Soil organic carbon density under different grasslands types of Yunnan province, southwest China

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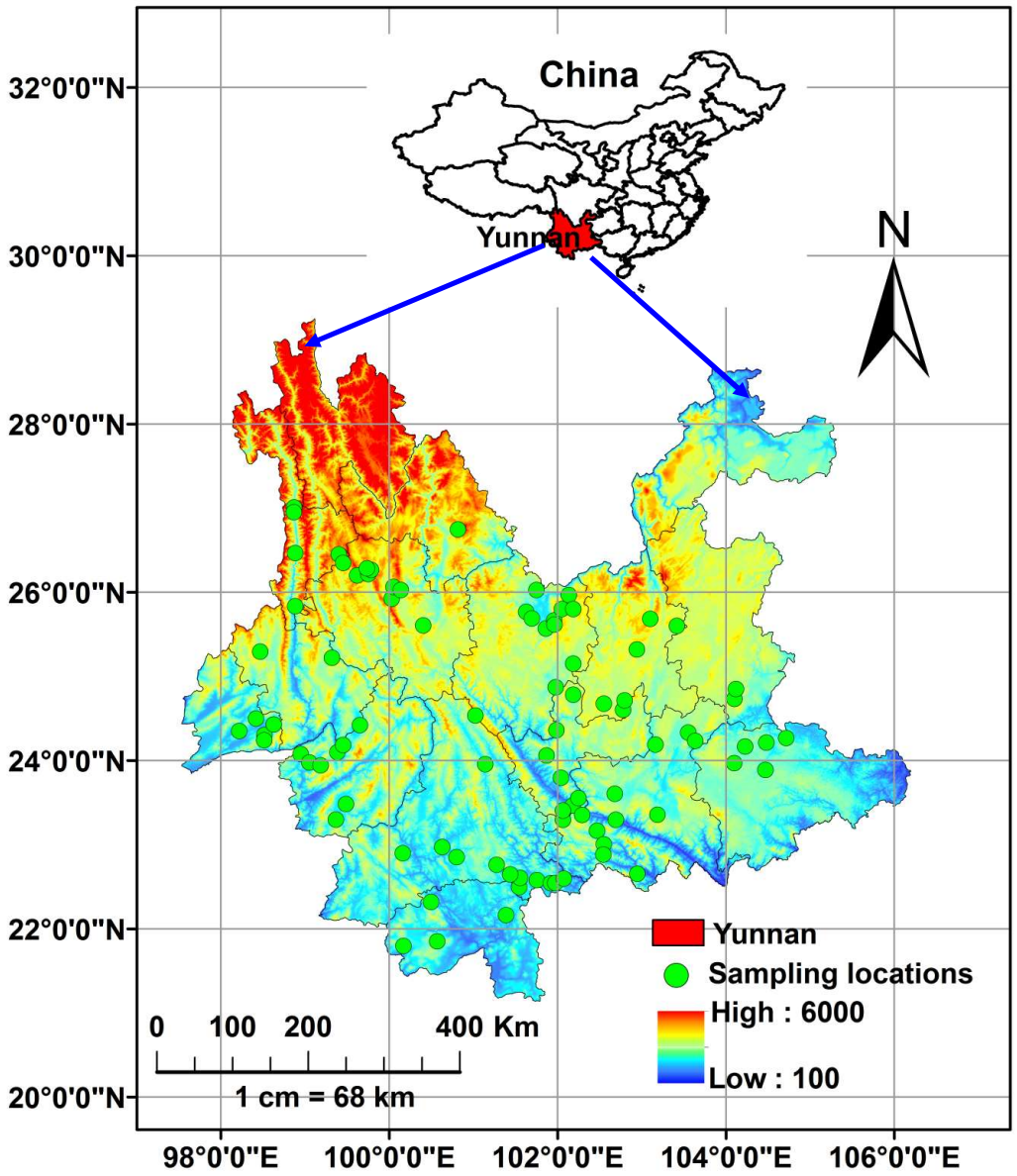
An overview

- Globally, grasslands are one of the most important vegetation types (~40 %) and important part of the terrestrial carbon (C) cycle system
- Grassland ecosystems as they contain more soil C per unit area than the global average (Jobbágy & Jackson, 2000).
- However, large areas of grasslands have experiences soil C loss due to the anthropogenic activities such as cropland conversion and intensive grazing etc.
- Chen (2000) and Sun (2000) showed that proportion of grasslands to the total land surface in China was 40% that covers approximately an area of 4,000,000 km^{-2} and contribute about 9–16% of total carbon (vegetation + soil) in the world grasslands (Ni, 2002).

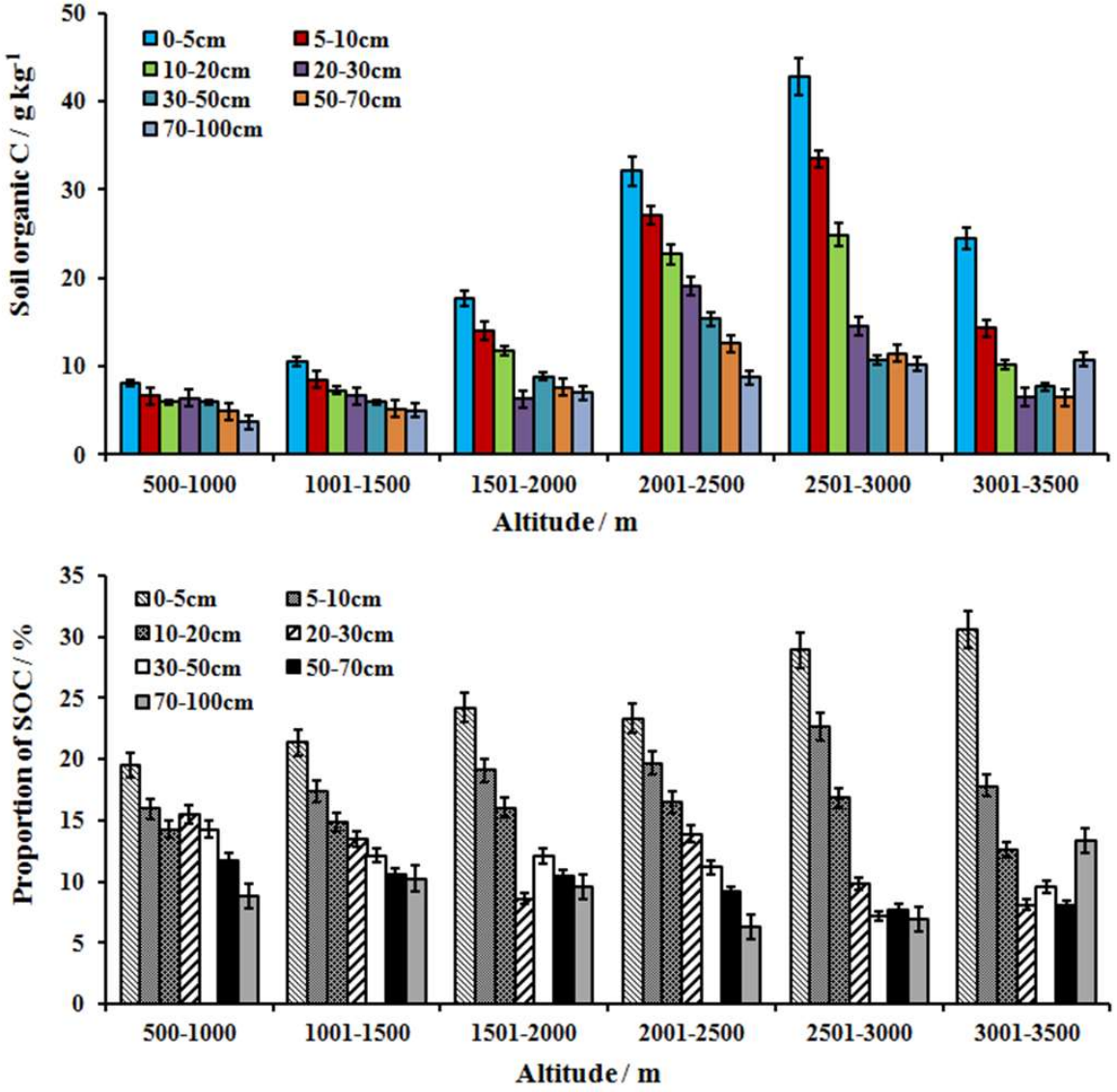

China
Yunnan
N
32°0'0"N
30°0'0"N
28°0'0"N
26°0'0"N
24°0'0"N
22°0'0"N
20°0'0"N
98°0'0"E
100°0'0"E
102°0'0"E
104°0'0"E
106°0'0"E
0 100 200 400 Km
1 cm = 68 km
Yunnan
Sampling locations
High : 6000
Low : 100

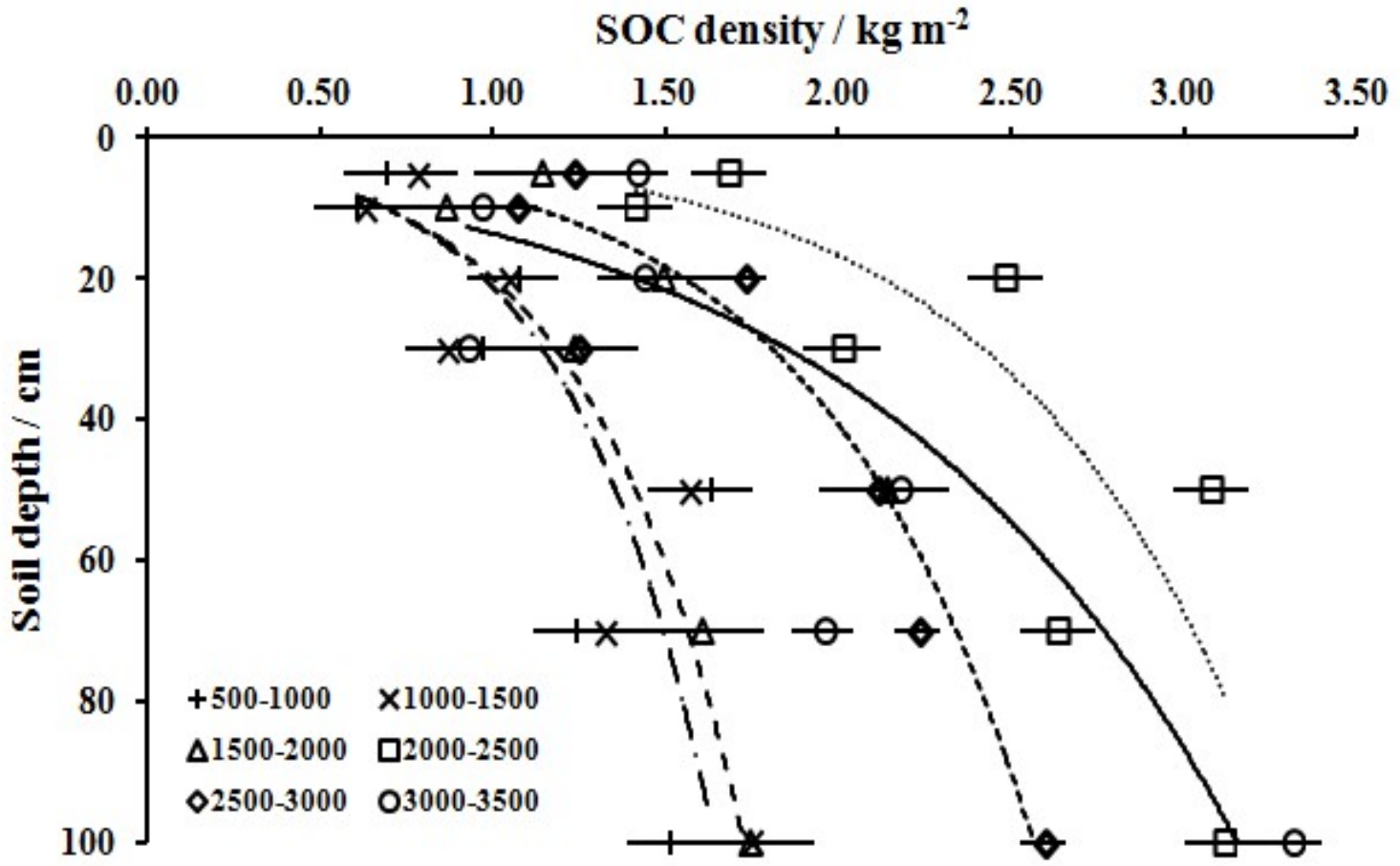
- In order to evaluate the spatial and vertical differences of SOC along topographical gradients, the data were grouped into slope-, altitudinal-, latitudinal- and longitudinal-gradients.
- In order to explain the variations in SOC density in different types and disturbance gradients of grasslands, we grouped the data into 6 different types of grasslands *viz*.,
  - alpine meadow (AM), arid-tropical shrub tussock scattered with trees (ATST), temperate desert (TD), temperate meadow-steppe (TMS), tropical shrub tussock (TST) and warm-temperate shrub tussock (WTST);
- 5 types of disturbance regime
  - clipping grass (CLG), grazing prohibition (GP), spring and autumn grazing (SAG), warm season grazing (WSG) and yearlong grazing (YG).
- Similarly, the grasslands were grouped under different frequencies of
  - MAT (5-10 °C, 10-15 °C, 15-20 °C and 20-25 °C) and
  - MAP (0-500 mm, 500-1000 mm, 1000-1500 mm, 1500-2000 mm, 2000-2500 mm) gradients to explain the temperature and precipitation influence on the SOC density.
- Also grouped by different soil types

Mean soil properties of grasslands in Yunnan province, SW China

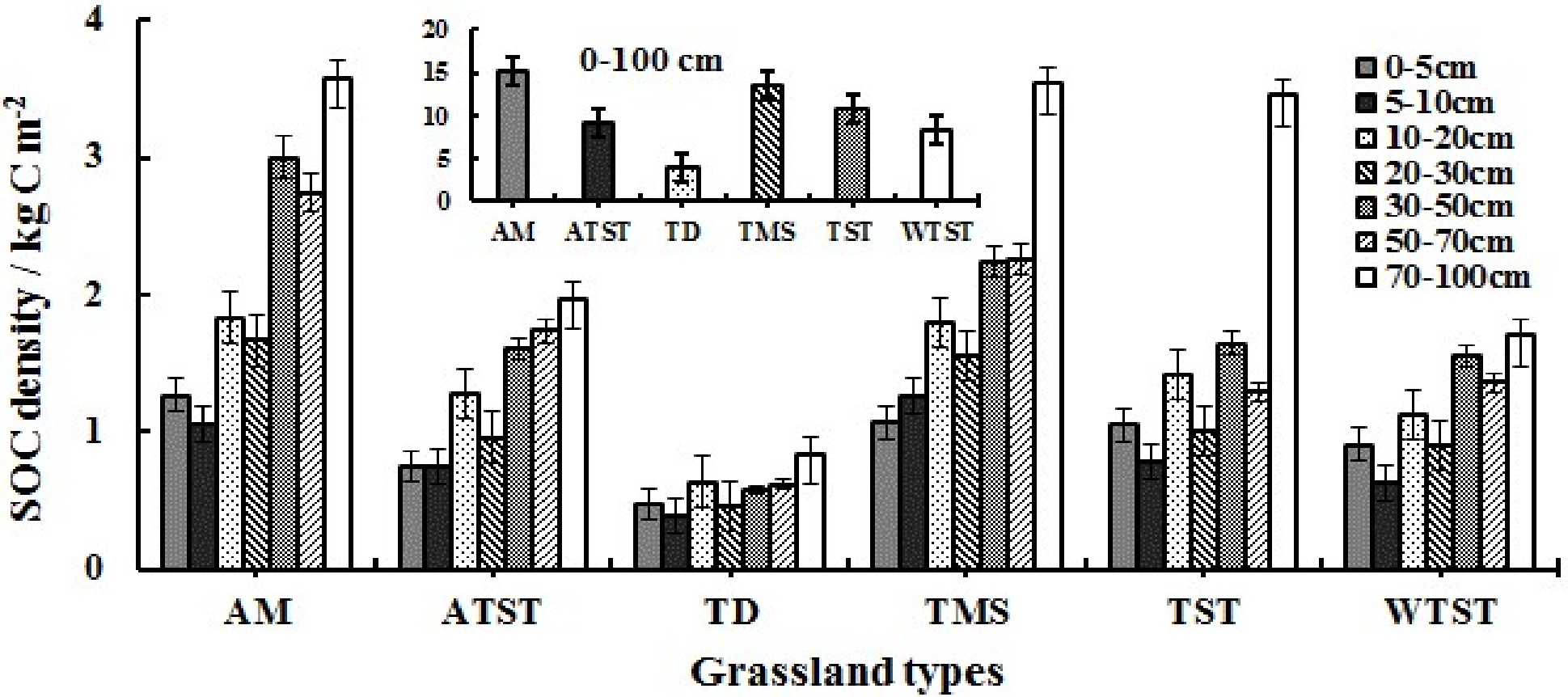
Soil properties	Soil depth / cm						
	0-5	5-10	10-20	20-30	30-50	50-70	70-100
Bulk Density / g cm^{-3}	1.22 ± 0.19	1.24 ± 0.20	1.28 ± 0.20	1.31 ± 0.20	1.32 ± 0.20	1.35 ± 0.20	1.37 ± 0.21
pH / soil : water, 1:5	6.47 ± 1.16	6.33 ± 1.21	6.31 ± 1.19	6.31 ± 1.18	6.29 ± 1.16	6.24 ± 1.37	6.22 ± 1.29
SOC / g kg^{-1}	18.34 ± 2.56	14.77 ± 1.94	12.26 ± 1.07	9.15 ± 0.76	8.80 ± 2.02	7.57 ± 1.67	6.48 ± 2.11
Total N / g kg^{-1}	2.55 ± 0.20	2.18 ± 0.18	1.79 ± 0.13	1.45 ± 0.10	1.37 ± 0.08	1.19 ± 0.07	1.02 ± 0.06
C:N molar ratio	7.40 ± 2.05	7.36 ± 1.13	7.02 ± 1.42	6.51 ± 0.56	6.73 ± 0.75	6.35 ± 1.29	6.29 ± 1.73

n = 92

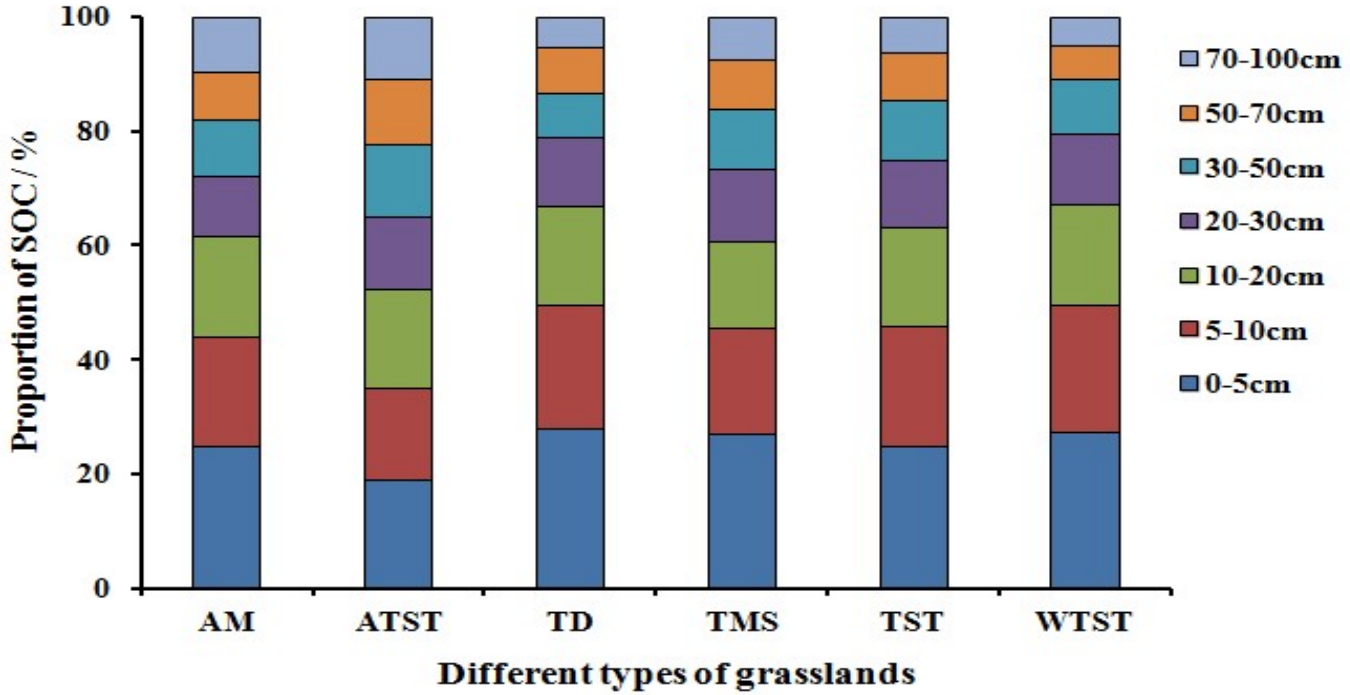

Soil organic C / g kg-1
0-5cm
5-10cm
10-20cm
20-30cm
30-50cm
50-70cm
70-100cm
0
10
20
30
40
50
500-1000
1001-1500
1501-2000
2001-2500
2501-3000
3001-3500
Altitude / m
Proportion of SOC / %
0
5
10
15
20
25
30
35
500-1000
1001-1500
1501-2000
2001-2500
2501-3000
3001-3500
Altitude / m

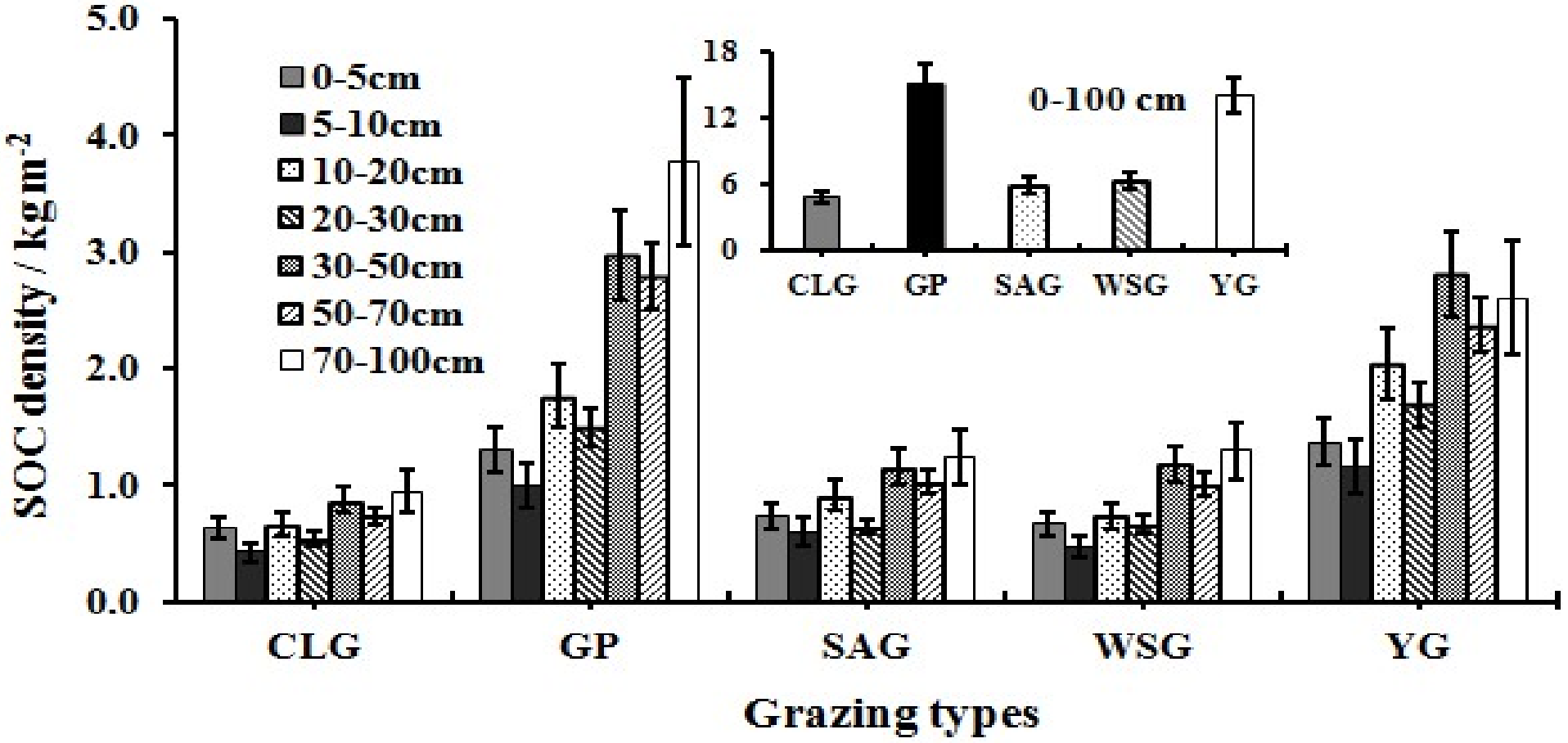


Soil organic carbon density along elevational gradients

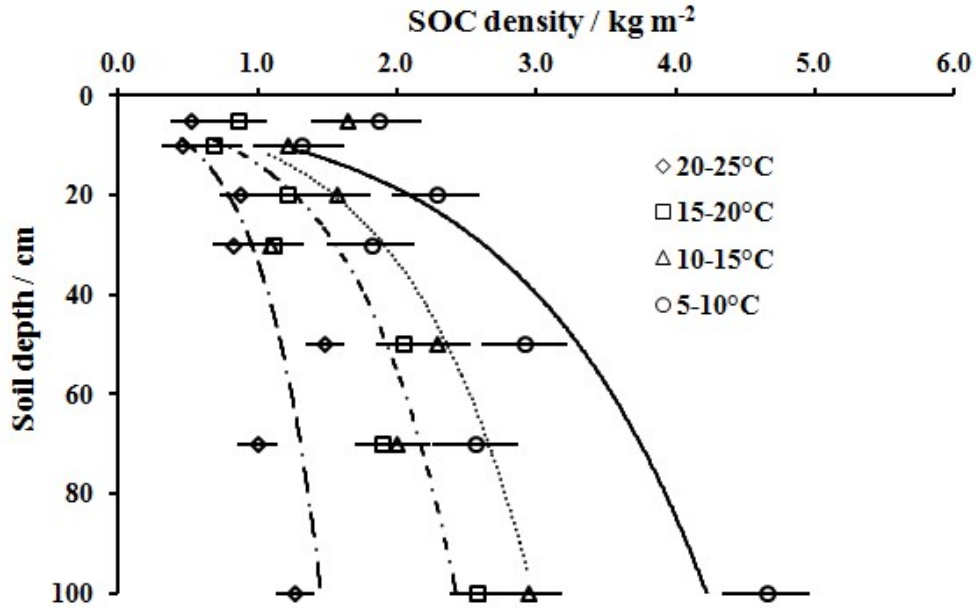


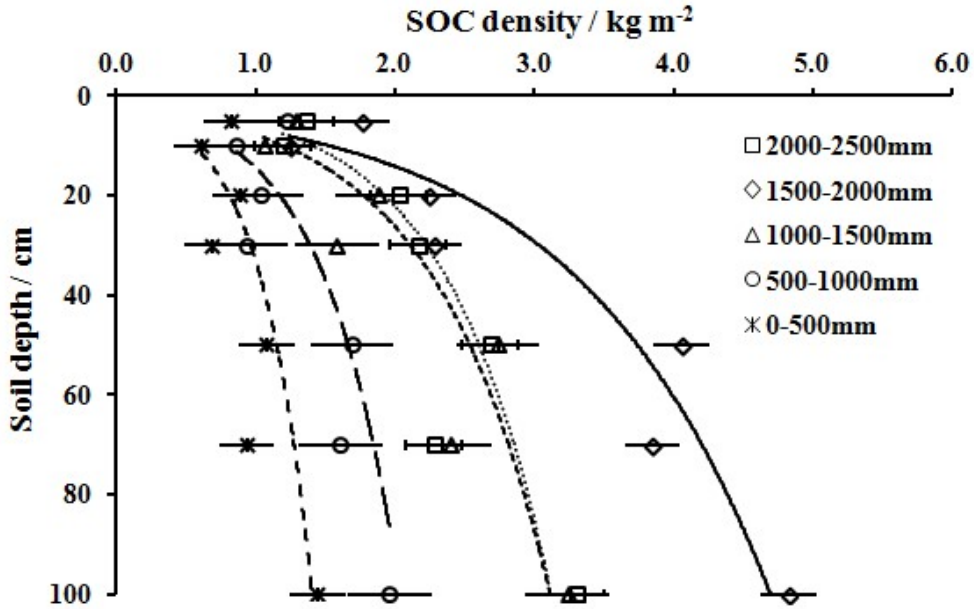
AM, Alpine meadow; **ATST**, Arid-tropical shrub tussock scattered with trees; **TD**, Temperate desert; **TMS**, Temperate meadow-steppe; **TST**, Tropical shrub tussock; and **WTST**, Warm-temperate shrub tussock


100
80
60
40
20
0
Proportion of SOC / %
AM
ATST
TD
TMS
TST
WTST
Different types of grasslands
70-100cm
50-70cm
30-50cm
20-30cm
10-20cm
5-10cm
0-5cm



CLG, Clipping grass; **GP**, grazing prohibition; **SAG**, Spring and autumn grazing; **WSG**, Warm season grazing; and **YG**, Yearlong grazing.



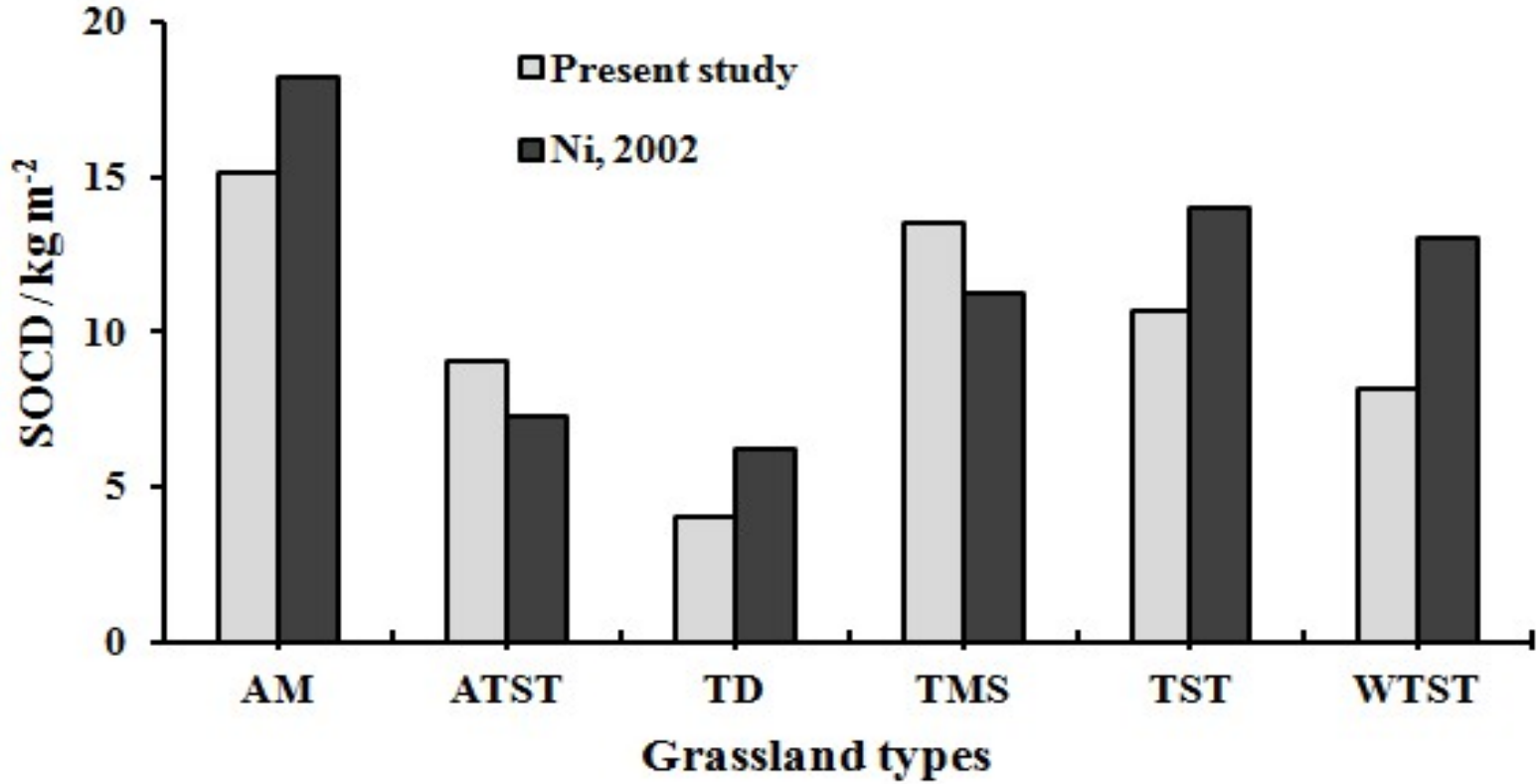


Soil organic carbon density along a temperature and precipitation gradients

SOC density in different soil types across different types of grasslands

Soil Types	Soil depth / SOCD / kg m^{-2}
	0-100
Ash dark brown soil	1.56±0.03
Brown calcium soil	16.65±2.01
Brown earth soil	**19.22±0.98**
Chernozem	2.63±0.14
Chestnut soil	13.63±1.15
Coastal sand soil	7.57±0.23
Dark brown soil	5.14±0.20
Light brown calcium soil	13.90±1.09
Light grey calcium soil	9.22±1.24
Meadow sand soil	5.62±1.01
Meadow soil	**19.78±1.07**
Sierozem	**0.90±0.03**

Comparison of mean soil organic carbon density (SOCD) at 0 – 100 cm soil depth in the present study with Ni, 2002.



AM, Alpine meadow; **ATST**, Arid-tropical shrub tussock scattered with trees; **TD**, Temperate desert; **TMS**, Temperate meadow-steppe; **TST**, Tropical shrub tussock; and **WTST**, Warm-temperate shrub tussock

- Across different grassland types, mean SOCD in 0-100 cm varied from 3.99 ± 0.27 kg m^{-2} for temperate desert (TD) to 15.15 ± 0.98 kg m^{-2} for alpine meadow (AM).
- SOCD was increased with decreasing mean annual temperature (MAT) and increased by increasing mean annual precipitation (MAP).
- Among soil types, meadow soils had highest SOCD with 19.78 ± 2.91 kg m^{-2} while, sierozem soils had lowest with 0.90 ± 0.02 kg m^{-2}.
- Climate and topographical factors explained about 27.61 % of the total variations in SOCD.

Our result implies that climatic factors along with soil types and topographical factors control SOC storage along depths in the grassland soil.

Types	Location	Soil depth / cm	SOCD / kg m^{-2}	Reference	Year
Grasslands	Global	100	10.80	Post et al.	1982
Grasslands	Global	100	14.31	Whittaker et al.	1975
TD	Global	100	6.20	Zinke et al.	1984
Hay meadow	Switzerland	100	6.11	Leifeld & Fuhrer	2009
Grasslands	China	100	13.20	Ni	2002
TST	China	100	14.00	Ni	2002
TMS	China	100	11.20	Ni	2002
TD	China	100	6.20	Ni	2002
AM	China	100	18.20	Ni	2002
WTST	China	100	13.00	Ni	2002
Tropical dry shrub-tussock with savanna	China	100	7.30	Ni	2002
Grasslands	China	100	8.50	Yang et al.	2010
Second soil survey	China	100	15.10	Xie et al.	2007
Grasslands	Loess Plateau, China	100	2.58	Li et al.	2013
Grasslands	Qinghai–Tibet Plateau, China	100	14.87	Liu et al.	2017
Grasslands	Qinghai–Tibet Plateau, China	100	7.96	Ma et al.	2016
Grasslands	Tibetan Plateau	100	8.40	Fan et al.	2008
Meadow	Qinghai–Tibet Plateau	100	11.63	Ma et al.	2016
Desert	Qinghai–Tibet Plateau	100	5.62	Ma et al.	2016
Steppe	Qinghai–Tibet Plateau	100	6.50	Ma et al.	2016
Shrub-tussock	Qinghai–Tibet Plateau	100	7.29	Ma et al.	2016
AM	Qinghai, China	50	53.13	Wang et al.	2002
AM	Tibet, China	50	29.05	Wang et al.	2002
AM	Qinghai, China	100	25.91	Liu et al.	2016
Desert steppe	Inner Mongolia, China	100	3.74	Yang et al.	2010
Typical steppe	Inner Mongolia, China	100	6.36	Yang et al.	2010
Meadow steppe	Inner Mongolia, China	100	12.69	Yang et al.	2010
Desert steppe	Xinjiang, China	100	4.29	Yang et al.	2010
Typical steppe	Xinjiang, China	100	8.08	Yang et al.	2010
Meadow steppe	Xinjiang, China	100	13.4	Yang et al.	2010
Mountain meadow	Xinjiang, China	100	20.13	Yang et al.	2010
AM	Yunnan province, China	100	15.15	Present study	Present study
ATST	Yunnan province, China	100	9.05	Present study	Present study
TD	Yunnan province, China	100	3.99	Present study	Present study
TMS	Yunnan province, China	100	13.49	Present study	Present study
TST	Yunnan province, China	100	10.66	Present study	Present study
WTST	Yunnan province, China	100	8.18	Present study	Present study

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