Interactive comment on “Diminished greenhouse warming from Archean methane due to solar absorption lines” by B. Byrne and C. Goldblatt

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Dear Dr. Haqq-Misra,

Thank you very much for the helpful review. We have addressed your comments individually below.

COMMENT: However, the greatest discrepancy between HITRAN 2000 and 2012 occurs for CH4 abundances that are likely to form a stratospheric organic haze layer (Fig. 4b,c), which would absorb incoming solar radiation and cool the surface. Although previous studies may have overestimated CH4 warming at these abundances as the authors argue, the significant cooling from the formation of organic haze would lower global temperature likely by much more that the difference between the two HITRAN
databases. Only when CO2 abundances are high and organic haze does not form (Fig. 4a) does the difference between the HITRAN databases seem to matter. For the Archean, this suggests that the improvement in radiative transfer is most applicable to haze-free high- CO2 environments. Possibly conditions like this may have been present in the Hadean or early Archean, which the authors may wish to discuss.

RESPONSE: We agree that the an organic haze would likely have a more significant radiative impact than shortwave absorption by methane. However, we disagree that the constraints in the late Archean imply that a haze would form at low CH4, as there is still considerable uncertainty in the CO2 abundance in the middle and late Achean and the CH4 abundance required for haze formation. Furthermore, there are no CO2 constraints before 2.69 Gyr ago, thus we believe that high methane abundances are plausible without haze formation in the middle to late Archean. We have addressed these concerns in the manuscript with the following paragraph:

“Geological constraints, based on the mass balance of weathering paleosols, have suggested that the atmospheric CO2 partial pressure was in the range 0.003-0.02 bar in the late Archean [2.69 Gyr ago, Driese et. al., 2011]. Given that an organic haze could form at CH4/CO2 ratios as low as 0.2-0.3, this would imply that an organic haze would form at CH4 abundances greater than 6x10-4-6x10-3. In the presence of an organic haze, shortwave aborption by CH4 would likely be of less importance. However, at the upper limit of this range, a CH4 abundance of 6x10-3 results in a significant (3â€ÂºK) difference in surface warming between HITRAN versions. Thus, given the constraints on atmospheric CO2 and organic haze, the calculated reduction in surface warming due to improved line data may have been radiatively important throughout the Archean. Furthermore, atmospheric CO2 constraints only exist for the latest Archean [2.69 Gyr ago, Driese et. al., 2011]. The solar luminosity used in this study (80% of today’s value) occurred 2.86 Gyr ago [equation 1, Feulner, 2012] which is 170 Myr before the earliest constraint on CO2 [2.69 Gyr ago, Driese et. al., 2011]. Thus, CO2 may have been significantly higher than 0.02 bar at this time, meaning atmospheric CH4
abundance larger than $6 \times 10^{-3}$ could have existed without haze formation.”

Interactive comment on Clim. Past Discuss., 10, 4229, 2014.