Severe convective storms in Europe and their relation to large-scale mechanisms

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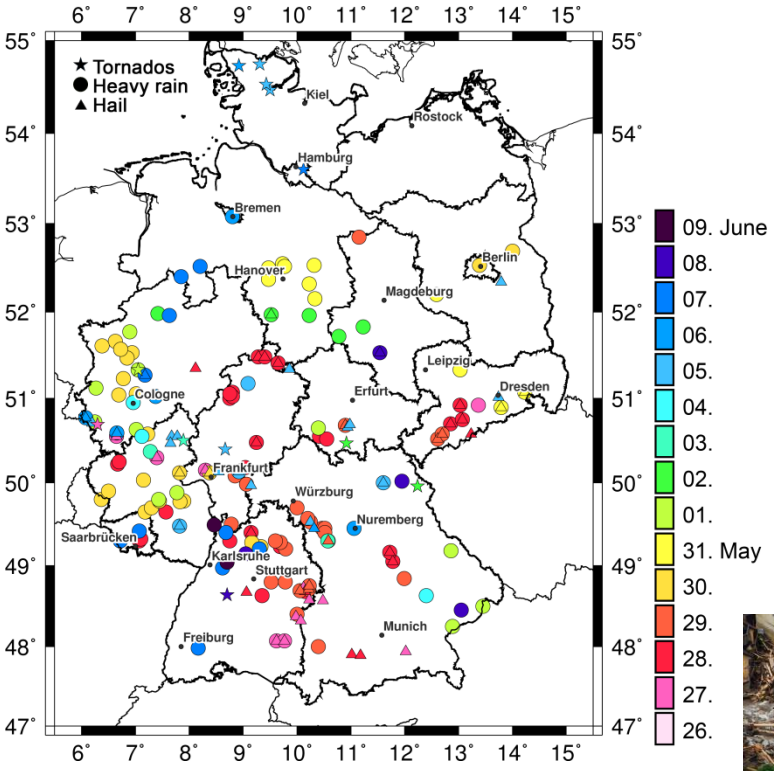
Example 2016: Exceptional sequence of SCS

Germany: 26 May to 9 June 2016



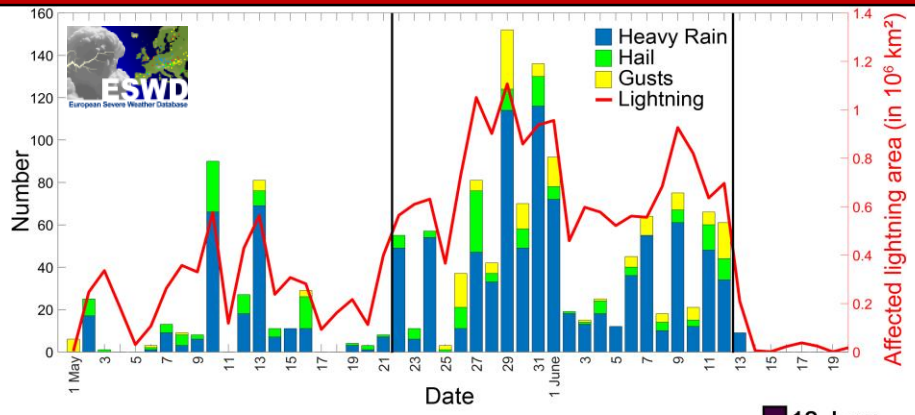
Data Source: ESWD European Severe Weather Database & newspapers

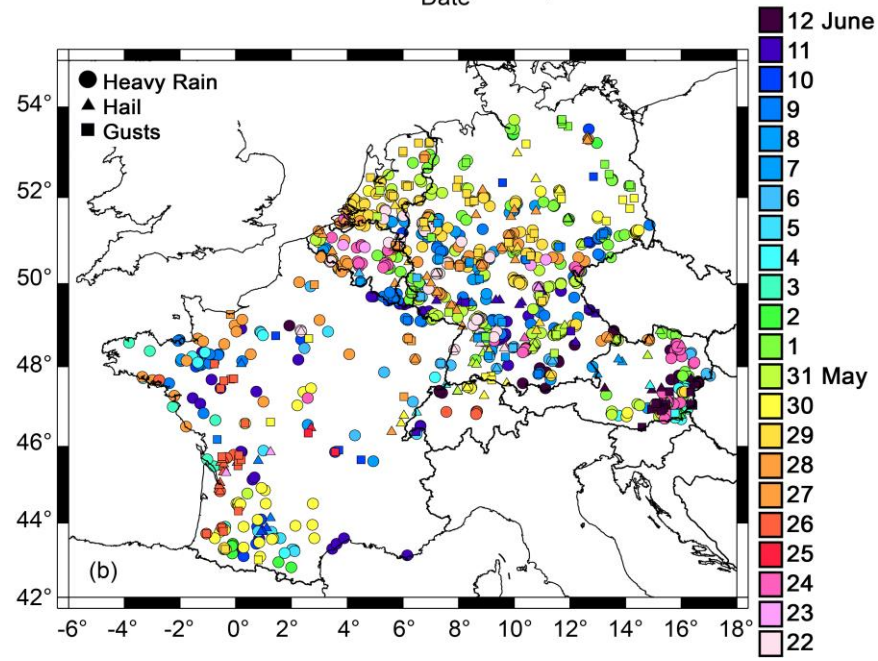
(Piper et al., 2016, NHESS)

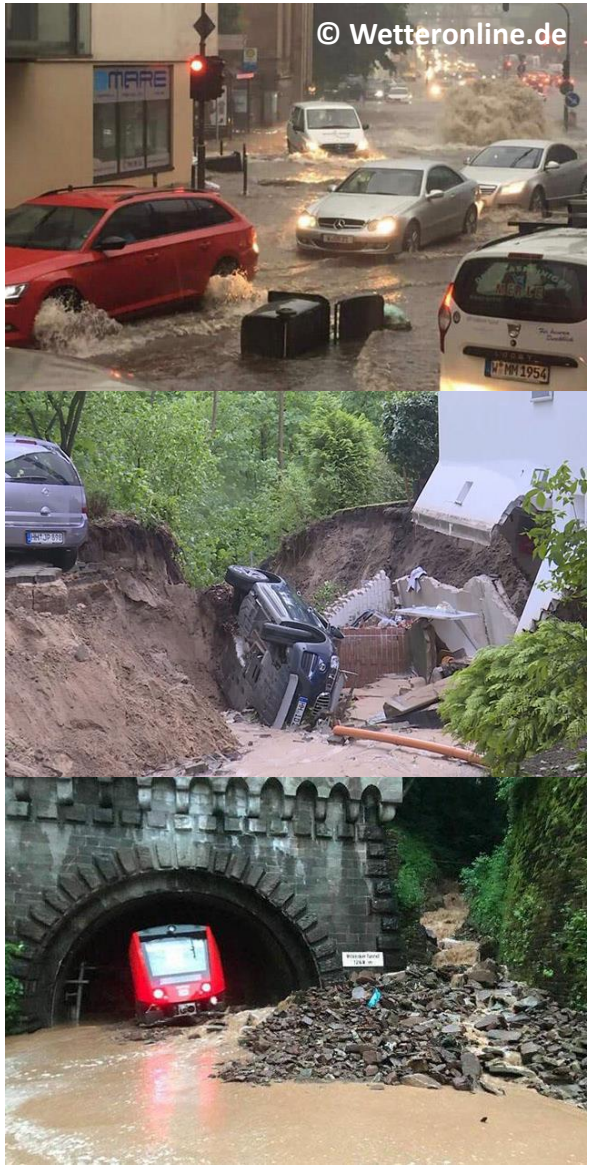
29 May 2016: Flash flood (Braunsbach, Germany)

Example 2018: Exceptional sequence of SCS

West/Central Europe: 22 May to 12 June 2018







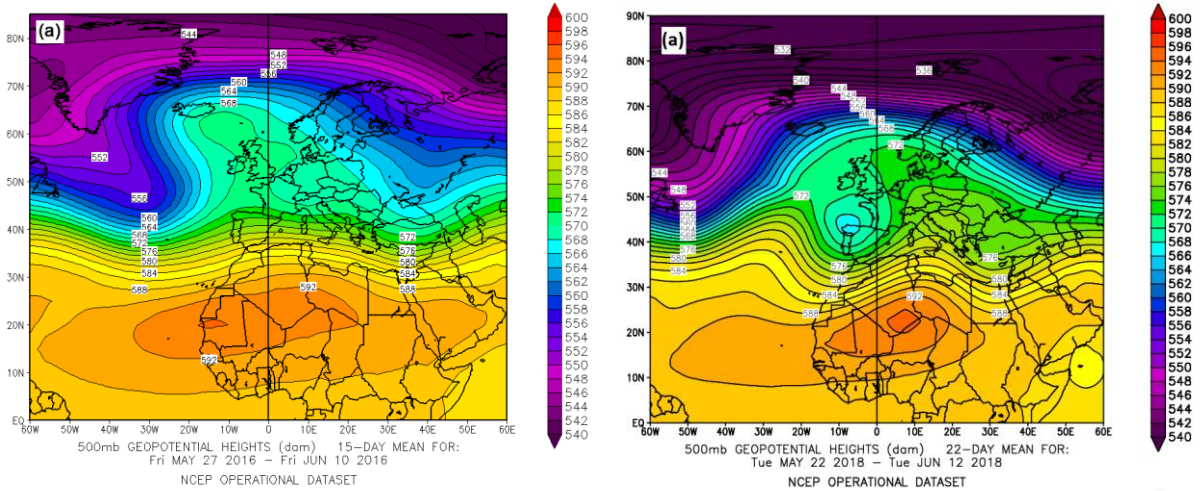
(Mohr et al., 2019b, Weather Clim. Dynam., in prep)

Atmospheric blocking

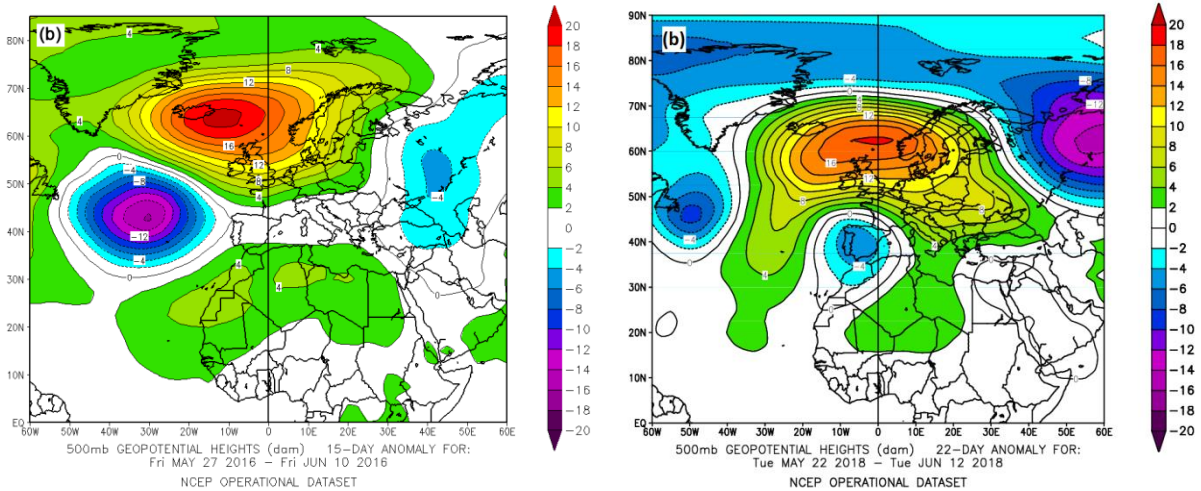
26 May to 9 June 2016

22 May to 12 June 2018

Geopotential height in 500 hPa 15/22 day mean



Geopotential height in 500 hPa anomaly



(NOAA/ESRL Physical Sciences Division, Boulder Colorado: http://www.esrl.noaa.gov)

(Piper et al., 2016, NHESS; Mohr et al., 2019b, Weather Clim. Dynam., in prep)

Atmospheric blocking

26 May to 9 June 2016

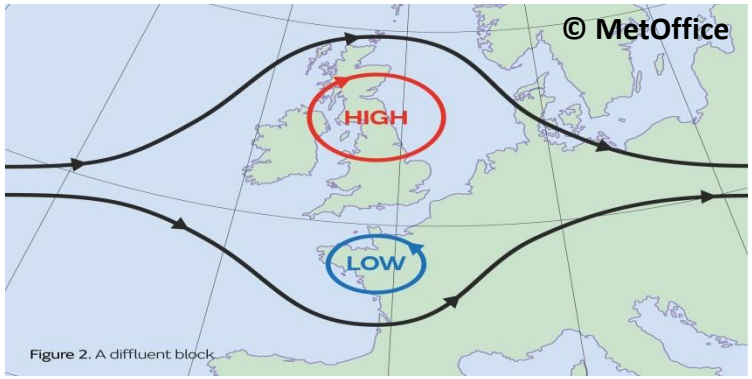
22 May to 12 June 2018

Geopotential height in 500 hPa 15/22 day mean

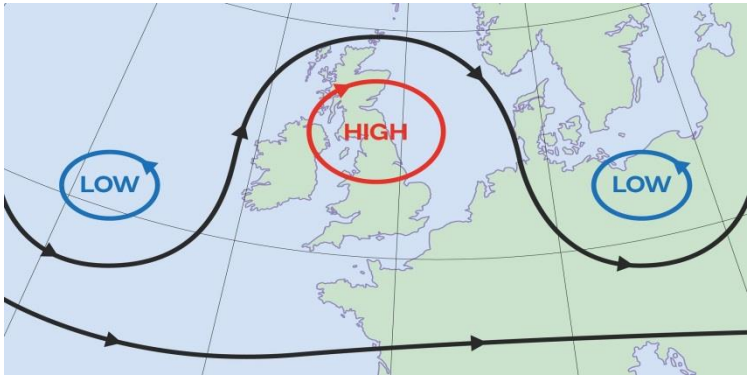
Geopotential height in 500 hPa anomaly

Atmospheric blocking pattern:

Dipole block



Omega block



(NOAA/ESRL Physical Sciences Division, Boulder Colorado: http://www.esrl.noaa.gov)

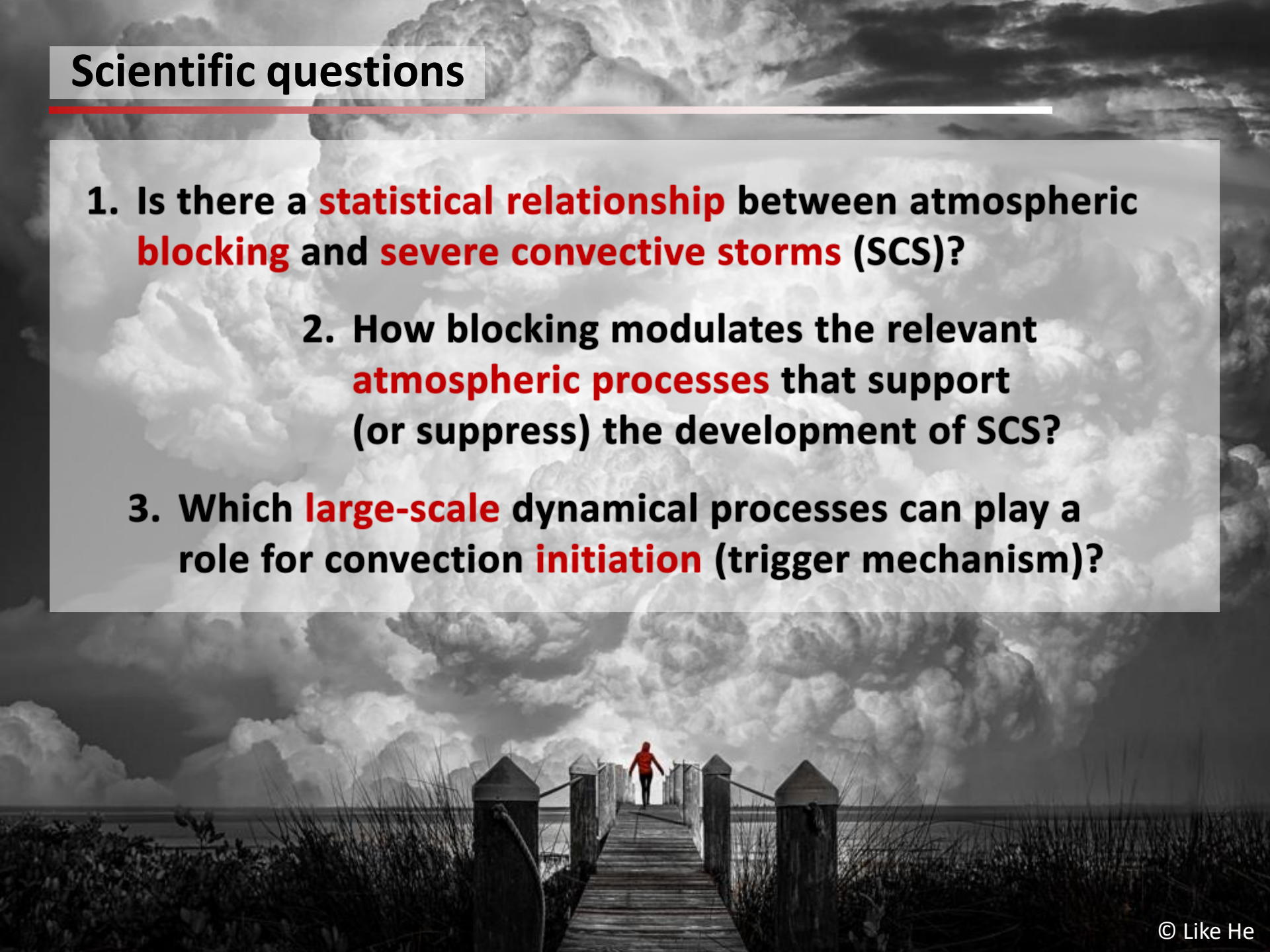
(Piper et al., 2016, NHESS; Mohr et al., 2019b, Weather Clim. Dynam., in prep)

Scientific questions

1. Is there a statistical relationship between atmospheric blocking and severe convective storms (SCS)?

2. How blocking modulates the relevant atmospheric processes that support (or suppress) the development of SCS?

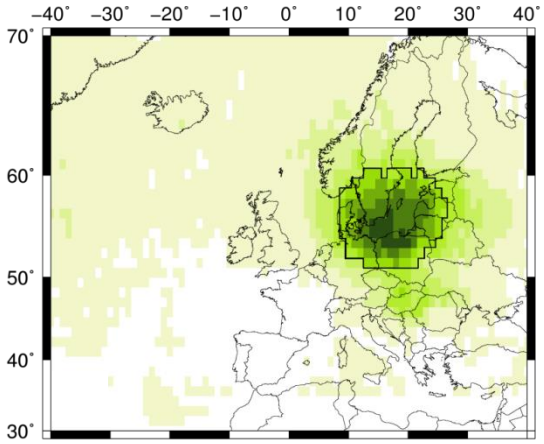
3. Which large-scale dynamical processes can play a role for convection initiation (trigger mechanism)?

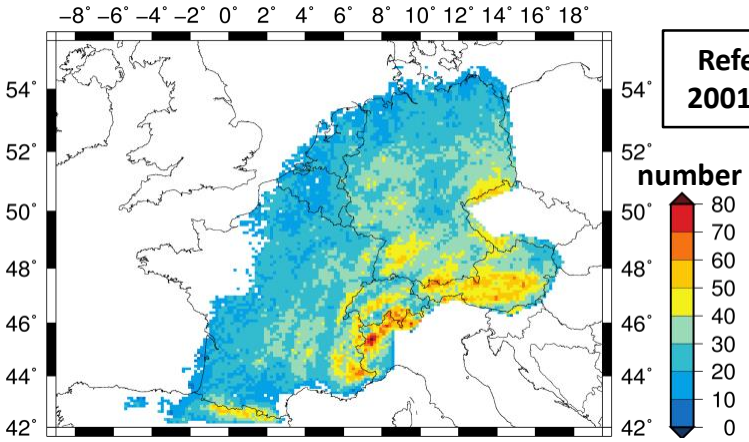


Blocking vs. thunderstorm days in Europa

Blocking over the Baltic Sea → Convection-favoring conditions

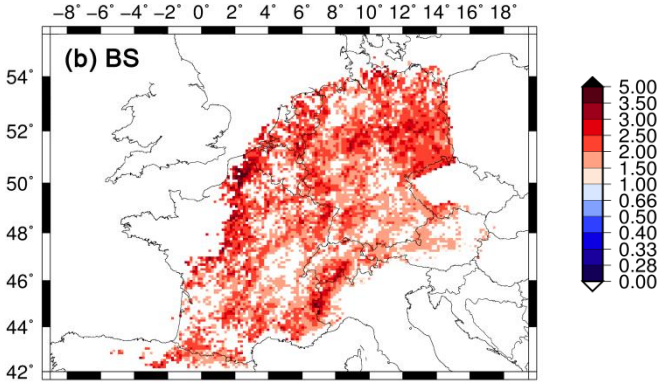
Blocking associated thunderstorm days





Reference period: 2001 – 2014 (MJJA)

Odds ratio



Only p-values at the 95 % significance level

OR>1: If there is blocking, the odds of a thunderstorm days increase (e.g., a value of 2 means a doubling of the odds).

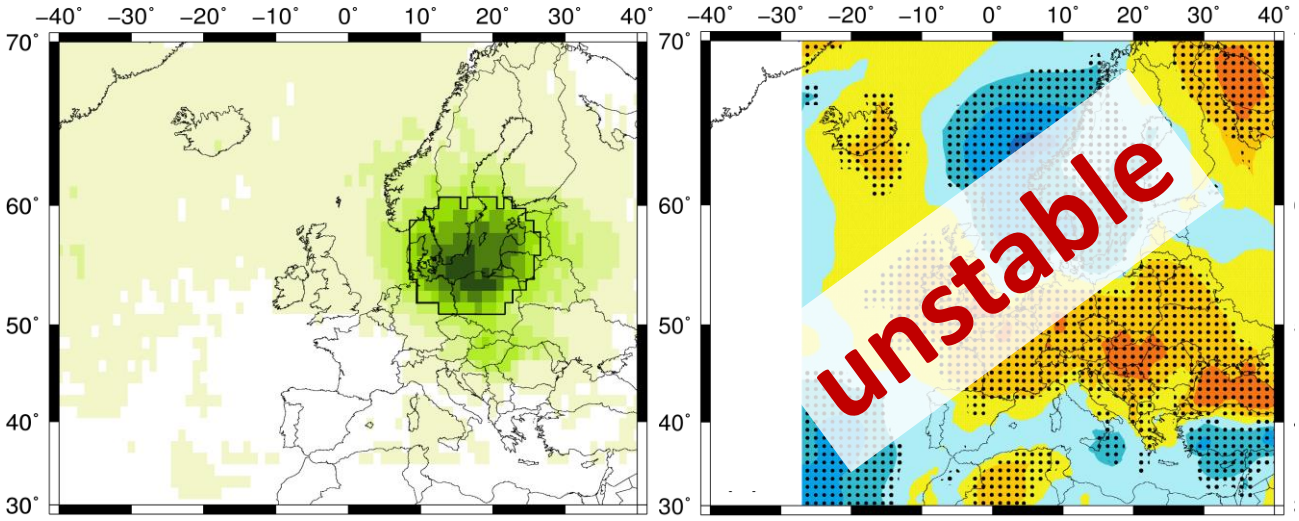
OR<1: If there is blocking, the odds for a thunderstorm days decrease (e.g., a value of 0.5 means a decrease of the odds by 50 %).

Blocking data (ERA-Interim; Schwierz et al., 2004); Thunderstorm days (BLIDS/EUCLID)

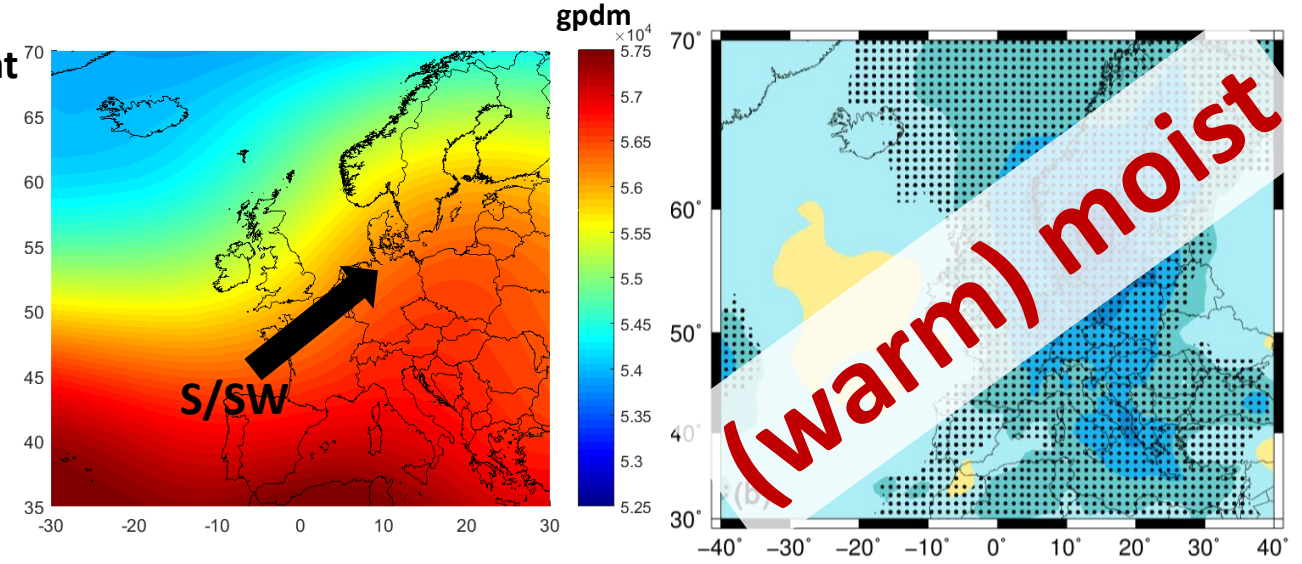
(Mohr et al., 2019a, QJRMS)

Baltic Sea: Convection-favoring conditions

Reference period:
2001 – 2014 &
1981 – 2010 (MJJA)



Geopot. height in 500 hPa
mean composite



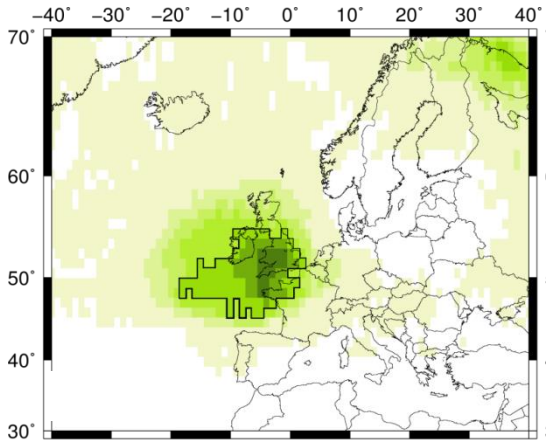
Data base: ERA-Interim

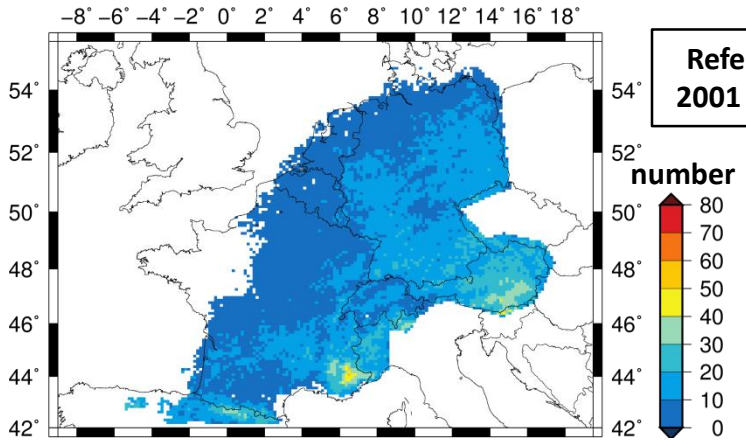
(Mohr et al., 2019a, QJRMS)

Blocking vs. thunderstorm days in Europa

Blocking over the Eastern North Atlantic → convection-inhibiting conditions

Blocking associated thunderstorm days





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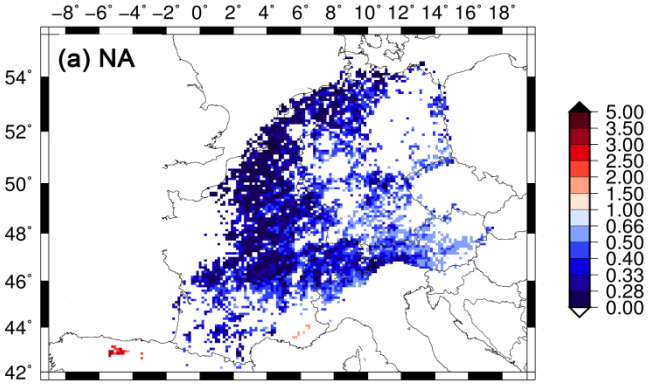

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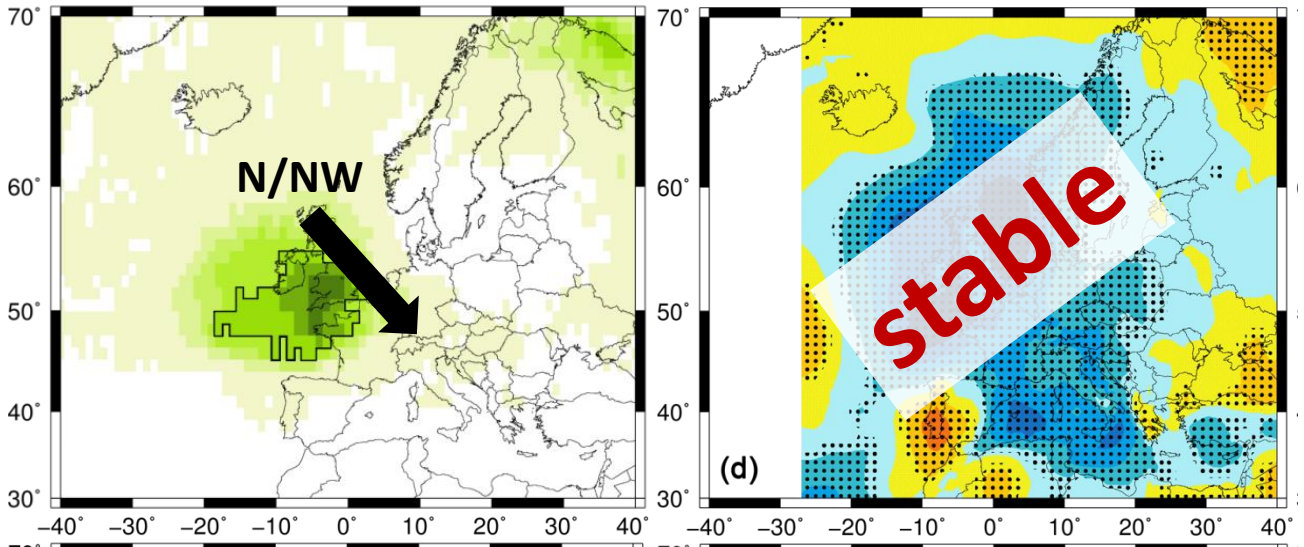
Blocking data (ERA-Interim; Schwierz et al., 2004); Thunderstorm days (BLIDS/EUCLID)

(Mohr et al., 2019a, QJRMS)

North Atlantic: Convection-inhibiting conditions

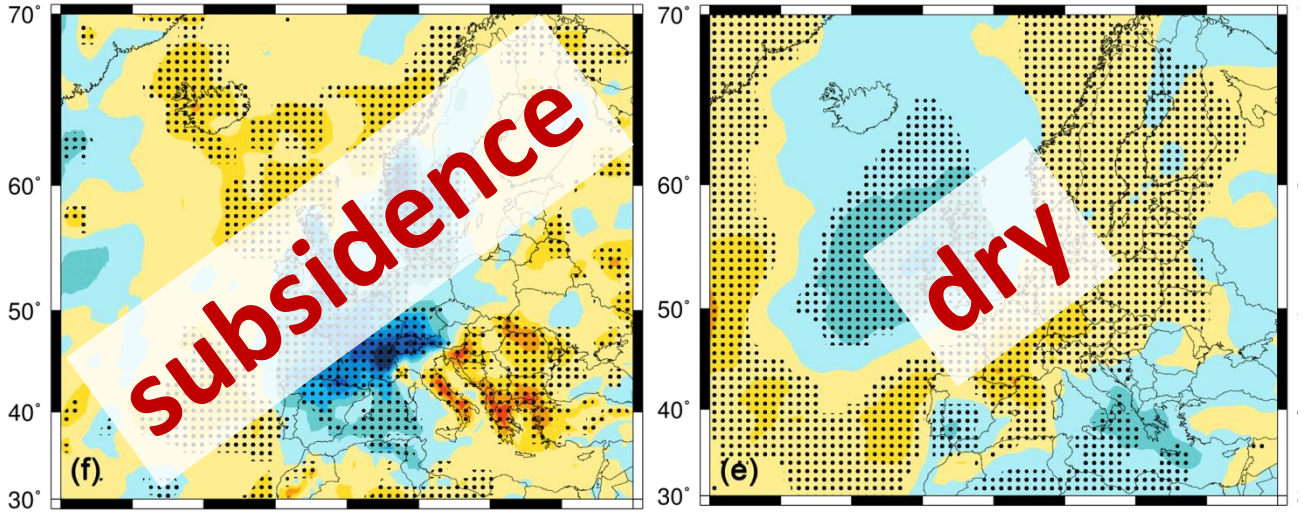
Reference period:
2001 – 2014 &
1981 – 2010 (MJJA)



Lifted Index
anomaly
composite

K
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0

OMEGA
anomaly
composite



hPa h⁻¹
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.0
−2.5

Precipitable
Water
anomaly
composite

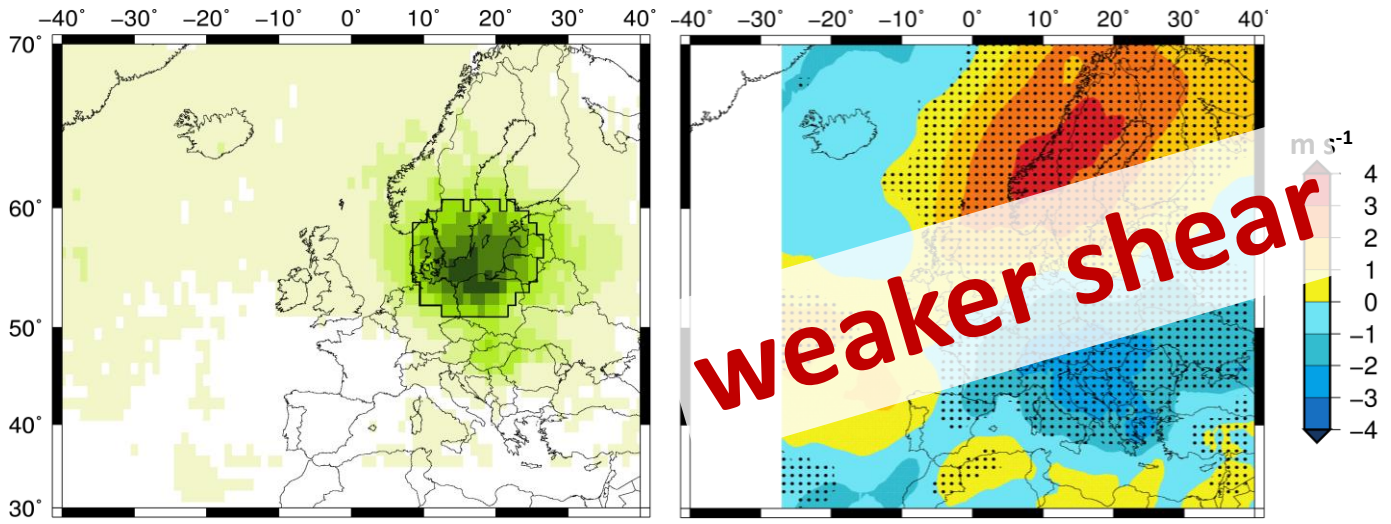
kg m⁻²
5
4
3
2
1
0
−1
−2
−3
−4
−5

Data base: ERA-Interim

(Mohr et al., 2019a, QJRMS)

Baltic Sea: Deep layer wind shear

Reference period:
2001 – 2014 &
1981 – 2010 (MJJA)



Wind Shear
500-925hPa
anomaly
composite

Data base: ERA-Interim

(Mohr et al., 2019a, QJRMS)

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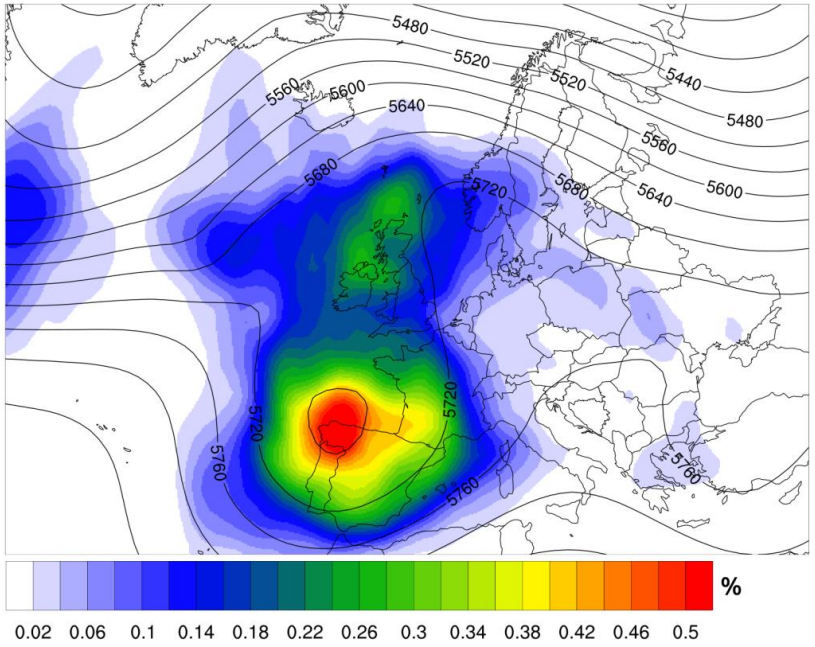
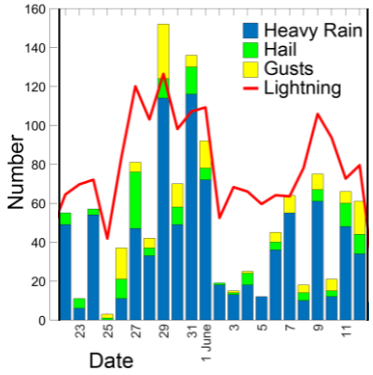
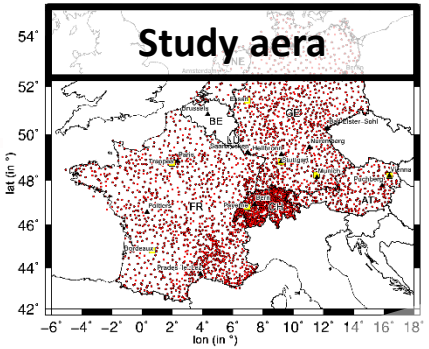
Example 2018: Cut-offs as trigger for convection

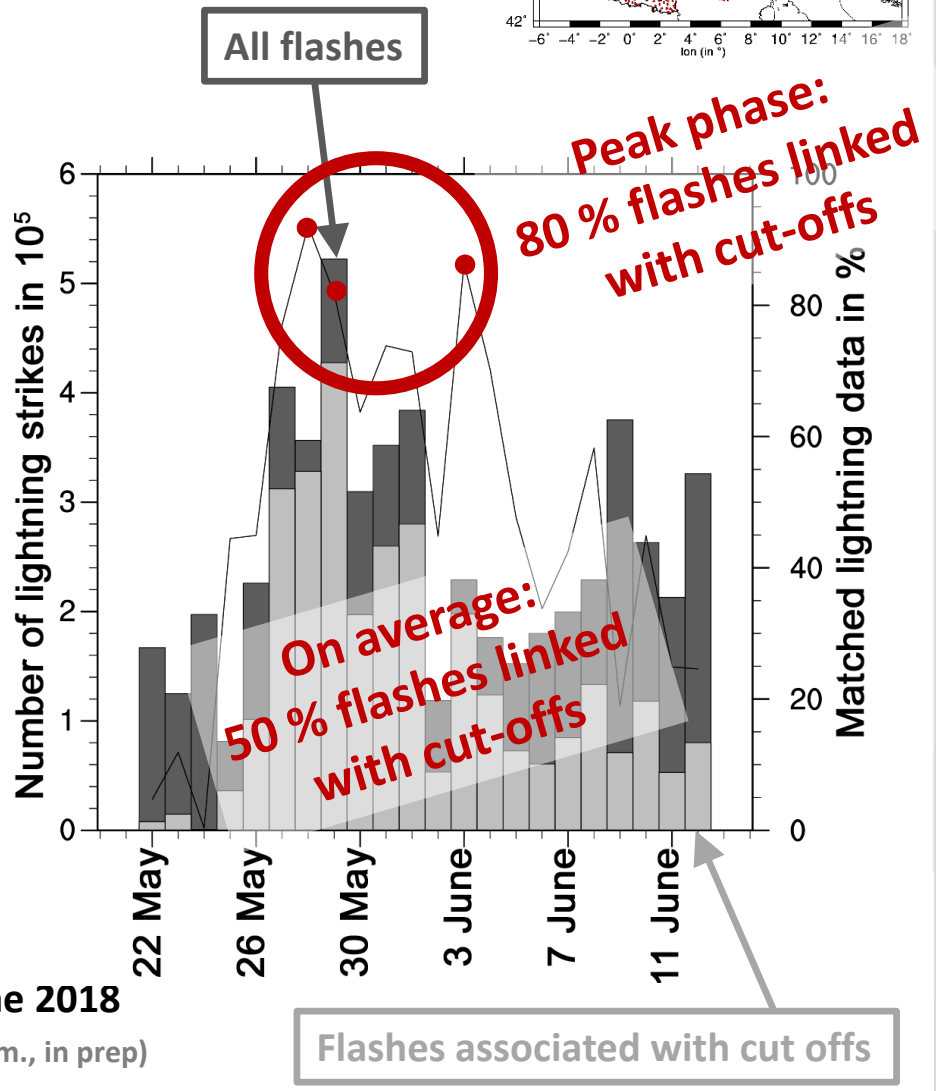
Composite mean 500 hPa geopotential height 500 hPa and cut-off cyclone frequency





Detection cut-off cyclones:
Potential vorticity on 325 K isentrope using the algorithm of *Wernli and Sprenger (2007)*





Study period: 22 May to 12 June 2018

(Mohr et al., 2019b, Weather Clim. Dynam., in prep)

Take-home messages…

- In Europe, **atmospheric blocking** create up- & downstream environmental conditions **influencing thunderstorm activity**.
- The southerly/southwesterly advection of warm, moist and unstable air masses on the western flank of a block over the **Baltic Sea** results in **convection-favoring conditions.**
- Blocking over the eastern **North Atlantic** leads to a northerly/northwesterly advection of dry and stable air masses (**convection-inhibiting conditions**).
- Thunderstorms related to **blocking** seem to be on average **less organized** (lower shear).
- Case study 2018: **Blocking** may also increase the probability of **cut-off lows**, which serve as **trigger mechanism** for deep moist convection.

Mohr, S., Wandel, J., Lenggenhager, S. and Martius, O. (2019a): Relationship between blocking and warm season thunderstorms in western and central Europe. ***Q. J. R. Meteor. Soc.,*** doi:10.1002/qj.3603.

Mohr, S., Wilhelm, J., Wandel, J., Kunz, M., Punge, H. J., Portmann, R., Schmidberger, M. and Grams, C. (2019b): The role of large-scale dynamics in an exceptional sequence of severe thunderstorms in Europe. ***Weather Clim. Dynam.*** (in final prep).

Piper, D., Kunz, M., Ehmele, F., Mohr, S., Mühr, B., Kron, A. and Daniell, J. (2016): Exceptional sequence of severe thunderstorms and related flash floods in May and June 2016 in Germany. Part I: Meteorological background. ***Nat. Hazards Earth Syst. Sci.,*** 16, 2835–2850, doi:10.5194/nhess-16-2835-2016.

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3rd European Hail Workshop

16 – 18 March 2020

Karlsruhe, Germany

Important Deadlines are:

Travel grants	15 November 2019
Abstract submission	**29 November 2019**
Registration	31 January 2020

Workshop website: http://ehw2020.imk.kit.edu