

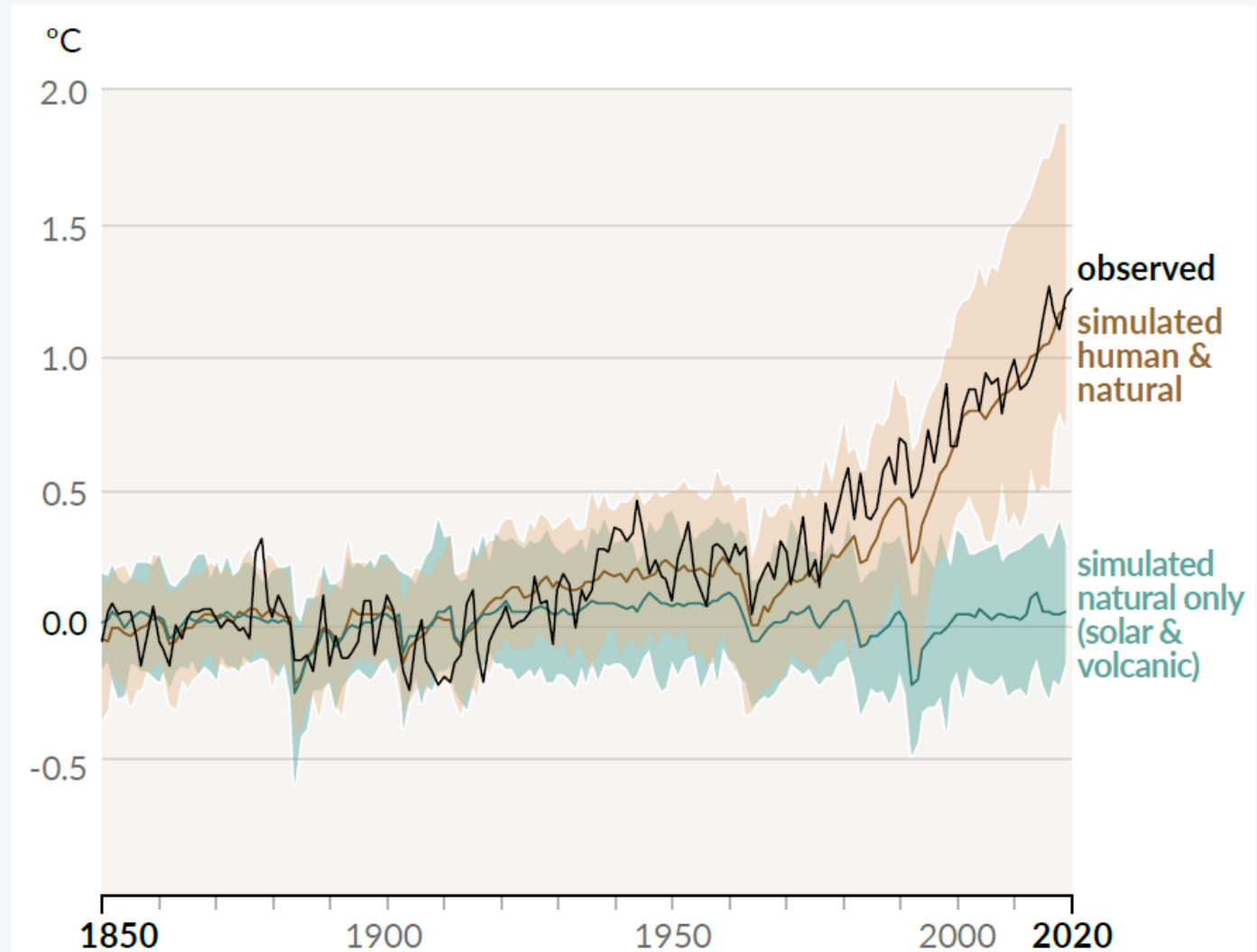
Climate projections for the Baltic Sea Region

Erik Kjellström
Rosby Centre, SMHI

1st WaterMan & ERB Water Core Group Dialogue Forum
8 November 2023

Earth is getting warmer due to human activities

- The past climate change cannot be explained taking into account only natural forcing
- The past climate can be understood taking into account anthropogenic forcing



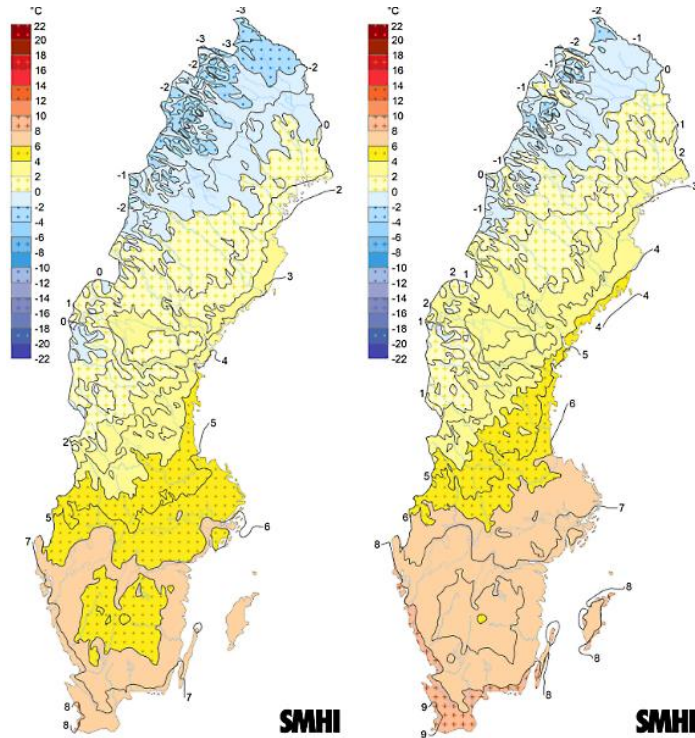
Strong warming in our region

SMHI

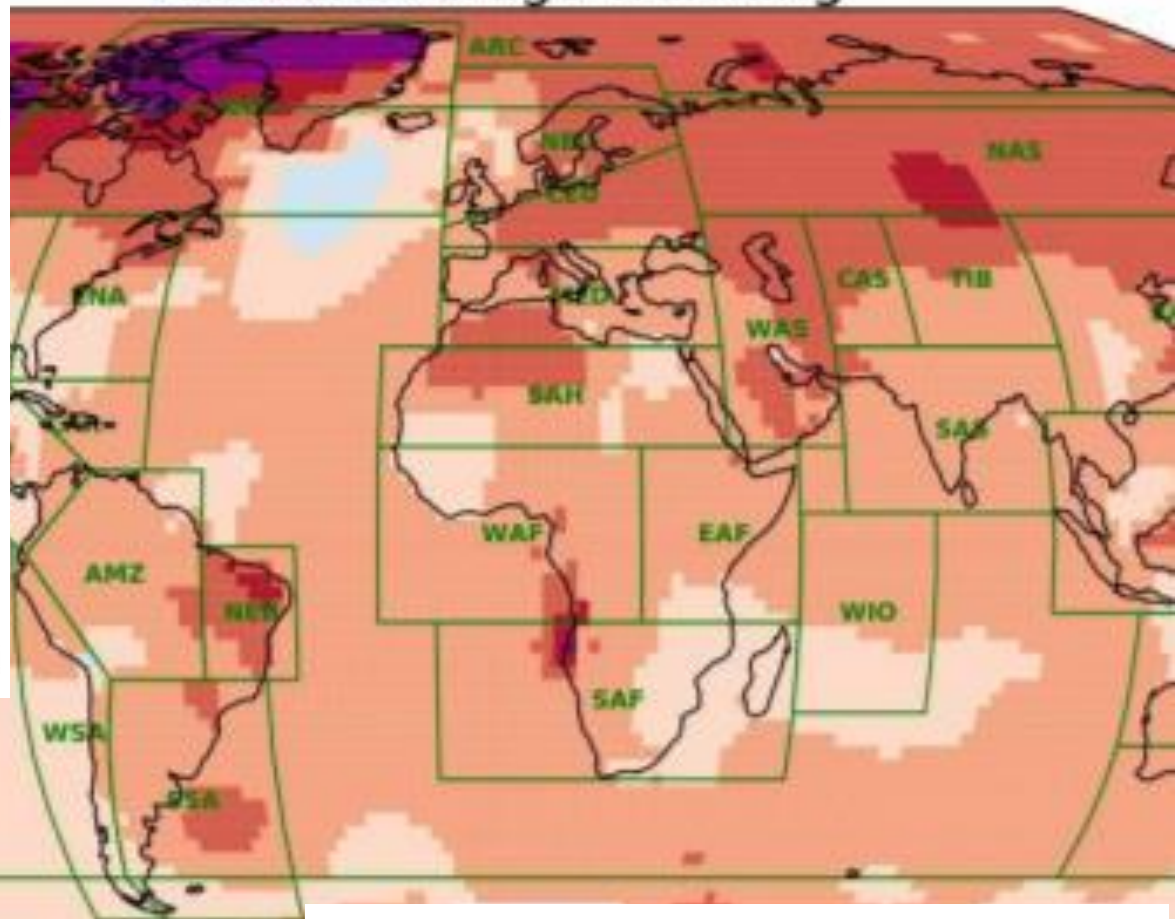
Annual mean temperature

1961-1990

1991-2020



Annual average warming

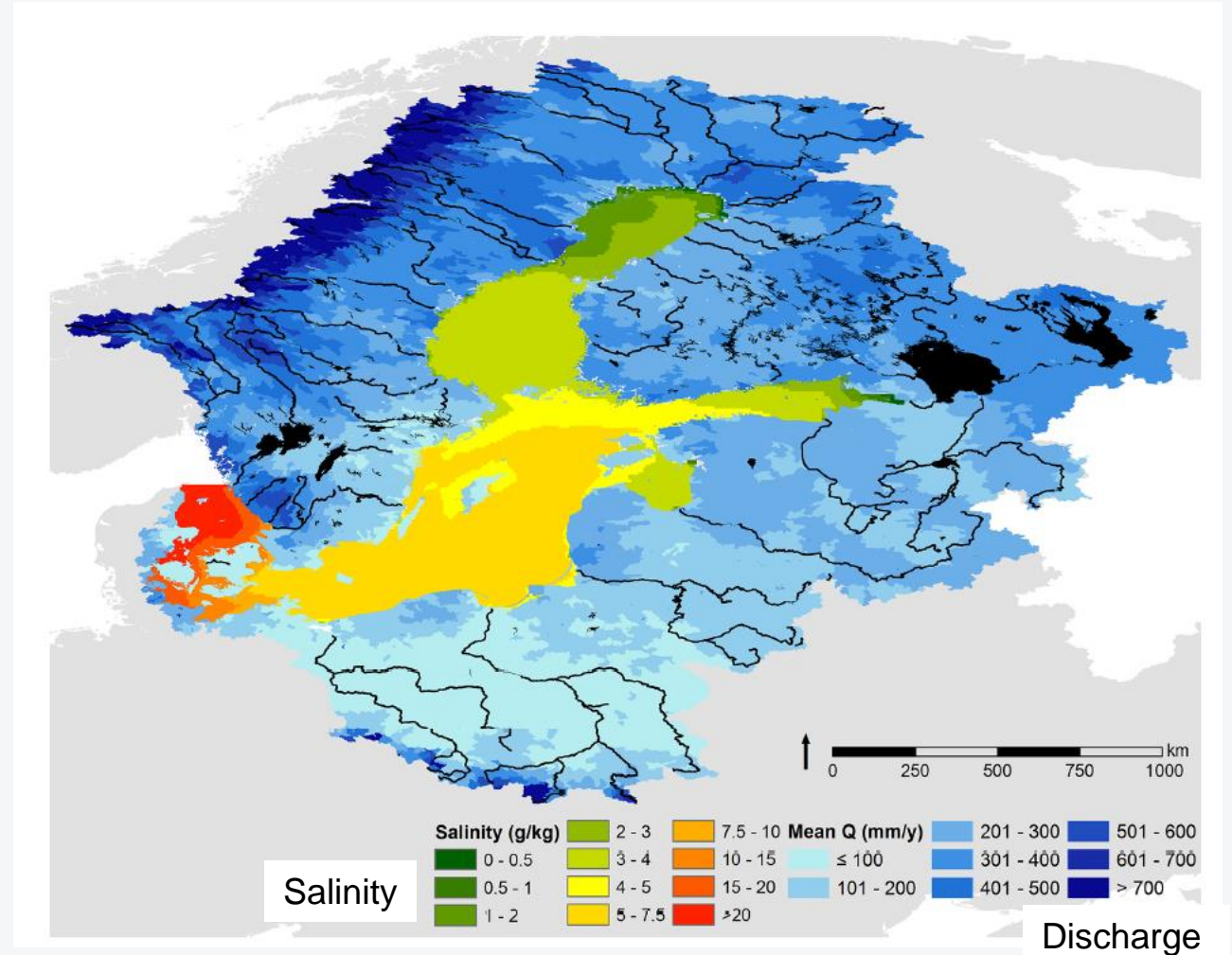
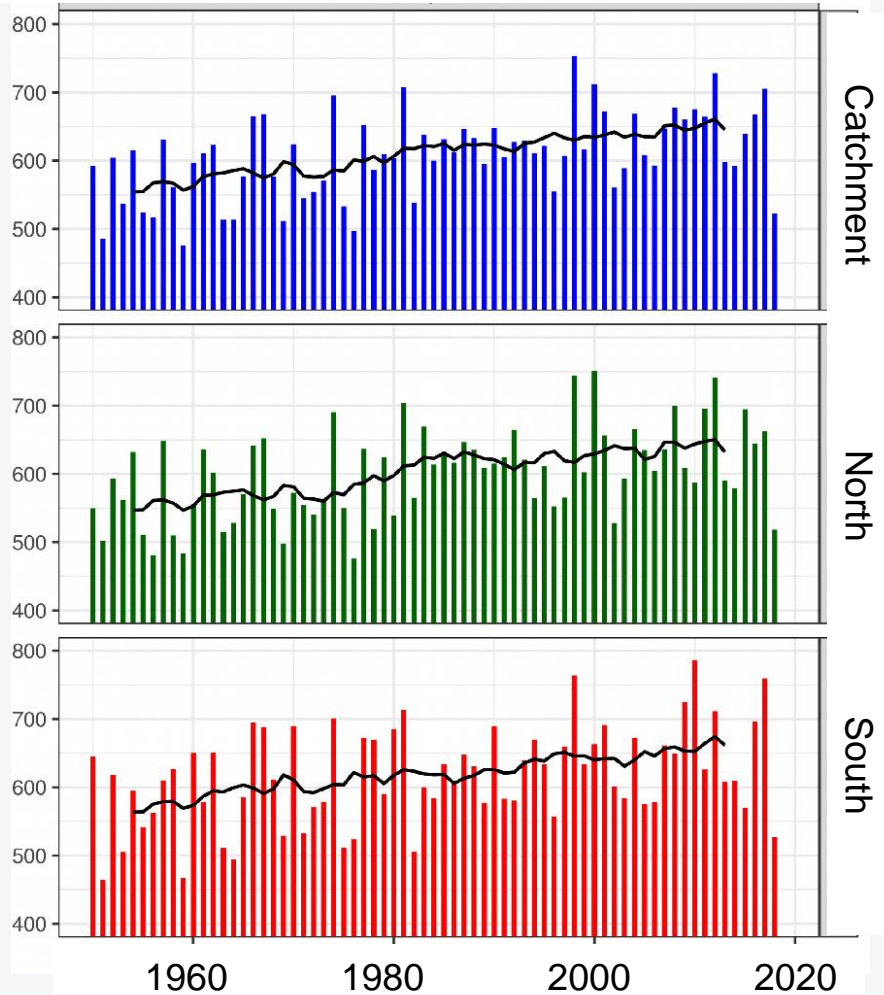


+1,1°C

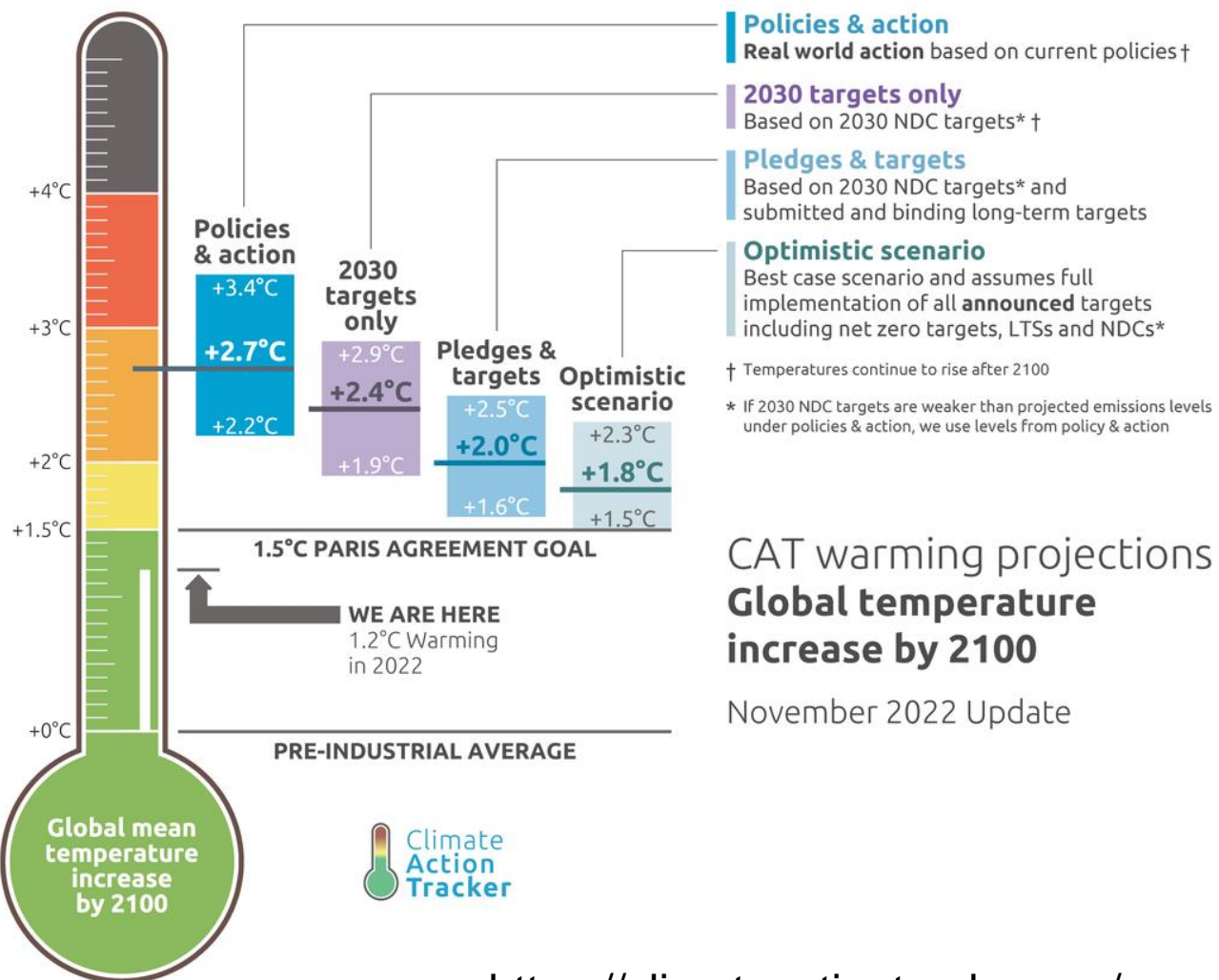
IPCC SR1.5: 2006-2015 compared to 1850-1900

Precipitation has been increasing

Precipitation (mm/year)



The future is (un)certain



Warming will continue:

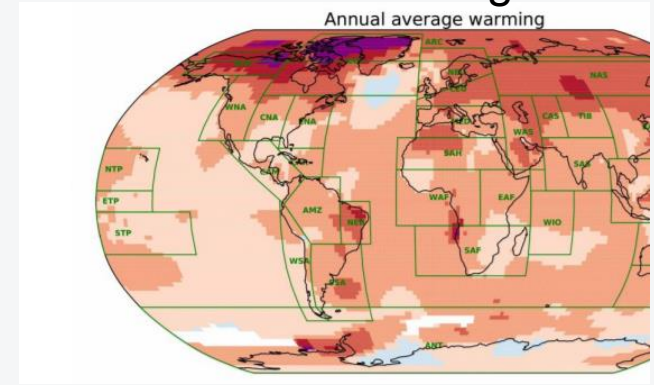
How much?

- Current warming rate c. 0.2°C per decade
- Reaches 1,5°C in < 20 years
- Reaches 2°C in an additional 25 years

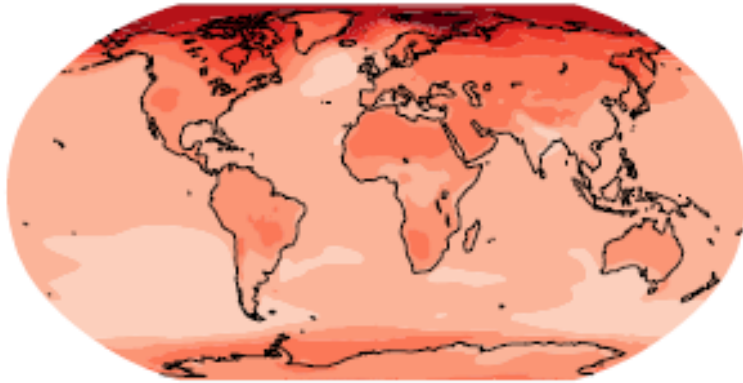
Uncertain about longer time scales

The warming will continue

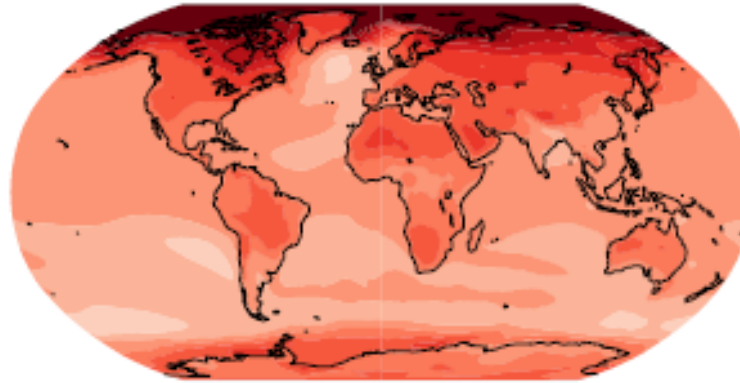
Observed changes



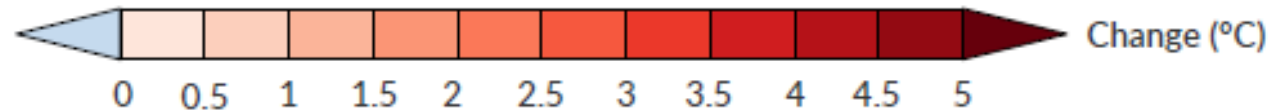
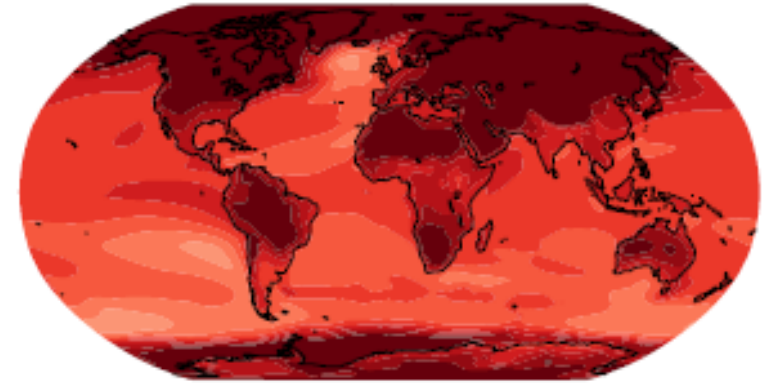
Change at 1.5°C global warming



Change at 2°C global warming

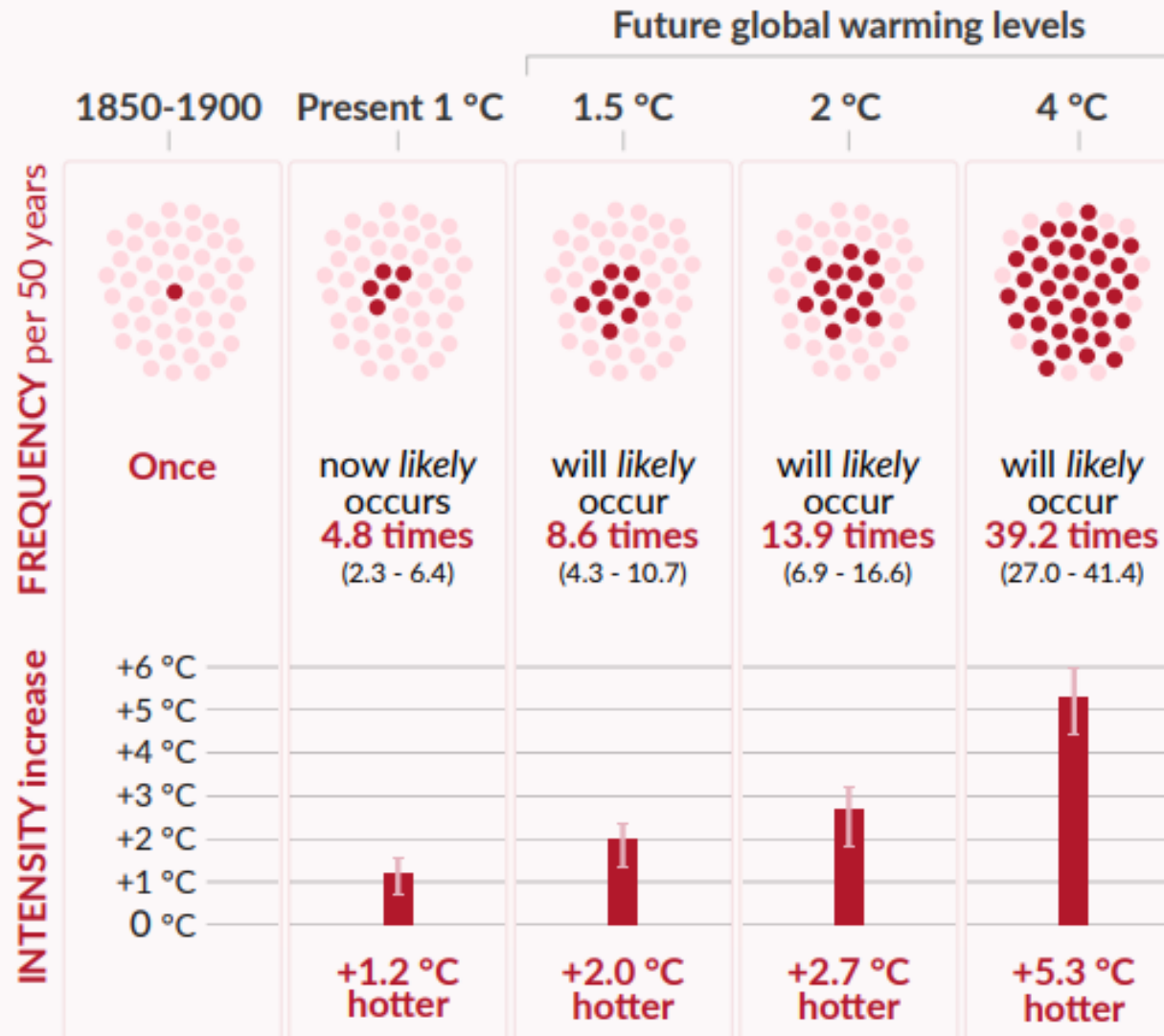


Change at 4°C global warming



Almost linear relation between global mean temperature increase and accumulated CO₂ emissions

Changing temperature extremes



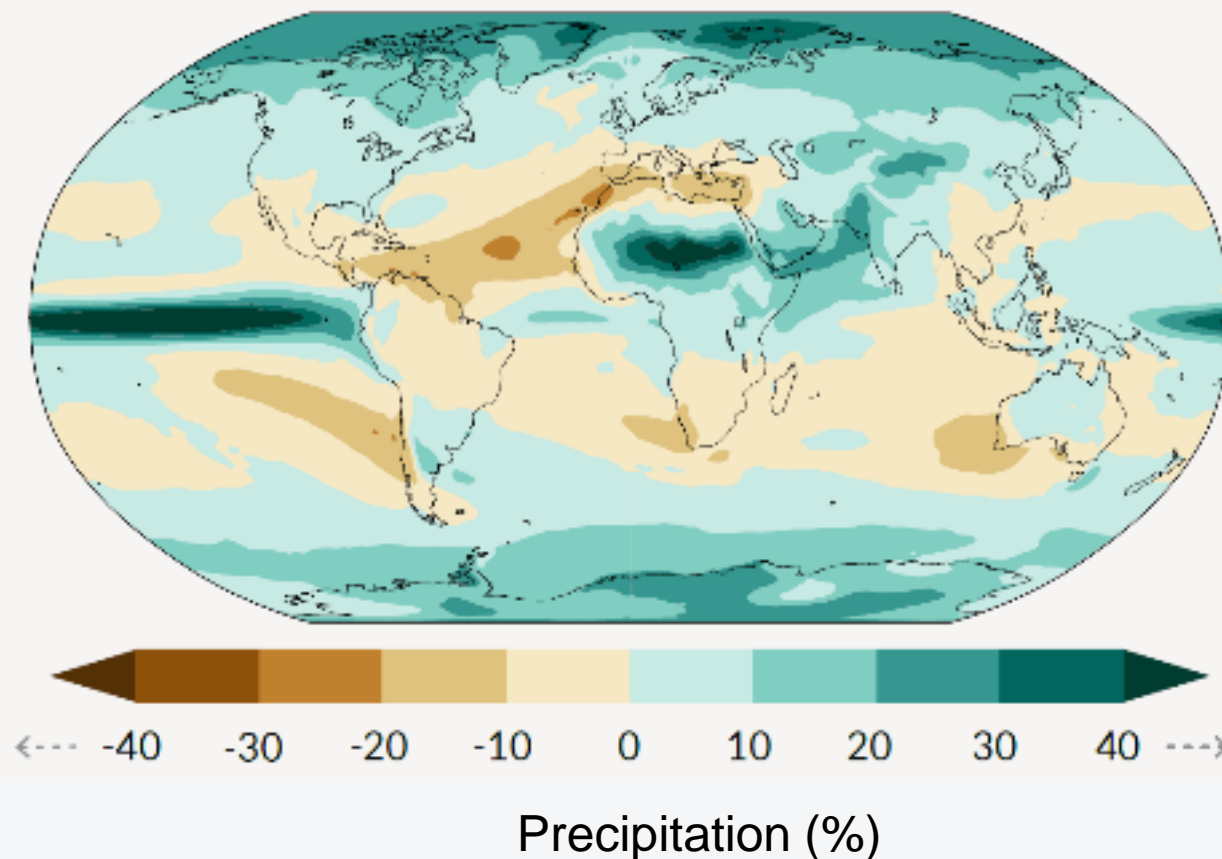
Ex. Heat wave over land, 50 year return time

- Has been more frequent and intense
- Will continue to become more frequent and intense

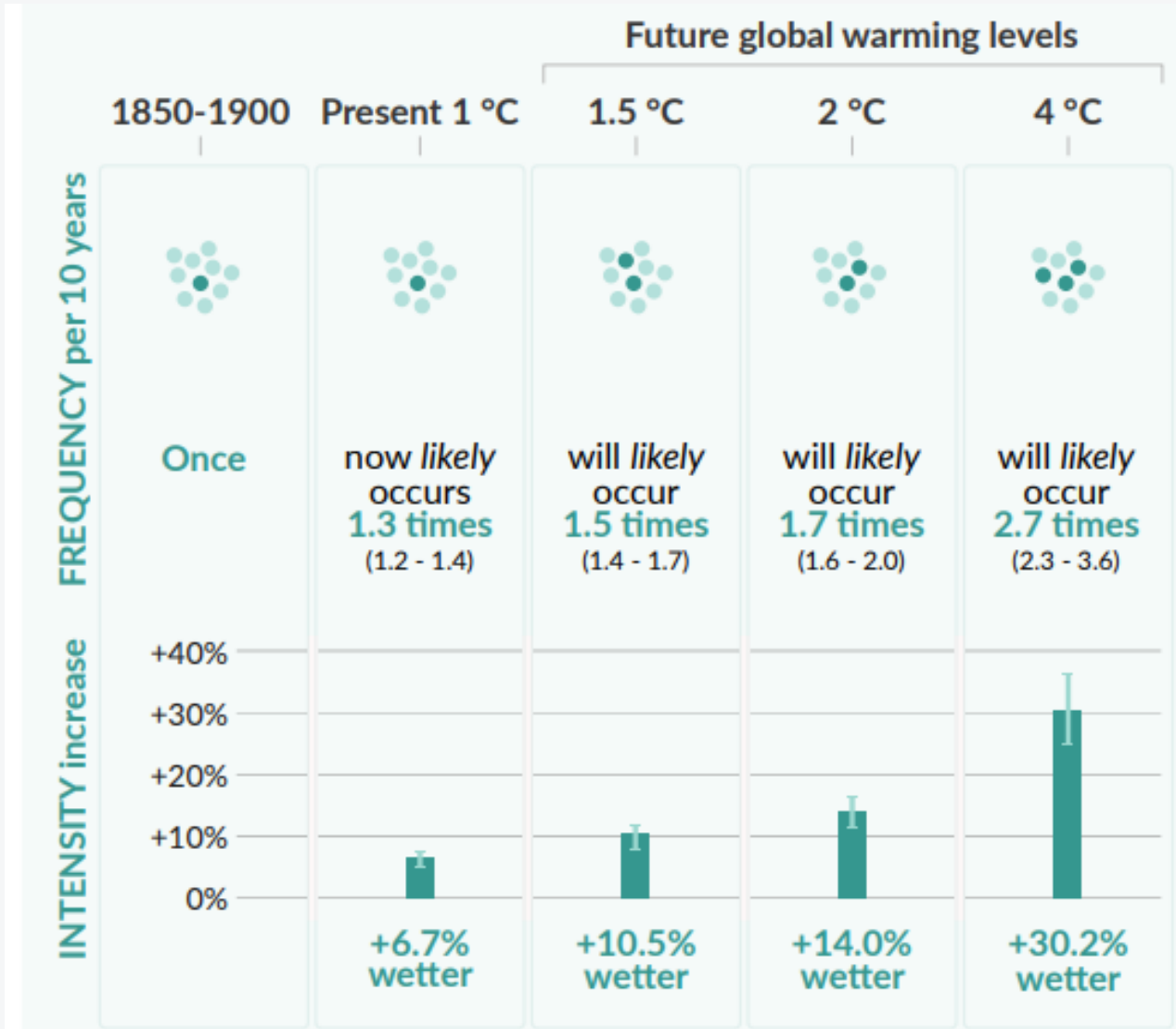
More intense hydrological cycle

- A warmer atmosphere can contain more water vapor
- Increased evaporation
- Intensifying precipitation
- Increased risk of drought
- Larger variability in precipitation
- Larger differences between "wet" and "dry"

At +2°C global warming



Changing precipitation extremes



Ex. Intense precipitation over land, 10-year return period

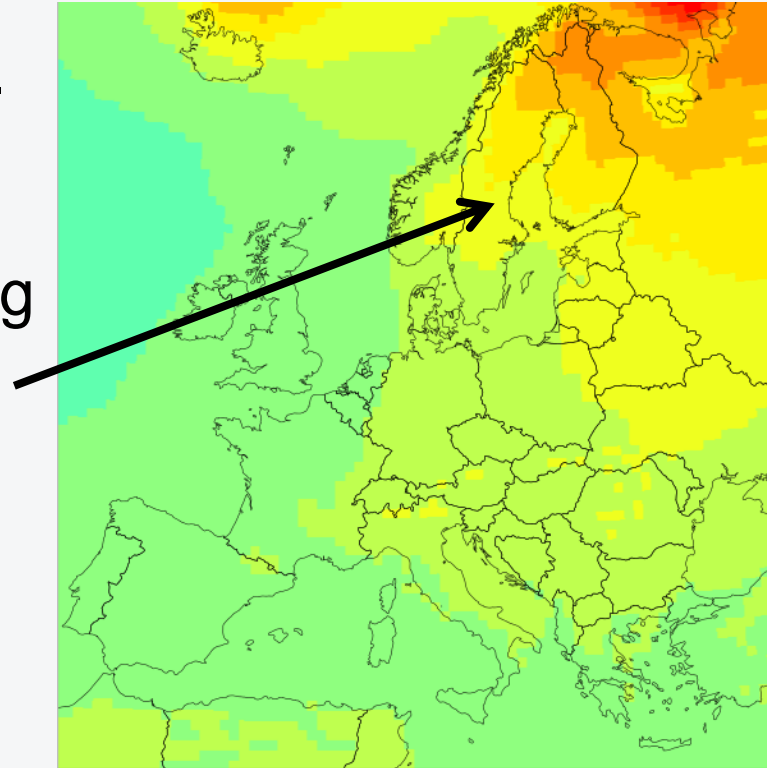
- Has been more frequent and intense
- Will continue to become more frequent and intense
- *Increase also in areas where total precipitation will decrease*

Climate change in Europe

Temperature change (°C) 1971-2000 to 2071-2100 following RCP4,5

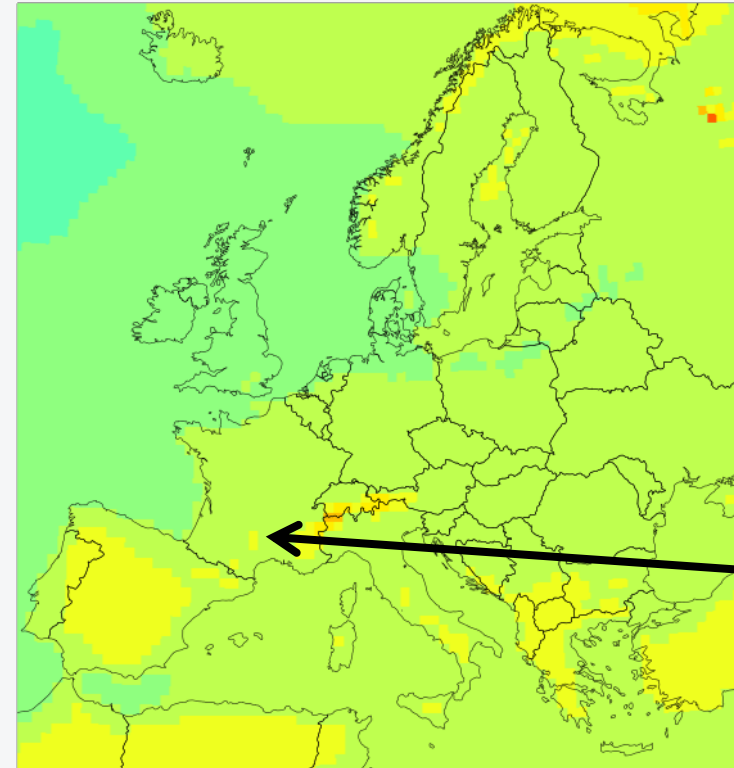
It gets warmer.

Especially in the north during winter ...



1 2 3 4 5 6 7 8 9 10 11

tas (°C)

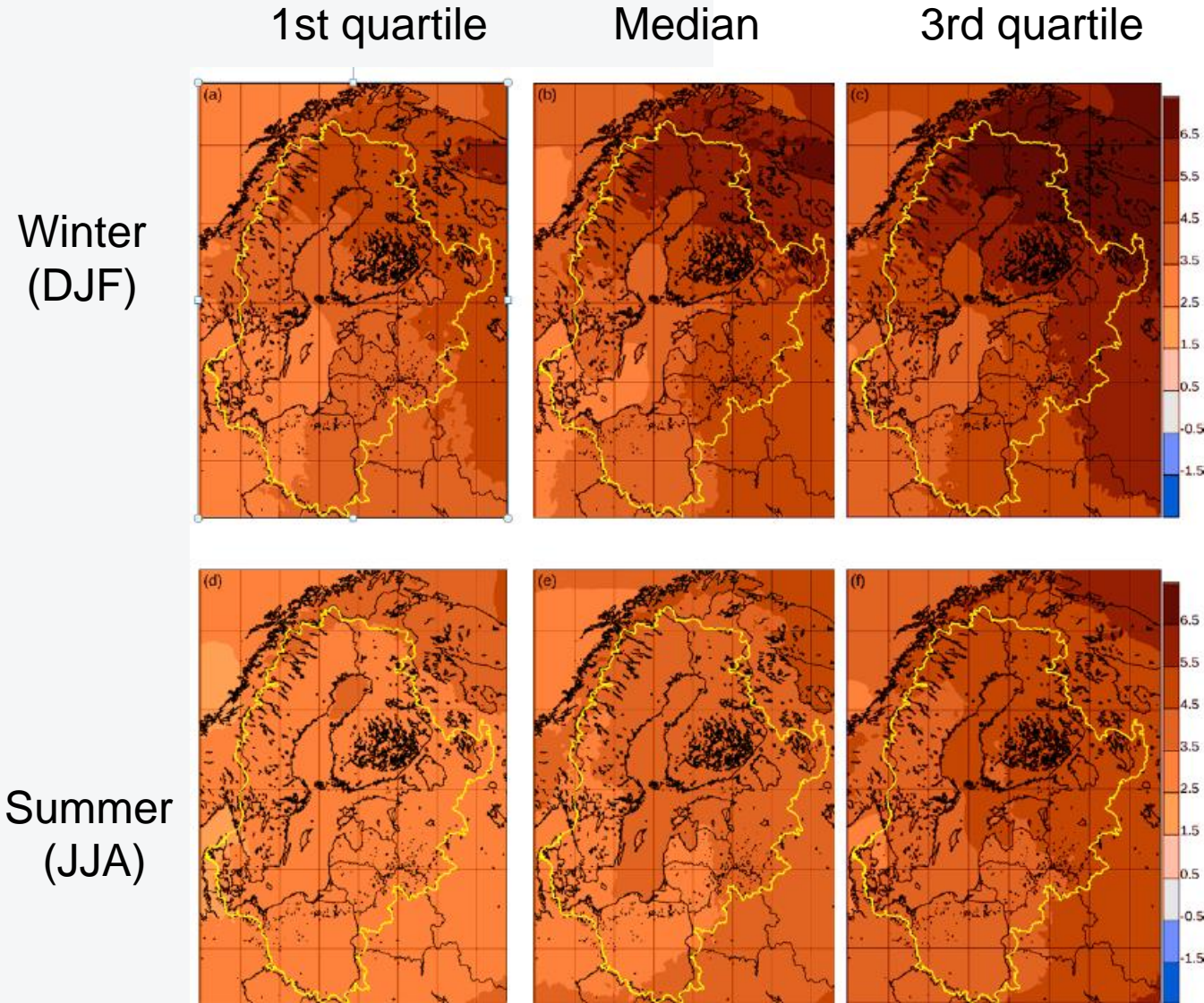


1 2 3 4 5 6 7 8 9 10 11

tas (°C)

... and in the south during summer

Warmer



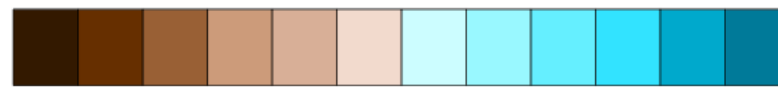
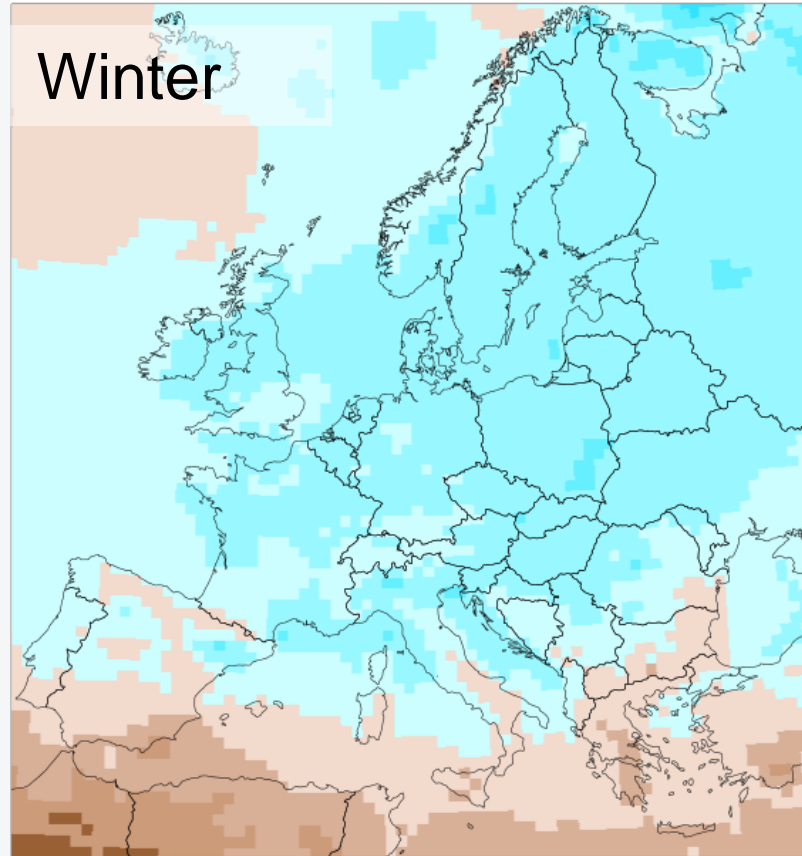
- Warmer in all the region
- Strongest warming in winter
- Strongest warming in the northeast
- Relatively similar between models

Christensen et al. Earth Syst. Dynam., 2022
124 RCM projections (11 RCMs, 8 GCMs, 3 RCPs)

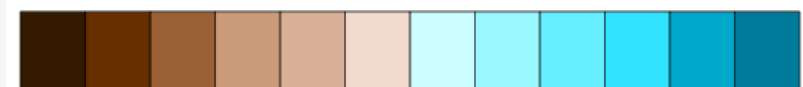
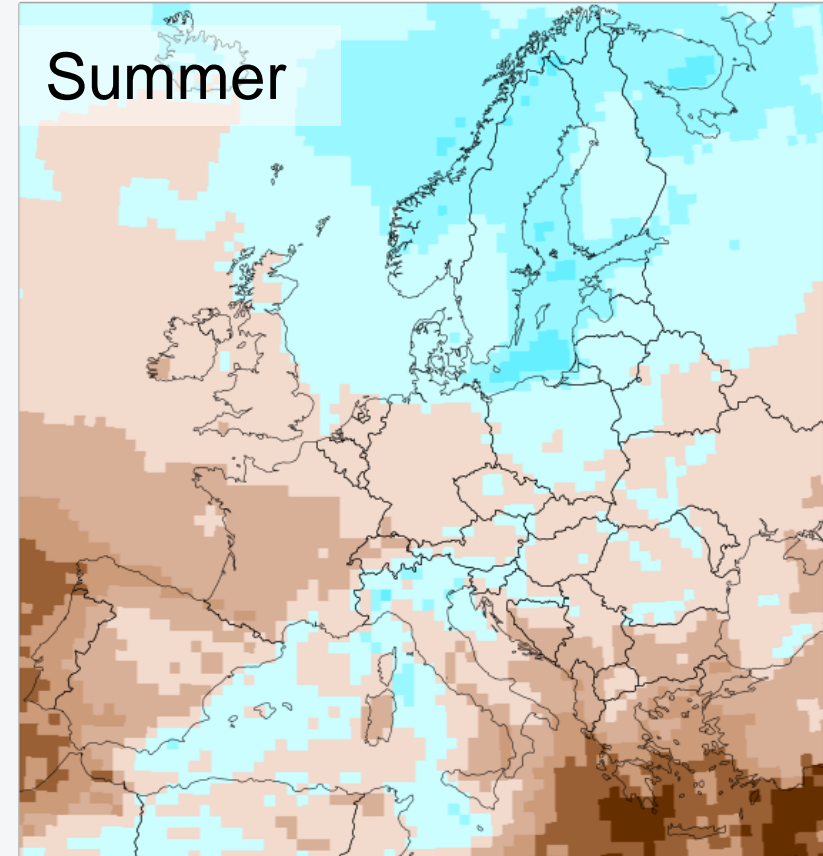
RCP 8.5 – very strong increases in future CO2 emissions!

Precipitation changes in Europe

It gets wetter in the north and drier in the south.

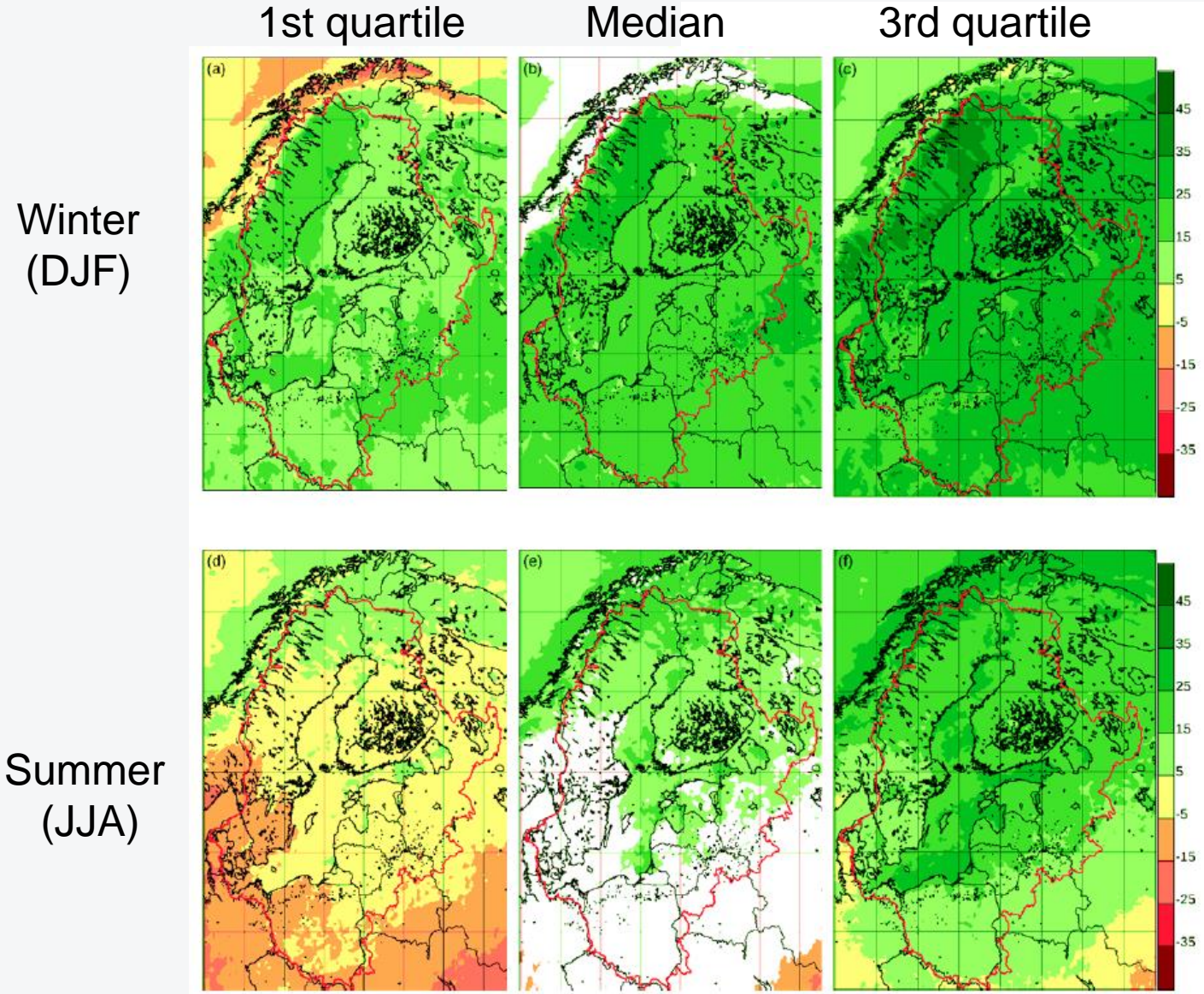


pr (%)



pr (%)

More precipitation

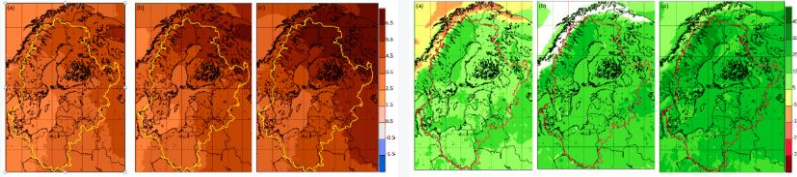


- On average more precipitation
- Strongest agreement in winter
- Potential decrease in the south in summer
- Large variability between models

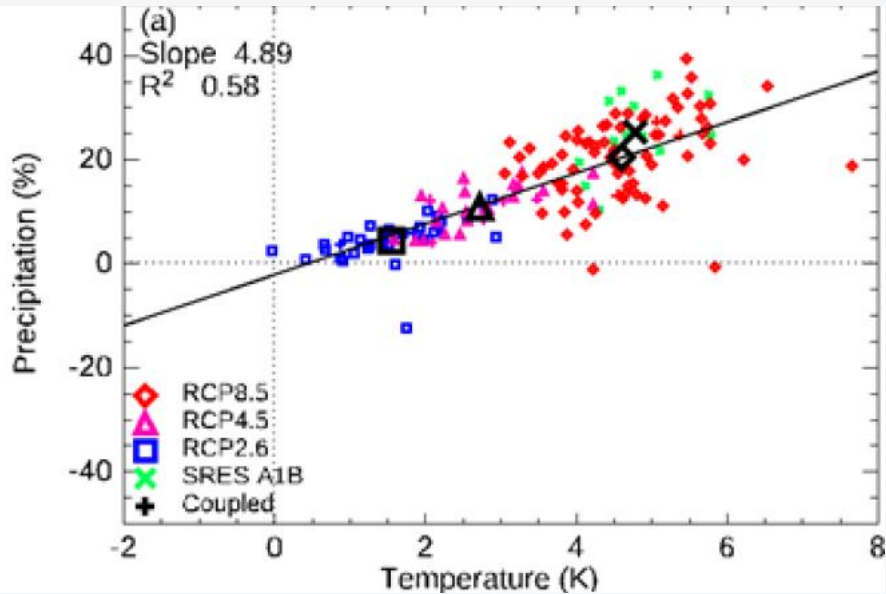
Christensen et al. Earth Syst. Dynam., 2022
124 RCM projections (11 RCMs, 8 GCMs, 3 RCPs)

RCP 8.5 – very strong increases in future CO2 emissions!

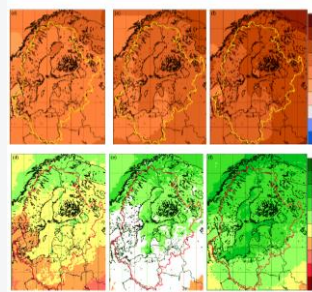
Different tendencies in summer and winter



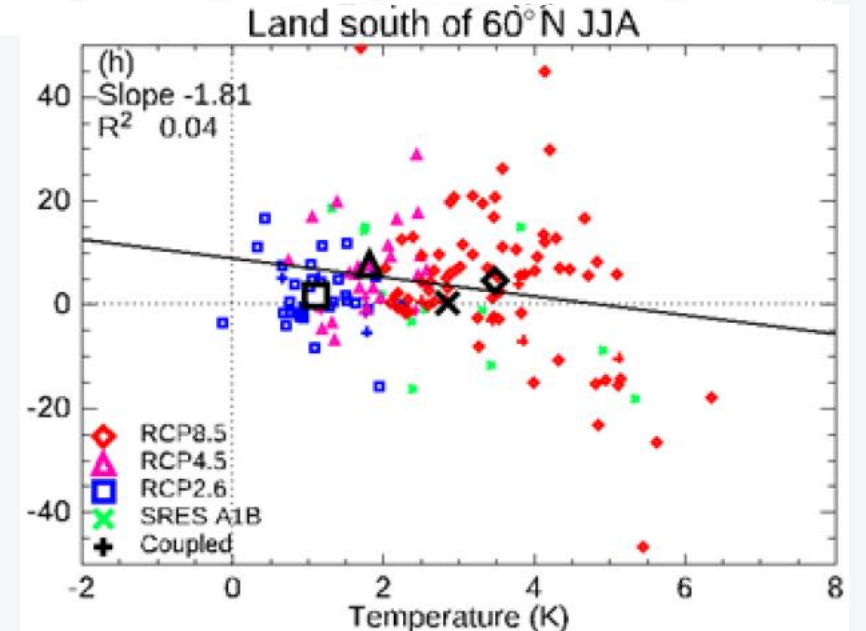
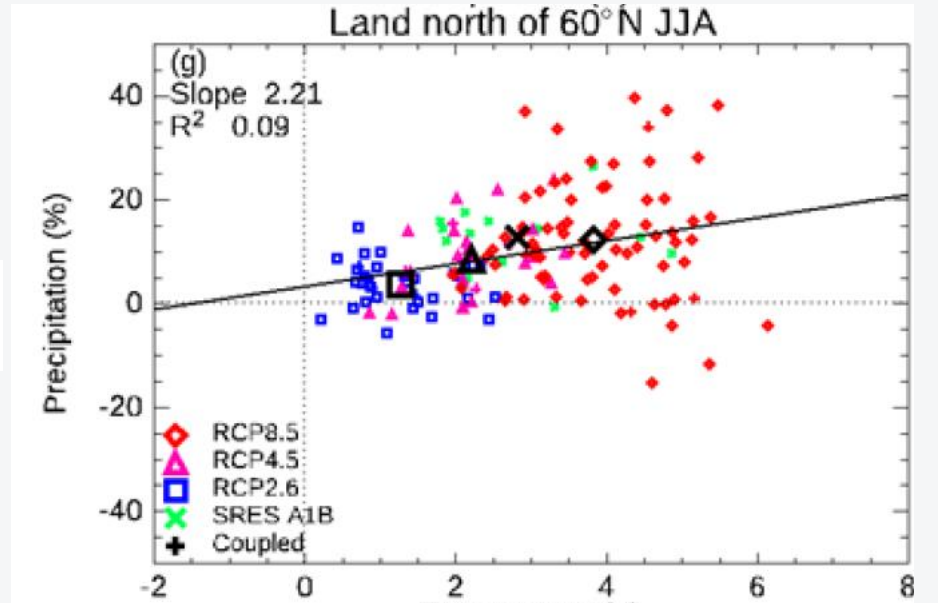
Winter (DJF) – full region



Summer (JJA)
North of 60°N

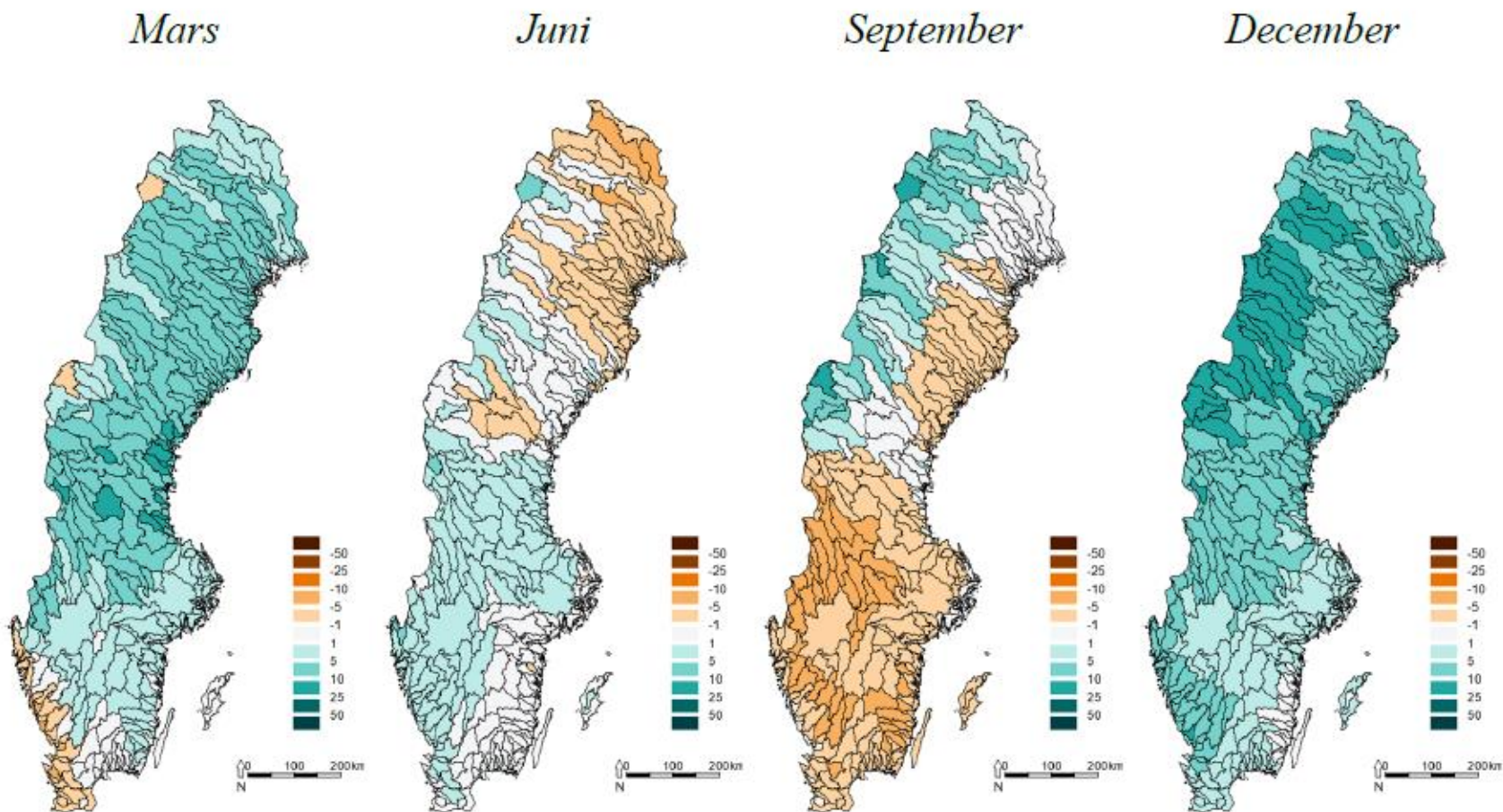


Summer (JJA)
South of 60°N



Both wetter and drier

Change in soil moisture (RCP4.5, 2041-2070 vs 1971-2000)



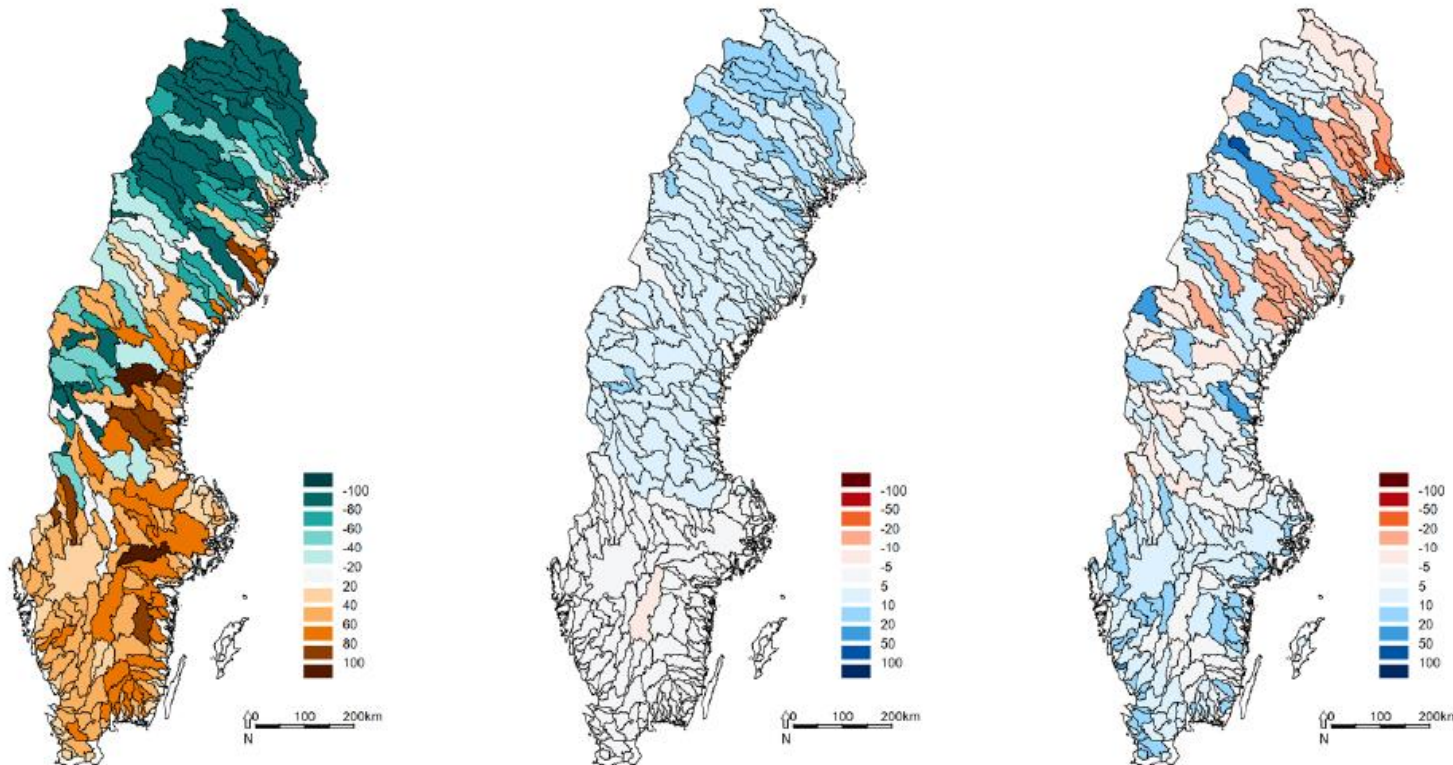
- Change in the seasonal dynamics
- Generally wetter but potentially drier in spring/summer/fall in different parts of the country
- Large interannual differences
- Stronger differences between wet and dry

Changes in the hydrological climate

Number of days with low flow

Average flow

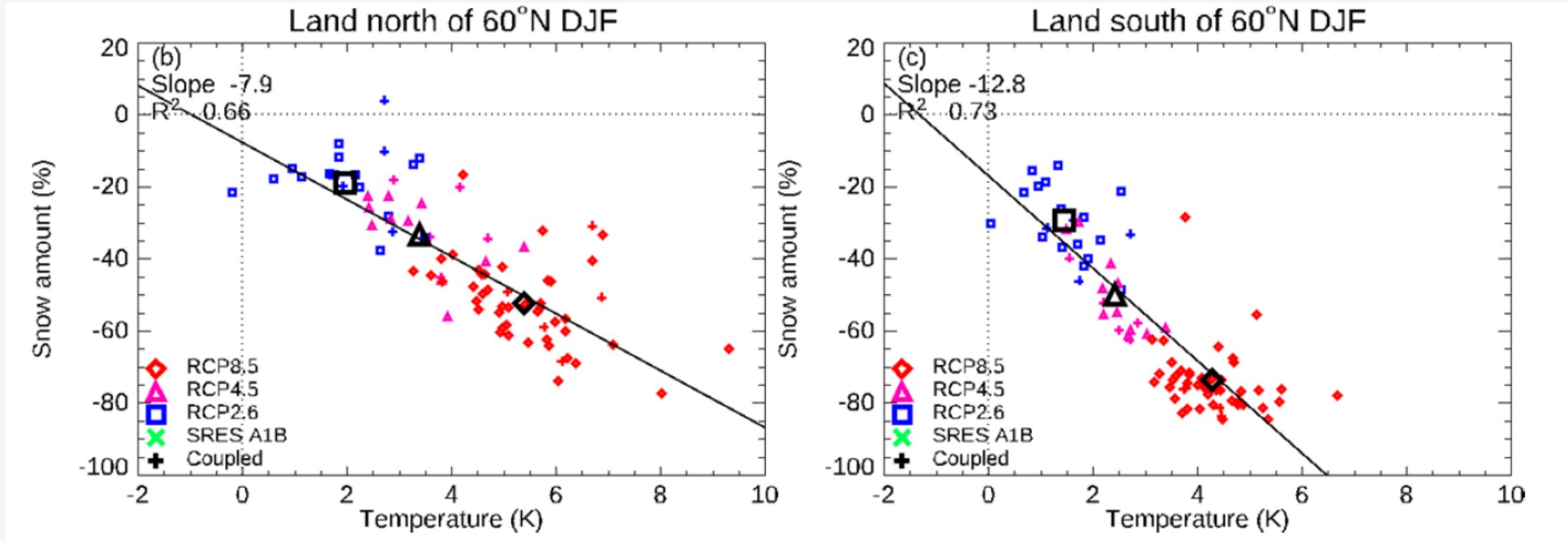
10-year flow



- On average wetter conditions (especially in the north)
- Generally larger risk of flooding (except in some areas where less snow reduces the risk)
- Can be drier in summer in some regions (mostly in the south)
- Larger differences between "wet" and "dry"

Figur 28. Hydrologiska beräkningar av förändring i vattenföring för 2041–2070 jämfört med referensperioden 1971–2000 i RCP4,5.

Less snow



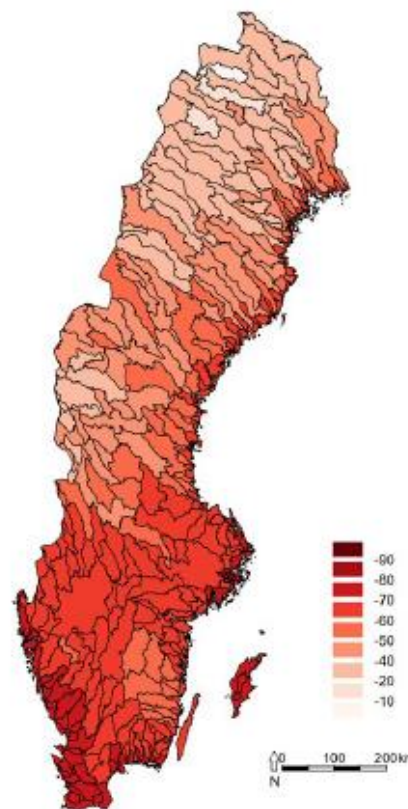
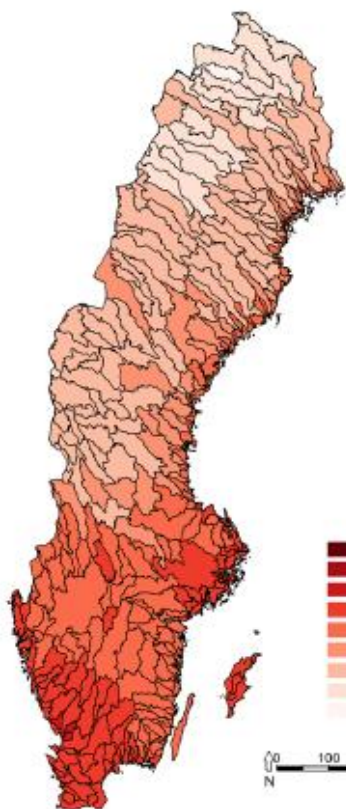
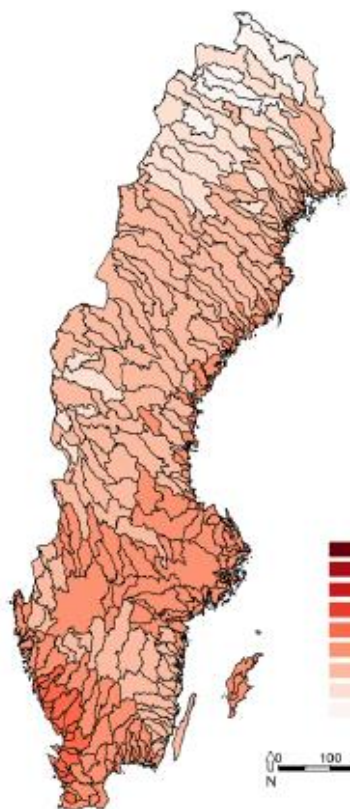
Less snow

Mean over the largest snow depth of the season

RCP2,6

RCP4,5

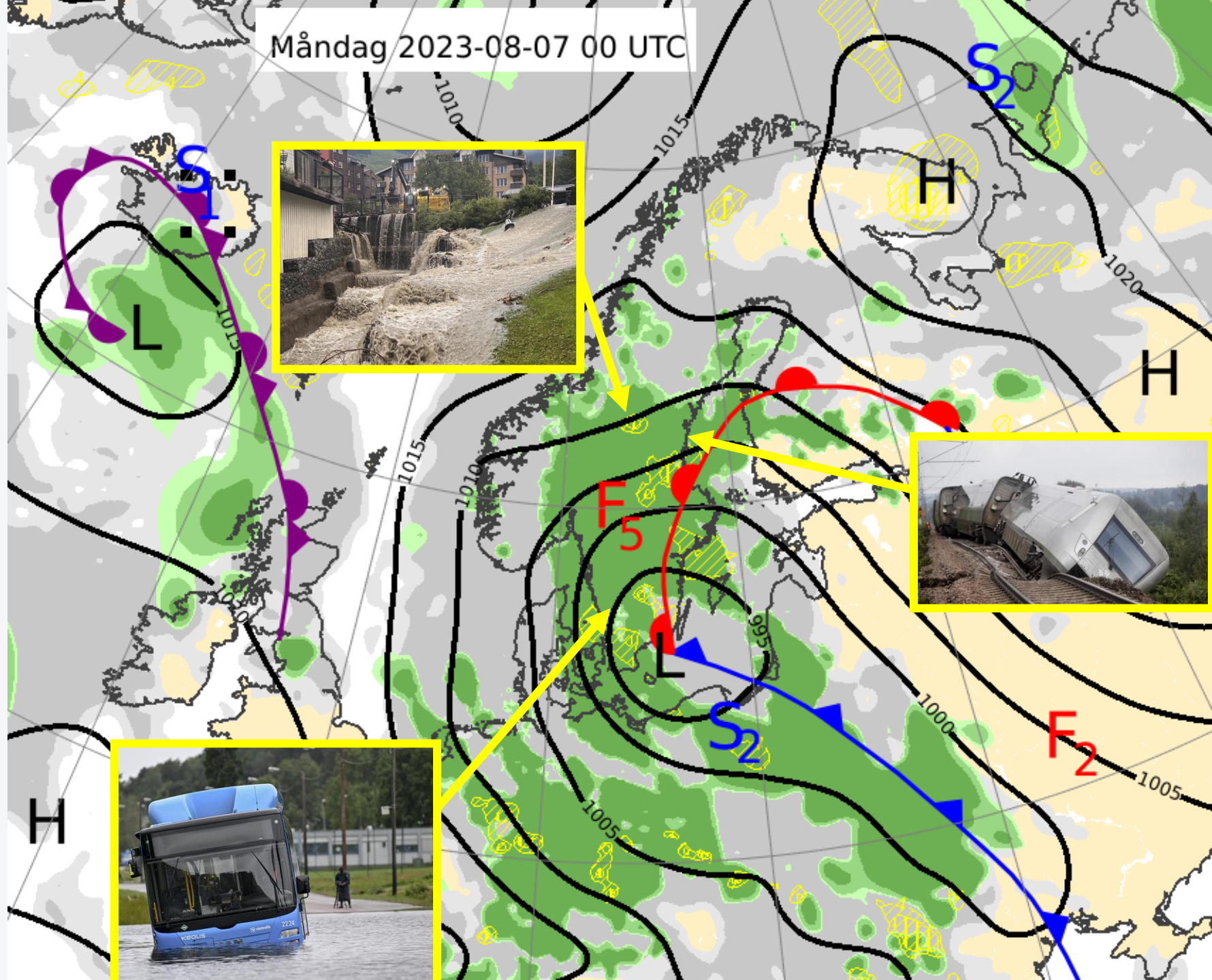
RCP8,5



- Snowseason length decreases everywhere
- Maximum depth decreases everywhere except for the far north
- Snowy winters can still exist (especially in the north)



More intense rainfall expected

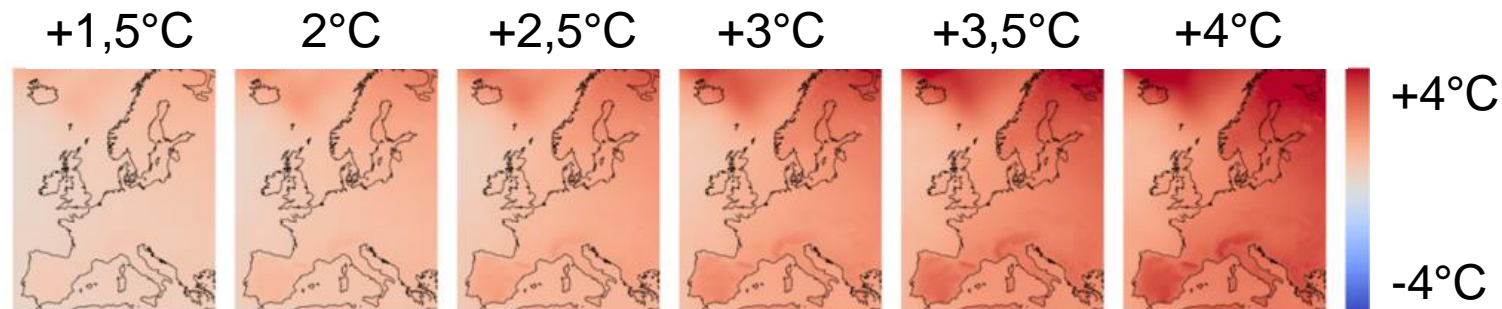


Måndag 2023-08-07 00 UTC

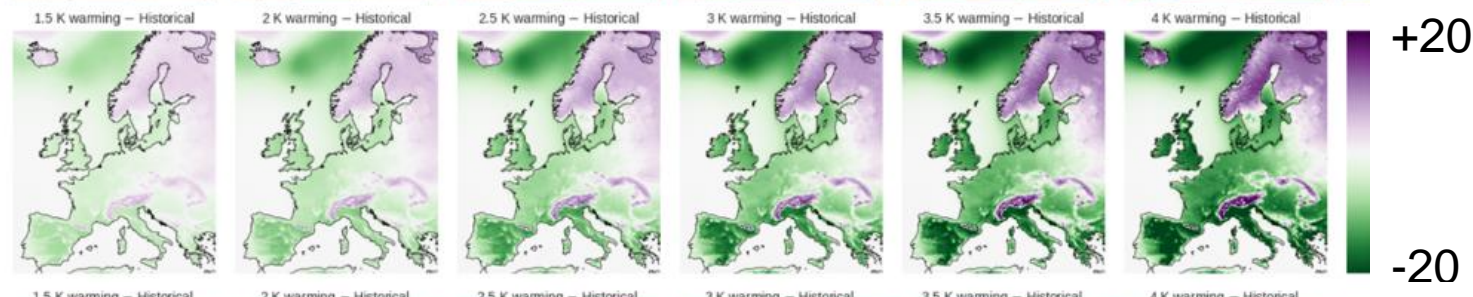


Gradual changes

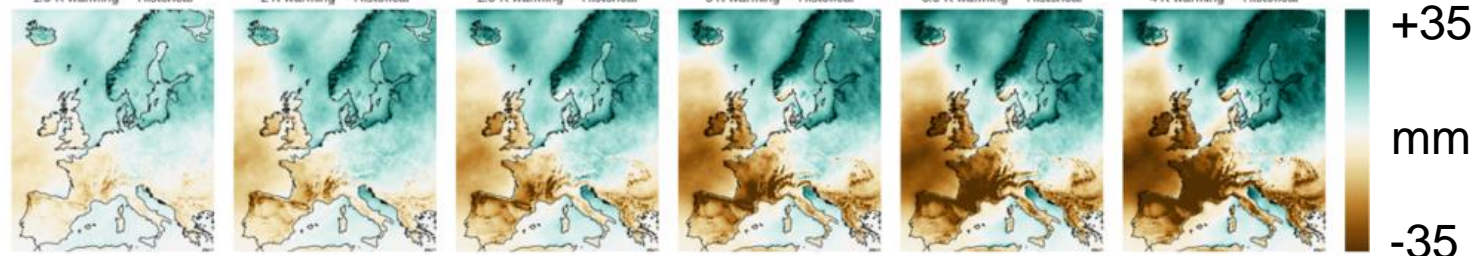
Annual mean temperature



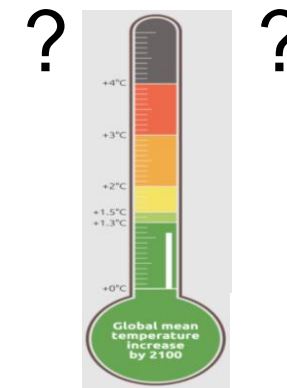
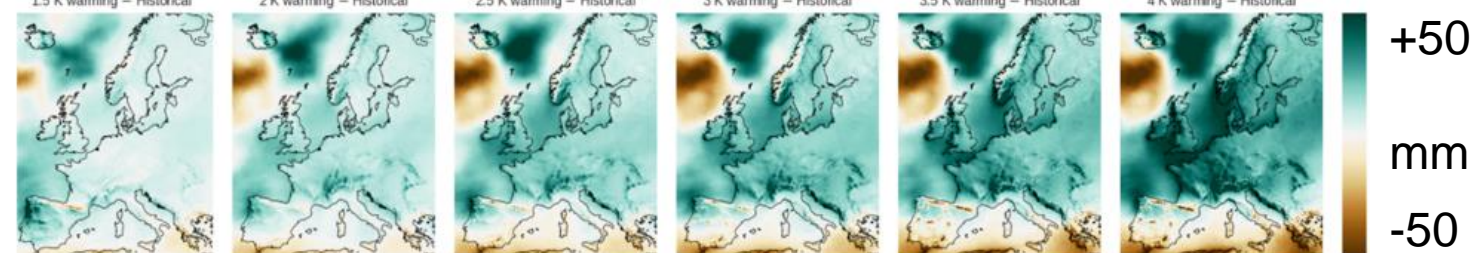
Number of days with zerocrossings (DJF)



Precipitation in summer (JJA)

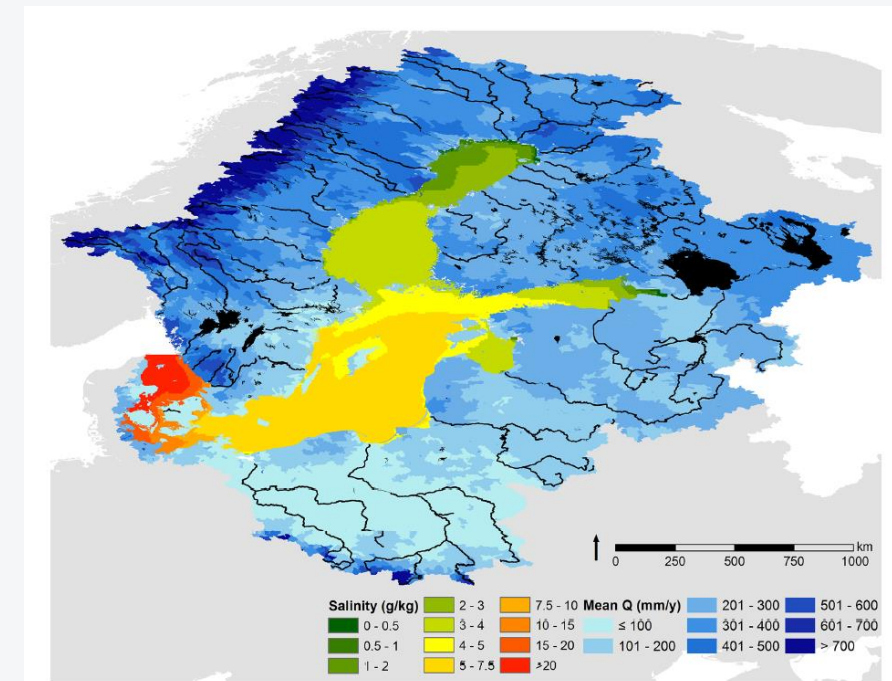


Precipitation in winter (DJF)



Expected changes in the Baltic Sea region

- Continued strong variability with large differences between warm/cold and wet/dry years
- Shift in climatic zones
 - ✓ Longer and warmer vegetation period
 - ✓ Shorter and milder winters with less snow
- More precipitation except in the south in summer
- Larger risk of flooding in most areas
- Increasing risk of heavy showers
- Increasing risk of drought
- Need for climate change adaptation



More climate scenarios available from SMHI

- Scenarios for different time periods and different degree of future climate forcing
- A number of meteorological, hydrological and oceanographical variables
- Presentation of climate change indicators

