Interactive comment on “A mechanism for dust-induced destabilization of glacial climates”
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In the paper a mechanism for explaining the jumps between the cold dry stadial state
and the warm wet interstadial state observed in the paleoclimatic records is proposed.
The idea is that dust pumped into the atmosphere by winds can change the stability
of the tropical atmosphere, such that convective heating is strongly reduced and the
climate falls into a stable, cold state. Two reasons for this are proposed. They are
both related to the absorption of incoming short wave radiation by the dust aerosols:
Firstly, the reduced radiative heating at the surface results in reduced evaporation, sec-
ondly, the heating of the atmosphere from aloft results in a more stably stratified mid-
troposphere, such that convection is reduced. Two factors for stabilizing this increased
dust load state are proposed: By reducing the hydrological cycle the residence time of
the dust in the atmosphere is increased, since rainout is less efficient, secondly with
colder and drier conditions more source areas for dust become available. (The last
part I also find interesting, as it is in line with the findings in an old (un-noted) paper
by myself: Marsh and Ditlevsen, Climate during glaciation and deglaciation identified
through chemical tracers in ice-cores, GRL, 24, 1319-1322, 1997 ! ) The quantita-
tive estimates of this mechanism are based on the NCAR radiative-convective column
model. Even though there are caveats in the modeling approach, especially in not in-
cluding the circulation, the authors convincingly show that the order of magnitude of
the observed changes in dust concentrations could be enough for the proposed mech-
anism to work. I find that this is a very interesting proposal, which should be published.
The main results are presented in figure 1. The authors propose three states of the
system, which should correspond to the stadial and the interstadial states (State 3 and
State 1 respectively) and an intermediate state (State 2). I suggest, for this to be con-
sistent with equation (1) that State 2 be identified with the unstable fixed point at x=0.5
(in figure 2). Going back to figure 1, I’d say that State 2 should be for ‘Dust Factor’ (=y)
approximately 25 (where precipitation has an inflection point) . The explanation for the
instability of State 2 then goes: If y becomes a little less than 25, the convection and
thus the rainout increases and y decrease further and if y increase, rainout is reduced
and y increase further. This is (almost) the same point where the difference in potential
temperature between mid-troposphere and surface change behavior. I must admit, I
do not understand how this difference can be negative (for y < 25). Please clarify.

Minor suggestions: Figure 1: Units for temperature are Celcius and not K. Consider
changing the State 1-3 bar. For readability it would be helpful with curves connecting
the plotting symbols (I guess we can safely assume that the model will produce smooth
curves). I’d personally like labels (‘precipitation’,’Theta(515)-Theta(surface)’ etc) in the
plot. Figure 2: This is only for easier understanding: When defining x=log_10(y), then
have it comparable with figure 1, such that x=0.5 is scaled to x=log_10(25) etc. And
if the time scale of jumping is meant to resemble the DO-events, the mean should be
3000 years rather than 1600 years.

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