Identifications of uncertainties in regional climate projections over the Baltic region

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Outline

✓ Sources of uncertainties in regional climate projections:

- different regional models
- different global models
- different emission scenario
- natural variability
- model formulation

✓ What kind of uncertainties is more important on regional scale (the Baltic region) and for different variables: temperature, precipitation and wind ?

Kjellström et al., 2011: 21st century changes in the European climate: uncertainties derived from an ensemble of regional climate model simulations. Tellus 63A
Nikulin et al., 2011: Evaluation and Future Projections of Temperature, Precipitation and Wind Extremes over Europe in an Ensemble of Regional Climate Simulations, Tellus 63A

SMHI The Rossby Centre ensemble (Europe)

ENSEMBLES

Regional Climate Model - RCA3

Different AOGCMs: boundary conditions

Different initial conditions: natural variability

Different model formulation: one AOGCM but different climate sensitivity

Different emission scenarios

Different horisontal resolution

No	AOGCM (Institute, country)		Scenario	Resolution, km
1	CNRM-CM3 (CNRM, France)		A1B	50
2	BCM (NERSC, Norway)		A1B	50
3				25
4	CCSM3 (NCAR, USA)		A2	50
5			A1B	50
6			B2	50
7	ECHAM4 (MPI-met, Germany)		A2	50
8			B2	50
9	ECHAM5 (MPI-met, Germany)		*A2*	50
10			A1B	50
11				50
12				50
13				25
14				*12.5*
15			B1	50
16	HadCM3 (Hadley Centre, UK)	ref (Q0)	A1B	50
17		low (Q3)		50
18		high (Q16)		50
19		low (Q3)		25
20	IPSL-CM4 (IPSL, France)		A1B	50

Model ensembles

RCM - RCA3, 50km, Europe

1. <u>Different GCMs</u> - one RCM driven by different GCMs
   driving GCMs: ECHAM5-r3, HadCM3-ref, BCM, CCSM3, CNRM, IPSL (A1B **6 members)**

2. <u>Natural variability</u> - one RCM driven by one GCM with different initial conditions
   driving GCMs: ECHAM5 (A1B **3 members:** r1, r2, r3)

3. <u>Emission scenario</u> - one RCM driven by one GCM with different emission scenarios
   driving GCMs: ECHAM5-r1 (**3 members:** B1, A1B, A2)

4. <u>GCM formulation</u>- one RCM driven by one GCM with different climate sensitivity
   driving GCMs: HadCM3 (A1B **3 members:** low, reference, high)

Data and method

Seasonal means: winter (DJF) and summer (JJA)

2m temperature, precipitation and 10m wind

Extremes

the 50 year return values (gust wind)

block maximum method

GEV stationary model (L-Moments)

Statistical tests:

bootstrapping

Observations

gridded E-OBS data set (*Haylock et al., 2008*)

Different driving global models

the key role of the driving GCMs

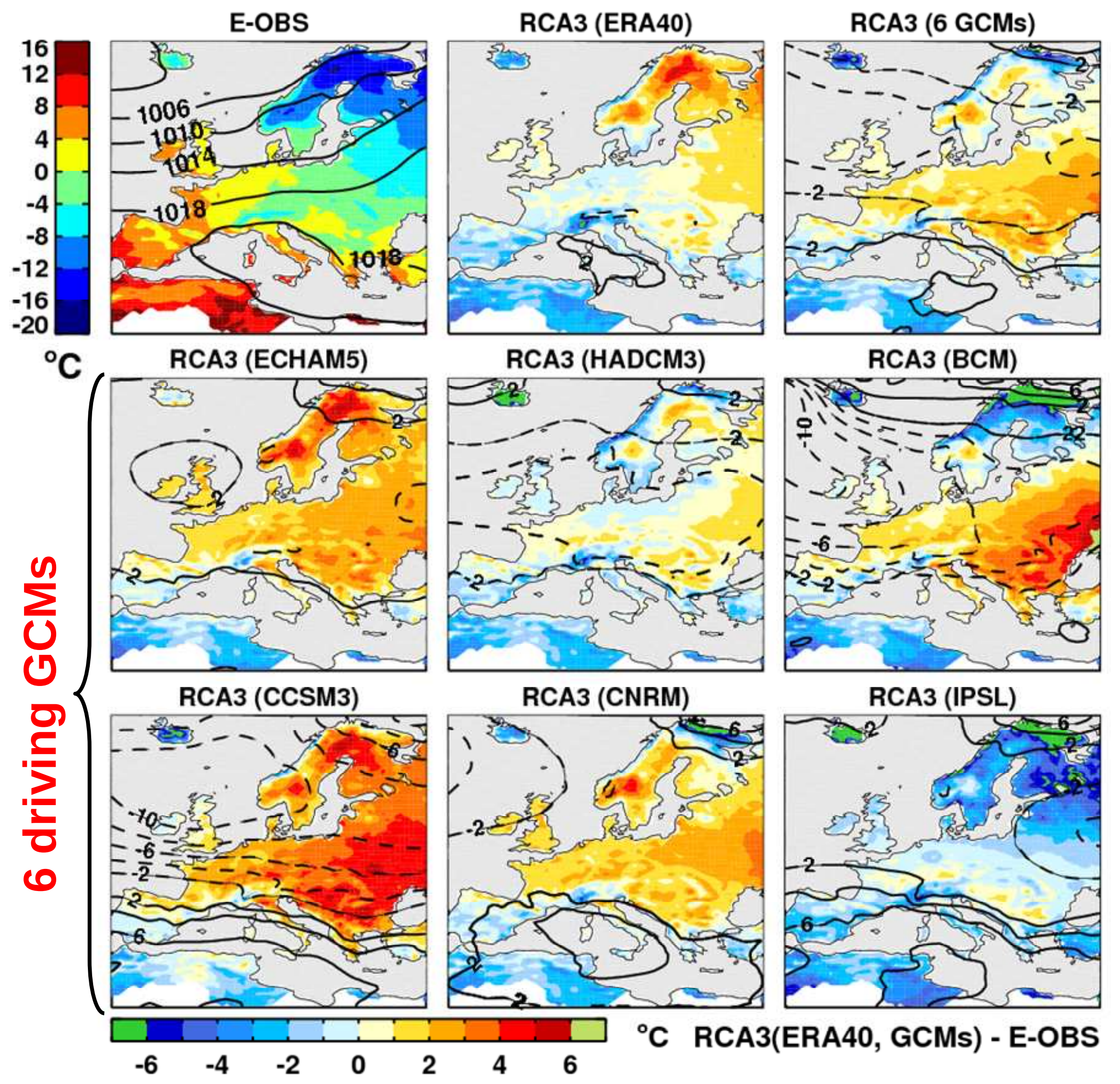
large spread among the simulations

difference among the simulations can locally reach 10℃

ensemble mean is better than most individual simulations

lines – sea level pressure

2m temperature Winter (1961-1990)



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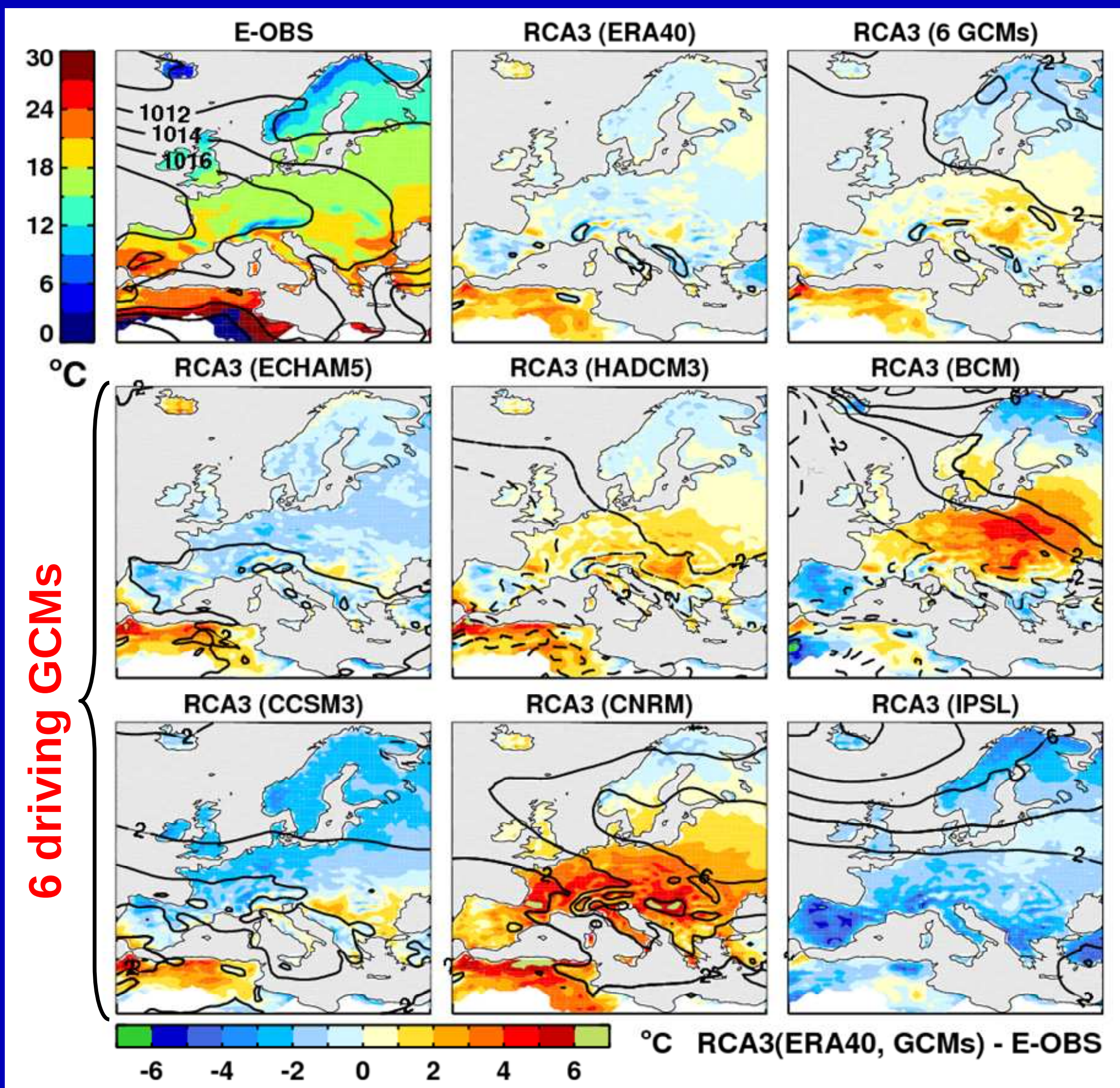
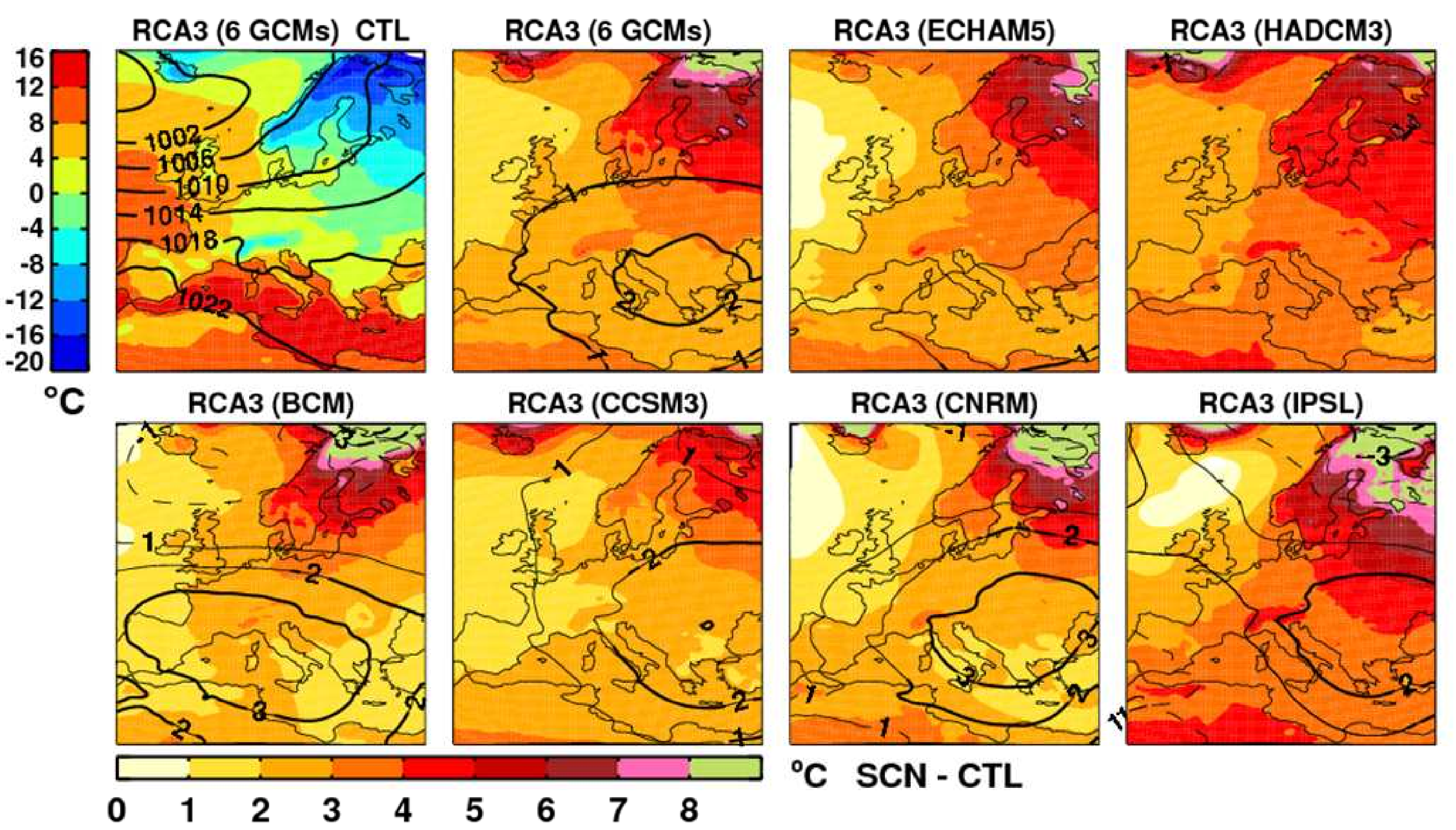


Different driving global models

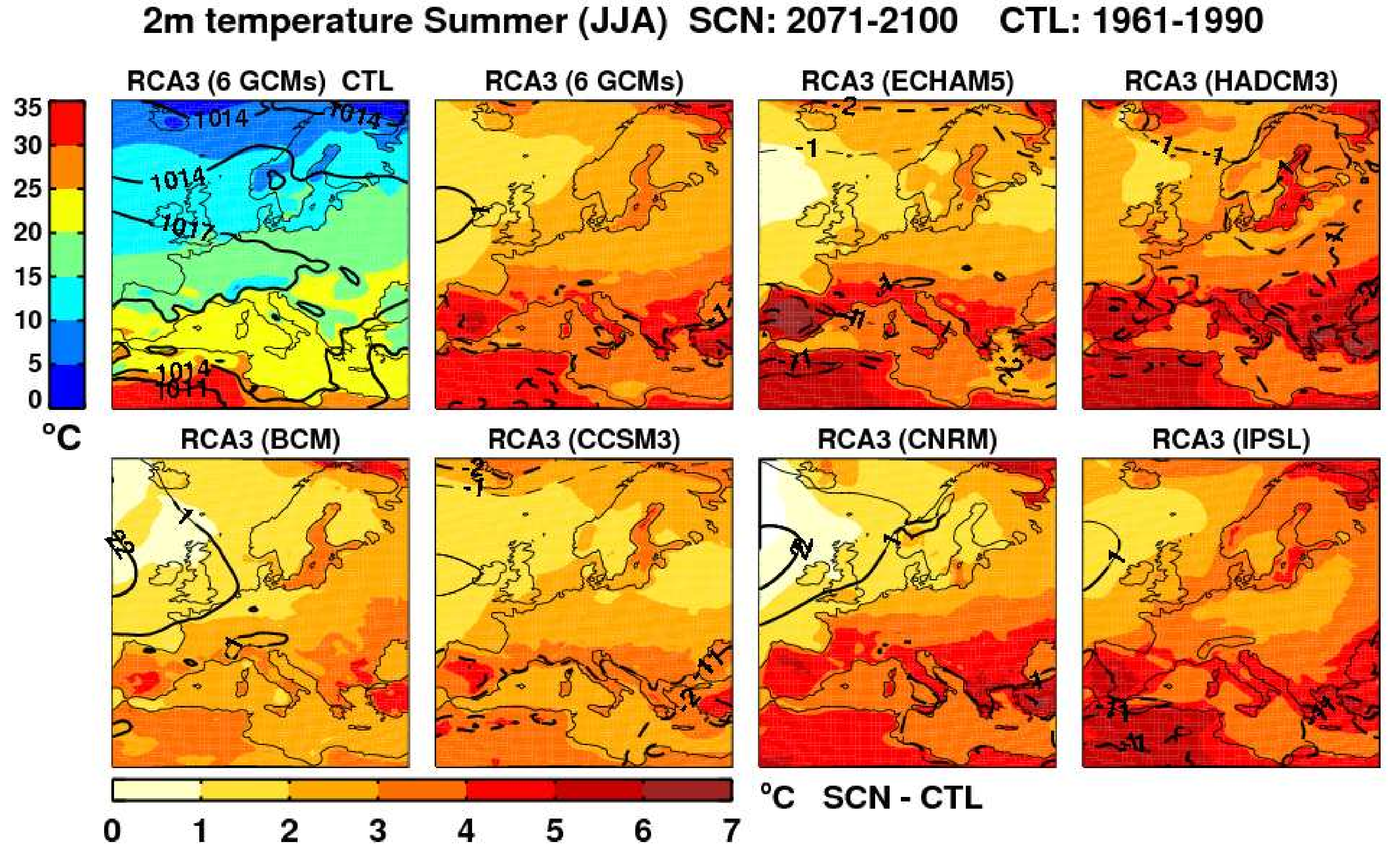
Winter 2m temperature CTL: 1961-1990 SCN: 2071-2100



all simulations show an increase in winter temperature
large deviations among the simulations in **CTL** but consistent geographical patterns of the projected future changes in **SCN (**varying magnitude**)**

Different driving global models

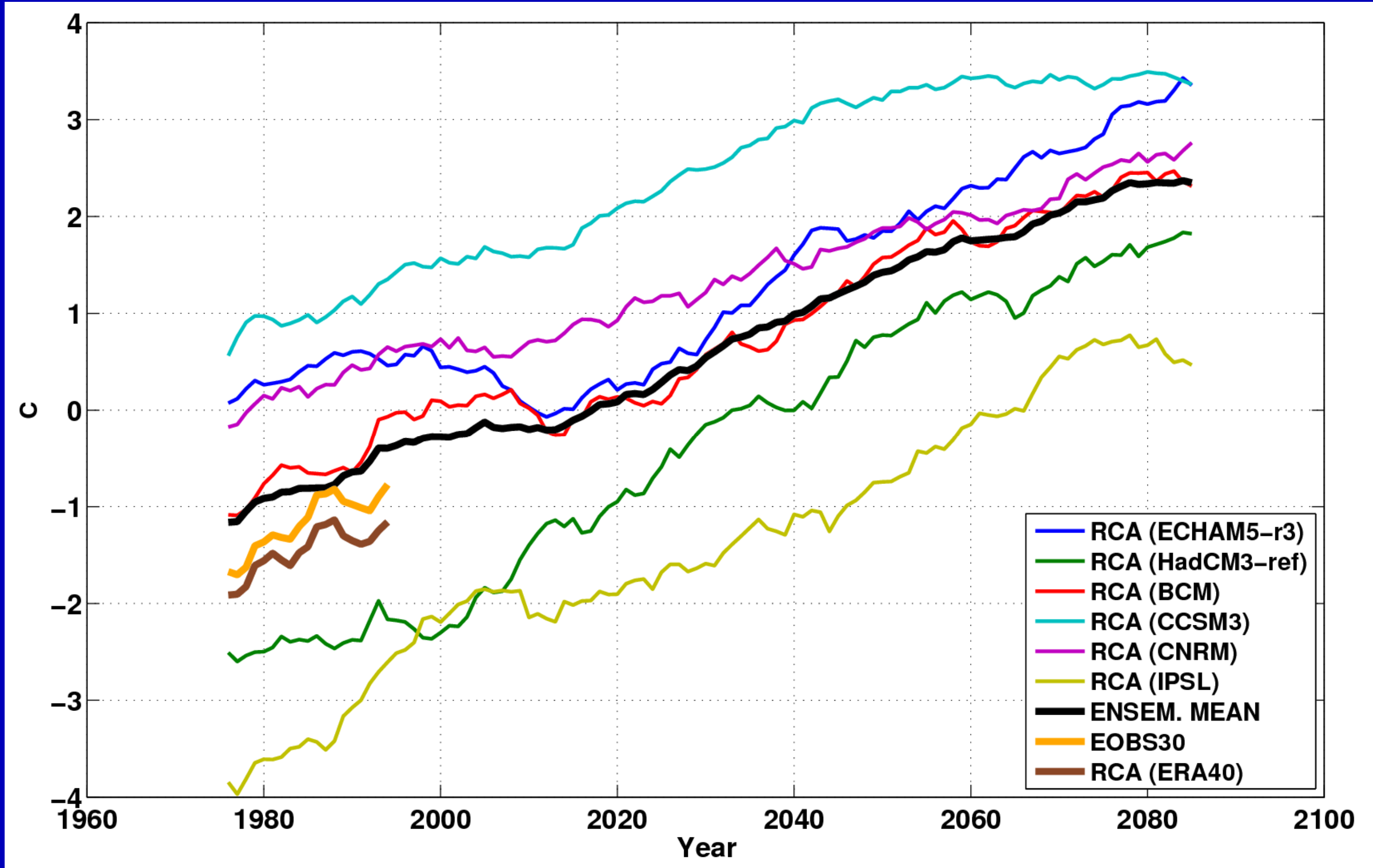
Summer 2m temperature CTL: 1961-1990 **SCN:** 2071-2100

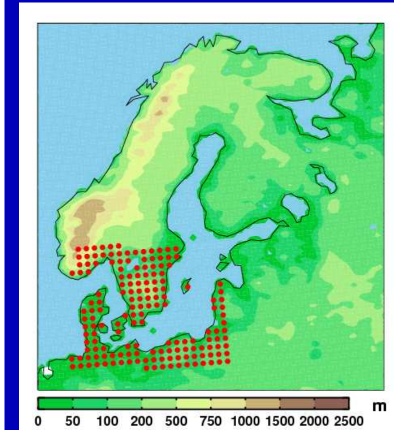


all simulations show an increase in summer temperature
consistent geographical patterns of the projected changes **(**varying magnitude**)**

Different driving global models

2m temperature Winter



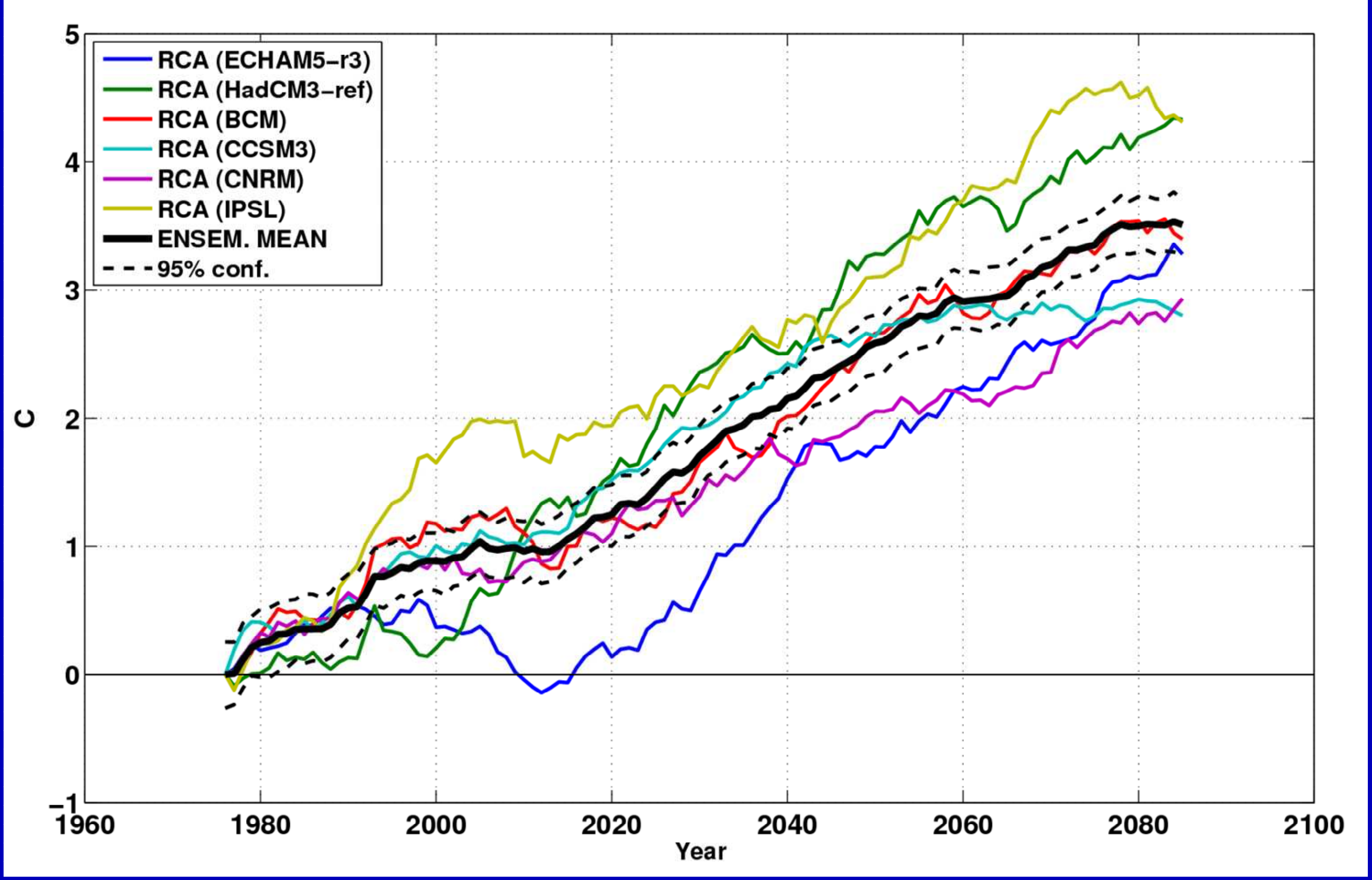


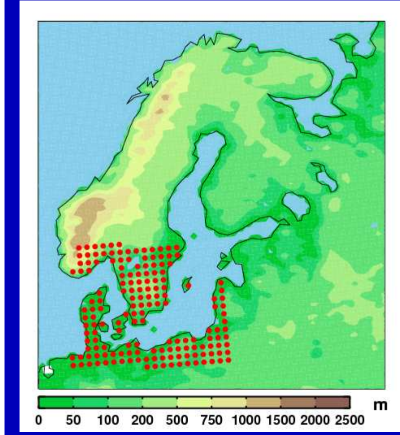
30-yr moving average of the red area average

common gradual increase

Different driving global models

Winter 2m temperature (anomalies wrt the 1961-1990 mean)





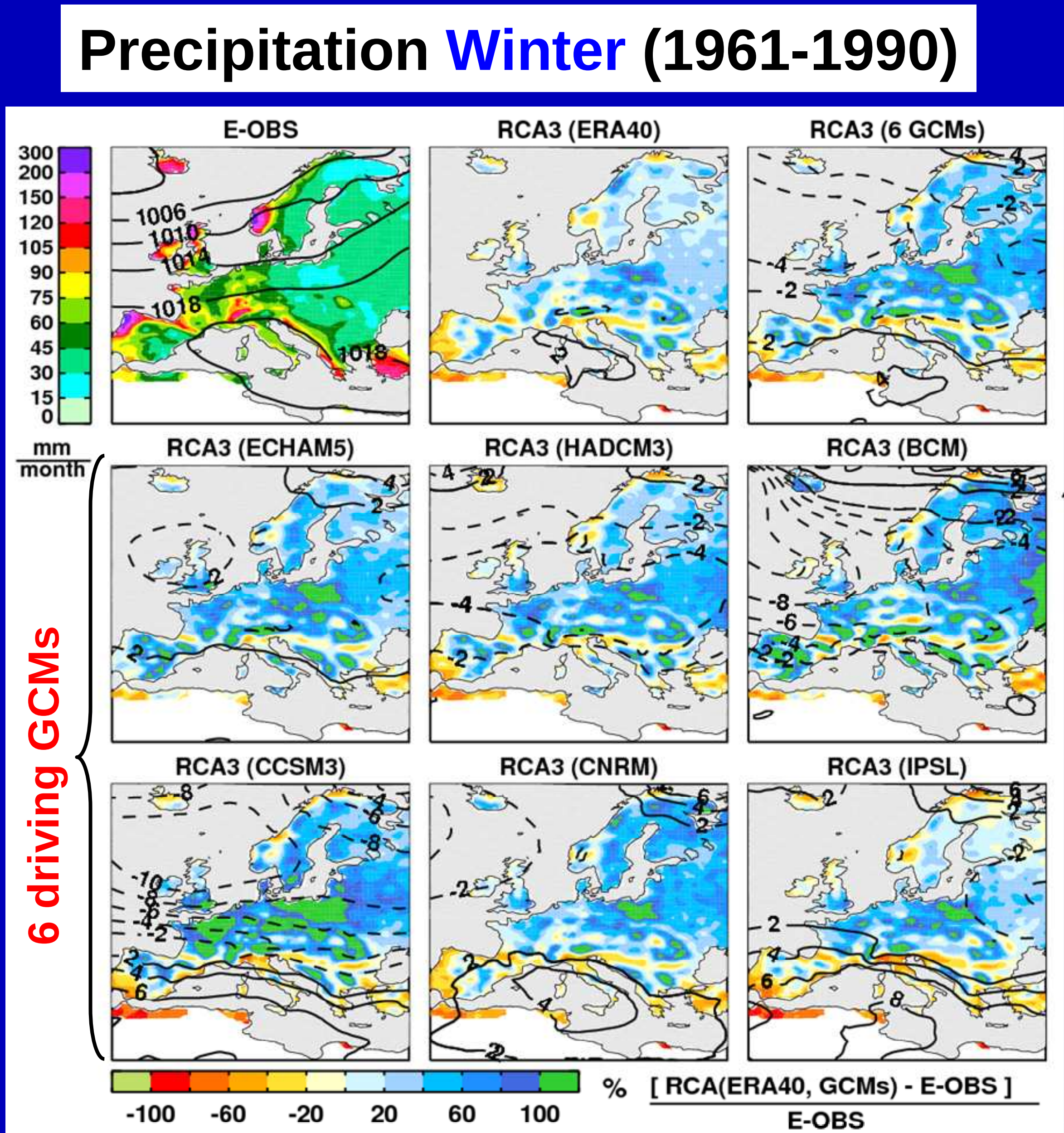
30-yr moving average of the red area average

similar tendency to higher temperature
decadal and multi-decadal variability is not so large
difference among the runs may be about 2℃

Different driving global models

an overestimation in a large fraction of the model domain

ensemble mean is not better than individual simulations



lines – sea level pressure

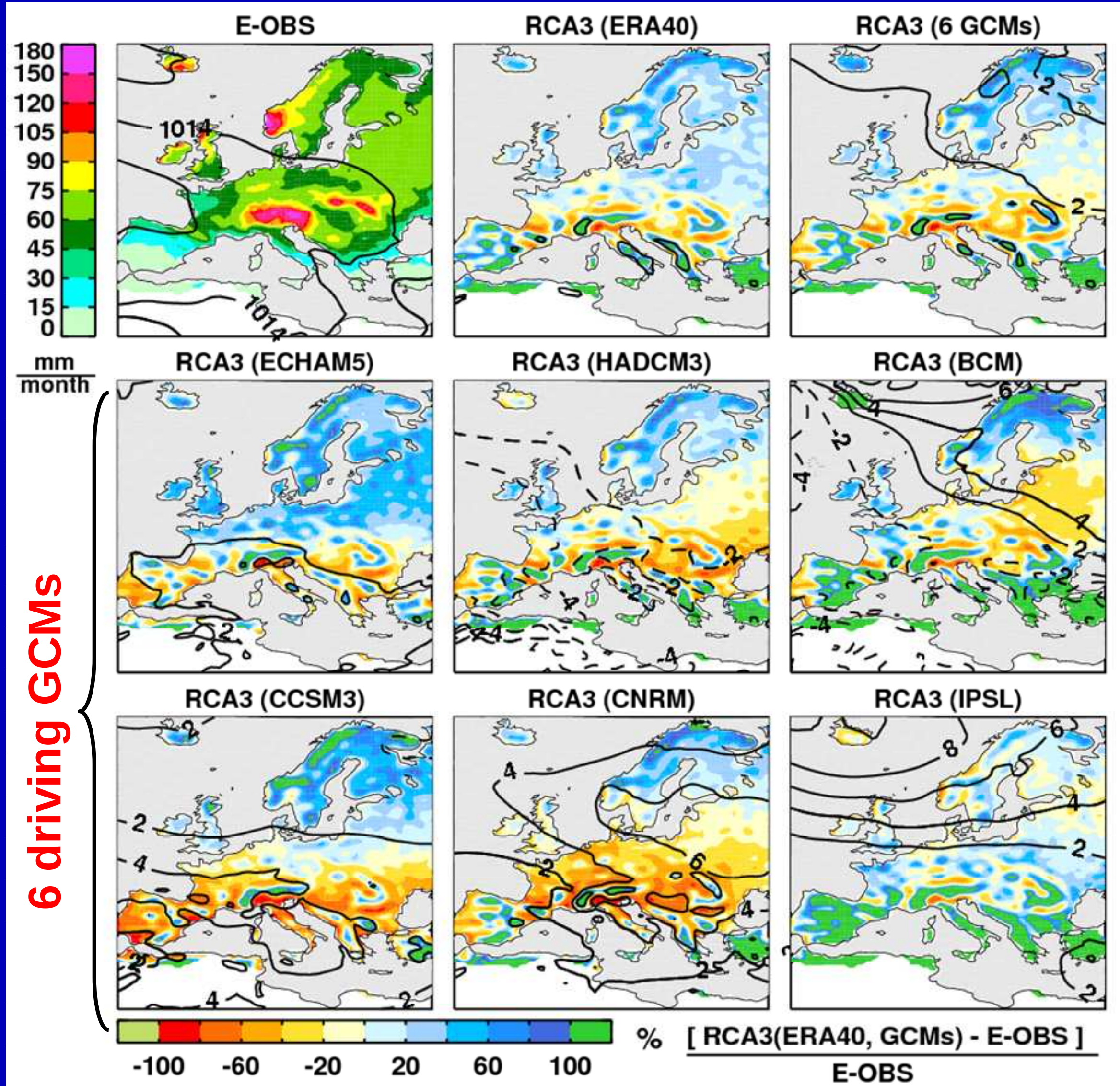
Different driving global models

Precipitation Summer (1961-1990)

an overestimation in northern Europe and some underestimation in southern Europe

biases among the simulations can locally be of opposite sign

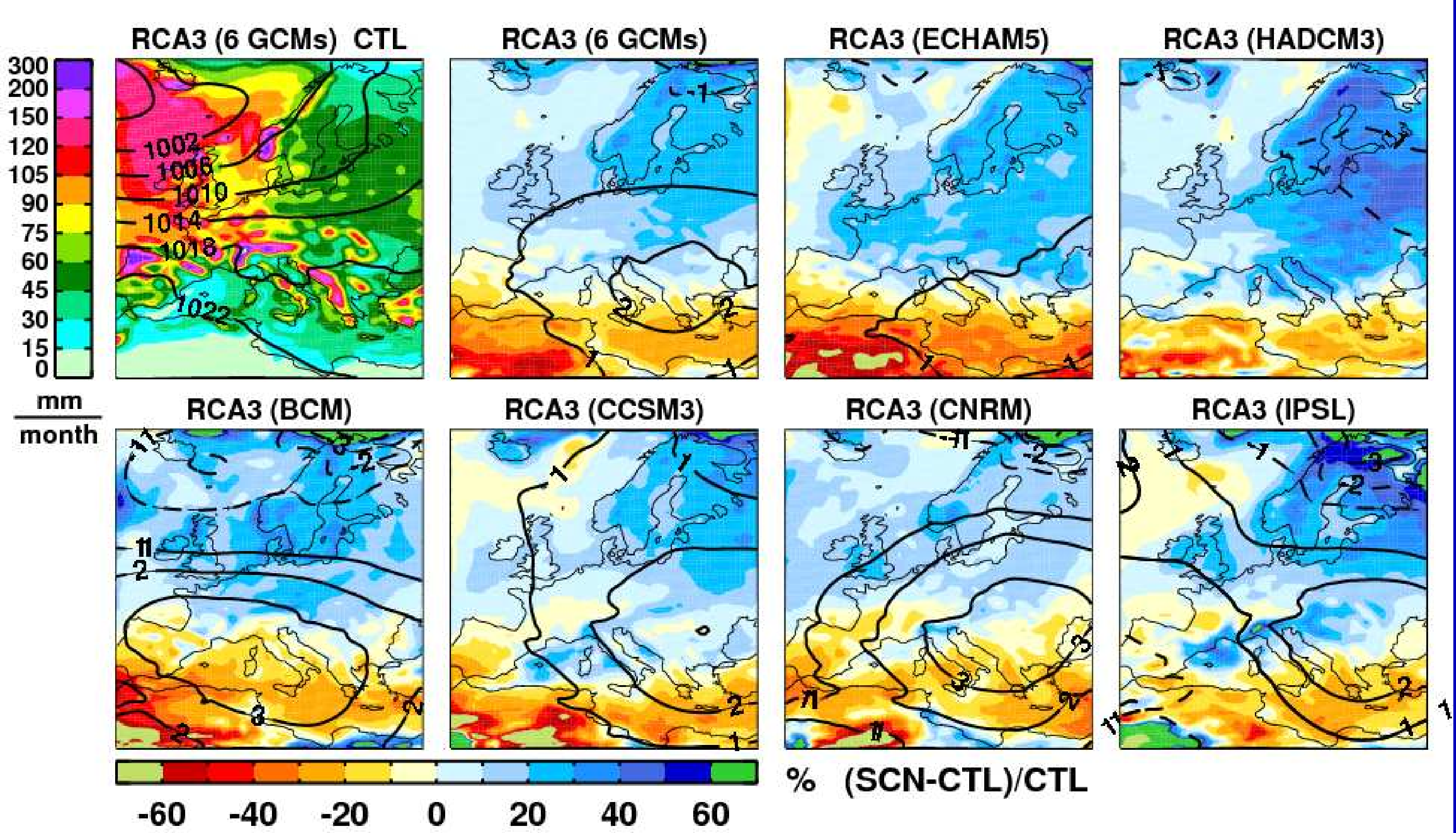
ensemble mean is close to RCA3(ERA40)



lines – sea level pressure

Different driving global models

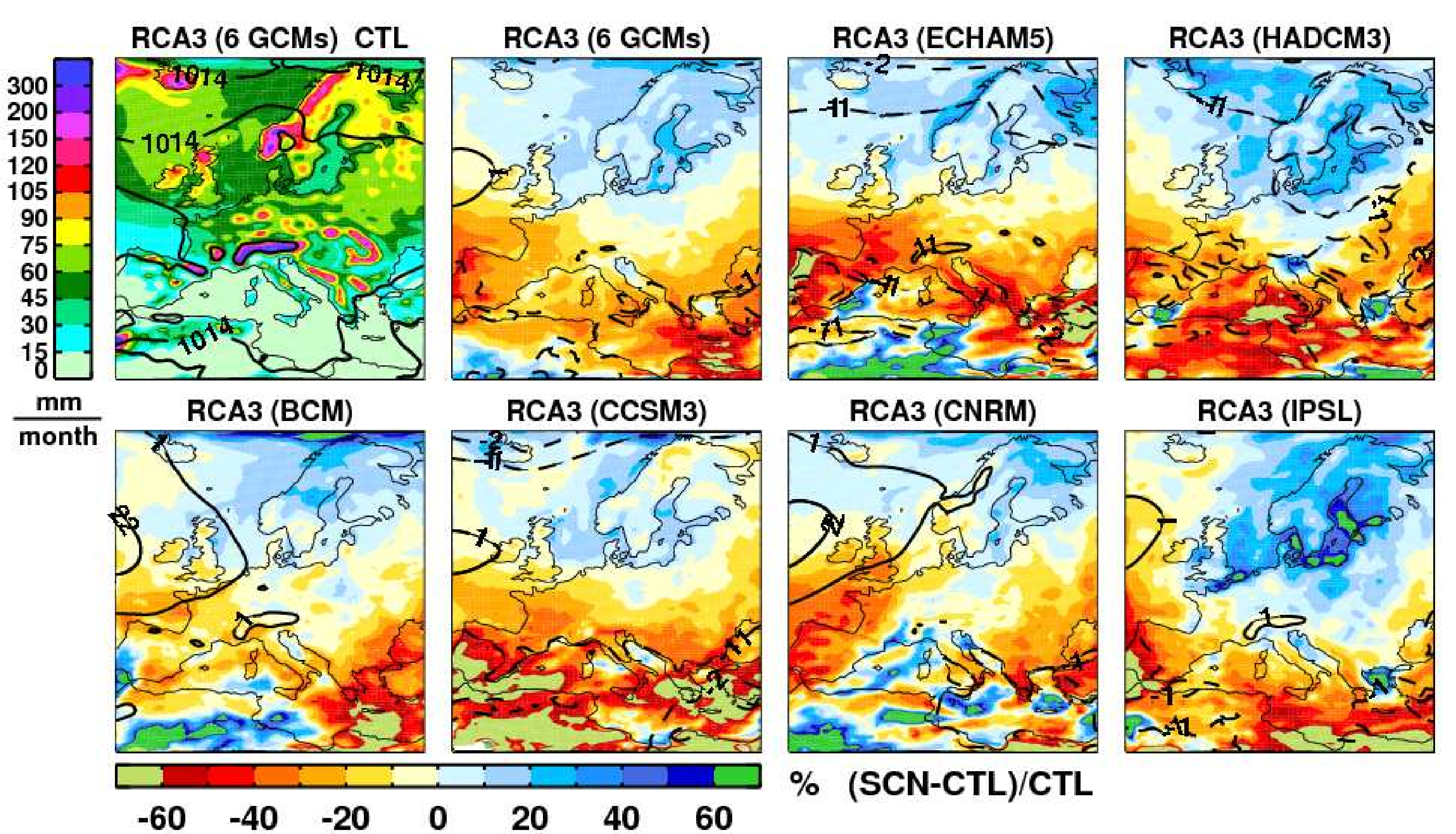
WINTER: Precipitation CTL: 1961-1990 SCN: 2071-2100



in general similar patterns of the projected changes
all simulation show an increase in precipitation over the Baltic region

Different driving global models

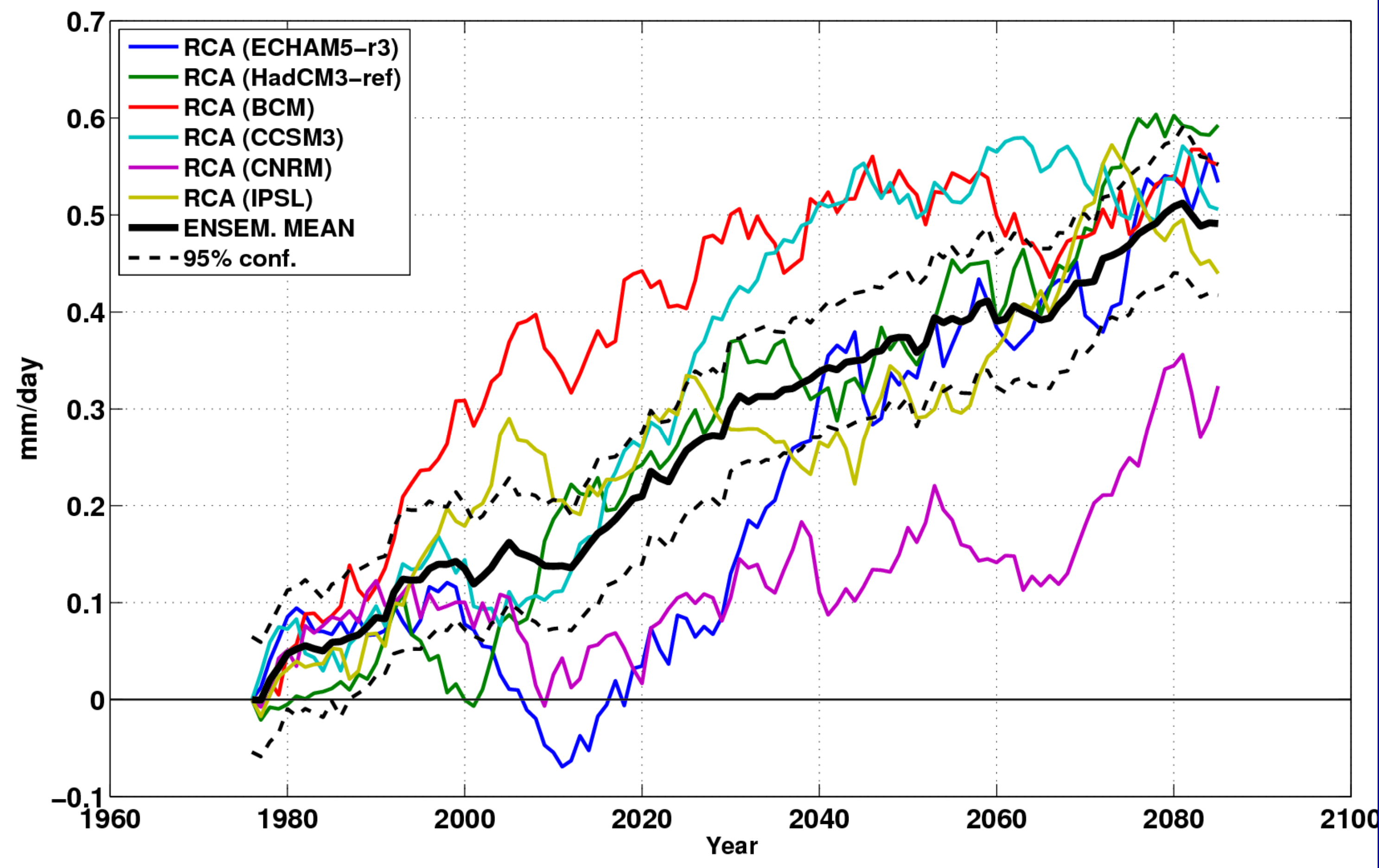
SUMMER: Precipitation CTL: 1961-1990 **SCN:** 2071-2100

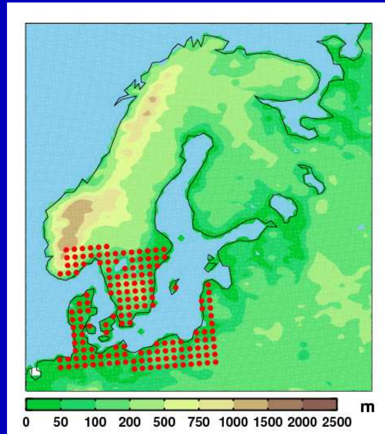


changes in precipitation over the Baltic region depend on driving GCMs
a transition zone between an increase and decease
a weak increase in the ensemble average

Different driving global models

Winter Precipitation (anomalies wrt the 1961-1990 mean)



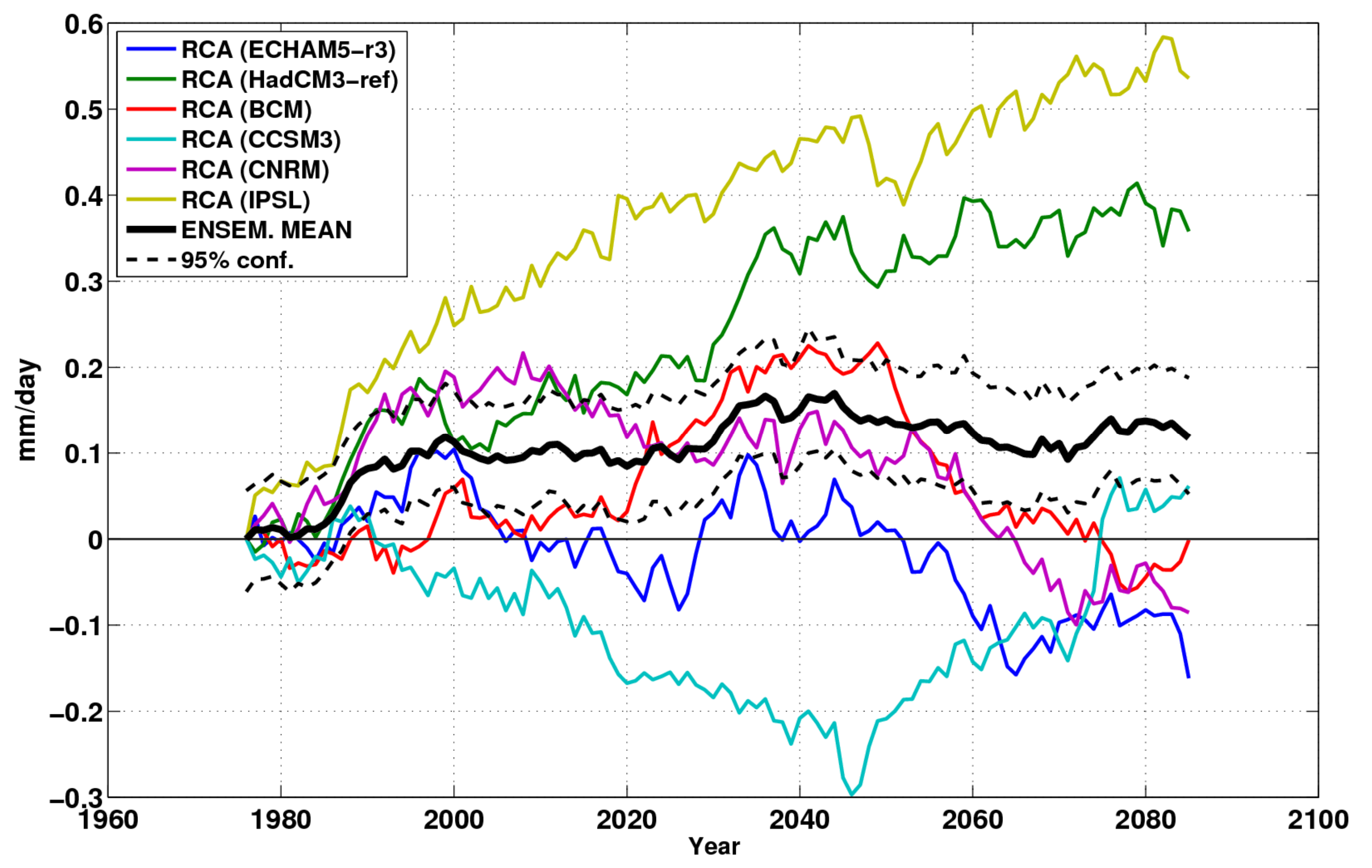


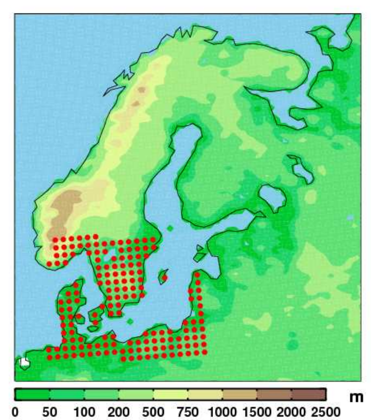
30-yr moving average of the red area average

common tendency to higher precipitation amount
decadal and multi-decadal variability is larger compared to temperature

Different driving global models

Summer Precipitation (anomalies wrt the 1961-1990 mean)



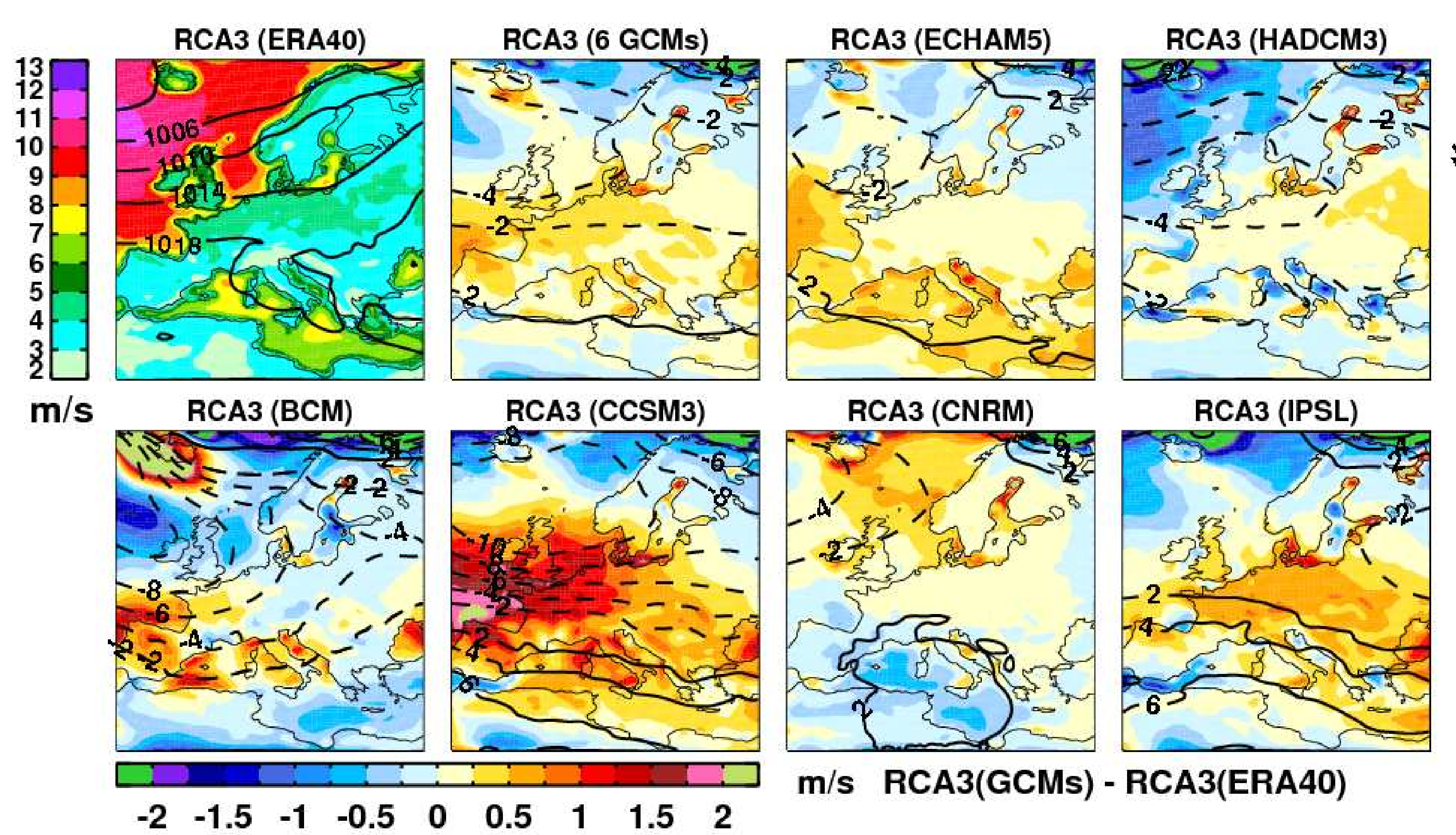


30-yr moving average of the red area average

diverse behaviour of different simulations
the ensemble mean is strongly dominated by one or two simulations
variability is large

Different driving global models

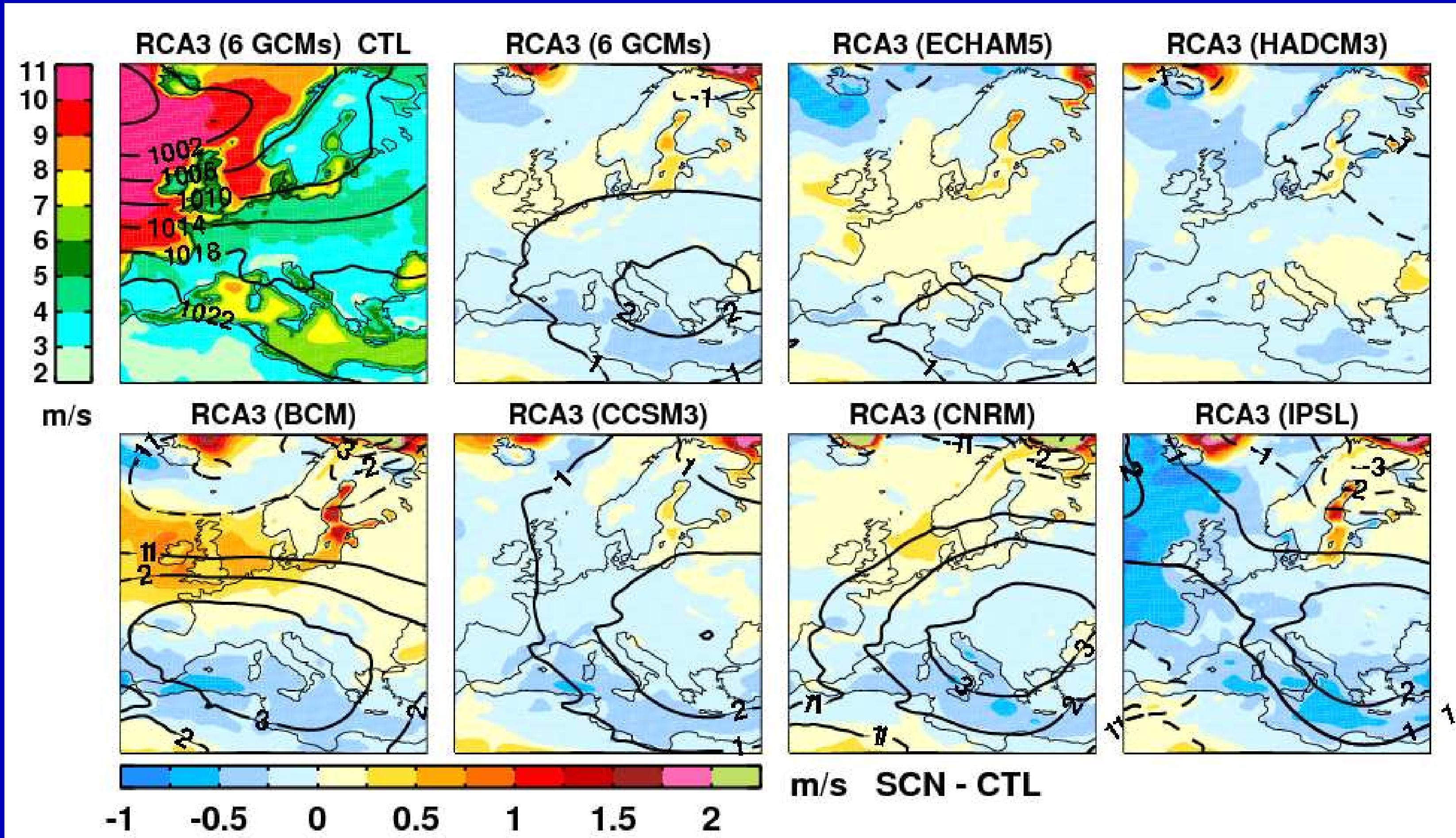
WINTER 10m Wind (1961-1990)



biases in wind are related to biases in sea level pressure - RCA3(CCSM3)

Different driving global models

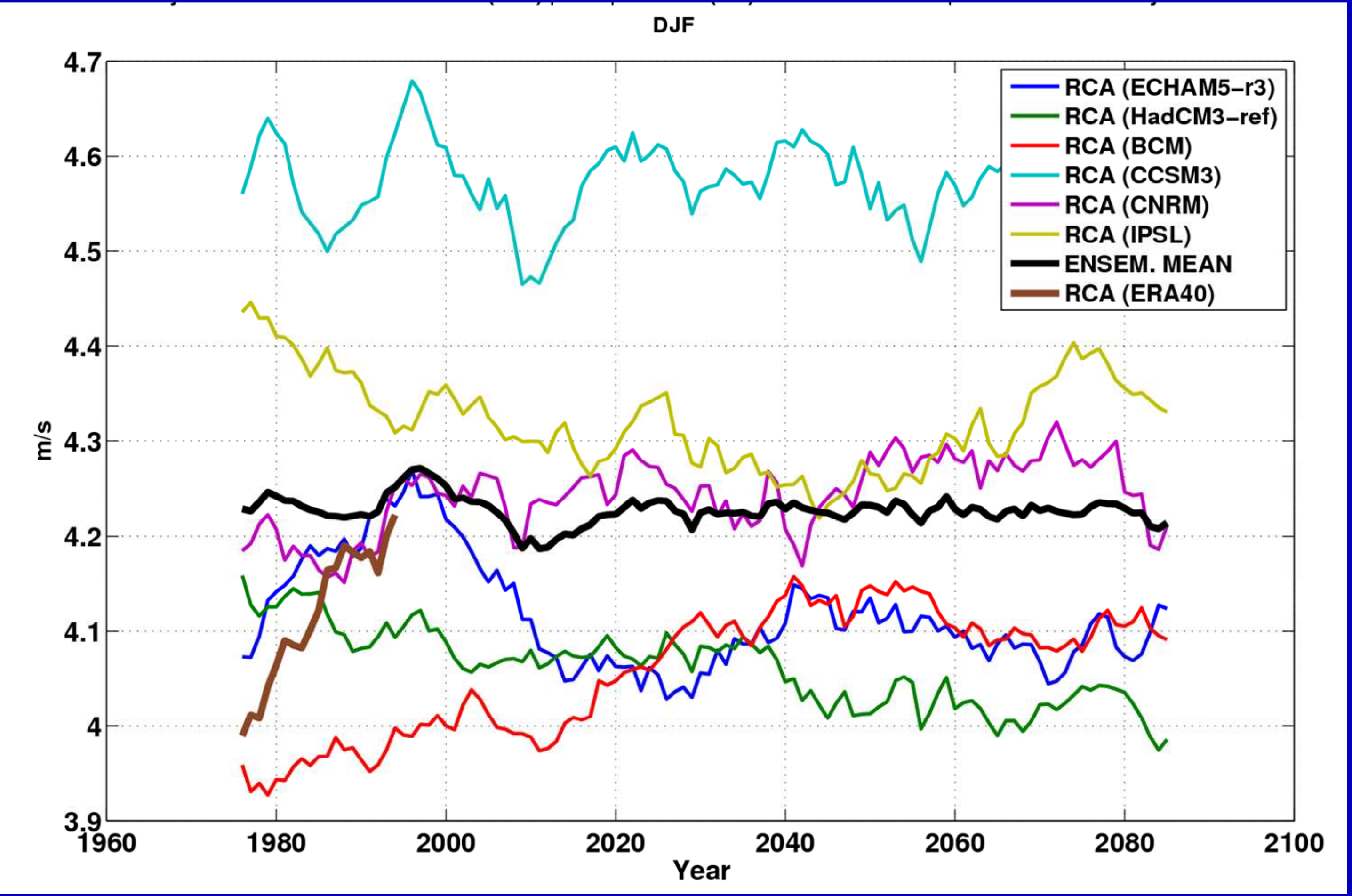
WINTER: 10m wind CTL: 1961-1990 SCN: 2071-2100

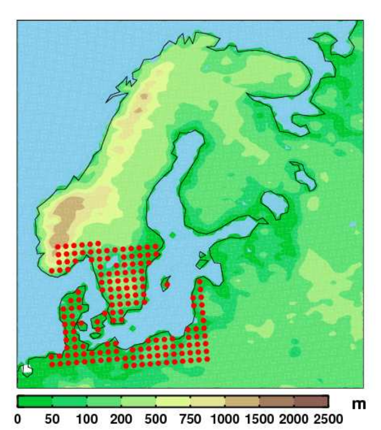


decreasing wind speed in the Mediterranean region
most simulations show an increase in wind speed over parts of the Baltic, White, Barents sea (reduction in sea ice in the driving GCMs)

Different driving global models

Winter 10m Wind



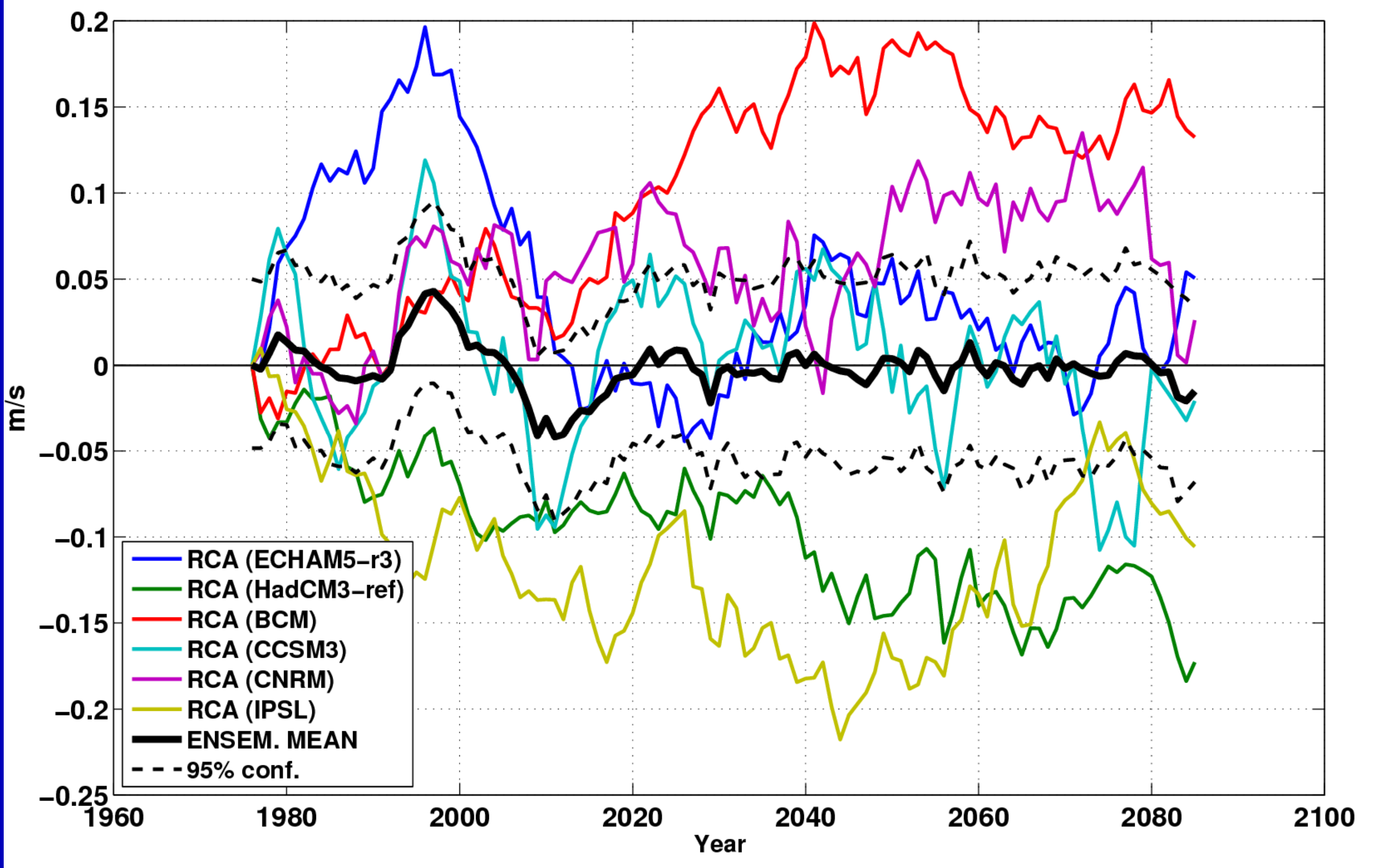


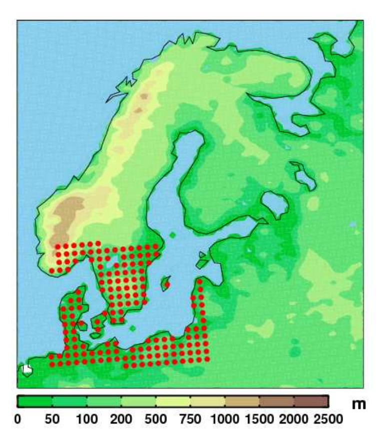
30-yr moving average of the red area average

no changes

Different driving global models

Winter 10 Wind (anomalies wrt the 1961-1990 mean)



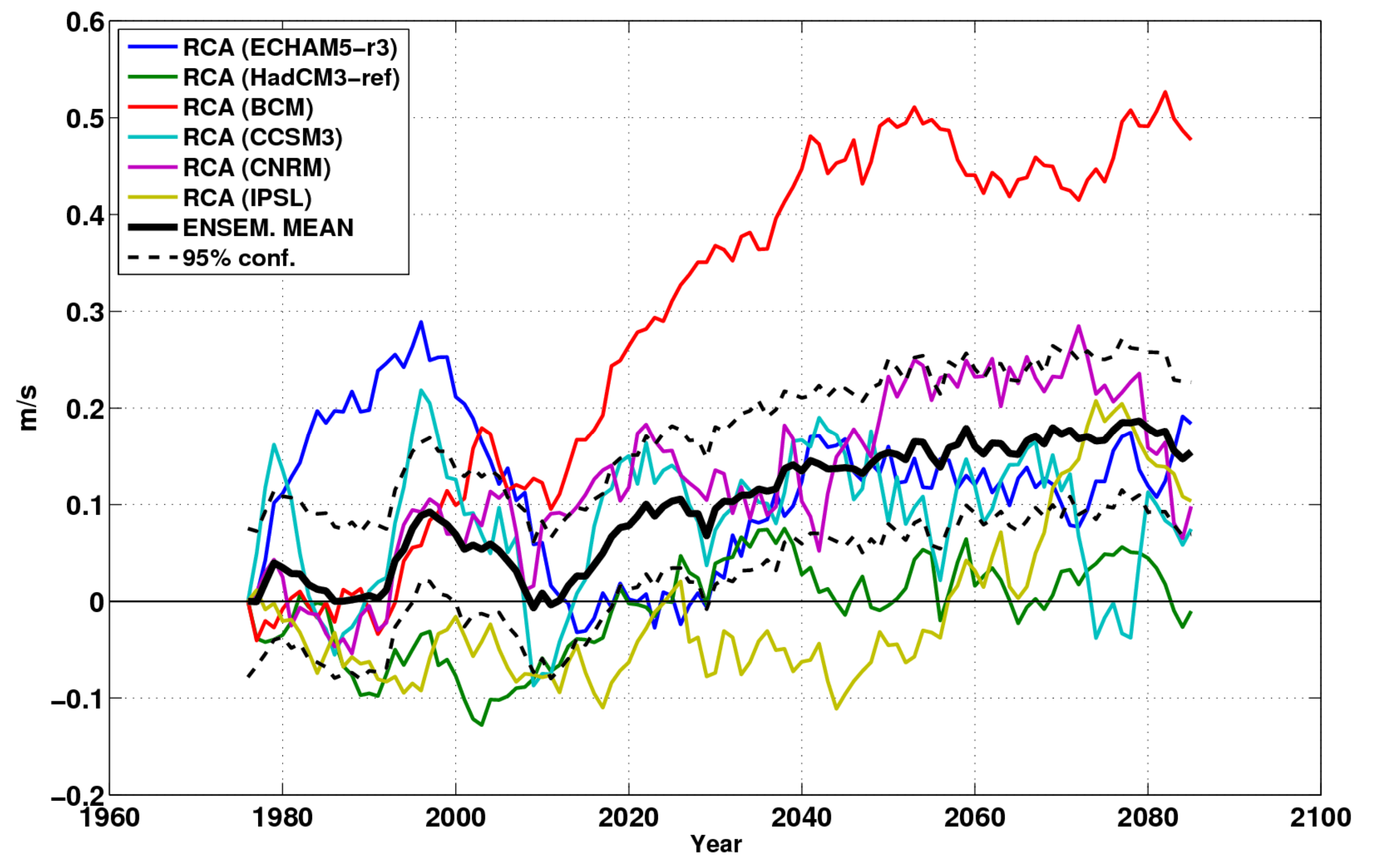


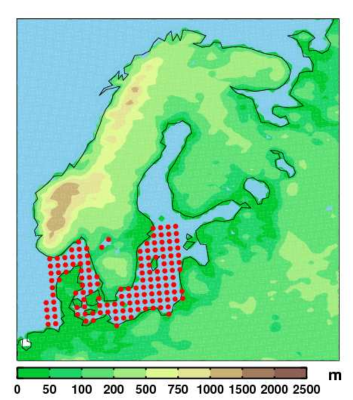
30-yr moving average of the red area average

large decadal and multi-decadal variability

Different driving global models

Winter 10m Wind (anomalies wrt the 1961-1990 mean)



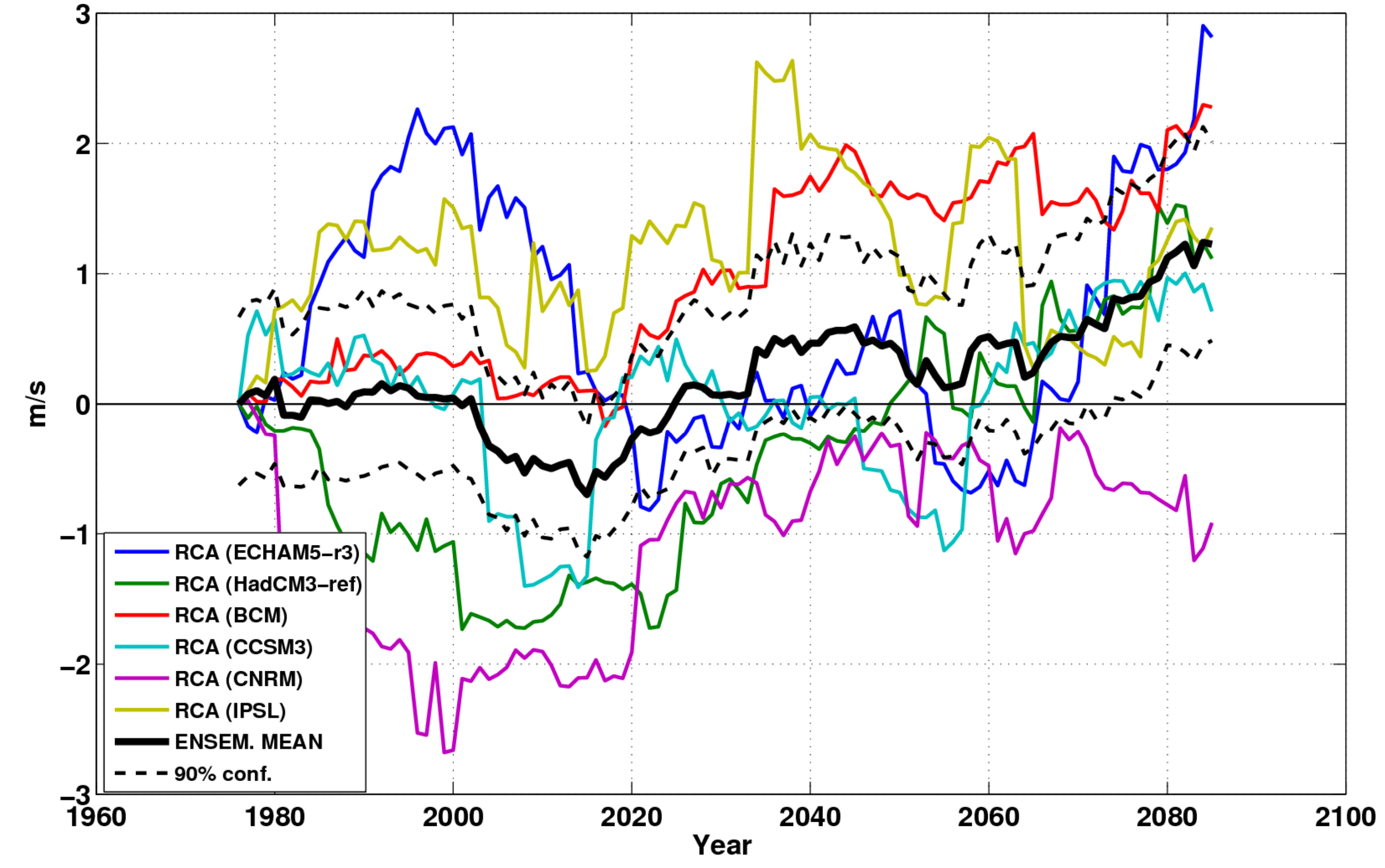


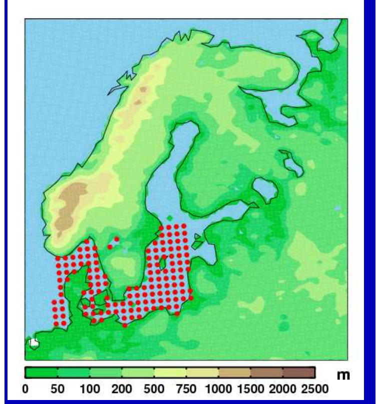
30-yr moving average of the red area average

strengthening of wind in the ensemble mean
strong influence of RCA3(BCM) on the ensemble mean

Different driving global models

Winter 50-yr return values of gust wind (anom. wrt 1961-1990)



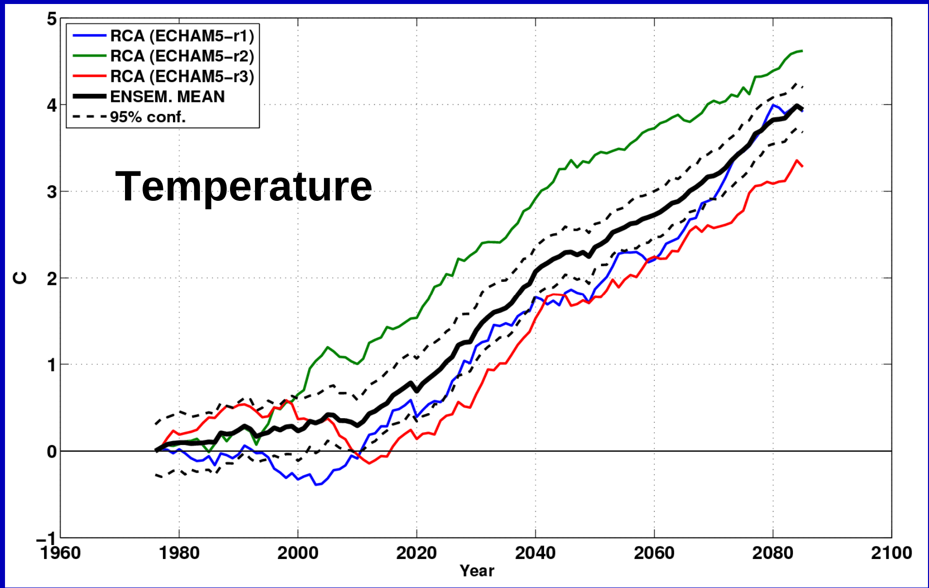


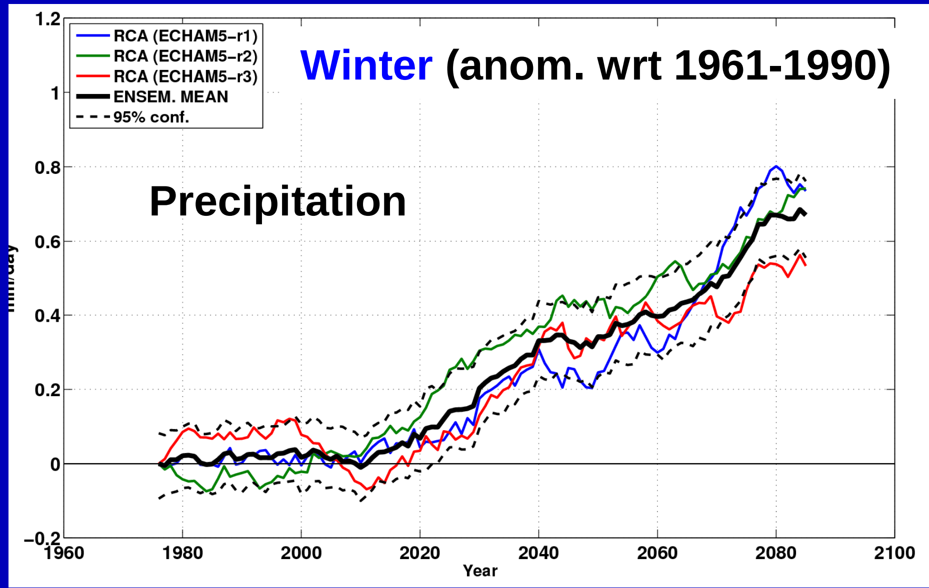
30-yr moving GEV of the red area average

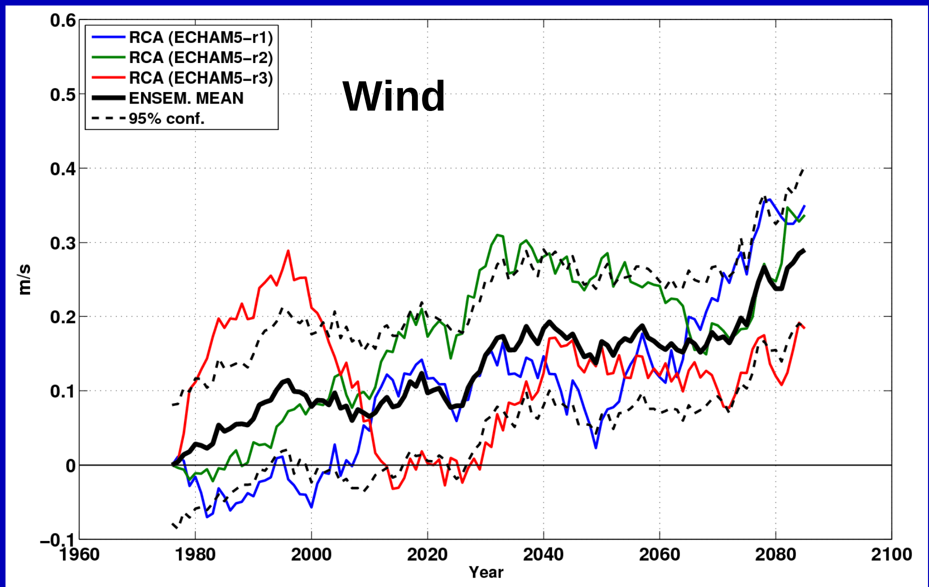
very large variability on decadal and multi-decadal time scales
a significant increase after 2080

Natural variability

One driving GCM (ECHAM5) with different intitial conditions (r1, r2 and r3)



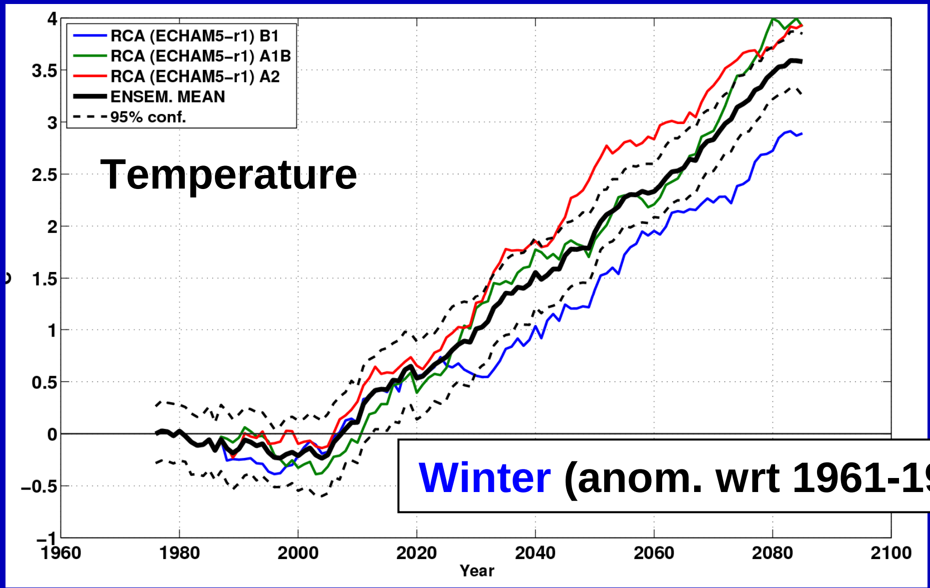


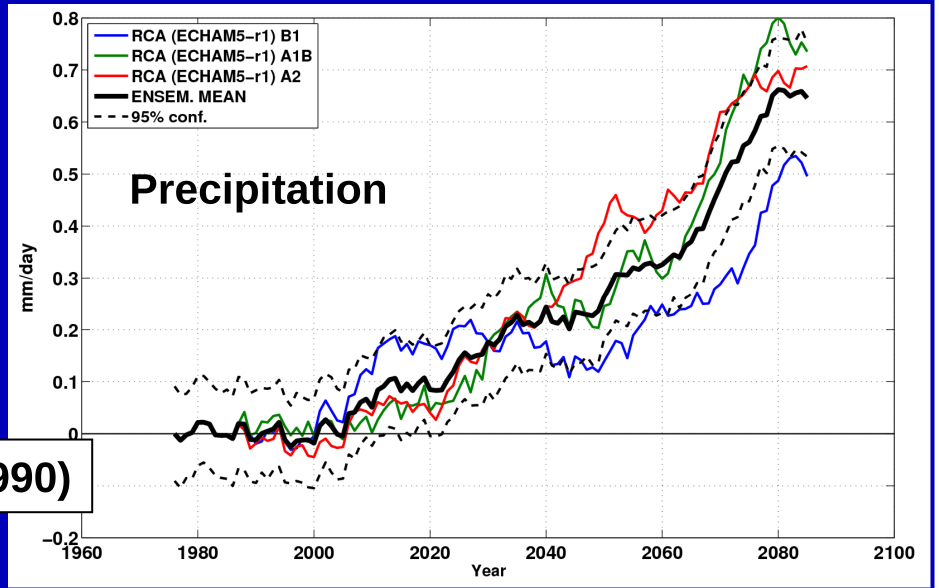


natural variability is important in coming decades but may be an important source of uncertainties even in the end of this century

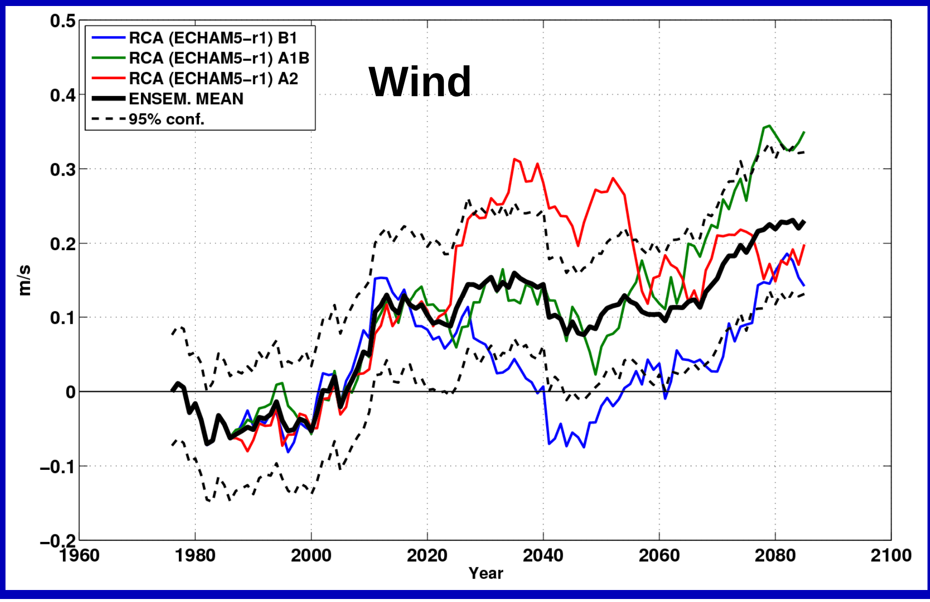
Emission scenarios

One driving GCM (ECHAM5) with different emission scenarios (B1, A1B, A2)





Winter (anom. wrt 1961-1990)



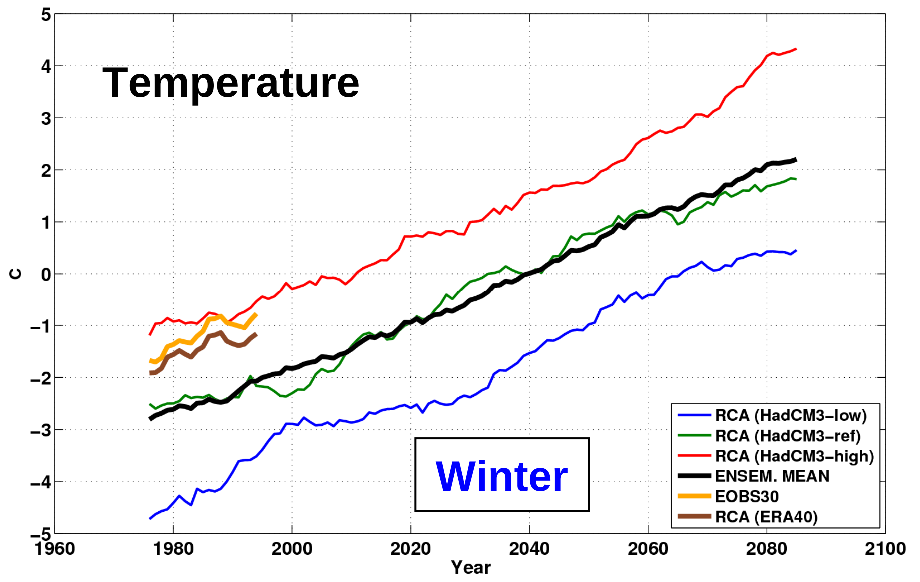
Temperature and precipitation:
- emission scenarios become important with time

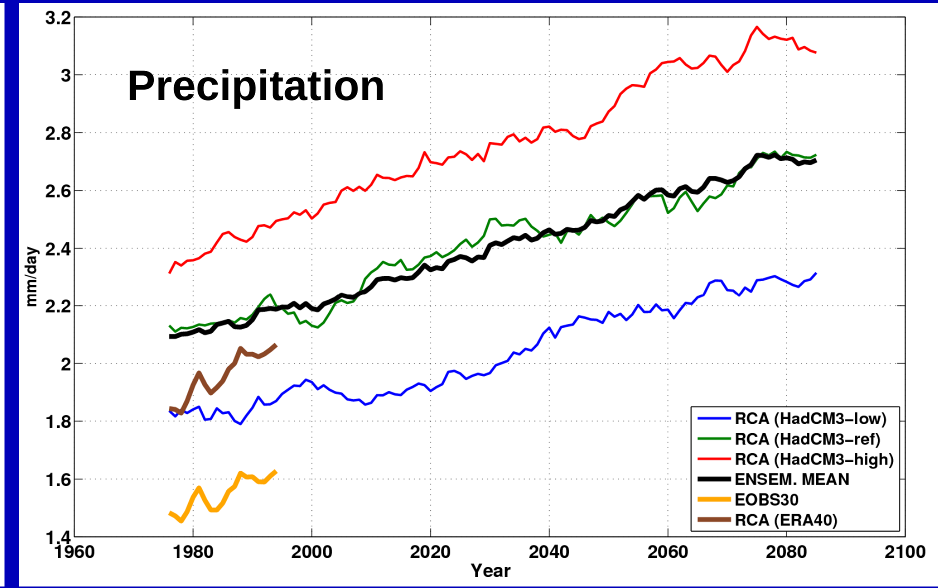
Wind:
- not so sensitive to emission scenarios, natural variability dominates

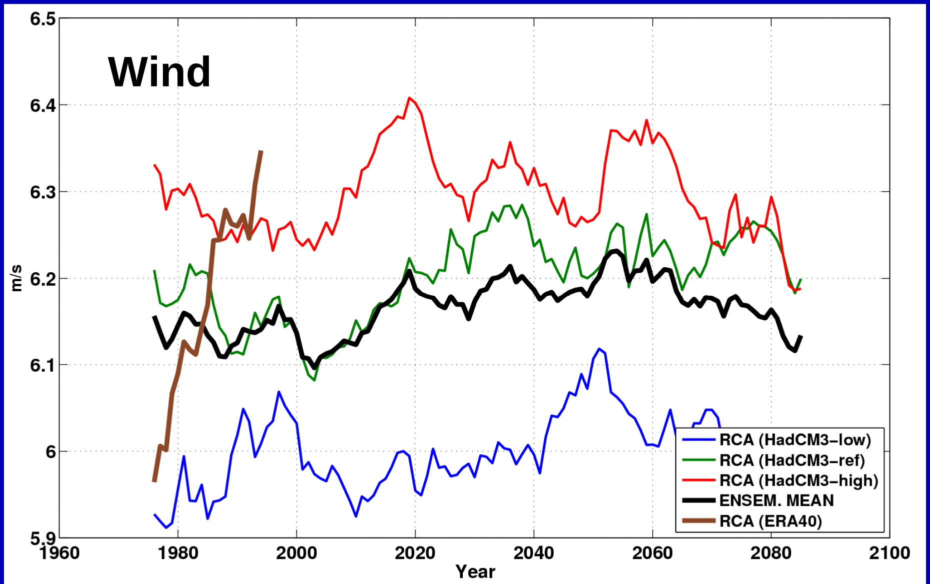
GCM formulation: climate sensitivity

SMHI

One driving GCM (HadCM3) with different parameter setting



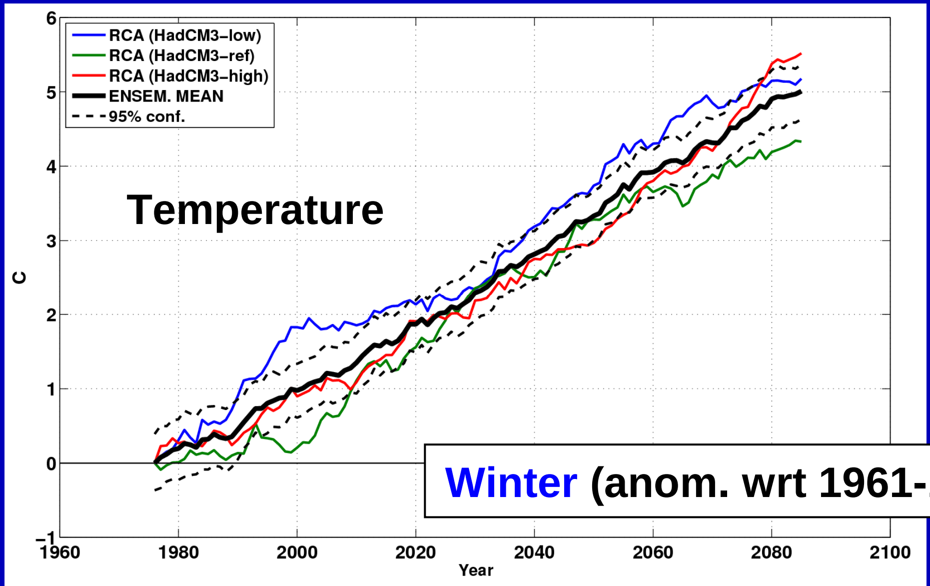


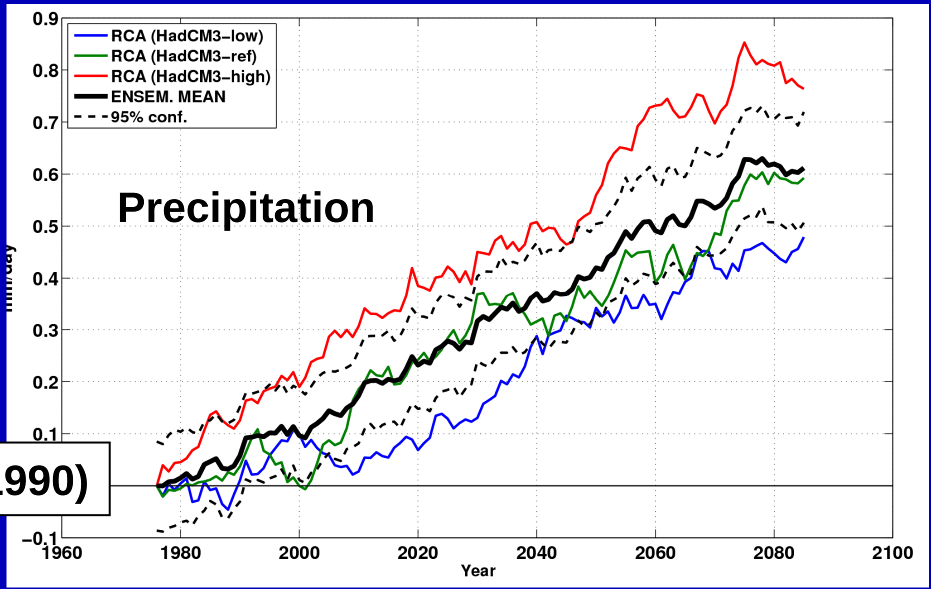


<u>HadCM3 with higher climate sensitivity</u>
higher temperature, precipitation and wind but again natural variability may be important for wind

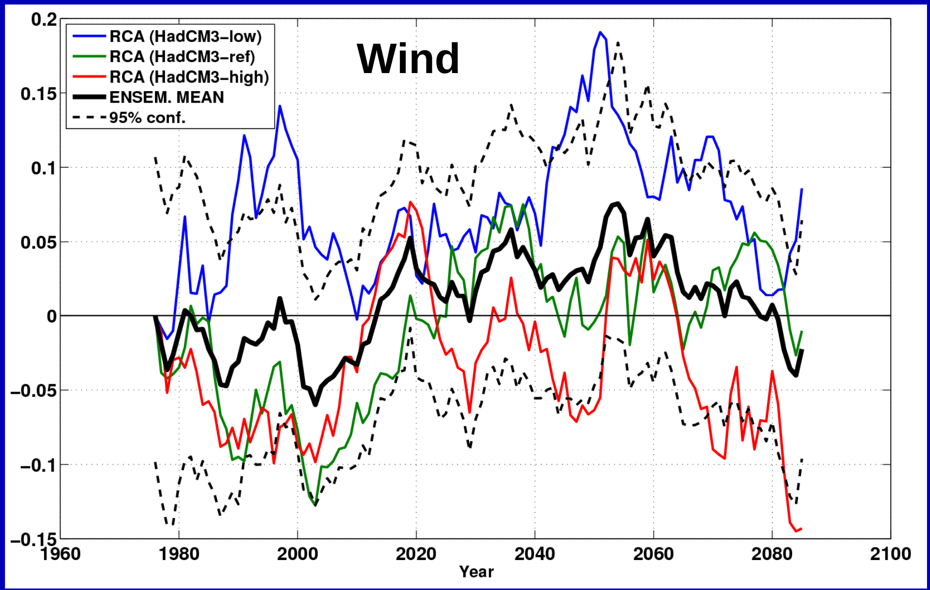
GCM formulation: climate sensitivity

One driving GCM (HadCM3) with different parameter setting





Winter (anom. wrt 1961-1990)



Higher climate sensitivity

- stronger climate change signal in precipitation but not in temperature (the control period is important)
- not so critical for wind

SMHI

Conclusions

ENSEMBLES

Uncertainties in climate projections over the Baltic region

Temperature and precipitation:

- different driving GCMs, natural variability and GCM formulation are an important source of uncertainties until 2100
- emission scenario is not important in coming decades

Wind:

- different driving GCMs are a dominant source of uncertainties
- natural variability is important as well
- emission scenarios and GCM formulation have minor influence