NOCCG

Lamont-Doherty Earth Observatory
COLUMBIA UNIVERSITY | EARTH INSTITUTE

Estimates of diurnal and daily Net Primary Productivity using the GOCI data

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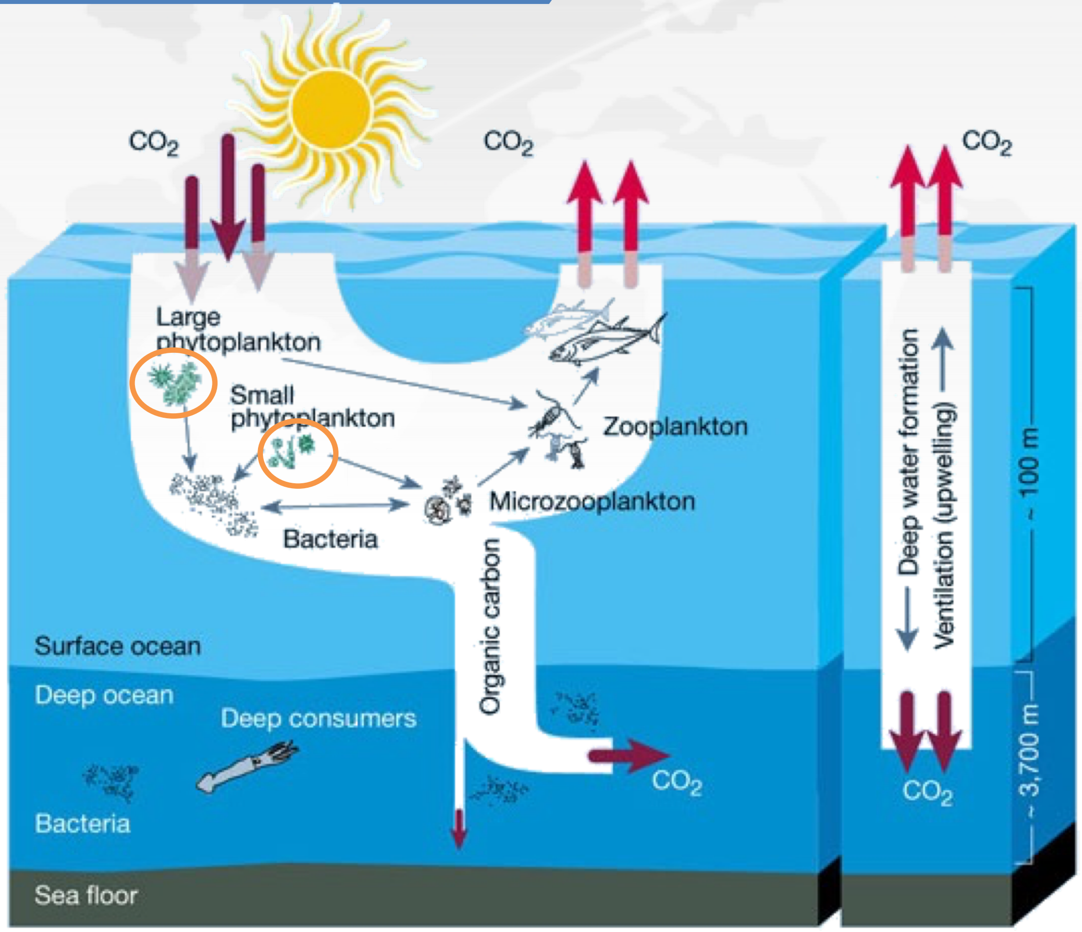
Scientific question



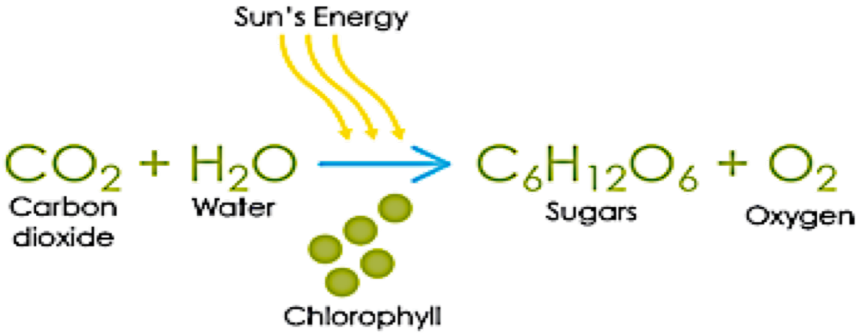
CO_2 & Biological Pump

Phytoplankton

Photosynthesis

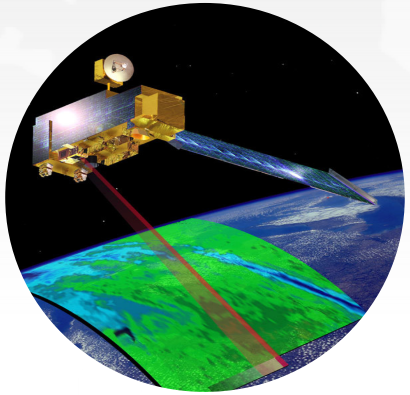
Chlorophyll *a*

Primary Productivity



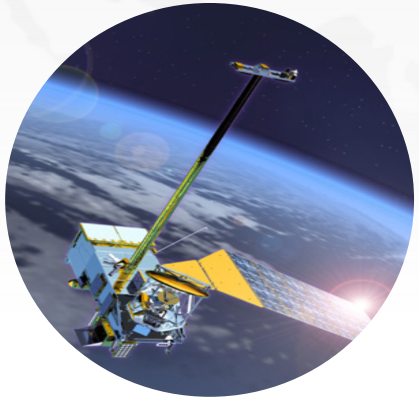
Background

MODIS



- Moderate Resolution Imaging Spectroradiometer
- polar-orbiting
- Aqua /Terra

VIIRS



- Visible Infrared Imaging Radiometer Suite
- polar-orbiting
- SNPP

GOCI

- Geostationary Ocean Color Imager
- geostationary-orbiting
- eight images per day

KORUS-OC

Currents:

- East Korean Warm current (EKWC),
- North Korea Cold current (NKCC),
- Tsushima Warm Current (TWC),
- West Korea Coastal Current (WKCC),
- Yellow Sea Warm Current (YSWW)
- Chinese Coastal Current (CCC).

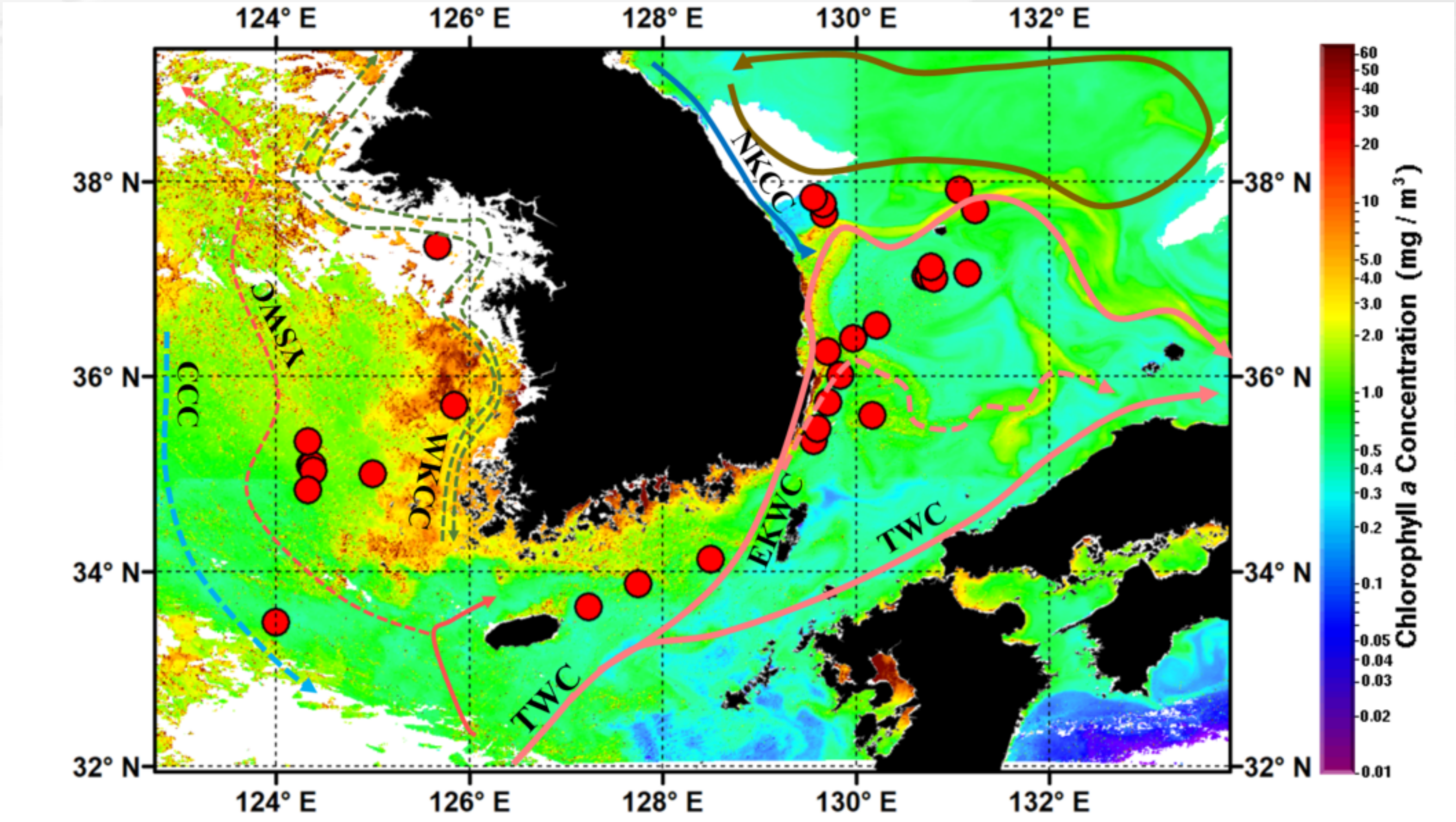


Fig. Locations of survey stations and diurnal stations (red) during KORUS cruise in May-June 2016.

NPP Model

AbPM

Mechanism model: Use $a_{ph}(\lambda)$ instead of Chl and $a^{*}_{ph}(\lambda)$, combined with light intensity $E_{day}(z,\lambda)$, and photosynthesis quantum yield $\phi(z)$ and other bio-optical parameters to calculate PP

$$PP_{AbPM} = \int_{0}^{Z_{eu}} \int_{400}^{700} \phi(z) \cdot a_{ph}(\lambda) \cdot E_{day}(z,\lambda) d\lambda dz$$

The quantum yield of photosynthesis ϕ is the key input of the AbPM model

ϕ can be well simulated by PAR_{day} ： (Kiefer & Mitchell, 1983)

$$\phi(z) = \phi_m \times \frac{K_\phi}{K_\phi + PAR_{day}(z)}$$

ϕ_m： Maximum quantum yield of photosynthesis

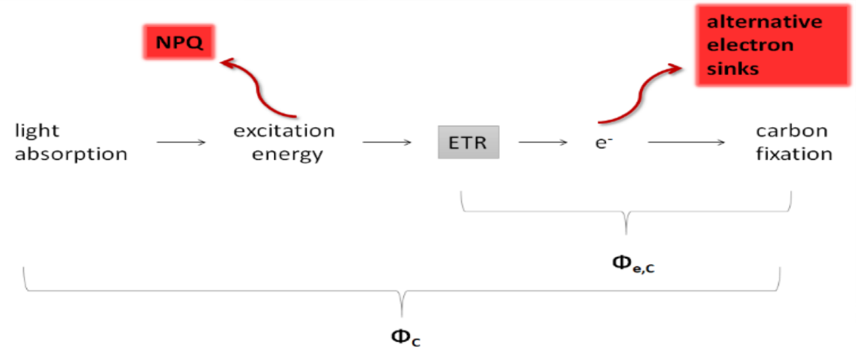
K_ϕ： the irradiance corresponds to 0.5 ϕ_m

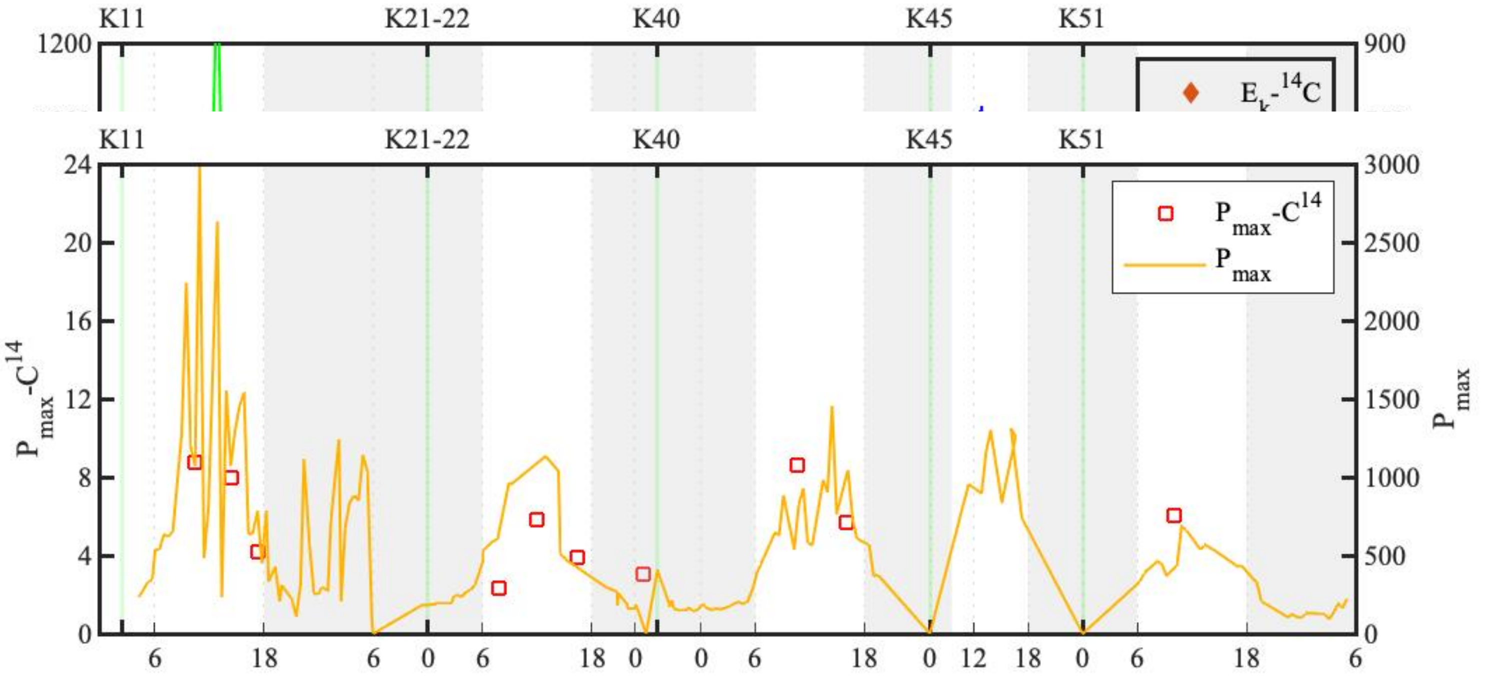
In-situ Datasets

$$PP_{AbPM} = \int_0^{Z_{eu}} \int_{400}^{700} \phi(z) \cdot a_{ph}(\lambda) \cdot E_{day}(z,\lambda) d\lambda dz$$

Calculate the *in-situ* ϕ and $\phi_{(z)}$

- ^{14}C method: ϕ_C (mol C [mol photons]$^{-1}$)
- ETR method: $\phi_{e,C}$ (mol photons [mol C]$^{-1}$)





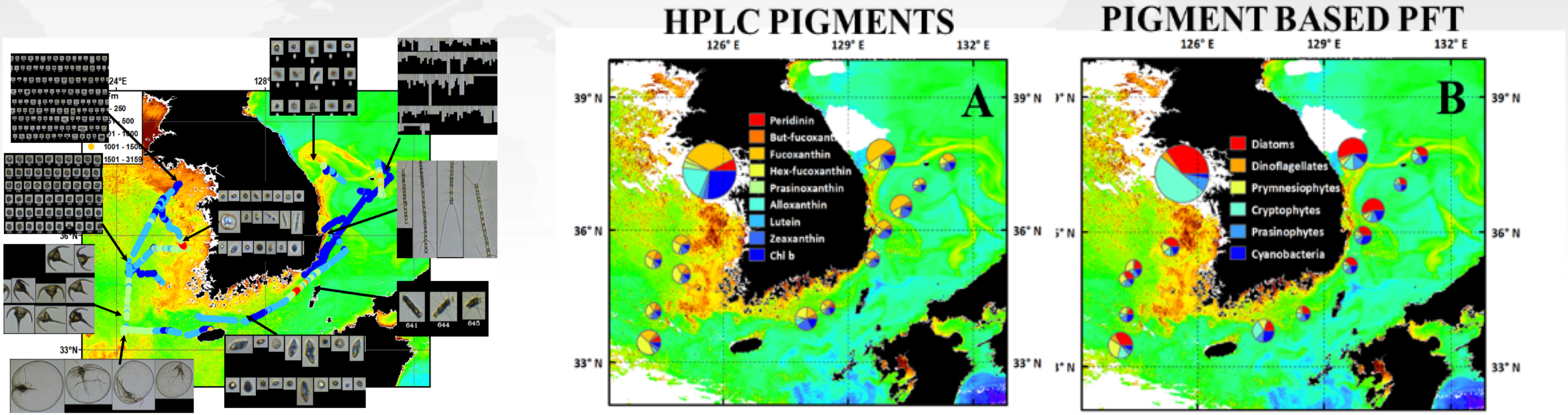
$$\phi(z) = \phi_m \times \frac{K_\phi}{K_\phi + PAR_{day}(z)}$$

Global:

ϕ_m = 0.06 mol C (mol photons)$^{-1}$;

K_ϕ = 10 mol m^{-2} d^{-1}。

In-situ Datasets



(a) ***(b)*** ***(c)***

Fig. (*a*) Phytoplankton species distribution, (b) Pigment compositions (%) by HPLC (c) PFTs obtained by CHEMTAX analysis of HPLC pigments

Optical-biogeochemical (O-BGC) Biomes

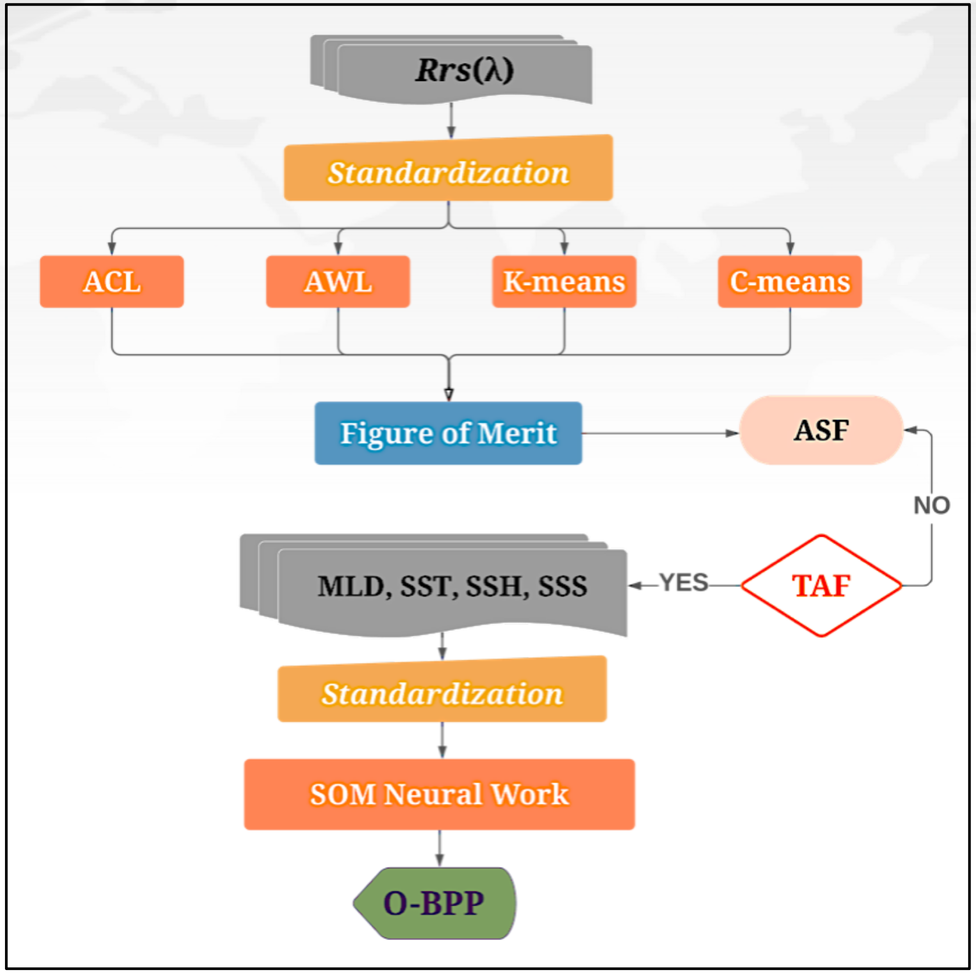
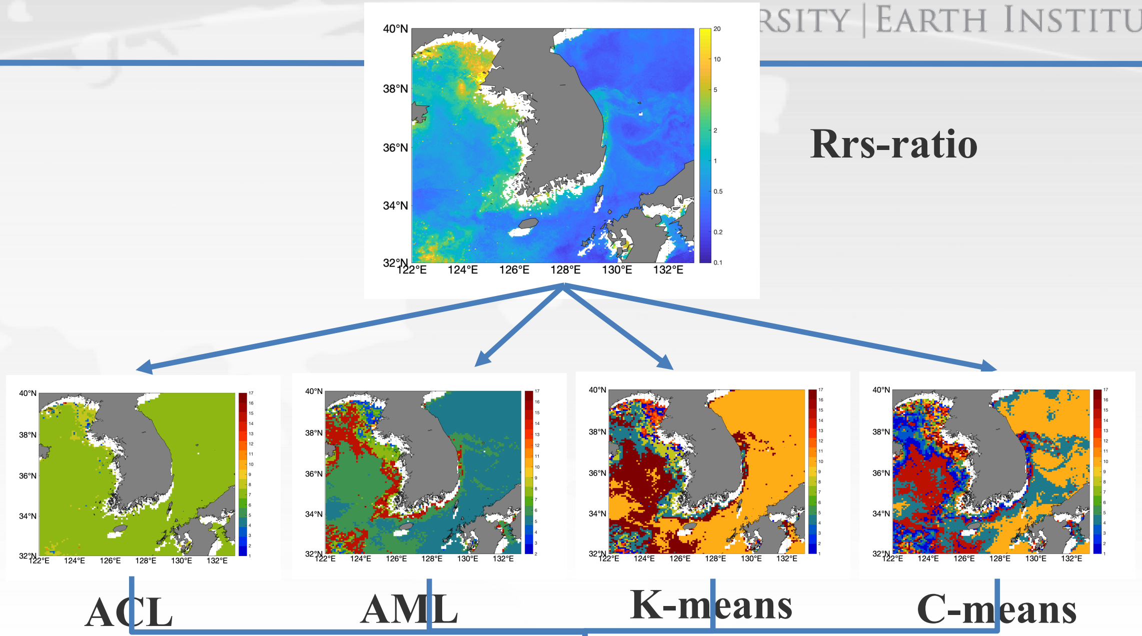


Fig. Flowchart depicting steps for partitioning O-BGC Biomes

Optical-biogeochemical (O-BGC) Biomes



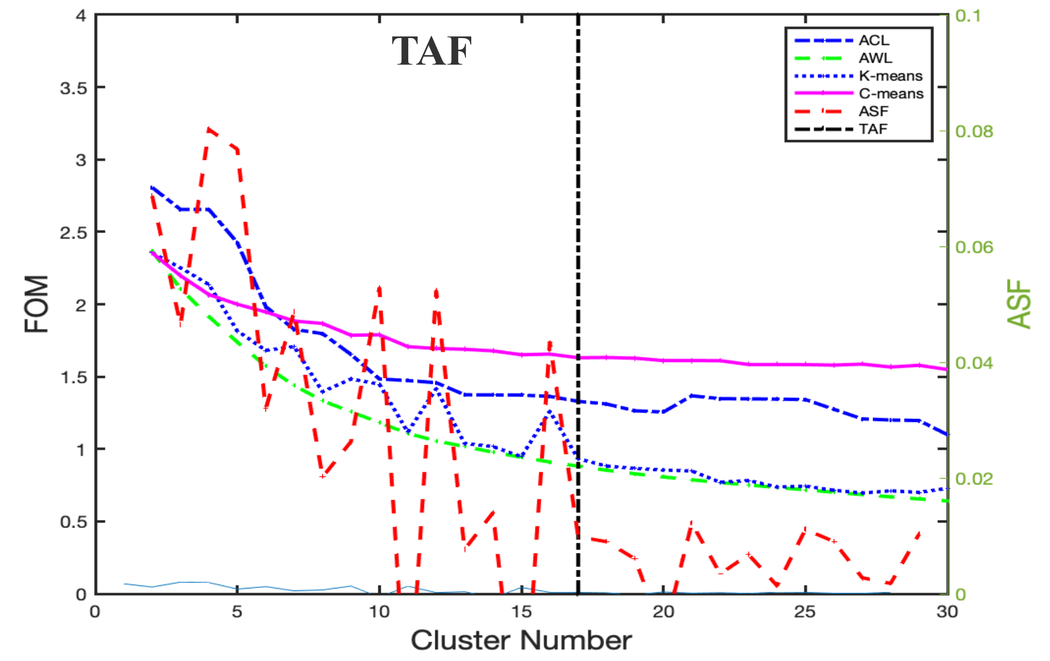
Standardization

Cluster Analysis

Threshold

- FOM(figure of merit)
- ASF(average slope function)
- TAF (THRESHOLD acceptable flatness)

- A
  Us... ree using
  the th... ethod.
- A
  Si... ier squared
  distan...
- K
  By
- C
  Da



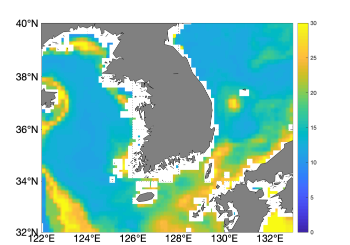
The cluster number

According to FOM and TAF, the number of Cluster = 17 (for here) is the most optimistic option.

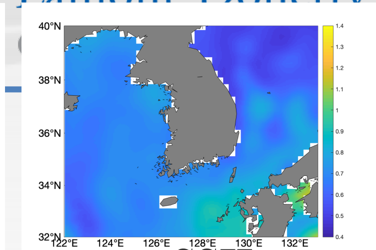
Optical-biogeochemical (O-BGC) Biomes

Input other parameters

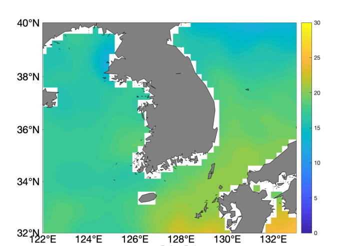
- The input order of the parameters does not affect the classification results
- The number and type of input parameters will affect the classification results



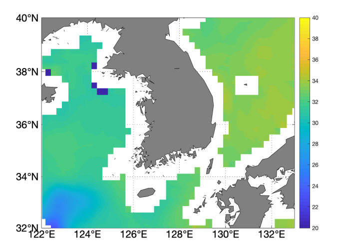
MLD



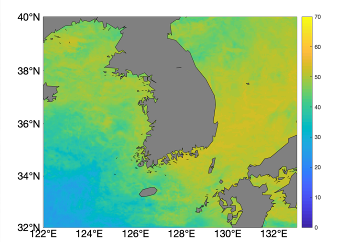
SSH



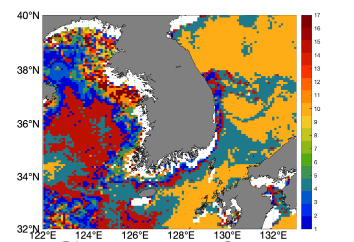
SST



SSS



PAR

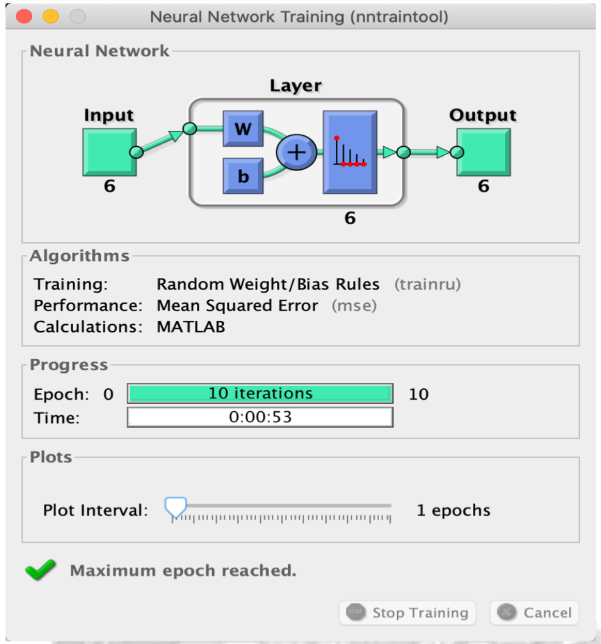


Cluster of Rrs

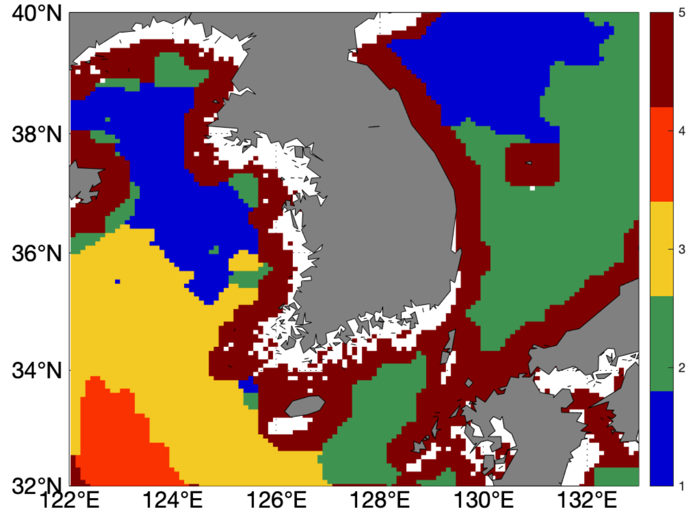
SOM Neural Network

- Self - Organizing Feature Map
- A self-organizing (competitive) neural network, to optimize the results of cluster analysis when input other parameters.

Optimize clusters



SOM



Provinces

Optical-biogeochemical (O-BGC) Biomes

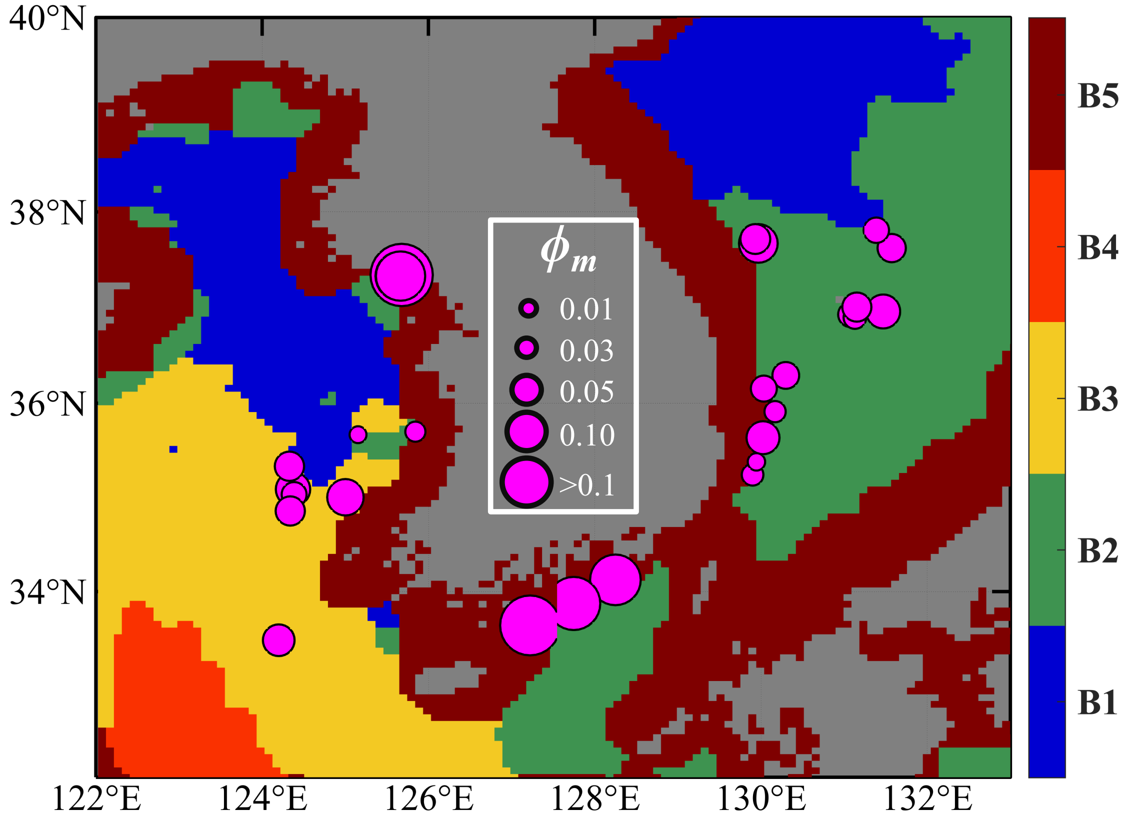


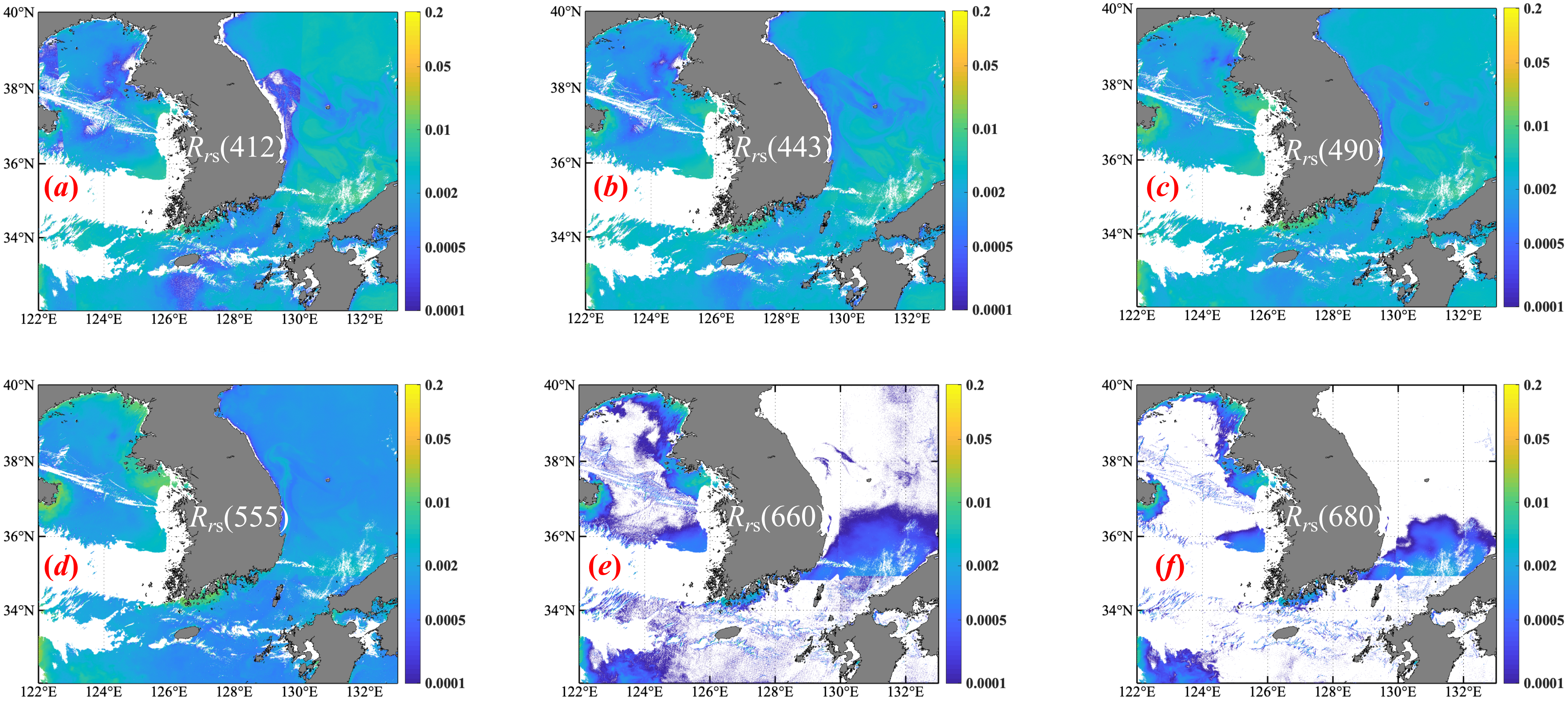
Table. ϕ_m derived from ^{14}C uptake P-E curves and K_ϕ estimated as the value of PAR_t at half ϕ_m.

Number of Biomes	K_ϕ mol photons m^{-2} h^{-1}	ϕ_m mol C [mol photons]$^{-1}$
Biome 1	0.511	0.012
Biome 2	0.408	0.029
Biome 3	0.639	0.037
Biome 4	0.417	0.042
Biome 5	0.383	0.074

Fig. Delineated optical biogeochemical (O-BGC) Biomes of waters around the Korean Peninsula and the match with φ_m *and* K_φ.

Hourly GOCI $R_{rs}(\lambda)$

Case 1: 06/02/2016 #02



Validation

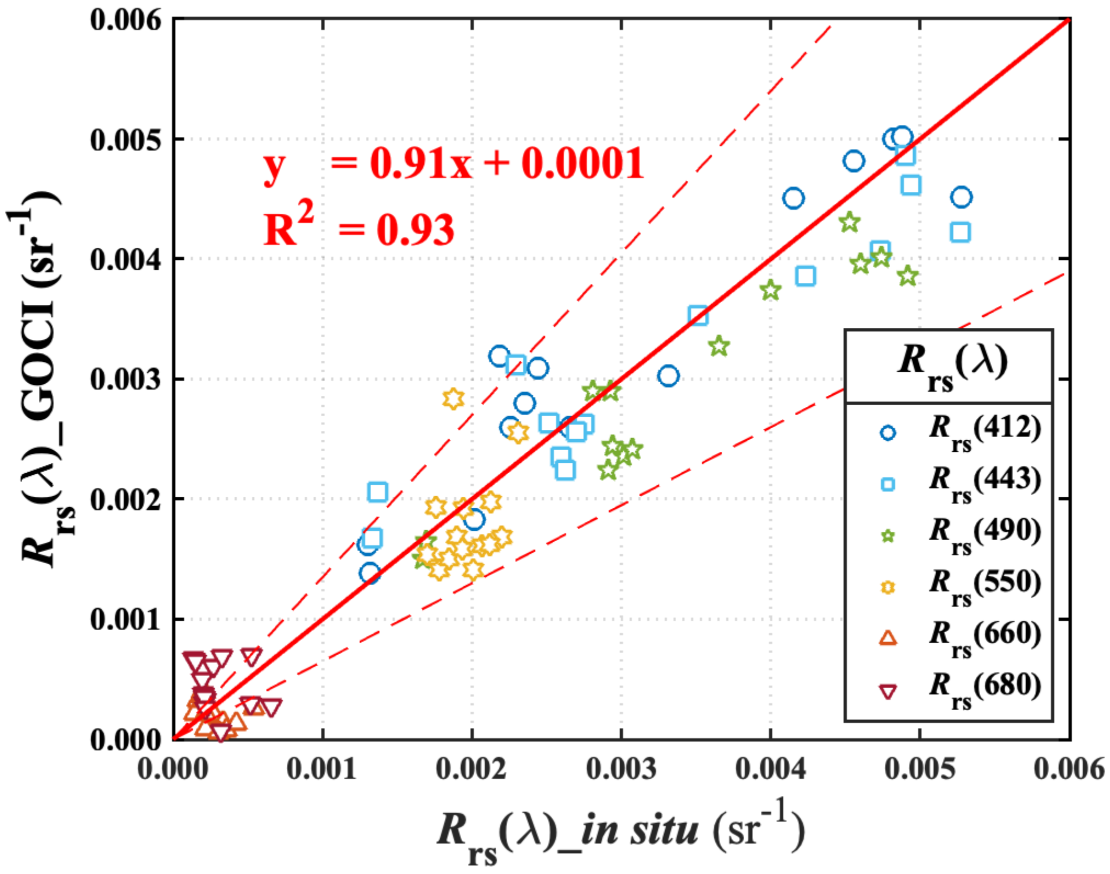
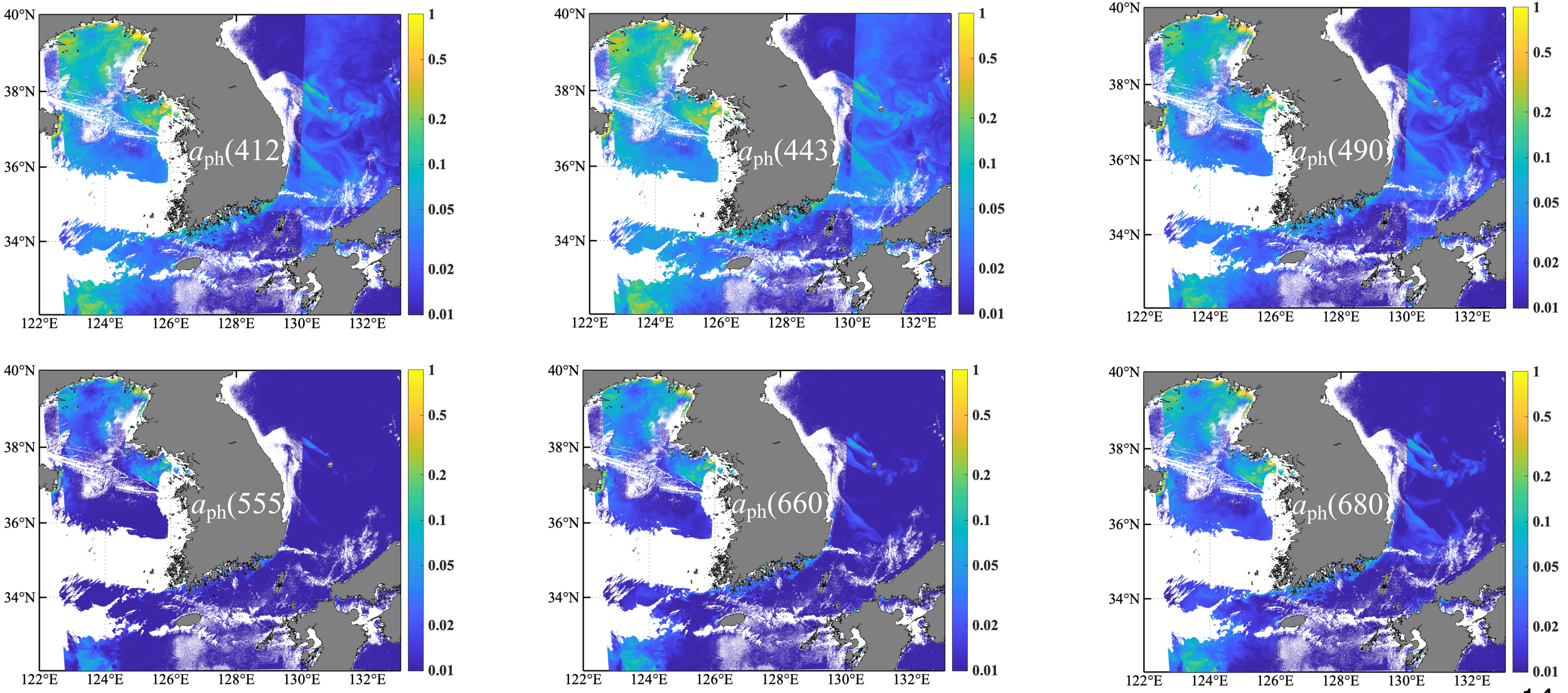


Fig. Comparisons of GOCI derived $R_{rs}(\lambda)$ with *in-situ* $R_{rs}(\lambda)$ measurements during KORUS-OC .

Hourly GIOP $a_{ph}(\lambda)$

Case 1: 06/02/2016 #02

$$PP_{AbPM} = \int_0^{Z_{eu}} \int_{400}^{700} \phi(z) \cdot a_{ph}(\lambda) \cdot E_{day}(z,\lambda) d\lambda dz$$



Download GOCI L1B products, calculate $a_{ph}(\lambda)$ in SeaDAS

Validation

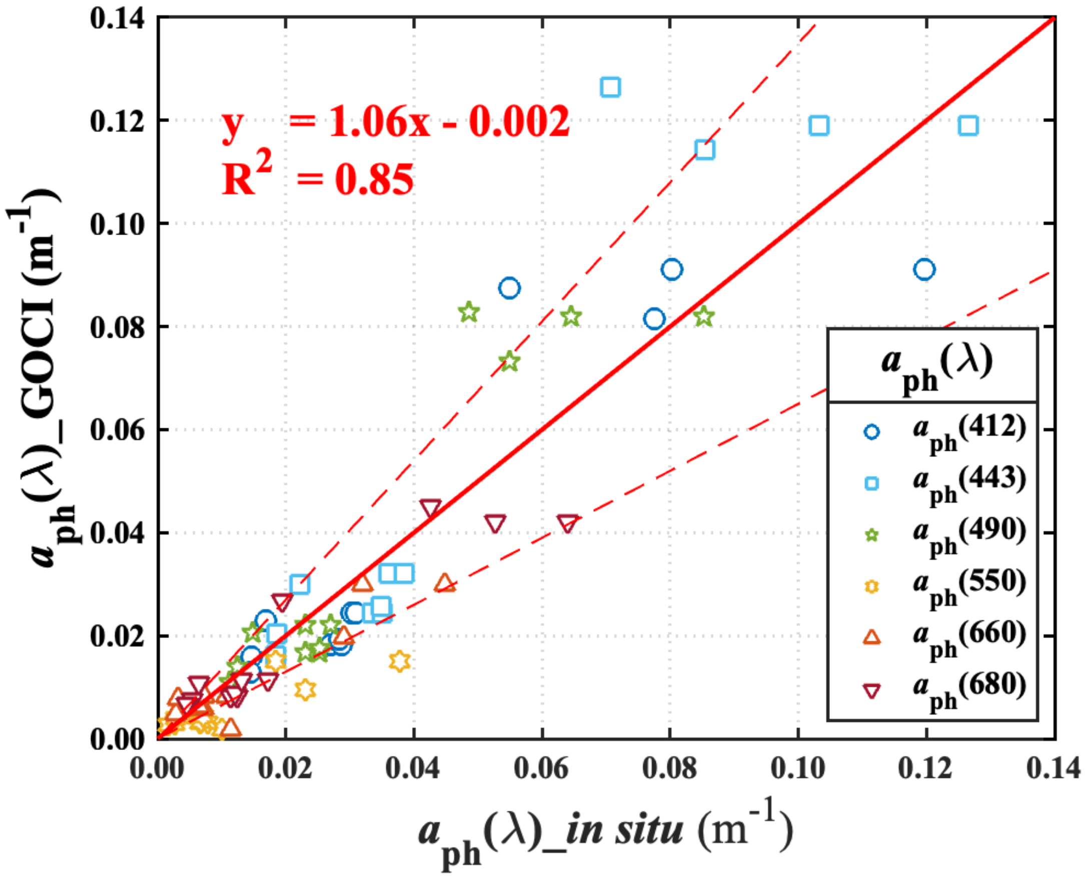


Fig. Comparisons of GOCI derived $a_{ph}(\lambda)$ with *in-situ* $a_{ph}(\lambda)$ measurements during KORUS-OC .

Hourly PAR

Case 1: 06/02/2016 #02

$$PP_{AbPM} = \int_{0}^{Z_{eu}} \int_{400}^{700} \phi(z) \cdot a_{ph}(\lambda) \cdot E_{day}(z,\lambda) d\lambda dz$$

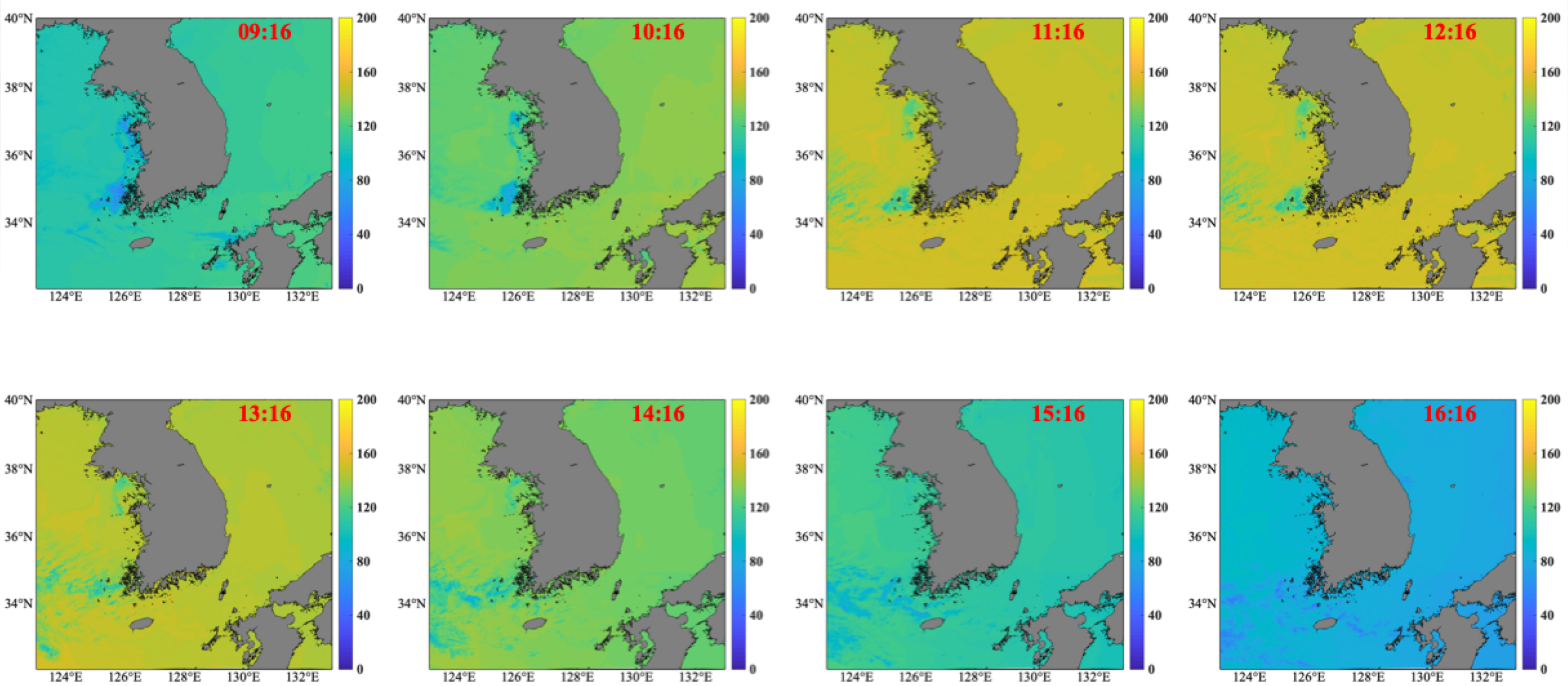


Fig. Hourly maps of PAR (mW cm^{-2} µm) from GOCI for 2nd of June 2016.

Hourly Results

Hourly Surface NPP (mg C m^{-3} h^{-1})

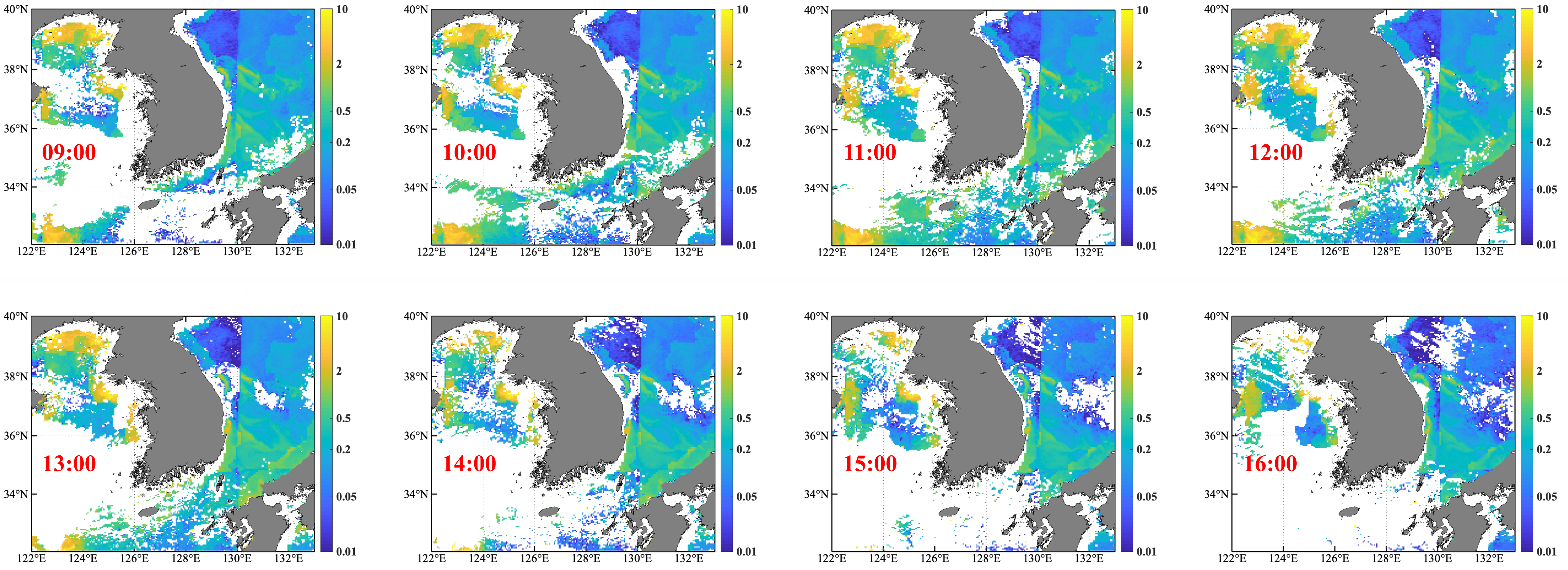


Fig. Hourly maps of surface primary production from GOCI for the 2nd of June 2016.

Hourly Results

Hourly Integrated NPP (mg C m^{-2} h^{-1})

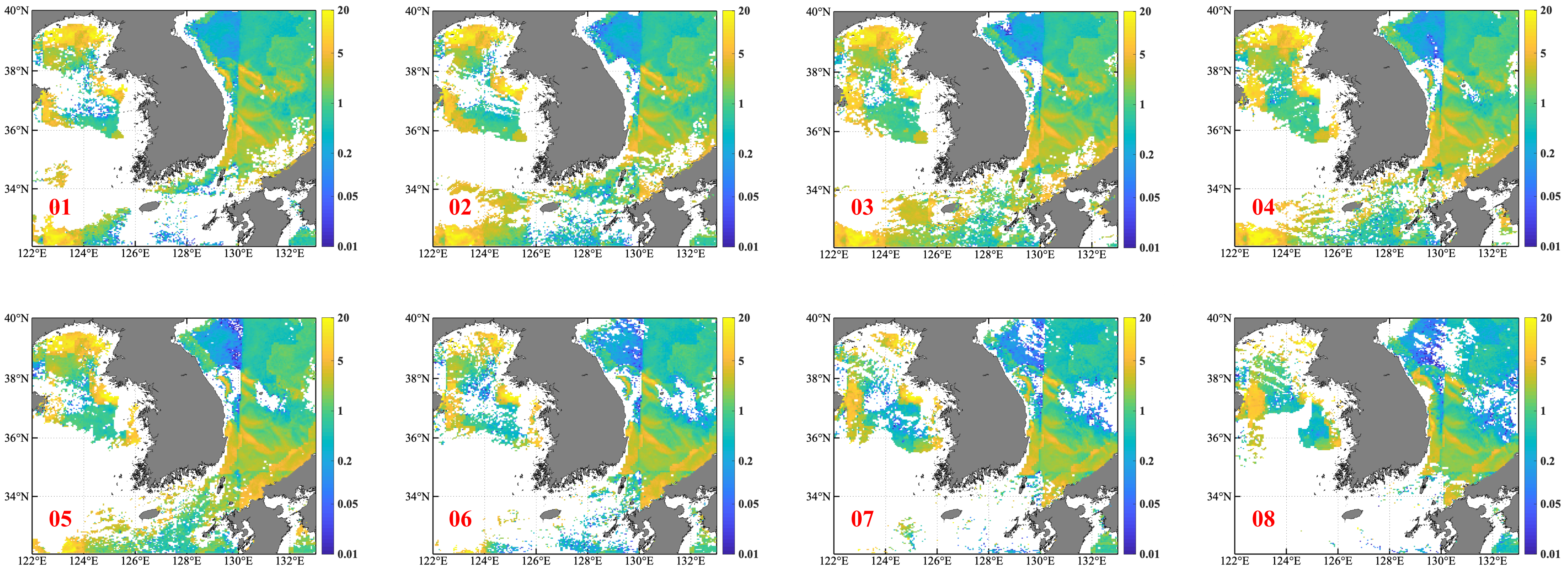
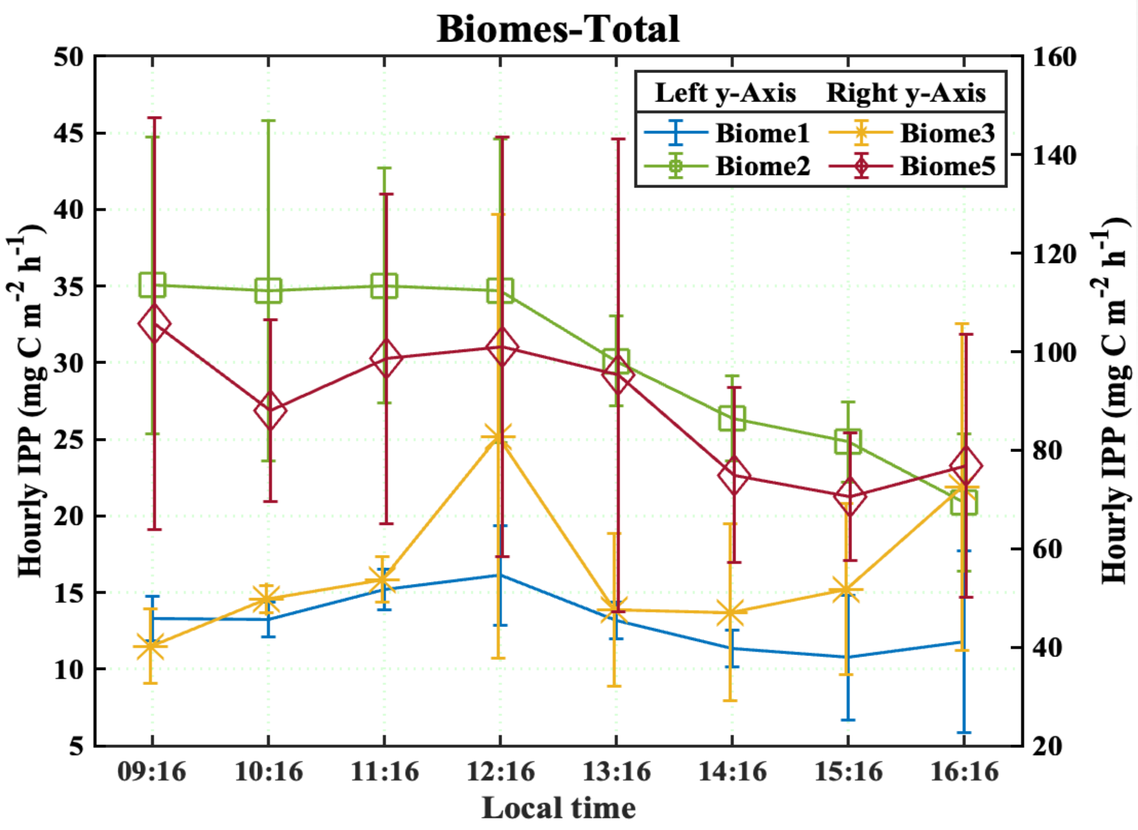
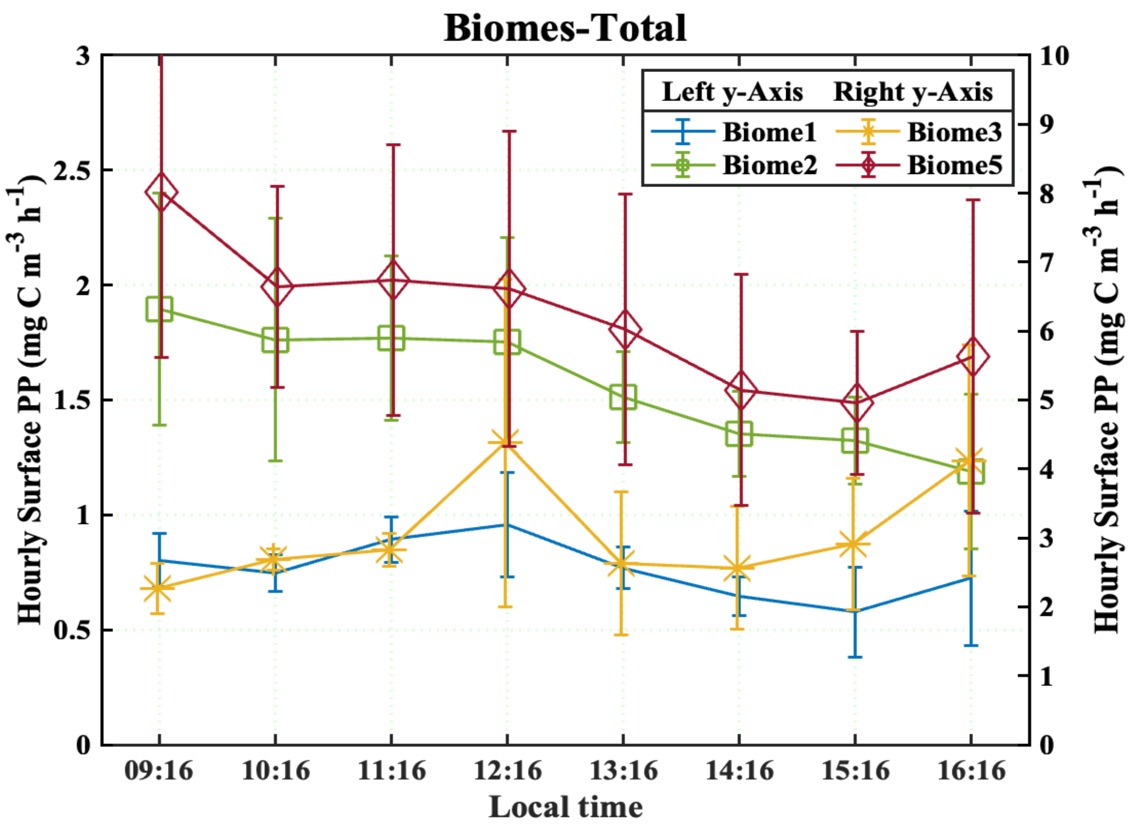


Fig. Hourly maps of Integrated primary production from GOCI for the 2nd of June 2016.

Hourly Results



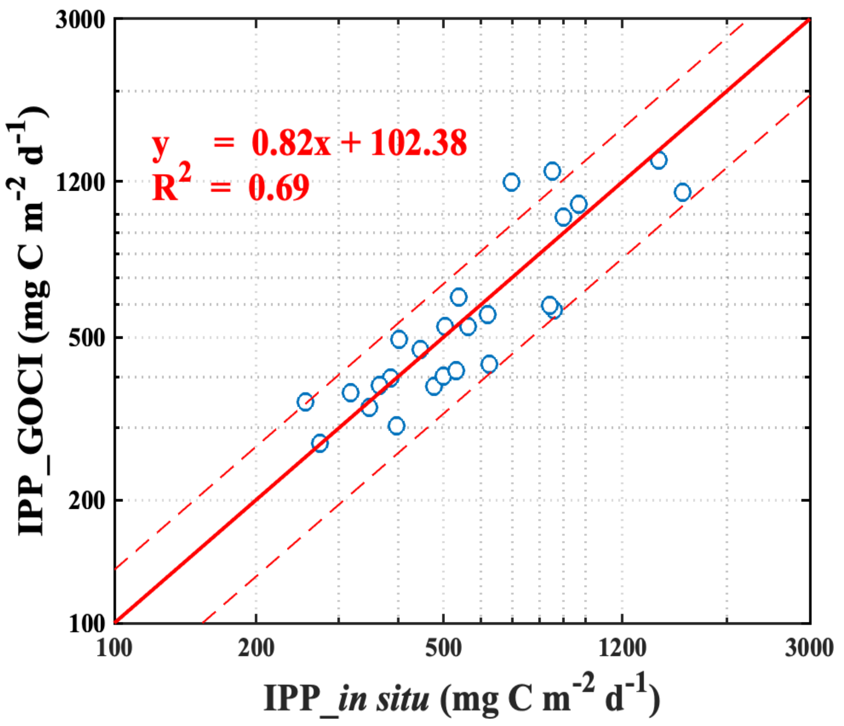
IPP (mg C m^{-2} h^{-1})

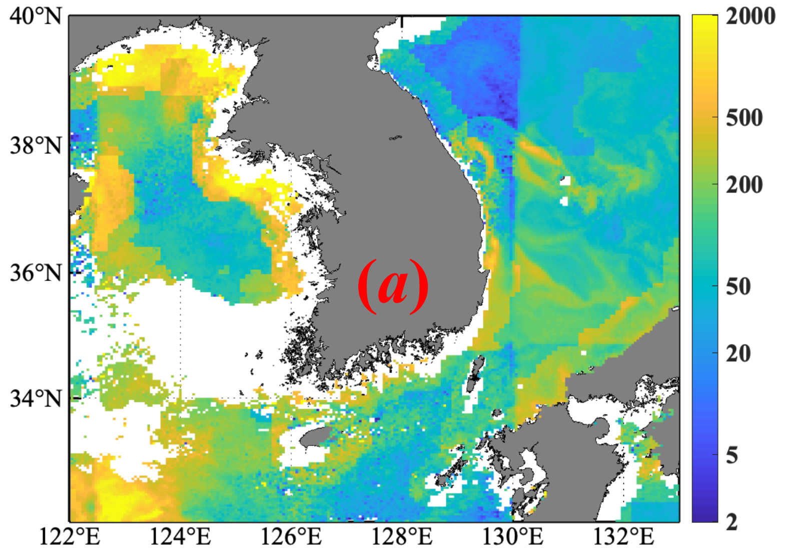


Surface PP (mg C m^{-3} h^{-1})

Fig. 8. Area averaged hourly rates of (*a*) IPP (mg C m^{-2} h^{-1}) and (*b*) Surface PP (mg C m^{-3} h^{-1}) at 4 biomes (without Biome 4) for the 2nd of June 2016.

Daily Results





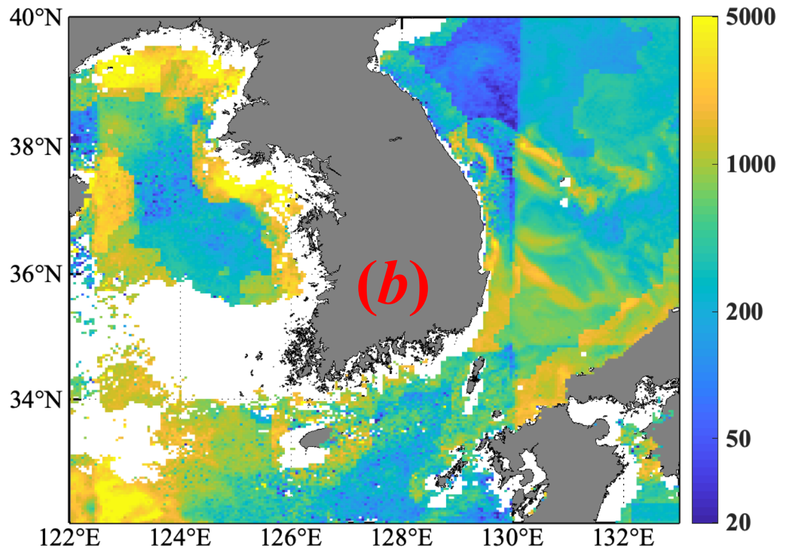


Fig. **Maps of (*a*) daily surface NPP (mg C m^{-3} d^{-1}) (*b*) daily Integrated NPP (IPP, mg C m^{-2} d^{-1}) from GOCI for 2nd of June 2016 and (*c*) Comparison of the IPP derived from GOCI using the AbPM and ^{14}C measured euphotic column IPP from the KORUS cruise.**

Daily Results

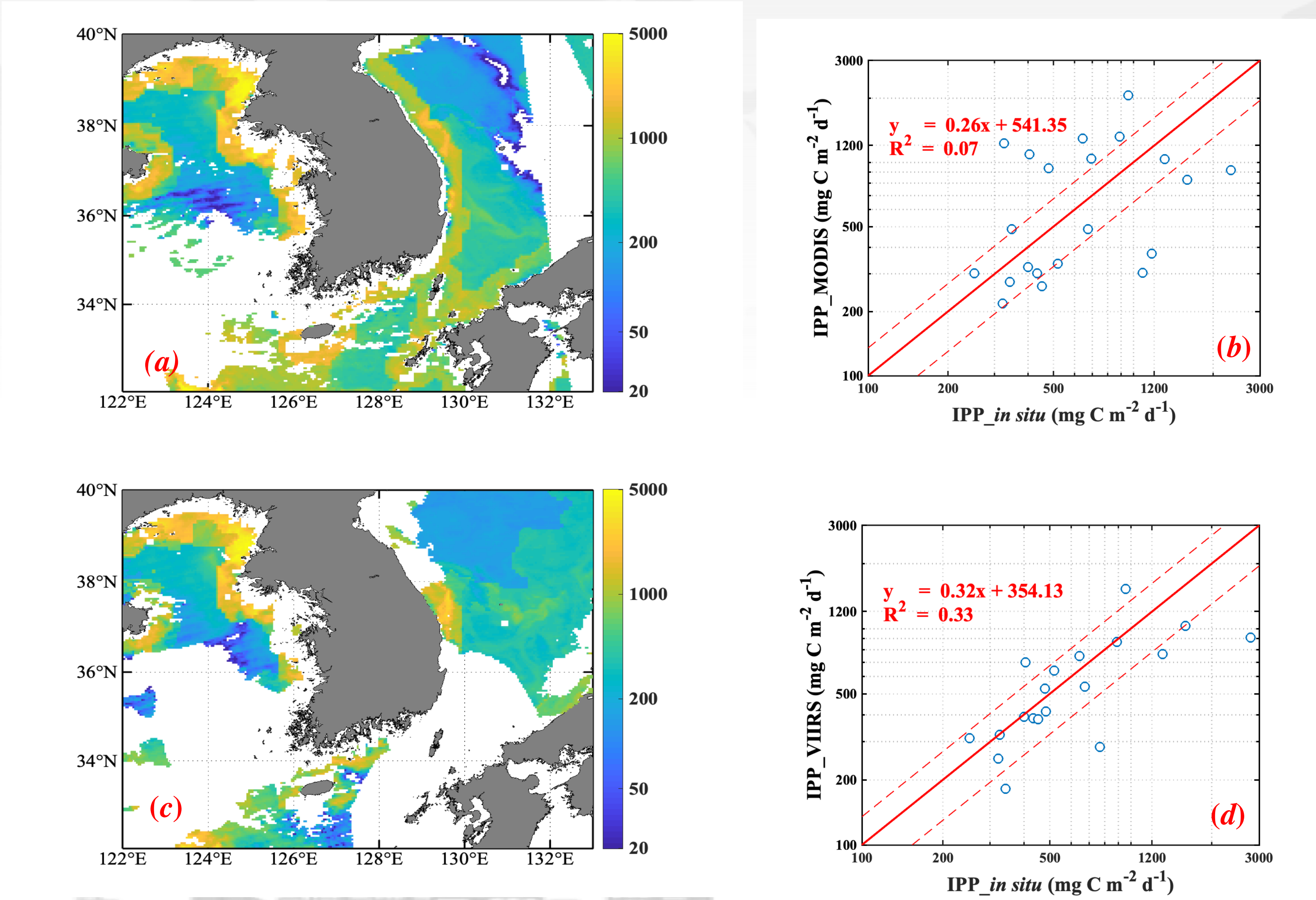


Fig. Maps of daily IPP (mg C m^{-2} d^{-1}) derived from (*a*) MODIS and (*c*) VIIRS for the 2^{nd} June 2016; Corresponding comparisons of shipboard ^{14}C based euphotic column IPP and IPP derived from (*b*) MODIS and (*d*) VIIRS.

Daily PAR

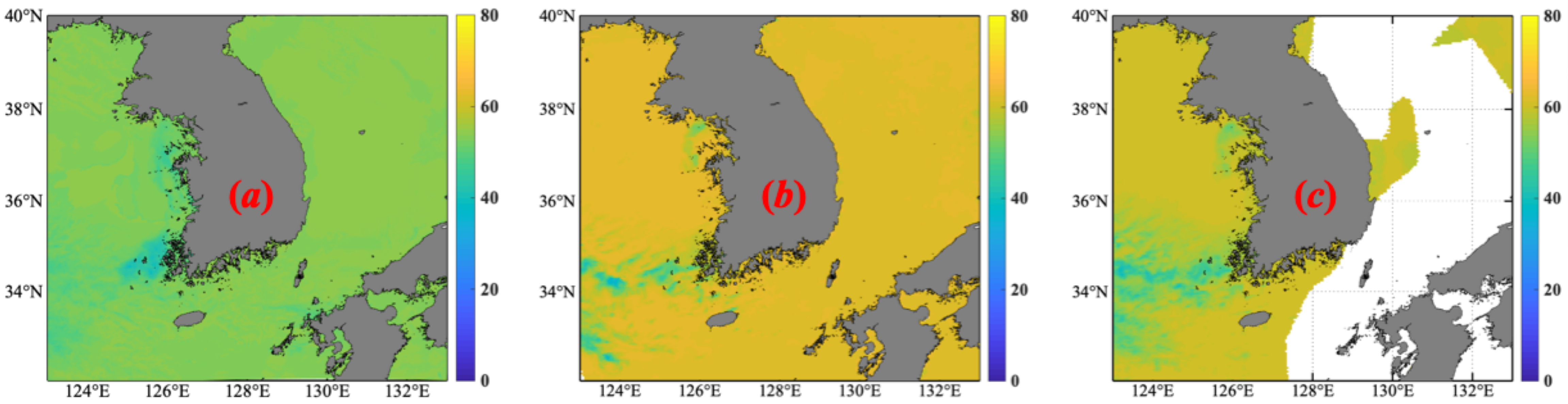


Fig. Daily PAR (mol m^{-2} d^{-1}) derived from (*a*) GOCI, (*b*) MODIS, and (*c*) VIIRS for 2nd June 2016.

Daily $a_{ph}(\lambda)$

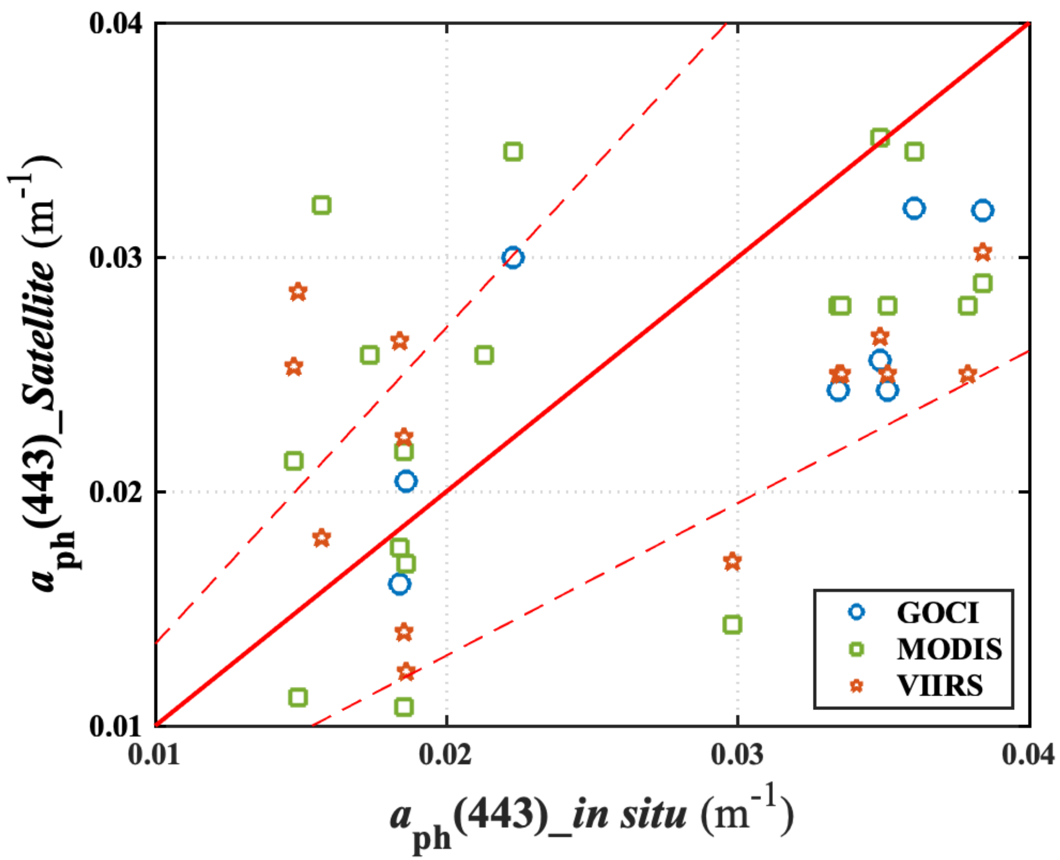


Fig. Comparison of the a_{ph}(443) (m^{-1}) from GOCI (R^2 = 0.84, RMSE = 0.0079), MODIS (R^2 = 0.27, RMSE = 0.0065) and VIIRS (R^2 = 0.68, RMSE = 0.0091) versus the *in-situ* a_{ph}(443) dataset. Solid red line is the 1:1 agreement line and the two dashed red lines indicate percent differences (35%).

Daily NPP

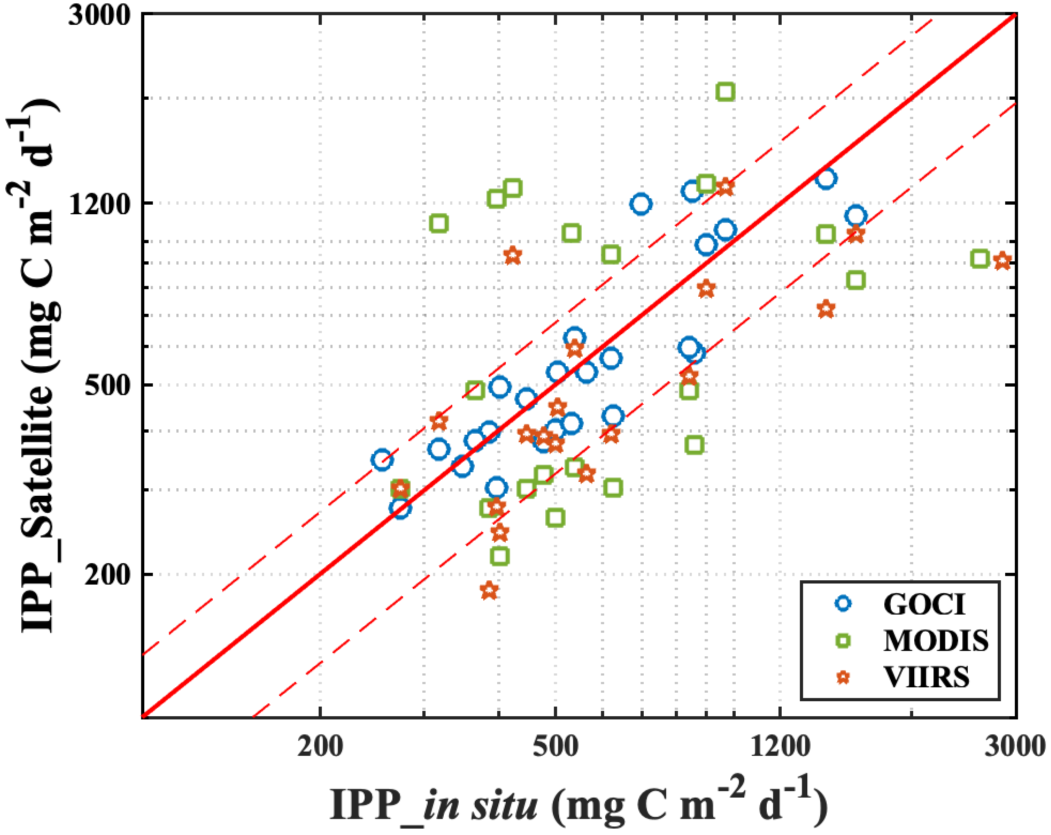


Fig. Comparison of IPP (mg C m^{-2} d^{-1}) from GOCI (R^2 = 0.69, RMSE = 182.47), MODIS (R^2 = 0.07, RMSE = 465.10) and VIIRS (R^2 = 0.36, RMSE = 239.87) versus *in-situ* ^{14}C IPP. Solid red line is the 1:1 agreement line and the two dashed red lines indicate percent differences (35%).

Global Sensitivity Analysis

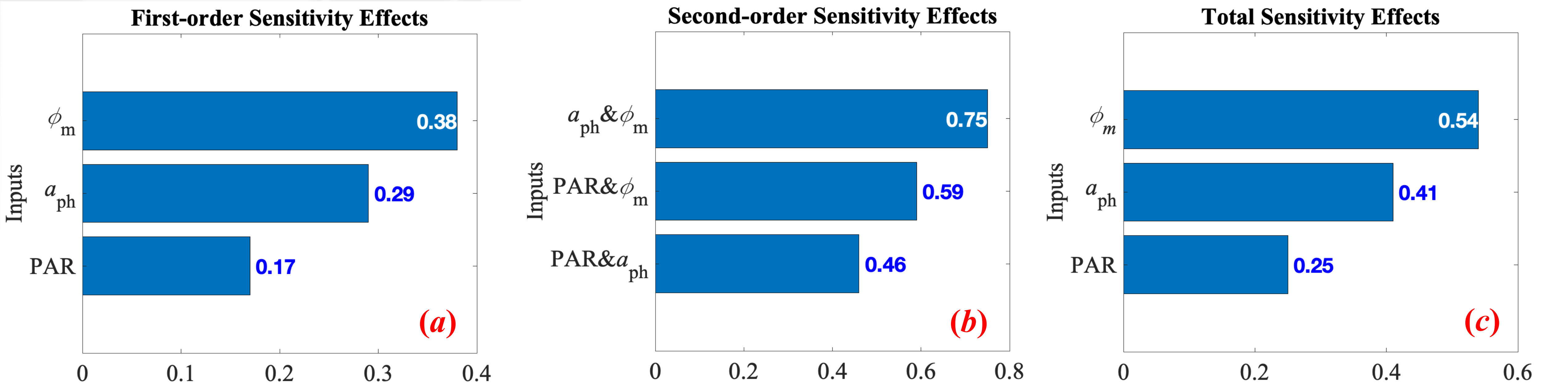


Fig. (*a*) First-order, (b) Second-order and (c) Total Sensitivity Effects from the Global Sensitivity Analysis (GSAT method) of a_{ph}(443), PAR and Phi as input parameters of NPP-AbPM-Phi model in calculating Daily IPP.

Sensitivity Analysis

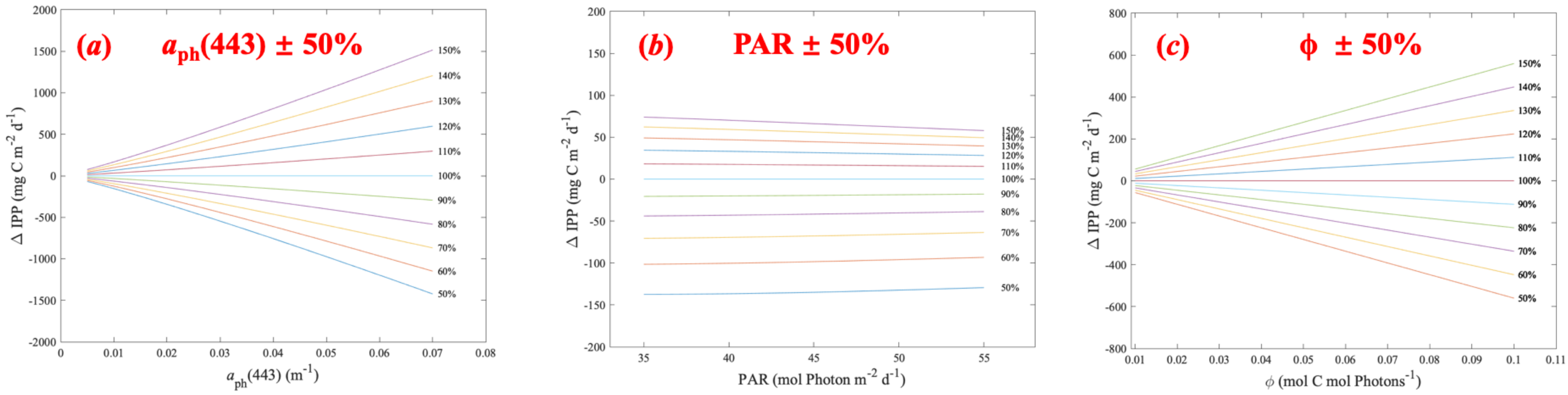


Fig. Sensitivity Analysis (± 50%) of input parameters (*a*) a_{ph}(443), (*b*) PAR and (*c*) Phi of the AbPM for calculation of daily IPP (mg C m^{-2} d^{-1}).

Thanks for your listening!

Wu J, Goes JI, do Rosario Gomes H, Lee Z, Noh JH, Wei J, Shang Z, Salisbury J, Mannino A, Kim W, Park YJ. Estimates of diurnal and daily net primary productivity using the Geostationary Ocean Color Imager (GOCI) data. *Remote Sensing of Environment*. 2022 Oct 1;280:113183.