11-7-2017

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

Recommended Citation

Turner, Jessica; Friedrichs, Carl; and Friedrichs, Marjy. "Improving modeled light attenuation (Kd) in a land-estuarine ocean biogeochemical model for Chesapeake Bay". 11-7-2017. 24th Biennial Conference of the Coastal and Estuarine Research Federation, Providence, RI. https://doi.org/10.21220/V5HT7Z.

It's in the wash(load): Impacts on light attenuation (K_d) 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

jsturner@vims.edu, marjy@vims.edu, carl.friedrichs@vims.edu, fda@vims.edu

Introduction

What is K_d?
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 K_d are computed as in Feng et al. (2015) except for addition of WL:

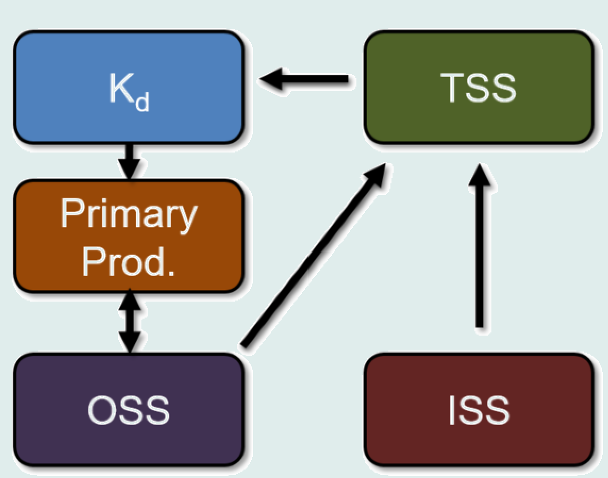

Figure 1. Interactions between ISS, K_d, TSS, Primary production, and OSS within the Ches-ROMS-ECB framework.

$$TSS = ISS + WL + OSS = ISS + WL + 2.9\ [Plankton + Detritus] \quad (1)$$

$$K_d = 1.4 + 0.063\ [TSS] - 0.057\ [S] \quad (2)$$

	Variable	Units	Settling Rate
TSS	Total suspended solids	mg l^{-1}	*
ISS	Inorganic suspended solids	mg l^{-1}	2 m d^{-1}
OSS	Organic suspended solids	mg l^{-1}	0.1 m d^{-1}
WL	Washload	mg l^{-1}	Non-settling
Plankton	Phytoplankton + zooplankton biomass	mg C l^{-1}	*
Detritus	Small + large detritus mass	mg C l^{-1}	*
2.9	Conversion from carbon to total mass	-	-
S	Salinity	psu	-

* Varies depending on composition

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 5).

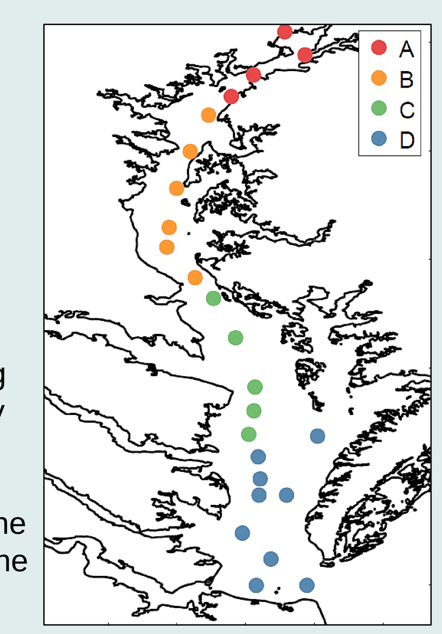

Figure 2. Mainstem Chesapeake Bay Program monitoring stations grouped by salinity regime:
A) Oligohaline
B) Upper-mesohaline
C) Lower-mesohaline
D) Polyhaline

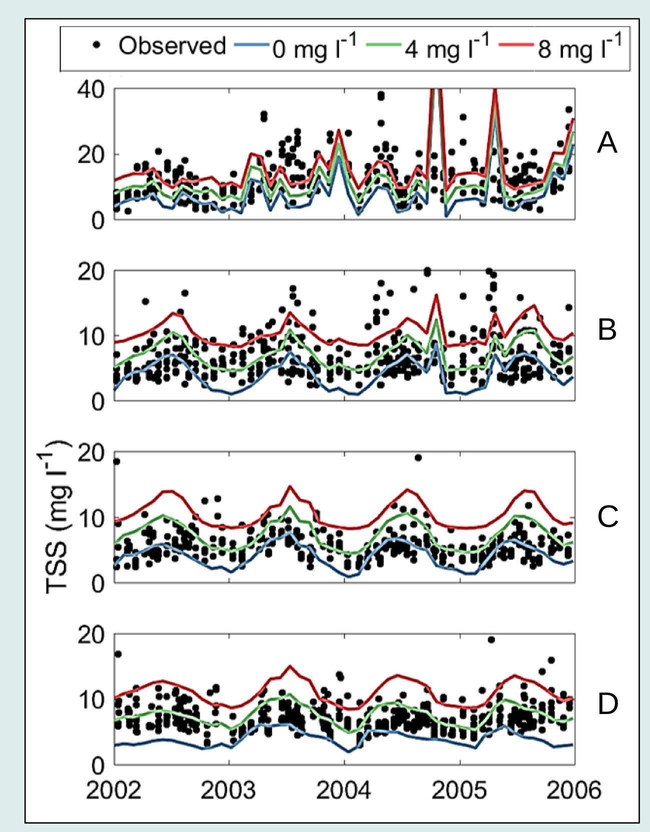

Figure 3. TSS (mg l^{-1}) with washload of 0, 4, and 8 mg l^{-1} compared with observed TSS from 2002-2005 by salinity regime.

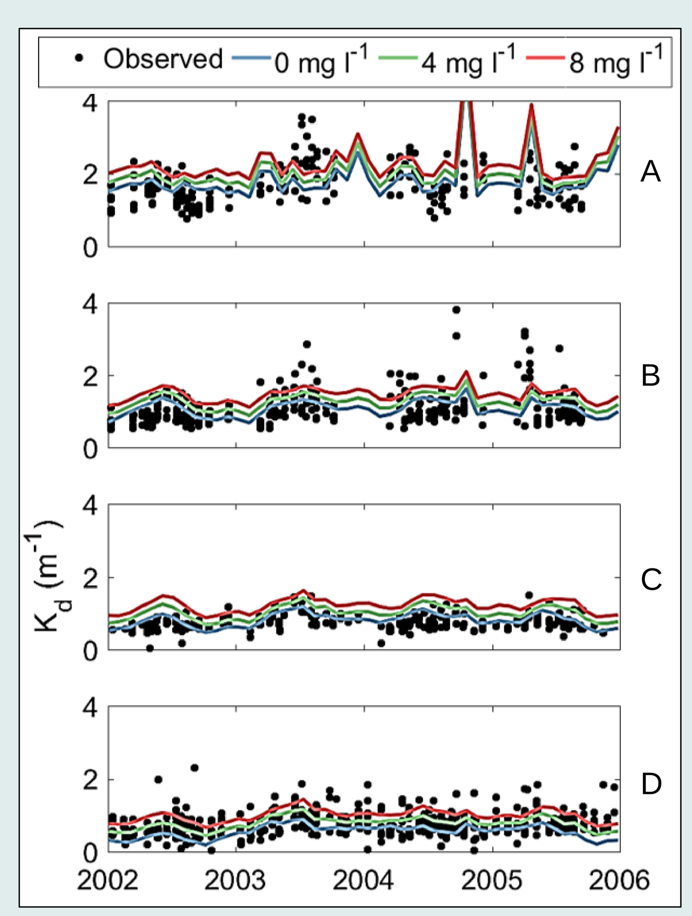

Figure 4. K_d (m^{-1}) with washload of 0, 4, and 8 mg l^{-1} compared with observed K_d from 2002-2005 by salinity regime.

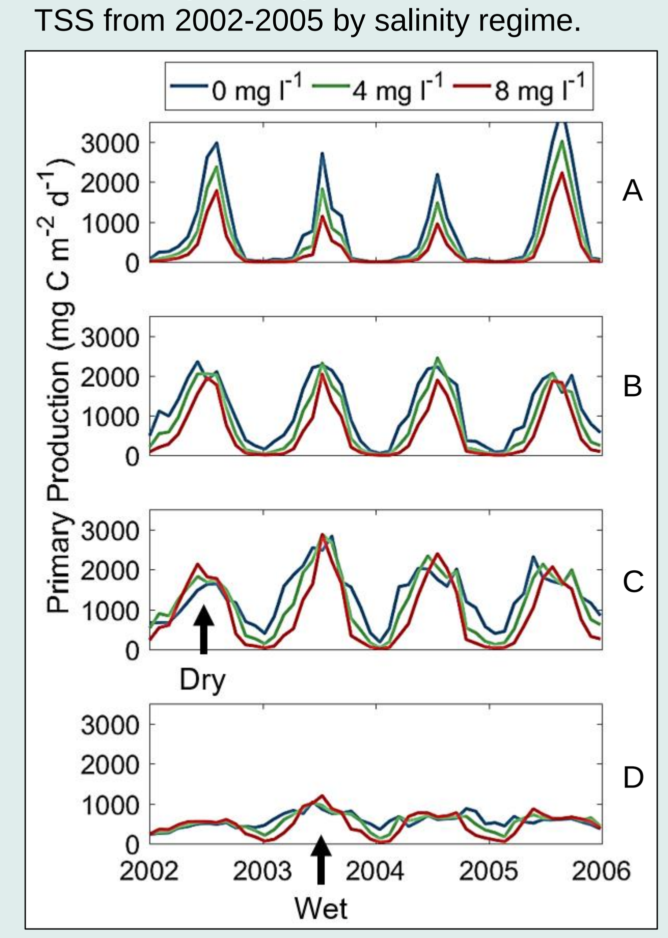

Figure 5. Depth integrated primary production (mg C m^{-2} d^{-1}), from 2002-2005 by salinity regime. Summer 2002 (dry conditions) saw a greater increase in PP in the lower-mesohaline, while summer 2003 (wet conditions) saw a greater increase in PP in the polyhaline.

Conclusions

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

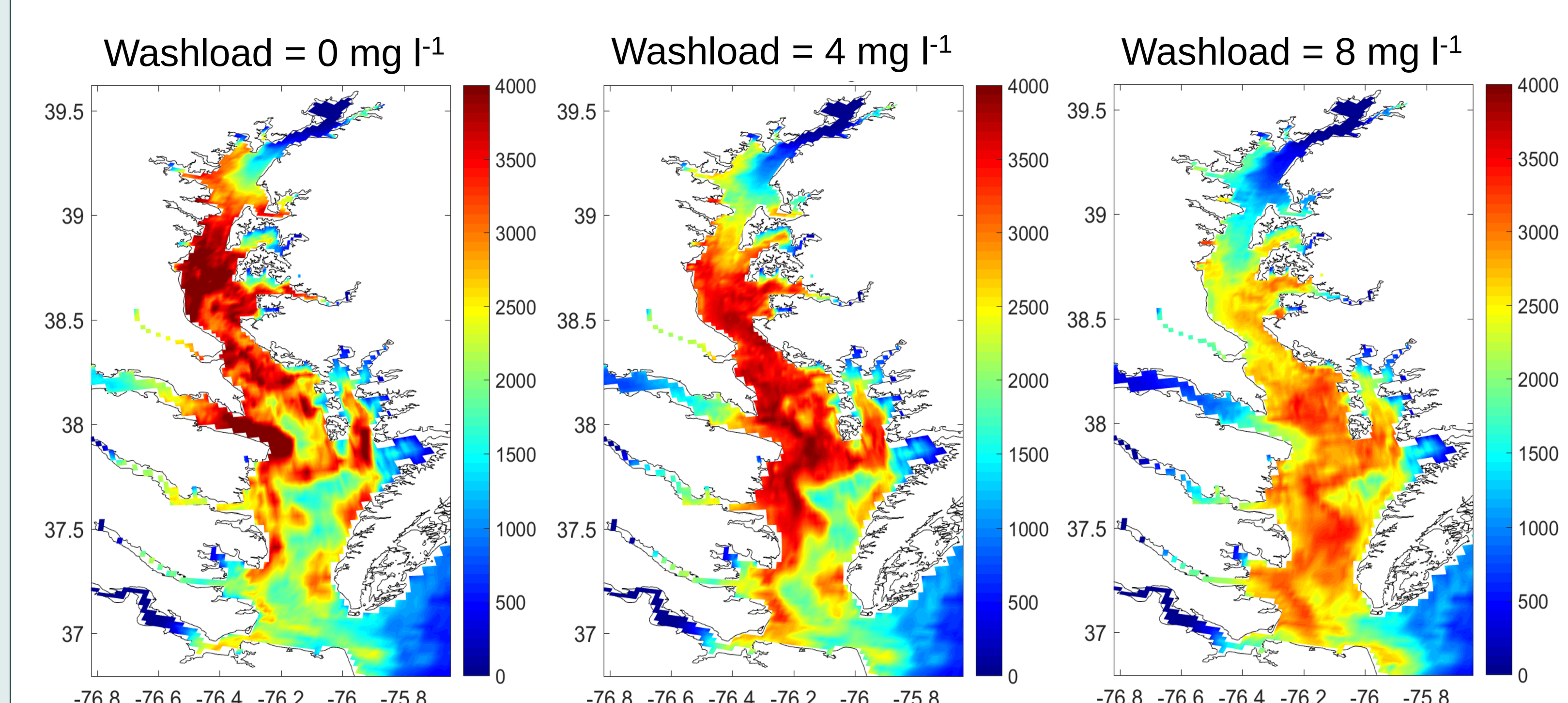

Figure 6. Depth-integrated primary production (mg C m^{-2} d^{-1}), on July 5, 2003, with added washload of 0, 4, and 8 mg l^{-1}. Increasing washload causes the location of maximum primary production to shift south, and causes the magnitude of primary production to decrease due to light limitation.

References

Einstein HA (1950) The Bed-Load Function for Sediment Transportation in Open Channel Flows. Soil Conserv Serv:1–31

Feng Y, Friedrichs MAM, Wilkin J, Tian H, Yang Q, Hofmann EE, Wiggert JD, Hood RR (2015) Chesapeake Bay nitrogen fluxes derived from a land-estuarine ocean biogeochemical modeling system: Model description, evaluation, and nitrogen budgets. J Geophys Res:1666–1695

Moriarty JM (2017) The Role of Seabed Resuspension on Oxygen and Nutrient Dynamics in Coastal Systems: A Numerical Modeling Study. Virginia Institute of Marine Science, College of William and Mary

Shenk GW, Linker LC (2013) Development and application of the 2010 Chesapeake Bay Watershed total maximum daily load model. J Am Water Resour Assoc 49:1042–1056

Woo HS, Julien PY, Richardson E V. (1986) Washload and Fine Sediment Load. J Hydraul Eng 112:111–123

Acknowledgements

This project was funded by the VIMS School of Marine Science and the NOAA's U.S. Integrated Ocean Observing System Office as a subcontract to VIMS under award NA13NOS0120139 to the Southeastern University Research Association. I would like to thank the COMT Chesapeake Hypoxia Team for their ideas and discussion. Many thanks to the Chesapeake Bay Program for the observational data provided on their website (datahub.chesapeakebay.net).