Clim. Past Discuss.,
https://doi.org/10.5194/cp-2020-117-AC1, 2021

Climate of the Past Discussions

Interactive comment on "On the phenomenon of the blue Sun" *by* Nellie Wullenweber et al.

Nellie Wullenweber et al.

csavigny@physik.uni-greifswald.de

Received and published: 9 February 2021

Reply to comments by anonymous referee #1

General Comments

This manuscript examines the unusual atmospheric conditions under which a blue sun can occur. The analysis is similar to previous work, in particular that by Horvath et al., (1993), but the authors extend the analysis by including more complete radiative transfer simulations. Results generally agree with previous work, but the authors find that higher aerosol optical depths are required when a realistic atmosphere is accounted for. Overall, the manuscript presents a well written description of the topic and analysis performed. I would recommend publication after minor corrections.

Reply: We thank the reviewer for his/her encouraging comments. We imple-

Printer-friendly version

Discussion paper

mented essentially all the changes requested by the reviewer (see detailed responses below).

Specific Comments

Line 126: Why is a reference of 350nm chosen? This seems generally beyond the limits of human vision. If "maximum anomalous extinction" is the ratio of red/blue extinction this seems an odd choice given the sensitivity curves in Figure 1.

Reply: This choice was somewhat arbitrary and the reviewer is correct that it was probably not the best choice. Although the main message of the Figures is essentially the same, we changed the reference wavelength to 400 nm.

Line 130: Along those lines, please define "maximum anomalous extinction".

Reply: We replaced this sentence by the following:

"As can be seen in Fig. 2, the strongest increase in extinction coefficient with increasing wavelength in the visible spectral range (or maximum anomalous extinction) is obtained under the assumptions made for median radii in the 400 – 700 nm range, with the specific values depending on the assumed refractive index."

We hope that this change clarifies the meaning.

Line 149: A brief description of what "int - transmission - CDI" means would be useful.

Reply: Good idea! We adapted the text and added more information here.

Line 149: Ehlers (2014) found that the forward scattering by aerosols was an important contribution to the blue sun on Mars. Do the radiative transfer calculations take this into account and is this not an important factor for the cases investigated here?

Reply: Thanks for this comment. Ehlers et al. (2014) found that scattering was important for the blue glow around the solar disk on Mars, but they also stated

that the slightly blue colour of the solar disk was caused by wavelength selective extinction (that's the effect our paper deals with; Ehlers et al. call this "bluing"). These effects have to be distinguished. Ehlers et al. did not state that scattering by aerosols was the cause of the blue colour of the solar disk.

For the SCIATRAN simulations presented in our paper only the transmission is calculated, scattering is not considered. In the revised version of the paper we will include a comparison of the contributions of transmission and scattering to the total intensity.

Line 223 – 227: Is a particle size assumed in this analysis, or is the wavelength-dependent extinction used directly?

Reply: The optical depth spectrum published by Wilson was directly used as input for the SCIATRAN simulations. We adapted the text to make this point clearer.

Figure 7: How does this compare to the wavelength dependence of the particle sizes used in the previous analysis?

Reply: The wavelength dependence in Fig. 7 is significantly weaker than for the results shown, e.g. in Fig. 4, where close to the optimum particle size parameters were chosen to produce a blue sun (see also Fig. 2 of the online version or Fig. 1 in the revised version of the manuscript). We added some text to the paper to mention this difference.

Line 237: "...despite the questionable spectral signatures in the solar transmission spectra." Although the included figures make it clear, I think this wording is a bit ambiguous as to whether your simulated spectra reproduce this feature. Just a suggestion, but I would rephrase to something like "...although the minimum in the solar transmission spectra near 490nm was not reproducible"

Reply: OK, text changed as suggested.

Line 250: Do the water vapour simulations fix the entire mixing ratio profile at 4/40

Reply: Yes, the water vapour mixing ratios in the troposphere were 4 / 40% at all altitudes. We added this piece of information to the manuscript.

Line 276: It is not clear to me from Pollack (1973) that the absorption could not be increasing for certain particle makeup. While clearly not necessary for a blue sun, I don't think this work has shown that it is an unlikely contributor, especially given the unknown makeup and rarity of the events

Reply: Thanks for this comment. We read Pollack (1973) again carefully and realized that our explanation in the paper is not entirely correct. Our main conclusion is, however, not affected. Fig. 1 of Pollack shows the spectral dependence of the "Extinction coefficient" and this quantity is increasing with increasing wavelength in the visible spectral range. However, this extinction coefficient is dimensionless and is different from the standard definition of the extinction coefficient, having a dimension of 1/length. Please have a look at equation 2 in Pollack, which shows Beer-Lambert's law. Here the wavelength appears in the denominator of the exponent making the extinction coefficient indeed dimensionless. In order to convert Pollack's extinction coefficient to the standard extinction coefficient one has to divide by the wavelength. If this is done then the extinction coefficients don't increase with wavelength any more.

Our explanations in lines 275 – 279 of the online manuscript wrongly discuss the spectral dependence of the refractive index, not the spectral dependence of Pollack's "extinction coefficient", we apologize. This is now corrected.

Regarding aerosol absorption as a possible source of blue suns we also carried out simulations including aerosol absorption (as suggested by reviewer 2) and added a section to the manuscript.

Technical Corrections

Figure 1: should the x, y, z labels have bars over them?

Reply: The reviewer is correct; the bars were missing. Following the recommendation by reviewer 2, we deleted this Figure, however.

Line 191: remove “of” from “aerosol with of a sufficiently small...”

Reply: Thank you – corrected.

Line 223: “...variation is with about 1

Reply: OK, changed!

Interactive comment on Clim. Past Discuss., https://doi.org/10.5194/cp-2020-117, 2020.