Geophysical Research Letters

Supporting Information for

BGC-Argo floats observe nitrate injection and spring phytoplankton increase in the surface layer of Levantine Sea (Eastern Mediterranean)

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Introduction

In the Supporting Information, a map of the PERLE cruises and of the BGC-Argo deployments is provided (Figure S1, Table S1). Processing and validation for the chlorophyll concentration (CHL) and nitrate concentration (NO3) datasets collected by BGC-Argo floats are also detailed (Text S1, Figures S2,S3). Time series from BGC-Argo floats, computed using profiles inside and outside the SST_{15} area (i.e. area where the SST annual absolute minima is less than 15°C, see main text) are also presented (Figures S4 and S5). Selected vertical profiles of density, CHL, backscattering coefficient (b_{bp}) and NO3, obtained from BGC-Argo profiles in the SST_{15} area are shown in Figure S6.

Text S1.

Six BGC-Argo floats are used in the paper (see Table S1 for the WMO numbers, the dates of deployment and, eventually, the dates of recovery; Figure S1 shows the positions of the deployments).

Following the recommendations and the protocols described in D'Ortenzio *et al.* (2020) and in Taillandier *et al.* (2018), discrete ship-based estimations of CHL and NO3 were performed to check the calibration state of the floats sensors. This was performed at the PERLE CAL in situ stations (see figure S1 for the positions of the stations).

For floats 691764, 6902900, 6902902 and 6902904, in situ sampling at deployment was not possible, and, then, a specific cast was performed few days before the deployment. In this case, the float was clamped on the rosette and discrete samples of CHL and NO3 were collected, while acquiring simultaneous profiles of CHL and NO3 with float sensors (D'Ortenzio *et al.*, 2020; Taillandier *et al.*, 2018). For float 6903247, discrete samples were collected at the deployment. In this case, the first BGC-Argo profile was obtained approximately 24h after the in situ cast. No ancillary data were available for float 6902898.

For the CHL parameter, in situ data from CAL stations were only used to verify the agreement between HPLC derived total chlorophyll-a and its proxy measured by fluorescence with the floats sensors as processed by the BGC-Argo standard algorithms. For the NO3 parameter, in situ data were also used to adjust the BGC-Argo profiles, by providing a field calibration that improved the factory calibration of the sensors and slightly modified the standard procedure (Johnson *et al.* 2018). The correction of NO3 processing was required because of the low nitrate concentrations of the Mediterranean waters and short range of variability. Details of the processing of BGC-Argo data for CHL and NO3 are given in the following.

The CHL floats profiles were obtained following the standard BGC-Argo protocol (Schmechtig *et al.,* 2015), which is recalled here:

- Sensors derived counts were transformed in CHL units by using factory calibrations furnished by manufacturer; a 0.5 factor was applied to the whole profile, as recommended by Roesler *et al.* (2017);
- An offset was calculated by setting values deeper than 800m to zero; the offset is further applied to the whole profile;
- Statistical tests were applied to identify and remove abnormal values and spikes. The Non Photochemical Quenching correction was not applied, as still not completely defined by the BGC-Argo data management team at the time of the paper submission (December 2020).

The comparisons between HPLC and BGC-Argo CHL estimations at CAL stations are provided in Figure S2, showing an overall good agreement. Only for the float 6903247, important differences are observed in the surface layer. We ascribed these differences to the delay of approximately 24h between the HPLC samples and the first BGC-Argo profile.

Profiles of NO3 concentration were collected by four of the six BGC-Argo floats considered in the study (see Table S1). These profiling floats were equipped with the same type of NO3 sensor: the Submersible Ultraviolet Nitrate Analyzer, the Deep SUNA model commercialized by Sea Bird Electronics. The principle of NO3 determination from the absorption spectrum of seawater is detailed by Johnson & Coletti (2002) and the algorithm of NO3 determination is reported in Sakamoto *et al.* (2009).

In practice, the deployment and data handling of such a sensor requires some care to assess its calibration state and ensure alignment of its dataflow with pressure, seawater temperature and salinity (Bittig *et al*., 2019). For this purpose, NO3 reference profiles were collected by shipborne CTD casts for every deployed sensor (Johnson *et al*., 2017). Metrological exercises were conducted for each float following the field operations and sampling detailed in Taillandier *et al.* (2018).
At the time of the data analysis, some floats were still active and not completely qualified in delayed mode in the Argo data system. In order to prevent any dishomogeneity in our data processing, we slightly adapted the recommended Argo official procedures (Johnson *et al.,* 2016) as follows:

- a correction of temperature compensation in the algorithm for NO3 determination (Sakamoto *et al*., 2009; Pasqueron de Fommervault *et al.,* 2015) with a wavelength offset of 208.5 nm applied to the whole collection for the four NO3 sensors;
- a correction of the pressure dependence of bromide absorption in seawater (Sakamoto *et al*., 2017; Pasqueron de Fommervault *et al*., 2015) with a multiplicative term applied to the whole collection for each sensor. To precisely assess this correction to reach the required accuracy in the Mediterranean Sea, we performed a comparison with reference profiles of NO3 at deployment. Values are reported in Table S1.

The temporal drifts of the SUNA sensors were corrected following the Argo procedures performed once the floats were at sea. The NO3 concentration was adjusted with an additive offset estimated from the GLODAPv2 climatology and applied to the whole profile (Johnson *et al*., 2013).

The comparisons between in situ and BGC-Argo NO3 estimations at CAL stations are provided in Figure S3, showing an overall good agreement. For the float 6902900, differences are observed for the recovery profile (blue lines and dots in Figure S3 upper panel). Again, these differences could be ascribed to the delay of approximately 10h between the NO3 samples and the BGC profile and by the distance of 25km between the recovery location and the CAL station in a dynamically active environment.

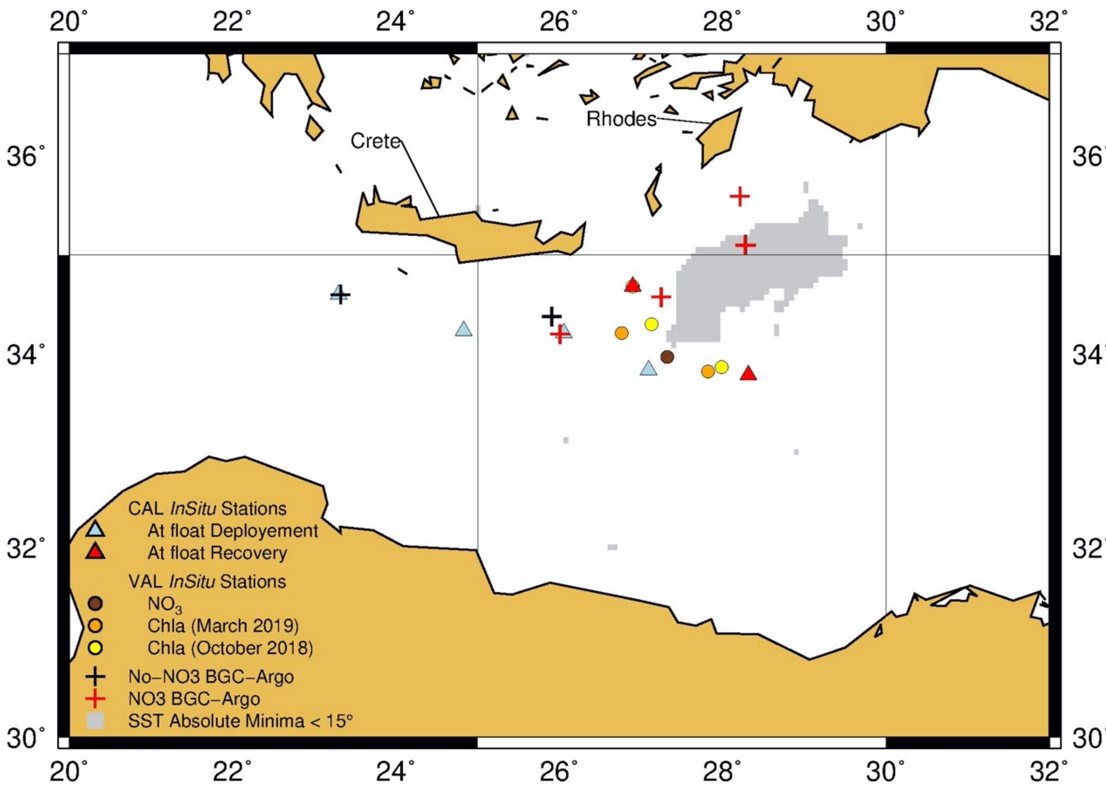


Figure S1. Positions of the CAL and VAL stations of the PERLE cruises and of the BGC Argo floats deployments. For the CAL in situ stations (triangles), colors indicate the positions of the stations carried out at the deployments (light blue) or at recovery (red) of BGC-Argo floats. For the VAL stations (triangles), colors indicate the parameters used in figure 2: CHL (orange and yellow) and NO3 (brown). Deployment positions of the BGC-Argo are also indicated with crosses: BGC-Argo equipped with NO3 sensors (red crosses) and without NO3 sensors (black crosses). The area having annual absolute SST minima less than 15°C (as obtained by satellite, see main text) is also indicated in grey.

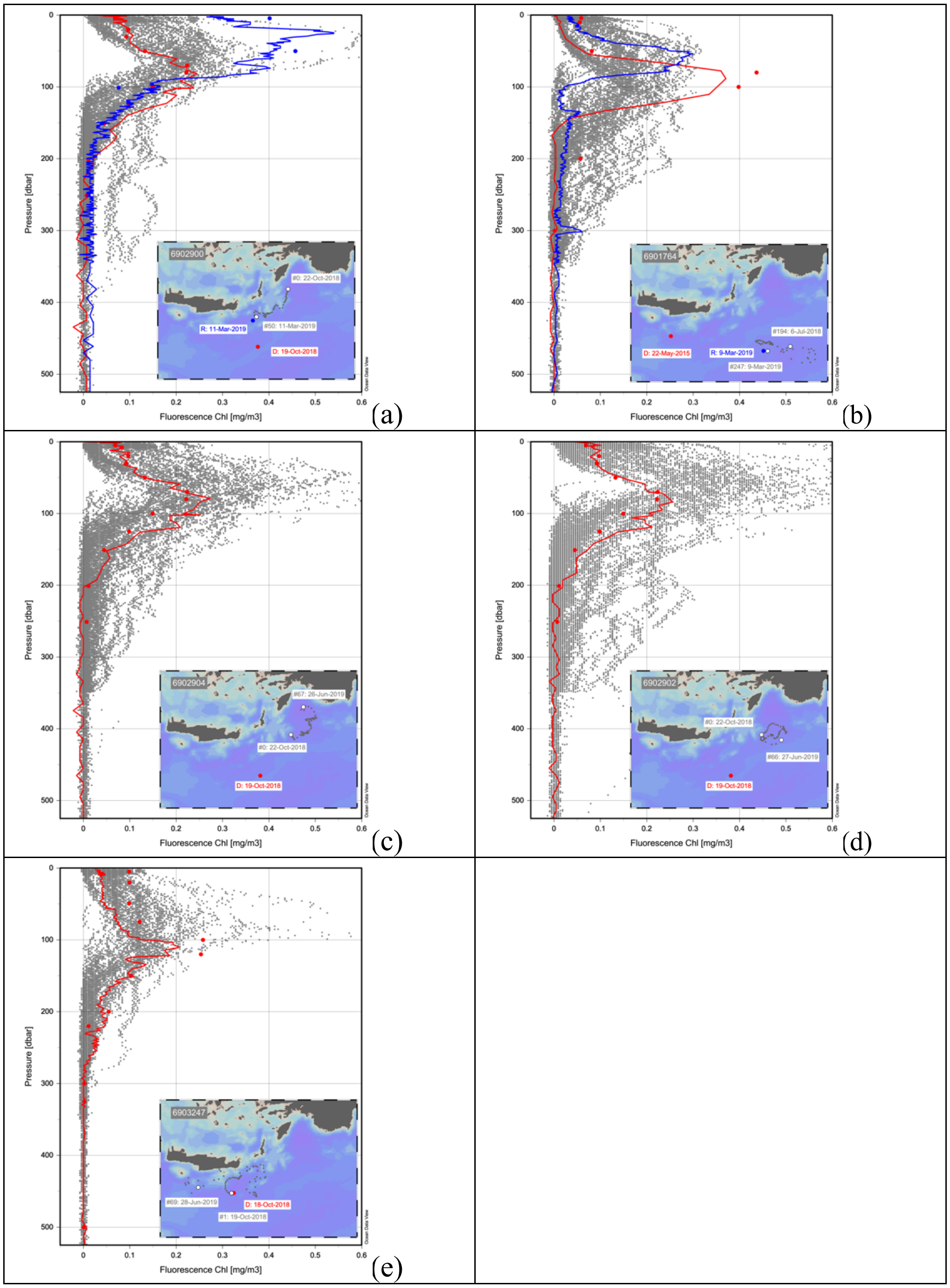


Figure S2. CHL profiles from BGC-Argo floats and from in situ HPLC samples obtained at the CAL stations. For each panel, the float profile and the *in situ* samples at the deployment (red points and lines) and at the recovery (blue points and lines) are shown. The whole data base of BGC-Argo profiles is also shown (grey points), Positions of the *in situ* profiles (CAL stations) at deployment and at recovery (if any) are represented by red and blue dots respectively in the map. Panel (a): float 6902900. Panel (b): float 6901764. Panel (c): float 6902904. Panel (d): float 6902902. Panel (e): float 6903247.

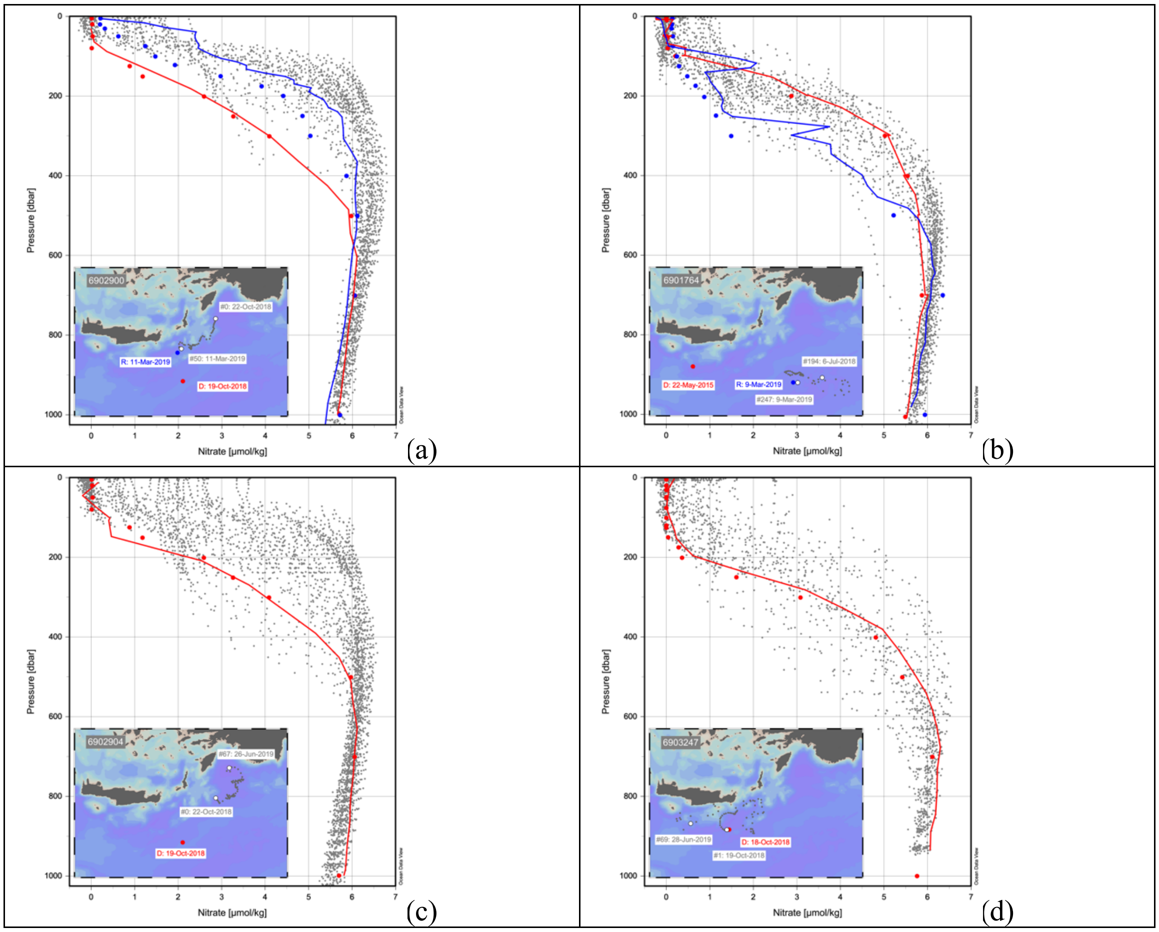


Figure S3. NO3 profiles from BGC-Argo floats and from *in situ* samples obtained at the CAL stations. For each panel, the float profile and the *in situ* estimations at the deployment (red points and lines) and at the recovery (blue points and lines) are shown. The whole data base of BGC-Argo profiles is also shown (grey points), Positions of the in situ profiles at deployment and at recovery (if any) are represented by red and blue dots respectively in the map. Panel (a): float 6902900. Panel (b): float 6901764. Panel (c): float 6902904. Panel (d): float 6903247.

WMO	NO3 sensor	Deployment Date	Status	Pressure Correction
6902900	Yes	22-Oct-2018	Recovered 51 profiles	0.015
6901764	Yes	23-May-2015	Recovered 247 profiles	0.018
6902904	Yes	28-Oct-2018	Still active	0.022
6902898	No	15-Oct-2018	Still active	
6902902	No	22-Oct-2018	Still active	
6903247	Yes	19-Oct-2018	Still active	0.020

Table S1. Table indicating the deployment date, status and coefficient of pressure correction computed for the four NO3 sensors used in this study.

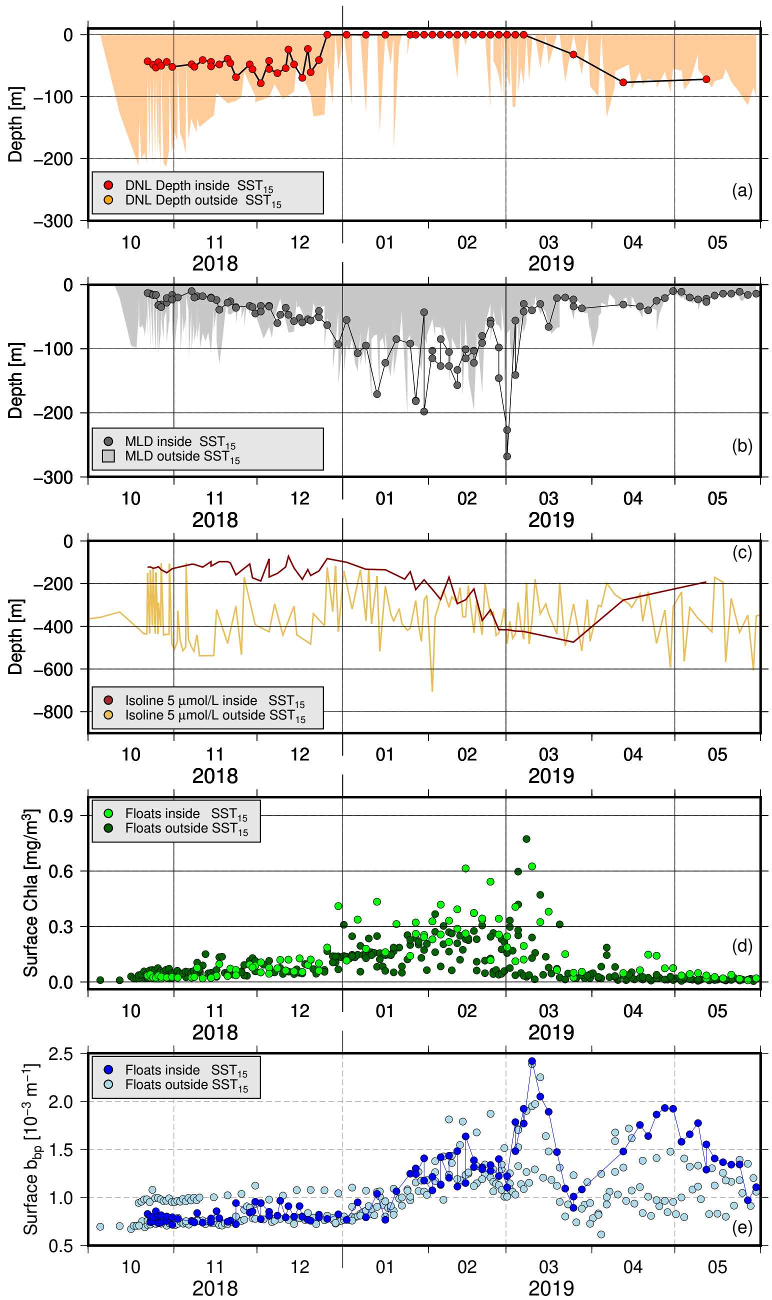
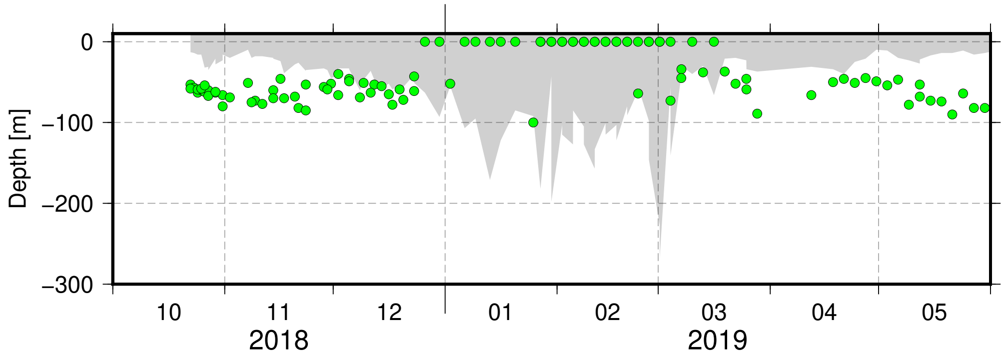


Figure S4. Time series from BGC-Argo floats, computed using profiles inside and outside the SST_{15} area. Panel (a): DNL depth (orange are: outside SST_{15} area; red points: inside SST_{15} area). Panel (b): MLD (grey area: outside SST_{15} area; black points: inside SST_{15} area). Panel (c): depth of NO_3 isoline 5 µmol/L (yellow line: outside SST_{15} area; brown line: inside SST_{15} area). Panel (d): CHL at surface (i.e. average of firsts 10m, dark green points: outside SST_{15} area; light green points: inside SST_{15} area). Panel (d): b_{bp} at surface (i.e. average of first 10m, light blue points: outside SST_{15} area; dark blue points: inside SST_{15} area).



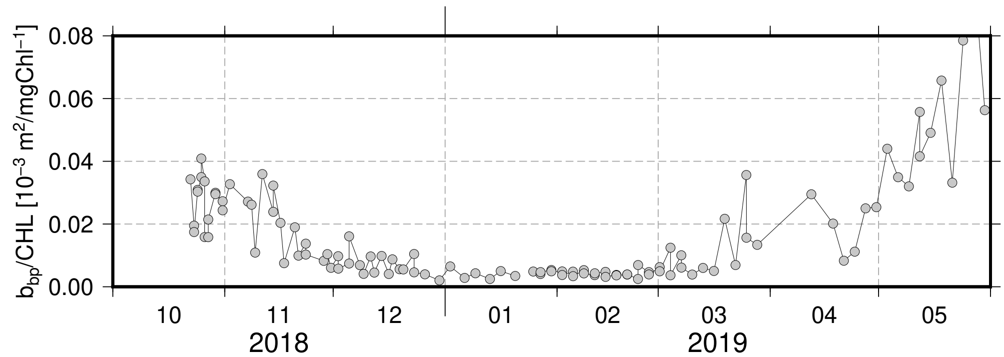


Figure S5. Time series derived from BGC-Argo floats profiles in the SST_{15} area. Upper panel: MLD (grey area) and Deep Chlorophyll Maxima depth (green point, zero values indicate absence of DCM). Lower panel: b_{bp} on CHL ratio at surface (i.e. average of values in the first 10m)

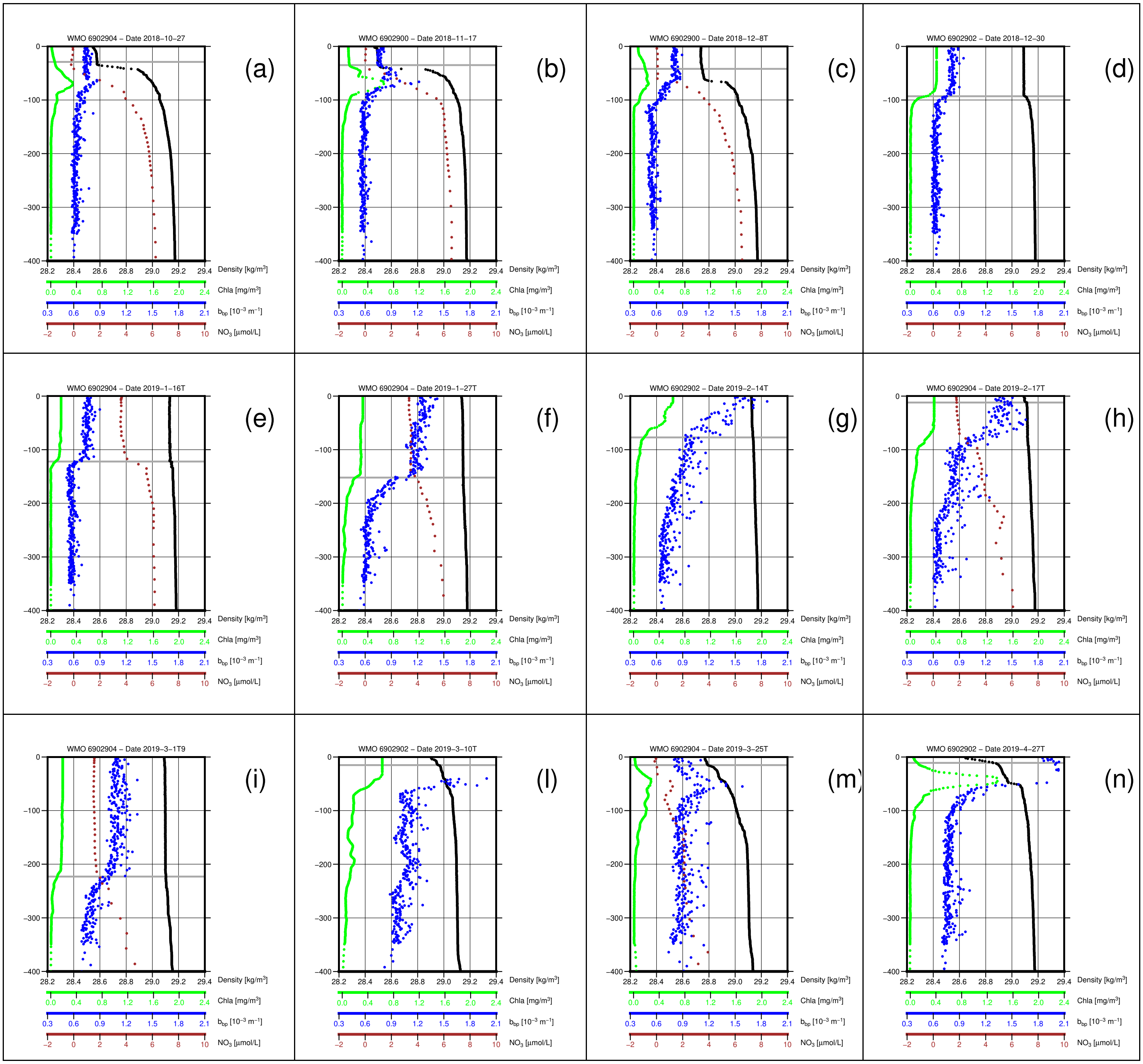


Figure S6. Vertical profiles of density (black points), CHL (green points), b_{bp} (blue points) and NO_3 (brown points) at selected dates, obtained from BGC-Argo profiles in the SST_{15} area. MLD is indicated as a grey bar. Date and WMO of corresponding float are indicated in the title of each panel.