Influence of atmospheric blocking on heatwaves in large model ensembles*


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Motivation

Using atmospheric blocking as covariate improves fit of extreme minimum temperature for winter in Europe (Sillmann et al., 2011)

- Quantifying conditional return periods
- Disentangling dynamics and thermodynamics

Research questions

To what extent are summer heatwaves associated with atmospheric blocking?

Are GCMs able to capture this relationship?

Can blocking be used as covariate to improve the quantification of heatwave return periods?
Three large initial condition ensembles

* ERA-Interim, 0.75° x 0.75°

(Dee et al., 2011)

50-member ensemble of CanESM2

(CanSISE project)
Resolution: 2.5° x 2.5°

21-member ensemble from NCAR-DOE CESM (CAM4)

(Fischer and Knutti, 2013)
Resolution: 1.9° x 2.5°

40-member ensemble from NCAR CESM1 (CAM5)

(Clara Deser and Jennifer Kay, Kay et al., 2015)
Resolution: 1° x 1°
Heatwave index

Heat Wave Magnitude Index daily
Combined measure of intensity and duration of a heatwave (Russo et al., 2015)
Most heatwaves associated with blocking

- 70% of strong heatwaves (HWMI≥10) associated with Scandinavian, European or Greenland blocking
- 26% of strong heatwaves (HWMI≥10) associated with no particular weather regime

(Weather regimes calculated following Grams et al., 2017)
Blocking index

Based on geopotential height at 500 hPa (Anstey et al., 2013)
Not all models capture blocking frequency well

Number of blocked summer days captured by CESM-CAM5, but underestimated by CESM-CAM4 and CanESM2
No robust trend in blocking
Relationship between blocking and heatwaves

a) European region

Higher blocking frequency in 9 days after onset -> higher HW magnitude
Relationship between blocking and heatwaves

a) European region

b) Russian region

Area-weighted average heatwave magnitude

Area-weighted average blocked days

ERAI [0.54]

ERAI [0.79]
Models capture observed relationship
Models capture observed relationship
Models can produce 2010-type heatwaves
2010-type heatwave in climate model

CanESM2, with the lowest resolution, is able to simulate an event similar to the 2010 Russian heatwave
Blocking is a suitable covariate for HW
Blocking is a suitable covariate for HW
Heatwaves are becoming much more intense

2031-2040 (RCP8.5)

2091-2100 (RCP8.5)
Future: Same blocking, same relative HW

Future HWs are defined wrt future climatology.

Absolute HW magnitude increases strongly
No robust dynamic contribution to HW change
Thermodynamics can explain HW change
Conclusions

• 70% of strong heatwaves are associated with blocking

• Even if GCMs underestimate blocking frequency, they capture the relationship between blocking and heatwaves

• Relationship does not change in future hence blocking is a meaningful covariate in estimating the GEV parameters of summer heatwaves in Europe/Russia

• No indication dynamic contribution to future heatwave changes but for individual events, actual circulation pattern is a key player

Backup
HWMId validation

Russo et al. (2015)