Atmos. Chem. Phys. Discuss., 2, S282–S285, 2002
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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Surface ozone depletion episodes in the Arctic and Antarctic from historical ozonesonde records" *by* D. W. Tarasick and J. W. Bottenheim

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Received and published: 31 July 2002

We thank Dr. Roscoe both for his kind remarks and for his very interesting and challenging review. We have added considerably to the discussion section in light of his comments and following further discussions with J. Abbatt (University of Toronto), P.B. Shepson (Purdue University) and J. Fuentes (University of Virginia). Our reply follows the numbering of Dr. Roscoe's review.

1. Fortunately one of us (DWT) attended the talks at EGS-2002. We are both aware of Hoenninger's work and agree that it is very interesting, and is consistent with the fact that (as we show in the revised Table 2) that partial depletion events are much more common further from the poles than the severe (<10 ppb) episodes that are seen at Alert, Eureka and Resolute. While the shorter period of daylight at lower latitudes

may well be part of the explanation for the smaller frequency of depletion events (our reaction (4) stops at night), as an overall explanation for our observations it unfortunately doesn't work, simply because Ny-Alesund, at 79 N, receives less sunlight than Resolute, at 75 N. So, while we by no means discount the potential importance of the availability of sunlight to a complete explanation of the depletion phenomenon, we prefer to speculate about frost flowers, as they have the advantage (at least at present) of potentially explaining all of our results.

2. We believe there is insufficient information in the sonde record to say whether or not the same mechanism operates in December in Antarctica. Certainly there is little evidence from our Table 1 that it operates in June in the Arctic. When we separate the 7 events in Table 1 for Neumayer in the summer by month as suggested, we find only 1 in December, 2 in January and 4 in February. Of course, with so few events, the statistics are poor. Using a 20 ppb criterion rather the 10 ppb one, we find 158 events (out of a possible 163!) — that is, summer tropospheric ozone values are usually below 20 ppb at the surface, which would suggest that the 7 events are most easily explained as statistical outliers. Examination of the individual profiles shows that they are very similar, with low ozone throughout the lower troposphere and no sharp change in potential temperature — in other words, normal summer profiles with low ozone. Ground-based (i.e. continuous) ozone measurements might shed more light on this.

3. All true, and we have toned down the statement about the BM sonde outliers. We do in fact see cases where the background current was clearly overestimated. This is only evident during severe depletion episodes: the ozone at the surface is recorded as -1 or -2 ppb! No doubt this happens at other times but is less obvious, and it is certainly not possible to overestimate the background current by the 30 ppb or more required to produce a false depletion episode. One possibility is a sonde improperly launched immediately after removing the ozone destruction filter (standard procedure is to allow ten minutes of running on surface air before launch); this would look like an exponential

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rise to normal values over the first minute (600m). But mechanical glitches (to which the old BM sondes were reputedly prone) can produce a loss of signal, and recovery; this is sometimes seen. Another more pertinent possibility is that a poorly conditioned sonde may increase its response over the flight such that the tropospheric part will be low relative to the stratospheric part of the profile: this appears to have been the case in general with the Canadian BM sondes [Tarasick et al., 2002], and was certainly more severe with some flights than with others. This will not produce what would seem to the eye to be a false depletion event, but rather a profile with low ozone throughout the troposphere; unfortunately, if low enough, our simple algorithm will detect it as a depletion event all the same.

4. Freiss et al. (2002) did indeed show many depletion events at Neumayer, but if memory serves, few below 10 ppb. Our severe selection criterion was required because of the sparseness of the data: an abrupt change from normal values to, say, 50 or 60obvious in a continuous measurement, but much less so when the sampling is only once or twice per week. When we use 20 ppb as our cut-off we find 76 events in the spring at Neumayer (but 158 in the summer). Actually the entire Neumayer dataset was recently resubmitted by Gert Koenig-Langlo to the WOUDC in the high-resolution, extCSV format, and so was some of the best data available to us.

5. Yes. We were originally inclined to argue this way, because the occurrence of open leads has probably increased with temperature, and other relevant processes might, but hesitated because the association of episodes with colder temperatures seemed to, if not refute the notion that the number could be increasing with warmer temperatures, then at least not support it. However, the Hoenninger observations do suggest a local versus transported air mass explanation for the association. Revisiting our Table 2, they further suggest that a better interpretation is that the three Arctic stations experience on average about the same temperatures during depletions (Resolute is colder, Alert warmer and Eureka the same) while the other four stations all experience colder temperatures during depletions.

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6. This very interesting comment provoked us to thinking more about this, and we have included a good deal of it in our substantially revised discussion.

7. This lamentable oversight has been corrected. Roscoe et al. (2001) was indeed relevant to our discussions, and should have been included.

Technical corrections: all done.

Tarasick, D.W., J. Davies, K. Anlauf, M. Watt, W. Steinbrecht and H.J. Claude, Laboratory investigations of the response of Brewer-Mast sondes to tropospheric ozone, J. Geophys. Res., in press, 2002.

Interactive comment on Atmos. Chem. Phys. Discuss., 2, 339, 2002.

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