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Evaluation of two different soil databases to assess soil erosion sensitivity with MESALES for three areas in Europe and Morocco

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A B S T R A C T

Modelling soil erosion sensitivity at continental scale provides a way to compare different countries and to identify those areas that are most seriously threatened. In this research, the MESALES model was applied to 3 large areas in Europe and Morocco, using soil data from ESDB and DSMW as well as from the newly developed e-SOTER database. Land use data were derived from the Global Land Cover 2000 database, and slope angle from the HYDRO1K DEM. The aim was to evaluate whether the e-SOTER database resulted in better assessment of soil erosion sensitivity than existing data. To judge this, expert opinion was used. The comparison of results obtained with existing data and with e-SOTER data showed considerable differences. However, it proved impossible to say which results were better. The main reasons for that were that MESALES predicts soil erosion sensitivity, which cannot be measured in the field, and that expert judgement of model results proved inconclusive. Another reason can have been that the e-SOTER database is as yet incomplete. The fact that the application of different soil databases resulted in quite different results does, however, indicate the importance of using the best available data for evaluation of soil threats. However, a current lack of options to validate soil erosion sensitivity estimates was also identified.

1. Introduction

Over the last decades there has been an increase in the application of assessment methods for soil erosion for large areas, including at the scale of the whole of Europe. This was on the one hand caused by an increased political need to have data about degradation for the whole of Europe that were created with the same method for all parts of Europe, so that different countries can be compared and the most seriously affected areas identified. Such information is needed to set up an adequate soil conservation strategy (Van Rompaey et al., 2003), such as the European Soil Strategy (European Commission, 2006). On the other hand, the advent of computer based databases and models made such continental assessments easier. While earlier evaluations (such as GLASOD (Global Assessment of Human-Induced Soil Degradation; Oldeman et al., 1991)) were mostly based on expert opinion, later evaluations have used erosion models of different complexity. For example, evaluations of soil erosion for (large parts of) Europe were done using CORINE (Coordination of Information on the Environment; CORINE, 1992), USLE (Universal Soil Loss Equation; Van der Knijff et al., 2000), MESALES (Modèle d'Evaluation Spatiale de l'ALéa Erosion des Sols — Regional Modelling of Soil Erosion Risk; Grimm et al., 2002), PESERA (Pan European Soil Erosion Assessment; Kirkby et al., 2008), using modelling based on erosion plot data (Cerdan et al., 2010) and based on soil data collection within the EIONET network (European Environment Information and Observation Network; Panagos et al., 2014). Most of these applications have used 1 km pixels.

However, a major difficulty is to obtain the input data for the models at 1 km resolution. To overcome this problem, data are often assumed to be homogeneous for areas that are significantly larger than the 1 km resolution of pixels, such as for Soil Mapping Units (SMUs). As a result, the way in which such homogeneous units are defined could well influence the outcome of a model considerably.

One of the most widely used soil databases in Europe is the European Soil Database (ESDB), which is maintained by, and freely available from, the European Soil Data Centre (ESDAC, Panagos et al., 2012). In this database, the spatial units to which soil data apply are derived from country-based soil maps. This might result in limitations for some applications that use soil data because units based solely on soil type might not be the most suitable units for all applications, and because different countries have applied different working methods to derive their soil map units (King et al., 1994). Therefore, the e-SOTER project developed a new set of rules to derive spatial units, based not only on soil data, but also on terrain data (Dobos et al., 2010a,b).

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As part of the e-SOTER project, it was evaluated how the new e-SOTER database could be used to evaluate threats to soils that exist in Europe (Eckelmann et al., 2006). Therefore it was decided to apply both databases for several models that deal with threats to soils. The selected models were MESALES (Le Bissonnais et al., 2002) and two models developed by the German Federal Institute for Geosciences and Natural Resources BGR (SGD and BGR, 2000) for soil erosion by water, and the method developed by Jones et al. (2003) for soil compaction. In this paper, the results of the evaluation for MESALES are described, while the results for the BGR methods and for the Jones et al. (2003) method are described by Hessel et al. (2012). MESALES is a decision tree model applicable for large areas, and expert opinion was used to develop the decision tree rules. MESALES can be used to either simulate soil erosion sensitivity or soil erosion risk. Soil erosion sensitivity is the intrinsic susceptibility that a certain location has for soil erosion, and is determined by the combination of land use, soil type and land form. Soil erosion risk is also determined by these factors, but in addition takes rainfall into account (Le Bissonnais et al., 2002; Nigel and Rughooputh, 2010). As rainfall is largely out of control of humans, the easiest way to achieve reduction in erosion is through management of land use, soil and land form, which can all be modified and managed by humans. Hence, soil erosion sensitivity provides information that is crucial to decide where to implement measures against erosion.

The aims of this paper are to:

- apply the MESALES method using existing (legacy) data (ESBD and the Digital Soil Map of the World; DSMW) on the one hand and the e-SOTER database on the other hand and
- evaluate whether the use of legacy data or e-SOTER resulted in a better assessment of sensitivity to soil erosion.

2. Methods

The MESALES model was applied to the ESDB and to the e-SOTER database for two areas (windows) in Europe, one located in Western Europe, covering part of western France and part of eastern Great Britain, and the other in Central Europe, covering parts of Germany, Slovakia, Hungary, and almost the whole of the Czech republic. In addition, one area in Morocco was also modelled using the Digital Soil Map of the World (DSMW, FAO, 2007). The location of all three windows is indicated in Fig. 3. Fig. 1 provides a flowchart of the methodology that was used. As can be seen from this chart, the work was divided in a test phase and an application phase. The chart also shows that for each window two databases were compared, namely ESDB and e-SOTER for the European windows and DSMW and e-SOTER for the Moroccan window. For each window, both databases were also compared with an expert evaluation. The following sections describe the MESALES model, the databases that were used and the methodology used for testing, application and comparison.

2.1. MESALES

The MESALES method is based on current expert knowledge and available data for the assessment of soil erosion risk at the European scale, and was described by Le Bissonnais et al. (2002), Grimm et al. (2002) and JRC (2014). The model is based on the assumption that soil erosion occurs when water that cannot infiltrate into the soil becomes surface runoff and moves downslope; thus the erosion process that is considered is erosion by overland flow. Land cover and crust formation on cultivated soils were considered as key factors influencing runoff and erosion. The model results in a qualitative assessment of soil erosion sensitivity or risk in 5 ordinal classes: very low, low, moderate, high and very high. In this study, MESALES was used to assess soil erosion sensitivity, for two main reasons. First, as the aim of the study was to evaluate the effect of using alternative soil databases, as few additional parameters as possible were used and second it is difficult to obtain rainfall (erosivity) data at sufficient spatial resolution.

The MESALES approach is different from other methods based on expert judgement, such as GLASOD, because for MESALES, expert knowledge was only used to develop the decision rules which are used to calculate erosion sensitivity, and not to assign erosion sensitivity classes directly to units on the map. In MESALES, classes for mapping units were assigned based on a modelling approach using a hierarchical decision tree classification. Decision tree methods have been used to assess soil erosion risk in various places around the World, such as Lebanon (Bou Kheir et al., 2006), Mauritius (Nigel and Rughooputh, 2010) and Mexico (Geissen et al., 2007), because they are simple and versatile, can deal with heterogeneous data and variable grid size, and do not require data that cannot be obtained at regional to national scale.

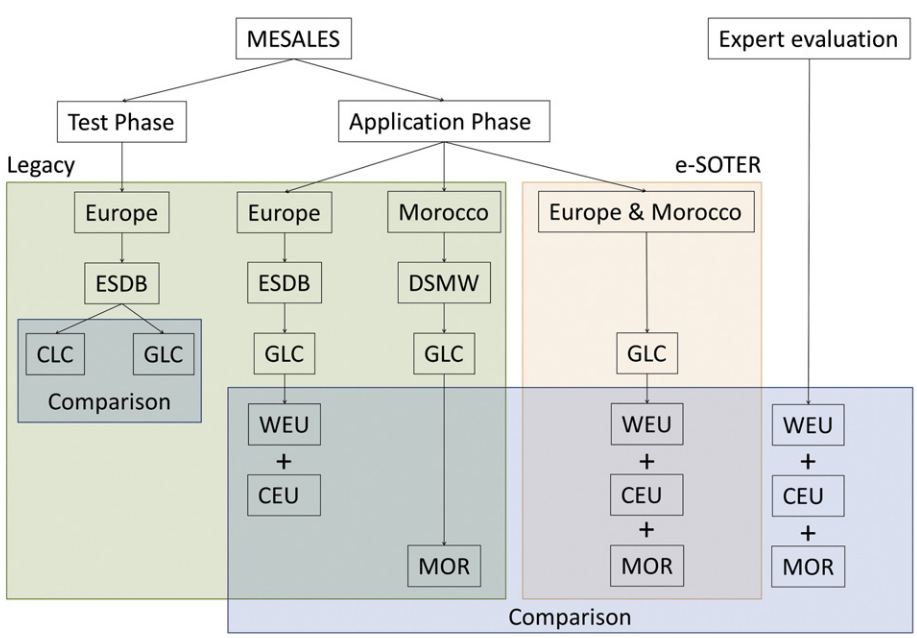

Fig. 1. Flowchart of the methodology followed in this paper.