

Influence of atmospheric blocking on heatwaves in large model ensembles*

*Schaller, N. et al. (2018). Environmental Research Letters, 13(5)

Nathalie Schaller, Jana Sillmann, James Anstey, Erich Fischer, Christian Grams and Simone Russo

GEWEX, Canmore, 07.05.18

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?



Heatwave magnitude



Geopotential height anomaly (500hPa)



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°



ERAI

CanESM2

CESM-CAM4

CESM-CAM5

3

Heatwave index

°CICERO

Heat Wave Magnitude Index daily

Combined measure of intensity and duration of a heatwave (Russo et al., 2015)

JJA 2003





JJA 2010

Most heatwaves associated with blocking



Weather regime

→ 70% of strong heatwaves (HWMId≥10) associated with Scandinavian, European or Greenland blocking

26% of strong heatwaves (HWMId≥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)

Blocked summer days

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

EUR trend 1979-2015



°CICERO



RUS trend 1979-2015

Relationship between blocking and heatwaves

a) European region



Area-weighted average heatwave magnitude

°CICERO

Higher blocking frequency in 9 days after onset -> higher HW magnitude

Relationship between blocking and heatwaves

a) European region



Area-weighted average heatwave magnitude

°CICERO

b) Russian region



Area-weighted average heatwave magnitude



Models capture observed relationship

a) European region



Area-weighted average heatwave magnitude



b) Russian region

Area-weighted average heatwave magnitude

h

Models capture observed relationship

a) European region



Area-weighted average heatwave magnitude

°CICERO

b) Russian region

Area-weighted average heatwave magnitude

Models can produce 2010-type heatwaves



Area-weighted average heatwave magnitude

°CICERO

b) Russian region



Area-weighted average heatwave magnitude





°CICERO

Blocking is a suitable covariate for HW

a) European region



Area-weighted average heatwave magnitude



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



Area-weighted average heatwave magnitude

°CICERO



Thermodynamics can explain HW change

a) European region



°CICERO

b) Russian region

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 contribtuion to future heatwave changes but for individual • events, actual circulation pattern is a key player

Environ. Res. Lett., 13(5)



Reference: Schaller, N., Sillmann, J., Anstey, J., Fischer, E.M., Grams, C.M. and Russo, S (2018).

Backup

European region JJA 1979-2015



Area average heatwave magnitude

°CICERO

Russian region JJA 1979-2015

Area average heatwave magnitude

HWMId validation



June 1969

12500

Chicago Tribune, July 11, 1954

Heat Wave in Russia

Temperature in Stalingrad were reported to have reached 100 F today as Russia's heat wave the most intense since 1938 showed no signs of letting up.

Chicago Tribune, June 28, 1969

Heat Wave Embroils Norway Oslo-Eggs were fried on railway tracks crossing the polar circle.



The Ottawa Journal, July 25, 1972 Finns Feel Heat Helsinki Finland's continuing heat wave it now has lasted five weeks has sent the national toil of drown



Chicago Tribune, July 3, 1976

Britain rushes curbs on water The last 14 months have been the driest and hottest since records

began 249 years ago. Below average winter rainfall has been worsened by a fierce summer heat wave.

The New York Times, Aug. 3, 1994 Europe Wilts, Records Fall In Heat Wave

Much of Europe baked in the sixth week of a heat wave today, with the temperature expected to go as high as 100 degrees in eastern Germany and Poland













574-57 The Guardian, Aug. 29, 2003

Heat wave killed 11,000 in France As temperatures rose to $40^{\circ}C$ ($104^{\circ}F$) in parts of the country there were massive backlogs and at hospitals many people died.



The New York Times, July 19, 2006 Heat Wave Claims Lives in Europe Five deaths related to the oppressive heat were recorded on Tuesday alone.



The Guardian, July 25, 2007

Death toll rises in southern Europe's heatwave Southern Europe sizzled in recordbreaking temperatures yesterday with the heatwave being blamed for deaths in Balkans and Greece.



Russians and Their Crops Wilt Under Heat Wave The heat has been besting decades-old

records here. At 92.5 F, Friday was the hottest July 16 ever in Moscow.



-Finland Times, Aug. 16, 2014

Long heat wave poses health risk The country has seen an exceptionally long heat wave this year, most similar to those in 2003 and 2010.