ASSESSING FUTURE CLIMATE CONDITIONS THROUGH CLIMATE MODELLING

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WEBINAR 2022-05-04

VISUALISING THE FUTURE – ADAPTING TO A CHANGING CLIMATE

Content

- Numerical climate models
- Future climate change in Sweden
- Climate models in support of climate change impact analysis and climate adaptation

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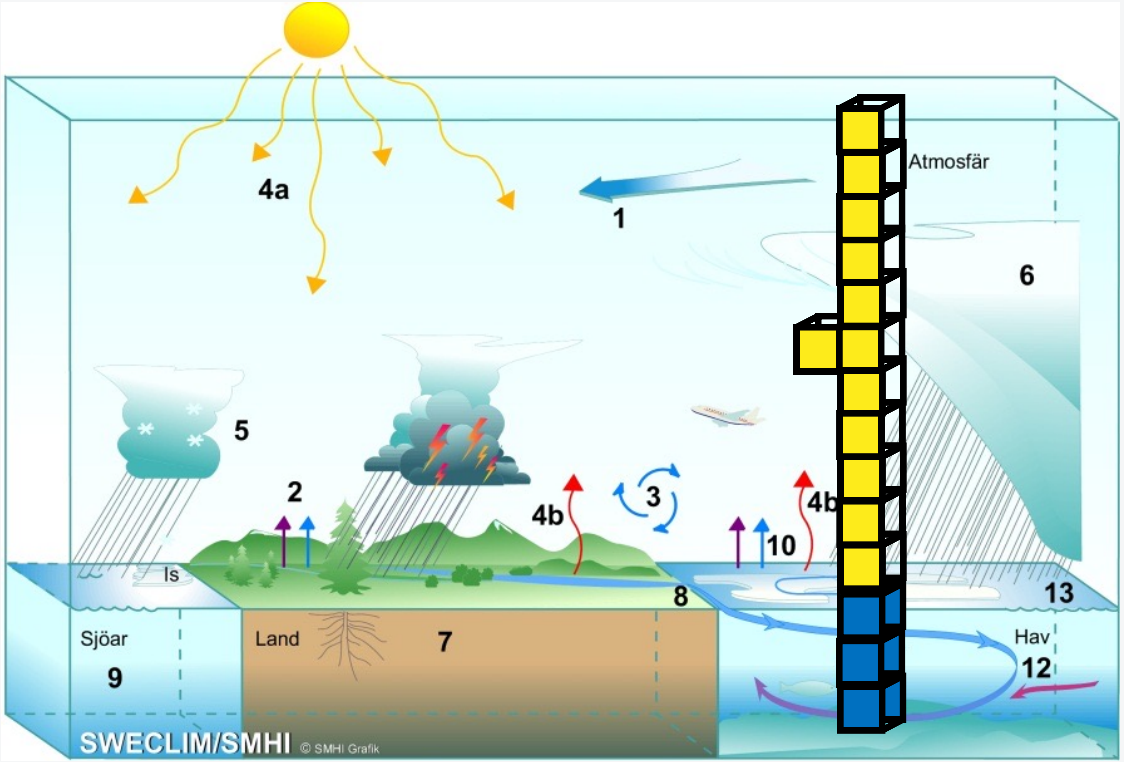
Construction of numerical climate models



Include all relevant processes and parts of the climate system

Set up a computational grid for atmosphere/oceans/land etc.

Formulation of the model

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Change in temperature (T) with time (t)

$$\frac{\partial T}{\partial t} + \vec{V} \cdot \nabla T + \omega \frac{\partial T}{\partial p} - \alpha\omega / Cp = Q / Cp$$

Relation between temperature and wind fields

Other factors influencing temperature

The atmosphere in a climate model

$$\frac{\partial u}{\partial t} + \vec{V} \cdot \nabla u + \omega \frac{\partial u}{\partial p} - fv + \frac{\partial \phi}{\partial x} = F_X$$

$$\frac{\partial v}{\partial t} + \vec{V} \cdot \nabla v + \omega \frac{\partial v}{\partial p} + fu + \frac{\partial \phi}{\partial y} = F_y$$

$$\frac{\partial \phi}{\partial p} = -\alpha$$

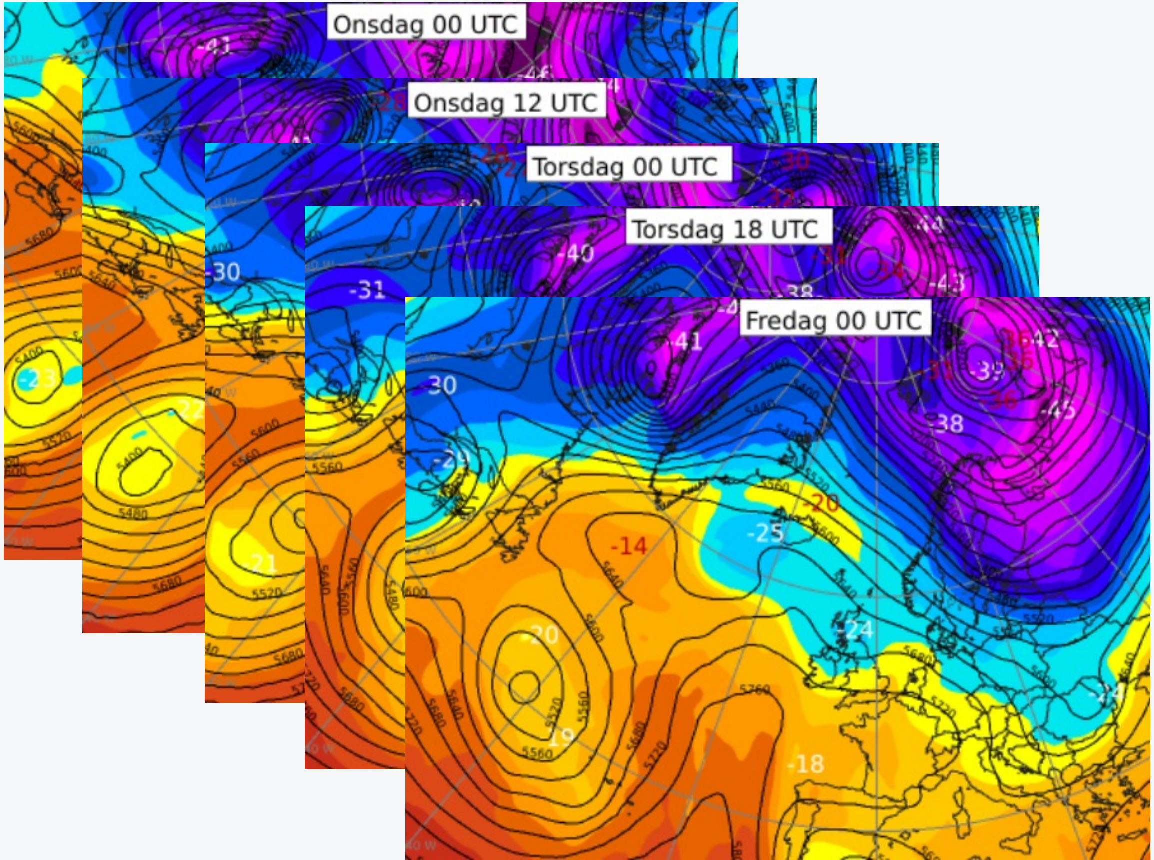
$$\frac{\partial T}{\partial t} + \vec{V} \cdot \nabla T + \omega \frac{\partial T}{\partial p} - \alpha\omega / Cp = Q / Cp$$

$$\nabla \cdot \vec{V} + \frac{\partial \omega}{\partial p} = 0$$

$$p\alpha = RT$$

$$\frac{\partial q}{\partial t} + \vec{V} \cdot \nabla q \cdot + \omega \frac{\partial q}{\partial p} = S_q$$

Climate models simulate weather



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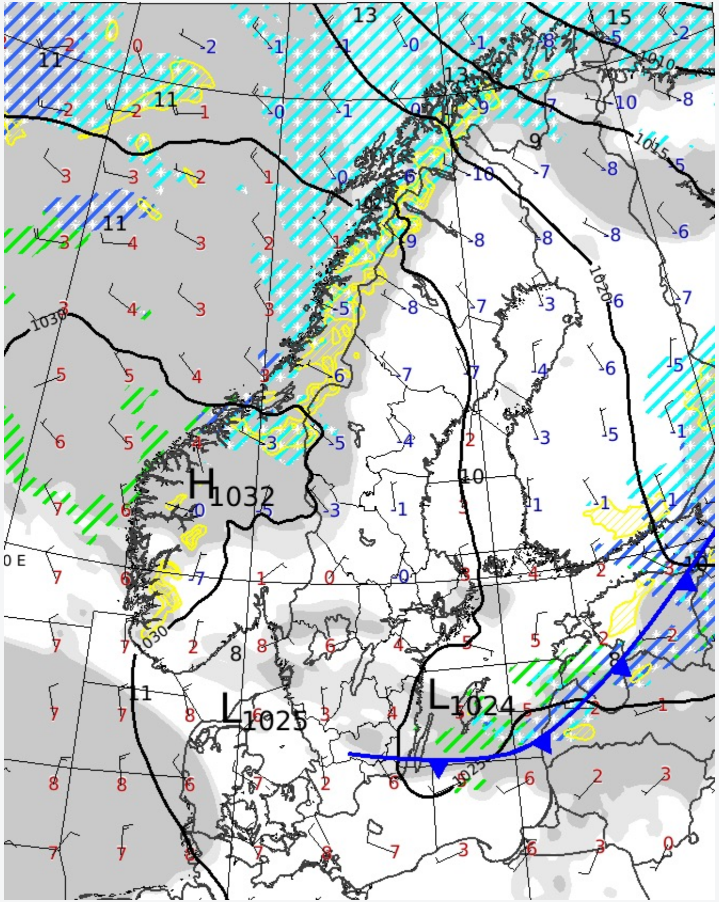

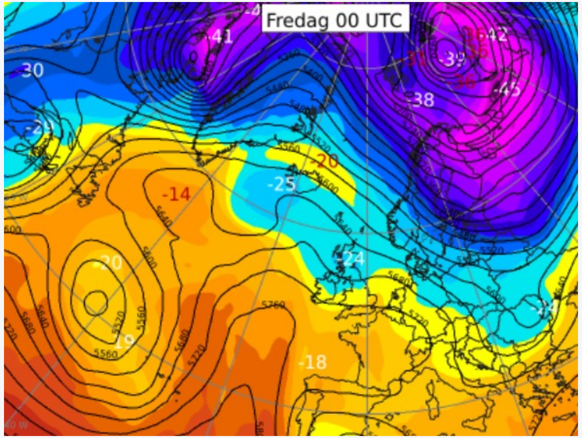

Climate models simulate weather

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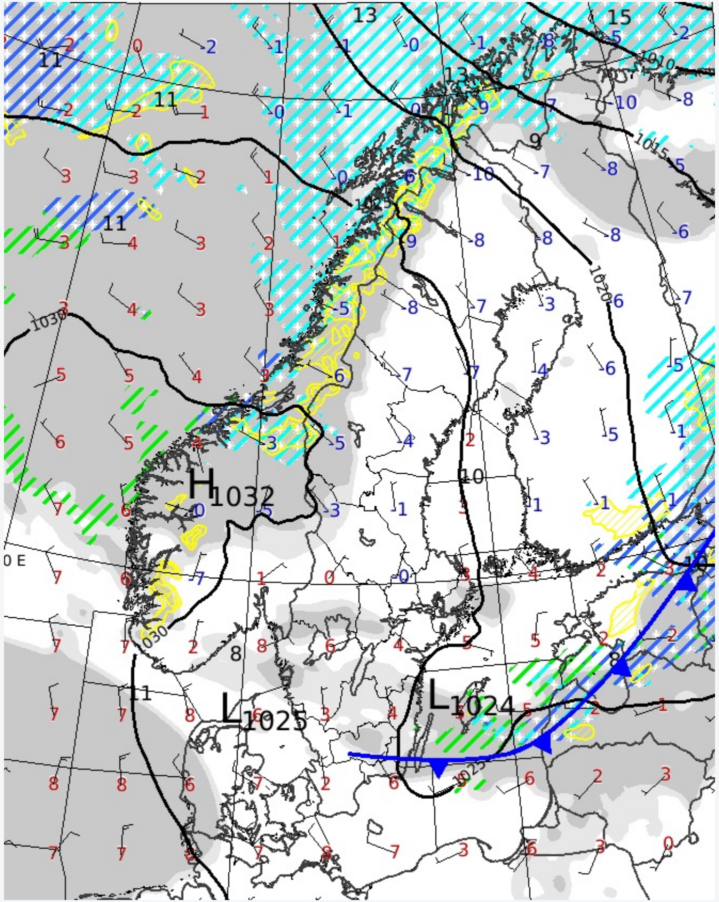

Climate models and numerical weather prediction (NWP) models are very similar

- In NWP it is important with the right initial conditions (today’s weather)
- After a few days to c. a week it is not possible to make a forecast for a certain day
- Climate models, however, can run for long periods and produce realistic weather conditions

Resolution in models is a limitation

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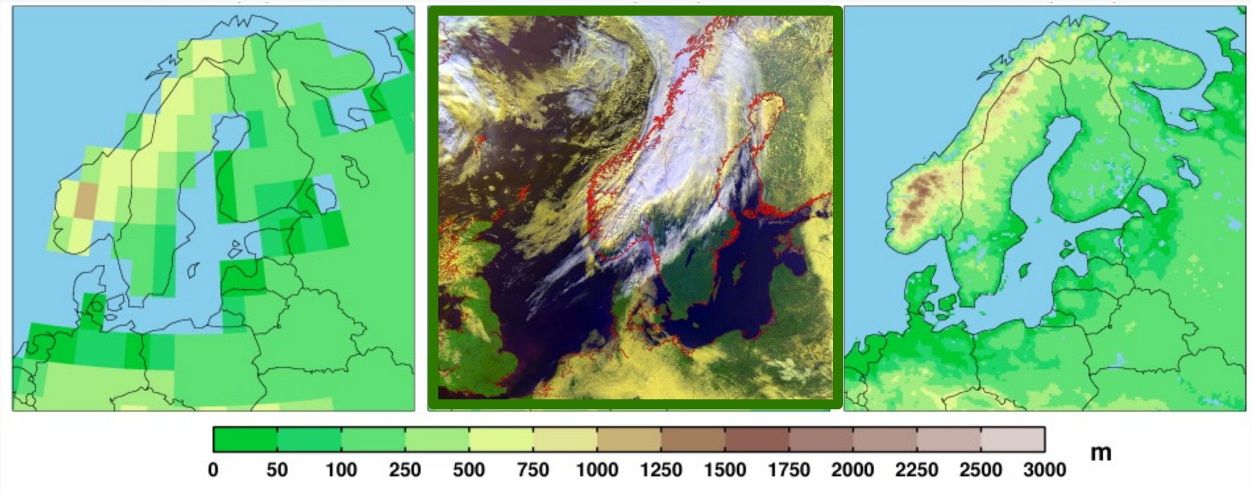
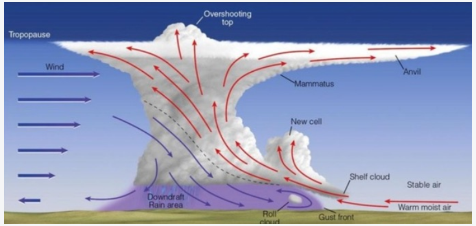
- Typical resolution in global climate models: 125-300 km (CMIP5);
  80-300 km (CMIP6)
- Typical resolution in regional climate models: 12,5 (50) km (EURO-CORDEX)

2° (c. 225 x 225 km)

0.11° (c. 12,5 x 12,5 km)





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An (un)certain future?

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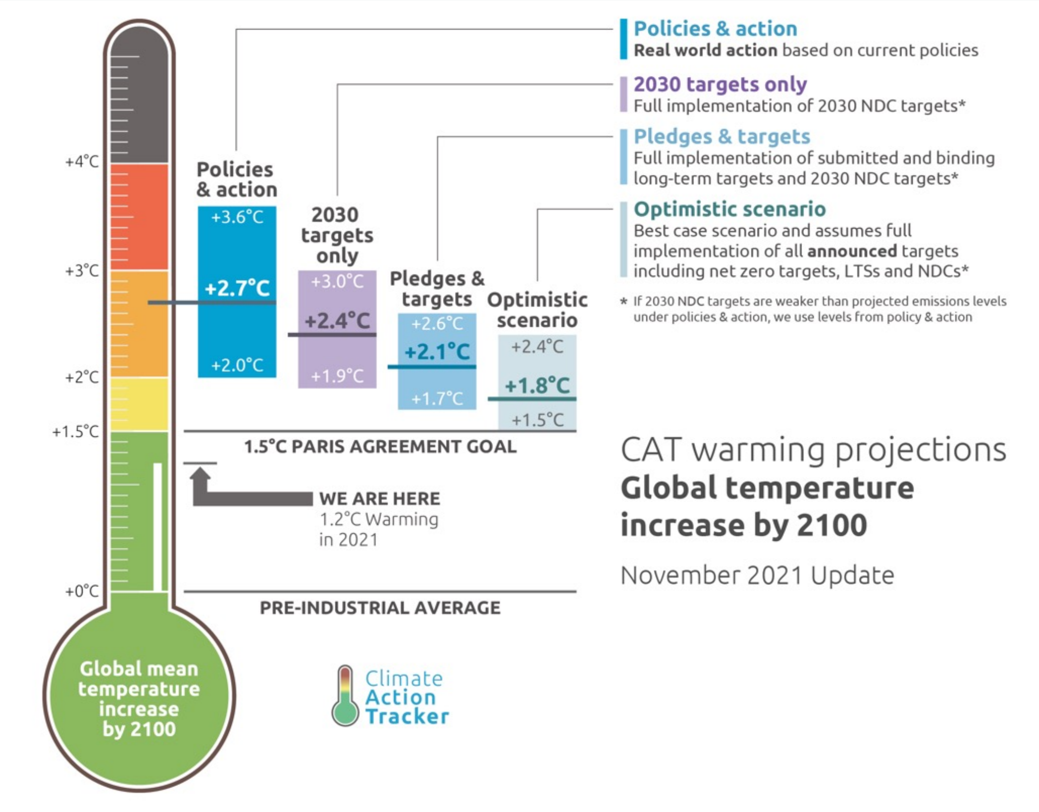
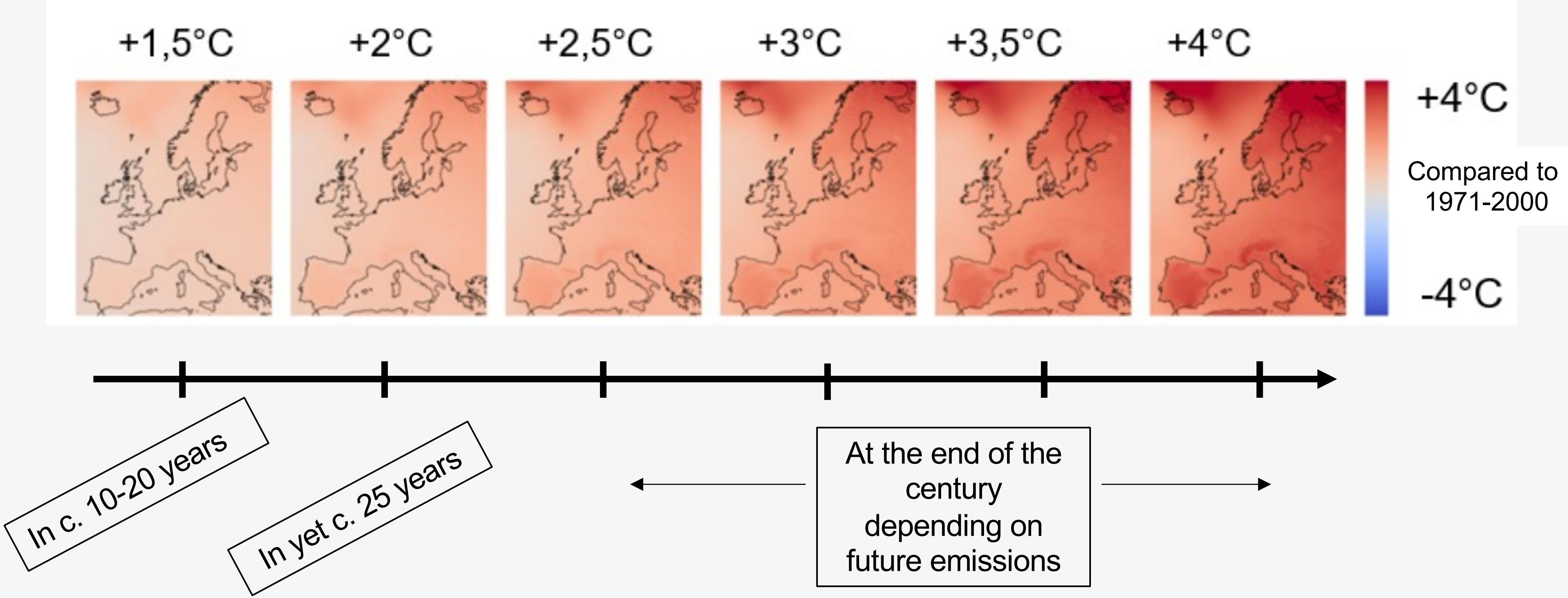


Increasing annual mean temperature at different degrees of global warming



Changes at different degree of global warming

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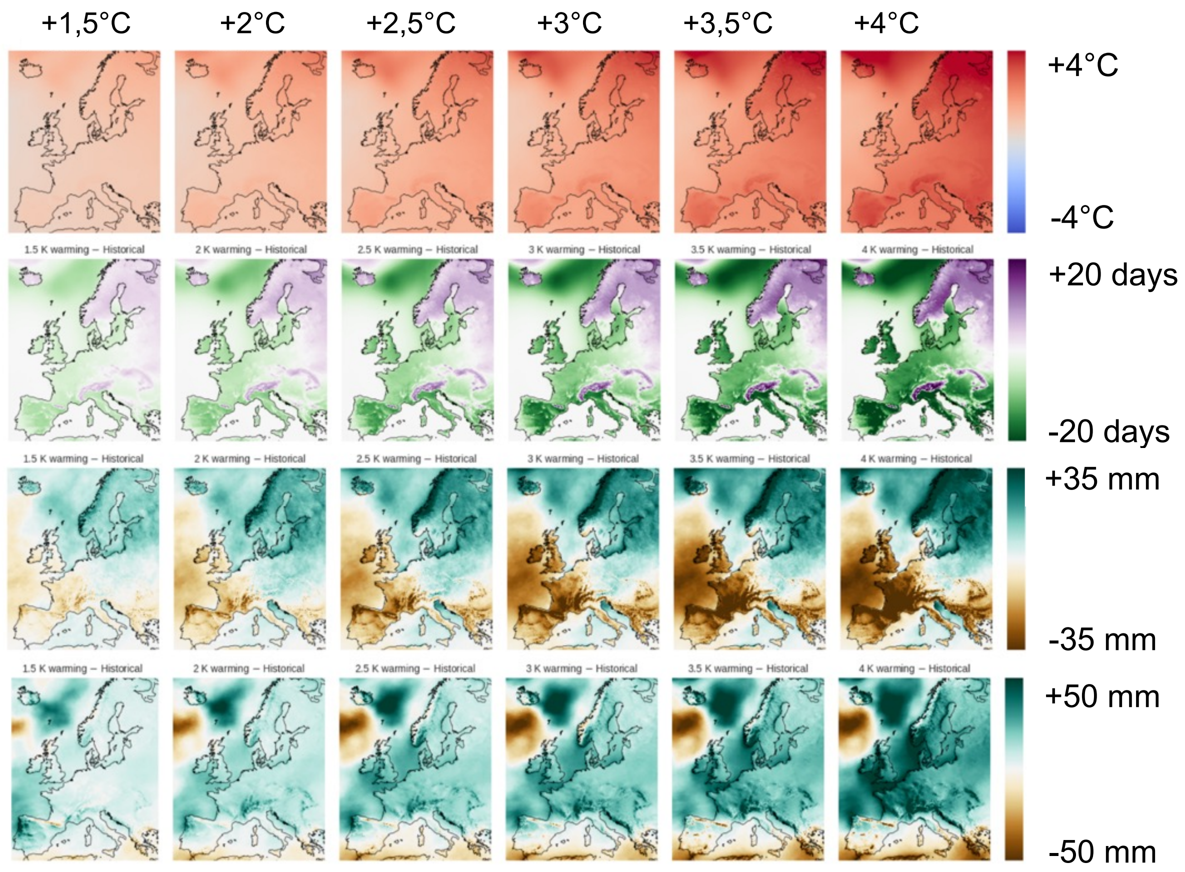
Annual mean temperature

Number of days with zerocrossings in winter (DJF)

Precipitation in summer (JJA)

Precipitation in winter (DJF)



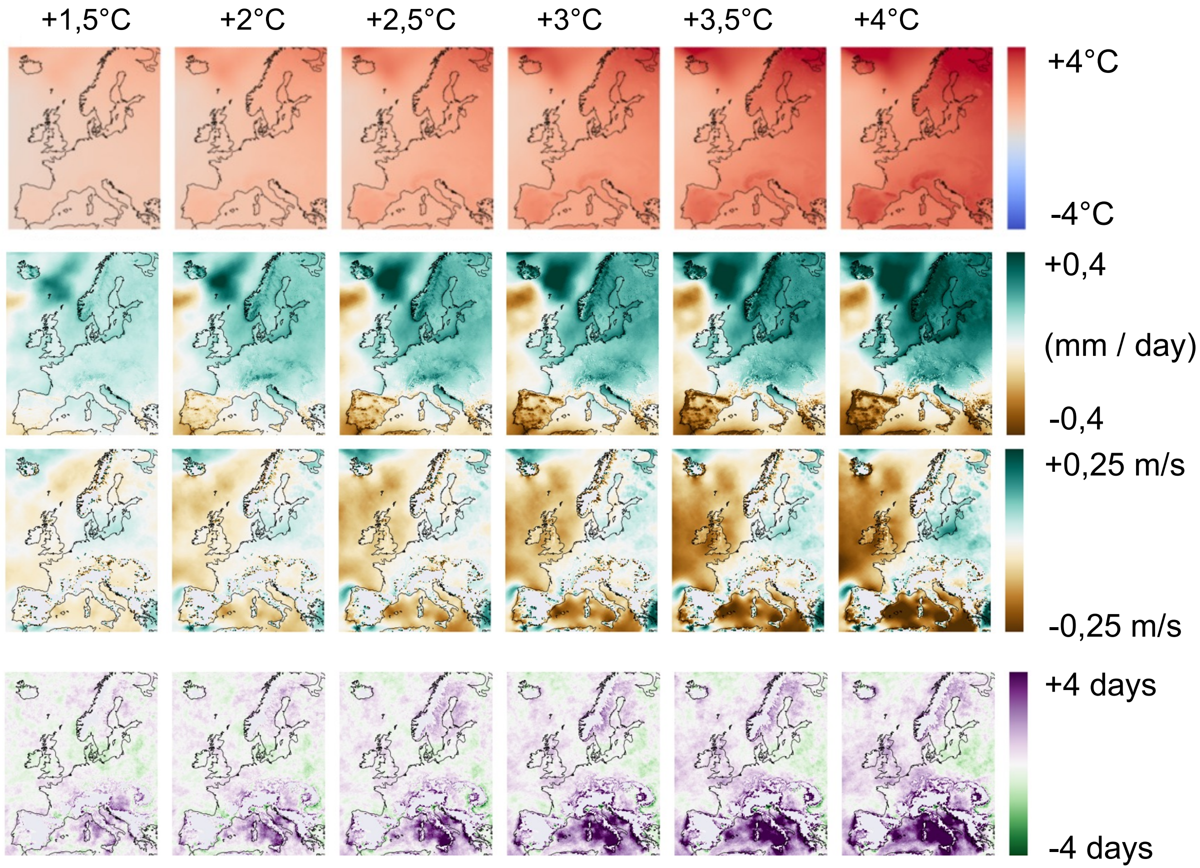
Changes at different degree of global warming

Annual mean temperature

Annual mean precipitation

Annual mean wind speed

Number of calm days (wind speed < 2m/s)



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Changes in heating/cooling demand

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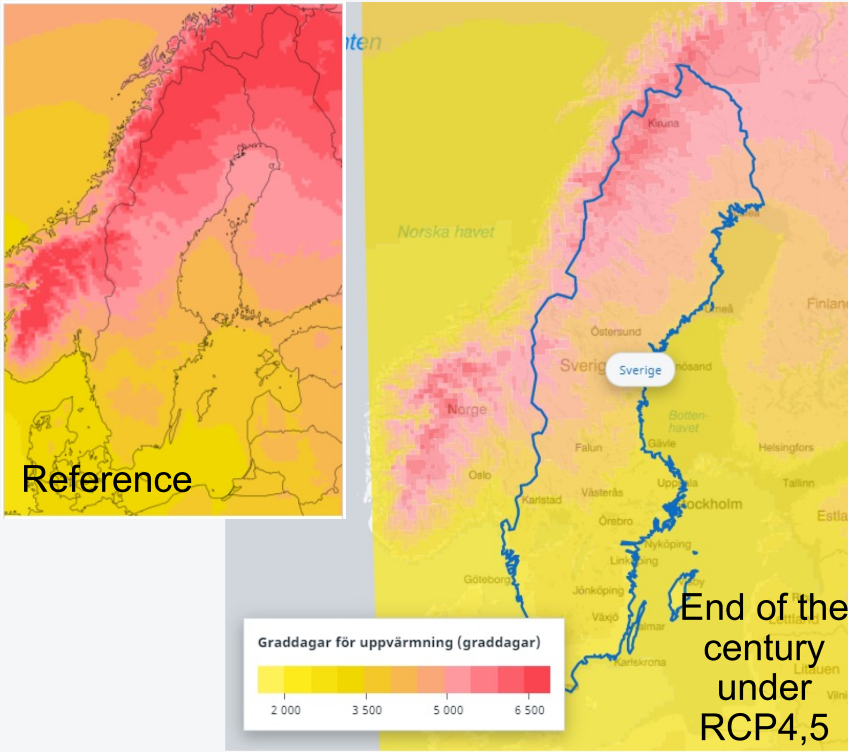
Increasing temperatures lead to:

- Shorter winters and less demand for heating
- Longer summers with increased demand for cooling
- Continued risk of cold snaps in winter and thereby need for sufficient margins in production potential

Degree days for heating (<17°C)



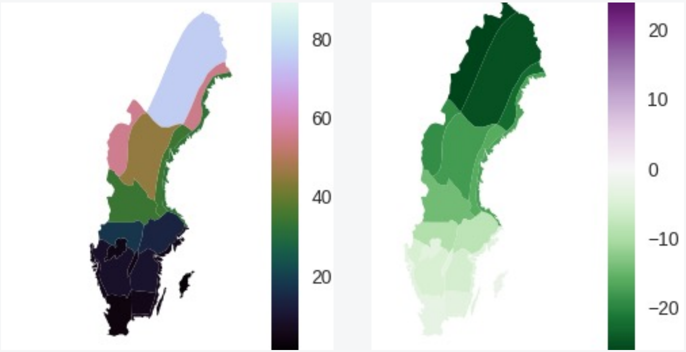
Cold extremes get less severe

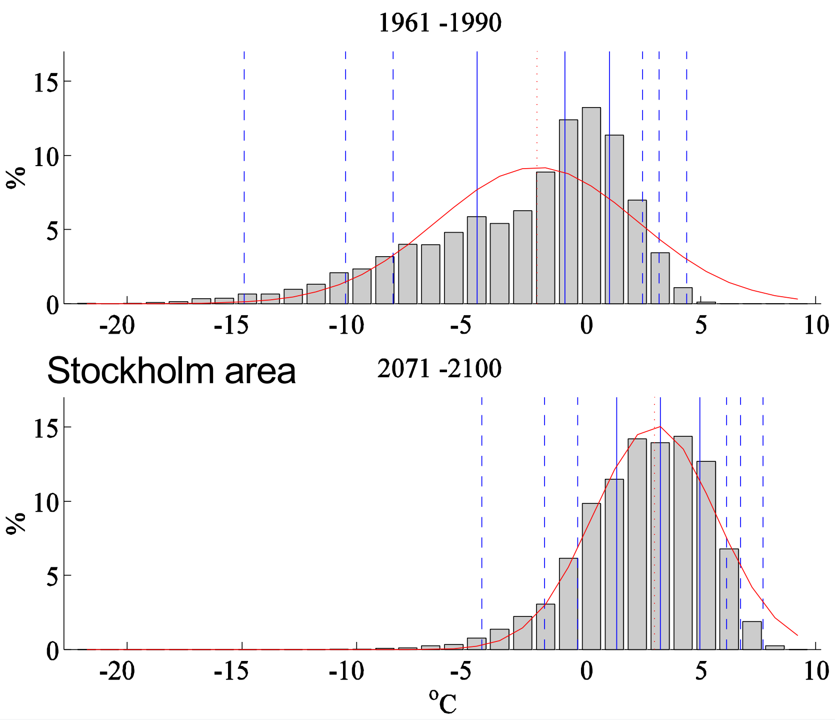
Temperature increase is largest for cold days in winter

Number of cold days (<-7°C) per year

1971-2000

At +2°C global warming





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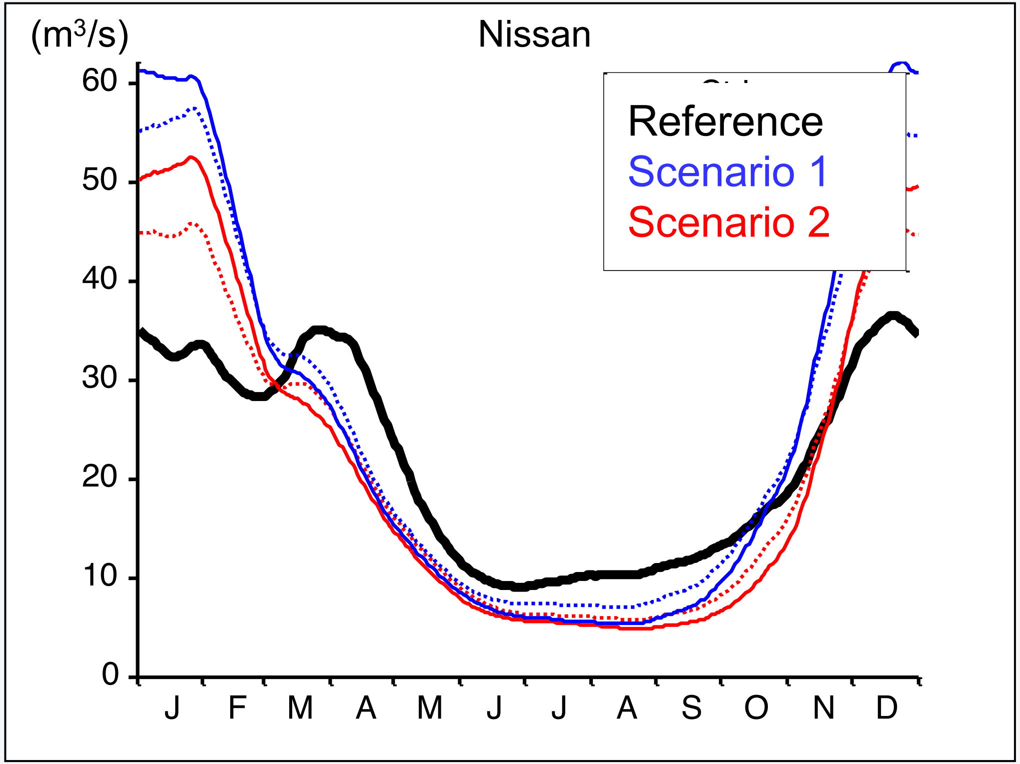
Impact on river discharge

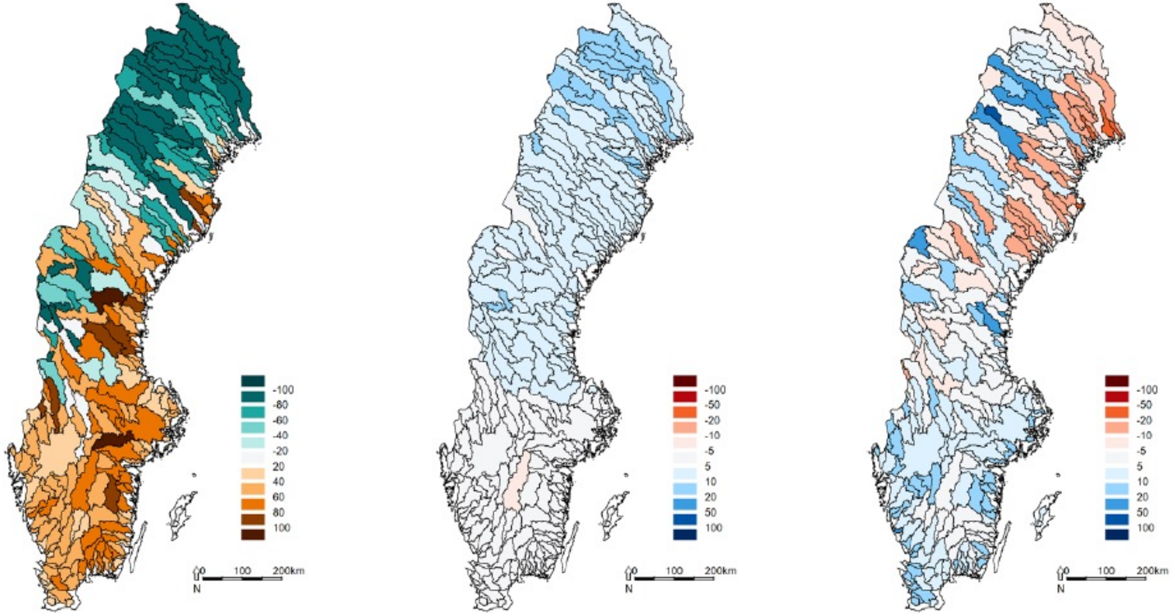
Increased precipitation and increasing temperatures give:

- Increased discharge in winter, less in summer
- Change in the seasonality
- Larger variations between warm/cold and wet/dry years



Consequenses of increasing precipitation

Number of days with low flow | Average river flow | 10-year flow event



Change in river flow for 2041-2070 compared to 1971-2000 in RCP4.5

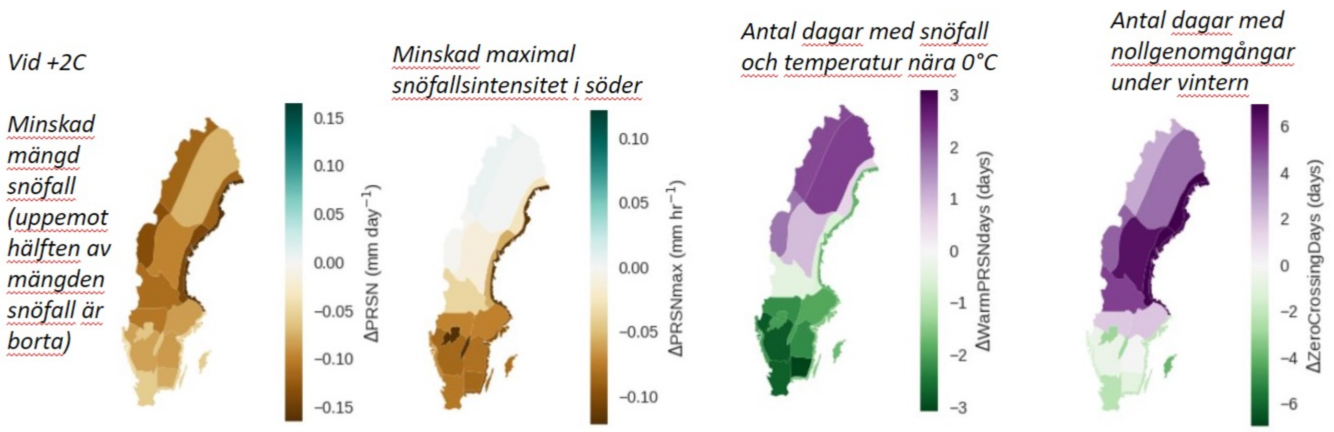
Consequences not directly addressed by climate models

Climate models can't answer all questions

Combination of indices may give a hint

Wet snow ("blötsnö")

Likely with less problems in the south.
Risk of increasing problems during winter in the north



More information about future climate conditions in Sweden

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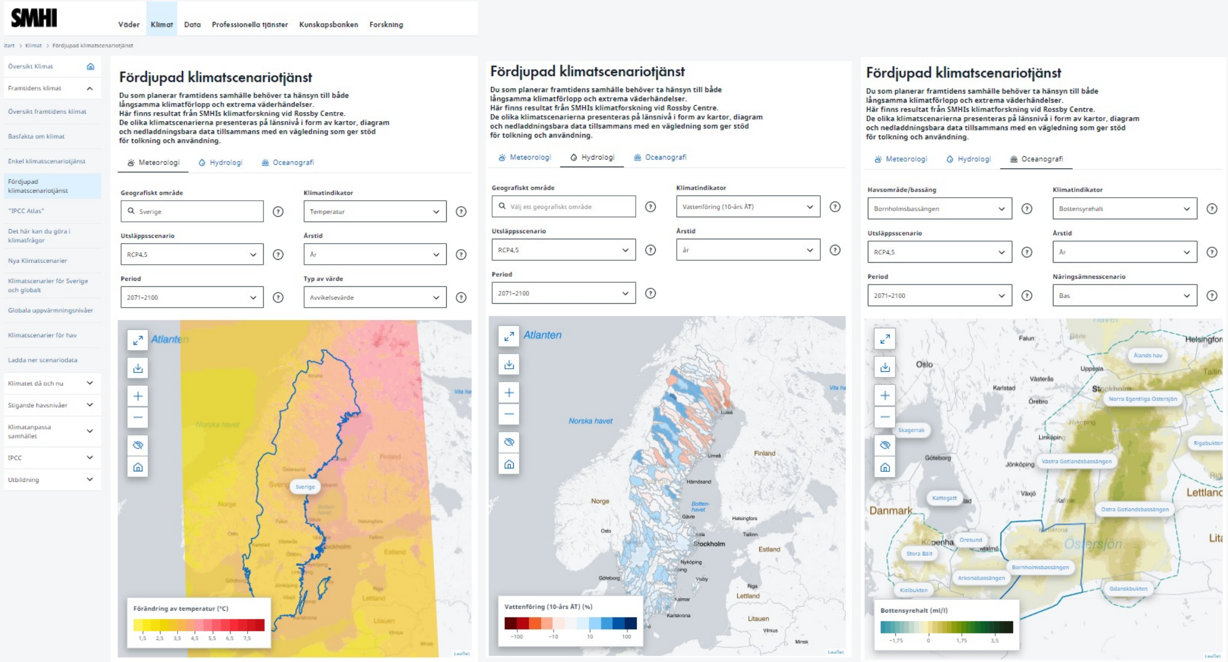

Strong changes with time:

- Warmer in all seasons
- Longer summer, shorter winter
- More precipitation and stronger precipitation extremes
- Increased risk for drought
- Uncertain changes in the wind climate

https://www.smhi.se/klimat

Suggested further reading

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SMHI Rapport Klimatologi 64, 2022

https://www.smhi.se/publikationer/

Nationella expertrådet för klimatanpassning 2022

https://klimatanpassningsradet.se/