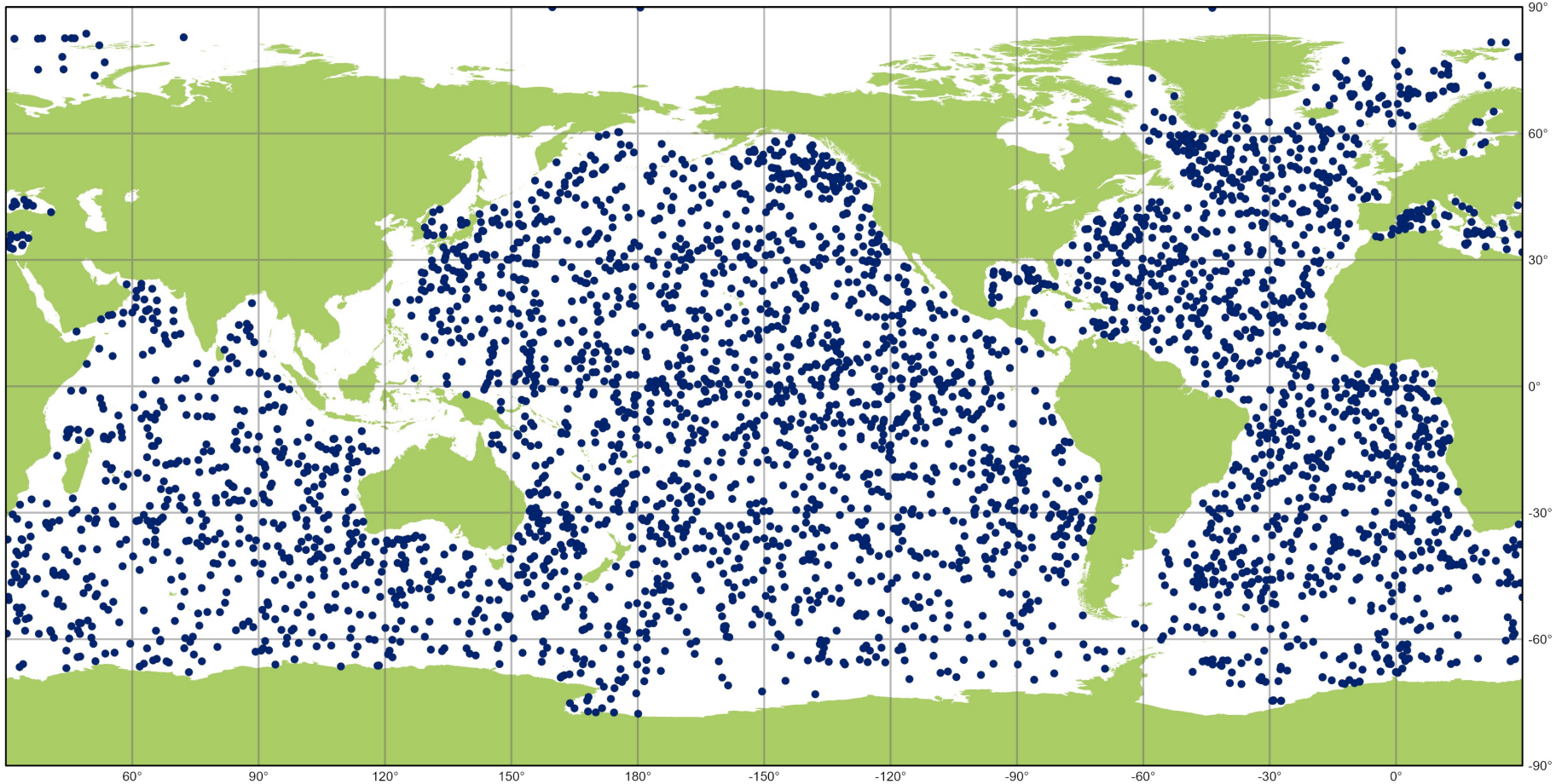
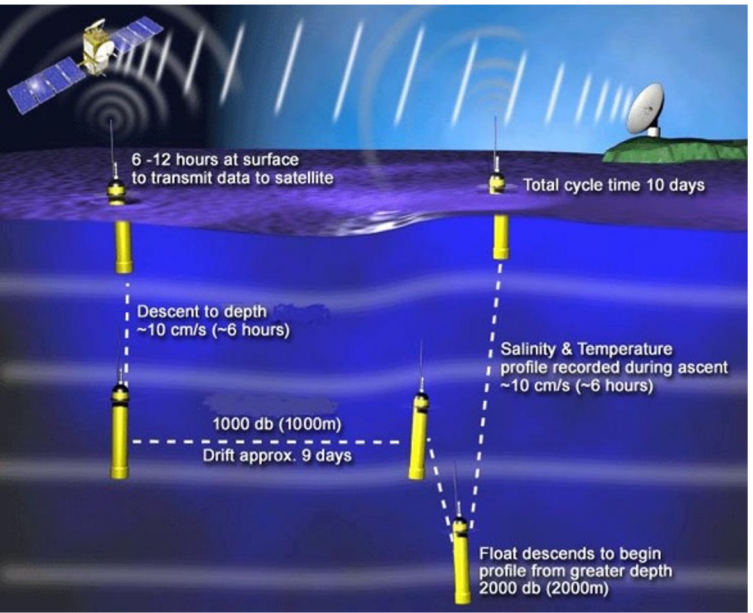


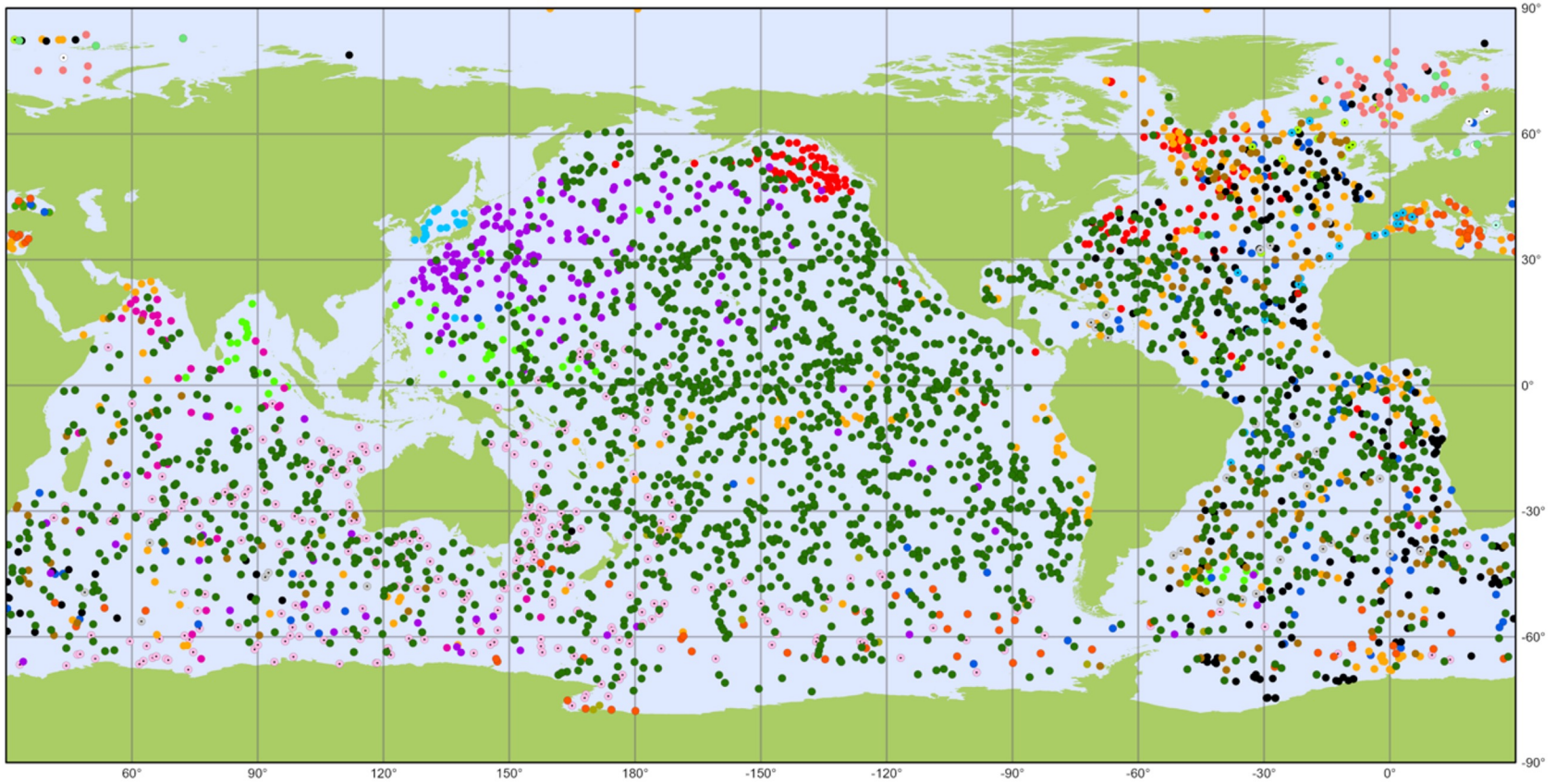
Argo and Sea level science: Present and Future Challenges

Susan Wijffels and the Argo Steering Team

Argo's original design: implemented 2000-2022

- ~3000 floats uniformly sampling the offshore oceans
- 30 nations
- spans 0-2000m
- 10,000 profiles/month
- mostly T/S measured
- data shared globally in real-time
- >5000 research papers





Argo

National contributions - 3885 operational floats

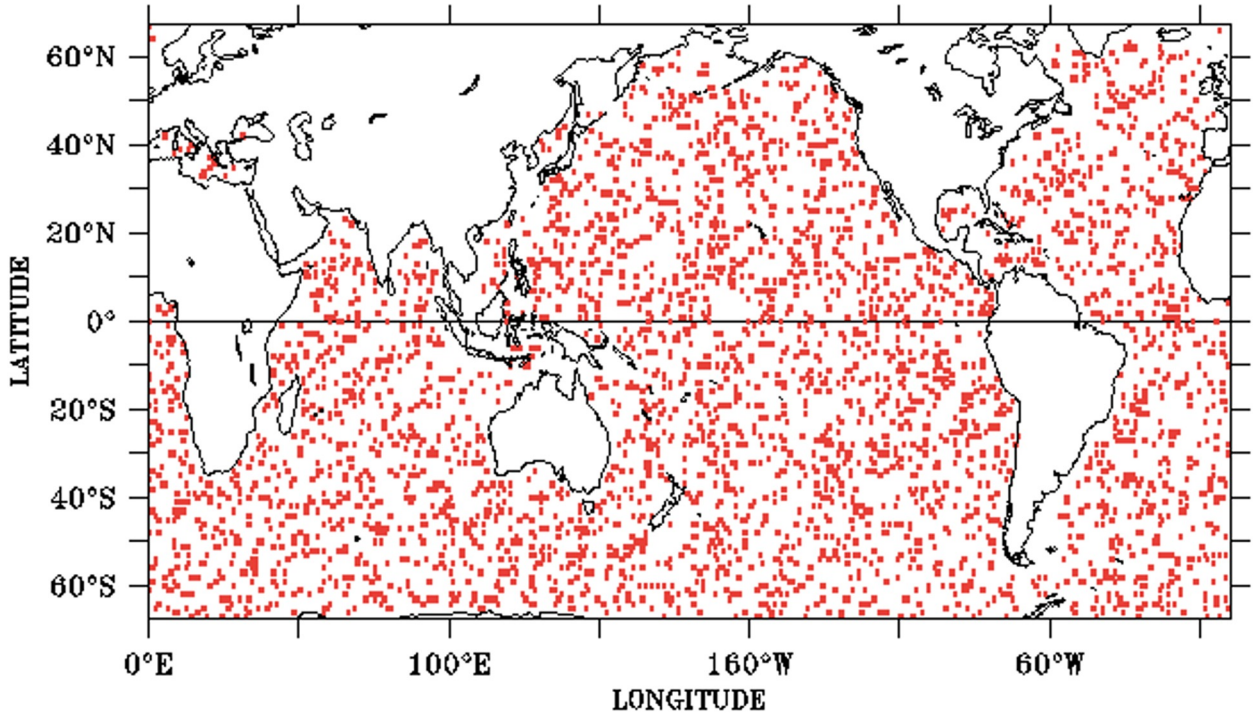
Latest location of operational floats (data distributed within the last 30 days)

September 2022

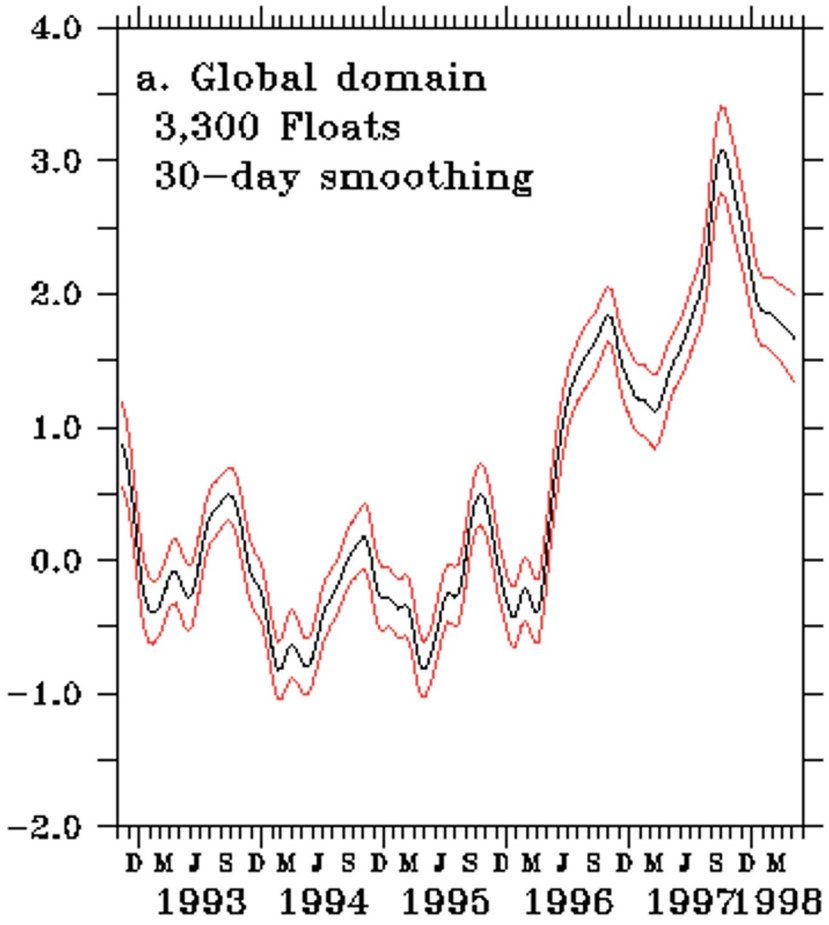
AUSTRALIA (313)	FINLAND (4)	IRELAND (17)	NEW ZEALAND (17)	SPAIN (21)
BULGARIA (6)	FRANCE (269)	ITALY (85)	NORWAY (47)	UK (135)
CANADA (149)	GERMANY (229)	JAPAN (202)	PERU (1)	USA (2127)
CHINA (57)	GREECE (3)	MOROCCO (1)	POLAND (12)	
EUROPE (100)	INDIA (40)	NETHERLANDS (33)	KOREA, REPUBLIC OF (17)	

Generated by ocean-ops.org, 2022-10-01
Projection: Plate Carree (-150,0000)

Argo's design was informed by satellite altimetry



Global average sea-level 'reconstructed' from sub-sampled altimetry sea level anomaly maps

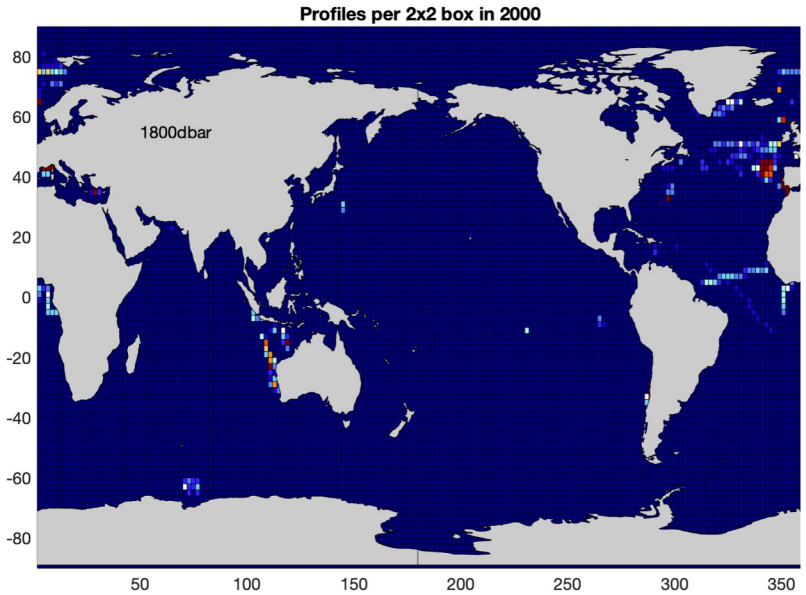


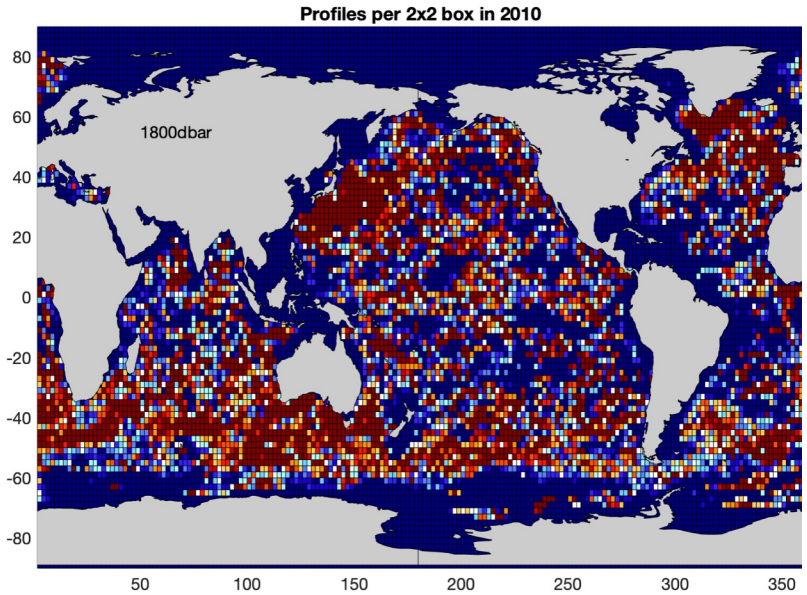
SLA plots from T/P were used to develop the original design and ensure the global change signal could be recovered.

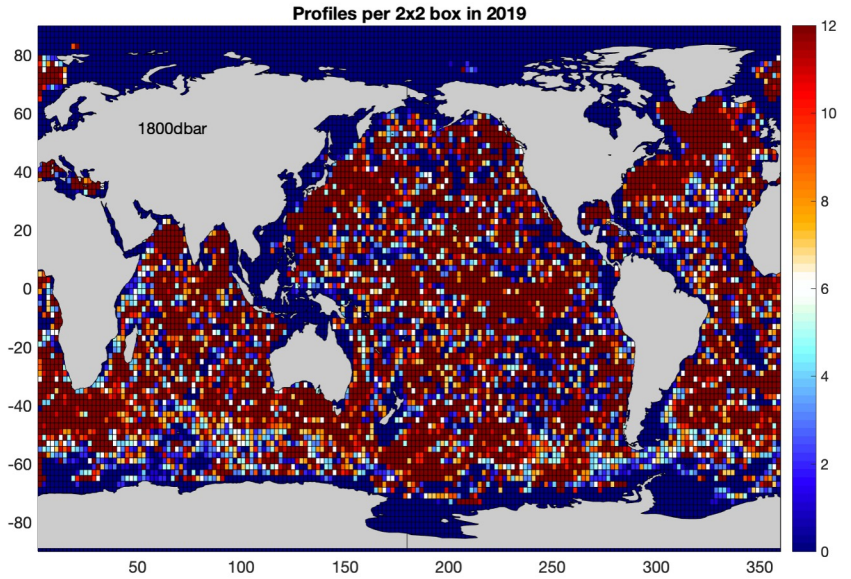
Similar tests were done regionally.

Roemmich & AST, 1998

Data coverage: 1800dbar







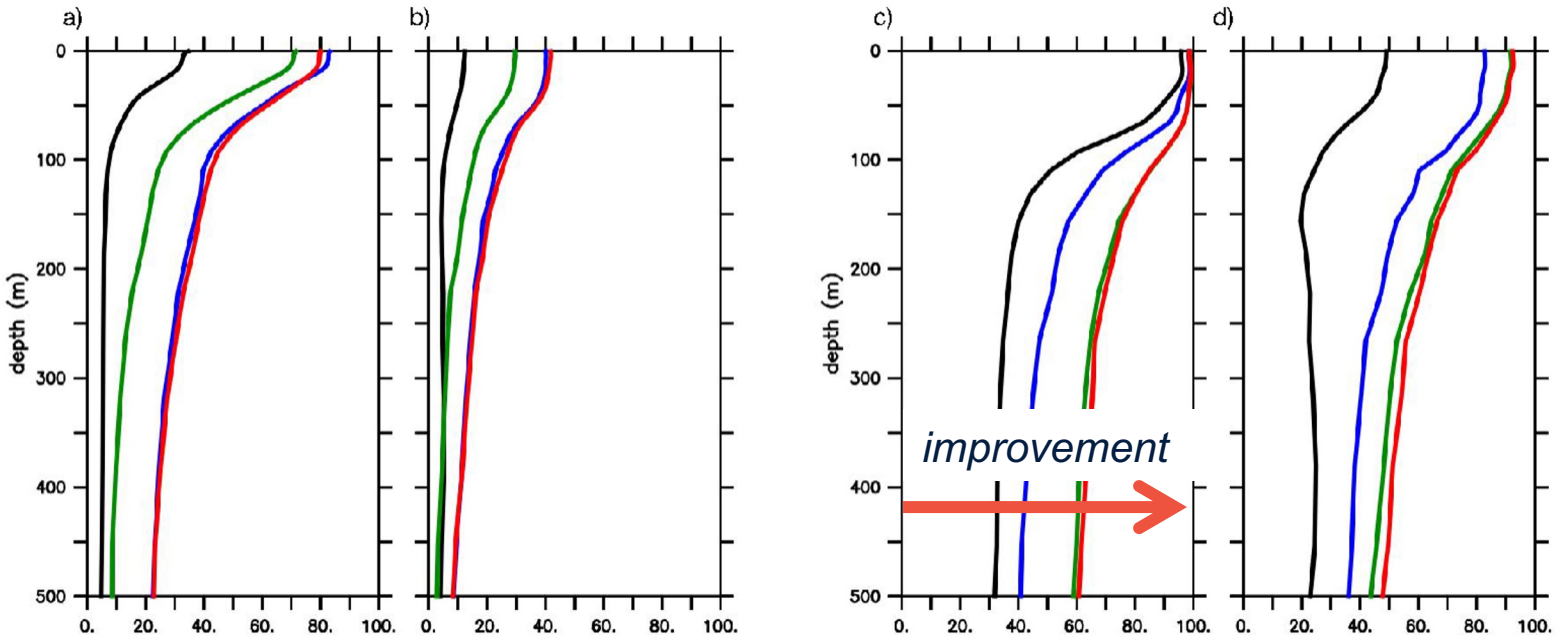
- 2000-2010: drastic improvement with implementation of core Argo
- Float engineering improvements 2010's -> reach 2000dbar in tropics
- Better float ice-avoidance algorithms – more polar profiles > 2015

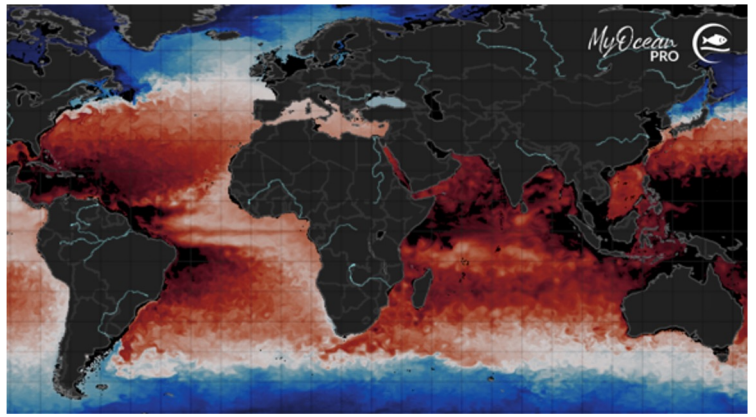
Impacts on ocean state-estimates

*Globally averaged % of **reconstructed Nature Run variance** for temperature and salinity for the OSSEs: FREE, NOMINAL (ALL), ONLYSAT, and ONLY INSITU*

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

Large scale



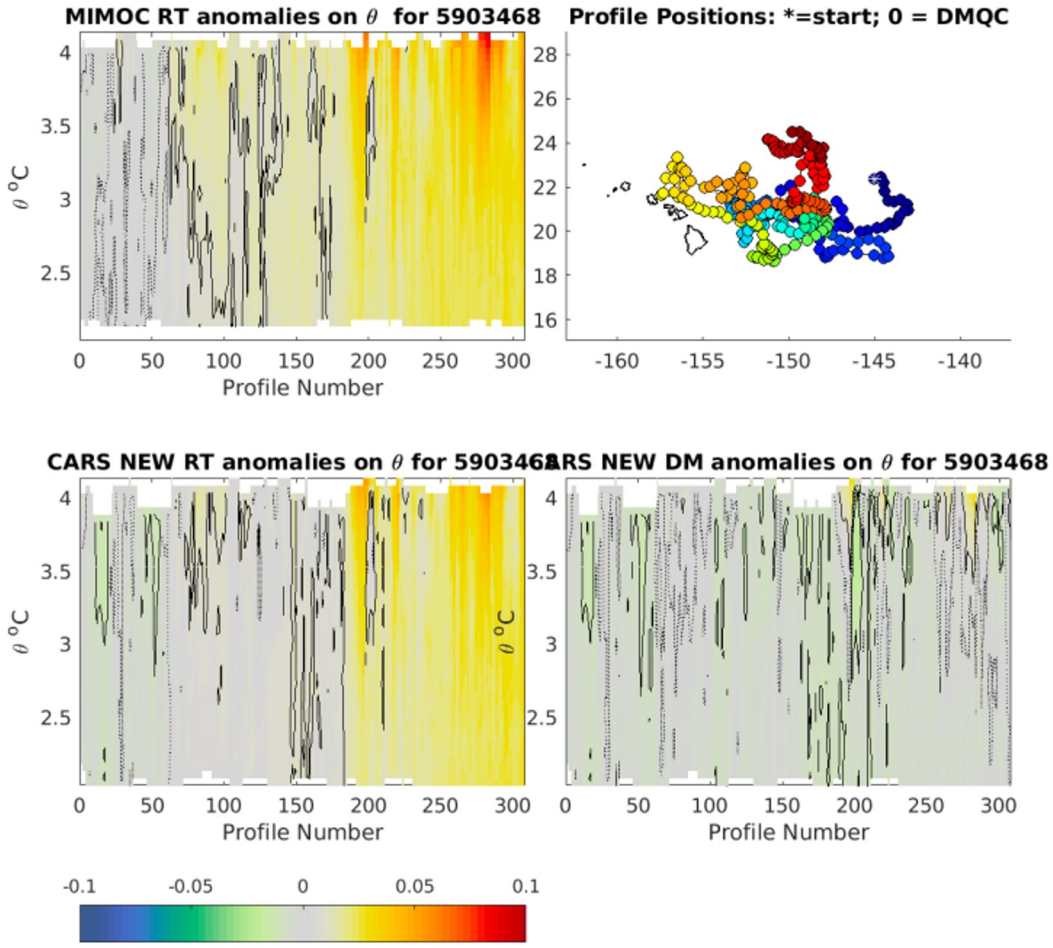


Argo constrains the ‘slow manifold’, satellites constrain the fast features and small spatial scales: a strong synergy is realized

Gasparin (2022), submitted to Frontiers

Challenges: salinity remains difficult to measure

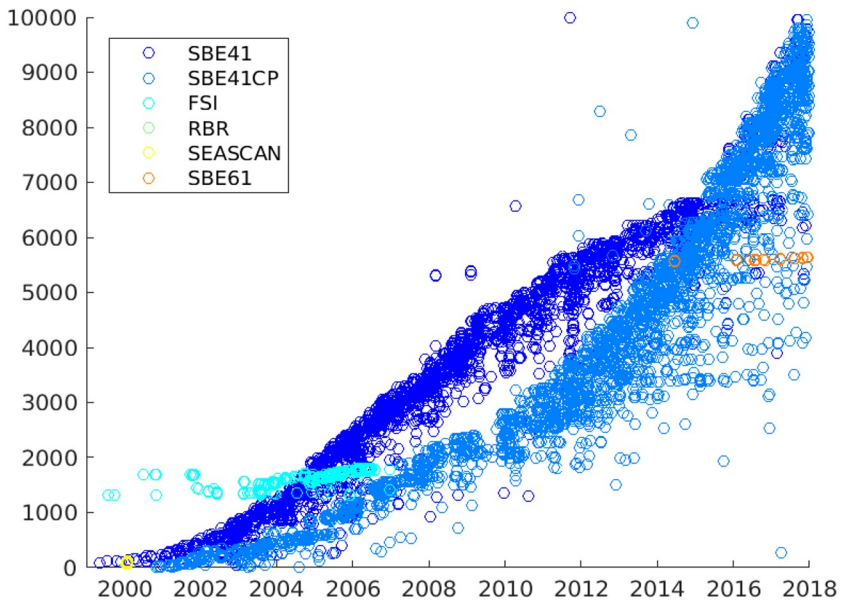
- Pre-2017 only **around 15%** of salinity sensors drifted saltier over 3-6 years
- **Corrections** could be **well-defined** and DMQC teams corrected for drift
- The physical cause of this slow salty drift was **never understood**
- Biofouling causes cells to drift fresh. This is **not seen** much in Argo.

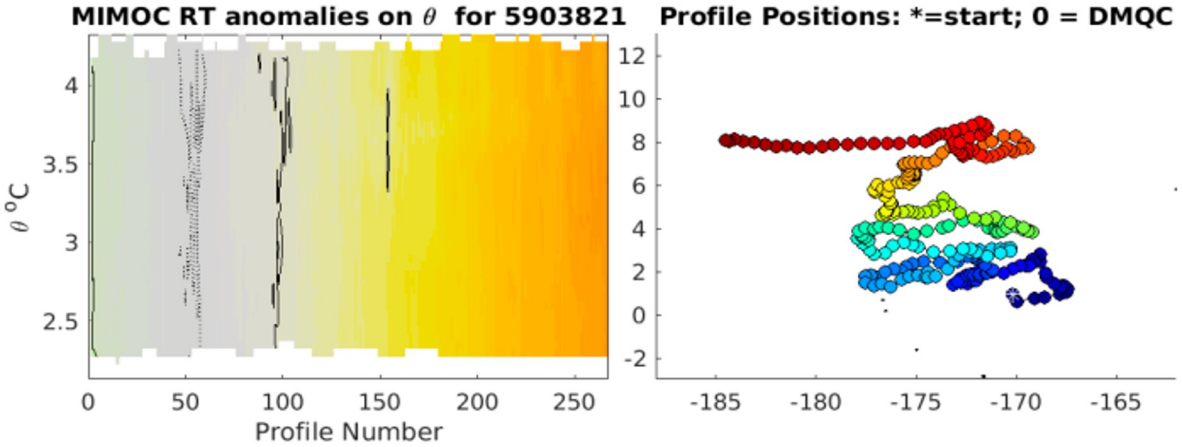


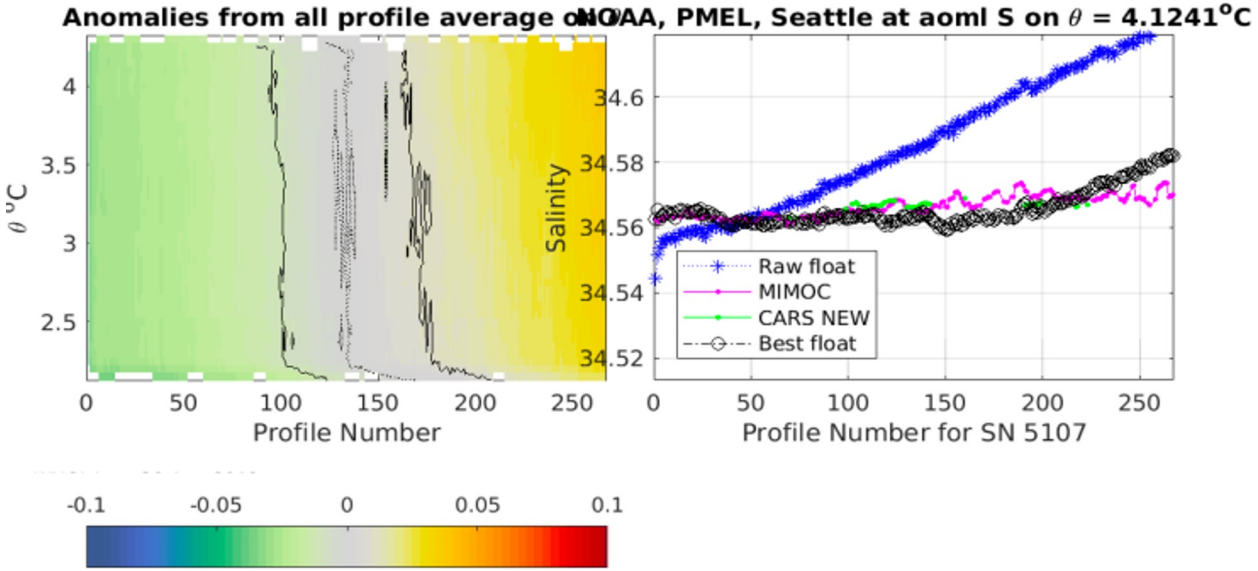
Float-climatology salinity differences (on theta levels)

Challenges: salinity remains difficult to measure

- In 2017, DMQC teams noted more frequent and fast drifts in some float CTDs
- Drift turned up < 2 years and was rapid and sometime catastrophic
- This triggered a **global census** by Argo

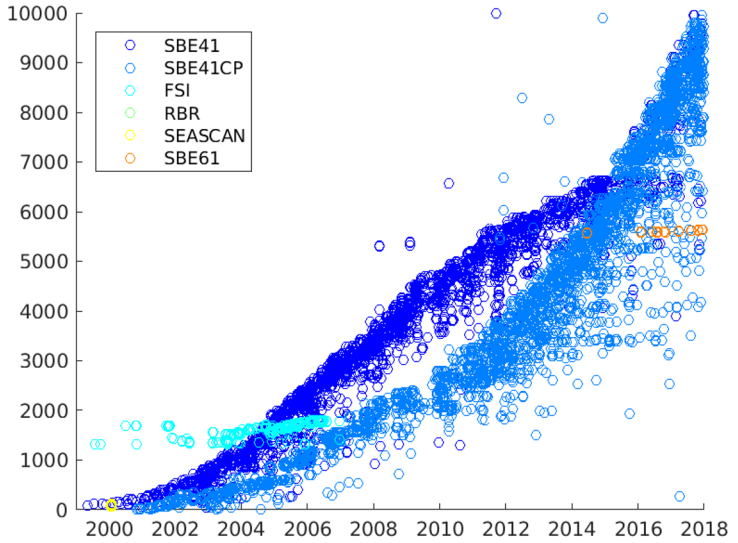


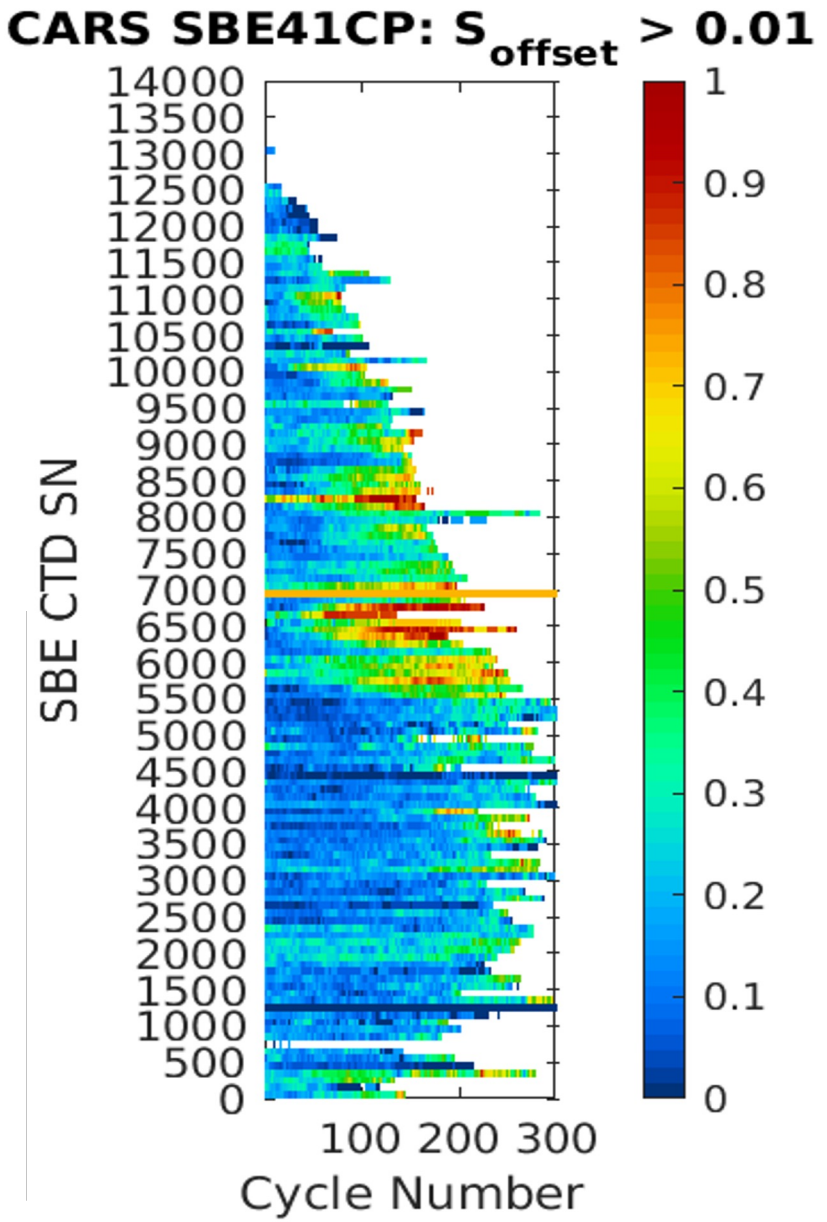




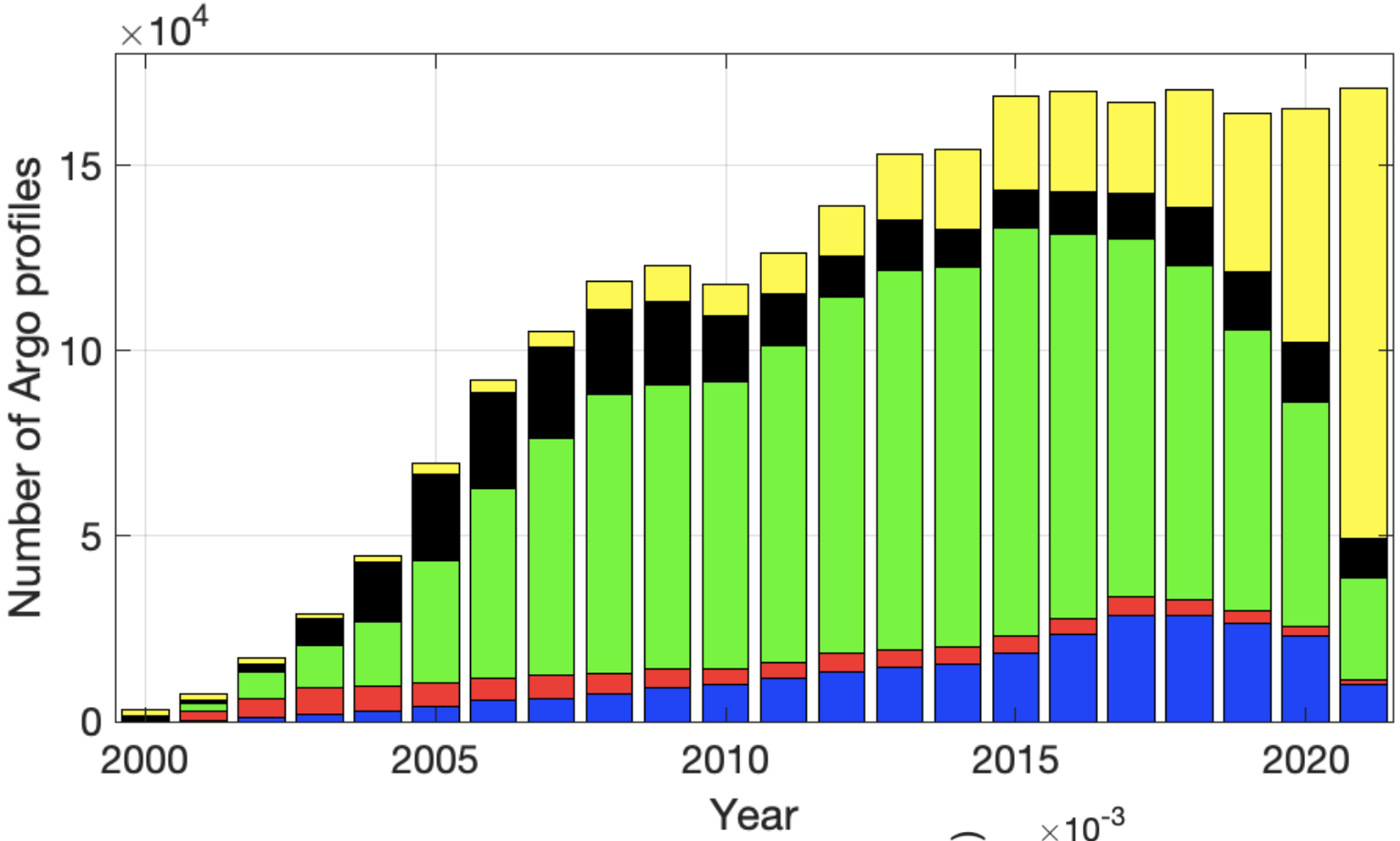
Challenges: CTD Manufacturing Issues

- Global analysis revealed a clear **batch behaviour** in frequency of fast drifters
- Engaged with manufacturer (SBE) 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 C-cell construction**
- Likely source of both fast and slow drift - breakdown of the encapsulant allows **water ingress into the cell**
- SBE made changes
  CTD SN > 11250.
- Drift in subsequent CTD is **greatly diminished** but these are still 'young'





Argo data teams got to work: flagging/adjusting



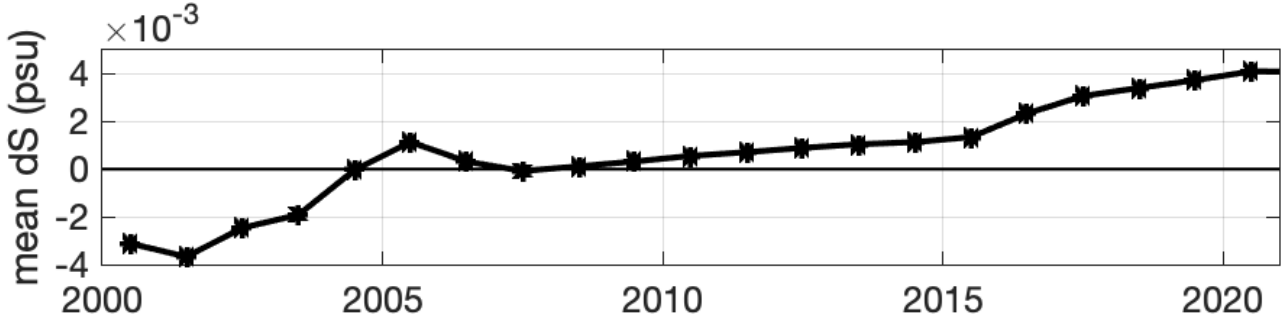
Adjustable salty drift (positive dS) 10%

Adjustable fresh drift (negative dS) 4%

No adjustment (good data) 54%

Unadjustable (bad data) 12%

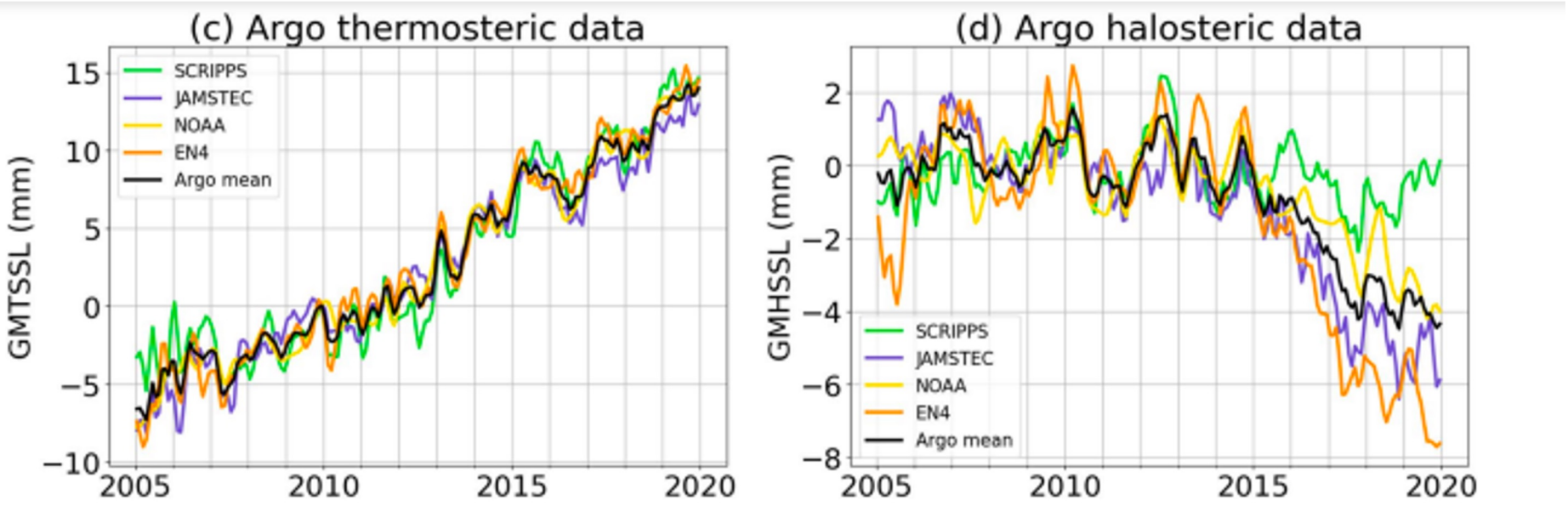
Not evaluated ('R' mode) 20%



Problem solved?

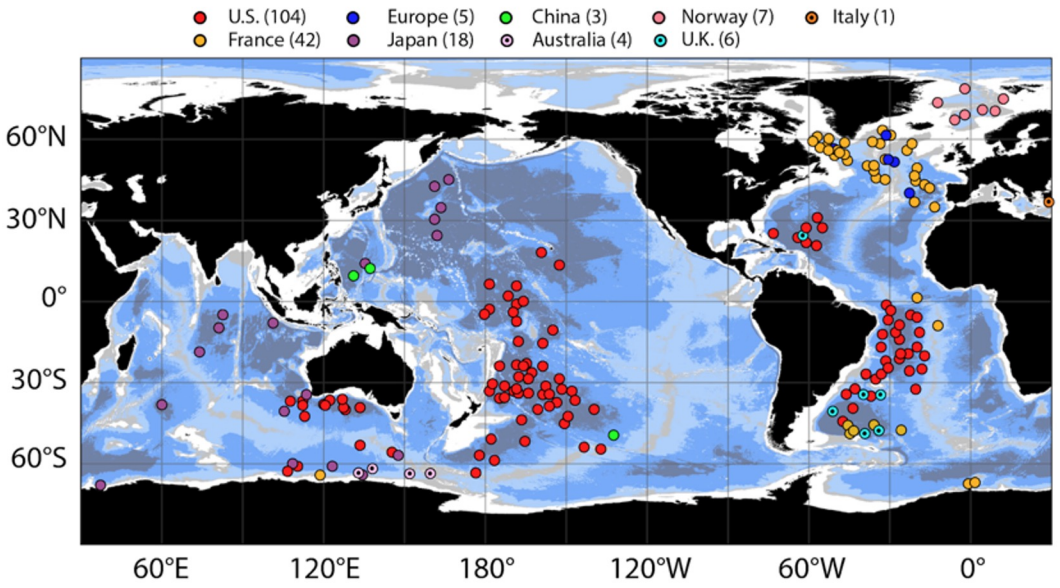
- Biased real-time data has clearly impacted the **closure of global sea level budget** using certain products

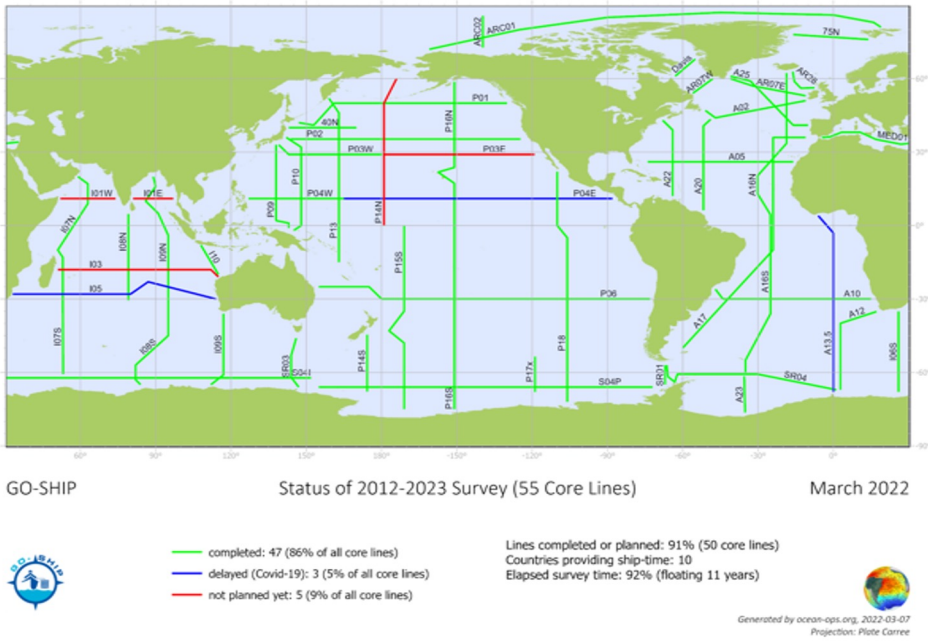
- Many global reanalysis groups are **not refreshing** their analysis **archives** with DMQC'd Argo data -> analyses with large and unrealistic halosteric sea level contraction

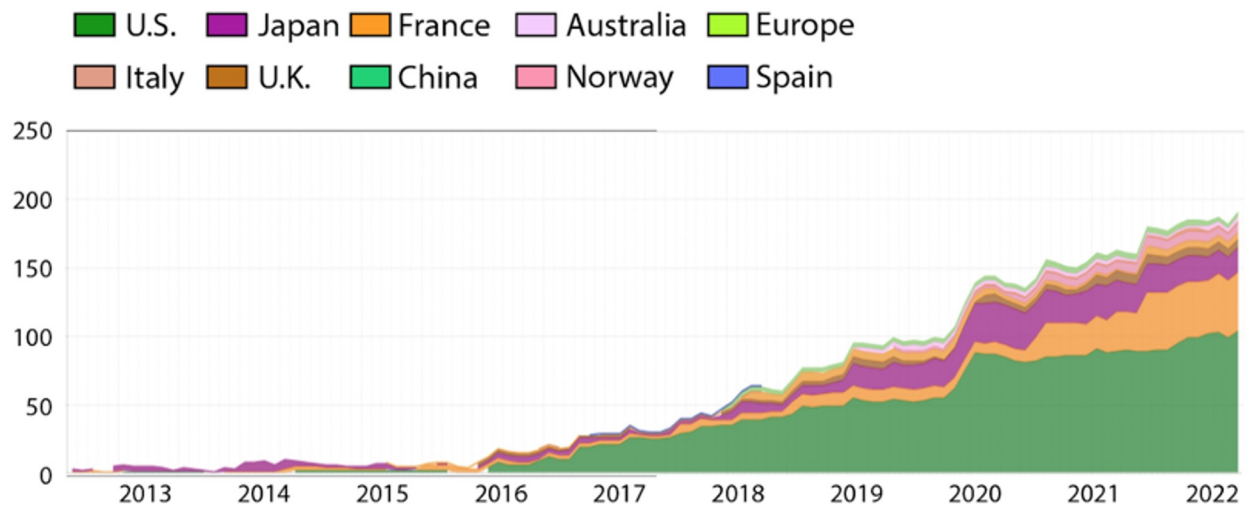


Barnoud, A., Pfeffer, J., Guérou, A., Frery, M.-L., Siméon, M., Cazenave, A., et al. (2021). GRL, 48, e2021GL092824. https://doi. org/10.1029/2021GL092824

Challenges: Gaps in the Deep, Polar Oceans and Marginal Seas







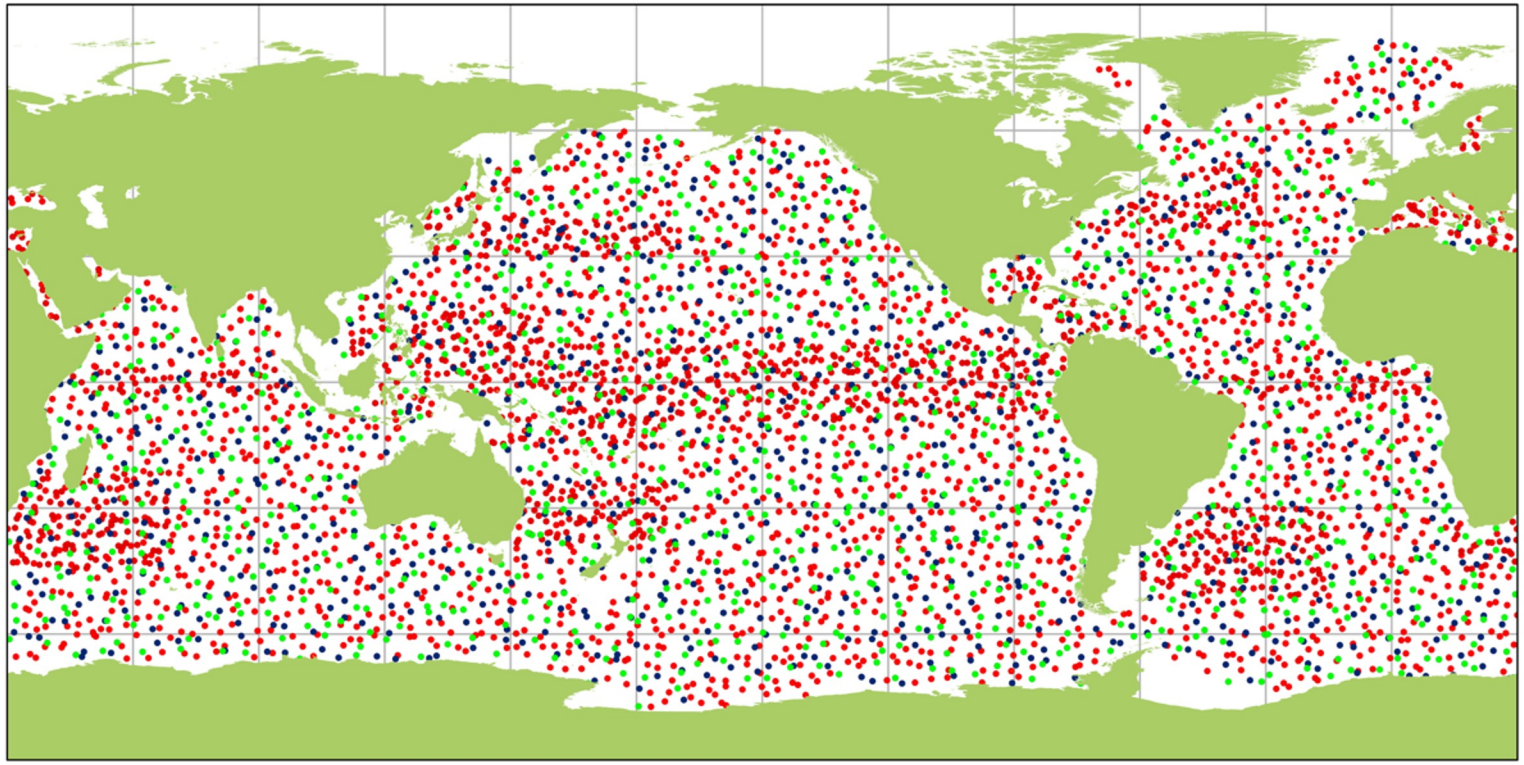
- GO-SHIP decadal surveys
- Deep Argo regional pilots
- Polar oceans remain poorly sampled

The solution: OneArgo

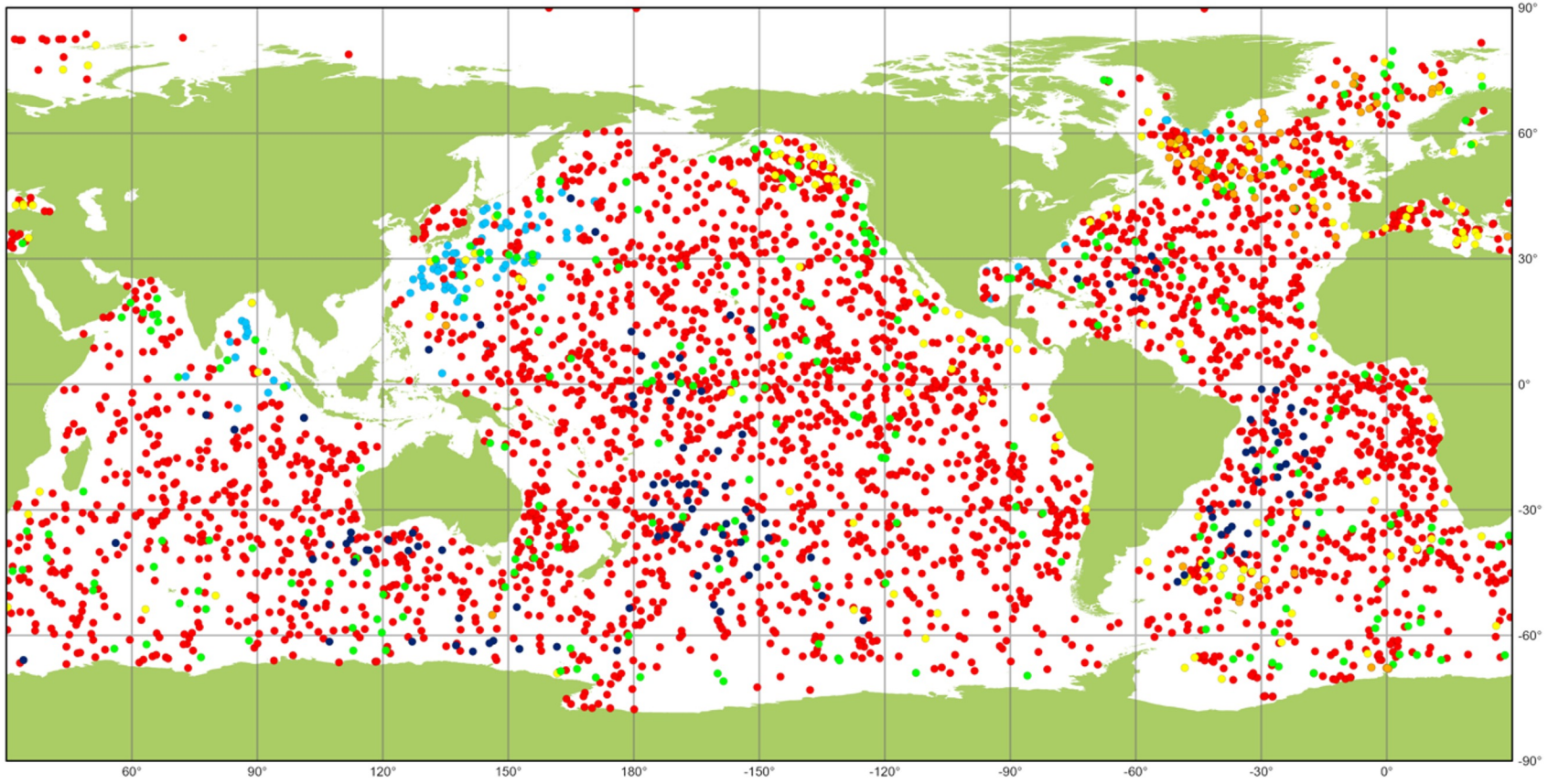
An **ambitious** but urgently needed expansion of the Argo array

Comprises 4700 floats including:

- 1200 deep floats
- 1000 biogeochemical floats
- Expansion into seasonal ice zones
- Enhanced sampling in the equatorial and western boundary regions



OneArgo – Achieved High Technical Readiness Level



Argo

Networks
3885 operational units

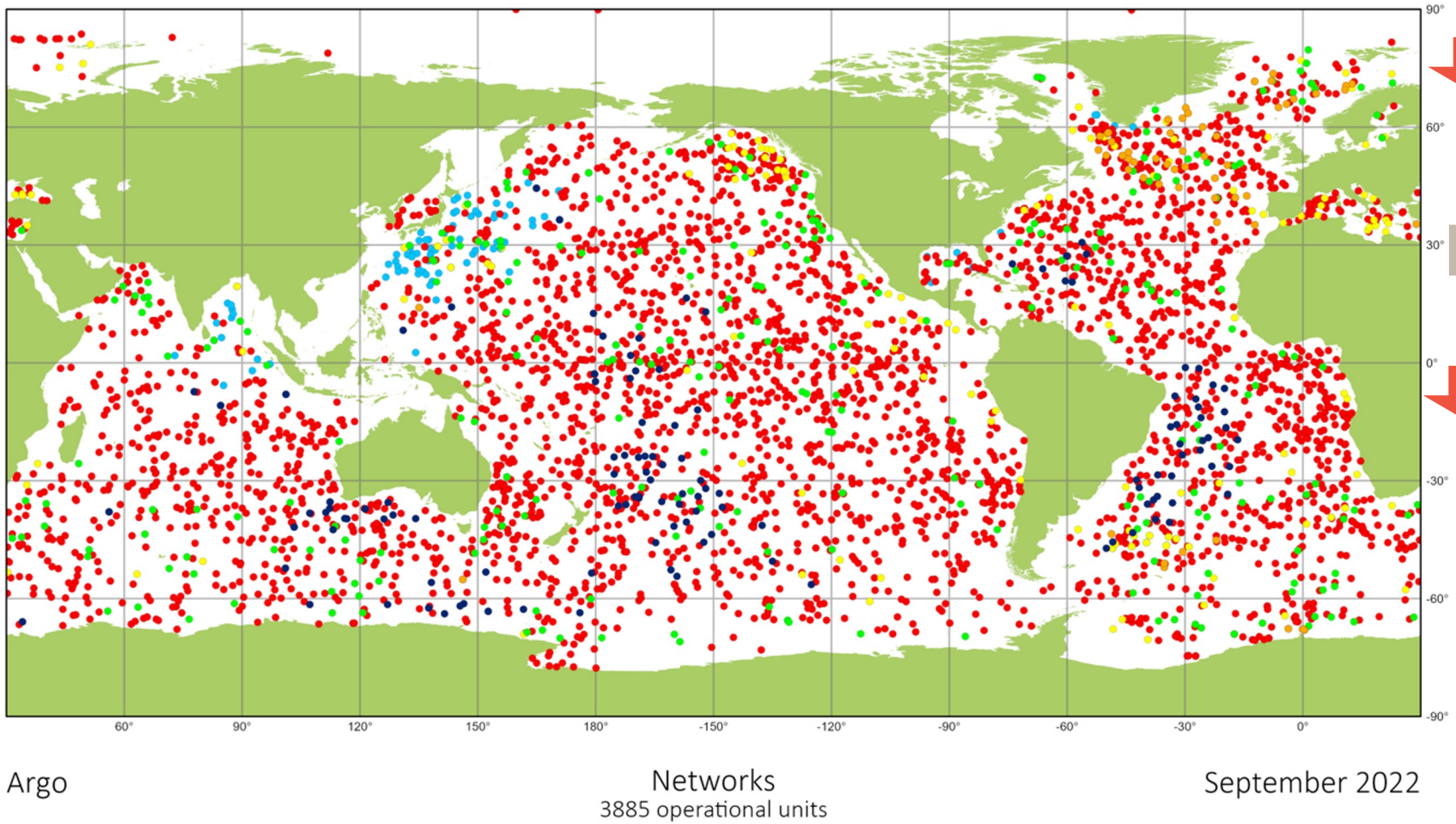
September 2022

- Deep (TSO only) (56)
- Deep (180)
- BioGeoChemical (without TSO only) (269)
- Core + 02 (TSO) (139)
- Core (3211)
- Equivalent (147)

Generated by ocean-ops.org, 2022-10-01
Projection: Plate Carree (-150,0000)

- 2019: OneArgo design articulated at OceanObs'19, approved by GCOS/GOOS
- 2015-22: successful deep pilot arrays and deep CTD technical developments
- 2015-22: BGC pilot arrays progress sensor and platforms
- 20XX: OneArgo design implemented?

OneArgo – successful pilots arrays, stalled global implementation



- Total = 3885/4700 (83%)
- Deep = 180/1250 (14%)
- Biogeochemical (>=5 params) = 269/1000 (28%)

Presently the Argo system is in net decline

Conclusions

- Argo and ocean surface topography from space are **a powerful observing system combination**
- Major gaps remain in the deep and polar oceans. **OneArgo** – like an array of microsatellites operating in the harsh deep and remote oceans – **will fill these gaps**
- It requires ~ **$120M/year funding globally**, similar in cost to a single sensor Earth Observing Satellite
- National Argo programs and our industrial partners have **successfully developed the capacity** to operate the OneArgo array
- without strong support to **implement OneArgo** (and maintain core Argo), **past successes** will be under **threat** and **future gains not realized**