AE21A-02 On the Relationship Between Lightning Characteristics and LNOx Production: Insights from TROPOMI NO2 retrieval and Lightning Mapping Array Measurements in the Ebro Valley

Tuesday, 12 December 2023
17:40 - 17:50
216 - South (Level 2, South, MC)

Abstract

Lightning is one of the main sources of NO_x in the Earth's atmosphere, contributing to about 10% of total sources of atmospheric NO_x. NO_x produced by lightning (LNO_x) is about 6 times more efficient in driving ozone production than anthropogenic NO_x emissions because it is injected in the mid/upper troposphere, producing about 100 molecules of ozone per molecule of LNO_x. Despite the importance of LNO_x in the chemical composition of the atmosphere, there is a large variability in NO_x production during the lifetime of thunderstorms [1]. In this study, we used the TROPOspheric Monitoring Instrument (TROPOMI) cloud and NO_2 research products along with Lightning Mapping Array measurements to investigate the possible relation between the amount of NO_x produced per lightning flash and flash channel length in the Ebro Valley. We found a possible positive relationship between both variables. In turn, the vertical structure of the analyzed lightning flashes indicates that longer flashes could release more LNO_x at lower altitudes than shorter flashes, while higher flash rates produce less LNO_x per flash. These findings present novel pathways towards improving the parameterization of LNO_x within chemistry-climate models.

The Lightning Imager onboard the Meteosat Third Generation (MTG) imaging satellite will report the occurrence of total lightning flashes from space every 1 ms, complementing the lightning data provided by ground-based lightning networks. More significantly, the MTG high-resolution Sentinel-4 (or Ultraviolet-Visible-Near-Infrared UVN) sounder will provide continuous (1-hourly) NO_2 estimates from space over Europe. The NO_2 measurements of MTG-UVN will enable us to calculate the temporal evolution of the LNO_x production efficiency over particular thunderstorms as long-lived mesoscale convective systems (MCS) and will be useful to estimate the background-NO_x before the inception of lightning.

[1] Pérez-Invernón, F. J., Huntrieser, H., Erbertseder, T., Loyola, D., Valks, P., Liu, S., Allen, D. J., Pickering, K. E., Bucsela, E. J., Jöckel, P., van Geffen, J., Eskes, H., Soler, S., Gordillo-Vázquez, F. J., and Lapierre, J.: Quantification of lightning-produced NOx over the Pyrenees and the Ebro Valley by using different TROPOMI-NO2 and cloud research products, Atmos. Meas. Tech., 15, 3329–3351

Plain-language Summary

Lightning in the Earth's atmosphere generates considerable amounts of nitrogen oxides (NO_x), playing a key role in the global budget of tropospheric ozone. However, the quantity of NO_x produced during thunderstorms varies significantly. In this research, we employed a space-based instrument called TROPOMI to observe clouds and measure NO_2, along with a network of antennas known as Lightning Mapping Array to map the spatial patterns of lightning strikes. Our primary objective was to investigate any potential correlation between the amount of NO_x produced by lightning and the channel length of lightning flashes in the Ebro Valley. We discovered a possible positive relationship between these two variables. Moreover, we examined the structure of the lightning flashes and observed that longer flashes release more NO_x at lower altitudes compared to shorter flashes. Additionally, a higher frequency of lightning flashes results in each flash producing less NO_x.

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