Quality Control and Validation for Tropospheric NO_2 Measurements Using a Three-wavelength Optical Parametric Oscillator Differential Absorption Lidar

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Nitrogen dioxide (NO_2) is very important in the tropospheric chemistry and its emission sources include transportation, industrial and chemical processes, activities for oil and gas development, soil emissions, lightning and wildfires [U.S. EPA, 2018]. Short-term NO_2 exposure, ranging from 30 minutes to 24 hours, can cause the exacerbation of asthma symptoms, in some cases resulting in hospitalization [Berglund, et al., 1993]. Long-term NO_2 exposure is likely to have a causal relationship with respiratory effects, based on evidence for the development of asthma [U.S. EPA, 2016]. Additionally, atmospheric processing of NO_2 leads to the formation of nitrogen-bearing particles that can eventually deposit to the surface, causing acidification, nitrogen enrichment, and other ecological effects [Russell et al., 2012]. Local or global NO_2 monitoring is essential for understanding atmospheric chemistry as well as for human-health and environmental management and control.

Hampton University (HU) built a Differential Absorption Lidar (DIAL) based on an Optical Parametric Oscillator (OPO) laser and applied a new technique to obtain more accurate measurements of NO_2 using three wavelengths emitted from OPO. NO_2 concentration profiles were obtained using the HU three-wavelength OPO DIAL and these results were compared with simulated data from WRF-Chem model to assess their accuracy. It is found that the boundary of aerosol layer (boundaries of boundary layer, aloft aerosol layer and cloud) can cause huge errors for the retrieval of NO_2 profiles because there is a sharp change of aerosol concentration at the boundary of aerosol layer. In this paper, a new method is proposed to judge the accuracy of retrieval of NO_2 at the boundary of aerosol layer for the quality control of retrieval of NO_2. Moreover, a new method is proposed to validate HU lidar NO_2 results using ground station measurements. The low-altitude NO_2 difference of two different times (t1 and t2) can remove the influence of partial lidar overlap. We propose to compare the low-altitude NO_2 density difference between t1 and t1 retrieved using HU lidar with ground station's to validate HU lidar results. The two methods also can be used for the retrieval of O_3 using DIAL.