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The landslide database for Germany: Closing the gap at national level

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ABSTRACT

The Federal Republic of Germany has long been among the few European countries that lack a national landslide database. Systematic collection and inventory of landslide data still has a long research history in Germany, but one focussed on the development of databases with local or regional coverage. This has changed in recent years with the launch of a database initiative aimed at closing the data gap existing at national level.

The present paper reports on this project that is based on a landslide database which evolved over the last 15 years to a database covering large parts of Germany. A strategy of systematic retrieval, extraction, and fusion of landslide data is at the heart of the methodology, providing the basis for a database with a broad potential of application. The database offers a data pool of more than 4,200 landslide data sets with over 13,000 single data files and dates back to the 12th century. All types of landslides are covered by the database, which stores not only core attributes, but also various complementary data, including data on landslide causes, impacts, and mitigation. The current database migration to PostgreSQL/PostGIS is focused on unlocking the full scientific potential of the database, while enabling data sharing and knowledge transfer via a web GIS platform.

In this paper, the goals and the research strategy of the database project are highlighted at first, with a summary of best practices in database development providing perspective. Next, the focus is on key aspects of the methodology, which is followed by the results of three case studies in the German Central Uplands. The case study results exemplify database application in the analysis of landslide frequency and causes, impact statistics, and landslide susceptibility modeling. Using the example of these case studies, strengths and weaknesses of the database are discussed in detail. The paper concludes with a summary of the database project with regard to previous achievements and the strategic roadmap.

1. Introduction

Landslide databases are valuable sources of information for research on landslides, not only in terms of their causes, types, and processes (e.g., Pelletier et al., 1997; Guzzetti et al., 2009; Damm et al., 2010; Rossi et al., 2010; Hurst et al., 2013; Tonini et al., 2014), but also the impacts and risks associated with them (e.g., Guzzetti et al., 2003; Damm, 2006; Hilker et al., 2009; Van Den Eeckhaut et al., 2010; Neuhäuser et al., 2012; Klose et al., 2014a; Klose et al., in press). A landslide database, often also referred to as landslide inventory, is a systematic collection of information on past landslides (Hervás, 2013). Besides some few event-based inventories, most landslide databases today are of historical nature, recording landslides at local to global scale over time (e.g., Malamud et al., 2004; Galli et al., 2008; Guzzetti et al., 2012). Their content and completeness vary strongly, mainly as a function of spatial and temporal data coverage (cf. Van Den Eeckhaut and Hervás, 2012). Global inventories give a valuable overview on distribution patterns and impacts of catastrophic landslides (e.g., Kirschbaum et al., 2010; Petley, 2012; USGS, 2014), but as the majority of landslides are local events, rarely receiving worldwide attention, they include in general only a fraction of the many landslides occurring each year (cf. Spizzichino et al., 2010).

A more reliable record of past landslides is usually provided by national or regional databases. Over the past two decades, there has been considerable progress in development of national landslide databases across the globe (e.g., Glade and Crozier, 1996; Devoli et al., 2007; Osuchowski, 2008; Liu et al., 2013), especially in many European countries (Dikau et al., 1996; Van Den Eeckhaut and Hervás, 2012). Various studies have recently reported on structure, content, and application of the 22 national landslide databases existing in Europe today, including, among others, Jelínek et al. (2001), Creighton (2006), Komac et al. (2007), Trigila and Iadanza (2008), Jaedicke et al. (2009), Schweigl and Hervás (2009), Foster et al. (2012), and Mrozek et al. (2014). Most of these databases store besides data sets on core attributes (e.g., location, occurrence date, movement type), a broad spectrum of additional data, ranging from landslide processes (size, velocity, etc.) and triggering or controlling factors (e.g., geology, land use, rainfall) to impact and mitigation of landslides (damage, fatalities, costs, etc.). Data collection in these cases is primarily based on data

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mining of press or historical archives, field work, and analysis of a variety of remotely sensed data (e.g., aerial photography, satellite imagery, LiDAR DEMs) (cf. Guzzetti et al., 2012; Van Den Eeckhaut and Hervás, 2012). An increasingly important role in tracking current landslides in Europe or other parts of the world is also played by public participation via online report systems (Baum et al., 2014) or by tools to explore web and social media contents (Battistini et al., 2013).

The Federal Republic of Germany joined only recently the group of EU member states that have available a national landslide database (Damm and Klose, 2014). With the launch of a national database initiative in recent years, a significant step has been made to close the gap at national level that existed in Germany for more than 40 years. Initial efforts in landslide mapping began as early as the mid-20th century (e.g., Ackermann, 1959), with the first spatial inventory having been compiled for the Weser-Leine Uplands, NW Germany, by Schunke (1971). However, it was not until the mid-1990s that research projects such as MABIS (Mass Movements in South, West, and Central Germany, 1995–2001) were focused on targeted database development, especially at local and regional level (Dikau and Schmidt, 2001). This and more recent projects resulted in landslide databases for different regions in Germany, including Rhine Hesse (e.g., Dikau et al., 1996; Glade et al., 2001), the Bonn metropolitan area (e.g., Grunert and Hardenbicker, 1991; Hardenbicker and Grunert, 2001), Thuringia (Baum and Schmidt, 2001; Schmidt and Beyer, 2001, 2003), the Southern German scarplands (e.g., Bibus and Terhorst, 2001; Terhorst and Kreja, 2009; Jäger et al., 2013), and the Bavarian Alps (Barnikel and Becht, 2004).

Inventory of landslides for large regions is a major research task of most state geological surveys in Germany today. Landslide databases are now available for four German federal states (Bavaria, Rhineland-Palatinate, Hesse, Saxony), while two further states (Mecklenburg-Western Pomerania, Schleswig-Holstein) are maintaining a landslide database for at least parts of the state. Most of these databases are accessible online and contain geospatial information for several hundred to a few thousand landslides of modern to pre-Holocene age. Profound insight into the structure and content of these landslide databases are provided by, among others, Obst and Schütze (2010), Bock et al. (2012), and Kött et al. (2012). The research activity at state level is accompanied by some first database initiatives in related disciplines, especially in fields such as transportation planning and coastal management (e.g., Krauter et al., 2012; LKN-SH, 2014).

Among the many landslide databases in Germany that have been developed before today, there is still only one database that has a broader geographic and thematic coverage. This national landslide database for Germany is introduced in the present paper. Today, data sets on more than 4,200 landslides with over 13,000 single data files are stored in this database that covers besides the Central Uplands, several main areas of landslide distribution in Germany, including the Southern German scarplands, the Alpine Foreland, and the coasts of the North and Baltic Sea (Fig. 1). The timeframe of the database is about the past 150 to 200 years, with the oldest landslide, however, being recorded as early as 1137. The database takes account of all types of landslides, especially slides and falls, and considers landslides in both urban and rural areas.

2. Goals and research strategy of database development

The main purpose of the landslide database presented in this paper is to store and provide detailed scientific data on landslides in Germany. The database has been developed for studying different aspects of landslides, especially their processes, causes, and impacts, not only at local or regional level, but also over broader geographic areas. While having evolved to a national database in recent years, the

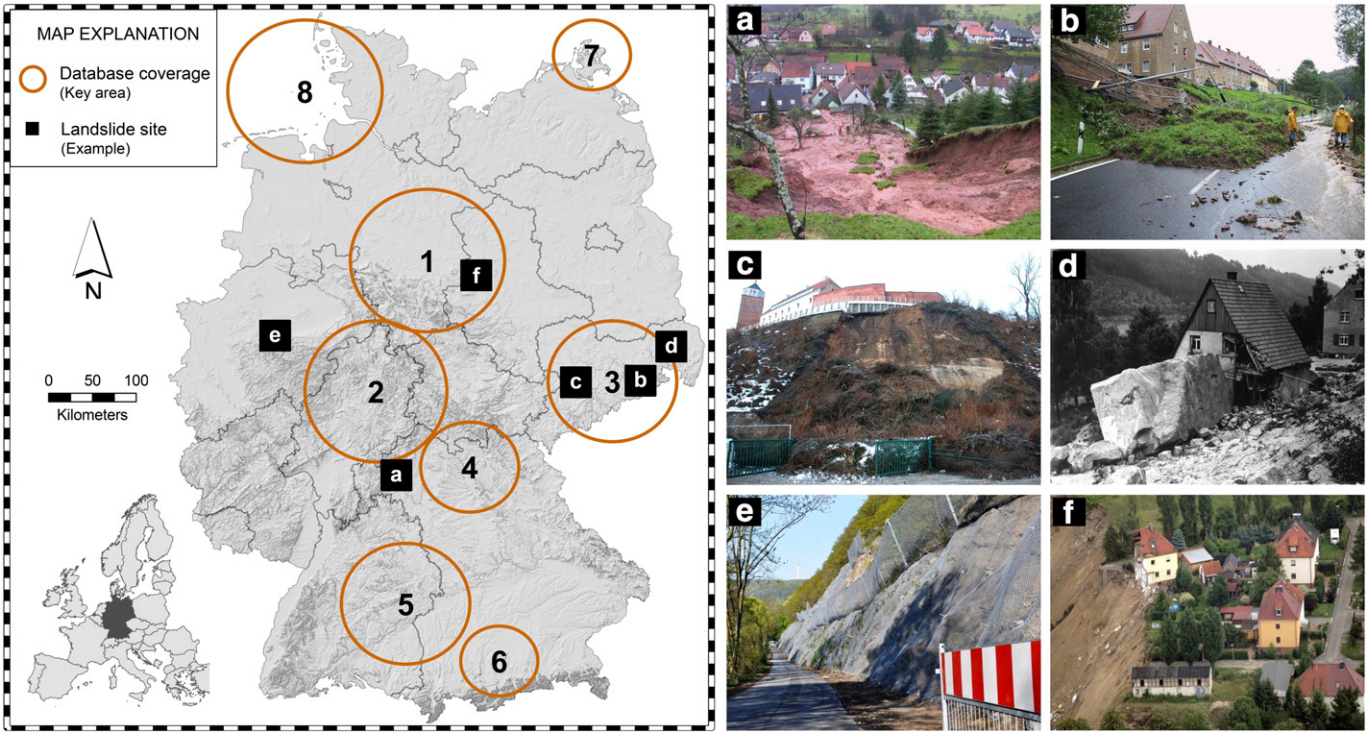

Fig. 1. Spatial coverage and key areas (1–8) of the landslide database for the Federal Republic of Germany. The figure also shows example landslide areas from different parts of Germany: (a) A year-2002 flowslide in highly saturated soil, Neustadt am Main, Bavaria (Photo by M. Nätscher and R. Stein, THW); (b) rotational slide after intense rainfall at a road cut in Glashütte, Saxony, in the year 2002 (Photo by H. Weber, Cunnersdorf, Saxony); (c) 2011 Burgberg landslide caused by the collapse of a retaining wall at a cultural heritage site in Eilenburg, Saxony (Photo: Database B. Damm); (d) historic rockfall (year 1936) near Postelwitz-Schmilka, Saxony (Courtesy of P. Dommaschk, LfULG); (e) recent landslide mitigation along the Hengsteysee-Trail in Syburg, North Rhine-Westphalia (Photo: Database B. Damm); (f) 2009 Nachterstedt landslide developed in the overburden of a coal mine in Nachterstedt, Saxony Anhalt (Photo: Database B. Damm).