

Review of

“The use of SMILES data to study ozone loss in the Arctic winter 2009/2010 and comparison with Odin/SMR data using assimilation techniques”,

by Sagi et al.

General Comments

This article presents the SMILES observations of ozone loss in the Arctic winter 2009/10. Although ozone loss estimation for this winter has been discussed in several publications, the SMILES data have not been used. Therefore, it is interesting to look at the ozone loss estimated from this new data set and how it compares with other published results. Unfortunately, the authors do not attempt to compare their results with any other studies published for this winter. A major revision is required before it can be considered for a publication in ACP.

Main points

The title sounds the data can be used to study only for this winter. The second part after "and" also does not synchronise with the first part of the title. So an appropriate title (e.g. Arctic ozone loss in 2009/2010 observed by SMILES: comparison with SMR ..) is required.

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Lines 2-3: what is this high “sensitivity” (vertical or horizontal or any other)?

Line 3: “high latitudes” ? write the exact latitude range

Line 6: “ozone loss due to the instability of the polar vortex”? What ozone loss is this?

Line 11: Only wind data? If you have also used temperature data, then use “meteorological data are taken from ...”

Line 13: I am confused. What is your focus, “cross-isentropic transport” or ozone loss in 2009/10?

Line 14: Limited latitude coverage of SMILES or SMR? and what is that coverage (lat. to lat.)

Lines 16—18: What is this “significant” ozone loss? How is it defined? You also need to say the exact altitude and period of the ozone loss.

Line 18: The ozone loss started by the end of January with 0.6—1.0 ppmv?

No. your analysis itself shows ozone loss even in late December. Please look at your figure 8.

Lines 19—20: “... loss started ...”. This contradicts your previous statement (which was also not correct). Also, I do not see these distinct phases of ozone loss in Figure 8.

Line 21: Lower stratosphere? No, not all altitudes. Specify the altitude range for this ozone loss.

Lines 23—24: This is common to both polar regions, not only for Antarctica, as you have mentioned in *Conclusions*. Please rewrite the sentence.

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Line 1: Wave activity is relatively higher in the Arctic.

Lines 3—4: Which fact? PSC formation / propagation of planetary waves / vortex instability? Please reformulate this sentence.

Line 5: No, this is not correct. You need to specify the altitude and period to make such a strong statement.

Line 7: 600 K is a bit higher for Arctic ozone loss analysis. It would be better to discuss the temperature structure at 450/475/500 K. Also, please refer Dornbrack et al. (2012) and discuss their findings with respect to your temperature analysis.

Dornbrack, A., Pitts, M. C., Poole, L. R., Orsolini, Y. J., Nishii, K., and Nakamura, H.: The 2009–2010 Arctic stratospheric winter –general evolution, mountain waves and predictability of an operational weather forecast model, *Atmos. Chem. Phys.*, 12, 3659–3675, doi:10.5194/acp-12-3659-2012, 2012.

Line 10: Not completely true for all PSC types, as it also depends on temperature.

Lines 12—13: As you haven't done the analysis of major warming of this winter, you need to cite a publication in which this analysis is given (e.g. Kuttippurath and Nikulin, 2012).

Kuttippurath, J. and Nikulin, G.: A comparative study of the major sudden stratospheric warmings in the Arctic winters 2003/2004–2009/2010, *Atmos. Chem. Phys.*, 12, 8115-8129, doi:10.5194/acp-12-8115-2012, 2012.

Lines 15—16: The instability of the vortex was not due to the warmings?
On the other hand, you have already stated that the temperatures were as low as 180 K in early January.

Line 24: Latitude range 38 N or 38 S. You need to state that clearly (somewhere earlier in this section, i.e. your measurements were during this particular period/winter and therefore, you calculate ozone loss for that winter). Otherwise, the readers might ask why you selected this winter for your study.

Line 23: The instrument operated only for this short period?

Line 28: Not because of its latitude coverage, but due to its limited coverage in the high latitudes. Also state the latitude band of those measurements (e.g. 38N—65N)

Line 29: Why do you want to compare with SMR, as there are other satellite measurements available for this winter with better altitude and latitude coverage (e.g. Aura MLS)? Perhaps, you would like to compare measurements from similar instruments?

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Line 1: Dynamical instability permitted more measurements? I did not understand this.

Lines 5—6: missing or not possible?

Line 7: blocked at “high latitudes” or blocked “high latitude measurements”?

Line 20: "Since it is a two-dimensional model, ..." Start the sentence something like this.

Lines 20—21: Is this sentence complete?

Lines 23—24: State why SMR is used for your comparison, if not mentioned before.

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Line 2: Why did you use N₂O in this study? Please write the reasons for this (e.g. Checking dynamics in the model).

Lines 23—24: Please add a figure of Averaging Kernels (with FWHM), which would give an idea of the vertical resolution of these SMILES retrievals. Please make sure that you select a retrieval at around 60 N.

Lines 25—27: Any validation results above 50 N to mention here? That would be more useful for this study. Also, what is the latitude range for this "mid-latitude", 30—60 N/S?

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Lines 2—3: Which band is used in this study (A or B)?

Line 9: What is LST, Local Solar Time? If yes, please write that.

Line 24: 60 N or S?

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Lines 1—2: SMR N₂O has vertical resolution of 1.5 km?

Lines 3—7: "Other measurement comparisons.....". If the listed studies/comparisons provide some information on the accuracy of SMR N₂O, then please write that explicitly here. Otherwise remove this sentence.

Line 18: "potential temperature levels ranging from..."

Line 24: Yes, it is conserved. But, please mention the duration with respect to altitude.

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Line 4: "To account for this", to account for diabatic descent?

Lines 5—7: Please reformulate this sentence.

Line 11: It is also appropriate for you to give the equation of advection, as you discuss this term later in Results section too.

Line 16: Speed of the phenomenon? What phenomenon?

Line 23: Remove theta, as you have already defined this in Line 7.

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Line 4: Delete “fields”

Line 6: What is your investigation period, December to March? Please mention that too.

Line 8: What is this measurement response? Derived from averaging kernels/FWHM?

Lines 14—15: “In the results, we..”, Is it because of the altitude coverage of the measurements or any other reason?

Line 17: write “US (United States) ...”.

Lines 23—25: Please mention the exact time period or dates; “at the beginning of the winter”, “one or two weeks ...” are not enough. Also, Kuttippurath and Nikulin (2012) have given a detailed analysis of these processes with potential vorticity maps. Please mention their findings here.

Lines 26—28: You need to cite Kuttippurath and Nikulin (2012) too here, as the central date (this is 9 February 2010 in their analysis) depends on the data used for the analyses. In addition, a detailed study of the major warming of this winter is presented by these authors.

Line 28: Cite Dornbrack et al., 2012 here, as they have given a detailed analysis on temperatures of different Arctic winters. Also, write the altitude of your analysis.

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Lines 1—2: How did you analyse the air mass transport from Pacific? If this is not from your study, you need to cite an appropriate publication.

Lines 4, 14: State the period of vortex break-up.

Lines 21—23: Vortex break-up by February 20? Then why do you show “vortex averaged ozone loss in March” (Figure 8)?

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Line 2: “more features and larger variation” of what?

Line 7: “Another important”

Line 9: Greater than 65 S? So what about 65 N (which is more relevant to this study)?

Line 10: This is an ideal case for Arctic vortex, which is seldom stable and isolated.

Lines 20—21: Yes, but after the SSW there are significant differences.

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Lines 1—2: Please specify the “significant” loss/value. The term significant is relative and hence, write the magnitude of that loss, with altitude and period.

Line 3: State the scale of the depletion occurred during the period, along with the loss rates.

Few things to be noted here:

Line 4: I do not see the equilibrium in your analyses.

Lines 5—6: Please state the mechanism for this ozone loss, as there are no PSCs and chlorine activation at these altitudes during the period. For instance: Kuttippurath et al. (2010) have given a detailed analysis of this winter in comparison to other winters in terms of ozone loss chemistry. Discuss their results here.

Kuttippurath, J., Godin-Beekmann, S., Lefevre, F., and Goutail, F.: Spatial, temporal, and vertical variability of polar stratospheric ozone loss in the Arctic winters 2004/2005–2009/2010, *Atmos. Chem. Phys.*, 10, 9915–9930, doi:10.5194/acp-10-9915-2010, 2010.

Was there any solid vortex in March, after the major warming in early February, to make a meaningful/reasonable ozone loss analysis? You state later in this section that the vortex broke-up by 20 February too. Furthermore, Dornbrack et al. (2012) show that the final warming was by around that date.

Please explain the reasons for the ozone production in the lower stratospheric altitudes (Figure 8). Also, please check your data and modelled tracer again.

Lines 7—8: I suspect there is hardly any solid vortex in March after the warming in February. It is better to show the average profile in February or both. Can you please explain the large/larger ozone loss in the lower stratosphere in March? In fact, I would expect larger ozone loss around 500 K in warmer Arctic winters.

Line 8: I do not see these different phases of ozone loss in Figure 8.

Line 12: Not sampling issues, but sampling differences.

Lines 25—28: I would expect the maximum/activated ClO values of around 1.5 ppbv, but those are about 3 times lower here? In addition, “enhancement of”, how much is this enhancement?

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Lines 1—2: Kuttippurath et al. (2010), has already analysed the chlorine activation during this winter with Aura MLS measurements and model simulations. Please discuss and compare your results with their findings.

Lines 3—4: This can be due to the NO_x chemistry. Kuttippurath et al. (2010) have done a detailed analysis of the contribution of various chemical cycles to the ozone loss in this winter as compared to other Arctic winters. Please discuss their analysis here.

Lines 6—7: Not in all other winters, but mostly in warm Arctic winters (e.g. Kuttippurath et al., 2010).

Lines 8—10: The sentence is not correct (e.g. What are lower altitudes, lower stratospheric altitudes?). References for colder winters such as 2004/2005 are not appropriate here. You could cite the studies for the warm Arctic winters (i.e. winters with major SSW) such as 2002/2003 and 2005/2006 for this. An example is given in the following study: Kuttippurath, J., A. Kleinböhl, M. Sinnhuber, H. Bremer, H. Küllmann, J. Notholt, S. Godin-Beekmann, O. Tripathi, and G. Nikulin (2011), Arctic ozone depletion in 2002–2003 measured by ASUR and comparison with POAM observations, *J. Geophys. Res.*, 116, D22305, doi:[10.1029/2011JD016020](https://doi.org/10.1029/2011JD016020).

Lines 14—16: Remove this sentence, no need to repeat it.

Line 19: to study polar ozone loss (specify the latitude band otherwise).

Compare ozone loss values published in other studies with your results. Make a new Section 4.3 for this. Some studies are listed below and search for the missing ones, if any.

Kuttippurath, J., Godin-Beekmann, S., Lefèvre, F., and Goutail, F.: Spatial, temporal, and vertical variability of polar stratospheric ozone loss in the Arctic winters 2004/2005–2009/2010, *Atmos. Chem. Phys.*, 10, 9915-9930, doi:10.5194/acp-10-9915-2010, 2010.

Wohlmann, I., Wegner, T., Müller, R., Lehmann, R., Rex, M., Manney, G. L., Santee, M. L., Bernath, P., Sumińska-Ebersoldt, O., Stroh, F., von Hobe, M., Volk, C. M., Hösen, E., Ravegnani, F., Ulanovsky, A., and Yushkov, V.: Uncertainties in modelling heterogeneous chemistry and Arctic ozone depletion in the winter 2009/2010, *Atmos. Chem. Phys.*, 13, 3909-3929, doi:10.5194/acp-13-3909-2013, 2013.

Hommel, R., Eichmann, K.-U., Aschmann, J., Bramstedt, K., Weber, M., von Savigny, C., Richter, A., Rozanov, A., Wittrock, F., Khosrawi, F., Bauer, R., and Burrows, J. P.: Chemical ozone loss and ozone mini-hole event during the Arctic winter 2010/2011 as observed by SCIAMACHY and GOME-2, *Atmos. Chem. Phys.*, 14, 3247-3276, doi:10.5194/acp-14-3247-2014, 2014.

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Lines 2—3: State also the ozone loss values here.

Line 7: You need to cite a publication which is relevant to this winter as I mentioned before (Kuttippurath et al. 2010).

Line 13: Merge this paragraph with the previous one by inserting the ozone loss values at appropriate places.

Table 1: What is this measurement response (averaging kernel/FWHM), please write that in the figure caption.

Figure 1: 600 K is very high for Arctic ozone loss analysis. What is the motivation for selecting this altitude? At 450 or 475 K would have been more useful for this study. I also do not see that you discuss the ozone loss at 600 K in that detail with respect to your temperature analysis.

Figure 2: Remove “An example”
70 degree, north? If yes, state that. Also write what you mean by measurement response.
Instead of N, write “Number of observations” in the Y-axis title, if it is the case.
Instead of GE put greater than or equal to sign in the title. Write “potential temperature” for PT.

Figures 3, 5: 70 N (please write the sign of the vortex edge)

Figure 4: Write “potential temperature” for PT; write the latitude sign for EQL (i.e. N or S)

Figure 9: What is active ozone? I thought you were presenting the observations. If not, what are SMILES and SMR here?

Technical corrections

This is not a complete list. Please go through your text to find other corrections.

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Line 1: Profiles are retrieved, not observed by these instruments.

Line 16: initialised “on”

Line 19: “ppmv”

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Line 3: not irregular, but infrequent

Line 9: write something like “showed lowers values ..” than decreased

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Line 7: “a few”

Line 8: write “Another”, for “An other”

Line 14: “other studies”

Line 19: delete “also” and state the reason for using the model (e.g. to simulate passive tracer)

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Line 20: further “details”

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Line 11: described by Frisk et al.

Line 19: lines at 501.5 GHz and

Line 24: in detail by Jones et al.

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Line 9: Delete “model” after the “Data)”

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Line 24: not divided by, but “split into”

Line 26: not reconnected, but merged (or combined)

Line 28: “The period shows”

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Line 12: “then the predicted and assimilated results should show the same values”?