SinoLC-1: the first 1-meter resolution national-scale land-cover map of China

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Note: This document only provides a brief introduction to the SinoLC-1 data, emphasizing the organization, download, and use guide of the data. We strongly suggest checking our paper which includes more detailed information about the data.

Paper link: https://essd.copernicus.org/preprints/essd-2023-87/

Introduction:

In China, the demand for a more precise perception of the national land surface has become most urgent given the pace of development and urbanization. Constructing a very-high-resolution (VHR) land-cover dataset for China with national coverage, however, is a non-trivial task and thus, an active area of research impeded by the challenges of image acquisition, manual annotation, and computational complexity. To fill this gap, the first 1-meter resolution national-scale land-cover map of China, SinoLC-1, was established using a low-cost deep learning-based framework and open-access data including global land-cover (GLC) products, open street map (OSM), and Google Earth imagery.

Based on large storage and computing servers, we took about 10 months to process the 73.25 TB dataset to obtain a final SinoLC-1 land-cover product covering the entire land surface of China, ~9,600,000 km^2. The SinoLC-1 product was validated using a visually interpreted validation set including 106,852 random samples and a statistical validation set collected from the third national land resource survey project (3rd NLRS)[1]. The validation results showed SinoLC-1 achieved an overall accuracy of 73.61% and a kappa coefficient of 0.6595. Furthermore, the statistical validation results collected from 31 provincial administrative regions, where three special administrative zones (Hongkong, Marco, and Taiwan) are not available in the 3rd NLRS project, indicated SinoLC-1 conformed to the official survey reports. In conclusion, as the first national 1-meter land-cover map for China, SinoLC-1 delivered accuracy and provided primal support for related research and applications throughout China. The SinoLC-1 data is freely accessible at https://doi.org/10.5281/zenodo.7707461 (Li et al., 2023).

[1] https://www.mnr.gov.cn/zt/td/dscqggtdc/

Reliable training labels were generated by combining three 10-meter GLC products and OSM data. These training labels and 1-meter resolution images derived from Google Earth were used to train the proposed framework, Low-to-high Framework (L2H-Frame). The proposed L2H-Frame is an efficient deep learning-based framework for national-scale VHR land-cover mapping, which is inspired by our previous work (Li et al., 2021). Based on a series of weaky- and self-supervised strategies, the L2H-Frame only takes open-access data sources (including VHR images and 10-meter resolution GLC products) as training data to produce the 1-m land-cover map of China, which allows the framework to maintain low capital expenditure cost in image acquisition and low labor cost in training label annotation.

Data organization:

The product is grouped by numerous city tiles in the GeoTIFF format, which are packaged in provincial administrative region folders and stored as ".zip" files. Each city tile is named "G_P_C.tif," where "G" explains the geographical region (south, central, east, north, northeast, northwest, and northeast of China) information, "P" explains the provincial administrative region information, and "C" explains the city name. For example, the 1-meter land-cover map for Wuhan City, Hubei Province is named "Central_Hubei_Wuhan.tif". Furthermore, each tile contains a land-cover label band ranging from 0 to 255, where the corresponding relationship between the value and the land-cover types of SinoLC-1 are shown in Table 1.

Since the Zenodo website[2] limits the storage size of a single version to **50 GB**, while the overall SinoLC-1 land-cover product has about **150 GB**, we stored the product into seven corresponding versions according to seven geographical regions of China, and the provincial administrative regions included in each geographical regions are shown in Table 2 and Figure 2 (a).

[2] https://help.zenodo.org/

Table 1. The classification system and legend of the SinoLC-1.

Land-cover type	Definition	Value	Color
Tree cover	Areas covered by trees generally have larger crowns and are higher than 5 meters. It can be sparse arbors or clustered forests which include evergreen forests, mixed forests, artificial forests, bamboo groves, etc.	2	(0, 100, 0)
Shrubland	Areas covered by clusters of shrubs with a height below 5 meters.	3	(255, 190, 35)
Grassland	Areas covered by low herbaceous plants. It generally includes natural grasslands with a fractional vegetation coverage greater than 5, rangeland with tree canopy density less than 0.3 or shrub canopy density less than 0.4, urban's vacant land dominated by grass, and other artificial grasslands.	4	(233, 255, 190)
Cropland	The arable land and human planted crops not at tree height including upland crops such as wheat, corn, potatoes, and cotton. and irrigated crops such as paddy filed, lotus root, and water spinach.	5	(255, 235, 175)
Building	Human-made structures and homogenous impervious surfaces including industrial, residential, commercial areas, and construction sites. It is generally located in urban and rural areas with high human activities.	6	(255, 170, 0)
Traffic route	Areas constructed according to certain technical standards and equipped with necessary transportation facilities, including railways, highways, urban/rural roads, and pipelines.	1	(255, 0, 0)
Barren and sparse vegetation	Areas covered by sparse vegetation or bare land covered by sand, gravel, or rocks, including mountains without dense vegetation and snow cover, deserts, grasslands degraded by drought, and wasteland in urban/rural areas with sparse or no vegetation.	7	(180, 180, 180)
Snow and ice	Areas covered by large-scale permanent snow or ice, including glaciers and permanent snowpack in mountain areas or high latitudes.	8	(240, 240, 240)
Water	Areas covered by water for a long period, including oceans, naturally formed water bodies such as lakes, rivers, and runoff, artificially formed water bodies such as reservoirs, canals, water conservancy facilities (with open water), ponds, and aquaculture farms.	9	(0, 100, 200)
Wetland	Areas with perennial or seasonal water accumulation and vegetation growth. It includes forest/shrub/grass swamps, peatlands, mudflat, mangroves, and coastal/inland tidal flats.	10	(0, 150, 160)
Moss and lichen	Surfaces or rocks attached by moss or tiny lichen plants.	12	(250, 230, 160)

Table 2. Data organization of the SinoLC-1 land-cover product.

Version (Geographical region)	Containing tile (Provincial region)	Version (Geographical region)	Containing tile (Provincial region)
South	Hainan	**Northeast**	Liaoning
	Guangxi		Jilin
	Guangdong		Heilongjiang
East	Fujian	**Northwest**	Shaanxi
	Anhui		Gansu
	Zhejiang		Xinjiang
	Shanghai		Ningxia
	Jiangsu		Qinghai
	Shandong	**Southwest**	Guizhou
	Jiangxi		Chongqing
	Taiwan		Xizang (Tibet)
Central	Hubei		Yunnan
	Hunan		Sichuan
	Henan		
North	Shanxi		
	Hebei		
	Beijing		
	Inner Mongolia		
	Tianjin		

Overview of SinoLC-1:

The produced SinoLC1 dataset is the first 1-meter resolution and currently the highest resolution land-cover product that covers all of China. Qualitative comparisons revealed the SinoLC-1 product with the highest spatial resolution yielded the most accurate land-cover edges, indicating the finest landscape details compared with five other widely used products. Moreover, with an additional "traffic route" land-cover type, the SinoLC-1 portrayed the details of the dense city and urban patterns more precisely. Figure 1 shows a demonstration of SinoLC-1 in Southern China. Figure 2 shows the geographical region borders and the results of O.A. in every Province. Figure 3 shows the overall SinoLC-1 land-cover product.

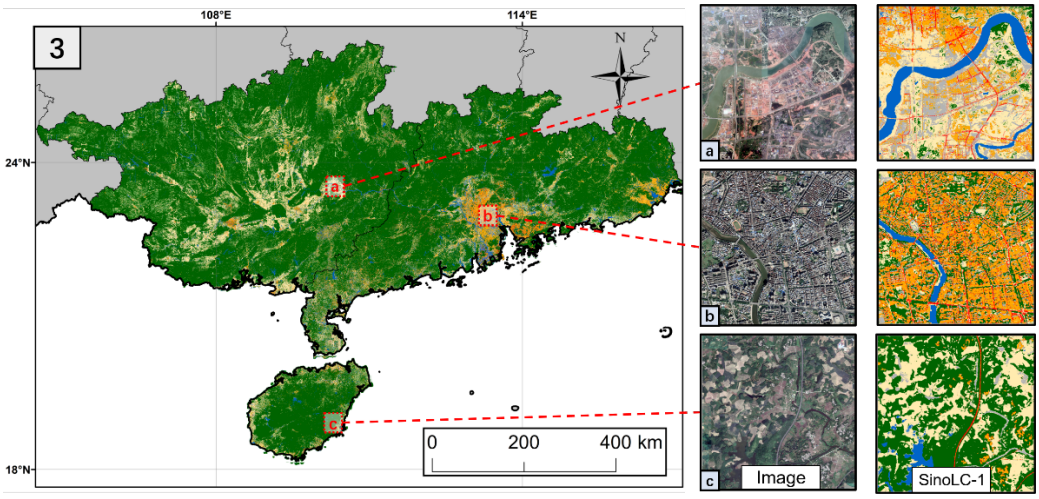
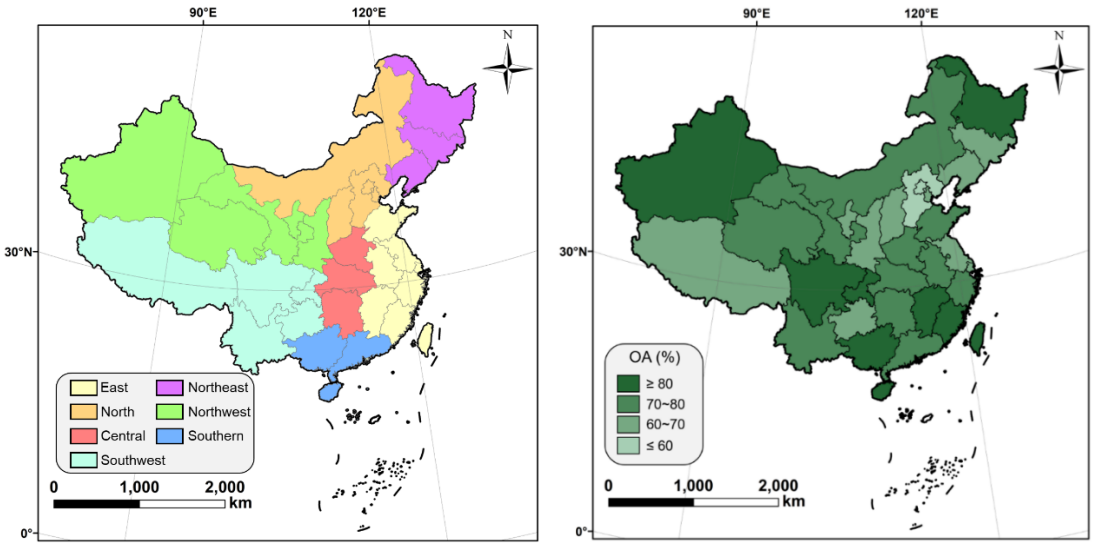


Figure 1. Demonstration of the sample areas of Guangxi, Guangdong, and Hainan.



(a) Seven geographical regions of China (b) Spatial distribution of O.A. for every province

Figure 2. Geographical region borders and the statistical results of O.A. all around China.

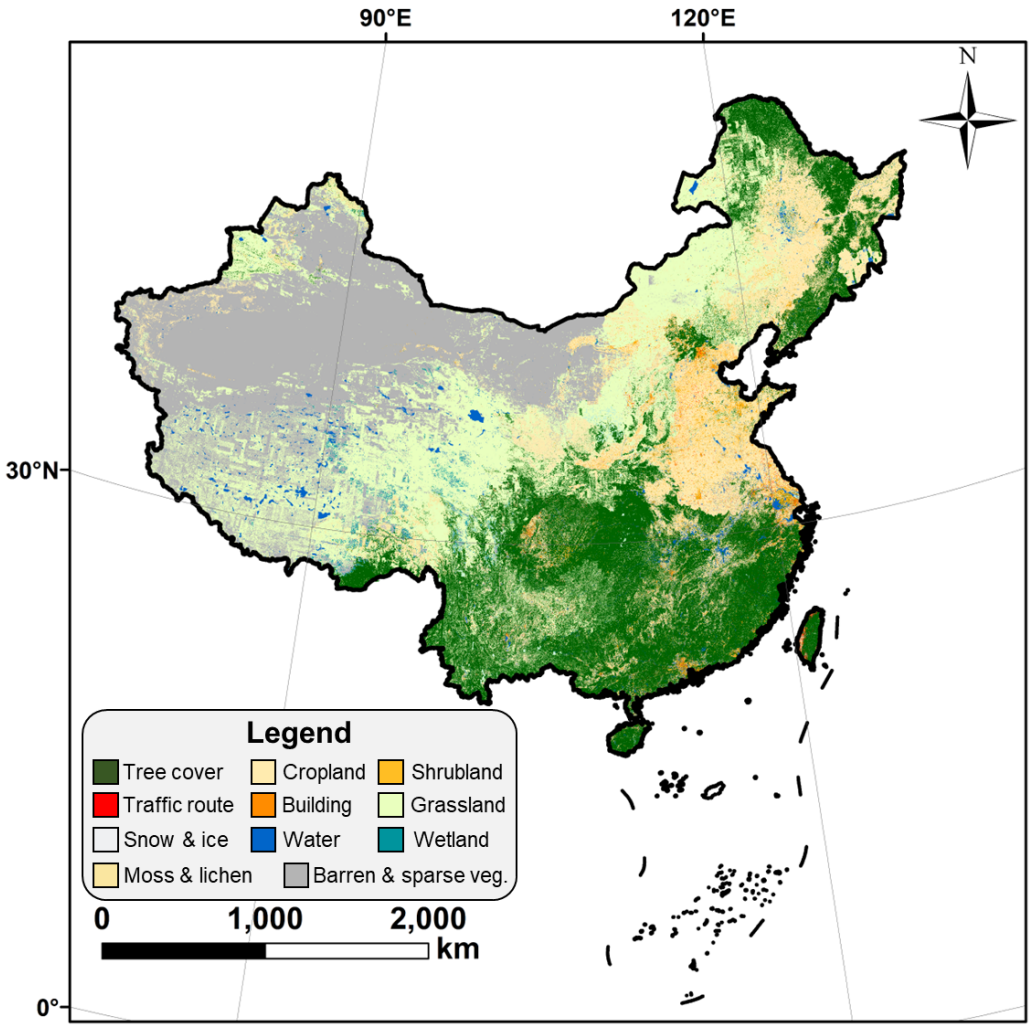


Figure 3. Demonstration of SinoLC-1: a 1-meter-resolution national-scale land-cover map of China.

Data download:

Figure 4 shows a simple way to download the SInoLC-1 data from the Zenodo website: https://doi.org/10.5281/zenodo.7707461. Firstly, users select the version of data, which represents the geographical regions (south, central, east, north, northeast, northwest, and northeast of China) on the right side of the web page. Secondly, users select the ".zip" files, which represent the provincial regions, to download. If there is not the city you require, try to find it in the updated version or send us an email.

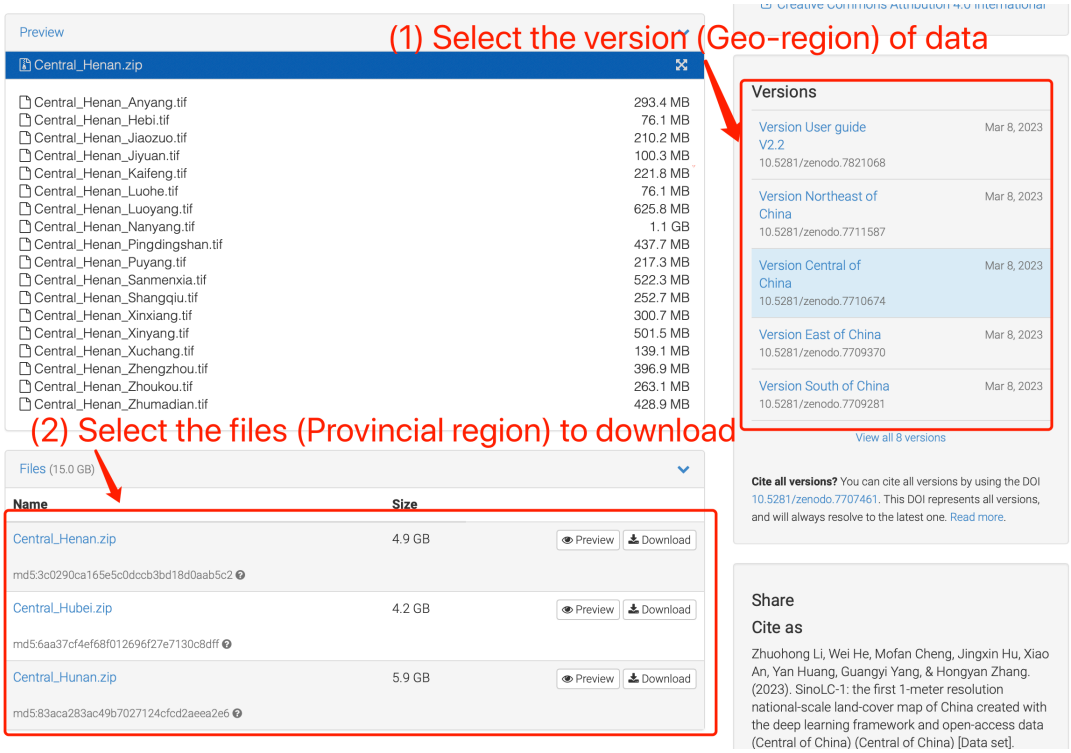


Figure 4. Demonstration of a simple example to download the SinoLC-1 data from the Zenodo website.

Data updating

The data is constantly updating, and we are collecting user feedback. if you have any data needs, questions, or technical issues, please contact us at ashelee@whu.edu.cn (Zhuohong Li), and we will reply carefully and provide assistance.

Updating on August 4, 2023: The tiff file of image capture time (Figure 5) and original tiles with the size of 6000 × 6000 pixels (Figure 6, including 1-m Google imagery and 1-m SinoLC-1 results) of Nanchang City, Jiangxi Province, Shanghai City, Hefei City, Anhui Province, Chengdu City, Sichuan Province have been updated.

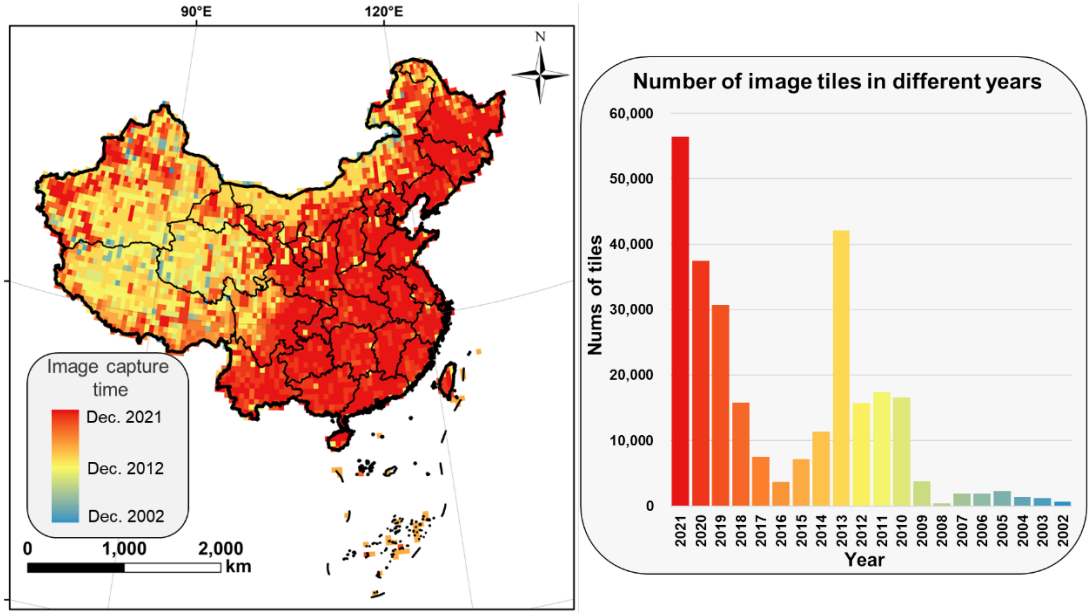


Figure 5. Demonstration of the image capture time and the number of image tiles in different years.

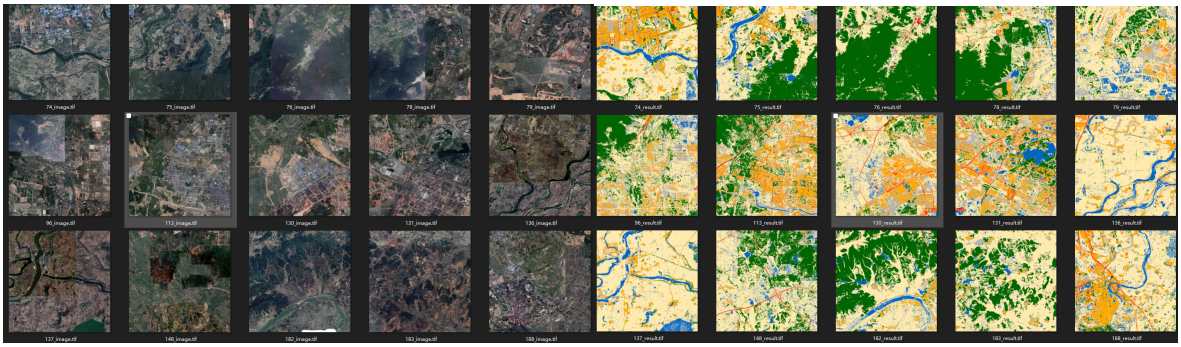


Figure 6. Demonstration of the original image and result batches.

Updating on June 30, 2023: The land-cover maps of Ganzi City, Sichuan province (Southwest), Jiuquan & Pingliang Cities, Gansu province (Northwest), and Zhuzhou City, Hunan Province (Central) have been updated.

References

Zhuohong Li, Wei He, Mofan Cheng, Jingxin Hu, Xiao An, Yan Huang, Guangyi Yang, & Hongyan Zhang.: SinoLC-1: the first 1-meter resolution national-scale land-cover map of China created with the deep learning framework and open-access data [Zenodo], https://doi.org/10.5281/zenodo.7707461 , 2023.

Zhuohong Li, Hongyan Zhang, Fangxiao Lu, Ruoyao Xue, Guangyi Yang, and Liangpei Zhang: Breaking the resolution barrier: A low-to-high network for large-scale high-resolution land-cover mapping using low-resolution labels, ISPRS Journal of Photogrammetry and Remote Sensing, 192 (2022): 244-267, https://doi.org/10.1016/j.isprsjprs.2022.08.008, 2022.