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Biogeosciences
Discussions

Interactive comment on "Phytoplanktonic response to contrasted Saharan dust deposition events during mesocosm experiments in LNLC environment" *by* C. Ridame et al.

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We would like first to thank the reviewers for their relevant comments and suggestions which helped us to improve our manuscript.

The title has been changed into 'Contrasted Saharan dust events in LNLC environment: impact on nutrients dynamics and primary production' to be more representative of the scientific content of the paper. Indeed, the main goal of this study is to explain why different phytoplanktonic responses (stimulation or no change) were observed after contrasted Saharan dust deposition event (wet versus dry; single deposition versus two successive deposition events) through the changes in the atmospheric supply of

new nutrient (N, P, Fe).

SPECIFIC REPLY TO REFEREE 1

GENERAL COMMENTS: The authors utilized a quasi-nature ecosystem (called mesocosm experiment) to investigate phytoplanktonic responding to contrasted Saharan dust deposition events in the low nutrient low chlorophyll (LNLC) regions. This experiment included both inside and outside mesocosm to minimize the uncertainty caused by volume of container and ship movement etc. The experimental results showed the importance of dust pathway and the type to phytoplanktonic community. Besides, the relevant parameters (chemical and physical index) sampling at different depth and their similarities in three periods P, Q, R provide this reviewer more confidence for the representativeness and reliability of data. Overall, this is an interesting paper and is suitable for the readership of Biogeosciences.

SPECIFIC COMMENTS This reviewer has a few minor comments for the authors considering: 1) page 771, lines 5-13, the pathway of deposition and types of dust cause the different responses to phytoplanktonic community. In order to simulate the natural wet and dry deposition, EC and non-EC dust is mixed with ultrapure and sea water, respectively. Why not use the same dust to represent wet and dry deposition or different types of dust mixed with the same solution? 2) This reviewer also has a concern about the non-EC dust mimicking a dry deposition. The dust deposited into the Mediterranean Sea usually experienced the long transport and its characters should change more or less due to interactions with anthropogenic pollutants. The use of the untreated original dust representing dry deposition is questionable.

RESPONSE: Indeed, the pathway of the deposition is important in the fate of new nutrient and thus in the impact they may have on biota. Because for aerosols transported in the atmosphere without the influence of clouds, the dissolution processes will occur mainly in seawater after this dry-type deposition event, the amendment of the dust mesocosms in DUNE-1-Q was conducted with dust mixed with surface seawater in order to mimic a dry deposition event. In case of a wet deposition event, several processes will occur between emission and deposition related to cloud chemistry and rainwater. For that reason, the seeding in DUNE-1-P and DUNE-2-R was performed with dust mixed with ultrapure water in order to mimic a wet deposition event.

Indeed, we had to consider during DUNE that wet deposition and dry deposition do not have the same 'history' from the emission to deposition at the sea surface. Most of this has been explained and justified in the methodology paper of Guieu et al, (2010). Indeed, it has been shown that the mixing with anthropogenic components, such as N, is a process that occurs mostly during cloud processes (wet deposition). Our approach to aging dust is based on previous works from Desboeufs et al. (2001), enabling the laboratory simulation of cloud evapocondensation cycling which reproduces the photochemistry and the gradients in pH and ionic strength during cloud processing of dust particles. As described in the review of Formenti et al., (2010), the reactivity of polluted species with dust is determined by several factors: chemical mineralogy of dust, transport pathways, the extent to which dust is transported across polluted sources and meteorology. The internal mixing between dust and other aerosols is favoured in the marine atmosphere where the relative humidity is high (Hanisch and Crowley, 2001) or by in-cloud processing (e.g. Crumeyrolle et al., 2008). Thus, this internal mixing is not systematically observed in the Mediterranean area (Marconi et al., 2014). Moreover, Kandler et al. (2007) show that the mixing is lower to 2% for the transported dust particles larger than 5 μm and to 5% for particles larger than 1 μm, i.e. for the particles preferentially removed by dry deposition. The size distribution and the chemical composition of our untreated dust (non-EC dust) are totally consistent with the characteristics of long-range transported dust (Guieu et al., 2010; Formanti et al., 2011; de Leeuw et al., 2014). From these points, we consider that the untreated dust is representative of dry-deposited dust in Mediterranean Sea. This information justifying the use of non-EC dust to simulate a dry deposition event has been added in the revised version in section 2.1.

3) The discussion was focused on the change of the elemental concentration rather than phytoplanktonic responses. This needs revision.

RESPONSE: The main part of the Discussion is focused on the impact of contrasted (wet and dry) Saharan dust events on the nutrient dynamics (N, P, Fe) as it is directly linked with the response of the phytoplanktonic community in term of biomass and CO2 fixation. For this reason, we have decided to change the title of our manuscript into 'Contrasted Saharan dust events in LNLC environment: impact on nutrients dynamics and primary production' which is more representative of the scientific content of the paper.

4) Page 776, lines 7-11, the authors claimed that the size structure of phytoplanktonic community was changing towards larger cells with the process from R1 to R2. It is well known that larger unicellular algae are more competitive than the smaller one under a relative nutrient-rich condition. More explanation is needed.

RESPONSE: This study is complementary to the companion paper from Giovagnetti et al. (2013) focusing on changes in the structure and composition of the phytoplanktonic community after wet deposition events during DUNE-2-R. Giovagnetti et al (2013) show that pico-phytoplankton (<3 μm) mainly responded to the first seeding (R1) whereas the larger cells (>3 μm) mainly increased after the second one (R2). The rapid response of picophytoplankton fits their dominance and ability to out-compete bigger cells under LNLC and high light conditions by having a higher efficiency in physiological processes in low-resource habitats when compared to bigger phytoplanktonic cells (Raven et al., 2005). Larger-sized cells have higher nutrient requirements for growth and need further nutrient supply in order to be able to adjust their physiology and compete for resource acquisition and biomass increase (Giovagnetti et al., 2013). After the second seeding (R2), the nutrient (N, P) concentrations were higher than after the first one (R1) which can explain why the response of larger cells dominated after R2. This information has been added in the Discussion section.

5) This reviewer is also surprised why the authors didn't use the collected rainwater for their experiments.

RESPONSE: To simulate a wet Saharan deposition event, we did not use collected rainwater but the fine fraction of a Saharan dust analog in order to obtain enough quantity of the same material. The amount of dust per mesocosm required was 41.5 g, which resulted in a total of 125 g of dust for the three replicates for only one seeding experiment (we performed four seeding experiments). Such a large amount of particles could not be collected from airborne dust in the vicinity of the experimental area. Moreover, Saharan dust events are sporadic and collecting rainwater on the field at the time of the mesocosms experiment would have introduced large uncertainties in the feasibility of the project. Thus, our strategy consisted of producing dust from the soil of an appropriate source area, the southern Tunisia. The methodology developed for the DUNE project and in particular the production of large amount of dust analog was one of the objectives of the project. This information has been added in the section 2.1.

6) The concentration of DFe dropped in the experiment of D-1-P,-Q, and D-2-R1, how can you consider that Fe was not a controlling factor of the phytoplankton growth.

RESPONSE: After the DUNE-1-P, -Q and DUNE-2-R1 seedings, DFe concentrations dropped to about 1.5-2 nM while the phytoplanktonic activity was either stimulated (P, R1) or unchanged (Q). This sink of DFe is due to scavenging on settling dust particles and aggregates in the Dust-meso (T. Wagener, personal communication, 2013; Wagener et al., 2010; Wuttig et al., 2013). Wagener et al. (2010) showed that the DFe decrease rate in the Dust-meso in DUNE-1-P was one order of magnitude higher than the overestimated biological consumption of iron, underlying that enhanced biological activity cannot explain by itself the observed decrease in DFe after wet deposition event. Besides, in the DUNE-1-Q experiment, the decrease in DFe concentration after dust addition was not associated with an increase in the phytoplanktonic activity. This information has been added in the Discussion section.

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