Geophysical Research Abstracts
Vol. 20, EGU2018-887-1, 2018
EGU General Assembly 2018

Applying the Optimal Estimation Method to retrieve the stratospheric ozone density profiles

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The measurements of stratospheric ozone with Differential Absorption Lidars (DIAL) provide an excellent mean to assess ozone trends in the stratosphere. Measurements of ozone have been made at the Observatoire de Haute-Provence (OHP) located in South-East France for more than 30 years. We have developed an Optimal Estimation Method (OEM) retrieval for stratospheric ozone number density using the raw measurements from the DIAL. The OEM uses the lidar equation as a first-principle forward model from which the ozone density, air density, dead-time, background counts, and constant of lidar signals are simultaneously retrieved. The OEM also provides a complete uncertainty budget on a profile to profile basis. In the method, the vertical resolution of the retrievals, and the maximum acceptable height for the retrieved profiles are determined by calculating averaging kernels. In addition, retrieving the air density along with the ozone density provides us with the opportunity to calculate the ozone volume mixing ratio. Thus, the method has the advantage for comparison of DIAL measurements with other ground-based instruments and satellite measurements which can drive a better understanding on the long-term trends of ozone profiles in the middle atmosphere.

In our retrieval, 2 channels of measurements at 2 wavelengths, are simultaneously used, and the final retrieved profiles along with profile based uncertainties are generated. Our ozone retrievals are validated against ozonesonde measurements, as well as the traditional analysis method. Although, both traditional and the OEM are in good agreements in the stratosphere, the OEM often captures more structure in ozone than the traditional method. At higher altitudes (above 40 km), as the sensitivity of the retrieval to the measurement is decreasing, the OEM retrieval tends to fall back to its a priori profile. This behavior is similar to the traditional method, where due to a poor signal to noise ratio the ozone retrievals above 40 km are less reliable.

Our retrieval has been tested for clear sky conditions with moderate aerosol loading. Under a volcanic eruption event, when the concentration of stratospheric aerosol is increased, the ozone profile retrievals can be affected. Using the OHP DIAL's two Raman channels, we are improving our retrieval to include the aerosol extinction coefficients along with the ozone and air density profiles.