Laying the groundwork

Harmonising information on land and soil into an accessible database is a sizeable task. **Vincent van Engelen** discusses Europe's contribution to the development of a global soil observing system

Could you begin by explaining the concept and relevance of e-SOTER?

Soil and land information is needed for a wide range of applications but available data is often inaccessible, incomplete, or out of date. The Group on Earth Observation (GEO) plans a Global Earth Observation System of Systems (GEOSS) and, within this framework, the e-SOTER project addresses the need for a global soil and terrain database. As the European contribution to GEOSS, it will deliver a web-based regional pilot platform with SOil and TERrain (SOTER) data, methodology, and applications, using remote sensing to validate, augment and extend existing data. The project has two major research thrusts. The first looks at improving the current SOil and TERrain (SOTER) methodology at scale 1:1 million in four windows in Europe, China and Morocco. Moderate-resolution optical remote sensing will be combined with existing parent material and geology and soil information, making use of advanced statistical procedures. The second seeks to develop advanced remote sensing applications within 1:250 000-scale pilot areas, including geomorphic landscape analysis, geological re-classified remote sensing, and remote sensing of soil attributes.

How does the SOTER methodology differ from previous models, such as that used in the FAO-Unesco Soil Map of the World?

The only harmonised global soil information is the FAO-Unesco Soil Map of the World (SMW) at a scale of 1:5 million (FAO-Unesco 1974-1981). This map has been based on soil surveys executed before its publication date. Mapping unit information is limited to soil names and information on topsoil and subsoil texture, and 3 slope classes. A much improved methodology for a World Soil and Terrain database (SOTER) incorporates quantitative information (up to 100 items) on both soils and terrain and these quantified soil attributes are linked to the mapping units and allow running of models. Information of SOTER and other sources has been added to the SMW to the recently published Harmonized World Soil Database (FAO/IIASA/ISRIC/ISSCAS/JRC, 2009)

e-SOTER takes advantage of advanced technologies such as moderate-resolution optical remote sensing. Can you elaborate on some of these; what do they contribute to the project?

In areas where soil parent material data is only available for parts of the mapping area, moderate-resolution optical remote sensing has been used. Multi-temporal images of MODIS bands were compiled into a 55-layer image representing the visible, NIR, MIR and thermal bands. The images also capture the temporal environmental conditions and changes that reveal surface conditions and therefore soil and parent material properties, such as speed of wetting and drying out, cooling down or warming up, which are parameters strongly correlating with the texture, colour, water content and water holding capacity. However, the 55 layers have a significant portion of information overlap; hence a principal component analysis (PCA) was used to decrease the number of input images. The best 15 PCA components were maintained and incorporated into the final image. From these images the following products were generated: a supervised classification into consolidated and unconsolidated soil parent material using training data from areas where such information is known and a soil texture classification using training data and expert knowledge.

Can you highlight some of the difficulties in establishing a comprehensive soil observing system?

Firstly, landform classification based on digital elevation models (DEMs) is still in its initial development and results are not yet universally applicable. e-SOTER is developing methods that will use natural breaks in the landscape slopes.

In addition to this, available DEMs contain artefacts and noise that influence their quality. e-SOTER has developed methods to remove these artefacts and reduce the noise. Remote sensing of soil properties is restricted by the vegetation cover: it is more successful on bare surfaces such as fallow land or semi-arid areas. Legacy soil data has been collected using a range of methods and therefore soil classification methods are not standardised. The remedy is to use a taxonomic neighbourhood method to translate into a global soil taxonomic system World Reference Base for Soil Resources (WRB).

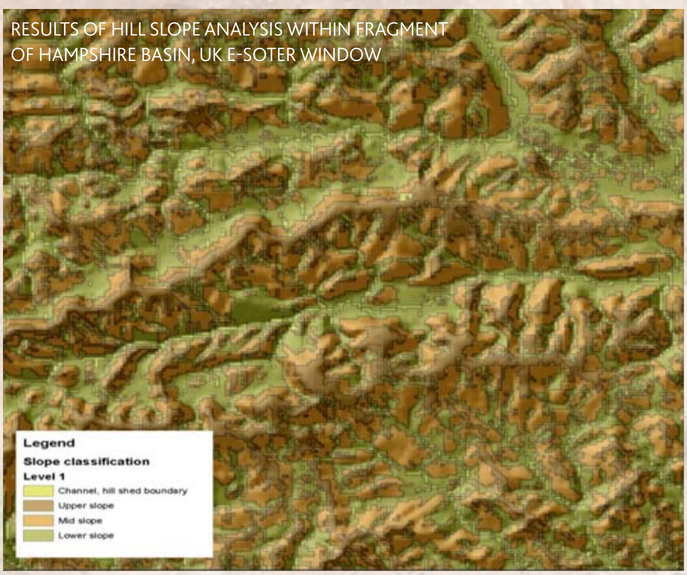
Meanwhile, data from local organisations are generally not provided in an OGC compliant interoperable way at present. A system needs to be implemented that allows either local organisations to host their data in a consistent way at their local premises, or at one central node for any given continent.

Finally, soil data characterisation on private property is often difficult due to restricted access. It is expected that data providers will appreciate the products of the GEOSS task and will see the benefit of contributing to the research.

Standardising soil data

European soil data is currently the focus of a large-scale unification effort. The **e-SOTER** project has been developed to help improve and standardise the compilation of soil and terrain information

MODERN-DAY POLICY makers seeking to monitor the environmental impact of land development and thus draw up legislation on the management of land rely heavily on SOil and TERrain (SOTER) information that is collected globally, nationally and locally. However, the current lack of comprehensive information about land resources has led to uninformed policies, continuing degradation of land and water resources, unnecessary carbon emissions, and no apparent likelihood of achieving the United Nations Millennium Development Goals towards ending world poverty. The viability and cost of vital infrastructure is affected just as much as food and water security and response to environmental change. In the case of the European Soil Thematic Strategy, the operational measures laid down in the Framework Directive and Impact Assessment are hindered by lack of accessible, easy to use, consistent, harmonised and relevant soil data. To produce such a comprehensive soil observing system, five components must be distinguished: data collection, transformation, data management, interpretations and delivery. In the current SOTER each of these areas falls short of the necessary level to provide a truly comprehensive system. For example, in the area of data collection soil and terrain data has been collected by national organisations at various scales using their own standards and methods. There are many data gaps, and the absence of standardisation in survey techniques and in the analysis of samples has created geometric and semantic mismatches at national boundaries. Regarding data management, the database is not accessible for online queries and cannot satisfy users' requirements for either seamless data surfaces or disaggregated attribute data. In summary, the present system cannot fulfil the requirement for immediately accessible, interoperable, digital information on specific soil and terrain attributes, and global coverage is incomplete. To address this issue the e-SOTER project has been set up as the European contribution to developing a Global Soil Observing System, with a view to overcoming the present shortcomings of SOTER and eventually provide a Regional Pilot Platform that can be extended worldwide.


RESULTS OF HILL SLOPE ANALYSIS WITHIN FRAGMENT OF HAMPSHIRE BASIN, UK E-SOTER WINDOW

ADDING VALUE

The e-SOTER project seeks to add value to the SOTER methodology through various means:

- Using remotely sensed data both to validate and correct existing survey data
- Generating new data surfaces; improving the quality of results of applications previously based on legacy data alone
- Providing a freely accessible web service that delivers both selected data in an easy-to-use format and procedures to compile e-SOTER databases locally.

The project also makes use of detailed digital elevation models (DEMs), recent advances in remote sensing, and new analytical tools for landform analysis, parent material detection and soil pattern recognition both to extend the legacy soil data and build a framework for new data acquisition. Remote sensing itself cannot generate the same kind of soil pattern as mapped in SOTER as, for example, it is limited in the number of classes it can identify and only a few remote sensing techniques can penetrate deep below the ground surface. However, the patterns detected by remote sensing are real and meaningful, and lend invaluable support to soil survey. As Vincent van Engelen, coordinator of the project outlines, e-SOTER has already achieved a number of notable successes: "A method to create an artefact-free SRTM-based digital terrain model (DTM) has been completed. Landform classification and delineation at a scale of 1:1 million using the DTM is now operational. Selected soil parameters can


LARGE VARIATION IN SOILS (HUNGARIAN e-SOTER AREA)

be derived from moderate resolution images and disparate national soil classifications have been converted into a standard one (World Reference Base for Soil Resources) using a taxonomic distance-based correlation, and an e-SOTERML has been developed. New approaches for landform mapping at larger scales are also available. Thus, the project is well on track to improve existing SOTER information.

DISSEMINATION

In addition to developing a global soil observing system, the project also seeks to fulfil certain other objectives. These include the running of a quality assessment of e-SOTER achieved through a validation and uncertainty analysis, application of the newly acquired e-SOTER in the field of major soil threats and comparisons with applications based on earlier datasets and, finally, full dissemination of the project's findings. Van Engelen describes the project's role in making its findings available to the wider research community: "These findings will be disseminated through various methods including: publications in peer-reviewed journals; presentations at conferences, congresses and workshops; the project website. In addition, two events have already been organised: one was held at mid-term in September 2010; the other will take place at the end of the project in February 2012. The project will also set up a web portal hosted by both ISRIC – World Soil Information, a foundation funded by the Netherlands Government, and the European Commission Joint Research Centre (JRC). Effective use will be made of Open Source

The current lack of comprehensive information about land resources has lead to uninformed policies, continuing degradation of land and water resources and unnecessary carbon emissions

software, thus allowing the information to be accessed universally.

COMBINED EXPERTISE

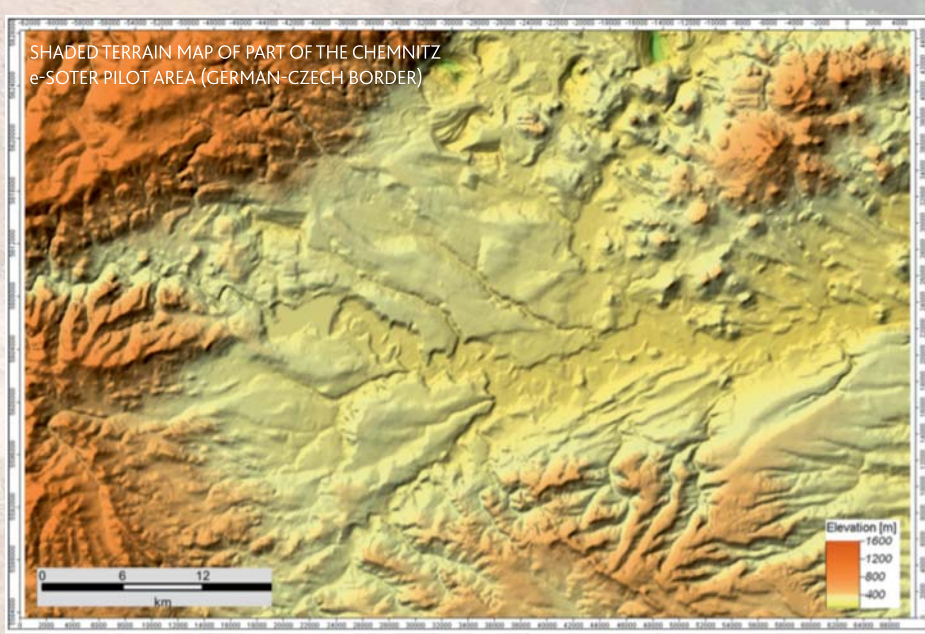
As well as receiving support from its partners, the project overall has been funded by the EU's Seventh Framework Programme (FP7). Van Engelen is explicit about the importance of this support both for financial reasons and to foster credibility: "Without FP7 funding, developments in the ongoing SOTER programme would have been significantly slower and acceptance of the methodology within Europe would have been lower". This is also emphasised by the involvement of 14 partner organisations which hail from the EU, Morocco and China. The majority of these organisations are comprised of national soil institutes or university departments which offer knowledge on soil inventories, using traditional and modern technologies such as remote sensing or spectroscopy; others, including an SME, provide expertise on web services development, database development, geo-morphometric modelling, etc., while the remainder focus on interpretations of the database.

COMPLETING THE PROJECT

The project has already achieved a great deal. Nonetheless, one final objective still remains – to produce a pilot platform and a portal that will provide open access to:

- A methodology to create 1:1 million-scale SOTER and an enhanced soil and terrain database at a scale of 1:1 million for the four windows
- An artefact-free 90m digital elevation model
- Methodologies to create 1:250,000-scale enhanced SOTER databases, and the resulting databases for four pilot areas
- Remote sensing techniques to derive soil attribute data
- Validation and uncertainty propagation analysis
- Dedicated applications related to major threats to soil quality and performance

Together, these will help set up a framework for new, cost-effective field survey and monitoring programs that can be applied locally and globally and represent the European contribution to a standardised soil and terrain database.



SHADED TERRAIN MAP OF PART OF THE CHEMNITZ e-SOTER PILOT AREA (GERMAN-CZECH BORDER)

INTELLIGENCE

e-SOTER

REGIONAL PILOT PLATFORM AS EU CONTRIBUTION TO A GLOBAL SOIL OBSERVING SYSTEM

OBJECTIVES

To address the need for a global soil and terrain database. As the European contribution to a Global Soil Observing System, it will deliver a web-based regional pilot platform with data, methodologies, and applications, using remote sensing to validate, augment and extend existing data.

PARTNERS

ISRIC – World Soil Information, The Netherlands
University of Miskolc, Hungary
Federal Institute for Geosciences and Natural Resource, Germany
Joint Research Centre, Italy
Cranfield University, UK
Alterra, The Netherlands
Szent Istvan University, Hungary
Scilands GmbH, Germany
Institut National de la Recherche Agronomique, France
University of Nottingham, UK
Czech University of Life Sciences, Czech Republic
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VINCENT VAN ENGELEN has over 25 years' experience in soil survey, working for national governments and international organisations. At ISRIC he has been principally responsible for the ongoing development of the global Soil and Terrain Database (SOTER), regional surveys and professional training worldwide.