D-3.1 Study on Marine Primary Productivity by means of Satellite Ocean Color Data Mapping and in situ Monitoring

Contact Person Satsuki Matsumura
Division Director, Oceanography and Southern Ocean Living Resources Division National Research Institute of Far Seas Fisheries
5-7-1,Odido,Shimizu-shi,Shizuoka,424 Japan
TEL 0543-34-0715 FAX 0543-35-9642 S.Matsumura/OMNET

Total Budget for 1990-1992 62,436,000 Yen

Abstract The photosynthesis by chlorophyll a is one of the most important factors for understanding carbon cycles and flux in the ocean. There are many steps to determine chlorophyll a concentration and primary productivity by satellite data. We advanced the study with dividing into four main classes: underwater algorithm, primary productivity experiments, atmospheric correction, disposal of information. Primary productibity measurement in equatorial waters was done as a references for coastal waters. And also time continuous underwater spectro optical measurement at coastal water has been done using by buoy system for better understandng of satellite data. It could be good sea trouth data for satellite observations in near future. With the use of our modified data processing algorithm that takes account for Asian dust aerosol, we processed a CZCS data set of 4,129 scenes that covers the Northwestern Pacific to form monthly and seasonally averaged composite images. The results were then remapped into 5 areas in Japanese marginal seas. The final product of about 5,000 images will be distributed in CD-ROM format.

Key Words Primary Productivity, Underwater Optics, Atomospheric Correction, Chlorophyll Map, Image Composition

1.Introduction

Our study objective is to elucidate the process of matter cycling by biological pump in the sea and develope the broad and long period observation system monitoring the change of it. We tried to map the chlorophyll a and primary productivity using the data of ocean color remote sensing.

Coastal Zone Color Scanner (CZCS) is the first satellite-borne ocean color sensor aboard Nimbus-7 that has been operated in 1978-1986. CZCS was an experimental satellite, so systematic observation data have not been obtained, but making data set during 10 years and developing chlorophyll a algorithm contributed much to the developement of ocean color remote sensing.

In July of 1994 NASA schedules to launch Sea WiFS which is a marine biological satellite, and in 1996 NASDA prearranges to launch ADEODS/OCTS. It is necesarry to start the basic study for mapping phytoplankton biomass before the data collecting by the satellites.

2.Research Objective

We must begin to grasp the broad chlorophyll a distribution in the case of understanding primary productivity of the sea in biogeochemical cycle. CZCS (Coastal Zone Color Scanner) was an only satellite monitoring the broad sea surface chlorophyll a. NASA had made the global chlorophyll a distribution. However, the resolution of chlorophyll a image was not high in the sea near Japan because of the affect of Asian dust aerosol. Our resarch objective is to understand the primary productivity process and develope underwater algorithm, and furthermore map chlorophyll a distribution near Japan using our new atmospheric correction considering Asian dust aerosol. There are many steps to estimate the chlorophyll a concentration and primary productivity from satellite data. In our study we advanced the study with dividing into four main classes: underwater algorithm, primary productivity experiments, atomospheric correction, disposal of information.

3. Result and discussion

3-1 Bio-optical survey by moored and drifting buoy.

Time continual underwater spectra optical measurement at coastal water has been done using by buoy system for better understanding of satellite data. Buoy observation has two purpose. One is taking sea truth data for satellite observation and the other is taking continual data linked to satellite data for understanding oceanic conditions. Although satellite data will be taken meanly once in several days, oceanic condition is changing daily or hourly. To see the phytoplanktological phenomena, hourly data is required.

Mooring buoy was set at off Miura peninsula 2.5km point during Dec.1991 to Feb.1992. It had Underwater spectrometer, underwater fluorescence meter, wave gage and meteorological equipment eg. wind direction, speed, Sky radiance meters.

Spectra radiance intensity ratio REu ($Eu\lambda 1/Eu\lambda 2$) can be changed by sun altitude and sky condition. Since chlorophyll measurement is made by RLu ($Lu\lambda 1/Lu\lambda 2$), change of incident light spectra ratio make error for chlorophyll density. In case of sun altitude is less than 25 degree, majority sun beam is reflected at sea surface, so sky radiance occupy the main part of underwater irradiance. In that case, bio-optical algorithm can not be used. Incident light change caused by sky conditions do not change spectra ratio so much. 30 percent change of incident light intensity occur less than 10 percent error for RLu. It makes about 18 percent error to chlorophyll density.

3-2 Primary productivity experiments

Primary propductivity experiments were carried out in the equatorial Pacific during the 1991/92 El-Nino (November 12 in 1991 to January 4 in 1992). Primary productivity was measured by the simulated in situ methods using a n onradioactive ^{13}C-technique. The isotopic ratios ($^{13}C/^{12}C$) were determined by ainfrared $^{13}CO_2$ analyzer (JASCO model EX-130S $^{13}CO_2$). The maximum values of the depth-integrated daily primary productivity per unit Chl.a (Chl-specific productivity) was observed around 4°S. In addition, to elucidate the east-west changes of the depth-integrated Chl-specific productivity along the equator, the results obtained between 5°N and 5°S were averaged (Fig.1). Chl-specific productivity increased from 160°E to 150°W, but the values at

120°W decreased about 30% compared with those at 150°W. In contrast, Chl.a did not show remarkable changes although it was slightly higher at 160°E and 180° than 150°W and 120°W. Comparing our results with the past results[1] in the equatorial upwelling region, it was found that primary productivity and standing crops of the primary producer remarkably decreased during the 1991/92 El-Nino event.

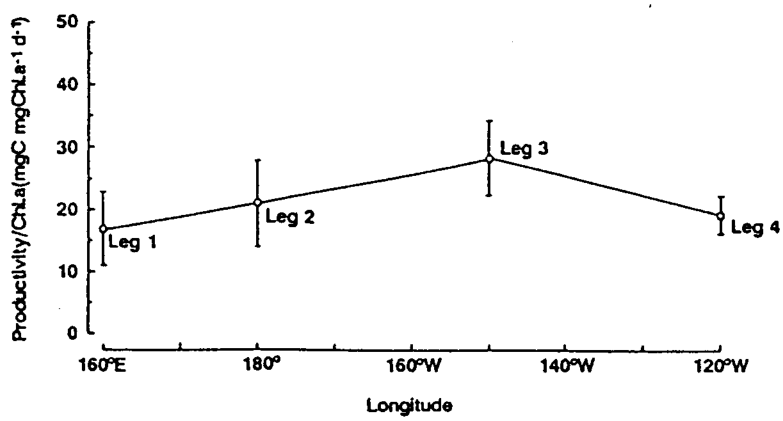

Fig. 1 The east-west change of the depth-integrated Chl-specific productivity along the equator. Open circles and bars indicate mean value and standard deviation, respectively.

3-3 Advanced atmospheric correction technique

An accurate method to eliminate large noise component to the atmospheric aerosol scattering is required to obtain quantitative ocean color measurements by remote sensing. In this study, two new methods to obtaine the aerosol parameter with satellite measurements over ocean were examined, at first. One method is to determine the aerosol parameter of each pixel using 2 band measurements of red and near-infrared. This method is useful to determine the aerosol parameter pixel by pixel base and applicable to segment ocean area with different atmospheric aerosol type, but neglecting wave length dependency of aerosol parameter. Another method is to determine mean aerosol parameter of a scene using statistical correlation analysis. This method based on a fact that the aerosol scattering pattern over ocean has no correlation with the ocean color pattern. The method can estimate wavelenght depoendency of aerosol parameter and useful to determine aerosol parameter of shorter band as 412nm and 443nm bands in OCTS abd Sea-WiFS. By combinative use of two methods developed in this study to obtain aerosol parameter, an atmospheric correction method to eliminate large noise component due to the aerosole scattering was finally proposed.

3-4 Automatic CZCS data processing system and composite image

As for the image composite, we have studied various technical aspects including averaging, cloud masking, edge-data masking and quality control issue, to develop a data processing system for large volume CZCS data set, consisting of a microVAX system with an optical disk drive and UNIX-based workstations all connected via local area network. With this system, we have processed all the NW Pacific CZCS data of 4,129 scenes provided by NASA Goddard Space Flight Center in optical disks to result in following output data (Fig.2).