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Biogeosciences Discussions

Interactive comment on "Fukushima-derived radiocesium in western North Pacific sediment traps" *by* M. C. Honda et al.

Anonymous Referee #1

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General comments This ms reports the presence of radiocesium from the Fukushima nuclear power plant (FNPP) accident in sinking particles caught in time-series sediment traps deployed between Nov. 2010 and July 2011 at two depths (500 and 4810m) and at two separate stations (K2 and S1) in the open western North Pacific Ocean. Sediment traps are now routinely used in many different oceanic regimes to measure the fluxes of sinking particles and the elements and radionuclides associated with them. However, what makes this particular flux study important is that the time-series traps were in operation when the accident occurred and radionuclides like 134Cs and 137Cs were released from a point source (Fukushima) into the atmosphere and surrounding ocean waters. This allowed measuring not only the specific activity of radiocesium in the trapped particles over time, but also discerning the times when the radiocesium reached certain depths and the speeds at which the contaminated particles sank to

depth. Hence an unplanned tracer experiment which will help further our understanding of particulate transport and transfer processes in the ocean. The presence of 134Cs in the particles, which was not measurable in these waters before the accident, and their 134Cs/137Cs ratio of ~ 1 which was identical to that in the releases from the FNPP verified the origin of the radioactive contamination in the sinking particles. As the authors point out in the Introduction, this accident is the first in which the majority ($\sim 80\%$) of the released radioactivity was deposited directly in the ocean. Thus, it will be of considerable interest to oceanographers that their findings on specific activities of radiocesium in sinking particles, radiocesium vertical fluxes, and particle sinking velocity estimates closely corroborate those which were reported for radiocesium in Mediterranean, Black Sea and North Sea waters following the Chernobyl accident. In summary, the ms is basically well-written, the high quality radionuclide data and their interpretation are clearly and logically presented, and the conclusions drawn from the results are reasonable. Because in situ radiotracer studies such as this one are very rare, and to my knowledge no similar particle flux measurements of Fukushima-derived radionuclides in marine waters have been reported, this ms will make an important contribution to the geochemical literature on vertical fluxes of radionuclides and particle sinking velocities in open ocean waters.

Specific comments 1) It is evident from the literature cited that the authors have ample experience measuring radionuclides in marine matricies using state-of-the-art analytical protocols, and consequently their resultant radionuclide measurements are of high quality. They also have experience in deploying sediment traps in the open ocean and preparing samples for elemental and radionuclide analyses. However, I take issue with one aspect of the pre-treatment of their sediment trap samples which could bias their particle flux results. To "eliminate zooplankton swimmers" they sieve the sediment trap samples through 1mm plastic mesh. While this mesh size will retain the larger crustaceans and many gelatinous forms like salps and medusae, etc., it is not sufficient to remove the many smaller forms such as copepodites and other micro-zooplankton species that are commonly found at depths down to 500 m. That is why most protocols nowadays first pre-screen through ~1000 μm mesh and then through much smaller meshes, e.g. 350-600 μm, so that those small forms can be easily "hand-picked" and removed from the particle sample. Failure to do so can lead to over-estimates of particle flux and also bias the elemental composition of what one believes are only sinking particles. The authors might want to consider what effect this aspect could have on their flux estimates as well as the biogeochemical composition of the particles, but I would imagine it would have a greater effect at the station K2 500 m sample, as that region is well-known to be highly productive with many different taxa of diatom-grazing zooplankton.

2) While the very general title of the ms correctly states what was found in their North Pacific sediment traps, I don't think it accurately reflects the important nature of this study and what was deduced from the radionuclide and particle flux measurements. A much more informative title might be something like…… 'Specific activity and vertical flux of Fukushima-derived radiocesium in sinking particles from two sites in the Northwestern Pacific Ocean'.

3) In paragraph 4.1 'Sinking Velocity', the authors have computed a maximum and minimum sinking speed through the top 500 m using modeled estimates of when the eolian radiocesium fallout arrived and was deposited on the surface waters at K2 (14 March) and S1 (18 March), and assuming that the first pulse of radiocesium arrived between 25 March and 6 April (see Fig.3). They report a range of 14 – 36 m/day at K2 and 8 – 20 m/day. It is not clear to me how these computations were made. If one assumes that the maximum velocity occurs if the radionuclides arrived on the 25th of March and the minimum velocity if they arrived only on the 6th of April, I compute a range of ~ 22 m/day (500m/23days) to ~ 45 m/day (500m/11d) at K2, and ~ 26 m/day (500m/19d) to ~ 71m/day (500m/7d). If the authors have a better method of estimating the maximum and minimum sinking velocity, it should be described in far more detail in the text.

Technical corrections and comments (given by page no.(P) and line no.(L))

P 2456, L 7-8: not sure 8 and 36 m/day are correct (see my specific comment above). L 14: should read: "…total 137Cs inventory by late June…" L 19-20: This sentence needs to be more specific, e.g. "…comparable to previously reported values derived from radiocesium inputs from the Chernobyl nuclear accident." P 2457, L 1: "radiologically-contaminated" is really not the proper adjective as radiological relates mainly to medical usages involving ionizing radiation. In the context of this paper's subject, it is sufficient to simply say "discharge of contaminated water" or "water contaminated with radionuclides". L 12: Aoyama et al. 2013 is cited as 2012 in the References, or an Aoyama et al. 2013 paper is missing from the References. P 2458, L 23: should read: "….to eliminate larger zooplankton swimmers." (see my specific comments above). P 2462, L 7: should read: "Unlike at K2-500 m, at K2-4810 m 134Cs activity increased…." L 25: should read: "The total 134Cs inventory and average…..". (Bqm-2 is not a flux). P 2463, L 12: should read: "….trap stations, but originated from contaminated eolian dust….". L 23: Is this Honda et al. (2009) citation correct? Or should it be the Honda et al. (2002) sediment trap paper listed in the References? P 2464, L 1 and 11: 25 March L 22: "..accident observed in this study,…" P 2465, L 20: Shouldn't this citation be Buesseler et al. (2012) which deals specifically with zooplankton? L 20: should read: "..of sinking particles measured in this study…." L 23: should read: "….materials that were measured…." Table 1a: There is no (b) indicating station S1 in this separate Table 1a. It is very confusing. If Tables 1a and 1b are to be separate, they should then be labeled Table 1 (only for K2 data) and Table 2 (only for S1 data). Table 1a and 1b legends: should read: "…error is based on one sigma….." Table 2: Bqm-2 is not a radiocesium flux. Flux is per unit of time (i.e. Bqm-2 day-1). Fig. 2 legend, first line: (b) K2-4810 m

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