RETRIVAL OF TOTAL SUSPENDED MATTER (TSM) USING REMOTELY SENSED IMAGES IN SHITOUKOUMEN RESERVIOR, NORTHEAST CHINA

Kaishan Song[1], Lu Dongmei[2], Dianwei Liu[1], Zongming Wang[1], Lin Li[3], Bai Zhang[1], Yuandong Wang[1]

1.Northeast Institute of Geography and Agroecology, CAS, Changchun 130012, China;
2.Computer Science and Engineering College, JLIAE, Changchun, 130024, China;
3.Department of Earth Science,IUPUI, Indianapolis, IN 46202, USA
Phone +86-431-85542364 or email: songks@neigae.ac.cn

1. INTRODUCTION

The most common ecological problem of inland water bodies is anthropogenic eutrophication mostly as a result of economic development and indiscriminate discharge of untreated or poorly treated sewage[1]. It has become the most widespread water quality problem in China and many other countries as well. Water quality deterioration and eutrophication have received more and more attention from the public and government, and many studies have been carried out on lakes around the world to assess their water trophic state. Digital evaluation of optical satellite information at visible and near-infrared wavelengths has been used to estimate different parameters in surface waters[2]. These investigations show that Landsat TM or IRS-P6 data can provide relatively low-cost, simultaneous information on surface water conditions from numerous lakes within a large geographic area.

2. MATERIALS AND METHODOLOGY

Shitoukoumen Reservoir is the major water sources for Changchun and Jiutai county, in the Jilin province of Northeast China, which provide more than 80% of the drinking water for Changchun City with population of more than 3.5 million. The reservoirs locates between 125°43′48″~125°50′6″E, and 43°51′18″N~ 43°57′54″N. Shitoukoumen Reservoir has a storage of 702 million m^3, with its drainage area 4975.6km^2 and surface area 94.2km^2 respectively. Generally speaking, the water conditions meet the quality for drinking water supply, however, in recent years, serious soil erosion and water loss in the upstream was brought forth by vairous human activities, such as deforestation and agricultural development, thus resulting in the deterioration of water quality in the reservoir.

A 20-point sampling route was set up in Shitoukoumen Reservoir in advance with Differential Global Positioning System Promark2. Total 58 samples were collected in six times of field measurements from 2007 to 2008. Reflectance spectra were measured with a Field Spec FR spectroradiometer (Analytical Spectral Devices, Inc., USA). Radiance were measured for both the water surface (Lsw) and a standard white reference panel (Lp) approximately 1m above water surface. Then the spectroradiometer was rotated upwards by 90–120º to measure the skylight radiance (*L*sky). Immediately after measuring spectra, surface water samples were collected with a polyethylene bottle for further laboratory analysis of water parameters. Total suspended matter (TSM) was determined gravimetrically from samples collected on the precombusted and pre-weighted GF/F filters after rinsing with distilled water. The remote sensing reflectance *R*rs could be computed by:

$$R_{rs} = \frac{(L_{lw} - rL_{sky})\rho_p}{\pi L_p} \tag{1}$$

where *r* is the reflectivity of skylight at the air-water interface and a value of *r*=0.025 is acceptable when wind speed is less than 5m/s[1]; ρ_p represents the reflectance of the white reference panel, which has been accurately calibrated to 30%.

3. RESULT AND DISCUSSIONS

By correlation analysis between remote sensing reflectance and TSM concentrations, we find a negative relationship in the blue band owing to the absorption of Chl-a and CDOM, as well as TSM absorption, but all positive correlations in the rest bands[3]. There are two spectral bands where the best relationship exist (correlation coefficient at each wavelength is greater than 0.6), i.e., a broad scope from 675nm to 948nm with the highest correlation coefficient of 0.947 at 873nm and a narrow band of 1029–1105nm. These relationships serve to guide the selection of most appropriate wavelengths to estimate TSM concentrations in empirical models based on band ratios.

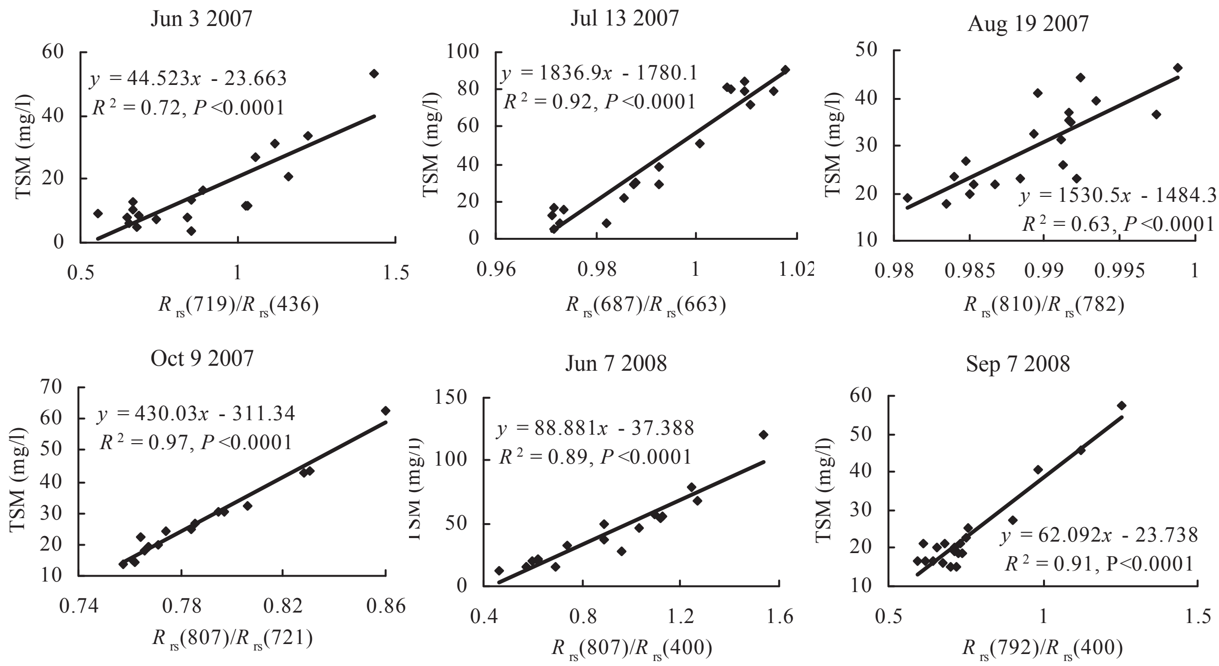

Fig.1 Curve fitting models for various month based on different band ratio combinations

In this study, a program was written to combine all the possible band ratios, the highest correlation band ratio were selected for the empirical model establishment. The best curve fitting models based on band ratios for each field sampling data were shown in Fig.1. It can be seen that the bands combination for the best fitting models are various from month to month. It indicate that the optimal band ratio for different month can be various due to the constituents variation from month to month caused by precipitation and soil erosions, which may as a result of the change by total suspended matter, CDOM and phytoplankton concentration[4].

Two cloud-free IRS-P6 images were selected for data analysis on the same days as our fieldwork being conducted. During the satellite passing data, weather conditions were adequate with a wind speed below 5 m s-1 and no cloud cover in the study area. Atmospheric correction was performed using the 6S model. The input to the 6S specifies geometrical, spectral, and atmospheric and target conditions, which were obtained from local weather stations. In order to extract the IRS-P6 data from the ground truth points (water sampling stations), the mean and standard deviation of IRS-P6 reflectance values were calculated using defined windows of 90 m × 90 m (4×4 pixel) for each ground truth point, and the mean value was used to establish the empirical models.

In this study, the correlation between in situ collected water TSM and IRS-P6 reflectance were listed in table.1 and table for July 13 2007 and September 7 2008, respectively. It can be seen that the band combination of Band4/band2 performs best for the July 13 2007 IRS-P6 images, and band4 also has a good relationship with TMS in this study. The similar result can be found from IRS-P6 images acquired on September 7 2008, also band4 performs the best for emperical models based on single band digital irradiance collected from satellite borne sensor. The scatter plot of the optimal regression model (Fig.2) final mapping result can be found in Fig.3, and it can be seen that there is obvious TSM distribution gradient in the Shitoukoumen Reservior.

Table.1 The correlation between various bands combination with TSM in July 2007

Band combination	*R*	Band combination	*R*	Band combination	*R*
band2	0.67	band3	0.80	band4	0.94
band4/band2	**0.97**	band4/band3	0.23	band3/band2	0.88
AVERAGE(2,3)	0.75	AVERAGE(2,4)	0.81	AVERAGE(3,4)	0.86
AVERAGE(2,3,4)	0.81	band2×band3	0.76	band2×band4	0.89
band3×band4	0.90	band2×band3×band4	0.87	band2-band3	-0.95
band2-band4	-0.04	band3-band4	0.56	band2-band3-band4	-0.96

Table.2 The correlation between various bands combination with TSM in September 2008

Band combination	*R*	Band combination	*R*	Band combination	*R*
band2	0.79	band3	0.87	band4	**0.95**
band4/band2	0.92	band4/band3	0.40	band3/band2	0.90
AVERAGE(2,3)	0.85	AVERAGE(2,4)	0.90	AVERAGE(3,4)	0.92
AVERAGE(2,3,4)	0.89	band2×band3	0.86	band2×band4	0.94
band3×band4	0.94	band2×band3×band4	0.93	band2-band3	-0.87
band2-band4	0.20	band3-band4	0.63	band2-band3-band4	-0.94

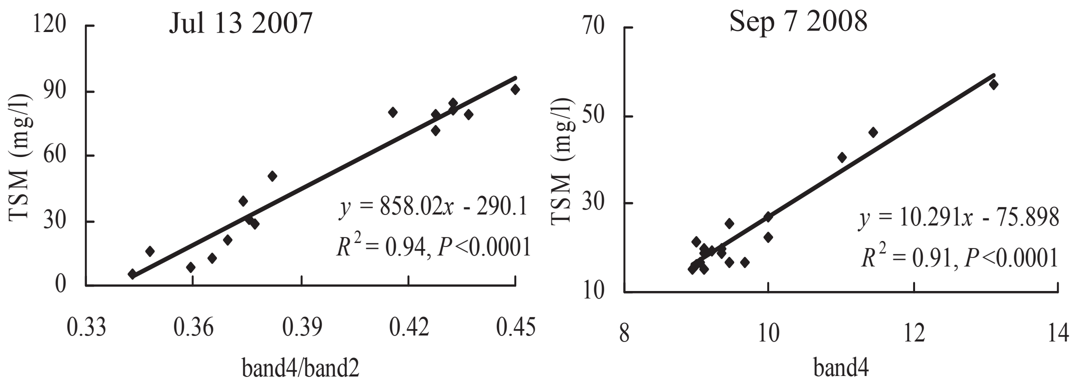

Fig.2 The scatterplot of band combination and TSM with IRS-P6 images

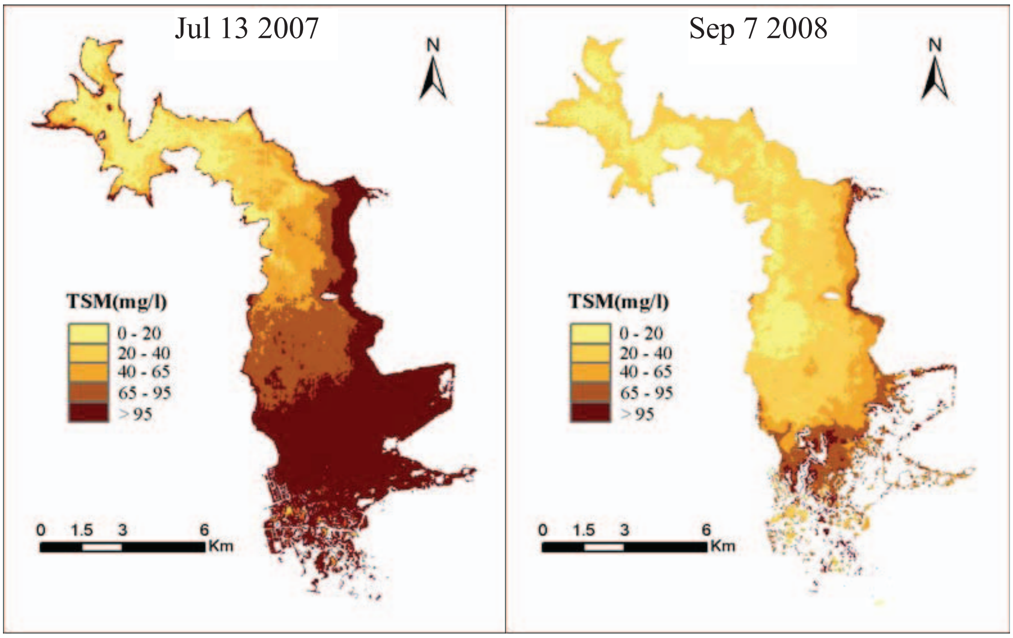

Fig. 3 the distribution of TSM derived from IRS-P6 images

4. REFERENCES

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