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Landslide incidence in the North of Portugal: Analysis of a historical landslide database based on press releases and technical reports

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ABSTRACT

This work presents and explores the Northern Portugal Landslide Database (NPLD) for the period 1900–2010. NPLD was compiled from press releases (regional and local newspapers) and technical reports (reports by civil protection authorities and academic works); it includes 628 landslides, corresponding to 5.7 landslides per year on average. Although 50% of landslides occurred in the last 35 years of the series, the temporal distribution of landslides does not show any regular increase with time. The relationship between annual precipitation and landslide occurrence shows that reported landslides tend to be more frequent in wetter years. Moreover, landslides occur mostly in the wettest months of the year (December, January and February), which reflects the importance of rainfall in triggering slope instability. Most landslides cause damage that affects people and/or structures; 69.4% of the landslides in Northern Portugal caused 136 fatalities, 173 injured and left 460 persons homeless. More than half of the total landslides (321 landslides) led to railway or motorway closures and 49 landslides destroyed 126 buildings.

The NPLD is compared with a landslide database for the whole of Portugal constructed from a single daily national newspaper covering the same reference period. It will be demonstrated that the regional and local newspapers are more effective than the national newspaper in reporting damaging landslides in the North of Portugal. Like other documentary-based landslide inventories, the NPLD does not accurately report non-damaging landslides. Therefore, NPLD was found unsuitable to validate municipal-scale landslide susceptibility models derived from detailed geomorphology-based landslide inventories.

1. Introduction

Huge efforts to collect, record and analyze information about the occurrence and impacts of natural disasters have been made worldwide (e.g. Alcántara-Ayala, 2002; Guha-Sapir et al., 2004). The development of natural disaster databases is crucial for risk management, because it facilitates the assessment of disaster risk and vulnerability at national and sub-national scales. In addition, the analysis of social, economic and environmental impacts of disasters needs to be made available to decision-makers and integrated in land use management and civil protection policies to prevent and mitigate disaster losses.

Landslides are natural processes that may cause considerable human, economic and material losses. The typology of landslides and their magnitudes, state of activity and temporal and spatial distributions in a specific area need to be examined with a robust landslide inventory. In addition, landslide inventory maps are crucial to assess landslide susceptibility, hazard and risk and to study the evolution of landscapes dominated by mass-wasting processes (Guzzetti et al., 2012).

A landslide inventory is a data set that may include single or multiple events (Ibsen and Brunsden, 1996; Glade, 2001; van Westen et al., 2008). Landslide inventory maps can be classified as archive and geomorphological inventories according to the type of mapping (Guzzetti et al., 2000; Malamud et al., 2004). An archive inventory shows information on landslides obtained from the literature or other archive sources, whereas a geomorphological inventory is obtained with geomorphological field mapping, aerial photo interpretation, analysis of surface morphology (e.g. analysis of digital elevation models), interpretation and analysis of satellite imagery and the use of new tools to facilitate field mapping (Guzzetti et al., 2012). Because of the different nature of data sources, archive inventories comprise accurate temporal information but lack geometrical data, whereas large scale geomorphological inventories provide detailed geometrical data but often lack the precise dates of landslide activity.

Any landslide inventory may be prepared using different techniques and in some cases it is possible to use two or more techniques. According to Guzzetti et al. (2012) the selection of a technique to produce a landslide inventory map depends on the purpose of the map, the extent of the study area, the scale of base maps, the resolution and characteristics of available imagery, the skills and experience of investigators and the resources available for the work.

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Landslide databases may have different spatial resolutions associated with available sources, the scale of investigation (from local to national) and data capture methods (Galli et al., 2008; Guzzetti et al., 2012; Van Den Eeckhaut and Hervás, 2012). Landslide inventories are usually classified in three scales (Guzzetti et al., 2000, 2012): (i) small scale (<1:200,000); (ii) medium scale (1:25,000 to 1:200,000) and (iii) large scale (>1:25,000). Such scales control not just the selection of landslide inventory techniques (van Westen et al., 2008) but also the selection of a feature to represent landslides. Landslides are mapped using polygon features in large scale inventories and point features in small to medium scale inventories (Carrara et al., 2003; Guzzetti and Tonelli, 2004; Guzzetti et al., 2012). Typically, the former relates to geomorphological inventories and the latter to archive inventories.

Press archives have been commonly used to build historical landslide inventories and to assess the temporal and spatial distributions of landslides (Cuesta et al., 1999; Carrara et al., 2003; Guzzetti and Tonelli, 2004). However, press archives present some limitations (Ibsen and Brunsden, 1996; Cuesta et al., 1999): (i) many archives only record unusual, catastrophic events that caused injuries to people, damage to property, roads or structures; (ii) archives are temporal and spatially bounded; (iii) original data often lack scientific accuracy; (iv) perceptions, skills and attitudes of observers as well as semantics of descriptions introduce uncertainties; and (v) reports changes in quality and quantity over time.

This paper presents a medium scale landslide inventory made for the Northern Region of Portugal (Northern Portugal Landslide Database; NPLD) for the period 1900–2010 based on press releases and technical reports. The main objectives of the study are: (i) to present the methodology used to construct the NPLD; (ii) to characterize the temporal and spatial distributions of landslides included in the NPLD; (iii) to assess the main damage caused by the landslides; (iv) to compare the NPLD with a landslide database for the whole of Portugal (WPLD) and to discuss their temporal and spatial accuracies; and (v) to summarize the advantages and limitations of landslide databases built from press releases and technical reports in relation to their applications to land use planning.

2. The study area

The Northern Region of Portugal (Fig. 1A) has an area of 21,287 km^2 (24% of the Portugal mainland) and a population of 3,689,682 inhabitants (37% of the Portugal mainland population). The area is mainly underlain by granites and metamorphic rocks such as schist. These rocks are strongly fractured and often covered with weathered materials resulting from chemical weathering. The area includes different types of landforms: mountains in the NW area, an inner plateau in the NE area, a narrow coastal platform, tectonic depressions and the deeply incised Douro valley. The elevation (Fig. 1B) ranges from 0 m along the Atlantic Ocean to 1544 m in the NW mountains where slope angles are frequently larger than 25°.

According to Köppen–Geiger climate classification system (Köppen, 1936) the Northern Region of Portugal has two subtypes of temperate climate: temperate with dry or temperate summer (Csb) in the west and central zones of the study area, and temperate with dry or hot summer (Csa) in the inner east zone. The mean annual precipitation (*MAP*) in the North of Portugal ranges from 2000–3000 mm in the NW Mountains to 300–500 mm in the Douro river valley. Along the year, precipitation is heavier during the autumn and winter seasons and the summer drought typically lasts for three months (June, July and August). From the biogeographic point of view two regions are present: the Euro-Siberian region (Cantabrian Atlantic Province) in the west zone and in the Mediterranean region (Carpetano-Iberian-Leonean Province) in the east zone (Costa et al., 1998). Oak trees (*Quercus robur*), beech (*Fagus sylvatica*), gorse bushes and heather (*Ulex europaeuss* L., *Ulex minor*, *Erica ciliaris* and *Erica cineria*) are dominant in the west zone whereas Sclerophillous trees and shrubs such as holm oaks (*Quercus rotundifólia*), cork oaks (*Quercus suber*), mastic trees (*Pistacia lentiscus*) wild olive trees (*Olea europaea* var. *sylvestris*) and laurus trees (*Laurus nobilis*) are dominant in the east zone (Costa et al., 1998).

The study area has been affected by different types of slope movements: rock fall, debris slide, debris flow and mud flow (Ferreira and Zêzere, 1997). Debris flows have been the most destructive slope

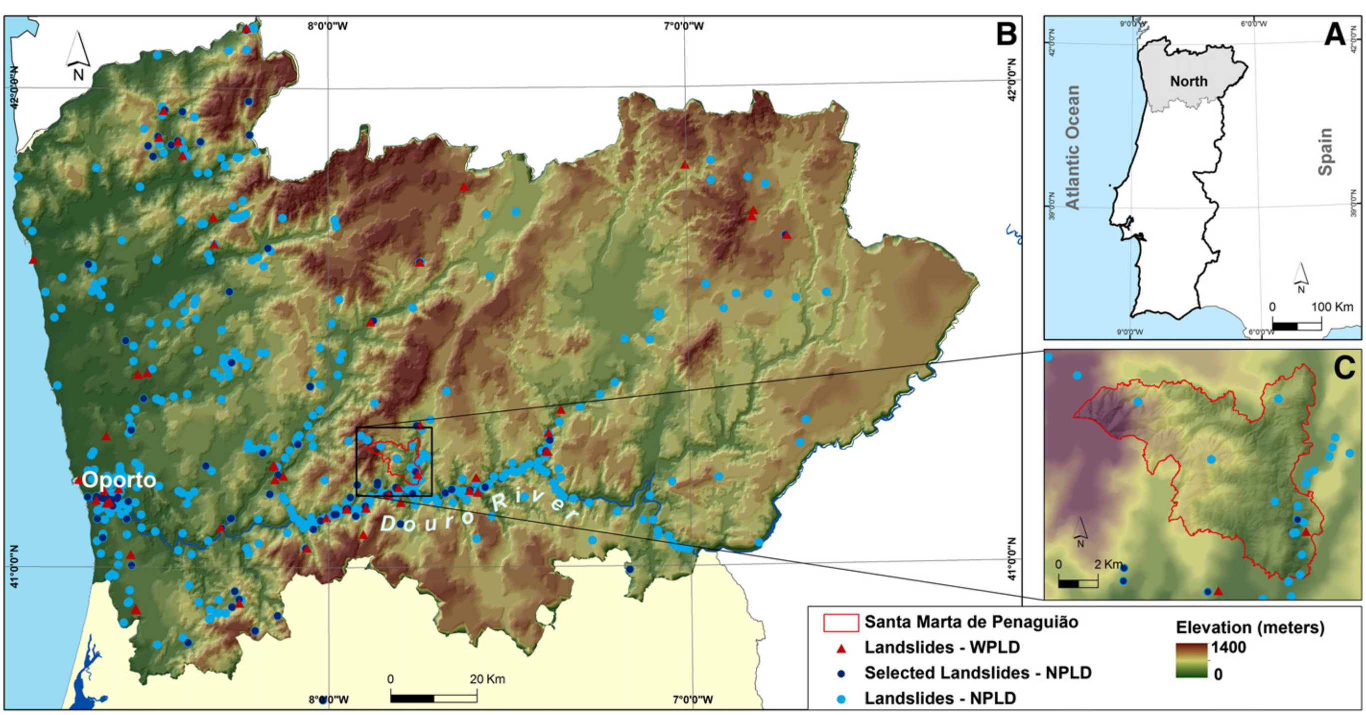

Fig. 1. Location of the North of Portugal (A) and landslide distribution in the North of Portugal (B) and in the test site of Santa Marta de Penaguião (C), according to the NPLD and the WPLD. The test site of Santa Marta de Penaguião is highlighted in red in (C).