National Strategy for Argo Global Network Profiling floats Deployments

Argo France Steering Committee

Ref : AF-2019-DEP-STRAT

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Version 7.0 – 05/04/2022

History

Authors	Update	Dated
N. Kolodziejczyk, T. Carval, H. Claustre, F. D'Ortenzio, N. Lebreton, P.-Y. Le Traon, G. Maze, N. Poffa, S.Pouliquen, A. Poteau, C. Schmechtig, et V. Thierry	Creation – v6.1	13/02/2019
N. Kolodziejczyk, X. André, T. Carval, H. Claustre, F. D'Ortenzio, N. Lebreton, P.-Y. Le Traon, N. Poffa, S.Pouliquen, A. Poteau, C. Schmechtig, R. Sauzède, V. Thierry	v 7.0	06/04/2022

Table of Contents

1 Background and Objectives

1.1 Background

To ensure the maintenance of the international OneArgo network (Roemmich et al., 2019) of autonomous profiling float (www.argo.net), France is committed to contribute to deploy a significant part of the global network (around 10%). The profiling floats of the Argo France program are funded by Ifremer and SHOM, supported by the French “Ministère de l’Enseignement Supérieur, de la Recherche et de l’Innovation'' funding via the “Très Grande Infrastructure de recherche” (IR*), “Contrat de Plan État-Région” (CPER), PIAs projects such as Equipex NAOS or Equipex+ Argo2030, and CNES. These purchases are part of the Coriolis inter-agency partnership. Between 50 and 70 T/S type profiling floats, so called “Core Argo” (Temperature/Salinity), T/S/DO (Dissolved Oxygen), Deep (“Deep Argo”) and BGC (Biogeochemical, “BGC Argo”) are purchased each year. A special feature of the Argo-France program is that these profiling floats are then made available to the national scientific community via the annual call for scientific proposal in the INSU/CNRS's LEFE/GMMC framework. Profiling floats that are not assigned to scientific teams as part of this call are deployed via opportunity campaigns by the Coriolis Deployment (CODEP) team.

1.2 Objectives

The purpose of this document is to define the strategy of the Argo-France program to prioritize the deployment zones and the default mode settings of the Argo France profiling floats. These recommendations are established and motivated by the expertise and historical interest of the French community, and in line with the international strategies and recommendations of the OneArgo program (AST, ADMT and Euro-Argo) or emerging projects. Therefore, the present document is intended to evolve over time. These recommendations aim at providing :

- Guidance for CODEP and french PIs to set up the float defaults mode and priority deployment zones
- Guidance for LEFE/GMMC scientific committee to evaluate the PI’s argo float deployment proposal

1.3 Procedure reminder

LEFE/GMMC call for scientific proposals

Principal Investigators (PIs) or scientific teams respond to INSU's LEFE/GMMC call for scientific proposals in September of each year (year N) to request profiling floats of T/S, DO, Deep, BGC type for deployment in the framework of their scientific projects. Then, in November (year N)

the Argo-France scientific committee (i.e. LEFE/GMMC) reviews the profiling float requests according to the scientific relevance of the request, the Argo France recommendations and the availability of the profiling floats. **For the purpose of their research, the GMMC PIs have the possibility to apply the float setup they need, within the limit fixed by the Argo France and GMMC scientific committee (explained in the LEFE GMMC Call), and established in concertation with Argo France steering committee.**

Then, the results are communicated to the scientific teams in charge of float stock management, reset, scheduling, logistics and shipments. : i.e. the CODEP (Cellule Opérationnelle Deployment Argo-France Coriolis) for profiling floats of T/S, DO, Deep type; and IMEV (ex-LOV) for BGC profiling floats. The deployment plan for the year N + 1 is planned (GMMC projections, historic and opportunity) and submitted for validation to the Argo-France Steering Committee before December of the year N. At the beginning of the following year (year N + 1), the responses are sent to the GMMC Pis by official mail.

The profiling floats are then assigned to PIs in the framework of their research project. They are now in charge of their profiling float : deployment, CTD casts during the deployment for calibration of the measurements (essential for T/S, T/S/DO, Deep, BGC), data tracking, quality control in delayed time (DM-QC) profiling float and feedback to CODEP and IMEV.

Limitations of the LEFE/GMMC call for scientific proposal

For several years, a significant part (> 50%) of the profiling floats made available to the community have not been allocated via the LEFE/GMMC scientific call. These non-GMMC deployments include recurring historical cruises (Pirata, Goodhope, Ovide). These profiling floats, which are not assigned via the LEFE/GMMC call, are put under the responsibility of the CODEP (for their deployment and management at sea) and the DAC Coriolis data center for the processing of their data, including delayed time QC.

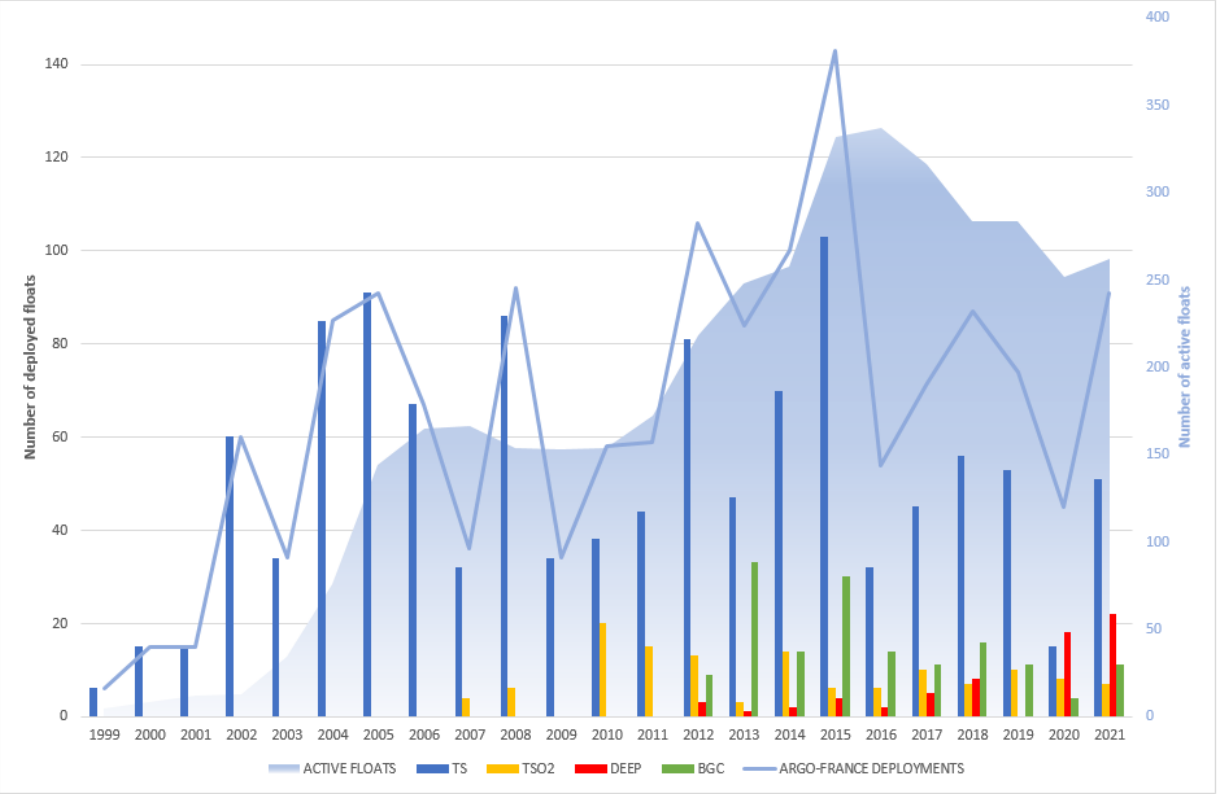

Figure 1: Number of Argo-France profiling float deployed per year since 1999 depending on the type of profiling float (T/S : Argo core, DO : Dissolved Oxygen, Deep : Deep Arvor, BGC : Biogeochemical)

1.4 Historical region for french deployments

Historically, France has mainly deployed core Argo profiling floats in the Atlantic Ocean, the Southern Ocean, and occasionally in the tropical Pacific and the Indian Ocean. More specifically, the regions that have been the aim of several scientific projects and campaigns are (see Figure 2 and 3):

- The subpolar gyre of the North Atlantic Ocean,
- The Southern Ocean, South Atlantic sector downstream of the Agulhas current,
- The West African coast, tropical Atlantic and Gulf of Guinea (Cape to Gibraltar),
- The Mediterranean Sea,
- The South Tropical Pacific and the Coral Sea,
- North Indian Ocean (Bay of Bengal and Arabian Sea),
- Eastern South Tropical-subtropical Pacific,
- Nordic Seas and Arctic Ocean.

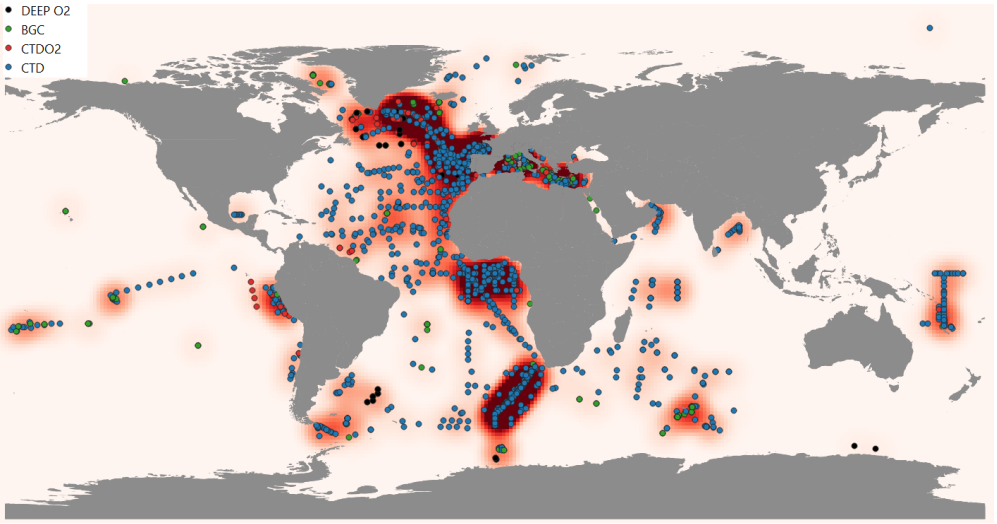

Figure 2: Position (and density) of Argo-France deployment since 1999

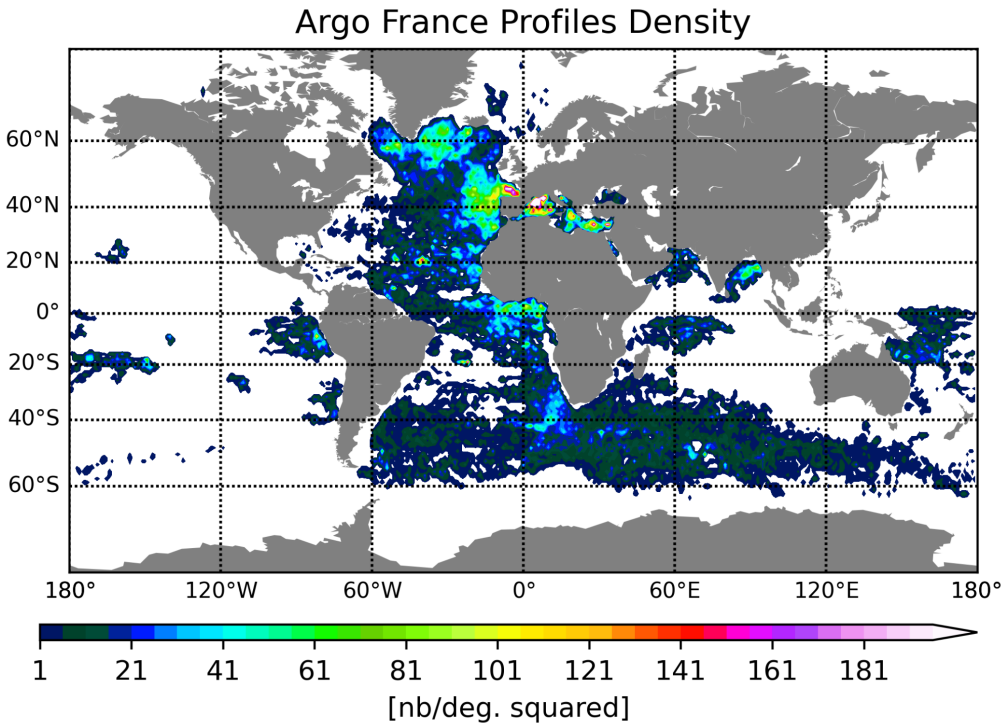

Figure 3: Density of French Argo profiles since 1999.

1.5 Seek for Opportunity (excluding GMMC)

Deployments of opportunity are thus opportunity are carried out from:

- oceanographic surveys on ships of "la Flotte Océanographique Française (FOF)" ;
- oceanographic surveys operated by SHOM (French Navy Hydrographic Service, ex : Borda,

Laplace, La Pérouse, Beautemps-Beaupré)

- oceanographic surveys on ships of the European Fleet (European Fleet ; ex : German on RV Polarstern, Meteor, Sonne ; Spanish on RV Hesperides ooru Sarmiento de Gamboa)
- other foreign fleets: South African; ex: SA Agulhas II.

  NB : Note that all of the cruises mentioned above offer the possibility of performing CTD cast during the deployment (mandatory for the calibration of Argo measurements).

- of transits on ships of FOF or SHOM
- of sailing boats (races, NGO, outreach...)
- of commercial lines in the framework global ocean observing system (TSG, XBT) - (Ex: NANTAISE MARITIME - COLIBRI/TOUCAN, Le Ponant - Le Commandant Charcot, …)
- French Navy Military vessels

1.6 Problematics related to the new floats capabilities

The purpose of this document is therefore to list recommendations for the use of the CODEP and PIs as guidance for looking for opportunities and "default" set up profiling floats under its responsibility.

These recommendations are established and motivated by the expertise and historical interest of the French scientific community ; and in line with the various international strategies and recommendations (AST, ADMT and Euro-Argo) or emerging projects (ex: TPOS 2020- TAOS).

Some of these Coriolis profiling floats have been upgraded with technological developments such as :

- Iridium communication mode with performances allowing the reprogramming of mission parameters of the profiling float along mission and a higher resolution of the vertical profiles (c.f. document in appendix on the coast of different sampling scheme)
- New DO sensors
- Extended exploration capabilities (up to 4000m for 'Arvor Deep', or in coastal areas for 'Arvor-C', outside CAD perimeter)
- Ice Avoidence Algorithm (ISA) for polar regions
- BGC sensors

These evolutions broaden the complexity of Argo deployment to that of the choice of mission parameters (e.g. the resolution of vertical sampling, the duration of cycles, the depth of profiles) ; and require deployment calibration profiles for the T/S/DO and deep measurements to ensure the high quality of measurements throughout the life of the profiling float. On the other hand, the DMQC of the data collected by these profiling floats is placed under the responsibility of the DAC Coriolis data center and based on the French DM-Operators.

2 Recommendation for core profiling float (P/T/S/ 0-2000m)

→ 25 iridium profiling floats[1]

2.1 Geographical Priorities

Priority 1 : **Southern Atlantic, Southern Ocean, Indian Ocean, Polar Ocean**

NB : areas under sampled in the global network (orange-red in Figure 4), and are pointed out by AST with high priority for deployment.

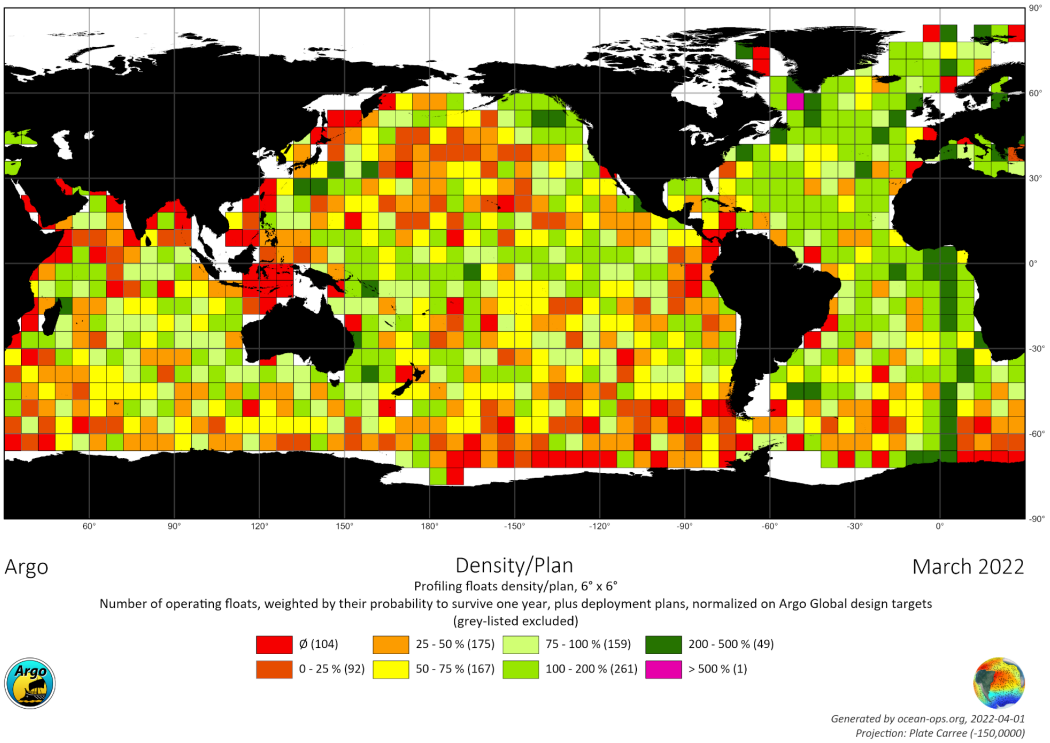

Figure 4 : Global Ocean Area that does not meet nominal sampling criteria (100 %) of the Argo core global network (1 profile / 3 °x3 °x 10days) in March 2022.

Priority 2 : French historical deployment regions

- If they are not sampled nominally following the objectives of the Core Argo network (following the AST OneArgo design identified in Figure 6).
- For opportunity : If they are not the aim of GMMC or international scientific surveys (PIRATA, OVIDE)

[1] average number over the period 2016-2020. Funding: Ifremer, SHOM, CPER, NAOS

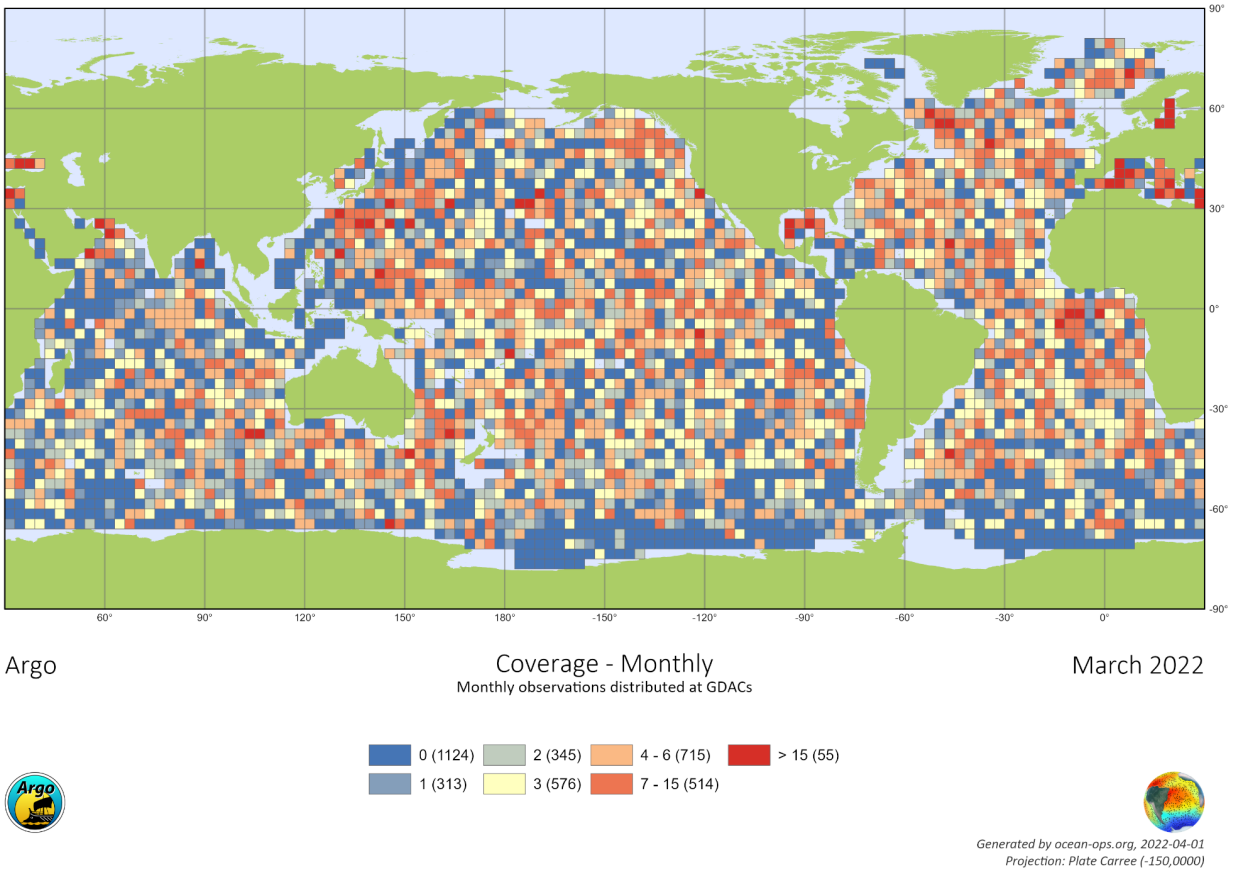

Figure 5 : Current Coverage (March 2022)

Priority 3 : Doubling the sampling in high variance regions (following the AST OneArgo design, Fig. 6). Specific work on the western boundary currents and piloting profiling floats to improve sampling will be conducted in the framework of the H2020 Euro-Argo-Rise project (2019-2022). The results will be sent to Argo-France Steering Committee.

- Western Subtropical North Atlantic Ocean (profiling float units x 2; Fig. 6)
- Equatorial Atlantic Ocean (profiling float units x 2 ; Fig. 6)
- South Atlantic Ocean (30°S/45°S-70°W-20°E - units of profiling floats x 2; Fig. 6)
- Equatorial Pacific Ocean (10°N/10°S-Units of profiling floats x 2; Fig. 6)

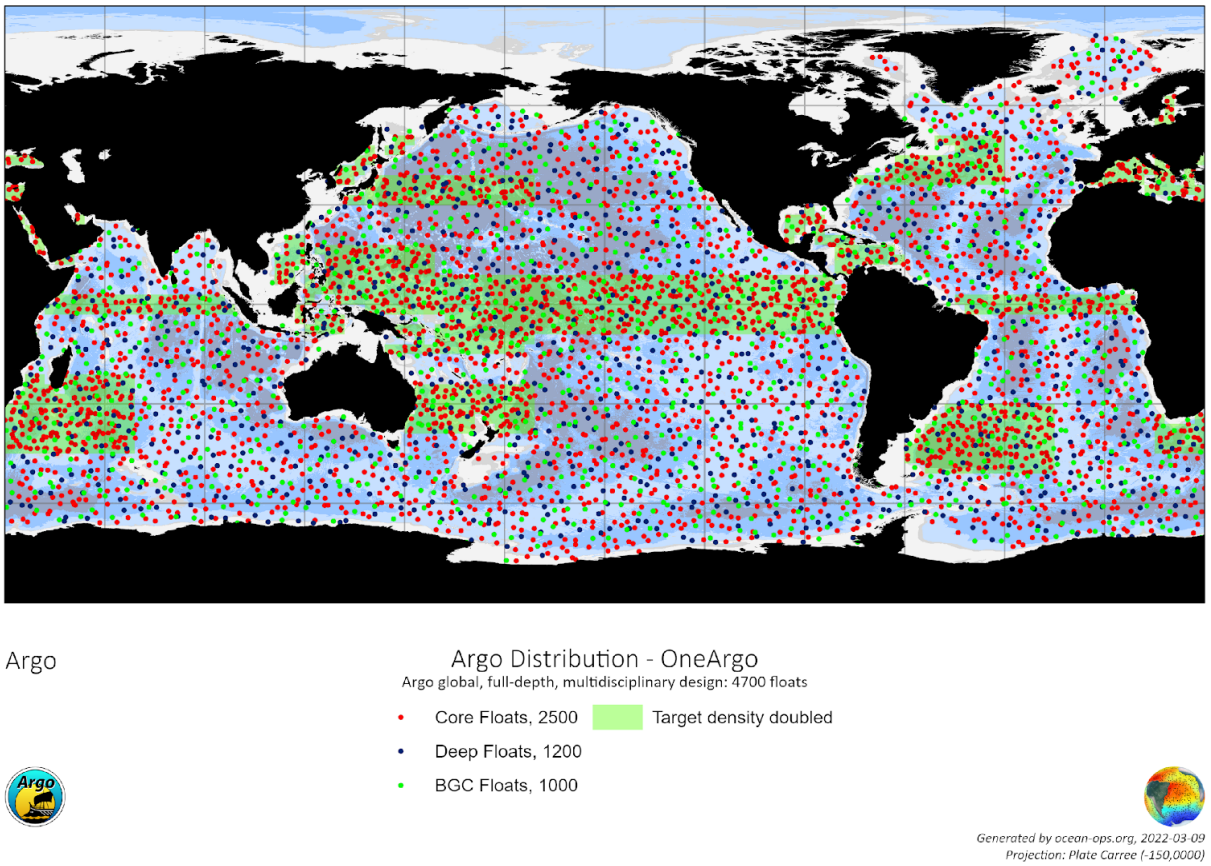

Figure 6: One Argo Design (1 prof / 10d x 3 ° x 3d = 1) and plan for Core, Deep and BGC

Priority 4: Adjacent regions - the goal of the network: 1profil x 3°x3°x10days in areas where the mesh is not reached (see Figure 4)

2.2 Vertical sampling scheme strategy

Iridium profiling floats can **transmit more than 1000 points vertically** at a cost comparable to the Argos communication system (about 70-80 points for profiling floats equipped with standard Argos transmission). The standard sampling strategies for the next 10 years are shown schematically in Figure 7. Iridium profiling floats are used to improve the vertical resolution in highly stratified layers, including the base of the mixing layer and the main pycnocline, where the vertical variability is particularly strong (internal waves, Rossby, mixing ...).

On the other hand, with an Iridium communication system the data transmission time on the surface is shorter (<1h, compared to ~ 6 to 8h with Argos). Nevertheless, it is recommended to **keep 2 GPS fixes after the ascent and before the dive.** In order to calculate trajectories and surface drift velocities, useful for derived products such as ANDRO (SNO Argo France). It is also anticipated that these 2 GPS fixes could be used for new applications related to the estimation of

small scale surface currents (e.g. cal/val SWOT and surface current doppler remote measurements).

Finally, the Iridium communication system offers the possibility to communicate with the profiling float and reprogram the mission parameters after deployment. It will be **possible to implement adaptive sampling strategies during the mission** in consultation with SNO Argo France scientists and following the recommendations of the Argo International regional strategies, especially in **the equatorial and western-westerly regions.** (Argo 2025 : AST, ADMT, Euro-Argo). Specific work on the western boundary currents and piloting profiling floats to improve sampling will be conducted in the framework of the H2020 Euro-Argo-Rise project (2019-2022). The results will be sent to Argo France Steering Committee.

layers	**sampling**	**Nb measurements/layer**	**Parameters for NKE float (soft 5900A04)**
0-400	1 dBar	400	`!MC 19 1`
400-1400	2 dBar	500	`!MC 17 400` `!MC 20 2`
1400-2000	5 dBar	120	`!MC 18 1400` `!MC 21 5`
Drift (at parking depth)	every 3 h	72	`!MC 9 3`
Surface	20 min	2	`!MC 23 20`

Estimated lifetime for Arvor (iridium) float with this set up : 226 cycles

Nota: the vertical grid of the ISAS optimal interpolation tool used by SNO Argo France and Mercator/Coriolis for the development of grilled products for research and operations (Gaillard et al., 2016) is built on 152 standard levels between 0-2000 m depth (see Figure 4).

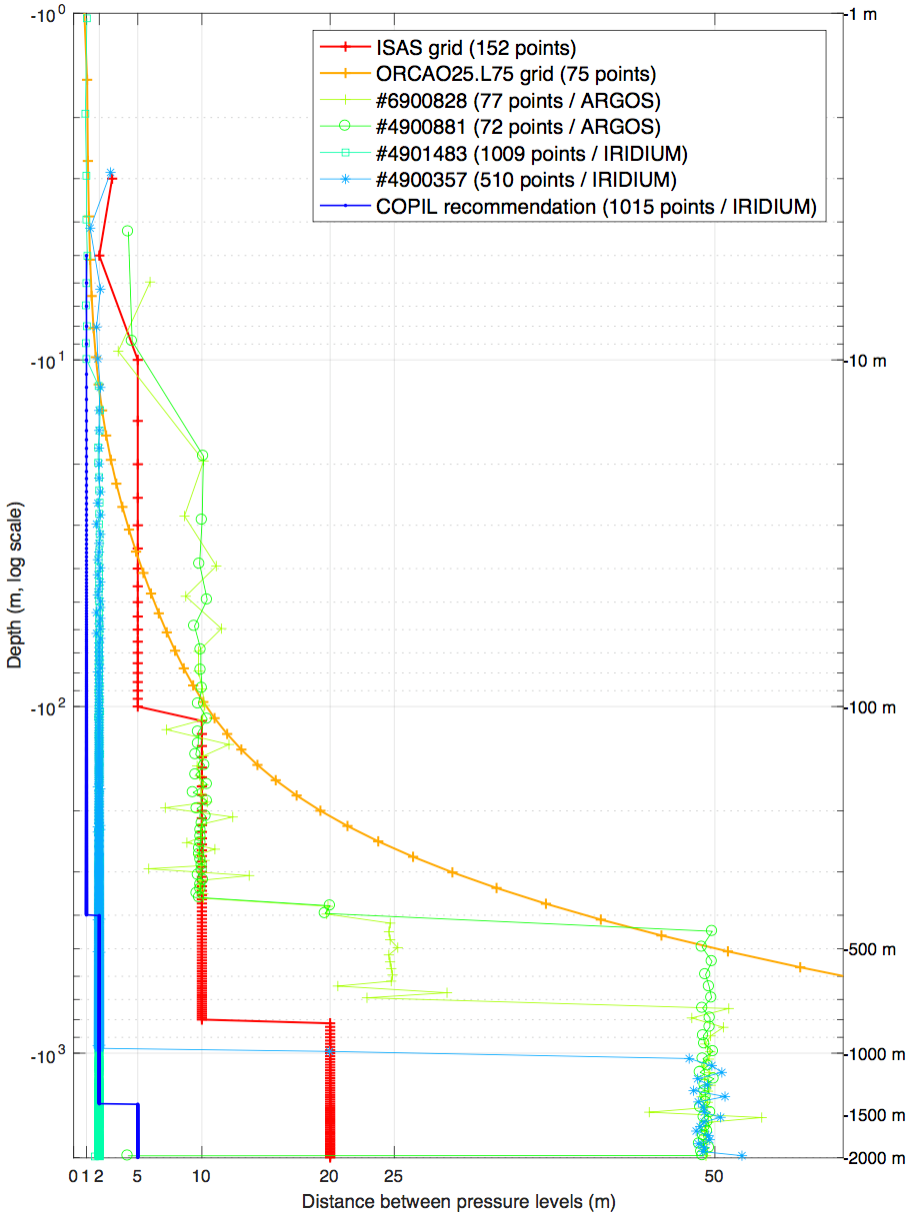

Figure 7: Example of vertical sampling scheme for 2 Argos flaots and 2 Iridiums floats between 0 and 2000 m depth. The ISAS standard grid and the Argo-France Steering Committee recommendation are also indicated.

2.3 Cycling strategy

The default settings for NKE ARVOR floats are to profile every 240 hours (10 days), and operate surfacing of profiles around 06:00 UTC (JULD_ASCEND_END), therefore most NKE floats surface around 06:00 UTC every 10 days (Fig. C.1). The Coriolis DAC is mostly populated by NKE T/S ARVOR floats. This may be problematic to resolve the diurnal cycle of temperature and salinity (Gill, 2012) with those floats. Biasing

the cycling stategy will also induce bias the climatic time series in near surface heat content and flux estimates.

We recommend the floats programmation to profile every **245 hours** to stick closer to the 240 hours cycle following the AST recommendations. For an NKE float, the parameters that adjust the float cycle time are MC2 and MC3, depending on the configuration of some other parameters. The cycle time can be changed by the commands !MC 2 245 and !MC 3 245. The rationale for such a recommendation is exposed in ANNEXE B of this document.

3 Recommendation for profiling floats equipped with DO sensor (P/T/S/DO 0-2000m)

→ **11 profiling floats per year**[2]

Dissolved oxygen (DO) measurements in oceanography have historically been associated with measurements from bathysondes (CTD-O_2) of cruise surveys. Argo profiling floats are not initially equipped with this type of DO sensor. Thus, historical DO measurements are biased towards the 90's (mainly provided by the WOCE experiment).

In particular, the DO measurements make it possible to better characterize deep mixing layers, particularly at high latitudes, monitoring the ventilation of deep water masses, carbon cycle, but also the evolution of the oxygen minimum zones (OMZ) in tropical ocean.

Since the mid-2000's, oxygen sensors have been available to equip Argo profiling floats, and the real-time data processing chain is being implemented at the international level with DACs and GDACs. However, the oxygen data can not be used as it and must be monitored and corrected in delayed mode (DM-QC).

Scientific expertise and complementary measures are needed to carry out these validations. Therefore, it is important to **prioritize the attribution of DO profiling floats via the GMMC call to Pis involved in the validation of the DO data, and the performing CTD-O_2 cast profiles when deploying** the Argo for the calibration of data.

For these same reasons, it is also important to **focus the deployment of opportunities in the areas of scientific expertise of SNO Argo France scientists** for which the DO measurements are of scientific interest.

In any cases, it is recommended to program the profiling float to **perform DO measurements in the air at the surface at each cycle (10 days)** order to quantify potential bias and drifts of the DO sensor.

3.1 Geographical priorities

Priority 1 : North Atlantic sub-polar gyre,
Priority 2 : South of the Gulf Stream and North Atlantic Drift,
Priority 3 : Eastern areas of tropical Atlantic basins.

[2] Average number of floats over 2022-2027. Funding: Ifremer, SHOM, CPER, NAOS

When the DO measurements will be stabilized and the QC procedure will be operational, the deployment priorities will aim to allow for optimal sampling over time and space to determine a climatology and a seasonal cycle, reliable oceanic 3D structure of oceanic DO. This sampling will have the same objectives as the Core Argo T/S network : i.e. 1 profile by 3°x3 °x10j, in consultation with the objectives of BGC Argo, and 2 **GPS points during surface transmissions.**

3.2 Vertical sampling scheme strategy

Layer	Sampling	Nb measurements/layer	Parameters NKE floats (soft 5900A04)
0-400	1 dBar	400	`!MC 19 1`
400-1400	2 dBar	500	`!MC 17 400` `!MC 20 2`
1400-2000	5 dBar	120	`!MC 18 1400` `!MC 21 5`
Drift (at parking depth)	every 3 h	72	`!MC 9 3`

In the Air	Every cycle	every 30 s over 5 min	`!MC 29 1`
			`!MC 30 30`
			`!MC 31 5`

Surface	20 min	2	`!MC 23 20`

Estimated lifetime for Provor-DO (iridium) float with this set up : 277 cycles

4 Recommendation for deep floats - Deep Arvor (P/T/S/DO 0-4000m)

The development of deep profiling floats is still recent and so far a global strategy for an Argo-deep network is that of setting up pilot areas and promote a global implementation. At French level, the strategy is developed through pilote area and entrusting the deployment to scientific scientists through the AO GMMC.

Deep ocean variability is small, and probably of the same order of magnitude as the precision of the T/S SBE41 probe equipping the profiling floats. To ensure the scientific quality of the measurements, **it is mandatory that scientific campaigns performing CTD-O_2 and winkler profiles be preferred during deployments** in order to have calibration measurements for deep Argo measurements.

The default programming of these profiling floats, which are all equipped with DO sensor and Iridium communication, will be:

- **10 day cycles (as only 24h multiple are possible on Deep Arvor),**
- **Drift to either 1000m or deeper. In this latter case, the choice is under the PIs responsability and should insure that the float will remain in Deep area (depth >2000m)**

to maximize the use of the float capability. Refined vertical sampling scheme in the surface and bottom layers.

4.1 Geographical priorities

At the French level, the deep profiling floats that will not be assigned during the GMMC call will have to be deployed:

- **Priority 1 : In the subpolar gyre of North Atlantic so as to sustain a deep Argo network in this area.**
- **Priority 2 : The Southern Ocean** for the monitoring of deep water masses formed along the Antarctic continent.
- **Priority 3 : The rest of the Atlantic Ocean** to strengthen and sustain a Deep-Argo array in that basin as part of OneArgo.

4.2 Vertical sampling scheme strategy

Deep Argo profiling floats have the capacity to perform profiles between 4000 m depth and the surface. In region less than 4000 m deep, the profiling floats will be able to sample the bottom boundary layer. In this boundary layer, mixing and turbulence processes are more intense due to current-topography interactions. Sampling may be increased in the bottom boundary layer to explore these still little known dynamic regimes. This sampling can be adapted according to the structures and bathymetry encountered thanks to 2-ways communication mode of the profiling float equipped with Iridium system (see Table 3.2).

This reference vertical sampling scheme makes it possible to identify 50 sampling points for the bottom boundary layer (considering a total number of 1000 points to be transmitted). The Deep-Arvor software will be updated to operate as follows:

Descent to the profile depth
Then start of the ascent:

- if "grounded”: sampling at 1m resolution for 50m, then sampling at the reference vertical sampling scheme (depending on the layer)
- if "not grounded": No change, sampling at the reference vertical sampling scheme.

Layer	Sampling	Nb of points / layer	Parameters NKE float (soft 5608A11)
0-400	1 dBar	400	`!PM 12 1`
400-1400	5 dBar	200	`!PM 10 400`

			!PM 13 5
1400-4000	7 dBar	370	!PM 11 1400 !PM 14 7
Drift (at parking depth)	Every 3 h	72	!PM 6 3
In the Air	Every cycle	Every 30 s per 5 min	!PT 33 1 !PT 30 30 !PT 31 5
Surface	20 min	2	!PM 16 20

Estimated lifetime for Arvor Deep (iridium) float with this set up : 113 cycles

5 Recommendation for BGC floats (Provor, P/T/S/DO/PH/FLBB/PAR/NO_3)

5.1 Geographical Priorities

Priority 1: AST recommandation and priority as part of OneArgo

Priority 2: Historical french region of scientific interest

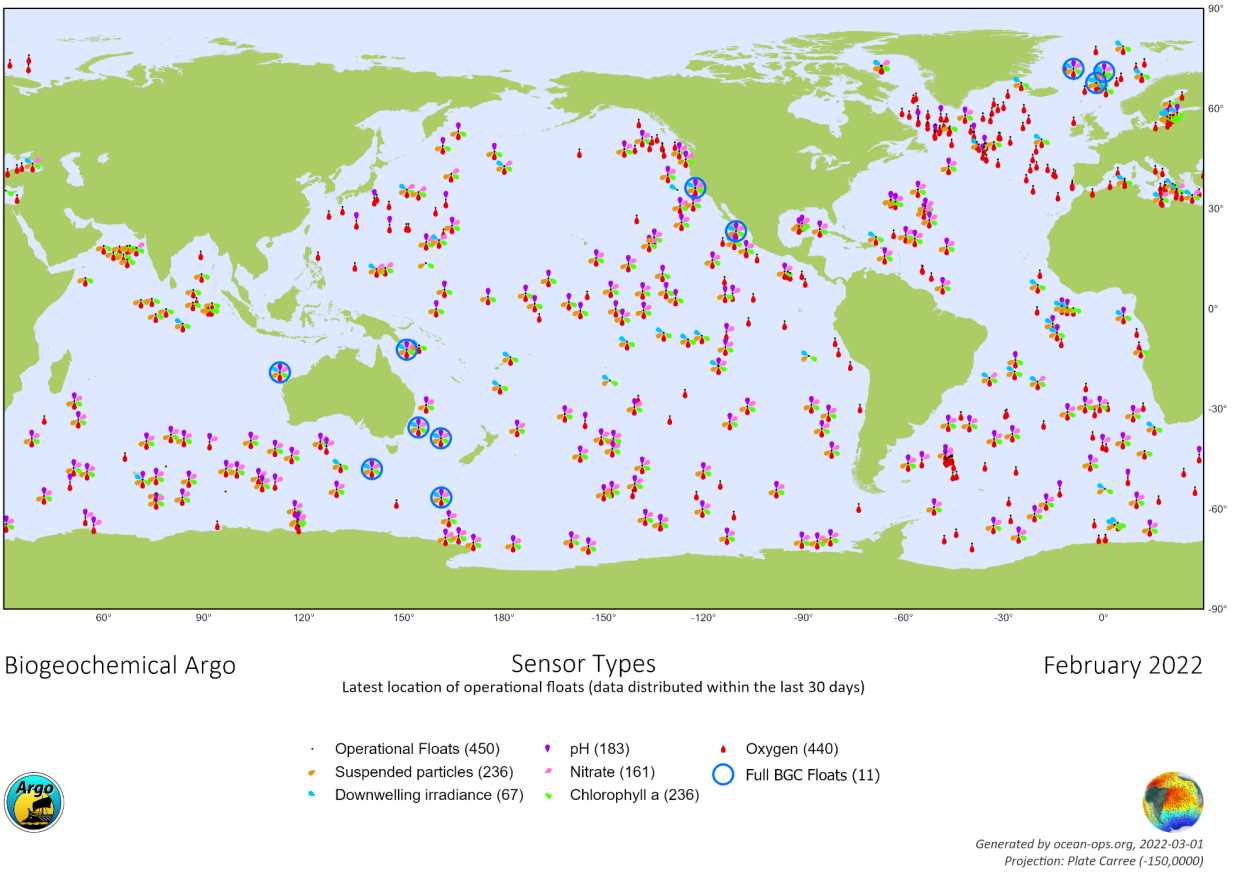

Figure 8: Current sampling of the BGC Argo network as a function of the measured variable among the 6 BGC variables (Suspended particles, Downwelling Irradiance, Chl-a, O_2, pH, NO_3)

5.2 Vertical Sampling

NKE CTS5 BGC are attributed by the GMMC scientific commitee. CTS5 floats are equipped with 6 sensors capable of measuring the full BGC parameters, i.e. Suspended particales, Downwelling irradiance, Disolved Oxygen, Nitrate, Chlorophyll-a and PH, plus the CTD parameters (P/T/S). The measurements have to be done during the ascent phase of the floats following the default vertical and along drift (1000 dbar) sampling scheme for each BGC variable as described in Table 5.2.

ASCENT							
CTS4 Ver_3							
	Surface	0-3m	3-10m	10-300m	300-1000m	1000-2000m	DRIFT ALL ZONE
DO (mode pulse)	na (descent is on 0-3m)	20sec	10sec (1m)	10sec (1m)	100sec (10m)	200sec (20m)	0
	Surface	0-1m	1-10m	10-300m	300-1000m	1000-2000m	DRIFT ALL ZONE
CTD (mode pulse at 2sec)	na	mean slide 1m	mean slide 1m	mean slide 2m	mean slide 10m	mean slide 50m	60 min
OCR (mode pulse)	na	60sec	2sec (0,2cm)	10sec (1m)	-	-	24 h
ECO (mode pulse)	na	60sec	2sec (0,2cm)	10sec (1m)	100sec (10m)	200sec (20m)	30 min
pH (mode pulse)	na	60sec	10sec (1m)	10sec (1m)	100sec (10m)	200sec (20m)	0
cROVER (mode pulse)	na	60sec	10sec (1m)	10sec (1m)	100sec (10m)	200sec (20m)	30 min
SUNA (mode pulse)	na	500sec	25sec (2,5m)	200sec (20m)	500sec (50m)	500sec (50m)	0
CTS5							
	Surface	0-1m	1-10m	10-300m	300-1000m	1000-2000m	DRIFT ALL ZONE
DO (mode pulse)	tt les 10sec durant 120s	60sec + dec 0.1	10sec (1m)	25sec (2,5m)	100sec (10m)	200sec (20m)	0
CTD (mode pulse at 2sec)	0	mean slide 0.5	mean slide 1m	mean slide 2m	mean slide 10m	mean slide 50m	60 min
ECO (mode pulse)	0	60 sec + dec 0.1	2sec (0,2cm)	10sec (1m)	25sec (2,5m)	200sec (20m)	30 min
TRIOS	?	?	?	?	?	?	
OCR (mode pulse)	tt les 2sec durant 120s	60 sec + dec 0.1	2sec (0,2cm)	10sec (1m)	-	-	24 h
pH (mode pulse)	0	60 sec + dec 0.1	10sec (1m)	25sec (2,5m)	100sec (10m)	200sec (20m)	0
cROVER (mode pulse)	0	60 sec + dec 0.1	10sec (1m)	10sec (1m)	25sec (2,5m)	200sec (20m)	30 min
SUNA (mode pulse)	0	500 sec + dec 1	25sec (2,5m)	100sec (10m)	500sec (50m)	500sec (50m)	0
	Surface	0-1m	2-100m	100-500m	500-1000m	1000-2000m	DRIFT ALL ZONE
UVP6-LPM	0	10s + dec 0.5	2s + mean 5	2s + mean 10	5s + mean 20	5s + mean 20	120 min

Table 5.2: Vertical sampling scheme for NKE CTS4 and CTS5 BGC floats.

5.3 Cycling Strategy

In the framework of OneArgo, the BGC Argo should contribute to CTD core measurements. The default cycling strategy defined for OneArgo will be 1 profile/10 days with 5 additionnal hours (as for core Argo) to allow a random sampling around the clock to be able to capture the diurnal variabiliy and not to bias the climatic timeseries. However, to be usefull some BGC measurement have to be done at specific time in the days. Fluorometer and backscattering measurement near surface mesurements may be prefered at night, but correction methods exist during daytime (Boss et al., 2016). Dissolved oxygen air calibration is suggested to be more accurate at night (Bushinky, 2016). For satellite callibration purpose, radiometer measurements (downwelling iradiance) should be perform at local noon when the solar irradiance is maximum to minimize the calibration error. Although the around the clock sampling will ensure the otpimal measurement time for most of the sensor, for radiometry measurements no more than ⅓ of profile should be forced at noon (otherwise randomly around the clock) [ref AST sampling doc]. This default recommendation exclude floats from project funded for specific sampling irradiance (*i.e.* satellite qual/val).

6 References

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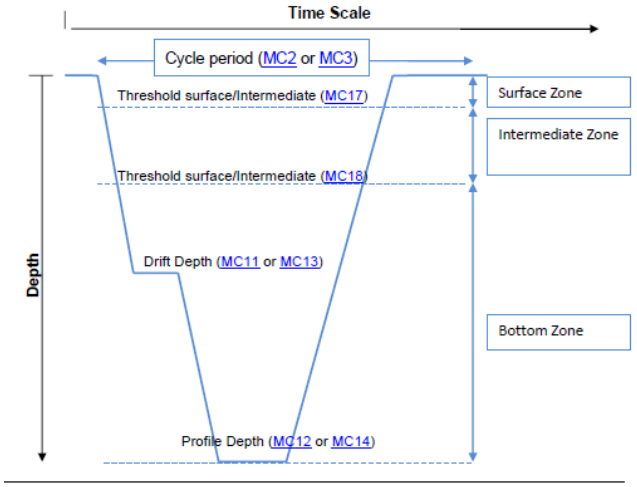
7 Annexes

ANNEXE A : Communication cost for Argos - Iridium SBD profiling float

The purpose of this appendix is to detail the different communication costs of the profiling floats in the so-called programming "opportunity" according to the type (T/S,T/S/O2 or DEEP).

Principle

NKE profiling floats (excluding BGC) have the possibility to perform vertical sampling in three layer - Surface, Intermediate and Bottom - according to the following diagram:



It is possible to adjust the depth of each layer and the layer sampling. Then, including the number of measurements in drift and the technical messages sent by the profiling float, it gives a volume of data transmitted in each cycle which is expressed in kilobytes.

Profiling float	P/T/S	P/T/S/O2	DEEP P/T/S/O2
Max Number of measurements (CTD ou CTDO)	2015	2015	4000

Historically Argo profiling floats were equipped with an Argos transmission and the vertical sampling scheme chosen was fairly standard at 101 vertical CTD points plus one point every 12h in drift, in order to limit the transmission time on the surface at 6 to 8 o'clock. The Iridium system allows to transmit many more points (cf Figure) in a much lower transmission time.

Since 2018, all profiling floats purchased by Ifemer and SHOM are upgraded to iridium, the French fleet will progressively replaced with Iridium floats in Rudics for BGC floats and in SBD for T/S/O2 and Deep. At the end of 2019, more than 50% of French floats will be iridium (75% for Argo global).

Billing

The principle of Argos billing by CLS is simple: From the moment when there is a daily transmission, CLS charges a daily unit at a fixed price (4 €). Each active platform also has a fixed monthly subscription fee (€ 15). The communication of a traditional profiling float that cycles to 10 days and emits 3 times a month will be billed 27 € (15 € + 3x4 €).

During the transition from Argos to Iridium for standard floats, the constraint was to remain globally

at a flat communication cost. The current Iridium provider, EADS, allows this through packages including a fixed number of KB/month. For floats equipped with DO, it is nevertheless important to note that the overall monthly cost of communication of the floats will be approximately doubled.

The following table is provided for an estimated theoretical volume of data and a USD/EUR to 0.9 exchange rate, it does not take into account the costs of activation of Iridium lines :

	P/T/S	P/T/S/02	DEEP P/T/S/02
Surface layer (m) :	400	400	400
Surface layer sampling (m)	1	1	1
Surface layer number of points	400	400	400
Intermediate layer (m) :	1400	1400	1400
Intermediate layer sampling (m)	2	2	5
Intermediate layer number of points	500	500	200
Deep layer (m)	2000	2000	4000
Deep layer sampling (m)	5	5	7
Deep layer number of points	120	120	370
Sampling in drift (h)	3	3	3
Number of points in drift	72	72	72
Total number of CTD points	**1092**	**1092**	**1042**
Data debit (Ko)/mois	**24507**	**50715**	**48465**
Iridium Monthly Coast SBD	**25.7 €**	**49.2 €**	**47.2 €**

The costs for “standard” profiling floats called “opportunity". However, a large number of profiling floats are allocated to scientific projects (GMMC) which will request specific set up then more expensive in communications, and this for a significant period of time in the life of the profiling float (see the profiling floats appendix of the GMMC call for scientific proposal). For example, some of the Arvor P/T/S profiling floats in daily mode used for vortex tracking have a monthly volume of transmitted data billed around € 90 versus € 25 for standard set up. This extra cost of “scientific programs” Is extremely variable and make more complex the evaluation on the global coast of the French Argo fleet.

ANNEXE B : Cycling strategy

The default settings for NKE ARVOR floats are to profile every 240 hours (10 days), and operate surfacing of profiles around 06:00 UTC (JULD_ASCEND_END), therefore most NKE floats surface around 06:00 UTC every 10 days (Fig. C.1). The Coriolis DAC is mostly populated by NKE T/S ARVOR floats. This may be problematic to resolve the diurnal cycle of temperature and salinity (Gill, 2012) with those floats.

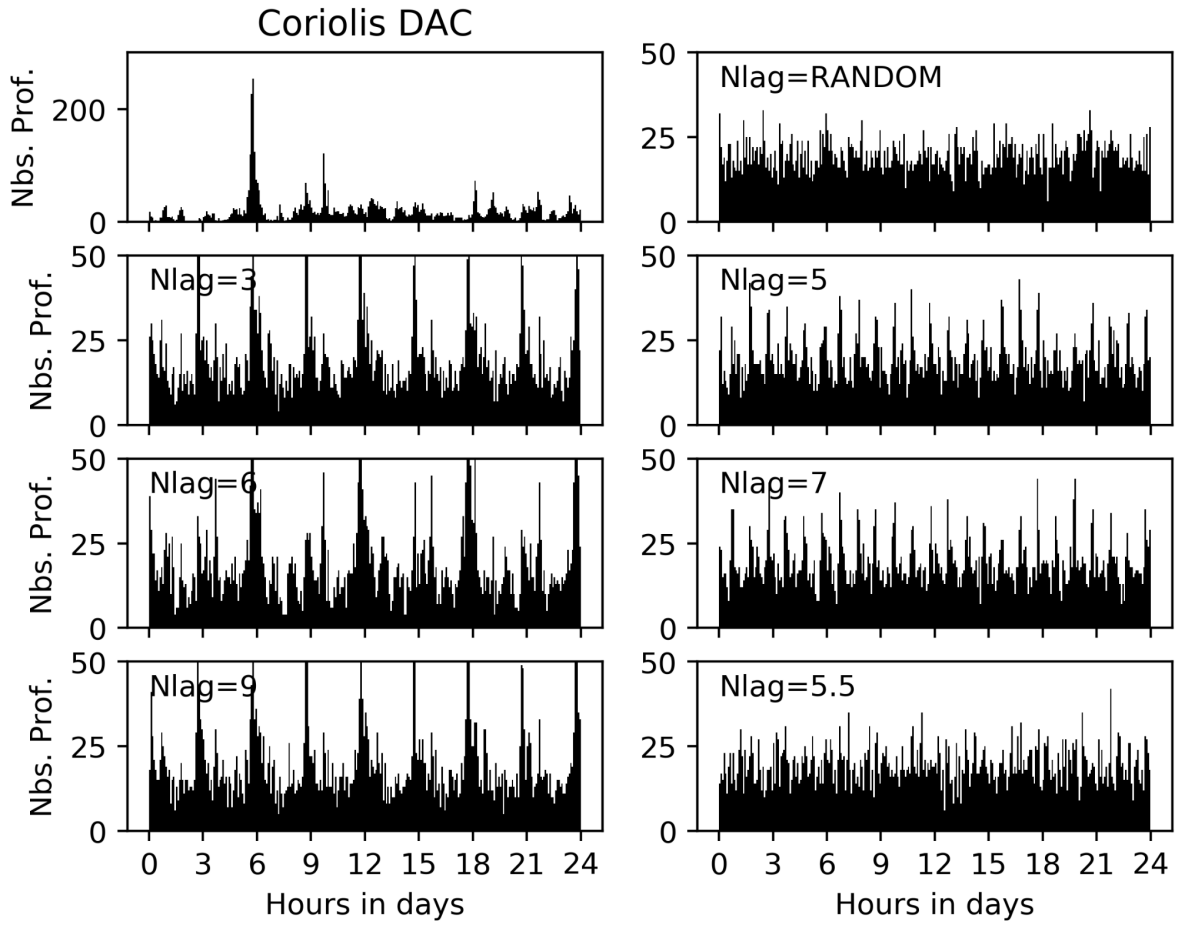


Figure C.1: Hour of surfacing of floats after profiling (JULD_ASCEND_END) distributed over a diurnal cycle for 200 Coriolis DAC most recent floats (on january 2022). (upper-left) Hour is mainly located around 06:00 UTC. This prevents Coriolis DAC floats T/S measurements to populate a robust diurnal cycle. Other panels modelize the probable time of surfacing of Coriolis floats if a lag of Nlag=Random (between -12 and 12 hours), Nlag=3,5,6,7,9,5.5 hours was applied to each cycle length (10 days + Nlag). The diurnal cycle will be populated more or less homogeneously.

To conserve a nominal AST's recommended cycle duration around 10 days, but in order to populate homogeneously a diurnal cycle after a certain number of cycles, it could be added to the 240 hours cycle duration with a few hours lag at each cycle. The best solution would be to have a random lag between -12 and 12 hours. The diurnal cycle would be populated homogeneously (Nlag=RANDOM, Fig. C.1). Any multiple

of 2 or 3 will prevent the profile to be shifted randomly 'around the clock'. Modes will appear every 2, 3 or 6 hours (Nlag=3,6,9, Fig. C.1). Nlag=5 or 7 would result in near surface profiling with a more 'around the clock' distribution (Nlag=5,7 Fig. C.1), i.e. closer to the Nlag=RANDOM distribution. Introducing Nlag=5.5, a non-integer hour lag, is even better (Nlag=5.5, Fig. C.1). However, this programmation may not be permitted by NKE floats software.

The second issue with the diurnal sampling strategy using lagged surfacing time is to populate the diurnal cycle homogeneously (as well as possible) without introducing seasonal bias. For example, choosing 1 hour lag will provide surface profiles between 06:00 UTC and 15:00 UTC in a diurnal cycle over the first 3 months (9 cycles ~ a season), then between 16:00 UTC and 01:00 UTC hours during the next season. This sampling will induce a seasonal bias in the diurnal cycle sampling. Considering Nlag = 5, 7 and 11 hours lag, the surfacing time in a diurnal cycle (starting at 06:00 UTC) is calculated in the Table C.1 for the 9 first cycles for each lag configuration. Actually, the best choice for populating as homogeneously as possible a season (9 cycles) is using Nlag=7. Choosing Nlag=7 gives a mean 2.5 h diurnal sampling with a STD=0.87. This is the most regular diurnal sampling over 1 season period. Choosing Nlag=5 will slightly increase the STD=1.5, for the same mean diurnal sampling.

However, this is not a big difference, thus we recommend the floats programmation to profile every **245 hours** to stick closer to the 240 hours cycle following the AST recommendations. For an NKE float, the parameters that adjust the float cycle time are MC2 and MC3, depending on the configuration of some other parameters. The cycle time can be changed by the commands !MC 2 245 and !MC 3 245.

sample in diurnal cy. Nlag (h)	1	2	3	4	5	6	7	8	9	mean (Δt) (h)	std (Δt) (h)
5	2	6	7	11	12	16	17	21	22	2.5	1.5
7	0	3	6	7	10	13	14	17	20	2.5	0.87
11	0	2	4	6	11	13	15	17	22	2.75	1.3

Table C.1: hours of surfacing for Nlag =5,7,11, for 9 samples in a diurnal cycle (i.e. 3 months for 10 days cycles).

ANNEXE C: Programmation – Digest

T/S and T/S/DO

Layer	Sampling	Nb of points / layer	Parameters NKE float (soft >= 5900A04)
0-400	1 dBar	400	!MC 19 1
400-1400	2 dBar	500	!MC 17 400 !MC 20 2
1400-2000	5 dBar	120	!MC 18 1400 !MC 21 5
Drift (at parking depth)	Every 3 h	72	!MC 9 3
In the Air (for DO floats)	Every cycle	Every 30 s per 5 min	!MC 29 1 !MC 30 30 !MC 31 5
Surface	20 min	2	!MC 23 20

DEEP DO

Layer	Sampling	Nb of points / layer	Parameters NKE float (soft 5608A11)
0-400	1 dBar	400	!PM 12 1
400-1400	5 dBar	200	!PM 10 400 !PM 13 5
1400-4000	7 dBar	370	!PM 11 1400 !PM 14 7
Drift (at parking depth)	Every 3 h	72	!PM 6 3
In the Air	Every cycle	Every 30 s per 5 min	!PT 33 1 !PT 30 30 !PT 31 5
Surface	20 min	2	!PM 16 20