Decadal trends of high-intensity precipitation events and relation to atmospheric circulation in Central Germany

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RESEARCH QUESTIONS
- Which trends appear in high-intensity precipitation events, comparing temporal high-resolution data (5min, 1h, 6h) with daily precipitation data in Central Germany (period 1961 to 2015)?
- How does atmospheric circulation impacts the occurrence of high-intensity precipitation events, comparing precipitation data with 5min and daily resolution?

METHODS
- Selection criteria of precipitation stations:
  - Central German stations with:
    - ...as little as possible data gaps in extended summer season (May to September)
    - ...no considerable shifts in station location and environment
- Linear regression (LR) and Mann-Kendall trend test (MK)
- "High-intensity precipitation event":

<table>
<thead>
<tr>
<th>Temporal resolution</th>
<th>Threshold value</th>
<th>Origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>5min</td>
<td>1</td>
<td>averaged over all stations during the period 1961 to 2015 in mm</td>
</tr>
<tr>
<td>1h</td>
<td>15</td>
<td>warning level 2 - DWG</td>
</tr>
<tr>
<td>24h</td>
<td>20</td>
<td>warning level 2 - DWG</td>
</tr>
</tbody>
</table>

Tab. 1: Threshold values for different temporal resolutions and their origin (H. & Brezowsky 2004 and DWG 2016).

RESULTS
- Trends (intensity):
  - 5min data: significant increase in intensity for almost all stations
  - 1h data: fewer stations with significant increase, but generally increasing trends
  - 24h data and daily data: no clear and significant trends
  - Increase in high-resolution data may be connected to a) more intense and/or higher number of convective showers and b) better observation methods for high-resolution precipitation
  - More research needed to find out extent of "real" climate signal

Fig. 3: Seasonal (May - September) daily added maximum precipitation for different temporal resolutions, averaged over all stations during the period 1961 to 2015 (in mm).

Fig. 4: Frequency of highly convection-relevant Grosswetterlagen (see Table 1) during the May - September and trends per year for GWLc (green) and SVGc (purple).

Fig. 5: Relative frequency of high-intensity precipitation events (5 min) for GWLc and SVGc (bottom) for May - September 2016 (data from 2003 - 2015)

Fig. 6: Relative frequency of high-intensity precipitation events (5 min) for GWLc and SVGc (bottom) for May - September 2016 (data from 2003 - 2015) and GWL (top) with highly convection-relevant Grosswetterlagen selected according to Table 1.

CONCLUSIONS
- Strong increase in high-intensity precipitation events of short duration (especially 5min, but also 1h)
- Clarification of causes still needed (climatology vs. improvement of recording equipment)
- Grosswetterlagen with southern component are more likely to cause these events, through the transport of warm air
- No significant increase in frequency of "highly convection-relevant" Grosswetterlagen, but possible backup for more events from the 1990s...

REFERENCES:

DATA
- Precipitation
  - Stations: 19 in Central Germany
  - Temporal resolution: from 5 minutes
  - Time frame: 1961 to 2015
  - Season: May to September
  - Origin: DWG (Climate Data Centre)

Fig. 2: Decadal number of high-intensity precipitation events and linear trends for different temporal resolutions starting with 5min – 24h, ending with 2004 – 2015.

Fig. 3: Seasonal (May – September) daily added maximum precipitation for four different temporal resolutions, averaged over all stations during the period 1961 to 2015 (in mm).

Fig. 4: Decadal number of high-intensity precipitation events and linear trends for different temporal resolutions starting with 5min – 24h, ending with 2004 – 2015.

Trends (occurrence):
- Very strong increase for 5min-events, especially during last two periods may be strongly related to change in measuring techniques from beginning of 1990s (see discussion in previous box)
- Moderate increase for 1h / 6h
- No trends for daily data

Annual cycle (occurrence):
- 5min-events: mainly driven by convection – peak in mid-July indicates importance of solar altitude and higher air temperatures
- Daily events: driven by convection (high level from end of May to beginning of August) and atmospheric circulation (peaks beginning of June and mid-July of August)

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Fig. 4: Seasonal (May – September) daily added maximum precipitation for four different temporal resolutions, averaged over all stations during the period 1961 to 2015 (in mm).

Fig. 5: Relative frequency of high-intensity precipitation events (5 min) for GWLc and SVGc (bottom) for May - September 2016 (data from 2003 - 2015) and GWL (top) with highly convection-relevant Grosswetterlagen selected according to Table 1.

GWLc (occurrence)
- High frequency of Grosswetterlagen with southeastern, southern and southwestern (warm) inflow and
- GWLc = relevance because of influence of cold air pool over western Europe with cold air stream from northern Europe or b) disturbances of the southern sector of the Atlantic frontal zone (especially Mannheim and Giessen) 2010.

Daily events
- Often connected to TM and southsoutheasterlies.

SVGc (occurrence)
- High frequency of Grosswetterlagen with southern and southwestern inflow and
- SVGc = relevance because of influence of cold air pool over western Europe and disturbances of the southern sector of the Atlantic frontal zone (especially Mannheim and Giessen) 2010.

Daily events
- Mostly connected to trough conditions, TM and zonal circulation types of various inflow directions.

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Fig. 7: Relative frequency of high-intensity precipitation events (5 min) for GWLc and SVGc (bottom) for May - September 2016 (data from 2003 - 2015) and GWL (top) with highly convection-relevant Grosswetterlagen selected according to Table 1.