Deutsches Zentrum für
Schienenverkehrsforschung beim
Eisenbahn-Bundesamt

Heavy precipitation events and pluvial flooding

Dr. Sonja Szymczak

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Conference on Rail Resilience to Climate Change

Examples of heavy precipitation events with impact on railways

14-15 July 2021: Western Germany and adjacent countries (Netherlands, Belgium)

www.spiegel.de

End of May /Beginn of June 2024: Southern Germany and Austria

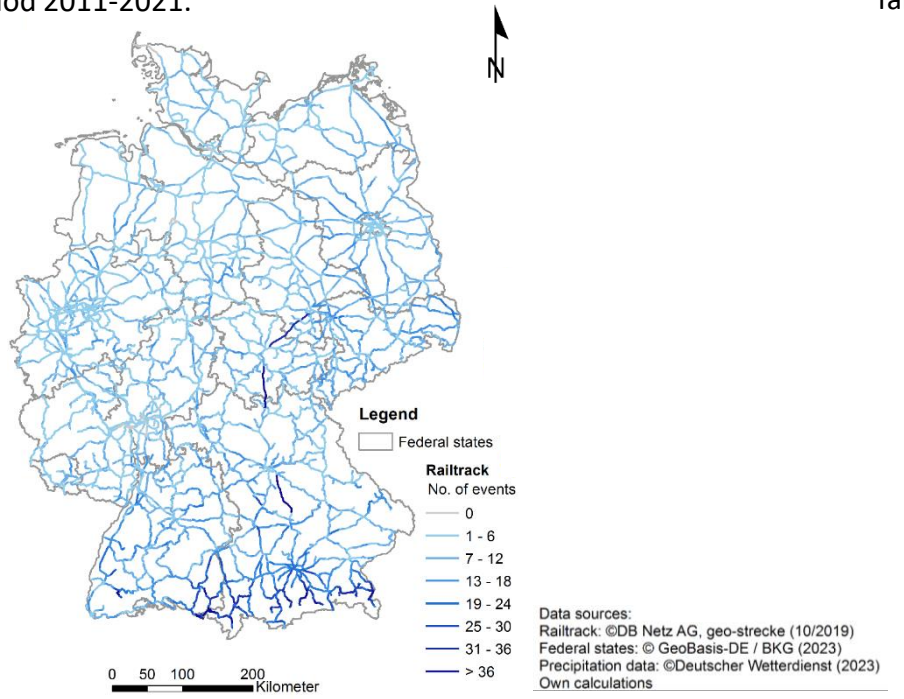
dpa/Marius Bulling

21 June 2024: Southern Switzerland / Northern Italy

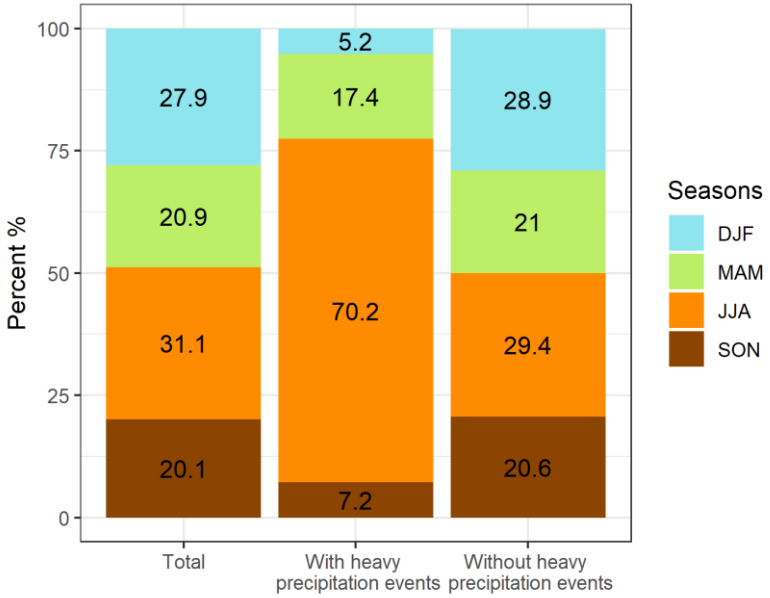
www.bahnonline.ch

Heavy precipitation events in Germany

Spatial intersection of heavy precipitation events from the CatRaRE dataset and the German rail network for the time period 2011-2021.



Seasonal distribution of natural hazard events reported for the German rail network (floods, gravitational mass movements, tree falls) with and without heavy precipitation events.



Szymczak et al. (2025)

Fluvial vs. pluvial flooding

Fluvial flooding

- along (large) rivers if discharge exceed the capacity of the riverbed
- triggered by long lasting precipitation, snow melt or a combination of different factors
- usually in larger rivers
- large-scale affected areas

- good predictability in terms of time of occurrence, spatial extent and magnitude

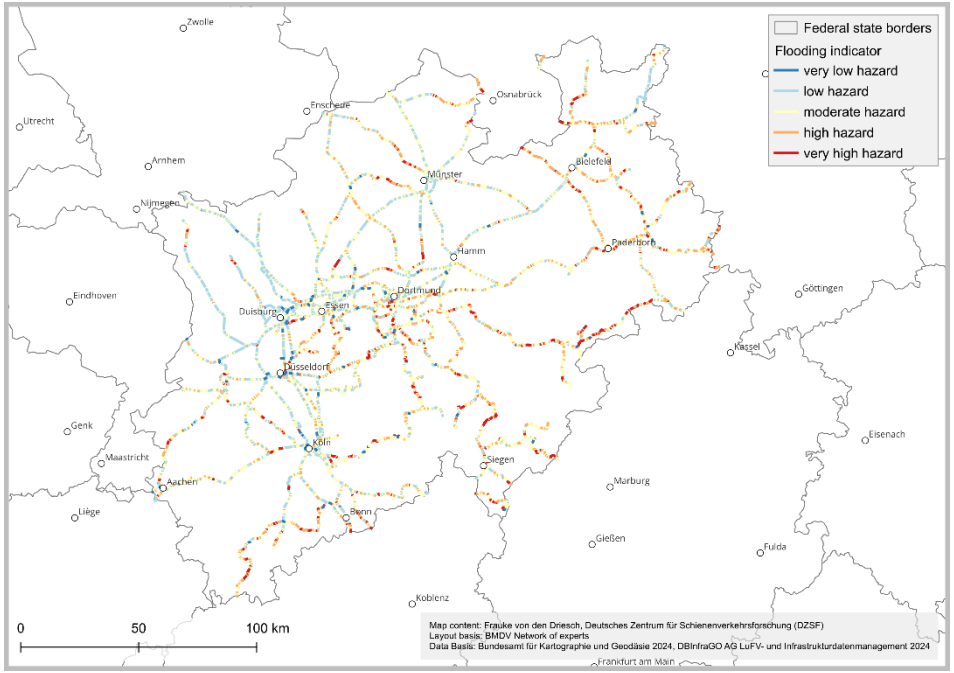
Pluvial flooding

- triggered by intense precipitation events which are not connected to rivers
- flooding can occur in areas usually not covered by water bodies (gully, hollow, depression)
- results often in flash floods in smaller rivers and creeks

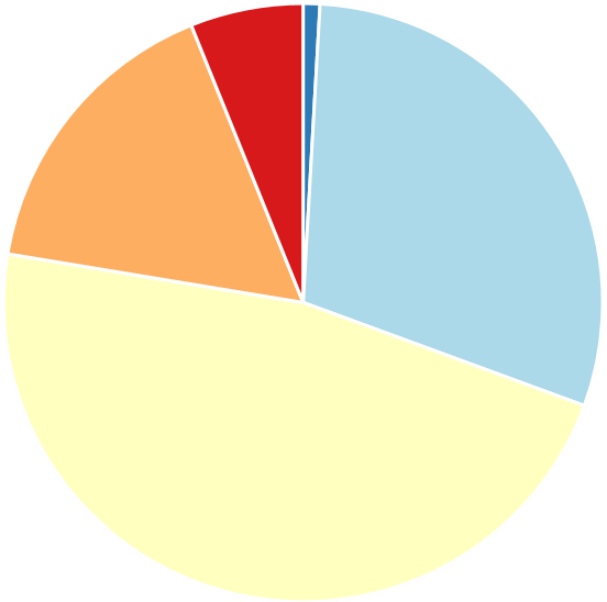
- poor predictability in terms of time of occurrence, spatial extent and magnitude

Flooding indicator

Aggregated flooding indicator for potential exposure of the Northrhine-Westphalia railway network to a 100-year heavy precipitation event (N_{100}).



Route share of the flooding indicator classes for the scenario N_{100}.



von den Driesch (in preparation)

Impacts of heavy precipitation events on railway infrastructure

Flooding of the track and adjacent infrastructure

Backwater effects, congestions at culverts and bridges

Railway embankment failure

Possible classification scheme of the damages

Top categories and first subcategories of object groups

Railway Infrastructure	**Track Superstructure**	Track, Switch/ Crossing, Protective Layer, Bedding/ Sleeper Plate
	Track Substructure	Pedestrian Crossing, Railway Overpass/ Bridge, Tunnel, Earthworks and Embankment, Sealing and Drainage System
	Geotechnical and Retaining Structures	Foundation, Rock/ Slope Protection, Retaining Structures, Miscellaneous
	Technical Infrastructure	Control, Signal and Safety Technology (CST), Telecommunications Facility, Power Supply System
	Buildings and other Structures	Railroad Crossing, Platform, Train Station, Other Structures/ Building
	Surrounding Areas	Traffic Area, Grassland, Water Body, Other Properties
	Miscellaneous	

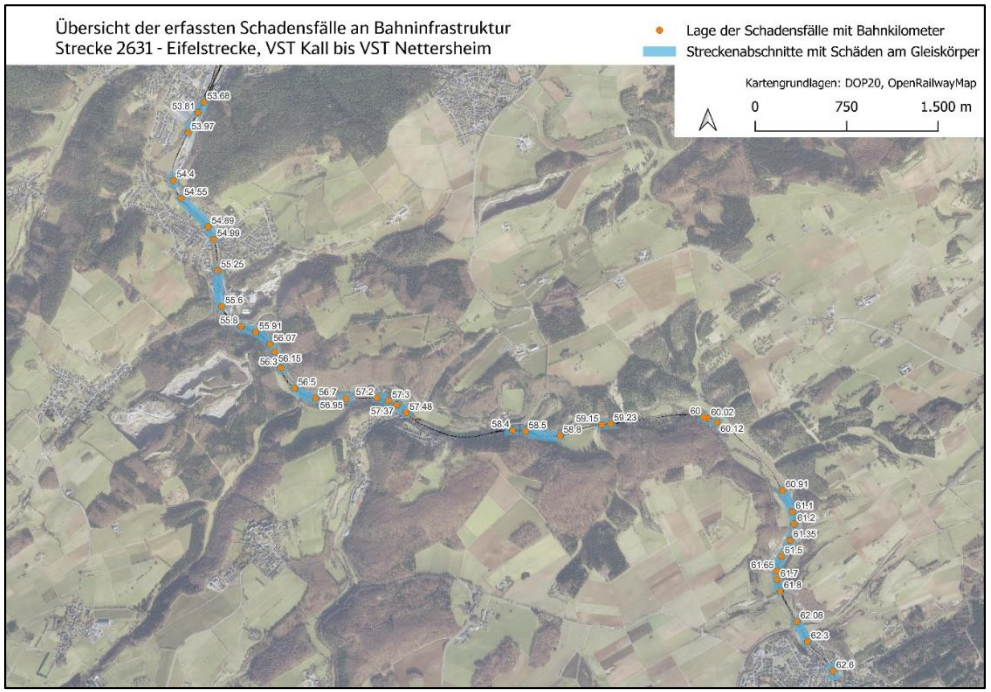
Top categories and first subcategories of damage processes

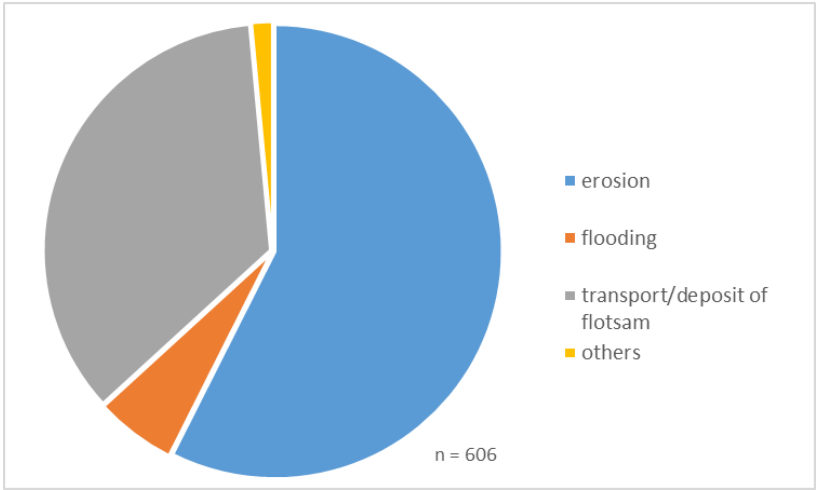
Damage Process due to Flash Flood and Flood	**Erosion**	Scouring, Mass Movement
	Flooding and Inundation	Saturation, Settling/ Sinking, Floodplain, Sweeping Off, Flooded Buildings
	Transport and Deposition of Debris	Obstruction/ Impact, Deposit
	Water Contact of Cables and Facilities	Facility Disruption, Water Contact of Cable
	Miscellaneous	Unauthorized Railroad Crossing, Lightning Strike/ Short Circuit
	Unknown	

Modified from Schriewer et al. (unpublished)

Application example of the classification scheme: Eifel route

Classification of damages to damage processes from photos and reports from a route section of the Eifel route between Kall and Nettersheim





Modified from Schriewer et al. (unpublished)

Implementation of adaptation measures

Process

Flooding of the track and adjacent infrastructure

Recommendations

Adapt dimensions of e.g. culverts to the projected climate change

Relocation of tracks or critical points

Implementation of adaptation measures

Process

Backwater effects, congestions at culverts and bridges

Recommendations

Build railway bridges more resilient to flood events: slimmer bridges structures, piers outside the riverbed

Implementation of adaptation measures

Process

Railway embankment failure

Recommendations

Relocation (if possible)
Increase the resistance with special techniques

Conclusions

- Heavy precipitation events and associated processes (flash floods, landslides) have a serious impact on railway infrastructure.
- The magnitude and frequency of heavy precipitation events is very likely to increase in future.
- The implementation of climate resilient construction methods and the development of adaptation to heavy precipitation events is of great importance.

Thank you for your attention!

Dr. Sonja Szymczak
Deutsches Zentrum für Schienenverkehrsforschung
+49 351 47931-165
SzymczakS@dzsf.bund.de

Deutsches Zentrum für Schienenverkehrsforschung
beim Eisenbahn-Bundesamt
August-Bebel-Straße 10
01219 Dresden
info@dzsf.bund.de
www.dzsf.de

Deutsches Zentrum für
Schienenverkehrsforschung beim

Eisenbahn-Bundesamt

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- Von den Driesch, F. (in preparation): Assessing heavy rainfall hazards on the German railway network: GIS-based development of a flooding indicator.