Review of the paper entitled “Responses of the 14 October 2023 annular solar eclipse observed in satellite temperature profiles” submitted to EGUsphere by A. R. Paulino et al.

Summary

This paper describes observations of temperature in the region from 15 km to 105 km as measured by the SABER instrument on the TIMED satellite during the annular solar eclipse event that occurred on 14 October 2023. The observations are potentially of interest to see how the Earth’s middle atmosphere responds to transient events. The authors examine SABER temperatures prior to and during the eclipse and from these observations determine the magnitude of the temperature change induced by the eclipse.

Recommendation

Regretfully, the paper must be rejected, but not for any fault in the analysis by the authors, but because the SABER temperature data are not suitable for analysis during eclipse events.

Specifically, the SABER temperature algorithm is not designed for, and does not account for, conditions during the eclipse. As described in the papers by Mertens et al. referenced by the authors, the SABER temperature retrieval involves complex non-LTE radiative transfer calculations involving the vibration-rotation bands of carbon dioxide (CO2) in the 15-micrometer spectral region. The non-LTE processes are substantially different for day than for night in that there is substantial absorption of solar radiation by CO2 during the day and of course, none at night. Consequently, the vibrational temperatures of the 15 micrometer bands of CO2 have a strong variation from day to night. To derive the temperature correctly, the SABER radiative transfer models must first compute the correct vibrational temperatures.

The algorithm used to analyze the SABER data during the eclipse is the daytime algorithm. It is not possible to switch from day to night for one or two profiles during operational processing. In addition, the SABER team has examined several eclipse conditions and found that even when near or “in” the eclipse region, the atmosphere that SABER views is almost always partly illuminated, so it is never completely in night conditions. For this reason, there is really no way for SABER to derive a valid temperature profile in or near to the eclipse region. (Note that SABER views the earth’s limb, not in the nadir, and consequently measures infrared emission over a long (~ 1000 km) path).

Perhaps the authors might have suspected something given the magnitudes of the changes in temperature reported in their paper. For example, the 45 K decrease in 104 km might have come across as likely non-physical. Does this result mean at night the temperature would decrease by over 100 K in maybe five to ten minutes after sunset? The authors are referred to the paper by Huang et al., 2006, specifically figures 1, 2, 3, and 4.

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These figures show the diurnal variation of the temperature at 55 km and 95 km measured by SABER and by the Microwave Limb Sounder (MLS) on the Aura satellite. The eclipse change in temperature in a couple of minutes surely cannot be larger than the diurnal change.

Also, it is quite likely that the warm stratosphere and the “troposphere” results at 15 km reported in the paper are likely algorithm effects due to the incorrect temperatures in the mesosphere and lower thermosphere arising from the daytime temperature algorithm being used instead of the night algorithm.

Lastly, there is one other point to make regarding the SABER algorithms, for the altitudes above 80 km, which again relates to the non-LTE radiative transfer calculations. A critical input to the temperature algorithm (which is discussed in the Mertens et al. papers) is the atomic oxygen concentration. SABER’s temperature algorithm uses atomic oxygen provided by the MSIS-2000 empirical model. As such, the atomic oxygen concentration from the empirical model cannot be expected to be correct if there are rapidly changing conditions to be properly modeled. This fact, in addition to the daytime/nighttime issues mentioned above, likely leads to the large and almost surely incorrect temperature changes reported in the paper.

In closing, the authors are encouraged to reach out to the SABER team if they have further questions about the validity and utility of the data during transient events.