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The Boundaries and Remote Sensing Classification Datasets on Large Wetlands of International Importance in 2001 and 2013

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Abstract: Wetland is one of the ecosystems with the highest biodiversity and productivity in the world. In this paper, we developed a dataset of 100 large Wetlands of International Importance (the "Ramsar Sites"), which was developed by the data integration and mining from the World Database on Protected Areas (WDPA) and remote sensing images, expecially the high resolution imagery provided on the Google Earth and the Tianditu platforms. Each site covers at least an area of 200,000 hm^2. Based on the Moderate Resolution Imaging Spectro radiometer (MODIS) 16-day composite products MOD13Q1 of these sites in 2001 and 2013, we applied the Savitzky-Golay filtering and time series reconstruction algorithms to Normalized Difference Vegetation Index (NDVI) data. The method of the Support Vector Machine (SVM) classifier was used to classify and map wetlands of these Ramsar sites. The time series data based wetland classification results were compared with high resolution remote sensing imagery and the relevant literatures. This method is more advantageous than single temporal imagery based wetland monitoring technique. The dataset consists of three components which are saved as .shp and .kmz file formats. The total data size is 102 MB in compressed file format.

Keywords: wetlands; boundary; remote sensing classification; wetland mapping; Ramsar sites

1 Introduction

Wetland is one of the ecosystems with the highest biodiversity and productivity in the world[1]. In recent years, large scale wetland monitoring and mapping emerged as a hot research topic and has been attracting great attention of many scholars because of its ecological significance. To understand the spatio-temporal change characteristics of wetland ecosystem is the key component of global change research[2]. The fast development of remote sensing tech-

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nique provides an objective means to global wetlands monitoring research. The remotely sensed time series data play an irreplaceable role in the research of wetland changes in the growth cycle or in a calendar year of wetland vegetation[3]. It is the main data source of the remotely sensed monitoring on large wetlands of international importance at the global scale of this paper. Along with our related scientific reports published, we make this dataset available for public use.

2 Metadata of Dataset

The metadata of the boundaries and remote sensing classification datasets on large wetlands of international importance in 2001 and 2013 is summarized in Table 1[4]. It includes the dataset full name, short name, authors, year of the dataset, temporal resolution, spatial resolution, data format, data size, data files, data publisher, and data sharing policy, etc.

Table 1 Summary of the RamsarSites_Top100_WetlandCover_2001/2013 metadata.

Items	Description
Dataset full name	The wetland cover datasets on the large wetlands of international importance in 2001 and 2013 by remote sensing data integration
Dataset short name	RamsarSites_Top100_WetlandCover_2001/2013
Authors	Zhang, H. Y. L-4985-2016, Institute of Remote Sensing and Digital Earth, CAS, zhanghy@ radi.ac.cn Niu, Z. G. L-4829-2016, Institute of Remote Sensing and Digital Earth, CAS, niuzg@ra di.ac.cn Xu, P. P. L-5064-2016, Institute of Remote Sensing and Digital Earth, CAS, 25486400 46 @qq. com Chen, Y. F. L-5003-2016, Institute of Remote Sensing and Digital Earth, CAS, 935836745 @qq.com Hu, S. J. L-6142-2016, Institute of Remote Sensing and Digital Earth, CAS, husj1989@y eah.net Gong, N. L-6422-2016, Shandong Agricultural University, gongningbaobao@126.com
Geographic region	100 large wetlands of international importance in the world, distributed in different continents
Year	2001, 2013
Temporal resolution	Yearly
Spatial resolution	250 m
Data format	.kmz, .shp
Data size	1.54 MB in .kmz format. 100 MB in compressed
Data files	The dataset consists of three files[4]. They are as follows. 1) Top100_boundary.kmz.zip. This is the boundaries of 100 large wetlands of international importance in the world. It is stored in a .kmz file applicable to Google Earth, and the data size is 1.54 MB 2) Ramsar2001.rar. This is the remotely sensed classification results of these wetlands in 2001. Its data size is 51 MB 3) Ramsar2013.rar. This is the remotely sensed classification results of these wetlands in 2013. Its data size is 49.6 MB Note: The classification results, Ramsar2001.rar and Ramsar2013.rar, are stored as ArcGIS shapefile vector format. Each vector file includes seven fields: (1) Area refers to the area of each patch in square meters; (2) RSN stands for Ramsar Site No., namely Ramsar number or the number of wetlands of international importance; (3) Lev3 indicates wetland code of that patch in the classification system[4] (Table 2); (4) the fields Name_EN and Name_CN refer to the English names and the Chinese names of the Ramsar sites respectively; and (5) the fields Country_EN and Country_CN respectively stand for the English names and the Chinese names of the country where the Ramsar sites lie in
Foundation(s)	National Natural Science Foundation of China (41271423)
Data publisher	Global Change Research Data Publishing & Repository, http://www.geodoi.ac.cn

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Items	Description
Address	No. 11A, Datun Road, Chaoyang District, Beijing 100101, China
Data sharing policy	***Data*** from the Global Change Research Data Publishing & Repository includes metadata, datasets (data products), and publications (in this case, in the *Journal of Global Change* ***Data*** *& Discovery*). ***Data*** sharing policy includes: (1) ***Data*** are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use *Data* subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute ***Data*** subject to written permission from the GCdataPR Editorial Office and the issuance of a ***Data*** redistribution license; and (4) If ***Data*** are used to compile new datasets, the 'ten per cent principal' should be followed such that ***Data*** records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset[5]

3 Methods

3.1 The Objective and Indicators of Wetland Monitoring by Remote Sensing

Based on some principles such as wetlands with an area larger than 200,000 hm^2, with established geographic extent and map information, 100 wetlands of international importance all over the world distributed at different ecological-climatic zones and continents were selected from the database of Ramsar sites (https://rsis.ramsar.org/) (Figure 1).

Indices for monitoring large wetlands of international importance mainly include the types and the area of land cover (Table 2). The conversion between wetlands and non-wetlands, the conversion in different wetland types and the changes on the area of different types, were used as important indicators to evaluate the ecological and environmental conditions of the wetlands. In general, if wetlands are converted into non-wetlands, or natural wetlands are converted into artificial wetlands, they usually lead to a deteriorated environmental condition and pose some threats to wetland biodiversity conservation. On the contrary, it often causes healthy development on the wetland environments.

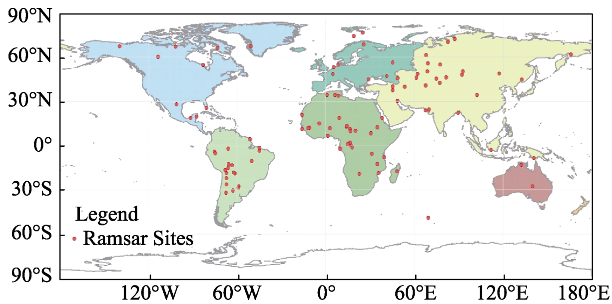

Figure 1 Spatial distribution of large wetlands of international importance

3.2 Methodology of Wetland Boundaries and Classification Dataset Development

Most of the wetland boundaries were delineated by reference to the scanned paper maps published on the Ramsar website (https://rsis.ramsar.org/. Retrieved on July 23, 2014)[6]. Another small part of them were derived from World Database on Protected Areas (https://www.iucn.org/; http://www.protectedplanet.net/. Retrieved on July 23, 2014) and the other products of literature and document. The maps were georeferenced in ArcGIS. Because there are many differences of wetland management and monitoring techniques in each country, some inconsistencies of the boundaries often occur in such occasion. Therefore we made modification and verification by using high resolution remote sensing images on Google Earth platform, based on the physiographic forms of wetlands such as walking along rivers, roads, and the ridge lines. The MODIS product MOD13Q1 (16-day composite, 250 m)

Table 2 Land cover classification system adopted in remote sensing based mapping on wetlands of international importance

Level 1	Level 2	Level 3	Code	Characteristics of time series NDVI	Definition or spatial distribution characteristics
Wetlands	Water		11	NDVI ⩽ 0.1	Including rivers, lakes, estuarine wa ter, reservoirs and urban entertainment landscape, wastewater treatment plant, etc. It mainly refers to permanent water body
	For-ested/shrub-dominated wetlands	Forested/shrub-dominated wet-lands (evergreen)	121	NDVI ⩾ 0.4. There is slight amplitude of variation on NDVI in a year	Including the forested/shrub-domin ated wetlands with evergreen vegetation located at the inland and coastal zone
		Forested/shrub-do min ated wet-lands (deciduous)	122	NDVI ⩾ 0.3. It presents a pattern of periodicity	Including the forested/shrub-dominated wetlands with deciduous vegetation located at the inland and coastal zone
	Marshes	Permanent marshes	131	0.1 ⩽ NDVI ⩽ 0.5. There is a relative slight amplitude of variation on NDVI in a year. In high-water season, there may be minus value of NDVI	Wetlands with oversaturated soil and permanently flooded herbaceous plants
		Seasonal marshes	132	0.1 ⩽ NDVI ⩽ 0.5. There is a periodic pattern of NDVI in a year. In high-water season, NDVI < 0	Herbaceous marshes flooded regularly or seasonally in leaf-on season
	Flooded flats/Intertidal zone / Estuarine deltas		14	NDVI ⩽ 0.2. In high-water season, NDVI < 0	They refer to inundated periodically and oversaturated soils distributed near lakes, rivers and estuary, with the vegetation coverage lower than 30%. They are often not covered with open water
	Paddy fields		15	NDVI < 0, at the early stage of crop growth. There is a steep decreasing trend of NDVI after crops harvesting	Arable land used for growing rice
	Tundra wetlands		16	In leaf-on season, NDVI < 0.6. They are usually distributed at high latitudes	
Non-wetlands	Snow		21		Perennial snow
	Natural vegetation	Forests/Scrublands	22	In the leaf-on season, NDVI>0.5	Forests and scrublands
		Grasslands	23	In the leaf-on season, 0.3 ⩽NDVI⩽0.6	
	Construction / Barren lands		24	0⩽NDVI⩽0.2	Including artificial construction such as buildings, roads, etc. and other forms of barren lands, e.g., rocks, barren sands
	Drylands		25	The occurrence of the slow growth and the steep drop-off of the NDVI value in a calendar year	Farms cultivated with dry-land crops as a result of their scarcity of water
	Cloud cover		32		These regions are covered by clouds
	Ocean		33		

in 2001 and 2013 downloaded from NASA (https://ladsweb.nascom.nasa.gov/data/) was used as the main data source. There are 23 periods of the images in each year. In this study, the images on the public service platform Tianditu (http://www.tianditu.com/map/index.html) powered by the National Geomatics Center of China (NGCC) and other geographic data were also used as auxiliary data. The Normalized Difference Vegetation Index (NDVI) can reflect the growth status of different vegetation types. By comparing the NDVI differences including the maximum, the minimum, and the range of annual NDVI, the emergence date of the positive NDVI value, and the growing season length, etc. between different vegetation types in the growth cycle or within a calendar year, and analyzing plants growth pattern[7], the accuracy of interpretation on different types of land cover types could be effectively improved. We applied Savitzky-Golay filtering to reconstruct NDVI time series dataset[8]. Based on the clustering results of time series data and the analysis on the features of different land cover types in high resolution remote sensing images, we collected 10−20 training samples for each type and used SVM classifier to delineate and map different types of wetlands. The minimum of the map unit is about 56.25 hm^2 for 3×3 pixels. The main methods and the technical flow are described in Figure 2.

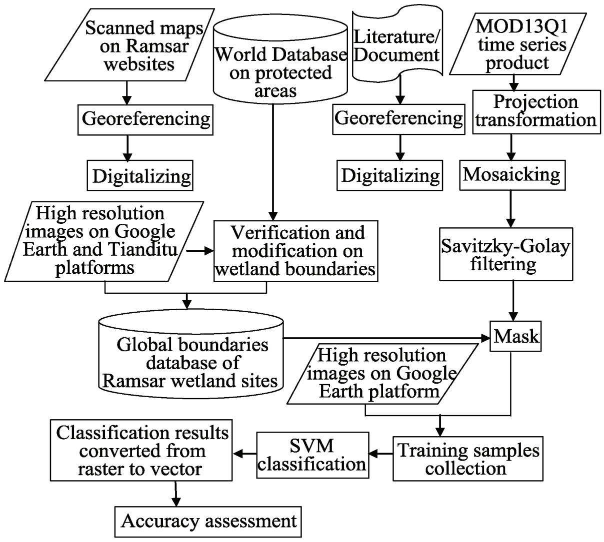

Figure 2 Flowchart for wetlands classification

4 Data Products

The dataset consists of three components, namely Top100_boundary kmz (1,470.14 KB), Ramsar2001.rar (52,245.46 KB) and Ramsar2013.rar (50,858.42 KB). They represent the boundaries of 100 large wetlands of international importance in the world, and the wetland classification results in 2001 and 2013, respectively (http://www.geodoi.ac.cn/WebEn/doi.aspx?Id=243).

4.1 Statistics on Large Wetlands of International Importance

The total area of 100 large wetlands of international importance is 138,392,121.05 hm^2. Okavango Delta System (Ramsar Site No.879), located in Botswana, ranks first. The statistical results are listed in Table 3.

Table 3 Statistics on large wetlands of international importance

Name of Ramsar Sites	Area (hm^2)	Country	Ramsar Site No.
Okavango Delta System	6,703,463.94	Botswana	879
Queen Maud Gulf	6,263,006.27	Canada	246
Ngiri-Tumba-Maindombe	6,194,581.31	Democratic Republic of the Congo	1784
Plaines d'inondation des Bahr Aouk et Salamat	6,187,728.80	Chad	1621
Grands affluents	5,787,900.96	Republic of Congo	1742
Plaines d'inondation du Logone et les dépressions Toupouri	4,017,225.78	Chad	1560
Complejo de humedales del Abanico del río Pastaza	3,781,662.25	Peru	1174
Malagarasi-Muyovozi Wetlands	3,705,800.43	Tanzania	1024
Río Yata	3,448,554.92	Bolivia	2094
Palmar de las Islas y las Salinas de San José	3,434,589.67	Bolivia	1088

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Name of Ramsar Sites	Area (hm^2)	Country	Ramsar Site No.
Delta Intérieur du Niger	3,143,537.63	Mali	1365
Río Blanco	2,909,863.42	Bolivia	2092
Plaine de Massenya	2,905,803.26	Chad	1839
Reentrancias Maranhenses	2,671,201.38	Brazil	640
Area between the Pura & Mokoritto Rivers	2,620,671.33	Russia	697
Sudd	2,470,516.39	South Sudan	1622
Gueltas et Oasis de l'Aïr	2,413,275.61	Niger	1501
Réserve Naturelle Nationale des Terres Australes Francaises	2,332,885.13	French	1837
Polar Bear Provincial Park	2,231,833.08	Canada	360
Pacaya-Samiria	2,194,600.24	Peru	546
Coongie Lakes	2,142,810.22	Australia	376
Río Matos	2,116,721.12	Bolivia	2093
Kakadu National Park	1,939,734.28	Australia	204
Parapolsky Dol	1,826,613.22	Russia	693
Baixada Maranhense Environmental Protection Area	1,811,854.16	Brazil	1020
Los Lípez	1,729,203.22	Bolivia	489
Lake Niassa and its Coastal Zone	1,697,149.57	Mozambique	1964
Partie tchadienne du lac Tchad	1,686,175.47	Chad	1134
Whooping Crane Summer Range	1,616,992.61	Canada	240
Parc National du Banc d'Arguin	1,477,460.61	Mauritania	250
Suakin-Gulf of Agig	1,450,427.12	Sudan	1860
Site Ramsar Odzala Kokoua	1,385,476.02	Republic of Congo	2080
Lago Titicaca	1,366,536.56	Bolivia	959
Bañados del Río Dulce y Laguna de Mar Chiquita	1,351,673.35	Argentina	1176
Mamirauá	1,319,593.43	Brazil	623
Lagunas altoandinas y puneñas de Catamarca	1,311,834.01	Argentina	1865
Tobol-Ishim Forest-steppe	1,278,538.61	Russia	679
Gambie-Oundou-Liti	1,246,779.36	Guinea	1579
Volga Delta	1,199,249.85	Russia	111
Lagunas de Guanacache, Desaguadero y del Bebedero	1,157,839.02	Argentina	1012
Zambezi Delta	1,140,940.11	Mozambique	1391
Lagos Poopó y Uru Uru	1,136,273.65	Bolivia	1181
Archipel Bolama-Bijagós	1,065,174.91	Guinea-Bissau	2198
Ili River Delta and South Lake Balkhash	973,699.53	Kazakhstan	2020
Lake Uvs and its surrounding wetlands	885,360.38	Mongolia	1379
Har Us Nuur National Park	859,526.41	Mongolia	976
Dinder National Park	855,072.75	Sudan	1461
Alakol-Sasykkol Lakes System	784,807.01	Kazakhstan	1892
Dewey Soper Migratory Bird Sanctuary	782,498.00	Canada	249
Le Lac Alaotra: Les Zones Humides et Bassins Versants	781,472.69	Madagascar	1312
Everglades National Park	754,573.06	United States	374
Brekhovsky Islands in the Yenisei estuary	737,894.04	Russia	698
Área de Protección de Flora y Fauna Laguna de Términos	734,350.69	Mexico	1356
Rufiji-Mafia-Kilwa Marine Ramsar Site	734,194.39	Tanzania	1443

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Name of Ramsar Sites	Area (hm^2)	Country	Ramsar Site No.
Dalai Lake National Nature Reserve, Inner Mongolia	733,235.89	China	1146
Sian Ka'an	655,727.26	Mexico	1329
Aydar-Arnasay Lakes system	636,595.85	Uzbekistan	1841
Isyk-Kul State Reserve with the Lake Isyk-Kul	629,536.18	Kyrgyzstan	1231
Chott El Jerid	616,315.19	Tunisia	1699
Lake Chad Wetlands in Nigeria	611,134.90	Nigeria	1749
Rio Sabinas	606,876.07	Mexico	1769
Eqalummiut Nunaat and Nassuttuup Nunaa	594,195.32	Denmark	386
Ilha do Bananal	592,910.39	Brazil	624
Site Ramsar du Complexe W	581,917.66	Benin	1668
Sangha-Nouabalé-Ndoki	552,358.22	Republic of Congo	1858
Wadden Sea	541,257.30	Netherlands	289
Cabo Orange National Park	523,199.02	Brazil	2190
Bafing-Falémé	522,191.82	Guinea	1719
Chott Ech Chergui	519,421.40	Algeria	1052
Bañados del Izozog y el río Parapetí	516,491.19	Bolivia	1087
Runn of Kutch	513,386.48	Pakistan	1285
Sundarbans Reserved Forest	499,921.44	Bangladesh	560
Upper Dvuobje	499,157.08	Russia	678
Jaaukanigás	491,725.87	Argentina	1112
Humedales Chaco	491,620.32	Argentina	1366
Schleswig-Holstein Wadden Sea and adjacent areas	481,776.92	Germany	537
Lake Sevan	474,652.91	Armenia	620
Lake Urmia [or Orumiyeh]	456,996.73	Iran	38
Danube Delta	451,407.18	Romania	521
Indus Delta	435,103.46	Pakistan	1284
Wasur National Park	411,337.03	Indonesia	1624
Chany Lakes	387,239.92	Russia	680
Tanjung Puting National Park	378,350.88	Indonesia	2192
Zones Humides du Littoral du Togo	368,011.51	Togo	1722
Shadegan Marshes & mudflats of Khor-al Amaya & Khor Musa	334,645.27	Iran	41
Turkmenbashy Bay	324,761.47	Turkmenistan	1855
Hopen	316,453.18	Norway	1957
Lesser Aral Sea and Delta of the Syrdarya River	313,371.18	Kazakhstan	2083
Bear Island	296,711.28	Norway	1966
Lemmenjoki National Park	285,550.79	Finland	1521
Lakes of the lower Turgay and Irgiz	263,261.44	Kazakhstan	108
Tengiz-Korgalzhyn Lake System	261,593.75	Kazakhstan	107
Gansu Gahai Wetlands Nature Reserve	247,747.47	China	1975
Etangs de la Champagne humide	241,348.36	France	514
Kama-Bakaldino Mires	223,709.33	Russia	670
Lake Khanka	192,382.13	Russia	112
Chott Melghir	192,282.62	Algeria	1296
Veselovskoye Reservoir	185,046.81	Russia	672
Petit Loango	150,542.08	Gabon	352
Old Crow Flats	31,461.26	Canada	244

4.2 Remote Sensing Classification Results on Large Wetland of International Importance in 2001 and 2013

Based on the remote sensing classification results on 100 large wetlands of international importance in 2001 and 2013, we calculate the subtotal area of different land cover types. The statistical results are shown in Table 4.

In 2001, the largest three wetland classes are forested/shrub-dominated wetlands (deciduous), seasonal marshes, and permanent marshes, respectively. Between 2001 and 2013, the total area of wetland reduced from 58,134,960 hm^2 to 57,734,032 hm^2, the big three losers were water, forested/shrub-dominated wetlands (deciduous), and tundra wetlands, respectively.

Table 4 Area of different land cover types in large wetlands of international importance

Code	Level 2	Level 3	Area (hm^2)	
			2001	2013
Wetlands			58,134,960.36	57,734,032.42
11	Water		7,962,751.49	7,220,121.10
121	Forested/shrub-dominated wetlands	Forested/shrub-dominated wetlands (evergreen)	5,670,938.35	5,372,163.35
122		Forested/shrub-dominated wetlands (deciduous)	17,989,514.92	17,264,579.94
131	Marshes	Permanent marshes	8,852,939.87	9,019,623.32
132		Seasonal marshes	11,446,049.25	12,970,340.19
14	Flooded flats/Intertidal zone / Estuarine deltas		3,677,715.96	3,755,553.93
15	Paddy fields		161,536.44	118,356.86
16	Tundra wetlands		2,373,514.09	2,013,293.73
Non-wetlands			80,256,924.04	80,657,761.93
21	Snow		203,466.14	161,471.34
22	Natural vegetation	Forests/Scrublands	49,795,219.42	49,793,411.47
23		Grasslands	10,253,074.54	10,202,998.58
24	Construction / Barren lands		10,255,547.25	9,634,365.16
25	Drylands		2,071,076.67	3,200,432.37
32	Cloud cover		54,188.66	53,787.91
33	Ocean		7,624,351.36	7,611,295.11

5 Data Validation

Validation on the world's large wetlands classification results accuracy was applied by using high resolution remotely sensed images. We randomly selected 10 wetlands of international importance in different continents as the testing regions except for the Antarctic. About 2,386 validation samples randomly collected were interpreted based on high resolution images of China's satellites GF-1, ZY-3. Accuracy of all land cover types was assessed. In general, the overall accuracy for all types is 88% and 89% in 2001 and 2013 respectively. And the Kappa coefficients are 0.86 and 0.87 respectively.

The dataset contains the boundaries of the world's 100 large wetlands of international importance and wetland classification results on them in 2001 and 2013 based on 250 m spatial resolution, 16-day composite product MOD13Q1. It provides important reference data for research on global wetlands and climate change.

Author Contributions

Six coauthors were engaged in the design and development of the boundaries and remote sensing classification datasets on large wetlands of international importance in 2001 and 2013. Zhang, H. Y. and Niu, Z. G. participated in all the technological processes of the design and methodological development of boundaries extraction, data collection and processing, data analysis and validation, etc. Zhang, H. Y., Xu, P. P., Chen, Y. F., Hu, S. J. and Gong, N. took part in the boundaries extraction and wetlands classification. And the author list was arranged in their workload order. Zhang, H. Y. wrote this paper, and Niu, Z. G. was in charge of the paper proofreading, editing and revision.

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References

[1] Costanza, R., d'Arge, R., de Groot, R., *et al*. The value of the world's ecosystem services and natural capital [J]. *Nature*, 1997, 387: 253–260.

[2] Kloiber, S. M., Macleod, R. D., Smith, A. J., *et al*. A semi-automated, multi-source data fusion update of a wetland inventory for East-Central Minnesota, USA [J]. *Wetlands*, 2015, 35: 335–348.

[3] Dong, J., Xiao, X., Kou, W., *et al*. Tracking the dynamics of paddy rice planting area in 1986–2010 through time series Landsat images and phenology-based algorithms [J]. *Remote Sensing of Environment*, 2015, 160: 99–113.

[4] Zhang, H. Y., Niu, Z. G., Gong, N., *et al*. The wetland cover datasets on the large wetlands of international importance in 2001 and 2013 by remote sensing data integration [DB/OL]. Global Change Research Data Publishing & Repository, 2015. DOI: 10.3974/geodb.2015.02.09.V1.

[5] GCdataPR Editorial Office. GCdataPR Data Sharing Policy [OL]. DOI: 10.3974/dp.policy.2014.05 (Updated 2017).

[6] Ramsar Convention Secretariat. The Ramsar convention manual: A guide to the convention on wetlands (Ramsar, Iran, 1971), 4th edition [Z]. 2006.

[7] Jin, Z., Xu, B. A novel compound smoother—RMMEH to reconstruct MODIS NDVI time series [J]. *IEEE Geoscience and Remote Sensing Letters*, 2013, 10: 942–946.

[8] Chen, J., Jönsson, P., Tamura,M., *et al*. A simple method for reconstructing a high-quality NDVI time-series data set based on the Savitzky-Golay filter [J]. *Remote Sensing of Environment*, 2004, 91: 332–344.