Annual Report 2012 of HICO Data User

Research Topic
Identification of diatoms in coastal waters using HICO imagery within the southern part of Hokkaido, Japan

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1. Introduction

The main objective of this study by using HICO data is to establish a hyperspectral approach for identifying diatoms or other phytoplankton groups in coastal waters. Since our target region, Funka bay located in southwest Hokkaido Island, Japan, is one of the most important aquaculture regions for scallops in Japan, to understand the influence of phytoplankton functional group on the cultured aquatic organisms is important. Within our ongoing project, we have been developing a method for identifying diatoms by light absorption coefficient of phytoplankton derived from hyperspectral remote sensing reflectance through the inversion method of quasi-analytical-algorithm (QAA, Lee and Carder, 2004; Lee *et al*., 2009). In this report, before we attempt to apply our method to HICO data, for the first time, we investigated atmospherically corrected hyperspectral remote sensing reflectance derive from HICO and MODIS/Aqua because atmospheric correction is a key factor in ocean color remote sensing products.

2. Method

2.1. HICO data

In our target region, ten HICO scenes have been found from May to June 2012. The clearly scene of HICO image on May 9, 2012 was selected for analysis in this report because the image was obtained under a situation of relatively clear sky and low view zenith angle (< 2 degree). Hyperspectral radiance of HICO L1B data, true color image, and atmospherically corrected hyperspectral remote sensing reflectance ($R_{rs}(\lambda)$) of HICO L2A data, which was kindly provided by Prof. Curtiss O. Davis and Dr. Nicholas B. Tufillaro, were used to investigate water mass and compare with both $R_{rs}(\lambda)$ derived from MODIS/Aqua and the past data of *in situ* hyperspectral $R_{rs}(\lambda)$ measured in our target region in 2011. Image processing was conducted by using ENVI 4.8 (ITT VIS).

2.2. MODIS/Aqua data

In addition, satellite image of MODIS/Aqua (Reprocessing 2012) on the same day (May 9, 2012) was used for comparison with HICO image. Calibrated top of atmosphere (TOA) radiance (Lt(λ)), quasi true color image having a resolution of 500 m, remote sensing reflectance were created from L1A data of MODIS/Aqua with the latest version of SeaDAS 6.4 (NASA).

3. Results and discussion

3.1. True color image

True color image created from HICO L1B data provided the very finely detailed image of water mass in Funka bay in May 9, 2012 (Fig. 1). In Funka bay, it is well known from *in situ* observation of mooring or model coupling Ocean General Circulation Model (OGCM) and hydrometeorological procedures that clockwise eddy is formed by the river discharge associated with snowmelt in the surface (e.g., Takahashi *et al*., 2010; Nakada *et al*., 2012). Furthermore, vertical mixing due to strong tidal effect occur around cape chikyu (See Fig.1). On the other hand, Ocean color radiometer of MODerate resolution Imaging Spectroradiometer (MODIS), which has a special resolution of 500 m at BGR bunds, is to coarse to characterize water dynamic within the size of Funka bay, Japan (Fig 2). Therefore, HICO image clearly revealed these water dynamics in more detail. This visibility is first evidence of water dynamics in Funka bay. High-resolution image of HICO has become an essential tool for monitoring water dynamic in coastal ocean.

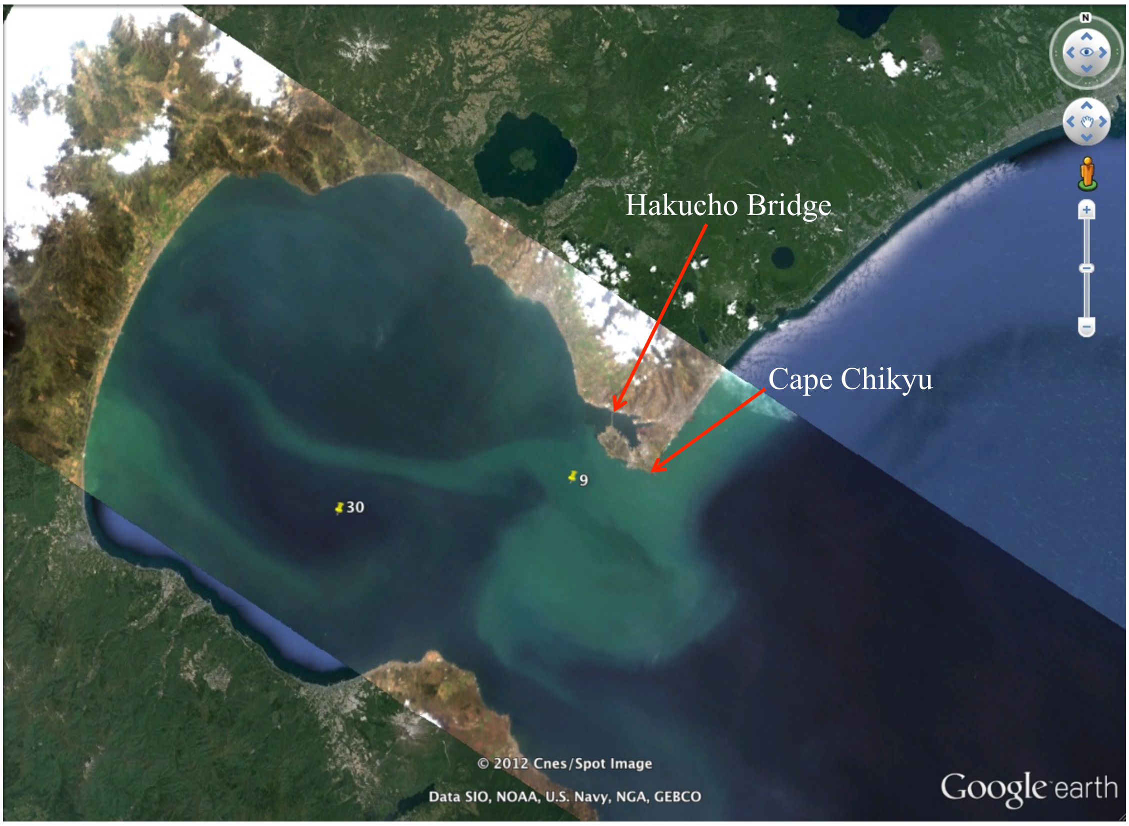

Fig.1. True color image of HICO (Red: 638.9 nm, Green: 553.0 nm, Blue: 461.4 nm) in May 9, 2012, overlaid on Google™ earth. The image was geolocated with the rad_geom file. Two yellow tags represent main sampling stations. Stns.9 and 30 are located off Cape Chikyu and near the center of Funka Bay, respectively. The bridge (Hakucho Bridge) was clearly identifiable from this HICO image.

Fig. 2. Quasi true color image of MODIS/Aqua (Red: 645 nm; Green: 555 nm, Blue: 469 nm) in May 9, 2012. Resolution is 500 m.

3.2. Hyperspectral remote sensing reflectance

Values of hyperspectral remote sensing reflectance ($R_{rs}(\lambda)$) corrected atmospherically by Tafkaa 6s (HICO L2A data) were within the range from 0.01 to 0.03 sr^{-1} in visible range (Fig. 3). These values were remarkably higher than multispectral $R_{rs}(\lambda)$ derived from MODIS (Fig. 3). In addition, compared with some of the past data of *in situ* hyperspectral $R_{rs}(\lambda)$ with HyperProII (Satlantic, Inc.) in Funka Bay during spring phytoplankton bloom in May and summer in September (Fig. 4), higher values of $R_{rs}(\lambda)$ in HICO data were found. However, the distribution of hyperspectral radiance derived from HICO data was thought to be similar to calibrated top of atmosphere radiance derived from MODIS data (Fig. 5). Therefore, the discrepancy of $R_{rs}(\lambda)$ between HICO and MODIS might be induced by the difference in operational atmospheric correction algorithms. Since it is the season for Yellow dust stemmed from the Gobi Desert in the western part of north subarctic pacific ocean during March to May, aerosols within the atmosphere could be contributed to retrieval of $R_{rs}(\lambda)$. Therefore, it is important to accurately estimate and remove the aerosol radiance contributions in the visible light, particularly dealing with cases for strongly-absorbing aerosols. Thus, we should need to specify the aerosol model and/or optical depth or attempt to use other operational atmospheric correction algorithms, such as Fast Line-of-sight Atmospheric Analysis of Spectral Hypercubes (FLAASH), to retrieve a more accurate product of hyperspectral $R_{rs}(\lambda)$.

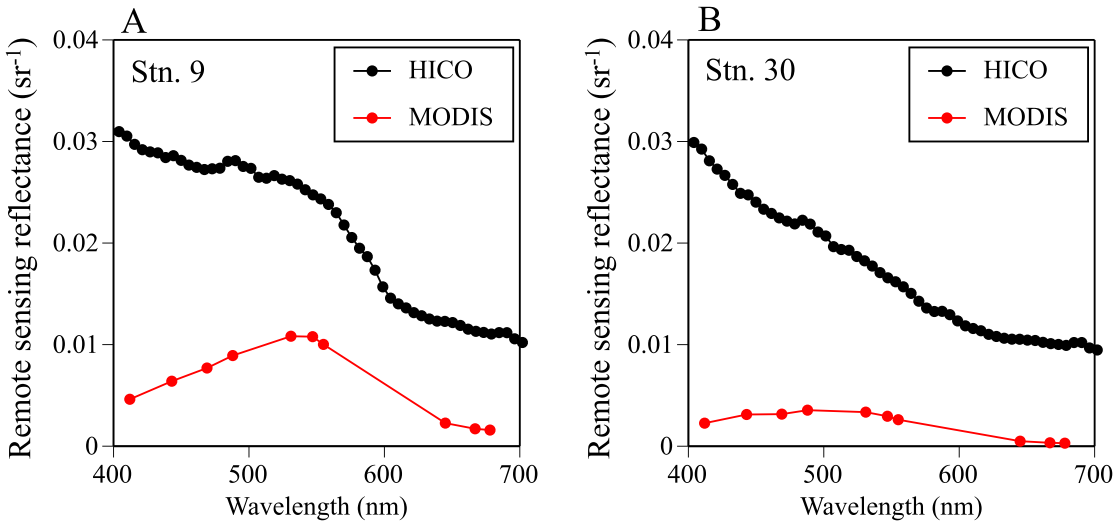

Fig. 3. Spectral distribution of remote sensing reflectance (sr^{-1}) derived from HICO and MODIS at Stns. 9 (A) and 30 (B) in Funka bay on May 9, 2012.

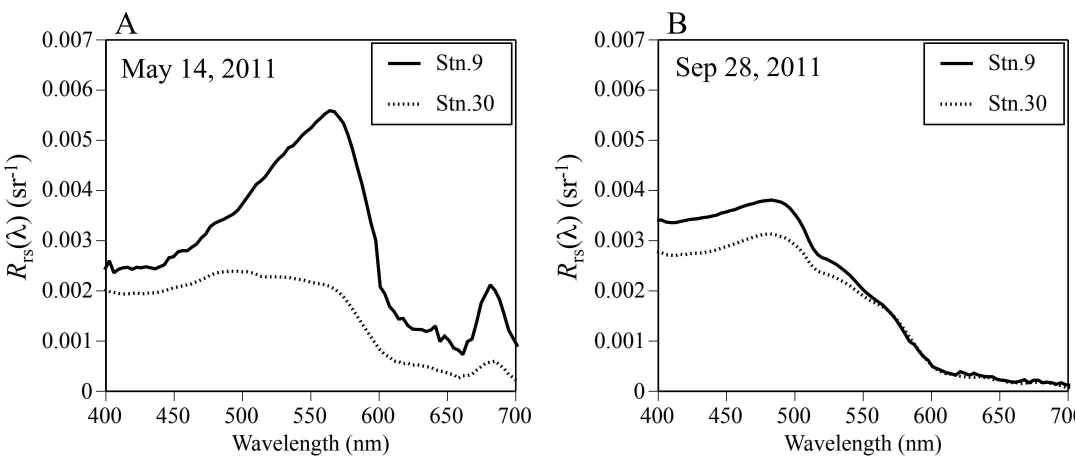

Fig. 4. Some of the examples of *in situ* hyperspectral remote sensing reflectance with HyperProII (Satlantic, Inc.) at two stations in Funka bay on May 14 (A) and September 28 (B), 2011. Solar zenith angles at Stns. 9 and 30 on May 14, 2011 were 39.4º and 33.1º, respectively. The angles on September 28, 2011 were 48.9º at Stn.9 and 54.1º at Stn.30. Chlorophyll *a* concentrations on May 14, 2011 (Stn.9: 4.98 mg m^{-3}, Stn.30: 3.14 mg m^{-3}) were higher than those on September 28, 2011 (Stn.9: 0.44 mg m^{-3}, Stn.30: 0.32 mg m^{-3}).

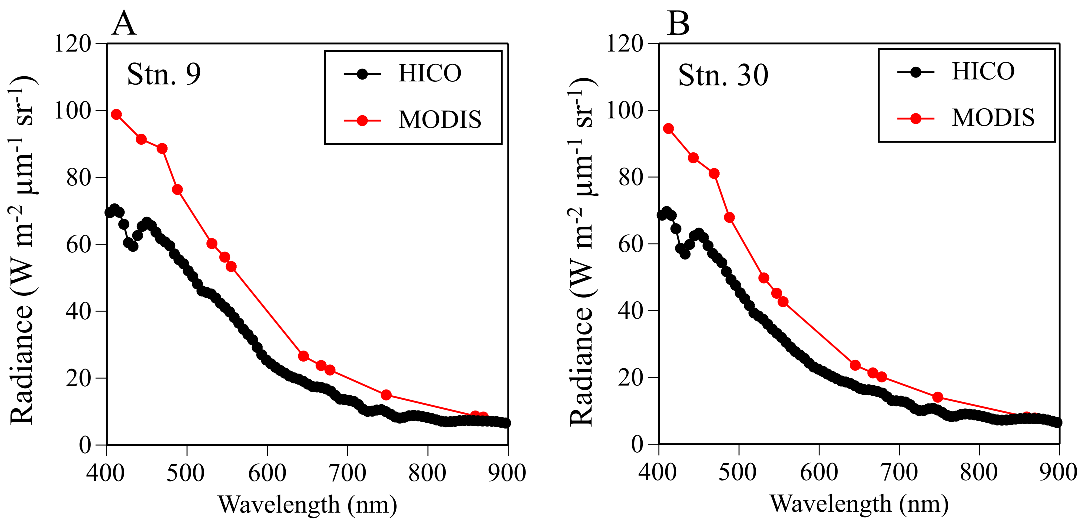

Fig. 5. Spectral distribution of radiance (W m^{-2} μm^{-1} sr^{-1}) derived from HICO and MODIS at Stns. 9 (A) and 30 (B) in Funka bay on May 9, 2012.

4. Summary

As shown in Fig.1, the high-resolution image derived from HICO was of great benefit to an assessment of water dynamic in Funka bay. Therefore, HICO scene has become an essential tool for monitoring water dynamic in coastal ocean. On the other hand, hyperspectral remote sensing reflectance was remarkably high compared with previous seasonal data of *in situ* hyperspectral remote sensing reflectance in Funka bay, which were measured during 2011. One of the main reason for this high $R_{rs}(\lambda)$ of HICO might be caused by the problems of the atmospheric correction because magnitude and spectral shape of hyperspectral radiance were reasonable. Therefore, more efforts will be need to investigate a suitable method of atmospheric correction in Funka bay. To keep HICO operating continuously is thought to be important for investigating our region and improving the atmospheric correction to more accurate product of hyperspectral $R_{rs}(\lambda)$.

5. Acknowledgment

We are deeply grateful to Prof. Curtiss O. Davis and Dr. Nick Tufillaro for the assistance of atmospherically corrected hyperspectral remote sensing reflectance in HICO data. We would like to thank Dr. Jasmine Nahorniak for her kind help and assistance. We express special thanks to HICO team for helpful supports.

6. Reference

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