**Title**

Impact of solar eclipses on NO2 in the Earth's atmosphere as measured from space by TROPOMI: Understanding the sensitivity of the Earth's atmospheric composition to short-term variations in sunlight

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**Abstract**

During a solar eclipse, sunlight incident on the Earth is reduced due to the (partial) shadow of the Moon. Atmospheric trace gas concentrations which are influenced by the amount of available sunlight, such as nitrogen dioxide (NO2), may be affected due to the disrupted photolysis processes. Large-scale observations of the increased NO2concentrations caused by the solar eclipse would improve our understanding of the sensitivity of NO2in the atmosphere to short-term variations in sunlight. Spaceborne
measurements can provide valuable information about the large-scale spatial distribution of NO2, which is provided daily by the TROPOMI instrument aboard the Sentinel-5 Precursor satellite by measuring and retrieving locally reflected sunlight. However, the TROPOMI NO2retrieval is unable to derive reliable concentrations during a solar eclipse, as solar eclipses are not taken into account in its retrieval algorithm. In this research, we have adjusted the NO2retrieval of TROPOMI such that it can handle solar eclipses and study the large-scale response of NO2during two solar eclipses over Europe in 2021 and 2022. We found a large-scale increase of NO2in the adjusted measurements, which linearly correlated with the degree of obscuration. We compared the measured NO2increase with the values from the atmospheric chemistry model TM5 including an applied eclipse implementation and we found a close agreement in most areas that are not highly polluted. Our measurements and model predict a NO2increase of 60%±12% and 70%±7% for an obscuration fraction of 1, respectively. More advanced chemistry modelling work is needed to explain the measurements in highly populated areas. We conclude that our results demonstrate that the TROPOMI algorithm is capable of correctly measuring NO2after an adjustment of the NO2retrieval. We have shown that it is possible to adjust an atmospheric trace gas retrieval for the influence of a solar eclipse. Moreover, we are the first to provide evidence for an increase in NO2during a solar eclipse using space-based measurement techniques and to quantify this increase on a large scale with the same instrument. Our measurements can be used to test atmospheric chemistry models, possibly improving their sensitivity to solar eclipses but also artificial shadows on the Earth induced by sunlight-intercepting geoengineering approaches.