Variations in projections of atmospheric climate change for the Baltic Sea region

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Context

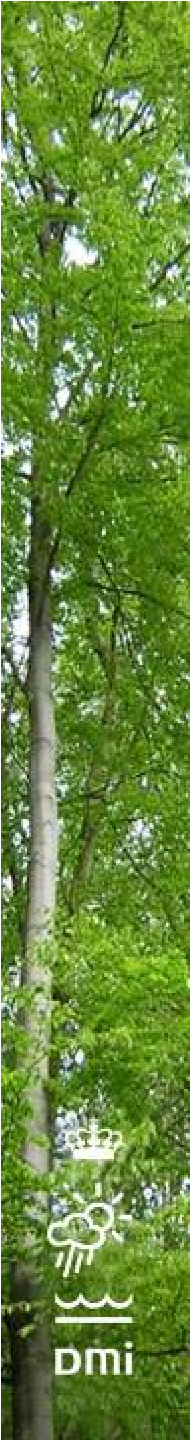
- Part of BACC2 chapter 4.3 on projected physical climate change (Atmosphere, hydrology, ocean and sea level)
- A literature survey, but with some original overview analysis based on available model data from the ENSEMBLES archive: http://ensemblesrt3.dmi.dk/
- Here supplemented with a study of ”emergence”

Categories of uncertainties

- Scenario
- Structural
  - Sensitivity; the ”unknown unknowns”
  - Model
- Statistical

Categories of uncertainties: What to do

- Scenario
  - Check scenarios
  - Pattern scaling, though not for everything
- Structural
  - Sensitivity
    - Better models; super-ensembles
  - Model
    - Better models; higher resolution; super-ensembles based probability densities
- Statistical
  - Ensembles of model runs



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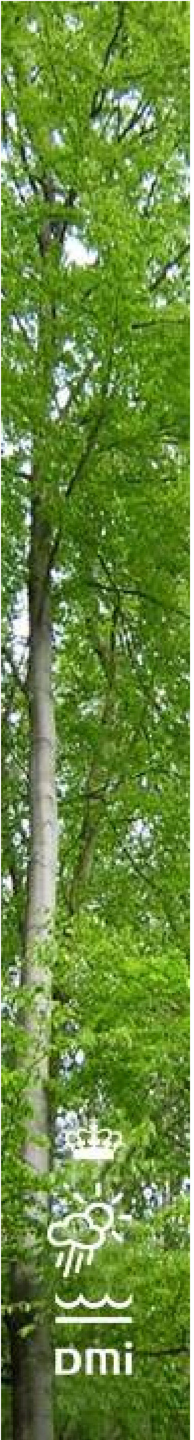
The ENSEMBLES GCM-RCM matrix

ENSEMBLES: FP6 project (2004-2009)

Climate and Energy Systems: Nordic Council (2007-2010)

Global model / Regional inst.	METO-HC Standard	METO-HC Low sens.	METO-HC Hi sens.	MPIMET Standard	MPIMET Ens.m. 1	MPIMET Ens.m. 2	IPSL	CNRM	NERSC	MIROC	CGCM3	Total number
METO-HC	2100	2100*	2100*	2100 (late 2010)								4
MPIMET				2100			2050*					2
CNRM								2100				1
DMI				2100*				2100	2100*			3
ETH	2100											1
KNMI				2100* 2100	2100*	2100*				2100*		1+4
ICTP				2100								1
SMHI		2100*		2100* 2100*					2100			3+1
UCLM	2050											1
C4I			2100*		2050 (A2)*							2
GKSS							2050*					1
METNO	2050*								2050*			1
CHMI								2050* (12/2009)				1
OURANOS**											2050*	1
VMGO**	2050*											1
Total (1951-2050)	5	2	2	7+2	0+1	0+1	2	3	3	0+1	1	25+5

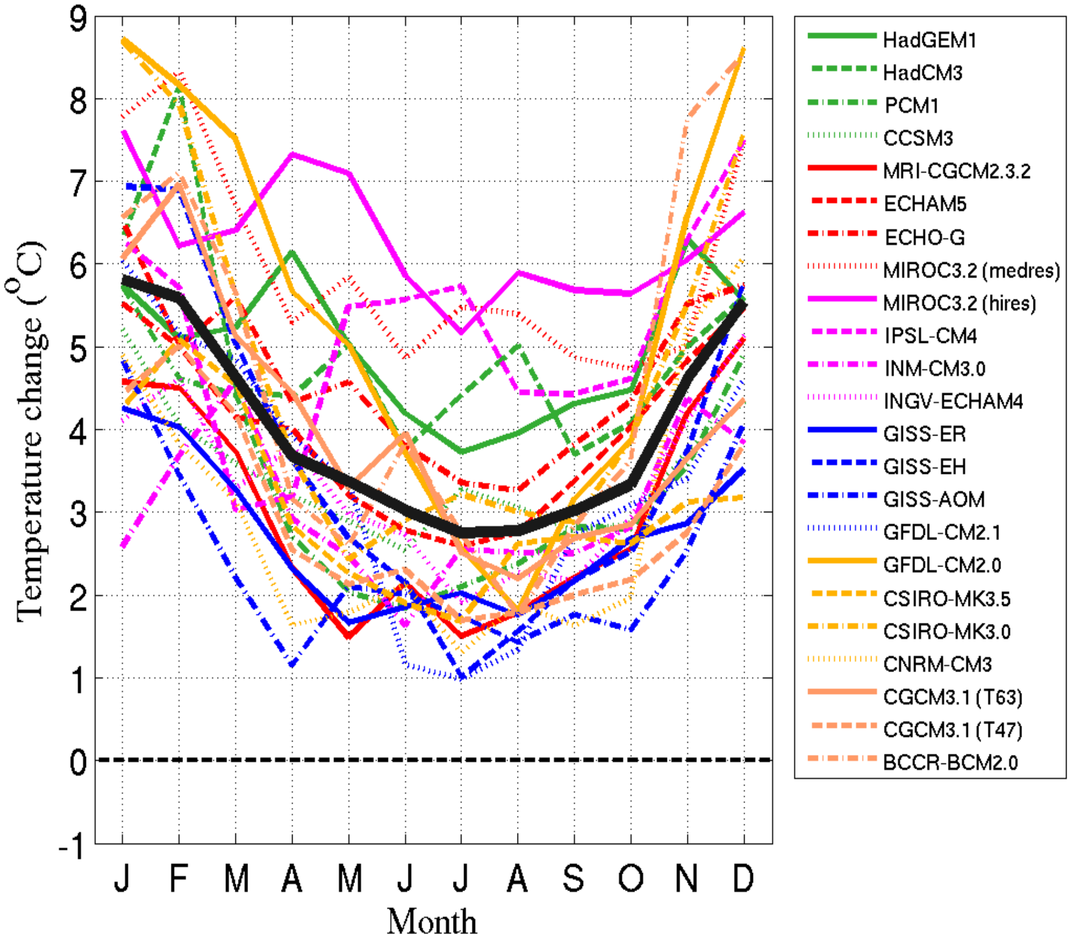
- 25 GCM-driven A1B-scenarios for 1961-2050 (2100) at 25km
- In addition ERA40-driven simulations for 1961-2000

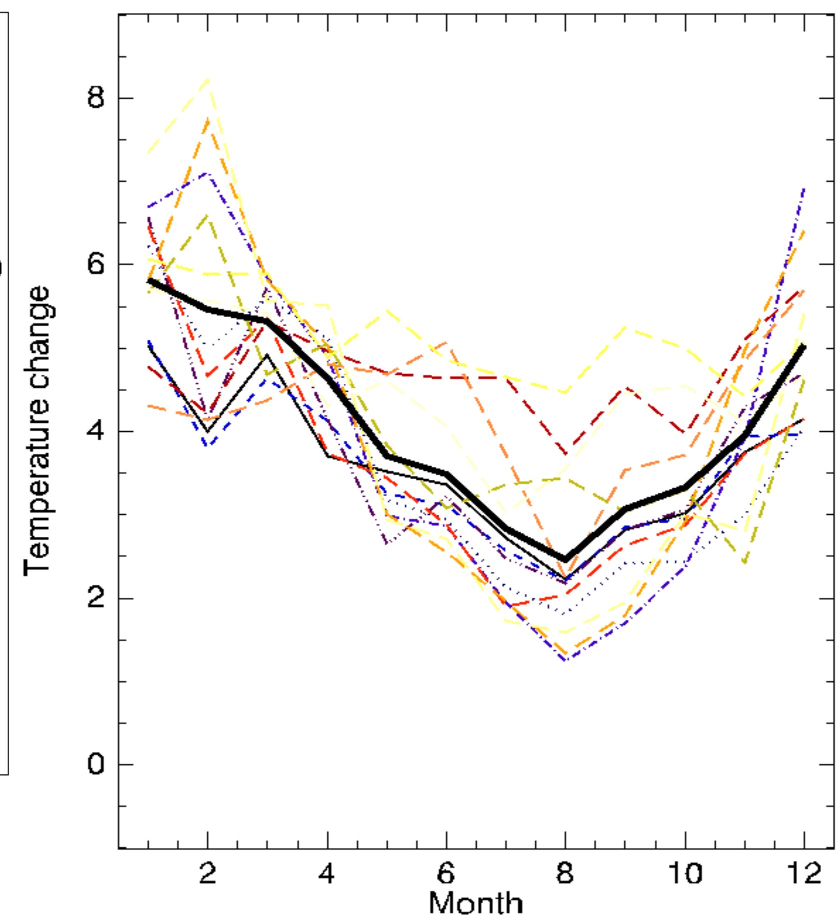


Spans of atmospheric projections from an ensemble

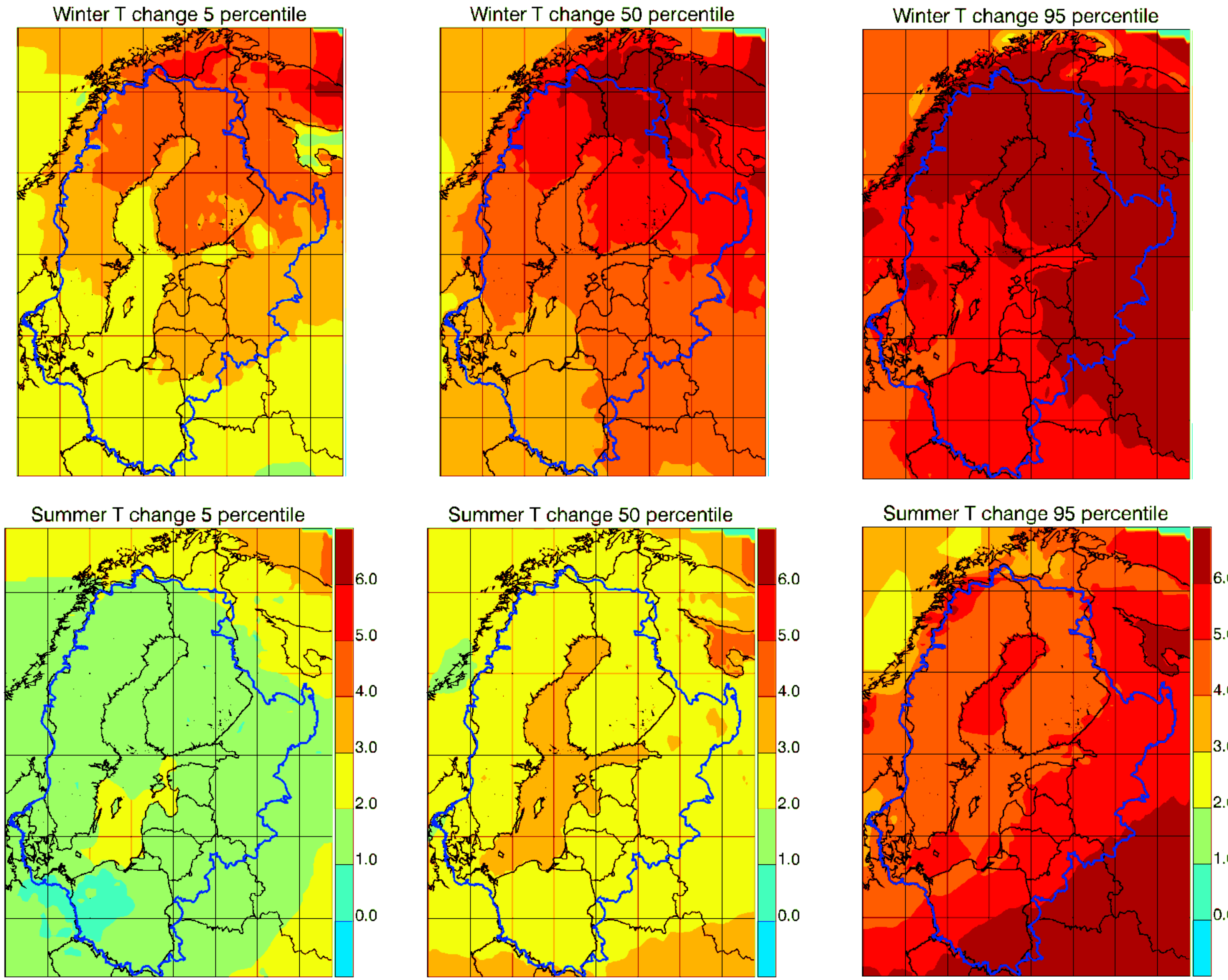
- Based on 13 RCM simulations from the EU FP6 ENSEMBLES project. Public archive at http://ensemblesrt3.dmi.dk/
- Study of the change between 1961-1990 and 2070-2099
- Algorithm: The 13 numbers are sorted, resulting in an approximate 5th percentile corresponding to the lowest value, a median, and an approximate 95th percentile.
- Comparison to CMIP3 GCMs for smaller area

GCM vs. RCM Northern Sweden T

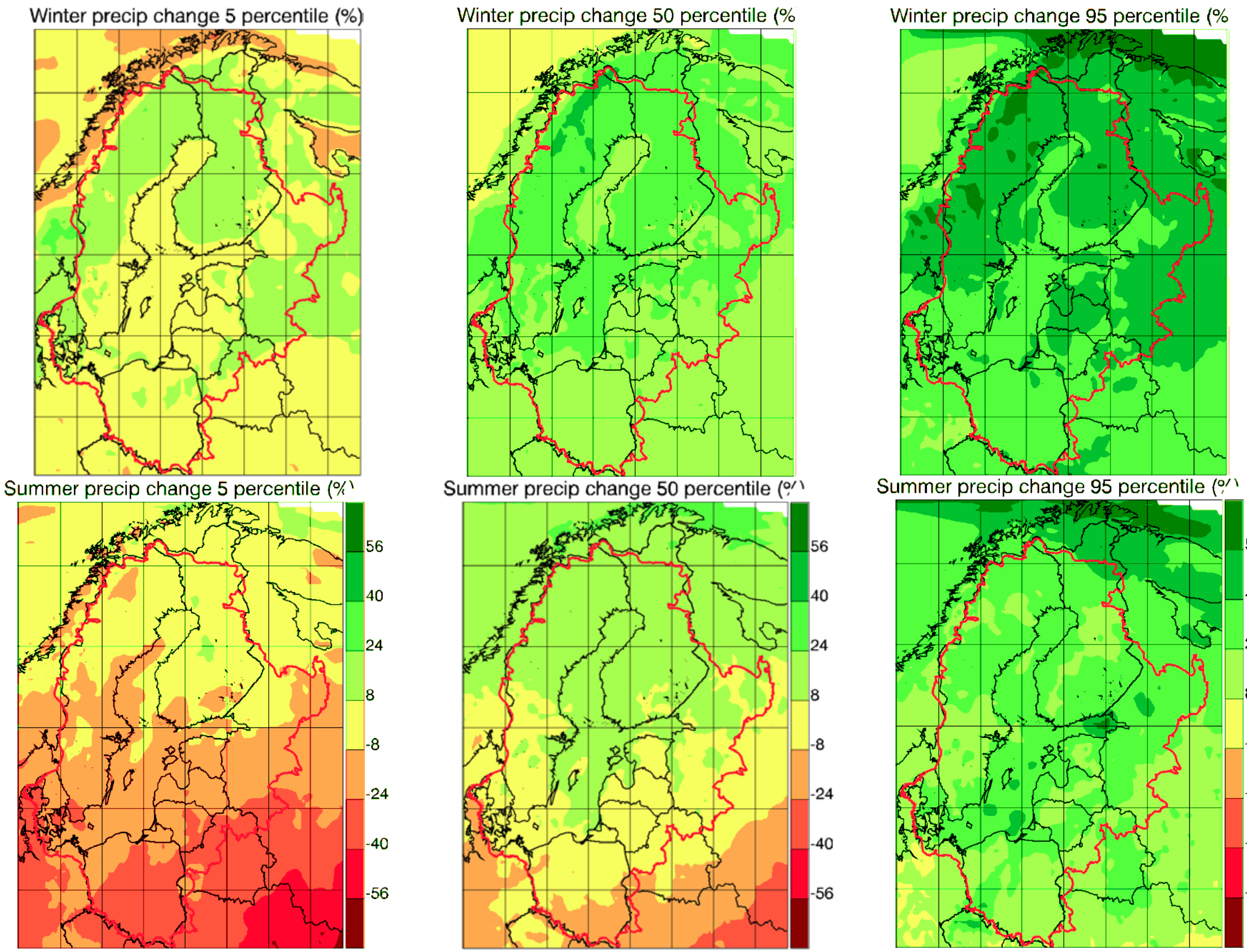




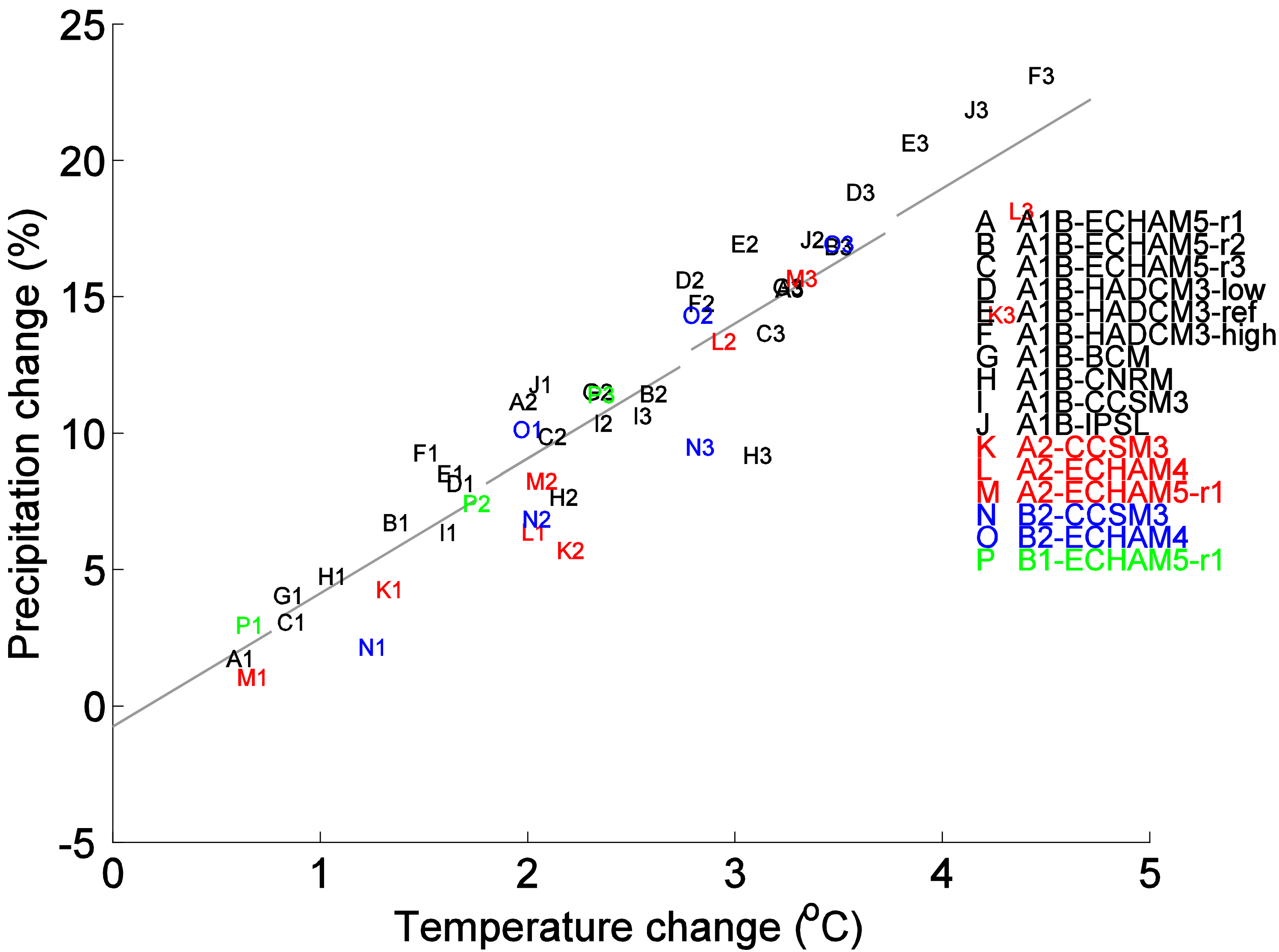
Span of projected warming

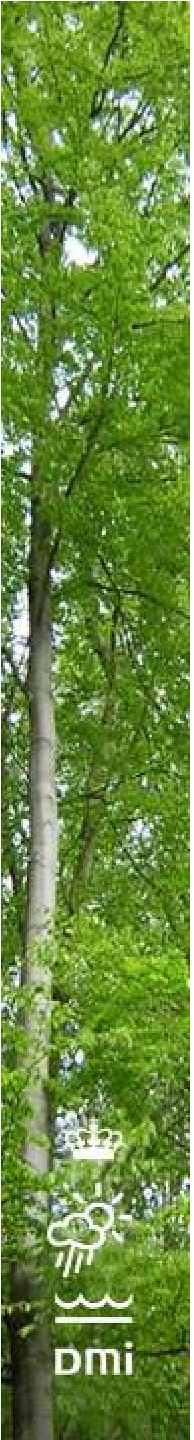


Span of precipitation change

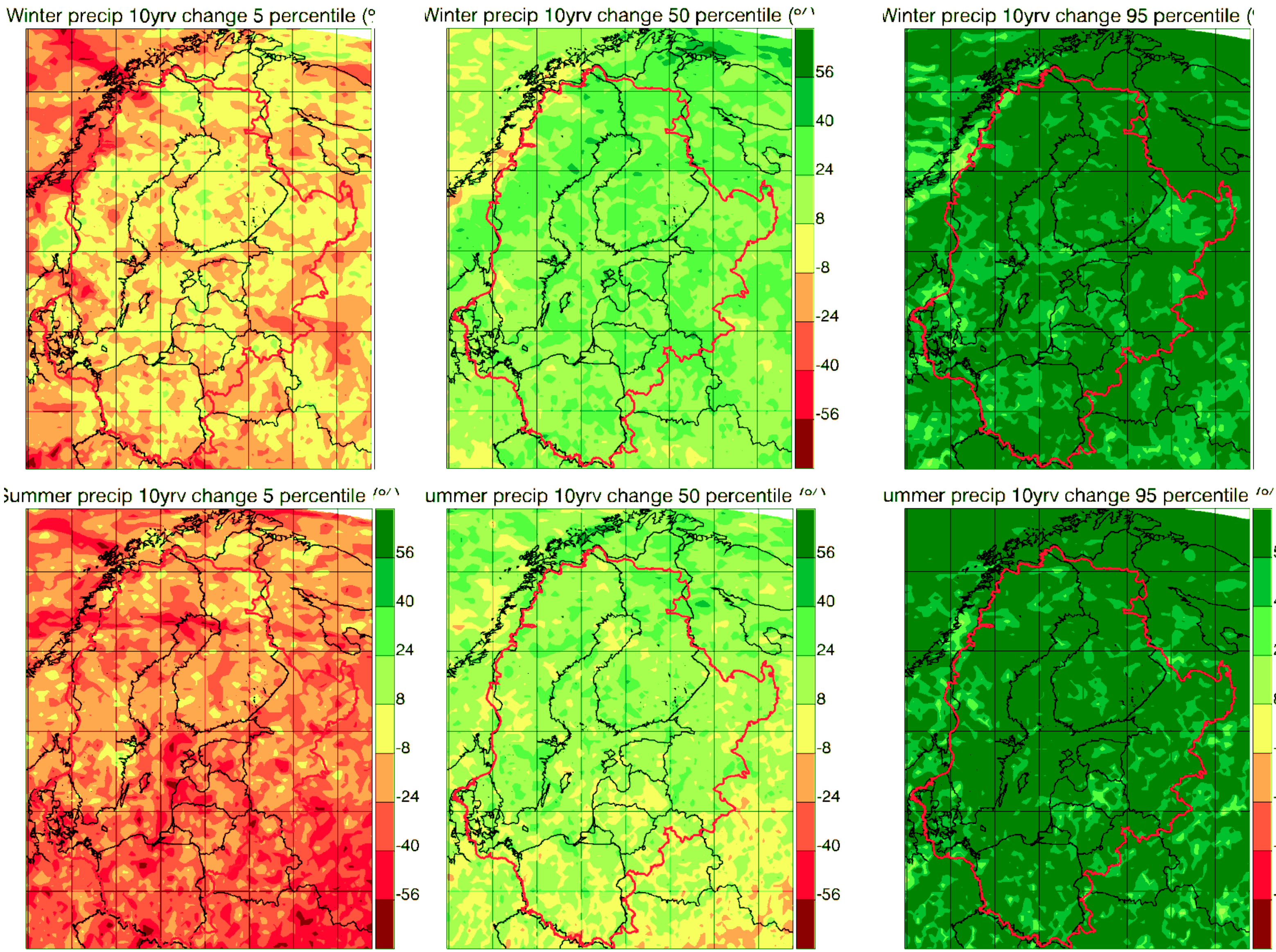


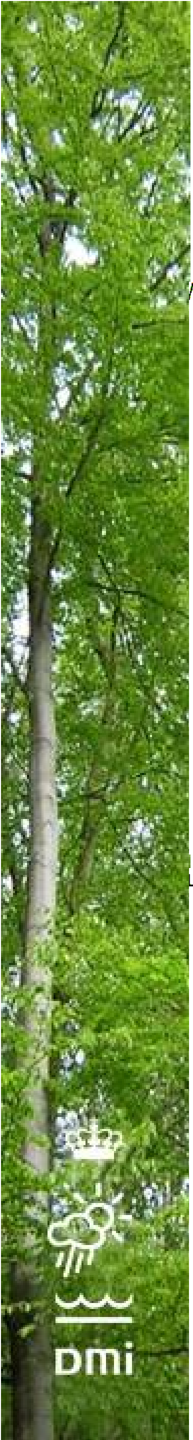
Relation between temperature and precipitation change



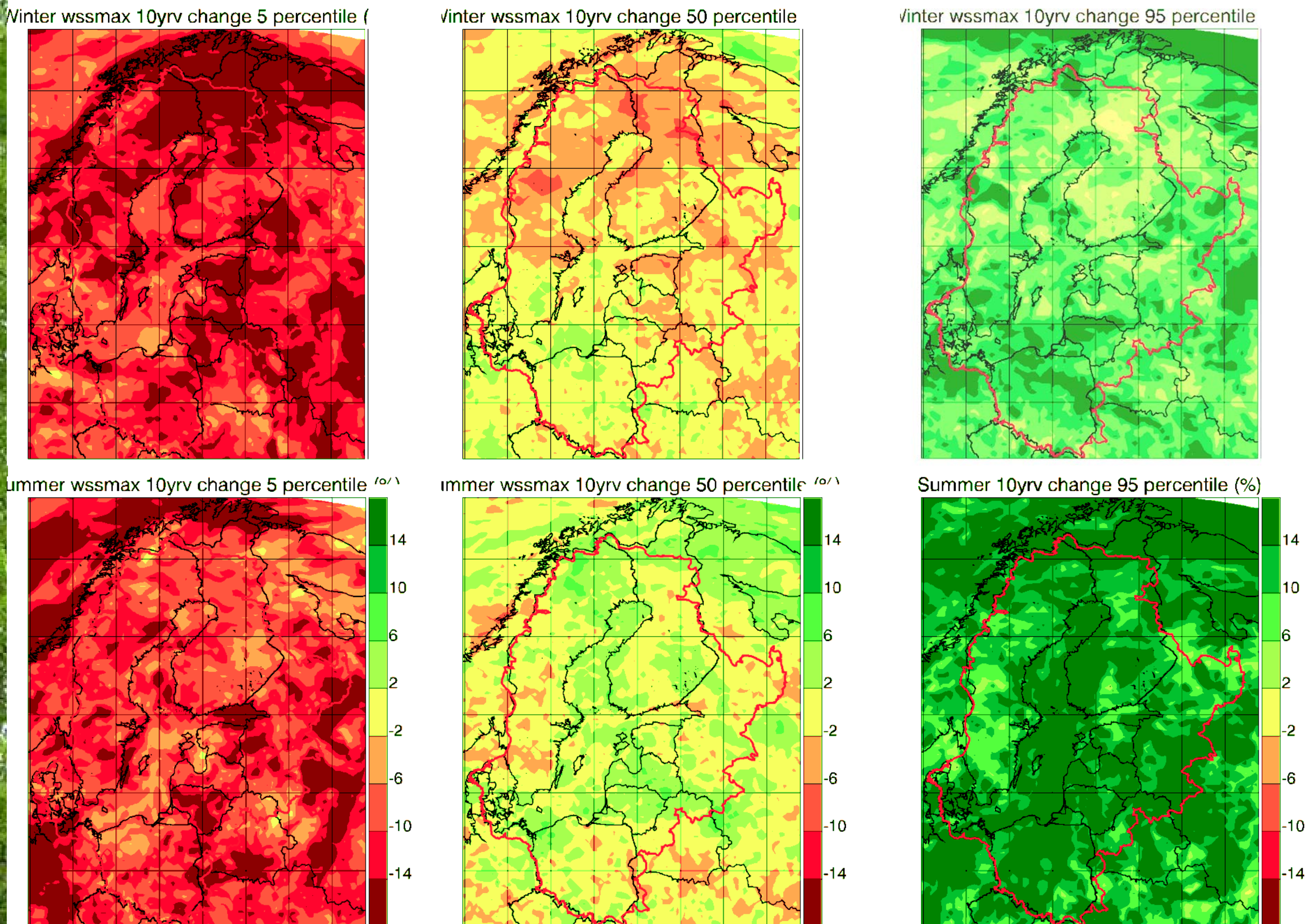


Span of 10y return value precip.

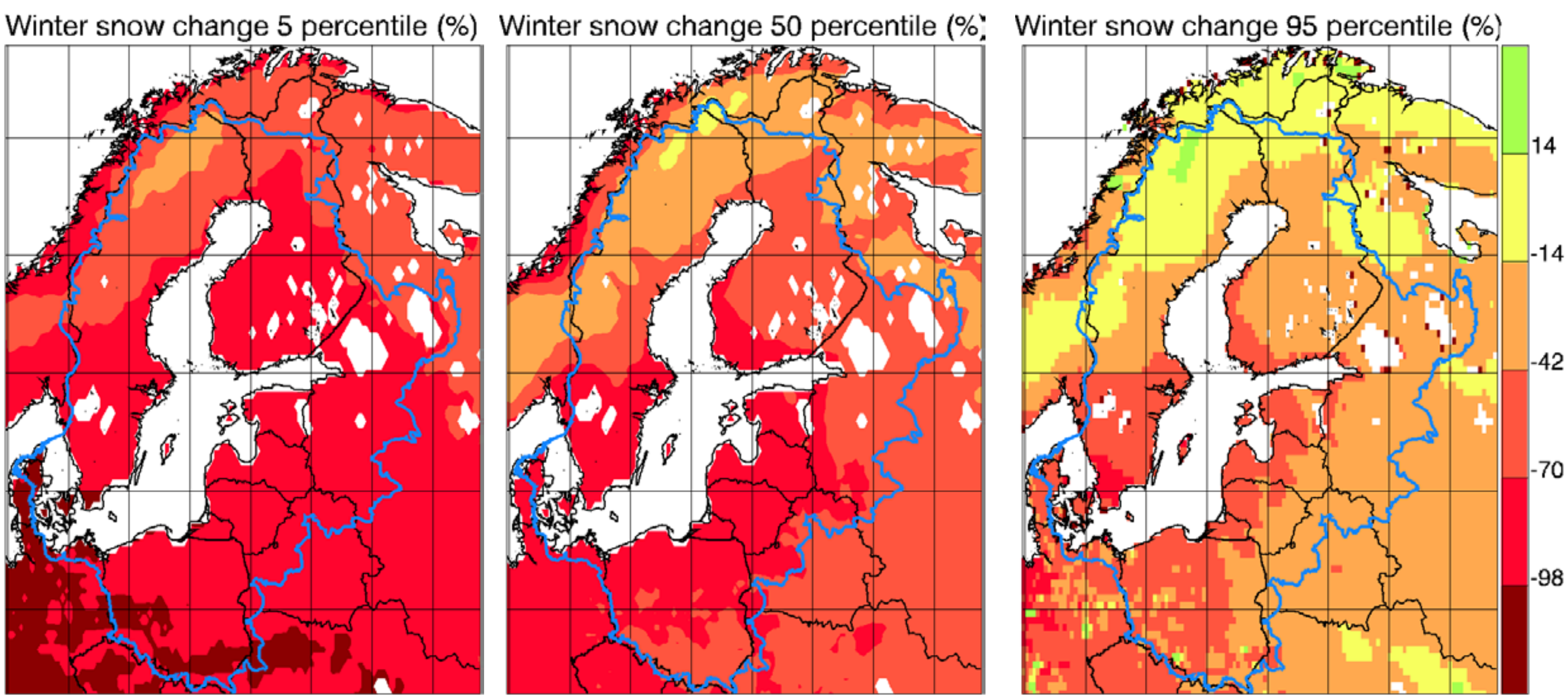




Wind extremes 10yrv



Snow change


Winter snow change 5 percentile (%)
Winter snow change 50 percentile (%)
Winter snow change 95 percentile (%)
14
-14
-42
-70
-98

When can we expect that climate change becomes detectable in Europe?

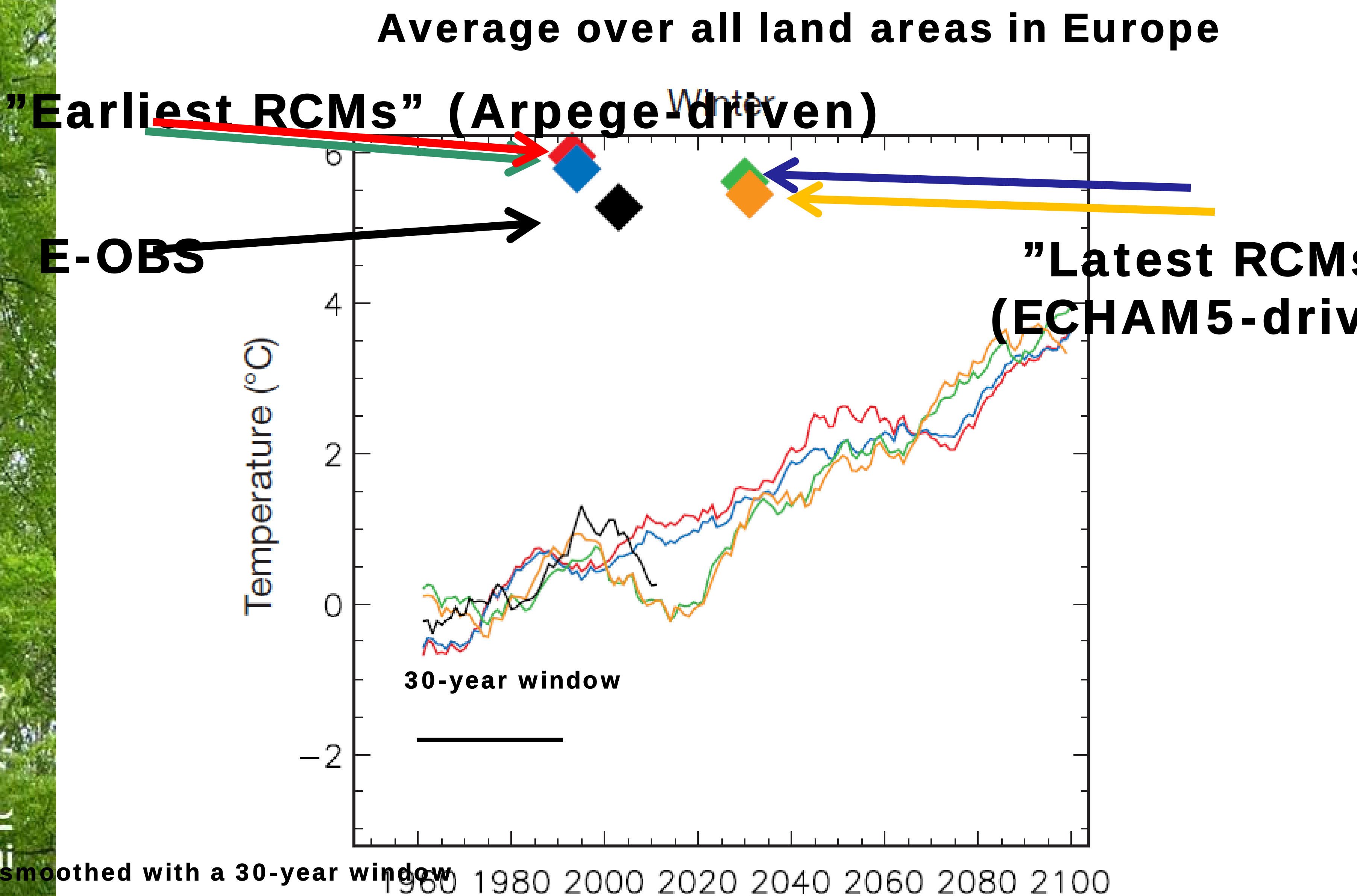
When can we expect to detect changes?

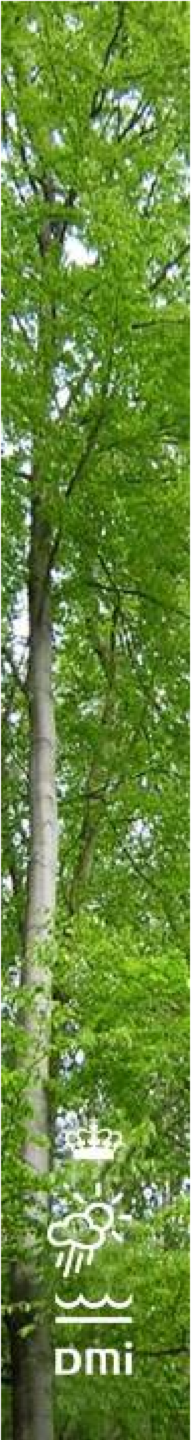
- Use the ENSEMBLES RCM ensemble (15 RCMs until 2100, 21 till 2050)
- Emergence of climate change based on statistical significance of differences between periods
- Calculate yearly (seasonal) anomalies based on all 30-year periods (1961-1990, 1962-1991, …, 2071-2100) w.r.t. 1961-1990
- Express deviations as a probability given the standard deviations of two samples (one from the reference period 1961-1990 and one from the future)
- Determine the probability that the two samples (reference and future) are drawn from the same population based on a Student’s t-test
- If the probability is less than 1% chance that the samples are from the same population the centre year was assigned as the year of emergence

Kjellström, E., Thejll, P., Rummukainen, M., Christensen, J.H., Boberg, F., Christensen, O.B., Fox Maule, C., 2013. *Emerging regional climate change signals for Europe under varying large-scale circulation conditions.* Climate Research doi: 10.3354/cr01146

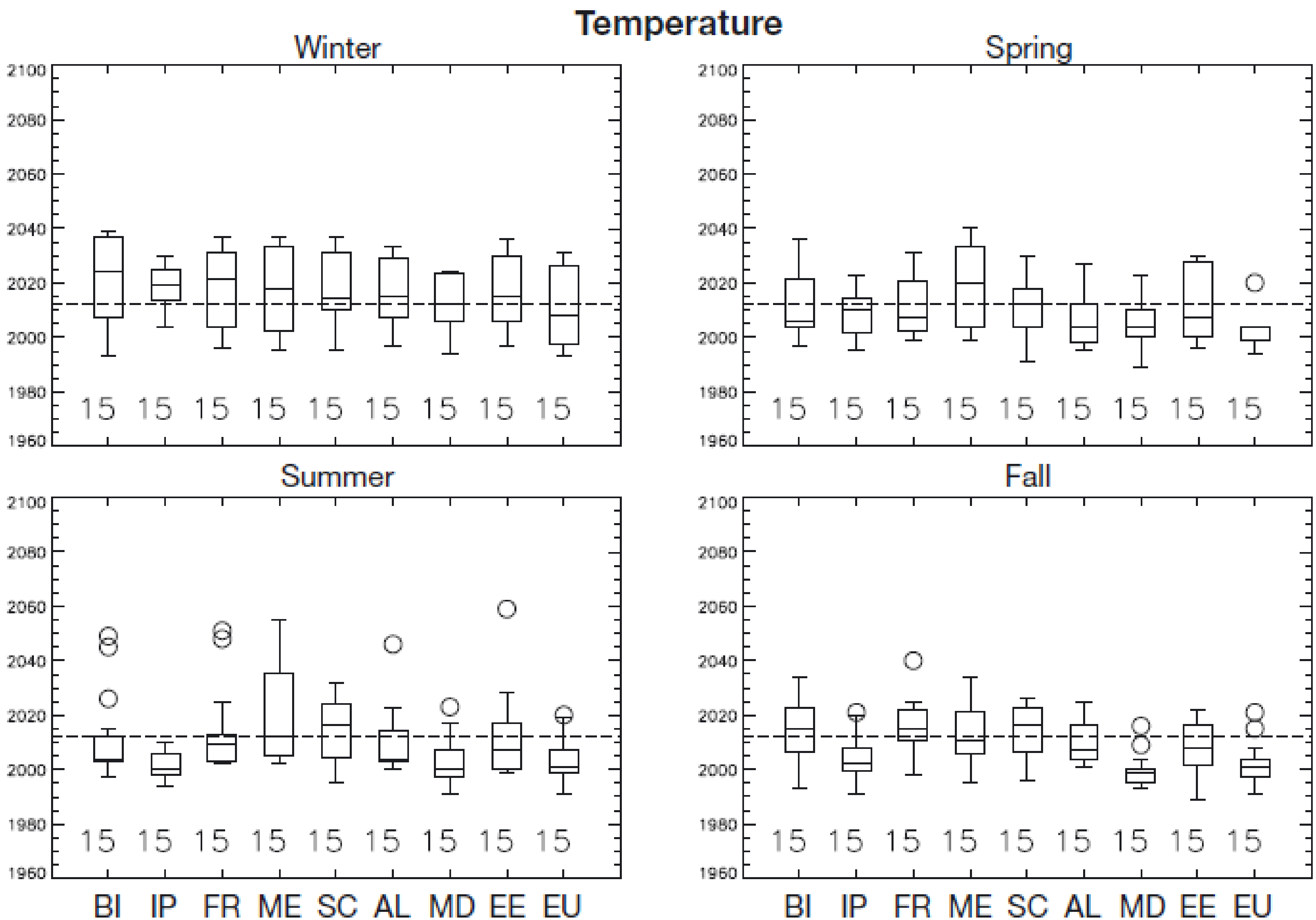
DMI

Emerging change





Time of significance (Kjellström *et al.*, 2013)



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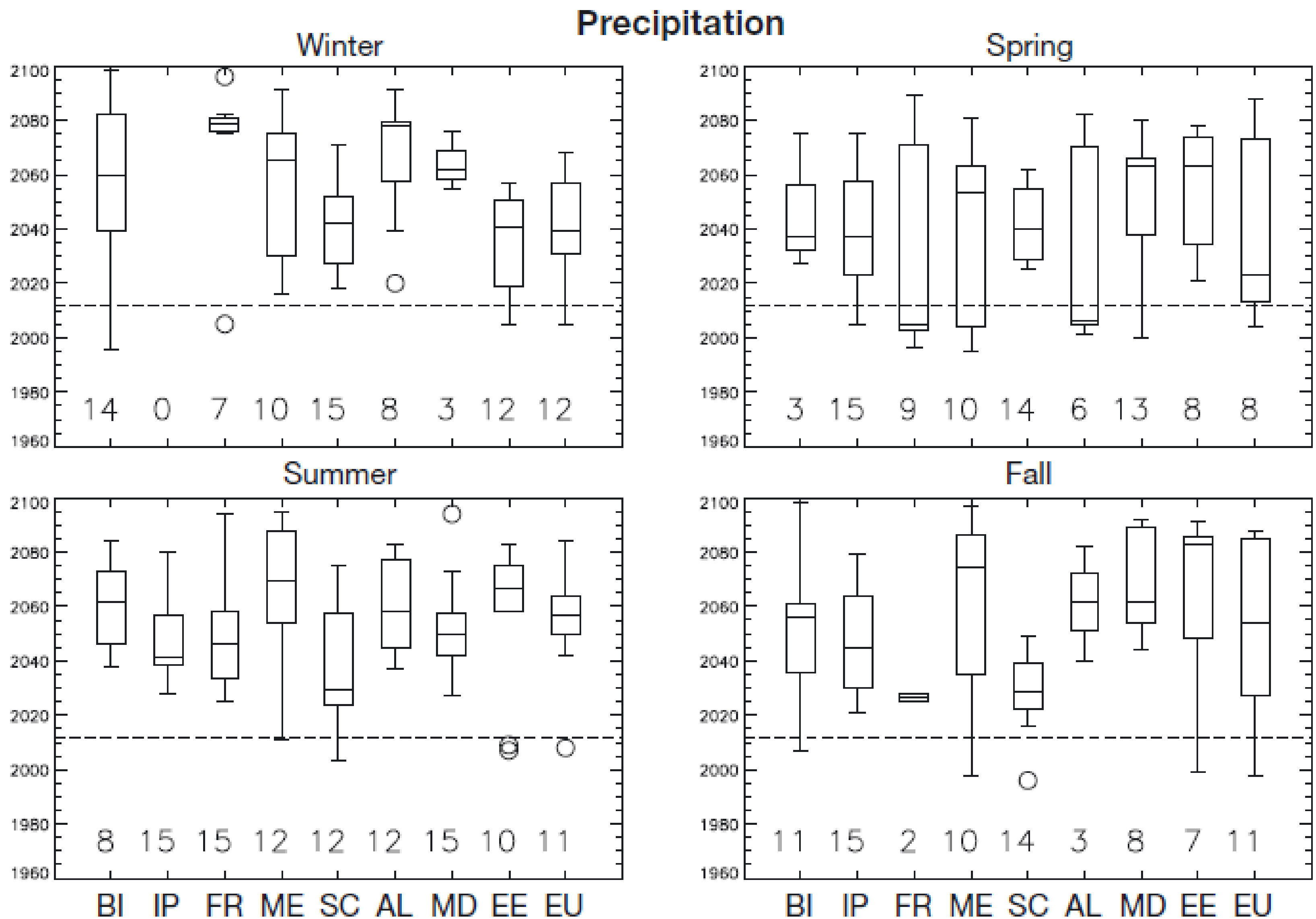
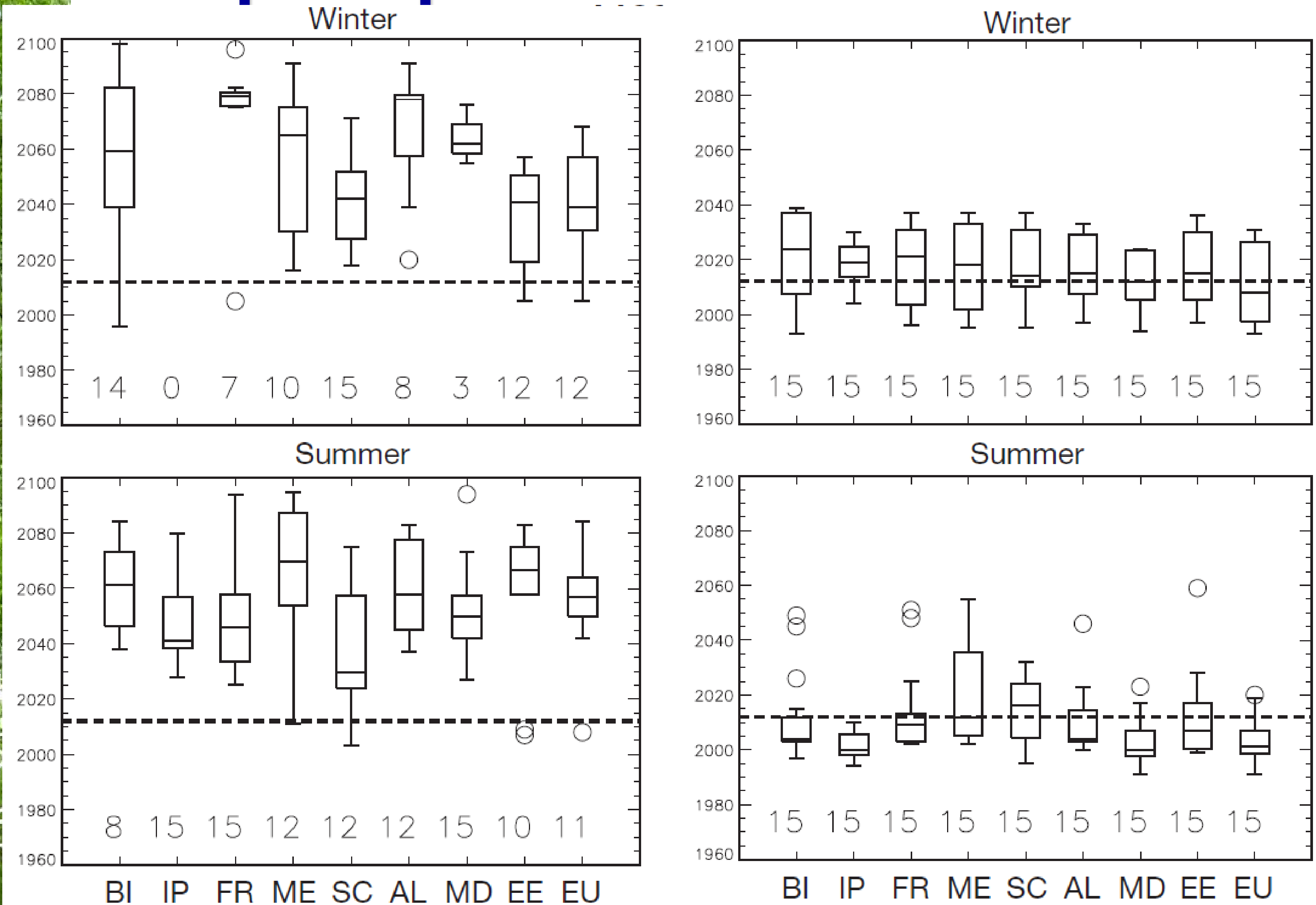


Temperature changes lead those in precipitation



Conclusions

- The collection of RCMs in the ENSEMBLES archive enables some estimation of model uncertainty
- Variations of T and precipitation are correlated
- Apparent significance of end-of-century heating, winter precipitation increase and snow decrease
- Quantification of uncertainties are paramount: When do we see climate change?
- Time of emergence of significant climate change depends on the field. Ensembles enable more robust estimation of time of emergence