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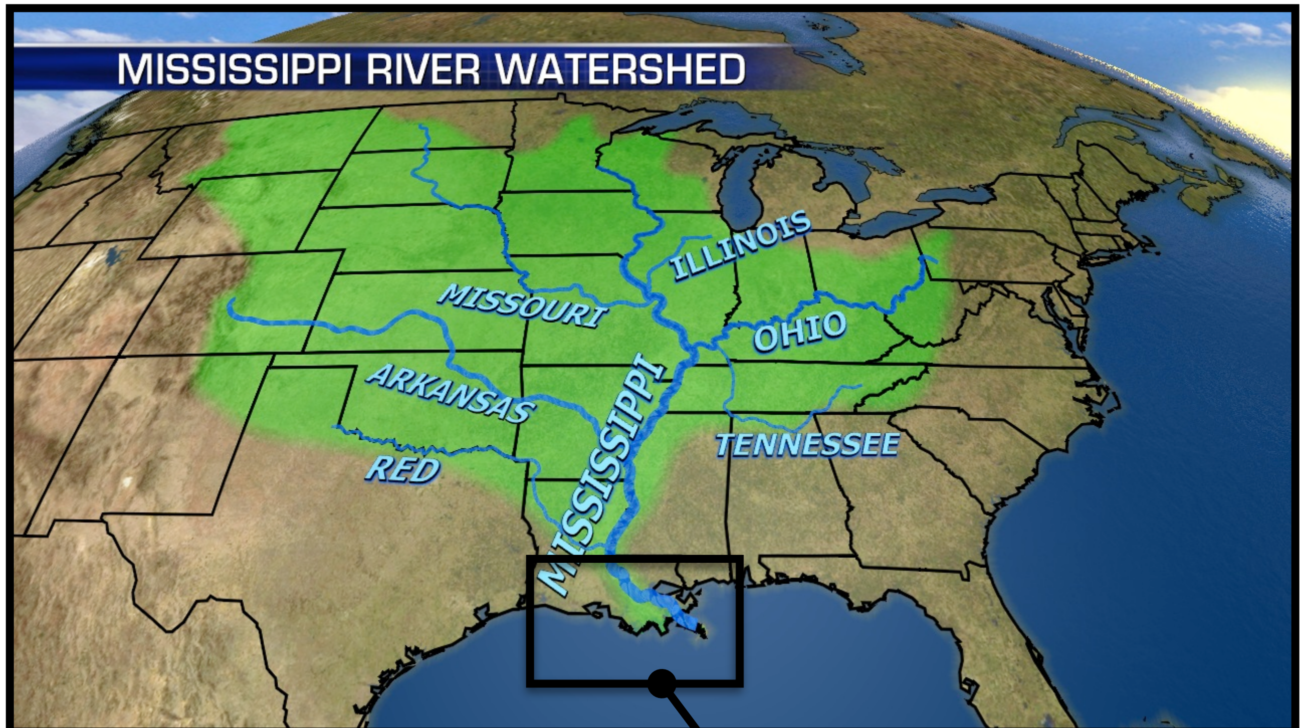
Processes controlling eutrophication-induced acidification in the northern Gulf of Mexico: Current state and projected changes from a coupled physical-biogeochemical model

A. Laurent[1], K. Fennel[1], L. Barbero[2,3], W.-J. Cai[4], W.-J. Huang[5], D. Ko[6], J. Lehrter[7] and R. Wanninkhof[3]

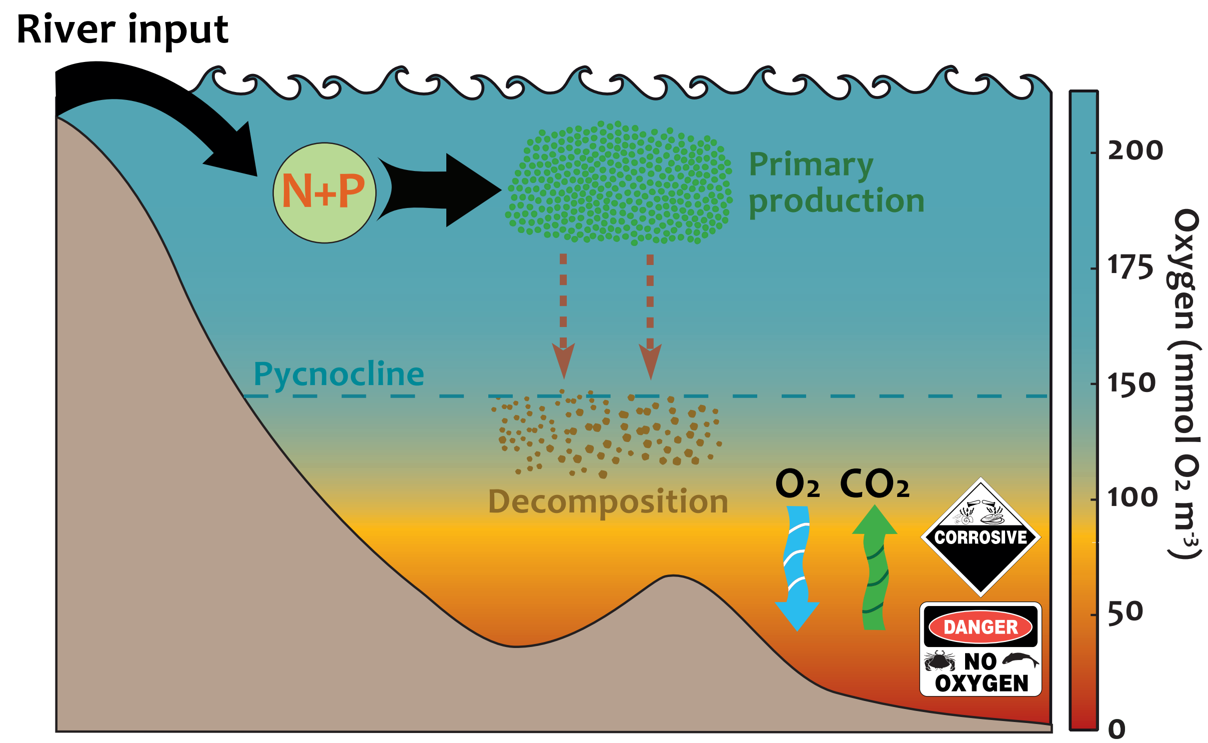
Session AH41A: Nutrient Enhanced Coastal Acidification and Hypoxia

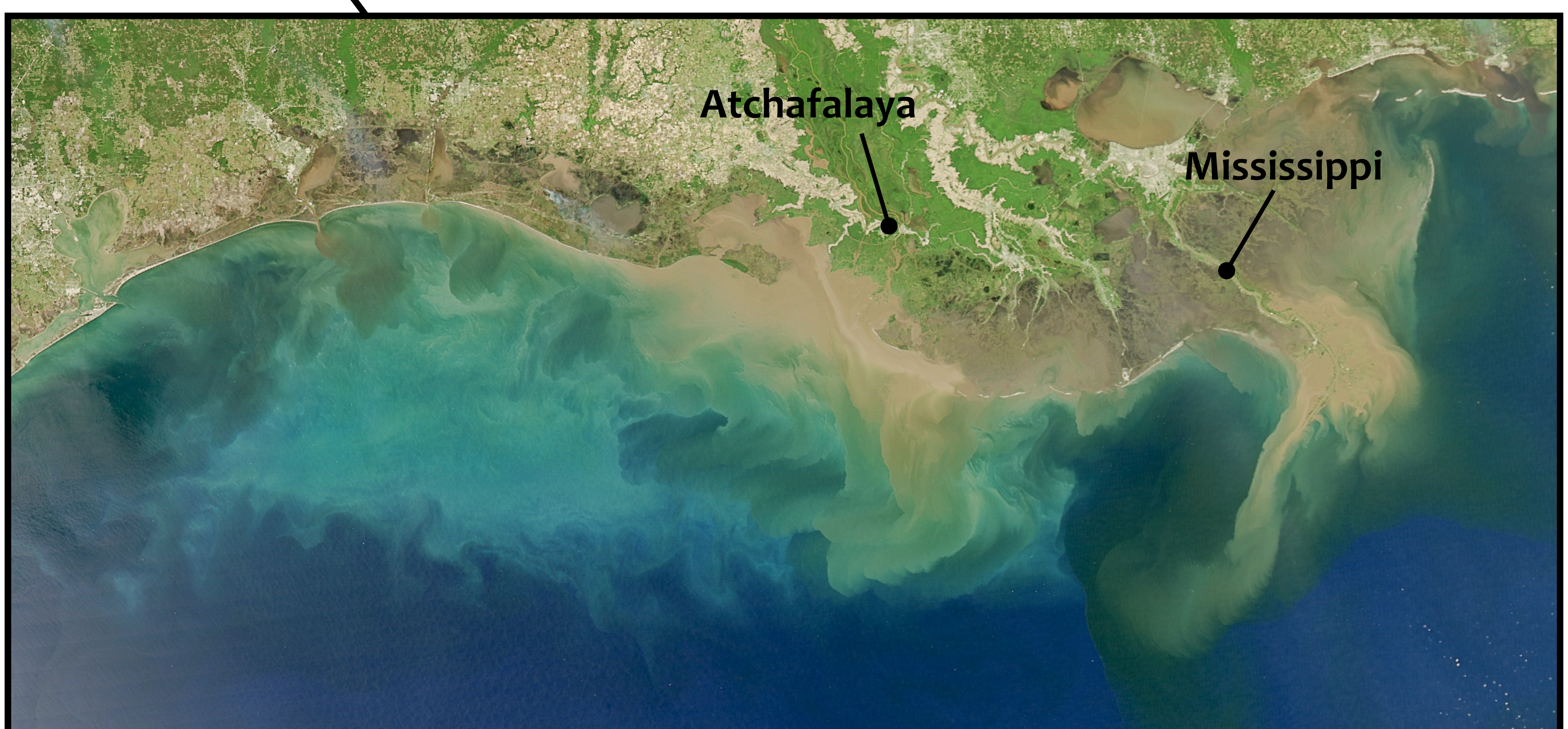
[1] Department of Oceanography, Dalhousie University, Halifax, Canada
[2] CIMAS/U. Miami, Miami, USA
[3] NOAA/AOML, Miami, USA
[4] University of Delaware, Newark, USA
[5] Department of Oceanography, National Sun Yat-sen University, Kaohsiung, Taiwan
[6] Naval Research Laboratory, Stennis Space Center, USA
[7] US EPA, Gulf Ecology Division, Gulf Breeze, USA

1. Introduction



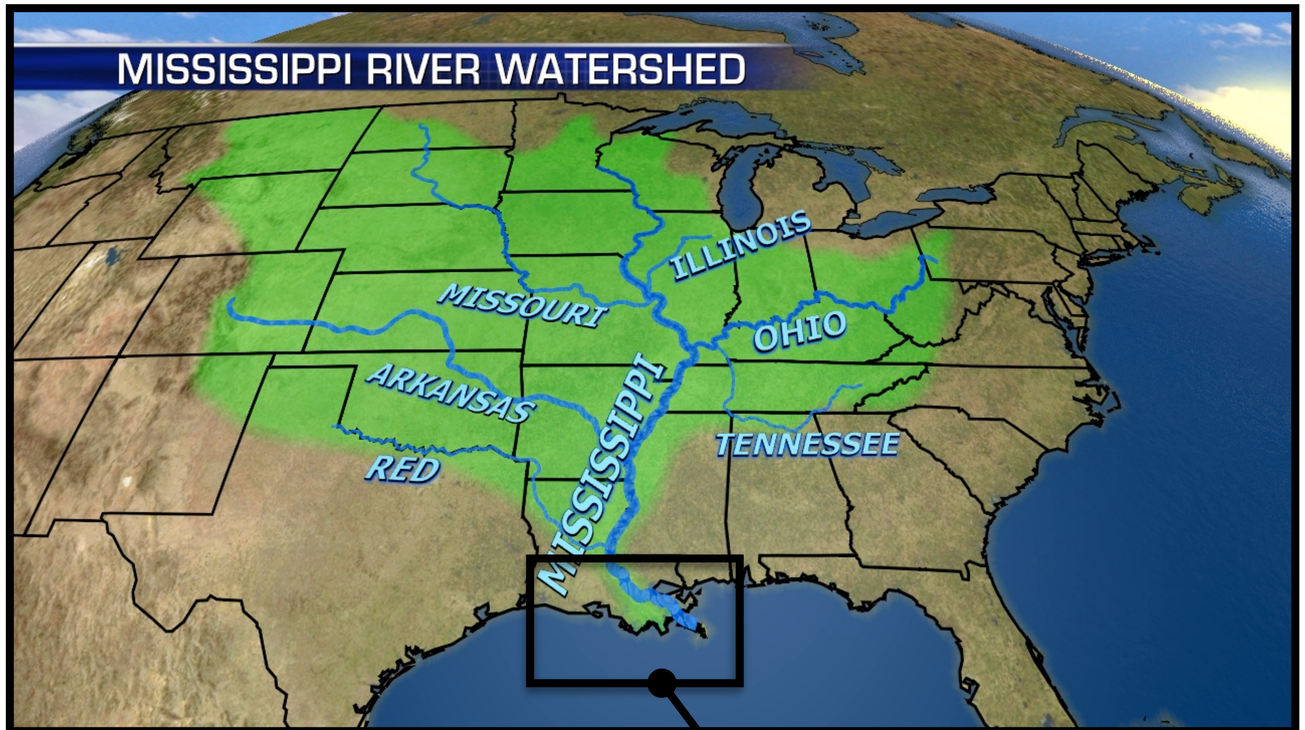
source: http://weather.blogs.foxnews.com





source: http://eoimages.gsfc.nasa.gov

1. Introduction



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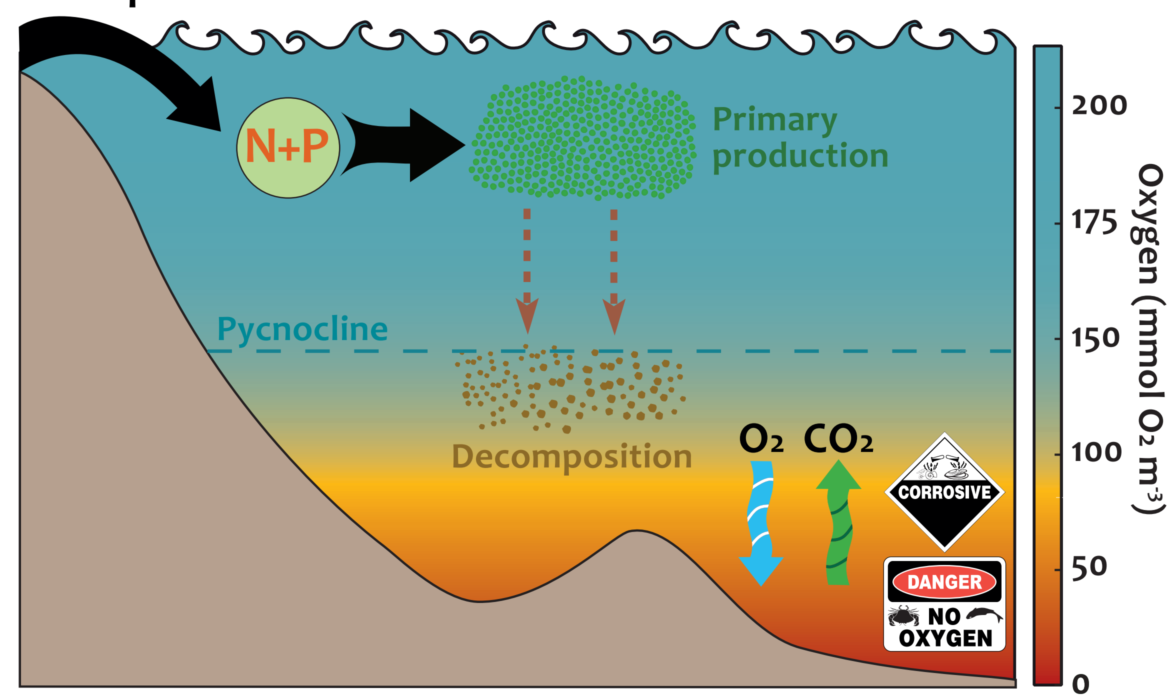

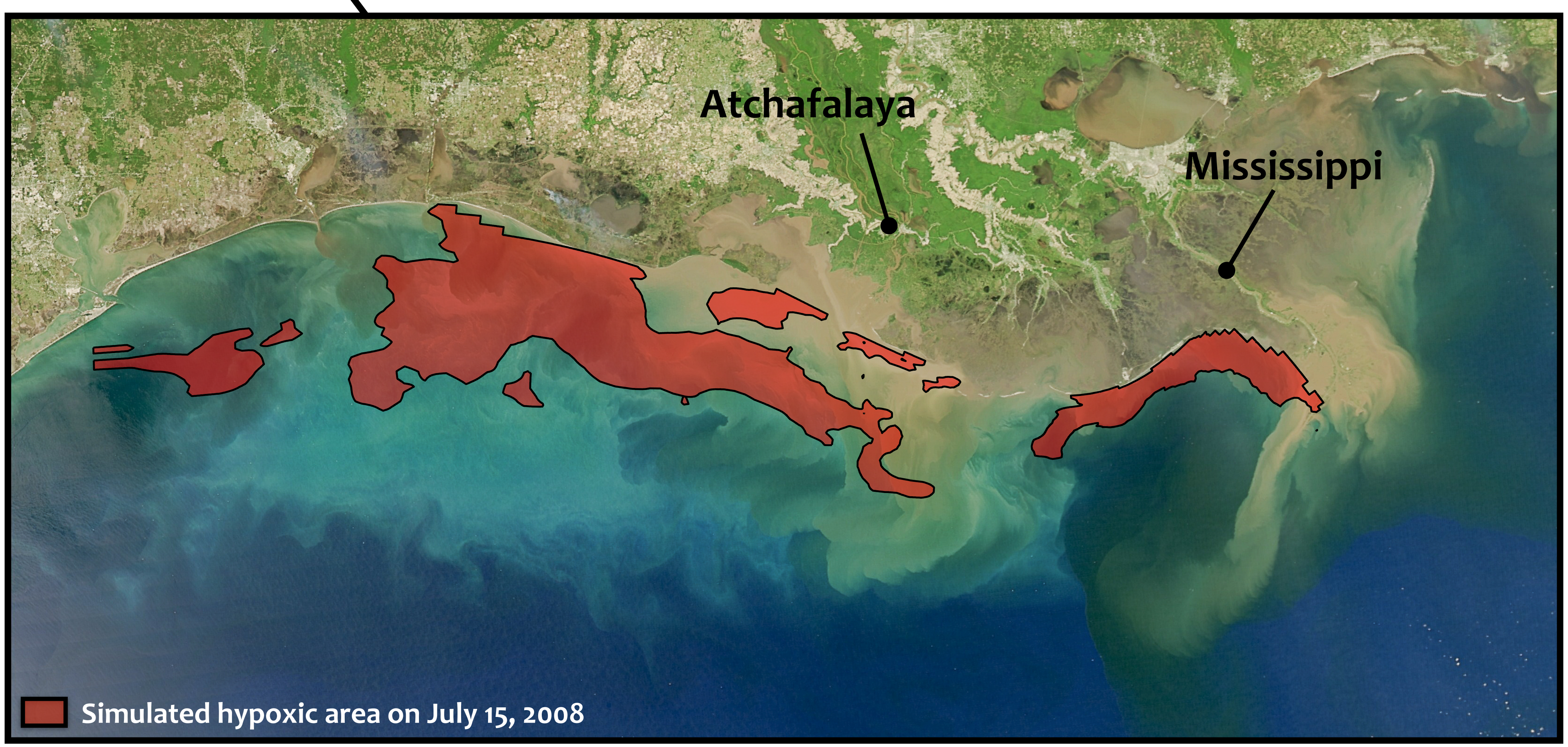

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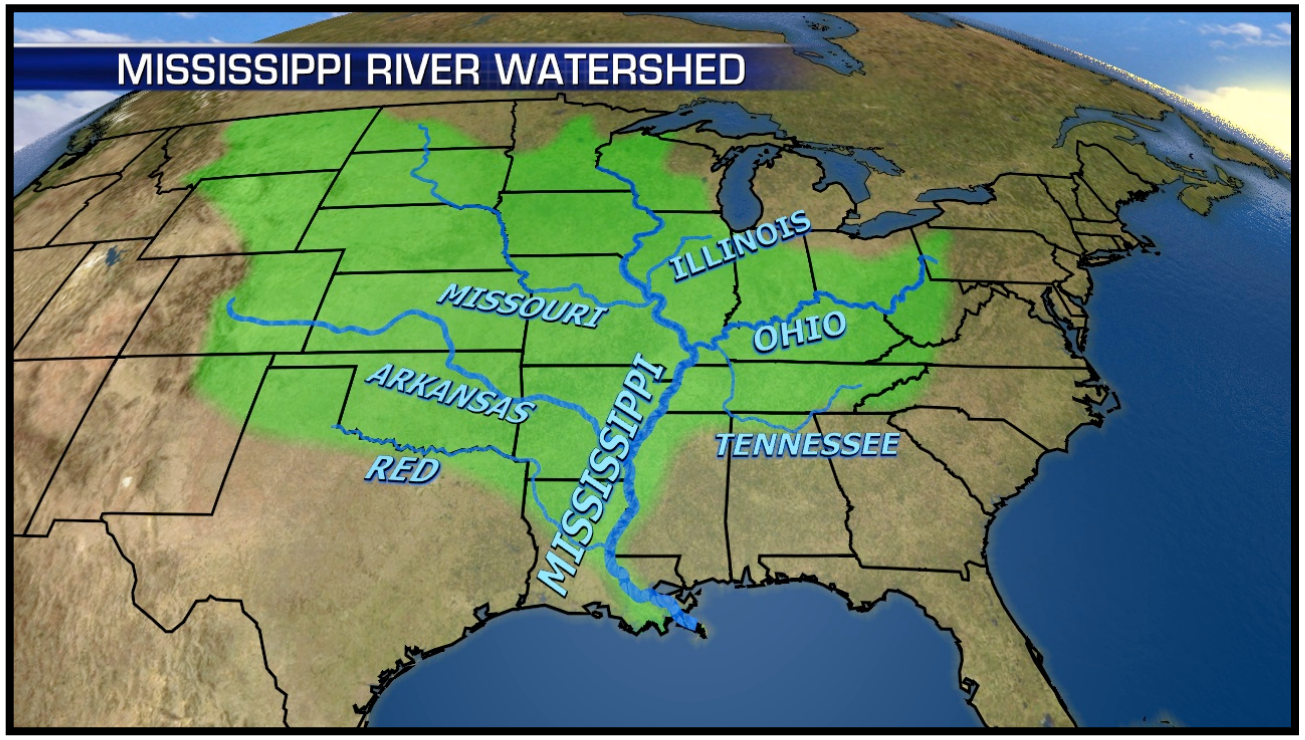
2. Objectives



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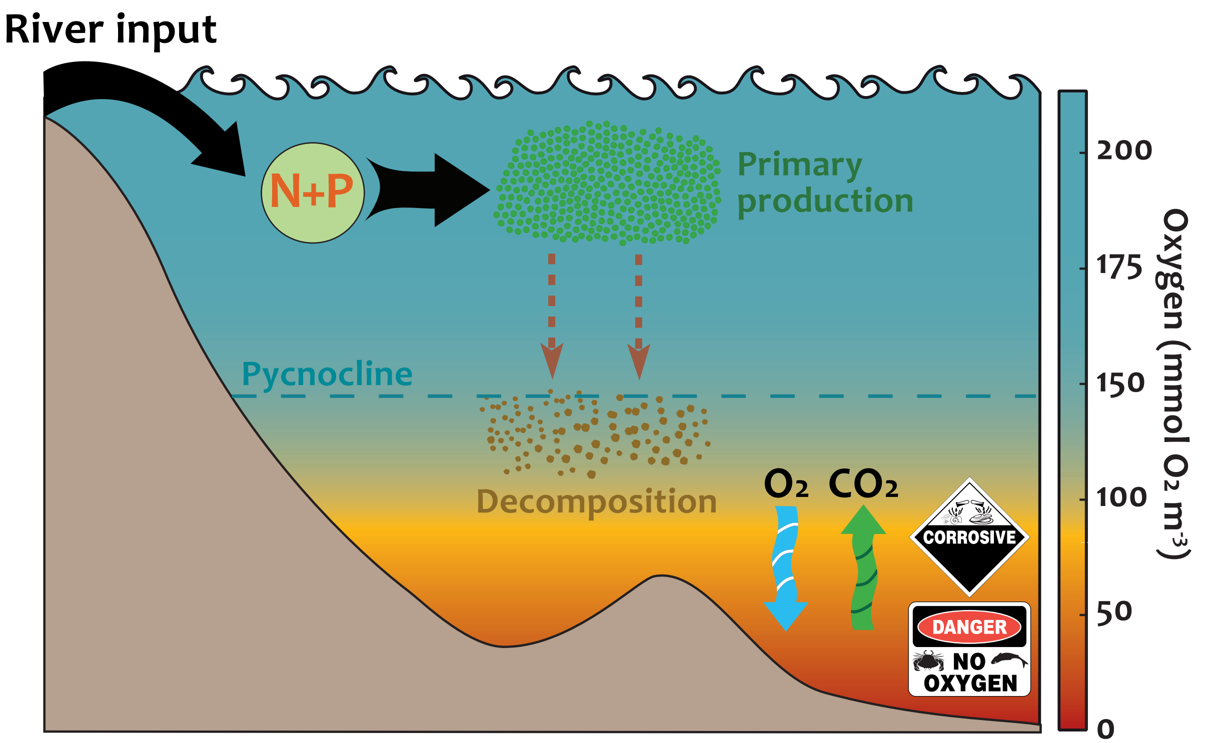
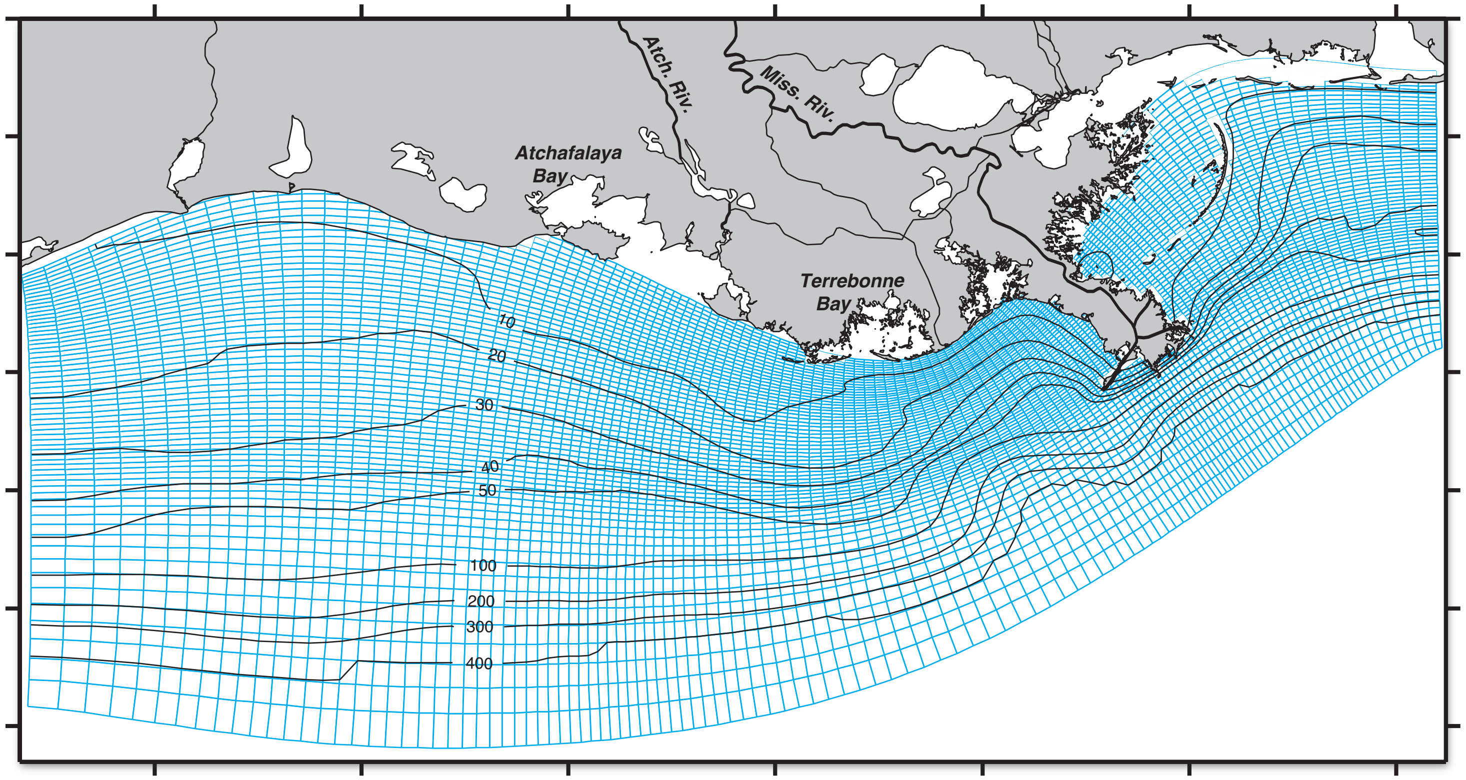


1. Investigate the current state of acidification on the Louisiana Shelf and its controlling processes

2. Simulate projected changes in a high CO_2 world (2100)

3. Modeling framework



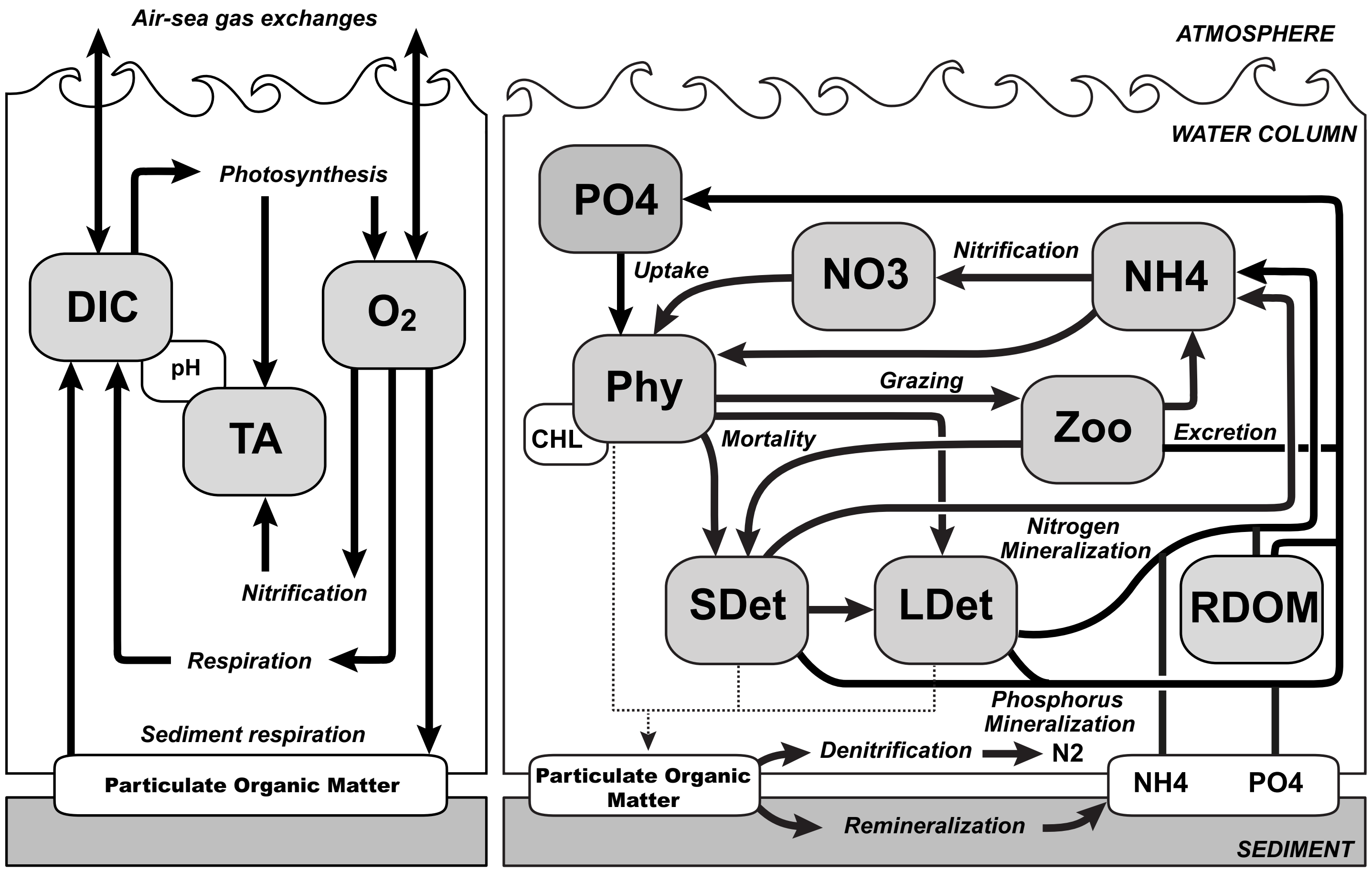
Circulation model (ROMS)

Resolution: 3-5 km in horizontal, 20 vertical layers

Forcing: 3-hourly winds; climatological surface heat and freshwater fluxes

River inputs: daily freshwater input (U.S. Army Corps of Engineers); monthly nutrient and particulate matter loads (USGS)

Boundary conditions: climatology



Biogeochemical model

Nitrogen cycle

see Fennel et al 2006, GBC; *Laurent & Fennel 2014, Elementa; Yu et al 2015, Biogeosciences*

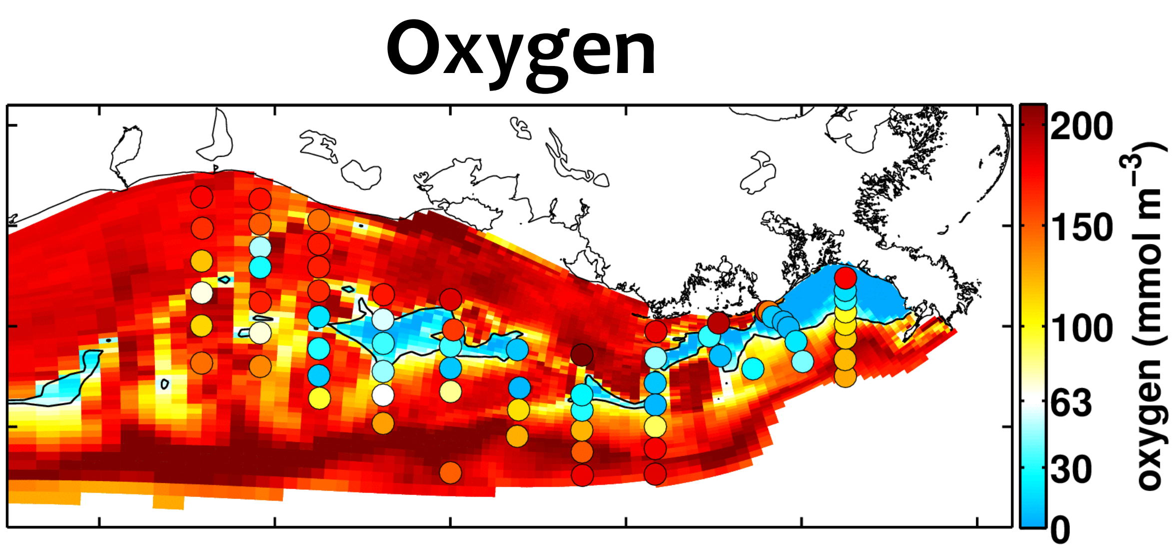
- *6 N-cycle state variables + O2*
- *PO4 and river DOM additional state variables*

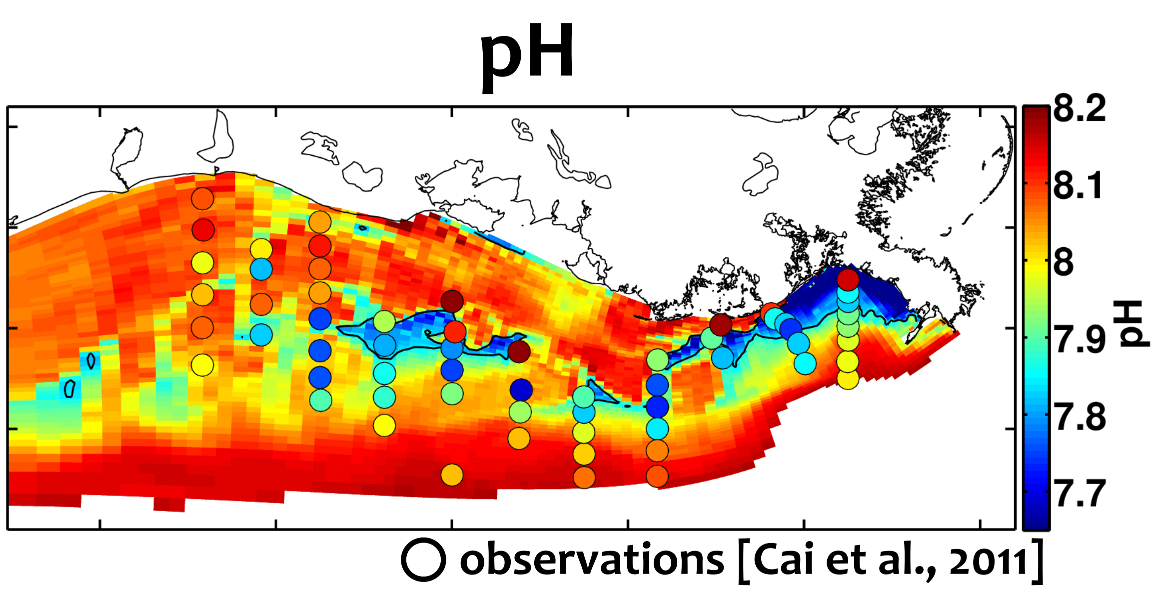
Carbon cycle

see Fennel et al 2008, GRL

- Initial, boundary and river TA and DIC determined from observations Cai et al (2010, 2011)
- Climatological atmospheric pCO2
- Bottom DIC flux function of sediment oxygen consumption (SOC)

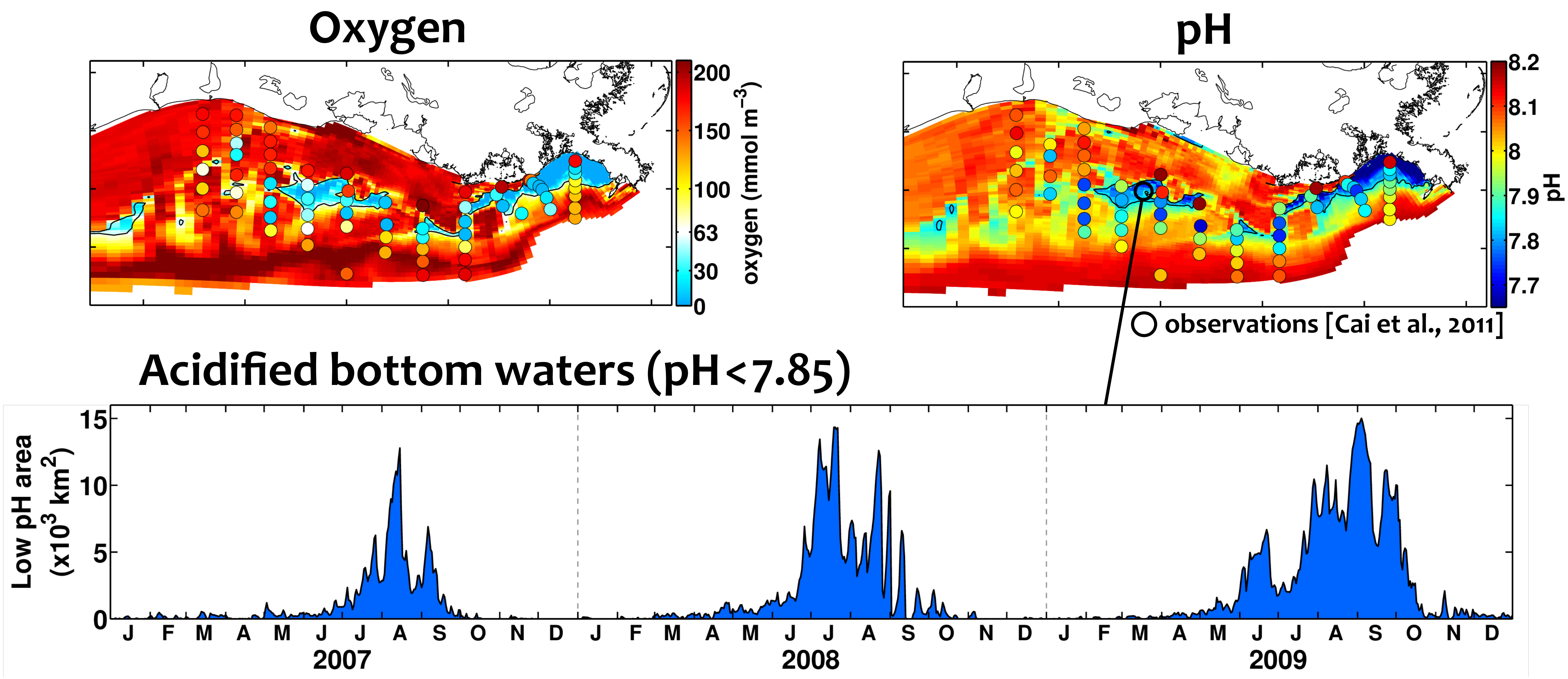
4.1 Current state





Laurent et al., submitted to GRL

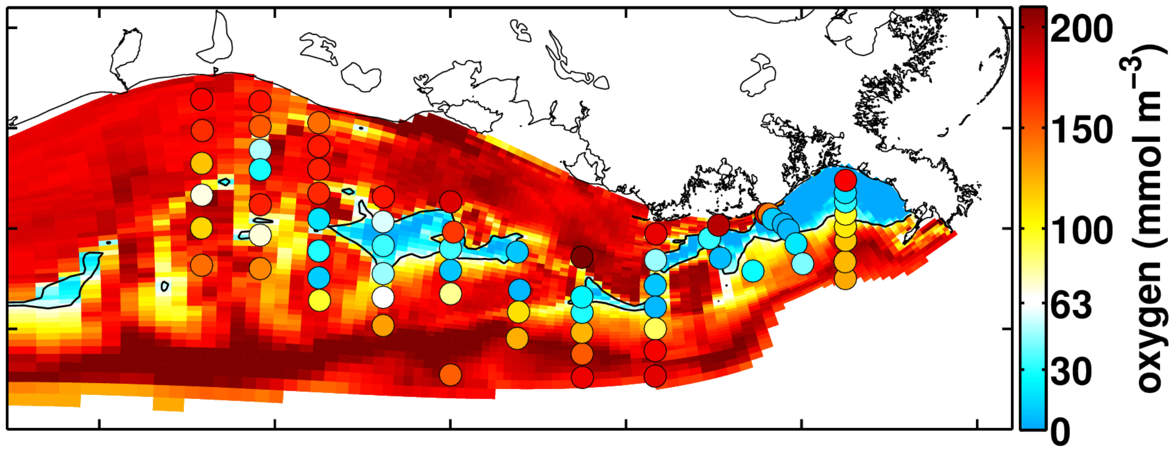
4.1 Current state



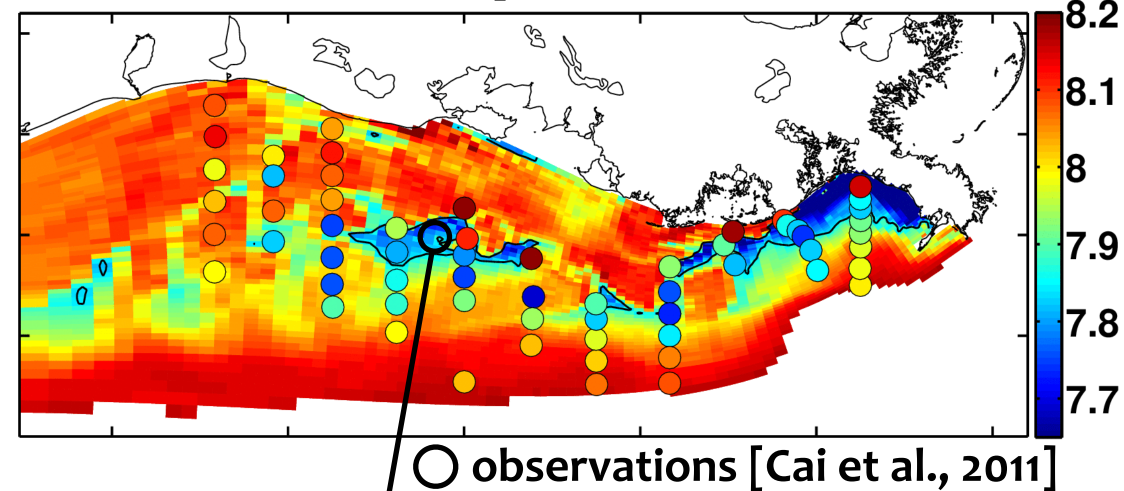
Laurent et al., submitted to GRL

4.1 Current state

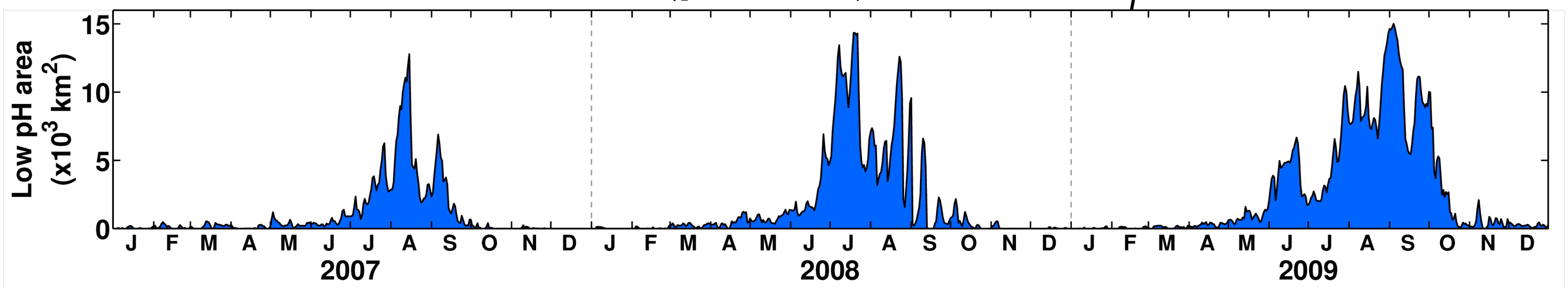
Oxygen



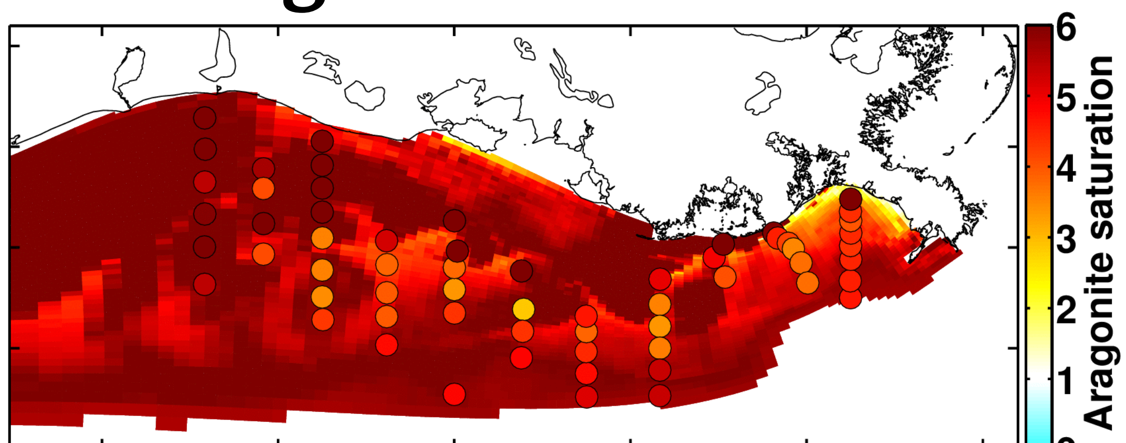
pH



Acidified bottom waters (pH<7.85)



Aragonite saturation

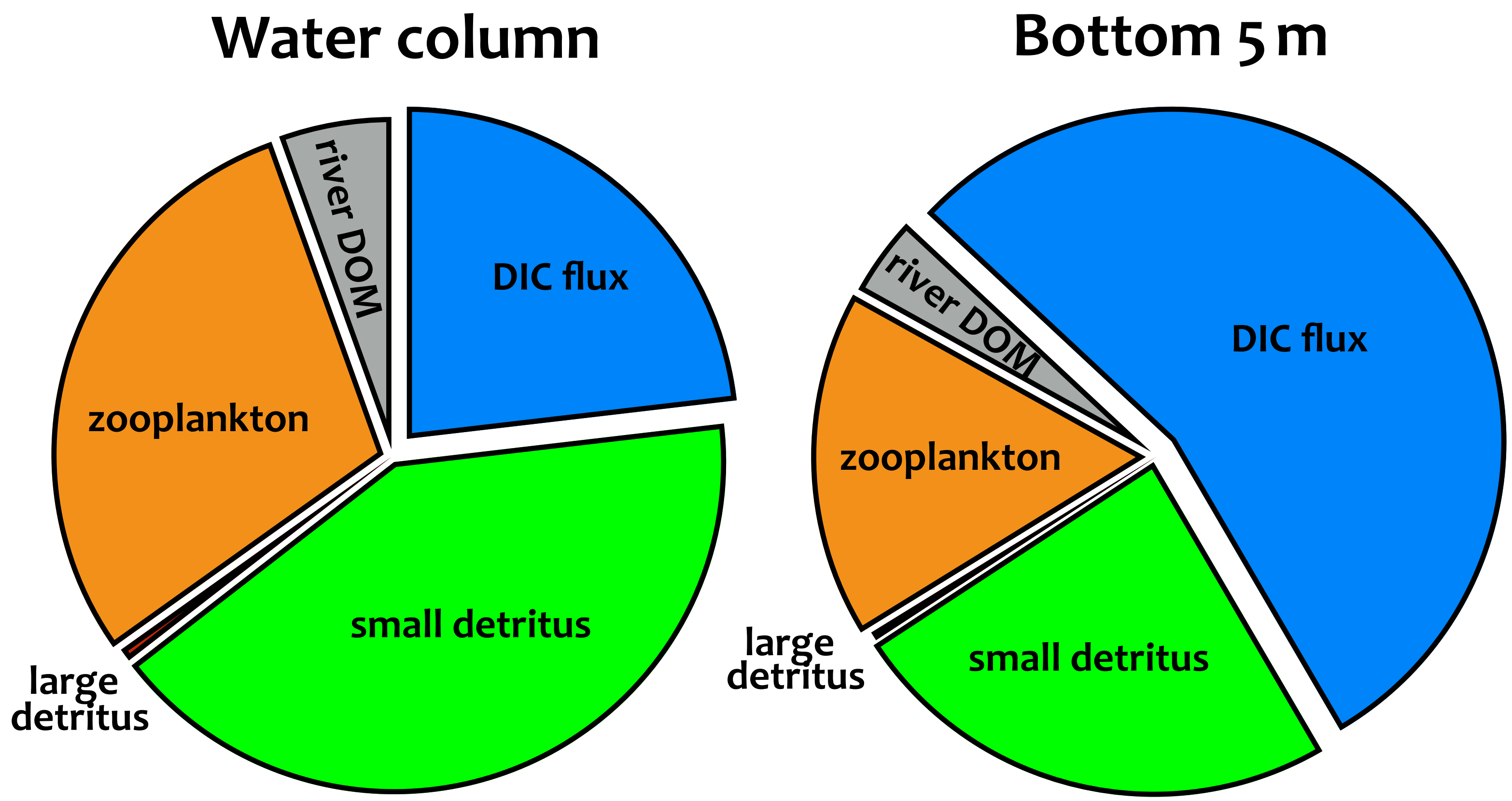


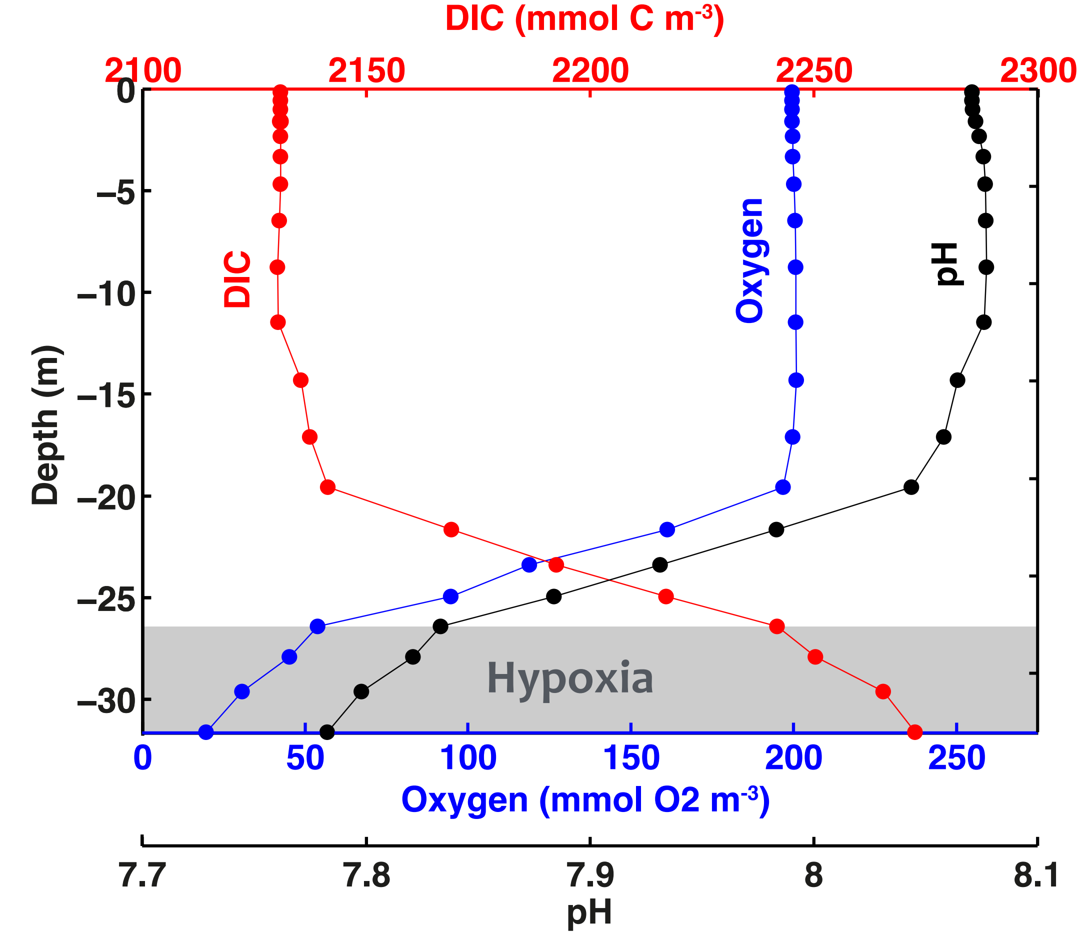
Currently, despite an extensive area of acidified waters, bottom waters are not corrosive to calcifying organisms.

Laurent et al., submitted to GRL

4.1 Current state

DIC production processes





1. Nitrification has a negligible effect on pH

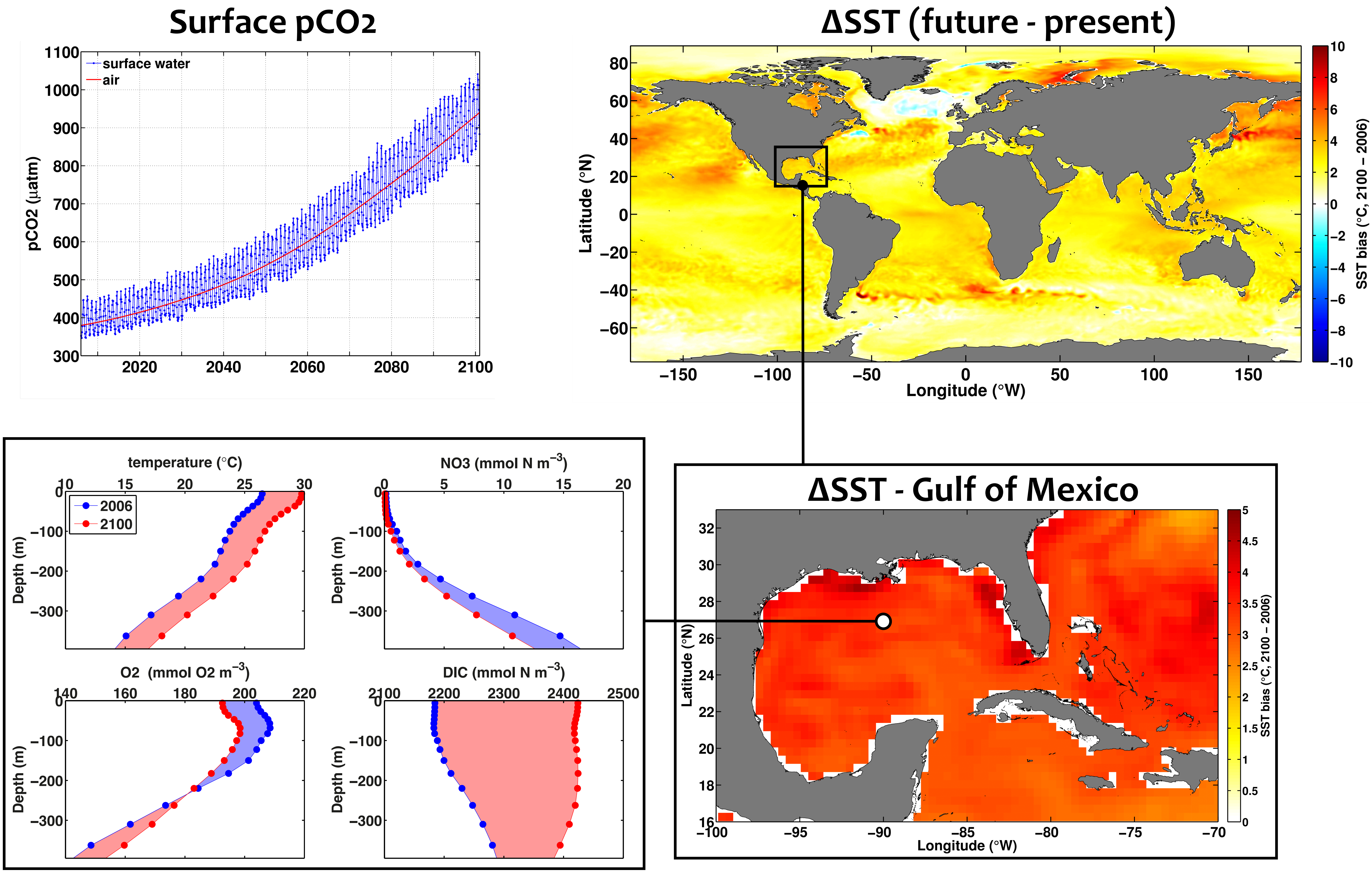
2. River DOM does not contribute significantly to acidification

3. Small detritus remineralization is the dominant DIC production process in the water column

4. Within the bottom 5 m, where acidification occurs, sediment-water DIC flux is the dominant DIC production process, hence has a dominant effect on acidification

4.2 Projected changes

MPI Earth System Model (CMIP5, RCP 8.5)



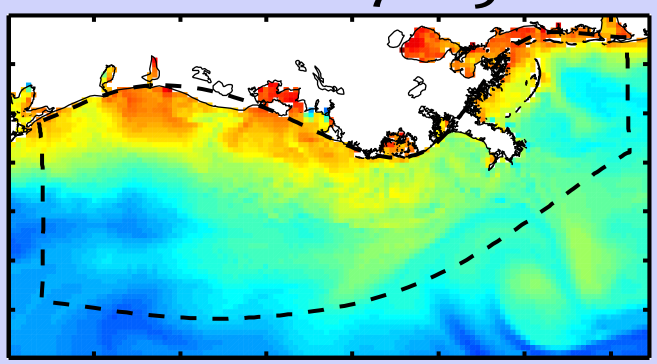
4.2 Projected changes

Two experiments to assess future changes

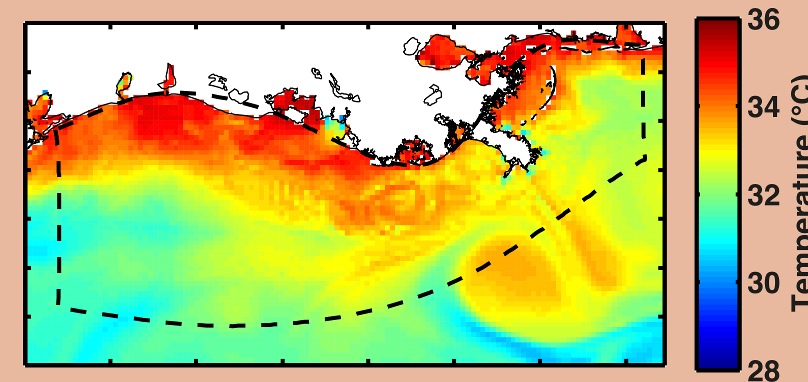
Present (2005-2007)	Future (3 years, ca. 2100)

- **Physics**
  - boundary/initial conditions from the regional IASNFS model

SST 2007-08-30

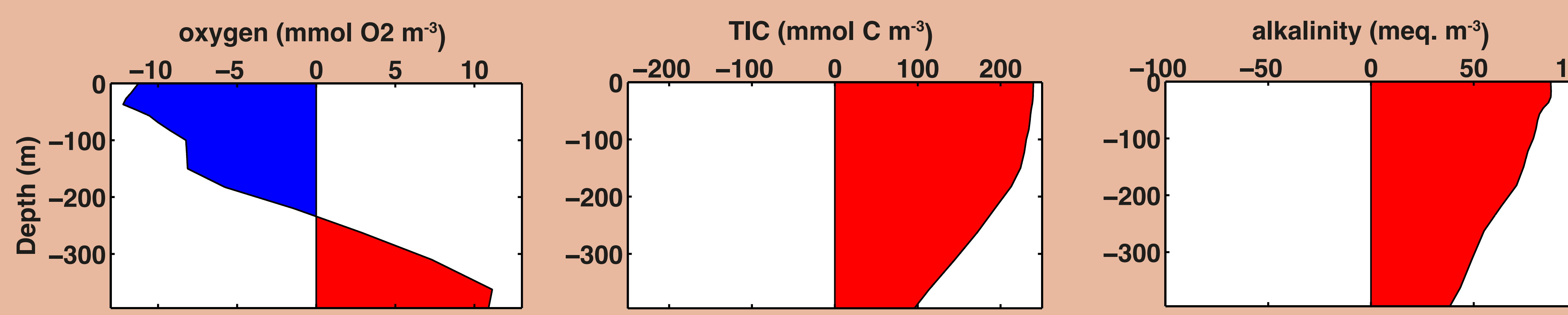


- T^{air} +3°C, river discharge +10%



- **Biology**
  - Present: same as for "current state"
  - Future:
    - $pCO2^{air}$ = 935 µatm (RCP 8.5)
    - Present + ΔBio from MPI-ESM

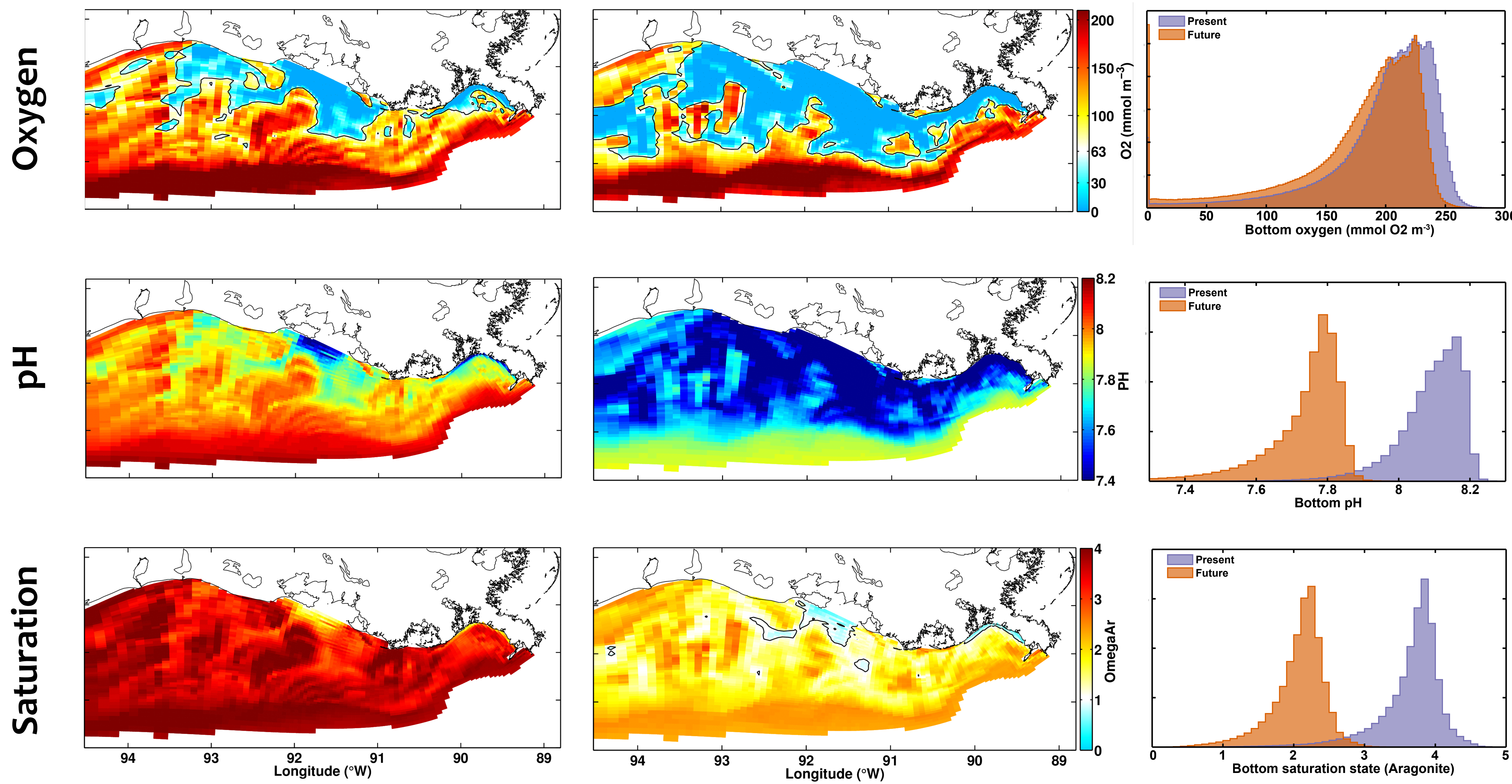
ΔO2 **ΔTIC** **ΔAlk.**



4.2 Projected changes

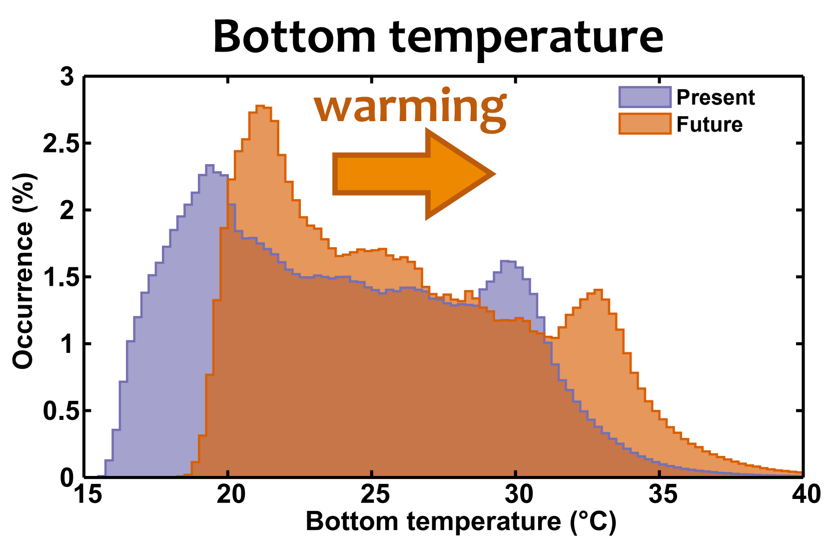
Present | **Future (2100)**

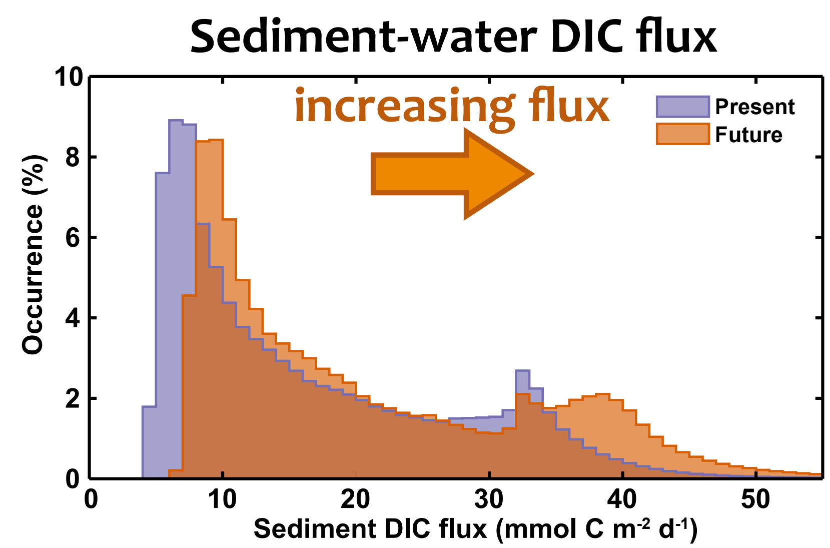
bottom waters in mid August | **June-September**



4.2 Projected changes

- **Increased stratification (+10%) and bottom water temperature (+7%)**
  - Stratification increases the potential for hypoxia and acidification
  - warmer bottom waters influence sediment-water fluxes





- **Expansion of hypoxia and acidification**
  - Doubling of hypoxic area
  - Lower pH (ΔpH = -0.46) due to increased DIC in the water column (+10%) and higher sediment-water DIC flux (+22%)
  - Decrease in aragonite saturation (from 3.8 to 2.1 in summer)

- **Corrosive waters appear but their spatial extent remains limited**

5. Conclusions

Current state

- An extensive area of acidified water occur on the shelf in summer
- These waters remain far from aragonite undersaturation
- Acidification is driven by the release of CO_2 from respiration in the sediment

Projected changes

- More stratification and higher bottom temperature
- Increase of hypoxia (at current nutrient load)
- pH and saturation state are expected to drop significantly
- Limited extent of corrosive waters