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# Projections of wintertime climate changes in the Baltic Sea catchment area

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# Outline

- **Projected changes in temperature and precipitation over the Baltic Sea**
  - simulations by 19 global climate models (CMIP3)

- **Projected changes in snow around the Baltic Sea**
  - regional climate model simulations
    (and INTAS/SCCONE observational data)

- **Projected changes in Baltic sea ice**
  - regional and global (TAR) climate model simulations

Results from the PRUDENCE and ACCLIM projects

http://prudence.dmi.dk/
http://www.fmi.fi/acclim

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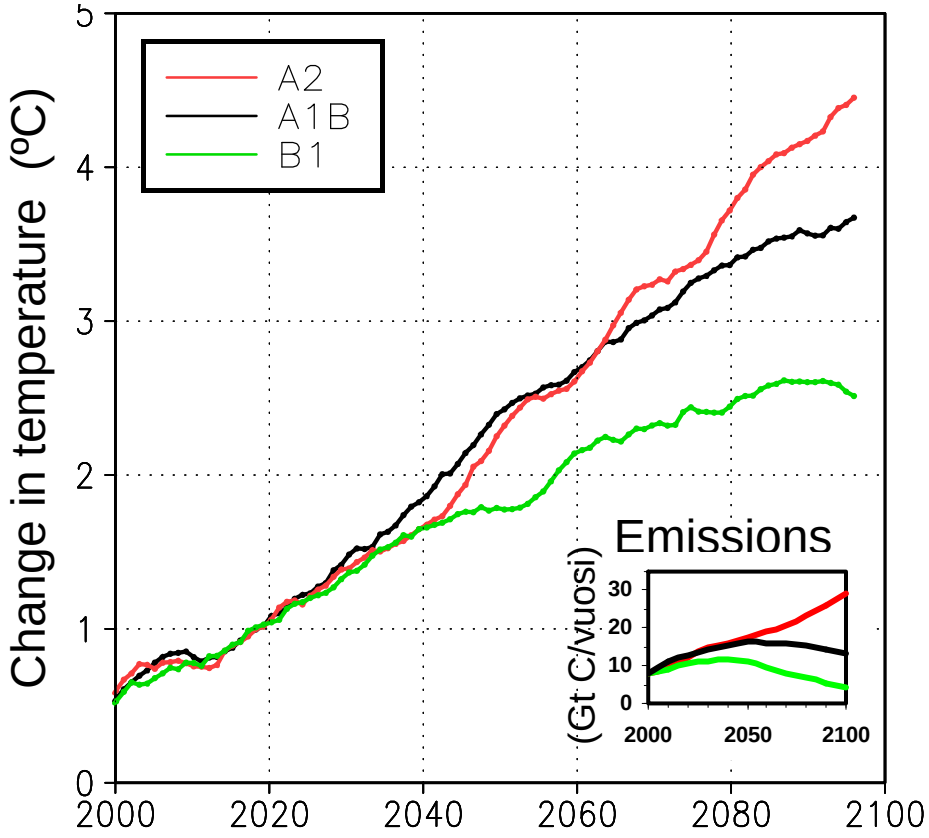
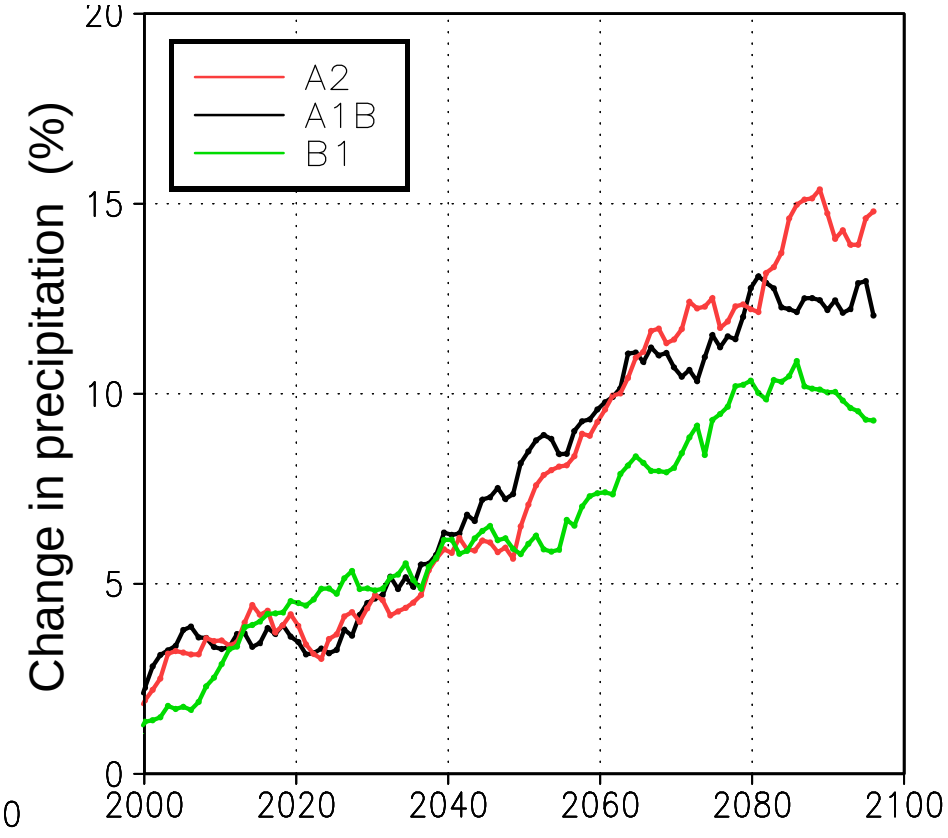
# Projections for the Baltic Sea

## Annual mean temperature




## Annual precipitation sum




Area averages across the Baltic Sea
based on 19 global climate models (CMIP3)

Source: Kimmo Ruosteenoja

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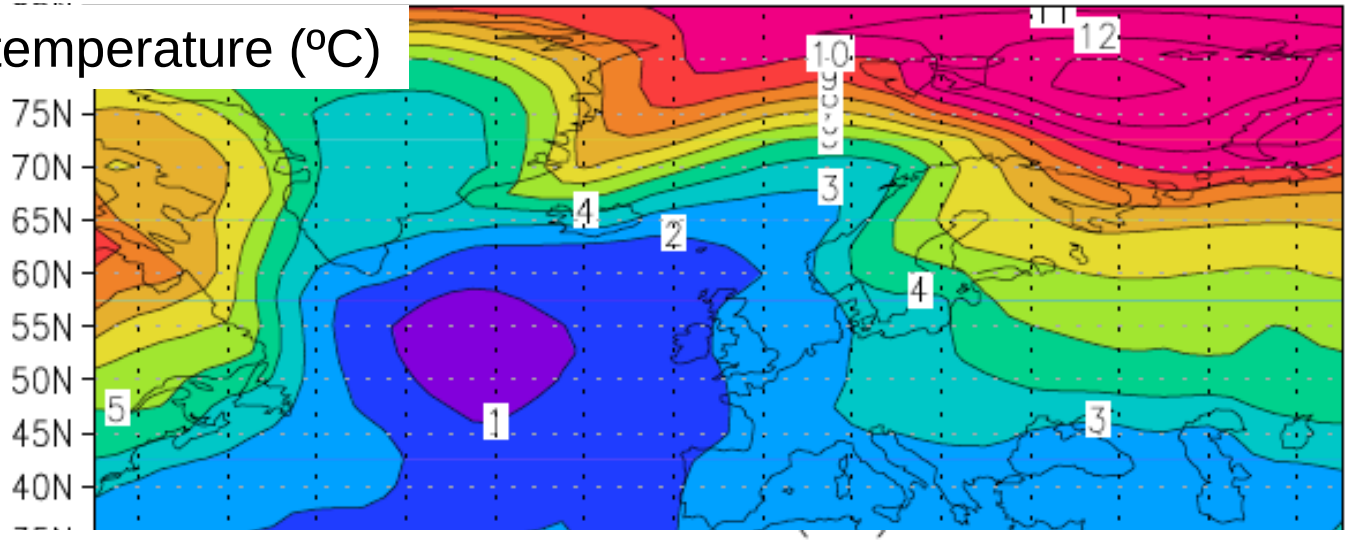
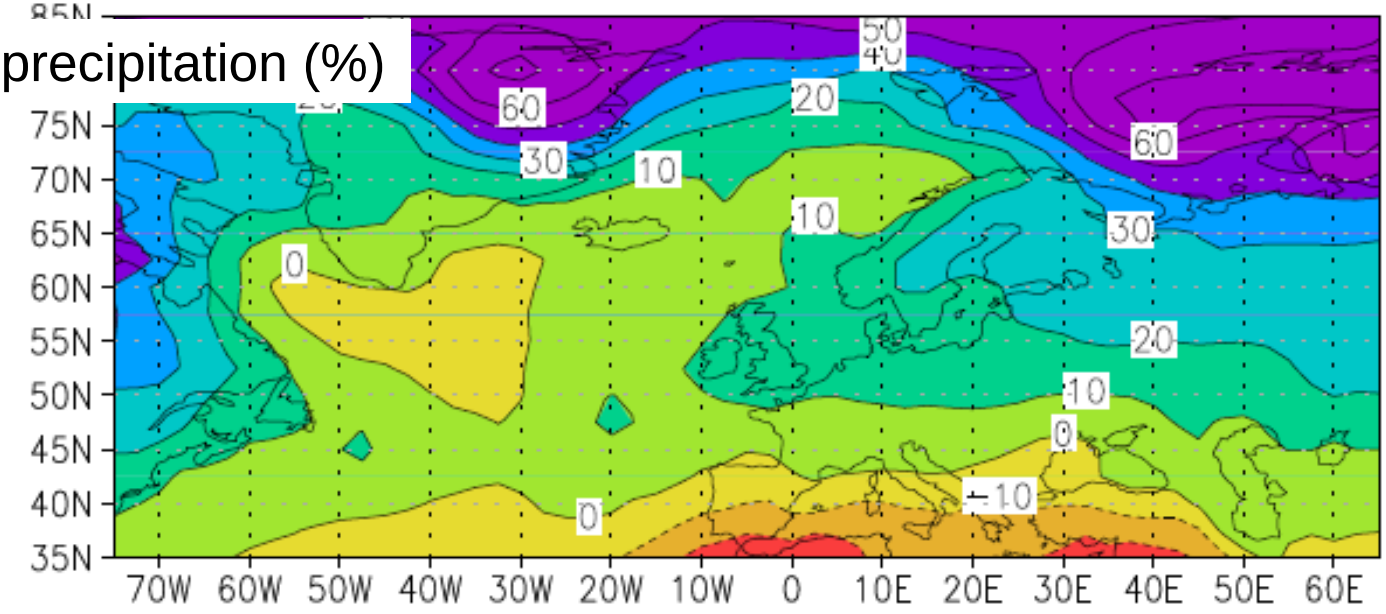
# Projected changes in winter (DJF) climate by 2070-99

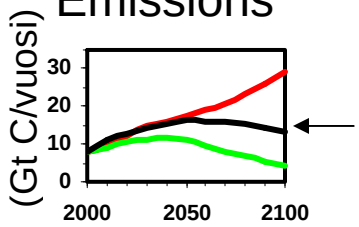
Mean temperature (ºC)




Mean precipitation (%)




SRES A1B Emissions



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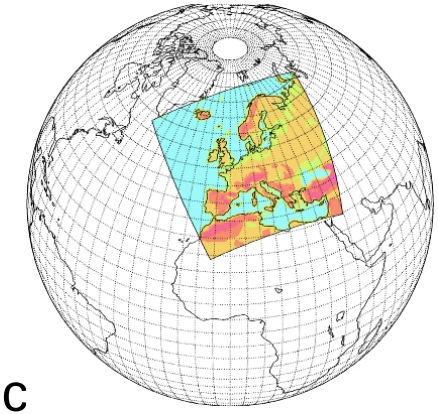
# Projected changes in snow

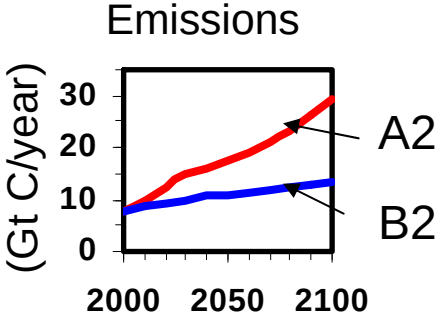


Output from PRUDENCE regional climate model (RCM) simulations:

- Six RCMs with a resolution of about 50 km
- Lateral boundary conditions from HadAM3H atmospheric general circulation model (GCM) (or from ECHAM4/OPYC3)
- SRES **A2** or (**B2**) emission scenario
- Two 30-year periods 1961–1990 and 2071–2100

For comparisons:

- INTAS/SCCONE data for snow cover




Jylhä K., Fronzek S., Tuomenvirta H., Carter T.R. and Ruosteenoja K.,2008: Changes in frost, snow and Baltic Sea ice by the end of the twenty-first century based on climate model projections for Europe. *Clim. Change,* 86, 441-462.

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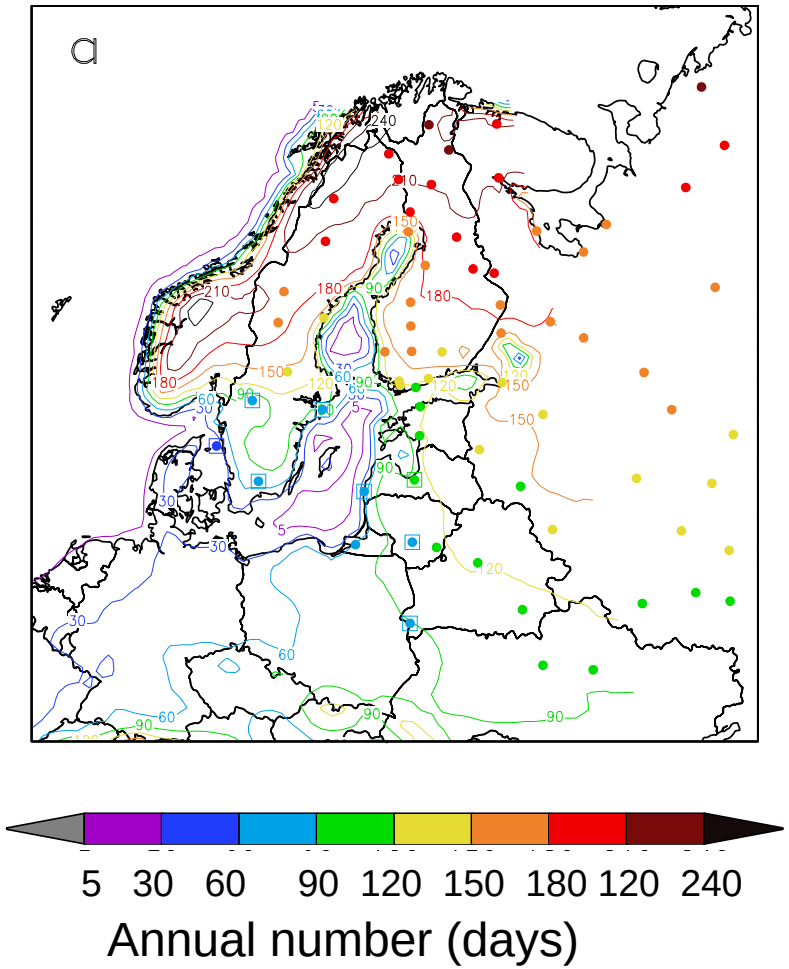
# Days with snow cover

INTAS/SCCONE observations 1961-1990




Model performance for snow cover

- Observations reasonably well simulated by the multi-model average.
- 76% of the cases in a correct interval of 30 days

Dots: observations
Contours: the mean of six RCM-H simulations

Ref: Jylhä et al. (2008)

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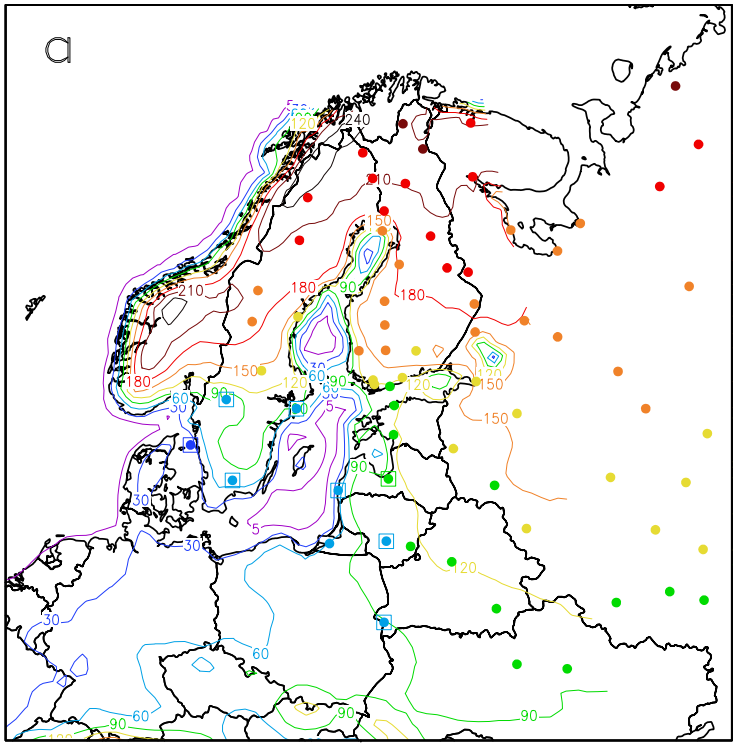
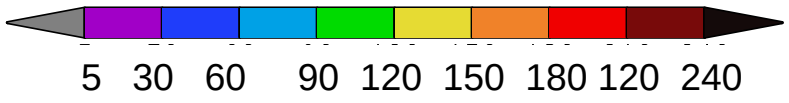
# Fewer days with snow cover

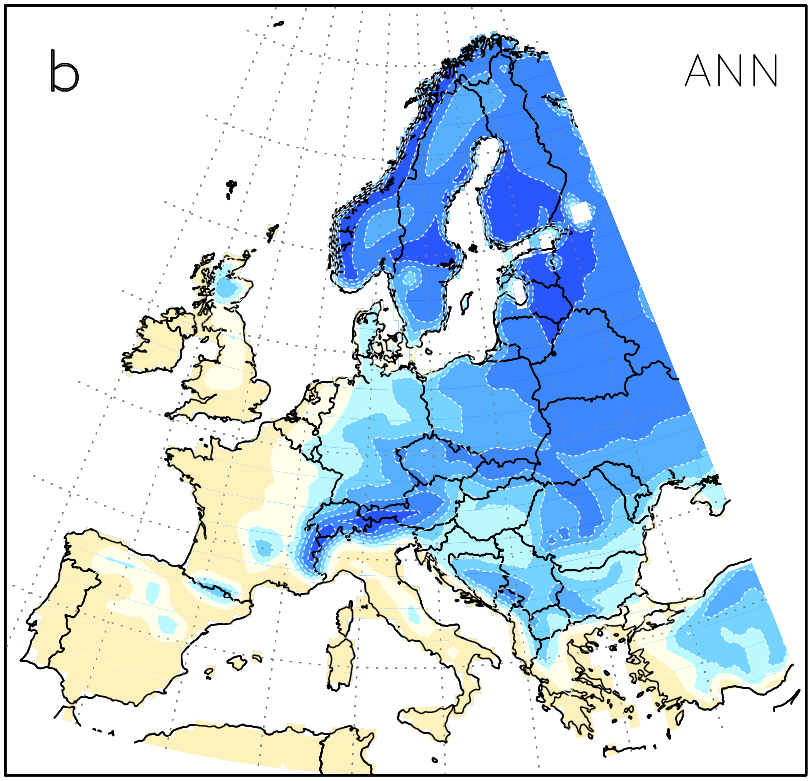
INTAS/SCCONE observations 1961-1990

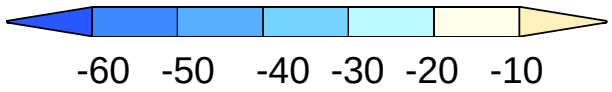



Number (days)

Projected changes by 2071-2100




Multi-model average change (days)

Ref: Jylhä et al. (2008)

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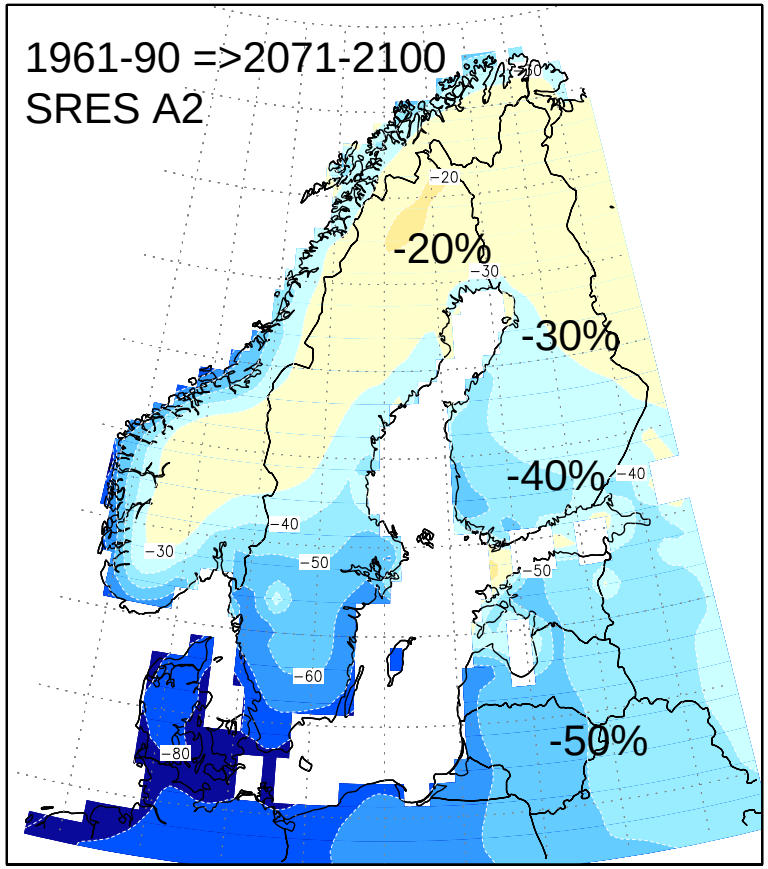
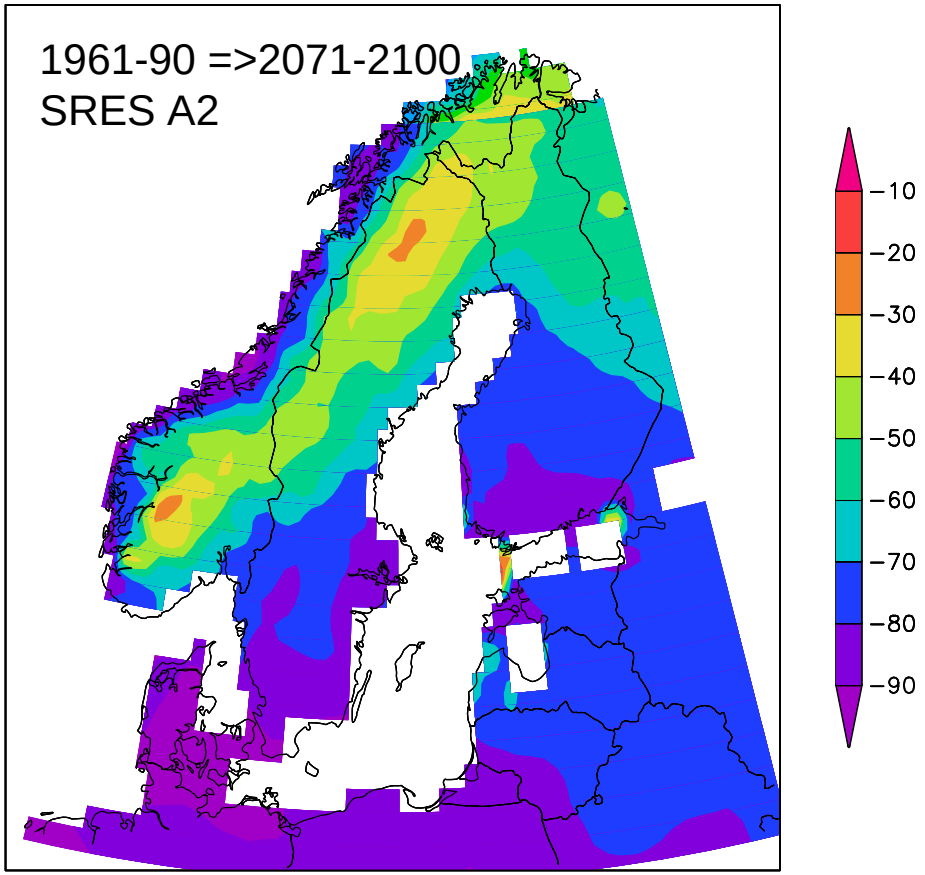
# Largest decreases in snow cover in SW Finland

Annual number of snow cover days




Annual mean snow water equivalent




Multi-model average change (%)

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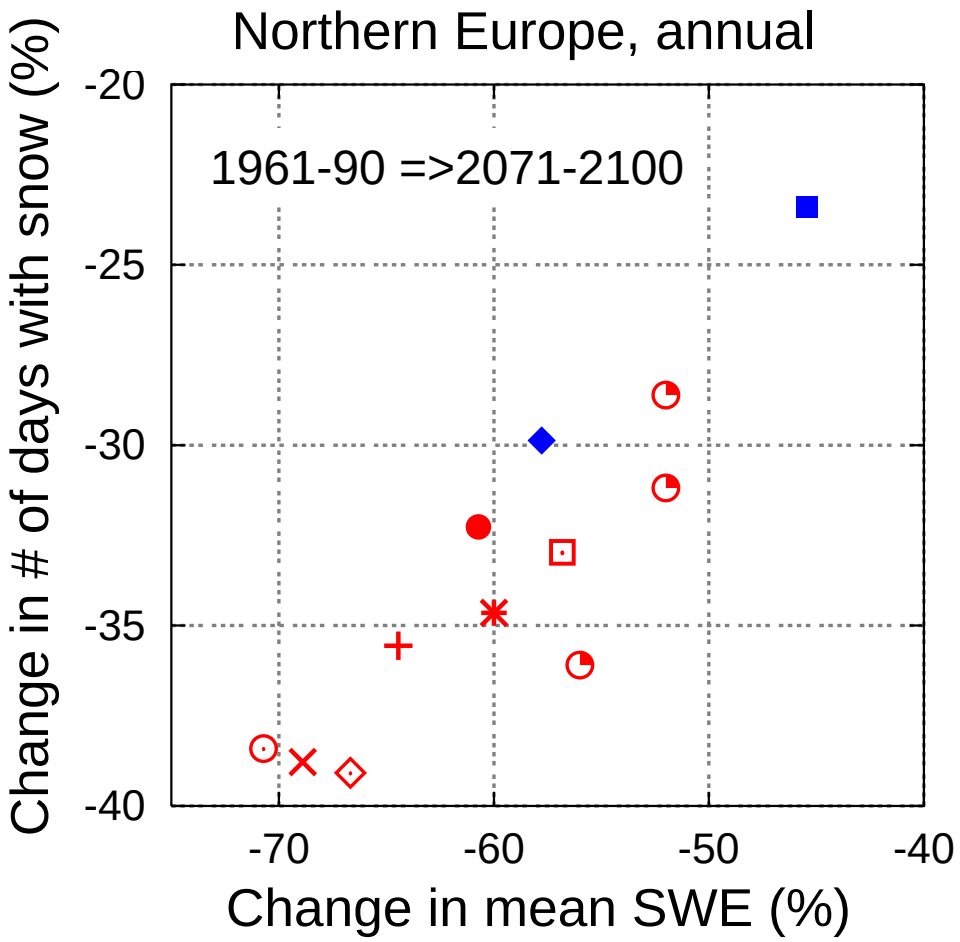
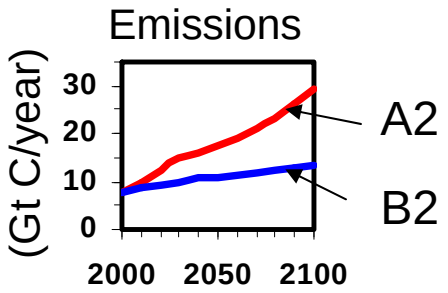
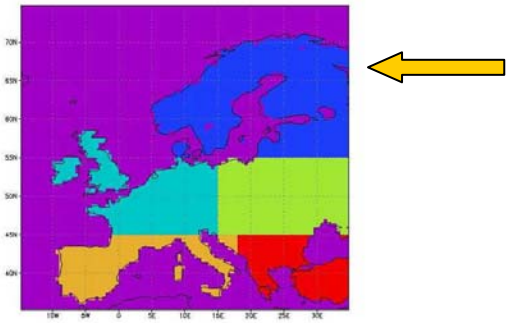
# Percentage reductions in the annual mean SWE > in # of days with snow




Climate model simulations

- HIRHAM HC A2 (3)
- HIRHAM EC A2
- HIRHAM EC B2
- RCAO HC A2
- RCAO HC B2
- RCAO EC A2
- RCAO EC B2
- CHRM HC A2
- CLM HC A2
- REMO HC A2



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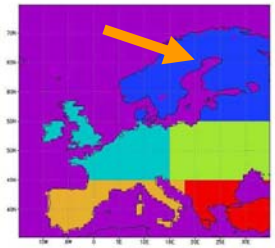
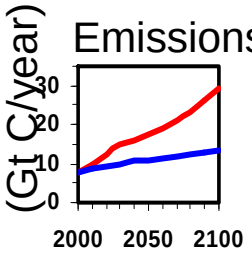
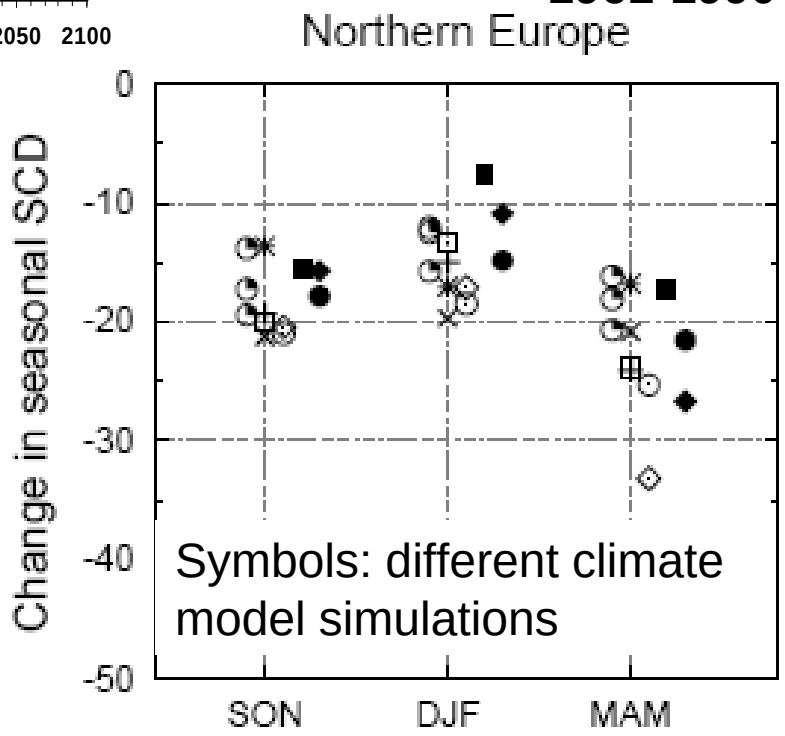
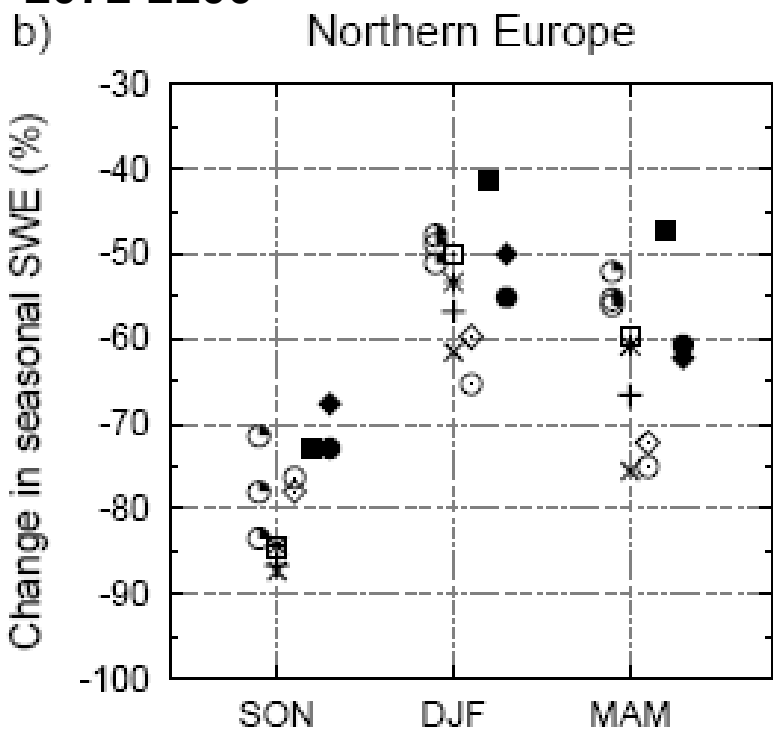


# Decreasing number of snow cover days and snow water equivalent




**1961-1990 => 2071-2100**




- **Absolute decreases (in days) largest in spring**
- **Percentage decreases (%) largest in autumn**

- **Percentage decreases (%) largest in autumn**

Ref: Jylhä et al. (2008)

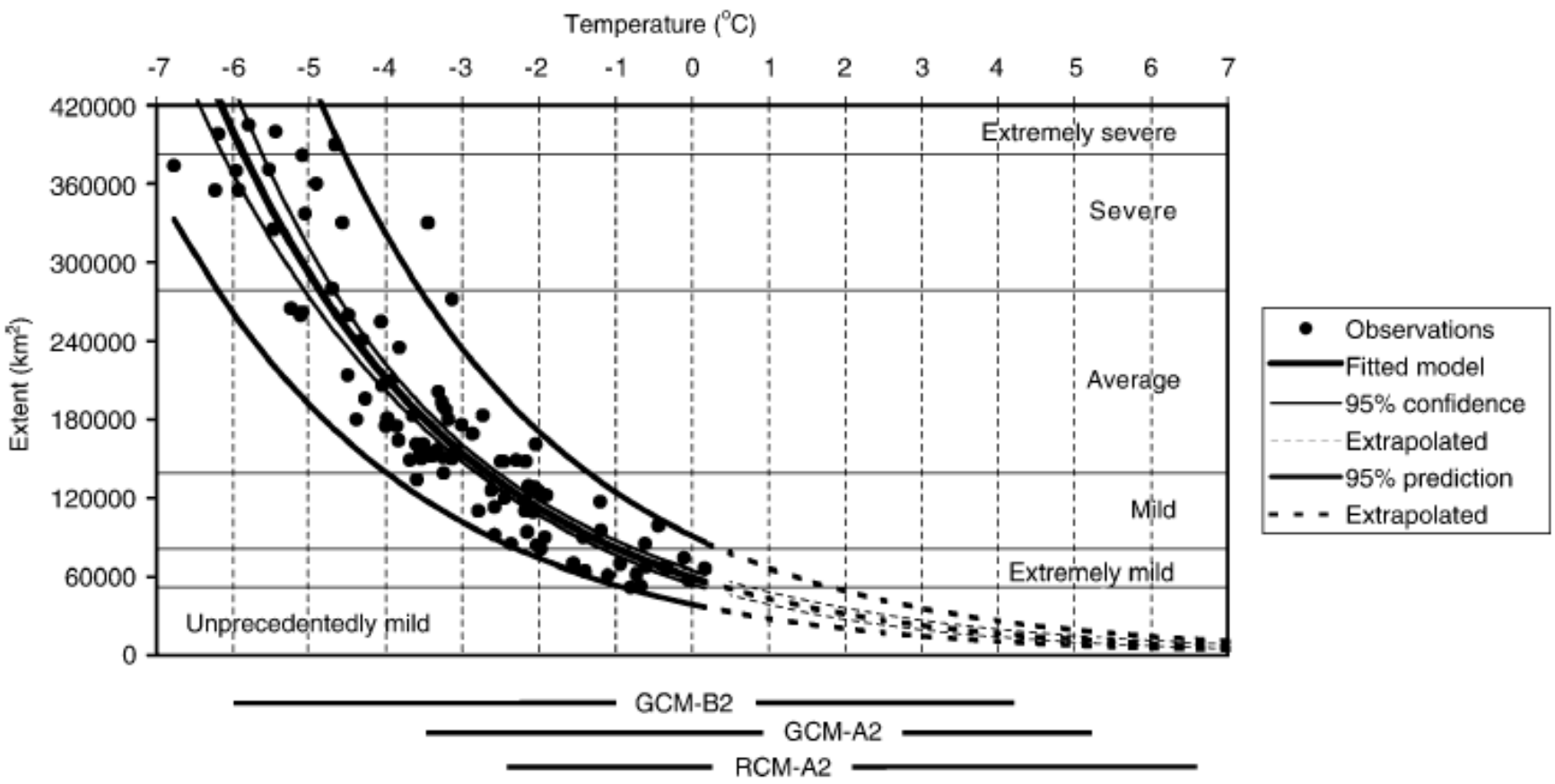



**Fig. 7** Maximum annual Baltic sea ice extent during 1902–2000 as a function of mean November–March temperature in coastal grid cells around the Baltic Sea. Observations are denoted by *points*, while estimates from a regression model (Eq. 1), with 95% confidence intervals for the *regression line* and 95% prediction intervals for individual data points, are indicated by *curves*. The *horizontal bars* give the ranges of AOGCM- and RCM-based scenarios for November–March average temperatures for all years of the period 2071–2100. Severity classes as defined by Seinä and Palosuo (1996) are shown, while a new class "Unprecedentedly mild", which lies outside the range of observations since 1720, has been added

Ref. Jylhä et al. (2008)

By S. Fronzek and T. Carter (SYKE)

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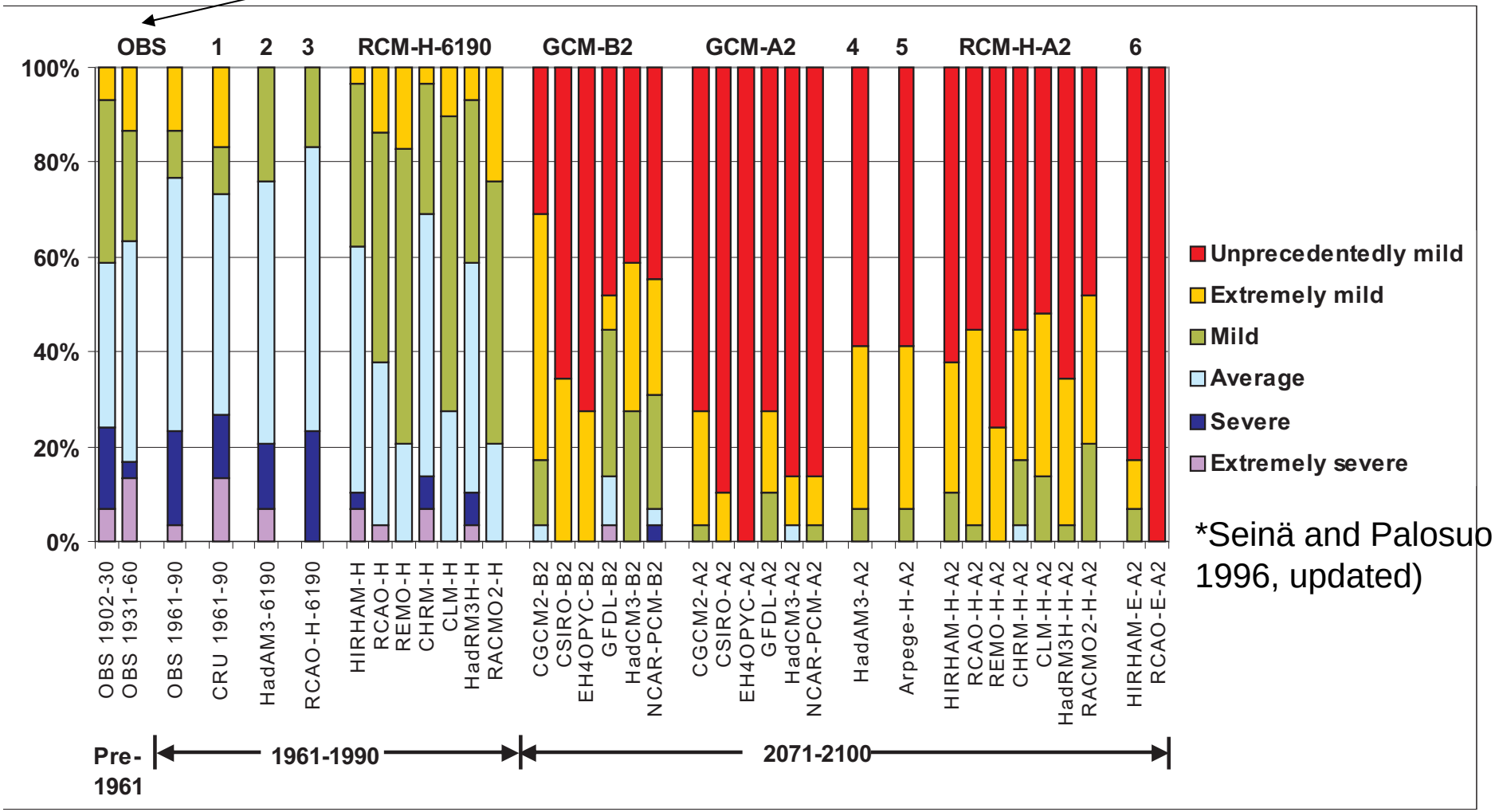
# Percentage of years belonging to different severity classes* for observed and modelled Baltic sea ice extent




*Seinä and Palosuo, 1996, updated)

Ref. Jylhä et al. (2008)

By S. Fronzek and T. Carter (SYKE)

Table 3. Some possible impacts of future changes in frost, snow and Baltic sea ice, or seasonal warming of the climate in general, together with a sample of possible adaptation measures.

| Projected changes | Effect / impact | Adaptation option |
|---|---|---|
| Fewer days with snow cover and reduced snow depth; less reliable snow conditions | Changes in snow-fed river systems[8]; Unfavourable for winter outdoor tourism[9];<br>Changes in road maintenance costs[10];<br>Reduction in beneficial insulation for vegetation | Modified management of water resources, snowmelt floods and hydropower generation;<br>Artificial snow at ski resorts; Alternatives to ski tourism; Substitution of recreational sites[11] |
| Reductions in Baltic sea ice extent | Decreased demands for ice-breaking by marine transport<br>Hampered breeding of seal species[15] | Less costs and traffic restrictions for sea transport |

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# Conclusions

## Snow:

- Fewer days with snow cover,
- smaller average snow water equivalent, and
- larger proportion of days with only a thin snow cover

at the end of this century than nowadays.

- the largest percentage reductions: in western and southern Europe
- the largest absolute changes: around the northern Baltic Sea,

on the western slope of the Scandinavian mountains and in the Alps.

## Baltic sea ice

– A drastic decrease in annual maximum ice extent can be expected in the future. A large proportion of the years during 2071-2100 was estimated to have sea ice extents smaller than ever observed during three centuries of available observations.

These results were consistent across all model simulations considered, irrespective of the forcing scenario and the driving GCM. However, details in the scenarios were subject to uncertainties due to various sources.