# Observing the Global Ocean: **20 years of progress**

Susan Wijffels

WOODS HOLE OCEANOGRAPHIC INSTITUTION

# A shared global challenge

- As for weather prediction, we need **global** observations to understand and predict the **local** oceans and climate
- No nation can achieve this alone
- International **collaboration** is essential
- Free and **real-time data sharing** is essential

- Australia must manage **serious ocean and climate risks**, and is responsible for a **vast ocean estate**
- IMOS has been a key enabler for the scale-up of Australia's contribution to the GOOS global commons
- Our future challenge – preserve progress/national capacity, support international cooperation and fill major gaps

**Gary Meyers 1941 – 2016**

# Much of the GOOS is built on the TOGA/WOCE legacy

- **World Ocean Circulation Experiment** (WOCE) – focussed on the ocean's roles in mean climate
- Hydrographic surveys
- Base-line boundary current moorings
- Satellite altimetry
- **Tropical Ocean Global Atmosphere** (TOGA)– focussed on El Nino prediction
- Repeat XBT lines
- Tropical moored arrays
- Process studies

**Established a new paradigm of data sharing** and **global coordination**
**Took many lessons from the WMO weather observing enterprise**

# Major global observing achievements

- **Remote sensing**:

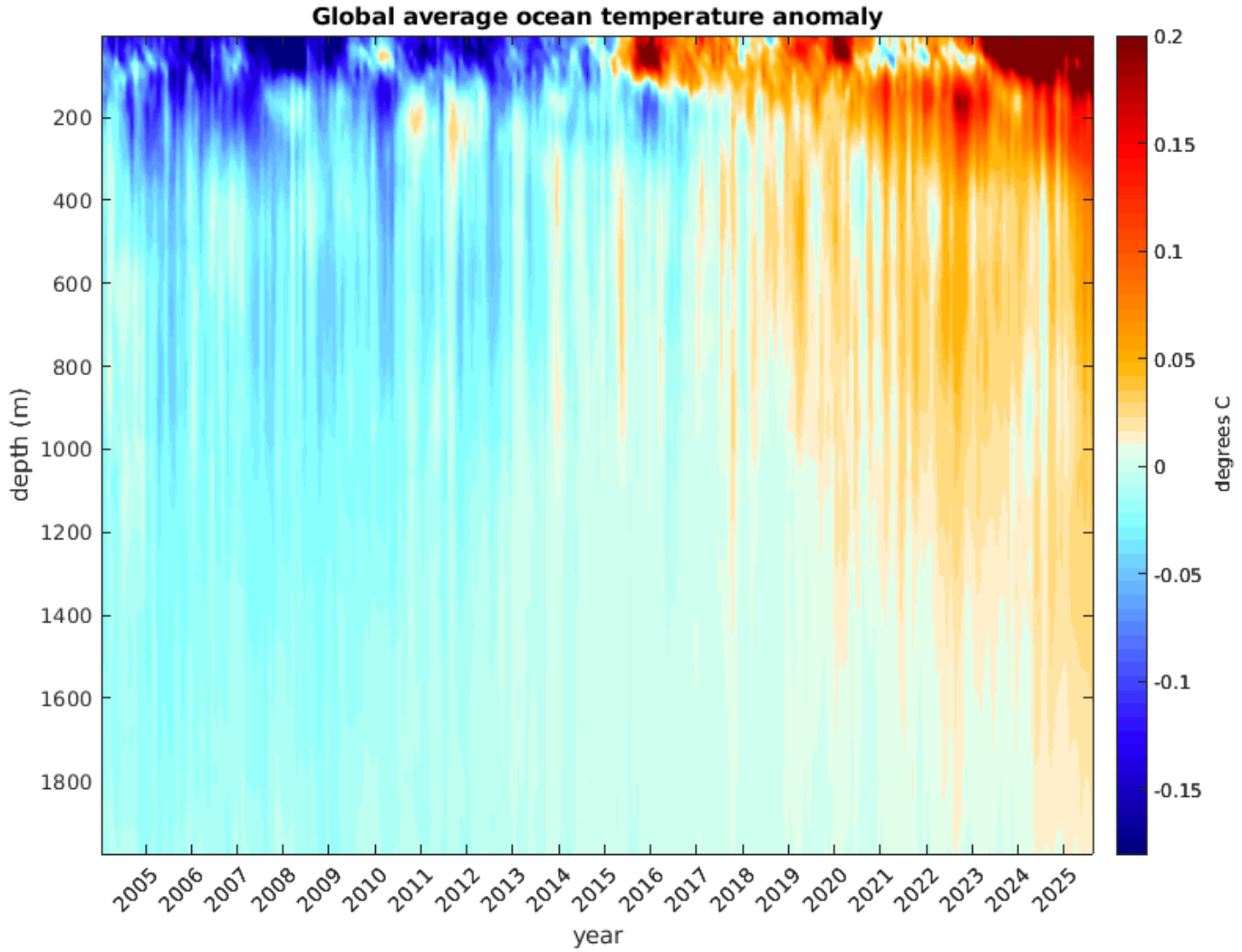
1. sea level anomaly – multiple altimetric missions
2. vector winds – scatterometers
3. ocean mass - gravity missions
4. optics - multispectral ocean colour missions
5. + surface waves, SSS,…

These **all require some in *situ data*** to track and validate retrievals: GLOSS, surface drifters, dedicated moored sites

- ***In situ* sensing**:

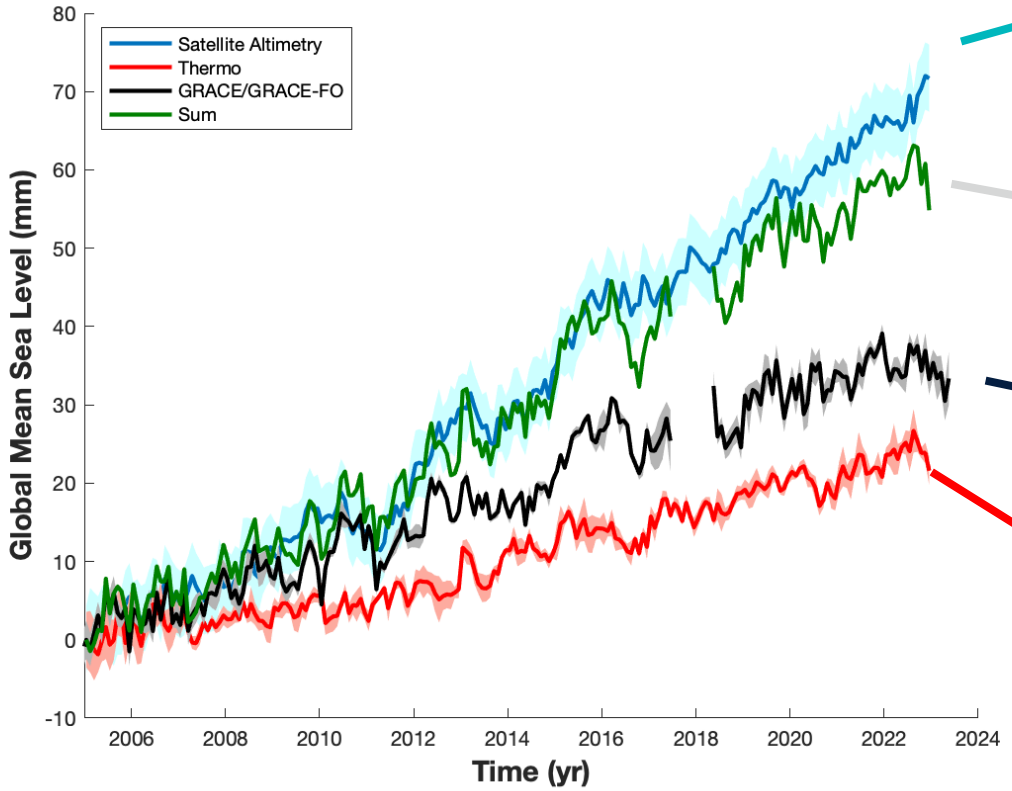
1. Deep ocean subsurface hydrography - massive expansion in deep ocean from Argo, GO-SHIP, Anibos (animal-borne CTDs), XBT line transport monitoring
2. Emerging glider and FVON networks on the shelves/slopes

# Tracking planetary change: warming



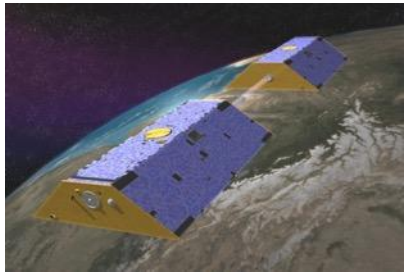

? Carbon
? Oxygen
? Nutrients
? Ecosystem change
? Deep oceans
? Polar oceans

# Tracking planetary change: sea level rise

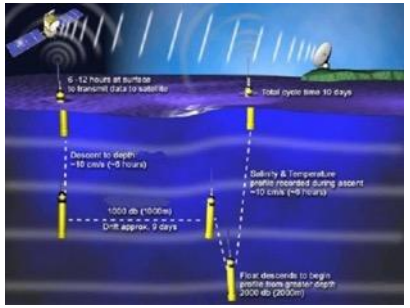



Topex/Poseidon/Jason

Argo + GRACE/GRACE-FO



GRACE / GRACE-FO

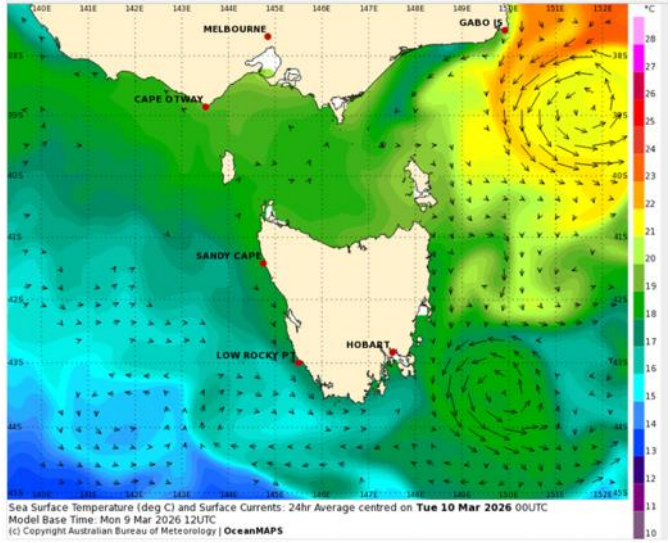


Argo

# Modelling and reanalysis: strong partnerships

- High resolution **ocean predictions**/reanalyses
- Couple **seasonal climate forecasting**
- Coupled **storm and weather forecasting**

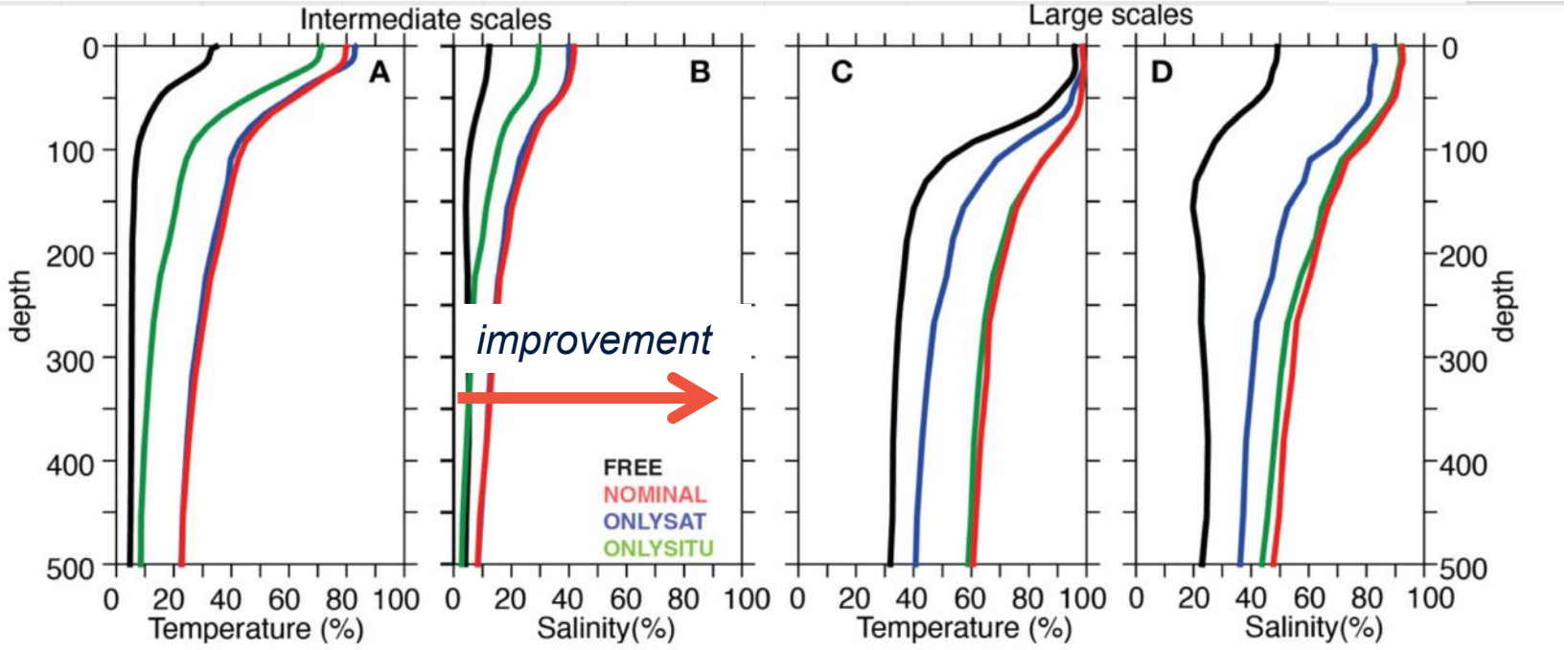
1. A major **pathway to impact**
2. Requires **real-time data** delivery (< 6 hours for NWP)
3. Requires known **observation errors**
4. Assist observing community in understanding **network** impacts and **design** choices e.g. SynObs project



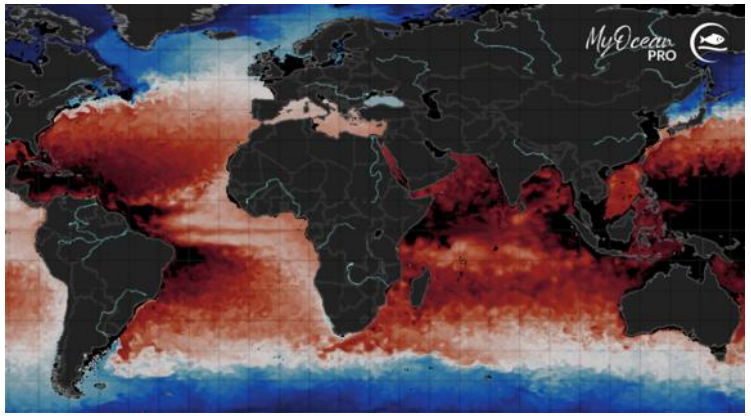

# Synergies in scales captured: Argo and altimetry

***Intermediate scales (100-1000 km/ 20-100 days)***

***Large scale***



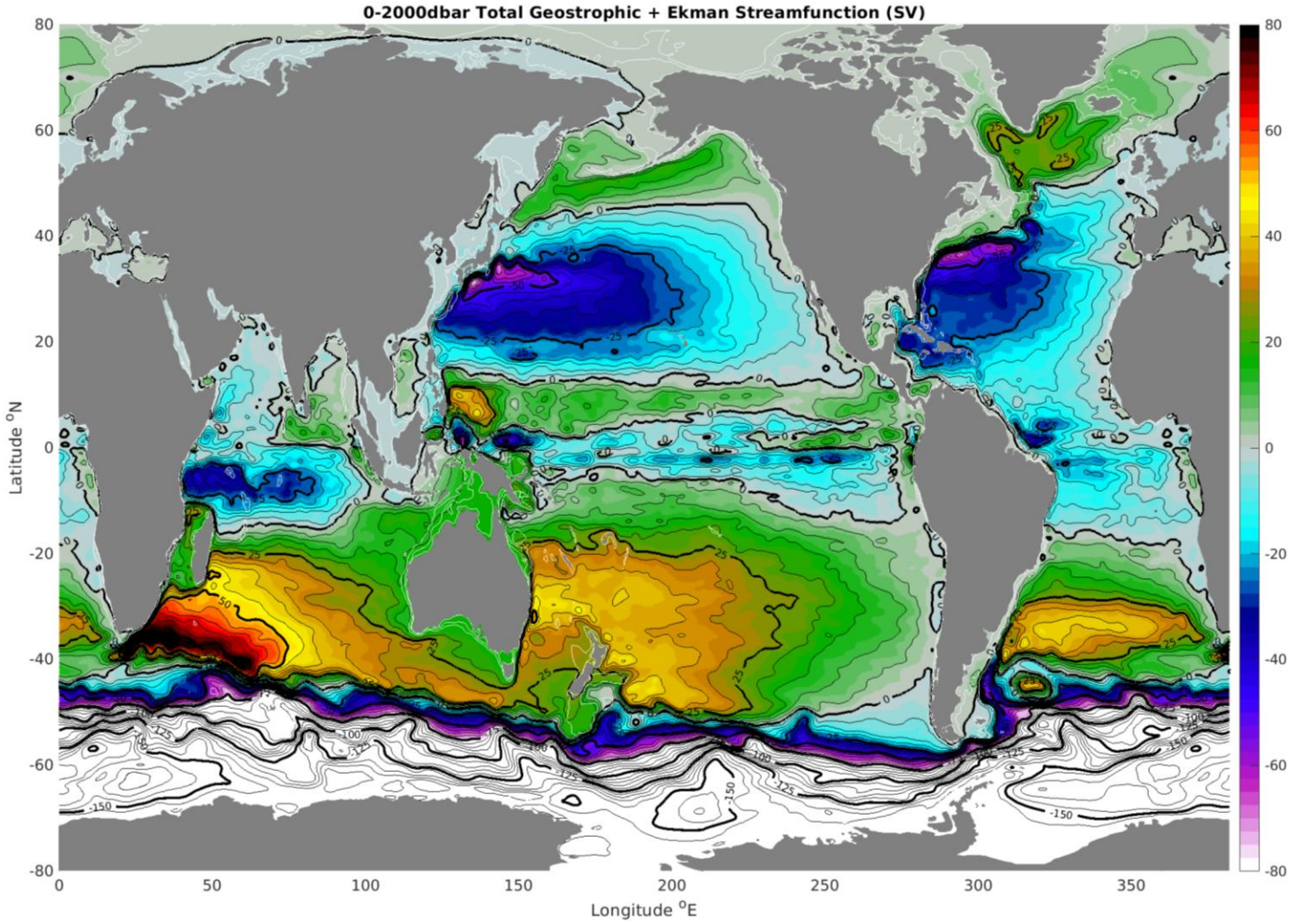

***Percent variance captured***




Argo constrains the 'largescale slow manifold', satellites SLA constrains the fast features and small spatial scales - a strong synergy is realized

*Gasparin et al. (2023), Frontiers MS*

# New insights: the mean ocean structure at the mesoscale



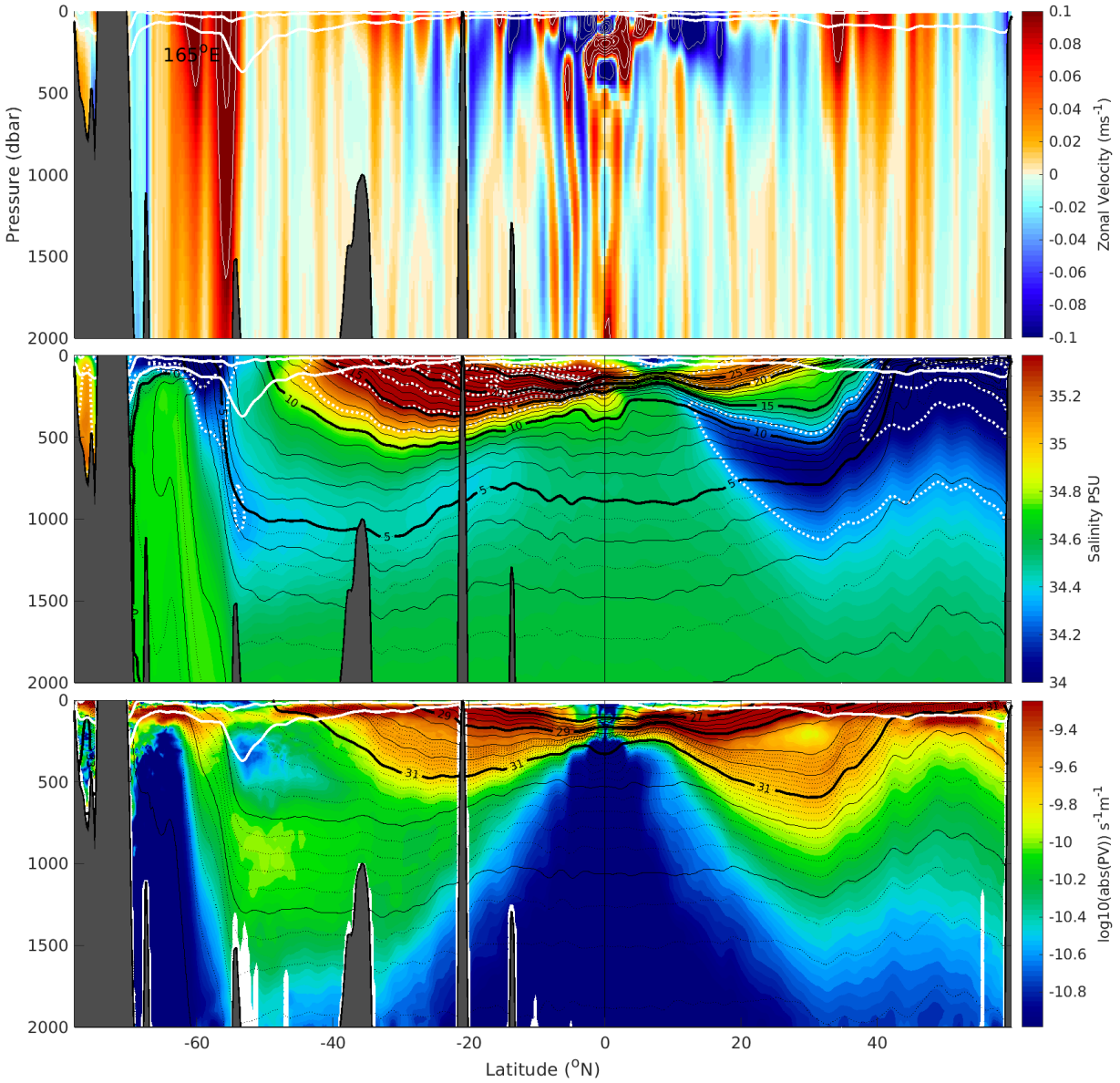

**0-2000dbar Ekman plus geostrophic transport streamlines**

- Indonesian Throughflow ~ 15Sv
- ACC  jets coalesce through fracture zones
- Boundary current standing meanders and eddies
- Boundary current recirculations
- Zapiola Gyre in the Argentine Basin
- Island tip jets



Wijffels, Gebbie, Robbins, 2024.

# Revisiting the mean ocean structure at the mesoscale



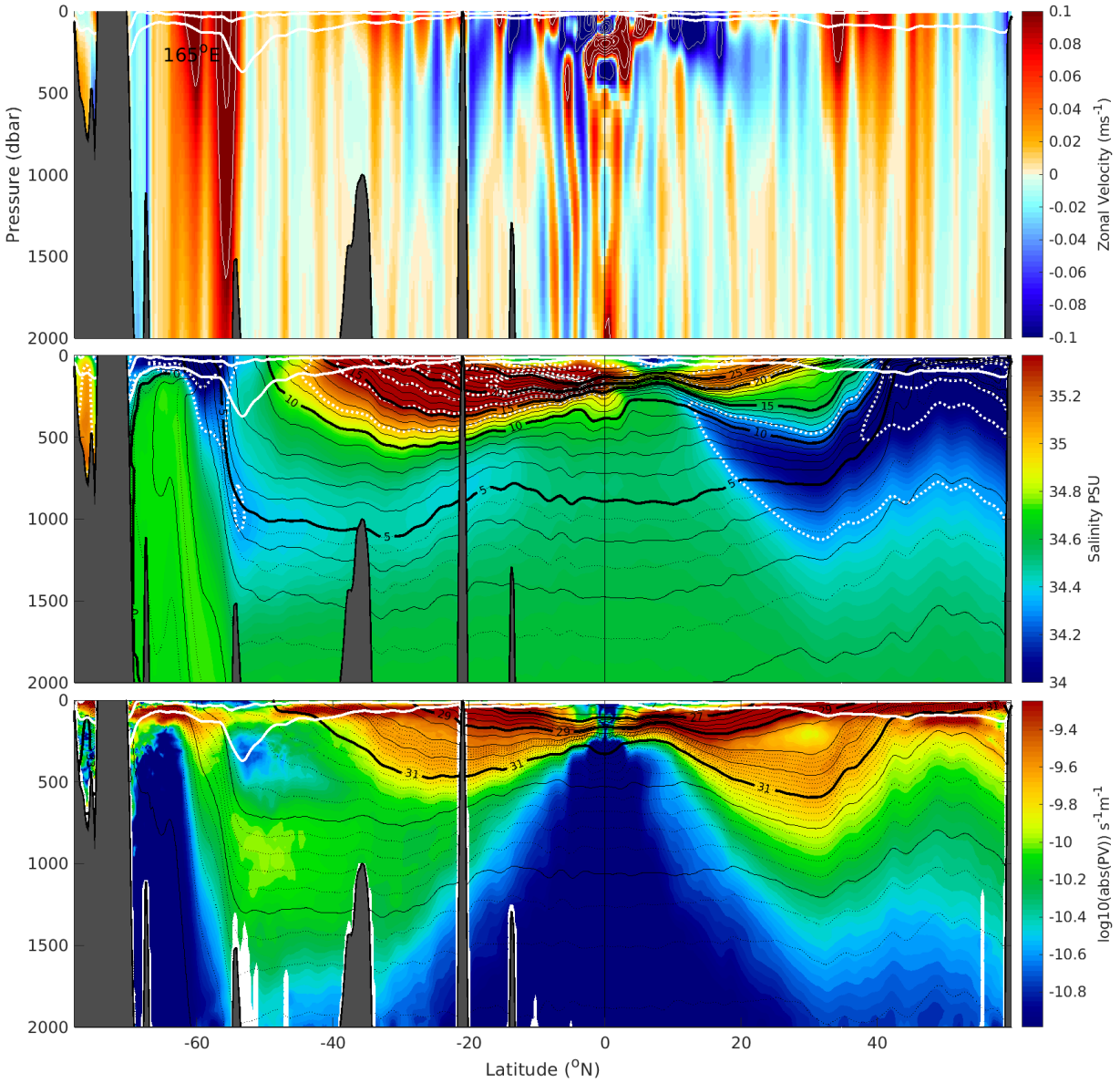

## 165°E Western Pacific

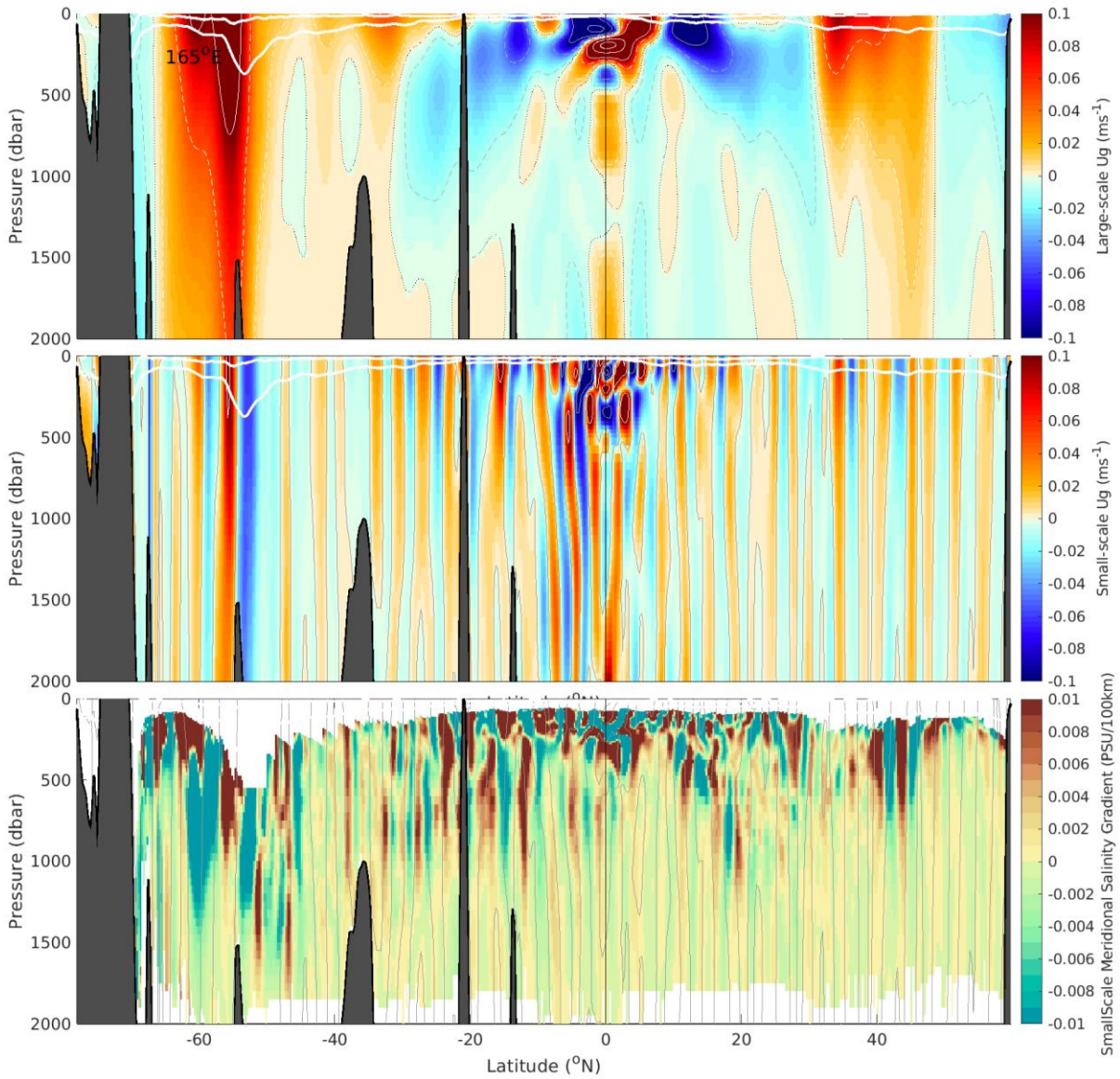
Zonal absolute geostrophic velocity

Salinity/temperature

PV/density

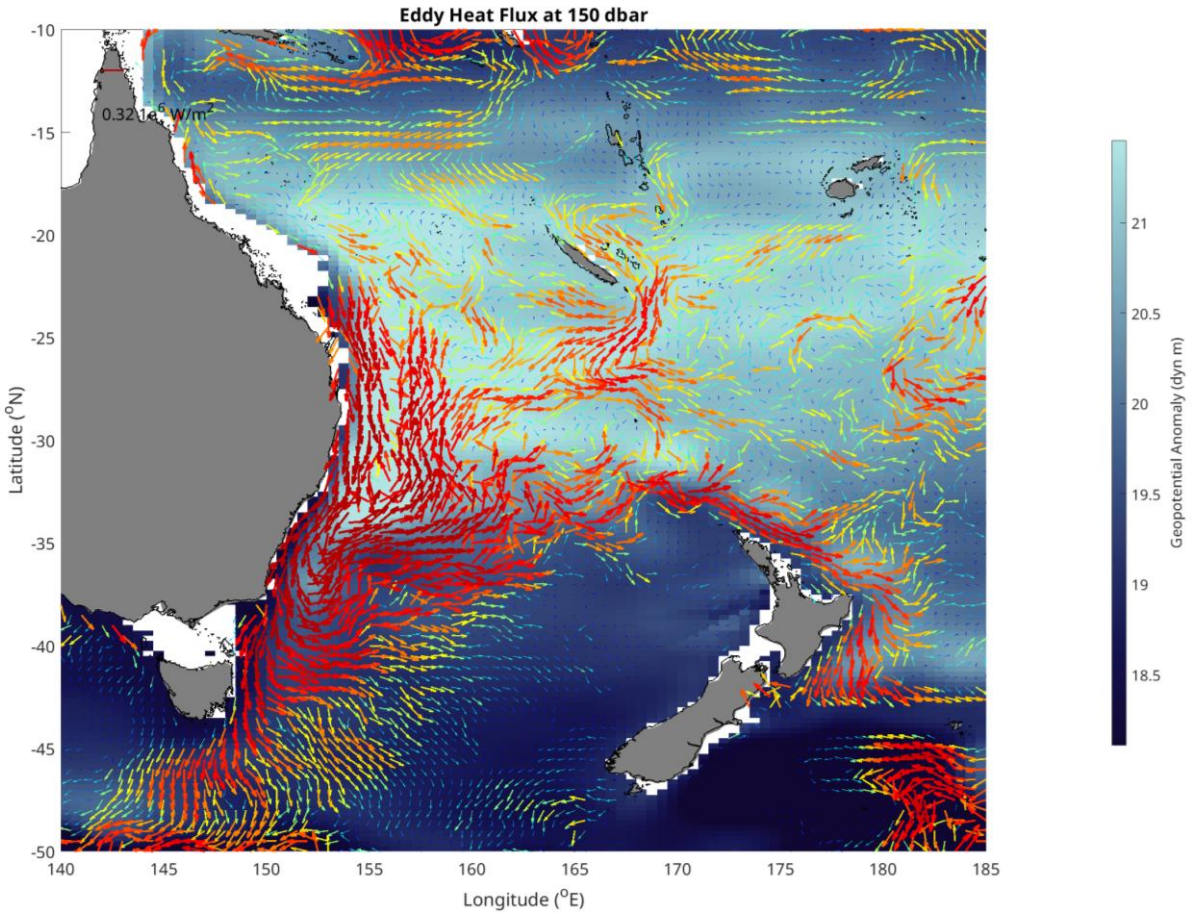
# New insights: the mean ocean structure at the mesoscale

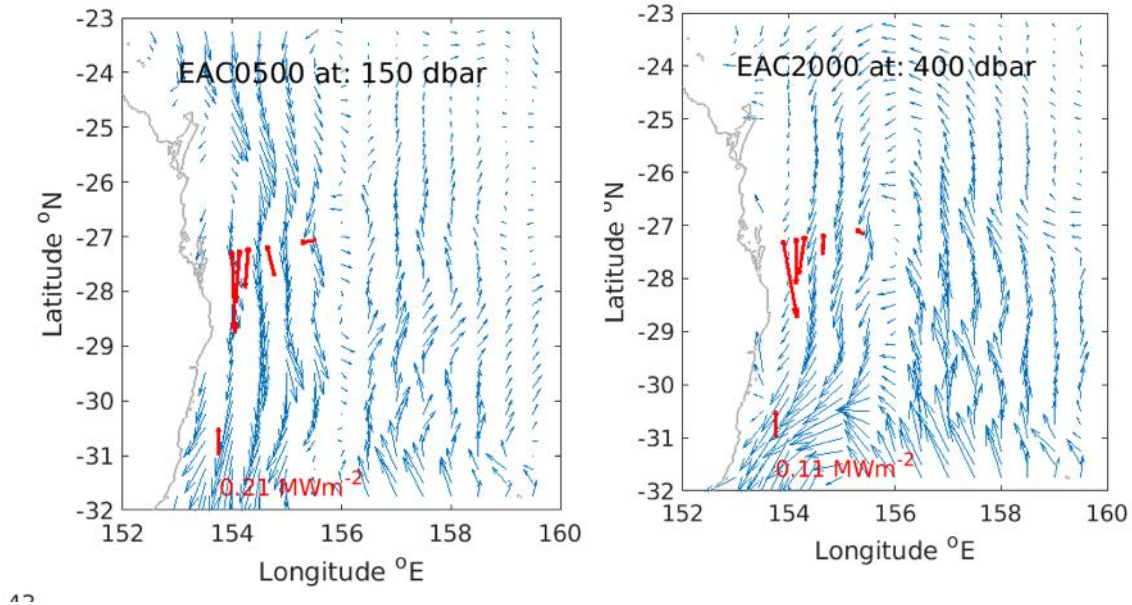


# Synergies – SLA+ Argo = eddy climate fluxes

## Eddy vector heat fluxes: 150m depth



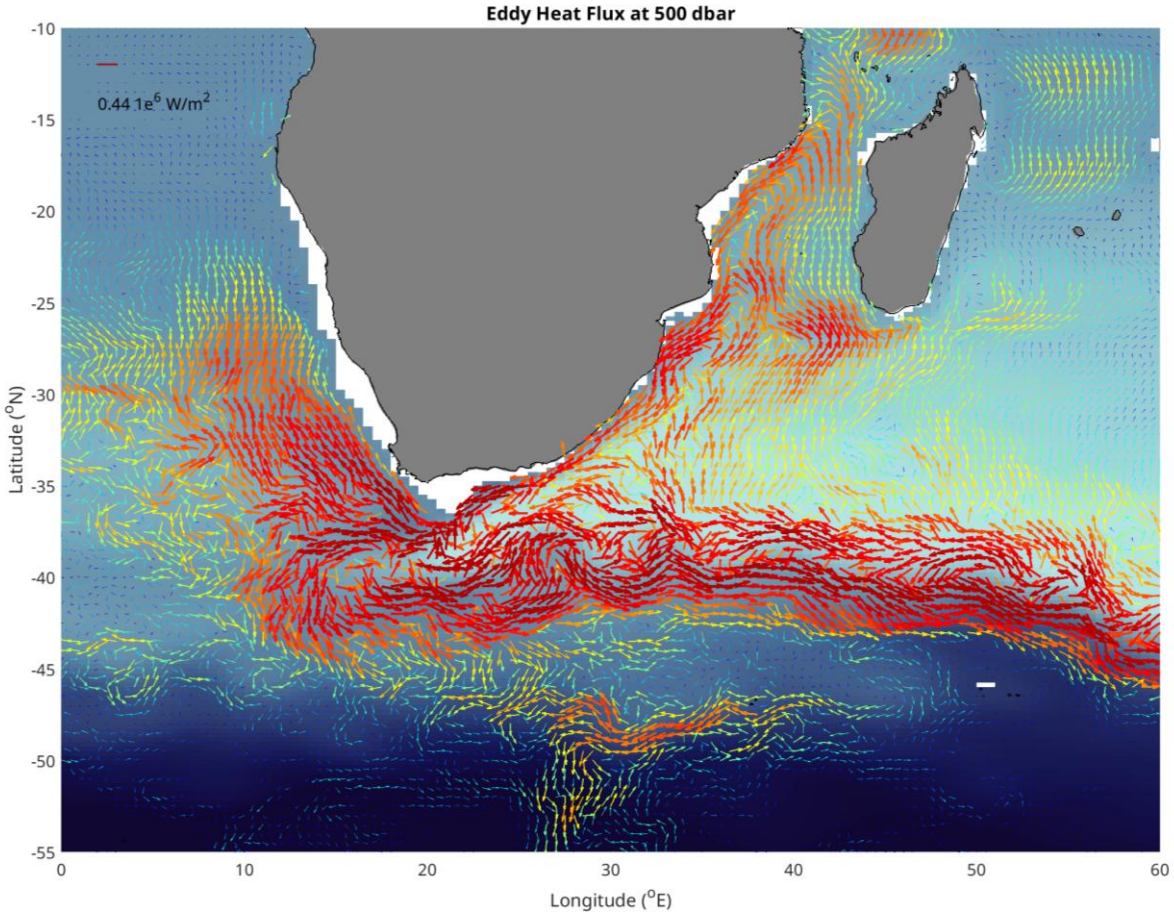



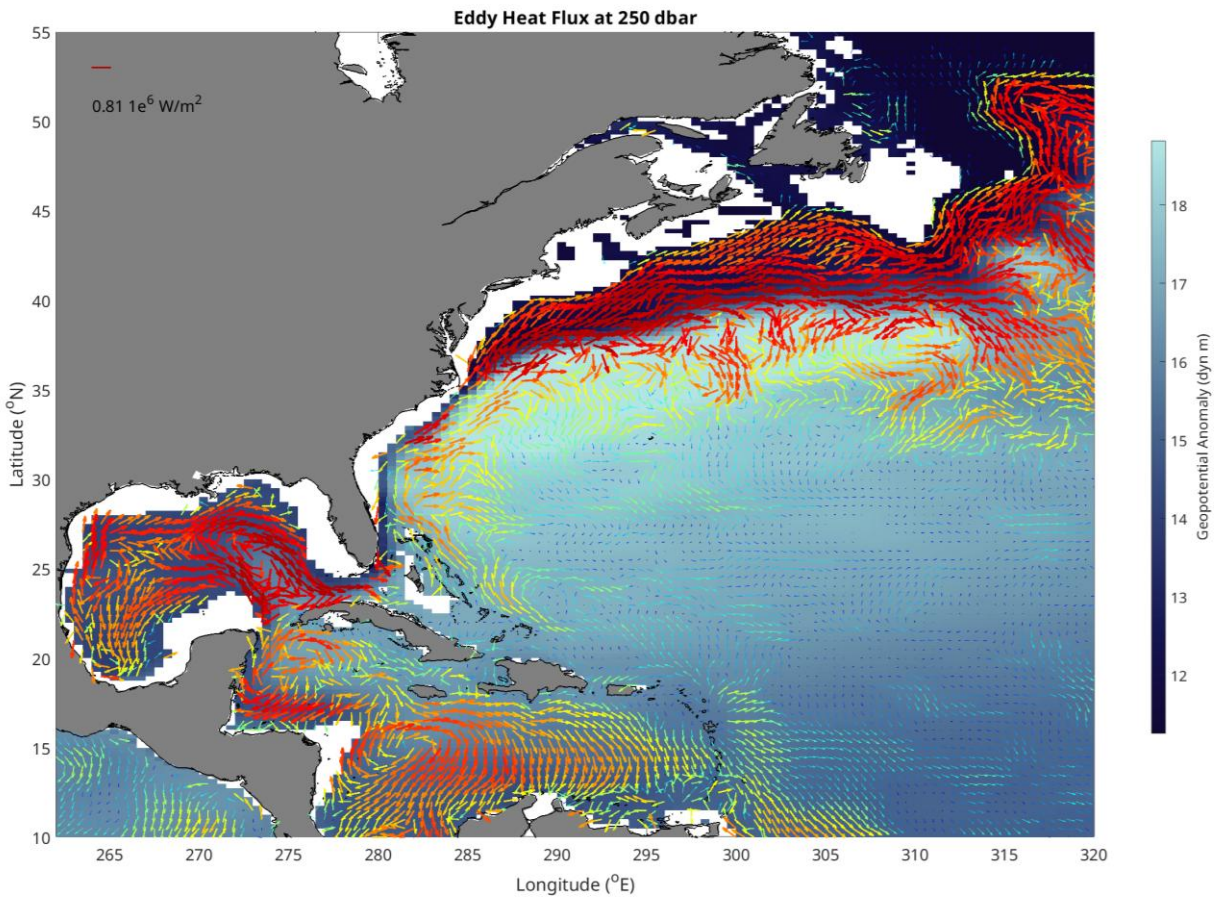

Validated using IMOS moored series



Wijffels, Gebbie, Robbins, Sloyan, in prep.

# Synergies – SLA/Argo = eddy climate fluxes



# The institutional challenge

- ‘operationalize’ = ‘hand-off mature networks’ to the ‘operational agencies’. This has not eventuated

- most operational agencies remain very ‘weather focussed - **lack a strong mandate to observe the oceans** and have little inhouse expertise

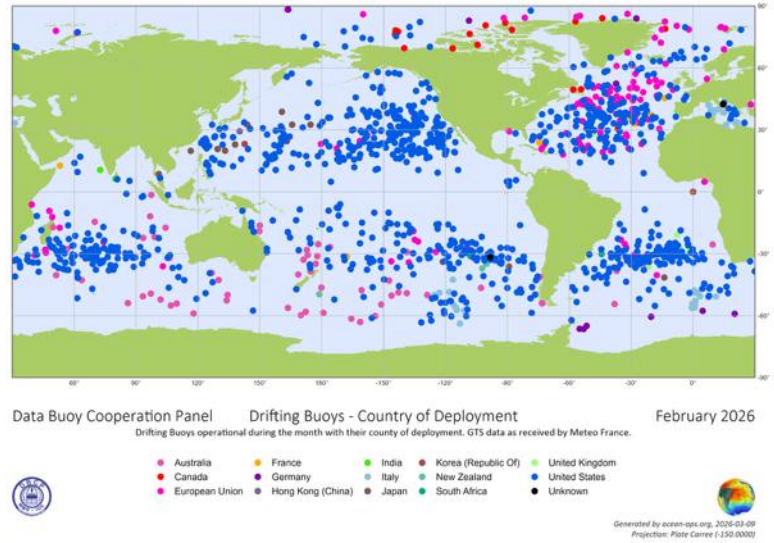
- Ocean observation capacity is often housed in **research agencies**: the technology is challenging, requires constant specialized vigilance and refinement, with strong partnerships with suppliers.

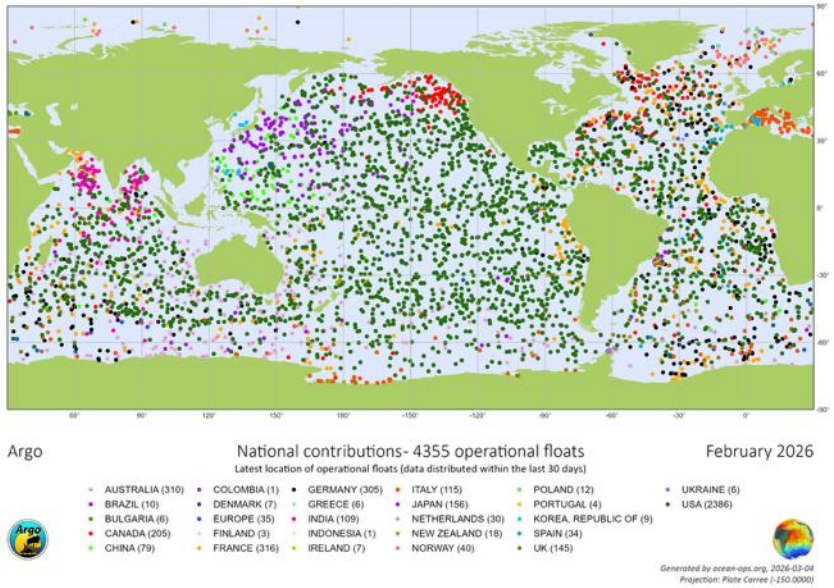
- IMOS represents a **very successful model** of sustainably funding operational and research agencies to collaboratively support expert teams to implement networks

- Need is to ‘operationalize’ the funding and not focus on where the work is done

# Looking forward

- There are many needed and exciting **future expansions**: biogeochemical/carbon, deep oceans, polar oceans, ecosystem observations
- The present  GOOS is **over-dependent on one nation** – likely not sustainable
- **Australia benefits** from billions in investments by other nations in both *in situ* and satellite data streams
- Australia is surrounded by some of the **most poorly observed oceans** and has a cutting-edge observing capacity
- A strong and growing Australian contribution to the global GOOS **can help bolster the present framework** of multinational and open data sharing.



# Summary

The global oceans community has **made major progress in the past 20 years:**

- We have **massively expanded** both the **satellite and *in situ* data streams** available for research and operational services
- Parallel and collaborative development of ocean, climate and coupled weather prediction services is **increasing our impacts on society**
- We must **consolidate these gains**, and expand into the big remaining gaps, exploiting new technological advances as they become available e.g. biological imaging, eDNA, new sensors, new platforms (e.g. smart cables)
- IMOS has helped develop **a strong Australian contribution to the GOOS**, by supporting research/operational agency collaborations
- IMOS serves as **a successful model** for the global community, and I hope will continue to directly support the global networks that Australia depends upon

**HAPPY 20TH BIRTHDAY!**

# Thank you

swijffels@whoi.edu

WOODS HOLE
**OCEANOGRAPHIC**
INSTITUTION