Improving modeled light attenuation (Kd) in a land-estuarine ocean biogeochemical model for Chesapeake Bay

Jessica Turner  
*Virginia Institute of Marine Science*

Carl Friedrichs  
*Virginia Institute of Marine Science*

Marjy Friedrichs  
*Virginia Institute of Marine Science*

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It’s in the wash(load): Impacts on light attenuation (Kd) and primary production in a hydrodynamic biogeochemical model for Chesapeake Bay

Jessica S. Turner, Marjorie A. M. Friedrichs, Carl T. Friedrichs, & Fei Da
Virginia Institute of Marine Science, Gloucester Point, VA
j.turner@vims.edu, marjy@vims.edu, carl.friedrichs@vims.edu, fda@vims.edu

Introduction

What is Kd?
The diffuse light attenuation coefficient of photosynthetically active radiation (PAR).

- Direct metric of light available for phytoplankton & SAV
- Major control on:
  - Water quality
  - Primary production
  - Biogeochemical cycling

What is washload?
A given concentration of particles that will not be deposited and are instead "washed through" the system (Einstein 1950; Woo et al. 1986).

Objective

Investigate effects of increased Bay-wide washload on spatial distribution of light attenuation and primary production.

Modeling Framework

Ches-ROMS-ECB is an estuarine-carbon-biogeochemical (ECB) model embedded in the Regional Ocean Modeling System (ROMS) framework (Feng et al. 2015), and in this implementation is forced with riverine inorganic and organic inputs from the Chesapeake Bay Program Watershed Model (Shenk and Linker, 2013). Modeled TSS and Kd are computed as in Feng et al. (2015) except for addition of WL:

\[ \text{TSS} = \text{ISS} + \text{WL} + \text{OSS} = \text{ISS} + \text{WL} + 2.9 \text{[Plankton + Detritus]} \]  

(1)

\[ K_d = 1.4 + 0.063 \times [\text{TSS}] - 0.057 \times [\text{S}] \]  

(2)

Simulations

1. No added washload, ISS from river inputs only
2. Added Bay-wide washload of 4 mg l\(^{-1}\) to TSS
3. Added Bay-wide washload of 8 mg l\(^{-1}\) to TSS

Results

Increasing washload in the Bay causes primary production (PP) to change throughout the bay:
- PP decreases year round in oligohaline (A) and upper-mesohaline (B) due to increased light limitation
- PP decreases in fall/winter/spring in lower-mesohaline (C) and polyhaline (D) due to increased light limitation
- PP increases in summer in lower-mesohaline (C) and polyhaline (D) due to increased nutrients resulting from reduced uptake in northern Bay (Figures 5.6)
- PP increases more in the lower mesohaline (C) during dry years (i.e. 2002) and increases more in the polyhaline (D) during wet years (i.e. 2003, Figure S).

Conclusions

- Small changes in TSS and Kd (all within the range of observations) cause large changes in the spatial distribution of primary production in summer.
- Increasing Bay-wide washload impacts the maximum primary production in summer.
- The distance southward that the bloom migrates depends in part on the freshwater flow characteristics during each year.

References


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