21st century changes in snow climate in Northern Europe:
a high-resolution view from ENSEMBLES regional climate models

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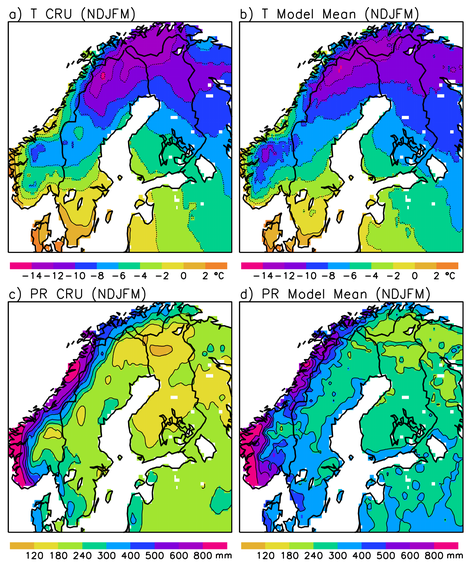
A. Introduction

Snow conditions are heavily affected by orography and the land-sea distribution. Therefore, future changes in regional snow climates should be preferably assessed using high-resolution regional climate models (RCMs).

Here, we study potential 21st century changes in snow conditions in Northern Europe, using 11 RCM simulations (8 RCMs using boundary conditions from 5 global models) from the ENSEMBLES project. All simulations are based on the SRES A1B scenario.

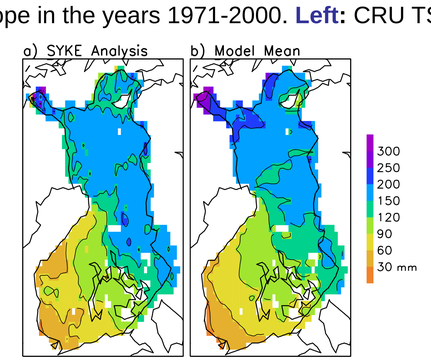
B. Multi-model mean present-day climate



Temperature in good agreement with observations

Precipitation exceeds observed values
(but difference at least partly explained by gauge undercatcth)

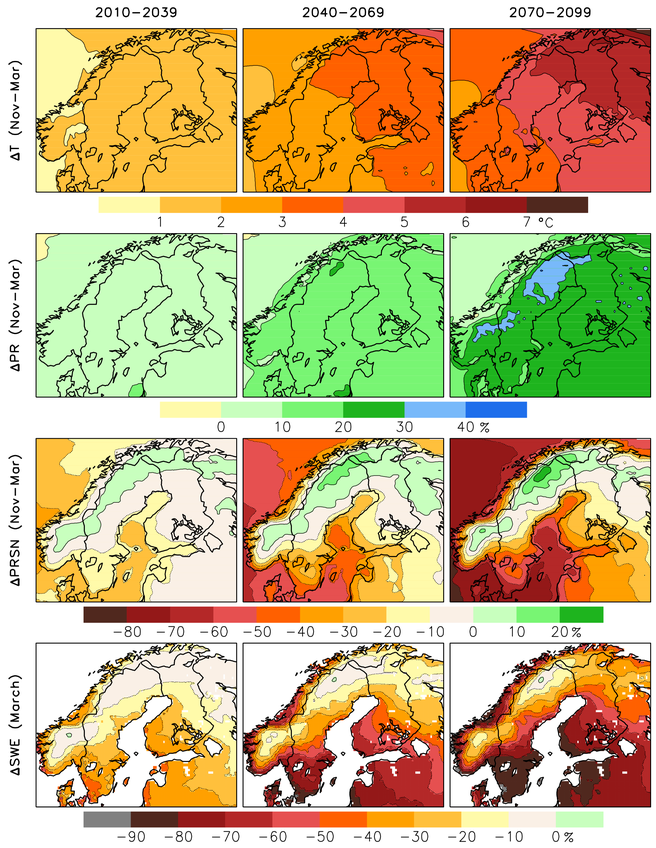
Fig. B1 November-March (NDJFM) mean temperature (top) and precipitation (bottom) in northern Europe in the years 1971-2000. **Left:** CRU TS2.1 observations; **Right:** 11-model mean.



Snow water equivalent (SWE) in good agreement with observations

Fig. B2 March mean snow water equivalent in Finland in the years 1991-2005.
Left: Observations by Finnish Environmental Institute;
Right: 11-model mean.

C. Multi-model mean changes in the 21st century



Higher temperatures

Larger total precipitation

Less snowfall in most areas
(larger fraction of winter total precipitation as rain)

Generally less snow even where snowfall increases
(more snowmelt in a warmer climate)

Fig. C1. 11-model mean changes in (rows 1-3) November-March mean temperature, precipitation and snowfall, and (row 4) March mean snow water equivalent. The changes represent differences from the mean values in the years 1971-2000.

D. Variation of March mean SWE change between the 11 RCM simulations …

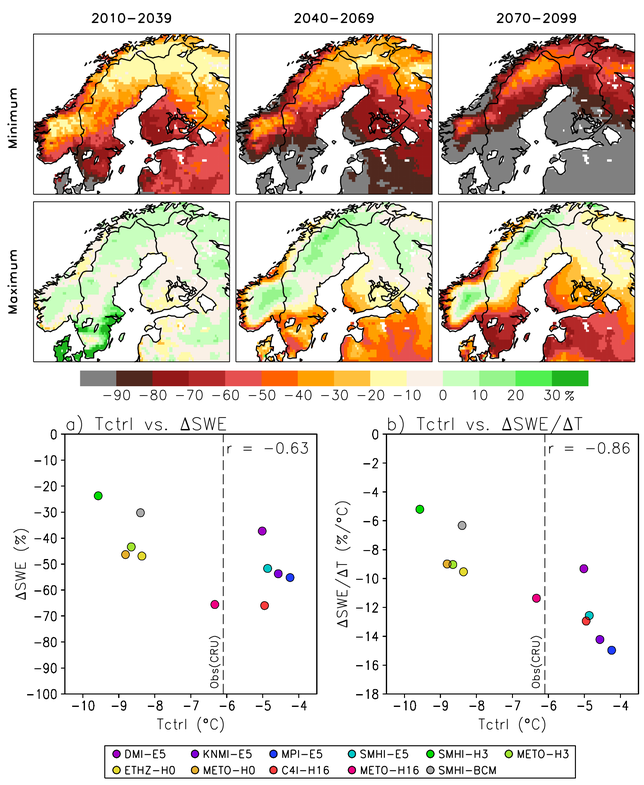


Fig. D1 Range of March mean SWE change among the 11 models, given by the local minimum (most negative) and maximum (least negative / most positive) values of change.

… is large, but partly explained by differences in present-day winter temperatures:

Fig. D2. (a) Relationship between the present-day (1971-2000) NDJFM Nordic mean temperature (horizontal axis) and March mean SWE change from 1971-2000 to 2070-2099 among the 11 models. The correlation between the two quantities is given in the upper right corner. (b) as (a), but the SWE change is normalized by the NDJFM mean temperature change.

E. Interannual variability of snow conditions

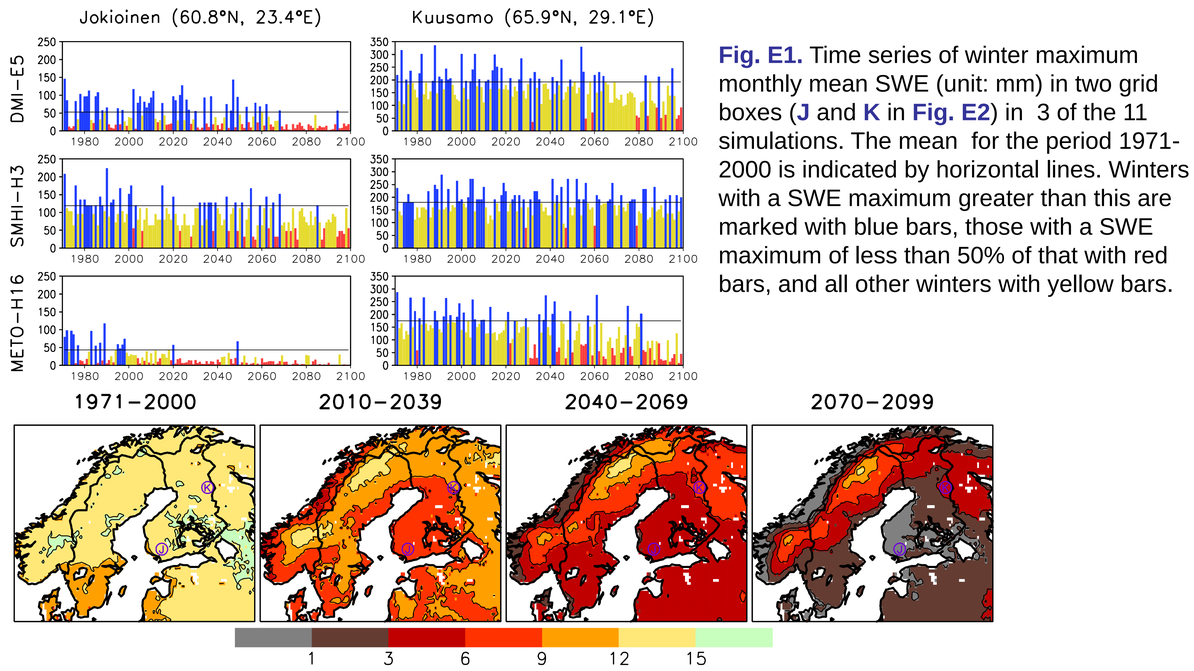


Fig. E1. Time series of winter maximum monthly mean SWE (unit: mm) in two grid boxes (**J** and **K** in **Fig. E2**) in 3 of the 11 simulations. The mean for the period 1971-2000 is indicated by horizontal lines. Winters with a SWE maximum greater than this are marked with blue bars, those with a SWE maximum of less than 50% of that with red bars, and all other winters with yellow bars.

Fig. E2. 11-model mean number (cases per 30 years) of winters with maximum monthly mean SWE greater than the corresponding mean for 1971-2000.

Individual snow-rich winters are expected to occur even in the future, but progressively more seldom with time.

F. Further reading

Räisänen, J. and J. Eklund, 2011: 21st century changes in snow climate in Northern Europe: a high-resolution view from ENSEMBLES regional climate models. *Climate Dynamics,* DOI: 10.1007/s00382-011-1076-3.