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Tropospheric NO_2 column retrieval from the Geostationary Environment Monitoring Spectrometer (GEMS)

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Nitrogen oxides play an important role in many atmospheric chemistry processes in both the stratosphere and troposphere. In this context, over the past few decades, NO_2 column measurements have been provided from polar sun-synchronous low-earth orbit (LEO) satellite instruments. These space-borne remote sensing measurements have contributed to our understanding of the global distribution of tropospheric NO_2 levels, their changes over time and estimates of emissions. However, the LEO instruments only observe NO_2 once per day at a specific local time, limiting the monitoring of diurnal variation in NO_2 due to variations in emissions and chemical reactions throughout the day. To address the shortcomings of the current atmospheric composition monitoring by LEO and to capture the diurnal variation of air quality processes at the local scale, the Geostationary Air Quality (Geo-AQ) constellation mission, consisting of three geostationary satellite sensors (i.e. Geostationary Environment Monitoring Spectrometer (GEMS) for Asia, Tropospheric Emissions: Monitoring of Pollution (TEMPO) for North America, and Sentinel-4 (S4) for Europe), has been launched.

In this study, we present a tropospheric NO_2 retrieval algorithm designed for geostationary satellites using GEMS measurements. The GEMS NO_2 retrieval algorithm is based on a heritage of NO_2 retrieval from previous LEO satellites, following a common approach consisting of three steps: (1) the spectral retrieval of total NO_2 slant columns using Differential Optical Absorption Spectroscopy (DOAS) technique, (2) the separation of slant columns into stratospheric and tropospheric contributions, and (3) the conversion of tropospheric slant columns to tropospheric vertical columns using air mass factors. However, to account for the characteristics of the geostationary satellite, such as hourly sampling, limited geographical coverage, and larger zenith angles, we developed and implemented a number of improvements in the DLR GEMS NO_2 retrieval algorithm. To estimate the stratospheric contribution and describe the diurnal variation of stratospheric fields, an improved stratosphere-troposphere separation approach was developed using the CAMS global forecast (IFS cycle 48r1) data and evaluated by comparing it to results obtained using the STREAM scheme. For the improved tropospheric AMF calculation, sensitivity tests were performed using different surface reflectance and cloud products. Notably, a cloud correction using cloud parameters from the DLR Optical Cloud Recognition Algorithm (OCRA) based on Loyola et al. (2018) improves the tropospheric NO_2 column retrievals for clear-sky

scenes.

Our GEMS tropospheric NO_2 retrieval results show good agreement with various reference datasets including ground-based and satellite measurements. Furthermore, the hourly sampling and high spatial resolution of GEMS tropospheric NO_2 columns demonstrate the capability for a detailed analysis of the diurnal evolution of NO_2 burden and emission strengths over Asia from space.