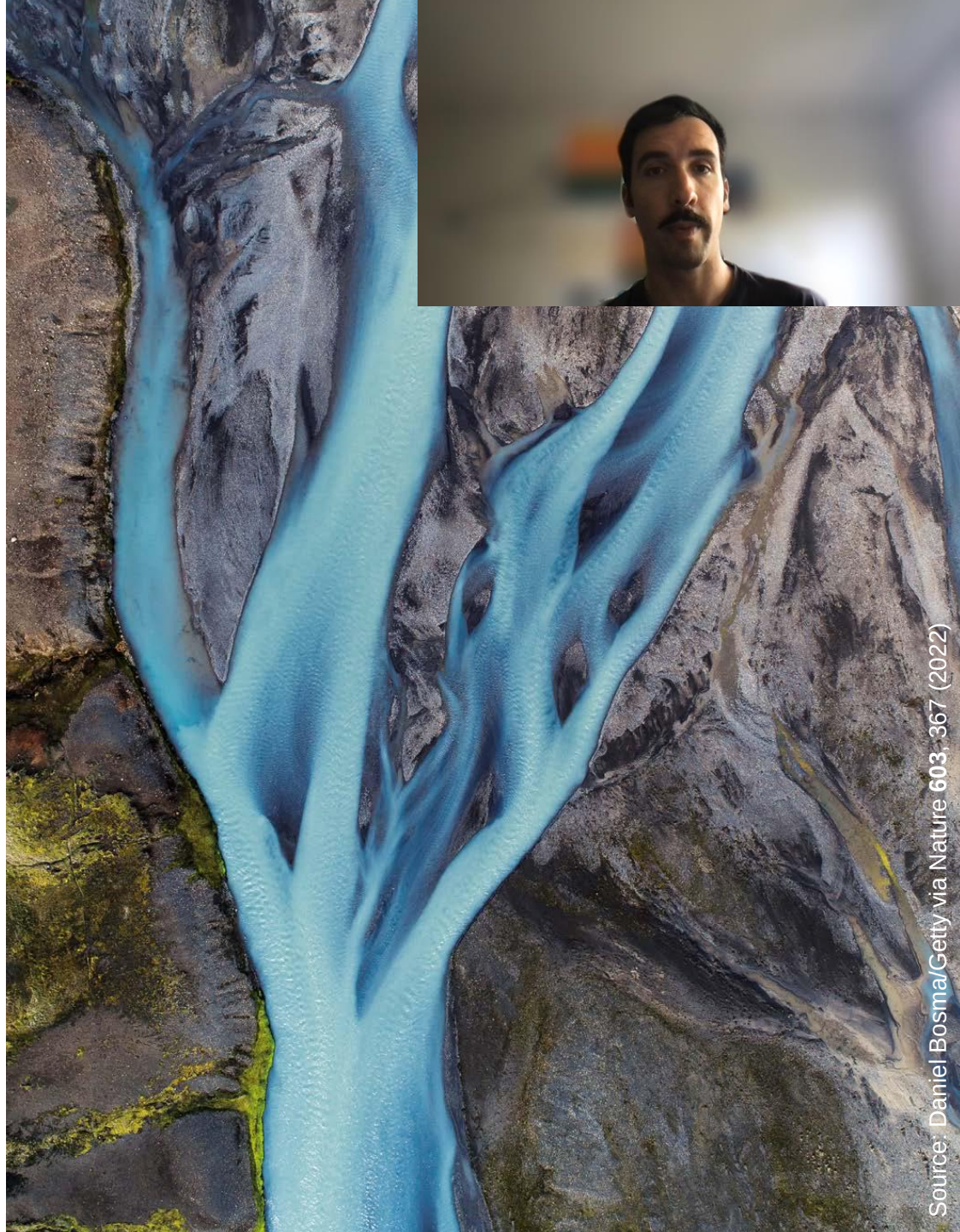
Global-ocean carbon and biogeochemical response to input from rivers and coastal wetlands

Raphaël Savelli[1], D. Menemenlis[1], M. Simard[1], D. Carroll[2], T. Van der Stocken[3], S. Dutkiewicz[4,5], Hong Zhang[1]

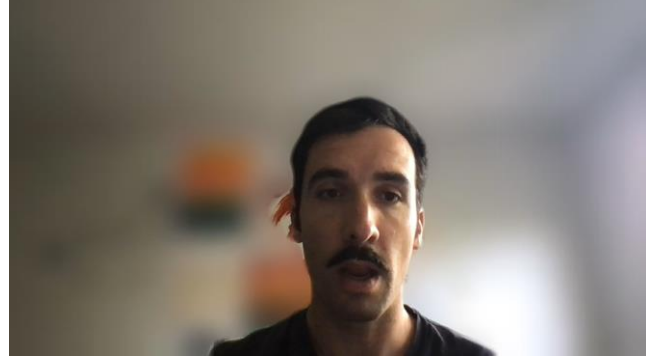
Jet Propulsion Laboratory, California Institute of Technology

ECCO Annual Meeting
January, 21, 2024

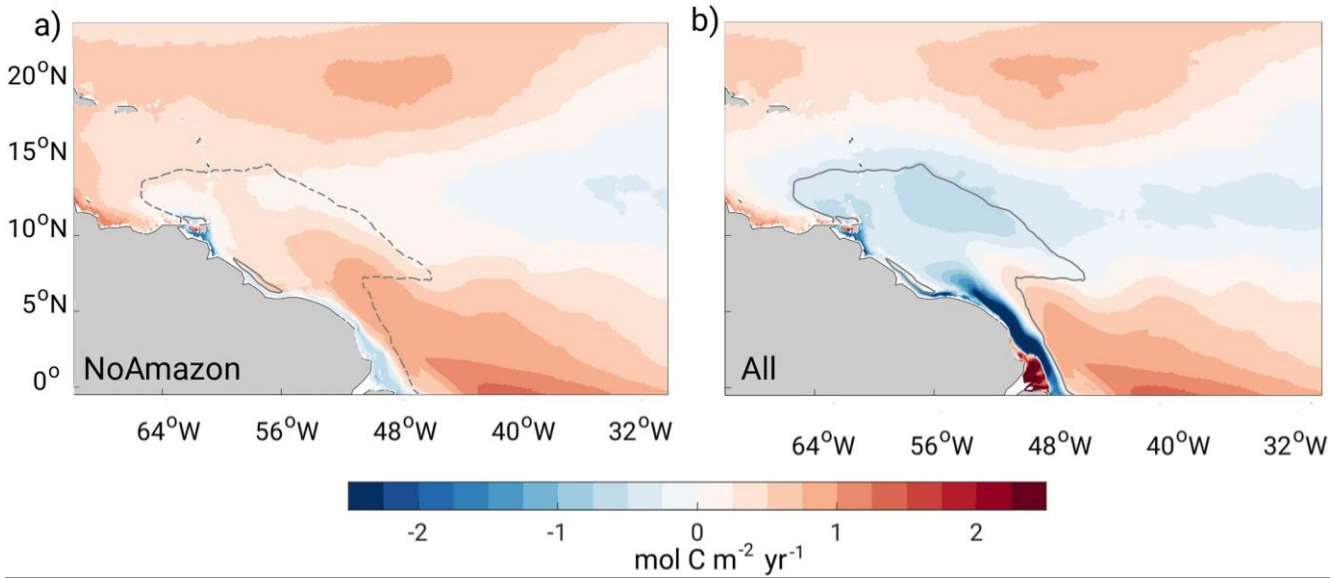
Jet Propulsion Laboratory
California Institute of Technology



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



INTRODUCTION



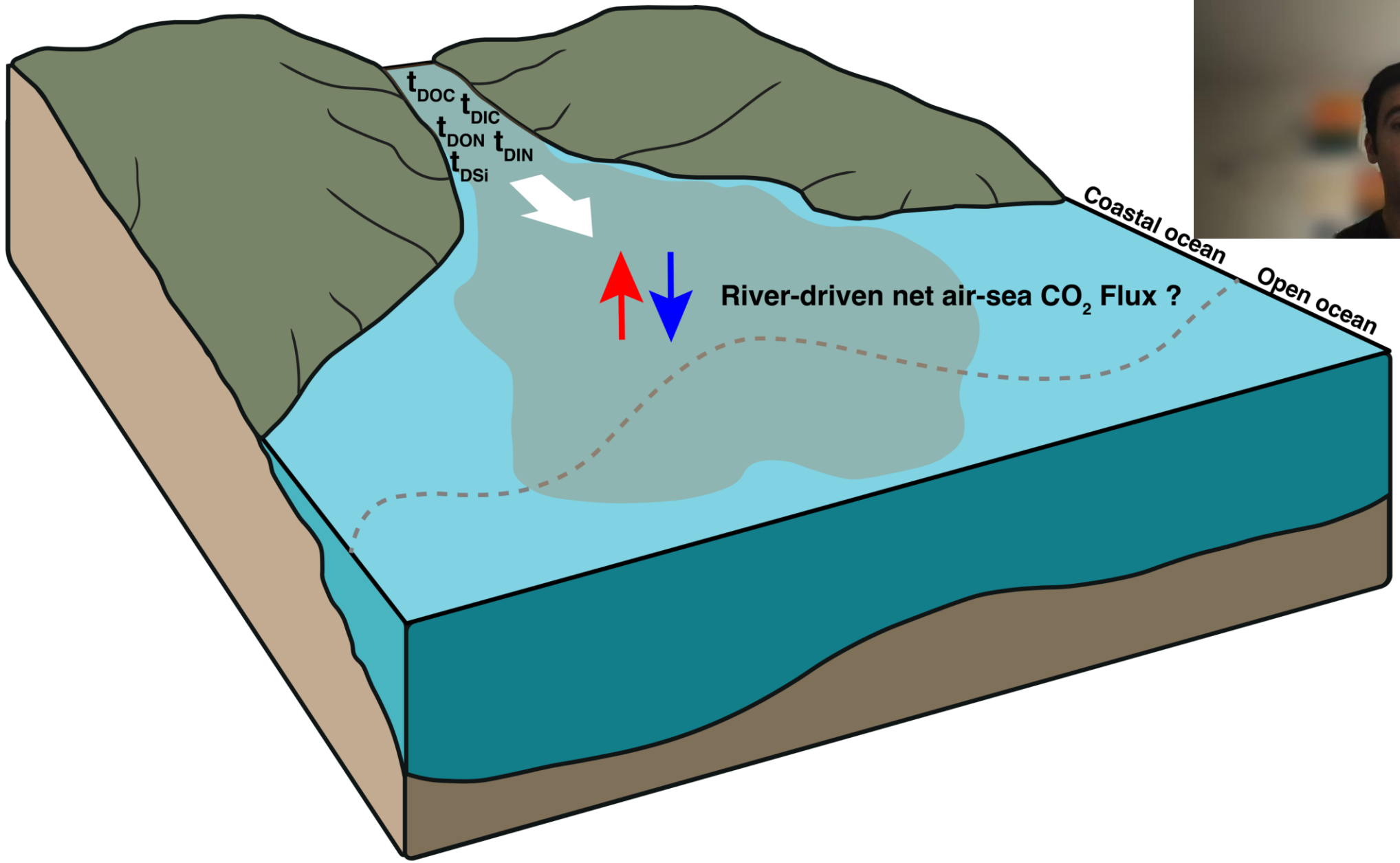
Simulated annual average air-sea CO2 flux density in the Western Tropical Atlantic.

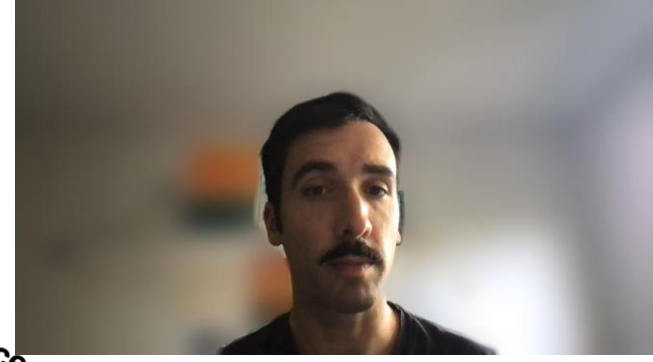
Louchard et al. (2021), *Global Biogeochemical Cycles*

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

- Significant amount of carbon and nutrients delivered to the ocean
- From natural and anthropogenic sources
- Key role in ocean and coastal waters biogeochemistry

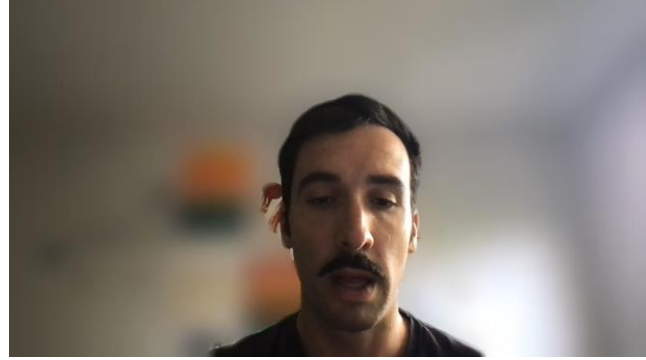
OBJECTIVE





Quantifying the impact of terrestrial carbon and nutrients in ocean carbon chemistry and biology

IMPLEMENTING DAILY, POINT-SOURCE DISCHARGE INTO AN OCEAN MODEL

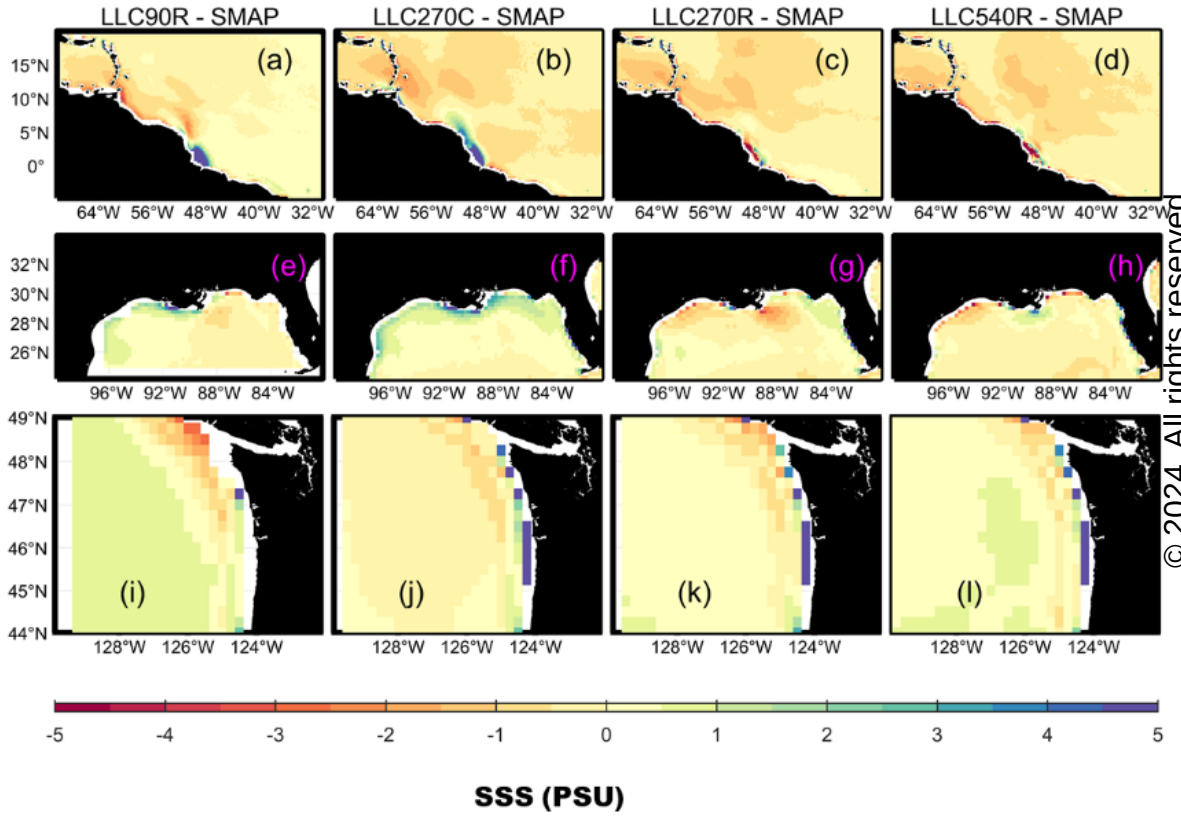


Geosci. Model Dev., 14, 1801–1819, 2021
https://doi.org/10.5194/gmd-14-1801-2021

Geoscientific Model Development
Open Access
EGU

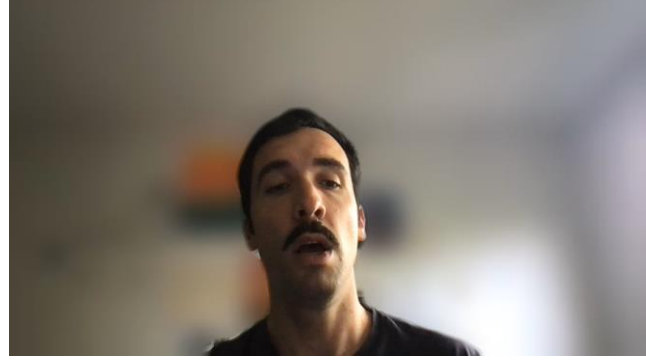
Improved representation of river runoff in Estimating the Circulation and Climate of the Ocean Version 4 (ECCOv4) simulations: implementation, evaluation, and impacts to coastal plume regions

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



Key point:

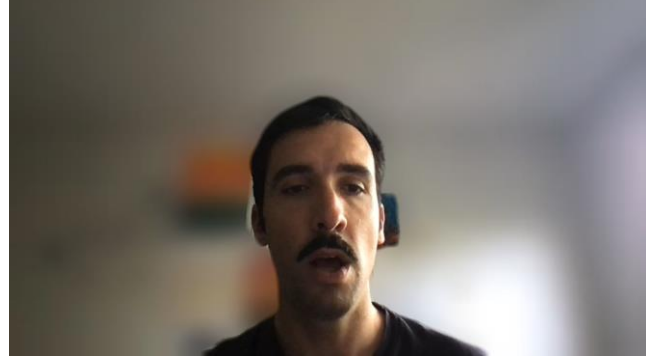
Simulated sea surface salinity better agrees with SMAP observations when considering daily point-source runoff and coarse resolution (ECCO LLC90).



IMPLEMENTING DAILY, POINT-SOURCE DISCHARGE INTO AN OCEAN MODEL

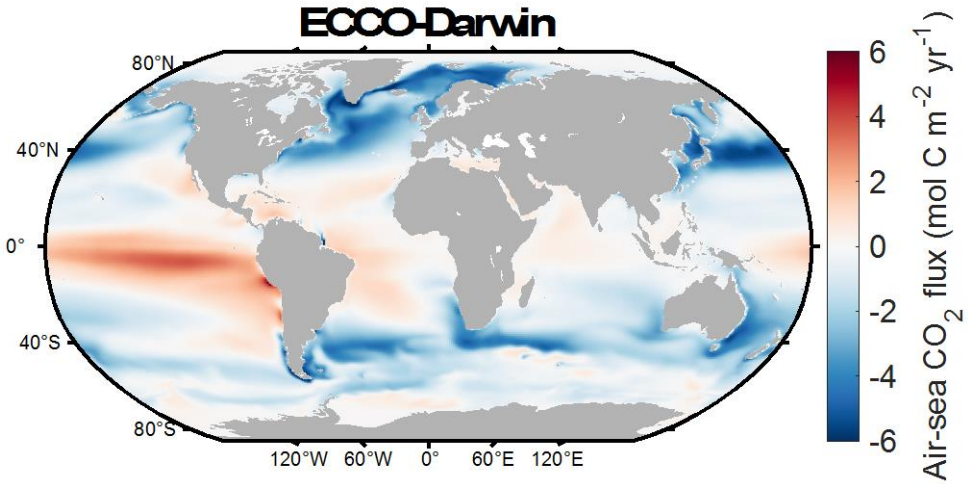
We combine different models to connect land and ocean:

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

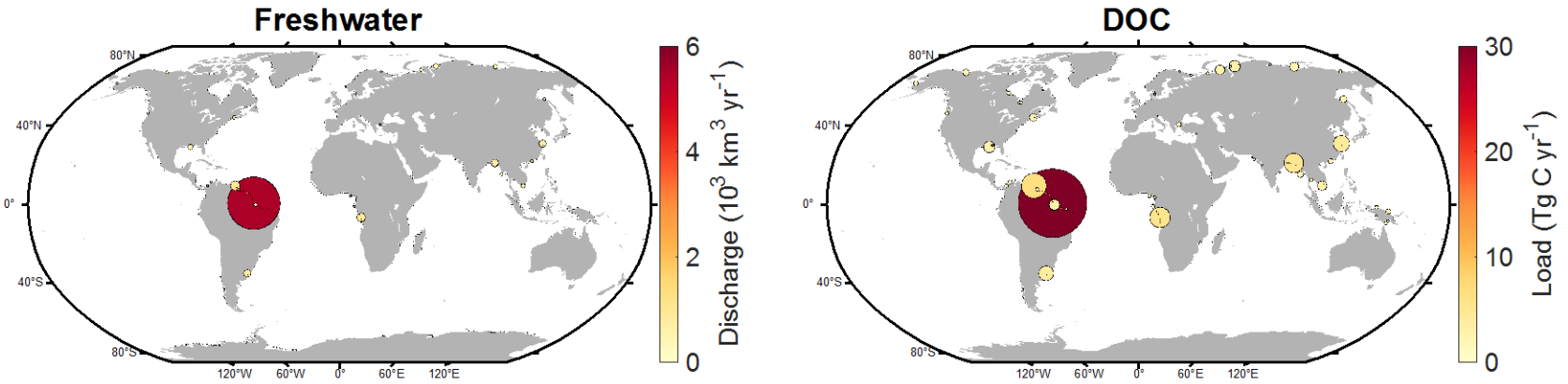


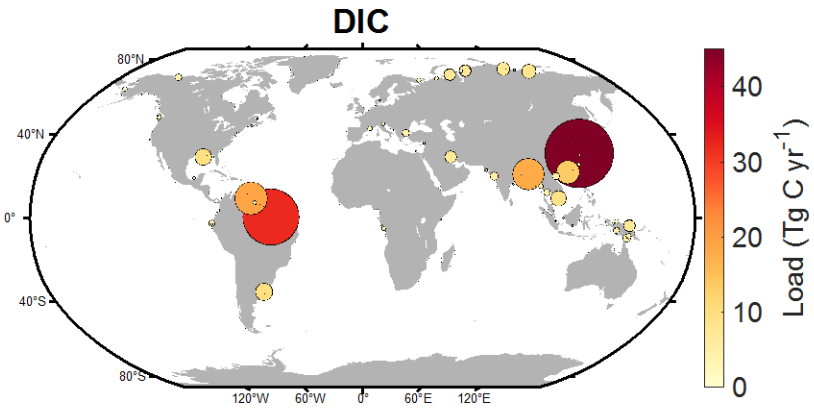
IMPLEMENTING DAILY, POINT-SOURCE DISCHARGE INTO AN OCEAN MODEL

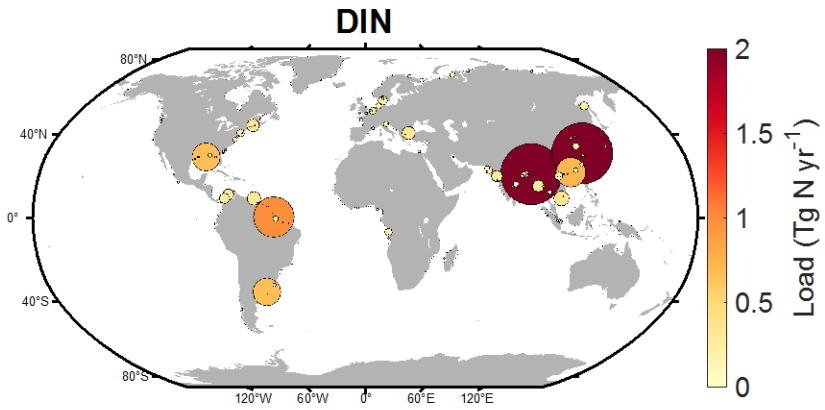
- New ECCO-Darwin version at 1 degree of horizontal resolution (LLC90)
- A baseline simulation and 6 sensitivity experiments

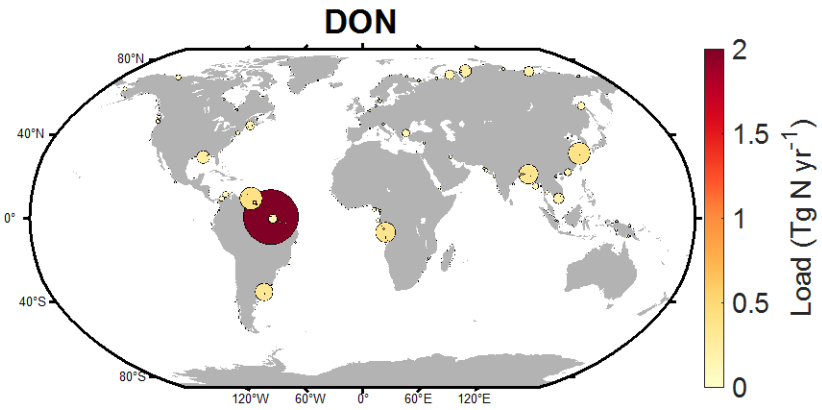


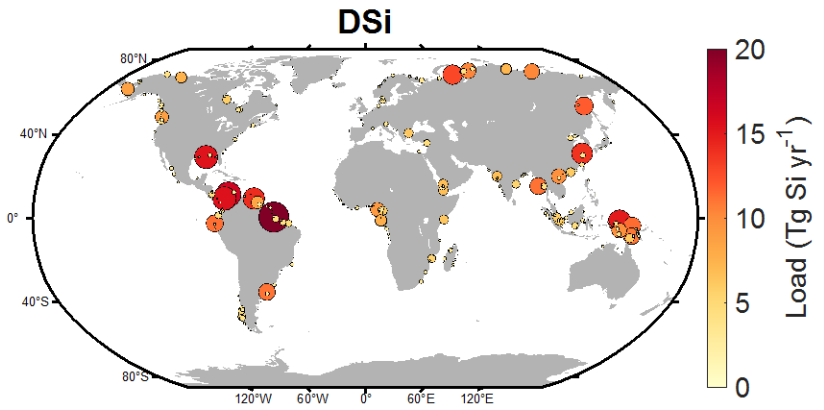
Name	DOC ($Tg\ C\ yr^{-1}$)	DIC ($Tg\ C\ yr^{-1}$)	DON ($Tg\ N\ yr^{-1}$)	DIN ($Tg\ N\ yr^{-1}$)	DSi ($Tg\ Si\ yr^{-1}$)
DC_{run}	170	381	0	0	0
DIC_{run}	0	381	0	0	0
DN_{run}	0	0	11.6	23.3	0
DIN_{run}	0	0	0	23.3	0
DSi_{run}	0	0	0	0	139.7
ALL_{run}	170	381	11.6	23.3	139.7

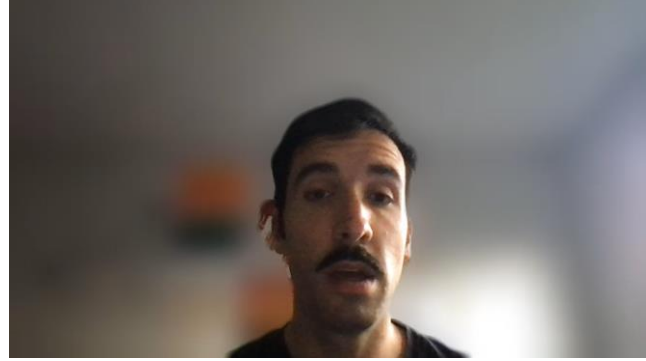








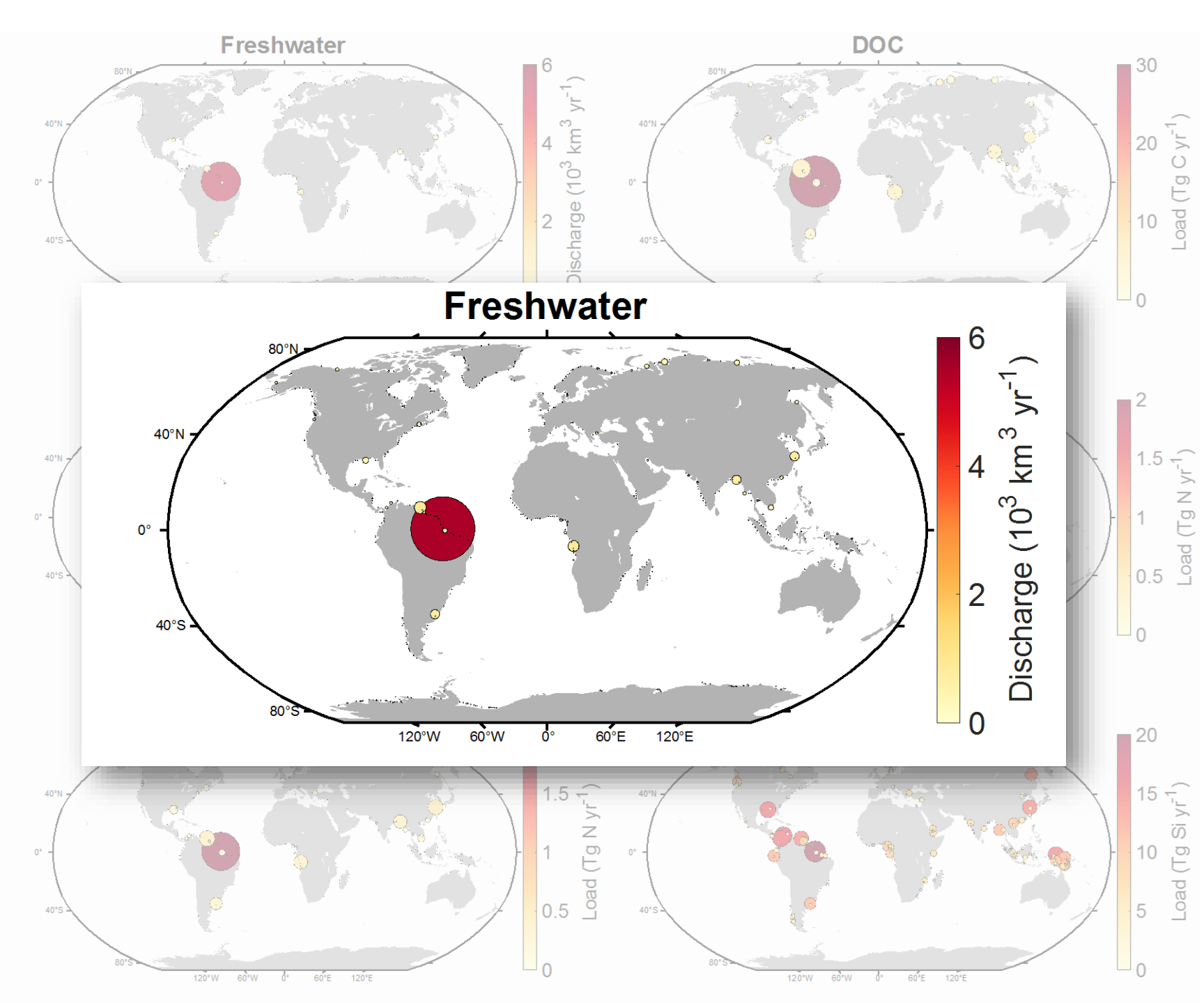


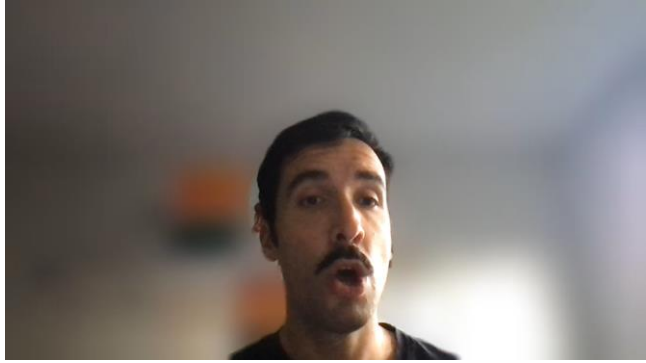


GLOBAL NUTRIENT DISCHARGE

Contrasting patterns in C/nutrient discharge:

- Arctic and Tropical Atlantic are dominated by dissolved carbon
- Southeast Asia is dominated by dissolved inorganic nitrogen





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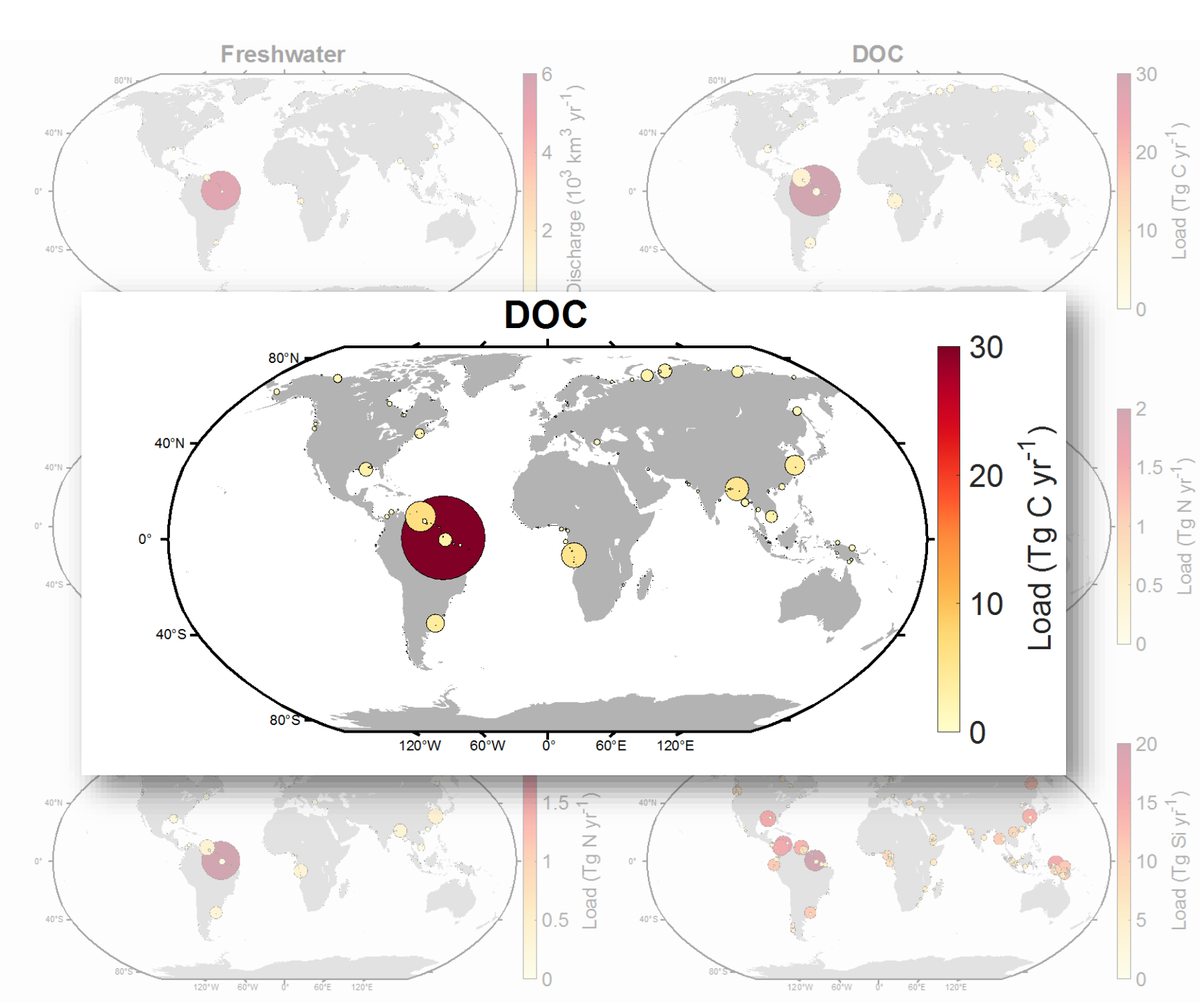

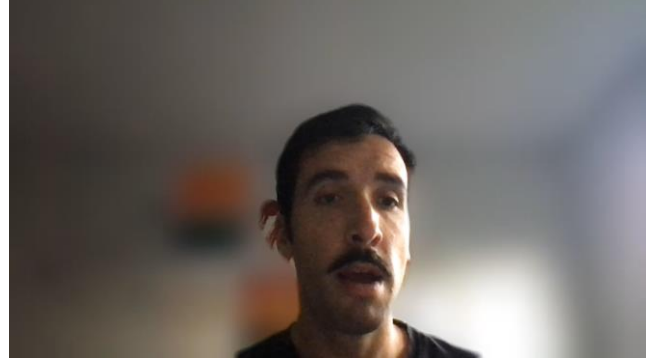

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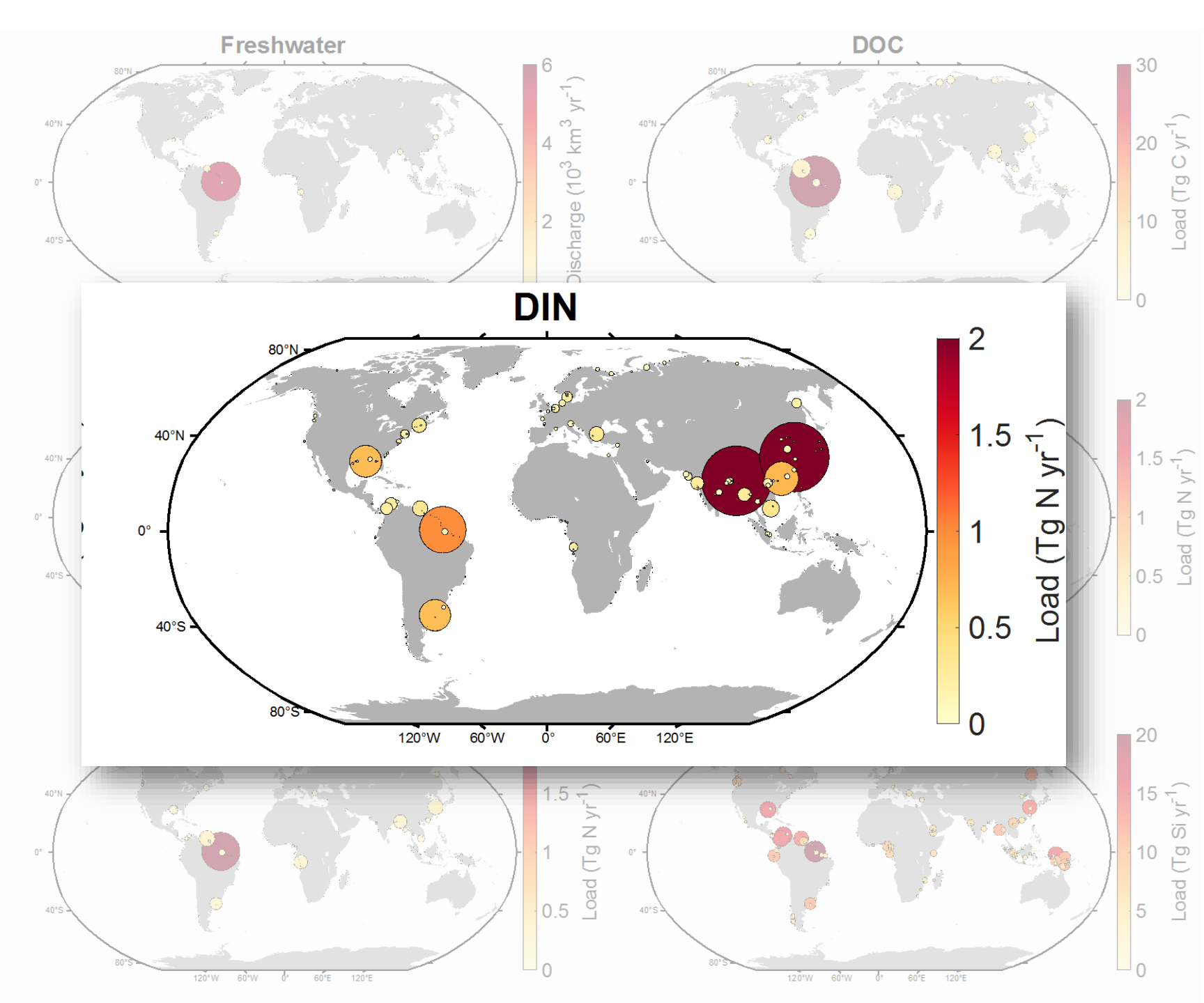

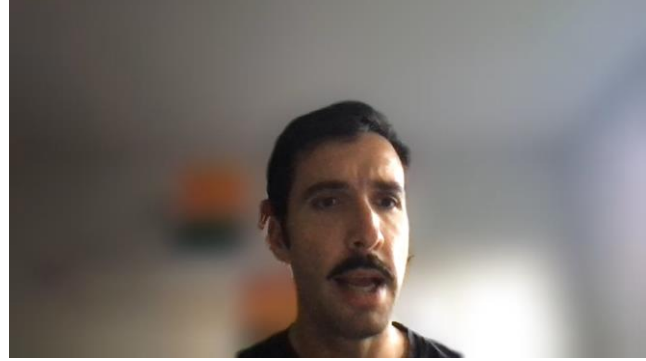

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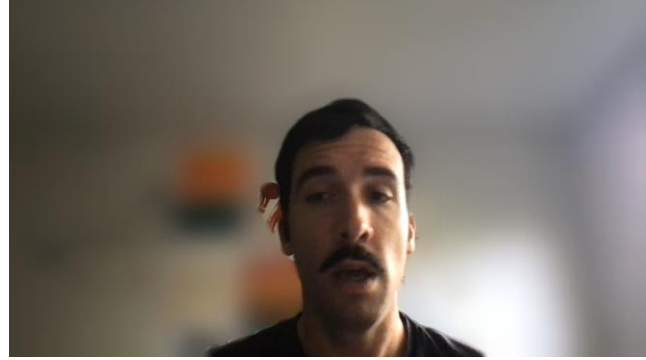
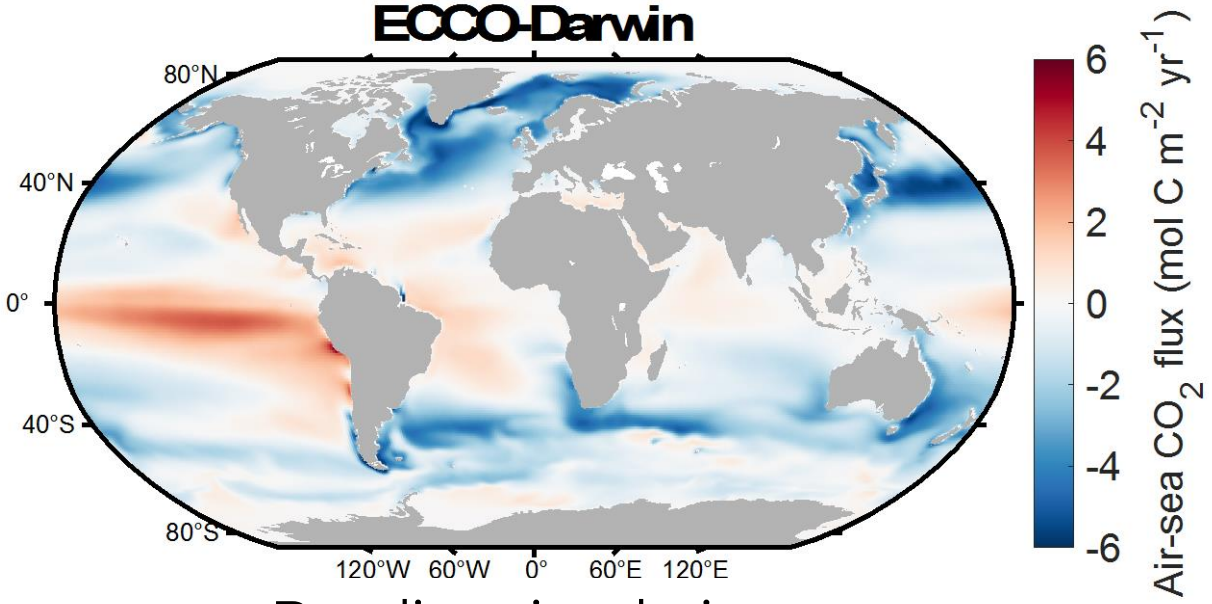
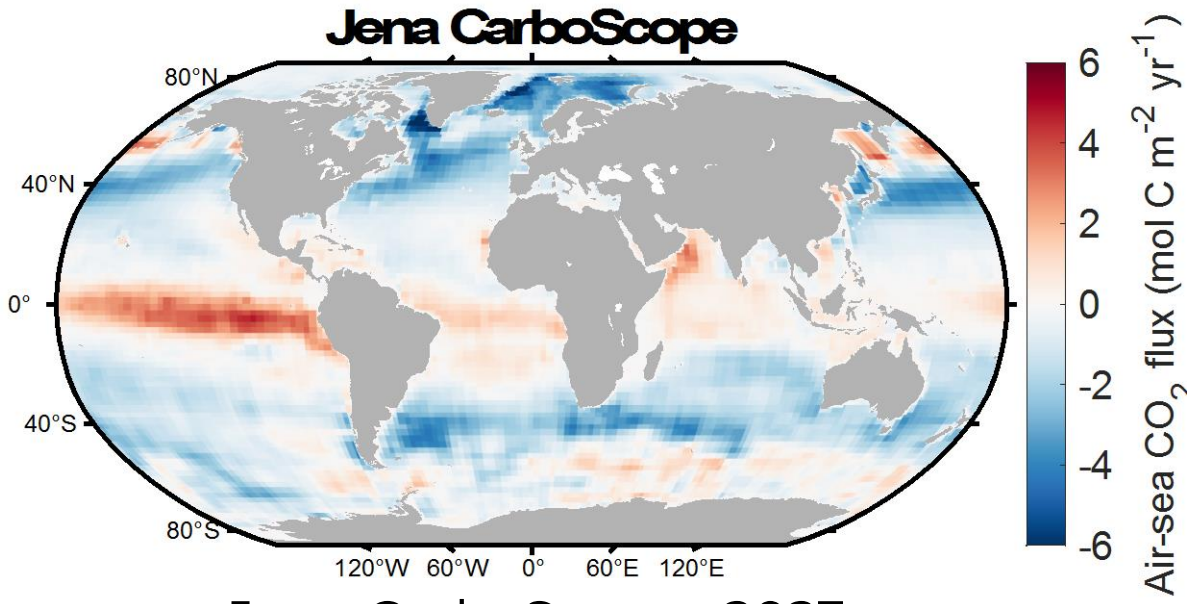


GLOBAL AIR-SEA CO_2 FLUX SENSITIVITY



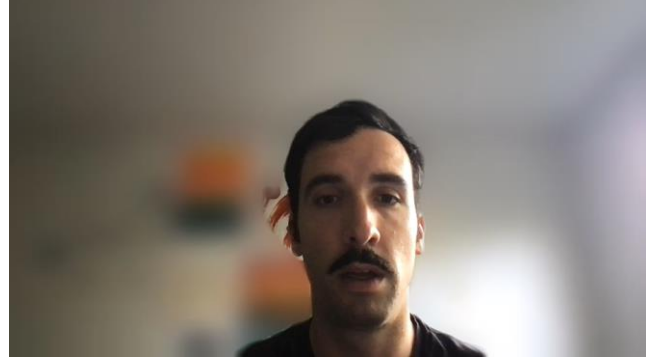
Baseline simulation



Jena CarboScope v2023

(Rödenbeck, 2005)

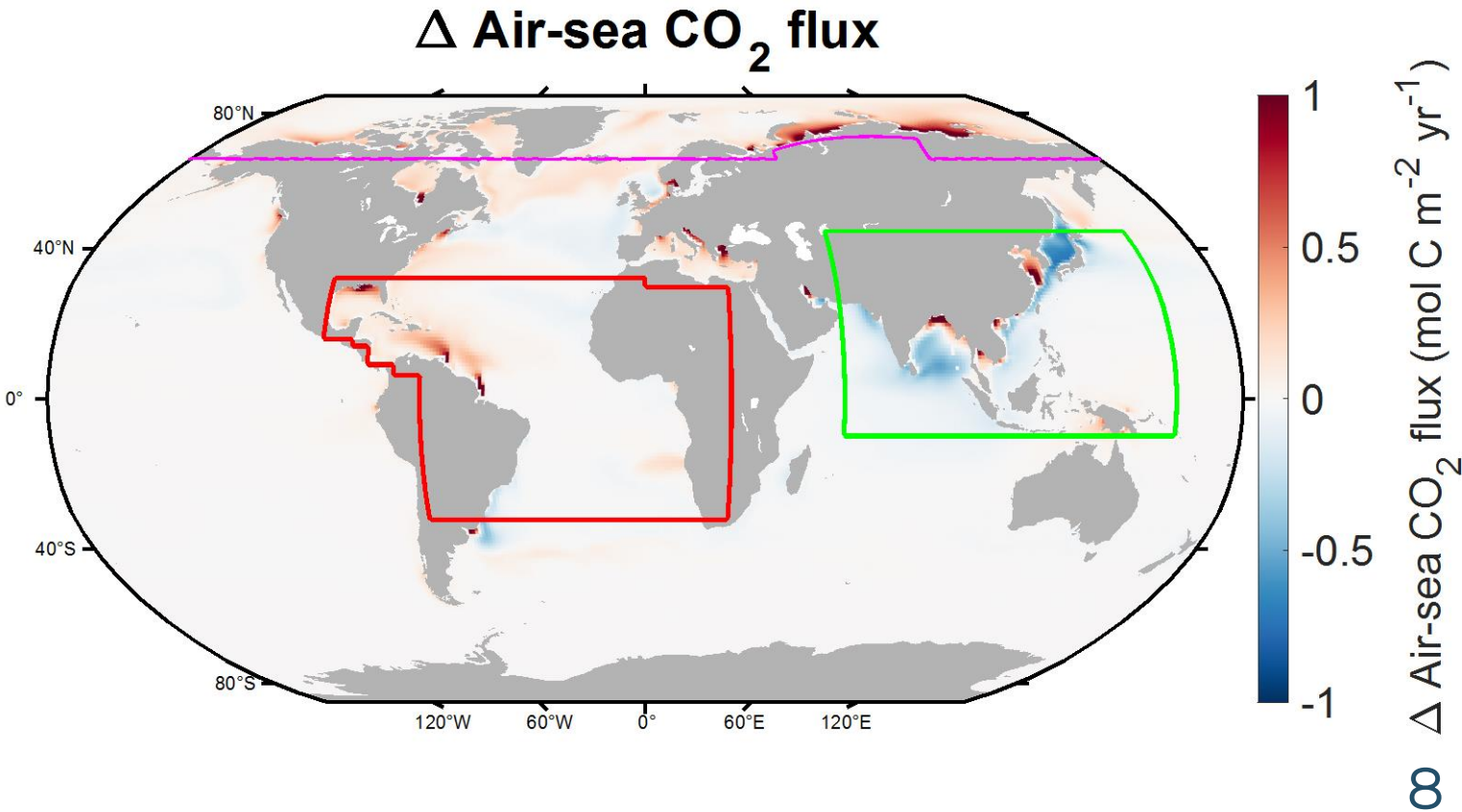
→ How does the simulation with riverine carbon and nutrients differ from the baseline ?

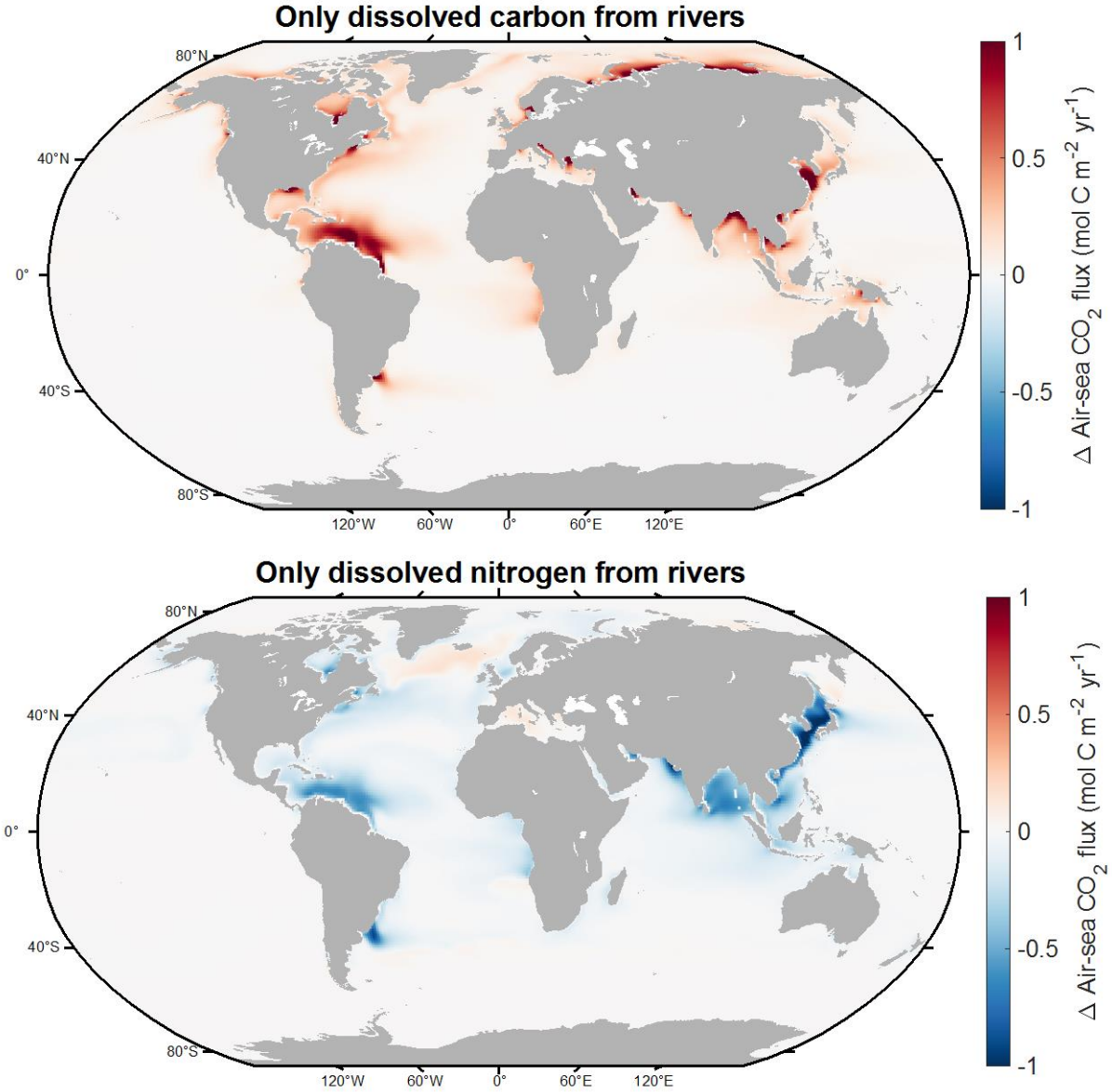


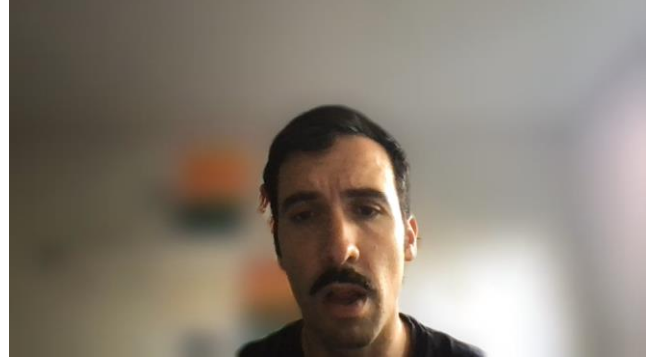
GLOBAL AIR-SEA CO_2 FLUX SENSITIVITY

Including riverine C/nutrients generally increases ocean CO_2 outgassing:

- Global: +1.5% (+0.03 Pg C yr^{-1})
- Arctic Ocean: +10%
- Tropical Atlantic: +20%
- Southeast Asia: -9%



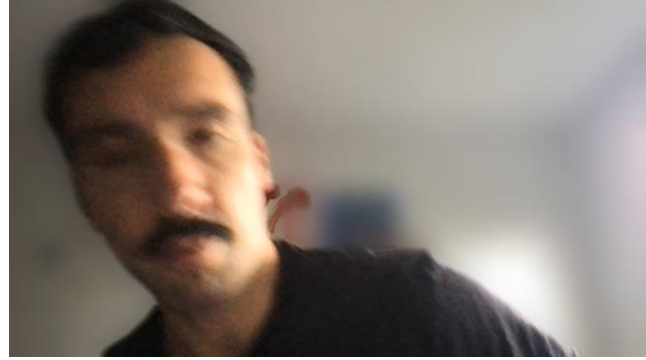




GLOBAL AIR-SEA CO_2 FLUX SENSITIVITY

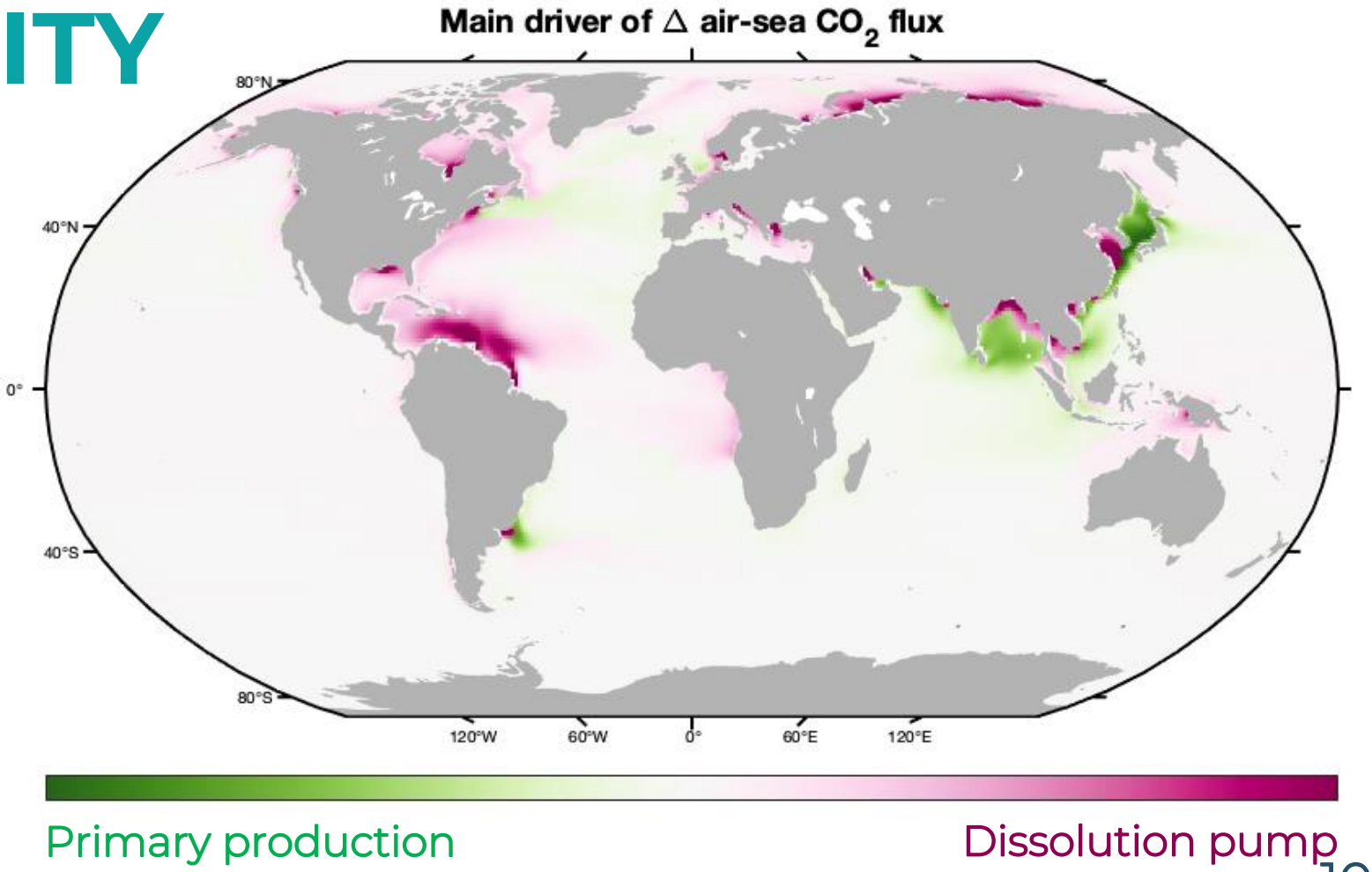
Riverine carbon and nitrogen play different roles in ocean biogeochemistry:

- C runoff drives more outgassing through physical/dissolution pump
- N runoff drives more ingassing through primary production



GLOBAL AIR-SEA CO_2 FLUX SENSITIVITY

- Change in air-sea CO_2 flux associated with the dissolution pump prevails next to big rivers mouths
- Primary production is controlling change in air-sea CO_2 flux further out



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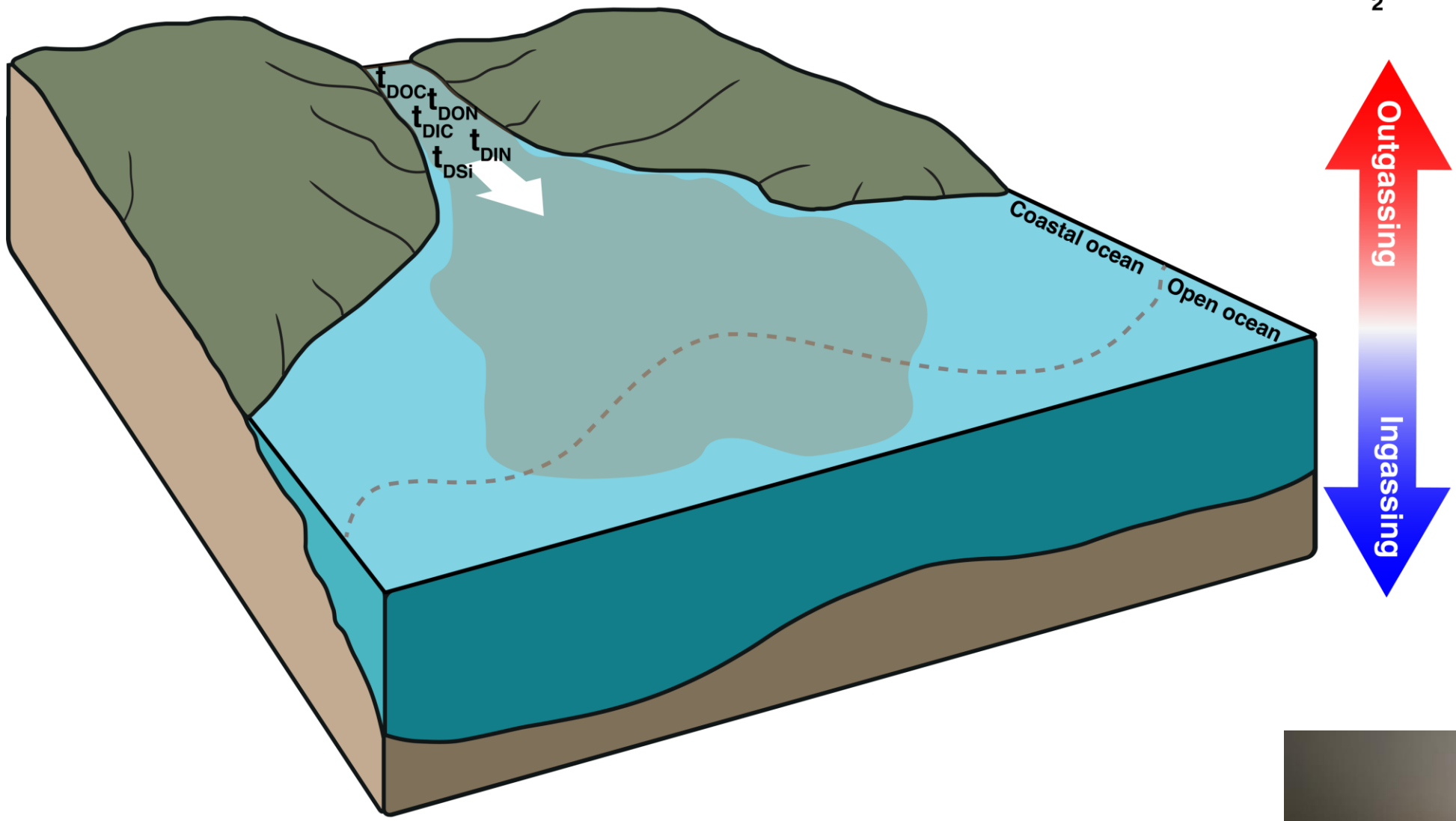

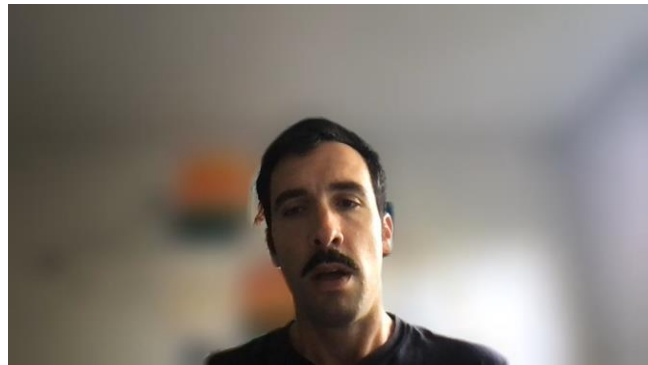

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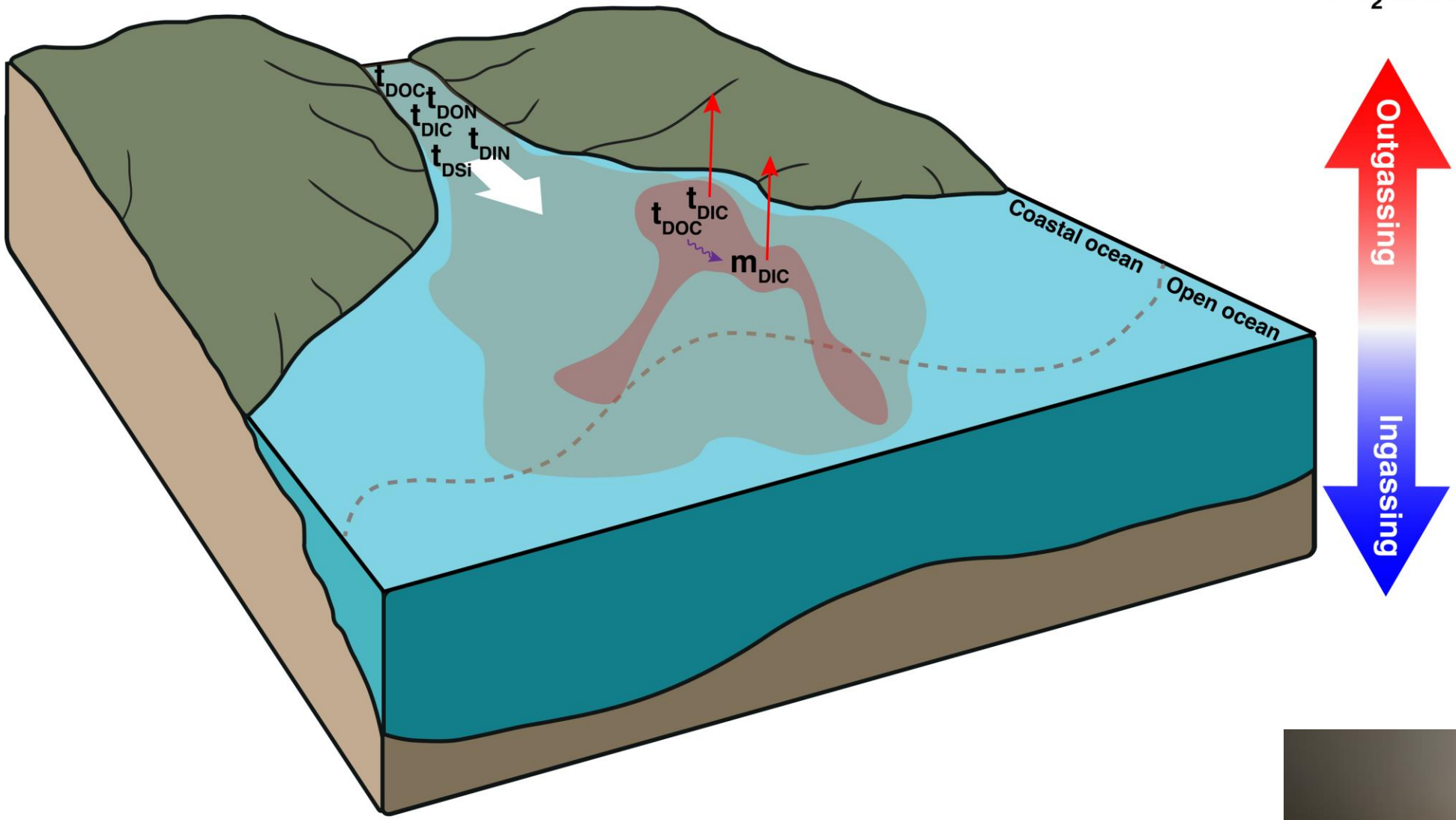

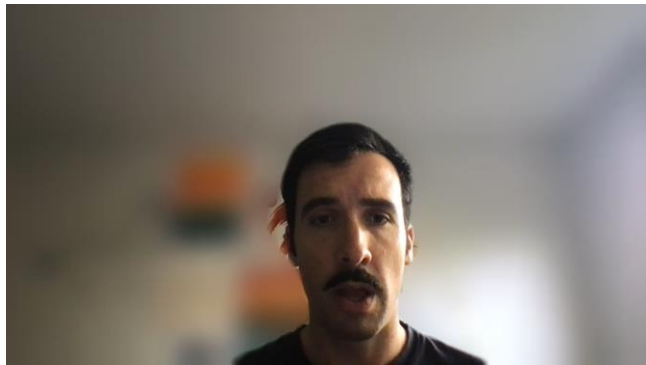

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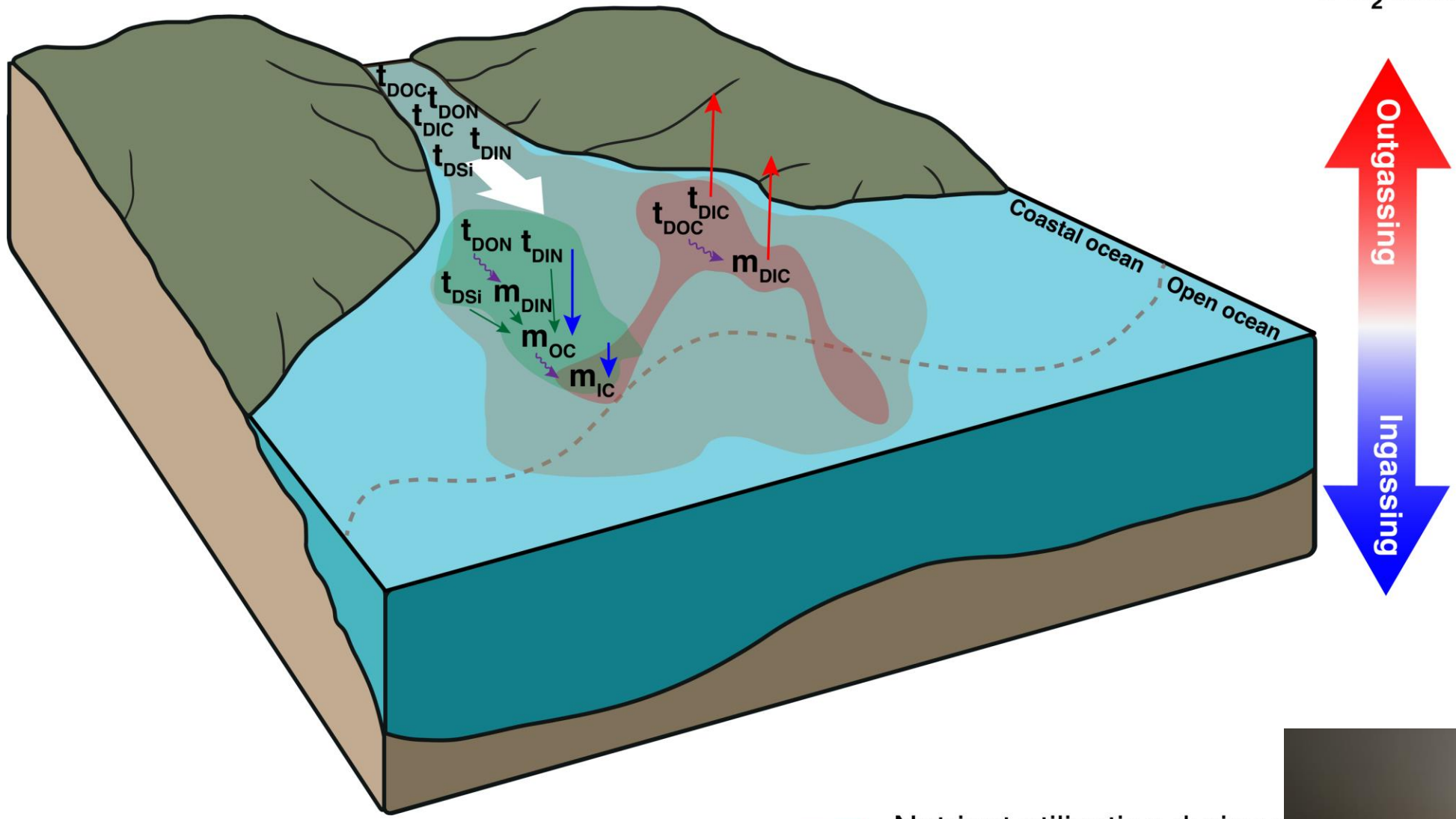

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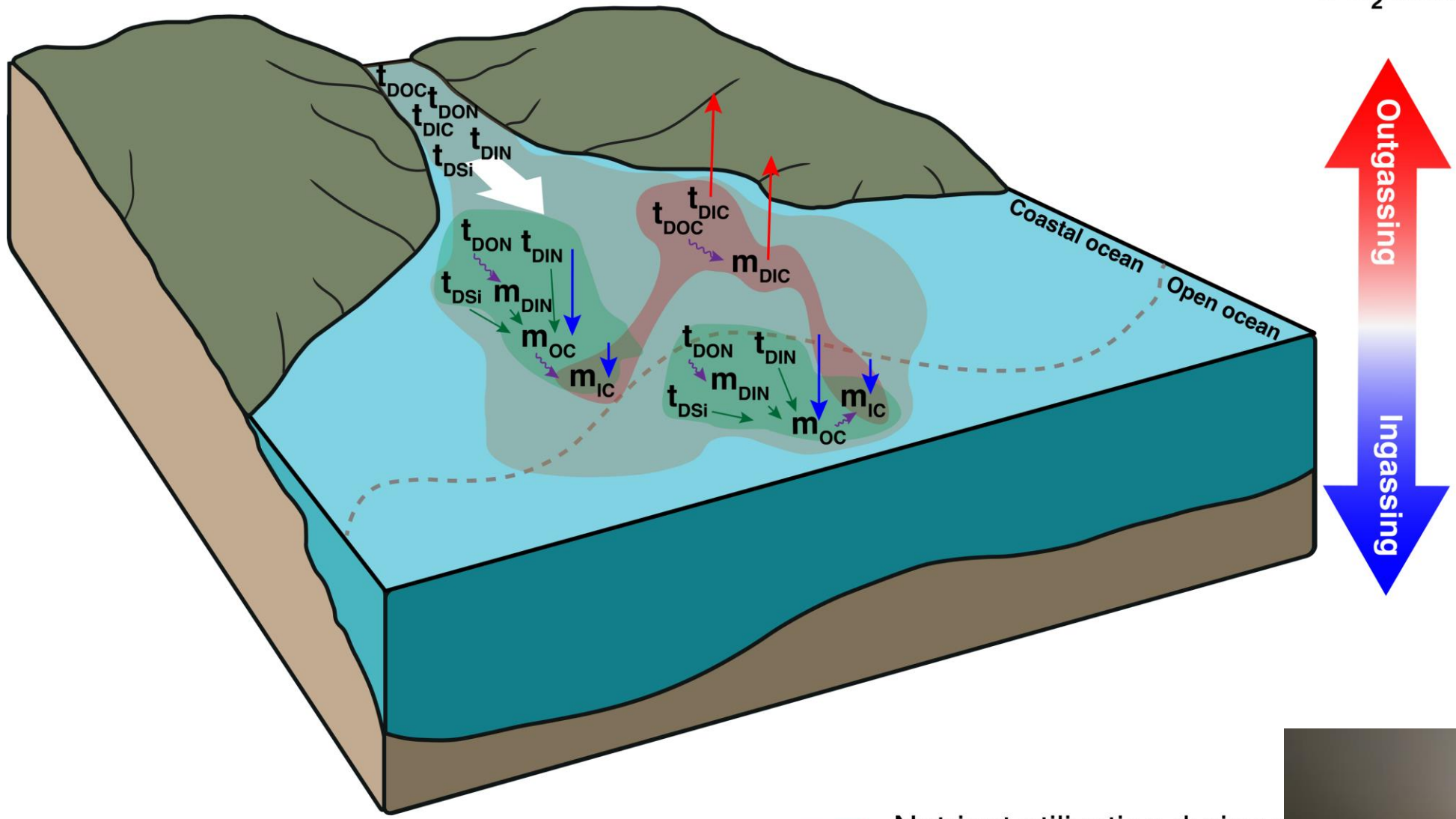

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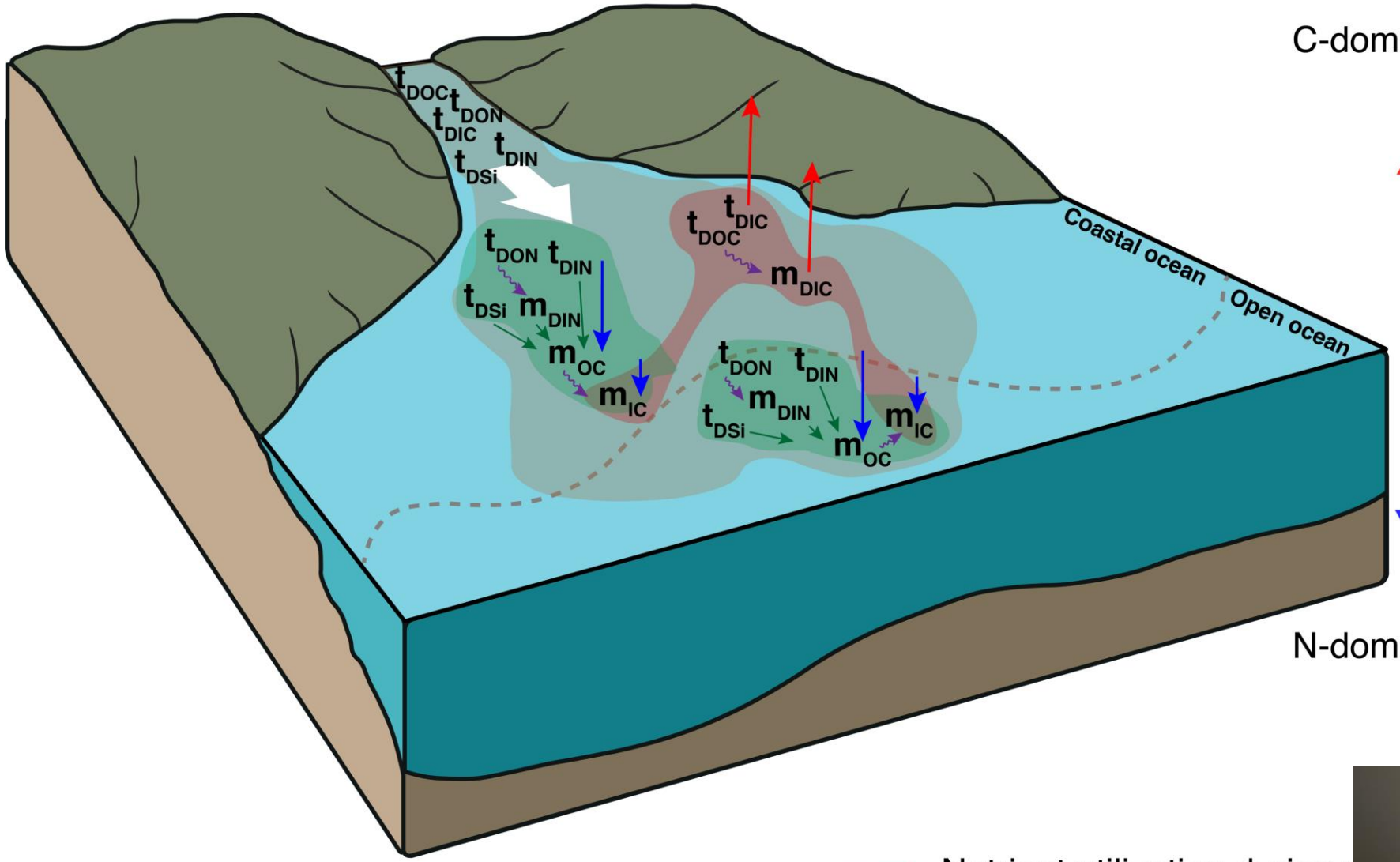
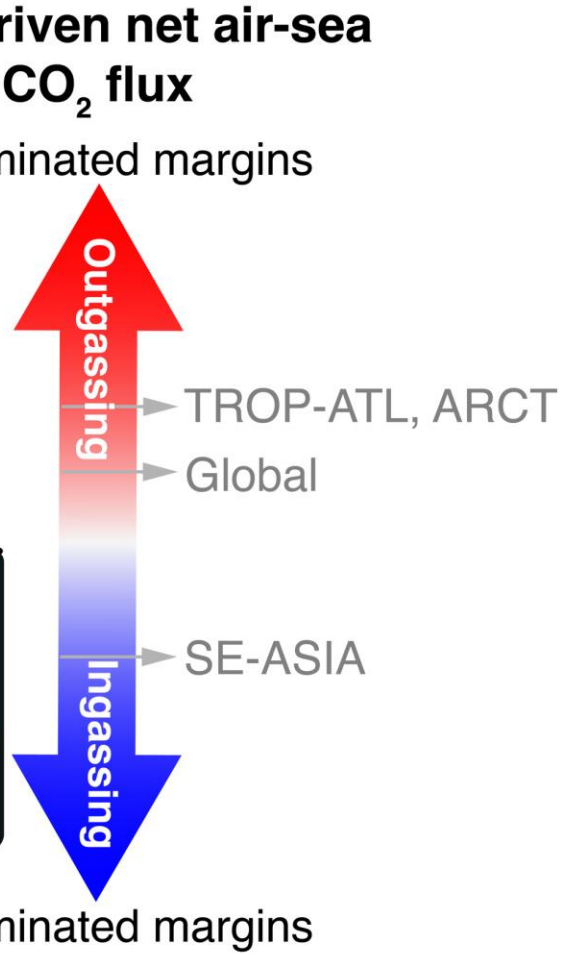
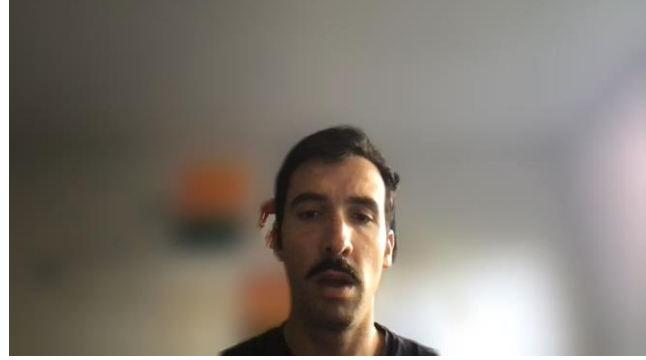


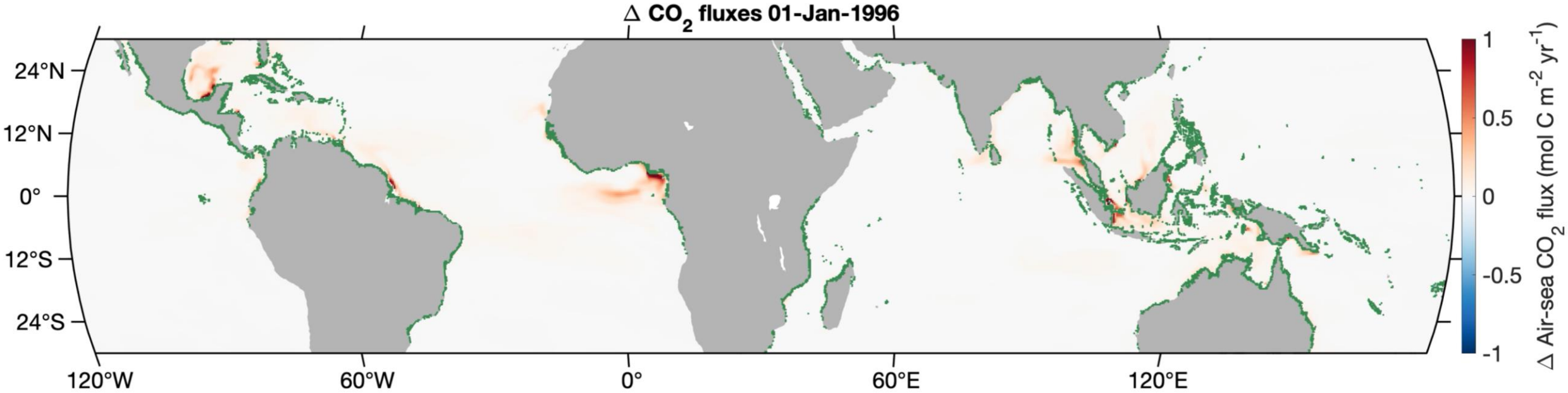


River plume
River-enhanced marine biological production
River-impacted dissolution of carbon

Nutrient utilization during p
production
Nutrient remineralization
Air-sea CO_2 flux

WHAT ABOUT CARBON FROM COASTAL WETLANDS ?





Change in air-sea CO_2 flux associated with export of carbon from mangroves

THANK YOU.

Raphaël Savelli[1], Dimitris Menemenlis[1], Marc Simard[1], Dustin Carroll[2], Tom Van der Stocken[3], Stephanie Dutkiewicz[4,5], Hong Zhang[1]

[1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA
[2]Moss Landing Marine Laboratories, San José State University, Moss Landing, CA, USA
[3]Ecology and Biodiversity Group, Department of Biology, Vrije Universiteit Brussel, Brussels, Belgium
[4]Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA, USA
[5]Center for Global Change Science, Massachusetts Institute of Technology, Cambridge, MA, USA

Article in prep.:

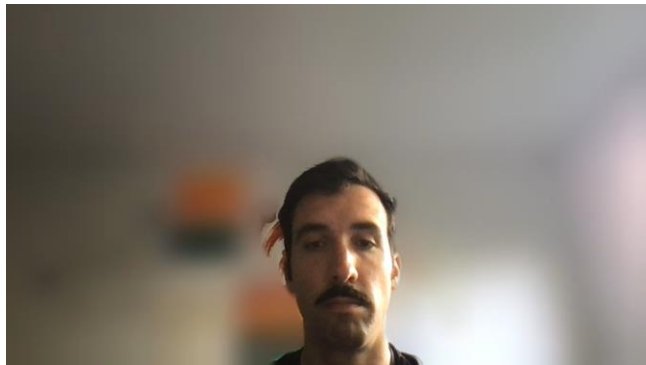
Savelli, R., Carroll, D., Menemenlis, D., Dutkiewicz, S., Manizza, M. Bloom, A., Castro-Morales, K., Miller, C., Simard, M., Bowman, K.W., Zang, H., (in prep), Role of riverine dissolved organic and inorganic carbon and nutrients in global-ocean air-sea CO_2 fluxes. Global Biogeochemical Cycles.

Open-source Model-data Availability

Platform-independent instructions / code for running ECCO-Darwin: https://github.com/MITgcm-contrib/ecco_darwin

ECCO-Darwin model output: https://data.nas.nasa.gov/ecco/

ECCO-Darwin ArcGIS StoryMaps: https://ecco-group.org/media.htm



If you have any questions or want further details, please, send me an email:

raphael.savelli@jpl.nasa.gov