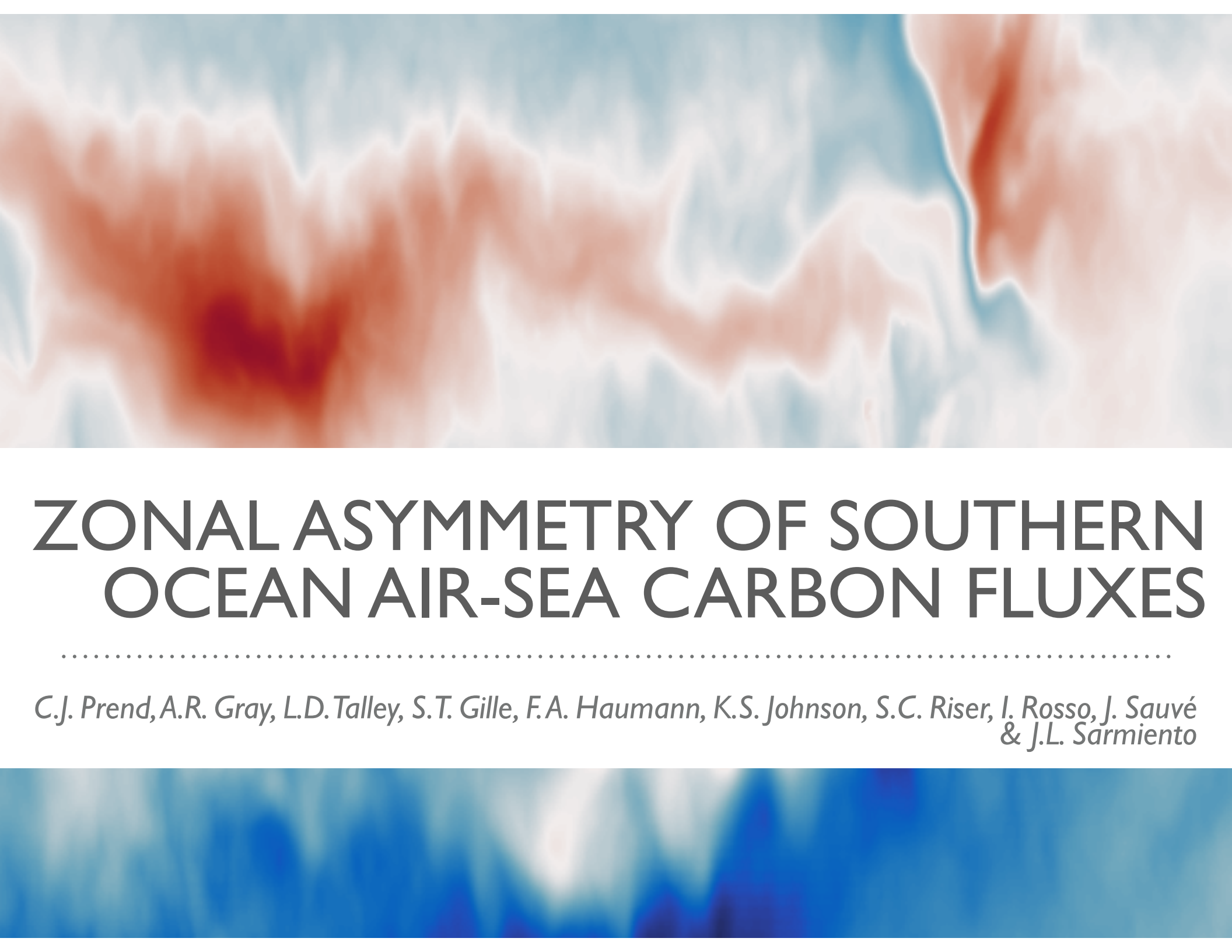
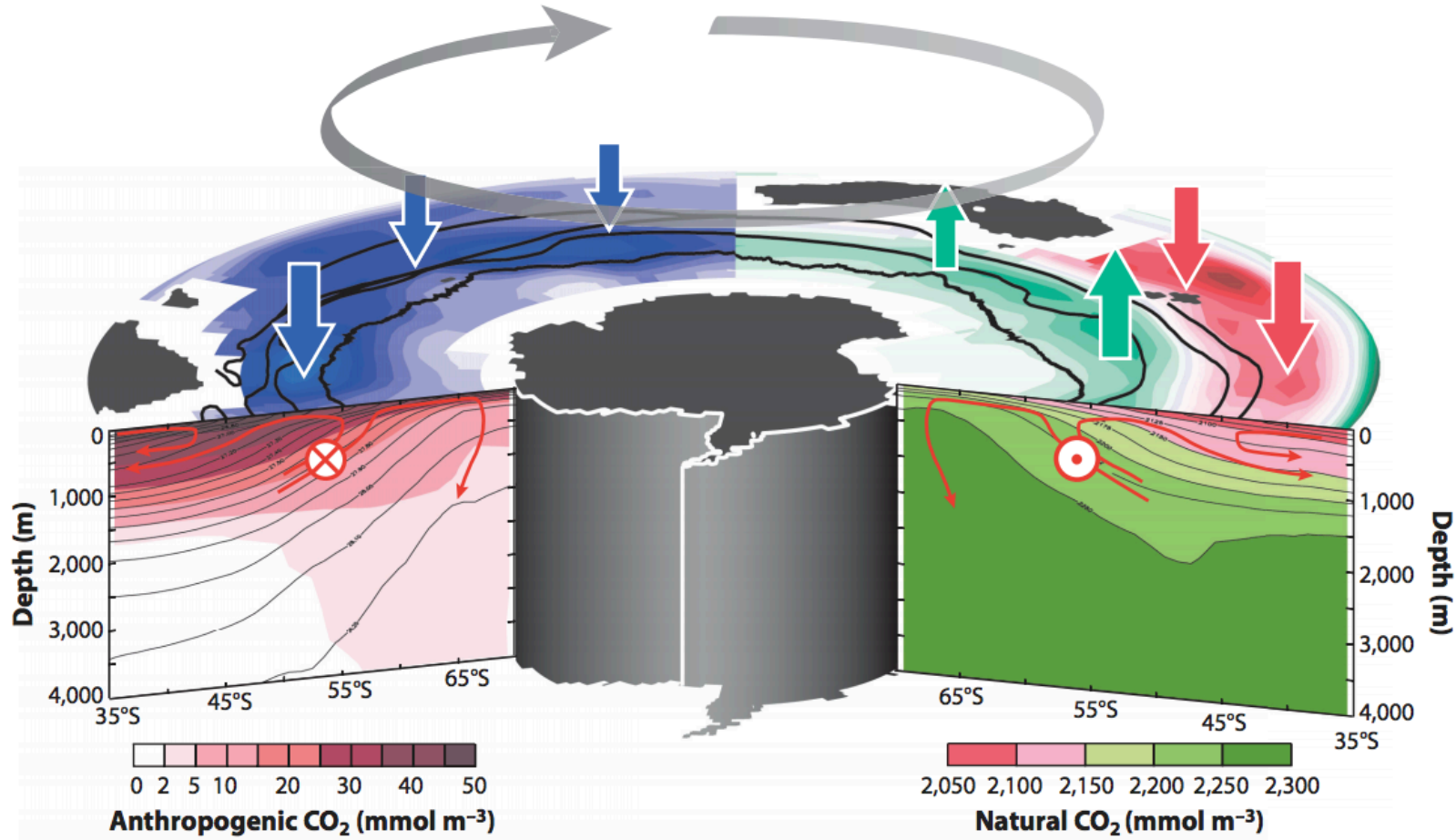




ZONAL ASYMMETRY OF SOUTHERN OCEAN AIR-SEA CARBON FLUXES

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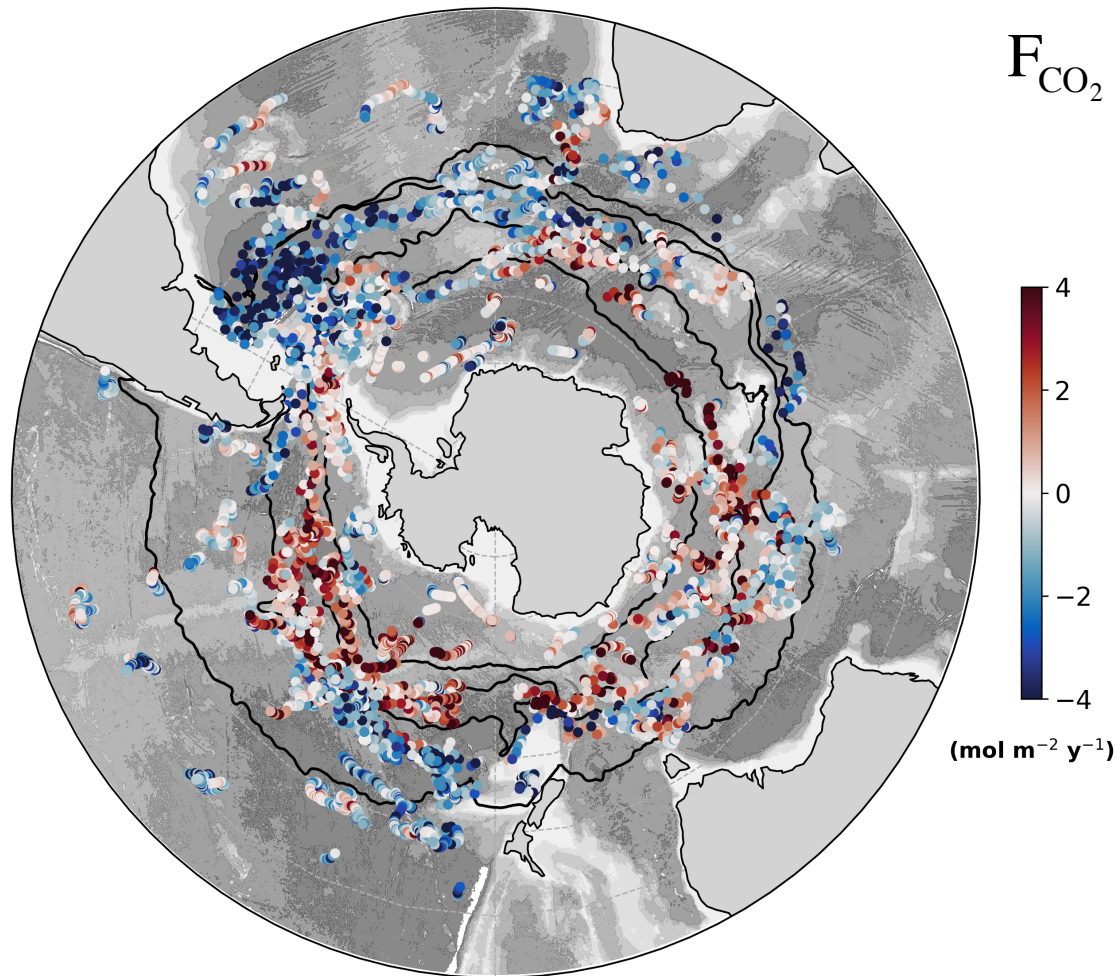
SOUTHERN OCEAN CARBON CYCLE



(Gruber et al., 2019)

Net air-sea carbon exchange in the Southern Ocean is a balance between subduction of anthropogenic carbon and outgassing of natural carbon. Both are tied to physical transport of water between the mixed-layer and interior.

AIR-SEA CARBON FLUX ESTIMATES



$$F_{\text{CO}_2} = kK_0(p\text{CO}_2^{\text{ocn}} - p\text{CO}_2^{\text{atm}})(1 - C_{\text{ice}})$$

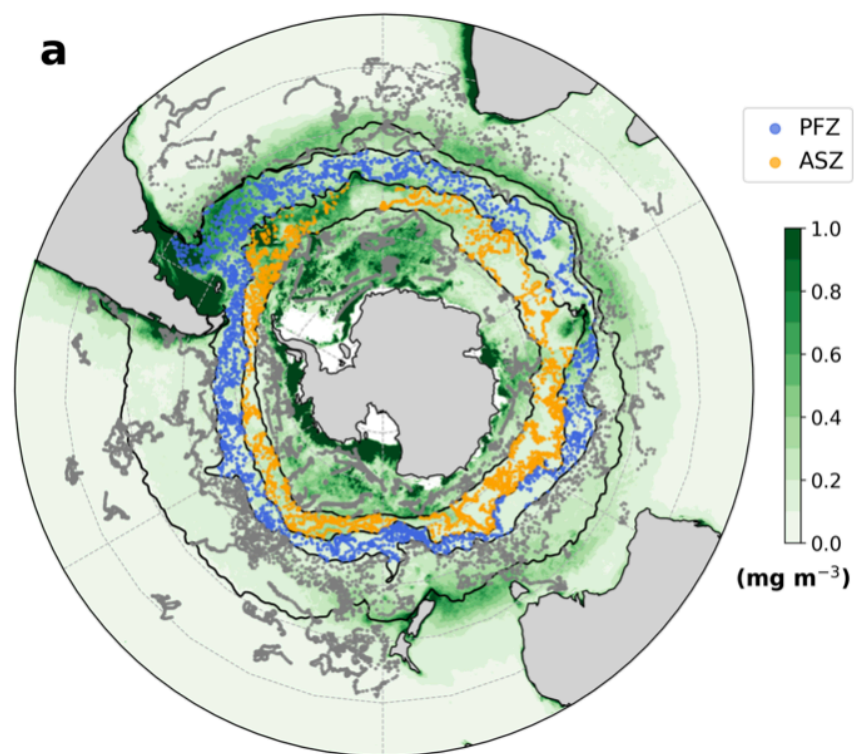
SOCCOM float-based carbon flux estimates are calculated following the method in Gray et al. (2018), using data through the end of 2020.



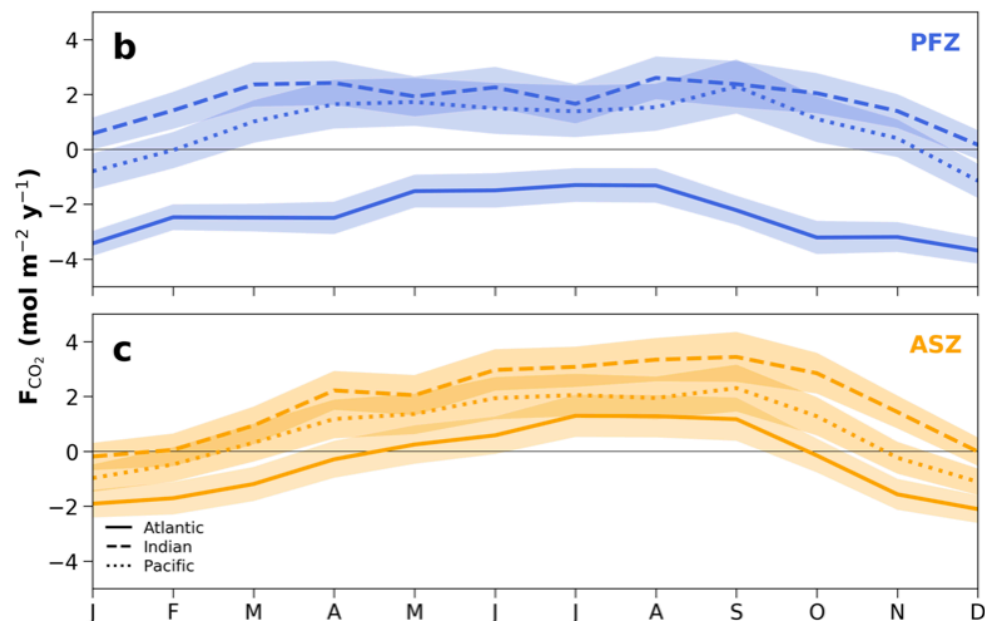
Temperature,
Salinity, Pressure,
Oxygen, Nitrate,
pH, Fluorescence,
and Backscatter.

Float data are starting to resolve detailed spatial patterns in air-sea carbon exchange. **What controls these patterns?**

ZONAL ASYMMETRY OF OUTGASSING

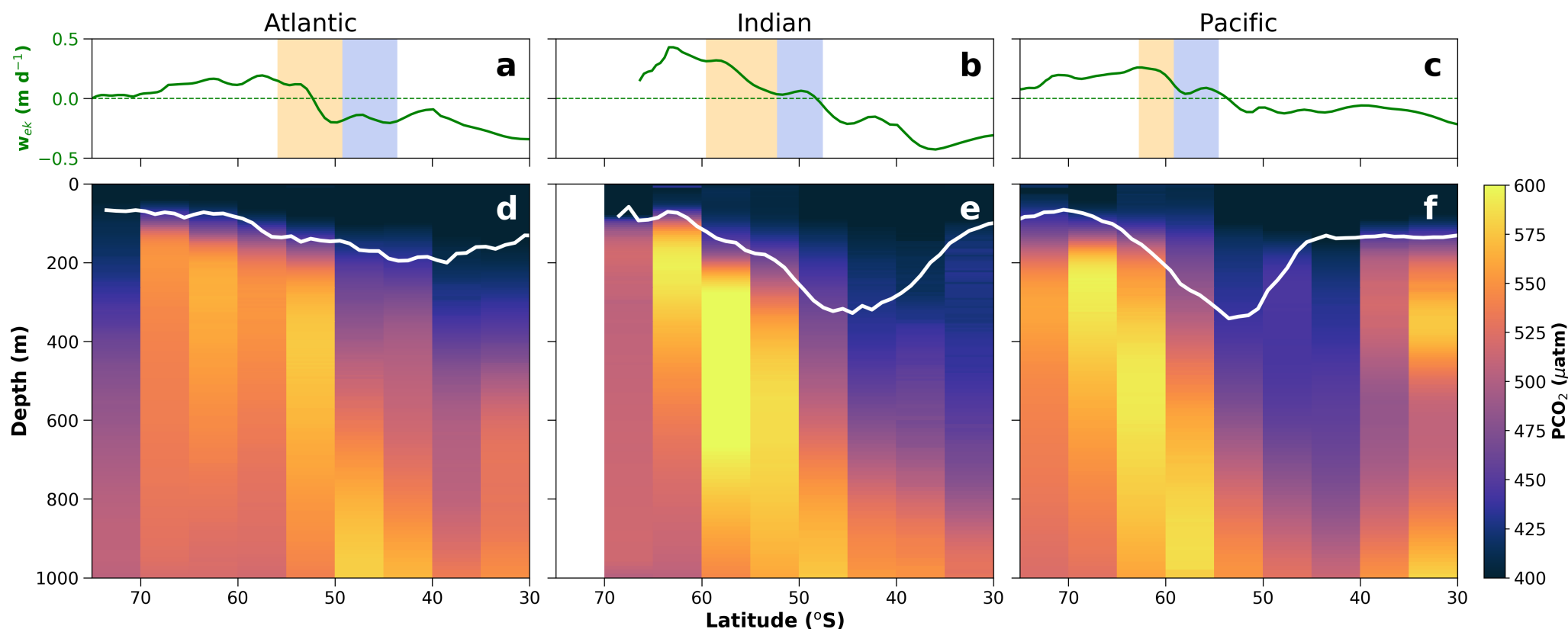


Air-sea flux climatologies



Air-sea flux climatologies are computed by ACC frontal zone. These suggest that **carbon outgassing occurs preferentially in the Indian and Pacific sectors**. Zonal asymmetry in outgassing is driven by differences in the annual mean surface ocean $p\text{CO}_2$ between basins, which can also be seen in other observation-based gridded $p\text{CO}_2$ data products.

UPWELLING OF CARBON-RICH DEEP WATER



Subsurface potential $p\text{CO}_2$ is calculated from the float data, which measures the outgassing potential of upwelled deep water. **The observed zonal asymmetry in surface $p\text{CO}_2$ between basins could be generated by differences in the entrainment fluxes of carbon.** These variations in entrainment are due to the distribution of MLD and Ekman pumping.

CONCLUSIONS

SOCCOM float data can be used to investigate the subsurface carbon content and transport processes that help drive air-sea flux variability, in contrast to past studies based on surface $p\text{CO}_2$ measurements alone.

Carbon outgassing within the ACC occurs preferentially in the Indo-Pacific sector due to a higher annual mean surface ocean $p\text{CO}_2$. This difference in $p\text{CO}_2$ is driven by the MLD distribution and seasonality, which lead to systematic differences between basins in the mixed-layer entrainment of upwelled carbon-rich deep water.

The zonal asymmetry of Southern Ocean air-sea carbon fluxes suggests that decadal trends based on sparse shipboard data must be interpreted within the context of measurement locations.

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Unlocking the mysteries of the Southern Ocean