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Climate of the Past Discussions

Interactive comment on "Role of the stratospheric chemistry-climate interactions in the hot climate conditions of the Eocene" *by* Sophie Szopa et al.

Anonymous Referee #1

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General comment

The manuscript presents the results of the ozone layer simulations during Eocene and preindustrial conditions as well as comparison with several climatological ozone datasets. The authors applied several models including Atmosphere-ocean GCM and vegetation model driven by the Eocene boundary conditions as well as chemistry-climate model LMDz-Reprobus (CCM LR). The authors analyze the ozone layer response to the enhanced concentrations of CO2, CH4 and N2O comparing with preindustrial run. The obtained results are mostly known from several previously published estimates of the ozone response to climate warming. The differences with the published results consist of very strong acceleration of the Northern polar night jet resulting in smaller total column ozone increase over the high-latitudes. The comparison with

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Discussion paper

other climatological datasets for preindustrial and present day conditions shows expected differences. The authors interpret this results as a necessity to use interactive ozone chemistry for the simulation of the Eocene or other extremely warm climates. This conclusion is supported by the strong (about 1.8 W/m**2) radiative forcing caused by switch from prescribed to interactive ozone. The obtained results are potentially interesting, but a lot of additional explanations and clarifications are needed before I can recommend the publication.

Major issues

1. Section 2: The used model setup is not clearly presented. I understand that FOAM+LPJ models are used to produce boundary conditions (topography, geography, 4xCO2 and so on) for Eocene. Then, in the section 2.2.2 it is said that CCM LR uses SST and land surface conditions. Does CCM LR use proper topography and land configuration? If the simulated period is around 55 Ma, why nothing is said about oxygen mixing ratio which was only about 17% and large increase of biogenic emissions (i.e., isoprene). These components can substantially change ozone mixing ratio in the both stratosphere and troposphere. How successful is FOAM simulations of the past climate? As far as I know the Eocene climate with no substantial horizontal temperature gradients is difficult to reproduce. From the first paragraph on page 6 I understood that CH4 and N2O have not been included in the CCM LR radiation code, but their influence is implicitly included in CO2. How exactly it was done? Did the author use greenhouse warming potential or some other scaling technique? I suggest rewriting section 2.2 to make it more understandable.

2. Section 3: Most of the results of this section agree well with several previous publications. On unexpected results is strong acceleration of the boreal polar night jet, which is more than two times stronger during Eocene. The authors explain it by the extra cooling of polar cap area by enhanced CO2. This result does not agree with previous publications. For example, for 4xCO2 case the acceleration of zonal wind was not detected (e.g., Ferraro et al., 2015, doi:10.1002/2014JD022734, Figure 4). Theo-

retically, it should be expected because the enhanced CO_2 cools down stratosphere everywhere and does not build up additional horizontal gradients. Maybe the cause is not CO_2? It should be clarified and analyzed. I would also suggest shortening second paragraph on page 8. I guess, most of the readers know the basic atmospheric dynamics.

3. Section 4: First of all, the considered effects are not related to interactive chemistry but rather to the use of not appropriate ozone field. I guess, most of the differences discussed in this section disappear if the authors use the model w/o interactive chemistry, but with the ozone field prescribed from the Eocene run. I do not see any reason to compare Eocene run with the results of the model run driven by OzRoyer. Obviously, there will be substantial difference due to different situation during Eocene and present day. Comparison with Oz1855 is also not instructive because the ozone field is very close to the results of preindustrial run.

4. Section 5: The problem here is related to the magnitude of radiative forcing. 1.8 W/m**2 from stratospheric ozone increase looks extremely overestimated and has probably wrong sign. Forster et al., 2011 (doi: 10.1029/2010JD015361) showed using very accurate LBL radiation codes that 10% decrease of the stratospheric ozone gives only about 0.25 W/m**2 (their Table 4). Portman and Solomon (2007, doi:10.1029/2006GL028252) concluded that the ozone radiative forcing caused by warming climate is within 0.1 W/m**2. I think that very large 1.8 W/m**2 ozone forcing (comparable to anthropogenic radiative forcing during 21st century) should be clearly explained. At least, its geographical, vertical and spectral signatures should be illustrated. In my opinion this forcing can be generated only by extraordinary high increase of the tropospheric or UTLS ozone (e.g., Beerling, 2011), which is not visible from presented results. The estimation of the surface temperature response using some other model sensitivity to homogeneous radiative forcing is oversimplified. If the obtained 1.8 W/m**2 is true (which I doubt) it will show the importance of the problem by itself.

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