DETECTION OF SHORT-TERM CHLOROPHYLL-A CHANGE WITH SEA SURFACE COOLING FROM SATELLITE DATA

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1. INTRODUCTION

Cold nutrient-rich water from below the shallow seasonal thermocline is sometimes injected into the surface layer when a storm passes in a warm season. Decrease in sea surface temperature (SST) and increase in chlorophyll-a concentration (Chl-a) in a short period due to storm passages have been clearly captured by satellite observations [1]. Understanding the short-term Chl-a increase phenomena associated with atmospheric disturbances will be important, for example, for the estimation of primary production [2] [3]. However, most of previous studies utilized hurricane/typhoon best track data and focused on tropical cyclones (TCs) only. In this study, we aimed at comprehensively detecting the rapid Chl-a increase and SST cooling events that accompanied atmospheric disturbances over the northwestern Pacific Ocean considering extratropical cyclones as well as typhoons by analyzing satellite data from August 2002 to July 2007.

2. DATA AND METHOD

We analyzed the merged level-3 chlorophyll data produced by NASA/GSFC from Aqua/MODIS and SeaWiFS data. The original grid interval of the merged Chl-a data is 1/12º, and the data were averaged in 0.25º grid before analyses. The optimally interpolated microwave daily SST dataset produced by Remote Sensing Systems (RSS) was also used in this study. Daily wind speeds in each 0.25º grid were obtained by averaging all the SSM/I and AMSR-E wind data produced by RSS. The analyzed region was from 100ºE to 160ºW and from 0º to 60ºN.

For each 0.25º grid, standard deviations of Chl-a were calculated for each month. We then picked up all events in which the increase in Chl-a within a 10-day interval (ΔChl) exceeded the monthly standard deviation. SST decrease (ΔSST) is here defined as the maximum SST drop within any 5-day interval from 5 days before the beginning of the event to the end of the event, when Chl-a reaches the maximum within the 10-day interval. We also extracted the maximum daily satellite wind speed (MDSW) in the same period from the satellite wind data.

3. RESULTS

The frequency of the detected events was very high in the subtropics where Chl-a is quite low (approximately less than 0.05 mg m^{-3}). About 85 % of the events had a ΔSST of less than 1.0 K, and most of them occurred south of 30ºN. On the other hand, ΔSSTs exceeding 2.0 K were concentrated south of Japan, in the Sea of Okhotsk, and between 35ºN and 45ºN. There was clear seasonality in the frequency of the events with large ΔSST. Beginning in May, the rapid SST cooling events start to occur south of 35ºN. The patterns of high frequency resemble the tracks of TCs, implying that these patchy patterns were caused by TCs. Beginning in August, the high-ΔSST events often occurred even north of 35ºN. SST cooling rarely appears south of 35ºN after November, but it still occurs north of the Kuroshio Extension even in winter. We examined the contributions of typhoons to the observed events. The events due to strong typhoons were concentrated west of the Izu Islands (around 135-145ºE), and south of the Ryukyu Islands (around 125-140ºE).

We then examined the relationships among ΔChl, ΔSST, and MDSW. ΔSST tended to increase as MDSW became higher, and the rate of increase was larger when the beginning Chl-a was higher. And ΔChl was larger as ΔSST became higher in oligotrophic regions. However, ΔChl either did not clearly increase or else decreased with ΔSST in eutropic regions.

4. DISCUSSION AND CONCLUSION

Our analysis was able to detect the cases in which Chl-a increased and SST decreased rapidly after the passages of TCs and extratropical cyclones. The events with large SST decreases often happened south of Japan, in the Sea of Okhotsk and in the regions between 35ºN and 45ºN, especially in the Kuroshio-Oyashio Extension region. They occurred most frequently in the late summer and autumn, and less frequently in spring. This suggests that large decreases in SST occur more easily during the short period when there is a mature seasonal thermocline. However, in areas near SST fronts, the events detected may have been caused by the horizontal migration of the SST fronts as well as by vertical mixing. The events south of Japan resulted from passages of TCs, and strong typhoons tended to cause the Chl-a increases south of the Ryukyu Islands. The typhoons had a stronger effect in the regions west of the Izu Islands and south of the Ryukyu Islands. In contrast, most of the events north of 35ºN were caused by extratropical cyclones.

The increase in Chl-a tended to become larger as the corresponding SST decrease became larger in oligotrophic regions. However, such a relationship could not be seen when Chl-a was larger than about 0.4 mg m^{-3}. The reason for this may be that the injection of nutrient-rich water from below the thermocline into the surface layer does not result in an increase of Chl-a in those regions where nutrients are not deleted near the surface even in summer.

5. REFERENCES

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