Estimation of picophytoplankton carbon based on the absorption coefficient of phytoplankton in the South China sea

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Introduction: Picophytoplankton (<2 μm), including *Prochlorococcus* (*Pro*), *Syn- echococcus* (*Syn*), and autotrophic picoeukaryotes (*PE*), are major components of the phytoplankton biomass, and main contributors to primary production and carbon flux in oligotrophic tropical and subtropical marine ecosystems. The South China Sea is always oligotrophic because of low macronutrient concentrations and possibly iron limitation, except for those regions affected by coastal upwelling and riverine discharge.

Sampling : Measurements of the absorption coefficient of phytoplankton aph, Abundances of picophytoplankton and Chla) were collected from 2013 to 2017 in South China Sea (Stations in Fig.1).
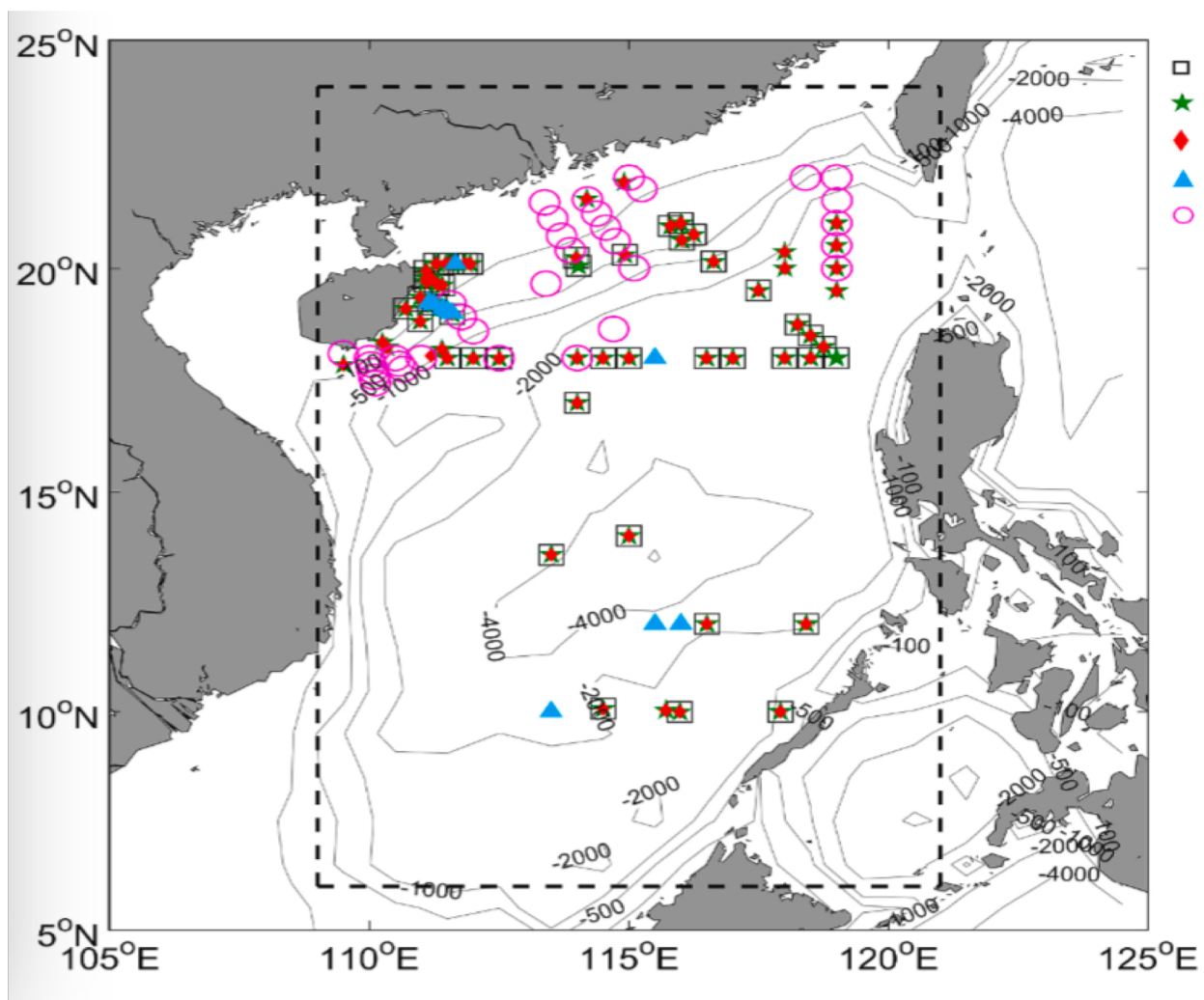
Algorithm Development: The cell abundances of the three picophytoplankton categories increased with Chl when the contribution of picoplankton to phytoplanotn Fp was ≥0.55,and still increased but slowly when Fp < 0.55 (Fig.2).
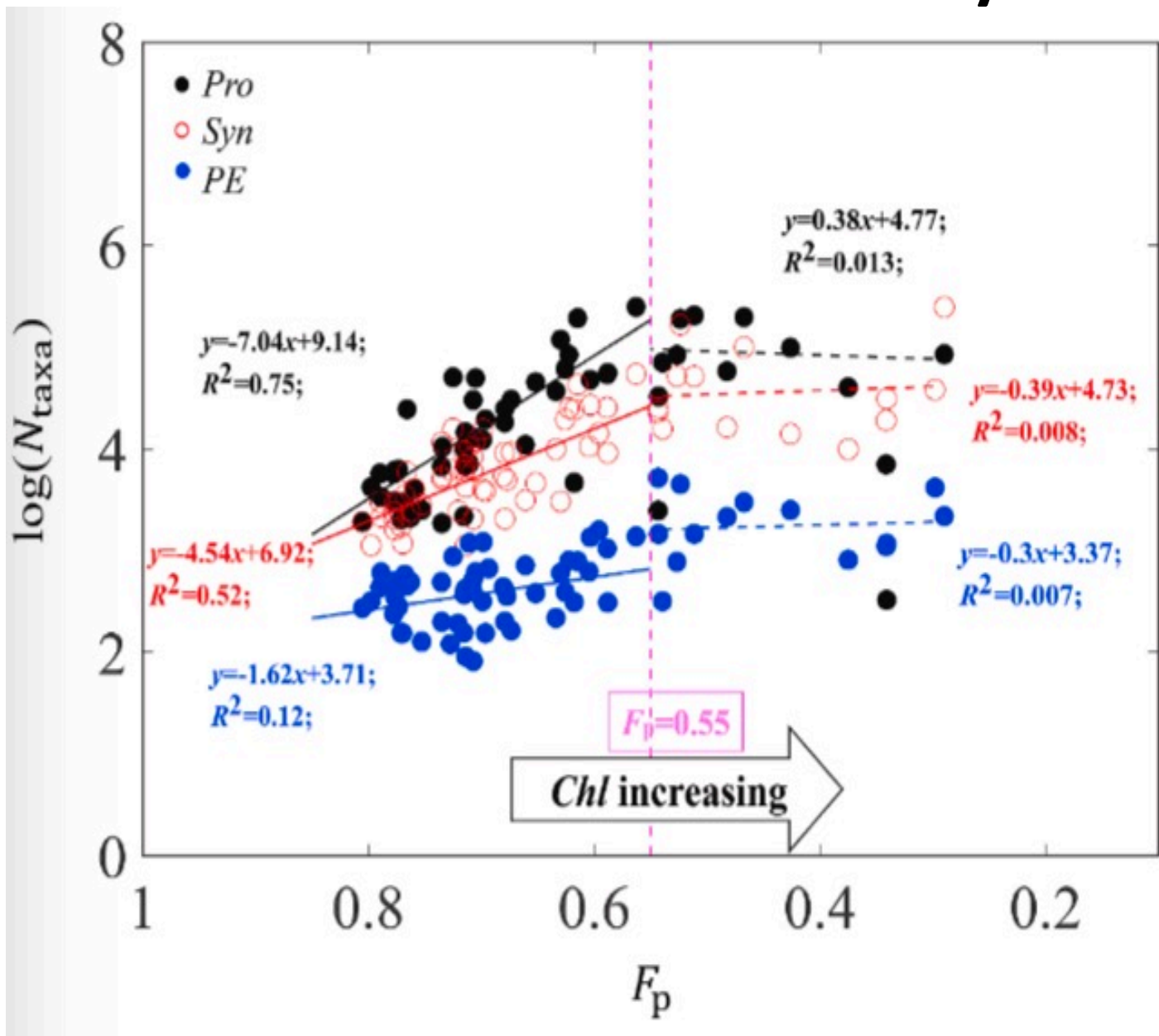

Fig.1

Fig.2

A Gauss-Newton function was used to estimate *N*Pro based on *a*ph(443).Given that the slopes of *N*Syn and *N*PE decreased when *F*p was <0.55, the power-law function was chosen to fit the relationships with the exponent being limited from zero to one (Fig.3).
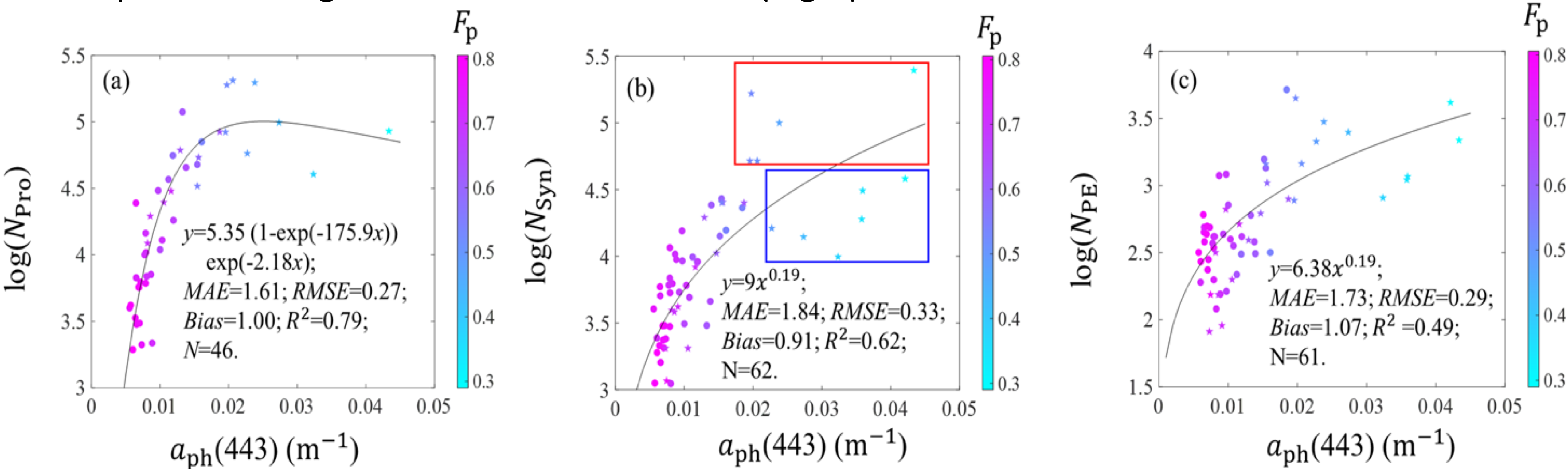

Fig.3

Cellular carbon content of picophytoplankton was estimated from cell abundances by assuming carbon conversion factors of 17.6 fg/cell for Pro, 74.55 fg/cell for Syn, and 779.9 fg/cell for PE. MODIS-Aqua Level-2 products aph(443) were used to estimate the picophytoplankton carbon (Fig.4)
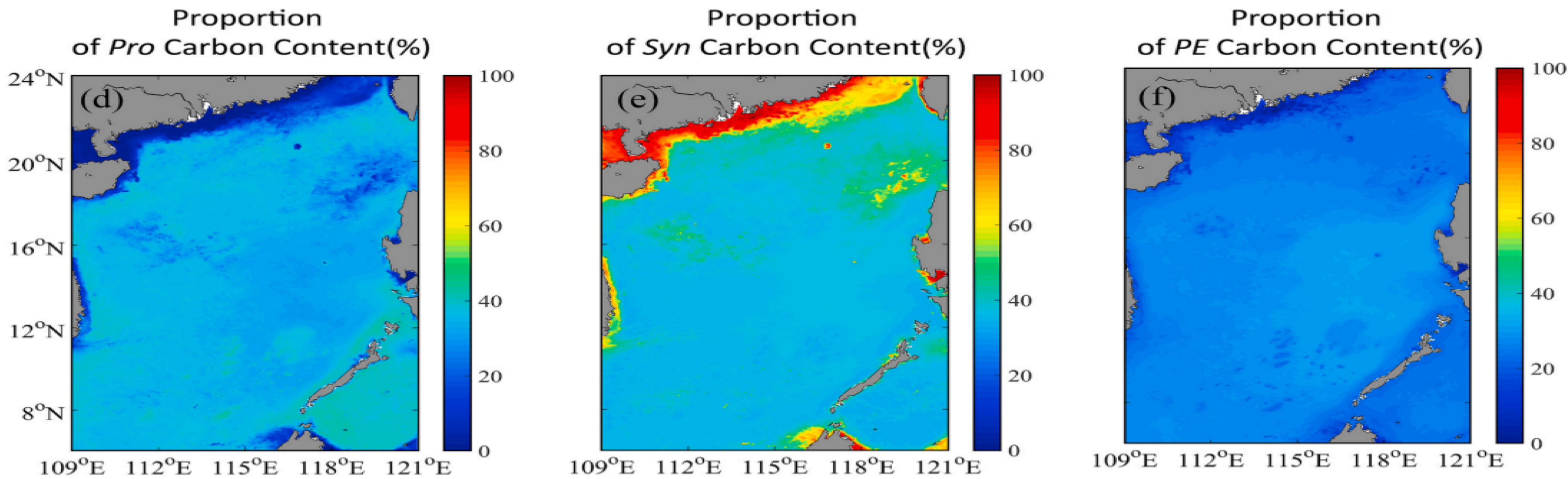

Fig.4

Estimation of vertical size-fractionated phytoplankton primary production in the Northern South China Sea

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Introduction: Modelling vertical changes of size-fractionated primary production (PP) offers a holistic route to describe marine ecosystems and constitutes an important part of remote sensing to accurately estimate the depth-integrated PP in the global oceans. In situ measured hyperspectral absorption and irradiance data were used to estimate vertical size-fractionated PP.

Sampling :

size-fractionated phytoplankton absorption coefficient aph, phytoplankton pigment, and size-fractionated Primary Production (PP) were collected in 2019 in South China Sea (Stations in Fig.1).
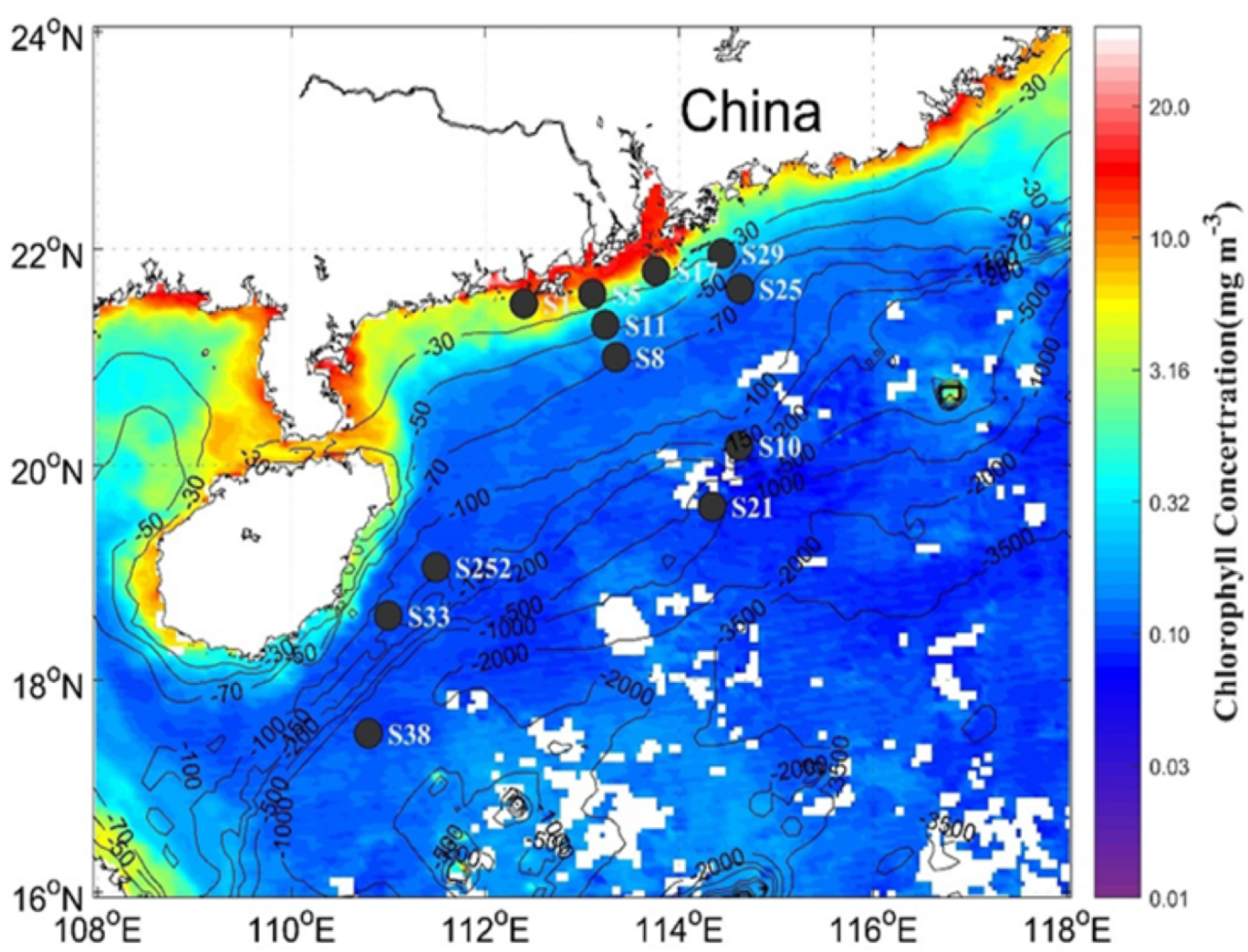

Fig.1

Model Development:

the absorption-based PP model is expressed as

$$PP(z,t) = \sum_{i=p,n,m} \Phi_{E,i}(z) * \overline{a_{ph,i}}(z) * I(z,t)$$

ΦE is the photosynthetic quantum yield of carbon fixation and the subscript E means that quantum yield is a function of light intensity. The second item is spectral-average aph over 400-700 nm are used. The third item denotes available photon energy for photosynthesis as a function of PAR . All three items were parameterized by aph ,phytoplankton size class, and PAR in our model (Deng et al. 2022)

Validation: Comparisons between size-fractionated and total PP and in-situ measurements were shown in IFig.2 and the statistical results were in Table 1.
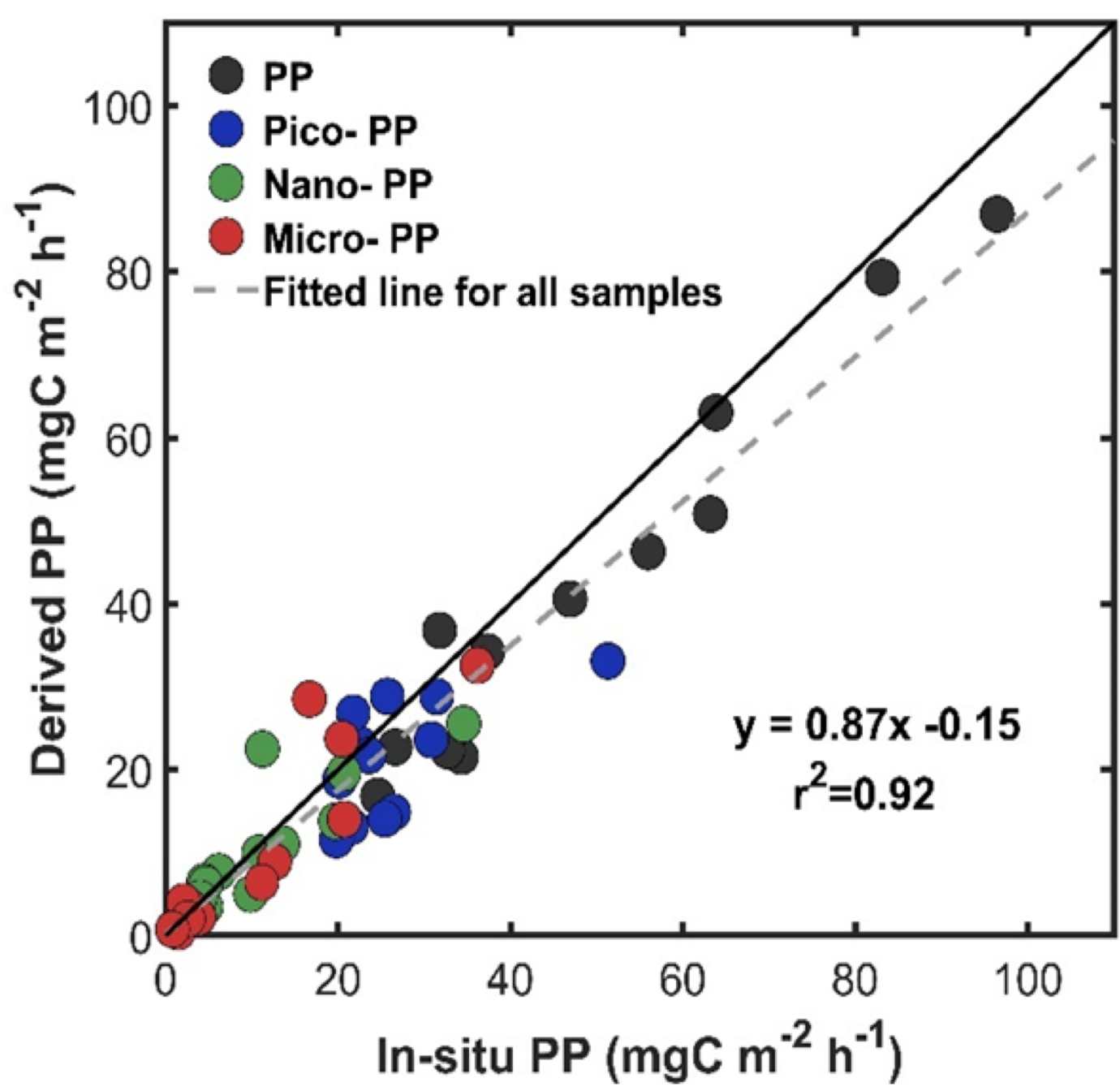

Fig.2

Table 1. Statistics for model derived PP against in-situ PP

	r^2	MAPD%	RMSD	slope	Intercept	N
All PP	0.92	23.33	6.68	0.87	0.15	48
Total PP	0.95	15.23	8.02	0.97	4.75	48
Pico PP	0.41	23.33	8.33	0.53	7.46	48
Nano PP	0.69	25.86	4.88	0.68	3.12	48
Micro PP	0.83	31.05	4.59	0.95	0.14	48

Sensitivity Analysis:

The estimation of PP was found to be the most sensitive to the relationship derived Maximum quantum yield of photosynthesis Φ_{max} from the ratio $a_{ph}(435)/a_{ph}(676)$ (FIg3)

Fig.3

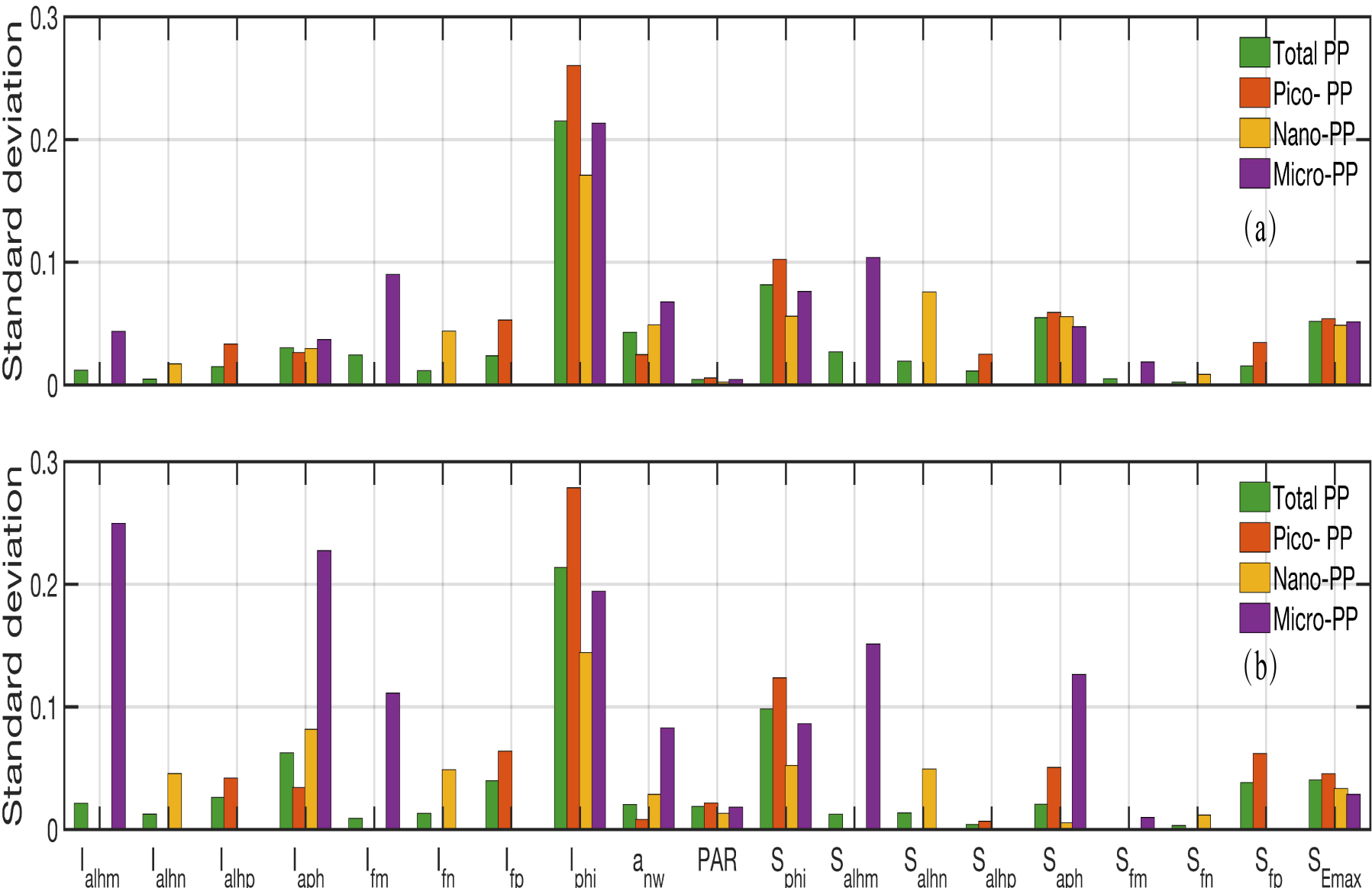**Application:** Vertical profile of model derived size-fractionated PP in the open ocean Sea.
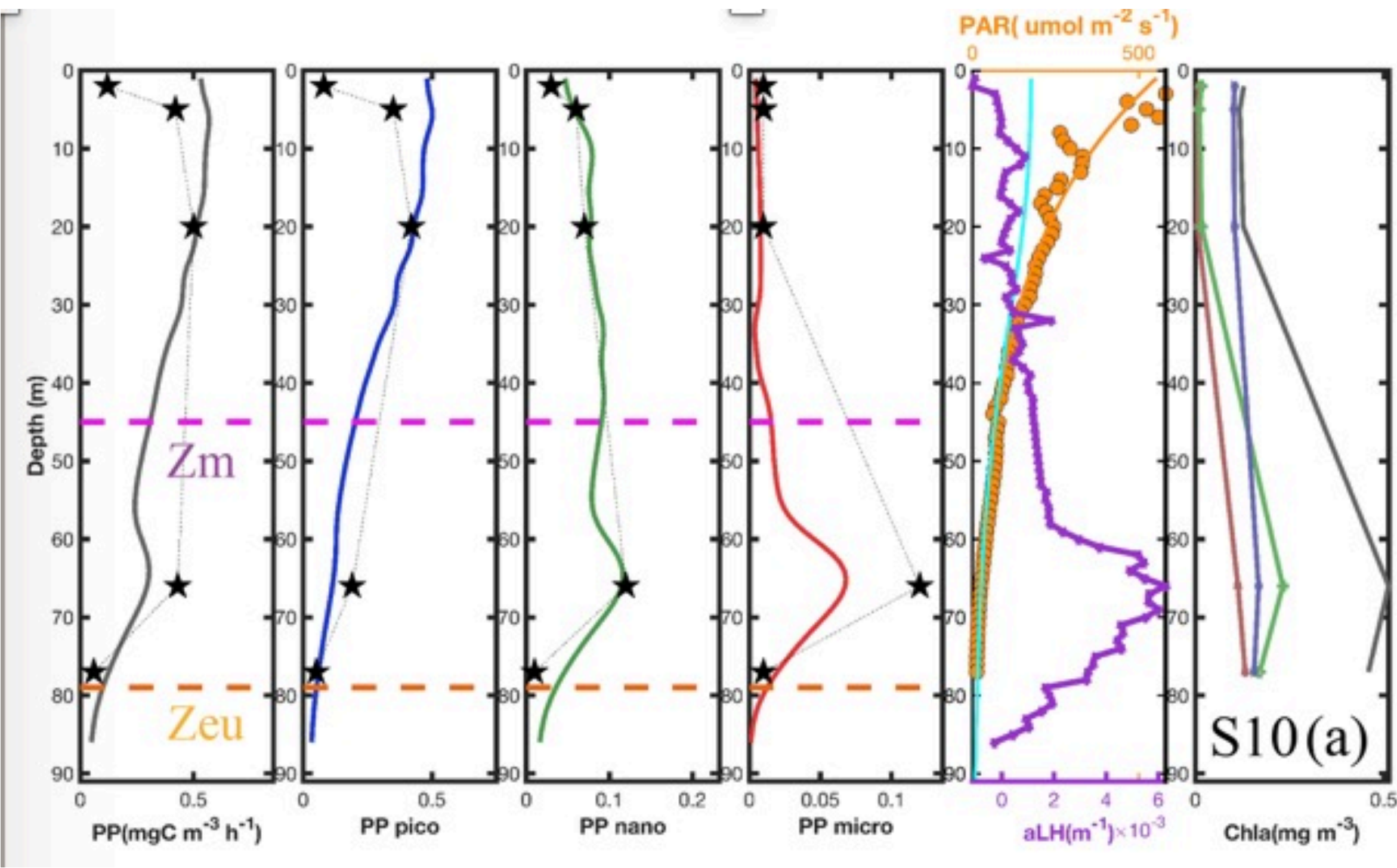

Fig.4