On the future of Argo: A global, full depth, and multi-disciplinary array

OO'19 CWP by the international Argo community and Argo Steering Team

Journées LEFE/GMMC 2019, 12-14 juin, Toulon

International community

78 authors
51 institutes
21 countries

France contribution:

12 authors, 2 leading
Ifremer, CNRS, Univ. de Brest et Sorbonne
LOPS, LOV, LSCE

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2018-12-24 4155 active floats

Argo key achievements

The infrastructure

+15 800 floats deployed

+3 000 monthly active floats since 2007

Global coverage, 350 ships mobilised

32 float models, 20 sensor manufacturers

The data

2.1 millions of Temperature/Salinity profiles

Open, free & live data stream

100% quality controlled

11 coordinated Data Centers

The science

3613 research papers

1 paper/day since 2014

Essential to any ocean state reports

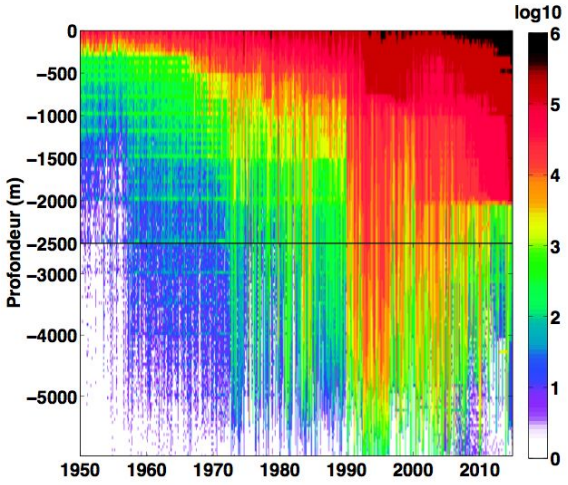
Essential to ocean model evaluation and development

A new array to reach new scientific frontiers

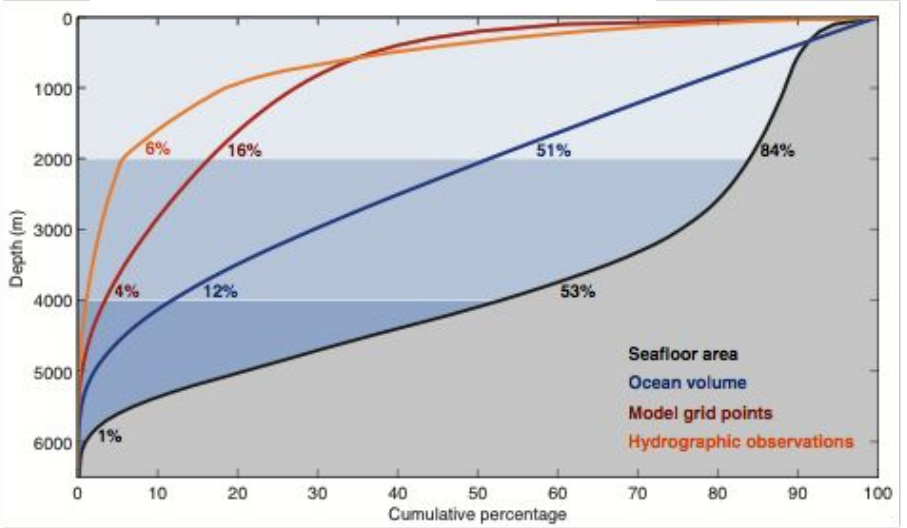
49%

The fraction of ocean volume **NOT** observed by Argo

The deep ocean, below 2000m, remains largely unknown away from sparse hydrographic sections and mooring sites



Measurements coverage in CORA



De Lavergne et al, Nat., 2016

The deep ocean, below 2000m, remains largely unknown away from sparse hydrographic sections and mooring sites

Deep Argo's scientific objectives are:

- to close the Earth's budgets of heat and freshwater,
- to assess the steric contribution to sea level rise,
- to improve our understanding of full-depth ocean circulation and water-mass transformation in the ocean interior,
- and to reduce uncertainties in coupled atmosphere-ocean models, reanalyses, and predictions

26%

The fraction of the anthropogenic carbon released to the atmosphere that is currently taken up in the ocean

Regional and global scale understandings of ocean biogeochemistry are missing

Changes produced by ocean warming, acidification, and deoxygenation will influence ecosystem functioning, and these changes may result in significant economic and non-economic costs to society

BGC Argo's scientific objectives are:

- to constrain processes controlling global oxygen, carbon and nitrogen distributions,
- to monitor ocean acidification,
- to quantify the strength of the biological carbon pump and its variability
- to support initialisation and validation of biogeochemical models, reanalyses, and predictions.

Major research and management topics and sensors applicable to topics

To reach these objectives, BGC-Argo will implement the monitoring of 6 variables

http://biogeochemical-argo.org

Research and management topic	O_2	NO_3	pH	Chla	Suspended particles	Downwelling irradiance
Carbon cycle						
Anthropogenic carbon uptake by the ocean	•	•	✓			
Variability in the biological pump	✓	✓	✓	✓	✓	✓
Variability in NCP	✓	✓	✓	✓	✓	✓
Mesopelagic respiration	✓		✓	✓	✓	
Particulate export				✓	✓	
Ocean deoxygenation/ denitrification	✓	✓	•	✓	✓	
Ocean acidification variability	•		✓		•	
Effects of changing carbonate saturation state.	•	•	✓		•	
Marine resource management	✓	✓	✓	✓	✓	✓
Reducing error in ocean carbon budget	•	•	✓		•	
Ocean Color validation				✓	✓	✓

Developing Deep-Argo & BGC-Argo

France leading efforts

ERC REMOCEAN

To address the causes of variability in the so-called biological oceanic pump in key oceanic areas. Development of profiling floats to measure oceanic variables essential for the characterization of phytoplankton dynamics and related carbon fluxes

1st operational Provor-BGC float

AST endorses new design including Deep and BGC extensions

2010.06 | 2011.06 | 2012.12 | 2014.05 | 2019.03

Equipex NAOS

To consolidate and improve the French contribution to the international Argo observing system and to prepare the next scientific challenges for in-situ monitoring of the world ocean

1st operational Deep-Arvor float

Worldwide efforts with key leadership

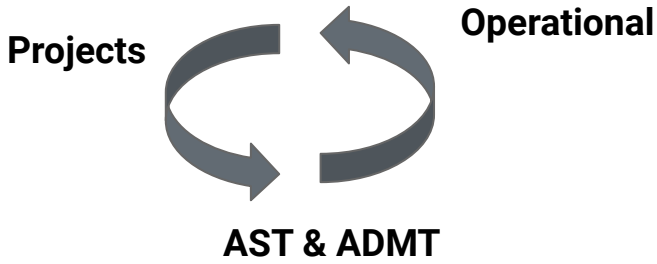
Along with France, the Deep-Argo technology was furthermore developed in the USA (SIO and Univ. Washington) and Japan (JAMSTEC) while the BGC technology was also developed in the USA (SIO, MBARI, Princeton…)

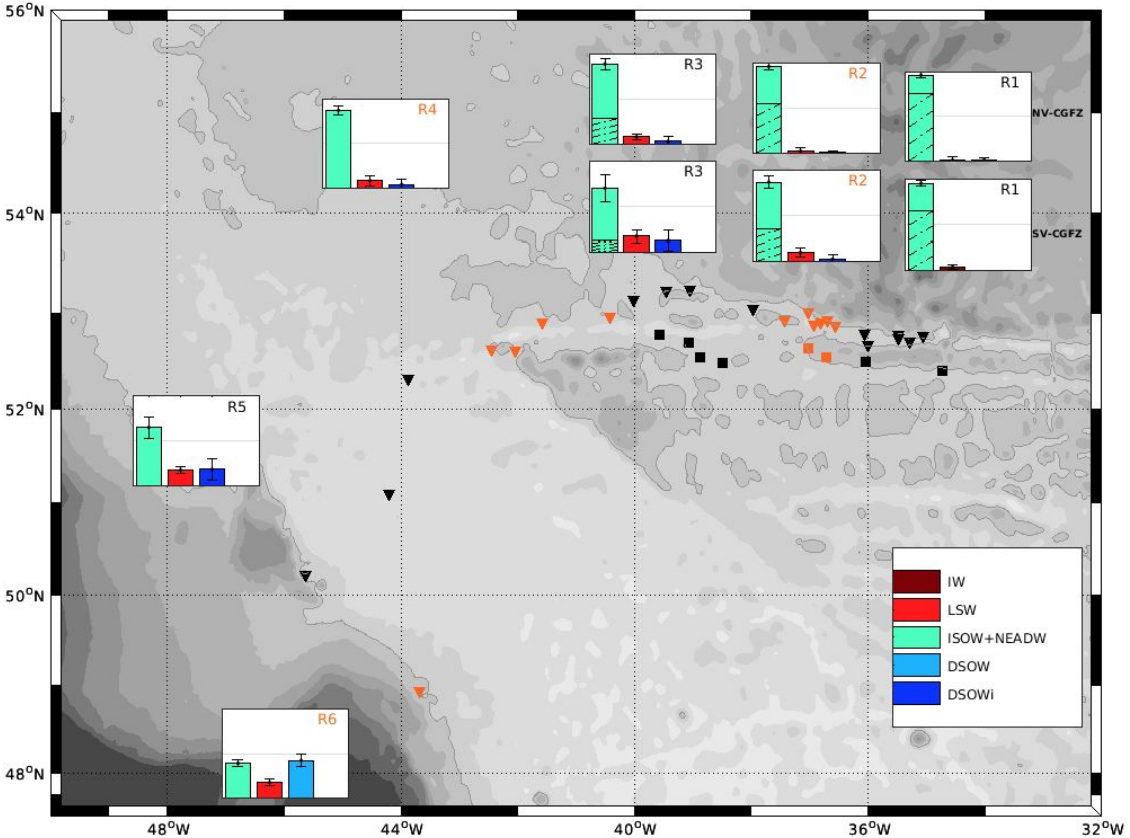
Successful pilot experiments initiated in the Pacific, Atlantic and Southern Ocean

Several workshops, community white papers and implementation plans published over the last 10 years.

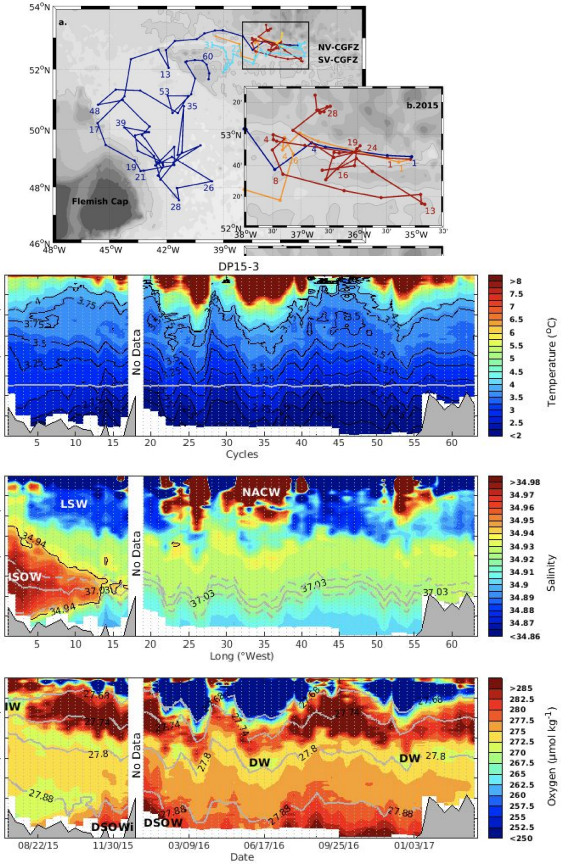
Extension developments were fully explained, motivated and reported on an annual basis to the Argo Steering Team and Argo Data Management Team.

This muted into an iterative process ultimately leading to the extensions readiness to fully integrate with the Argo historical mission.



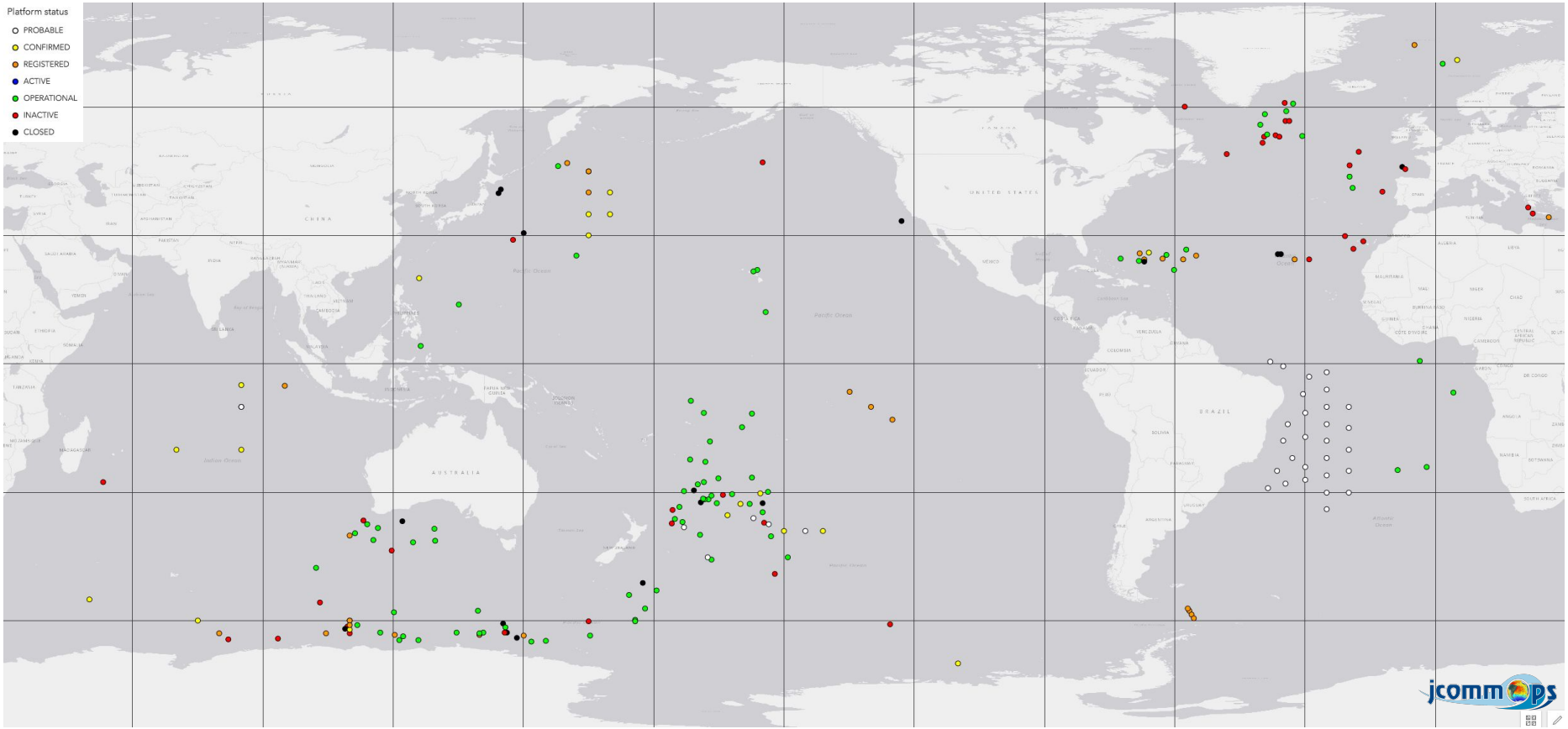


Racape et al, 2019



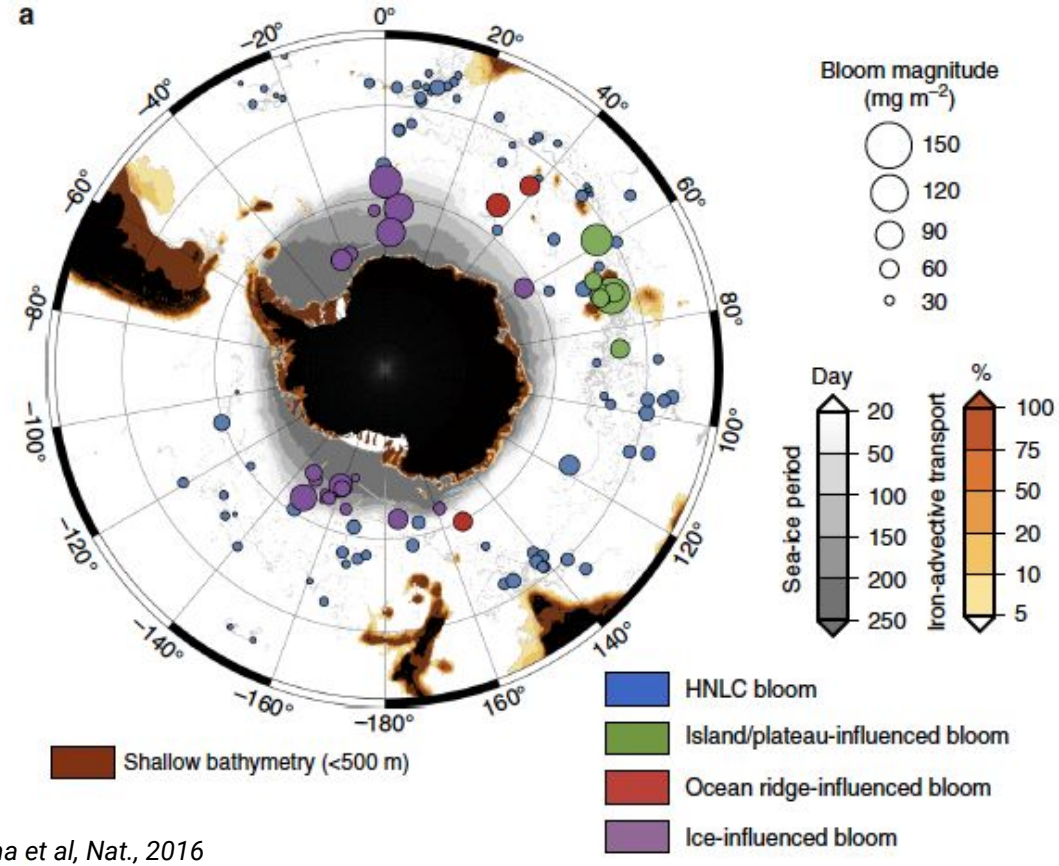
Deep-Argo first results

Deep-Arvor deployed in the North Atlantic subpolar gyre
Charlie-Gibbs Fracture Zone



Deep-Argo array as of today: **80 active floats, 49 planned**

Target: 1200 floats

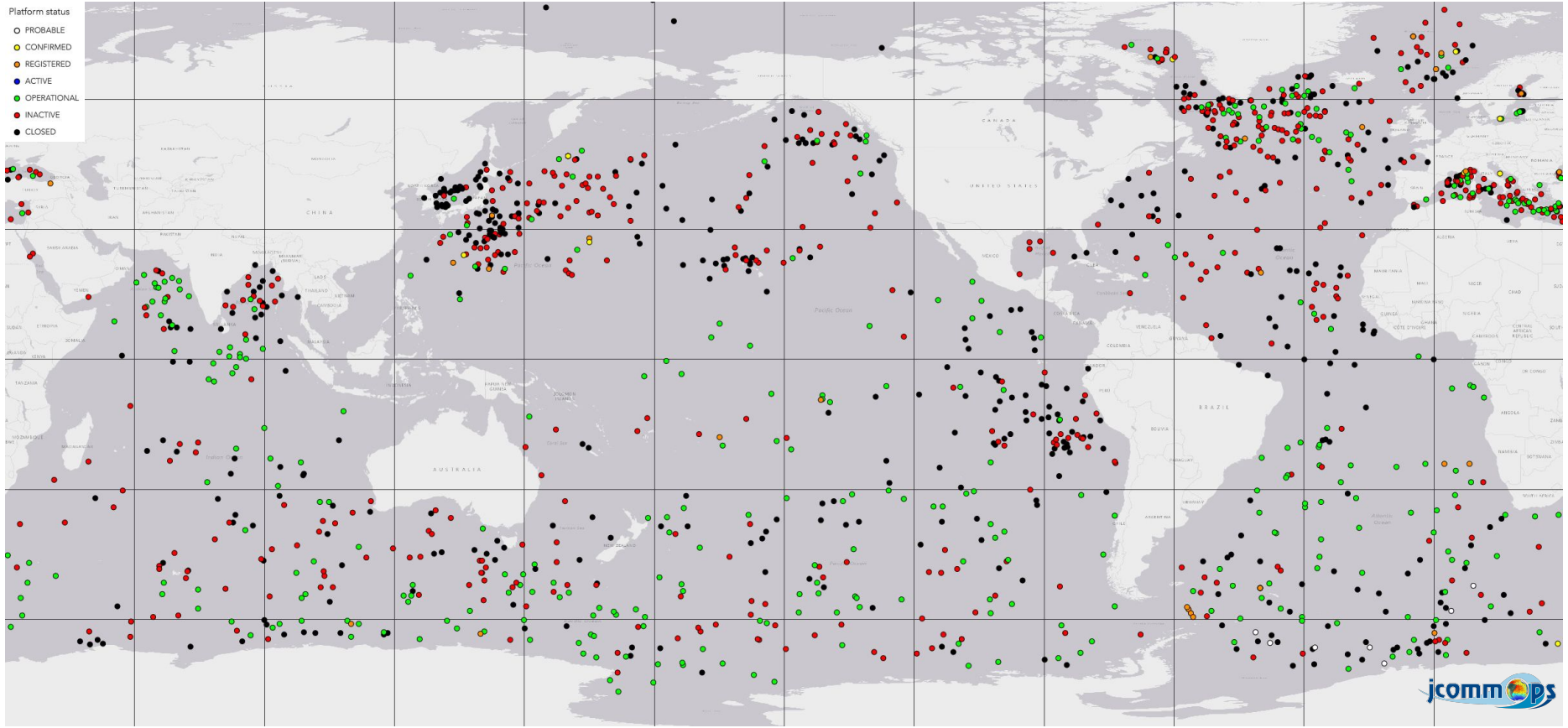


Ardyna et al, Nat., 2016

Improved understanding of blooms in iron limited regions

Hydrothermal vents trigger massive phytoplankton blooms in the Southern Ocean

More bibliography at:
http://www.argo.ucsd.edu/Bibliography_BGCArgo.html



BGC-Argo array as of today: **361 active floats, 47 planned**

Target: 1000 floats

Challenges deep-dive

Sustainability

Going deep

Going green

Make the core Argo mission a long term success

Secure operations funding

Improve float performances

Sustain quality sensor procurements

Maintain reliable and responsive Data Centers

Accurately observe the full water-column

Ensure large production of robust and cost-effective deep floats

Procure the array with accurate and stable sensors, to the WOCE quality standards

Develop specific quality control procedures

Entail a new oceanographic revolution

Ensure large production of reliable and cost-effective BGC floats and sensors

Create quality control procedures from scratch

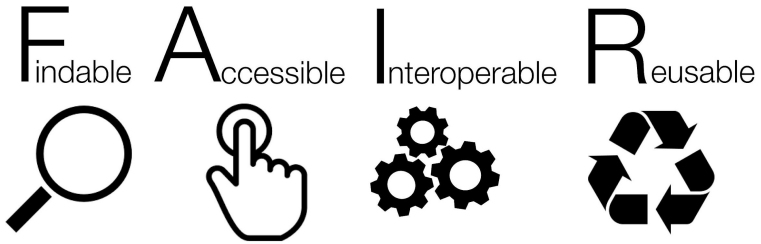
Strong national commitments for implementation

A framework for new developments and further extensions

The Argo community is preparing for even more

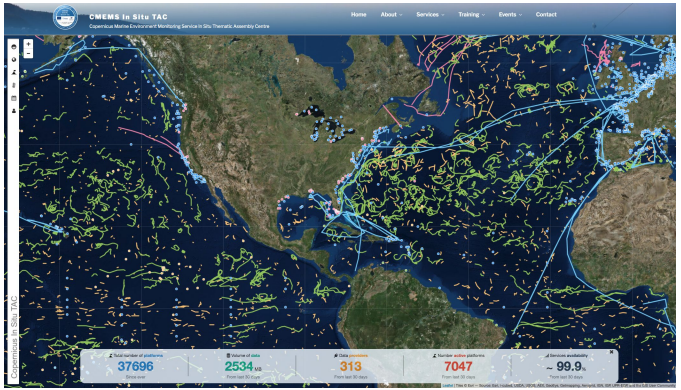
Data management and distribution

The Argo Data Management Team is implementing a framework to make Argo data:



Argo is constantly working on new end user services to better fulfill their needs

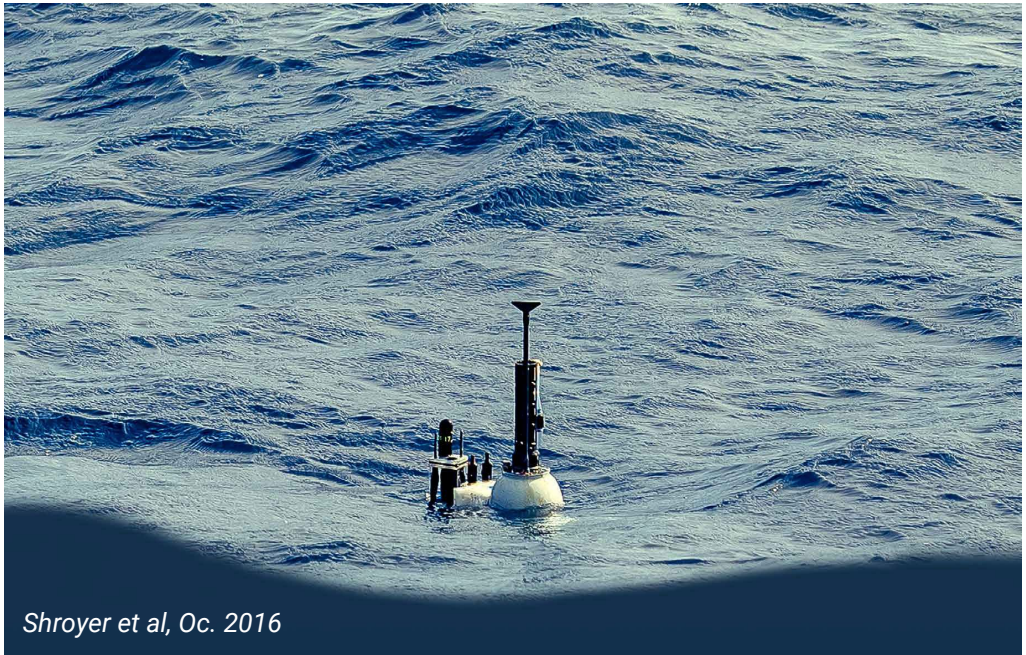
Eg: the new CMEMS In Situ TAC web service, see poster #55



The Argo community is preparing for even more

As new sensors develop, new opportunities arise

In the CWP a new enhancement is suggested for possible future inclusion in Argo, consisting of:
direct shear and scalar microstructure (turbulence) measurements



Shroyer et al, Oc. 2016

The Argo community is preparing for even more

Improved resolution in critical regions

- **Seasonal Ice zones**. Float reliability in the sea-ice zone has been shown. But a remaining challenge is the accurate estimate of location.
- **Marginal Seas**. Operating a float array in enclosed seas has been shown to be feasible, and will require a modest amount of floats. However, implementation requires active and strong logistical and political support from coastal
- **Tropical enhancements**. Heavily rely on moorings difficult to sustain. Securing observations of these regions require a double Argo density.
- **Western Boundary Currents enhancements.** With high levels of mesoscale variability, a double Argo density in WBC is a first step to better constrain the variability of these circulation choke points.

Impact

Improved ocean knowledge

Enlarge user community

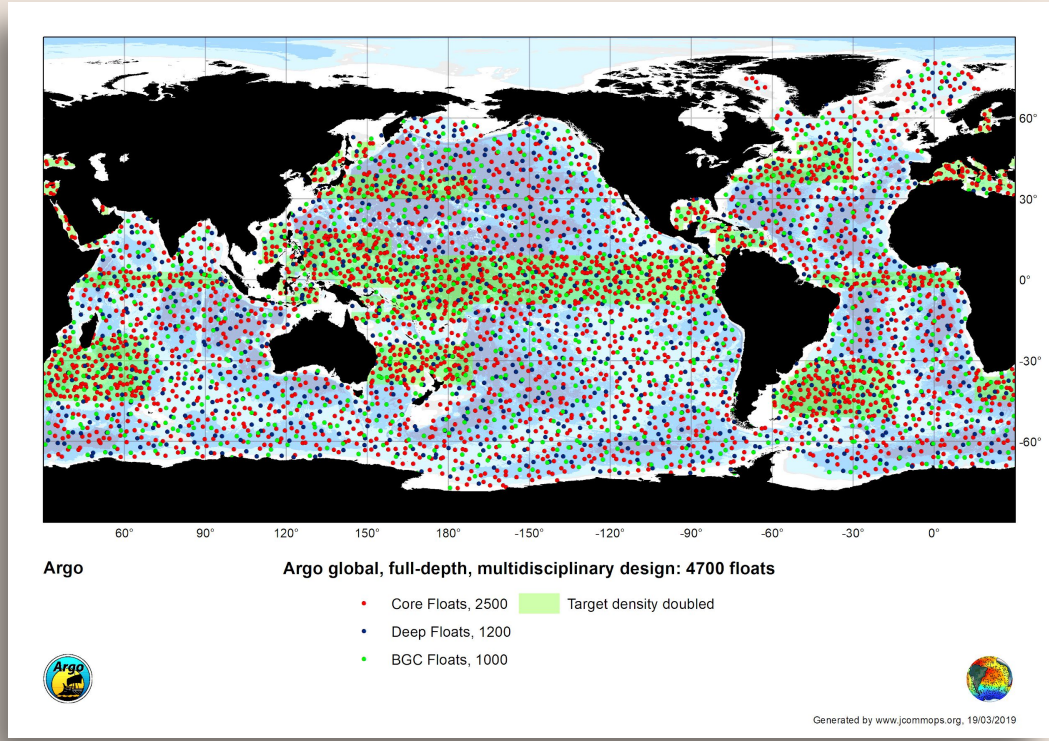
Strengthen link with society

From 3000 to 4700 active floats

2500 core, 1200 Deep, 1000 BGC

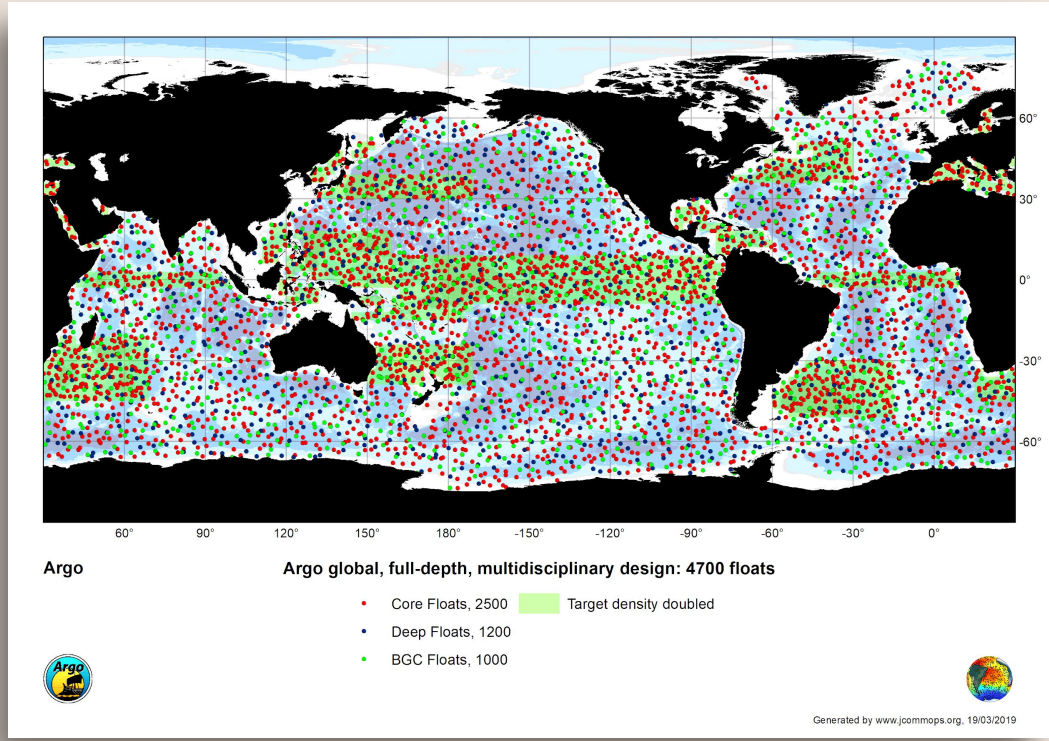
From 2 to 8 parameters

Double observed volume



How to support the new Argo design ?

- Engage with the Argo community
- Talk about it
- Ask GMMC to deploy new type of floats
- Help us to lobby for recurrent funds
- Use the data
- Cite Argo DOI (10.17882/42182)



Argo-France: activities

Développement du flotteur

Industrialisation

Coordination nationale
du programme + TGIR
Euro-Argo

Achat

Stockage, recette

Coordination des déploiements

Suivi à la mer

Stockage, recette, déploiements BGC

DAC T/S
réception, décodage, RTQC

DAC BGC (en cours de mis en oeuvre)
réception, décodage, RTQC

GDAC
assemblage, distribution

DMQC des flotteurs français

Centre Régional Argo Nord Atlantique
cohérence DMQC pour l'Atlantique Nord

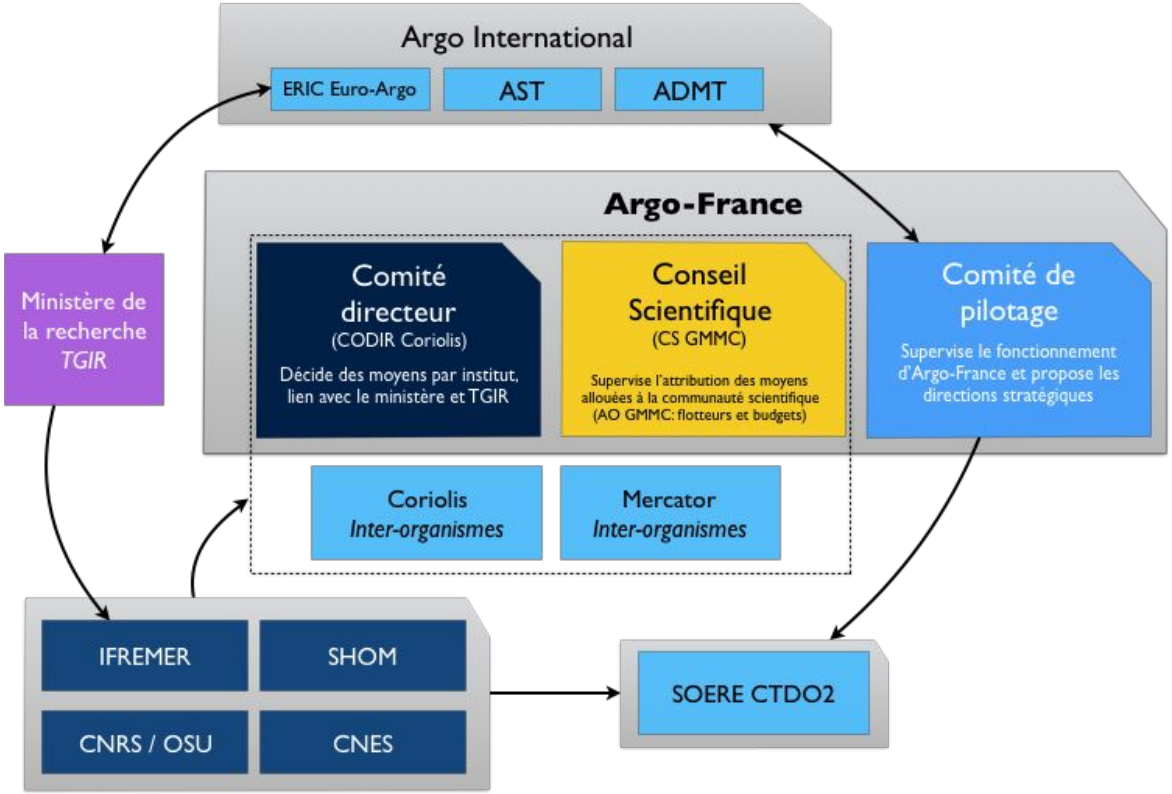
Animation scientifique
mailing list, AO LEFE/GMMC, bibliographie, meetings, ...

Représentation internationale
ADMT, AST, ERIC Euro-Argo, DMQC, BGC Argo

R&D et travail communautaire
accompagnement, veille, expertise , outils/méthodes, ...

Valorisation
produits L1/L2/L3, ISAS, ...

Argo-France: governance



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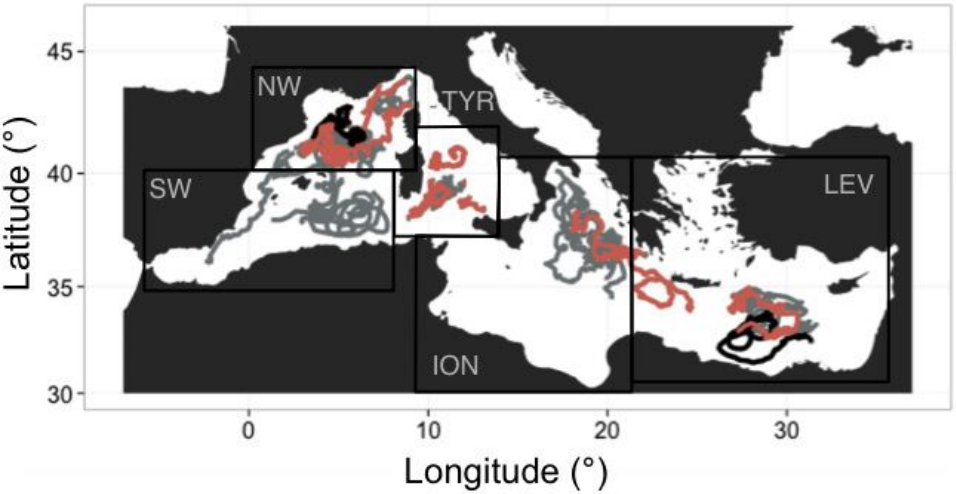
Experts ad hoc



Deep chlorophyll maximum formation mechanisms

Improved regional understanding through basin scales studies

Barbieux et al, Biog., 2019