"Sediment transport along the Cap de Creus Canyon flank during a mild, wet winter"

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Anonymous Referee #2

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The manuscript describes the extensive monitoring of water and sediment fluxes caused by downwelling currents during moderate storms at the flank of the Cap de Creus Canyon. Detailed hydrographic and hydrodynamic observations allow quantify sediment fluxes along the flank of the canyon and compare them with observations at the head of the canyon. From observations, main hydrographic processes and paths of sediment transport are inferred. Although the export of sediment from the continental shelf to deep areas through submarine canyons has already been described in previous studies, this manuscript provides high resolution data and adds new knowledge, especially to differentiate downwelling processes from that of dense shelf water cascading, and also shows that the entry of water and sediment into the canyon not always take place through the head of the canyon. The manuscript is well-written and interesting and I recommend publication after minor changes.

- About storm characterization: I understand that the Hs is the maximum Hs during the storm. This should be specified in the manuscript.

Yes, every time Hs was reported in the text to characterize storms, we meant the *maximum* Hs. This has been specified throughout the revised manuscript.

Additionally, it is necessary to provide information, at least, about the wave period (the maximum Tp during the storm will give a better characterization of storms). *Finally, the use of expressions as* "under limited external forcing", "mild storms", "highly dynamic area" is quite subjective. I suggest to characterize the storm intensity in terms of "return period" or some similar quantitative expression

The paragraph mentioned by the referee has been rewritten to include the requested information:

"Three E-SE storms hit the GoL shelf during the study, peaking on 8, 13 and 15 March with maximum significant wave heights (Hs) of 3.3, 4.6 and 4.1 m and maximum wave peak periods of 10.1, 10.2 and 9.4 respectively. These wave conditions correspond to typical winter storms in the region. According to their maximum Hs, their return periods are between 1 and 2 years Guizien (2009)."

- Advective and downward particle fluxes: Horizontal and downward particle fluxes mean different mechanisms and different methods were used to monitor them. Mixing both in the description is confusing. Advective fluxes represent sediment transport whereas downward particles mainly represent sediment accumulation. If the Winter was “weak” or “strong” in terms of sediment transport it is more related to advective fluxes (i.e. strong advective currents can prevent settling of particles ...). Higher down-ward particle fluxes mean that a high amount of sediment arrives but the sediment transport is low at the site. I suggest to clarify these concepts in the description and discussion.

We agree with the referee about the important distinction of these two concepts. The results (section 4.1 in particular) and the discussion have been rewritten to better clarify these ideas.

- “origin” of sediment: The postulated origin of sediment that increases the turbidity (and sediment transport) in the downwelling layer is the sediment erosion at the inner shelf. This is in agreement with observations in previous studies. These studies demonstrated that sediment erosion was favoured by the presence of fresh sediment, in the form of ephemeral layers, recently deposited at the inner shelf by a combination of river floods and storm activity. In this context, it should be interesting to evaluate if this is the situation for the sequence of storms in March: previous river flood, transport of sediment towards the inner shelf (role of the 9 March storm?), and finally offshore transport to deeper areas. It seems that the sequence of storms can play a significant role in the delivery of sediment from the shelf to deeper areas.

We appreciate this insightful comment. In fact, the time series of downward settling flux at the canyon head for the entire winter (Fig. 3) suggest accumulation of sediments during December and January, in coincidence with relatively high river discharge from the Rhône. We believe this accumulation of sediments during early winter was partially flushed by the storms of 13-15 March. The storm of 9 March could have helped to bring the fresh sediments closer to the canyon. All these points are now clarified in the discussion.

- is the sediment transport relatively confined or more relevant near the bottom? “The present results seem to challenge that notion.” Be careful with this affirmation, it is too general and must be qualified further. You provide observations of a water layer more than 100 m thick with high turbidity and sediment transport. Therefore, you can affirm that sediment transport is not only confined very near the bottom. However, you don’t provide details about sediment transport on the bottom boundary layer, the first meters above the bottom, although it is suggested that this sediment was resuspended from the bottom by waves and wave induced currents at the inner shelf (at this point probably the concentration and sediment transport will be higher near the bottom).

In fact, we were not able to measure sediment transport near the bottom so we cannot actually compare with the water column. The bottommost turbidimeter was placed at 12 meters above the bottom (mab) while current measurements were available only from 40 mab upwards.

What we can report, as described in the text, is that suspended sediment concentrations were high and within the same order of magnitude from 12 to 115 mab, and currents also comparable in the range profiled by ADCPs (40 to 140 mab) at both mooring lines deployed in the south canyon flank. This is enough to assert that significant sediment transport was taking place in the water column, not confined near the sea bottom.

We agree with the referee that sediment transport was very probably even higher closer to the bottom.

This opens a question: the sediment is resuspended according to usual wave dominated bottom boundary layer processes, transported offshore and re-distributed (almost homogeneously) through a 200 m thick cold water layer. Perhaps authors can suggest some ideas of how this resuspended sediment is homogenized in the water column.

The sediment is resuspended by wave action. This 200 m thick cold layer has a common origin, these are coastal and/or shelf waters, homogenized and cooled by the action of winds and low temperatures, then injected into the canyon by storm-induced downwelling. A more comprehensive and detailed study on the coastal-shelf-canyon connections is desirable and some of the authors envisage it for the future.

Minor comments:

- Page 18221, line 2: “among other parameters”, what parameters?

The paragraph has been expanded in this way:

“CTD casts were carried out using a Seabird 911Plus CTD probe equipped with a SBE 32 Carousel water sampler. 13 data channels (pressure, dual temperature and conductivity with pump, dissolved oxygen, light attenuation, turbidity, fluorescence, dissolved oxygen, Photosynthetically active radiation, Surface photosynthetically active radiation, Colored Dissolved Organic Matter, and altimetry) were measured at a rate of 24 Hz.”

- Page 18221, line 21: “to average winter storms in the region” reference?

A reference has been added: Guizien (2009).

- Page 18223, lines 8-9: Eastern storms and tramontane wind gust, do they produce exactly the same effect?

The reviewer refers to this paragraph: "*Several decreases of near-bottom temperature simultaneous to increases of current speed were observed at the canyon head, in general associated to E-SE storms or strong Tramontane wind gusts*."

NW and E-SE winds produce different effects as explained in the second paragraph of the section "Study area". However, both can result in the injection of cold waters flowing at high speeds in the canyon. The former, by cooling the shelf waters may cause its downslope sinking (= cascading), the latter by promoting the forced downwelling of relatively cold (but relatively fresh too) shelf waters at the Cap de Creus region, as observed in this study. Note that this paragraph is included in the results section, we are describing the time series for the entire winter 2010-2011, the exact explanation about what happened in the months previous to the CASCADE Cruise (March 2011) is out of our current possibilities.

- Page 18232, lines 1-3, I don't understand this sentence.

We have rewritten the sentence in this way:
"Previous studies have suggested that, during major episodes of offshore transport such as cascading and storm-induced downwelling, the main water flow tends to contour the CCC following the isobaths and then enters the canyon preferentially by its southern flank, affecting only partially the canyon head."

- Page 18233, lines 9-17, the settling of particles was higher at the flank of the canyon, but settling particles is not sediment transport...

We agree with the referee. That important distinction has been highlighted in the text. In fact, we suspect that the traps were overtrapping the flux due to the high speeds and tilting of the line (Fig. 2).

Section 5.4.- This section seems out of the main scope of the manuscript. If necessary, please provide additional information of erosional marks: what sediment, morphology, ...

We agree with the referee that this is not the core of the present paper but is a consequence to the main observations that, we believe, is worth to mention.

Together with the estimation of sediment transport and its routes, we have studied the dynamics of an episode of storm-induced downwelling inside the CCC. A logical follow-up to the study is to ask where does the downwelled water go when the external forcing disappears or relaxes? And which preferential routes or channels it uses to leave the canyon confinement? Section 5.4 tries to give an answer to these questions, while pointing out an overlooked aspect of the CCC morphology. We expect that this particular subject (the potential of shallow cascading and downwelling/upwelling to erode and shape the canyon flanks) will be further developed in the future through more dedicated studies.

-Conclusions, line 6: this amount is quite speculative (as explained previously in the manuscript) and it should be noted here

We have modified the sentence in this way to satisfy the referee:

"We provide a rough estimation of 10^5 tons of suspended sediments being transported into the canyon within the downwelled coastal plume during the 3-day stormy period."

- Current speed from figures 4 and 5 is difficult to compare (along canyon and total respectively). From these figures, I'm not sure that both datasets are consistent between them.

Even though the locations are not the same (canyon head in Fig. 4 and southern flank in Fig. 5; see Fig. 1 for respective locations) The datasets are coherent between them. Note that the timeline in Fig. 5 is a zoom in the longer timeline of Fig. 4. (the zoomed period is marked with a square and a label in Fig. 4.

In Fig. 4 we have used a rotated current velocity because it allows a better comparison with temperature and sediment flux time series. We could also use in Fig. 5 a rotated component instead of current speed module + direction, but we chose the second option because the temporal evolution of current direction is easier to follow in this way and it becomes clear to the viewer how the currents, initially isotropic are consistently directed along-isobaths when the turbid shelf water mass enters the canyon.

References:

Guizien, K.: Spatial variability of wave conditions in the Gulf of Lions (NW Mediterranean Sea), Vie et milieu, 59, 261-270, 2009.