Reply to the referee on the paper: “Variability of mineral dust deposition in the western Mediterranean basin and South-East of France” by J. Vincent et al.
The modifications in the manuscript are indicated in red.

Interactive comments on “Variability of mineral dust deposition in the western Mediterranean basin and South-East of France” by J. Vincent et al.

Anonymous Referee #3

The present study shows the result of the quantification of dust deposition obtained for a 3 years period in a network integrated by 5 sites in the Western Mediterranean basin. The study is based on the weekly sampling of the insoluble fraction of dust (deposited by both dry and wet mechanisms) by using the same sampler, the CARAGA collector, devised for automatic collection at remote sites. The study is of high interest and deserves publication. However, the sampling methodology presents some limitations that should be taken into account in the conclusions.

Saharan dust events have a clear impact on mineral dust loadings in particulate matter and on dust deposition. Deposition of mineral dust is a topic of high interest as a source of nutrients. Magnitude of dust deposition may considerably vary depending on sources, transport mechanisms, distant to the source, and deposition processes (wet/dry). Saharan dust is an important source of nutrients to the Mediterranean Sea. However, the local or regional dust contribution may also be relevant in semi-arid areas (such as those in the Mediterranean region). Contribution of other sources of mineral dust seems to be relevant at the northern sites (Frioul).

The CARAGA collector was devised for automatic sampling of the deposition in remote areas, thus permitting to cover a wide spatial area. As a major limitation, the CARAGA collector permits to sample only the insoluble fraction of deposition. Although, a major fraction of dust is insoluble; solubility may increase during transport by different chemical and physical processes. Moreover, an important fraction of relevant nutrients (nitrogen or phosphorous compounds) is water soluble and therefore is not sampled by using this method. It should be considered by the authors to modify the CARAGA collector in order to sample also the soluble fraction in the future.

The aim of this study is to document the Saharan dust deposition in terms of mass, mainly because data on deposition are limiting to validate dust transport models. And 3D models only simulate the mass of the deposited material. Thus, providing relevant information for numerous cases of desert dust deposition in this area is of large interest to better constrain the dust mass budget in dust transport models. The whole procedure (especially the only collection of the insoluble material) was thought to allow us to collect dust deposition over a long period of time and at different stations as simultaneously as possible. The soluble fraction of the deposition being not collected, the information on the chemical composition will not allow to directly and simply discuss the transfer of specific nutrients.
The following sentence was added in the paper to recognize the potential wider use of the sampling device after adapting the collector and the protocols: “The CARAGA

system is best suited for the collection of the non-soluble fraction of dust, but it could be used for evaluating other inorganic or organic particles after adapting the sampling and lab protocols".

In this study, some of the sites selected for this study are relatively close to urban/industrial areas; this is a good opportunity for comparison of results obtained by CARAGA with other conventional methods for sampling deposition. CARAGA doesn't permit to differentiate wet/dry deposition. Samples are collected in a filter and washed at the end of the sampling period (defined as a week). Therefore it is no possible to quantify the fraction of deposition accounted by wet or dry processes. As suggested by the other referees, this limitation should be taken into account in the conclusions.

The following sentences were added in the text: "In this study, no direct measurements of dry-only or wet-only deposition are performed. However, in order to provide information on the relative importance of dry and wet deposition to the MIDD, the daily precipitation measured at the sampling stations were analyzed in combination with the forward dust air mass trajectories starting from the identified provenance areas and reaching the sampling sites. When no precipitation is recorded we consider that dust deposition is driven by dry deposition processes. As mentioned by Löye-Pilot and Martin (1996), significant deposits can occur in almost "dry conditions", i.e. very low and short rain events and/or fog periods that classical meteorological rain gauges cannot detect. As a consequence, in these cases, the deposition is considered as dry and this leads to a possible overestimation of the contribution of the dry to the total deposition".

As reported in section 3.1, a number of studies have demonstrated that 1 single strong episode of Saharan dust may account for a high percentage of the total annual deposition of mineral dust. Therefore, it is important to sample continuously in order to have continuous register of deposition without gaps. The use of unattended CARAGA instruments may help to avoid gaps during sampling. However, simultaneous samples were very low during the study period (only 17 weeks –out off 75- with simultaneous samples at more than one site. Is there any explanation for these sampling gaps?

We agree with the referee that it is important to obtain continuous registers of deposition with limiting gaps for documenting sporadic strong episodes of Saharan dust. Depending on the site, the data recovery rate of weekly atmospheric deposition samples ranges from 77% to 91% for the sampling period.
82% of the MIDD were recorded when at least 4 stations were simultaneously operating (i.e. 62 weeks out of 75 with simultaneous samples when at least 4 stations were simultaneously operating). The sentence was not correctly written leading to a misunderstanding. Only 17 MIDD (out of 98) are observed simultaneously at more than one site. The sentence was rephrased: "98 MIDD have been collected during 75 different weeks of sampling and 82% of these MIDD were recorded when at least 4 stations were simultaneously operating. However, only 17 of these MIDD have affected more than 1 station during the same sampling week (12 at 2 stations, 4 at 3 stations, and 1 at 4 stations)".

Methodology: Filter ash. This method has been used by J.M. Prospero and coworkers since the mid-1960s for ambient particulate matter; see Prospero, J.M., 1999 (JGR, 104, 15917–15927): These authors performed the chemical characterization of dust. In the present paper, dust was not analyzed. It could be interesting to characterize the samples in order to evidence variations between the different sites and periods.

The reference to the J.M. Prospero's work was added in the text: "Prospero (1999) collected atmospheric particles on filters which were placed in a muffle furnace during 14h at 500°C, the ash residue weighted being assumed to be mineral dust". In our study, we focus on the mass deposition in order to constrain this parameter which is commonly simulated by 3D atmospheric models. The discussion on the mass deposition presented in the paper points out the variation of the deposition observed at the different sites and their temporal variability. As mentioned above, chemical analyses are interesting but require a different procedure of sampling (e.g. to collect both soluble and insoluble fraction).

Minor comments

L202: What is the % of retention of these filters for particles of 1 µm?

Regarding the specificities of these filters, Sheldon (Limonology and Oceanography, 1972) pointed out that "all cellulose ester membranes (Millipore) retained particles much smaller than the stated pore size, even from small samples with low particle concentrations". Sheldon (1972) also presented very satisfying retention curves for Millipore filters: up to 80% for particles of 0.5 µm in diameter with 0.45 µm filter porosity, and up to 90% for particles of 1 µm in diameter with a 1.2 filter porosity (estimation based on Figure 2 published in Sheldon R.W., Size separation of marine seston by membrane and glass-fiber filters, Limnology and Oceanography, 17, 3, 494–498, 1972). A sentence was added in the text: "Moreover, Sheldon (1972) indicated that Millipore© cellulose esters filters, with porosity ranging from 0.45 to 8 µm, have high percentages of retention of particles of 1 µm ranging from 80% to 100%".

L221 L222 L224: add wk-1 to the weekly deposition rates: 3.2 g m-2 wk-1

The correction was done when the weekly deposition was mentioned in the text: "… 3.2 g m^{-2} wk^{-1} and 2.7 g m^{-2} wk^{-1} were measured at Mallorca and Lampedusa".

L232: a gradient of dust with the latitude has been also observed by Pey et al 2013.

The Pey et al.'s work is now cited in the text when the gradient of dust with the latitude is mentioned: "Previous observations also pointed out a gradient of dust content in the western Mediterranean atmosphere (see for example Barnaba and Gobbi, 2004; Pey et al., 2013)".

L234-L250: taken into account that the present study only considered the insoluble fraction, when comparing with other studies it should be indicated the fraction sampled at each case: bulk deposition; soluble+insoluble …

The indications of the fractions sampled (bulk, insoluble and/or soluble…) for the different studies were added in Table 1.

L305. Delete "studies"

Done.

L300-L313: this paragraph (and this from L317-L324) could be moved to the Method section

This paragraph presents the Hysplit backward trajectories and the satellite data used to identify Saharan dust events. The section "3. Experimental setup" was renamed "Materials and methods". A new section "3.4 Air mass trajectories and satellite observations" was added. The paragraph mentioned by the reviewer and the presentation of the satellite products was moved into this new section.

L364-L367: I wonder these differences can be explained by the precipitation events. Wet deposition of Saharan dust can be very important. During these wet episodes, ambient air concentrations not necessarily high. There is a number of papers showing the meteorological scenarios of Saharan dust resulting on wet or dry events. For Lampedusa, as shown in Figure 5, this seems not to be the explanation. AOD reflects the concentration of dust in the whole column; however, as concluded by Marconi et al., Atmos. Chem. Phys., 14, 2039–2054, 2014, at Lampedusa, "Saharan dust transport occurs above the marine boundary layer, and no significant mixing of the dust below and above the boundary layer takes place; resulting in high difference between boundary layer and free tropospheric dust evolution;

Wet deposition due to precipitation, which can be very intense as mentioned by the referee, could explain a part of these differences, as well as dynamical conditions of dust transport and their vertical mixing. Following the comment of the referee, the study of Marconi et al. (2014) is now mentioned to illustrate this point. A sentence was added to point out these works: "Marconi et al. (2014) mentioned that in Lampedusa no significant correlation between aerosol optical thickness and PM10 or non-sea-salt Ca is found for the period June 2004-December 2010. These authors suggested that even when the dust is very likely present in the lower and mid-troposphere simultaneously, the aerosols observations at the surface are generally decoupled from what takes place above in the atmospheric column".

Figure 3. It will help the interpretation to mark the periods with influence of SDE at each site.

Done. The time periods with influence of SDE were marked for each site on Figure 3 and the caption of the figure was rephrased: "The numbers of most intense dust deposition for each station as described in §4.3 are indicated by black bars above the deposition flux values: 34 in Lampedusa, 20 in Mallorca, 11 in Corsica, 18 in Frioul and 15 in Le Casset".