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

(Version 3.0)

Niels H Batjes

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ISRIC World Soil Information

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Inquiries:
c/o Director, ISRIC – World Soil Information
PO Box 353
6700 AJ Wageningen
The Netherlands
Telefax: +31-(0)317-471700
E-mail: soil.isric@wur.nl
Web: www.isric.org

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ABSTRACT

A harmonized, gridded global data set of soil parameter estimates is described. It includes files listing: (1) soil parameter estimates for the component soil units of each terrestrial grid cell, in *un-binned* format, and (2) soil parameter estimates aggregated or *binned* into a number of predefined classes.

The spatial data, with a resolution of ½ by ½ degree, was derived from the ISRIC-WISE soil database. The land surface between longitudes -180° W and +180° E and latitudes +90° N and -90° S has been characterized using 45948 unique map units. Each of these can comprise from one to ten soil units, characterized according to the original legend of the 1:5 million scale Soil Map of the World (FAO-Unesco 1974). Soil parameter estimates for each of these units were derived from analyses of some 9600 profiles held in WISE, version 2.0.

Twenty-two soil variables, identified as being useful for agro-ecological zoning, land evaluation, crop growth simulation, modelling of soil gaseous emissions and analyses of global environmental change, were considered. Parameter estimates for these variables are given for the topsoil (0-30 cm) and the subsoil (30-100 cm) for: content of organic carbon, total nitrogen, the C/N ratio, pH(H_2O), CEC_{soil}, CEC_{clay}, base saturation, total exchangeable bases, aluminium saturation, exchangeable sodium percentage (ESP), electrical conductivity of saturated paste (ECe), calcium carbonate content, gypsum content, content of sand, silt and clay, content of fragments > 2 mm, bulk density, total porosity. Total available water capacity (TAWC; -10 to -1500 kPa, corrected for the presence of coarse fragments) is given in mm to 100 cm depth for deep soil units, to 10 cm for shallow Lithosols, and to 30 cm for Rankers and Rendzinas. Soil drainage class and 'effective' soil depth are presented on a profile basis.

The parameter estimates — medians — presented here should be seen as best estimates; possible types and sources of uncertainty are discussed in the report.

The data are considered appropriate for exploratory studies at global scale (< 1:5 000 000).

Keywords: soil parameter estimates, environmental modelling, ISRIC-WISE database, secondary data

1. INTRODUCTION

Harmonized data sets of soil properties are needed for a wide range of environmental studies, including agro-ecological zoning, assessments of food productivity, soil gaseous emissions/sinks and environmental change (Batjes *et al.* 1997; Bouwman *et al.* 2002; Cramer and Fischer 1997; Fischer *et al.* 2002; Scholes *et al.* 1995; van Drecht *et al.* 2003). Until the global update on world soil resources in the Soil and Terrain Database project (SOTER, see Nachtergaele 1999; Oldeman and van Engelen 1993) has been completed, the combination of spatial data derived from the digital Soil Map of the World (SMW, see FAO 1995a) and soil parameter estimates derived from the ISRIC-WISE database (Batjes 2002b) will probably remain the most-detailed source on world soils for global modelling. Nonetheless, various sources and types of uncertainty are associated with the spatial and attribute data (see Batjes 1999; Bouwman *et al.* 1999; Burrough 1986; Cramer and Fischer 1997; Fischer *et al.* 2002; Goodchild and Gopal 1989; Nachtergaele 1999).

This report describes the data and procedures used to develop a global data set of soil parameter estimates, with a spatial resolution of ½ by ½ degree, derived from the ISRIC-WISE database. The latter was developed for a *Geographical Quantification of Main Soil Factors that Control Processes of Global Change*, pending world coverage by SOTER (see Batjes and Bridges 1994; Batjes *et al.* 1995).

Each grid cell of WISE may contain from 1 up to 10 component soils, characterized according to the original FAO Legend (FAO-Unesco 1974). Earlier versions of WISE-derived spatial data only presented soil parameter estimates as classes; these were considered most appropriate for displaying results at the considered resolution (Batjes 1996, 2002c). Various modelling groups, however, have since then indicated that they would prefer having *un-binned* values to run their models; such data are presented in this report together with the classified data.

2. MATERIALS AND METHODS

2.1 Soil units

The spatial data for WISE have been aggregated from the soil geographic information held on the 5 by 5 arcminutes version of the Soil Map of the World (FAO 1995a), using procedures described in Batjes *et al.* (1995). Each ½ by ½ degree grid cell was characterized by up to 10 soil units.

The SMW Legend (FAO-Unesco 1974) considers 106 soil units, coded from Af to Zt, clustered into 26 major soil groupings. In addition to these, there are six miscellaneous units: DS= dunes or shifting sands; ST= salt flats; RK= rock outcrops; NA= no data; WT= inland waters or oceans; and GL= Glaciers.

2.2 Soil parameter estimates

Twenty-two soil variables, commonly required in studies of environmental change, were considered in this study (Table 2). Parameter estimates for these variables — by soil unit, depth zone and topsoil textural class — were derived from analyses of some 9600 soil profiles in the ISRIC-WISE database. Most of these were sampled and analysed between 1960 and 2000. Soil parameter estimates were calculated for the topsoil (0-30 cm) and subsoil (30-100 cm), in accordance with FAO practice (Batjes 2002b).

The median was used, as it is more resistant to erratic extreme observations than the mean, particularly in case of non-normally distributed populations. Information about the number of observations (sample sizes), means, coefficients of variation, 95%-confidence intervals, medians, and medians of absolute deviations for all soil parameters may be found elsewhere (Batjes 2002a, b).

For several of the 106 soil units of the original FAO Legend, there are still relatively few or no measured data in WISE. Less-than-complete data were available for many soil profiles because only selected measurements were undertaken during the original surveys. As a result, soil parameter estimates for these units often had to be derived using taxotransfer rules – the procedure and assumptions have been detailed in Batjes (2002a).

Minor modifications for gravel content and available water capacity (TAWC, defined here as -10 to -1500 kPa), based on expert-judgement, were introduced for some soil units (i.e. Regosols, Podzols, Lithosols, Rendzinas and Rankers). Information on soil drainage classes per FAO soil unit was taken from Batjes (1997), again with minor changes based on expert-judgement.

The soil depths presented here by soil unit represent the median of the maximum depths, sampled during pit description. Consequently, the actual soil depth may be larger than the values shown here, in particular for deeply weathered soils from the Tropics.

Table 1. List of soil variables, their abbreviations and units of measurement

Abbreviation	Description	Units
- For topsoil and subsoil:		
ORGC	Organic carbon	% (mass)
TOTN	Total nitrogen	% (mass)
CN	C/N ratio	-
PHH2O	Soil reaction in water	pH units
CECsoil	Cation exchange capacity	$cmol_c\ kg^{-1}$
CECclay[a]	Cation exchange capacity of clay size fraction	$cmol_c\ kg^{-1}$
TEB	Total extractable bases	$cmol_c\ kg^{-1}$
BSAT	Base saturation (as % of CEC_{soil})	%
ALSAT[b]	Aluminium saturation (as % of effective CEC)	%
ESP	Exchangeable sodium percentage (% of CECsoil)	%
ECE	Electrical conductivity of saturated paste	$dS\ m^{-1}$
CACO3	Calcium carbonate content	% (mass)
GYPSUM	Gypsum content	% (mass)
SAND	Sand	% (mass)
SILT	Silt	% (mass)
CLAY	Clay	% (mass)
GRAVEL	Fragments >2 mm	% (volume)
BULK	Bulk density	$g\ cm^{-3}$
TOTPOR	Total porosity	%
- For whole profile (to 1 m or less):		
TAWC[c]	Total available water cap. (from -10 to -1500 kPa)	mm
DEPT	Depth to physically limiting layer	cm
DRAINY	Drainage class (FAO 1977)	classes

[a] CEC_{clay} was calculated from CEC_{soil} by assuming a mean contribution of 350 $cmol_c\ kg^{-1}$ OC, the common range being from 150 to over 750 $cmol_c\ kg^{-1}$ (Klamt and Sombroek 1988). [b] Effective CEC was defined as sum of exchangeable bases plus exchangeable ($H^+ + Al^{3+}$) (van Reeuwijk 2002). [c] The soil water potential limits for TAWC conform to FAO standards (i.e. pF2.0 to pF4.2, see Doorenbos and Kassam 1978). TAWC values were corrected for the presence of fragments >2 mm, and are given in mm for the default soil depth of 100 cm except for shallow Lithosols (to 10 cm) and Rankers and Rendzinas (to 30 cm).

Inherently, there were no soil parameter estimates for the miscellaneous units considered on the Soil Map of the World. The following assumptions were used:

- Dune sands (DS): soil parameter estimates for Arenosols (Q) were used as default, except for organic carbon content that was set to 0.2% for the topsoil and 0.1% for the subsoil.
- Not Determined (NA): as above, but using soil parameter estimates for Arenosols (Q) as the default.

- Salt Flats (ST): as above, but using soil parameter estimates for Solonchaks (Z) as the default.
- Rock outcrops (RK): all parameter estimates were set at -95 for GIS-visualisation purposes.
- Lithosols are less than ≤ 10 cm thick over continuous, coherent hard rock; for GIS-visualisation purposes all parameter estimates for the 'subsoil' were set at -95 (see RK).
- Glaciers and land ice (GL): all parameter estimates were set at -98.
- Oceans and inland waters (WT): all parameter estimates were set at -99.

2.3 Spatial data

The grid cells in WISE are written row-wise from the West to the East starting at the Northwest corner. The spatial data is bound by longitudes -180° W and +180° E and latitudes +90° N and -90° S. This corresponds to 720 columns and 360 rows, or 259200 grid cells of ½ by ½ degree.

There are 45948 unique map units, which consist of soil units or associations of soil units, on the WISE map. When a map unit or grid cell is not homogeneous, it is composed of one dominant soil unit and up to 10 component soils. The relative extent of the various soil units within a grid cell was obtained using composition rules developed by FAO (see Batjes *et al.* 1995; FAO 1995b).

Statistics for the proportion of the dominant and component soils are given in Table 2. The median area of the dominant soil unit ($soil_1$) within a grid cell is 43%, with lower and upper quartiles of 33 and 57% respectively. The median area for $soil_1$, $soil_2$, $soil_3$, $soil_4$ and $soil_5$ combined is 98%, with a lower quartile of 90% (Table 3).

Table 2. Relative proportion of dominant and component soils within the map units of WISE

Descriptive statistics	Relative proportion[a] of dominant and component soils (%)									
	Soil1[b]	Soil2	Soil3	Soil4	Soil5	Soil6	Soil7	Soil8	Soil9	Soil10
Minimum	14	0	0	0	0	0	0	0	0	0
1st Quartile	33	17	9	4	0	0	0	0	0	0
Median	43	22	14	8	4	10	0	0	0	0
3rd Quartile	57	28	18	11	8	5	3	1	0	0
Maximum	100	50	33	25	20	17	12	10	9	7

[a] The actual area within a ½ by ½ degree grid will vary with latitude — the grid cell size is about 55 x 55 km^2 at the equator and will decrease gradually to the

poles according to a cosine function of latitude. [b] $Soil_1$ is the dominant soil and $Soil_2$ to $Soil_{10}$ the component soils.

In 75% of the cases, $soil_6$ to $soil_{10}$ account for less than 10% of a grid cell, with a maximum of 41% (Table 3). In 25% of the cases, these 'minor' soils account for an estimated 10 to 41% of a grid cell area. The minimum relative area occupied by $soil_1$ to $soil_5$ is 59%.

Table 3. Relative proportion of main and 'other' soil units within the WISE map units

Descriptive statistics	Relative proportion[a] of main and minor soil units (%) [a]	
	Soil1 to Soil5 [b]	Soil6 to Soil10
Minimum	59	0
1st Quartile	90	0
Median	98	2
3rd Quartile	100	10
Maximum	100	41

[a] Main soil units refers to $soil_1$ to $soil_5$, while minor soil units are considered to correspond with $soil_6$ to $soil_{10}$.

From the above it follows that the full grid-cell composition must be considered when making interpretations of the spatial data.

3. RESULTS

Output is largely presented in MSAccess® and ArcView3.3® format, and it includes some 125 files (see Table I in Appendix 2). The associated information can be converted to a wide range of data formats, using the in-built export facility of the various software packages, depending on the user's specific needs.

There are two types of output files for the soil parameter estimates. The first shows the data in *binned* format, i.e. each file lists the spatially dominant class and its relative extent in a given grid cell. The second shows the underlying data in *un-binned* format. The structure of the various files is described in Appendix 1.

If the relative area of water/oceans or glaciers in a grid cell is > 55 per cent[1], the cell was re-coded as being a WT (-1) or GL (-2) unit respectively. Similarly, if the combined area of WT and GL units in a grid cell exceeded 55% — and both WT and GL were < 55 per cent — these

[1] The limit of 55%, rather than 50%, was used to emphasize 'terrestrial' units on the binned GIS maps; this was particularly useful for demarcating small islands – the actual (estimated) area of land is documented in the attribute files.

grid cells were allocated to the spatially dominant unit. If rock outcrops (RK) were predominant (>55%), this was re-coded to -3. Otherwise, the grid cell was considered to be 'land'; abbreviated as LN, including both the area of soil units (SO) and Rock Outcrops (RK).

Five single classes and three soil complexes have been defined for all LN-units, irrespective of the soil parameter under consideration. The procedure is illustrated in Table 4, using soil pH as an example. If no single unit — i.e. class 1 to 5 — was predominant in a given grid cell, the grid was coded as being a complex (class 6, 7, or 8). The relative extent of each class has been documented in the attribute files (see Appendix 1). Details about the composition of the various classes, and associated map units, may be found in the *un-binned* data.

Table 4. General procedure for allocating grid cells to a binned-class with coding conventions.

pH_{water}:

Critical limits:		5.5	6.5	7.5	8.5	
Map units:						
	CLAS1	CLAS2	CLAS3	CLAS4	CLAS5	
	1	2	3	4	5	
Single units:	<—>	<—>	<—>	<—>	<—>	
(and coding)						
Complex units:	6					
(and coding)	<———>					
			7[a]			
		<———>				
				8		
			<———>			

[a] In case of *very* complex map units or grid cells, the grid cell was assigned to 'code 7' by default.

Selection of class boundaries for preparing *binned* data is always arbitrary (see Anon. 1984; Landon 1991; Sys *et al.* 1993); moreover, such limits are often fuzzy (Burrough 1989) — users can easily generate other classes from the *un-binned* data should this be needed for specific model applications. The critical limits used here for each soil parameter are listed in the Legend files (see Appendix 1).

Ultimately, the type of research purpose will determine which parameter estimates will be required for a specific application; the corresponding selections can best be made with tailor-made programs designed to meet the scope of these applications.

The information held in the *binned* and *un-binned* output files can be *joined* with the spatial data through the unique map unit code (*SNUM*) and unique ID-field (*VALUE*) of each grid cell in a Geographical Information System.

The current project file (*.apr) only presents a selection of GIS-views, as an example: organic carbon content, soil pH, soil drainage class, soil depth, and soil water holding capacity (Figure 1). Other views can easily be generated from the tables holding the various soil parameter estimates.

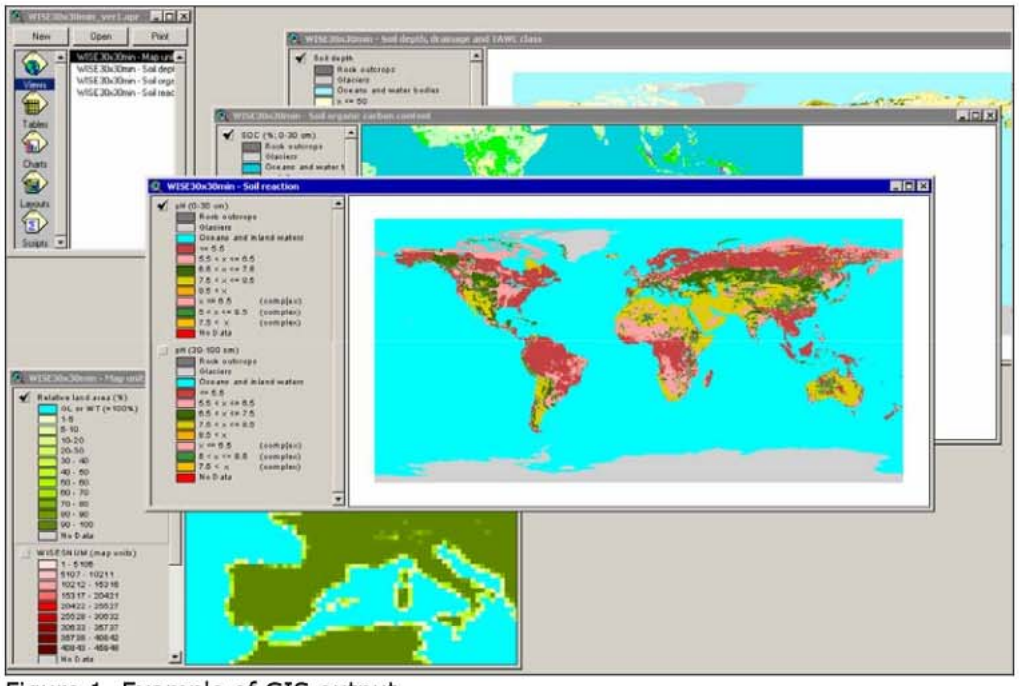


Figure 1. Example of GIS output

4. DISCUSSION AND CONCLUSION

Generalisation of soil geographic and soil profile data for use in global models requires transforming heterogeneous data into uniform, harmonized information that is considered representative at a much lower spatial resolution; the associated uncertainties are often large yet difficult to quantify.

Several authors have reviewed the advantages and disadvantages of the Soil Map of the World and its grid-based derivatives (Bouwman *et al.* 1999; Cramer and Fischer 1997; Nachtergaele 1999). The spatial data are outdated, being largely based on soil surveys carried out prior to the 1980s (FAO-Unesco 1971-1981), and the associated area data were derived using coarse composition rules (see FAO 1995a). The density and quality of soil profiles in WISE — presently some 9600 — also varies greatly from one region to the other. International comparison of soil analytical data remains fraught with uncertainty (Batjes 2002a, p. 6-10).

For any given soil unit it has been necessary to apply the same parameter estimates irrespective of its location in the world — for example, the same values were used for Orthic Luvisols in Germany and South Africa. In other words, regional differences in climate, parent material, slope and land use/management on soil variation within a taxonomic unit could not yet be taken into account explicitly. Further, the original SMW Legend (FAO-Unesco 1974) does not differentiate soils with an argic horizon according to their clay activity, unlike more recent systems (FAO 1988; Soil Survey Staff 2003; WRB 1998).

Many of the above issues are being tackled by the World Soils and Terrain Database project (Batjes 2003; Oldeman and van Engelen 1993; Van Engelen *et al.* 2005). Continental updates in SOTER are already available for South America and the Caribbean (Batjes 2005b; Dijkshoorn *et al.* 2005), Central and Eastern Europe (Batjes 2005a; FAO and ISRIC 2000) and Southern Africa (Batjes 2004; FAO and ISRIC 2003). The available SOTER updates have already been merged into a Harmonized Global Soil Resources Database with a 5 by 5 arcminutes resolution (Van Engelen *et al.* 2005). Nonetheless, until global coverage is achieved in SOTER, the FAO-Unesco Soil Map of the World will remain the best geographic source on global soil resources and WISE, probably, one of the most comprehensive sets of globally distributed soil profile data.

The current data should be seen as best possible estimates based on: (1) the currently available soil geographic data as derived from the 1:5 000 000 SMW and (2) the present selection of soil profile data in WISE.

Clustering of soil profile data for this study was in accordance with FAO-conventions (FAO 1995a); by soil unit, depth layer (0-30 cm and 30-100 cm) and textural class of the topsoil (0-30 cm). In accord with the recommendations of a joint study by FAO/IIASA/ISRIC (Batjes *et al.* 1997) and other studies (Spain *et al.* 1983), medians were used, as opposed to means, as this will reduce the effects of outliers.

Coefficients of variation (CV) of individual soil properties within soils mapped as single series commonly range from 20% to 70% (Beckett and Webster 1971; Landon 1991). They can even be larger when soils are mapped at a higher hierarchical level, such as the FAO soil unit (Batjes 2002b) and USDA suborder (Eswaran *et al.* 1995; Kimble *et al.* 1990). Similarly, Spain *et al.* (1983) reported large interquartile ranges for organic carbon levels in Australian Great Soil Groups. Variations tend to be highest for chemical properties, which are most readily modified by differences or changes in land use/management. Some of the properties under consideration are not diagnostic in the FAO Legend. Consequently, the uncertainty attached to the soil parameter estimates can be large (see Batjes 2002a). The above limitations should be understood and accepted when using the present data.

The current data set is considered appropriate for environmental studies at a global scale pending completion of a harmonized, global SOTER product at scale 1:5 000 000.

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APPENDICES

Appendix 1: Structure of main output tables

There are three types of output tables, each of which have a similar structure:

- Un-binned data *(*tables like*: yVar)*:

Soil parameter estimates for the component soil units of a grid cell are stored in tables called *yVAR*, where *Var* is the abbreviation of the soil parameter (see Table 1). For example, table y*ORGC* contains estimates for the median content of organic carbon, both for the topsoil (0-30 cm) and subsoil (30-100 cm). Total available water capacity (TAWC; -10 to -1500 kPa, corrected for the presence of coarse fragments) is given in mm to 100 cm depth for deep soil units, to 10 cm for shallow Lithosols, and to 30 cm for Rankers and Rendzinas. Soil drainage class and 'effective' soil depth are presented on a profile basis.

Tables like *yVAR* present the parameter estimates 'as is', that is in *un-binned* format.

Structure of table yOrgC[a]:

Name	Data Type	Description
SNUM	Number	Unique number for WISE map unit
AREA1	Number	Relative area of SOIL1[a] in map unit (%)
ORGC_1**t**	Number	Median organic carbon content (%) in **t**opsoil (0-30 cm)
ORGC_1**s**	Number	As above, but for the **s**ubsoil (30-100 cm)[b]
AREA2	Number	Relative area of SOIL2 in map unit (%)
ORGC_2t	Number	Median organic carbon content (%) in topsoil (0-30 cm)
ORGC_2s	Number	As above, but for the **s**ubsoil (30-100 cm)
…		
AREA10	Number	Relative area of SOIL10 in map unit (%)
ORGC_10t	Number	Median organic carbon content (%) in topsoil (0-30 cm)
ORGC_10s	Number	As above, but for the subsoil (30-100 cm)

[a] The number of soil units in a map unit may vary from one to ten (for details see table: *WISE30x30min_SNUM*). Each map unit may cover several grid cells.

[b] In case of Lithosols (< 10 cm thick) there are no soil parameter estimates for the 'subsoil'; this has been flagged with a -95 (see text).

Structure of table yDEPT[a]:

Name	Data Type	Description
SNUM	Number	Unique number for WISE map unit
AREA1	Number	Relative area of SOIL1 in map unit (%)
DEPT_1	Number	Median soil depth
AREA2	Number	Relative area of SOIL2 in map unit (%)
DEPT_2	Number	Median soil depth
…		
AREA9	Number	Relative area of SOIL9 in map unit (%)
DEPT_9	Number	Median soil depth
AREA10	Number	Relative area of SOIL10 in map unit (%)
DEPT_10	Number	Median soil depth

[a] In the case of TAWC, soil parameter estimates are given for the whole profile (0-100 cm or less when applicable, e.g. to 10 cm for Lithosols; see Table 1). Soil drainage class is on a profile basis, while "effective" soil depths represents the median of the maximum depths for each soil unit, as sampled during pit description.

- Binned data *(tables like: Binned _VAR_z)*:

Data held in tables like *yVAR* have been used to generate a series of classified or *binned* data (see Section 3). These tables have been generated to facilitate visualization with GIS, since most grid cells comprise more than 1 soil unit or miscellaneous unit. Soil parameter estimates can be linked (joined) to the geographical data — grid units (*VALUE*) — through the unique map unit code (*SNUM*).

Binned data sets are presented by soil parameter, for the topsoil (0-30 cm; for example *Binned_OrgC_topsoil*) and subsoil (30-100cm; for example *Binned_OrgC_subsoil*), respectively the profile for drainage, soil depth and profile available water capacity (e.g. *Binned_Drain_profile)*.

Structure of table Binned_OrgC_topsoil [a]:

Name	Data Type	Description
SNUM	Number	Unique number for WISE map unit
FinRAT	Number	Unique code for spatially dominant OrgC-class [a]
FinAREA	Number	Relative area of covered by class FINRAT [b]
CLAS1 [a]	Number	Relative area of CLAS1-rated soil units (%)
CLAS2	Number	Relative area of CLAS2-rated (%)
CLAS3	Number	Relative area of CLAS3-rated (%)
CLAS4	Number	Relative area of CLAS4-rated (%)
CLAS5	Number	Relative area of CLAS5-rated (%)
SO	Number	Relative area of soil units (SO; %)
RK	Number	Relative area of rock outcrops (RK; %)
LN	Number	Relative area of land units (LN= SO + RK; %)
WT	Number	Relative area of Oceans/water (WT; %)
GL	Number	Relative area of glaciers (GL; %)

[a] For details see text (Section 3); the legend is given in tables like *Legend_ORGC*.
[b] These percentages refer to the whole grid cell. The spatial dominance of a given class, however, was determined with respect to the total land area within the grid cell.

Note: To speed up data loading when running the GIS-project file (*.apr) selected MSAccess® tables have been converted to dBaseIV®. The *binned* dbf files are of the following form: CACO3_t.dbf for topsoil data (0-30 cm) and CACO3_s.dbf for subsoil (30-100 cm) data, and the corresponding legend file *Legend_CACO3.dbf*. *Un-binned* dbf files are named *yVAR.dbf*. In GIS, linkage to the soil geographical data (VALUE) is through the unique map unit code (*SNUM*).

- Legend files (tables like: *Legend_Var)*:

All legend files have the same structure. They all include 11 classes (*FinRAT*): three miscellaneous units (-1 for WT, -2 for GL, and -3 for RK), five single units (number 1 to 5), and three complex units (number 6, 7 and 8). The legend file soil pH, table *Legend_PHH2O*, is presented below as an example. For a given soil property, the same legend files have been used for the topsoil and subsoil; all classes, however, need not appear on each map.

Name	Data Type	Description
FinRAT	Number	Unique code for spatially dominant class [a]
FinCLAS	Number	Brief description of class boundaries/legend

[a] The soil variable under consideration follows from the table's name.

FinRAT [a]	FinCLAS	
-3	RK (Rock outcrops)	
-2	GL (Glaciers and land ice)	
-1	WT (Oceans and inland waters)	
1	PHH2 <= 5.5	(≥ 55% of grid cell)
2	5.5 < PHH2 <= 6.5	(≥ 55% of grid cell)
3	6.5 < PHH2 <= 7.5	(≥ 55% of grid cell)
4	7.5 < PHH2<= 8.5	(≥ 55% of grid cell)
5	8.5 < PHH2	(≥ 55% of grid cell)
6	pHH2 <= 6.5	(complex)
7	5.5 < PHH2 <= 8.5	(complex)
8	7.5 <= PHH2	(complex)

[a] See text and Table 4 for details. The relative area (%) in a grid cell represented by the specified class (*FinCLAS*), with code *FinRAT*, is documented under *FinAREA*. PHH2 is the abreviation for soil pH, measured in water (seeTable1).

In case of single 'terrestrial' classes, the relative area (FinArea) of the dominant class (FinRAT) is always ≥ 55%, see for example map unit 17833. In case of complex map units (see 8), however, this may be less. In map unit 36342, for example, land (LN) units cover some 58% of the grid cell, while the dominant soil complex (8) covers only 32% of the total land area.

SNUM	FinRAT	FinAREA	CLAS1	CLAS2	CLAS3	CLAS4	CLAS5	SO	RK	LN	WT	GL
17833	4	65.5	19.5	10	5	65.5	0	100	0	100	0	0
45580	8	69.4	0	25	0	32.6	36.8	94.4	0	94.4	5.6	0
31563	8	*55.7*	0	13.3	4.6	49	6.7	73.6	26.4	100	0	0
36342	8	*31.7*	23.4	3.3	0	0	31.7	58.4	0	*58.4*	41.6	0

Appendix 2: Installation procedure and contents of data set

The soil parameter estimates and GIS image files are provided in one single zip file called W*ISE30by30min.zip*. The file size is about 94 Mb zipped and about 1.3 GB unzipped. The various folders and individual files are listed in Table A.

The compressed file can be unzipped to any folder (X), in which all files will be decompressed to subfolder *X:\WISE30by30min*. This subfolder will contain:

1) The project's apr-file: *wise30by30_ver1.apr*. This file should be accessed from within ArcView®.

2) The MSAccess® database containing all the soil parameter estimates, both in an *un-binned* and *binned* format (*WISE30by30min.mdb*; see Appendix 1 for details).
3) Five subfolders: WISEsnum, which holds the grid (*VALUE*) and map unit (*SNUM*) references; *DBF*, which holds dBaseIV versions of the parameter estimates and explains the legends used for the *binned* data sets; *Info,* which holds the GIS topology; *LegendFiles,* with selected ArcView legend files*;* and, *Readme1st* with a brief documentation and the current report.

The first time the project is opened and saved on a new system, the path statements will be automatically updated to the new folder-settings in the new project or apr-file.

Only a limited selection of possible outputs (views) has been included in the GIS project file. Other selections can easily be generated by joining the relevant attribute tables to the gridded data using fields *SNUM* and *VALUE* for the linkage.

Commercially available ArcView® GIS software, inclusive of the Spatial Analyst® extension, is needed to manage the GIS files (ESRI 1996). The current project file can be imported into ArcGIS9-ArcMap® using the 'import from ArcView project …' button.

The project file was developed for use on a 17 inch screen.

Table A. Directory of folder C:\WISE30x30min

Folder and file names [a]	Size
Folders	
c:\wise30x30min\dbf	
c:\wise30x30min\info	
c:\wise30x30min\legendfiles	
c:\wise30x30min\readme1st	
c:\wise30x30min\wisesnum	
C:\WISE30x30min\	
isric-disclaimer.tif	914 KB
wise30by30min.ldb	1 KB
wise30by30min.mdb	304000 KB
wise30x30min_ver1.apr	267 KB
wise30x30min_ver1__bak.apr	267 KB

c:\wise30x30min\dbf

- *Binned data sets*

alsat_s.dbf	11711 KB
alsat_t.dbf	11711 KB
bsat_s.dbf	11711 KB
bsat_t.dbf	11711 KB
bulk_s.dbf	11711 KB
bulk_t.dbf	11711 KB
caco3_s.dbf	11711 KB
caco3_t.dbf	11711 KB
cecc_s.dbf	11711 KB
cecc_t.dbf	11711 KB
cecs_s.dbf	11711 KB
cecs_t.dbf	11711 KB
clay_s.dbf	11711 KB
clay_t.dbf	11711 KB
cn_s.dbf	11711 KB
cn_t.dbf	11711 KB
dept_p.dbf	11711 KB
drain_p.dbf	11711 KB
ece_s.dbf	11711 KB
ece_t.dbf	11711 KB
esp_s.dbf	11711 KB
esp_t.dbf	11711 KB
grav_s.dbf	11711 KB
grav_t.dbf	11711 KB
gyps_s.dbf	11711 KB
gyps_t.dbf	11711 KB
orgc_s.dbf	11711 KB
orgc_t.dbf	11711 KB
phh2o_s.dbf	11711 KB
phh2o_t.dbf	11711 KB
tawc2_p.dbf	11711 KB
teb_s.dbf	11711 KB
teb_t.dbf	11711 KB
totn_s.dbf	11711 KB
totn_t.dbf	11711 KB

- *Un-binned data sets*

yalsat.dbf	27865 KB
ybsat.dbf	27865 KB
ybulk.dbf	27865 KB
ycaco3.dbf	27865 KB
ycecc.dbf	27865 KB
ycecs.dbf	27865 KB
ycfrag.dbf	27865 KB
yclay.dbf	27865 KB
ycn.dbf	27865 KB
ydepth.dbf	18891 KB
ydrain.dbf	19788 KB
yece.dbf	27865 KB
yesp.dbf	27865 KB
ygyps.dbf	27865 KB
yorgc.dbf	27865 KB
yphh2o.dbf	27865 KB

```
ysand.dbf                                28763 KB
ysilt.dbf                                28763 KB
ytawc2.dbf                               18891 KB
yteb.dbf                                 27865 KB
ytpor.dbf                                28763 KB

- Legend files (for binned data sets)
legend_alsat.dbf                             1 KB
legend_bsat.dbf                              1 KB
legend_bulk.dbf                              1 KB
legend_caco3.dbf                             1 KB
legend_cecc.dbf                              1 KB
legend_cecs.dbf                              1 KB
legend_clay.dbf                              1 KB
legend_cn.dbf                                1 KB
legend_dept.dbf                              1 KB
legend_drain.dbf                             1 KB
legend_ece.dbf                               1 KB
legend_esp.dbf                               1 KB
legend_grav.dbf                              1 KB
legend_gyps.dbf                              1 KB
legend_orgc.dbf                              1 KB
legend_phh2o.dbf                             1 KB
legend_tawc2.dbf                             1 KB
legend_teb.dbf                               1 KB
legend_totn.dbf                              1 KB


c:\wise30x30min\info
arc.dir                                      4 KB
arc0000.dat                                  1 KB
arc0000.nit                                  1 KB
arc0001.dat                                  1 KB
arc0001.nit                                  1 KB
arc0002.dat                                  1 KB
arc0002.nit                                  1 KB
arc0002r.001                               366 KB
arc0003.dat                                  1 KB
arc0003.nit                                  1 KB
arc0004.dat                                  1 KB
arc0004.nit                                  1 KB
arc0005.dat                                  1 KB
arc0005.nit                                  1 KB
arc0005r.001                                42 KB
arc0006.dat                                  1 KB
arc0006.nit                                  1 KB
arc0007.dat                                  1 KB
arc0007.nit                                  1 KB
arc0008.dat                                  1 KB
arc0008.nit                                  1 KB
arc0008r.001                               366 KB
arc0009.dat                                  1 KB
arc0009.nit                                  1 KB
arc0010.dat                                  1 KB
arc0010.nit                                  1 KB
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arc0011.dat                                1 KB
arc0011.nit                                1 KB
arc0011r.001                               2 KB


c:\wise30x30min\legendfiles
depth of soil.avl                          5 KB
drainage.avl                               5 KB
landarea.avl                               5 KB
organic carbon.avl                         5 KB
ph_water.avl                               5 KB
tawc2.avl                                  5 KB


c:\wise30x30min\readme1st
isric_report_2005_08.pdf                 362 KB
readme1st---wise30x30min instal...        80 KB



c:\wise30x30min\wisesnum
dblbnd.adf                                 1 KB
hdr.adf                                    1 KB
log                                        1 KB
sta.adf                                    1 KB
vat.adf                                  358 KB
w001001.adf                              202 KB
w001001x.adf                               5 KB
```

[a] The data are stored in 5 folders, including some 130 files. Total file size is some 1.3 GB unzipped and 94 MB zipped.

———