

Constraining the twilight zone remineralization rate in South China Sea basin: insights from a multi-method intercomparison

Chao Xu¹, Mingwang Xiang¹, Bingzhang Chen², Yibin Huang³, *, Bangqin Huang^{1,*} Email: xuchao3091@live.com

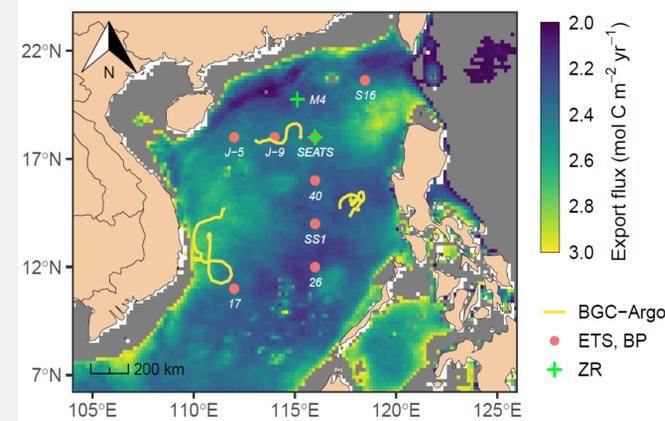
1.State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, China; 2.Department of Mathematics and Statistics, University of Strathclyde, Glasgow, UK; 3. NOAA/OAR Pacific Marine Environmental Laboratory, Seattle, WA, USA



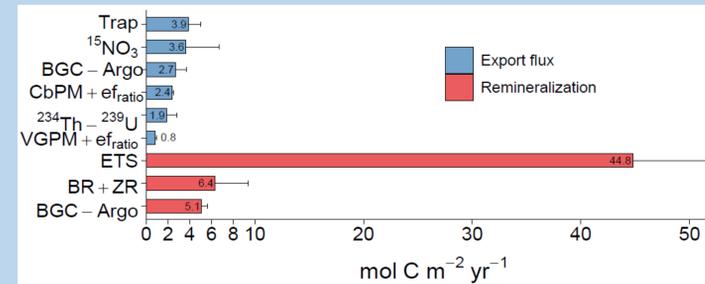
Introduction

The remineralization rate in the twilight zone is critical to determines the efficiency of carbon sequestration by biological carbon pump. However, we have not been able to measure the remineralization rate accurately in the twilight zone, and fail to satisfy the constraint that the upper carbon supply should meet the carbon demand at depth. We aim to answer:

1. What is the remineralization rate in the twilight zone of the South China Sea basin and which method is more reasonable?
2. Whether the carbon supply can be balanced with the biotic respiration in the twilight zone?



Results2 - Intercomparison between carbon export from the upper ocean and depth-integrated remineralization at depth



- The export carbon flux from the upper ocean was estimated in the range of 0.8 – 3.9 mol C m⁻² yr⁻¹.
- The ETS approach may overestimate the twilight zone remineralization.

Figure 2 The inter-comparison between upper carbon supply and depth-integrated respiration among multiple methods.

Methods

BGC-Argo floats + mass balance model

Electron transport system (ETS)

Bacterial respiration + zooplankton respiration (BR+ZR)

$$BR = (1 - BGE) * (Rate_{Leu} * LeuCF) / BGE$$

$$ZR = \exp(1.741 + 0.851 * \ln(NW) + 0.064 * T) * RQ * 12/22.4$$

Results1 – Respiration profiles based on multiple methods

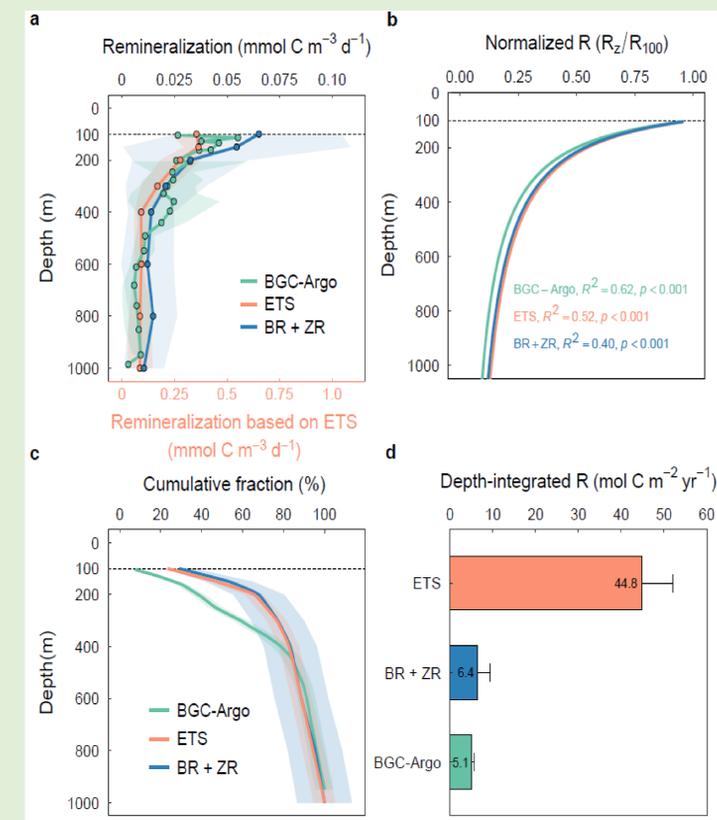
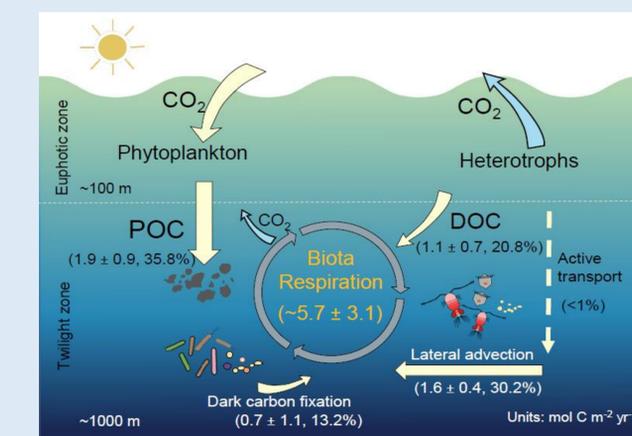


Figure 1 (a) Depth profiles of remineralization rates based on three methods. The shading area represents the propagated error. (b) The fits of power function of normalized remineralization among three methods. (c) Depth cumulative fraction (mean ± SE) of remineralization rate along with depth. (d) Depth-integrated remineralization (mean ± SD) of three methods.

- The remineralization determined by multiple methods all showed the similar decreasing trend over the depth.
- Remineralization determined by ETS approach was nearly an order of magnitude higher than these of BGC-Argo floats and BR+ZR.
- Over 80% of the remineralization occurs in the range of 100 ~ 400 m.

Results3 - The South China Sea carbon budget



The total carbon supply to the twilight zone at the SCS basin was estimated to be 5.3 ± 1.4 mol C m⁻² yr⁻¹, which can be comparable with the depth-integrated remineralization of 5.7 ± 3.1 mol C m⁻² yr⁻¹ within the uncertainties.

Figure 3 Schematic of transport mechanisms and organic carbon fluxes of the twilight zone in the South China Sea.

Conclusions

We estimated the remineralization rates based on three methods in the SCS basin and reported the potential overestimation of the ETS method. Moreover, by integrating the different carbon sources in the twilight zone, we find other carbon sources besides the POC flux contributed ~64% of the total carbon sources in the twilight zone at the SCS, indicating that they are key to reconciling the carbon budget in the twilight zone.