The Challenges in Sustaining and Evolving Argo

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Euro-Argo, Brest, France, 2016

Outline

- Progress toward the original goals

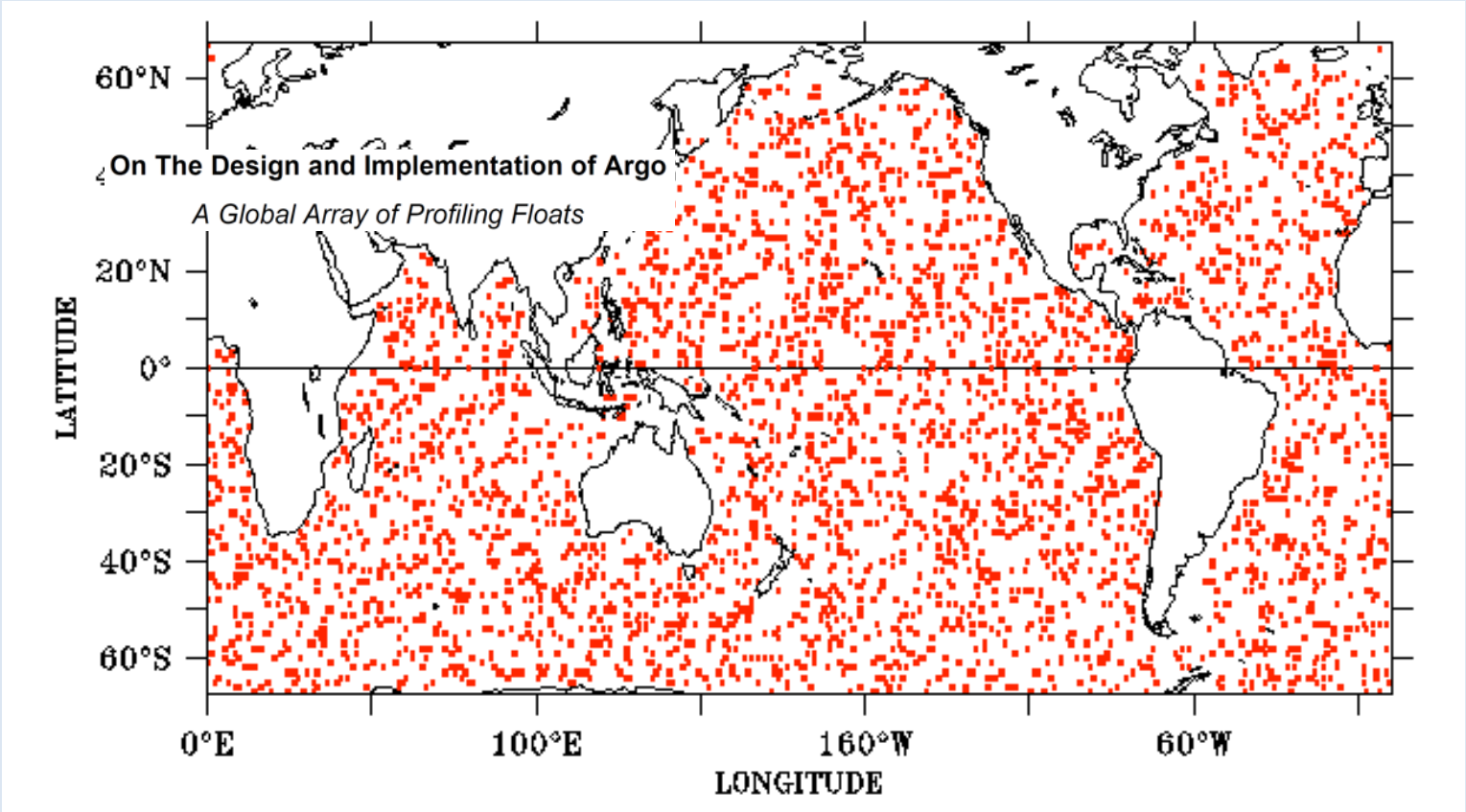
- Challenges:

1. Data complexity
2. Changing technology
3. Funding outlook

- Evolving the design

1. Spatial completeness
2. Regional enhancements
3. New parameters and applications

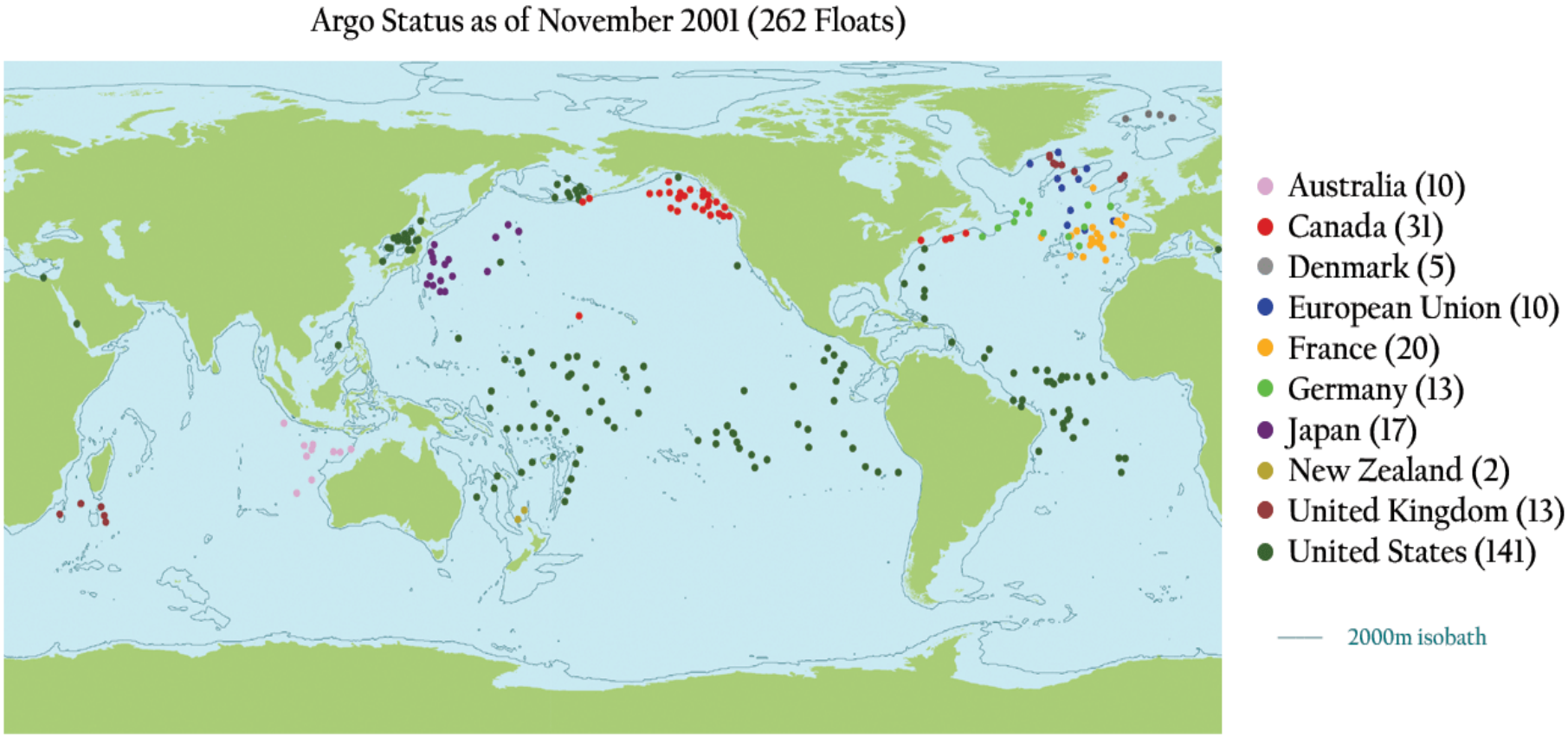
Argo in 1998
an idea



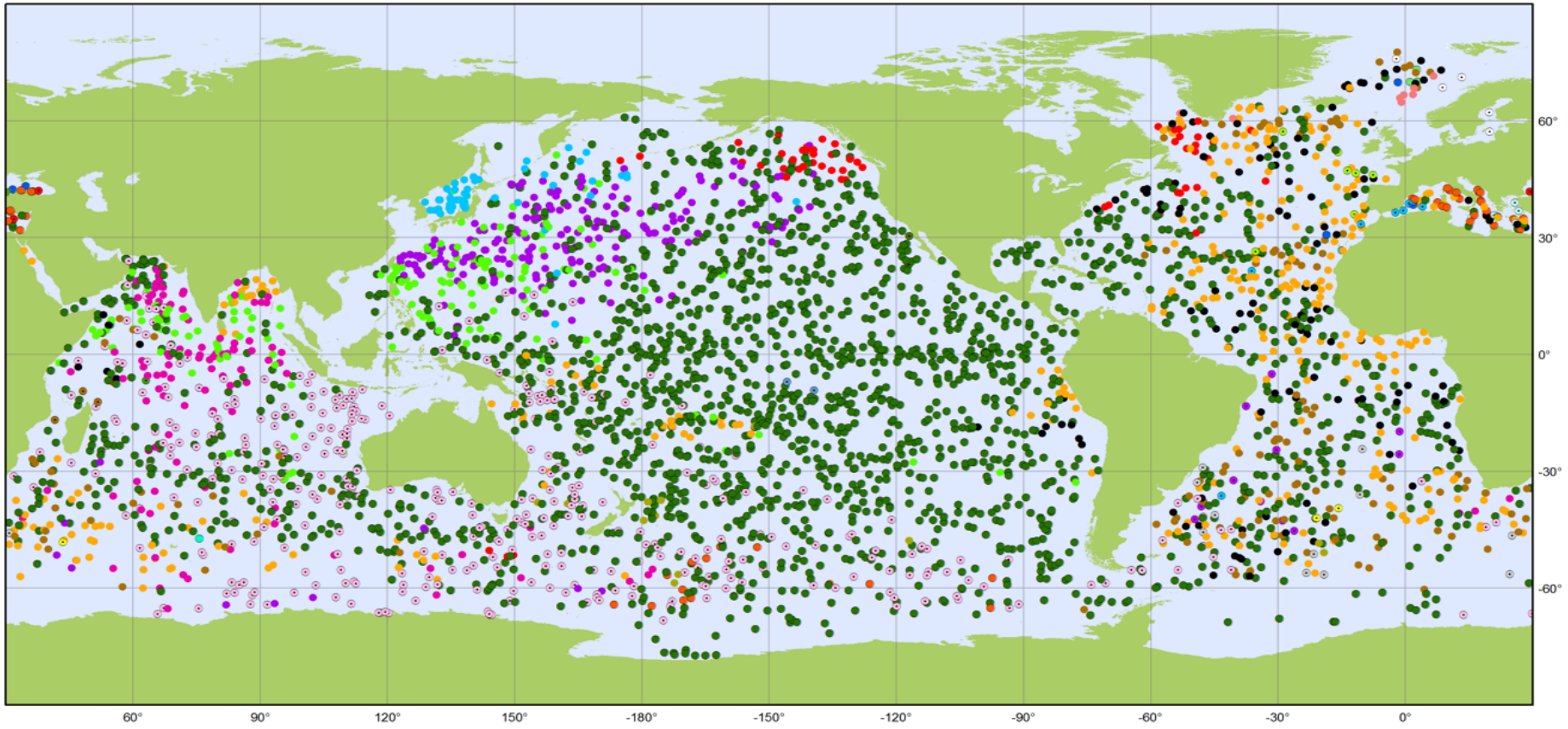
Fom the 1998 Argo Design document: See http://www.argo.ucsd.edu/argo-design.pdf

Profiles - 0 – 2000m
Velocity - trajectories

Argo in 2001


Argo Status as of November 2001 (262 Floats)
Australia (10)
Canada (31)
Denmark (5)
European Union (10)
France (20)
Germany (13)
Japan (17)
New Zealand (2)
United Kingdom (13)
United States (141)
2000m isobath

Argo in 2016



Argo

National contributions - 3856 Floats

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

February 2016

ARGENTINA (3)	CHINA (165)	GERMANY (124)	JAPAN (197)	NEW ZEALAND (12)	SPAIN (9)
AUSTRALIA (382)	ECUADOR (2)	GREECE (7)	KENYA (1)	NORWAY (8)	TURKEY (3)
BRAZIL (11)	EUROPE (5)	INDIA (108)	MAURITIUS (4)	POLAND (3)	UK (139)
BULGARIA (2)	FINLAND (5)	IRELAND (7)	MEXICO (2)	SOUTH AFRICA (1)	USA (2151)
CANADA (57)	FRANCE (337)	ITALY (47)	NETHERLANDS (12)	SOUTH KOREA (52)	

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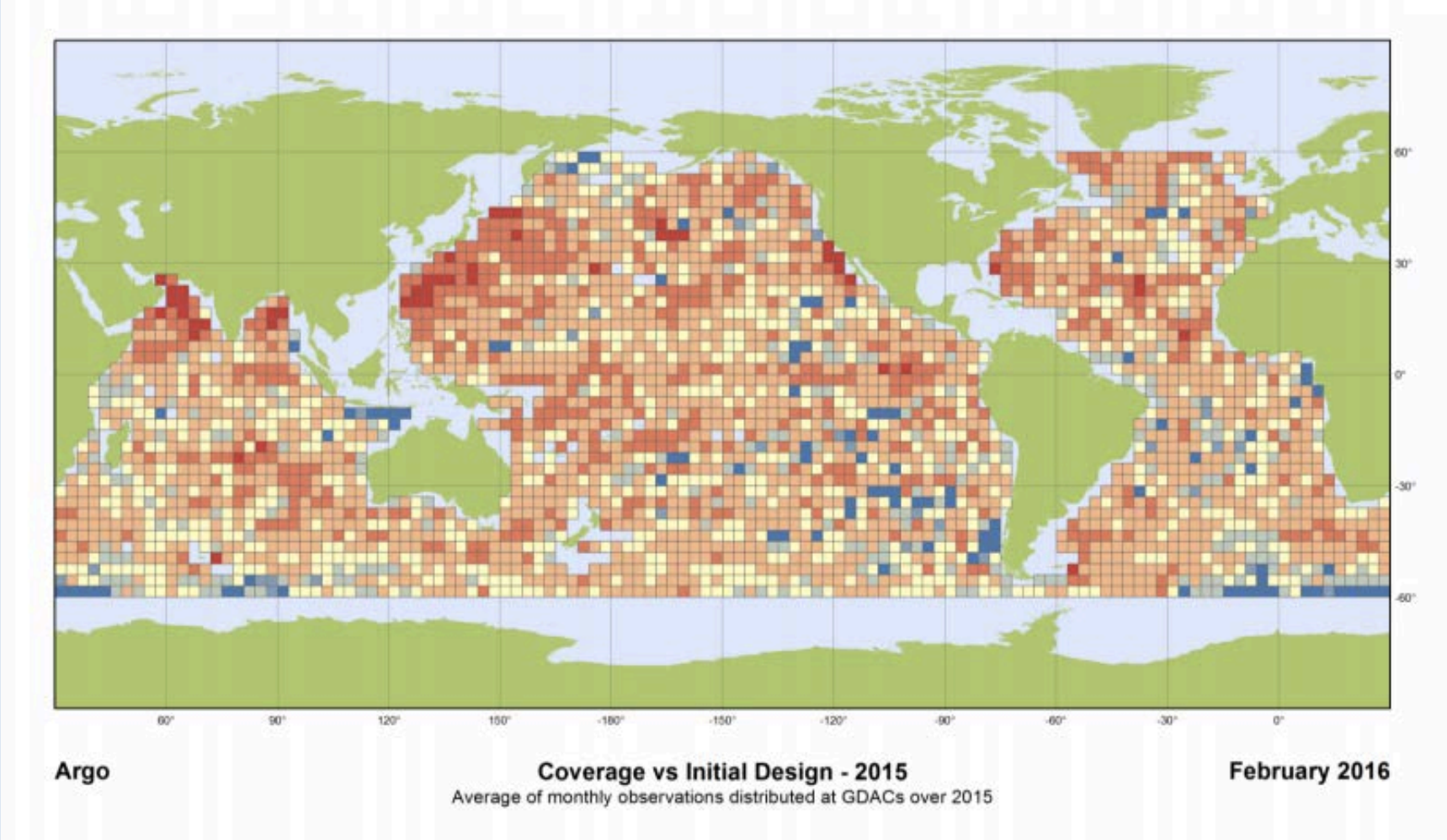
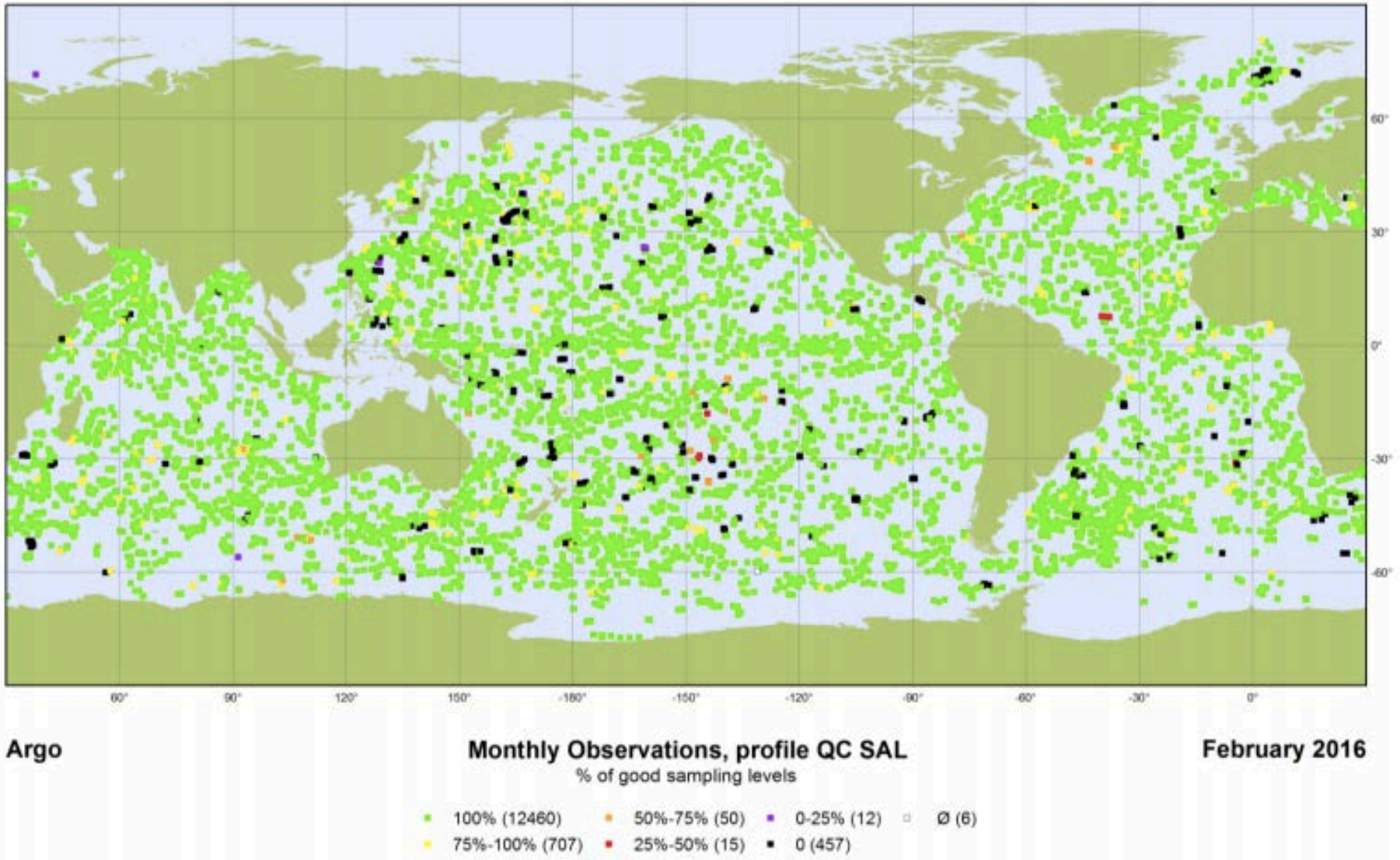
Success: Profile coverage

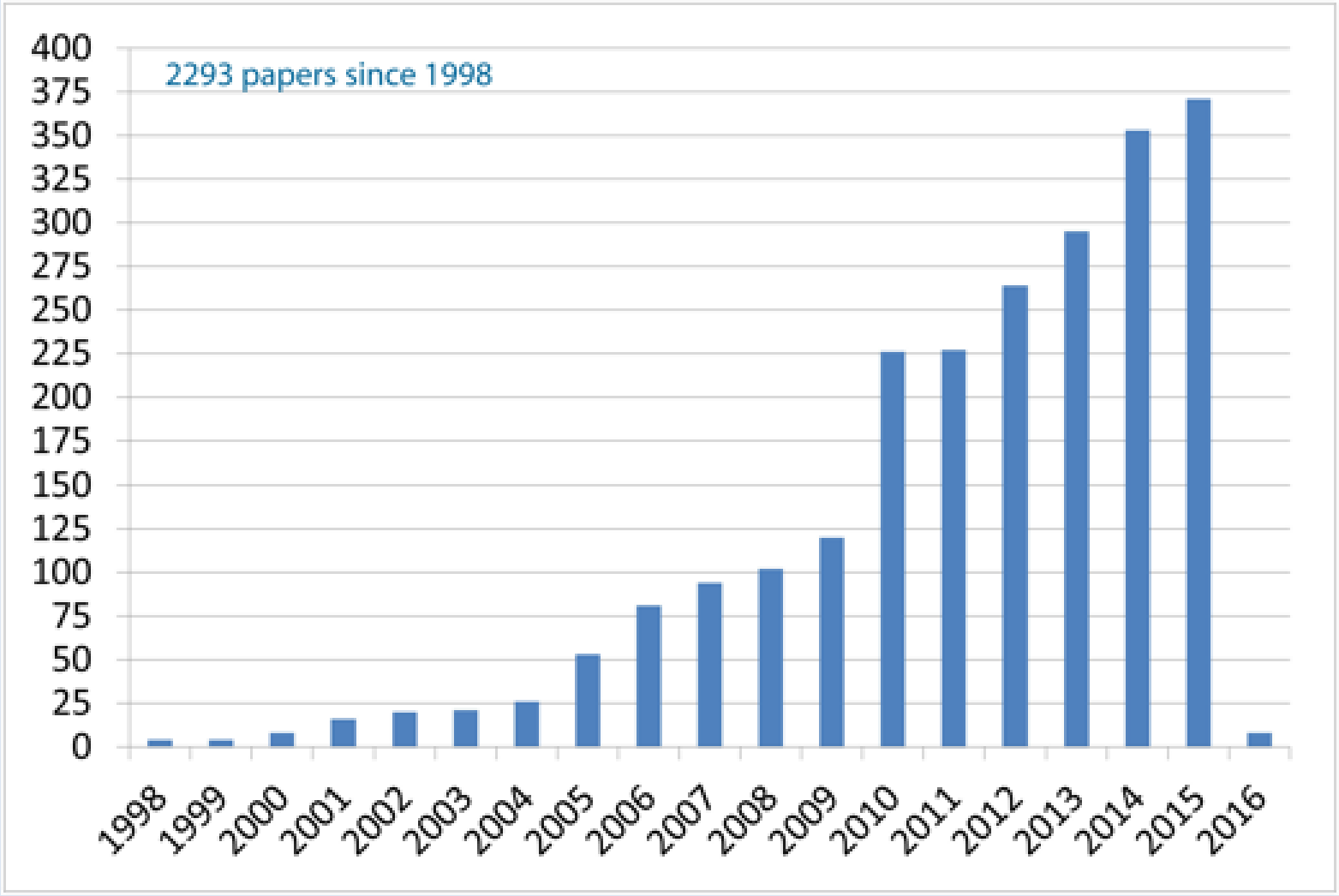


- Nearly global and nearly uniform

Success: Profile data quality is very high and largely meets Argo targets

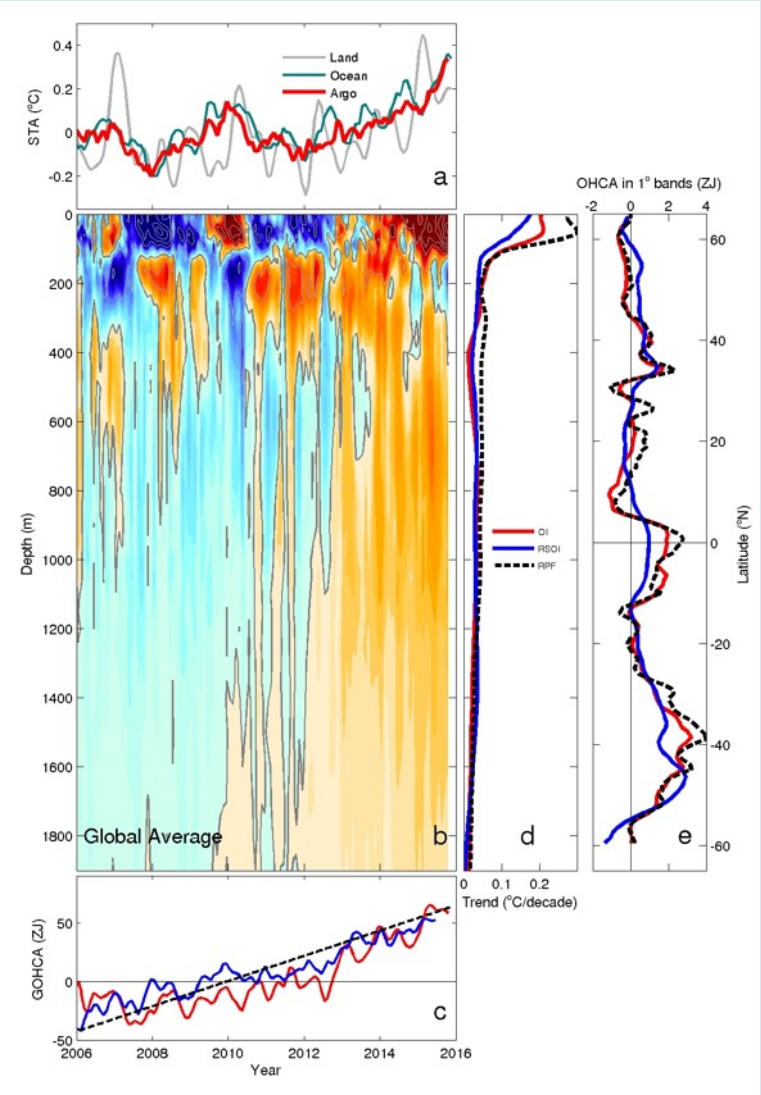


Uptake is now very broad



On average 1 paper per day is published using Argo

Enables near real time tracking of the warming of Earth

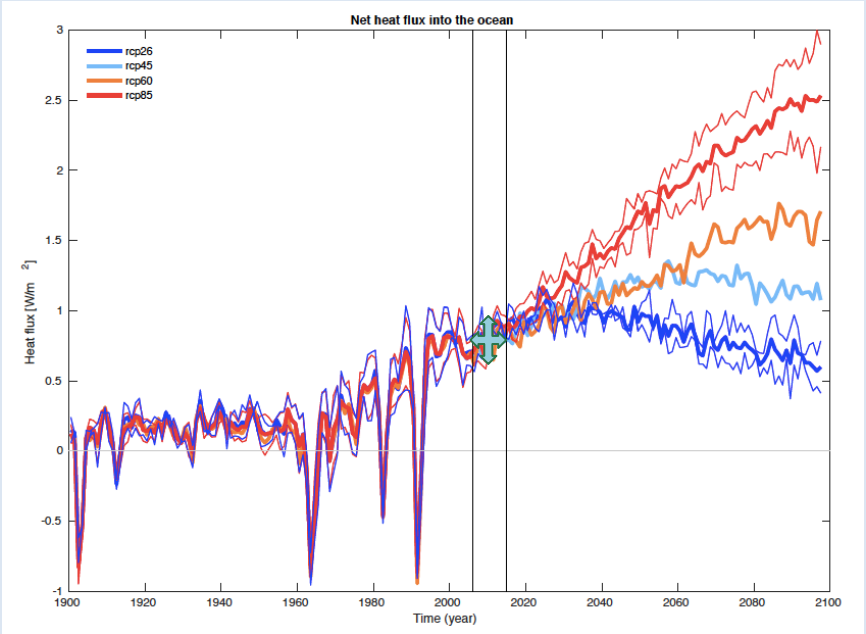


Robust across 3 very different analyses: 0.64-0.7 Wm^{-2}

Southern Hemisphere dominated

Warming down to Argo's current sampling depth of 2000m.

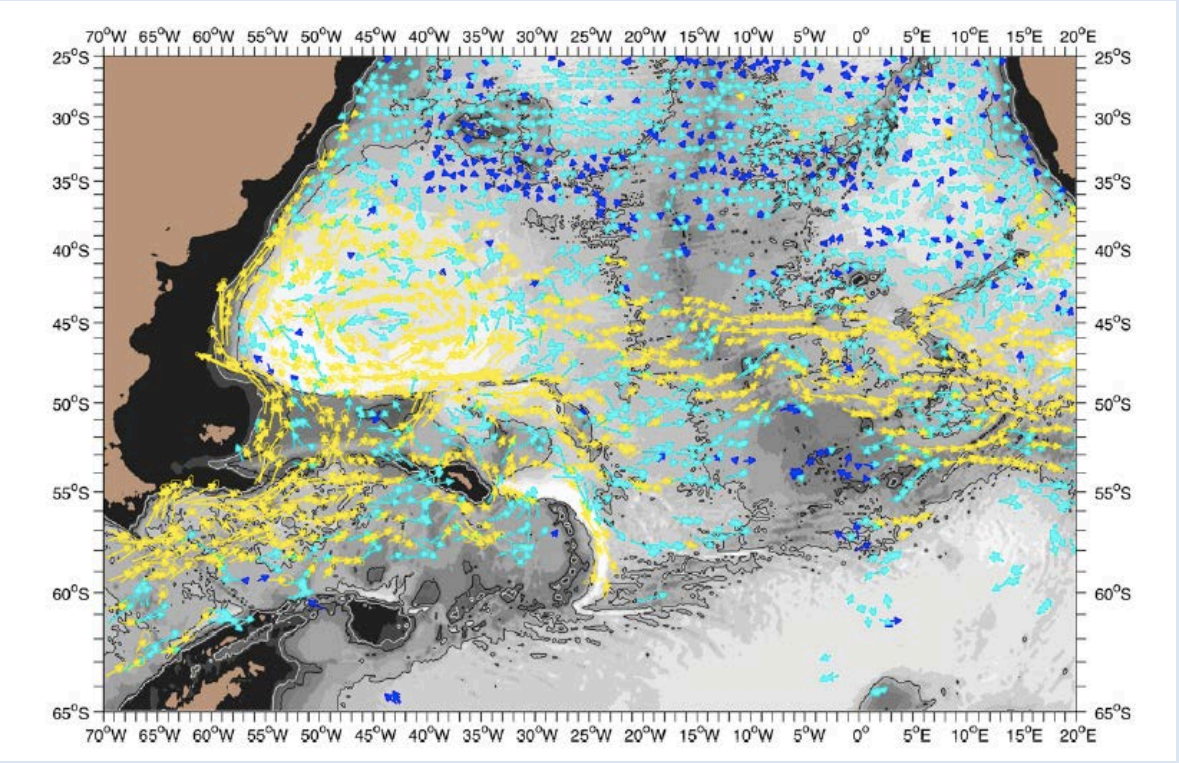
Agrees with CMIP5 projections

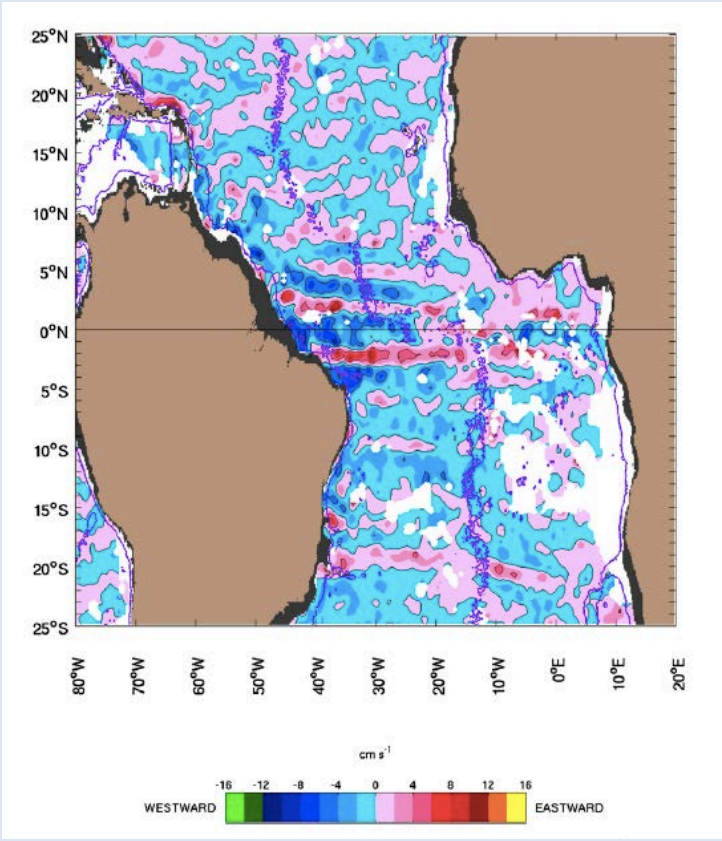


Wijffels, Roemmich, Church, Monselesan and Gilson, NCC,2016.

Assume 0.07Wm^{-2} for the deep ocean(GOSHIP) and that 17% of deep ocean not measured by Argo has the same warming rate

Argo trajectories give unprecedented details of ocean circulation at 1000m





Ollitrault and Colin De Verdiere, 2014

Caveat – these authors could not use the distributed Argo files !

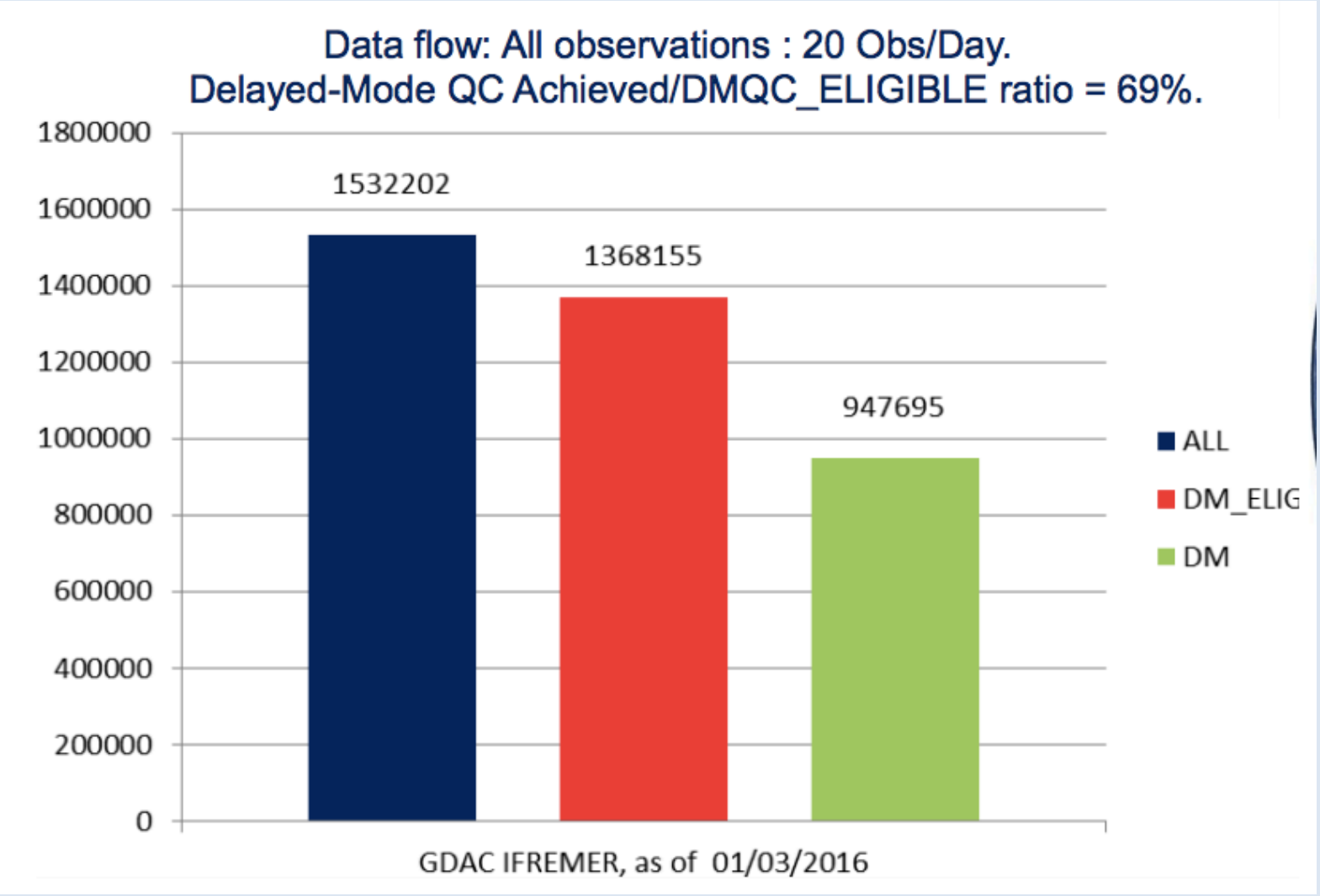
Difficulties

- **Trajectory** files were **not complete** and often incorrect
- Argo could not distribute **complex missions** or sensor sampling schemes e.g. two different vertical grids
- Argo could not distribute many **bio-BGC or other parameters**
- Meta and technical data were **not machine parse-able**

Led to a **major format change** = V3.1

- Greatly **improved completeness** and rigour
- Positioned Argo data system for **future evolution**

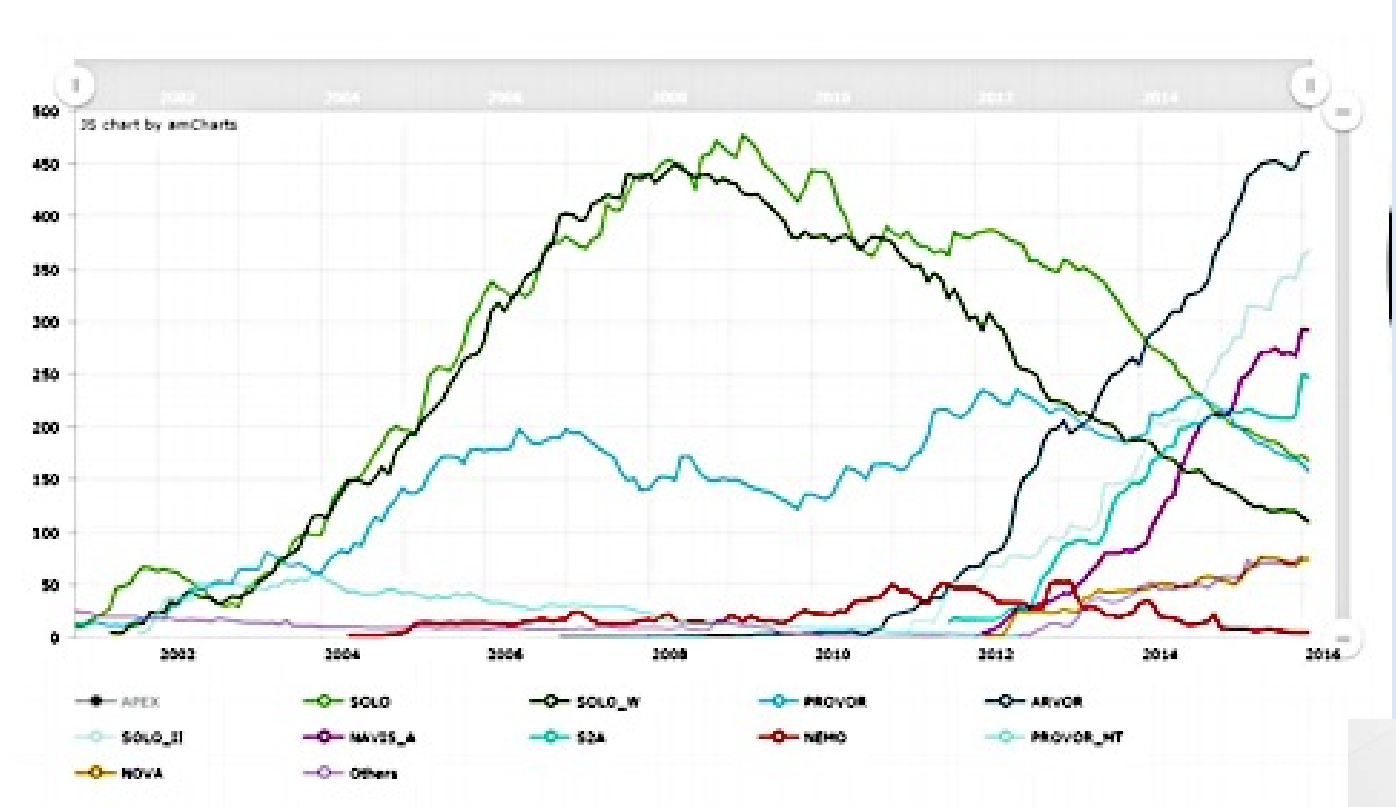
Impacts- slow down in climate quality QC throughput



Impacts: skyrocketing data complexity

- Technical and meta data – hundreds of defined names/definitions
- Complex engineering data – is this all needed?
- Many Argo Data Centres are not keeping up
- How does the Argo data system remain inclusive and yet rigorous and high quality?

Changing technology: threat and opportunity



New float types – reliability?
New sensors – accuracy and stability?
Careful testing, close monitoring is required

Threats: US, Japan and Australia are big contributors which have declining base funding

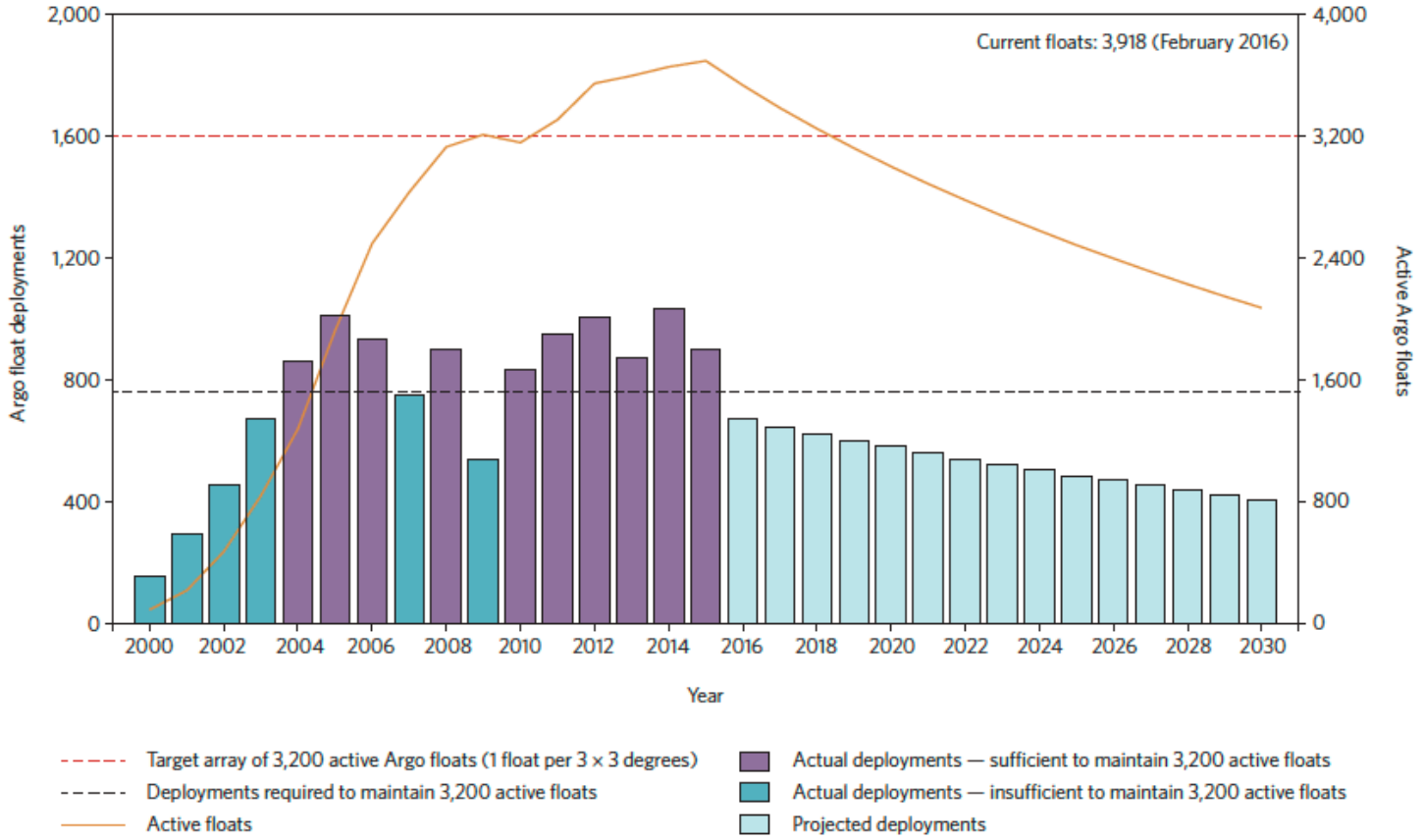
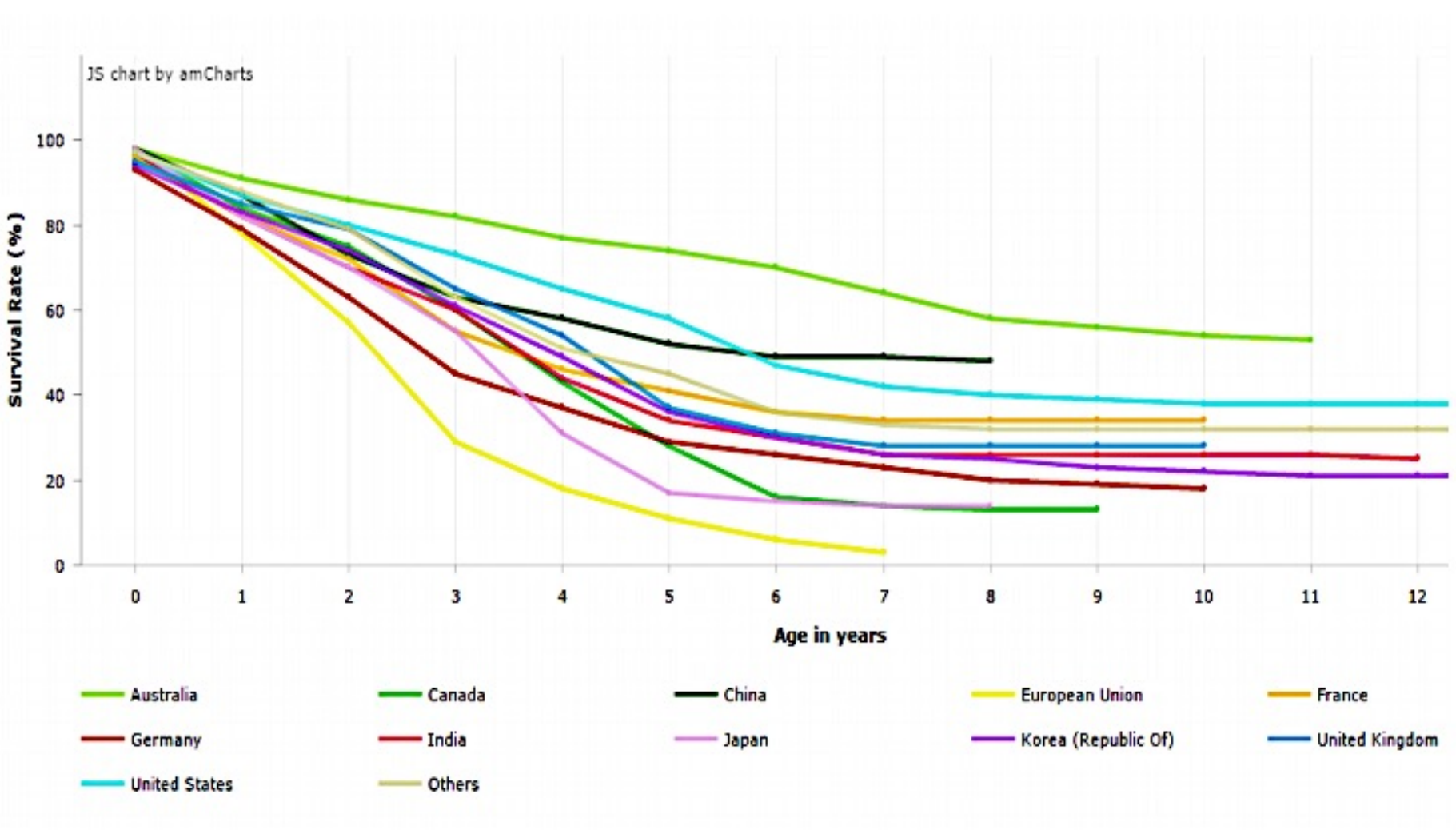


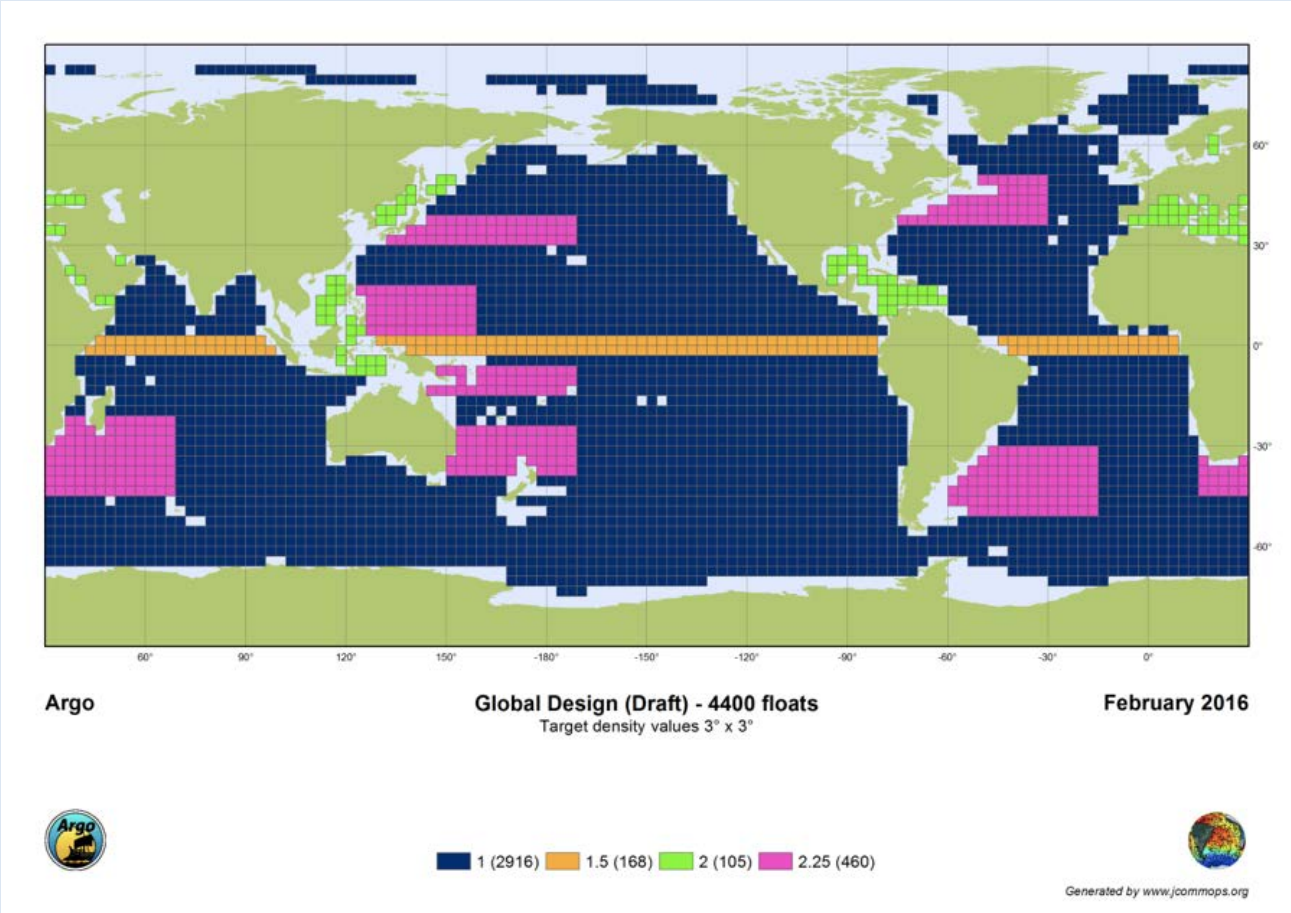
Figure 2 | Historical and projected Argo float deployments and the resulting global array density. Due to a reduction in projected Argo float deployments, the array is anticipated to drop beneath 3,200 in 2018.

Increased investment from Europe is extremely important

Float longevity remains variable: if we lift all programs we can help offset declines



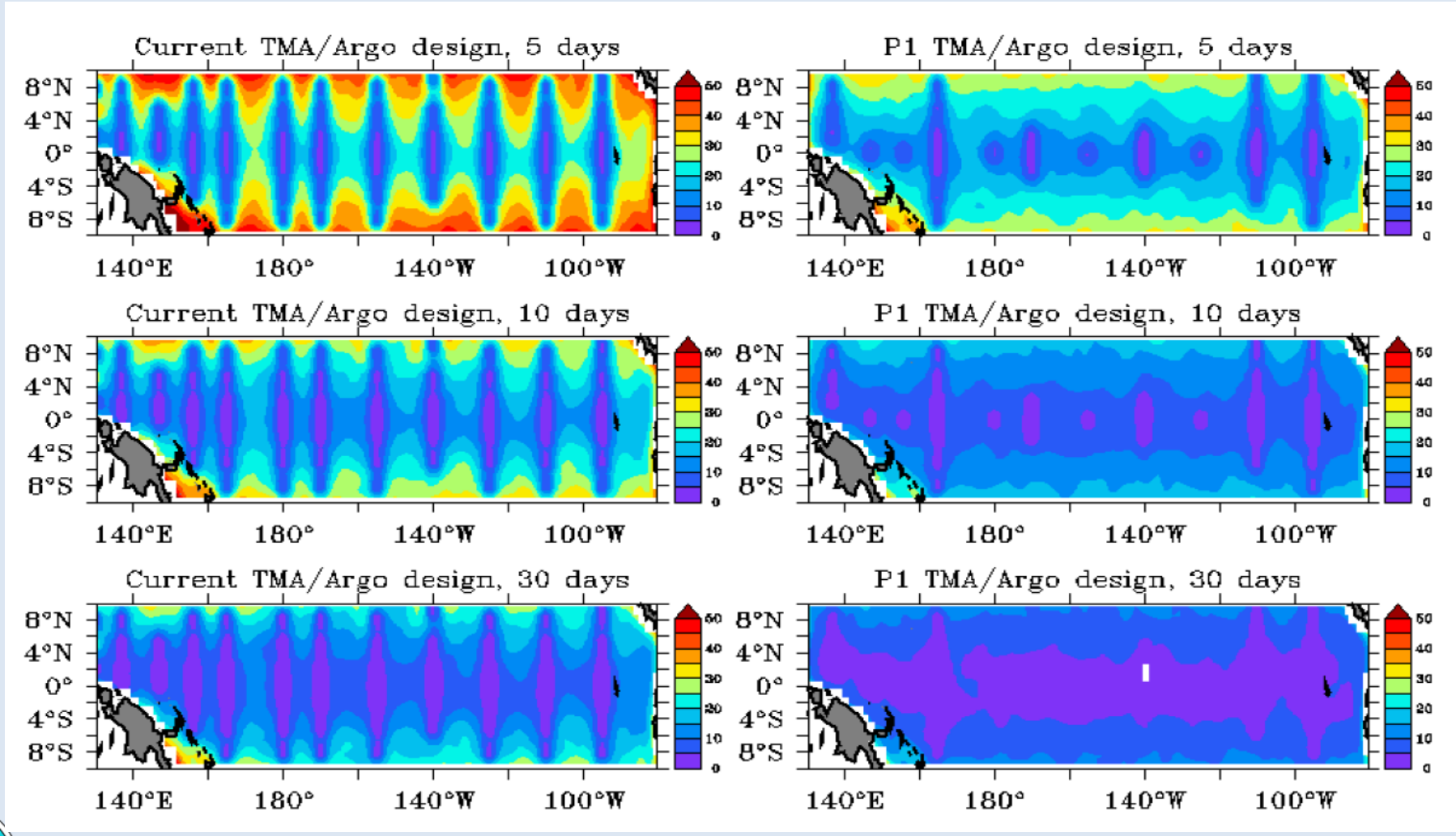
Opportunities: sketch of new design



- Same mission – tracking the slow manifold - more spatially complete and better signal to noise
- higher sampling in WBCs and equatorial regions
- Marginal Seas: enhanced sampling - determined by regional partnerships
- Seasonal Ice zone: normal sampling [Fast ice zone requires different technology]

Spatial completeness: 3800 array + regional enhancements = 4400 array

Gains by doubling density in Tropical Pacific



Deep Argo

- Prospectus
- Sensor development: SBE 61
- Regional pilots
- Global design and costing

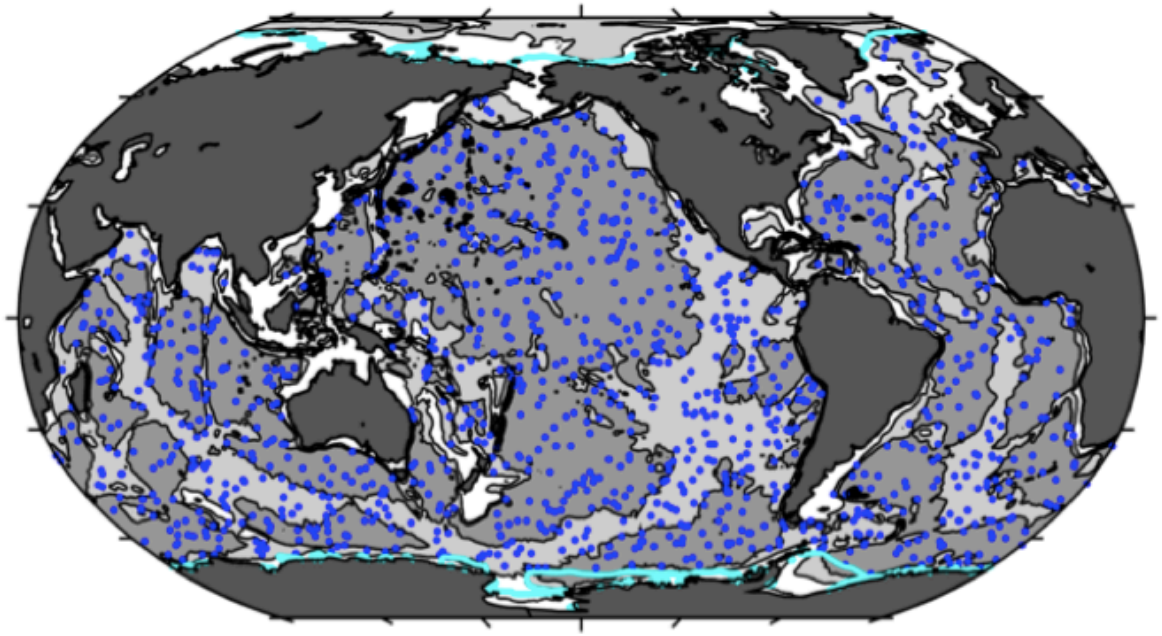
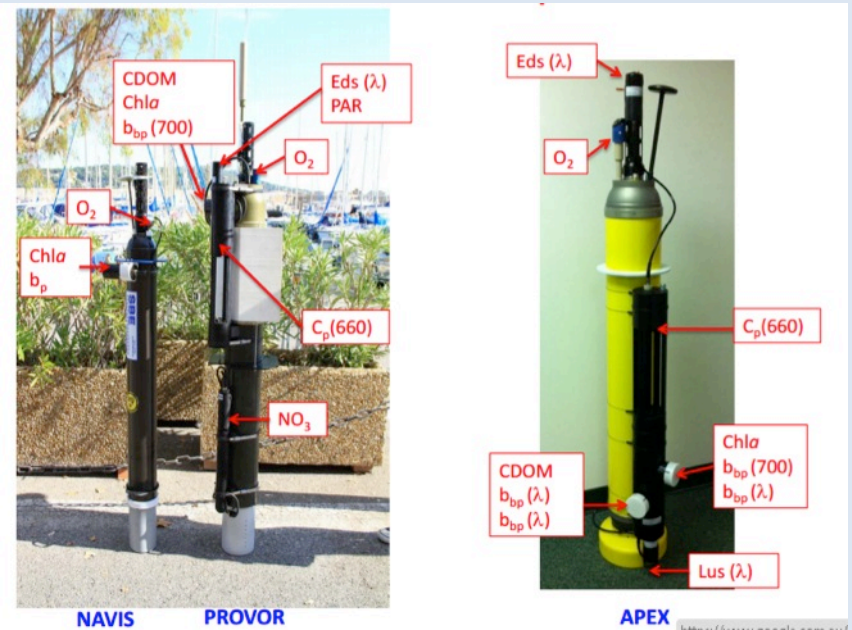


Figure 5: Straw-plan of a nominally 5° x 5° distribution of 1228 Deep Argo floats (blue dots) randomly populating the global ocean excluding areas shallower than 2000 m (white areas), and areas with mena 1981-2010 ice concentrations > 75% (poleward of thick cyan contours). Lightest gray areas indicate bottom depths between 2000 m and 4000 m, darker gray areas indicate bottom depths exceeding 4000 m, and darkest gray areas indicate land (Johnson et al., 2015).

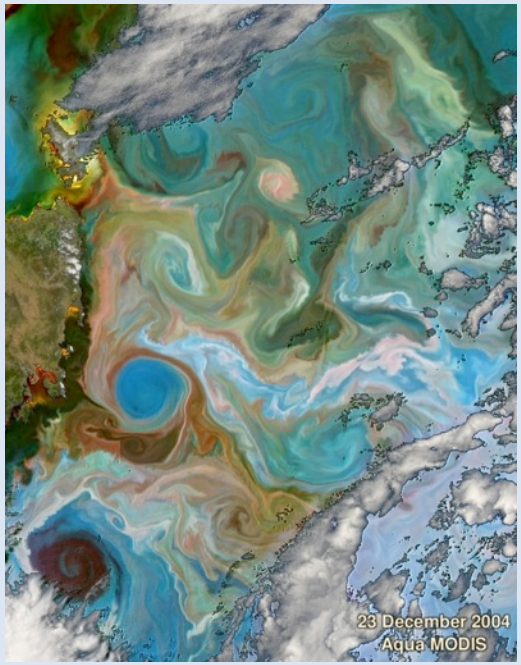
New Missions?
BGC-Argo

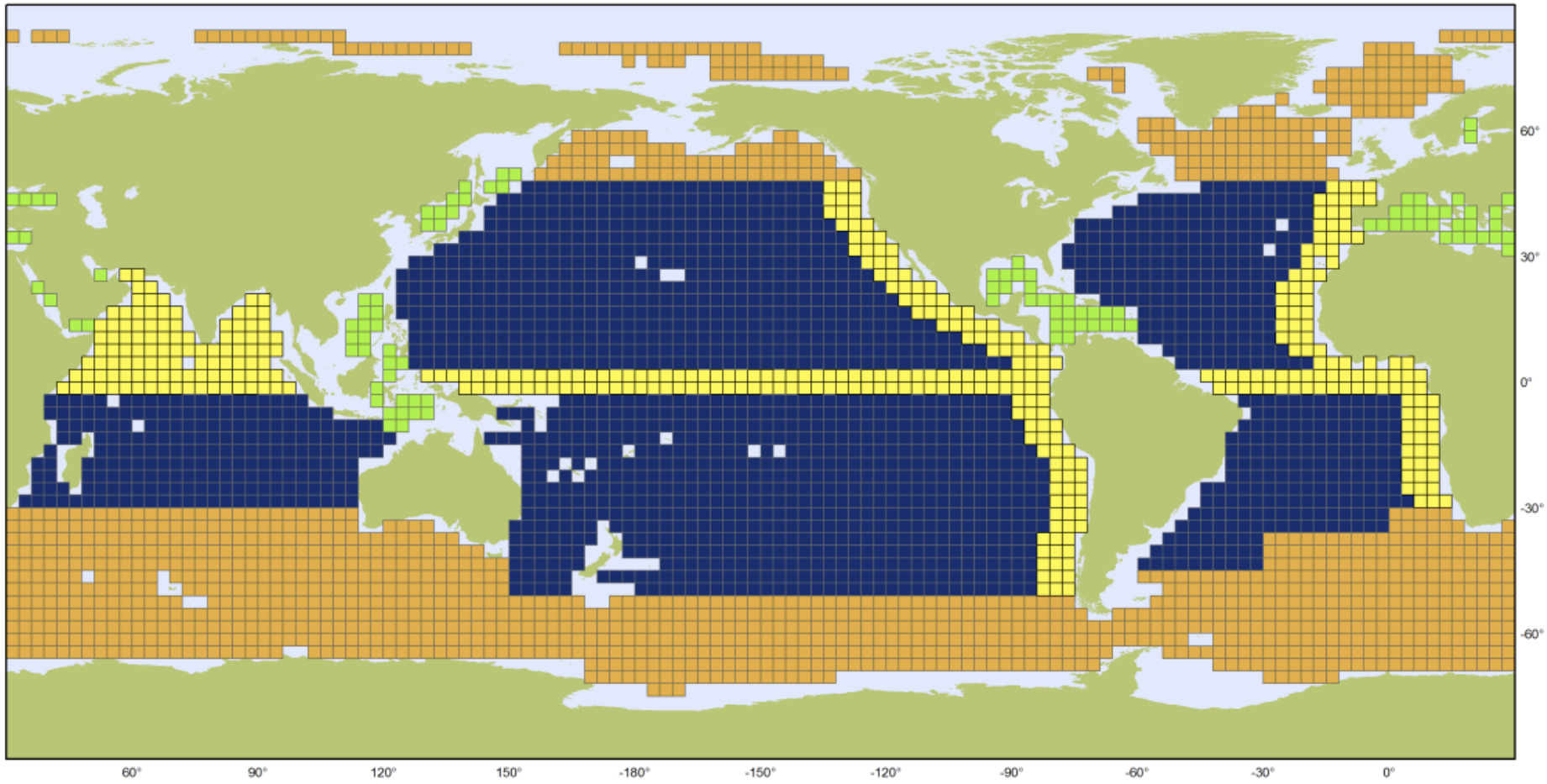
Goals

- Understand the fundamental bio-geo-chemical cycling in the oceans, and thus the foundation of biological productivity patterns
- To track any long term trends – there is already evidence of significant ocean oxygen changes



Subsurface partner of ocean colour satellite data





Argo

Bio Design (Draft) - ~900 floats

Target density values 3° x 3°

February 2016

0.1 (1796) 0.3 (1324) 0.5 (422) 1 (107)

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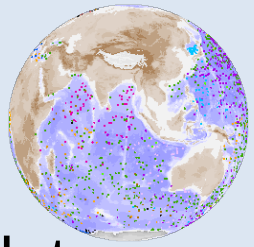
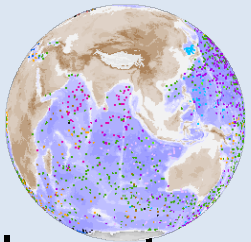
Challenges



- Sustaining our achievements and delivering fully on data quality and completeness
- Evolving to meet new needs and to exploit new technologies without endangering progress to date
- Working with other elements of the Global Ocean Observing System on network design and data management. Argo cannot become the global ocean profile data system, it is just one element
- Spatial completeness remains subject to both technology advances but also regional political advances in data sharing and cooperation.

Summary



- GOOD NEWS: Argo currently is operating well and largely achieving its goals and piloting enhancements
- BAD NEWS: several major contributors may have declining resources.
- The coming decade will see Argo extended into the deep ocean, marginal and coastal seas(?), and seasonal ice zones, and including new biogeochemical sensors
- Argo needs your help in evolving its new design to be: scientifically rigorous, realistic (robust technology) and multi-application (value for investing nations).
- Euro-Argo is an essential partner and is already helping to advance on many of these challenges.