Tropospheric and Lower Stratospheric Ozone Profiles From AERI-X Emission Spectra

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Introduction

The University of Denver Atmospheric Emission Radiometric Interferometer-Extended (AERI-X) has been in regular operation at the Southern Great Plains (SGP) Atmospheric Radiation Measurements (ARM) Program site, conditions permitting, since the mid-1990s. We present here the analysis of several spectra from May 10, 1999, and demonstrate the ability to retrieve the tropospheric ozone profile at the ARM site. While the presence of ozone in the stratosphere is of vital importance for several reasons, in the troposphere, ozone is a pollutant and a powerful oxidizer. For these reasons, it is desirable to gather information about the amount and variability of tropospheric ozone. As part of the analysis, temperature and water vapor profiles are also retrieved.

The AERI-X

The AERI-X measures downwelling thermal radiation, as well as two black bodies, one at near ambient temperature and one typically 40 K warmer. It is a Michelson interferometer that employs corner cubes rather than flat mirrors. It has an optical path difference of 10 cm, resulting in a resolution of 0.1 cm^{1}. Sampling is initiated based on the presence of a white light zero path difference signal (Zpd) that ensures the infrared signal is sampled in a manner consistent from scan to scan and target to target. This allows several scans of a given target to be co-added to improve signal-to-noise ratio. Typically, 25 scans of the sky view, and 25 of each blackbody are added to provide a single interferogram for each target. A complex fast fourier transform (FFT) is performed on each interferogram and a calibration process similar to that described in Revercomb et al. (1988) is applied. The result is an atmospheric spectrum whose radiative calibration is generally good to 2% or better. The signal-to-noise ratio for typical spectra is better than 50:1.

Spectral Analyses

The ozone, temperature, and water vapor profiles are derived by creating a model of the atmosphere from a priori knowledge and adjusting it to provide the best fit to a given spectrum. For this study the Sequential Evaluation Algorithm for Simultaneous and Concurrent Retrieval of Atmospheric Parameter Estimates (SEASCRAPE) (Fogal and Murcray 1999; Fogal et al. 1999) is used to determine the atmospheric profiles. The high-resolution transmission (HITRAN) database (Rothman et al. 1998) with improved water lines from Toth (1998) is used to construct the spectrum. A typical spectral fit is shown in Figure 1. The larger excursions in the residuals are due to less than optimal fits to the water lines. The input to SEASCRAPE consists of temperature (T), H_2O, CO_2, O_3, N_2O, CH_4, HCN, and NH_3 profiles. The T and H_2O profiles were created from radiosonde flight profiles recorded on May 10th and 11th of 1999. The constituent profiles are mid-latitude climatologies. The profile adjustments are carried out in an optimal manner, similar to that first described by Rodgers (1976) and the uncertainties in a priori knowledge are carried through the calculation resulting in the uncertainties indicated by the error bars on the plot showing the retrieved ozone profiles in Figure 2. The error bars apply only to one measurement but are indicative of all the profiles shown.

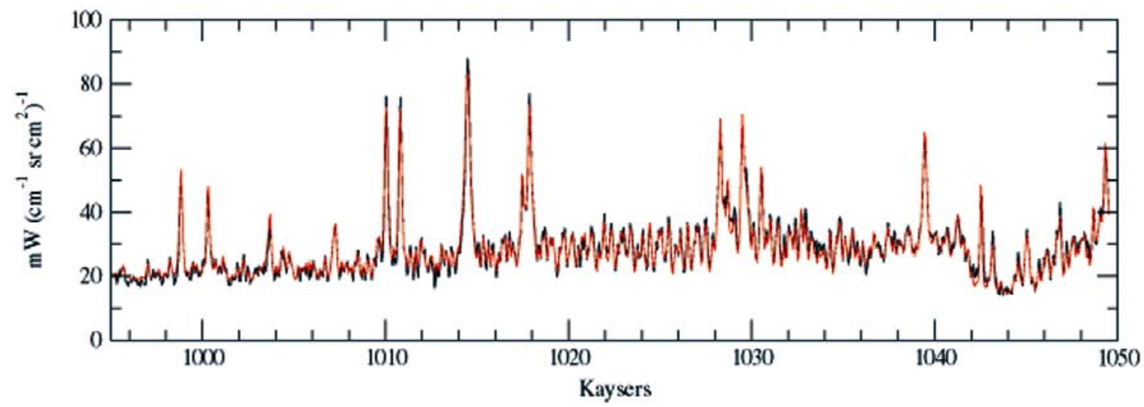

Figure 1. Typical fit to ozone band.

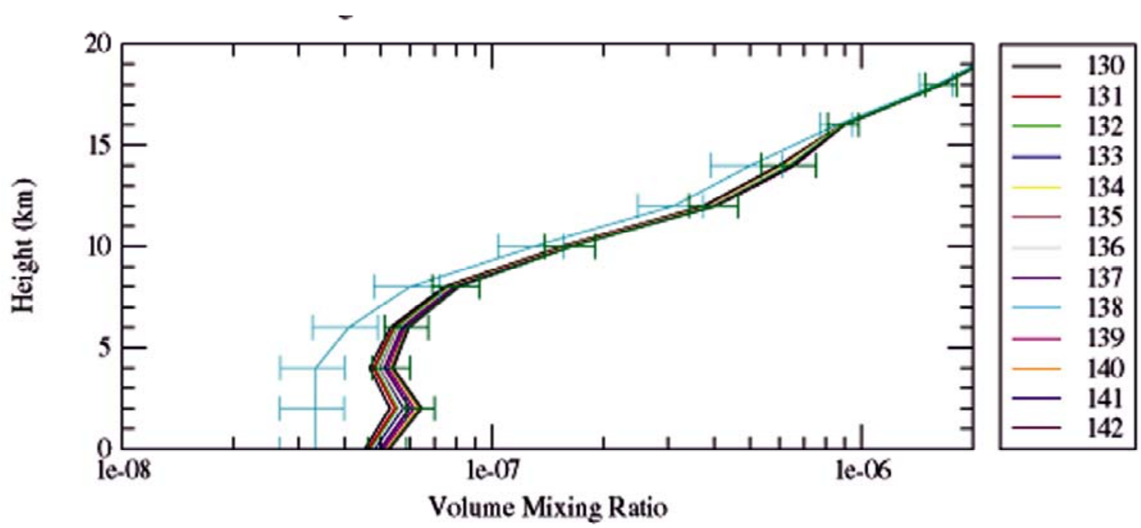

Figure 2. Retrieved ozone profiles.

The retrieved temperature and H_2O profiles are not shown here. They indicate somewhat variable conditions are present initially, and that they become more stable towards the middle of the time interval over which the interferograms were recorded. The O_3 profiles show a small but steady increase with scan number. Roughly 2 hours pass between the first (130) and last (142) profile in this set. Careful inspection shows that the first eight profiles are distinct, but the last five lie on top of each other. This behavior is consistent with that seen in both the temperature and water vapor retrieved profiles. The

AERI-X auxiliary data coupled with data from other sensors such as AERI and the Millimeter Wave Radiometer indicate that clouds were present before and after this set of measurements, and that it was likely raining beforehand. This helps to explain the rather large variations in both the retrieved temperature and H_2O profiles.

Conclusions

While the change in the retrieved O_3 profiles is not large, it does demonstrate the sensitivity of the AERI-X - SEASCRAPE combination. Also, the tropospheric portion of the retrieved profiles is approximately 50% larger than the a priori climatological profile. The significance of this is unknown as this is a brief interval during disturbed atmospheric conditions. On the other hand, it is well known that tropospheric ozone pollution is becoming a significant problem, albeit one largely connected to urban settings. However, this data indicates that tropospheric ozone can be also enhanced in rural settings and monitoring it will help us to understand the situations in which the ozone concentration increases.

References

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