North Atlantic storm track sensitivity to AMOC collapse in regional climate simulations

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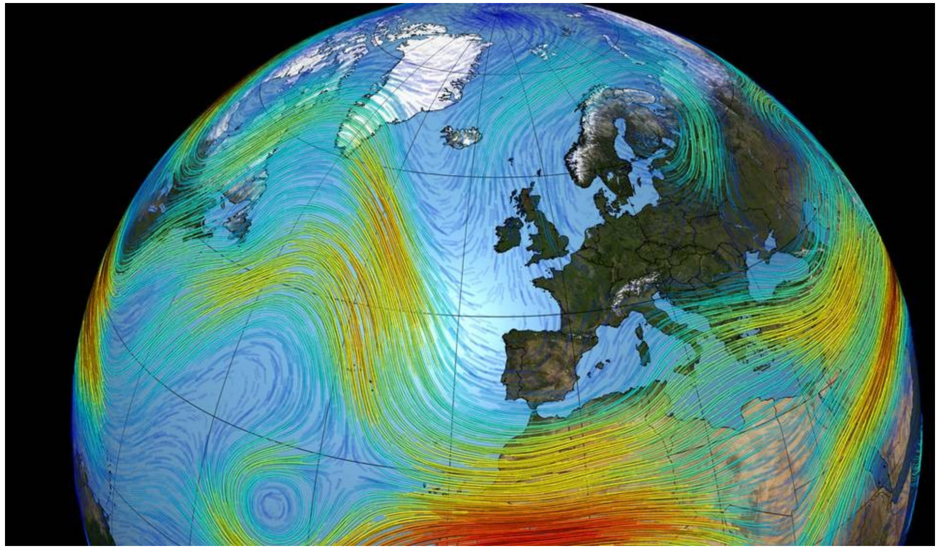
ClimTip

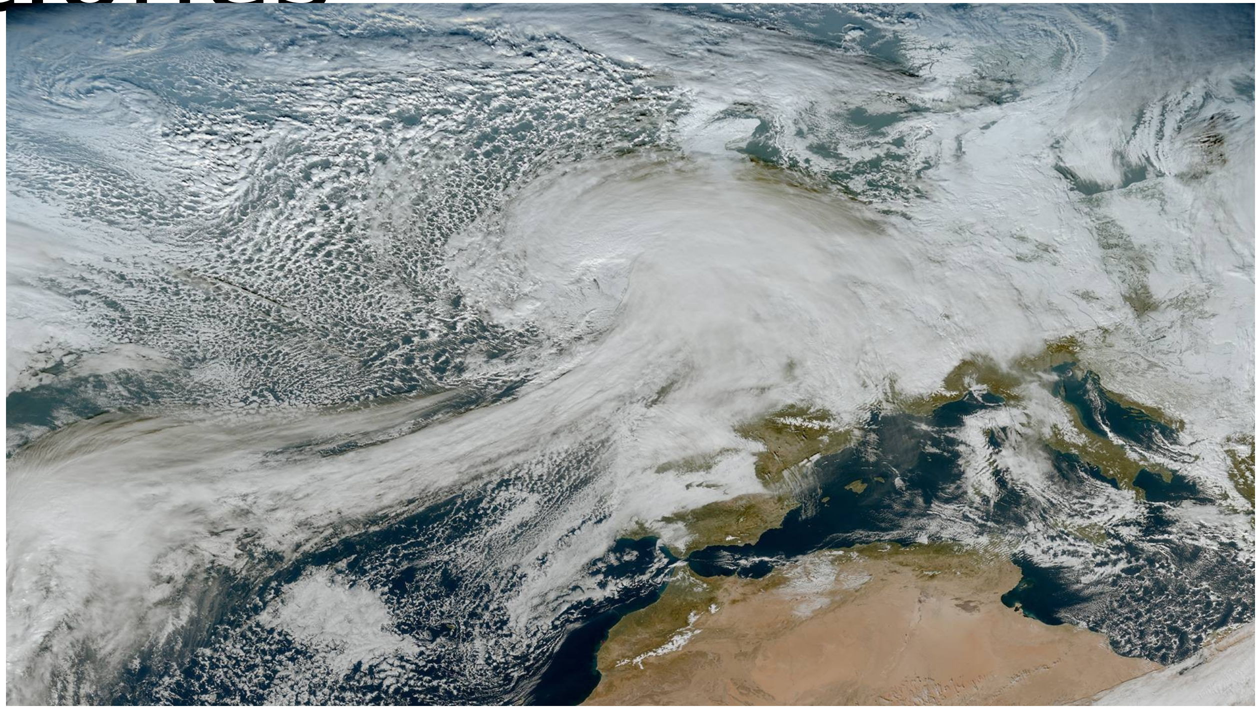
Funded by the European Union

Introduction

Jet stream and extratropical cyclones



https://svs.gsfc.nasa.gov/4171/



https://www-cdn.eumetsat.int/files/2026-01/storm-Goretti.jpg

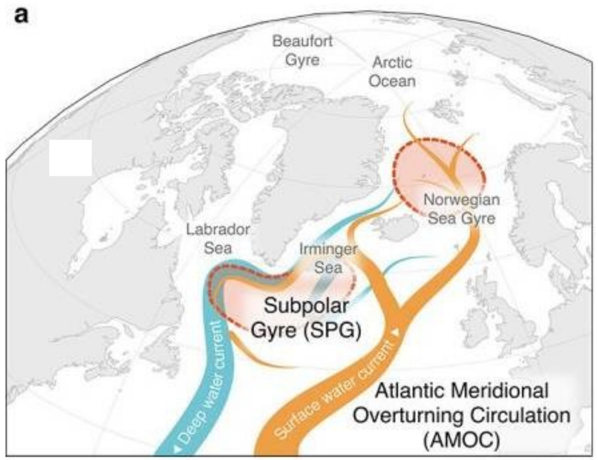
Extreme storms

Alex (October 2020)
Loss of ~2.5 billion EUR
15 fatalities

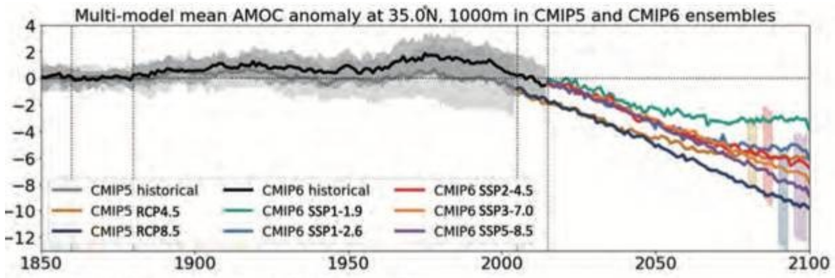
Eunice (February 2022)
Loss of ~3 billion EUR
17 fatalities

Boris (September 2024)
Loss of ~4 billion EUR
27 fatalities

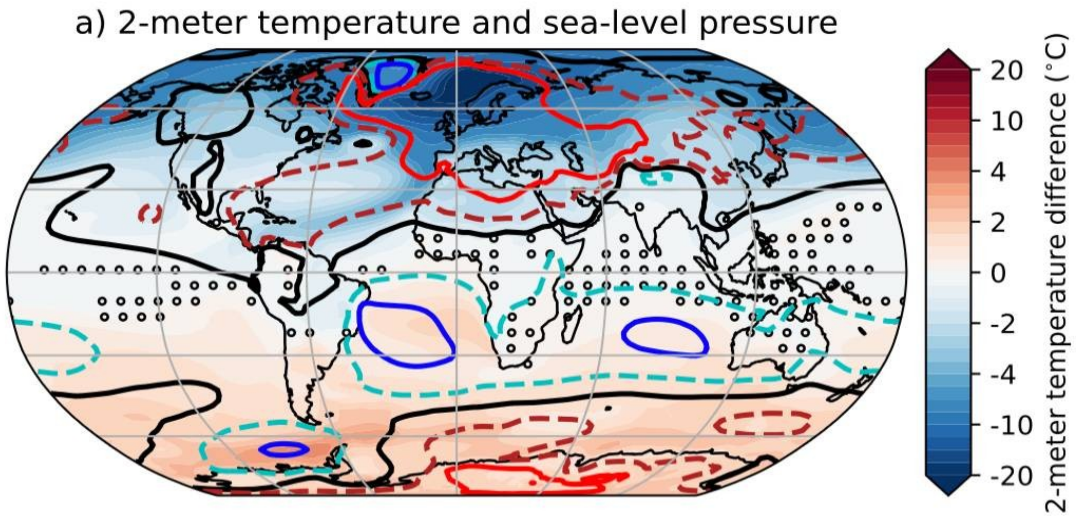
AMOC tipping



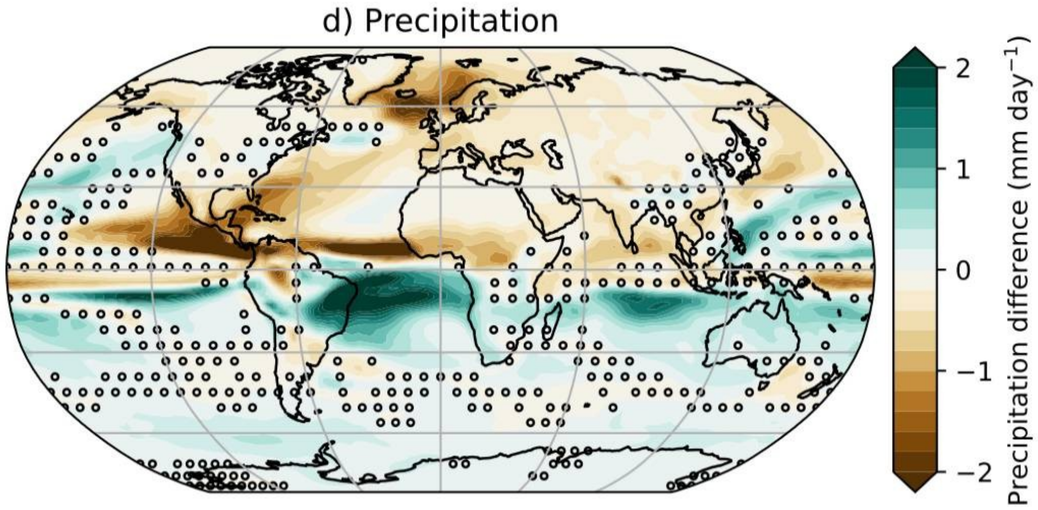
https://report-2023.global-tipping-points.org/



IPCC
AR6



Van
Westen
et al.
2024



Overarching objective

Atmospheric dynamics

AMOC tipping

Assess **regional** impacts of **AMOC tipping** on the North
Atlantic **jet stream** and extratropical **cyclones** over

Methods

ClimTip experimental setup

Global ESM models

CESM1

~ 1° resolution

MPI-ESM-HR

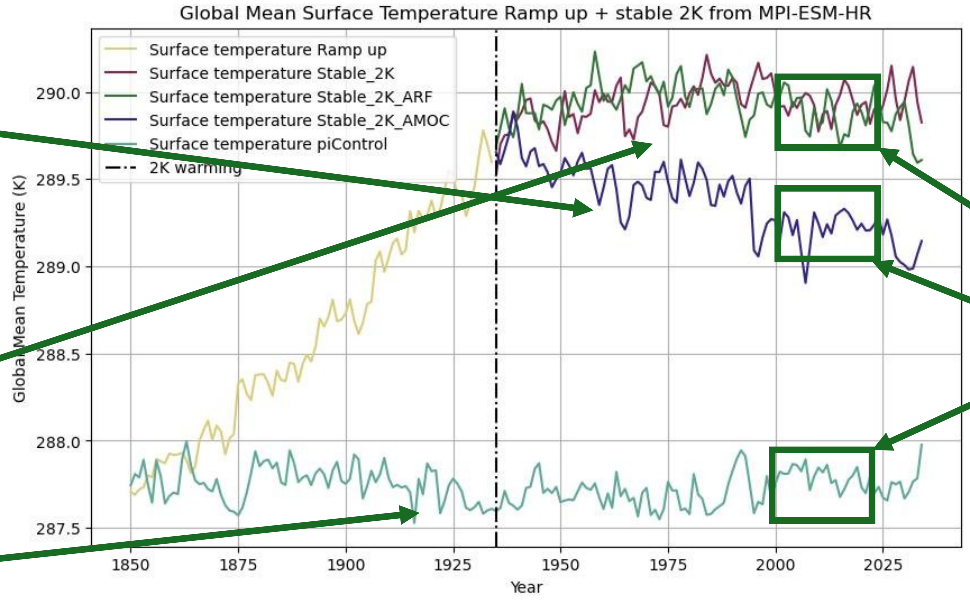
~ 0.9° resolution

Scenarios

Stable warming + AMOC collapse

Stable warming (2K)

Preindustrial control



Downscaling simulations

Figure from Lucas Ferreira-Correa

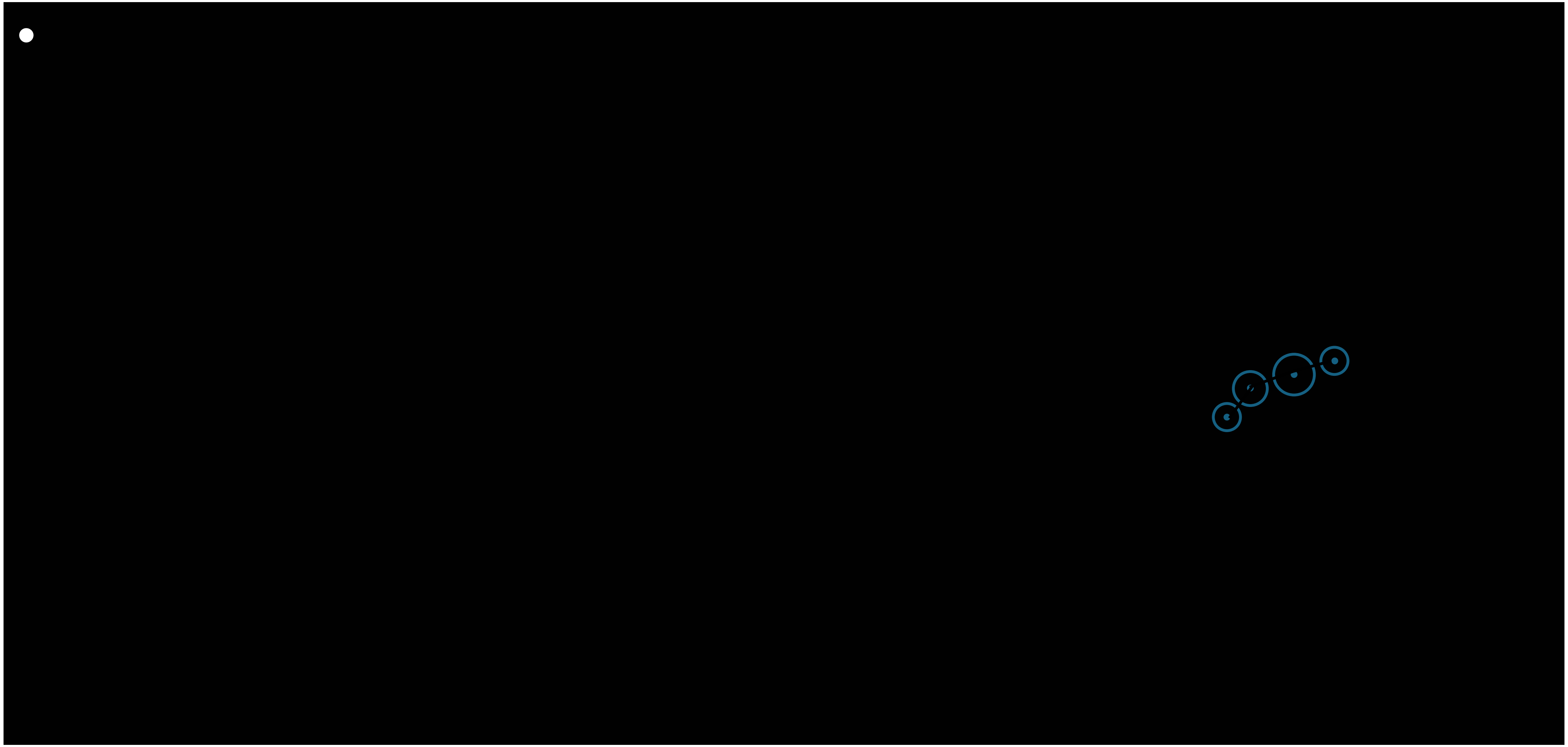
Dynamical downscaling

[redacted]

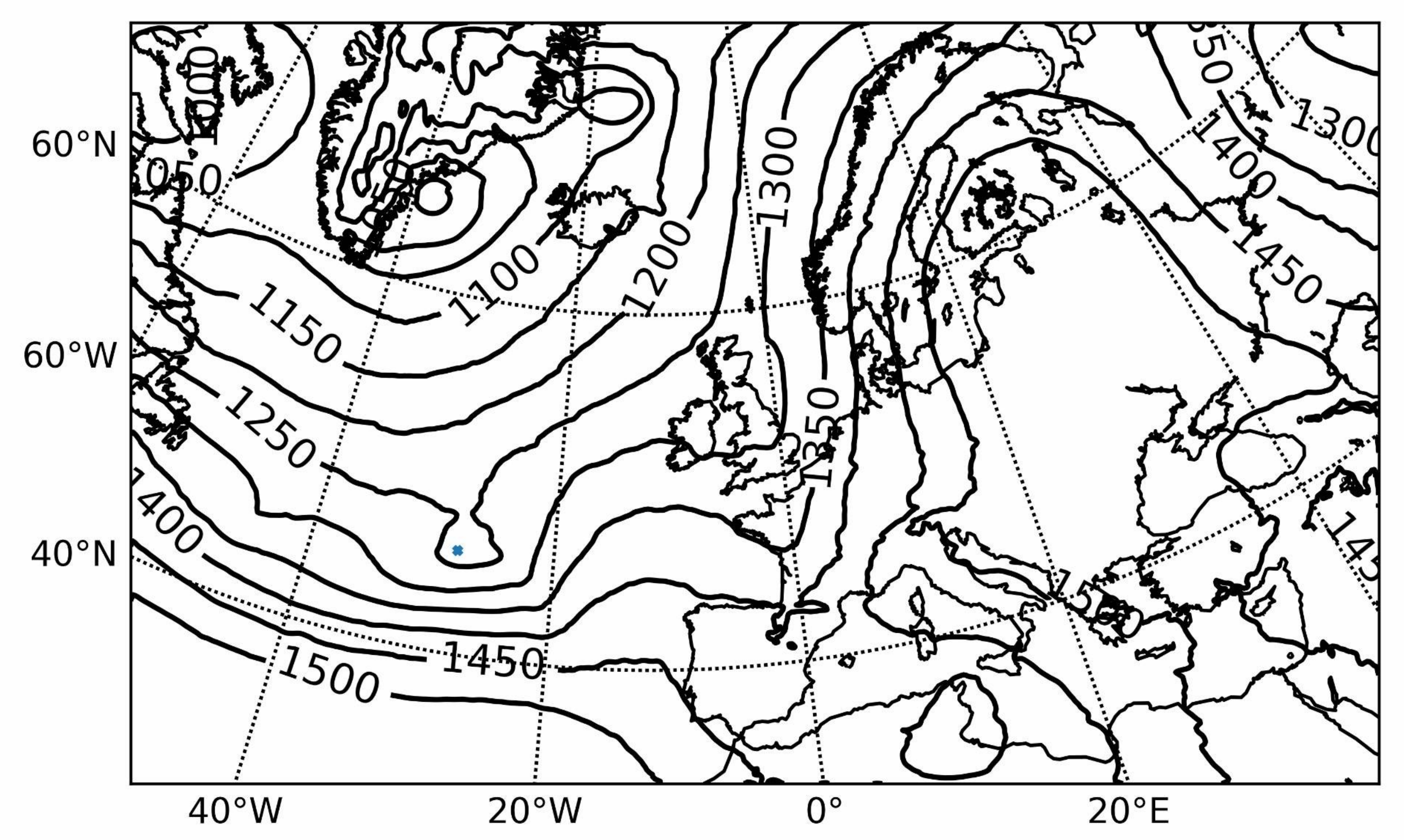
Regional model **15 km**

- WRF model
- 6h-Boundary conditions from the global model
- hourly output
- 20-year simulations + spin-up for each

Cyclone tracking



Cyclone tracking example



Results

Sea surface temperature (DJF)

Global warming

AMOC collapse

MPI

CESM

MPI T2K - piC

MPI AMOC - T2K

CESM T2K - piC

CESM AMOC – T2K

Warming at high latitudes

Intensified cooling

Decrease in sea ice

Increase in sea ice

Arctic amplification

Sea surface temperature (JJA)

MPI T2K - piC

Weaker warming hole

Strong cooling

MPI AMOC - T2K

CESM T2K - piC

CESM AMOC – T2K

Baroclinicity (Isentropic slope)

- [redacted]he growth potential of baroclinic [redacted]
- [redacted] growth of transient eddies [redacted]the jet

Baroclinicity (Isentropic slope DJF)

MPI T2K - piC

Increase in the south in MPI and extended increase in CESM

Increase in baroclinicity equatorward of the jet mean position in MPI and poleward in CESM

MPI AMOC - T2K

CESM T2K - piC

CESM AMOC – T2K

Baroclinicity (Isentropic slope JJA)

Similar response with AMOC collapse

Increase with a SW-NE pattern

Decrease with the South

MPI T2K - piC

MPI AMOC - T2K

CESM T2K - piC

CESM AMOC – T2K

Zonal wind speed (250 hPa DJF)

Similar shift in MPI
Intensification and extension in CESM

Equatorward shift of the jet in MPI and poleward shift in CESM

MPI T2K - piC

MPI AMOC - T2K

CESM T2K - piC

CESM AMOC – T2K

Zonal wind speed (250 hPa JJA)

Triple pattern with AMOC collapse

Increase with a SW-NE tilt in MPI and triple pattern in CESM

Different areas with positive and negative trends

MPI T2K - piC

MPI AMOC - T2K

CESM T2K - piC

CESM AMOC – T2K

Extreme cyclone distribution (DJF)

MPI T2K - piC

MPI AMOC - T2K

Increase in high latitudes

Reduction over Scandinavia and eastern Europe

Shift in the distribution

Decrease over the continent

CESM T2K - piC

CESM AMOC – T2K

Extreme cyclone distribution (JJA)

Increase over southern/eastern Europe

Reduction of extreme cyclones

Shift in the distribution

Increase over the ocean

MPI T2K - piC

MPI AMOC - T2K

CESM T2K - piC

CESM AMOC – T2K

Extreme cyclone precipitation composite (DJF)

Largest decrease near
The cyclone centre

Largest increase near
The cyclone centre

MPI T2K - piC

MPI AMOC - T2K

CESM T2K - piC

CESM AMOC – T2K

Extreme cyclone precipitation composite (JJA)

Similar

Decrease near the centre with AMOC collapse

Increase near the centre with warming

MPI T2K - piC

MPI AMOC - T2K

CESM T2K - piC

CESM AMOC – T2K

Conclusions

Conclusions

- Different temperature changes depending on the driving model

  different jet response in both scenarios

- Contrasting cyclone frequency responses
  for different models

- Cyclone precipitation response linked to
temperature changes