

# European summer climate variability in a changing climate

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# Research questions

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**European surface temperature variability changes in a changing climate:**

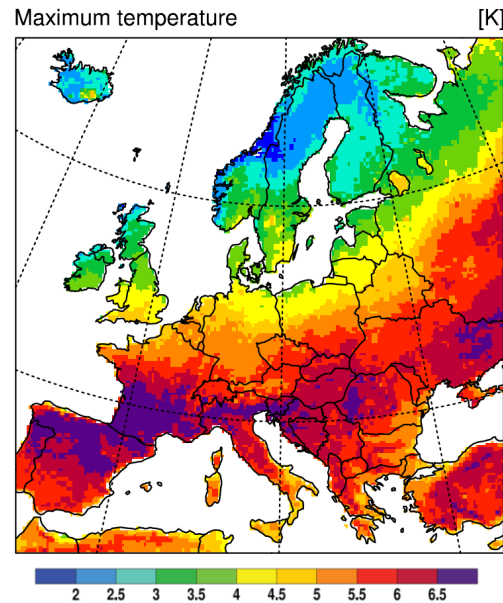
- **Do variability changes matter?**
- **What are the expected changes at interannual versus daily time-scales?**
- **What are the differences between the PRUDENCE and the ENSEMBLES simulations?**

# Changes in daily variability

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Ensemble mean changes (6 RCMs, ENSEMBLES)  
(2071-2100 vs. 1961-90)

Change in 99th  
percentile

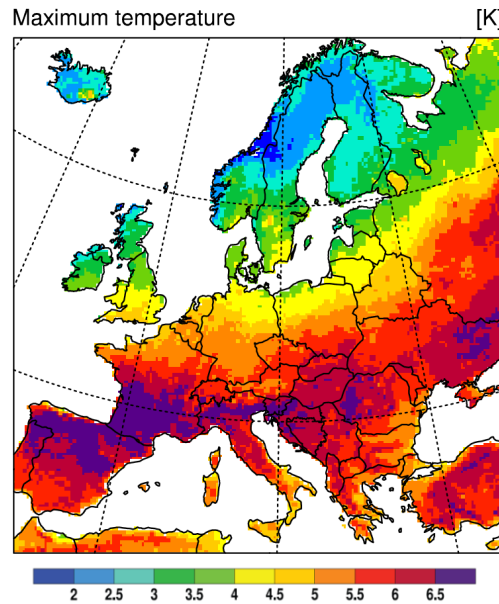


Fischer and Schär, *Nature Geoscience* (2010)

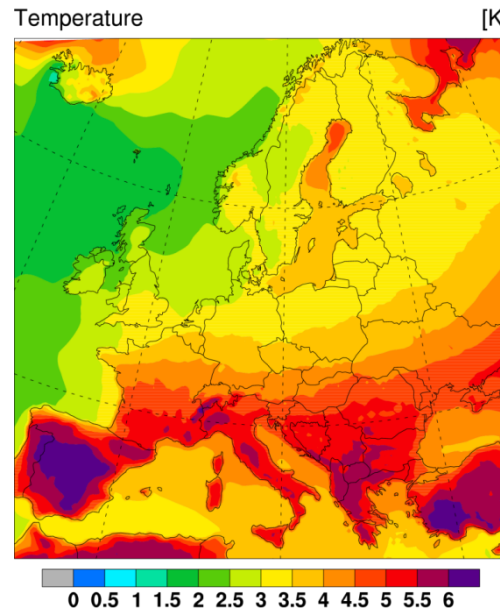
# Changes in daily variability

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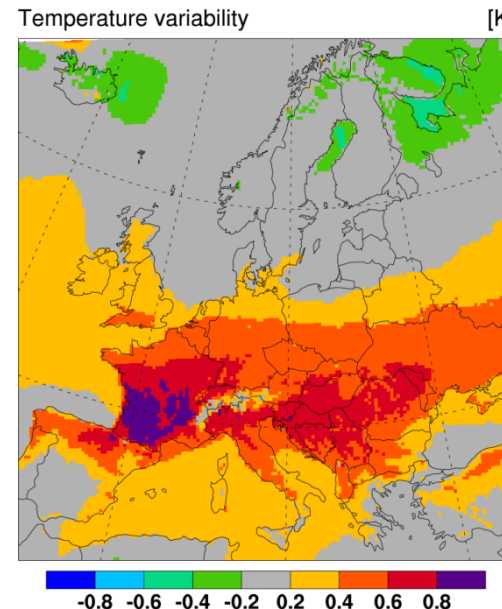
Change in 99th  
percentile



Change in JJA mean



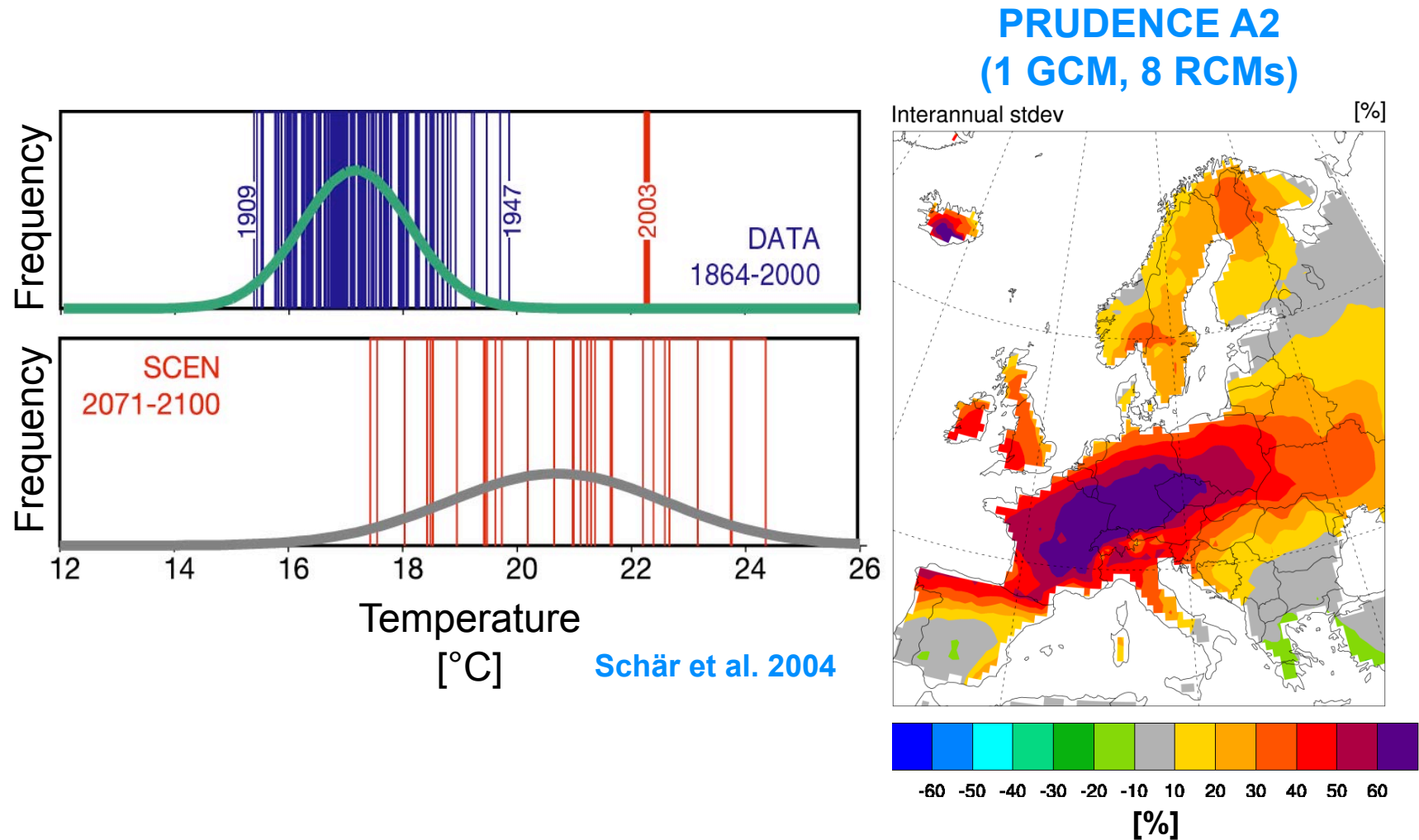
Change in JJA  
variability



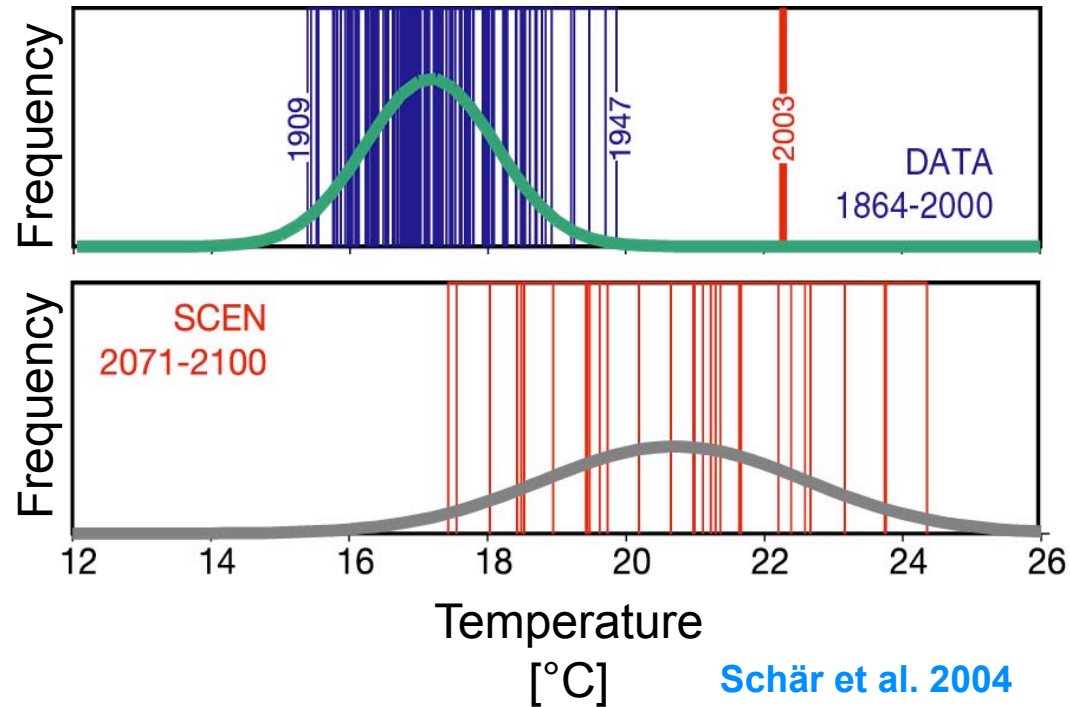
Number of hot days (exc. freq):  
mainly accounted for by mean change

Fischer and Schär, *Nature Geoscience* (2010)

# Summer 2003 and interannual variability



# Summer 2003 and interannual variability

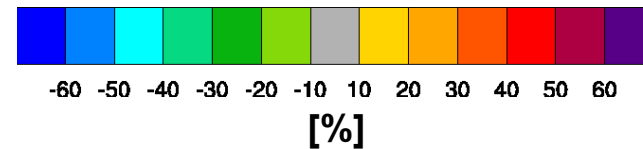
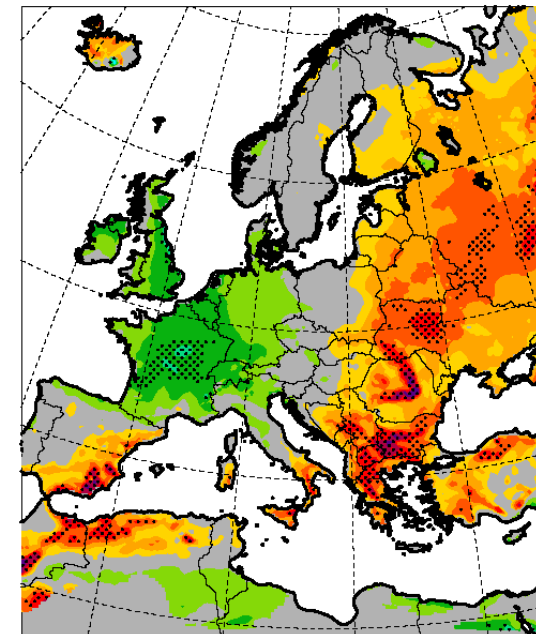


Schär et al. 2004

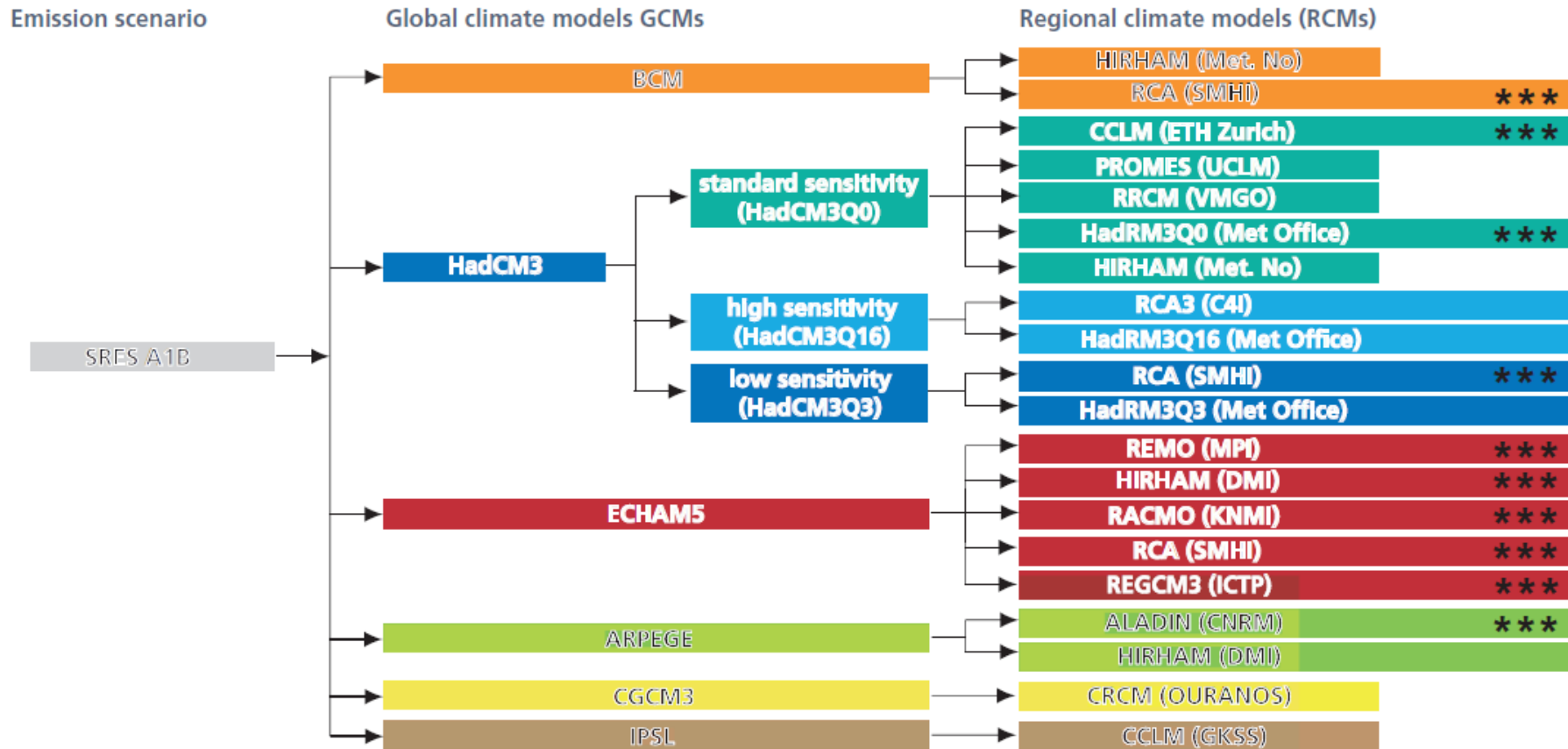
## ENSEMBLES 1 RCM

SMHI [-HadCM3Q3 A1B]

JJA Temperature IAV Change [%]

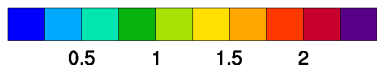
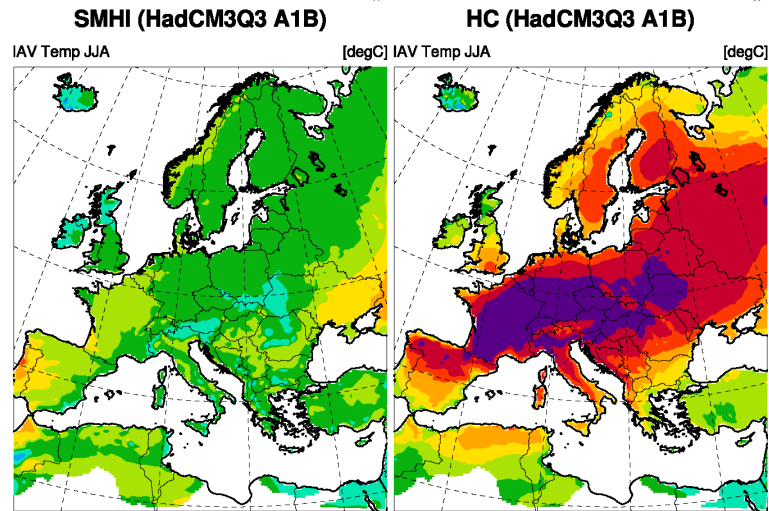
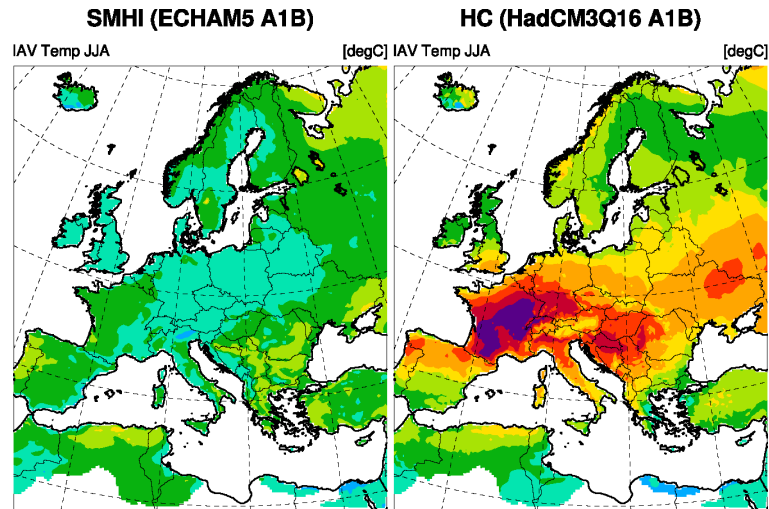


# ENSEMBLES projections over Europe



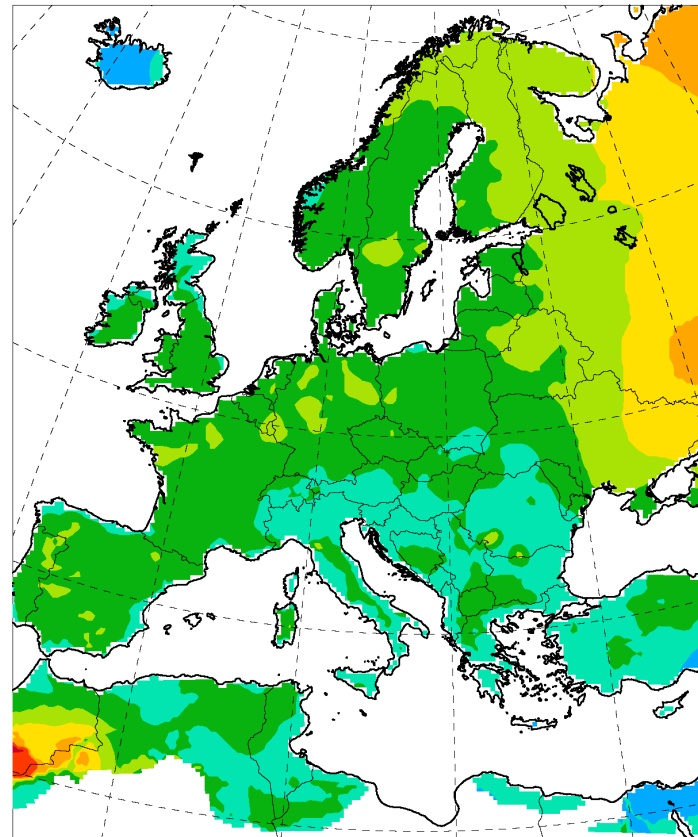
ENSEMBLES final report and CH2011 scenarios

# Validation (interannual summer variability)



## EOBS Interannual Temp. Var. JJA

IAV Temp JJA [degC]





# △ Interannual summer variability

**PRUDENCE A2**  
(1 GCM, 8 RCMs)

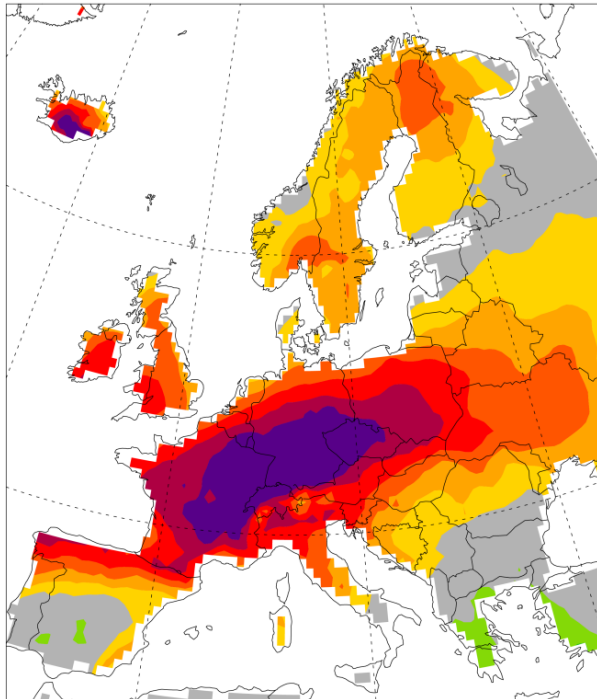
**ENSEMBLES A1B**  
(6 GCMs, 14 RCMs)

GCM-weighted average

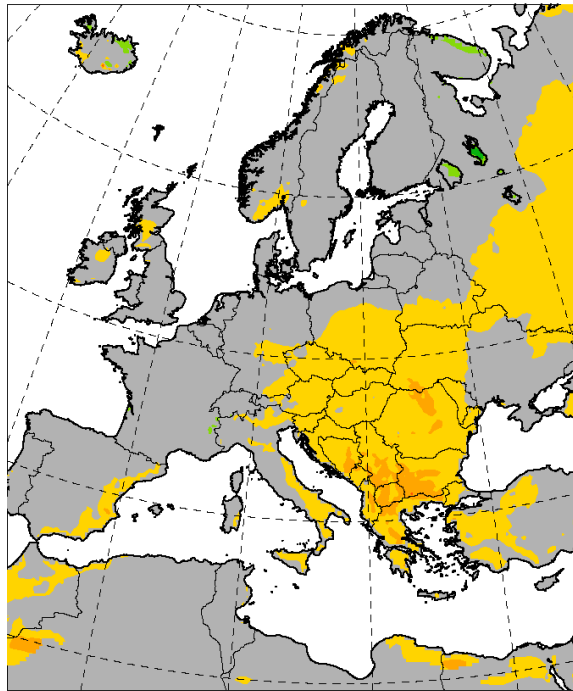
Averaged across RCMs

Interannual stdev

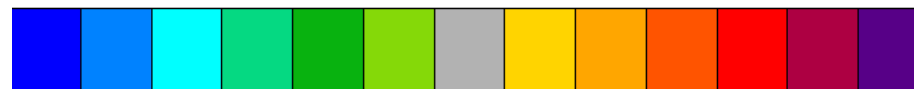
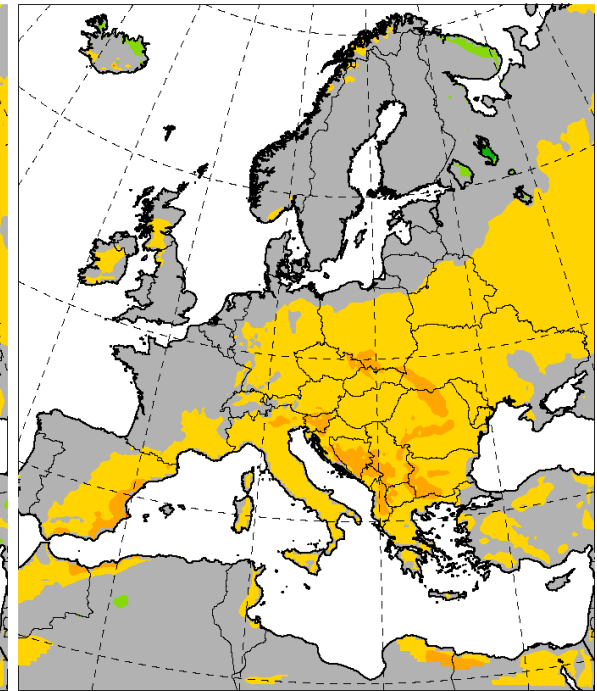
[%]



IAV Change JJA



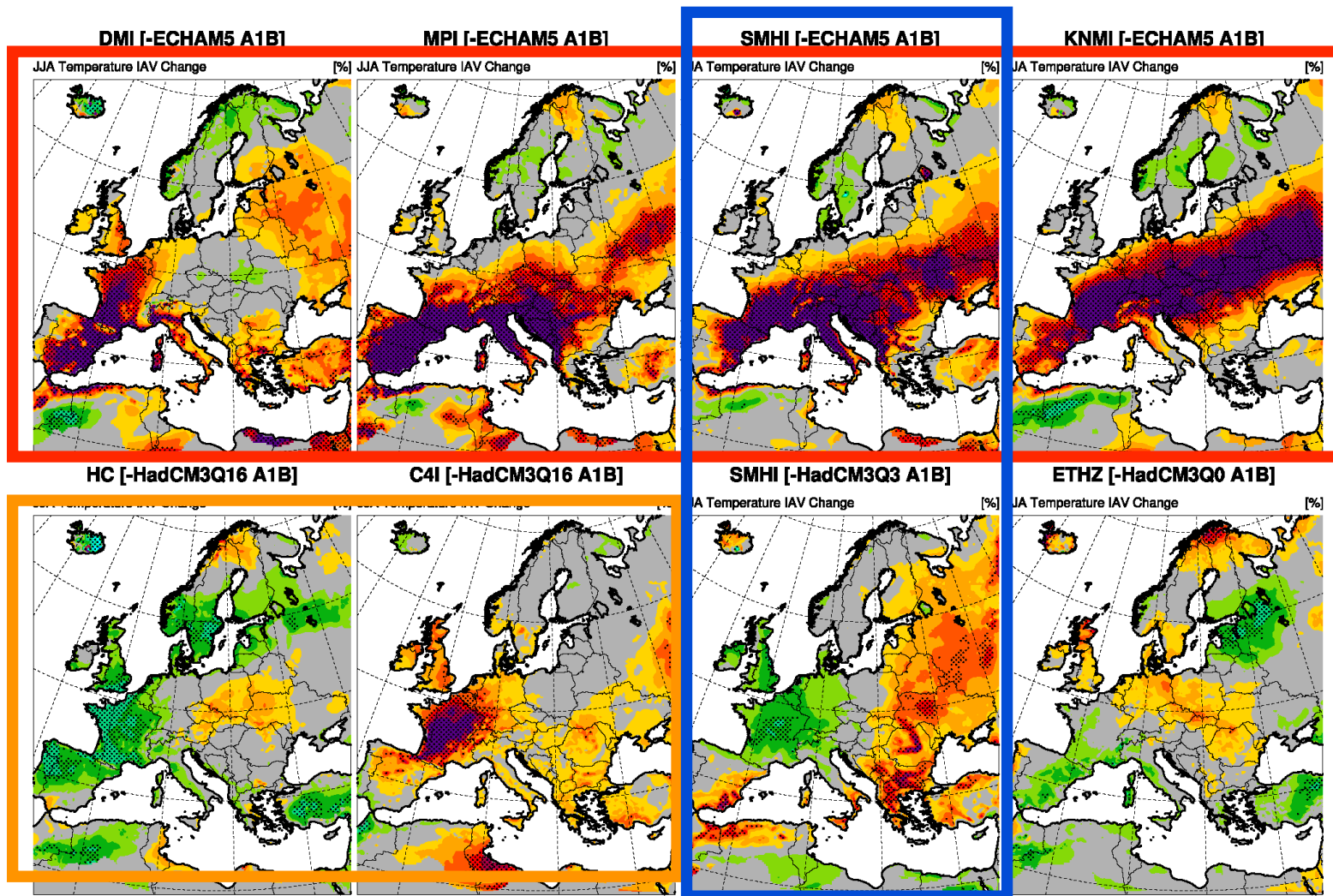
[%] IAV Change JJA



-60 -50 -40 -30 -20 -10 10 20 30 40 50 60

[%]

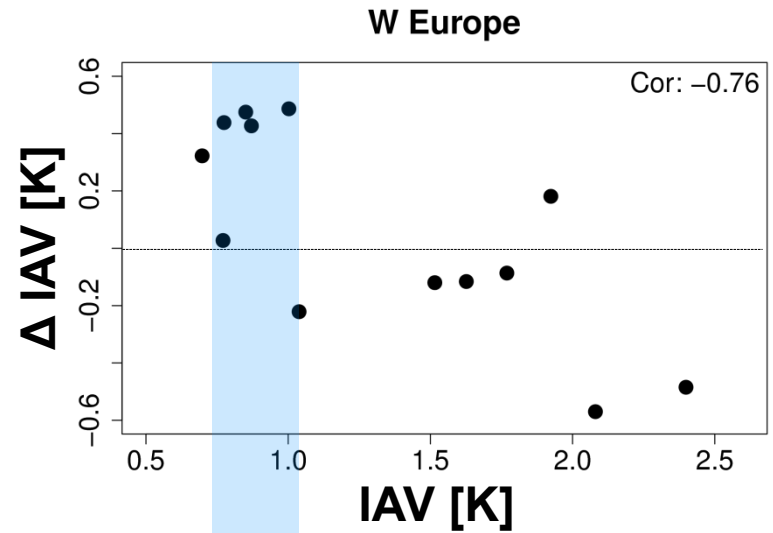
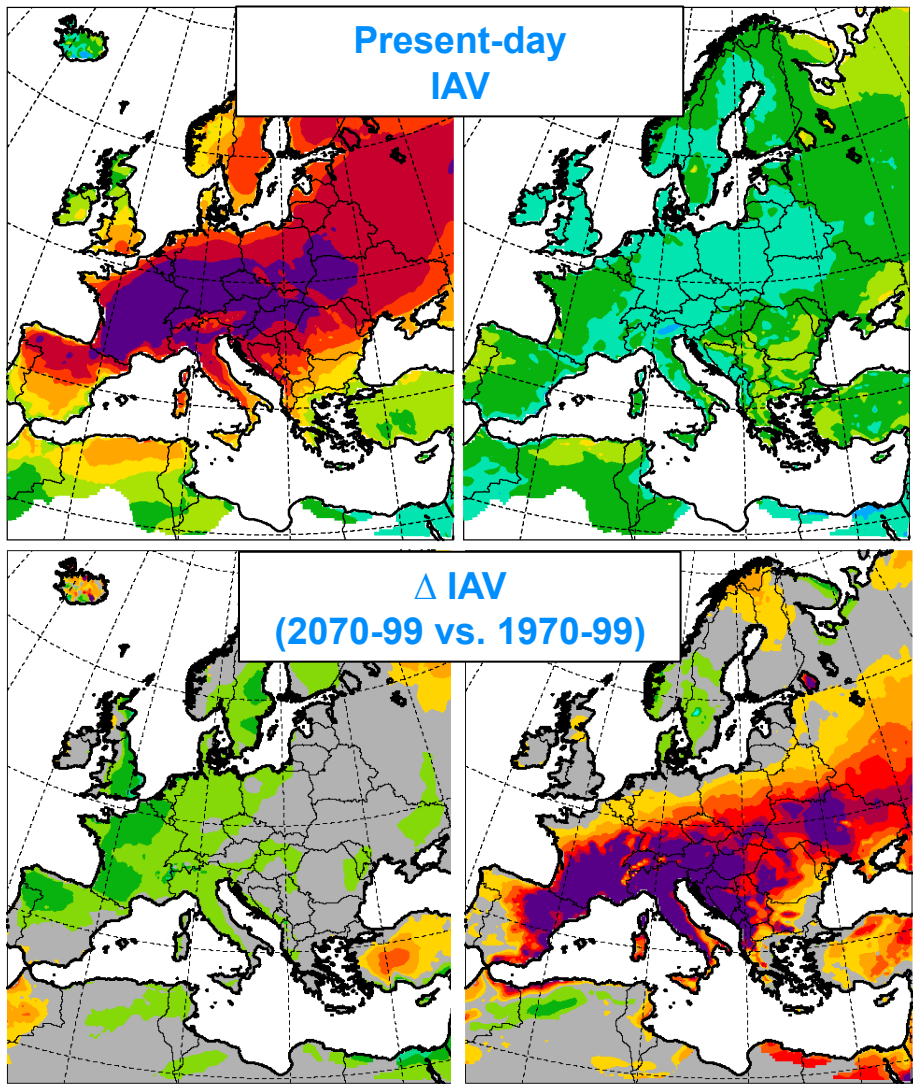
# Individual RCMs



Same driving GCMs

Same RCM

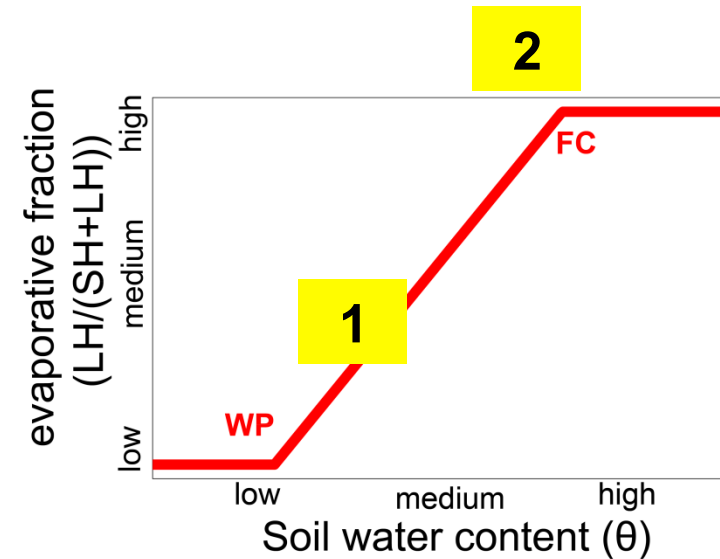
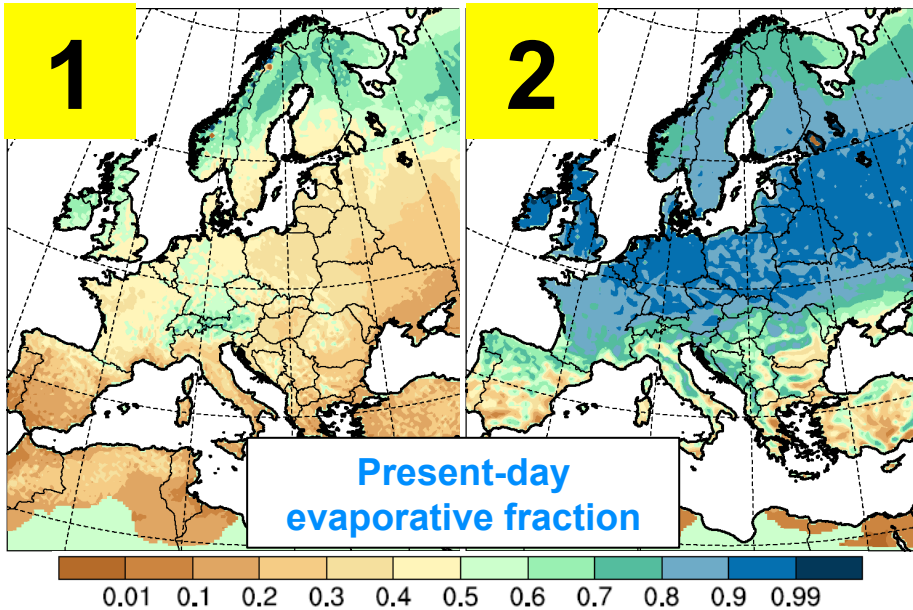
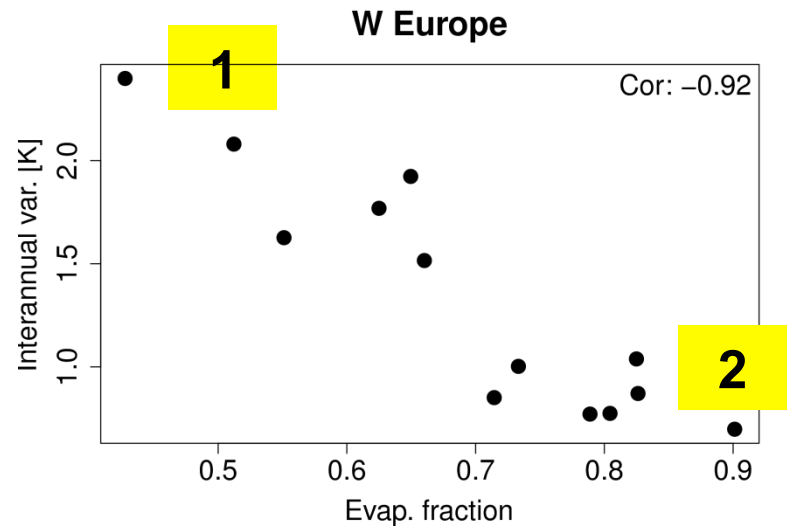
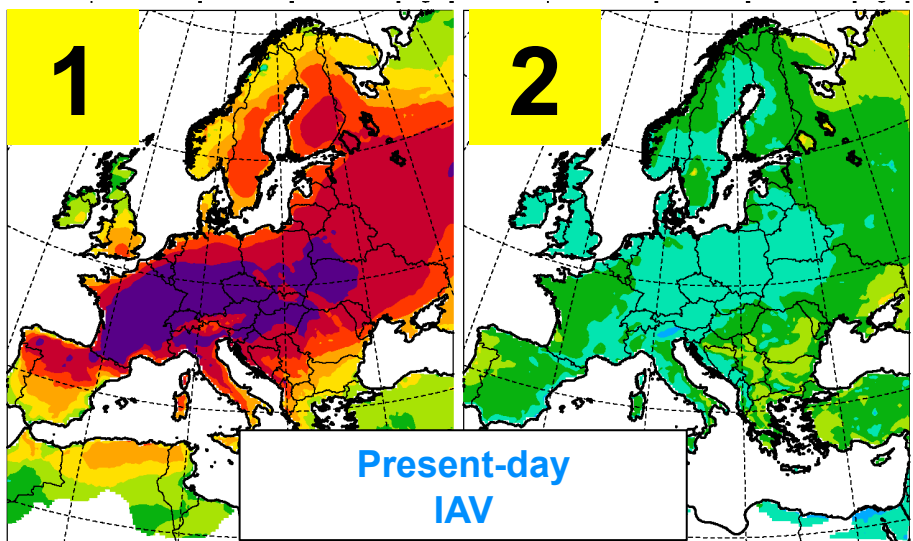
# Changes in interannual summer variability



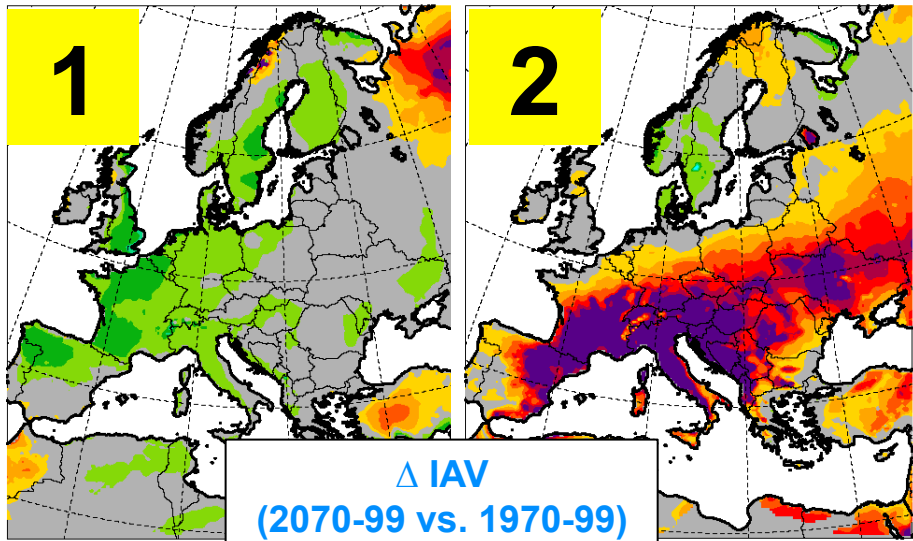
Most models with realistic present-day IAV show increases

Models with high present-day IAV tend to show decreases

# Interannual summer variability vs. evap fraction

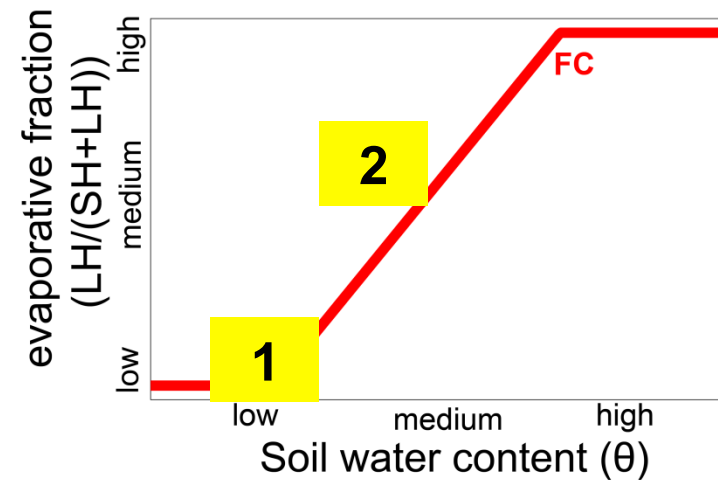
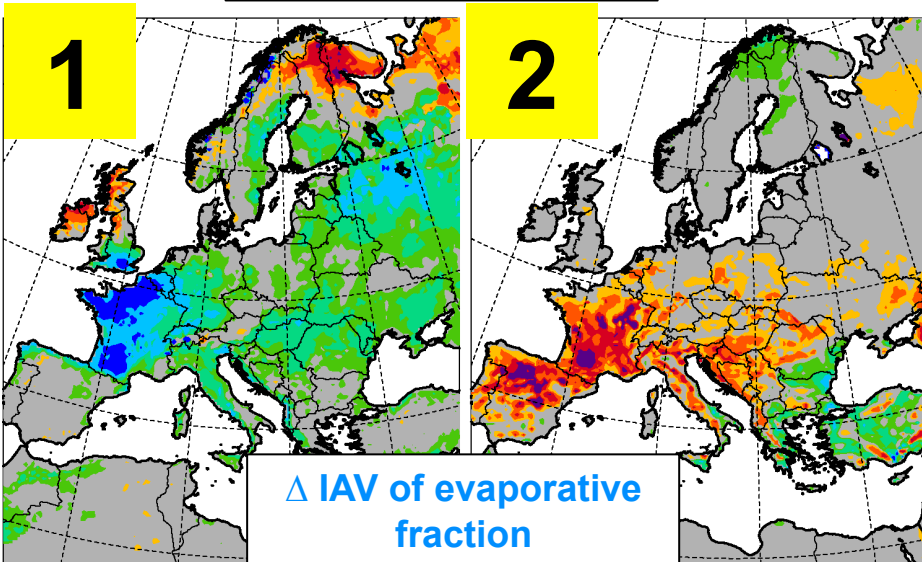


# Interannual summer variability



Once the soils are dry in most summers IAV decreases again

See Seneviratne et al. (2006) for detailed discussion based on 1 RCM



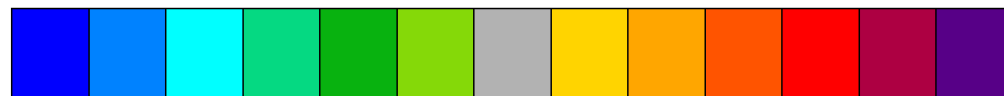
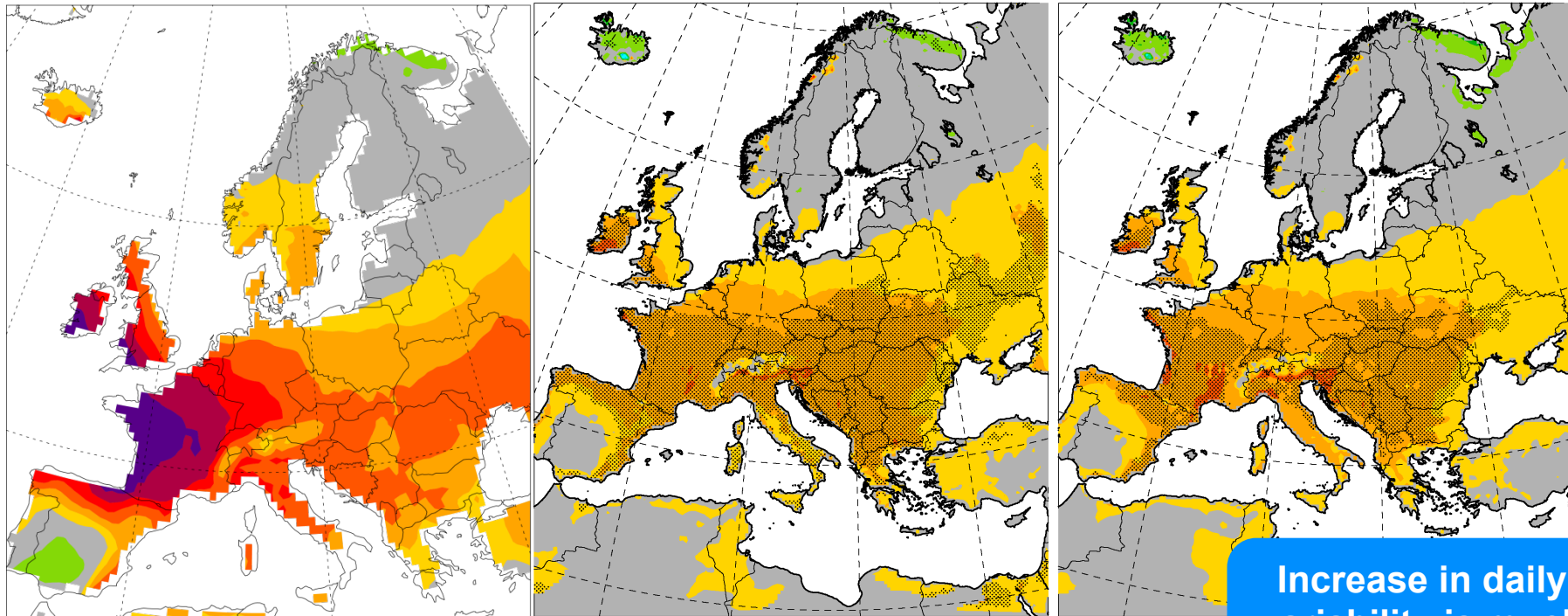
# Δ daily variability (JJA, 2070-99 vs. 1970-99)

**PRUDENCE A2**  
(1 GCM, 8 RCMs)

**ENSEMBLES A1B**  
(6 GCMs, 14 RCMs)

GCM-weighted average

Averaged across RCMs

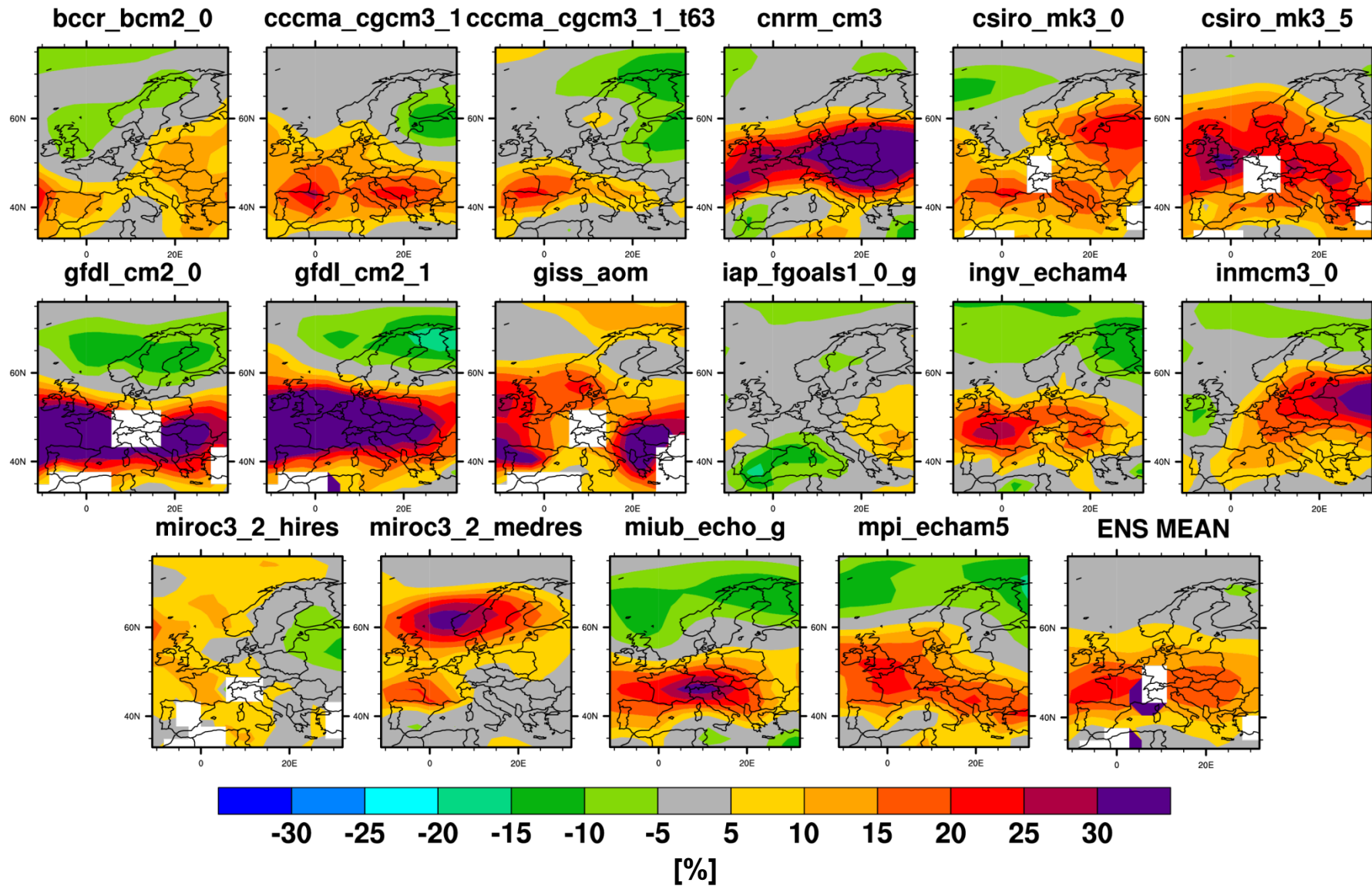


-30 -25 -20 -15 -10 -5 5 10 15 20 25 30

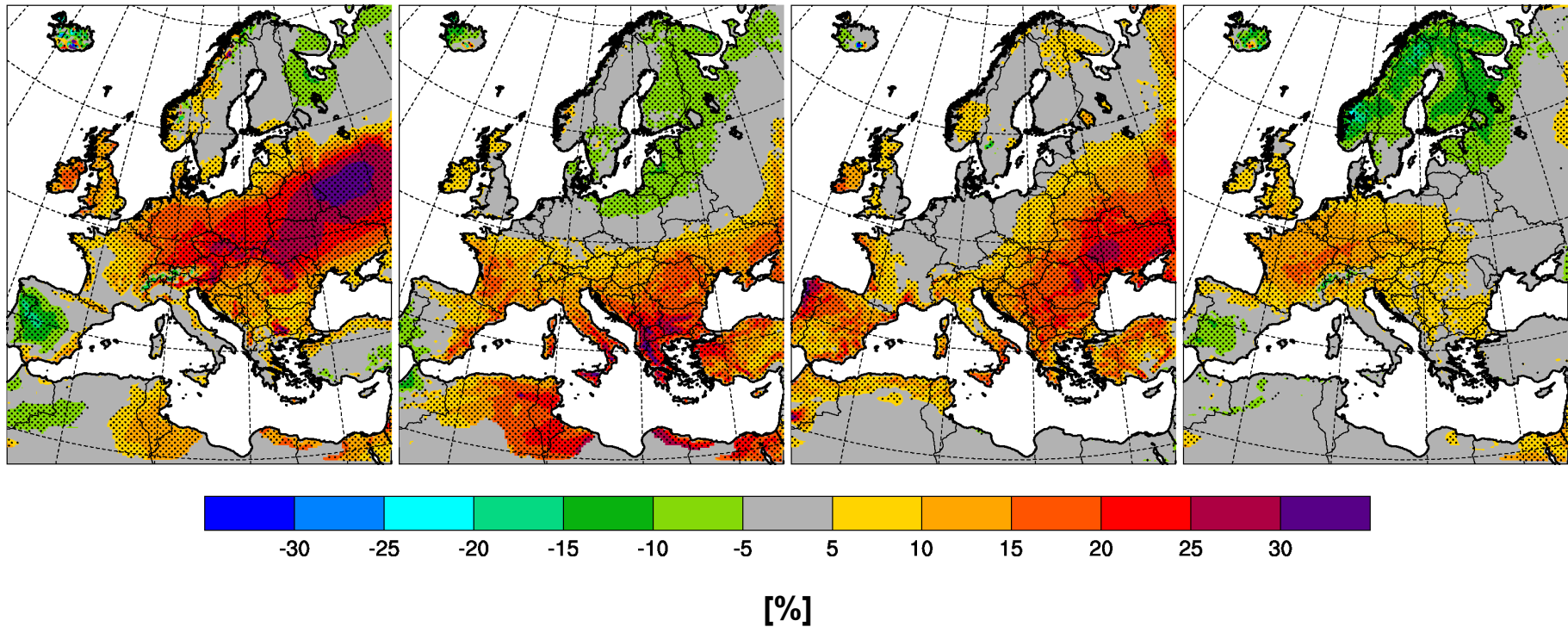
[%]

**Increase in daily variability is much more robust!**

# Δ daily variability (JJA), CMIP3 GCMs (A1B)



# $\Delta$ daily variability (JJA, 2070-99 vs. 1970-99)

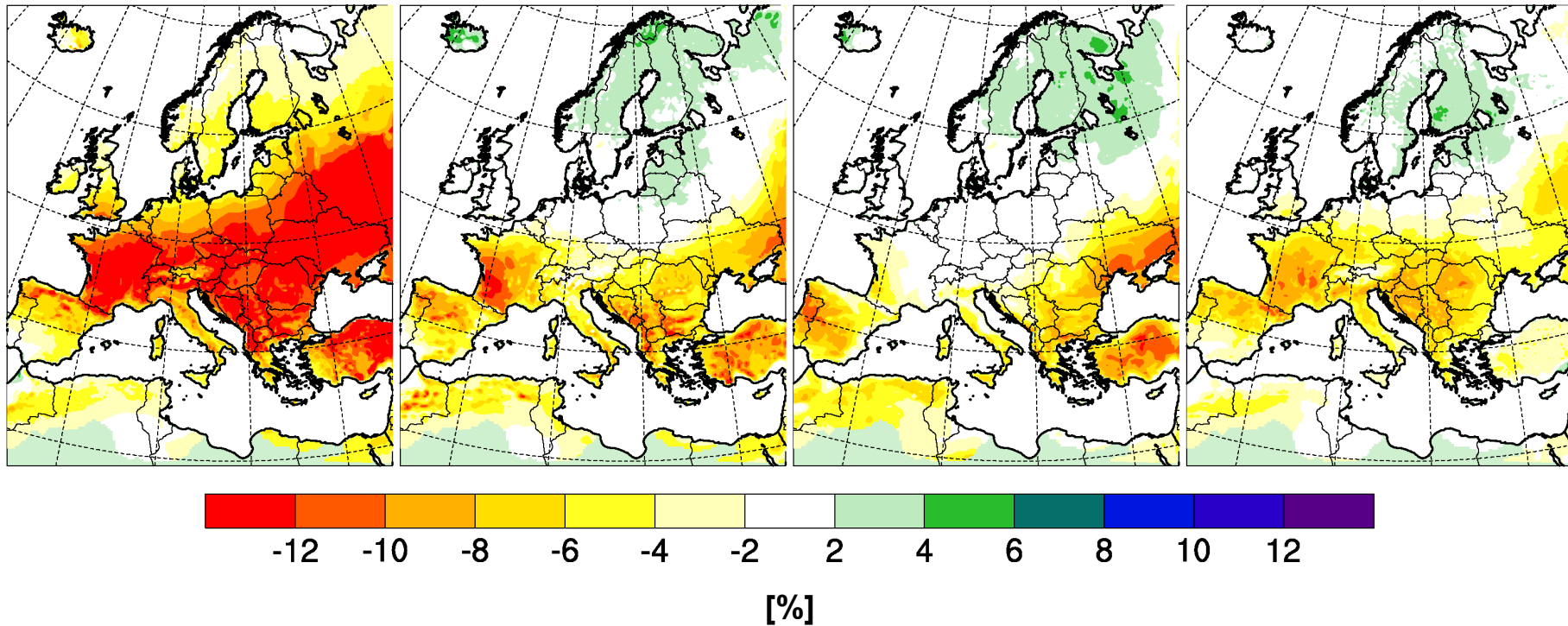


Central European climate  
is becoming more  
continental

Changes occur mainly at  
intraseasonal time scales  
(Fischer and Schär 2009)



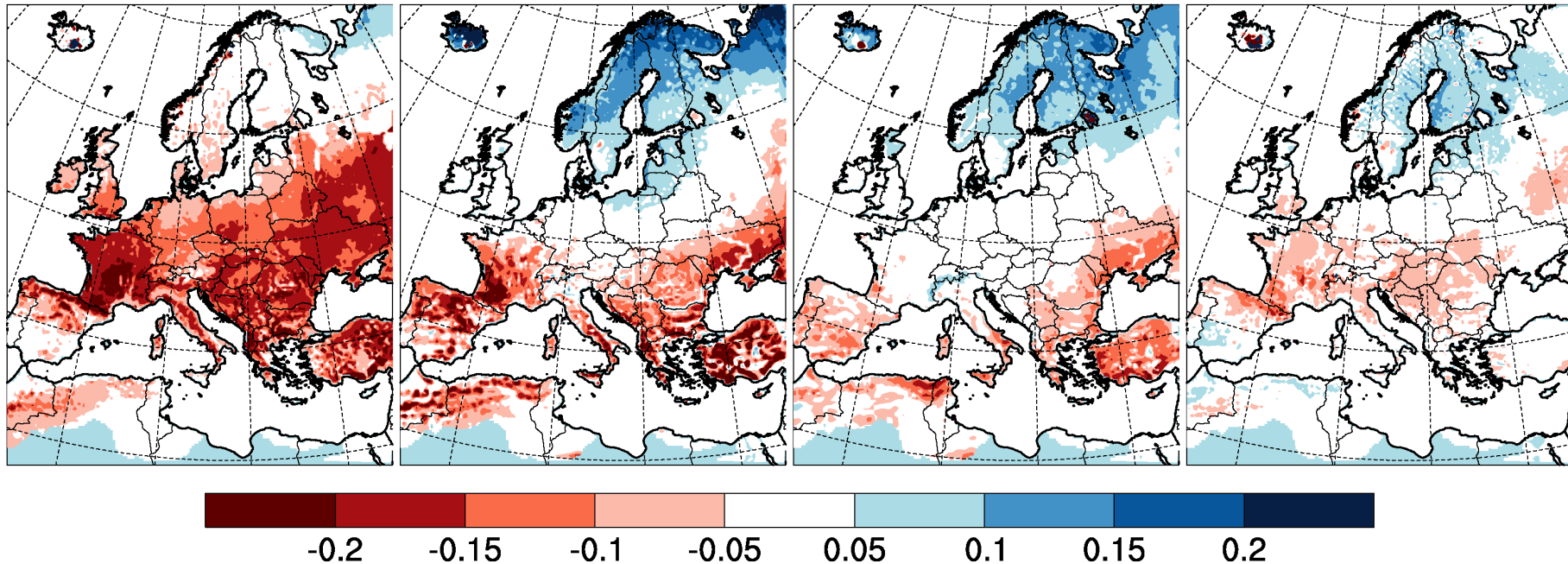
# $\Delta$ relative humidity (JJA, 2070-99 vs. 1970-99)



Change in daily variability is strongly anticorrelated with  $\Delta$ RH

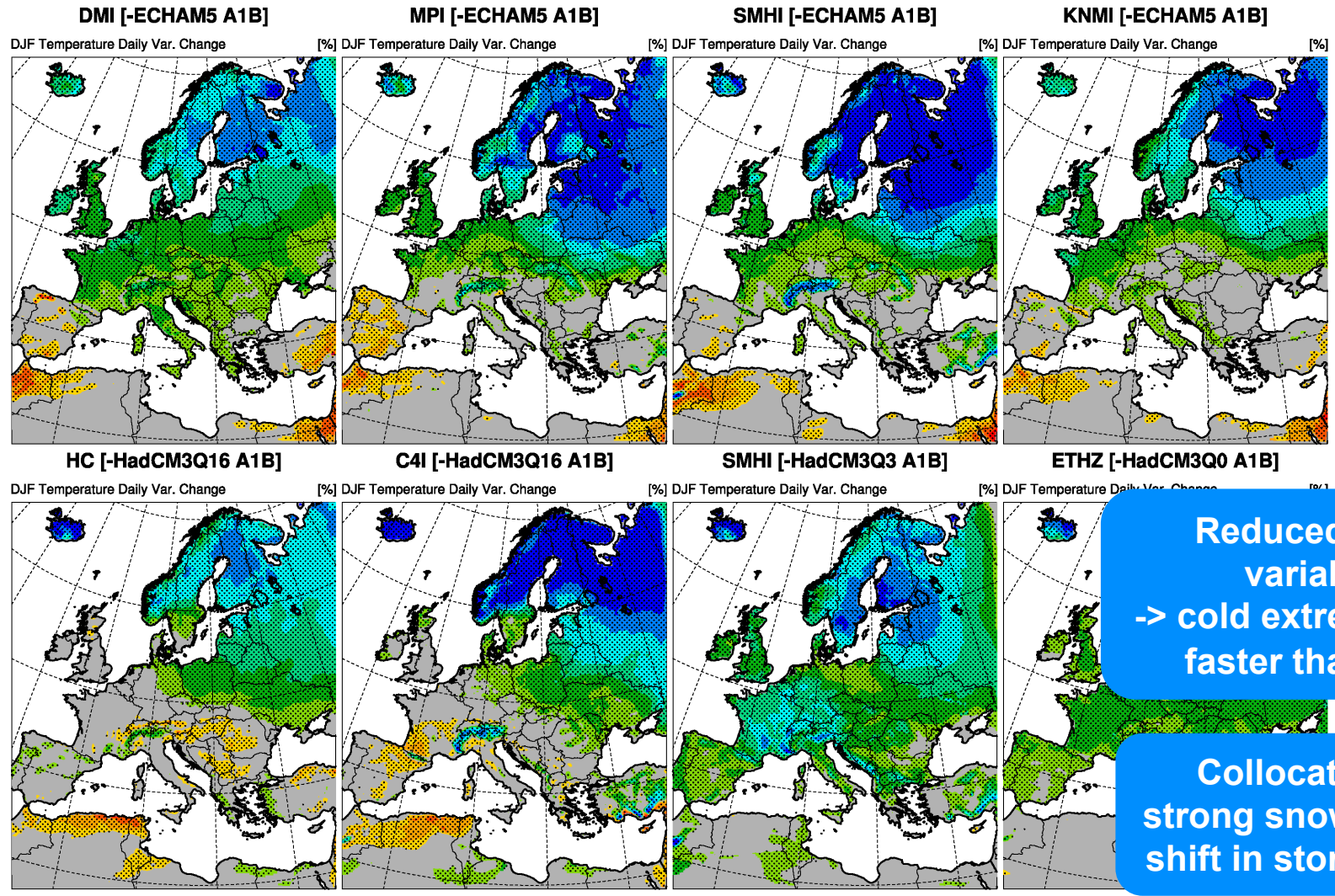
Enhanced daily variability collocates with enhanced DTR, similar driving processes (Fischer and Schär 2009)

## $\Delta$ evaporative fraction (JJA, 2070-99 vs. 1970-99)



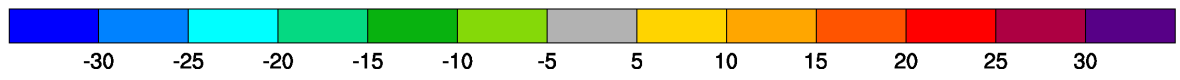
Latent heat flux acts as  
a damping factor of  
daily variability

# Δ daily variability (DJF, 2070-99 vs. 1970-99)



Reduced winter variability  
 -> cold extremes warm faster than mean

Collocates with strong snow melt and shift in storm tracks?



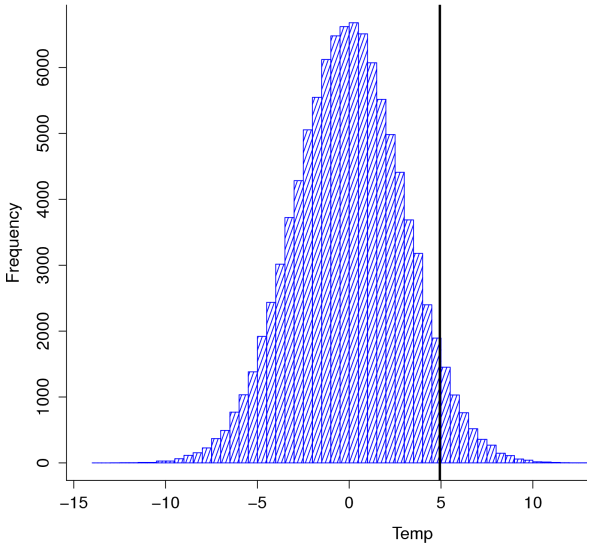
# Conclusions

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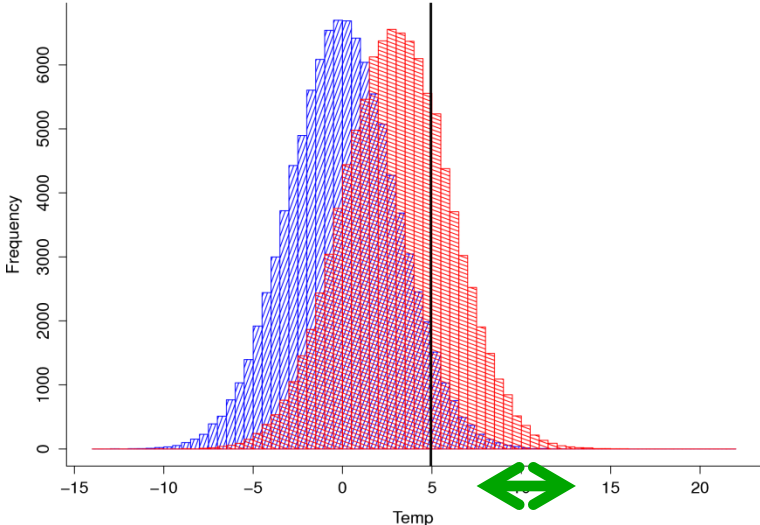
- **Changes in interannual variability (IAV) are more diverse in ENSEMBLES than in PRUDENCE.**
- **Most ENSEMBLES models with realistic present-day IAV show variability increases with climate change.**
- **IAV is low for dry and wet soil states, but high in the transition in between.**
- **Changes in daily summer temperature variability are remarkably robust across PRUDENCE and ENSEMBLES simulations as well as CMIP3 GCMs.**
- **Observed increase in daily variability increases confidence.**
- **Daily variability is enhanced due to more continental climate (i.e. reduced relative humidity, smaller latent heat flux and presumably lower cloudiness)**

# Does variability matter?

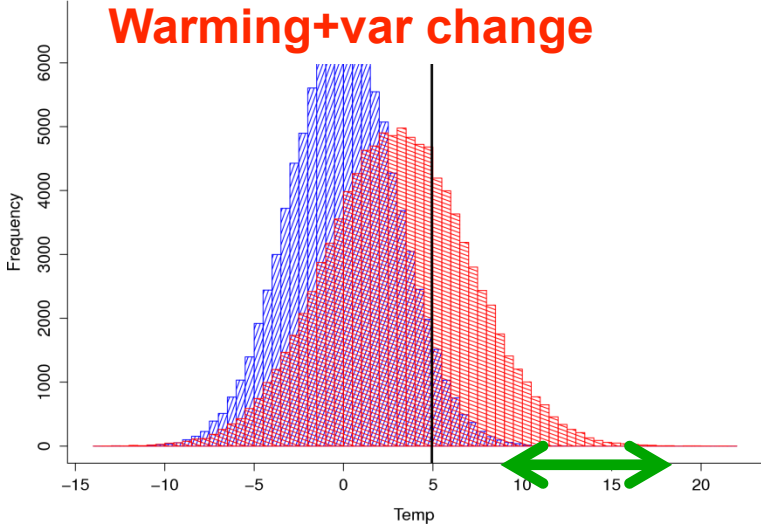
Present-day



Warming-only

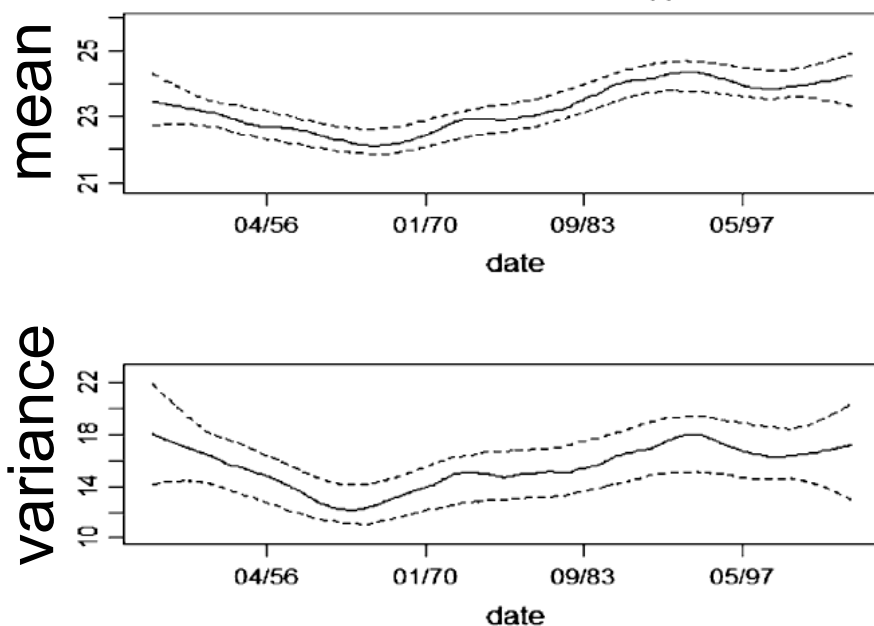


Warming+var change



# Observed relationship mean and variance?

Temporal evolution of mean and variance,  
Summer daily maximum temperature  
(La Rochelle, France)

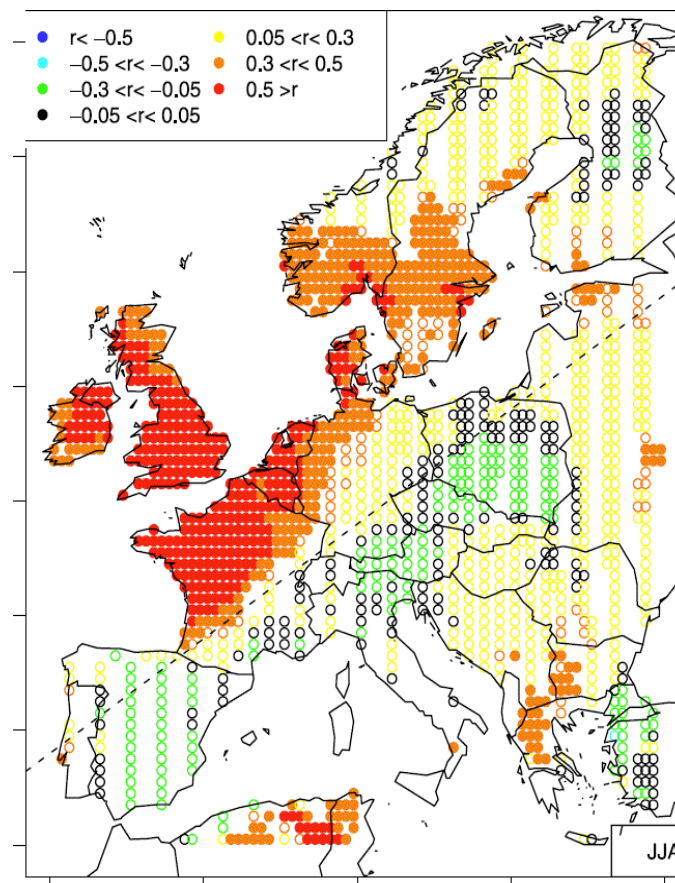


Evolution of mean and  
variance correlate!

Warm periods have  
higher variability

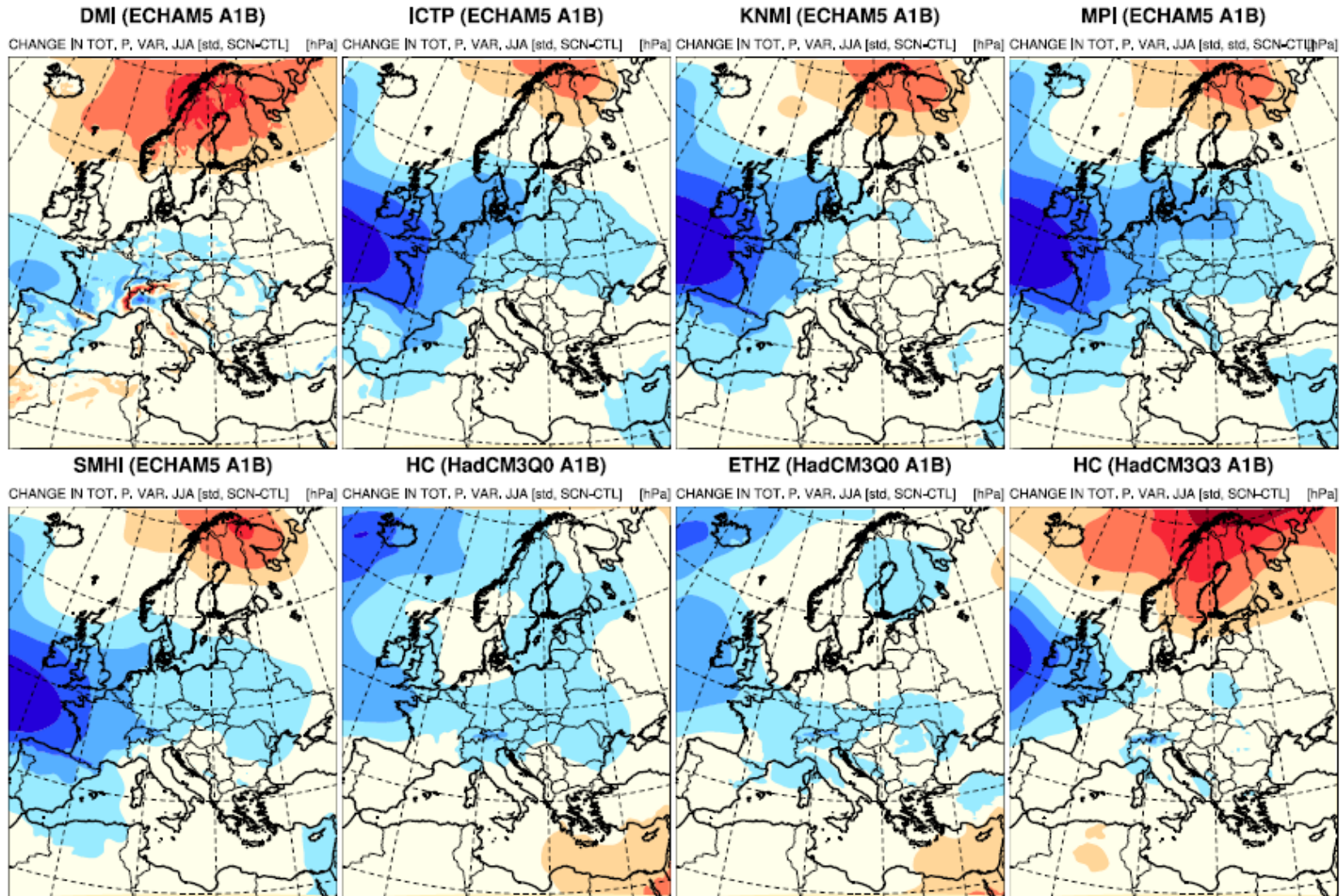
(Parey et al., 2010)

Correlation between mean and variance  
over Europe, summer  
(ECA&D data set)

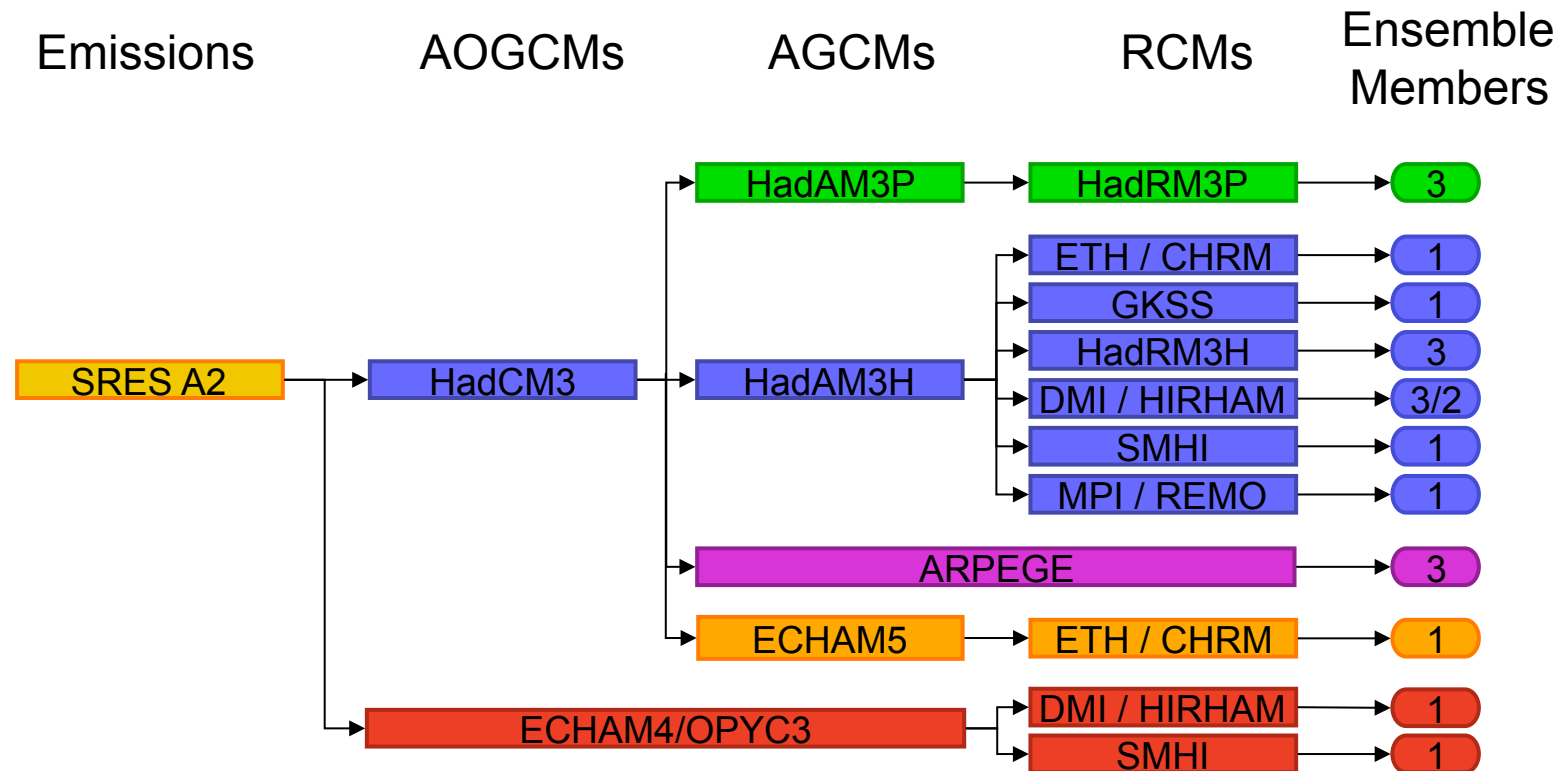


(Yiou et al., 2009)

# Changes in IAV of SLP?



# PRUDENCE A2 projections over Europe



(Christensen and Christensen 2007)

For analysis of interannual variability see Vidale et al. 2007

For analysis of daily variability see Fischer and Schär 2009)