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Interactive Comment

Interactive comment on "A mechanism for dust-induced destabilization of glacial climates" *by* B. F. Farrell and D. S. Abbot

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We agree with Heavens that the quantity, size distribution and composition of the dust in the glacial atmosphere are uncertainty and that both the size and composition of the dust aerosols have a strong effect on radiative properties. It is also true that large aerosols have substantial long wave cross-section that would tend to oppose the upper level heating and surface cooling effect of the small aerosols involved in the dust feedback destabilization we propose. However, as Heavens also observes, these large aerosols are concentrated primarily in the vicinity of source regions and it is the small (Dd < 2μ) aerosols that have long lifetimes, interact primarily with short wave radiation and produce strongly negative radiative forcing [2]. We are proposing that a hemispheric to global scale upper atmosphere layer of these fine aerosol particles was

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established and stabilized by feedbacks arising from the small aerosol's suppression of precipitation which both decreased scavenging of aerosols and increased aridity in dust source regions. Large aerosols, as noted in the review, are confined to source regions and are rapidly removed from the column which would leave behind the small aerosol with their primarily short wave absorption properties. Concerning the issue of the dust loading in simulations and observations, as pointed out in [2] the specification of dust used in GCM's is empirical and has limited physical basis and as noted in [3] the simulations underestimate continental dust deposition by as much as three orders of magnitude. We take this only as indicative that present day simulations of dust dynamics are not sufficiently advanced that they can preclude the possibility that a rare sequence of events could result in a fine dust layer of hemispheric extent forming in the upper troposphere. It is noteworthy that the physical mechanism responsible for the establishment and persistence of the analogous stable global upper atmosphere dust layer that occurs episodically in the Martian atmosphere is still not agreed on despite the availability of extensive observations and it is unlikely that this phenomenon would have been predicted in the absence of direct observation. Moreover, the effect on the climates of Mars and Earth arising from the injection of dust and aerosols into the atmosphere by the 2001 Martian planet-encircling dust storm and the Mt. Pinatubo eruption in 1991 have many parallels including extensive surface cooling, as discussed in [1]. Concerning the agreement between marine records of dust deposition and the simulations of [3], we do not believe these are inconsistent because, as we discuss in the paper, what is relevant is the column dust load, not the rate of deposition. If the residence time of dust were to increase by a factor of 2-4x, as we propose to have been the case, then the 2.5x deposition rate cited by [3] would be consistent with 5-10x increase in column dust load as we propose.

[1] B. A. Cantor. MOC observations of the 2001 Mars planet-encircling dust storm. Icarus, 86:60–96, 2007.

[2] J. F. Kok. A scaling theory for the size distribution of emitted dust aerosols suggests

climate models underestimate the size of the global dust cycle. Proceedings of the National Academy of Sciences, 108:1016–1021, 2011.

[3] N. M. Mahowald, D. R. Muhs, S. Levis, P. J Rasch, M. Yoshioka, C. S. Zender, and C. Luo. Change in atmospheric mineral aerosols in response to climate: Last glacial pe- riod, preindustrial, modern, and doubled carbon dioxide climates. Journal of Geophysical Research, 111:D10202, 2006.

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