Session 2:
Climate projections, stories and integration

Chair: Taru Palosuo, Natural Resources Institute Finland

Session 2

Session 2	***Climate projections, stories & integration*** *Chair: Taru Palosuo (Luke)*
10:20	SSP-based regional climate projections *+ Discussion* *Kirsti Jylhä, Petri Räisänen & Laura Utriainen (FMI)*
10:40	Climate- and adaptation-stories *+ Discussion* *Karoliina Rimhanen (Luke) & Nina Pirttioja(Syke)*
11:00	Integrated regional scenarios *+ Discussion* *Timothy Carter (Syke)*
11:20 – 11:30	**Refreshment break/Jaloittelutauko**

SSP-based regional climate projections

Kirsti Jylhä, Dr.

Petri Räisänen, Dr.

Laura Utriainen, MSc.

Survey on weather and climate data needs

5 highest rankings for single variables

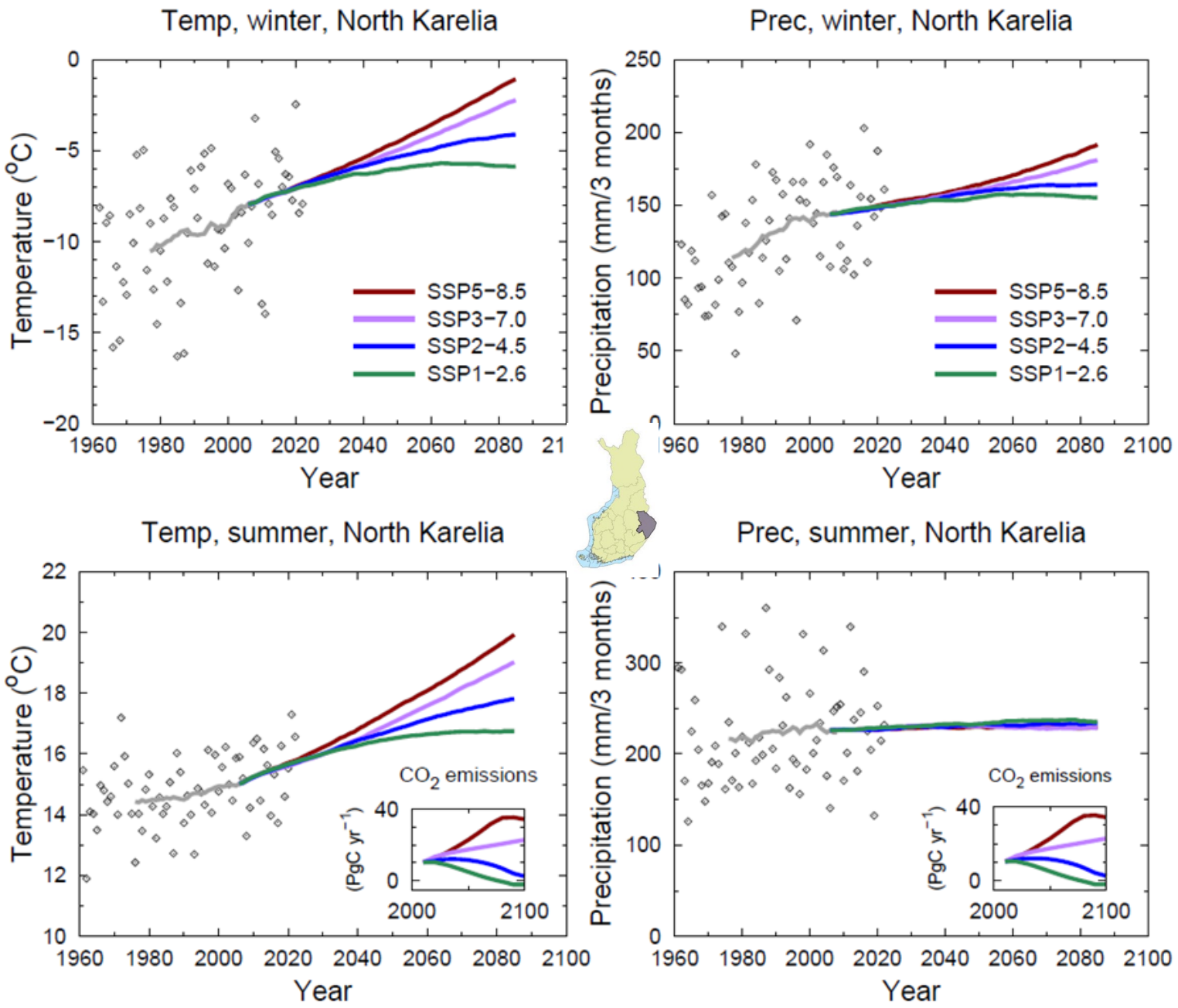
Ostrobothnian counties (n=13)

1 **Heavy/abundant precipitation**
2 High temperatures
3 **Heatwaves**; Growing season
4 Severe frosts; **Cooling needs of buildings**; Abundant solar radiation; Solar energy production potential; Variations in the start and end dates of a season
5 Wind energy production potential; **Low temperatures**; Strong winds

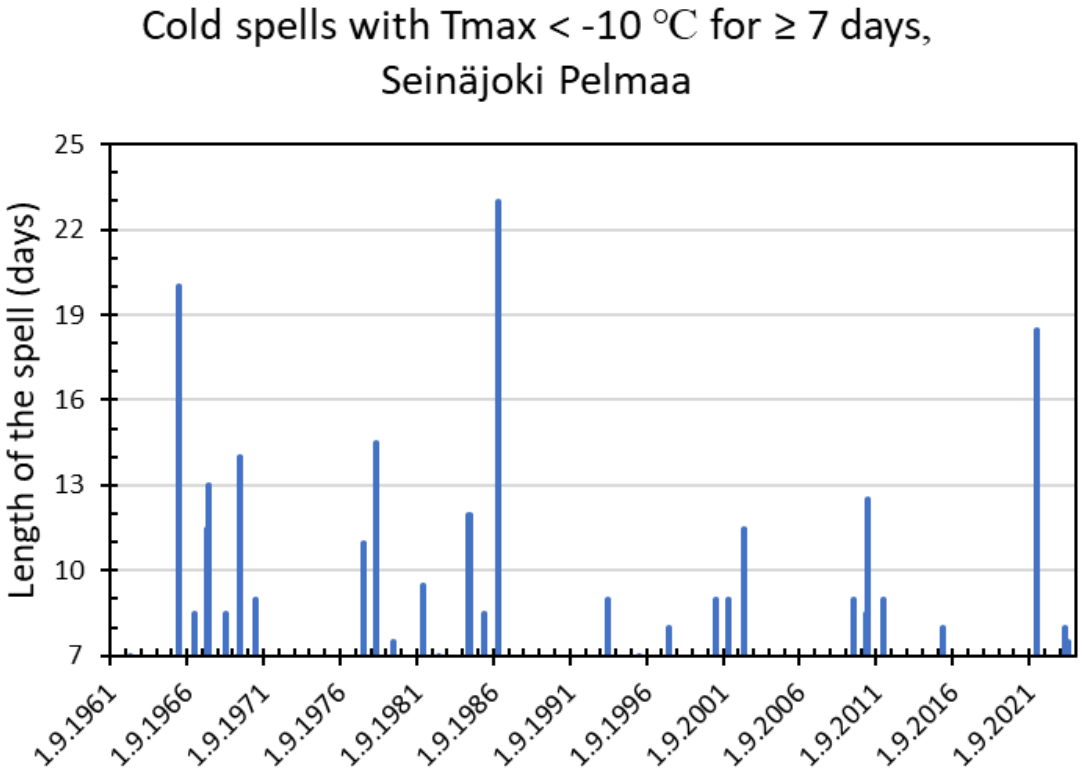
North Karelia (n=6)

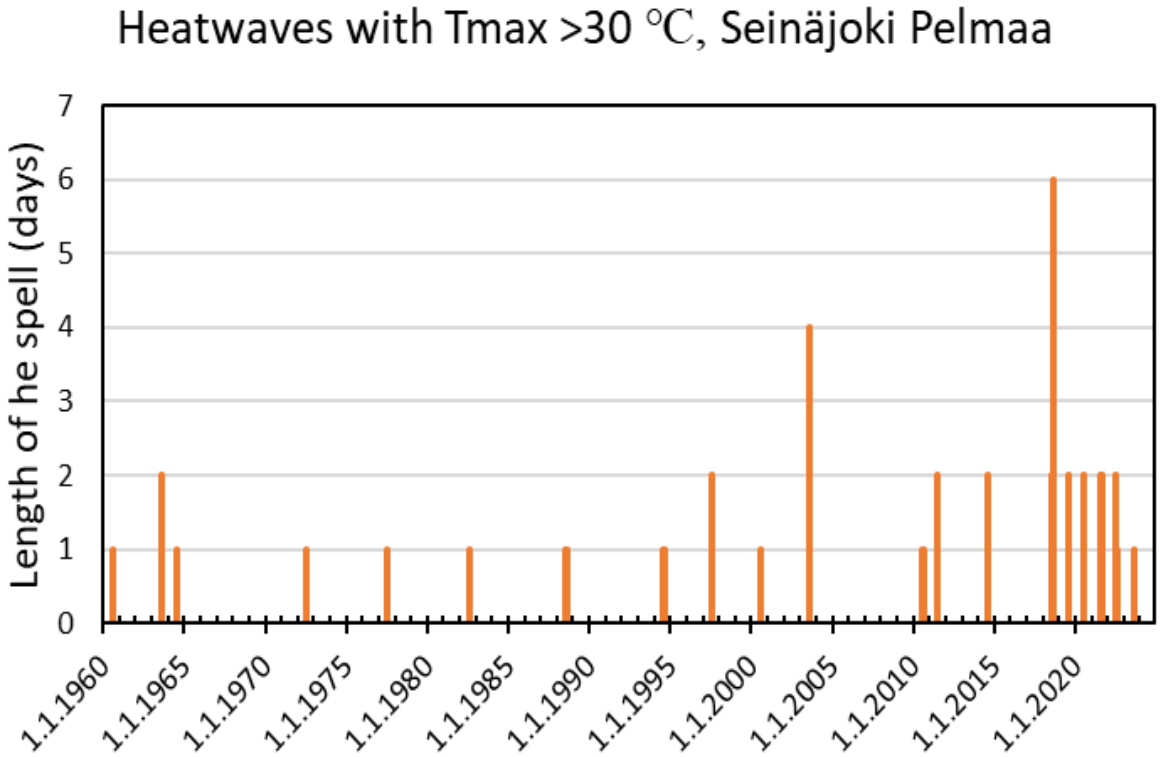
1 Wintertime rains
2 **Heavy/abundant precipitation**; Freezing rain
3 **Heatwaves**; **Snow on the ground**; Snowless period in winter
4 Rapid change in snow cover
5 **Heating needs of buildings**; Number of wet days; Long dry period; **Snow depth or water content**; High temperatures

- The annual mean temperature in **Finland** rises about 1.6 times **faster** than the global average.
- Weather conditions **vary** from year to year — the **trend** towards a warmer climate, with more precipitation in winter, is already evident.
- The warming trend continues inevitably — both **mitigation and adaptation** are needed!



Observations already show a tendency towards fewer cold spells and more frequent heatwaves



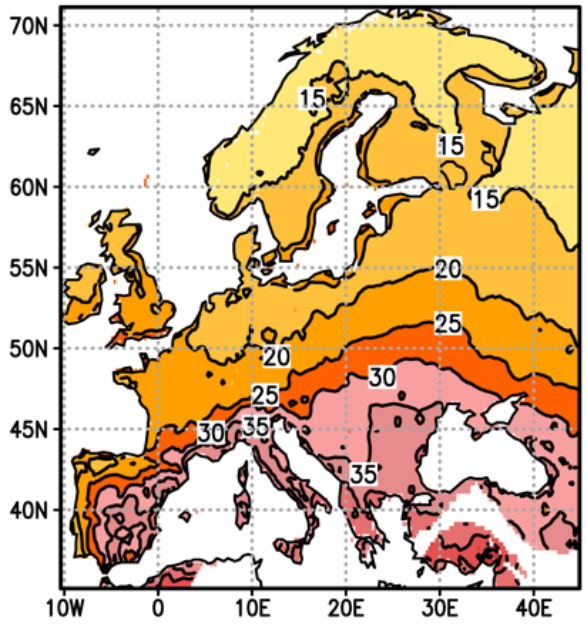


Tmax = Daily maximum temperature

Shown are the **longest period** of each year with Tmax <-10 °C (left) or Tmax >30°C (right)

Heatwaves and cold spells at the 0.5–2.0 °C global warming levels above pre-industrial conditions

From the 0.5°C to the 2.0°C global warming level

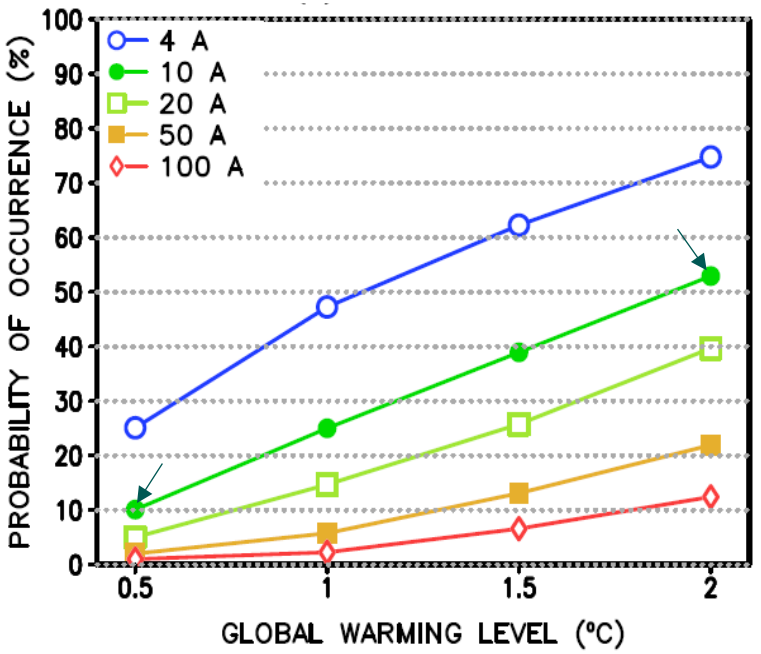


The average **annual number of heatwave days*** will increase ~2 weeks in Finland

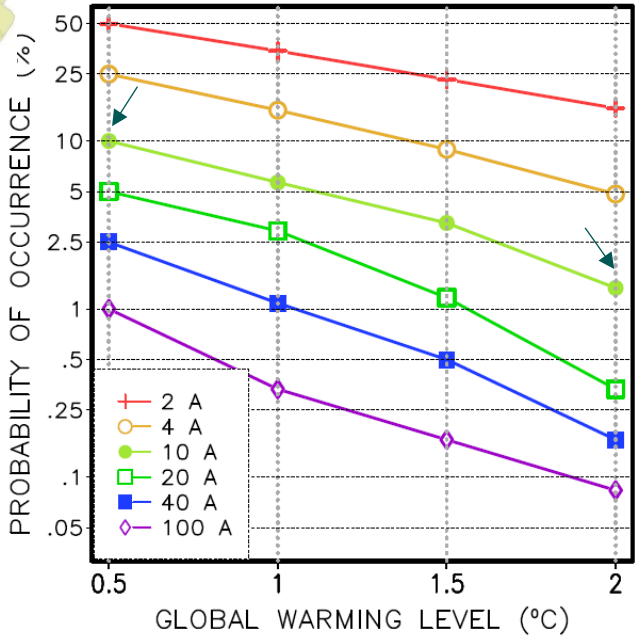
* Tday> 90th percentile for ≥ 3 days

(Ruosteenoja & Jylhä, 2023a, 2023b)

Heatwaves



Cold spells

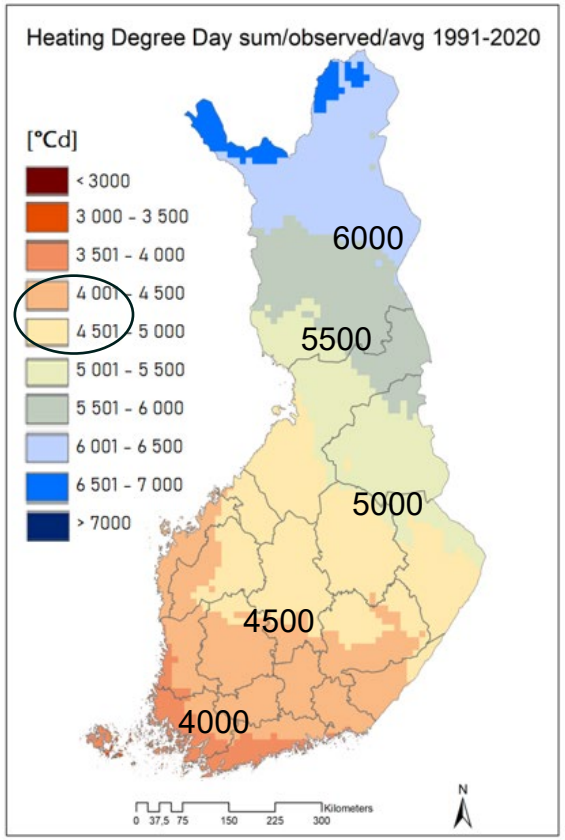


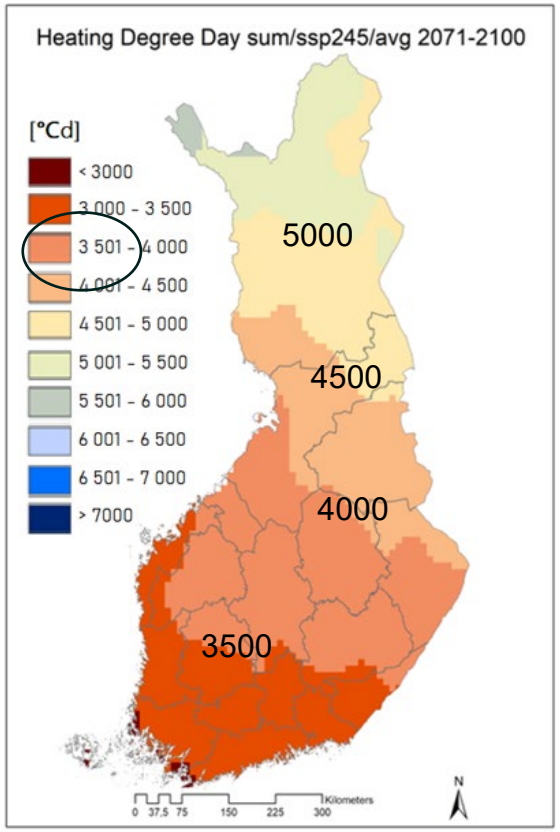
An annual maximum **heatwave** with an extremity index larger than that occurring on average once in **10 years** at the **0.5 °C global warming level** will occur on average once in **2 years** at the **2.0°C global warming level**.

An annual maximum **cold spell** with an extremity index larger than that occurring on average once in **10 years** at the **0.5 °C global warming level** will occur on average once in about **50 years** at the **2.0°C global warming level**.

Projected changes in building energy demand

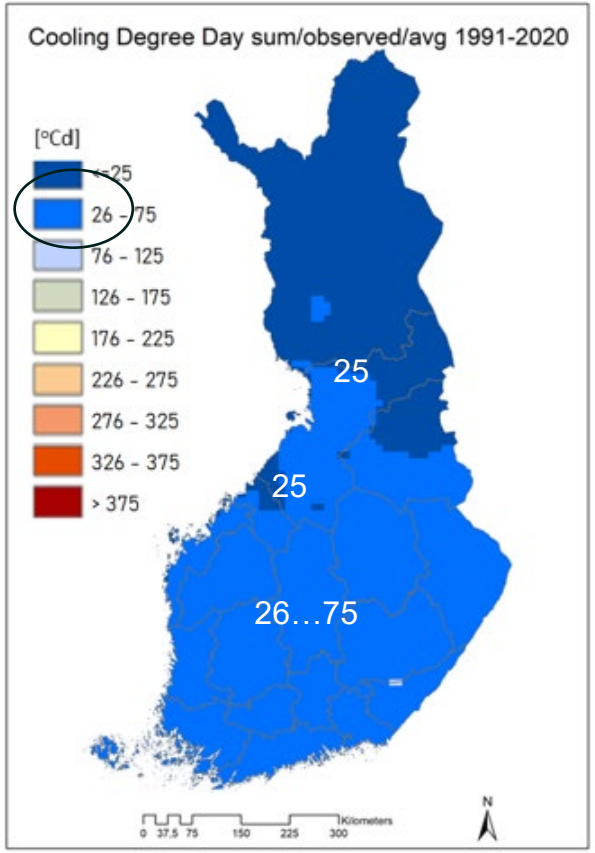
Decreases in heating energy demand

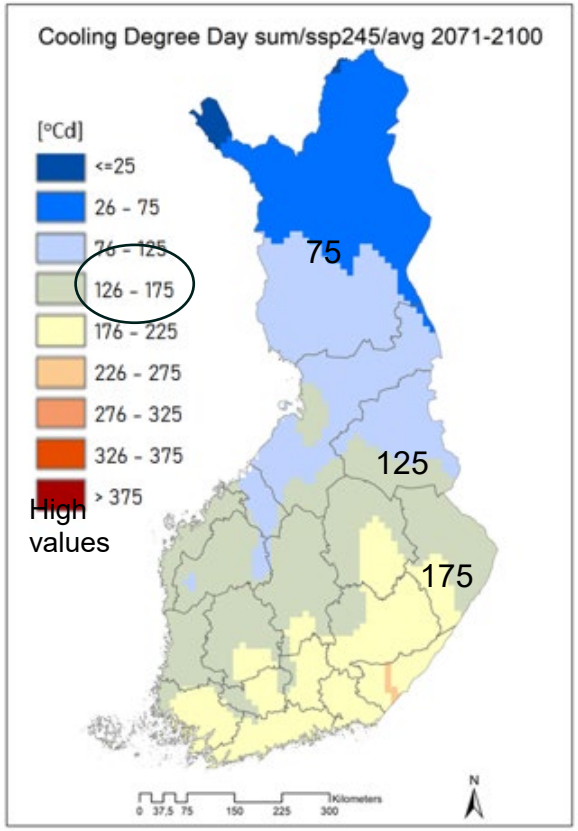




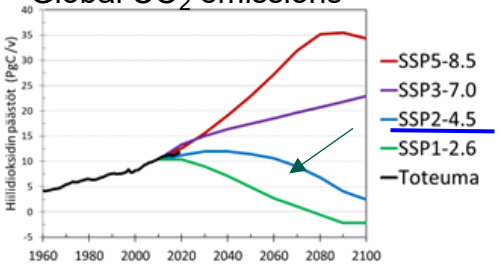
(Pirinen ym., 2024)

Increases in cooling energy demand



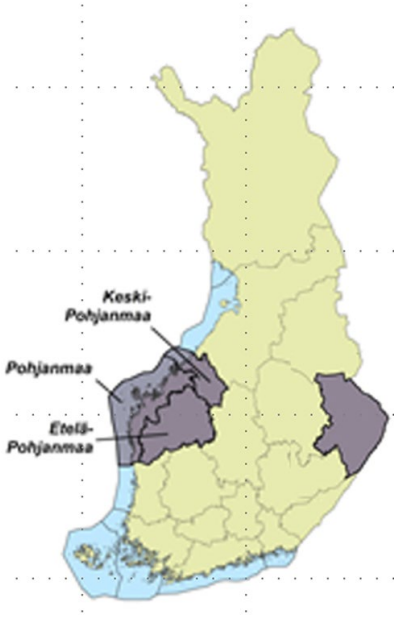


Global CO_2 emissions

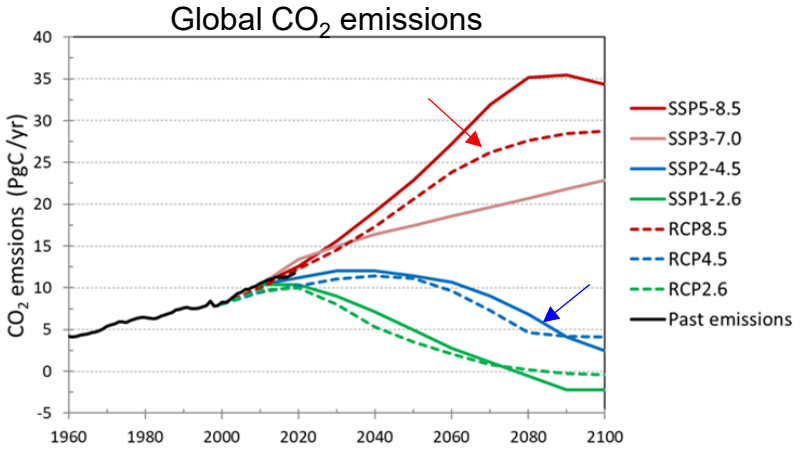


Summary

- The most recent climate projections based on SSP scenarios and simulations with the so-called CMIP6 model generation
  - Regionally targeted and tailored climate scenarios for North Karelia and Ostrobothnian counties
  - General climate projections for the whole country
  - => Benefit also for the other regions



- Next:
  - Future SSP-based future snow scenarios
  - RCP-based regional climate projections for summer precipitation



Future snow scenarios for Northern Europe

Petri Räisänen, Anna Luomaranta & Kirsti Jylhä

Future snow scenarios for Northern Europe

(Petri Räisänen, Anna Luomaranta & Kirsti Jylhä)

Approach

- Scenarios developed using data from CMIP6 global climate models

- 11 Earth System Models selected based on
  * general performance in simulating Northern European climate (Ruosteenoja 2021)
  * comparisons with ERA5-Land snow data (Jokioinen & Sodankylä)

- Weighting based on Transient Climate Response to avoid a “hot model” bias

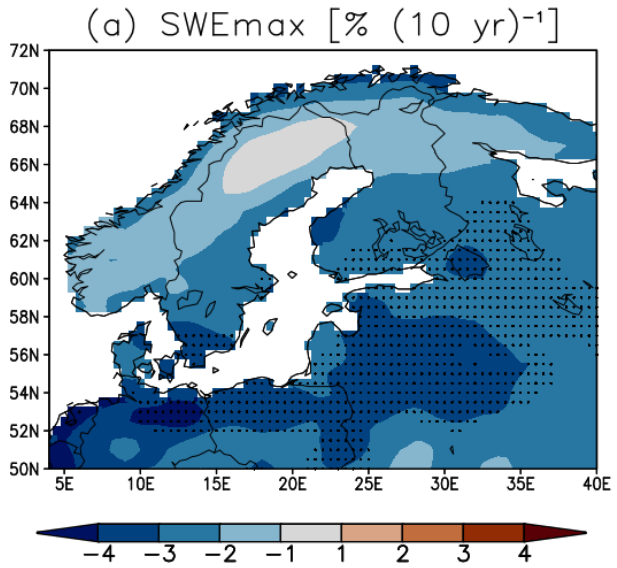
Focus on

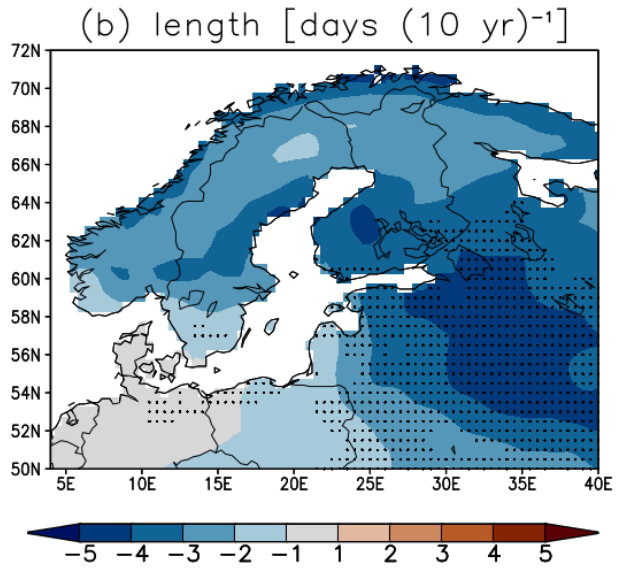
- winter’s SWE maximum
- length / start / end of the longest continuous snow period

Multi-model mean trends over 2023-2100

Moderate emission scenario SSP245

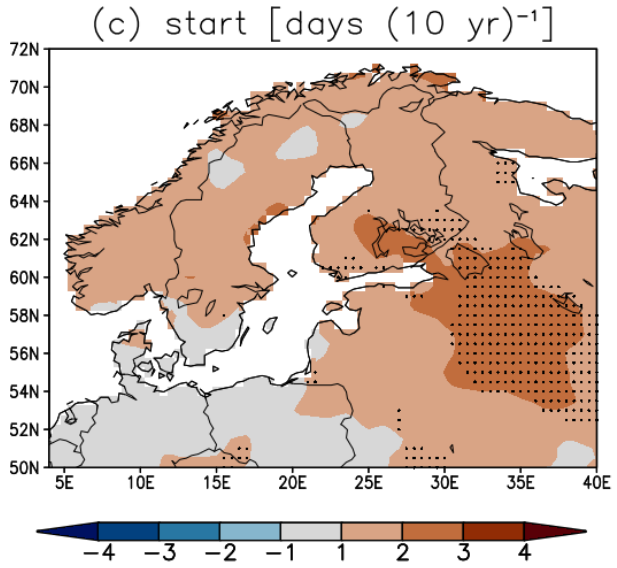
Maximum snow loads reduced, especially in the south

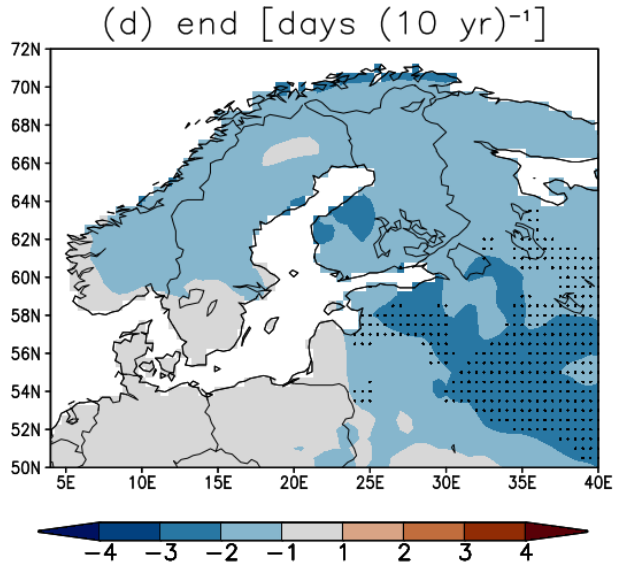




Snow season length reduced

Snow season start delayed



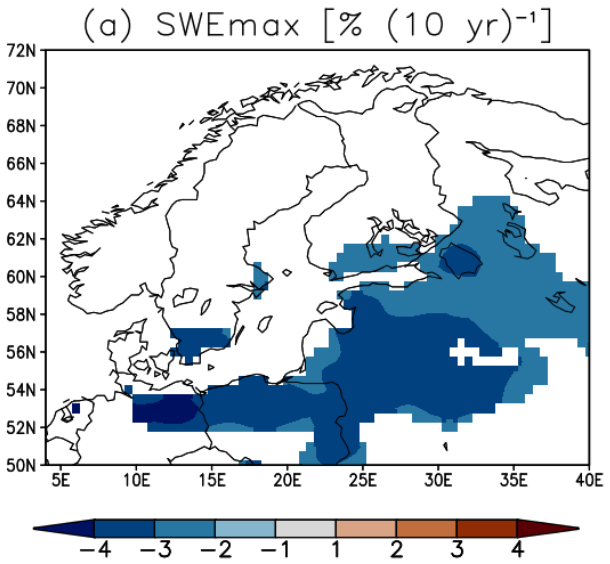


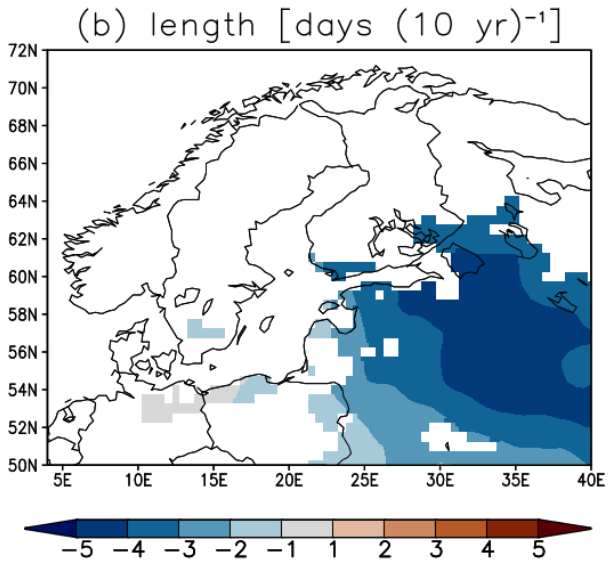
Snow season end advanced

Trends significant at the 90% confidence level

(i.e., the 5-95% uncertainty range does not include zero)

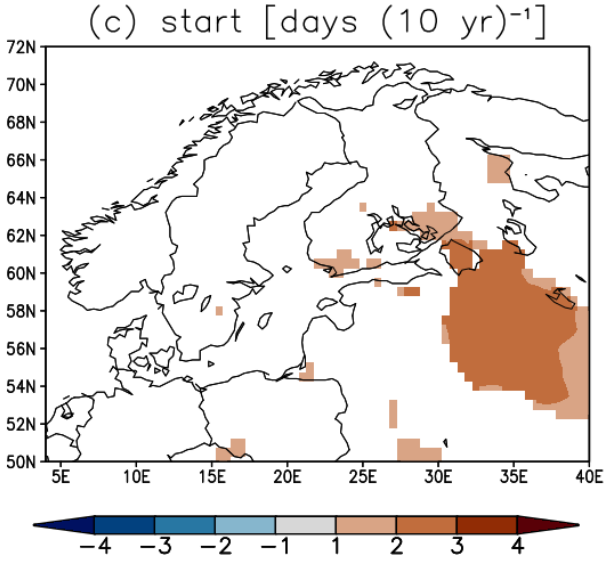
Maximum snow loads reduced, especially in the south

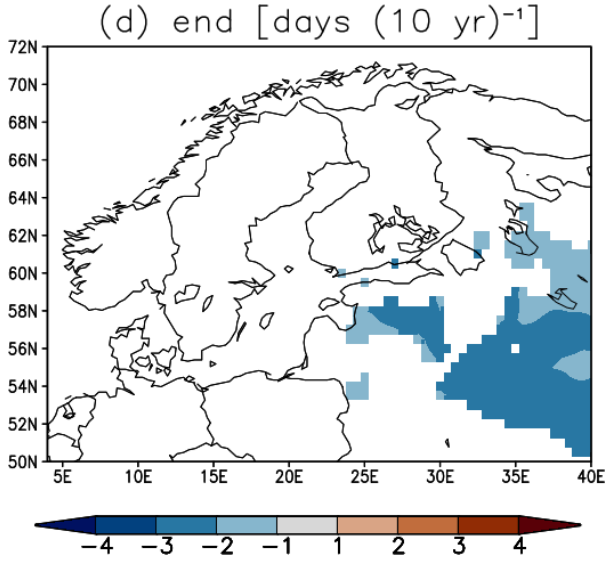




Snow season length reduced

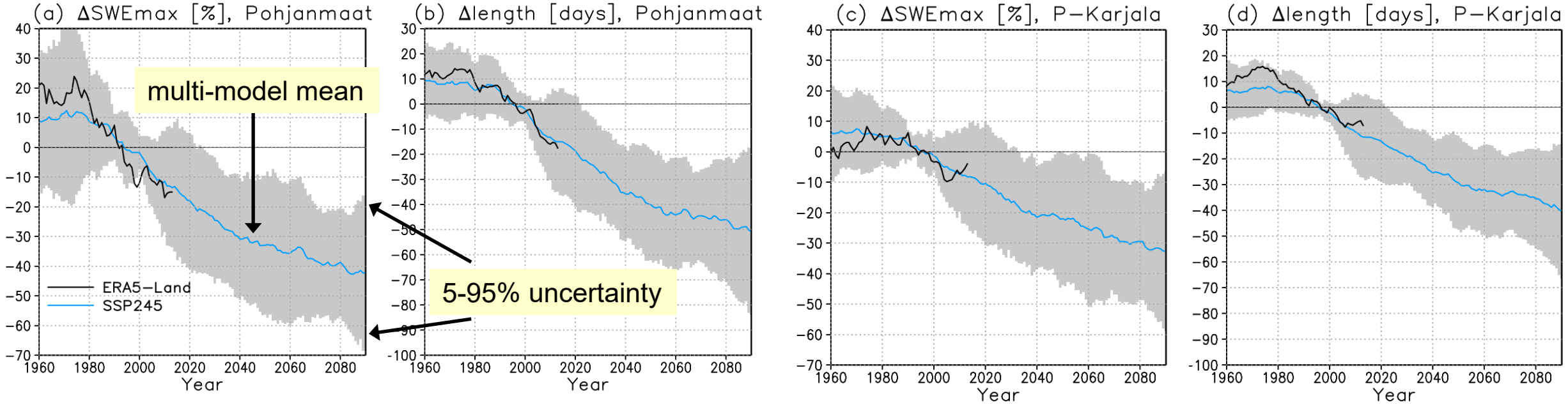
Snow season start delayed





Snow season end advanced

20-year running-mean differences to 1981-2010, “Ostrobothnias” and North Karelia (SSP245)



Ostrobothnia + southern & central Ostrobothnia

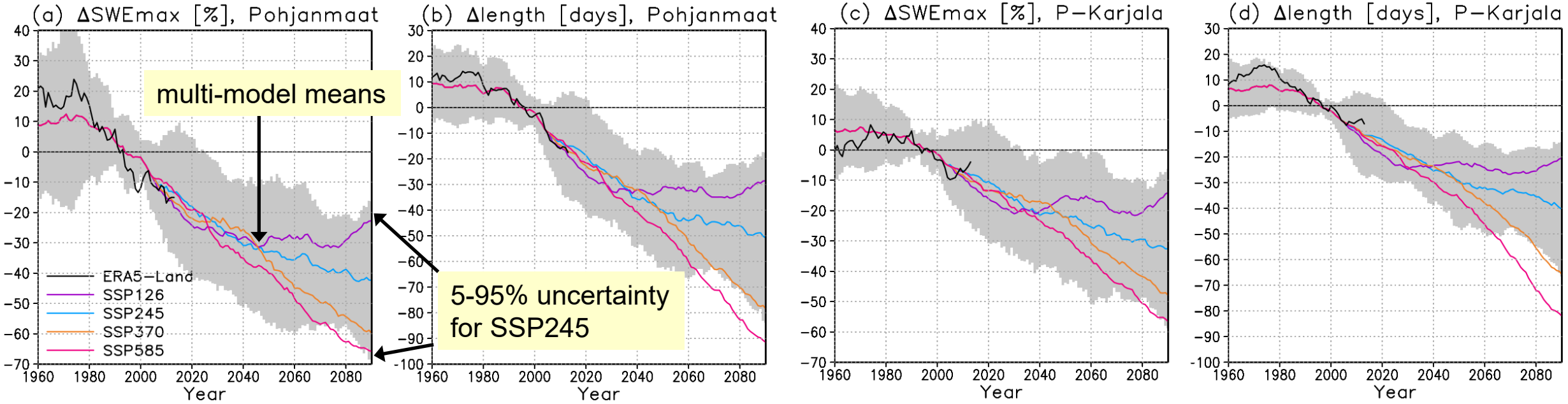
- **In year 2024**, the multi-model mean maximum SWE is 21% lower and the snow season is 22 days shorter than in 1981-2010
- **In year 2090**, the maximum SWE is 42% lower and the snow season is 51 days shorter

North Karelia

- **In year 2024**, the multi-model mean maximum SWE is 13% lower and the snow season is 16 days shorter than in 1981-2010
- **In year 2090**, the maximum SWE is 33% lower and the snow season is 40 days shorter

The spread (5-95% uncertainty) around the multi-model mean (MMM) is substantial …

20-year running-mean differences to 1981-2010, scenarios SSP126, SSP245, SSP370 & SSP585



- As expected, the multi-model mean changes are larger for scenarios with larger radiative forcing (after ca. 2040)
- The multi-model means for the other scenarios stay mostly within the 5-95% uncertainty range of SSP245 (except for SSP585 towards the end of 21st century)

Snow scenarios: concluding remarks

CMIP6 multi-model mean results indicate that with progressing climate warming, snow is generally reduced

- maximum SWE is reduced
- snow seasons will be shorter, start later and end earlier
- the changes are larger for emission scenarios with larger radiative forcing

However, there is substantial quantitative uncertainty in the future snow trends, even for a fixed emission scenario

- both due to modelling uncertainty and internal ("random") climate variability
- for long-term (2023-2100) trends for the SSP245 scenario, the 1-sigma uncertainty due to internal climate variability alone is at least 30-50% of the multi-model mean trends

Räisänen, P., A. Luomaranta and K. Jylhä, 2024: Future snow scenarios for Northern Europe based on Coupled Model Intercomparison Project phase 6 data. Int. J. Climatology, submitted 30 Aug 2024.

RCP-based regional climate projections: Summer precipitation

Laura Utriainen, Meri Virman, Anton Laakso, Jenna Ritvanen, Kirsti Jylhä, and Joonas Merikanto

RCP-based regional climate projections: Summer precipitation

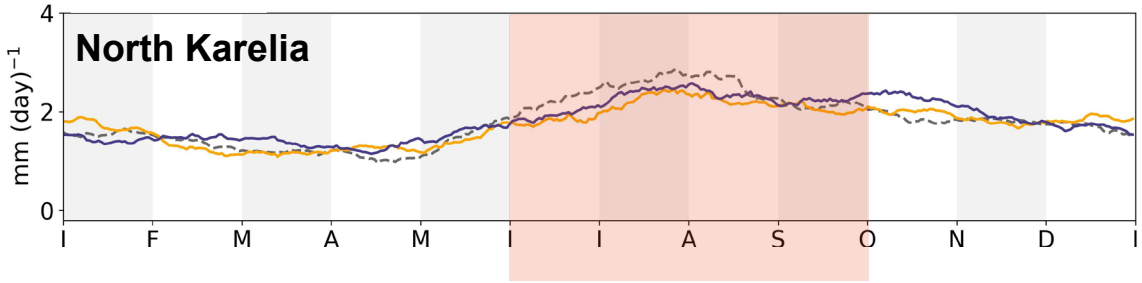
Less frequent but more intense summertime precipitation in Finland: Results from a convection-permitting climate model

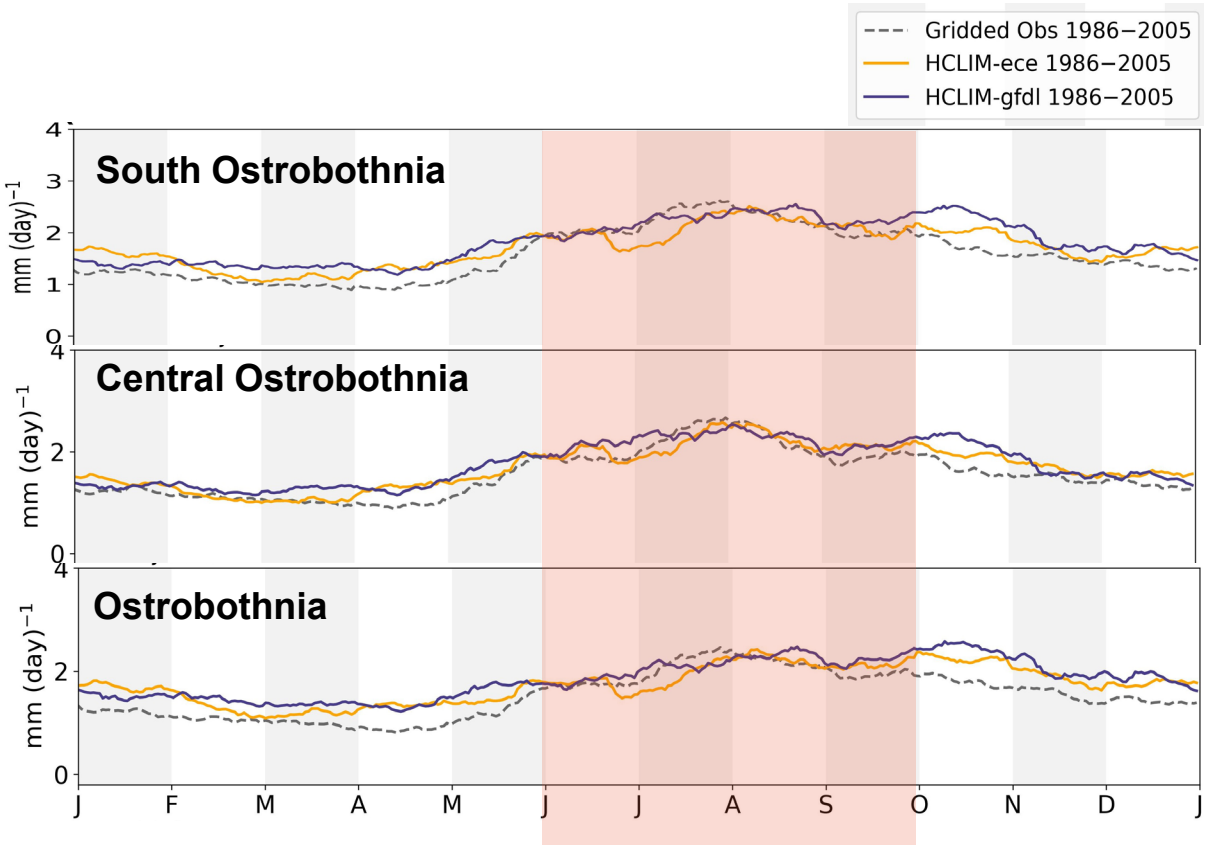
Laura Utriainen, Meri Virman, Anton Laakso, Jenna Ritvanen, Kirsti Jylhä, and Joonas Merikanto

Submitted in Boreal Environments Research in July, 2024

- ***HARMONIE-Climate model (3 km x 3 km)***
- Verified against multiple observational datasets in Nordics and in Finland

- *Added-value:* Sub-daily and daily precipitation
- *Summertime:* June, July, August, September





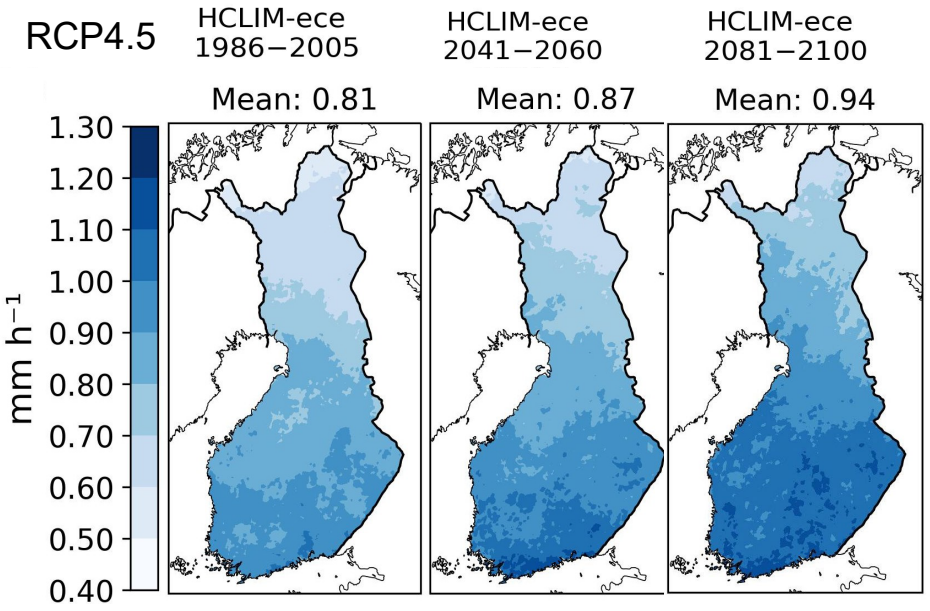
**HCLIM = HARMONIE-Climate model*

RCP-based regional climate projections: Sub-daily summer precipitation

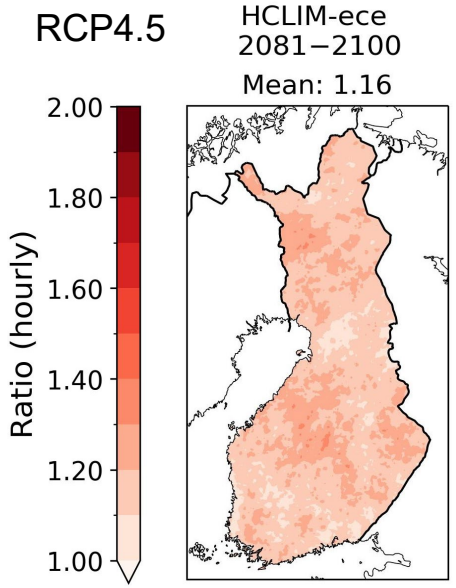
A) Results:

1. Mean *wet hour intensity (mm/h) increases in Finland already in mid-century and further in late century

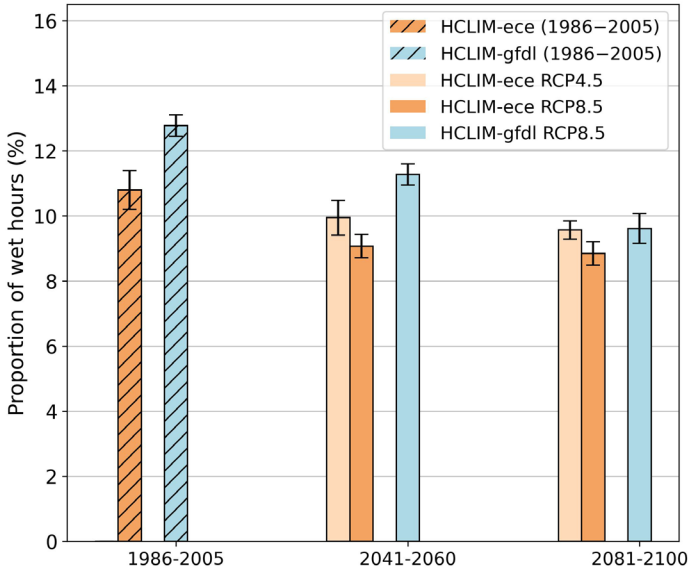
**Wet hour ≥ 0.1 mm/h*



2. Increase happens at the same rate everywhere in Finland



3. The wet hour frequency decreases in summertime



HCLIM = HARMONIE-Climate model

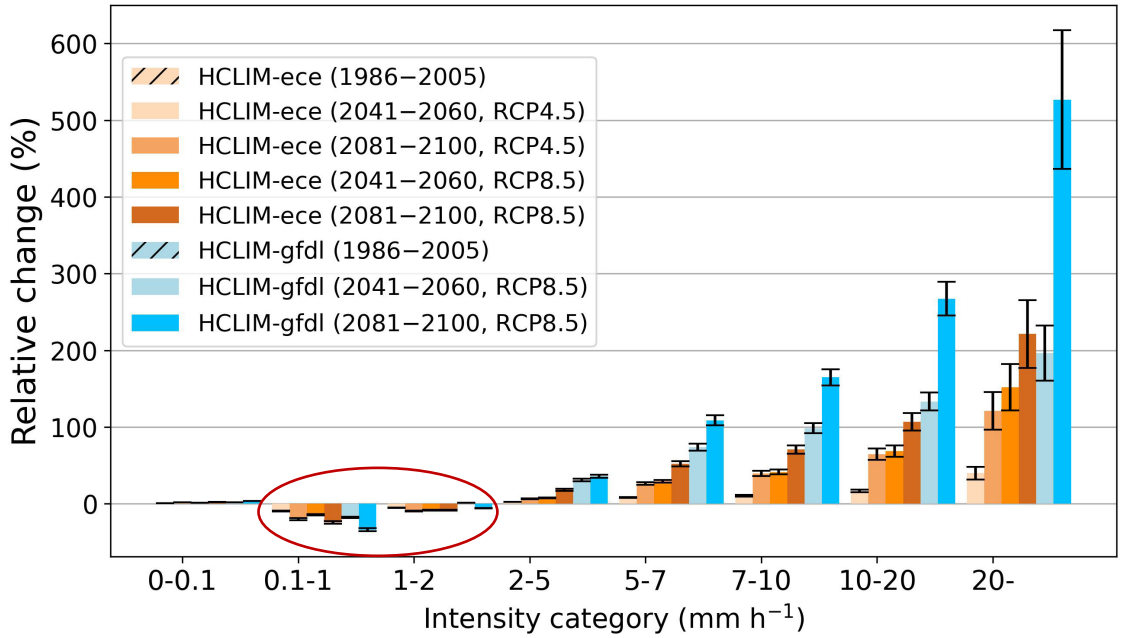
RCP4.5 = Moderate scenario
(emissions peak at 2040 and then decline)

RCP8.5 = Pessimistic scenario
(emissions continue to rise throughout the century)

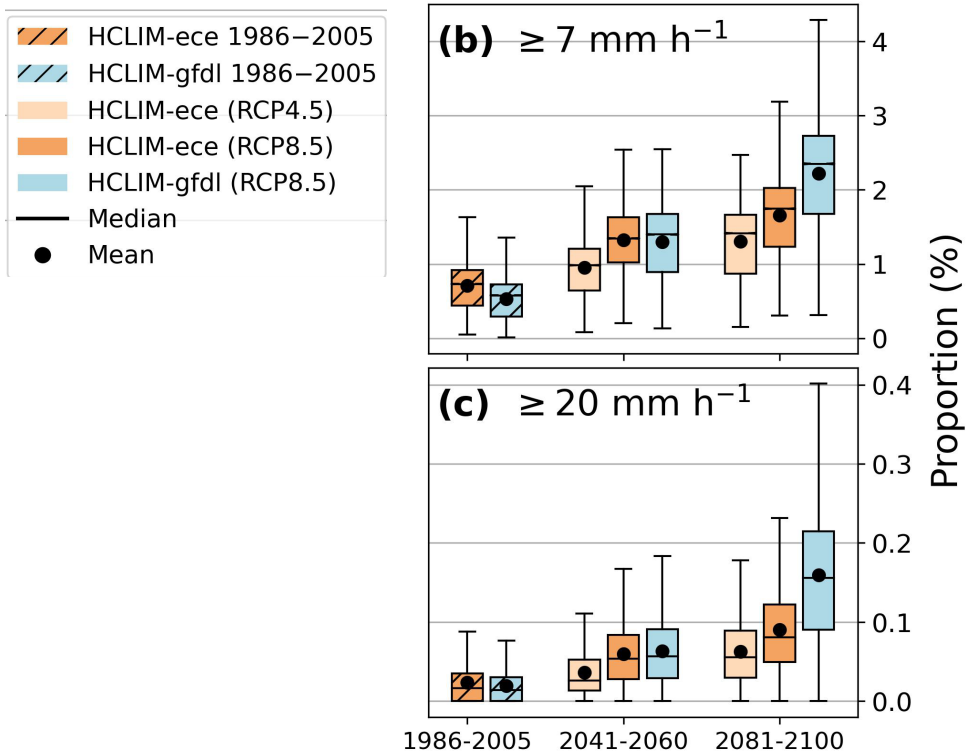
RCP-based regional climate projections: Sub-daily summer precipitation

B) Results:

1. The frequency of light hourly precipitation events decrease while freq. of ≥ 2 mm/h events increase
e.g. In RCP8.5, freq. ≥ 20 mm/h events become 2–3x as common in mid-century and 3–6x in late century



2. Events of 7 mm/h (*heavy rain FMI*) and 20 mm/h (*national alert threshold in FMI*) contribution to overall wet hours increases.



*HCLIM = HARMONIE-Climate model

RCP-based regional climate projections: Summary

1. Regional model HCLIM (3 km x 3 km) **represents very well small-scale events** like sub-daily summer precipitation.

2. It **rains most during summertime** in North Karelia, South Ostrobothnia, Central Ostrobothnia, and Ostrobothnia (as well as in Finland generally)

3. **Mean wet hour precipitation increases** already in mid-century and continues to increase in late-century (both RCP4.5 and RCP8.5) and the rate is uniform across Finland.

4. Wet hours are projected to become **less frequent**

5. Frequency of **light rain decrease**, while freq. of **moderate and heavy rain increases**

6. Heavy rain 7 mm/h and national alert limit 20 mm/h contributions to all wet hours increase