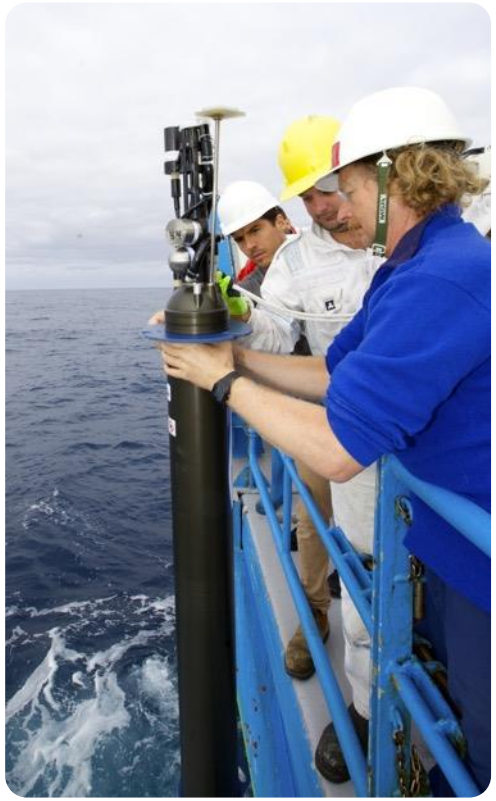
CELEBRATING 20 YEARS
OF SUSTAINED MARINE OBSERVING

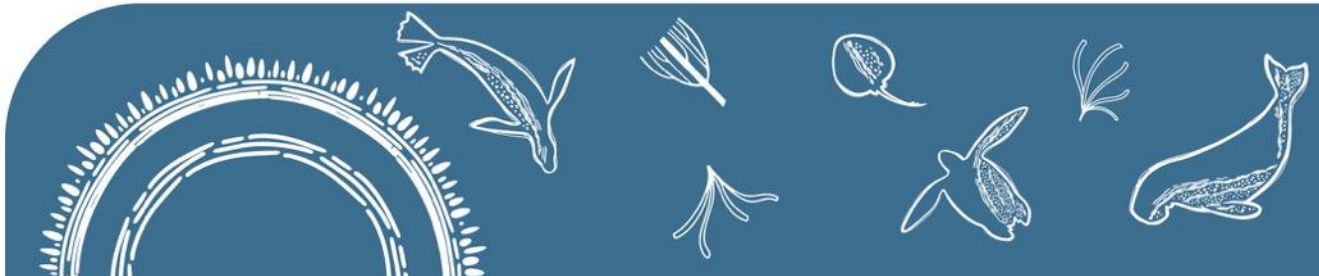
IMOS
Integrated Marine Observing System



Argo Australia

20 years of impact

P. R. Oke, A. Foppert, L. Krummel, J. Lovell, P. M. McMahon, G. S. Pilo, S. R. Rintoul, T. Rykova, C. Schallenberg, R. Scott, D. Slawinski, P. Strutton, E. M. van Wijk



IMOS acknowledges the Traditional Custodians and Elders of the land and sea on which we work and observe, and recognise them as Australia's first marine scientists and carers of sea Country. We pay our respects to Aboriginal and Torres Strait Islander peoples past and present.

What is Argo Australia?

Argo Australia is a national collaborative, research infrastructure, funded by the Australian Government.

1. National

- National Collaborative Research Infrastructure Strategy - Department of Education
- Deploying and operating floats all around Australia and in the Southern Ocean

2. Collaborative

- CSIRO (lead operator)
- IMOS (lead funding agency)
- BoM
- AAPP
- AGO (Defence)
- … plus many supporting agencies (including ARC and Australian Universities)

3. Research Infrastructure

- Systematic and sustained observing of the marine environment
- Open data access for operational applications, scientific research, and other purposes

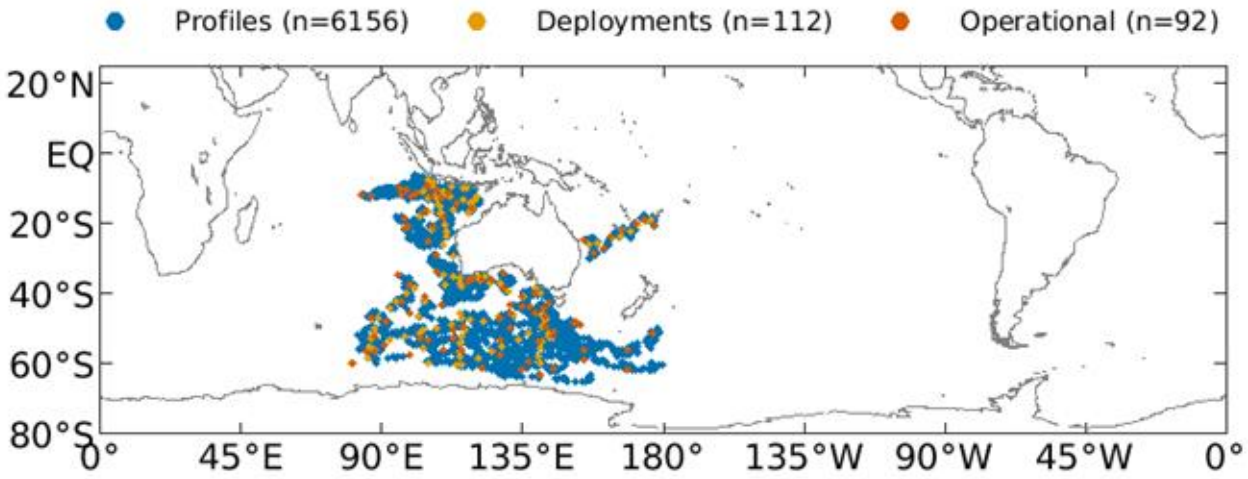
NCRIS
National Research Infrastructure for Australia
An Australian Government Initiative

CSIRO | AUSTRALIAN ANTARCTIC PROGRAM | IMOS Integrated Marine Observing System | Australian Government Bureau of Meteorology | Australian Geospatial-Intelligence Organisation

How has Argo Australia changed with support from IMOS?

Before IMOS

- First Australian deployment 21 October 1999
  - Deployed112 floats
  - 4% of the global ocean sampled*
  - 6% of the S.H. ocean sampled*
  - Maintain 92 operational floats
- Australia delivered ~6,000 profiles
- Global Argo delivered ~230,000 profiles
  - Core Argo (T/S)



* % sampled by area

Before IMOS

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- 4% of the global ocean sampled*
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- Maintain 92 operational floats
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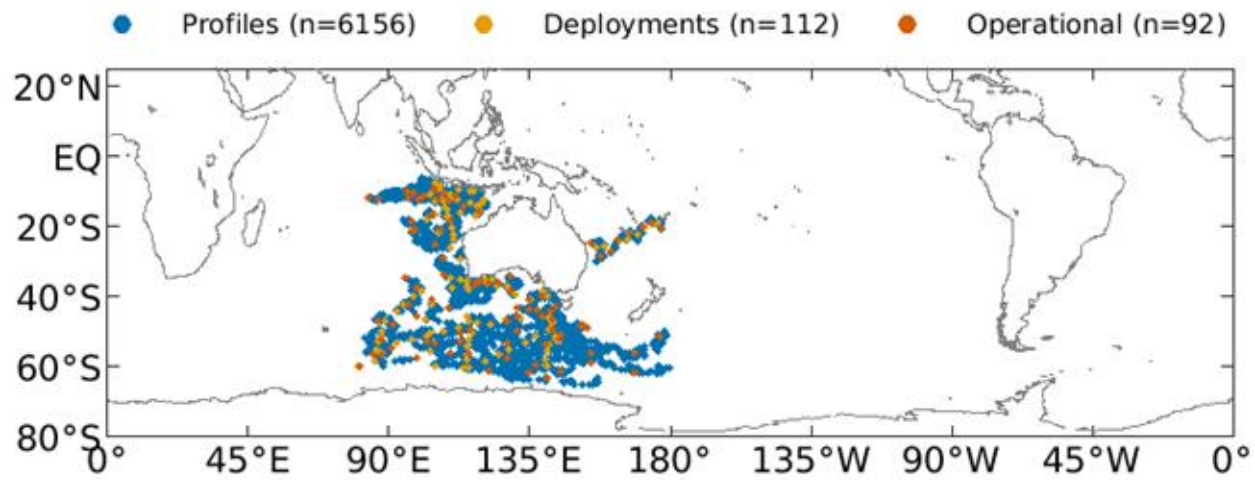
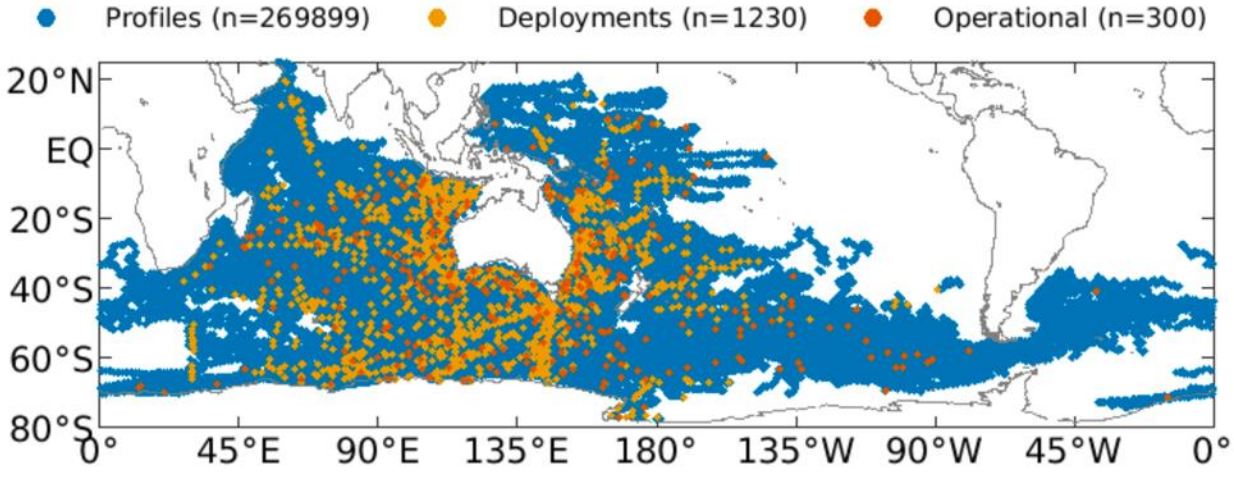
After IMOS

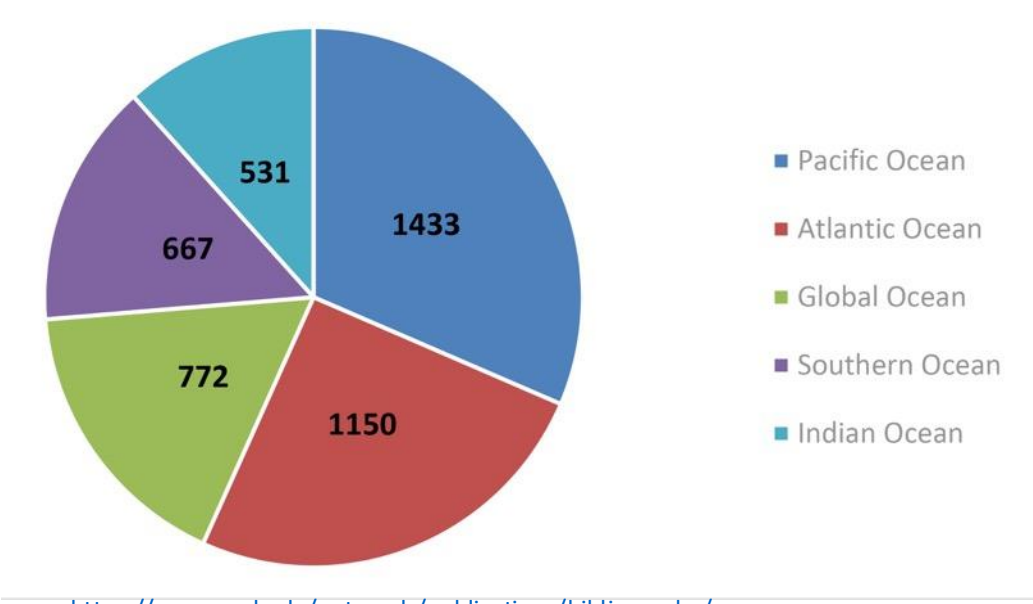
- 1230 floats ***(+1120)***
- 49% of the global ocean sampled* ***(+45%)***
- 79% of the S.H. ocean sampled* ***(+73%)***
- Maintain 300 operational floats ***(+208)***
- Australia delivered ~270,000 profiles ***(+263,000)***
- Global Argo delivered ~3.6 million profiles ***(+3.3m)***
- Core Argo (T/S) + BGC Argo + Deep Argo
- 111 floats with Oxygen, 34 floats with FI
- 17 deep floats (+12 leveraged for Antarctic basin)



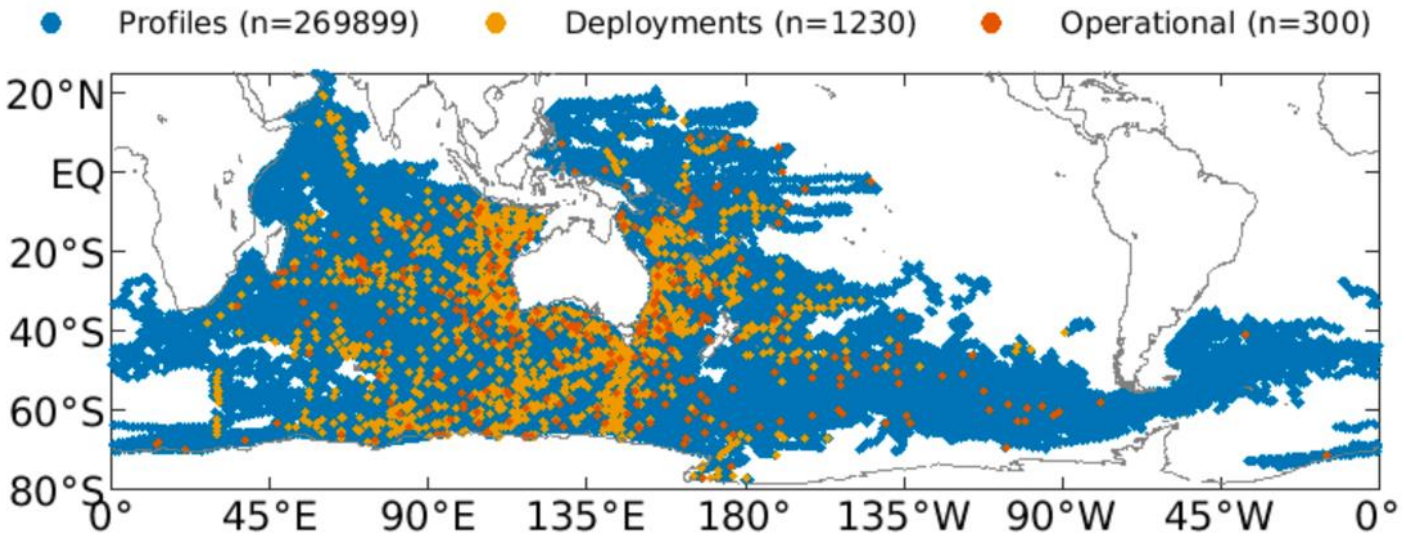


* % sampled by area

Our footprint



https://argo.ucsd.edu/outreach/publications/bibliography/



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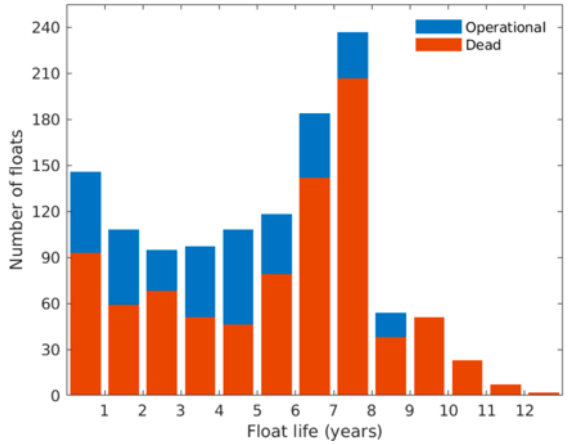
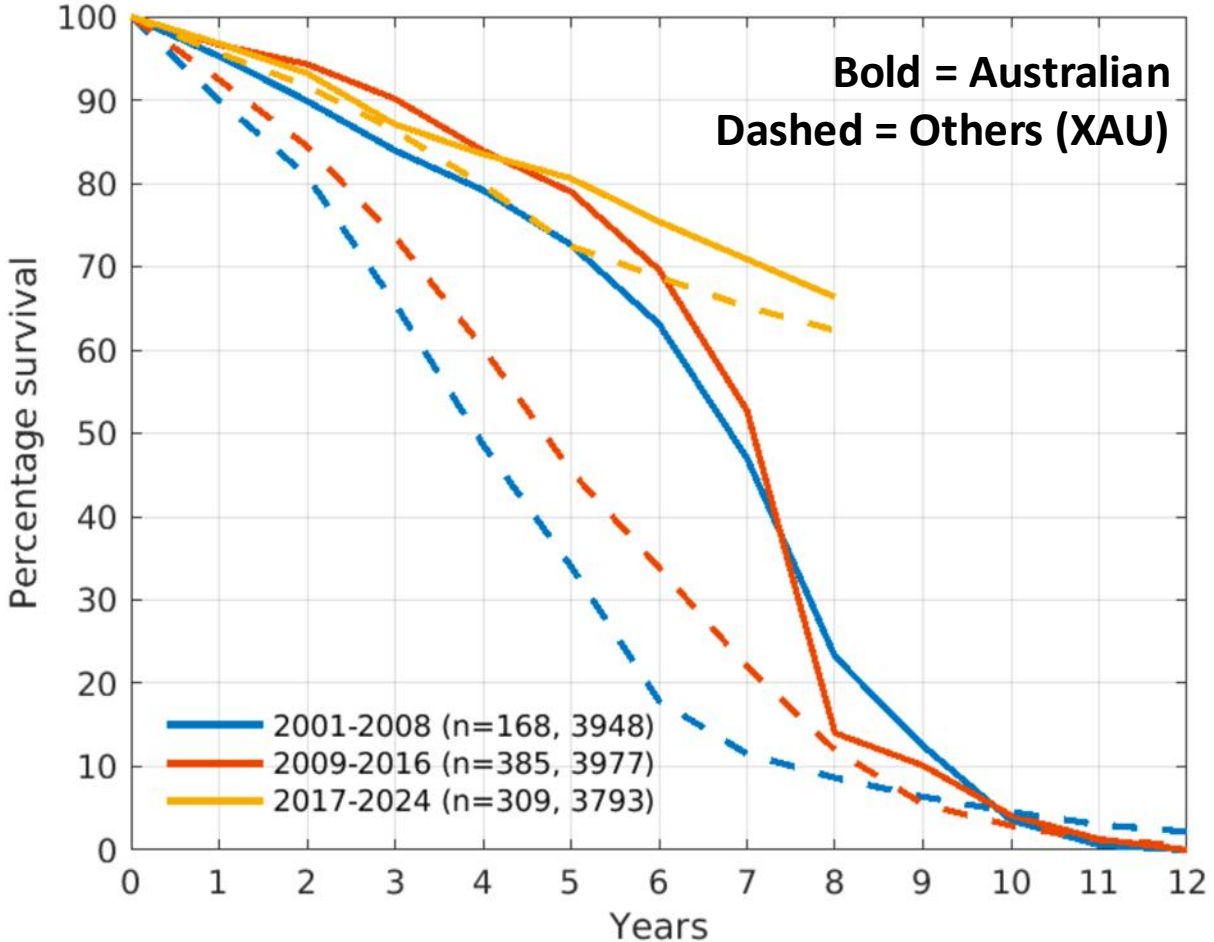
IMOS Integrated Marine Observing System

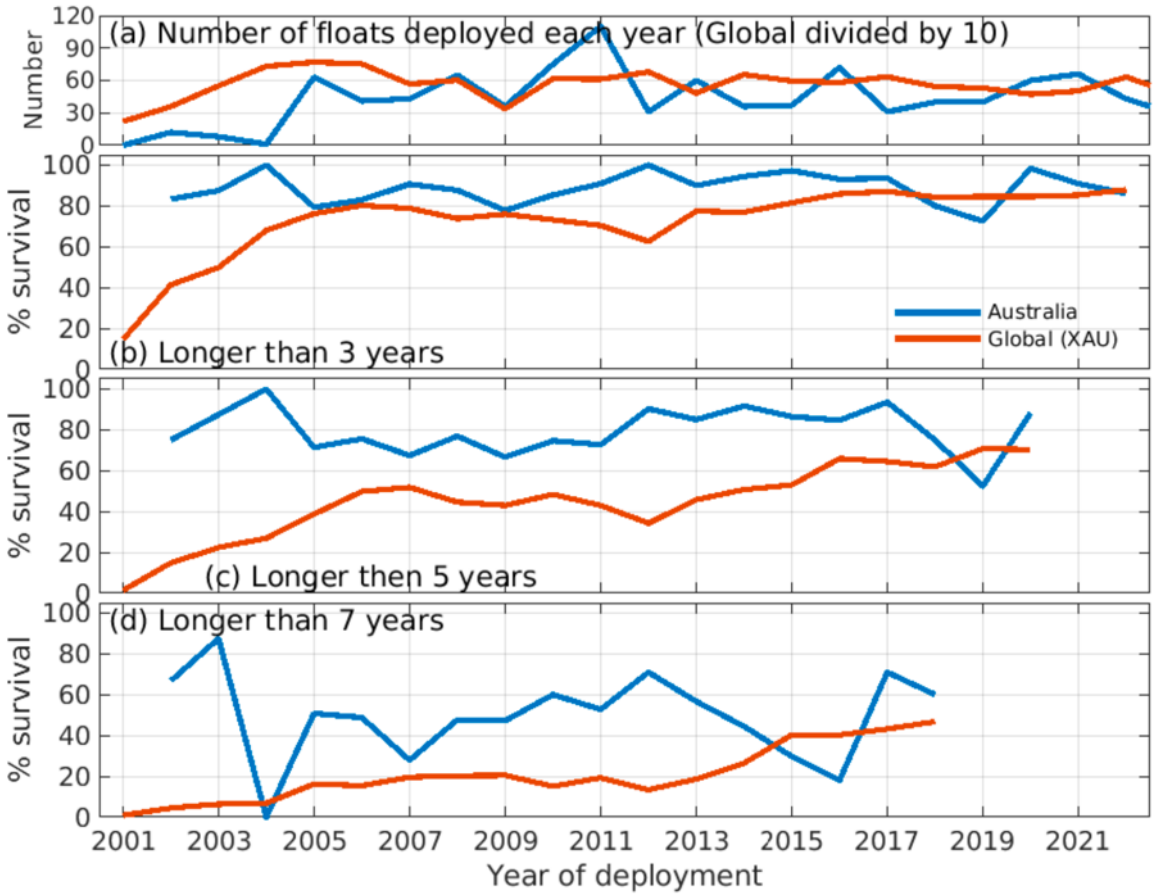
How do our floats perform?

Our float performance

- Australian floats return ~230 profiles over ~6.5 years
- All others combined return ~165 profiles over ~4.5 years
- Australian floats out-perform international benchmarks







What are we doing right?

- **Careful testing**
- **Conservative pre-deployment action**
- **Diversified fleet**
- **Comprehensive and attentive operation**

… a testament to our team.

Our team

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Our team

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Our International Leadership … building community … promoting best practice

Over the last 20 years, the Argo Australia team have served as:

- Argo Steering Team Co-Chair (Susan)
- Argo Data Management team Co-Chair (Anne Thresher)

… plus many other terms on mission and steering teams.

We initiated and co-lead an Argo Delayed-Mode Quality Control Discussion Series

Meeting 25
March 2026, 12am-2am (HBA)
Agenda:
- Christine Boone: Altimetry data plots
- Matthew Alkire: Continued discussion of D-Traj files
- Birgit Klein, Cecile Cabanes, Tatiana Rykova: TBTO follow-up

Meeting 24
30 January 2026, 4pm-6pm (HBA)
Agenda:
- Deb West-Mack: Looking at Trajectory Files
- Delphine Dobler: Audit of neglected profiles

Action 24.1: DMQC Community needs to agree on quality targets for DTraj files (Recall: "Perfect is the enemy of good enough")
Action 24.2: Code and instructions have been shared (thanks Deb) ... let's get started!

We initiated and co-lead an international technical community of practice

Real-time float management *… an example of best practice delivering real benefit*

- Sometimes a float develops a technical issue.
- One example, is when the air bladder malfunctions … so the float can't properly pop up out of the water to send data.
- If we don't know … or we don't notice … we just don't receive data … it's lost.
- If we notice, we can manage the float mission to extend the life of a float.

Real-time float management *… an example of best practice delivering real benefit*

Example log from our Python Real-Time (PyRT) data processing system
… called PyRT

159	-57.417	119.561	2024-05-27T08:58:02Z	L1	1991.5	4.2	995	7	11.50
160	-57.610	119.893	2024-06-06T12:07:41Z	L1	1983.9	4.4	991	7	11.43
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182	--	--	2025-01-16T13:08:25Z	C	1985.8	4.2	992	7	11.21
183	--	--	2025-01-26T16:48:13Z	C	1983.2	4.3	991	7	11.04

Real-time float management *… an example of best practice delivering real benefit*

Data for consecutive profiles

Green is normal operation

Italics … means there was no GPS fix … meaning that the float didn't surface and transmit properly … but data was later received by putting the float into a recovery mode.

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Real-time float management *… an example of best practice delivering real benefit*

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We would have lost a lot of data

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Real-time float management *… an example of best practice delivering real benefit*

Status history [add]

Date	User	Status	Notes
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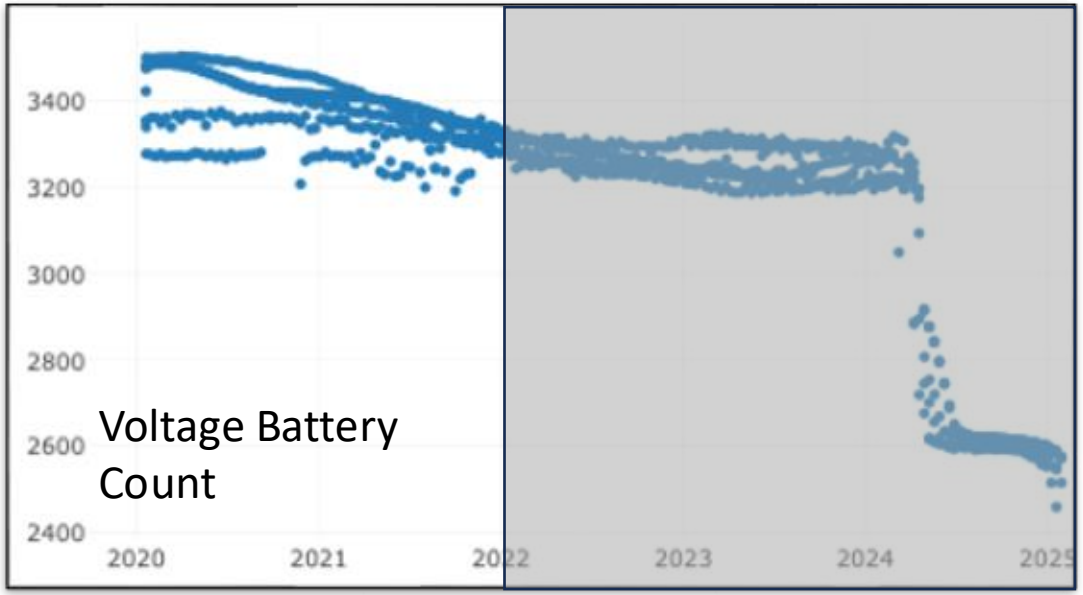
2022-01-18 21:57:46	roger	Fault	Recovery mode on to return outstanding files
2022-01-19 20:15:48	roger	Fault	Recovery mode disabled
2023-08-16 22:12:50	roger	Normal operation	Recovery for outstanding files completed.
2023-10-08 22:27:51	gabi	Normal operation	Put in recovery mode for 6 hours to get a GPS fix
2023-12-06 21:46:53	roger	Normal operation	File recovery/GPS fix done



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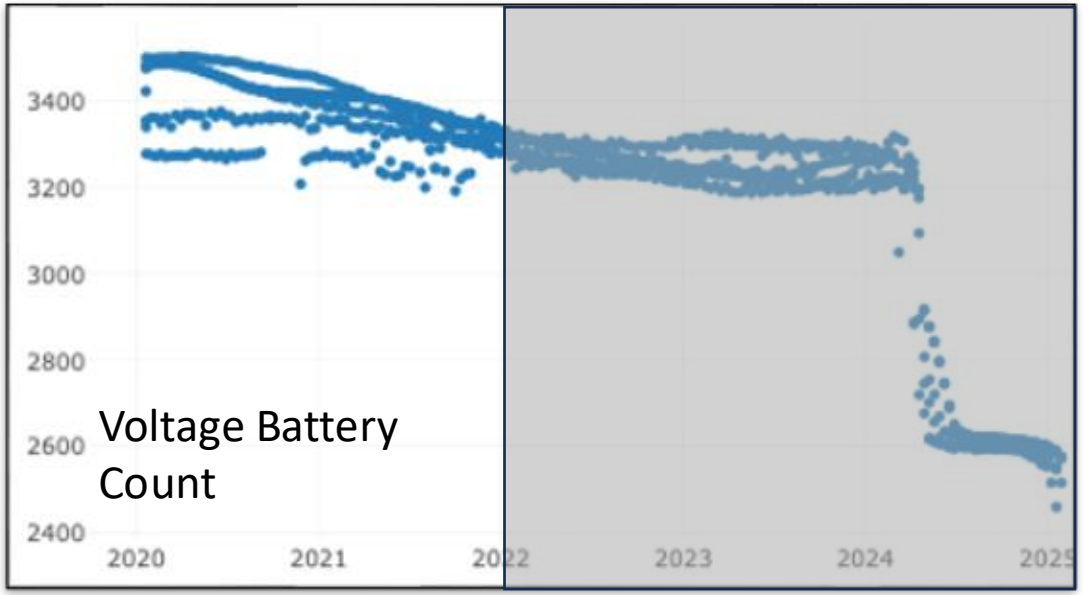

- In this example, we nursed the float three years … extending the float life from 2 years to 5 years.
- We've done this for over 20 floats so far … rescuing about 2000 profiles … equivalent to over 40 years of data.

CELEBRATING 20 YEARS OF SUSTAINED MARINE OBSERVING

IMOS Integrated Marine Observing System

Sustained investments in people and systems pays off

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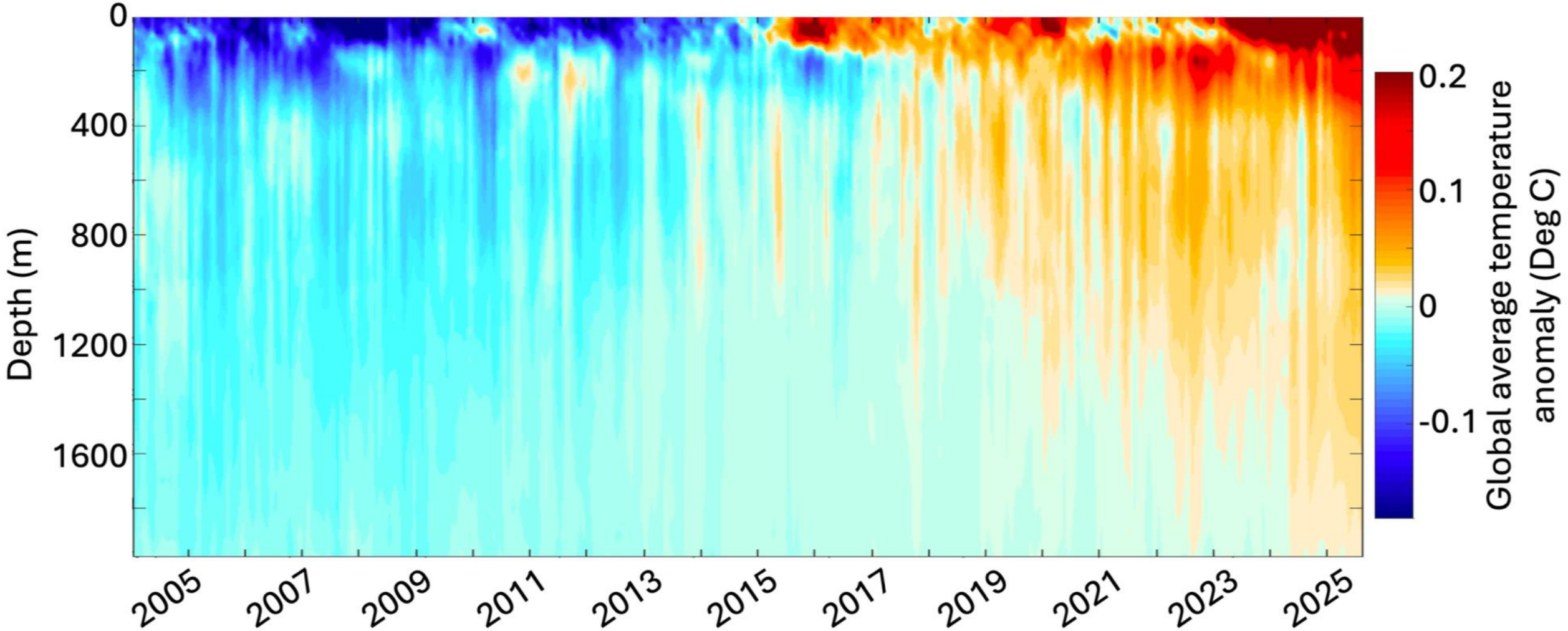
Application of Argo data

Quantifying deep ocean warming



Argo floats measure ocean warming … no models, no complicated assumptions, just observations.
Sourced from: https://www2.whoi.edu/site/argo/impacts/warming-ocean/,
based on Roemmich and Gilson (2009)

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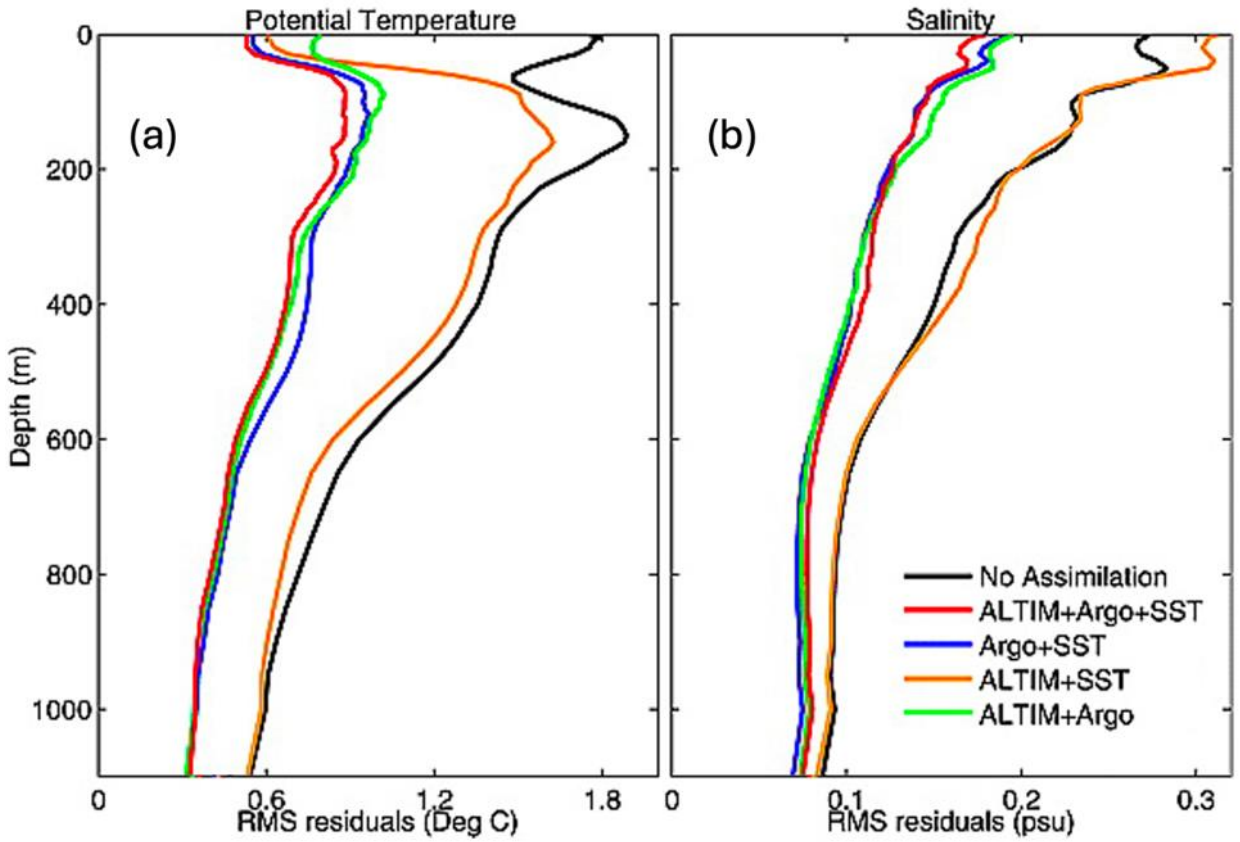
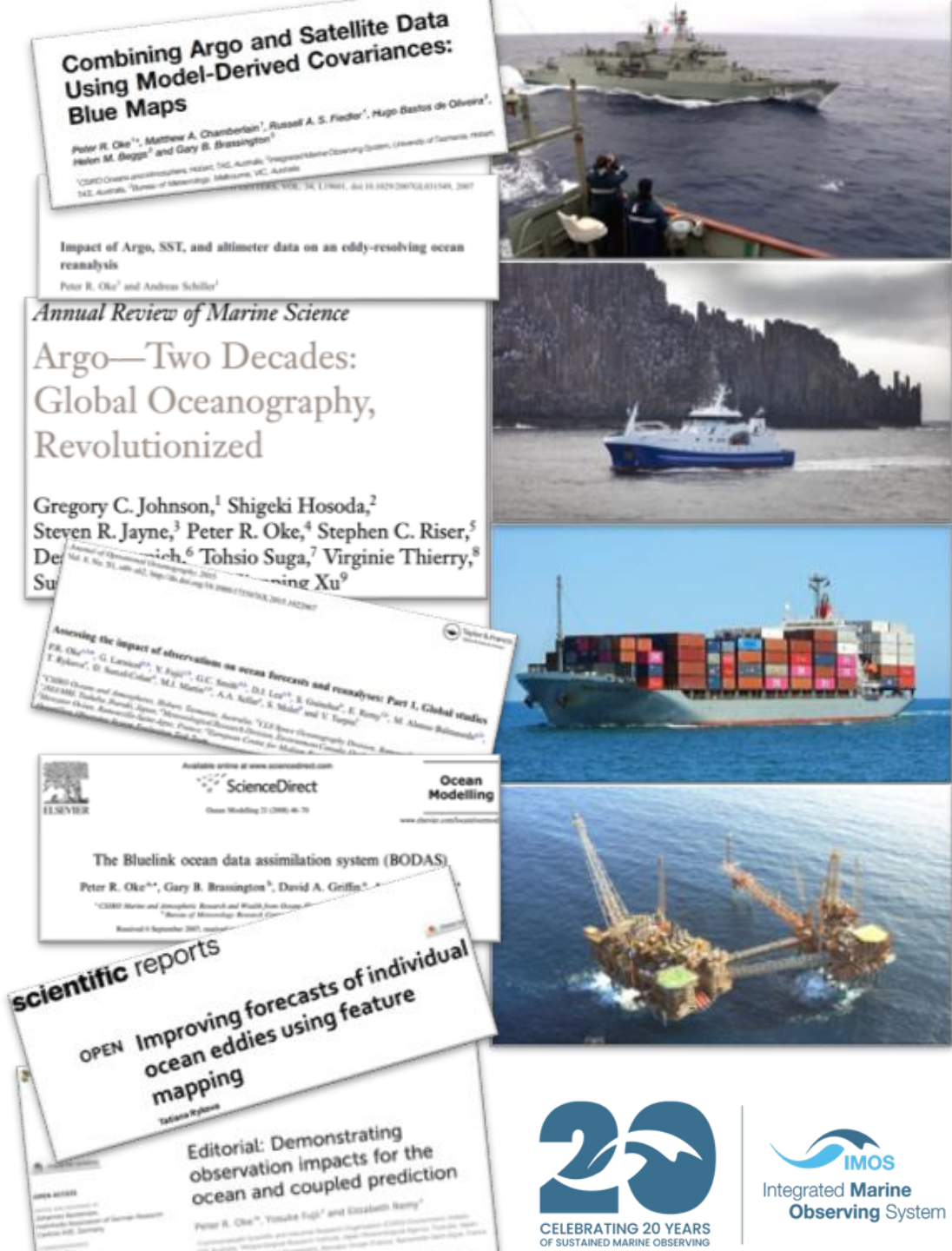
Ocean forecasting and reanalysis

- Argo is the only ocean observing platform with global coverage that provides sufficient data to initialize ocean forecasts.



Model-observation mis-fits after assimilation when different sub-sets of the GOOS are assimilated.
Oke and Schiller (2007)



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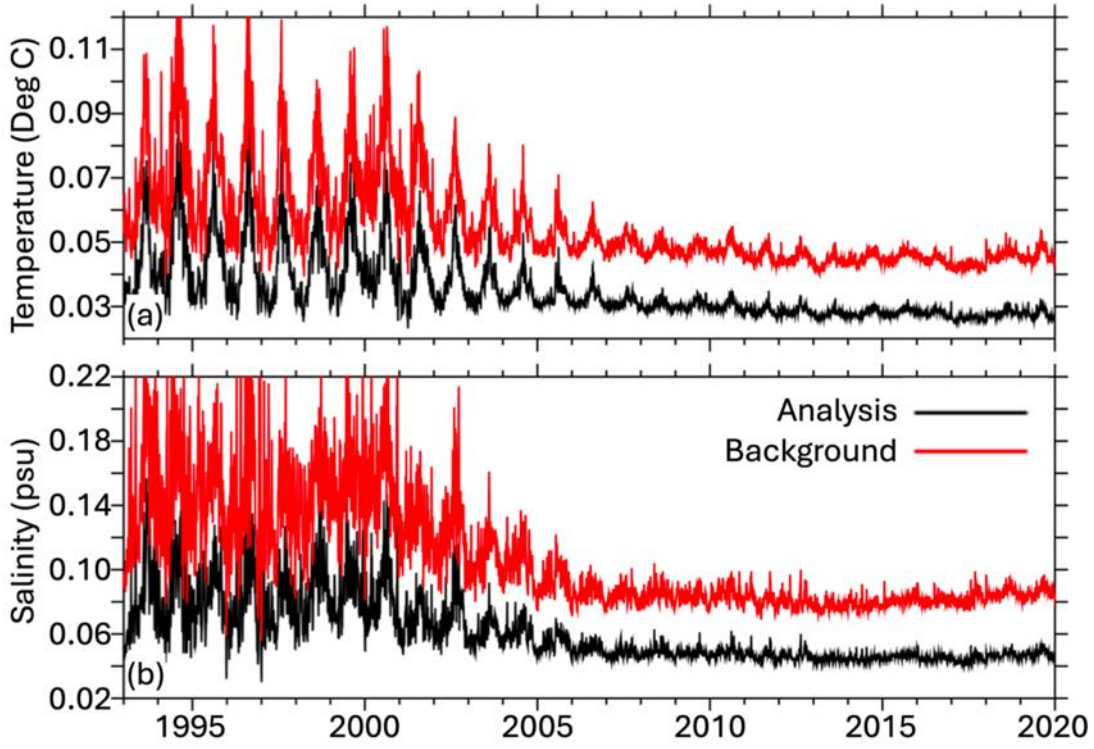
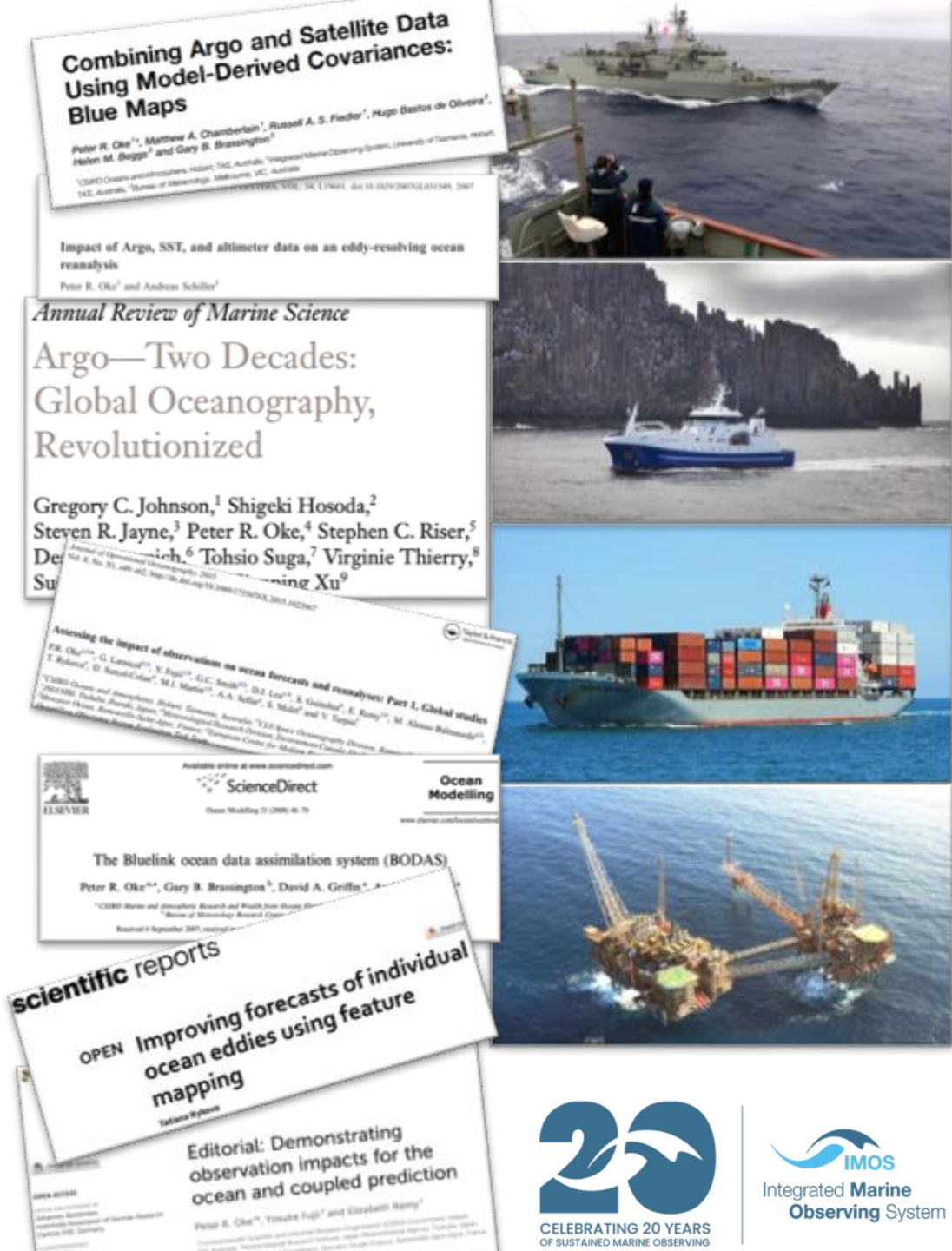


Model-observation mis-fits before (red) and after (black) assimilation, showing that ocean reanalyses are poorly constrained without Argo, and well-constrained with Argo. *Chamberlain et al. (2021)*



Understanding ocean biogeochemistry

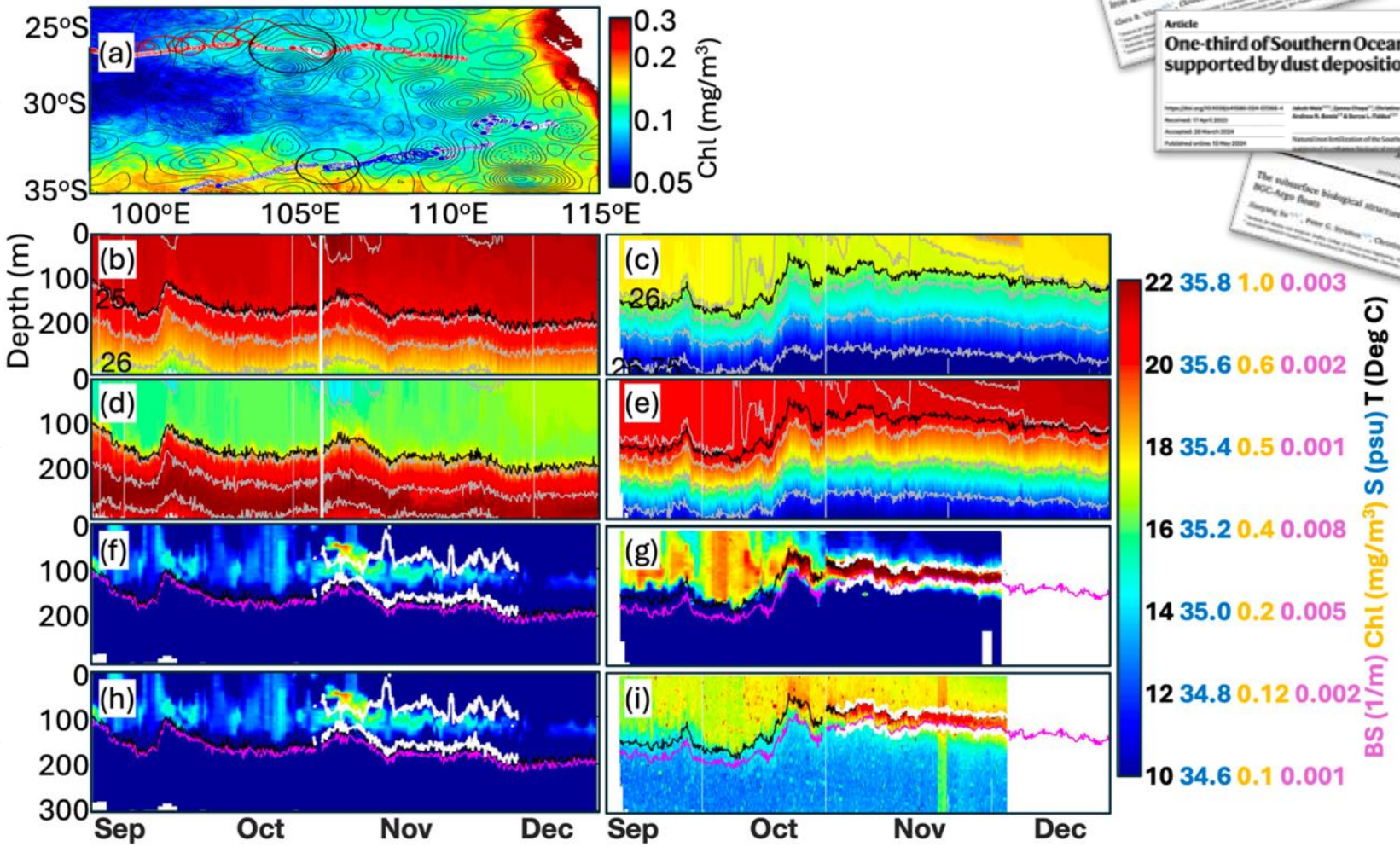
Ocean Colour →

Temperature →

Salinity →

Chlorophyll →

Backscatter →



Comparison of physical and biogeochemical properties of a cyclonic and anticyclonic eddy in the Indian Ocean, observed by BGC Argo.
Strutton et al. (2023)

The breadth of studies using BGC Argo data is massive!

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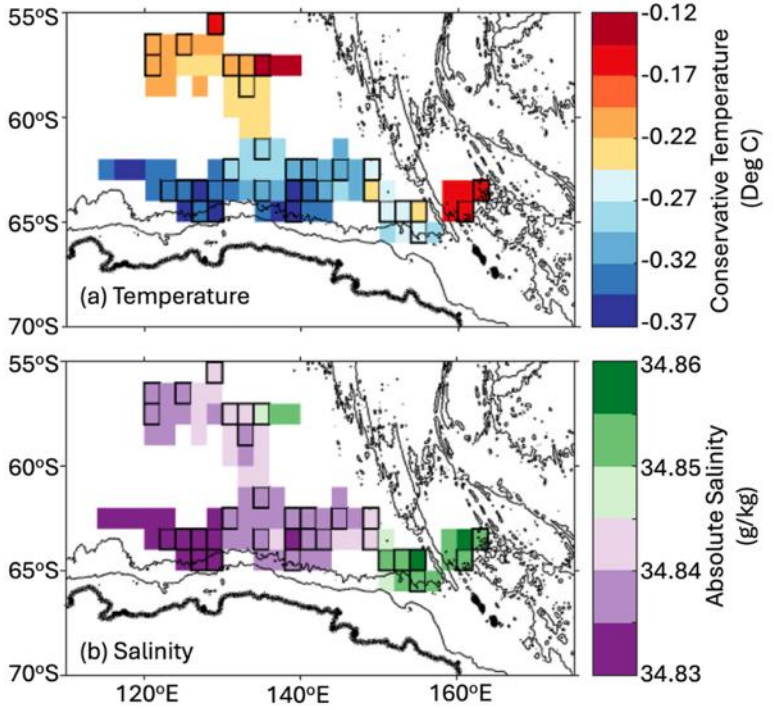
Deep Argo pilot experiment in Australian-Antarctic Basin

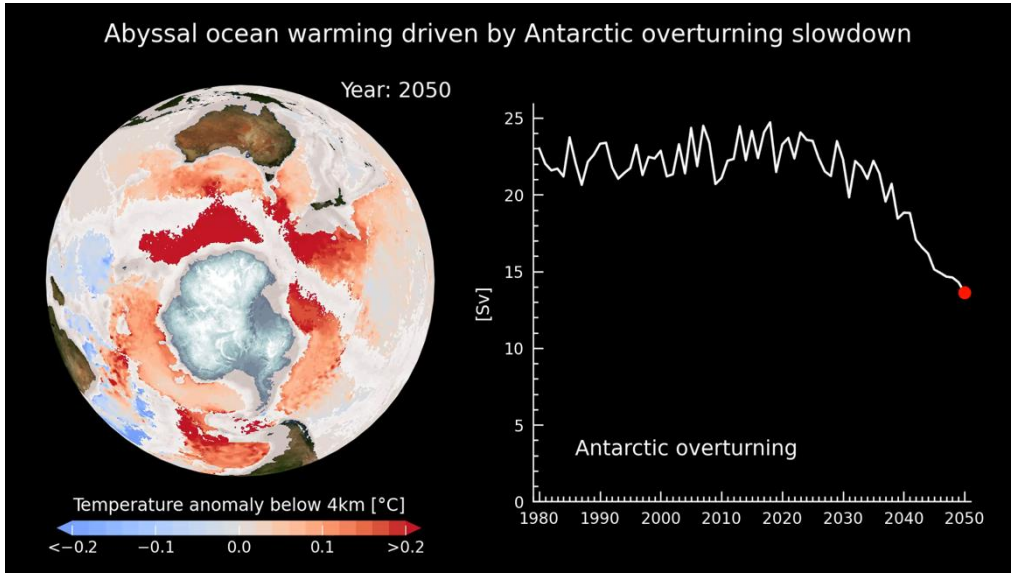
- Deep Argo floats measuring Southern Ocean change through the full ocean depth
- Supported largely by AAPP; IMOS-funded floats to be deployed next year
- Demonstrated feasibility of Deep Argo deployments in sea ice zone (one float is 7+ years old and still going!)
- >1700 profiles between 2018 and 2023, tripling number of deep profiles in the basin and a ten-fold increase in winter data

- Revealed pathways and properties of Antarctic Bottom Water (AABW)
- Quantified rapid change in the deep ocean
- Improved estimates of ocean warming below 2000 m
- Identified new sources of Antarctic Bottom Water

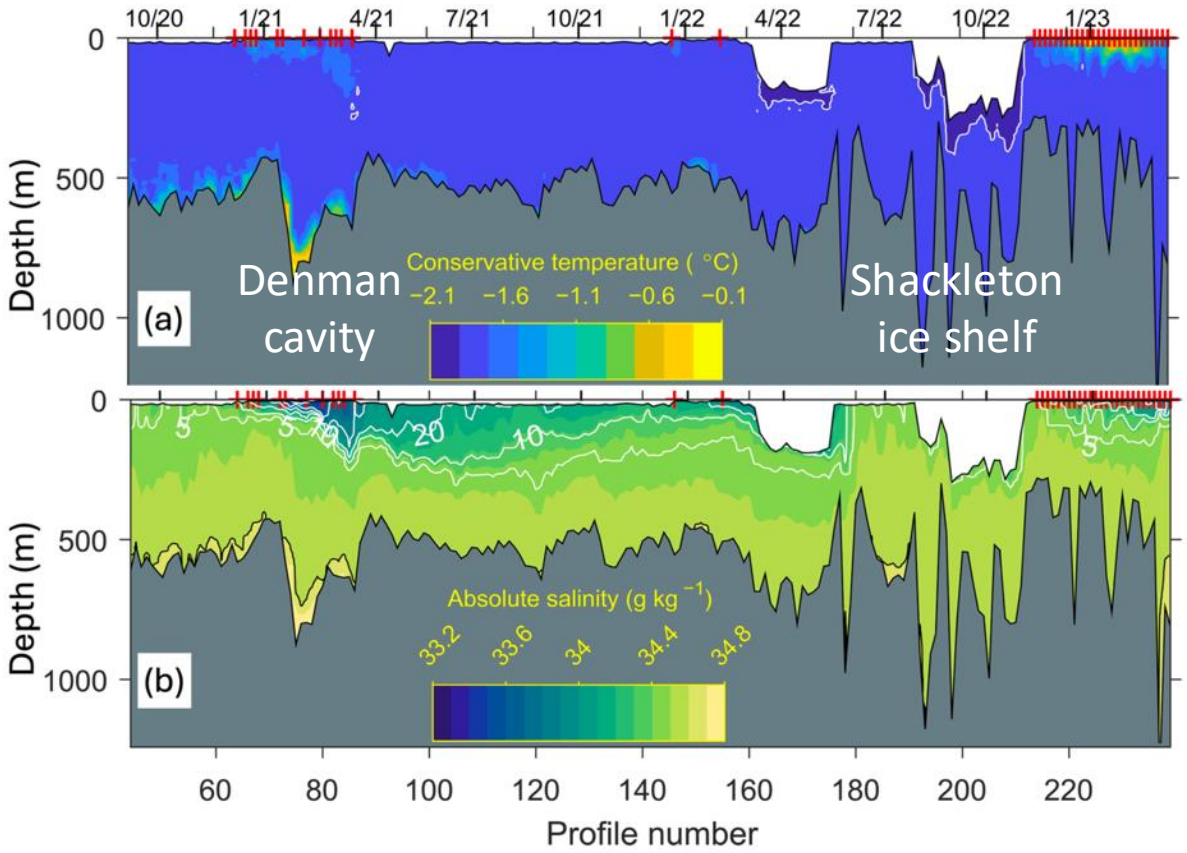


(above) Bottom temperature and salinity of AABW from Deep Argo (Foppert et al. 2021)

(right) Movie of projected deep warming and slowing of overturning 2000-2050 from model study of Li et al. (Nature, 2023)



Argo Australia under ice

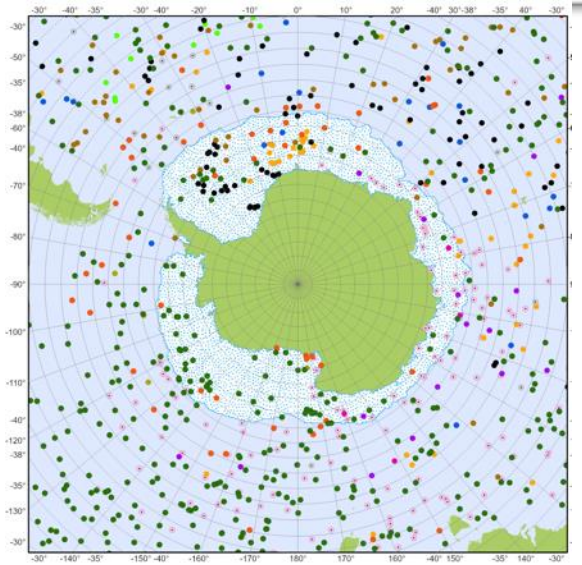


(a) Temperature and (b) salinity, for a float that drifted ~300 km under ice over 2.5 years

… showing Circumpolar Deep Water penetrating the Denman cavity;

… the Shackleton ice shelf cavity dominated by colder water → weaker melt rates.

Rintoul et al. (2025)



AUSTRALIA (140)
CANADA (1)
CHINA (10)
EUROPE (22)
FRANCE (50)
GERMANY (82)
INDIA (4)
ITALY (53)
JAPAN (17)
NETHERLANDS (16)
NEW ZEALAND (5)
UK (52)
USA (377)

Australia has deployed over 200 floats south of 60°S, with 44 floats deployed on the Antarctic continental shelf.

Average float life under ice is almost 6 years.

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The breadth of applications informed by Argo – particularly by Deep and BGC Argo – is growing every year

A comment on the benefits and risks of being part of an international Program

What keeps me up at night …

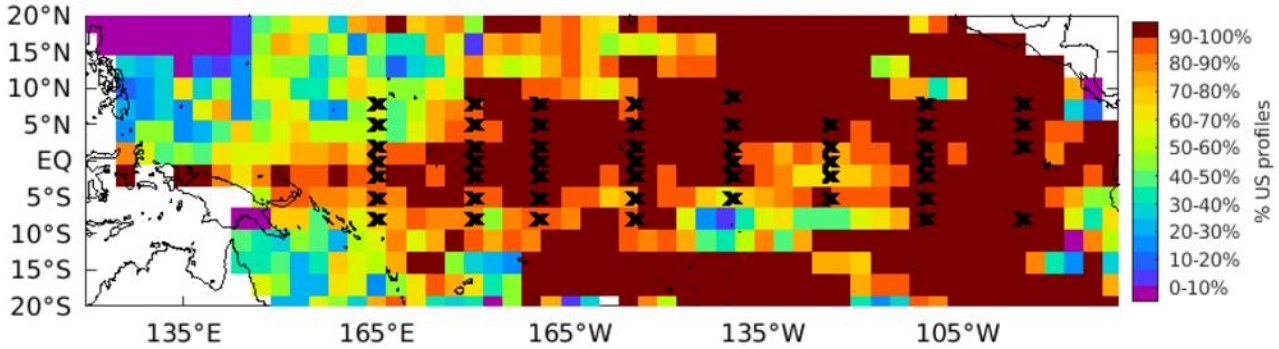
What keeps me up at night …

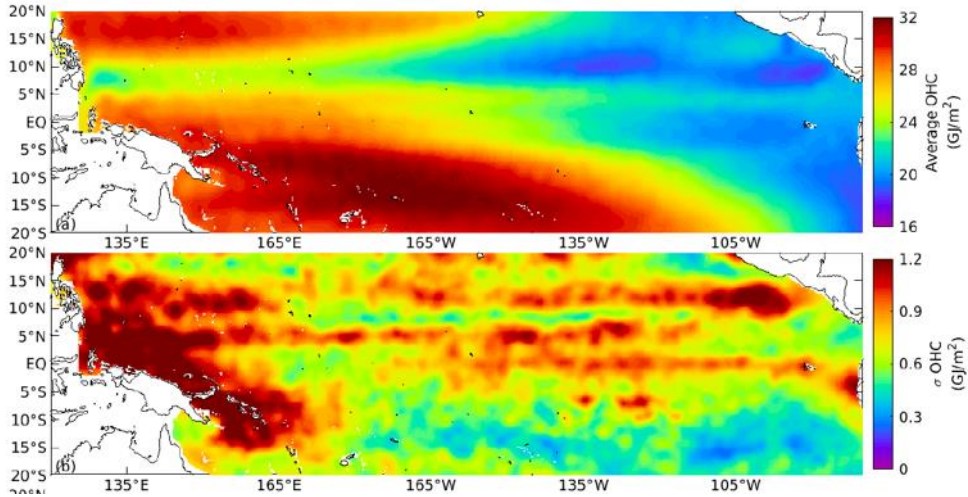
- **Our dependence on US Argo**
- **How can Argo Australia respectfully and efficiently engagement with Traditional Owners?**

… we potentially sample every Sea Country

Monitoring climate variability

- US Argo are the biggest supported of Argo … over 50%.
- Up to 95% of Argo floats in the tropical Pacific are US-operated.





- To demonstrate the importance of Argo in the Tropical Pacific, and to understand our dependence on US contributions …
  - Simple analysis system that combines Argo and TAO
  - Weekly, gridded fields of T & S for 5 years
  - Comparison of analysis with and without US Argo data

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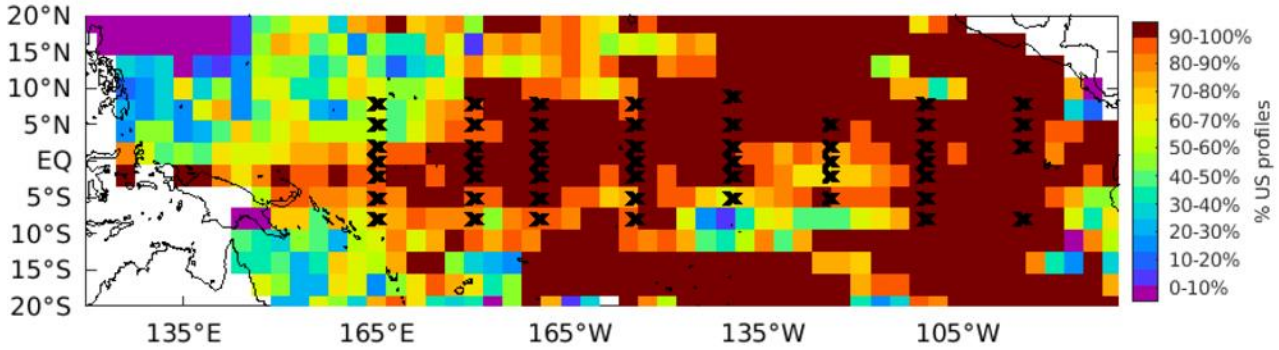

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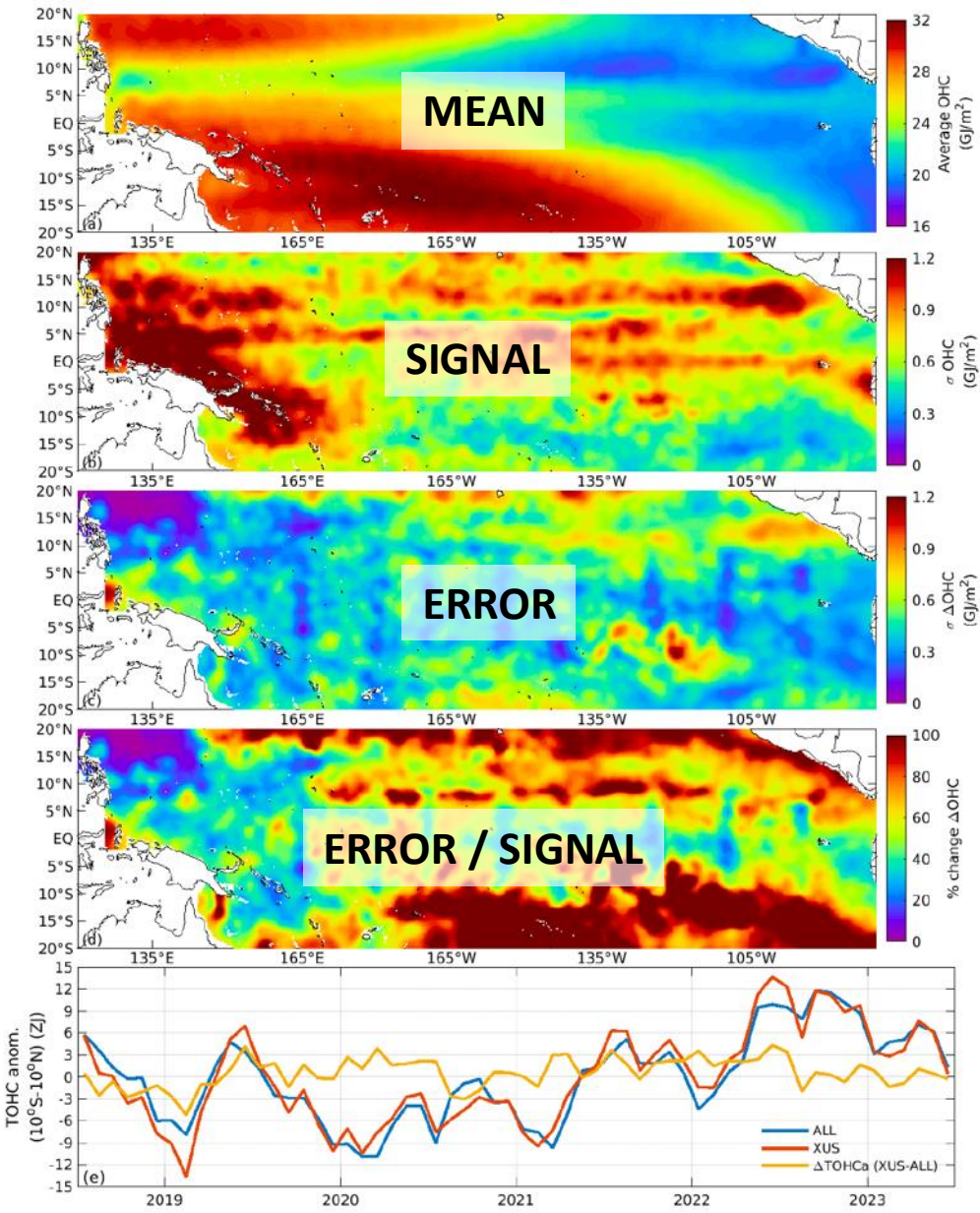
- Loss of so much data will lead to degraded estimates of Ocean Heat Content in the Pacific, with errors exceeding 40% of the variability.
- **Implication … we risk not being able to monitor ENSO.**



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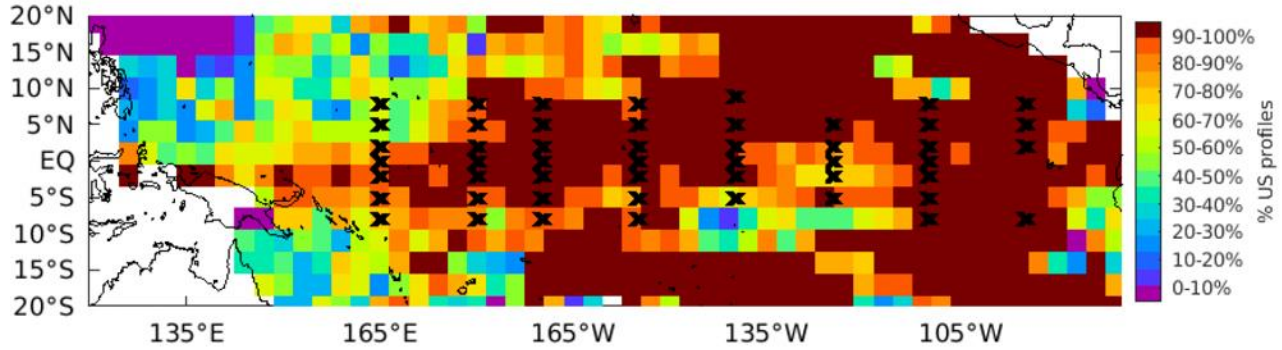

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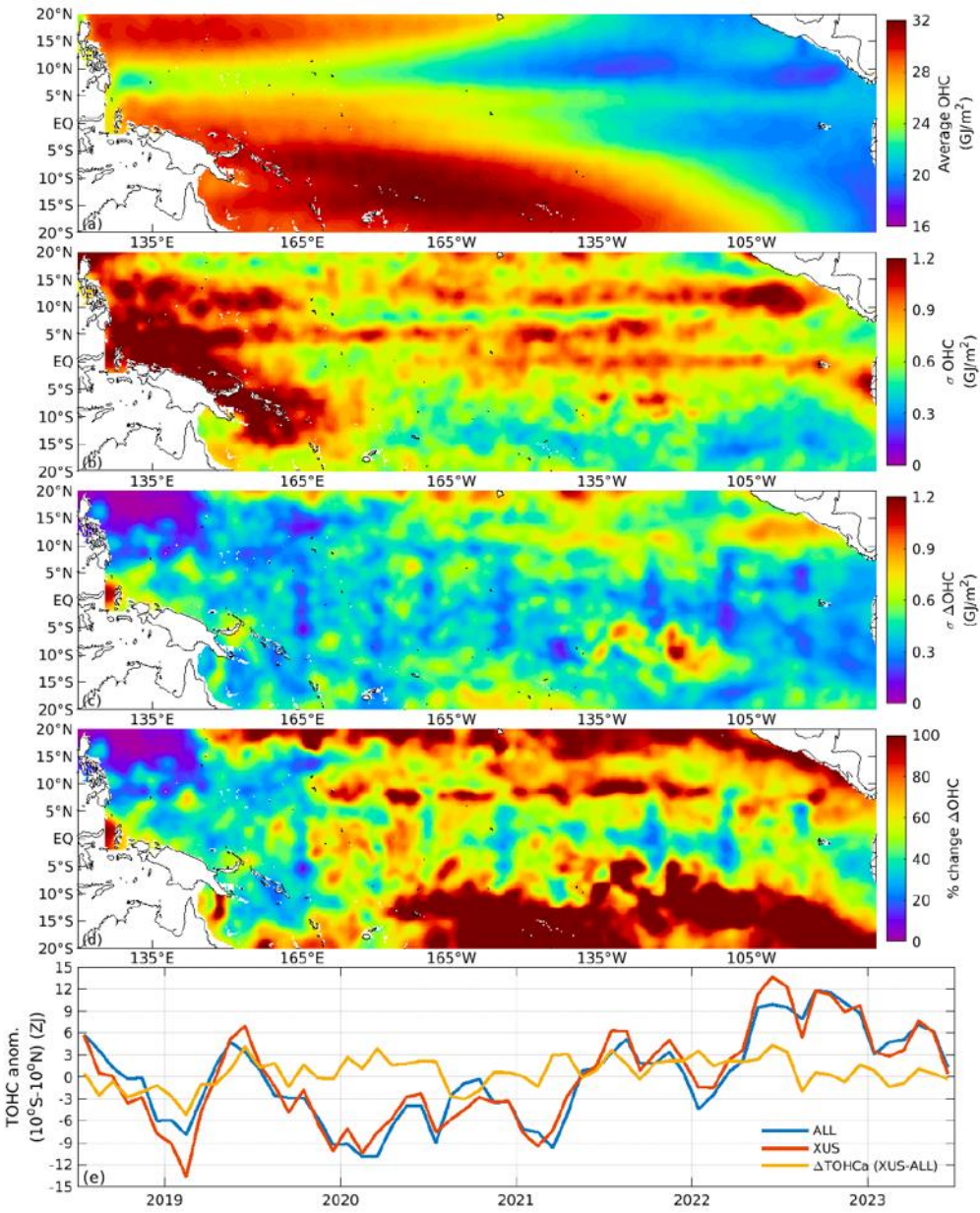
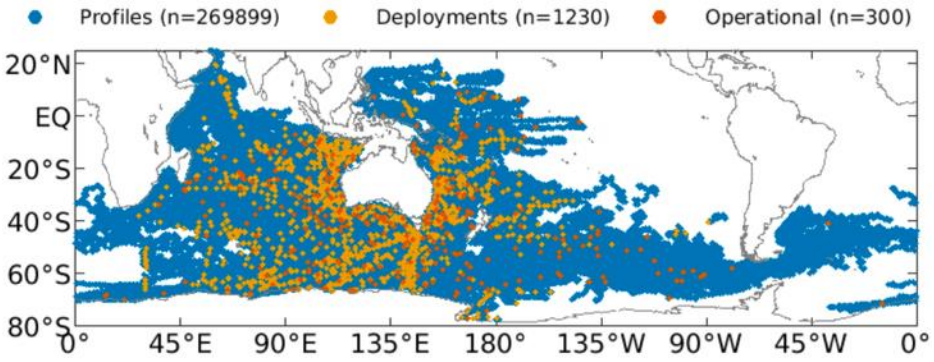


CELEBRATING 20 YEARS OF SUSTAINED MARINE OBSERVING

IMOS Integrated Marine Observing System

Conclusion and Summary

- Argo Australia is a National partnership
- We've deployed **over 1230 floats** and collected **over 270,000 profiles**.
- We maintain an operational fleet of **~300 floats**, delivering data in near-real-time to support operational applications.
- We've carefully quality controlled the entire fleet … revisiting every float every 12 months … guaranteeing a research-ready data stream.



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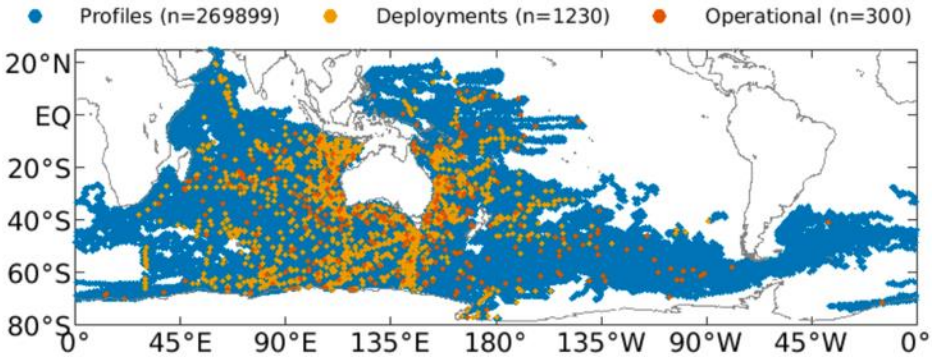

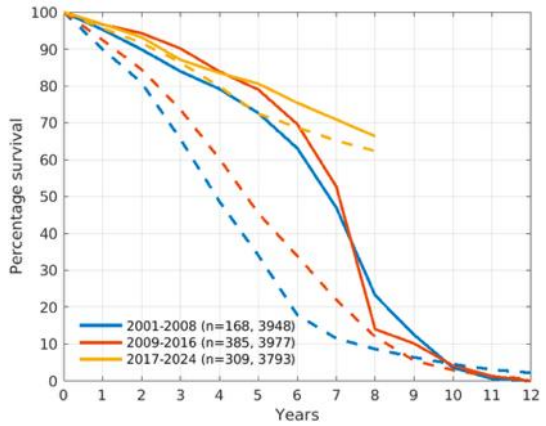

Our floats last **~6.5 years** … ahead of international benchmarks of ~4.5 years

… success we attribute to careful pre-deployment testing, active float management, and an intentionally diversified fleet.

Our team are leaders in our community … Australia has an important an ongoing role to play to maintain and grow our impact.

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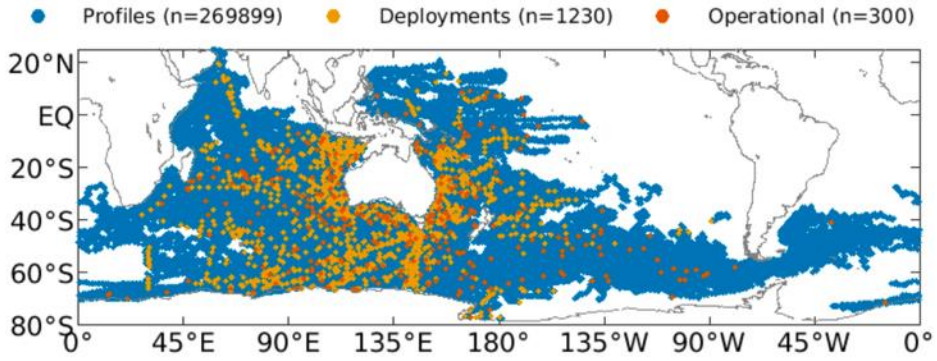

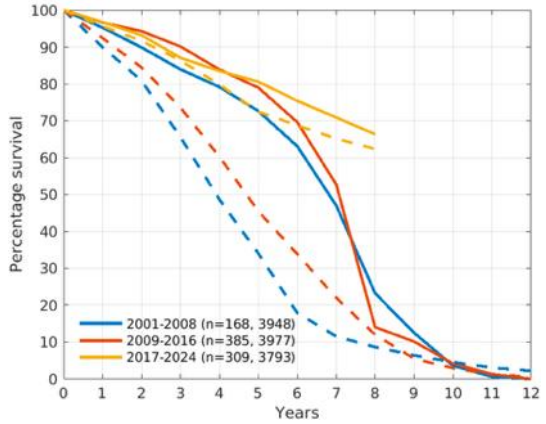

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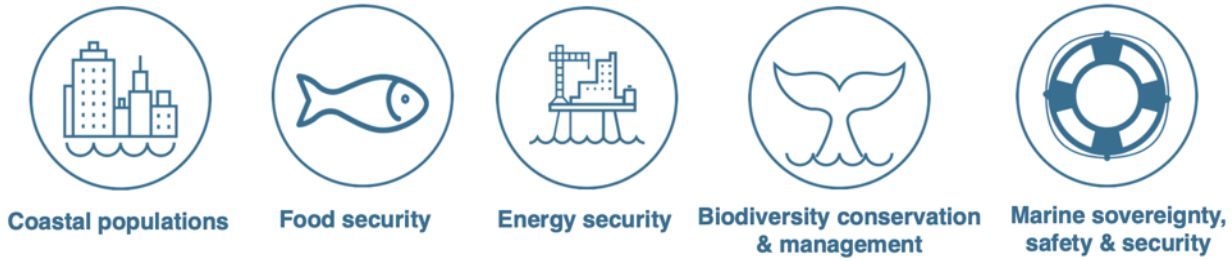
- Our data informs a broad scope of research, and underpins a wide range of operational services, delivering actionable societal benefit.



Metric	Fleet	
	Australia	Global
Total number of floats[a]	1,228	19,914
Total number of Argo floats[b]	1,090	15,233
Number of dead Argo floats[b,c]	758	10,962
Average number of profiles per float[b,c]	235	175
Median number of profiles per float[b,c]	252	165
Average number of years of survival[b,c]	6.07	4.55
Median number of years of survival[b,c]	6.73	4.36
Percentage of floats with zero profiles[a,c]	1.52%	2-2.4%
Percentage of Argo floats with <10 profiles[b,c]	0.92%	2.04%
Percentage of Argo floats with <30 profiles[b,c]	3.03%	6.79%

[a] Using operational and dead floats. Floats are "dead" if they haven't returned any data since the end of 2024.
[b] Using only Argo floats that run the 10-day cycle and deliver data in NRT.
[c] Using only dead floats.

- **Fewer failures. Longer lifetimes. More data.**
  Australian-operated floats outperform global benchmarks … delivering value to funders, partners, and stakeholders.

- **No unplanned outages.**
  Real-time data delivery you can rely on … trusted by the operational community.

- **98% DMQC complete.**
  Climate-quality, research-ready data … available and accessible.

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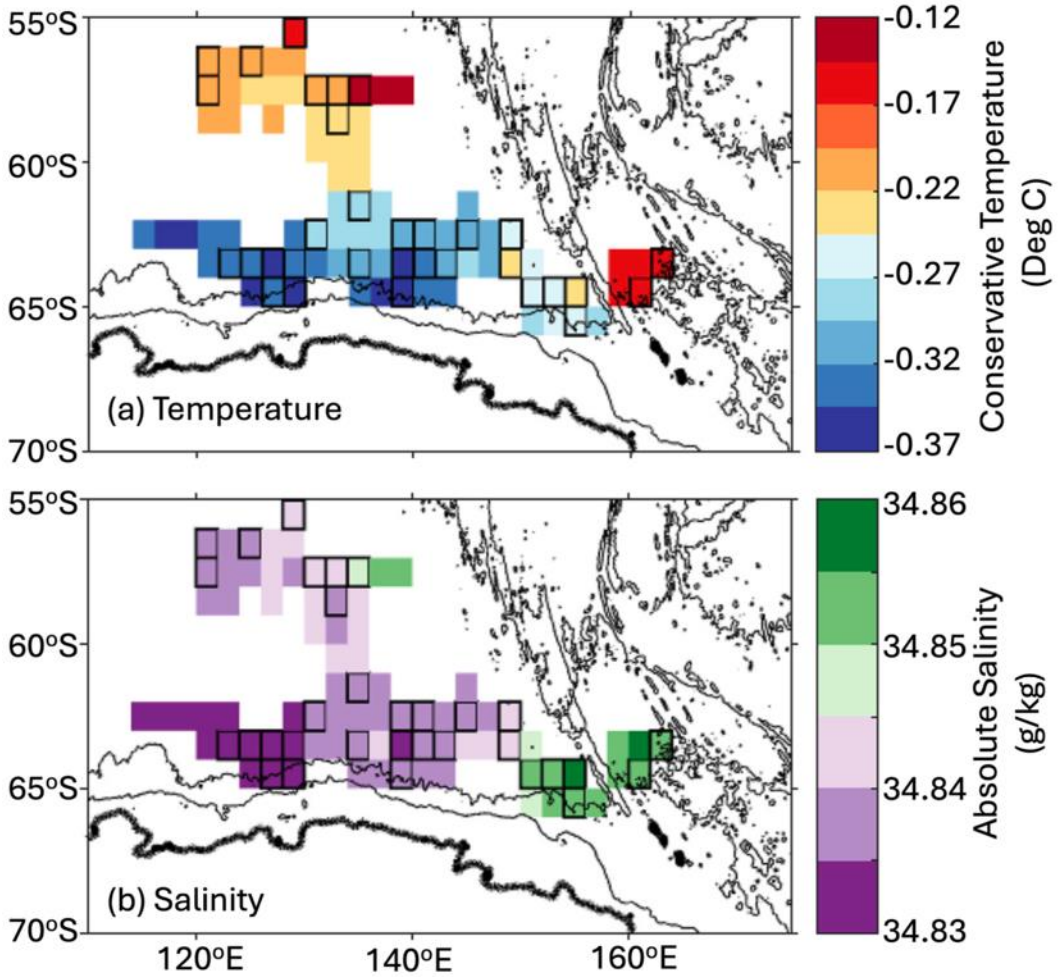
Quantifying climate change by sampling the most climate-sensitive regions



Deep floats collected more than 1700 profiles in the Australian Antarctic Basin between 2018 & 2023

… tripling the number of deep profiles in the region

… and increasing the number of winter profiles by a factor of 10.

Mean (a) temperature and (b) salinity of Antarctic Bottom Water, measured by an array of 12 Deep Argo floats over a 2-year period. Pixels represent area-averages over each 2×1° box; regions with >5 profiles outlined in black.
Foppert et al. (2021)

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NCRIS
National Research Infrastructure for Australia
An Australian Government Initiative

Australia's Integrated Marine Observing System is enabled by the National Collaborative Research Infrastructure Strategy (NCRIS). It is operated by a consortium of institutions as an unincorporated joint venture, with the University of Tasmania as Lead Agent.

PRINCIPAL PARTICIPANTS

University of Tasmania (Lead Agent)

Australian Government

Australian Institute of Marine Science

Australian Government Bureau of Meteorology

CSIRO

Government of South Australia

SARDI South Australian Research and Development Institute

The University of Western Australia

sims sydney institute of marine science

UTS

The University of Sydney

Macquarie University

UNSW Sydney

SIMS is a partnership involving four universities

ASSOCIATE PARTICIPANTS

Curtin University

Australian Government Department of Climate Change, Energy, the Environment and Water Australian Antarctic Division

Australian Antarctic Program

Deakin University

The University of Melbourne

IMOS thanks the many other organisations who partner with IMOS, providing co-investment, funding and operational support, including investment from the Tasmanian and Western Australian Governments.