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Three-dimensional modeling of the $O_2(^1\Delta)$ dayglow and implications for ozone in the middle atmosphere.

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Future space missions dedicated to measuring CO_2 on a global scale can make advantageous use of the O_2 band at $1.27 \mu m$ to retrieve the air column. The $1.27 \mu m$ band is close to the CO_2 absorption bands at 1.6 and $2.0 \mu m$, which allows a better transfer of the aerosol properties than with the usual O_2 band at $0.76 \mu m$. However, the $1.27 \mu m$ band is polluted by the spontaneous dayglow of the excited state $O_2(^1\Delta)$, which must be removed from the observed signal.

We investigate here our quantitative understanding of the $O_2(^1\Delta)$ dayglow with a chemistry-transport model. We show that the previously reported -13% deficit in $O_2(^1\Delta)$ dayglow calculated with the same model is essentially due to a -20 to -30% ozone deficit between 45 - 60 km. We find that this ozone deficit is due to excessively high temperatures ($+15$ K) of the meteorological analyses used to drive the model in the mesosphere.

The use of lower analyzed temperatures (ERA5), in better agreement with the observations, slows down the hydrogen-catalyzed and Chapman ozone loss cycles. This effect leads to an almost total elimination of the ozone and $O_2(^1\Delta)$ deficits in the lower mesosphere. Once integrated vertically to simulate a nadir measurement, the deficit in modeled $O_2(^1\Delta)$ brightness is reduced to $-4 \pm 3\%$. This illustrates the need for accurate mesospheric temperatures for a priori estimations of the $O_2(^1\Delta)$ brightness in algorithms using the $1.27 \mu m$ band.