The Spectral Discrimination of Surface Harmful Algal Bloom in Complicated Coastal Water Conditions

2009-10-27

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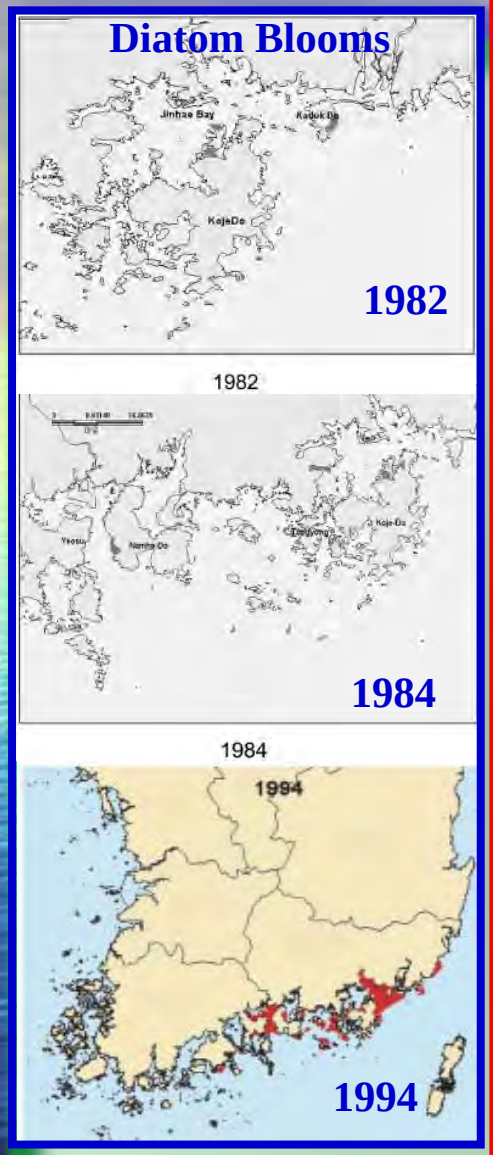
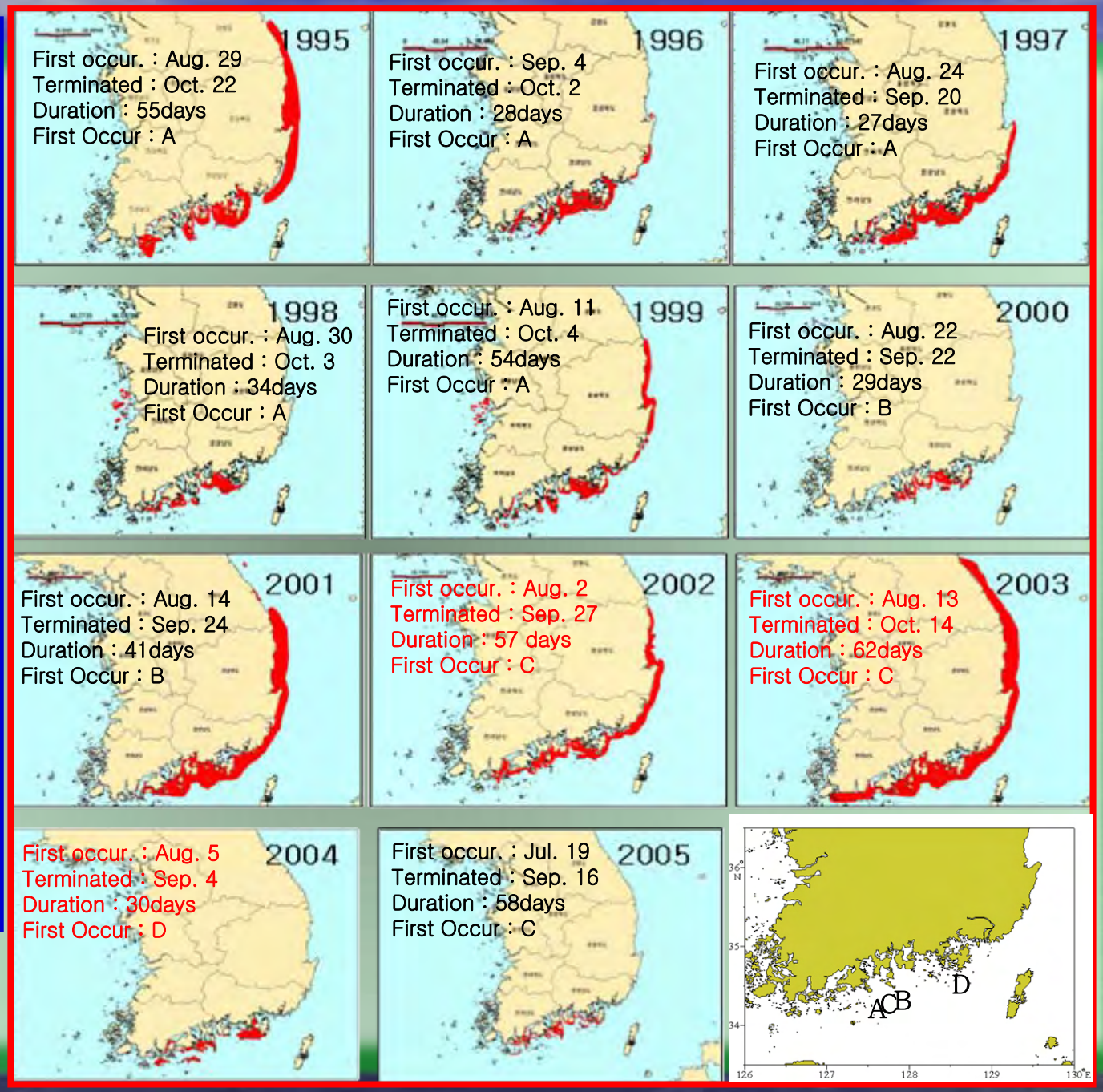
1: HyARC, Nagoya University, Japan, 2: NFRDI, Korea

1. Introduction

Before 1995



After 1995 : *C. polykrikoides* Blooms



2. Methods and Data: To detect the huge blooms from space

1) Five MODIS satellite data were matched with in-situ red tide information (NFRDI).

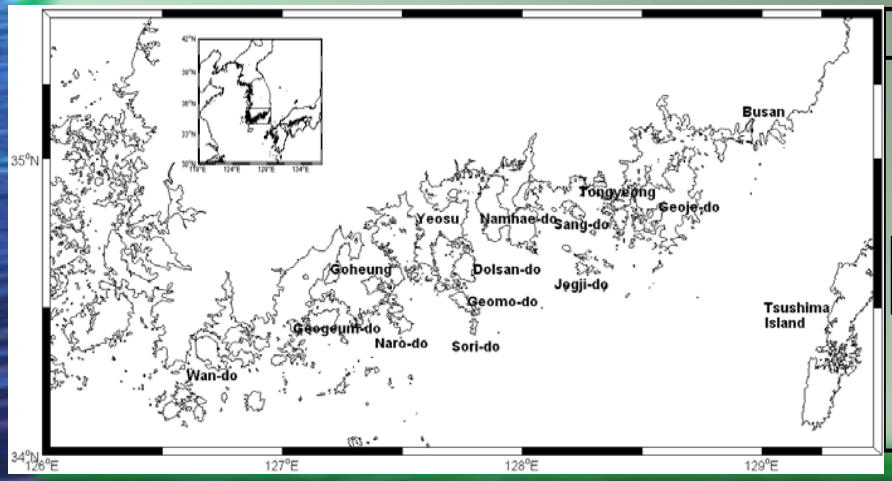
2) MODIS satellite products :

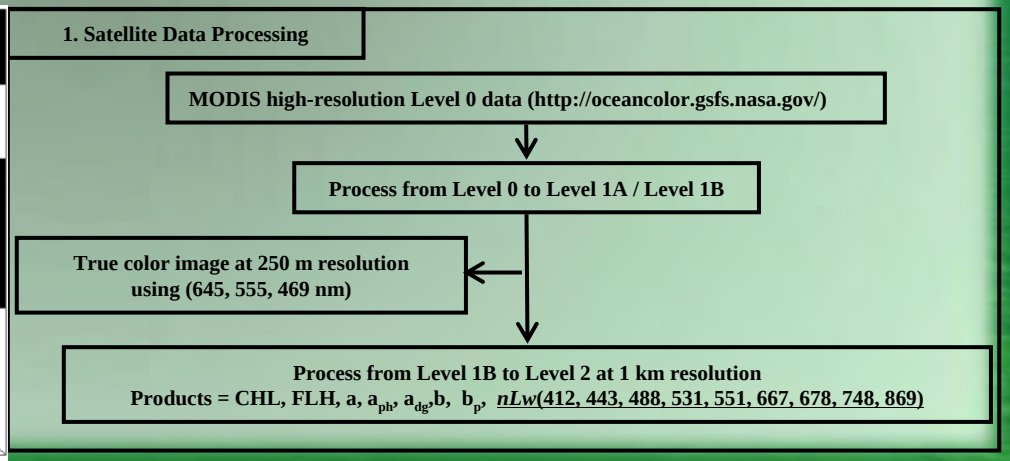
- the spectral normalized water-leaving radiance (nLw),
- satellite chlorophyll concentration (Chlor-a),
- fluorescence line height (FLH),
- phytoplankton absorption (a_{ph}) and detritus/gebstoff absorption (a_{dg}),
- particle backscattering coefficients (b_p).

3) ~ 300 satellite sub-sample data collected from red tide areas :

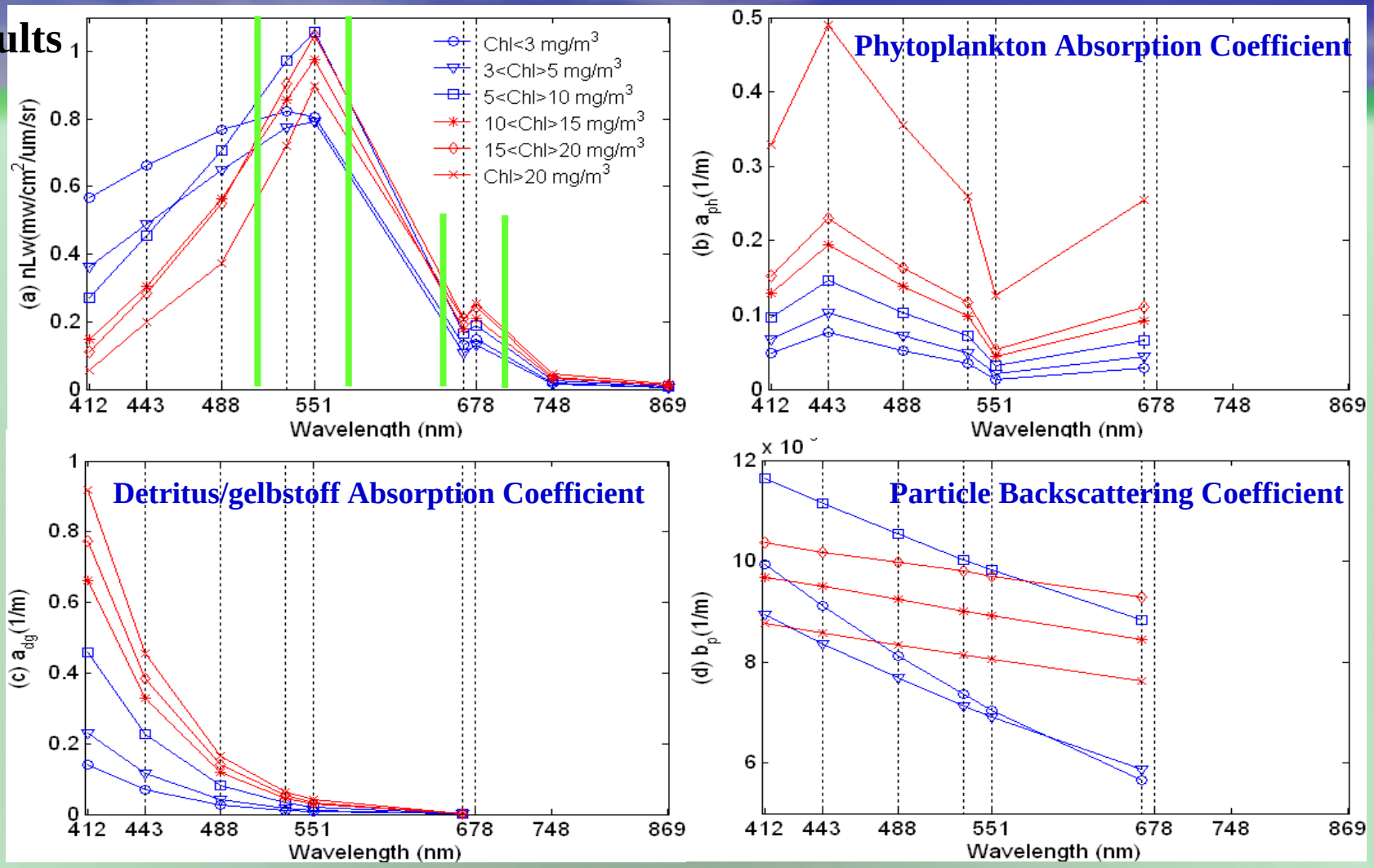
- the spectral response of red tide signals
- the red and non-red tide waters -> spectral classification and band ratio.

4) Demonstrates how the improved discrimination in mapping HAB distributions.



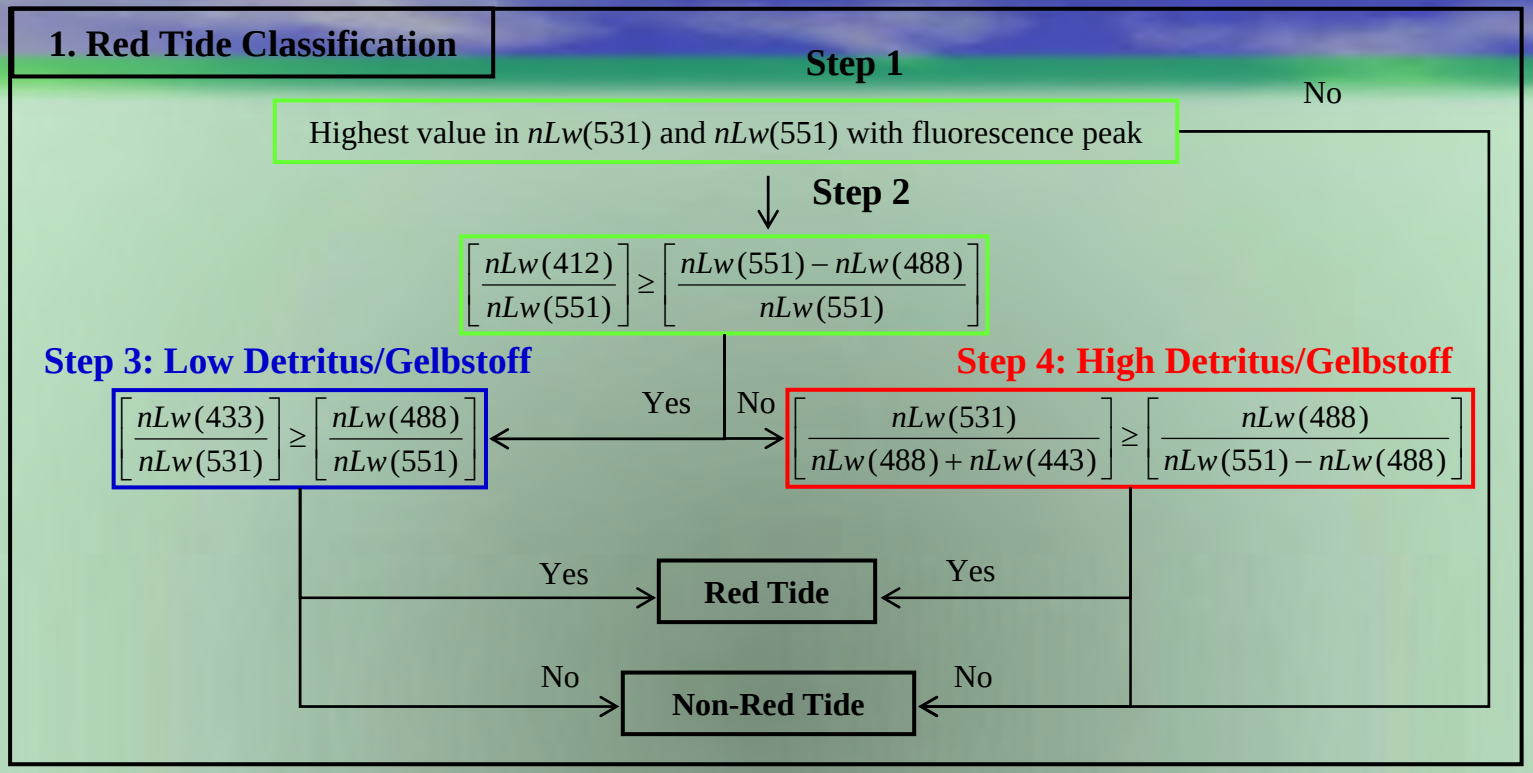


3. Results



1. The potential spectral characteristic of red tide : averaged MODIS chlorophyll-a concentration.
2. Radiance spectra : two dominant peaks at 531/551 (green bands) and 678 (red band) nm.
3. Low value at blue wavelengths (> 10 mg m^{-3} : red line) : high phytoplankton and detritus/gebstoff absorptions and small difference between blue and red bands
4. High value at blue bands (< 10 mg m^{-3} : blue line) : low phytoplankton and detritus/gebstoff absorptions and high difference between blue and red bands.

3. Results



1. *C. polykrikoides* blooms :

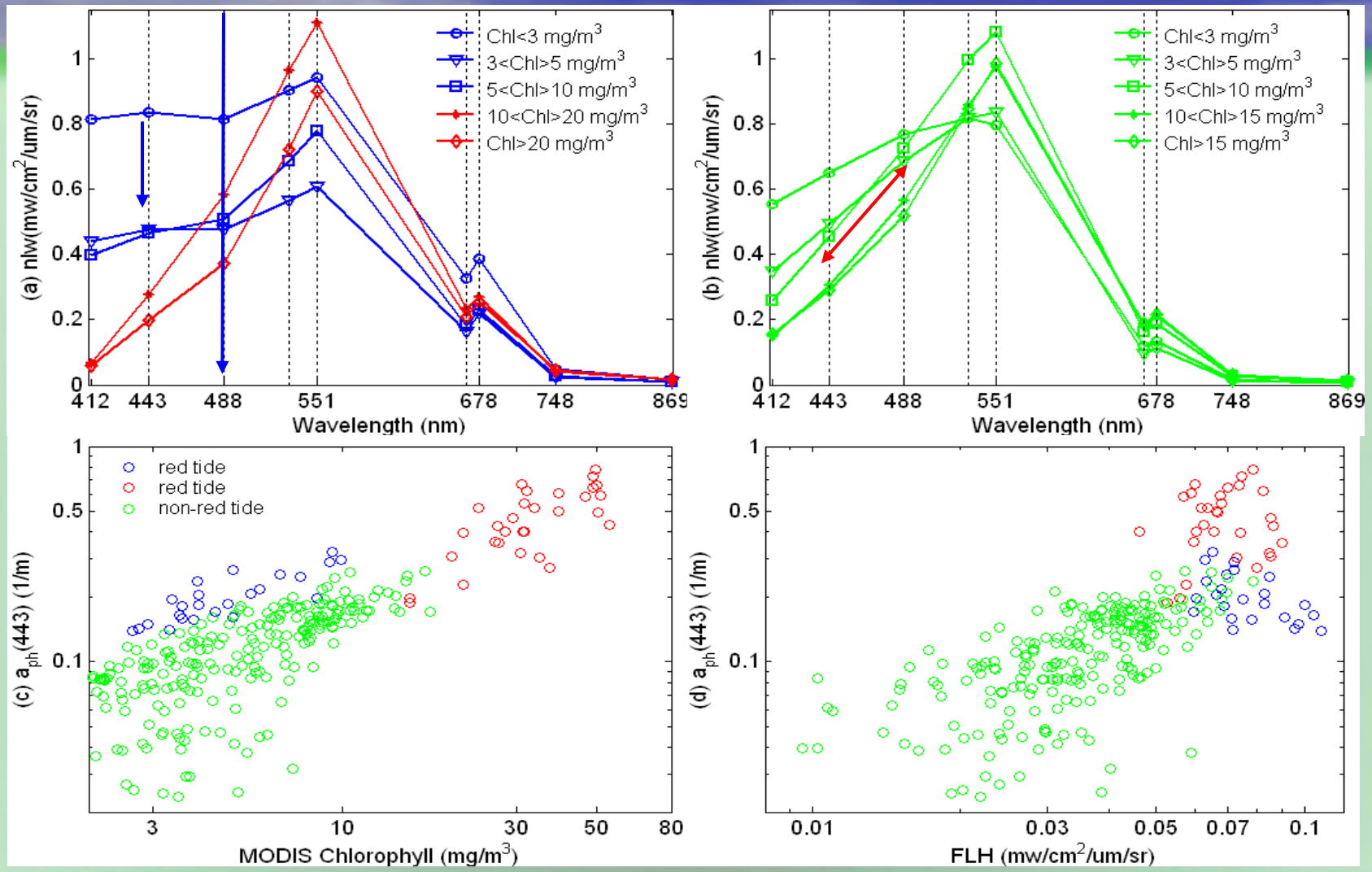
- Onshore (high influence of CDOM or organic/inorganic material, increasing absorption in blue bands)
- Offshore (less influence of CDOM or organic/inorganic material, decreasing absorption and increasing water backscattering in blue bands).

2. Step 2 : Relatively high and low contribution of detritus/gelbstoff to chlorophyll

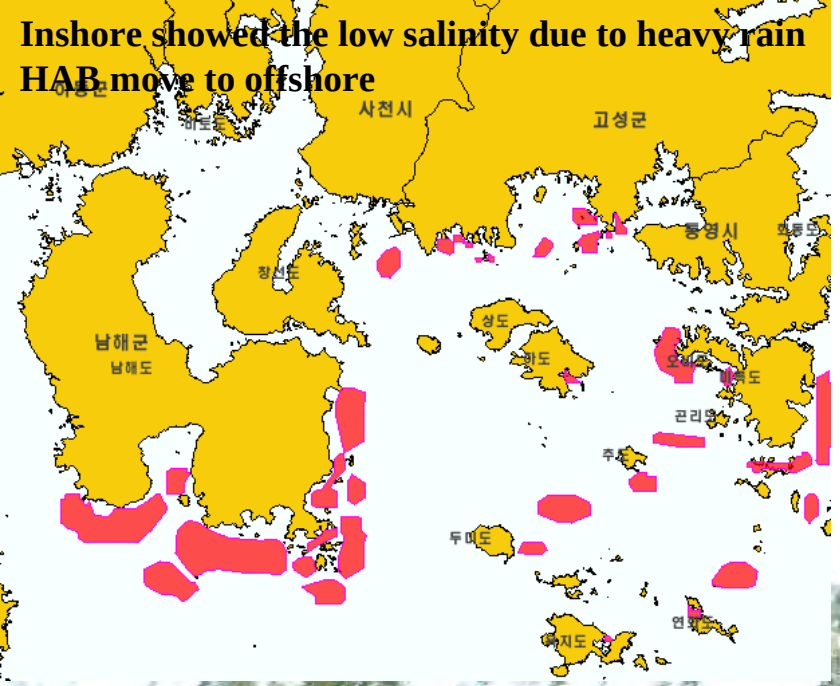
3. Step 3 : Lower contribution of CDOM to chlorophyll

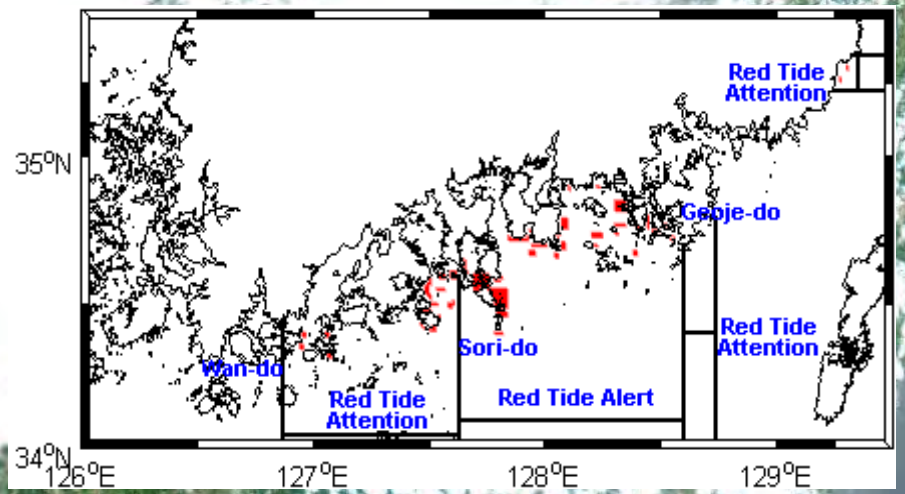
4. Step 4 : Higher contribution of CDOM to chlorophyll

4. Discussions Red Tide Difference between red and non-red tide Non-Red Tide



1. Blue bands : Increasing pigment absorption at 443 nm caused lower slope between blue and green bands.
2. Different radiance value at blue bands : the relative effect of CDOM per chlorophyll
3. Red tide waters are related to enhanced phytoplankton absorption and FLH with varying chlorophyll



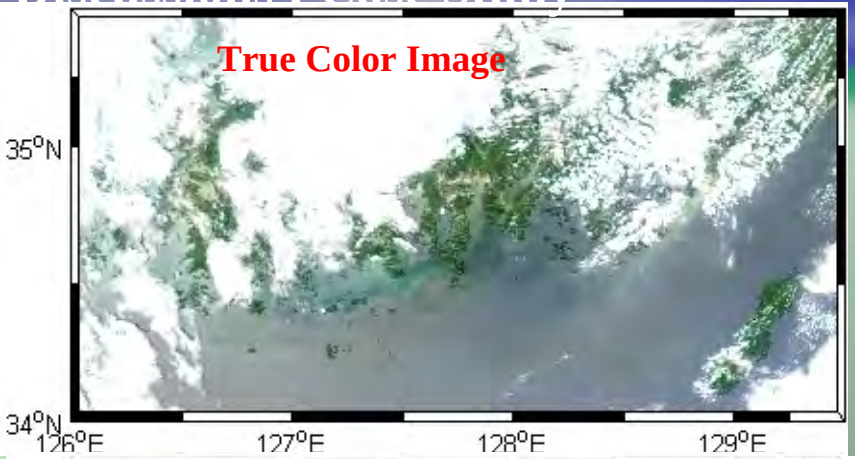


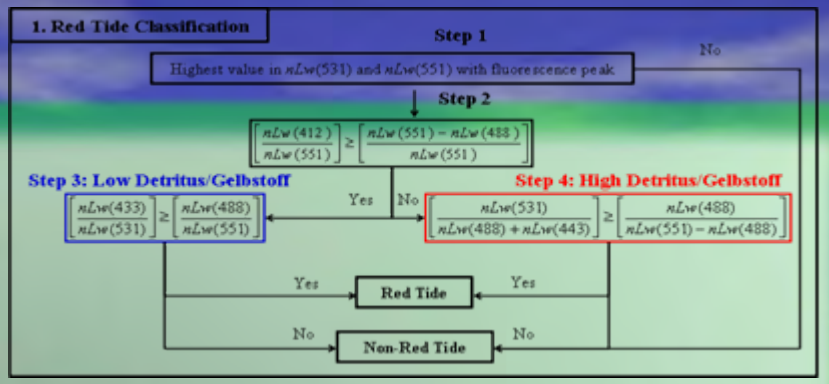
- Visual appearance of *C. polykrikoides* bloom :

the discolored water from blue to dark red/brown.

- Increasing absorption of chlorophyll and non-living particles induced the decreasing radiance at blue wavelengths with no scattering the light that visually appeared in water discolored as dark or black.

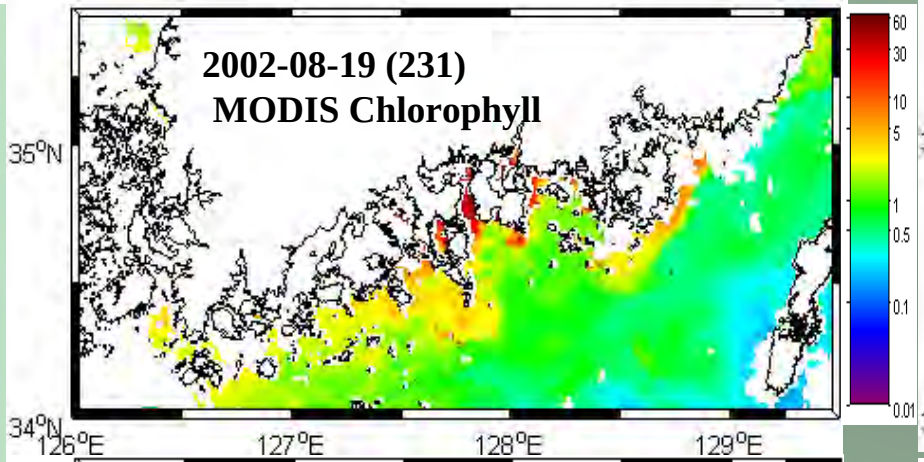
4. Discussions : Case Study

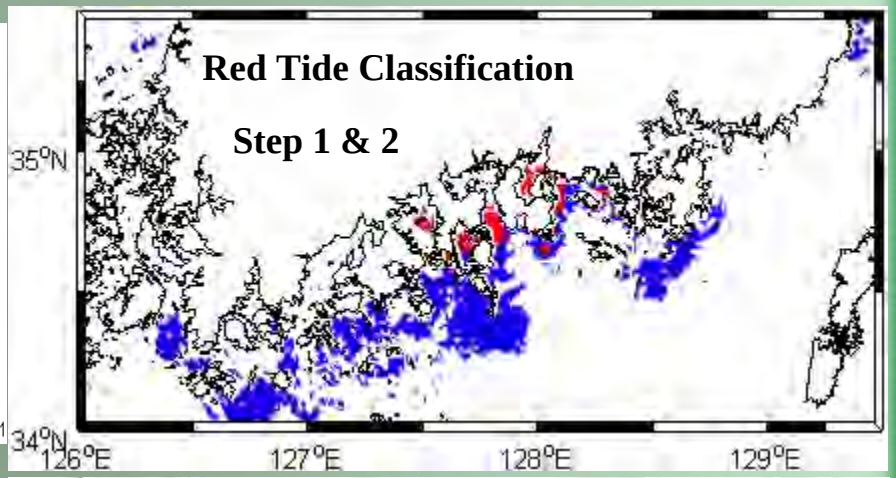


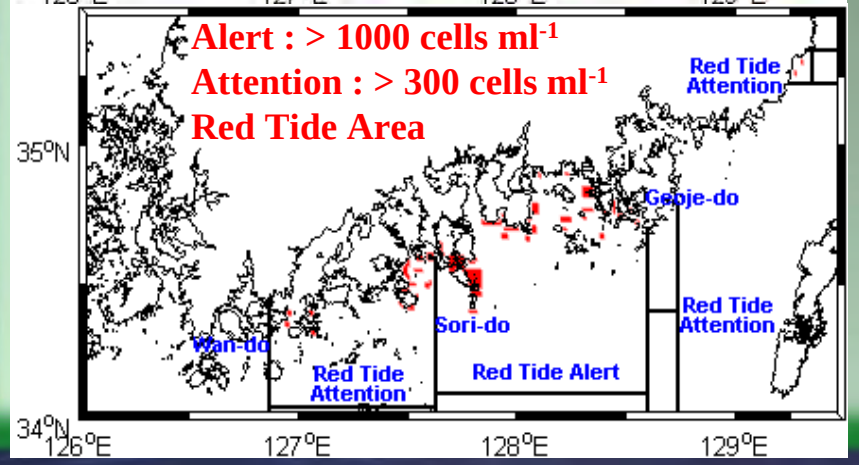


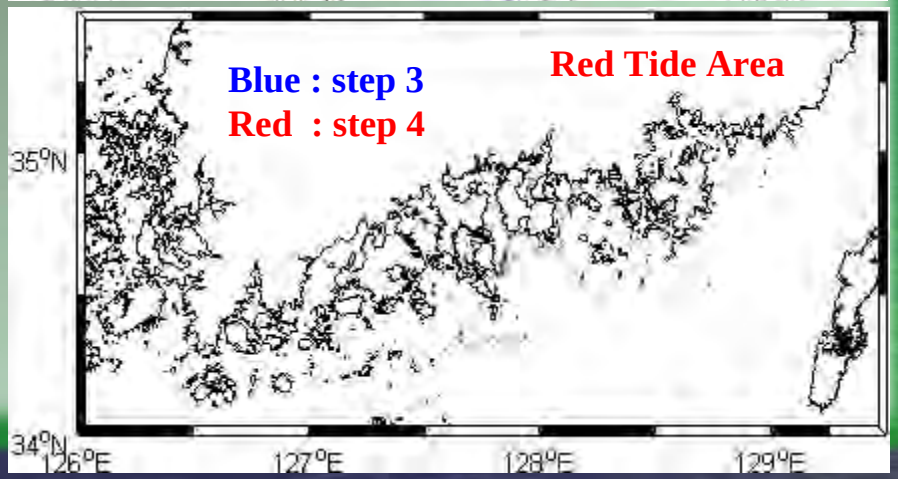
Blue : low gelbstoff/detritus

Red : high gelbstoff/detritus









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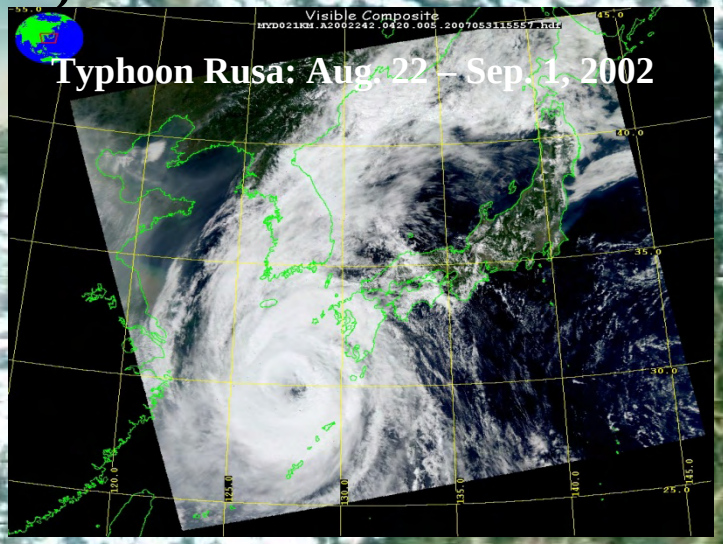

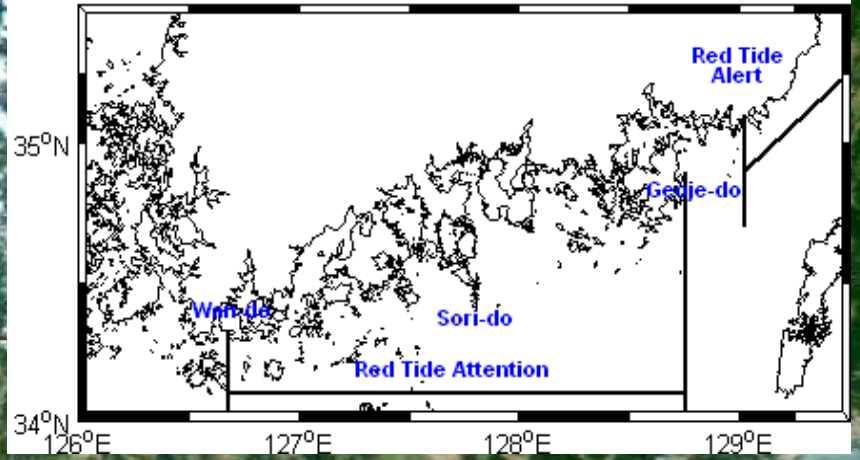

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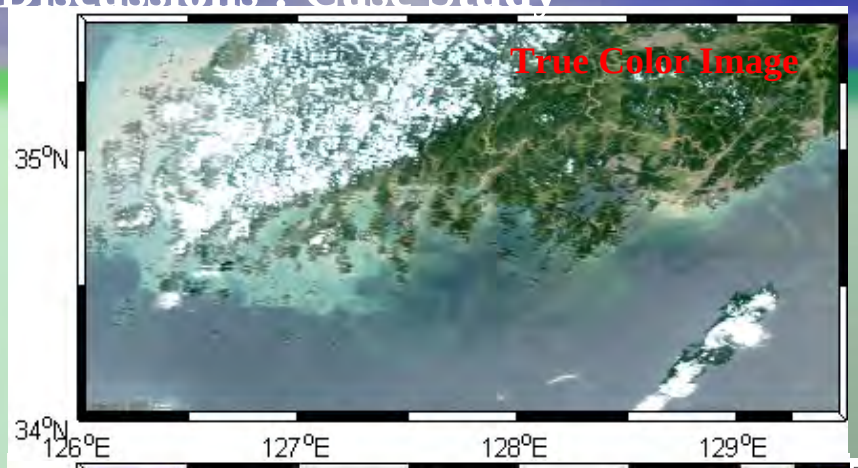

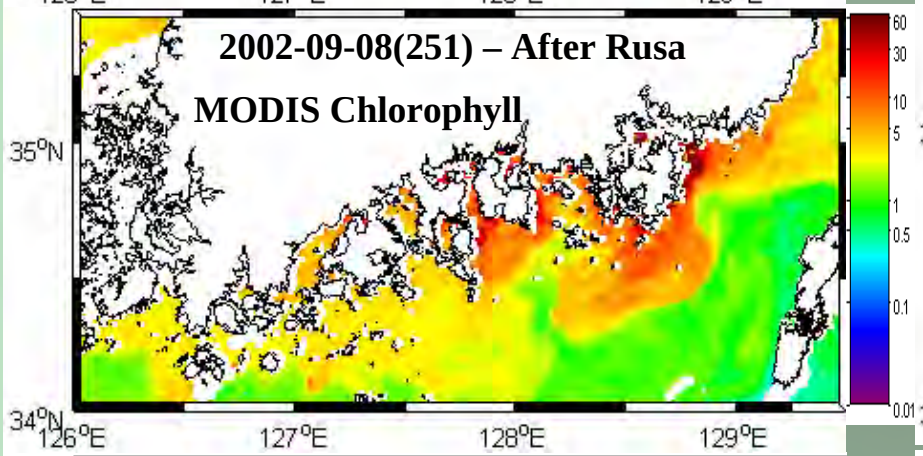

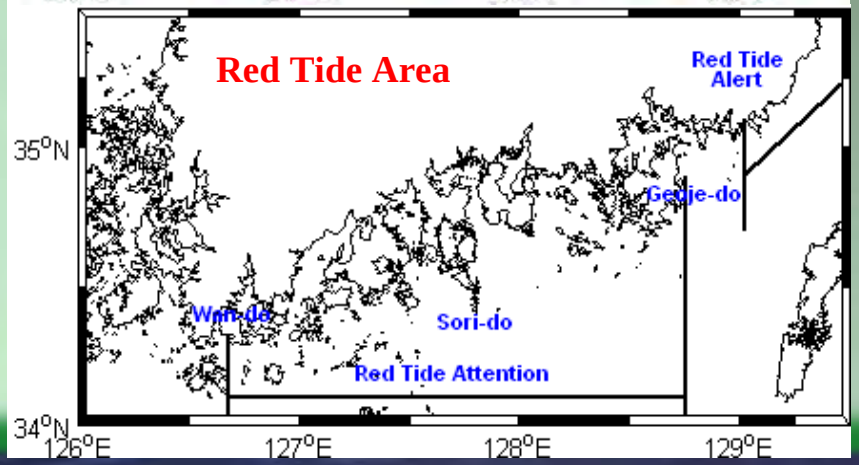

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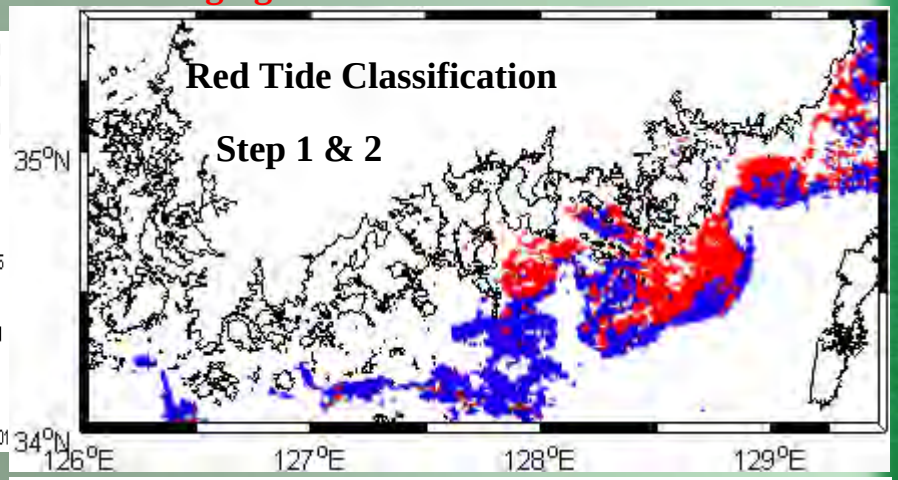

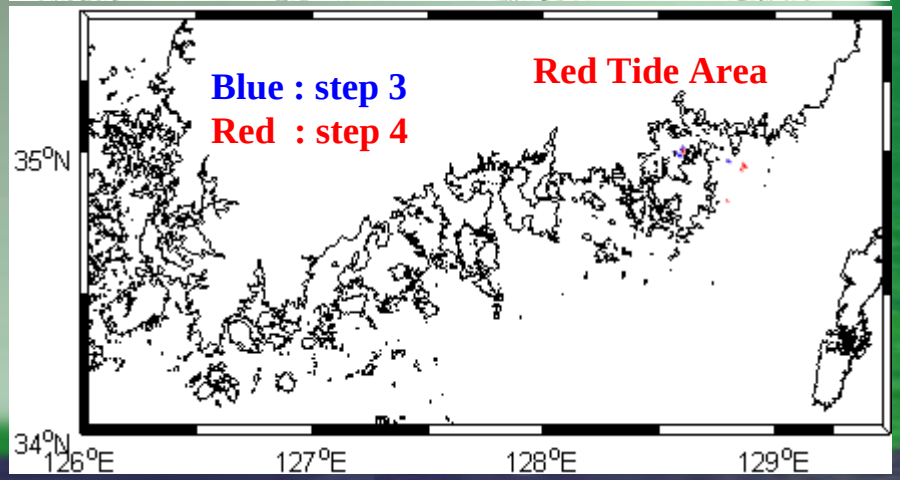

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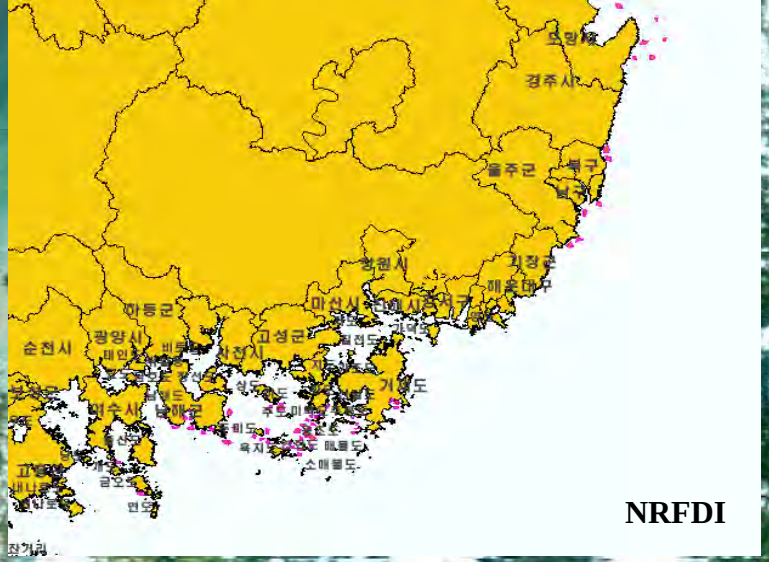

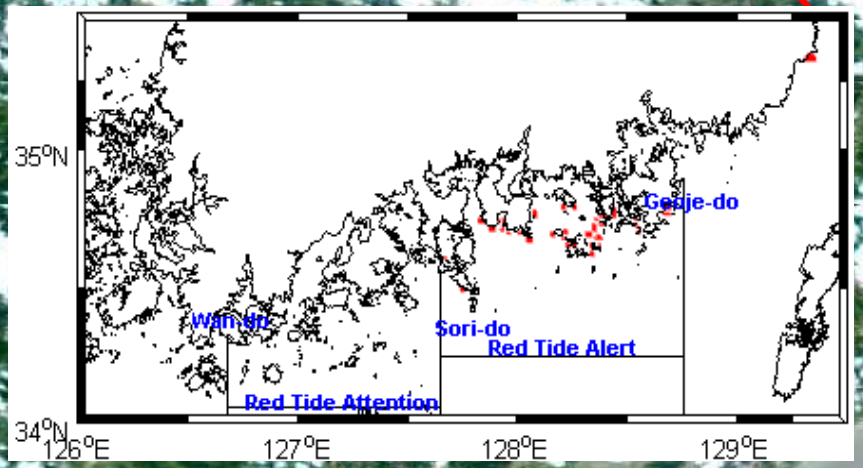

4. Discussions : Case Study

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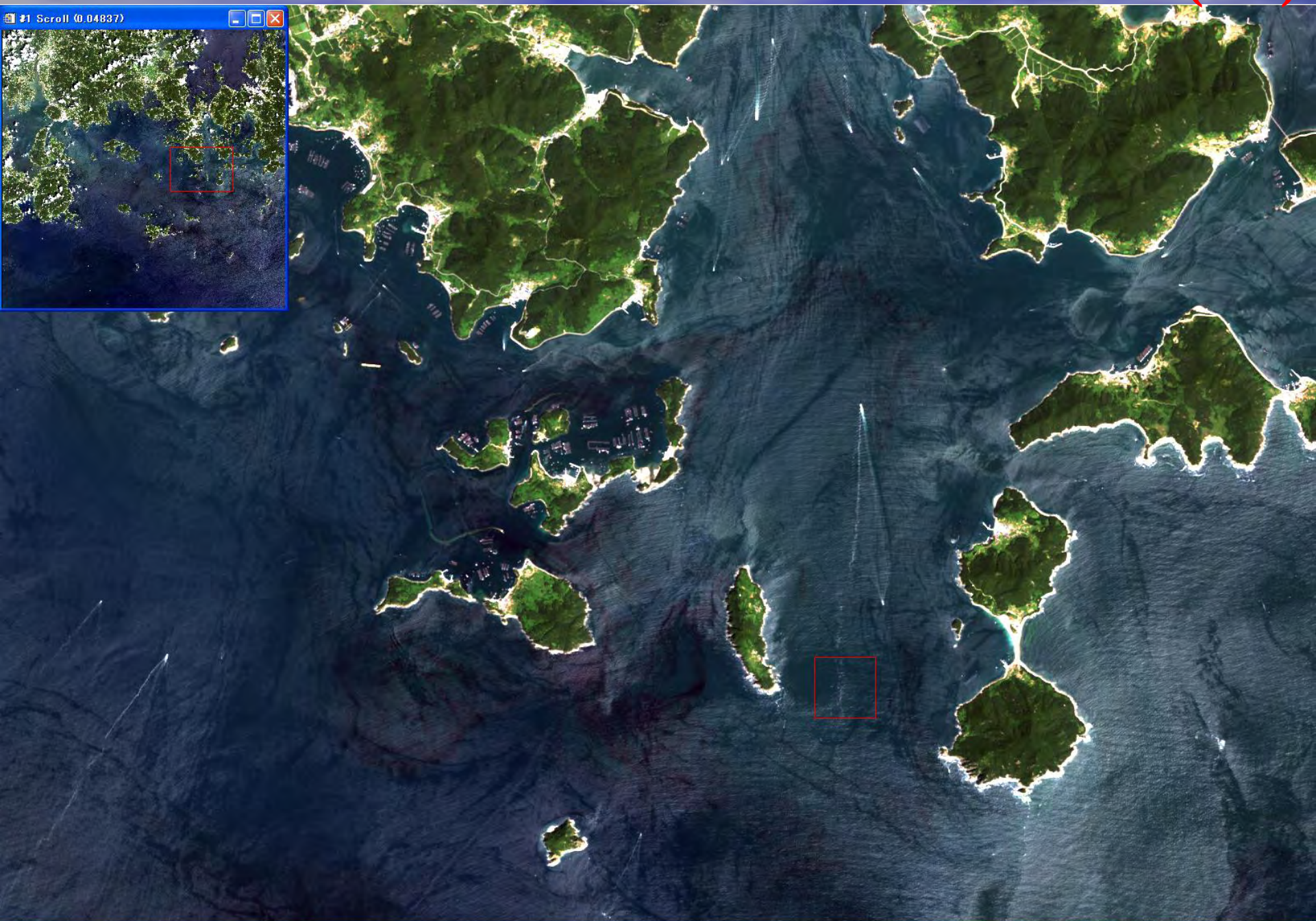

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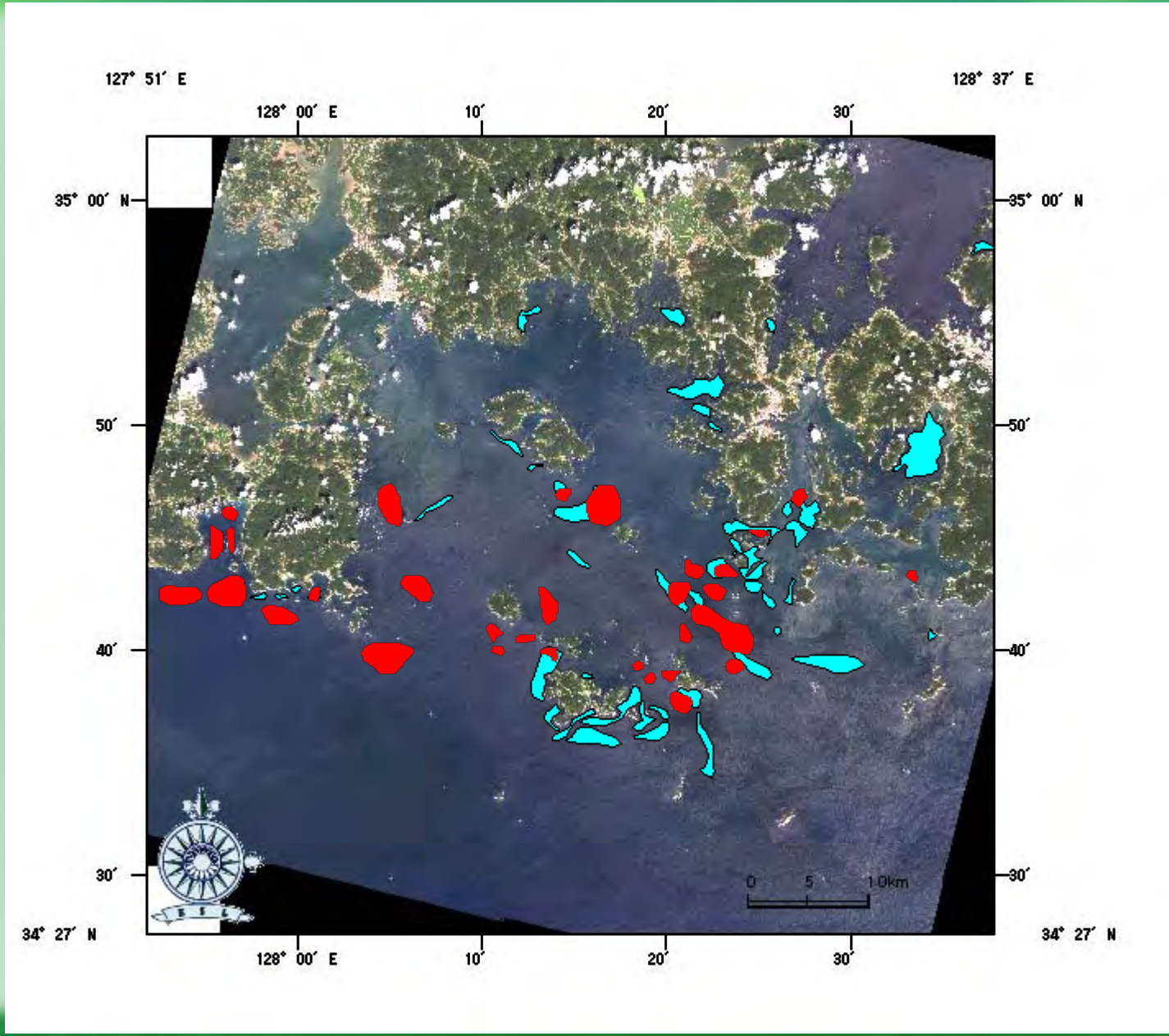

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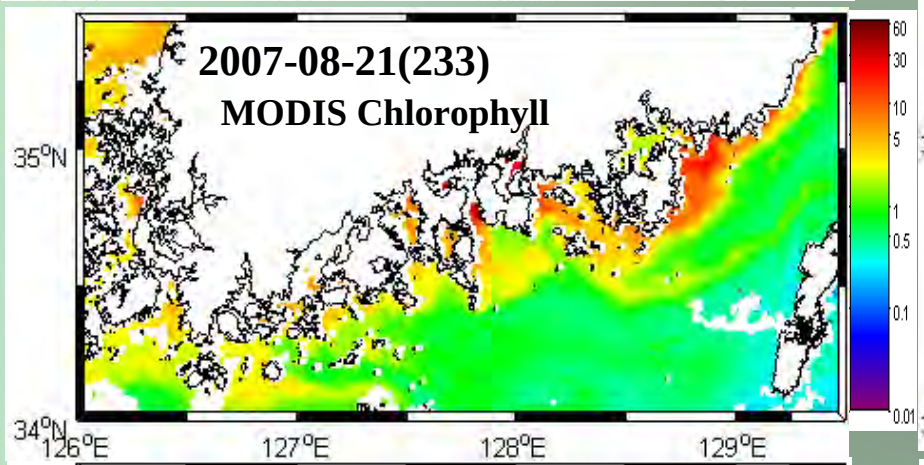
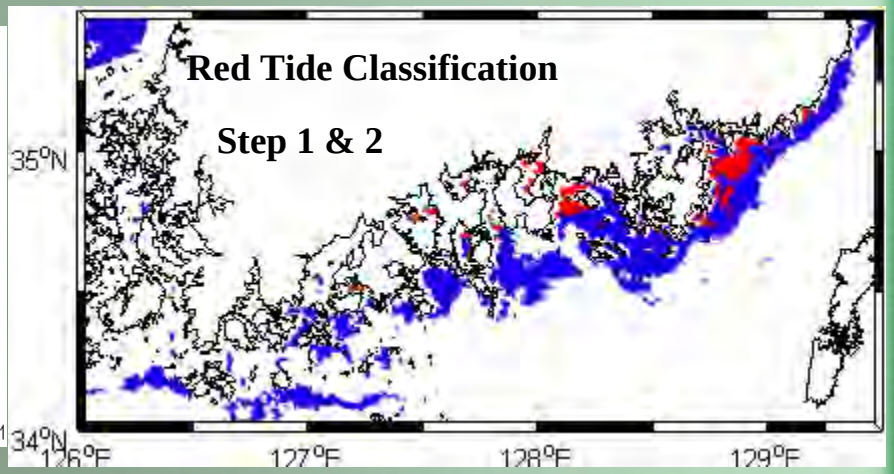
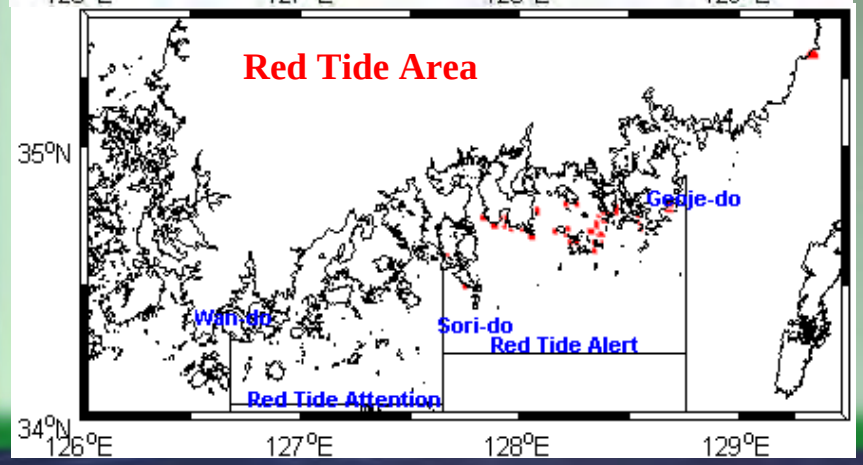
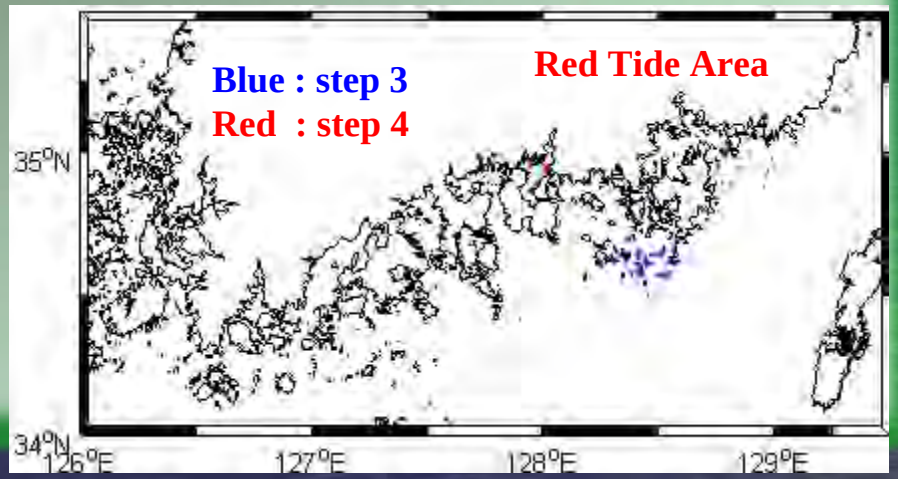








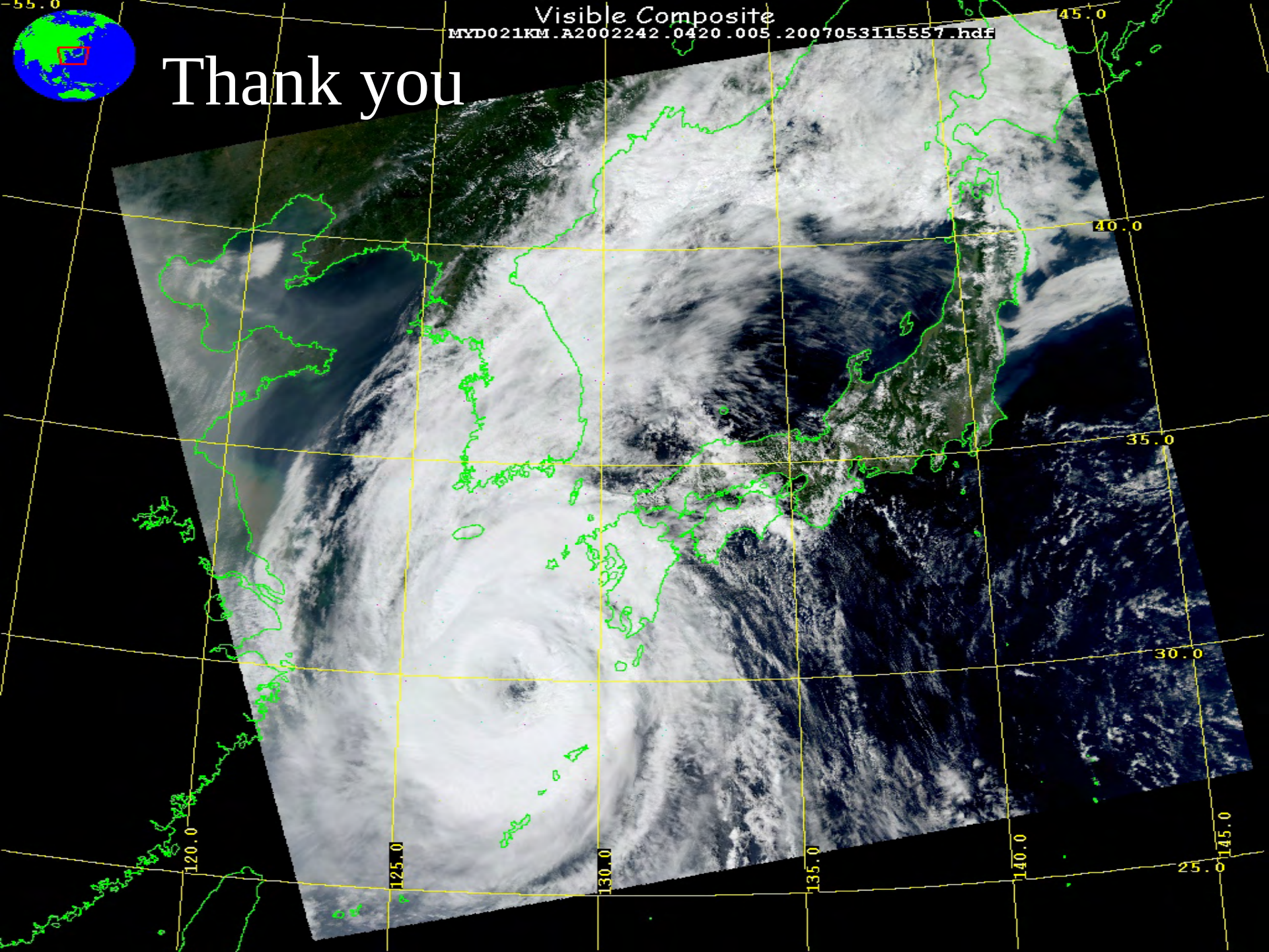
5. Conclusions

1. For understanding of algal blooms at the South Sea of Korea, we developed a systematic method for classifying complicated coastal waters included red tide using MODIS remote sensing data.

2. We developed a spectral classification to discriminate the red and non-red tide conditions, which guided by different four criteria.

3. *C. polykrikoides* blooms in SSK observed that radiance is higher at green bands and lower at blue bands due to the influence of strong pigment backscattering and high chlorophyll absorptions

4. Analysis of MODIS ocean color imagery revealed that pixel-based classification projected into distinct clusters in space domain, suggesting that this approach is promising for mapping phytoplankton blooms from various water conditions regionally based on remote sensing data.


Visible Composite
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45.0
40.0
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125.0
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145.0

Thank you

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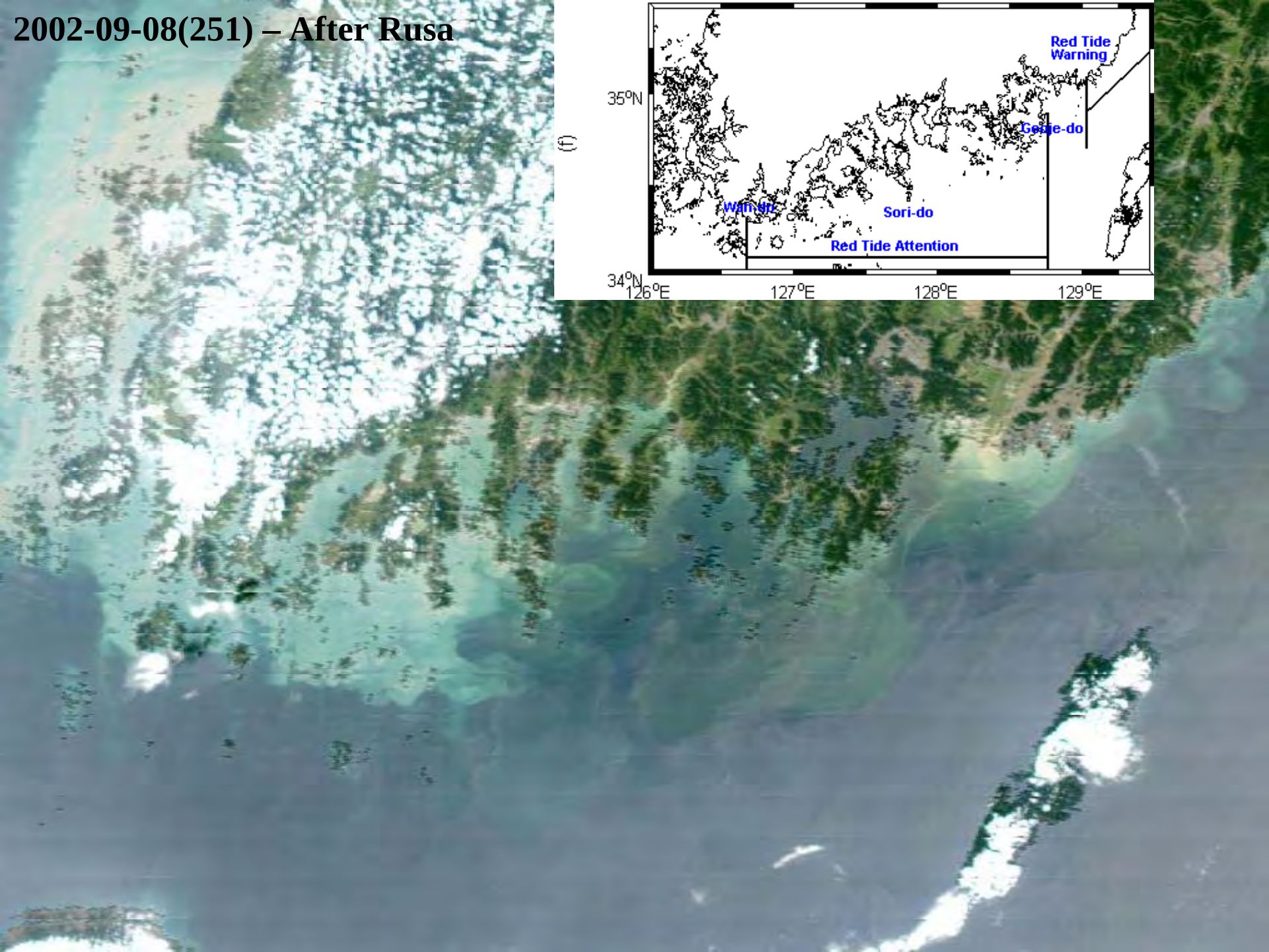

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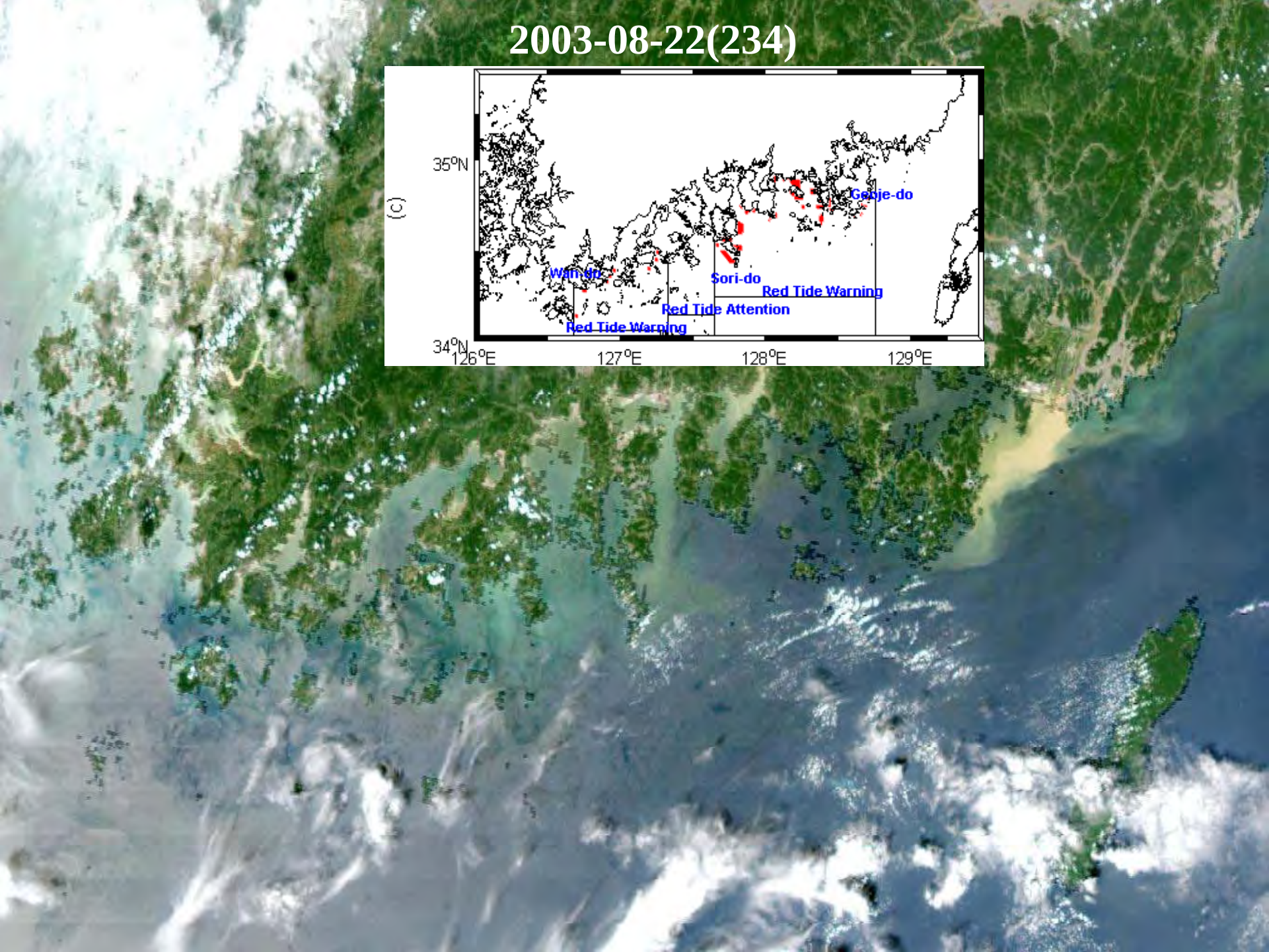

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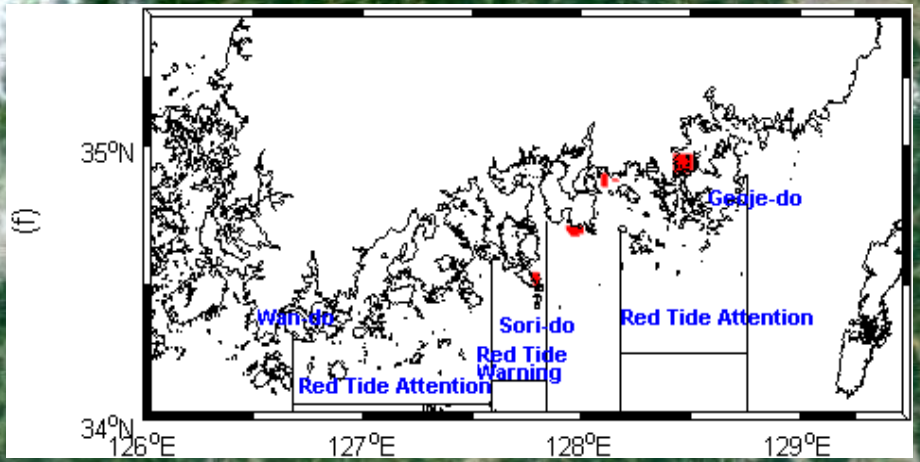

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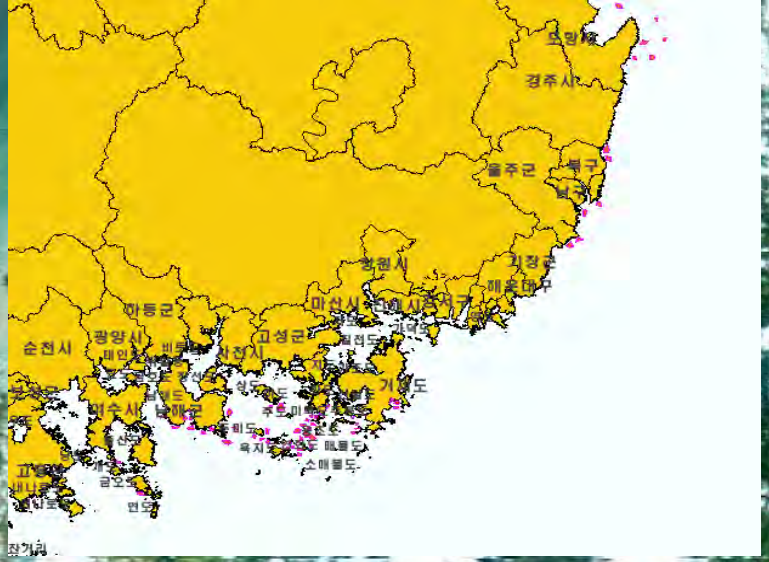

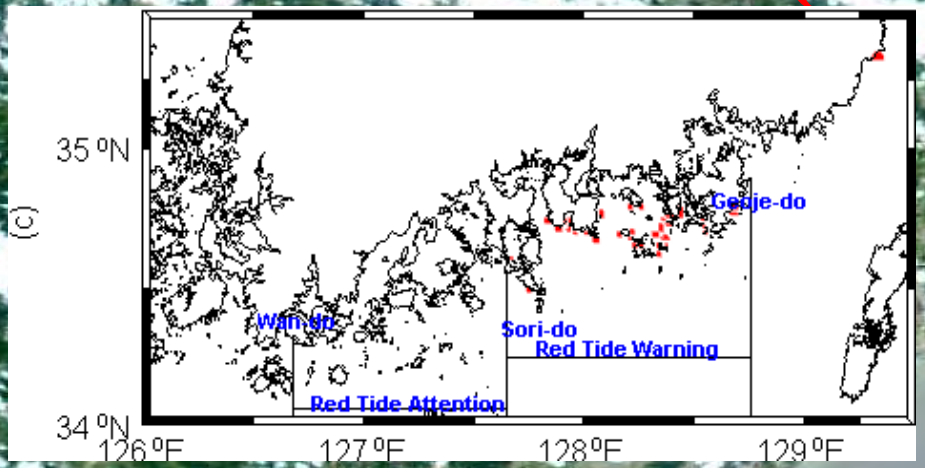

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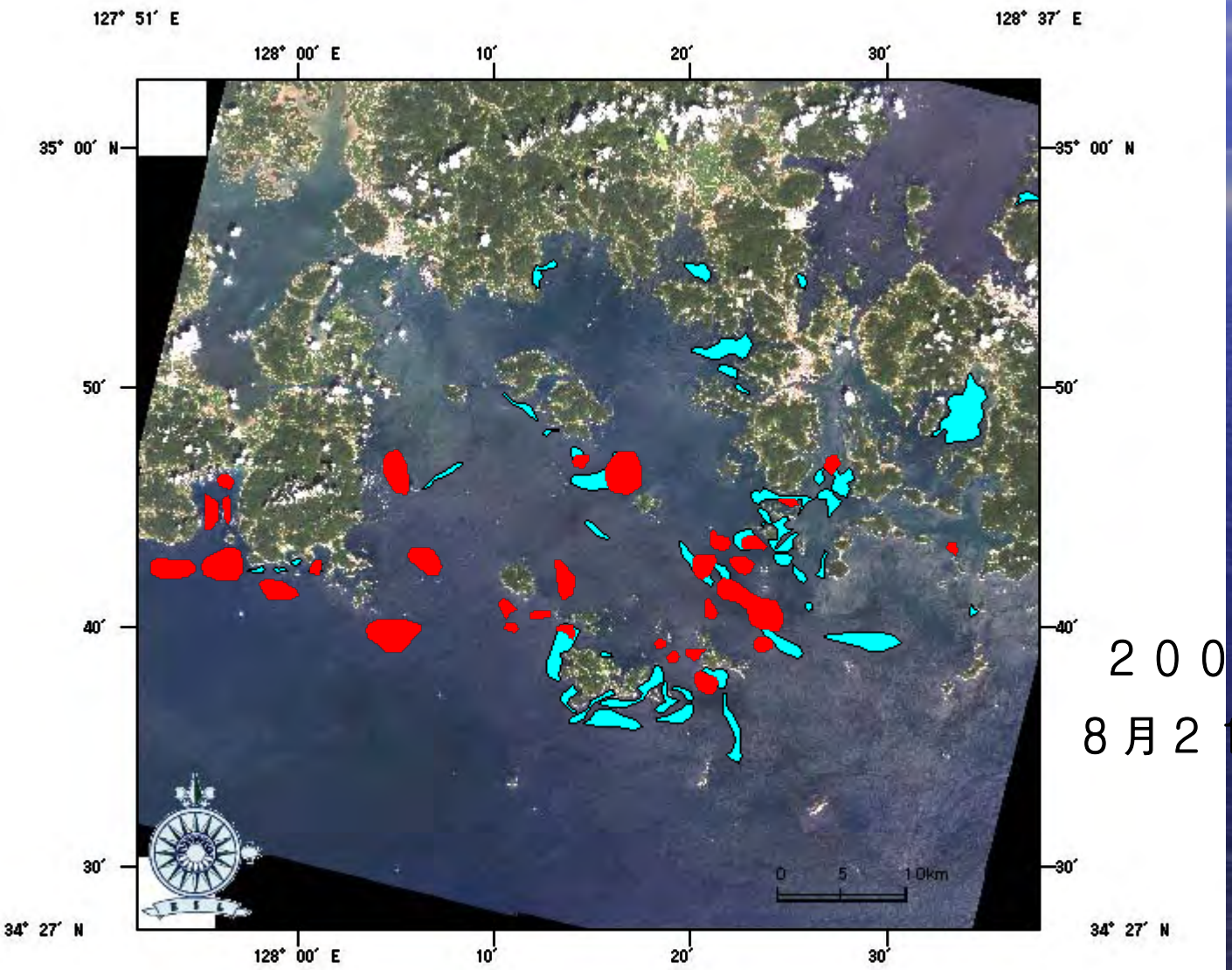

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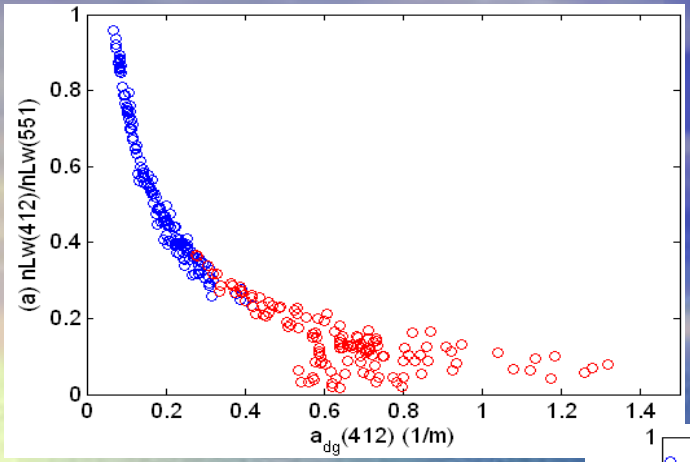
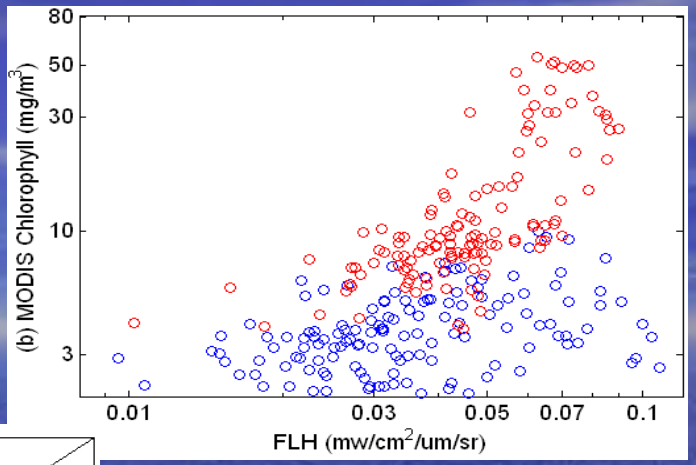
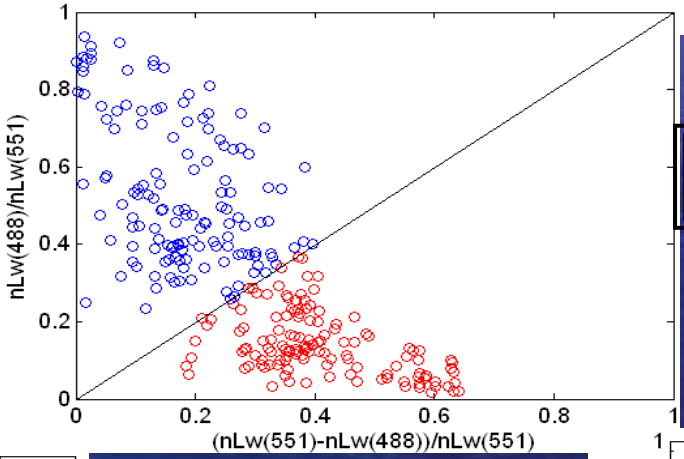
3. Results





Blue circle :

$$\left[\frac{nLw(412)}{nLw(551)}\right] \geq \left[\frac{nLw(551)-nLw(488)}{nLw(551)}\right]$$



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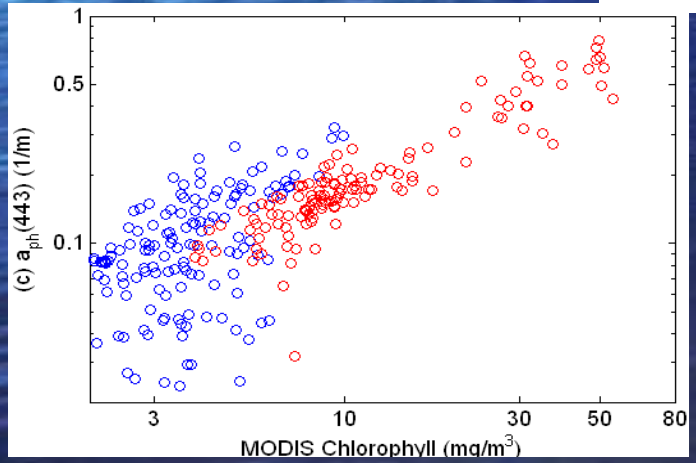
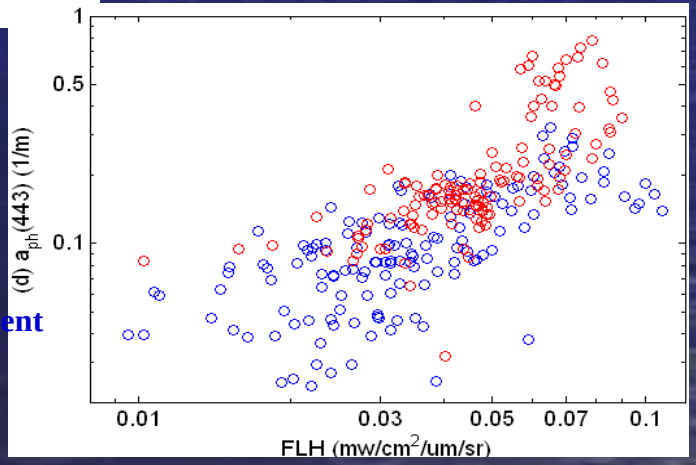
$$\left[\frac{nLw(412)}{nLw(551)}\right] < \left[\frac{nLw(551)-nLw(488)}{nLw(551)}\right]$$



Phytoplankton Absorption Coefficient

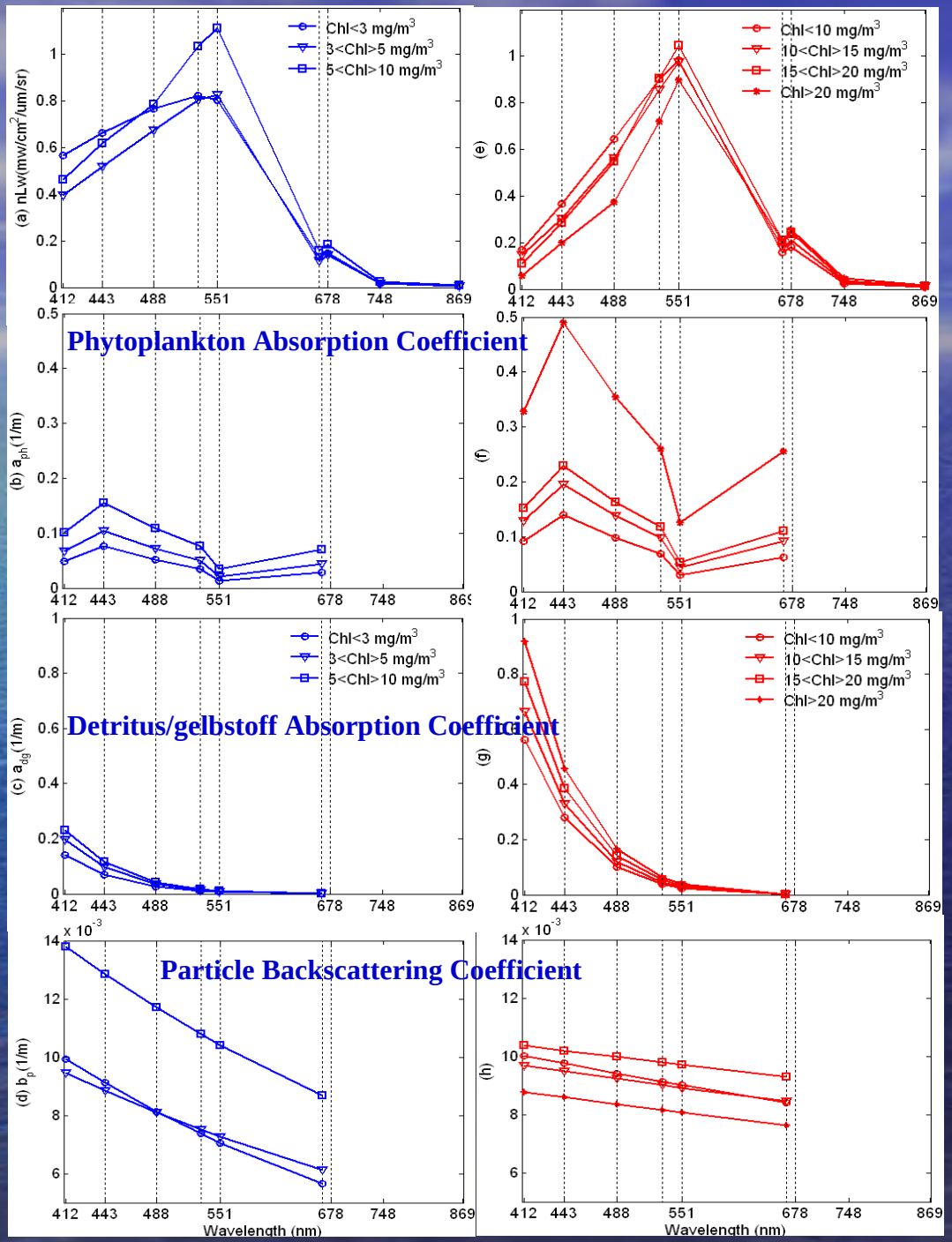


3. Results

Blue Line :

$$\left[\frac{nLw(412)}{nLw(551)}\right] \geq \left[\frac{nLw(551)-nLw(488)}{nLw(551)}\right]$$

Low effect of Detritus/gelbstoff



Red Line :

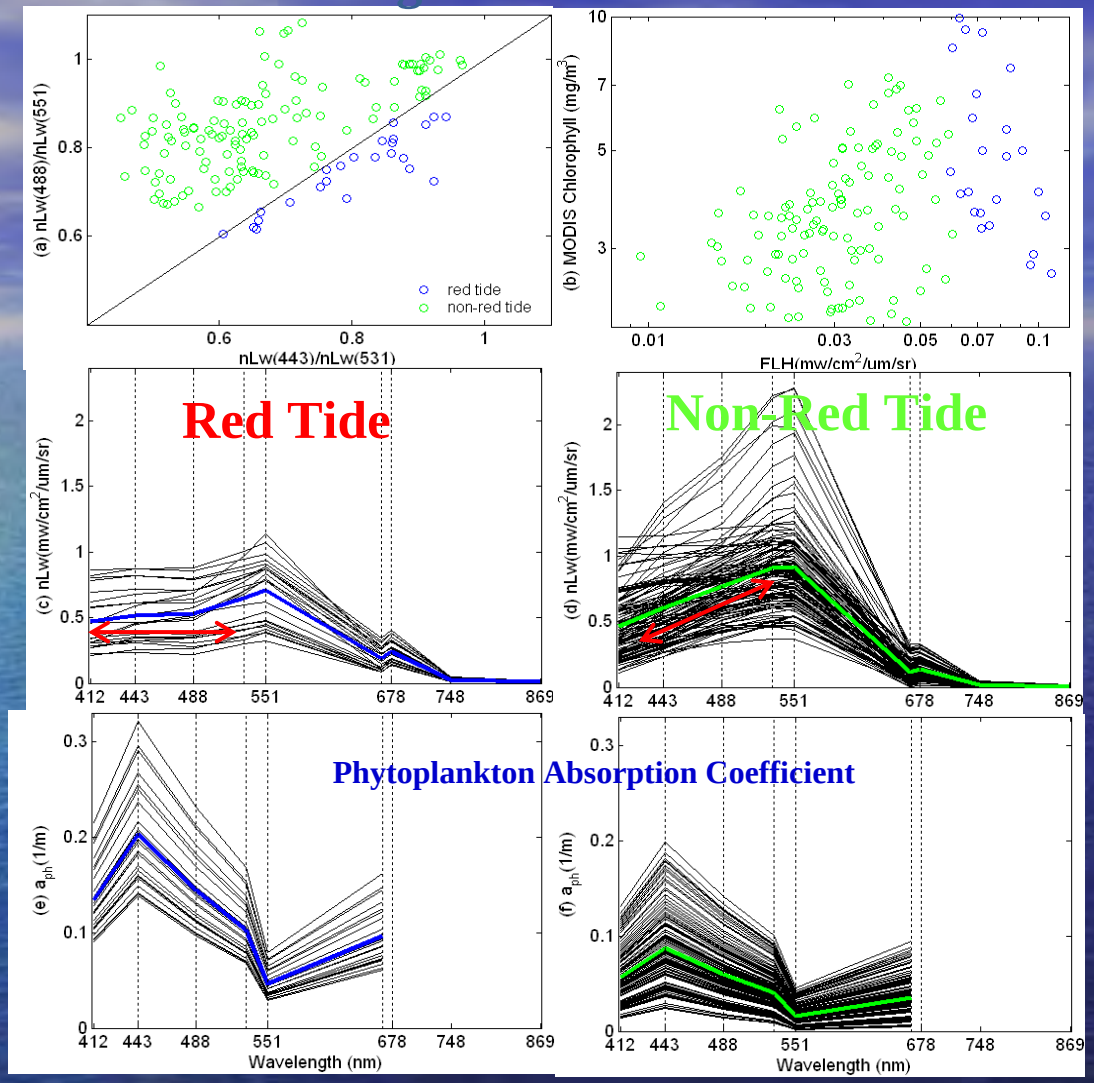
$$\left[\frac{nLw(412)}{nLw(551)}\right] < \left[\frac{nLw(551)-nLw(488)}{nLw(551)}\right]$$

High effect of Detritus/gelbstoff

3. Results : Low effect of Detritus/gelbstoff

Blue Color :

$$\left[\frac{nLw(443)}{nLw(531)}\right] \geq \left[\frac{nLw(488)}{nLw(551)}\right]$$



Green Color :

$$\left[\frac{nLw(443)}{nLw(531)}\right] < \left[\frac{nLw(488)}{nLw(551)}\right]$$

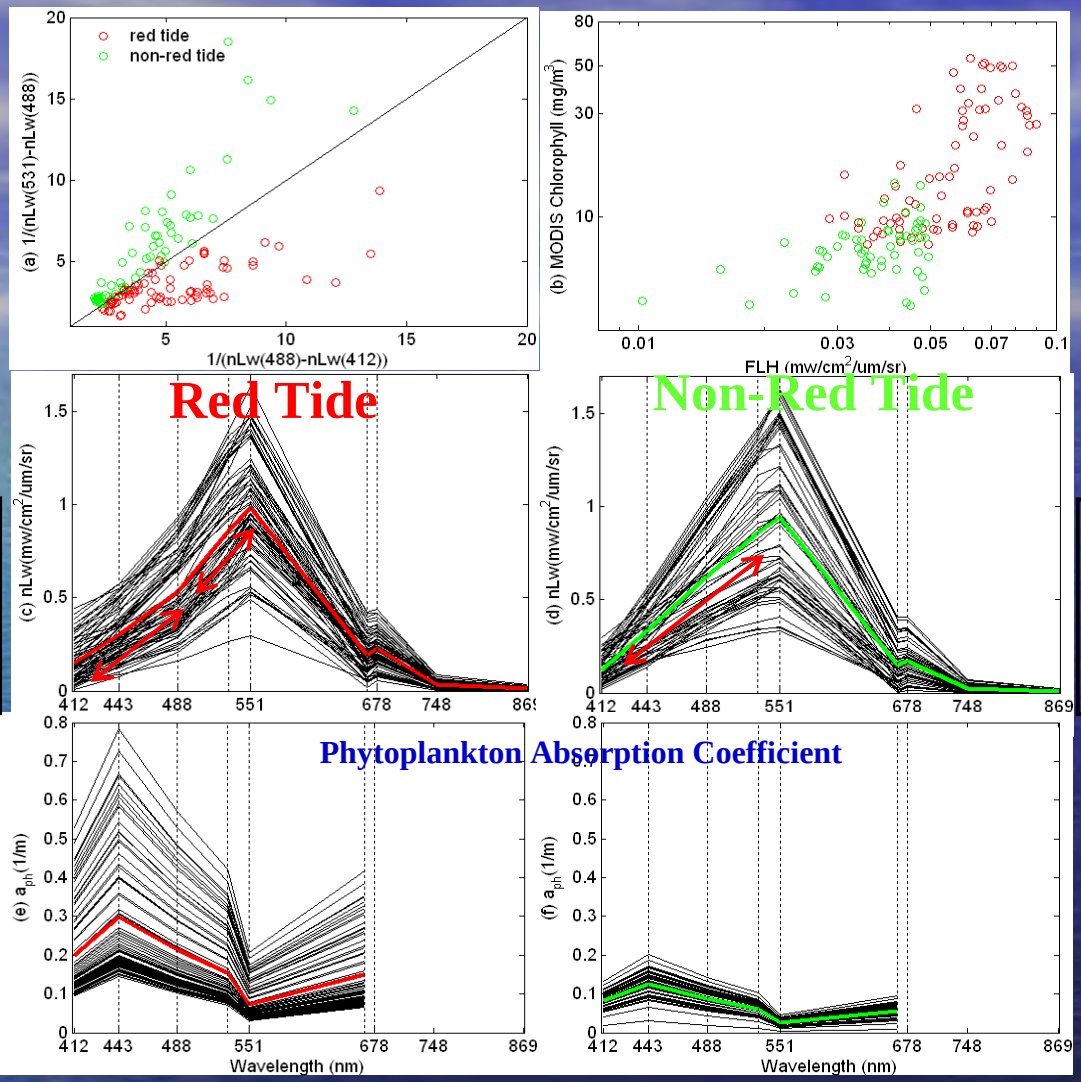
1. **Red tide : relative high FLH and phytoplankton absorption values.**

2. **Non-red tide : relative low FLH and phytoplankton absorption values.**

3. Results : High effect of Detritus/gelbstoff

Red Color :

$$\left[\frac{1}{nLw(488)-nLw(443)}\right] \geq \left[\frac{1}{nLw(531)-nLw(488)}\right]$$



Green Color :

$$\left[\frac{1}{nLw(488)-nLw(443)}\right] < \left[\frac{1}{nLw(531)-nLw(488)}\right]$$

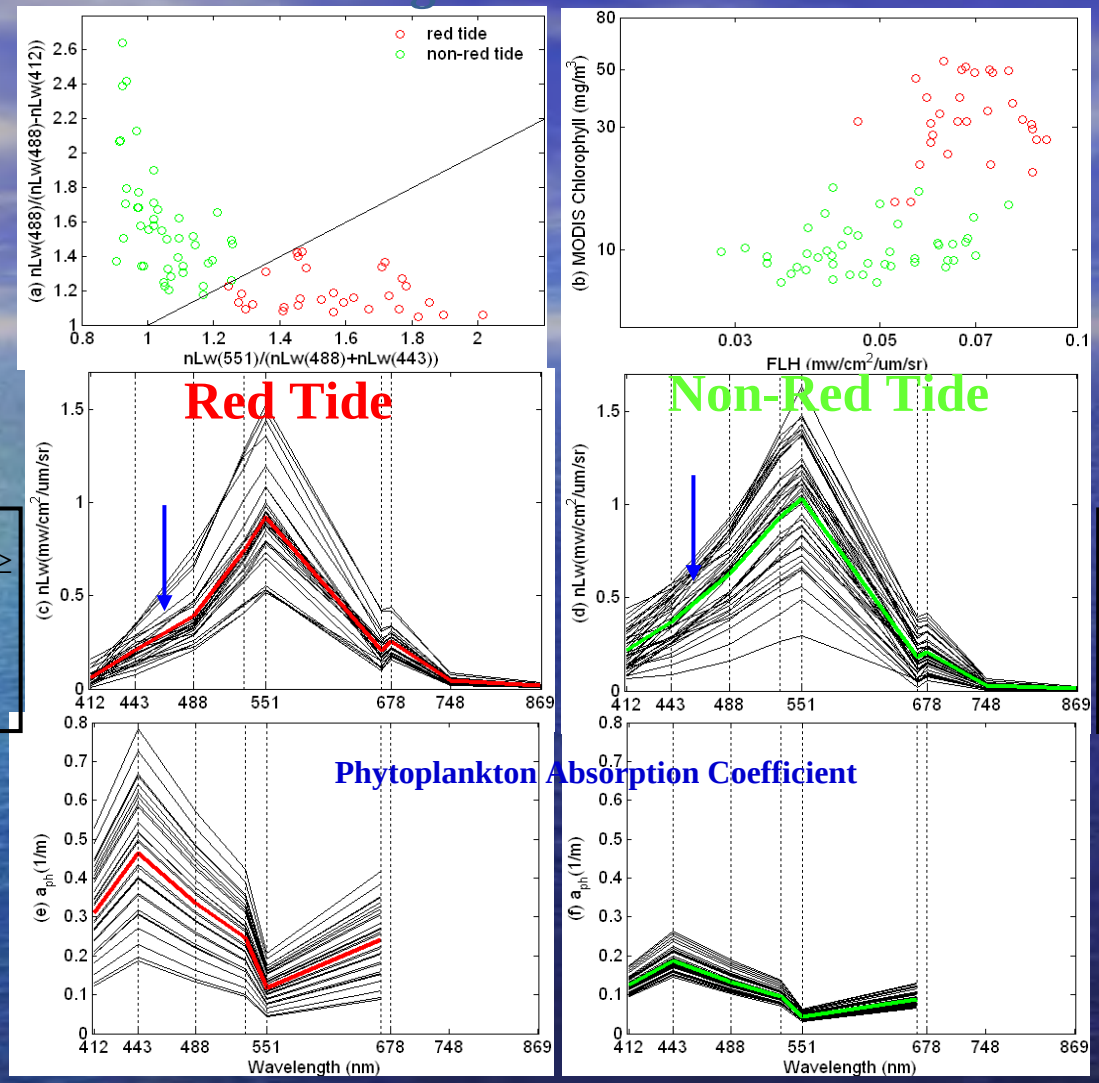
1. **Potential Red tide : relative high FLH, satellite chlorophyll and phytoplankton absorption values.**

2. **Non-red tide : relative low FLH and phytoplankton absorption values.**

3. Results : High effect of Detritus/gelbstoff

Red Color :

$$\left[\frac{nLw(551)}{nLw(488)+nLw(443)}\right] \geq \left[\frac{nLw(488)}{nLw(488)-nLw(412)}\right]$$



Green Color :

$$\left[\frac{nLw(551)}{nLw(488)+nLw(443)}\right] < \left[\frac{nLw(488)}{nLw(488)-nLw(412)}\right]$$

1. **Red tide : relative high FLH, satellite chlorophyll and phytoplankton absorption values.**

2. **Non-red tide : relative low FLH and phytoplankton absorption values.**

3. Results and Discussions : Water type classification

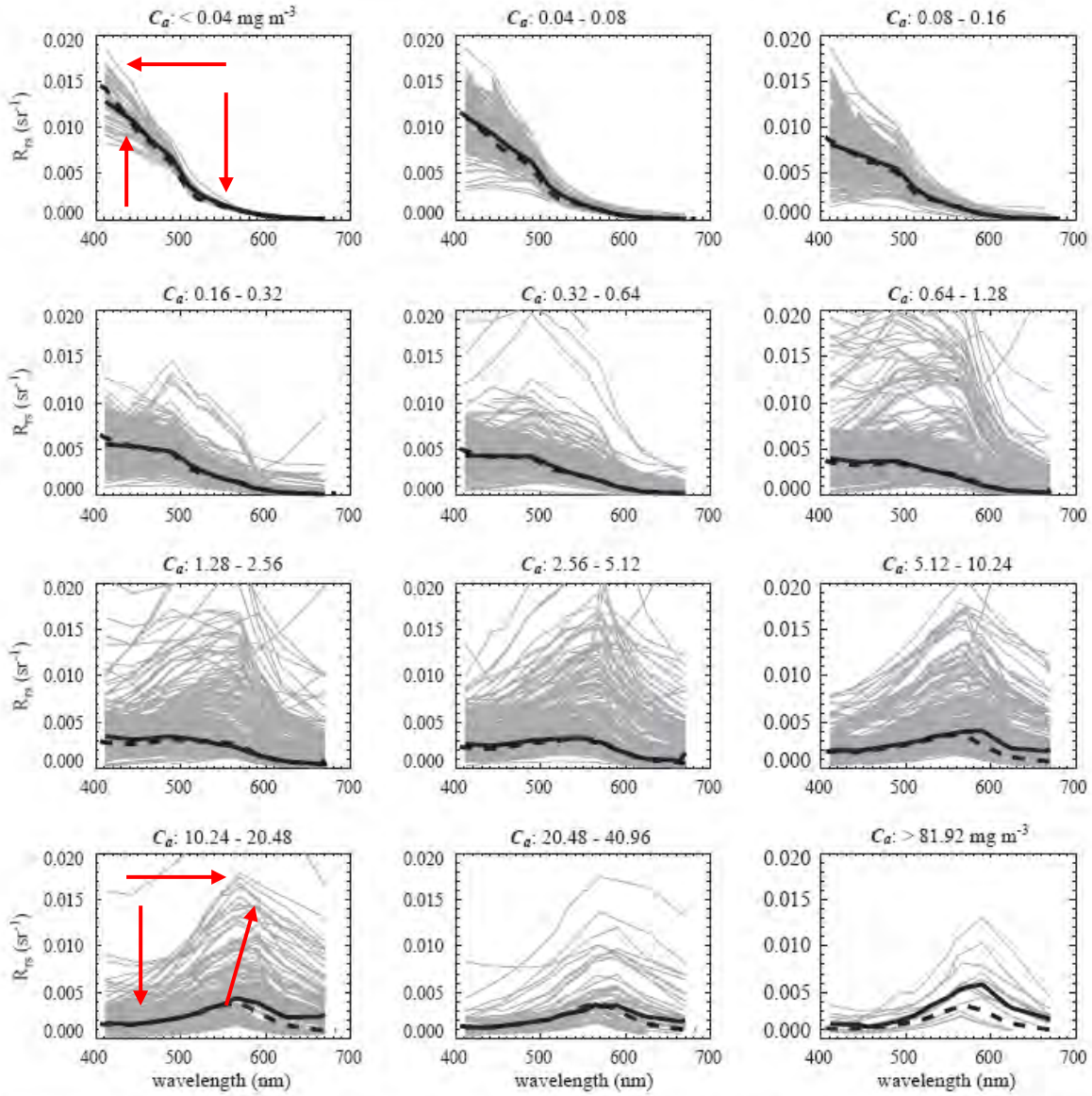
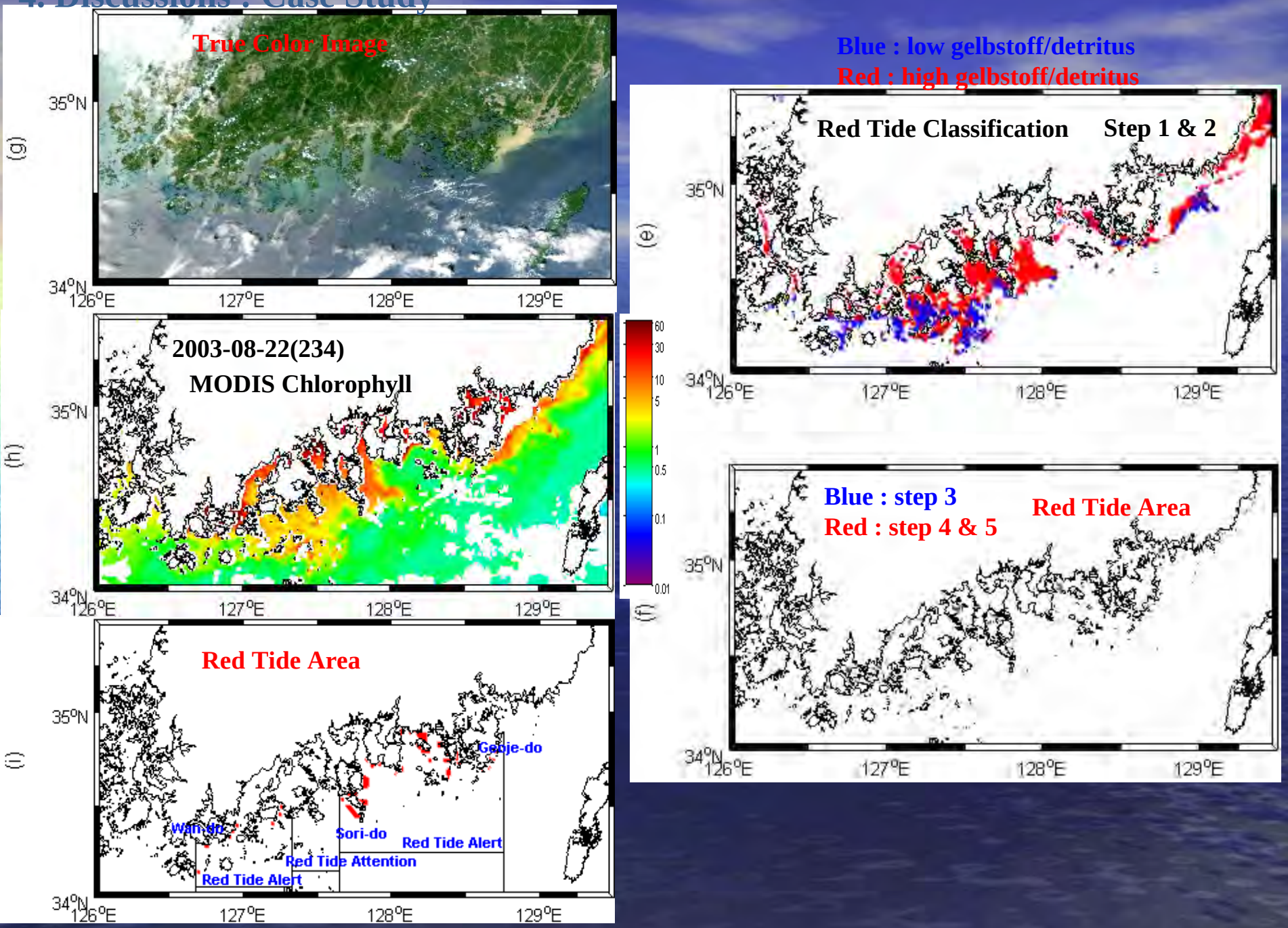


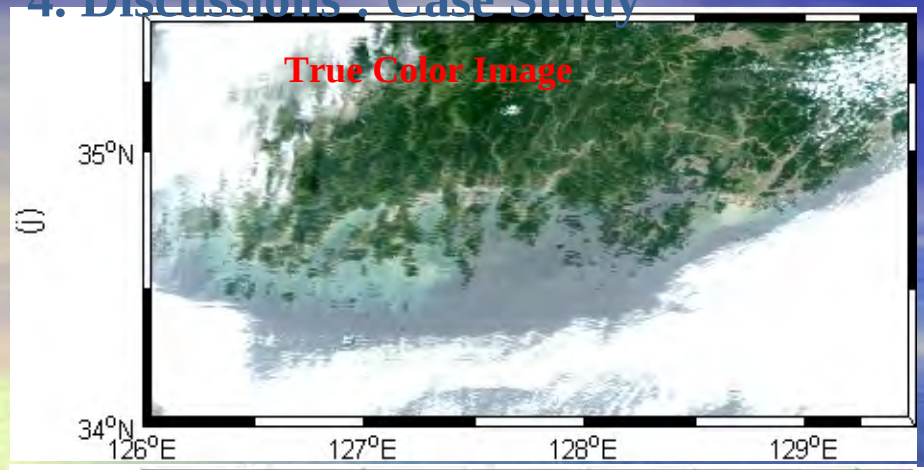
Fig. 9. The NOMAD $R_{rs}(\lambda)$ spectra displayed for geometrically increasing chlorophyll a concentration ranges, as indicated by the title of each plot. Solid black lines indicate the median spectrum for each chlorophyll a range. Dashed black lines display a theoretical clear-water spectrum for the median chlorophyll a concentration for each range. The latter spectra were derived using the Case-1 approximations described in Morel and Maritorena (2001).

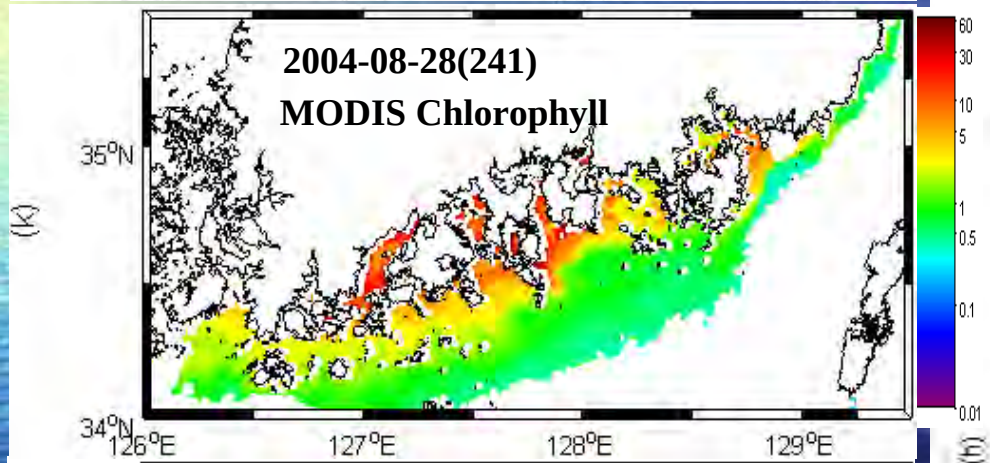
Werdell and Bailey (2005)

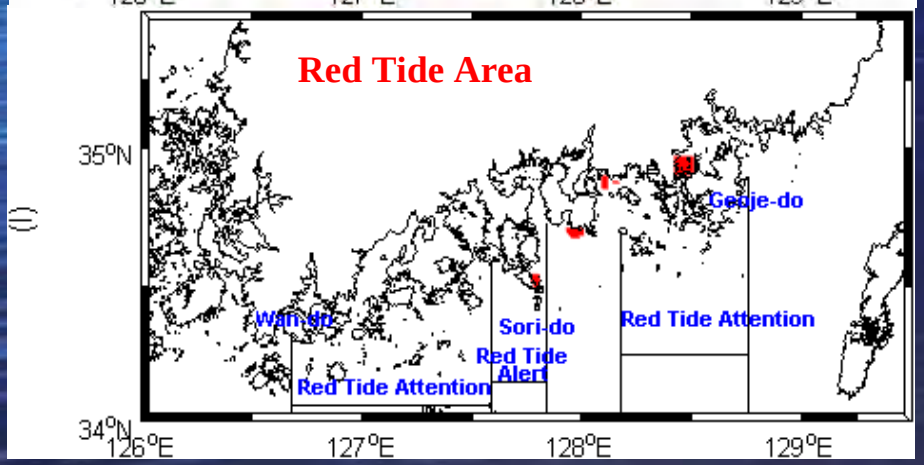
4. Discussions : Case Study



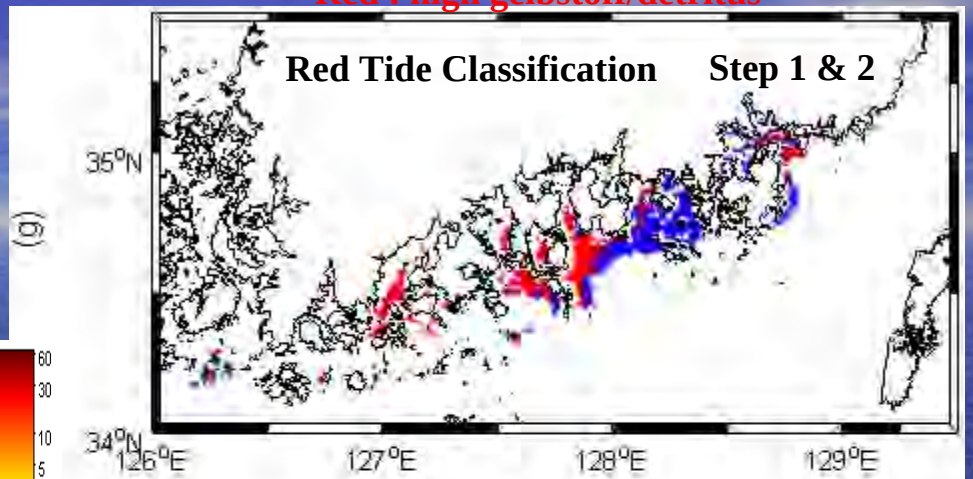
4. Discussions : Case Study

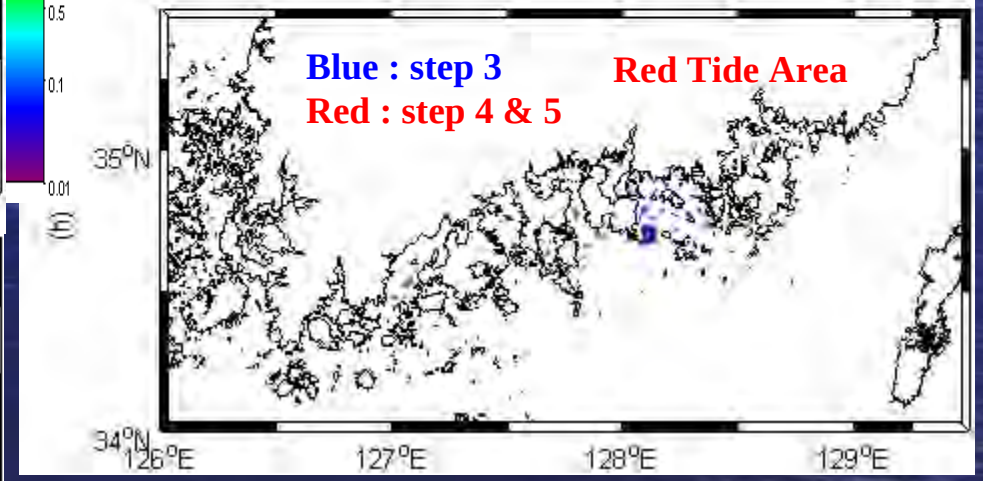




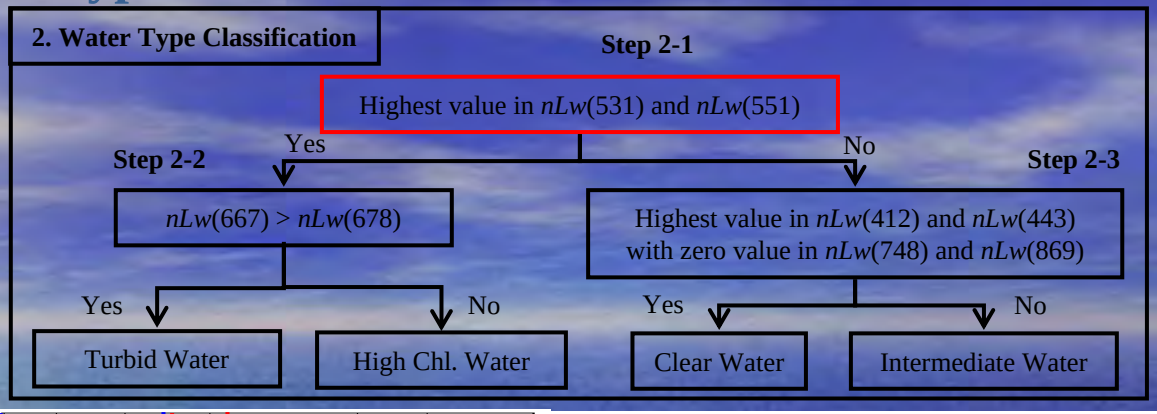


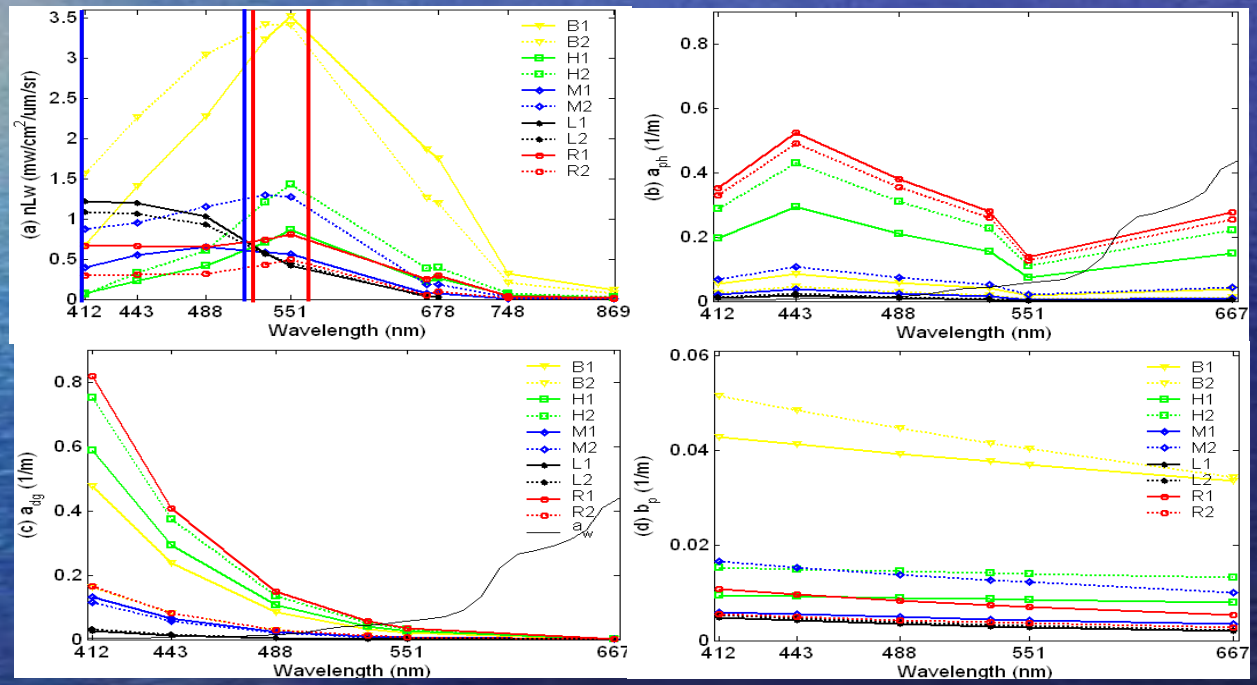
Blue : low gelbstoff/detritus
Red : high gelbstoff/detritus





3. Results : Water Type Classification

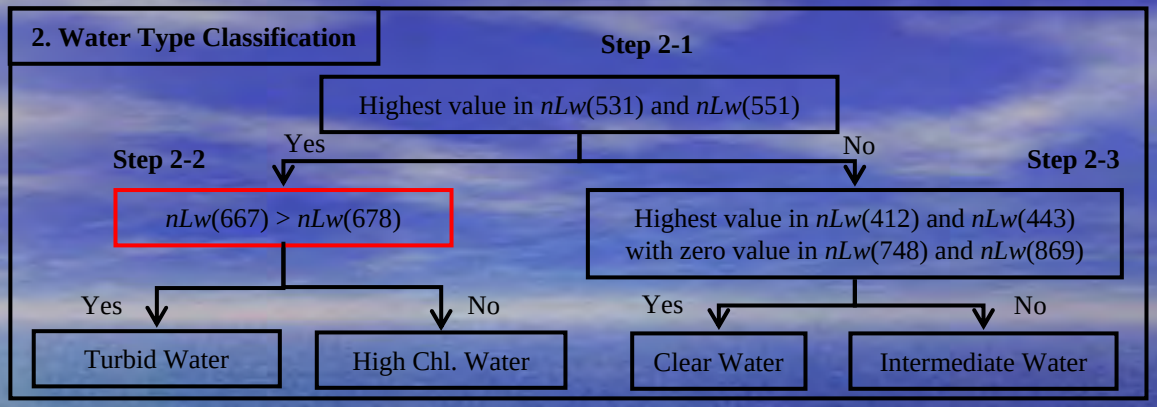


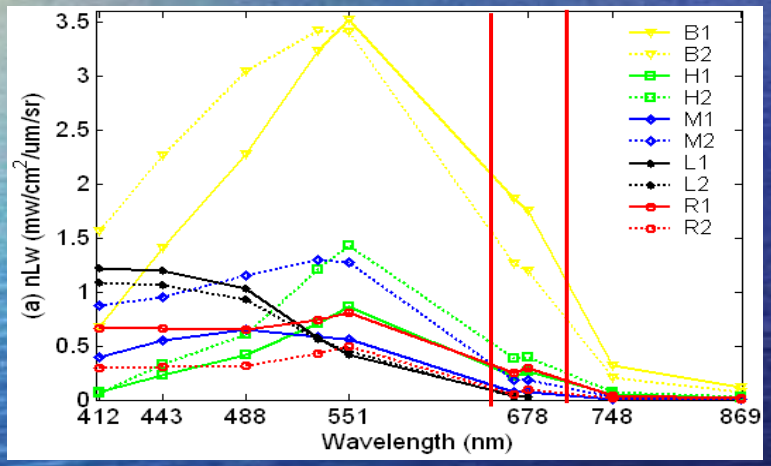


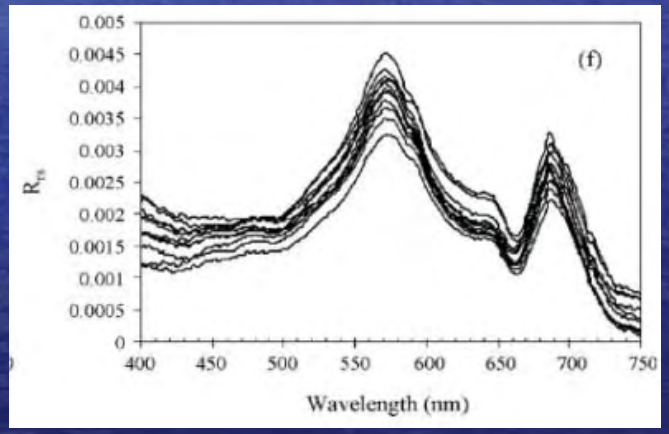
Bright color (B1, B2) : Radiance peaks at green band. Higher radiance and particulate backscattering but phytoplankton absorption is minimal

High chlorophyll and red tide (H, R) : Radiance peaks at green band. Higher absorption of the phytoplankton and gelbstoff/detritus . Particulate backscattering values are ~3-4 times lower than in bright color samples.

3. Results : Water Type Classification

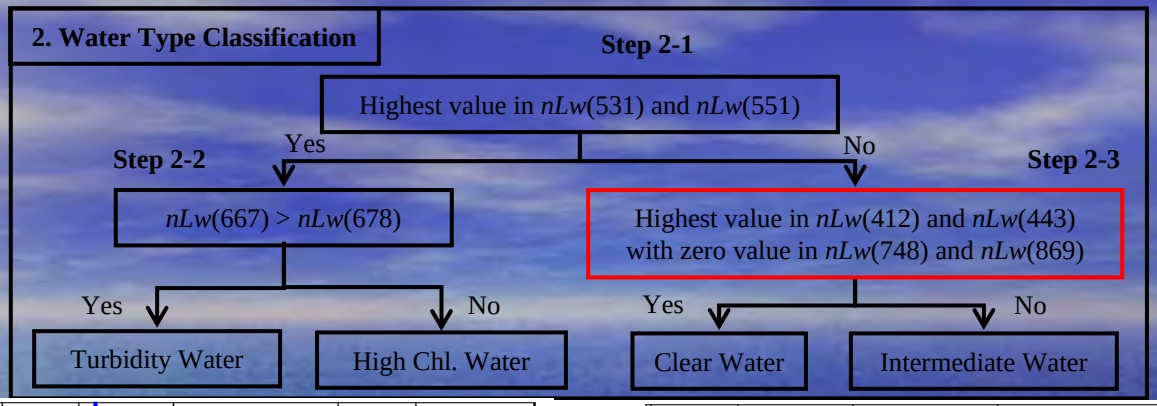


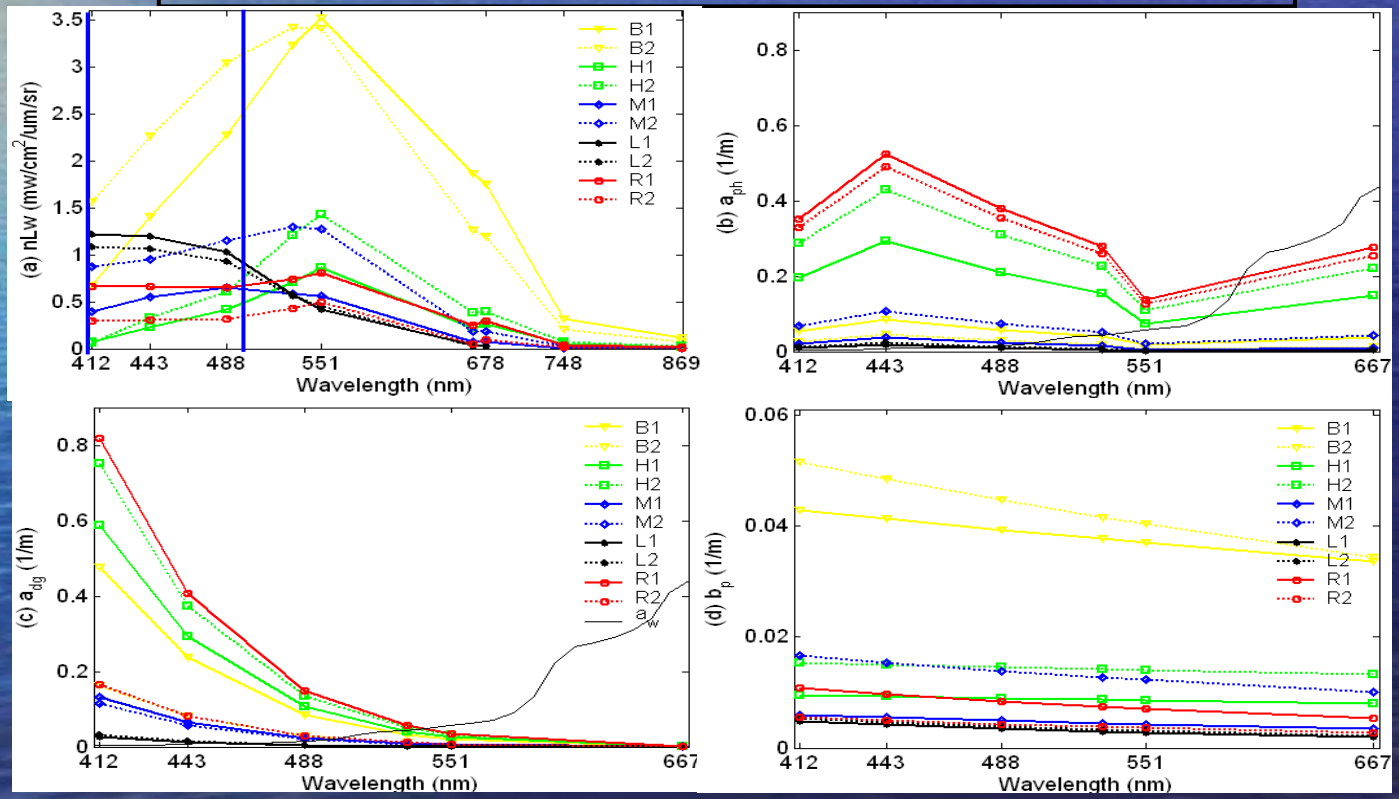




Weak fluorescence signals disappeared through surface turbid water column due to complex interactions with suspended particulate materials (Ahn and Shanmugam, 2006; Babin et al., 1996)

3. Results : Water Type Classification





Low and moderate chlorophyll (L, M) : Radiance peaks from 412 nm to 531 nm (blue to green bands) absorption and backscattering of the phytoplankton, gelbstoff, and detritus in all visual wavelengths