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Interactive comment on "Atmospheric Fe supply has a negligible role in promoting marine productivity in the Glacial North Pacific Ocean" *by* Francois Burgay et al.

Anonymous Referee #3

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Review of "Atmospheric Fe supply has a negligible role in promoting marine productivity in the Glacial North Pacific Ocean" by Burgay et al. This study presents the dust and iron flux (sourced from dust) in the NEEM ice core from MIS5c-5d to MIS 1. These records are compared to East Antarctic ice core records (Talos Dome and Dome C) to observe the similarities or differences between hemispheres. The authors find some similarities between Talos Dome and NEEM (interior East Antarctic site has lower dust and Fe flux), but found considerable differences during MIS 4. More text expanding on why this difference is observed, and why these specific ice cores were chosen for comparison would benefit the manuscript. Given the potential role of dust-borne Fe on marine biological activity, the authors then correlate their ice core dust and Fe record

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to marine sediment core records of biological productivity. Authors find a correlation between dust-borne Fe transport and biological productivity in the transition zone of the North Pacific but not in the subarctic Pacific. However, the records of Fe supply to these specific sites are not presented (only proxies for biological productivity), so they may be receiving different amounts of dust flux and Fe composition compared to what is observed at NEEM ice core. It would be beneficial for the authors to acknowledge this assumption. That being said, the title of the manuscript may need to be altered. I have outlined specific suggestions for improving the manuscript below.

Specific comments:

The authors should comment on changes in water stratification that may occur during glacial periods in the North Pacific, is productivity is more limited by nitrate rather than Fe? What are the upwelling conditions like near the sediment core records you are comparing the ice core dust flux to? Need more information that suggests atmospherically transported Fe (versus upwelling) is the primary source of Fe to these sites.

Can you comment about oxygen content in the Glacial North Pacific during this time period?

Need to define the time period covered by the Holocene in the text, currently only in Table 3? Make sure all time periods are defined in the manuscript.

Why don't you compare your NEEM record to other Greenland ice core records? Or more information is needed as to why you chose Talos Dome, Law Dome, and Dome C specifically to compare your NEEM Fe flux to.

Abstract: Please list the time period that the data covers in this study.

Throughout the manuscript, past tense (e.g. was explained) is used instead of present (is explained, or is attributable to. . .). I suggest changing to present, but this is a stylistic request that is up to the authors.

lines 16-17: One sentence is attributing aeolian dust as one of the main Fe sources

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to the ocean and the second sentence is stating that ice cores provide a sensitive and continuous archive for reconstructing Fe fluxes over last millennia. I suggest the authors add a sentence or portion of a sentence stating how aeolian dust transported over past climate periods is preserved in the ice core record.

Line 19: In a portion of the Arctic region over the last 108 kyr.

Line 21: remove “the” before Marine Isotope Stage 4.

Line 21: Avoid starting sentences with “They”, instead combine the two sentences together or redefine what “they” is.

Line 22: Comparison of our data with. . .

Line 23: “we found that the coldest periods are characterized by the highest Fe fluxes, but marine productivity in the subarctic Pacific Ocean did not increase likely due to greater sea-ice extent and the absence. . .”

Line 29: “. . .that provide records of temperature, atmospheric dust load, and atmospheric gas composition variability during the Holocene and late Pleistocene (refs)”

Line 31: There are many ice core records that provide this information besides what is cited here, I would suggest being specific about the ice cores that were presented by the studies cited here, or expand the references listed.

Line 31: Glacial periods were dustier and characterized by a lower CO2. . ..

Line 32-33: This dichotomy is explained through several different hypotheses: the increase in aridity and newly exposed continental shelves. . .

Line 34: What do you mean by “enhancement”? Be more specific here.

Line 34: an increase in the aerosol. . .

Line 35-36: increased glacial-derived mobilization of highly bioavailable iron (Fe) from physical breakdown of bedrock. . .

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Line 36-37: more vigorous polar circulation capable of entraining addition dust from lower latitudes.

Line 38: through both physical and biological mechanisms. Dust particles can absorb and scatter incoming solar radiation and outgoing infrared radiation. . .

Line 40: Conversely, once deposited on the ocean surface, the mineral dust delivered major and micronutrients (including Fe).

Define “iron” as “Fe” and use this throughout the manuscript

Line 43-44: should also cite Shoenfelt et al., 2017; High particulate iron(II) content in glacially sourced dusts enhances productivity of a model diatom, Science Advances 3, e1700314.

Line 53: the average flux and concentration values of dust?? or leachable Fe?

Lines 62-63: the evolution of global atmospheric circulation

Lines 66: which provides unique insight

L 67: and the Last Glacial Period (suggest choosing a format for this and sticking to it throughout the entire manuscript)

L 68: “and various palaeoproductivity records from the. . .” Which records? list them here.

L 95: A 120 second rinsing step with 2% HNO3 occurred after each sample analysis to reduce any possible memory effect, and the vials used. . .

L98: . . .it was quantified using the interference-free isotope 57Fe and external calibration curves with acidified standards. . .

L116: The last 4000 years are characterized by. . .

L137: What makes this fraction the leachable Fe concentration? Are you assuming that the 1 month leaching at a pH of 1 in HNO3 is the labile portion?

L144:. . .is likely related to the proximity of the ice core site to nearby regional dust deflation areas in Victoria Land that may not reach the central Antarctic Plateau (Delmonte et al., 2013)

L146: The LGM (19- 26.5 kyr b2k) was characterized by Fe fluxes on the same order. . .

L152-153: . . .compared to Antarctica.

L159:. . .one important question remains regarding whether its increase in flux triggered the marine productivity. . .

L160-163: This is an important point. To know the truly labile portion of Fe present in the ice core dust, it would be necessary to leach the dust in conditions similar to what is observed in the modern ocean (with the assumption that the pH and chemistry of the modern ocean is similar to what was observed during MIS 4 and the LGM). Could be useful to discuss that a bit more here.

L164: "Geochemical evidence indicates the dust source influencing Greenland and the North Pacific is similar in origin from the East Asian deserts (references)." Is this in the ice core record or marine sediment record?

L164: What time periods? glacial and interglacial? What about Lupker et al. 2010 [Isotopic tracing (Sr, Nd, U and Hf) of continental and marine aerosols in an 18th century section of the Dye-3 ice core (Greenland), Earth and Planetary Science Letters 295, 277-286] who suggested Sahara as an additional potential source?

L166: ". . .is primarily deposited over the HNLC region. . ."

L168: ". . .may reflect potential Fe fertilization effects promoted by increased atmospheric Fe supply."

L170: "resulted in enhanced MPP by more than 60% in this region."

L171-173: would suggest combining these two sentences together.

L177: For the period ranging from the LGM to the Holocene. . .

L178-181: Please include the lat, long, and depth of the sediment cores or indicate where this data is available (Table 4).

L 183-185: All sediment cores compared here share the same Asian dust source. . .

L190: need some information about what brassicasterol concentration is informing on.

L193: "The disagreement between Fe in the ice core record and MPP response may reflect the key conditions that result in intensified primary production such as well-developed water stratification. . ."

L198: replace "than during" with "compared to"

L199: which drove the system towards. . .

L201-202: second half of this sentence doesn't make sense to me.

L205-207: okay but what about when the sea ice eventually melts? How long is this sea ice thought to have persisted for? If atmospheric dust was deposited on sea ice surfaces presumably when the sea ice melted there would be a pulse of Fe to the surface ocean? It would be interesting to expand on this here.

L229: un-capitalize "aeolian"

L235: Thus, additional atmospheric Fe supply had little effect on phytoplankton productivity, suggesting their growth and productivity was likely. . .

L239: other influences (e.g. meltwater. . .)

L246: what does "This" refer to? both sentences in line 243 and 246 start with "This", try to avoid starting sentences like that.

Conclusions & future perspectives I think this section can be expanded upon, right now it just reads like a quick summary of the main points brought up in the manuscript without expanding on why we see the largest differences in the Fe record during MIS

4, what this means in terms of dust supplied Fe to subarctic Pacific in previous climate regimes (e.g. Mid Pleistocene Transition?).

L249: the first Fe record from mineral dust input?

L252: The greatest difference observed between the sites in opposite hemispheres occurred during MIS 4. . .

L252: What is the underlying mechanism for this large difference during MIS 4? or hypothesis? you should state that here.

L260: This study provides an upper limit for estimating the potentially bioavailable Fe supplied to marine phytoplankton, and additional studies should focus on analyzing the labile and bioavailable Fe fractions to constrain realistic Fe supply and response of the marine ecosystem.

Figures Figure 1: Suggest making x-axis in kyr rather than years. Make fonts on axes, labels, and numbers indicating Dansgaard-Oeschger events all need to be larger. The lines on all three lines is extremely faint, is it the top layer in the figure? Would be helpful to split up panels into 1a, 1b, and 1c.

Figure 2: Same comments as figure 1, all fonts need to be larger on axes labels, etc. Location of ice cores should be noted in the figure caption. E.g. pink circle indicates location of NEEM core. Would be helpful to split up panels into 2a, 2b, and 2c.

Figure 3: all fonts need to be larger, the figure should be split up into figure 3a, 3b, 3c. The shaded rectangles should be located behind the data instead of on top.

Figure 4: Font size is fine on this figure, but same suggestion about the years axes (kyr instead of years b2k). Same comment about shaded rectangles located behind data. Need to split up into 4a, 4b, and 4c. Suggest changing the introductory sentence of this figure caption, something like: “Relationship between Fe flux in the NEEM core, and MPP in the subarctic Pacific ocean over the last 26 kyr; would be helpful to give readers some context into what the brassicasterol/TOC is telling us. For example, higher ratios

indicate more productivity, and lower ratios suggest less productivity so having an arrow indicating this on the right-hand side can aid the reader in visualization.

Table 1: should the first period be: “Holocene (pre-7.2 kyr)” rather than “post-7.2 kyr”? Caption should start with “Temporal resolution of NEEM ice core” or something like that.

Table 2: need period at the end. Need to indicate that the first two are averages.

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