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Fig. S1 Zonal distribution of (a) 0-30 cm and (b) 0-100 cm SOC density (t ha<sup>-1</sup>).



Fig. S2 Global SOC density (0-100 cm) varied by datasets. (a-d) SOC density (t ha<sup>-1</sup>) based on HWSD, WISE30sec, GSDE, and SoilGrids250m, respectively.



Fig. S3 Differences of 0-30cm SOC density (t ha<sup>-1</sup>) between datasets.



Fig. S4 Spatial differences of 0-100 cm SOC density (t ha<sup>-1</sup>) between individual dataset and the mean of five datasets. Left shows the absolute difference of (a)HWSD, (b)WISE30sec, (c)GSDE, (d)SoilGrids250m, (e)GSOCmap and (f)UM2021. Right shows the relative difference of (g)HWSD, (h)WISE30sec, (i)GSDE, (j)SoilGrids250m, (k)GSOCmap and (l)UM2021.



Fig. S5 Spatial differences of 0-30cm SOC density (t ha<sup>-1</sup>) between individual dataset and the mean of five datasets in the northern circumpolar permafrost region. Left shows the absolute difference of (a)HWSD, (b)WISE30sec, (c)GSDE, (d)SoilGrids250m, (e)GSOCmap and (f)UM2021. Right shows the relative difference of (g)HWSD, (h)WISE30sec, (i)GSDE, (j)SoilGrids250m, (k)GSOCmap and (l)UM2021.



Fig. S6 The coefficient of variations (CV, %) estimated for (a) 0-30 cm and (b) 0-100 cm SOC density (t ha<sup>-1</sup>) using five datasets in the northern circumpolar permafrost region.



Fig. S7 Spatial distribution of 0-100 cm SOC density (t ha<sup>-1</sup>) in the northern circumpolar permafrost region from (a)HWSD, (b)WISE30sec, (c)GSDE, (d)SoilGrids250m and (e)UM2021.



Fig. S8 Spatial differences of 0-100cm SOC density (t ha<sup>-1</sup>) between individual dataset and the mean of five datasets in the northern circumpolar permafrost region. Left shows the absolute difference of (a)HWSD, (b)WISE30sec, (c)GSDE, (d)SoilGrids250m and (e)UM2021. Right shows the relative difference of (f)HWSD, (g)WISE30sec, (h)GSDE, (i)SoilGrids250m and (j)UM2021.



Fig. S9 The coefficient of variations (CV, %) estimated for (a) 0-30cm and (b) 0-100 cm SOC density (t ha<sup>-1</sup>) using five datasets in the Tibetan permafrost region.



Fig. S10 Spatial differences of 0-30cm SOC density (t ha<sup>-1</sup>) between individual dataset and the mean of five datasets in the Tibetan permafrost region. Left shows the absolute difference of (a)HWSD, (b)WISE30sec, (c)GSDE, (d)SoilGrids250m, (e)GSOCmap and (f)UM2021. Right shows the relative difference of (g)HWSD, (h)WISE30sec, (i)GSDE, (j)SoilGrids250m, (k)GSOCmap and (l)UM2021.



Fig. S11 Spatial distribution of 0-100 cm SOC density (t ha<sup>-1</sup>) in the Tibetan permafrost region from (a)HWSD, (b)WISE30sec, (c)GSDE, (d)SoilGrids250m and (e)UM2021



Fig. S12 Spatial differences of 0-100cm SOC density (t ha<sup>-1</sup>) between individual dataset and the mean of five datasets in the Tibetan permafrost region. Left shows the absolute difference of (a)HWSD, (b)WISE30sec, (c)GSDE, (d)SoilGrids250m and (e)UM2021. Right shows the relative difference of (f)HWSD, (g)WISE30sec, (h)GSDE, (i)SoilGrids250m and (j)UM2021.



Fig. S13 Soil profiles from the WoSIS database by biome. The size of the rectangle represents the size of the area of each biome on land.



Fig. S14 Coverage of original data sources for (a)HWSD, (b)WISE30sec, (c)GSDE, (d)SoilGrids250m, and (e)GSOCmap. ESDB: the European Soil Database; China: the 1:100 million scale Soil Map of China and the soil database of China for land surface modeling; SOTWIS: SOTER and WISE-derived databases; DSMW: the Digital Soil Map of the World; ISCN and Arctic Region: International Soil Carbon Network and soil profile data from the northern circumpolar region; GSM: the U.S. General Soil Map; SLC: the Soil Landscapes of Canada; ASRIS: the Australian Soil Resource Information System polygon attributed surface; WoSIS: the World Soil Information Service soil profile database.

Soil property	Dataset						Dataset				
	HWSD	GSDE	WISE30sec	SoilGrids	GSOCmap	Soil property	HWSD	GSDE	WISE30sec	SoilGrids	GSOCmap
Reference soil depth	4	~				Base saturation	~		~		
Depth to bedrock	~			~		pH (H <sub>2</sub> O)	~	$\checkmark$	~	~	
Soil phase	~	~				pH (KCL)		~		~	
Available water capacity	~	~	~	~		pH (CaCl <sub>2</sub> )		$\checkmark$			
Saturated water content				~		Calcium carbonate	~	~	~		
Drainage class	~	~	$\checkmark$			Gypsum	~	~	~		
Soil water regime	~	~				Electrical conductivity	~	~			
Impermeable layer	~	~				ESP <sup>a</sup>	~	~	~		
Obstacles to roots	~	~				TEB <sup>b</sup>	~		~		
Additional property	~	~				Exchangeable Ca		~			
Texture class	~	~	~	~		Exchangeable Mg		~			
Organic carbon	~	~	~	~	$\checkmark$	Exchangeable K		~			
Bulk density	~	~	~	~		Exchangeable Al		~			
Sand	~	~	~	~		Exchangeable acidity		~			
silt	~	~	$\checkmark$	$\checkmark$		Sodic soil grade				$\checkmark$	
clay	~	~	~	~		Acidic subsoil grade				~	
Gravel	~	~	~	~		Aluminum saturation			~		
CEC (soil)	~	~	~	$\checkmark$		Volumetric water content (-10kPa)		~	~		
CEC (clay)	~		~			Volumetric water content (-33kPa)		~	~		
Effective CEC			~			Volumetric water content (-1500kPa)		~	$\checkmark$		
C/N ratio			$\checkmark$			Water-soluble phosphorus		$\checkmark$			
Total carbon		~				The amount of phosphorus (by Bray method)		$\checkmark$			
Total nitrogen		$\checkmark$	$\checkmark$			The amount of phosphorus (by Olsen method)		$\checkmark$			
Total sulfur		~				The amount of phosphorus (by New Zealand method)		~			
Total phosphorous		4				The amount of phosphorus (by Mechlich method)		4			
Total potassium		$\checkmark$									

## Table S1 Attribute table of global soil datasets

<sup>a</sup> Exchangeable sodium percentage. <sup>b</sup> Total exchangeable base.

Name (version)	Data access
HWSD	http://webarchive.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/HWSD_Data.html?sb=4
(Version 1.21)	(last access: 5 July 2022)
WISE30sec	https://data.isric.org/geonetwork/srv/eng/catalog.search#/metadata/dc7b283a-8f19-45e1-aaed-e9bd515119bc
	(last access: 5 July 2022)
GSDE	http://globalchange.bnu.edu.cn/research/soilw (last access: 5 July 2022)
SoilGrids250m	https://files.isrie.arg/seilerids/formar/2017.02.10/dets/(last.assass) 5 July 2022)
(Version 1.0)	https://mes.isite.org/songrids/former/2017-05-10/data/ (last access. 5 July 2022)
GSOCmap	http://54 220 242 110/GSOC map/ (last access: 5 July 2022)
(Version 1.5)	http://54.229.242.119/030Chiap/ (last access: 5 July 2022)
UM2021	https://datadryad.org/stash/dataset/doi:10.7941/D1GD1H (last access: 5 July 2022)
WoSIS	https://data.isric.org/geonetwork/srv/eng/catalog.search#/metadata/ca880bd4-cff8-11e9-8046-0cc47adaa92c (last access: 5 July 2022)

## Table S2 Supplementary table for URLs of each dataset used in this study