North Atlantic–European weather regimes in a changing climate: present and future

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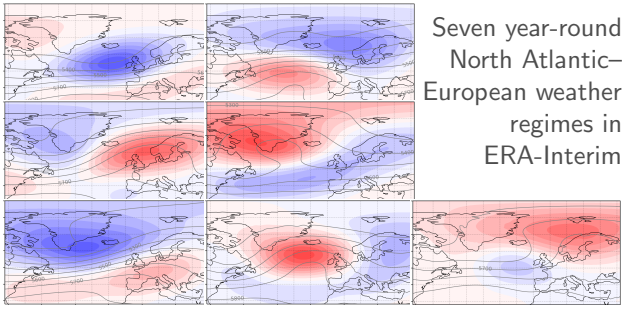
Does the frequency of these weather regimes change in future climate conditions? If so, how?



Seven year-round North Atlantic–European weather regimes in ERA-Interim

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North Atlantic–European weather regimes in CESM - Summary

We investigated how year-round weather regimes over the North Atlantic and Europe are represented in climate simulations using the Community Earth System Model (CESM) large ensemble for present-day and future (RCP8.5) climate conditions.

Key findings:

1. CESM present-day **climate simulations match re-analyses data (ERA-Interim) very well** (same mean climate and only slightly lower variability in model than in re-analysis)
2. frequencies of **weather regime occurrence agree well in the re-analysis and model data** of present-day climate conditions
3. a **climate change effect is observed in the frequencies of weather regimes** when comparing present-day and future climate conditions in CESM, we observe an **increase in Atlantic Trough (AT) and European Blocking (EuBL)**

Background information - Data

- The data we use are 700 simulated years with the CESM large ensemble for present-day and future climate conditions. Specifically, the data set consists of 35 members, with 10 year runs in present-day and future (RCP8.5) climate conditions each, i.e., **350 years present-day and 350 years future simulations**.
- Six-hourly geopotential height fields (Z500) from **CESM are projected onto the Z500 patterns** of seven year-round North Atlantic–European weather regimes (WRs) identified in ERA-Interim[2] (Grams et al. 2017).
- In ERA-Interim the **seven WRs explain 70% of the variability in geopotential height at 500 hPa year-round**.
  They have the following names:
  1. Atlantic Trough (AT)
  2. Greenland Blocking (GL)
  3. Atlantic Ridge (AR)
  4. Scandinavian Trough (ScTr)
  5. European Blocking (EuBL)
  6. Scandinavian Blocking (ScBL)
  7. Zonal Regime (ZO)
  0. No regime (NoRe)

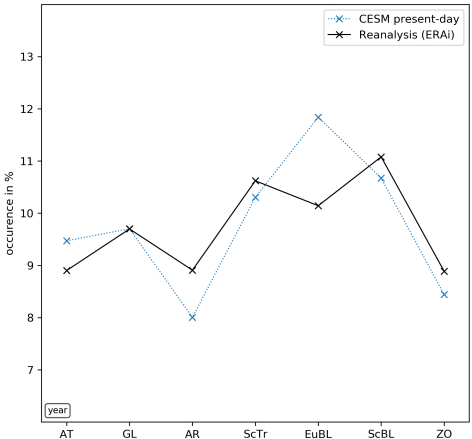
1 see mean WR patterns on slide 6

Frequencies of weather regimes in CESM climate simulations: **year-round**

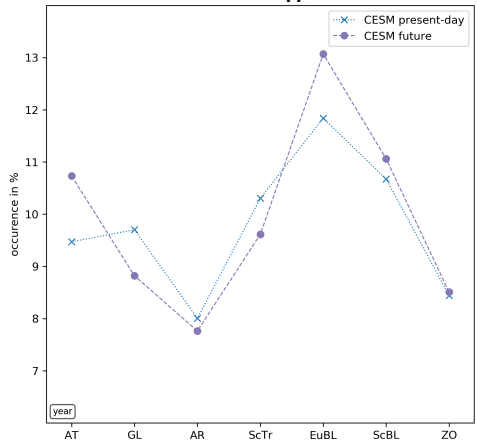
Model validation (left): WR frequencies in **present-day climate are similar to ERA-Interim**. The model is however biased to underestimate the occurrence of AR, while over estimating the occurrences of EuBL.

Climate change effect (right): Differences in WR frequencies between future and present-day simulations imply climate change related changes in large scale dynamics. Specifically an **increase in AT and EuBL**.

model validation



climate change effect

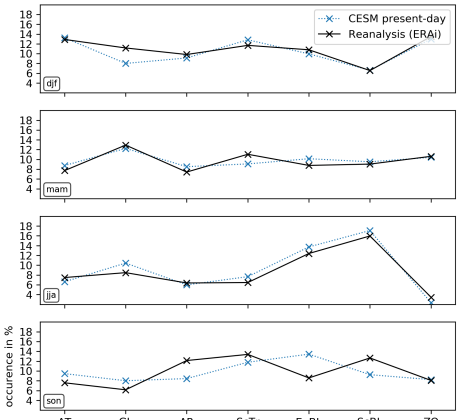


Frequencies weather regimes in CESM climate simulations: **seasonal**

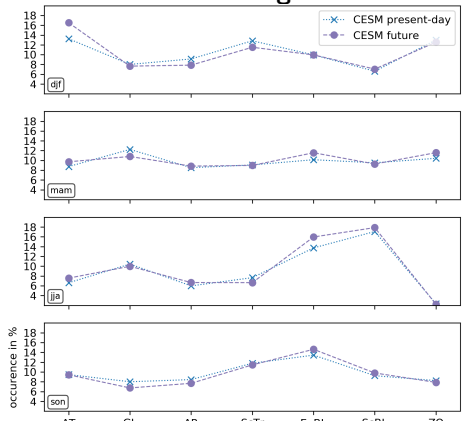
Model validation (right): WR frequencies agree well with re-analysis, **main source of model bias are differences in regime frequencies in autumn (son)**, e.g., AR and EuBL.

Climate change effect (left): changes in regime frequencies due to climate change are different in each season. An increase in EuBL is visible in all seasons but winter (djf).

model validation



climate change effect



Method and contact details

North Atlantic–European weather regimes (WRs):
Are based on a k-means algorithm applied to ERAI data from 1979 - 2015 (Grams et al. 2017). The seven WRs are principal components of the geopotential height anomaly at 500 hPa over the North-Atlantic (80W 40E 30N 90N), which is first normalized by the spatial mean of the 30 day standard deviation.

Data preparation:
Projecting new data (here the CESM data) onto the WRs requires the new data to be normalized prior to projection. The CESM data was thus compared to its own climatology and then normalized with the spatial mean of its own 30day standard deviation over the North-Atlantic, prior to projection.

For details on WRs see:
Grams, C.M., Beerli, R., Pfenninger, S., Staffell, I. and Wernli, H. (2017). Balancing Europes wind-power output through spatial deployment informed by weather regimes. Nature Climate Change, 7(8):557 562.

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Find abstract here: `https://doi.org/10.5194/egusphere-egu2020-4589`

Additional information

Mean patterns during the WRs in ERA-Interim (1979-2015).
Grey lines = mean Z500; Filled contours = mean Z500 anomaly.