Reply to Anonymous Referee #2 (replies marked by ➢)

This manuscript aims at comparing fluxes observed in a series of short cores along a transect off shore Pakistan. Results are evaluated in the context of observations of several short sediment trap time series.

➢ We thank the referee for his work and detailed comments, which are very helpful to improve the paper, which in our opinion discusses a rather unique data set on the flux and accumulation of sedimentary particles on the continental slope off Pakistan. We recognize that the manuscript has to be rewritten to be acceptable for publication in BGD. One of the major flaws of the present manuscript is to better combine trap and sedimentary flux data and to explain, why all of the four sediment traps (deployed during different years, seasons and water depths) failed to collect sediment material after the late winter period. This was observed during winter 1993/1994 and during the last deployment in 1995/1996 (Andruleit et al., 2000, von Rad et al., 2002).To our opinion, this can only be attributed to exceptionally strong, re-occurring winter high flux events (HFE). Quantitative description of the flux and composition of the event in the context of the seasonal evolution for fluxes and comparison to the sediment flux at the sea floor are used to constrain the important winter flux process. Therefore, we used a young marker bed (recorded in our cores) that facilitates a precise reconstruction of flux rates at the sea floor. We cannot exclude that evidence from only four traps leaves room for alternative explanations of incidental malfunction.

This potentially allows evaluating the sedimentary fluxes in vertical versus lateral dimensions. The different components that together make up the sediment are separated into different - rather coarse- groups to further distinguish sedimentary sources.

➢ Evaluating the sedimentary fluxes in vertical versus lateral dimensions provide clues of the flux and sedimentation processes along the steep Makran Margin and an explanation, why it was impossible to achieve a continuous trap record off Pakistan. Although we cannot yet provide a plausible mechanism for these winter events, our discovery may lead to a better understanding of the processes of varve formation and preservation potential of carbon in the Arabian Sea.

The data is presented however in a confusing manner. In its present form the manuscript is not suited for publication. The manuscript suffers from several major flaws.: -Overall organization of the paper is confusing.

➢ We agree that the paper was somewhat confusing and incomplete. We are grateful to the detailed critical comments of the reviewers. Hence we re-wrote the paper completely and hope that that the revised paper presents the data and conclusions much better.

The paper would benefit from a more straightforward organization. First show the regional differences in the fluxes as a function of water depth or offshore distance. The sediment trap data (which has been published before) can be referred to in order to provide the context to explain the observed high fluxes close to the shelf.

➢ We acknowledge the suggestions of the referee to more properly organize the study. After presentation of the more technical data to achieve precise flux rates in the series of 16 short cores we present these fluxes as a function of water depth in Fig. 5.

The key message is ultimately quite simple: resuspension and sediment transport during winter.

➢ We agree with the referee that the winter processes play an important role. Evidence is presented in Fig. 6 demonstrating the strong increase in water column flux near the end of the winter (NE-monsoon) season. We clearly describe the process of the winter HFE. By interpreting the sedimentological and observational data we conclude that an enormous sediment resuspension on the shelf and redeposition at the

continental slope takes place regularly during February/March within a relatively short time window.

The final evidence is lacking because of the terminated sediment series, which leaves some room for alternative explanations.

- A distinct annual high sedimentation event during winter has a large impact on the accumulation of sediment material off the Makran and Indus margins. We argue that only by the regular reoccurrence of the HFE the high sediment accumulation rates on the slope at OMZ depths can be explained. Mass transport by turbidites and suspensates, frequently observed along steep margins, cannot explain the patterns, because of the intact varve-type lamination in our profiles for the ca. 90 years before 1993-1995 (Fig. 2; + see added core photos of two cores MC3 and MC5 as supplementary).
- In the revised version, we more clearly emphasize that final direct evidence for the exact volume of HFE-flux and duration of these events is lacking, because the termination of the HFE period could not be monitored.

The figures are not up to publication standards and difficult to interpret. Figure one is ok, but the subsequent figures are very difficult to read. Figure 2 shows a few examples of sediment cores, presumably plotted versus depth?

- The short profiles have been plotted vs. depth (in cm). We will add the legends missing at the y-axes.

If the only purpose of this figure is showing that there is a distinct turbiditic layer that can be correlated across the shelf it would be better to show core pictures. Maybe keep 2D and add pictures to show correlations?

- We refer to the detailed description and X-radiograph of SO90-58KG (Fig.3, Staubwasser and Sirocko, 2001). Scans and X-radiographs of sediment lamination of core 39KG are illustrated in Fig. 5, von Rad et al., 1999, Quat Res.51). As supporting online material, we provide core photos of cores MC3 and MC5.
- We unified different fonts.

Correlations shown in figure 3 are not very convincing for all cores, which is essential for subsequent calculation of fluxes. What is the evidence for the correlations plotted between e.g. 76KG and MC1, or 143KG and 72KG?

- Cores 72KG and 143KG show clear maxima in the uppermost sections. We agree that MC1 may not show significant changes. The cores MC1 and 76KG will be identified clearly as the most uncertain profiles. However, MC1 has 2 AMS-dates that support the varve-counted and Pb-dated stratigraphic framework. We will more clearly discuss the identification of the turbidite to be distinct by its high density of > ~ 0.8 g/cm-3 from the sediments above and also below. As for Fig 3, we add the caption of the y-axis for these short cores.

In figure 4 it is not clear what is plotted on the y-axis. Not from the figure, nor from the caption. Possibly it is water depth. But why are these dots connected in that case?

- The vertical axis is water depth in m.

What is the difference between relative and percentage? No units are provided.

- We apologize the confusion between figure and caption for Fig 4. We agree that lines between the points are not justified. However for better visibility of the trends and local maxima, we will use stippled lines between data points. We emphasize that most of the described maxima/minima are supported by diverse data points.

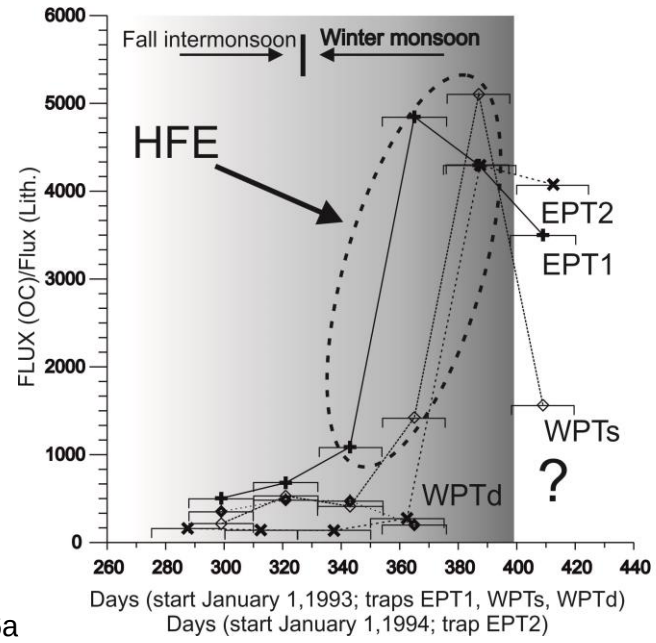
Figure 5 is intended to show differences in fluxes against water depth (not indicated at axis). This mainly shows that the bulk AR controls all components. This should probably be the main conclusion.

- We emphasize this important point. Off the Makran dispersal of sediment stirred up from the shelf during a relatively short period in winter seems to control sediment accumulation. We added the missing caption of the y-axis.

It is impossible for me to understand figure 6. May be replot as x-y graph, flux versus OC percentage?

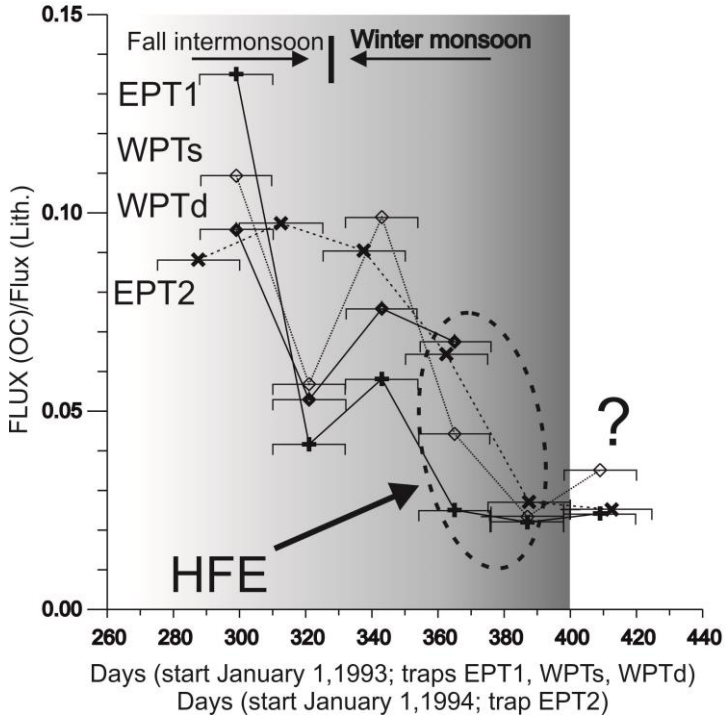
- The figure is intended to illustrate the key message. The design did not use the conventions showing time series of fluxes. We have re-designed the figure and present fluxes not as single points, but as sampled intervals. For more clarity and space, we split Fig. 6 into two Figs. 6a and 6b. Furthermore, we added the data from EPT2 which are in full agreement with the observations in EPT1, WPTs, and WPTd.
- Fig 6a shows that total flux is low (< 1000 mg m-2d-1) in the inter-monsoon season (during fall), but rises to more than 5 times higher values in the three shallow traps EPT1/WPTs and EPT2 collecting at 534 and 590 m, respectively. Flux peaked during days 350 to 400. Thereafter the flux declines in all cases, but remains relatively high compared to the pre-HFE period. Traps stop collecting after day ~420.
- Following Fig. 6b, similar changes in the flux composition can be observed at different water depths and years. We show these compositional shifts by the ratio between organic matter (OM) flux and the lithogenic (lith.) flux for example, which is between 0,09 and 0,14 in fall and declines to low ratios of < 0,04, indicating a much higher lithogenic fraction. Also, data of the organic fraction are presented for the first time in our study. We hope that the new Figs 6a +b are now better organized indicating the fall inter-monsoon and winter monsoon periods (shaded).

Schulz and von Rad Biogeosciences 2014 Fig.6A revised



- Fig 6a

Schulz and von Rad Biogeosciences 2014 Fig.6B revised



➢ Fig. 6b

Figure 7 shows same as figure 5, plotted differently.

➢ We delete Fig. 7

The figure has no references to literature after about 2000. This is strange as several high quality publications appeared after that. This should absolutely be updated.

➢ We updated the literature referring to the following overview publications and mostly refer to the recent study of biogeochemical and benthic issues published in DSRII in 2009, focusing on the Indus area (Cowie, G.L. and Levin, L.A., 2009. Benthic biological and biogeochemical patterns and processes across an oxygen minimum zone (Pakistan margin, NE Arabian Sea).- Deep Sea Research II, 56/6-7: 261-270.)

➢ Helly J. and Levin, L., 2004. Global distribution of naturally occurring marine hypoxia on continental margins.- Deep-Sea Research I 51 (2004) 1159–1168.

➢ We will more in detail refer to the studies of:

- Brand, T.D. and Griffiths C., 2009. Seasonality in the hydrography and biogeochemistry across the Pakistan margin of the NE Arabian Sea.- Deep Sea Research II, 56/6-7: 283-295.
- Cowie, G.L., Mowbray, S., Lewis, M., Matheson, H., and McKenzie, R., 2009. Carbon and nitrogen elemental and stable isotopic compositions of surficial sediments from the Pakistan margin of the Arabian Sea.- Deep Sea Research II, 56/6-7: 271-282.
- Jeffreys, R.M., Wolff, G.A. and Cowie, G.L. 2009. Influence of oxygen on heterotrophic reworking of sedimentary lipids at the Pakistan margin.- Deep Sea Research II, 56/6-7: 358-375.
- Law, G.T.W., Shimmield, T.M., Shimmield, G.B., Cowie, G.L. Breuer, E.R. and HarveyM., 2009. Manganese, iron, and sulphur cycling on the Pakistan margin.- Deep Sea Research II, 56/6-7: 305-323.

- Levin, L.A., Whitcraft, C.R., Mendoza, G.F. Gonzalez, J.P. and Cowie, G., 2009. Oxygen and organic matter thresholds for benthic faunal activity on the Pakistan margin oxygen minimum zone (700–1100m).- Deep Sea Research II, 56/6-7: 449-471.
- Vandewiele, S., Cowie, G., Soetaert, K. and Middelburg J.J., 2009. Amino acid biogeochemistry and organic matter degradation state across the Pakistan margin oxygen minimum zone.- Deep Sea Research II, 56/6-7: 376-392.
- Woulds, C., Schwartz, M.C., Brand, T., Cowie, G.L., Law, G. and Mowbray, S.R., 2009. Porewater nutrient concentrations and benthic nutrient fluxes across the Pakistan margin OMZ.- Deep Sea Research II, 56/6-7: 333-346.

➢ We will refer to the more sedimentological aspects on the characterization of the sedimentary environment only in the vicinity off Ormara. The authors report on the clay mineral composition of sediments, estimations of the sedimentation rates on the Indus shelf, turbidite frequency and varve analysis off the Makran.

- Bourget, J. Zaragosi, S.,Ellouz-Zimmermann, S, Ducassou, E., Prins, M., Garlan, T., Lanfumey, V., Schneider, J.-L., Rouillard, P., and Giraudeau, J., 2010. Highstand vs lowstand turbidite system in the Makran active margin: Imprints of high-frequency external controls on sediment delivery mechanisms to deepwater systems.- Marine Geology, 274: 187-208.
- Limmer, D.R., Köhler, C.M., Hillier, S., Moreton, S.G., Tabrez, A.R., and Clift, P.D., 2012. Chemical weathering and provenance evolution of Holocene-Recent sediments from the Western Indus Shelf, Northern Arabian Sea inferred from physical and mineralogical properties.- Marine Geology, 326-328: 101-115.
- von Rad, U., Ali Khan, A., Berger, W.H. Rammlmair, D., and Treppke, U., 2002. Varves, turbidites and cycles in upper Holocene sediments (Makran slope, northern Arabian Sea).- In: Clift, P.D., Kroon, D., Gaedicke, C., and Craig, J. (eds), The Tectonic and Climatic Evolution of the Arabian Sea Region, Geol. Soc. Spec. Publ. 195: 387-406.

The text needs a lot of attention and rephrasing:

➢ We add a completely revised manuscript to the final authors comments. In the following, we refer to major points of the review. However all reviewer suggestions will be addressed with the most important changes marked in red below.

More detailed comments P12417 The title is too long.

➢ We will shorten the title to: *Vertical and lateral sediment flux on the the continental slope off Karachi (Pakistan): correlation of sediment trap and -core results.*

Figure 6 and 7 should be deleted.

➢We cannot accept to delete Fig. 6, which was redrawn and will be better addressed in the text.

➢Fig. 7 deleted.

P12418 L. 5 delete “to explore: topography” (this is not discussed in the text). ➢Done
L. 16 delete “in this environment.” ➢Done.
L. 18-19 differentiate the components ➢Done.
L. 19-20 Not for abstract (clogging of funnel) ➢Done.
L. 24 Why “seems to be a function of water depth”. It is a function of water depth, although not necessarily mechanistic.

P. 12419 L. 4-6 ➢Done.
Rephrase L. 7-9 Nobody published on the Arabian Sea after 2000? ➢See the list of added literature
L. 12-13 Rephrase ➢Done.
L.20-21 Not a sentence:?? ➢Deleted.

P12420 L. 10-14 Not relevant. Delete L. ➢Deleted.
16 change “suitated” into “suited” ➢Done.
L. 17 delete “on” ➢Done.

P12421 L. 4 Bacterial exposure does not stop at a certain depth. Change this into oxygen exposure ➢O.k.
L. 7 What is meant with “local productivity”? Benthic secondary productivity? ➢Will say surface water biological productivity.
Seems not relevant here. ➢We here included recent literature, referring to states of OM degradation
L18-20 What is poorly sorptive mineral matter? This is rather speculative and should be either supported by data or deleted. ➢Poorly sorptive: deleted. L. 23 Delete “will” ➢O.k.

P 12422 L. 4 Specify size range looked at. ➢Inserted.new text that describes the trap records (Andruleit et al., 2000; Schulz et al., 2002) in detail. L 15-26 Not relevant for this manuscript. Delete. ➢Shortened to ~50 %.

P 12423 L. 1-2 Delete ➢Deleted. L. 5-6 Where does “respectively” refer to? ➢O.k. L. 13 Delete “structure” ➢O.k.L. 18-19 Change order ➢O.k. L. 20 Rephrase ➢O.k. L. 22 Not clear where “significance” refers to. Explain. ➢O.k. L. 15-23. Seems not relevant here and might be deleted. ➢Shortened.

P 12424 L. 2 Change “followed within” to “correlated between” ➢O.k. L. 8 Change “and” to “at” ➢O.k. L. 9-11 Rephrase ➢O.k. L. 18 Delete “up to” ➢O.k. L. 21 Change “the” in “a” L. 22 ➢O.k. Delete “finally” ➢O.k. L. 22 Delete “possibly” ➢O.k. L. 23 Delete “(see discussion)” ➢O.k.

P 12425 L.2 change “age control” in “accumulation rates” and combine with 3.3 ➢Done.L. 10- 18 This is not something that nowadays is presented as state-of-the art sub-division into important sedimentary groups. It is also rather dubious whether this is adding anything to the overall discussion. If this is kept as a part of the manuscript it should be better explained what the added value is over just looking into TOC and CaCO3. Probably better to leave out completely. ➢Only short explanation here, but will be important in the discussion. L. 20 Delete “at the BGR”. It is irrelevant where the cores were stored. ➢Deleted L. 23 Delete “alternatively” ➢O.k. L. 24-25 This is not really dealing with the physical properties with the sand fraction, but rather with the overall sediment physical properties. ➢Sand fraction deleted here.

P 12426 L. 2 change “the” in “a depth of” ➢Done.L. 11 Delete “and to : : :during” ➢O.k. L. 12 add
“related high productivity” after “monsoon” ➢O.k. L. 13 Specify “narrow intervals” ➢O.k. L. 19 add
“at” between “determined” and “the” ➢O.k.

P 12428
L. 1 Change “percent” in “wt. %” ➢O.k. L. 11 Delete “that layer” ➢O.k. L. 11 add “this layer”after “OMZ” ➢O.k.L. 17 change “ideally applied” into “used” ➢O.k. L. 18 delete “for core correlation” ➢O.k. L. 23 change “in most case” to “by”, delete “extremely” ➢O.k.L. 24 Delete “however” ➢O.k. L. 24-26Rephrase ➢O.k.

P 12429 L. 1 add “greater” after “at” ➢O.k. L.6 changes “dates” to “ages” ➢O.k. L. 8 change “was” to“be” ➢O.k. L. 17 add “somewhat” after “is” ➢O.k. L. 25 add “to” after “restricted” ➢O.k. L. 25 delete “depth” ➢O.k. L. 26 add “to” after “down” ➢O.k.

P 12430 L1. Not clear why this would be a causal relationship. Please explain or omit. ➢Wrong depth; should read <. L. 1 change “seen in” to “in line with the” ➢O.k. L. 7- P1431 L. 13 The only publication on benthic foraminiferal faunas referred to is a German internal report from the 1970’s. Please update ➢Done by referring to Schumacher et al., 2007 and Larkin and Gooday, 2009.

P 12432 L. 13 Sentence is not clear: “This of trend in:.”. Rephrase. ➢O.k.L. 17 change “deeper” to “greater” ➢O.k.L. 17-19 Would you expect that? Strange argumentation. ➢Deleted. L. 25 Delete “also” ➢O.k.

P 12433 L. 5-13 Rephrase ➢O.k. L. 22 change “in” to “on” ➢O.k. L. 26 delete “the” before “shallow” ➢O.k.

P 12434 L. 5 Behind what? Not clear what is referred to. ➢Deleted. L. 12 change “down” to “lower on” O.k., change “in” to “on” ➢O.k. L. 14 delete “high vertical and lateral” ➢O.k. L. 14 “due to”? Please explain causal relationship is not clear. ➢Deleted L. 18 delete “when”, delete “next” ➢Deleted L. 19 change ➢O.k.

P 12435 L. 3 delete “the settling” ➢O.k. L 5-8 delete: speculation. ➢O.k. L. 18 change “distant” to “away” ➢O.k. L. 20 delete “period of an” ➢O.k. L. 22 delete “may”, delete “must have” ➢O.k. L. 23 delete “have HFE received” ➢O.k. L. 26 delete “may”, change “on” to “that” ➢O.k.

P12436 L. 3 delete “may”, add an s to “argue”, delete “the” ➢O.k L. 6 delete “the major source of material from” ➢O.k L. 7 add “provides the main source” after “depth” ➢O.k L. 8 explain what you mean with “atlas values”? Are your referring to a specific atlas? ➢We refer to Antoine et al. (see references), avoiding the term atlas values. L. 16 “The elevated productivity near-shore” How do you know that? Has this been measured or is this an assumption. Explain or delete. ➢We refer to the CSZS (coastal zone color scanner) data of Antoine, which show that PP is enhanced rather permanently in the near-coastal zone.