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The development of fine-resolution China Water Cover Map based on time series Sentinel imagery

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Abstract: Though the information on the distribution and changes of water cover types is essential to understand the relationship between human activities and natural processes, its timely and accurate acquisition and updating are difficult to be accomplished, especially at global or national scales. From water cover perspective, we firstly suggest a comprehensive water cover classification system in terms of water sources, water body shapes and water usage. We develop an automatic and operational classification method to produce an unprecedented China Water Cover Map (CWaC) with a spatial resolution of 10 meters, based on the time series Sentinel-1/2 images in the year 2020 on the Google Earth Engine. Validation shows that this dataset has an overall accuracy of 85% and kappa coefficient of 0.83. The CWaC is the first thematic mapping on water cover types for whole China, providing information on complete water cover types. Comparisons with other six water-related data products highlights the advantages the CWaC in acquiring high spatial and temporal resolution information on complete water cover types at large scale. We anticipate that this freely available data will provide evidence of state and change in wetlands, help to improve understanding human influence on hydrologic cycle, and inform water-management decision-making.

KEYWORDS: water cover types; shape feature; flooding frequency; Sentinel imagery; GEE

Introduction

Human has been altering the global hydrological cycle through farm irrigation, construction of dams, development of aquaculture, and rice planting etc. Study shows that 57 per cent of the Earth's seasonal surface water storage variability occurs in human-managed reservoirs (Cooley et al., 2021), and the artificial reservoirs could have impacts on global sea level (Chao et al., 2008).Though the knowledge of the spatial and temporal dynamics of global surface water had been greatly increased in the last few years (Han and Niu, 2020; Pekel et al., 2016). However, most researchers studied the dynamic change of water body solely, not providing the information on different water-cover types, such as rivers, lakes, reservoirs, ponds, and rice fields (Han and Niu, 2020; Li et al., 2020; Pekel et al., 2016). The knowledge of the long-term changes and trends of the complete water cover types especially in large scales is still surprisingly limited, which hinders our understanding the relationship between human activities and hydrologic cycles under the background of global changes.

Objectives

(1) to put forward to a water cover types classification system based on water sources, water body shapes and water usage;
(2) to produce an accurate and up-to-date fine-resolution water cover map of China using the time series Sentinel-1 (SAR images) and Sentinel-2 (optical images) images on the Google Earth Engine (GEE).

Methods

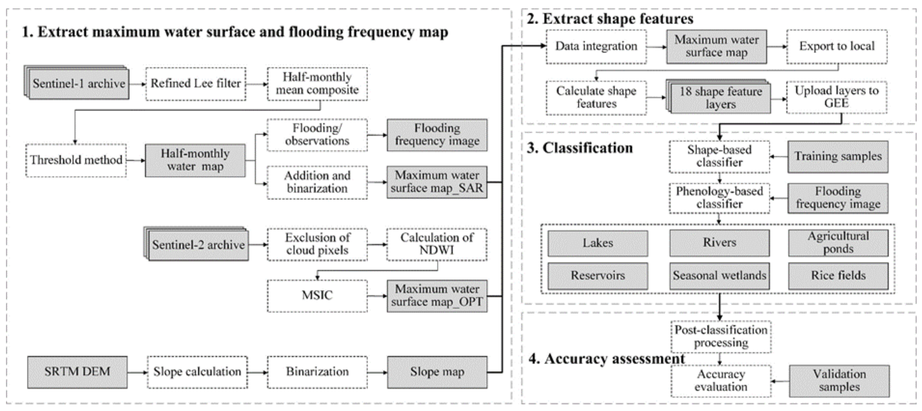

Figure 1. Flow scheme of this study

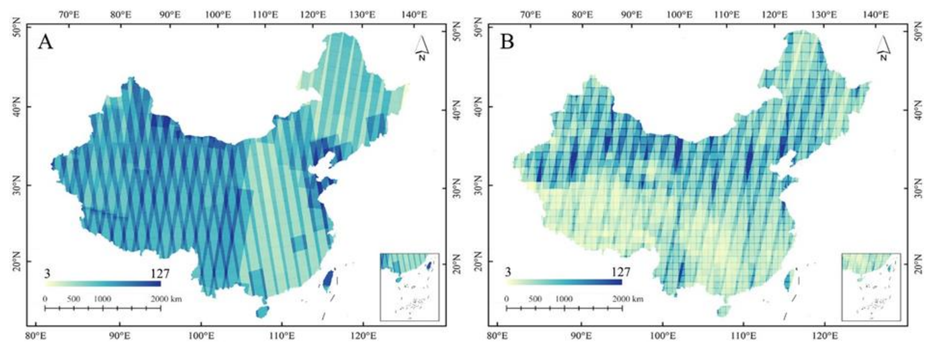

Figure 2. Spatial distribution of Sentinel-1 observations (A) and Sentinel-2 observations (B) in 2020.

Results

The overall accuracy of the CWaC is 85.5% and the kappa coefficient is 0.83. The classification accuracy of rivers, reservoirs, lakes, agricultural ponds, and rice fields all exceed 80%, and the classification accuracy of lakes is the highest.

Table 1. Confusion matrix for the 2020 water cover type map in China

Classification	Rivers	Reservoirs	Lakes	Agricultural ponds	Seasonal wetlands	Rice fields	Total	PA (%)
Rivers	896	10	19	13	118	6	1062	**84.4**
Reservoirs	51	771	24	52	17	10	925	**83.4**
Lakes	23	32	940	12	12	5	1024	**91.8**
Agricultural ponds	2	21	5	691	7	49	775	**89.2**
Seasonal wetlands	55	31	47	25	710	49	917	**77.4**
Rice fields	14	25	0	6	86	847	978	**86.6**
Total	1041	890	1035	799	950	966	5681	
UA (%)	**86.1**	**86.6**	**90.8**	**86.5**	**74.7**	**87.7**		**85.5**

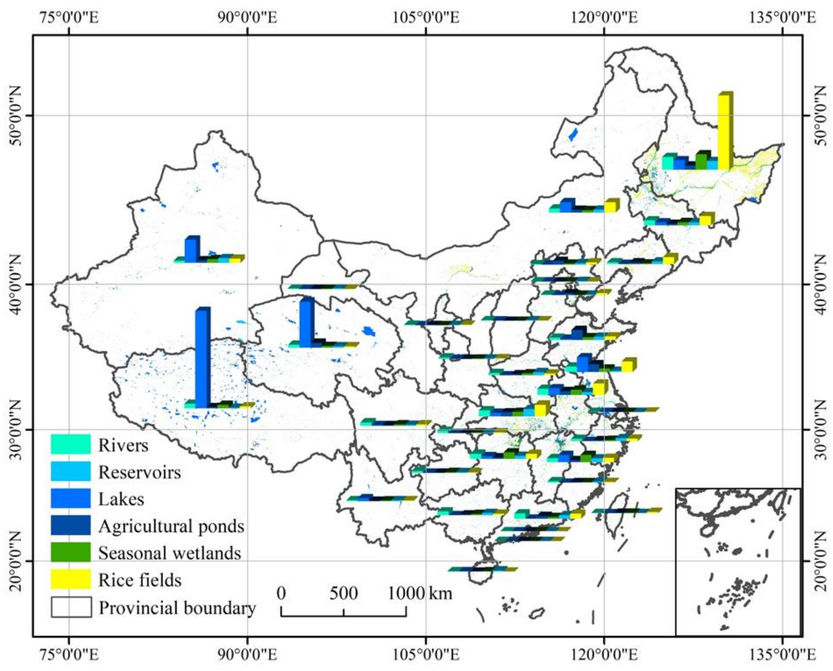

Figure 3. Provincial scale comparison of water cover area in China

Among the 34 provinces, Heilongjiang, Tibet and Qinghai have the largest water cover area. The water cover area of these provinces accounts for about 41.5% of the total water cover area. Lakes are mainly distributed in Tibet and Qinghai Province, while rivers are extensively found in the whole China. Seasonal wetlands are mainly distributed in Heilongjiang Province. Reservoirs are mainly distributed in Heilongjiang, Hubei and Xinjiang provinces, accounting for about 31.1% of the total area of the reservoir. Rice fields are mainly distributed in Heilongjiang, provinces in the middle and lower reaches of the Yangtze River and Monglia.

Discussion

The areal differences between the GSW and the CWaC mainly come from the differences of data sources and its spatial resolution, which the GSW is based on the Landsat OLI optical images with 30-m spatial resolution while the CWaC is based on the combination of Sentinel-1 SAR and sentinel-2 optical images with 10-m spatial resolution.

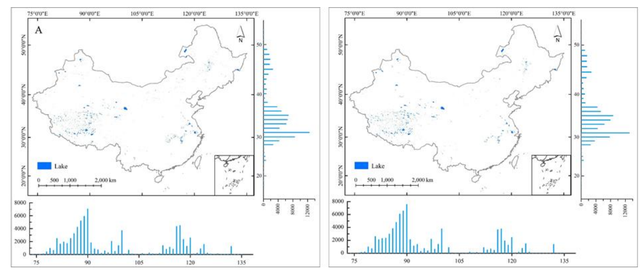

Figure4. Spatial comparison of lakes between the CLD (A) and the CWaC (B)

The wetland extracted by the CWaC is obviously underestimated, and the reason is the different definitions of wetland in these two datasets

Although the observations of sentinel -1 and 2 have shown great advantages in monitoring flooding and permanent water bodies, they still have some limits on mapping some specific water cover types, such as rice fields and seasonal wetlands. The imaging mechanism of Sentinel-1 image and the limited effective observation of Sentinel-2 image resulted in less rice field area in the CWaC.

Conclusion

This study obtained the latest various water cover types information through automatic classification methods, which provided basic data for studying the temporal and spatial changes of specific water cover types and their driving forces

China water cover map in 2020 was developed with unprecedented spatial resolution, using the time series Sentinel-1 and Sentinel-2 images on the GEE, which reflects the latest area and distribution of water cover types in China.

We anticipate that this freely available data will provide evidence of state and change in wetlands, help to improve understanding human influence on hydrologic cycle, and inform water-management decision-making.

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