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REQUIREMENTS FOR AN INTERNATIONAL RADIOCARBON SOILS DATABASE

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INTRODUCTION

Up to now, Global Carbon Cycle Models (GCCM) have only represented the soil and biosphere in a very simplified way. For example, the High Resolution Biosphere Model (HRBM) (Esser 1987; Esser and Lautenschlager 1994) distinguishes five subreservoirs and determines the fluxes between them for selected area of a global grid. The models have not yet been sufficiently tested against global observations. Such testing is difficult because the observed variables are in turn dependent on the behavior of other geological carbon pools, *e.g.*, the atmosphere and ocean.

Data on the following variables are readily available in the scientific literature:

Atmospheric CO_2 concentration since 1860 (or for the past 160,000 yr from the Vostok ice core)
Atmospheric $\delta^{13}C$ since 1860
Atmospheric ^{14}C since 1860 (or for the past 8000 yr from the dendrochronological record)

The data and/or information that is necessary as input for effective GCCM testing include:

How much carbon is/can be stored in soil
How much carbon is/may be released as CO_2, CH_4 and CO
Which factors influence the net storage and/or release of carbon, especially climatic factors (feedback effects)
What are the rates of net storage or release of carbon as a function of soil type and in response to the prevailing environmental conditions.

These data are available neither in direct form nor for every point or area on the globe. They may be derived from secondary data by calculation, estimation or a submodel. A minimum set of these secondary data is, for example, the one used in the HRBM:

Soil type
Composition of vegetation
Type of land use
Mean temperature
Annual precipitation

There are several sources of these secondary data:

FAO soil classification and soil map (Driessen and Dudal 1989)
USDA Soil Taxonomy (Soil Survey Staff 1994) and related maps
Agroclimate maps
Estimations of Bohn (1979), Buringh (1984) and others on global soil carbon amounts and distributions
Estimations on a soil system depending on carbon depth profiles (Cherkinsky and Chichagova 1990)
Maps of net primary plant production (Lieth 1978, *etc.*)
Soil carbon models (Parton *et al.* 1995, *etc.*)
Soil radiocarbon dates

Because ^{14}C dates of soil organic matter (SOM) represent a fingerprint of the history of its dynamics, they can be useful in reconstructing its major parameters, especially in determining whether a soil sample has been a source or a sink of carbon. To serve the purpose of GCCMs, the data should cover the major soil classes and regions of the Earth and be available in digital and unambiguous structured form.

The Structure of the IRSDB

Existing ^{14}C dates of soils have been produced for different reasons, mostly to answer pedogenetic questions and without regard to the evaluation of carbon cycling. Therefore, additional information on the environmental context of these data is necessary to ascertain whether and how they may be useful for the purpose of GCCMs.

In Tucson on June 5–7, 1992 a NASA-sponsored workshop was held to discuss and plan the structure and installation of an International Radiocarbon Soils Database (IRSDB). As a result, the following hierarchically ordered list of database fields was proposed by the participants. The field names were designed to be compatible with the proposed International Radiocarbon Data Base (IRDB) (Kra 1986; Walker and Kra 1988). Data that are essential for assessing carbon turnover and, therefore, global change calculations, are marked by an asterisk (*); those that might overload the database are marked with a question mark (?). All other fields were recognized as generally useful and should be added to the database if available.

Proposed List of the IRSDB Database Entry Fields:

General

* Labcode and no.
* Single sample or sample set (profile or catena, set no.)
* Submitter (name and address)
* Collector (name and address)
* Date of sampling
* Date of measurement
* Sampling location (longitude, latitude)
* Pretreatment for dating
* Type of soil fraction(s) or other material used for dating

Results

* ^{14}C result (pM ± error (as defined by Stuiver and Polach 1977); raw data)
* $\delta^{13}C$
* Possible contamination
* Submitter's comment
* Lab's comment

Context

* Literature References
  Original field of study
? Quality control figure

Environmental Data

  Country
  Site description

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Parent material, time of deposition
Topography (landform?)
Ecosystem type and climatic conditions (mean temperature and annual rainfall)
Vegetation (actual, history and potential)
Land use

Profile-Related Data

* Soil order and type (both FAO and local classification)
Profile description (data related to carbon turnover and migration)
Humus form
Rooting pattern
Stratigraphy
Physical barriers to water penetration
Reference to Soil Conservation Service file

Sample-Related Data

* Sampling depth interval, depth and horizon
Method of sampling
* Bulk density
? Soil color (wet, moist, dry)
* Particle size distribution (<2 mm, >2 mm) (at least texture)
Clay type
* pH (and method)
Eh
? CEC
* C content (organic and inorganic)
C_{org}/N ratio
? Lignin content
? Phosphorus (and method)
? Microbial biomass
? Data on other isotopes (heavy, stable)

In addition, a standard exchange format for the ^{14}C and additional data of the IRSDB, which serve as input to GCCMs, should be defined (*cf.* Wilcock *et al.* 1986; Walker *et al.* 1990).

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Appendix

Ecosystem Type and Climatic Conditions

Boreal forest	Tropical moist forest
Tundra and alpine meadow	Tropical seasonal forest
Temperate evergreen forest	Tropical woodland
Temperate deciduous forest	Tropical grassland
Temperate woodland	Swamps and marshes
Temperate grassland	Desert

Soil Order and Type

A. *Major Soil Groupings of the FAO System (Driessen and Dudal 1989)*:

Histosols	Fluvisols	Plinthosols	Solonchaks	Luvisols
	Gleysols	Ferralsols	Solonetz	Podzoluvisols
Anthrosols	Leptosols	Nitisols	Gypsisols	Planosols
	Regosols	Acrisols	Calcisols	Podzols
Andosols		Alisols		
Arenosols	Cambisols	Lixisols	Kastanozems	
Vertisols			Chernozems	
			Phaeozems	
			Greyzems	

B. *Orders of Soil Taxonomy (Soil Survey Staff 1994)*:

Alfisols	Entisols	Mollisols	Ultisols
Andisols	Histosols	Oxisols	Vertisols
Aridisols	Inceptisols	Spodosols	