

Co-Editor-in-Chief Decision:

Christine Klass, 29 Jul 2021

Responses in blue

Dear authors,

The text of the manuscript has been greatly improved, however, in particular in the results section, the text warrants further polishing (comments are given in the annotated manuscript).

We warmly thank you for these comments and we have accounted for all your corrections except one:

Lines 405-406 of the pdf: Substitution of 'contributed' by 'represented' . We prefer to keep 'represented'. The term contribution would imply a direct utilization of organisms to satisfy their N or P requirements, which is not sure. The flux could be direct or indirect after circulation through the microbial food web. Also, ectoenzymatic hydrolysis and N₂ fixation can fuel different categories of microorganisms (phytoplankton and heterotrophic prokaryotes).

Response to your comment line 335 of the pdf:

"At the short stations and sites, the term $\text{NO}_3_{\text{ML}} - \text{NO}_3_{\text{NDLb}}$ can be inferred by the difference between mean nanomolar (LWCC) concentrations within the NDlb and the ML, as advective fluxes could not be characterized "

Why not please explain?

The sentence was modified to be more explicit as :

'At short stations, only single casts were carried out, preventing any estimation of temporal variations of the MLD (dMLD/dt) required for the calculation of vertical advective fluxes. Thus only a qualitative assessment of nutrient fluxes across ML is given'.

Response to your comment line 469 of the pdf:

"This does not correspond to the data on NO₃ fluxes in Table S2. Can you explain the difference?"

Yes we apologize for this error. Table S2 presents the DIN (NH₄+NO₃) and in the text we described NO₃ only. We modified table S2 and text to talk only about DIN.

I also noticed one issue that should be clarified:

- Lines 445-448 of the pdf: I fail to understand the argument here. In the text before increases in windspeed associated with rain events are presented as driving MLD and NO₃ increases between the 25th and 27th of May; while here the authors shift to invoke dry deposition without presenting any quantitative basis. By looking at Fig. 4 average ML NO₃ concentrations increase from ~20nM to ~125nM. This implies that N stocks in the upper 20m of the water column increase from 400 $\mu\text{Mol}/\text{m}^2$ to 2500 $\mu\text{Mol}/\text{m}^2$ necessitating an N input of 2100 $\mu\text{Mol}/\text{m}^2$ (2.1 mmol/m²).

We agree with your comments, the exact values are noted Table S1

On 25 May , MLD 14 m, mean NO₃ in ML 14 nM, in NDlb 14 nM

On 27 May MLD 18 m, man NO₃ in ML 127 nM, in NDlb 103 nM

On 29 May MLD 16 m, mean NO₃ in ML 92 nM, in NDlb 67 nM

We also calculated NO₃ integrated stocks in the ML (cited on Table S2) : On 25 May: 195 $\mu\text{mole}/\text{m}^2$, on 27 may: 2113 $\mu\text{mole}/\text{m}^2$, i.e., a net difference of + 1918 $\mu\text{mole}/\text{m}^2$ in 2.12 days between the 2 casts, confirming your estimates.

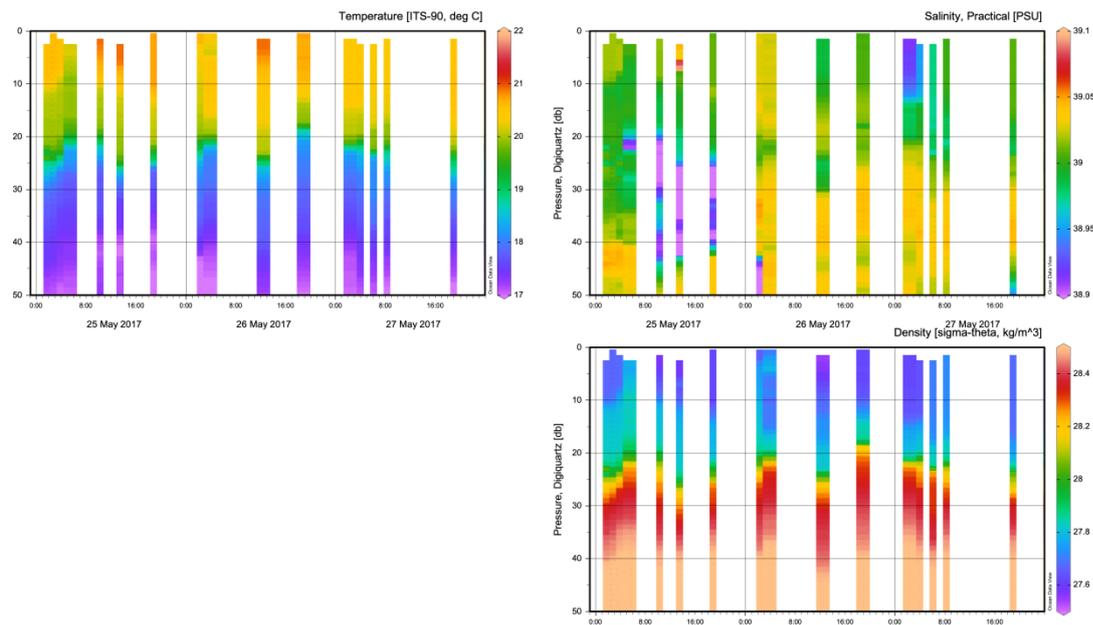
Based on the deposition values given in table 3 and table S2, it seems clear that neither of these (wet or dry) terms can explain these changes in such a short period of time.

We agree, dry deposition: at best $32.6 \mu\text{mole}/\text{m}^2/\text{d}$ (on 27 May) $\times 2.12 = 69 \mu\text{mole N}/\text{m}^2$ in 2.12 days, N_2 fixation at best $6.1 \mu\text{mole}/\text{m}^2/\text{d} \times 2.012 = 12.9 \mu\text{mole}/\text{m}^2$ so we agree that the sum of these 2 fluxes are not sufficient to justify such increase in the ML. The wet deposition flux cited Table 3 ($67 \mu\text{mole NO}_3/\text{m}^2$) corresponds to the rain front of the 29 May and should not be considered here).

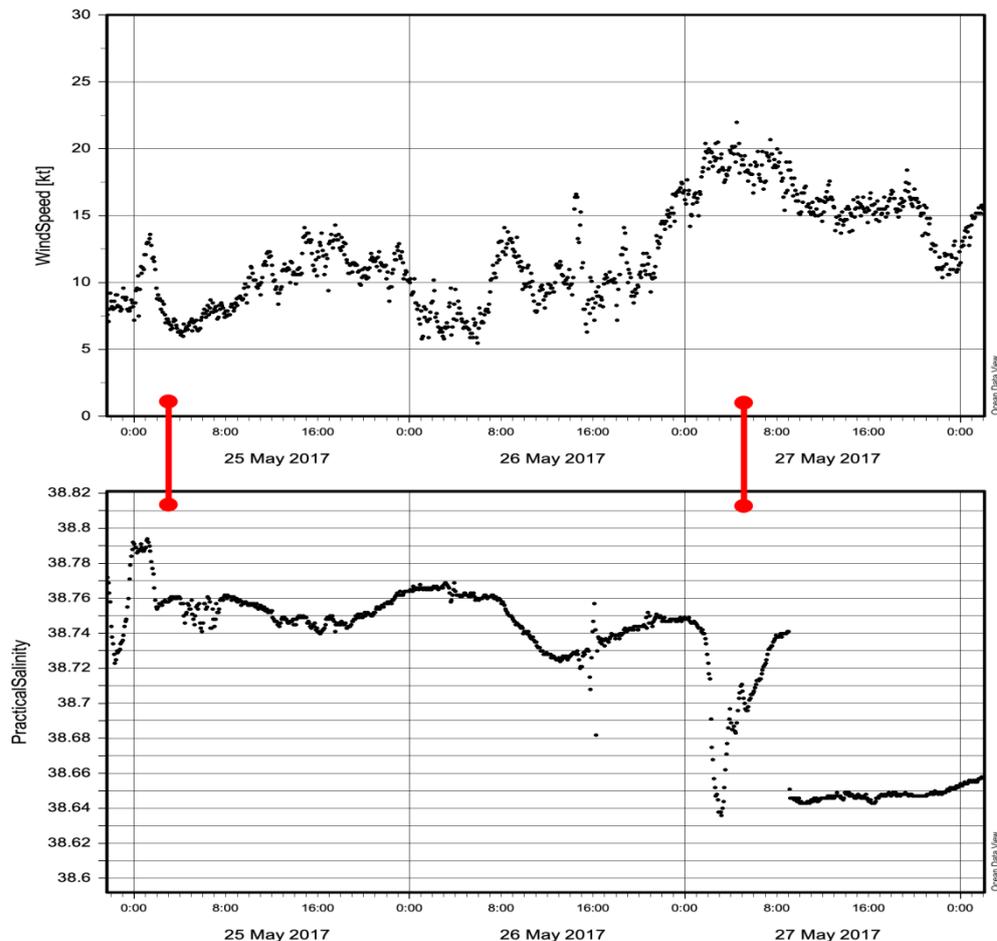
This is compounded by the fact that these changes actually occur throughout the water column including below the NDLb. Do you have an explanation? Could it be that different water masses were sampled at ION?

Yes, it is clear that both ML and NDLb are enriched in NO_3 . The main problem is that the CTD casts are not sufficiently close to allow us to calculate subtle variations in $d\text{MLD}/dt$ together with NO_3 vertical gradients. As we discuss later for FAST, these can be temporary very important to justify intermittently large source of exchange of NO_3 between ML and NDLb. Furthermore, at ION we have only 3 nitrate profiles, and the second one (on 27 May) is not sufficiently deep (it stops at 45m) to see any change in the form of the deep nitracline below NDLb.

The changes in water mass properties remain small below the MLD of all the casts done between 25 and 27 May (see the figure below). Thus we could not conclude on a significant vertical mixing nor to a water mass change.



The thermosalinograph allowed us to get continuous information of the surface water together with the wind. The wind is plotted on Figure 3 of the ms and we present below a detailed view of the wind, and surface salinity between the 25 and the 27 May, with the 2 casts sampled for nutrients indicated in red:



On this graph, the wind stress of the 27 May is concomitant to a lowering of 0.1 unit of the surface salinity, which is also visible on the 27 May cast down to about 10 m depth. Thus we could not exclude the possibility of an intrusion of a low-salinity surface water lens. This salinity decrease corresponds approximatively to a rainfall of 20 liters over a layer of 10 m, corresponding to a precipitation of 20 mm i.e. much higher than the rain event of the 29 May cited Table 3.

A possible scenario could be the following: a low-salinity lens could have its origin from the rain events observed in the ship's vicinity on the 26 May. This lens could be advected via Ekman transport associated to the wind stress to progressively influence the station location.

The sentence in the ms was modified as (lines 620-624 of the revised word doc in 3.3) :
Due to the lack of high frequency sampling, it was not possible to quantitatively assess the effects of dry /wet atmospheric deposition nor the one of nitrate injection from below the NDLe by vertical advection at ION. The intrusion of a low-salinity lens was clearly visible on the thermosalinograph record and on the 27 May CTD cast, extending down to 10 m depth (data not shown). This low-salinity lens could be formed by the rain event noted on 26 May in the vicinity of the station. It was clear that ION on days 27 and 29 was characteristic of group 4 (i.e. higher NO₃ concentrations in the ML than in the NDLe), presumably related to NO₃ rainfall inputs.

Also, in lines 731-732 of the pdf you mention "considering both the local rain fluxes and the horizontal oceanic mixing of water masses affected by the rain front". However, horizontal mixing was not considered here. Can you clarify what is meant by this?

You are right, the concept of "horizontal mixing" in this sentence in conclusion is confusing. We

meant that for either dry deposition directly measured or wet deposition indirectly inferred during long stations, their signature was detected in sea water nutrient concentrations. As you can see Table 3, the nutrients in rain were analyzed in the rain sampled on board, whereas the whole rain flux was derived from mean precipitation estimated from radar data in the vicinity of the ship's position.

We removed this sentence.