Impact of Atmospheric Circulation on Flooding Occurrence and Type in the Moselle Basin

Judith Meyer[1,2], Audrey Douinot[1], Carol Tamez-Meléndez[1,3], Erwin Zehe[4], Olivier Francis[2], Laurent Pfister[1,2]

1. Motivation

Recent accumulation of flash floods in Luxembourg, i.e.:

Event	Date	P [mm/d]	Atmosph. circulation pattern
1	2016-07-22	50-70	HFZ (High, Scandinavia, cyclonal)
2	2018-05-31	100-120	SEZ (South-Est, cyclonal)
3	2018-06-09	50-70	HNZ (High, Iceland, cyclonal)

2. Hypothesis

The recent increase in flash flood occurrences in Luxembourg is triggered by a change in atmospheric circulation patterns.

Hypothesis testing:
(1) Seasonal analysis of precipitation (P) events ≥ 50 mm
(2) Atmospheric circulation patterns during P events
(3) Comparison of data with flash flood data base

3. Data availability

- Area: Moselle basin (F, LUX, D)
- Precipitation (P) stations[2]: 98
- Atmospheric circulation patterns: (Hess & Brezowsky classification[1, 2])
- Time step: daily
- Time period: 1954-2018

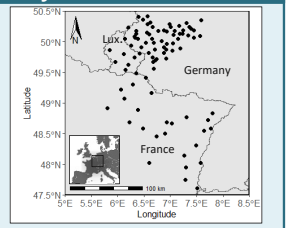

Fig. 1: Study area with precipitation stations.

4. Occurrence of precipitation events ≥ 50 mm

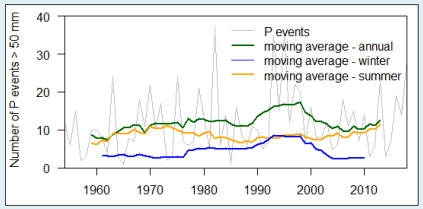

Fig. 2: 11-year moving average of the number of P events per year.

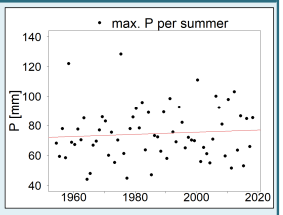

Fig. 3: Max. P event per summer.

- Oscillation in the total number of P events
- Rather constant number of P events during the summer
- Increase in the P amounts of the highest events per year

5. Atmospheric circulation patterns during summer

- Increase in trough weather patterns (BM, TRM, TRW) & SWZ
- No change in the weather patterns, during Luxembourgish flash floods (HNZ, HFZ, SEZ)

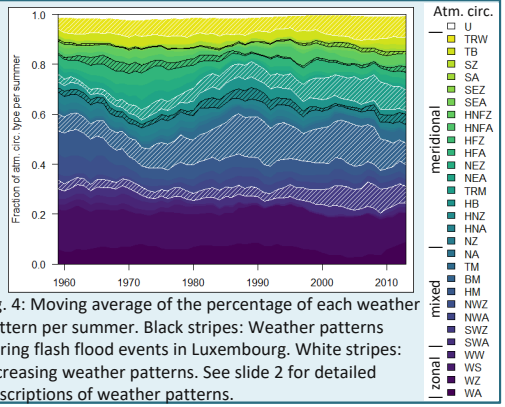

Fig. 4: Moving average of the percentage of each weather pattern per summer. Black stripes: Weather patterns during flash flood events in Luxembourg. White stripes: increasing weather patterns. See slide 2 for detailed descriptions of weather patterns.

6. Atm. circulation patterns during P events

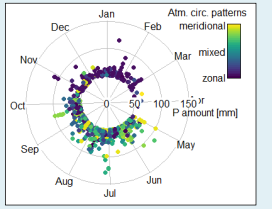

Fig. 5: Atm. circ. patterns within the course of a year during P events. See Fig. 4 & slide 2 for a detailed legend.

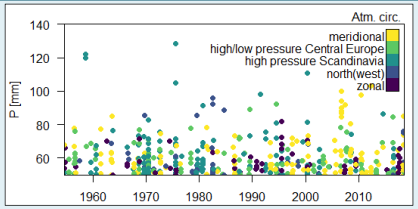

Fig. 6: P amount and atm. circ. patterns of events during the *summer*. See Fig. 4 for a detailed legend.

- Events during winter due to zonal circulation
- Non-zonal weather patterns in summer
- Recently summer P events occurred more often during meridional circ. patterns

7. Conclusion & Outlook

(1) Number of P events during summer stayed similar over time (Fig. 2), while increasingly higher maxima were reached (Fig. 3).
(2) The general fraction of days with meridional circulation patterns during summer stayed similar (Fig. 4)
→ Yet, weather patterns causing P events during summer have shifted from zonal to meridional circulation patterns (Fig. 6).

(3) Ways forward:
- Link to increasingly observed flash floods north of the Alps
- Understanding of related runoff generation processes

[1]: Catchment and Ecohydrology Group (CAT), Luxembourg Institute of Science and Technology (LIST), Belvaux, Luxembourg (judith.meyer@list.lu)
[2]: Faculty of Science, Technology and Medicine (FSTM), University of Luxembourg, Belval, Luxembourg
[3]: Institute of Water Resources and River Basin Management, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany
[4]: Institute of Hydraulic Engineering and Water Resources Management, TU Vienna, Vienna, Austria

References:
[1]: Hess P., Brezowsky H. (1977): Katalog der Grosswetterlagen Europas 1881–1976, 3. verbesserte und ergänzte Aufl. Berichte des Deutschen Wetterdienstes 113. Offenbach am Main.
[2] German Weather Sercive, MeteoFrance, ECAD, LIST, ASTA, MeteoLux, AGE

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Subjective atmospheric circulation type classification according to Hess & Brezowsky [1]

Nr.	Abbr.	Circulation type [engl.][2]	Circulation type [original] [1]
A) Zonal Circulation			
1	WA	Anticyclonic Westerly	Westlage, antizyklonal
2	WZ	Cyclonic Westerly	Westlage, zyklonal
3	WS	South-Shifted Westerly	Südliche Westlage
4	WW	Maritime Westerly	Winkelförmige Westlage
B) Mixed circulation			
5	SWA	Anticyclonic South-Westerly	Südwestlage, antizyklonal
6	SWZ	Cyclonic South-Westerly	Südwestlage, zyklonal
7	NWA	Anticyclonic North-Westerly	Nordwestlage, antizyklonal
8	NWZ	Cyclonic North-Westerly	Nordwestlage, zyklonal
9	HM	High over Central Europe	Hoch Mitteleuropa
10	BM	Zonal Ridge across Central Europe	Hochdruckbrücke (Rücken) Mitteleuropa
11	TM	Low (Cut-Off) over Central Europe	Tief Mitteleuropa
c) Meridional circulation			
12	NA	Anticyclonic Northerly	Nordlage, antizyklonal
13	NZ	Cyclonic Northerly	Nordlage, zyklonal
14	HNA	Icelandic High, Ridge C. Europe	Hoch Nordmeer-Island, antizyklonal
15	HNZ	Icelandic High, Trough C. Europe	Hoch Nordmeer-Island, zyklonal
16	HB	High over the British Isles	Hoch Britische Inseln
17	TRM	Trough over Central Europe	Trog Mitteleuropa
18	NEA	Anticyclonic North-Easterly	Nordostlage, antizyklonal
19	NEW	Cyclonic North-Easterly	Nordostlage, zyklonal
20	HFA	Scandinavian High, Ridge C. Europe	Hoch Fennoskandien, antizyklonal
21	HFZ	Scandinavian High	Hoch Fennoskandien, zyklonal
22	HNFA	Trough C. Europe High Scandinavia-Iceland	Hoch Nordmeer-Fennoskandien, antizyklonal
23	HNFZ	Ridge C. Europe High Scandinavia-Iceland	Hoch Nordmeer-Fennoskandien, zyklonal
24	SEA	Anticyclonic South-Easterly	Südostlage, antizyklonal
25	SEZ	Cyclonic South-Easterly	Südostlage, zyklonal
26	SA	Anticyclonic Southerly	Südlage, antizyklonal
27	SZ	Cyclonic Southerly	Südlage, zyklonal
28	TB	Low over the British Isles	Tief Britische Inseln
29	TRW	Trough over Western Europe	Trog Westeuropa
30	U	Transition	Übergang

[1]: Hess P., Brezowsky H. (1977): Katalog der Grosswetterlagen Europas 1881–1976, 3. verbesserte und ergänzte Aufl. Berichte des Deutschen Wetterdienstes 113. Offenbach am Main.
[2]: James, P. M. (2007): An objective classification method for Hess and Brezowsky Grosswetterlagen over Europe, Theor. Appl. Climatol., 88,17-42, doi: 10.1007/s00704-006-0239-3.