Project:
GEOCARBON

Project full title:
Operational Global Carbon Observing System

European Commission - FP7
Collaborative Project (large scale integrating project) - for specific cooperation actions (SICA) dedicated to international cooperation partner countries
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1. Introduction

1.1 Short summary

The ability to predict the effects of environment (e.g. climate and atmospheric composition) and land use change on Soil Organic Carbon (SOC) dynamics is of outmost importance in formulating environmental and agricultural policies. In particular analysing the extent of additional carbon that can be sequestered in soil at global level can provide an indication for detecting gap hotspots, to be intended as areas to be prioritized via additional sub-regional to local scale studies, so to better support planning and policy makers to provide environmental services.
The work performed in this package integrates and optimizes data that are used to improve observations and create an improved baseline global database on carbon stocks. The activities build upon existing observations and datasets to elaborate, harmonize and synthetize information to derive global datasets related to the global carbon cycle and its dynamics. The main activities include:

1) Collection of the existing datasets on soil profiles
2) Screening and validation of the available data for their use in the assessment and/or validation
3) Harmonization of the existing soil profiles using pedo-transfer functions
4) Spatialization of the profiles data to create the database
5) Preparation of the preliminary database

6) Application of eventual calibration and preparation of the final global SOC database at 30 arc-second resolution
7) Preparation of the final report and metadata records.

1.2 Rationale for this deliverable
This deliverable is important to provide baseline assessment to improve observations and create an improved baseline global database on carbon stocks. This deliverable is addressing the need for improved and consistent information on global databases related to the soil carbon database, and contributes directly in harmonizing and synthetizing information to derive global datasets related to the global carbon cycle and its dynamics.

1.3Problems encountered and envisaged solutions
Funding is one of the main constrains to perform all the activities which could contribute to improve the quality of the database. FAO has been mobilizing limited internal funds from its activities to ensure that the delivery requirements are met.

2 Full description

Task 1. Create the Soil organic carbon stock profiles database
The new Global Soil Organic Carbon (SOC) stock database is a relational database compiled using MS Access. The database includes data on: a) soil classification and site data; b) source of data; c) SOC stock for the 0-30 and 30-100 cm depth of mineral soil, and d) information on the vegetation and/or land use to which each single profile refers.
The data merged for the creation of this database were found after an in depth research to individuate the available soil organic carbon databases. Five major known databases were selected. The World Soil Information (ISRIC) provided the main sources of information, thanks to the version 3.1 of the WISE3 database, the most updated version of the database already used by Batjes (1996) for quantifying the global carbon budget. Besides, several SOil and TERrain (SOTER; van Engelen and Wen 1995) databases for different countries were also obtained from ISRIC: China; Senegal, Gambia, South Africa, Upper Tana (Kenya), Congo, Burundi, Rwanda, Cuba, Argentina and Tunisia. Another important source of data were the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) and the United States Geological Service (USGS) databases (Harden 2008), obtained through the National Soil Carbon Network (NSCN 2011), storing mostly data about soils of the United States, Alaska included (Soil Survey Staff 2011). In addition, a database specific for European soils, SPADE M version 2 (Hiederer et al. 2006), was obtained from the European Soil Bureau. Then, from the International Institute for Applied Systems Analysis (IIASA) the “Land Resources of Russia” was obtained, a database specific for Russian soils (Stolbovoy et al. 2002). All of these databases were already used in many publications (Jobbagy and Jackson 2000; Batjes and Dijkshoorn 1999; Batjes 1997) and widely accepted in the scientific community.
This work was enriched with the addition of data never published before such those contained in the database provided by the University of Tuscia, related to soil profiles mostly located in Europe (Spain, Italy, Germany, Belgium, Netherlands, Denmark, Sweden) and in a minor part in central and western Africa (Ghana and Gabon), and FAO datasets including profiles North and East Africa (Libia, Somalia) and South America (Bolivia). These two latter databases represent about 11% (1’614 profiles) of the total of 14’212 profiles used (Table1).
All the available databases used in this work, with the information about useful profiles after checking their redundancy and validity for calculating the SOC stock, while the distribution of the profiles in the different continents is showed in the Figure 1 below.

Source	Profiles
WISE3	5’037
USDA-NRCS	4’786
SOTER*	2’123
Univ. Tuscia DB	1’497
SPADE	405
Russia	247
FAO profiles	117
Total	**14’212**

*= includes SOTER China (1’410 profiles), Tunisia (40 profiles), Cuba (1 profile), Argentina (5 profiles), Burundi-Congo-Rwanda (35 profiles), Upper Tana (59 profiles), South Africa (569 profiles), Senegal-Gambia (4 profiles)

Table1

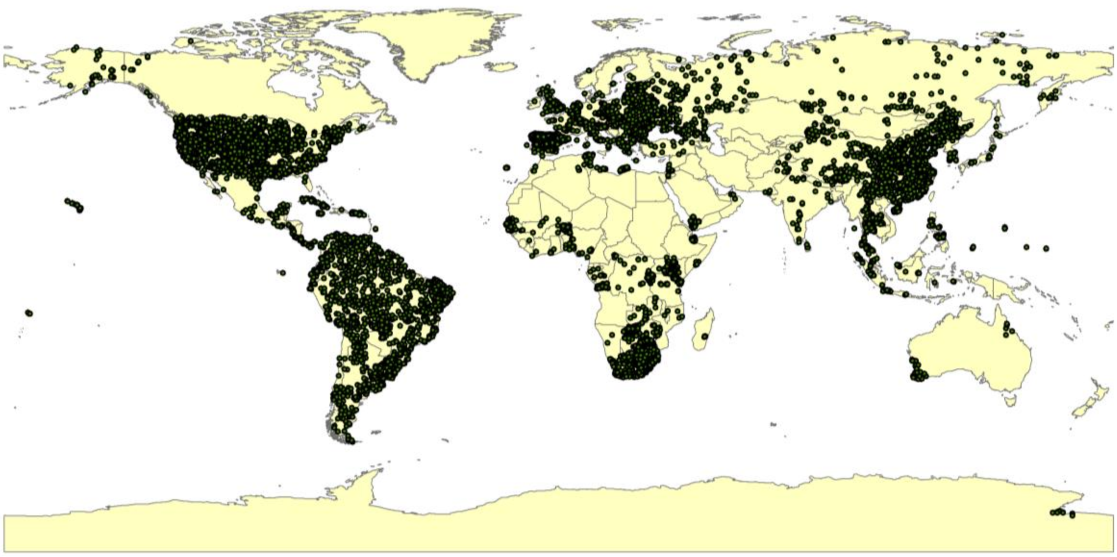

Figure 1: Map showing the distribution of all profiles used to calculate SOC stock.

Strict criteria have been defined for accepting profiles into the database of actual SOC stock: a) completeness and apparent reliability of data; b) traceability of source of data; c) classifiable in the original and revised FAO or Soil Taxonomy classification; d) geo-referencing. Upon their entry into our database, the data have been screened for inconsistencies using visual and automated procedures.

The analytical methods used to determine the parameters necessary to calculate the SOC stock, and present in the different databases are fully comparable. The comparability of the USDA-NRCS and of the ISRIC Soil Information System (ISIS) databases has been already documented (Vogel 1994), while for the new data that were never published before the same criteria for data selection as described in the WISE3 report were used (Batjes 2008).

$$SOC \text{ stock } (\text{Mg ha}^{-1}) = \sum_{horizon=1}^{horizon=n} \left[OC \times BD \times Depth \times \left(1 - \left(\frac{frag}{100}\right)\right) \right] \quad [1]$$

where SOC is soil C content per unit area (Mg C ha^{-1}), *OC* is the C concentration in soil sample (kg C kg^{-1} soil), the *BD* is the soil bulk density of the fine earth expressed as (Mg m^{-3}), *Depth* is the thickness of the horizon within the considered section (cm) and *frag* is the percent of rock fragments.

The SOC stocks were calculated according to equation 1 for all the horizons of the profiles. Then taking into account the thickness of the horizons, the SOC stocks were normalized for the 0-30 and

30-100 cm depths. All the databases were merged together so to obtain a single database where the SOC stock from the 0-30 and 30-100 cm depths, is connected with the geographic coordinates, the soil classification, the vegetation and the land use.

Task 2. Create the Soil organic carbon stock spatial database

After calculating the SOC stock related to actual conditions (assuming with a good approximation a covered reference period from 70s' to 2000s' according to the profile dating), three attributes have considered to examine the spatial distribution of SOC for topsoil (0-30 cm) and subsoil (30-100 cm): i) the type of soil, which represents the background for C content; ii) the climate characterization of the areas, which is a "natural" driver of physical (water, nutrients) processes involving soil; and iii) the land use/cover (LUC), which is a proxy of the human impacts in soil dynamics.

Homogeneous Land Units (HLUs) have been extracted (at 5 arc-minute spatial resolution) by spatially combining 5 macro-categories of climate – (A: Tropical/megathermal climate, B: Dry (arid and semiarid) climate, C: Temperate/mesothermal climate, D: Continental/microthermal climate, E: Polar climate (highlands/mountains/alpine), 4 macro-classes of LUC (Agriculture, Forestry (forest, woodlands, plantations), Grazing (grassland, savannas, tundra, steppe), Unused (Desert/Ice)and 31 soil types, all referring to the actual (1976-2000) time frame, taken as representative of soil sampling, topsoil and subsoil stock statistics (mean, standard deviation etc.) have been calculated inside each HLU from profile data.

Five classes, based on actual period, have been differentiated for topsoil and subsoil according to their distribution, as below reported.

<u>Subsoil</u>:

- Very low (<10 Mg/ha);
- Low (10-30 Mg/ha);
- Medium (30-50 Mg/ha);
- High (50-70 Mg/ha);
- Very high (>70 Mg/ha).

<u>Topsoil</u>:

- Very low (<15 Mg/ha);
- Low (15-40 Mg/ha);
- Medium (40-70 Mg/ha);
- High (70-140 Mg/ha);
- Very high (>140 Mg/ha).

The various combination of climate, LUC and soil are represented by a largely different number of profiles, so maps in show a standardized index 0-1 (here called FREQUENCY INDEX), where 0 stands for HLUs without profiles, while 1 stands for the LHU with the highest number of profiles.

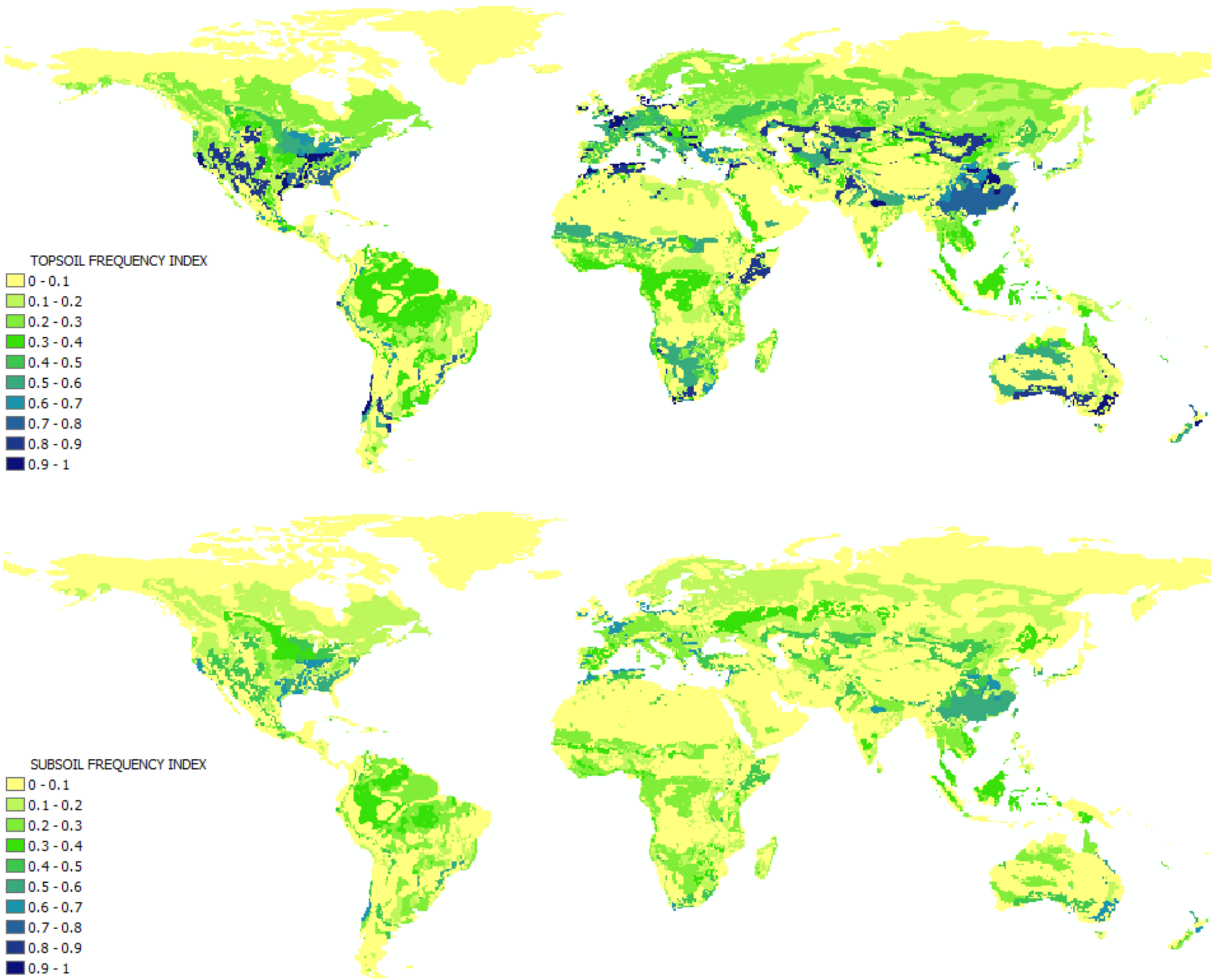

Figure 2: Topsoil (upper) and subsoil (lower) frequency index as spatialized across combinations of HLUs for the actual period.

Conclusions

The preliminary database provided by FAO and its partners as part of the work-package delivery on the soil organic carbon and properties for top- and sub-soil is an important global product which contributes to the improved baseline global database on carbon stocks. It is also an important database that provides core information related to the global carbon cycle and its dynamics.

The outputs of this work package can be further enhanced using additional datasets such as the new Global Land Cover – Share database that is being prepared for public release by FAO, new datasets on soil profiles and properties that are expected to be available through the Global Soil Partnerships which would contribute to prepare the final database at 30 arc-second resolution.

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