Atmos. Chem. Phys. Discuss., 8, S9186–S9191, 2008
www.atmos-chem-phys-discuss.net/8/S9186/2008/

Atmospheric Chemistry and Physics Discussions

ACPD

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Interactive Comment

Interactive comment on "Large surface radiative forcing from surface-based ice crystal events measured in the High Arctic at Eureka" *by* G. Lesins et al.

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Received and published: 17 November 2008

Recommendation: accept after revisions.

GENERAL COMMENT

The radiative forcings obtained in this study are peculiar to the local topography of Eureka, so they represent a much smaller area than the SHEBA measurements. However, I think the paper is worth publishing because Eureka is a major atmospheric observatory, so its climate needs to be fully characterized.

MAJOR COMMENTS

Full Screen / Esc

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Interactive Discussion

Discussion Paper

This paper is not about diamond dust. Diamond dust is a <mixing cloud> (Bohren, 1987) formed by mixing of two saturated air masses at two very different temperatures. Ice crystals form because of the concave-upward shape of the Clausius-Clapeyron p(T) relation. This paper is instead about <residual blowing snow> which does not depend on a temperature inversion. Diamond dust crystals differ from residual blowing snow particles in their shapes and origin. Photographs of both are shown by Walden et al. (2003). It is important not to call the crystals diamond dust if their origin is blowing snow. The Glossary of Meteorology definition of diamond dust states <Crystals originate from air having a higher moisture content above a thermal inversion aloft, where mixing leads to nucleation and growth . . . .>

Title: I would change <surface-based ice crystal events> to <residual blowing snow>, as explained above. And are these events really <surface-based> (at the Eureka surface), if their origin is up on the ridge-top?

Abstract lines 14-18. <This work . . . points to a new source of boundary layer ice crystal events distinct from the classical diamond dust phenomenon.> Blowing snow is well-known, not a <new source>. Its effects on longwave radiation in Antarctica have been published by Yamanouchi and Kawaguchi (1985).

P 17693 line 3. <forward scattering>. Not just forward scattering, but all kinds of halos, including those opposite the sun, are produced by diamond dust. See Tape (1994). However, halos are not produced by residual blowing snow because those particles have lost their flat faces and sharp corners, becoming somewhat rounded.

P 17693 line 6. <generally accepted>. Give a reference for this statement. I thought instead that most diamond-dust crystals result from freezing of liquid aerosol particles (which may contain sulfuric acid), and the crystals subsequently grow by vapor deposition.

P 17694 line 6. Ice crystals (IC) are distinguished from blowing snow (BS) in the present-weather (ww) codes in meteorological observations. [IC are ww codes 76,

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78; BS are codes 38, 39.] What was the ww report from the Eureka weather station during these events? I would not be surprised if the weather observers reported IC during residual blowing snow; this often happened at South Pole Station because the observers did not examine the crystal shapes under a microscope and instead based their distinction on the wind speed.

P 17696 line 14. <minimum lidar height used is 100 m>. It may often happen that most of the optical depth is below 100 m, both for diamond dust and blowing snow. In drifting snow events it is common for most of the suspended snow particles be in the lowest few centimeters of the atmosphere.

P 17696 line 16. <linearly extrapolated>. How valid is the linear extrapolation? What span of heights was used to define the line to be extrapolated? The curvature of Figure 8d suggests that a nonlinear extrapolation would be better. What fraction of the total inferred optical depth was below 100 m, as obtained by this extrapolation?

P 17699 line 15. Define <effective radius>. Grenfell and Warren (1999) compared three choices of effective radius; their differences can be large.

P 17699 Eq. 1. (a) How was the value of p chosen (p=7)? (b) A plot of the size distribution would be nice. (c) Are there any observations of size distributions at Eureka? (d) You could compare both the analytical and measured size distributions to those of Antarctic diamond dust (Walden et al. 2003 Figure 6) and residual blowing snow (Figure 7)

P 17701 line 3. This sentence suggests that the motivation for this work is climatic. But Eureka is in a fjord and therefore idiosyncratic; measurements made on a nearby mountaintop or on the ocean would be different. It seems to me that the SHEBA result is applicable to a much larger area than is the Eureka result.

P 17701 last paragraph. Why do you want to screen out cases in which water droplets were present in the near-surface ice-crystal layer? They also contribute to the climate.

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P 17706 lines 21-22. As particle size decreases from 50 to 10 microns the extinction efficiency decreases by 20% but the total cross-sectional area of particles increases by a factor of 5 (for constant IWP).

P 17707 line 12. <suggested that another more prolific source of ice crystals may be responsible.> Did you look at any of these crystals under the microscope? That would easily distinguish diamond dust from residual blowing snow (compare Figures 2a and 2b of Walden et al 2003).

P 17710 lines 10-14. This sublimation of blowing snow implies that some of the <ice crystal radiative forcing> is actually caused by increased humidity of the atmosphere compared to the next day without blowing snow.

Tables 1 and 2. (a) Add some columns to these tables, showing how often the reports were of <ice crystals> (ww 76, 78) and how often they were of <blowing snow> (ww 38, 39). (b) What was the minimum cloud amount you required to classify the sky as <cloudy>?

Table 4 caption last line <The effective radius . . . is 50 microns>. Point out that this effective radius is much larger than that of Antarctic ice crystals in winter (12 microns; Walden et al 2003), probably because of the higher temperatures in the Arctic.

Table 4, inversion height. Compare these values to the seasonal average inversion height at Eureka (1.2 km; Figures 1 and 2 of Walden et al. 1996).

Table 4 last 2 lines. The IC top temperature is colder than the maximum inversion temperature, but is the IC top altitude above or below the inversion top? Maybe you answered this question without my noticing.

Figure 2. The gray legend and gray lines are too faint.

Figure 3. Axis labels and legends are illegible. Much larger font is needed.

Figure 12. Legends in these figures are illegible. Increased font size is needed. Also

expand each part of Figure 12 by a factor of 2 in each dimension.

MINOR COMMENTS

P 17696 line 25. <170h>. Table 1 says 205 h.

P 17696 line 26. <9.1%>. Table 1 says 11.0%.

P 17698 line 6-7. Why is the 9-hour period 03-12 UT missing?

P 17698 line 14. <surrounding clear regions>. Are there always surrounding clear regions?

P 17698 line 20. <nearly>. Is this qualifier needed?

P 17699 line 11. Define ECC.

P 17707 line 25. Why <unique>? Terra and Aqua see the whole earth, not just Eureka.

Figure 8d. Say that this is cumulative optical depth.

SPELLING AND GRAMMAR

P 17693 line 12. Witte. Reference list says Witt.

P 17695 line 18. Change <are> to <is>

P 17697 line 7. Change <at> to <an>.

P 17698 line 5. Change <occurs> to <occur>.

P 17698 line 13. Change <substantial> to <substantially>

P 17701 line 7. Change <is> to <are>

P 17701 line 15, 16. Change <which> to <that> (in two places)

P 17702 line 2. Change <This criteria was> to <These criteria were>

P 17710 line 16. Savelyec. Reference list says Savelyev.

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Table 1 caption line 5. Delete <an>

Table 3 caption line 4. Change <hourly> to <hour>

Table 4 caption line 6. Change <are> to <is>.

Figure 3 caption line 2. Change <studies> to <studied>.

Figure 12 caption line 1. Change <are> to <is>.

REFERENCES

Bohren, C.F., 1987: Mixing clouds. Chapter 5 of Clouds in a Glass of Beer: Simple Experiments in Atmospheric Physics. Wiley, 195 pp.

Grenfell, T.C., and S.G. Warren, 1999: Representation of a nonspherical ice particle by a collection of independent spheres for scattering and absorption of radiation. J. Geophys. Res., 104, 31697-31709.

Tape, W., 1994: Atmospheric Halos. Antarctic Research Series, volume 64, American Geophysical Union, Washington, D.C., 143 pp.

Walden, V.P., A. Mahesh, and S.G. Warren, 1996: Comment on <Recent changes in the North American Arctic boundary layer in winter.> J. Geophys. Res. (Atmospheres), 101, 7127-7134.

Walden, V.P., S.G. Warren, and E. Tuttle, 2003: Atmospheric ice crystals over the Antarctic Plateau in winter. J. Appl. Meteor., 42, 1391-1405.

Yamanouchi, T., and S. Kawaguchi, 1985: Effects of drifting snow on surface radiation budget in the katabatic wind zone, Antarctica. Annals of Glaciology, 6, 238-241.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 17691, 2008.