Statistical analysis of very high-resolution precipitation data and relation to atmospheric circulation in central Germany

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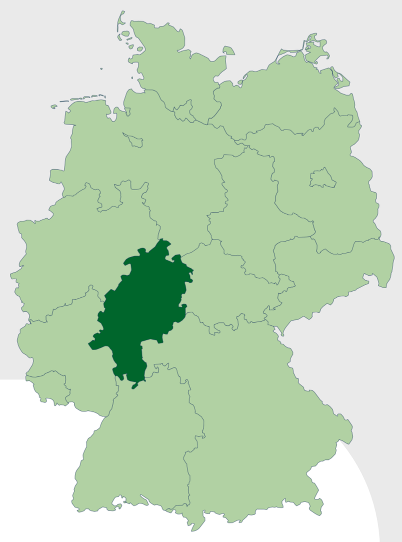


1) Introduction

Precipitation gauges based on a **weighing system** allow the recording of high-intensity precipitation events with a **very high temporal resolution (1 minute).** The corresponding measuring network for the German state of Hesse is **investigated for the first time** to answer the following questions:

a) Are the recorded precipitation data **plausible & comparable**?

b) Is there a connection between **short-term precipitation intensity** and **atmospheric circulation***?

2) Data & Study area

- Measuring period: **2000–2016**
- PLUVIO-OTT precipitation gauges
- Combination of two observational networks:
  1. German Weather Service (**DWD, 79 stations**)
  2. Regional water authority of the state of Hesse (**HLNUG, 47 stations**)

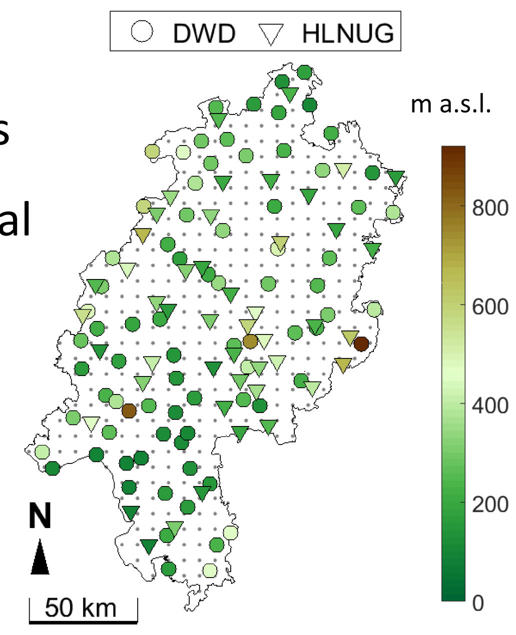


Fig. 1: State of Hesse with coordinates of 126 measuring stations (+ interpolation grid).

*Circulation patterns investigated using **29 Großwetterlagen (GWL; sub-types)** based on Werner and Gerstengarbe (2010):

WA = Anticyclonic Westerly, **WZ** = Cyclonic Westerly, **WS** = South-Shifted Westerly, **WW** = Westerly, Block Eastern Europe, **SWA** = Anticyclonic South-Westerly, **SWZ** = Cyclonic South-Westerly, **NWA** = Anticyclonic North-Westerly, **NWZ** = Cyclonic North-Westerly, **HM** = High over Central Europe, **BM** = Zonal Ridge across Central Europe, **TM** = Low (Cut-Off) over Central Europe, **NA** = Anticyclonic Northerly, **NZ** = Cyclonic Northerly, **HNA** = Icelandic High, Ridge Central Europe, **HNZ** = Icelandic High, Trough Central Europe, **HB** = High over the British Isles, **TRM** = Trough over Central Europe, **NEA** = Anticyclonic North-Easterly, **NEZ** = Cyclonic North-Easterly, **HFA** = Scandinavian High, Ridge Central Europe, **HFZ** = Scandinavian High, Trough Central Europe, **HNFA** = High Scandinavian Iceland, Ridge Central Europe, **HNFZ** = High Scandinavian Iceland, Trough Central Europe, **SEA** = Anticyclonic South-Easterly, **SEZ** = Cyclonic South-Easterly, **SA** = Anticyclonic Southerly, **SZ** = Cyclonic Southerly, **TB** = Low over the British Isles, **TRW** = Trough over Western Europe, U = not defined

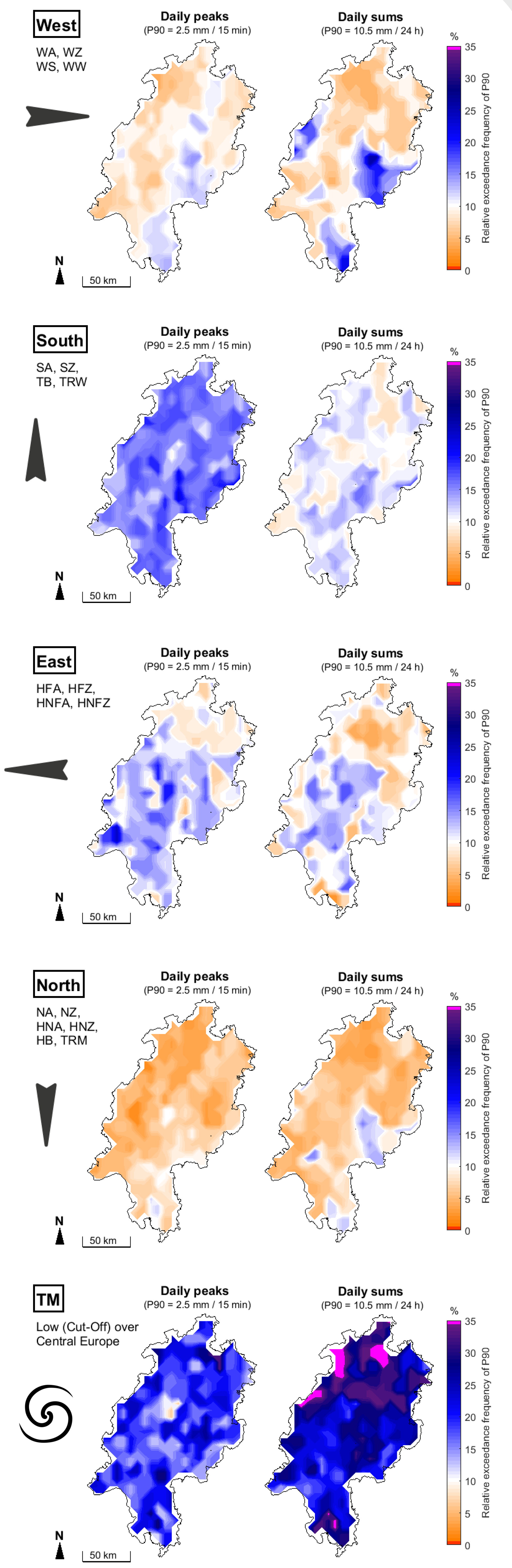
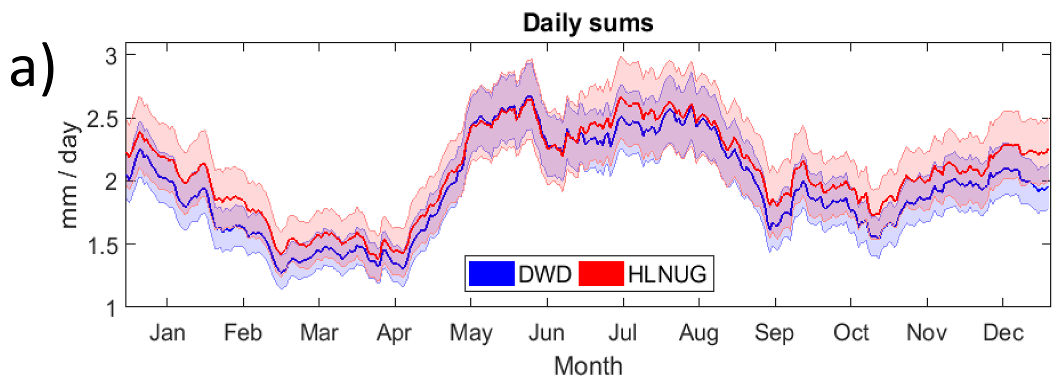


Fig. 4: Relative exceedance frequency of the 90th percentile (P90) of daily 15-min peak values (left) and daily sums (right) for different Grosswettertypen (major types, consisting of 1-6 sub-types), spatial distribution with nearest neighbour interpolation.

3) Quality / Comparison of datasets

- **Annual sums** of PLUVIO data and "conventional" Hellmann data **do not differ significantly** (not shown)
- **Daily sums** of DWD and HLNUG datasets (observed via PLUVIO) **do not differ significantly** (**Fig. 2a**),



BUT:

- According **1-min peak** values **differ largely** (**Fig. 2b**)
- Improved by **summation** of the data → **15-min** (**Fig. 2c**)

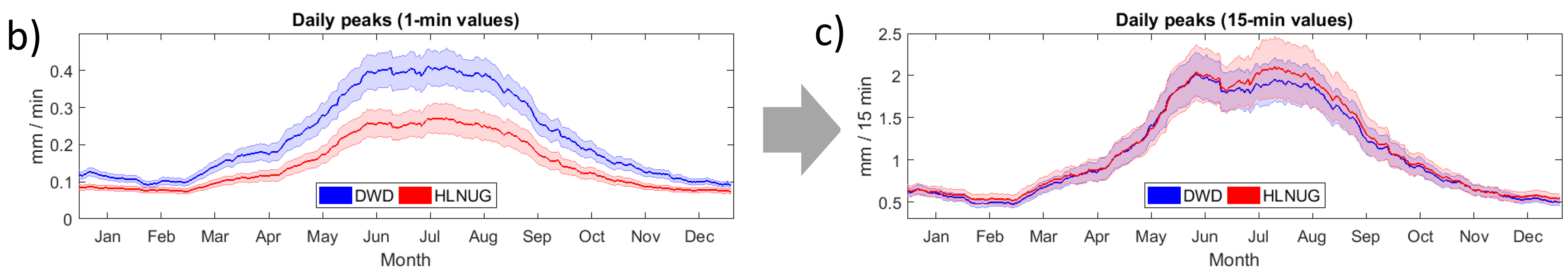


Fig. 2: Seasonal cycle of daily sums (a) and **daily 1min/15min maximum values (b, c),** averaged over all years (2000–2016) and all stations (DWD: red; HLNUG: blue); using of moving averages (30 days) and 95% confidence intervals (coloured area).

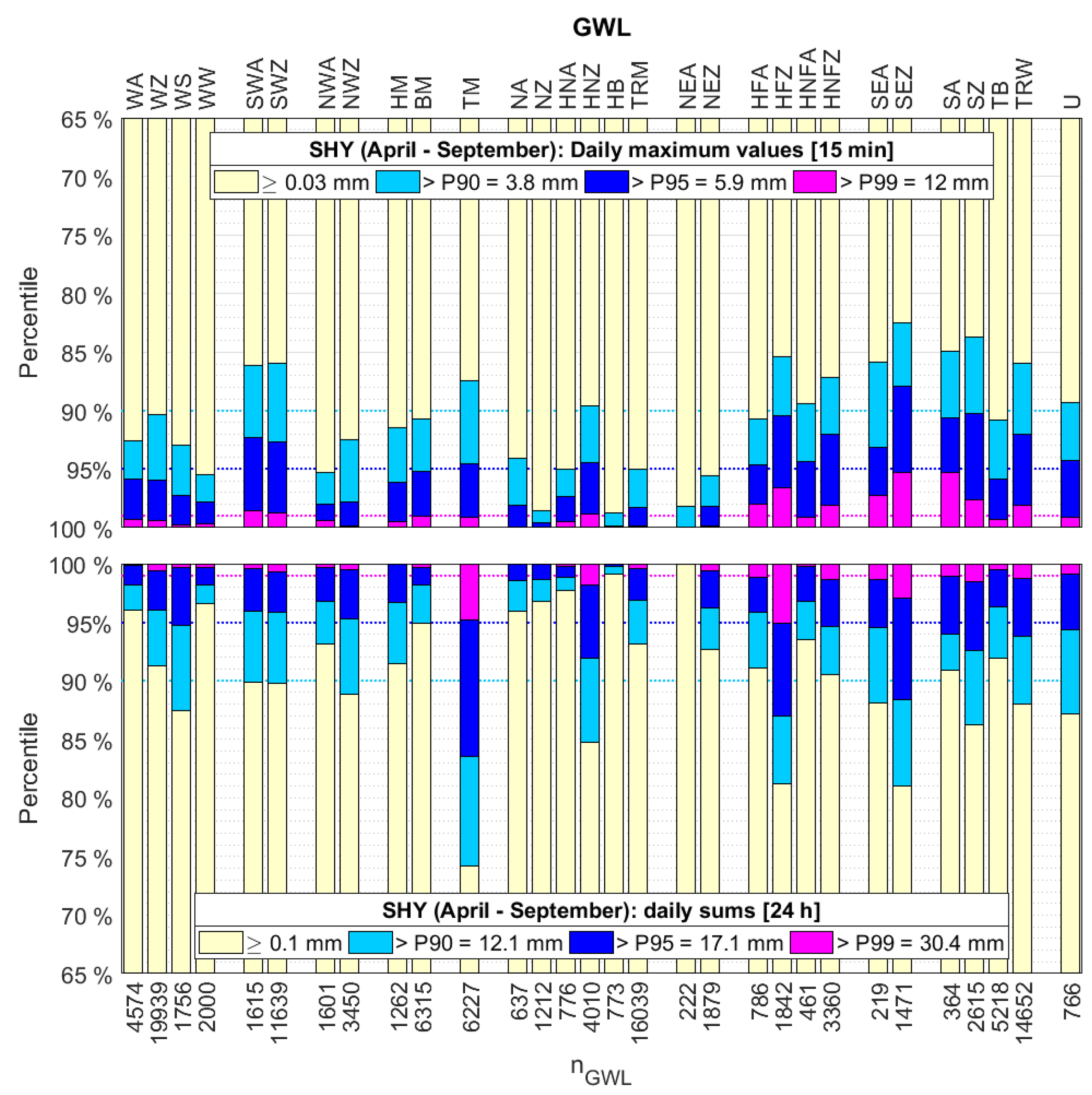


Fig. 3: Relative percentage of high-intensity precipitation classes (> 90/95/99th percentile = P90/95/99) for different circulation patterns (*) for daily 15-min peak values (above) and daily sums (below) during the summer half year (April – September), total number of included precipitation days per GWL at the bottom (sum of all stations).

4) Circulation patterns

- Westerly air mass inflow → advection of maritime moisture; strong correlation between precipitation intensity and topography (**Fig. 4**)
- Continental air mass inflow from Southern/Eastern Europe → positive effect on precipitation intensity; randomly distributed convective events (**Fig. 3 & 4**)
- High risk of heavy (daily) precipitation during TM days → low pressure systems that stagnate over Central Europe (**Fig. 3 & 4**)
- Trough conditions over Central Europe (TRM) not relevant for heavy precipitation in Hesse, trough over Western Europe (TRW) much riskier (**Fig. 3**)

5) Conclusions

- Different datasets of identical instruments produce different results → different software calibration?
- Possibility of improving the comparability of high-resolution precipitation datasets by accumulating 1-min values to coarser resolutions (in this case 15 min)
- Clear connection between atmospheric circulation and heavy precipitation events over Hesse
- Different impacts of atmospheric circulation patterns between intense daily and sub-daily events → importance of expanding and enhancing high-resolution precipitation observations

Reference

Werner, P. C. und F.-W. Gerstengarbe (2010): Katalog der Großwetterlagen Europas (1881-2009). 7., verbesserte und ergänzte Auflage. Berichte des Deutschen Wetterdienstes 119.