

RESEARCH ON THE RETRIEVAL MODEL OF HOT-POLLUTING FOR WARM-LIQUID LETTING IN NUCLEAR POWER STATION

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ABSTRACT:

Warm- liquid is discharged at the speed of 100m³/S when the nuclear power station are running, which becomes hot-polluting because of the rising temperature near the shore area.. The hot-polluting temperature retrieval model of Tianwan nuclear power station with the high spectrum heat infrared remote sensing technique is discussed in this paper. The technique route of the monitoring Warm- liquid field of the nuclear power is put forward. The process of transforming the grey scale of the heat infrared image band remote sensing data with ASTER multi-spectrum scanner TIR into radiation brightness information to obtain the offing brightness temperature is discussed. The temperature retrieval model is put forward with single window arithmetic. The model need not estimate the temperature parameter. It not only predigests the regression estimate but also increasers the retrieval precision of the single window arithmetic.

1. BACKGROUND

It is especial environment in ocean and shore area because there are complex nature phenomenon such as biology diversity, offing temperature, ocean wave spectrum and the sea breeze vector. The condensate water will be discharged at the speed of 100m³/S when the nuclear power station are running. The condensate water from a single unit can make the temperature of the near sea area of 18-20km² rise 3-5⁰C averagely which becomes hot-polluting. Tianwan nuclear power station lies in Lianyungang urban. The beeline distance to the lianyungang port is about 5 km. Lianyungang is the east bridgehead of the new continent bridge of Asia and Europe. In China 21st Agenda , Lianyungang has been planned as a international port city, the tourism center with graceful environment, the international trade center and the traffic hinge. It is important to study the influences of the near shore environment of hot field of warm- liquid near Tianwan nuclear power station for the regional sustainable development.

It is determined the physical characteristics such as sea water area, temperature and deep promptly in real time with the ocean remote sensing technique and detect the hot field of warm-liquid changes and the responds after influence. The dynamic prompt intelligent monitoring system can be constructed by studying temperature retrieval of warm- liquid and the environment evaluation.

The ASTER heat infrared multi-spectrum scanner TIR is a high resolution heat infrared sensor in the first EOS Terra planet. It has five bands heat infrared(8~12m) images information (8~12m) and can reflects the temperature information and the temperature regional difference of the offing. The data synchronization is well and its spatial resolution can achieve 90m/pixel. The heat field and its spatial distributing of the shore area can be analyzed with remote sensing data for retrieval temperature .It can applies advantage qualifications to study the

spatial distributing and its inner structure of the heat field.

2. THE RESEARCH TECHNIQUE ROUTE

In the study it is carried out investigating for the remote sensing backgrounds value first. The ASTER infrared mult-sectrum scanner (TIR) data before Tianwan Nuclear Power Station running were collected and the distinguish sign of the hot infrared radiation of the offing was developed. Before the station running, the water absorbs much sun radiation and the temperature rises slowly than the land. On the remote sensing images, the tone is dark and the hot infrared band radiation is low. When the station is running, the warm- liquid temperature is high than that of the surround water, the tone is tint on the hot infrared images. Bases on the difference of the temperature, the study tries to directly obtain the warm- liquid temperature value by using ASTER hot infrared image band calibration temperature field ASTER. The water temperature and its time and spatial distributing are measured by contrasting to the sampling value. The research technique route of the survey for heat field are as Fig1.

3. MODEL OF TEMPERATURE (SST) RETRIEVAL

3.1 Model of Bright Temperature Retrieval

The brightness temperature is the corresponding temperature to the heat radiant intensity by remote sensor in its observation range at a certain altitude, which including the influence of the heat radiation conduction of the atmosphere and the offing. The ocean water temperature can be figured out based on the brightness temperature. It is essential to develop a model to figure out brightness temperature.

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14	10.95×10^{-6}	11.65×10^{-6}	11.3×10^{-6}	5.225×10^3
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Table 1 The max and min parameters of the radiant brightness with TIR remote sensor

If ignoring the atmosphere influence, the Planck radiant function^[4] to calculate the brightness temperature could be applied directly with radiant brightness L_n .

$$T_n = \frac{C_2/\lambda_n}{\ln\left(\frac{C_1}{\pi \lambda_n^5 L_n} + 1\right)} \quad (2)$$

In the formula, T_n is the coast zone land and seawater brightness temperature;
 n is Wavelength and bands of ASTER TIR (Band 10, 11, 12, 13, 14)

C_1 and C_2 are radiation constant.

$$C_1 = 2\pi hc^2 = 3.7418 \times 10^{-16} (Wm^{-2})$$

$$C_2 = hc/k = 1.4388 \times 10^{-2} (mK)$$

h : Planck's constant (6.626176×10^{-34})
 k : Boltzmann's constant (1.380662×10^{-34})
 c : Speed of light (2.997925×10^8)

Based on ignoring the atmosphere and the other influence factors and supposing the seawater is the complete radiator-the seawater is regarded as black body because of its high absorptivity, the surface temperature can be figured out by measuring the sea surface radiation brightness. Then the real temperature can be figured out with atmosphere rectification.

3.2 Transition mode of the sea surface temperature

The true temperature of the land surface or the offing have not be calculated by using the image grey level value directly or transforming it into pixel brightness temperature in most applications. The ASTER TIR runs at the altitude about 700km in space. When the offing heat radiation reaches to the TIR remote sensors through atmosphere, it has been weakened because of the absorbing by the atmosphere. On the other hand, atmosphere itself emits a certain heat radiation and it can reach to the TIR remote sensors. The offing heat radiation and the temperature change can not be showed directly. There is certain extent error in the conclusion of the analyzing the regional environment images by using the TIR original data directly. Hot remote sensing is a complex process. The whole influences among the process of the heat conduction must be considered if we want to measure the temperature retrieval in heat radiation intension from satellite remote sensors. The action of atmosphere absorbing and the atmosphere heat radiation intension must be estimated by using a atmosphere model. Then the atmosphere influence could be reduced from the heat radiation measured by satellite remote sensors and the heat radiation becomes the offing heat radiation. The offing temperature can be calculated.

It should take the equation of heat radiation conduction as the base to calculate the offing temperature with remote sensing data. Supposing the seawater as a black body, its radiation rate is 1. The heat radiation total intension includes the heat radiation from the atmosphere and those from atmosphere upwards to the remote sensors in the equation. The radiation has been

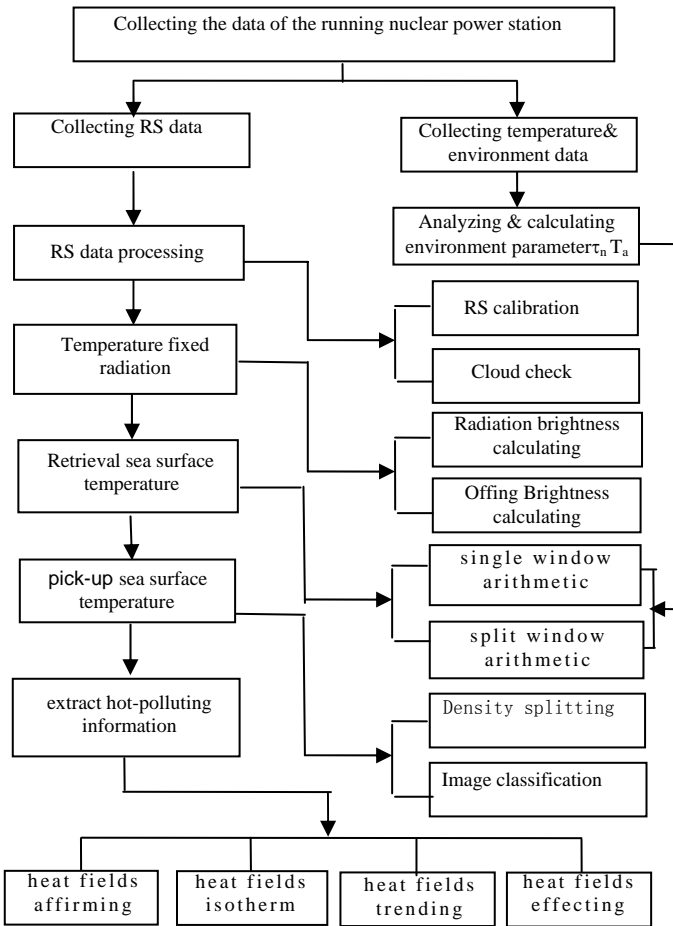


Figure 1. Technique way of hot-field research

It is well known that remote sensing data can be expressed with grey scale(DN). The DN value ranges form 0 to 255, and the large the value is, the stronger the brightness is. The stronger of the brightness means that the surface heat radiant intensity is stronger and the temperature is higher for the hot infrared remote sensing data. The process of calculating the brightness temperature from hot remote sensing data is to translate the DN value into the corresponding heat radiant intensity, then calculates the corresponding brightness temperature based on the radiant intensity. The mode to reflect the sea temperature by ASTER\TIR hot remote sensing data is similar to the mode of calculating the brightness temperature by TM heat infrared remote sensing data^[5]. First the image brightness ND is need to be transformed in to radiant brightness L_n .^[7]

$$L_n = (DN_n - 1) \cdot R_n \quad (1)$$

In the formula, L_n is the pixel radiant brightness of No. n band data of TIR;

DN_n is the grey scale value.

R_n is the max and the min parameters of the hot infrared band TIR(10~14) of ASTER remote sensor. (table 1)

Band (n)	λ_{min}	λ_{max}	λ_n	R_n
10	8.125×10^{-6}	8.475×10^{-6}	8.30×10^{-6}	6.882×10^3
11	8.475×10^{-6}	8.825×10^{-6}	8.65×10^{-6}	6.780×10^3
12	8.925×10^{-6}	9.275×10^{-6}	9.10×10^{-6}	6.590×10^3
13	10.25×10^{-6}	10.95×10^{-6}	10.6×10^{-6}	5.693×10^3

weakened by the absorbability of the atmosphere during the process in reaching to the remote sensors across the atmosphere. For the radiation black body, its total radiation intension and temperature have close relationship with the wave length. They can be expressed by the function:

$$B_{\lambda}(T) = \frac{C_1}{\lambda^5 (e^{C_2/\lambda T} - 1)} \quad (3)$$

in the function, $B_{\lambda}(T)$ is the seawater radiation intension, it can be expressed $.Wm^{-2}sr^{-1}m^{-1}$
 C_1 and C_2 : are radiation constants;
 T is the temperature, the unit is K.

In the common the sea water is taken as approximately black body and its radiation rate approaches to 1.It range from 0.96 to 0.99^[2]. Considering the atmosphere influence, the offing radiation intension by ASTER TIR remote sensors can be expressed by the following function.

$$B_{TIR_n}(T_n) = \tau_{TIR_n} B_{TIR_n}(T_s) + I_{TIR_n}^{\uparrow} \quad (4)$$

In the function, τ_{TIR_n} is the atmosphere penetrativity rate;

T_n is the brightness temperature;

$B_{TIR}(T_n)$ is the offing heat radiation intension of n band distance received with TIR remote sensors,; which rest with the brightness temperature T_n of the TIR pixel. ;

$B_{TIR_n}(T_s)$. is the real offing heat radiation intension of n band distance received with TIR remote sensors ,which rest with the offing temperature T_s . ;

$I_{TIR_n}^{\uparrow}$ is the upward heat radiation intension of TIR n bands. supposing the average atmosphere action temperature is T_a

$$I_{TIR_n}^{\uparrow} \approx (1 - \tau_{TIR_n}) B_{TIR_n}(T_a) \quad (5)$$

Based on the mono-window algorithm by Qin Zhi-hao in 2001[3], formula is ratiocinated for calculating temperature retrieval by the mono-window n band of ASTER TIR data :

To calculate the offing temperature needs to expand the Planck function in linearity. Planck function closes to linearity as the temperature changing. For the No n given band range of TIR, especially in the narrow range ,for example less than 15°C, the linearity feature is more evident. The Planck function can be expanded with Taylor expanding formula. Sufficient precision can be ensured with the first two items.

$$B_{TIR_n}(T_n) = B_{TIR_n}(T) + (T_n - T)(B_{TIR_n}(T)/\partial T) = (L_n + T_n - T)(B_{TIR_n}(T)/\partial T) \quad (6)$$

In the formula, L_n is temperature parameter(K),which can be defined as

$$L_n = B_{TIR_n}(T) / [(B_{TIR_n}(T)/\partial T)] \quad (7)$$

The essential meaning of linearization the Planckfunction is to associate the fixed temperature $B_{TIR_0}(T)$ with heat radiation intension .The fixed temperature T is the key to calculate further. In most cases, there are relationships $T_s > T_n > T_a$. Therefore, we define the fixed temperature T as T_n . For TIR, the Planck function T_s , T_n and T_a be expanded further:

$$\begin{cases} B_{TIR_n}(T_s) = (L_n + T_s - T_n) \partial B_{TIR_n}(T_n) / \partial T & (8) \\ B_{TIR_n}(T_a) = (L_n + T_a - T_n) \partial B_{TIR_n}(T_n) / \partial T & (9) \\ B_{TIR_n}(T_n) = (L_n + T_n - T_n) \partial B_{TIR_n}(T_n) / \partial T = L_n \partial B_{TIR_n}(T_n) / \partial T & (10) \end{cases}$$

Integrate these functions and puting down equation(4) and remove the item $\partial B_{TIR_n}(T_n) / \partial T$, we can find the new formula

$$L_n = C_n(L_n + T_s - T_n) + D_n(L_n + T_a - T_n) \quad (11)$$

In the formula, parameter C_n and D_n can be defined respectively:

$$C_n = \tau_n \varepsilon_n \approx \tau_n \quad (12)$$

$$D_n = (1 - \tau_n)[1 + \tau_n(1 - \varepsilon_n)] \approx 1 - \tau_n \quad (13)$$

From formula(11), we can infer:

$$T_s = \frac{1}{C_n} [L_n - D_n(L_n + T_a - T_n)] + T_n - L_n \quad (14)$$

Integrating formula (12) 、 (13) with formula (14), the calculating formula of mono-window n offing temperature of ASTER TIR.

$$T_s = \frac{1}{\tau_n} [T_n + T_a(\tau_n - 1)] \quad (15)$$

In the common, the parameter of atmosphere average acting temperature T_a and the atmosphere permeation ratio τ_n which is suit to temperature retrieval of TIS data can be ensured easily. They can be estimated by the atmosphere moisture content or humidity and average temperature at the altitude 2 meter. In most cases, every local weather observation station have real time data of these two observation index when the satellite across the sky. The offing temperature calculation precision can reaches less 1.0°C by this method^[6].

4. EXPERIMENTATION ANALYSE OF THE RETRIEVAL SEA SURFACE TEMPERATURE IN THE RESEARCH AREA

Located in Yellow Sea, Tianwan nuclear power station, China is chose as a case study in order to verify the above method. ASTER data is selected on February 26,2005 , March 20,2007 . It is made use of ENVI4.2 and Matlab 7.1 to finish the inverse modeling of sea surface temperature by mono-window method. At the same time. Finally, sea surface temperature estimation result is established (Fig. 2).

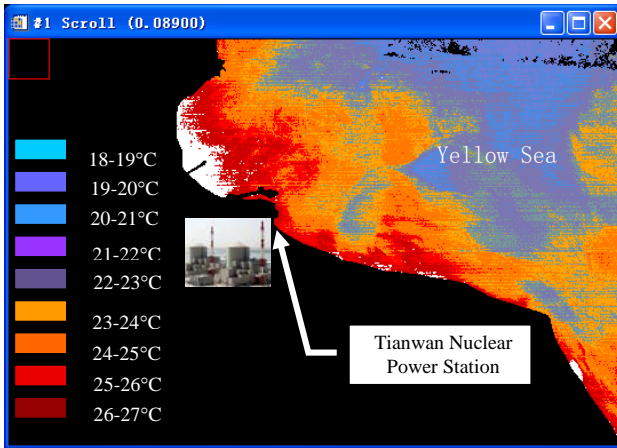


Figure 2. Retrieval of the sea surface temperature

To judge of the Precision of mode is importance for the fact application. In order to give a comparison between our research results based on the sea surface temperature estimation model and fact standard temperature, the same pixel information is compared with measure temperature of the ocean environment monitoring station. the comparison result is listed in table 2.

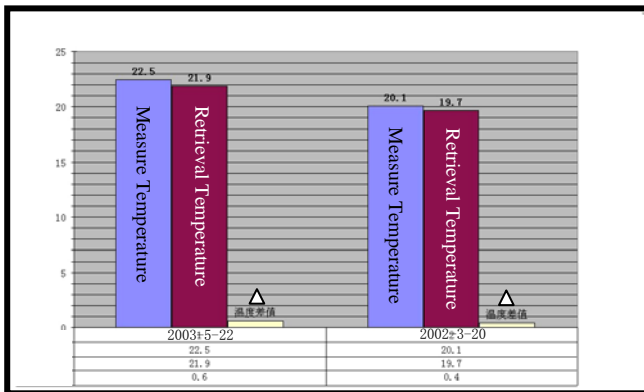


Table2 Comparison between research results and standard temperature

Above analysis indicates that the error is inevitable for parameter estimation in sea surface temperature. The error of the method given in this paper is completely accepted by some users for mono-window algorithm. The offing area temperature calculation precision can reach less 1.0°C by this method.

5. CONCLUSION

In this paper, the process of transforming the grey scale of the heat infrared image band remote sensing data with ASTER multi-spectrum scanner TIR into radiation brightness information to obtain the offing brightness temperature is discussed. The temperature retrieval model is put forward with the mono-window algorithm. The model combines the characteristics of the heat infrared image band remote sensing data with ASTER multi-spectrum scanner TIR. The model need not estimate the temperature parameter. It not only simplify the regression estimate but also increase the retrieval precision by the mono-window algorithm. The model can be used in the

study of monitoring the heat field and heat pollution near the nuclear power station. It can spare time, man power and the cost is low. It is real and scientific and has many advantages contrasting to the traditional investigate means.

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