S-World – global soil map

Jetse J. Stoorvogel et al

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100years 1918 — 2018

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Overview

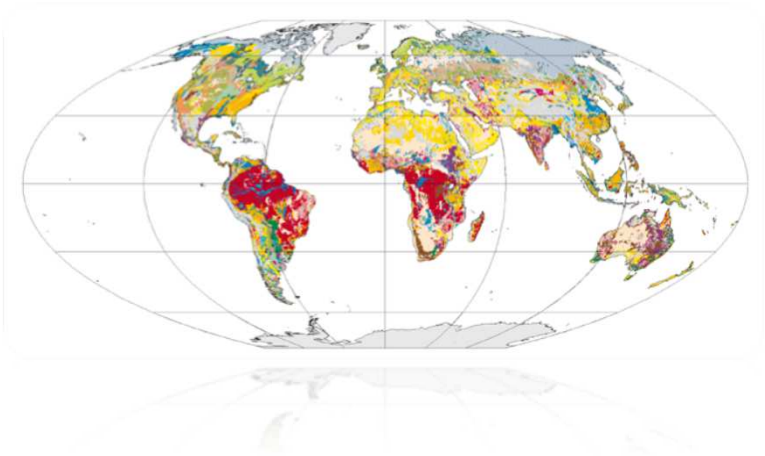
- Background
- The S-world methodology
- Modelling changes in soil resources
- From soil properties to national accounts
- Data quality
- The Mexican application

Backgrounds

- Soil resources are extremely important

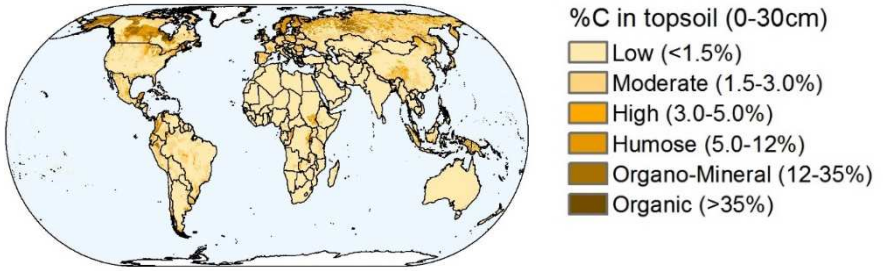
Backgrounds

- Soil resources are extremely important
- > 70% of the earth surface has not been mapped at a scale below 1:1 million



Backgrounds

- Soil resources are extremely important
- > 70% of the earth surface has not been mapped at a scale below 1:1 million
- Quantitative insight in soil properties



Backgrounds

- Soil resources are extremely important
- > 70% of the earth surface has not be 1:1 million
- Quantitative insight in soil properties
- Widespread soil degradation

Source	Calculation method	Estimate
GLASOD (Oldeman et al., 1990)	Expert opinion	15% of land is degraded
Drenge & Chou (1992)	Expert opinion	70% of drylands affected by degradation (36 million km^2)
FAO TerraSTAT (Bot et al., 2000)	Expert opinion	65% (60 million km^2) of the world's land is slightly to severely affected by degradation
FAO GLADA (Bai et al., 2008)	Satellite-based approach (NDVI)	Over the 1981–2006 period, about 24% of land was degraded, substantially (27 million km^2)
Cai et al., (2011)	Biophysical Models	Almost 10 million km^2 of degraded and abandoned lands
Ramankutty & Foley (1999)	Based on land abandonment	Cropland abandonment increased from 0.6–22 million km^2, 1950–1990
HYDE Database (Campbell et al., 2008)	Based on land abandonment	3.8–4.7 million km^2 abandoned land (over the last 300 years)
FAO Pan-tropical Landsat	Based on land abandonment	0.8 million km^2 of cropland and pasture was abandoned temporarily or permanently, in the 1990s
Le et al., (2014)	Satellite-based approach (NDVI)	29% of land contains degradation hotspots

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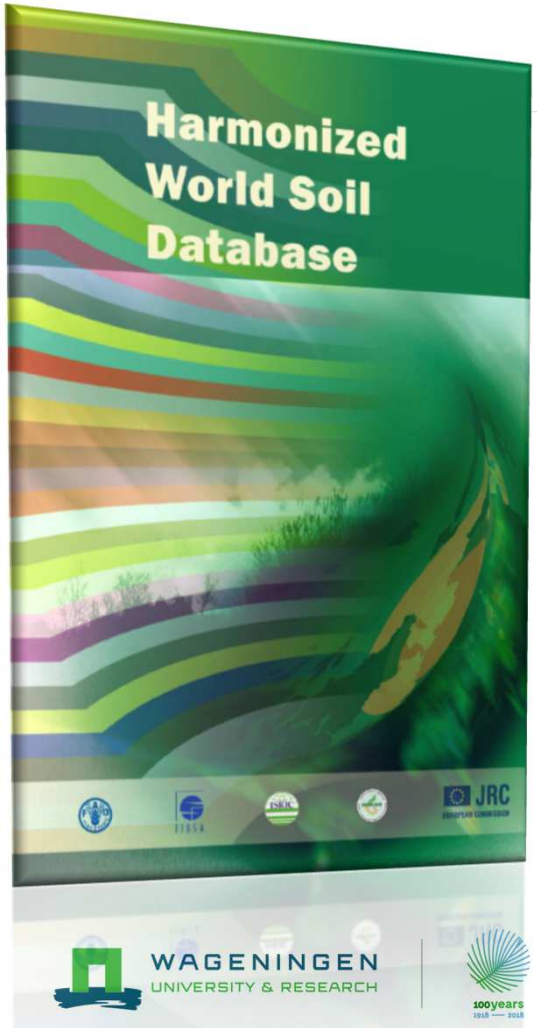
The challenge

Soil conditions

- Global coverage
- Quantitative
- Consistent
- High resolution
- High quality
- Temporal dynamics
- Based on existing data



Harmonized World Soil Database

- Resolution
- Consistency
- Quality

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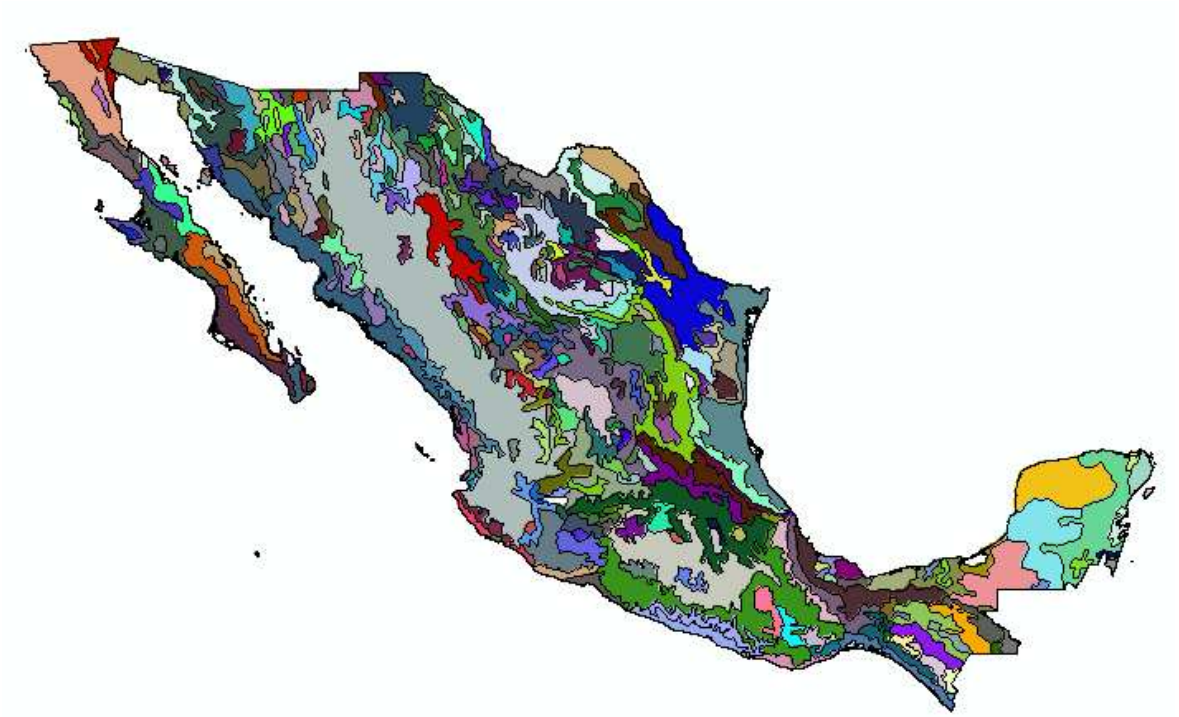
The issues - resolution



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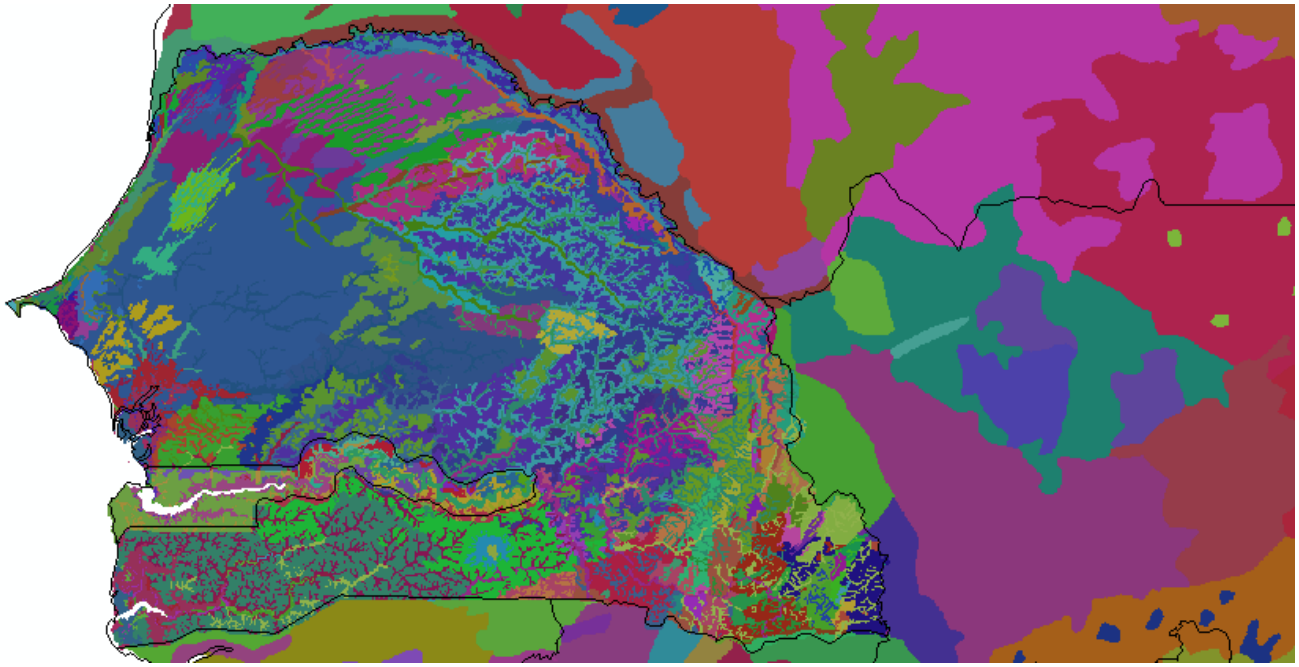
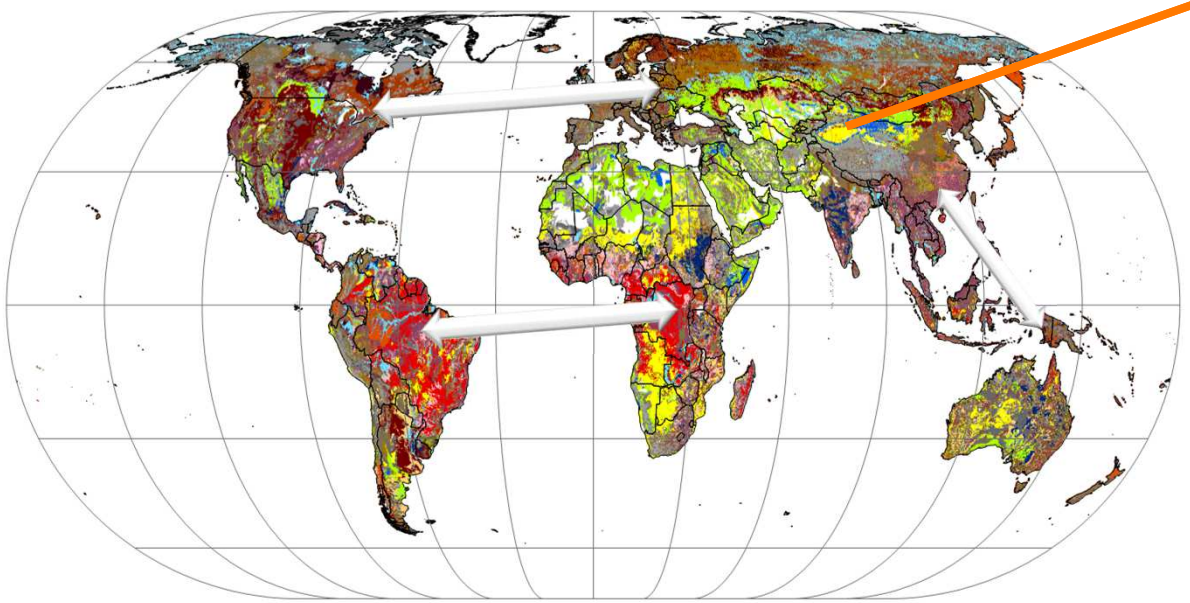
The issues - consistency



The issues - Quality



Delineated area

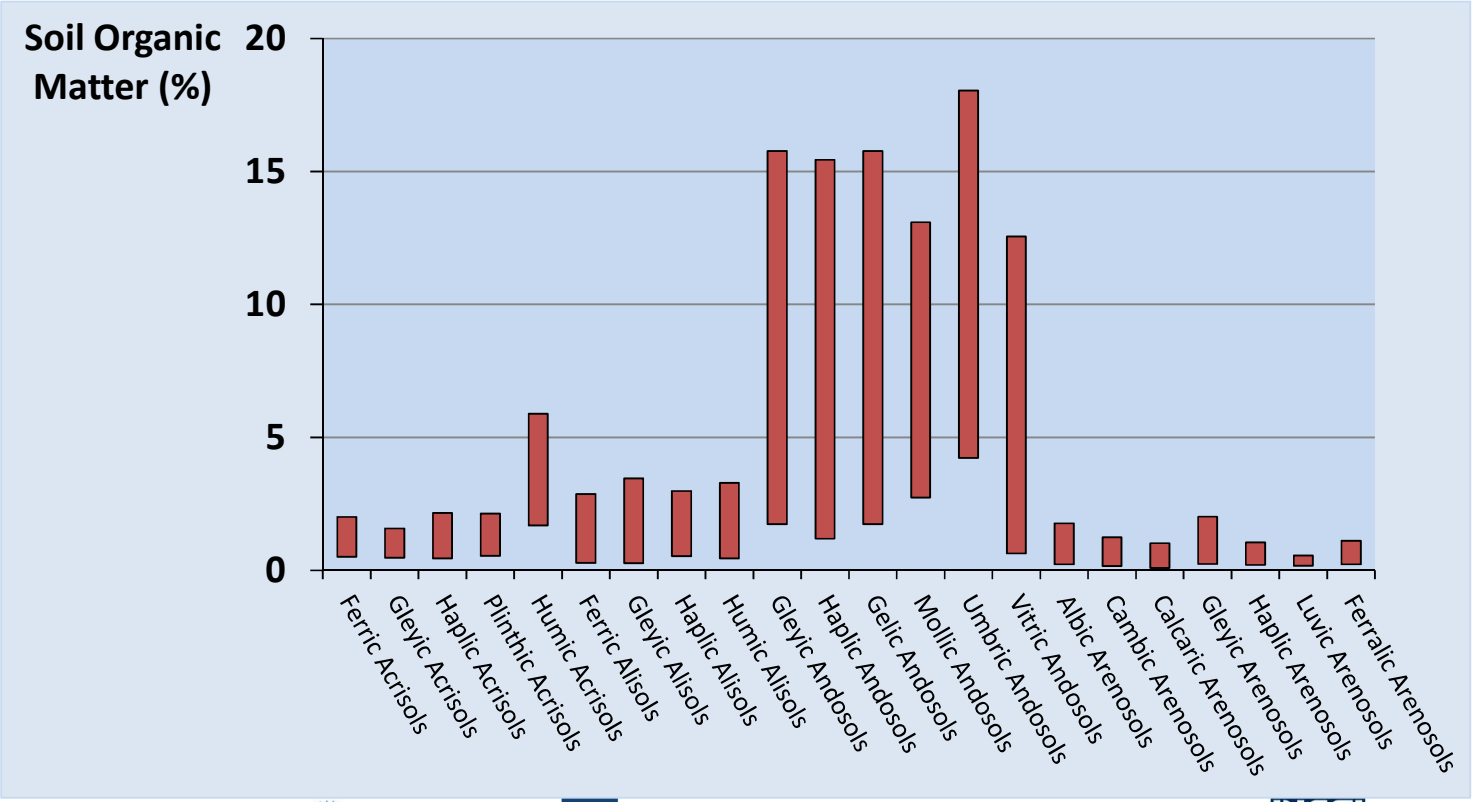
Mapping unit

Soil type(s)

Soil profile

Soil properties

The issues - Quality



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The methodology

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Land Degrad. Develop. **28**: 22–33 (2017)
Published online 1 December 2016 in Wiley Online Library (wileyonlinelibrary.com) **DOI**: 10.1002/ldr.2656

S-WORLD: A GLOBAL SOIL MAP FOR ENVIRONMENTAL MODELLING

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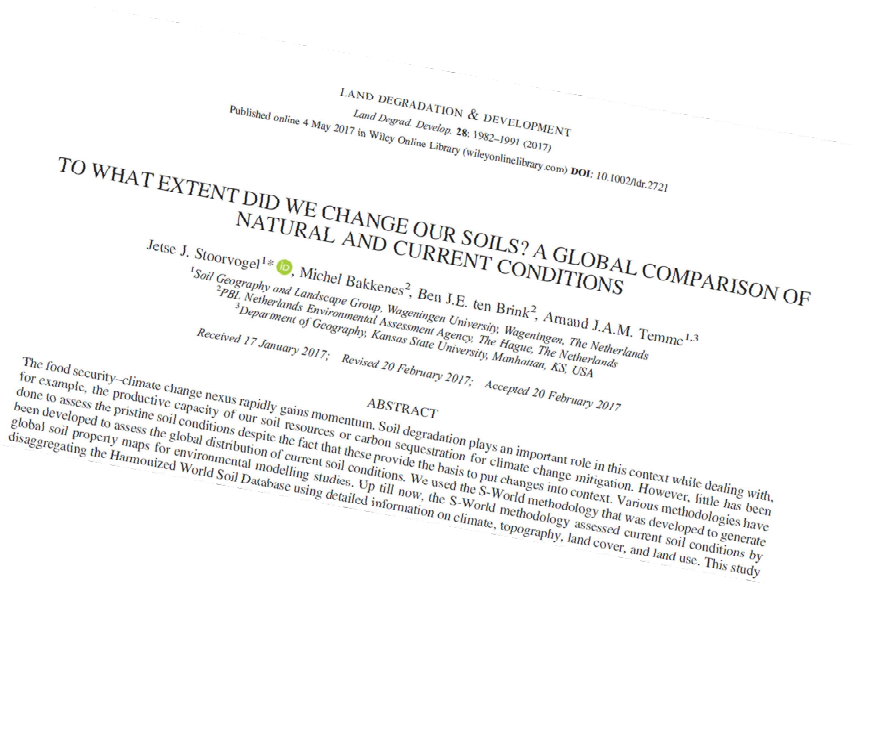
[1]*Soil Geography and Landscape Group, Wageningen University, Wageningen, The Netherlands*
[2]*PBL Netherlands Environmental Assessment Agency, The Hague, The Netherlands*
[3]*ISRIC – World Soil Information, Wageningen, The Netherlands*

Received 19 September 2016; Revised 21 October 2016; Accepted 21 October 2016

ABSTRACT

The research community increasingly analyses global environmental problems like climate change and desertification with models. These
Global environmental modelling studies require global, high resolution, spatially exhaustive, and quantitative data describing the soil profile
This study aimed to develop a pedological approach that takes stock of available legacy and auxiliary data to create a global, 30 arc second
soil property database for modelling. The methodology uses the Harmonized World Soil Database and the ISRIC-WISE 3.1 soil profile
database. Auxiliary information at 30 arc second resolution for various landscape properties is used to describe the variation in landscape



LAND DEGRADATION & DEVELOPMENT
Land Degrad. Develop. **28**: 1982–1991 (2017)
Published online 4 May 2017 in Wiley Online Library (wileyonlinelibrary.com) **DOI**: 10.1002/ldr.2721

TO WHAT EXTENT DID WE CHANGE OUR SOILS? A GLOBAL COMPARISON OF NATURAL AND CURRENT CONDITIONS

Jetse J. Stoorvogel[1]*, Michel Bakkenes[2], Ben J.E. ten Brink[2], Arnaud J.A.M. Temme[1,3]
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[2]*PBL Netherlands Environmental Assessment Agency, The Hague, The Netherlands*
[3]*Department of Geography, Kansas State University, Manhattan, KS, USA*

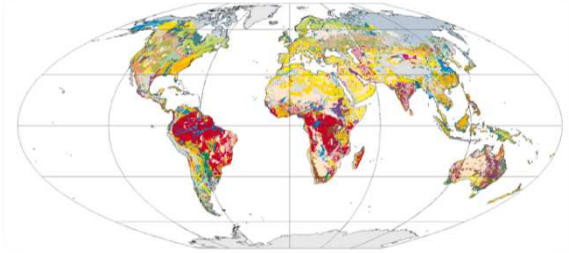
Received 17 January 2017; Revised 20 February 2017; Accepted 20 February 2017

ABSTRACT

The food security–climate change nexus rapidly gains momentum. Soil degradation plays an important role in this context while dealing with,
for example, the productive capacity of our soil resources or carbon sequestration for climate change mitigation. However, little has been
done to assess the pristine soil conditions despite the fact that these provide the basis to put changes into context. Various methodologies have
been developed to assess the global distribution of current soil conditions. We used the S-World methodology that was developed to generate
global soil property maps for environmental modelling studies. Up till now, the S-World methodology assessed current soil conditions by
disaggregating the Harmonized World Soil Database using detailed information on climate, topography, land cover, and land use. This study

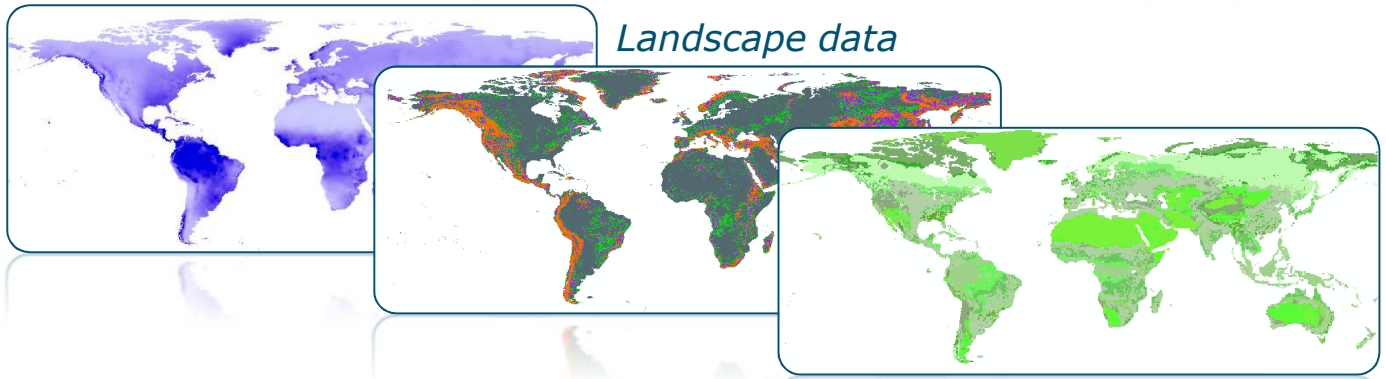
Starting point

Harmonized World Soil Database

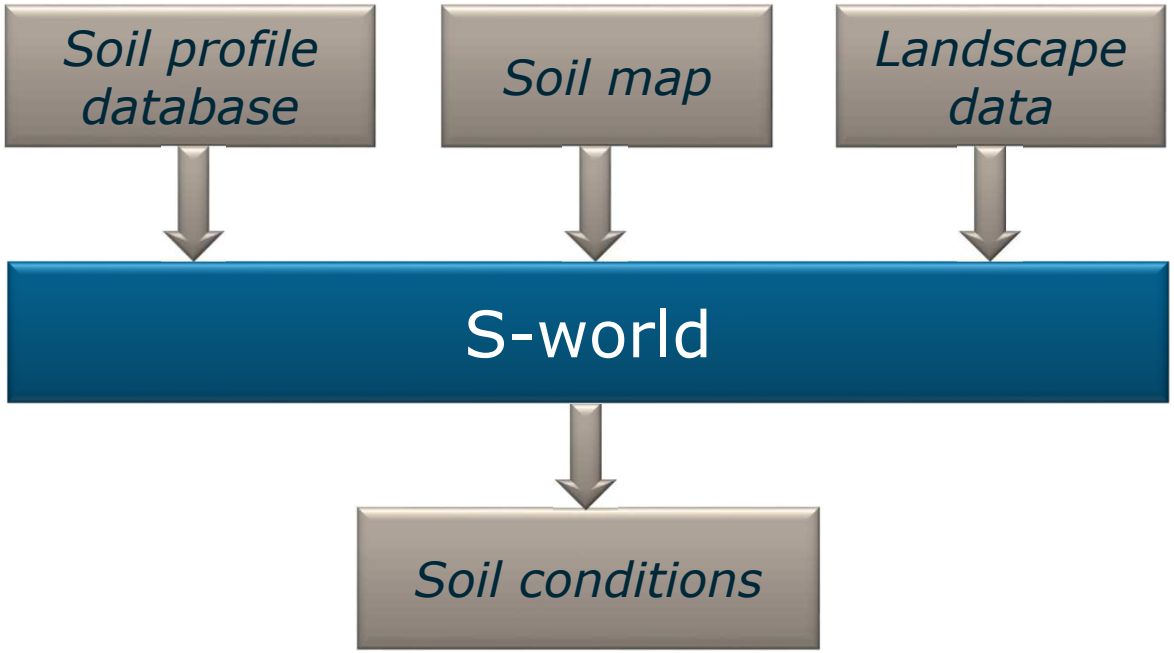


WISE database

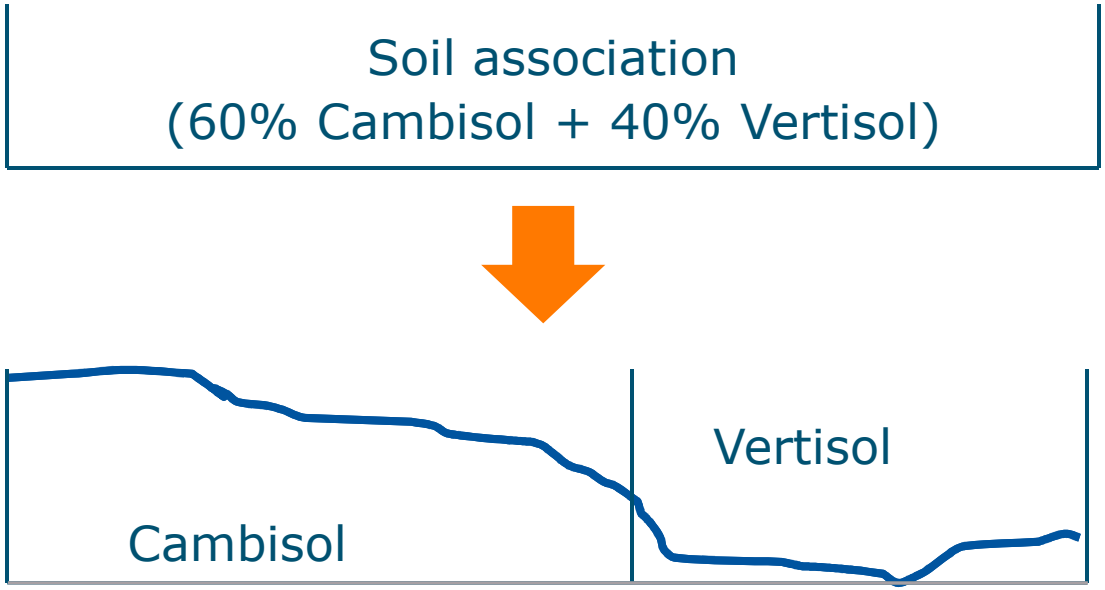
Landscape data



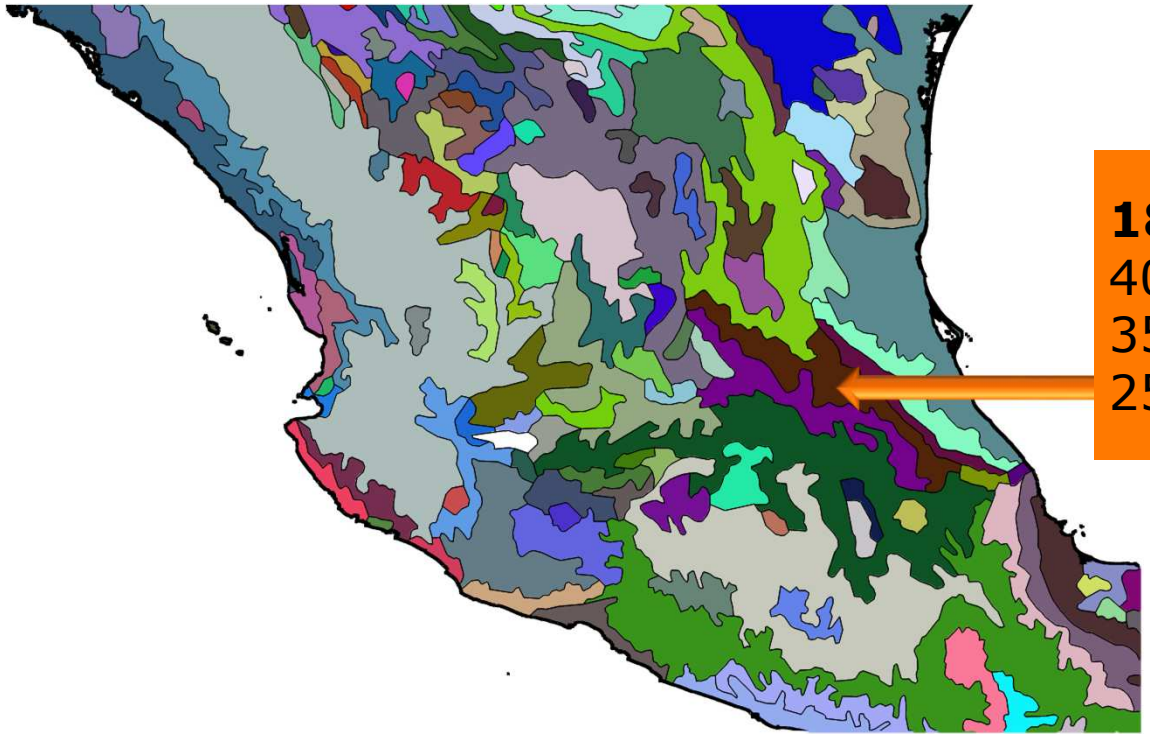
S-World


Soil profile database
Soil map
Landscape data
S-world
Soil conditions

Step 1: Disaggregating soil associations



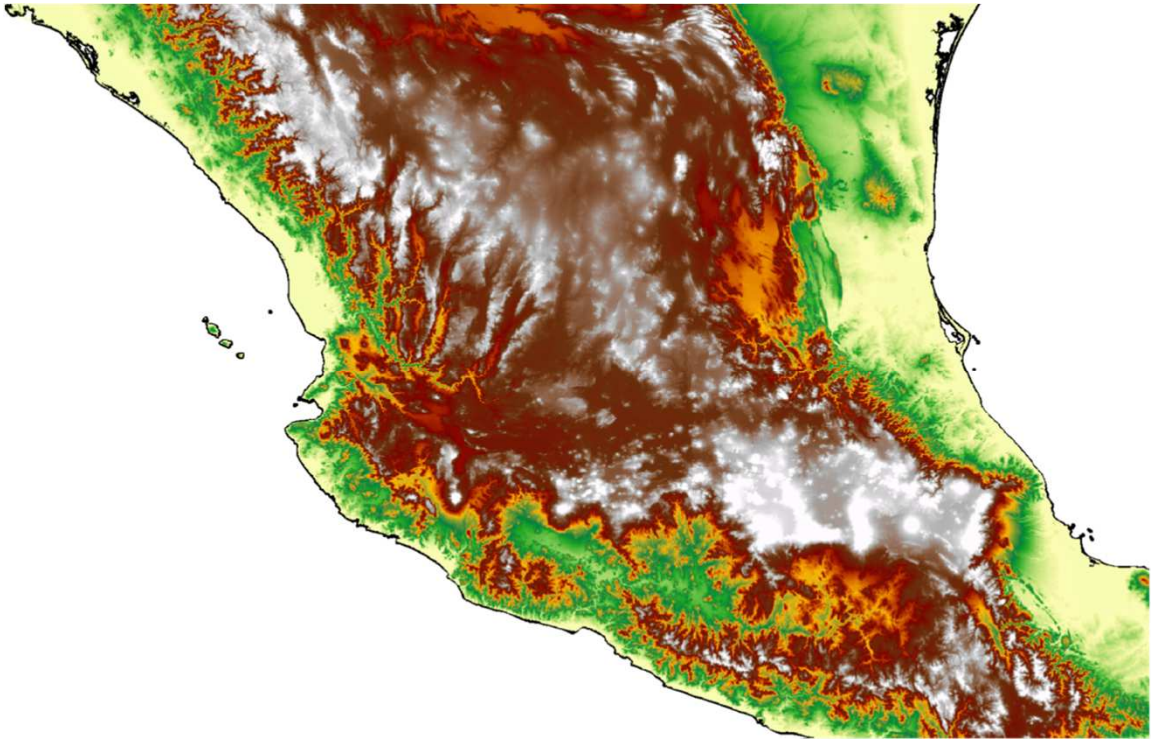
Harmonized World Soil Dtabase



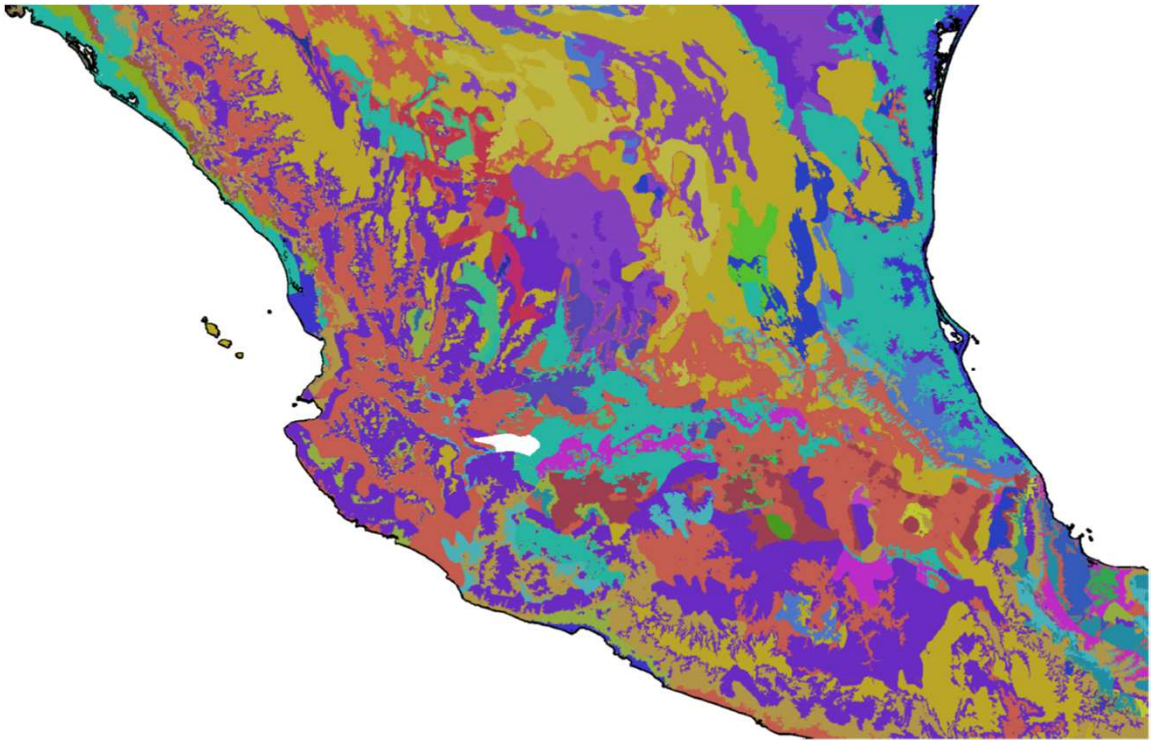
18322

40%	Vertic Leptosol
35%	Haplic Phaeozem
25%	Chromic Luvisol

Elevation



Disaggregated soil map



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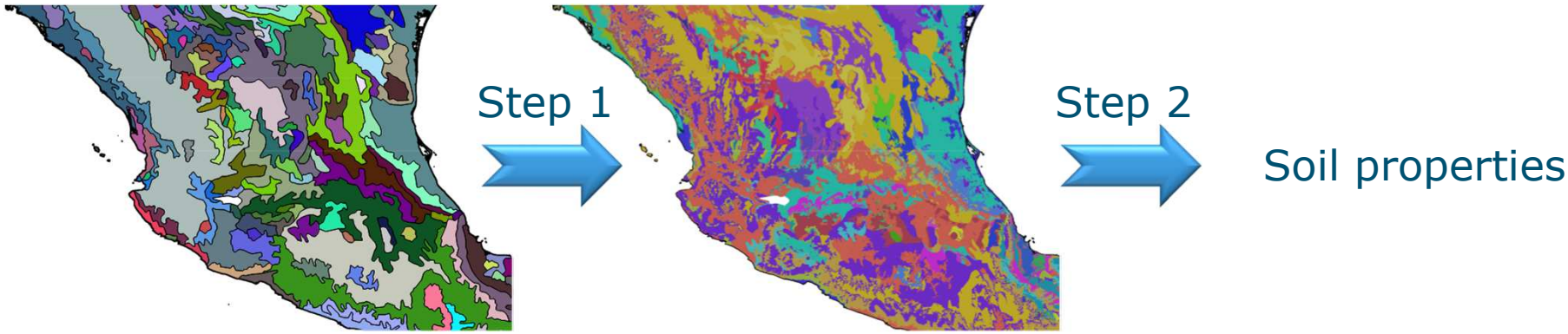
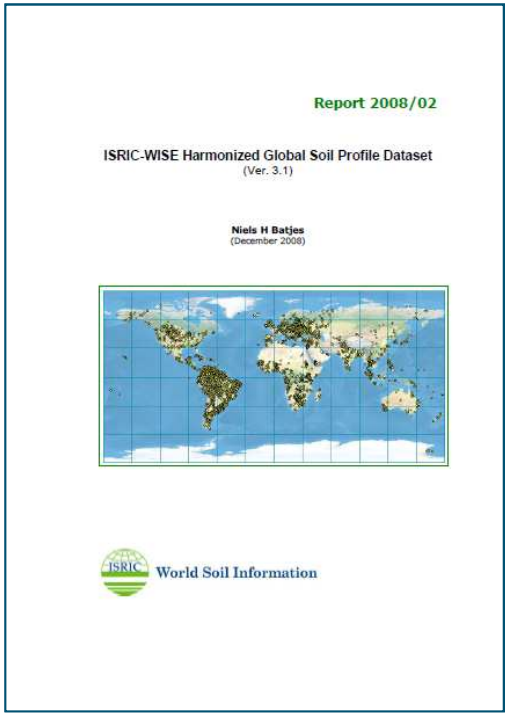
Step 2: Assigning soil properties



Soil properties



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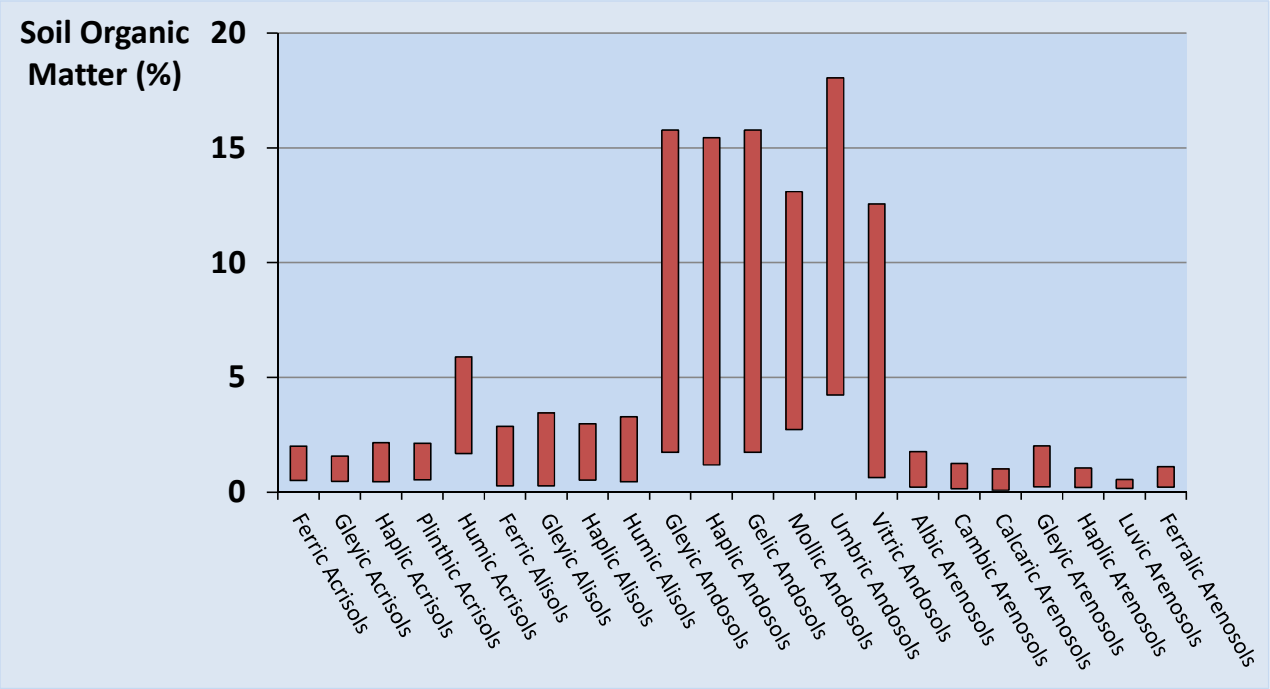
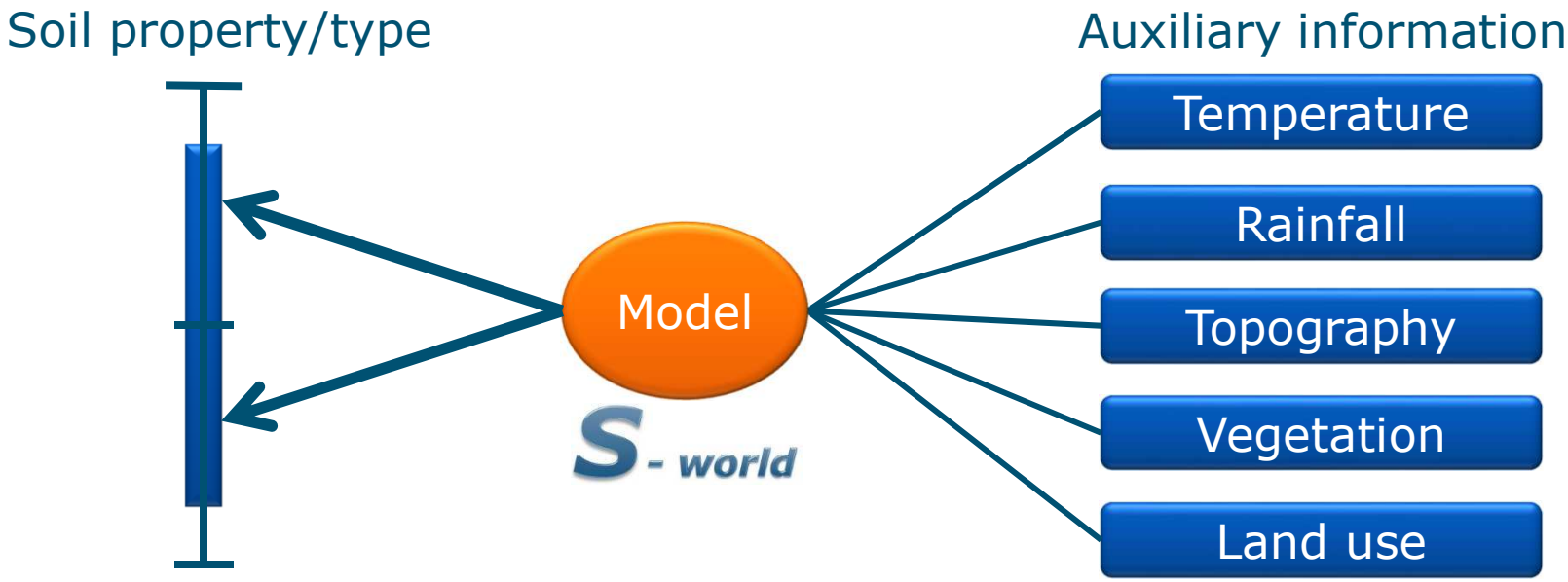
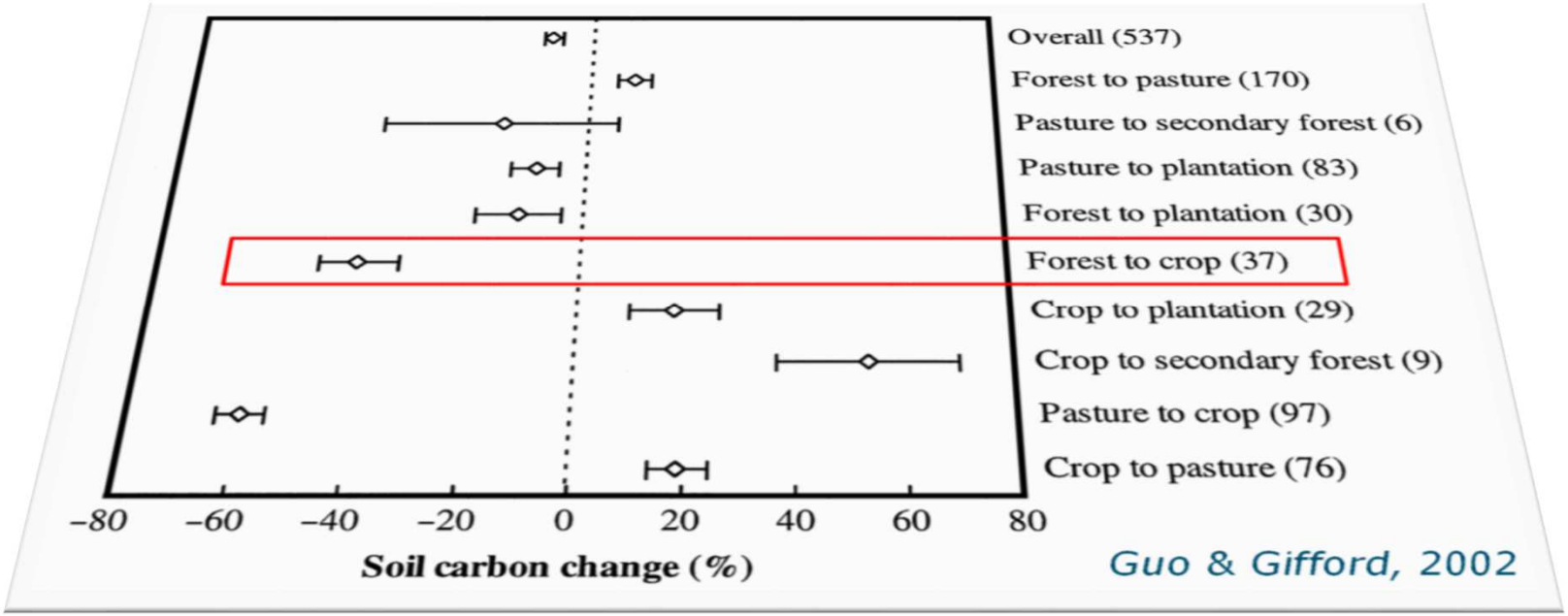


Towards soil properties



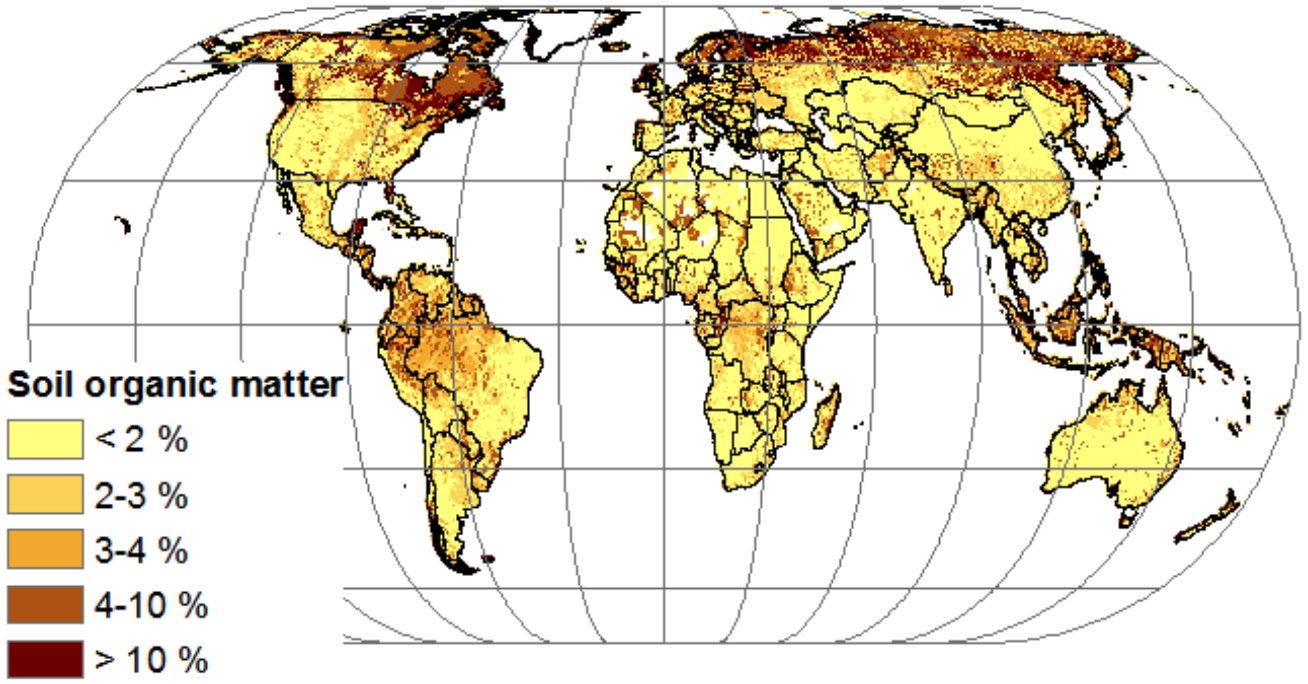
Meta-analysis



Model parameters

	Annual temperature	Annual rainfall	Slope	Land use intensity
Depth topsoil	0.2	0.3	-0.4	-0.1
SOM topsoil	0.1	0.3	-0.1	-0.5
Soil depth	0.2	0.2	-0.4	-0.2
Clay%	0.3	0.3	-0.3	-0.1
Sand%	-0.3	-0.3	0.3	0.1

Global soil property maps



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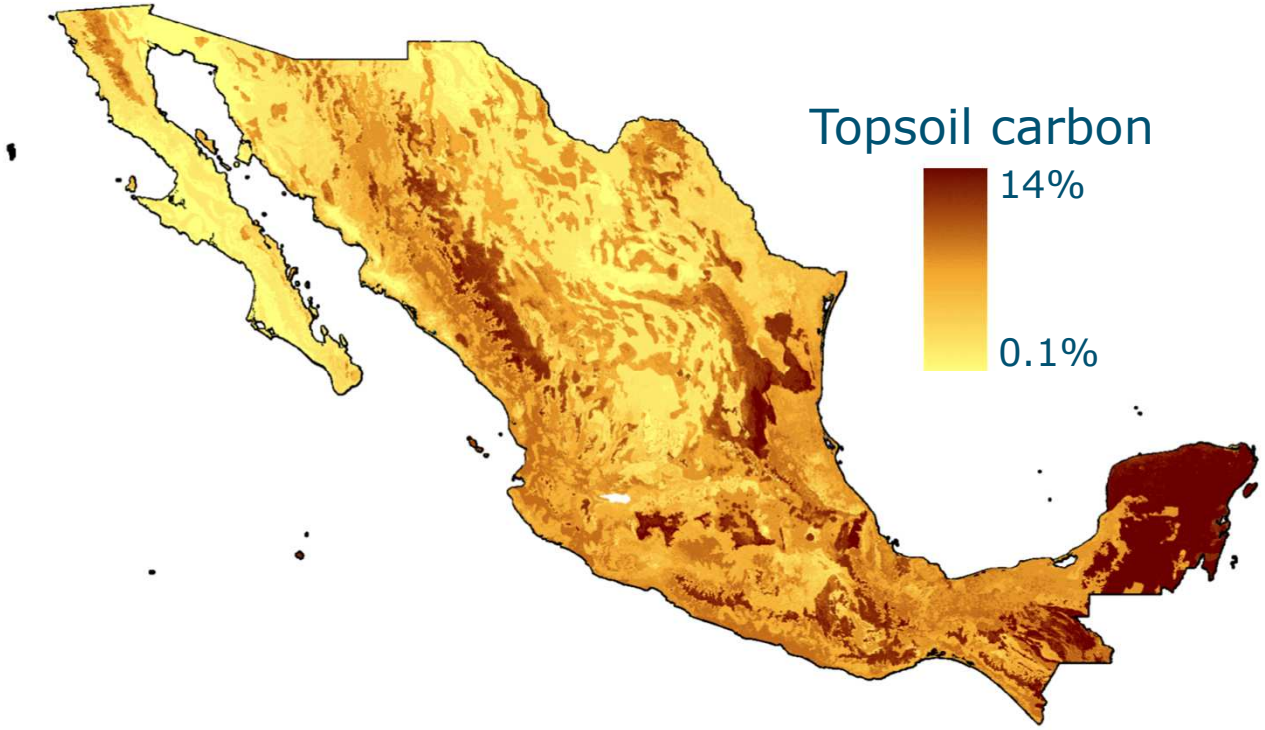

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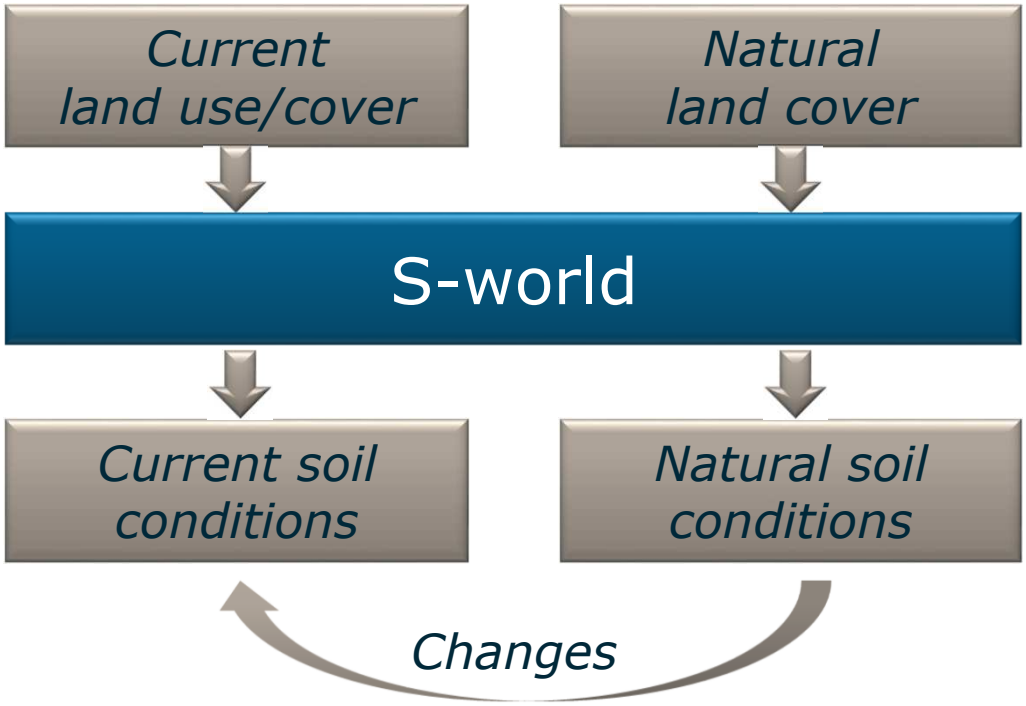
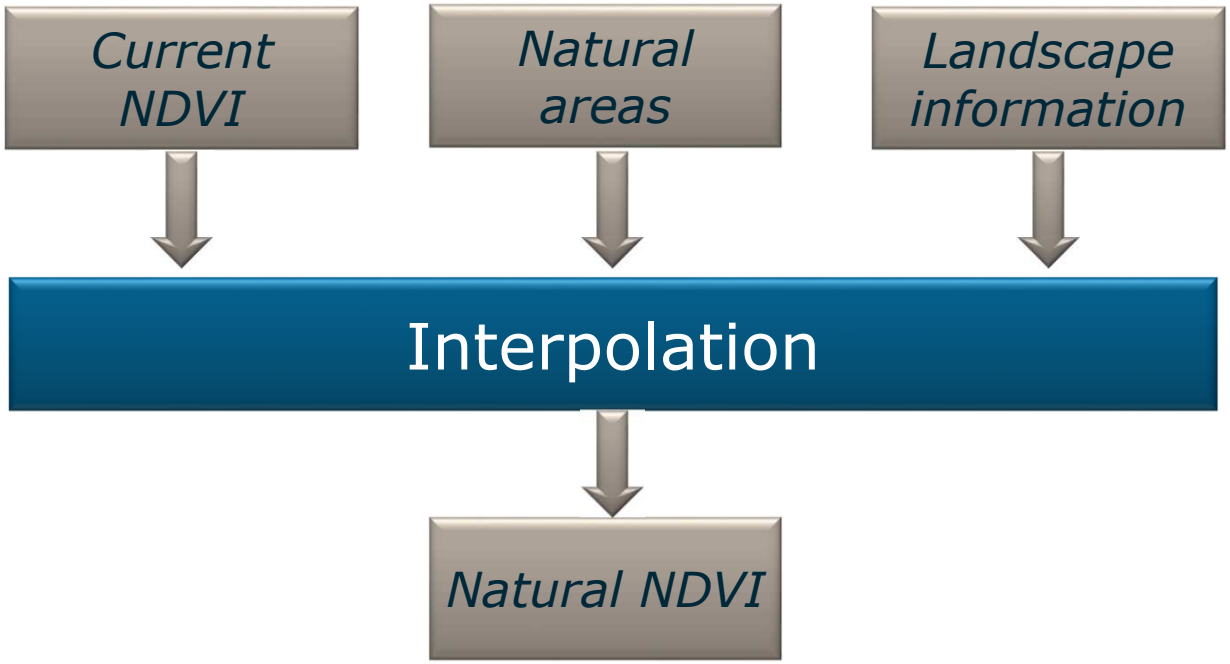
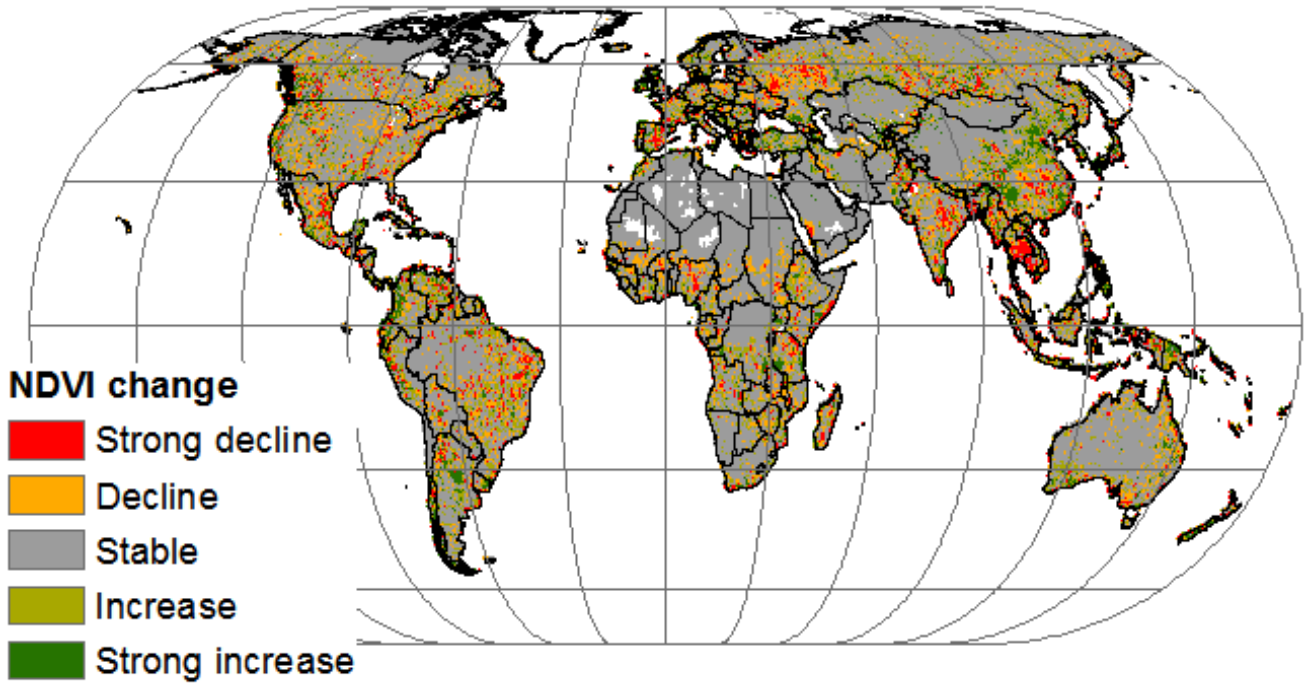
Human induced soil changes



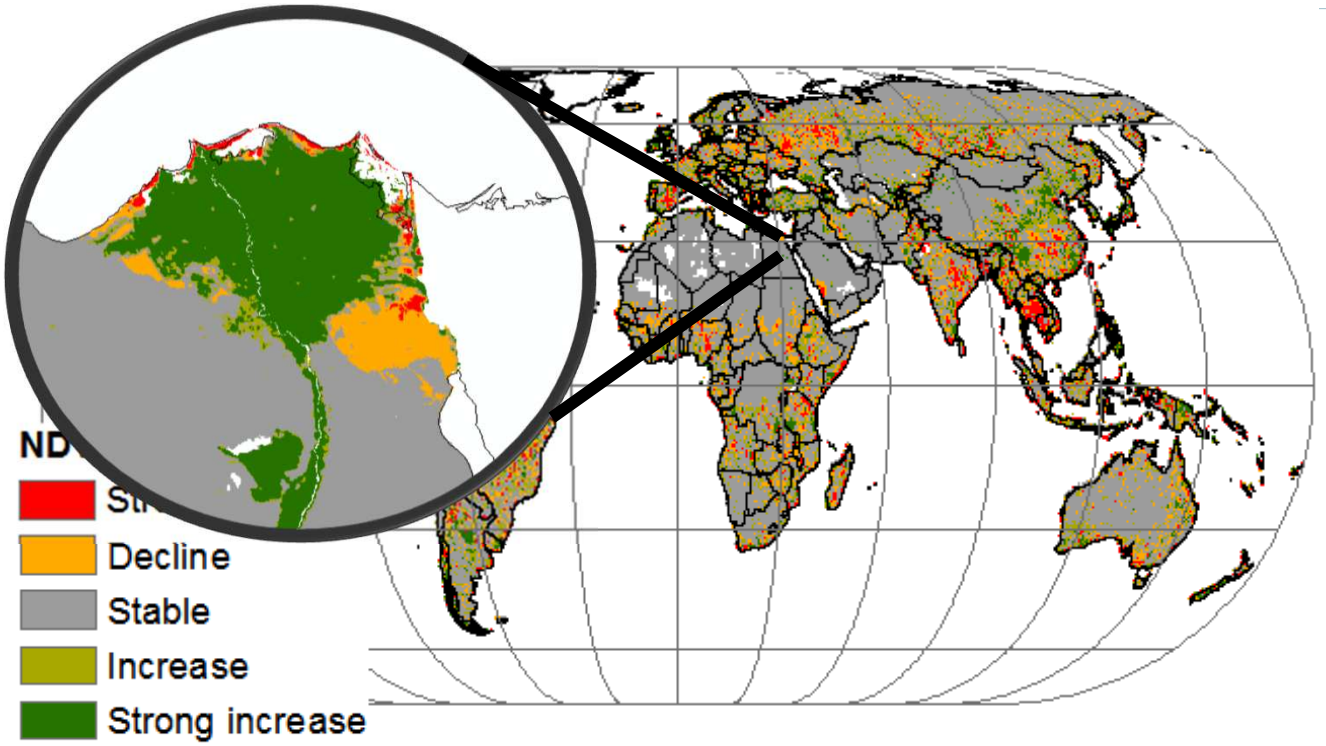
“Natural” NDVI



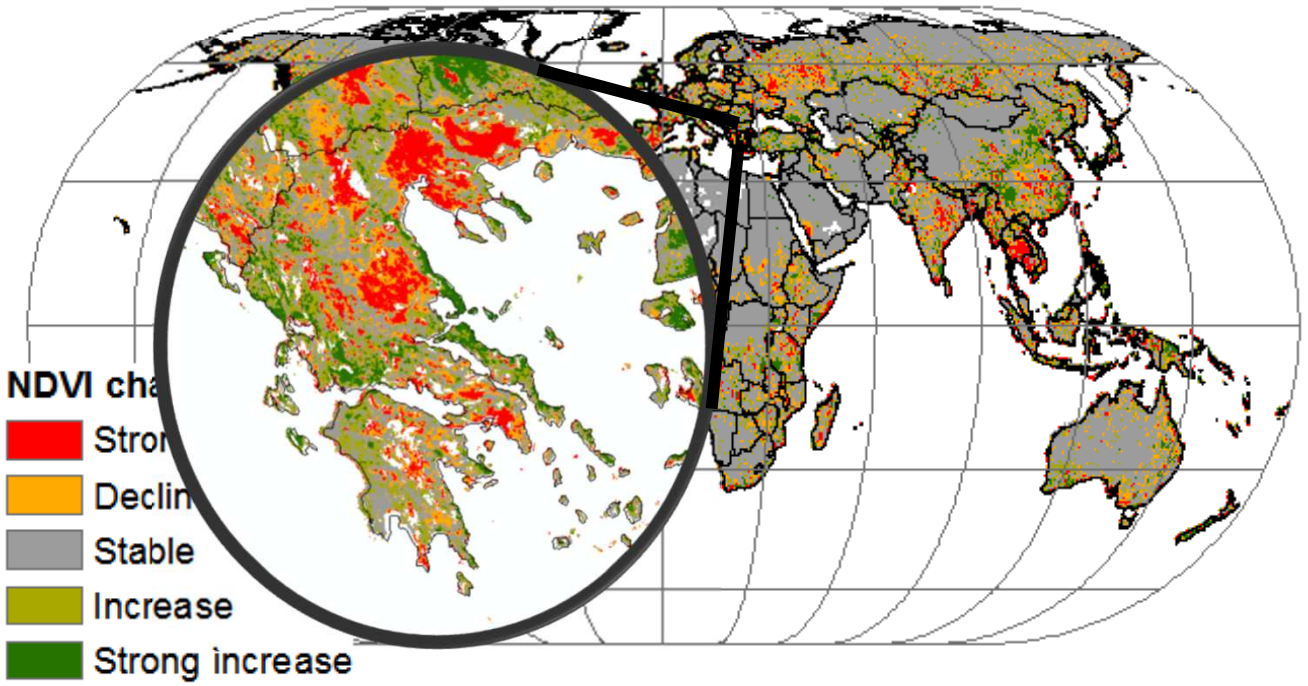
Current versus natural NDVI



Current versus natural NDVI

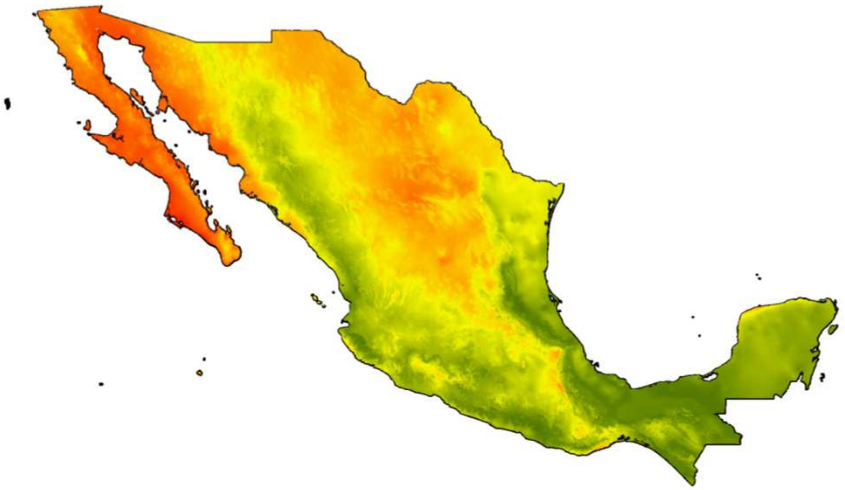


Current versus natural NDVI

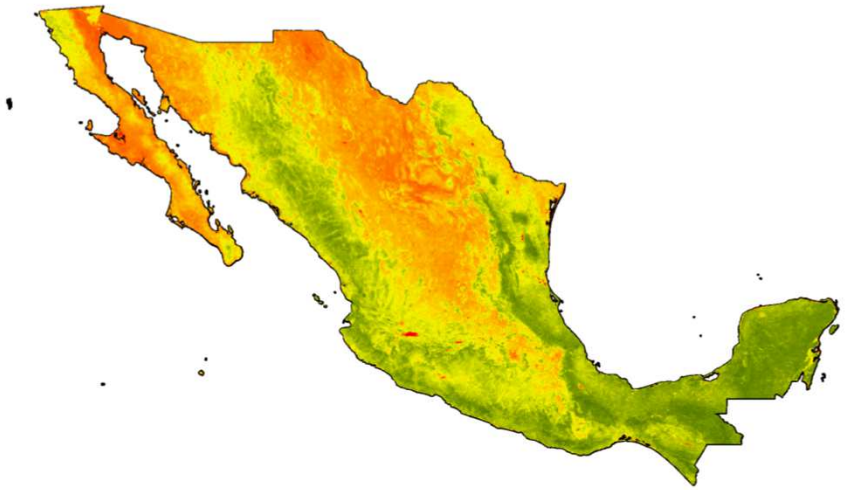


NDVI changes

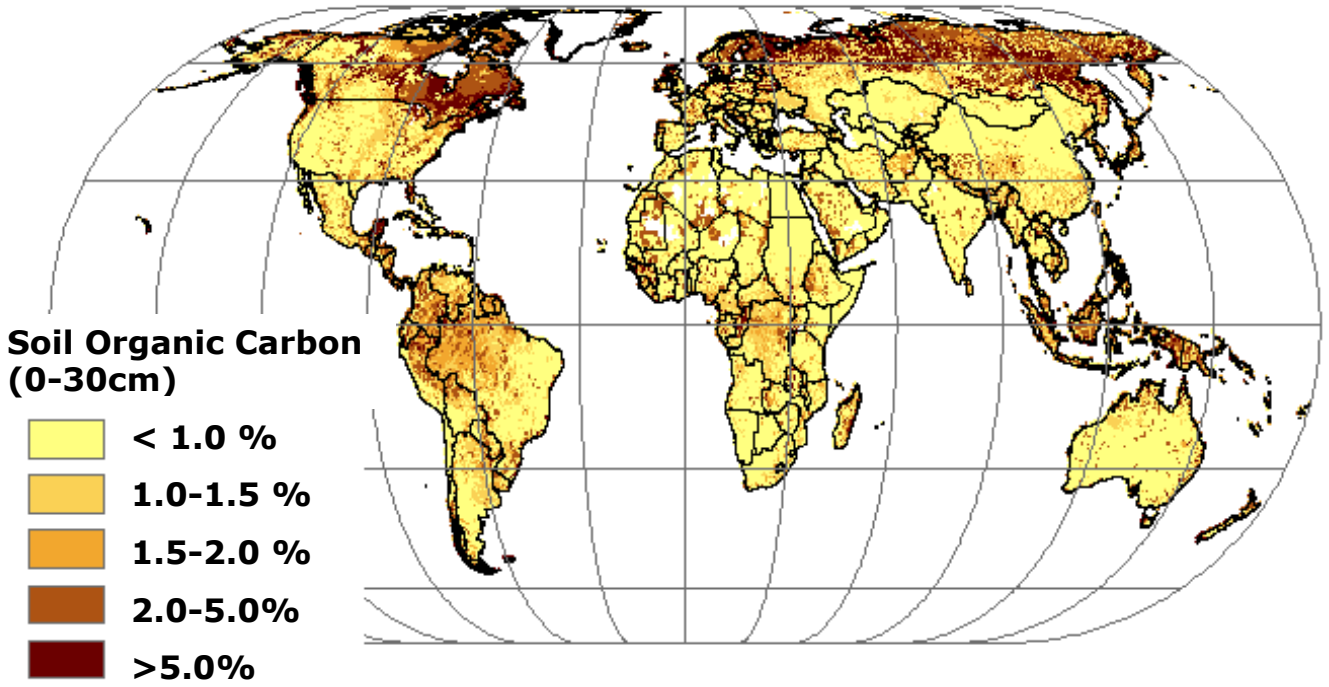
Natural



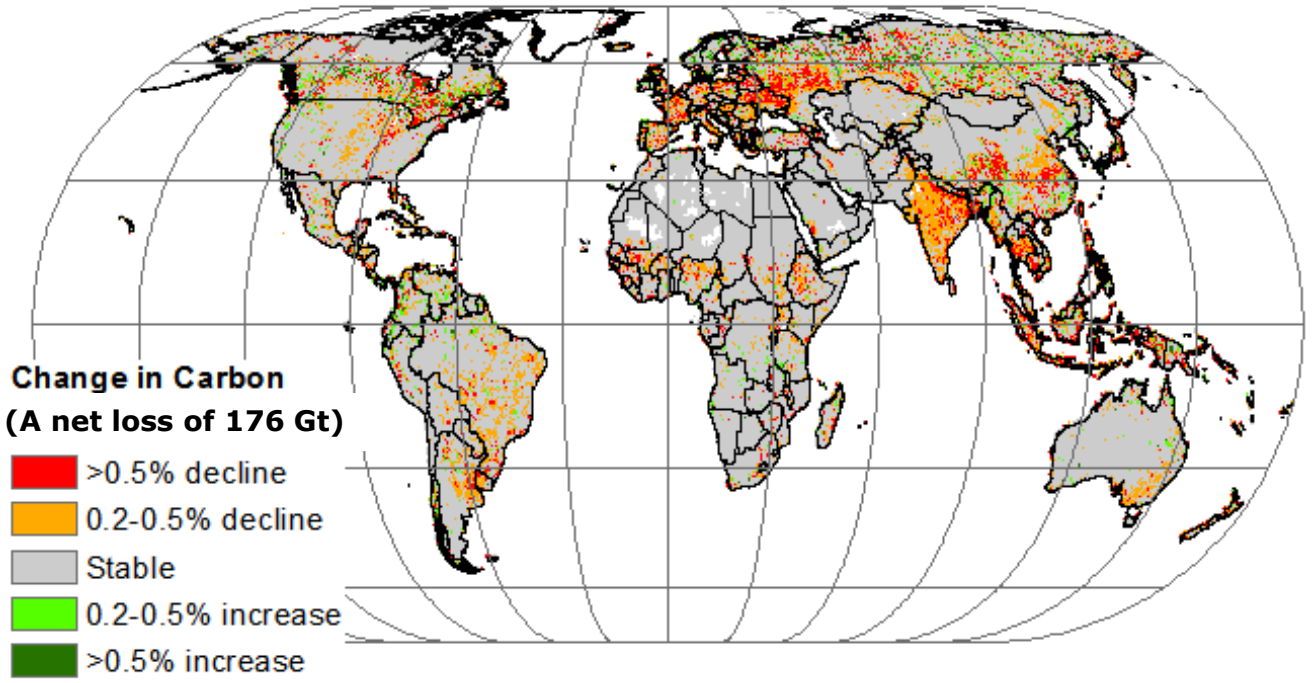
Actual



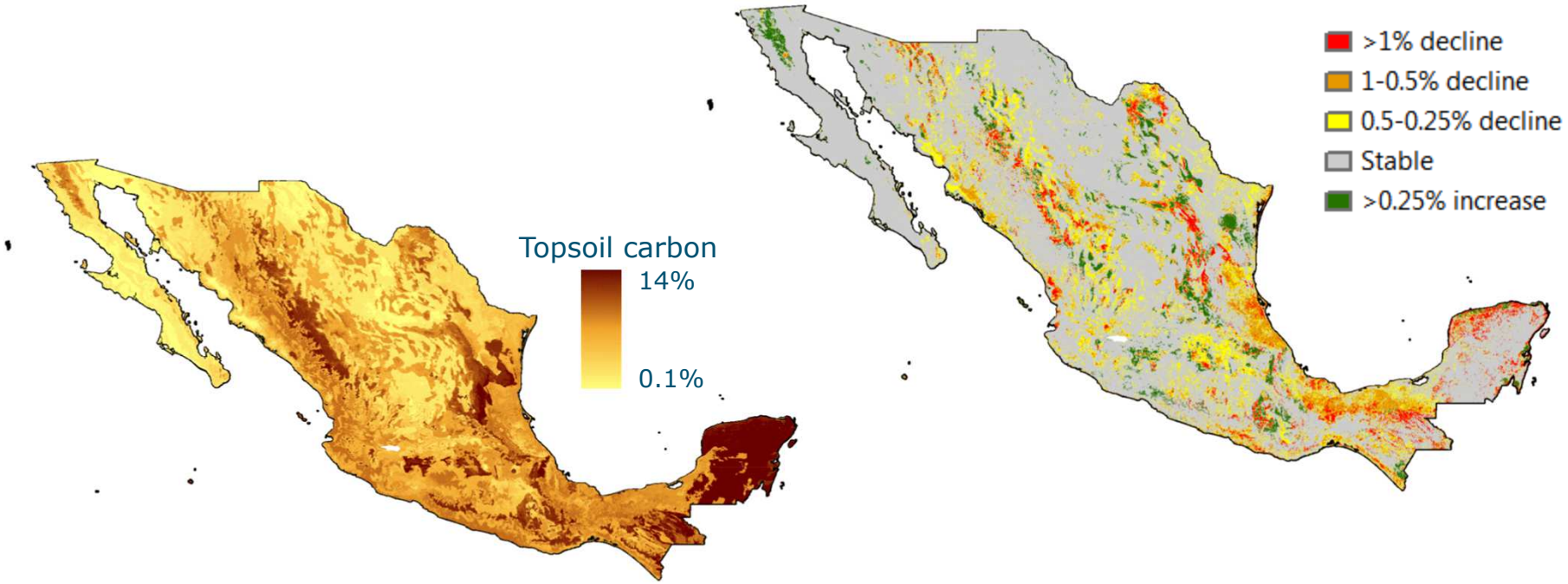
Soil organic Carbon (topsoil)



Changes in soil organic carbon



Changes in topsoil organic carbon



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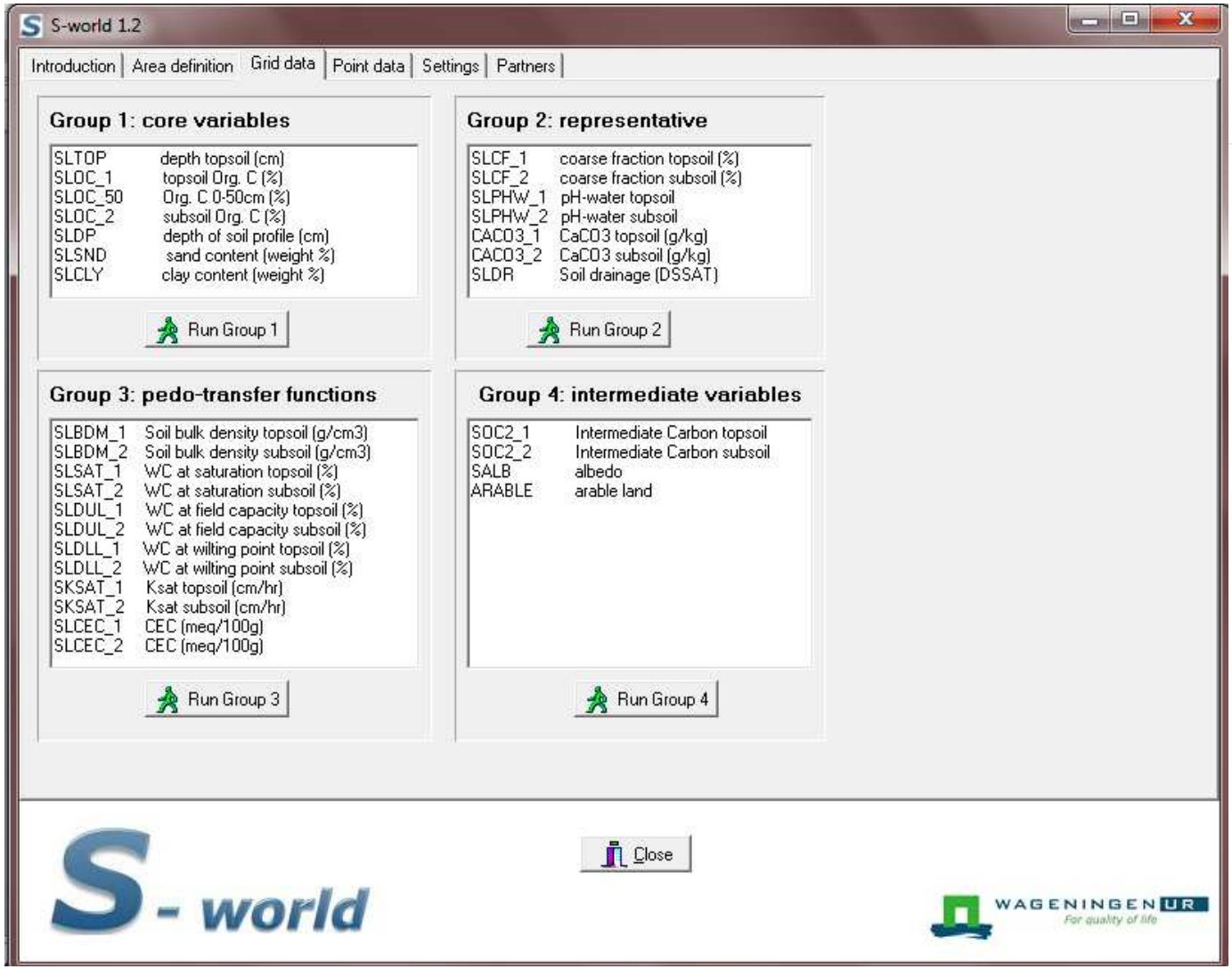
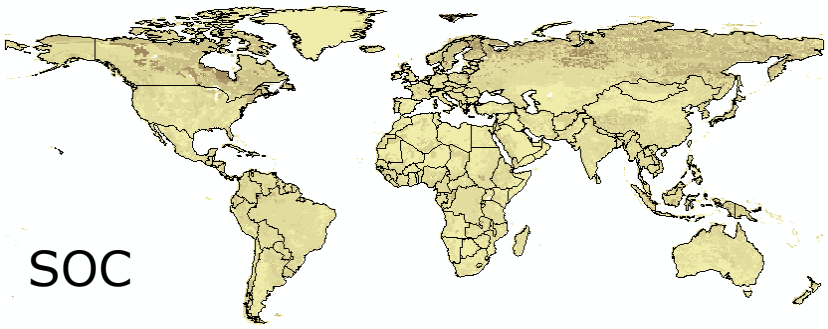
From soil properties to ecosystem services

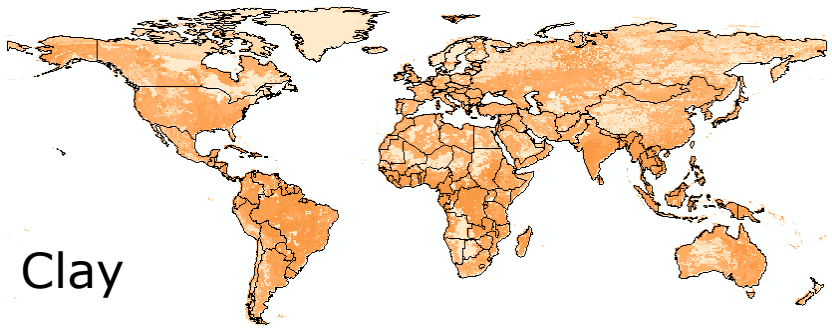
- Soil organic matter content
- Clay content
- Sand content
- Soil depth
- pH

- Carbon sequestration
- Water holding capacity
- Infiltration/runoff
- Soil fertility


S-world 1.2
Introduction
Area definition
Grid data
Point data
Settings
Partners
Group 1: core variables
SLTOP depth topsoil (cm)
SLOC_1 topsoil Org. C (%)
SLOC_50 Org. C 0-50cm (%)
SLOC_2 subsoil Org. C (%)
SLDP depth of soil profile (cm)
SLSND sand content (weight %)
SLCLY clay content (weight %)
Run Group 1
Group 2: representative
SLCF_1 coarse fraction topsoil (%)
SLCF_2 coarse fraction subsoil (%)
SLPHW_1 pH-water topsoil
SLPHW_2 pH-water subsoil
CACO3_1 CaCO3 topsoil (g/kg)
CACO3_2 CaCO3 subsoil (g/kg)
SLDR Soil drainage (DSSAT)
Run Group 2
Group 3: pedo-transfer functions
SLBDM_1 Soil bulk density topsoil (g/cm3)
SLBDM_2 Soil bulk density subsoil (g/cm3)
SLSAT_1 WC at saturation topsoil (%)
SLSAT_2 WC at saturation subsoil (%)
SLDUL_1 WC at field capacity topsoil (%)
SLDUL_2 WC at field capacity subsoil (%)
SLDLL_1 WC at wilting point topsoil (%)
SLDLL_2 WC at wilting point subsoil (%)
SKSAT_1 Ksat topsoil (cm/hr)
SKSAT_2 Ksat subsoil (cm/hr)
SLCEC_1 CEC (meq/100g)
SLCEC_2 CEC (meq/100g)
Run Group 3
Group 4: intermediate variables
SOC2_1 Intermediate Carbon topsoil
SOC2_2 Intermediate Carbon subsoil
SALB albedo
ARABLE arable land
Run Group 4
Close
S - world
WAGENINGEN UR
For quality of life

Modelling studies





SOIL.SOL - Notepad

File Edit Format View Help

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*SOILS

*TO00000001  S-world      TOAM     210 CREATED by S-World
@SITE        COUNTRY          LAT     LONG SCS FAMILY
 Generic     Generic        51.97   -5.661 Generic
@ SCOM  SALB  SLU1  SLDR  SLRO  SLNF  SLPF  SMHB  SMPX  SMKE
   -99  0.11   6.0  0.30  68.2  1.00  1.00 IB001 IB001 IB001
@  SLB  SLMH  SLLL  SDUL  SSAT  SRGF  SSKS  SBDM  SLOC  SLCL  SLSI  SLCF  SLNI  SLHW  SLHB  SCEC
    35   -99  0.25  0.35  0.38   0.8 -99.0   1.5   1.3  33.0  34.0   0.0 -99.0   5.9 -99.0 -99.0
   115   -99  0.40  0.48  0.50   0.6 -99.0   1.2   0.5  46.0  28.0   0.0 -99.0   5.7 -99.0 -99.0
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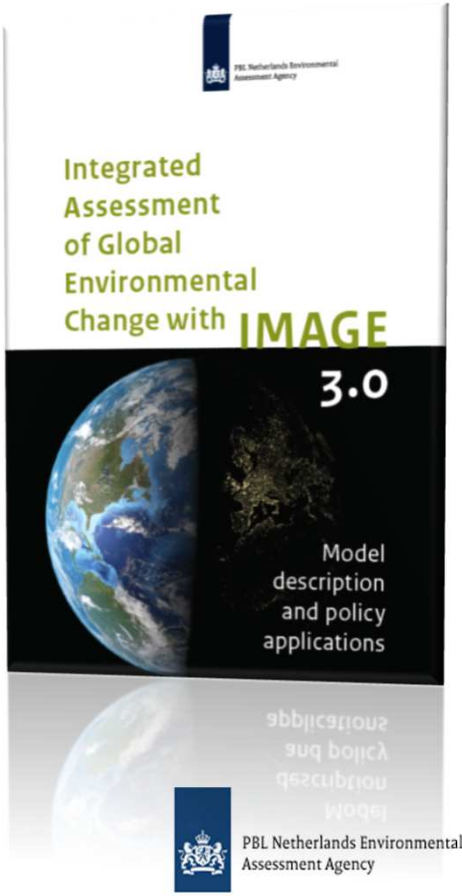
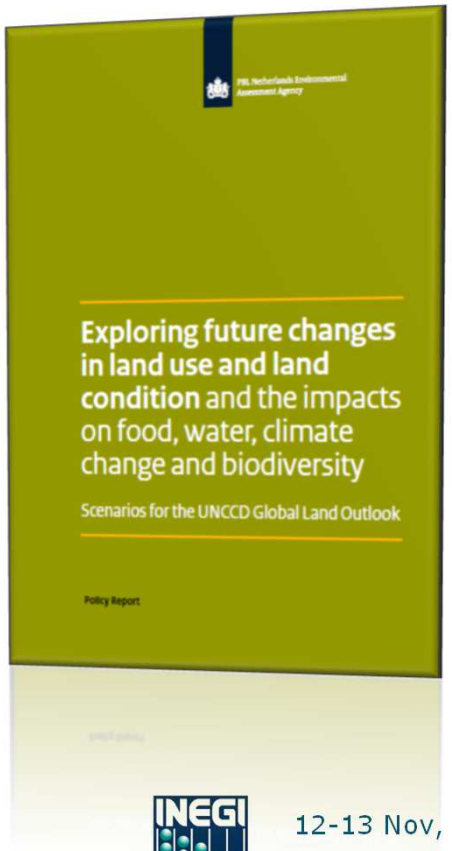
Results





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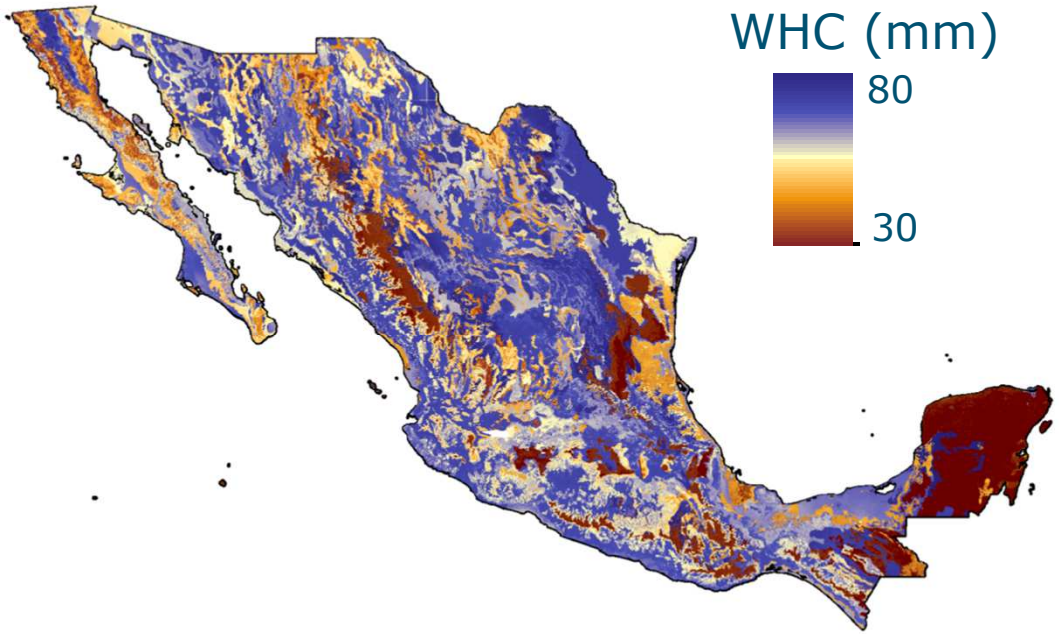
Water holding capacity



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100years

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	MIN	MAX	MEAN	STD
Aguascalientes	39	81	60	11
Baja California	28	80	53	12
Baja California Sur	32	80	57	9
Campeche	54	81	72	6
Chiapas	47	81	66	6
Chihuahua	29	81	62	10
Coahuila	37	81	65	9
Colima	43	72	67	5
Distrito Federal	45	71	62	8
Durango	29	81	65	10
Guanajuato	33	81	63	8
Guerrero	49	81	65	6
Hidalgo	39	81	66	5
Jalisco	30	81	62	9
México	39	80	64	8
Michoacán	39	81	63	6
Morelos	42	72	64	6
Nayarit	40	81	66	7
Nuevo León	39	81	69	7
Oaxaca	40	81	64	7
Puebla	38	81	65	8
Querétaro	42	81	65	7
Quintana Roo	44	81	77	8
San Luis Potosí	37	81	67	8
Sinaloa	45	81	66	6
Sonora	29	81	63	9
Tabasco	53	74	65	2
Tamaulipas	49	81	64	7
Tlaxcala	43	80	66	7
Veracruz	43	81	65	5
Yucatán	65	81	80	2
Zacatecas	29	81	63	11

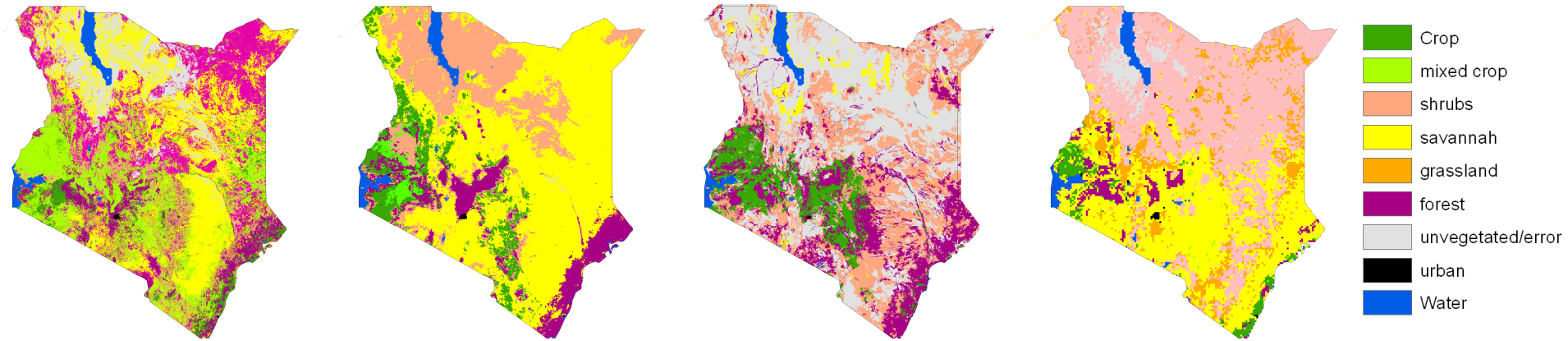
Accounts

- Spatial information on soil properties and derived information at a 30arc-sec resolution
- Tabular information per state and municipality
- For current conditions as well as natural conditions

Overview

- Background
- The S-world methodology
- Modelling changes in soil resources
- From soil properties to national accounts
- Data quality
- The Mexican application

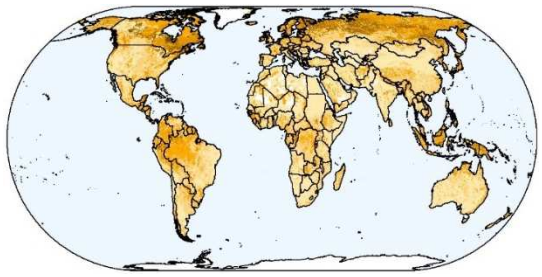
The challenge for the global modeller - data



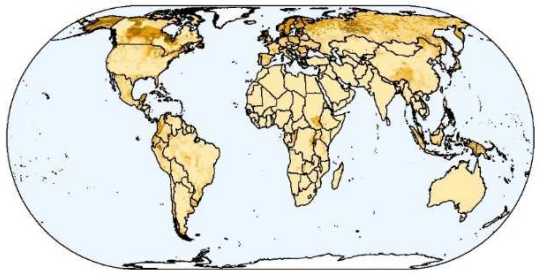
Globcover GLC2000 MODIS Africover

Zhe Guo, HarvestChoice 2011 (unpublished).

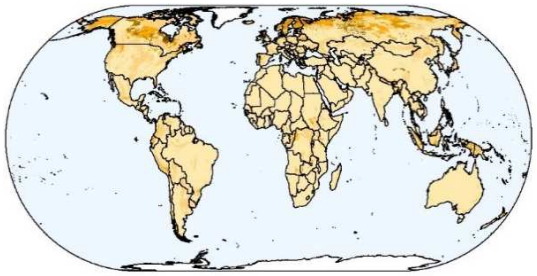
S-World



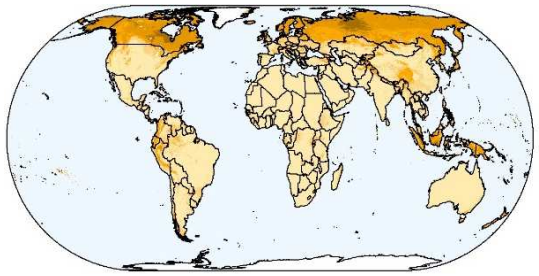
GSDE



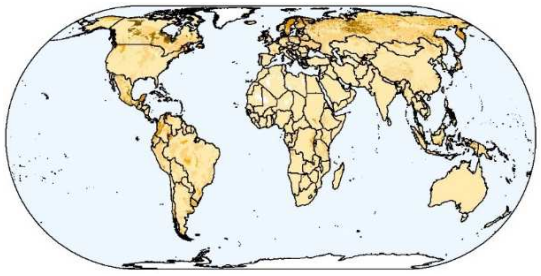
IGBP-dis



SoilGrids



HWSDd



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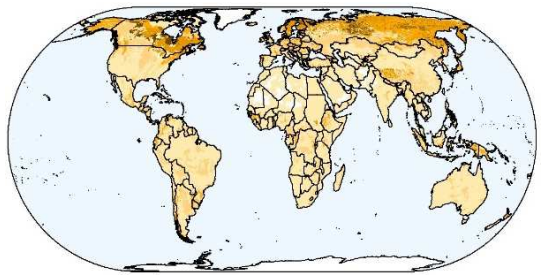
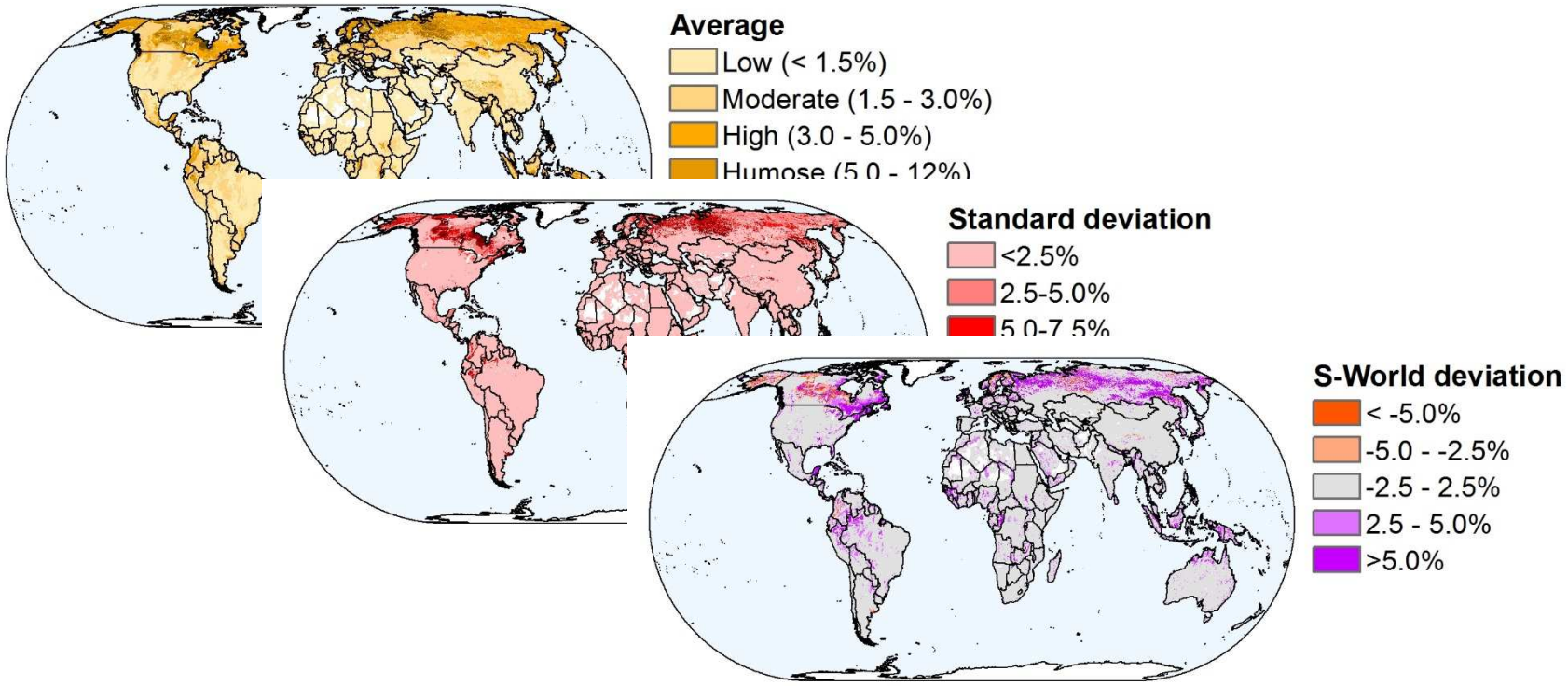


%C in topsoil (0-30cm)

- Low (<1.5%)
- Moderate (1.5-3.0%)
- High (3.0-5.0%)
- Humose (5.0-12%)
- Organo-Mineral (12-35%)
- Organic (>35%)

%C in topsoil (0-30cm)



Overview

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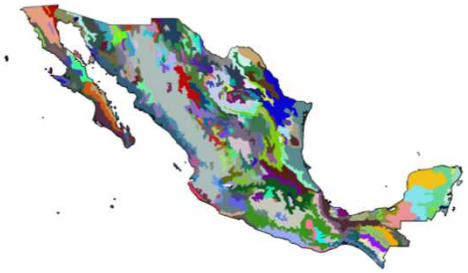
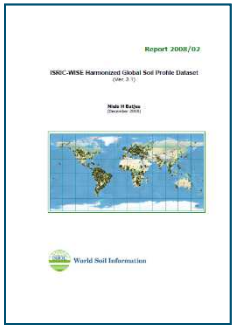
The case of Mexico - currently

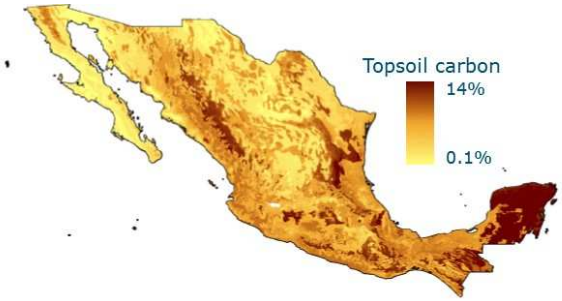


HWSD



WISE

GlobCov



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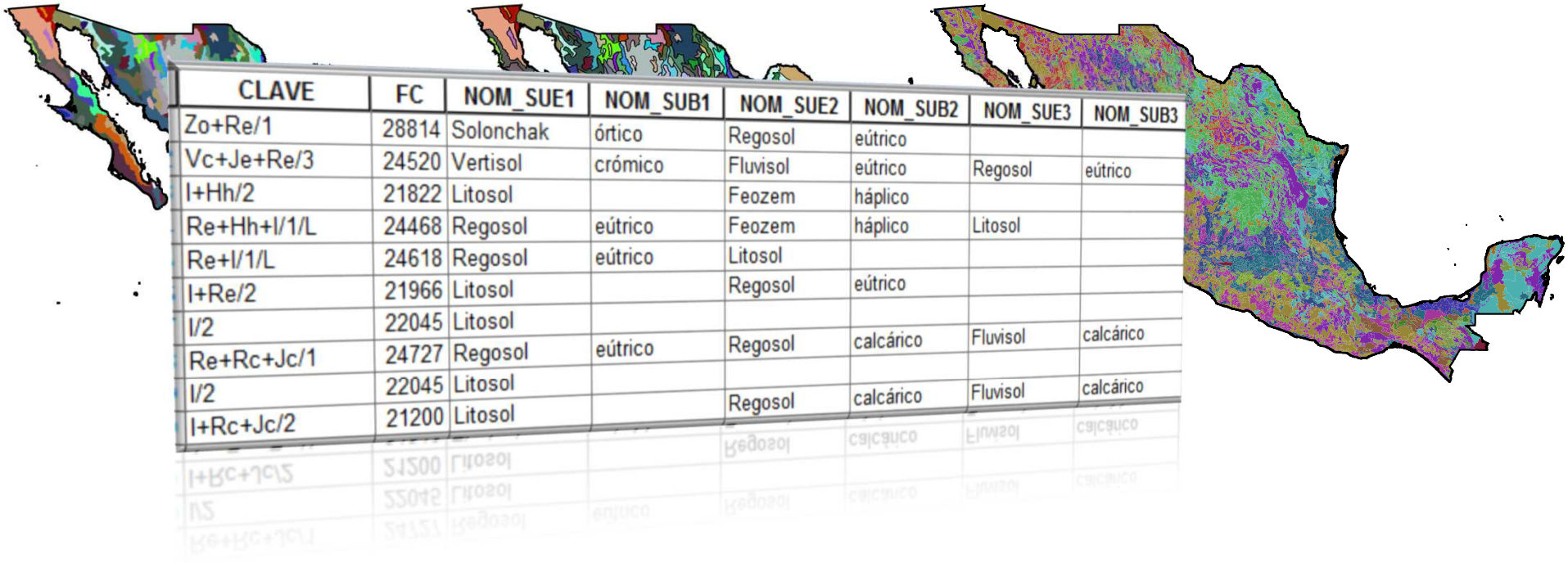
Accounts including

- Soil organic carbon
- Soil texture
- Soil pH
- Soil depth
- Bulk density
- Water holding capacity
- Soil types

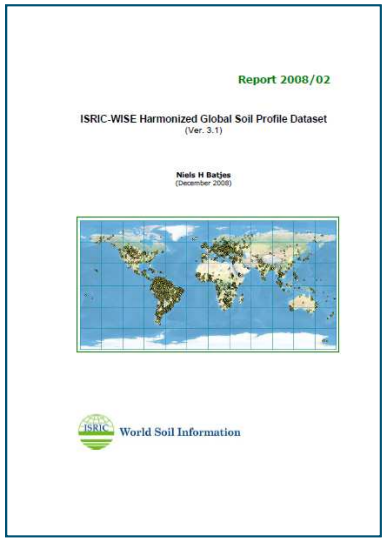
- Spatial variation at 30 arcsec (1km)
- Current and natural conditions
- Summary statistics per state and municipality

Soil map

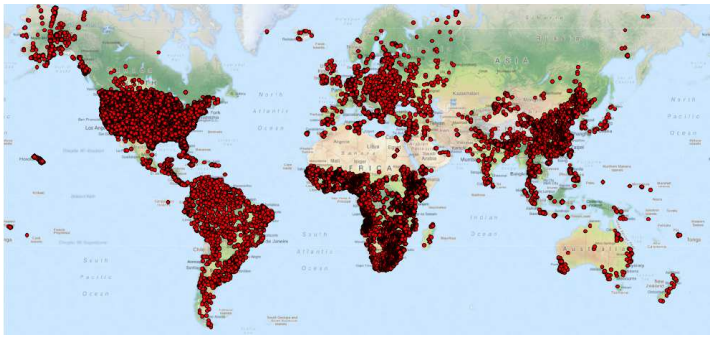


CLAVE	FC	NOM_SUE1	NOM_SUB1	NOM_SUE2	NOM_SUB2	NOM_SUE3	NOM_SUB3
Zo+Re/1	28814	Solonchak	órtico	Regosol	eútrico		
Vc+Je+Re/3	24520	Vertisol	crómico	Fluvisol	eútrico	Regosol	eútrico
I+Hh/2	21822	Litosol		Feozem	háplico		
Re+Hh+I/1/L	24468	Regosol	eútrico	Feozem	háplico	Litosol	
Re+I/1/L	24618	Regosol	eútrico	Litosol			
I+Re/2	21966	Litosol		Regosol	eútrico		
I/2	22045	Litosol					
Re+Rc+Jc/1	24727	Regosol	eútrico	Regosol	calcárico	Fluvisol	calcárico
I/2	22045	Litosol					
I+Rc+Jc/2	21200	Litosol		Regosol	calcárico	Fluvisol	calcárico

Soil profile data



WISE



WOSIS

15:00-15:30

Soil Profile Data

Mr. Alejandro Ibelles

Land use data

GlobCov

12:30 – 13:30

Information on Land Use and Vegetation produced by INEGI

Mr. Arturo Victoria, Deputy Director for land-use and vegetation information

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Future

- Use the current S-World data for soil accounts
- Improve S-World with Mexican data to get a specific national accounts.