TM Water Area Revision Based On MODIS Time Series Data

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Abstract: It is meaningless to compare global land surface water area of two periods directly considering that TM images are mono-temporal and water products interpreted only reflect water distribution at some certain moment. Due to the large inter-annual and seasonal variation of water, there exist dry season, normal river flow periods and high water season. It is essential that we should adjust the global water products of two periods to the same period simultaneously, and then talk about variations between two periods' water products. There are different phase variations in two periods' water products interpreted at the same place. Therefore, we used MODIS time series data to make related analysis and interpolate temporal information.

Keywords: two periods' data · water area revision · MODIS time series data

1.1 Introduction

To make a comparison between global land surface water area of two periods based on 30m resolution TM images, we should revise data and take water seasonal variation into consideration. It mainly dues to:(1)In the global scale of year 2000 and year 2010,we cannot

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acquire the Landsat.TM images in the same date;(2)It is irrational to compare water area extracted from TM images directly as the actual land surface water area was closely related to weather conditions at that time.

1.2 TM Water Area Revision

1.2.1 MODIS Water Extraction Method

Generally speaking, water reflectance is small and it declines while wavelength increasing. Researchers have put forward different methods to extract water according to water characteristic. Yan[1] raised a method, with MODIS data, which used NDWI, Snow Index and visible spectrum, near-infrared multichannel information to extract water pixels and mixed pixels in research region gradually. Liu[2] made use of modified linear decomposition of mixed pixels method to extract water based on MODIS reflectance data, and combined MODIS temperature product and DEM of SRTM to correct influence the shadow made on extraction. Ding[3] used spectrum-photometric method to extract water from MODIS images, and its extraction was faster than NDVI method.

This paper adopted K-Means clustering method to process 500m resolution MODIS 8 days synthetic reflectance data MOD09A1,and pick out spectrum cluster with water characteristic.(data source: https://wist.echo.nasa.gov/api/)

1.2.2 MODIS Data Revise Ideas

With well temporal resolution, the visit cycle of MODIS synthetic reflectance data MOD09A1 is 8 days. Namely it can explore any place on the earth repeatedly every 8 days. Therefore we could use the well temporal resolution to remedy temporal discontinuity and large time phase diversity of TM data at the same place.

In the Koppen-Geiger climate classification, as Fig.1.1 shows, due to similar climate condition in the same climatic zone, we deemed seasonal variation of water area alike in the same climatic zone. We took annual average value A_M of water area as revise datum in each climatic zone. As for MODIS images, corresponding water area of MODIS at the moment t

when TM images acquired was A_t^{MODIS} ,then correction coefficient was $K_t = A_M^{MODIS} / A_t^{MODIS}$ .Here we considered that correction coefficient calculated from MODIS was identical to it from TM at the same place. And now we could revise TM images by calculating MODIS correction coefficient, in the meanwhile, considering the identical correction coefficient in the same climatic zone.

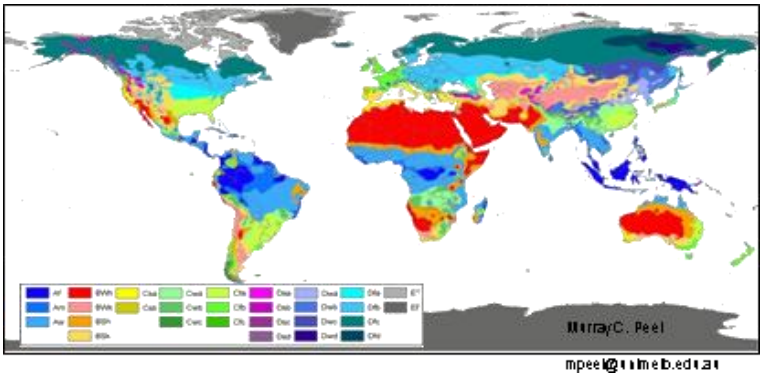

Fig.1.1 Koppen-Geiger climate classification

1.3 Experimental Procedure

①Clipping the water achievements extracted from MODIS reference to TM single scene coverage area according to the Landsat path/row numbers;

②Counting the total area of TM water achievements (exclude water area less than 0.25km^2) and MODIS water achievements (40/46 time interval) respectively in the same clipping area;

③Revising TM water area according to the formulas as follows (revise to annual average water area):

$$K_t = A_M^{MODIS} / A_t^{MODIS} \qquad (1.1)$$

$$\bar{A}_t^{TM} = A_t^{TM} \times K_t = A_t^{TM} \times A_M^{MODIS} / A_t^{MODIS} \qquad (1.2)$$

where t is the moment when TM images acquired. Water area derived from TM images is A_t^{TM}, water area derived from MODIS images is A_t^{MODIS}, the annual average water area derived from MODIS images is A_M^{MODIS}, correction coefficient is K_t, TM water area after revising is $\bar{A}_t^{TM}$.

1.4 MODIS Data Revise Flow

The MODIS data revise flow is as follows:

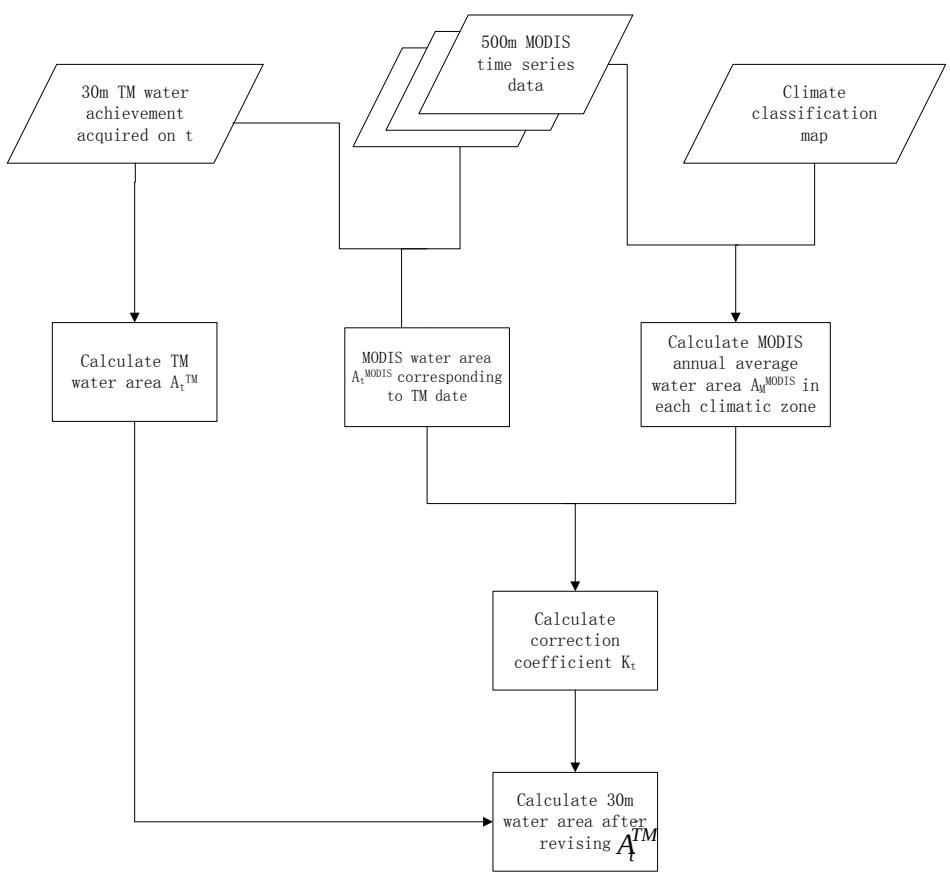

Fig.1.2 Flow of MODIS water achievements revising TM water achievements

Water extraction of MODIS 8 days reflectance data sketch is as follows:

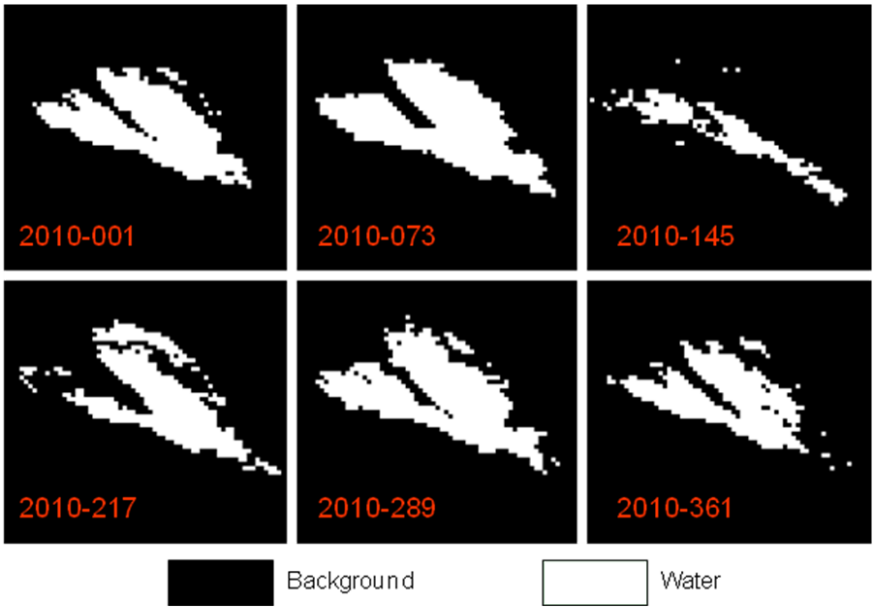

Fig.1.3 Water extraction of MODIS 8 days reflectance data sketch

1.5 Experimental Process

It occurred that there was no images during a periods of time or no water could be extracted on the corresponding TM date when acquiring and interpreting MODIS data. Therefore, it came out no correction coefficient. When dealing with 6968 scenes TM data of year 2000, 5960 of them got correction coefficients. When dealing with 6917 scenes TM data of year 2010, 5545 of them got correction coefficients. As for TM data with no correction coefficients, we took K=1.

The MODIS calculation of every 8 other days corresponding TM date at the same Landsat path/row is as follows:

Table 1.1 Difference between MODID data and TM data at the same place

Landsat (path/row)	TM data acquiring time	TM whole scene water area（exclude water area less than 0.25km^2）	MODIS001 water area	MODIS009 water area	…	MODIS361 water area
114027	20010925	16.55	15.44	14.25	…	15.56
115013	19990826	88.34	76.89	91.46		85.67
116042	20001210	120.28	105.70	98.11	…	110.39
…	…	…	…	…	…	…

We can see that from Table 1.1, the water area calculated from MODIS images always vary within a certain range around water area calculated from TM images. Therefore, we can depict the relation curve of water area extracted from TM data, water area extracted from MODIS data and MODIS annual average water area. It shows as Fig.1.4:

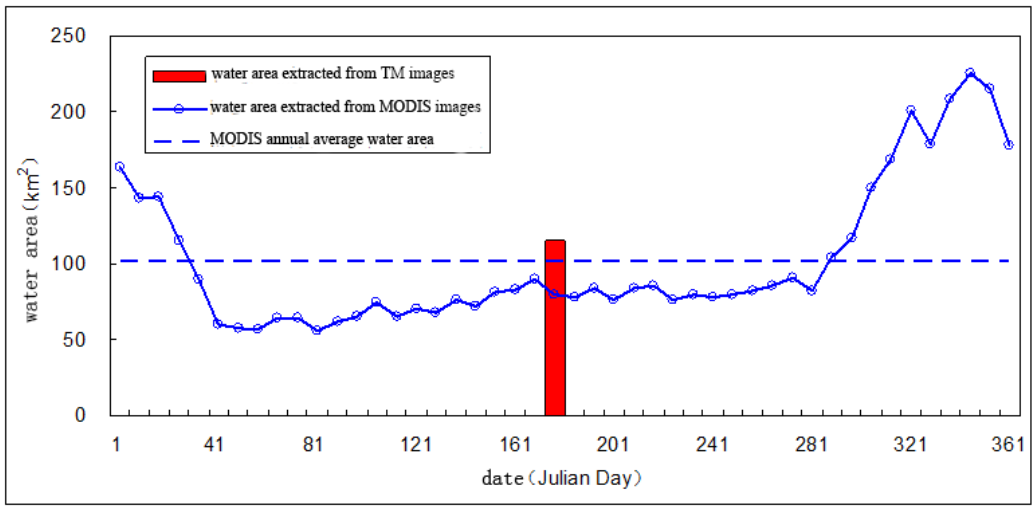

Fig.1.4 MODIS data revise sketch

①Picking out 485/485 images with the same path and row numbers respectively from two periods' TM data;

②According to the two periods' TM data, we had extracted water from 245/245 MODIS images of year 2000 and year 2010;

③There were 221/221 MODIS images with the same path and row numbers of the two periods in the above 245/245 MODIS images;

④Excluding images where correction coefficients were larger than 2.0, there remained 196 MODIS images;

⑤After area revising, the result is as follows:

Table 1.2 TM water area revision before and after comparison

Map sheet numbers	Year 2000 TM water area before revising（km^2）	Year 2000 TM water area after revising（km^2）	Year 2010 TM water area before revising（km^2）	Year 2010 TM water area after revising（km^2）
221	121220.65	102527.86	123157.98	106893.89
196	110867.93	100707.72	112993.52	101198.52

⑥The water area, extracted from TM images and MODIS images respectively, are shown in Fig 1.5 and Fig 1.6 by comparison(exclude TM water area polygons less than 0.25km^2).

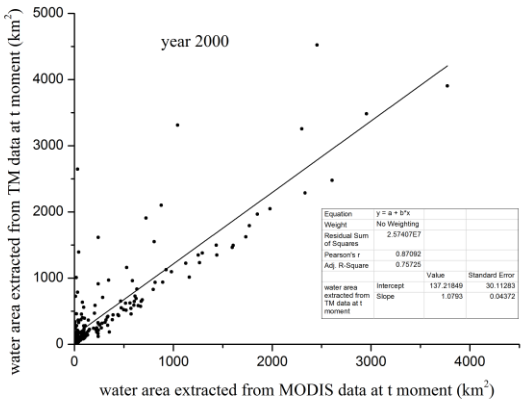

Fig.1.5 Comparison between TM and MODIS water extraction of year 2000

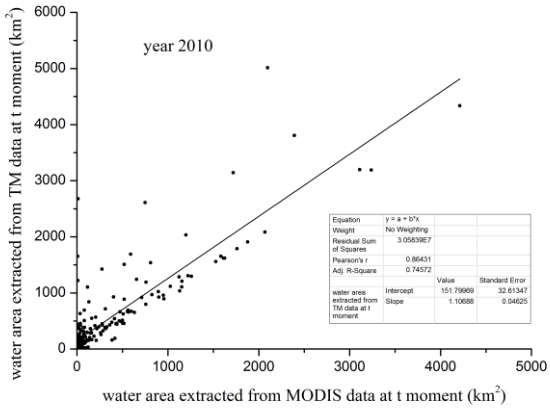

Fig.1.6 Comparison between TM and MODIS water extraction of year 2010

We conclude from the linear-regression analysis results shown as Fig.1.5 and Fig.1.6 that the results mainly focus on the range within 1000km^2, and appear well correlation from 200 km^2 to 750 km^2.Over all, correction coefficient of two periods are around 0.75, which indicates common correlation between water area extracted from TM images and that from MODIS images.

1.6 Conclusions

With two periods' MODIS data .this paper has discussed the relationship between mono-temporal TM images and long time series MODIS images. Even though there exist some questions in the practical operation, we have confirmed the correction relationship between TM images and MODIS images. It can be concluded as follows:

①Revise two periods' TM images to the annual average level with correction coefficient reference to MODIS time series data, and compare two periods' data after revising;

②As Table 1.2 shows, water area after revising is less than that before revising in some extent. Water area after revising reflects annual average level. In the actual selected region, water area of year 2010 after revising is larger than water area of year 2000 after revising by comparison;

③As for some certain regions, such as Poyang Lake, we can see its continuous change intuitively through MODIS time series data, and infer its dry season or wet season, which will provide precious information for research on Poyang Lake;

④This paper demonstrates not only the interoperability and relevance of data under different spatial scale, but also the feasibility to revise 30m resolution data making use of 500m resolution data.

1.7 References

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