Quantifying the impact of terrestrial carbon and nutrients on the ocean carbon cycle

Raphaël Savelli, D. Menemenlis, M. Simard, D. Carroll

Jet Propulsion Laboratory, California Institute of Technology

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Jet Propulsion Laboratory
California Institute of Technology

INTRODUCTION

Source: Daniel Bosma/Getty via Nature **603**, 367 (2022)

Inland waters and rivers = about 1% percent of the Earth's surface but:

- ~30 000 $km^3\ yr^{-1}$ of freshwater discharge
- Significant amount of carbon and nutrients delivered to the ocean
- From natural and anthropogenic sources
- Key role in ocean and coastal waters Physics and biogeochemistry

IMPLEMENTING DISCHARGE INTO THE ECCO OCEAN STATE ESTIMATE

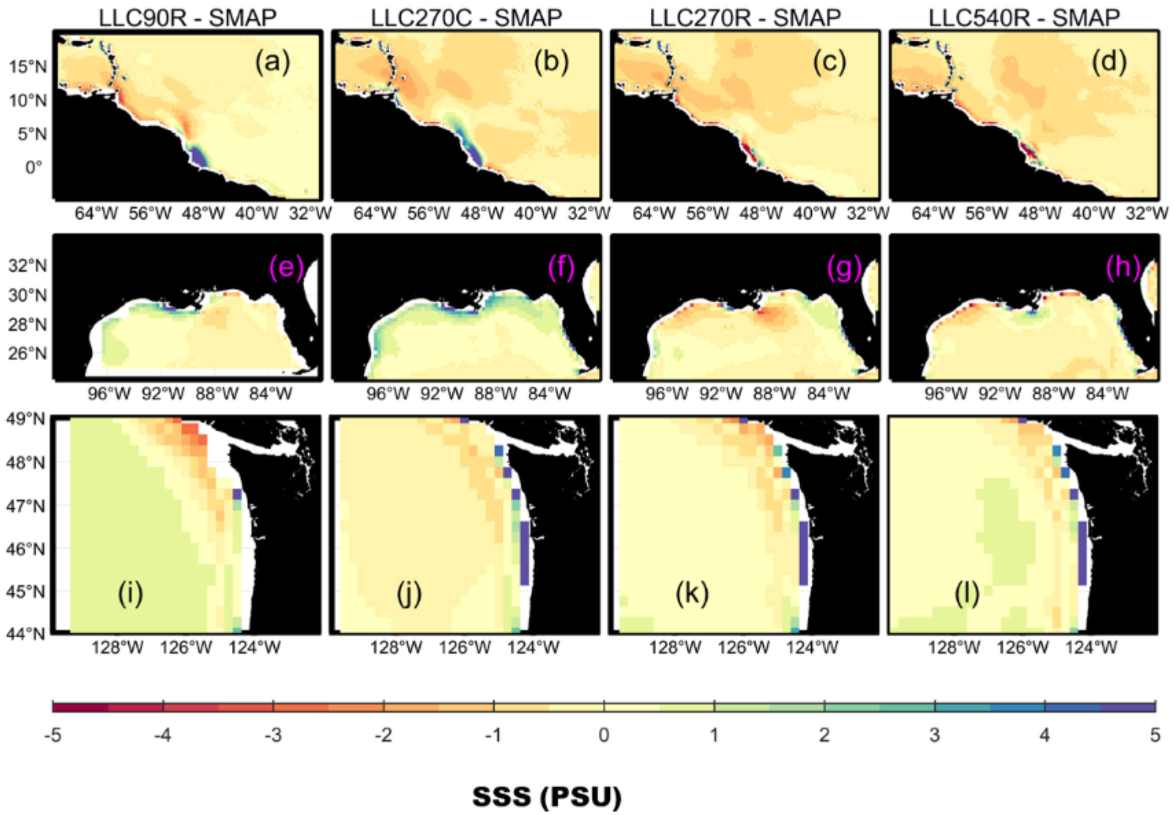
Geosci. Model Dev., 14, 1801–1819, 2021
https://doi.org/10.5194/gmd-14-1801-2021

Geoscientific Model Development
Open Access
EGU

Improved representation of river runoff in Estimating the Circulation and Climate of the Ocean Version 4 (ECCOv4) simulations: implementation, evaluation, and impacts to coastal plume regions

Yang Feng[1,2,3], Dimitris Menemenlis[4], Huijie Xue[1,2], Hong Zhang[4], Dustin Carroll[4,5], Yan Du[1,2,6], and

Freshwater & global



Key point:

Simulated sea surface salinity better agrees with SMAP observations when considering daily point-source runoff and intermediate resolution (ECCO LLC270).

IMPLEMENTING DISCHARGE INTO THE ECCO OCEAN STATE ESTIMATE

Freshwater & global

JAMES Journal of Advances in Modeling Earth Systems®

RESEARCH ARTICLE
10.1029/2021MS002715

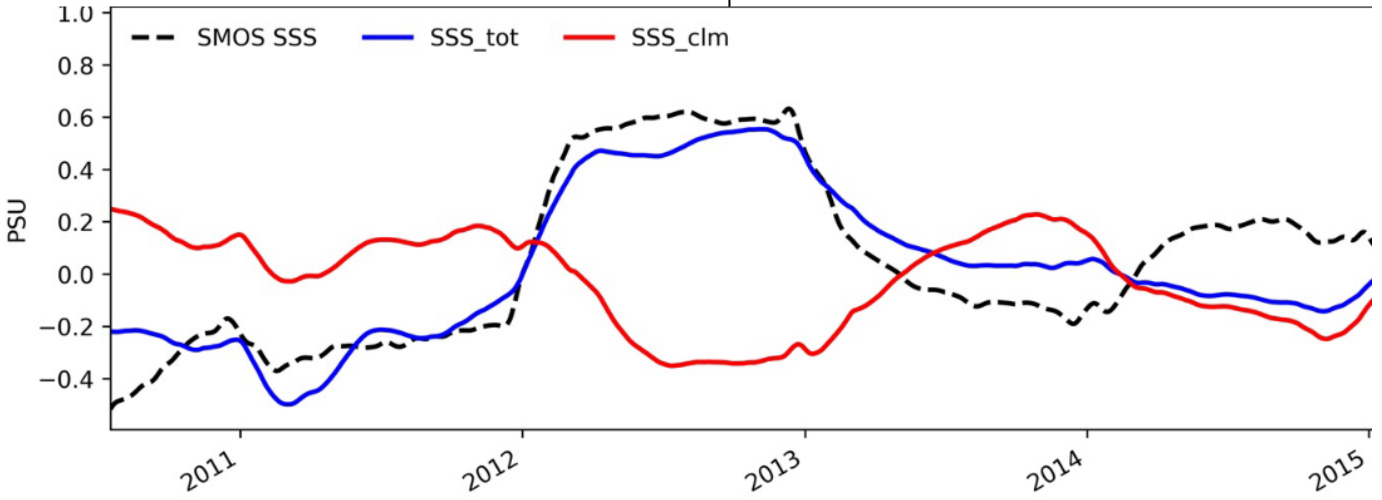
Influence of Nonseasonal River Discharge on Sea Surface Salinity and Height

Hrishikesh A. Chandanpurkar[1,2,3], Tong Lee[1], Xiaochun Wang[4], Hong Zhang[1], Severine Fournier[1], Ian Fenty[1], Ichiro Fukumori[1], Dimitris Menemenlis[1], Christopher G. Piecuch[5], John T. Reager[1], Ou Wang[1], and John Worden[1]

[1]Jet Propulsion Laboratory, California Institute of Techno
SK, Canada, [3]FLAME University, Pune, India, [4]Universit
Oceanographic Institution, Woods Hole, MA, USA

Key Points:

- Nonseasonal discharge (deviation from seasonal climatology) has measurable impacts on model salinity and sea level near major rivers
- Inclusion of nonseasonal discharge leads to notable improvement of model-observation comparison near



Key point:

The simulation of sea surface salinity and height in ECCO LLC270 is improved near river mouths when preferring daily freshwater discharge over climatology.

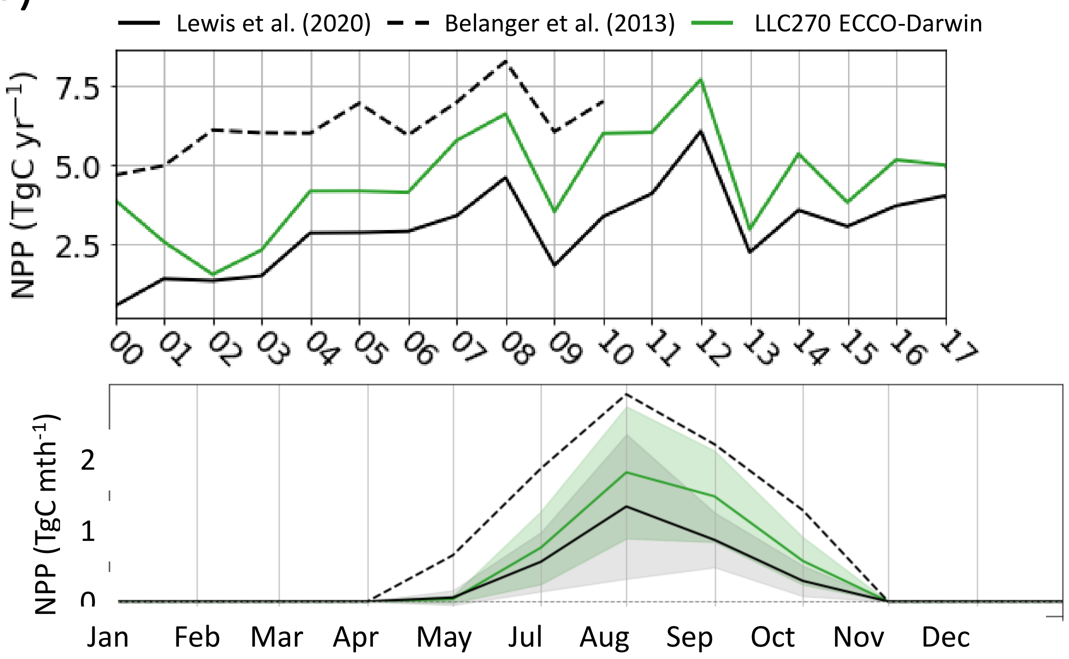
IMPLEMENTING DISCHARGE INTO THE ECCO OCEAN STATE ESTIMATE

Freshwater, BGC & regional

Biogeochemical River Runoff Drives Intense Arctic Ocean Outgassing

Clément Bertin (PhD student, La Rochelle Université)

(*in revision*, Geophysical Research Letters)



Key point:

Primary production and air-sea CO_2 exchanges are better resolved in a ECCO-Darwin LLC270 regional set-up of the Southeast Beaufort Sea with freshwater and BGC discharge.

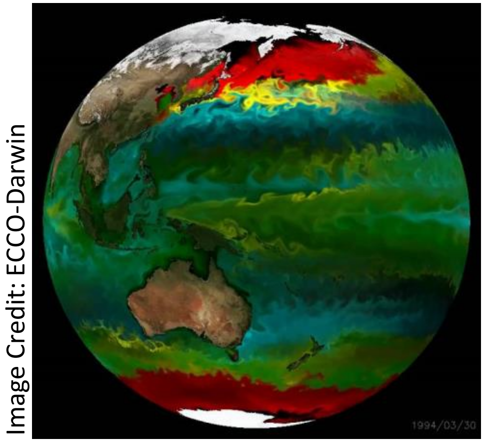
OBJECTIVE

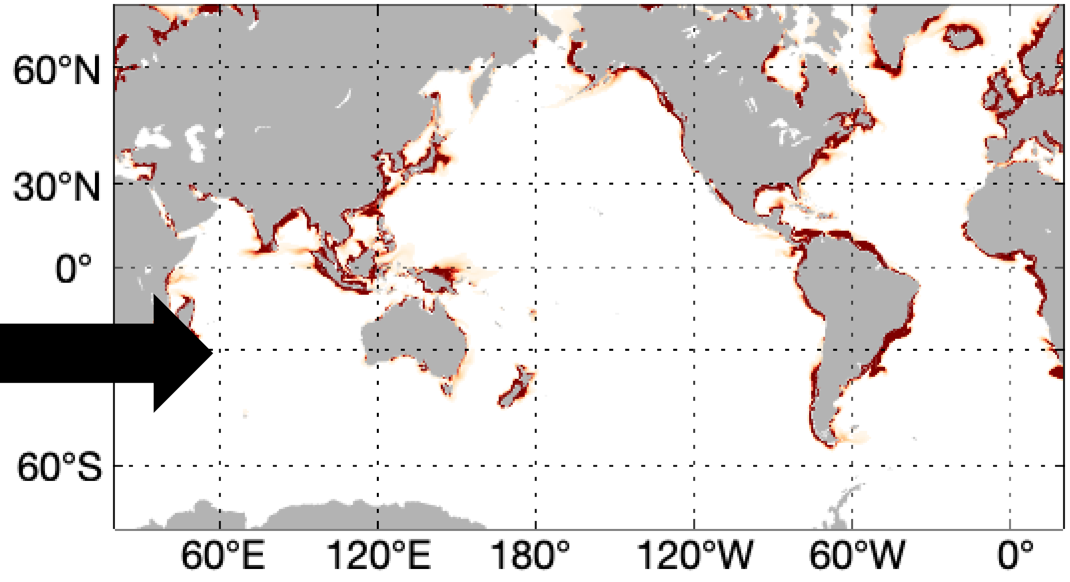
Quantifying the impact of terrestrial carbon and nutrients on the ocean carbon cycle at the seasonal and inter-annual time-scale.

Freshwater, BGC & global

Image Credit: Town of Westminster, Massachusetts

Image Credit: ECCO-Darwin





Freshwater and terrestrial carbon and nutrients.

ECCO-Darwin ocean biogeochemistry model.
Carroll et al. (2020), *Journal of Advances in Modeling Earth Systems.*

Daily-resolved freshwater, carbon and nutrients river fluxes along the coastline.

IMPLEMENTING DAILY DISCHARGE INTO ECCO-DARWIN

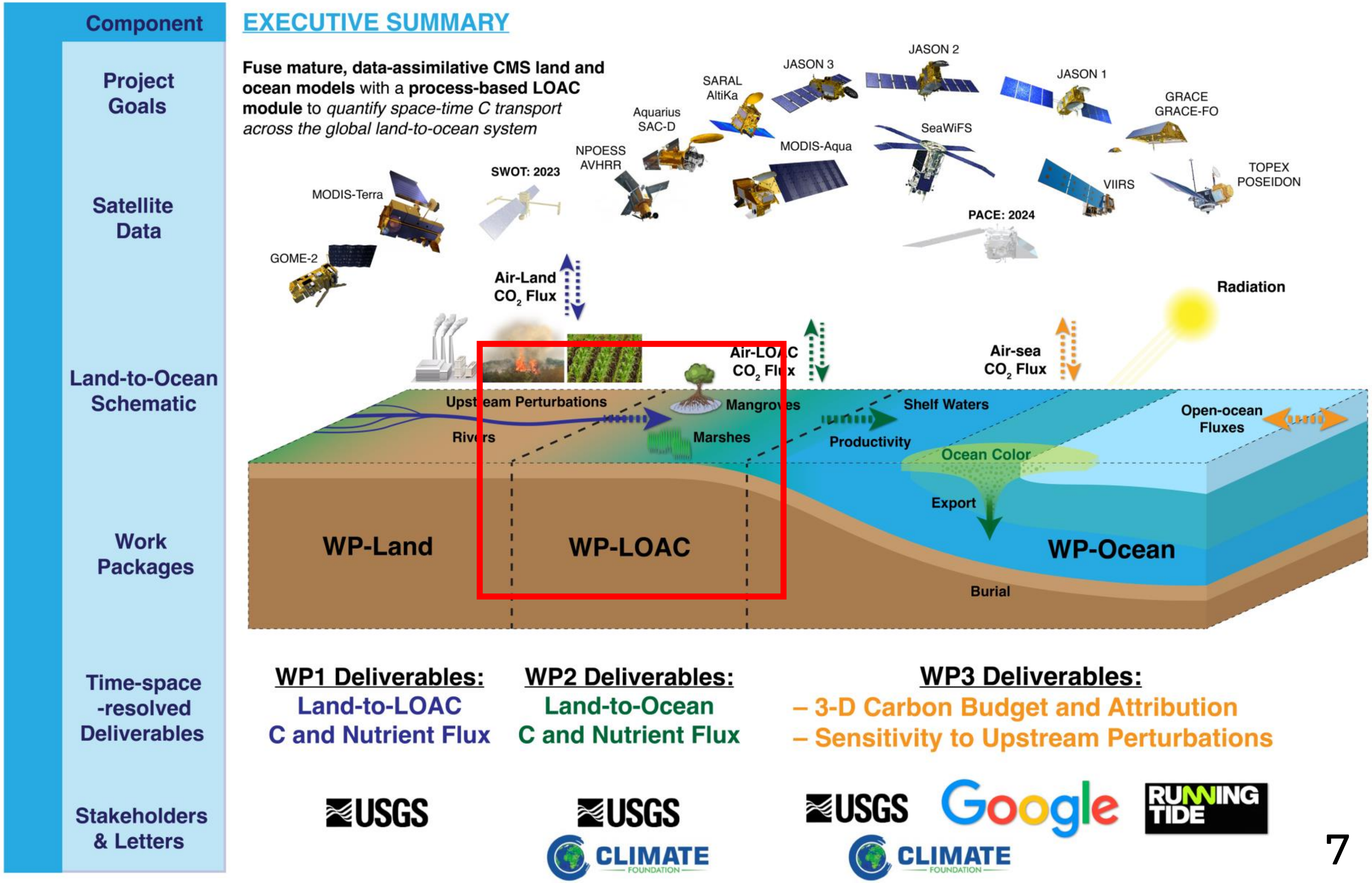
We combine different models to connect land and ocean:

	Model	Period	Grid	Variables of interest
Ocean Physics	ECCO LLC270	1992-present	1/3°	Sal., temp., mixing, transport
Ocean biogeochemistry	Darwin	1992-present	1/3°	Nutrients, carbon, phyto.
Daily discharge	JRA55-do	1958-present	55 km	Freshwater runoff
Annual nutrients and carbon discharge	Global NEWS 2	2000	Point	Dissolved and particulate organic and inorganic nutrients (N, P, Si) and carbon

→ Daily fluxes of nutrients and carbon, globally

THE LAND-TO-OCEAN AQUATIC CONTINUUM (LOAC)

The LOAC processes need to be resolved in order to close the carbon cycle loop.



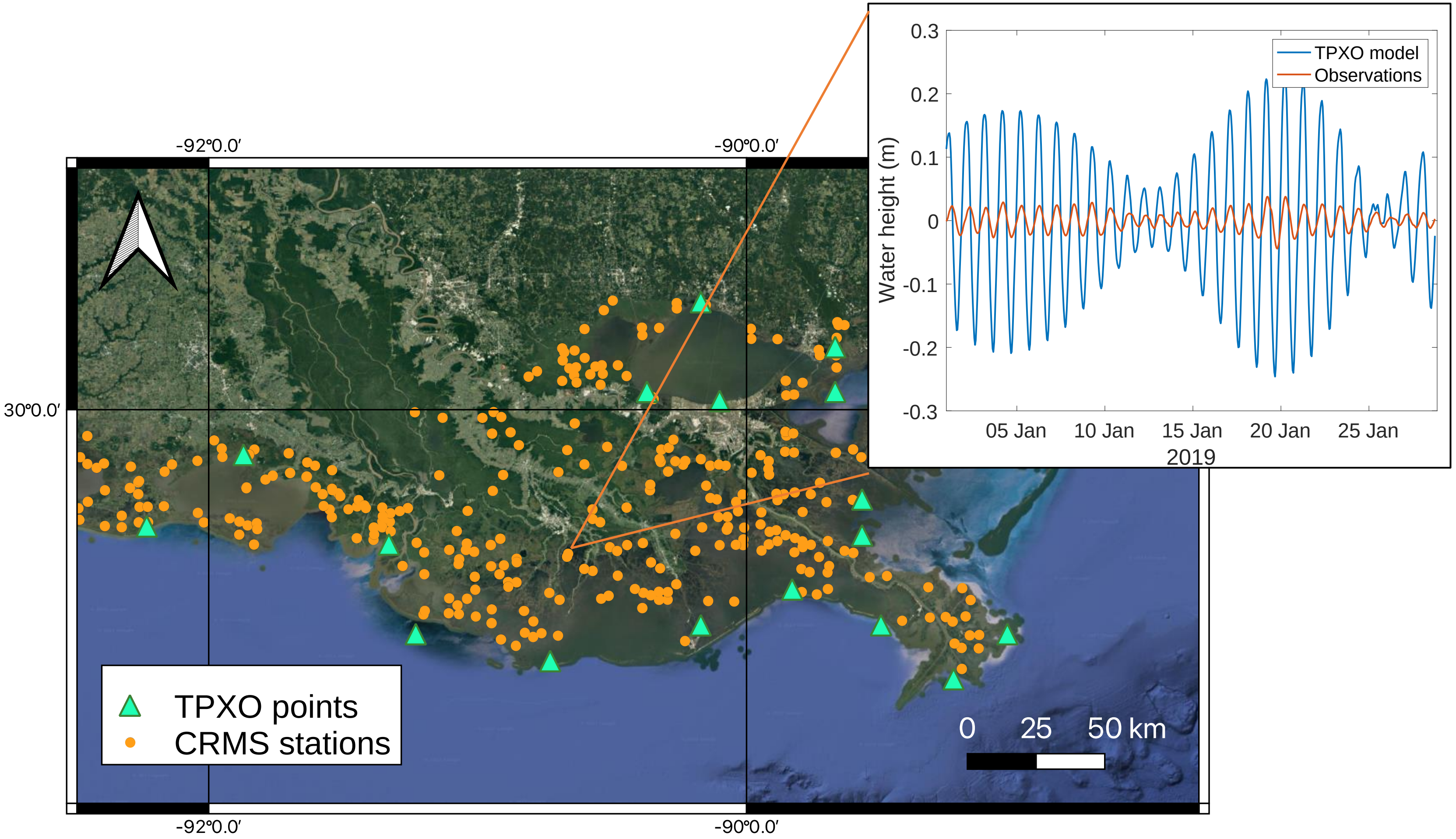
CMS proposal 2022, PI D. Carroll: *Closing the Carbon Cycle Loop: Quantifying Land-to-Sea Carbon Fluxes*

THE LAND-TO-OCEAN AQUATIC CONTINUUM (LOAC)

Example: Tides along the coastline

Global models of tides lack of precision at the land-sea interface.

Example of TPXO in the Mississippi delta:



CRMS stations network and TPXO points along the coastline.

Egbert et al. (2002), ***Journal of Atmospheric and Oceanic Technology.***

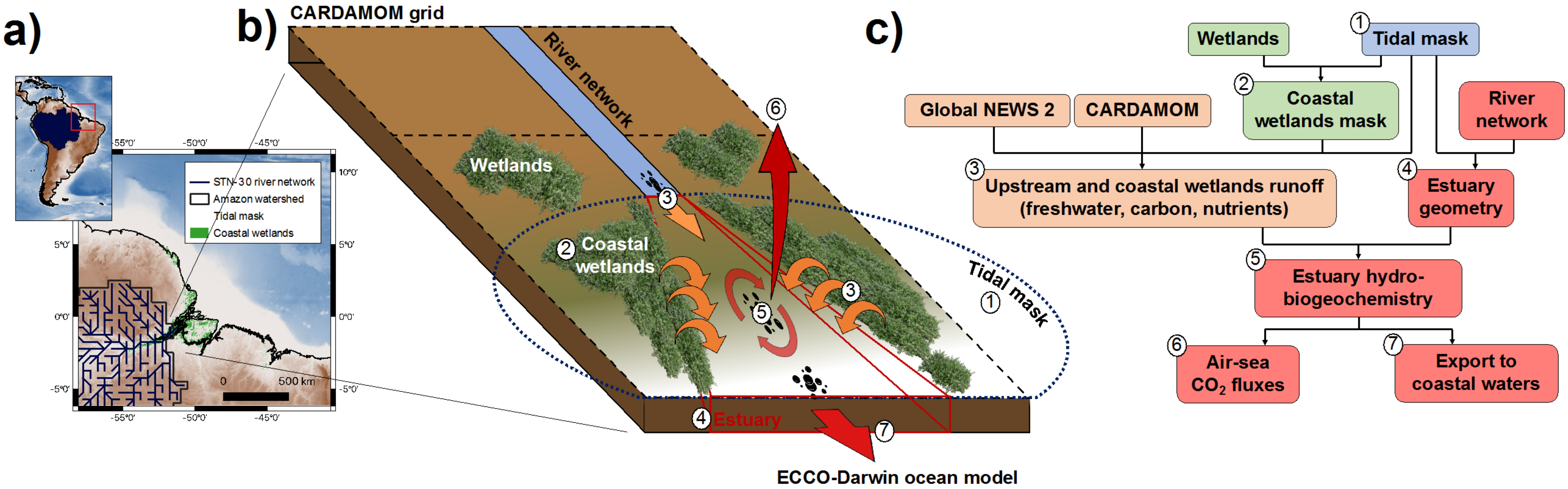
THE LAND-TO-OCEAN AQUATIC CONTINUUM (LOAC)

CMS proposal 2022, PI D. Carroll: Closing the Carbon Cycle Loop: Quantifying Land-to-Sea Carbon Fluxes

The LOAC module combines:

- Estuary box model
- Continental and coastal wetlands biogeochemical inputs

} Physics & Biogeochemistry



THE LAND-TO-OCEAN AQUATIC CONTINUUM (LOAC)

Tidal Mask

Tidal Amplitude:

TPXO model	*Egbert and Erofeeva* [2002]
CRMS tidal gauges	www.lacoast.gov/CRMS/

Ground Elevation:

GLO-30 DEM	doi.org/10.5270/ESA-c5d3d65

Coastline:

GSHHS coastline	*Wessel and Smith* [1996]

NASA Satellites Used:

TOPEX/Poseidon

Coastal Wetlands Mask

Mangroves:

Global Mangrove Watch	*Bunting et al.* [2022]

Marshes:

Global wetlands extent	*Zhang et al.* [2022]
Tidal wetlands loss/gain	*Murray et al.* [2022]

NASA Satellites Used:

STRM, LANDSAT, Terra ASTER

Estuary Geometry and Net Carbon Balance

River Networks:

STN-30	*Vörösmarty et al.* [2000]
SWORD	*Altenau et al.* [2021]
MERIT	*Yamazaki et al.* [2019]
HDMA	*Verdin* [2017]
Width and depth	*Andreadis et al.* [2013]

Hydro-biogeochemistry:

C-GEM	*Volta et al.* [2014]

Atmospheric Forcings:

ERA-Interim	*Dee et al.* [2011]

NASA Satellites Used:

SRTM, LANDSAT

Upstream and Coastal Wetlands Runoff

Freshwater, C, and Nutrients:

CARDAMOM	*Bloom et al.* [2020]
Global NEWS 2	*Mayorga et al.* [2010]

Wetlands Biomass:

Mangroves	*Simard et al.* [2019]
Marshes	*Byrd et al.* [2021]

Wetlands Soil Carbon:

Mangroves	*Sanderman et al.* [2018]
Tidal wetland-marshes	*Holmquist et al.* [2019]
	Wardrup et al. [2021]

NASA Satellites Used:

SRTM, MODIS, LANDSAT, ICESat

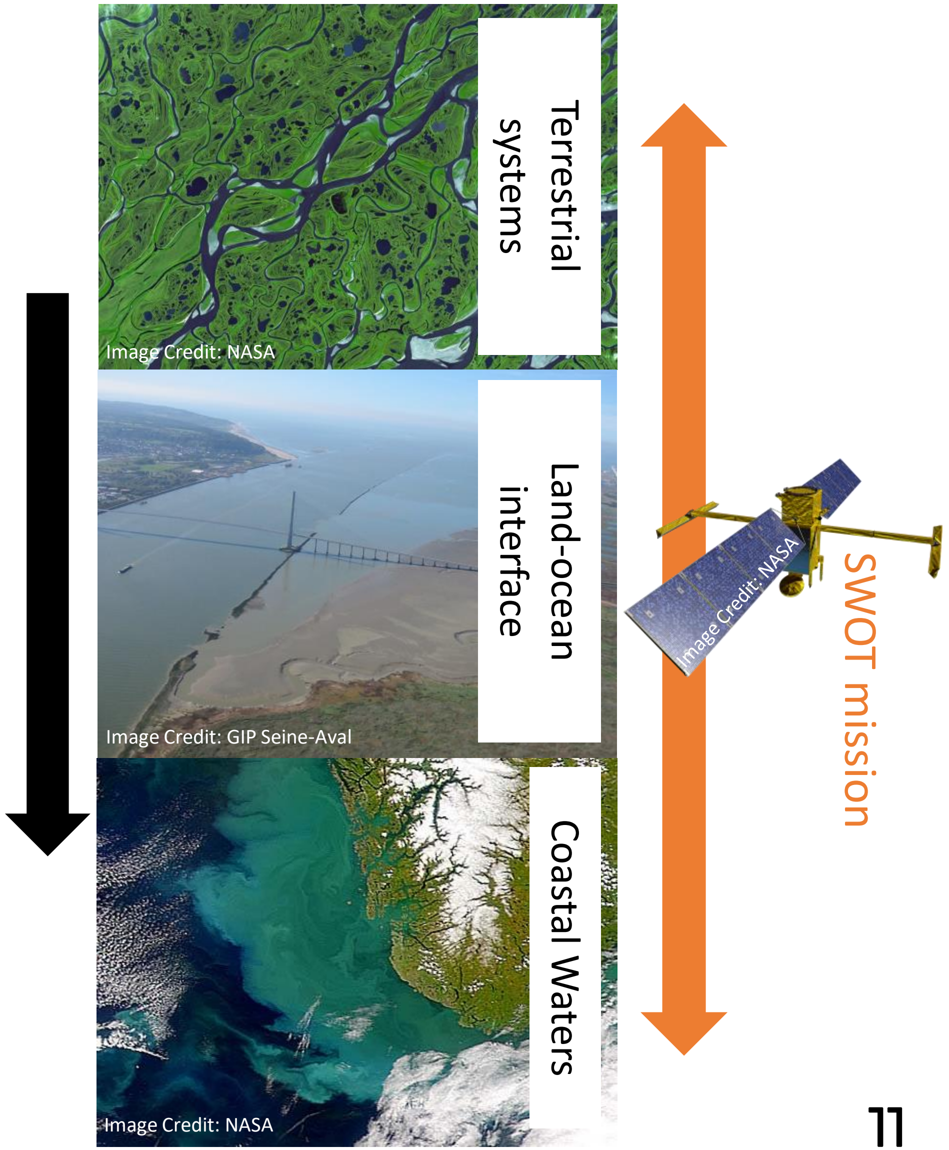
Sources and inputs for the LOAC module

CONCLUSIONS AND PERSPECTIVES

This project highlights challenges, globally :

- Implementing discharge of terrestrial carbon and nutrients into ECCO-Darwin
- Representing tides along the coastline
- Urgent need for MITgcm coastal wet/drying capability

The recently-launched SWOT mission motivates and enables studies at the land-ocean interface, regions of significant societal importance.



Thank you for your attention.

Raphaël Savelli, raphael.savelli@jpl.nasa.gov

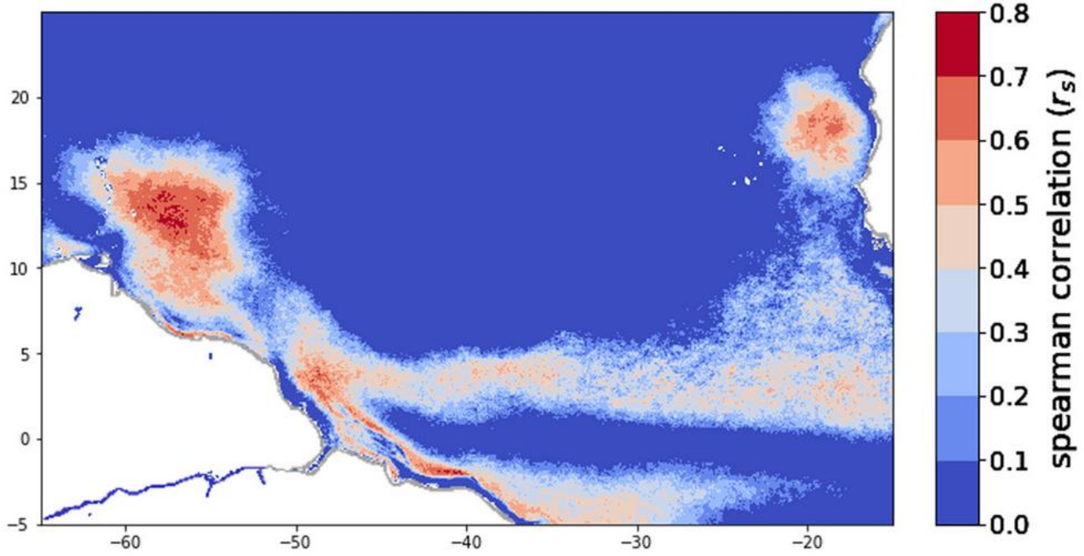
Dimitris Menemenlis, Jet Propulsion Laboratory, California Institute of Technology

Marc Simard, et Propulsion Laboratory, California Institute of Technology

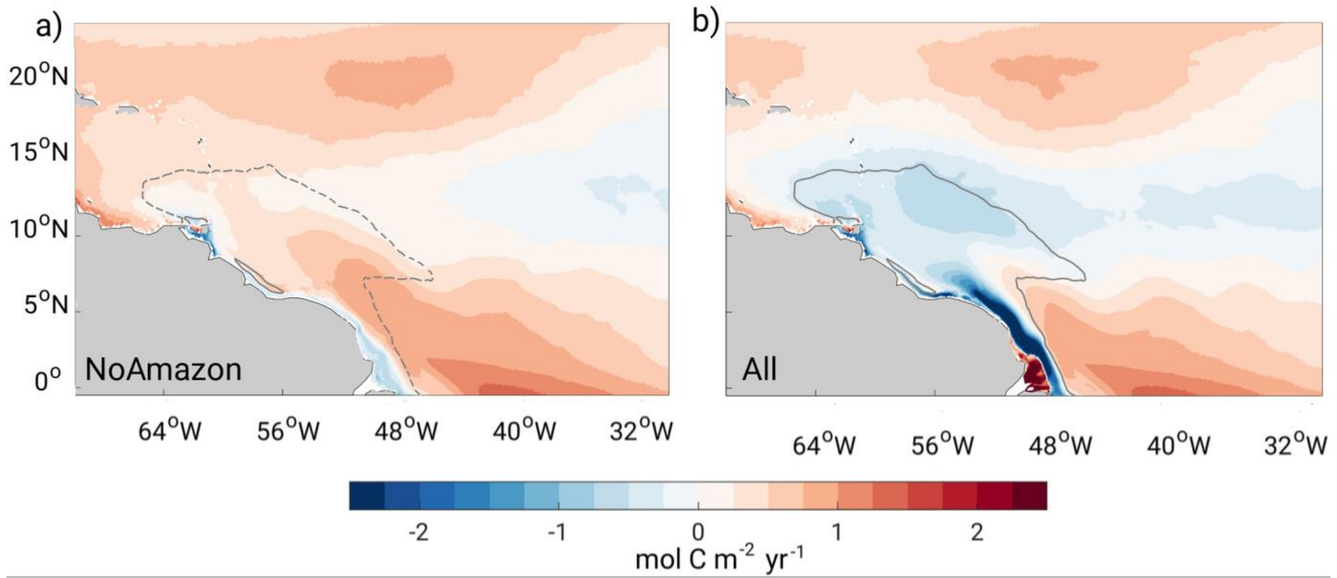
Dustin Carroll, Moss Landing Marine Laboratories

Jet Propulsion Laboratory
California Institute of Technology

ROLE OF TERRESTRIAL LOADS IN COASTAL WATERS

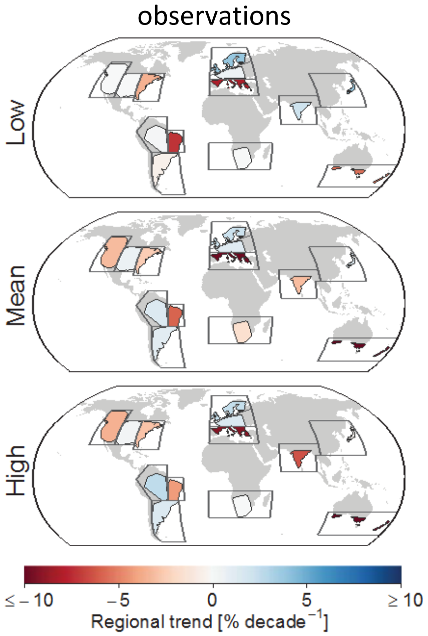


Correlation between remotely sensed MODIS chl-a concentrations and Amazon river flow.
Auricht et al. (2022), *Remote Sens Ecol Conserv.*

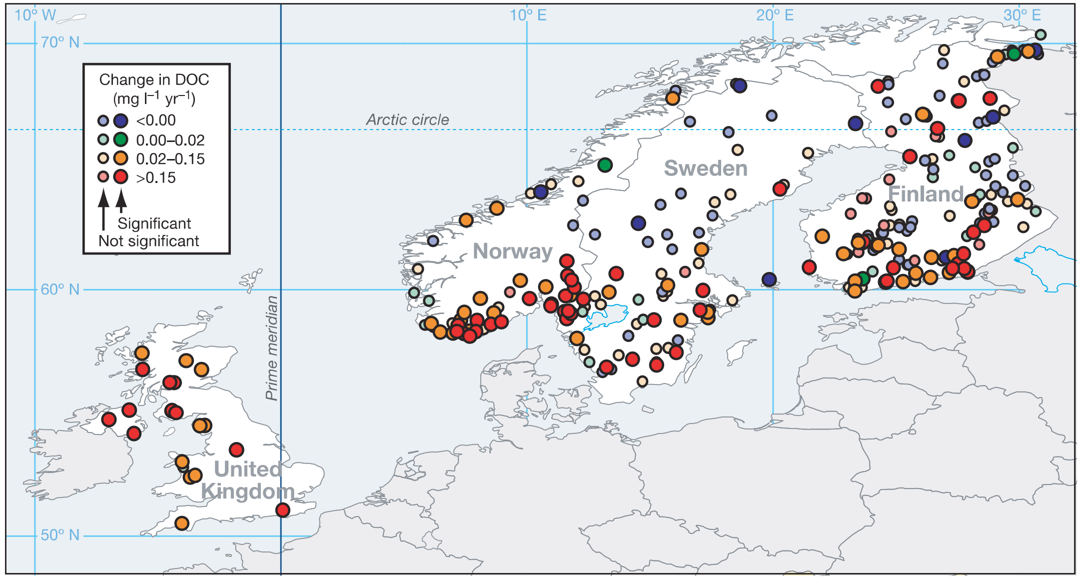


Simulated annual average air-sea CO2 flux density in the Western Tropical Atlantic.
Louchard et al. (2021), *Global Biogeochemical Cycles*

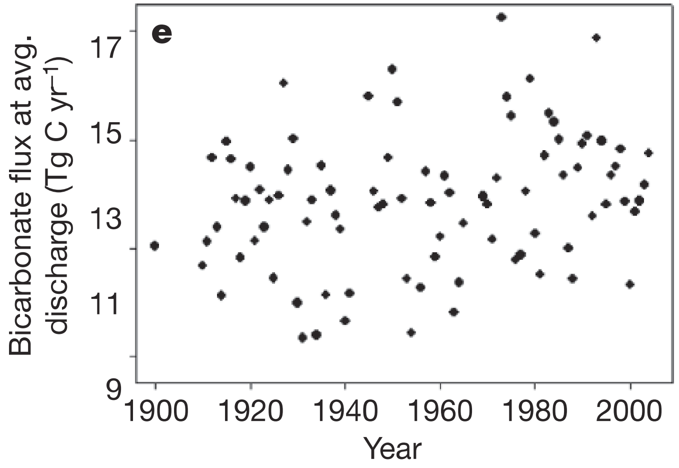
CHANGE IN RIVERINE FLUXES



Trends in river flow (1971–2010). Gudmundsson et al. (2021), *Science*.

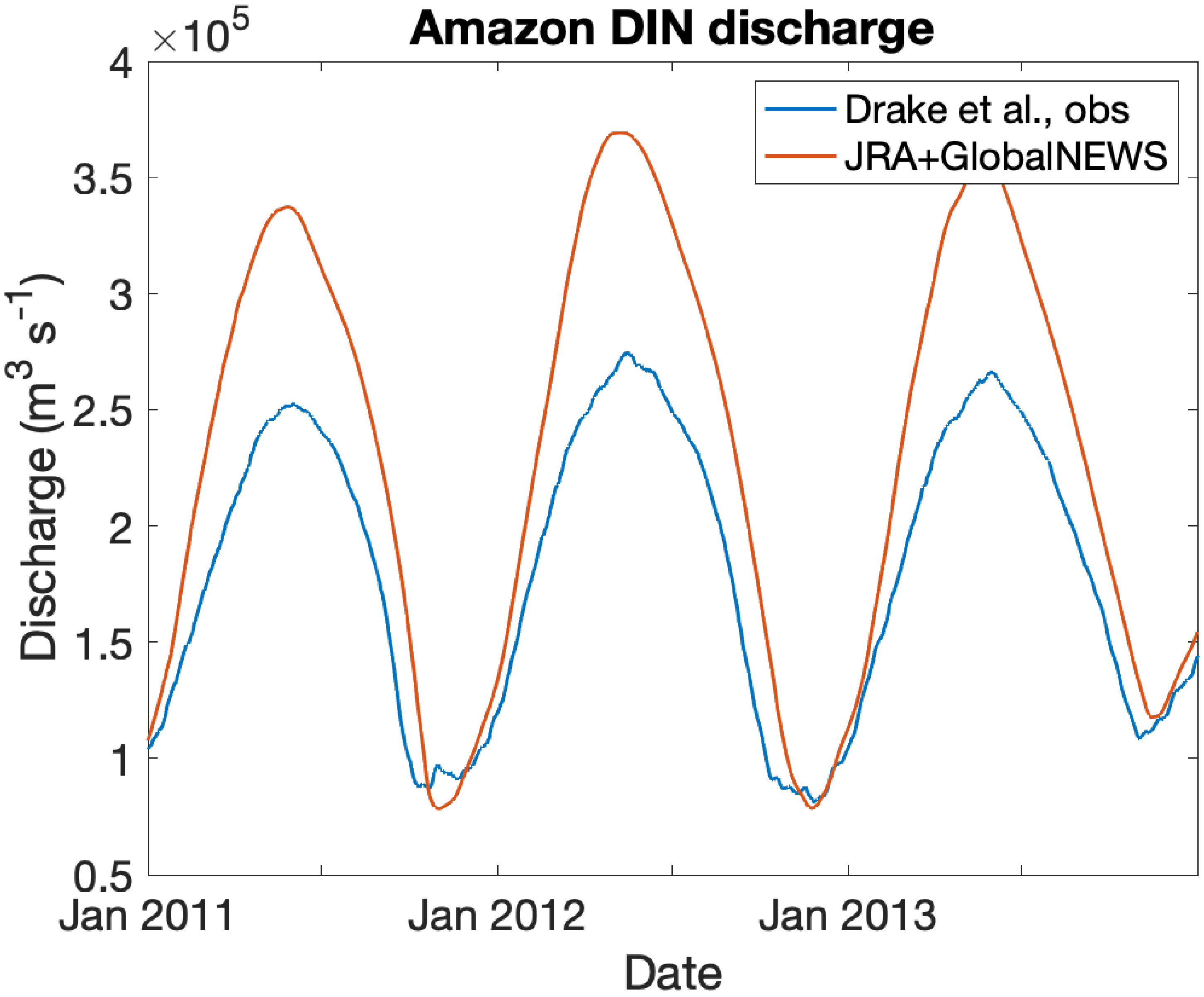


Trends in dissolved organic carbon in surface waters from 1990–2004. Monteith et al. (2007), *Nature*.

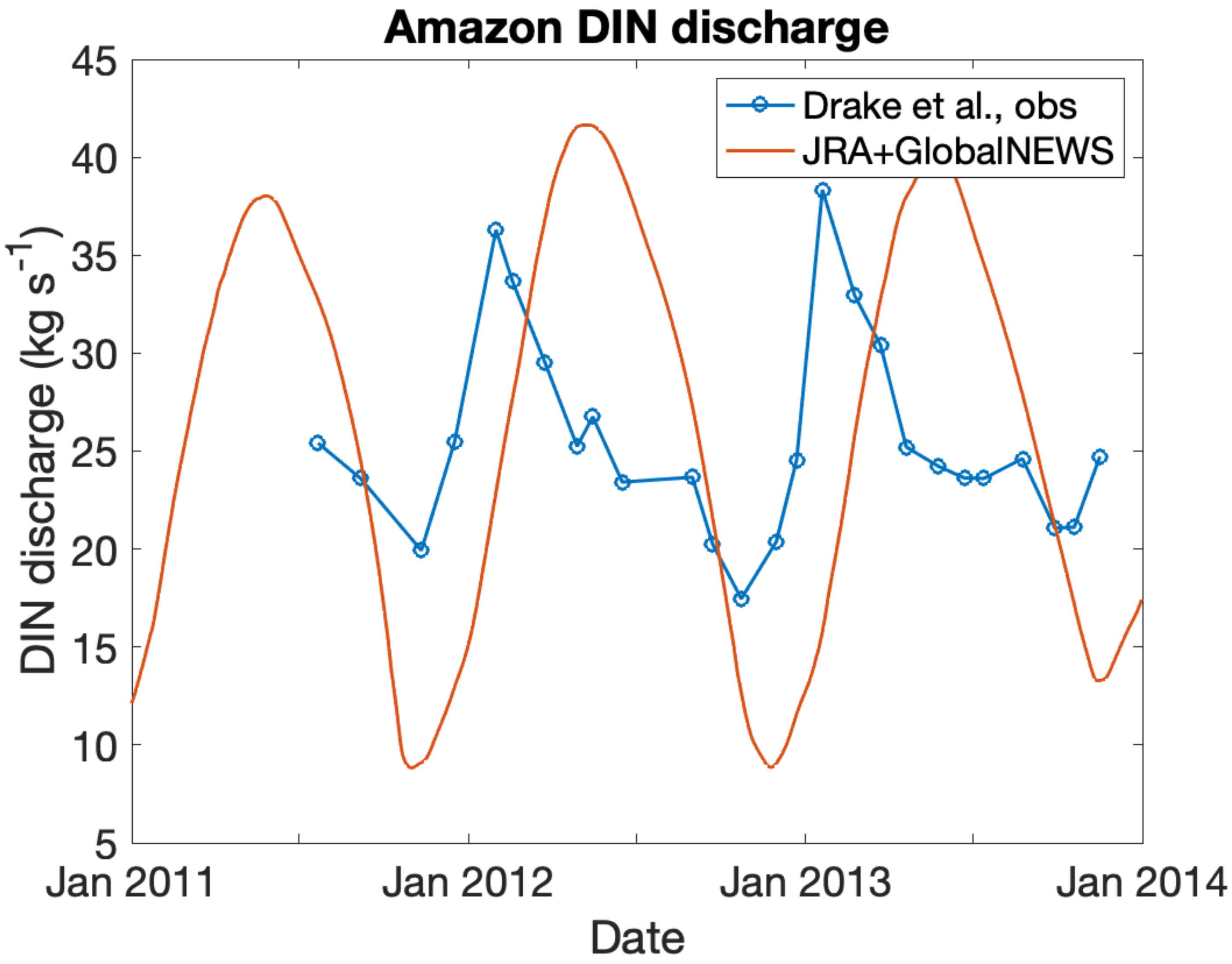


Bicarbonate flux at average discharge for the Mississippi River. Raymond et al. (2008), *Nature*.

IMPLEMENTING DAILY DISCHARGE INTO ECCO-DARWIN



IMPLEMENTING DAILY DISCHARGE INTO ECCO-DARWIN



IMPLEMENTING DAILY DISCHARGE INTO ECCO-DARWIN

Make it bigger and add observations from Tank et al