



**ASSESSING FUTURE
CLIMATE CONDITIONS
THROUGH CLIMATE
MODELLING**

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WEBINAR 2022-05-04

VISUALISING THE FUTURE – ADAPTING TO A CHANGING
CLIMATE

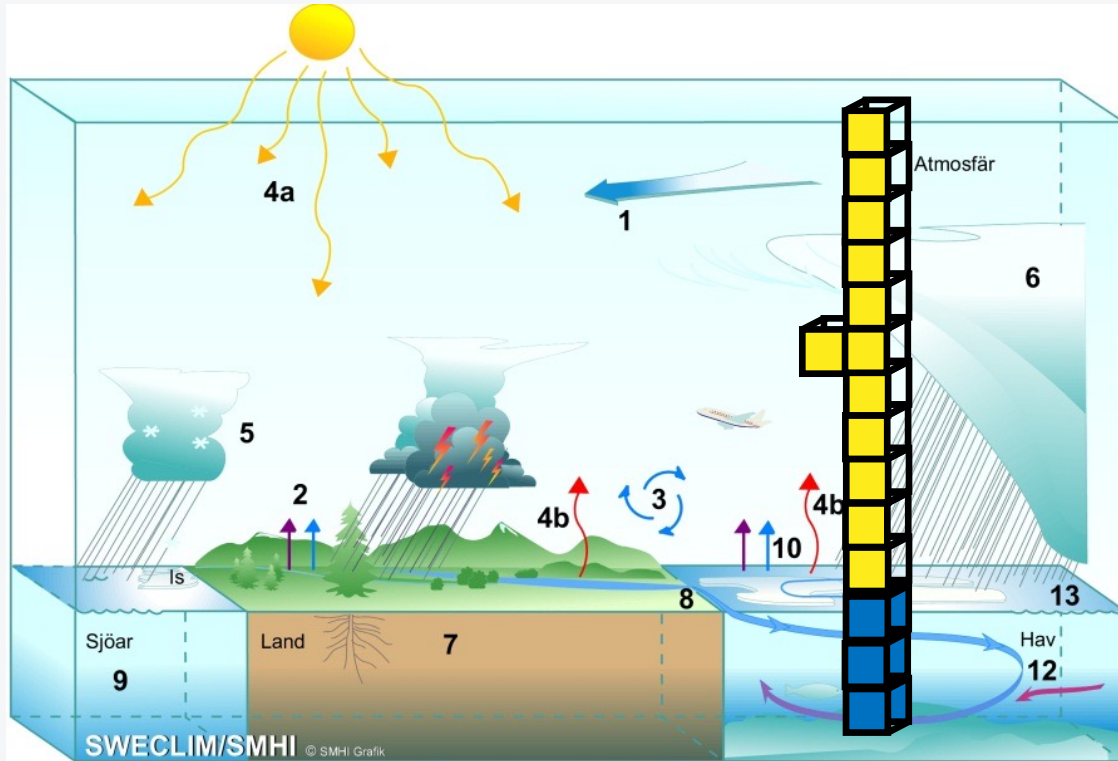
Content

- 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

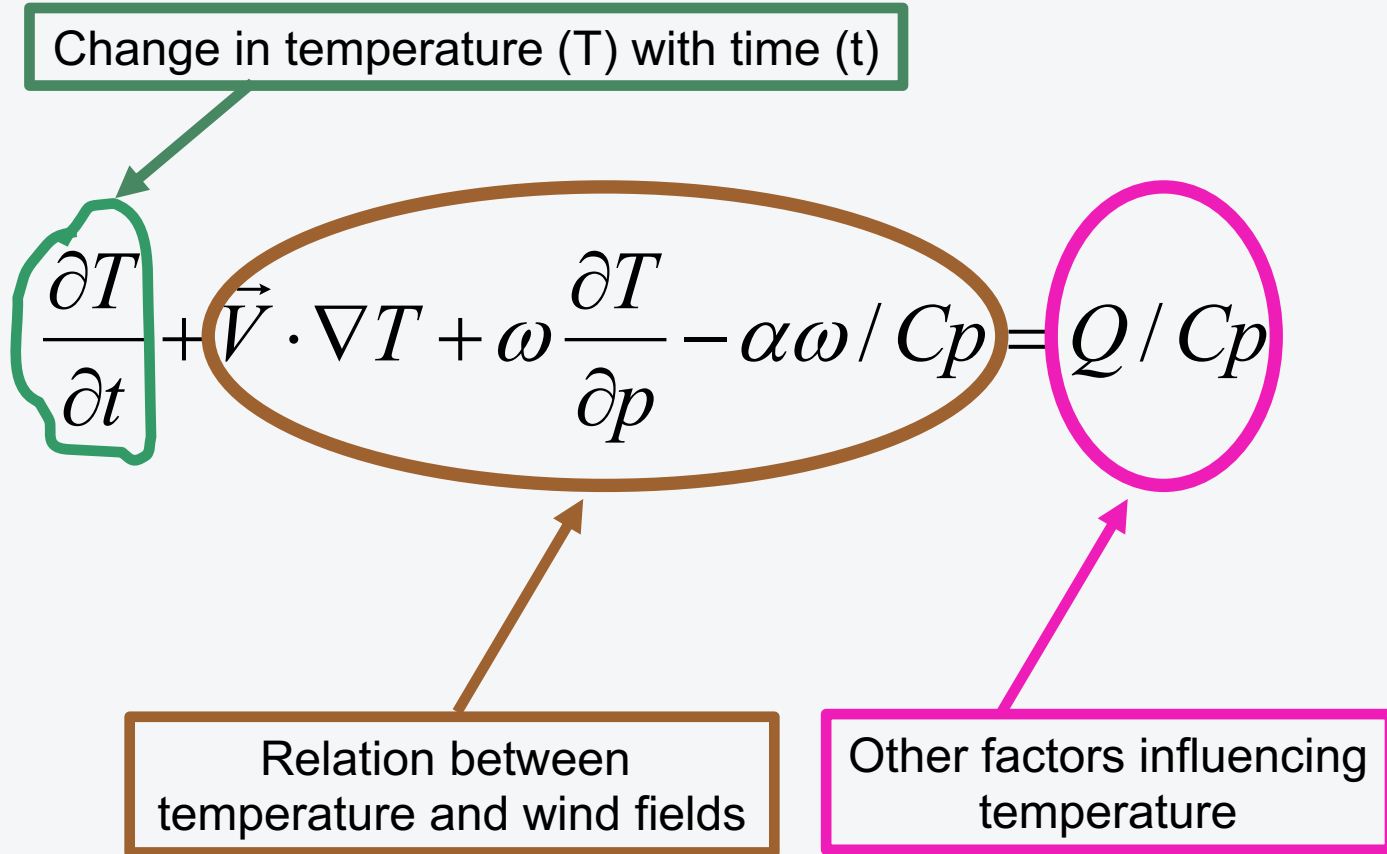


Include all relevant processes and parts of the climate system

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

Formulation of the model

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The atmosphere in a climate model

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

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

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

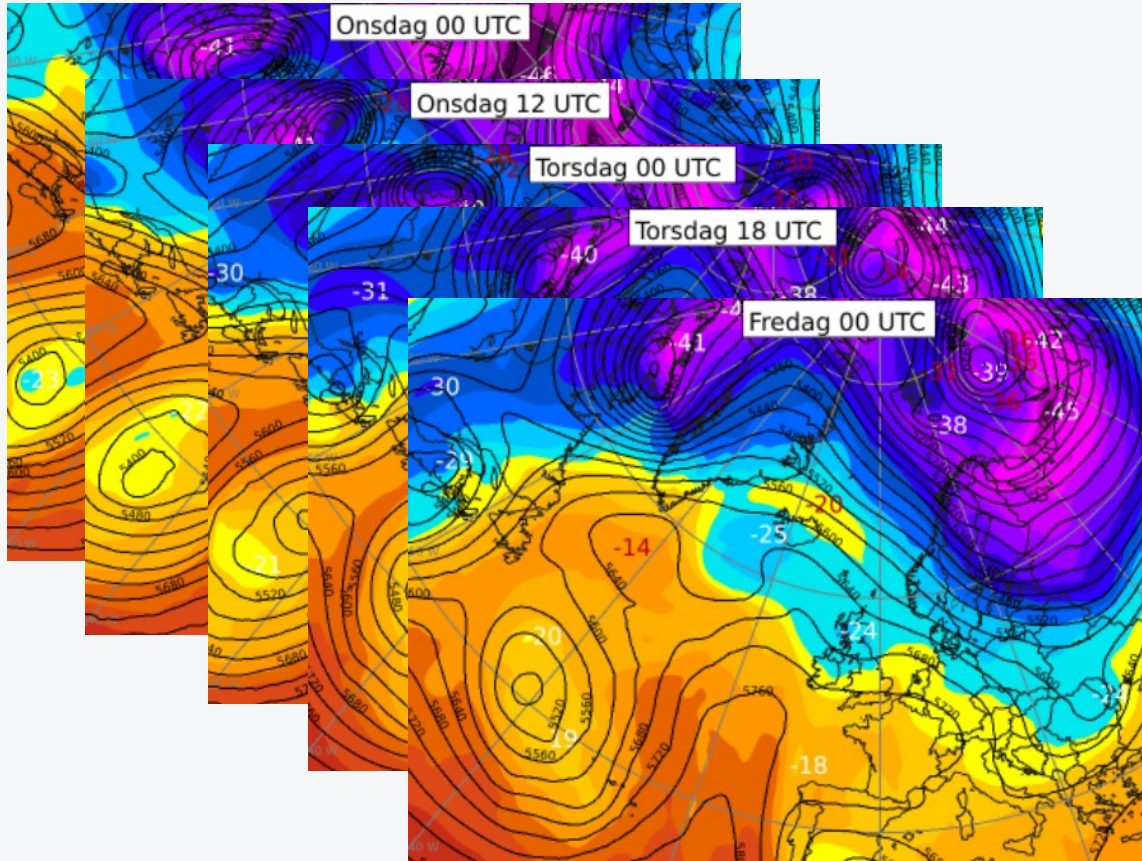
$$p\alpha = RT$$

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

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

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

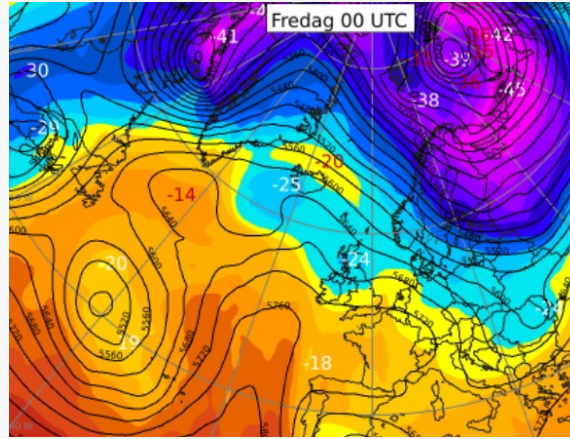
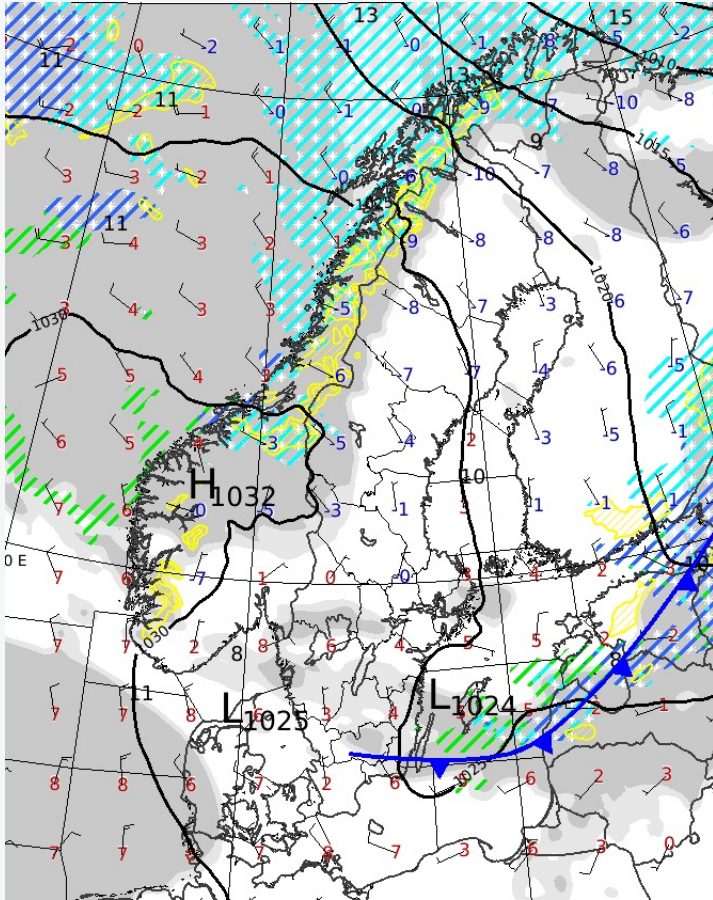
Climate models simulate weather



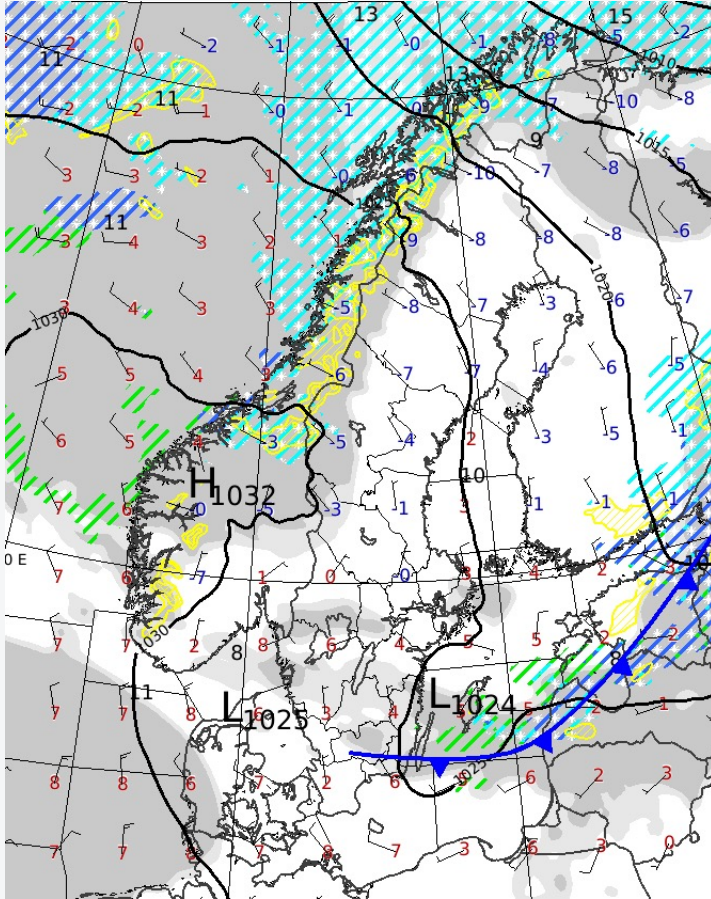
$$\begin{aligned} \frac{\partial u}{\partial t} + \vec{v} \cdot \nabla u + \omega \frac{\partial u}{\partial p} - fv + \frac{\partial \phi}{\partial x} &= F_x & \nabla \cdot \vec{V} + \frac{\partial \omega}{\partial p} &= 0 \\ \frac{\partial v}{\partial t} + \vec{v} \cdot \nabla v + \omega \frac{\partial v}{\partial p} + fu + \frac{\partial \phi}{\partial y} &= F_y & p\alpha &= RT \\ \frac{\partial \phi}{\partial p} &= -\alpha & \frac{\partial q}{\partial t} + \vec{v} \cdot \nabla q + \omega \frac{\partial q}{\partial p} &= S_q \\ \frac{\partial T}{\partial t} + \vec{v} \cdot \nabla T + \omega \frac{\partial T}{\partial p} - \alpha \omega / C_p &= Q / C_p \end{aligned}$$

Climate models simulate weather

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Climate models simulate weather



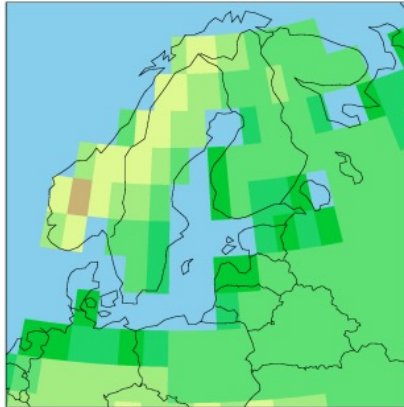
Climate models and numerical weather prediction (NWP) models are very similar

- 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

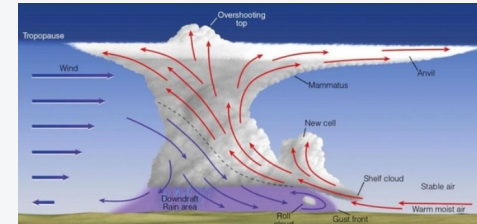
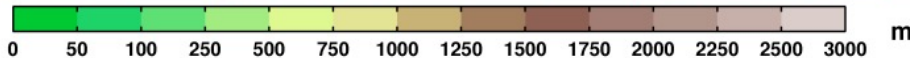
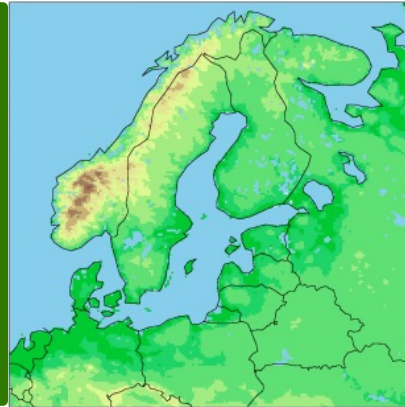
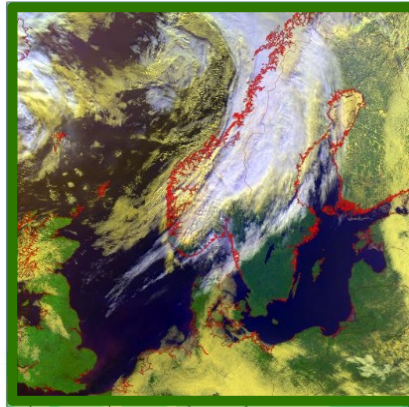
Resolution in models is a limitation

- 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)



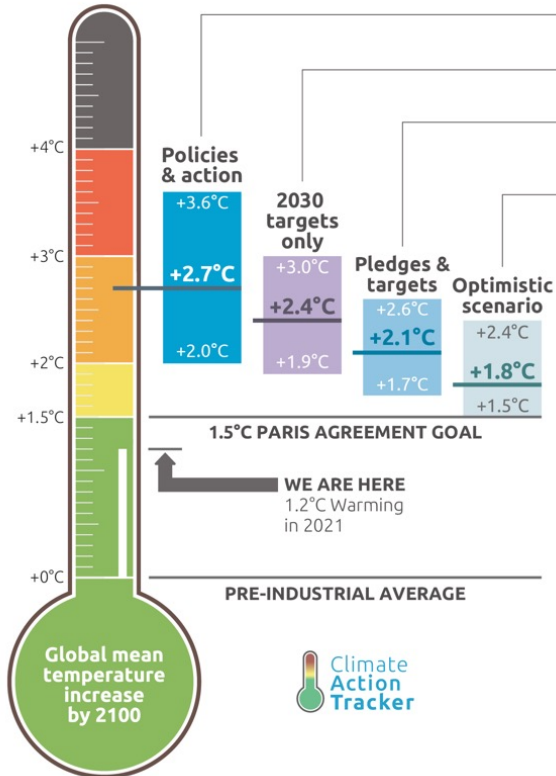
0.11° (c. 12,5 x 12,5 km)



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An (un)certain future?



Policies & action
Real world action based on current policies

2030 targets only
Full implementation of 2030 NDC targets*

Pledges & targets
Full implementation of submitted and binding long-term targets and 2030 NDC targets*

Optimistic scenario
Best case scenario and assumes full implementation of all **announced** targets including net zero targets, LTSs and NDCs*

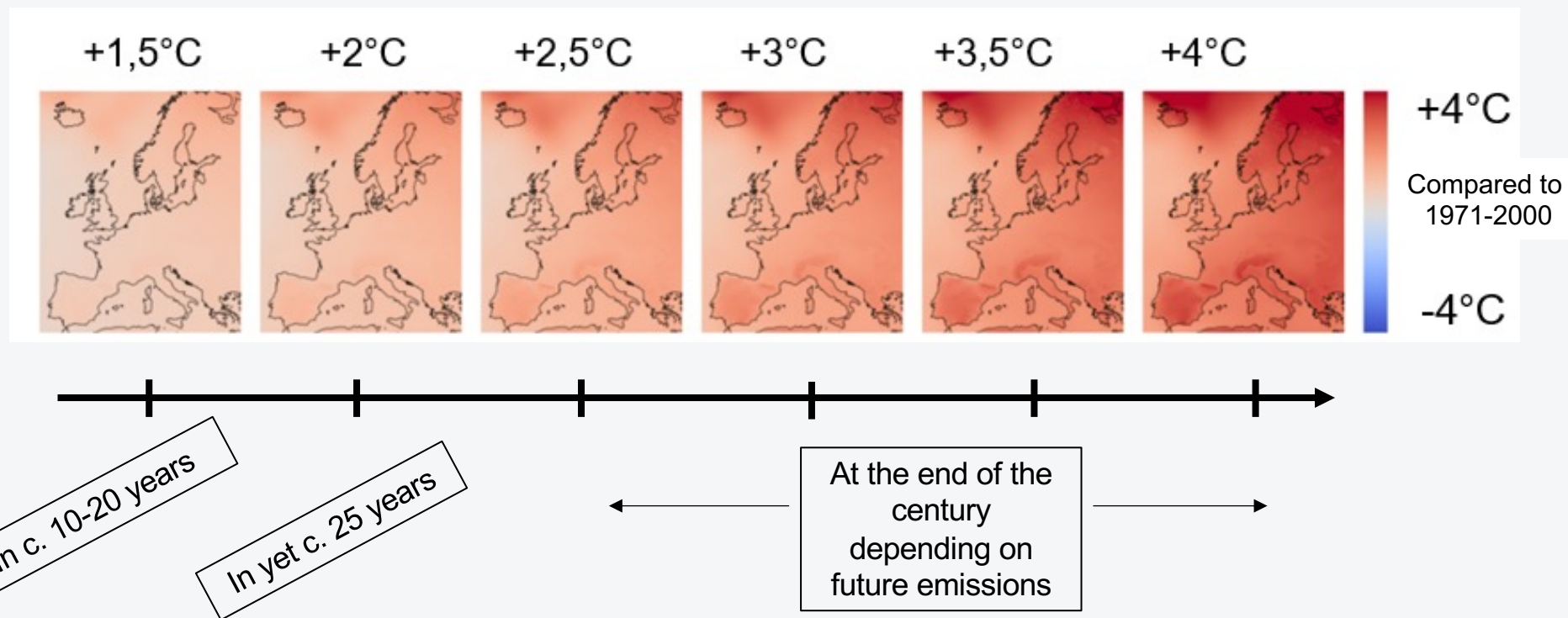
* If 2030 NDC targets are weaker than projected emissions levels under policies & action, we use levels from policy & action

CAT warming projections Global temperature increase by 2100

November 2021 Update



Increasing annual mean temperature at different degrees of global warming



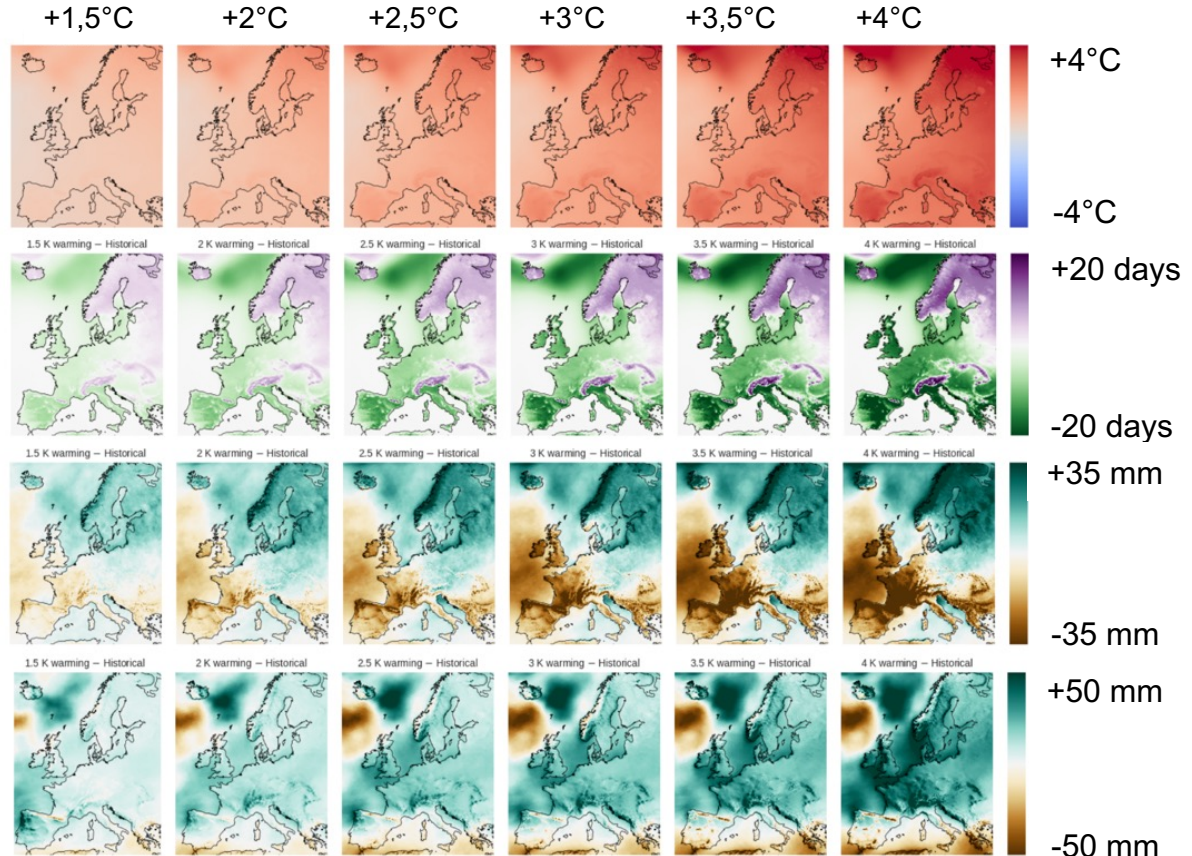
Changes at different degree of global warming

Annual mean temperature

Number of days with zero crossings in winter (DJF)

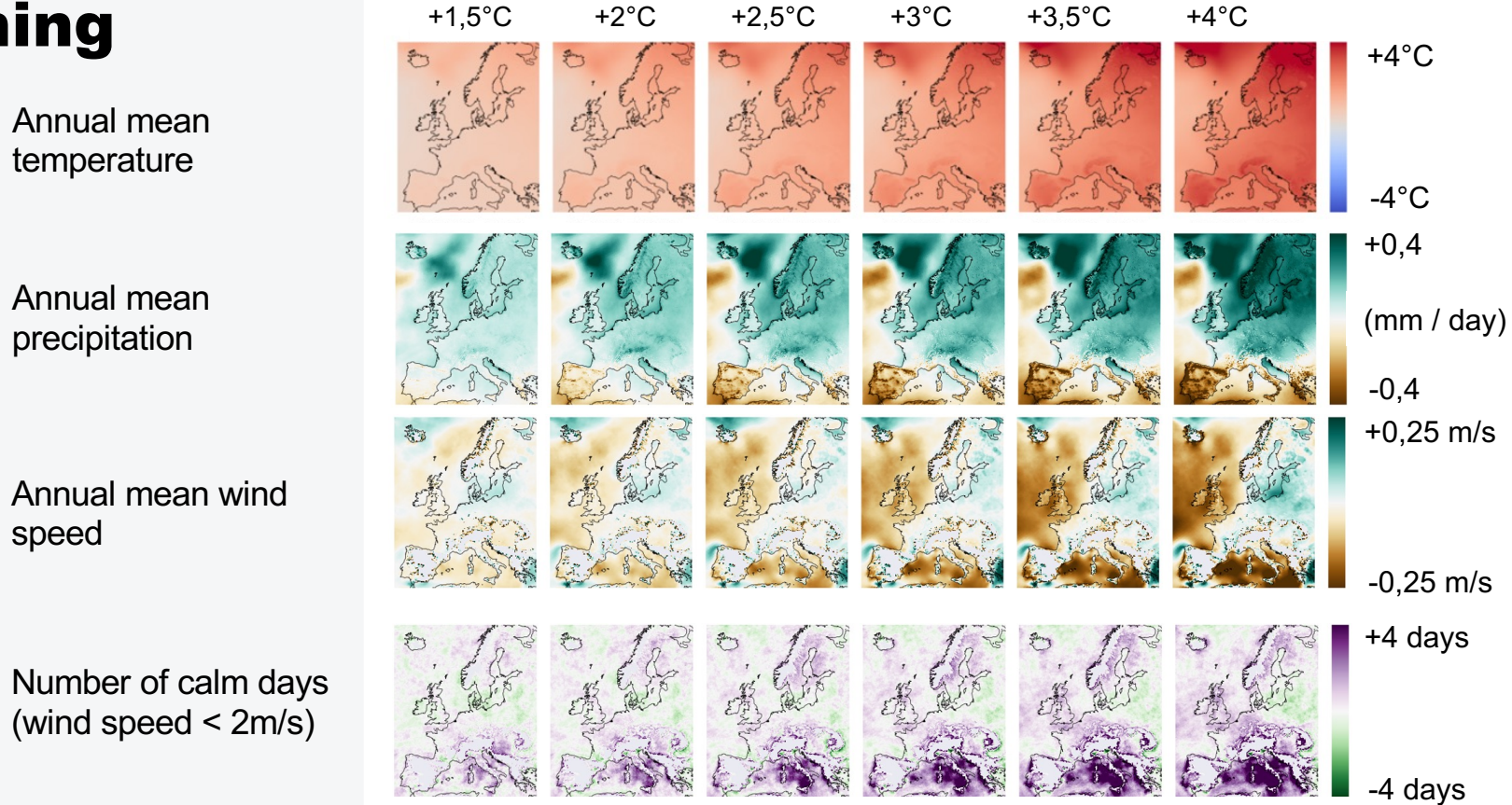
Precipitation in summer (JJA)

Precipitation in winter (DJF)



Changes at different degree of global warming

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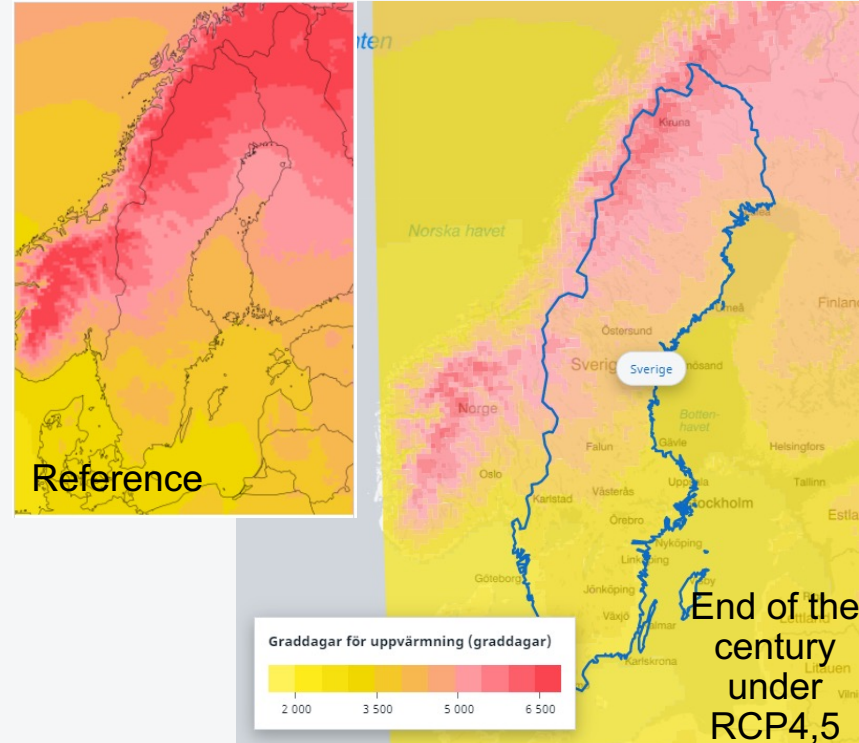
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Changes in heating/cooling demand

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)



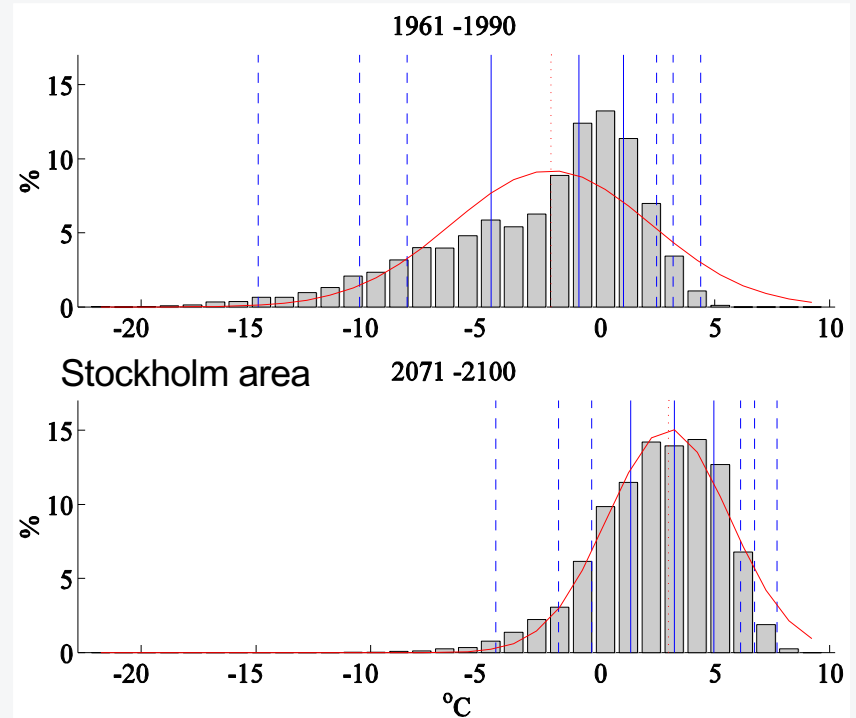
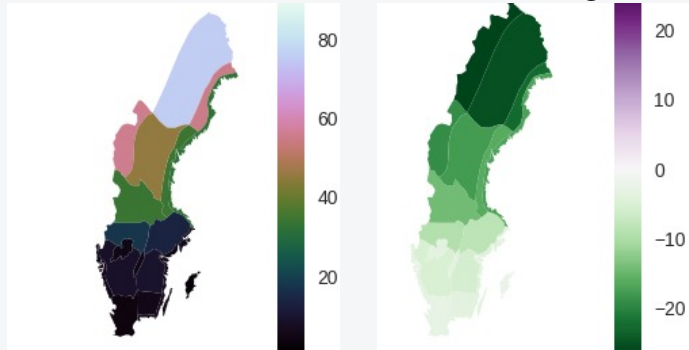
Cold extremes get less severe

Temperature increase is largest for cold days in winter

Number of cold days (<math>< -7^{\circ}\text{C}</math>) per year

1971-2000

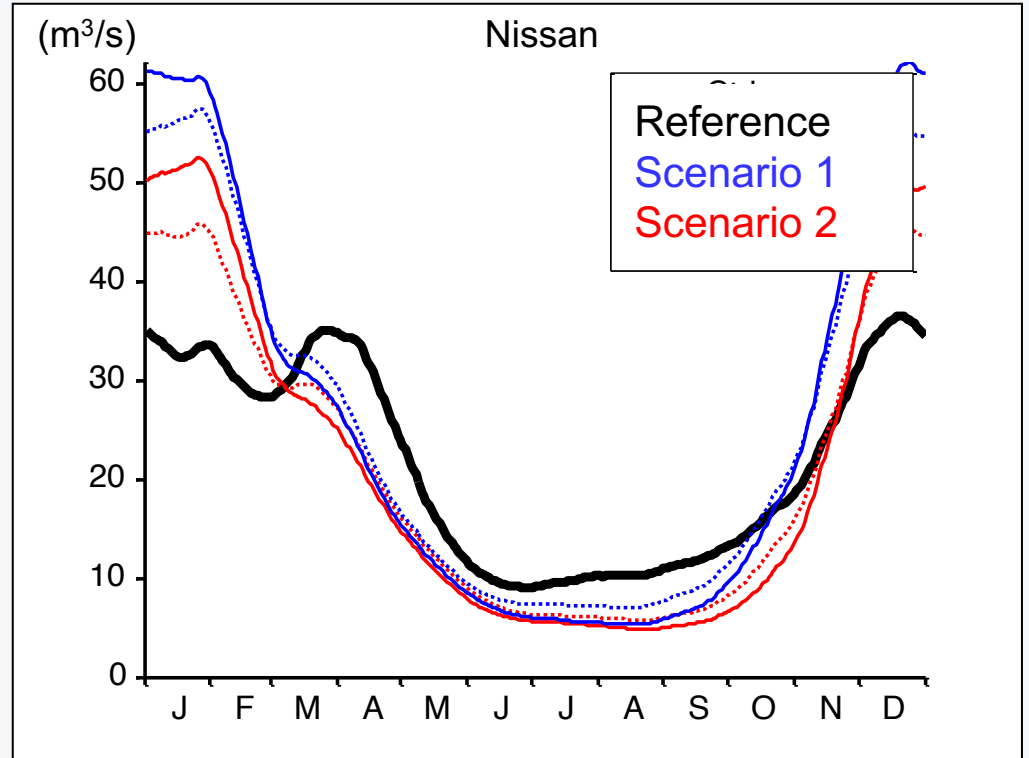
At +2°C global warming



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

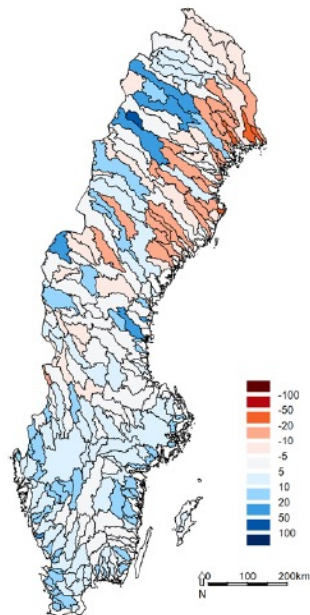
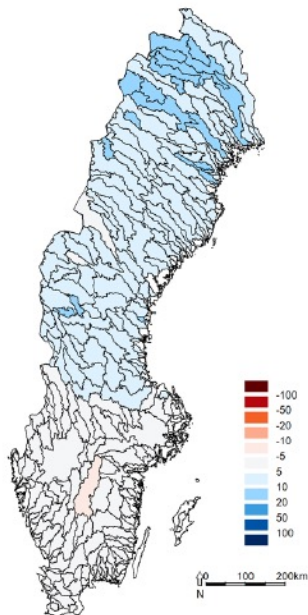
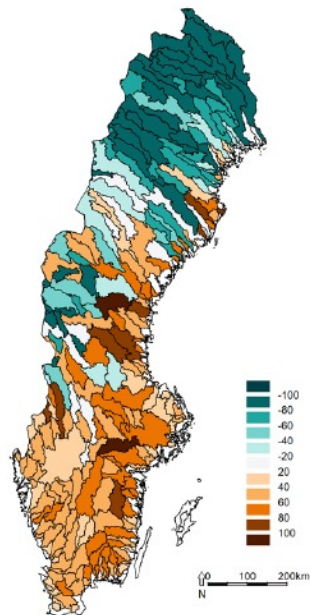


Consequenses of increasing precipitation

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

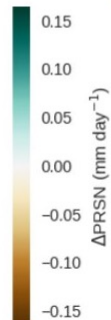
Wet snow ("blötsnö")

Likely with less problems in the south.

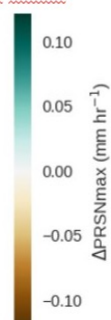
Risk of increasing problems during winter in the north

Vid +2C

Minskad mängd snöfall (uppemot hälften av mängden snöfall är borta)



Minskad maximal snöfallsintensitet i söder



Antal dagar med snöfall och temperatur nära 0°C



Antal dagar med nollgenomgångar under vintern



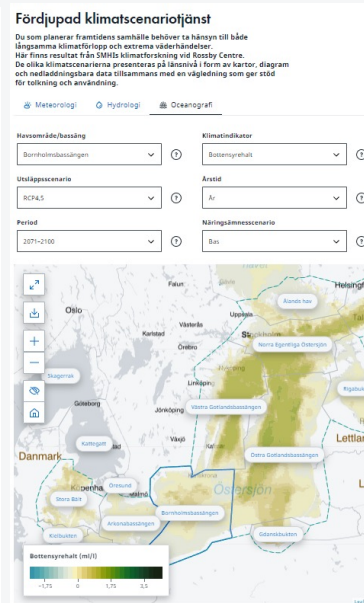
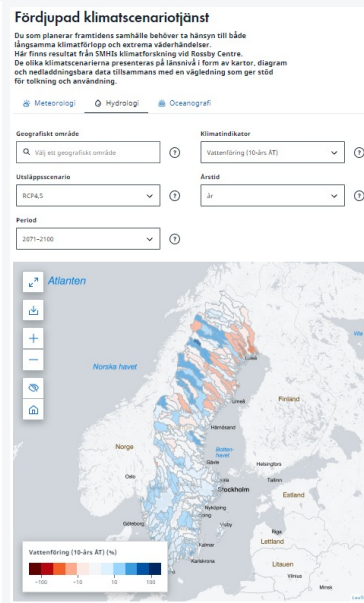
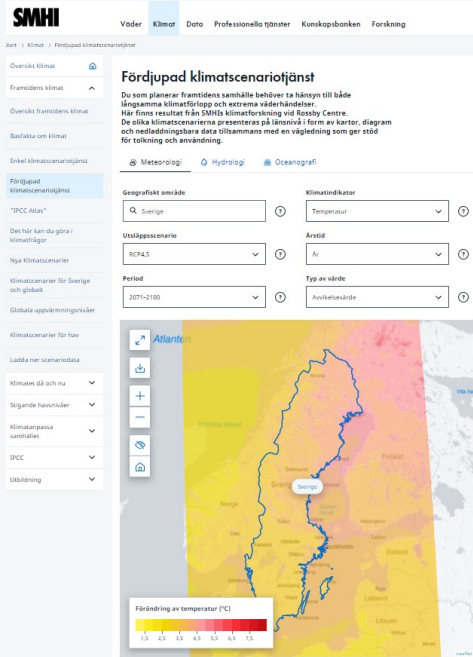
KLIMATFÖRÄNDRINGARNAS
INVERKAN PÅ ENERGISYSTEMET

RAPPORT 2007:8



More information about future climate conditions in Sweden

SMHI



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

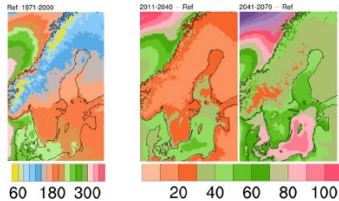
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KLIMATOLOGI Nr 64, 2022

Klimatinformation som stöd för samhällets klimatanpassningsarbete

Erik Kjellström, Lotta Andersson, Lars Arneborg, Peter Berg, René Capell, Sam Fredriksson, Magnus Hieronymus, Anette Jönsson, Lena Lindström, Gustav Strandberg



Första rapporten från Nationella expertrådet för klimatanpassning **2022**



NATIONELLA EXPERTRÅDET FÖR
KLIMATANPASSNING

SMHI Rapport Klimatologi 64, 2022

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

Nationella expertrådet för
klimatanpassning 2022

<https://klimatanpassningsradet.se/>