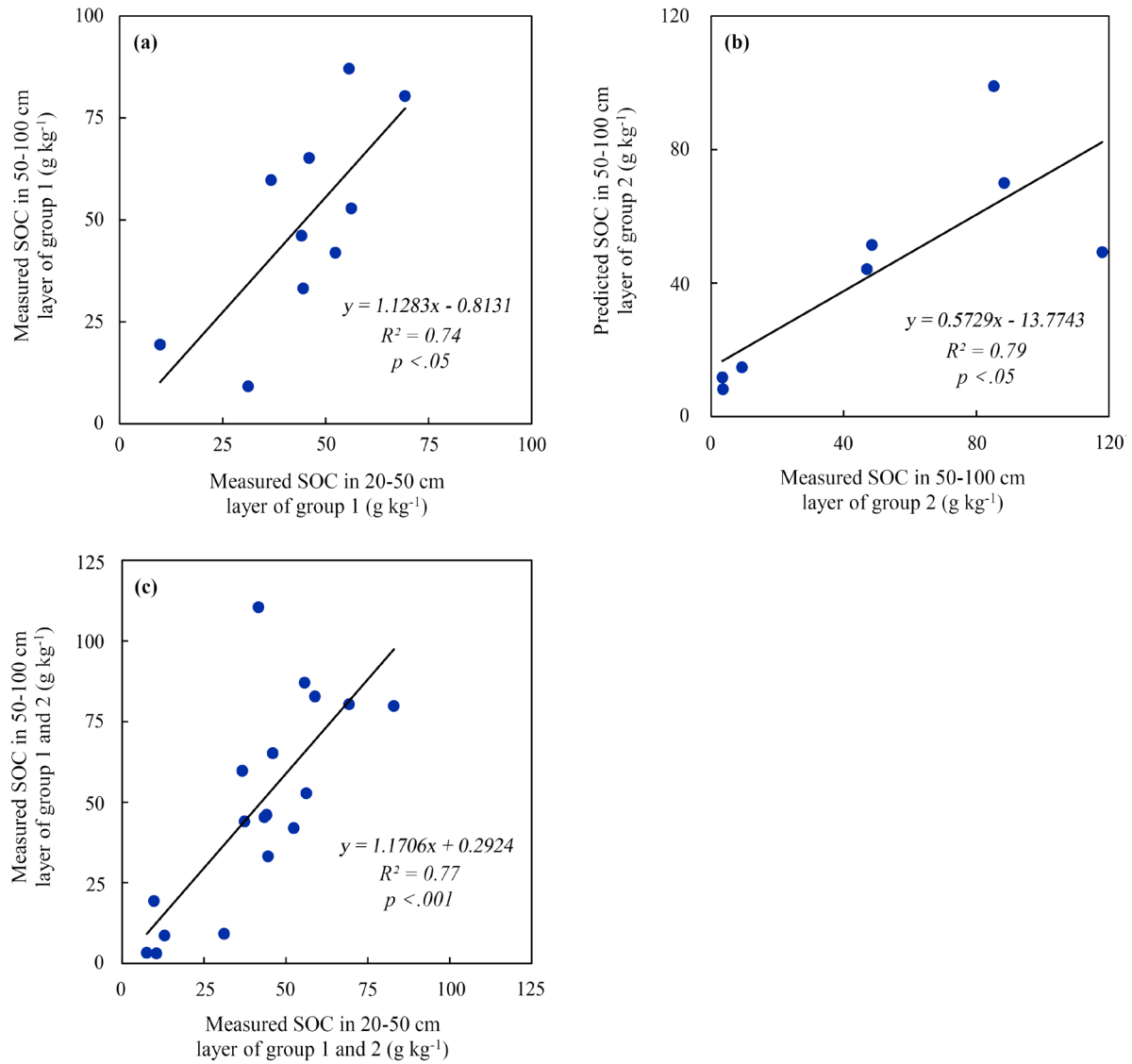
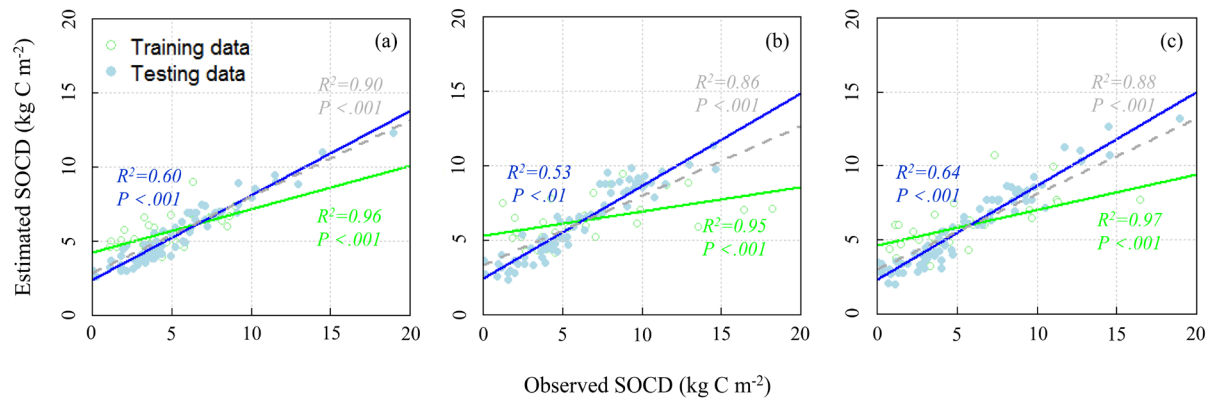


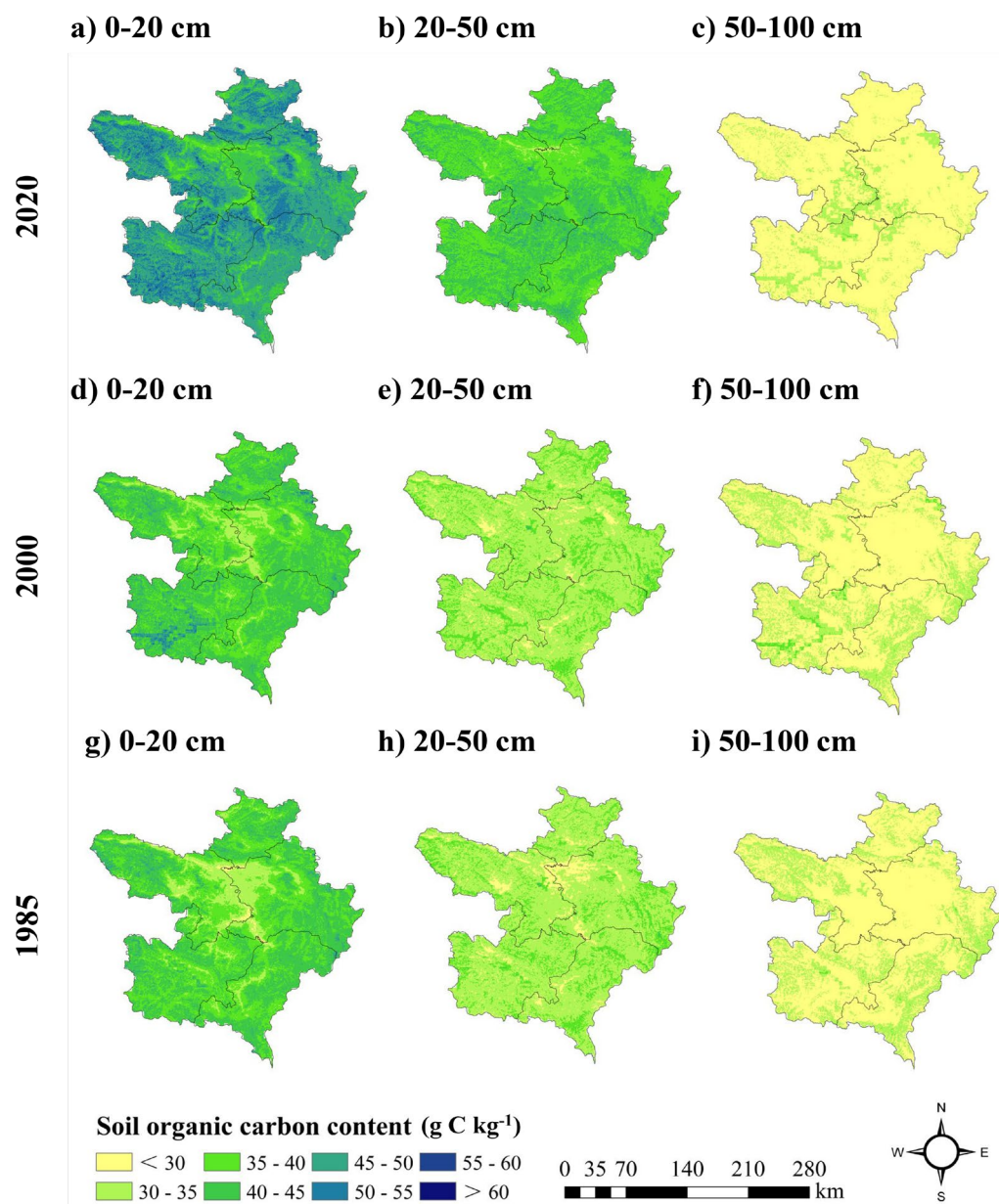
**Figure S1.** Relationships between measured SOC content in 0-20 cm layer and measured SOC content in 20-50 cm layer of group 1 (a), between measured SOC content in 20-50 cm layer and predicted SOC content in 20-50 cm layer of group 2 (b), between measured SOC content in 0-20 cm layer and measured SOC content in 20-50 cm layer of group 1 and 2 (c).



**Figure S2.** Relationships between measured SOC content in 20-50 cm layer and measured SOC content in 50-100 cm layer of group 1 (a), between measured SOC content in 50-100 cm layer and predicted SOC content in 50-100 cm layer of group 2 (b), between measured SOC content in 20-50 cm layer and measured SOC content in 50-100 cm layer of group 1 and 2 (c).



**Figure S3.** Comparison between estimated and observed SOC at the training and testing phases in the three soil layers. (a) , (b) and (c) are samples in the 0-20 cm, 20-50 cm and 50-100 cm soil layers. The blue line shows the performance of the model in the training samples and the lightgreen one indicates that in the testing samples. The grey dashed line shows the prediction accuracy of the model compared to all measurements, including training and testing samples.  $R^2$ , coefficient of determination.

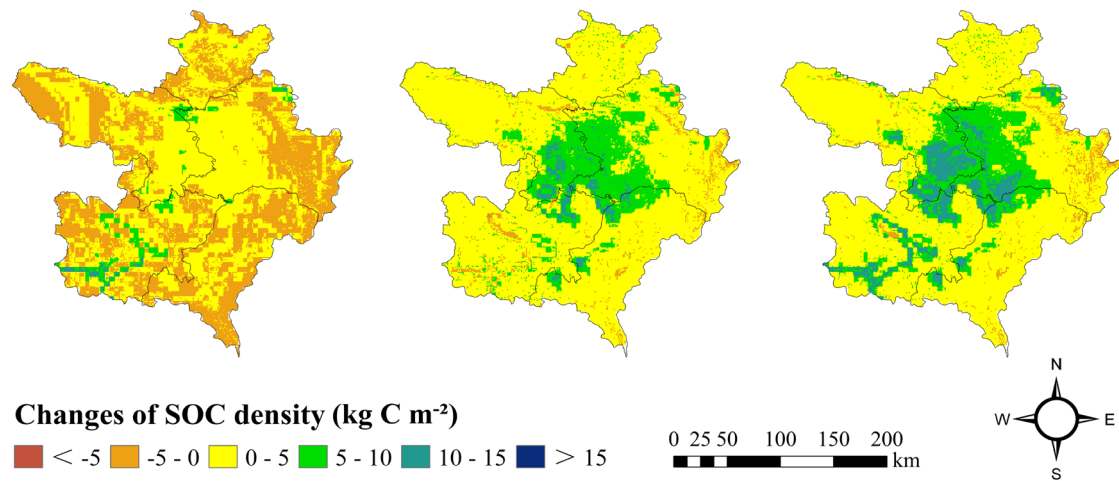


**Figure S4.** Spatial distribution of SOC content in each soil layer of Zoige wetland during 1985-2020.

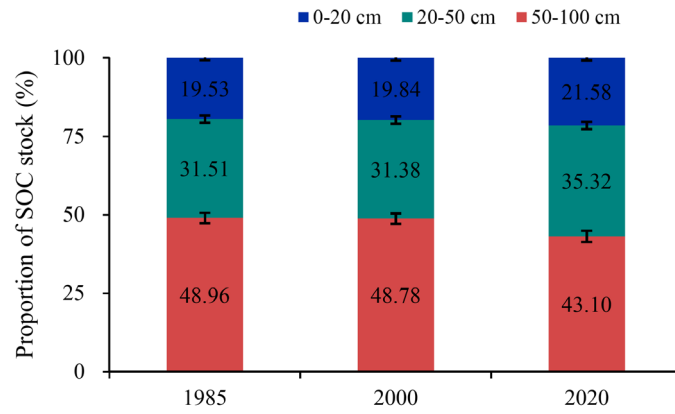
a) Between 2000 and 1985

b) Between 2020 and 2000

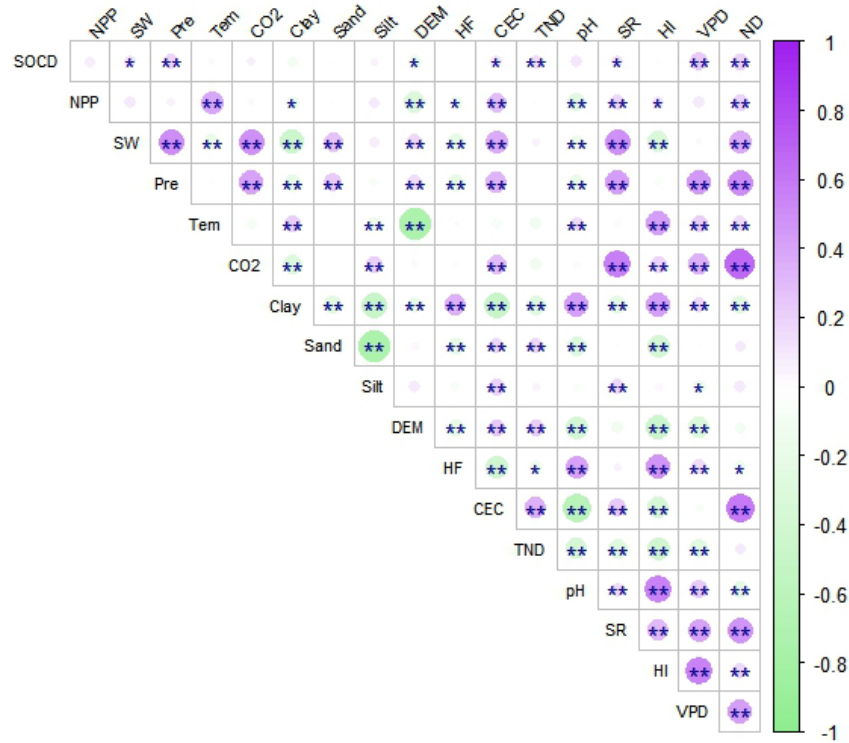
c) Between 2020 and 1985



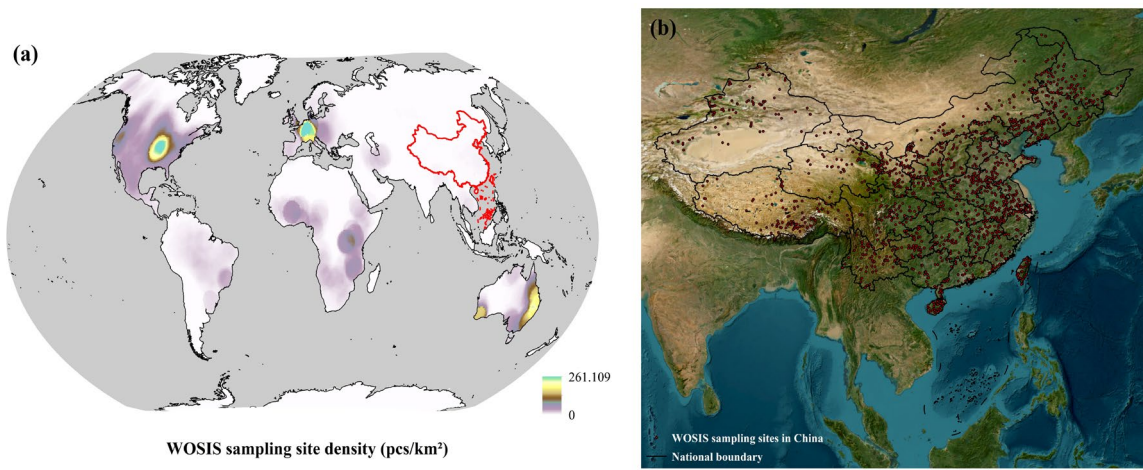
**Figure S5.** Spatial distribution of SOC density changes across the Zoige wetland area during 1985-2020.



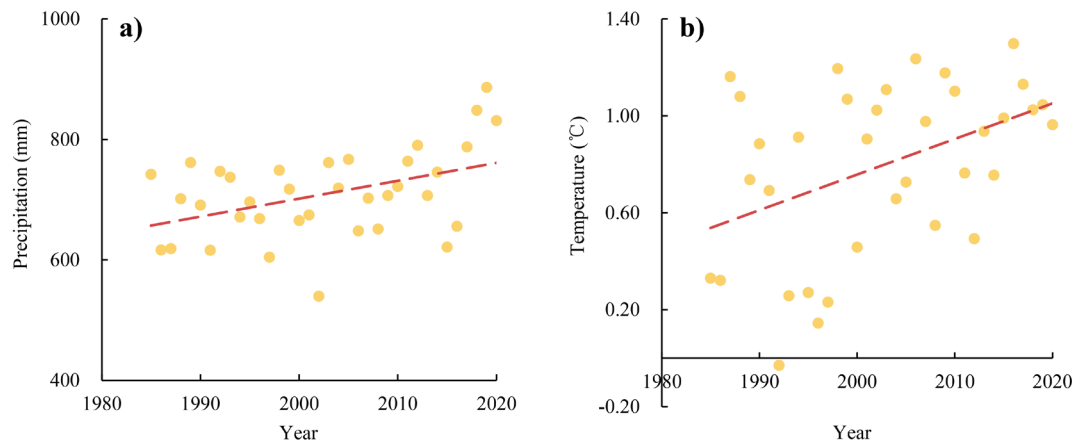
**Figure S6.** Distribution of soil organic carbon stocks in different soil layers in Zoige wetland during 1985-2020. The values in the figure are the mean values of the percentage of soil organic carbon allocation for the whole region, and the error line represents the standard deviation.



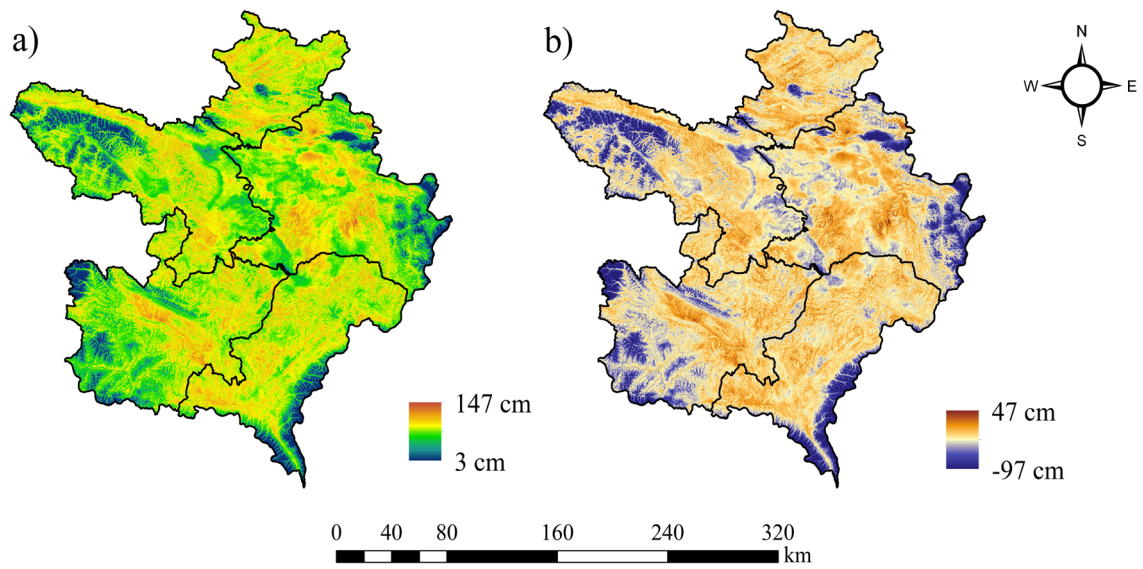
**Figure S7.** Pearson correlations between control variables and SOC density in Zoige wetland. Abbreviations: SOCD, soil organic carbon density; NPP, net primary productivity; SW, soil water; Pre, precipitation; Tem, temperature; CO<sub>2</sub>, CO<sub>2</sub> fertilization; HF, Human footprint; TND, total nitrogen density; SR, solar radiation; HI, humidity index; VPD, vapor pressure deficit. \* represents  $P < 0.05$ , \*\* represents  $P < 0.01$ .



**Figure S8.** Point density analysis of WOSIS global sampling points (a) and the distribution of WOSIS sampling points in China (b).



**Figure S9.** Annual precipitation (a) and average annual temperature (b) of the Zoige wetland from 1985 to 2020. The red dashed line is the trend line of the scattered points.



**Figure S10.** Soil layer thickness (a) and difference with 1m deep soil (b) in Zoige wetland. The brown area in (b) represents the soil layer thickness greater than 1m, and the purple area represents the soil layer thickness less than 1m.

**Table S1.** Comparison of GSCC soil types appearing in the manuscript with ST classifications.

GSCC classification	ST classification
brown earths	Alfisols
dark-brown earths	Alfisols
cinnamon soils	Alfisols
gray-cinnamon soils	Alfisols
chernozems	Mollisols
skeletal soils	Entisols
meadow soils	Inceptisols
mountain meadow soils	Inceptisols
bog soils	Histosols
peat soils	Histosols
felty soils	Inceptisols
dark felty soils	Inceptisols
frigid frozen soils	Entisols

**Table S2.** Variables used in the modelling of changes in soil carbon.

Variable	Features	Unit	Resolutions	Resources
Soil properties	Clay content	%	1:1 million	RESDC
	Silt content	%		
	Sand content	%		
	pH	-	90 m	NESSDC
	CEC	cmol(+)/kg		
	TN density	kg/m <sup>2</sup>		
Climate variables	Temperature	°C	1 km	Peng et al. (2019)
	Precipitation	mm		
	Humidity index (P/PET)	-		
	Soil water	%	4 km	TerraClimate
	Vapor pressure deficit	kPa		
	Solar radiation	W/m <sup>2</sup>		
Environment variables	DEM	m	30 m	GDEMv3
	Net primary productivity	g/m <sup>2</sup> /day	500 m	MOD17A2H
	CO <sub>2</sub> fertilization	ppmv	1.9° × 3.75°	CAMS-GLOB GHG
	Nitrogen deposition (NH <sub>x</sub> and NO <sub>y</sub> )	g/m <sup>2</sup> /yr	0.5°	NACP
Human factors	Human footprint	-	1 km	Mu et al., (2022)

**Table S3.** Descriptive statistics of SOCD and other Variables in our dataset.

Variable	Unit	Max	Min	Mean	Median	SD	CV
SOCD	kg C m <sup>-2</sup>	171.0	1.9	33.8	26.5	31.0	30.6
Clay	%	29.0	8.0	21.2	20.0	4.3	20.5
Silt	%	49.0	12.0	32.8	30.0	6.2	18.7
Sand	%	80.0	29.0	46.0	45.0	5.5	12.0
Tem	°C	7.9	0.1	2.6	2.4	1.0	37.2
Pre	mm	910.0	529.4	692.1	694.5	72.5	10.5
HI	-	704.6	470.7	620.5	631.4	41.8	6.7
SW	%	98.5	50.4	75.8	74.9	11.4	15.0
VPD	kPa	6.8	3.5	5.1	5.1	0.6	12.6
SR	W/m <sup>2</sup>	1679.7	144.5	340.2	161.6	492.6	144.8
DEM	m	3996.0	2898.0	3480.4	3456.0	132.2	3.8
NPP	g/m <sup>2</sup> /day	550.5	186.9	376.0	377.4	38.4	10.2
CO <sub>2</sub>	ppmv	4.4	3.6	4.1	4.2	0.2	4.8
ND	g/m <sup>2</sup> /yr	1562.9	773.8	1141.3	1187.1	219.2	19.2
HF	-	30.2	2.7	12.9	13.4	5.3	41.4

SD, standard deviation; CV, coefficient of variation; SOCD, soil organic carbon density.

**Table S4.** Soil organic carbon density (kg C m<sup>-2</sup>) of different soil types in Zoige wetland.

Soil type	2020	2000	1985
Brown earths	53.99±4.06	48.61±3.53	47.88±1.70
Dark-brown earths	50.23±3.40	47.89±3.34	46.63±1.66
Cinnamon soils	53.18±4.40	50.26±4.29	48.97±1.76
Grey-cinnamon soils	54.34±4.53	52.49±5.67	47.62±2.32
Chernozems	49.28±1.69	46.30±1.38	46.09±1.44
Skeletol soils	47.70±0.45	46.67±0.76	47.71±1.12
Meadow soils	51.48±3.93	47.54±3.04	46.42±2.33
Mountain meadow soils	47.74±0.90	46.21±1.33	46.51±1.39
Bog soils	50.99±3.81	45.94±2.75	45.15±1.86
Peat soils	51.89±3.90	46.42±2.11	45.49±1.41
Felty soils	48.54±1.01	45.54±1.04	45.72±1.02
Dark felty soils	48.74±2.78	45.14±2.34	44.84±1.58
Frigid frozen soils	49.60±0.76	47.03±1.01	47.10±0.96

**Table S5.** Soil organic carbon density (kg C m<sup>-2</sup>) in each layer of different soil types in Zoige wetlands.

Soil type	2020				2000				1985			
	0-20 cm	20-50 cm	50-100 cm	0-20 cm	20-50 cm	50-100 cm	0-20 cm	20-50 cm	50-100 cm	0-20 cm	20-50 cm	50-100 cm
Brown earths	10.99	18.20	21.47	9.87	15.57	23.17	9.61	15.53	22.74			
Dark-brown earths	11.01	17.78	21.44	9.69	15.14	23.06	9.29	14.86	22.47			
Cinnamon soils	11.45	18.92	22.81	10.06	16.23	23.97	9.61	15.96	23.39			
Grey-cinnamon soils	11.76	18.98	23.50	10.67	16.41	25.41	9.42	15.39	22.81			
Chernozems	10.77	17.46	21.05	9.04	14.57	22.73	8.76	14.39	22.95			
Skeletal soils	10.45	17.25	20.00	9.17	14.81	22.69	9.60	15.46	22.65			
Meadow soils	10.77	17.81	23.00	9.13	15.00	23.40	8.66	14.71	23.06			
Mountain meadow soils	10.63	16.95	20.16	9.20	14.09	22.92	9.10	14.00	23.40			
Bog soils	11.12	18.08	21.80	9.31	14.86	21.77	9.00	14.60	21.55			
Peat soils	11.26	18.40	22.22	9.43	15.16	21.83	9.07	14.90	21.52			
Felty soils	10.12	16.77	21.65	8.64	13.92	22.98	8.63	13.97	23.12			
Dark felty soils	10.65	17.37	20.72	9.13	14.10	22.00	8.83	14.08	21.93			
Frigid frozen soils	10.72	17.37	21.54	9.33	14.39	23.31	9.17	14.55	23.39			

**Table S6.** Proportion of soil organic carbon allocated to different soil types during 1985 to 2020.

Soil type	2020				2000				1985			
	0-20 cm	20-50 cm	50-100 cm	0-20 cm	20-50 cm	50-100 cm	0-20 cm	20-50 cm	50-100 cm	0-20 cm	20-50 cm	50-100 cm
Brown earths	21.69%±0.47%	35.93%±0.99%	42.38%±1.17%	20.30%±0.66%	32.03%±0.88%	47.67%±1.09%	20.07%±0.52%	32.43%±0.70%	47.50%±1.04%			
Dark-brown earths	21.91%±0.52%	35.40%±1.11%	42.69%±1.40%	20.23%±0.64%	31.62%±1.11%	48.15%±1.24%	19.93%±0.47%	31.88%±0.88%	48.19%±1.19%			
Cinnamon soils	21.53%±0.61%	35.58%±0.96%	42.89%±1.29%	20.01%±0.57%	32.30%±0.79%	47.69%±0.99%	19.63%±0.59%	32.60%±0.72%	47.77%±0.94%			
Grey-cinnamon soils	21.68%±0.41%	35.00%±1.21%	43.32%±1.35%	20.32%±0.78%	31.27%±1.57%	48.41%±1.39%	19.78%±0.63%	32.32%±1.00%	47.90%±1.29%			
Chernozems	21.85%±0.48%	35.44%±0.45%	42.71%±0.85%	19.50%±0.64%	31.45%±0.72%	49.05%±0.96%	19.00%±0.54%	31.21%±0.83%	49.78%±1.04%			
Skeletal soils	21.90%±0.28%	36.17%±0.36%	41.93%±0.39%	19.64%±0.24%	31.74%±0.28%	48.62%±0.25%	20.11%±0.20%	32.41%±0.36%	47.48%±0.49%			
Meadow soils	20.72%±0.86%	34.59%±1.08%	44.69%±1.74%	19.20%±0.89%	31.56%±0.89%	49.23%±1.27%	18.66%±0.80%	31.68%±0.89%	49.67%±1.30%			
Mountain meadow soils	22.27%±0.58%	35.50%±0.93%	42.23%±1.40%	19.90%±0.37%	30.49%±0.64%	49.61%±0.87%	19.57%±0.27%	30.11%±0.31%	50.32%±0.51%			
Bog soils	21.80%±0.60%	35.45%±1.09%	42.75%±1.45%	20.26%±0.63%	32.35%±0.95%	47.39%±1.21%	19.93%±0.55%	32.33%±0.95%	47.73%±1.17%			
Peat soils	21.70%±0.59%	35.47%±0.95%	42.83%±1.36%	20.31%±0.61%	32.67%±1.01%	47.02%±1.29%	19.94%±0.50%	32.76%±0.96%	47.30%±1.18%			
Felty soils	20.85%±0.55%	34.55%±0.90%	44.60%±1.29%	18.97%±0.52%	30.57%±0.73%	50.46%±1.09%	18.88%±0.49%	30.56%±0.70%	50.56%±1.02%			
Dark felty soils	21.85%±0.76%	35.64%±1.08%	42.51%±1.65%	20.23%±0.84%	31.23%±1.10%	48.74%±1.59%	19.70%±0.69%	31.40%±1.14%	48.90%±1.61%			
Frigid frozen soils	21.62%±0.77%	34.96%±1.20%	43.42%±1.72%	19.84%±0.87%	30.60%±1.03%	49.56%±1.32%	19.47%±0.63%	30.88%±0.95%	49.65%±1.36%			

**Table S7.** Synthesis of soil organic carbon density in the three soil layers in Zoige wetland from this study and previous investigations.

Soil layer (cm)	Period	Study area	SOC density (kg C m <sup>-2</sup> )	References
0-20	2020	Zoige alpine wetland	10.69	Our study
0-20	2000		9.11	
0-20	1985		8.86	
0-20	-		10.15	
0-20	-		12.40	
0-20	2014		6.97	
0-10	2020		25.92	
20-50	2020	Zoige alpine wetland	17.49	Our study
20-50	2000		14.40	
20-50	1985		14.31	
20-50	-		13.38	
20-50	-		11.96	
20-50	2014		7.79	
50-100	2020	Zoige alpine wetland	21.39	Our study
50-100	1985		22.23	
50-100	2000		22.39	
50-100	-		17.04	
50-100	-		14.87	
50-100	2014		9.07	
0-100	1990		54.01	
0-40	2015~2019	Coastal wetlands of China	2.24~12.61	Xia et al., 2022
40-100	2015~2019		2.18~18.91	Xia et al., 2022

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- Peng, S., Ding, Y., Li, Z., 2019. High-spatial-resolution monthly temperature and precipitation dataset for China for 1901-2017. *Earth System Science Data Discussions* 1–23. <https://doi.org/10.5194/essd-2019-83>