Interactive comment on “Application of a Lagrangian transport model to organo-mineral aggregates within the Nazaré canyon” by S. Pando et al.

S. Pando et al.

s.pando@jacobs-university.de

Detailed response to Anonymous Referee #1 comments

Specific Comments

- This section (Introduction) is too extensive and some paragraphs are too big. This is, in part, because some ideas are repeated. The section will gain objectivity if properly trimmed;

Response: This section has been rewritten according to the reviewer’s suggestion.

- A conceptual model for the fate of aggregates in submarine canyons is provided, but it is a little bit confusing. Authors should consider using bullets to summarize the main components/processes of this conceptual model;

Response: This section has been rewritten for a better understanding.

- Please set a paragraph to clearly state the objectives of the work. In the actual state of the paper the objectives are mixed up with some generic observations.

Response: Modified as suggested.

- This section (Material and methods) is adequately organized and even though the modelling details are not given, the references provide the source for most model architecture and implementation details. For its importance in the paper, there is just one point that needs to be better explained, namely the residence time. As it is now (p.454, l.22), it is not obvious if the time is for all particles to leave the box or if it is a mean time. Please make this concept clear.

Response: The residence time concept used in our manuscript is an alternative approach to the one proposed by (Braunschweig et al., 2003;Malhadas et al., 2009). "For this project we use the term "residence time" for the temporal interval required by the OMAs to leave each monitor box. This is a new and alternative approach to the previous concept proposed by (Braunschweig et al., 2003)." P7 L2-4

- Different horizontal viscosities are advanced for each level and no explanation is provided for this choice.

Response: We corrected the values and rephrased the two sentences on P7 L26-28: "The simulations had a time step of 15 s and a horizontal viscosity of 10 $m^2 s^{-1}$ for the third level. The first and the second level had a time step of 900 s and 60 s and a horizontal viscosity of 30 $m^2 s^{-1}$ and 20 $m^2 s^{-1}$ respectively". The selected values for this parameter are inversely proportional to the grid resolution step (Δx, Δy).

- Consider changing the name of this section to" Methods"

Response: Changed as suggested P4 L24

- I suggest authors to summarize the major results in section 3.1(Results) in a table

Response: A number of paragraphs of this section were rephrased to present a better description of the results in figures 3-5. Therefore, we considered the additional table unnecessary. Figures 3-5 depicted the model results for the fraction of aggregates that were leaving the monitor boxes. This type of oscillation gives a general idea of the transport patterns in each box.

- I would like to see a clear justification or a hypothesis to why the aggregates with 2000 µm show a distinct behaviour from the other size classes (Discussion).

Response: The U^*_d is higher in the 2000 µm size class than in the other size classes. This difference (Table 1) will cause the aggregates of the 2000 µm to deposit earlier than the other size classes. Additionally, the higher U^*_{cr} of the 2000 µm aggregates will result in lower resuspension rates than the 4000 µm aggregates. Although the 429 µm size class needs even more shear stress for resuspension, that time is compensated by the time they take to settle, as can seen by their much lower U^*_d. The comment by the reviewer opens an opportunity for further work to investigate the U^*_d of particles of different sizes less or larger than the 4000 µm diameter. This might help establish the U^*_d cut-off value for different OMAs class sizes.

- I suggest some changes in this section (Conclusion), namely, removing some generalist observations about the model, and the inclusion of specific conclusions regarding the dynamics of aggregates (i.e., what does the model results help to explain or clarify). Suggestion of topics to address: more active areas/depths, relations between aggregate movements and energy, particle size behaviour, transport patterns...

Response: Changed as suggested

- Following the trend of most open-access publication nowadays, I would suggest to authors to include in this section (Acknowledgements) a brief mention of each author contribution to the work.

Response: Changed as suggested, P14 L7-9: "Conceived and designed the experiments: SP, MJ and LT. Performed the experiments: SP and MJ. Analyze the data: SP, MJ, RG and LT. Contributed reagents/materials/analysis tools: SP, MJ, PAJM and LT. Writing the paper: SP and RG."

- Figures 3-5 and 8-10 must be significantly bigger in the final document. Otherwise the text in them will be impossible to read.

Response: Format changed

Technical Corrections

P448

L5: please rephrase this sentence to avoid repetitions: "...patterns of the organo-mineral aggregates along the Nazaré canyon comparing three different classes of organo-mineral aggregates." Changed as suggested: P2 L4-6

L8: "suspended matter is resuspended.." Suspended matter is, by definition, in the water column. As such, this observation must be changed to something like "deposited matter is resuspended..". Changed as suggested: P2 L7

L9: This sentence starts in the same way as the previous: "The results showed..." Please change. Also, I suggest changing to present tense instead of past tense: "The results show...". Changed as suggested: P2 L7-9

L15: please change to "between the shelf and open ocean has been the focus..". Changed as suggested: P3 L2-3

P449

L7: "Consequently" is more appropriate than "Hence". Changed as suggested: P3 L12

L8: This sentence must be changed. The budget is by definition the balance of sinks and sources. "Global carbon budgets" for instance. Changed as suggested: P3 L13

L13: "hydrodynamic processes interacting with the bottom topography..." Please explain. **Response:** The details of this assertion will be presented in a manuscript ready for submission to a peer reviewed journal.

L18: Please change to "circulation, for example, will..." and "will mostly concentrate organic material...". Changed as suggested: P3 L23-25

L21: "the largest canyon in the Portuguese coast..". Changed as suggested P3 L26

P450

L15-20: please rephrase this sentence (is done... is done..). Rephrased as suggested: P4 L3-9

l.25: A new paragraph should start here. Changed as suggested: P4 L7

P451

L18: This sentence (However...) is anecdotal and should be removed. This sentence was removed.

L19: This sentence cannot start with 'hence' because it is not a logic following of the previous statement. Also, the sentence is confusing and too big. Rephrased as suggested: P4 L19-20

L23: the other way around: to assess if our numerical model agrees with the present conceptual model. Rephrased as suggested: P4 L20-22

P452

L4: "from the 500 m at the Nazaré beach.." this is confusing. Rephrased as suggested: P4 L26-28

L7: correct "embraces. a..". Corrected as suggested: P4 L30

L8: suggestion: "starting at 50 m and extending to the depth of 2700 m..". Changed as suggested: P4 L30 and P5 L1

L11: This observation (The canyon cuts..) needs to be properly explained. How the rugged topography intensifies hydrodynamic processes? How is the tidal energy trapped? **Response:** The details of this assertion will be presented in a manuscript ready for submission to a peer reviewed journal.

L25: The first sentence of the first paragraph of subsection 2.2 must be rephrased. Rephrased as suggested: P5 L16-17

P454

L22: "The residence time is the temporal interval..." (for example). Changed as suggested: P7 L2-4 and a new sentence was added to clarify the concept of residence time.

P455

L16: "15 days spin-up.." (no need for the quote). Removed as suggested.

L25: In this description it is not clear what are the box properties and the particle properties. Please make this clearer. Changed as suggested: P8 L2-4

P456

L5: "was displaced" or "was placed/located"? Changed as suggested: P8 L10-11

L12: The sentence starting with "the monitoring boxes.." is incomprehensible. This is the methodological section and this seems to be a result (some were escaping..). If not, what does this means? Changed as suggested: P8 L17-18

L16: "the followed nested levels.." or "the following nested levels"? Changed as suggested: P8 L20

L20: change to "inside each box for the spring of 2009 is...". Changed as suggested: P8 L24

P457

L1: change to "(due to transport)". Changed as suggested: P8 L30

L11: The sentence starting here is confusing. I suggest to stick to the simulation day and not to the expression "and 28 days later..". This sentence was rephrased: P9 L9-11

L26: I suggest "...by the model for an initial period of 22 days, the half-life of fresh phytodetritus (Thomsen et al., 2002), and..". Changed as suggested: P9 L23

P458

L3: Please rephrase this sentence "The 4000 um size..". Rephrased as suggested: P9 L27-28

L10: The first paragraph of this section belongs to the material and methods. Changed as suggested: P7 L4-8

L15: Mean average of particles in the box? The concept of velocity must be clarified. Changed as suggested: P7 L8

P459

L13: "longer displacements" should be changed. Changed as suggested P10 L29

L16: what is a "long displacement"? Long compared to what? This paragraph was rephrased to allow the reader to grasp the intended idea P11 L2-7

L18: The sentence "hence, at canyons head..." must be rephrased because it has a poor construction. Changed as suggested: P11 L4-5

P460

L2: "...canyon functions.." better expressed as "this section of the canyon is an area of deposition..". Changed as suggested: P11 L15

L17: please change "the 2000 um ones.." to "aggregates with 2000 um systematically...". Changed as suggested: P11 L29-30

L25: check this sentence "As our simulation..." because it needs some improvement. Changed as suggested: P12 L5-7

P461

L16: Observed by whom? Reference inserted: P12 L24

Detailed response to Anonymous Referee #2 comments

Specific comments

The introduction is too extensive, presenting huge paragraphs and a great number of references. A proper introduction should be written by presenting the problem/issue in study; the main advances in the study of the proposed issue, the methodology followed and finally a brief paragraph containing the main objectives of the paper.

Response: This section has been rewritten according to the reviewer's suggestion.

This manuscript presents a huge amount of references (67). The number of references should be reduced, because there is no need to present 5 or 6 references to emphasize an idea or a characteristic of the study region.

Response: The number of references was reduced in the revised manuscript.

In general the study area is well described. However, the oceanographic features of the study area should be highlighted. That is, the authors should describe velocity patterns and the tidal circulation in the study area to produce a more complete picture of the physical features that control the advection of particulate matter in the canyon.

Response: We fully accept the reviewer comment. The aim of the current manuscript was to describe the transport patterns of OMAs in the Nazaré canyon. However, the physical features of the Nazaré canyon have been prepared for another manuscript to be submitted to a peer reviewed journal. The intended manuscript will describe in detail the main oceanographic features of the canyon and the potential linkage with the Lagrangian transport model.

At the end of the section 2.4 (Model setup for the Nazaré canyon), the author state that the nested levels are validated allowing the linkage to the lagrangian transport model.

Where are the validation results? There is any paper/thesis or report where they are referred? If not you should present some validation results, concerning tidal propagation and velocity patterns. If you don't have data to compare you should refer this.

Response: The aim of the current manuscript was to introduce our concept and approach. The validation results will be published in the follow-up manuscript which is ready for submission.

Section 3 (Results) presents some problems that I would like to discuss with the authors. The main problem here is a question of terminology. The concept of residence time is not well used by the authors. The residence time is a number and presents no dynamic features. That is, the residence time is an average amount of time that a particle or set of particles spends in a particular system or place (is only a number). The results depicted in figures 3, 4 and 5 are the temporal evolution of the particle fraction in each emission box not the residence time. Therefore the authors should take this into account and should revise this whole section. Moreover, the results presented in figures 3, 4, and 5, reveal that the chosen location for the emission/monitoring boxes presents a high particle fraction. The values are always rather high (ranging between 0.7-0.9), revealing that the particles are advected back and forth to outside/inside the box. So you cannot refer a residence time here.

Response: The residence time concept used in our manuscript is an alternative approach to the one proposed by (Braunschweig et al., 2003). "The residence time is the temporal interval required by the OMAs to leave each monitor box. This is a new and alternative approach to the previous concept proposed by (Braunschweig et al., 2003)." P7 L29-31

All the results show a significant difference between the 2000 μm OMAs and the other two classes. However, the there is no answer to these differences? Which canyon characteristic modulates the behavior of this size class of OMA? I would like to see a clear justification to this.

Response: The $U*_d$ is higher in the 2000 µm size class than in the other size classes. This difference (Table 1) will cause the aggregates of the 2000 µm to deposit earlier than the other size classes. Additionally, the higher $U*_{cr}$ of the 2000 µm aggregates will result in lower resuspension rates than the 4000 µm aggregates. Although the 429 µm size class needs even more shear stress for resuspension, that time is compensated by the time they take to settle, as can seen by their much lower $U*_d$. The comment by the reviewer opens an opportunity for further work to investigate the $U*_d$ of particles of different sizes less or larger than the 4000 µm diameter. This might help establish the $U*_d$ cut-off value for different OMAs class sizes.

What is the purpose of showing distance and displacement results? The OMS velocity in each box is presented in kmy-1. Why? The SI units are m/s (or cm/s). What is the probable justification to a velocity difference of the order of 500 km/y between the different class size of OMAs?

Response: This manuscript applied Lagrangian model with a purpose of providing results in a spatial and temporal approach of quantifying the carbon flux through the canyon. The output parameters such as distance, displacement and velocity describe non-linear transport of the OMAs within the canyon. The non-use of standard SI units was intentional in order to offer a general idea of OMAs transport over large distances throughout the year. The results showed the average distance, displacement and velocity of the OMAs size classes for each box (Figs. 8-10). The distance was related to the total length that the OMAs travelled (km), the displacement was the difference between the initial and final position of the OMAs (km) and the velocity of the OMAs was in km y^{-1}. Fig. 6 depicted the dispersion patterns of the 429 µm and we observe that in box 2 (located at the shelf break) few particles were already travelling long distances after 22 days, therefore the particles could have a reach this maximum velocity (500 km/y).

Detailed response to Henko de Stigter's comments

General comments

Using a Lagrangian transport model coupled to a 3D ocean model, Pando and co-authors attempt to get a quantitative understanding of the particulate transport through the canyon. Interesting though this may be for better understanding of relevant transport processes, the authors unfortunately lose contact with the observational reality where they conclude that "the canyon is not a conduit of organo-mineral aggregates to the deep sea". The authors could contribute significantly to science if they would face the discrepancy between observations and model results and critically discuss the flaws in the previously published observations and their interpretation or in the present model.

Response: In this study, experimental observations on particle resuspension- and transport-characteristics from canyons and open slopes over the last decade, were interpolated and complemented with the application of the MOHID model. First, it was necessary to reproduce the system dynamics using the hydrodynamic model, then evaluate transport patterns of the OMAs during a particular time, namely Spring 2009 by applying the Lagrangian model. These models are versatile tools that allow us to have an integrated overview of the system which are challenging to achieve by simple combination of available analytical methods. Despite the strengths shown by the model application, a number of limitations have made it difficult to address all features of the canyon system and to answer to all the relevant questions. For instance, our simulations have a temporal limitation because they simulate only a quarter of the year which coincide with the spring-summer period where oceanic and atmospheric conditions are not intensified as in the winter regime. Other critical limitations such as the sediment gravity flows and aggregation/disaggregation processes (as pointed out by the Reviewer) and river discharges are not considered in our simulations. The current manuscript describes the transport patterns and behavior of organo-mineral aggregates (OMAs), which are responsible for the horizontal transfer of particulate organic carbon within the canyon. Other publications on Nazaré Canyon have focused on transport of lithogenic particles (e.g. De Stigter et al., 2007). These particles however have a different transport behavior. Our manuscript is a first attempt to describe the lateral advection of OMAs. Our future work will try to determine the hydrodynamic conditions for a fast downslope transport of OMAs. However, under the hydrodynamic conditions of Spring 2009, this was not the objective. The OMAs were resuspended over many resuspension cycles, moved up and down the canyon, traveled therefore over long distances but the net downslope transport was small. Our results are therefore not contradictory to the general observed conclusions, but show that a general conclusion of fast downslope transport for all types of particles in Nazaré Canyon cannot be made.

We agree with the Reviewer that a previous concluding statement generalized the transport of OMAs in canyon throughout the year. As a mirror of our model results, this statement has been rewritten in the abstract and conclusion (P2 L9-11 and P13 L1-3).

Specific comments

Although I can not boast on any experience with numerical modelling and thus am not qualified to evaluate the technical qualities of the presented model, it is not so hard to identify at least three important shortcomings of the model:

1. Sediment gravity flows, which were identified as the dominant process in transport of particulate matter to the middle and lower canyon reaches (de Stigter et al., 2007; Martín et al., 2011; Masson et al., 2011) are not included in the model. The obvious reason is that these flows are not predictably related to any of the oceanographic or meteorological forcing parameters included in the model. Although there appears to be a relationship with severe southwesterly storms passing over the Portuguese margin (Martín et al., 2011), the timing and geographic extent of the flows and the volume of sediment transported are unpredictable with the current knowledge.

Response: As one of the model limitations, the sediment gravity flows are not included in the MOHID model processes. Since the model is an open-source software, it permits a continuous inclusion of new developments based on new processes.

2. Internal tides, as far as I understand the working of the oceanographic model, are not included in the model. Yet they appear to be the dominant process of particulate matter resuspension and transport in the upper Nazaré Canyon, as demonstrated by in-situ observation of near-bed currents and suspended matter concentration with benthic landers (de Stigter et al., 2007). The currents associated with the internal tide, generated by the interaction of the barotropic tide with steep canyon topography (Quaresma et al., 2007) appear far more effective in particle resuspension and transport at greater depths in the canyon than the relatively weak barotropic tidal currents included in the model. For the benefit of readers like myself who are not familiar with these models, it may be good to specify which processes are exactly included in the model (and which not), and on which observational or model data they are based.

Response: The internal tides are taken in account in the model results. This process will be described and published in the follow-up manuscript which is ready for submission.

3. Whereas the model considers the organo-mineral aggregates as static entities occurring in three size classes, studies of natural aggregates show that aggregates in the benthic boundary layer are continuously subject to aggregation and disaggregation processes (e.g. Thomsen and van Weering, 1998), producing a wide range of aggregate sizes with a correspondingly wide range of hydraulic behaviour. Enhanced shear occurring during peaks in tidal currents in the canyon may not only resuspend but also break up aggregates, favouring their dispersion over longer distances than predicted by the model. Water column observations in Nazaré Canyon show that nepheloid layers with suspended particulate matter concentrations typically one or two orders of magnitude higher than in open slope waters constitute a permanent mist in upper canyon, extending several tens to hundreds of metres above the canyon floor (de Stigter et al., 2007; Oliveira et al., 2007; Tyler et al., 2009). Although the dynamic behaviour of aggregates in itself is probably very difficult to include in the model, the authors could probably give

some indication of how the diminution of aggregates to sizes smaller than 429 µm would alter the model results.

Response: As one of the model limitations, the aggregation/disaggregation processes are not included in the MOHID model processes. Since the model is an open-source software, it permits a continuous inclusion of new developments based on new processes. Results on particle characteristics in the benthic boundary layer from the European continental margin between 1993 (EU OMEX I) and 2010 (EU HERMES) revealed an average particle size of 429 µm for BBL aggregates at the slope and within sampled canyons. All data between 1993 and 2002 went into a table on typical particle characteristics (Thomsen and Gust, 2000) and since then this table has been continuously updated. All results show that the critical shear velocities ($U*_{cr}$ and $U*_{d}$) would increase and the settling velocity would decrease with decreasing particle size. Thus smaller particles would be transported over longer distances and this could result in net downslope transport and accumulation of the "fine" fraction at the continental rise.

4. Apart from these shortcomings, which properly addressed could be turned into interesting topics for discussion, the authors should give a careful and critical look at the numerous references included mostly in the introduction. Quite a number of these could probably be discarded as being of no direct relevance to this study. When referring to large projects that formed the background for the present study, reference should be made to key papers giving an introduction to these projects, rather than to a random selection of papers produced in relation to the mentioned projects. A proper reference for OMEX could be Wollast and Chou (2001), for EUROSTRATAFORM Weaver et al. (2006), and for HERMES Weaver and Gunn (2009).

Response: changed P3 L3-4

5. Papers containing observations that are relevant to the present study should not only be mentioned in the introduction, but also where appropriate in the discussion. A number of references should be discarded, as they do not contain what they are cited for. This is for example the case for García et al. (2010), Koho et al. (2008) and Contreras-Rosales et al. (2012) where cited in the specific context of Nazaré Canyon.

Response: These sections were rewritten. Changed P3 L4-12.

Technical corrections

P448

L8: How is suspended matter resuspended? Changed as suggested: P2 L7

L25: In these studies submarine canyons are identified as. . .Changed as suggested: P3 L7

P449

L10-11: Most of the present understanding. . .has been derived from field observations. . .which are summarised in conceptual models. Changed as suggested: P3 L15-17

L26: Koho et al., 2008 should be Koho et al., 2007. Changed as suggested: P3 L30

L27-29: Bad English, please rephrase. This sentence was removed.

P450

L11-12: Either “bulk” or “mainly” is redundant. Changed as suggested: P3 L31

L11-14: I miss reference to studies by García et al. in the context of organic matter quality. This sentence was removed.

L15: Most of the time the sinking of particles is more properly described as horizontal than vertical. This sentence was removed.

L19-20: The BBL is where organic carbon mineralization predominantly takes place. . . This sentence was removed.

L20-22: Bad English, please rephrase. This sentence was removed.

P451

L22-24: I think it is more appropriate to turn the argument around, and assess whether the present numerical model agrees with existing observations and conceptual models. Changed as suggested: P4 L20-22

L24-26: Our final aim was to test the hypothesis that the Nazaré Canyon acts as a conduit for organo-mineral aggregate transport to the deep-sea. Rephrased as suggested: P4 L22-23

P452

L3: The western Iberian shelf and slope are intersected. . . Changed as suggested: P4 L26

L4: 500 m what? Distance to shore or depth? Changed as suggested: P4 L27-28

L6: For subdivision of canyon better refer to Vanney and Mougenot (1990) and/or Lastras et al. (2009). Changed as suggested: P4 L28

L25-26: Bad English, please rephrase. Changed as suggested: P5 L16-17

P453

L1: How are these size classes defined? 429-429 μm, 2000-2000 μm and 4000-4000 μm? **Response:** The three OMAs classes are: 429 μm, 2000 μm and 4000 μm. The classes are based on clear-cut mean diameters of the aggregates and not a range of possible diameters.

L4: What is the reason to choose this peculiar size class, 429 μm? **Response:** The 429 μm corresponds to a standard particle size observed in several study areas. It was also chosen taking in account the OMAs data from (de Jesus Mendes and Thomsen, 2007) and corresponds to an area which BOBO data are available too (PE 218-04). Results on particle characteristics in the benthic boundary layer from the European continental margin between 1993 (EU OMEX I) and 2010 (EU HERMES) revealed an average particle size of 429 μm for BBL aggregates at the slope and within the sampled canyons. All data between 1993 and 2002 went into a table on typical particle characteristics (Thomsen and Gust, 2000) and since then, this table has been continuously fed with additional data.

P454

L23: required by. . . Sentence rephrased: P7 L2-3

P455

L3-7: Here it would be good to describe in more detail which processes are included in the operational model. **Response:** The detailed processes of the operational model have already been presented by (Mateus et al., 2012) and the work is cited on P7 L14. In short, section 2.3.1 and 2.3.2 gives a generic description of hydrodynamic and lagrangian models in which the relevant authors are cited.

L22: . . .distributed along the Nazaré Canyon at water depths between 59 and 3189 m (Table 2) (Include depths as additional column in this table). Changed as suggested: P7 L29-30. Depths included in the table.

L23: 400m deep? From the context I gather the 400 m refers to the horizontal dimension of the cells, not the vertical. Changed as suggested: P8 L1-2

P456

L3: What is lower limit of depth range of the upper canyon? Please refer to Vanney and Mougenot (1990) and/or Lastras et al. (2009). Changed as suggested: P8 L9-10

L13-14: . . . of which part escaped from the box depending on the hydrodynamic conditions affecting the box. Changed as suggested: P8 L17-18

P457

L27: Give original reference for half-life of phytodetritus instead of Thomsen et al. (2002), for example Sun et al. (1991). Changed as suggested: P9 L24

P459

L23: Only box 10 is located in the middle Nazaré Canyon; all other boxes are in the upper canyon and hence subject to vigorous internal tidal currents. Changed as suggested: P11 L8

P460

L1: This obviously does not agree with frequent resuspension and transport observed by de Stigter et al. (2007) in the upper canyon. Changed as suggested: P11 L15-16

L10-11: Faunal abundances and biomass generally show a decreasing trend with increasing water depth in the ocean, which is generally related to the decreasing primary organic flux from the photic zone, rather than to variations in lateral transport. Rephrased as suggested: P11 L20-24

P461

L15-16: What are stationary mass fluxes? Changed as suggested: P12 L23

L22-23: Adequate reproduction of circulation by the model is not demonstrated in this ms, and can thus not be included as a conclusion. Removed as suggested

P471: Why are escape percentages in Table 2 different from what is shown in Fig. 3, 4, 5 as endpoint after _110 days? **Response:** Figures 3-5 depict the pattern and the residence of the OMAs inside each box while Table 2 complements the observations by showing the percentage of OMAs that escape from the boxes after 110 days.

References

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Mateus, M., Riflet, G., Chambel, P., Fernandes, L., Fernandes, R., Juliano, M., Campuzano, F., de Pablo, H., and Neves, R.: An operational model for the West Iberian coast: products and services, Ocean Sci. Discuss., 9, 1651-1689, 10.5194/osd-9-1651-2012, 2012.

Thomsen, L., and Gust, G.: Sediment erosion thresholds and characteristics of resuspended aggregates on the western European continental margin, Deep Sea Research Part I: Oceanographic Research Papers, 47, 1881-1897, Doi: 10.1016/s0967-0637(00)00003-0, 2000.