Biogeosciences Discuss., 10, C231–C236, 2013
www.biogeosciences-discuss.net/10/C231/2013/

Biogeosciences Discussions

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

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Received and published: 6 March 2013

General comments

The manuscript by Pando and co-authors addresses a question of fundamental importance with regards to the exchange of organic carbon between coastal seas and the deep ocean, namely the quantification of aggregate transport through submarine canyons under influence of ocean currents and tides. Aggregates, composed of a variable amount of organic and mineral material, are the major component of particulate matter in the benthic boundary layer of marginal seas and the open ocean, and the vehicles by excellence for lateral transport of organic carbon. Substantial transport of

aggregated particulate matter is assumed to take place in submarine canyons, establishing exchange of particulate organic as well as inorganic matter between coastal seas and the deep sea. In the case of the Nazaré Canyon, a large submarine canyon on the Portuguese continental margin which was chosen as the subject of this study, there is substantial observational evidence for active down-canyon transport of suspended sediment (de Stigter et al., 2007; Oliveira et al., 2007; Martín et al., 2011; Masson et al., 2011), organic matter (García and Thomsen, 2008; García et al., 2008) and trace metals (Richter et al., 2009). 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.

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. 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. 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. 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). 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. Concerning presentation, the manuscript is overall clearly structured, tables and graphs are clear and of sufficient quality, but the English grammar and syntax could be improved. Some suggestions are included in the list below.

Technical corrections

P448L8: How is suspended matter resuspended? P448L25: In these studies submarine canyons are identified as... P449L10-11: Most of the present understanding...has been derived from field observations...which are summarised in conceptual models. P449L26: Koho et al., 2008 should be Koho et al., 2007. P449L27-29: Bad English, please rephrase. P450L11-12: Either “bulk” or “mainly” is redundant. P450L11-14: I miss reference to studies by García et al. in the context of organic matter quality. P450L15: Most of the time the sinking of particles is more properly described as horizontal than vertical. P450L19-20: The BBL is where organic carbon mineralization predominantly takes place... P450L20-22: Bad English, please rephrase. P451L22-24: 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. P451L24-26: 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. P452L3: The western Iberian shelf and slope are intersected... P452L4: 500 m what? Distance to shore or depth? P452L6: For subdivision of canyon better refer to Vanney and Mougenot (1990) and/or Lastras et al. (2009). P452L25-26: Bad English, please rephrase. P453L1: How are these size classes defined? 429-429 μm, 2000-2000 μm and 4000-4000 μm? P453L4: What is the reason to choose this peculiar size class, 429 μm? P454L23: required by… P455L3-7: Here it would be good to describe in more detail which processes are included in the operational model. P455L23: 400m deep? From the context I gather the 400 m refers to the horizontal dimension of the cells, not the vertical. P455L22: …distributed along the Nazaré Canyon at water depths between 59 and 3189 m (Table 2) (Include depths as additional column in this table). P456L3: What is lower limit of depth range of the upper canyon? Please refer to Vanney and Mougenot (1990) and/or Lastras et al. (2009). P456L13-14: …of which part escaped from the box depending on the hydrodynamic conditions affecting the box. P457L27: Give original reference for half-life of phytodetritus instead of Thomsen et al. (2002), for example Sun et al. (1991). P459L23: 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. P460L1: This obviously does not agree with frequent resuspension and transport observed by de Stigter et al. (2007) in the upper canyon. P460L10-11: 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. P461L15-16: What are stationary mass fluxes? P461L22-23: Adequate reproduction of circulation by the model is not demonstrated in this ms, and can thus not be included as a conclusion. P471: Why are escape percentages in Table 2 different from what is shown in Fig. 3, 4, 5 as endpoint after ~110 days?

References not included in the ms:

Koho K.A., Kouwenhoven, T.J., de Stigter, H.C, van der Zwaan, G.J., 2007. Benthic foraminifera in the Nazaré canyon, Portuguese continental margin: influence of sedimentary disturbance on fauna. Marine Micropaleontology 66, 27-51.

Sun, M., Aller, R.C., Lee, C., 1991. Early diagenesis of chlorophyll-a in Long Island Sound sediments: A measure of carbon flux and particle reworking. Journal of Marine Research 49, , 379-401.

Vanney, J.R., Mougenot, D., 1990. Un canyon sous-marin du type "gouf": le Canhão da Nazaré (Portugal). Oceanologica Acta 13, 1–14.

Weaver, P.P.E., Canals, M., Trincardi, F., 2006. EUROSTRATAFORM: special issue of Marine Geology. Marine Geology 234, 1-2.

Weaver, P.P.E., Gunn, V., 2009. HERMES: Hotspot Ecosystem Research on the Margins of European Seas. Oceanography 22, 12-15.

Wollast, R.,Chou, L., 2001. Ocean Margin EXchange in the Northern Gulf of Biscaye: OMEX-1. An introduction. Deep-Sea Research II 48, 2971-2978.

Interactive comment on Biogeosciences Discuss., 10, 447, 2013.