Nordic weather extremes as simulated by the Rossby Centre Regional Climate Model: model evaluation and future projections

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Objectives

- ✓ an ensemble: one regional climate model driven by different global climate models
- ✓ evaluation of the simulated temperature, precipitation and wind extremes over Scandinavia
- ✓ projected climate changes in Nordic extremes
- ✓ degree of dependency of the simulated temperature, precipitation and wind extremes on driving global climate models

Nikulin et al., Tellus A 2010, accepted

Models

Regional climate model

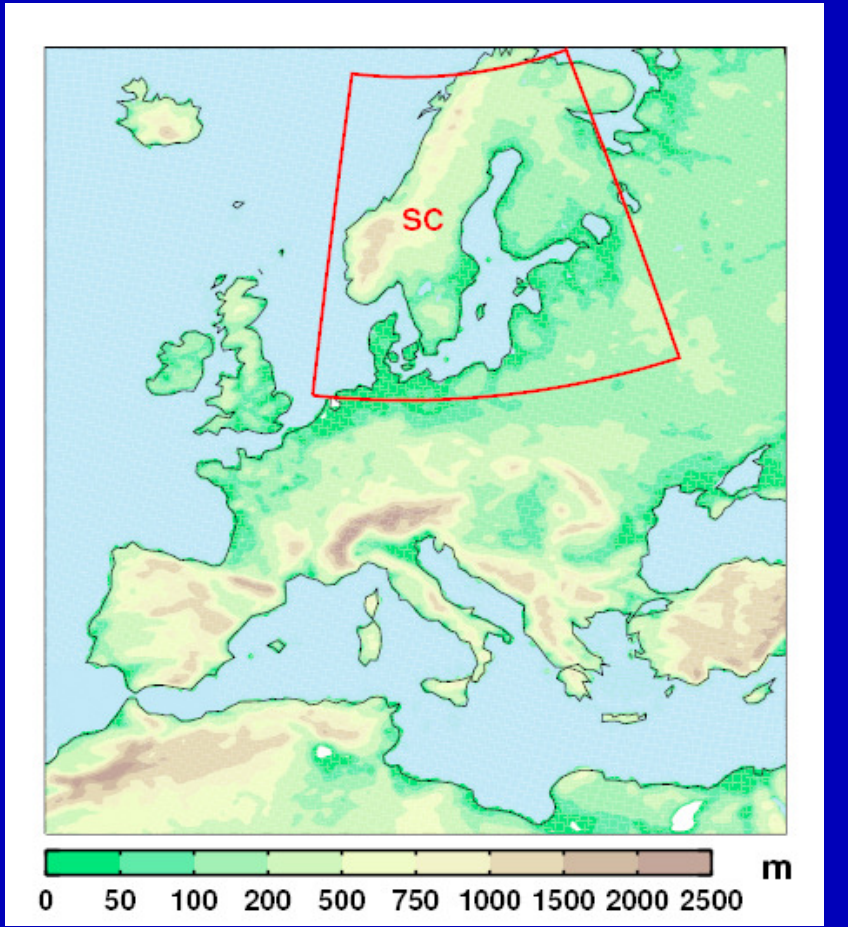
RCA3 (Rossby Centre, SMHI, Sweden)
Europe, resolution: 50 km

Reference simulation

driven by ERA40 Reanalysis

Forcing global models (A1B)

ECHAM5-r3 (MPI, Germany)
HadCM3-ref (MOHC, UK)
BCM (NERSC, Norway)
CCSM3 (NCAR, USA)
CNRM (CNRM, France)
IPSL (IPSL, France)



Data and method

Variables (daily)

max and min 2m temperature

max 10m gust wind (*Brasseur 2001*)

accumulated precipitation

Extreme events

the generalised extreme value (GEV) distribution

the 20-year return values of

annual max/min temperature and max gust wind

summer and winter maximum of precipitation

fitting the GEV: stationary model, L-moments

statistical tests: parametric bootstrap

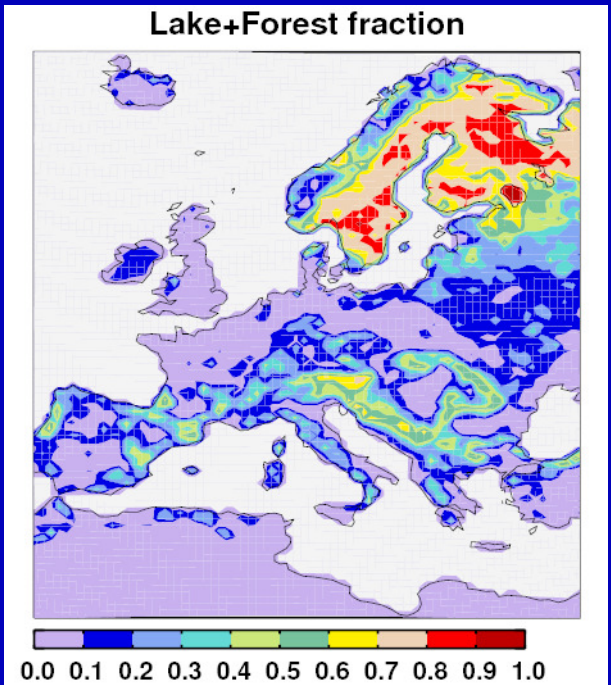
Observations

gridded E-OBS data set (ver. 1.1) (*Haylock et al., 2008*)

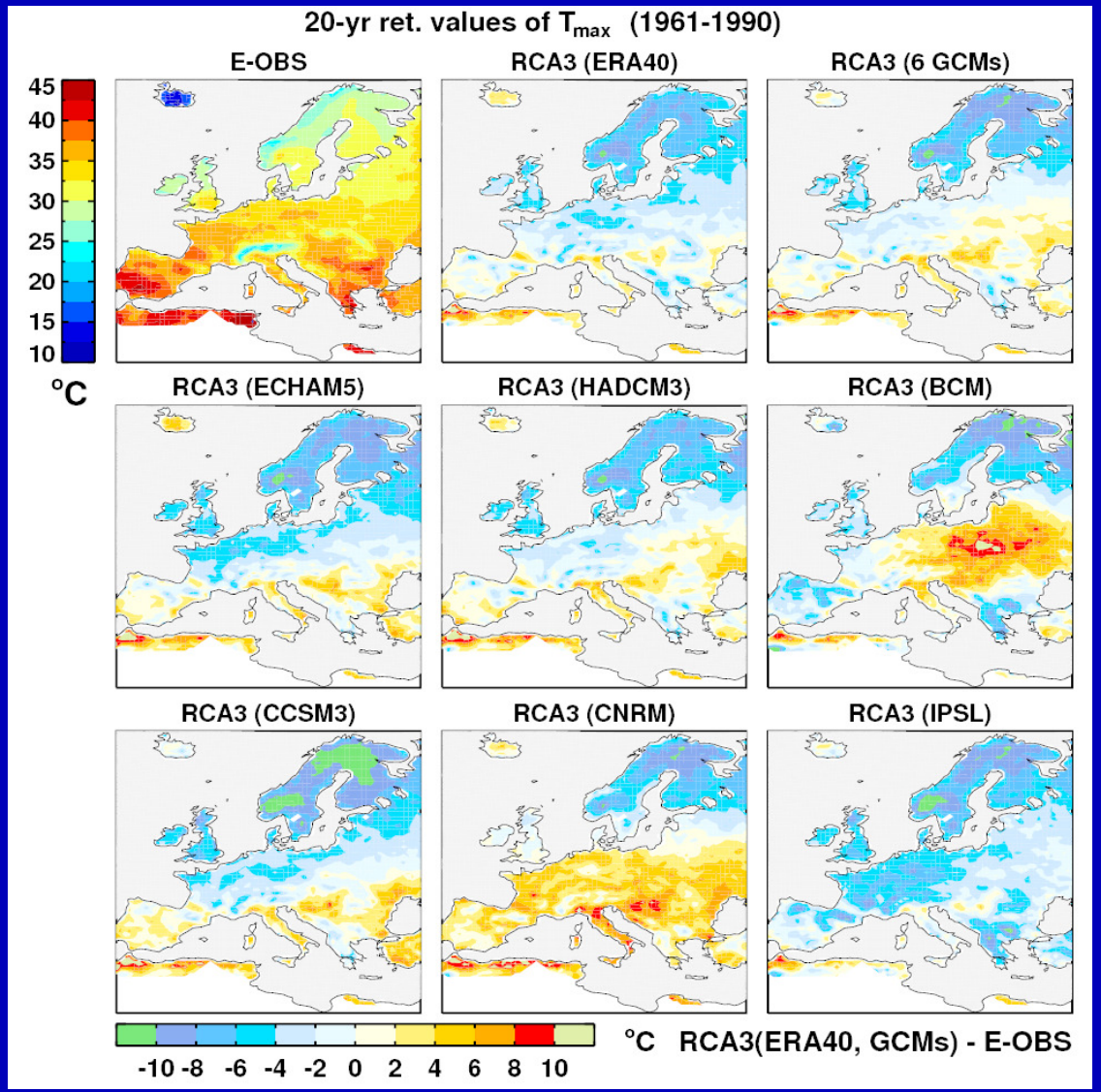
Evaluation of warm extremes (1961-1990)

the key role of the driving GCMs over central Europe

strong underestimation of warm extremes over Scandinavia (large lake+forest fraction)



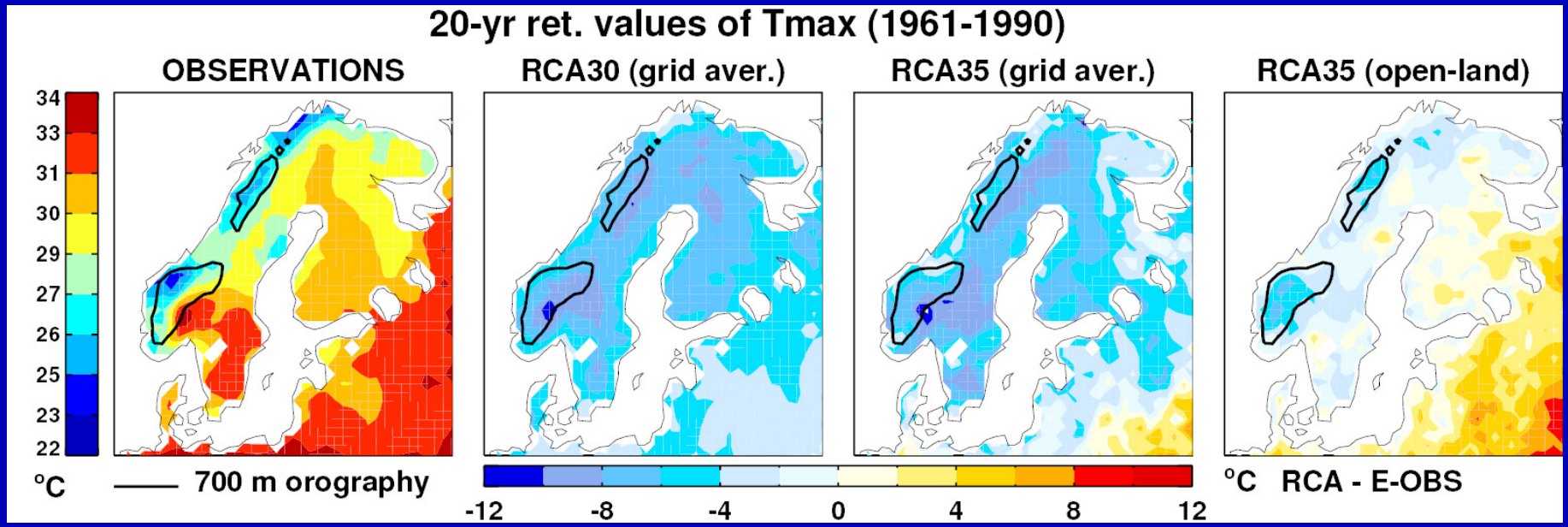
20-yr. return values of T2max



Warm extremes on open land (1961-1990)

20-yr. return values of T2max

Open-land T2max



intermediate version of RCA35

Potential problem for model evaluation over Scandinavia:

a large fraction of forest and lakes but the observations represent open-land temperature

Evaluation of cold extremes (1961-1990)

biases of opposite sign among simulations show the key role of the driving GCMs in winter

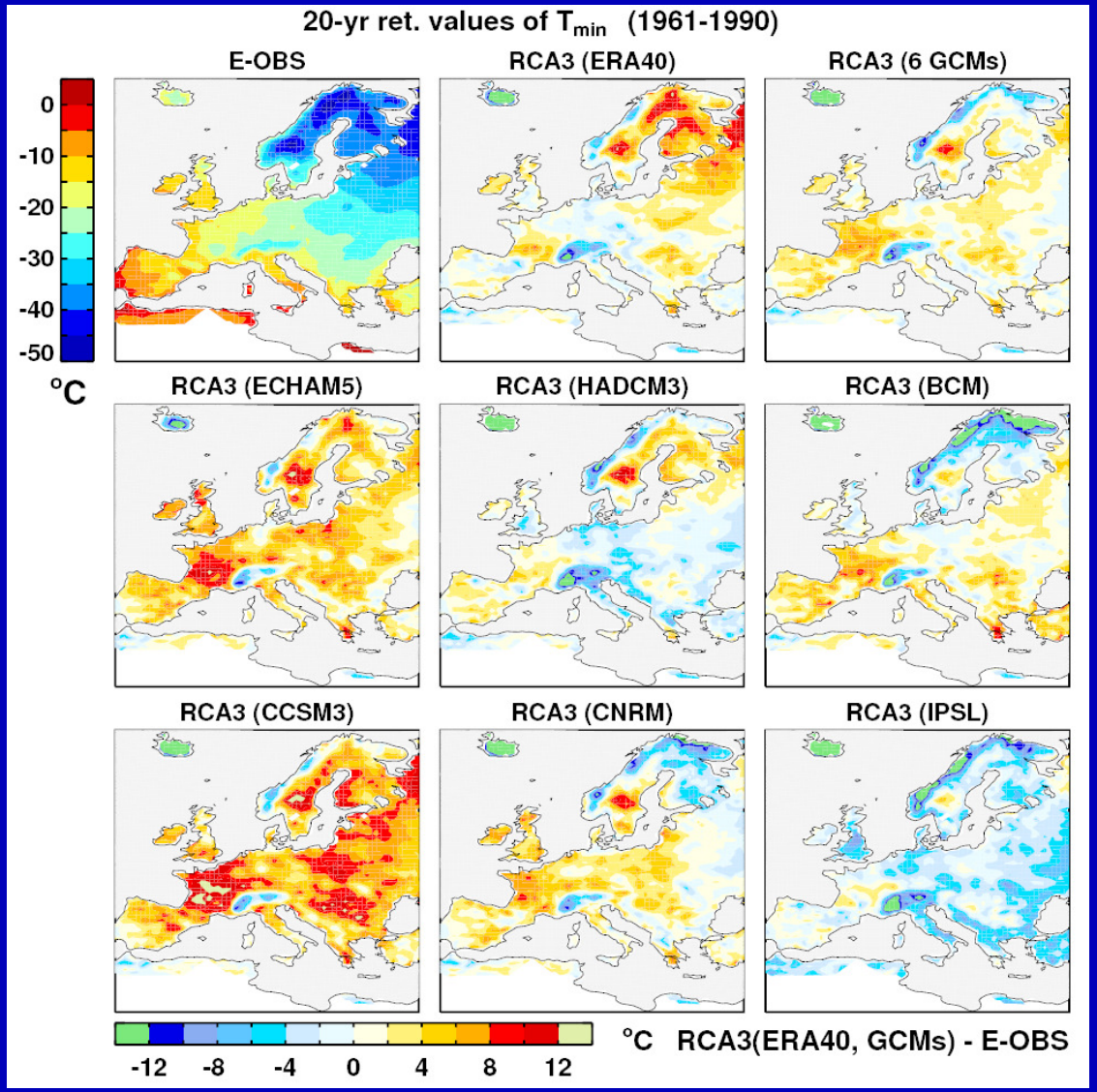
Scandinavia:

warm bias in the reference simulation RCA3(ERA40)

common cold bias over the Scandinavian Mountains

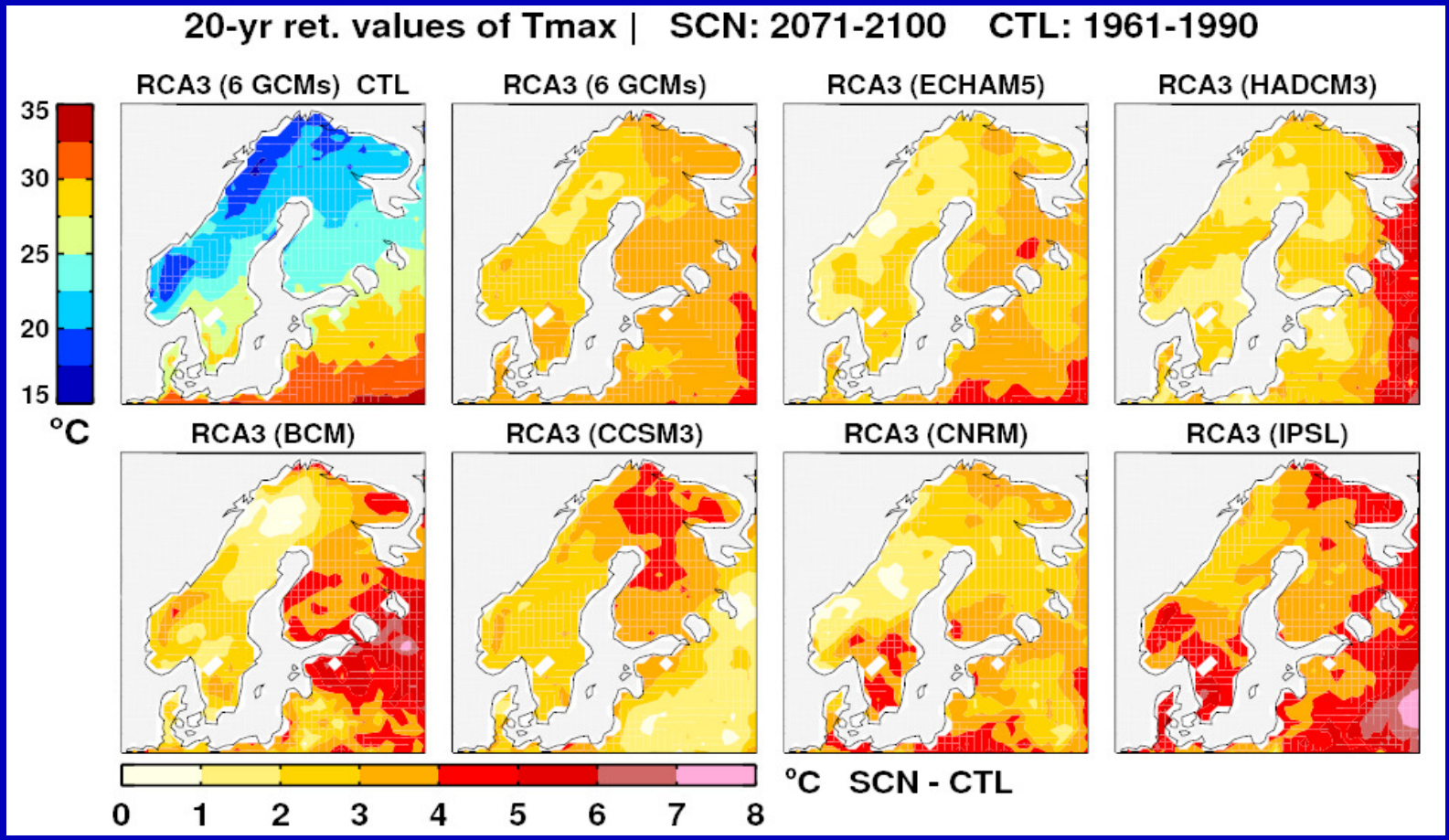
the ensemble mean bias is smaller comparing to the RCA3(ERA40) run

20-yr. return values of T2min



Climate change in warm extremes

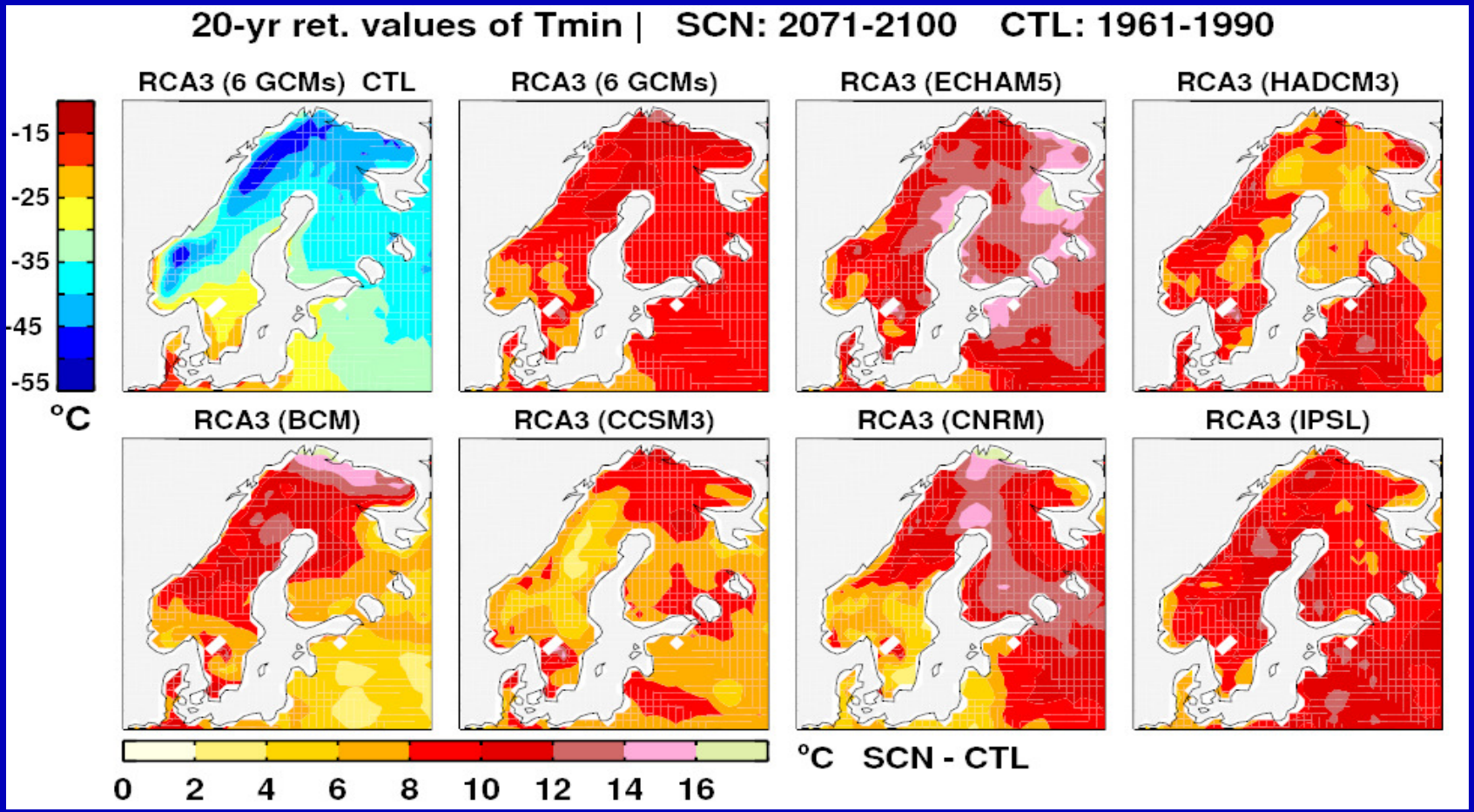
20-yr ret. val. of T2max **CTL:** 1961-1990 **SCN:** 2071-2100



all simulations show an intensification of warm extremes
varying magnitude and spatial pattern

Climate change in cold extremes

20-yr ret. val. of T2min **CTL:** 1961-1990 **SCN:** 2071-2100

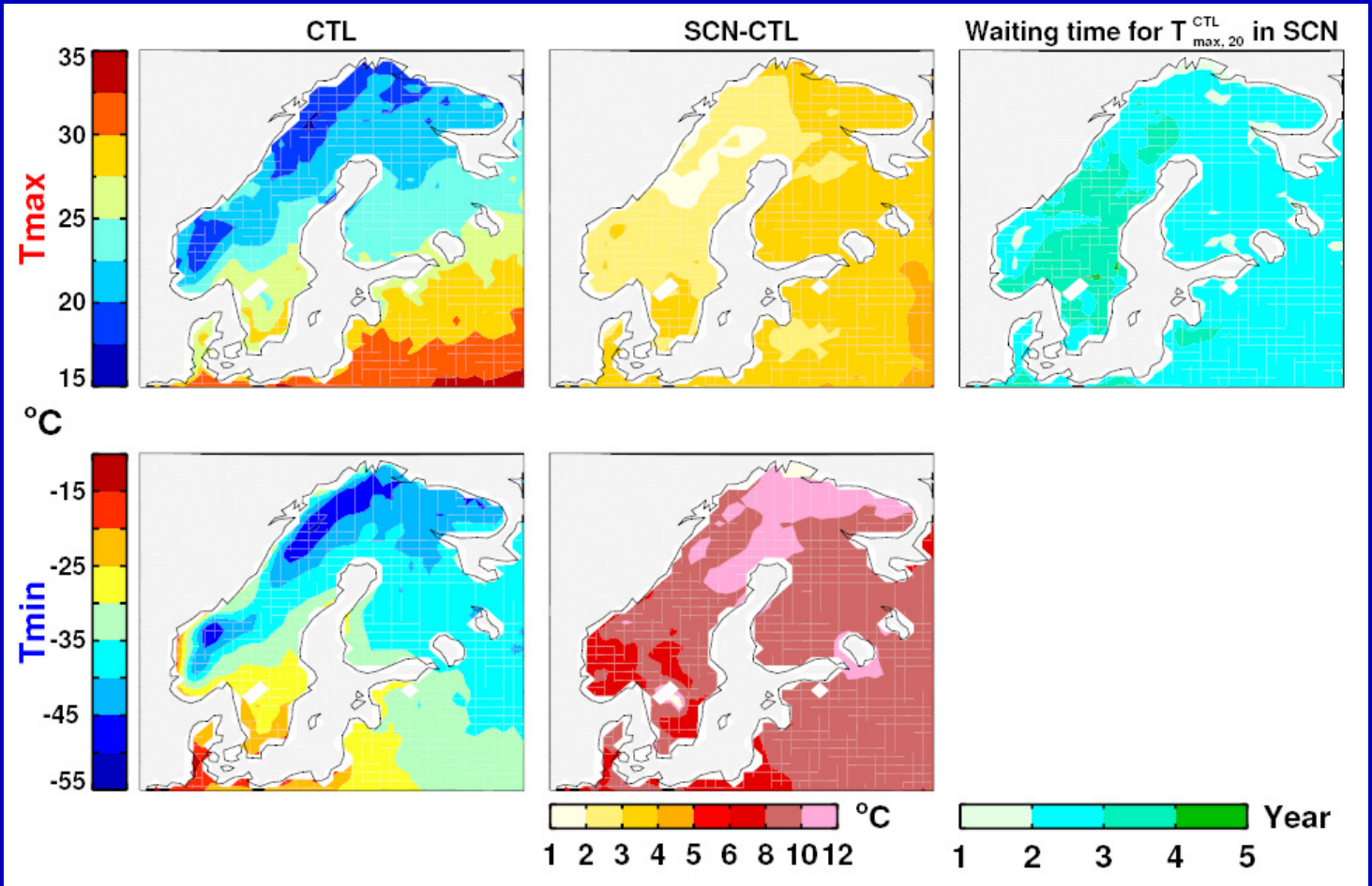


all simulations show a strong reduction of cold extremes
varying magnitude

Recurrence time of CTL extremes in SCN

ENSEMBLE MEAN

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



- ✓ warm extremes (once in 20 years in **CTL)** may occur every second year in SCN
- ✓ cold extremes may almost disappear (once in several hundred years)

Evaluation of precipitation extremes

a complex structure of biases in precipitation extremes

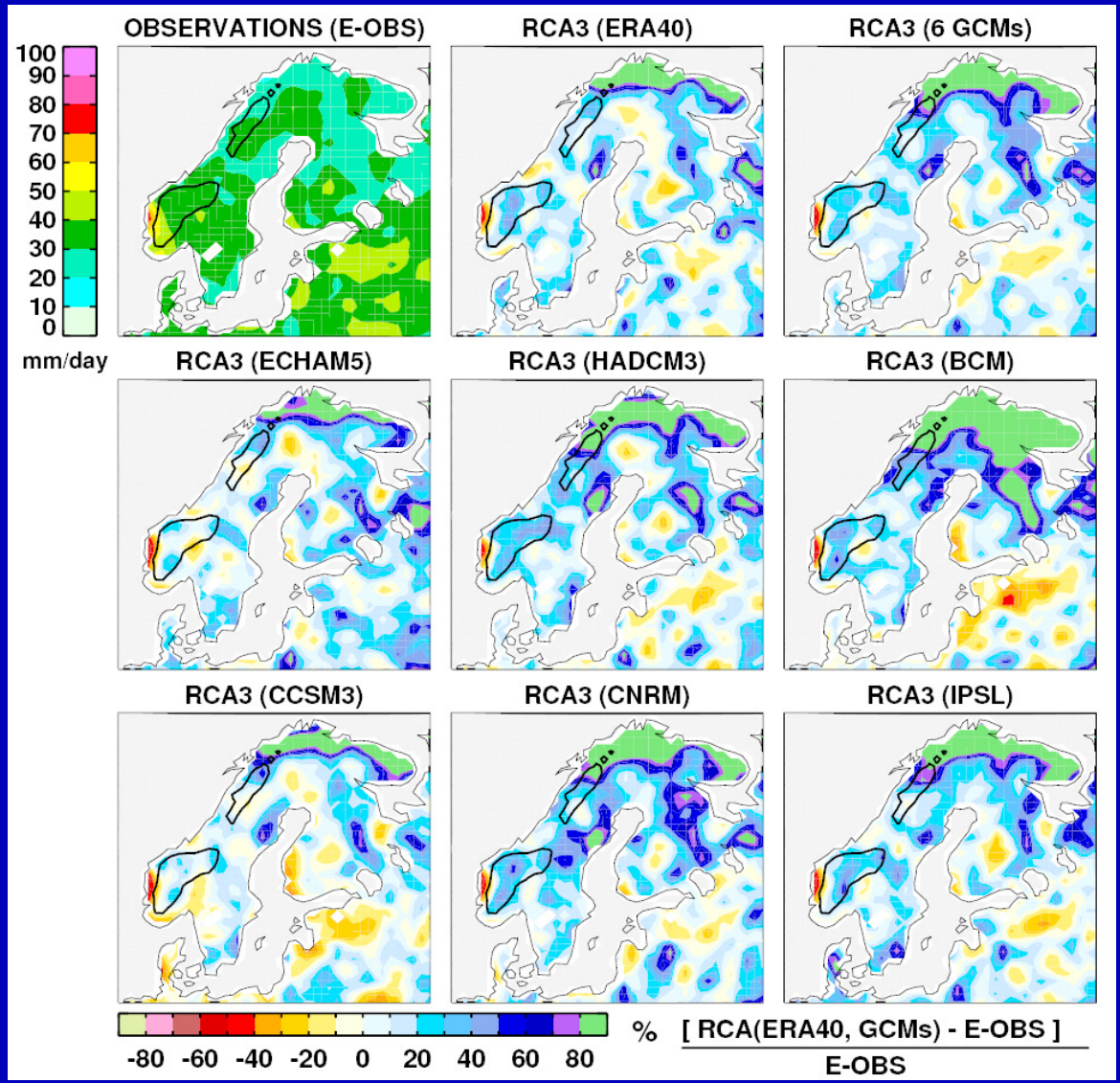
Common features:

overestimation of precipitation extremes

too intense precipitation extremes in northern Scandinavia
(close to the boundary relaxation zone, a few observational stations)

biases < 20-30% are not significant at the 10% sig. level

$P_{max,20}$ / Summer (1961-1990)



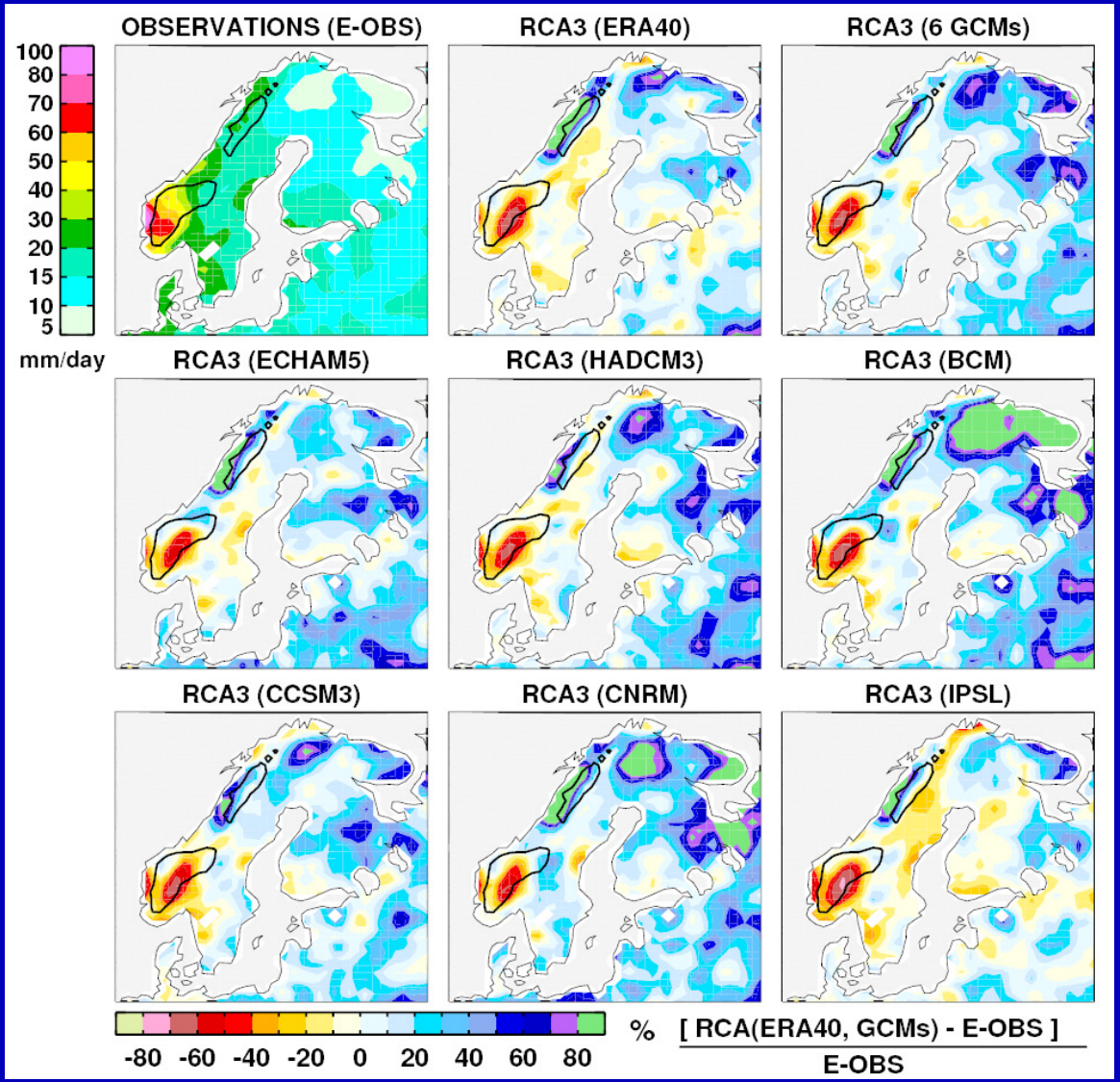
Evaluation of precipitation extremes

$P_{max,20}$ / Winter (1961-1990)

underestimation over mountain slopes in southern Scandinavia

overestimation in northern Scandinavia

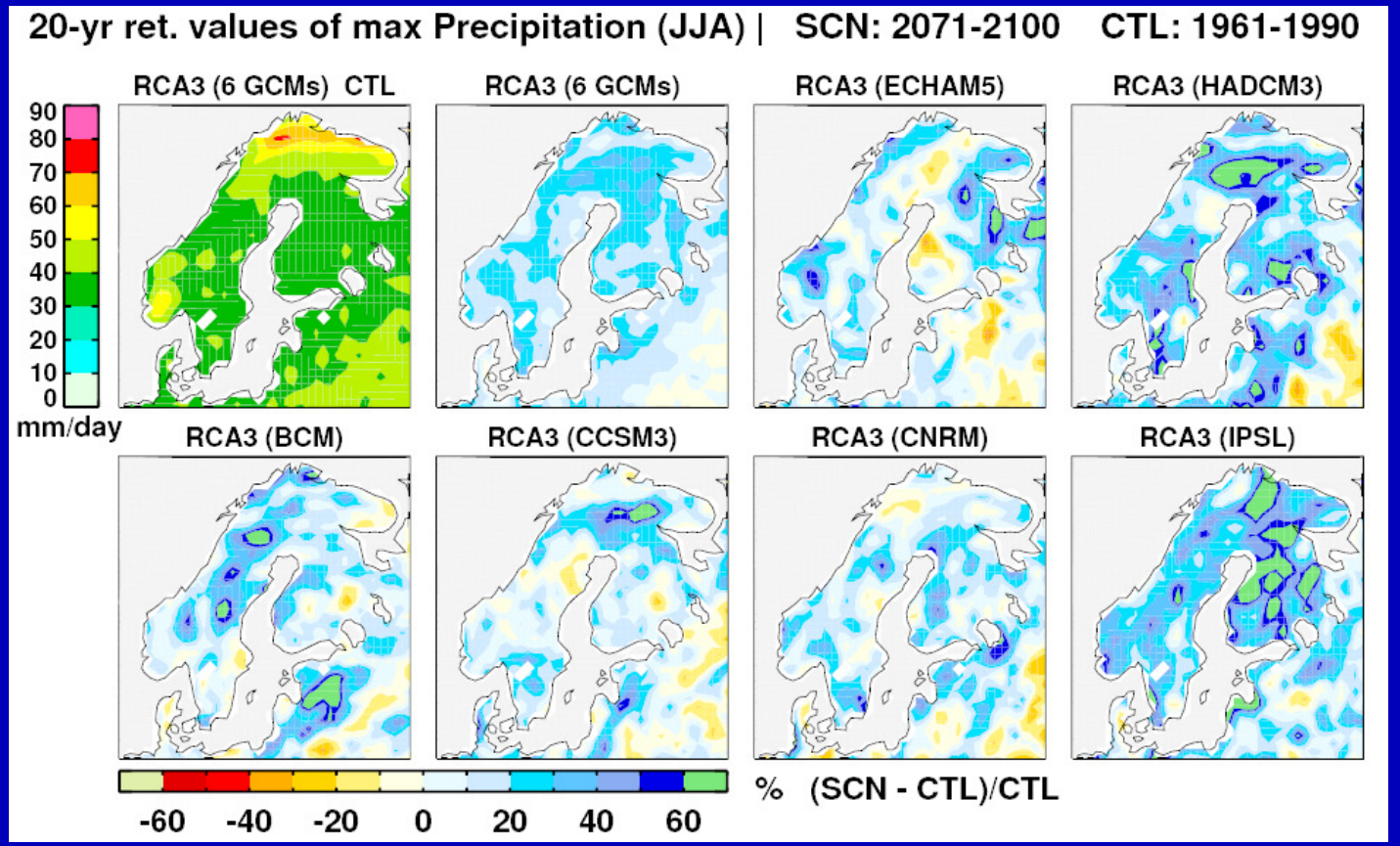
biases < 20-30% are not significant at the 10% sig. level



Climate change in precipitation extremes

$P_{max,20}$ Summer

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

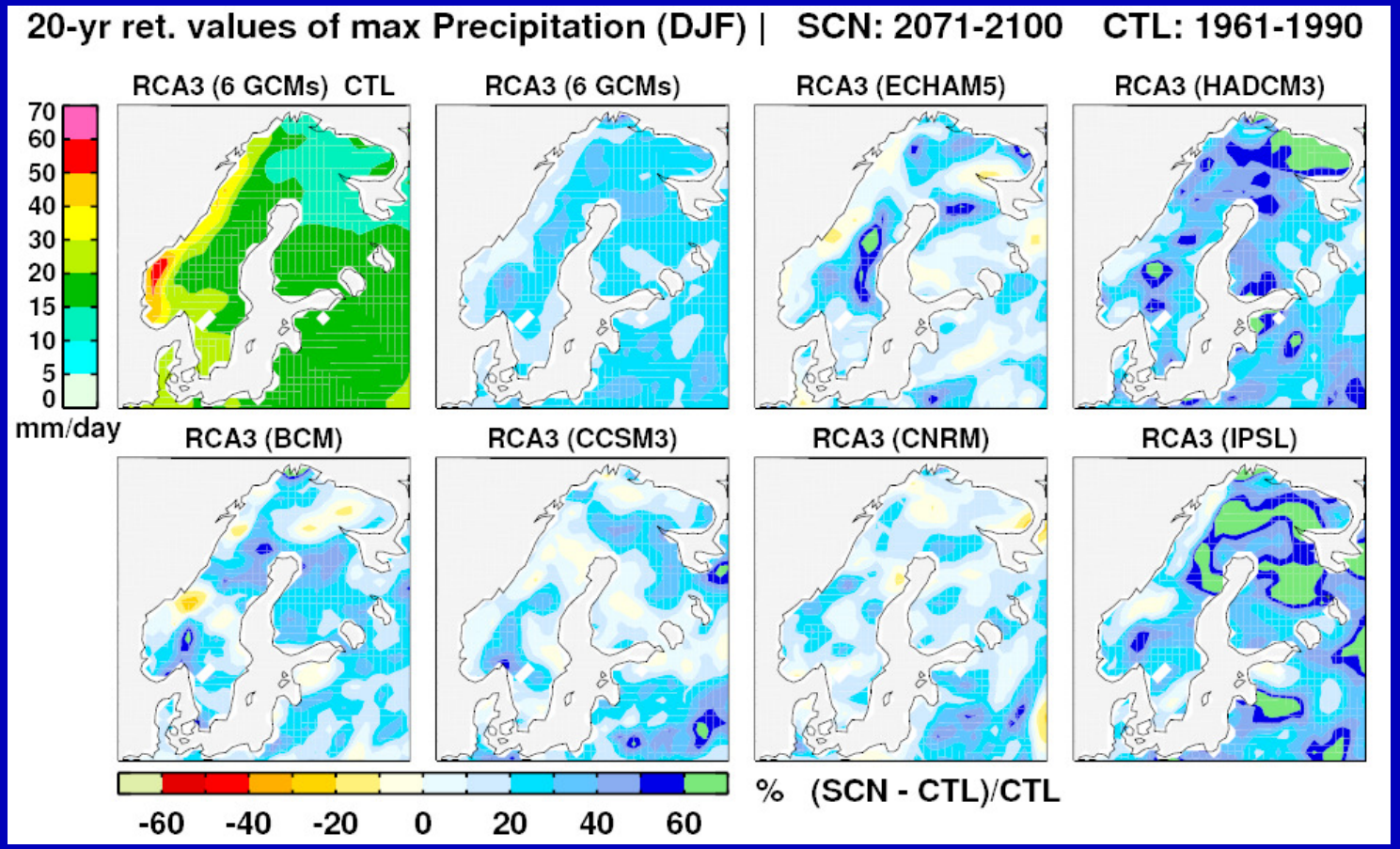


- ✓ individual simulations: an common intensification of precipitation extremes
- ✓ ensemble mean: significant increase (larger than 10%) in intense precipitation over the whole Scandinavia

Climate change in precipitation extremes

$P_{max,20}$ Winter

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



- ✓ individual simulations: an common intensification of precipitation extremes
- ✓ ensemble mean: significant increase (larger than 10%) in intense precipitation over the whole Scandinavia

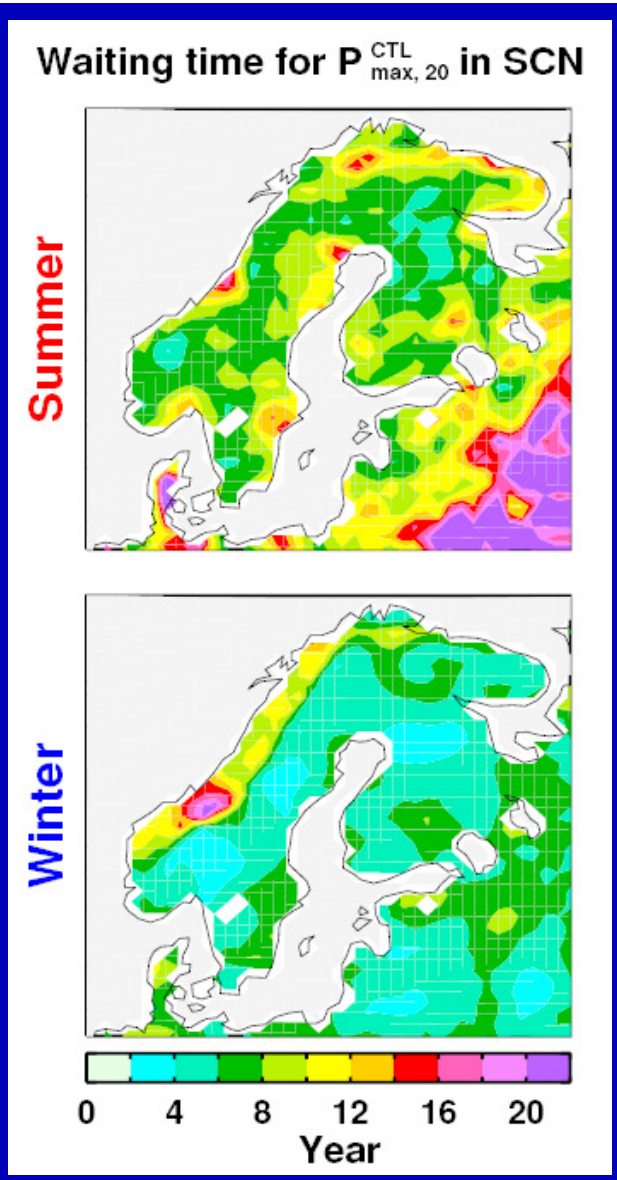
Climate change in precipitation extremes

ENSEMBLE MEAN

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

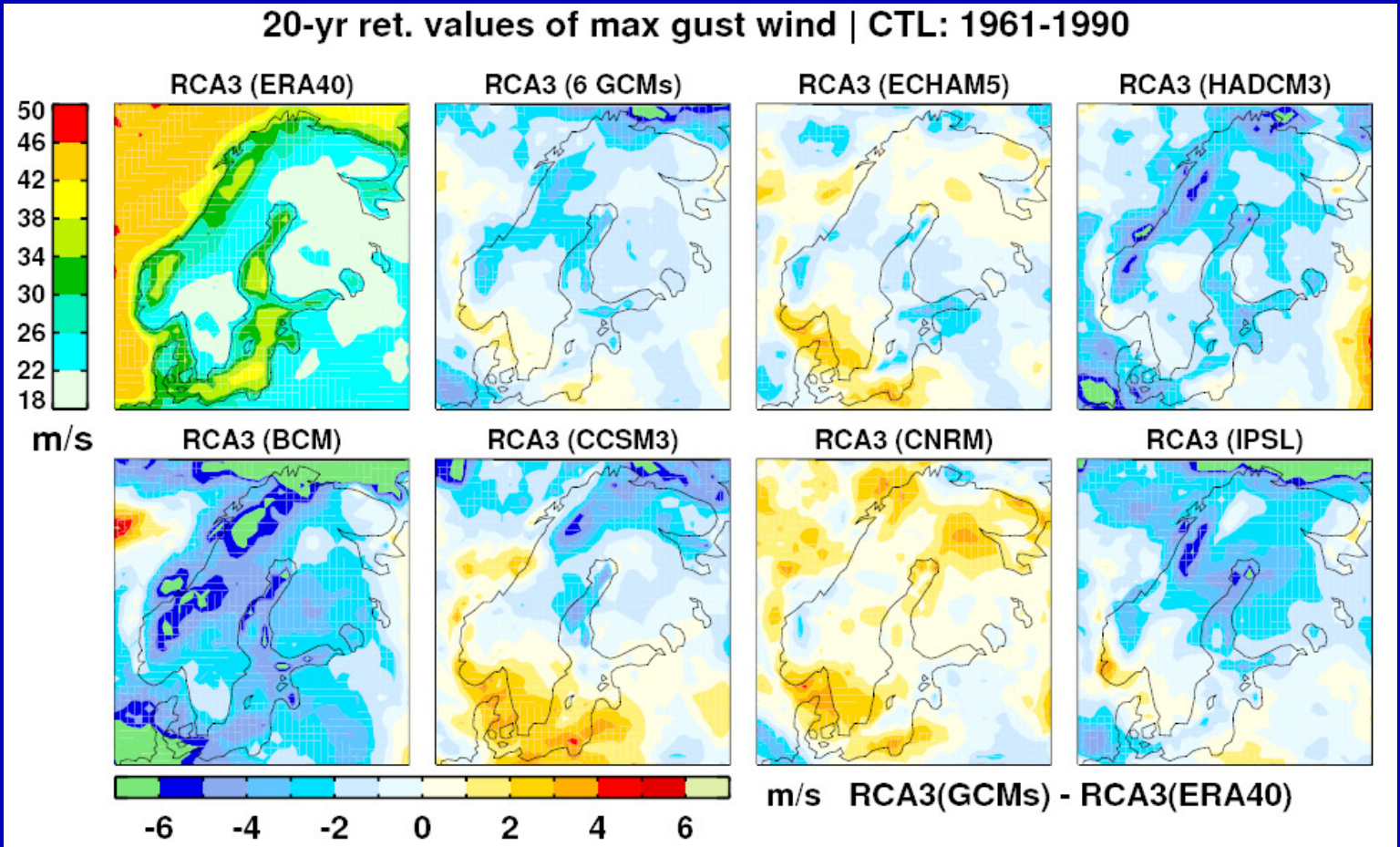
Recurrence time

recurrence time of intense precipitation reduces from 20 years in **CTL** to 6-10 years in **SCN** in summer and to 2-4 years in winter



Evaluation of wind extremes

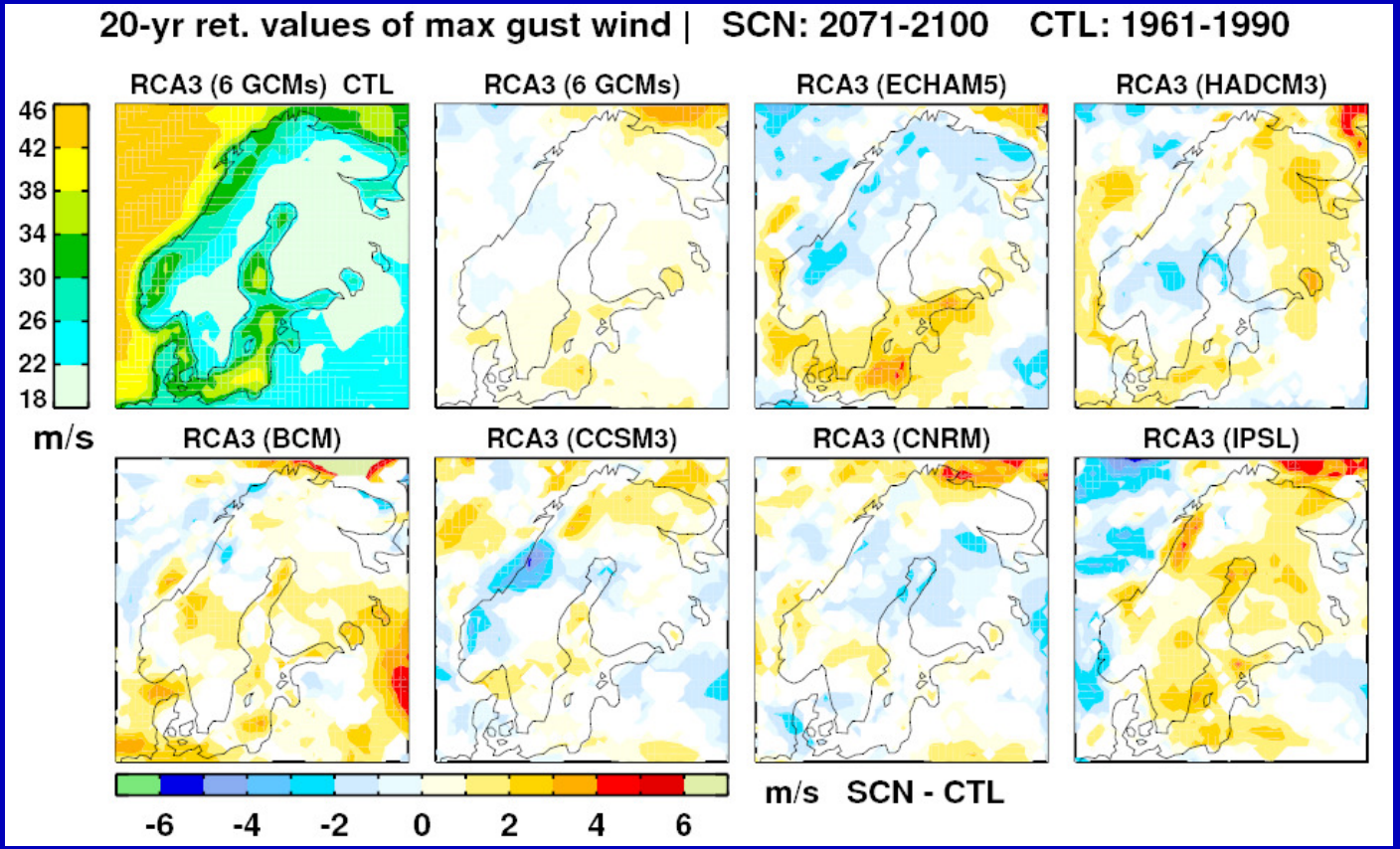
20-yr. return values of gust wind (1961-1990)



- ✓ large spread among the simulations
- ✓ individual simulations can locally differ by 10 m/s

Climate change in wind extremes

20-yr ret. val. of W_{max} CTL: 1961-1990 SCN: 2071-2100



- ✓ strengthening of extreme gust winds over the Barents Sea (reduction in sea ice)
- ✓ a tendency to strengthening of wind extremes over the Baltic Sea
- ✓ ensemble mean is sensitive to the number of simulations in the ensemble

Conclusions

Simulated Weather Extremes over Scandinavia in Regional Climate Model – RCA3

CONTROL PERIOD (1961-1990)

- ✓ strong underestimation of warm extremes (open-land observation and grid box average model, not sensitive to driving GCMs)
- ✓ the key role of driving GCMs in the simulated cold extremes
- ✓ a general overestimation of precipitation extremes for all simulations
- ✓ a large spread among the simulations driven be different GCMs in wind extremes

FUTURE CHANGES (2071-2100)

- ✓ all simulations show an intensification of warm extremes and strong reduction of cold extremes (not so sensitive to a choice of driving GCMs)
- ✓ a common intensification of precipitation extremes in both winter and summer (not so sensitive to a choice of driving GCMs)
- ✓ strengthening of wind extremes over the Barents and Baltic sea (very sensitive to driving GCMs)