We are grateful to the reviewers and the editors for their time and efforts to review this manuscript. We have taken efforts to improve the grammar and structure of the sentences to make the manuscript more readable. Below we list detailed responses to the editor's comments and suggestions. The comments and suggestions are in italics, followed by the response in normal font with changes highlighted in blue. The line number for each modification in the change tracked version is also listed.

Comments from the Editor

Minor Edits:

1) *In the Methods section, please include your method for correcting data with the nitrate blank concentration and isotopic composition, as you describe in your response to the referees.*

Response: We have added the following text in the revised manuscript:

"…reference material solution using 1M NaCl solution. The blank filter samples were processed following the same procedure as atmospheric samples and measured for their isotope ratios. The measured nitrate isotope ratio of each atmospheric sample was further corrected by deducting the contribution from filter blanks.", line 211-213.

2) *In the Methods section, please include your explanation of how the uncertainty associated with the isotopic measurements was calculated, as you describe in your response to the referees.*

Response:

"…deducting the contribution of the filter blanks. The measurement uncertainty was assessed based on the reduced standard deviations of the residuals from the linear regression between the measured reference materials and their expected values as detailed in Erbland et al. (2013). The overall measurement uncertainties…", line 215-217.

3) *In Line 801, the authors state the snowpack data was "significantly different" from that of the atmospheric and surface-snow nitrate. Please provide statistics to back of this statement of significance or change the wording here.*

Response: We have changed the word "significantly" to "distinctly".

4) *Please double-check your reported d15N values from Jarvis et al (2009), and one referee notes that the values reported in your manuscript are different than the 2006 and 2007 data reported in Jarvis et al (2009). If your reported values are an average of the two years, please include that information in the manuscript.*

Response: We have checked the $\delta^{15}N(NO_3^-)$ reported in Jarvis et al. (2009) and are sure that the used value is consistent. Jarvis et al. (2009) reported monthly means of atmospheric $\delta^{15}N(NO_3^-)$ and seasonal means of surface snow and snowpack over **two years** (i.e., 2006 and 2007), and in this manuscript we used the averages of the two years. We have added more explanations in the main text:

"…for samples with coarser than monthly resolution, seasonal averages were used, and

we here reported seasonal averages of multiple years if more than one year's data are available in the literature.", line 234-235.

5) *In Lines 401-403, please add justification for the reader as to why the Fibiger et al. (2016) data is out of range and not shown.*
Response: We have added the following justification in the main text in the revised manuscript:
"…In addition, the averaged $\delta^{18}O(NO_3^-)$ of atmospheric nitrate in gas-phase samples collected by Jarvis et al. (2009) in March and June is (34.1 ± 1.7) ‰, and by Fibiger et al. (2016) in May and June is (54.2 ± 8.5) ‰ for the year of 2010 and (90.5 ± 12.5) ‰ for the year of 2011. These values are out of range of the snow samples as well as our atmospheric samples, and in order to better show the seasonality of $\delta^{18}O(NO_3^-)$ in snow and atmospheric samples as indicated by other data, we didn't plot these data in Figure 2d…", line 385-391.

The caption of Figure 2 has also been changed accordingly:
"…The atmospheric $\delta^{18}O(HNO_3)$ data in Fibiger et al. (2016) and Jarvis et al. (2009) are both out of range of the snow samples as well as our atmospheric samples thus are not shown here.", line 408-410.

6) *The referee's suggestion of citing the Shi et al. study should be included as its evidence for a small to minimal change in the isotopes can be used to back up this study's claim that this process is not important under the conditions at Summit.*
Response: We have added the following text in the revised manuscript:
"…Jiang et al. (2021) have discussed the effect of the physical release on nitrate isotopes and suggest that this effect is negligible at Summit. This is because that the physical release rate and the associated isotope effects are relatively small at cold temperatures. Shi et al. (2019) performed field NO_3^- volatilization experiments and found no isotope fractionation occurring in $\delta^{15}N(NO_3^-)$ when the temperature was set to –24 °C. When the temperature increased to –4 °C, a small positive fractionation constant (4.9 ± 2.1‰) was observed, while at Summit the temperature is below –10 °C throughout the year as shown in Figure 1a.", line 429-435.

7) *Supplementary Table 1: either explain why the Jarvis et al. (2009) data is bolded, or remove the bold font here*
Response: We remove the bold font in the table.

Technical Corrections:
Line 33: should be "atmospheric"; remove the comma
Line 34: add "the" before "snowpack"; change to "…, while the surface snow… was in between the atmosphere and the surface snow."
Line 35: change to "atmospheric"
Line 39: add "the" before "snowpack" here
Line 75: add "an" before "increasing"; add "sites" after "inland"
Line 84: add comma after "contribute"

Line 89: change "in general" to "generally"
Line 93: change "recycle" to "recycling"
Line 109: change to "periods"
Line 127: add "a" before "seasonal"
Line 129: add "an" before "annual"
Line 133: changes to "scales"
Line 139: add "the" before "snowpack"
Line 153: add comma after "depth"
Line 154: add comma after "zone"
Line 169: change "critical to assess" to "critical for assessing"
Line 172: capitalize "Atmospheric" in the subsection title here
Line 174: remove "by"
Line 177: change "till" to "until"
Line 185: add "that" after "assumed"
Line 188: should this be "field" instead of "filed"?
Line 197: change "were" to "was"
Line 198: change "were" to "was"
Line 199: add "the" before "blank"
Line 200: change to "…concentrations exceeding 3 times that of the blank..."
Line 214: change to "atmospheric"
Line 232: change to "atmospheric"
Line 251: add "to" after "matched"
Line 257: change to "atmospheric"
Line 267: "inconsistence" is not a word, perhaps "being inconsistent" instead
Line 269: add "the" before "current"
Line 297: change to "… a more efficient scavenging…"
Line 343: missing a ")" somewhere in here
Line 380: add "the" before "current"
Line 400: change to "standard"
Line 402: add "and" before "thus"
Line 421: change to "have discussed"
Line 422: change to "suggest"
Line 423: change to "… discuss the other processes and compare…"
Line 428: change to "types"
Line 453: change "to" to "for"
Line 606: add "the" before "total"
Line 752: change to "appear"
Line 754: add "the" before "local"
Line 801: change to "atmospheric"
Line 817: should this be "thought" instead of "sought"?
Line 821: change to "qualitative"
Line 857: change to "modeling"
Line 862: change to "times"

Response: We appreciate a lot for the editor's careful checking on these typos and we

have revised them accordingly.

Lines 49-52: multiple referees are confused by this sentence because the isotopes are by photolysis. Please clarify or reword here.
Response: The original sentence has been revised as follows:
"…This likely suggests the oxygen isotopes are also affected before preservation in snow at Summit, but the degree of change for $\delta^{18}O(NO_3^-)$ should be larger than that of $\Delta^{17}O(NO_3^-)$. This is because photolysis is a mass-dependent process that would directly affect $\delta^{18}O(NO_3^-)$ in snow but not $\Delta^{17}O(NO_3^-)$ as the latter is a mass-independent signal…", line 49-51.

Line 52: the phrase "Although with uncertainties,…" doesn't make sense. Please revise.
Response: The original sentence has been revised as follows:
"…Although there were uncertainties associated with the complied dataset, the results suggested that post-depositional processing at Summit can induce changes in nitrate isotopes especially $\delta^{15}N(NO_3^-)$, consistent with a previous modeling study…", line 51-53.

Line 85: perhaps "suggested to have a minimal effect under…" instead; perhaps "…under typical ranges of temperatures in polar regions" instead
Response: The original sentence has been revised as follows:
"The evaporation of nitrate from snow grains may also contribute, but this process has been suggested to only have a minimal effect under typical ranges of temperatures in the polar regions (Shi et al., 2019).", line 83-84.

Lines 96-97: reword the phrase "…and this need to be fully understanding when interpreting ice core nitrate records." Perhaps ", which needs to be fully understood to interpret ice-core nitrate records."
Response: The original sentence has been revised as follows:
"Thus, the final archived snow nitrate, defined as nitrate buried below the photic zone, would be largely impacted by post-depositional processing, which needs to be fully understood to interpret ice-core nitrate records.", line 94-95.

Lines 103-107: this is a run-on sentence, consider breaking into two sentences
Response: The original sentence has been revised as follows:
"…For example, Geng et al. (2014) found correlations between $\delta^{15}N(NO_3^-)$ and snow accumulation rate across the GISP2 ice core record except in periods with very low snow accumulation rate (<0.08 m ice a^{-1}) and high dust concentrations. In the latter situation, $\delta^{15}N(NO_3^-)$ became negatively correlated with dust concentration. These correlations reflect the effect of snow accumulation rate and snow light absorbing impurities on the degree of post-depositional processing, respectively…", line 104-105.

Line 120: the phrase "…, but less to TCO" doesn't make sense. Please reword.
Response: We have rephrased this sentence as follows:

"…while a recent study suggested the preserved $\delta^{15}N(NO_3^-)$ is more sensitive to snow accumulation rate and light penetration depth than to changes in TCO (Winton et al., 2020). Nevertheless, in periods…", line 119.

Lines 123-125: the phrase "…, changes in the degree of post-depositional processing and thus the associated isotope effects are expected." doesn't make sense after the first half of the sentence, please reword.

Response: We have rephrased this sentence as follows:

"…Nevertheless, in periods with relatively constant snow accumulation rate but distinct surface actinic flux (e.g., the switch of the polar night and polar day over a year, and the Antarctic ozone hole period), changes in the degree of post-depositional processing and the associated isotope effects should be expected…" line 123.

Lines 137-138: the phrase "…which is however minimum at Summit given the high snow accumulation" doesn't make sense here, please reword.

Response: We have changed this sentence as follows:

"…In contrast, the model predicted minimum changes in $\Delta^{17}O$ of snow nitrate on both seasonal and annual scales because the photo-driven post-depositional processing affects $\Delta^{17}O$ mainly from the cage effect (i.e., the intermediate photo-products (NO_2^- and NO_2) exchange with water oxygen or react with radicals such as OH in snow grains to regenerate nitrate before being emitted to the atmosphere) (McCabe et al., 2005; Meusinger et al., 2014), and the cage effect is minimum at Summit given the high snow accumulation rate", line 137.

Lines 310-314: you suddenly represent the isotopic values differently here (without parentheses), be consistent throughout the manuscript

Response: We only added parentheses for the values with uncertainty before the unit. For the values here representing the upper and lower range, we don't feel it's necessary to add parentheses to be consistent.

Lines 858-860: this phrase needs to be reworded

Response: We have changed this sentence as follows:

"…Further numerical modeling is needed to correct the effects of post-depositional processing on $\delta^{15}N(NO_3^-)$, which is critical for the retrieval of information on past atmospheric NO_x emissions using ice core $\delta^{15}N(NO_3^-)$ records (Hasting et al., 2009, 2015).", line 858-861.