D-3.2 Study of Biological Processes and Material Flux around Continental Shelf with Satellite Ocean Color Data and Physical-Biological Model

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Abstract
Coastal Zone Color Scanner data around Japan was searched and data catalog was assembled. Ship-observed phytoplankton data was also searched and it was found that there were very few ship data which can be used to verify the ocean color data. Comparison between CZCS and ship-data taken around Izu local upwelling area on May 23, 1982, was conducted. The comparison showed that CZCS data underestimate the surface phytoplankton pigment with a factor of 1/5 when typical atmospheric correction algorithm was used. New atmospheric correction algorithm which is suitable for aerosol around Japan is required. However, oceanographic features detected by the CZCS data clearly showed the usefulness of the ocean color data for monitoring environmental changes and for understanding ecosystem of coastal and open ocean area. Vertically one-dimensional ecosystem models were developed and compared with the ship data taken at the Izu local upwelling area. Primary production is reasonably predicted by the model when the environmental parameters during the incubation for primary production was well known. Predicting phytoplankton biomass is much difficult for local upwelling; however it is useful to predict for much large scale changes. Satellite data assimilation for ecosystem model is useful but further study is required.

Key Words Ocean Color Remote Sensing, Physical-Biological Model, Flux, Phytoplankton, Data Analysis System

1. Introduction

Recent expansions of human activities start to affect to large area of ocean, including continental shelf and open ocean. It is necessary to develop the method to assess the effects of human activities to the large scale ocean. Since the ocean is wide and the environments naturally vary considerably with time and space and since the ship operations are limited for the time and space frequencies, it is not easy to observe the environmental changes in the ocean. Recent development of satellite remote sensing technology allows us to observe the large scale ocean with high resolution in space and in time.

Satellite ocean color is one of the necessary tools to determine the long-term and wide-area environmental changes of ocean. Coastal Zone Color Scanner (CZCS) had been operated during November 1978 to June 1986 and the detection capability of surface chlorophyll concentration was ensured. Presently at least two satellite ocean color sensors are planned to be operated; U.S. SeaWiFS will be launched on 1994 and Japanese OCTS/ADEOS will be launched on 1996. It is necessary to develop possible analysis methods of ocean color data based on present CZCS data before these new sensors will be operated. This research focuses on development of an analysis system of the data in conjunction with ship observed data. Furthermore physical-biological models are developed in order to estimate primary production around continental shelf area of Japan.

2. Data Number of CZCS around Japan

As the first step of the research, CZCS data around Japan (20-50° N, 120-180° E) was examined by a browse system developed by NASA Goddard Space Flight Center (GSFC), and catalog of these data was assembled[1]. GSFC stored 4089 CZCS scenes from 1228 days during November 1978 to June 1986, and 80% of the scenes are from 1979 to 1982. Time variation of monthly data number is different year by year. Data around Wake, Mariana, Minami-torishima, and East China Sea are 1100 to 1500 scenes and data around Kuroshio Extension, Sea of Japan and Midway are about 800 scenes. Data around Kuroshio, Sanriku, Sea of Okhotsk, and Emperor Sea Mountains are about 500 scenes, and Yellow Sea and Seto Inland Sea are 300-400 scenes. About 25% of the data is not useful because of the cloud cover or only small portion of the area is covered, and most of the rest of the scenes are also not perfectly clear. However, the amount of data is considerably large compared with ship observation. Future satellite will supply more data around Japan, and it is certainly useful.

Ship observation data from the Japan Oceanographic Data Center[2] was also searched to find the data which coincide with CZCS data. There are 64 stations of 19 days which may be useful for the direct comparison of the ship-observed chlorophyll data to CZCS chlorophyll data. The number is not sufficient for verification of satellite data. It is necessary to make better coordination to obtain sea-truth data for verification in order to make future ocean color satellite data useful.

3. Data Analysis System

Data analysis system was constructed with a workstation and a color printer which are connected with other personal and mainframe computers and other devices by ethernet. The network capability makes possible to use present setup of hardware and commercial software as much as possible. We also developed software to convert satellite data[3] and to display the data with combination to ship data[4].

4. Comparison of Ship and CZCS Data

We found data from a cruise for the study of Izu local upwelling region which were coincide with a fine CZCS data on May 23, 1982. CZCS and ship observed phytoplankton pigment data were compared as the first case around Japan[3]. CZCS considerably underestimated the phytoplankton pigment concentrations with a factor of 1/5 when popular atmospheric correction algorithms were used. Good correspondence was found when the atmospheric correction parameters were adjusted so that one pixel of the CZCS data was equivalent to the ship observed data. Cause of the underestimation is probably the unsuitable atmospheric correction algorithm for the local aerosol. It is necessary to develop suitable atmospheric correction algorithm for the aerosol around Japan. However, the good correspondence after adjusted atmospheric correction parameters and observed oceanographic patterns in the data indicates that the ocean color satellite data is very useful to understand the interaction between coastal area and open ocean.

Monthly average of CZCS data was also compared with monthly average ship-observed data. The monthly averaged CZCS data also underestimate the averaged ship data; however the underestimation is about factor of 1/2 and better than the data on May 23, 1982. Further verification of satellite ocean color data with ship data is necessary to make the satellite data useful.

5. One-Dimensional Physical-Biological Model

One of the main focuses of this research is development of physical-biological models which coupled with satellite ocean color data in order to estimate primary production around Japan. Two kinds of vertically one-dimensional physical-biological models for the Izu local upwelling area were developed because satellite and ship data were available for this area[6]. These modeling efforts will be the basis of future expansion of the model to much wider scale continental shelf area.

First model simulate the spectral dependent light fields and primary production in the upper ocean. Comparison to in situ data sets indicate that the model can reasonably estimate the spectral light field and primary production in a regional upwelling area. However, phytoplankton biomass changes caused by growth and other factors and environmental changes during incubation may induce the large variabilities of primary production. Information of biomass changes in the incubation bottle and environmental change of the bottle during primary product measurements is necessary for the interpretation of the measurements.

Second model is a simple nutrient-light-temperature phytoplankton growth model with diffusion estimated from observed density distribution. The simple vertically 1-D model was not enough to simulate the phytoplankton growth in a regional upwelling area under the dynamic flow regime. However, a simulation of spring bloom off Hokkaido and comparison with monthly satellite data could explain the timing of spring bloom[7]. The 1-D model is useful to simulate larger scale variability of primary production.

Once phytoplankton and ecosystem dynamics are simulated, there are many error sources in the model and input parameters. In order the simulation model to keep close to the nature, it is necessary to update the model with observation data. Satellite data may be useful for the update, and the development of methods of satellite data assimilation to ecosystem model is necessary[8]. Simple time-dependent model without spatial dimension was used to consider the effects of phytoplankton data assimilation into ecosystem model[9]. The simple experiments indicate that simple replacement of phytoplankton model results with observed data may not improve all the model output. Further development of data assimilation method is necessary in order to use ecosystem simulation model.

6. Conclusion

In this study, we searched CZCS data around Japan and compared the data with coincide ship-observation. It is clear that more ship data is necessary for the verification of future ocean color satellite data. Comparison between the CZCS and ship data indicate that the development of new atmospheric correction algorithm which is suitable for the aerosol around Japan. However, the oceanographic features seen in the data is clearly useful for the detection of environmental changes of coastal and open ocean. Vertically one-dimensional ecosystem models were developed and compared with the ship-observed primary production and chlorophyll changes of Izu local upwelling area. Results of the ecosystem models indicate that primary production can be predicted reasonably when environmental parameters during the incubation for primary production measurements were well known. Prediction of chlorophyll changes with one-dimensional model is much difficult for local upwelling but is possible for much large scale phoneme. Satellite data assimilation to the ecosystem model may be useful but is not a simple problem and further study is required.

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