



FACULTY OF
AGRICULTURE
AND ENVIRONMENT

Global space-time soil carbon assessment

José Padarian
Uta Stockman
Budiman Minasny
Alex McBratney

June – 2016

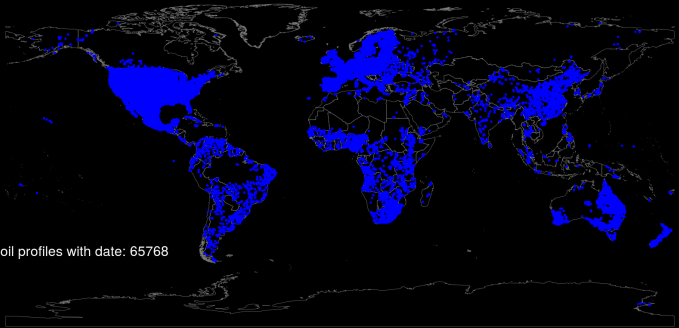
Motivation

- ▶ Evaluate soil quality and condition (SOC)
- ▶ “Large” amount of legacy data
- ▶ Producing outdated maps?
- ▶ Monitoring

Motivation

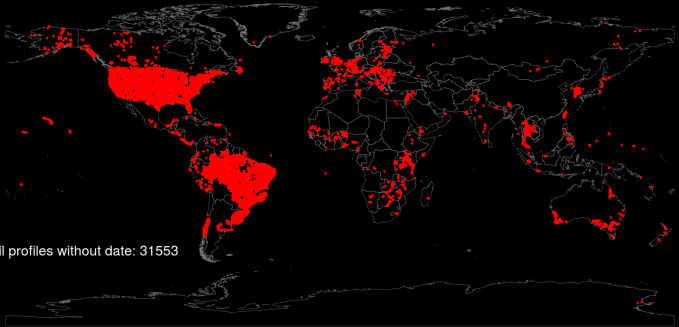
- ▶ Evaluate soil quality and condition (SOC)
- ▶ “Large” amount of legacy data
- ▶ Producing outdated maps?
- ▶ Monitoring

We need to add a time component



Soil profiles with date: 65768

A world map with a black background and white country outlines. Numerous small blue dots are scattered across the map, representing soil profiles that include a date. The dots are most densely clustered in North America, Europe, and parts of Asia and Africa. A scale bar is visible at the bottom left of the map area.



Soil profiles without date: 31553

A world map with a black background and white country outlines. Numerous small red dots are scattered across the map, representing soil profiles that do not include a date. The distribution is similar to the top map, with higher concentrations in North America, Europe, and parts of Asia and Africa. A scale bar is visible at the bottom left of the map area.

- ▶ Elevation, slope
- ▶ Total annual precipitation, mean annual temperature
- ▶ Köppen-Geiger climate groups
- ▶ Landcover

- ▶ Elevation, slope
- ▶ Total annual precipitation, mean annual temperature
- ▶ Köppen-Geiger climate groups
- ▶ Landcover

$$SOC_{xyt} = f(elev_{xy}, slope_{xy}, tap_{xy}, mat_{xy}, lc_{xyt})$$

Baseline

- ▶ Generate “baseline” for year 2001

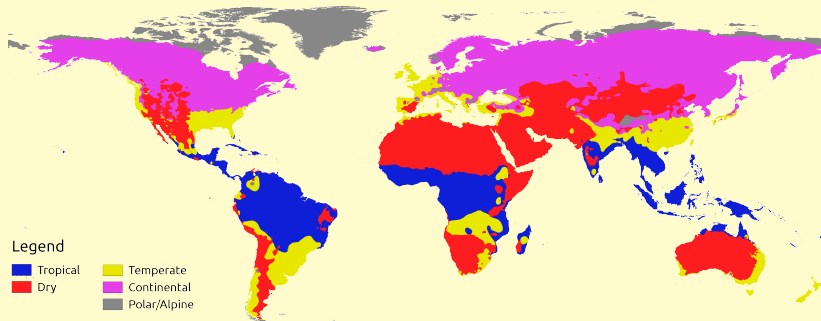
Landcover tracking

- ▶ **When** a landcover change occurs
- ▶ From landcover **X** to **Y**
- ▶ **How long** does this landcover persists

MCD12Q1: Landcover type (IGBP)

Original class	New class
Evergreen Needleleaf forest	5
Evergreen Broadleaf forest	4
Deciduous Needleleaf forest	5
Deciduous Broadleaf forest	4
Mixed forest	4
Closed shrublands	2
Open shrublands	2
Woody savannas	3
Savannas	3
Grasslands	3
Croplands	2
Cropland/Natural vegetation mosaic	2
Barren or sparsely vegetated	1

Köppen-Geiger climate groups



Mean SOC content (equilibrium)

	Tropical	Dry	Temperate	Continental	Polar/Alpine
lc_1	-	0.34	0.81	0.75	-
lc_2	1.50	1.05	3.07	5.22	3.67
lc_3	1.15	1.27	9.91	9.11	3.65
lc_4	3.09	3.75	12.92	9.86	4.77
lc_5	-	4.67	6.26	11.59	10.42

Example: Continental

	lc_1	lc_2	lc_3	lc_4	lc_5
lc_1	1.00	6.96	12.15	13.15	15.45
lc_2	0.14	1.00	1.75	1.89	2.22
lc_3	0.08	0.57	1.00	1.08	1.27
lc_4	0.08	0.53	0.92	1.00	1.17
lc_5	0.06	0.45	0.79	0.85	1.00

Example: Continental

	lc_1	lc_2	lc_3	lc_4	lc_5
lc_1	1.00	6.96	12.15	13.15	15.45
lc_2	0.14	1.00	1.75	1.89	2.22
lc_3	0.08	0.57	1.00	1.08	1.27
lc_4	0.08	0.53	0.92	1.00	1.17
lc_5	0.06	0.45	0.79	0.85	1.00

Landcover 3 has 1.75 times more SOC than Landcover 2

Effect of temperature

Arrhenius function

$$e^{-E/k(T+273.15)}$$

where:

- ▶ E is the “activation energy”
- ▶ k is Boltzmann’s constant
- ▶ T is mean annual temperature in °C

E is different for photosynthesis and respiration:

Photosynthesis ≈ 0.3

Respiration ≈ 0.65

Effect of rainfall

Sigmoid function

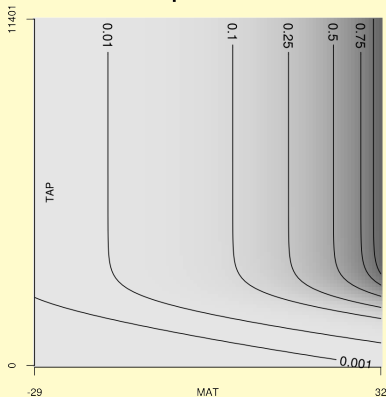
$$\frac{1}{1 + e^{0.003(R - 11401/5)}}$$

where:

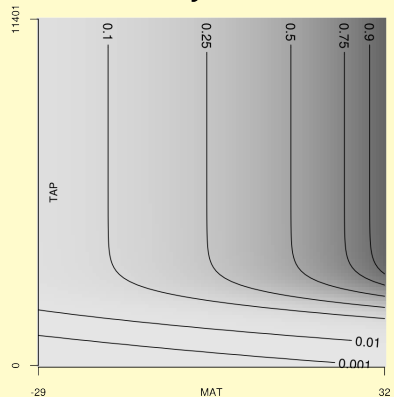
- ▶ R is total annual rainfall in mm

Weights

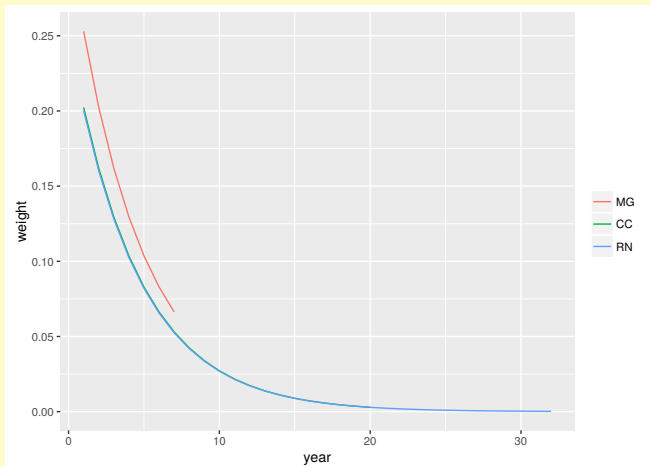
Respiration



Photosynthesis

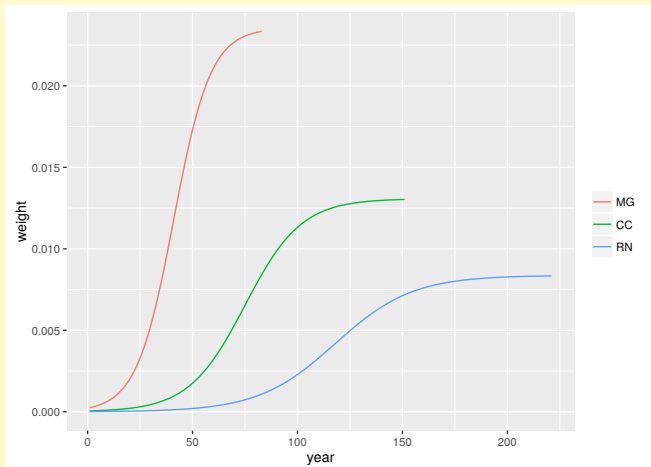


Loss: exponential decay



MG (MAT: 24 °C, TAP: 1900 mm), CC (MAT: 14 °C, TAP: 500 mm), and RN (MAT: 9 °C, TAP: 200 mm)

Accumulation: sigmoid function



MG (MAT: 24 °C, TAP: 1900 mm), CC (MAT: 14 °C, TAP: 500 mm), and RN (MAT: 9 °C, TAP: 200 mm)

Example

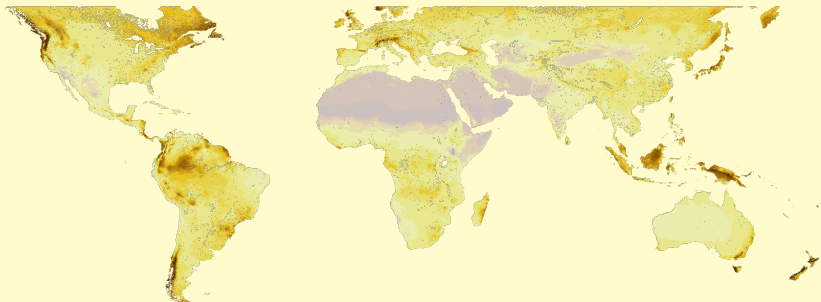
- ▶ Continental climatic group
- ▶ Landcover 3 (1.76 time higher) → Landcover 2
- ▶ MAT: 24^o C, TAP: 1900 mm → w: 0.125

Example

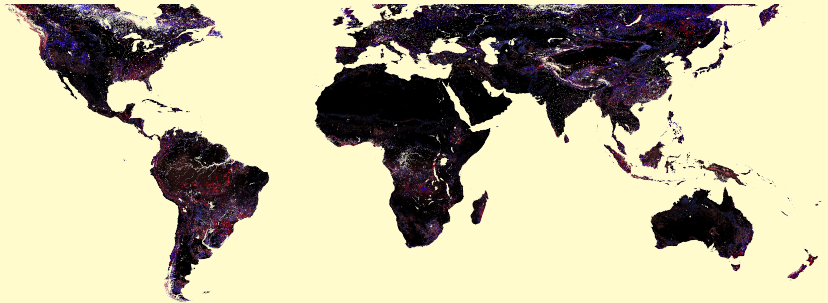
- ▶ Continental climatic group
- ▶ Landcover 3 (1.76 time higher) → Landcover 2
- ▶ MAT: 24^o C, TAP: 1900 mm → w: 0.125

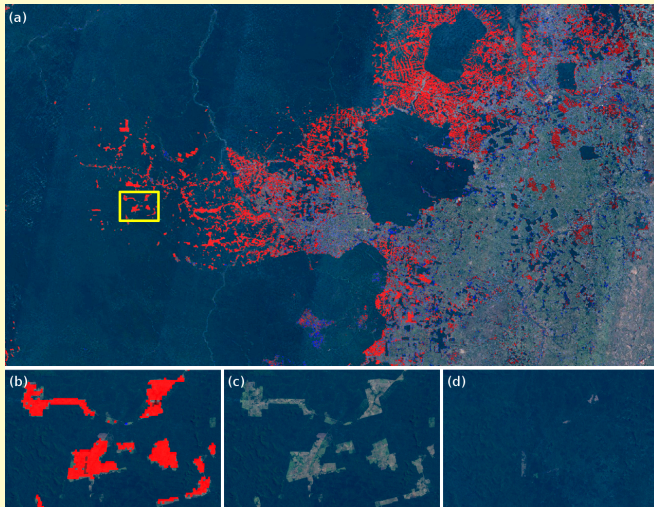
Year	0	1	2	3	4	5	6	7	8
SOC	1.00	0.89	0.80	0.73	0.68	0.63	0.60	0.57	0.57
Δ		-0.11	-0.09	-0.07	-0.06	-0.04	-0.04	-0.03	0.00

Baseline



Change 2001-2009

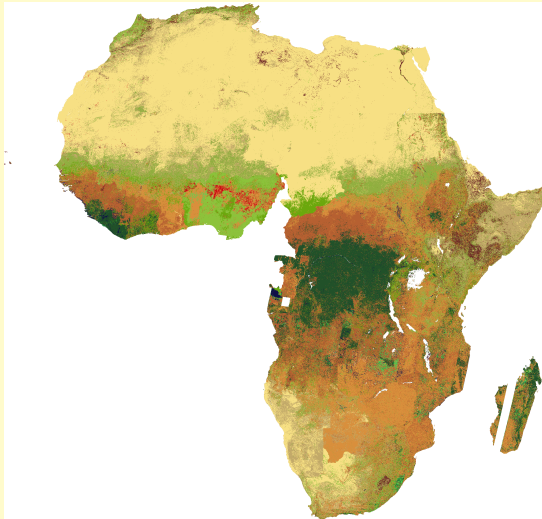




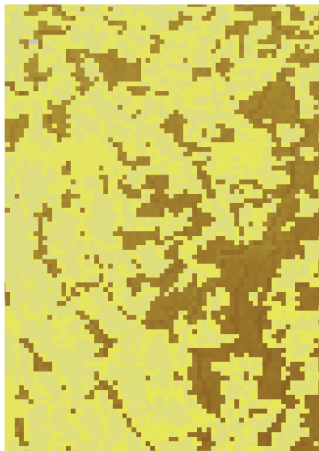
TODO list

- ▶ How to use the rest of the data (without date)?
- ▶ What happened before 2001?
- ▶ Better resolution?
- ▶ ...

Lancover based on Landsat: Africa, 2000

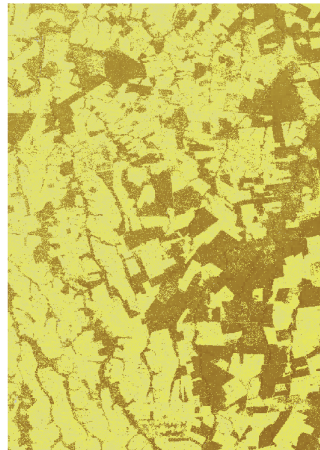
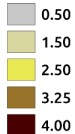


Downscaling: Mato Grosso, Brazil



1000 meters

SOC (%)



100 meters



Thanks!



Arrhenius, S. *et al.*, 1915. Quantitative laws in biological chemistry.