Argo and Sea Level Science: Present and Future Challenges

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On behalf of the Argo Steering Team

Challenges: CTD Manufacturing Issues

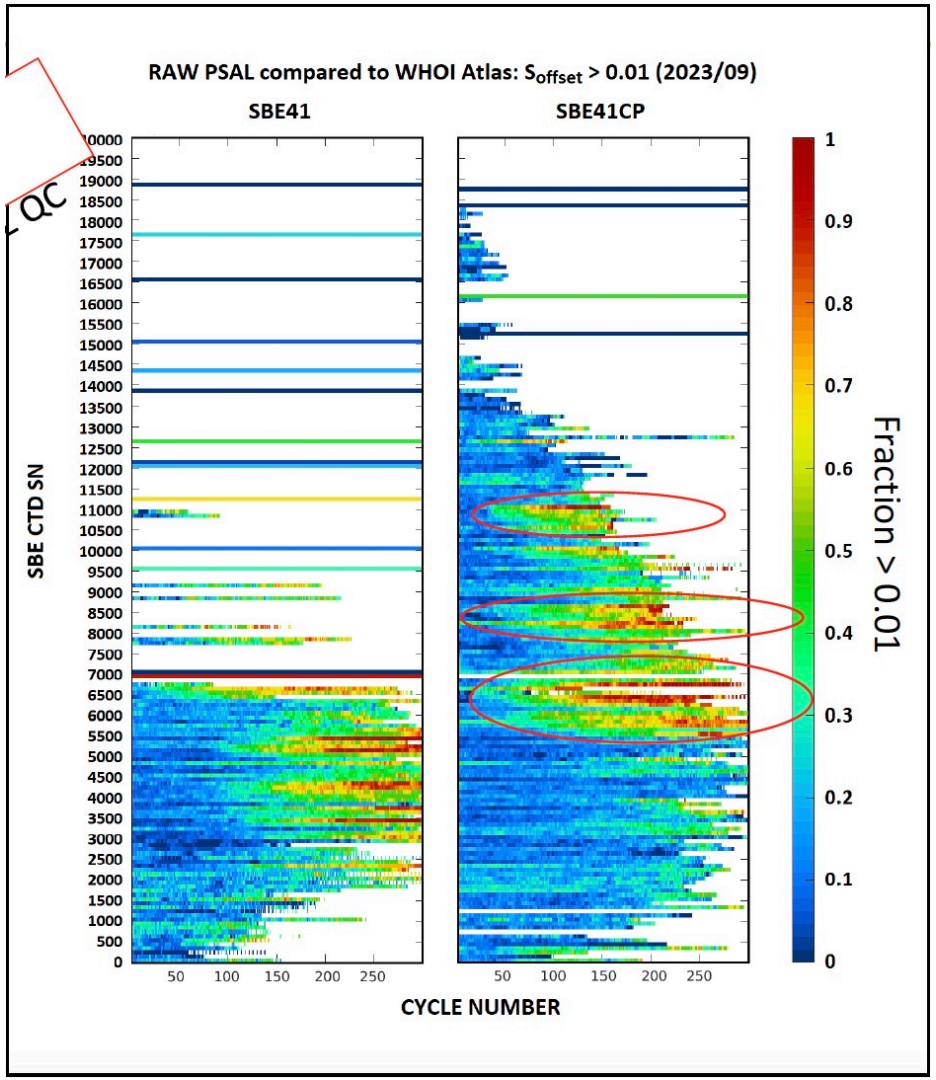
- Global analysis revealed a clear **batch behaviour** in frequency of Abrupt Salinity Drifters (ASD) SeaBird Scientific (SBS) CTDs with SN > 6000 with drift rates accelerating rapidly and abruptly with some CTDs drifting earlier than cycle # 80 (~2 years after deployment at 10-day sampling)

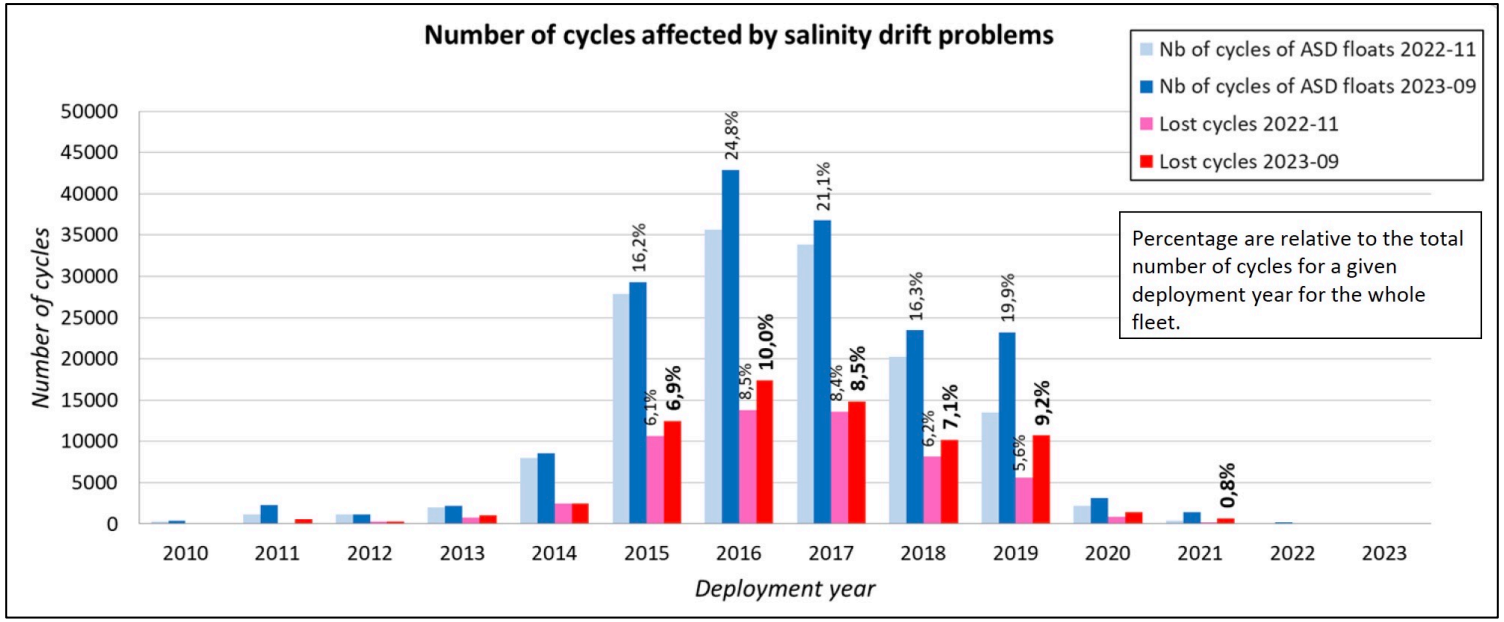
$$S_{offset} = \langle PSAL_{\theta} - CLIM_{\theta} \rangle_{coldest\ \theta}$$

$$Fraction > 0.01 = \frac{Nb\ of\ S_{offset} > 0.01\ PSU\ by\ batch\ of\ 100\ SN}{Nb\ of\ S_{offset}\ by\ batch\ of\ 100\ SN}$$

- International Argo partners engaged with manufacturer (SBS) to find the cause
- After many tests and analysis of retrieved floats, they eventually discovered and confirmed it was due to changes in the **encapsulant used in conductivity cell construction**
- Likely source of both fast and slow drift - breakdown of the encapsulant allows **water ingress into the cell**
- **SBS made engineering changes** CTD SN > 11250.

Status of salinity drift in the Argo dataset





- The frequency of abrupt salty drifter (ASD) has greatly diminished within batches of SBS CTDs manufactured after the manufacturer's engineering change and deployed since 2020
- International DMQC operators will continue to monitor ASD status

Recommendations for Argo data use

Use of quality flags and adjusted Argo profiles to filter "bad" data

- **Biased raw** Argo salinity leads to **spurious results in global sea level estimates**
- Best ways to ensure that instrument bias is filtered out is to **use delayed mode (adjusted) data**
- Detailed quality control flags, delayed-mode process, validation of the adjusted salinity, and associated uncertainty estimates are described in Wong et al (2023; https://doi.org/10.5194/essd-15-383-2023)

Refresh analysis archives with DMQCed Argo data

When using Argo profiles from the GDACs, make sure to stay up to date:

- Download a recent monthly DOI tarball: https://doi.org/10.17882/42182
- Use rsync to keep your local mirror up to date: http://www.argodatamgt.org/Access-to-data/Argo-GDAC-synchronization-service
- Make a selection on the Argo data selection tool: https://dataselection.euro-argo.eu/
- Select Argo data via ERRDAP: www.ifremer.fr/erddap/index.html

When using an Argo product created by a third party and listed on this webpage https://argo.ucsd.edu/data/argo-data-products/, be aware that the Argo data in that product may not be up to date. Contact the producers for more information.

Challenges: Facilitate usage of Argo data

https://argo.ucsd.edu/

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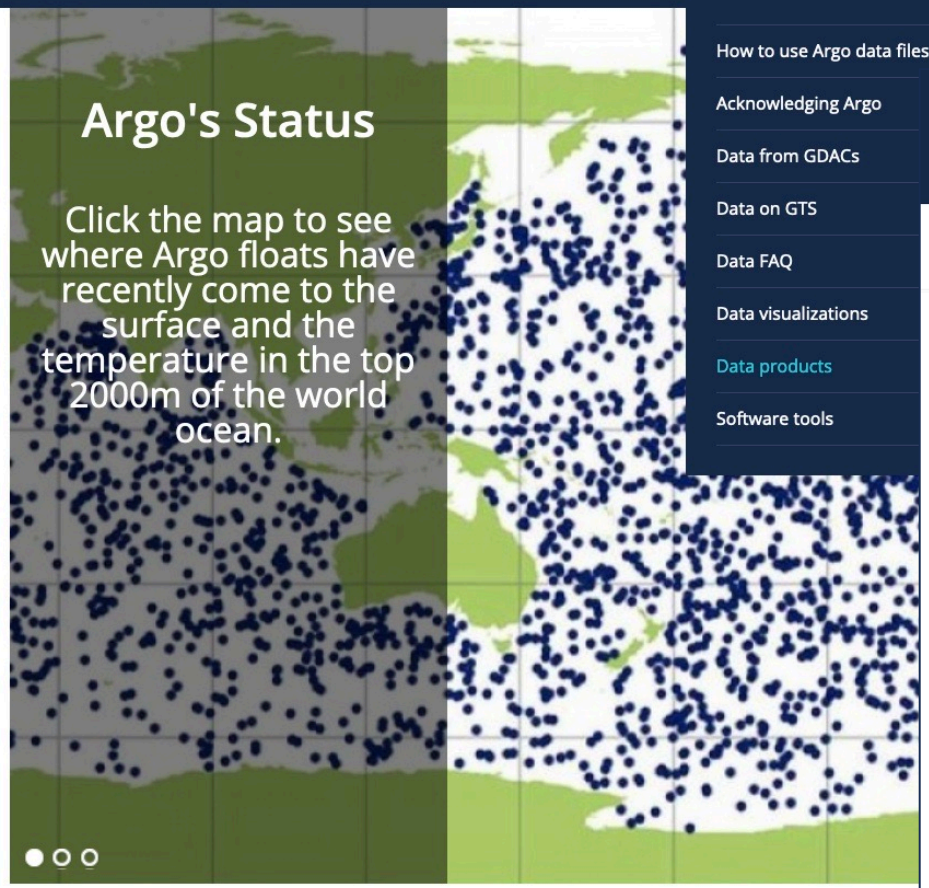

- How to use Argo data files
- Acknowledging Argo
- Data from GDACs
- Data on GTS
- Data FAQ
- Data visualizations
- Data products
- Software tools

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Argo data products

ARGO DATA › ARGO DATA PRODUCTS

Argo's more than 3500 floats provide 100,000 plus temperature and salinity profiles each year which create a large data set available on the Argo GDACs. As an alternative to using individual profiles from the GDACs, different groups around the world have produced various products based on Argo data. While these products include Argo data, they are not maintained by Argo itself. These products fall into the following categories:

- Gridded fields of temperature, salinity, mixed layer depth, etc.
- Velocity products
- Collections of profiles that have all been interpolated to the same pressure levels (standard depth level profiles)
- Collections of profiles that have been put through additional quality control measures

Below you will find links to the gridded products. Please click the other links above to access other Argo products or visit our operational center page to look at data from model outputs using Argo.

While each producer makes every effort to remove errors from their product, some might still exist. Therefore, users are reminded that these products are to be used cautiously. Please notify the producer if an error is discovered. Please credit the product appropriately.

If you have gridded fields or other products based on Argo data that you would like added to this page, please email **argo@ucsd.edu** with all the necessary data for the table.

If using one of these products in a publication, please remember to acknowledge Argo data with the following statement and the Argo DOI.

Development of new Argo Products

Scripps Argo Trajectory-Based Velocity Product

N. Zilberman, M. Scanderbeg, A. Gray, and P. Oke

Collections »

Scripps Argo Trajectory-Based Velocity Product

About this collection

Extent

2 digital objects.

Cite This Work

Zilberman, Nathalie V.; Scanderbeg, Megan C.; Gray, Alison R.; Oke, Peter R. (2022). Scripps Argo trajectory-based velocity product 2001-01 to 2020-12. In Scripps Argo Trajectory-Based Velocity Product. UC San Diego Library Digital Collections. https://doi.org/10.6075/J0KD1Z35

Description

This dataset contains absolute velocity estimates from quality controlled Argo trajectory files.

Both Scripps trajectory products include trajectories from Core, BGC and Deep Argo floats starting in 2001. Only trajectories with cycles ranging from 5 - 25 days are included in the products.

The products include both a transmitted and extrapolated trajectory-based velocity (if available) for each cycle. The extrapolated velocities are only available for floats equipped with the Argos positioning system which have six or more good quality surface fixes.

PRODUCTS:
There are two product netCDF files within the archive:
- Quality controlled Argo trajectory-based velocities within the 800 - 1200 db range
- Quality controlled Argo trajectory-based velocities within the 100 - 6200 db range

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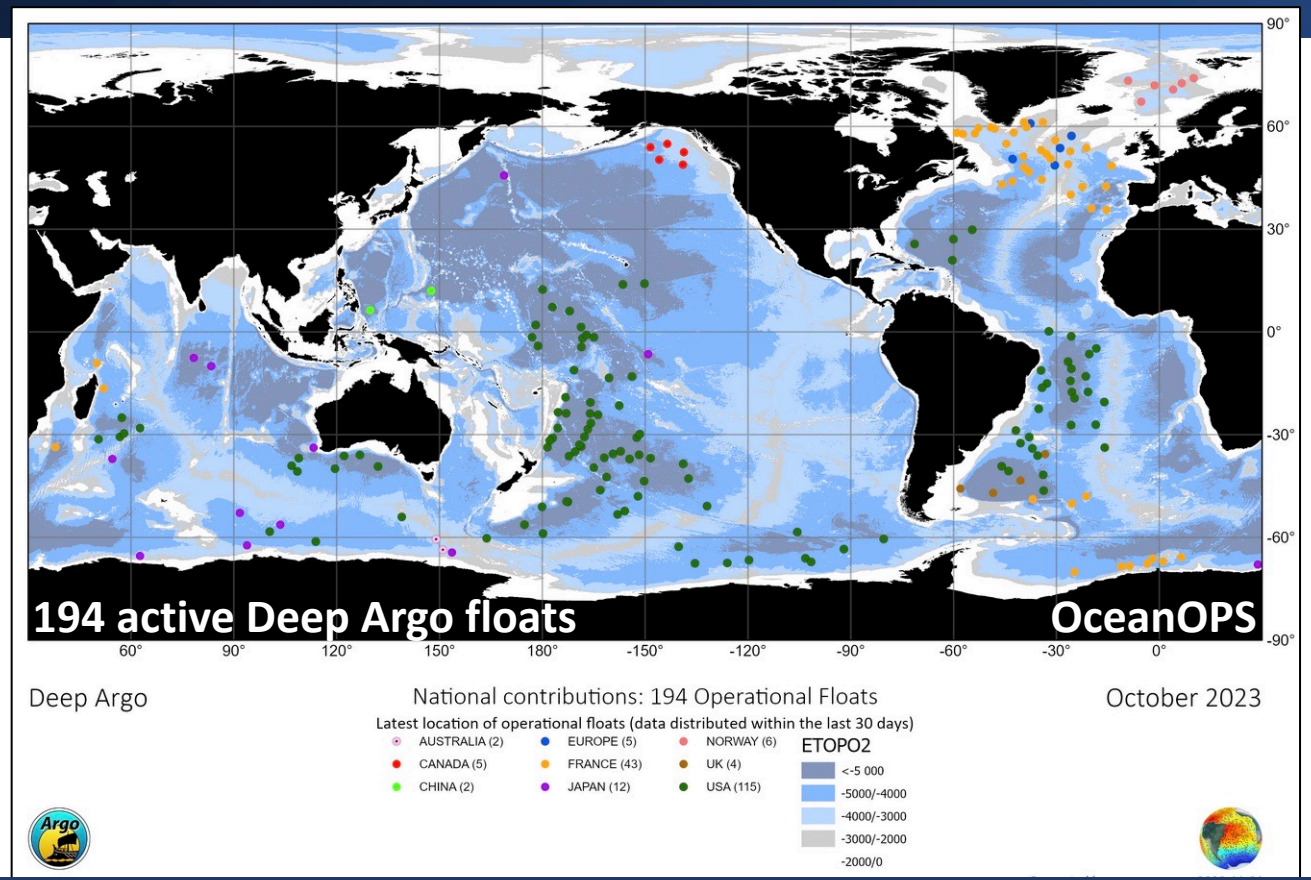
Work In Progress – Towards a simplified, vertically gridded Argo T/S dataset

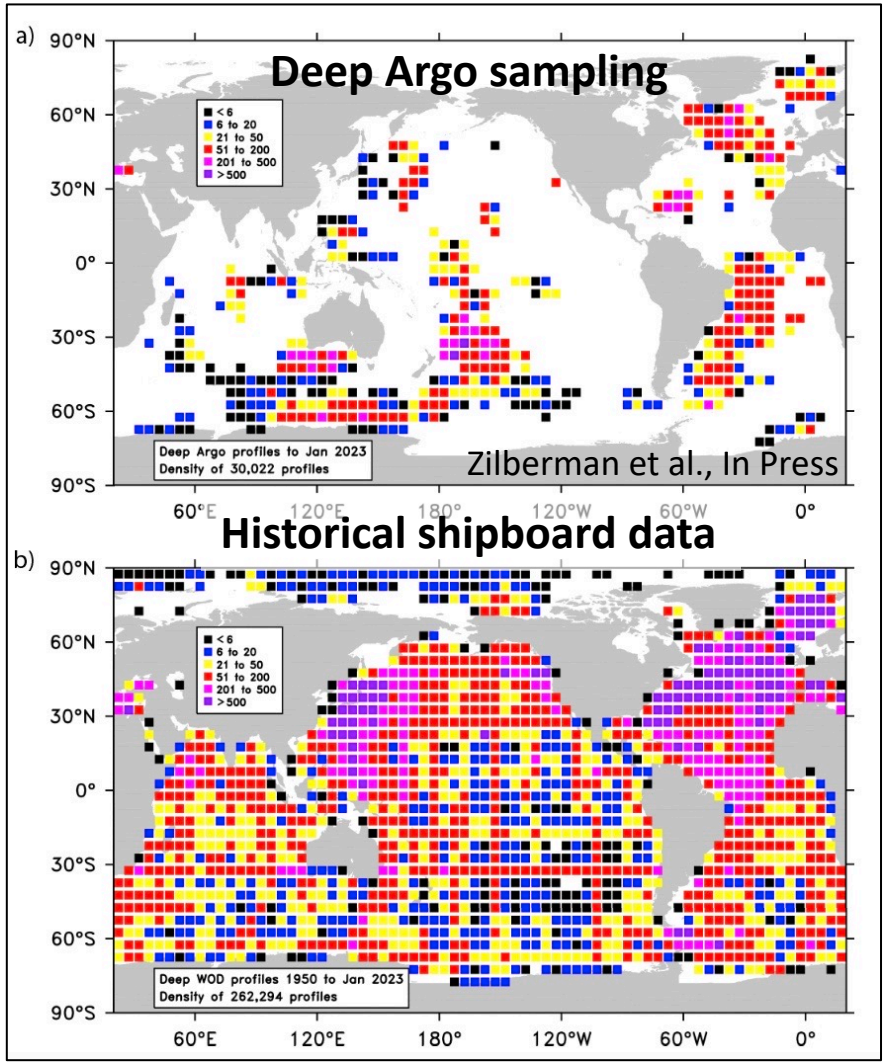
A. Wong, B. Owens, et al.

Tentative goals

- Develop an “easy” data product that will facilitate usage of Argo temperature/salinity (T/S) by the general scientific community
- A selected subset (only “good” data) from the monthly archive of the T/S data at the Argo Global Data Assembly Center
- Vertical grid 0-2000 dbar follows the spacings of the MIMOC climatology (Schmidtko et al. 2013).
- Vertical interpolation follows the method in Barker & McDougall (2020)
- A simple and intuitive format; documented to adhere to the FAIR data principles

Challenges: Extending Argo sampling to the Deep Ocean





- In <7 years, Deep Argo has accumulated in regional pilot arrays about as many full-depth profiles as ships over the past 70 years (Zilberman et al., In Press)
- 194 Deep Argo floats are currently active (50% U.S.)
- Targeted global array of 1,200 Deep Argo floats, 5° x 5° x 10-day sampling

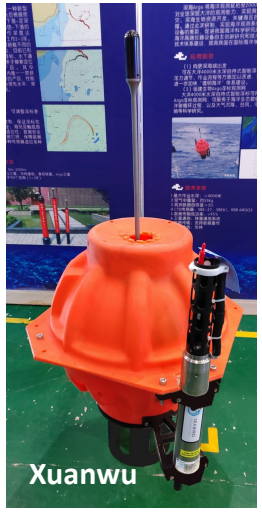
Active Deep Argo float models

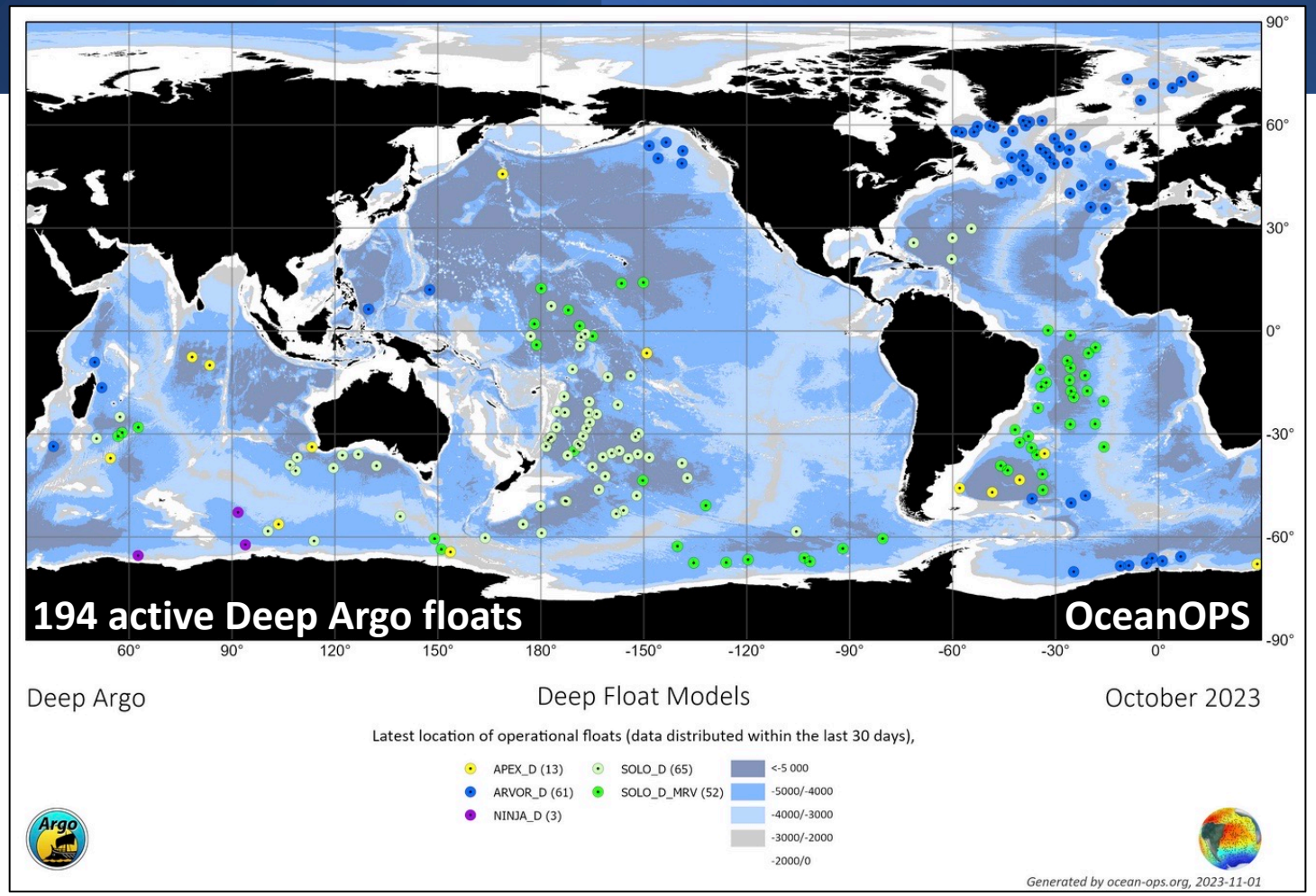
0-4000 m

Deep Arvor

Deep NINJA

0-6000 m

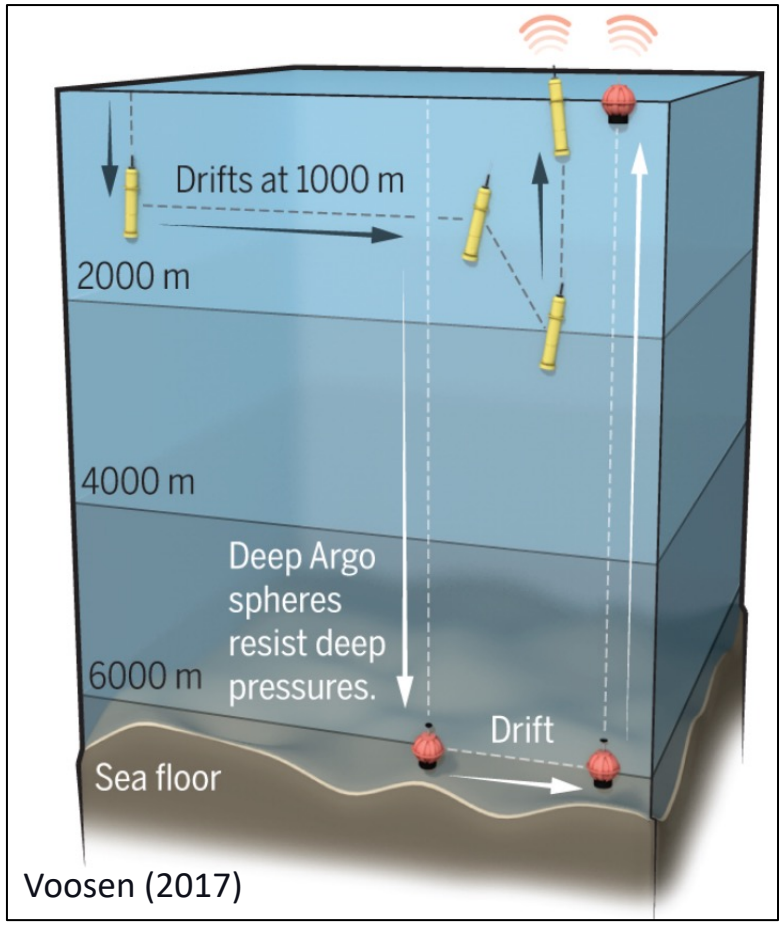




- 67% of active Deep Argo floats are capable of profiling to 6000 m
- 33% of the Deep Argo fleet can measure to 4000 m
- 3 additional Deep Argo float models are under development

Deep Argo float Mission

Deep Argo float cycle



Voosen (2017)

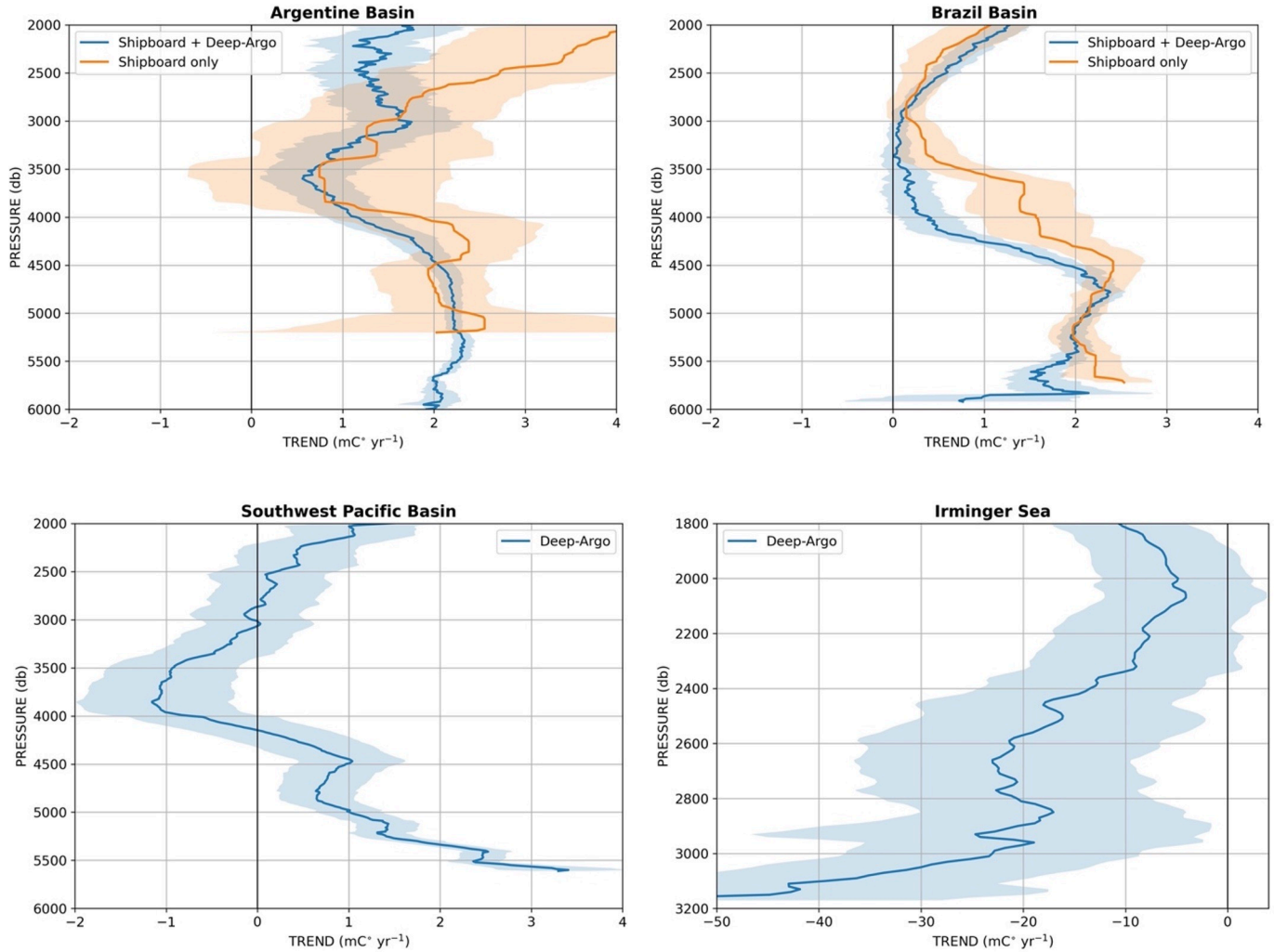
- Profile temperature and salinity to 4000-6000 m at nominal 10-day sampling
- Minimum lifetime > 4 years
- Data shared publicly in near real-time and QCed version
- Floats can profile to maximum depth on ascent and/or descent Measurements on ascent at least in the upper 1000 m
- Vertical resolution is 2-dbar bin-averaging in the upper 2000 m, and 10-25-dbar below 2000 m
- Transition to parking depth at 1000 m
- Prioritize deployments in deep ocean regions (> 2000 m)

Deep Argo CTD Sensor Status

Testing of the SBS61 on the Deep SOLO float by the Scripps Argo lab

- Targeted accuracies of temperature, salinity, and pressure ±0.001°C, ±0.002 PSS-78, and ±3 dbar
- Reduce errors in decadal trends of deep OHC from ±0.04 to ±0.006 W m^{-2} dec^{-1}, and deep steric sea level from ±0.73 to ±0.1 mm dec^{-1}
- 2 SBS Deep Argo CTDs (extended-depth SBE41 and the SBE61) are operational. A pilot RBR CTD is under testing
- SBE61 has demonstrated ±0.001°C accuracy in the field
- A method was successfully implemented to reduce salinity bias to ±0.002 PSS-78 on the extended-depth SBE41 and the SBE61
- Pilot SBS61 Deep Argo CTD (SBE61 with Keller pressure sensor) shows ±3 dbar in the field

Scientific Value of Deep Argo #1: Close the Earth Energy Imbalance



- Confidence limits of deep-ocean warming rates from Deep Argo are 10 times tighter than historical data in the Argentine Basin, and 2 times tighter than historical data in the Brazil Basin

- Deep Argo indicates an acceleration of abyssal warming in the Southwest Pacific in 2010s compared to 1990-2000s and 2000-2010s

- Deep Argo float measurements show warming to cooling reversal in the deep subpolar Atlantic Ocean in 2014

Zilberman et al., In Press

Scientific Value of Deep Argo #2: Close the Sea Level Budget

Synergies between Argo, GRACE and Altimetry

Session chairs: Felix Landerer, Steve Nerem, Susan Wijffels, Nathalie Zilberman
(Thu, Nov 09 2023, 11:00 - 12:30)

Tortuga Beach Room (#209A)

11:00 - 11:13:
Monitoring the global ocean heat content from space geodetic observations
Michael Ablain (Magellium, France), Marti Florence (Magellium, France), Rousseau Victor (Magellium, France), Fraudeau Robin (Magellium, France), Benoit Meyssignac (LEGOS, Université de Toulouse, CNES, CNRS, IRD, UPS, France), Alejandro Blazquez (LEGOS, Université de Toulouse, CNES, CNRS, IRD, UPS, France)

11:13 - 11:26:
Mapping steric sea level from satellite altimetry, GRACE/GRACE-FO, and Argo.
Sara Reinelt (University of South Florida, United States), Don Chambers (University of South Florida, United States)

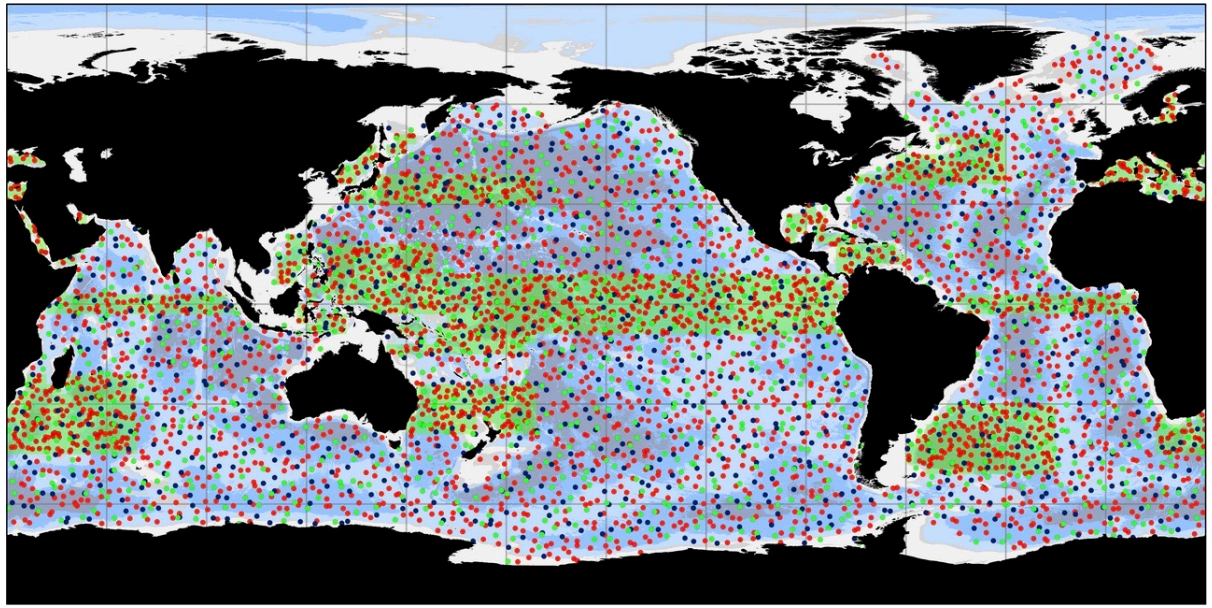
11:26 - 11:39:
Deep-ocean steric sea level variations in the Northwest Atlantic Basin revealed using Deep Argo and Bermuda Atlantic Time-series Study full-depth profiles
Nathalie Zilberman (Scripps Institution of Oceanography, United States), William Llovel (LOPS - CNRS/IFREMER/IRD/UBO, France), Antoine Hochet (LOPS/CNRS, France), Jacob Steinberg (NOAA/GFDL, United States)

11:39 - 11:52:
Can Deep Argo Close the Sea Level Budget in the Southwest Pacific Basin?
Paige Lavin (University of Maryland; NOAA/STAR, United States), Gregory Johnson (NOAA/PMEL, United States)

- Deep Argo has the capacity to resolve deep-ocean steric sea level
- Deep-ocean steric sea level in the deep western boundary current of the northwest Atlantic Ocean contributes to 30% of full-depth interannual steric sea level variations

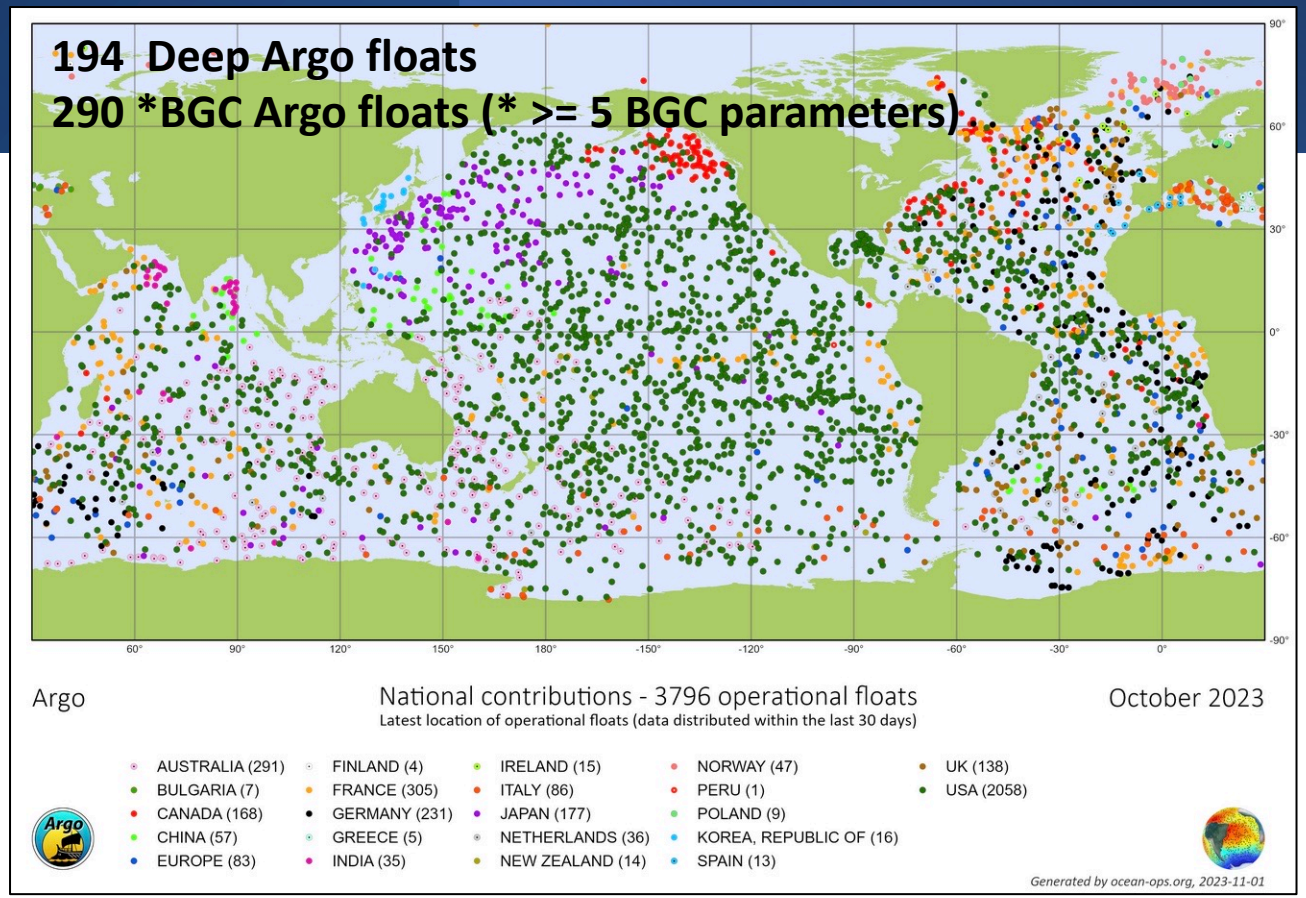
Challenges: Resources have not been secured to implement OneArgo

The OneArgo Design will fill major gaps in the Deep Ocean and the Polar Ocean



Comprises 4700 floats including:

- 1200 Deep Argo floats
- 1000 Biogeochemical Argo floats
- Expansion into seasonal ice zones
- Enhanced sampling in the equatorial and western boundary regions



Presently the Argo system is in **net decline** and the implementation of OneArgo **has stalled**

Total = 3796/4700 (81%)

Deep = 194/1250 (15%)

Biogeochemical (*>=5 params) = 290/1000 (29%)

Summary

- Report from the Argo Data Management Team indicates a significant decrease in occurrences of Abrupt Salinity Drifters subsequent to change from CTD manufacturer
- Argo is a living dataset. Recommendation to use Argo data quality flags and frequently refresh archives prior to performing analysis
- Products to facilitate the use of the Argo dataset are available on the Argo website. New products are under development
- Deep Argo can rapidly densify deep-ocean observations to the seafloor. Deep Argo's ability to resolve deep-ocean heat content and steric sea level has been demonstrated
- Resources have not been secured to implement the OneArgo design. The global Argo array is in net decline