Using NASA assets to better understand biogeochemical fluxes at the land/ocean interface

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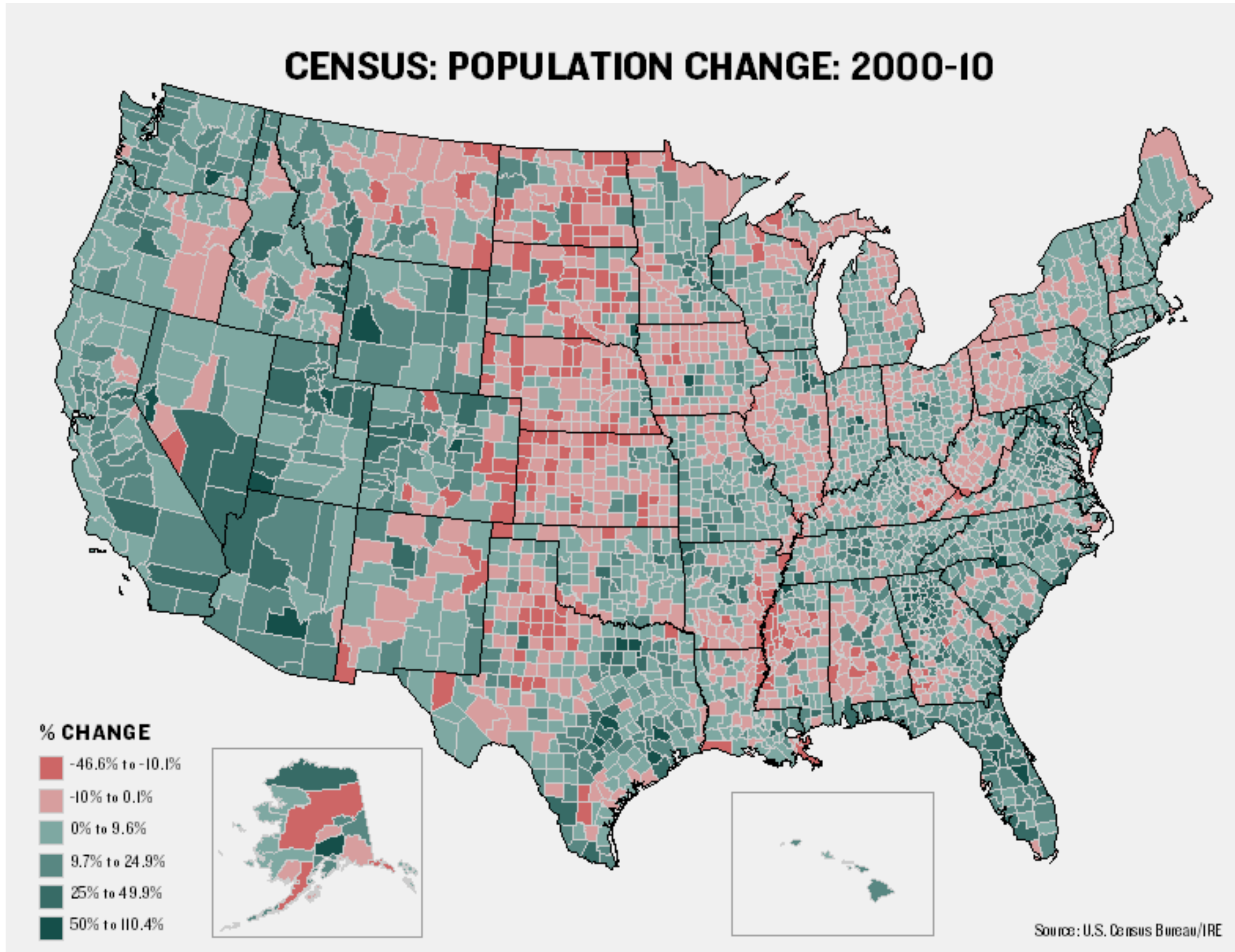
VIMS | William & Mary
Virginia Institute of Marine Science

1940-2015 75 Years

NASA

Motivation:
Why study coastal land/ocean BGC fluxes?

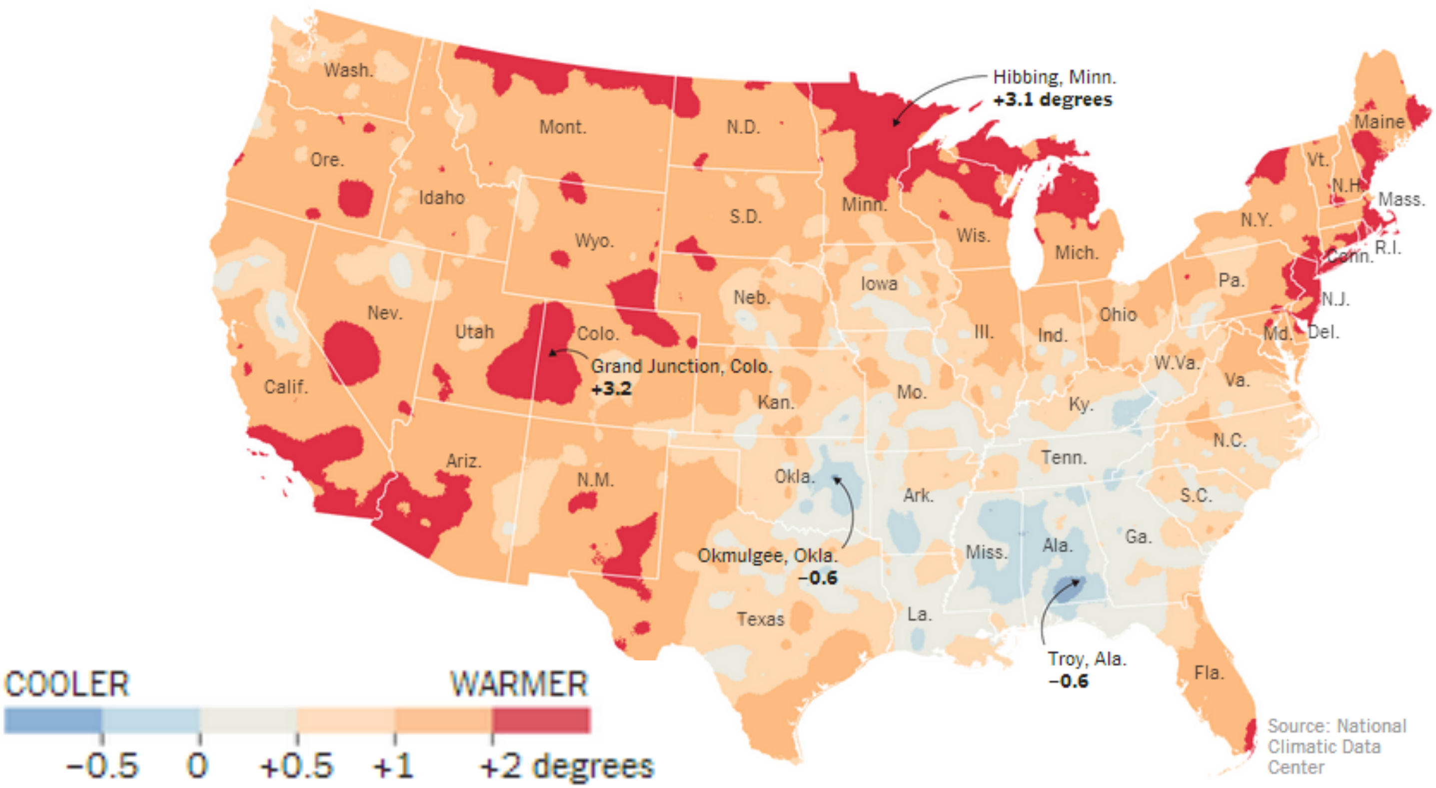
- -50% to -10%
- -10% to 0%
- 0% to 10%
- 10% to 25%
- 25% to 50%
- > 50%



Coastal population density is high and is increasing

Motivation:
Why study coastal land/ocean BGC fluxes?

1991-2012 average temperature compared with 1901-1960 average



How are changes in coastal population density + climate change affecting coastal land/ocean BGC fluxes?

Land/ocean BGC fluxes

→ Where are we coming from?

We know that these changing fluxes are significantly affecting ecosystem services in the coastal zone:

Eutrophication
Harmful algal blooms
Coastal hypoxia
Coastal acidification
Wetlands loss
Fisheries reductions

→ Where are we going?

How much are these changes due to localized anthropogenic effects (LULCC) and can potentially be managed locally

&

how much is due to climate change (sea level rise, increasing temperature and precipitation, changes in storminess) ?

Outline

How are NASA projects diagnosing current land/ocean BGC fluxes along the U.S. east coast?

- Dissolved organic carbon budget on the MAB
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How are NASA projects estimating changing BGC inputs to coastal waters due to climate change and human impacts?

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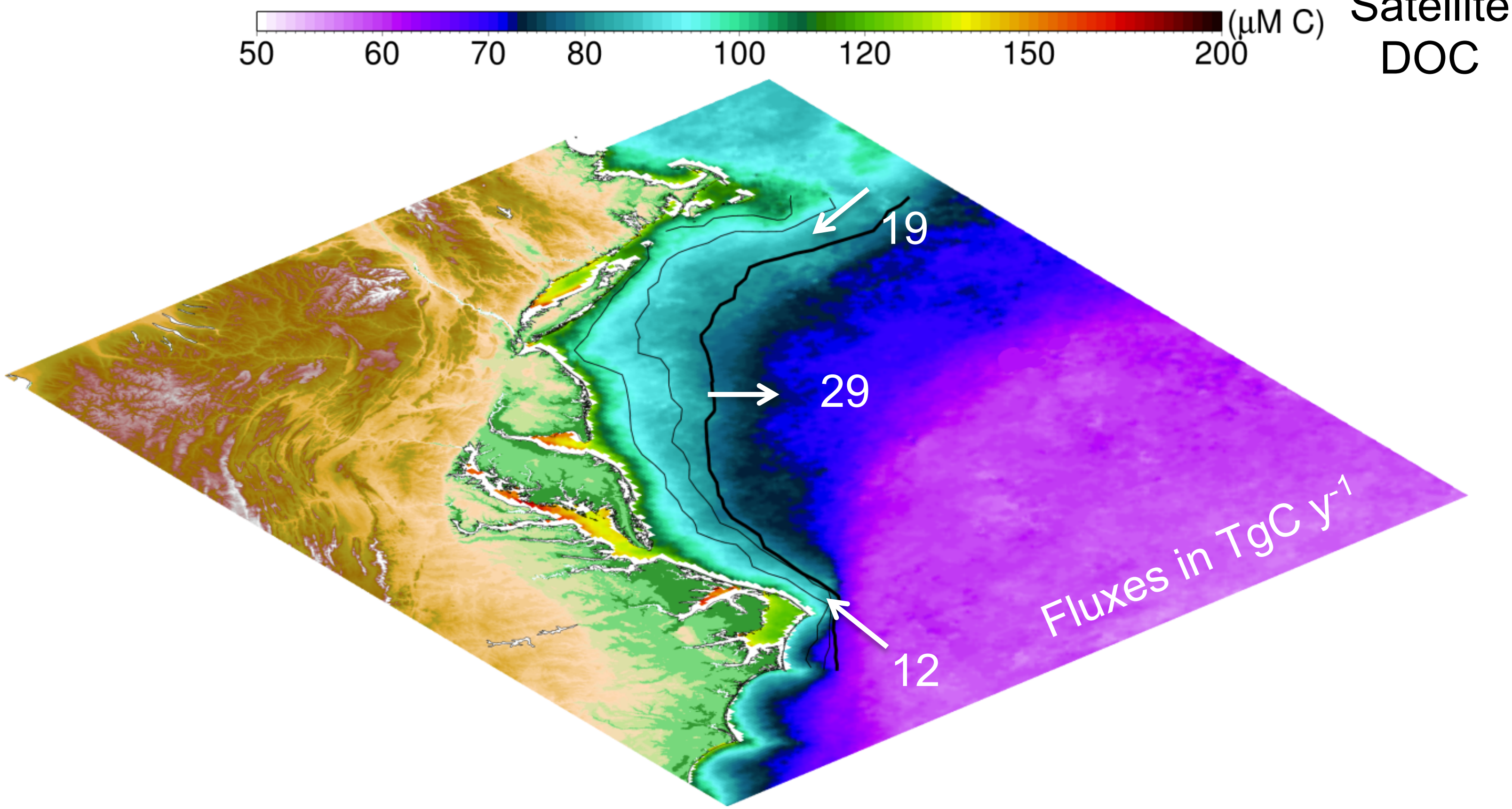
- Great Lakes (land use)
- West Coast (land/water use)
- Gulf of Mexico (land+climate change)
- East Coast (land+climate change)

Future Opportunities

Lateral fluxes of DOC in Mid-Atlantic Bight

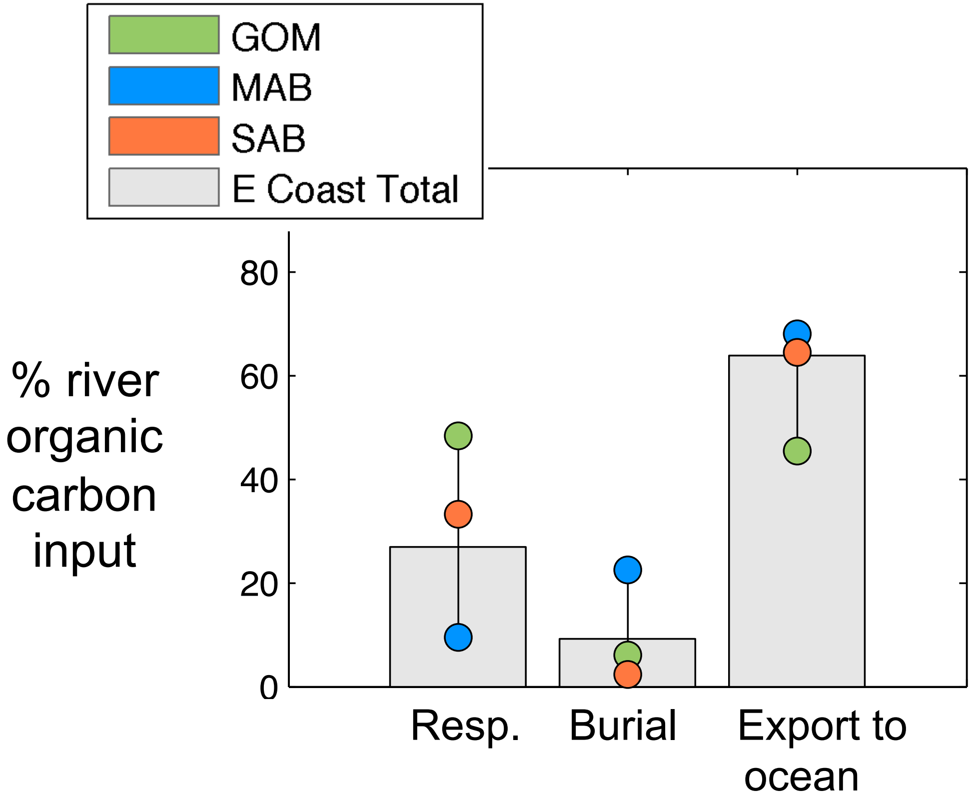
Satellite DOC + circulation model + in situ profiles

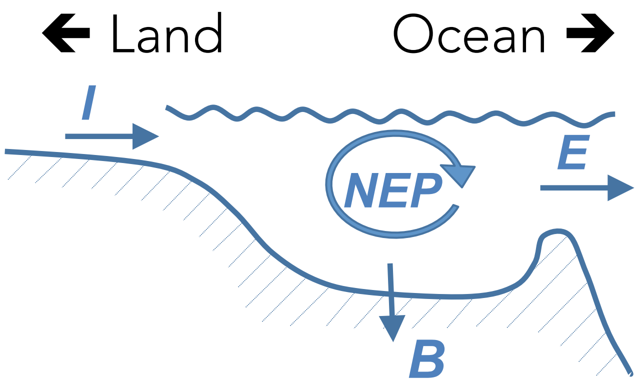


- Develop neural network (NN) model based on observed T, S, DOC, and apply NN model to modeled T, S and satellite DOC to get DOC profiles
- Combine DOC profiles with modeled velocities to get lateral flux of DOC from shelf to open ocean
- Highlights significant interannual variability

[Signorini et al. poster #170]

TOC budget of U.S. East Coast estuaries

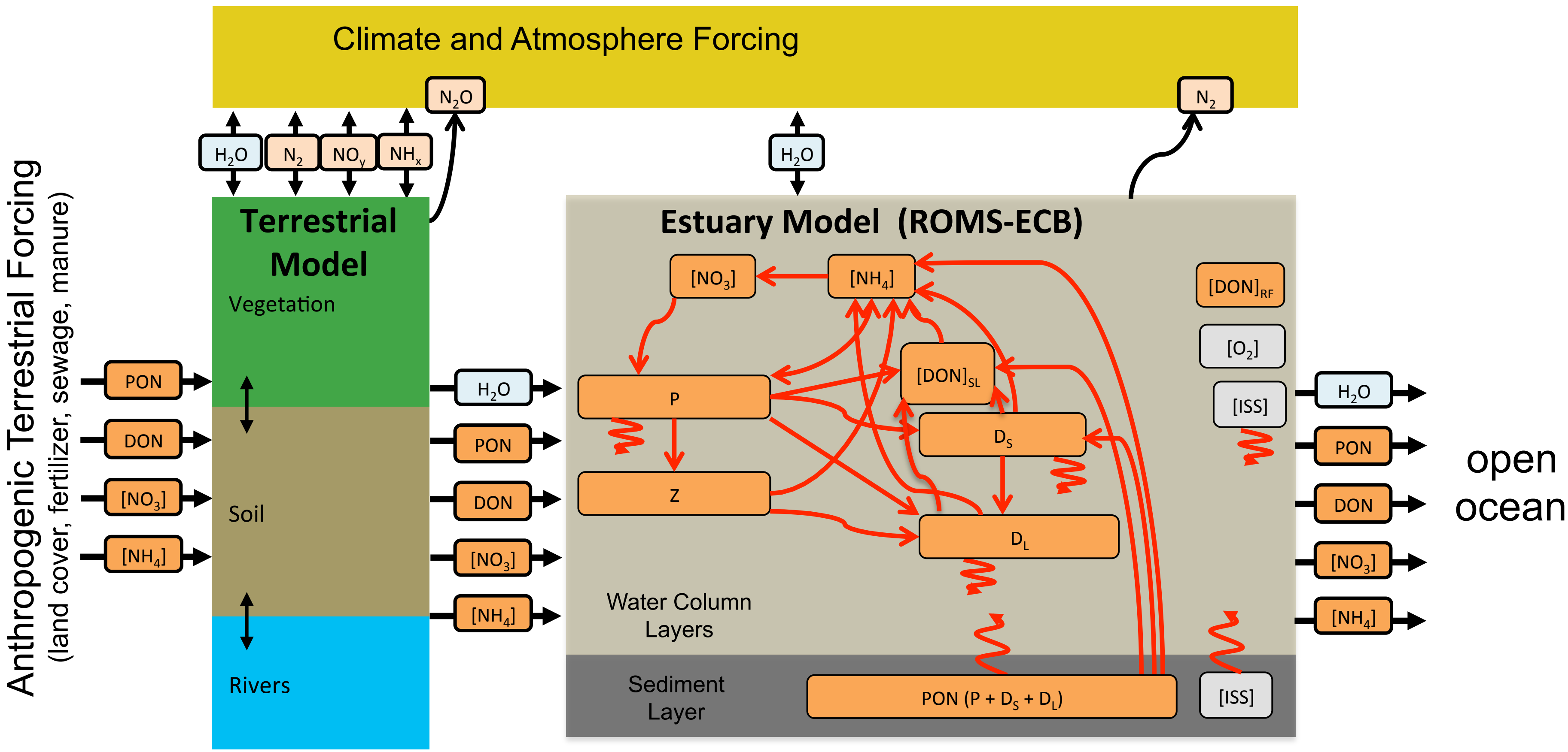




Based on data synthesis, U.S. East Coast estuaries bury and respire ~ 40% of riverine + tidal wetland TOC inputs

[Herrmann et al., 2015 GBC]

U.S. East Coast
Land-Estuarine-Ocean Biogeochemical Modeling System



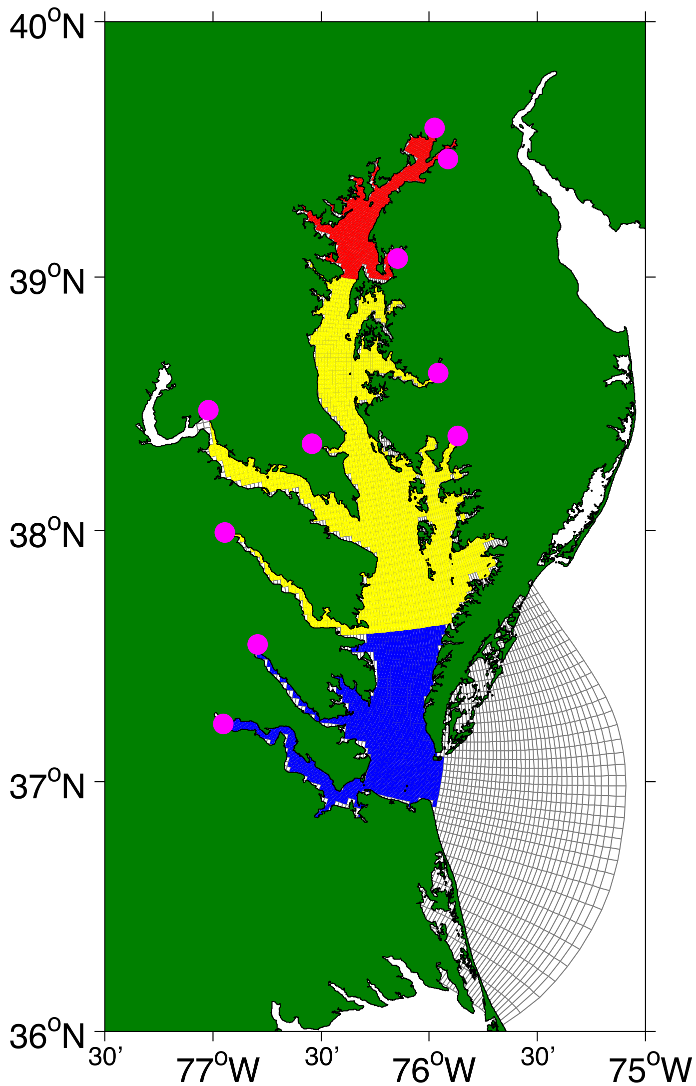
Dynamic Land Ecosystem Model (DLEM)
Tian et al.

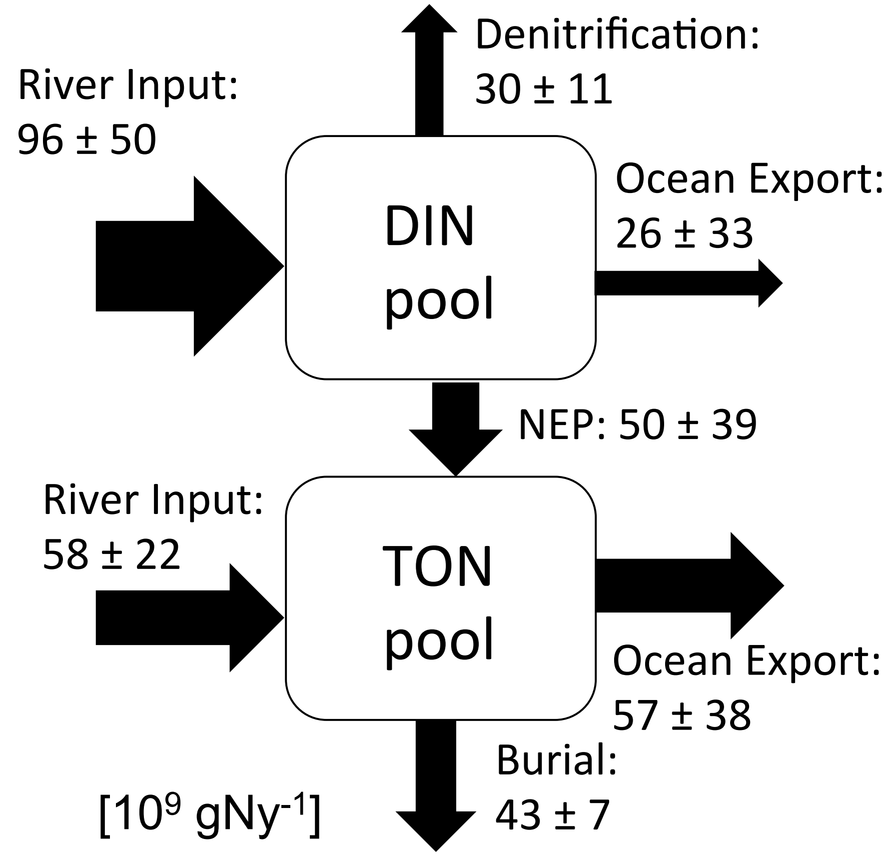
Regional Ocean Modeling System – Estuarine Carbon Biogeochemistry Model
Feng et al.

How much of the nitrogen entering through the rivers make it out to the shelf?

[Feng et al., 2015, JGR-BGS in revision]

ECB Model Chesapeake Bay





- 70% of riverine inorganic N is processed inside the estuary; 30% gets exported
- Similar amounts of organic N coming in from the rivers, gets exported to the shelf

[Feng et al., 2015, JGR-BGS in revision]

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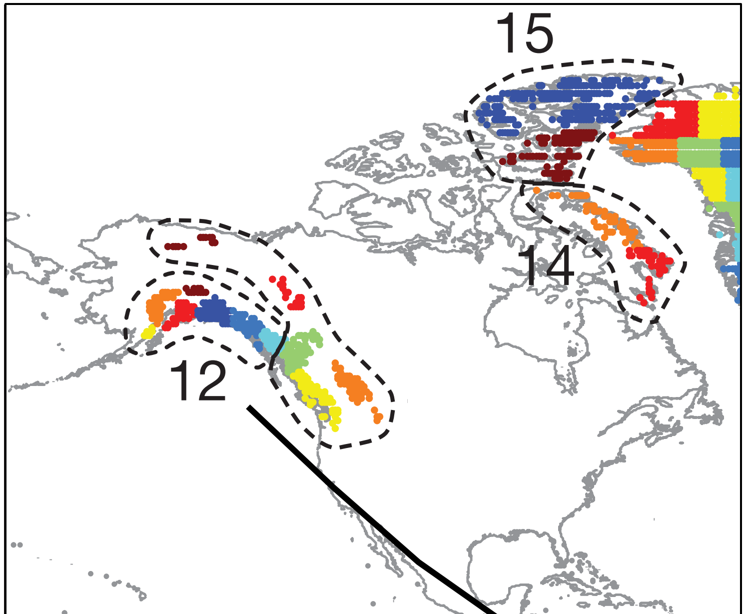
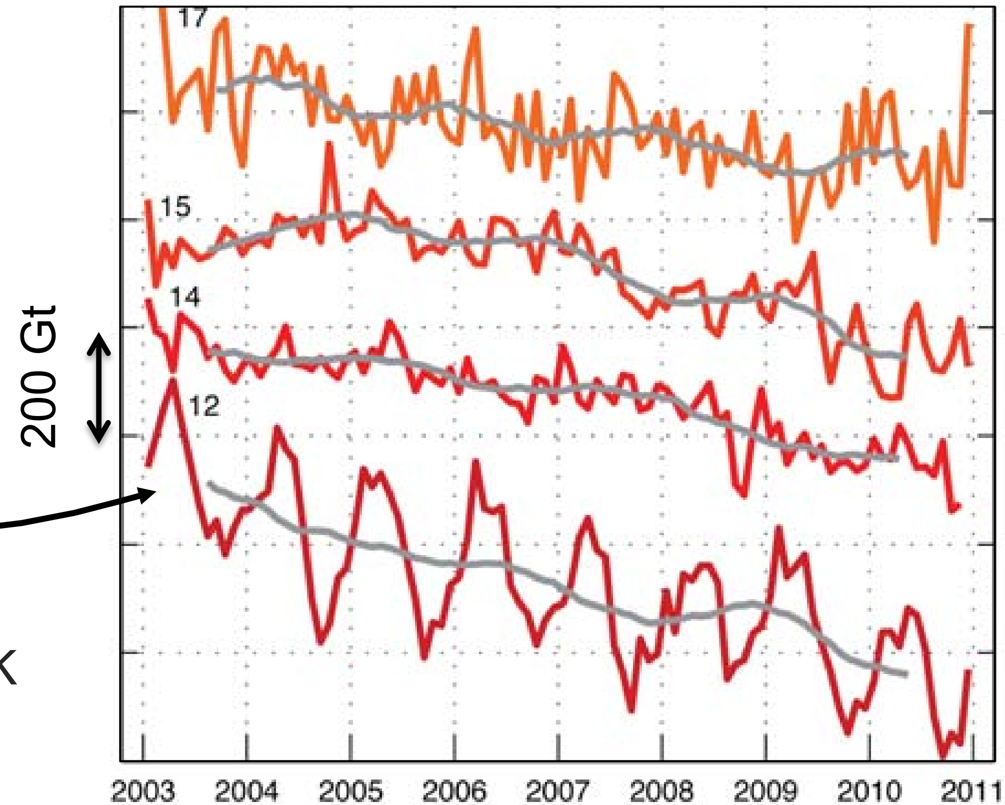
Future Opportunities

Climate Change Impacts on Land/Ocean Fluxes: Receding Glaciers in Southern Alaska

Rob Campbell et al.



Loss of glacier mass



Receding glaciers result in more Fe being available to the coastal AK ecosystem:

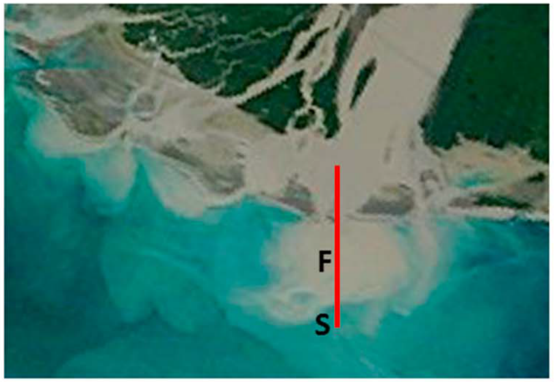
- Direct riverine input of Fe
- Aeolian deposition of Fe

[Jacob et al., Nature 2012]

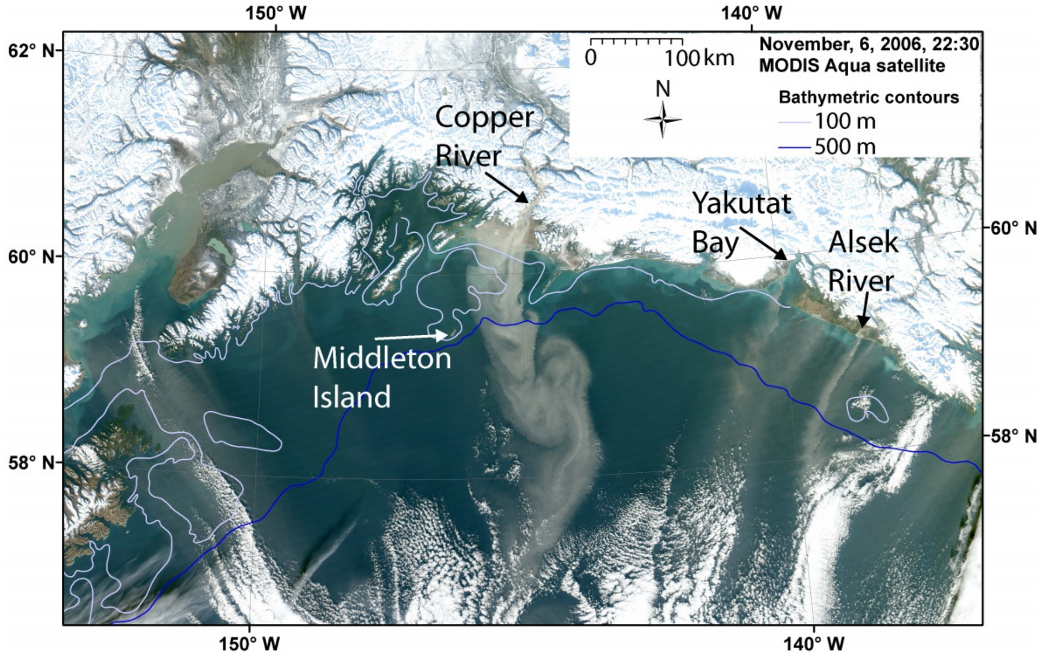
Climate Change Impacts on Land/Ocean Fluxes: Receding Glaciers in Southern Alaska

Rob Campbell et al.

Input of Fe from Copper River



Aeolian input of Fe



Katabatic winds entrain glacial flour, transport 100's of km's into Gulf of Alaska. Transport estimated at 25-80 kton for this event (early Nov. 2006).

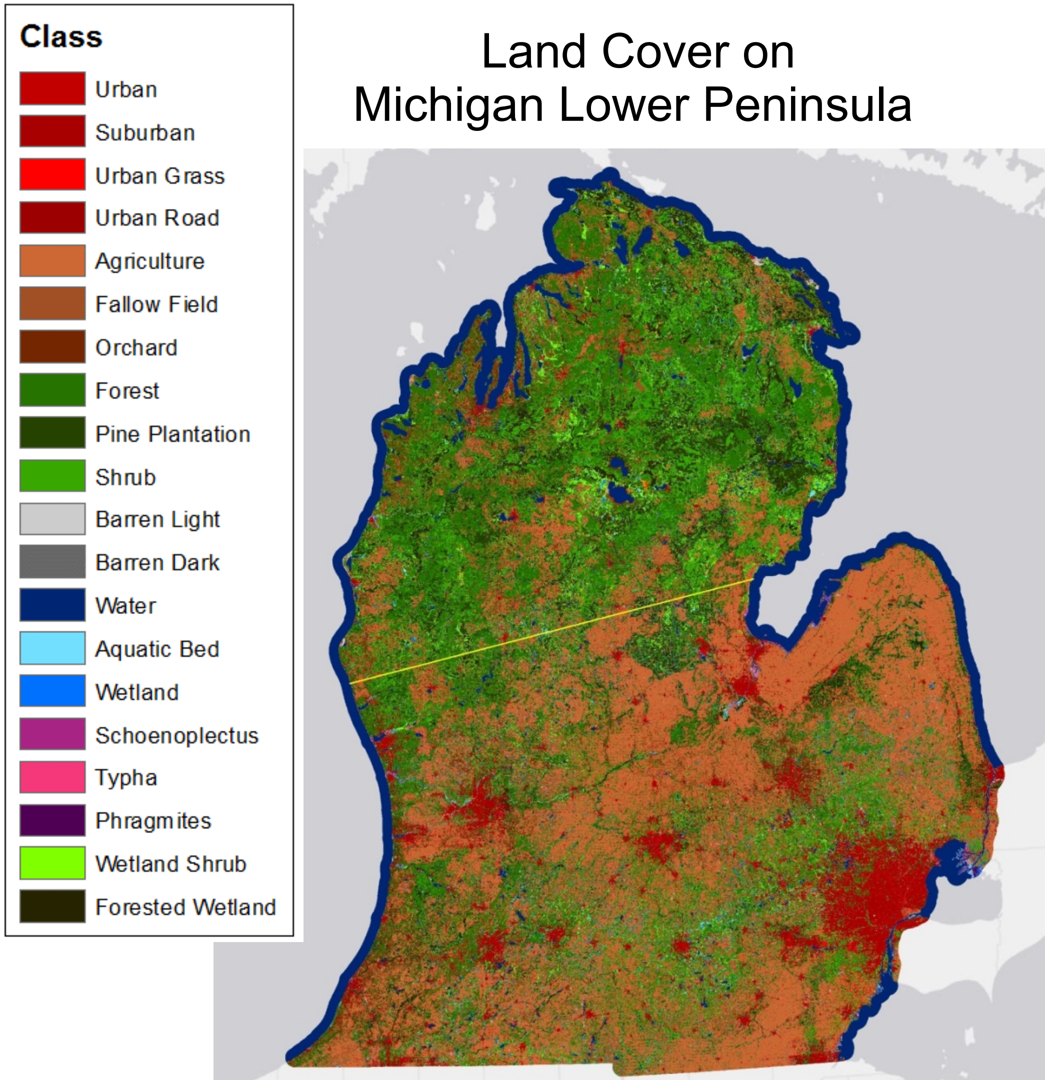
- Transport of dissolved/dissolvable Fe to Fe-limited portion of the Gulf of Alaska
- Magnitude will also change in future (colonizing plants bind up flour in soils)

[Schroth et al., GRL 2014]

Land Use Impacts:
Wetland Plant Invasions in the Great Lakes

Laura Bourgeau-Chavez et al. [see poster #112]

Land Cover on
Michigan Lower Peninsula



Remote Sensing Results
Landsat & PALSAR

Northern Lower Peninsula:
→ largely forest

Southern Lower Peninsula:
→ largely agriculture + urban

Phragmites:
% area is 2 x greater in south

Typha (cattail):
% area is 7 x greater in south

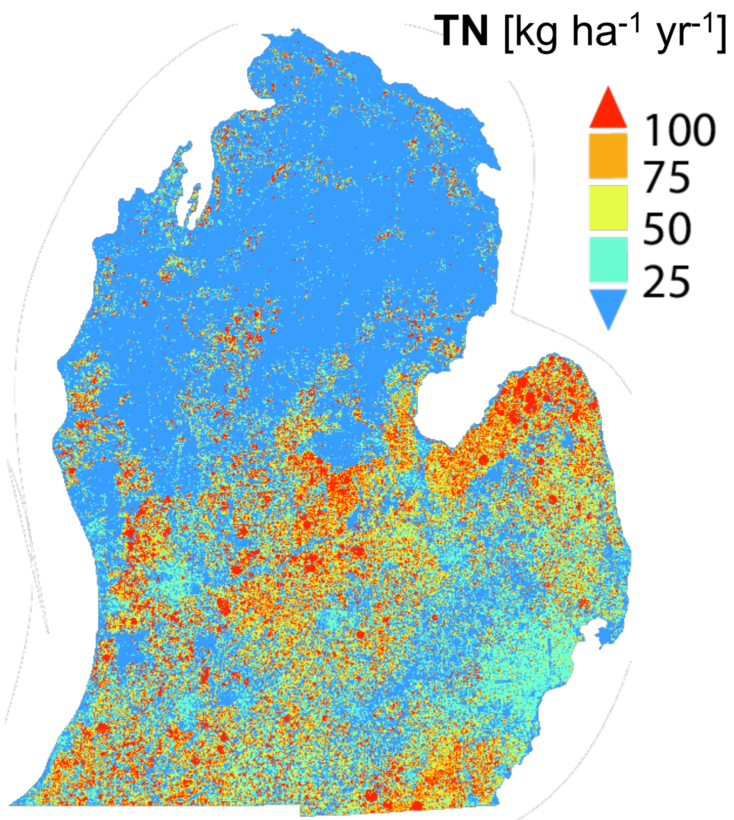
[See poster #112]

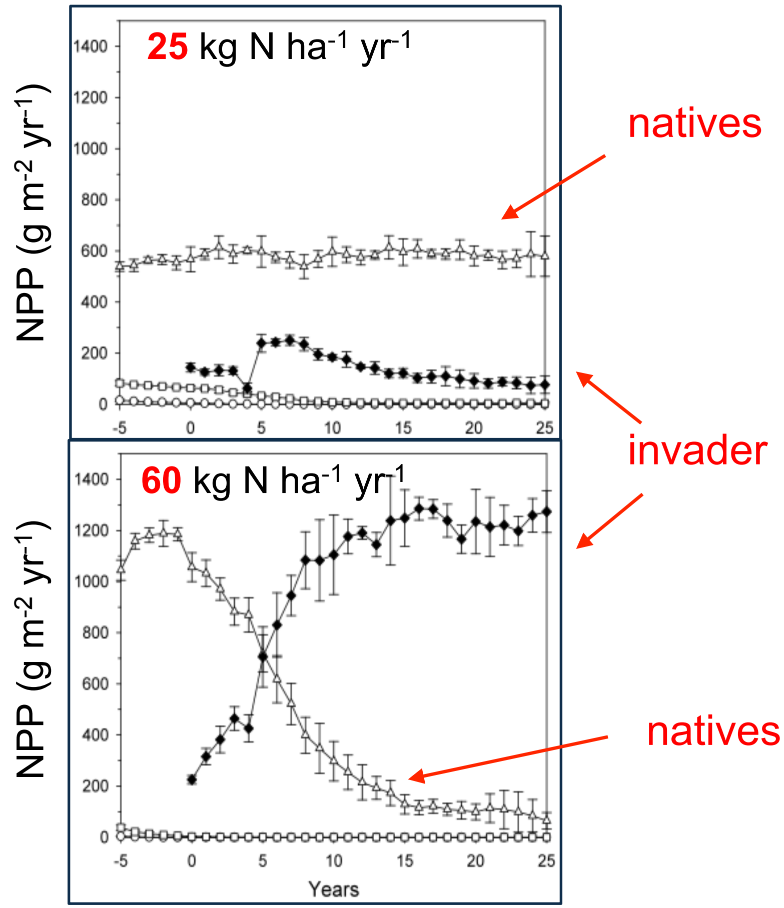
Land Use Impacts:
Wetland Plant Invasions in the Great Lakes

Laura Bourgeau-Chavez et al. [see poster #112]

Nutrient Loading + Hydrologic Model → Wetland Model

[Hyndman et al.]





[Currie et al., Ecol. Mod. 2014]

Nutrient loading estimates to be linked with hydrologic model (LHM)

Greater N inflow causes greater invasion in wetland model (MONDRIAN)

Water/Land Use Impacts: Effects of Increased Water Demand and Nutrient Inputs on the San Francisco Bay Ecosystem

Curtiss Davis et al.

Satellite Observations

MODIS
- 1 km GSD, 16 day revisit,
- ocean bands, moderate SNR

LDCM-OLI
- 30 m GSD, 16 day revisit,
- land bands, moderate SNR

HICO on the ISS
- 90 m GSD, high SNR
- hyperspectral (400 – 900 nm)
- collects scenes on demand

MERIS
- 2002-2012, 10 year time series
- 300 m GSD, 16 ocean bands

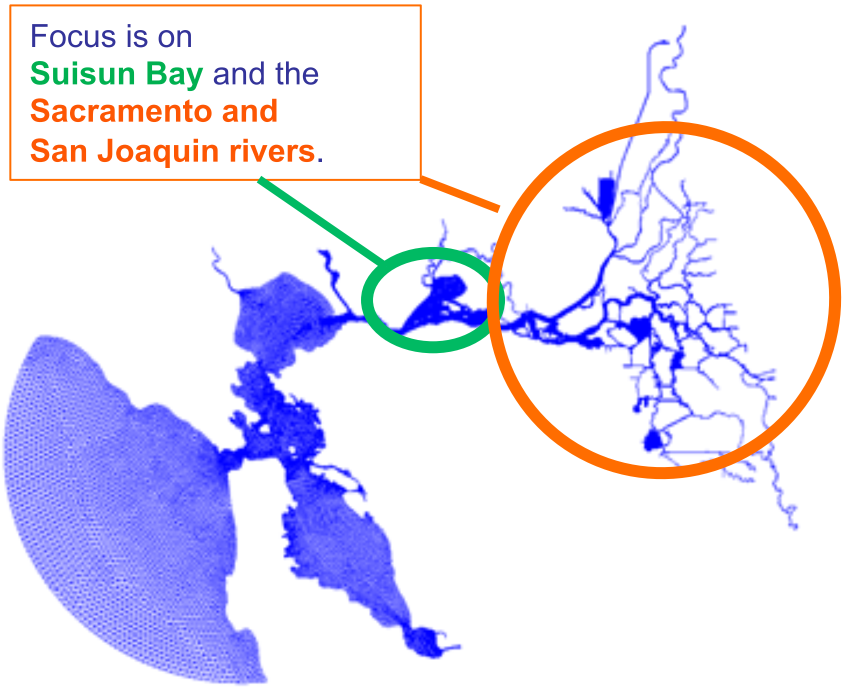
OLCI
- a MERIS follow-on
- to be launched in 2015

Shipboard Data

Parameters: nutrients, phytoplankton, suspended sediments, CDOM, optics
Cruises : 30 days over three years
Leveraged programs: USGS and RTC

Human/Land Use Impacts: Effects of Increased Water Demand and Nutrient Inputs on the San Francisco Bay Ecosystem

Curtiss Davis et al.



Model domain of the SELFE+COSINE model of San Francisco Bay and Sacramento-San Joaquin River Delta

By including water diversions, flow management and nutrient inputs from sewage treatment plants, they will be addressing:

- How will increasing population density and demand for fresh water affect coastal biogeochemistry in this region?
- How are phytoplankton concentrations affected by the ammonia inputs from the Sacramento River vs. the nitrate inputs from the San Joaquin River?

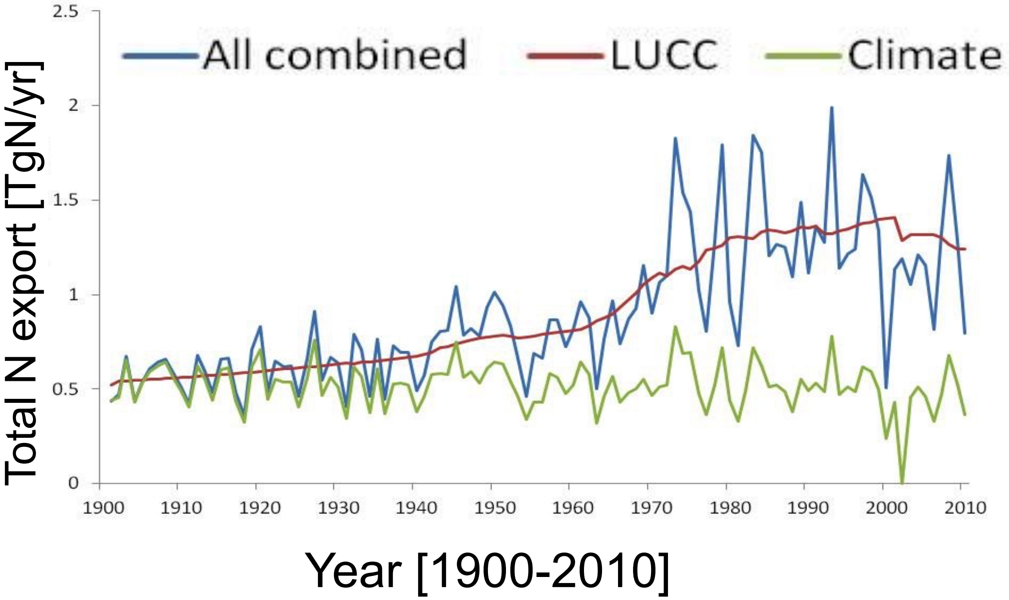
Land Use and Climate Change Impacts: Northern Gulf of Mexico

Steve Lohrenz et al.

Mississippi River watershed

Source: EPA, Mississippi River Gulf of Mexico Watershed Nutrient Task Force, 2011

Dynamic Land Ecosystem Model

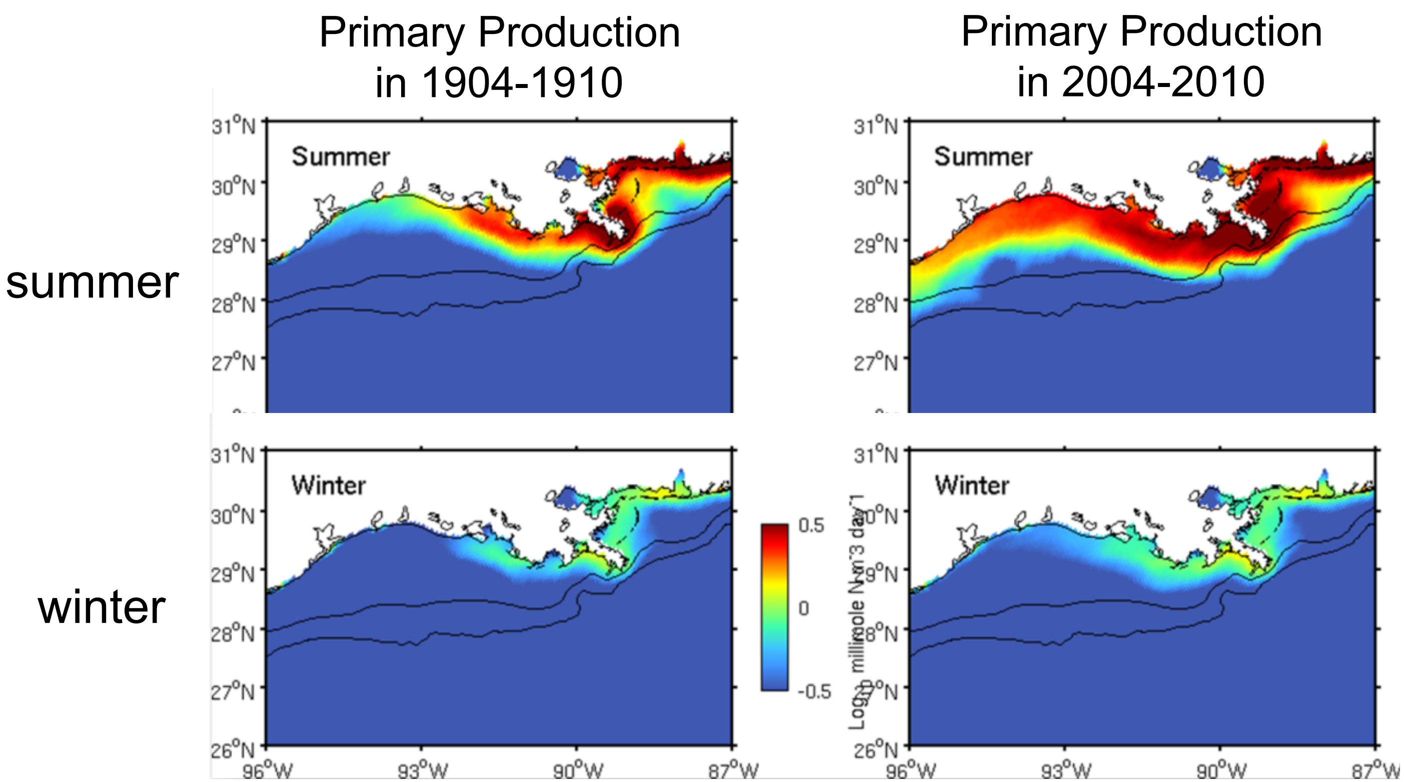


Long term increases in dissolved inorganic nitrogen flux from Mississippi River basin

[Tian et al.]

Land Use and Climate Change Impacts: Northern Gulf of Mexico

Steve Lohrenz et al.



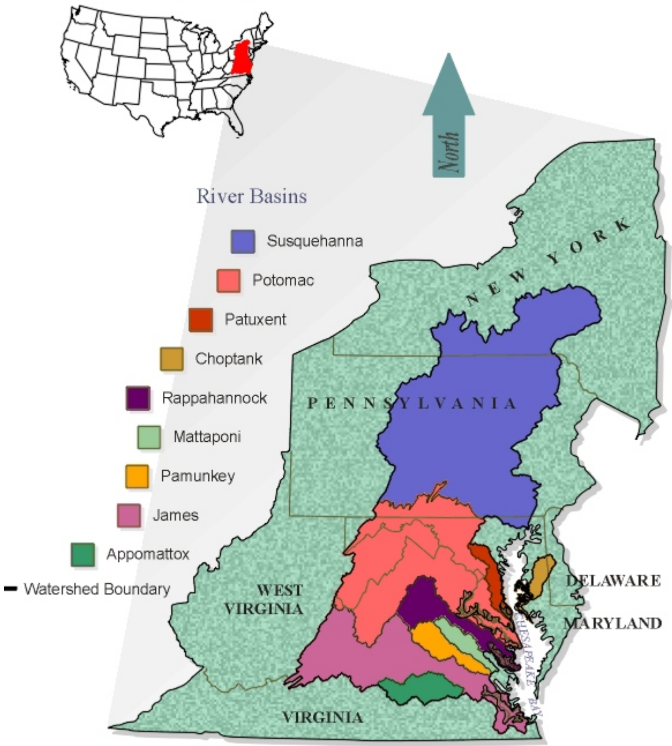
- Increase in DIN leads to ~20% increase in ocean primary production
- May have significant impacts on hypoxic shelf area

[He, Tian et al.]

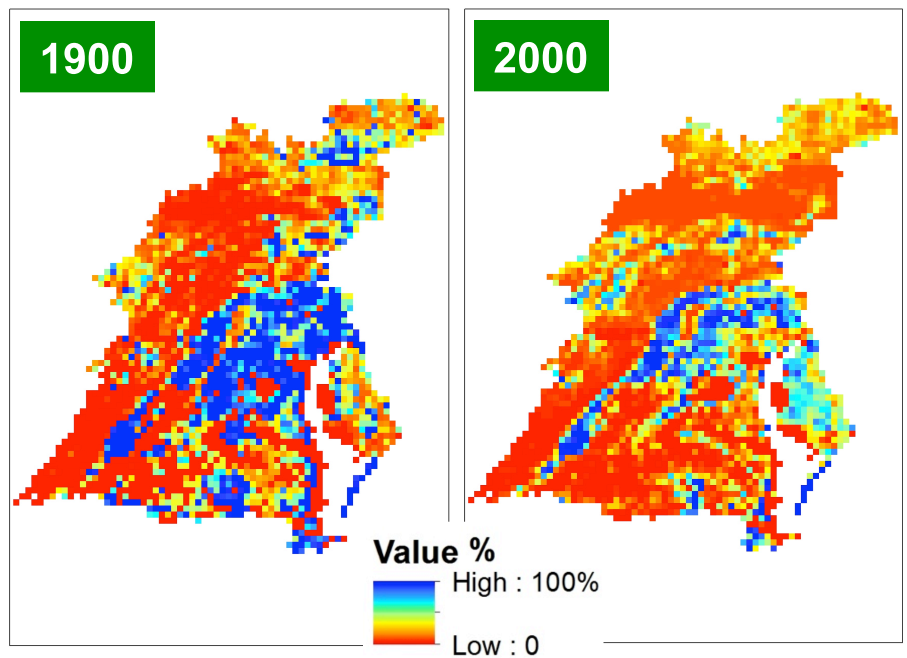
Land Use and Climate Change Impacts: US East Coast

Ray Najjar et al.

Chesapeake Bay Watershed



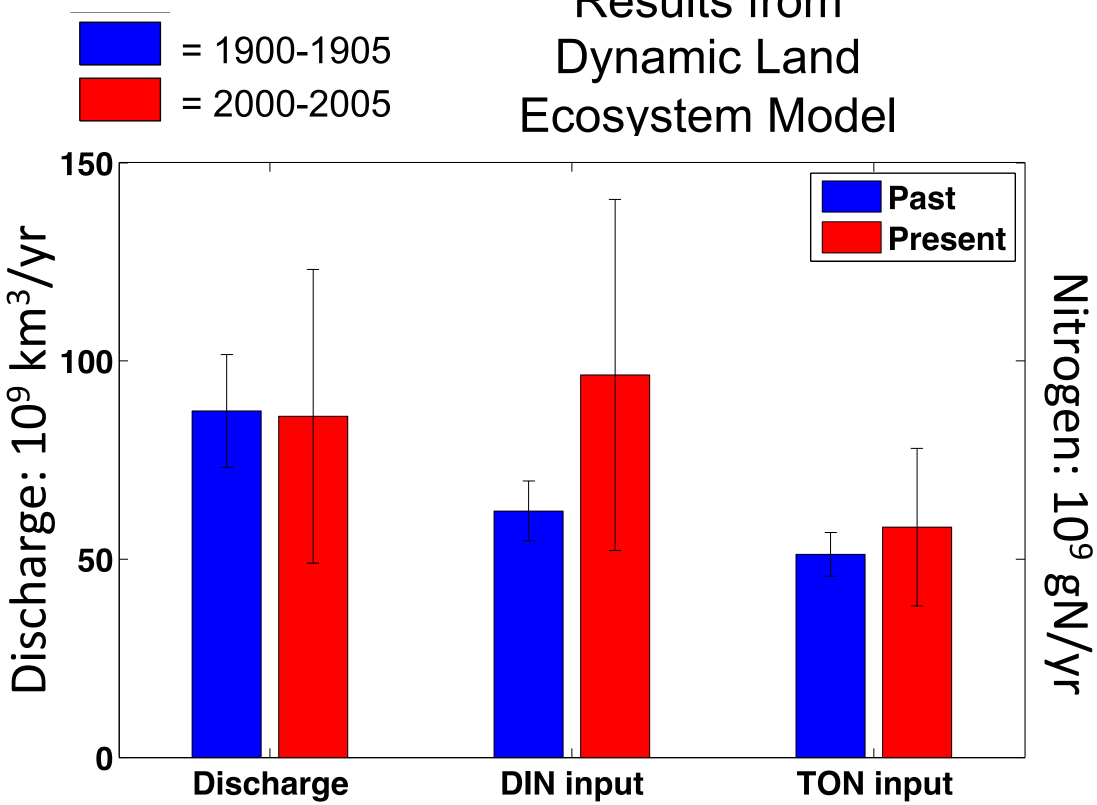
Reductions in Cropland Area



[Tian et al.]

Effects of Land Use Impacts: Increased nitrogen loading to Chesapeake Bay

Cathy Yang Feng et al. [see poster #80]



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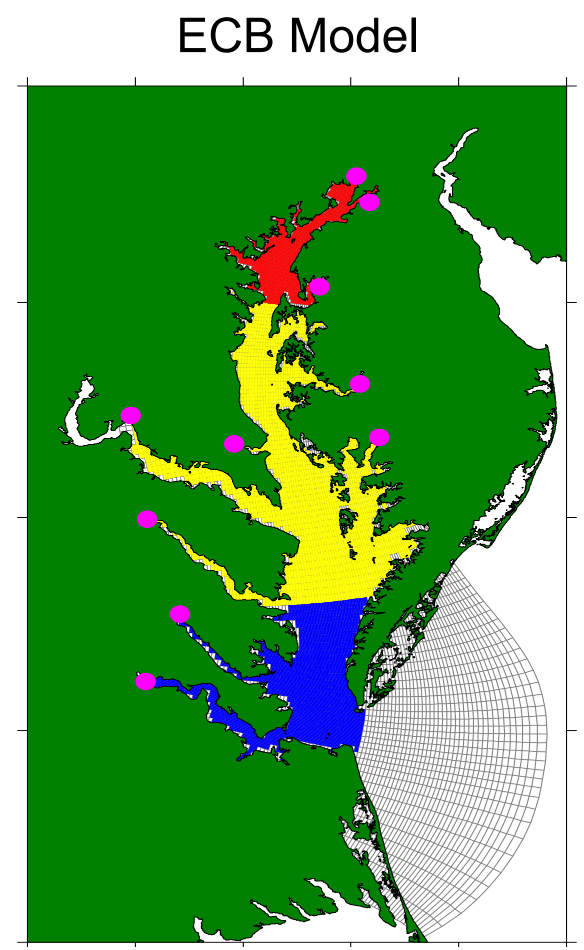

[Feng et al.]

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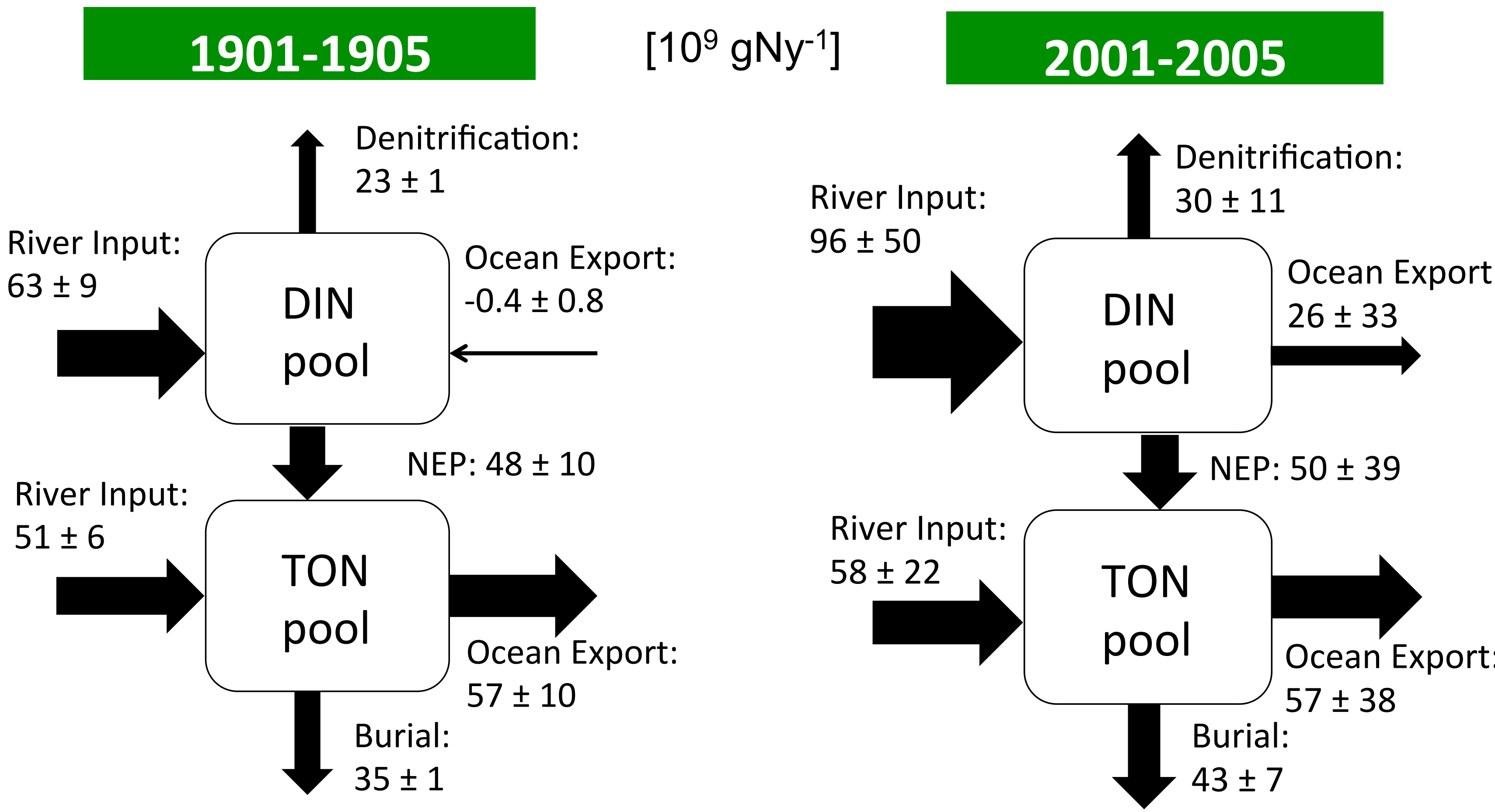

- Very little change in input/export of organic N
- Very little change in Net Ecosystem Production
- Dramatically increased export of inorganic N

[See poster #80]

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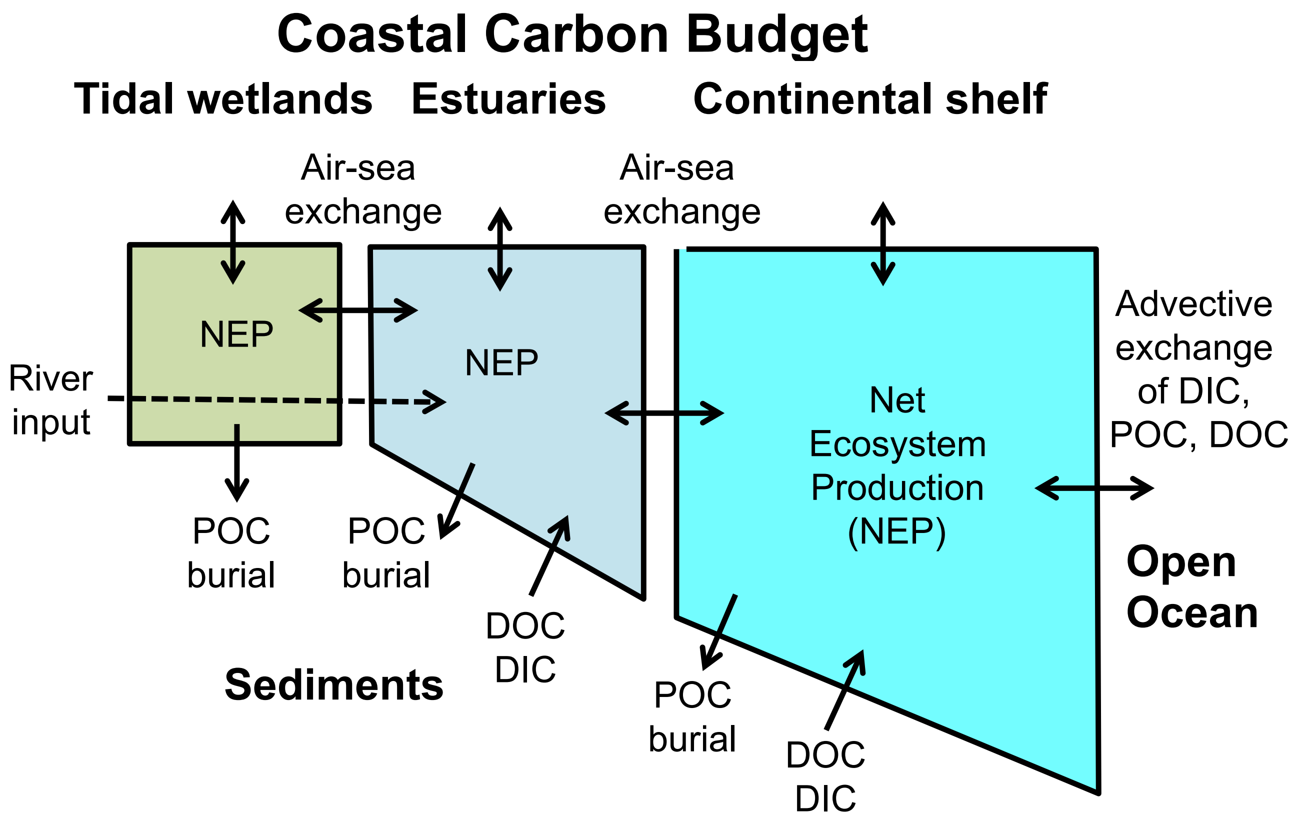
Future Opportunities – CCARS and Arctic-COLORS

Coastal CARbon Synthesis (CCARS):
Developing an Interdisciplinary Science Plan for North American Coastal Carbon Research



- Providing core science plan recommendations to help agencies prioritize future investments in coastal carbon cycle research: designed to help the community move from "diagnosis" toward "attribution", "prediction" and "decision support".
- Science plan identifying key areas for future research to be delivered to USGCRP Carbon Cycle Interagency Working Group expected 2015

Arctic-COLORS:

Arctic - Coastal Land Ocean Interactions

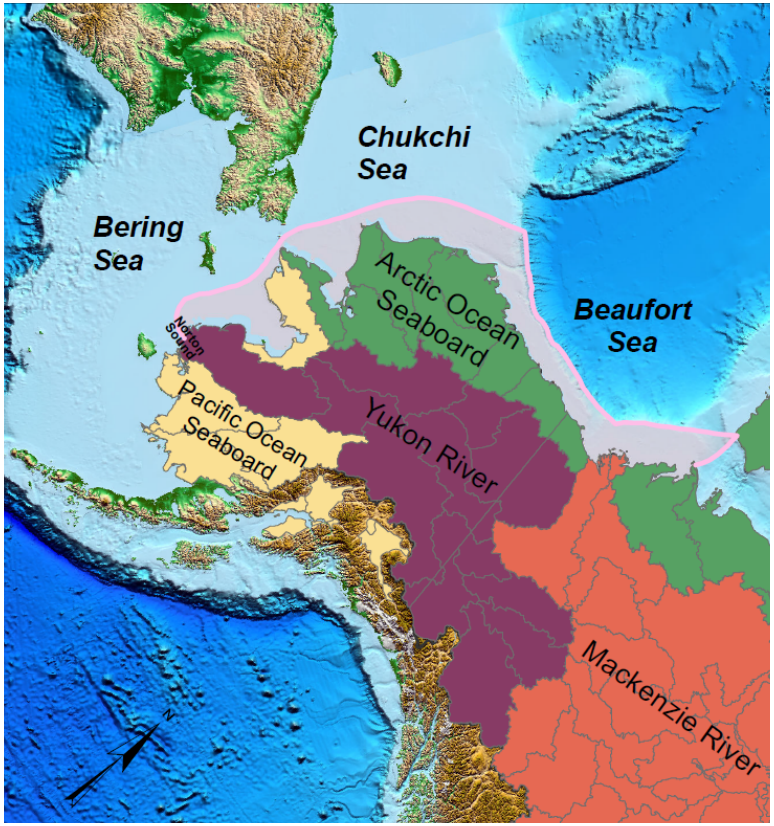
PIs: Mannino, Del Castillo, Friedrichs, Hernes, Matrai, Salisbury, Tzortziou

Arctic-COLORS is a Field Campaign Scoping Study funded by NASA's Ocean Biology and Biogeochemistry Program

➔ Addressing a needed linkage between field campaigns focusing on the Arctic open ocean environment, and field activities focusing on Arctic river processes, chemistry and fluxes

➔ **Overarching objective**: to better understand and predict the impact of climate change on land-ocean interactions in the Arctic Ocean, and examine the effect of these changes on river-dominated coastal ocean biology, biogeochemistry, biodiversity.

CC&E Townhall:
Tuesday 12:45-1:30



[See poster #168]

Summary

Land/ocean interface is a critical zone for future study

Population and human impacts are increasing

Climate change effects are strong

→ How much of the observed changes in coastal waters can be managed locally?

NASA assets are required for studying land/ocean fluxes

High temporal/spatial variability of these regions require an interdisciplinary approach, involving remote-sensing + models + in situ data

Improvements needed:

coastal waters algorithms are critical

(See Guild et al. poster #83)

Are active NASA (IDS) projects on all five U.S. coasts

More results soon, so stay tuned! (And check out the posters!)

Check out the posters!

- Juan Torrez-Perez et al. (#72)
- Maritza Barreto et al. (#73)
- Cathy Feng et al. (#80)
- Liane Guild et al. (#83)
- Sherry Palacios et al. (#106)
- Laura Bourgeau-Chavez et al. (#112)
- Antonio Mannino et al. (#168)
- Sergio Signorini et al. (#170)
- Ray Najjar et al. (#171, #172)
- Maria Herrmann et al. (#173)
- Hanqin Tian et al. (#207)