ISRIC World Soil Information Service (WoSIS ver. 2.0)

Towards the standardization and harmonization of world soil data

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ISRIC World Soil Information

Thematic day on "Soil data – New developments and applications" organised by the Dutch Soil Science Society (NBV) and ISRIC – World Soil Information (Wageningen, 4 December 2015)

World Data Centre for Soils WDC Wageningen ICSU WORLD DATA SYSTEM

World Soil Day

2015 International Year of Soils

GLOBAL SOIL PARTNERSHIP

Context

ISRIC mission:
"To serve the international community with information about the world's soil resources to help addressing major global issues"

Three priority areas:
- *soil data and soil mapping*
- *application of soil data in global development issues*
- *training and education*

Source infographic: FAO 2015

WoSIS objective

- Developing a centralized enterprise database to:
  - safeguard world soil data ‘as is’
  - share soil data (point, polygons and grids) upon their standardization and harmonization
  - provide input for a range of applictions

“*We need to better understand and manage our global soil resources*”
Status of the World Soil Resources Report
(GSP, 4 December 2015)

“Decision makers and managers must have access to the information they need, when they need it, and in a format they can use” (GEO, 2010)

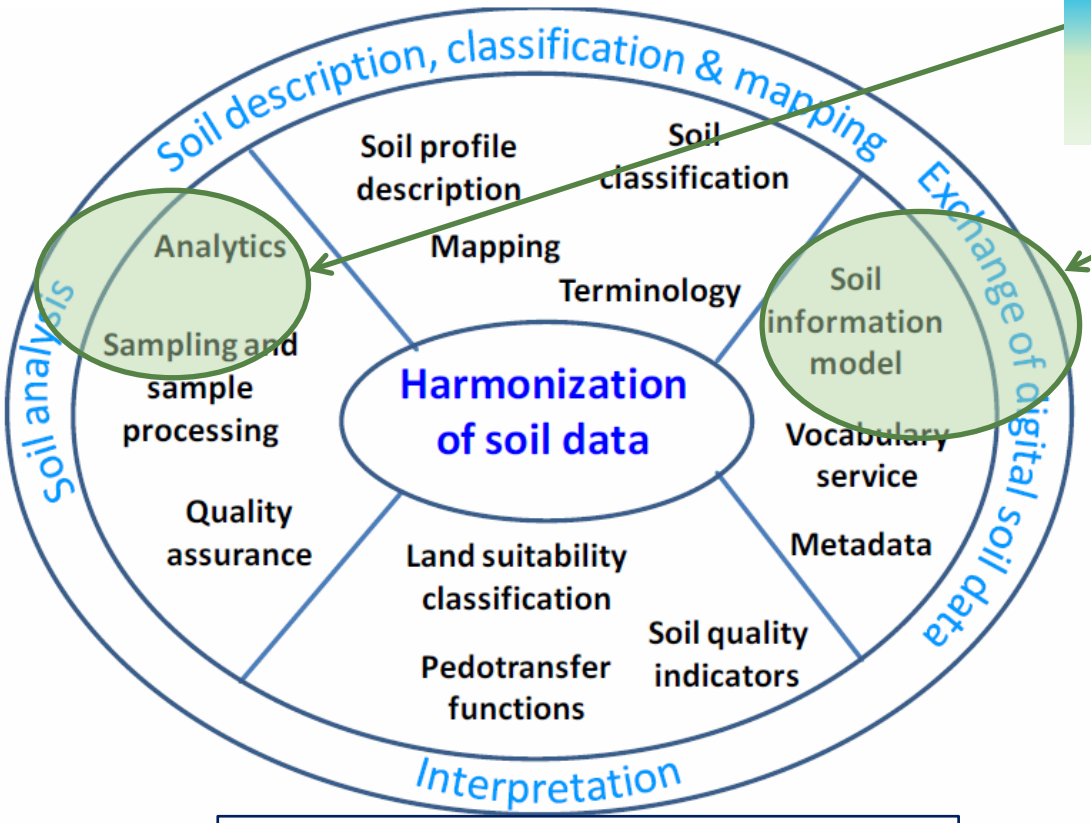
Basic WoSIS principles

- Everybody may contribute data for inclusion in WoSIS
- Data providers must indicate how their data may be distributed
- Conditions for use (licences) are stored/enforced in WoSIS
- The submitted data will be gradually standardized and harmonized, ultimately to make them “comparable as if assessed by a single given (reference) method”
- All quality-assessed and harmonized “shared” data will be made queryable using various web services embedded in ISRIC’s upcoming Spatial Data Infrastructure

➢ *The next slides serve to illustrate some of these ongoing developments*

Areas of harmonization

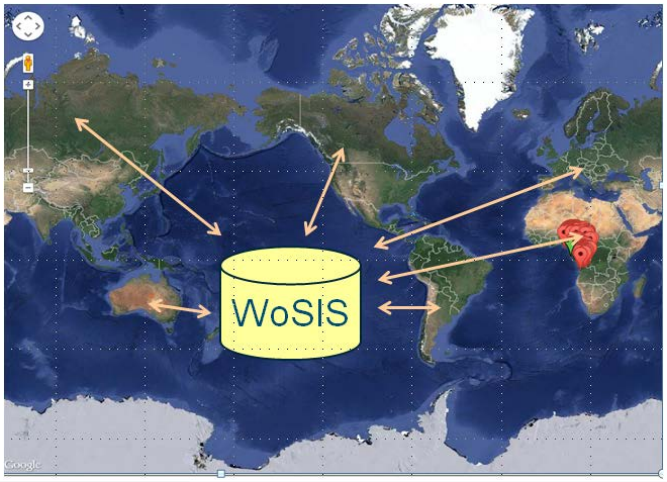
Initial focus in WoSIS 2



GSP areas of harmonization

"Providing mechanisms for the collation, analysis and exchange of consistent and comparable global soil data and information"
(Baritz et al. 2014, GSP Pillar V)

Source data



- Depend on soil profile data provided by a wide range of international partners
- Not all profile data are freely accessible due to inherited restrictions (licences)
- Access rights and lineage are managed in WoSIS 2

WoSIS - Cooperating institutions and experts

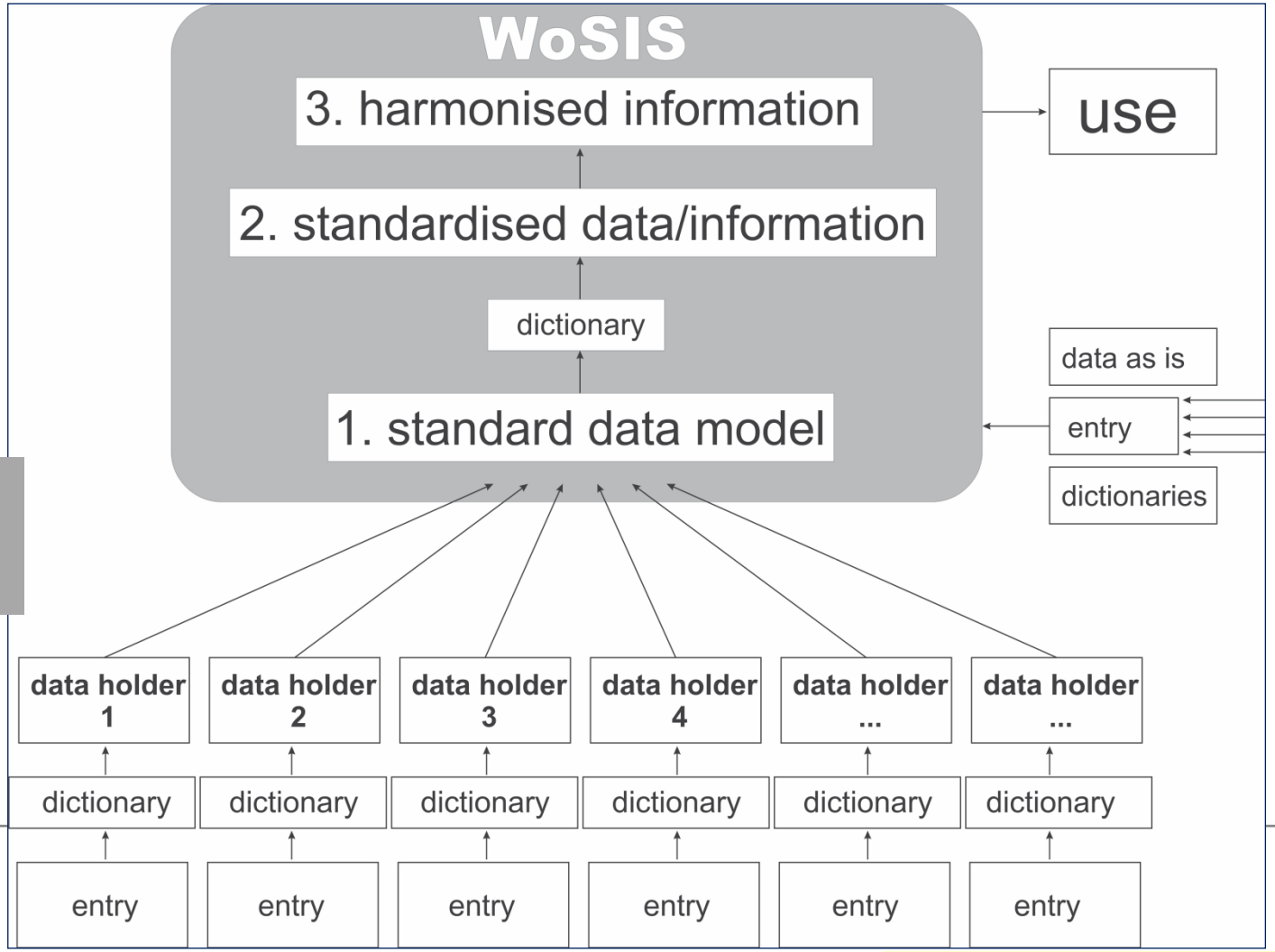
Special thanks go to the steadily growing number of data providers, including soil survey organisations, research institutes and individual experts, that have contributed data for consideration in WoSIS:

- Africa Soil Profiles Database (for contributors see: http://www.isric.org/content/africa-soil-profiles-database)
- Food and Agriculture Organisation of the United Nations (FAO): various inputs through SOTER and WISE-related projects (see: http://www.fao.org/3/a-i3161e.pdf (12)).
- National Cooperative Soil Survey, National Cooperative Soil Characterization Database (NCSS; see: http://ncsslabdatamart.sc.egov.usda.gov/)
- National Soil Profile database for Canada, Canadian Soil Information Service (Ca
http://wms1.agr.gc.ca/xgeng/pedon.zip (0))
- International Soil Carbon Network (ISCN, see http://iscn.fluxdata.org/Pages/default.aspx)

and many others ...

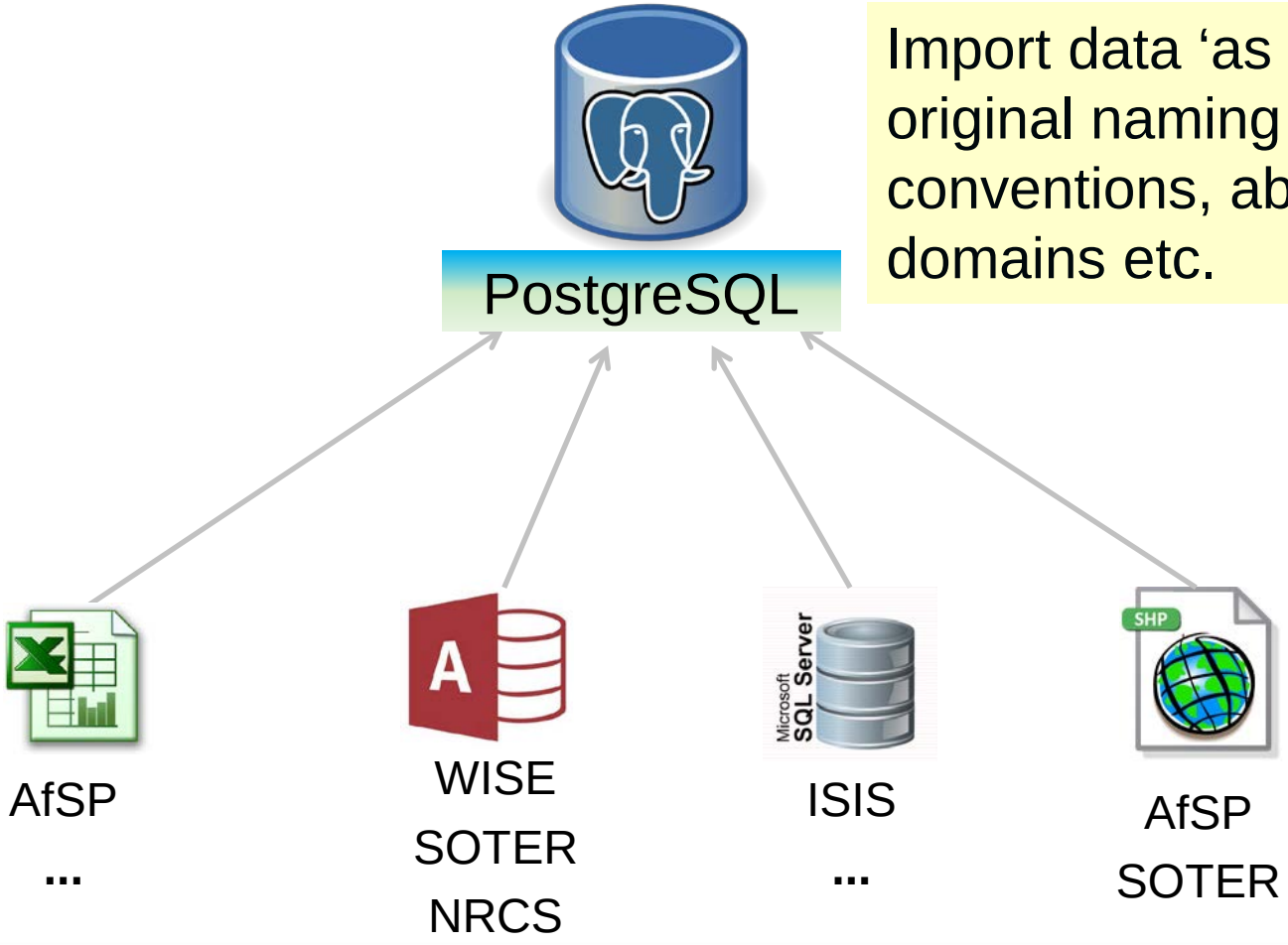
Towards data standardization and harmonization

import source data 'as is' in PostgreSQL



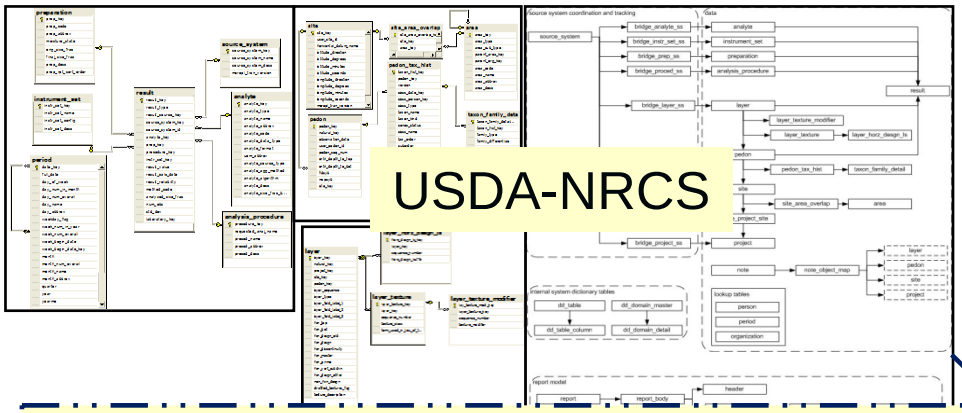
Ribeiro et al. (2015)

Data base format conversion

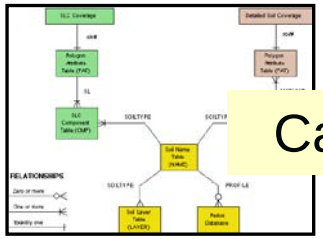


Import data ‘as is’, with the original naming and coding conventions, abbreviations, domains etc.

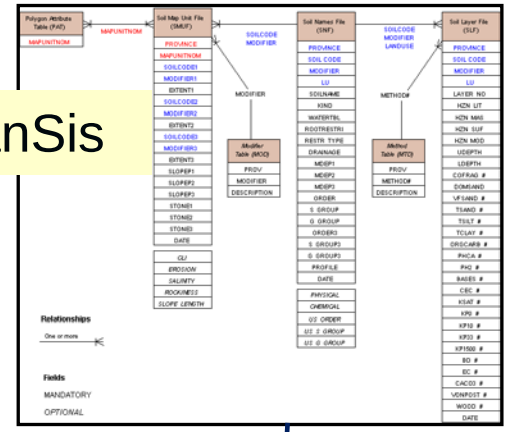
Map source data into WoSIS2 data model



USDA-NRCS

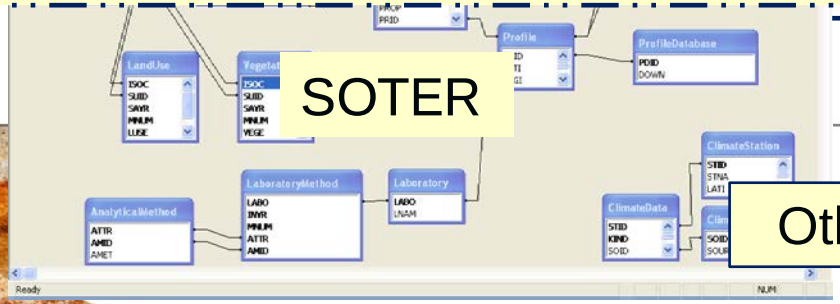


CanSis



Soil data holdings are organised according to numerous:

- data models
- data conventions
- data contents



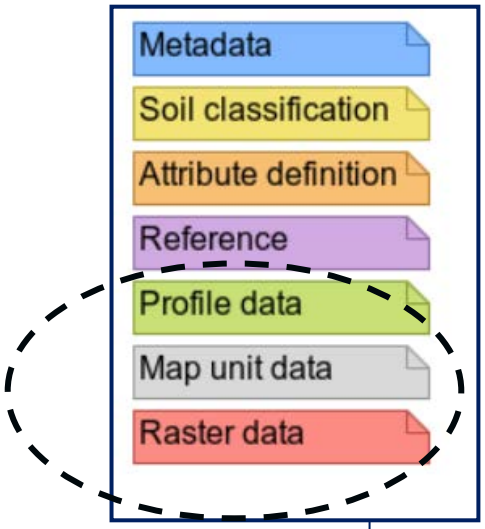
SOTER

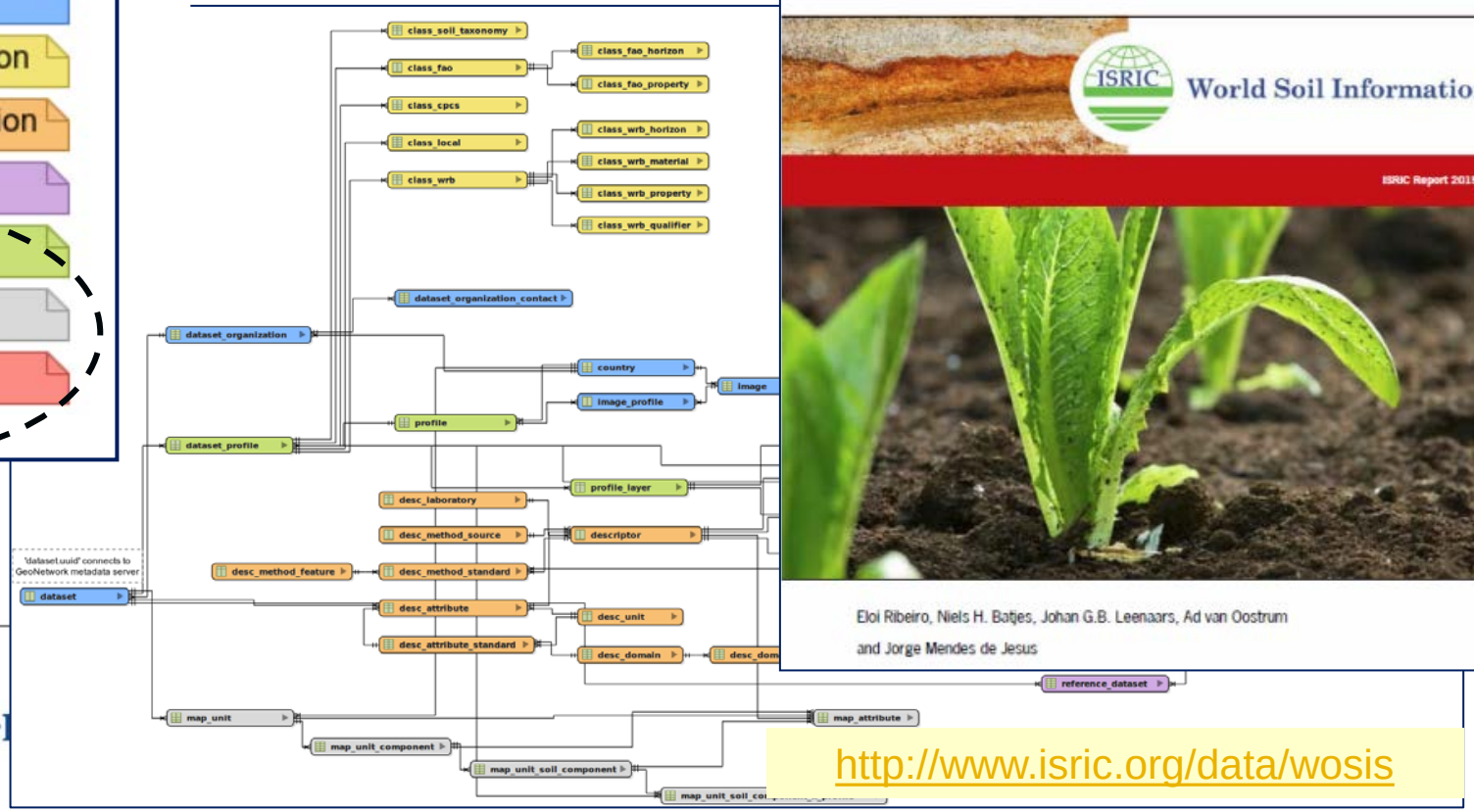
WoSIS2 data model

Other data providers ...

WoSIS2 data model

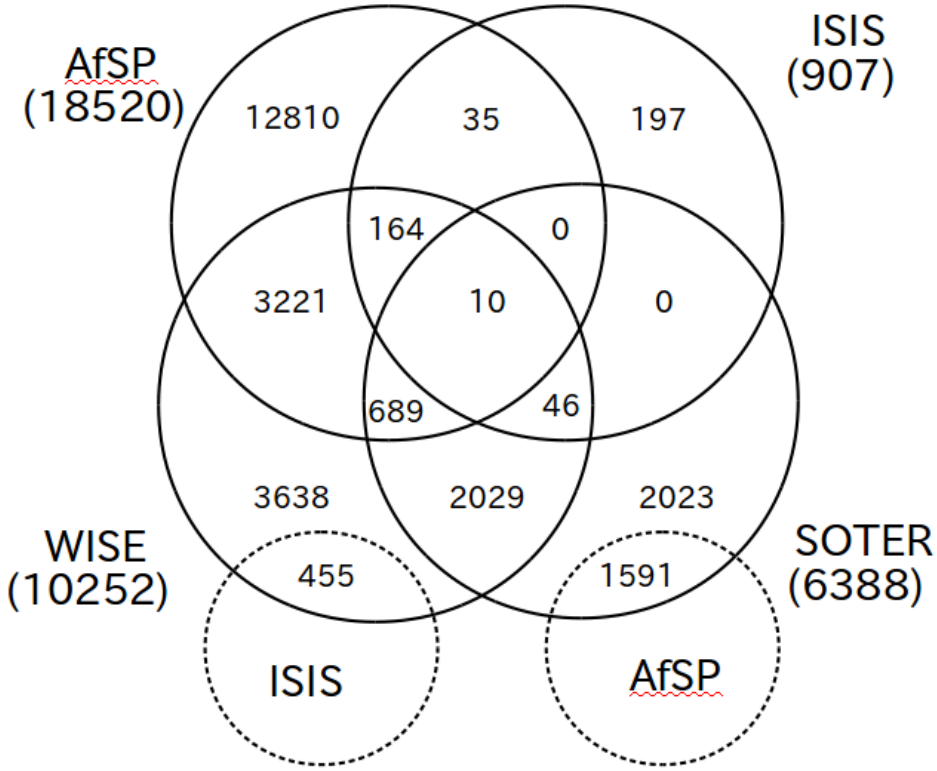
- Relational model implemented in PostgreSQL
- 44 interrelated tables





http://www.isric.org/data/wosis

Flag repeated profiles



Key:

- ISIS - ISRIC Soil Information System (***reference*** *collection*)
- SOTER - Soil and Terrain database programme (***compilation***)
- WISE - World Inventory of Soil Emission potentials (***compilation***)
- AfSP - Africa Soil Profiles database (***compilation***)

Data holdings in WoSIS 2

(December 2015)

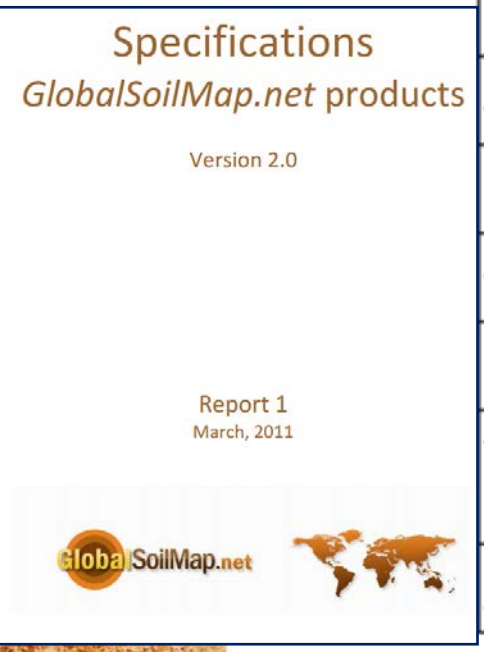
- About 98,000 unique profiles
- Some 76,000 profiles are georeferenced within defined limits
- Number of measured data for each property varies between profiles with depth, generally depending on the purpose of the initial studies
- Source data based on diverse (inter)national standards
- Generally, limited quality information provided with the source (analytical) data

Lineage:
- Datasets, reports & maps

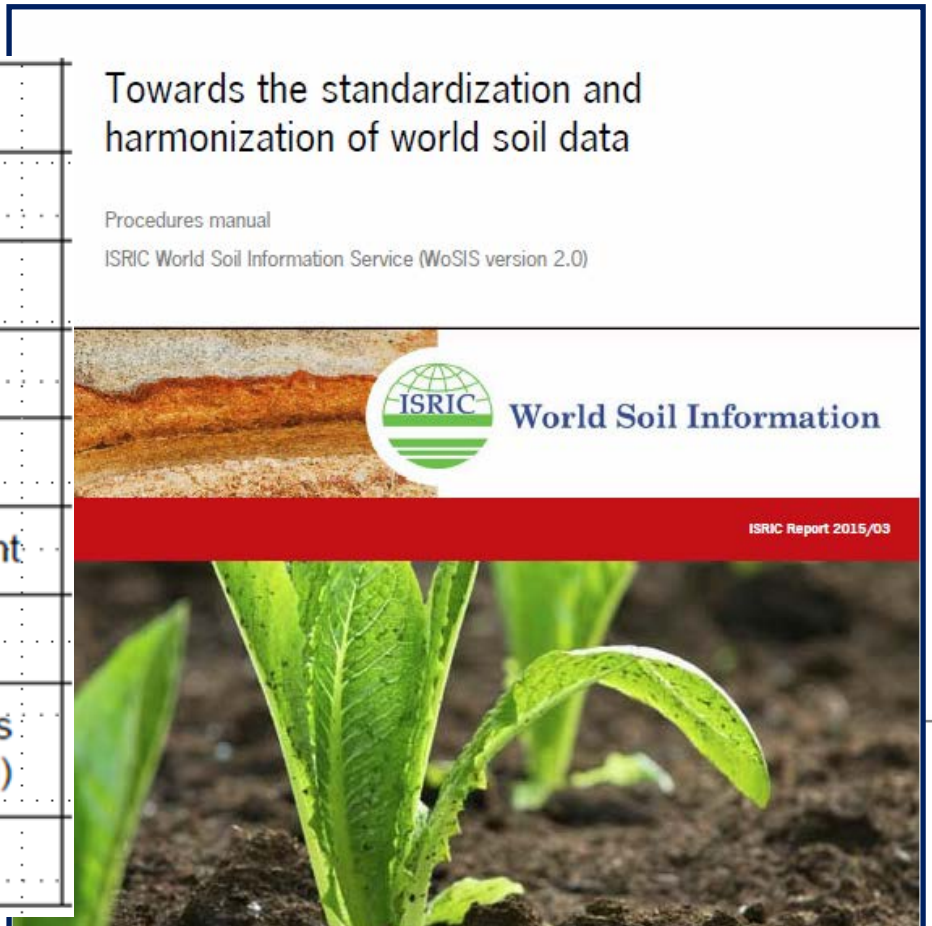
Soil observations and measurements:
- Feature (georeferenced profiles & layers)
- Attribute (x-y-z-t, map, class, site, layer-field, layer-lab)
- Method
- Value, including units of expression

Standardize soil (analytical) method descriptions

- Initial focus on 9 properties considered in the GlobalSoilMap specifications



pH
Organic carbon
CEC
Bulk Density
Water Holding Capacity [b]
Calcium carbonate equivalent
Sand, silt, clay fractions
Coarse fragments (>2mm, as volume percent of whole soil)
Electrical conductivity



Standardize soil analytical method descriptions

- ‘A property is best described by key elements of the (laboratory) procedure applied’ (Soil Survey Staff, 2011)
- Similar approach has been developed for WoSIS 2: ‘Major characteristics of commonly used methods for determining a given soil property are characterised’

Feature name	Analytical method		
	ISO [a]	USDA [b]	ISRIC
Solution	KCl	KCl	KCl
Concentration	1 M	1 M	1 M
Ratio	1 : 5	1 : 1	1 : 2.5
Instrument	Electrode	Electrode	Electrode

[a] ISO 10390:2005 specifies an instrumental method for the routine determination of pH using a

- Code confidence in the ‘translation’: ‘Low’, ‘Medium’, ‘High’
- Standardize units of measurements

GSM: pH water, 1:5

WoSIS 2 – 'Standardized' contents

	desc_attribute_standard_id	desc_unit_id	n_attributes	n_profiles	n_rows_source	n_rows_standard
	Bulk density	kg/dm³	34	25014	446769	446613
	Bulk density whole soil	kg/dm³	4	32852	438749	438739
nt	Calcium carbonate equivalent fraction	g/kg	1	601	2164	2164
nt	Calcium carbonate equivalent total	g/kg	18	32244	168412	168395
	Organic carbon	g/kg	26	66689	388368	387835
	Total carbon	g/kg	3	20857	103781	103781
	Clay fraction	g/100g	1	2235	12835	12835
	Clay total	g/100g	23	87308	525061	525052
	Coarse fragments gravimetric fraction	g/100g	29	35437	4181475	4181342
	Coarse fragments gravimetric total	g/100g	2	34003	294652	294617
	Coarse fragments volumetric fraction	cm³/100cm³	10	32846	1103614	1103146
	Coarse fragments volumetric total	cm³/100cm³	23	46582	302388	282415
	pH CaCl2	unitless	8	47730	293977	293966
	pH field	unitless	1	15	87	43
	pH H2O	unitless	26	84528	567623	558458
	pH KCl	unitless	19	16641	110490	110482
	pH NaF	unitless	2	5844	29904	29890
	pH NH4CL	unitless	1	24	148	148
	pH unknown	unitless	2	35	236	236
	Sand fraction	g/100g	79	63631	1854800	1854799
	Sand total	g/100g	21	85941	516729	516727
	Silt fraction	g/100g	8	50486	616493	616319
	Silt total	g/100g	20	83367	505054	504992
	Water retention gravimetric	g/100g	16	36747	383479	379597
	Water retention volumetric	cm³/100cm³	104	21726	167630	167403
			481		**13,014,918**	**12,979,994**

- Some 28.5 million soil analytical records in WoSIS 2
- 45% thereof has been 'standardized' and quality-assessed

Harmonize to reference method ‘Y’

(*not yet undertaken in WoSIS*)

Table 11 Example regression equations for converting values of pH between different methods

No.	Target Method (Y)	Source Method (X)	Equation	R2	Reference
1	pH (1:1 0.01 m CaCl2)	pH (1:1 water)	y = 1.08(x) - 0.973	0.98	Miller and Kissel (2010)
2	pH (1:1 0.01 m CaCl2)	pH (saturated paste)	y = 1.10 (x) - 0.923	0.98	Miller and Kissel (2010)
3	pH (1:1 0.01 m CaCl2)	pH (1:2 water)	y = 1.05 (x) - 0.950	0.97	Miller and Kissel (2010)
4	pH (1:1 water)	pH (1:1 0.01 m CaCl2)	$y = x + 0.267 (EC\ 1:1\ water)^{-0.445}$	0.99	Miller and Kissel (2010)
5	pH (1:2 water)	pH (1:1 0.01 m CaCl2)	$y = x + 0.239 (EC\ 1:1\ water)^{-0.505}$	0.98	Miller and Kissel (2010)
6	pH (1:5 0.01 m CaCl2)	pH (1:5 water)	y = 1.012 (x) - 0.76	0.99	Convers and Davey (1988)

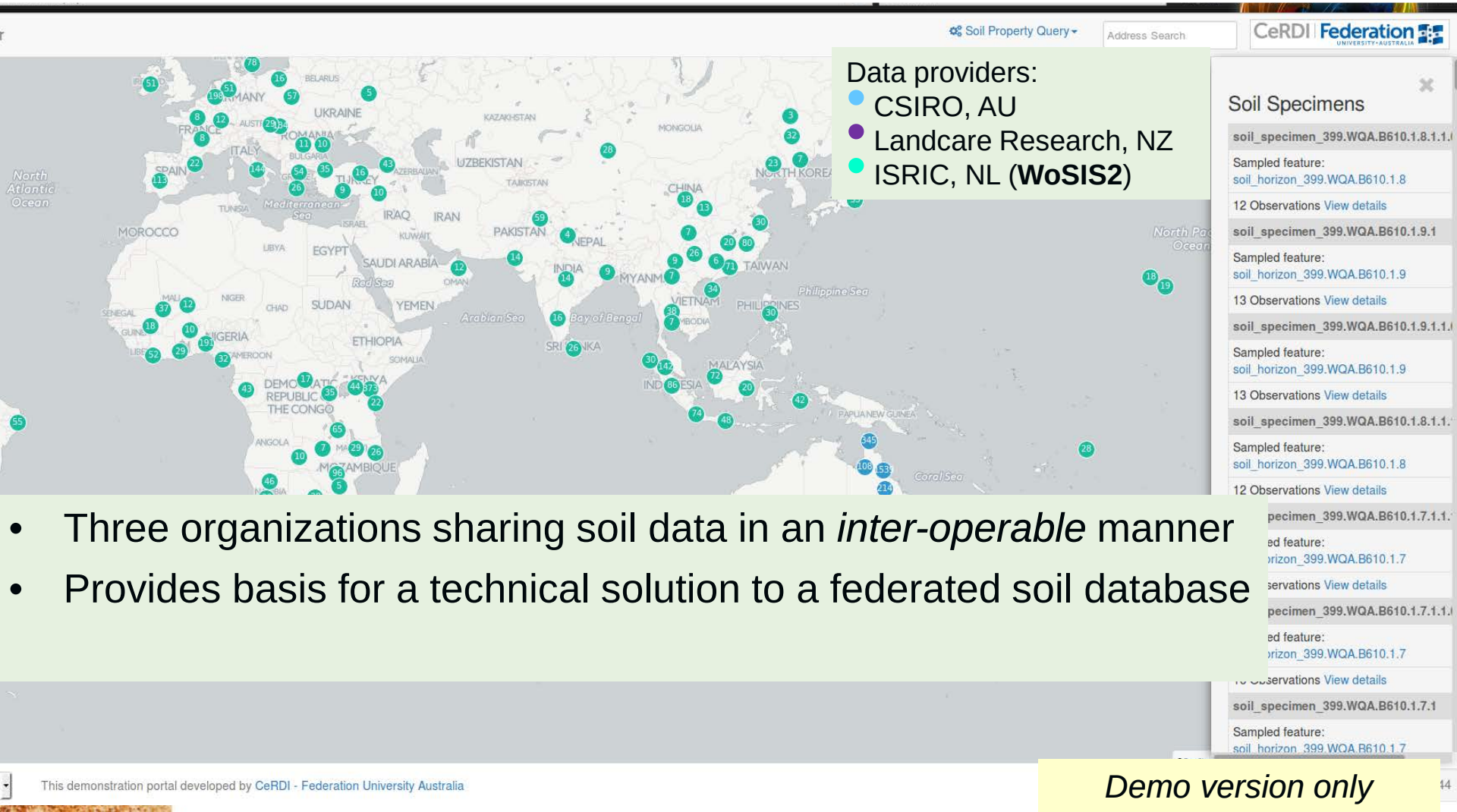
- “Make the data comparable, as if assessed by a single given (reference) method”
- “There is generally no universal equation for converting from one method to another in all situations” (GlobalSoilMap 2013)
- This would imply that: “each regional node will need to develop and apply node-specific conversions (towards the GSP-adopted standard methods and soils), building on comparative analyses of say archived samples” (Baritz et al., 2014)

OGC soil IE experiment

- OGC Soil Data Interoperability Experiment
- Development and testing of a Soil Markup Language (soilML)
  (Geography ML compatible encoding for soil features)
- WoSIS2 data model was used for testing
  (Soil IE presentation at 97th OGC Tech. Comm., Sydney, Australia, 3/12/ 2015)
- On the way to a new OGC standard?

IE initiators:
- CSIRO, Commonwealth Scientific and Industrial Research Organisation, Australia
- Landcare Research New Zealand *(Tech. Lead)*
- ISRIC - World Soil Information, The Netherlands

OGC soil IE experiment



- Three organizations sharing soil data in an *inter-operable* manner
- Provides basis for a technical solution to a federated soil database

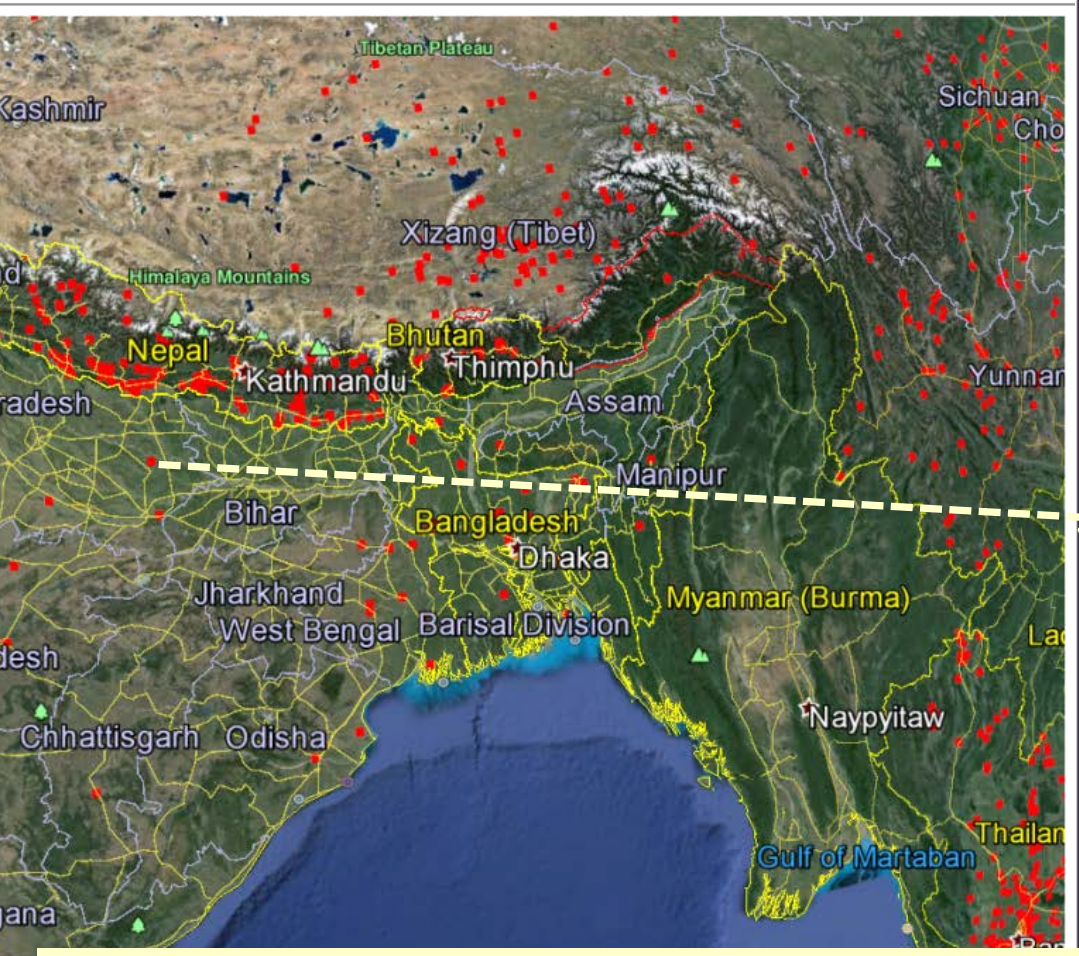
OGC soil IE experiment

- ISRIC developed a Web Processing Service (WPS) and Soil Pedotransfer Service (*prototype*):
  - Get soil horizon information on texture from the server
  - Apply PTF to calculate: bulk density, available water (FC, WP), and saturated hydraulic conductivity

```
<?xml version="1.0"?>
- <wps:ExecuteResponse xml:lang="en-CA" serviceInstance="http://wps.isric.org/wps:80/wps?service=w
xsi:schemaLocation="http://www.opengis.net/wps/1.0.0 http://schemas.opengis.net/wps/1.0.0/wp
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:xlink="http://www.w3.org/1999/
xmlns:ows="http://www.opengis.net/ows/1.1" xmlns:gml="http://www.opengis.net/gml">
  - <wps:Process wps:processVersion="0.1">
      <ows:Identifier>pedotransfer_texture</ows:Identifier>
      <ows:Title>Soil Pedo Transfer service</ows:Title>
      <ows:Abstract>Process will calculate wilting point, field capacity and bulk density based on pa
        EXPERIMENTAL SERVICE NO WARRANTY OF VALUES GENERATED OR SERVICE UPTIME. Ex
        request=execute&service=wps&identifier=pedotransfer_texture&version=1.0.0&datainpu
  </wps:Process>
  - <wps:Status creationTime="2015-11-30T09:29:11Z">
      <wps:ProcessSucceeded>PyWPS Process finished</wps:ProcessSucceeded>
  </wps:Status>
  - <wps:ProcessOutputs>
    - <wps:Output>
        <ows:Identifier>soilhorizon</ows:Identifier>
        <ows:Title>Parsed XML section used for calculation</ows:Title>
      - <wps:Data>
        - <wps:ComplexData mimeType="text/xml">
```

Serving WoSIS data to the user

(prototype)



profile_ph.102932

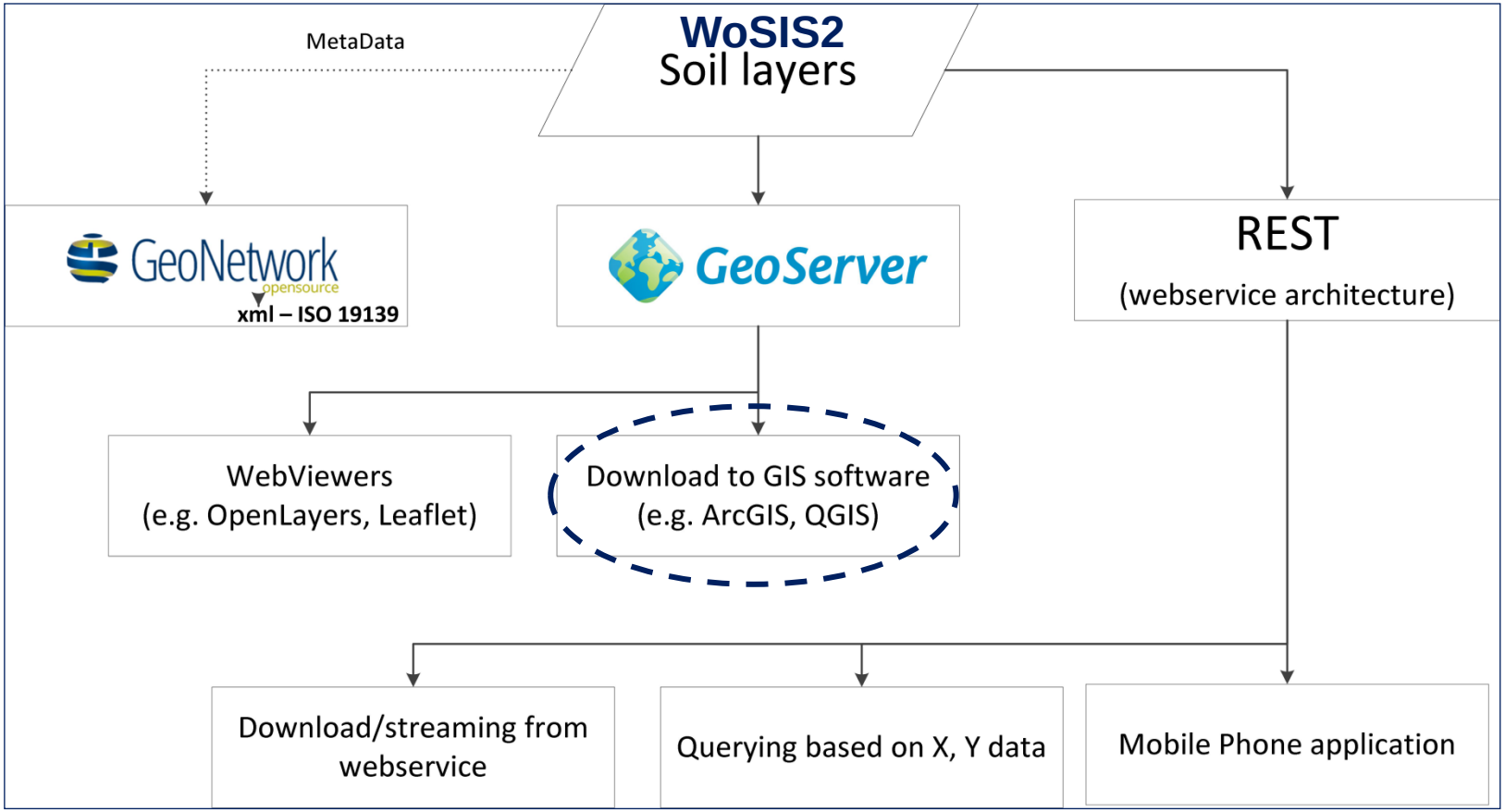
profile_ph

- **gid:** 102932
- **dataset_id:** WISE
- **profile_co:** IN0124
- **profile_id:** 67260
- **profile_la:** 30408
- **observatio:** 1-12-79 0:00
- **upper_dept:** 0
- **lower_dept:** 15
- **agg1:** pH
- **agg2:** pH H2O
- **source_att:** pH water
- **source_a_1:** pH, measured in water
- **source_a_2:** unitless
- **source_a_3:** Real
- **source_ana:** pH in 1:2 soil/water solution
- **source_val:** 7.1
- **standard_a:** pH
- **standard_1:** unitless
- **standard_2:** Real
- **standard_3:** concentration = not applied, instrument = unknown, ratio = 1:2, solution = water [H2O]
- **country_id:** IN
- **st_y:** 23.1666666666667
- **st_x:** 79.95

- Content consistency checks are ongoing
- Prototype WFS (via www.isric.org/data/wosis)
- Official release in 2016 through ISRIC's upcoming GeoNode

Interoperability and webservices

(SDI under development)



Work in progress ...

Conclusions

- Disparate source databases pose many and diverse challenges
- In view of its global scope, WoSIS will always remain ‘work in progress’
- Future releases of WoSIS will consider a broader range of soil data and their standardization/harmonization
- WoSIS-derived data will be served using an increasing range of webservices through ISRIC’s evolving SDI (2016)

Thank you

Further information: www.isric.org/data/wosis

2015 International Year of Soils

GLOBAL SOIL PARTNERSHIP

ISRIC World Soil Information

World Data Centre for Soils WDC Wageningen

ICSU WORLD DATA SYSTEM