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WORLD INVENTORY OF SOIL EMISSION POTENTIALS

GUIDELINES FOR SOIL PROFILE SELECTION AND PROTOCOL FOR COMPLETING THE WISE DATA ENTRY SHEETS

Batjes, N.H.

February 1993

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INTERNATIONAL SOIL REFERENCE AND INFORMATION CENTRE

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World Inventory of Soil Emissions: Report of Working Group Discussions and Recommendations. Proceedings of an international workshop organized in the framework of the Netherlands National Research Programme on Global Air Pollution and Climate Change (24-27 August 1992). WISE Report No. 1, ISRIC, Wageningen, ii + 20 p.

World Inventory of Soil Emission Potentials. Proceedings of an International Workshop organized in the framework of the Netherlands National Research Programme on Global Air Pollution and Climate Change (24-27 August 1992). WISE Report No. 2, ISRIC, Wageningen, iv + 122 p. [ISBN 90-6672-049-2].

A Review of Soil Factors and Processes that Control Fluxes of Heat, Moisture and Greenhouse Gases. Technical Paper 23 / WISE Report 3, ISRIC, Wageningen, viii + 201 p. [ISBN 90-6672-048-4].

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1 Introduction

1.1 Soil databases under development at ISRIC

Internationally there is an increasing demand for quantitative information on a wide range of soil attributes for applications in the field of land evaluation, crop production potentials and to model the consequences of a range of processes of global change (Bliss, 1990; Oldeman and Sombroek, 1990). To meet this demand, the International Soil Reference and Information Centre (ISRIC) has been developing several soil databases. These include the ISRIC Soil (Pedon) Information System (ISIS; Van Waveren and Bos, 1988a and 1988b), a comprehensive digital World Soils and Terrain Database with a spatial resolution of 1:1 M (SOTER; Van Engelen and Wen Ting-tiang, 1993), a more generalized soil database with a spatial resolution of 1:5 M (WISE; Batjes and Bridges, 1992a), and a cartographic and bibliographic information system of soil and terrain resources (STRING).

This report describes the procedures for collecting and storing soil profile data for the WISE database, which is being developed at ISRIC within the framework of a project on 'World Inventory of Soil Emissions Potentials' (Batjes and Bridges, 1992a and 1992b). The WISE project is carried out within the wider framework of the Netherlands National Research Programme on Global Air Pollution and Climate Change (NOP-MLK). A background to the WISE project is given in Section 2.

The activities of WISE are complementary to the other soil database developments taking place at ISRIC. Important differences in objectives between ISIS, SOTER and WISE are as follows. ISIS is a database of reference pedons that has been developed to store and handle the documentation of ISRIC's Soil Reference Collection (Van Waveren and Bos, 1988a and 1988b). Each soil profile in ISIS is meant to be representative for the 'central concept' of a particular FAO soil unit, but it need not be the most representative profile for the considered soil unit in terms of spatial extent in any particular area. Appropriate profiles are identified, sampled and analyzed within the framework of a 'National Soil Reference Collection and Database' (NASREC), using a standard set of analytical procedures (Van Reeuwijk, 1992). A 'simplified' variant of ISIS, known as SDB, is in use in various field projects of FAO (FAO-ISRIC, 1989).

SOTER involves a full-scale update of both the soil boundaries and soil typology worldwide, at a scale of 1:1 M. Underlying the SOTER approach is the grouping and mapping (polygon based) of land areas showing a distinctive and often repetitive pattern of landform, slope, parent material and soils. These areas are delineated on the base map as SOTER units. Each SOTER unit is geo-referenced and linked into a digital database with the key attributes of their component terrain and soil units (see Van Engelen & Wen Ting-tiang, 1993). SOTER provides a tool for proceeding with an update of the Soil Map of the World, which was compiled at a scale of 1:5 M by FAO-Unesco (1971-1981), the information of which is known to be partly out of date. This update would be at a scale of 1:1 M. In view of the magnitude of the task ahead, worldwide coverage by SOTER is scheduled to take from 10 to 20 years. Meanwhile, there remains a demand for a comprehensive, 'interim' digital dataset of global soil resources, presenting more information than the databases which have been derived from the original, printed version of the Soil Map of the World (e.g. Zobler, 1986). The WISE project aims to provide a basic dataset of soil profiles, considered representative for the soil units shown on the 'cleaned', digital version of the 1:5 M Soil Map of the World, within 2 years.

Another soil database development at ISRIC is the development of a cartographic and bibliographic information system of soil and terrain resources (STRING). Unlike SOTER and WISE which essentially focus on characterizing properties of major world soils and their geographical distribution, the aim of a STRING is to present a regional inventory of published bibliographic and cartographic documentation on soil and terrain resources. It also gives details about the national and regional institutions responsible for soil resources inventories. A methodology for STRING is being developed and applied for the Region of the Sahara and Sahel Observatory (OSS). It may form the basis for similar activities in other parts of the world. Ultimately, the linkage of ISIS, SOTER and STRING will permit the development of an integrated information system on soil and terrain resources.

1.2 Structure of report

A background to the WISE project is given in Section 2.1. Guidelines for selecting appropriate soil profiles for inclusion in WISE are presented in Section 2.2. The general structure of the soil-attribute component of the WISE database is discussed in Section 2.3. Conventions for encoding the site and horizon data are listed in Section 3. Concluding remarks and a broad time-frame for developing and implementing the WISE database are presented in Section 4. A proforma data entry sheet is attached as Appendix 6, while the preceding appendices include the coding conventions for the country codes, FAO-Unesco 1974 Legend, FAO-Unesco's Revised Legend of 1988, and a procedure for encoding analytical methods and 'sources'.

2 The WISE database

2.1 Background

One of the proposed applications of the WISE database, within the framework of the NOP-MLK programme, will be to refine current estimates of potential methane production of hydromorphic soils. Other possible applications of a global database of soil resources include land evaluation, an overall assessment of the vulnerability of soils to pollution, and an assessment of the greenhouse gas emission potential of soils. A difficulty in identifying the attributes that should be included in the WISE database is that all possible applications of the database cannot be determined *a priori*. As new environmental problems arise, the data needs may change. In many situations, models still have to be developed and parameterized. Sensitivity analyses will be needed to show which soil attributes are 'most' important at the considered spatial scale of 1:5 million or, alternatively, whether other environmental factors, such as climate, geology, hydrology and land use are more significant controls with respect to a particular 'problem'. Consequently, a basic list of 'commonly required' site and soil attributes is proposed for inclusion in the WISE database. It is an amalgamation of the attributes identified as being important by the WISE workshop (Batjes, 1992), the IGBP-DIS and GCTE workshop at Silsoe (October 1992), and those listed in the 'Guidelines for completing proformas: EC Soil Analytical Database' (Madsen and Jones, 1992).

In the WISE project, geo-referenced profile data or 'point data' will be linked into a rasterized version of the 'cleaned', digital version of the 1:5 million scale Soil Map of the World (SMW92), released in 1992 by FAO-AGLS. Each grid cell will be characterised by its main soil units; a suitable procedure for the rasterization of SMW92 is being developed by FAO in collaboration with ISRIC (Van Engelen, 1992; Nachtergaele, 1992). The general format of the files of SMW92 has been presented by FAO (1991).

The Legend of the original Soil Map of the World (FAO-Unesco, 1974) is used to group soil units in WISE. The classification (map unit code) and geographical coordinates provide the logical 'link' for relating the 'point data' stored in the profile database into the 'area data' shown on the gridded SMW92 (Figure 1).

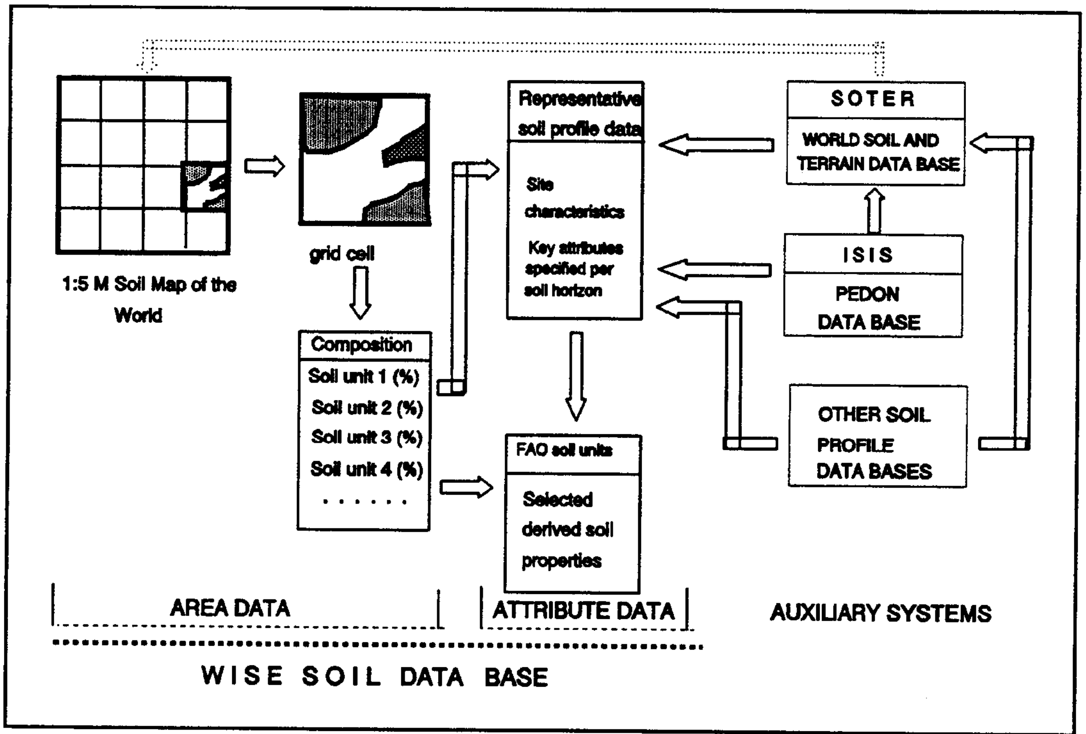

Figure 1. Schematic representation of the WISE database (From Batjes, 1992)

The following paragraphs present guidelines to enable a standardized selection, storage and subsequent manipulation of the site and profile data that are needed to compile the soil profile component of the WISE database. They are based on the procedures developed for ISIS (Van Waveren and Bos, 1988b) and SOTER (Van Engelen and Wen Ting-tiang, 1993), with simplifications necessary to accommodate the 'broader' scope of the WISE database development activity.

2.2 Criteria for selecting soil profiles

Since the early days of pedology, a wide range of soil profiles has been described and analyzed from the various regions of the globe. The collection of reliable data is the most important step in creating any database. ISRIC is looking for profiles, representative of areas covered by the dominant, associated and included SMW soil units in a particular area.

Individual soil units of the Soil Map of the World occur in widely differing environments, for instance in terms of climate and parent material, which will be reflected in the soil properties. As a result, a stratification of soil profiles within a particular FAO-Unesco soil unit is necessary. The original Luvisols (FAO-Unesco, 1974), for instance, are now divided into Lixisols and Luvisols with reference to their cation exchange properties (FAO-Unesco, 1988). Lixisols, with mainly low activity clays predominate in the warm tropics on strongly weathered materials, whereas less strongly weathered Luvisols are extensive in cooler regions. A climatic stratification, such as the Köppen classification, should be superimposed onto the Soil Map of the World to provide a framework for presenting regional differences in properties of Luvisols, for instance.

The profiles can be entered into a basic standard data set containing a number of soil properties/attributes which can be used for global modelling purposes. ISRIC's experience is that this information is available but variable in content, so it is necessary to make a selection. Inevitably, there will be some details of profiles or analyses which remain unavailable, but providing descriptions are full and most analyses are present, they are acceptable for WISE's purpose (all missing data will be 'flagged'). The quality of soil data internationally and variable 'spatial relevance' are recognized as being a 'sensitive' issue in any soil database compilation activity (Bouma *et al.*, 1989; Mausbach *et al.*, 1991). As WISE is a short-term project, a pragmatic approach must be adopted when collecting a set of regionally representative soil profiles.

The profiles should be chosen from already described profiles of soils occurring in the region/country and should be representative of the map units of the Soil Map of the World, starting with the dominant and associated soil units. It may well be that the Institute/Organization has several suitable profiles from a soil unit from different parts of the country. If regional differences in climate, physiography and lithology are reflected in the soils, a form/photocopy for each description should be provided. The ideal format would be to have soil profiles described according to the Guidelines for Soil Description (FAO-ISRIC, 1990), but other formats are also acceptable. Soil profiles collected prior to the 1960s, in principle, shall not be considered in WISE as techniques for sampling, describing and analyzing soils have greatly improved since that time, making correlation difficult.

The number of soil profiles that is needed for a particular area will depend largely upon the complexity of the soil pattern and size of a country. The appropriate number, ISRIC has to leave to the expert judgement of national correlators. There is no maximum number, but with larger numbers of profiles the effectiveness of the database will be improved, allowing for a better estimation of medians and confidence intervals for selected (quantified) attributes.

It is desirable that the selected profiles have been analyzed as fully as possible and that the analyses have been carried out by a laboratory using quality control. A comprehensive summary of the analytical methods is necessary so that results of different methods of analysis used by different laboratories can be correlated (in so far as technically feasible). A copy of the analytical methods should be enclosed with the profile data sheets so that these can be 'encoded' as a key-attribute file linked to the profile data (see Appendix 4).

2.3 Structure of soil attribute database

Basically, the profile database includes two main files, with associated key-files that allow computerized 'translation' of the coding systems used, namely the SITE and HORIZON file (Figure 2). The site data and analytical data for the respective horizons ISRIC wishes to include in the WISE profile database, are presented in Sections 3.1 and 3.2. A proforma data entry sheet is attached as Appendix 6.

The relevant information can only be processed and computerized at ISRIC in a meaningful manner if the following guidelines are strictly adhered to. The non-numerical or descriptive site information, inherently, will be given as classes. A draw-back of using classes is that the information has to be aggregated into a limited number of categories with somewhat arbitrarily defined boundaries. The class-boundaries and names adopted here are those of the 'Guidelines for Soil Description' (FAO-ISRIC, 1990). In situations where other definitions and class-boundaries have been used, these should clearly be specified. Regrouping and processing of the collected class-data into the classes used in WISE would be done at ISRIC, so as to permit a check on data quality.

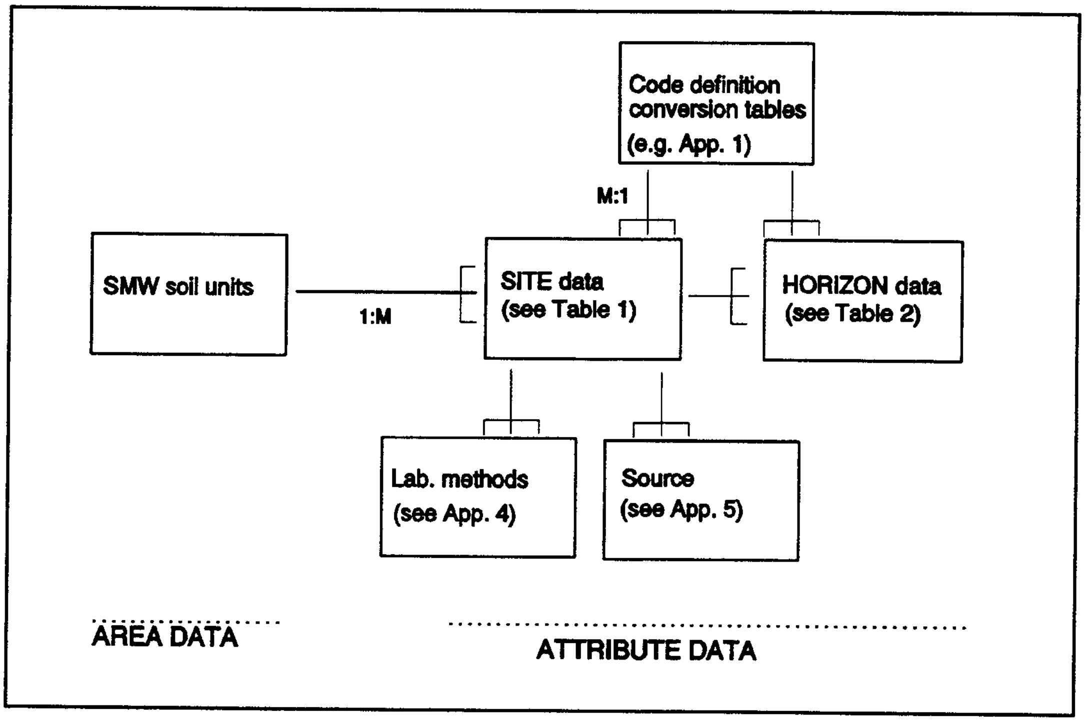

Figure 2. Schematic representation of the SITE and HORIZON data files, and related key-attribute files (M:1 stands for many to one relations, and 1:M for one to many relations)

Chemical and physical data from 'actual' profiles are stored as 'measured values', indicating the methods according to which they were determined. Such data are needed to calculate ranges (e.g. extremes, medians and standard deviations) for selected soil characteristics. They will permit the development of pedotransfer functions and provide a basic input for quantitative models. If the need arises, measured data can always be recombined into class-values according to the specific needs of the user. This is a useful feature as boundaries for defining classes differ widely between countries (Vogel, 1986). These common differences in class definitions and boundaries often make it difficult to 'correlate' classes between different systems, making it difficult to off-load this type of information from one digital system to another. For instance, slope -classes in ISIS (Van Waveren and Bos, 1988a), SDB (FAO-ISRIC, 1989) and the 'Guidelines for Soil Description' (FAO-ISRIC, 1990) are difficult to equate.

The procedures for WISE will be adopted from those of the ISIS software. Attributes for which no information is available or which have not been measured should be labelled '-99' (minus 99). A consequent use of this convention is crucial to ensure the integrity of the database; the dBASE III$^+$ and dBASE IV software does not differentiate between 'zero' values and 'empty numerical fields'.

3 Attributes and coding procedures

3.1 Site attributes

3.1.1 Soil reference number and classification

The attributes proposed for the SITE data file are listed in Table 1 and the coding procedure is described in the following paragraphs.

Table 1. List of attribute data for the SITE data file

WISE_ID	unique in WISE
Soil classification and source	
FAO-Unesco classification (1974 Legend)	Mandatory
Phase	
Topsoil texture class	
FAO-Unesco classification (1988 Revised Legend)	
Phase	
USDA subgroup level classification	
Edition (year) of Soil Taxonomy	
Local classification	
Source	
Laboratory name and ID	
Soil profile description status	
Date of description	
Location	
Country	
Location of soil profile	
Latitude	
Longitude	
Altitude	
General site data	
Major landform	
Landscape position	
Aspect	
Slope	
Drainage class	
Groundwater depth	
Soil depth to rock, impervious layers, etc.	
Parent material	
Remarks on parent material	
Köppen climate classification	
Name of (representative) climate station	
Land use or vegetation	

WISE_ID:
This code, which provides the reference to the soil profile in question, consists of the country's ISO-3166 code (see Appendix 1), followed by 3 numbers (Example: BR022). A unique code will be generated at ISRIC when the profile data are entered into the computer.

FAO-Unesco classification (1974):

Classification of profiles according the 1974 Legend of FAO-Unesco is mandatory, as it is needed to link the profile 'point data' in the 'area data' shown on the gridded, digital version of the Soil Map of the World. The classifications will be encoded using Appendix 2.

FAO-Unesco phase (1974):

The (main) phase is to be specified using the codes presented in the table below.

Code	Description
ST	stony
PE	petric
MK	petrocalcic
LI	lithic
MY	petrogypsic
PH	phreatic
X	fragipan
MQ	duripan
Z	saline
SO	sodic
CE	cerrado
MS	petroferric

Topsoil texture class (FAO-Unesco, 1974):

This refers to the textural class of the upper 30 cm of the mineral soil. Three classes are considered as follows:

Code	Description	Range in % clay and sand
C	coarse textured	< 15% clay* and > 65% sand
M	medium textured	< 35% clay and < 70% sand or $\leq$ 85% clay if clay $\geq$ 15%
F	fine textured	> 35% clay

* Clay, silt and sand-size minerals as used in FAO-ISRIC (1990).

FAO-Unesco classification (1988):

These are to be encoded using the symbols shown in Appendix 3. A useful summary of changes in FAO-Unesco soil units in the 1974 and Revised Legend is given in the Booker Tropical Soil Manual (Landon, 1991 p. 449).

FAO-Unesco phase (1988):
The (main) phase is to be specified using the codes presented below:

Code	Description
AN	anthraquic
DU	duripan
FR	fragipan
GE	gelundic
GI	gilgai
IN	inundic
SK	skeletic
YR	yermic

Code	Description
PF	petroferric
PH	phreatic
PL	placic
SO	sodic
RU	rudic
SA	salic
TK	takyric
LI	Lithic

USDA Soil Taxonomy and edition of classification system:
To be specified at the subgroup level, as a text string with a maximum length of 50 characters. A second column is provided to specify the version/year of the USDA system that has been used (e.g. 1975, 1987, 1990, 1992).

Soil classification according to National System:
To be entered as a text-string, up to a maximum of 50 characters (abbreviate if necessary).

Source:
These fields contain the reference to the source from which the soil profile data were derived, using a text-strings for the author(s) plus initials, up to a maximum of 70 characters, and the year of publication respectively. A more extensive description is given in the relevant conversion-file (see Appendix 5).

Laboratory methods:
This field provides a reference to the laboratory where the measurements have been made (see Appendix 4) and the procedures that have been followed to determine a certain attribute (see Table 3).

Date of description:
Specified as month and year (MM/YY).

Soil profile description status:
The status of the soil profile description refers to the (likely) quality of the soil description and the analytical data. The status is allocated after screening of the profile description and analytical data sheets. It may serve as an indicator of the accuracy and reliability of the data shown. The following distinctions are made (modified after FAO-ISRIC, 1990).

Code	Description
1	ISIS or other Reference Pedon Description (additional information is provided under the heading 'Source').
2	Routine profile description in which no essential data are lacking from the description, sampling or analysis.
3	Incomplete description in which certain relevant elements are missing from the description, an insufficient number of samples collected, or the reliability of the analytical data do not permit a complete characterization of the soil. The description is however useful for specific purposes and provides a satisfactory indication of the nature of the soil in the FAO-Unesco (1974) Legend.
4	Other descriptions in which essential elements are lacking from the description, preventing a satisfactory soil characterization and classification*.

* Generally not recommended for consideration in WISE.

3.1.2 Location and general site attributes

Country:
The country code is specified according to ISO-codes as listed in Appendix 1.

Location: latitude and longitude of soil profile
In instances where no coordinates have been provided with the original descriptions, the geographical location can be given as a text-string (e.g. town, province). Ideally, the full coordinates of the soil profile are given as degrees, minutes and seconds latitude (N or S) and longitude (E or W). The coordinates can be derived from an appropriately detailed topographical map.

Altitude of soil profile:
The elevation relative to mean sea level is to be specified in meters, preferably from a detailed topographical map. The elevation is to be specified in metres (1 foot = 0.3048 m).

Major landform:
Major landforms are described principally by their morphology and not by their genetic origin, or processes responsible for their shape. The first differentiating criterion is the dominant slope, followed by relief intensity. Four groups are distinguished at the highest level of landform separation, conform to the SOTER procedures (see Van Engelen and Wen Ting-tiang, 1993):

Code	Landform	Description
L	Level lands	Lands with characteristic slopes of 0-8 %, and a relief intensity of less than 100 m per km.
S	Sloping lands	Lands with characteristic slopes of 8-30 % and a relief intensity of more than 50 m per slope unit. Areas with a limited relief intensity (< 50 m per slope unit) but slopes in excess of 8% are included, as are isolated mountains (relief intensity > 600 m) with slopes of 8-30 %.
T	Steep lands	Lands with characteristic slopes of over 30 % and a relief intensity of mostly more than 600 m per 2 km.
C	Lands with composite landforms	Lands made up of steep elements together with sloping or level lands, or sloping lands with level lands, in which at least 20 % of the area consists of land with the lesser slope.

Codes for second level major landforms will be used in the WISE database. The initial breakdown of major landforms is made according to the procedures of the SOTER Manual (Van Engelen and Wen Ting-tiang, 1993).

First level	Second level	Gradient	Relief intensity
L - level land	LP - plain	0-8%	< 100 m/km
	LL - plateau	0-8%	< 100 m/km
	LD - depression	0-8%	< 100 m/km
	LF - low-gradient footslope	0-8%	< 100 m/km
	LV - valley floor	0-8%	< 100 m/km
S - sloping land	SM - medium-gradient mountain	15-30%	> 600 m/2km
	SH - medium-gradient hills	8-30%	> 50 m/s.u.
	SE - medium-gradient escarpment zone	15-30%	< 600 m/2km
	SR - ridges	8-30%	> 50 m/s.u.
	SU - mountainous highland	8-30%	> 600 m/2km
	SP - dissected plain	8-30%	> 50 m/s.u.
T - steep land	TM - high-gradient mountain	> 30%	> 600 m/2km
	TH - high-gradient hill	> 30%	< 600 m/2km
	TE - high-gradient escarpment zone	> 30%	> 600 m/2km
	TV - high gradient valleys	> 30%	variable
C - lands with composite landforms	CV - valley	> 8%	variable
	CL - narrow plateau	> 8%	variable
	CD - major depression	> 8%	variable

Note: s.u. stands for slope unit. Where this is not clear from the gradient or relief intensity, the distinction between the various second level major landforms follows from the description

Landscape position:

The physiographic position of the site where the profile is located is specified as follows (after FAO-ISRIC, 1990 p. 7).

Code	Description
Position in undulating to mountainous terrain	
CR	Crest
UP	Upper slope
MS	Middle slope
LS	Lower slope
BO	Bottom (flat)
Position in flat or almost flat terrain	
HI	Higher part
IN	Intermediate part
LO	Lower part
BO	Bottom (drainage line)

Aspect:

The aspect of the site is to be entered as a text code, using the following format: N, NNE, NE, ENE, E, ..., NNW. In case of flat or almost level land, the aspect is indicated as O.

```
         N
     NNW NNE
    NW      NE
  WNW        ENE
W        O        E
  WSW        ESE
    SW      SE
     SSW SSE
         S
```

Slope:

The slope refers to the inclination of the land immediately surrounding the site. The measured or estimated slope angle is specified according to the nearest per cent.

Drainage class:

The internal drainage class is specified according to the classes and coding conventions of FAO-ISRIC (1990 p. 20). Intergrades may be indicated by a combination of two class codes, for instance 'VP' for very poor to poor drainage.

Code	Description
V	very poorly drained
P	poorly drained
I	somewhat poorly (imperfectly) drained
M	moderately well drained
W	well drained
S	somewhat excessively drained
E	excessively drained

Depth of groundwater table:

Specify the measured or estimated depth to the groundwater table, if present, indicating the mean highest and mean lowest depths during a year, in centimetres from the surface. If the water-table always occurs at a great depth, this should be indicated by entering similar values for the mean high and low values (e.g. 200 cm).

Soil depth to rock:

This refers to the average measured or estimated depth, in cm, to a layer that *physically* precludes the development of most roots. Limitations of a chemical nature, such as high levels of salt/alkali, are not considered under this heading.

Parent material or lithology:

The main parent rock/material over which the soil has been formed is specified using the categories considered in the SOTER manual (Van Engelen and Wen Ting-tiang, 1993) and FAO-ISRIC (1990, p. 14). When necessary, additional remarks about the parent material can be specified as 'text' on the proforma, with a maximum length of 50 characters.

Major class		Group		Type	
I	igneous rock	IA	acid igneous	IA1	granite
				IA2	grano-diorite
				IA3	quartz-diorite
				IA4	rhyolite
		II	intermediate igneous	II1	andesite, trachyte, phonolite
				II2	diorite-syenite
		IB	basic igneous	IB1	gabbro
				IB2	basalt
				IB3	dolerite
		IU	ultrabasic igneous	IU1	peridotite
				IU2	pyroxenite
				IU3	ilmenite, magnetite, ironstone, serpentine
M	metamorphic rock	MA	acid metamorphic	MA1	quartzite
				MA2	gneiss, migmatite
		MB	basic metamorphic	MB1	slate, phyllite (pelitic rocks)
				MB2	schist
				MB3	gneiss rich in ferro-magnesian minerals
				MB4	metamorphic limestone (marble)
S	sedimentary rock	SC	clastic sediments	SC1	conglomerate, breccia
				SC2	sandstone, greywacke, arkose
				SC3	siltstone, mudstone, claystone
				SC4	shale
		SO	organic	SO1	limestone, other carbonate rocks
				SO2	marl and other mixtures
				SO3	coals, bitumen & related rocks
		SE	evaporites	SE1	anhydrite, gypsum
				SE2	halite
U	unconsolidated	UF	fluvial		
		UL	lacustrine		
		UM	marine		
		UC	colluvial		
		UE	eolian		
		UG	glacial		
		UP	pyroclastic		
		UO	organic		

Köppen climate classification:

The climate classification at the site is given according to the Köppen system which considers precipitation effectiveness for plant growth as the major classification factor, and uses the appropriate seasonal values of temperature and precipitation to determine the limits of climatic groupings.

The Köppen system figures a shorthand code of letters designating major climate groups, subgroups within these major groups, with further subdivisions to distinguish particular seasonal characteristics of temperature and precipitation (adapted from Strahler, 1969 p. 224).

a) Major climate groups

Code	Classification and description
A	Tropical climates: Average temperature of every month is above 18 °C. These climates have no winter season. Annual rainfall is large and exceeds annual evaporation.
B	Dry: Potential evaporation exceeds precipitation on the average throughout the year. No water surplus; hence no permanent streams originate in B climate zones.
C	Warm temperate (mesothermal) climates: Coldest month has an average temperature under 18 °C, but above -3 °C. The C climates thus have both a summer and a winter season.
D	Snow (microthermal) climates: Coldest month average temperature under -3 °C. Average temperature of the warmest month above 10 °C, that isotherm corresponding approximately with poleward limit of forest growth.
E	Ice climates: A polar climate type with average temperature in no month averaging over 10 °C. These climates have no true summer

b) Subgroups

Subgroups within the major climate groups are designated by a second letter according to the following code:

S*	Steppe climate, a semiarid climate with about 380 to 760 mm of rainfall annually at low latitudes.
W	Desert climate. Arid climate. Most regions included have less than 250 mm of rainfall annually.
f	Moist. Adequate precipitation in all months. No dry season. This modifier is applied to major climate types A, C and D.
w	Dry season in winter of the respective hemisphere (low-sun season)
s	Dry season in summer of the respective hemisphere (high-sun season)
m	Rainforest climate despite a short dry season in monsoon type of precipitation cycle. Applies only to A climates.

* The letters S and W are applied only to the dry climates (i.e. BS and BW).

From combinations of the two letter groups, 11 distinct climates emerge as follows:

Af	Tropical rainforest (also Am a variant of Af)
Aw	Tropical savanna
BS	Steppe climate
BW	Desert climate
Cw	Temperate rainy (humid mesothermal) climate with dry winter
Cf	Temperate rainy (humid mesothermal) climate moist all seasons
Cs	Temperate rainy (humid mesothermal) climate with dry summer
Df	Cold snowy forests (humid microthermal) climate moist in all seasons
Dw	Cold snowy forest (humid microthermal) climate with dry winter
ET	Tundra climate
EF	Climates of perpetual frost (ice-caps).

c) A third letter may be added to differentiate still more variations. Meanings are as follows:

a	With hot summer; warmest month over 22 °C (C and D climates)
b	With warm summer; warmest month below 22 °C (C and D climates)
c	With cool, short summer; fewer than four months over 10 °C (C and D climates)
d	With very cold winter; coldest months below - 38 °C (D climates only)
h	Dry-hot; mean annual temperature over 18 °C (B climates only)
k	Dry-cold; climates annual temperature under 18 °C (B climates only).

The final code to be stored in the WISE database thus consists of a combination of three letters, for example BWk would refer to a dry-cold, desert climate.

Name and coordinates of meteorological station:
When available, the name (and geographical coordinates) of a neighbouring climate station, considered representative for the climatic conditions at the site of the soil profile, should be specified on the proforma. A copy of average long-term data would be useful. Entry of these data into a climate file, using the format of the climate files attached to ISIS (Van Waveren and Bos, 1988b), is not considered a task of WISE.

Land use and Vegetation:
The current land use or vegetation at a site is described using the classes given by FAO-ISRIC (1990 p. 13) which are also used in SOTER.

- **S Settlement Industry**
  - SR Residential use
  - SI Industrial use
  - ST Transport
  - SC Recreational use
  - SX Excavations
- **A Crop Agriculture**
  - AA Annual field cropping
    - AA1 Shifting cultivation
    - AA2 Fallow system cultivation
    - AA3 Ley system cultivation
    - AA4 Rainfed arable cultivation
    - AA5 Wet rice cultivation
    - AA6 Irrigated cultivation
  - AP Perennial field cropping
    - AP1 Non-irrigated cultivation
    - AP2 Irrigated cultivation
  - AT Tree and shrub cropping
    - AT1 Non-irrigated tree crop cultivation
    - AT2 Irrigated tree crop cultivation
    - AT3 Non-irrigated shrub crop cultivation
    - AT4 Irrigated shrub crop cultivation
- **H Animal Husbandry**
  - HE Extensive grazing
    - HE1 Nomadism
    - HE2 Semi-nomadism
  - HI Intensive grazing
    - HI1 Animal Production
    - HI2 Dairying
    - HI3 Ranching
- **F Forestry**
  - FN Natural forest and woodland
    - FN1 Selective felling
    - FN2 Clear felling
  - FP Plantation forestry
- **M Mixed farming**
  - MF Agro-forestry
  - MP Agro-pastoralism (cropping and livestock systems)
- **E Extraction and Collection**
  - EV Exploitation of natural vegetation
  - EH Hunting and fishing
- **P Nature Protection**
  - PN Nature and game reserve
    - PN1 Reserves
    - PN2 Parks
    - PN3 Wildlife management
  - PD Degradation control
    - PD1 Without interference
    - PD2 With interference
- **U Not Used and Not Managed**

For arable use, the dominant crops which are grown should be mentioned (after FAO-ISRIC, 1990). Other 'combinations' of crops, and codes, may be added to the list as the need arises.

BA	Barley	GR	Groundnut	SO	Sorghum
BE	Beans	MA	Maize	SB	Soybean
CH	Cashew	MI	Millet	SC	Sugar cane
CA	Cassava	OP	Oil palm	SF	Sunflower
CO	Cocoa	PE	Peas	SP	Sweet potato
CC	Coconut	PO	Potato	TE	Tea
CF	Coffee	RI	Rice	TB	Tobacco
CT	Cotton	RB	Rice (flooded)	VE	Vegetables
CP	Cowpea	RU	Rice (upland)	WH	Wheat
FR	Fruit trees	RR	Rubber	YA	Yams

Vegetation:
The natural vegetation at a site is described using the broad classes given by Unesco (1973), conform with the coding conventions of SOTER:

F	**Closed Forest**		D	**Dwarf scrub**	
	FE	Evergreen forest		DE	Evergreen dwarf shrub
	FS	Semi-deciduous forest		DS	Semi-deciduous dwarf shrub
	FD	Deciduous forest		DD	Deciduous dwarf shrub
	FX	Xeromorphic forest		DX	Xeromorphic dwarf shrub
				DT	Tundra
W	**Woodland**		H	**Herbaceous**	
	WE	Evergreen woodland		HT	Tall grassland
	WS	Semi-deciduous woodland		HM	Medium grassland
	WD	Deciduous woodland		HS	Short grassland
	WX	Xeromorphic woodland		HF	Forb
S	**Scrub**				
	SE	Evergreen shrub			
	SS	Semi-deciduous shrub			
	SD	Deciduous shrub			
	SX	Xeromorphic shrub			

3.2 Horizon attributes

3.2.1 Introduction

For each of the individual horizons, the attributes listed in Table 2 are to be specified. The logical reference to the corresponding 'site data' file is provided by the unique combination of WISE_ID and HORIZON_NO.

It is recommended that no more than 6 soil horizons are presented on each data entry sheet. If more horizons have been described, it will be necessary to 'condense' this information into a smaller number; for instance numerical data for similar horizons, such as a Btg1 and Btg2, would have to be averaged.

The general, chemical and physical attributes which are to be specified for each major soil horizon, as characterized by its upper and lower depth below the surface, are discussed in the next paragraphs. Preferably, the horizon designation should be given according to the terminology of FAO-ISRIC (1990). Otherwise, the 'local' system should be used.

3.2.2 General attributes

Matrix colour:
In combination with information on current land use or vegetation, the surface colour may provide a measure for the possible (inferred) range in albedo. Colour of the subsurface horizons in combination with data on cation exchange capacity (CEC), organic matter content and clay content may provide a rough indication of the mineralogy.

Both the surface colour under dry and moist conditions are needed, using the Munsell Colour Charts. Munsell colour codes have the general form: hue, value, chroma (e.g. 5YR3/2).

Table 2. List of attributes of the HORIZON data file

WISE_ID
HORIZON_NO
General attributes
Depth, top
Depth, bottom
Horizon designation
Matrix colour (dry and moist)
Mottling
Presence of roots
*Chemical attributes**
Organic Carbon
Total N
Total P
pH-H_2O
pH-KCl
pH-$CaCl_2$
Electrical conductivity
Free $CaCO_3$
$CaSO_4$
Exchangeable Ca^{2+}
Exch. Mg^{2+}
Exch. Na^+
Exch. K^+
Exch. Al^{3+} + H^+ (exchangeable acidity)
Exch. Al^{3+} (exchangeable aluminum)
CEC soil (NH_4OAc at pH7)
ECEC soil
Base saturation
*Physical attributes**
Structure type
Particle size distribution:
w% sand (specify esd)
w% silt
w% clay
Stone and gravel content
Bulk density
Volume per cent water held at selected pF values
Hydraulic conductivity

*: Methods are to be specified in a separate 'analytical methods' key-attribute file.

Mottling:
The abundance of mottling is defined using the broad classes of FAO-ISRIC (1990 p.42).

Code	Description	% of occurrence
N	none	positive statement
V	very few	0-2 %
F	few	2-5 %
C	common	5-15 %
M	many	15-40 %
A	abundant	> 40 %

Presence of roots:
Information on both the size and abundance of roots is generally adequate to characterize their distribution in a profile. The abundance is coded as follows, with reference to the root size (FAO-ISRIC, 1990 p. 63):

Abundance of roots (expressed as number of roots per square decimeter)

Code	Quantity	Description
0	no roots	0
V	very few	1-20
F	few	20-50
C	common	50-200
M	Many	> 200

Description of root sizes

Code	Description	Diameter (mm)
V	very fine	< 0.5 mm
F	fine	0.5-2 mm
M	medium	2-5 mm
C	coarse	> 5 mm
X	all	very fine roots to coarse

3.2.3 Chemical data

Measured data are to be entered for both the chemical and physical attributes, indicating the methods of analysis and the laboratory where the analyses have been carried out (see Appendix 4). Coding conventions for the different analytical methods used to determine a specific attribute will be developed as the soil profile gathering programme proceeds (see Table 3).

Organic carbon:
Organic carbon (% by weight) is specified with 2 decimal places. The code for the measurement method is to be specified in the 'analytical methods' key attribute file.

Total Nitrogen:
Total nitrogen (% by weight) is rounded to 2 decimal places (to permit calculation of C/N quotients).

Total P:
Total P content, by weight, is specified as mg P_2O_5 kg^{-1} soil.

Table 3. Proposed method for coding analytical methods

Organic carbon:
OC1: Method of Walkley & Black for organic carbon
OC2: Loss on ignition (%)
OC.: ....
OCy: Method y
Total Nitrogen:
ON1: Wet digestion (Kjeldahl method; %)
ON.: ......
ONz: Method z
$CaCO_3$ content:
CA1: Calcimeter (%; CO_2-emitted)
CA.: ......
CAj: Method j
etc., for other methods

pH-H_2O:
Measured in water at a soil:water ratio which is to be specified in the 'analytical methods' key-file. One decimal is adequate.

pH-KCL:
Measured in 1 *M* KCl solution at the soil:solution ratio specified with the data.

pH-$CaCl_2$:
Measured in 1 *M* $CaCl_2$ solution at the soil:solution ratio specified with the data.

Electrical conductivity (EC):
Specify the EC for the horizon, indicating the soil:water ratio. The unit used is mS cm^{-1} or dS m^{-1}, originally mmho cm^{-1}, at 25 °C.

$CaCO_3$:
Total $CaCO_3$ content (% by weight) is rounded off to the nearest integer.

$CaSO_4$:
Total gypsum ($CaSO_4.2H_2O$) content, by weight %, is rounded off to the nearest integer.

Exchangeable bases (Ca^{2+}, Mg^{2+}, K^+ and Na^+):
To be specified in cmol(+) kg^{-1} for the 1 *M* ammonium acetate (NH_4OAc) method buffered at pH7.

Exchangeable acidity (Al^{3+} and H^+) and aluminum:
Obtained with a percolation of a soil sample with 1 *M* KCl. Exchangeable acidity is measured by titration of the percolate, and exchangeable aluminum is determined separately in the percolate. Both values are expressed as cmol(+) kg^{-1}.

Cation exchange capacity (CEC):
CEC is given in cmol(+) kg^{-1} according to the 1 *M* NH_4OAc method at pH7 (one decimal place).

Effective cation exchange capacity (ECEC):
ECEC is determined by summation of exchangeable bases and exchangeable aluminum, and expressed in cmol(+) kg^{-1}.

Base saturation (BS):
Defined as nearest integer, and expressed as sum of exchangeable cation bases (Ca^{2+}, Mg^{2+}, K^+ and Na^+) divided by the CEC, measured with the NH_4OAc method buffered at pH7, times 100%.

3.2.4 Physical data

Soil structure:
Describe the type of soil structure according to the classes of FAO-ISRIC (1990 p. 51), using the coding conventions shown below:

Code	Description of class	Code	Description
SG	single grain	AS	angular and subangular blocky
MA	massive	SA	subangular and angular blocky
GR	granular	SN	nutty subangular blocky
PR	prismatic	AW	angular blocky wedge-shaped
PS	subangular prismatic	AP	angular blocky parallelepiped
CO	columnar	PL	platy
AB	angular blocky	RS	rock structure
SB	subangular blocky	SS	stratified structure

Particle size distribution:

The particle size distribution refers to the fine earth fraction (< 2 mm). It is necessary to specify 'esd' or equivalent spherical diameter for the clay-, silt-, and sand-size fractions, indicating the relevant upper-limit (rounded to nearest integer) (Example: In USDA system: <2 μm, < 50 μm and < 2 mm). The weight percentages of sand-, silt- and clay-size materials are given as integers.

Stone and gravel content:

Give a visual estimate of the percentage of large rock and mineral fragments with a diameter larger than 2 mm, rounded off to the nearest 5 per cent.

Bulk density:

Bulk density is given as g cm^{-3}, using two decimals.

Soil water retention:

The *volume* percentage of water (MC) in the soil horizon, at selected pF-values, is to be specified as an integer. The moisture content is expressed on a percent by volume basis:

MC (% by volume v/v) = MC (% by weight w/w) x Bulk density (kg m^{-3})

The pF-values or suctions at which the soil water retention measurements were made must be specified on the data entry sheet (see Appendix 6). Indicate which pF values are considered to correspond with the Field Capacity and the Permanent Wilting Point so that the Available Water Capacity (AWC) can be calculated.

Note: pF is the $\log_{10}$ [head(cm of water)], i.e. a head of 100 cm of water corresponds with a pF of 2.0.
1 bar = 1017 cm of water = 100 kPa = 0.987 atmosphere.

Hydraulic conductivity:

When available, ISRIC would welcome data on hydraulic conductivity or permeability (cm hr^{-1}) at various soil moisture conditions (pF values); to this avail a column has been left open on the data entry sheet. Ideally, at least two values would be needed; the first for the saturated and the second for the non-saturated hydraulic conductivity.

4 Conclusions

The usefulness of the ultimate database will depend to a large extent upon the willingness and ability of national soil specialists in providing ISRIC, and by implication a wider range of researchers internationally, with the necessary data. All organizations (and researchers) that have contributed to the soil profile gathering activity will be acknowledged in the technical monograph that will accompany the ultimate WISE database. It is the intention - upon agreement of the sponsoring agency - that this database be made available in the public domain.

The aspect of variable quality and 'spatial relevance' of soil profile data at the international level is recognized as being a 'sensitive' in developing the database. Since WISE is a short-term project, a pragmatic approach must be adopted when collecting a set of soil profiles considered regionally representative for the major soil units. These profile data will be linked into a grid version of the Soil Map of the World. Depending on the international response, a prototype for a 'small part of the world' should start to emerge by the middle of 1993 while the full database is to be completed in 1994, providing the basic soil-data for making, for instance, a refined estimate of global, potential methane production of hydromorphic soil units.

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List of abbreviations

GCTE	Global Change and Terrestrial Ecosystems Project (IGBP)
FAO	Food and Agricultural Organization of the United Nations
ICSU	International Council of Scientific Unions
IGBP	International Geosphere-Biosphere Programme: A Study of Global Change (ICSU)
NASREC	National Soil Reference Collection
ISIS	ISRIC Soil Information System
ISRIC	International Soil Reference and Information Centre
ISSS	International Society of Soil Science
NOP	Netherlands National Research Programme on Global Air Pollution and Climate Change
SDB	Soil Database (FAO-ISRIC)
SMW	Soil Map of the World (1:5 M, FAO-Unesco)
SOTER	World Soils and Terrain Digital Database
Unesco	United Nations Educational, Scientific and Cultural Organization
USDA	United Stated Department of Agriculture
WISE	World Inventory of Soil Emission Potentials

App. 1. Country ISO-3166 codes (1992)

Code	COUNTRY
AF	Afghanistan
AL	Albania
DZ	Algeria
AS	American Samoa
AD	Andorra
AO	Angola
AI	Anguilla
AQ	Antarctica
AG	Antigua and Barbuda
AR	Argentina
AM	Armenia
AW	Aruba
AU	Australia
AT	Austria
AZ	Azerbaijan
BS	Bahamas
BH	Bahrain
BD	Bangladesh
BB	Barbados
BE	Belgium
BZ	Belize
BJ	Benin
BT	Bhutan
BO	Bolivia
BW	Botswana
BV	Bouvet Island
BR	Brazil
IO	British Indian Ocean Territory
BN	Brunei Darussalam
BG	Bulgaria
BF	Burkina Faso
BU	Burma
BI	Burundi
BY	Belarus
CM	Cameroon
CA	Canada
CV	Cape Verde
KY	Cayman Islands
CF	Central African Republic
TD	Chad
CL	Chile
CN	China
CX	Christmas Island
CC	Cocos Islands
CO	Colombia
CG	Congo
CK	Cook Islands
CR	Costa Rica
HR	Croatia
CU	Cuba
CY	Cyprus
CS	Czechoslovakia
CI	Côte d'Ivoire
DK	Denmark
DJ	Djibouti
DM	Dominica
DO	Dominican Republic
TP	East Timor
EC	Ecuador
EG	Egypt
SV	El Salvador
GQ	Equatorial Guinea
EE	Estonia
ET	Ethiopia
FK	Falkland Islands
FO	Faroe (Islands)
FJ	Fiji
FI	Finland
FR	France
GF	French Guiana
PF	French Polynesia
TF	French Southern Territories
GA	Gabon
GM	Gambia
GE	Georgia
DE	Germany, Fed. Rep. of
GH	Ghana
GI	Gibraltar
GR	Greece
GL	Greenland
GD	Grenada
GP	Guadeloupe
GU	Guam
GT	Guatemala
GN	Guinea
GW	Guinea-Bissau
GY	Guyana
HT	Haiti
HM	Heard and McDonald Islands
HN	Honduras
HK	Hong Kong
HU	Hungary
IS	Iceland
IN	India
ID	Indonesia
IR	Iran, Islamic Republic of
IQ	Iraq
IE	Ireland
IL	Israel
IT	Italy
JM	Jamaica
JP	Japan
JO	Jordan
KH	Kampuchea, Democratic
KZ	Kazakhstan
KE	Kenya
KI	Kiribati
KR	Korea, Republic of
KP	Korea, Dem. Peopl. Rep.
KW	Kuwait
KG	Kyrgystan
LA	Lao, People's Democratic Rep.
LB	Lebanon
LS	Lesotho
LR	Liberia
LY	Libyan Arab Jamahiri

LI	Liechtenstein
LT	Lithuania
LU	Luxembourg
MO	Macau
MG	Madagascar
MW	Malawi
MY	Malaysia
MV	Maldives
ML	Mali
MT	Malta
MH	Marshall Islands
MQ	Martinique
MR	Mauritania
MU	Mauritius
MX	Mexico
FM	Micronesia
MD	Moldova, Republic of
MC	Monaco
MN	Mongolia
MS	Montserrat
MA	Morocco
MZ	Mozambique
NA	Namibia
NR	Nauru
NP	Nepal
NL	Netherlands
AN	Netherlands Antilles
NT	Neutral Zone
NC	New Caledonia
NZ	New Zealand
NI	Nicaragua
NE	Niger
NG	Nigeria
NU	Niue
NF	Norfolk Island
MP	Northern Mariana Islands
NO	Norway
OM	Oman
PK	Pakistan
PW	Palau
PA	Panama
PG	Papua New Guinea
PY	Paraguay
PE	Peru
PH	Philippines
PN	Pitcairn
PL	Poland
PT	Portugal
PR	Puerto Rico
QA	Qatar
RE	Reunion
RO	Romania
RU	Russian Federation
RW	Rwanda
LC	Saint Lucia
WS	Samoa
SM	San Marino
ST	Sao Tome and Principe
SA	Saudi Arabia
SN	Senegal
SC	Seychelles
SL	Sierra Leone
SG	Singapore
SB	Solomon Islands
SO	Somalia
ZA	South Africa
ES	Spain
LK	Sri Lanka
SH	St. Helena
KN	St. Kitts and Nevis
PM	St. Pierre and Miquelon
VC	St. Vincent and the Grenadines
SD	Sudan
SR	Suriname
SJ	Svalbard and Jan Mayen
SZ	Swaziland
SE	Sweden
CH	Switzerland
SY	Syrian Arab Republic
TW	Taiwan, Province China
TJ	Tajikistan
TZ	Tanzania, United Republic of
TH	Thailand
TG	Togo
TK	Tokelau
TO	Tonga
TT	Trinidad and Tobago
TN	Tunisia
TR	Turkey
TM	Turkmenistan
TC	Turks and Caicos Islands
TV	Tuvalu
SU	USSR
UG	Uganda
UA	Ukraine
AE	United Arab Emirates
GB	United Kingdom
US	United States
UY	Uruguay
UM	US. Minor Outlying Islands
UZ	Uzbekistan
VU	Vanuatu
VA	Vatican City State
VE	Venezuela
VN	Viet Nam
VG	Virgin Islands (U.K.)
VI	Virgin Islands (U.S.)
WF	Wallis and Futuna Islands
EH	Western Sahara
YE	Yemen
YD	Yemen, Democratic
YU	Yugoslavia
ZR	Zaire
ZM	Zambia
ZW	Zimbabwe

App. 2. Codes for FAO-Unesco (1974) classification

Record#	KEY	UNIT
1	Af	ferric acrisol
2	Ag	gleyic acrisol
3	Ah	humic acrisol
4	Ao	orthic acrisol
5	Ap	plinthic acrisol
6	Bc	chromic cambisol
7	Bd	dystric cambisol
8	Be	eutric cambisol
9	Bf	ferralic cambisol
10	Bg	gleyic cambisol
11	Bh	humic cambisol
12	Bk	calcic cambisol
13	Bv	vertic cambisol
14	Bx	gelic cambisol
15	Cg	glossic chernozem
16	Ch	haplic chernozem
17	Ck	calcic chernozem
18	Cl	luvic chernozem
19	Dd	dystric podzoluvisol
20	De	eutric podzoluvisol
21	Dg	gleyic podzoluvisol
22	Fa	acric ferralsol
23	Fh	humic ferralsol
24	Fo	orthic ferralsol
25	Fp	plinthic ferralsol
26	Fr	rhodic ferralsol
27	Fx	xanthic ferralsol
28	Gc	calcaric gleysol
29	Gd	dystric gleysol
30	Ge	eutric gleysol
31	Gh	humic gleysol
32	Gm	mollic gleysol
33	Gp	plinthic gleysol
34	Gx	gelic gleysol
35	Hc	calcaric phaeozem
36	Hg	gleyic phaeozem
37	Hh	haplic phaeozem
38	Hl	luvic phaeozem
39	I	lithosol
40	Jc	calcaric fluvisol
41	Jd	dystric fluvisol
42	Je	eutric fluvisol
43	Jt	thionic fluvisol
44	Kh	haplic kastanozem
45	Kk	calcic kastanozem
46	Kl	luvic kastanozem
47	La	albic luvisol
48	Lc	chromic luvisol
49	Lf	ferric luvisol
50	Lg	gleyic luvisol
51	Lk	calcic luvisol
52	Lo	orthic luvisol
53	Lp	plinthic luvisol
54	Lv	vertic luvisol
55	Mg	gleyic greyzem
56	Mo	orthic greyzem
57	Nd	dystric nitosol
58	Ne	eutric nitosol
59	Nh	humic nitosol
60	Od	dystric histosol
61	Oe	eutric histosol
62	Ox	gelic histosol
63	Pf	ferric podzol
64	Pg	gleyic podzol
65	Ph	humic podzol
66	Pl	leptic podzol
67	Po	orthic podzol
68	Pp	placic podzol
69	Qa	albic arenosol
70	Qc	cambic arenosol
71	Qf	ferralic arenosol
72	Ql	luvic arenosol
73	Rc	calcaric regosol
74	Rd	dystric regosol
75	Re	eutric regosol
76	Rx	gelic regosol
77	Sg	gleyic solonetz
78	Sm	mollic solonetz
79	So	orthic solonetz
80	Th	humic andosol
81	Tm	mollic andosol
82	To	ochric andosol
83	Tv	vitric andosol
84	Vc	chromic vertisol
85	Vp	pellic vertisol
86	Wd	dystric planosol
87	We	eutric planosol
88	Wh	humic planosol
89	Wm	mollic planosol
90	Ws	solodic planosol
91	Wx	gelic planosol

92	Xh	haplic xerosol
93	Xk	calcic xerosol
94	Xl	luvic xerosol
95	Xy	gypsic xerosol
96	Yh	haplic yermosol
97	Yk	calcic yermosol
98	Yl	luvic yermosol
99	Yt	takyric yermosol
100	Yy	gypsic yermosol
101	Zg	gleyic solonchak
102	Zm	mollic solonchak
103	Zo	orthic solonchak
104	Zt	takyric solonchak

Unit codes

117	J	fluvisols
118	K	kastanozems
119	U	rankers
120	R	regosols
121	H	phaeozems
122	X	xerosols
123	D	podzoluvisols
124	P	podzols
125	W	planosols
126	Q	arenosols
127	G	gleysols
128	S	solonetz
129	T	andosols
130	M	greyzems
131	A	acrisols
132	N	nitosols
133	F	ferralsols
134	Z	solonchaks
135	E	rendzinas
136	C	chernozems
137	Y	yermosols
138	V	vertisols
139	B	cambisols
140	O	histosols
141	L	luvisols

App. 3. Codes for FAO-Unesco (1990) classification

Record#	KEY90	FAO90
1	FL	Fluvisols
2	FLe	Eutric Fluvisols
3	FLc	Calcaric Fluvisols
4	FLd	Dystric Fluvisols
5	FLm	Mollic Fluvisols
6	FLu	Umbric Fluvisols
7	FLt	Thionic Fluvisols
8	FLs	Salic Fluvisols
9	GL	Gleysols
10	GLe	Eutric Gleysols
11	GLk	Calcic Gleysols
12	GLd	Dystric Gleysols
13	GLa	Andic Gleysols
14	GLm	Mollic Gleysols
15	GLu	Umbric Gleysols
16	GLt	Thionic Gleysols
17	GLi	Gelic Gleysols
18	RG	Regosols
19	RGe	Eutric Regosols
20	RGc	Calcaric Regosols
21	RGy	Gypsic Regosols
22	RGd	Dystric Regosols
23	RGu	Umbric Regosols
24	RGi	Gelic Regosols
25	LP	Leptosols
26	LPe	Eutric Leptosols
27	LPd	Dystric Leptosols
28	LPk	Rendzic Leptosols
29	LPm	Mollic Leptosols
30	LPu	Umbric Leptosols
31	LPq	Lithic Leptosols
32	LPi	Gelic Leptosols
33	AR	Arenosols
34	ARh	Haplic Arenosols
35	ARb	Cambic Arenosols
36	ARl	Luvic Arenosols
37	ARo	Ferralic Arenosols
38	ARa	Albic Arenosols
39	ARc	Calcaric Arenosols
40	ARg	Gleyic Arenosols
41	AN	Andosols
42	ANh	Haplic Andosols
43	ANm	Mollic Andosols
44	ANu	Umbric Andosols
45	ANz	Vitric Andosols
46	ANg	Gleyic Andosols
47	ANi	Gelic Andosols
48	VR	Vertisols
49	VRe	Eutric Vertisols
50	VRd	Dystric Vertisols
51	VRk	Calcic Vertisols
52	VRy	Gypsic Vertisols
53	CM	Cambisols
54	CMe	Eutric Cambisols
55	CMd	Dystric Cambisols
56	CMu	Humic Cambisols
57	CMc	Calcaric Cambisols
58	CMx	Chromic Cambisols
59	CMv	Vertic Cambisols
60	CMo	Ferralic Cambisols
61	CMg	Gleyic Cambisols
62	CMi	Gelic Cambisols
63	CL	Calcisols
64	CLh	Haplic Calcisols
65	CLl	Luvic Calcisols
66	CLp	Petric Calcisols
67	GY	Gypsisols
68	GYh	Haplic Gypsisols
69	GYk	Calcic Gypsisols
70	GYl	Luvic Gypsisols
71	GYp	Petric Gypsisols
72	SN	Solonetz
73	SNh	Haplic Solonetz
74	SNm	Mollic Solonetz
75	SNk	Calcic Solonetz
76	SNy	Gypsic Solonetz
77	SNj	Stagnic Solonetz
78	SNg	Gleyic Solonetz
79	SC	Solonchaks
80	SCh	Haplic Solonchaks
81	SCm	Mollic Solonchaks
82	SCk	Calcic Solonchaks
83	SCy	Gypsic Solonchaks
84	SCn	Sodic Solonchaks
85	SCg	Gleyic Solonchaks
86	SCi	Gelic Solonchaks
87	KS	Kastanozems
88	KSh	Haplic Kastanozems
89	KSl	Luvic Kastanozems
90	KSk	Calcic Kastanozems
91	KSy	Gypsic Kastanozems
92	CH	Chernozems
93	CHh	Haplic Chernozems
94	CHk	Calcic Chernozems
95	CHl	Luvic Chernozems
96	CHw	Glossic Chernozems
97	CHg	Gleyic Chernozems
98	PH	Phaeozems
99	PHh	Haplic Phaeozems
100	PHc	Calcaric Phaeozems
101	PHl	Luvic Phaeozems
102	PHj	Stagnic Phaeozems
103	PHg	Gleyic Phaeozems

104	GR	Greyzems
105	GRh	Haplic Greyzems
106	GRg	Gleyic Greyzems
107	LV	Luvisols
108	LVh	Haplic Luvisols
109	LVf	Ferric Luvisols
110	LVx	Chromic Luvisols
111	LVk	Calcic Luvisols
112	LVv	Vertic Luvisols
113	LVa	Albic Luvisols
114	LVj	Stagnic Luvisols
115	LVg	Gleyic Luvisols
116	LX	Lixisols
117	LXh	Haplic Lixisols
118	LXf	Ferric Lixisols
119	LXp	Plinthic Lixisols
120	LXa	Albic Lixisols
121	LXj	Stagnic Lixisols
122	LXg	Gleyic Lixisols
123	PL	Planosols
124	PLe	Eutric Planosols
125	PLd	Dystric Planosols
126	PLm	Mollic Planosols
127	PLu	Umbric Planosols
128	PLi	Gelic Planosols
129	PD	Podzoluvisols
130	PDe	Eutric Podzoluvisols
131	PDd	Dystric Podzoluvisol
132	PDj	Stagnic Podzoluvisol
133	PDg	Gleyic Podzoluvisols
134	PDi	Gelic Podzoluvisols
135	PZ	Podzols
136	PZh	Haplic Podzols
137	PZb	Cambic Podzols
138	PZf	Ferric Podzols
139	PZc	Carbic Podzols
140	PZg	Gleyic Podzols
141	PZi	Gelic Podzols

142	AC	Acrisols
143	ACh	Haplic Acrisols
144	ACf	Ferric Acrisols
145	ACu	Humic Acrisols
146	ACp	Plinthic Acrisols
147	ACg	Gleyic Acrisols
148	AL	Alisols
149	ALh	Haplic Alisols
150	ALf	Ferric Alisols
151	ALu	Humic Alisols
152	ALp	Plinthic Alisols
153	ALj	Stagnic Alisols
154	ALg	Gleyic Alisols
155	NT	Nitisols
156	NTh	Haplic Nitisols
157	NTr	Rhodic Nitisols
158	NTu	Humic Nitisols
159	FR	Ferralsols
160	FRh	Haplic Ferralsols
161	FRx	Xanthic Ferralsols
162	FRr	Rhodic Ferralsols
163	FRu	Humic Ferralsols
164	FRg	Geric Ferralsols
165	FRp	Plinthic Ferralsols
166	PT	Plinthosols
167	PTe	Eutric Plinthosols
168	PTd	Dystric Plinthosols
169	PTu	Humic Plinthosols
170	PTa	Albic Plinthosols
171	HS	Histosols
172	HSl	Folic Histosols
173	HSs	Terric Histosols
174	HSf	Fibric Histosols
175	HSt	Thionic Histosols
176	HSi	Gelic Histosols
177	AT	Anthrosols
178	ATa	Aric Anthrosols
179	ATc	Cumulic Anthrosols
180	ATf	Fimic Anthrosols
181	ATu	Urbic Anthrosols

App. 4. Laboratory reference files

The laboratory reference files contain information on the laboratory and analytical methods (adapted after Van Engelen and Wen Ting-tiang, 1993).

a) Laboratory name file

LAB_ID
This is the unique identification code for the laboratory in which the analyses for the considered soil profile have been made. The LAB_ID consists of the country ISO-code plus a number.

Laboratory name
The laboratory's name is entered as text-string (max. of 50 characters).

b) Laboratory attribute file

LAB_ID
This is the same code as indicated above.

Attribute
Attribute, discussed under numeric 'chemical and physical' horizon data, that was analyzed (e.g. organic carbon).

Method of analysis
Method_ID of analysis, given as a code (e.g. OC1, see Table 3).

c) Laboratory methods file

Method of analysis
The laboratory method code as indicated above (e.g. OC1).

Description
A concise summary, as text string of at most 50 characters, of the analytical method (e.g. organic carbon according to Walkley and Black method).

App. 5. Source reference files

This file provide a summary of the source from which the profile data were derived:

Authors and initials:
The names of the author(s), with initials, are specified in the same way as on the data entry proforma. In case of multiple authors (max. 70 characters), the format is as follows: Name-1, initials, Name-2, initials, and Name-3, initials. (For example: Van Waveren, E.J. and Bos, A.B.)

Year of publication:
Self-explanatory (e.g. 1988)

Title of publication:
The title is given as a text string (max. 100 characters). For example: ISRIC Soil Information System.

Series, publisher and place of printing:
The above are entered as one text string (max. 100 characters). For example: Technical Paper 15, International Soil Reference and Information Centre, Wageningen.

App. 6. WISE soil data entry sheet

WISE_ID: |___|___|___|___|___|

WISE Soil Profile Data Entry Sheet - A

FAO-Unesco soil unit (1974): |___|___| Remarks:________________
Phase (1974): |___|___| Remarks:________________
Topsoil texture class: |___|
FAO-Unesco soil unit (1988): |___|___| Remarks:________________
Phase (1988): |___|___| Remarks:________________
USDA subgroup: *Descriptive* ________________
edition (year): |___|___|
Local soil classification: *Descriptive* ________________
Source (Authors + initials): *Descriptive* ________________
year: |___|___|
title: *Descriptive* ________________
____
series/publisher/year: *Descriptive* ________________
____
Laboratory name: *Descriptive* ________________
____

LAB_ID: |___|___|___|___|
Soil prof. description status: |___| Remarks:________________
Date (MM|YY): |___|___|___|___|

Country: |___|___| Remarks:________________
Location: *Descriptive* ________________
Coordinates of soil profile:
LAT.: |___| N or S |___|___| degrees |___|___| minutes |___|___| seconds
LON.: |___| E or W |___|___|___| degrees |___|___| minutes |___|___| seconds
Altitude: |___|___|___|___| m
Landform: |___|___| Remarks:________________
Landscape position: |___|___| Remarks:________________
Aspect: |___|___|___|
Slope gradient (%): |___|___|___|
Drainage class: |___|___| Remarks:________________
Groundwater depth (mean high): |___|___|___| cm
Groundwater depth (mean low): |___|___|___| cm
Soil depth to rock: |___|___|___| cm
Parent material/lithology: |___|___|___| Remarks:________________
Remarks on p.m./lithology: *Descriptive* ________________
Köppen climate classification: |___|___|___| Remarks:________________
Name of climate station: *Descriptive* ________________
Current land use: |___|___| Remarks:________________
Main crop (for arable uses): |___|___| Remarks:________________
Vegetation: |___|___| Remarks:________________
Remarks on vegetation: *Descriptive* ________________

WISE_ID: |___|___|___|___|___|

WISE Soil Profile Data Entry Sheet - B

Horizon		top (cm)	bottom (cm)	Org. C (%)	Tot. N (%)	Tot. P (mg P_2O_5 kg^{-1})	pH			EC (dS m^{-1})	$CaCO_3$ (w%)	$CaSO_4$ (w%)	Exch. base cations (cmol(+) kg^{-1})				Exch. $Al^{3+}+H^+$ (cmol(+) kg^{-1})		CEC (cmol(+) kg^{-1})	ECEC (cmol(+) kg^{-1})	BS (%)
No.	Design.						H_2O	KCl	$CaCl_2$				Ca^{2+}	Mg^{2+}	K^+	Na^+	Acid.	Al^{3+}			
1																					
2																					
3																					
4																					
5																					
6																					

Hor	Matrix colour		Mottling	roots	Struct. type	Particle size distribution			Stone and gravel content (%v/v tot. soil)	Bulk dens. (g cm^{-3})	volume per cent water (% v/v) held at: (indicate pF for Field Capacity and Permanent Wilting Point)						AWC (% v/v)	Hydr. cond. (cm hr^{-1})	
	Dry	Moist				sand size	silt size	clay size			pF=	pF=	pF=	pF=	pF=	pF=		Sat.	Unsat.
1																			
2																			
3																			
4																			
5																			
6																			

- A reference to laboratory methods is attached as photocopy No.: ____________ (LAB_ID: ____________)
- A climatic data sheet is attached as photocopy No.: ____________ (CLIM_ID: ____________)
  Name of climate station: ____________ LAT.: |___|___| degrees |___|___| minutes, |___| N or S LON.: |___|___|___| degrees |___|___| minutes, |___| E or W.
- The Data Entry Sheets should be used in conjunction with: *World Inventory of Soil Emission Potentials: Guidelines for soil profile selection and protocol for completing the WISE data entry sheets.* WPP 93/02, ISRIC, Wageningen.
  Missing numerical values must be entered as '-99.'