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ISRIC-WISE GLOBAL DATA SET OF DERIVED SOIL PROPERTIES ON A 0.5 BY 0.5 DEGREE GRID

(Version 2.0)

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INTERNATIONAL SOIL REFERENCE AND INFORMATION CENTRE

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Abstract

Selected spatial soil data layers on a 0.5 by 0.5 degree global grid are presented. They have been derived from soil geographic and attribute data held in ISRIC's WISE-database, version 2.0. The data sets include: (1) depth to physically limiting layer; (2) profile available water capacity (-10 to –1500 kPa); (3) soil drainage class; (4) cation exchange capacity (CEC_{soil}); (5) cation exchange capacity of clay fraction, corrected for the contribution of organic matter (CEC_{clay}) (6) soil reaction (pH_{water}); (7) base saturation; (8) organic carbon content (wt %); and, (9) content of organic and carbonate carbon to 1 m depth (kg C m^{-2}). In the case of themes 4 to 7, data sets are presented both for the topsoil (0-30 cm) and subsoil (30-100 cm). The relative area within a grid cell that is represented by the considered classes is also shown for each theme. The data set is presented in ArcView® format so as to facilitate its use in a wide range of global environmental studies.

Keywords: digital data sets; GIS; soil properties; global change

1. Introduction

The compilation and processing of large-scale data sets of the world's environmental resources, using well-documented procedures and standards, is crucial for many global modelling activities (Scholes *et al.*, 1995; Zuidema *et al.*, 1994). A comprehensive review of the data required for global terrestrial modelling can be found in Cramer and Fischer (1997).

Requirements for soil and terrain information include the need for an up-to-date geographical coverage, access to secondary soil information obtained via transfer functions or models from the primary (measured) soil data, and monitoring of changes in soil characteristics as associated, for example, with changes in land use systems and processes of global change (Baumgardner, 1999; Bullock, 1999). Generalisation of soil profile data for use in regional and global models requires transforming very heterogeneous data into homogenous information that is considered to be representative at a much lower spatial resolution. Ideally, the scale of modelling should coincide with the scale of the questions to be answered and the processes involved (Cramer and Fischer, 1997; Middelburg *et al.*, 1999). In practice, however, there are often data limitations and aggregation problems. Bouwman *et al.* (1999), for example, discussed these aspects in relation to trace gas scaling.

The most comprehensive and detailed geographic overview on world soil resources is the1:5 million scale Soil Map of the World (FAO-Unesco, 1974-1981). This map is a compilation of numerous national and regional maps, based on a common legend. At the time of compilation, in the 1960s to early 80s, soil maps for many countries were available for limited areas only and at various scales. Further, only a limited number of regionally representative profiles were available at the time. Hence, initial interpretations were often of a qualitative nature and based on expert-estimates.

With the completion of the Digital Soil Map of the World (FAO, 1995) and the first version of the WISE soil database at ISRIC (Batjes, 1997; Batjes and Bridges, 1994), it became possible to list median soil parameter estimates for each soil unit of the world. Staff at ISRIC, IIASA (International Institute for Applied Systems Analysis), and FAO subsequently developed a common methodology for deriving a set of 20 soil parameters identified as being important for land evaluation in the context of regional and global agro-ecological zoning (Batjes *et al.*, 1997). That study was later refined under a Research Agreement with the International Food Policy Research Institute (Batjes, 2002a; Batjes, 2002b). A main guiding criterion in that work has been that results must allow linkage with the digital Soil Map of the World, and its grid-based derivatives, through the FAO soil legend code.

Examples of applications of the soil parameter and spatial data sets that have been derived from WISE, version 1.0 (Batjes, 1996a; Batjes, 1997; Batjes *et al.*, 1997), include modelling of global environmental change (Alcamo *et al.*, 1998; Bouwman and Van Vuuren, 1999; Cindery *et al.*, 1998; Ganzenveld *et al.*, 1998; Hootsmans *et al.*, 2001), up-scaling and down-scaling of greenhouse gas emissions (Bouwman *et al.*, 2002a; Bouwman *et al.*, 2002c; Denier van der Gon *et al.*, 2000; Knox *et al.*, 2000), global emissions of NH_3 (Bouwman *et al.*, 2002b), and agro-ecological zoning (Fischer *et al.*, 2001; Fischer *et al.*, 2002). Further, a subset of 1125 profiles from WISE, version 1.0, provided the soil profile attribute basis for the activities of the Global Soil Data Task Force of IGBP-DIS (2000).

The present report presents a revised set of spatial databases of derived soil properties for the world, at 0.5 x 0.5 degree resolution. Section 2 outlines the data and methods used. Possible limitations that are associated with the current data set are discussed in Section 3, while meta-data are presented in the Appendix.

2. Data and methods

Median soil parameter values derived from version 2.0 of the WISE soil profile data set (Batjes, 2002a; Batjes, 2002b), which includes over 9600 globally distributed soil profiles, have been linked to a 0.5 by 0.5 degree resolution version of FAO's 1:5 million scale Soil Map of the World (Batjes *et al.*, 1995) through the soil unit code. The resulting files are presented as an ArcView project (ESRI, 1996).

The current data set, or Arc View project (file: wise_fc.apr), includes the following views (Fig. 1):

(1) Profile Available Water Capacity (PAWC; -10 to –1500 kPa or pF2.0 to pF4.2) in mm water to 1 m depth, with a correction for gravel content.
(2) Soil organic carbon concentration (% C), both for the topsoil (0-30 cm) and subsoil (30-100 cm depth).
(3) Soil pH, both for the topsoil and subsoil.
(4) Cation exchange capacity (CEC_{soil}) , both for the topsoil and subsoil.
(5) Cation exchange capacity of the clay fraction corrected for the contribution of organic matter (CEC_{clay}), both for the topsoil and subsoil.
(6) Base saturation, expressed as % of CEC_{soil}, both for the topsoil and subsoil.
(7) Soil drainage class
(8) Soil depth class.

In addition, the current data set includes a copy of data sets on soil organic and carbonate carbon stocks to 1 m depth, which so far have only been available as IDRISI raster images (as kg C m^{-2} to 1 m depth), after: Batjes, 1996a; Batjes, 1996b).

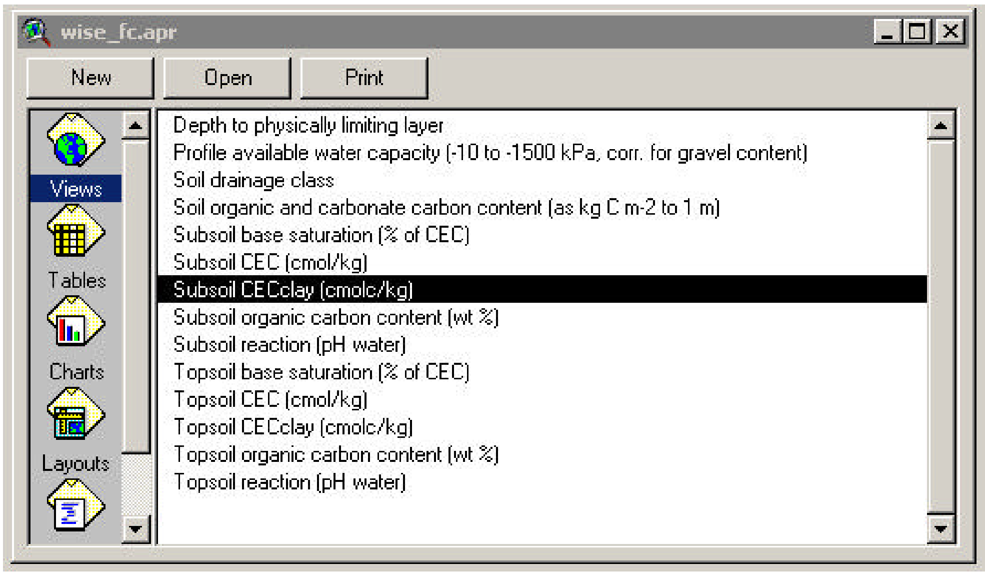

Figure 1. List of views in project “wise_fc.apr”.

Inherently, the choice of class boundaries for mapping a particular soil parameter will always be subjective. Class boundaries for the respective attributes have been derived from various sources (Anon., 1984; FAO, 1983; Landon, 1991; Sys *et al.*, 1993), keeping in mind the 0.5 by 0.5 degree resolution and 1:5 million scale of the soil geographic database; the selected class limits are listed on the respective legends. Figure 2 shows the legend for the theme “topsoil pH”, as an example.

Oceans and glaciers are mapped as *single* units when they are spatially dominant in a grid. Single units are defined also when one of the possible legend classes predominates in a grid (see Fig. 3). In the case of very complex units – a grid cell in WISE may contain up to 10 component soil units –, it has been necessary to define a so-called “complex” unit on the legend (see category “4.5 – 8.5 (complex)” in Fig. 2).

The approach described above is considered more appropriate than procedures in which profile available water capacity (PAWC) or soil pH per grid cell, for example, have been determined by multiplying the relevant parameter value for each component soil unit by its relative proportion in a map unit (e.g., Carter and Scholes, 2000; Kern, 1995), because the latter approach ignores spatial heterogeneity. Further, for some attributes such as soil pH, a spatially weighed value will be less meaningful (i.e., in view of the log scale).

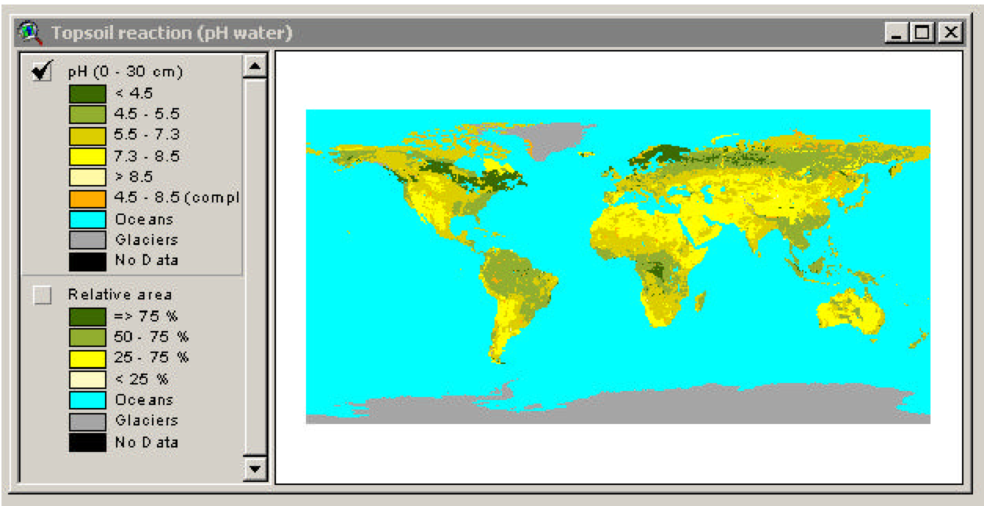

Figure 2. Example of spatial data set for the theme “pH (0-30 cm)”.

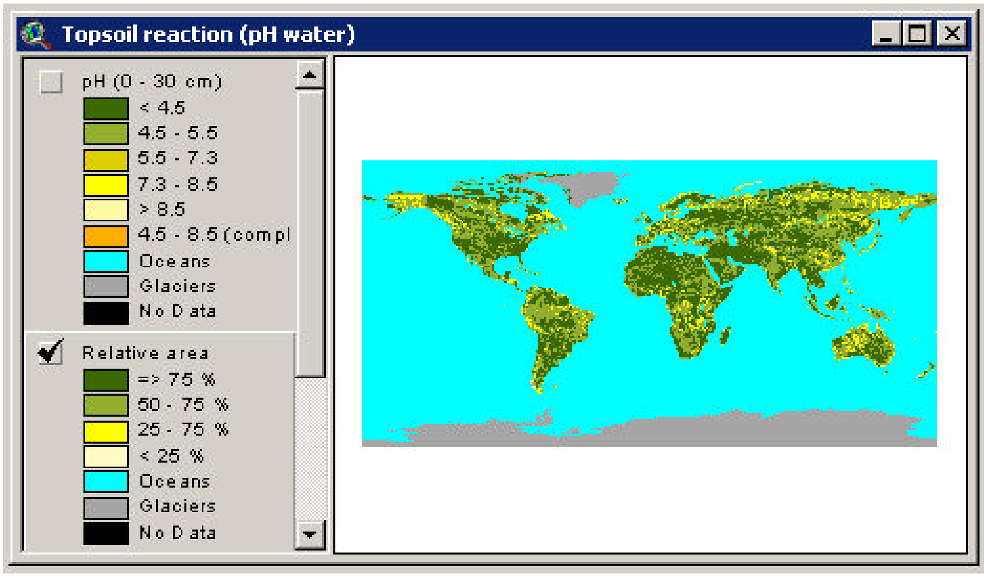

Figure 3. Relative area within a grid corresponding with the categories shown for “pH (0-30 cm)”.

An advantage of the current approach is hat the minimum probability of occurrence of a certain parameter range in each grid cell can be specified (Fig. 3). In many studies, however, only the spatially dominant soil type of compound map units has been used (Foussereau *et al.*, 1993; Van Diepen, 1993) or an artificial, spatially weighed value has been generated. Such simplifications are fraught with uncertainty because the actual percentage of occurrence of the spatially dominant soil unit within a map unit, or 0.5 by 0.5 grid cell, can vary widely.

The WINZIP®-compressed documentation and data files are available via the ISRIC home page (http:\\www.isric.org), via menu item "soil data". Upon decompression, the various files will be extracted to folder D:\WISE_FC. In order to access and manipulate the data files, however, the ArcView® software must have been installed on your PC-system. The data files can be accessed by opening project WISE_FC.APR, which is stored in folder D:\wise_FC.

3. Discussion

Generalisation of soil geographic and soil profile data for use in global models requires transforming heterogeneous data into uniform, harmonized information that is considered to be representative at a much lower spatial resolution.

Several authors have reviewed the advantages and disadvantages of the Soil Map of the World and its grid-based derivatives (Bouwman, 1990; Nachtergaele, 1999; Batjes, 2000). The spatial data are known to be outdated and the associated area data, of necessity, have been derived from composition rules (FAO, 1995). The density and quality of the available soil profiles also varies greatly from one (agro-ecological) region to the other (Batjes, 2002b). Hence, the current update of the information on the world's soil resources at scale 1:5 million in SOTER, the World Soils and Terrain Database programme (Oldeman and van Engelen, 1993; Van Engelen, 1999). Examples of currently completed updates are the SOTER database for Latin America and the Caribbean (FAO *et al.*, 1998) and the one for Central and Eastern Europe (FAO and ISRIC, 2000). SOTER mapping at 1:5 M scale is ongoing in Europe and the USA (King *et al.*, 2002; Dobos *et al.*, 2002). Until global coverage is achieved in a 1:5 M scale SOTER, however, FAO's Soil Map of the World will remain the best geographic source on global soil resources.

The current spatial data set should be seen as the best possible estimate, based on the currently available soil geographic information and present selection and clustering of soil profile data. A comprehensive update of soil parameter data sets for the world, at scale 1:5 million, will first become feasible upon the completion of the World Soil and Terrain (SOTER) programme.

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Appendix

DATA-SET TITLE

ISRIC-WISE global data set of derived soil properties on a 0.5 by 0.5 degree grid (version 2.0)

DATA-SET DESCRIPTION

Data Set Name:

ISRIC-WISE global data set of derived soil properties on a 0.5 by 0.5 degree (Version 2.0)

Principal Investigator:

Niels H. Batjes

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ORIGINAL DESIGN

Variables/themes:

(1) Depth to physically limiting layer
(2) Profile available water capacity (between –10 to -1500 kPa, corrected for gravel content)
(3) Soil drainage class
(4) Cation exchange capacity (CEC_{soil}), both for the 0-30 cm and 30-100 cm zone.
(5) Cation exchange capacity of the clay fraction, corrected for the contribution of soil organic matter (CEC_{clay}), both for the 0-30 cm and 30-100 cm zone.
(6) Soil reaction (pH_{water}), both for the 0-30 cm and 30-100 cm zone.
(7) Base saturation, as % of CEC_{soil}, both for the 0-30 cm and 30-100 cm zone.
(8) Organic carbon content (wt %), both for the 0-30 cm and 30-100 cm zone.
(9) Content of organic and carbonate carbon to 1 m depth (as kg C m^{-2}).

The legend classes are documented by theme within each view. For each of the above (items 1 to 8), the relative area represented by a given legend class is also shown.

Origin:

The current spatial data sets were derived from the World Inventory of Soil Emission Potentials (WISE) database which consists of: (1) a file with data on the type and relative extent of the component soil units of each ½^o latitude by ½^o longitude grid cell of the world, derived from the corrected 1:5 M scale FAO-UNESCO Soil Map of the World; and (2) selected physical and chemical data for over 9600 soil profiles considered representative for the respective soil units of the world.

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Version 1.0 of the WISE database has been developed at ISRIC in the framework of the Dutch National Research Programme on Global Air Pollution and Climate Change (Project 851039). Preliminary analyses of version 1.0 of the WISE data set for use in global and regional AEZ studies were carried out in a collaborative activity of ISRIC, IIASA and FAO in 1997. In 2001, the WISE data set was further expanded and the analyses refined in the context of Research Agreement Contract No. 2001X020.ISR with the International Food Policy Research Institute (IFPRI).

Geographic coverage:

Global

Maximum Latitude	+ 90 degrees (N)
Minimum Latitude	- 90 degrees (S)
Maximum Longitude	+180 degrees (E)
Minimum Longitude	-180 degrees (W)

Geographic sampling:

Spatial soil data derived from centre-point sampling of 5 by 5 minute grid cells of the 1:5 M scale FAO-UNESCO Soil Map of the World, giving the full soil unit composition for these cells. This information was then aggregated to half-degree grid cells using FAO's Soil Composition Rules (see FAO World Soil

Resources Report 67; gridding algorithms developed by Dr F.O. Nachtergaele, FAO-AGL).

Temporal sampling:

Soil properties were derived from over 9600 soil profiles considered to be representative for the 106 soil units shown on the Soil Map of the World, mostly collected between 1950 and 2001.

INTEGRATED DATA-SET

Data-set citation:

Batjes, N.H., 2002. ISRIC-WISE global data set of derived soil properties on a 0.5 by 0.5 degree grid (Version 2.0). Report 2002/03 (available on-line via: http:\\www.isric.org), ISRIC, Wageningen.

Projection:

Geographic (lat/long; decimal degrees)

Data representation:

Various classes and explanatory notes on these classes (see map legends)

Size:

Un-compressed data volume is about 0.5 Mb.

DATA-SET INSTALLATION

Entering WISE_FC.zip will extract the relevant files to folder: D:\WISE_FC. These files can be accessed using ArcView®, by opening the project with the named: WISE_FC.APR.

Content: 14 files in 32 directories (about 0.4 Mb)

ADDITIONAL REFERENCES

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