BG-2018-228. Tracing water masses with ^{129}I and ^{236}U in the subpolar North Atlantic along the GEOTRACES GA01 section

This manuscript focus on the distribution of 129I and 236U along the GEOVIDE section (transect GEOTRACES GA01) in spring 2014. GEOVIDE cruise covered the subpolar North Atlantic Ocean and the Labrador Sea. This manuscript represents an important updated dataset and the authors successfully use 129I and 236/238U and 236U/129I atom ratios to describe water masses. The authors confirm with this study the major potential of the combination of 129I and 236U as circulation tracers, especially in the area of study and the Arctic Seas and I really enjoyed reading it.

However, I think that given that the combined use of 129I and 236U provide such rich information, some of the results provided could be discussed in more depth. My impression is that the description and overall use of some the data still require a bit of discussion.

If I am not mistaken, the paper have three main objectives that should be emphasized and clarified in the abstract and the introduction.

1. Update and improve the database of 129I and 236, to be used for future studies and/or modelisation of the ocean circulation in the North Atlantic

2. Present new evidences of the advantages of using both radionuclides as dual tracers in the ocean. In this case, what I miss in the text is a more detailed explanation/introduction of why and how 236U, 129I and 236/129I combined provide different and complementary information. The authors reference previous works but should provide the reader with a bit of context and additional information about how these tracers/methodology work.

3. Use the tracers to understand ocean circulation in the area. This seems to be the main objective of the paper, however the conclusions from this part are mixed with the other two objectives, together with what is already known and what is novel in this paper. e.g. the final conclusion in the Abstract "Data of 129I and 236U from 2014 and the 129I time series in the Labrador Sea agrees with the hypothesis that Atlantic Waters follow at least two circulation loops from their source region […] recirculation in the Arctic Eurasian Basin" is not new was already stated by Orre et al. (2010) with 129I and partially by Povinec et al., (2003) using other radioactive tracers such as 137Cs. But there is missing information in the abstract to emphasize that the other conclusions are indeed novel, i.e contribution of ISOW to eastern SPNA is quite recent.

A general comment on the paper is that it presents an impressive dataset and it would be desirable to make more clear which of the conclusions are confirmations of previous hypotheses/results. In the text it is indeed explained, however I think that the novel results, found mainly from the dual use of these radiotracers, are mixed with results that are confirmation of known facts and its relevance it is not explicitly enhanced, which is a shame. Section 3.4 is basically where the novel features of these tracers are presented, in contrast with previous sections that basically use previous data and hypotheses and verify that the new 129I and 236U data are in agreement. However, this distinction is, in my opinion, not totally clear especially when presenting section 3.3. Novel and/or on

discussion hypotheses reinforced by these dataset should be highlighted. I would also emphasize conclusions obtained by the use of 236U and 129I/236U, since they are novel tracers and the first time that they are measured simultaneously in the area. However, in this sense I find the Conclusion section very well structured.

Finally, it is assumed in the text that the reader knows well about the ocean circulation in the North Atlantic and Arctic Oceans and about 129I and 236U, if this is the case, the paper is quite straightforward to read. But in my opinion one can get easily lost if that is not the case, I have add a few examples of this in the specific comments below.

To provide a general background to better understand the discussion of the results I suggest something like:

1. Presenting first a brief introduction to ocean circulation and water masses involved with the data.

2. Explain in more detail the role of 129I, 236U and 236U/129I as ocean tracers of the SPNA, making clear what we have learn so far using them i.e. provide context. It would be also good to better explain how to read and understand Figure 3. Which is extremely useful and provides a lot of information.

ABSTRACT

I think that these lines “Results show that part of the effluents discharged from Sellafield and La Hague apparently enter the eastern SPNA directly through the Iceland-Scotland passage or the English Channel/Irish Sea, as it is shown by elevated 129I concentrations and 129I/238U ratios in shallow central waters flowing in the West European Basin (WEB)” are saying the same than these ones "The Iceland-Scotland Overflow Water spreading pathways into the eastern SPNA have been confirmed by the unequivocal transport of reprocessing 129I into the deep WEB”.

When it is said “The Iceland-Scotland Overflow Water spreading pathways into the eastern SPNA have been confirmed by the *unequivocal transport* of reprocessing 129I into the deep WEB”, it should be briefly explained why we find this transport unequivocal.

INTRODUCTION

When one reads from lines 15 (Page 3) to line 23 (Page 4) gets a very general idea about how 129I and 236U are distributed in the North Atlantic, but do not get a precise picture of what are the paths followed by the radionuclides when released by the RP. That information is given later in the text, the problem is that it is scattered in different sections of the manuscript.

Furthermore, lines 15 to 20 (Page 4) provides some information about previous results of 236U/129I however it does not explain what these numbers represent or why and how they change geographically or in time. For example, it is not explained *why* “Yet, LSW

and DSOW were *clearly* identified by 236U/238U >1000 x 10^{-12}"; or *why* the atom ratio varies *from* "$^{129}I/^{238}U$ < *1 for GF to about 1 - 350* for European NRPs".

Lines 10-15 (Page 4). Why reference data are given here and not for 129I?

Line 18 (Page 5). No mention to deep water formation at the Greenland Sea? And ISOW formation? ISOW is later described (Line 7, Page 8), but it would be easier to follow the manuscript having the whole picture since the beginning.

SECTION 3.1.

Line 5 (Page 7). A brief introduction to 129I/236U ratios is missing to understand their values and the further discussions.

Line 10-30 (Page 7). I also miss a complete introduction to water mass structure. It will be easier to follow the discussion if first we understand water mass structure and then 129I and 236U/238U are given. This way, ISOW description (Lines 7 -11, Page 8) should be move to that introduction, and merge with description in Page 5.

Line 26 (Page 7). "SAIW probably incorporates 129I from precursor water masses (e.g., waters carried by LC and/or LSW) while forming in the western SPNA". Why is that? Some of the statements, like this one, are properly given but not explained in terms of 129I (or 236U/238U) values.

Line 5 (Page 8). "Thus, 2014 data probably reflects the dilution with old LSW and SPMW carrying less 129I and 236U than MW". How is it that waters from LSW and SPMW, both affected by NFRP, carry less 129I and 236U/238U than MW, also mainly affected by GF? Is it the influence of Marcule?

Lines 1-13 (Page 8). This is clearly explained, but it will be even easier to follow if the name of stations and references to Table 2 are given.

Lines 14 -18. As already said, previous brief introduction to the use of 129I/236U as tracer should be included to make this lines easier to follow.

This way it said "The highest 129I/236U ratios (> 100) are present in waters transported by the shallow EGC and LC. Overflow waters are also distinguishable by their relatively high 129I/236U ratios (60 to 110 for DSOW, 15 to 40 for ISOW)" Why is that?

SECTION 3.2.

Line 25- 30 (Page 8). I really like Figure 3. I contains lots of information, may be it could be further explained in the mentioned intro introducing the 129I/236U tracer?

SECTION 3.3.

Line 14 (Page 9). “129I discharge rate from European NRPs was observed in the whole water column, being more pronounced (about 10 times increase) in overflow waters”. This actually an previously observed fact but an explanation should be given here.

Figure 4A. Indicate in the caption that Smith 2016 corresponds to 2012 and 2013 profiles. “The depth distribution of 129I concentrations in the Labrador Sea in 2014 (station 69), displays 129I concentrations in DSOW about 15 % lower than in 2012 – 2013 (Smith et al., 2016)”. Is this because samples from 2012-2013 are measuring the peak in the NFRP releases? If this is the case, please mention that the explanation for that decrease will be given in Section 3.5.

As I said, it is a well-known fact DSOW present an increase in 129I concentrations for all years. This is already approached by previous works, but a brief discussion could be also given here.

Line 18 (Page 9). “The main difference between the 129I depth profiles in the Irminger Sea (station 44) and central Labrador Sea (station 69) in 2014 is the surface 129I peak in the latter one (Figure 4A). Which is probably caused by waters that split off from the boundary currents, either the West Greenland Current or the LC”. I don’t quite understand this. Splitting won’t change 129I concentrations.

Line 26 (Page 9). “This similarity suggests little time variation and similar water mass composition for that region, although PAP might present slightly larger 129I concentrations because of its proximity to Sellafield and La Hague”. And will support the later mentioned hypothesis of direct contribution of NFRP to SPNA without previous recirculation (Line 10, Page 10).

SECTION 3.4.

Line 17 (Page 10). “twice” instead of “two times”

Line 16 -17 (Page 10). “near-surface transport of 129I from European NRPs also across Iceland-Scotland into the eastern SPNA” is also clearly seen in Table 2. That shows that profiles 1, 13 and 21 strongly contrast from profiles 6 and 32. Not only due to ISOW (IcSPMW) contribution in intermediate depths but also at shallower depths.

Line 27 (Page 10). allowing to identify key circulation features such as the EGC/LC and the DWBC in the Labrador and Irminger Seas. Explain in terms of radioactive tracers.

Line 30 -30. Differences of 129I and 236U in boundary currents are mentioned but not explained. It should be further discussed in terms of radioactive tracers.

Line 1-2 (Page 11). “EGC shows particularly high 129I concentrations and 129I/236U ratios because it is carrying Arctic water of Atlantic origin (PIW-Atlantic) and RAW that have been largely influenced by NRP effluents”. I assume the authors do not explain this further because this is well known from previous works. Nevertheless, a brief description should be given, may be in the previously mentioned introduction?

Line 5-6 (Page 11). “while its 236U/238U ratios are likely > 2000 10-12 due to GF and unconstrained Arctic rivers inputs”. Influencing how? In 236U, 129I or both?

Line 12 (Page 11). “rise of 129I concentrations at certain depths on the Greenland slope (e.g., station 60; Figure 2 and Figure S1), and particularly in bottom waters of the Irminger Sea (station 44), which are probably related to the cascading of 129I-rich waters from the Greenland Shelf”. And why not an increase in 236U?

Line 22-23 (Page 11). “The ISOW is best distinguished by its relative 129I concentration maxima”. Explain origin of this maximum

Line 24 (Page 11). The differences can be more clearly seen in Table 2.

Line 24-25(Page 11). “Further, in the next years one can expect a stronger 129I signal associated with ISOW in the SPNA due to the releases from the NRPs”. Explain this further.

Line 3 (Page 12). “The evolution of 129I (and 236U) in the SPNA is closely related to the effluents discharged from the two European NRPs”. It sounds weird to mention this at the end of the paper.

Line 18 (Page 12). “Data reported in this study (2014) supports this ‘Arctic loop’ and suggests that the second 129I front probably peaked before the GEOVIDE cruise”. Could Vivo et al. values be also used to support this “Arctic loop”?