Referee #1. Stefano Miserocchi

The paper aims to determine the temporal and spatial evolution of benthic remineralization in the bed sediments of Rhone River prodelta. This is done by intensive sampling in the prodelta area over almost 2 years. The benthic remineralization fluxes have been determined in three different ways: from in situ oxygen profiles, ex situ profiles and sediment core incubation in the laboratory. The different approaches provide consistent results evidencing the role of diffusive exchange at the sediment water interface. The main conclusion are: - a clear pattern of decreasing oxygen consumption fluxes with distance from the river mouth that is present during time when "normal" river discharge conditions occurs. - in june 2008, after a period high river discharge, the deposition of a "flood layer" happened and the oxygen demand in the area in front of the main Rhone River mouth decreases decisively. - After six months the initial conditions were reestablished and some speculations on the involved processes are given. In general I found the paper to be well organized and the method and the conclusion to be sound. The figures are well done and add significantly to the paper. However, I have some specific comments that might help to improve the final quality of the paper.

Specific comments: The authors should be clearer in some parts of the section 4.2 Spatial and temporal distribution… of the discussion part..

Reply: Thanks to the referees' comment, the discussion have been reframed, rewritten and scanned carefully to avoid improper English expression, light up the text and make it clearer.

The data presented in Fig. 11 are very important and add a lot to the discussion. However, the data presented are not mentioned in Material and methods (i.e. coring during September and October 2008, OC profiles, the sediment core description method and the station at 45 m is not included in the list of table 1).

Reply: The description of the coring in September and October 2008 (location of the station), the OC profiles and the sediment core description method have been added to the Materials and methods section.

DATE	LATITUDE	LONGITUDE	DEPTH (m)
8 june 2008	43° 18.427	04° 51.316	42
6 september 2008	43° 18.420	04° 51.300	45
16 october 2008	43° 18.435	04° 51.321	46
4 december 2008	43° 18.418	04° 51.370	46

Also referring to fig 11. data interpretation, the evolution of the June 2008 flood deposit could be compared respect to river discharge and wave heights time evolution to better validate the deposition/resuspension processes.

Reply: As suggested by the referee and pointed out further below, the evolution of the June 2008 flood deposit was compared to the river discharge time evolution. No further flood events (>3000 m^3s^{-1}) occurred between June and November 2008 (cf. Fig. 2, p10807). The new layer observed in December 2008 followed an annual flood that most likely brought new rich material (see further comment). Significant wave heights in 2008 in this area from June to December 2008 did not exceed 4 m: therefore limited wave-induced resuspension at 45m depth and below occurred during this period. This feature has been included in the revised manuscript (section 2.2 Field sampling work and sampling procedures). It constitutes, as pointed by the referee, another argument in the revised discussion part in favor of a June 2008 flood deposit remaining in the prodelta.

Beside that, other chemical tracers (e.g.. 7-Be) could better explain new sedimentation processes.

Reply: Ongoing analysis, implying radionuclides (137Cs, 134Cs and 210Pb), X-ray, grain size and organic matter compounds measurements on the 4 cores (June, September, October and December 2008), are still in process and data are not available yet. 7Be data are available only for June and December 2008. 7Be has a half-time of $T_{1/2}$ = 53.3 days, and is a good short-term proxy for flood inputs in coastal environments (Mullenbach and Nittrouer, 2000;Sommerfield et al., 1999). In June 2008, 7Be activity was almost constant (37 ± 12 Bq kg^{-1}) in the top-first 30 cm of the sedimentary column: this layer displayed also constant low organic carbon (OC) contents and corresponds to the flood deposit estimated from our visual sedimentological observations on the core. Below, the 7Be activity decreases while OC content increase. Therefore, this bottom layer is likely to correspond to the former sediment surface: the decrease in 7Be activity observed would represent the sedimentation processes before the flood i.e. during normal discharge rates conditions and therefore moderate and rather continuous inputs.

In December 2008, 7Be activities were measured until 17.5 cm depth. The December 2008 cruise was carried out one month after an annual flood. The large 7Be activities observed in the upper part of the core (~100 Bq kg^{-1}) clearly indicate recent deposition of material potentially related to the November flood. This data will be published, along with some others (grain size, water content, BIT index, redox front survey) in an article in preparation focused on the evolution of the June 2008 flood deposit.

The 2 –4 cm ochre mud layer observed in June and September 2008 core (fig . 11) seems unrealistic to me: too thick given the oxygen penetration < 5 mm measured at the station B.

Reply: An error has occurred in the figure 11: the ochre mud layer was only 1-2 cm thick. This has been corrected in the revised manuscript. This 1-2 cm ochre mud layer is not incompatible with < 5 mm oxygen penetration depths, since it reflects more to suboxic-anoxic interface than a strict oxic-suboxic limit (Mulsow et al., 2006;Hargrave et al., 2008). This layer, which includes nitrification and Mn-oxides reduction processes, is generally thicker than the oxygen penetration depth, as has been observed in a comparable coastal environment by (Xu et al., 2009). In addition, redox potentials have been measured and provide good information about the oxidized layers in the June 2008 deposit and the redox front evolution. Indeed, the redox potential profile in the June 2008 flood deposit presents positive values from the surface until 10 cm depth. Then anoxic processes settle down with values more and more negative until the 28-30 cm level. In the underlying ochre mud (30-32 cm), the redox potential rises again, reflecting thus the location of the old sediment-water interface. Below this former interface, the dark muds with strong H_2S smell are reduced twice more than the bottom part of the flood deposit: this likely reflects the anoxic processes taking place in the sedimentary column under normal discharge rates conditions. These data have been added to the revised manuscript.

Another issue is that looking at fig. 11 the Dec 2008 cruise do not seems to represent a “normal discharge period” because a new 19 cm thick layer (see also P15 L 13) has been deposited after October 16 (probably due to the water discharge peak of almost 5000 m^3s^{-1} occurred in mid November 2008 (I extrapolate these numbers from figure 2 and probably are not so exact). I brief, please clarify what is the meaning of “normal discharge conditions” respect to “major flood conditions”. Taking in consideration the data presented in fig. 2 and fig. 11 (integrated SPM amount and new deposit due to Nov 2008 discharge peak) the Apr 07 and Sept 07 cruises discharge conditions seems different from Dec 2008 ones.

Reply: We agree with the referee that the limits and conditions of “normal discharge period” have not been clearly defined. We meant that at the sampling time, the Rhône River discharge rates were around average and did not exceed 3000 m^3s^{-1} (the discharge rate at Arles for a annual flood being 4280 m^3s^{-1}): the inputs during the cruises in April 2007, September 2007 and December 2008 were moderate, compared to the high discharge rates (liquid and particulate) delivered during the June 2008 cruise. Discharge rates in April and September 2007 (Q ~ 500 m^3s^{-1}) were particularly low compared to December 2008 (Q ~ 2000 m^3s^{-1}), and explain the differences in integrated SPM amount. Nevertheless, the December 2008 cruise followed a 6-days annual flood that occurred on November the 1st and brought 0.43 10^6 tons of sediments, corresponding to 1.26 10^4 tC (vs. 4.9 10^6 tons of sediments and 7.9 10^{4} tons of OC delivered in 10 days in June 2008). Therefore, although discharge rates can still be considered as "normal" during the December 2008 cruise, conditions in the sediment might be different from the ones in April and September 2007. Nevertheless this difference does not show up in the DOU rates distribution. In the Rhône River prodelta, benthic mineralization one month after a moderate flood (such as the one of November 2008) is similar to the one under low discharge rates conditions (such as the year 2007). We therefore qualified these conditions as "normal" as opposed to the June 2008 flood conditions, where benthic mineralization rates were affected by the changes in river discharge rates. The discussion of the revised manuscript about the evolution of the flood deposit includes now these aspects: the definition of discharge rate conditions (normal vs. flood) and their implications to biogeochemical condition in the sediment have been made clearer.

On P16 L18-19 (in the conclusion part) the sentence "...which create a rapid relaxation of the oxygen distribution towards its initial state (<6 months)" it is not clear to me. Please clarify. From the discussion part I understood the relaxation of mineralization occurred immediately after the deposition of the June 2008 flood layer. From the cited sentence I can understand the rapid (?) relaxation occurring in the six months from June 2008 to Dec 2008.

Reply: Since no oxygen measurements were performed in September or October 2008, we can not clearly constrain the time scales involved in the return to "normal" conditions. Therefore, reviewing the potential processes involved in the return to stationary conditions, we assessed the time constants implied for the Rhône River prodelta. To achieve this, we performed this calculation using the oxygen consumption rates derived from the PROFILE software. Compared to diffusion time-scales, it indicates the relative importance of mineralization reaction processes (combination of chemical species via reactive oxidation processes but also re-establishment of the microbial community), and their timescale (hours vs. years). One can thus assume that the re-establishment of stationary conditions in the sediment will be rather quick. This is consistent with our observations in December 2008. As discussed above, a flood had occurred just one month before our cruise and DOU rates in sediments of the prodelta already showed similar to low discharge rates conditions, suggesting thus a dynamic and rapid system. This November flood was different from the June one (~ 11 times less particles, but just ~ 6 times less carbon delivered) and the response induced to the sediment might therefore have been different. Nevertheless, it still indicates that sediments off the Rhône River are reactive enough to display stationary conditions one month after a flood event. This is in agreement with flood event studies in other coastal environments that evidenced remediation time scales around weeks (Bentley and Nittrouer, 2003;Eyre and Ferguson, 2006;Eyre and Twigg, 1997;Deflandre et al., 2002). In addition, the Rhône River discharge rates were low between June and November flood (cf. Fig. 2, p10807) and no significant differences appeared between the September and October cores (same low OC content layer, cf. Fig. 11, p10816). This suggests that only little particulate material was delivered in the prodelta between the two floods, and the surface ochre mud present in September (and October) could thus correspond to the "new" redox front already settled back two months after the flood event. Therefore, it appears that the dynamics of the Rhône River inputs and the sedimentation processes associated are key factor for carbon mineralization processes in the sediment. Our data suggest that the response of the benthic degradation system of the Rhône River prodelta to flood inputs involves rapid processes with time scales not exceeding the month.

We are aware that this point is mainly speculative and thanks to referees' comment this part of the discussion has been rewritten carefully. We clarified this time scales concern while cautiously avoiding drawing any final conclusions that our data do not support.

Minor comments:

I have found some minor typing errors, but since English is not my first language I do not assure the quality of my check for English grammar.

P4, L 17 please check "extending then the shoreline" probably replace "then" with "from"

Fig. 1 caption. Replace: "sampled the four cruises" with "sampled during the four cruises"

P9 L19 Replace: "enriched:" with "enriched."

Reply: This has been added to the revised manuscript.

P9 L27 Replace: "ighest" with "highest"

Reply: This has been previously corrected and the online version of the manuscript includes these corrections.

P13 L28 "discharge was similar (4 Mt)". It is better to use the same unit for sediment load. (i.e. Exponential notation as in line P13L19). Probably a reference is needed.

P13 L18. "This annual flood delivered up to 3.5 10ˆ6 tons of sediment in a 10 days period". Please consider to insert a reference to the figure 2.

Reply: This has been added to the revised manuscript.

P14L16 "bio-available compounds (4 vs. 7 mg g-1 d.w.)" these kind of date is not mentioned in Material and methods.

Reply: This data (Buscail, R., pers. Communication) has been clarified directly in the discussion of the revised manuscript. These "bio-available compounds" corresponds to the sum of lipids, proteins and carbohydrates present in the sediment, and thus potentially available for organisms.

The following references are missing in the references list:

Eyre et al., 2006 Rees et al., 2005 Ulses et al, 2008 Cathalot et al, In prep

Table 3 : The date relative to station K present a (*) that is not explained. The numbers of digits is not homogeneous.

Reply: This has been previously corrected. The online version of the manuscript includes the above references and the explanation for (*).

References:

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