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Climate of the Past Discussions

Interactive comment on "Holocene atmospheric iodine evolution over the North Atlantic" *by* Juan Pablo Corella et al.

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Referee #3: In the paper "Holocene atmospheric iodine evolution over the North Atlantic" by J. P.Corella and co-authors a new record of iodine concentration in the ReCAP ice core (Greenland) is presented. The record covers the full Holocene and an interesting discussion about iodine variations in the atmosphere across different climatic periods is shown. In particular the authors elaborate here an easy conceptual model which seems to be very effective in explaining iodine variability during the three time periods here considered: Holocene Thermal Maximum, Neoglacial period and Great Acceleration. The paper shows a very good laboratory intercomparison exercise, showing a general agreement in the measured iodine concentrations. This work is generally well presented and well written and will surely be a milestone in the use

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of halogens measured in ice cores to achieve information about Sea Ice in the North Atlantic.

Response: We appreciate the positive feedback from reviewer 3. We have addressed below all the comments and suggestions made by reviewer.

Referee #3: My main concern about the paper is the lack of discussion about the possible post-depositional effects of iodine species in the snow. A detailed discussion about the preservation of iodine compounds in the snow and their stability in time due to a possible photochemical degradation should be added to the text. Before concluding that iodine is a real marker reflecting the past North Atlantic conditions, the authors should assess that the very low concentrations they are measuring are really telling us a story about past conditions, or, at least, that the record obtained is not significantly different from what was deposited in the Renland Ice Cap.

Response: We agree with the reviewer on the fact that photochemical processes on snow and ice lead to iodine recycling for the surface snow. Indeed, several laboratory and field experiments reported in the literature (e.g Frieb et al., 2000; Spolaor et al. 2013; Galvez et al., 2016; Kim et al., 2016; Spolaor et al., 2019) have shown that iodine concentrations from in polar regions may suffer from significant photo-chemical post-depositional processes that may affect the iodine concentration in ice and snow at daily to seasonal scales. Nevertheless, large variations in the net iodine depositional fluxes in coastal Greenland ice cores at centennial to millennial time scales are not expected. We have added a section in the new version of the manuscript where the post-depositional processes affecting iodine re-emission from ice and snow at different time scales are fully addressed

Referee #3: Moreover, the meteorological conditions were surely very different in the different time periods here shown, and the authors should clarify why the variability of iodine is mainly linked to the primary productivity and not to changes in transport efficiency through time.

Response: It is difficult to reconstruct meteorological conditions accurately in Greenland during the Holocene, but the best indicator we have of the conditions at the site is the reconstructed accumulation rate shown in Figure S2. This was reasonably stable for the last 8000 years, suggesting relatively constant snowfall and surface conditions. The absence of any significant correlation between the Holocene accumulation rate and the concentration of impurities such as iodine and ssa, is the first indication that the observed pattern of those impurities is not dominated by snow deposition or meteorological effects. The scale of variability exhibited in the RECAP Iodine record (both concentrations and fluxes) is further inconsistent with possible changes in transport efficiency. The iodine concentration changes by more than a factor of 4 within a few centuries during the Holocene, which is an enormous change. For comparison, best-available estimates suggest only a minor change in transport efficiency (much less than a factor of 4) over the glacial-interglacial transition for dust travelling to Greenland from deserts in central Asia (Schüpbach et al., 2018)

Referee #3: Other papers by the authors reported an halogen enrichment factor by subtracting the sea salt contribution. I'm not sure about which is the best way to proceed, but I would like to know why in this paper this elaboration was not considered. I suspect that an elaboration of the iodine values with sodium can infer to iodine a variability which mainly comes from Na+ concentrations. Once these points will be addressed I would recommend the publication of this paper.

Response: As suggested by reviewer, we have added a new figure (Fig. S5) showing the iodine to sodium ratio. In this figure we show that the I/Na ratio show the same trends that the iodine concentration and fluxes throughout the Holocene reinforcing our interpretation that ssa would only represent a minor contributor explaining the iodine variability in ReCAP during the Holocene. We have added this new information in the revised manuscript.

Minor issues.

Referee #3: Line 59: Change to "Ice core..."

Response: Done

Referee #3: Line 109: explain what UPW means.

Response: Done

Referee #3: Line 110: How were the d.l. calculated? Explain briefly how the two labs measured this figure of merit of the two methods.

Response: This information has been added to the methods section in the new version of the manuscript

Referee #3: Line 116: Is there an age model for the RECAP ice core? Give more information on this point: how was the age scale built? Which absolute markers were used (i.e. volcanoes, tephra, etc)? Which is the uncertainty in the bottom part of the ice core?

Response: The ReCAP ice core record covers the last 120 kyr BP and has been published in Simonsen et al., 2019. All the details regarding the chronology are fully explained. Addressing the specific questions made by reviewer: -The RECAP timescale down to 458.3 m (4048.1 y b2k) was produced using the StratiCounter automated layer counting software (https://github.com/maiwinstrup/StratiCounter) (Winstrup, 2016). -The software was constrained to fit 28 volcanic marker horizons dated in other Greenland ice cores (DYE-3, GRIP, GRIP and NEEMS1) formalised in the Greenland Ice Core Chronology 2005 [Rasmussen et al., 2013]. Below 458.3 m, the timescale was derived automatically using a shape-preserving piecewise cubic interpolation (Vinther, et al., 2008) between 15 chronological tie points (volcanic markers or climate transition matches) used to constrain the timescale back to 11703 y b2k. -As the RECAP timescale is synchronised to GICC05, it inherits the uncertainty budget associated with that timescale and presented in the aforementioned references.

Referee #3: Line 137-138: units are not readable...

Response: This has been corrected in the new version of the manuscript

Referee #3: Line 141: remove the comma between m-2 and yr-1.

Response: Done

Referee #3: Line 198: Two references by Telesinski et al. were published in 2014, please call them a) and b) in order to make clear which reference you are referring to in the text.

Response: Done

Referee #3: Line 198: is c. for ca.?

Response: YES, this error has been corrected.

Referee #3: Line 240: remove M.M. before Telesinski.

Response: Done

Referee #3: Line 412: check the references: something wrong happened to the title of this paper.

Response: The typos from the title reference title have been corrected now

Referee #3: Figure 2 caption: use "concentration and flux" or "concentrations and fluxes", not a mix

Response: Done

Referee #3: Figure 2: during the HTM the authors' reconstruction seems to be very smoothed with respect to the marine records. Is it due to the poor resolution at this depth? Please discuss this point in the text.

Response: Yes, this is due to the lower time resolution (same 55 cm sampling resolution but increased ice compression) at this depth. This has been discussed in the new version of the manuscript. "The iodine and sodium measurement temporal resolution ranged from sub-annual in the upper metres during the Great Acceleration (average resolution of 1.31 samples/yr), subdecadal resolution during the Late Holocene (average resolution of 0.23 samples/yr), and sub-centennial resolution during the Neoglacial and the HTM (average resolution of 0.035 and 0.011 samples/yr respectively) according to the RECAP ice core age-depth model and our sampling resolution".

Referee #3: Figure 2 and text: is flux adding something new with respect to concentration? The two profiles are very similar and the authors should discuss this point in terms of wet/dry deposition mechanisms at the drilling site.

Response: According to Wolff et al 2006 if the accumulation rate is low, dry deposition dominates and fluxes are proportional to the air concentration, while if the accumulation rate is high, wet deposition dominates the dry deposition, the concentration is proportional to the air concentration. Therefore, since accumulation rates in ReCAP are much higher than other Greenland sites summarized in Maselli et al (2017) and Rhodes et al (2017) we may suggest that wet deposition dominates. Nevertheless, this relation is not straight forward and we prefer to add both concentration and fluxes. Both iodine concentration and fluxes shown similar trends. This agreement between concentration and fluxes reinforces our explanation of external forcings (i.e. marine bioproductivity and sea ice dynamics, driving the iodine levels variability throughout the Holocene. We have mentioned this in the revised version of the manuscript.

References Frieß, U., Deutschmann, T., Gilfedder, B., Weller,R., and Platt, U.: Iodine monoxide in the Antarctic snowpack, Atmospheric Chemistry and Physics, 10, 2439-2456, 2010 Gálvez, Ó., Baeza-Romero, M. T., Sanz, M., and Saiz-Lopez, A.: Photolysis of frozen iodate salts as a source of active iodine in the polar environment, 2016. Kim, K., Yabushita, A., Okumura, M., Saiz-Lopez, A., Cuevas, C. A., Blaszczak-Boxe, C. S., Min, D., W. Yoon, H.-I. and Choi, W., Production of molecular iodine and tri-iodide in the frozen solution of iodide: implication for polar atmosphere, Environmental science & technology, 50(3), 1280-1287, 2016.

Maselli, Olivia J., Chellman, Nathan J., Grieman, Mackenzie, Layman, Lawrence, McConnell, Joseph R., Pasteris, Daniel, Rhodes, Rachael H., Saltzman, Eric and Sigl,Michael. Sea ice and pollution-modulated changes in Greenland ice core methane sulfonate and bromine. Climate of the Past, 13 (1). pp. 39-59. 2017

Rhodes, R. H., Yang, X., Wolff, E. W., McConnell, J. R., & Frey, M. M. Sea ice as a source of sea salt aerosol to Greenland ice cores: a model-based study. Atmospheric Chemistry and Physics, 17(15), 9417-9433. 2017 Simonsen, M.F., Baccolo, G., Blunier, T., Borunda, A., Delmonte, B., Frei, R., Goldstein, S., Grinsted, A., Kjær, H.A., Sowers, T., Svensson, A., Vinther, B., Vladimirova, D., Winckler, G., Spolaor, A., Vallelonga, P., Plane, J., Kehrwald,N., Gabrieli, J., Varin, C., Turetta, C., Cozzi, G., Kumar, R., and Boutron, C.: Halogenspecies record Antarctic sea ice extent over glacial–interglacial periods, Atmospheric Chemistry and Physics, 13, 6623-6635, 2013.

Spolaor, A., Barbaro, E., Cappelletti, D., Turetta, C., Mazzola, M., Giardi, F., Björkman, M.P., Lucchetta, F., Dallo, F., Pfaffhuber, K.A., Angot, H., Dommergue, A., Maturilli, M., Saiz-Lopez, A., Barbante, C. and Cairns, W.R.L. Diurnal cycle of iodine and mercury concentrations in Svalbard surface snow. Atmos. Chem. Phys. Discuss. 2019, 1-25. 2019

Schüpbach, S., Fischer, H., Bigler, M., Erhardt, T., Gfeller, G., Leuenberger, D.et al. Greenland records of aerosol source and atmospheric lifetime changes from the Eemian to the Holocene. Nature communications, 9(1), 1476. 2018

Winstrup, M. and Vallelonga, P.. East Greenland ice core dust record reveals timing of Greenland ice sheet advance and retreat. Nature Communications, 2019, in press.

Vinther, B. M. et al. Synchronizing ice cores from the Renland and Agassiz ice caps to the Greenland Ice Core Chronology,. J. Geophys. Res. 113, D08115, doi:08110.01029/02007JD009143. 2008

Winstrup, M. A Hidden Markov Model Approach to Infer Timescales for High-Resolution

Climate Archives. (AAAI Press). 2016

Wolff, E. W., Fischer, H., Fundel, F., Ruth, U., Twarloh, B., Littot, G. C., ... et al. Southern Ocean sea-ice extent, productivity and iron flux over the past eight glacial cycles. Nature, 440(7083), 491. 2006

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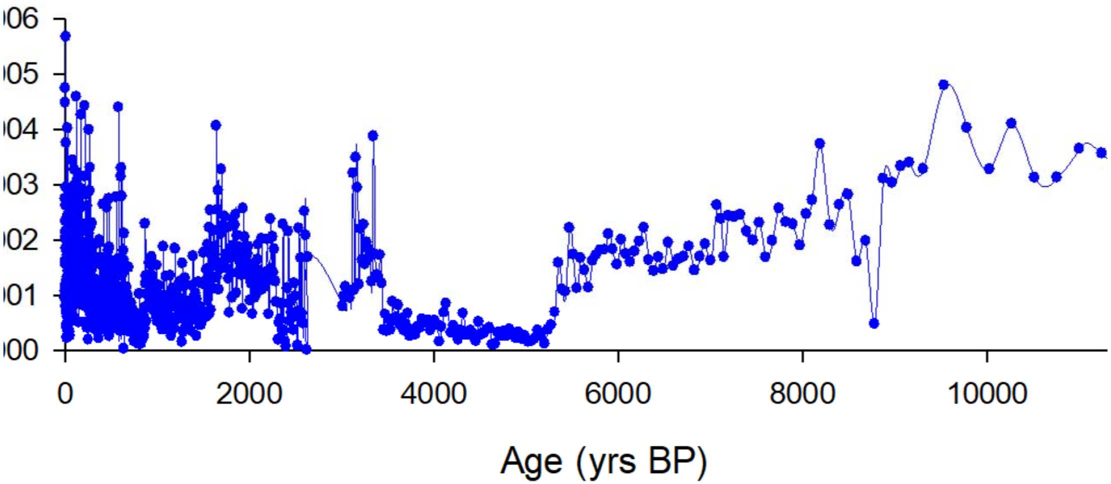

Fig. 1. Fig. S4: ReCAP ice core iodine to sodium concentration ratio during the Holocene

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