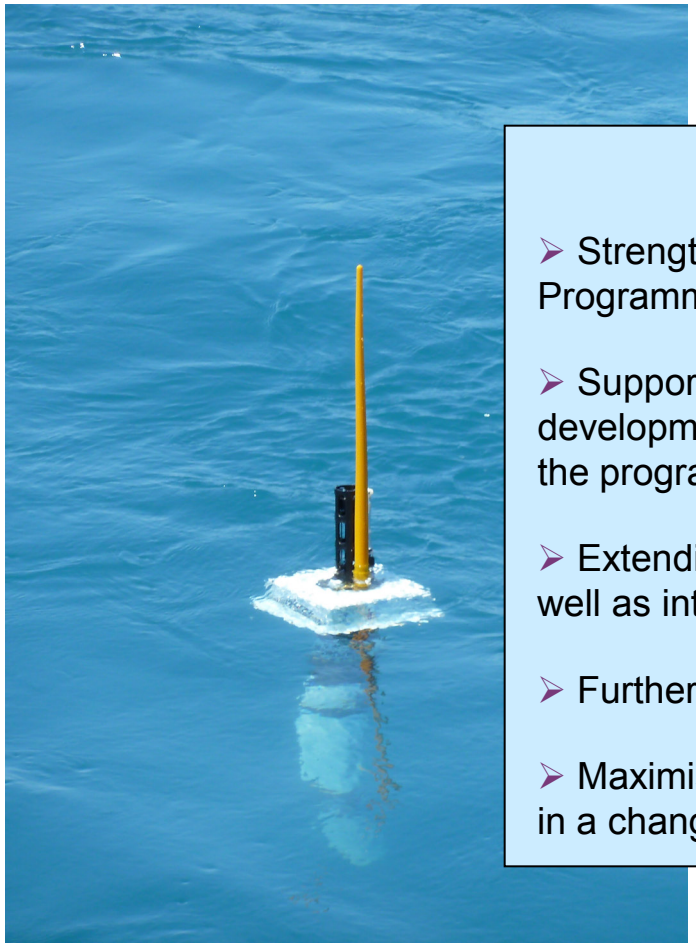
New phase of Argo in Europe: strategy and implementation issues



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Main goals:

- Strengthening Europe's role in and contribution to the **global Argo** Programme
- Supporting the implementation of the EU Marine Policy through the development and subsequent incorporation of **biogeochemical** sensors into the programme
- Extending spatially the observations into the **European and Polar Seas**, as well as into the abyssal parts of the oceans
- Further developing the existing **data management** system
- Maximising the relevant **knowledge** of the Seas and Oceans, e.g. their role in a changing climate.

Euro-Argo Requirements

Euro-Argo needs to meet requirements from the **research** and **operational** (Copernicus) oceanography community in Europe with a **focus on European Seas**. This requires adaption of the 'Core Argo' design to these needs and **evolutions in array design, float technology and data systems**.

In particular the European research community will need refinement of Argo strategy and technology in the following areas:

- **Monitoring of European marginal seas**
- **Monitoring of high latitudes**
- **Monitoring of the near surface oceans**
- **Monitoring of the abyssal oceans**
- **Monitoring of ecosystem parameters**

Mediterranean Sea

Main requirements/recommendations:

Maximum profiling depth of 2000 m at every cycle or every two cycles, with a short 700 m profile in between. Cycles of **5 days**. Parking depth between 300 and 400 m to track the LIW

Argos-3 or Iridium **2-way telemetry** to reduce surfacing time and probability of hazards (stranding, theft by seafarers, etc.)

Need to set up a link with ship agencies that operate R/Vs in the Mediterranean and seek ships of opportunity for more **effective deployments**.

Need to establish **collaboration** with all Mediterranean countries (especially in Africa and Middle East) to maintain basin-wide geographical coverage (by deploying floats in the waters and recovering stranded instruments on their coasts)

Some floats should be equipped with optical sensors to monitor dissolved **oxygen** and other **biogeochemical** parameters (typically 20-25% of the array).

Operate **deep** floats in specific deep areas to monitor abyssal properties and close basin budgets of heat and salt.

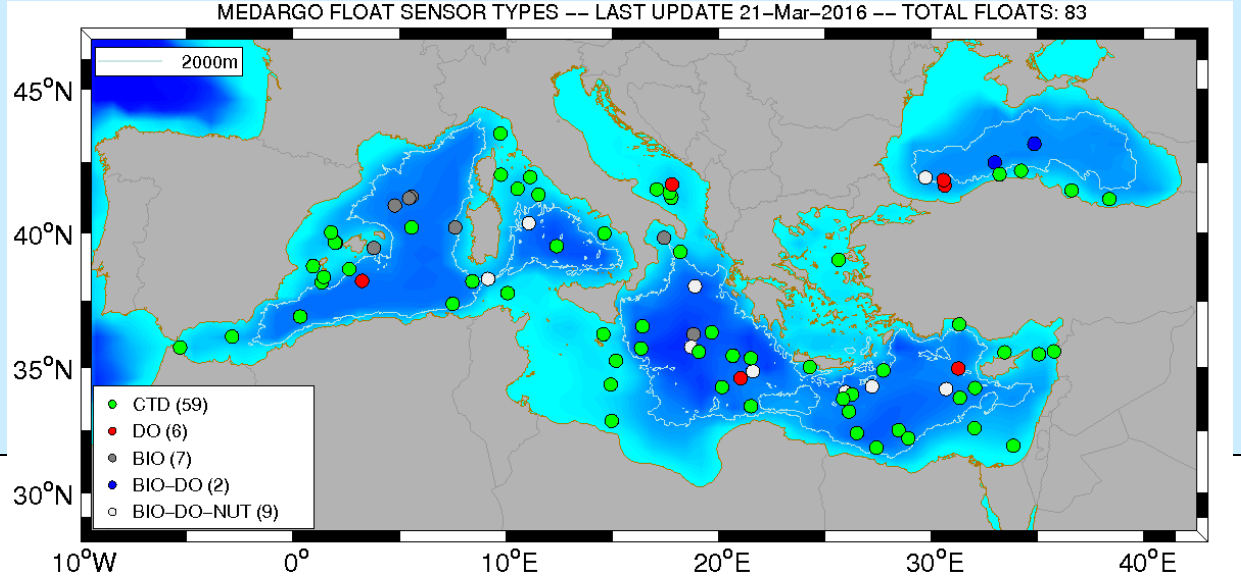
Mediterranean Sea

Main goals (target):

Maintain a network of **60 Argo floats** in the Mediterranean (i.e. about twice the standard global Argo density) for providing a better understanding of temporal and spatial variations in each sub-basin. In order to achieve this goal, about **30 floats should be deployed every year**. All floats should use Iridium or Argos-3 telemetry. Furthermore, about 15 instruments (25%) should be equipped with biogeochemical sensors. A few deep floats should be operated.

Current status:

More than 70 floats are active in the Mediterranean (contributions from 8 countries), including 52 floats with Iridium telemetry,15 bio floats and 4 floats with DO sensors. Deployments of deep floats are planned for 2016 and 2017.



Implementation achieved, but non-uniform sampling!

Black Sea

Main requirements/recommendations:

Similar to those of the Mediterranean.

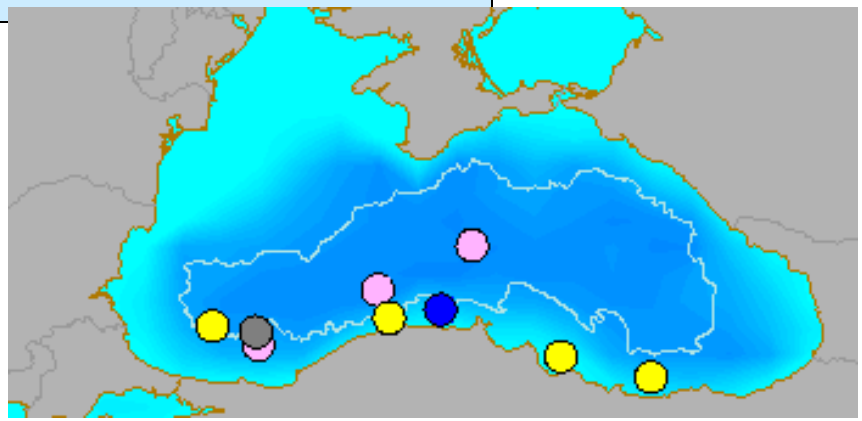
Main goals (target):

Maintain a network of **10 Argo floats** in the Black Sea. All floats should use Iridium or Argos-3 telemetry. Furthermore, about 3 instruments (25%) should be equipped with biogeochemical sensors.

Current status:

9 floats are active in the Black Sea (contributions from 4 countries), including 5 floats with Iridium telemetry,3 bio floats and 2 floats with DO sensors.

Implementation quasi-achieved, but non-uniform sampling!



Baltic Sea

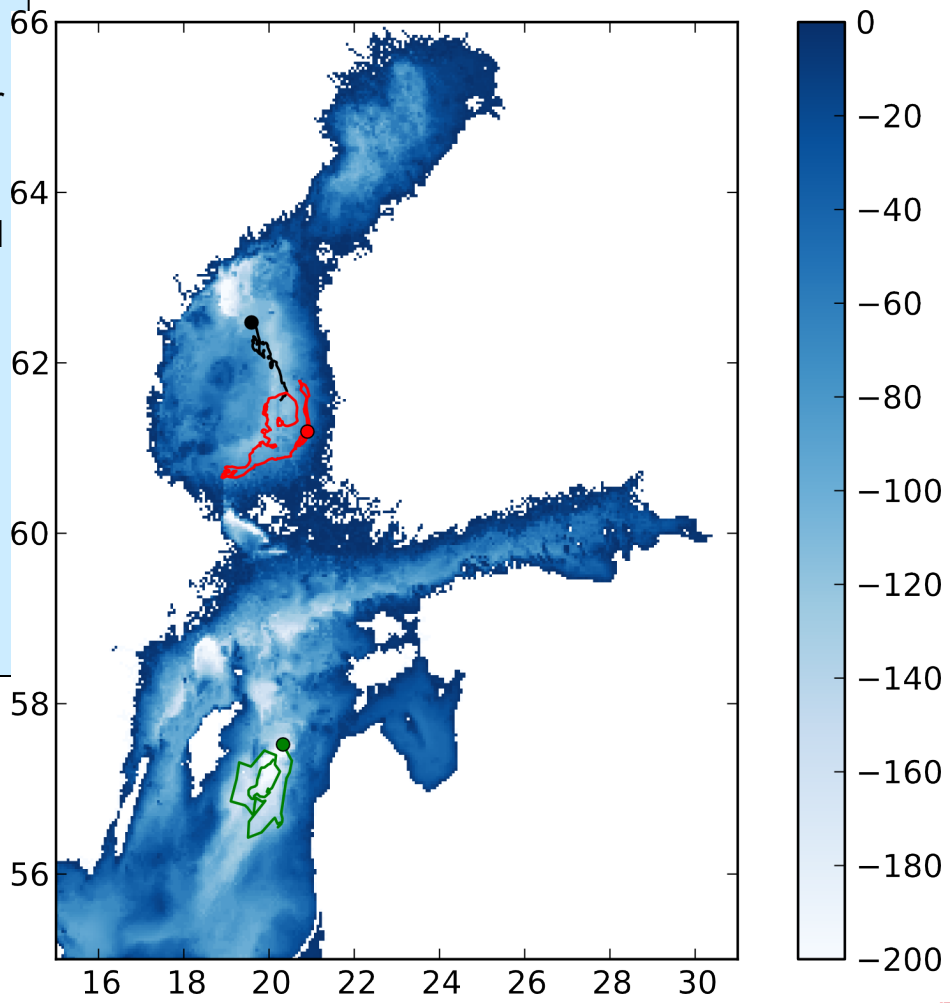
Main requirements/goals:

Ideally, the Baltic Sea Argo network should cover all major basins of the Baltic Sea but in practice sufficient network would include one float in the Bothnian Bay, two floats in the Bothnian Sea and four floats in the Baltic Proper. So, in total we need **9 floats**, including some of them with BGC sensors.

Current status:

2 floats are active (operated by FMI). Poland plans to deploy floats starting in 2016.

Implementation in progress!



Nordic Seas

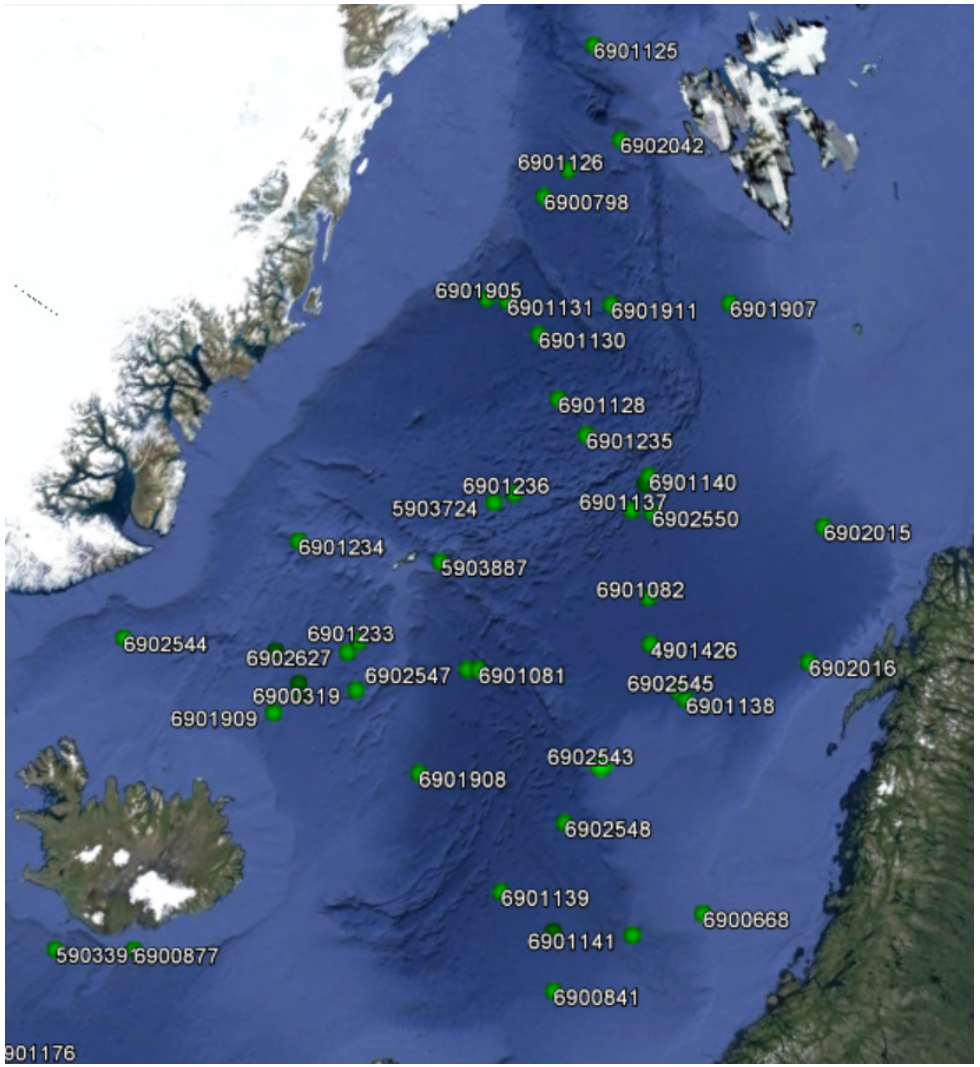
Main requirements:

A total of **39 floats** should be active in the Nordic Seas. 29 of the floats should be operated within the deep basins and 10 floats within the boundary currents. With an approximate life time of floats of 3 years in the deep basins and 2 years in the boundary currents **9-10 deployments per year** are needed in the deep basins and 5 deployments in the boundary current.

Current status:

About 23 floats are currently operated in the Nordic Seas (contributions from EU and US), including some bio floats.

Implementation in progress!



Arctic Ocean

Main requirements:

Continue European contribution to provide ice tethered platforms.

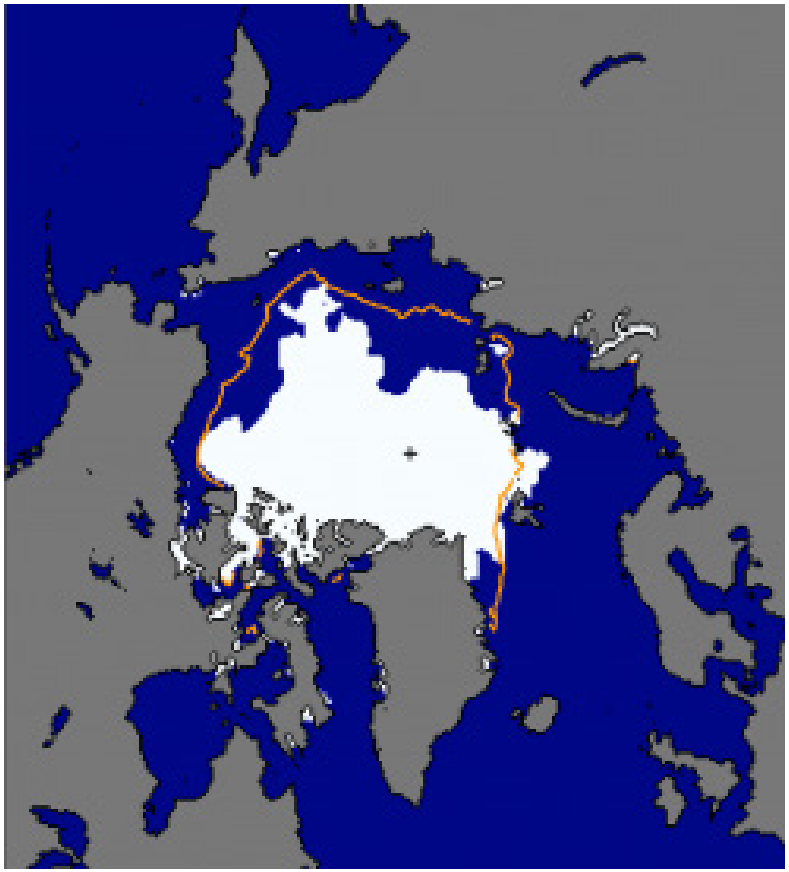
Utilize standard Argo-floats in ice free shelf areas.

5 floats in ice-free areas!

Pilot project with international partners (US, Canada)

Current status:

Several tethered platforms but no Argo floats



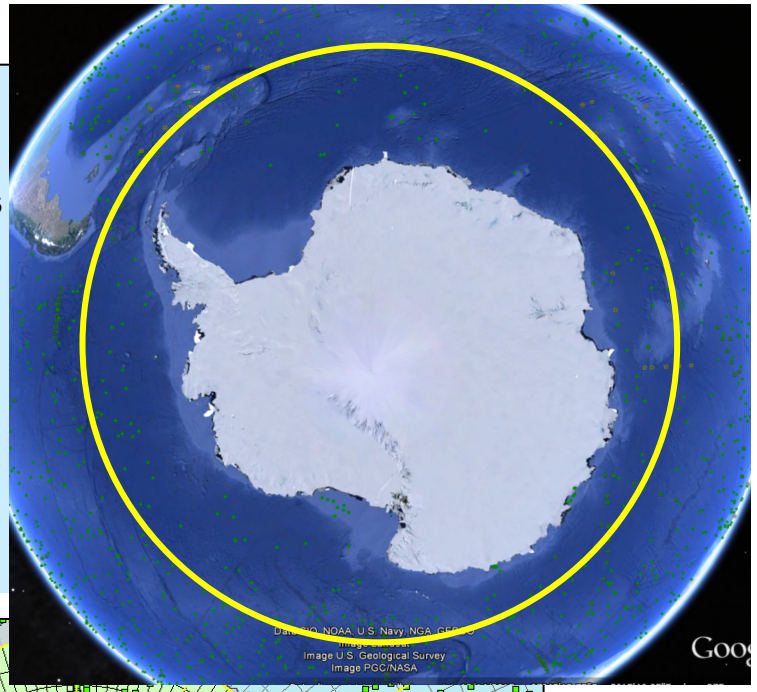
To be implemented!

South of 60°S (Weddell Sea)

Main goals:

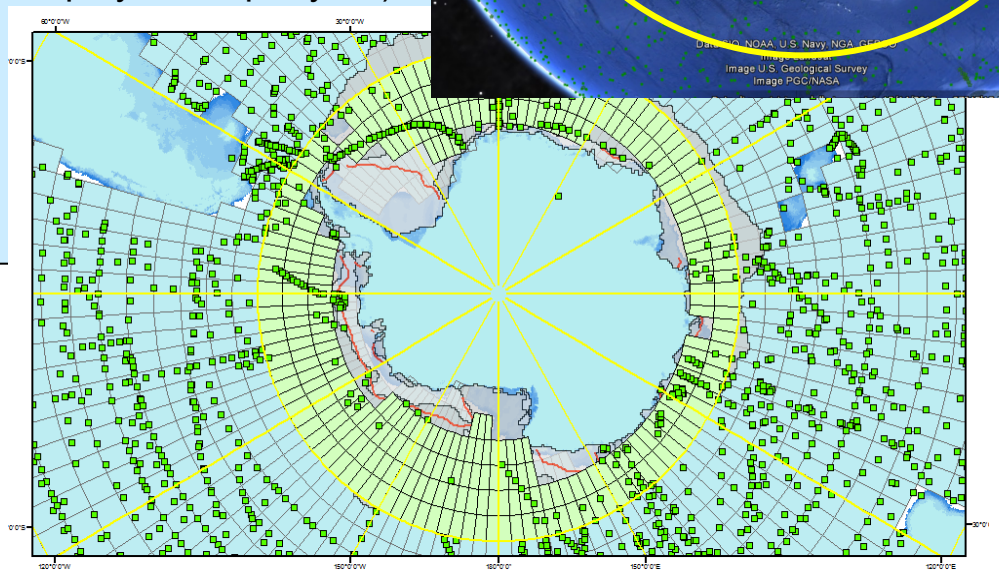
To extend Argo to beyond 60°S in the seasonal ice zone at the nominal core Argo design density would require **320 active floats in the Southern Ocean**. These calculations are based on the number of floats required to populate the area between 60°S and the fast ice edge with an assumed profiling depth of 2000 m.

Due to the strong research interest of European scientist in the Weddell Gyre and the already installed RAFOS array this area is one of the chosen places for a European enhancement of the global Argo. **81 floats should be active in the Weddell Gyre** based on the nominal design density (25 deployments per year).



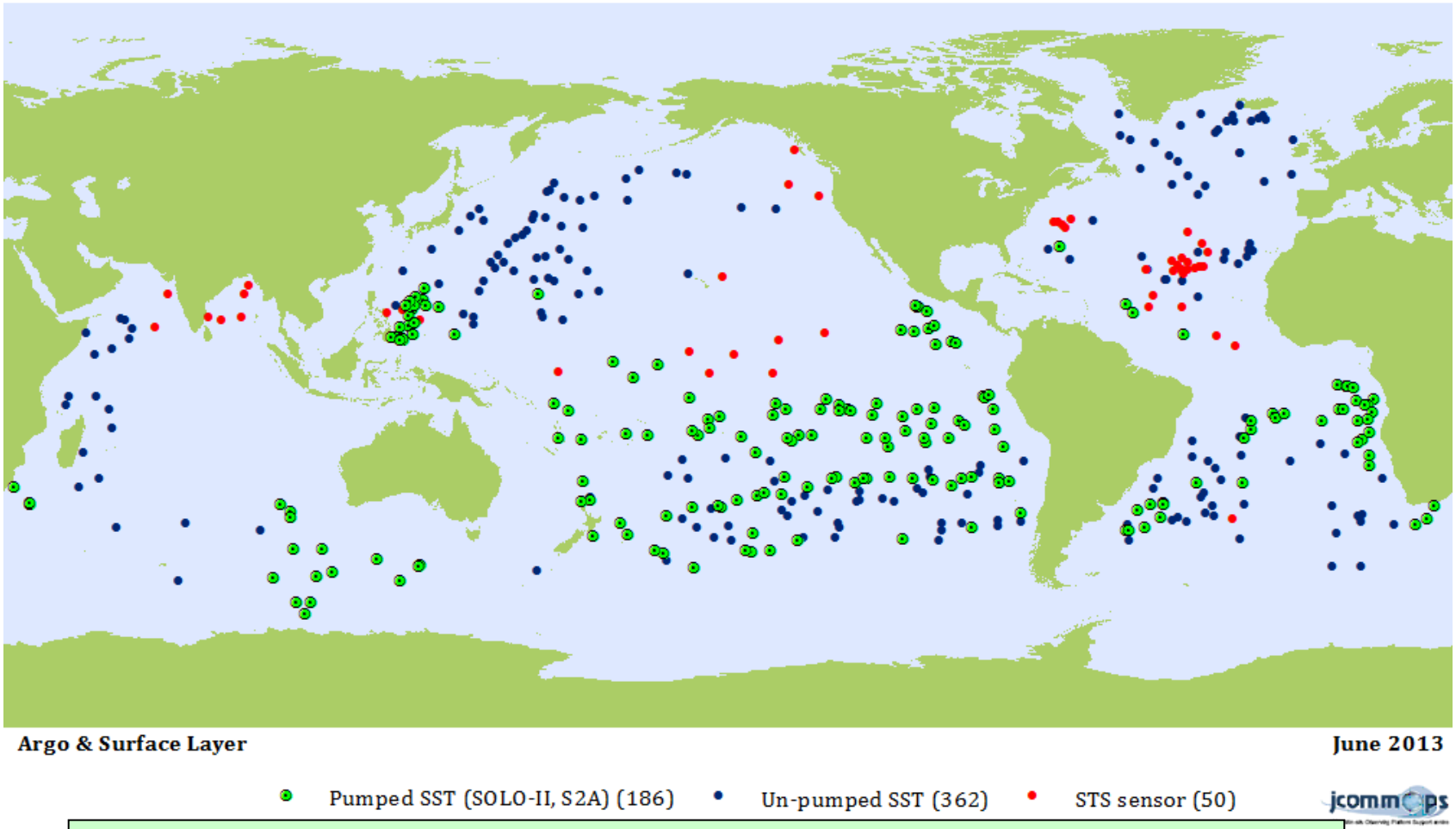
Current status:

Reasonable quantity of floats south of 60°S and some outside Weddell Sea



Implementation?

Near-surface temperature & salinity profile measurements

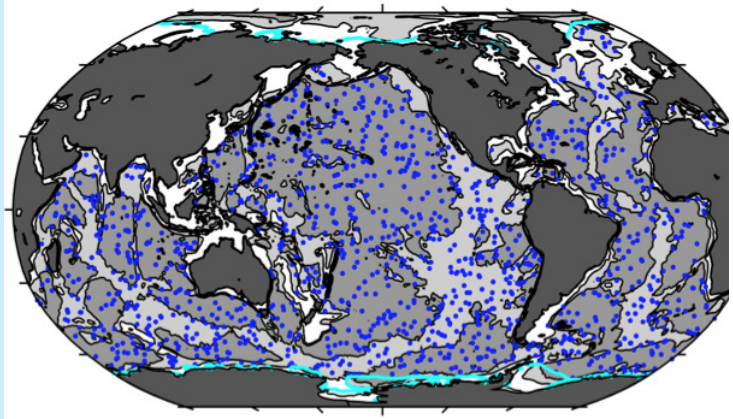


Implementation in progress (higher vertical resolution nearer to surface, additional un-pumped CTD)

Abyssal Oceans

Main goals:

The Deep-Argo array is about 20% of the international target (240 floats). Considering a life-time of 150 cycles (without O2 sensor, 130 cycles with O2) and a 15-day-cycle, the float life time is about 6 years. The European target could be to deploy **40 floats per year**, or for the next 4 years to **upgrade 50** of the 200 core Argo floats to Deep-Argo floats (that is 25% of the core Argo floats).



Focus the European deployment where large deep signal are located, that is where deep-water masses are formed, namely the **North-Atlantic Ocean and the Southern Ocean**.

Technical Developments:

to demonstrate that deep Argo floats can routinely meet the **mechanical requirements** of deep profiling and lifetime survival

to demonstrate that the sensors have the required quality (**stability and accuracy**) to meet the scientific needs identified by OSSE (Ocean Observing System Experiments)

to develop a rigorous **data quality procedure** that satisfies the criteria for climate studies in the deep ocean and the careful collection of a reference database for the quality control of the data.

Implementation started. Still some technical issues

Biogeochemical floats (BGC) floats in World Ocean

Requirements:

Development of profiling floats that allow the measurement of key variables of biogeochemical and ecosystem relevance (i.e. **oxygen, chlorophyll, backscattering, and nitrate**). In the future, an intensification of the measurements of these four variables by bio floats would permit the elaboration of a unique data set, with which key questions in the role of the ocean in climate could be addressed.

The overall array, realizing true multi-scale sustained observations of global marine biogeochemistry and bio-optics, should satisfy the requirements for **validation of ocean color remote sensing** as well as the needs of a wider community investigating the **impact of global change on biogeochemical cycles and ecosystems**. A first target would be to start with the implementation **20% of the Argo floats** with these measurements within a five-year term.

Technical developments:

Add additional parameters:

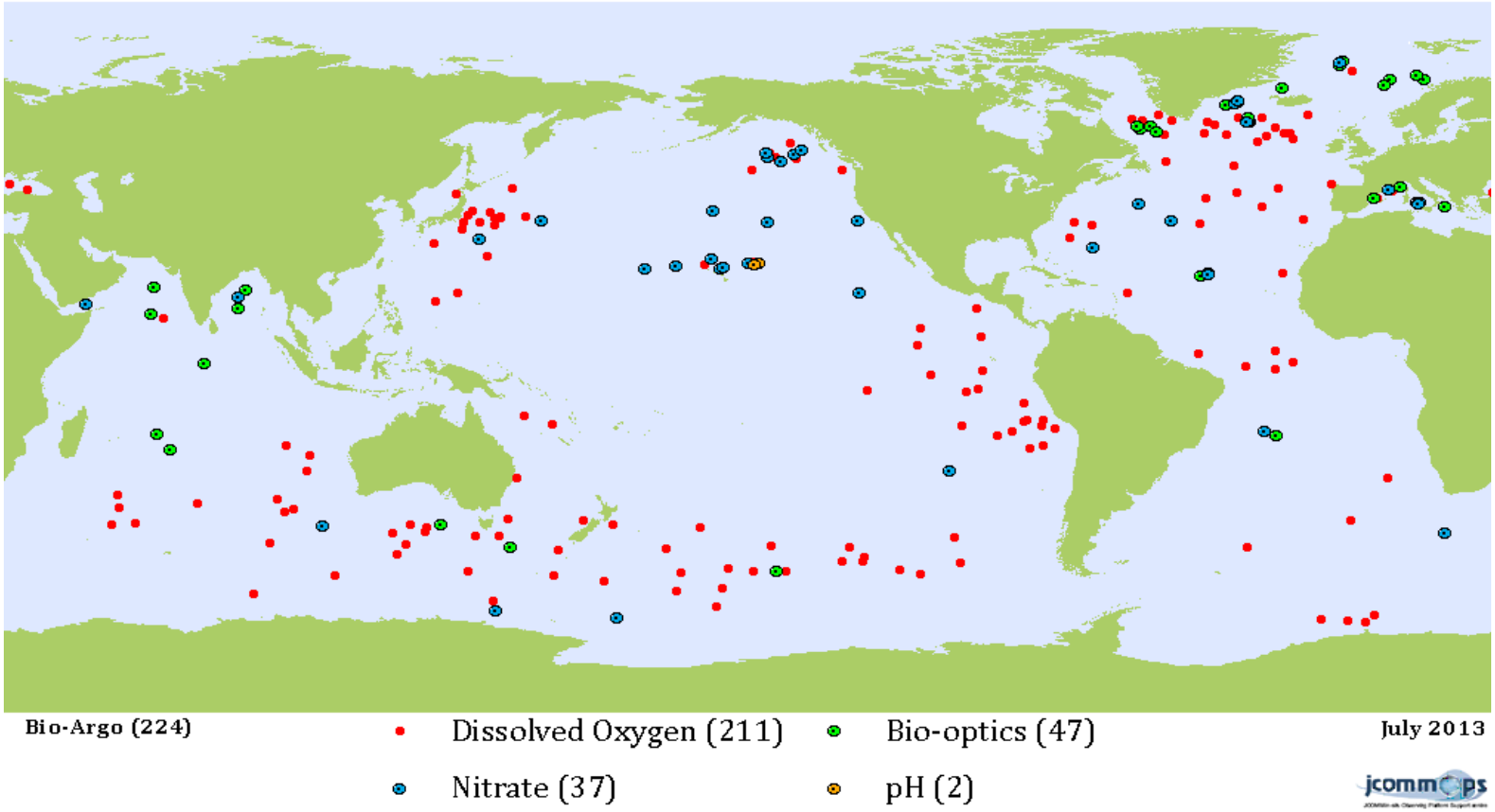
Beside the first four variables to be implemented on the developing Bio-Argo array (Oxygen, Chlorophyll a, backscattering, nitrate), there are important additional measurements, some of them ready for implementation on the array, that are required for a proper observation of biogeochemical cycles and ecosystems. These include:

Carbon/pH sensors for e.g. measuring ocean acidification.

Irradiance sensors for primary production estimate

Acoustic/optical sensors for measuring the zooplankton

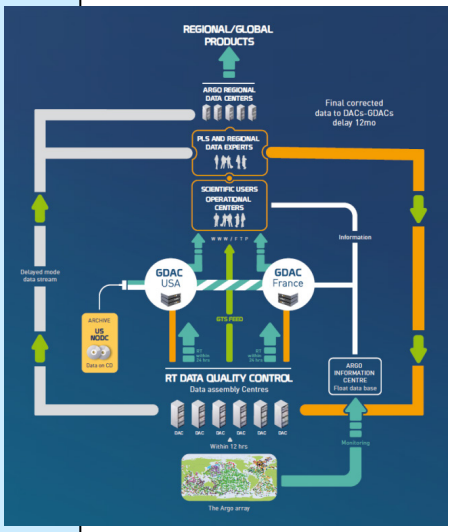
Biogeochemical floats (BGC) floats in World Ocean



Implementation in progress. Pilot experiments in Med (NAOS, Argo-Italy) where > 20 % are BGC floats.

Data Management

Main goals:



Improvements of float technology will require **data transmission modifications**, enhancement of the floats format to integrate the new variables. The two Euro-Argo DACs (Ifremer/Coriolis and BODC) will be upgraded to process the new floats including new biogeochemical parameters.

For the **new parameters** real time data quality control will need to be defined by the research teams, turned into operation by the Euro-Argo DACs after agreement within the International Argo Data Management Team.

Sampling marginal seas, abyssal oceans, boundary currents, near surface layer, or partially ice covered regions will require **additional delayed validation activities** to assess and eventually propose modifications either in the real time or in the delayed mode procedures.

Finally to reach the requirement of the climate community and have the capability to build Climate Ocean indicators from Argo data, **reprocessing in delayed mode** of the Argo data should be envisaged.