Sensitivity analysis of ocean net primary production algorithms

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Estimation of ocean net primary production of phytoplankton (NPP) is important to understand the global carbon cycle and marine ecosystem. We have developed NPP estimation algorithm using absorption coefficient of phytoplankton (a_{ph}) for SGLI/GLI. However, sensitivity of the absorption-based NPP algorithms to input parameters has not investigated. Here, we present the results of sensitivity of NPP algorithms for Bering-Chukchi Seas and for global ocean.

Absorption-based PP algorithm

$$PP_{eu} = (P^{B}_{opt} \times C_{surf}) \times \left(0.66125 \times \frac{PAR}{(PAR + 4.1)}\right) \times Z_{eu} \times DL$$

(VGPM, Behrenfeld an Falkowski, 1997)

$$PP_{eu} = P_{opt} \times \left(0.66125 \times \frac{PAR}{(PAR + 4.1)}\right) \times Z_{eu} \times DL$$

$$= f[a_{ph}(\lambda, 0-)] \times \left(0.66125 \times \frac{PAR}{(PAR + 4.1)}\right) \times Z_{eu} \times DL$$

For the Bering and Chukchi Seas

Type L : $P_{opt} = 10^{(A \cdot X + B)}$

Type D: Same formula as Type L but divided the dataset into three PAR range

X:
log-transformed absorption coefficient,
$\bar{a}_{ph}(0-)$, $a_{ph}(443, 0-)$,
or log-transformed absorbed radiation by phytoplankton,
$\overline{ARP}(0-)$, or $ARP(443, 0-)$

$\overline{ARP}(0-) = \bar{a}_{ph}(0-) \times PAR/D\,L$
$ARP(443, 0-) = a_{ph}(443, 0-) \times PAR/DL$

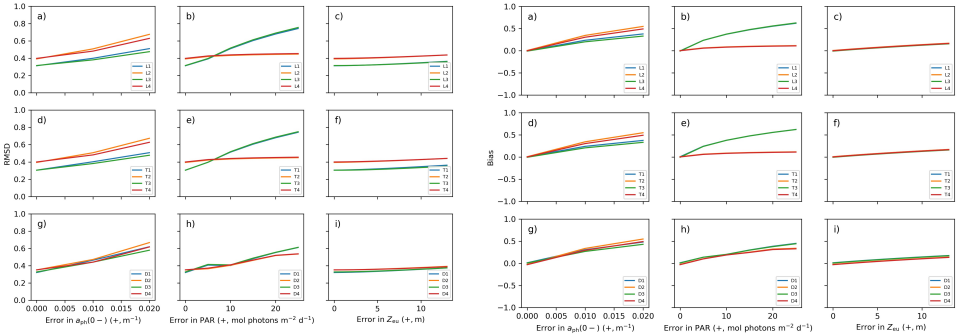


Fig. Variation of RMSD and Bias for PP_{eu} estimation in relation to errors in $a_{ph}(\lambda, 0-)$, PAR, and Z_{eu}.

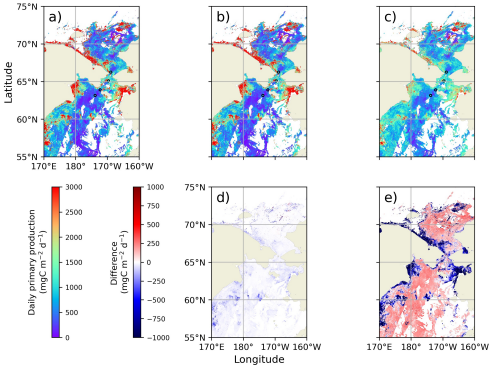
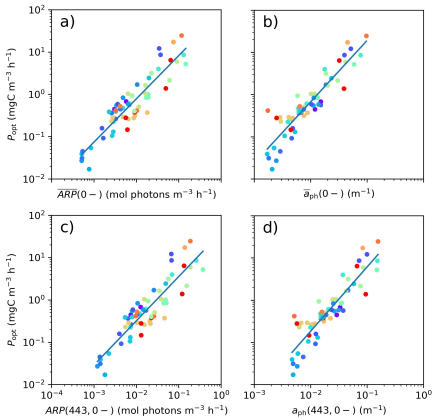


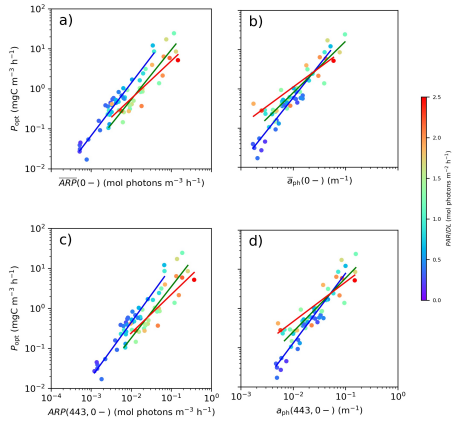
Fig. Distribution of daily primary production in euphotic layer (PP_{eu}) estimated from the SGLI data using (a) L2 model and daily bin PAR data, (b) L2 model and weekly running-mean PAR, and (c) D2 model. Data for the period July 1–16, 2018 were composited. Panels (d) and (e) show the differences, i.e., (b) – (a) and (c) – (a), respectively. Open circles indicate locations at which PP_{eu} was measured during the OS56 cruise in July 2018.

Sensitivity analysis revealed that error not only in the absorption coefficient but also in PAR influences PP_{eu} estimation, particularly when using ARP. The algorithm using absorption coefficients applied to Second-generation Global Imager data provided satisfactory estimation of PP_{eu} in the Pacific Arctic where sky condition can be variable.

Type L



Type D



The global algorithm

Version 3.8.2

$z = z_0 + B \exp[-\ln(X/c)^2/2D^2] + E \exp[-\ln(Y/F)^2/2G^2] + \exp[-\ln(X/c)^2/2D^2 - \ln(Y/F)^2/2G^2]$

$R^2 = 0.88$
Too much saturation in high a_{ph} range.
Interpretation of z function is difficult.

Version 3.8.3

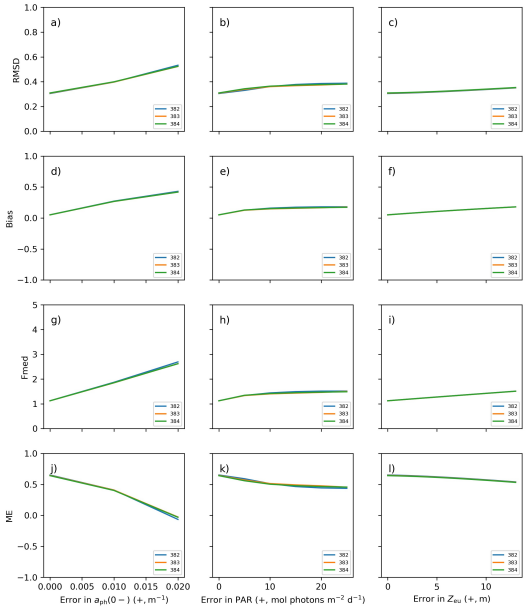
$z = z_0 + a_1 \cdot X + a_2 \cdot X^2 + a_3 \cdot X^3 + a_4 \cdot X^4 + b_1 (1 - \exp(-b_2 \cdot Y/b_1)) \cdot \exp(-b_3 \cdot Y/b_1) + c \cdot X \cdot Y$

$R^2 = 0.89$
P-E curve function was included (red part).
Some coefficients are insignificant.

Version 3.8.4

$z = a_2 \cdot X^2 + a_3 \cdot X^3\, b_1 (1 - \exp(-b_2 \cdot Y/b_1))$

$R^2 = 0.88$
Same function as ver. 3.8.3.
Only significant coefficients were used.



The global algorithms use absorption coefficient of phytoplankton (a_{ph}) as an input. Error in the absorption coefficient impacts on PP_{eu} estimation, but error in PAR does not influence the estimation. Accurate estimation of a_{ph} is important for the global NPP estimation algorithms.