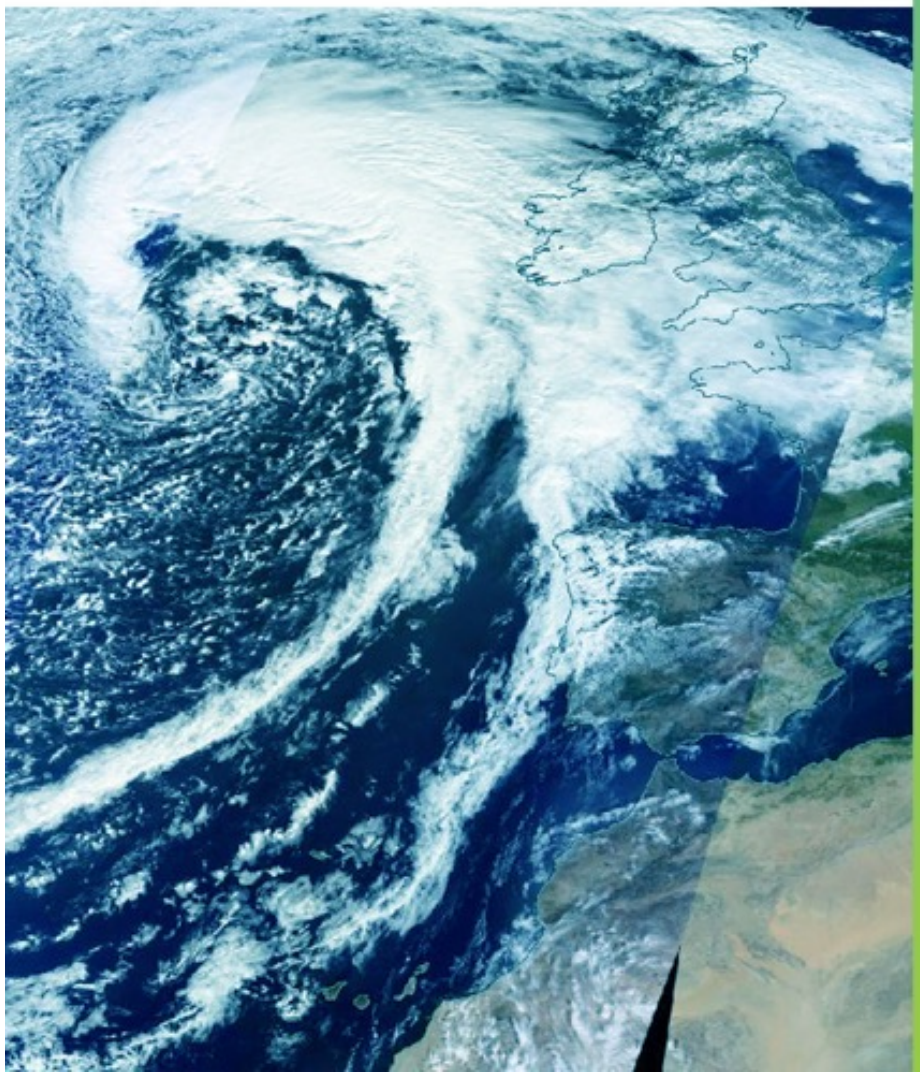
imprex

Learn from today to anticipate tomorrow



A surrogate warming experiment on summertime extreme precipitation events in Europe comparing a convective permitting model to coarser scale RCMs

Erik Kjellström, Petter Lind, Danijel Belušić and Geert Lenderink,

ICRC-CORDEX 2019, 16 October 2019, Beijing

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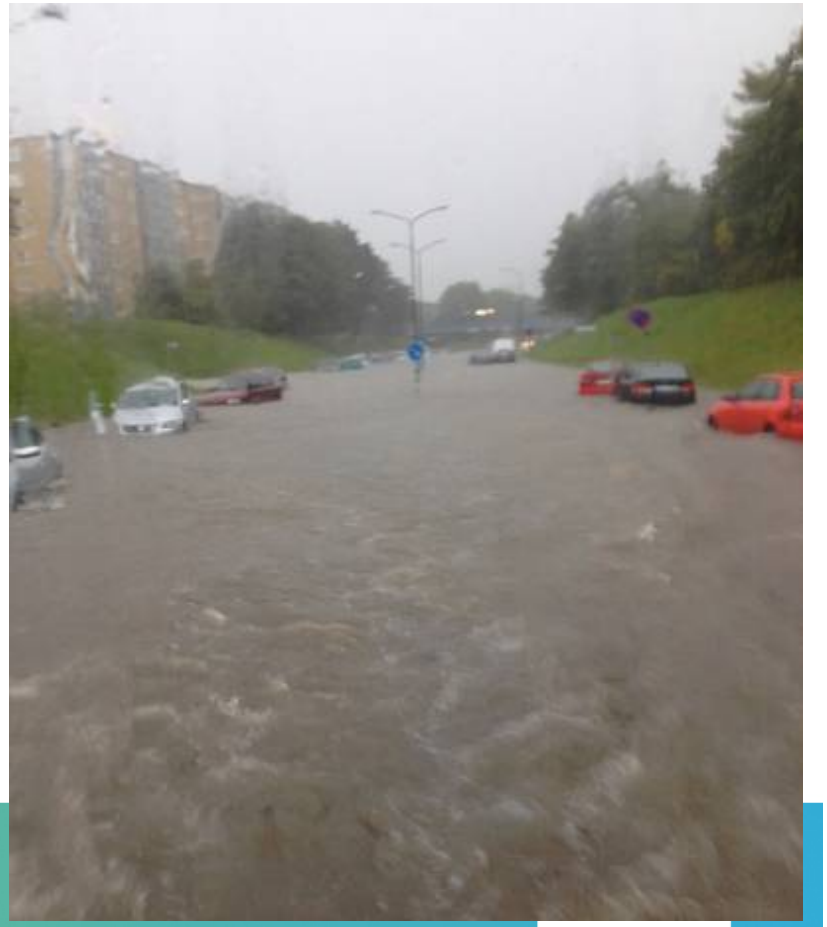
SMHI

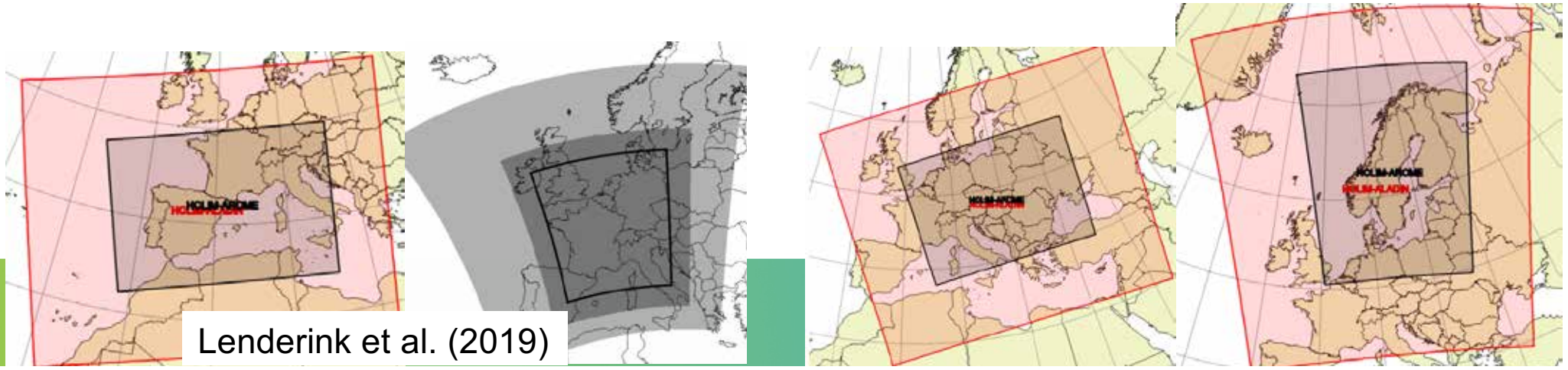
Motivation

- Warmer climate, more intense cloudbursts
- Cloudbursts are better represented by convection permitting models than by models with convection parameterization
- A number of papers indicate convection permitting models show stronger increase in intensities



Climate simulations

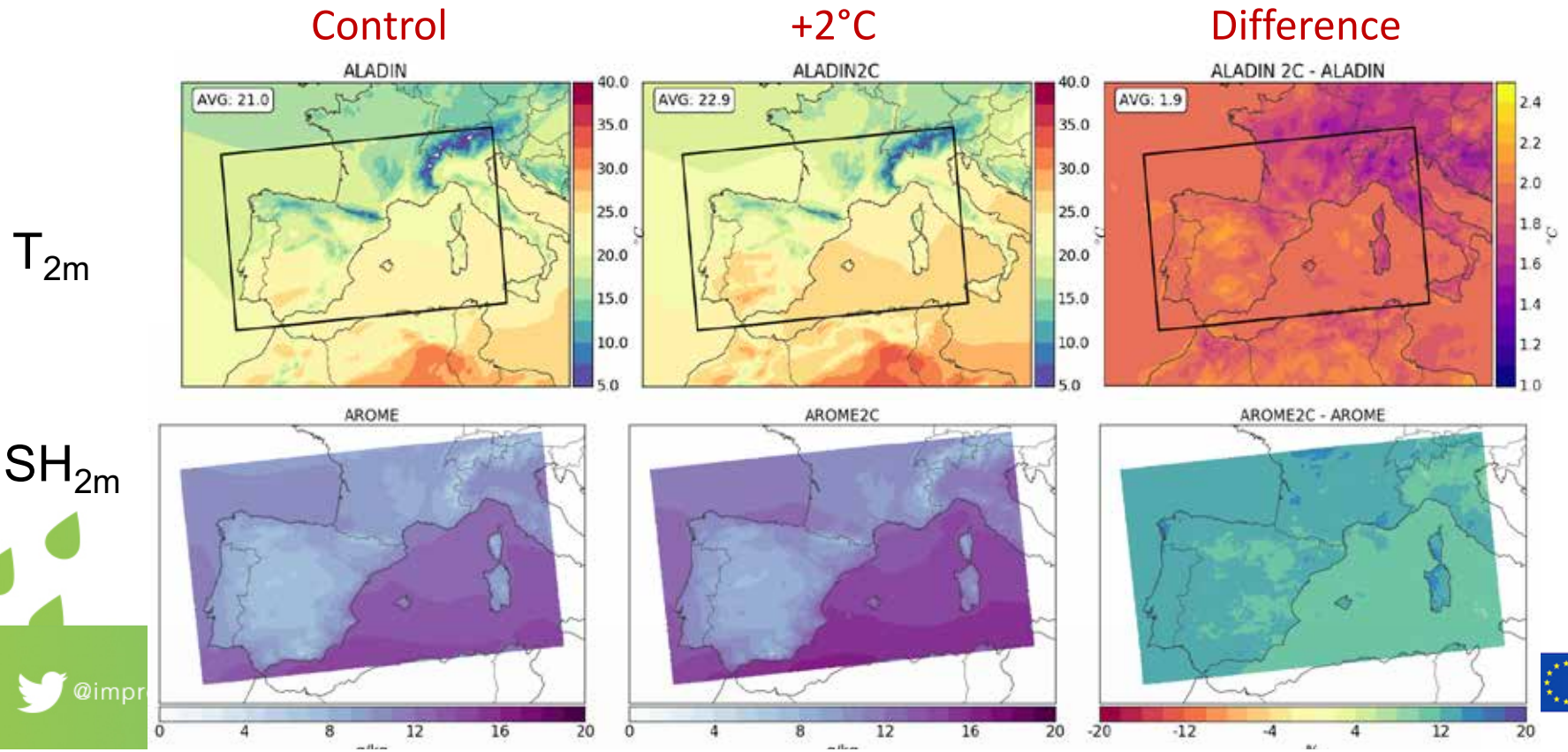
1. 10 summer months with most precipitation in E-OBS from 2000-2016
2. Downscaling of ERA-Interim in two steps:
   i) to c. 12 km gridscale (EURO-CORDEX-type)
   ii) to 2.5-3 km with HCLIM-AROME
3. A surrogate climate change experiment where the temperature on the boundaries and SST in i) is increased by +2°C and specific humidity on the boundaries are set to keep RH constant.



Lenderink et al. (2019)

+2°C warming

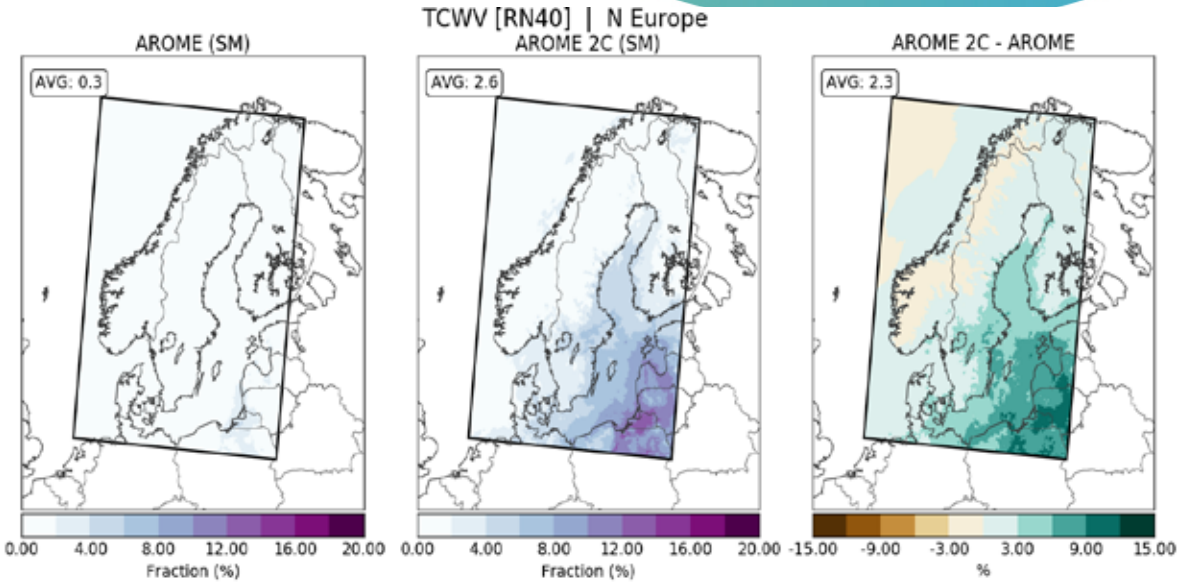
- T_{2m} increases by close to +2°C
- Smaller T_{2m} increase over much of the land areas due to enhanced evapotranspiration
- SH_{2m} increases everywhere

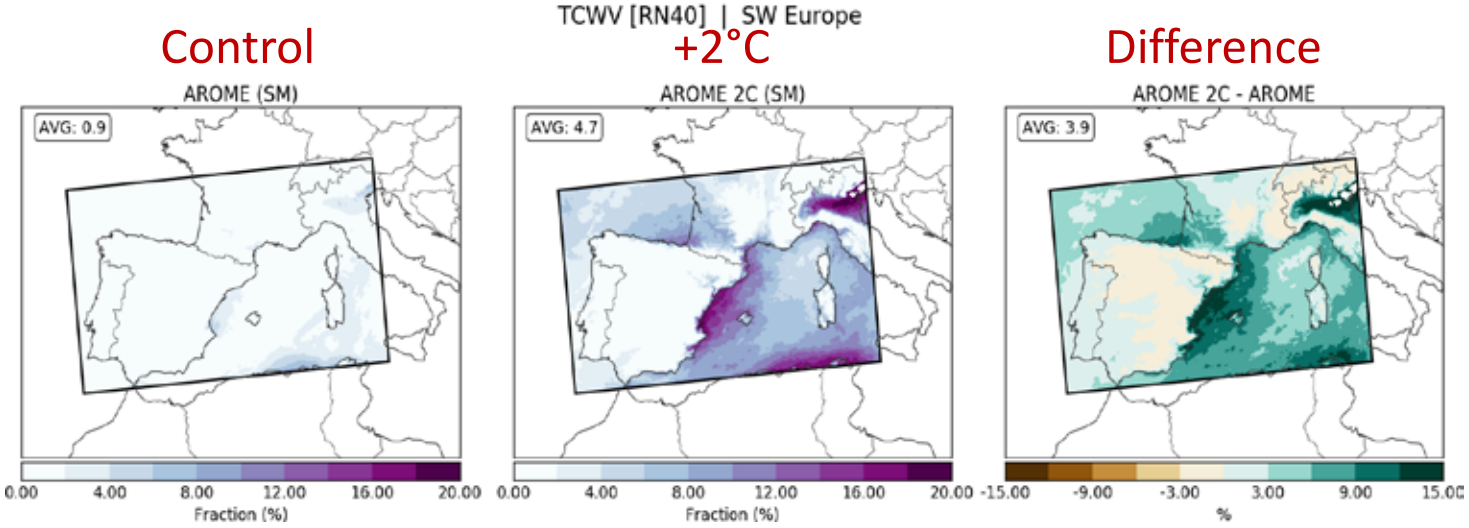


Strong increase in humidity

Fraction of days with > 40 kg/m2 cloud water (very humid conditions)

Number of days with very humid conditions increase significantly!

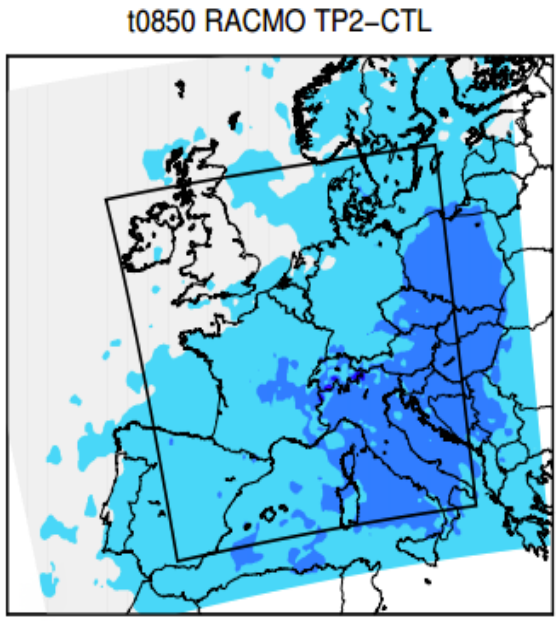




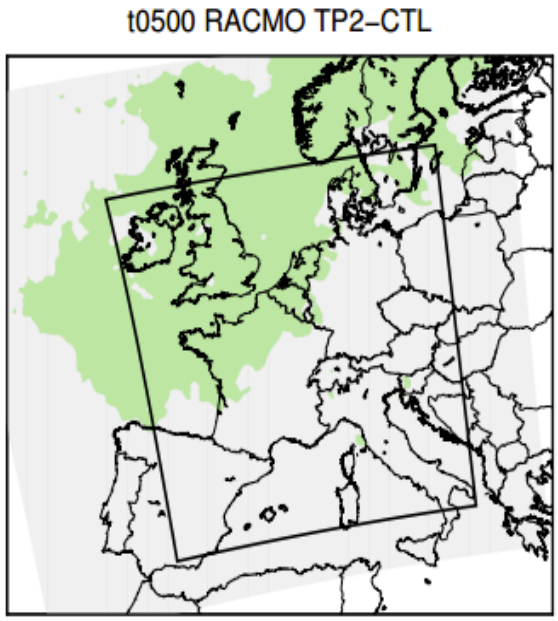
Changing stability of the atmosphere (1)

- Upper levels warm more (as pressure levels are pushed upwards) leading to slightly more (less) stable conditions at high (low) levels

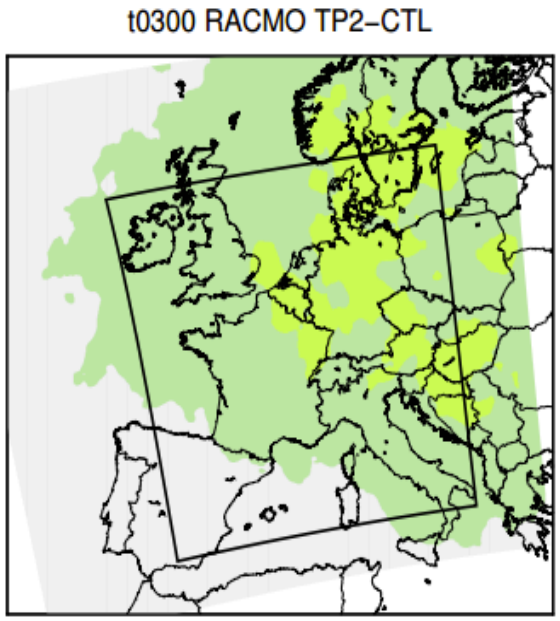
850 hPa (c. 1500 m)



500 hPa (c. 5500 m)

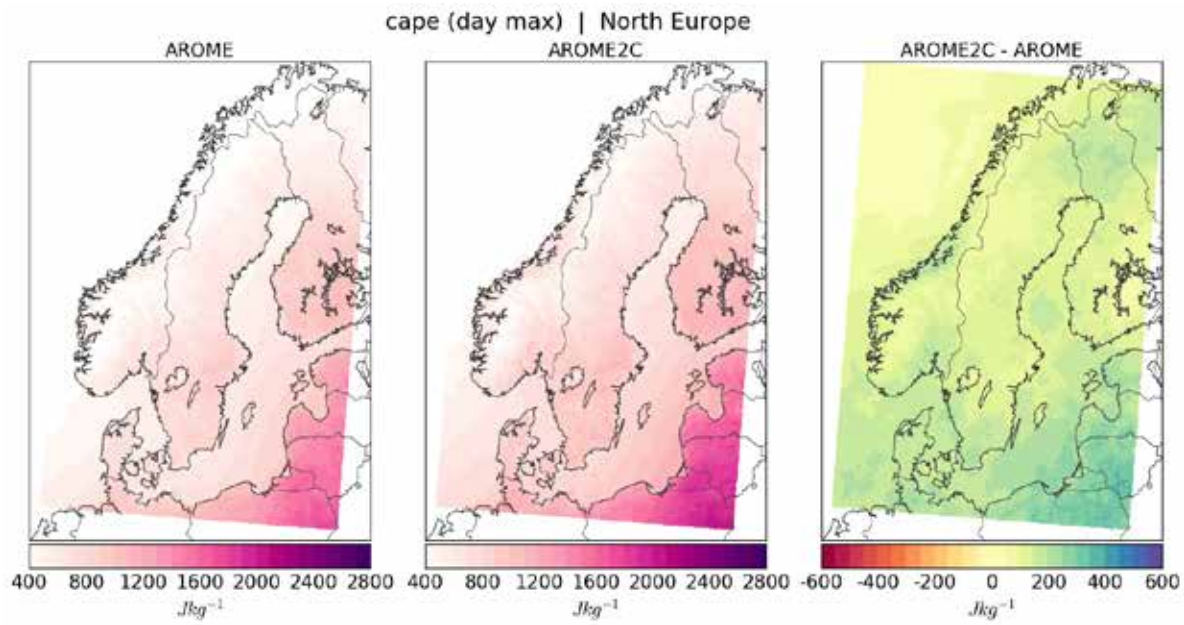


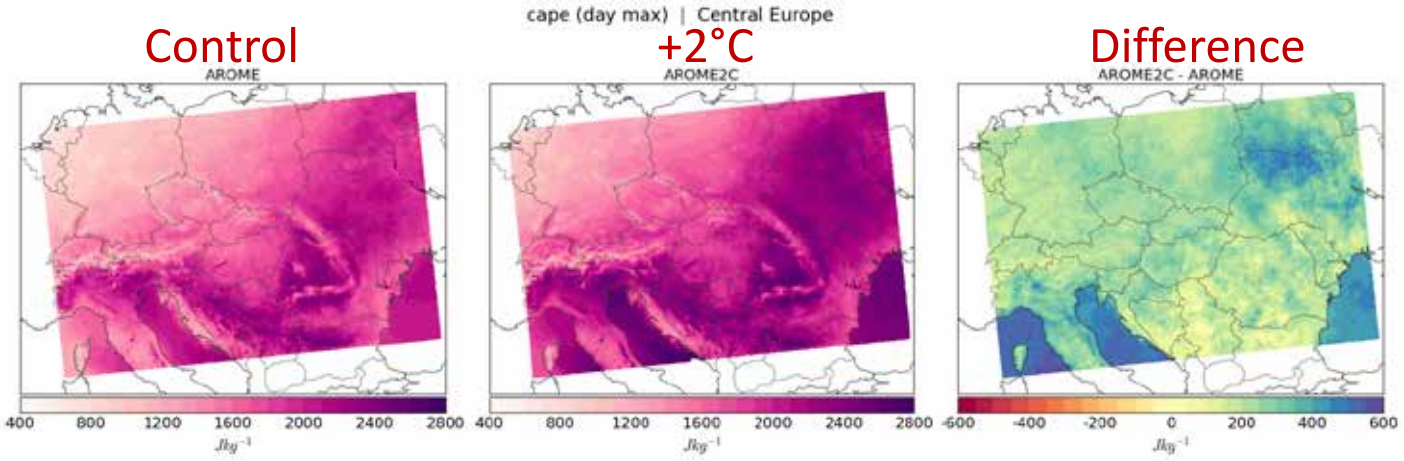
300 hPa (c. 9000 m)



Changing stability of the atmosphere (2)

- Maximum CAPE increases due to increased availibility of humidity (more favorable for convection)



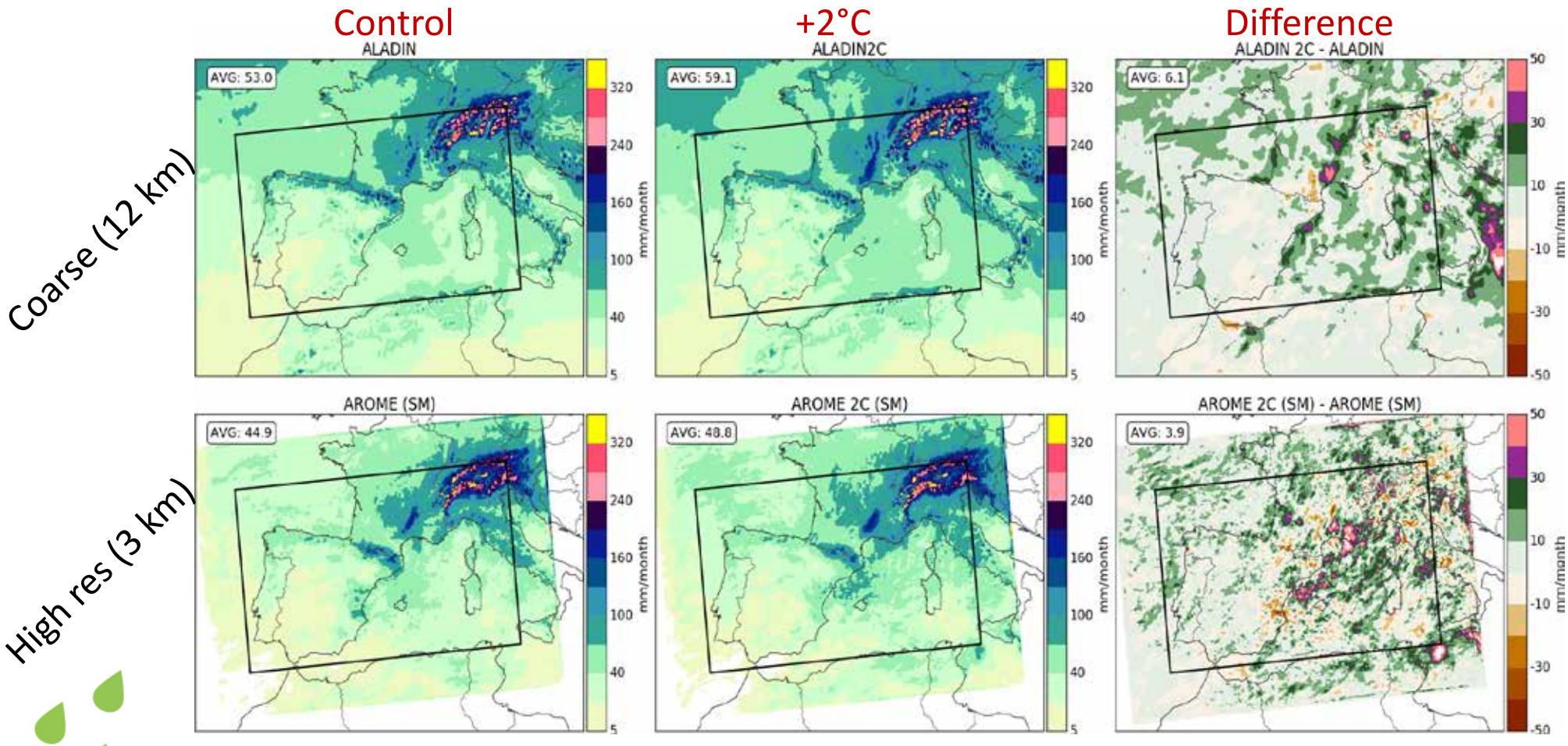


Changing risk of deep convection?

- Large increases in humidity due to the warmer conditions
- Some stabilization of the middle and upper troposphere – lowermost atmosphere becomes less stable
- Increasing maximum CAPE
- The surrogate climate change experiment indicates conditions favorable for deep convection and heavy precipitation

Changes in monthly mean precipitation

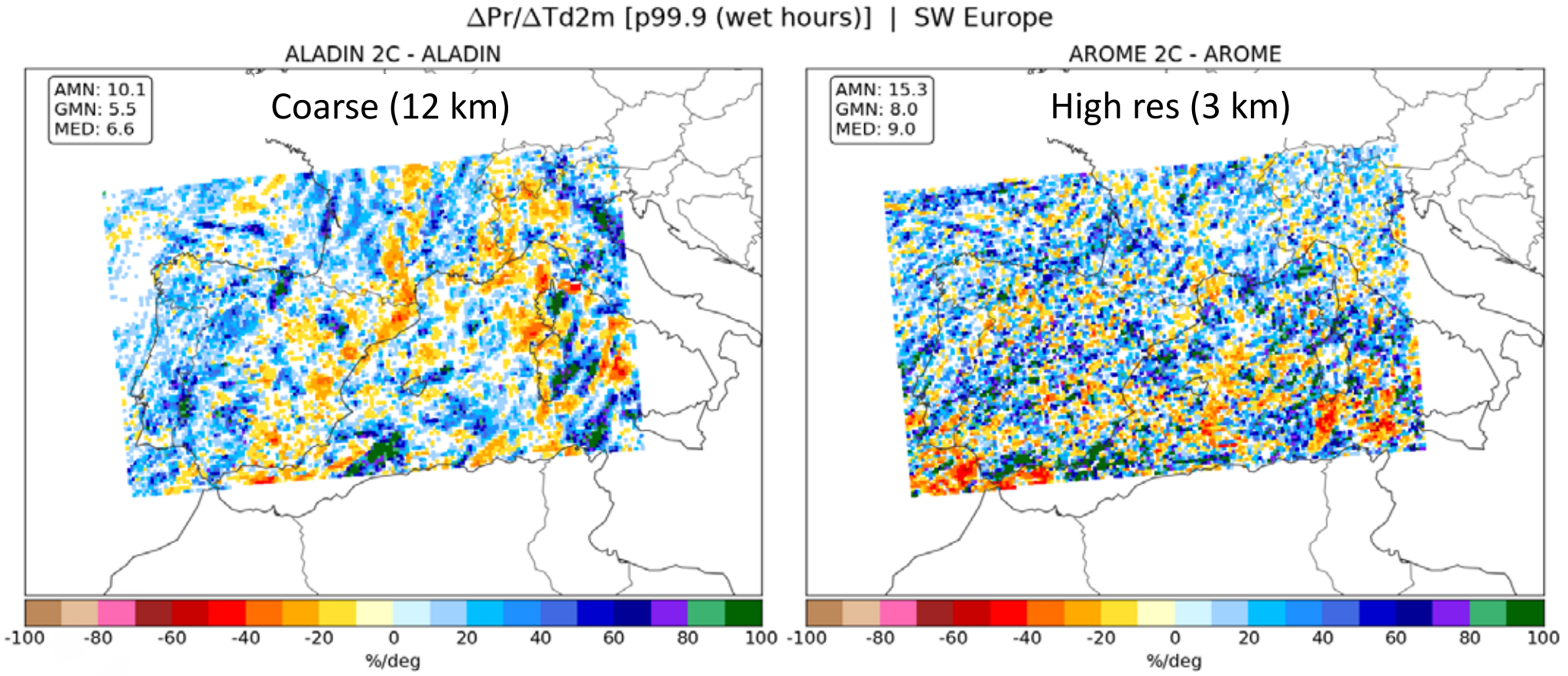
c. +5 % / degree (cf. Clausius-Clapeyron c. + 6.5% / degree)



Changes in heavy precipitation

Increases of c. 5 % / degree for the coarse model.

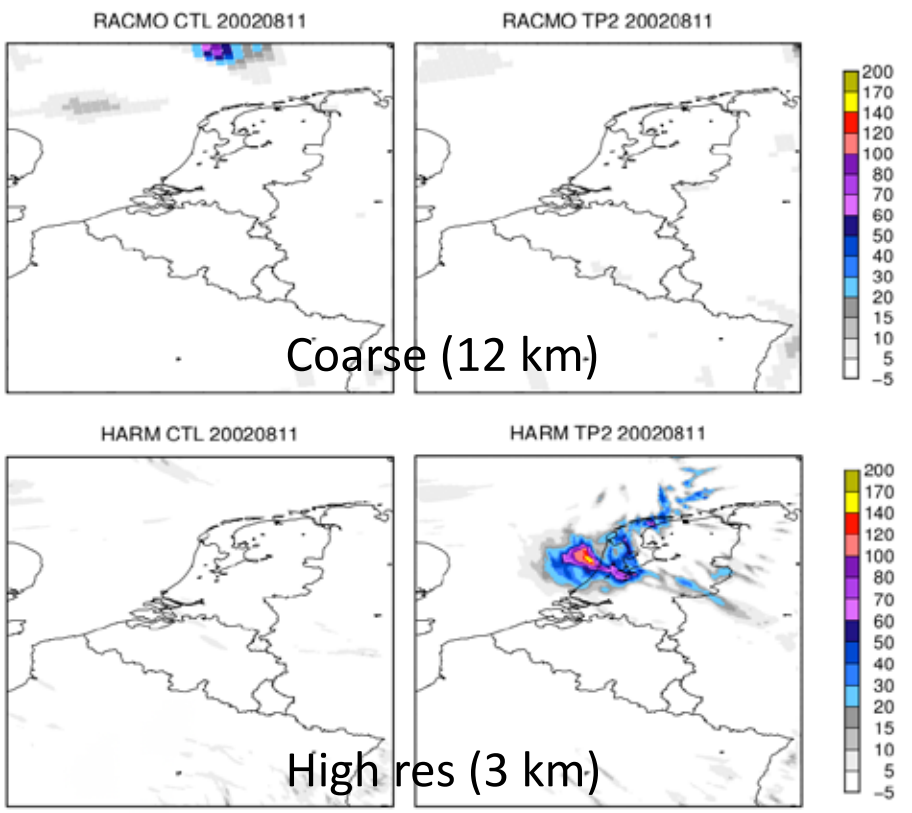
Increases up to almost 10 % / degree for the high res model.

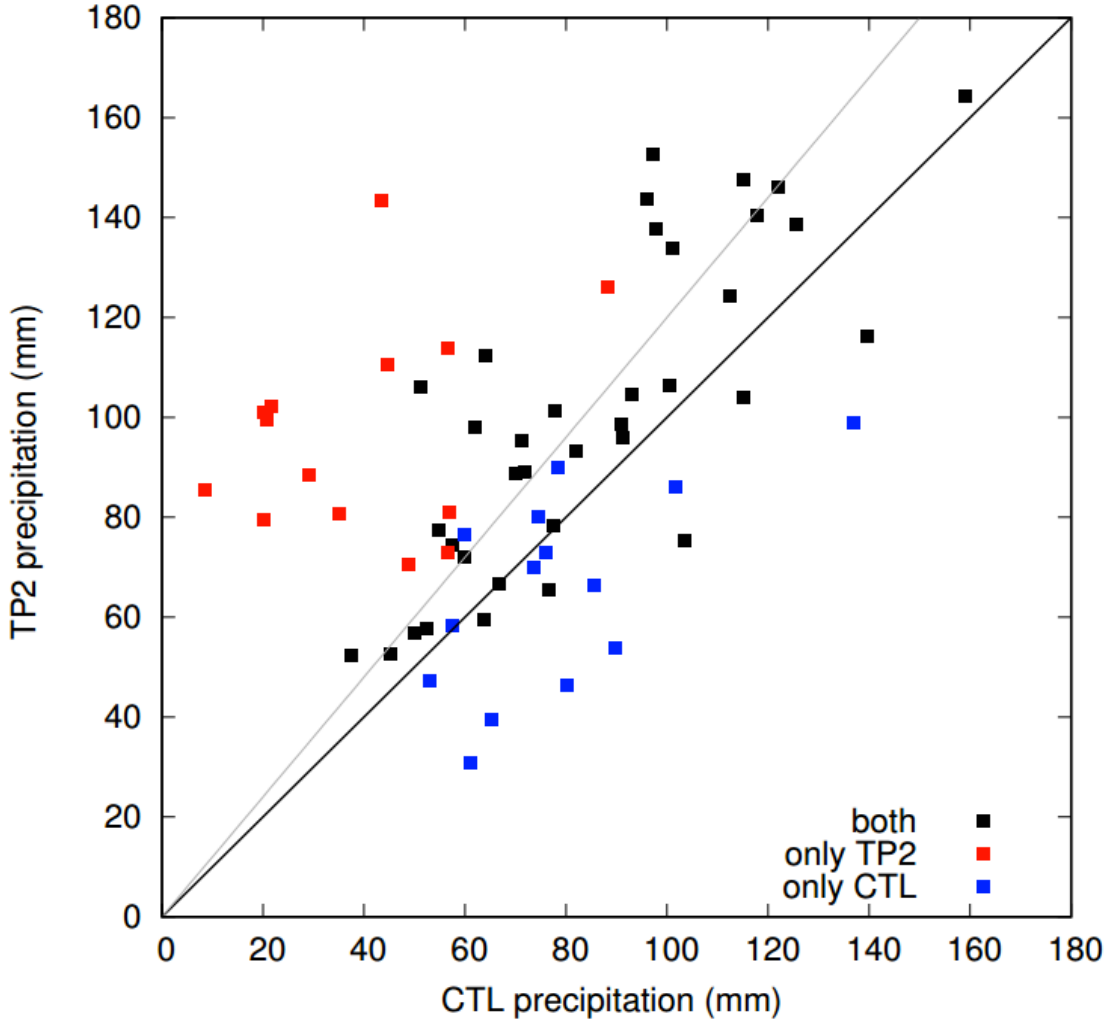


Sampling issues?

Are extremes in the control experiment also there in the +2C setting?

Control +2°C



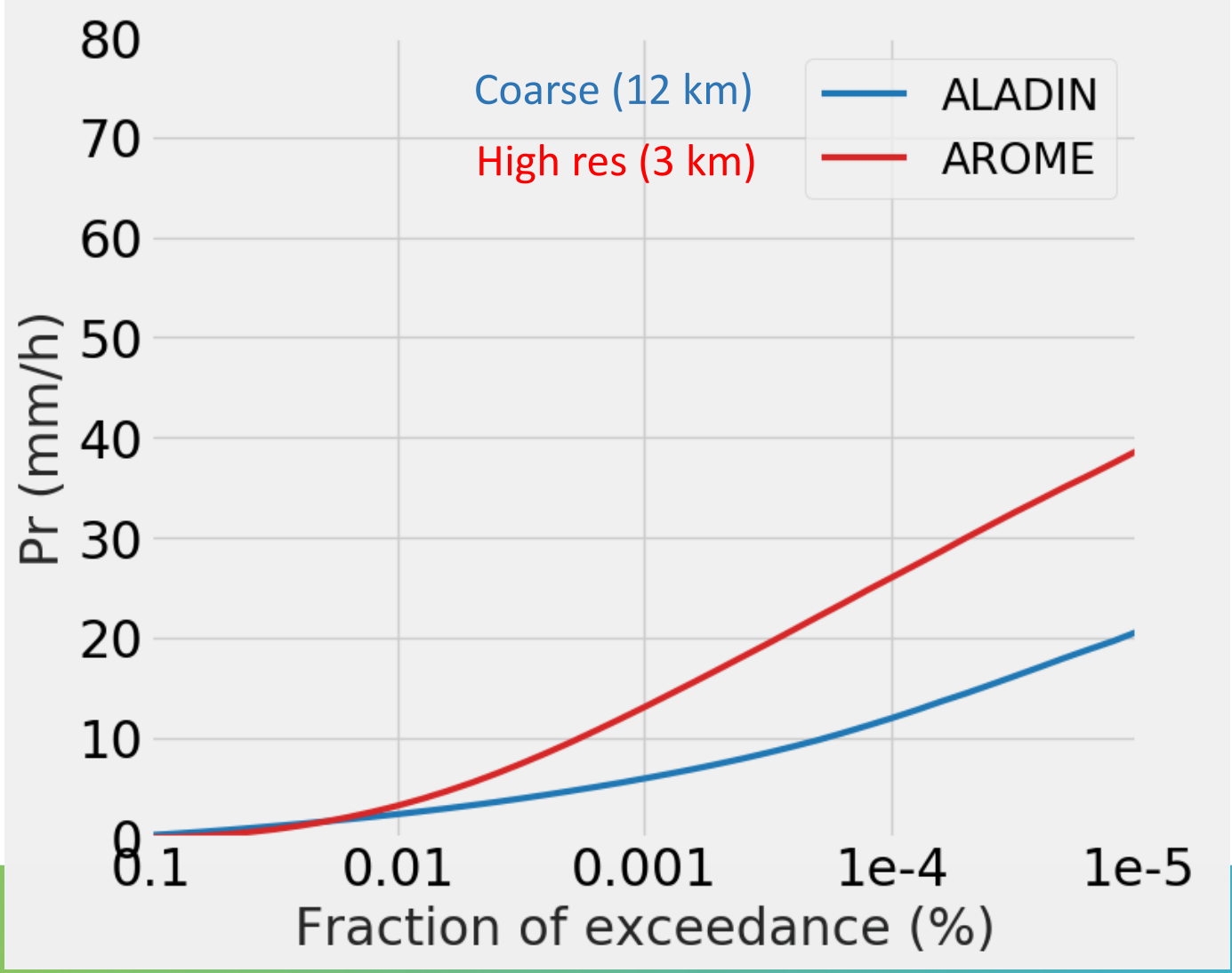


Hourly extremes

Aggregation to the 12 km grid

- High resolution model adds value at the coarse scale

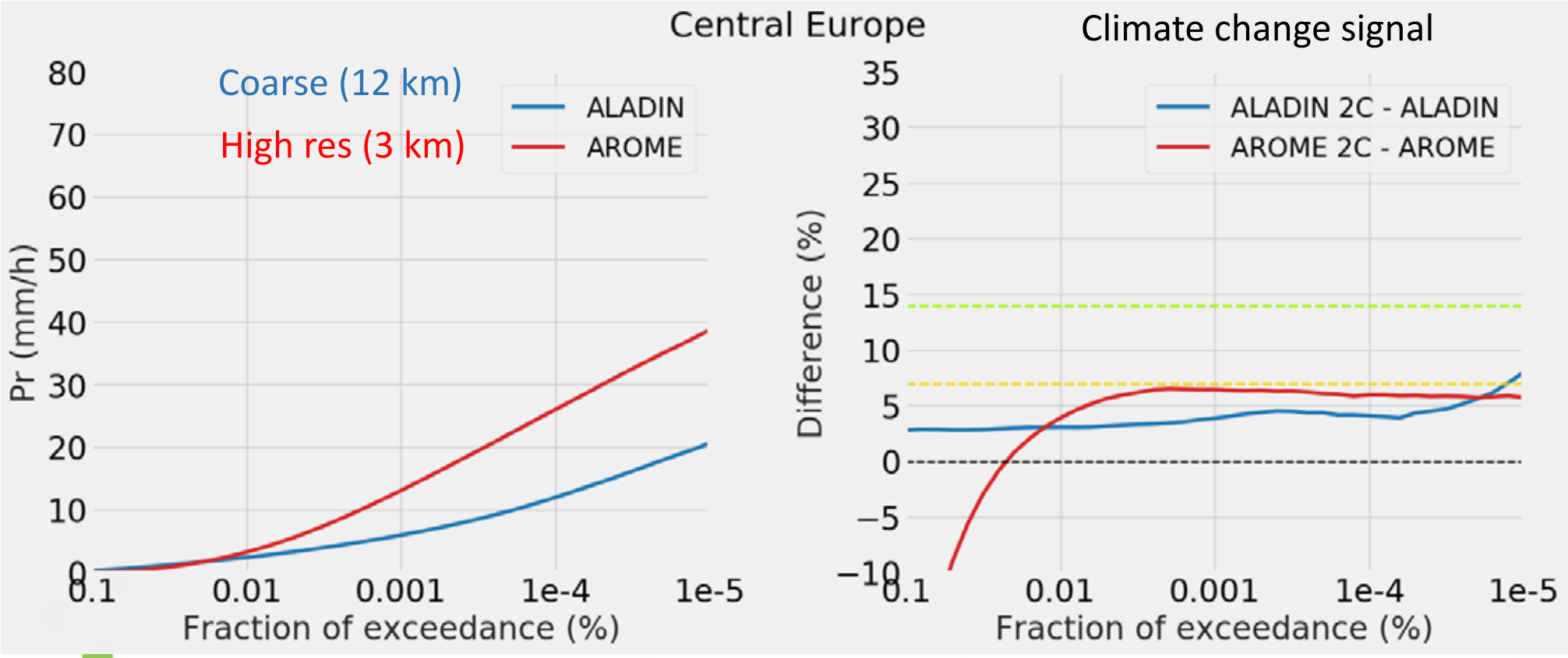
Central western Europe



Changing hourly extremes

Aggregation to the 12 km grid

- Changes at the coarse scale grid are mostly larger in the high-res model for extreme precipitation

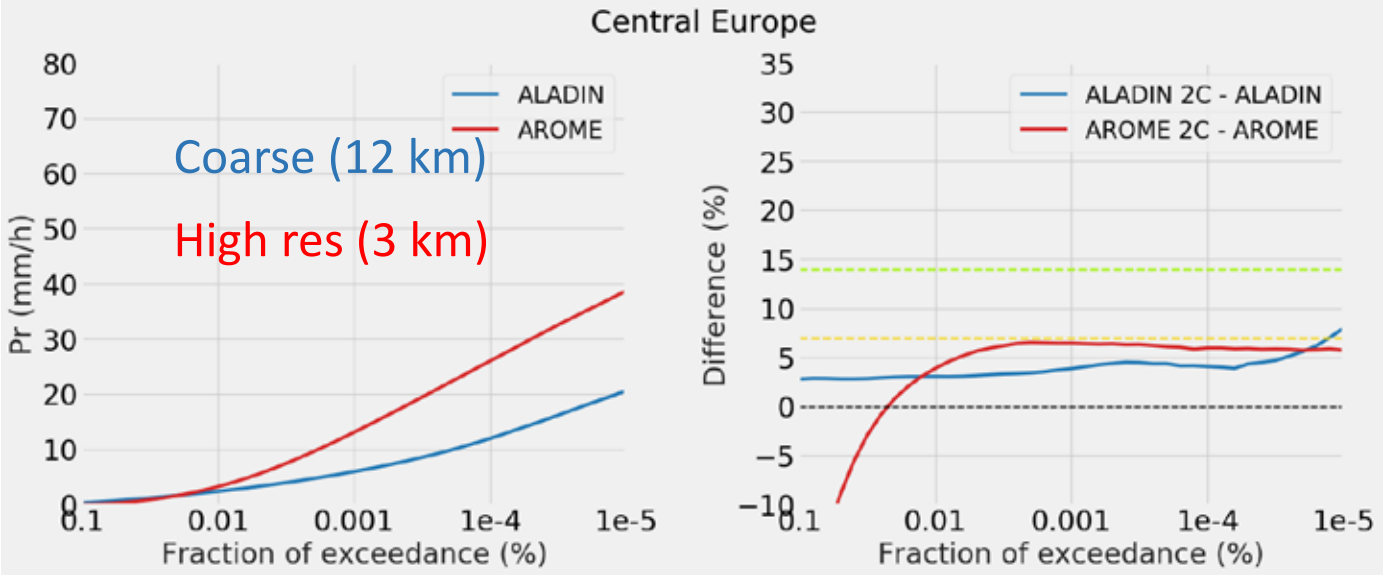


Changing hourly extremes

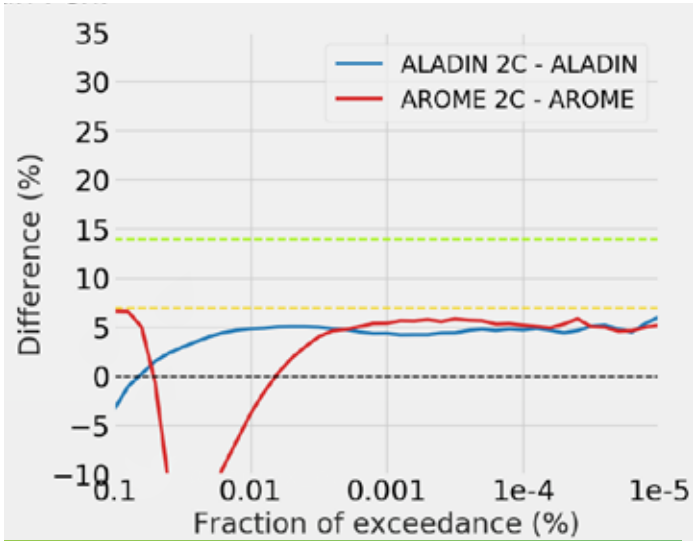
Aggregation to the 12 km grid

- Changes at the coarse scale grid are mostly larger in the high-res model
- Not always at the high-end (larger convective systems?)

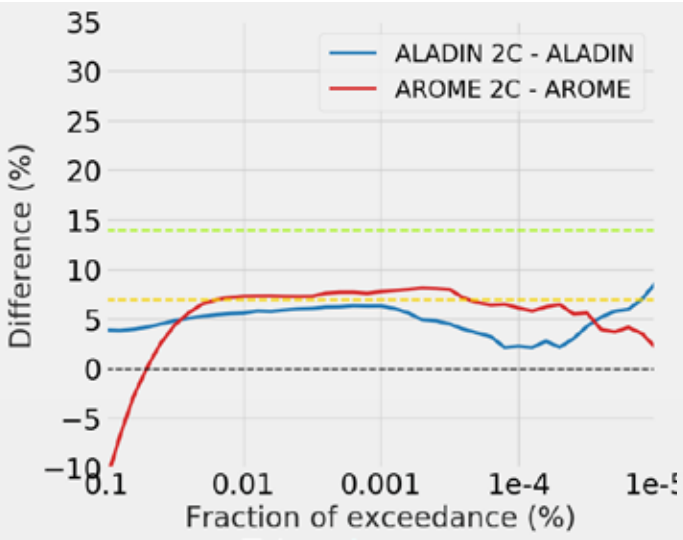
Climate change signal



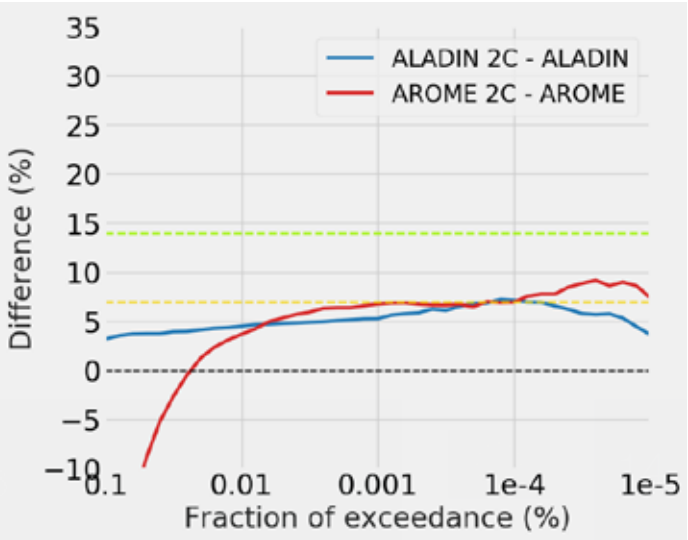
Iberian Peninsula



Mid Sweden



Po Valley

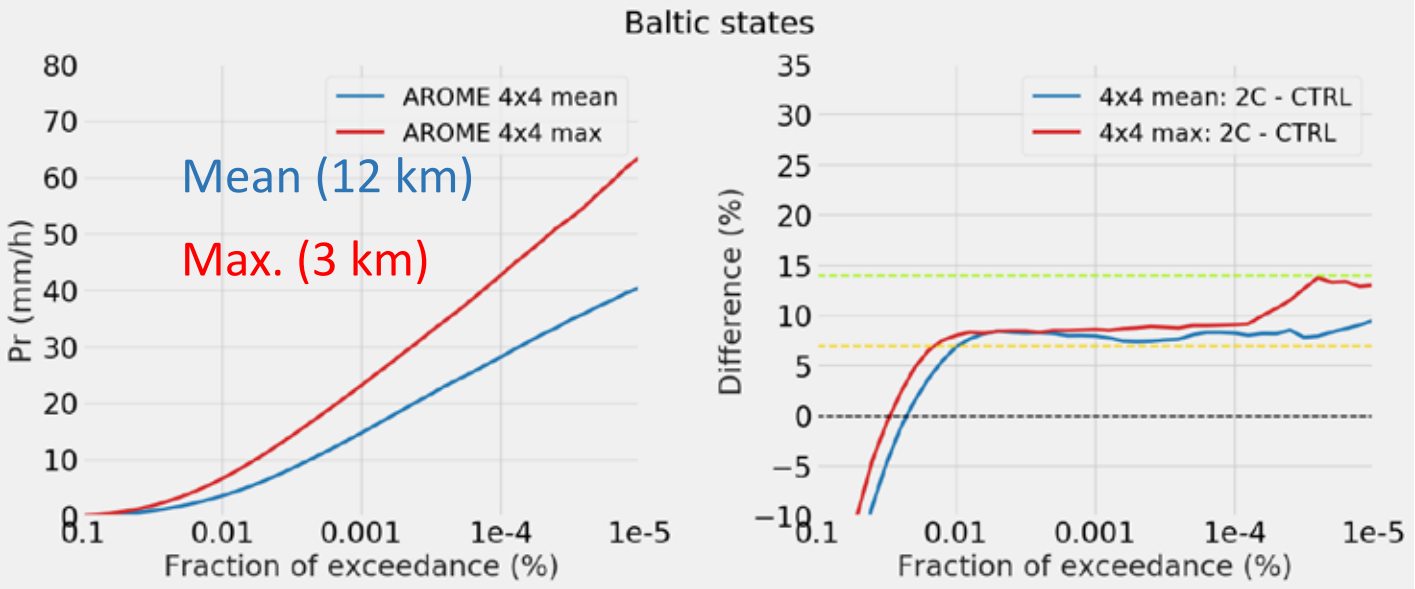


Changing hourly extremes

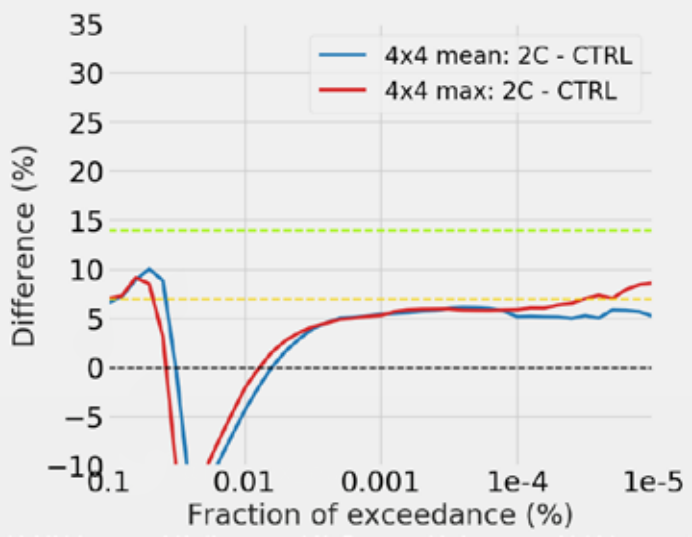
High resolution has an impact

- Local maxima always higher than mean.
- Response depends on environment (moisture availibility?)
- Response larger at the far end tail.

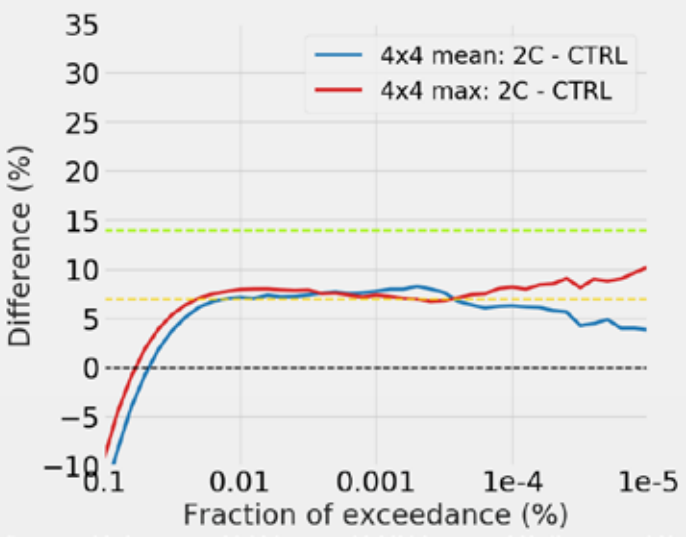
Climate change signal



Iberian Peninsula



Mid Sweden



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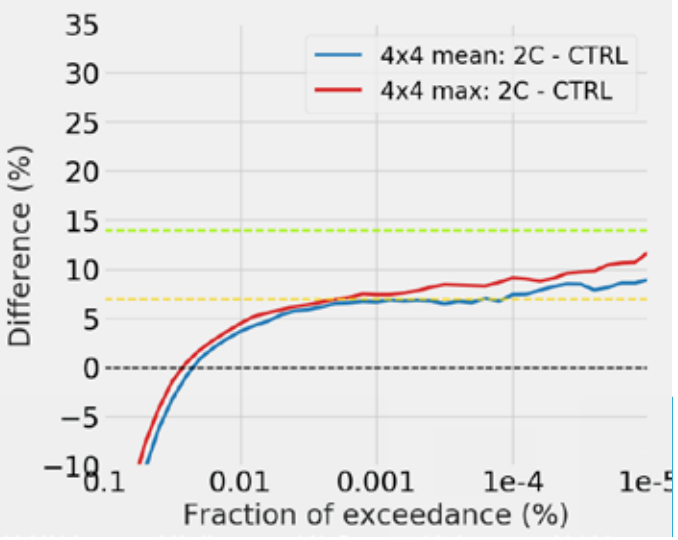

Summary

- Precipitation increases in the +2C climate and more for extremes than for average conditions.
- Precipitation extremes increases more in the convection permitting simulations.
- Clear illustration of added value of downscaling.
- The increase in extreme precipitation differs between regions, ranging from 1 to 2 times the Clausius-Clapeyron ratio, with the largest increases at the high-end of the distribution and in moist environments.

Lenderink, G., Belušić, D., Fowler, H., Kjellström, E., Lind, P., van Meijgaard, E., van Ulft, B. and de Vries, H., 2019. Systematic increases in the thermodynamic response of hourly precipitation extremes in an idealized warming experiment with a convection-permitting climate model. Environ. Res. Lett. 14, 074012, DOI: 10.1088/1748-9326/ab214a