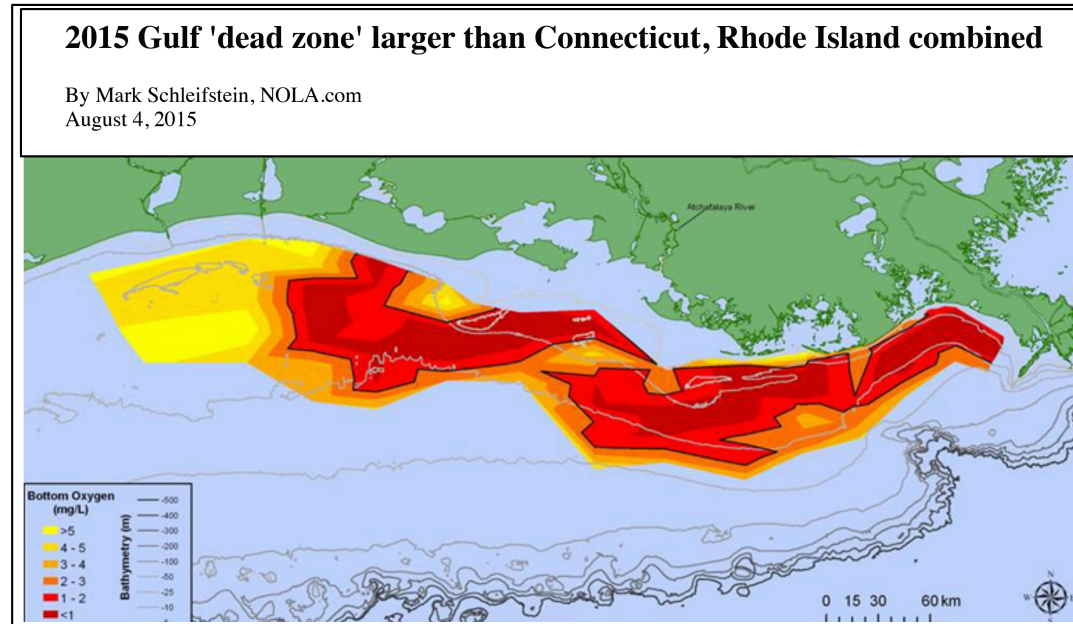


Coupling Sediment Transport and Biogeochemical Processes:

The Role of Sediment & Particulate Organic Matter Resuspension on Oxygen Dynamics



Julia Moriarty

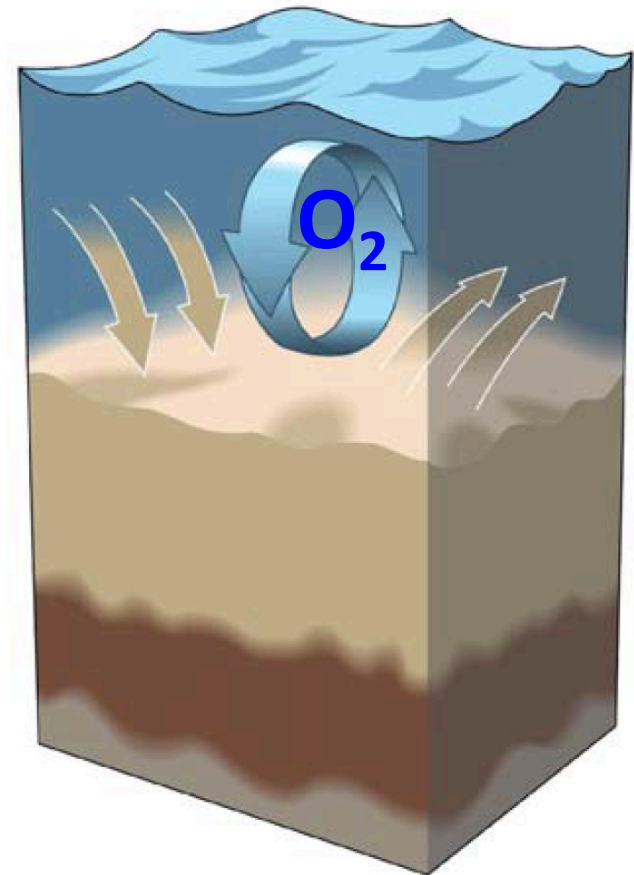
CSDMS Annual Meeting; 23-25 May 2017

Collaborators:

Courtney Harris, Marjorie Friedrichs
Katja Fennel (Dalhousie), Kevin Xu
(LSU), Christophe Rabouille (CNRS)

How Does Resuspension Affect Oxygen Dynamics?

1. Flux of O_2 into the seabed
2. Decomposition of resuspended particulate organic matter consumes oxygen
3. Redistribution of organic matter

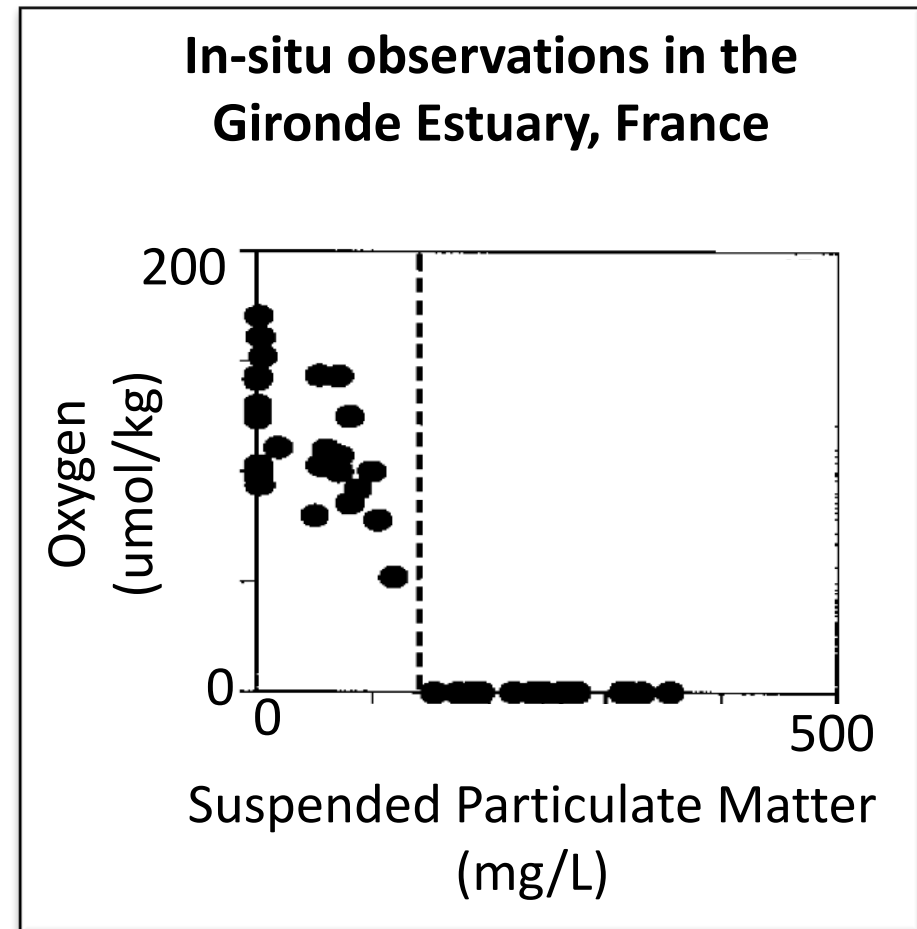


Toussaint et al. (2014), Abril et al. (1996), Sloth et al. (1996); Jorgensen et al., 1996; Aller (1998); Glud (2008); McKee et al. (2004); Lampitt et al. (1995); Moriarty et al. (2017)

After McKee et al. (2004);

How Does Resuspension Affect Oxygen Dynamics?

1. Flux of O_2 into the seabed
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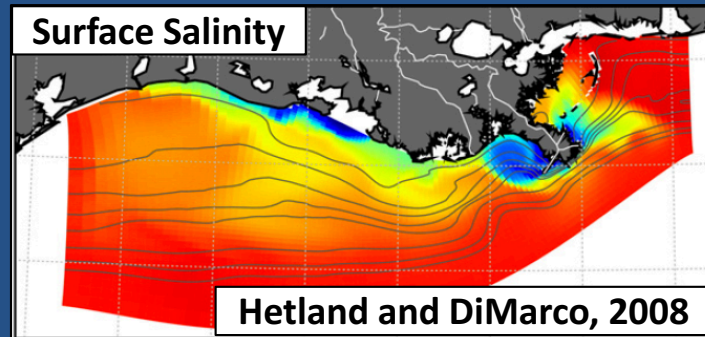


Abril et al. (1996)

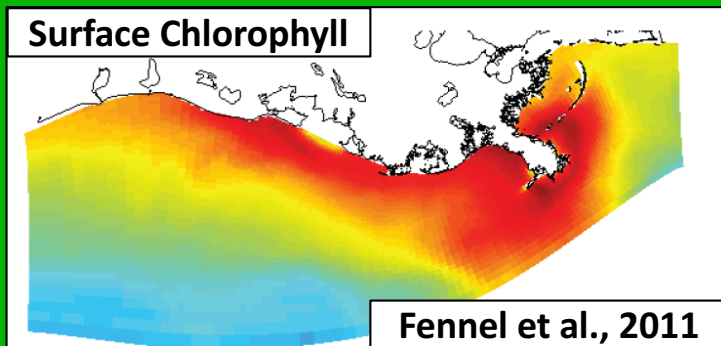
Toussaint et al. (2014), Abril et al. (1996), Sloth et al. (1996); Jorgensen et al., 1996; Aller (1998); Glud (2008); McKee et al. (2004); Lampitt et al. (1995); Moriarty et al. (2017)

Previous Modeling Efforts

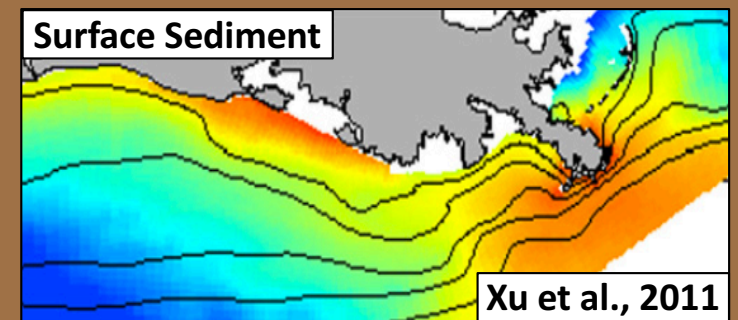
Hydrodynamics



Water Column Biogeochemistry

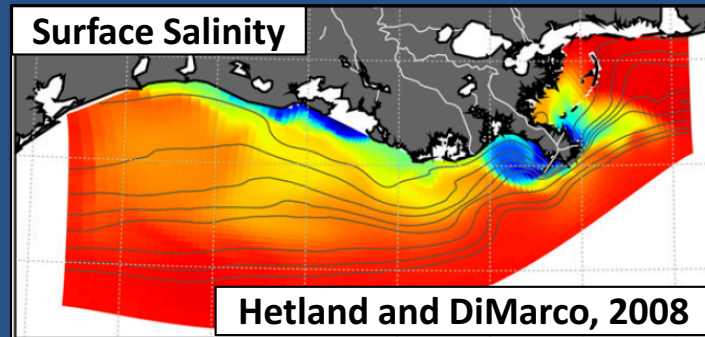


Sediment Transport

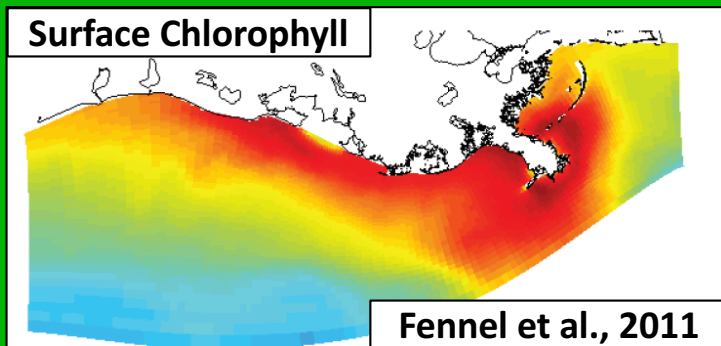


Previous Modeling Efforts

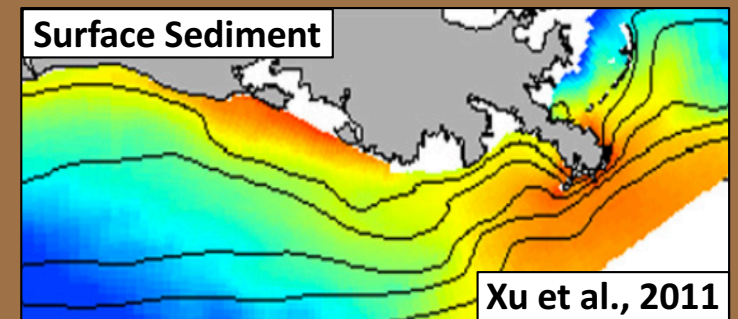
Hydrodynamics



Water Column Biogeochemistry



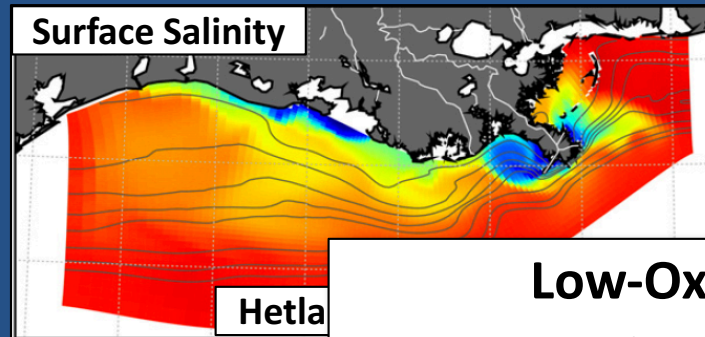
Sediment Transport



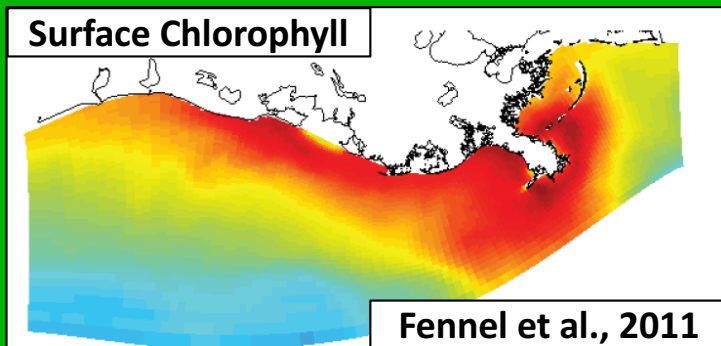
???

Previous Modeling Efforts

Hydrodynamics



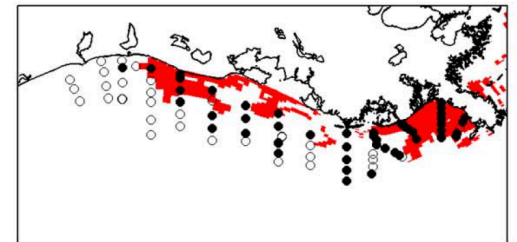
Water Column Biogeochemistry



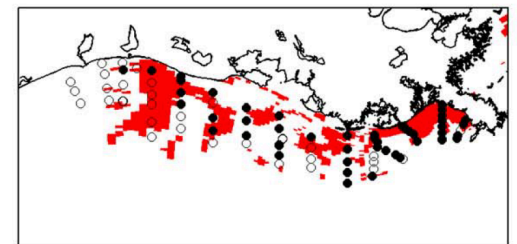
Low-Oxygen Areas: Gulf of Mexico

Parameterization:

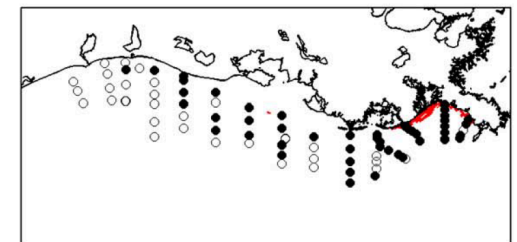
#1



#2



#3

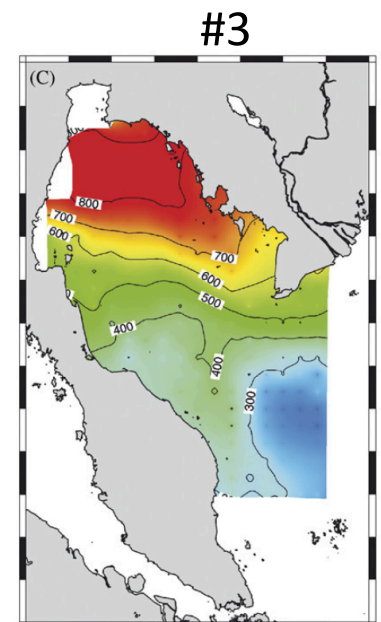
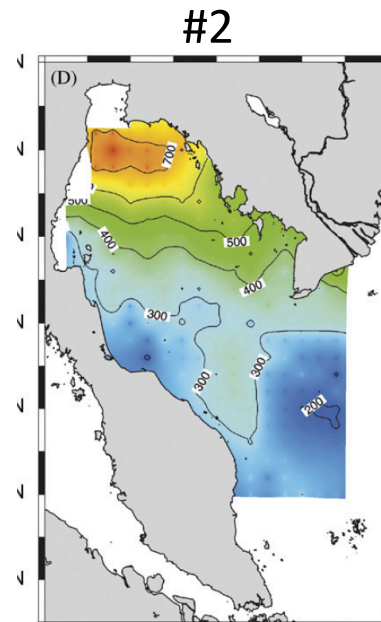
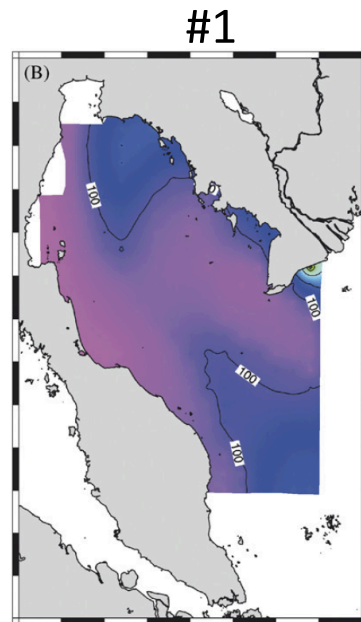
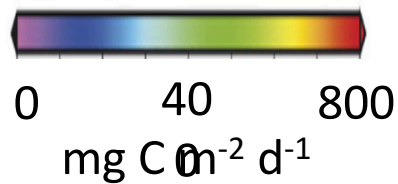


(Fennel et al., 2013)

Motivation: Models are sensitive to Parameterization of Seabed Biogeochemical Processes

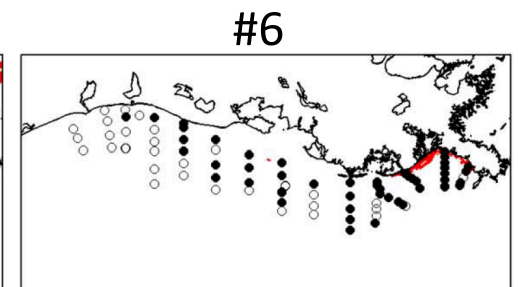
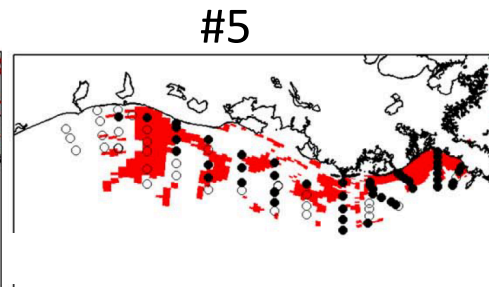
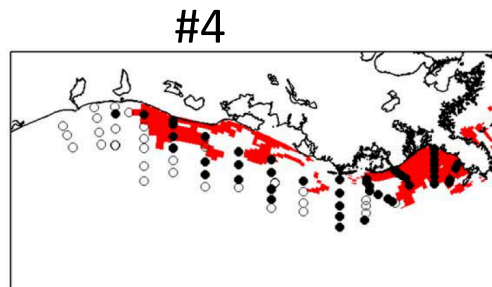
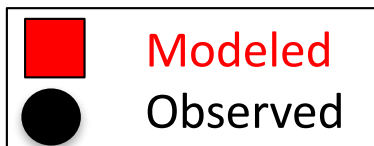
Parameterization of Seabed Processes (i.e., Bottom Boundary Condition)

Primary
Production:
Gulf of Thailand
(Liu et al., 2007)

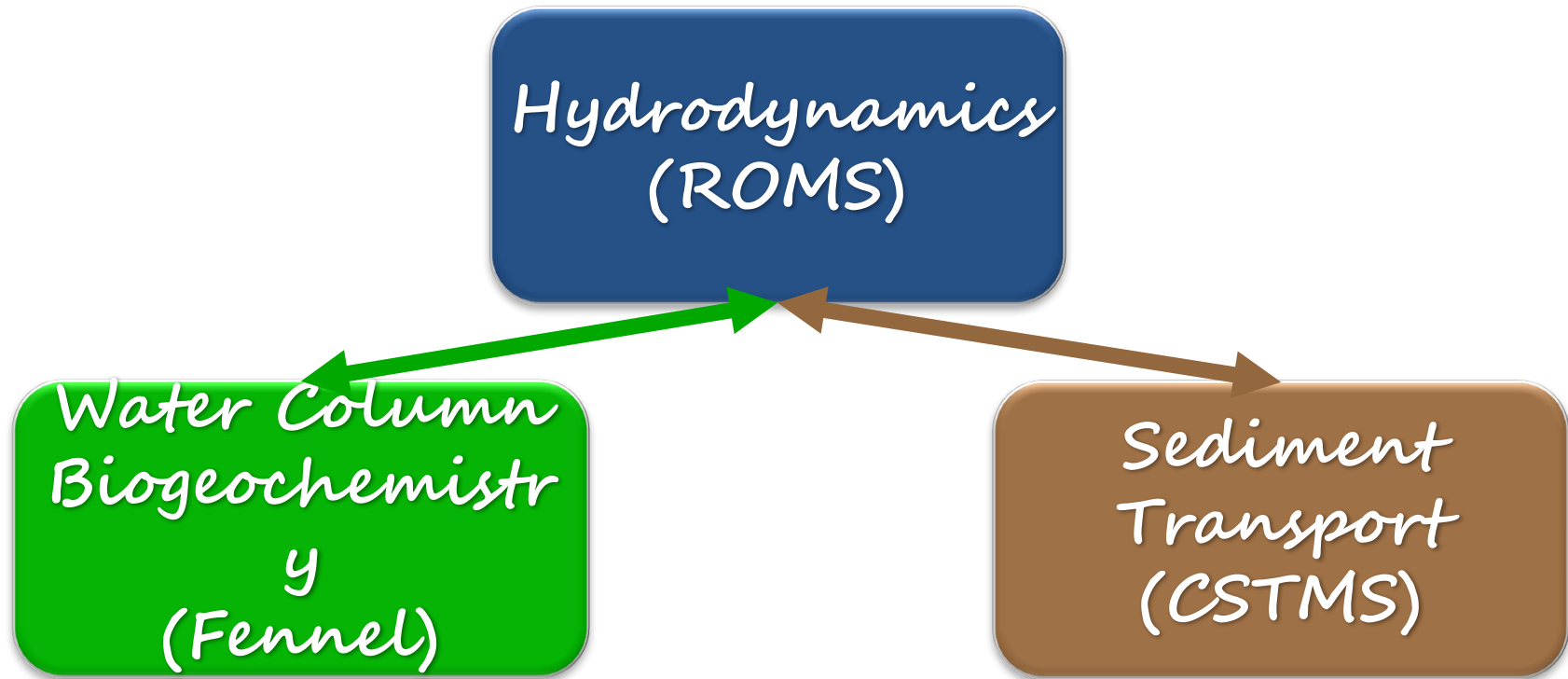


Parameterization of Seabed Processes (i.e., Bottom Boundary Condition)

Low-Oxygen Areas:
Gulf of Mexico
(Fennel et al., 2013)

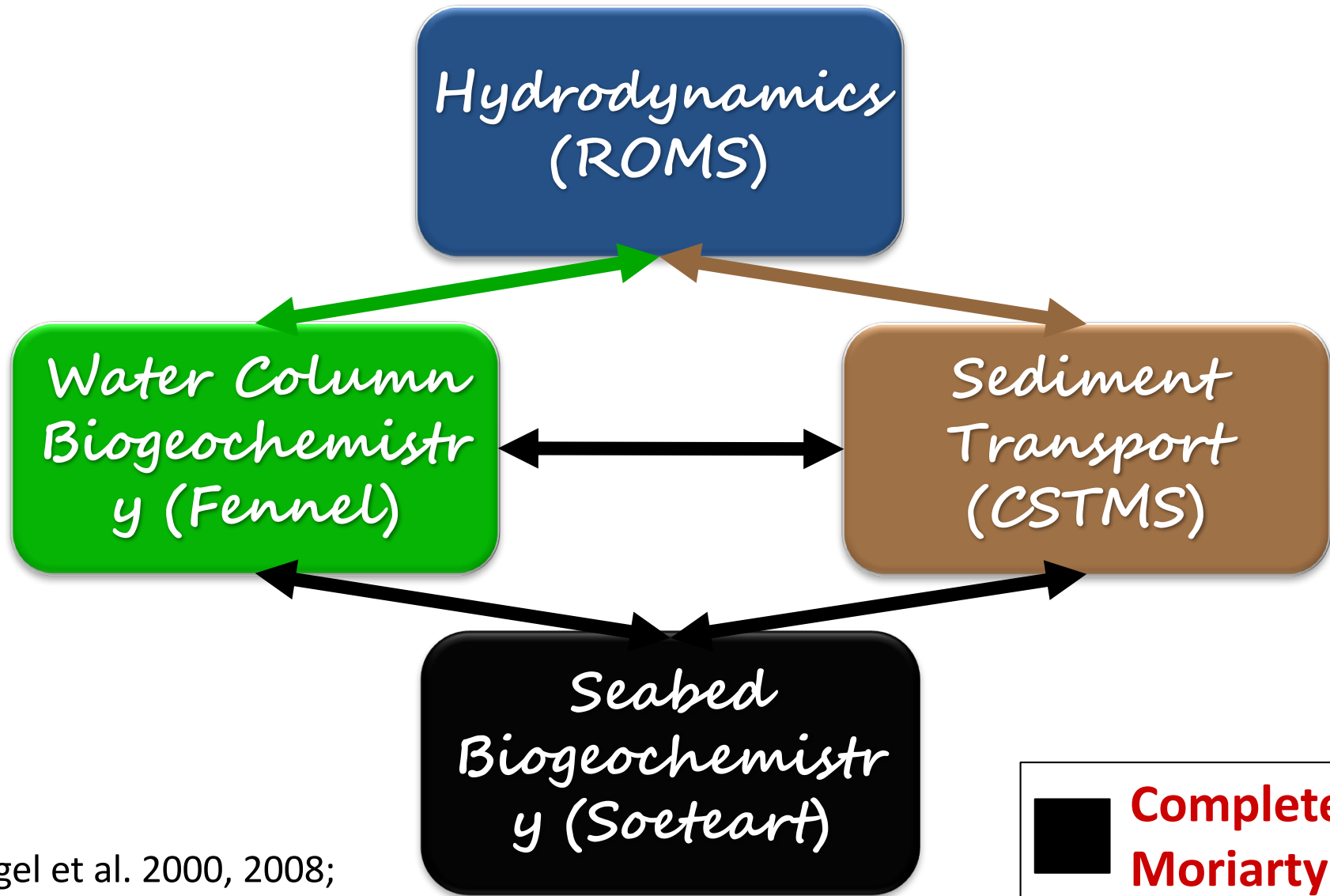


ROMS Framework



Haidvogel et al. 2000, 2008;
Warner et al. 2008; Fennel et al.
2013;

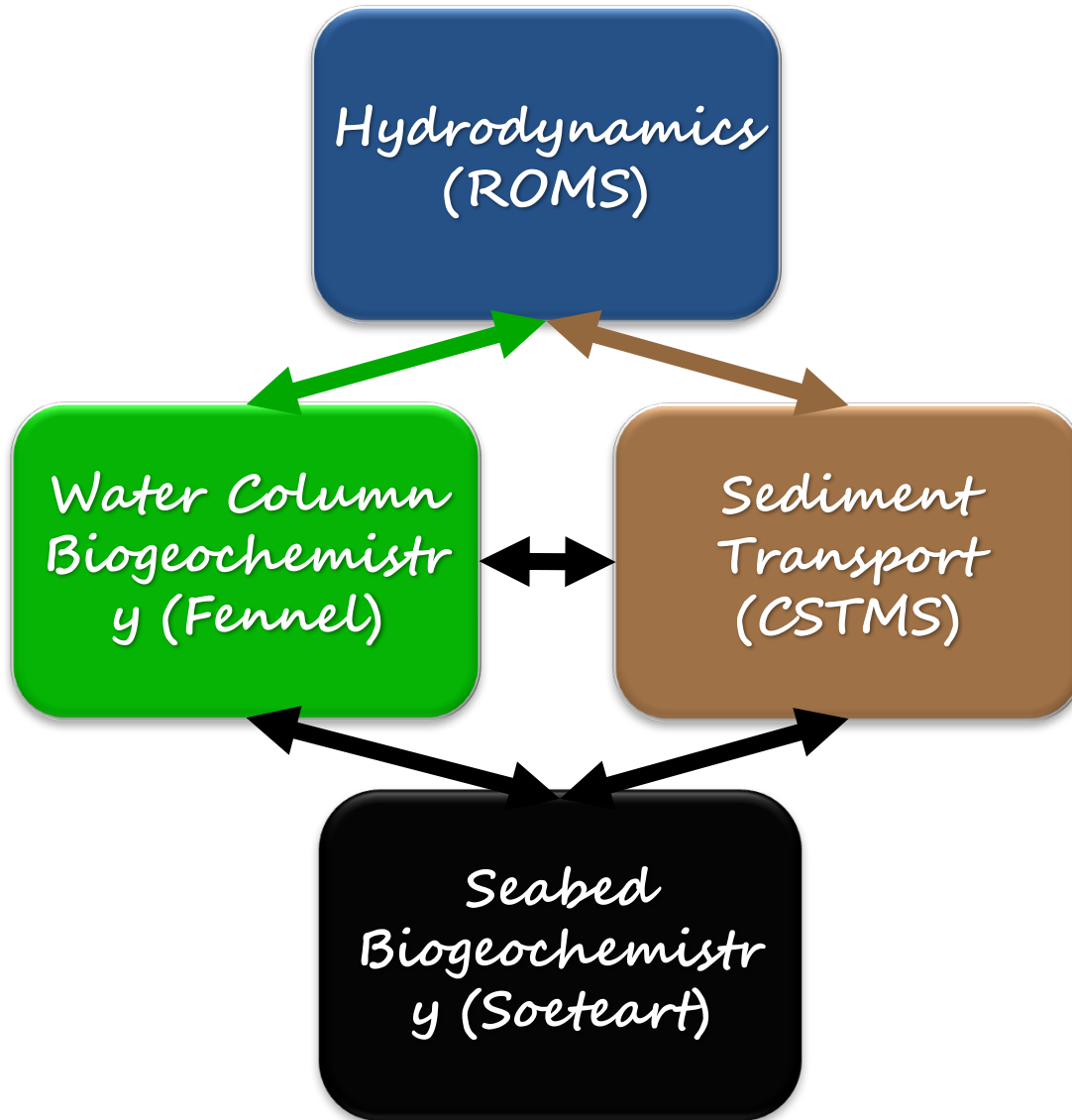
HydroBioSed: A Coupled Model



Haidvogel et al. 2000, 2008;
Warner et al. 2008; Fennel et al.
2013; Soetaert et al. 1996

■ **Completed for
Moriarty et al.
(2017)**

HydroBioSed

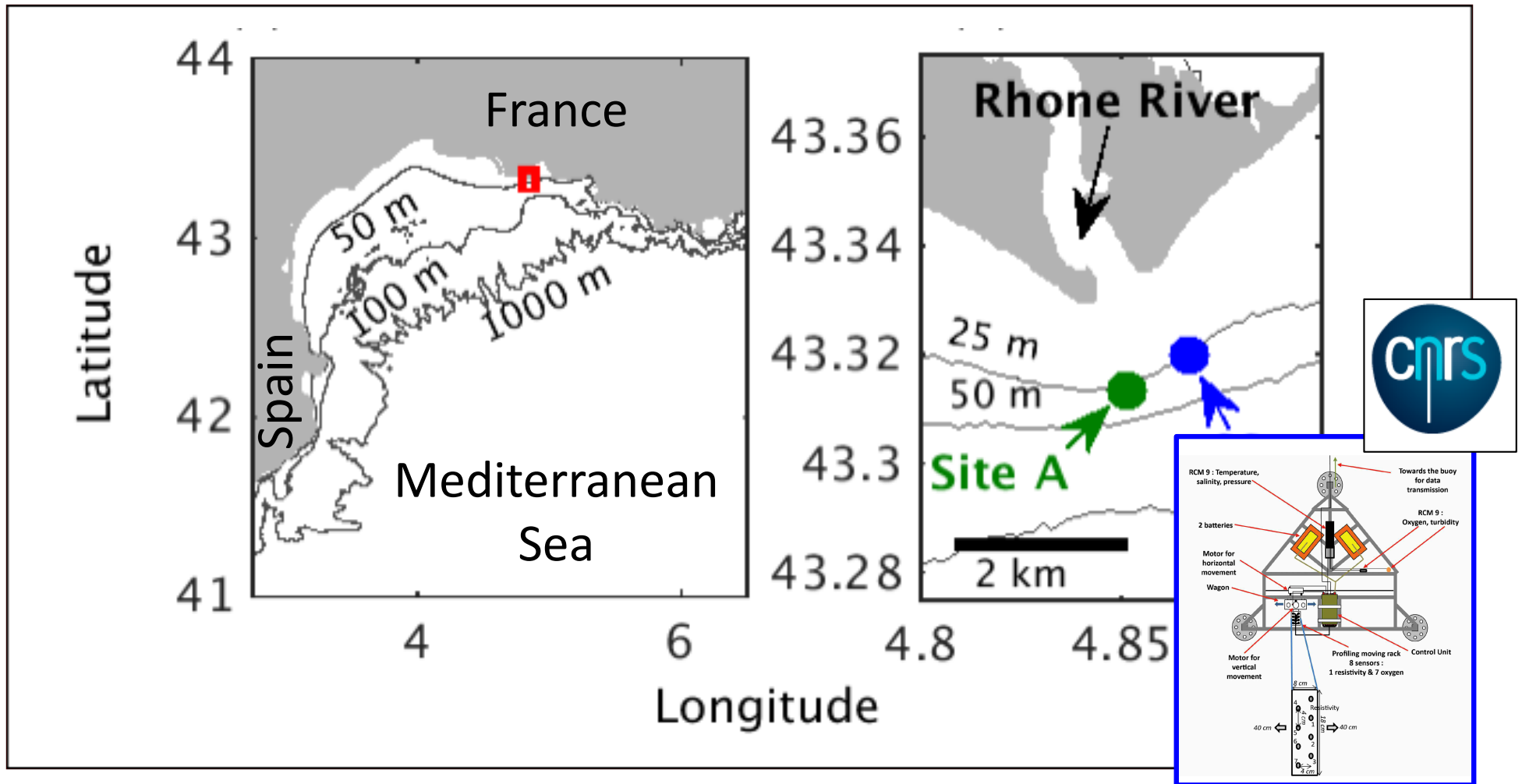


New model processes include:

1. Erosion of organic matter & storage in seabed
 - Redistribution of resuspended organic matter
2. Fluxes of oxygen at seabed - water interface
3. Decomposition of organic matter and oxidation of reduced chemical species in seabed

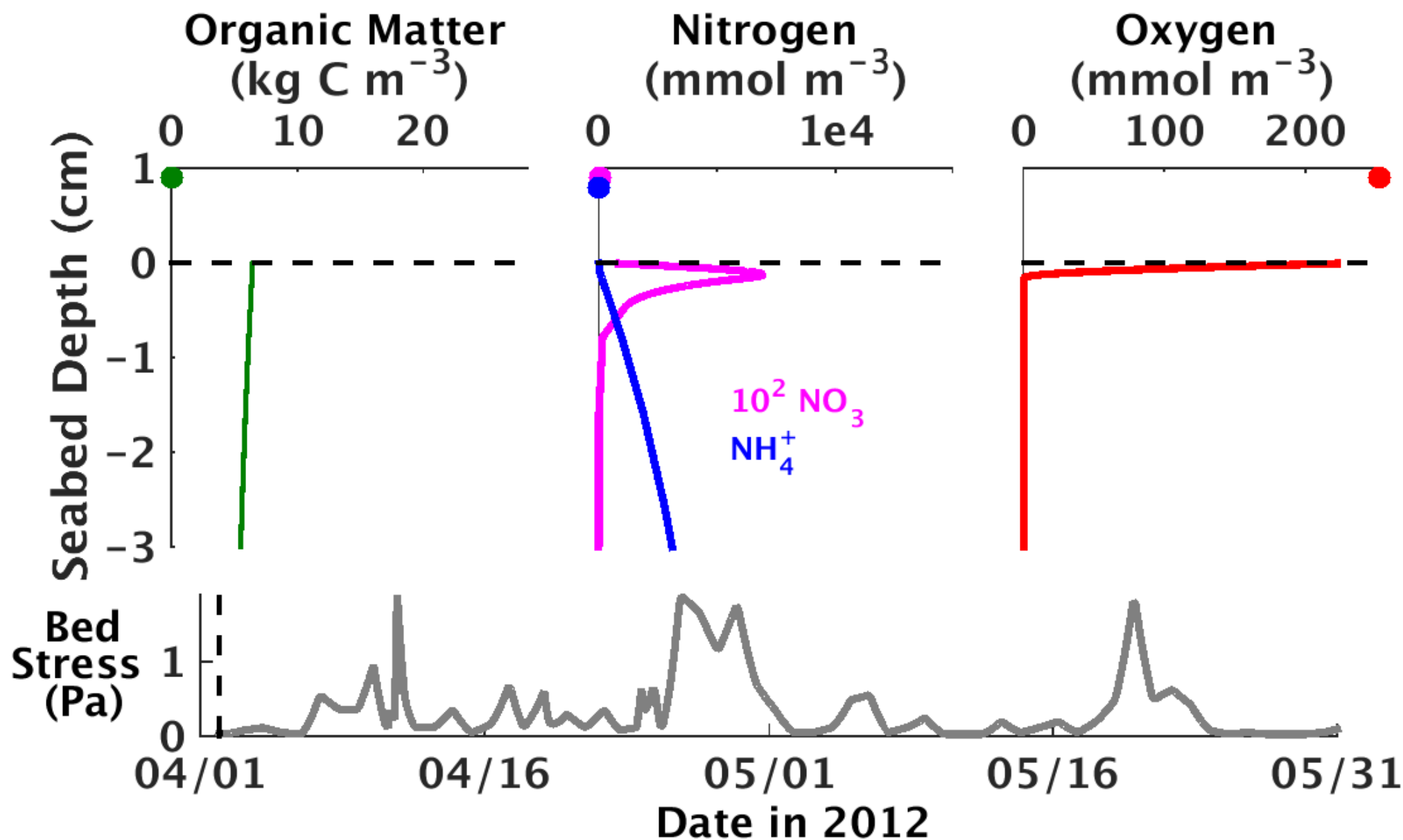
**Completed
for Moriarty
et al. (2017)**

1-D Model Implementation: Rhone Delta, France



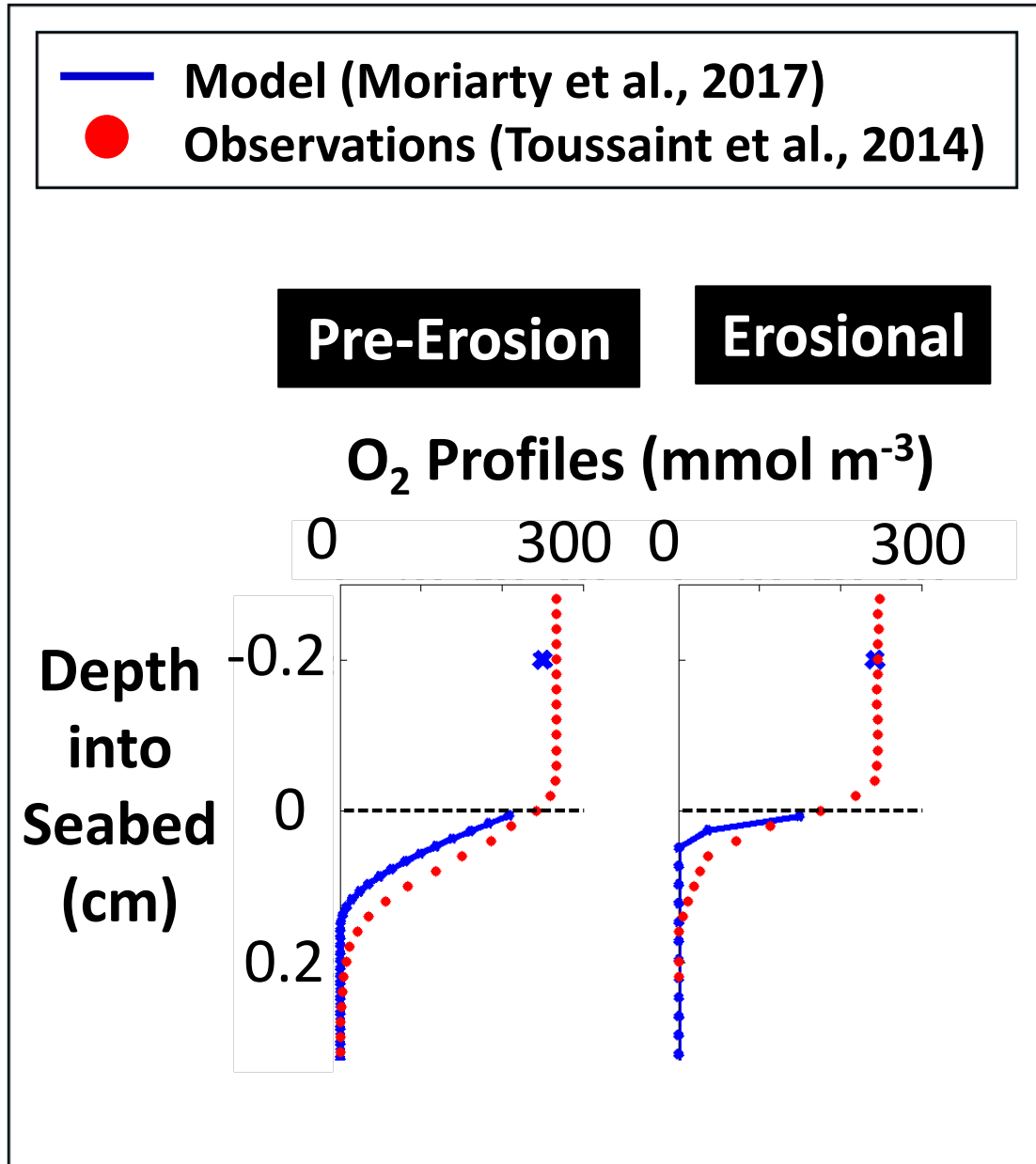
Toussaint et al. (2014)

Model Day 0

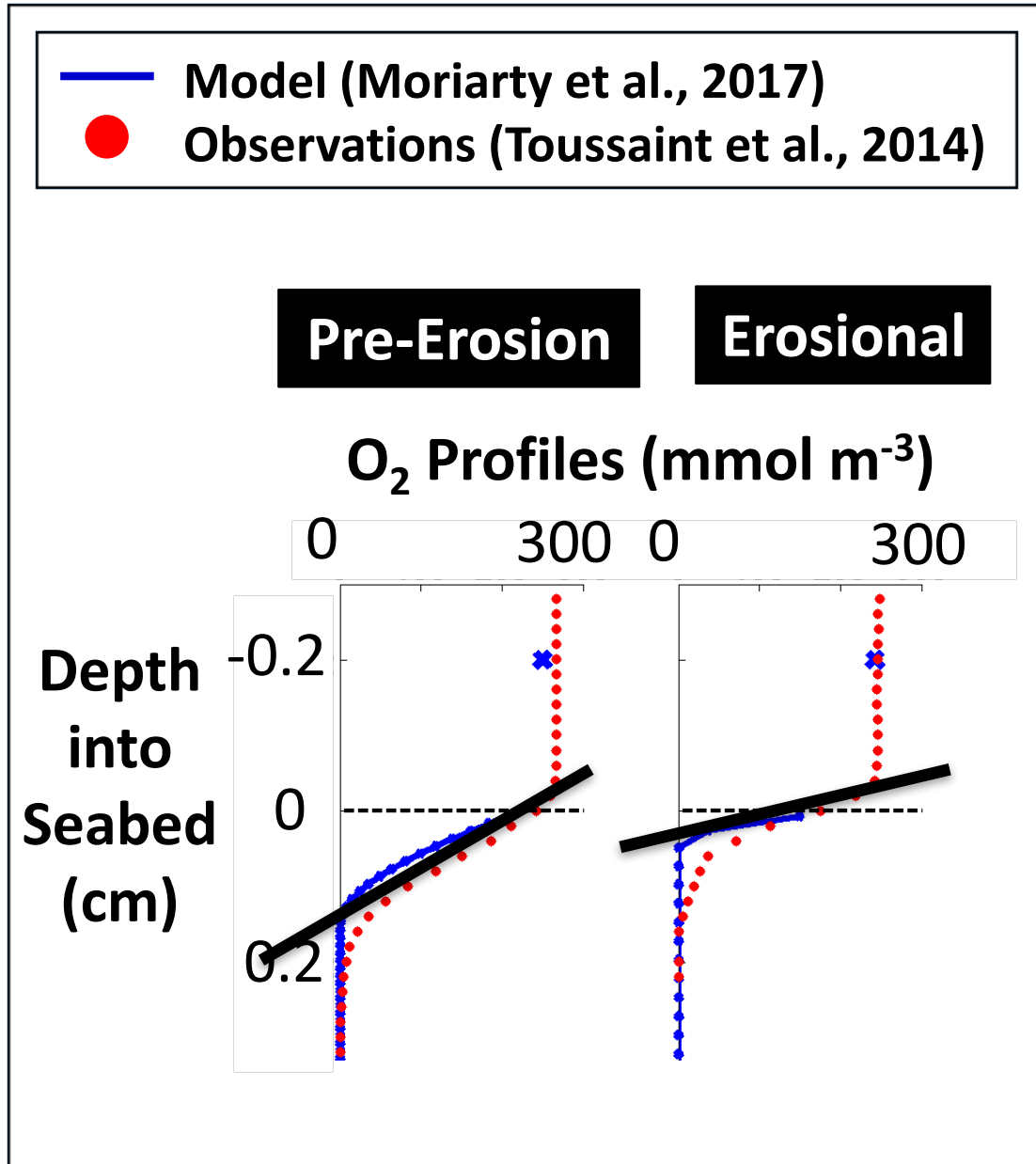




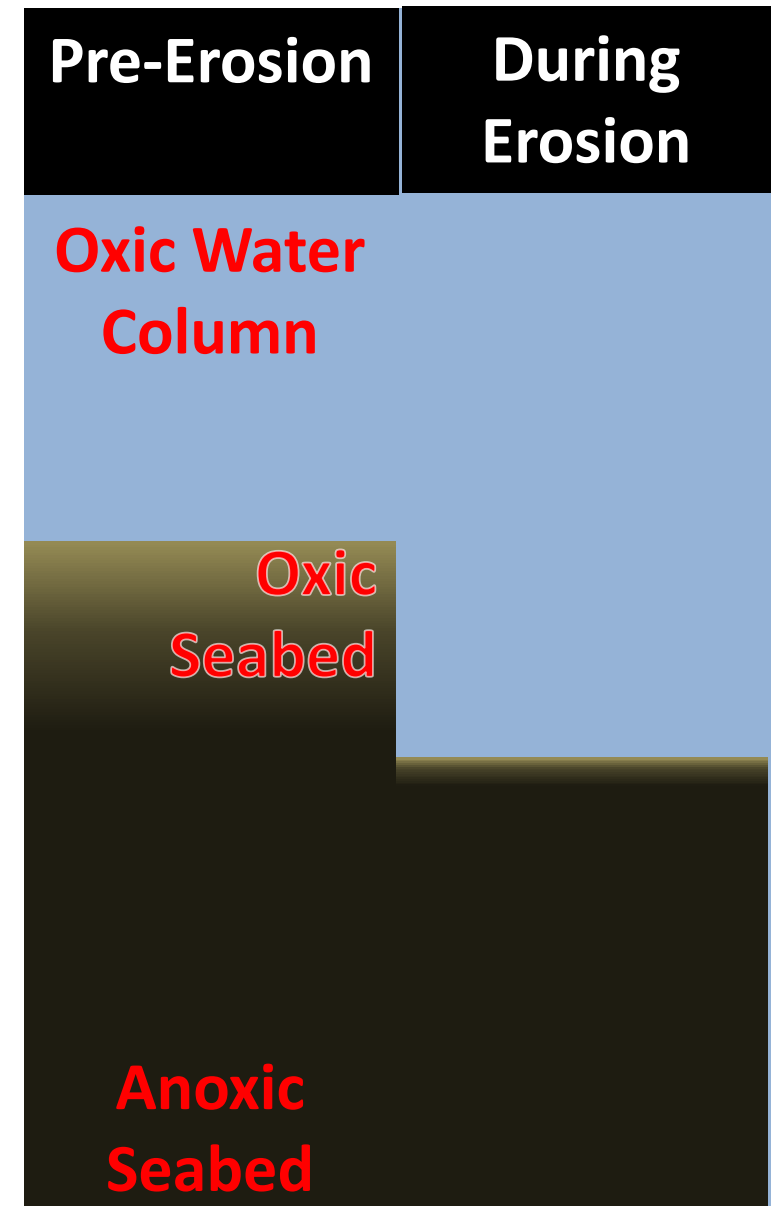
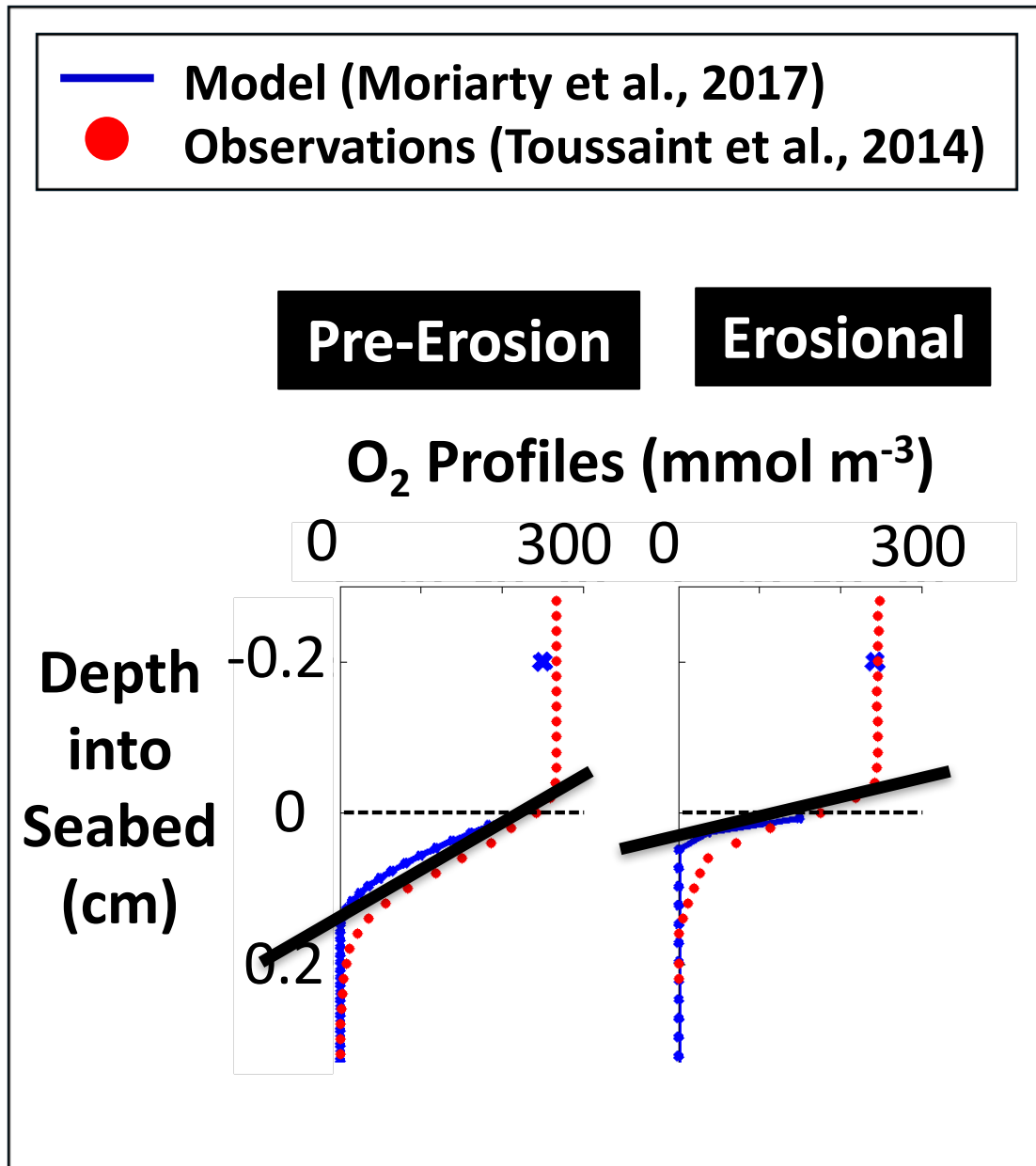
Result #1: Resuspension Increased Flux of Oxygen Into Seabed



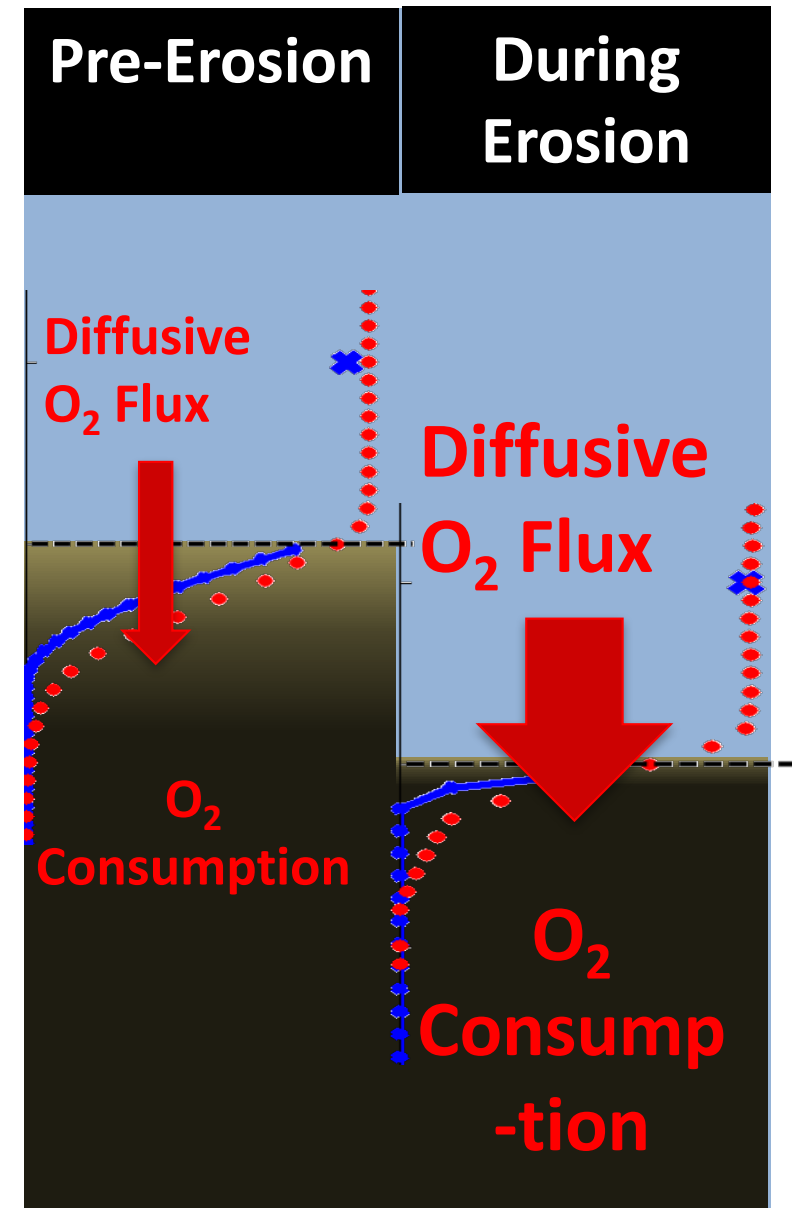
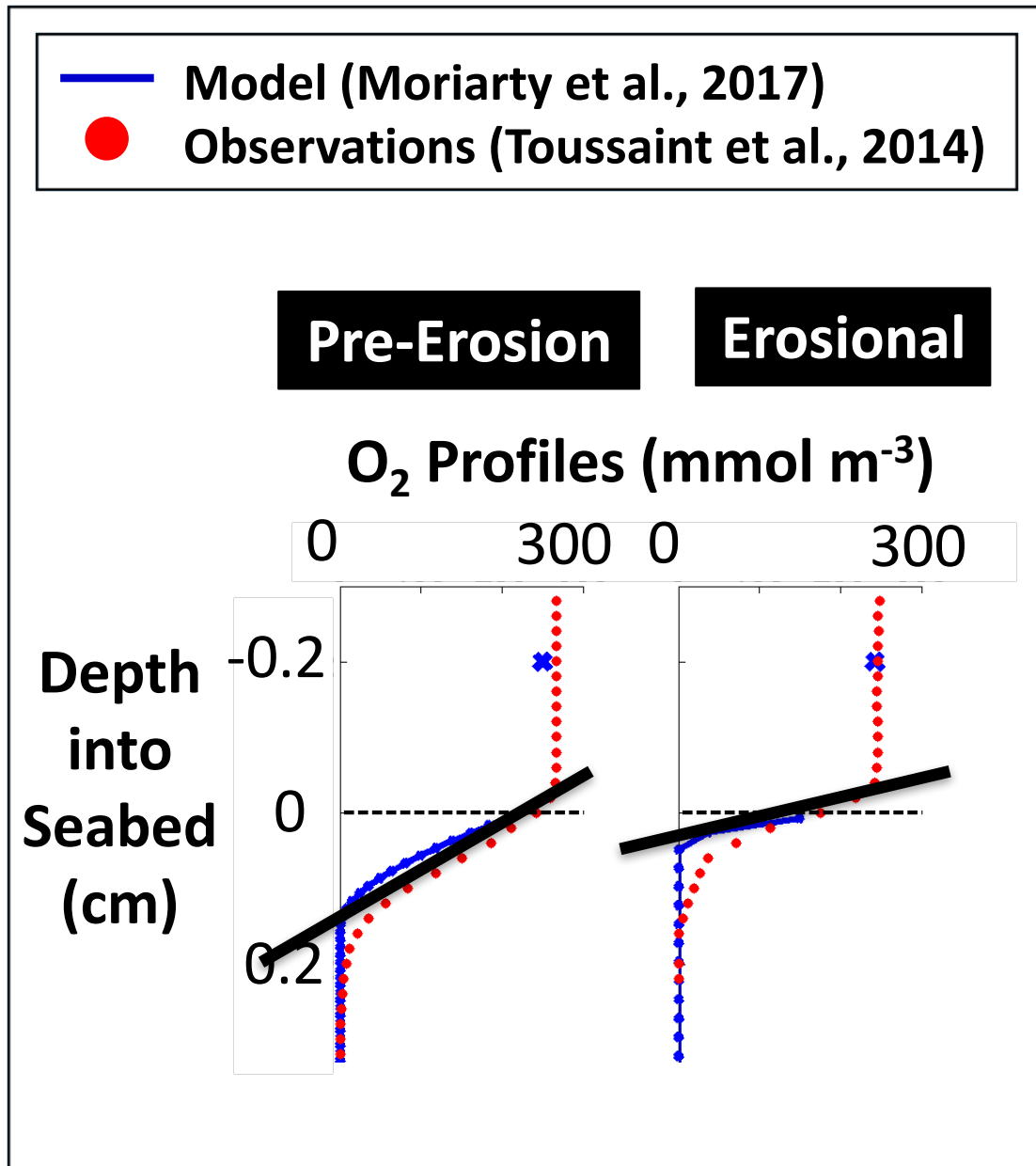
Result #1: Resuspension Increased Flux of Oxygen Into Seabed



Result #1: Resuspension Increased Flux of Oxygen Into Seabed

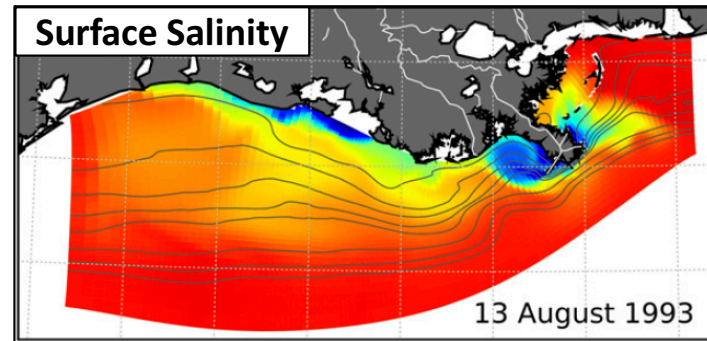


Result #1: Resuspension Increased Flux of Oxygen Into Seabed

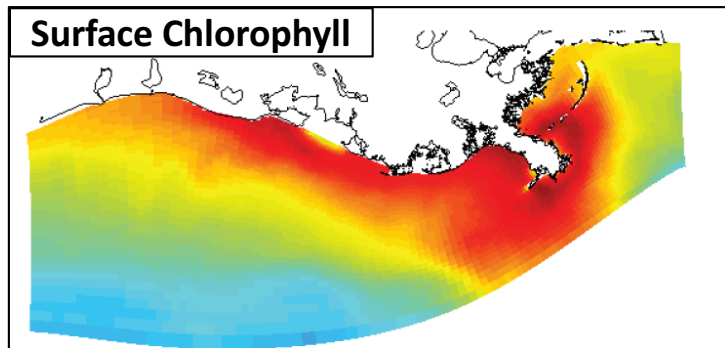


HydroBioSed Implementation for Northern Gulf of Mexico

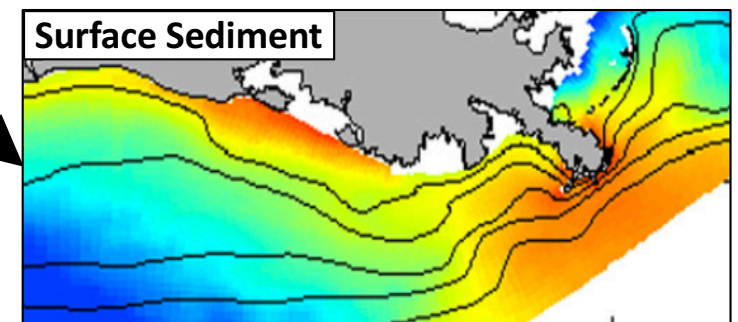
Hydrodynamic Set-up:
Hetland and DiMarco (2008)



Water Column
Biogeochemistry Set-up:
Fennel et al. (2011)

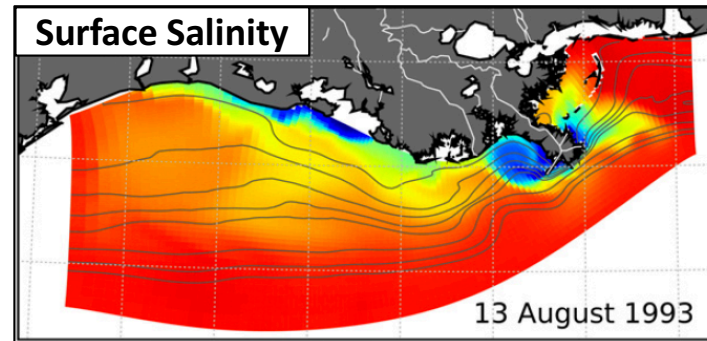


Seabed &
Sediment Set-up:
Xu et al. (2011)

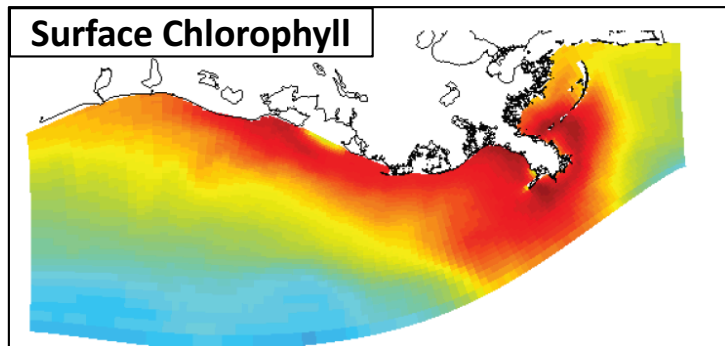


HydroBioSed Implementation for Northern Gulf of Mexico

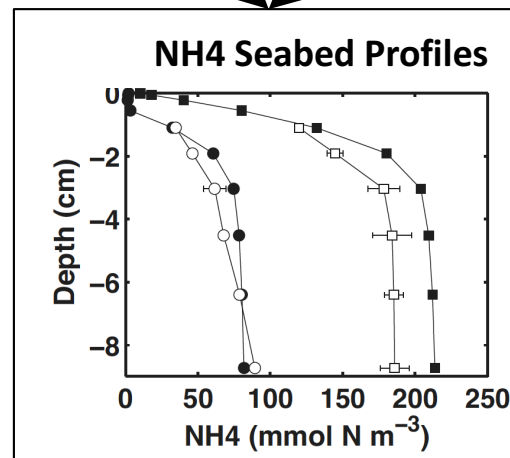
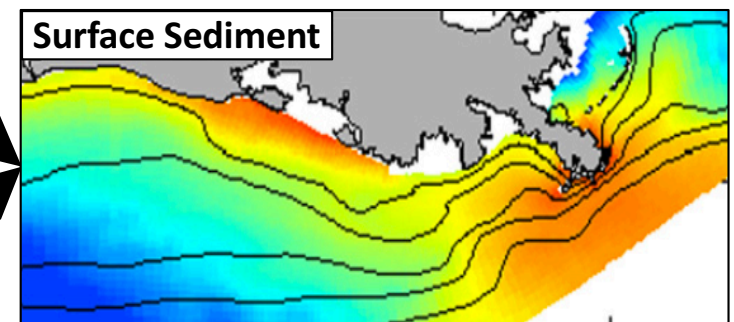
Hydrodynamic Set-up:
Hetland and DiMarco (2008)



Water Column
Biogeochemistry Set-up:
Fennel et al. (2011)



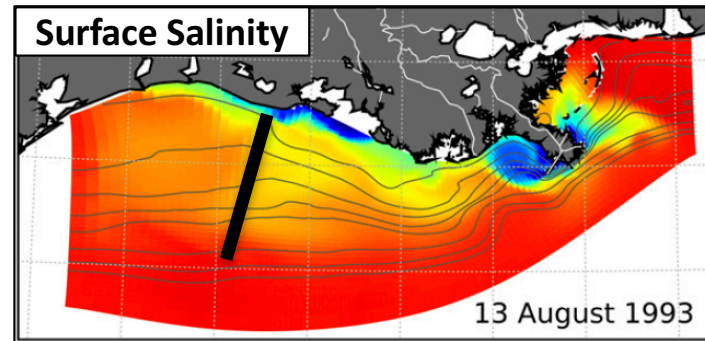
Seabed &
Sediment Set-up:
Xu et al. (2011)



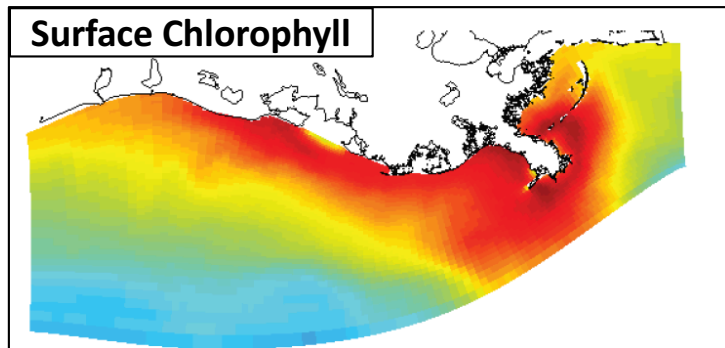
Seabed
Biogeochemistry
Set-up:
Laurent et al.
(2016)

HydroBioSed Implementation for Northern Gulf of Mexico

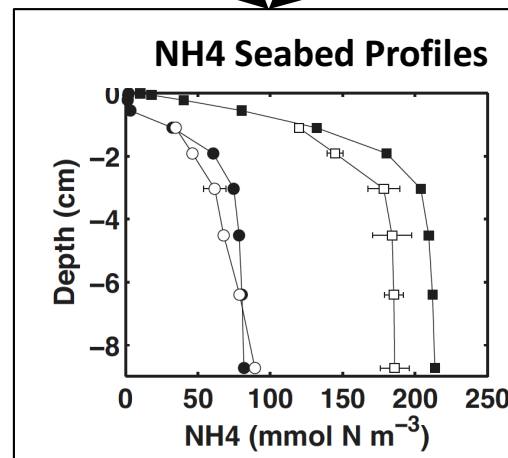
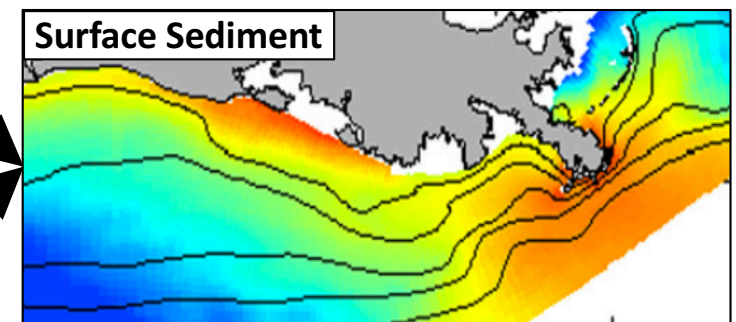
Hydrodynamic Set-up:
Hetland and DiMarco (2008)



Water Column
Biogeochemistry Set-up:
Fennel et al. (2011)



Seabed &
Sediment Set-up:
Xu et al. (2011)

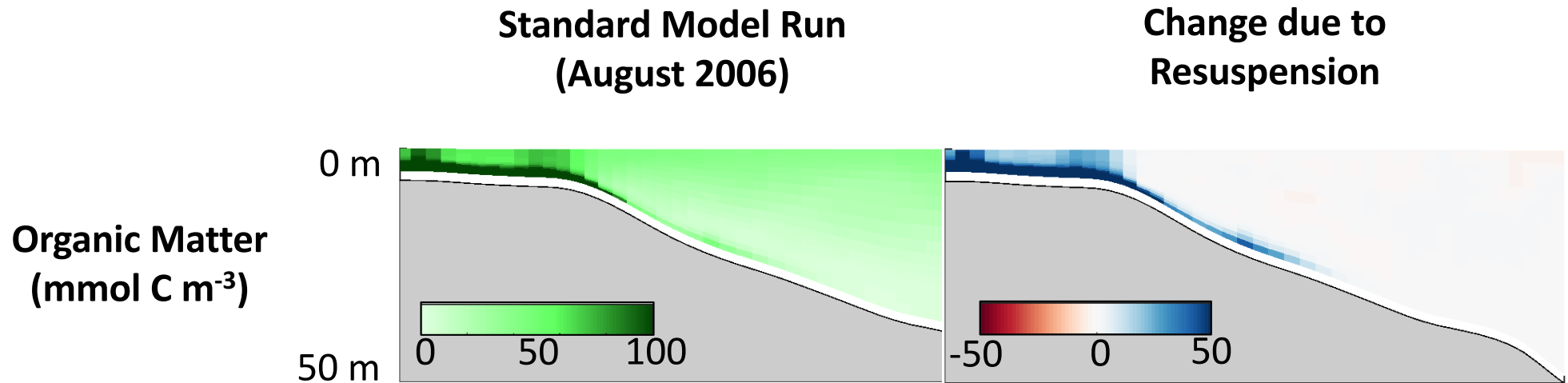


Seabed
Biogeochemistry
Set-up:
Laurent et al.
(2016)

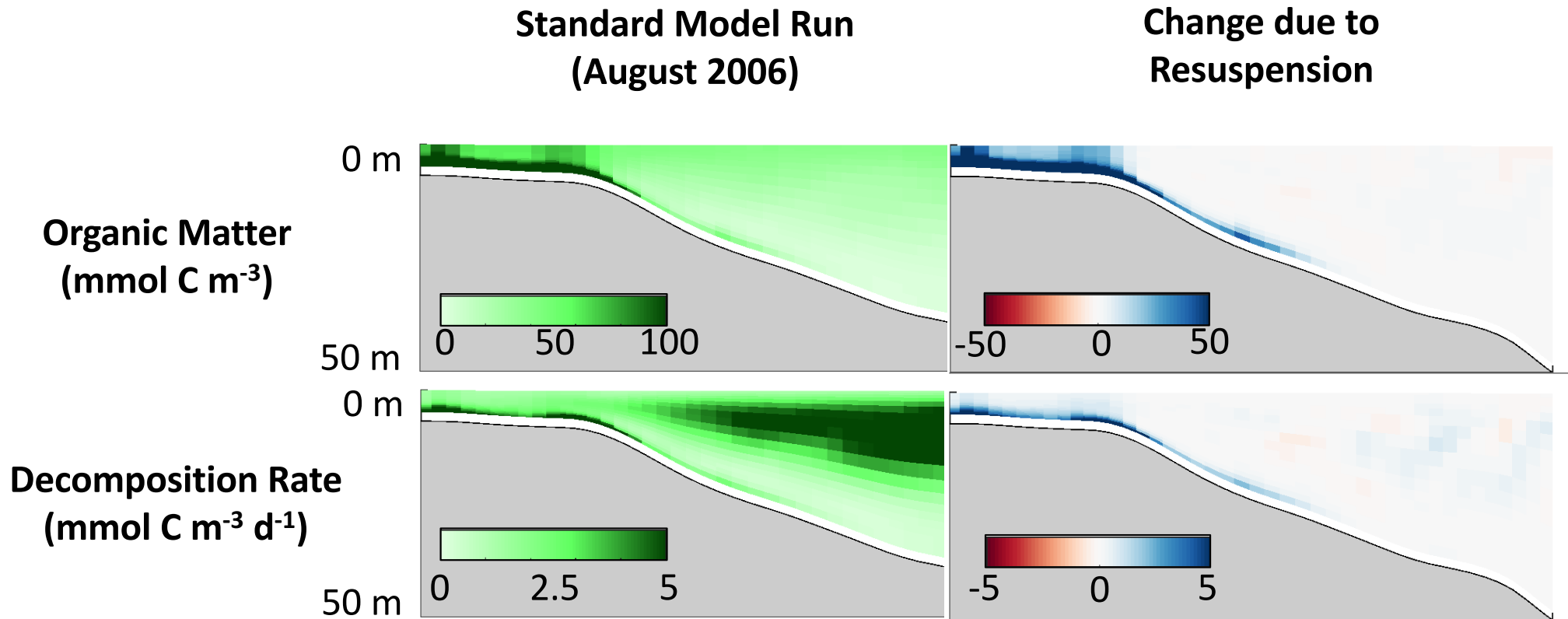
January – December 2006



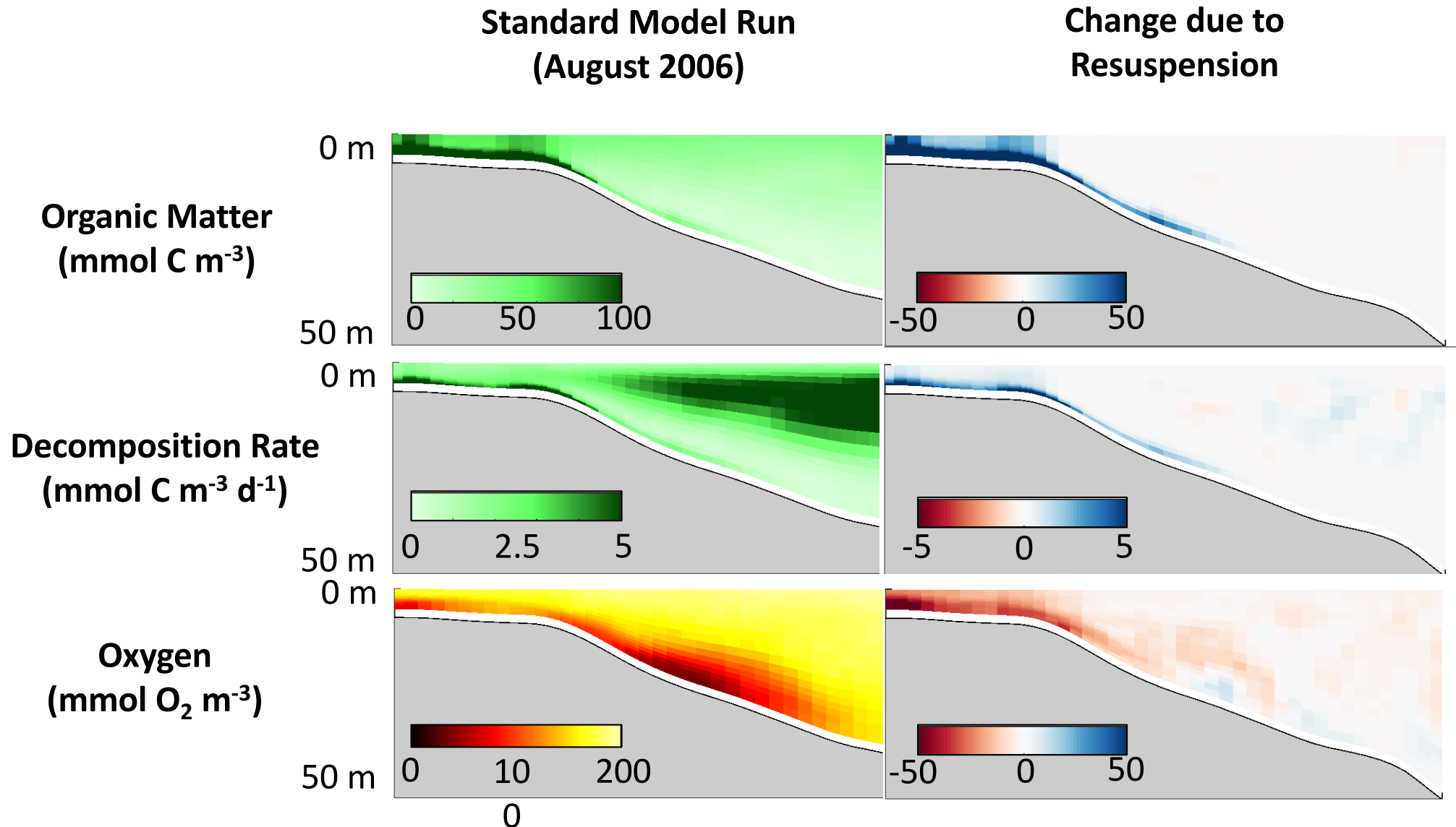
Result #2: Decomposition of resuspended organic matter increased bottom water oxygen consumption



Result #2: Decomposition of resuspended organic matter increased bottom water oxygen consumption



Result #2: Decomposition of resuspended organic matter increased bottom water oxygen consumption

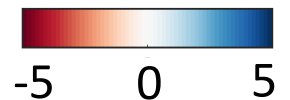
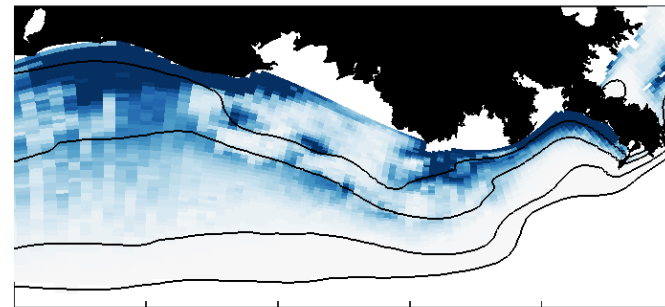
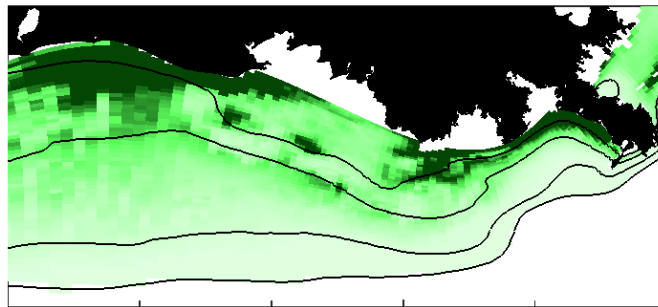
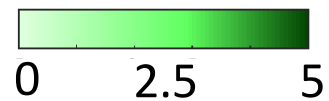


Result #3: Redistribution of organic matter affects patterns of oxygen depletion

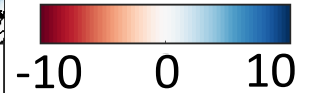
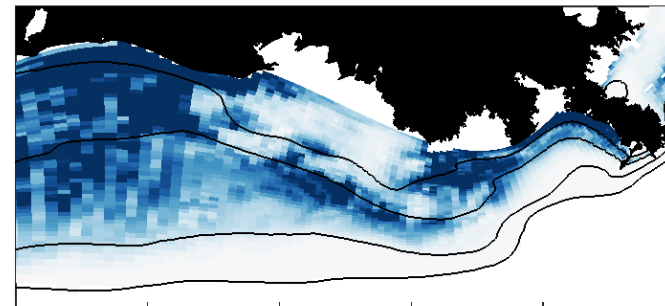
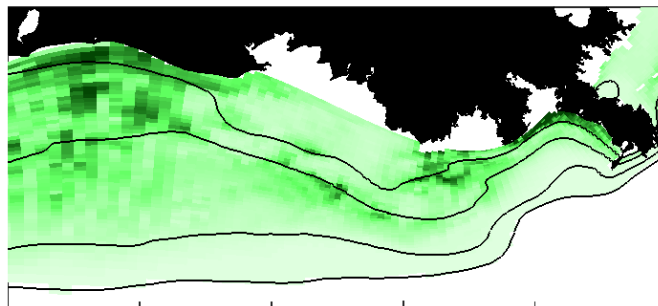
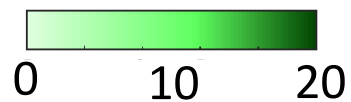
Standard Model Run
(July 2006)

Change due to
Resuspension

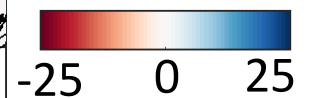
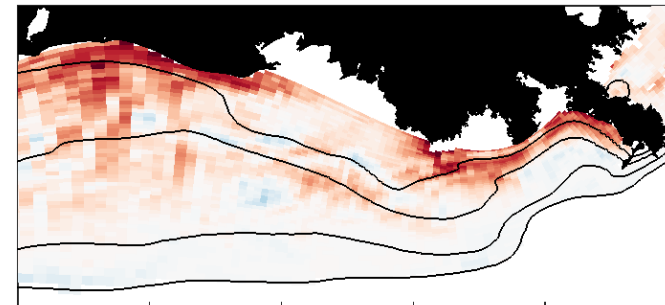
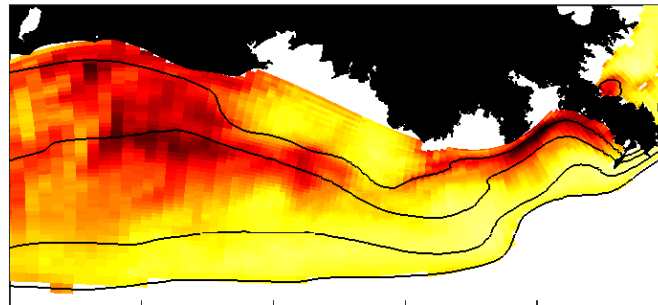
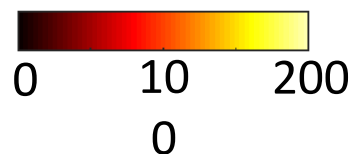
Organic Matter
(mmol C m⁻³)



Decomposition
Rate
(mmol C m⁻³ d⁻¹)



Oxygen
(mmol O₂ m⁻³)

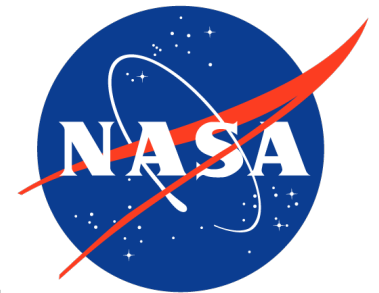
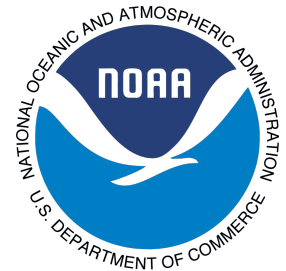


Conclusions

- HydroBioSed, a coupled model that accounts for resuspension and deposition, as well as biogeochemical processes, was developed and implemented for the Rhone Delta (Moriarty et al., 2017) and Northern Gulf of Mexico.
- Resuspension increased fluxes of oxygen into the seabed and increased bottom water oxygen consumption.
- Ongoing work: implement model for Chesapeake Bay, and investigating the effect of resuspension on light attenuation.

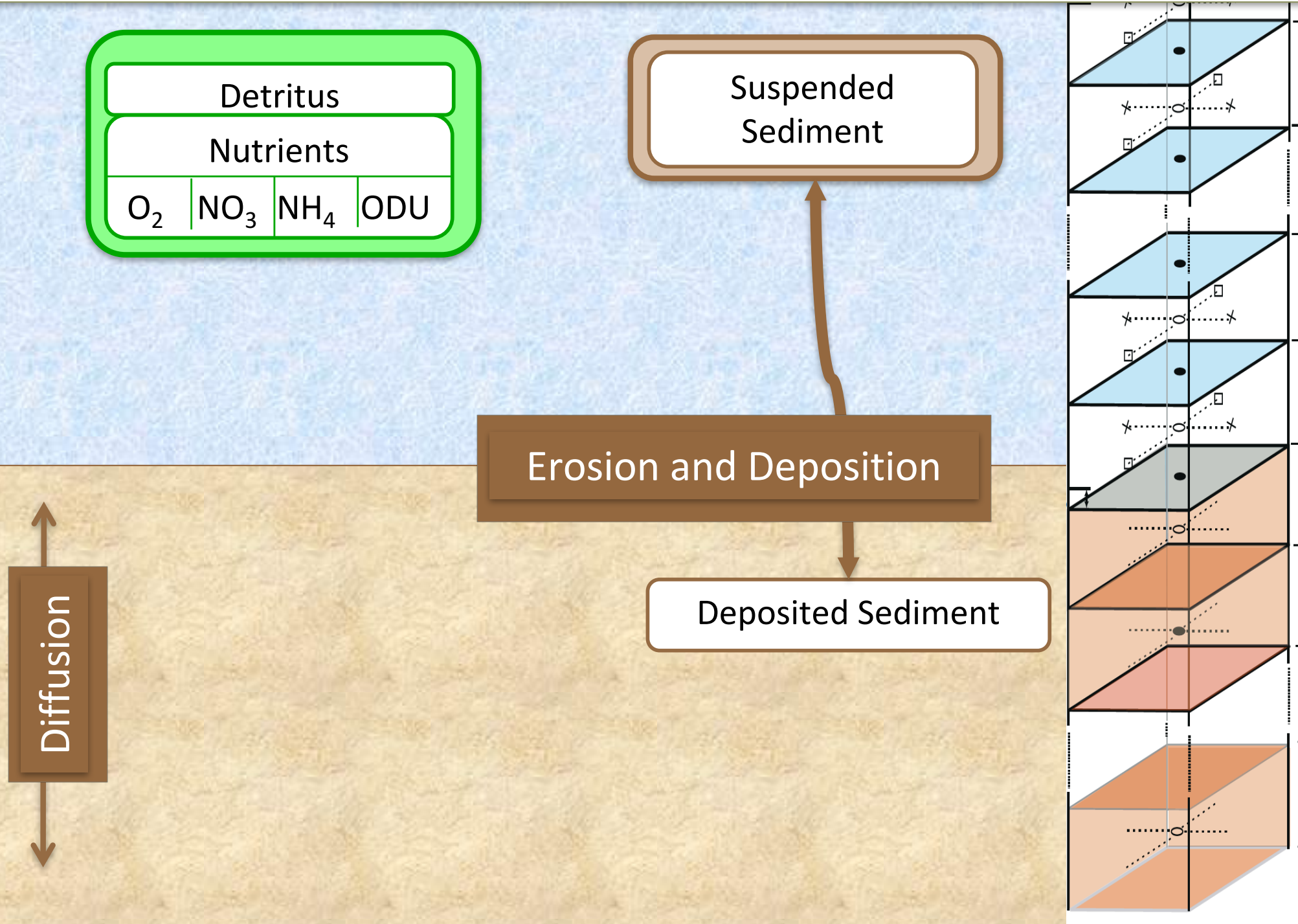
Acknowledgements

- Collaborators
 - Courtney Harris
 - Marjorie Friedrichs
 - Katja Fennel (Dalhousie)
 - Kevin Xu (LSU)
 - Rob Hetland and Steve DiMarco (TAMU)
 - Liz Canuel
 - Carl Friedrichs
 - Harris & Friedrichs Labs
- Support
 - NOAA's Mechanisms Controlling Hypoxia Project
 - VIMS Graduate Program
 - NASA

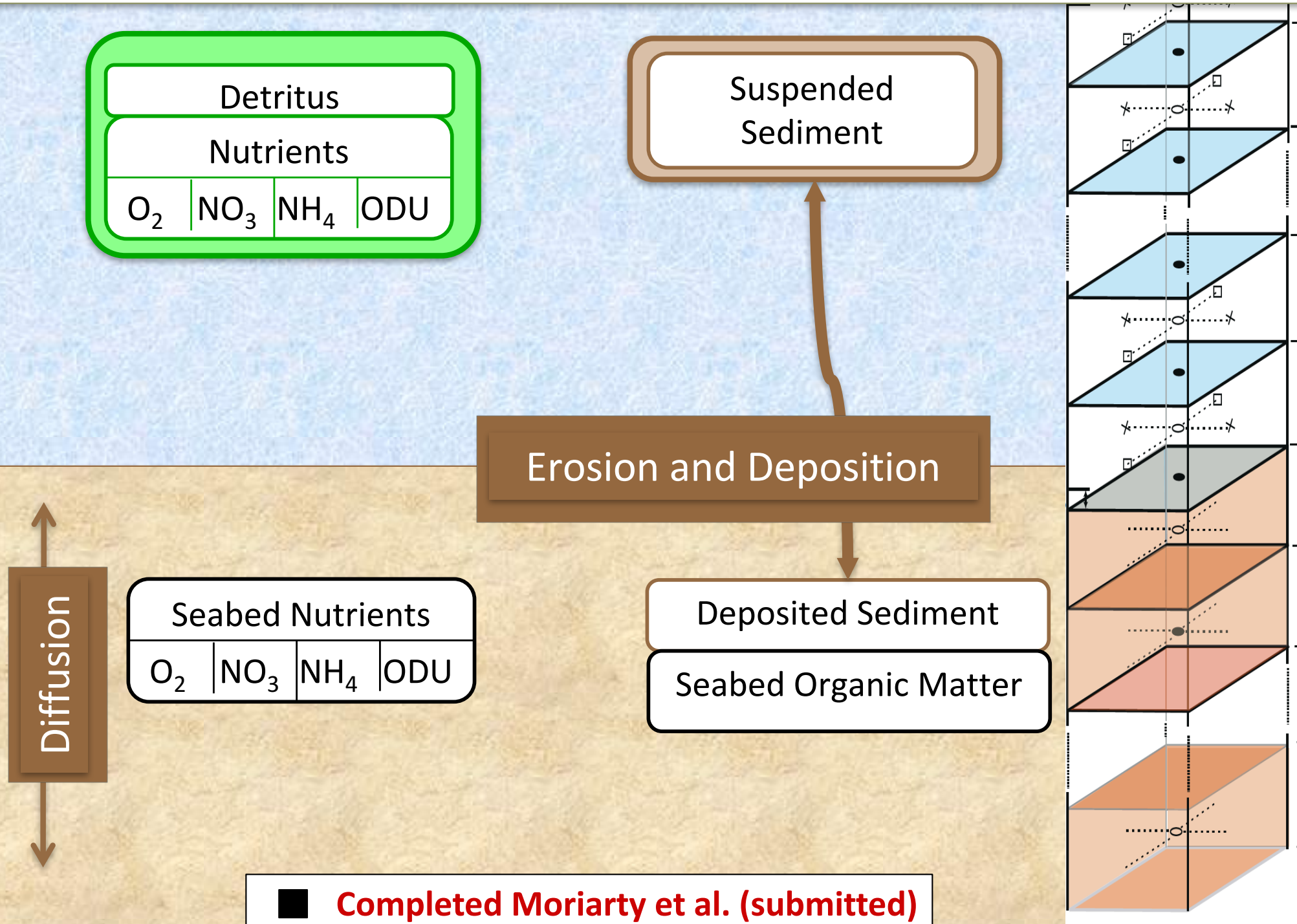


Extras

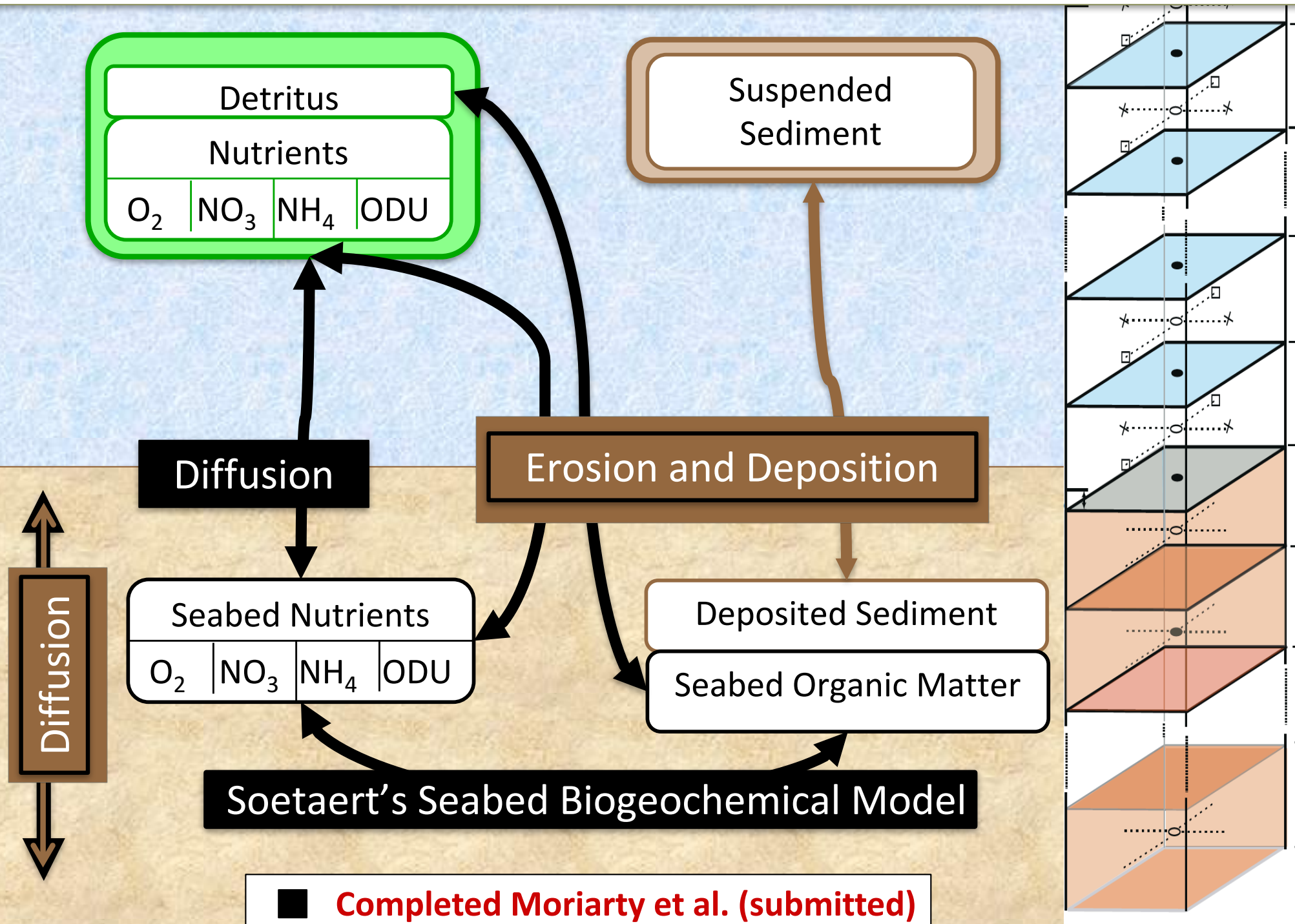
Water Biogeochemistry + Sediment + Seabed Biogeochemistry



Water Biogeochemistry + Sediment + Seabed Biogeochemistry



Water Biogeochemistry + Sediment + Seabed Biogeochemistry



Model Implementations: Northern Gulf of Mexico (Xu et al., 2011)

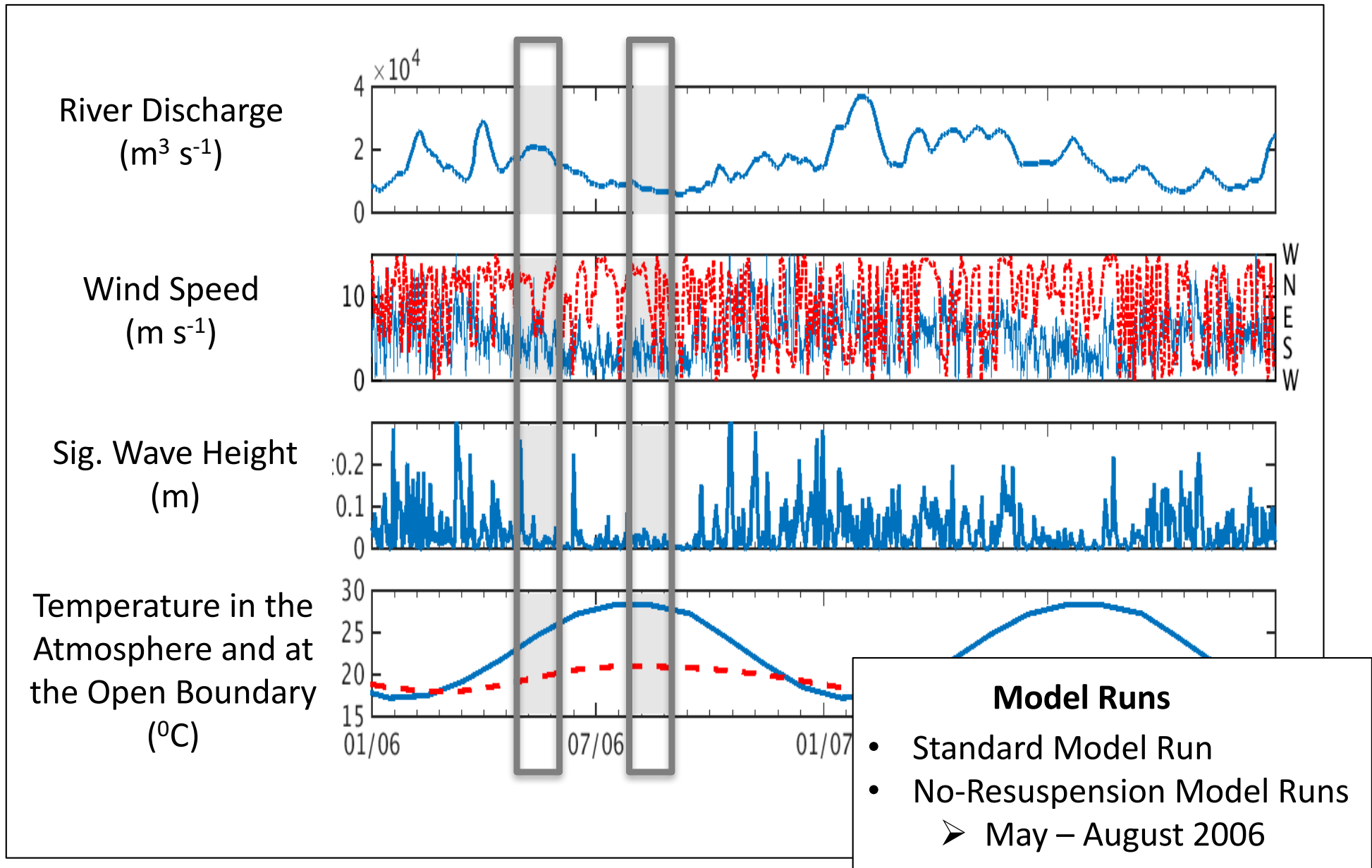
Table 1

Properties of six sediment tracers in the model.

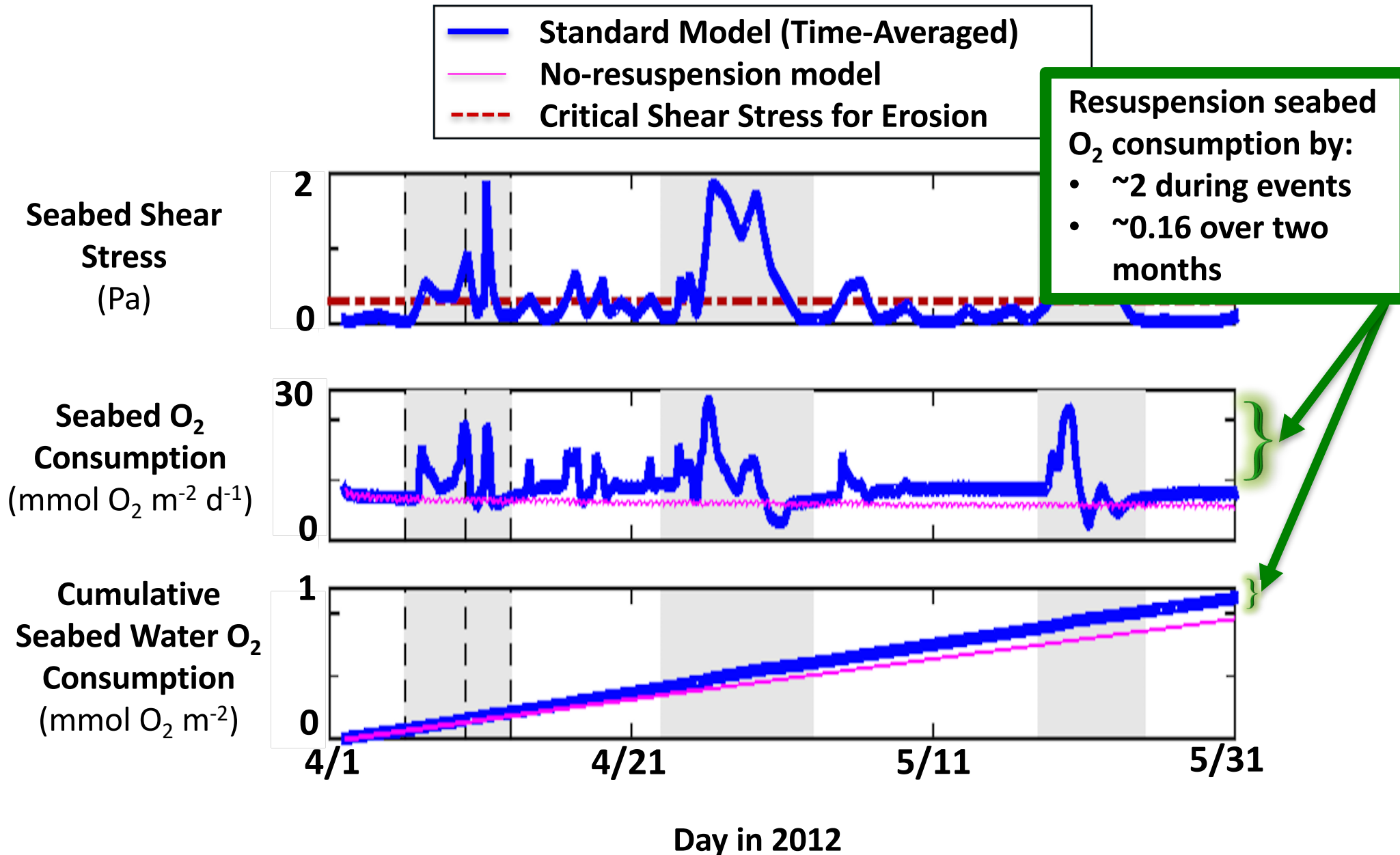
Sediment	Type	τ_{cr} (Pa)	W_s (mm/s)	Fraction
Mississippi	Large flocs	0.11	1	50%
	Small flocs	0.11	0.1	50%
Atchafalaya	Large flocs	0.03	1	10%
	Small flocs	0.03	0.1	90%
Sea bed	Sand	0.13	10	Spatially variable, see Fig. 3B
	Mud	0.11	1	

Model Implementation for the Northern Gulf of Mexico

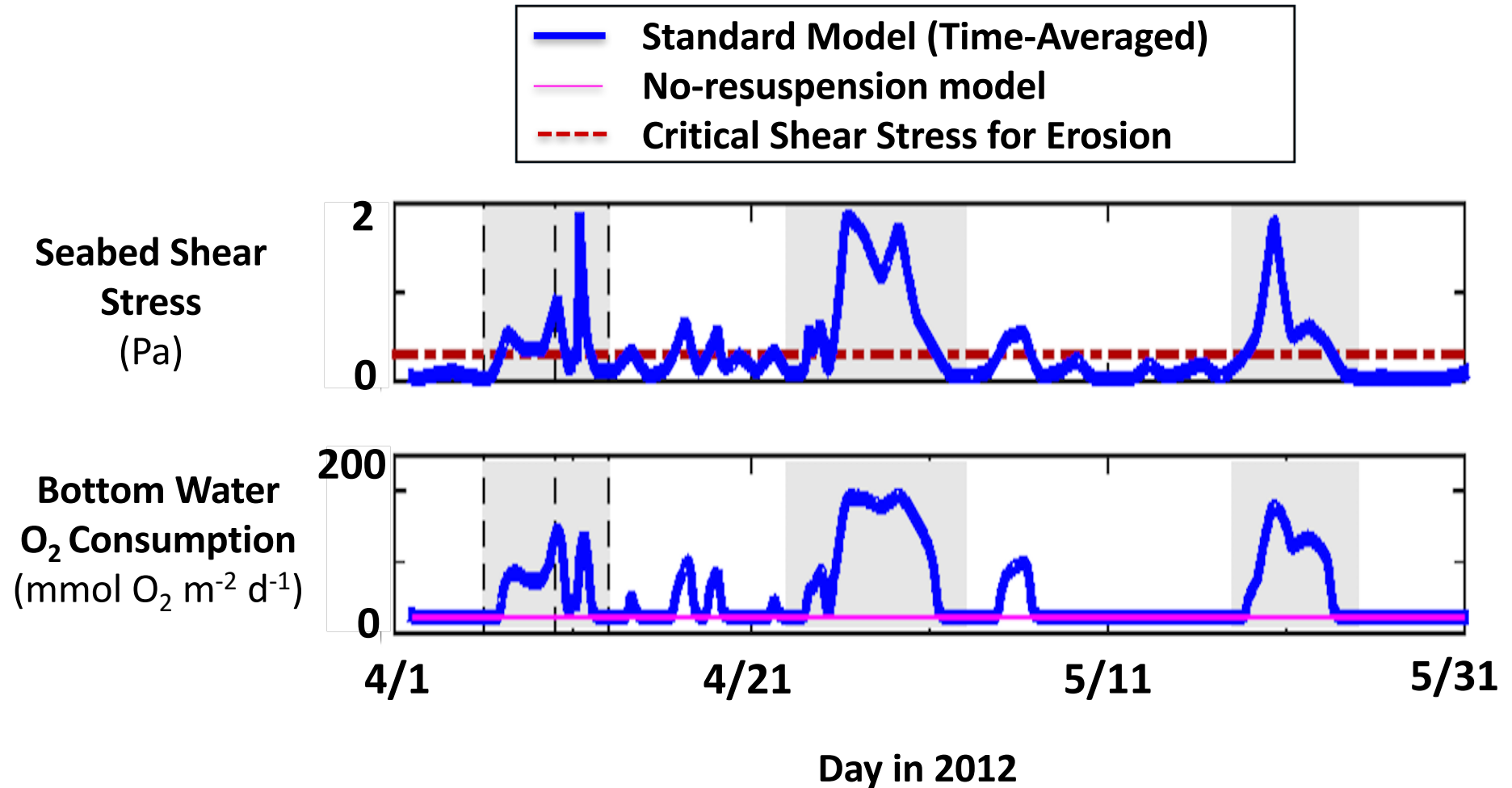
Forcing for 2006-2007



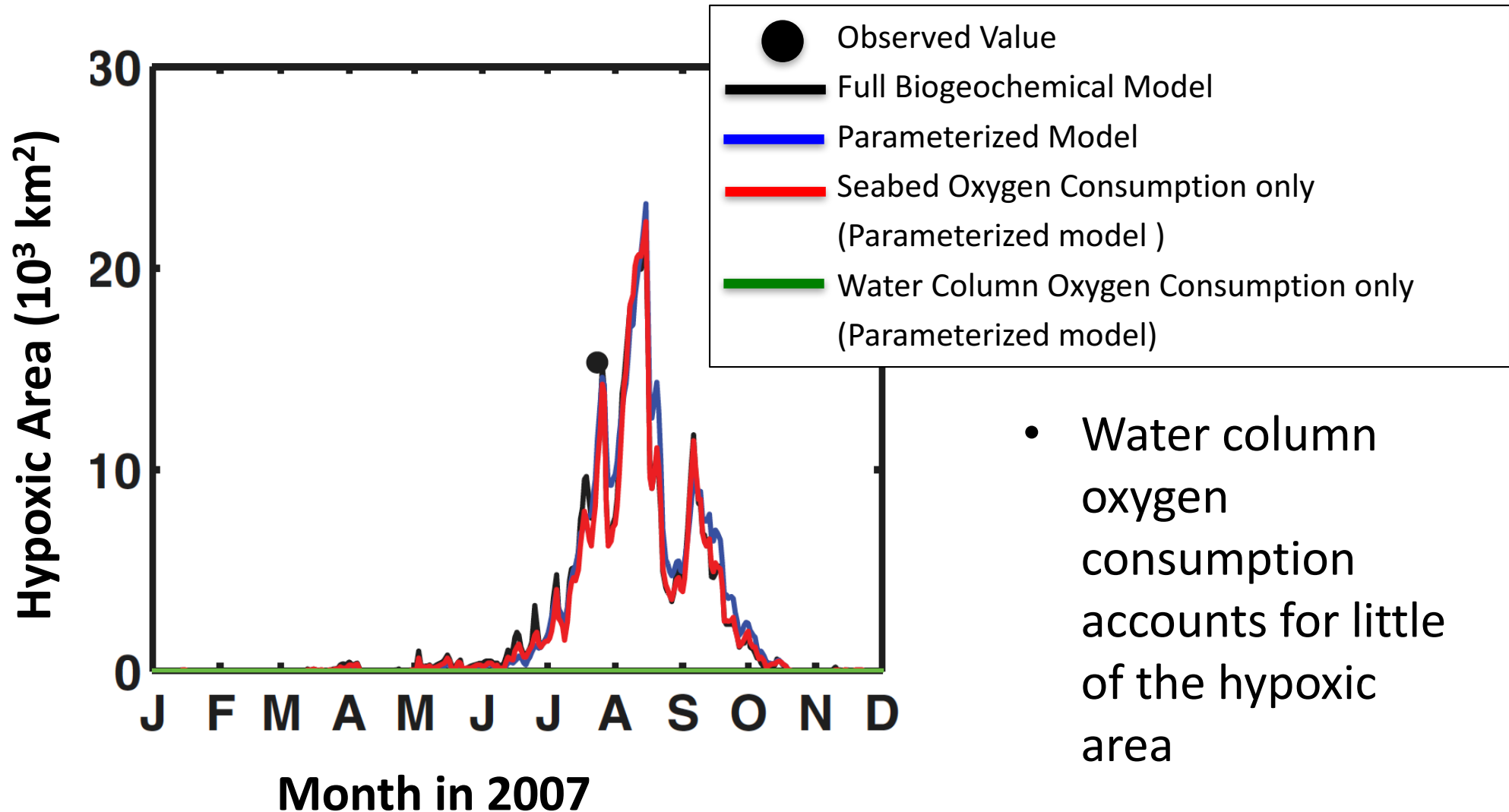
Rhone Delta: Resuspension increased seabed oxygen consumption



Rhone Delta: Decomposition of Resuspended Organic Matter Increased Bottom Water Oxygen Consumption

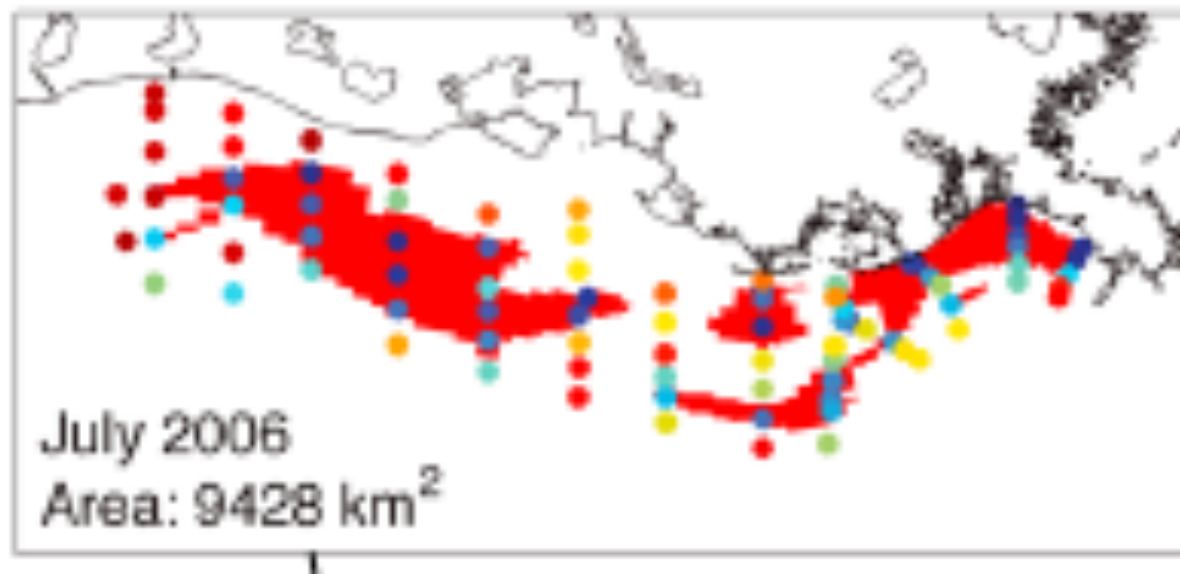


In Northern Gulf of Mexico,
seabed oxygen consumption can account for almost
all of hypoxic area



- Water column oxygen consumption accounts for little of the hypoxic area

Figure from Fennel et al. (2013)



- Observations from summer hypoxia cruises (e.g. see Rabalais et al., 2002)