HICO imagery of Funka Bay, Japan

Toru Hirawake, Tomonori Isada, and Sei-Ichi Saitoh

Faculty of Fisheries Sciences, Hokkaido University, Hakodate, Japan
"Hakodate Marine Bio-Cluster Project"
Theme 1: Monitoring and Forecasting
- Study area -

- Study area
  - Pacific Ocean
  - Sea of Okhotsk
  - Oyashio current
  - Funka bay
  - Hakodate
  - Tsugaru warm current
  - Tsugaru Strait
Toward sustainable cultures

- Funka Bay is one of the most important aquaculture sites in Japan, especially scallops and kelps. More than 36% of the scallops and kelps production in Japan is from aquaculture, (FAO, 2007; 2009).

- In Funka bay, it is well known that diatoms as well as harmful algae like dinoflagellate influence the cultured aquatic organisms, subsequently leading to fisheries marketing and human health concerns.

- Therefore, for sustainable scallop and kelp cultures, to understand the influence of phytoplankton functional group on the cultured aquatic organisms is important.

- One of the objectives in this project is to develop a method to indentify diatoms and dinoflagellate by using ocean color remote sensing.
Cruises

2010
1. US194 (Apr 19~21)
2. US196 (May 21~23)
3. US199 (Jun 19)
4. US201_1 (Aug 20~22)
5. US201_2 (Aug 28~30)
6. US208 (Oct 21~23)
7. US210 (Nov 10~13)

2011
8. US219 (Feb 6~8)
9. OS225 (Feb 21~25)
10. US222 (Mar 6)
11. US228 (May 14~16)
12. US232 (Jul 27~28)
13. US237 (Sep 27~29)
14. US242 (Nov 17~19)

2012
15. US246 (Jan 10)

Research Vessels

Ushio-Maru and Oshoro-Maru

Sampling sites

- Funka bay; 8 sites
- Tsugaru Strait; 4 sites
Funka bay tuned algorithms for primary production and phytoplankton size classes

Primary production

Method
Behrenfeld and Falkowski (1997)
Hirawake et al. (2011, 2012)

Micro-sized phytoplankton

Method
Uitz et al. (2006); Hirata et al. (2011)
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.
Quasi true color image of MODIS/Aqua (Red: 645 nm; Green: 555 nm, Blue: 469 nm) in May 9, 2012. Resolution is 500 m.
Spectral distribution of radiance derived from HICO and MODIS

The distribution of hyperspectral radiance derived from HICO data was thought to be similar to calibrated top of atmosphere radiance derived from MODIS data.
Remote sensing reflectance ($sr^{-1}$)

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.

- Values of hyperspectral $R_{rs}(\lambda)$ corrected atmospherically by Tafkaa 6s were within the range from 0.01 to 0.03 sr$^{-1}$ in visible range.

- These values were remarkably higher than multispectral $R_{rs}(\lambda)$ derived from MODIS/Aqua.
In situ hyperspectral remote sensing reflectance ($R_{rs}(\lambda)$) with HyperProII

During spring bloom

2010

May 21, 2010

2011

May 15, 2011

Solar zenith angles and Chl $a$ concentration
Stn.13; 45.1°, 3.62 mg m$^{-3}$
Stn.SE9; 21.7°, 2.74 mg m$^{-3}$

Solar zenith angles and Chl $a$ concentration
Stn.9; 39.4°, 4.98 mg m$^{-3}$
Stn.30; 33.1°, 3.14 mg m$^{-3}$
**In situ** hyperspectral remote sensing reflectance ($R_{rs}(\lambda)$) with HyperProII during summer

**2010**

- **August 21, 2010**
  - Stn.13; 37.7°, 0.64 mg m⁻³
  - Stn.SE9; 40.0°, 0.60 mg m⁻³

**2011**

- **September 14, 2011**
  - Stn.9; 48.9°, 0.44 mg m⁻³
  - Stn.30; 54.1°, 0.32 mg m⁻³

Solar zenith angle and Chl a concentration
Ternary plots representing the relative contribution of NAP, phytoplankton, and CDOM to absorption

- Spring bloom (Chl $a > 2$ mg m$^{-3}$)
- Non bloom
Spatiotemporal change of phytoplankton community structure estimated by HPLC-CHEMTAX (Mackey et al., 1996; Wright et al., 2009)

- Diatoms bloom during spring
- Predominance of cyanobacteria during summer

Photos by Dr. Koji Suzuki
• The high-resolution image derived from HICO was of great benefit to an assessment of water dynamic in Funka bay.

• It is important to accurately estimate and remove the aerosol radiance contributions in the visible light.

• Therefore, we should need to specify the aerosol model or attempt to use other operational atmospheric correction algorithms to retrieve a more accurate product of hyperspectral $R_{rs}(\lambda)$.

**Summary**

- **HICO L1b**
  - Atmospheric correction (e.g., TAFKAA, Cloud and Shadow, FLAASH)

- **HICO L2 Hyperspectral $R_{rs}(\lambda)$**
  - QAA_v5 (Lee *et al.*, 2009)

- **Hyperspectral IOPs**
  - Derivative analysis and similarity index (e.g., Kirkpatrick *et al.*, 2000; Craig *et al.*, 2006)

- **Identification of PFTs**