North Atlantic winter storm changes under global warming of 1.5°C and 2°C

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ABSTRACT

In this study, we investigate potential changes in simulated winter storminess and extreme precipitation under 1.5°C and 2°C global warming scenarios of the HAPPI project using the highly resolved NCAR Community Atmosphere Model CAM5 (0.25°x0.25°, 3-houly).

The main results are:

- Improved large-scale circulation pattern over North America and Europe, and a reduced zonal bias in storm track.
- The 2°C warming scenario indicates a poleward shift and intensification of the storms over the Euro-Atlantic region mainly after exceeding the 1.5°C global warming level.
- Increase in precipitation, wind extremes, and storminess over Northern Europe with a maximum over the northwestern coasts of the British Isles and Scandinavia.
- Near-future changes in winter storm activity over the North Atlantic and Western Europe will increase nonlinearly with further warming rather than linearly.

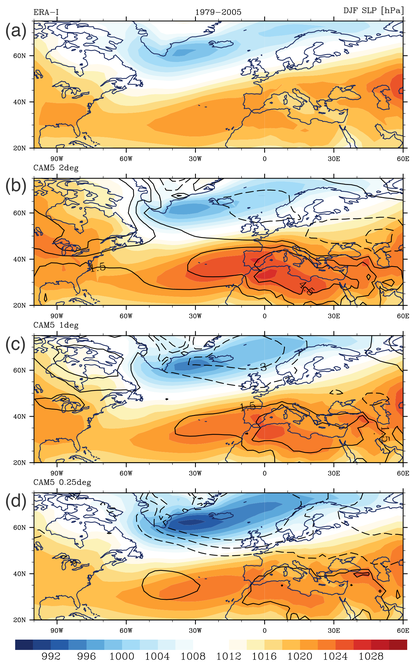
Half a Degree Additional warming, Prognosis, and Projected Impacts (HAPPI) project:

- present decade (2006-2015):
  - observed SSTs and sea ice;
- +1.5°C warming:
  - changes in SST from RCP2.6 runs (2091-2100 mean) are added to the observed SSTs;
  - GHG, aerosols and land-use and cover from year 2095;
- +2°C warming:
  - changes in SSTs and GHGs from weighted sum of RCP2.6 and RCP4.5 (2091-2100 mean)

Large-scale atmospheric circulation over the North Atlantic

Impact of the resolution

Higher horizontal resolution (0.25°) provides considerably better representation of the large-scale atmospheric flow (e.g. midlatitude jet stream). The zonal bias of the mean ambient flow is reduced and this presumably yields better representation of storminess.



DJF sea level pressure [hPa] for 1979-2005, regridded to 2.5° x 2.5° horizontal grid for a) ERA-Interim (ERA-I,~0.75° lat-lon original resolution), b) CAM5 at ~2°, c) ~1°, and d) ~0.25° lat-lon resolution. Contours show the difference to ERA-Interim.

Future projections

Global warming by 1.5°C:

- weak/no indication for intensification and poleward shift of the meridional cells

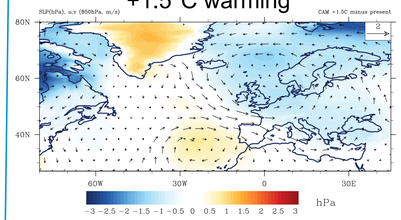
Global warming by 2°C:

- strong intensification & poleward shift for the meridional cells, and midlatitude westerlies
- intensified westerlies & increase in precipitation extended east-ward (max: the north of British Isles to the north coast of Scandinavia)

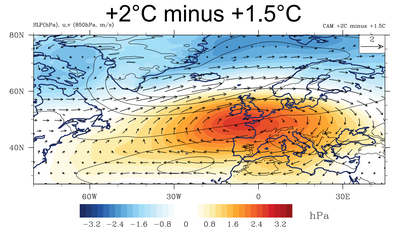
The additional 0.5°C warming from the +1.5°C levels yields:

- strong intensification and poleward shift of DJF SLP gradient, with maximum anticyclonic anomaly and drying over the northern Bay of Biscay
- north-eastward shift of bipolar DJF precipitation pattern

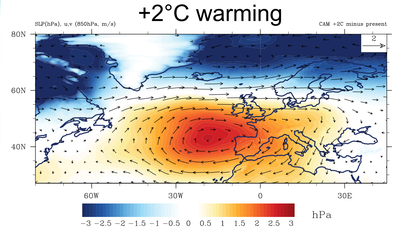
+1.5°C warming

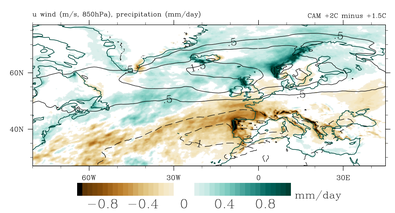


+2°C minus +1.5°C



+2°C warming

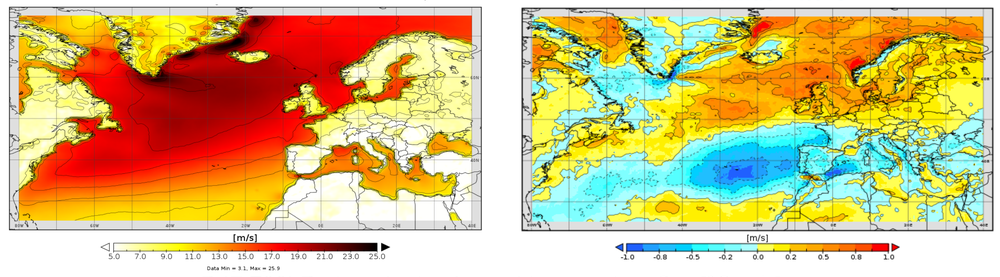




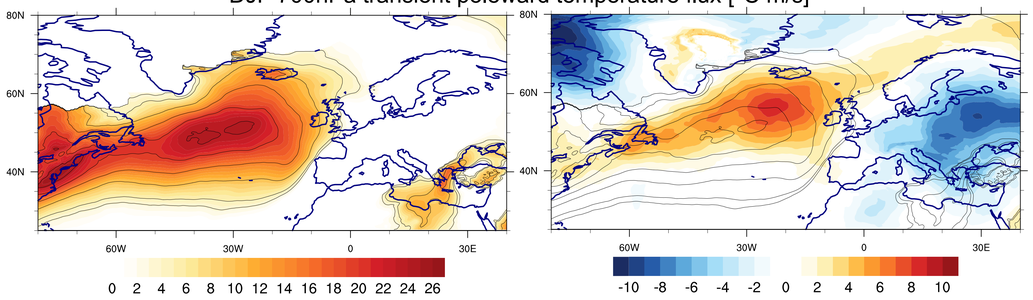
Difference between +1.5°C and 1979-2005 climatology, 2°C and climatology, +2°C and 1.5°C ensembles in DJF sea level pressure [shaded, hPa] and wind vectors at 850hPa [m/s], precipitation [mm/day] and zonal wind [contours] in CAM5_0.25. Contours show DJF sea level pressure in present climate 1979-2005.

Present climate and future changes in subdaily weather extremes

1980-2005 95th daily wind percentiles [m/s] 2°C minus +1.5°C



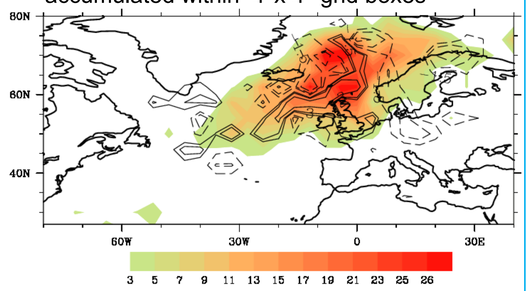
DJF 700hPa transient poleward temperature flux [°C m/s]



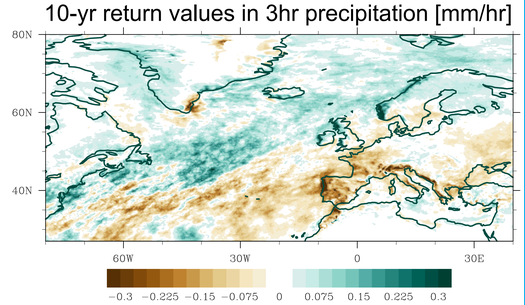
The additional 0.5°C warming from the +1.5°C levels yields:

- *increase* in extreme winds, transient poleward temperature flux (VT) and storm track density over the poleward flanks of the DJF climatology (maximum between British Isles and Iceland);
- *north-eastward extension* for extreme winds and VT (towards the Scandinavian coast)
- *negative* anomalies of VT and track density north-east of Iceland and central-eastern Europe
- *north-eastward shift* of bipolar changes in extreme precipitation:
- *maximum*: in the north-west coasts of British Isles and Scandinavia and over the Norwegian Sea;
- *minimum*: colocated with anticyclonic DJF SLP anomaly centered over the Bay of Biscay and northwestern Iberian Peninsula

Number per decade of 3-h storm occurrences accumulated within 4°x 4° grid boxes



10-yr return values in 3hr precipitation [mm/hr]



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M. Barcikowska, S. Weaver, F. Feser, S. Russo, F. Schenk, and M. Zahn, 2018: Euro-Atlantic winter storminess and precipitation extremes under 1.5°C versus 2°C warming scenarios. Earth System Dynamics, 9, 679-699, https://doi.org/10.5194/esd-9-679-2018