Norwegian Meteorological Institute met.no

Climate Change in Norway: What can we expect?

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Presentation by

Inger Hanssen-Bauer & Torill Engen-Skaugen

Background: Climate trends in Norway through the 20th century

- Increased annual mean temperature 0.5 - 1.0 °C, statistically significant almost everywhere

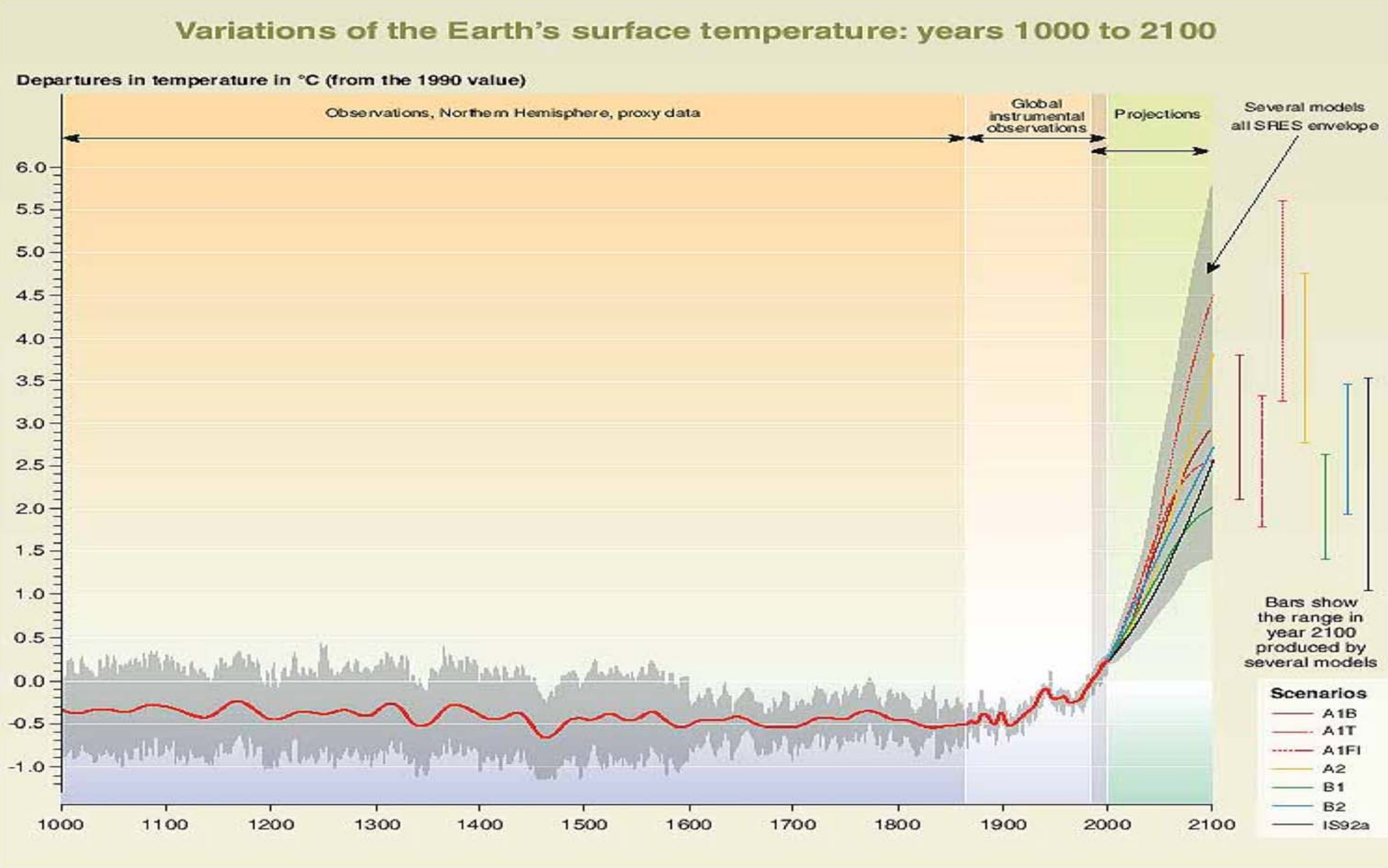
- Warmer spring everywhere, warmer winter in south, warmer summers in the north

- Precipitation has increased by 3 to 20%. Statistically significant increase in 9 of 13 regions

- Max precipitation increase (15-20%) in western regions

- Difficult to quantify changes in wind conditions because of few high quality homogeneous series

Background:
Projected global temperature change



Projected global temperature increase (IPCC AR4)

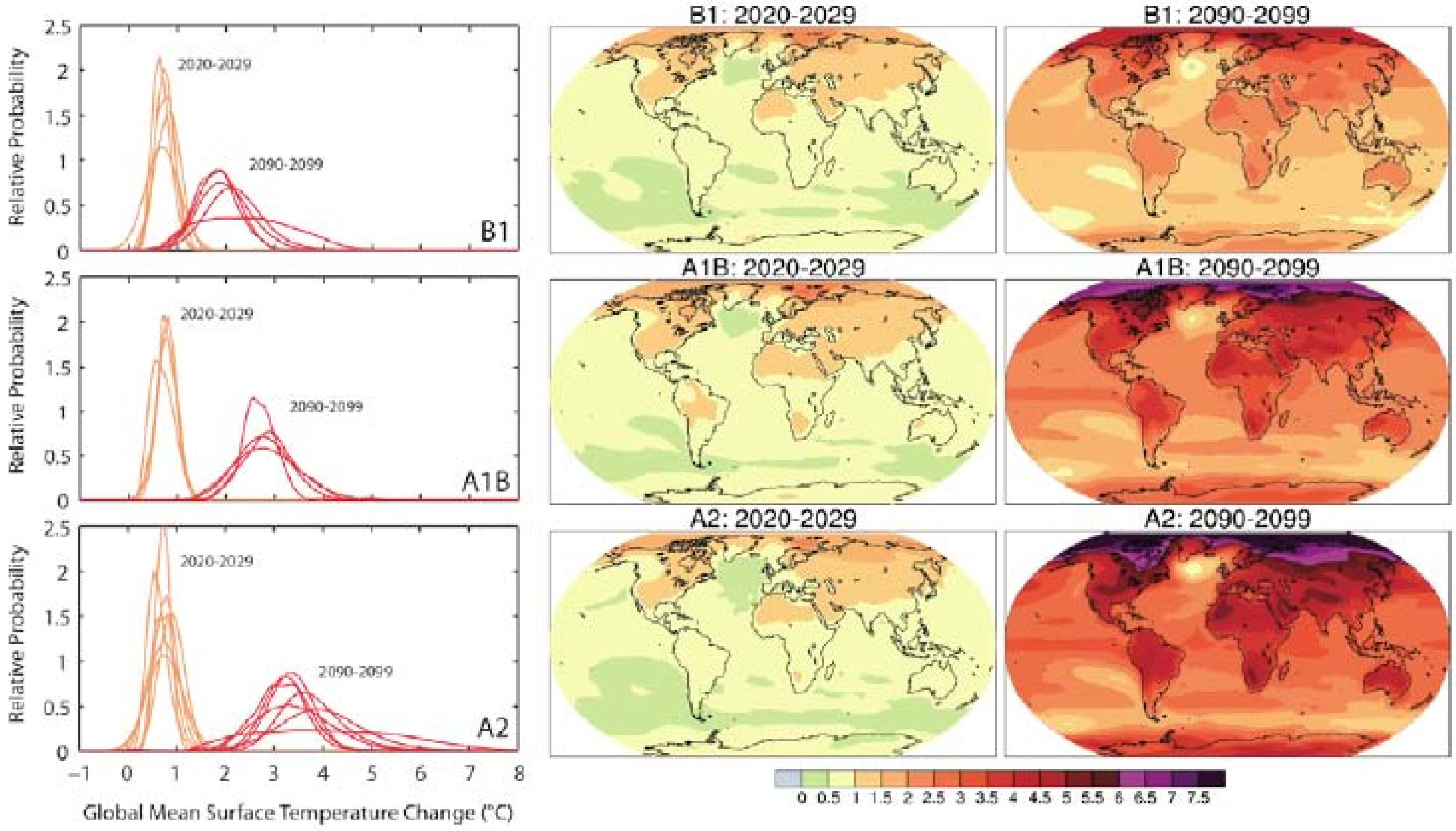
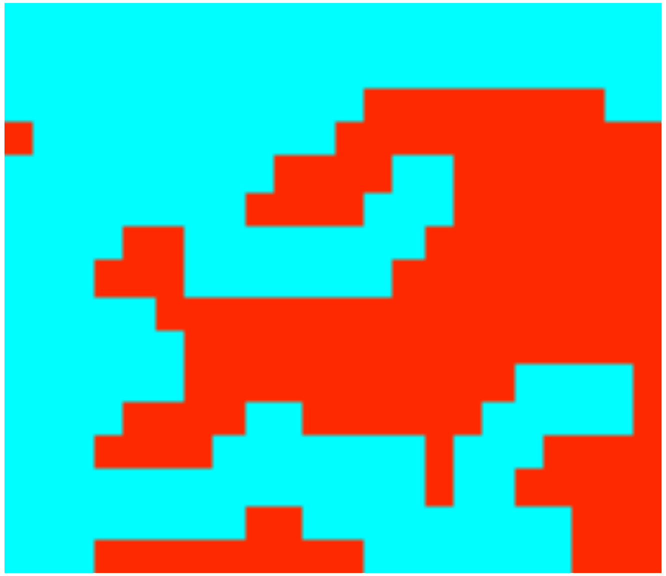


FIGURE SPM-5. Projected global average temperature changes for the early and late 21st century relative to the period 1980–1999. The central and right panels show the AOGCM multi-model average projections for the B1 (top), A1B (middle) and A2 (bottom) SRES scenarios averaged over decades 2020–2029 (center) and 2090–2099 (right). The left panel shows corresponding uncertainties as the relative probabilities of estimated global average warming from several different studies for the same periods. {Figures 10.8 and 10.28}

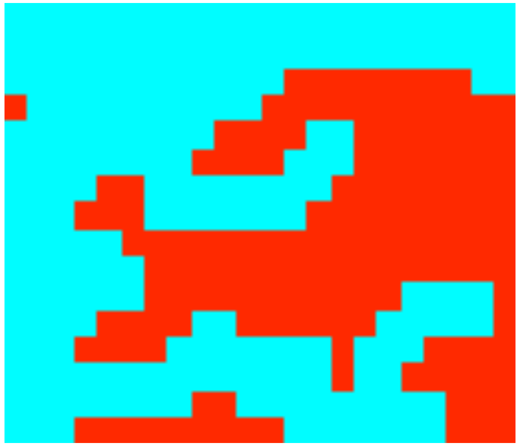
Regional climate scenarios are established by ”downscaling” results from global climate models

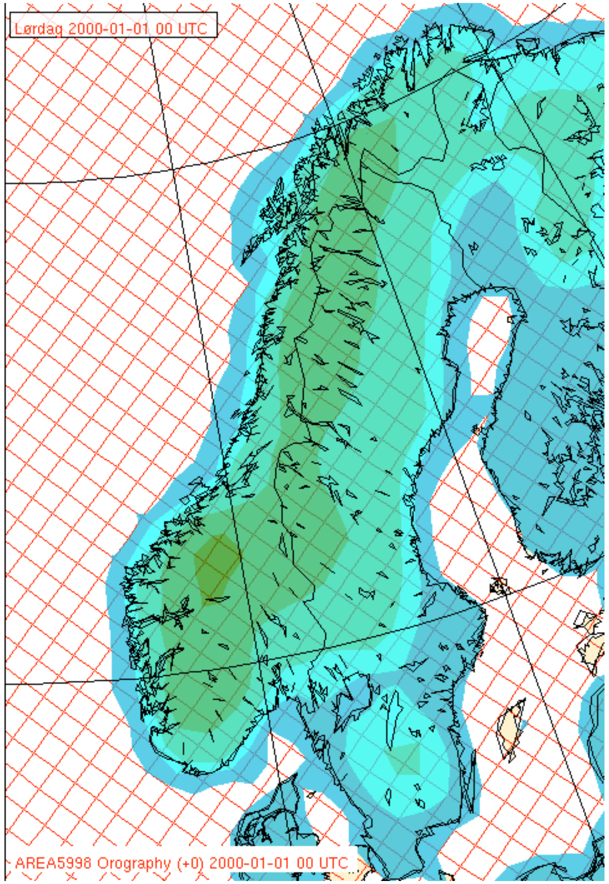
Downscaling is necessary because Europe looks like this in a typical global climate model….



Downscaling methods used in Norway:

- Statistical-empirical downscaling
- Regional climate models/dynamical downscaling

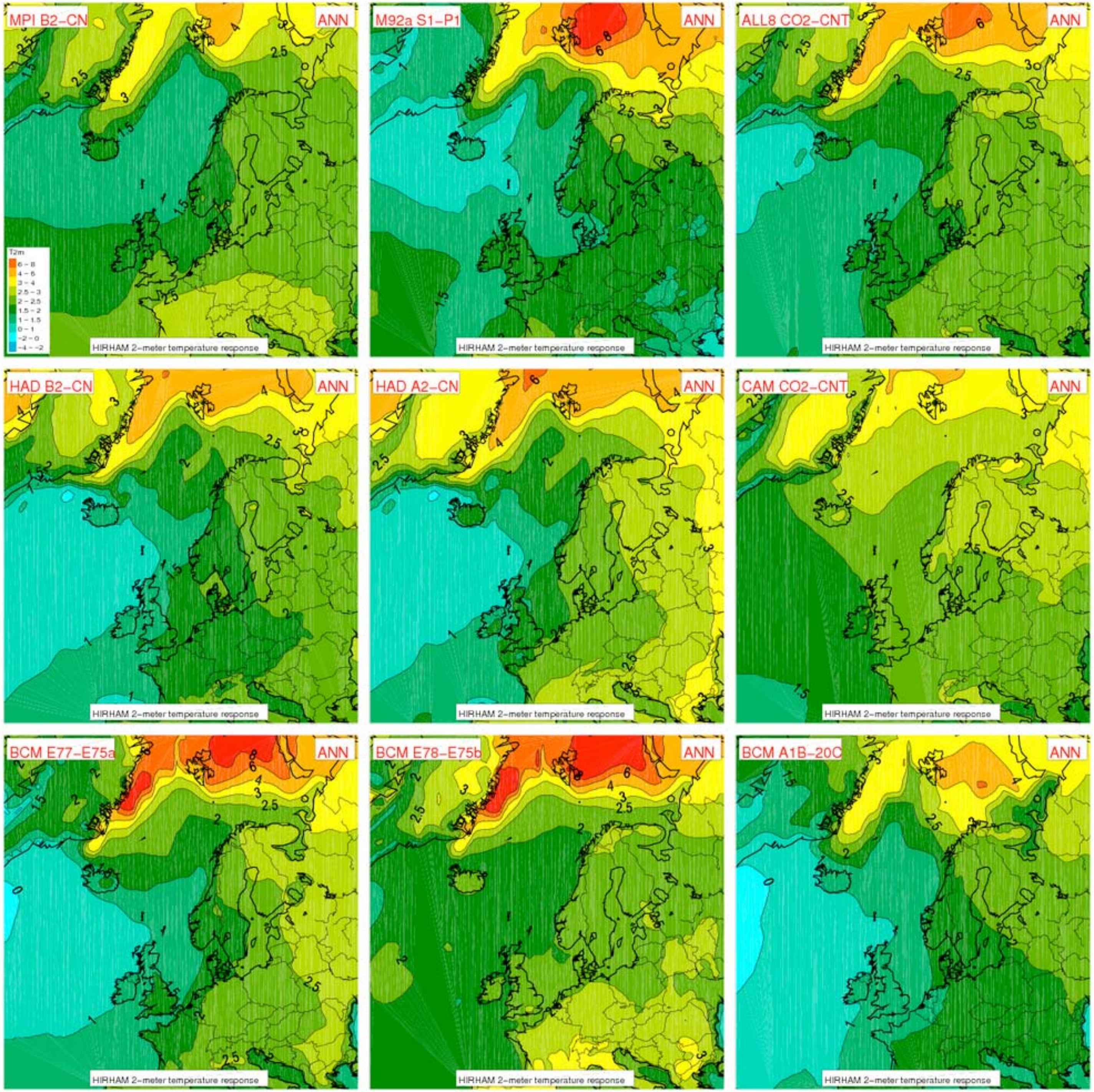



Lørdag 2000-01-01 00 UTC
AREA5998 Orography (+0) 2000-01-01 00 UTC

RegClim: Survey of RCM-runs

Simulation	Emission	Resolution (km)	Time-slice
ERA-15	-	50	1979-1993
ECHAM4/OPYC3 a)	IS92a	50	1980-1999, 2030-2049
ECHAM4/OPYC3 b)	IS92a	50	1980-2049
ECHAM4/OPYC3 c)	IS92a	50	1980-1999, 2030-2049
ECHAM5	B2	50	1961-1990, 2071-2100
HadAm3H	A2	50	1961-1990, 2071-2100
HadAm3H	B2	50	1961-1990, 2071-2100
ERA-40	-	25/50	1960-2000
CAM-Oslo	-	50	1*CO2, 2*CO2
BCM1 (high/low AMOC)	CMIP2	50	1*CO2, 2*CO2
BCM2	A1b	25/50	1961-1990, 2071-2100

a), b) & c): Different domains



Scaled scenarios for annual mean tempeature

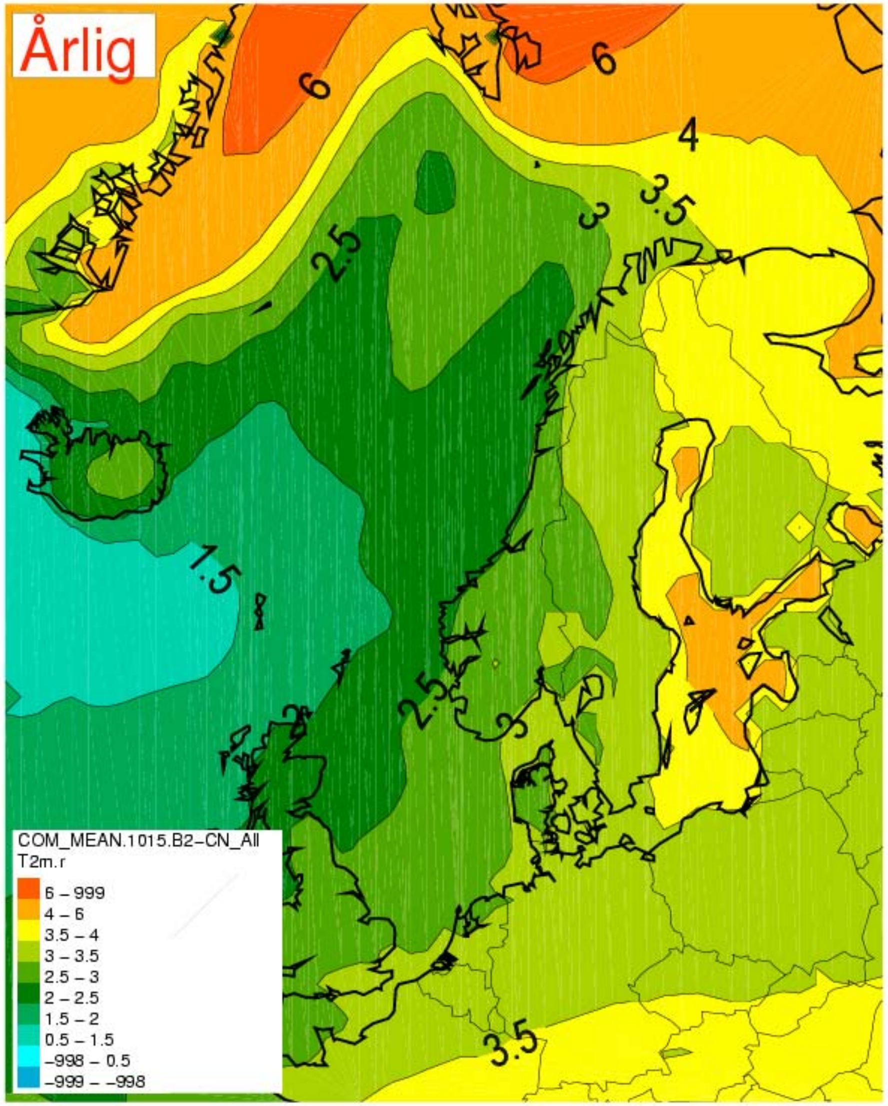
Projected change, 70 yrs

8 scenarios

Haugen & Iversen 2007

Temperature scenarios (1961-1990) ▶(2071-2100)

HadCM + MPI (under B2) downscaled by HIRHAM



Haugen & Iversen 2005

Temperature scenarios (1961-1990) ▸(2071-2100)

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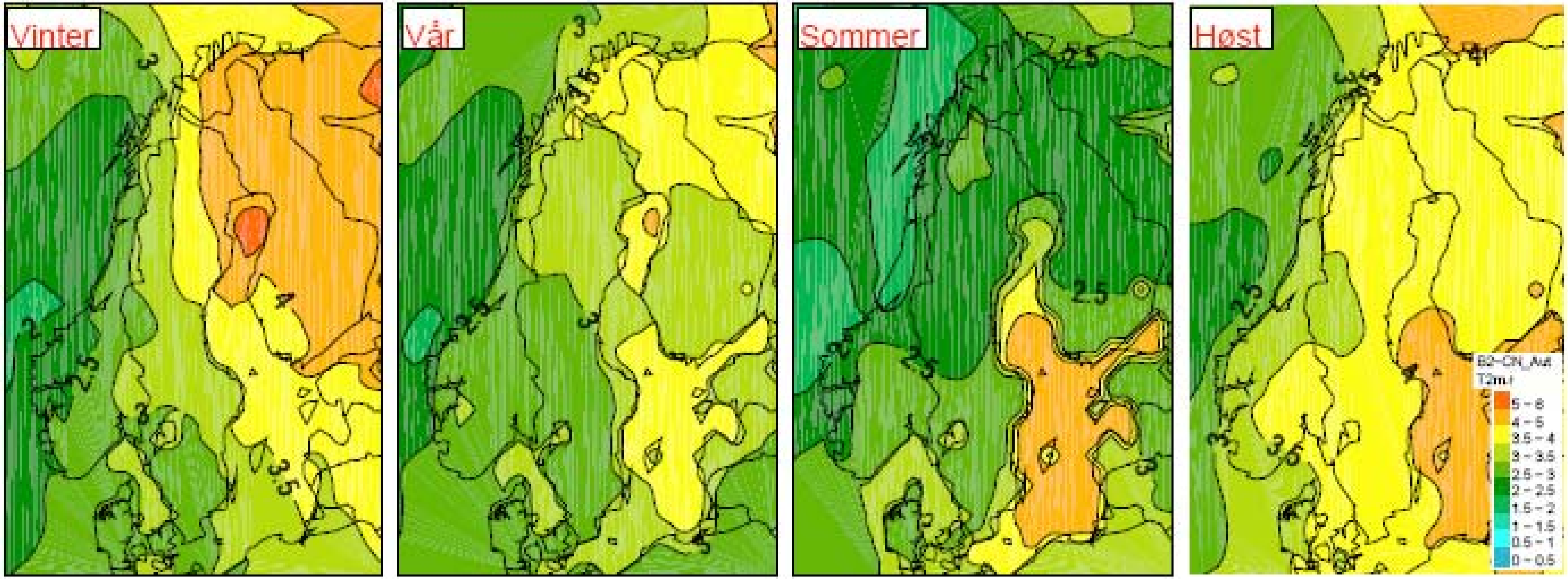
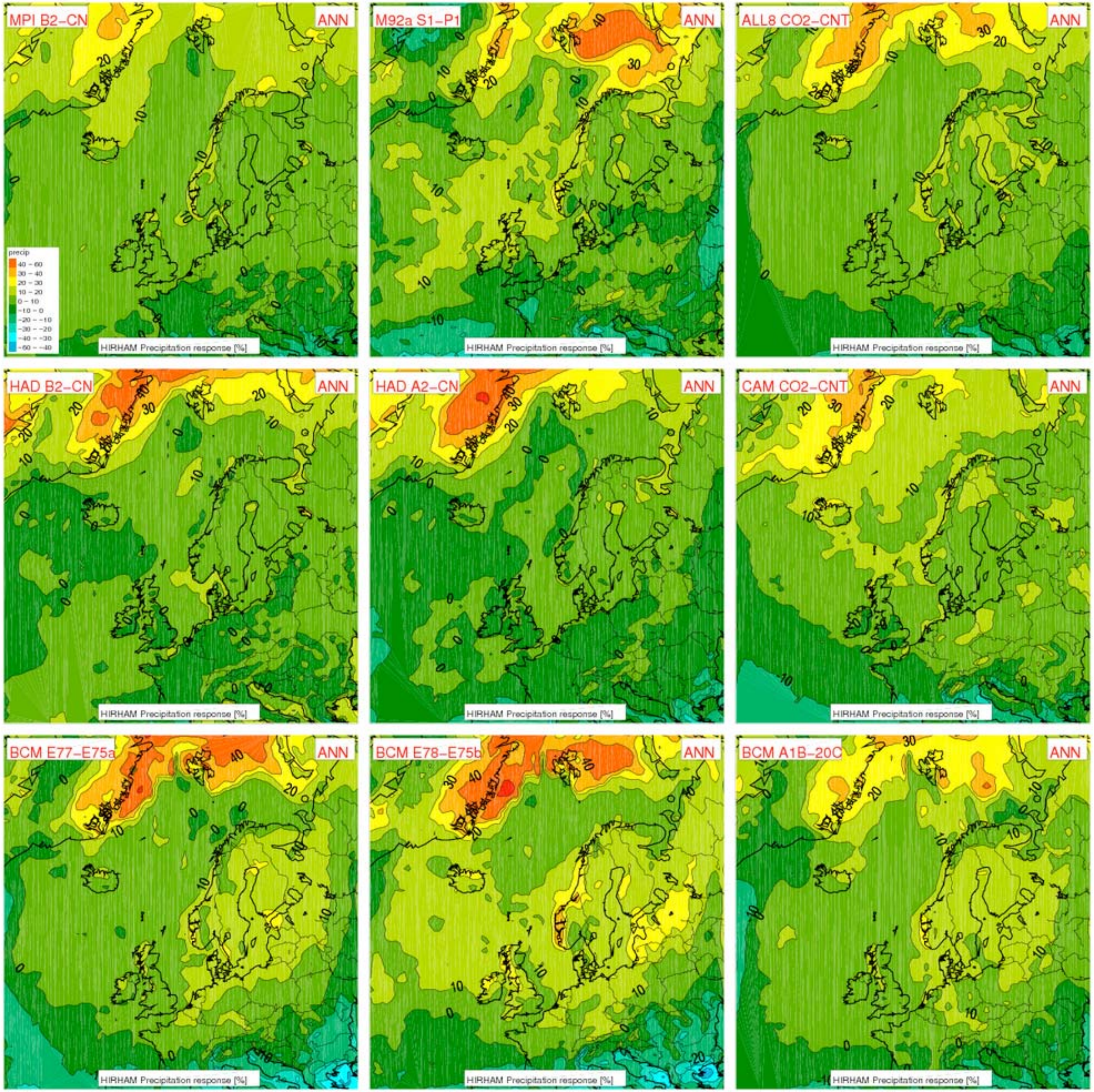


Winter Spring Summer Autumn

Temperature scenarios

- The ”HM-scenario” gives a 2.5 to 4 ^{o}C increase in the annual mean temperature in Norway from 1961-1990 to 2071-2100.
- Several common features for different models.
- Minimum warming in south-western regions, maximum in Finnmark.
- Minimum warming along the coast, maximum in inland areas. More warming in winter than in summer most places.
- Winter, spring and autumn: Faster warming in the north.
- Increased growing season and decreased heating season.



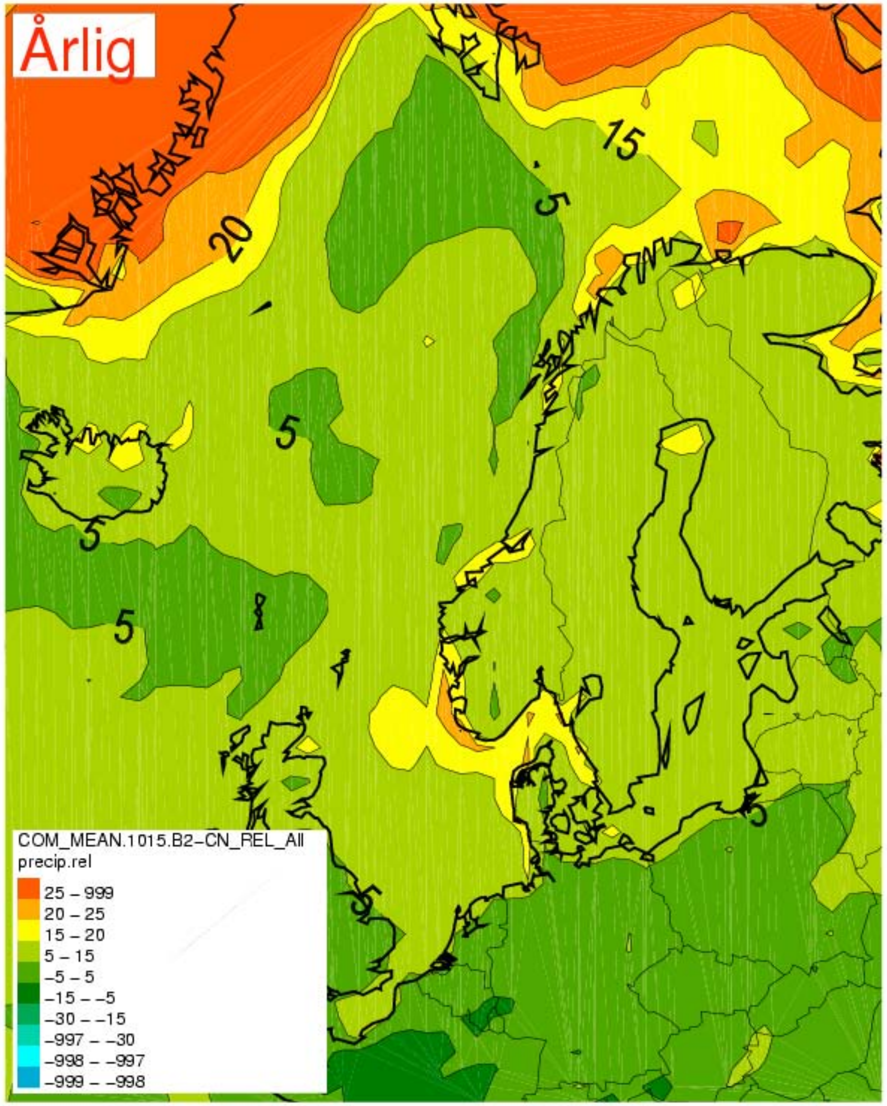
Scaled scenarios for annual precipitation

Estimated change, 70 yrs

8 scenarios

Haugen & Iversen 2007

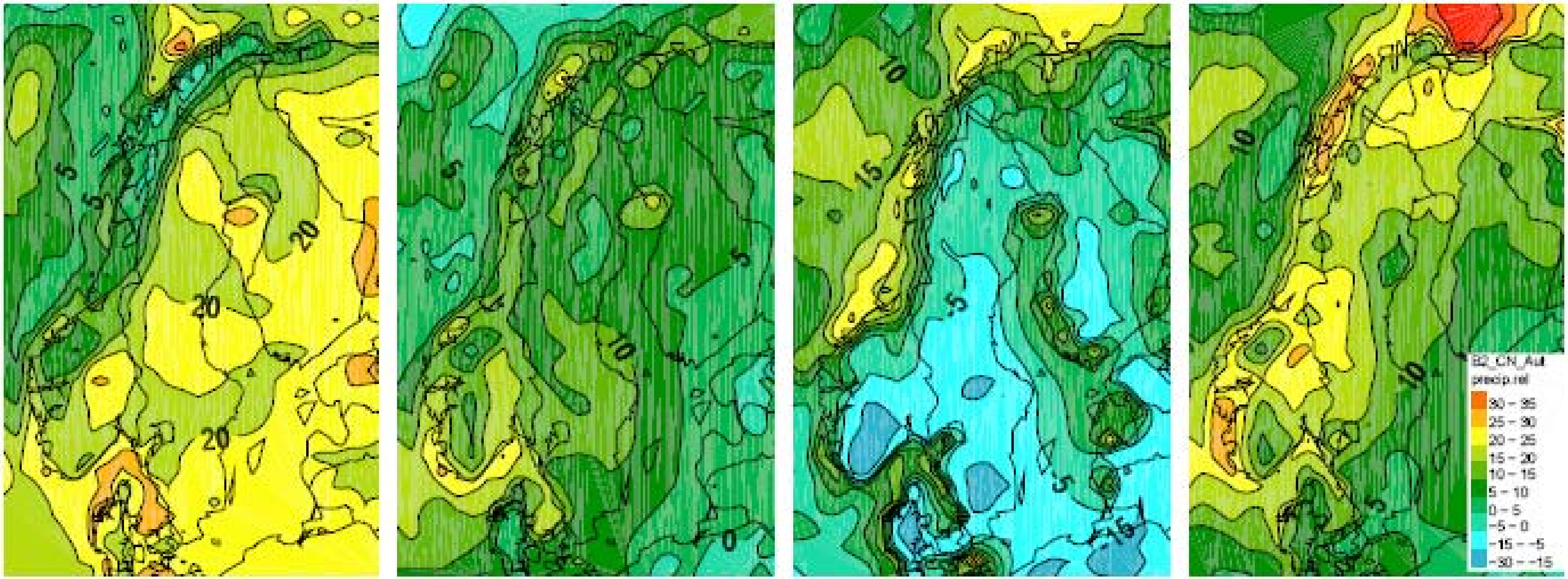
Nedbør scenarier (1961-1990) ►(2071-2100)
HadCM + MPI (under B2) nedskalert med HIRHAM



Haugen & Iversen 2005

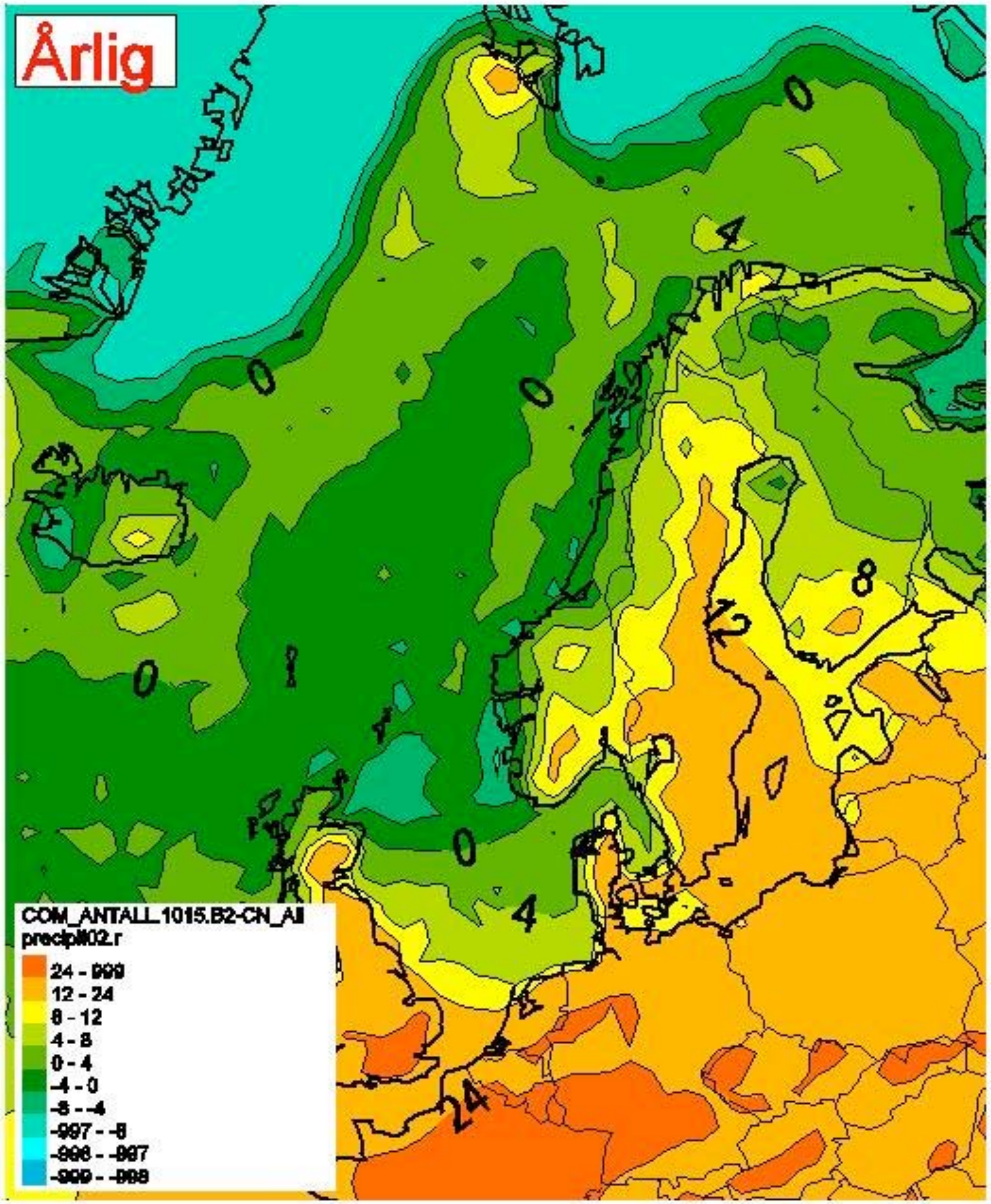
Precipitation scenarios (1961-1990) ▸(2071-2100)

HadCM + MPI (under B2) downscaled by HIRHAM

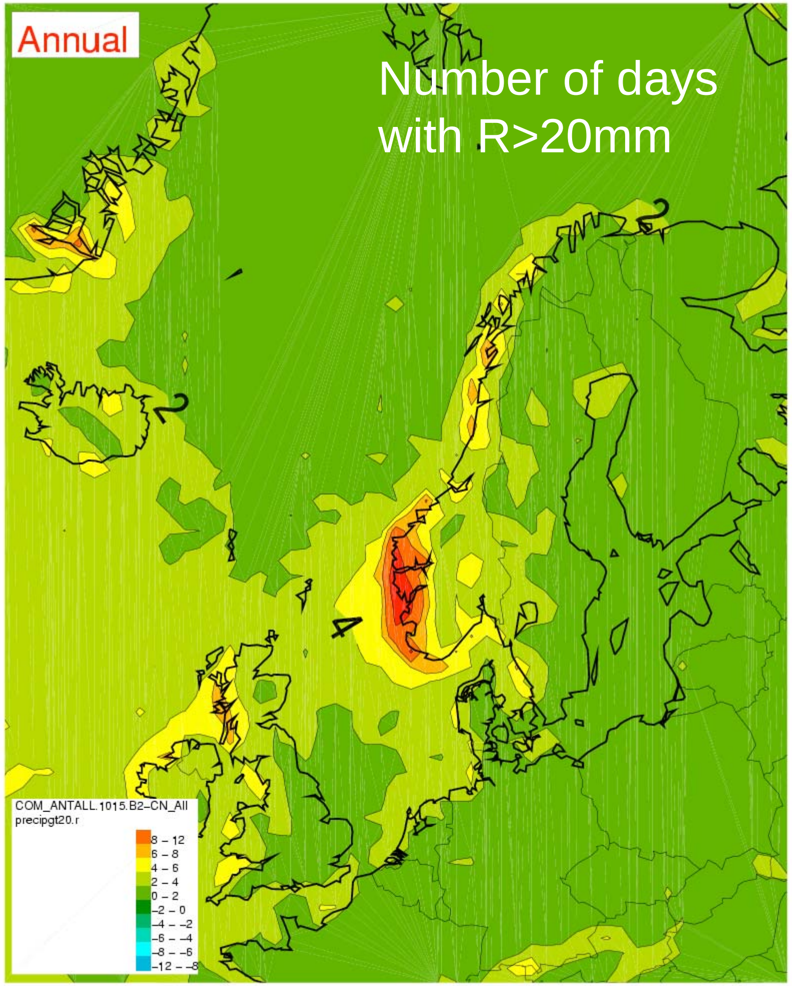


Winter Spring Summer Autumn

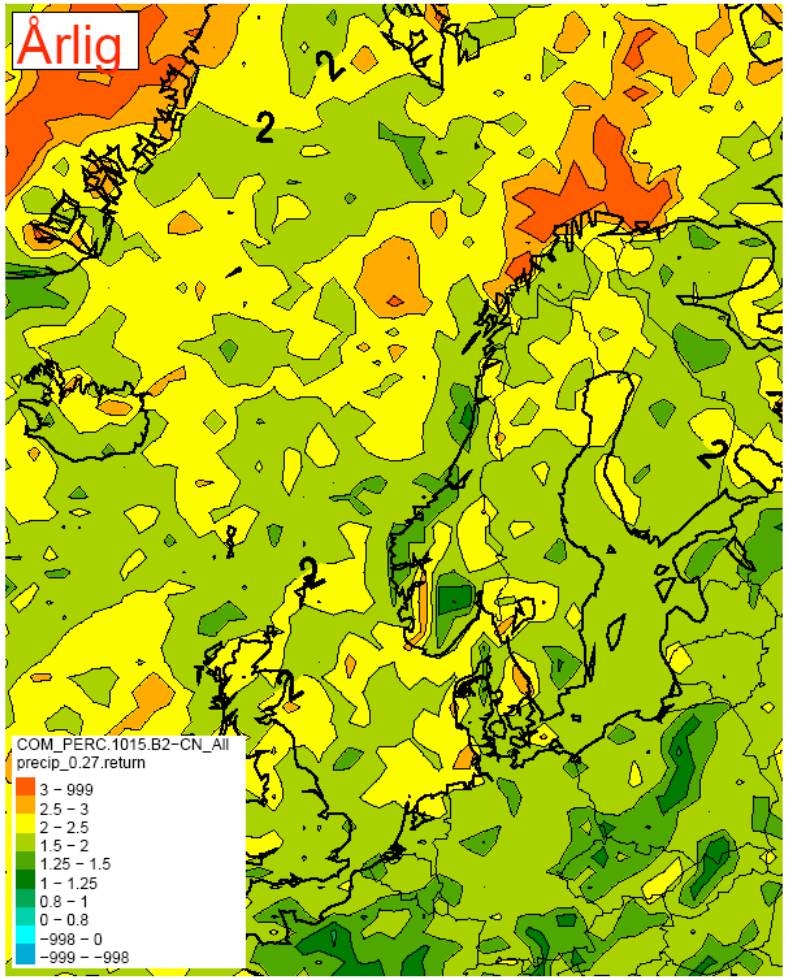
Increased number of ”dry” days



PROJECTED CHANGE IN "EXTREME" PRECIPITATION



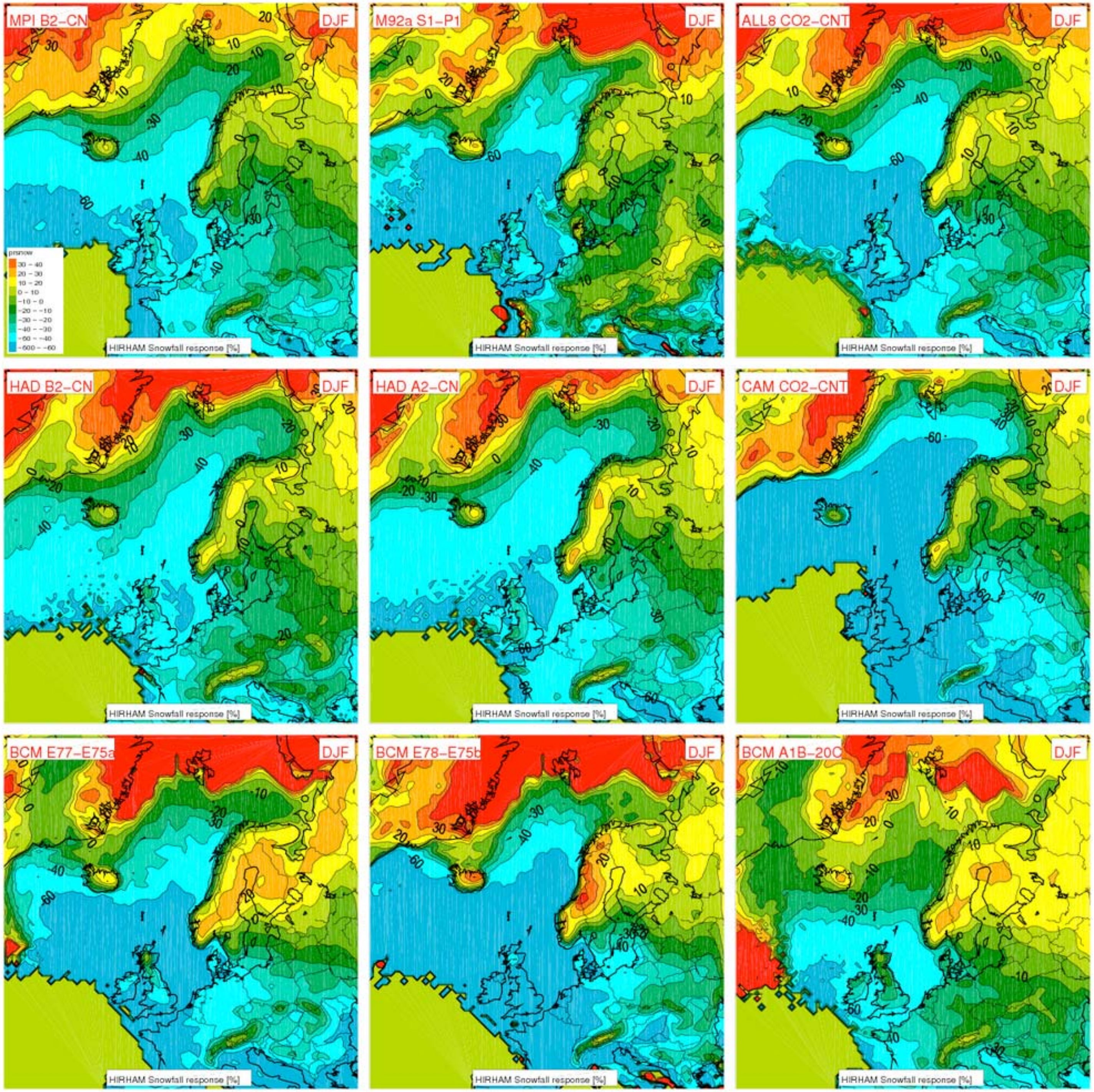
South-Western Norway up to15 more days per year with R>20 mm (~20% increase)



All parts of Norway: More frequent extreme precipitation episodes.

Precipitation scenarios

- The ”HM-scenariet” gives at average a 5-15% increase in annual precipitation in Norway.
- Differences between different models are considerable locally, but there are common features.
- The models indicate precipitation increase especially in autumn and winter
- Most models indicate reduced summer precipitation in eastern parts of South-Norway.
- Increased risk for extreme events in all seasons.

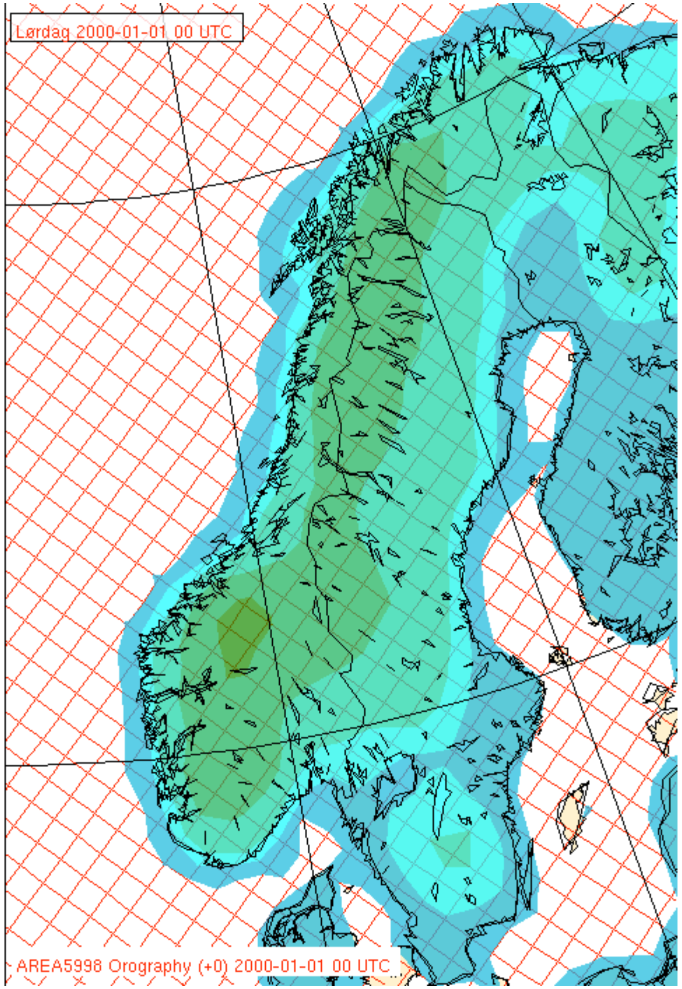


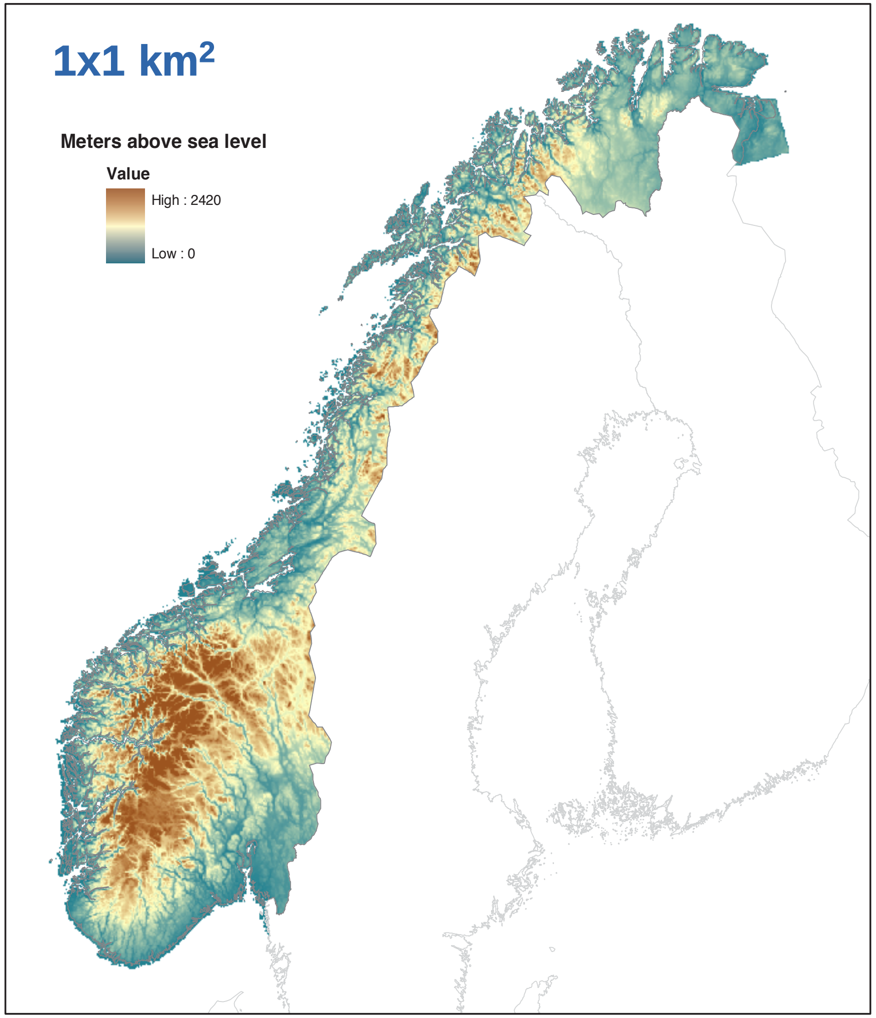
Scaled scenarios for snowfall in DJF

Estimated change, 70 yrs

8 scenarios

Haugen & Iversen 2007


Lørdag 2000-01-01 00 UTC
AREA5998 Orography (+0) 2000-01-01 00 UTC


1x1 km²
Meters above sea level
Value
High : 2420
Low : 0

➔ Empirical adjustment is needed...

- Common method: ”Delta change”

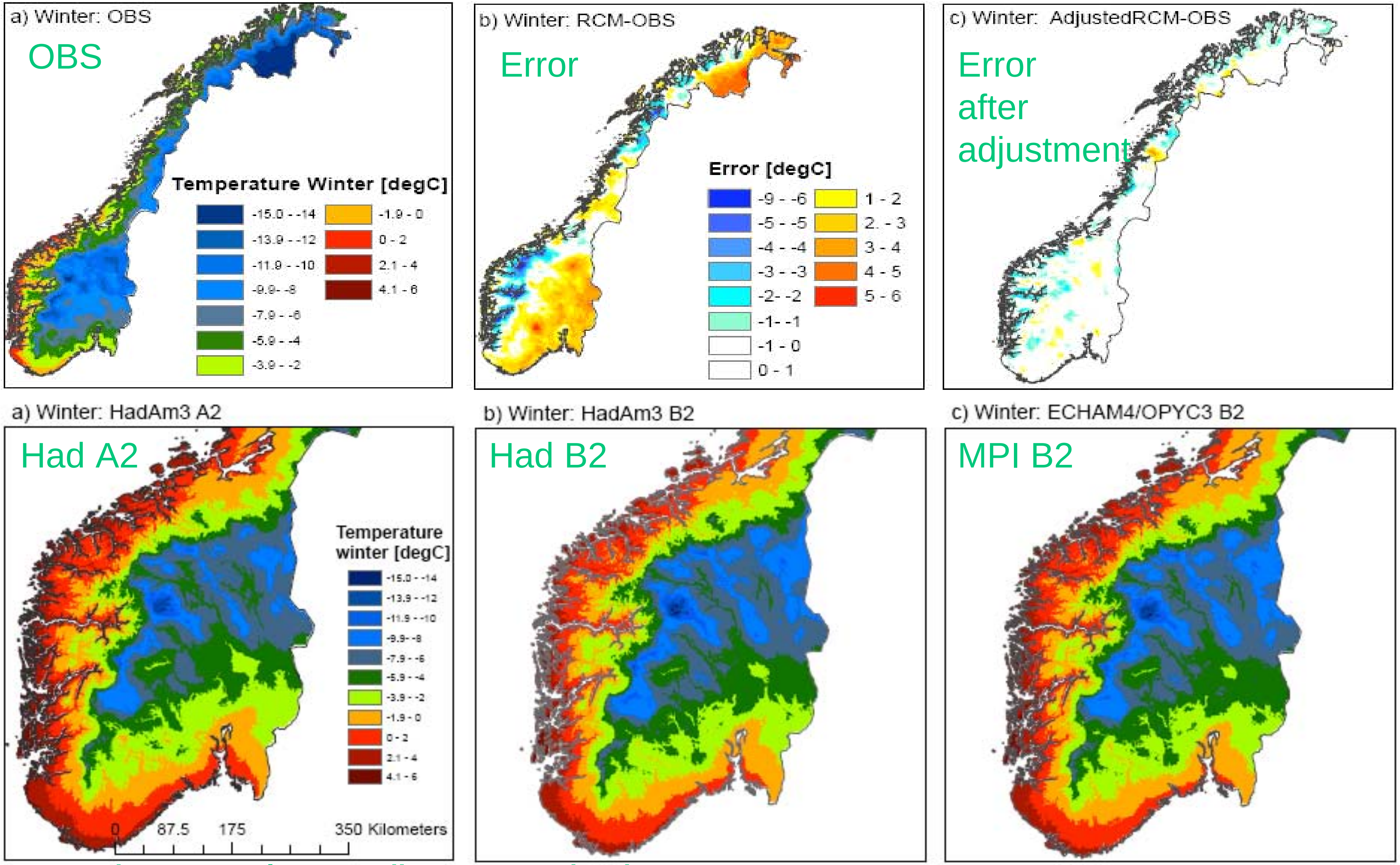
  Climate scenario =

  Observed climatology + modelled change

- Alternative:

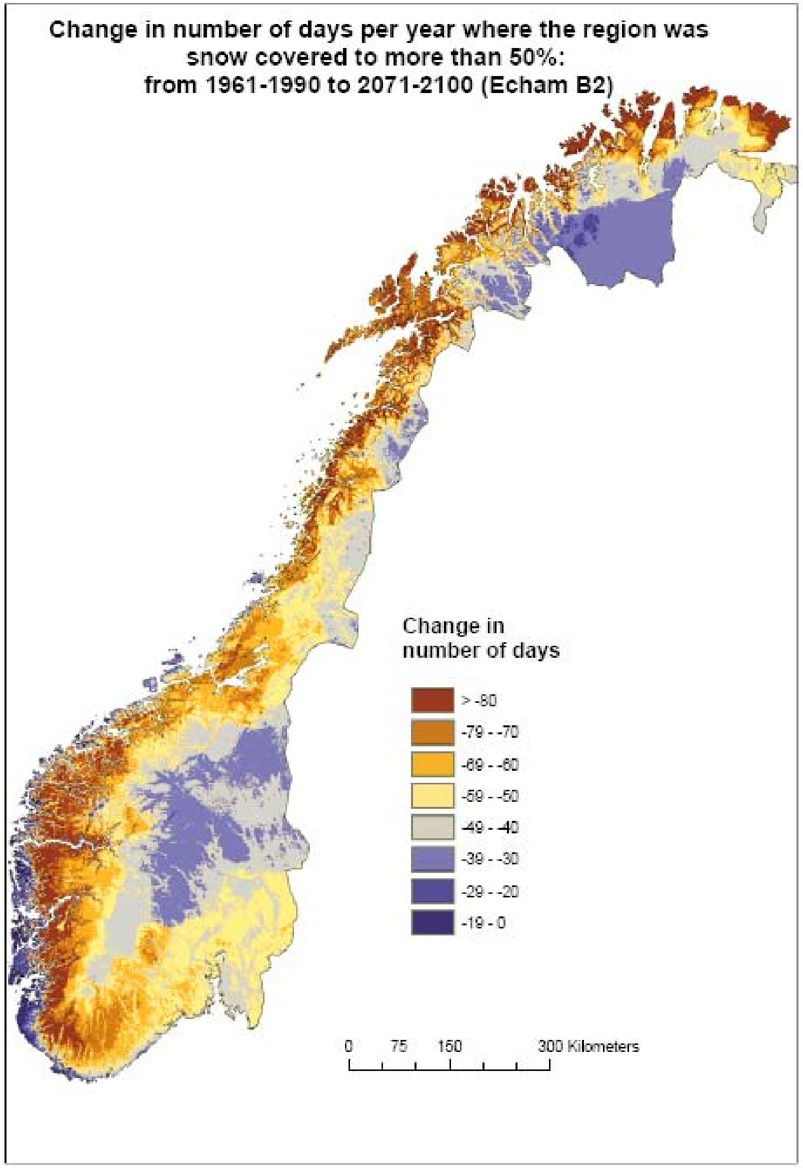
  Adjust the statistical distributions for the ”control period” to make the distributions comparable to observed climatology. Perform similar adjustments for the scenario period. Particularly important in mountainous regions.

Empirical adjustment of HIRHAM temperature
Upper row: Validation Bottom: Adjusted scenarios



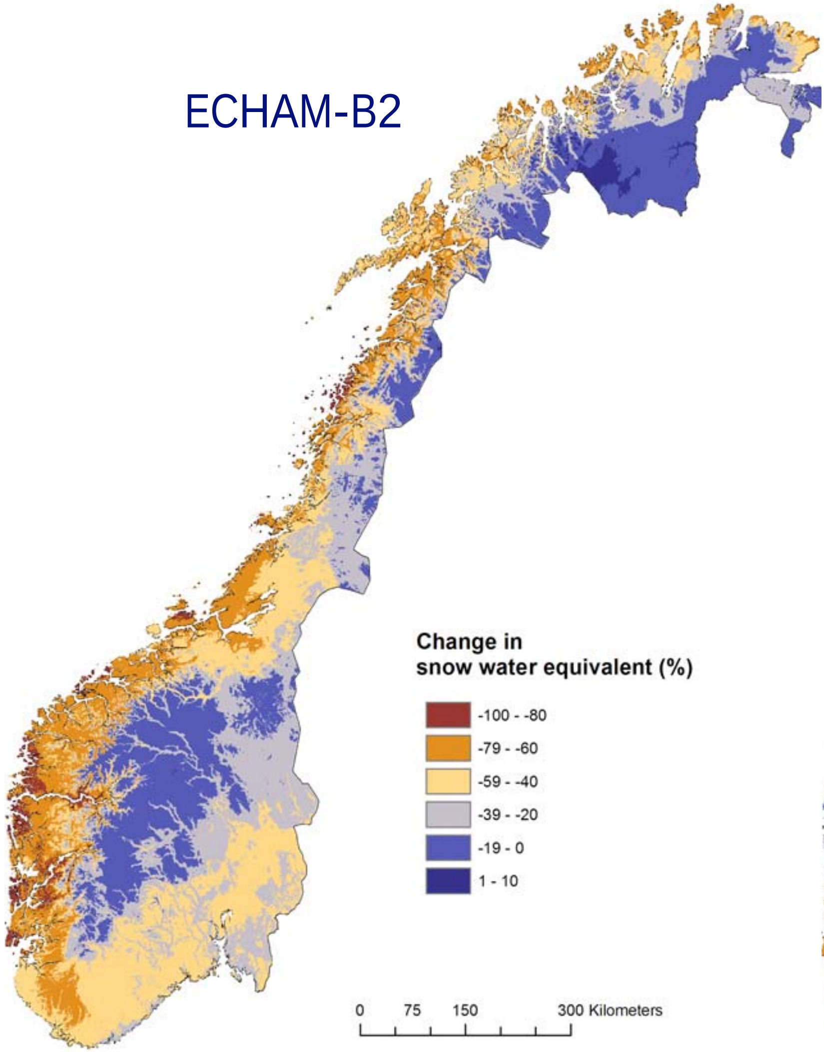
Engen-Skaugen et al. 2007: *Climate Dynamics, in press*

Projected change in number of days per year with snow cover>50% from 1961-1990 to 2071-2100 (NVE/met.no)

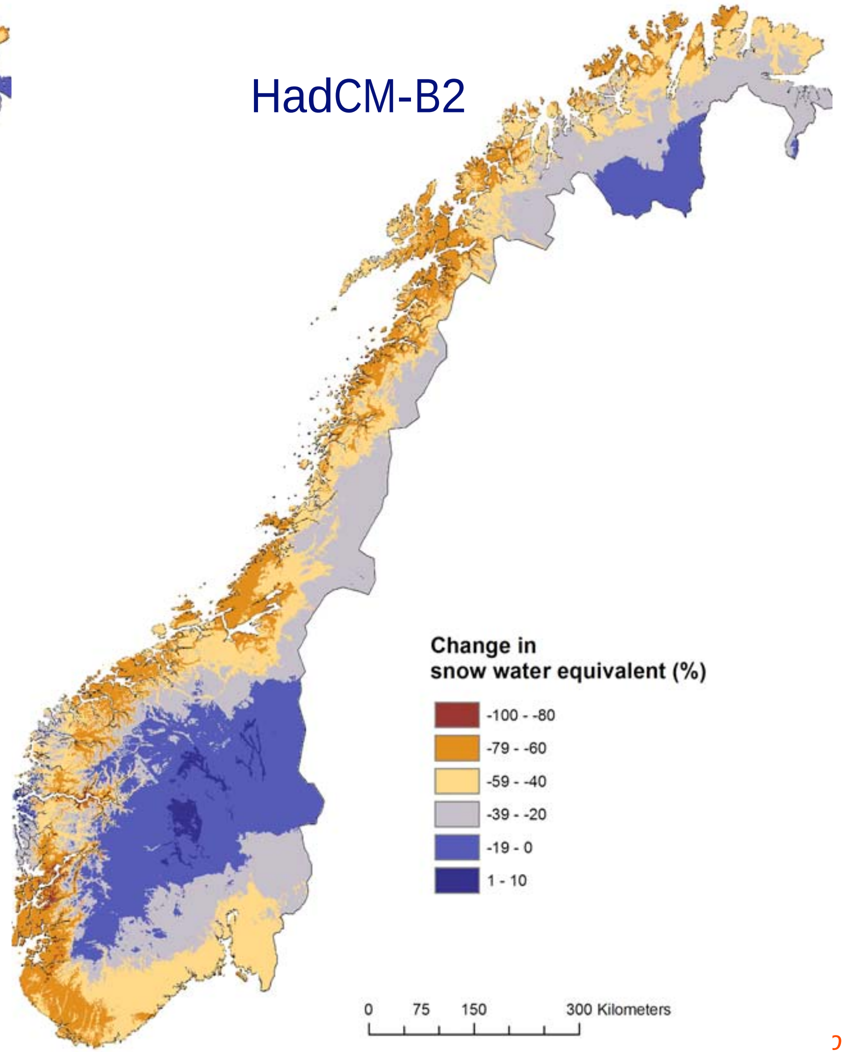


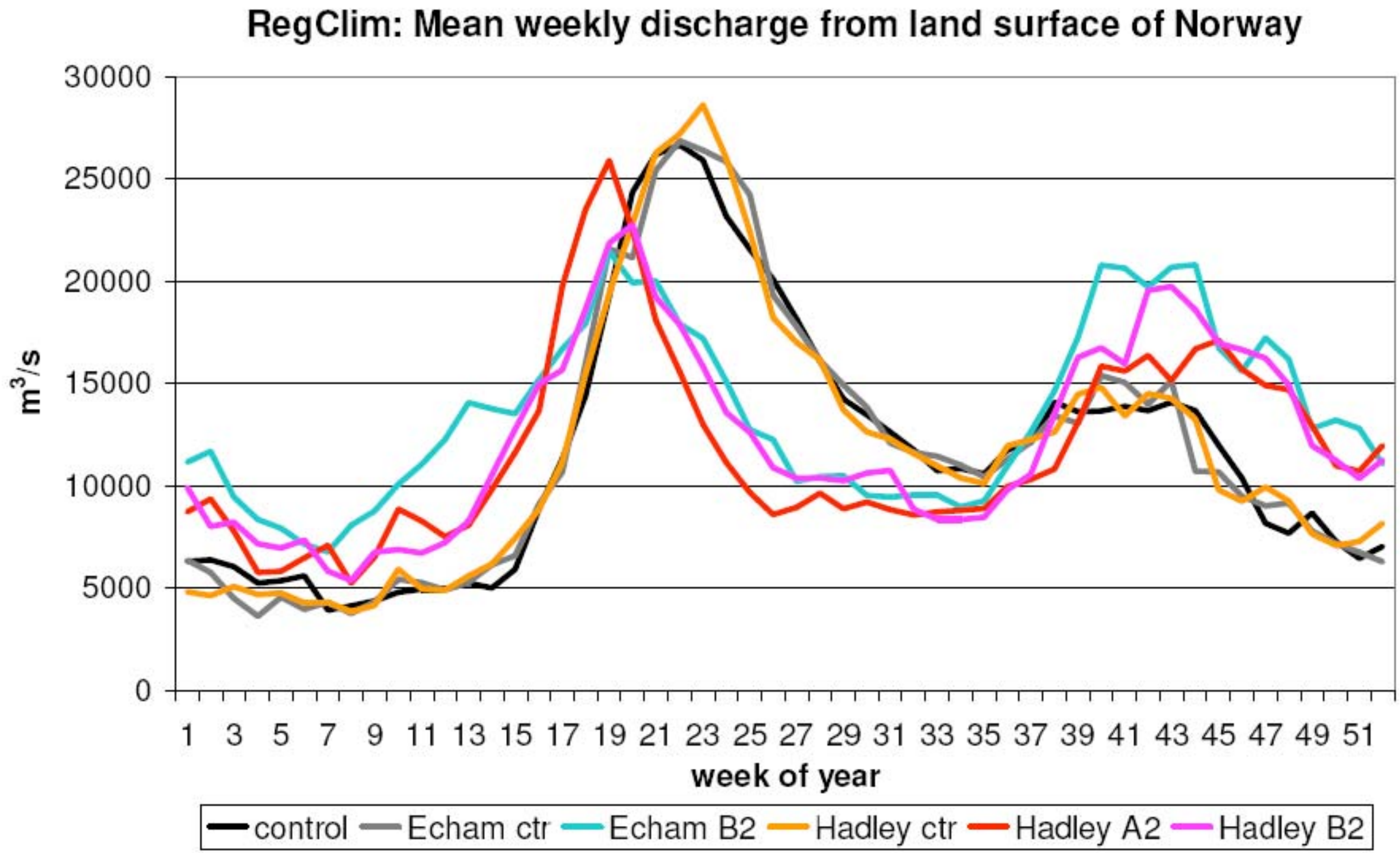
Projected change in annual maximum snowdepth (water equivalent) in %, from 1961-1990 to 2071-2100 **(NVE/met.no)**

ECHAM-B2



HadCM-B2




RegClim: Mean weekly discharge from land surface of Norway
30000
25000
20000
15000
10000
5000
0
m3/s
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51
week of year
control
Echam ctr
Echam B2
Hadley ctr
Hadley A2
Hadley B2

Snowmelt floods

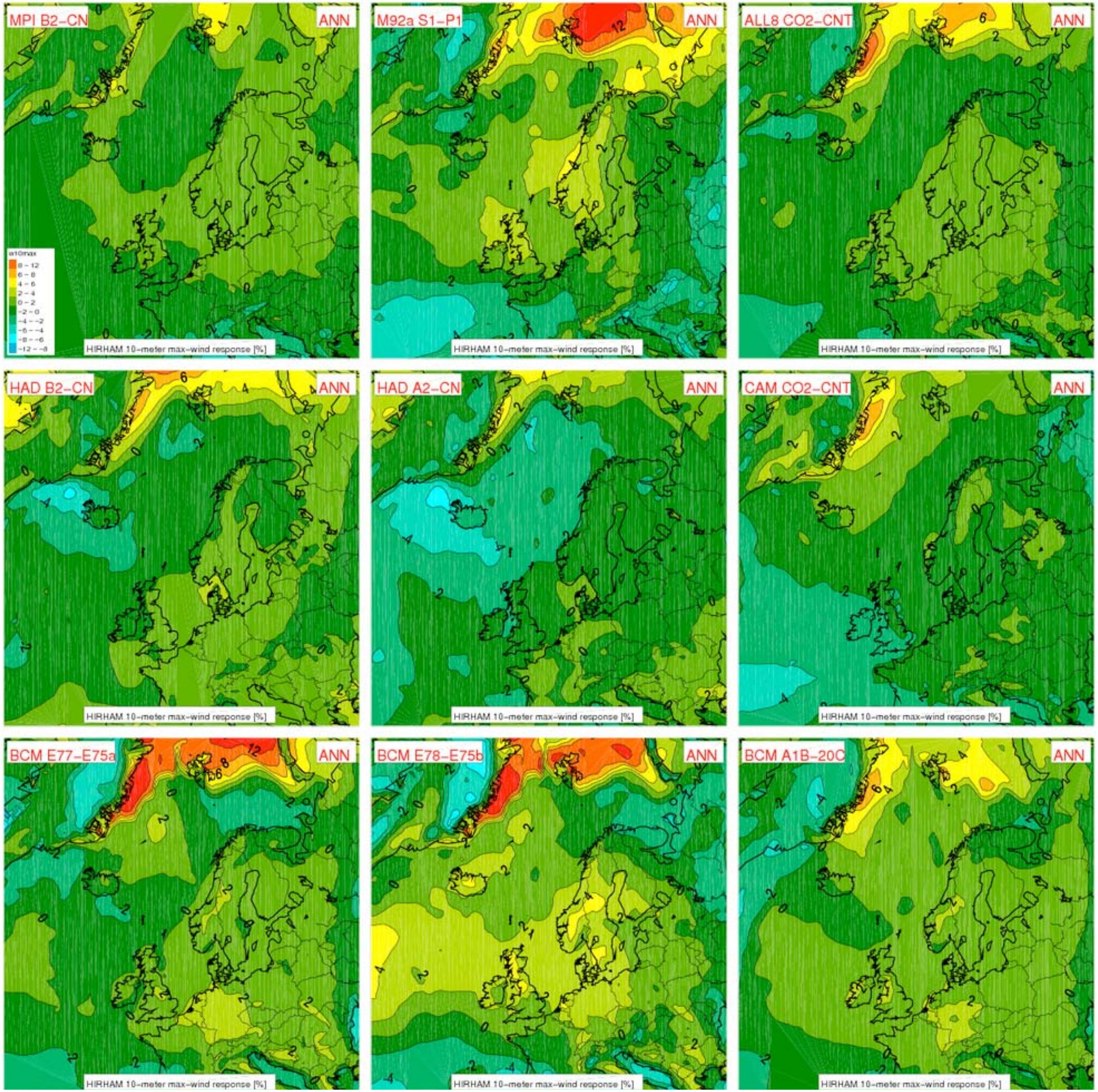
- The largest floods are often caused by a combination of rain and snowmelt.
- Reduced snow reservoirs in spring reduces the risk of flood in spring.
- On the other hand: The risk is increased in autumn and winter.

Rainfloods

- Warm summers → increased risk for local rainfloods.
- The climate scenarios indicate increased number of days with large amounts of precipitation, even in areas where reduced summer precipitation is projected.

Snow- and streamflow-scenarios

- Shorter snow season all over the country.
- Above 800 m altitude and in the northern inland: Possibly larger snow depth in mid-winter around 2050.
- Max snow-depth in extreme winters may increase above ~1500 m a.s.l. and in the north also toward 2100, but average snow-depth will probably decrease everywhere.
- Reduced and earlier snow melt in spring → reduced snowmelt floods in spring.
- Increased precipitation and snowmelt in autumn and winter → increased runoff and flood risk in autumn and winter.
- Urbane areas/small fields: More intense showers → increased risk for rainfloods.



Scaled scenarios for annual mean wind speed

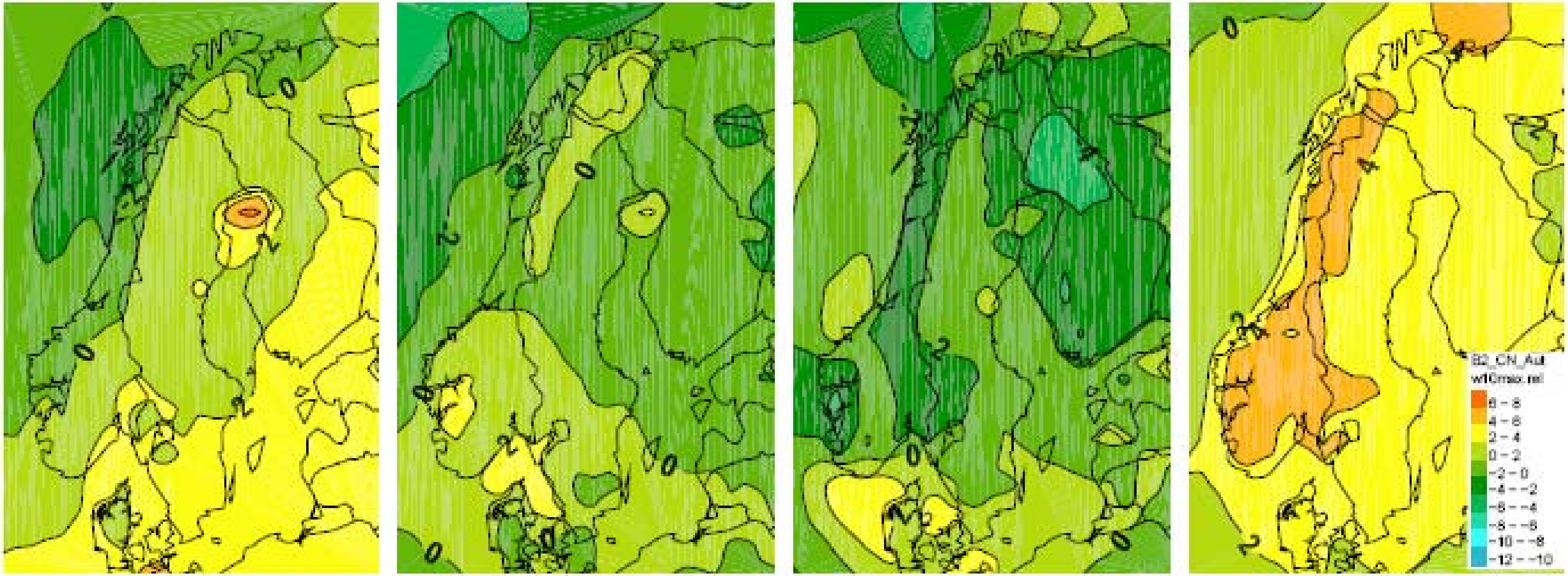
Estimated change, 70 yrs

8 scenarios

Haugen & Iversen 2007

Vind-scenarios (1961-1990) ▶(2071-2100)

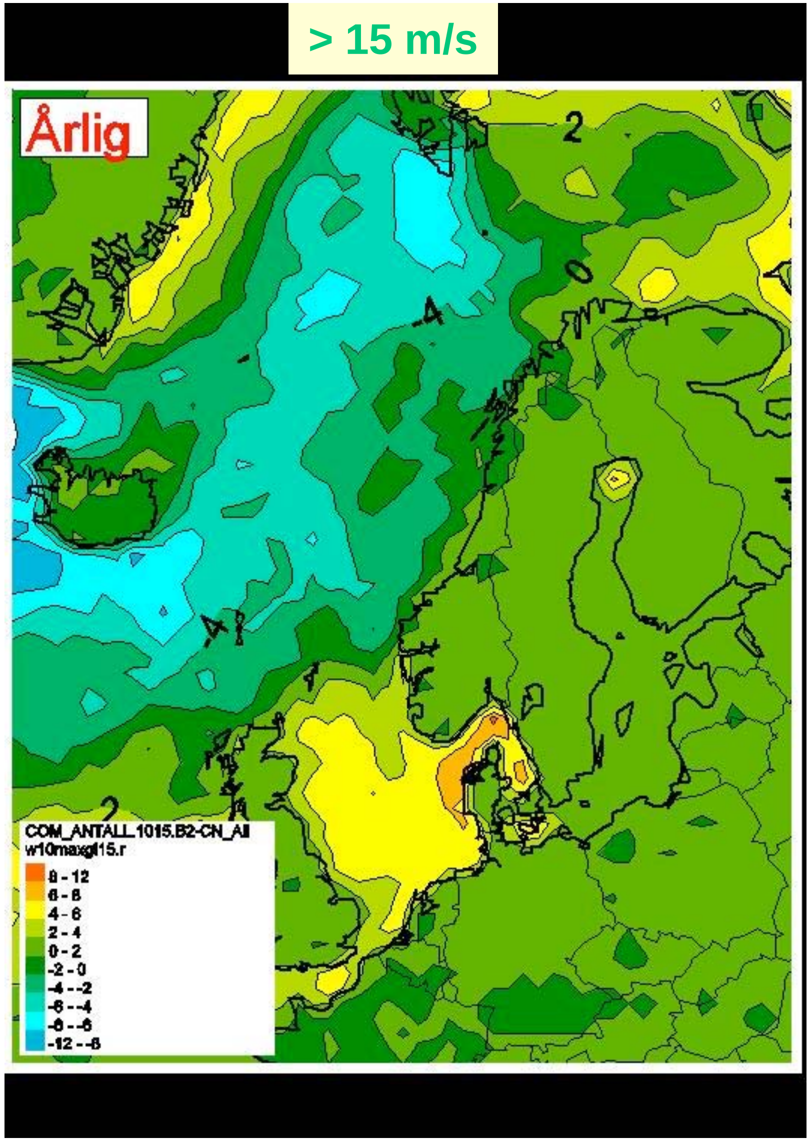
HadCM + MPI (under B2) downscaled with HIRHAM

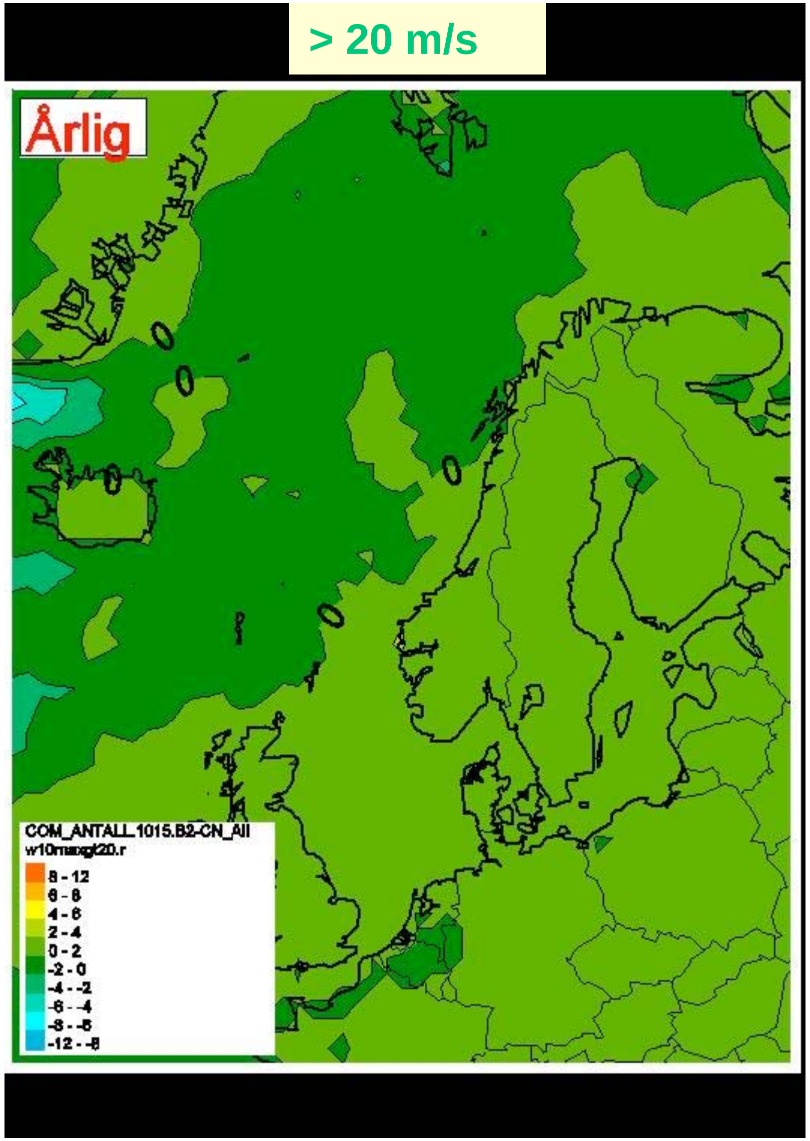


Winter | Spring | Summer | Autumn

MPI and HAD combined – B2

Increased number of days per year with max wind speed





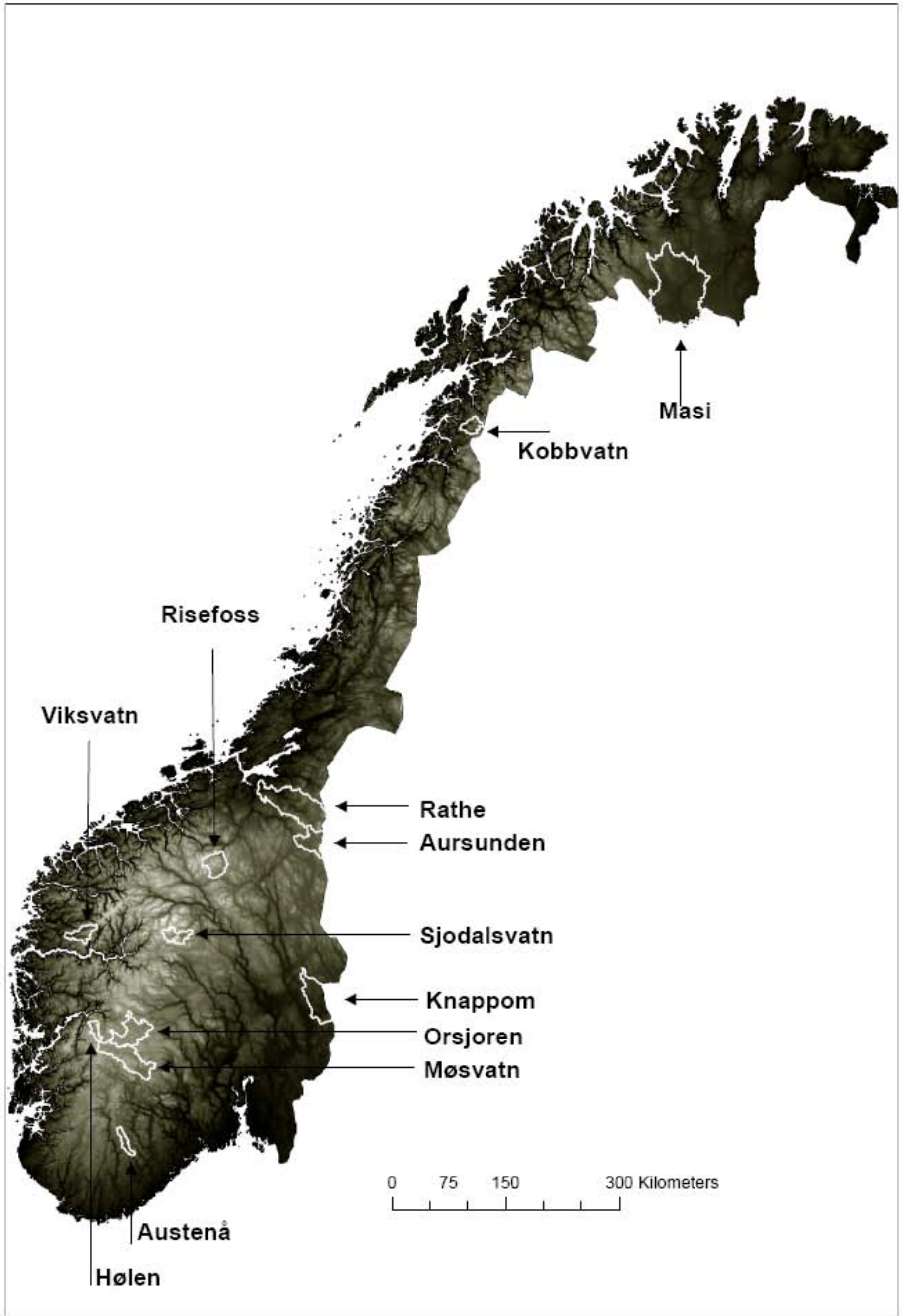
Summary, downscaled scenarios

- Temperature: Different models give similar patterns of warming. ”B2”: Typical 2.5-4.0 ^{o}C warming from 1961-90 to 2071-2100. More in winter than in summer, more in inland than along the coast. Except from the summer: more in the north than in the south.
- Precipitation: Considerable differences between different models, but at average increased annual precipitation over Norway in all models. Increase in autumn and winter precipitation in most of the country. Probably decreased summer precipitation in parts of South-Norway. More frequent days with heavy precipitation.
- Snow: Shorter season all over the country. Maybe more snow in some mountain areas around 2050, but less snow below ~800 m a.s.l. Max snow-depth in extreme years may increase in some mountain areas also later in the century.
- Floods: Changed pattern.
- Wind: Small tendencies. Slightly stronger wind in the autumn?

Thanks for your attention!

Available downscaled climate scenarios for Norway

- For selected localities: Empirically downscaled temperature and precipitation scenarios for the period 1961-2050 or 1961-2100. Monthly time resolution.
- Regional model scenarios for the periods 1961-1990 and 2071-2100: Hadley A2 and B2, MPI B2. MPI 1980-2050 IS92a. 3 runs with BCM and "control" + "2xCO2" with CAM-Oslo). Diurnal values of a number of variables.
- Adjusted regional model scenarios for temperature and precipitation: Hadley "control" 1961-1990 + "scenario" 2071-2100 A2 and B2. MPI "control" 1961-1990 + "scenario" 2071-2100 B2. MPI 1980-2050 IS92a



Statistikk for to nedbørfelt

(NVE/met.no)

Knappom
170-808 masl
Median: 411 masl
Area: 1625 km2
Forest:78%, Bog: 17%
Annual runoff: 441 mm/yr
Sjodalsvatn
940-2362 masl
Median: 1467 masl
Area: 474 km2
Mountain: 71%, Glacier: 9%
Annual runoff: 1314 mm/yr

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