APPLICATION OF REMOTE SENSING FOR INTERPRETATION OF PRIMARY PRODUCTIVITY IN BIEN DONG (EASTERN) SEA

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ABSTRACT

The quantity of primary productivity help us not only to understand matter and energy bases of primary productivity, but also access and predict bio-resources, particularly fishery resources. Besides, values of primary productivity also are indicators for environmental quality and ecological conditions in sea water. The distribution of primary productivity, chlorophyll, biomass of phytoplankton are main parameters which help us to understand the role of the ocean in global bio-geochemistry cycle.

Today, with remote sensing technique, combines with mathematic modeling, the primary productivity has been dealed with in global and also region scales. Some popular modelings such as VGPM (Behrenfield and Falkowski, 1997), MLDM (Howard and Yoder 1996 /6/) were used for calculating primary productivity. The main parameters used for calculating primary productivity are chlorophyll, sea surface temperature, solar radiation, mixing layer,…

Using of ocean color images such as SEAWIFS, OTCS, AVVHR, we tried to calculate the distribution of primary productivity in upwelling region in Southern central region of Vietnam sea.

The results show that:

- *This is the first time the remote sensing technique has been used for calculating primary productivity in a large scale in Vietnam seas.*
- *The studied results show that there are typical dynamic processes as upwelling phenomena in South-West monsoon in coastal seas of Vietnam.*
- *The distribution trend of primary productivity we have from remote sensing technique is similar with other study results and also directly measurements in this sea region (Nguyen Tac An, 1985 /1/, 1989/2/).*
- *These results will make premises for fishery oceanography studies by modern methods in Vietnam sea in the next time.*

1. INTRODUCTION

The quantity of primary productivity help us not only to understand matter and energy bases of primary productivity but also access and predict bio-resources, particularly fishery resources. Besides, values of primary productivity also are indicators for environmental quality and ecological conditions in sea water. The distribution of primary productivity, chlorophyll, biomass of phytoplankton are main parameters which help us to understand the role of the ocean in global bio-geochemistry cycle.

Today, with remote sensing technique, combines with mathematic modeling, the primary productivity has been dealed with in global and also region scales. Some popular modelings such as VGPM (Behrenfield and Falkowski, 1997), MLDM (Howard and Yoder

1996 /6/) were used for calculating primary productivity. The main parameters used for calculating primary productivity are chlorophyll, sea surface temperature, solar radiation, mixing layer,…

In this paper, the authors try to assess primary productivity in the coastal and offshore of Weastern - South part of Bien Dong Sea (belong to Ninh Thuan - Binh Thuan area of Vietnam) by using the algorithms of VGPM and MLDM combined with remote sensing technique.

2. USED MATERIAL AND PROCESSING SOFTWARE

The data sources used in this paper are:

- The SEAWIFs (Sea View Wide Field of View Sensor) image source (include sea surface temperature and chlorophyll images) on the period of Mid of June 1997. These are color composite images download from website of SEAWIFs.
- Application of software HLAC-MEAS2 and SCILAB of NASDA for determining interpretation algorithms.
- Software IDRISI32 has been used for data processing and multiple dimension calculation.
- The Vertically Generalized Production Model – VGPM of Michael J. Behrenfeld and Paul G. Falkowski (1997a /4/) (Mixed Layer Production Model - MLDM) of Katherin Howard and Jim Yoder (1996 /6/) are 2 main choosing models for calculating the primary productivity in coastal and offshore of Weastern - South part of Bien Dong (Eastern) Sea.
- The final processing data is transfer to GIS layers and overlays together in the base of MapInfo.

3. THEORETICAL BASE FOR CALCULATING PRIMARY PRODUCTIVITY FROM SATELLITE IMAGES AND SOME MAIN RESULTS

The calculation of marine primary productivity based on the basic concepts of photosynthex and carbon fixing processes which happened mainly in euphotic layer. For the calculation of marine primary productivity, the authors try to apply some popular models based on the above-mentioned principles and try to assess the ability of application for the Bien Dong (Eastern) Sea.

3.1 The Vertically Generalized Production Model – VGPM : of Michael J. Behrenfeld and Paul G. Falkowski (1997a) /4/. This model shows the relationship of content of surface chlorophyll with integrated primary productivity in all water columns of euphotic layer.

The original formula of VGPM was written as following:

$$PPeu = 0.66125 * PBopt* (Eo/ Eo + 4.1) Csur* Deu* Hirr \quad (1)$$

Where:

- PPeu: daily primary productivity in euphotic layer (unit : mg C/m^2*ngày)
- PBopt: the index shows optimum photosynthectically flux in euphotic layer (unit: mg C/mg Chl * h)
- Eo: photosynthectically available radiation – PAR (unit: W/m^2)
- Csur : the content of surface chlorophyll (unit: mg Chl/m^3)
- Deu : euphotic depth (m)

- Hirr: The light duration in the day (h)

The index of optimum photosynthectically flux in euphotic layer PBopt is considered to be like the daily maximum carbon fixing intensity in all water column in euphotic layer. According to Behrenfeld and others (1997b) /5/, this index can also determine sea surface temperature (SST) by order 7 analytic function .

$$PBopt = 1.2956 + 2.749*10^{-1}* SST + 6.17*10^{-2}* SST^2 - 2.05*10^{-2}* SST^3 + 2.462*10^{-3}* \quad (2)$$

$$SST^4 - 1.348*10^{-4}* SST^5 + 3.4132*10^{-6}* SST^6 - 3.27*10^{-8}* SST^7 \quad (3)$$

The sea surface temperature – SST is determined directly from ocean color image (in here is SEAWIFs image). The relationship between digital number (DN) and SST are determined by algorithm:

$$T = 0.150041*DN - 1.8572 \text{ with } r^2 = 0.99976 \quad (4)$$

The photosynthectically available radiation (PAR) depends mainly on marine surface radiance, we can collect this value directly from SEAWIFs images or some other satellite image sources such as AVHRR (Advanced Very High Resolution Radiometer) image. Unfortunaly, in present time, we have not find correspondence algorithms for interpretation of Eo value from these image sources. Based on the measurement material in the tropical sea regions and Bien Dong Sea, we choose Eo= 0.5 W/m^2.

The content of surface chlorophyll Csur is also determined directly from ocean color image (in here is SEAWIFs image). The relationship between digital number (DN) and SST are determined by algorithm:

$$Csur = e^{(0.034538776.DN) - 4.605169916} \text{ with } r^2 = 0.99876 \quad (5)$$

The depth of euphotic layer is the depth where the photosynthectically available radiation has been reduced 1% compared with this value in surface (Morel & Smith, 1991). According to Morel and Berthon (1991) /8/, Deu related strongly to with sum content of chlorophyll (including chlorophyll-a, b, c, pheaphytin, carotein...)

Some relationships are presented as follow:

$$Chlototal = 38.0 * Csur^{0.425} \text{ (if } Csur < 1) \quad (6)$$

$$Chlototal = 40.2 * Csur^{0.507} \text{ (if } Csur >= 1) \text{ and} \quad (7)$$

$$Deu = 200.0 * Chlototal^{-0.239} \text{ (if } Deu > 102) \quad (8)$$

$$Deu = 586.2 * Chlototal^{0.239} \text{ (if } Deu <= 102) \quad (9)$$

This thing equilibrium with :

$$Deu = 68.89 * Csur^{-0.125} \text{ (if } ur < 0.0435) \quad (10)$$

$$Deu = 37.67 * Csur^{-0.317} \text{ (if } 0.0435 <= Csur <= 1) \quad (11)$$

$$Deu = 36.12 * Csur^{-0.378} \text{ (if } Csur > 1) \quad (12)$$

The daily duration Hirr depends on the acquisition time (convert to Julian day) and geographical latitude. In this case we chose Hirr = 12 h

3.2 The Mixed Layer Depth Model (MLDM) : that has been proposed by Katherin Hower and Jim Yoder (1995) is similar with model VGPM, here:

$$PP = Csur * [(Pmax * Ebar)/ (Pmax/k + Ebar)] * MLD \quad (13)$$

The Mixed Layer Depth - MLD is considered as coincident with the thickness of quasi uniform temperature layer. The studies of V.V. Lanh and T.P.H. Son (2002) /7/ show that,

the thickness of this layer changes from 20m to 125 m and the their distribution related to the forming of high/low temperature center which happened in the region. The map of the thickness of quasi uniform temperature layer can be used to replace the distribution map of Mixed Layer Depth.

Pmax is similar with PBopt, it characterizes for the factors of surface active layer which affect photosynthetically ability and is a function of sea surface temperature:

$$Pmax = 24 * e^{0.009*SST} \quad (14)$$

Ebar is charaterized by active photosynthetically radiance and presents by following formula:

$$Ebar = Eo * (1 – exp (Kpar* MDL)/ Kpar* MDL \ (W/m^2) \quad (15)$$

Kpar is reducing diffusion coefficient of the photosynthectically available radiation – PAR. According to Nelson and Smith (1991) /8/, Kpar depends on the content of surface chlorophyll:

$$Kpar = 0.004 + 0.0088 *Csur + 0.054 *Csur^{-0.06} \quad (16)$$

k is a parameter related to optimum photosynthectically ability, it is determined through initial slope of saturation light curve. According to N.T.An and others (2000) k = 0.08

The general schema that show calculated processes presents concretely in figure1.

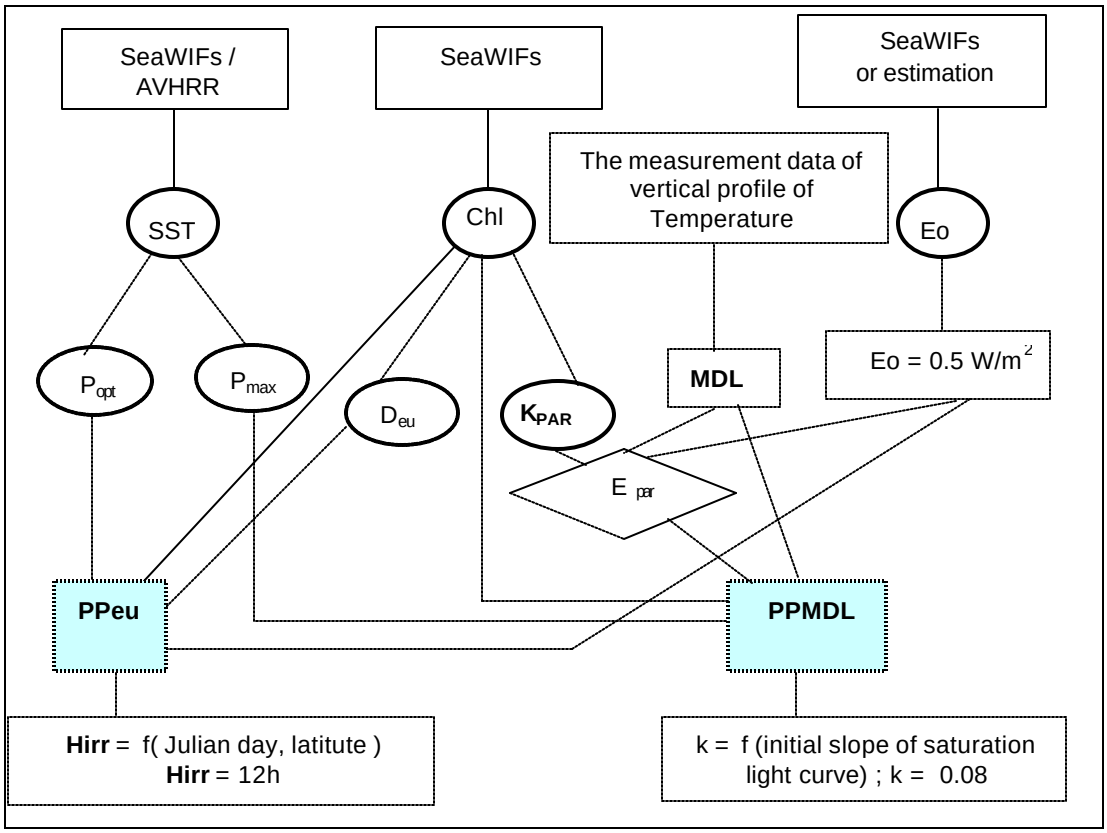

Figure 1: The schema shows calculated procedure of Primary Productivity PPeu and PPMDL based on data collecting mainly from satellite images and measurements

From the collected and processed data as mentioned above, a series of processes of map overlay and calculation have been carried out and some results are presented in figure 2.

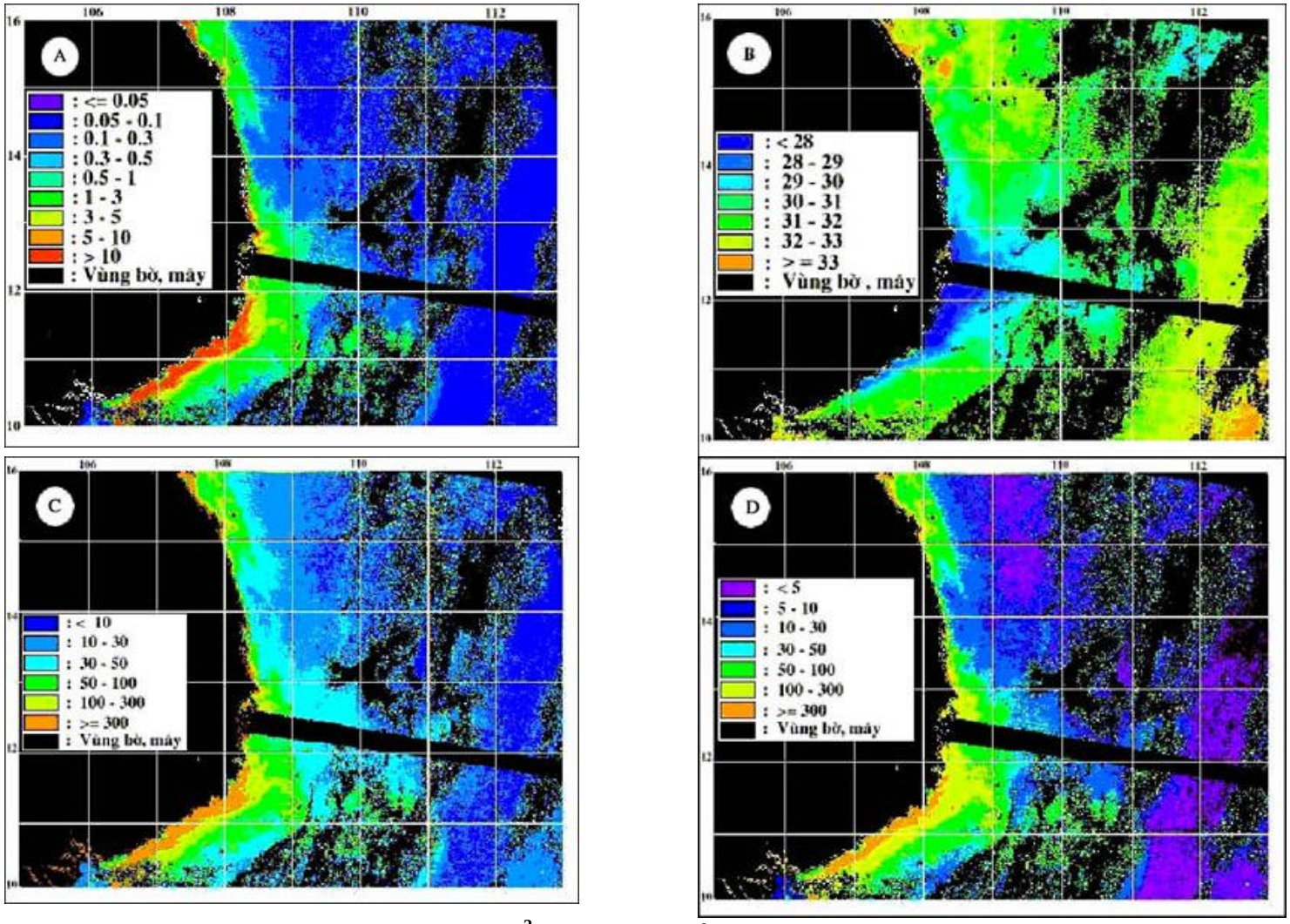

Figure 2: Distribution of Chlorophyll (mgC/m^3) (A) and SST (^{o}C) (B) from SEAWIFs image with date 10/6/1997 Primary Productivity – Peu (C) (mgC/m^2*day) from VGPM model and PMDL (D) from MDML model

The results show that:

- The modeling of Primary Productivity calculation based on satellite images has been using effectively in a large scale in Bien Dong Sea.
- The studied results detected the characterized hydro dynamic processes such as upwelling phenomena in South –West monsoon in Southern Coastal water of Vietnam.
- The distribution trend of Primary Productivity from two models is similar and the difference is small when compared with directly measurement data in this region (N.T.An, 1985, 1989). The calculated results can be accepted and applied (especial VGPM model) for the study on the distribution characteristic of Primary Productivity, on the variability of Carbon in biogeochemistry cycle and also on fishery oceanography.

4 CONCLUSION

- The modeling of Primary Productivity calculation based on satellite images has been using effectively in a large scale in South China Sea.
- The studied results detected the characterized hydro dynamic processes such as upwelling phenomena in South –West monsoon in Southern Coastal water of Vietnam.
- The distribution trend of Primary Productivity from two models is similar and the difference is small when compared with directly measurement data in this region (N.T.An, 1985, 1989). The calculated results can be accepted and applied (especial VGPM model) for the study on the distribution characteristic of Primary Productivity, on the variability of Carbon in biogeochemistry cycle and also on fishery oceanography.
- These results open a new way in oceanography study by applying ocean color images. However, in order to be able to collect real data image, we need to register for becoming authorized user of SEAWIFs and other organizations.

5. ACKNOWLEDGMENT

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