European climate change at different global warming levels as derived from a large ensemble of EURO-CORDEX simulations

Erik Kjellström, Grigory Nikulin and Gustav Strandberg
Rossby Centre, SMHI

with acknowledgements to the EURO-CORDEX team!

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Aim and questions

To characterize European climate change at a number of different global warming levels (1.5, 2.0, 2.5 and 3.0°C) in a large set of RCM simulations at 12.5 km grid spacing

- **At which of the warming levels can we detect statistically significant climate change for different variables and climate indices?**
- **To what extent are changes at the different warming levels different?**
- **How are different sources of uncertainty (GCM, RCM, natural variability) influencing the CC signal?**

RCM simulations

31 EURO-CORDEX simulations with 7 RCMs under RCP8.5

RCM / GCM	CCLM	RACMO	RCA	HIRHAM	REMO 2009/ 2015	REG CM4-6	WRF 361H	ALADIN
ECEARTHr12								
ECEARTHr1								
ECEARTHr3								
MPIr1								
MPIr2								
HadGEMr1								
CNRMr1								
IPSLr1								
NORESMr1								
CANESMr1								
MIROCr1								

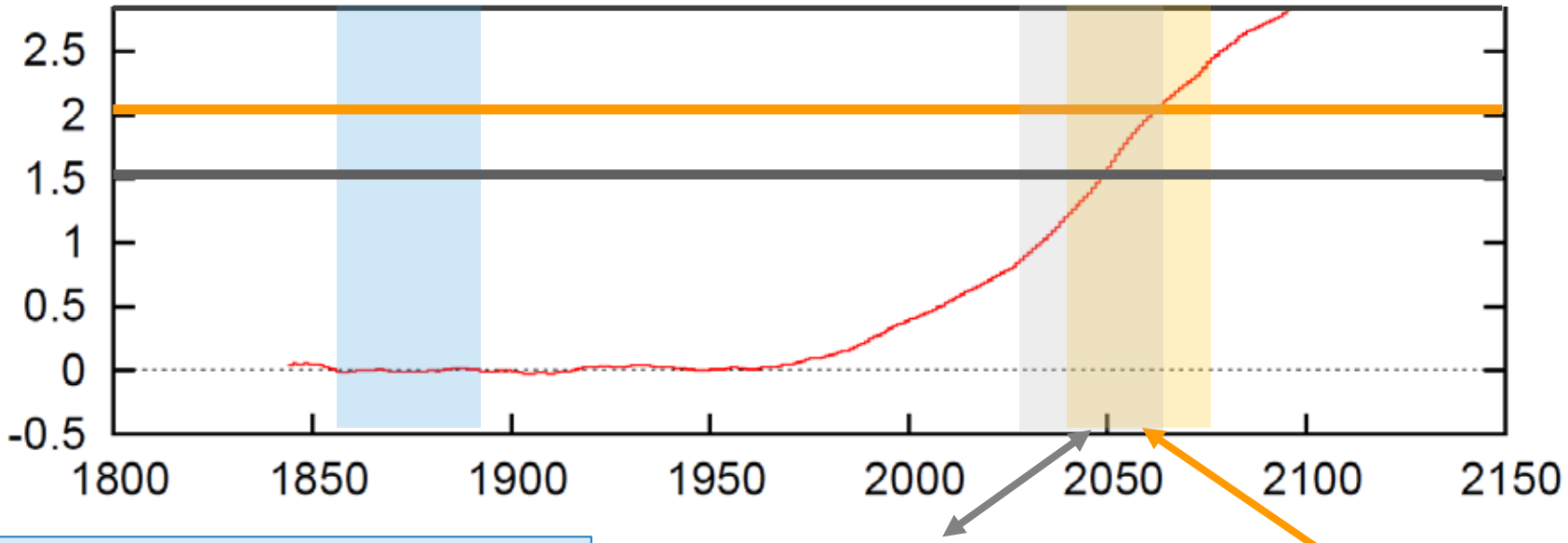
Kjellström et al., 2018, *Earth Syst. Dynam*., 9, 459-478, https://doi.org/10.5194/esd-9-459-2018.

More recent simulations

When do we reach **2(1.5)˚C** warming?

Global annual mean 2m-temperature

30-year running mean anomaly w.r.t. 1861-1890
in one simulation by one global climate model



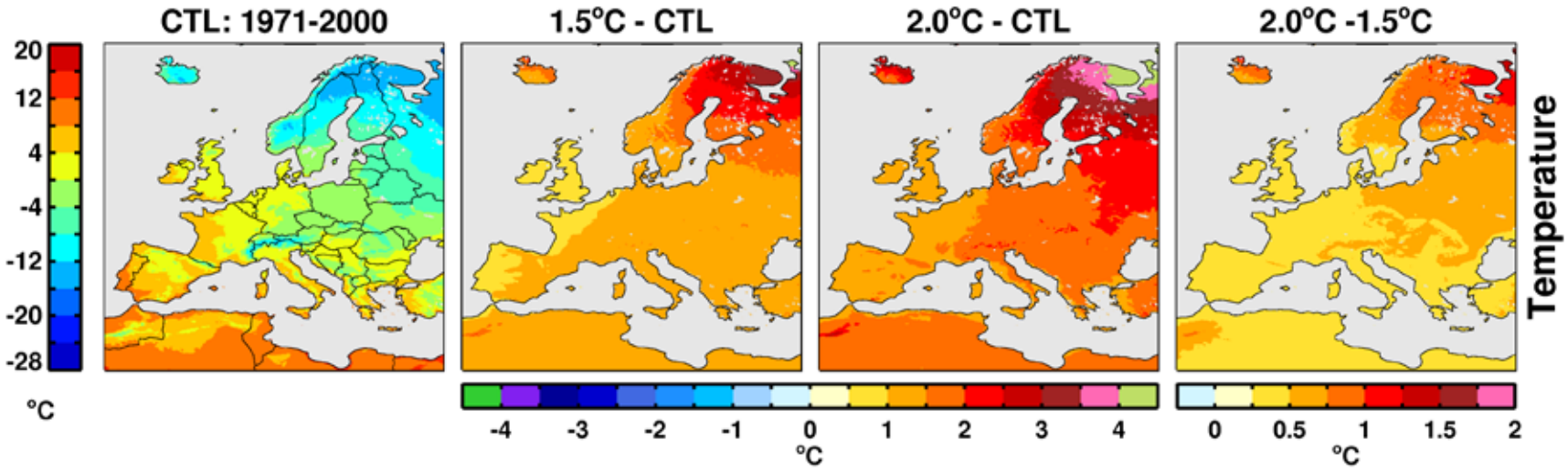
”Preindustrial” conditions
(1861-1890)

1.5°C warming
(2033-2062)

2°C warming
(2046-2075)

EURO-CORDEX ensemble and analysis

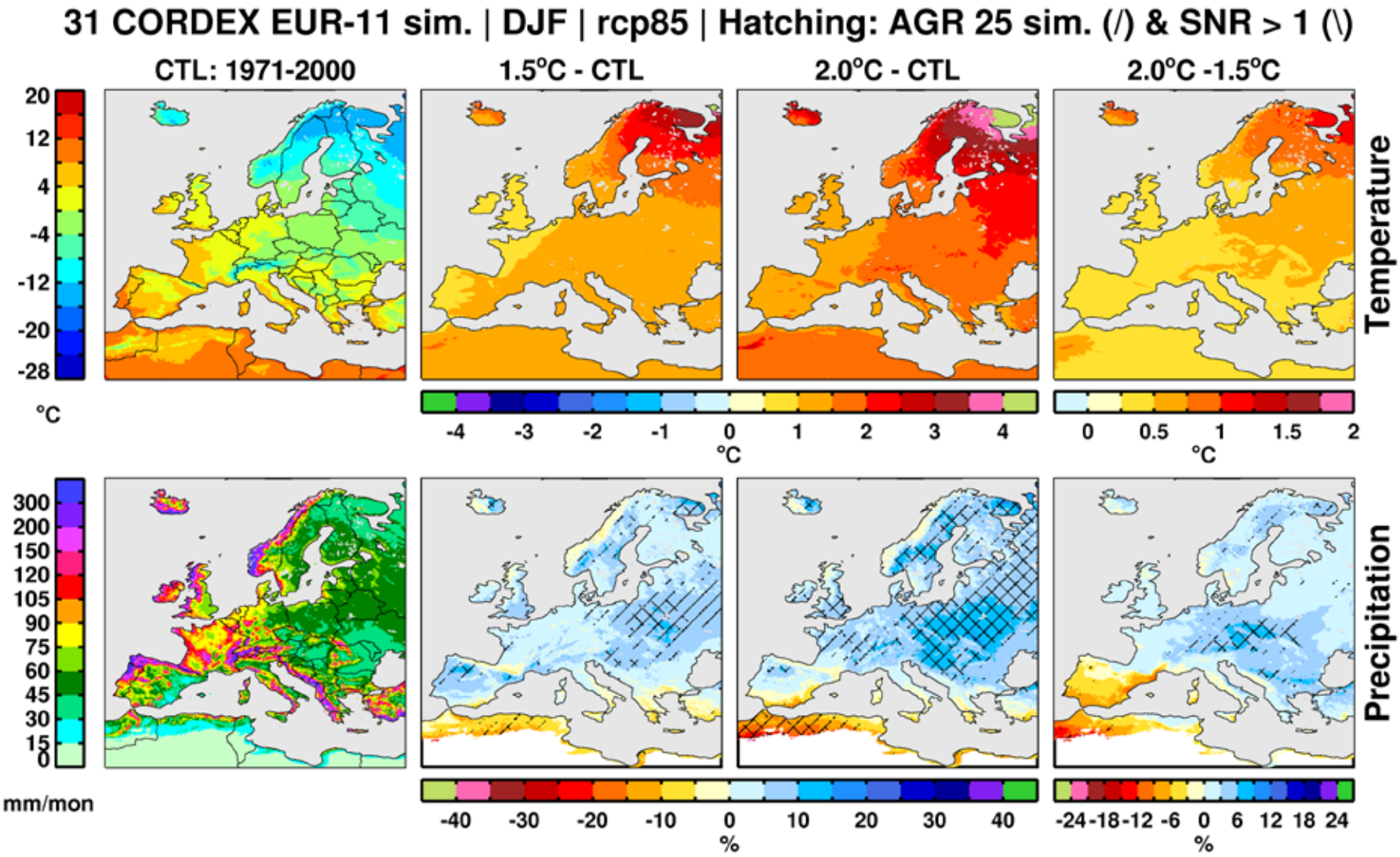
CONTROL 1971-2000 | **+1.5°C minus CONTROL** | **+2.0°C minus CONTROL** | **+2.0°C minus +1.5°C**



Ensemble mean near-surface temperature change (DJF)

From observations (www.smhi.se): DJF mean temperature 1971-2000 as an average for Sweden is 1.1°C above that in 1861-1890

Ensemble mean climate change (DJF)

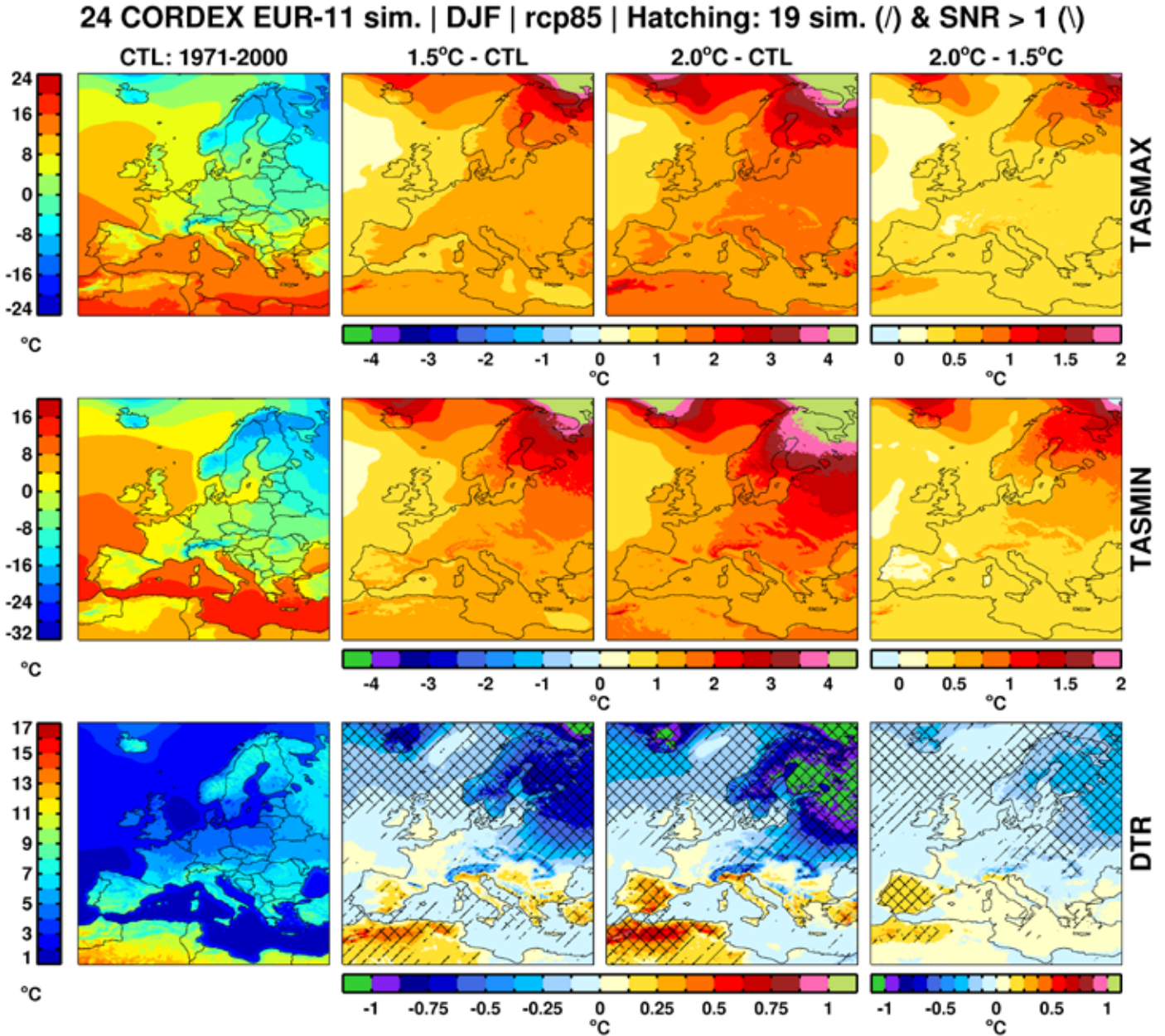


80% of the models AGRee on sign of change

AGR & SNR (mean / stddev) > 1

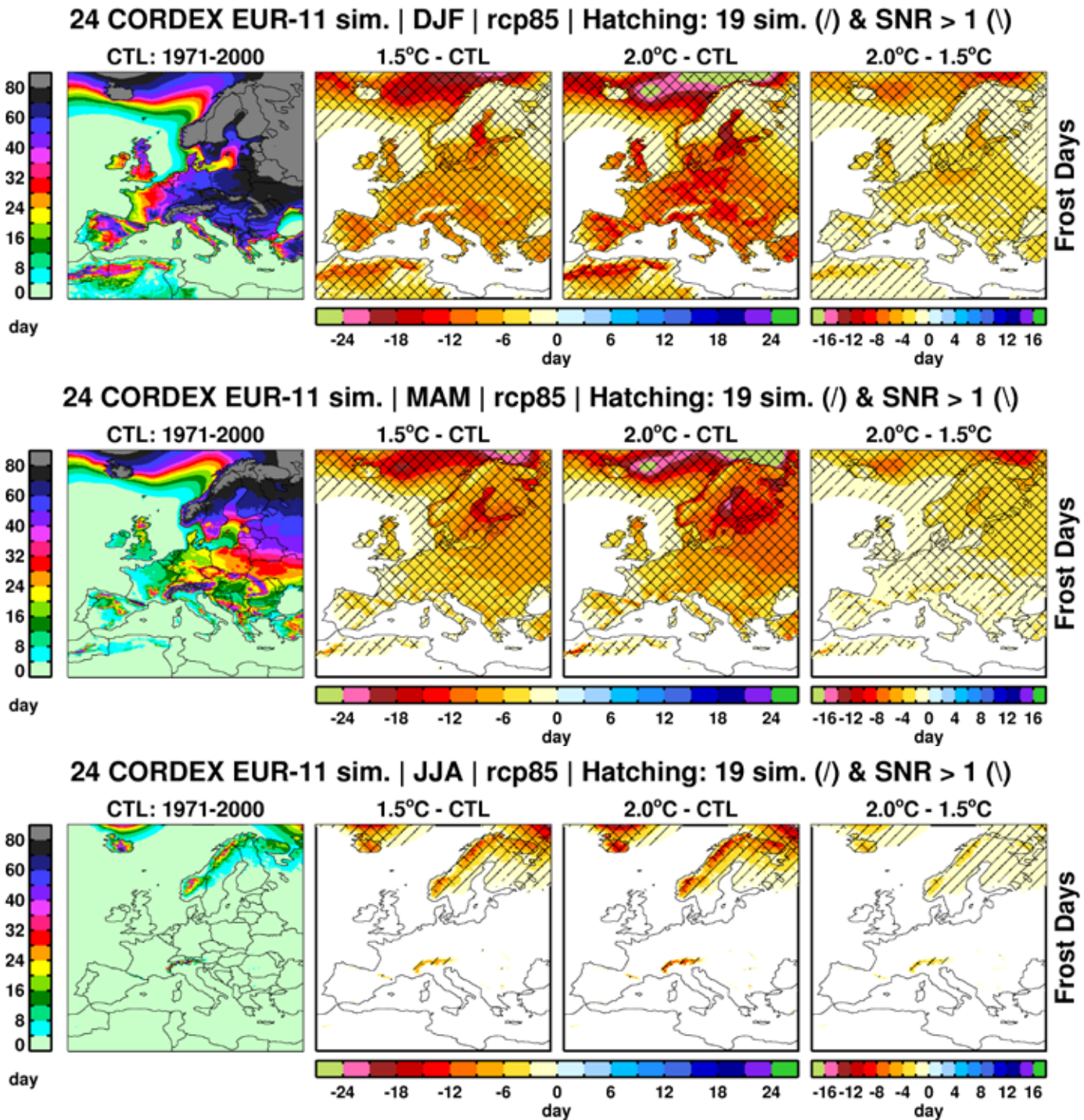
Temperature climate (DJF)

- T increases most significant in the northeast
- Minimum temperatures increase more than maximum (decreasing variability)
- Reduced diurnal temperature range



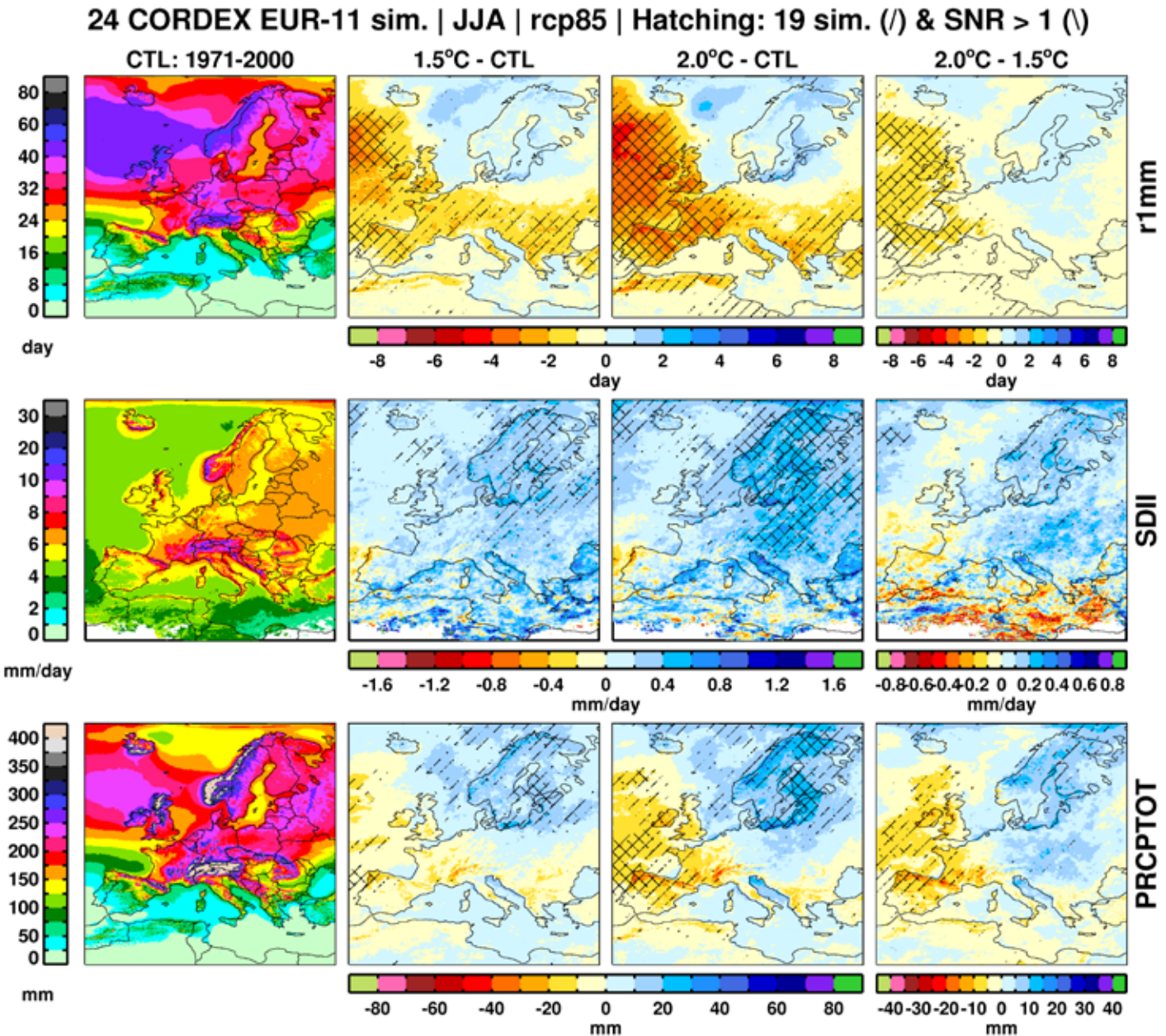
Frost days

- Frost days decreasing in all areas where there are frost days in CTL
- Winter changes relatively small in the coldest regions (N. Scand. and the Alpine region)
- Notable changes over the ocean



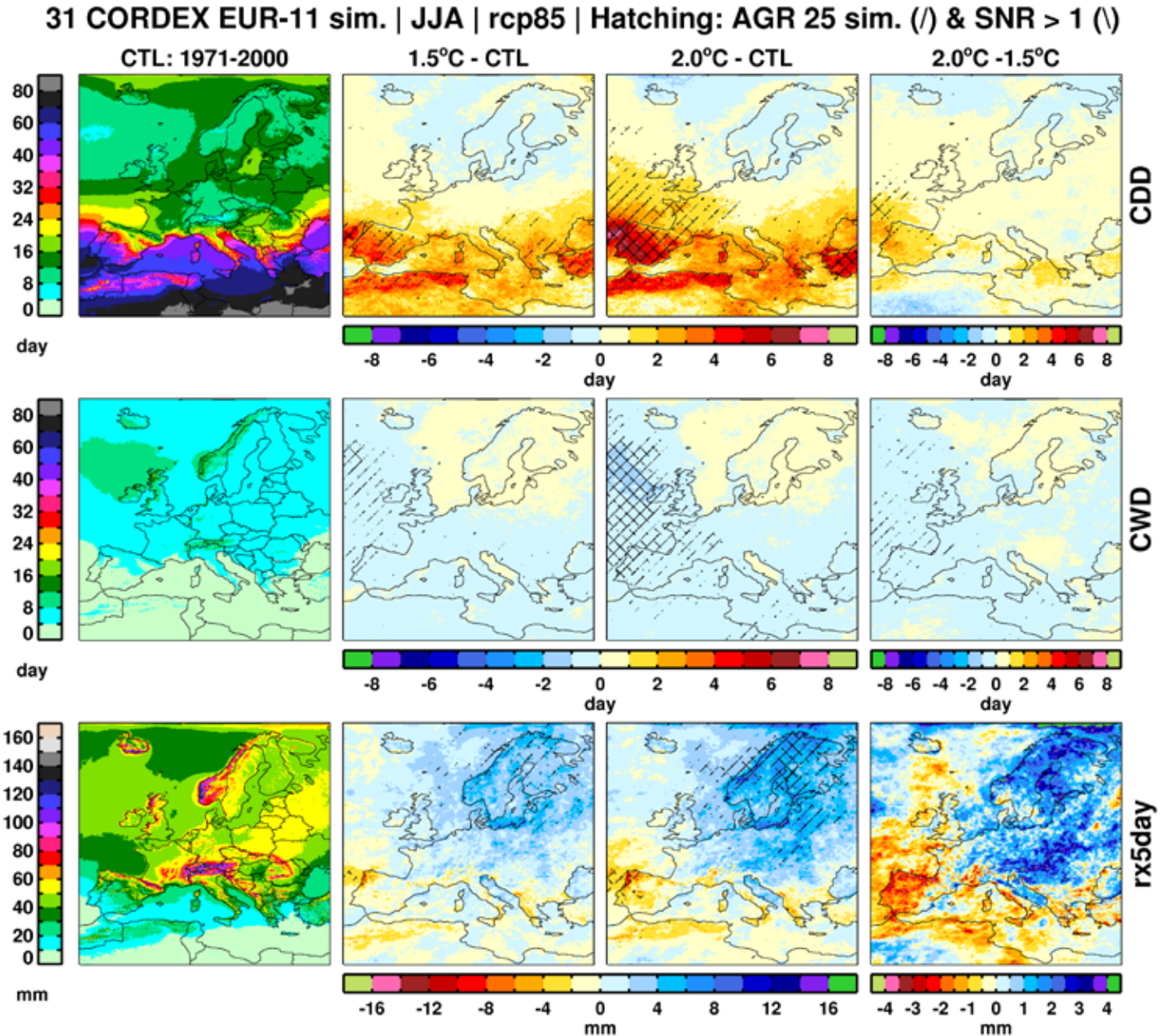
Some precipitation indices (JJA)

- Number of wet days decrease in the south and over the Atlantic
- Precipitation increase on the wet days
- Wetter in the north, drier in the south and west.

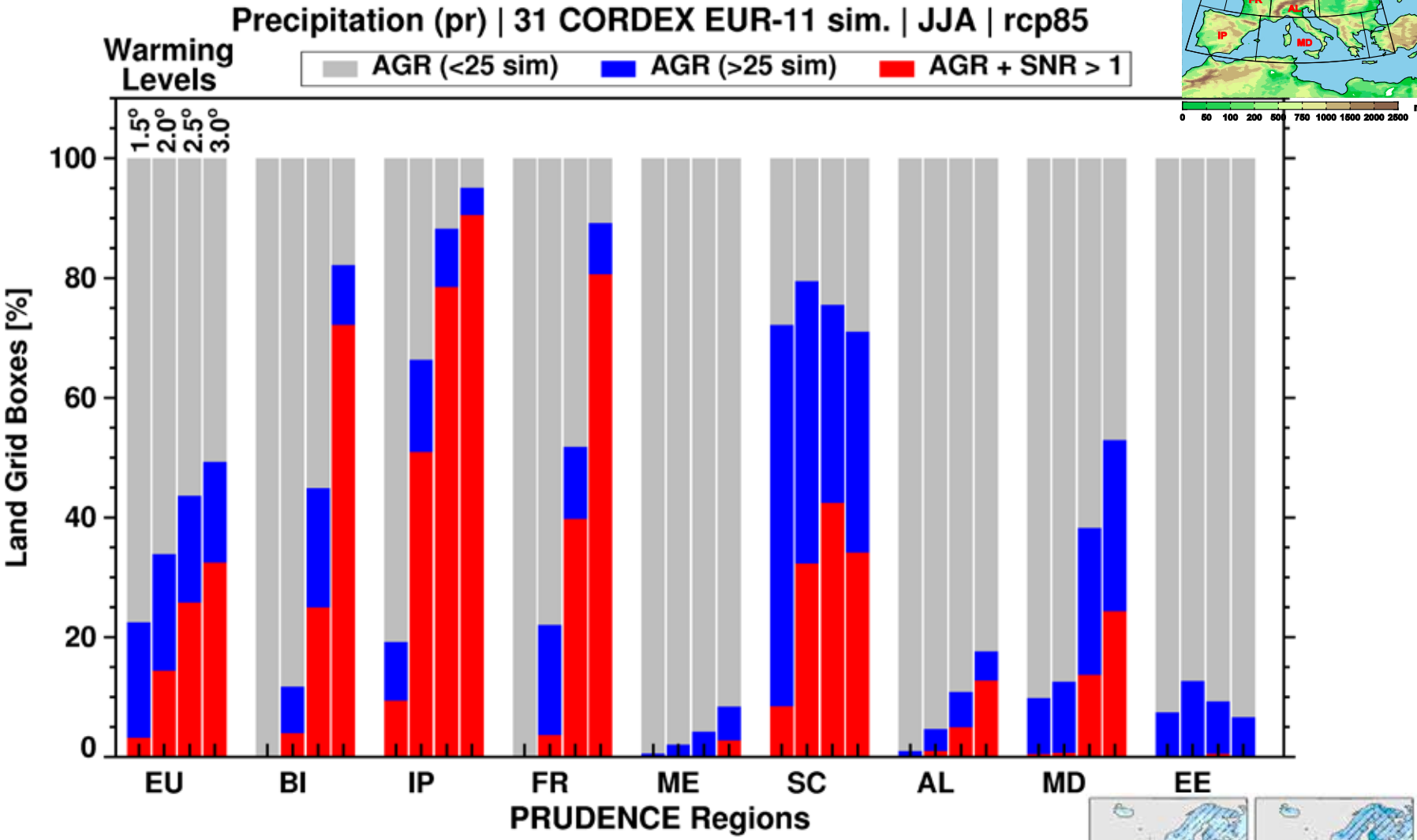


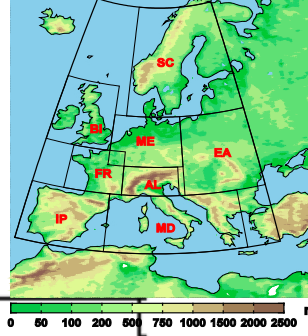
Wet and dry periods (JJA)

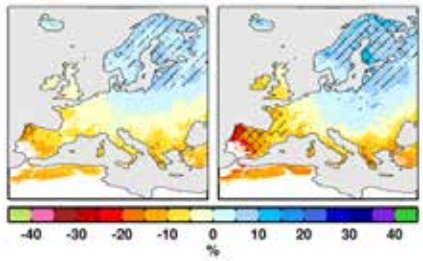
- Drier conditions in the south and in the west
- Max. five-day precipitation increases in central and northern Europe



Changes over time (precip JJA)



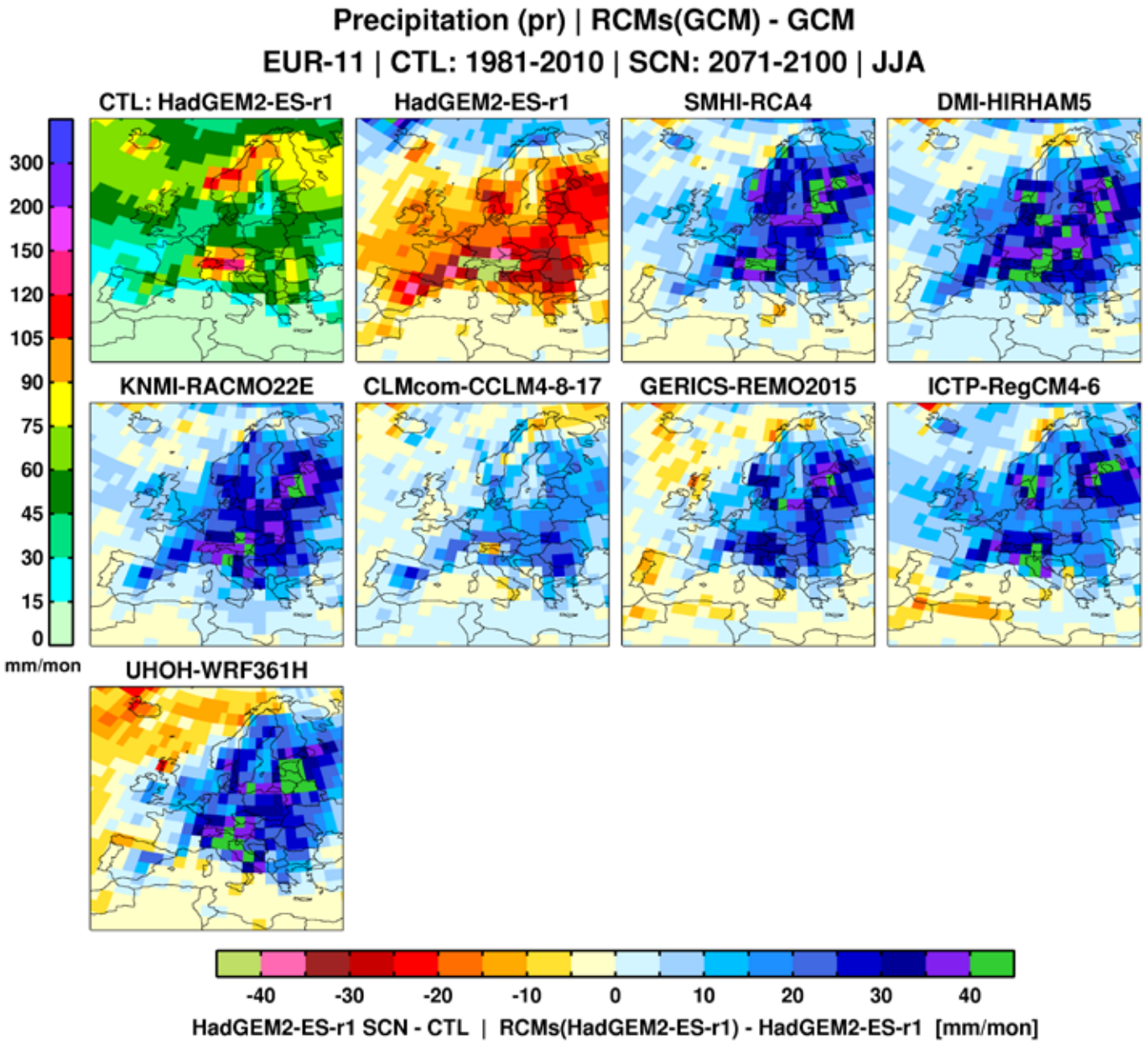




- Increasing agreement with GWL in most regions
- Some regions show little agreement even at +3°C

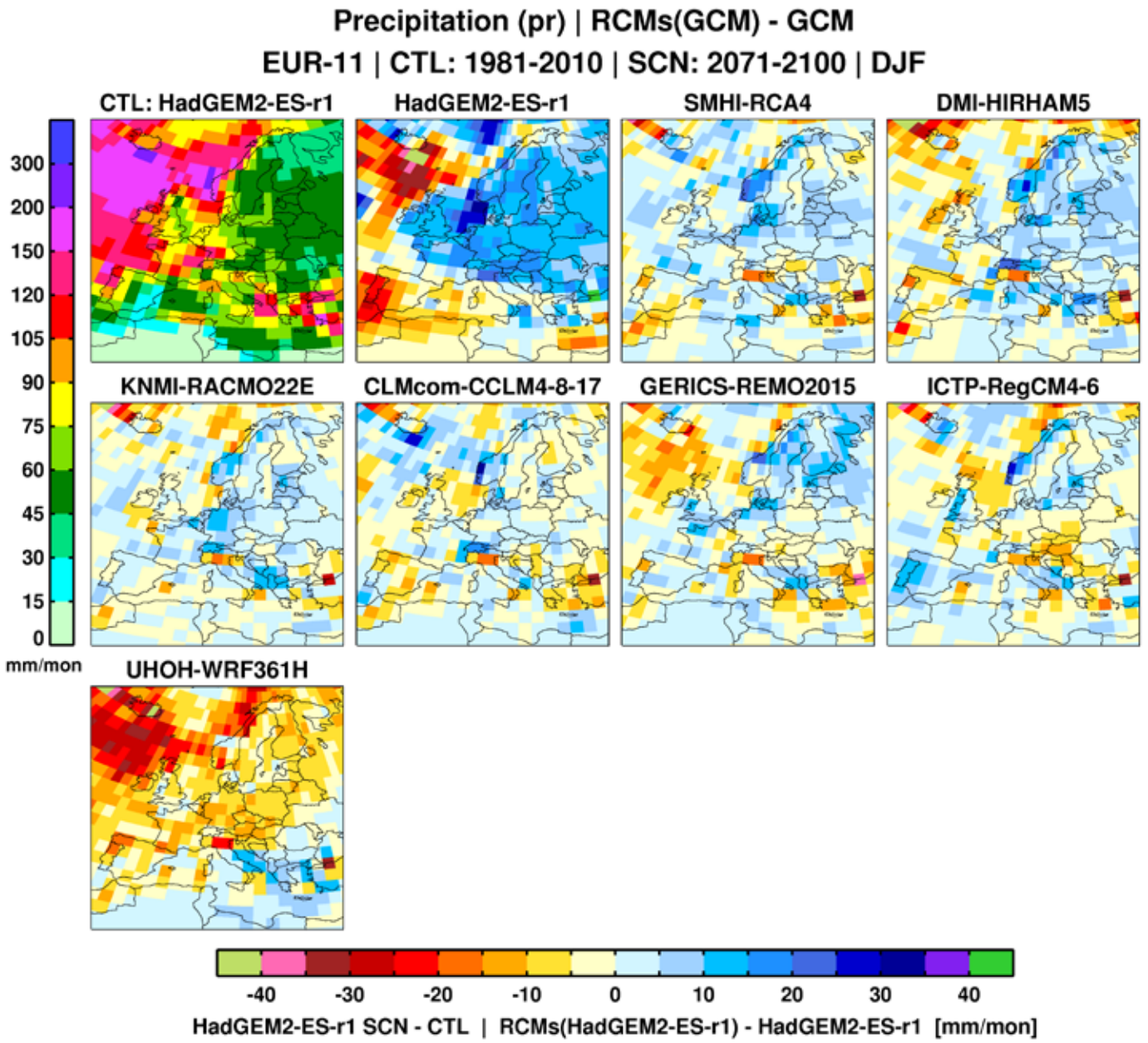
Same response in RCMs (and GCMs)?

- HadGEM2 show decreasing precipitation in most of Europe
- RCMs modifies the change significantly



Same response in RCMs (and GCMs)?

- HadGEM2 shows increasing precipitation in most of Europe
- RCMs add detail (e.g. the Scandinavian mountains, the Alps)
- One RCM (WRF) show large differences in the large-scale response



Conclusions

- Already at GWL1.5 many changes are significant while at GWL2 and higher GWLs changes get stronger and more robust
- Significant differences are found between variables/indices for different GWLs
- Spread in results is related to choice of GCM, RCM and ensemble member and varies with variable
- Generally, there is a large impact of large-scale circulation given by GCMs and natural variability
- The RCMs can strongly modify the climate change signal given by the GCM

Results for an earlier version based on a subset of the simulations can be found in: Kjellström et al., 2018. European climate change at global mean temperature increases of 1.5 and 2 °C above pre-industrial conditions as simulated by the EURO-CORDEX regional climate models, *Earth Syst. Dynam*., 9, 459-478, https://doi.org/10.5194/esd-9-459-2018.