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Opportunities offered by the Design and the Use of a Gridded Multi-Scale European Soil Information System in Support of European Soil Policy

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Abstract: During the last years the need for a coherent approach to soil protection has come on the political agenda in Europe and in this context of a European Soil Thematic Strategy (STS), the European policy makers require access to European soil data to assess the state of soils at European level. The creation of European soil datasets is not new but has always been the result of a complex and time-consuming undertaking, the best example being the development of the European Soil Database. In the light of updates to existing soil data and of collection of new soil data simplification is needed through a suitable technical framework. Recently, the INSPIRE initiative (Infrastructure for Spatial Information in Europe) has embarked on a common framework for spatial data in the EU. One pillar is to conduct reporting and analysis of environmental information on the basis of a hierarchical system of grids. This system constitutes a suitable framework for the building of a nested system of soil data and could lay the basis for a Multi-scale European Soil Information System (MEUSIS). In order to achieve this, a common standard for the collection of harmonized soil information is to be developed and implemented. MEUSIS, aiming to be the harmonized soil information system for Europe which potentially could streamline better the flow of information from the data producer at a local or regional scale to the data users at wider scales, will offer a number of opportunities. The parties involved in the use of such a system are the data contributors, the data users (scientists and policy makers) and the data managers, who generally speaking will only benefit from such an approach.

Keywords: grid, European reference grid, INSPIRE, soil data, ESDAC

1. BACKGROUND

During the last years the need for a coherent approach to soil protection has come on the political agenda in Europe; it was introduced as one of the thematic strategies within the Community's 6th Environment Action Programme. In this context of a European Soil Thematic Strategy (STS), the European policy makers require access to European soil data and information of various types to assess the state of soils at European level. Also, as part of the newly proposed Soil Framework Directive (SFD), Member States would need to delineate and communicate to the European Commission so-called "risk areas" which are areas at risk to major soil threats (soil erosion, lack of organic matter, etc.). The way to do this practically would need to be discussed between Member States and EC once the Directive will be into force.

As part of this need to collect and assess soil data and information, the European Commission (EC) and the European Environment Agency (EEA) decided to establish a European Soil Data Centre (ESDAC), located at the EC's Joint Research Centre, as one of ten environmental data centres in Europe. Each environmental data centre acts as the primary data contact point for the EC's DG ENV in order to fulfill its information needs. ESDAC operates under the scheme illustrated by figure 1.

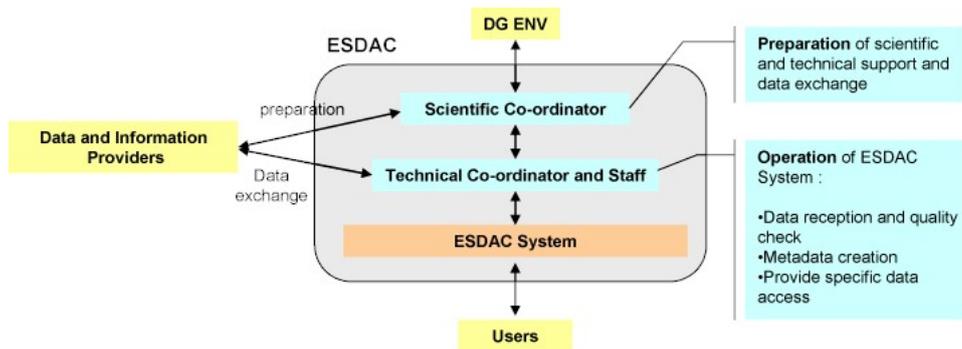


Figure 1. Operational ESDAC

The sources of soil information that currently reside at the ESDAC are JRC in-house and commissioned soil research activities, results from activities within the European Soil Bureau Network (the major scientific network for soil in Europe), results from EU funded soil related projects and results from collaborations with other organizations in the area of soils (e.g. EuroGeoSurveys). In the future, ESDAC would also need to prepare for the receipt, processing and making available reporting data coming from Member States in the context of the SFD.

In the past the JRC, mainly in its capacity of secretary to the ESNB, played a crucial role in the development of European soil datasets. The European Soil Database (ESDB), covering the EU27 has been developed jointly with European partners and is the only harmonized coverage of digital soil information for Europe [ESDB]. It is the result of a complex and time-consuming undertaking, due to the vast heterogeneity of soil data in countries. In the light of updates to such a database and of collecting other data in relation to the STS, simplification is needed through a suitable technical framework.

2. INSPIRE

The INSPIRE Directive [INSPIRE], aiming at the establishment of an Infrastructure for Spatial Information in the European Community (INSPIRE), entered into force in May 2007. This directive recognizes that the general situation on spatial information for environmental purposes in Europe is one of fragmentation of datasets and sources, gaps in availability, lack of harmonization between datasets at different geographical scales and duplication of information collection. The initiative intends to trigger the creation of a European spatial information infrastructure that delivers to the users integrated spatial information services. These services should allow the users to identify and access spatial or geographical information from a wide range of sources, from the local level to the global level, in an inter-operable way for a variety of uses. Policy-makers at European and national level are among the main targeted users who would need access to a number of services that include the visualization of information layers, overlay of information from different sources, spatial and temporal analysis, etc.

INSPIRE and soil data

Soil data are regarded as spatial data in the INSPIRE Directive (Annex III) and therefore Member States have to take them into account when setting up or adapting their national spatial data infrastructures. A common European data specification for soil will need to be set up in order to make data interoperability between soil data services possible. Given the heterogeneity of soil data models in Europe, as revealed by the reports [xxx] and [xxx], and more recently by work in the ENVASSO project [ENVASSO], together with the experiences within the European scientific soil data community during the set-up of the European Soil Database, it will be necessary to simplify significantly the way in which soil data are going to be represented.

INSPIRE and ESDAC

The INSPIRE Directive addresses Member States only and it is their task to come to a common position concerning soil data through collaborative work between so-called Legally Mandated Organizations (LMO) and the soil Spatial Data Interest Community (SDIC). The European Commission, and therefore the ESDAC, is not formally required to take part in this process. However, if ESDAC wants to consolidate its role as a compiler and provider of European datasets, it is only natural that it will interact with soil data players at Member State level and try to influence any decisions on European soil data representation.

INSPIRE and grids

During the preparation of the INSPIRE Directive, it was already realized that grids (or rasters) could offer tremendous opportunities to the representation of spatial data. Following the recommendations by the EEA and the INSPIRE Implementing Strategies Working Group, a European-wide reference grid (or raster) should be devised and adopted to facilitate the management and analyses of spatial information for a variety of applications; therefore, the JRC organized the “1st Workshop on European Reference Grids” [EUROGRID], inviting leading experts of different communities representing users of European grids. A grid for representing thematic information is a system of regular and geo-referenced cells, with a specified shape and size, and an associated property. A common position was reached and a “standard” technical solution was identified to be recommended for future adoption. It was also agreed to test this proposed solution in a number of initiatives. The selected grid would be used in spatial analyses, mapping and for the reporting of other sources of information to a common grid. The main recommendations from this Workshop to the European Commission were:

- to adopt a common geodetic datum (ETRS89) and coordinate reference system (ETRS89 Lambert Azimuthal Equal Area) for reporting, statistical analysis and display;
- to promote the wider use of these standards within all member states and internationally, by appropriate means (recommendations, official statement, ...);
- to adopt a common European Grid Reference System for Reporting and Statistical Analysis. The system should be able to store regular grids and should be designed as reference for future Grids related to European territory; the System must satisfy a number of key principles, the most important being: easy to manipulate, hierarchical, be based on a Unified European Grid Coding System, based on units of equal area, adopt ETRS-LAEA;
- to encourage future European projects to make use of a standard European grid.

INSPIRE: the proposed grid.

The European Grid Reference System consists of hierarchically nested grids of regular and geo-referenced cells, with a specified shape and size. The system is based on ETRS-LAEA and its projection is centered on the common point (N 52°, E 10°); figure 2 illustrates the projection and extent; the coordinate system is metric and the sizes of the cells are 100km, 50km, 25 km, 1km, 500m, 250m 100m, etc.



Figure 2. Projection and extent of the ETRS_LAEA based grid system

At a specific level of the hierarchy, the cell is uniquely coded; e.g. the point with real world coordinates (5780354, 6436122) could be coded as 5780_6436 at the 1-km-level and as 578_643 at the 10-km-level. The nested nature of the grid system is illustrated in figure 3.

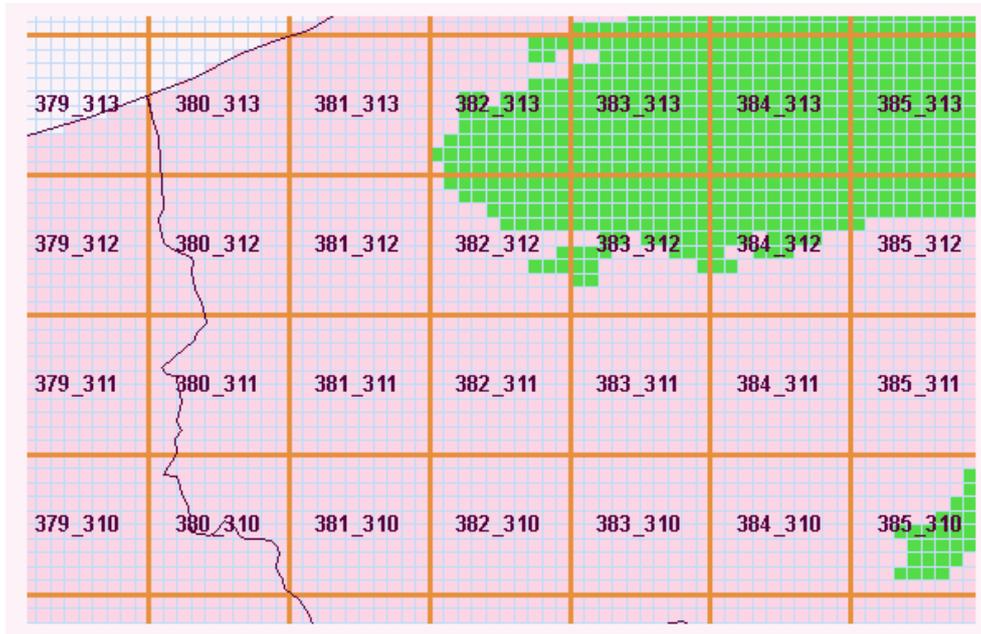


Figure 3. Nested grids.

Taking into consideration the recommendation to promote the wider use of such grids and in the context of dissemination of its soil data, the JRC European Soil Portal (eusoils.jrc.it) has taken the initiative of offering its European Soil Database as a library of rasters, one for each soil property [ESDB_RL]. Figure 4 illustrates one soil property, first as a European map, then as a detail for Spain, which reveals the 1km resolution.

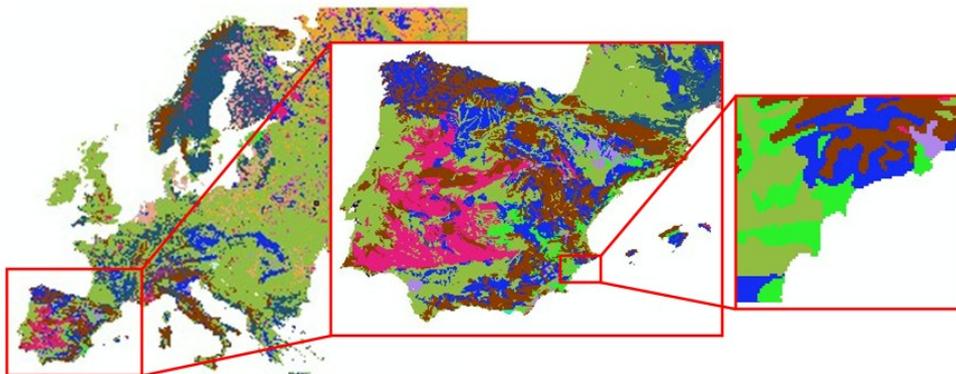


Figure 4. The “Limitation for Agricultural Use” soil property for Europe, as a raster

The idea of gridding has also been experimented with in a set of initiatives, linked to JRC: the ECALP project, the MEUSIS_SK project and the SIAS project.

3. ECALP: SOIL INFORMATION SYSTEM FOR THE ALPINE TERRITORY.

The objective of the ECALP project (2004-2006) [ECALP] was to create a system for gathering, and processing soil data for the Alpine Territory, creating a so-called Alpine Ecopedological Information System to provide information to operational end users, land managers at different levels and soil scientists together with experts of other disciplines (in particular those using soil information for environmental and agricultural applications). The project participants came from the Alpine countries and formed a network of regional and national institutions which own and manage soil data. Particular attention was given to participants that would provide soil data close to national frontiers, as one could expect harmonization issues with trans-national boundary areas. It was decided to experiment with an INSPIRE-based 1km-cell (or pixel) grid approach as paradigm for data collection. A number of trans-boundary pilot areas of around 200 km² (figure 5a) were defined, for which partners had to provide specific soil information in a common format for data exchange that was agreed beforehand. This format incorporated main soil and environmental features such as physiography, land use, topsoil and subsoil texture, drainage, rootable depth, parent material and soil type. Part of the exchange format was dedicated to metadata, i.e. information about data sources and collection and evaluation procedures used by each partner. Partners had to interpret and convert part of their traditional vector-based databases into the agreed raster format, as illustrated in fig 5b. This was not always a straightforward process due to the fixed spatial scale, potential loss of information and vector-to-raster issues. Also cross-boundary pixels needed special agreements on how to fill.

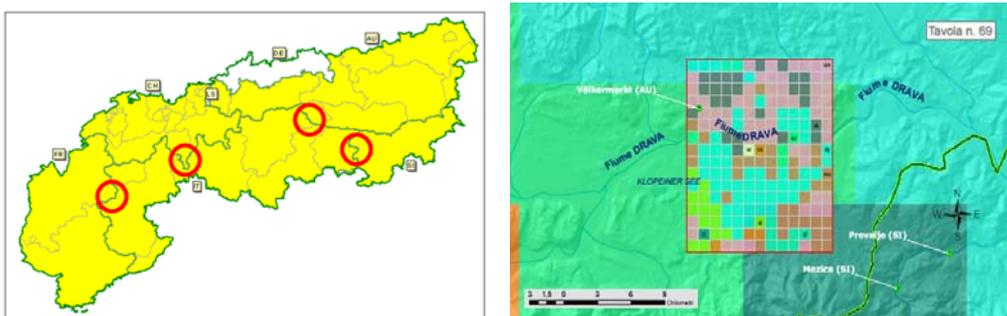


Figure 5.(a) ECALP Pilot areas, and (b) soil map example

4. MEUSIS_SK: A MEUSIS APPROACH FOR SLOVAKIA

During 2005-2006 the Soil Science and Conservation Research Institute from Bratislava conducted on behalf of the European Commission a study [MEUSIS_SK] that applied techniques which are foreseen in a Multi-scale European Soil Information System. In essence, the requirements were that the same soil data were to be provided for grid cells with different resolution, for the pilot areas of Slovakia indicated in figure 6. At 10km resolution for the whole of Slovakia (blue cells), at 5km for a part of Slovakia (green cells) and 1km for an even smaller area of 4000km² (red cells). Freedom was given as to which data sources would be applied at a particular resolution.

Data sources for the pilot areas are represented by (i) primary geo-referenced data sources, used directly for pixel description (primary spatial information on the delineated soil bodies, e.g. soil map of Slovakia), (ii) secondary geo-referenced data, as a source of additional information for the primary geo-referenced data geographical (e.g. database of soil ecological units) and (iii) geo-referenced soil profile data used mostly for morphological and analytical information on the primary geo-referenced data soil bodies. This project encountered no difficulties as only one party was involved in the set-up of the soil maps.

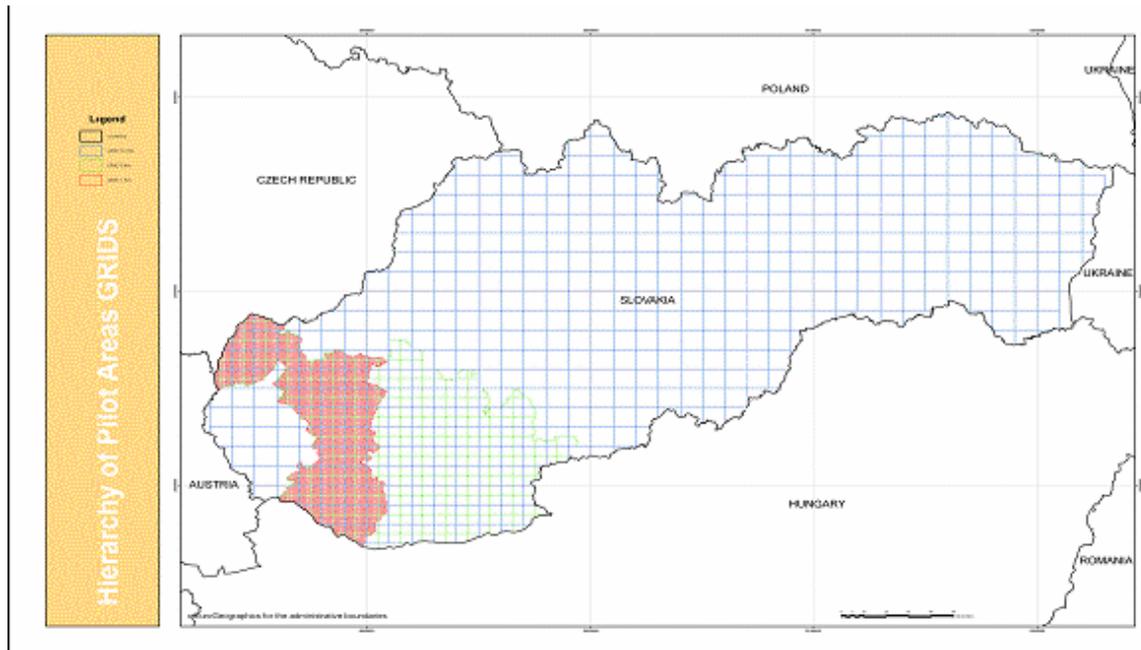


Figure 6. Overview of the MEUSIS_SK Slovakian pilot areas

5. MEUSIS IN ITALY (SIAS PROJECT)

The JRC is currently participating, in collaboration with the Italian Environment Agency (APAT), in a pilot project that seeks to develop an Italian Soil Database for soil erosion and soil organic matter according to INSPIRE principles and following a grid-based methodology with participatory contributions from Italian regional offices that are, according to Italian law, are the hold the soil [SIAS]. This approach exploits the possibility to transfer soil data and expertise which are available at local level to, in a first instance, the national level (APAT) and, in a second instance, to the European level (ESDAC). Again, as for ECALP, this happens according to agreed formats, but this time special attention is given to shared data quality indicators, both as quantitative indexes of data availability and specific confidence levels. The project involves all the 21 regions as data providers with different backgrounds and expertise; a priori, the data quality seemed to vary heavily from region to region and a minimum of harmonization was required. Therefore, it took a considerable amount of time to find a compromise for a suitable Data Exchange Format (available classes for specific properties, methodologies to derive properties, data typing, etc.). This project is still under development and the first results are expected by the end of 2008.

6. MEUSIS, THE CONCEPT

The INSPIRE grid system proposal could lay the basis for a Multi-scale European Soil Information System (MEUSIS), a system whereby soil data produced at a certain scale can easily be integrated or compared with soil data produced at another scale, provided that the rules for representation of the data are equal at all scales. From the local level (at high resolution, e.g. 100m), through the regional and country level (at medium resolution, e.g. 1km) up to the European level (at coars resolution, e.g. 5 or 10km).

In order to achieve this, a common standard for the collection of harmonized soil information must be developed. As some experience has shown, this is not an easy task and requires really the careful consideration and views of all players involved in the data contribution process.

In order to provide soil data in grid format, data providers will likely need to process their original soil data, held in traditional vector-based soil databases, in order to fit a grid, and again experience shows that this could lead to misinterpretations or even errors.

The MEUSIS concept offers a number of opportunities. Once data have been communicated in the form of grids, updates will be facilitated since it requires only the communication of data values for specific cells. MEUSIS also provides a suitable structure so that coherent and complementary data, available at various levels of a nested set of geographical scales, can fit together. Finally MEUSIS will also integrate into a comprehensive monitoring- and reporting system with different layers of various themes governed by INSPIRE principles.

MEUSIS aims to be the harmonized soil information system for Europe which will streamline better the flow of information from the data producer at a local or regional scale to the data users at wider scales (National, European and Global scales), all at the service of various levels of policy-makers, not the least environmental policy-makers at the European level.

MEUSIS: the way ahead

The SIAS project is to our knowledge the first in its kind in Europe that derives data for an INSPIRE theme at a country level from data at regional level, following a technical approach for reporting that was suggested by INSPIRE itself. In that respect, we are eagerly waiting for the results of this exercise which will be available by the end of 2008. It is the ambition of the ESDAC to set up a similar scheme which will let data flow from country level to European level in a similar fashion. For that, with or without European soil legislation that will oblige Member States to provide the Commission with soil "risk area" data, many financial and human resources are to be mobilized to act in a suitable technical framework. This is not the case yet, but soon when Member States will be faced with the transposition and implementation of the INSPIRE Directive into their national legislation, activities will speed up.

7. MEUSIS EVALUATION: DESIGN VERSUS USE

The parties involved in the use of a system such as MEUSIS are the data contributors, the data users (scientists and policy makers) and the data managers.

For the data contributors, there is an effort to be made in order to transpose their local data to an agreed format that structurally and semantically could be very different; this format could be imposed rigidly by the designers of the system but will receive a better acceptance if it is a trade-off between all involved parties. The partitioning of the geographical areas in fixed cells and the association of soil property values to such cells implies that data contributors, in order to deliver their geo-referenced soil data, only need to transmit data tables in which each record is linked to a cell identifier.

It is envisaged that the primary end-user of such a system will be the (European) policy-maker who needs, at all times, to be able to consult the state of European soils. The data of such a gridded system are easily presented and are difficult to misinterpret. Moreover, such gridded data can easily be overlaid with data from other themes, similarly gridded and often necessary to conduct integrated studies or to run environmental models. The other category of end-users, scientists, often at the service of policy-makers, benefit from the same advantages.

From the data management point of view, the grid approach offers many advantages, the most important being the utmost simplification of the geometrical model that needs to be dealt with; as a matter of fact, data management boils down to the proper organization of delivered data values within database tables.

On a whole, the grid approach will not contribute directly to the quality of final decision-making but needs to be seen as a tool that has a facilitating role in the overall decision-

making process that includes data contribution, data use and data management alike: the relatively simple underlying data structure allows all participating partners to interoperate and communicate efficiently and effectively.

Does the design and use of such a system fit the needs of its stakeholders? This is very difficult to answer a priori but there are many signs that such grid architecture is appropriate for all, relying on the limited but encouraging experience in the set-up of prototypes mentioned in this text.

8. CONCLUSIONS

In the context of various developments that take place at European level (i.e. the coming into force of the INSPIRE Directive which includes suggestions for data reporting, the establishment of a European Soil Thematic Strategy which includes the proposal for a Soil Framework Directive and the set-up of the European Soil Data Centre mainly as a vehicle for serving the European policy-maker with relevant soil data), the technical approach for setting up a Multi-scale European Soil Information System, based on the INSPIRE advocated grid approach for reporting, has a good potential to contribute to the efficiency and the effectiveness of the decision-making at European level in the field of soil, primarily because the proposed grid system is based on a relatively simple data structure that is easy to follow by all parties. A few examples from work at the JRC contribute to this statement and the outcome of other examples (like the Italian SIAS project) will hopefully confirm this.

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