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Climate change drove the decline in Yangtze Estuary net primary production over the past two decades

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Abstract: Net primary productivity (NPP) is highly sensitive to multiple stressors under progressive and intensifying climate change and anthropogenic impacts. Understanding spatiotemporal distribution patterns and the associated driving factors that govern estuary NPP is paramount for regional carbon (C) budget assessments. Using a combined remote sensing and machine learning (ML) approach, the average NPP of the Yangtze Estuarine-Offshore Continuum (YEOC) was measured at 273.19±21.26 mgC m^{-2} d^{-1} over the past two decades. Temporally, NPP exhibited a significant downward trend between 2002–2022. Hydroclimatic factors (climate fluctuations, sea level rise, and discharge) drove phytoplankton biomass (Chl-*a*) while light conditions (PAR and Kd_{490}) affected photosynthesis rates. Together, they can explain 65% of NPP variation. Anthropogenic disturbances (i.e., damming and nutrient emissions) were not significant. Additionally, changes in NPP decreased phytoplankton C sequestration rates from 11.9 Tg C yr^{-1} to 10.4 Tg C yr^{-1}, reducing the estuary's C sink capacity, which relies on biological C fixation. This study highlights the climate's influence on spatiotemporal transformation of YEOC NPP while enhancing our understanding of the response of EOC C budgets to climate change and anthropogenic activities.

1. INTRODUCTION

The estuary-offshore continuum (EOC), located at the interface of land, ocean, and atmosphere, plays a critical role in regional C cycling. As the foundation of ecosystem C sequestration, spatiotemporal variations in NPP are essential for assessing coastal C budgets. Although previous studies have indicated that climatic factors and anthropogenic activities may influence NPP, the dominant drivers and underlying mechanisms in the intensively disturbed YEOC remain unclear. This study aims to: (1) evaluate the NPP spatiotemporal patterns in the YEOC over the past two decades; (2) clarify the relative contributions of climatic events and anthropogenic activities; (3) explore the impacts of NPP changes on regional C budgets.

2. METHODOLOGY AND RESULTS

Combining remote sensing and ML, an NPP estimation model was developed using 55 in-situ NPP observation from 2002 to 2021 and algorithms such as support vector regression (SVR) and random forest (RF). The RF model performed best (R^2=0.81, RMSE=92.55 mgC m^{-2} day^{-1}), significantly outperforming traditional bio-optical models. The main research results are as follows:

(1) Over the past two decades, the mean NPP was 273.19±21.26 mgC m^{-2} day^{-1}, exhibiting a significant decreasing trend (-2.51 mgC m^{-2} day^{-1} $year^{-1}$). Spatially, NPP decline was concentrated in the upwelling zone (29°-32°N, 122°-123.5°E) with an annual change rate of -1.04±1.12 mgC m^{-2} day^{-1}.
(2) Climate change influenced NPP through multiple pathways, explaining 65% of the variation. Specifically, PDO and ENSO regulated the East Asian monsoon, altering Yangtze River discharge and estuarine salinity. Sea-level rise enhanced seawater intrusion, increasing estuarine salinity and reducing photosynthetic efficiency. Weakened upwelling intensity decreased nutrient supply, particularly diminishing spring NPP peaks. Declines in PAR and increased wind speed exacerbated turbidity, shortening the euphotic layer depth and intensifying light limitation. Although Three Gorges Dam construction reduced sediment load, nutrient fluxes showed no significant trend, and anthropogenic activities made negligible contributions to NPP.
(3) The NPP decline caused phytoplankton C sequestration rates to decrease from 11.9 to 10.4 Tg C $year^{-1}$, weakening the YEOC's C sink capacity. Changes in the continental shelf's partial pressure of C dioxide (pCO_2) may lag behind a continuous atmospheric pCO_2 increase, indicative of an increasing trend in CO_2 absorption. From 2003 to 2019, atmospheric pCO_2 in the East China Sea increased at 2.22 µatm yr^{-1}, while YEOC seawater pCO_2 rose at 3-4 µatm $year^{-1}$, indicating decaying C sink function. Long-term NPP decline may shift the YEOC from a "C sink" to a "C source".

REFERENCES

Wang, M, Sun, K, Jia, J, Wu, F and Gao, Y. (2024) Climate Change Drove the Decline in Yangtze Estuary Net Primary Production Over the Past Two Decades. Environmental Science & Technology. 58 (43), 19305–19314.

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