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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Mineral dust variability in central West Antarctica associated with ozone depletion" *by* M. Cataldo et al.

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Answers to interactive comment on "Mineral dust variability in central West Antarctica associated with ozone depletion" by Heitor Evangelista and M. Cataldo. Anonymous Referee #1

General remarks of the Referee:

1. Pg. 12690. During this portion of the manuscript the authors fully discuss Patagonian dust transport and deposition to Antarctica. While I agree that Patagonian dust transport is a dominant source of dust deposited to Antarctica, from the study by Li et al. [2008] (Fig. 10) it can be seen that Australian dust can contribute an equal fraction (or even a majority fraction) of dust deposited to West Antarctica. While this will

not change the results of this study, I feel the authors should add a short discussion, similar to the one focused on Patagonia, about Australian dust transport to Antarctica. Authors: We have added the following sentence in the "Introduction" section: "Quantitatively the dust in Southern Hemisphere originates primarily from Australia (∼120 Tg a-1) followed by Patagonia (∼38 Tg a-1), (Li at al., 2008). Although fluxes are quite different, it is estimated that South America and Australia would contribute about equally to the total dust burden and deposition in Southern Ocean and Antarctica due to prevailing westerly wind pattern, meridional fluxes and the continental distances involved. The influence of these dust sources protrude in different sector of Antarctica's interior. The southward flow of Patagonian semi-desert tends to hit the Antarctic continent in its West side at Antarctic Peninsula and Ellsworth Land, and in its East side from Dronning Maud Land to approximately Princess Elizabeth Land at the Indian Ocean coast. In contrast, the influence of Australian dust predominates in Victoria Land and part of Mary Byrd Land (Li et al., 2008)."

Additional reference:

1. Li, F., Ginoux, P., and Ramaswamy, V.: Distribution, transport, and deposition of mineral dust in the Southern Ocean and Antarctica: Contribution of major sources, J. Geophys. Res., 113, D10207, doi:10.1029/2007JD009190, 2008.

2. Pg. 12695. The authors state that ozone data was obtained from the Halley Bay Antarctic station. Can you explain why this station's data was chosen for evaluation? Is this station the most representative (i.e., closest in proximity) to the MJ ice core? The Halley Bay station seems to be located on the coast of East Antarctica which may not be representative of central West Antarctica. Please provide information that would convince the readers that the ozone data obtained from Halley Bay is representative of all Antarctica and most importantly central West Antarctica. Authors: Ozone database from Halley Bay station shows high similarity to that of South Pole station (see Fig 1. compile here just for illustration) depicting thereby a regional scenario for the ozone depletion. Both databases are equally used in the issue of ozone depletion in most

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studies. We choose to use Halley Bay station data since it is located in a closer latitudinal band (75°35âĂšS for Halley and 79°55âĂšS for Mount Johns). We changed the following sentence in the text: "Ozone data presented here are measurements taken during October at Halley Bay Antarctic station. . ." to "Ozone data presented here are measurements taken during October at Halley Bay Antarctic station, which database is essentially the same as for South Pole station, . . ."

Fig 1.

3. Pg. 12697. When evaluating the magnitudes of mineral dust deposited on Antarctica, which has experienced long-range transport, wet deposition fluxes are likely to be important (at least comparable to dry deposition fluxes). During the period of decreasing dust deposition to West Antarctica (coinciding with the positive phase of the AAO) were precipitation/snowfall rates decreasing? Li et al. [2010] uses an ice accumulation rate to understand dust deposition in ice cores and these authors state: "The dust concentration in the ice cores mentioned above would depend on the amount of dust removed from the atmosphere by local precipitation and the ice accumulation rate". Specifically, I would like to understand if precipitation/wet deposition rates are decreasing, does this always mean dust concentrations transported to the region are also decreasing? Could the authors please expand on the availability of precipitation data and if decreasing precipitation rates could produce the correlation of the concentration of dust in the ice core and ozone concentration. Authors: Precipitation data of Mount Johns (mean of 400 mm yr-2) have not varied significantly before and after 1979. Probably because Mount Johns site is located in a near transient region between Antarctic Peninsula and Marie Byrd Land by the West side (where increasing precipitation trends are expected) and the Antarctic Plateau (where decreasing trends are expected, at least partly). That's because we have not explored the parameter "precipitation" in the manuscript. Glaciochemical EDX technique employed here do not allow the total elemental concentration (e.g.: in ng/L), but the dust particle abundances distributed in the ice core. The sentence: ". . . dust concentration in the ice cores would

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depend on the amount of dust removed from the atmosphere by local precipitation and the ice accumulation rate . . .” is correct but must be seen with caution. Depending on the state of the atmosphere we would also have less dust microparticles in the lower atmosphere concomitant to less moisture been advected towards Antarctica’s interior. So it is not possible for all time basis and all geographical sites attribute the variations of dust concentrations in ice cores to the regional precipitation alone. In this case, a continued study of the drilling site would help to clarify the above statement. To illustrate that, and on basis of NCEP-NCAR reanalysis, we compiled the meridional wind around and inside Antarctica (just for illustration). From the simplified result in Fig. 2 one may observe that meridional wind component around Antarctica has slightly decline (from North to South) during the epoch of the ozone depletion in contrast to the increased westerly winds. The opposite seemed to occur between 70S and 90S, with increases from South to North. This would have implications in dust apportioning at the drilling site due to an unfavorable scenario for air masses/water moisture (and also dust microparticles) advection into the Antarctica’s interior.

Fig 2.

4. Pg. 12698. Table 1 shows data of wind speed variations at meteorological stations in Antarctica. The concerning aspect of the data presented is that all of the stations which indicate increasing wind speeds over Antarctica display increasing wind speeds that are well within the factor of uncertainty presented in Table 1. Authors: From a look at Figure 2(B) one may observe that the region around Antarctica, where increasing winds are expected to occur as an effect of ozone depletion, resides mostly in the Southern Ocean. On the other hand, ground meteorological stations that monitor winds are installed not exactly in this “windy belt” but in the boundaries of the Antarctic continent (coast line), a region of apparently lesser influence. Considering that Figure 2(B) is a model description, we were encouraged to compare the pattern of modeled increasing winds with measured data. The scenario pointed out by Lenton et al. (2009) depicts mostly a near neutral wind response at the Antarctic coast, with some exceptions (e.g.:

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Peninsula Antarctica). The meteorological stations located at islands, a little off shore, (Orcadas, Signy, Marsh, Bellingshousen, Grytviken and Macquarie) have all presented increases (Campbell is an exception). This increase is not of statistical significance, but represents a slightly increment in the wind trends during the last decades and has to be considered. Also from Lenton et al. (2009), the increments are significant but not that expressive (see Figure 2 in the manuscript). In our compilation we obtained a median increase of 1.05 m/s for all stations with positive increase and a median increase of 0.4 m/s with respect to all stations.

We have changed the following sentence in the "Results and Discussions" section: "Table 1 encloses data of 22 Antarctic stations with data continuity large enough to accomplish the above requirement. Compiled wind data show enhances in 64% of the stations after 1979." to

"Table 1 encloses data of 22 Antarctic stations with data continuity large enough to accomplish the above requirement. Compiled wind data show enhances in 64% of the stations after 1979. Although wind increases are not of statistical significance, they do represent slight increments in the trends during the last decades."

Additionally, in the title of Table 1 we have added the sentence : " "Increase" and "Decrease", (+/-), refer to trends".

5. Could the authors add a couple sentences to the conclusion section of the manuscript that focuses on the anthropogenic influence on ozone depletion and the possible impact this could have on dust transport to Antarctica? Past studies have shown that increased desertification in Patagonia and Australia can increase the amount of mineral dust transported to Antarctica, however, to the best of my knowledge, I have never read/heard about the possible connection between anthropogenic emissions, ozone depletion, and mineral dust transport to Antarctica. This could be a very interesting conclusion from this work. Authors: This proposition is already implicit in the text. In Dixon, Mayewski and collaborators (International Journal of Climate,

2011) they argue on the impact of ozone depletion in the terrigenous particulate matter reaching West Antarctica. Our work corroborates this finding but in a more general view, in the sense that our observations and model allowed us to deeper the debate and give a more general description of the mechanisms behind. We have expanded the following sentence in "concluding remarks" item : ". . . Our data show that during the ozone depletion period, dust advection to the central Western Antarctic sector changed from a stable to a reducing deposition pattern. It suggests that climatically driven processes due to ozone depletion may act differently on the Antarctic continental scale, with respect to the atmospheric transport of particulate matter." to

". . . Our data show that during the ozone depletion period, dust advection to the central Western Antarctic sector changed from a stable to a reducing deposition pattern. It suggests that climatically driven processes due to ozone depletion may act differently on the Antarctic continental scale, with respect to the atmospheric transport of particulate matter. Although other databases must be accomplished to better characterize the ozone depletion effects over the atmospheric transport towards Antarctica, data obtained till now suggest that anthropogenic processes with implications in the stratospheric ozone balance would promote climate changes and ultimately changes in the particulate matter inflow to Antarctica."

We have also improve the following sentence in "Concluding remarks" section: ". . .For the last decades, in contrast, combined climate models, ground-based observations, satellite observation and annually resolved geochemical databases from ice cores have together provided a unique opportunity to improve knowledge to directly associate the climate dynamics at the Antarctic and surrounding continents with dust microparticle sources, their time variability and diameter distribution while deposited in Antarctic ice sheet.". to

". . .For the last decades, in contrast, climate and atmospheric circulation models, ground-based and satellite observations together with high resolved geochemistry from ice cores have provided a unique opportunity to improve knowledge to directly as-

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sociate the climate dynamics (mainly wind intensity and cyclone energy) at Antarctica and surrounding continents with dust microparticle characteristics (concentrations/abundances and diameter) deposited in the ice sheet."

Specific remarks of the Referee:

Overall, the manuscript is very well written and my only specific suggestion (besides the one listed below) is to consider expanding each acronym the first time it is used in the text. Authors: Essential ones were expanded.

1. The latitude and longitude of the MJ ice core location is provided (79.55S, 94.23W), however, I feel it would be beneficial to illustrate the location either on a new figure or one of the existing figures. Authors: It is already shown in Figure 6.

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 12685, 2012.

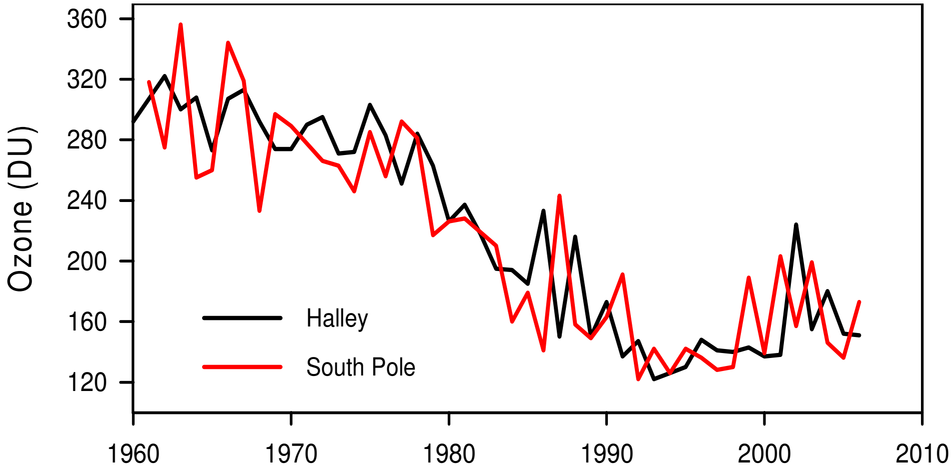

Fig. 1 – Databases of Halley Bay station and South Pole Station for Ozone concentrations (month: October).

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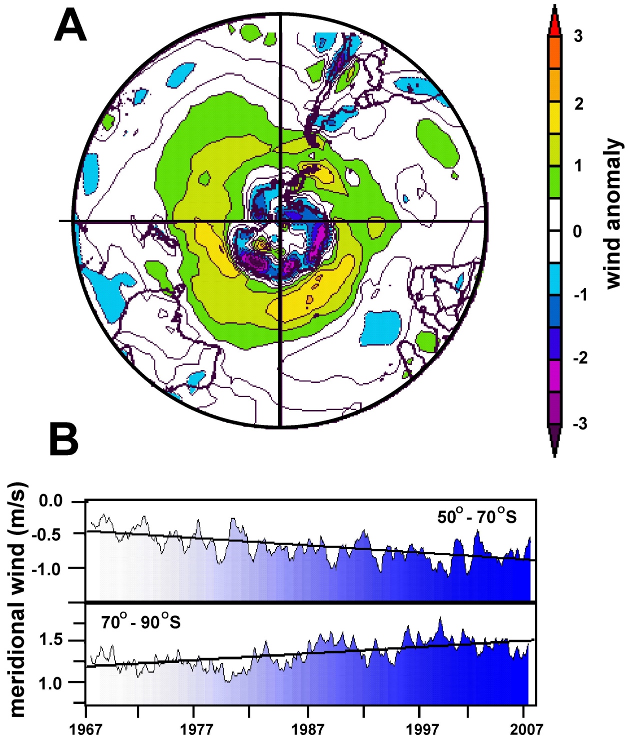

Fig. 2 – (A) wind anomaly (after 1979 minus before 1979);
(B) meridional wind from NCEP-NCAR Reanalysis in 2 latitudinal bands

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