High resolution climatology of lightning in Central Europe

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Objectives

• Analyse occurrence of thunderstorms in Germany (and neighbouring areas)

• Determine spatial and temporal distribution of thunderstorms

• Study lightning characteristics

• Determine thunderstorm dependence on synoptical situation
Data

- Lightning detection network LINET:
  - 2007 – 2012
  - 36 million strokes
  - Mapped on a 1 km * 1km grid

- Human thunderstorm observations:
  - 20 weather stations
  - 1961-now
Spatial distribution

Rhine-Main-Valley

Vogelsberg
Rhoen
Main Valley
Spessart
Rhine Valley
Odenwald

200 km

200 km

height (m)

0 250 500 750 1000
Spatial distribution

Rhine-Main-Valley

# days (> 1 stroke/km²)
Spatial distribution

Rhine-Main-Valley

- Vogelsberg
- Rhoen
- Main Valley
- Spessart
- Odenwald
- Rhine Valley

# days (> 1 stroke/km²)

Berlin

# strokes

0.0 1.0 2.0 3.0 4.0 5.0

0.0 6.0 12.0 18.0 24.0 30.0
Spatial distribution

Berlin

# strokes

0.0  6.0  12.0  18.0  24.0  30.0
Spatial distribution

Mean annual number of days with >2 strokes <15km
Spatial distribution

Mean annual number of days with thunderstorm

Mean annual number of days with >2 strokes <15km
Temporal distribution

annual cycle

- Annual cycle (geographically varying)
- High year-to-year variability
Temporal distribution

- Annual cycle (geographically varying)
- High year-to-year variability

Annual cycle graph:
- Mean
- Symbols: individual years

Diurnal cycle:
- Winter
- Spring
- Summer
- Autumn

Diurnal cycle has an annual cycle
Lightning characteristics

• annual cycle of IC height
Objectives

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Synoptical classification

Following Hess and Brezowsky 1952, based on global NWP analysis
Synoptical classification

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wa</td>
<td>Anticyclonic Westerly</td>
</tr>
<tr>
<td>Wz</td>
<td>Cyclonic Westerly</td>
</tr>
<tr>
<td>Ws</td>
<td>South-Shifted Cyclonic Westerly</td>
</tr>
<tr>
<td>Ww</td>
<td>Maritime Westerly (Block E. Europe)</td>
</tr>
<tr>
<td>SWa</td>
<td>South-Westly European Anticyclone</td>
</tr>
<tr>
<td>SWz</td>
<td>South-Westly European Cyclone</td>
</tr>
<tr>
<td>NWa</td>
<td>North-Westly European Anticyclone</td>
</tr>
<tr>
<td>NWz</td>
<td>North-Westly European Cyclone</td>
</tr>
<tr>
<td>HM</td>
<td>High over Central Europe</td>
</tr>
<tr>
<td>BM</td>
<td>Zonal Ridge across Central Europe</td>
</tr>
<tr>
<td>TM</td>
<td>Low over Central Europe</td>
</tr>
<tr>
<td>Na</td>
<td>Anticyclonic Northerly</td>
</tr>
<tr>
<td>Nz</td>
<td>Cyclonic Northerly</td>
</tr>
<tr>
<td>HNa</td>
<td>High Norwegian Sea, Ridge C. Europe</td>
</tr>
<tr>
<td>HNz</td>
<td>High Norwegian Sea, Trough C. Europe</td>
</tr>
<tr>
<td>HB</td>
<td>High over the British Isles</td>
</tr>
<tr>
<td>TrM</td>
<td>Trough over Central Europe</td>
</tr>
<tr>
<td>NEa</td>
<td>Anticyclonic North-Eastery</td>
</tr>
<tr>
<td>NEz</td>
<td>Cyclonic North-Eastery</td>
</tr>
<tr>
<td>SEa</td>
<td>Anticyclonic South-Eastery</td>
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<tr>
<td>SEz</td>
<td>Cyclonic South-Eastery</td>
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<tr>
<td>Sa</td>
<td>Anticyclonic Southerly</td>
</tr>
<tr>
<td>Sz</td>
<td>Cyclonic Southerly</td>
</tr>
<tr>
<td>TB</td>
<td>Low over the British Isles</td>
</tr>
<tr>
<td>TrW</td>
<td>Trough over Western Europe</td>
</tr>
<tr>
<td>Ü</td>
<td>Transitional Days</td>
</tr>
</tbody>
</table>

How often do thunderstorms occur under certain synoptical conditions?

→ For each class calculate thunderstorm occurrence.

Following Hess and Brezowsky 1952, based on global NWP analysis
Thunderstorm activity vs synoptic pattern

summer (AMJJAS) 2007-2012

T (Central Europe low pressure)
Thunderstorm activity vs synoptic pattern

H (Central Europe high pressure) summer (AMJJAS) 2007-2012
Thunderstorm activity vs Synoptic pattern

Example: Anticyclonic South-Easterly

Courtesy: Paul James
Summary

• Spatial distribution
• Temporal distribution
• Lightning characteristics
• Dependence on synoptical situation

Outlook

• Extension of synoptical pattern statistics
• Thunderstorm characteristics depending on synoptical situation

More information

Wapler (2013): High-resolution climatology of lightning characteristics within Central Europe, submitted to MAP.
Wapler and Frank (2013): Analysis of lightning flash characteristics in Central Europe, Poster 92.
Appendix
Spatial distribution

Mean annual number of strokes per km²
Spatial distribution

Mean annual number of days with > 1 stroke per km²
Spatial distribution

Mean annual number of days with >2 strokes <15km
Spatial distribution

Mean annual number of strokes per km²

Mean annual number of days with > 1 stroke per km²

Mean annual number of days with >2 strokes <15km
Thunderstorm activity vs synoptic pattern

T (Central Europe low pressure) summer (AMJJAS) 2007-2012
Thunderstorm activity vs synoptic pattern

Z (general cyclonic) | summer (AMJJAS) 2007-2012
Thunderstorm activity vs synoptic pattern

A (general anticyclonic)

summer (AMJJAS) 2007-2012
Thunderstorm activity vs synoptic pattern

H (Central Europe high pressure) summer (AMJJAS) 2007-2012