Estimates of diurnal and daily Net Primary Productivity using the Geostationary Ocean Color Imager (GOCI) data

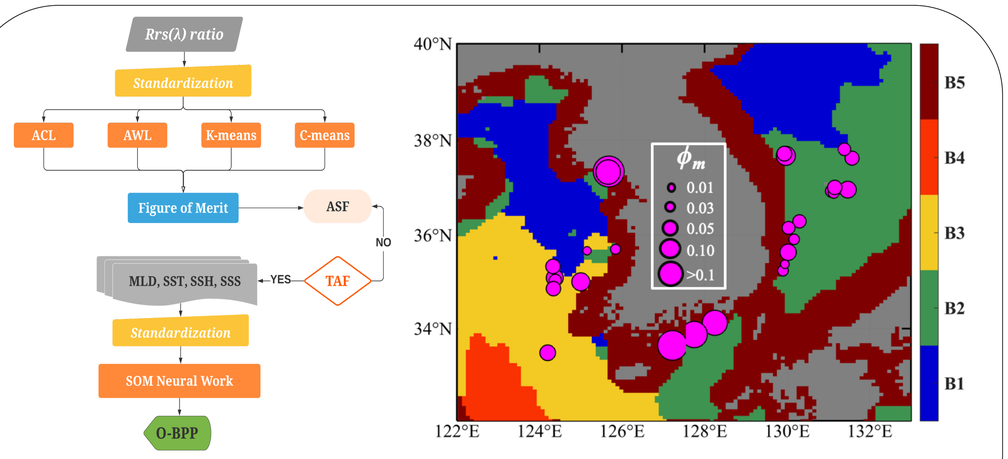
Jinghui Wu[1], Joaquim Goes[1], Helga do R Gomes[1], Zhongping Lee[2], Jianwei Wei[3], Antonio Mannino[4], Joe Salisbury[5]

[1]*Lamont Doherty Earth Observatory, Columbia University, Palisades, New York, US*
[2]*Department of Oceanography, Xiamen University, Xiamen, China*
[3]NOAA, NESDIS, College Park, Maryland, USA
[4]NASA, GFSC, Greenbelt, USA
[5]University of New Hampshire, USA

SUMMARY: For the past three decades, polar-orbiting ocean color satellites have provided local, regional to global scale estimates of oceanic net primary production that have greatly aided studies of ocean carbon cycling, food web dynamics and climate change. Despite considerable progress, accurate estimates of daily ocean productivity from space have not been realized because polar-orbiting satellites are unable to account for variations in phytoplankton physiology and carbon fixation rates from changing incident irradiance levels over the course of the day. Here we have attempted to exploit the unique short-temporal measurements provided by the Korean Geostationary Ocean Color Imager (GOCI), to obtain for the first time, diurnal and daily measurements of surface- and euphotic-column integrated Net Primary Productivity (NPP). These estimates are based on the Absorption Based Productivity Model (AbPM), and are calibrated with a bio-optical database of measurements made at different times of the day during the Korea-US Ocean Color (KORUS-OC) cruise in May-June, 2016. Photo-physiological rate estimates, varied across different water types encountered around the Korean Peninsula, but on account of their limited number, were regionally scaled through the use of dynamic optical-biogeochemical (O-BGC) Biomes. Comparisons of GOCI-derived estimates of daily and weekly integrated NPP against in-situ measurements, clearly underscore the superiority of geostationary-orbiting ocean color satellites, which consider the dramatic short-term fluctuations in phytoplankton light absorption and incident irradiance fields over the course of the day.

METHODS AND APPROACH

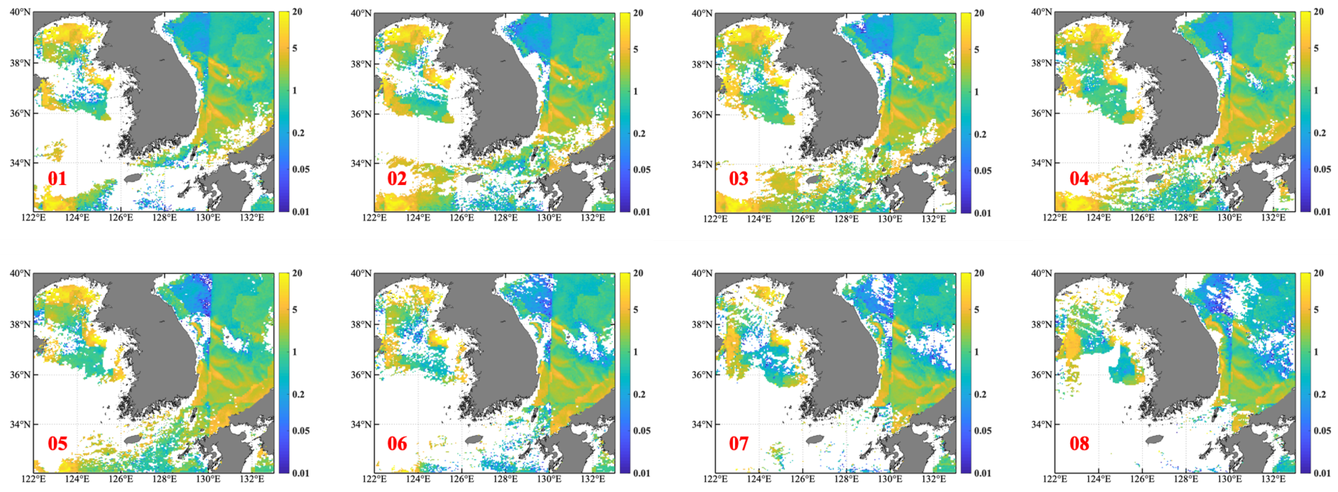
1. Assemble key in-situ optical, biological, and photo-physiological and NPP measurements;
2. Generate and assemble quality-assured hourly and daily R_{rs} , a_{ph} and PAR data from GOCI missions;
3. Refine, and validate innovative O-BGC provinces (BIOMES) at Korean Peninsula;
4. Fine tune remote sensing algorithms and characterize major PFTs and their photo-physiological status and photosynthetic parameters (ϕ_m and E_ϕ) within each BIOMES;
5. Estimated hourly and daily NPP by AbPM model and compare the results against *in-situ* measurements.
6. Comparison of daily NPP from MODIS-Aqua, VIIRS-SNPP and GOCI-NPP.
7. Characterize the uncertainties in NPP through use of variability in a_{ph}, ϕ_m and E_ϕ discernible in BIOMES.
8. Work with NASA OBPG to produce, disseminate and archive NPP products
9. These works can also be extended to NASA's upcoming hyperspectral missions PACE and GLIMR.



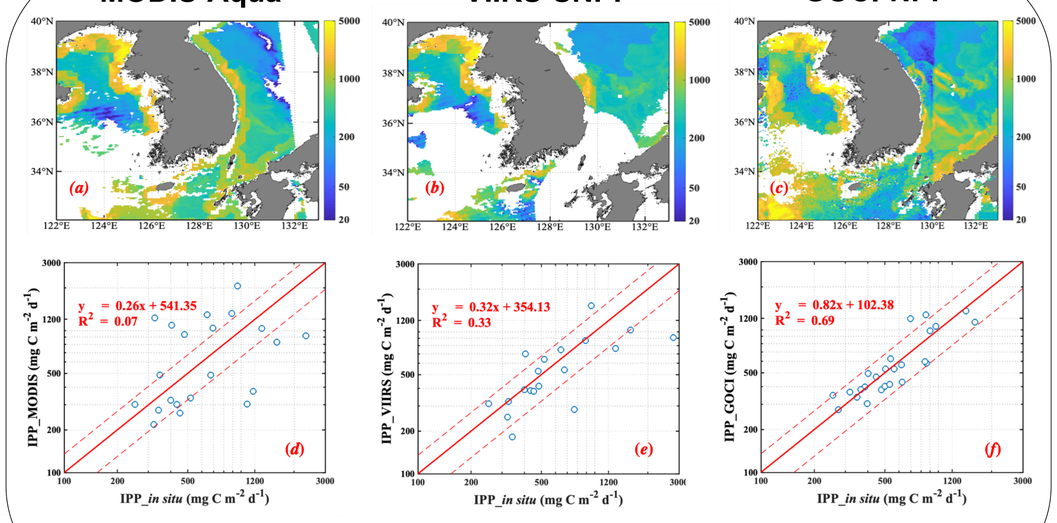
Flowchart for partitioning Korean Peninsula into dynamic O-BGC provinces and match with measured the quantum yield of photosynthesis (ϕ) data

Absorption based Production model (AbPM)

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

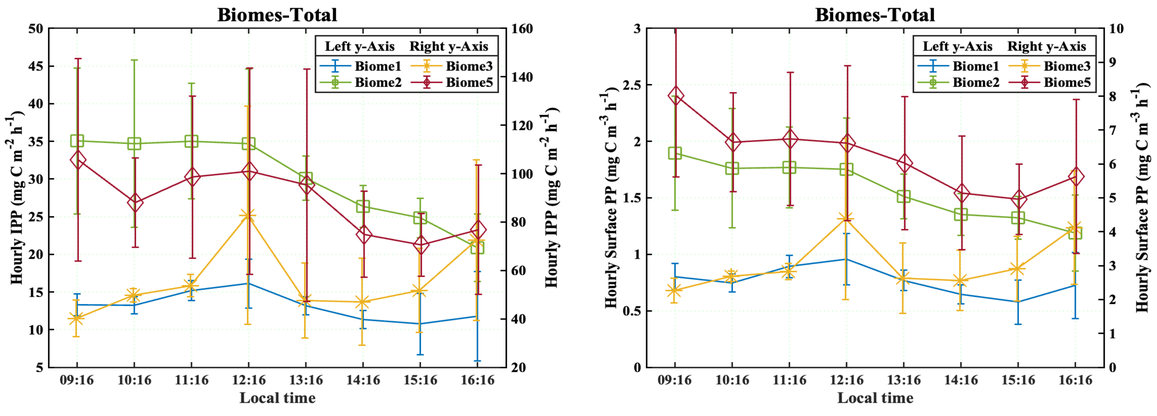


Hourly maps of Integrated NPP (mg C m^{-2} h^{-1}) from GOCI for the 2nd of June 2016.



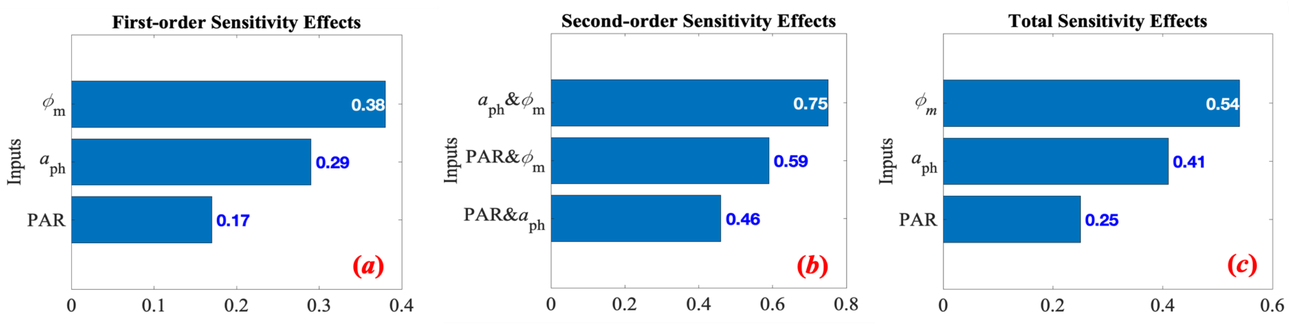
Comparison of Daily Integrated NPP (mg C m^{-2} d^{-1}) estimates from 3 satellites

Area averaged hourly rates of (*a*) Integrated NPP and (*b*) Surface PP at 4 biomes.



IPP (mg C m^{-2} h^{-1}) Surface PP (mg C m^{-3} h^{-1})

Global Sensitivity Analysis (GSAT method)



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

(Wu et al., 2022. RSE)