The Fifth International Conference on Railway Technology
RAILWAYS 2022
22–25 August 2022
Montpellier, France

Proceedings of the Fifth International Conference on
Railway Technology:
Research, Development and Maintenance
Edited by J. Pombo
Civil-Comp Conferences, Volume 1, Paper 33.5
Civil-Comp Press, Edinburgh, United Kingdom, 2022, doi: 10.4203/ccc.1.33.5

Climate-related analyses along the Austrian Railway Network, part I:
Standardized hazard event database

Stephan Hörbinger[1], Helene Müller[1], Hans Peter Rauch[1], Christian Rachoy[2]

[1]Institute of Soil Bioengineering and Landscape Construction, University of Natural Resources and Life Sciences, Peter-Jordan-Strasse 82, 1190 Vienna, Austria
[2]ÖBB-Infrastruktur AG, Vienna, Austria

Abstract

Extreme weather and climate events interact with landscapes and infrastructure. Especially within alpine regions natural hazards present severe threat to the vulnerability of critical infrastructure. The intersection between hazard event data und meteorological variables in the spatio-temporal domain requires a certain quality standard in both, the localisation of the events, as well as the categorization for the hazard events. This paper highlights the importance of a standardized hazard event database and the methods used for its generation. Uniform hazard data must be seen as a first step for derivation of climate indices (paper II) and hazard management plans. It generates an overview of past events, creates comparability over the whole observation period and makes outlooks for future periods possible.

Keywords: natural hazard, climate change, vulnerability, railway infrastructure, standardized database.

1 Introduction

Extreme weather and climate events interact with exposed and vulnerable human, ecological and physical systems [1]. In terms of ecological and physical dimensions, associated natural hazards (flooding, flash flood, avalanche, snow, icing, uprooting trees, mudslide or falling rocks) may lead to significant damages and service

interruptions along critical infrastructures such as railways. Especially in alpine regions the exposure and therefore the vulnerability of critical infrastructure is high [2]. The changing frequency of extreme weather events, that is caused by climate change can affect disaster risk, the spatial identification of vulnerable and exposed areas along critical infrastructures will help to structure and organize future hazard management and infrastructure planning.
To increase the resilience (safety, availability, and economy) of railway infrastructures to natural hazards, railway operators require an evidence-based catalogue of appropriate adaptation measures. In three short papers, foundations for adaptation measures to climate change are presented, which were developed within the framework of the project "clim-ect":

(1) generating a standardized and historical data basis on previous weather-induced damage events along the railway infrastructure (data processing), intersecting weather-induced damage events with meteorological data (data analysis and clustering);

(2) creating climate indices (CIs) based on objective multivariate statistics along the railway network;

(3) creation of a vegetation database and calculation of climate envelope models of railway relevant species in Austria.

This paper focuses on point (1): weather-induced damage events occurring along the Austrian railway network over the last 30 years are compiled in a standardized database that will serve as key input for the subsequent spatio-temporal intersection and climate-related analysis. The necessity of generating a standardized database of weather-induced damage events is a substantial added value for scientists and railway operators in the context of points (2) and (3), but also in an overall context of natural hazard management and infrastructure planning. The paper will reflect on key challenges in generating uniform data attributes. Specific focus will be given on space, height (both retrieved by geocoding methods within a GIS environment) and hazard information and categorization.

2 Methods

Within point (1) of the research project “clim_ect” records concerning past natural hazards that lead to interruptions of service along the 5.500 km of the Austrian Railway Network in the observation period 1990 – 2019, were transformed into a standardized hazard event database. The establishment of the database took place in four steps:

- Review and processing of case related data:
  Within the historically developed structure of hazard event records, analysis concerning all given attributes and the description of the event locations were

made. All events were merged to a preliminary non-standardized database and a consecutive event ID was introduced.

- Geocoding of all past events:
  For a standardized geocoding of all weather-induced damage events different approaches of manual mapping, depending on the structure of the input data, were used: (i) Input data based on route kilometres: mapping based on route kilometres. (ii) Input data referring to two stations describing the location of the event: geocoding at the central point between two stations. (iii) Input data referred to one specific station: location of this station was used. The mapping processes of (i) and (ii) were simplified to a resolution of 100 m.

- Classification of geocoding:
  The accuracy of the mapping process was documented in a categorized way for each event. Five classes were introduced: (i) < 1 km, (ii) 1-10 km, (iii) 10-20 km, (iv) > 20 km and (v) geocoding based on one station. The geocoordinates of each event were computed via geometry calculation in ArcMap and the altitude was extracted from a digital elevation model (DEM).

- Categorization of hazards:
  For further usage of the event data, a uniform process-based categorization was made. Spatial and temporal information was intersected with meteorological data using hazard related attributes combined with meteorological threshold values and decision tree models. Nine different categories were implemented: flooding, flash-floods, wind-storm, mudslide, falling rocks, heat, icing, avalanche and snow.

As final step, these datasets were merged with additional, original and non-standardized attributes. Additional information considered consequences of the weather-induced damage events, such as derailment, collision, obstruction, fire and other consequences, event costs and duration of service interruption.

3 Results

The analysis of historical event records showed that methods for data collection changed considerably over time. Especially several changes in hazard categorization were challenging drivers in the standardization procedure. Moreover, the documentation of event locations was adapted over the observation period. An increase of spatial resolution over the years was detected.
Based on this input data and the procedure described in Methods, 84% of all recorded events were mapped, geocoded and function with all their non-standardized attributes (information on date of the event, type, consequences, costs, interruption of service etc.) as input data for further standardization measures. The percentage of a possible geocoding is higher for events that took place recently. The years 2012, 2015, 2016, 2018 and 2019 showed a geocoding rate of more than 99%.

Regarding the spatial resolution of the localization and the resulting classification of geocoding, 64% of all geocoded events are related to class (i) < 1 km. Class (ii) 1-10 km amounts to 19% and is followed by 6% of geocoded events in class (iii) 10-20 km and 1% with the classification (iv) > 20 km. Geocoding based on one station, class (v), occurs in 9% of the events.
A further reduction of events took place due to the removal of multi-referenced events and a quality check. In total, 70% of all input datasets could be uniquely assigned to a hazardous event and were considered for further analysis. Among the nine categories described in Methods, two showed higher relevance: More than 50% of events were classified as wind-storm events and 17% were related to snow. All other categories had abundances between 1 and 7%. Within the procedure of hazard categorization, 10% of events were evaluated to be of non-meteorological or unknown cause.
In Figure 1, a timeline of occurring events split into nine event categories is plotted. With the exception of windstorm events, no clear trends in changes in the frequency of hazardous events could be observed. The cluster of wind-storm peaks in the recent past is related to the severe storm events Kyrill (2007), Paula (2008), Emma (2008), Niklas (2015), Xavier (2017) and Fabienne (2018).

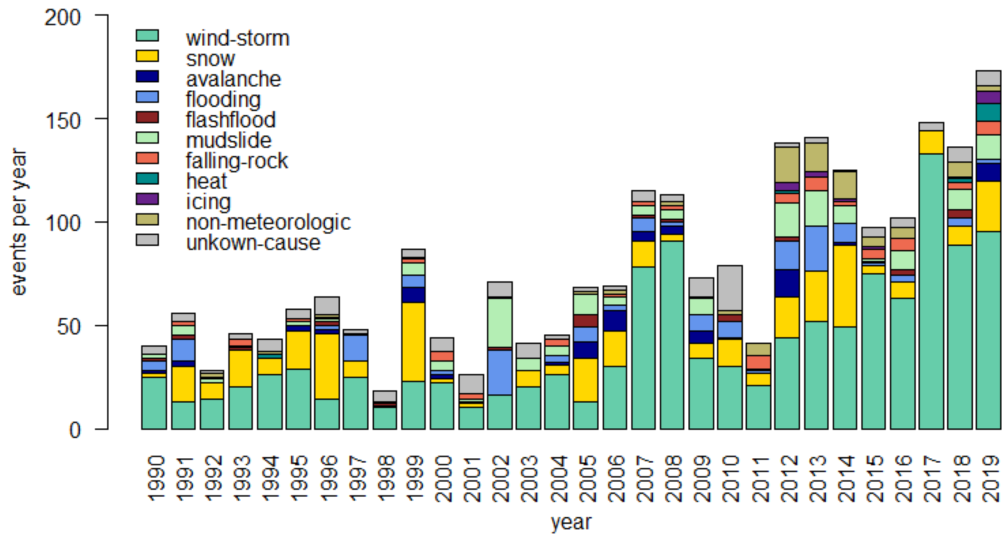

Figure 1: Timeline of weather-induced damage events along the railway system of the Austrian Federal Railways in the period of 1990 - 2019

4 Conclusions and Contributions

The transformation from historically developed hazard records into a standardized hazard event database was challenging and time-consuming. The working process included the preparation of a highly standardised data set, the maintenance of a high information value, the documentation of simplifications, assumptions and accuracy in terms of geocoding and hazard categorization. These efforts resulted in a

standardized hazard event database, which delivers vital aspects for further research within the project “clim_ect” and provides a basis for future hazard documentation.
The intersection between hazard event data und meteorological variables in the spatio-temporal domain requires a certain quality standard in both, the localisation of the events, as well as the categorization for the hazard events. Given that the raw data records were inhomogeneous in both of those issues, the quality control was of huge importance. Meteorological data (temperature, precipitation) and a digital elevation model is then used to verify and/or correct the categorization. As shown in the result section, a substantial amount of data was either inadequately categorized, or not even of meteorological cause.
The resulting categorized and geocoded hazard event database considers 70% of the original events documented by the Austrian Federal Railways from 1990 - 2019. This provides a solid, uniform basis for statistical analysis and future projections. The introduced geocoding and categorization of hazards is also applicable beyond scientific expertise and can therefore be proceeded within future hazard documentation of the Austrian Federal Railways.
This paper highlights the importance of a standardized hazard event database and the methods used for its generation. Uniform hazard data must be seen as a first step for derivation of climate indices (paper II) and hazard management plans. It generates an overview of past events, creates comparability over the whole observation period and makes outlooks for future periods possible.

Acknowledgements

This research was funded by The Austrian Research Promotion Agency (FFG). We want to thank our colleagues from “Klimawirkanalysen entlang der ÖBB-Bahnstrecken – clim_etc” project for the good collaboration and working on equal footing.

References

[1] IPCC, 2012: Managing the Risks of Extreme Events and Disasters to Advance ClimateChange Adaptation. A Special Report of Working Groups I and II of theIntergovernmental Panel on Climate Change [Field, C.B., V. Barros, T.F. Stocker,D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen,M. Tignor, and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, UK,and New York, NY, USA.

[2] T. Glade, M. Mergili, K. Sattler, F. Rudolf-Miklau, S. Mehlhorn, H. Schechtner, R.E. Pöppl, C. Matulla, G. Pistotnik, W. Lenhardt, H. Vacik, G. Laaha, C. Zangerl, R. Kaitna, M. Papathoma-Köhle, K. Hager, S. Jachs, S. Achleitner, B. Gems, S. Schneiderbauer, G. Blöschl, P. Strauss, A. Preh, A. Studeregger-Renner, J.C. Otto, A. Fischer, W. Schöner, M. Winkler, K. Kleemayr, F. Sinabell, P. Wiltsche, and V & R Unipress GmbH Verlag. ExtremA 2019 : Aktueller Wissensstand Zu Extremereignissen Alpiner Naturgefahren in Österreich. 2020. Print. Vienna University Press.