Part 1 Response to the Reviews

1. Response to reviewer 1

Questions: This manuscript showed some potential for publication. However, after looking into more detail it shows (1) a lot of duplication (previous paper Lu et a., 2017), (2) lack of sufficient accuracy assessment, (3) some incorrect quotes and very general statements. In terms of methodology this manuscript is almost exactly the same as presented by Lu et al., 2017. I do not disagree with the idea of using same methodology for a larger area of interest. But the methodological paragraphs are 90% identically with even same Figure and Table. Some adjustments are mentioned but are not discussed. In terms of accuracy assessment there is a lack of detailed analyses of the presented product. The presented numbers are based on calculated total areas over the entire region for maximum water surface area and do not even analyze the temporal scale. The second dataset for cross comparison GWS (Pekel et al., 2016), was only used to compare visually for two zoom-in areas. With the final statement that both datasets look alike and have similar patterns. The temporal resolution is not validated at all. The effort of accuracy assessment which was performed is not state of the art and does not mirror the real quality of the presented product. In my view this manuscript does not have much of novelty and the statement about "lack of water surface products for China" is also not correct.

Responses: Many thanks to the reviewer for his/her review and comprehensive, in-depth and constructive suggestions. Please find the detailed responses to all the suggestions along with proposed changes below. We also uploaded the updated manuscript using track change (in response to both reviewers) in a separate post.

As for the duplication problem of the method introduction, due to the emphasis of this paper is introduce of the new dataset based results, so in the methodology part we only introduced the supplemented and optimized content (Section 3.1 and 3.2) on the basis of previous achievements.

On the issue of accuracy evaluation, we have increased the accuracy analysis of temporal process data.

We also revised the grammar and inaccurate expressions one by one according to the comments of the reviewers.

Questions: General Comments:

I would recommend English gramma check. Some sentences are understandable but have incorrect gramma (e.g. P1 L16, P1 L21, P 2 L5-6, P2 L17, P4 L2, P4 L10-11 and more) Please be consistent: either dataset or data set. Sometimes you use both options in one paragraph (e.g. P4) The methodological content is almost identical in many parts with Lu et al., 2017

Abstract and conclusion: Almost the same content!

Response: We have corrected the grammatical and expression errors one by one, and made the abstract and conclusions different from each other.

Introduction

Question: P 2 L 2: First statement -> please provide a source

Response: We added the reference from Lu and He, 2006.

Question: P2 L 15: statement incorrect. The data is being produced from July 2002-ongoing.

Response: We revised it as ‘However, the temporal resolution of the former research is near monthly, and the latter research only produced datasets of 2013-2015 at the moment, the entire MODIS archive back to July 2002 is still ongoing (Klein et al., 2017).’

Question: P2 L19-24: this information could be summarized with key parameters in a table

Response: We summarized them into a table named ‘Table 1 National and regional surface water related datasets of China’

Question: P3 L3-4: NDWI is mostly known from McFeeters 1996 as well as Gao 1996

Response: We added these two original references.

Question: P3 L5: wrong citation of Feyisa et al. 2014 instead of 2018

Response: It is a wrong typing caused problem. We have revised in the new version.

Question: P3 L7-8: incorrect statement for Pekel et al., 2014

Response: We changed the statement as 'the multiband transformation method (Pekel et al. 2014)'

Question: P3 L24: LBV?

Response: It is a new transformation method proposed by Zhang et al. (2017). It means: L, the general radiance level; B, the visible–infrared radiation balance; V, the radiance variation vector between bands. We added this explanation in the manuscript.

Question: P4 L2: first sentence does not make sense.

Response: We revised this sentence as 'China is one of the countries that have the highest densities of rivers and lakes in the world…..'

Question: P4 L9-11: This statement is not true as there are datasets which reflects the spatial and temporal characteristics of surface water such as Pekel et al., 2016, Klein et al., 2017, Ji et al., 2018.

Response: We changed this statement as 'Therefore, there is an urgent need for spatio-temporal continuous surface water datasets to support the robust and efficient management of water resources, and to investigate the relationship between the national surface water and the global climate and human activities. However, until now, full public sharing data products with moderate spatial resolution and near-daily temporal resolution are still lacking in China.

Question: P4 L14: why does ISWDC ends with 2016?

Response: We are going to extend the ISWDC to 2019, when it is finished we will update it onto the zenodo platform.

Question: P5 L16: Something should be following. Instead the paragraph ends here.

Response: Maybe here is a grammar caused mistake. We did not end the sentence here. The Section 3.1 and 3.2 are explanations of the sentence of 'In this study the last two steps related to 'annual water surface mask acquisition' and 'final water surface mapping' are updated and improved as in following sections 3.1 and 3.2.

Question: P5 Figure 1 is exactly the same as in Lu et al., 2017 if you have improved two steps, why don't update the figure as well and discuss the adjustments?

Response: Figure 1 shows the core steps of our mapping method for MODIS MOD09Q1 images. As we mentioned in the manuscript, we only updated (Section 3.1) and improved (Section 3.2) the last two steps of the method, the overall structure of the method did not change, so we did not change the flowchart. But we explained the adjustments in Section 3.1 and Section 3.2, and we changed the title of the final step as 'Final water surface mapping'.

Question: P5-7: is almost identically with your paper about Tibetan Plateau (TB). Even the table 1 with selected images is the same. Was there no difference of analyzing only TB and entire China? Maybe instead of copy-pasting the same text, you should clearly point out the updates and improvement which you did. At the moment, you only mention there were improvements but you do not mention where exactly these improvements are and why it was necessary.

Response: In this new version, we have deleted some duplicated words, and explained the changes made in this study and the contents inherited from Lu et al. (2017).

Question: Paragraph 3.2. boundary extraction? Your dataset is a raster data with pixel values for water and no water. For water boundary I would expect a vector dataset with lines or polygons which determines the boundaries of a water body. This paragraph is unclear and does not correspond to the header of the paragraph.

Response: The major content of this section is about the improvement of the threshold value determination during the final step of water surface mapping. We changed the title of this section and optimized the description and interpretation.

Question: P7 L10-13: why is the difference between ice layer and water body in winter small?

Response: Thanks for pointing out this issue. We have corrected this point. In the new version, we changed it as 'In the process of water turning into ice in winter, the pixel value of ice is higher than that of water, and it accounts for a large proportion. The average pixel value will cause the ice layer to be extracted as the water surface.'

4 Accuracy Assessment

Questions: P9 L7-8: what is the logic behind this procedure? You are comparing a static dataset of a certain year with the maximum area of ISWDC of corresponding year. What is the interpretation of calculated R2 in that case? To compare the total area over such a large area of all selected water bodies seems to be very shallow and not state of the art. I would expect a pixel based approach to actually assess the real quality at acertain time for a certain pixel.

Response: This comparison is very similar as we extracted lot of samples from water bodies from images having 30m resolution and took them as ground truth data for accuracy analysis. As the national land cover data in 2000, 2005, 2010 are based on 30 m Landsat images that mainly obtained in summer season. The water surface in these datasets can be equated with annual maximum water surface results. So we compared them with our maximum ISWDC of corresponding year. The calculated R^2 is based on the area of different size of water bodies. The larger the R^2, the better the consistency and the smaller the area error between the two datasets. Furthermore, the results of confusion matrix are equivalent to pixel scale analysis although it's not as intuitive as visual contrast.

Question: Paragraph 4.2: it is only a visual interpretation of two zoom-in images without any quantitative results.

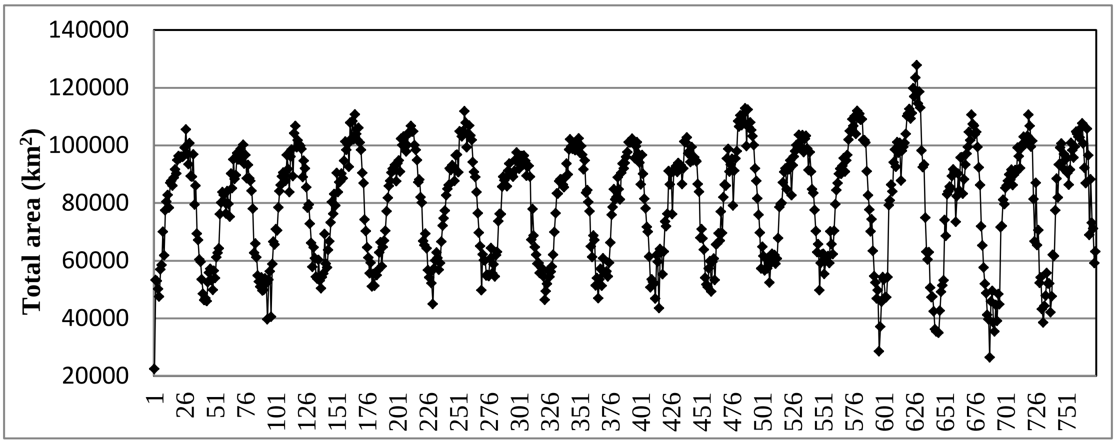
Response: We added a comparison between the annual permanent water of ISWDC and GSW in whole China in 2000-2015. The results show that the two datasets are also very consistent in time series analysis.

Question: 5.1 The multi-year average analysis can also be done with GSW dataset. Therefore, I don't see any novelty or interesting facts especially since you mentioned that both datasets indicate similar patterns. Where is the advantage or novelty of using ISWDC in this case?

Response: In this section, we added the results of time series analysis of surface water change in China and different geographical regions with the ISWDC. These results fully reflect the characteristics and advantages of high temporal resolution of the ISWDC.

Question: P13 Figure 5: this figure shows that, in general, the total surface water of China has a clear seasonality. However, the curves of single years cannot be determined due to figure design.

Response: We are trying to use the 8-day time series surface water area data from 2000 to 2016 to show the inter-annual and annual changes (see the following figure), but with this figure the seasonality characteristic is obscured. So the original figure is retained but we optimized the figure.



Question: P13 Figure 6: In this Figure you show red lines, which are probably the water body borders. Are these polygons also distributed? So far I was only able to download binary raster data and no vector data.

Response: Yes, the red lines in the original Figure 6 are the water body borders that we extracted with the binary raster data. Although we delete this figure in our new version, we will distribute the vector version of ISWDC while submitting revised article.

Question: P14 L11-12: again a statement which I do not agree with as the presented dataset covers almost the same time span as it is covered by GWS (Pekel et al., 2016).

Response: We deleted this statement and changed it to 'It is a full public sharing long time series data product with moderate spatial resolution and high temporal resolution, and is a very good basic data source for the analysis of the dynamic changes of surface water in China and regions in the past 20 years'.

Question: The dataset itself is a mosaic for China area for temporal steps of 8 days and can used by interested scientists or organizations for different purposes. However, without sufficient quality layer or accuracy assessment especially of the different time steps.

Response: In the new version of the dataset, the vector files are added, and accuracy evaluation and possible problems are explained.

2. Response to reviewer 2

General Remarks

Questions: The paper is in general well written but lacks the bigger picture. The work reported understandably China focused but the authors miss the opportunity to discuss how their techniques could be applied elsewhere and what the long term benefits are. It is highly recommended that such a discussion be included.

Response: In the new version of manuscript, we changed the title of Section 6 to Discussion and conclusions, and extended the final paragraph to discuss the application of our method, datasets and future plan.

Questions: Although a degree of statistical testing has been applied, the results of which are reported, the paper lacks a discussion of the overall uncertainty associated with the surface water areas reported. It is highly recommended that such a discussion be added.

Response: In the new final section, we added a paragraph to discuss the overall uncertainties.

Questions: Section 5.2 Although the links to the data work and there is a 'ReadMe' file accompanying the data the metadata it contains is minimal. This section needs expansion to include a description of the data archive structure, access, and usage licensing as well as the file formats and metadata provided.

The authors are providing imagery (including .tif format). It is advised that the metadata in the 'ReadMe' file be embedded into the files - this would improve the usability of the data in the long-term. For example the following could be used and or adapted to meet the authors needs https://iptc.org/standards/photo-metadata/photo-metadata/

Response: We have added vector data of the datasets and detail introduction of the data using and transferring.

Specific edits

Questions:

Page 1 15: ‘for the time’ change to ‘for time’ 16: ‘create Inland’ change to ‘create an Inland’ 16: ‘maps the water body’ change to ‘maps water bodies’ 17: ‘0.0625 km2 17 in the terrestrial land of China for the period 2000–2016, in 8-day temporal’ change to ‘0.0625 km2 17 within the land mass of China for the period 2000–2016, with 8-day temporal’ 18: remove ‘the’ at end of line 20: ‘data with the’ change to ‘data with’ 21: ‘2015 too’ change to ‘2015’ 23: ‘and as input’ change to ‘and as an input’.

Page 2 3: ‘systems in’ change to ‘systems in a’ 5: ‘has a role’ change to ‘have a role’ 9: ‘But’ change to ‘but’ 9: ‘did limited exploration for’ change to ‘were limited’ 17: ‘but in’ change to ‘but only in’ 17 – 19: ‘Their research hotspot was Qinghai-Tibetan Plateau due to the existence of the largest number of inland lakes there with the highest elevation on the planet (Lu et al., 2017).’ This sentence does not make any sense and needs restructuring. 20: ‘Almost every 10-year of lake water surface area datasets from 1960s to present has been produced’ change to ‘Almost every 10-year since the 1960s lake water surface area datasets have been produced’

Page 3 1: ‘dataset.’ change to ‘datasets are available.’ 3: ‘is water’ change to ‘is a water’ 3: ‘as Normalized’ change to ‘ as the Normalized’ 8: ‘these methods to extract water boundary is to determine’ change to ‘these methods in extracting the water boundary is to determine’ 11: ‘experience causes’ change to ‘experience which causes’ 11: ‘and it is’ change to ‘and is’ 12: ’apply to large scale and large amount of data research’ change to ‘apply on larger scales and to large amounts of data’ 16: ‘and divided it’ change to ‘and to divide these’ 18: ‘of visual’ change to ‘of a visual’

Page 4 2: ‘China is one of the most rivers and lakes in the world’ change to ‘China has one of the highest densities of rivers and lakes in the world’ 3: ‘exceeding 1000 km2, and 2928 lakes with an area larger than 1 km2 and a total area of 91,020 km2 (Ma’ change to ‘exceeding 1000 km2, 2928 lakes with an area larger than 1 km2 giving in total a surface water area of 91,020 km2 (Ma’ 5: ‘resources are very uneven in distribution.’ Change to ‘resources are unevenly distributed.’ 7: ‘bought’ change to ‘placed’ 10: ‘China. So the research to’ change to ’China, hence the potential to’ 12: Remove ‘Therefore’ and ‘research’ 17: Replace ‘other’ with ‘existing’ 20: ‘to the water’ change to ‘to a water’

Page 5 4: ‘as an ancillary’ change to ‘as ancillary’ 7: ‘The first one’ change to ‘The first’ 9: ‘The second one’ change to ‘The second’

Page 6 4: ‘extraction of’ change to ‘extraction of the’ 7. ‘the cloud and cloud shadows in this process’ change to ‘cloud and cloud shadow in this process’ 8: What is the time period referred to by the statement ‘over longer time periods’ 10: remove ‘if ‘ before equation

Page 7 5: ‘will be’ change to ‘will also be’ 8: ‘values of’ change to ‘values for’ 10: ‘values of’ change to ‘values for’ 12: ‘extracted as’ change to ‘extracted as the’

Page 9 9: ‘high consistency’ change to ‘highly consistent’ 11: ‘respectively (Figure 3).’ change to ‘respectively is shown in figure 3.’

Page 12 3: ‘series surface’ change to ‘series of the surface’ 4: ‘area such as’ change to ‘area; including; 6: ‘as a cross-validation’ remove ‘a’ 8: ‘models’ change to ‘model’

Response: All these grammatical errors have been corrected.

Question: Table 19: need to include uncertainty accessioned with the values given

Response: Because in the Section 4 we have already assessed the accuracy of the datasets. And we did not have real ground truth data whole the China, so we only calculated the surface water area in different regions directly.

Question: Page 13 Figure 5: There are no error bars on this figure – they need to be added or an explanation as to why they are not shown. The axis tick marks need to be ‘out’ rather than ‘in’ to improve clarity. The x axis labelling is cluttered and needs revision to make clearer

Response: We have tried to add the error bars in this figure, but when we added them on it, the figure looks very crowded and the useful information like the change points in different time will be buried. But we improved the clarity about the axis and the curves in each year based on the above suggestions.

Questions: Page 14 11: ‘2016 was’ change to ‘2016 has been’ 11: ‘series and’ change to ‘series with’ 12: ‘of surface’ change to ‘of a surface’ 12: ‘in China’ change to ‘for China’ 13:‘in high consistency’ change to ‘is highly consistent’ 14: ‘data in’ change to ‘data from’16: ‘0.88 in’ change to ‘0.88 for the’ 18: ‘and Poyang Lake region) with the GSW dataset, especially for the large water bodies (as lakes and’ change to ‘and Poyang Lake region) to that of the GSW data set, especially for large water bodies (such as lakes and’ 19: ‘and the’ change to ‘and’ 20: remove ‘for’ 21: ‘process’ change to ‘processes’

Response: All these grammatical errors have been corrected.

Part 2 List of All Relevant Changes

1. Grammatical modification of the full text.

2. Dataset and citation DOI update.

3. Added a new table of national and regional surface water related datasets of China in Section 1.

4. Refined the method section and updated Figure 1.

5. Improved the accuracy evaluation of time series data and added a new figure (Figure 4).

6. Expanded the section of 'Applications and data availability', updated Figure 5, and replaced the Figure 6.

7. In the part of discussion and conclusion, the uncertainty of data and methods and the application prospect of methods are added.

8. Adjusted the sort of funding information and supplemented some references.

Part 3 Marked-up Manuscript

Time series of Inland Surface Water Dataset in China (ISWDC) for 2000-2016 derived from MODIS archives

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Abstract. The moderate spatial resolution and high temporal resolution of the MODIS imagery make it an ideal resource for ~~the~~ time series surface water monitoring and mapping. We used MODIS MOD09Q1 surface reflectance archive images to create an Inland Surface Water Dataset in China (ISWDC), which maps ~~the~~ water bodies~~y~~ larger than 0.0625 km^2 within the land mass~~in the terrestrial land~~ of China for the period 2000–2016, ~~in~~with 8-day temporal and 250 m spatial resolution. We assessed the accuracy of the ISWDC by comparing with the national land cover derived surface water data and ~~the~~ Global Surface Water (GSW) data. The results show that the ISWDC is closely correlated with the national reference data with ~~the~~ determinant coefficients (R^2) greater than 0.99 in 2000, 2005, and 2010, while the ISWDC possess very good consistency, very similar change dynamics~~has~~, and similar spatial patterns in different regions with the GSW ~~data set~~dataset~~ in 2015 too~~. The ISWDC ~~data set~~dataset can be used for studies on the inter-annual and seasonal variation of the surface water systems. It can also be used as reference data for verification of the other surface water ~~data set~~dataset ~~verification~~ and as an input parameter for regional and global hydro-climatic

models. The ISWDC data are available at http://doi.org/10.5281/zenodo.2616035.

1 Introduction

Surface water is the most important source of water from planetary water resources available for the survival of both human and ecological systems ~~in a sustainable environment~~ (Lu and He, 2006). It is a key component of the hydrological cycle and the key factor affecting sustainable development of human society and ecosystem. Both climate change and human activities ~~has~~ have a role in affecting ~~and modifying the location and persistence of the~~ the surface water availability at a given area and time. In order to locate the position and examine the change in dynamics of the inland surface water, regional and global ~~data set~~datasets have already been produced through remotely sens~~ing~~ed data by various researchers (Carroll et al., 2009; Verpoorter et al., 2014; Feng et al., 2015; Klein et al., 2014; Tulbure et al., 2016~~).~~), ~~But~~ but these contemporary researches ~~did limited exploration for~~were limited to measuring long-term changes at high spatial and temporal resolution. Pekel et al. (2016) quantified the changes in global surface water (GSW) over the past 32 years (1984-2015) at 30-~~metre~~ meters resolution by using the Landsat ~~satellite images~~imagery. Klein et al. (2017) generated a 250 m daily global dataset of inland water bodies based on a combination of MODIS Terra and Aqua daily classifications. However, the temporal resolution of the former research is near monthly, and the latter research only produced ~~data set~~datasets ~~of~~ from 2013-2015 at the moment, while the entire MODIS archive back to July 2002 ~~to~~ is still ongoing (Klein et al., 2017).~~.~~

In China numerous regional case studies have been done and produced some surface water ~~data set~~datasets but only in bits and pieces (Du et al., 2012; Lai et al., 2013; Luo et al., 2017). Their research ~~hotspot~~ mainly focused on lakes in~~was~~ Qinghai-Tibetan Plateau~~ due to the existence of the largest number of inland lakes there with the highest elevation on the planet~~ (Lu et al., 2017). Several research groups are focusing on the lake water changes of this region. Almost every 10-year since the 1960s lake water surface area datasets have been produced~~Almost every 10-year of lake water surface area datasets from 1960s to present has been produced~~ (Song et al., 2014; Zhang et al., 2014, 2017; Wan et al., 2014, 2016). At the national scale, the national wetland remote sensing datasets in 1978, 1990, 2000 and 2008 (Niu et al., 2012), the national land cover datasets in 1990, 2000, 2010, and 2015 (Wu et al., 2017), and the national land use datasets in 1990, 1995, 2000, 2005, 2010, 2015 (Liu et al., 2018) contain the inter-decadal or 5-year time scale water surface dataset (Table 1). However, these datasets are available ~~have~~ with limited temporal resolution and not freely and fully shared.

Table 1 National and regional surface water related datasets of China

Dataset	Author	Time series	Resolution
Lake water surface of Tibetan Plateau	Lu et al., 2017	8-days, 2000-2012	250m
Lake surface area of Tibetan Plateau	Song et al., 2013	1970s, 1990, 2000, 2003-2009, 2011	60m, 30m
Lake area of Tibetan Plateau	Zhang et al., 2014, 2017	1970s, 1990, 2000, 2010	15m, 30m
A lake dataset for the Tibetan Plateau	Wan et al., 2014, 2016	1960s, 2005, 2014	16m, 30m
China national wetland datasets	Niu et al., 2012	1978, 1990, 2000, 2008	30 m
China national land cover datasets	Wu et al., 2017	1990, 2000, 2010, and 2015	30 m
China national land use datasets	Liu et al., 2018	1990, 1995, 2000, 2005, 2010, 2015	30m

The most commonly used method of water extraction is a water index method, such as the Normalized Difference Water Index (NDWI) (Gao, 1996; McFeeters, 1996; Rogers and Kearney, 2004), Modified Normalized Difference Water Index (MNDWI) (Xu, 2006), and Automated Water Extraction Index (AWEI) (Feyisa, et al., ~~2018~~2014). Furthermore, the single band threshold segmentation method (Li et al., 2012, Lu et al., 2017) and the multiband transformation ~~threshold segmentation~~ method (Pekel et al. 2014) are also in practice. The key step for using these methods in extracting the water boundary is to determine~~these methods to extract water boundary is to determine~~ the threshold value for segmentation. The existing threshold determination methods include human visual judgment (Huang et al., 2008; Li et al., 2012) and sample statistical analysis (Feyisa et al, 2014; Pekel etc., 2014; Pekel et al., 2016). The former relies on subjective experience, which causes the extraction results to be unstable, and ~~it is~~ thus difficult to apply ~~to~~ on larger scales and to large amounts of data~~research~~. Although the latter can get more accurate results through extensive sampling statistics, the use of a unified threshold for whole image or whole region may produce large errors in the local area. In order to overcome these problems, various comprehensive classification methods are widely used. Verpoorter et al. (2014) combined the Principal Component Analysis (PCA) and the Modified Brightness Index (MBI) to generate supervised classes, and to divide~~d~~ ~~it~~ these into water and non-water regions by using the decision tree method. Pekel et al. (2016) proposed an expert system by synthetic use of a visual analytical spectral library, NDVI index, HSV transformation results, and decision tree method. Khandelwal et al. (2017) introduced a global supervised classification based approach by defining initial spatial extents of each water body, using the global sample datasets, and incorporating all the spectral reflectance bands of the MODIS imagery~~s~~. Use of supervised classification and decision tree method may improve the accuracy of water surface boundary extraction, however it increases the difficulty and efficiency of the method at the same time. Zhang et al. (2017) proposed an automatic threshold determination method based on the LBV (L, the general radiance level; B, the visible–infrared radiation balance; V, the radiance variation vector between bands) transformation of Landsat 8 OLI surface reflectance images. It was verified as an accurate, simple, and robust method for surface water extraction. However, the cloud pixels and atmospheric correction influences ~~are~~ were not considered.

China is one of the countries that have the highest densities of ~~China is one of the most~~ rivers and lakes in the world. There are more than 1500 rivers with an area exceeding 1000 km^2, ~~and~~ 2928 lakes with an area larger than 1 km^2 and giving in a total surface water area of 91,020 km^2 (Ma et al. 2011). However, ~~due~~ owing to the influence of climate, geography and ~~monsoon climate~~landscape of the country, these surface water resources are ~~very~~ unevenly ~~in~~ distributed~~ion~~. They are found more in the South than in the North, and more in the East than in the West. With the development of the economy, the increase in the demand for industrial, agricultural and domestic water has ~~brought~~ placed great pressure to these surface water systems, especially during the irrigation and drought season (Gong et al., 2011; Barnett et al., 2015). ~~However, until now, there exists no single data set that can fully reflect both the spatial distribution characteristics and time variations of surface water in China. So the research to investigate the relationship between the national surface water and the global climate and human activities is limited.~~Therefore, there is an urgent need for spatio-temporal continuous surface water datasets to support the efficient and robust management of water resources, and to investigate the relationship between the national surface water and the global climate and human activities. However, until now, full public sharing data products with moderate spatial resolution and near-daily temporal resolution are still lacking in China.

~~Therefore, i~~In order to address these limitations and to fulfill the ~~research~~ need to develop a comprehensive spatio-temporal dataset~~ both spatially and temporally~~, this paper presents the Inland Surface Water Dataset in China (ISWDC) during the period of 2000-2016 (and will be continuously updated for the subsequent years on zenodo platform), which is derived from the 8-day and 250 m spatial resolution MODIS MOD09Q1 product. After recalling the methodology used in surface water mapping from the MODIS MOD09Q1 as described by Lu et al. (2017), the precision and accuracy of the ~~data set~~dataset are reported, including the cross comparison with ~~other~~ existing national and global ~~data set~~datasets.

2 Study area and data

The inland water of this ~~data set~~dataset refers to ~~the~~ a water body larger than 0.0625 km^2 of the terrestrial land of China. The MODIS MOD09Q1 imagery has been used to extract surface water (https://ladsweb.modaps.eosdis.nasa.gov/search/). MOD09Q1 is a MODIS level 3 land surface reflectance product. It is an 8~~-~~-day synthetic imagery of Band 1 (red band) and Band 2 (near-infrared band) with the spatial resolution of 250 m. In this study the near-infrared band is directly used to extract the surface water. There are 22 scenes covering the whole territory of China for every single date in a form of mosaic. For the complete temporal coverage from February 24, 2000 to December 26, 2016, total 16698 images were used. The SRTM (Shuttle Radar Topography Mission) DEM data with 90 m spatial resolution is used as ~~an~~ ancillary data for surface water extraction, which is jointly measured by NASA-JPL (NASA Jet Propulsion Laboratory) and NIMA (National Imagery and Mapping Agency (Slater et al., 2006).

Two types of reference ~~data set~~dataset are used for cross comparison. The first ~~one~~ is a ~~–~~derived sub-dataset of surface water from China national 30 m land cover ~~data set~~dataset of 2000, 2005 and 2010 (Liu et al., 2014; Wu et al. 2017). The second ~~one~~ is the global surface water (GSW) at 30 meter resolution for 2000-2015 produced by Pekel et al. (2016).

3 Methods

The ~~single band one by one water body~~ threshold segmentation method proposed by Lu et al. (2017) which employs single band with one-by-one segmentation of water bodies is used to extract the surface water boundary, which includes four steps: interferences removal, preliminary water surface mapping, annual water surface mask acquisition, and water surface boundary extraction (Figure 1). In this study the last two steps of the method are updated and improved as in following sections 3.1 and 3.2~~:~~.

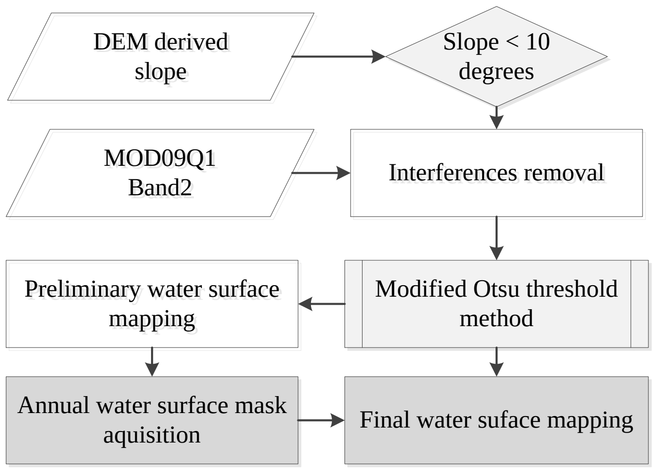


Figure 1 Flowchart of the water surface extraction method reference to Lu et al. (2017)

3.1 Annual water surface mask acquisition

The water surface mask is a key input data for excluding land disturbance factors that affect the extraction of the water surface boundary. It is generated from the preliminary water surface mapping results based on the modified Otsu threshold method applied on the selected images having lesser cloud cover and better quality in each year~~, by applying modified Otsu threshold method~~ (Lu et al., 2017). In order to eliminate error in water area information caused by the cloud and cloud shadow~~s~~ in this process, the determination probability (p) parameter is used based on the fact that the cloud and its shadow will not appear in the same position ~~over longer time periods~~for several days. The equation is as follows,

$$\cancel{if}\ \sum_{i=1}^{n} d_i \geq n \times p, D=1$$

where n is the number of the preliminary water surface mapping images, d_i is the pixel value of image i, D is the pixel value of the annual water surface mask, p is the determination probability for identifying water pixel. ~~Table 1 shows the images used for annual water surface mask generation and the determination probability for each year, which were visually selected and determined based on the size of the water bodies and the ratio of the cloud cover in the whole image. The images with relatively larger water body areas and little cloud cover were finally chosen. The determination probability (p) was determined based on the cloud and its shadow elimination effect (Lu et al., 2017).~~ In this study the reference images from 2013 to 2016 were selected and the determination probability (p) was determined based on the same rule with Lu et al. (2017). Furthermore, the annual reference images and determination probability (p) of 2000-2012 are directly used here because they were originally obtained based on the whole images of China.

Table 1 ~~the~~ The images used for annual water surface mask generation and the determination probability each year

Year	Selected 8-day image dates (DOY)	Determination probability (p)
2000	185、201、209、233、241、249、257、265、281、305	0.2
2001	185、193、201、233、241、249、257、265、273、281	0.2
2002	185、193、209、217、225、233、241、249、257、265	0.2
2003	177、193、201、209、217、233、249、257、265、289	0.3
2004	185、201、217、225、233、249、257、265、273、281	0.2
2005	209、217、225、233、241、249、257、265、273、281	0.2
2006	137、145、169、177、185、193、201、209	0.2
2007	185、193、201、209、217、225、233、241、257、265	0.3
2008	193、201、209、225、233、241、249、257、265、273	0.3
2009	129、137、153、169、185、193、201、233、241、249	0.3
2010	185、209、217、225、233、241、249、257、273、281	0.2
2011	161、169、177、185、201、209、217、225、233、265	0.2
2012	185、201、209、217、225、233、241、257、265、273	0.2
2013	185、193、201、209、217、225、233、249、257、281	0.2
2014	193、201、209、225、233、241、249、265、257 、273	0.3
2015	201、209、217、241、249、257、265、273、281、28	0.2
2016	193、209、225、241、257、265、273、289、305	0.2

3.2 ~~Water surface boundary extraction~~Final water surface mapping

Before determining the threshold value for each water body in the final step of the water surface extraction method (Lu et al., 2017), the average pixel value in the mask area is used to eliminate the influence of the land pixels ~~(Lu et al., 2017)~~. Although this ~~method~~ way can improve the accuracy of water surface extraction, the average pixel value in different season will also be different. In order to optimize this process~~solve this problem~~, 423 sample lakes and rivers in different regions of the country are selected (Figure 2) to obtain the reference average pixel value in different season. Two images with lesser clouds are selected for each season in each year, and the average pixel values ~~of~~ for spring, summer, and autumn are calculated based on the water body samples. They were used as the upper limit threshold for ~~extracting the water surface boundaries~~ determining the pixel value range for the final step of water surface mapping. In the process of water turning into ice in winter, the pixel value of ice is higher than that of water, and it accounts for a large proportion.~~Due to the smaller difference between the pixel values of ice layer and the water surface in winter,~~ ~~t~~The average pixel value will cause the ice layer to be extracted as the water surface, the minimum pixel value of the samples are used as the upper limit threshold for water surface ~~boundary extraction~~mapping in winter. Finally, based on the upper limit thresholds in different seasons each year, the final binary water surface images of different time period are obtained by using the modified Otsu threshold method again (Lu et al., 2017).

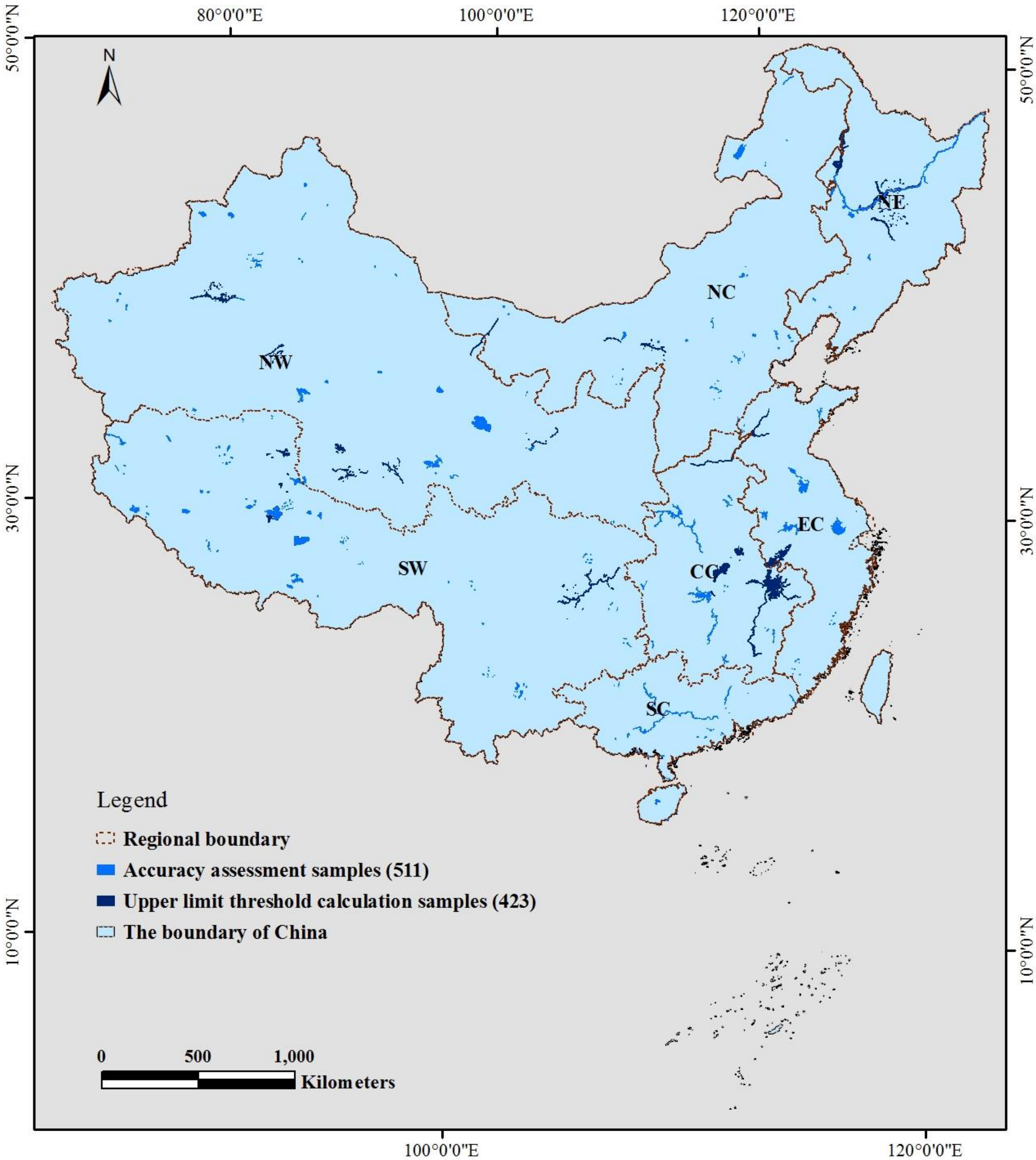


Figure 2 The boundary of China, the accuracy assessment and the upper limit threshold calculation samples for surface water extraction. NW: Northwest China, SW: Southwest China, SC: South China, CC: Central China; NC: North China, NE: Northeast China, EC: East China.

4 Accuracy assessment

4.1 Comparison with the national land cover ~~data set~~dataset

Based on the 30 m resolution national land cover ~~data set~~dataset of 2000, 2005, and 2010, 511 ~~lake and river~~ samples from lakes and rivers spreading out across the country~~different regions~~ are selected as ground truth data (Figure 2), including 11 very large water bodies with areas larger than 1000 km^2, 12 large water bodies with areas larger than 500 km^2 and lesser than 1000 km^2, 29 medium sized water bodies with area larger than 100 km^2 and lesser than 500 km^2, and 459 smaller water bodies with areas lesser than 100 km^2. They were compared with the maximum ISWDC in the corresponding years.

The results show~~s~~ that the ISWDC are ~~in~~ highly consistent~~cy~~ with the reference land cover derived surface water data. The determinant coefficients (R^2) in 2000, 2005 and 2010 are found 0.9974, 0.992, and 0.9932, respectively ~~is~~as shown in ~~f~~Figure 3~~respectively (Figure 3)~~. The confusion matrix analysis results show that the average user accuracy is 91.13%, the average producer accuracy is 88.95%, and the average Kappa coefficient is 0.88 in three years (Table 2).

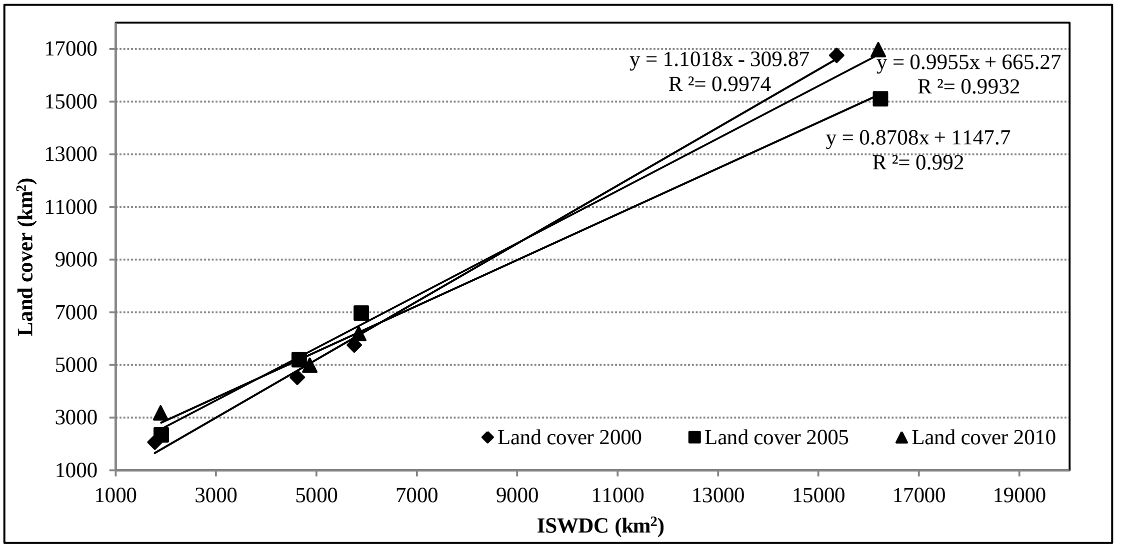


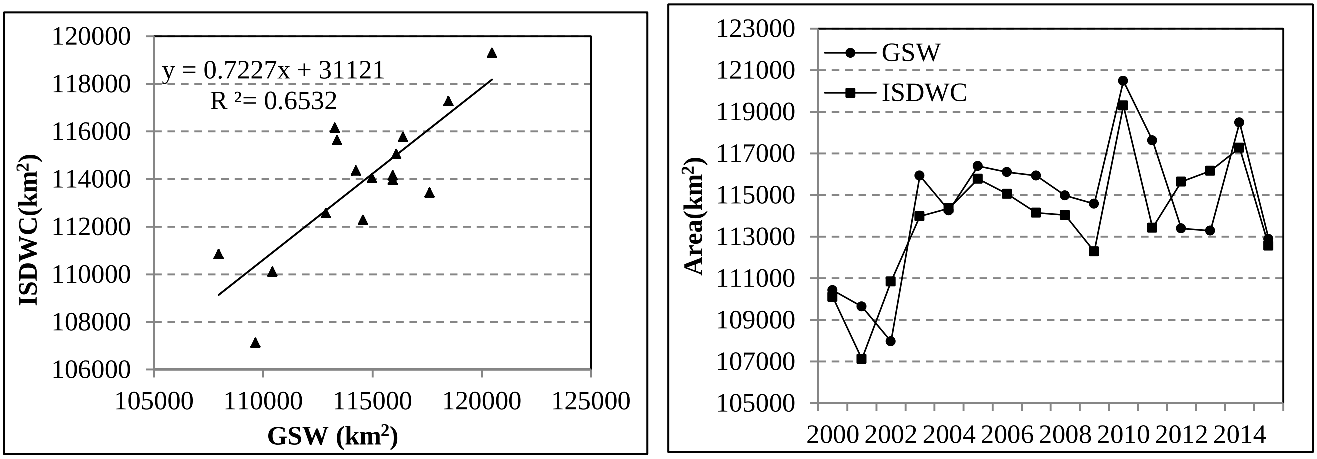
Figure 3 Comparison of the total area of surface water body samples with different size (< 100 km^2, 100-500 km^2, 500-1000 km^2, >1000 km^2) between ISWDC and the National land cover derived surface water data.

Table 2 Accuracy analysis samples in different region and the assess results

Sample regions	Sample water bodies				
	Very large	Large	Medium	Small	Total
North China (NC)	1	1	1	73	76
Northeast China (NE)	1	2	2	21	26
East China (EC)	2	1	3	34	40
Southwest China (SW)	2	3	5	75	85
Northwest China (NW)	2	2	13	166	183
Central China (CC)	2	1	2	46	51
South China (SC)	1	2	3	44	50
Average user accuracy	96.14	94.75	93.69	79.96	91.13
Average producer accuracy	92.64	88.87	92.69	81.60	88.95
Average Kappa coefficient	0.94	0.93	0.93	0.72	0.88

4.2 Assessment against the global surface water ~~data set~~dataset

The time series of annual ISWDC and GSW permanent water bodies of whole China ~~in~~from 2000-2015 were also compared. The results show that the two datasets ~~also have~~possess very good consistency (Figure 4a) and very similar ~~rules~~change dynamics ~~of change process~~ (Figure 4b). The annual ISWDC and GSW permanent water bodies with area larger than 0.0625 km^2 in 2015~~ are presented in Figure 4. Our results~~ also indicate similar spatial patterns in different regions (Figure 5). For the lake groups in central Qinghai-Tibetan Plateau, the comparison between ISWDC obtained from MODIS and Landsat derived GSW indicated a closer pattern between the two results (Figure ~~4a~~5a). For the rivers and lakes interlaced with Poyang Lake region, in addition to the narrow width of the river and some small water bodies, the coincidence between the two ~~data set~~datasets is also very high (Figure ~~4b~~5b). The over-extracted water (red regions in Figure ~~4~~5) on the margins for large water bodies like Siling Co, Namco, Poyang Lake, and some of the wide rivers, and the under-extracted slender rivers and small water bodies (green regions in Figure ~~4~~5), for the ISWDC ~~data set~~dataset, are mainly caused by the mixed pixel effects due to relatively coarse spatial resolution of the MODIS images.



（a） (b)

Figure 4 Comparison of the time series annual ISWDC and GSW permanent water bodies of whole China ~~in~~from 2000-2015. (a) is the correlation analysis result, (b) is the change trend comparison result.

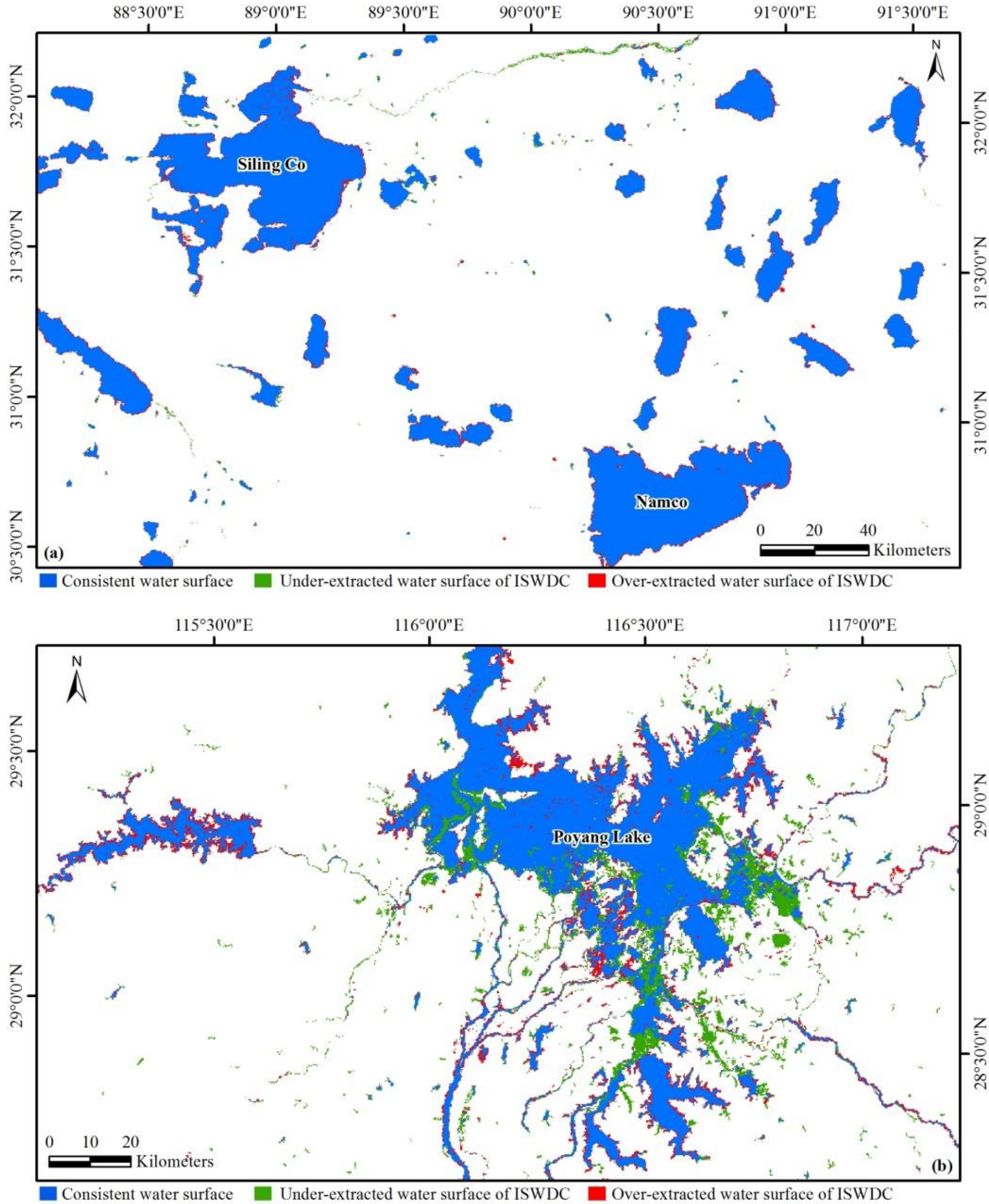


Figure ~~4~~ 5 Comparison of permanent water bodies derived from ISWDC and GSW over the sites of the central Qinghai-Tibetan Plateau (a) and Poyang Lake region (b).

5 Applications and data availability

5.1 Time series of surface water ~~data set~~dataset applications

~~The t~~Time series of ~~the~~ surface water ~~data set~~dataset can be used to analyze the inter-annual and seasonal variation characteristics of surface water area, ~~such as~~including inter-annual variation trend, abrupt change time, intra-annual hydrological process monitoring ~~and so on~~etc. (Huang et al., 2018; Xing et al., 2018). Similarly, it can also be used as~~ a~~ cross-validation reference data for global surface water ~~data set~~datasets ~~–~~with similar spatial resolution (Klein et al., 2017), and as a key input parameter for regional and global hydro-climatic model~~s'~~ calibration and evaluation (Khan et al., 2011; Stacke and Hagemann, 2012).

~~In addition, t~~For example, based on the ISWDC from 2000-2016, the annual variation of surface water in China can be ~~clearly obtained,~~obtained by superimposing all the 8-day time series water surface area data of each year. Figure 6 shows that the surface water area began to increase in early March and increased gradually in spring and summer. After reached its peak in autumn, it then began to decrease gradually. The annual variation of surface water area in different regions can also be portrayed by calculating the multi-year average of every 8-day data. Figure 7 shows that the surface water area of Southwest China (SW) and Northwest China (NW) is very large and inter-seasonally it varies greatly than the surface water area of other regions. Surface water area in Northeast China (NE) began to increase rapidly in spring. It reached a peak in May and decreased slightly in June-July. After reaching~~ed~~ its maximum in August-September, it began to decline again in October. In North China (NC), surface water area is relatively small, but the change still shows ~~a strong~~some seasonality. There is a significant increase in summer and autumn, but the range of increase and decrease is relatively small. Surface water area in Central China (CC) and Eastern China (EC) varies steadily during the year. It reaches its maximum in summer and begins to decrease gradually in late summer and early autumn. Surface water area in South China (SC) was relatively stable throughout the year. ~~he time series of~~

~~water surface data can also be used to delineate the annual variation of surface water, such as the annual maximum and minimum water surface occurrence time (Figure 5) and lake freezing and thawing process (Figure 6).~~

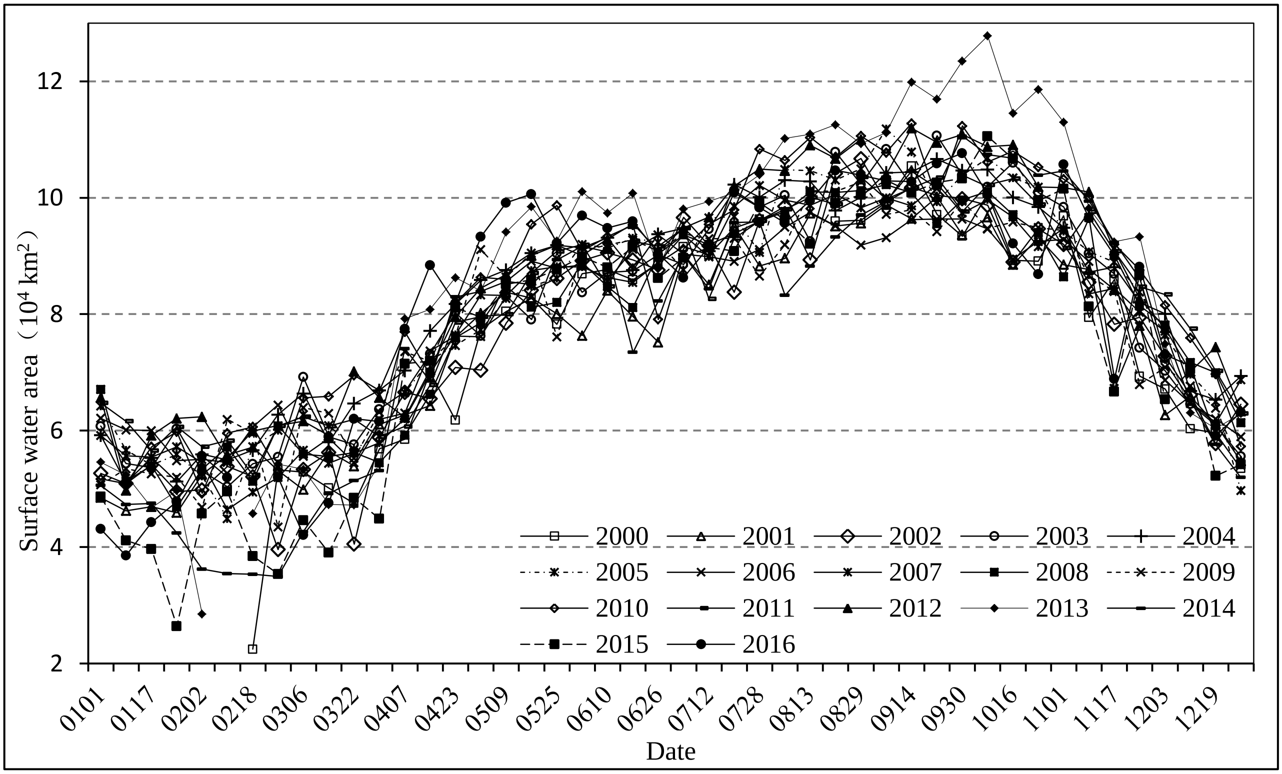


Figure 6 Annual change of total water area during the period of 2000-2016.

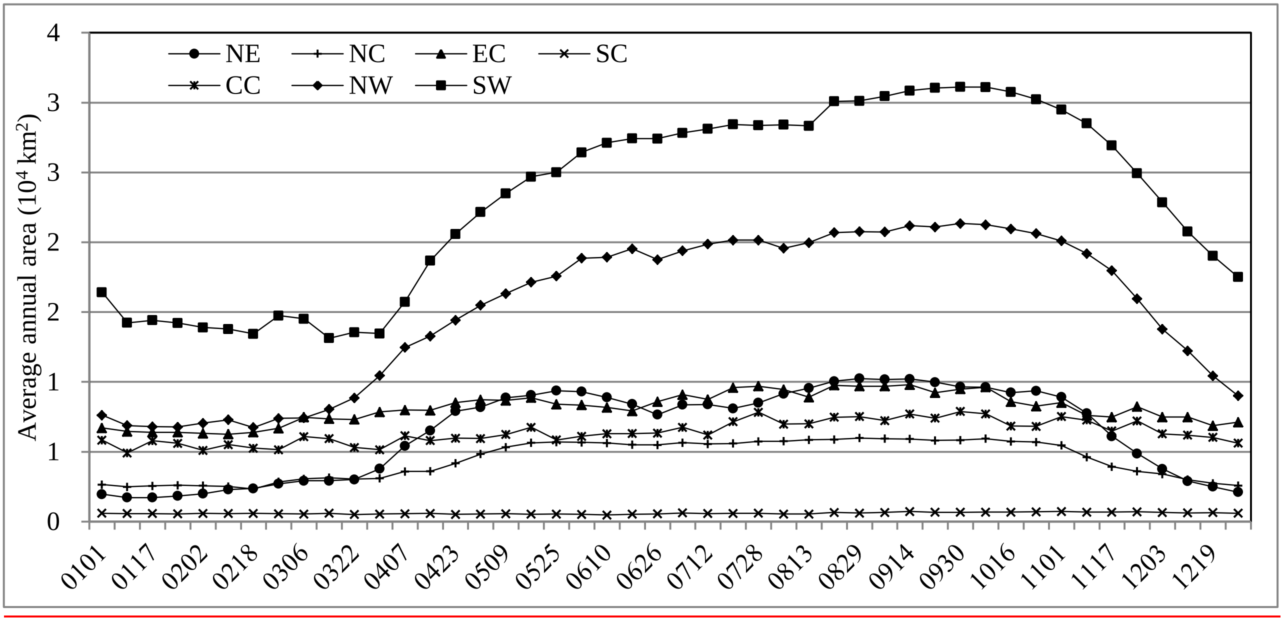


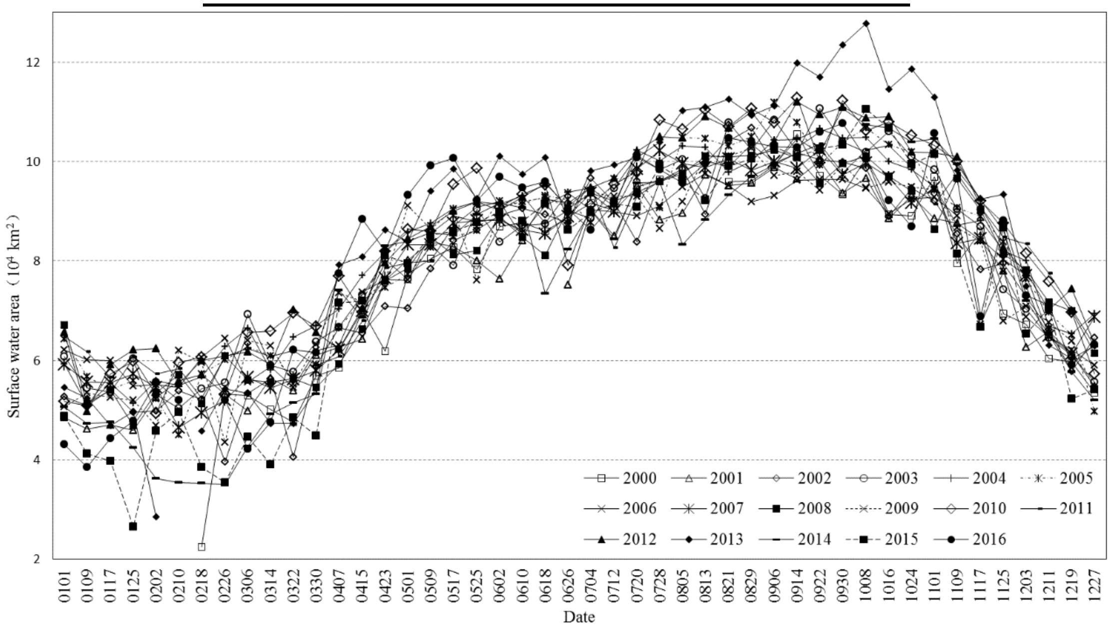
Figure 7 Average annual 8-day surface water area of different regions of China from 2000 to 2016. NE: Northeast China, NC: North China, EC: East China, SC: South China, CC: Central China, NW: Northwest China, SW: Southwest China.

Furthermore, ~~Based on the ISDWC from 2000-2016,~~ the spatial distributions of surface water can ~~be~~ clearly be depicted by means of multi-year average analysis. The results in Table 3 show that surface water of inland China is mainly distributed in ~~the~~ western China, accounting for 49.13% of the total surface water area, with 29.88% in the Southwest China (SW) and 19.25% in the Northwest China (NW), followed by the Central China (CC) and East China (EC), which accounted for 8.13% and 24.78% of the total surface water area, respectively. The North China (NC), Northeast China (NE) and South China (SC) account for the other 17.96% of the national surface water area.

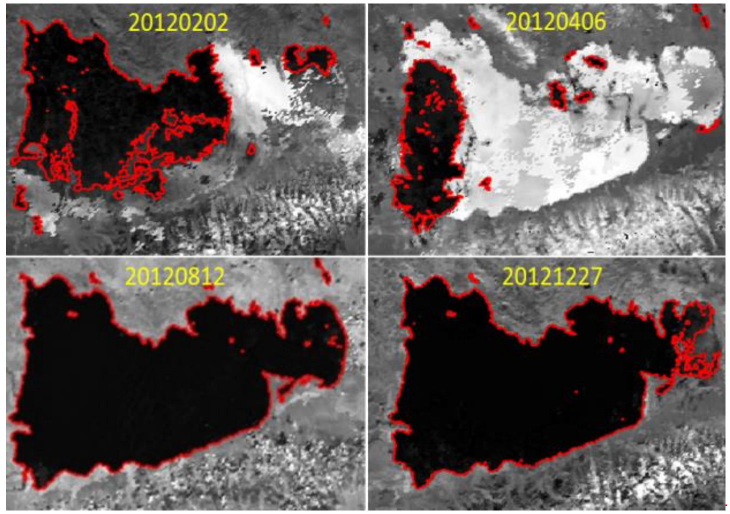
Table 3 The average distribution of surface water area in inland China ~~in~~ from 2000-2016

Regions	Area(km^2)	Area percentage (%)
North China (NC)	6250.6	6.11
Northeast China (NE)	8991.3	8.79

East China (EC)	25342.3	24.78
Central China (CC)	9313.4	8.13
South China (SC)	3126.0	3.06
Southwest China (SW)	30548.6	29.88
Northwest China (NW)	19680.2	19.25
Total	103252.3	100.00



~~**Figure 5 Annual change of total water area during the period of 2000-2016.**~~



~~**Figure 6 Freezing and thawing condition in different dates of Namco Lake in 2012**~~

5.2 Data availability

The ISWDC ~~data set~~dataset is distributed under a Creative Commons Attribution 4.0 License. The data may be downloaded from the data repository Zenodo at http://doi.org/10.5281/zenodo.2616035~~http://doi.org/10.5281/zenodo.1463694~~ (Lu et al., ~~2018~~2019). In each 8-day surface water image, the pixel values of 1 and 0 represent the water and the background respectively. The 8-day data in each month can be used to calculate the monthly water occurrence and all the 8-day data in each year can be used to calculate the yearly water occurrence, by summing up all the surface water images together in corresponding time periods. The vector datasets of the 8-day surface water boundaries extracted from the raster data products can also be obtained through the same link.

6. Discussion and ~~Conclusions~~conclusions

In this study, the 8-day 250-meter resolution surface water ~~data set~~dataset of inland China (ISWDC) from 2000 to 2016 ~~was~~ has been introduced. It is a fully public sharing data product with prominent features of long time series, moderate spatial resolution and high temporal resolution.~~consistent spatial~~

~~resolution, which and~~The ISWDC is a ~~very good~~valuable basic data source for the analysis of the dynamic changes of surface water in China ~~and regions~~ in the past 20 years.~~solves the problem of lack of surface water area data set with long time series in China~~.

The accuracy analysis results show that the ISWDC ~~are in~~is highly consisten~~cy~~ with the national land cover derived surface water data ~~in~~ from 2000, 2005 and 2010, with the determinant coefficients (R^2) of 0.9974, 0.992, and 0.9932 respectively. The average user accuracy is 91.13%, the average producer accuracy is 88.95%, and the average Kappa coefficient is 0.88 ~~in~~ for these three years. Furthermore, in terms of temporal variation, the ISWDC and the GWS ~~have~~possess ~~very good~~excellent consistency and very similar ~~rules~~change dynamics ~~of change process~~ during the whole time period, which simply shows that both datasets are highly correlated. For the spatial distribution characteristics, the ISWDC in 2015 has similar spatial patterns in different regions (including the central Qinghai-Tibetan Plateau and Poyang Lake region) to that of the GSW dataset, especially for larger water bodies (such as lakes, water reservoirs and wide rivers). ~~and Poyang Lake region) with the GSW data set, especially for the large water bodies (as lakes and reservoirs) and the wide rivers.~~

Based on the ISWDC for ~~of~~ 2000-2016, the spatial distribution characteristics and temporal variation processes of surface water can be described through the multi-year average spatial statistics and annual data overlapping analysis. In addition, the ~~data set~~dataset can also be used as a cross-validation reference data for other global surface water ~~data set~~datasets, and a key input parameter for regional and global hydro-climatic models.

~~Because~~As ISWDC only uses MODIS MOD09Q1 near-infrared band ~~is used~~ for water surface extraction ~~in this method~~, thus the accuracy of datasets depends mainly on the quality of the original 8-day synthetic images. When there are clouds exist in the water distribution region in the synthetic image at a certain time, the cloud covered water surface will not be extracted ~~and~~which causes underestimation for ~~the results~~extracting water bodies ~~will be caused~~. In addition, the reference images used to produce the annual water surface mask will also affect the accuracy of the final results~~ accuracy~~. For example, if the selected image does not contain the information of the actual maximum water surface occurrence in that year, it may lead to the exclusion of that part of the water pixels which lies outside the mask. Furthermore, because of the small difference of reflectance between the ice-water mixing boundary in autumn and spring, the accuracy of water surface area extraction will be limited in these two seasons.

Although the water surface extraction method designed in this study is aimed at extracting water surface information from the MODIS MOD09Q1 images, its core process is automatic thresholding for estimation of water bodies~~y~~ one by one. Therefore, this method is also applicable to traditional water body indices~~ex~~, such as NDWI, MNDWI and AWEI, or to other water surface information based on enhanced thematic data. In the future, while continuing to extend the existing datasets from 2017 to now by using this method, the 30-meter GWS dataset in China will be extended. At the same time, the national 10-meter spatial resolution water surface dataset based on Sentinel-2 imagery will be produced. After the national scale datasets are completed, the corresponding global scale datasets are also expected.

Author contributions. SL supervised the downloading and processing of satellite images and designed the methodology. JM contributed to downloading, processing satellite images, and extracting the surface water data (~~ISDWC~~ISWDC). XM extracted the reference surface water data from the national land cover ~~data set~~datasets and analyzed the accuracy of the ~~ISDWC~~ISWDC. HT extracted the Global Surface Water (GSW) from the Google Earth Engine platform. HL made contribution for manuscript structure design and revision. MHAB optimized article structure, figures and English grammar. All authors have read and approved the final paper.

Acknowledgements. We thank ~~the Key Program of the National Natural Science Foundation of China (91637209),~~ the National Key Research and Development Program of China (2017YFC0405802, 2016YFC0503507-03), the Key

Program of the National Natural Science Foundation of China (91637209), the project of China geological survey (DD20160106), and the Strategic Priority Research Program of the Chinese Academy of Sciences (XDA19070201) for financial support. We thank NASA EOSDIS LAADS DAAC platform (https://ladsweb.modaps.eosdis.nasa.gov/) and NASA-JPL and NIMA for providing the MODIS and SRTM ~~data set~~datasets. We also thank JRC and Google Earth Engine (https://earthengine.google.com) for providing the Global Surface Water (GSW) ~~data set~~dataset.

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