Global Soil Organic Carbon Sequestration Potential Map

GSOCseq

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Technical Workshops. 2020

Workshops- Modules

Module I

- **Day 1: Introduction Theoretical**. Framework; RothC Model; General Approach; Required Input Data; Software requirements; Scripts

- **Day 2: Preparation of data.** Theoretical– Practical. Data harmonization and their scripts.

- **Day 3: Running the model** Practical . “Target points” generation where the model is to be run. Running the model in 3 phases (Case study by GSP).

- **Day 4:** Products Generation of the different Maps (Case study by GSP).

- **Day 5: End of Module I** Preparation of data for next module. Reporting.Consultation, Errors

Summary INPUTS

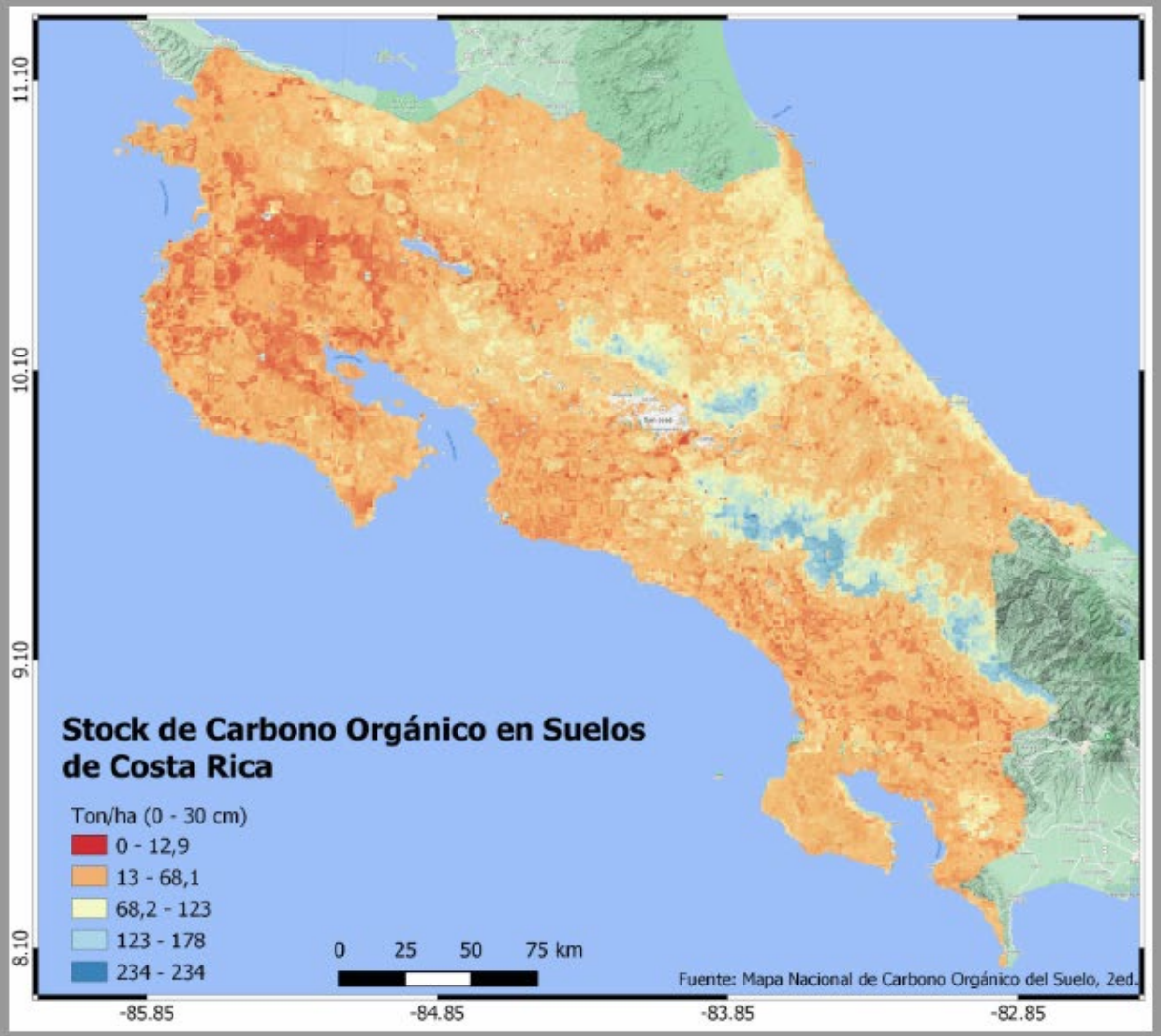
Input data requirements				
Data	**Variables**	**Time series**	**Units**	**Type**
Climatic data	Monthly air temperature	1980-2000; 2001-2020 (or until last year available)	°C	Raster
	Monthly evapotranspiration (Penman-Monteith)	1980-2000; 2001-2020 (or until last year available)	mm	Raster
	Monthly precipitation + irrigation	1980-2000; 2001-2020 (or until last year available)	mm	Raster
Soil data	Topsoil clay content (0-30 cm)	-	%	Raster
	Current Soil organic carbon stocks (0-30 cm)	Latest version of national FAO-GSOC map	tC ha^{-1}	Raster
Land use/cover	Predominant land use/cover, re-classified into: Minimum: 4 default classes required by model: agricultural crops, grassland/shrubland/savannas ; forests; others Optimum: 12 classes defined in the FAO Global Land Cover - SHARE (GLC-SHARE)	Minimum: representative 2000-2020 (or last year available) Optimum: annual land use 2000 to 2020	1-11	Raster
	Monthly vegetation cover. Obtained from national statistics/local expert knowledge; or derived from NDVI or spectral indexes (see section 3.3.4)	Minimum: average 2015- 2020 (or last year available period) Optimum: monthly soil cover 2000 to 2020	0-1	Raster

Summary

- Global layers (TerraClimate, ISRIC,ESA, etc.)

- National layers when available!

Example. Costa Rica GSOCseq map
Initial SOC stocks - GSOC map



Characteristics

- 2nd edition
- Resolution : 1x1km
- Random forest (49 spatial covariables)
- Data base: Base de datos de Suelos de Costa Rica del Centro de Investigaciones Agronómicas de la UCR

- Last updated version of GSOCmap
- Ideally:Average, Max and Min values for each pixel (based on % uncertainties)
- Use standard % uncertainty coefficients if no uncertainties available

Example. Costa Rica GSOCseq map
Clay Map

Characteristics

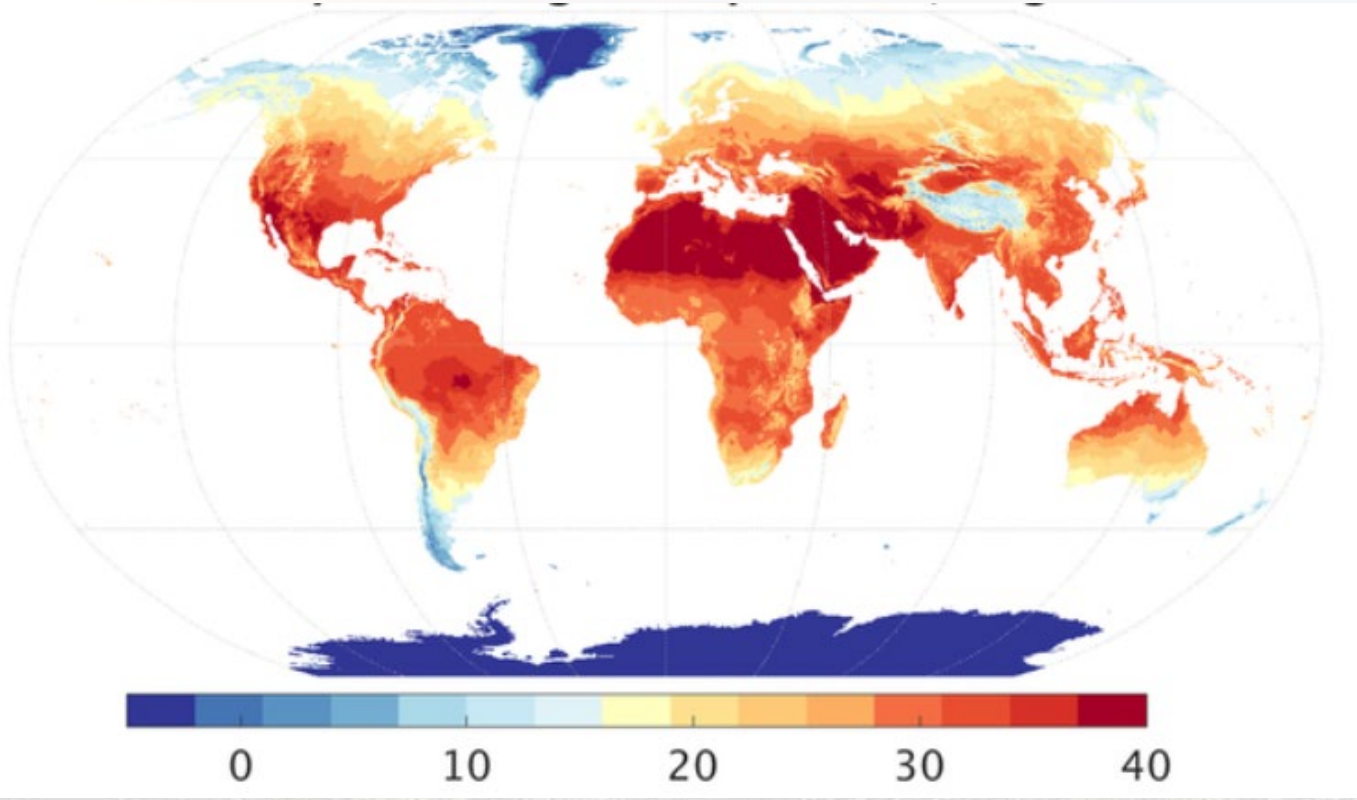
- **Soilgrids Clay content 0-30 cm (weighted average)**
- **Resampled to : 1x1km**
- **Validation dataset: Base de Datos de Suelos de Costa Rica; Mapa de Ordenes de Suelos**

- National clay content layers (products available from GSOCmap)
- ISRIC if no national layer (Now, uncertainties available)
- Ideally: Average, Max and Min values for each pixel (based on % uncertainties)
- Use standard % uncertainty coefficients if no uncertainties available

Additional global climate data set

GEE and R scripts

- TerraClimate is a dataset of monthly climate for global terrestrial surfaces from 1958-2019
- monthly temporal resolution and a ~4-km
- GEE and R scripts to download and prepare the data for you AOI will be provided soon



Example. Costa Rica GSOCseq map
Climatic variables

Climate Engine

http://climateengine.org/data

Evapotranspiration

NCEP Climate Forecast System Reanalysis dataset" (NCEP-CFSR)

$1187.5\ Km^2$

Temperature

Precipitation

Climate Hazards Group InfraRed Precipitation with Station data" (CHIRPS, por sus siglas en inglés)

$22.5\ Km^2$.

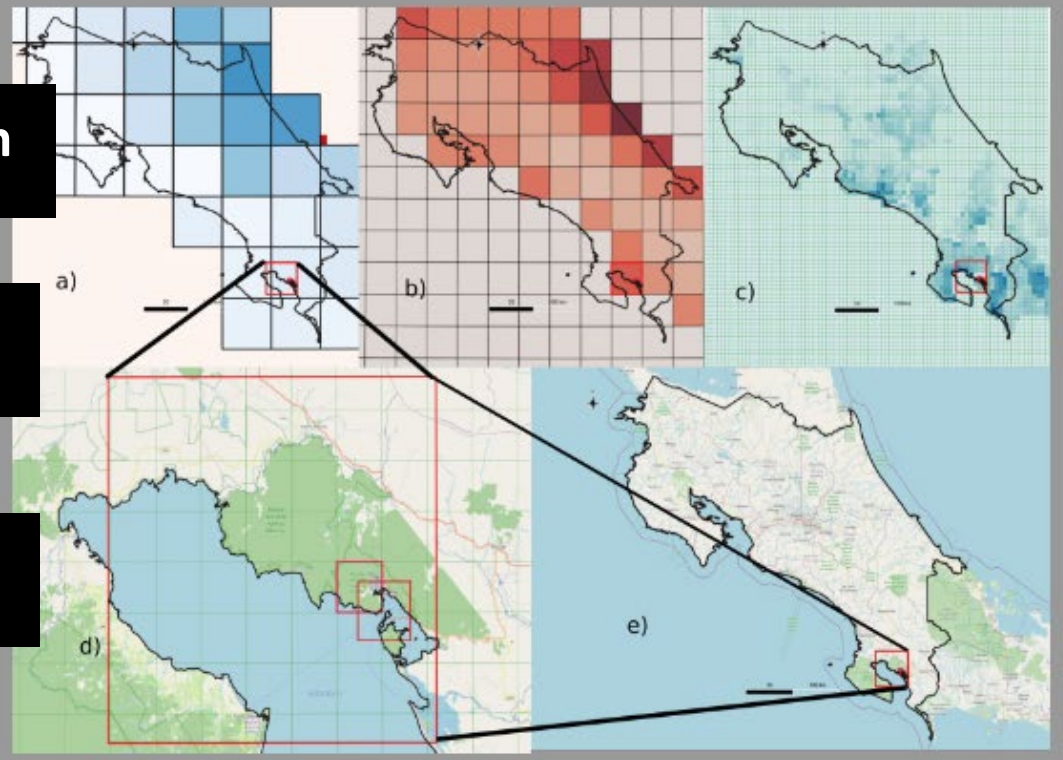
Different regional databases

Example. Costa Rica GSOCseq map
Climatic variables

Evapotranspiration

Temperature

Precipitation

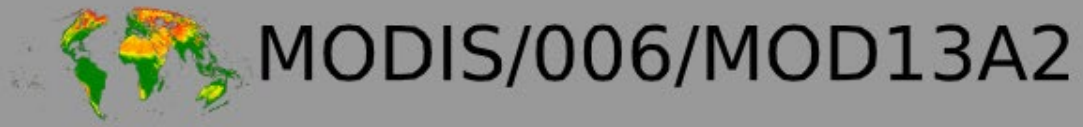


Diferencias entre tamaños de píxeles: a) Resolución del "Climatic Research Unit Time-series" (CRU), en b), la resolución del NCEP-CFSR para temperatura y evapotranspiración. Enc), se muestra la resolución para los productos CHIRPS de precipitación. En d), el recuadro de laresolución de NCEP-CFSR y precipitación. Finalmente, en e), se muestra el tamaño de pixel deNCEP-CFSR en el contexto de Costa Rica.

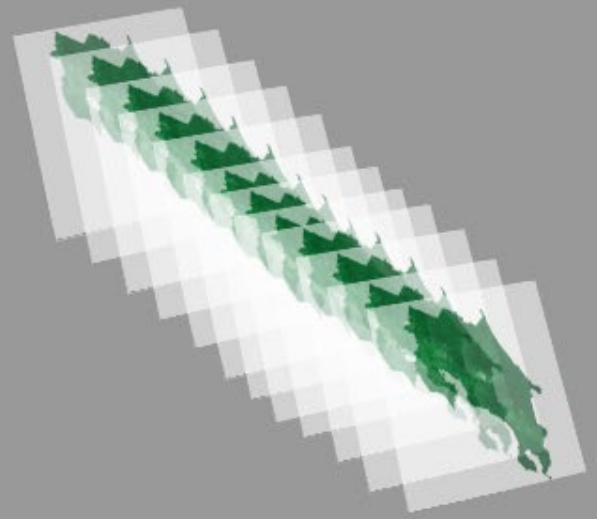
- National or regional climatic layers
- Monthly data: 1981-2000; 2001-2020
- CRU if no national/regional layer
- Ideally: Average, Max and Min values for each pixel (based on % uncertainties)
- Use standard % uncertainty coefficients if no uncertainties available

Example. Costa Rica GSOCseq map
Vegetation cover Map

From MODIS NDVI
Modified threshold; vegetated NDVI > 0.3 (default script 0.5)



1 layer per month

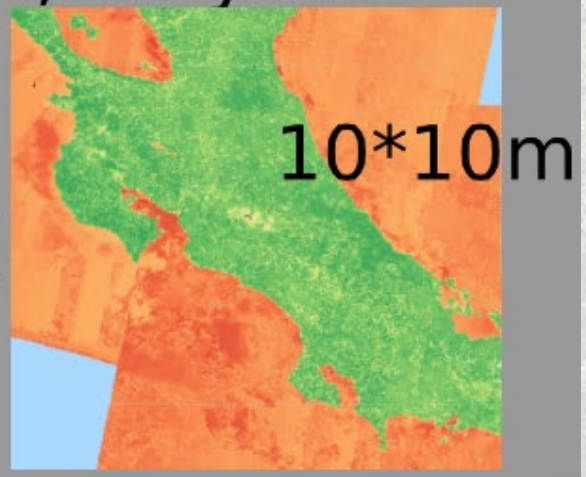


- NDVI Google earth Engine Script
- Thresholds can be Modified to copy regional trends
- Other preferred indexes : e.g. BSI (Bare soil index)
- Final product: Monthly cover 0.6 (vegetated) - 1.0 (non vegetated)
- Resolution : 1kmx1km

Example. Costa Rica GSOCseq map
Land Use Layer

Google Earth Engine

Bandas utilizadas
B2, B3, B4 y B8
EVI
NDVI
NDWI



- National layers, always preferred

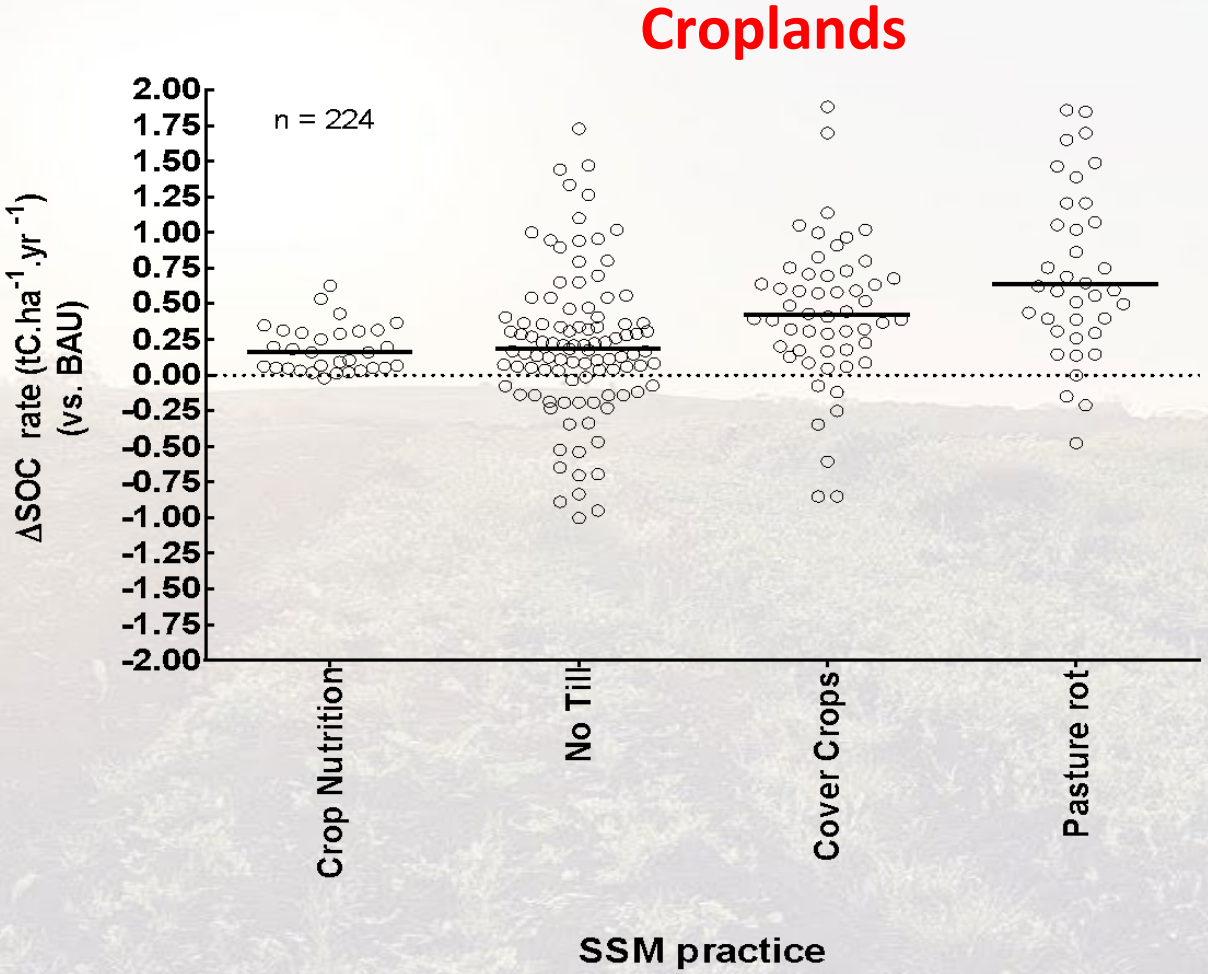
  (at least last available land use); re-classified into FAO Land Use classes

- Global layer ESA if no national layers

Example

Meta-analysis
Local results of SOC changes

Adjust % increment in C inputs (Additional, Non standard products)



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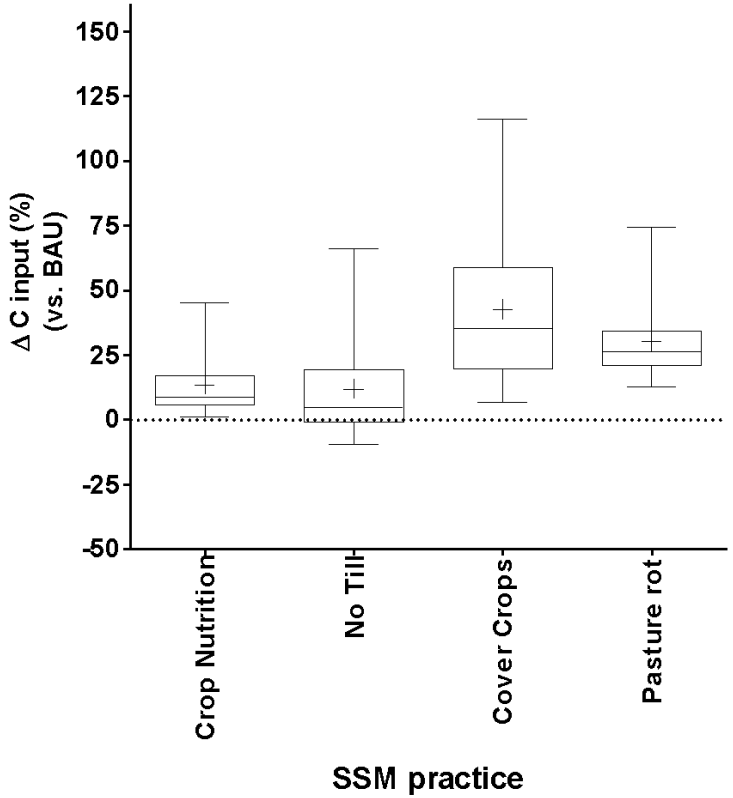
Adjust % increment in C inputs (Additional, Non standard products)

Meta-analysis

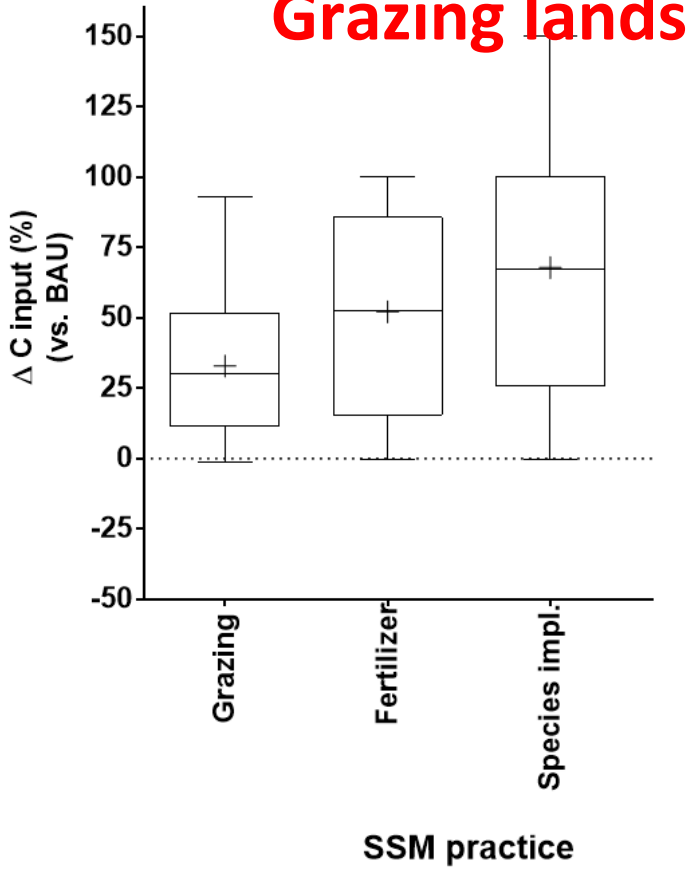
Local results of increase in C inputs:

- From published studies
- From Yield and production data (e.g. field trials)

Croplands



Grazing lands

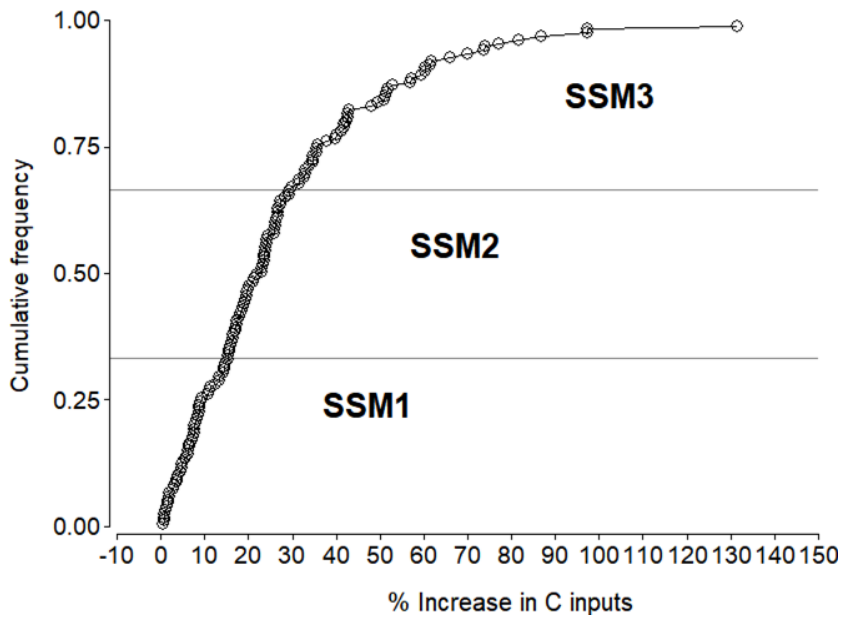


Example

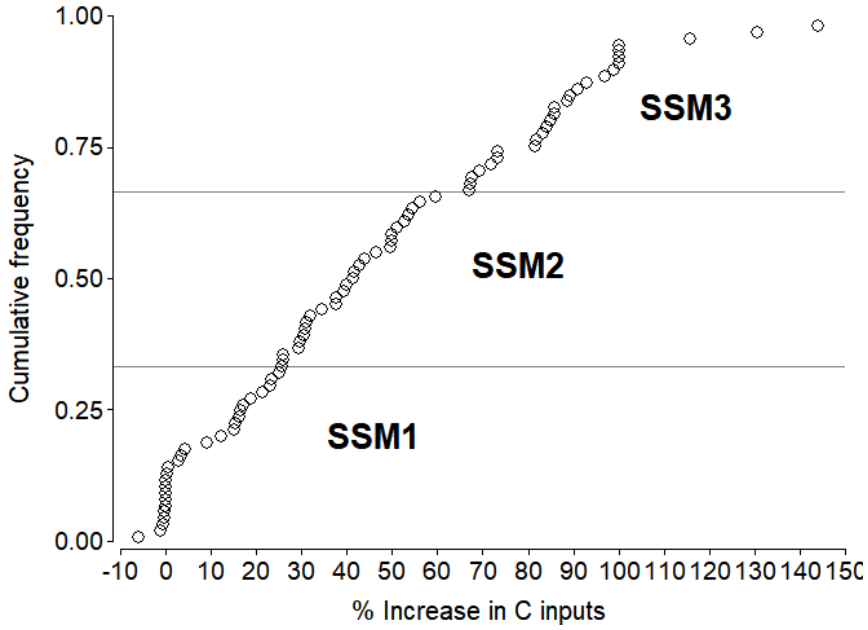
Meta-analysis
Local results of SOC changes

Adjust % increment in C inputs (Additional, Non standard products)

Croplands



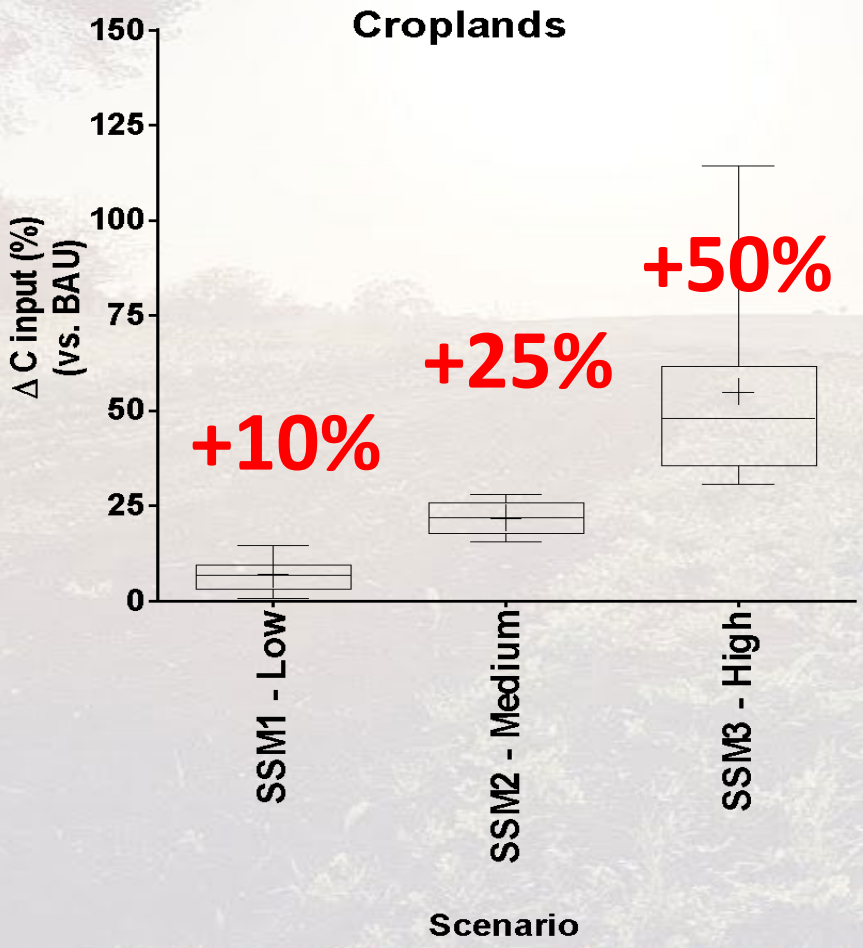
Grasslands

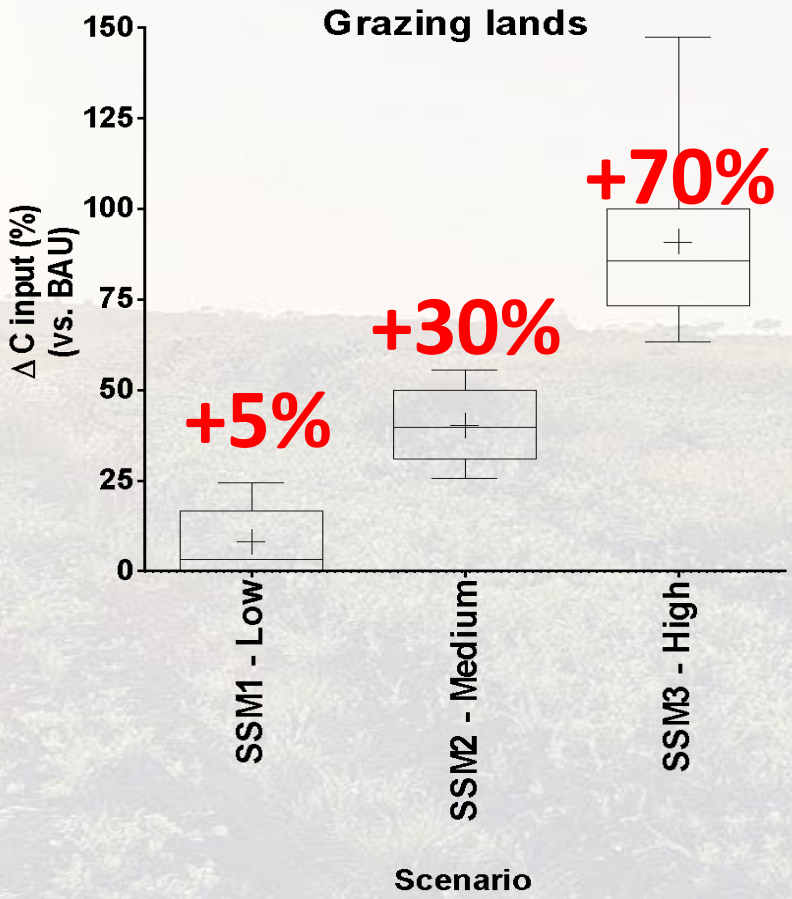


Example

Meta-analysis
Local results of SOC changes

Adjust % increment in C inputs (Additional, Non standard products)





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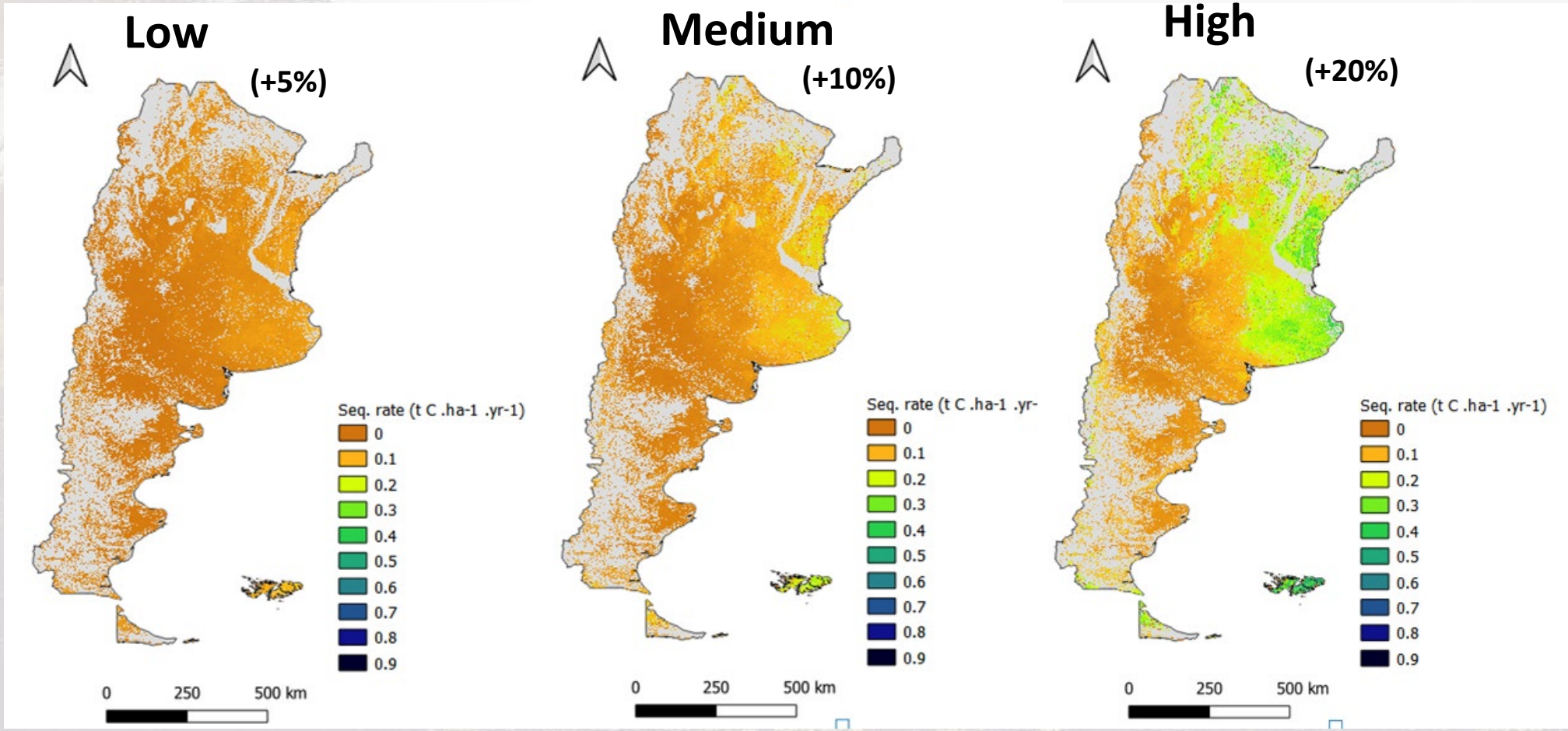
Standard Products



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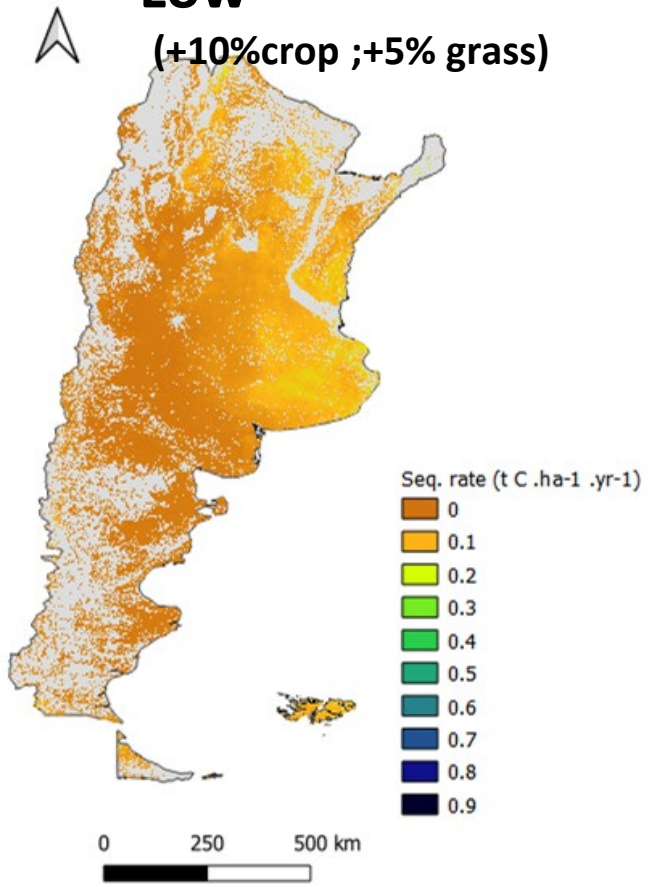
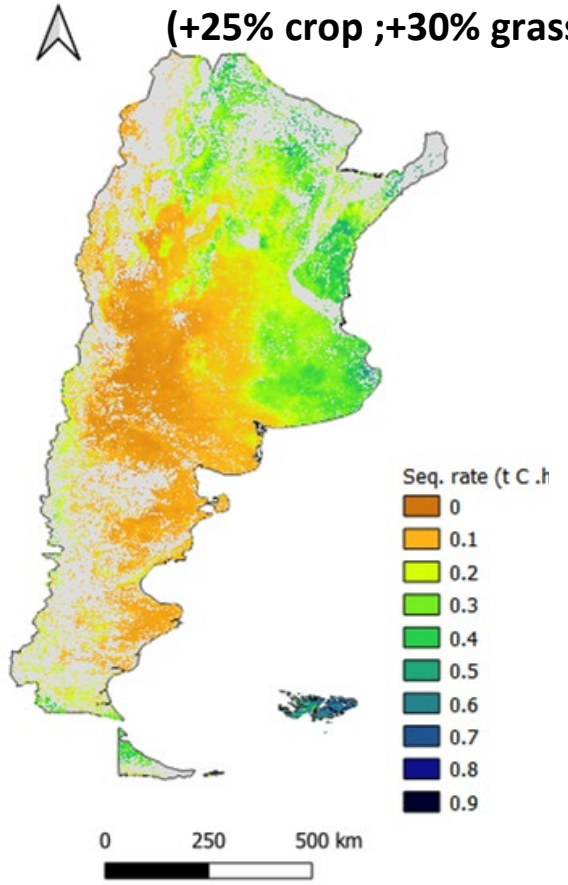
Non-Standard Products
Using modified coefficients

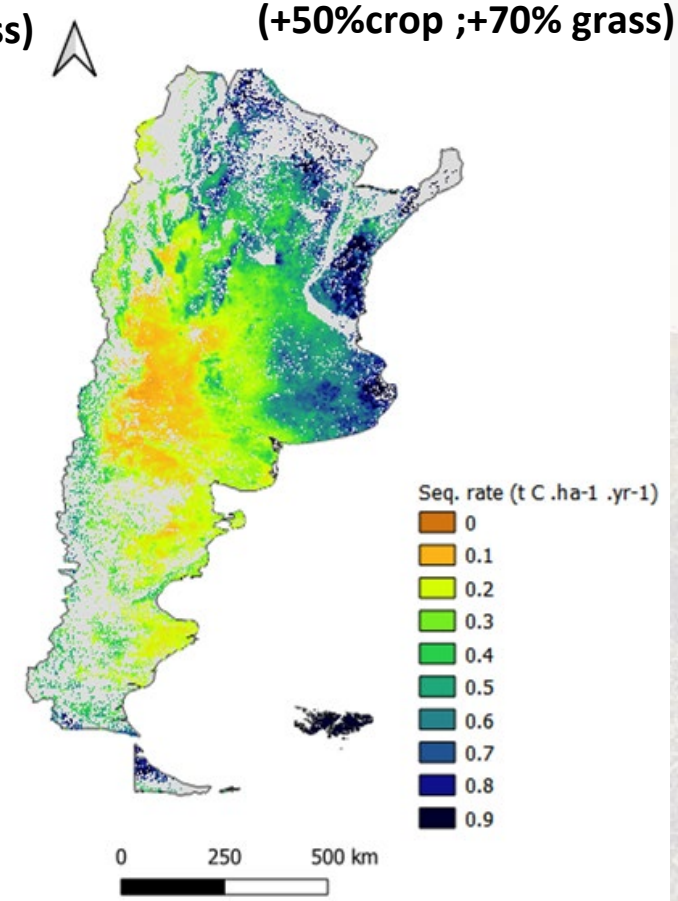
Low
(+10%crop ;+5% grass)



Medium
(+25% crop ;+30% grass)



High
(+50%crop ;+70% grass)



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… Some aspects to consider

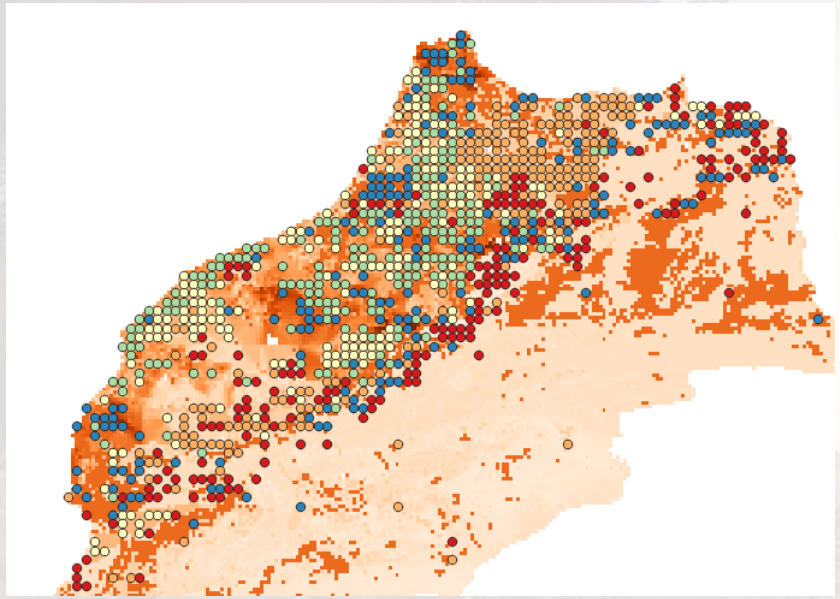
- **Units**: Clay content (g/kg vs. %); GSOC Map (g C/m2 vs TC/ha); units and sca

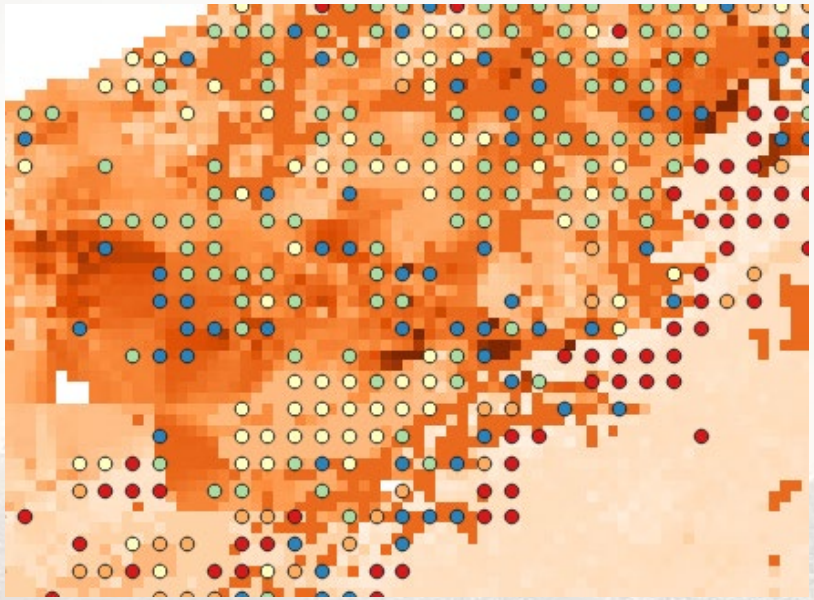
- **Outliers**...can be reprocessed ("euler" vs "lsoda")... Generally <2% points...Run those points with SoilR

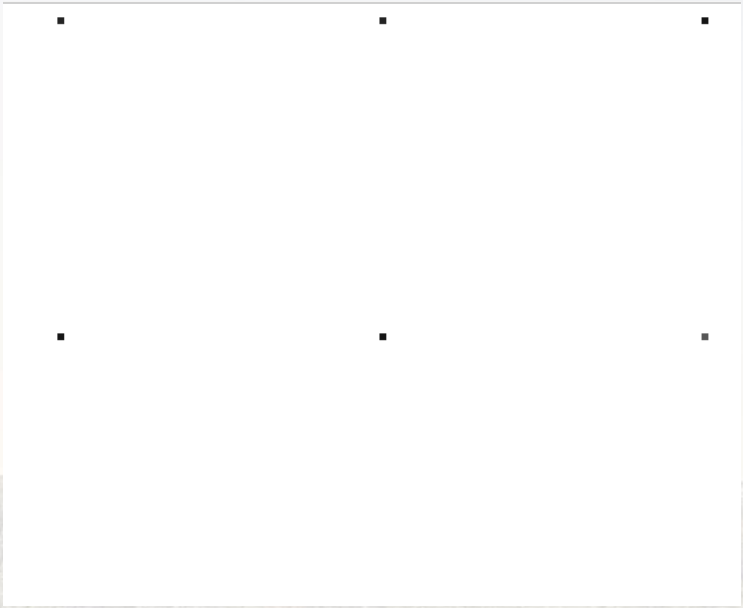
… Some aspects to consider

- **Time (Spin up)!** = monthly runs, 500 years ...Can take more than 15 days, specially in countries with large agricultural areas:
  - First run a subset of points
  - Start with standard product (target points in agricultural + grazing lands)
  - Run by **provinces/chunks**

… Some aspects to consider

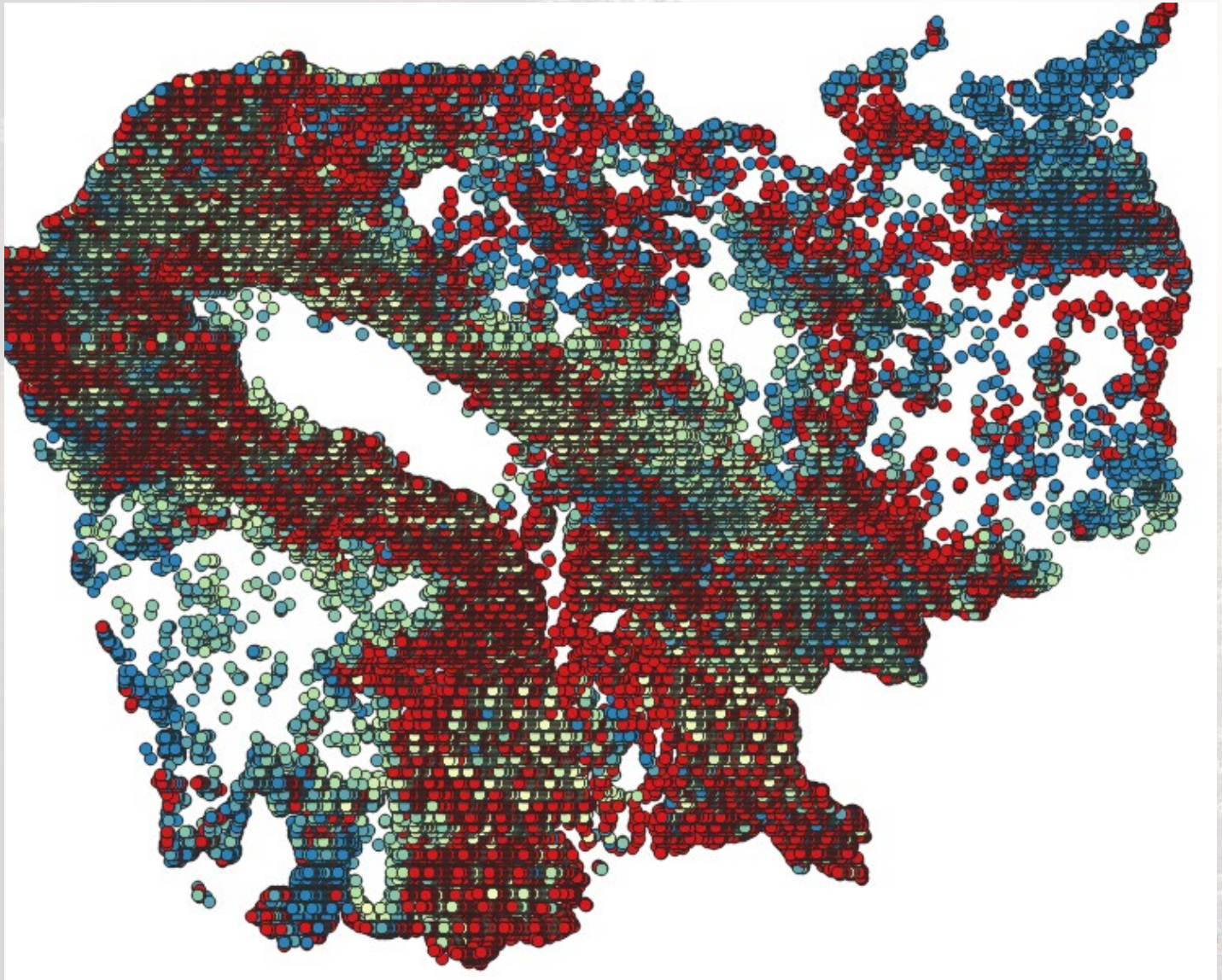






- Generate target points and run the model for all points
- Subset just to test if the model is working ok

… Some aspects to consider



- Check Forward Vector for NA or 0 values
- Start checking the stocks at T0
- Filter Select points with no data and re-run model

(lsoda vs euler in the scripts 13, 14, 15)

- Check input layers have data for that areas!

Standard Products: Final and intermediate Products

- |_ **Maps**
  - |_ **National Absolute SOC Sequestration rate Map for the BAU scenario** *(ISO3CountryCode_* **GSOCseq_ASR_BAU_***Map030.tiff)*
  - |_ **National Absolute SOC Sequestration rate Map for the SSM1 scenario (Low)** *(ISO3CountryCode_* **GSOCseq_ASR_SSM1_***Map030.tiff)*
  - |_ **National Absolute SOC Sequestration rate Map for the SSM2 scenario (Medium)***(ISO3CountryCode_* **GSOCseq_ASR_SSM2_***Map030.tiff)*
  - |_ **National Absolute SOC Sequestration rate Map for the SSM3 scenario (High)***(ISO3CountryCode_* **GSOCseq_ASR_SSM3_***Map030.tiff)*

  - |_ **National Relative SOC Sequestration rate Map for the SSM1 scenario (Low)** *(ISO3CountryCode_* **GSOCseq_RSR_SSM1_***Map030.tiff)*
  - |_ **National Relative SOC Sequestration rate Map for the SSM2 scenario (Medium)***(ISO3CountryCode_* **GSOCseq_RSR_SSM2_***Map030.tiff)*
  - |_ **National Relative SOC Sequestration rate Map for the SSM3 scenario (High)***(ISO3CountryCode_* **GSOCseq_RSR_SSM3_***Map030.tiff)*

  - |_ **Initial SOC Stocks at T0** *(ISO3CountryCode_* **GSOCseq_T0_***Map030.tiff)*

|_ **Uncertainty Maps**

  - |_ **Uncertainties: National Absolute SOC Sequestration rates for the BAU scenario** *(ISO3CountryCode_* **GSOCseq_ASR_BAU_***UncertaintyMap030.tiff)*
  - |_ **Uncertainties: National Absolute SOC Sequestration rates for the SSM1 scenario (Low)** *(ISO3CountryCode_* **GSOCseq_ASR_SSM1_** *UncertaintyMap030.tiff)*
  - |_ **Uncertainties: National Absolute SOC Sequestration rates for the SSM2 scenario (Medium)***(ISO3CountryCode_* **GSOCseq_ASR_SSM2_** *UncertaintyMap030.tiff)*
  - |_ **Uncertainties: National Absolute SOC Sequestration rates for the SSM3 scenario (High)***(ISO3CountryCode_* **GSOCseq_ASR_SSM3_** *UncertaintyMap030.tiff)*

  - |_ **Uncertainties: National Relative SOC Sequestration rates for the SSM1 scenario (Low)** *(ISO3CountryCode_* **GSOCseq_RSR_SSM1_** *UncertaintyMap030.tiff)*
  - |_ **Uncertainties: National Relative SOC Sequestration rates for the SSM2 scenario (Medium)***(ISO3CountryCode_* **GSOCseq_RSR_SSM2_** *UncertaintyMap030.tiff)*
  - |_ **Uncertainties: National Relative SOC Sequestration rates for the SSM3 scenario (High)***(ISO3CountryCode_* **GSOCseq_RSR_SSM3_** *UncertaintyMap030.tiff)*

- |_ **Documents**
- |_ **Report** (ISO3CountryCode_Report.doc, docx)

7 Final Standard Products with their uncertainties

29 Total products (considering intermediate)

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..After Generating the Map…

https://fao-gsp.github.io/GSOCseq/annex-ii-quality-assurance-and-quality-control.html

Step 1 Check that 29 products have been labeled appropriately and are in the correct format

Step 2 Check the projection and resolution of all products

Step 3 Check that the products were generated for agricultural and grazing areas only

Step 4 Check that all target areas have been included in the process

Step 5 Check for units, range, and outliers

..After Generating the Map…

https://fao-gsp.github.io/GSOCseq/annex-ii-quality-assurance-and-quality-control.html

Final SOC Stocks

- Most of the values should fall between 15-100 t/ha
- Minimum values should be greater than 0 (except for -999 Values, which indicate no data values)
- -999 values should be masked out
- There should not be negative values other than -999
- Maximum values should not exceed 800 t/ha.
- Mean values SOC SSM3 > SSM 2 > SSM 1 > BAU

..After Generating the Map…

https://fao-gsp.github.io/GSOCseq/annex-ii-quality-assurance-and-quality-control.html

Absolute sequestration rates (ASR)

- The expected range for all maps should fall between -4 to +4 t/ha
- ASR BAU: usually most values from -0.5 to + 0.5, with median values near 0 or lower
- ASR SSM1: usually most values -0.4 to + 0.6, with median near 0 or higher (similar to BAU)
- ASR SSM2: usually most values -0.3 to + 0.7
- ASR SSM3: usually most values -0.2 to + 0.8
- -999 and -49.95 Values (-999/20) indicate no data values. Values <= -49.95 should be masked out
- Negative values other than -999 and -49.95 (meaning SOC losses between 2020 and 2040) should not exceed -4
- Maximum values should usually not exceed +4.
- Mean values SSM3 > SSM 2 > SSM 1 > BAU

..After Generating the Map…

https://fao-gsp.github.io/GSOCseq/annex-ii-quality-assurance-and-quality-control.html

Relative sequestration rates (RSR)

- The expected range should fall between 0 to +4 t C/ha (with most data being distributed between 0 to +1)
- RSR SSM1: usually most values range from 0 to + 0.6, with median near 0 or higher (similar to BAU)
- RSR SSM2: usually most values range from 0 to + 0.7
- RSR SSM3: usually most values range 0 to + 0.8
- -999 and -49.95 Values (-999/20) indicate no data values. Values <= -49.95 will be excluded from Global product
- There should not be negative values other than -999 and -49.95:
- Maximum values should usually not exceed +4.
- Mean SOC values in order of size SSM3 > SSM 2 > SSM 1

Technical Report

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GLOBAL SOIL PARTNERSHIP

Technical Report

Country name: Soil Organic Carbon Sequestration Potential National Map. National Report. Version 1.0. Year: 2020

Author One[1], Author Two[2], Author Three[n]
[1]Affiliations author One, email and brief contact details on one line
[2]Affiliations author Two
[n]Affiliations author "n". Add more institutions as required

Executive summary

Provide a general introduction to the importance of the topic in the country, should state concisely the scope of the report and give the principal findings. Max. 300 words.

Abbreviations - Define abbreviations upon first appearance in the text. Please do not use non-standard abbreviations unless they appear at least three times in the text. Keep abbreviations to a minimum

1. Introduction

Should include if possible:

- General introduction: importance of SOC stocks and SOC sequestration at country level
- Country context: mention current main agricultural production systems and main products (e.g. top five agricultural products in total production and area); mention land use and management changes in the past decades if relevant, and effects on SOC stocks (cites).
- Mention sustainable soil management practices and business as usual practices in main agricultural regions and productive systems; Range and examples of the effects of sustainable practices on SOC stocks (t C. $ha^{-1}yr^{-1}$) observed within the country (cites).
- Examples of past use of SOC models in the country to estimate SOC changes (cites).
- Examples of previous SOC sequestration potential national or subnational map/s or projected SOC stocks national or subnational map/s (cites).
- Objective of the national SOC sequestration potential map.
- Institutions involved in the process.

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2. Methods

2.1. Study area

Should include if possible:

- Country area km^2
- Total agricultural land area (croplands + grazing lands), and per land use considered in the products.
- Brief description of predominant climate types (e.g. IPCC 2019 or preferred classification). General range in average annual temperature, annual precipitation, annual evapotranspiration.
- Brief description of predominant soil classes at country level (e.g. World Reference Base, 2006 or preferred classification at country level). General range in Clay content (%)
- Orography, general description
- Total SOC stocks (Pg) and range in t C.ha^{-1} (0-30 cm) (GSOC map latest version)
- Figures can be included.

2.2. General Methodology

- Brief description of the methodology (including modifications when applicable), Soil Depth, SOC model (including modifications when applicable) and software used to produce the maps: mandatory maps using standard procedures for harmonization purposes and additional national maps using preferred models and methodologies. Direct reference to FAO-GSP Technical Specifications and Country Guidelines for Global Sequestration Potential Map v1.0 (http://www.fao.org/3/cb0353en/CB0353EN.pdf) if no modifications/adjustments were applied to the original methodology.
- Brief description of the methodology used to estimate uncertainties.

2.3. Input data layers

2.3.1. Climatic data sets

- Climatic variable used for the spatial simulations, data source, time series, units, resolution.
- Downscaling, upscaling procedures when applicable.

2.3.2. Soil data sets

- Soil variable (e.g. clay content) used for the spatial simulations: data source, depth, units, resolution.
- SOC stocks used for model initialization (e.g. GSOC map latest version): data source, depth, units, resolution. Include special time considerations (e.g. year considered to initialize the model; year to which these stocks were assumed to correspond).

2.3.3. Land use and land use change data

- Data source for land cover or land use layers, time series; specific time (if no land use change was considered), resolution.
- Considered and aggregated classes (e.g. croplands, tree crops, grasslands, shrublands) to run the model. Used land use aggregation scheme (e.g. to convert from land cover classes), when applicable.
- Downscaling, upscaling procedures when applicable.

2.3.4. Land management, C inputs and scenarios

- Standard C input increase scenarios (+5, +10, +20 %)
- Modified scenarios according to local data.
- NPP estimation methodology and modifications, when applicable.
- Residue quality (decomposable plant material / resistant plant material, DPM/RPM ratio) assigned to each land us class, when applicable.
- Alternative procedures to estimate C inputs, when applicable.
- Methodology used to estimate monthly vegetation cover when applicable.

2.4. Model/s performance evaluation

As data required to quantify the accuracy of the estimates do not yet exist (projected SOC stocks 2020-2040) the model can be evaluated if it explains past events (ex-post validation). If local results from different management practices on SOC stocks are available (an ad-hoc meta-analysis within country can be conducted; already published results), and the collected activity data allow to perform simulations with these records, model-produced estimates shall be compared with the observed results. References to already published results in the country using the selected SOC model and their validation methodologies should be included.

When available legacy data, please include in this section:

- Description of the methodology used for model evaluation: predicted SOC stocks vs observed SOC stocks. E.g. statistic methodologies used to compare results: R^2; Root Mean Squared Error in t C.ha^{-1} and as a % of the observed mean; other preferred statistic methodologies; e.g bias error, d-index, model efficiency (ME), etc.

2.5. Uncertainties

This section should include a brief description of the selected approach to estimate uncertainties (Max/Min variation in SOC stocks from uncertainties in parameters as in GSOCseq Technical Manual v1.0; Montecarlo simulations; other). Include estimated uncertainty (%) in input data layers when available.

3. Results

3.1. Summary and spatial prediction of SOC sequestration rates in Country

This section should include:

- Figures including absolute sequestration rates (in t C $ha^{-1}.yr^{-1}$) for the business as usual scenario and standard +5, 10, +20% scenarios (SSM1-SSM3) (4 maps).
- Figures including relative sequestration rates (in t C $ha^{-1}.yr^{-1}$) for the standard +5, 10, +20% scenarios (SSM1-SSM3) (3 maps).
- *(Results from absolute and relative sequestration rates may be similar depending on input data layers, specially depending on climatic data layers from 2000-2020, and land use layers used in 2000-2020).*
- Figures including absolute and relative sequestration rates if alternative models and methodologies were used.

Figures should include latitude, longitude, scale, and legend.

- Summary / Histogram/ boxplot of absolute and relative sequestration rates for the different scenarios (all land uses grouped)
- Summary / Histogram/ boxplot of absolute and relative sequestration rates for the different scenarios, for the different land uses of choice.
- Summary of projected Total sequestration after 20 years per area unit (in t $C.ha^{-1}$) and national total SOC sequestration (all modelled area, Pg C)

3.2. Model performance evaluation

- This section should include results from the available model performance evaluation exercises (comparing observed vs simulated SOC stocks):
  - Statistic results (R^2; Root Mean Squared Error in t $C.ha^{-1}$and as a %, of the observed mean; other preferred statistic methodologies; e.g bias error, d-index, model efficiency, etc) from ad-hoc meta-analysis and model validation exercises, or from already published results in the country using the selected SOC model.
  - General comparison of modelling results and available experimental sequestration rates within a specific region of interest (within the agroecological area where long term experiments were undertaken).

3.3. Uncertainties

This section should include:

- Figures including uncertainties (%, as explained in Technical Manual) in absolute sequestration rates for the business as usual scenario and standard +5, 10, +20% scenarios (SSM1-SSM3) (4 maps).
- Figures including uncertainties (%, as explained in Technical Manual) in relative sequestration rates for the standard +5, 10, +20% scenarios (SSM1-SSM3) (3 maps)
- Figures including uncertainties (%, as explained in Technical Manual) in absolute and relative sequestration rates if alternative models and methodologies were used

Per area

		Average Absolute sequestration			Relative sequestration		
	Area	Low	Medium	High	Low	Medium	High
	Km2	t C . ha-1 yr-1			t C . ha-1 yr-1		
Croplands							
Grasslands							
Tree-crops							
….. (other)							
Average all land uses							

Country Total

		Absolute sequestration			Relative sequestration		
	Area	Low	Medium	High	Low	Medium	High
	Km2	Mt C yr-1			Mt C yr-1		
Croplands							
Grasslands							
Tree-crops							
….. (other)							
Total Sum							

4. Discussion and relevant considerations

If relevant, this section should include:

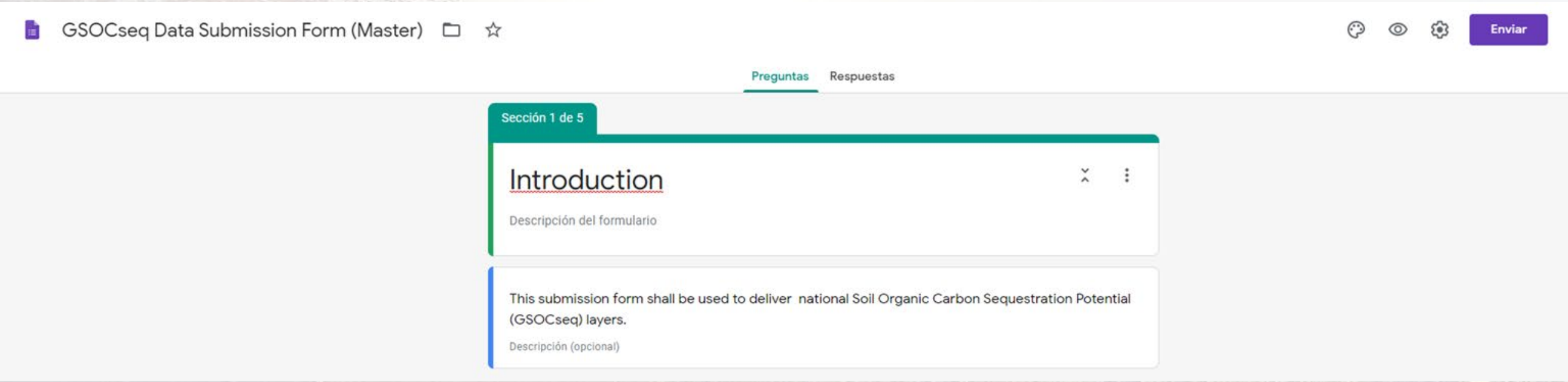
- a brief interpretation of results
- comparison of results with previous studies within the country or similar agroecological zones, when applicable
- comparison among different methodologies, modifications or different data bases used to generate the products, when applicable
- limitations of the work, relevant comments and considerations
- future requirements to refine the products
- potential uses of the products

5. Acknowledgments

6. References

References should be written in the FAO referencing style available with Mendeley and Zotero. If written manually, they should follow the following criteria:

Data submission



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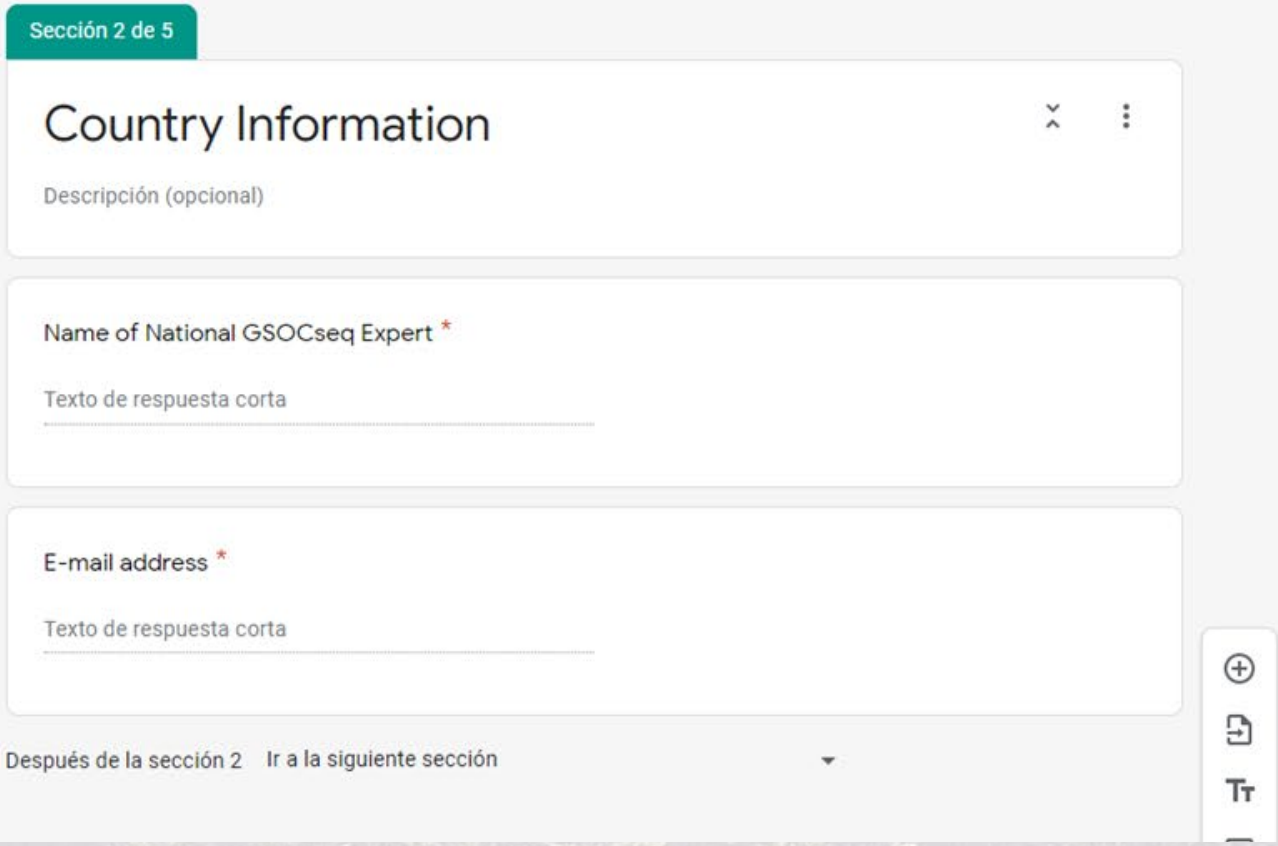
Data submission



Dat

Sección 3 de 5

Upload GSOCseq Layers

GSOCseq layers shall be delivered in GeoTIFF format. GeoTIFF is a standard .tif or image file format that includes additional spatial (georeferencing) information embedded in the .tif file as tags. These are called embedded tags, tif tags. These tags include raster metadata such as spatial extent, coordinate reference system, resolution, no data values.

National Absolute SOC Sequestration rate Map for the BAU *

Añadir archivo

National Absolute SOC Sequestration rate Map for the SSM1 scenario (Low) *

Añadir archivo

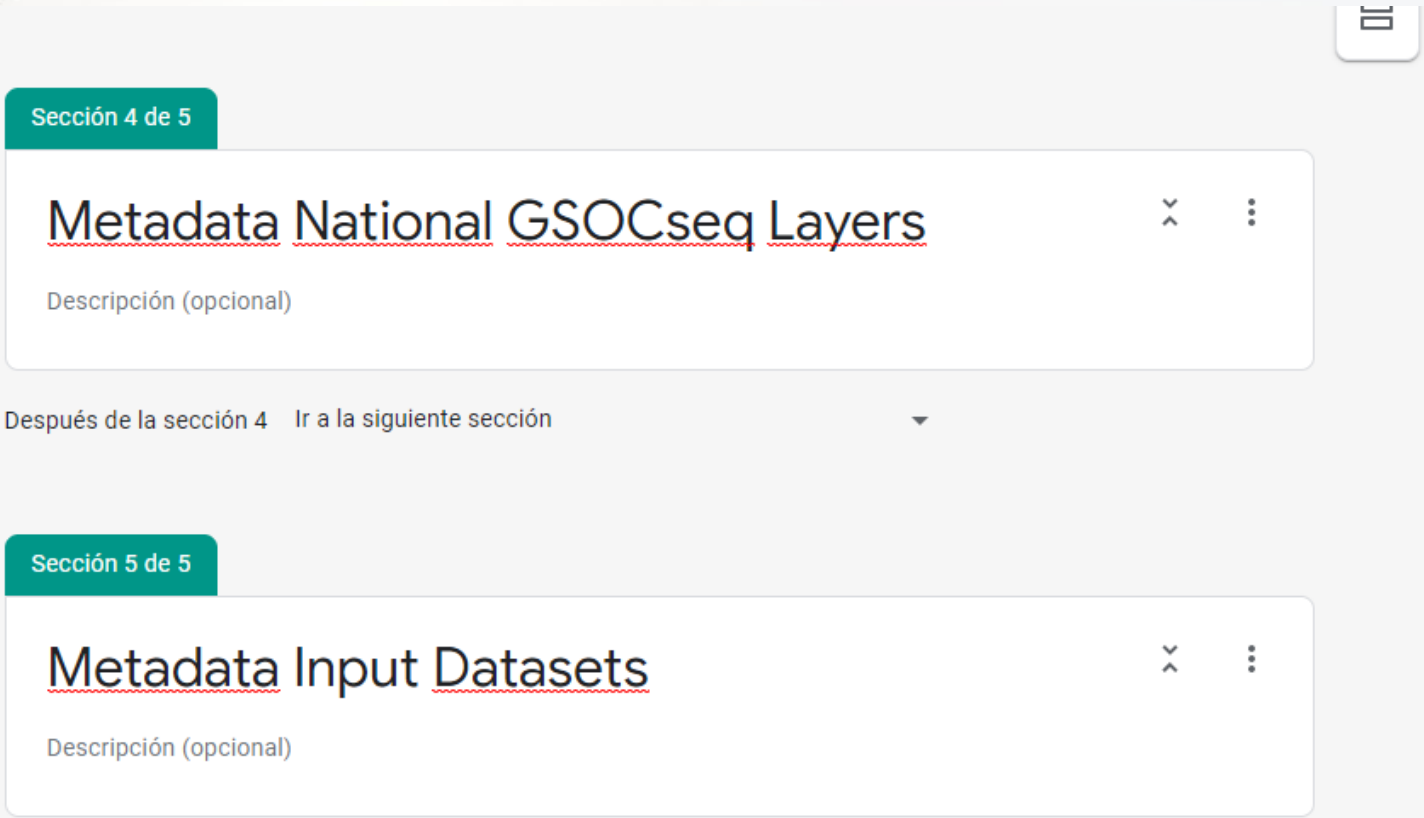
National Absolute SOC Sequestration rate Map for the SSM2 scenario *

Añadir archivo

National Absolute SOC Sequestration rate Map for the SSM3 scenario *

all

Data submission



THANK YOU
MUCHAS GRACIAS

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