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Atmospheric Blocking Trends and Variability in CMIP6-Simulations

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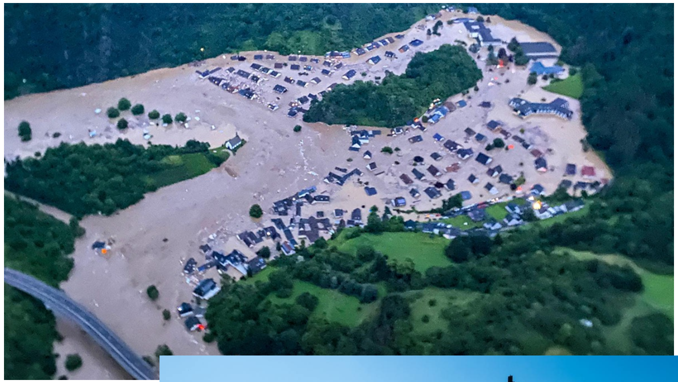
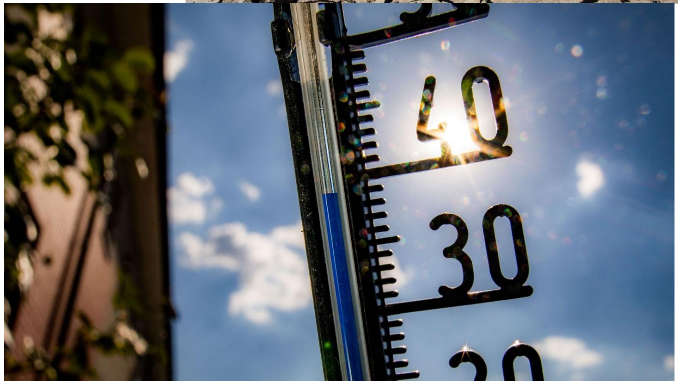
Motivation

- atmospheric blocking related to different kinds of weather extremes
- high socio-economic impact of these extremes

→ importance of robust trends of future blocking occurrence





Definition of Blocking

- using index based on geopotential height at 500 hPa (Z_{500}), blocking is defined as reversal of geopotential height gradient (Scherrer et al., 2006; Davini et al., 2012; based on Tibaldi and Molteni, 1990)
- block at point (λ_0, ϕ_0) if GHGS > 0 and GHGN < - 10 m/°lat

$$GHGS(\lambda_0, \phi_0) = \frac{Z_{500}(\lambda_0, \phi_0) - Z_{500}(\lambda_0, \phi_S)}{\phi_0 - \phi_S}$$

$$GHGN(\lambda_0, \phi_0) = \frac{Z_{500}(\lambda_0, \phi_N) - Z_{500}(\lambda_0, \phi_0)}{\phi_N - \phi_0}$$

$\phi_S = \phi_0 - 15°; \phi_N = \phi_0 + 15°$

- min. 5 days
- blocking frequency defined as fraction of blocked days

Blocking in Historical CMIP6-Simulations

- models underestimate blocking in blocking centres, especially in Europe
- underestimation higher in second half of 20th century

→ no increase of blocking frequency as in reanalyses

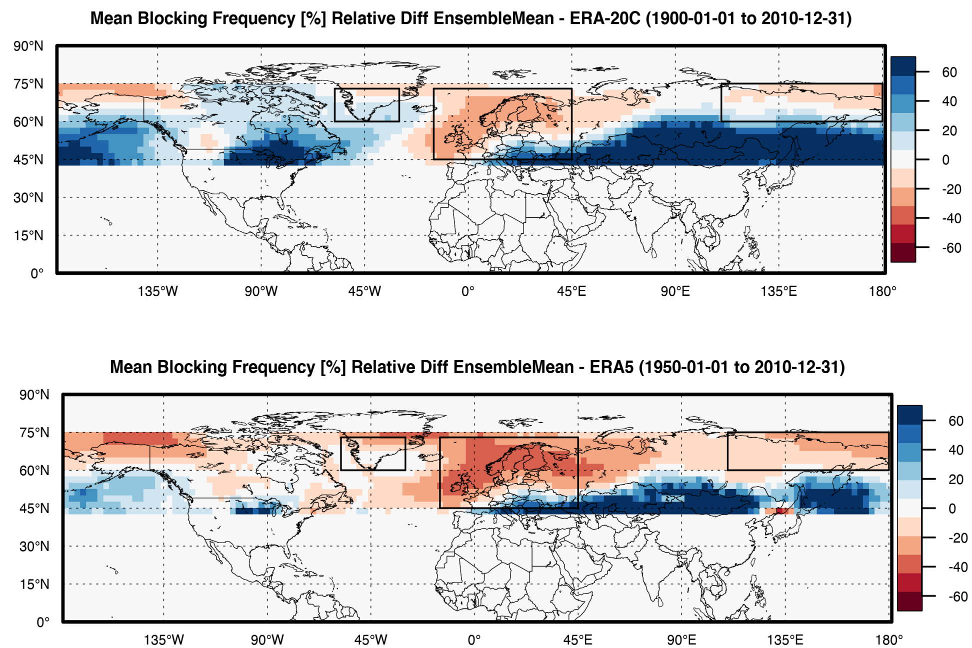


Figure: Relative difference of blocking frequency between ensemble mean of historical CMIP6-simulation and ERA-20C (top) and ERA5 (bottom).

Blocking in CMIP6-Scenarios

- models simulate general decrease of blocking frequency
- exceptions: parts of Siberia and Northern America
- decrease stronger for high emission scenario

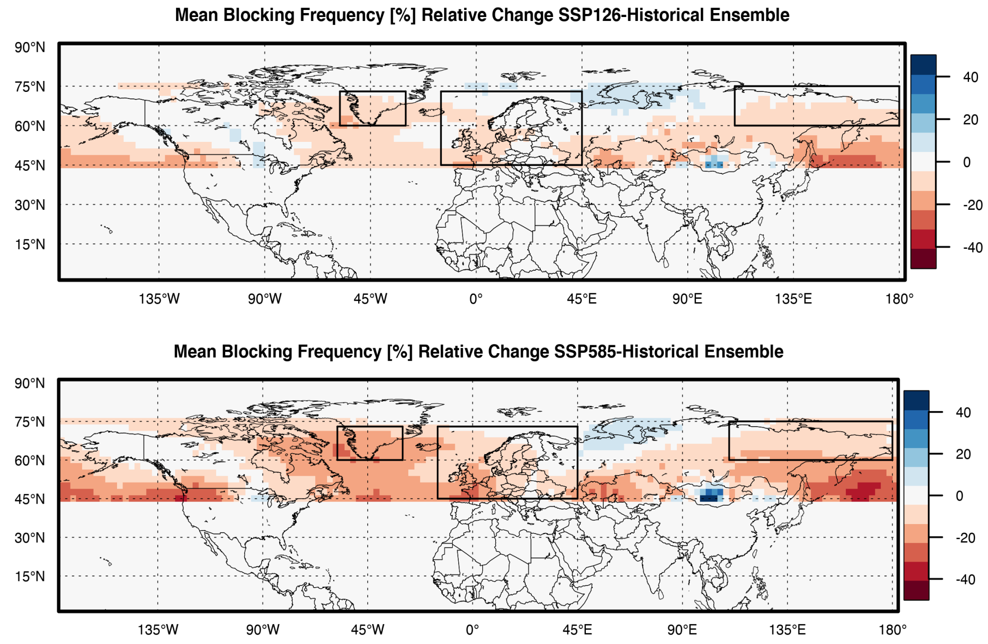


Figure: Relative change of blocking frequency between SSP126- (top) / SSP585-scenario (bottom) (2015-2100) and ensemble mean of historical simulation (1900-2010).

Seasonal Blocking-Trends in Scenarios

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- strong decrease of winter blocking frequency, especially over oceans
- strong decrease of summer blocking frequency in Southwestern Europe, increase in parts of Siberia
- increase more pronounced for long blocks (min. 10 days)

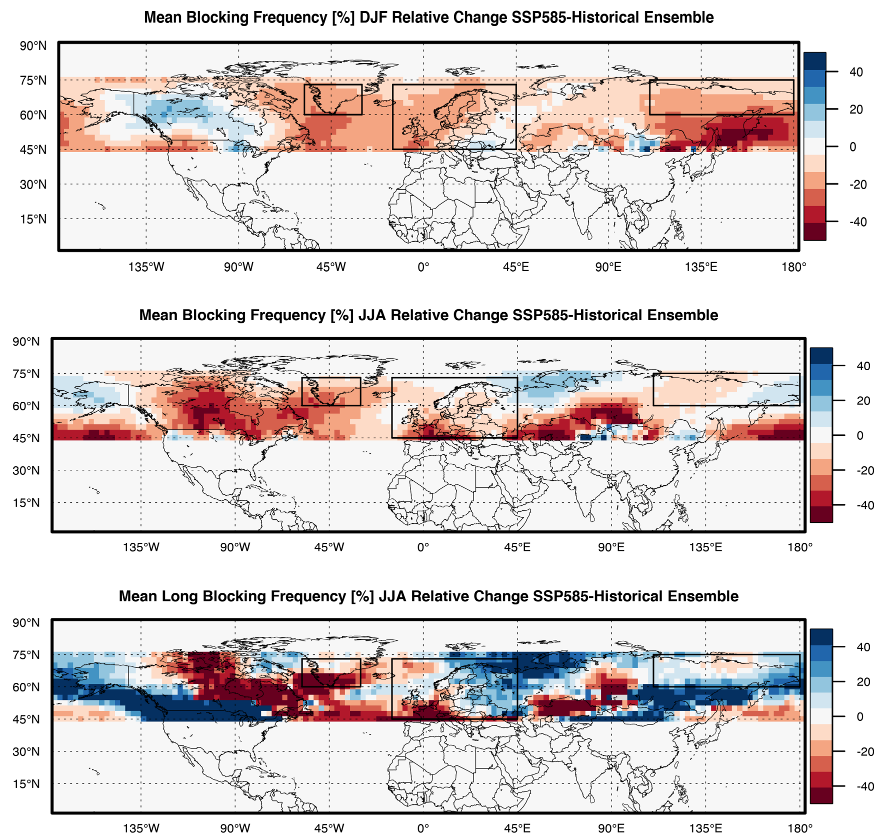

Figure: Relative change of blocking frequency between scenario and historical simulations for SSP585. Top: Winter changes; Centre: Summer changes; Bottom: Summer changes (long blocks).

Conclusions

- CMIP6-Models still underestimate blocking frequency, especially in Europe
- scenarios simulate decrease of blocking in future
- decrease stronger for high emission scenarios
- trend well pronounced for winter, less clear for summer

→ increase of persistent blocks in Europe

References

- Davini, P., C. Cagnazzo, S. Gualdi, and A. Navarra, 2012: Bidimensional diagnostics, variability, and trends of Northern Hemisphere blocking. *J. Climate*, **25**, 6496–6509, https://doi.org/10.1175/JCLI-D-12-00032.1.
- Scherrer, S. C., Croci-Maspoli, M., Schwierz, C. and Appenzeller, C. 2006. Two-dimensional indices of atmospheric blocking and their statistical relationship with winter climate patterns in the Euro-Atlantic region. Int. J. Clim. 26, 233–249. doi:10.1002/joc.1250
- Tibaldi, S. and Molteni, F. (1990). On the operational predictability of blocking. Tellus A, 42: 343-365. doi:10.1034/j.1600-0870.1990.t01-2-00003.x