National Aeronautics and Space Administration

Advancing satellite-constrained air-sea CO_2 fluxes with a focus on the strength of the Southern Ocean carbon sink

Lionel A. Arteaga (NASA GSFC | GESTAR), Seth Bushinsky (Univ. Hawaii), Cecile Rousseaux (NASA GSFC), Brad Weir (NASA GSFC | GESTAR), Lesley Ott (NASA GSFC)

Fate of anthropogenic CO_2 emissions

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Sources

9.6 ± 0.5 Gt C/yr

89 %

1.2 ± 0.7 Gt C/yr

11 %

=

Partitioning

5.2 ± 0.02 Gt C/yr

48 %

2.9 ± 0.4 Gt C/yr

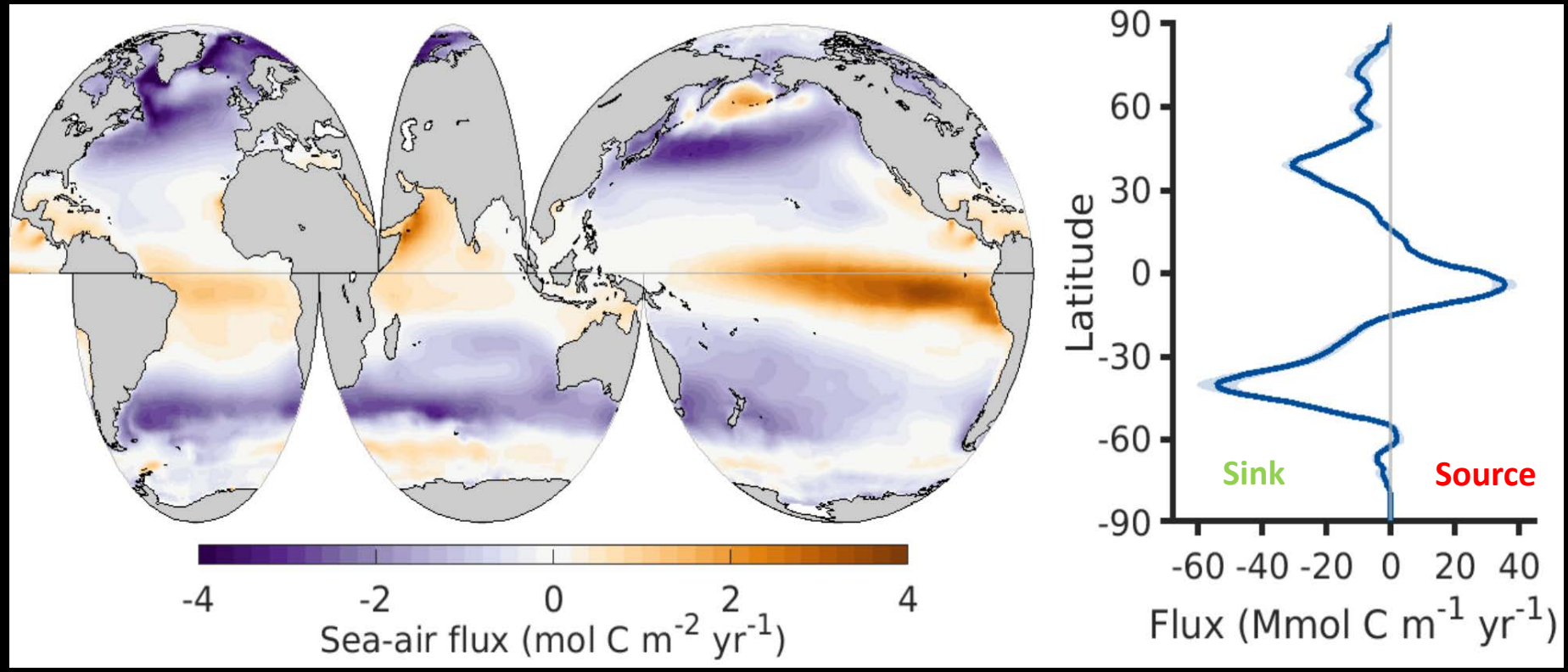
27 %

3.1 ± 0.6 Gt C/yr

29 %

Budget imbalance (net source – net sink) = -0.3 GT c/yr

Global oceanic carbon flux based on pCO_2 obs.



DeVries et al. (2023)

SO responsible for 40 % (~ 1 Pg C yr^{-1}) of oceanic anthropogenic uptake (~ 2.5 Pg C yr^{-1})

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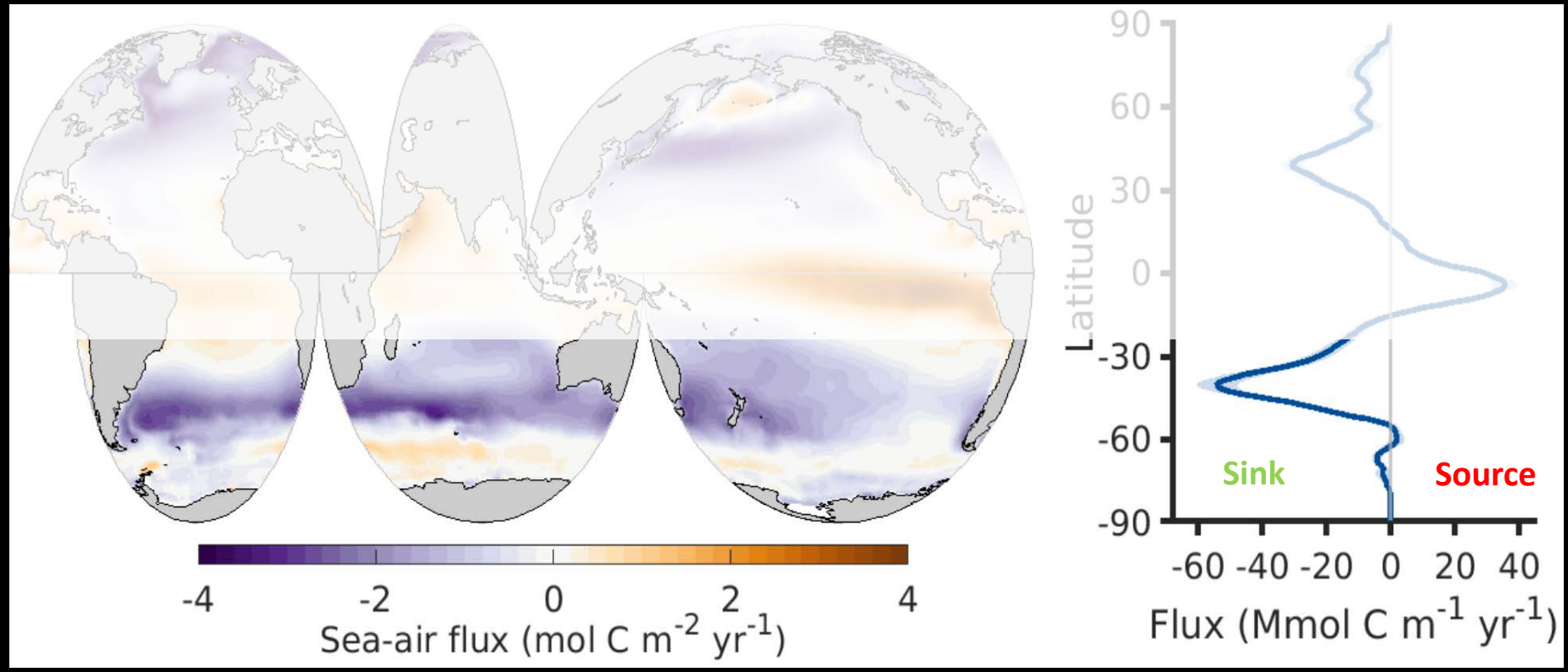

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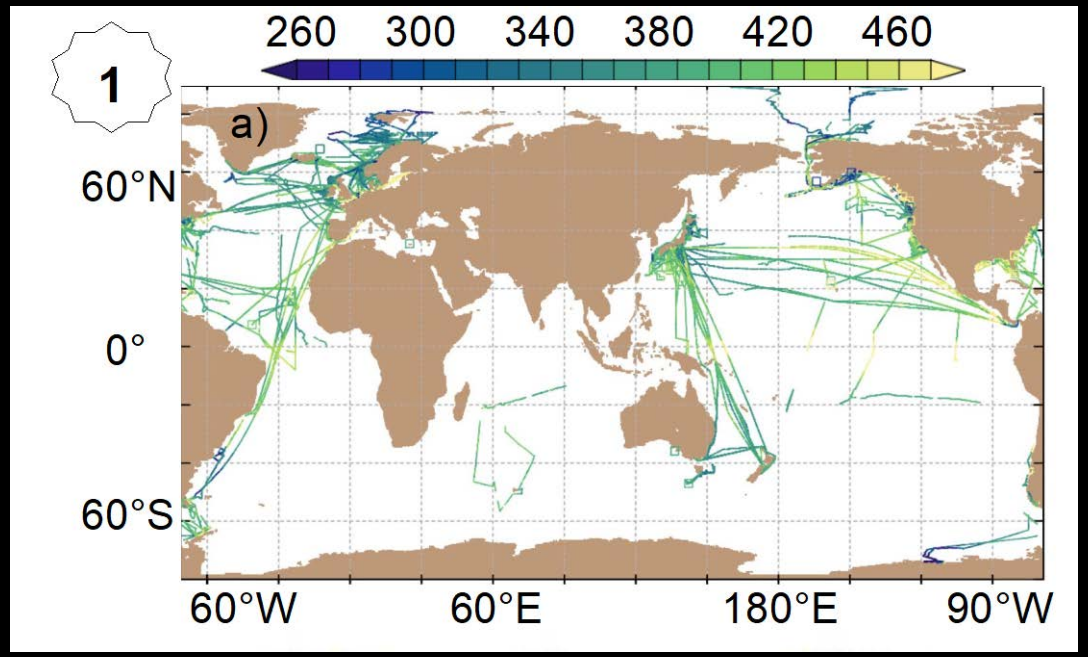
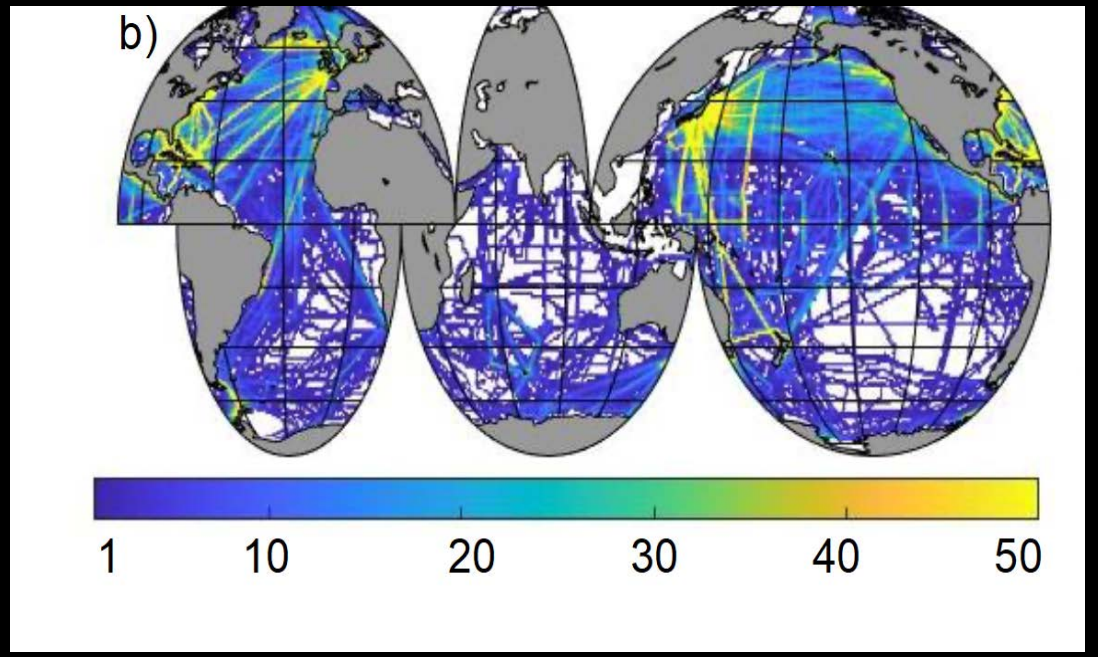
SOCAT version 2023 – An alarming decline in the ocean CO_2 observing capacity



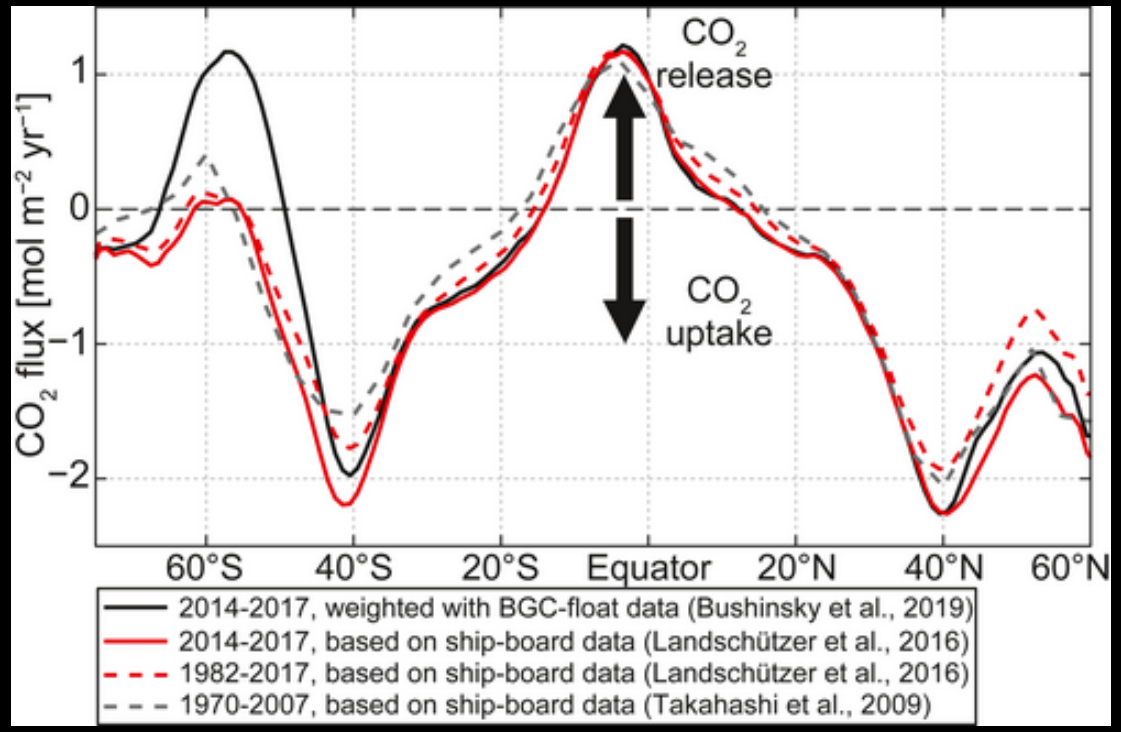
Newly available fCO_2 with accuracy < 10 uatm in 2023



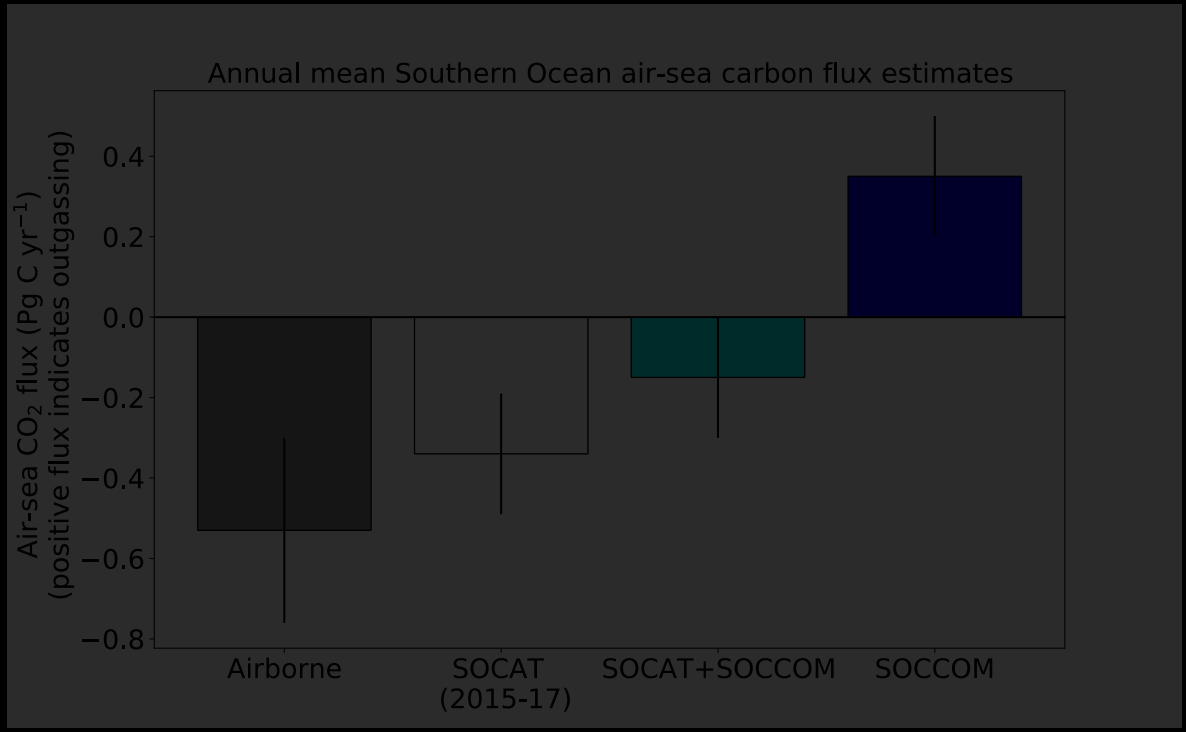
Number of individual months with 1° x 1° gridded surface ocean fCO2 values between 1970 and 2022

Bakker et al. (2023)

Uncertainty in Southern Ocean carbon flux



Chen et al. (2023)



Adapted from Long et al. (2021)

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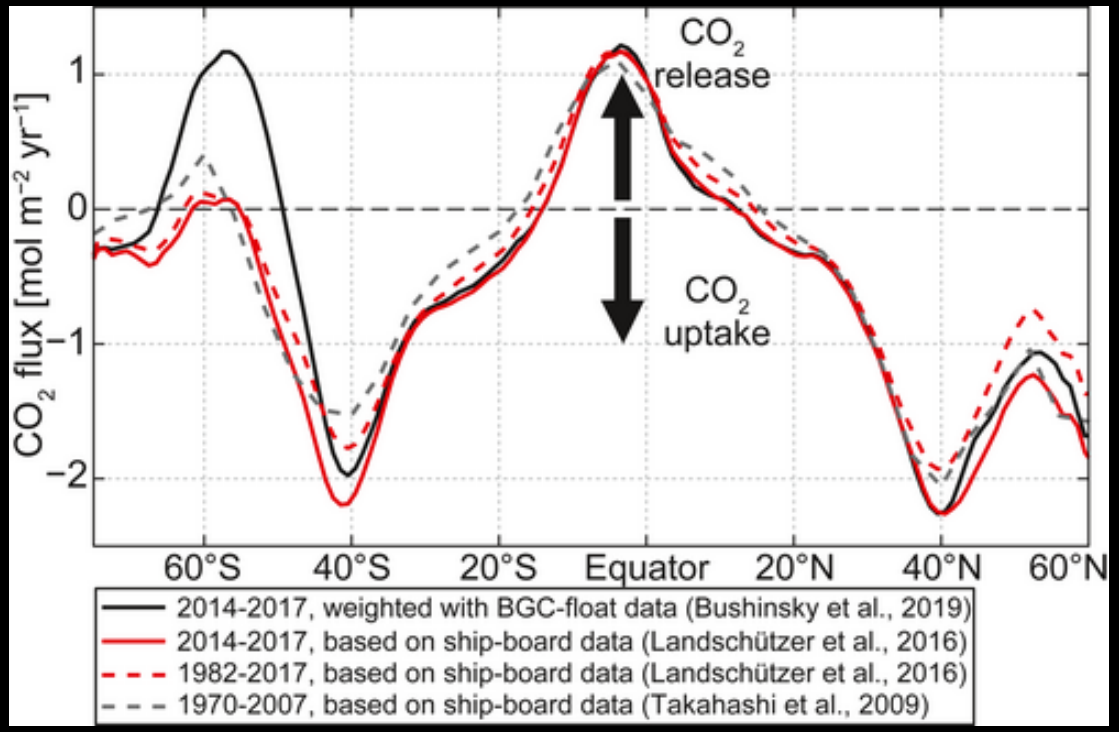

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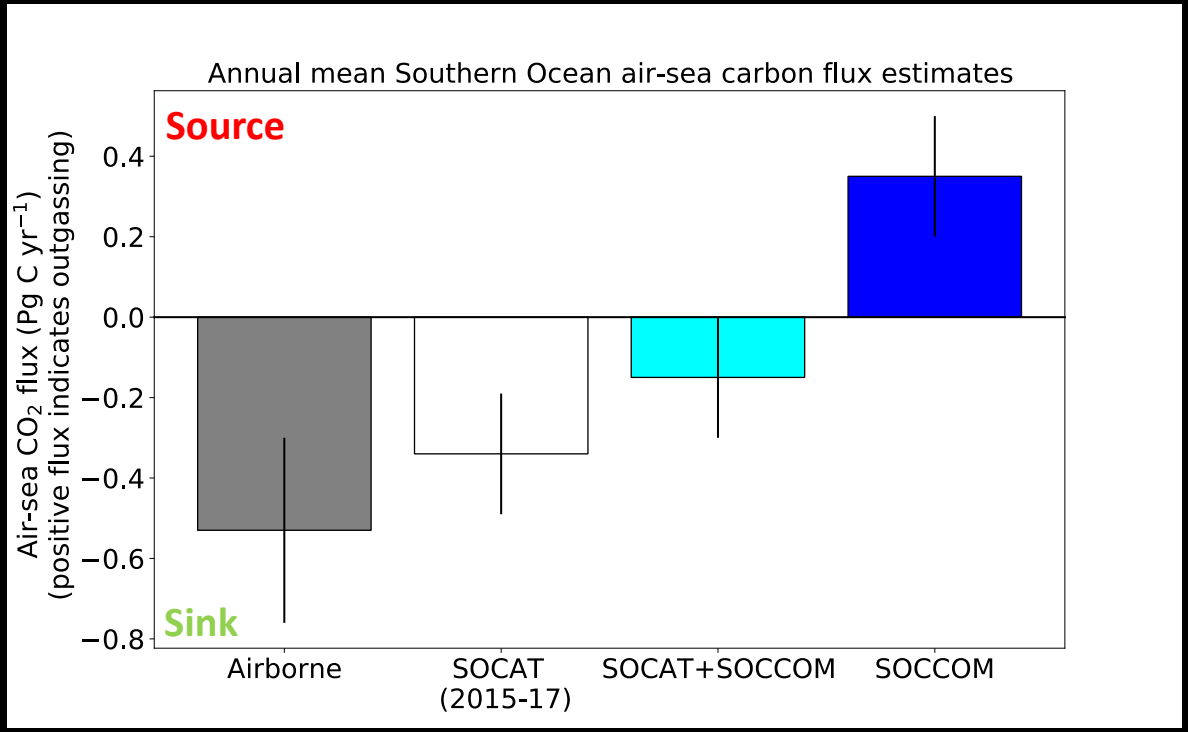

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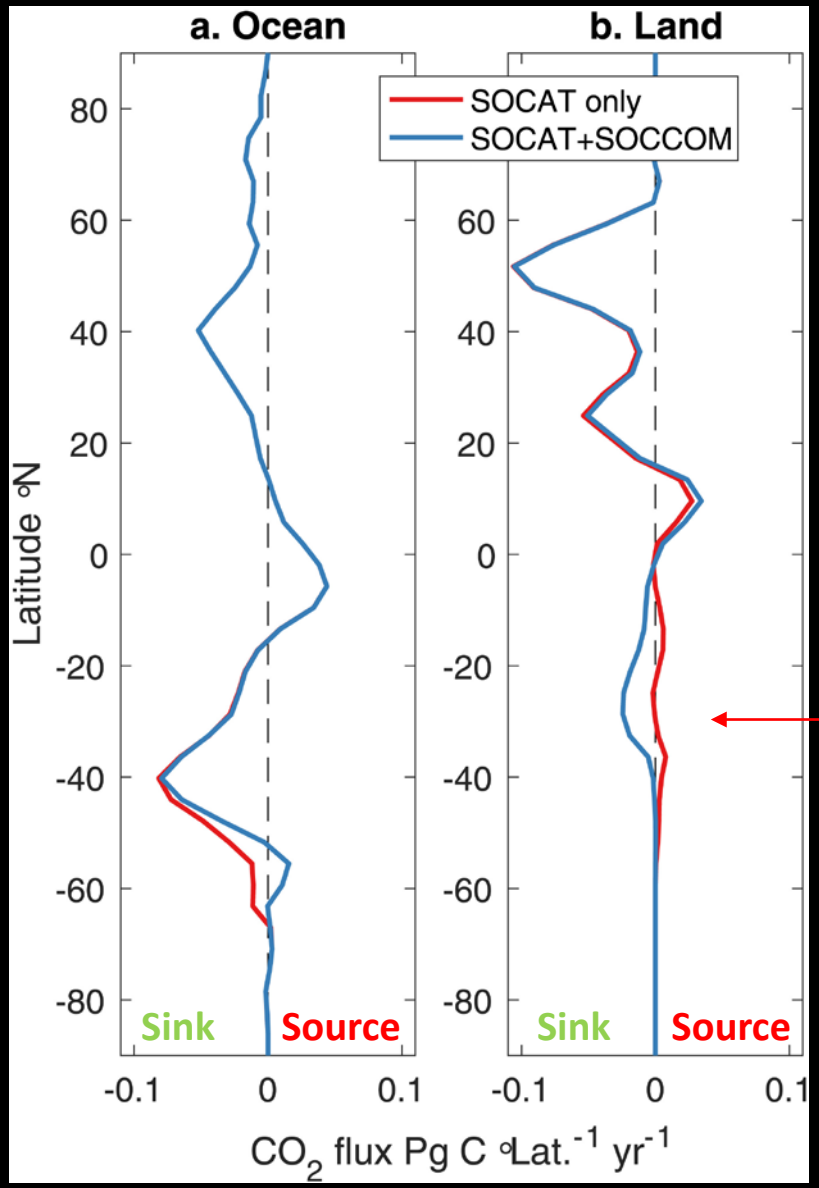

Implications:

Potential revision of ocean and land fluxes if SOCCOM floats are right (*Bushinsky et al., 2019*)

Our proposal aims to reduce uncertainty in the SO carbon flux by:

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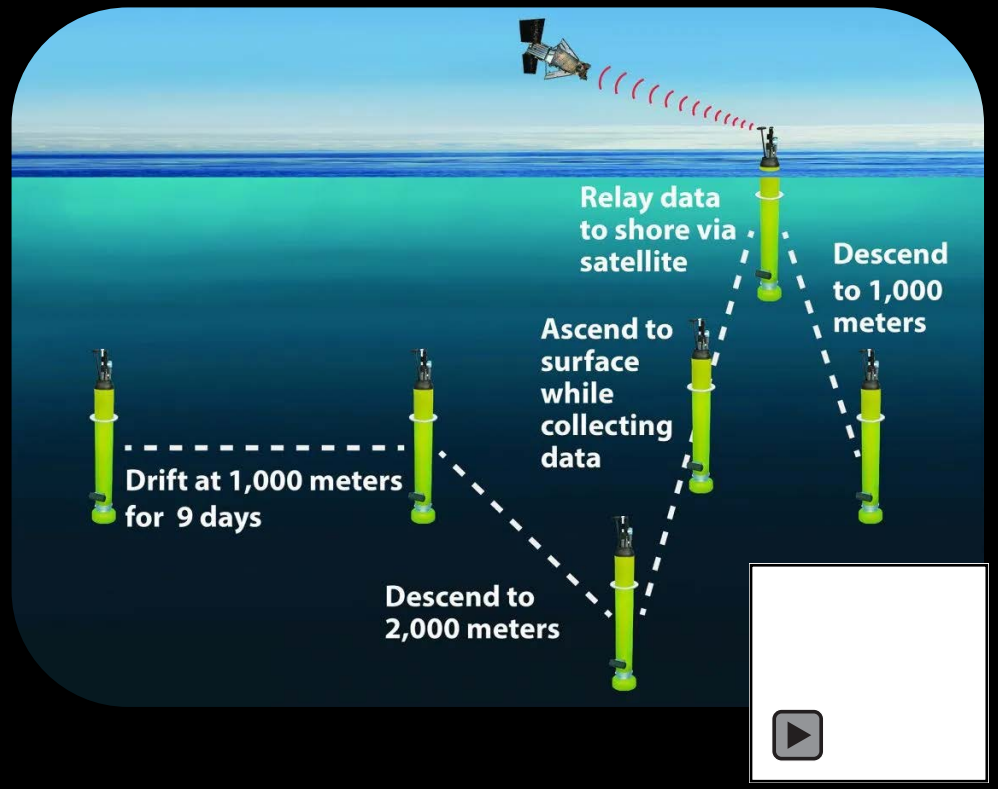
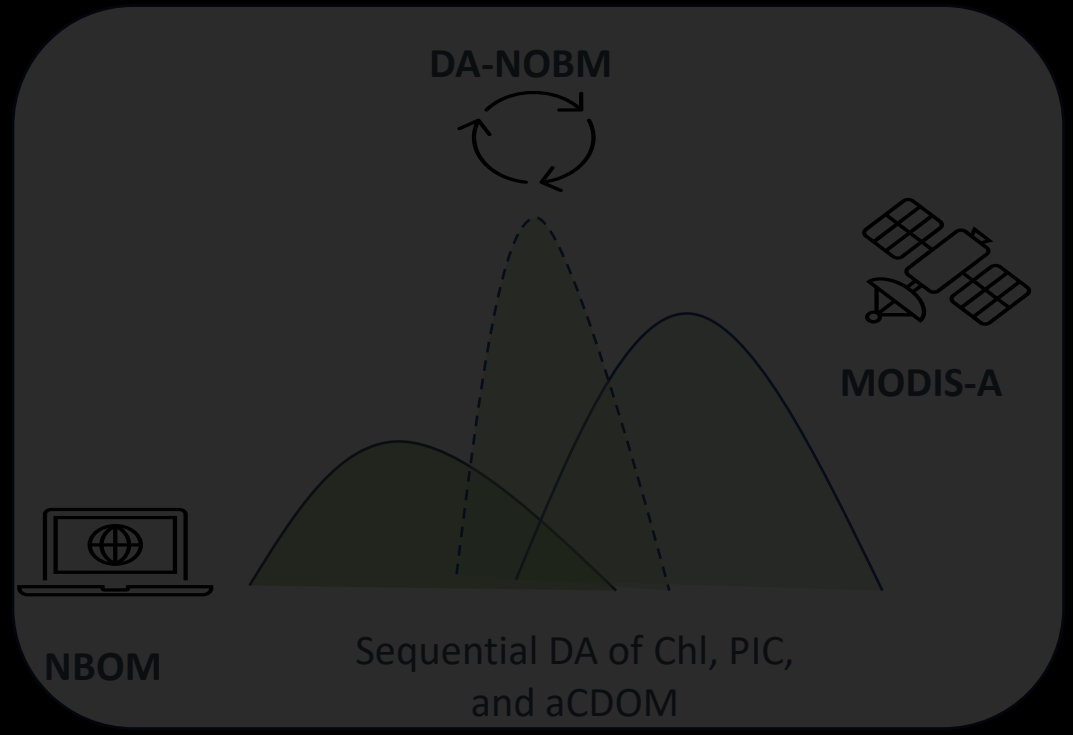
Observations

1) Improving float-based estimates from the SOCCOM array



Modeling and satellite data assimilation

2) Assessing impact of ocean color assimilation on organic carbon fluxes and air-sea CO_2 in the **NASA Ocean Biogeochemical Model (NOBM)**



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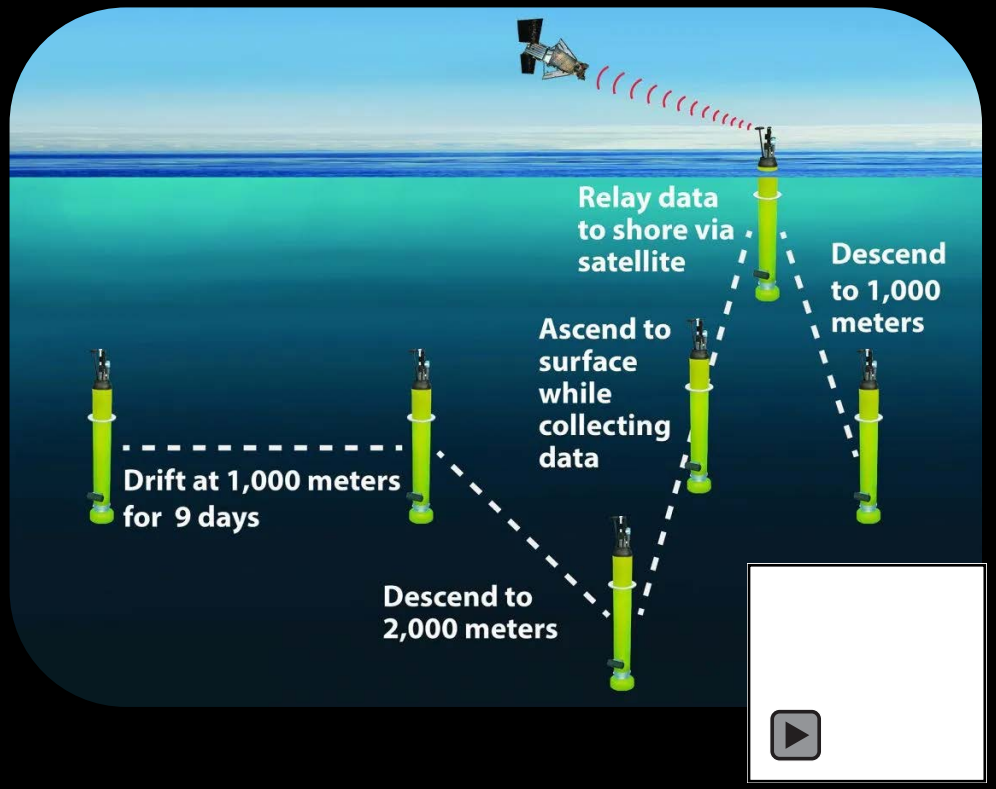

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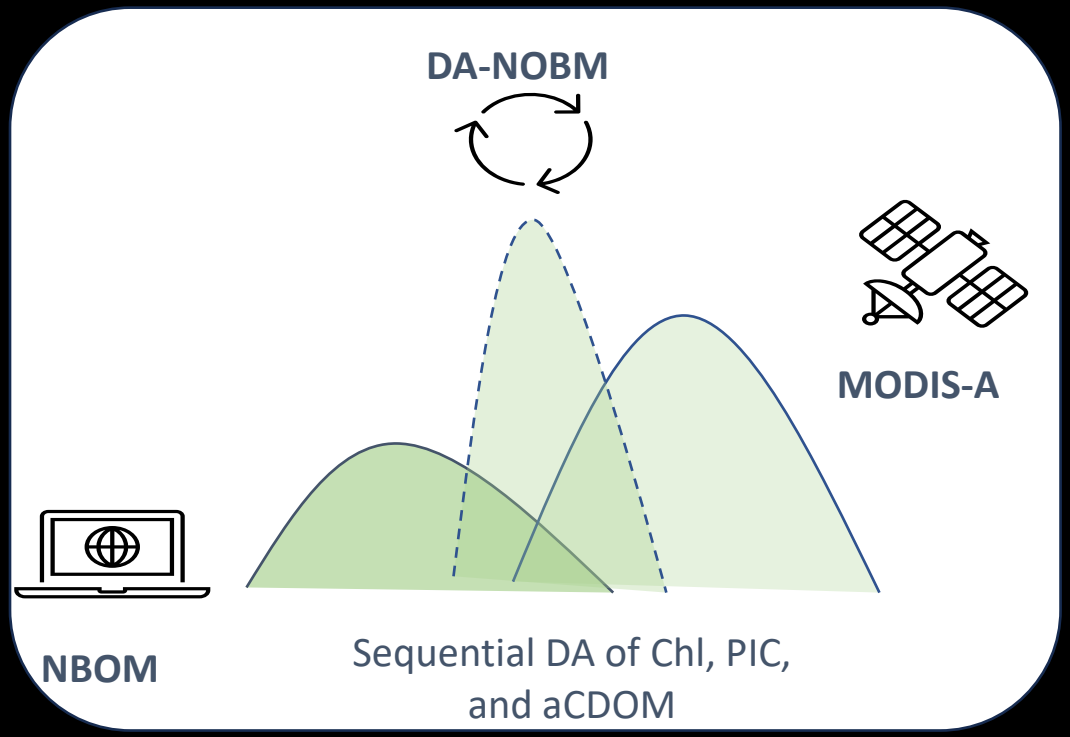

Observational work led by Seth Bushinsky (Uni Hawaii)

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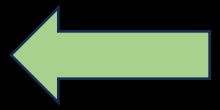

Generally good agreement in summer, worse in winter (but fairly variable)

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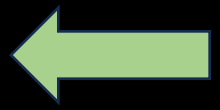

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Modeling work at NASA GSFC

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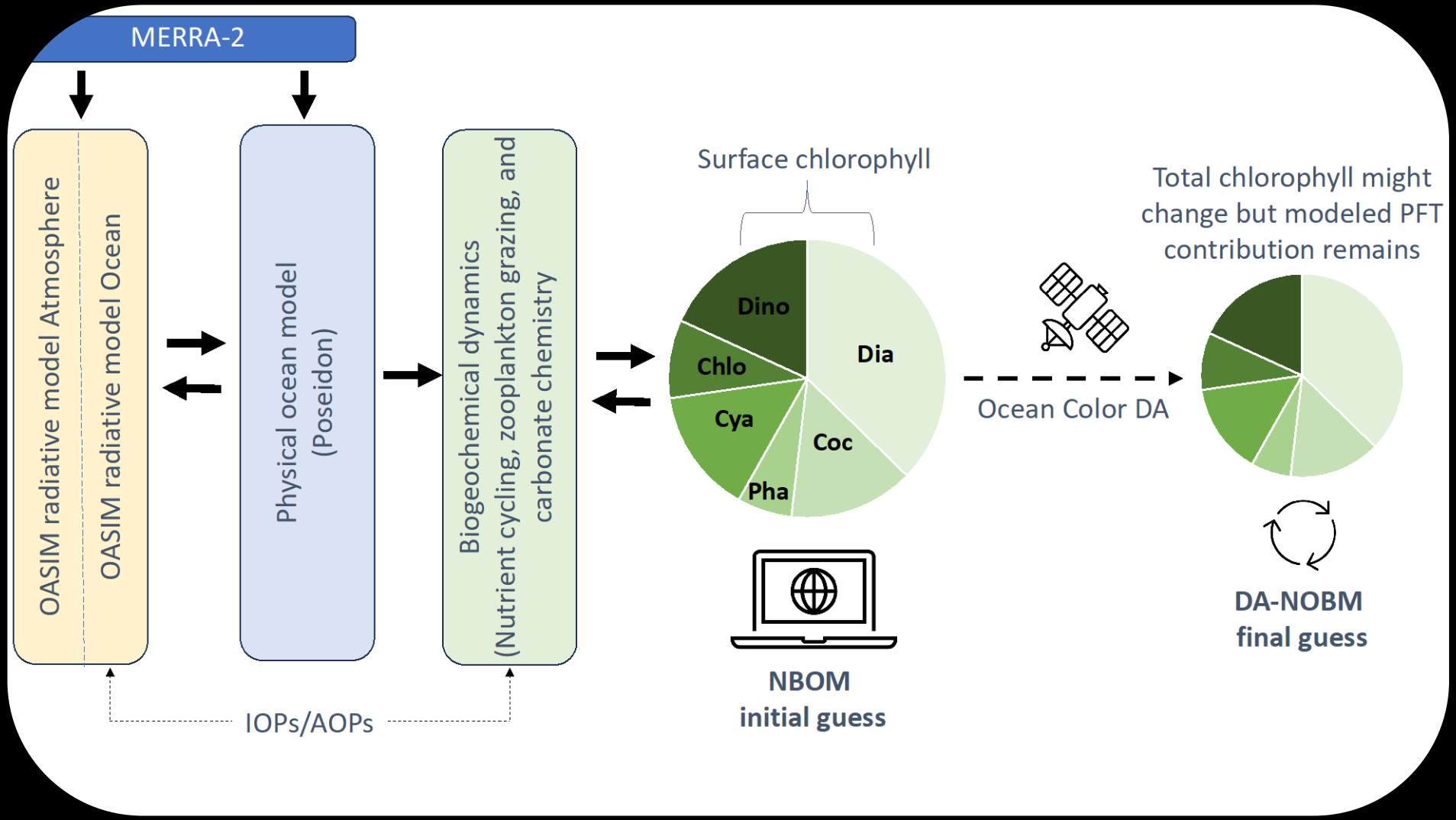
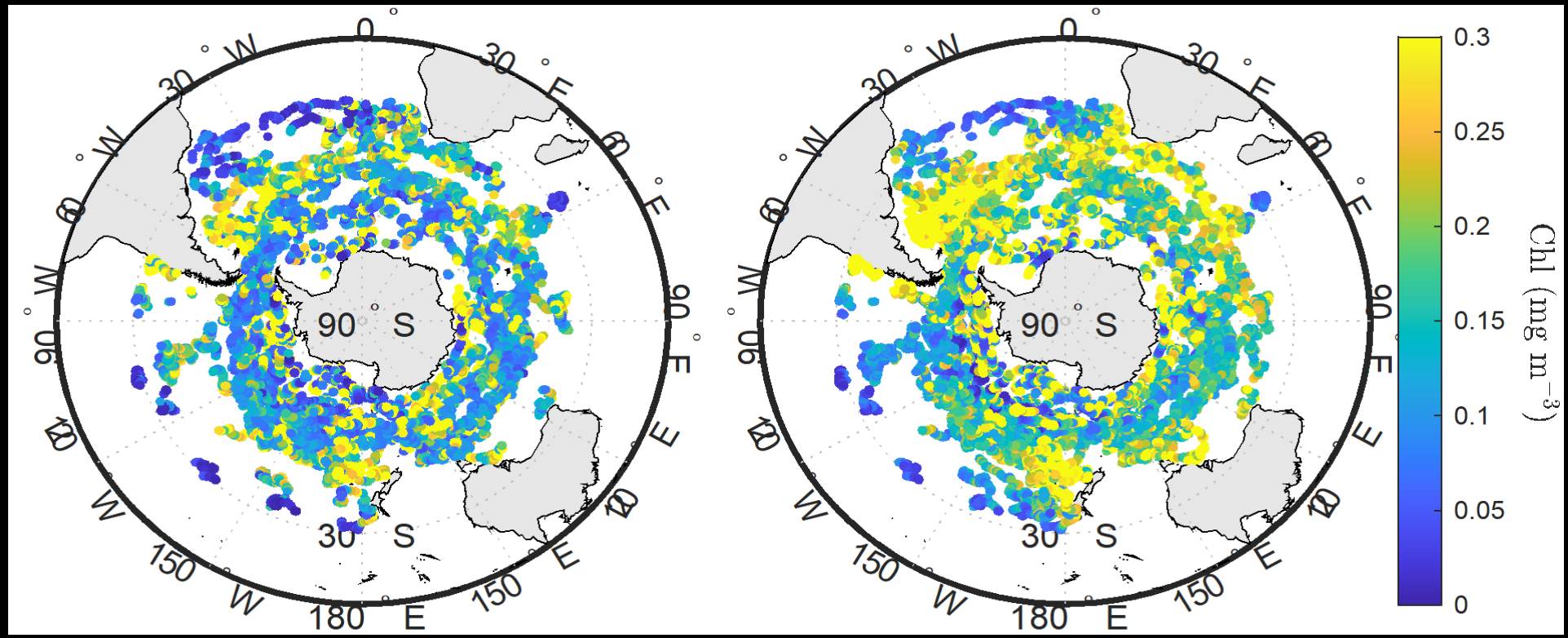


Modeling work at NASA GSFC

Chlorophyll

Floats

NOBM

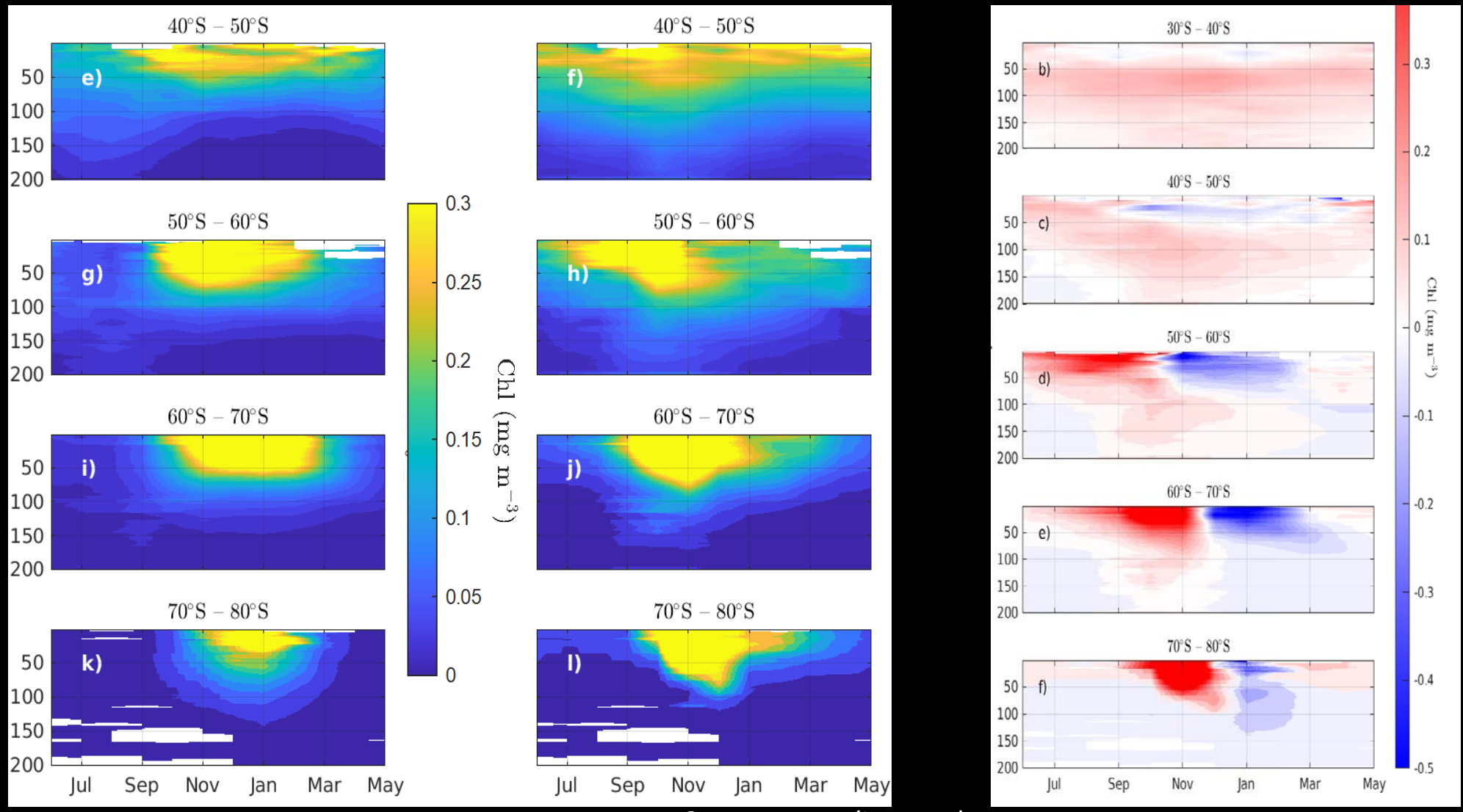


Arteaga & Rousseaux (in prep.)

Floats

Model

Model - Floats



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Stakeholders and deliverables

Scientific Committee on Oceanic Research

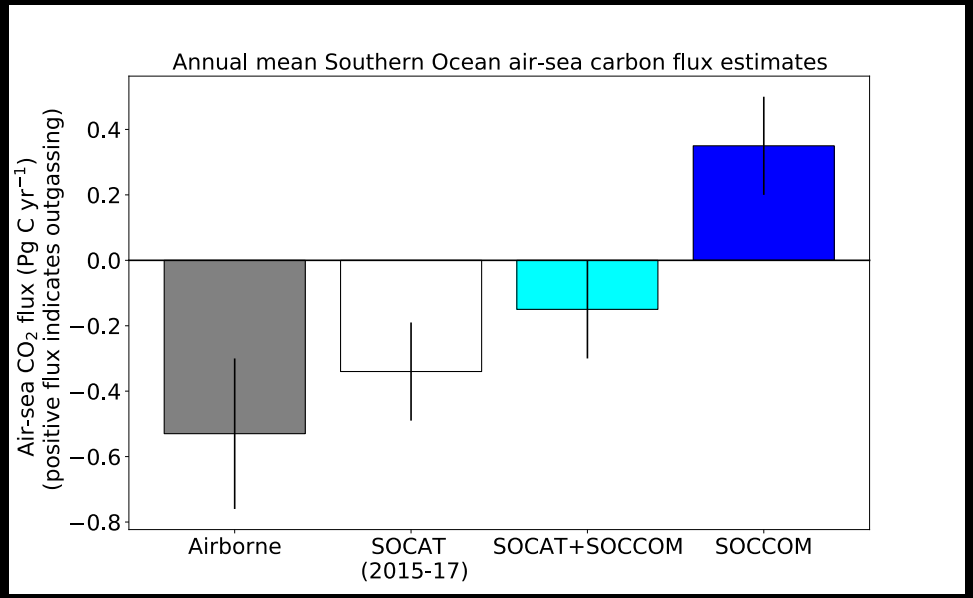
Ocean-based Climate Solutions

Specific deliverables:

1. Seasonally-adjusted float-based Southern Ocean air-sea CO2 fluxes
2. Investigation of uncertainties in Southern Ocean air-sea CO2 flux from the NOBM
3. Model-based carbon export partitioning by phytoplankton functional types (PFTs)

Take home message

Resolve large uncertainties in the Southern Ocean carbon flux



- Improve in situ float-based fluxes

- Assess the value of satellite ocean color in informing/improving model-based fluxes

- Deliver biogenic carbon export and understanding the role of biological complexity in regulating air-sea CO_2 fluxes

https://science.gsfc.nasa.gov/sed/bio/lionel.arteagaquintero
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Southern Ocean carbon cycle

Anthropogenic: Net uptake

Natural: Equilibrium

Gruber et al (2019)