# RETRIEVAL OF WATER QUALITY FROM CHINA'S FIRST SATELLITE-BASED HYPERSPECTRAL IMAGER (HJ-1A HSI) DATA

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## ABSTRACT

A Micro-satellite Constellation for Monitoring and Forecasting Environment and Disaster was successfully launched in China on September 6, 2008. The Micro-satellite Constellation includes two small satellites, Satellite-A (abbreviated as HJ-1A) and Satellite-B (abbreviated as HJ-1B). On HJ-1A, a Hyperspectral Imager (abbreviated as HSI) is installed, which is China's first satellite-based hyperspectral remote sensor. It has 115 spectral bands over the spectrum range of 0.45-0.95 μm. The average spectral resolution of HJ-1A HSI is 5 nm. The spatial resolution and swath of HJ-1A HSI are 100 m and 60 km respectively (Zhang, et al. 2009). HJ-1A HSI has the advantages of high spectral resolution and wide swath, and therefore has much potential in monitoring water quality of large-scale inland waters.

To validate and spread the application of HJ-1A HSI in monitoring water quality of large-scale inland waters, we used a scene of HJ-1A HSI image to retrieve total suspended matter of Lake Taihu. Lake Taihu is the third largest lake located in eastern China (Ma and Dai, 2005). Total suspended matter is a kind of typical water quality parameter, and plays an important role in evaluation of inland water quality (Zhang, et al. 2004; Zhang, et al. 2008).

A scene of HJ-1A HSI image was acquired on May 9, 2009 at 02:51:55 UTC. Atmospheric correction of this image was done by ENVI FLAASH module. But the result of FLAASH is just the reflectance image, and it still includes the contribution of skylight reflected by water surface. To remove the contribution of skylight reflected by water surface from the reflectance image, we used 6S to

calculate it (Li, 2007). Finally, we obtained the remote sensing reflectance (abbreviated as $R_{rs}$) image, which only includes the information of water-leaving radiance. A spectrum at a pixel in the $R_{rs}$ image is shown in Figure 1.

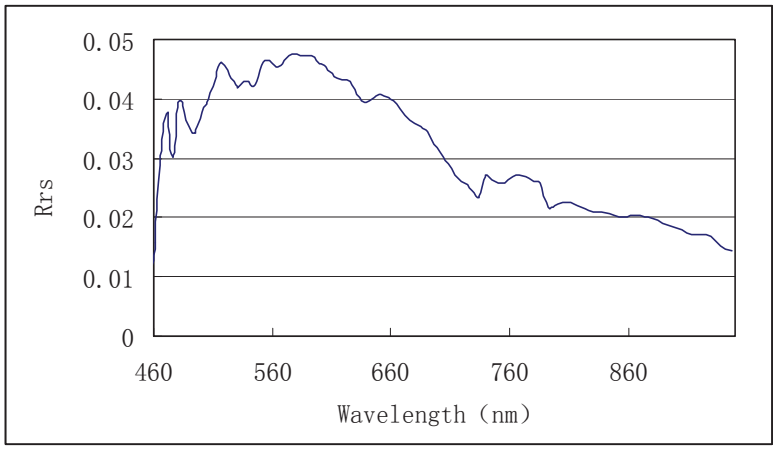


Figure 1. A spectrum at a pixel in the $R_{rs}$ image

Lake Taihu is a turbid Lake, and the average concentration of total suspended matter of Lake Taihu is over 50 mg/L. The reflectance spectrum in near-infrared wavelength region is mainly controlled by the backscattering of total suspended matter, so the $R_{rs}$ spectrum is not low in near-infrared wavelength region. An analytical method was developed to retrieve total suspended matter in turbid inland waters, which needs one near-infrared band as input (Li, 2007). The formula of this analytical method is as follows:

$$C_s = \frac{R_{rs}(\lambda_1)}{x + yR_{rs}(\lambda_1)} \tag{1}$$

Where,

$$x = \frac{\frac{f}{Q}(1-r(\theta_v))*(1-r(\theta_s))/1.77}{\frac{a_w(\lambda_1)}{\tilde{b}_{bp}b'_p(\lambda_1)}} \tag{2}$$

$$y = \frac{\frac{f}{Q}*2-1}{\frac{a_w(\lambda_1)}{\tilde{b}_{bp}b'_p(\lambda_1)}} \tag{3}$$

In these equations, $C_s$ is concentration of total suspended matter, $\lambda_1$ is a near-infrared band, $a_w$ is absorption coefficient of pure water, $b'_p$ is specific back-scattering coefficient of total suspended matter,

$\tilde{b}_{bp}$ is backscatter to total scatter ratio of total suspended matter, $f$ is anisotropy factor of the light filed in the water, $Q$ is the ratio of upward irradiance to upward radiance under water, $\theta_s$ is sun zenith angle, $\theta_v$ is viewing zenith angle.

We used this analytical method to retrieve total suspended matter of Lake Taihu from the $R_{rs}$ image we had obtained. In this study, we used the 852 nm band of the $R_{rs}$ image as input. The inputs of this method also include the specific inherent optical properties data (mainly $b'_p$ and $\tilde{b}_{bp}$) of Lake Taihu. Since we did not have the specific inherent optical properties acquired simultaneously with the HJ-1A HSI image, we used the specific inherent optical properties acquired on April 2007 instead. With all these inputs, we obtained the retrieved total suspended matter map of Lake Taihu shown in Figure 2.

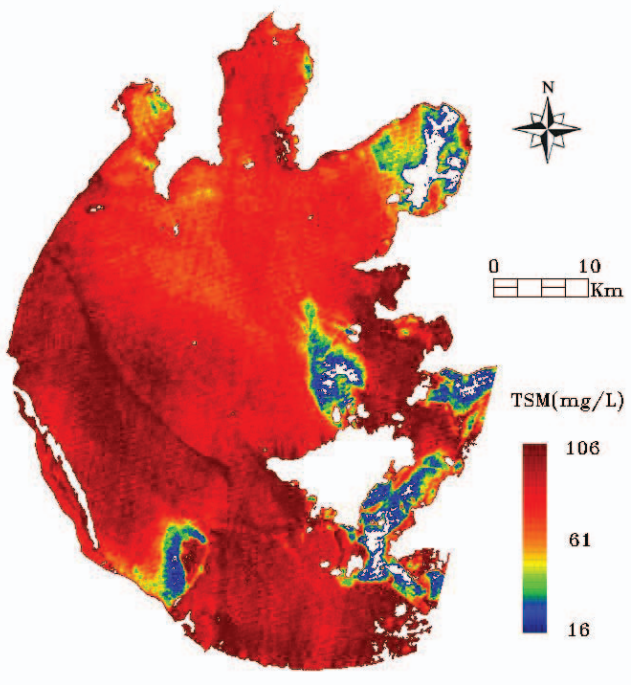


Figure 2. Total suspended matter map of Lake Taihu retrieved from HJ-1A HSI data.

We measured the total suspend matter at a station in Lake Taihu on May 8, 2009. This concentration data is used to evaluate the accuracy of the retrieved total suspended matter map. The relative error is smaller than 30%, which shows that the retrieved total suspended matter results are reasonable. From this validation experiment, it can be seen that HJ-1A HSI has much potential in monitoring water quality of large-scale inland waters.

## REFERENCES


[1] B. Zhang, Z. C. Chen, J. S. Li, L. R. Gao, "Image quality evaluation on Chinese first earth observation hyperspectral satellite," IGARSS, 2009.

[2] R. H. Ma, J. F. Dai, "Investigation of chlorophyll-a and total suspended matter concentrations using Landsat ETM and field spectral measurement in Lake Taihu, China," International Journal of Remote Sensing, 2005, 26(13), 2779~2795.

[3] Y. L. Zhang, B. Q. Qin, W. M. Chen, L. C. Luo, "A study on total suspended matter in Lake Taihu," Resources and Environment in the Yangtze Basin, 2004, 13(3): 266~271.

[4] B. Zhang, J. S. Li, Q. Shen, and D. M. Chen, "A bio-optical model based method of estimating total suspended matter of Lake Taihu from near-infrared remote sensing reflectance," Environmental Monitoring and Assessment, 2008, 145: 339~347.

[5] J. S. Li, "Study on retrieval of inland water quality parameters from hyperspectral remote sensing data by analytical approach ----taking Taihu Lake as an example," Ph.D Dissertaion, Graduate School of Chinese Academy of Sciences, Beijing, China. 2007.