Journal of the Korean Society of Remote Sensing, Vol. 14, No.3, 1998, pp.277~284

Global Patterns of Pigment Concentration, Cloud Cover, and Sun Glint: Application to the OSMI Data Collection Planning

Yongseung Kim*, Chiho Kang, and Hyo-Suk Lim***

Space Division, Korea Aerospace Research Institute* Department of Astronomy, Yonsei University**

색소농도, 운량 및 태양반사의 전구분포 : OSMI 자료수집계획에 대한 응용

김용승* · 강치호 · 임효숙***

한국항공우주연구소 우주사업단*, 연세대학교 천문우주학과**

Abstract

To establish a monthly data collection planning for the Ocean Scanning Multispectral Imager (OSMI), we have examined the global patterns of three impacting factors: pigment concentration, cloud cover, and sun glint. Other than satellite mission constraints (e.g., duty cycle), these three factors are considered critical for the OSMI data collection. The Nimbus-7 Coastal Zone Color Scanner (CZCS) monthly mean products and the International Satellite Cloud Climatology Project (ISCCP) monthly mean products (C2) were used for the analysis of pigment concentration and cloud cover distributions, respectively. And the monthly-simulated patterns of sun glint were produced by performing the OSMI orbit prediction and the calculation of sun glint radiances at the top-of-atmosphere (TOA). Using monthly statistics (mean and/or standard deviation) of each factor in the above for a given 10° latitude by 10° longitude grid, we generated the priority map for each month. The priority maps of three factors for each month were subsequently superimposed to visualize the impact of three factors in all. The initial results illustrated that a large part of oceans in the summer hemisphere was classified into the low priority regions because of seasonal changes of clouds and sun illumination. Sensitivity tests for different sets of classifications were performed and demonstrated the seasonal effects of clouds and sun glint to be robust.

요 약

해색관측센서 (OSMI)의 월별 자료수집계획을 수립하기 위해 색소농도, 운량 및 태양반사의 세가지 영향요소에 대한 전구분포가 검토되었다. 위성의 임무 제한조건 (예, 임무주기)을 제외한 이들 세 요소들은 OSMI 자료수집에 매우 중요한 것으로 간주된다. Nimbus-7 CZCS 월평균 자료 및 ISCCP 월평균 자료가 색소농도 및 운량 분포 분석에 각각 사용되었다. 그리고 태양반사의 월별 모사분포는 OSMI 궤도예측 및 대기 상층부 태양반사 레이디언스 계산을 수행함으로 얻어졌다. 주어진 경위도 10° 격자에 대한 상기 각 요소의 월별 통계자료 (월평균 혹은 표준편차)를 이용해 월별 우선순위도를 생성시켰다. 이어서 세 요소의 중복효과를 보기위해 각 달의 세 요소에 대한 우선순위도를 중첩 시켰다. 초기결과는 하반구의 대부분이 구름과 태양반사의 계절변화로 인해 우선순위가 낮은 지역으로 분류됨을 보였다. 서로 다른 분류세트에 대한 민감도 시험을 하여 구름과 태양반사의 계절변화가 강건함을 보였다.

1. Introduction

The ocean scanning multispectral imager (OSMI) is designed to observe the global ocean color in support of biological oceanography. The OSMI collects data in the six visible spectral bands with the nominal selection centered at 412, 443, 490, 555, 765, and 865 nm. However, data collection capabilities of the OSMI are significantly limited by its 20% duty cycle per orbit because most of the sunlit globe can be covered with a 40% duty cycle. In addition to the limited duty cycle, there are other factors such as sun glint and clouds to be considered in the OSMI data collection planning. Data from regions of sun glint and clouds will be masked in the data processing algorithm because of high reflectivity. It is therefore very important to develop a data collection plan for the OSMI mission considering the above impacting factors.

In this study we focus on the development of a monthly data collection plan and provide a rationale behind it. We have examined the global patterns of pigment concentration, cloud cover, and sun glint. The Nimbus-7 Coastal Zone Color Scanner (CZCS) monthly mean products and the International Satellite Cloud Climatology Project (ISCCP) monthly mean products (C2) were used for the analysis of pigment concentration and cloud cover distributions, respectively. Since pigment concentration is closely linked to the ocean color, its mean and variations would be suitable to characterize global oceans for the ocean color monitoring. Unlike the patterns of pigment concentration and cloud cover, the monthly patterns of sun glint were simulated by performing the OSMI orbit prediction and the calculation of sun glint radiances at the top-of-atmosphere (TOA).

2. Data

The Nimbus-7 CZCS monthly mean pigment concentration data(Feldman *et al.*, 1989) are used to calculate the multi-year averages and intra-annual variations for the period of January 1982 to December 1985. The CZCS monthly mean products of a 1° latitude by 1° longitude grid were obtained from the Jet Propulsion Laboratory Physical Oceanography Distributed Active Archive Center. The CZCS data spans from 1978 to 1986 but the twelve month data in a year are available for the above period. The International Satellite Cloud Climatology Project (ISCCP) monthly mean products (C2) (Rossow and Schiffer, 1991) of a 2.5° latitude by 2.5° longitude grid were downloaded from the web site (http://isccp.giss.nasa.gov). And the eight year mean (July 1983 through June 1991) cloud cover data are used for this analysis. As for sun glint data, we incorporate the monthly simulated patterns as described in the following section.

3. Methods

We first calculate the multi-year monthly statistics, such as mean and standard deviation (intra-annual variations), for the CZCS data. The cloud cover data are the eight year mean monthly product obtained from the ISCCP data. The monthly patterns of sun glint are produced by performing the OSMI orbit prediction and the calculation of sun glint radiances at the top-of-atmosphere (TOA) (Lim *et al.*, 1998). These monthly statistics are subsequently binned into given grid boxes of 10(latitude by 10(longitude while calculating mean values. Based on the grid mean value, each grid box can be classified into a specific region of priority.

1) Monthly Statistics

Global patterns of pigment concentration, cloud cover, and sun glint are shown in Fig. 1. It is evident that the high mean pigment concentrations occur near coast areas and low values are seen over open oceans. Distributions of intra-annual variations also show the similar features over coast and open ocean areas. Note that log-transformation has been applied to the pigment concentration data to enhance the patterns of open oceans. Distributions of clouds over oceans exhibit the maximum amounts in the mid-latitude storm tracks while showing the lowest amounts in the sub-tropical regions. Sun glint patterns illustrate that a large portion of the satellite pass on the right side of sub-satellite point is contaminated by sun glint.

2) Classification

Using monthly statistics of pigment concentration, cloud cover, and sun glint, we generate the monthly bin products. Binning is performed for a 10° latitude by 10° longitude grid. Each grid value is then used to classify a given grid into a certain region of priority based on the threshold values in Table 1. It is noted that threshold values for pigment concentration include three types of water: eutrophic, 1.0< mean; mesotrophic, 0.3<mean≤1.0; oligotropic, mean<0.3 (units in mg/m^3). The highest priority (class 1) corresponds to the highest mean and standard deviation for pigment concentration, the lowest cloud cover, and the sun glint radiance of 865 nm band less than 0.5 $mW/cm^2/sr/\mu m$. The threshold value for a sun glint radiance is based on the SeaWiFS algorithms (McClain *et al.*, 1995).

4. Results and Discussion

The monthly bin products of pigment concentration, cloud cover, and sun glint are finally superimposed to examine the impact of three factors in all. Priority classes have been normalized for superimposition. The results are shown in Fig. 2. It appears that a large part of oceans in the summer hemisphere is classified into the low priority regions (hereinafter called seasonal belt) because of seasonal changes of clouds and sun illumination. However, most of coast areas exhibit

Table 1. Classification based on monthly statistics of pigment concentration, cloud cover, and sun glint

Priority	Pigment Concentration(mg/m^3)		Cloud Cover (%)	Sun Glint ($mW/cm^2/sr/\mu m$)
	10^{Mean} (M)	Standard Dev.(σ)	CC	I_{glint}
1	1.0<M	$5.0<\sigma$	0<CC≤20	$I_{glint}<0.5$
2		$2.5<\sigma\le5.0$	20<CC≤50	$0.5\le I_{glint}$
3		$0.0\le\sigma\le2.5$	50<CC≤80	
4	0.3<M≤1.0	$5.0<\sigma$	80<CC≤100	
5		$2.5<\sigma\le5.0$		
6		$0.0\le\sigma\le2.5$		
7	0.14<M≤0.3	$5.0<\sigma$		
8		$2.5<\sigma\le5.0$		
9		$0.0\le\sigma\le2.5$		
10	M≤0.14	$5.0<\sigma$		
11		$2.5<\sigma\le5.0$		
12		$0.0\le\sigma\le2.5$		

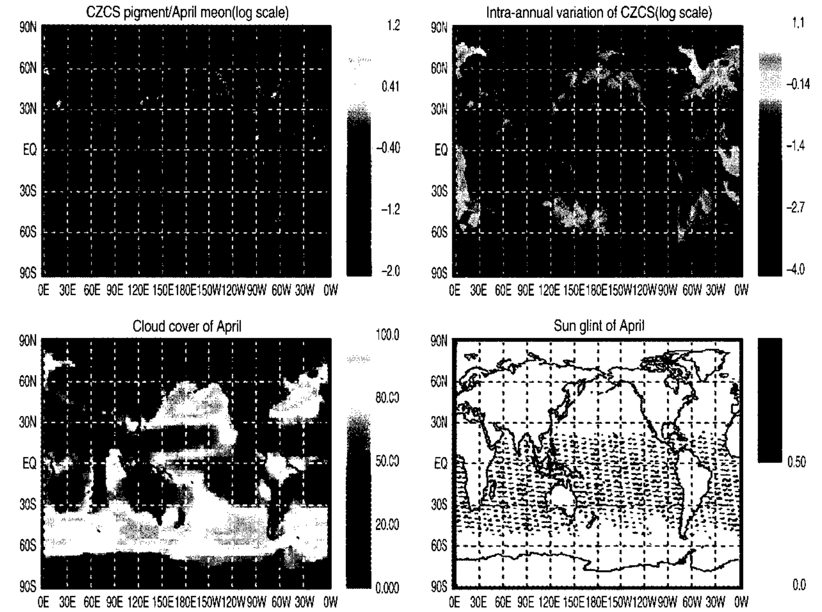

Fig. 1. Global patterns of mean pigment concentration (top-left), cloud cover (bottom-left), and sun glint (bottom-right) for the month of April. Intra-annual variations of pigment concentration for the period of January 1982 to December 1985 are shown in the top-right panel. Units are referred to Table 1.

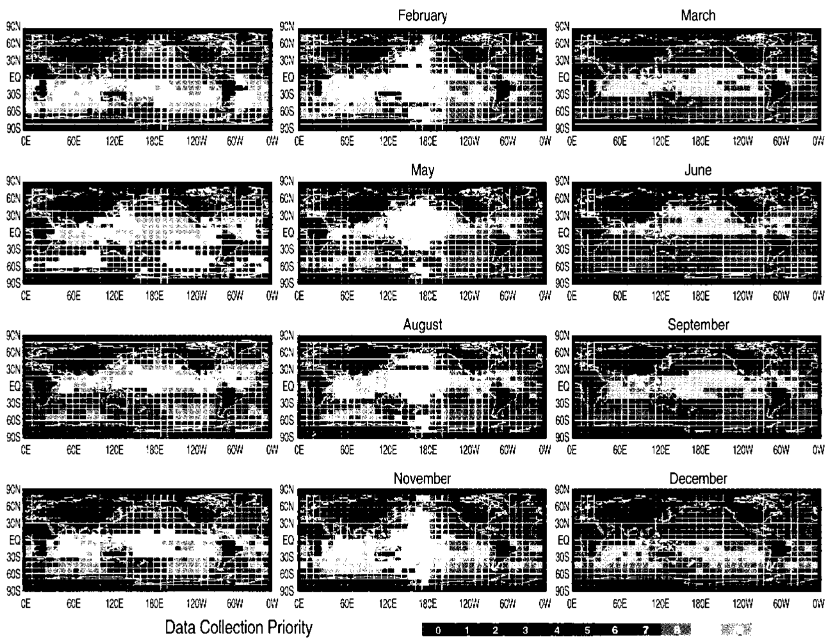

Fig. 2. Monthly priority maps (preliminary) for the OSMI data collection.

the relatively high priority values. This is encouraging in that coast areas need to be monitored in any case due to the high variability of pigment concentration. Concerning the results shown in Fig. 2, it would be appropriate to examine the frequency distributions of priority. We plot three cases for each month as shown in Fig. 3 to demonstrate how clouds and sun glint affect the priority determined by pigment concentration distributions. Overall results (thick solid line) reveal the bimodal distributions in 11 of 12 month cases. Bimodal features may be useful when grouping the regions of interest for the purpose of data collection. By this, however, we should not imply that the current ramification point (priority 6) is ideally suitable for the OSMI data collection. Of particular interest is to note that the addition of clouds and sun glint to the priority distribution of pigment concentration results in a rise of priority rank. This is mainly caused by averaging in which significant compensation occurs in open oceans with low priority.

Although the classification of cloud cover and sun glint given in Table 1 appears to be

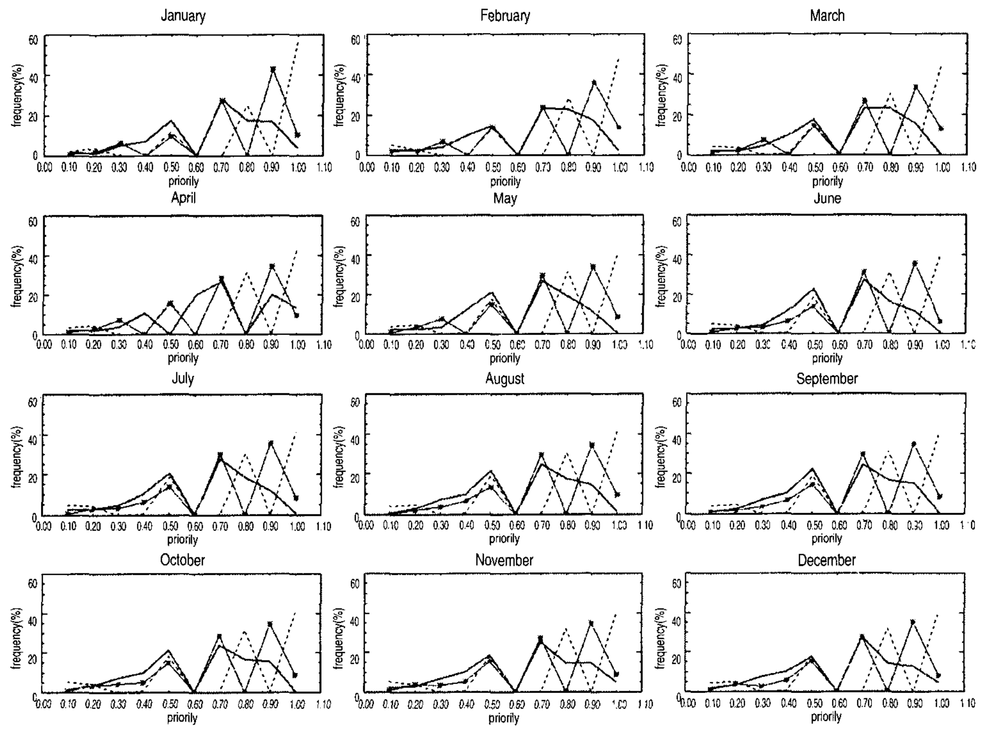

Fig. 3. Effects of cloud cover and sun glint on the priority distribution of pigment concentration. Dashed line denotes the histogram of CZCS pigment concentration alone. Solid line with asterisk denotes the histogram of CZCS pigment concentration and cloud cover. Thick solid line represents the histogram of three factors together. Priority values of X-axis must be multiplied by a scale factor of ten.

reasonable, it is necessary to perform the sensitivity test that employs the different sets of classifications. Two test sets are supplemented for this analysis: Case 1 - two priority classes for both clouds and sun glint, and Case 2 - four priority classes for both clouds and sun glint. Preliminary results indicate that the aforementioned seasonal belts are present in both cases (figures not shown). Compared to the current classification, the priority of seasonal belt in Case 1 is lowered while that of Case 2 remains to be nearly the same. A notable rise of priority out of seasonal belt is also seen in Case 2. It seems that the extent of seasonal belt would be relatively insensitive to varying the classification of clouds and sun glint.

5. Summary

In an effort to support the data collection planning of the OSMI, we have analyzed the global patterns of pigment concentration, cloud cover, and sun glint. These three factors are considered critical for the OSMI data collection. Pigment concentration is the primary parameter that can be derived from the OSMI measurements. And the OSMI measurements over clouds and sun glint will no longer be useful because of the high surface reflectivity. Using monthly statistics of each factor, we produced the priority maps of each factor and superimposed them to see the effect of three factors together.

The preliminary results of this study illustrated that a large part of oceans in the summer hemisphere was classified into the low priority regions because of the effects of clouds and sun glint. By performing the sensitivity test, the effects of clouds and sun glint were shown to be robust for different sets of classifications. In addition, the extent of the aforementioned low priority regions appears to be relatively insensitive to varying the classification of clouds and sun glint.

Acknowledgments

This study was supported by the ministry of science and technology of Korea (grant N97120 and N98100).

References

Feldman, G., N. Kuring, C. Ng, W. Esaias, C. Mc Clain, J. Elrod, N. Maynard, D. Endres, R. Evans, J. Brown, S. Walsh, M. Carle, and G. Podesta, 1989. Ocean color: Availability of the global data set, *Eos, Trans. AGU,* Vol. 70, 634.

Lim, H. S., Y. Kim, and D. H. Lee, Simulated radiances of the OSMI over the oceans, 1998. *Proc.of International Symposium on Remote Sensing*, Kwangju, Korea, Sept. 16-18, 43-48

McClain, C. R., K. Arrigo, W. E. Esaias, M. Darzi, F. S. Patt, R. H. Evans, J. W. Brown, C. W. Brown, R. A. Barnes, and L. Kumar, 1995. SeaWiFS algorithms, Part 1, *NASA Tech. Memo.* 104566, Vol. 28, 38 pp., Greenbelt, Md.

Rossow, W. B. and Schiffer, R. A. 1991. ISCCP cloud data products, *Bull. Am. Meteorol. Soc.,* Vol. 72, 2-20.