

## World Inventory of Soil Emission Potentials (WISE): geographic quantification of soil factors that control fluxes of greenhouse gases

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### **Abstract**

Scientists at the International Soil Reference and Information Centre (ISRIC) have been developing a digital database to permit a better quantification of the role of soils in controlling processes of global change. The database is a combination of soil area-data and soil attribute-data. The area-data, based on a digitized and edited version of the 1:5 M Soil Map of the World prepared by the Food and Agriculture Organization (FAO), specify the type and extent of the main soil units for each  $\frac{1}{2}^\circ$  latitude by  $\frac{1}{2}^\circ$  longitude grid. The properties of these soil units can be characterized using representative soil moisture held in the WISE attribute database, for example soil organic carbon pools, moisture holding capacities, and soil fertility. In first instance, however, the WISE database has been used to make an inventory of the world's poorly drained soils, in order to provide the geographical basis for an improved estimate of methane emission potentials using auxiliary models and GIS.

### **1. INTRODUCTION**

Climatologists, oceanographers and atmospheric chemists involved in modelling the effect of the increase of radiatively active trace gases in the atmosphere, have taken into consideration the interaction between the ocean and the atmosphere [1]. However, relationships between processes controlling the production, absorption and emission of  $\text{CO}_2$ ,  $\text{N}_2\text{O}$  and  $\text{CH}_4$  in soils, and the relationships with atmospheric gas concentrations were less well understood and given less importance. As a result, difficulties were encountered in balancing the values found in the atmosphere with known values for emission and destruction of the natural trace gases in the global equation. The World Inventory of Soil Emission Potentials (WISE) project was conceived to attempt a geographical quantification of soil factors and processes that control fluxes of greenhouse gases, at a spatial resolution of  $\frac{1}{2}^\circ$  latitude by  $\frac{1}{2}^\circ$  longitude, for primary use in Global Change research [2].

## 2. THE WISE DATABASE

### 2.1 Database structure

The three-year WISE project has been accomplished in two distinct phases. The first phase was devoted to a literature study of the chemical, physical and biological factors controlling the gaseous exchanges involved in order to identify the soil attributes needed to develop the WISE database [3], for further discussions during an international workshop [4]. The soil attributes to be collected may be considered in three groups: general information, physical data and chemical data (see ref. 2 for further details). These attributes, which are common to both the European soil database, and subsequent proposals for an IGBP-DIS World Soil Database appear to have gained wide support amongst the scientific community.

The second phase of the WISE project started with the compilation of guidelines for the selection of soil profiles, and development of a relational data management system for handling the data. In parallel with this, colleagues at FAO have developed the gridding algorithms necessary to generate the basic spatial data for the WISE database. The cartographic base has been built up mechanically, by identifying the soil units which occur in each  $5' \times 5'$  grid-cell according to FAO's composition rules [5]. The next step involved computing the percentage area of each soil unit present in the 36 cells which make up the  $\frac{1}{2}^\circ \times \frac{1}{2}^\circ$  grid cell [Nachtergaele, unpublished data]. This information has then been used by WISE project staff to prepare the soil area data relevant to each terrestrial grid. Each area on the map is linked by the FAO-Unesco map legend descriptors to a suite of representative soil profiles held in the soil profile data files, which increases the value of the geographical information.

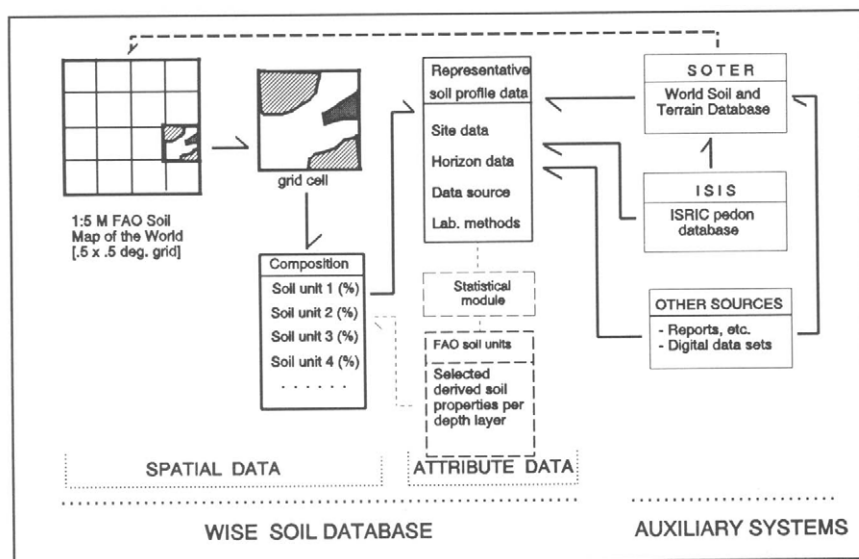


Figure 1. Schematic representation of the WISE database.

The attribute data, and the area data form two major elements of the WISE database (Fig. 1). In order that this information can be effectively used, it can be linked to a geographical information system (GIS) from where the soil information can be brought together with other global databases containing climatic, land use and hydrological information for subsequent modelling work and scenario analyses.

## 2.2. Data sources

An international workshop confirmed that development of the WISE database should take place, based on the present international data sets held by ISRIC's Soil Information System (ISIS), the National Resources Conservation Service (NRCS) of the United States Department of Agriculture (USDA), and FAO's Soil Database System (SDB), together with regional and national data sets where these were available and accessible. The resources of the ISRIC library collection would also be used [4].

As part of the WISE programme of activities, ISRIC initiated the development of an automated facility to transfer data from one digital profile database to another. Mechanical transfer of data is a very efficient procedure when many profiles are involved and it permits uniform standards of treatment to be maintained. The transfer program has been used to bring the data from ISRIC-ISIS, FAO-SDB and USDA-NRCS holdings into the uniform WISE format [Tempel, *unpublished data*]. All mechanical transfers of data have been subject to routine quality checks. Additionally, the inferred quality of the data has been flagged in the database, and source of material documented.

Table 1 gives an overview of the distribution of the profiles available by broad geographic area. It will be clear that the distribution throughout the world is not uniform. Two areas significantly lacking in information are Siberia and China, and it is not surprising that few soil profiles have been described and analyzed from the central parts of the Sahara. In the absence of information, or at least its unavailability, the geographical spread of representative profiles is the best that could be achieved in the period available for compilation.

Table 1. Number of profiles in the WISE database per broad geographic area\*.

Geographic Area	No. of profiles
Africa	1595
Australia and Pacific Islands	85
China, India, Indonesia, and Philippines	424
Europe	490
North America	122
South America and Caribbean	486
S.W. and N. Asia	478

\* An additional 650 profiles are available from the NRCS data set, including 260 profiles from the USA.

### 2.3. Quality control

Great stress has been laid upon the systematic collection and recording of data as well as careful consideration of the laboratory methods by which the analytical results were obtained. For each individual set of data the laboratory name and the methods used have been recorded. In parallel with the work of the WISE data compilation, ISRIC staff carried out a review of the comparability of different soil analytical methods, with particular attention for pH, CEC and organic carbon determinations [Vogel, *unpublished data*].

Four criteria have been defined for accepting profiles into the WISE database: (a) completeness and apparent reliability of data; (b) traceability of source of data; (c) classifiable in the FAO-Unesco legend [6]; and (d) geo-referenced within defined limits. All profiles included in the WISE database have been printed-out for a visual check on the data, to complement the computerized data checking procedure.

## 3. DATABASE APPLICATIONS

In view of the range of soil attributes considered, the WISE database can be used for a wide range of environmental studies at the macro level, which include assessments of crop production potentials, soil gaseous emissions and soil pollution studies.

Experience gained in the collection and compilation of the profile data has shown that certain values, in most cases the physical values, are often missing. In order for the WISE database be of optimum usefulness for modelling purposes, it will first be necessary to develop pedotransfer rules or functions to fill-in eventual missing values—to be stored in a separate derived database file—, for example bulk density data.

Upon the advice of the expert panel consulted about the activities of the WISE project [4], collaboration was sought with institutes which had facilities for laboratory and field measurements of methane production, absorption and emission, and experience in CH<sub>4</sub>-model development. So far an inventory of soils with high methane emission potentials has been prepared, using the WISE database linked to a GIS. This inventory forms one of the GIS data-layers necessary to refine global estimates of methane emissions from poorly drained soils. A preliminary development has been to assign soil units to one of a number of potential methane emission categories [7], but this information is still too limited for a sound spatial extrapolation using the WISE database [8, 9].

Over the past few years, much progress has been made in understanding the environmental controls on methane production, absorption and emission at site-level spatial and temporal scales. However, it remains difficult to explain regional differences in methane emission, ecological responses to climate change, and the effect of other perturbations such as drainage and flooding regimes in a global model [8, 10]. Results of this type of research are required before the potential of the WISE database for making a refined calculation of soil methane emissions can be fully utilized [9]. A recent, added scientific challenge has been to find an explanation for the currently decreasing annual increase rate of atmospheric methane concentrations [11].

#### 4. CONCLUSIONS

Although attempts have been made in the past to use the FAO-Unesco Soil Map of the World as a basis for determining the nature of the soil cover for modelling purposes, the resolution used was coarse and the potential of the map as a source of information was only partially exploited. The gridding procedure developed by FAO staff as part of the WISE project has greatly increased the amount of information about the world soil pattern which can be derived from the FAO-Unesco Soil Map of the World at a scale of 1:5 M. The WISE database has assembled, in a uniform manner, over 4000 representative soil profiles with their morphological, chemical and physical attributes in a single user-friendly database. It represents a major achievement in soil science and it should soon provide a useful international soil profile data set for global modelling purposes.

An important development has been the request by the Global Soil Data Taskgroup of the International Geosphere-Biosphere Project's Data and Information System (IGBP-DIS) for a subset of the WISE profile database as a foundation for their soil data gathering activity [12].

While some immediate applications have been investigated by ISRIC staff, many of the opportunities provided by the existence of the WISE database still remain to be exploited in the future. A project proposal has been formulated, in close collaboration with modellers of the IMAGE group [13], for possible implementation during the Second Phase of the Netherlands National Research Programme.

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