Air-sea fluxes in Antarctica InSync

Marcel du Plessis, University of Gothenburg

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SOOS SOUTHERN OCEAN OBSERVING SYSTEM

UNIVERSITY OF GOTHENBURG

esa

Uncertainties in Ocean CO_2 uptake

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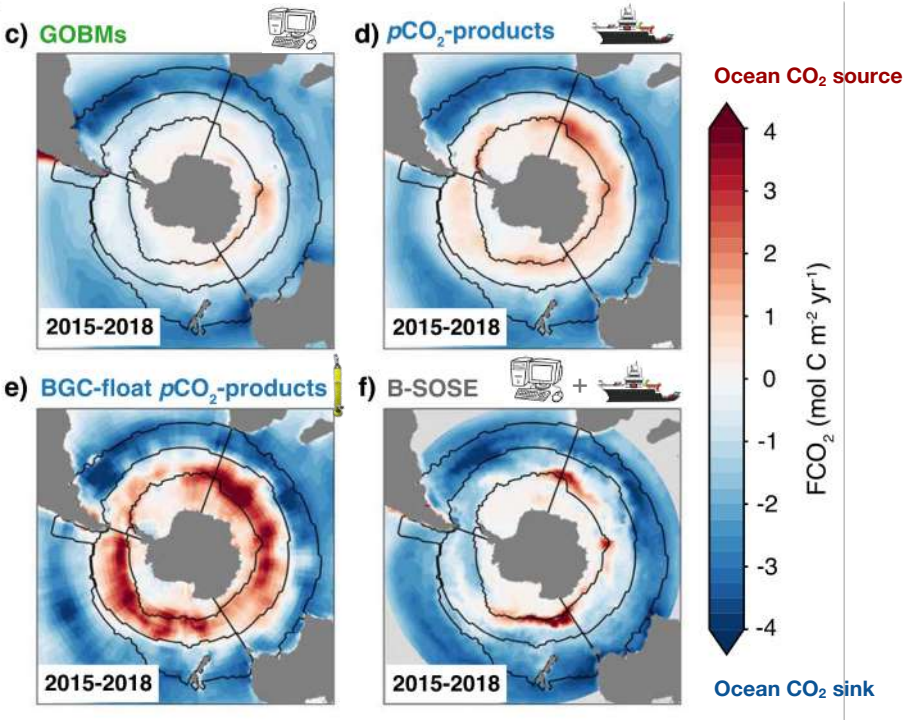
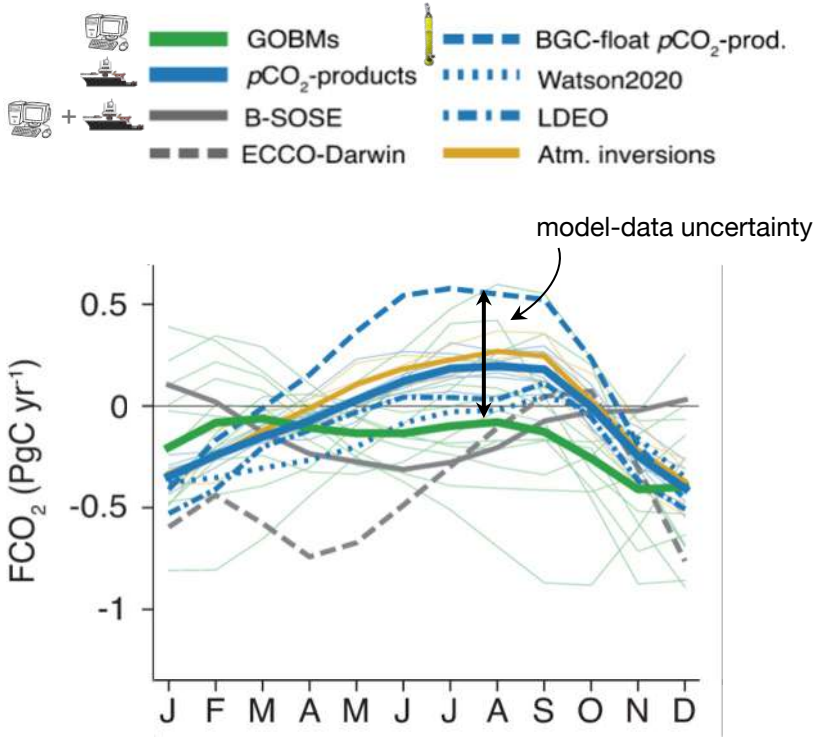
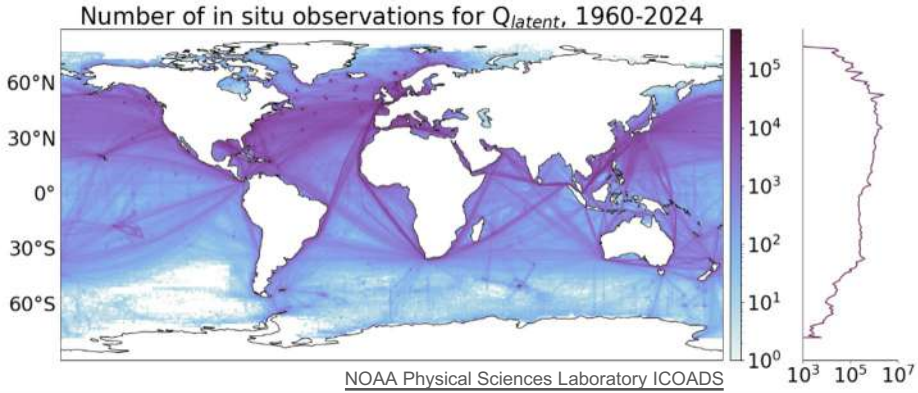
Models & data-products differ in the sign of uptake in polar Southern Ocean



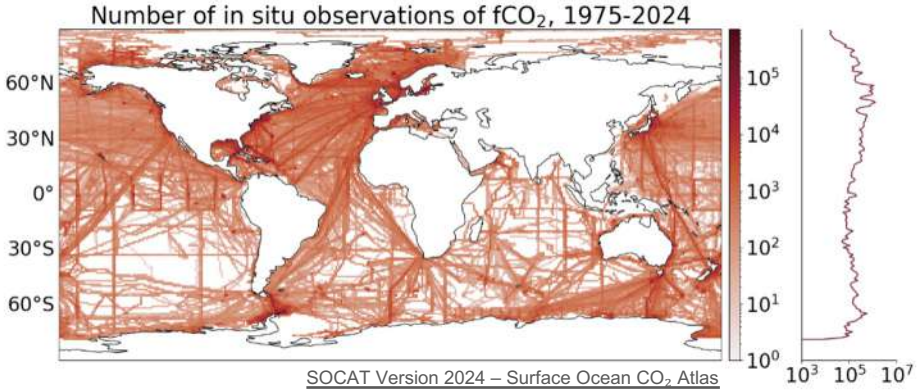


Hauck et al. 2023

Southern Ocean “data desert”



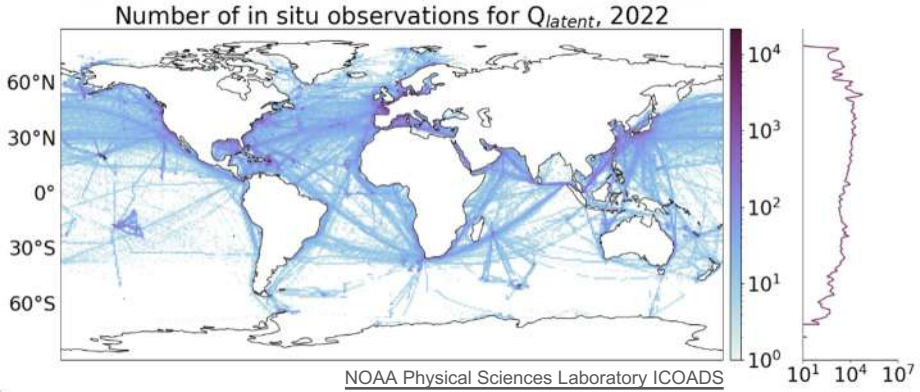
NOAA Physical Sciences Laboratory ICOADS



SOCAT Version 2024 – Surface Ocean CO_2 Atlas

- Data distribution of key observations for heat and carbon fluxes is severely lacking in the Southern Ocean
- Regions as large as countries that have not been sampled.

Southern Ocean “data desert”



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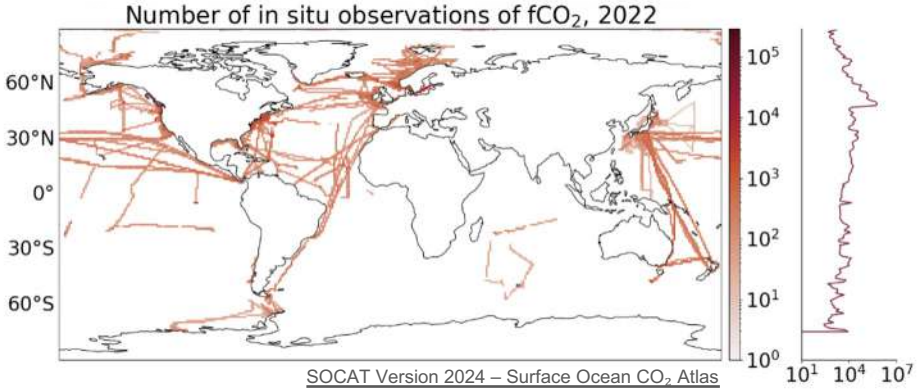
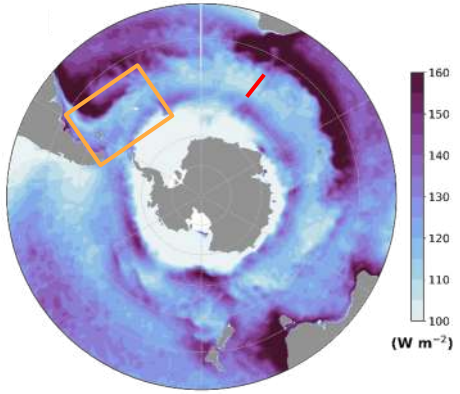


SOCAT Version 2024 – Surface Ocean CO_2 Atlas

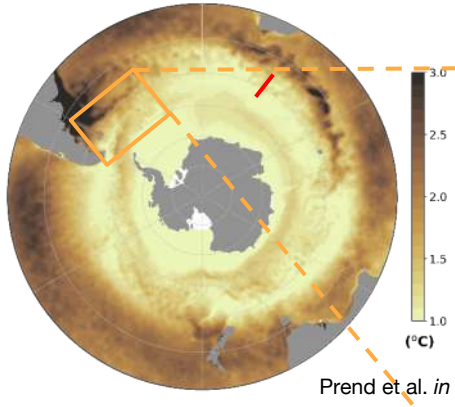
- Data distribution of key observations for heat and carbon fluxes is severely lacking in the Southern Ocean
- Regions as large as continents that have not been sampled.

Small processes have big impacts!

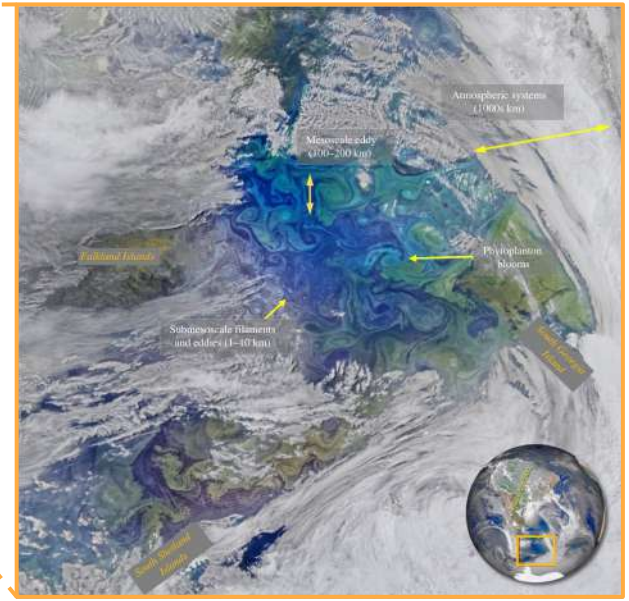
Heat flux variance

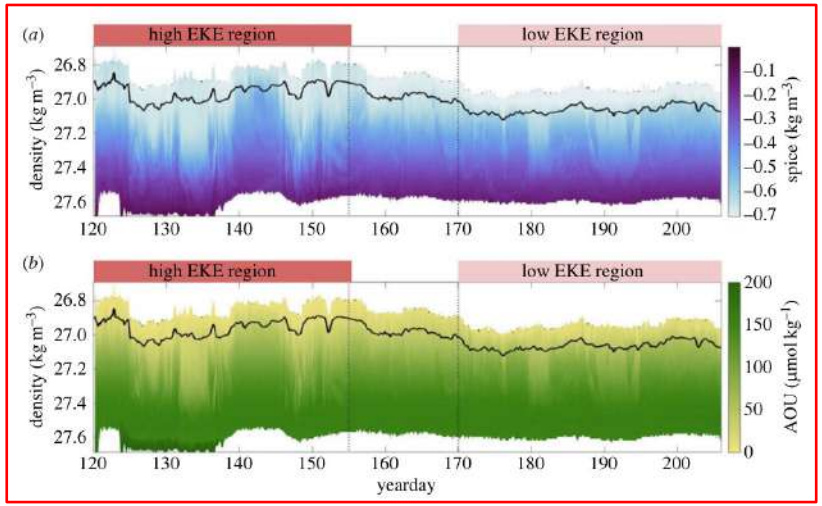


Surface temperature variance



Prend et al. *in prep*





Swart et al. 2023 *Royal Soc*

We need an understanding of the long-term impacts of small-scale processes.

Intermittent and extreme events govern air-sea exchange

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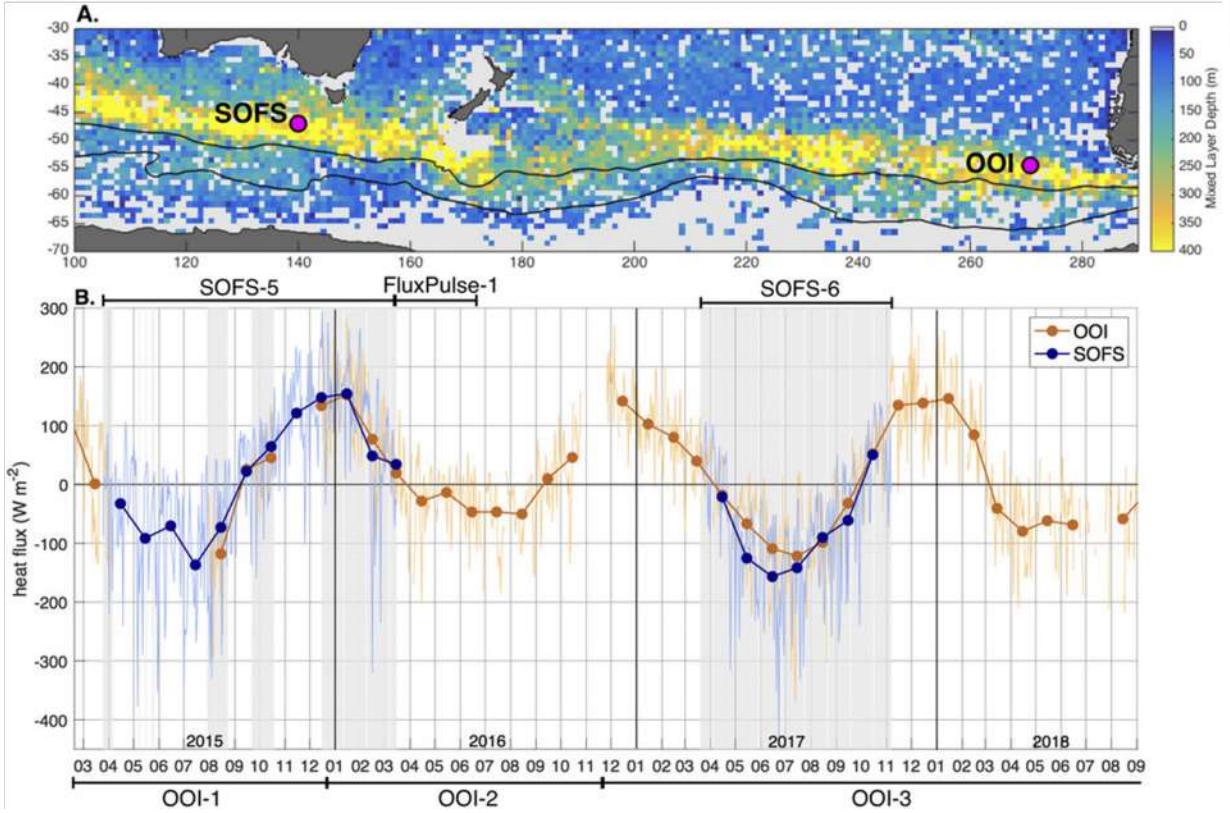
At Southern Ocean flux moorings, highly episodic heat loss from the ocean

Heat loss leads to deep mixed layers, and drives air-sea exchange with ocean interior

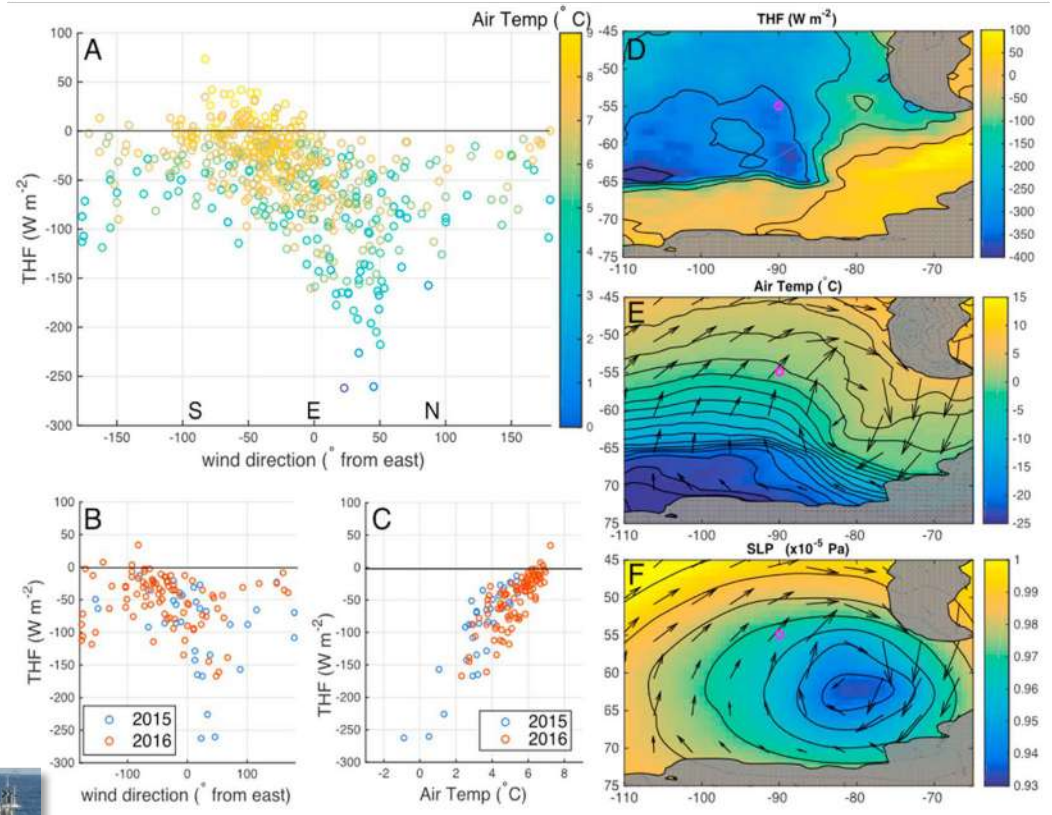
Heat loss events linked to strong winds from the south

If we want to understand how the ocean sequesters heat or CO_2, need to understand events



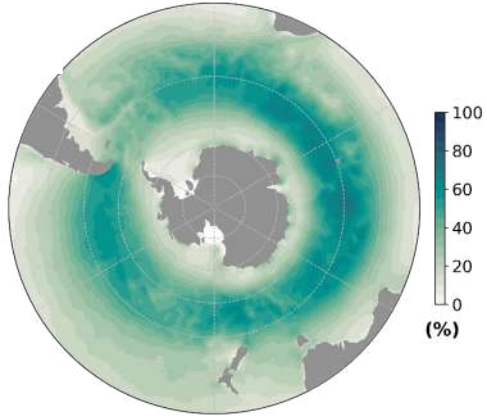
Tamsitt et al. 2020 *J Clim*

Intermittent and extreme events govern air-sea exchange

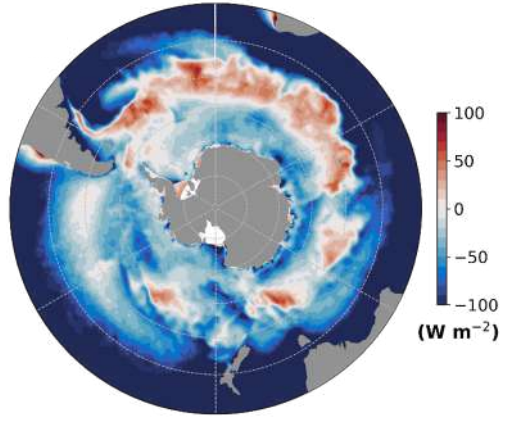


Ogle et al. 2018 *GRL*

Storm Occurrence (%)



Net heat flux during storms

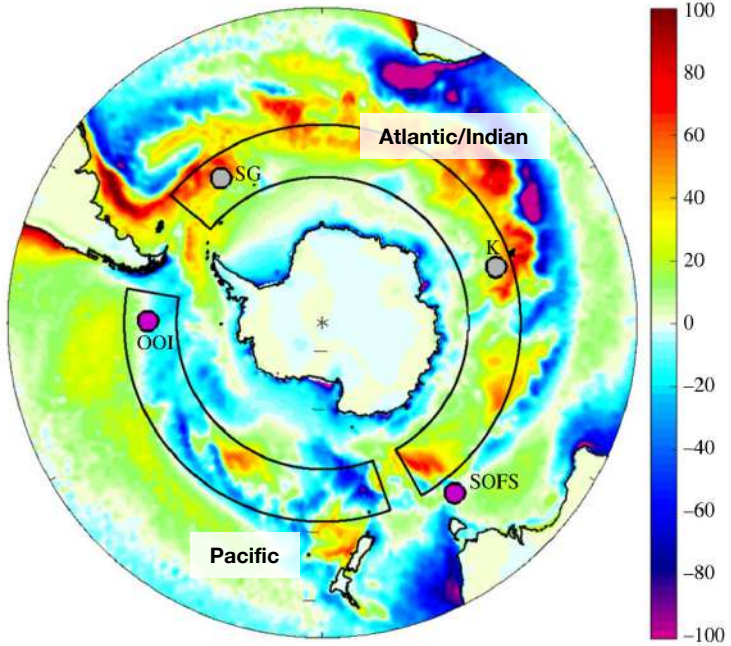


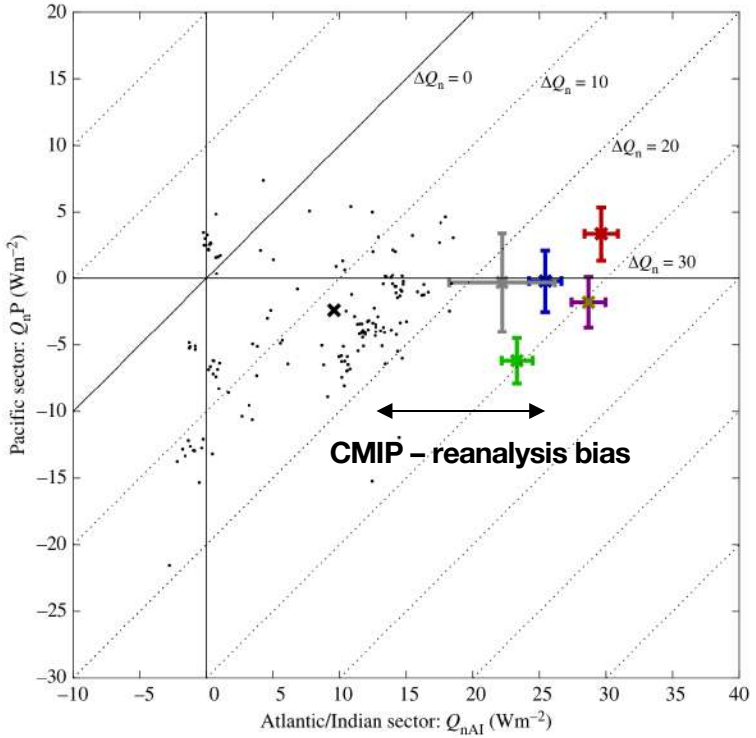
Prend et al. *in prep*

Intermittent and extreme events govern air-sea exchange

Reanalysis models show increased heat uptake in the Atlantic/Indian sector compared to CMIP models

The role of storms and small-scale processes is not accounted for and need better constraining

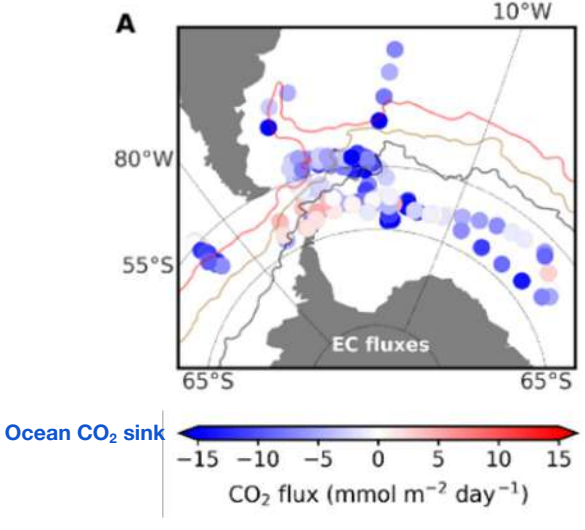




Josey et al. 2023 *Royal Soc.*

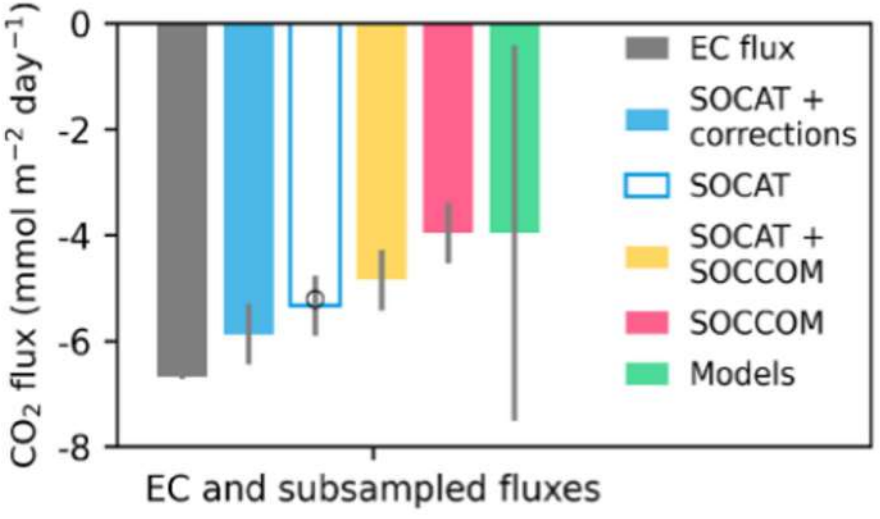
Importance of direct flux observations

Plymouth Marine Laboratory



Direct flux observations show an improved flux representation by correcting for cool skin and warm biases.

Southern Ocean uptake stronger than data-products and models



Dong et al. 2024 *Science Advances*

Satellite validation

In the pipeline:

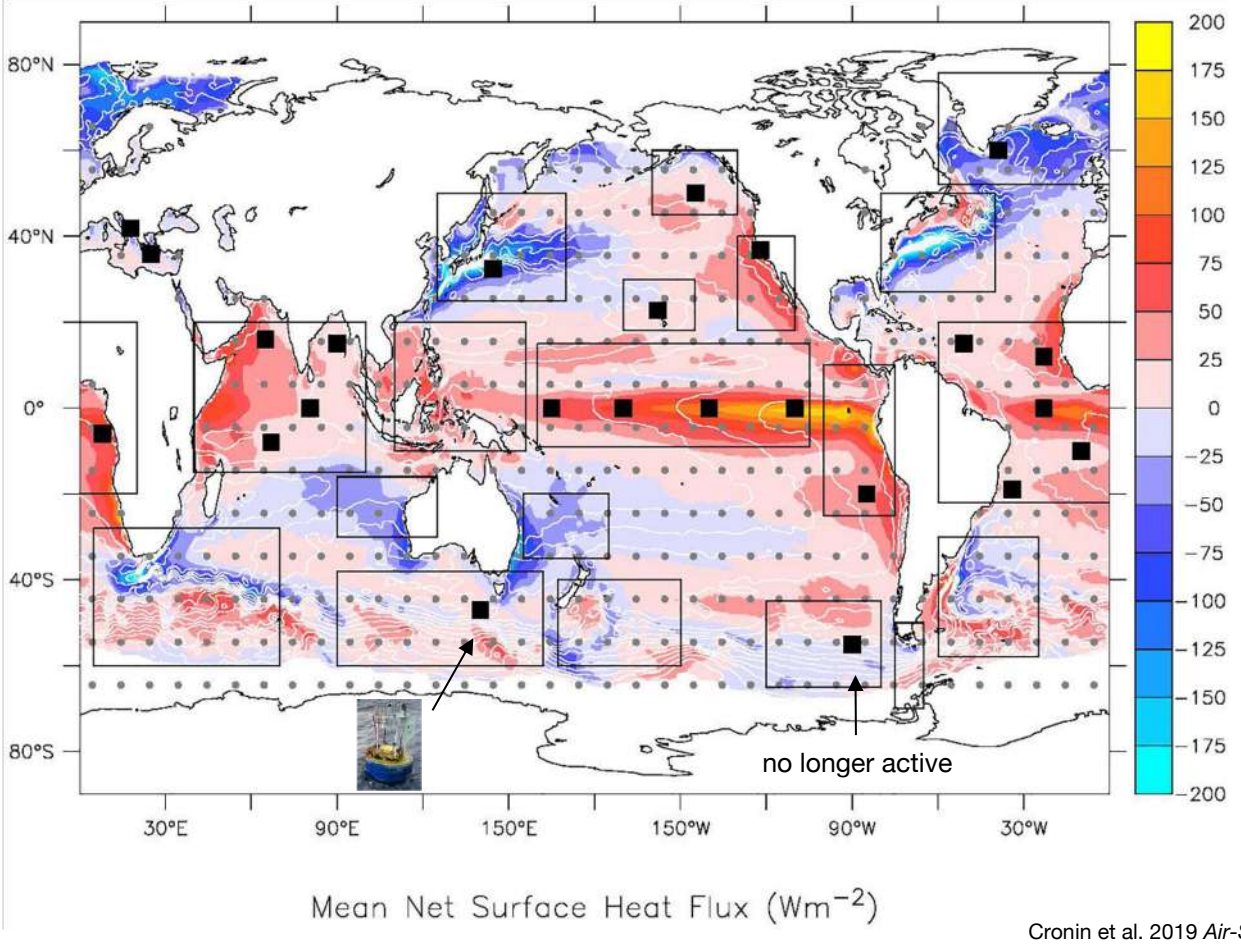
- *Harmony* (ESA) scheduled to launch in 2029: momentum fluxes in small regions with 20 km x 20 km patches for waves)
- *CIMR* (high-resolution microwave SST, the first satellite to launch in time for AA InSync),
- *ODYSEA* (Phase A proposal to NASA with CNES support) with winds (5 km) and currents (~25 km). In about a year, NASA expects to select 2 of the 4 Phase A concepts for flight, with launch dates anticipated in 2030 and 2032.

Image: ESA Harmony

Concepts for future proposals:

- *Butterfly*: near-surface temperature and humidity (turbulent heat fluxes using bulk parameterization, in development)
- *SeaSTAR* (high-resolution winds, waves, and currents using SAR and targeting coastal regions)

Ocean Obs ‘19 vision for a flux observing system



Cronin et al. 2019 *Air-Sea Fluxes With a Focus on Heat and Momentum*

Observing Air-Sea Interactions Strategy (OASIS)

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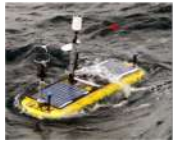
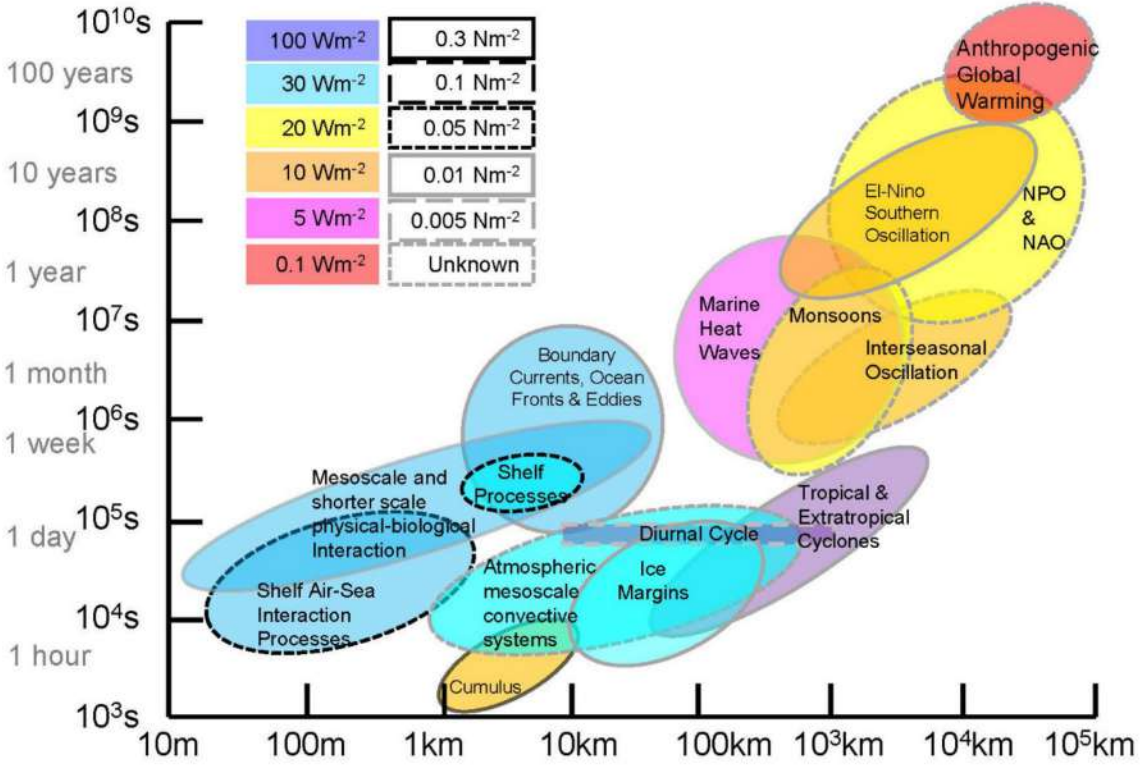
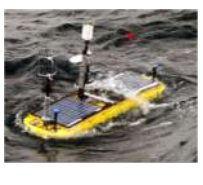
Cronin et al. 2022 *ICES*

We will need to bring in all technologies







Cronin et al. 2019

Community effort required

- Define regional and seasonal patterns of interest
- Key variables (EOVs, ECVs)
- Observational and measurement protocols (sensors, type, testing)
- Resource requirements (who needs what?)
- Community workshop(s)?
- FAIR principles: improved data sharing infrastructure

SOCAT · SURFACE OCEAN CO₂ ATLAS ·

SOOS map