[13] [15] [16]	[23] [24] [25] [26]	[32] [33]	40
5	MPI-ESM-LR-r1i1p1	REMO 2009	Climate Service Center (CSC)	[1] [6]	[8]	[13] [15] [17]	[20]	[28] [29]	27
6	CNRM-CM5-r1i1p1	RCA 4	Swedish Meteorological and Hydrological Institute (SMHI)	[7]	[12]	[18] [19]	[27]	[34] [35]	40
7	ICHEC-EC-EARTH-r12i1p1	RCA 4	Swedish Meteorological and Hydrological Institute (SMHI)	[7]	[12]	[18] [19]	[27]	[34] [35]	40
8	IPSL-CM5A-MR-r1i1p1	RCA 4	Swedish Meteorological and Hydrological Institute (SMHI)	[7]	[12]	[18] [19]	[27]	[34] [35]	40
9	MOHC-HadGEM2-ES-01	RCA 4	Swedish Meteorological and Hydrological Institute (SMHI)	[7]	[12]	[18] [19]	[27]	[34] [35]	40
10	MPI-ESM-LR-r1i1p1	RCA 4	Swedish Meteorological and Hydrological Institute (SMHI)	[7]	[12]	[18] [19]	[27]	[34] [35]	40

# Comparison of GCM and RCM projections for RSDS

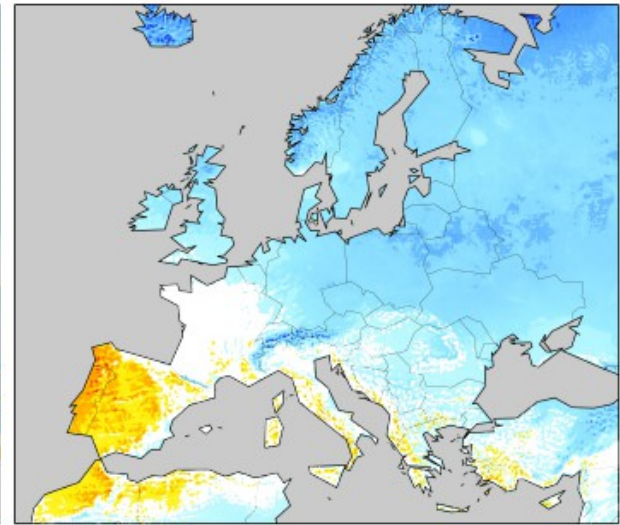
CNRM-CM5-r1i1p1



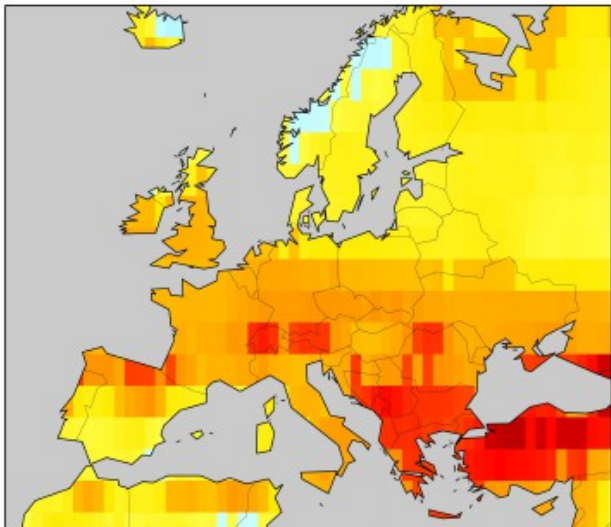
RCA4 – 0.44°



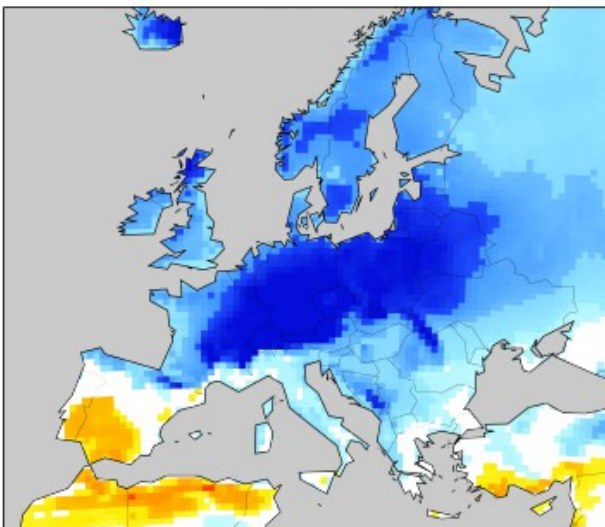
RCA4 – 0.11°



IPSL-CM5A-MR-r1i1p1



WRF3.3.1 – 0.44°



WRF3.3.1 – 0.11°

