PRIMARY RESULTS IN MONITORING SEA SURFACE TEMPERATURE (SST) FROM MODIS IMAGERIES, CASE STUDY: EAST SEA, VIET NAM

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ABSTRACT

The MODIS sensor (Moderate Resolution Imaging Spectroradiometer) mounted on Terra satellite (launched on December, 1999), and Aqua (launched on May, 2002) has been an important instrument to assist studies of land, ocean surface and atmostpheric interaction. The MODIS image can be used to measure sea surface temperature (SST) every day and the primary results demonstrate the effectiveness of employing the MODIS imageries in monitoring sea surface temperature in East Sea area, Viet Nam. This paper introduces the methodology of images processing and accuracy of the case study shows that the proposal solution can be efficiently applied in comparison with the conventional approach.

Key words: MODIS, Sea Surface Temperature (SST)

1 INTRODUCTION

In development countries, the oceanography studying by using modern technologies has been taking place strongly. Beside traditional approaches, many other satellites were launched for supporting it. From sensors attached on these satellites, the ocean surface parameters have been measured widely, they are covered globe. One of them, it is sea surface temperature (SST). SST is an important parameter not only for oceanography studying but also in climate change research.

From 1960s, SST values were measured. The first way, they were from sailing vessels. Next, they were from ships (Emery et al., 2000). And then, they are measured from drifting or moored buoys. Based on these SST measurements, they made the standard data set used to calculate the algorithm coefficients in today's calculation of SST from satellite infrared radiances (Emery et al., 2002). Some of sensors could be used to measure SST such as: Scanning Radiometer, SR (middle

1970s), Very High Resolution Radiometer, VHRR, Advanced VHRR, AVHRR (1979 to present) on NOAA satellite; Terra (1999), Aqua (2002) on MODIS satellite.

Nowadays, the low resolution satellite imageries have been delivering free cost on internet, in company with our desire to establish SST data set for primary studying about oceanography and climate change. This paper introduces the methodology of MODIS images processing and accuracy of the case study in East Sea area, Viet Nam.

2 METHODS

2.1 Study area

Study area is the East Sea area, Viet Nam. It covers from $7^0$00'N to $13^0$00'N and from $102^0$00'E to $112^0$00'E (figure 1).

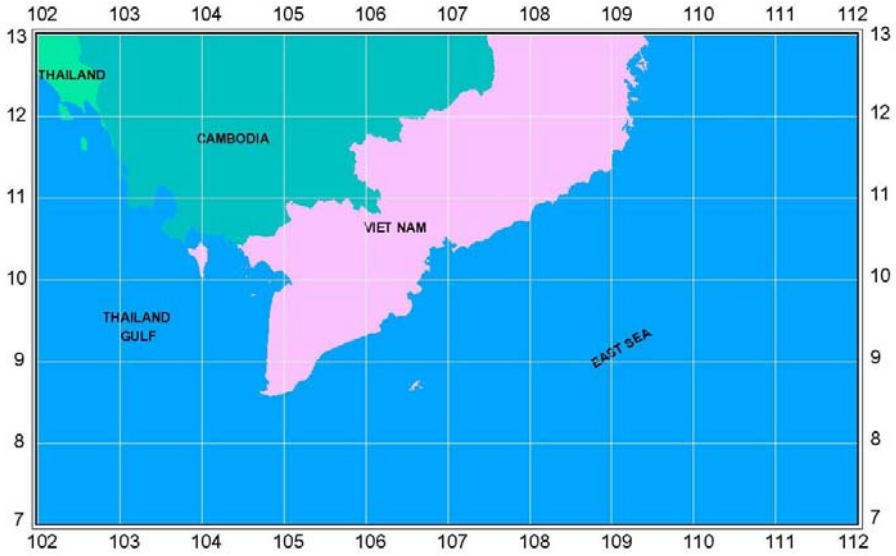

Figure 1: East Sea, Viet Nam

The SST data (1989-1995) and data of marine hydrometeorology (1986 - 1995) of the coastal marine meteorological stations from 6°N to 21°30N and from 103°E to 114°E (Nguyen Thanh Vinh) showed that: at Vung Tau station (φ = 10°20; λ = 107°05), the annual average: 28.3°C, the annual absolute maximum: 31.5°C; the annual absolute minimum: 24.8°C and the annual amplitude: 6.7°C; at Phu Quoc station (φ = 10°13; λ = 103°58), the annual average: 29.1°C, the annual absolute maximum: 35.1°; the annual absolute minimum: 22.0° and the annual amplitude: 13.1°C. They also showed that: exists an upwelling. The area of strong activities of upwelling is about φ =10°45 - 11°30 N and λ = 108°30 - 109°30E in the North of Binh Thuan - Ninh Thuan.

2.2 Data collections

SST measurements

The SST measurements were collected from Institute of Oceanography, Nha Trang. They were measured from May to October 2007 and from April to June 2008 at 22 points (KC-01 to KC-20 and KC-BS1, KC-BS2) in Binh Thuan (figure 2). They were measured from sea surface down to 0.5 meter. The change of SST values following depth at each sample point is minor, about 0.4^0C (figure 3

and figure 4) . In this paper, only SST values on sea surface of each point (table 1) are used to compare with SST extracted from MODIS imageries.

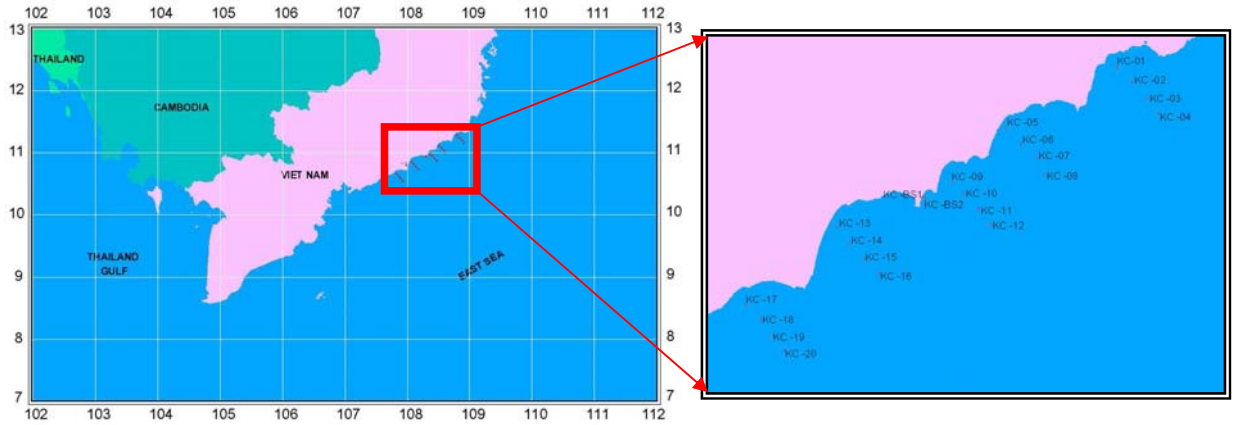

Figure 2: The position of measured SST points

ID	B	L	Date	Local Time	Depth (m)	Temp. (C^0)	Date	Local Time	Depth (m)	Temp. (C^0)	Date	Local Time	Depth (m)	Temp. (C^0)
KC-01	108.81	11.28	22-Apr-2008	11:52	0.16	30.188	24-May-2007	09:14	0.02	30.034				
KC -02	108.85	11.24	22-Apr-2008	10:46	0.21	29.293	24-May-2007	10:06	0.30	29.780				
KC -03	108.89	11.20	22-Apr-2008	09:48	0.14	29.237	24-May-2007	11:00	0.22	29.296				
KC -04	108.92	11.16	22-Apr-2008	08:31	0.12	29.167	24-May-2007	11:56	0.29	28.879				
KC -05	108.52	11.12	24-May-2008	07:38	0.23	28.621	25-May-2007	09:19	0.26	30.168	24-Aug-2007	14:19	0.38	25.858
KC -06	108.56	11.08	24-May-2008	08:12	0.21	28.267	25-May-2007	10:19	0.32	28.788	24-Aug-2007	13:24	0.37	25.490
KC -07	108.60	11.04	24-May-2008	08:52	0.23	28.775	25-May-2007	11:09	0.30	28.520	24-Aug-2007	12:22	0.21	26.605
KC -08	108.62	11.00	24-May-2008	09:32	0.10	28.219	25-May-2007	12:00	0.25	28.022	24-Aug-2007	11:28	0.01	26.969
KC -09	108.38	10.98	24-May-2008	14:02	0.12	28.466	25-May-2007	17:57	0.14	28.124	24-Aug-2007	07:27	0.35	25.309
KC -10	108.41	10.95	24-May-2008	13:23	0.04	28.263	25-May-2007	17:10	0.04	28.154	24-Aug-2007	08:15	0.33	25.780
KC -11	108.45	10.91	24-May-2008	12:39	0.07	28.223	25-May-2007	16:13	0.29	28.417	24-Aug-2007	09:00	0.33	27.001
KC -12	108.48	10.87	24-May-2008	11:49	0.19	27.886	25-May-2007	15:11	0.48	28.939	24-Aug-2007	09:55	0.38	27.665
KC -13	108.08	10.86												
KC -14	108.11	10.82												
KC -15	108.15	10.78												
KC -16	108.19	10.74												
KC -17	107.84	10.66	26-May-2008	11:51	0.26	28.924								
KC -18	107.88	10.62	26-May-2008	10:37	0.19	28.936								
KC -19	107.91	10.58	26-May-2008	09:52	0.00	28.393								
KC -20	107.94	10.54	26-May-2008	09:01	0.15	27.953								
KC -BS1	108.30	10.94												
KC -BS2	108.31	10.94												

Table 1: SST values on sea surface of sample points

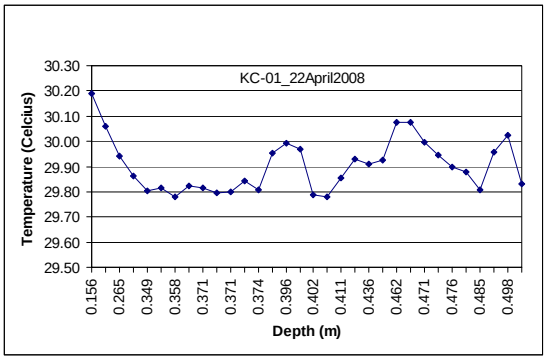

Figure 3: SST measurements at KC_01

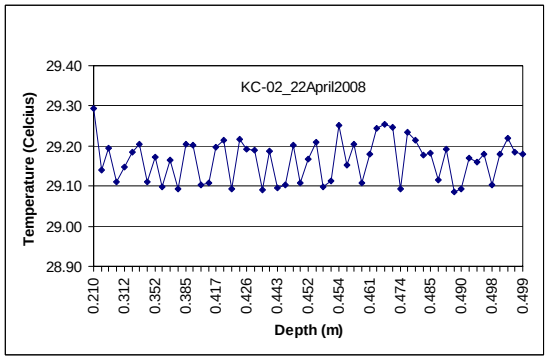

Figure 4: SST measurements at KC_02

MODIS imageries

To estimate the accuracy of SST values extracted from satellite data, MODIS Aqua were also collected on 22 April, 24 May and 26 May 2008; 24-25 May, and 24 August 2007.

2.3 Algorithms for calculating SST

There were many other algorithms for calculating SST from satellite infrared radiances. The fundamental approach was the Multi-Channel SST (MCSST; McClain et al. 1985) which was the procedure first associated with the split-window technique. To improve the MCSST, scientists at NOAA/NESDIS decided to alter the regression formulation to include non-linear effects (Walton et al., 1990, Walton et al., 1998). The first official alternative algorithm was called the Cross Product SST (CPSST) to emphasize the nonlinear part of the computation. Some very modest changes were later made to the CPSST and the algorithm is now known as the non-linear or NLSST. This is also algorithm used to process SST from MODIS imageries.

The formulation calculated SST as following:

$$MODIS\_SST = C_1 + C_2*T_{31} + C_3*T_{3132}*T_b + C_4*(\sec(\theta) - 1)$$

where:

T_{31}: brightness temperature band 31.

$T_{3132} = (T_{32} - T_{31})$.

T_b: environmental temperature

θ: zenith angle

C_1, C_2, C_3, C_4 : constants

3 RESULTS

3.1 SST map

The SST values extracted from MODIS imageries were mapped as below:

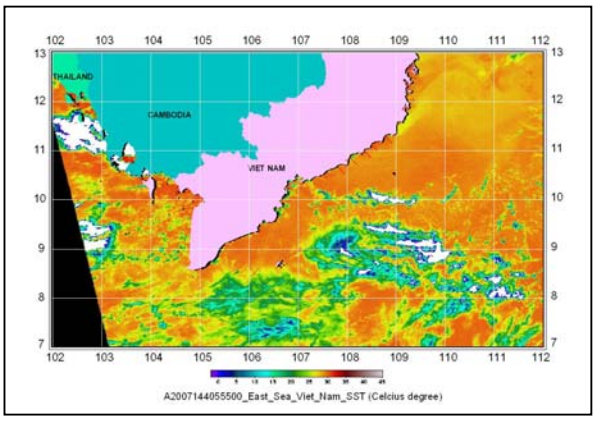

Figure 5: SST on 24 May 2007

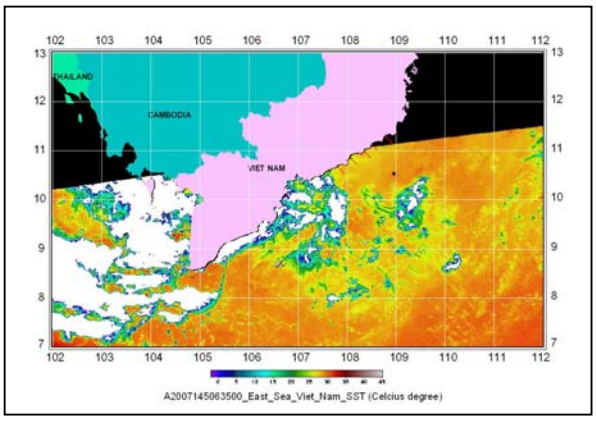

Figure 6: SST on 25 May 2007

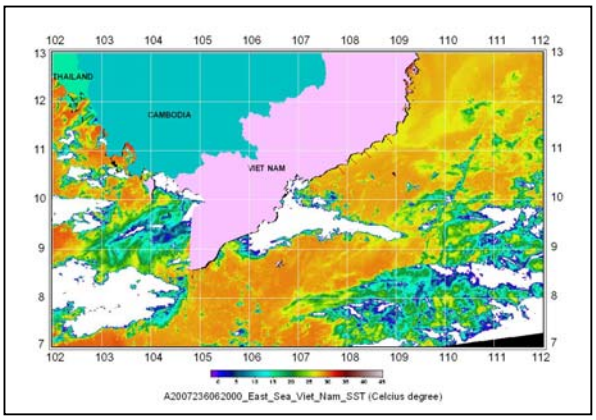

Figure 7: SST on 24 Aug 2007

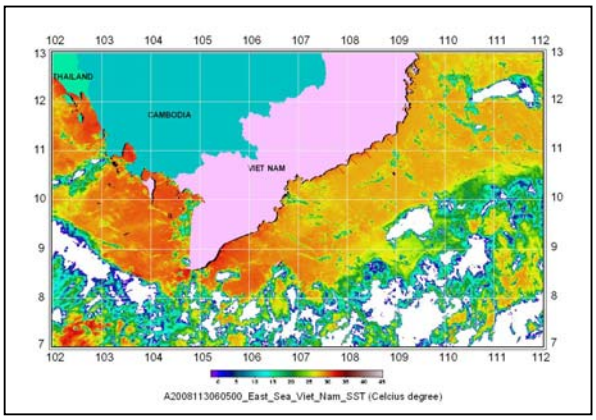

Figure 8: SST on 22 April 2008

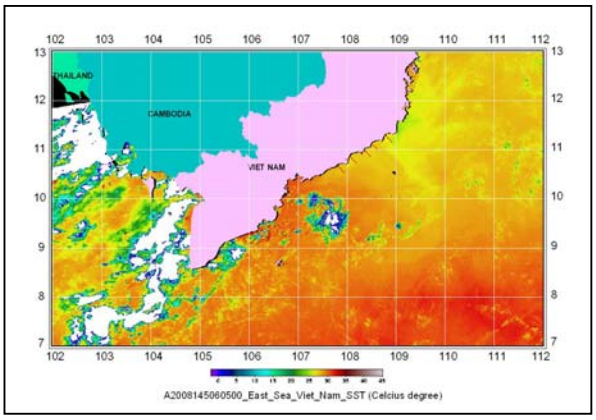

Figure 9: SST on 24 May 2008

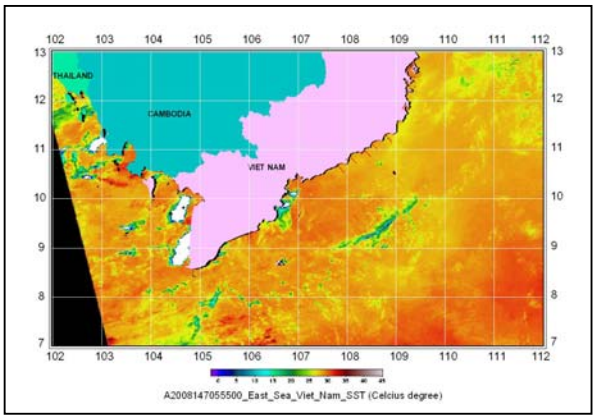

Figure 10: SST on 26 May 2008

3.2 The accuracy

To estimate the accuracy of extracted SST results, each pair of measured and processed SST values at the coordinate of station will be compare. The error will be presented in table 2 below:

ID	B	L	Date	Depth (m)	Temp. (^{0}C)	SST (^{0}C)	Error
KC-01	108.81	11.28	24-May-2007	0.02	30.034	30.060	-0.026
KC-02	108.85	11.24	24-May-2007	0.30	29.780	29.925	-0.145
KC-03	108.89	11.20	24-May-2007	0.22	29.296	29.615	-0.319
KC-04	108.92	11.16	24-May-2007	0.29	28.879	29.570	-0.691
KC-07	108.60	11.04	25-May-2007	0.30	28.520	27.775	0.745
KC-08	108.62	11.00	25-May-2007	0.25	28.022	27.465	0.557
KC-09	108.38	10.98	25-May-2007	0.14	28.124	28.040	0.085
KC-10	108.41	10.95	25-May-2007	0.04	28.154	28.835	-0.681
KC-11	108.45	10.91	25-May-2007	0.29	28.417	27.805	0.611
KC-12	108.48	10.87	25-May-2007	0.48	28.939	27.955	0.984
KC-05	108.52	11.12	24-Aug-2007	0.38	25.858	26.115	-0.257
KC-06	108.56	11.08	24-Aug-2007	0.37	25.490	26.300	-0.810
KC-07	108.60	11.04	24-Aug-2007	0.21	26.605	26.945	-0.340
KC-08	108.62	11.00	24-Aug-2007	0.01	26.969	27.565	-0.596
KC-09	108.38	10.98	24-Aug-2007	0.35	25.309	26.080	-0.771
KC-10	108.41	10.95	24-Aug-2007	0.33	25.780	26.630	-0.850
KC-11	108.45	10.91	24-Aug-2007	0.33	27.001	27.650	-0.650
KC-12	108.48	10.87	24-Aug-2007	0.38	27.665	28.400	-0.735
ID	**B**	**L**	**Date**	**Depth (m)**	**Temp. (^{0}C)**	**SST (^{0}C)**	**Error**
KC-01	108.81	11.28	22-Apr-2008	0.16	30.188	29.920	0.268
KC-02	108.85	11.24	22-Apr-2008	0.21	29.293	29.590	-0.297
KC-03	108.89	11.20	22-Apr-2008	0.14	29.237	29.455	-0.218
KC-04	108.92	11.16	22-Apr-2008	0.12	29.167	28.955	0.212
KC-05	108.52	11.12	24-May-2008	0.23	28.621	27.830	0.791
KC-06	108.56	11.08	24-May-2008	0.21	28.267	27.540	0.727
KC-07	108.60	11.04	24-May-2008	0.23	28.775	27.840	0.935
KC-08	108.62	11.00	24-May-2008	0.10	28.219	27.620	0.599
KC-09	108.38	10.98	24-May-2008	0.12	28.466	27.820	0.646
KC-10	108.41	10.95	24-May-2008	0.04	28.263	27.699	0.563
KC-11	108.45	10.91	24-May-2008	0.07	28.223	27.630	0.593
KC-12	108.48	10.87	24-May-2008	0.19	27.886	27.605	0.281
KC-17	107.84	10.66	26-May-2008	0.26	28.924	29.195	-0.271
KC-18	107.88	10.62	26-May-2008	0.19	28.936	28.870	0.066
KC-19	107.91	10.58	26-May-2008	0.00	28.393	28.690	-0.297
KC-20	107.94	10.54	26-May-2008	0.15	27.953	29.100	-1.147

Table 2: The error between measured and processed SST values

On 2007, the maximum error is ± 0.984 and the minimum error is ± 0.026. On 2008, the maximum error is ± 1.147 and minimum error is ± 0.066.

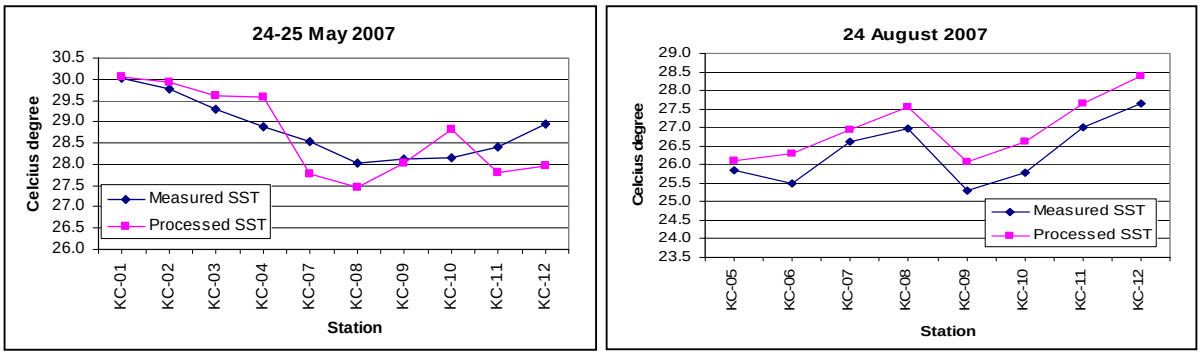

Figure 11: The error between measured and processed SST values on 2007

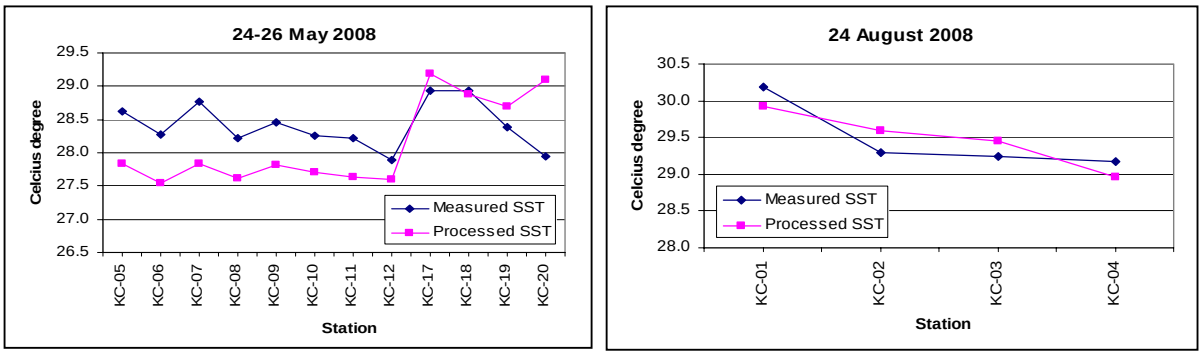

Figure 12: The error between measured and processed SST values on 2008

4 CONCLUSIONS

This study would present the capability of MODIS imageries in supporting SST value daily on the world. However, the extracted SST results should be estimated the accuracy based on different study area. For more reliable, measured SST values at marine meteorological stations (Vung Tau, Phu Quoc,…) in this area should be collected.

Unstill now, extraction SST value from MODIS imageries has been continuing. Measured SST values at marine meteorological stations in this study area have been collected. And in next time, we hope to establish the data set of SST daily to monitor its change.

5 REFERENCES

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