A Result of Measurement of Atmospheric Parameters From Ground for Marine Remote Sensing

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Abstract

Various algorithms of estimated of chlorophyll a and suspended sediment content have been developed, include correction for atmospheric effects over the ocean, especially, at the turbid coastal and estuarine waters.

This paper will decribe a result of measurement of atmospheric parameters from ground at Hangzhou for marine remote sensing and show a very linear relation between atmospheric optical depth $\tau(\lambda)$ and path radiance $L_a(\lambda)$, such as follows:

$$\tau(\lambda)=a+bL_a(\lambda)$$

This result can be applied to reduce the item of atmospheric effects and will simplify the radiative transmiting eqation and algorithems for estimating chloropyll a and suspended sediment content at turbid coastal and estuarine area.

Introduction

In recent year, the estuarine and other turbid coastal water have become the subject of much interest and research. Most of the investigations of these areas have been driven by concern over water quality and the effects of pollution on fisheries and recreational use. Satillite is a valuble tool to provide usable data on sediment and chlorophyll informations

In order to determine the water colour from space the atmospheric trasmission coefficient (T_a) must be determined and path radiance (L_a) must be removed from satellite image data . In such clearer oceanic water, upwelling radiance from the subsurface of water can be established zero in red and near-IR bands, comparing visible bands atmospheric path radiance can be approximated as detected radiance from satellite (Gordon, 1978). Eliminating atmospheric Path radiance from upwelling radiance by subsurface of water is difficult at best in estuarine water because two kind of radiances can not be distinqished in turbid water. Sturm (1981), Llemas and Philpot (1983) have suggested a method 'clearwater subtraction technique', correcting path radiance for AVHRR data. They assume that L_a is constant over the whole study area. Taking the lowest value of radiance at clearwater area means that the upwelling radiance at this area is negligible.The accuracy of the correction usually is accceptable.

This paper will demonstrate the results of atmospheric parameters measurement from ground and relation bertween different

parameters, and discuss possibility of atmospheric correction using ground measurement for AVHRR data in turbid coastal water.

The Basic Principle of Measurements

1. Atmospheric optical dapth $\tau(\lambda)$:
According to solar radiance transmitting equation, the solar radiance reached to surface of earth $L_g^S(\lambda)$ can be written as:

$$L_g^S(\lambda) = L_o(\lambda) . e^{-\tau(\lambda) Sec\theta} \quad \text{--------(1)}$$

or

$$\ln L_g^S(\lambda) = \ln L_o(\lambda)^{-\tau(\lambda) Sec\theta} \quad \text{--------(1')}$$

Where $L_0(\lambda)$ is the solar radiance at top of atmosphere. $\tau(\lambda)$ is the mean atmospheric optical depth and θ_o is the solar zenith angle.

If the atmospheric state is stable, during measurement, $\tau(\lambda)$ and $L_o(\lambda)$ both are constant. Measuring $L_g^S(\lambda)$ with different time (i.e. different solar zenith angle θ, $\tau(\lambda)$ could be caculated from $L_g^S(\lambda)$ using Eq.(1') with known value $L_o(\lambda)$.

2. Atmospheric path radiance $L_a(\lambda)$:
Rogers (1973) and Duntley (1973) have shown a method of measuring path radiance from ground station.Here taking a brief only. If the atmosphere is homogenous and it's scattering is isotopy the atmospheric path radiance $L_a(\lambda)$ can be obtained from measuring $L_g^a(\lambda)$ on ground using following equation.

$$L_a(\lambda) = L_g^a(\lambda) . \left(\frac{1 - e^{-\tau(\lambda)}}{1 - e^{-\tau(\lambda) sec\beta}} \right) \quad \text{--------(2)}$$

Where $\tau(\lambda)$ is optical depth as above. $L_g^a(\lambda)$ is measuring value at atmospheric radiance with sensor elevation angle at back sun light direction. (see Fig. 1).

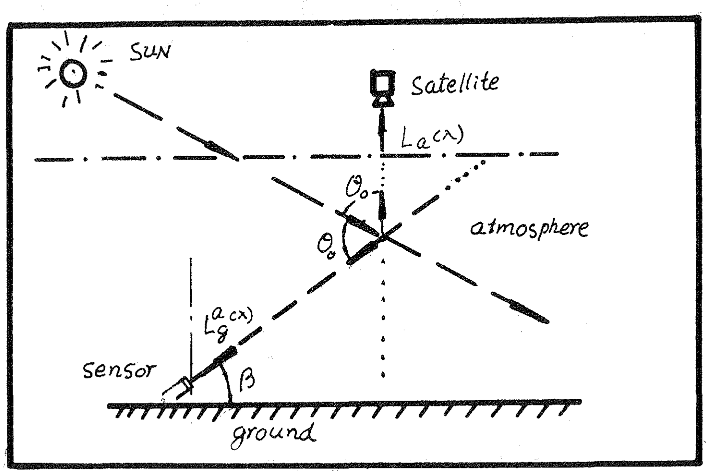

Fig 1. The geometry of measuring path radiance from ground

Measuring and Results

Solar radiance reached to ground $L_g^s(\lambda)$ and atmospheric path radiance $L_g^a(\lambda)$ were measured at Hangzhou ground station on sep. 17, 1987. All data were collected by a four chanels radiometer, which was made by the Institute of Technology and Physics, Academy of Sciences of China, at Shanghai. The characteristics of four chanels radiometer was list on table 1.

Table 1. The characteristics of four chanels radiometer.

Chanel	Wavelength (μm)	Aperture (cm)	Angle of fie. (°)	Meansensitivity A/W
1	0.48-0.53	7.1	58 33	>0.2
2	0.53-0.58	7.1	58 08	>0.2
3	0.58-0.68	7.1	57 39	>0.2
4	0.70-1.05	7.1	57 06	>0.2

$L_g^s(\lambda)$ and $L_g^a(\ )$ were obtained every 15 minutes 8:30 to 10:30

~~1 0.48-0.53 .3805 .0346~~

AM. $\bar{L}_o(\lambda)$ value was taking from recommendation value(Thekaekara and Drummond, 1971) as Table 2. list the mean solar radiances for each chanel. The solar radiances $L_o(\lambda)$ at top of atmosphere were calculated with $L_o(\lambda)=\bar{L}_o(\lambda).(1+0.0167\cos(D-3))^2$, D is the Julian date (day of the year). the $\tau(\lambda)$ and $L_a(\lambda)$ were directly calculated from $L_g^s(\lambda)$ and $L_g^a(\lambda)$ using Eq.(1) and Eq (2) with $L_o(\lambda)$. And atmospheric transmission coefficent $T_a(\lambda)$ was obtained by it's definition form, i.e.

$$T_a(\lambda)=e^{-\tau(\lambda)} \qquad \text{-------(3)}$$

Table 3. shows all $\tau(\lambda)$, $T_a(\lambda)$ and $L_a(\lambda)$ values ~~of~~ measured from Hangzhou ground station on sep. 17, 1987.

From above results, we found a strong linear relation between the atmospheric optical depth $\tau(\lambda)$ and path radiance $L_a(\lambda)$ at each chanel (see Fig.2). It means the $\tau(\lambda)$ could be estimated from $L_a(\lambda)$ with:

$$\tau(\lambda)=a+bL_a(\lambda) \qquad \text{---------(4)}$$

or reversally, from $\tau(\lambda)$ to get $L_a(\lambda)$. Table 4 gaves the constant values of a and b for four chanels.

Table 2. Mean solar radiance at top of atmosphere for each chanel ($mw\cdot cm^{-2}, \mu m^{-1}\, sr^{-1}$)

(μm)	0.48-0.53	0.53-0.58	0.58-0.68	0.70-1.05
$\bar{L}_o(\lambda)$	30.4463	27.67722	25.0629	15.4983

Table 3. Measured value of $\tau(\lambda)$, $T_a(\lambda)$ & $L_a(\lambda)$ at Hangzhou station on sept. 17,1987.

Time	0.48-0.53 (µm)			0.53-0.58 (µm)		
hhmm	τ	Ta	La	τ	Ta	La
0841	.546	.579	4.6577	.208	.812	12.3251
0910	.540	.583	4.7311	.176	.839	11.7969
0922	.615	.541	6.8172	.194	.824	16.3367
0936	.650	.522	7.7632	.220	.803	17.5188
0949	.619	.538	6.0402	.193	.824	14.4735

Time	0.58-0.68 (µm)			0.70-1.05 (µm)		
hhmm	τ	Ta	La	τ	Ta	La
0841	.627	.534	7.0200	1.472	.229	.5658
0910	.532	.587	.8658	1.445	.236	.5048
0922	.517	.562	2.7780	1.704	.182	.9622
0936	.714	.489	3.5249	1.784	.168	1.2349
0949	.566	.568	1.6305	1.778	.169	.7507

La* ($mw \cdot cm^{-2} \cdot \mu m^{-1} sr^{-1}$)

Table 4. The constant vavlue of a & b for 4 chanels.

Chanel	Wavelength (µm)	a	b
1	0.48-0.53	.5330	.0138
2	0.53-0.58	.0963	.0066
3	0.58-0.68	.5330	.0138
4	0.70-1.05	1.2056	.4843

Conclusion

The atmospheric path radiance $L_a(\lambda)$ can be measured from ground station only in special case that the solar zenith angle θ_0 is greater then 45°, and the atmospheric optical depth $\tau(\lambda)$ in any time at ground station such as light house or hydrography station located on coastal zone or island. So that, the $L_a(\lambda)$, in case θ_0 less then 45°, can be easly drifed from $\tau(\lambda)$.

The $\tau(\lambda)$ and $L_a(\lambda)$ has a good linear relationship as same as Ahern et al's (1977). It shows the radiative equation of atmosphere can be reducible for remote sensing. It is possible to simply the algorithms of correction of atmospheric effect on satellite data for coastall zone water.

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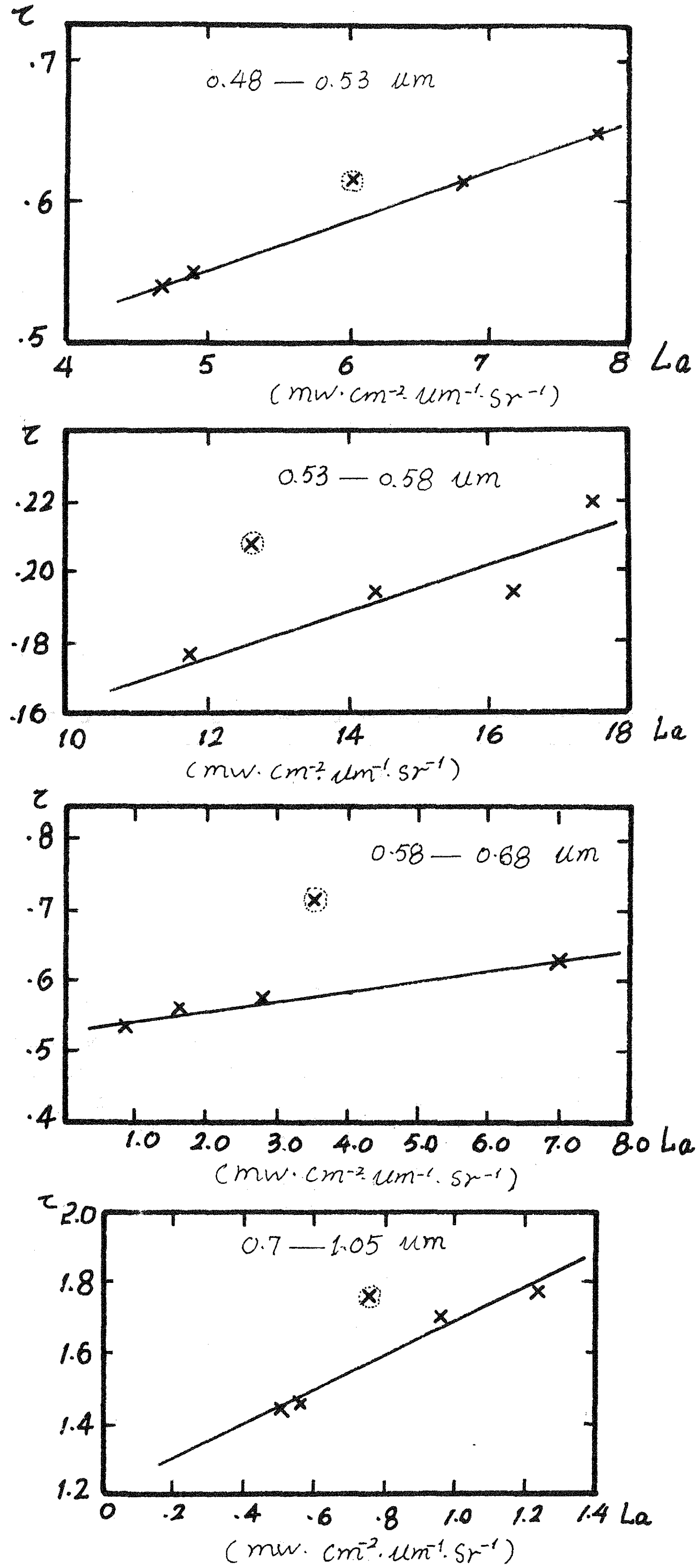

Fig 2. A strong linear relation between ( ) and La( ).

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