Science of the Total Environment 442 (2013) 235–246

Contents lists available at SciVerse ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Estimating the soil organic carbon content for European NUTS2 regions based on LUCAS data collection

Panos Panagos *, Cristiano Ballabio, Yusuf Yigini, Martha B. Dunbar

Joint Research Centre of the European Commission, Institute for Environment and Sustainability, E. Fermi 2749, IT-21027 Ispra (VA), Italy

HIGHLIGHTS

► Soil organic carbon data were collected through LUCAS survey.
► The surveyed soil organic carbon data was compared to modeled data.
► The comparison between modeled and surveyed data follows patterns depending on European regions.

ARTICLE INFO

Article history:
Received 21 August 2012
Received in revised form 1 October 2012
Accepted 1 October 2012
Available online 22 November 2012

Keywords:
Organic carbon
Soil
LUCAS
NUTS2
Data collection
Europe

ABSTRACT

Under the European Union Thematic Strategy for Soil Protection, the European Commission Directorate-General for the Environment and the European Environmental Agency (EEA) identified a decline in soil organic carbon and soil losses by erosion as priorities for the collection of policy relevant soil data at European scale. Moreover, the estimation of soil organic carbon content is of crucial importance for soil protection and for climate change mitigation strategies.

Soil organic carbon is one of the attributes of the recently developed LUCAS soil database. The request for data on soil organic carbon and other soil attributes arose from an on-going debate about efforts to establish harmonized datasets for all EU countries with data on soil threats in order to support modeling activities and display variations in these soil conditions across Europe.

In 2009, the European Commission's Joint Research Centre conducted the LUCAS soil survey, sampling ca. 20,000 points across 23 EU member states. This article describes the results obtained from analyzing the soil organic carbon data in the LUCAS soil database. The collected data were compared with the modeled European topsoil organic carbon content data developed at the JRC. The best fitted comparison was performed at NUTS2 level and showed underestimation of modeled data in southern Europe and overestimation in the new central eastern member states. There is a good correlation in certain regions for countries such as the United Kingdom, Slovenia, Italy, Ireland, and France. Here we assess the feasibility of producing comparable estimates of the soil organic carbon content at NUTS2 regional level for the European Union (EU27) and draw a comparison with existing modeled data. In addition to the data analysis, we suggest how the modeled data can be improved in future updates with better calibration of the model.

© 2012 Elsevier B.V. All rights reserved.

1. Introduction

The decline in soil organic carbon (SOC) is recognized as one of the eight (8) soil threats identified in the European Union Thematic Strategy for Soil Protection (COM (2006)231 final) (EC, 2006). One of the key goals of the strategy is to maintain and enhance SOC levels. A recent policy document known as the Roadmap to a Resource Efficient Europe (COM(2011) 571 final) (EC, 2011), which is one of the building blocks of Europe 2020 strategy, sets the objective of increasing current levels of soil organic carbon in areas by 2020 where less than 2% of SOC has been detected.

SOC levels have direct impacts on biophysical processes such as erosion, soil nutrient cycling, and greenhouse gas fluxes (Batjes, 2002). The benefits of soil conservation for mitigating climate change (increased carbon sequestration) should not be underestimated (Kuhlman et al., 2010). In fact, the quantification of SOC in Europe is an important factor in the preparation of climate change and agricultural policies (Schils et al., 2008). Furthermore, at a global scale European SOC data are of relevance since "soils" is among the mandatory carbon pools to be reported on under the "Land Use, Land-Use Change and Forestry" (LULUCF) activities listed in articles 3.3 and 3.4 of the Kyoto Protocol (UNFCCC, 1998).

In many European countries, the SOC content is known locally from national/regional/local soil surveys conducted by soil scientists. Non-spatial SOC at European scale has been estimated based on data

* Corresponding author.
E-mail address: panos.panagos@jrc.ec.europa.eu (P. Panagos).

0048-9697/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.scitotenv.2012.10.017

from existing soil monitoring networks (Saby et al., 2008a, 2008b), using a limited number of monitoring sites per country. The density of the sample sites varies considerably between countries and the estimates rely on various assumptions, such as the distribution of sample sites.

In this paper, we compare the SOC data from the LUCAS 2009 campaign (Palmieri et al., 2011) with the modeled OCTOP data (Jones, et al., 2005). Since the LUCAS soil survey was conducted only in 23 EU member states, the comparison will be carried out accordingly. While the OCTOP data provide a good overall picture in Europe, they could be improved through the integration of SOC data soil survey campaigns that better reflect the actual site-specific situation of topsoil SOC in each country.

The objectives of this paper are to demonstrate how the LUCAS soil data collection allows us to:

- improve the estimates of SOC content (%) at European scale through regional analyses;
- compare the ground measurements with the model estimates and, consequently, improve the current pan-European picture of SOC content; and
- minimize the uncertainty of SOC estimation at the NUTS2 level.

It is not within the scope of this paper to assess changes in SOC resulting from land use changes. Moreover, we will not explore the situation in individual regions in order to avoid the large site-specific differences. It is important to note that our approach is based on a SOC comparison at European scale in order to better reflect the current overall continent-wide picture.

2. Data and methods

2.1. NUTS

NUTS (Nomenclature of the Territorial Units for Statistics) is a hierarchical system that divides the economic territory of the EU into different levels for the purpose of regional statistics. Eurostat, the statistical office of the European Commission, distinguishes between three sub-national regional aggregates: NUTS1 (large regions with a population of 3–7 million inhabitants); NUTS2 (groups of counties and unitary authorities with a population of 0.8–3 million inhabitants); and NUTS3 regions (counties of 150–800 thousand inhabitants) (Becker et al., 2010).

NUTS2 represents basic regions for the application of regional policies. The term 'region' is used to describe this level of geography for convenience in the rest of this article. In the 27 EU member states there are 285 NUTS2 administrative units, with areas ranging from 13 km^2 to 165,075 km^2.

2.2. LUCAS database

LUCAS is an in-situ survey, which means that the data are gathered through direct field observations. The aim of the LUCAS survey is to gather fully harmonized data on land use/cover and their changes over time in the EU 27. In the LUCAS (2009) survey, 265,000 geo-referenced points were visited by more than 500 field surveyors. The survey points were selected from a standard 2 km × 2 km grid based on stratification information provided by Martino and Fritz (2008).

For the first time the LUCAS (2009) survey included a soil module. Top soil samples (0–30 cm) were collected from 10% of the survey points, thus providing approximately 20,000 soil samples. LUCAS soil samples were taken from all land use/land cover types; however, the survey focused mainly on agricultural areas. Each soil sample was taken from the topsoil zone (top 30 cm) with a weight of ca. 0.5 kg. The objective of the soil module was to improve the availability of harmonized data on soil parameters in Europe. The 20,000 LUCAS soil samples were analyzed in a single ISO-certified laboratory that used harmonized chemical and physical analytical methods (ISO standards, or their equivalent) in order to obtain a coherent and harmonized dataset with pan-European coverage. The analysis results formed the LUCAS soil database, including, inter alia, SOC in top soils (0–30 cm) expressed in g/kg.

In order to be representative of individual land uses, the LUCAS points were stratified accordingly. Moreover, the points above 1000 m in altitude were excluded with few exceptions.

The LUCAS SOC data were aggregated in NUTS2 spatial units, which correspond to the European regional level. The aggregation into NUTS2 units is directed at the implementation of various policies, such as soil protection measures. For the 23 member states subjected to the analysis, there are 248 NUTS2 regions. The LUCAS survey was carried out in 236 regions ranging from 387 km^2 (Bremen DE050) where 1 point was sampled to 165,075 km^2 (Övre Norrland SE33) and 536 points were sampled. A trial to perform the aggregation at NUTS3 level was insignificant as 42% (424 out of 1027) of the NUTS3 provinces have less than 8 samples. In comparison, at the NUTS2 level only 20 regions (8%) have less than 8 samples.

The average density of LUCAS soil points is ca. 1 sample every 199 km^2, which corresponds ca. to a 1 grid cell of 14 km × 14 km. In addition, the median of the LUCAS soil points density dataset is approximately 200 km^2, meaning that 50% of the regions have a reasonable point density. This can be considered a first indicator for the confidence level of the LUCAS soil sampling campaign. As can be seen in Fig. 1, in southern Europe the soil samples were more sparsely distributed than in France and central European countries.

An additional indicator of representativeness of LUCAS soil point data is the elevation comparison. The Digital Elevation Model (DEM) at 100 meter resolution was used to classify the percentage of the areas according to elevation in the 23 member states. The comparison in Table 1 demonstrates that LUCAS soil point data are representative of general elevation in the studied countries.

The only non-representative class is the elevation above 1000 m where LUCAS points were rarely sampled.

2.3. Organic carbon content (%) in topsoils dataset

The current (modeled) dataset of the SOC distribution available at European scale (known as OCTOP; Jones et al., 2005) is used both by EU policy makers as input for developing strategies for soil protection and by scientific communities, such as in climate change modeling, biodiversity, agriculture, and food security.

The dataset was created by combining a pedotransfer rules system with detailed thematic input data layers. The effects of vegetation, land use, soils, and temperature were taken into account in the calculations of SOC. The method used to generate the OCTOP estimates is based on the pedotransfer rule (PTR) 21 of the European Soil Database (ESDB) (King et al., 1994), which was developed by Van Ranst et al. (1995). The SOC output values are defined through a series of conditions using a variety of ESDB key soil attributes (soil type, texture, and land use). The OCTOP data were validated using measured SOC data from more than 12,000 profiles in England/Wales and Italy (Bellamy et al., 2005).

The dataset is available in 1 km × 1 km grid spacing and can be downloaded free of charge from the European Soil Data Centre (Panagos et al., 2012). According to ESDAC statistics the majority of intended use of OCTOP data is for research (71%) and for policy purposes (11%). While the OCTOP data provide a good overall picture in Europe, they could be improved through the integration of SOC data from soil sampling campaigns, such as LUCAS, which reflect the actual situation of topsoil SOC in each country.

2.4. EIONET-SOIL data

In 2010, the JRC, which hosts the European Soil Data Centre (ESDAC), collected SOC and soil erosion data in the EU by means of

Download English Version:

https://daneshyari.com/en/article/4428996

Download Persian Version:

https://daneshyari.com/article/4428996

Daneshyari.com