

Highlights 2014-2015



World Soil Information

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(Credit: Stephan Mantel)

International Developments

2015 has been a landmark year for those who care for soils. Important processes were converging, including the UN International Year of Soils, the development of the Sustainable Development Goals (SDGs) defining the Post-2015 development agenda, and the climate conference in Paris. Soils are important factors in achieving three of the 17 SDGs. Goal 15 is directly related to protecting, restoring and promoting the sustainable use of terrestrial ecosystems and to halting and reversing land degradation. Goal 2 calls for the achievement of food security and the promotion of sustainable agriculture. Goal 17 focuses on strengthening means of implementation and revitalising global partnerships for sustainable development. The significant role that soils can and should play in climate change mitigation and adaptation was also stressed at the Climate Conference in Paris (December 2015). Not surprisingly, these developments have helped to propel soils on to the political agenda. To support the processes above, the provision of quality-controlled soil data and information is critical to being able to address issues of food security, food safety, biodiversity, water management and climate change.

The Global Soil Partnership (GSP), facilitated by the Food and Agriculture Organization of the United Nations (FAO), is the most important international mechanism that could provide the international community with the soil information required. ISRIC has been full-heartedly supporting the GSP in the past years in its efforts to build a global partnership of soil information institutes that works towards global soil data gathering and sharing with end-users. And we will continue our support in the years to come. We have also strengthened our relationships with the United Nations Convention to Combat Desertification (UNCCD). Above and below ground soil organic carbon is one of the three indicators selected to monitor Land Degradation Neutrality. ISRIC has offered to help countries in assessing the soil organic carbon content of their soils, now (as a baseline) and in the future (to assess trends over time).

Trusted broker of soil information

ISRIC, the World Data Centre for Soils (WDC-Soils) within the ICSU World Data System, further strengthened and elaborated its role as a globally operating trusted broker of soil information. For this, the institute has implemented a centralised, online SQL-server database known as World Soil Information Service (WoSIS), that can handle soil point, polygon and grid data. WoSIS will serve a growing selection of quality-

assessed soil data to the international user community as more and more partners decide to share their data freely using our services.

Using point data served from WoSIS and a growing selection of co-variate layers, we have further developed SoilGrids, a global framework for automated, digital soil mapping. In 2014, we have released a first SoilGrids product for the world at 1km resolution as a 'proof-of-concept'. In 2015, with partners, we produced a SoilGrids product with a resolution of 250m for Africa; mid 2016, we will release a 250m resolution product derived through machine learning with global coverage and increased accuracy.

Innovation

ISRIC increased its investment in developing innovative products that add value to the available soil information. The 250x250 meter SoilGrids product for Africa was converted into a product indicating plant available water holding capacity for the continent, which is indispensable information for crop growth modellers. ISRIC also started programmes with various partners in order to deliver innovations for soil fertility management, monitoring and predictions of soil organic carbon stocks, and the monitoring of land degradation. These programmes will yield their first results in 2016.

ISRIC has been working on the development of various apps. SoilInfo app brings soil information to the user, but also allows the user to upload and store soil observations in a dedicated environment. Within the context of the EU-funded iSQAPER project, ISRIC is contributing to the development of an app for land quality assessments.

Education

Over the last two years, the World Soil Museum has developed into a 'to-go-to' place for visitors, students and employees of the Wageningen-based institutions and companies. Visitor numbers have more than doubled and the museum now plays an important role in many education programmes of Wageningen University. In 2015, ISRIC has made considerable progress in developing the online version of the World Soil Museum. From mid-2016, this virtual museum can be visited online, not only to consult the 90 soil profiles that are on permanent display in the physical museum, but also the full ISRIC reference collection of over 1,000 monoliths.

Soil standards

We will continue to contribute to standard setting for

soil data gathering, storage and serving. It is within this context that we have worked on interoperability of soil information with the Open Geospatial Consortium (OGC) and the International Union of Soil Sciences (IUSS) working group on Soil Information Standards. We have also strengthened our collaboration with the IUSS World Reference Base (WRB) Working Group to improve spatial prediction of soil classes based on point observations.

Open data

We are convinced that in order to address pressing global issues such as climate change, food security, flooding, drought and declining biodiversity, the international community has to join forces. This also means proactive sharing of open data to make information available, accessible, citeable and usable. It is within this context that ISRIC joined the Global Open Data for Agriculture and Nutrition (GODAN) partnership in 2015. From

2016, we will share our own products with an open data licence. Obviously, soil data provided to ISRIC by third parties will be managed in compliance with the license specified by the data provider.

Outlook

The year 2016 is special year for us, as we will celebrate our 50th anniversary; there will be various events to make the year a memorable one. ISRIC will continue to support the international community with the provision of quality-assessed soil data and information. In association with our partners, we will create innovative products in response to the special needs of our clients. We will also improve our online communication with the implementation of a new corporate website. Investments are also required to further organise and prepare the world soil reference collection, and launch the online World Soil Museum.

International Year of Soils 2015

To support the UN International Year of Soils (IYS 2015) initiative and propagate the importance of soils, we have been organising and contributing to a series of soil-based events both inside and outside of Wageningen. These activities were aimed at a wide range of target groups.

They included a soil-themed film and discussion event, as well as exhibitions using our soil reference collection in Vienna, Madrid and Leuven. ISRIC also provided IYS 2015 targeted contributions to scientific conferences in Berlin and Wageningen.

Soil Data and Mapping

Standardisation and harmonisation of soil data

Within the framework of the Data project, ISRIC is developing a centralised and user-focused server database known as WoSIS (World Soil Information Service) that draws on contributions from many data providers. The aims of the project are to safeguard world soil data 'as is' (especially for soil legacy data), share soil data (point, polygon, and grid) upon their standardisation and harmonisation and, ultimately, provide quality-assessed input for a growing range of environmental applications. Data in WoSIS are handled in compliance with ISRIC's data policy, respecting inherited restrictions as specified by the data providers. So far, special attention has been paid to the standardisation of soil analytical method descriptions with focus on the set of soil properties considered in the GlobalSoilMap specifications. The resulting standardised point data set, representing data from over 80,000 profiles, was made available to the international community in December

2015. At ISRIC, the standardised data are mainly used to make global SoilGrids products.

Towards global soil data interoperability

ISRIC is a key node for collating, analysing and sharing soil data worldwide within the ICSU World Data System. In conjunction with the WoSIS activities, we contributed to the development of uniform procedures for the exchange of soil data between multiple partners and sources using web services. With Landcare New Zealand (lead), the Commonwealth Scientific and Industrial Research Organisation (CSIRO, Australia) and other partners, ISRIC has contributed to the development and testing of soilML (Soil Markup Language). Feasibility of the data exchange was demonstrated during the soil interoperability (soilIE) exercise supported by the OGC. Results were presented during the 97th OGC Technical Committee meeting in Sydney (December 2015). Subject to further review, soilML may become an OGC standard



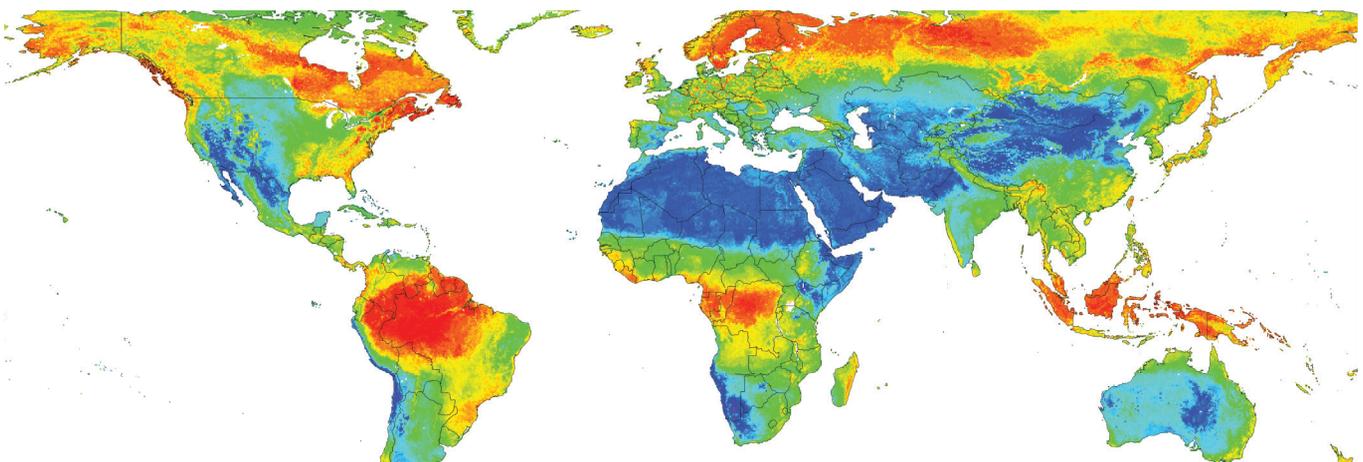
Location of soil point data served through WoSIS (Dec. 2015)

for the collation and transfer of soil data and information. An accepted soilML standard is important for the global community as it provides a technical basis for the exchange of standardised information between multiple data providers in an open setting.

High resolution soil property and class maps for the world

With partners, we have been implementing and serving SoilGrids. The first version (2014), with predictions at a spatial resolution of 1 km, mainly served as a proof-of-concept demonstrating that global compilations of soil profiles and co-variate layers (e.g. land use, elevation, and parent material) can be used in an automated framework to produce complete and consistent spatial predictions of soil properties and soil classes. In 2015, we improved the SoilGrids system to address several accuracy and usability concerns. Building on our

experience with random forest algorithms to predict soil properties for the Africa Soil Information Service, we have replaced the original linear models with tree-based, machine learning models to account for non-linear relationships. SoilGrids predictions are now primarily data-driven and the whole process is fully automated. The initial list of covariates has been extended to better represent factors of soil formation and the spatial resolution of the covariates has been improved to 250 m. The global compilation of soil profiles and samples used for model development has also been extended with extra observations for the Arctic Circle, Brazil, Mexico, and the Russian Federation. Cross-validation showed that these improvements have resulted in jumps in accuracy *vis à vis* the initial SoilGrids1km product. SoilGrids at 250 m resolution will be freely released in mid-2016 under an open data licence.



Test run of SoilGrids250m predictions based on machine learning (soil pH predicted at a depth of 5 cm; red colours indicate low pH values, blue values alkaline soils)

Crowd-sourcing of soil data

In 2015, we released a new version of the SoilInfo app. The re-designed app permits entry of soil observations in the field; so far, users can upload soil information using a template following the FAO Guidelines for soil profile description. The SoilInfo app provides therefore an important tool for crowd-sourcing point data for future

consideration in WoSIS and other applications. Further, the app provides live access to spatial predictions from SoilGrids, including organic carbon content, bulk density and pH, at seven standard depths, as well as predicted soil classes based on the WRB and the USDA (United States Department of Agriculture) classification systems.

Application of Soil Information in Global Development Issues

Food security

Soil data in support of crop yield modelling in Africa

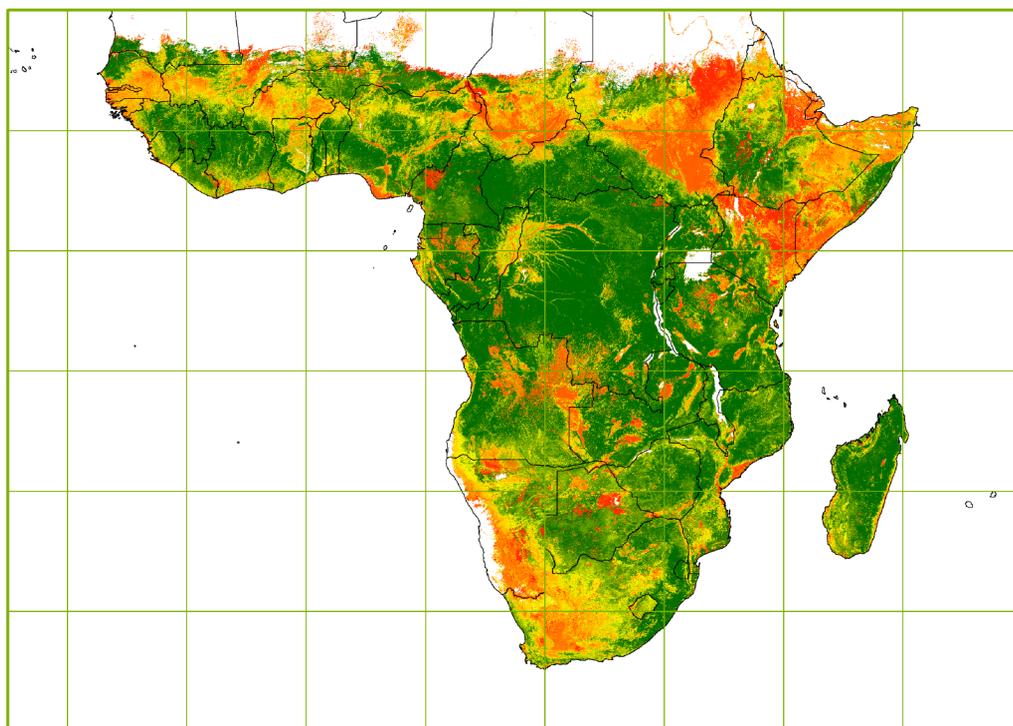
Within the framework of two projects funded by the Bill and Melinda Gates Foundation, AfSIS (Africa Soil Information Service) and GYGA (Global Yield Gap Analysis project), SoilGrids250m for Africa was updated and used to estimate the plant-available water holding capacity in the rooting zone of maize, using pedotransfer functions. The consortium subsequently used the maps to model and map water-limited crop yield potentials and crop yield gaps for ten AGRA (Alliance for a Green Revolution in Africa) countries, in support of soil security in Africa. Main partners involved in this specific application are the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), University of

Nebraska, Plant Production Systems of Wageningen UR, and Columbia Global Centres.

The above studies were underpinned by the extended Africa Soil Profile Database, collated for the AfSIS project, which holds geo-referenced data for some 18,500 soil profiles; these holdings were also incorporated into WoSIS.

Scaling up of evidence-based best practices

Within the CASCAPE project, we described and classified the major agricultural soils of thirty *woredas* (districts). This study provided the basis for scaling up of recommended land management practices in Ethiopia. CASCAPE, a project aimed at building capacity



Root zone plant-available water holding capacity in sub-Sahara Africa (from high (green) to low (red))

for scaling up of evidence-based best practices in agricultural production in Ethiopia, is a joint effort of the governments of Ethiopia and The Netherlands. The project is executed by Alterra, Wageningen UR, in collaboration with partners of the Agricultural Growth Programme (AGP), and in consultation with the EthioSIS (Ethiopian Soil Information System) project.

Framework for soil fertility recommendations

Numerous fertiliser field trials have been carried out throughout eastern and southern Africa by the International Fertilizer Development Center (IFDC). So far, data analyses have focused on average yield

responses and economic returns of specific fertiliser treatments with respect to control treatments. ISRIC was contracted to evaluate the feasibility of using geospatial information to refine present soil fertility recommendations. Further, ISRIC developed a prototype agronomic database to store results of IFDC's fertiliser field trials plus the corresponding soil data. Nineteen experts were trained in using the database during a workshop in Kigali, Rwanda. The work was carried out in cooperation with the Virtual Fertilizer Research Center (VFRC), IFDC, and Wageningen UR with contributions from the Rwanda Agriculture Board and the Institut des Sciences Agronomiques du Burundi.

Combatting land degradation

Preventing and remediating soil degradation through land care

The RECAP (Preventing and remediating degradation of soils in Europe through land care) project started in 2013 and focuses on effective prevention, remediation and restoration measures using an innovative trans-disciplinary approach, actively integrating and advancing knowledge of stakeholders and scientists in 17 case studies, covering a range of soil threats in different bio-physical and socio-economic environments across Europe. Within this project, ISRIC developed appropriate land management measures based on a literature review and stakeholder consultations in the case study areas. ISRIC also provided technical assistance with respect to mapping land degradation and conservation technologies according to the methodology of WOCAT (World Overview of Conservation Approaches and Technologies).

Cost-effective tools to manage soil quality and function

The EU-Horizon2020 funded project on 'Interactive Soil Quality Assessment in Europe and China for Agricultural Productivity and Environmental Resilience' (iSQAPER, 2015-2020) aims to provide agricultural land users and decision-makers with science-based, easy to apply and cost-effective tools to manage soil quality and soil function. ISRIC carried out a detailed literature survey to underpin the development of an app. This app is to provide options to land users for cost-effective agricultural management activities aimed at enhancing soil quality and crop productivity.

Potential productivity and potential resilience of land

In 2015, ISRIC joined the Land-Potential Knowledge System (LandPKS) initiative led by the USDA Agricultural Research Service, New Mexico State University

(Las Cruces). LandPKS aims at establishing a global infrastructure and methodology for assessing potential productivity and potential resilience of land. The current version of the LandPKS app provides users with point-based estimates of land potential based on the integration of simple, geo-tagged user inputs with data, information, and knowledge stored in the cloud. As such, LandPKS provides a robust spatial framework for targeting investments in climate change mitigation and adaptation. Within the LandPKS initiative, ISRIC will provide global soil data (based on the upcoming SoilGrids250m web service) to support complex analysis and prediction of land productivity and resilience.

Improving soil and water management

The Green Water Credits (GWC) initiative develops funding mechanisms between upstream land managers implementing soil and water conservation measures and downstream beneficiaries. In Algeria, a GWC demonstration project was undertaken by a group of seven partners under the lead of ISRIC (2012-2015). The project showed the viability of a GWC investment model within the Oued de la Mina, a catchment of the Cheliff Basin in Northern Algeria. The SWAT (Soil-Water Assessment Tool) model was used to analyse the impacts of defined land use management strategies on the water and sediment dynamics in the La Mina basin, and WEAP (Water Evaluation and Planning tool) to evaluate different scenarios for upstream and downstream interactions. The project was formally closed with a training for some 25 young professionals from various Algerian institutions.

Monitoring is an essential element in the GWC concept as it is necessary to establish a proper compensation

mechanism. For this, the project tested the applicability of drones to record field-level terrain features that are important controls of soil erosion and other land degradation phenomena. Drones also proved suited to identify various sustainable land management practices; tests were undertaken in southern Spain where environmental conditions are similar to those in the La Mina basin.

In China, a GWC demonstration project was completed

in the upstream of the Danjiangkou Reservoir, the water source for the South-to-North Water Transfer from the Yangtze River to Beijing. Results were presented and discussed with the stakeholders; applicability of the GWC concept still has to be appraised within the Chinese legal framework for eco-compensation.

GWC initiatives are important in addressing pressing worldwide issues related to water scarcity, food security, and improving the livelihood of the rural poor.

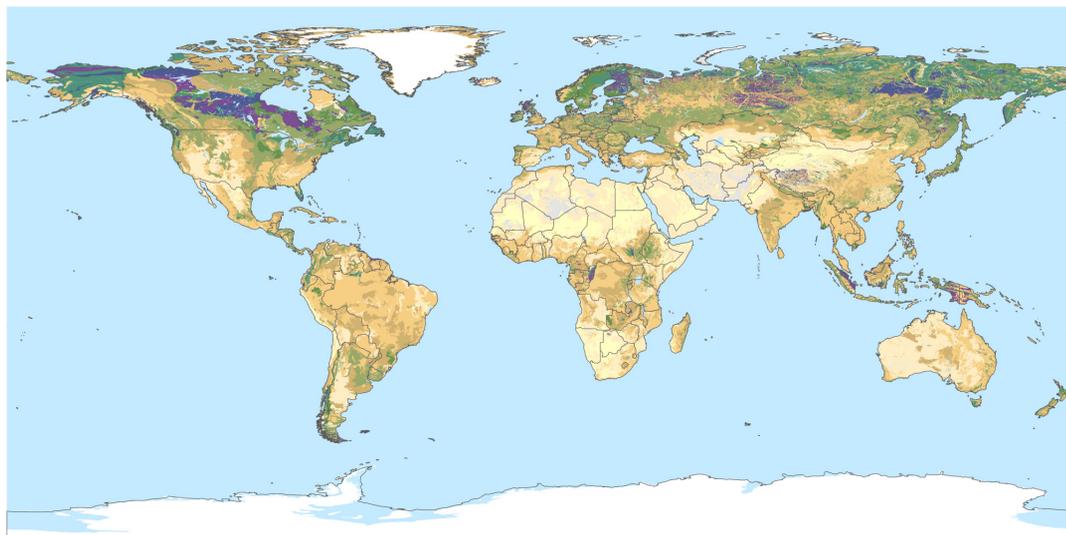
Mitigation and adaptation to climate change

Sequestering carbon in grass- and rangelands in sub-Saharan Africa

The Africa Bureau of the United States Agency for International Development (USAID), through the Adapting Livestock Systems to Climate Change Innovation Lab at Colorado State University (CSU), aims to better understand the impacts of improved land management practices in grasslands and rangelands in Africa, especially in relation to pastoralist communities and their livestock. An international writing team, comprising scientists of AGRA, CSU, ICRAF (World Agroforestry Centre), ILRI (International Livestock Research Institute), FAO and ISRIC, coordinated by CSU carried out a comprehensive assessment of the current state of the science of carbon sequestration in grasslands, and conducted a stocktaking of ongoing and recently completed range and grassland management projects in Africa. The resulting report will help USAID to determine if “it is strategic to invest resources in sequestering carbon in grass- and rangelands” in sub-Saharan Africa.

Global assessment of soil organic carbon stocks

A harmonised world dataset of derived soil properties to 200 cm depth, at a nominal resolution of 1x1km resolution (WISE30sec), was created using conventional soil mapping techniques that consider a 7-layer data model. The dataset presents ‘best-estimates’ for 20 soil properties that are commonly required for global agro-ecological zoning, land evaluation, crop growth simulation, modelling of soil gaseous emissions, and analyses of global environmental change. The study showed that some 30% of the total stock of soil organic carbon (SOC) to 2 m depth (2060 ± 215 Pg C) is held in the Northern Circumpolar Region, which is considered most sensitive to climate change. These findings contribute to the ongoing discussions about the size, and regional distribution, of SOC stocks worldwide as derived from conventional mapping (e.g. Harmonised World Soil Database) and digital mapping approaches such as SoilGrids. and GlobalSoilMap.



Soil organic carbon content to 1 m depth ($Mg C ha^{-1}$) derived from the WISE30sec database

Reference Collections

World soil museum

The aim of the World Soil Museum is to inform and educate a wide audience about the nature and diversity of soils in the world and to show their importance for society and science; as such, it plays a key role in ISRIC's education programme. In 2014 we opened new premises for the World Soil Museum on the Wageningen Campus. Some 90 profiles from ISRIC's soil reference collection, in total consisting of over 1,000 monoliths, are on display providing a unique overview of the main soil types of the world. Principles of soil formation and soil classification are explained on panels; tablets and thematic-stations are used to disclose soil data and provide connections between each monolith, supporting information, soil stories, and to show the importance of judicious land management in regulating land degradation, biodiversity, food security and climate change. In 2015, we started working on a virtual version of the World Soil Museum aimed at enhancing the accessibility to ISRIC's reference collection and educational activities.



Preparation of a soil monolith in ISRIC's workshop
(Credit: Annamária Laborczi)

World soil reference collection

ISRIC further consolidated and extended the World Soil Reference Collection. New monoliths were taken in Belgium, Bhutan, Georgia, Ghana, Indonesia, Spain, Surinam, and The Netherlands. Boxes with the 'raw' monoliths and the associated soil samples were transported to the ISRIC workshop for further processing. New procedures for the preparation of the monoliths, that are environmentally friendly and pose no risk to human health, were developed and tested; generally, the optimal combination of solvents and impregnants is soil type specific. In conjunction with the above research, the storage, registry, documentation, and accessibility of the entire collection (samples, hand specimens, and monoliths) were improved. This with a view to increase the scientific and educational scope of the World Soil Reference Collection, and to make the materials suited for consideration in the upcoming virtual soil museum.



Visitor querying SoilGrids using the central thematic station
(Credit: Mike Bink)



Exploring the monolith collection using a tablet
(Credit: Mike Bink)

We thank our local partners, in the mentioned countries, for the assistance they provided in selecting, sampling and shipping the monoliths. The above activities are co-funded by the Netherlands Ministry of Economic Affairs, Wageningen UR, and ISRIC.

Soil reference library

Since its creation in 1966, ISRIC has maintained a repository for 'endangered' documents on soil resources. At present, the collection consists of some 10,000 soil-related maps, of which 80% have been digitised, and some 16,700 reports, of which some 30% are available online in full-text format. Statistics show that there is a steady demand for the scanned materials held in ISRIC's online library by users from all over the world. At ISRIC, the library holdings provide a valuable source of soil point and map data for consideration in WoSIS.



Scanning a soil map for inclusion in the online ISRIC Library (Credit: Theo Jacobs)

Training and Education Programme

Since 2013, ISRIC has been organising an annual Spring School consisting of two five-day courses that are run in parallel: Hands-on Global Soil Information Facilities (GSIF), and World Soils and their Assessment (WSA). The former introduces participants to methods and software for the management, analysis and modelling of soil data within the R environment for statistical computing. The GSIF course covers a variety of subjects, such as 2D and 3D geostatistics, regression modelling for soil mapping, quantification of uncertainty in soil modelling, sampling for soil mapping, and soil data visualisation. The focus of the WSA course is on international standards for soil assessment. Special

attention is paid to the diversity of world soils, their main forming factors, classification according to the World Reference Base for Soil Resources, and management. The World Soil Museum plays an important role in the Spring School as it provides the reference monoliths for the soil classification exercises.

The Spring School was attended by 49 participants from 27 countries in 2014 and by 48 participants from 29 countries in 2015, thereby creating a fruitful basis for international exchange of information and future project-based cooperation.



Participants and lecturers of the 3rd annual Spring School (2015) (Credit: Theo Jacobs)

Guest researchers, thesis students and internships

ISRIC welcomed six guest researchers from Brazil, China, Ireland, Kenya, and the USA as well as three trainees from France, Germany and Morocco. The main objective of these researchers was to gain practical experience in working with digital soil mapping and global soil information facilities tools, and to discuss options for project-based collaboration.

ISRIC staff supervised two MSc thesis and four PhD thesis students from Wageningen University; the latter included two Guest PhD candidates from Argentina and Brazil.

A recent graduate of Wageningen University stayed with us for a short while, as a volunteer, to gain experience in soil research and GIS methodology. Two volunteers helped ISRIC by receiving and assisting visitors in the World Soil Museum.

Website

The website provides an important entry point to ISRIC's data holdings and services. In 2015 it was consulted by some 104 thousand visitors, up from about 80 thousand

in 2014, and some 50 thousand in 2013. These numbers reflect the growing importance of the website in our information dissemination strategy.



Identifying stakeholder groups during the Access project kick-off meeting (Credit: Theo Jacobs)

Since the last update of the website in 2011, ISRIC has been diversifying and elaborating its products and services. At the same time web technologies have been rapidly developing. The Access project, initiated in 2015, was implemented to re-design ISRIC's corporate website in order to serve better our diverse user groups. The upcoming website will include a newly implemented data download/upload centre and provide improved guidance for professionals from a wide range of scientific disciplines. The project is also looking into how new clients, such as policy and decision-makers, or people from the private sector can be better targeted and served.

Staff

Early 2014 was a period of transition in ISRIC's management. Dr Hein van Holsteijn, interim director, was responsible for the daily management of the institute, while Prof. Dr Peter de Ruiter, Chair of the ISRIC Managing Board, dealt with international relations. As of 1st September 2014, Ir Rik van den Bosch was appointed as Director. He has previously held several management positions at Wageningen UR. From 2012-2014 van den Bosch was manager business development *water* at Alterra and responsible for cooperation with strategic clients. Further, he was a member of the Board of Climate-KIC, a European innovation community for climate adaptation and mitigation.

Staff Publications

ISRIC staff, in conjunction with colleagues from other institutes, have contributed to a range of peer-reviewed and other publications on digital soil mapping, conventional soil mapping, and use of soil data in support of sustainable land management. One paper that stands out and needs to be specially mentioned here is "SoilGrids1km — global soil information based on automated mapping." Full references to our publications may be found at <http://www.isric.org/biblio>

Awards and scientific recognitions

Three ISRIC scientists were specially acknowledged during the period under review. Our former colleague Dr Otto Spaargaren[†] was awarded the 2014 Guy Smith Medal by the IUSS Commission on Soil Classification; he was recognised for his major contributions to international soil classification and correlation with special reference to the development of the World Reference Base for Soil Resources. Dr Gerard Heuvelink, who also holds a position of Associate Professor in Geostatistics with the Soil Geography and Landscape chair group of Wageningen University, was awarded the Webster Medal of the Pedometrics Commission of the IUSS in 2014; pedometrics is “the application of mathematical and statistical methods to study the spatial distribution and origin of soils”. In 2014 the *European Journal of Soil Science (EJSS)* recognised “Total carbon and nitrogen in the soils of the world”, first published by Ir Niels Batjes in 1996, as its third Landmark Paper. Landmark Papers are papers that the *EJSS* has singled out as having made an outstanding contribution to the field of soil science.



Dr Otto Spaargaren was handed the 2014 Guy Smith medal during a special session in Wageningen (From left to right: Prof. Seppe Deckers, Dr Peter Schad, Dr Otto Spaargaren, Ir Rik van den Bosch, and Prof. Dr Karl Stahr).

Membership of editorial boards

The expertise of ISRIC’s staff covers a wide range of disciplines. Four staff members are associate editors (*European Journal of Soil Science; Spatial Statistics*) and/or Editorial Board members of one or more Scientific

Journals, including *Agriculture, Ecosystems, and Environment; Environmental and Ecological Statistics; Geoderma; Geoinformation; Geographical Analysis; and, International Journal of Applied Earth Observations.*



Field description of a soil profile during the annual Spring School (Credit: Theo Jacobs)



(Credit: Stephan Mantel)



World Soil Information

ISRIC – World Soil Information is an independent foundation with a mission to serve the international community with data about the world's soil resources to help addressing major global issues.

ISRIC was founded following a recommendation of the International Soil Science Society (ISSS) and a resolution of the United Nations Educational, Scientific and Cultural

Organization (UNESCO). Since 1966 it has been supported by the Netherlands Government. ISRIC is the *World Data Centre for Soils*, since 1989, within the ICSU World Data System.

ISRIC has a strategic association with Wageningen UR (University & Research Centre).

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