

## ***Interactive comment on “Drivers of variations in the vertical profile of ozone over Summit Station, Greenland: An analysis of ozonesonde data” by Shima Bahramvash Shams et al.***

### **Anonymous Referee #1**

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Shima Bahramvash Shams et al. analyse ozonesonde data from Summit Station, Greenland to determine the primary drivers of ozone variations at this station by using a stepwise multiple regression analyses. They find that the QBO has the strongest influence for ozone variations over Greenland. This influence is not as strong found over other Arctic stations and thus the authors suggest that Greenland may be particularly sensitive to the QBO. This is a quite interesting study, but it lacks in presentation. I would suggest major revisions before this study can be considered for publication in ACP. I give detailed comments and suggestions for improvements below.

C1

### **General comments:**

So far, the results are mainly presented in a descriptive manner than really explaining something. Furthermore, the entire analyses is described and documented in much more detail than actually necessary for a research paper. Therefore, I would first of all suggest to reduce the number of tables and figures to what is really needed. For example, the few values for latitude, longitude and altitude of the stations could be easily (if not already done so) given in the main text. Tables 2 and 3 could be provided (if necessary) in a supplement. The numbers from Table 4 which are important could be given in the main text of the manuscript or in the respective figures.

How can you justify an extrapolation to 60 km? From Figure 2 one can see that there are generally no ozonesondes measuring above 40 km, except the 2 balloons that measured up to 50 km that were removed from further analysis due to erroneous readings from the pressure sensor. That means extrapolation is done over an altitude range of at least 20 km. How can you be sure that your results are not just reflecting the climatological changes and not the actual changes? Why don't you extrapolate the profiles up to 30-40 km as it would match the typical maximum altitude for the measurements of the ozonesondes?

In this study the results for only one station are presented, but it would be more interesting to have such an analyses for several stations that can be compared to each other. As it is done now (with just mentioning the other two stations that however cannot be analysed because they do not provide measurements for all seasons) it is in my opinion not sufficient.

What is the reason for the QBO influence over Greenland. If you cannot find such an influence over other Arctic stations, how can you then be sure that this is not just a measurement artifact? This really needs some more discussion, analyses and scientific explanations to be sure that there really is a connection.

C2

**Specific comments:**

P1, L12: Here you state that “12 years” of data were used, but later you always state “11 years” of data were used.

P1, L15: Extended to 60 km from which altitude? How many km are extrapolated?

P2, L14-15: This sentence could be misleading and should thus be rephrased. The reason why there is less photochemical loss of O<sub>3</sub> is because if temperatures are warmer, there are less PSCs and if there are less PSCs there are less surfaces for heterogeneous reactions that convert the inert reservoir species into reactive species that destroy ozone.

P2, L17-18: This only holds with the current ozone loading. When the chlorine concentrations decline, there will be no longer massive ozone destruction due to chlorine. Thus, this sentence should also be rephrased.

P2, L26: Remote sensing instruments → from space or ground? Please be more precise.

P2, L27-29: I do not agree to this statement. There are plenty of satellite measurements providing global daily measurements of ozone. Not all satellite instruments are dependent on solar radiation. There are many satellite instruments that are capable of measuring during polar winter.

P3, L19: This needs some more explanation. How is a climatology used to create a vertical profile?

C3

P4, L1: for analyses? Do you mean for this analyses?

P5, L4: Column abundance in the vertical profile sounds a bit weird. Do you mean here “the total amount of ozone in the vertical column”?

P5, L16: What is the purpose of the extrapolation? To fill the missing levels or to extend the column?

P5, L22-24: I would not put the text into brackets. I would suggest to either remove the brackets or to put the text into a footnote.

P5, L25. What do you mean with “is used to 60 km”?

P6, L34: What do you mean with “using data from the dates of ozonesondes”? Do you mean for the same dates as the ozonesonde measurements? Please rephrase accordingly.

P7, L1: The given list of sources rather gives the links to the “data” used for the “proxies” than to the “proxies” themselves.

P7, L10: What do you mean with forward selection?

P7, L29: Minimal in four months? In which month do you get the absolute minimum?

P8, L15: In Fig 7b the minima are not that apparent? Why? Further, it would be worth (especially in Fig 7a) to mark these low areas during these winters for better visibility.

C4

P8, L26: Also here the text should be either given without parentheses or as a footnote.

P9, L8: Winter accumulation? Accumulation of what? Of ozone?

P9, L18: What is FTS? Has the abbreviation been introduced?

P10; L3: "12 years" or "11 years"? The number of years used is not the same throughout the manuscript.

P10, L22: Positive or negative → What do you mean? positive "and/or" negative

P10, L24: Time trends? Do you mean time series or trends?

P11, L19-20: That is too simplified and could be misleading. The photochemical loss of ozone is less than temperatures are warmer, because PSC will not form that are a necessary requirement for the processes leading to ozone depletion.

P12, L4: Please rephrase "changes in final model".

P12, L10: Also this sentence is formulated in that way that it could easily be misunderstood. The reactions involving the surfaces of Polar Stratospheric Clouds lead to ozone loss not the PSC itself.

P12, L16: Two times "layer", thus one "layer" is obsolete.

P12, L22: Caused in part? Isn't it mostly this process? What other processes are responsible for the seasonal cycle?

C5

P13, L1: This sentence should be rephrased. Not the equivalent latitude itself affects the ozone. It is just a different way for analysing/presenting the data and if course of the data is plotted on equivalent latitudes instead of latitude, the distribution or profile looks a bit different.

P14, L13: What is GrIS? Please clarify.

P14, L17: In global? But in your study only local ozone concentrations are considered. What do the here presented results mean for the ramifications of the Montreal Protocol?

**Technical corrections:**

P1, L11: there are few. . . → there are only few. . . .

P1, L21: due primarily → primarily due

P2, L13: weaken → "weak" or "weakening of the vortex"

P2, L19: arctic atmospheres → Arctic atmosphere

P2, L23: remove space between parentheses and reference.

P2, L28: remove space between parentheses and reference.

P2, L31: for validation → for the validation

P3, L5: evaluate → validate

C6

P3, L24: I would suggest to write instead of “this research” rather “this study” or “this research study”.

P4, L4: remove space between parentheses and reference.

P4, L8: ozonesonde → ozonesondes

P4, L9: then an → then with an

P4, L27: profiles has significant missing → the profiles has a significant amount of missing values

P5, L5: defined using → defined by

P5, L6: thickness of compressed → thickness of a compressed gas

P5, L11: Letters and numbers should put in the according sub and subscripts.

P5, L16: What do you mean with “appreciable ozone”. Wouldn’t the right wording be “applicable” or “measurable”.

P6, L18: either “retrieved from” or “measured by”.

P6, L18-19: rephrase sentence to avoid repetition of “which”.

P6, L24: in the section 4 → in section 4

P6, L25: depend → depends

## C7

P6, L28: Write either “below” or “section 4”

P6, L30: Reference should be given here without parentheses.

P7, L28: add comma after “(in DU)”.

P7, L29: in the ozone → in ozone

P9, L8: before ozone transport → before ozone is transported

P9, L19: March-September → March to September

P9, L20: January-November → January to November

P11, L29: influence → influenced

P12, L21: impacts → is responsible for

P12, L29: in upper stratosphere → in the upper stratosphere

P13, L9: found insignificant → found to be an insignificant

P14, L14: remove space between parentheses and reference.

P28, l4: with → which