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Atmospheric
Chemistry
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Discussions

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

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Reviewer's comment: General Comments of the Reviewer: This is an interesting paper that provides a convincing analysis of microparticle concentration decreased by strengthening westerly winds while the size of the deposited particles is increased by stronger storms. Some issues do need attention however, and these are outlined below.

1. I would not term the Mount Jones site as being in central West Antarctica. Rather it is in the far eastern part of the West Antarctic Ice Sheet (see Fig. 6) if one excludes the Antarctic Peninsula.

Authors : Probably the reviewer made a little confusion in the terminology between

Mount Jones (77o 14’S;142o 04’W) and Mount Johns (79o 55’S;094o 23’W), the second one the coring site, both located at West Antarctica. Using an acceptable geographical definition for West Antarctica as “ The portion of Antarctica on the west side of the Transantarctic Mountains bounded by the Ross and the Ronne Ice Shelves, the Antarctic Peninsula and the Pacific Ocean sector”, it is safe to say that Mount Johns do belong to the Central portion of West Antarctica (Fig. 1 helps clarify the difference of locations).

Fig. 1

2. It is important to remember the observed seasonality of the trends in the SAM. They are pronounced in the summer and fall but near zero in the winter and spring. There is a delay between ozone depletion in the stratosphere and the impact in the troposphere. How does the seasonality in the SAM behavior relate to microparticle concentration, i.e., when do you think these particles are primarily deposited?

Authors : We agree with the reviewer with respect the lagged behavior between ozone depletion season and the climatic impact in the troposphere. We have presented some current references in this topic in the manuscript. The glaciochemical analysis presented here allowed only the annual resolution. It is a limitation of most ice core analysis with very few exceptions, mostly restricted to sites of greater snow accumulation and well established seasonal markers or analysis derived from snow pits. Although we have more than one data point for each annual layer, it is not safe to attribute a set of data to any season. In this work, the relation between dust variability (dust diameter and relative abundance of insoluble dust microparticles) and the atmospheric dynamics was tested for different parameters : AAO, cyclone depth (annual and DJF) and winds around Antarctica at 2 latitudinal bands (30S-50S and 50S-70) (annual and DJF). Considering the above parameters wind intensity and cyclone depth/energy have provided higher correlation levels with dust parameters, compared with AAO. Concerning the question “when do you think these particles are primarily deposited?”. It is difficult to answer this question, but one may attempt based on the continuous aerosol elemental

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composition monitoring database, obtained by stacked filter of week resolution, conducted between 1985 and 1993 at King George Island (62S, NE Antarctic Peninsula), which is a database that reflects somehow the Patagonian semi-desert dust variability reaching Antarctica. In that case, Al, Fe, Ti and Si peaks in August, austral winter (Correa, A. 1998. “Aerossóis Atmosféricos na Antártica : Sazonalidade, Composição Elementar e Relação com El Nino”. Thesis. Universidade de São Paulo. 152pp). Here we have plotted selected data for DJF meteorological/climate parameters (due to the lagged effects of ozone depletion) and the annual variability of same parameters. The annual databases when correlated with dust parameters did exhibited statistically significant r-Pearson values.

3. In Figure 1, tell us precisely what smoothers were put through the data points. Justify this degree of temporal smoothing. In (f) what AAO (SAM) indices values are plotted? Annual or DJF?

Authors : We have used polynomial fits to show trends for dust and ozone. Both are polynomial fit of degree 3. We have added that in the revised text. We used that considering the higher coefficient of determination, R2, we got using it. They are shown bellow :

3.1 For ozone time series - Coefficient of Determination (R-squared) : Degree 0: 0 Degree 1: 0.803152 Degree 2: 0.814924 Degree 3: 0.898769

3.2 For Dust time series - Coefficient of Determination (R-squared) : Degree 0: 0 Degree 1: 0.109727 Degree 2: 0.159355 Degree 3: 0.175438

In the last version of the manuscript, AAO refers to the annual database. For consistency with the other parameters used, we have changed Fig.1 of the manuscript by introducing the AAO values for DJF and annual values, as depicted bellow (Fig. 2).

Fig. 2

4. In Figure 2, you have compared observed annual wind speed changes (after ver-

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sus before 1979) versus a stratospheric ozone depletion simulation contrasted with a steady ozone concentration simulation for 1994-2004 from one chemistry-climate model (annual zonal wind stress difference shown?). First you should explain more carefully what is being compared. Second, would different models show the same results?

Authors : Our purpose was to show how models depict a scenario of increased winds around Antarctica starting from the end of 70's decade and that includes the ozone depletion as one potential cause. Models suggest that such process is not restricted to the Antarctic continental margin but extending far up the boundaries of the surrounding continents. Although models output converge to a pattern of increased winds, instrumental evidences were not fully explored. The wind stress behavior as shown in Lenton et al. (2009) gives also a great idea of such impact. A more careful analysis of the text, let us see that the parameter "wind stress anomaly", as presented in Fig. 2 of the manuscript, is probably not the ideal one for a direct comparison with the wind instrumental databases. Therefore we changed the comparison with Lenton at al. (2009) model to a NCEP-NCAR reanalysis of surface winds before and after 1979. The wind anomaly map resulted from the above reflects somehow the pattern of Lenton at al. (2009) wind stress anomaly.

Fig. 3

An important observation raised from the NCEP-NCAR reanalysis anomaly was that it does not reproduce the instrumental wind decreases of Campbell, Mirny and those stations at the Weddell sector (Halley, Marambio and Esperanza) and the same for the coastal sector between Terre Adélie and the Ross Ice Shelf. Nevertheless, the median variability of +0.41 m/s derived from instrumental data, considering all stations around Antarctica, is quite well reproducible. We have provided a new caption to Fig.2, accordingly. Another model as proposed by Thompson and Solomon (2002) suggest a similar behavior for wind anomaly after the 70's decade.

We have changed the following paragraph at Results and Discussions section :

“Model simulations indicate that the wind increased significantly over the Southern Ocean region after 1979. Nevertheless, closer to the sea ice edge (where most of the stations of in Table 1 are located), increases of wind intensity is expected to be less and not homogeneously distributed. In Fig. 2 we compare wind trends, from ground stations, with the wind variability derived from a model proposed by Lenton et al. (2009) that used the IPSL-CM4-LOOP prognostic 3D-coupled carbon-climate-model. The model predictions (of increase/decrease) apparently fails only in the Indian Ocean sector where data from Syowa, Novolazareskaya, Molodeznaja and Mirny exhibit wind increases contrasting to wind decreases predicted by the model. An important point to consider is that the model is particularly robust to comparisons at the North-Northeast Antarctic Peninsula, the closest Antarctic Sector to Patagonia semi-desert that is the most probable source region of mineral dust reaching Antarctica”.

To the revised text as follows :

“Model simulations indicate that surface wind and wind-stress have increased significantly over the Southern Ocean after 1979 (Thompson and Solomon, 2002; Lenton et al., 2009; Swart and Fyfe, 2012). In Fig. 2 we have compared surface wind trends from ground stations with NCEP-NCAR reanalysis. An important observation raised from the comparison is that reanalyzed data did not reproduced the instrumental wind decreases observed in Campbell, Mirny and at those stations in the Weddell sector (Halley, Marambio and Esperanza). The same holds true for the coastal sector between Terre Adélie and the Ross Ice Shelf. Differently from the Northern Antarctic Peninsula result where the model was particularly robust. In general, the median difference (2010-1979 minus 1960-1979) of +0.41 m/s derived from instrumental data, considering all stations at Table 1, was well reproduced.”

New reference to the revised version :

Swart, N. C. and Fyfe, J. C.: Observed and simulated changes in the Souther Hemisphere surface westerly wind-stress, Geophys. Res. Lett., 39, L16711, 2012.

5. Note contrary to your text, Mirny shows a wind speed decrease while the model shows an increase. Also from page 12698 “complied wind data show enhances in 64% of the stations after 1979” – “enhances” means “increases”?

Authors : Yes, it is true that Mirny presents a decrease and the model an increase, but it just reflect one inconsistence of the model. We have pointed that in the revised text. Specifically in the case of Mirny, there is an 11-year gap in the database between 1990 and 2001, and wind trend seems to be clearly affected by this gap. Yes, in the cited sentence “enhance” means “increases”. We will correct that in the revised version.

6. I would like to see a discussion of the schematic in Figure 6 compared to temperature trend analyses of Steig et al. (2009) and O’Donnell et al. (2011, J. Climate); these analyses imply variations in the marine air penetrating West Antarctica. Nicolas and Bromwich (2011, J. Climate) also discuss the influence of marine air in West Antarctica. Are these analyses consistent with your conclusions?

Authors : Follows a short discussion with respect the reviewer comment. The text will be added to the revised version (Section 4 “Concluding remarks”). We have extended our answers to recently published paper of Schneider et al. (2012) that discuss Steig et al. (2009) and O’Donnell et al. (2011) findings together. Fig. 6 and its caption were updated with data from 3 new sites at West Antarctica : Talos Dome (Sala et al., 2008), Dyer Plateau (Thompson et al., 1994) and Siple Station (Mosley-Thompson, 1992). Also a chronological line enclosing the period when climatic and geochemical parameters have increased significantly was added to the figure in order to better summarize the manuscript discussion:

“A summary of the geochemical data in West Antarctica as depicted in Fig. 6 with the Antarctic near-surface temperatures as proposed by several authors (eg.: Steig et al., 2009; O’Donnell et al., 2011; Schneider et al., 2012) clearly shows that the West Antarctica experiences both elevated temperatures and high incursions of air masses

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from lower latitudes, judging from the increasingly contents of mineral dust in recent firn/ice layers. Additionally, according to Nicolas and Bromwich (2011), the low pressures centered over the Ross Sea (as opposed to the Bellingshausen Sea) are found to be one important factor in delivering heat and moisture into West Antarctica, with consequences to surface mass balance. They attribute that to changes in cyclonic activity in the South Pacific sector of the Southern Ocean. Also Schneider et al. (2012) demonstrated that trends in near surface winds and geopotential heights over the high-latitude South Pacific are consistent with recently observed impacts on regional sea ice and air temperature anomalies. An interesting aspect of Fig.6, is that dust increases slightly precede the climatic changes. However, data reported in the literature reveals steeper behavior since the end of 70's decade. In this context, the impact of wind intensification driven by ozone depletion or AAO phase change should be considered as an additional forcing acting in the climate system, not necessarily the trigger of the observed dust concentration increases, but important players to the regional environmental interpretation."

Considering the new data of Talos Dome in the revised version, we have added the following text in the "Introduction" section :

"At Talos Dome, the Southern most interface of Western Antarctica, the XX century record of dust concentrations showed marked increments around the 30' decade, followed by two decades of reduction, an a second increase after the 60's to the top of the record, Sala et al. (2008). The authors argued that the increased soluble dust record and mean March-to-November 500 mbar geopotential height at that site were likely associated with enhanced cyclonic conditions."

New references added to the revised version :

1. Schneider, D. P., Deser, C., and Okumura, Y.: An assessment and interpretation of the observed warming of West Antarctica in the austral spring. Climate Dynamics, 38, 323-347, 2012.

2. Nicolas, J. P., and Bromwich, D. H.: Climate of West Antarctica and Influence of Marine Air Intrusion. Jornal of Climate, 24, 49-67, 2011.

3. Sala, M., Delmonte, B., Frezzotti, M., Proposito, M., Scarchilli, C., Maggi, V., Artioli, G., Dapiaggi, M., Marino, F., Ricci, P. C., and De Giudici, G.: Evidence of calcium carbonates in coastal (Talos Dome and Ross Sea area) East Antarctica snow and firn: Environmental and climatic implications. Earth and Planetary Science Letters, 271, 43-52, 2008.

4. Mosley-Thompson, E..: Paleoenvironmental conditions in Antarctica since A.D. 1500: Ice core evidence, in Climate since A.D. 1500, edited by R. S. Bradley and P. D. Jones, pp. 572-591, Routledge, London, 1992.

5. Thompson, L. G., Peel, D. A., Mosley-Thompson, E., Mulvaney, R., Dal, J., Lin, P. N., Davis, M. E., and Raymond, C. F.: Climate since AD 1510 on Dyer Plateau, Antarctic Peninsula: evidence for recent climate change, Annals of Glaciology, 20(1), 420-426(7), 1994.

Revised Fig. 6 in the manuscript:

Fig. 4

Figure Captions

Fig. 1 - Location of Mount Johns at West Antarctica.

Fig. 2 - Insoluble dust particles from Mount Johns and climatic parameters/indices since 1960.

Fig. 3 - (A) Surface wind trends, from Antarctic stations, before and after 1979 (see Table 1); and (B) for comparison, simulated wind anomaly by NCEP-NCAR reanalysis relative to 1979 at 925 hPa.

Fig. 4 - Schematic summary of recently observed patterns of mineral dust deposition in Western Antarctica and continental climatic changes. (Air temperature at West

Antarctica Ice Sheet, WAIS, is presented in Schneider et al., 2012; geochemical data of Talos Dome in Sala et al., 2008; Marie Byrd Land in Dixon et al., 2011; James Ross Is. in McConnell at al., 2007; Dyer Plateau in Thompson et al., 1994; Siple Station in Mosley-Thompson, 1992; and Mount Johns, this issue).

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

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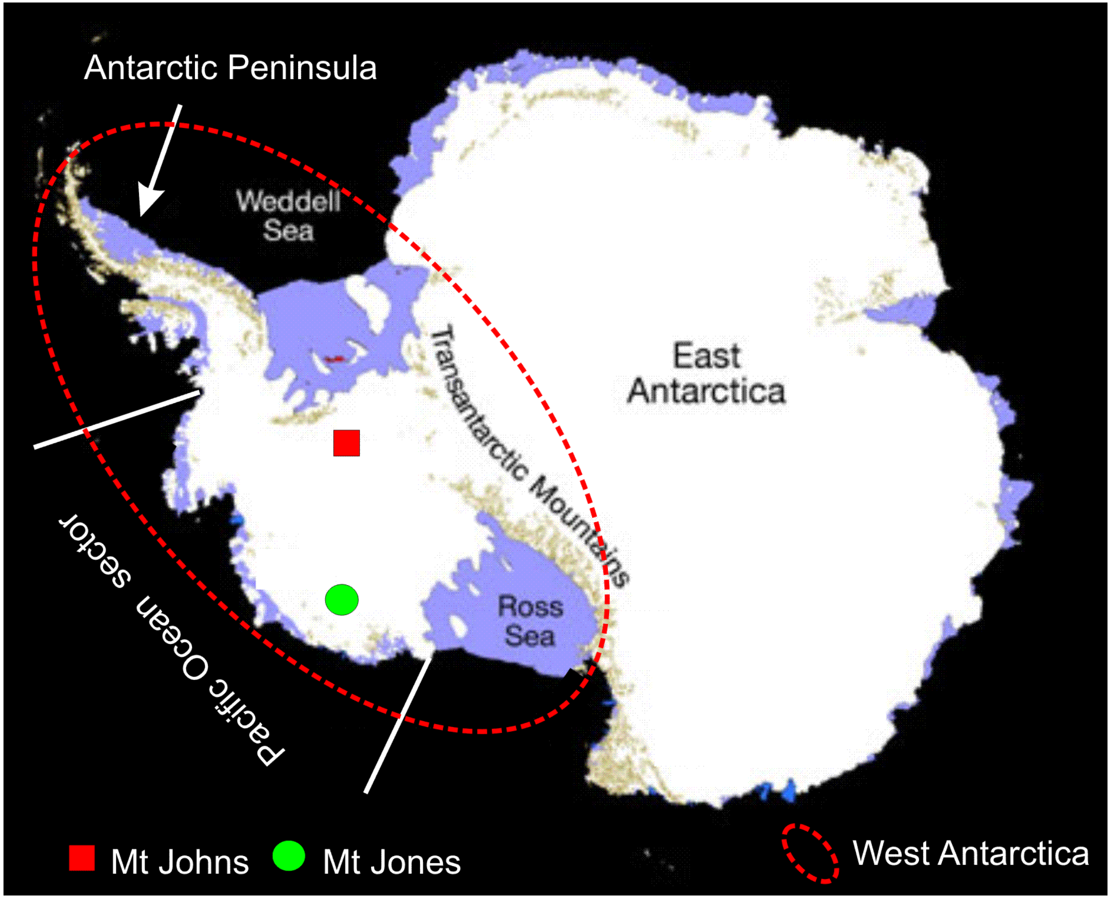
Antarctic Peninsula
Weddell Sea
Transantarctic Mountains
East Antarctica
Ross Sea
Pacific Ocean sector
🟥 Mt Johns
● Mt Jones
West Antarctica

Fig. 1.

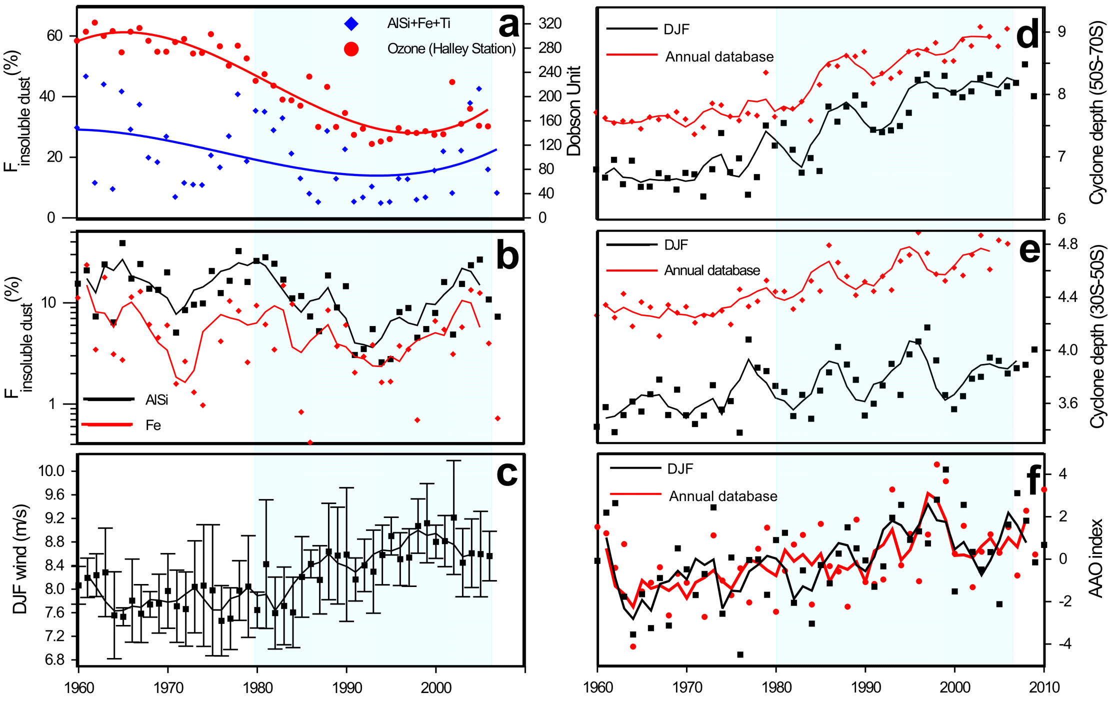

Fig. 2.

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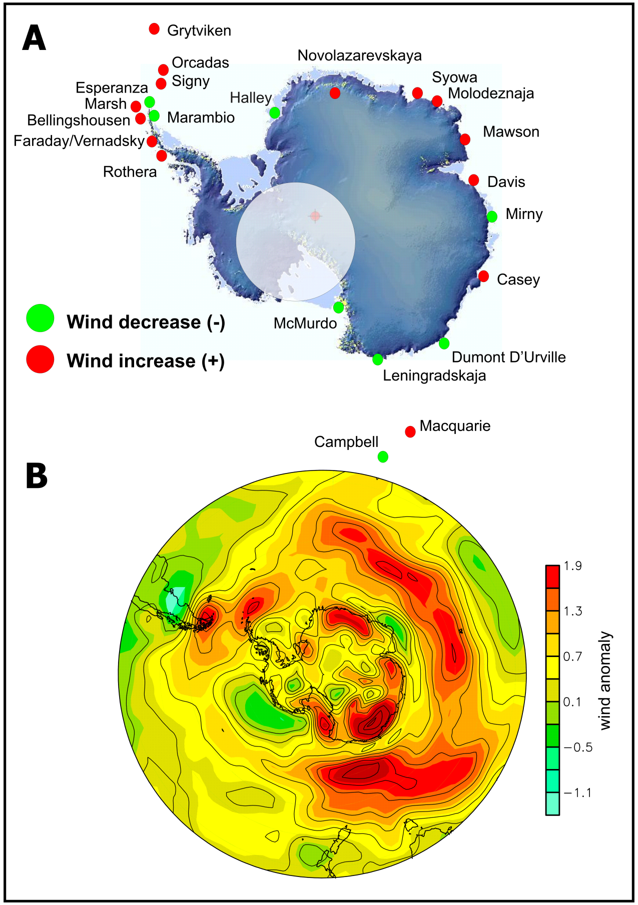
A
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Molodeznaja
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Wind decrease (-)
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wind anomaly

Fig. 3.

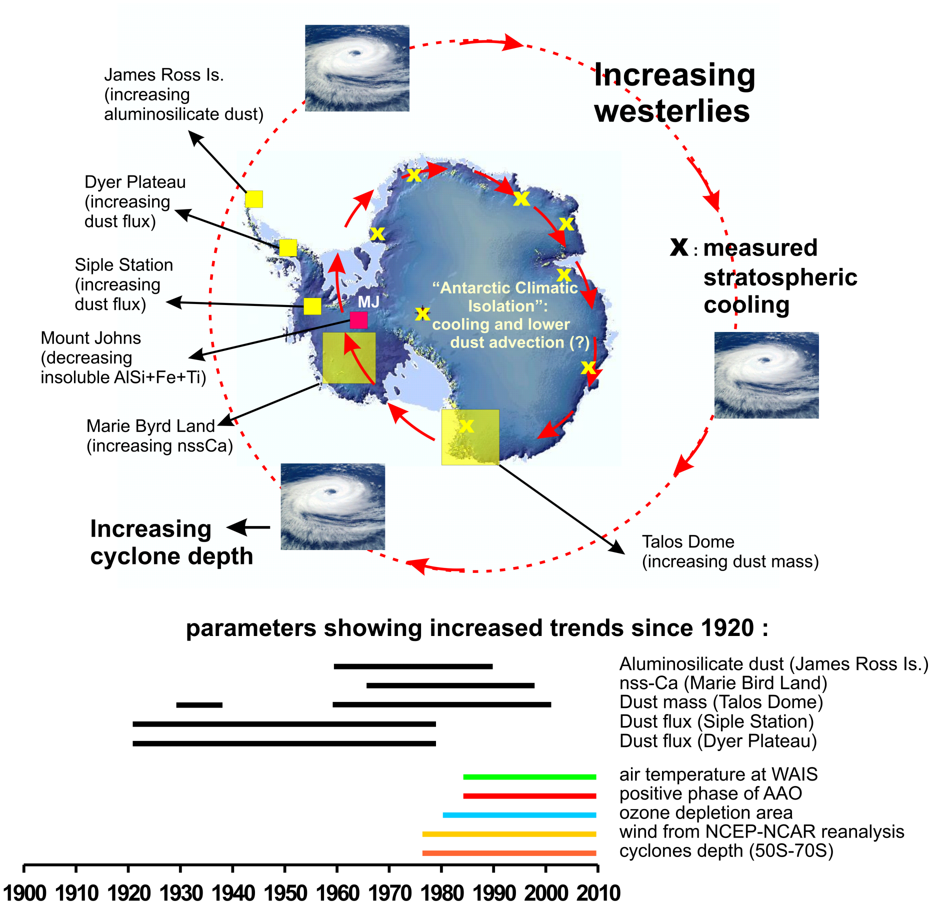
James Ross Is.
(increasing
aluminosilicate dust)
Dyer Plateau
(increasing
dust flux)
Siple Station
(increasing
dust flux)
Mount Johns
(decreasing
insoluble AlSi+Fe+Ti)
Marie Byrd Land
(increasing nssCa)
Increasing
cyclone depth
Increasing
westerlies
X : measured
stratospheric
cooling
MJ
"Antarctic Climatic
Isolation":
cooling and lower
dust advection (?)
Talos Dome
(increasing dust mass)
parameters showing increased trends since 1920 :
Aluminosilicate dust (James Ross Is.)
nss-Ca (Marie Bird Land)
Dust mass (Talos Dome)
Dust flux (Siple Station)
Dust flux (Dyer Plateau)
air temperature at WAIS
positive phase of AAO
ozone depletion area
wind from NCEP-NCAR reanalysis
cyclones depth (50S-70S)
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

Fig. 4.