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Mapping Soil Organic Carbon Stocks Using a General 3D Mapping Approach in the Northeast Tibetan Plateau, China

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Introduction

Importance of SOC in the Tibetan Plateau

- High soil carbon density
- Sensitivity to global environment change

SOC maps in the Tibetan Plateau

- Lack maps in fine resolution

  (Polygon-based or coarse resolution)

- With large uncertainty
- Challenge in accurately mapping SOC and estimating its stock, e.g., difficult in sampling and large spatial heterogeneity of soil

Introduction

Digital soil mapping (DSM)

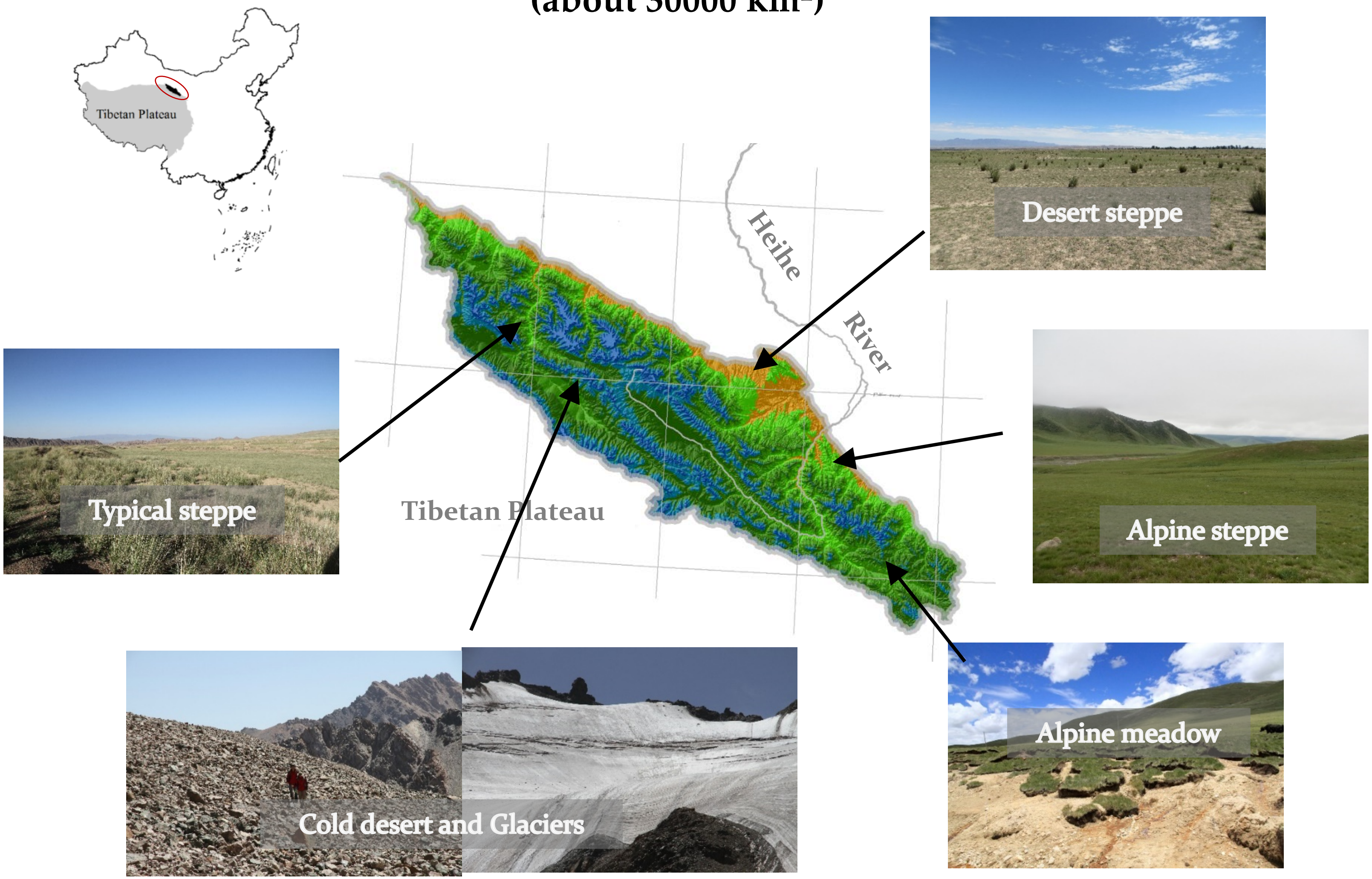
- A new and progressive technology in estimating SOC stock
- Various 3D methods developed in previous research are available

Objectives

- Access a 3D mapping framework (exponential function + random forest) in describing the lateral and vertical variation of SOC in the Tibetan Plateau
- Provide spatially explicit maps of SOC based on raster grid (90m*90m)
- Identify key factors that influence on estimates of soil carbon stock

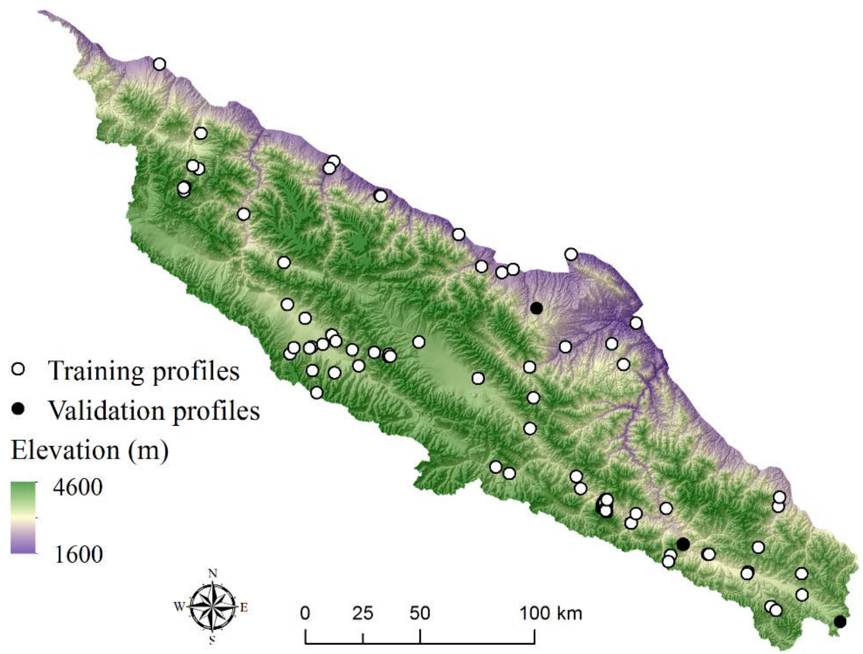
Study area

(about 30000 km^2)



Soil data

- Purposively sampling, 2012-2013
- 99 sites
- Depth to 1.2 m or bedrock
- Pedogenetic horizon (96 sites) and 5 cm interval (3 sites)
- Organic carbon content (g kg^{-1})
- Bulk density (g cm^{-3})
- Gravel content



SOC content in mass basis (g kg^{-1}) was converted to volume basis (kg cm^{-3})

$$C_v = C_m \times \rho \times (1 - G)$$

Predictors (c, o, r, n)

Type	Source	Resolution	Number	Variables
Climate	National climate data	1 km	2	Mean annual precipitation/ temperature
Organism	Landsat 5	30 m	4	Bands 3, 4, 5 and NDVI
Relief	SRTM DEM	90 m	10	Elevation, slope, aspect, TWI, MRVBF …
Spatial position	Coordinates	90 m	2	Lat, Log

Methodology

SOC depth modeling

- Exponential decay function
- Corrected by pedogenetic surface horizons

Spatial modeling

- Random forest with 18 environmental covariates
- Resolution: 90 m

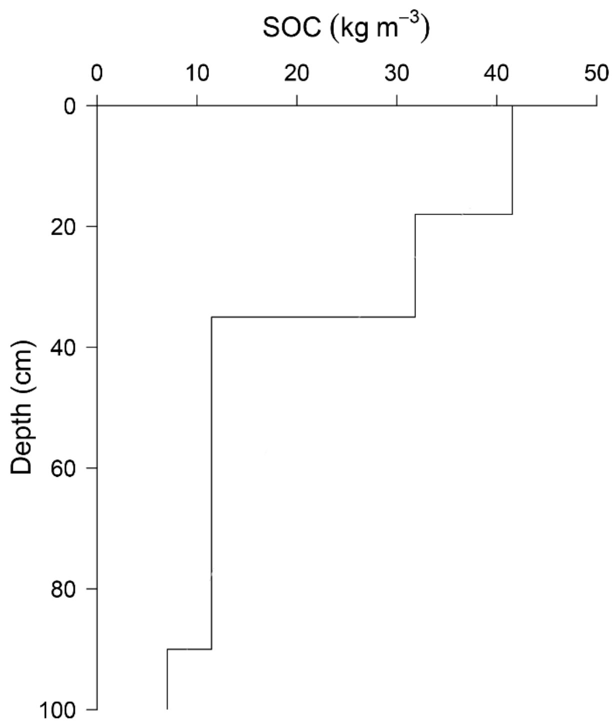
Validation

- 96 calibration sites (pedogenetic)
- 3 validation sites (5 cm interval)

SOC depth modeling

Mattic epipedon

- a diagnostic surface horizon in Chinese Soil Taxonomy
- mixture of plant roots, under alpine meadow
- high content of organic carbon
- Criterions:
  - thickness (> 5 cm)
  - textile roots (> 50%)
  - C/N (14–20)
  - saturation (< 1 month)
  - soil bulk density (0.5–1.1 g m^{-3})
  - soil temperature (cyric)
  - … …
- 41 pedons



SOC depth modeling

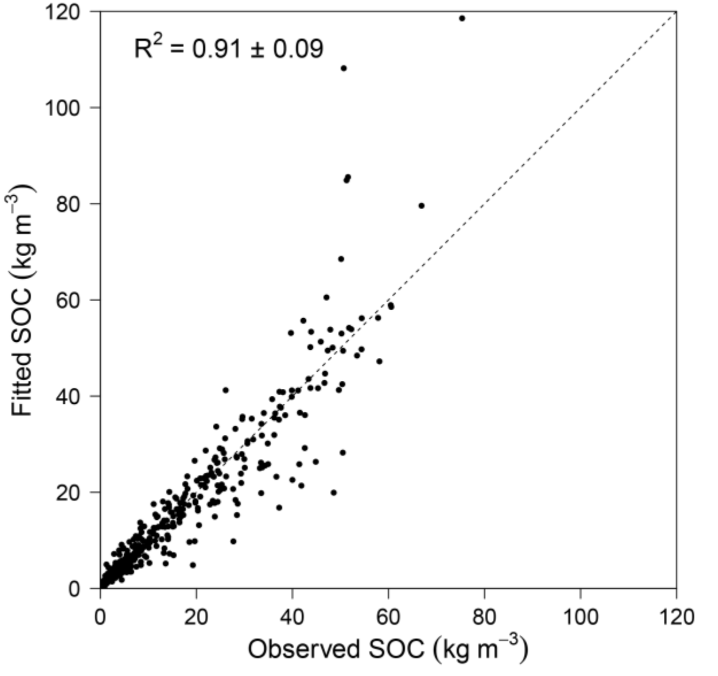
Defining the depth function

- Exponential decay function
- The mattic epipedon

Equation:

$$z \le d_{mat} : C_v(z) = C_{mat}$$
$$z > d_{mat} : C_v(z) = C_a \exp(-kz)$$

Four parameters:
Mattic epipedon
Mattic depth
C_a
k



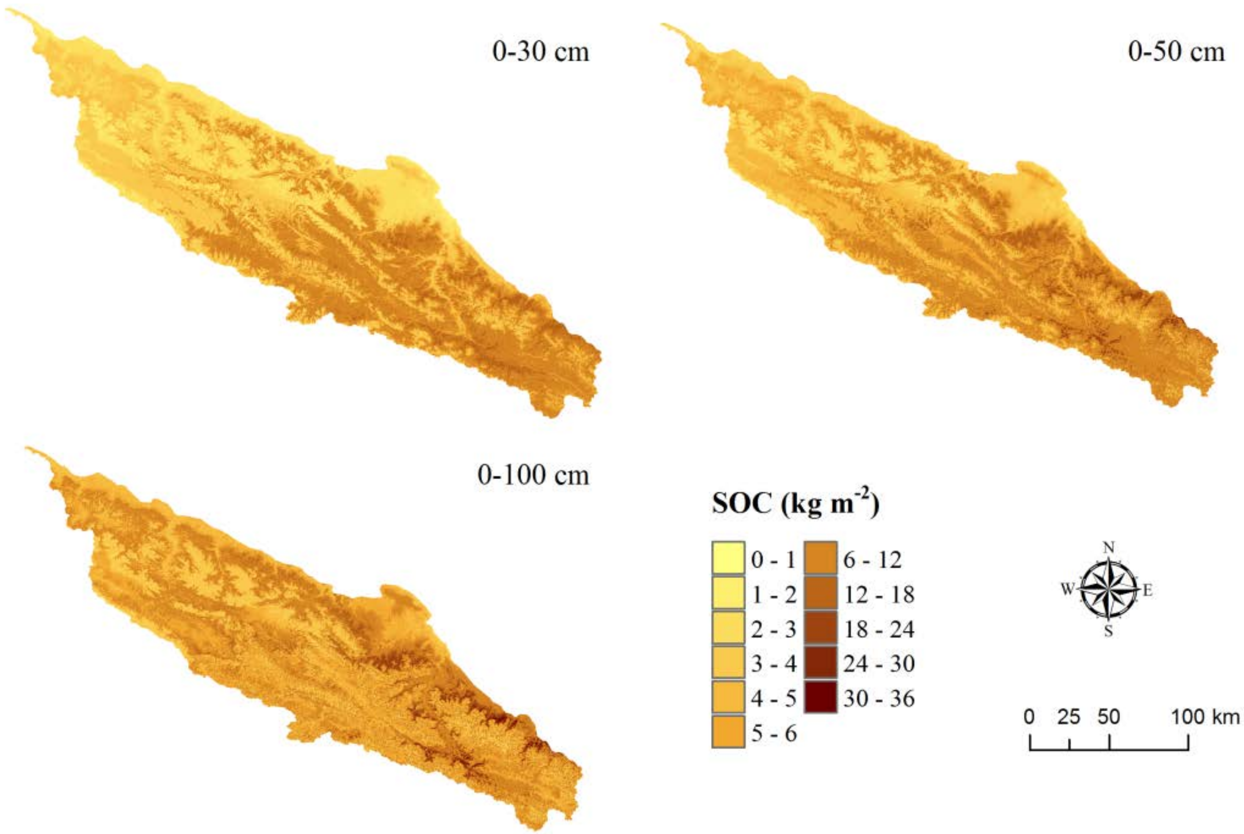
Spatial modeling

Predictive accuracy: SOC (kg m^{-2})

	Indices	Min	Mean	Max	SD
Internal	ME	-0.07	-0.06	-0.04	0.005
	RMSE	1.33	1.35	1.36	0.006
	Lin's cof	0.89	0.90	0.90	0.001
Independent	ME	-0.60	-0.59	-0.57	0.004
	RMSE	0.92	0.94	0.95	0.004
	Lin's cof	0.53	0.54	0.55	0.004

Spatial distribution

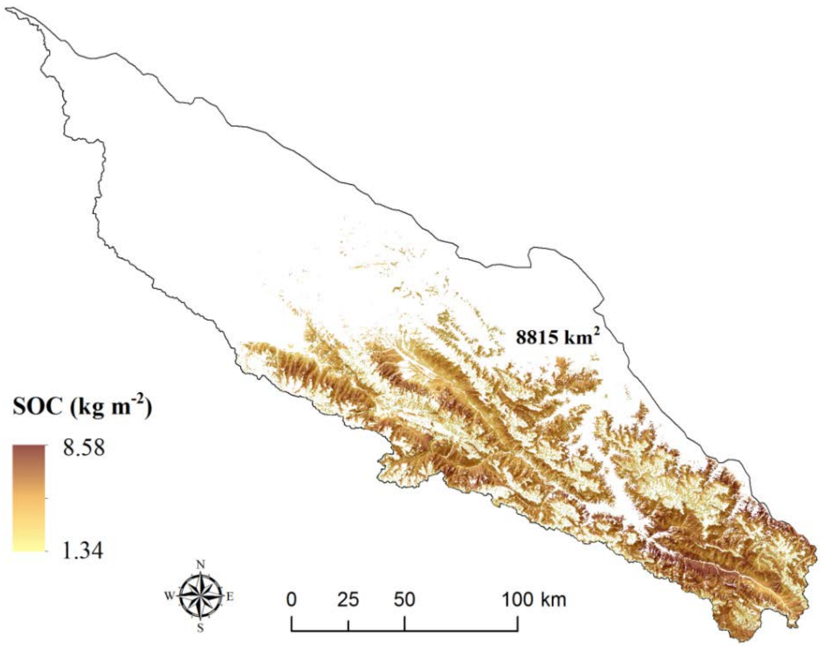
SOC at 0-30, 0-50 and 0-100 cm



Spatial distribution

SOC in the mattic epipedon

(Area = 8815 km²; Mean depth = 14 cm)



SOC stock

Layer	Density (kg m^{-2})	Total stock (Tg)	Relative stock (%)
Mattic horizon	4.99	43.95	20.94
0-30 cm	5.54	168.89	$\boxed{80.48}$
0-50 cm	6.11	186.22	88.73
0-100 cm	6.89	209.87	100

Conclusions

The DSM approach is able to provide good maps of SOC in alpine ecosystems

- Depth function integrating exponential function and the mattic epipedon is useful to describe vertical distribtion of SOC
- RF is flexiable to map depth functions using covariates
- Reasonable performances

In the Tibetan Plateau, the mattic epipedon is a key factor to :

- Reflect realistic distibution of SOC
- Reach reliable estimates of soil carbon stock

THANK YOU

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REFERENCE:

Yang, R.M. et al. Precise estimation of soil organic carbon stocks in the northeast Tibetan Plateau. Sci. Rep. 2016, 6, 21842.