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# Convection in future winter storms over northern Europe.

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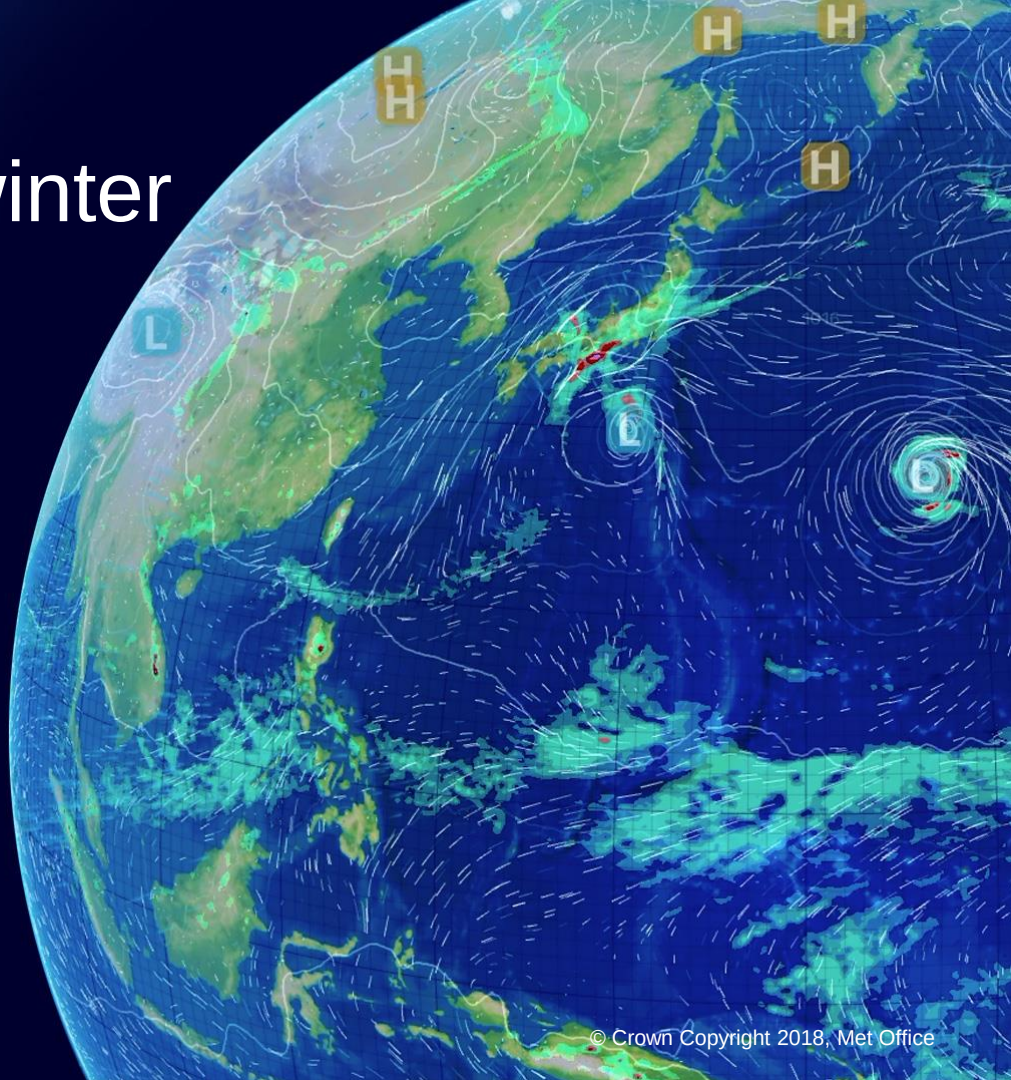
EUCP
European Climate Prediction system



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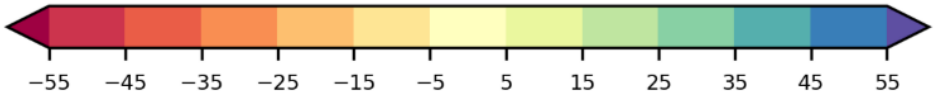
EUCP European Climate Prediction system

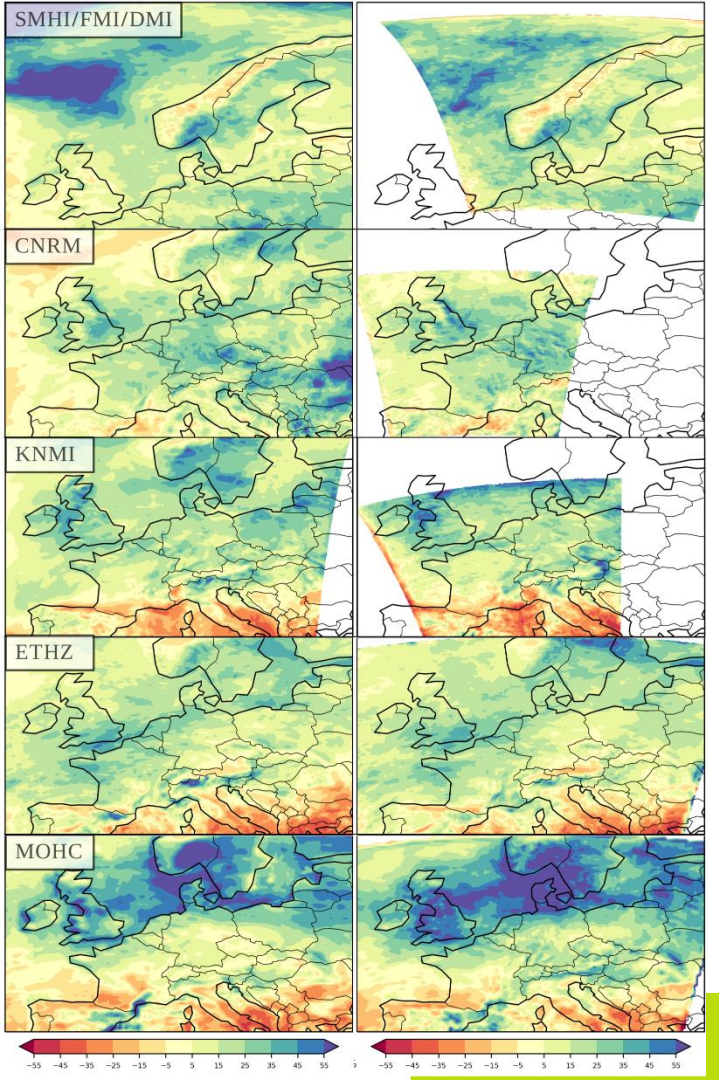
Increase in future mean precipitation over northern Europe

MOHC shows a larger increase in precipitation, and even more so in CPM.

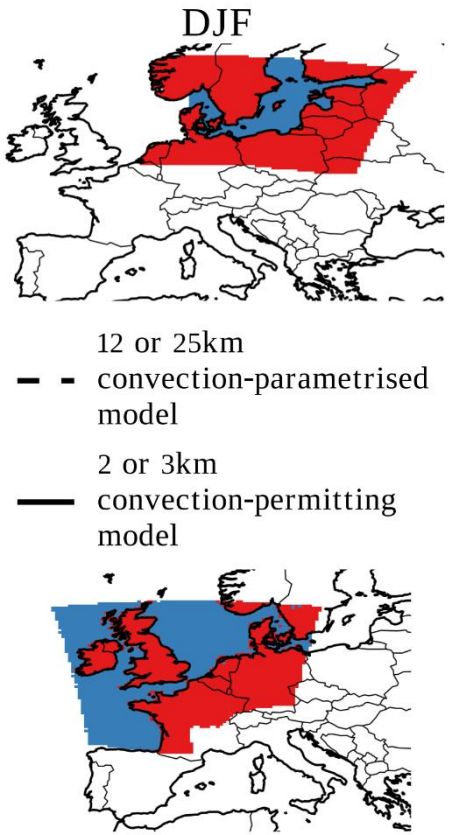
Left: convection-parameterised model (RCM ~12-25km)
Right: convection-permitting model (CPM ~2-3km)

% change



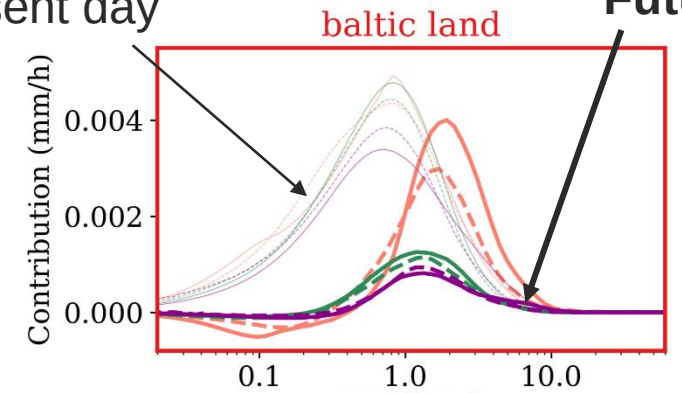



# Heavy precipitation rates responsible for mean increase

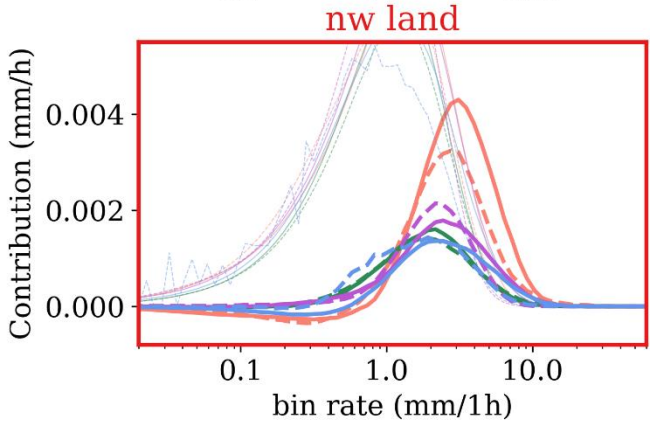



Present day

**Future changes**

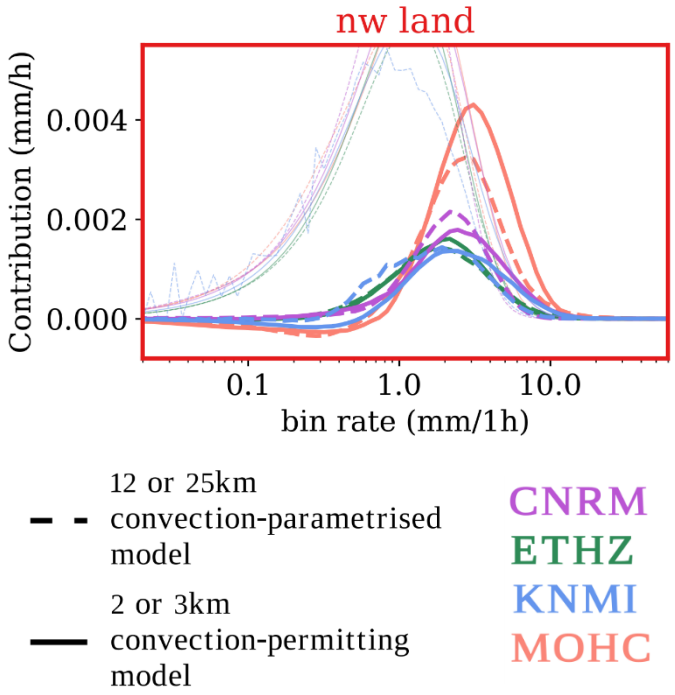



DMI/FMI/SMHI/METNO
ETHZ
MOHC




CNRM
ETHZ
KNMI
MOHC

# MOHC models: larger precipitation increase at 2.2km, why?



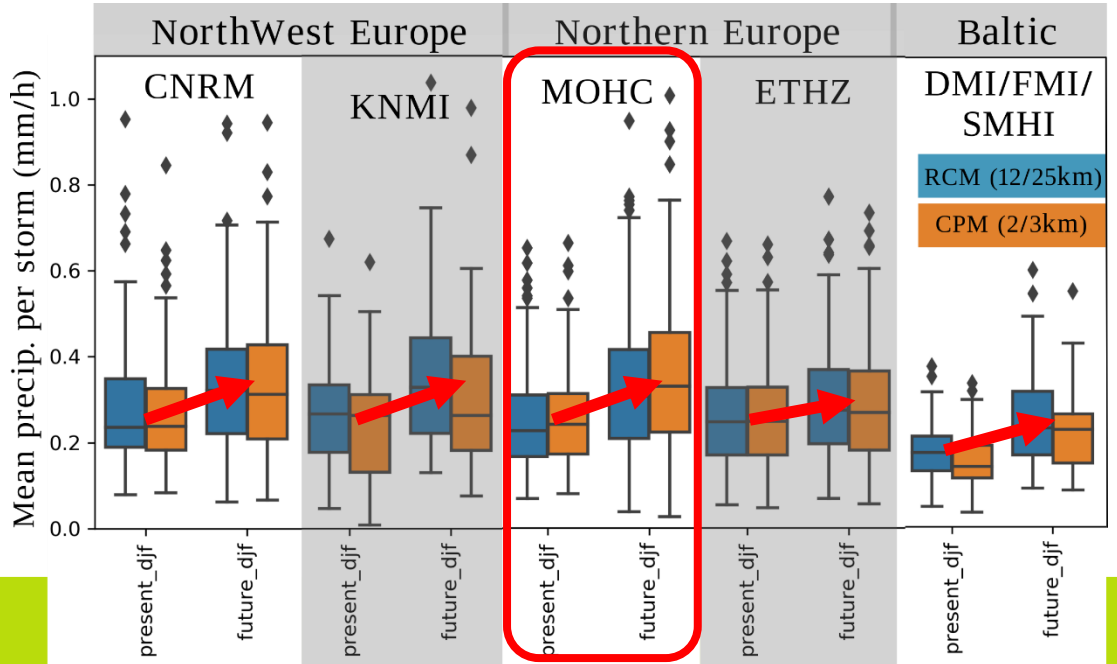

- With smaller domain runs & newer model version, Kendon et al. (2020) showed that about **half** of the larger increase of precipitation **over the UK only** was linked with convective showers being advected over land in a 2.2km model and not a 12km model.

- In these European runs, this further increase also happens over the ocean: likely something else than only shower advection.

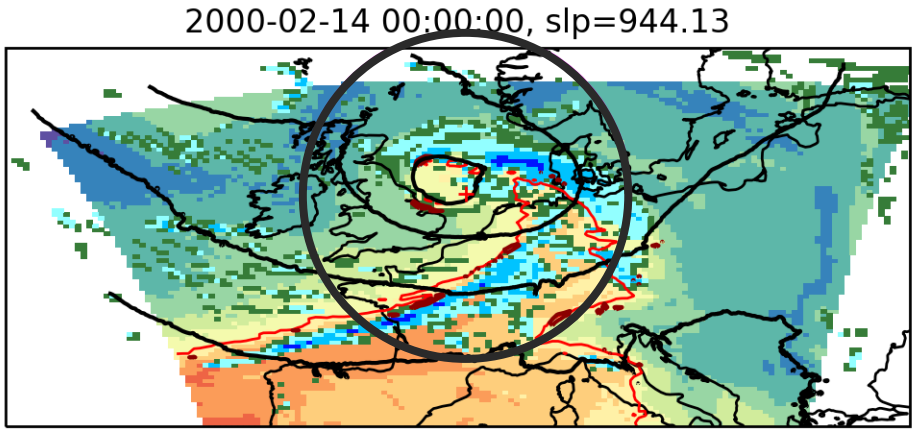
# Storm by storm approach

Using TempestExtremes, we tracked MSLP minima in the 12km/25km driving model.
From now on, we are looking at storm characteristics over northern Europe.

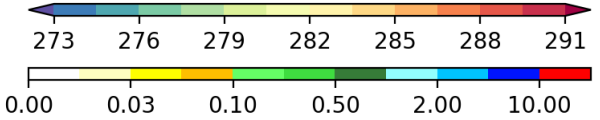
In all models, precipitation per storm increases in winter.



# Storm by storm approach – definition of sectors

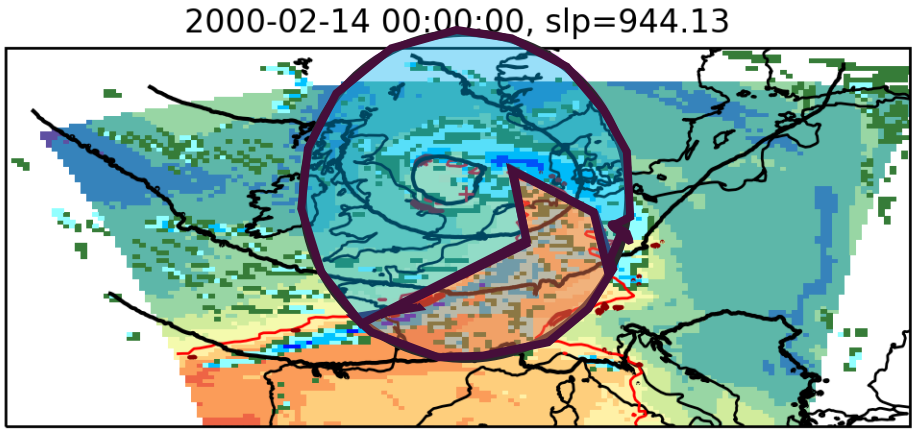



Wet bulb potential temp. (WBPT) 850hPa




IsoWBPT going through the 99th centile of WBPT gradients.

# Storm by storm approach – definition of sectors

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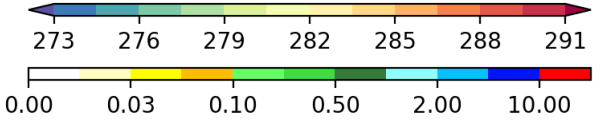



IsoWBPT going through the 99th centile of WBPT gradients.

All storm

warm sector

cold sector

# Storm by storm approach – breaking down the precipitation pdf by different storm sectors.

All precipitation in storms

Precipitation in warm sectors

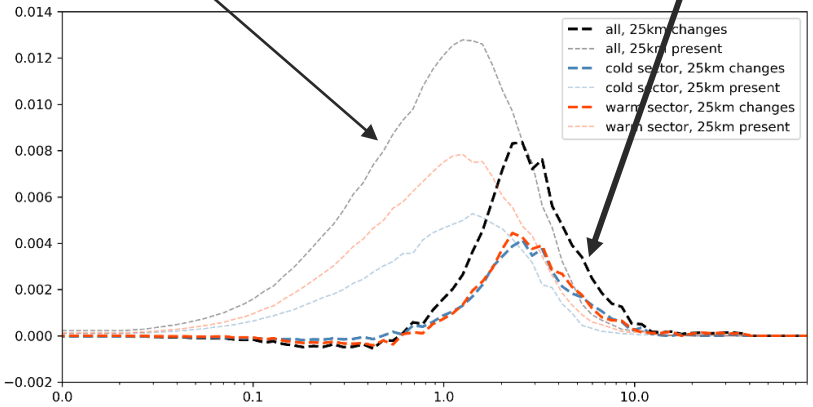
Precipitation in cold sectors

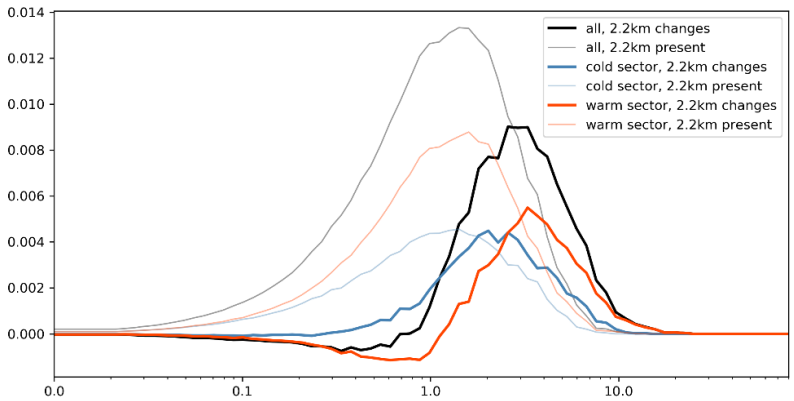
Present day

25km MOHC

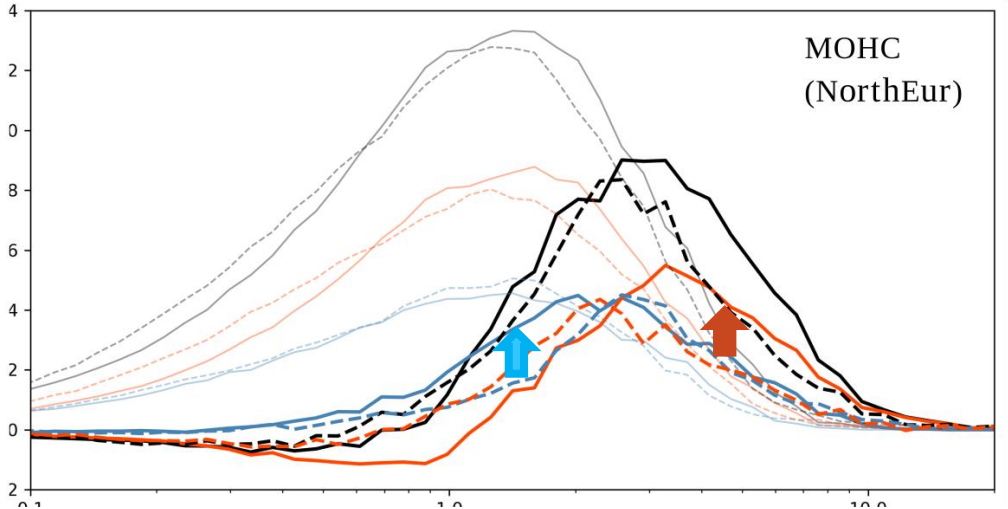
**Future changes**

2.2km MOHC



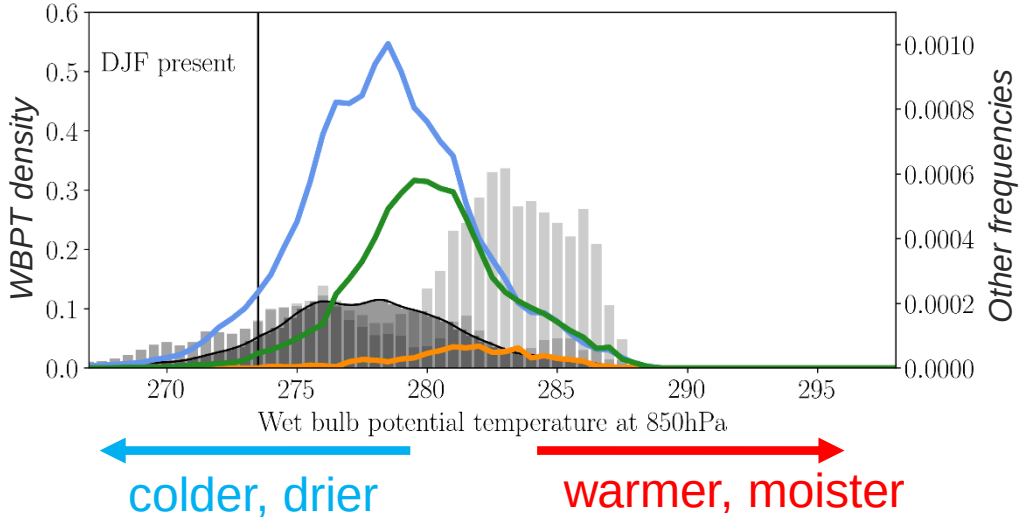



# Storm by storm approach – breaking down the precipitation pdf by different storm sectors.




More increase at low intensity in cold sector (like Kendon et al. 2020)

+ more increase at higher intensity in warm sector.




colder, drier

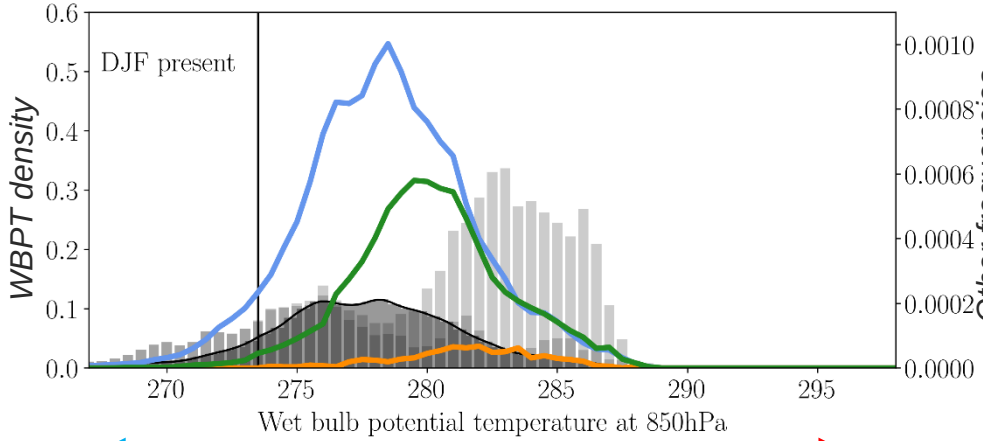
warmer, moister

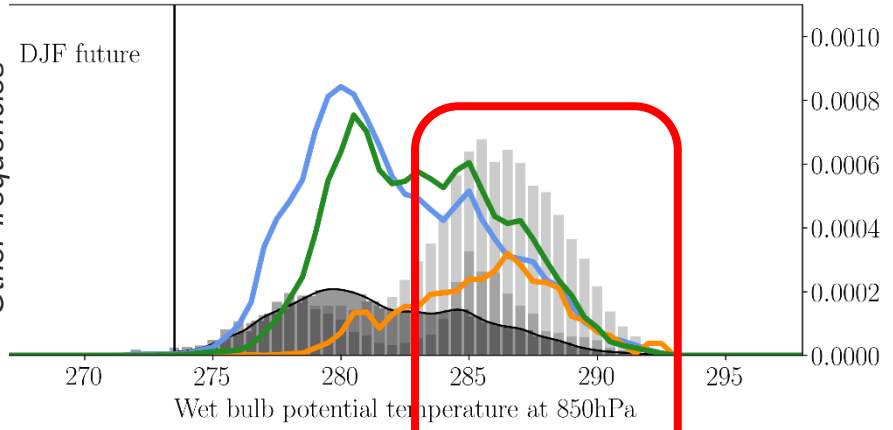
Occurrences of:

Scaling:

| | |
|---|---|
| low rain rates (0.1 to 1mm/h) | freq/20 |
| moderate rain rates (1 to 5mm/h) | freq/10 |
| high rain rates (> 5mm/h) | freq |
| CAPE (>500 J/kg/m2) | Freq |
| CIN <-100 J/kg/m2) | Freq |

Wet-bulb potential temperature freq. (left axis)

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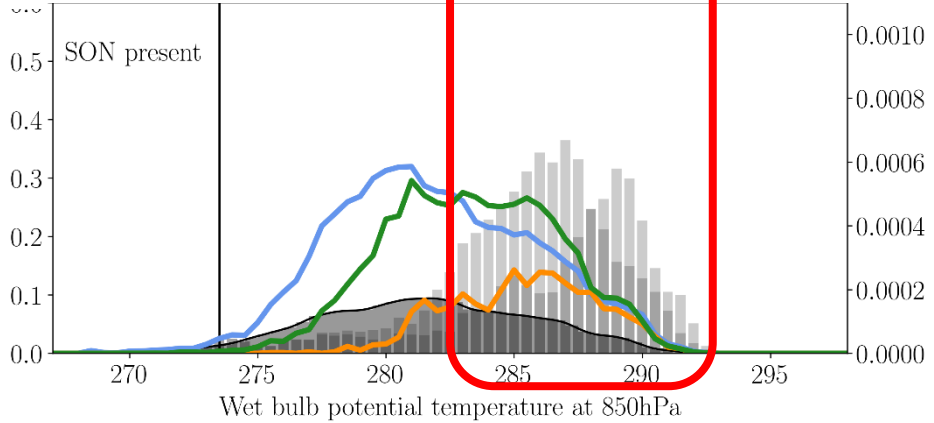


Occurrences of:

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| CAPE (>500 J/kg/m2) | Freq |
| CIN <-100 J/kg/m2) | Freq |

Future winter storm resemble present-day autumn ones (more intense precipitation) in the warm sector.

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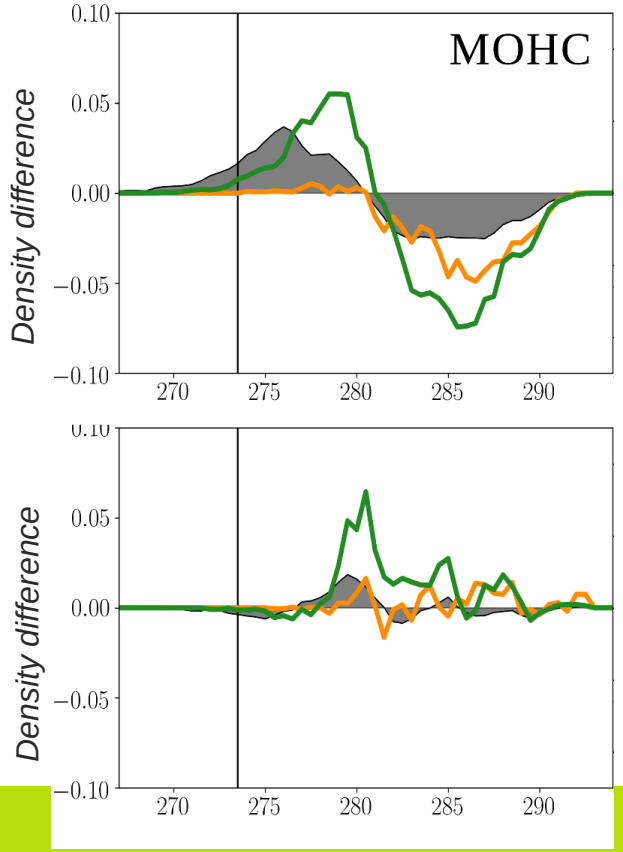
# Same plots as before but showing the differences with present-day autumn storms: future winter storms are very close.

DJF$_{present}$ – SON$_{present}$

DJF$_{future}$ – SON$_{present}$




Occurrences of:

moderate rain rates (1 to 5mm/h)

high rain rates (> 5mm/h)

Wet-bulb potential temperature freq.

Scaling:

freq/10

freq

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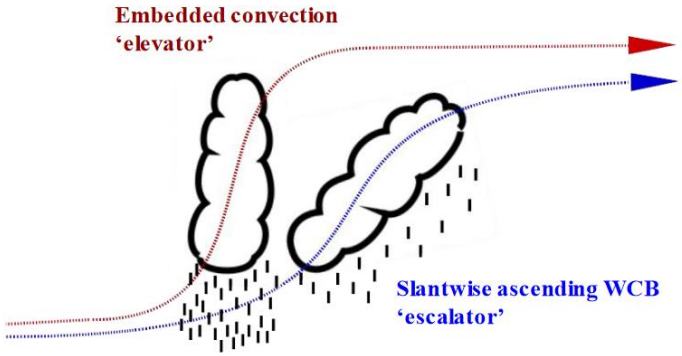
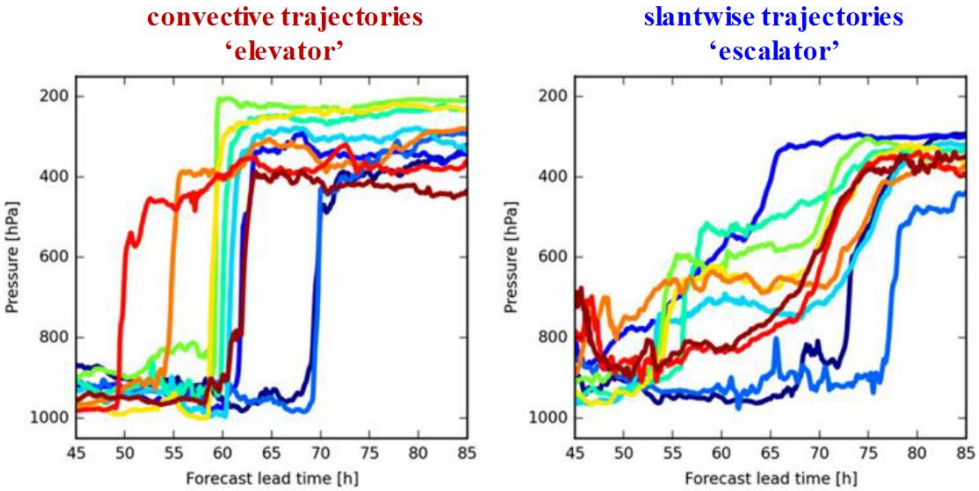
# Good candidate to explain this is that future winter storms have more embedded convection in warm conveyor belt, like present-day autumn storms

**Embedded convection**
'Escalator-elevator' concept
Neiman et al. 1993, MWR




Evolution of pressure with time for 10 randomly selected ascending trajectories: a) convective trajectories and b) non-convective trajectories (Rasp et al. 2016).

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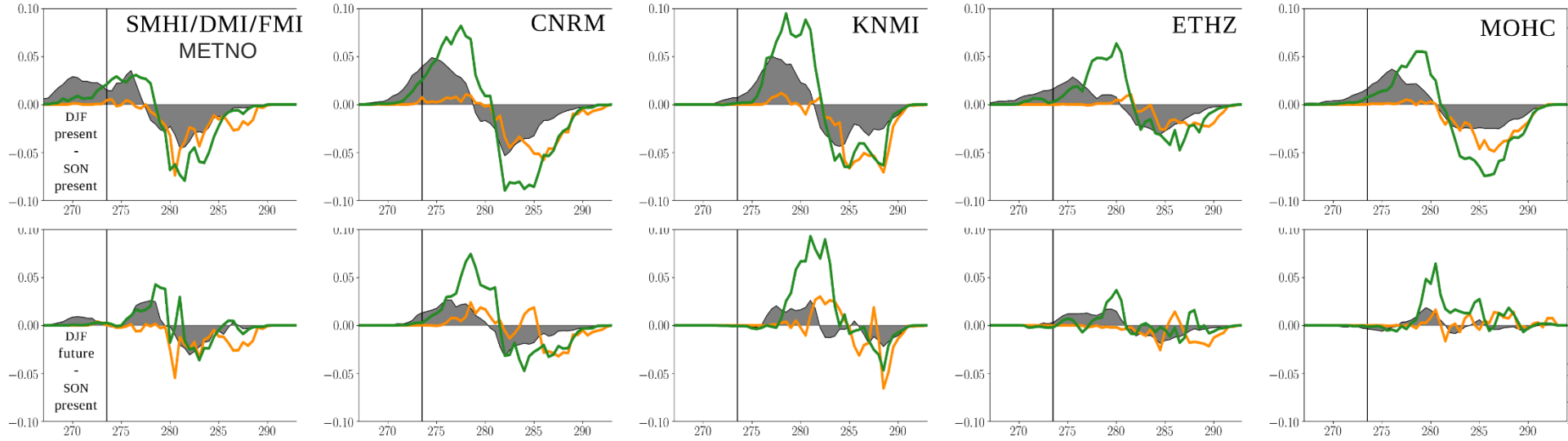
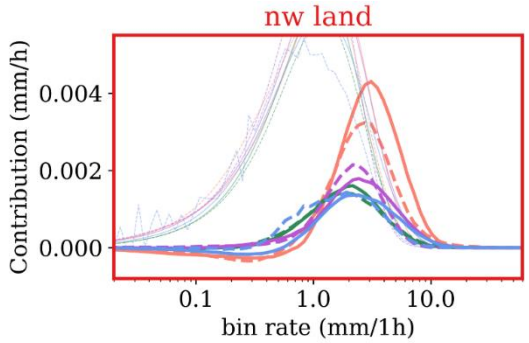
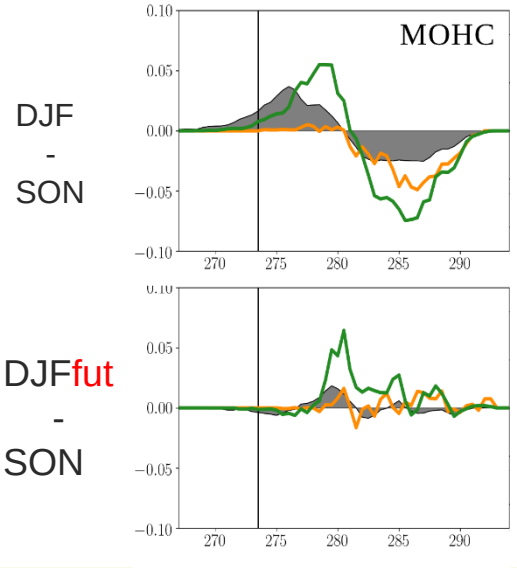
Occurrences of:
- moderate rain rates (1 to 5mm/h)
- high rain rates (> 5mm/h)
- Wet-bulb potential temperature freq.

Scaling:
- freq/10
- freq




In the other models, future winter storms are only “half way” between present winter and present autumn, with increases in intense precipitation less dramatic than in MOHC models and less different from their driving model (not shown).

# Conclusions:

Independently from changes in storm frequency:

- All models agree on: precipitation per storm increases at the end of the century (RCP85) because of increases in moderate and heavy precipitation.
- MOHC future winter storms thermodynamically look like present-day autumn storms. A good candidate to explain larger increases in convection-permitting model is increased embedded convection in the warm conveyor belt (in addition to more convective shower advection over land).
- Other models have more moderate changes, with future winter storms “only half-way” to present-day autumn storms.