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Climate of the Past Discussions

Interactive comment on "Radiative effects of ozone on the climate of a Snowball Earth" *by* J. Yang et al.

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This paper investigates the effect of ozone concentration on the radiation and temperature fields in Snowball states. I recommend the publication of this paper, since this paper adds a new information on conditions of global glaciation and deglaciation. However, I hope that Abstract and Conclusion are changed because of the reason described below.

1 Major Comments

In this paper, radiation budgets are precisely examined in snowball states with various ozone concentration. However, what are described as the final result in Abstract and Conclusion are only the vales of temperature changes for decreased ozone cases.

These values contain large uncertainties as described in next paragraph. My opinion is that emphasis of only these vales might be confusing and spoil the worth of this study, and that the descriptions of Abstract and Conclusion should be changed.

As described in this paper, the changes of atmospheric/surface temperature with change of radiative forcing strongly depend on snow-albedo feedback and water- vapor feedback. The efficiency of these feedback processes largely change with implementations of parameterization scheme of physical processes in GCM. For example, snow depth which is one of the important quantity determining the efficiency of snow-albedo feedback depends on settings of snow albedo, thermal (diffusion) model of snow layer, model of surface evaporation flux, and so on. The atmospheric water vapor content which influences water-vapor feedback is largely varied with parameterization schemes such as cumulus process, turbulent vertical diffusion process, surface flux, and so on. Therefore, a set of values of temperature change obtained by only one experiment contains a large uncertainties. In order to understand the dependence of temperature on ozone concentration in Snowball states, much more experiments and analysis should be needed. At least, model ensemble experiment will be needed as performed in global warming problem (ex. IPCC report).

Based on a recognition that much more studies are needed for this problem, the worth of this paper is, in my opinion, that opposing effects in one GCM are analyzed: (1) warming effect by solar radiation increase v.s. cooling effect by longwave radiation decrease at tropopause, (2) warming effect by cloud absorption of longwave radiation v.s. cooling effect by cloud scattering/reflection of solar radiation. I consider that the most valuable points of this paper are not the values of temperature change, but presentations of one example of feedback process behaviors in decreased ozone conditions, and a basic analysis way for investigating the effect of ozone concentration.

Therefore, I consider that the results of analysis for opposing effects in some feedback processes should be emphasized in Abstract and Conclusion, in addition to the description of the values of temperature change written in current manuscript. Moreover, remarks on uncertainties of model and on a necessity for model ensemble experiment might be added to Conclusion.

2 Minor comments

I have some questions and comments to Figure 4. These are as follows.

* I could not understand what are plotted in Figure 4. I feel that more explanations are needed for both of SW and LE, for example, detailed calculation methods for SW and LE.

My guess is that SW plotted in Figure 4 is the difference of downward short wave radiation at tropopause for case with ozone and without ozone. If my guess is correct, I cannot understand the physical meaning of Net = SW + LW; SW is obtained as model difference while LW is a results of case with ozone.

* p3591 l26-27: I cannot understand the reason why surface albedo influences Net radiation. I imagine that this problem is caused by my misunderstanding for SW. I hope that some description are added.

* p.3592 l24-25: Why the longwave radiation decreases in polar region? It may be good to add the reason to manuscript.

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