LONG RANGE TRANSPORT OF FOREST FIRE SMOKE AEROSOLS

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ABSTRACT

During the International Consortium for Research on Transport and Transformation (ICARTT) study in 2004, the Dalhousie Raman Lidar was operated at a field site at Chebogue Point, Nova Scotia, Canada (43.7ºN, 66.1ºW). Optically thin aerosol layers were observed in the troposphere and up to 8 km in altitude from July 11 to 13. The source of the aerosols was determined to be intense forest fires in Alaska. The vertical structure of the aerosol was reproduced using the FLEXPART transport model, and the optical properties of the aerosols were determined.

1. INSTRUMENTATION

The Dalhousie Raman Lidar uses a frequency-doubled pulsed Nd:YAG laser (20 Hz, 500 mJ/pulse) in the transmitter. In the receiver, a 30 cm Newtonian telescope is coupled into a polychromator using a single multimode fiber optic so that a common overlap function is found at all wavelengths. The polychromator separates the elastic (532 nm) and molecular nitrogen Raman (607 nm) return signals into separate channels, and the backscattered signals are detected using photomultiplier tubes and fast photon-counting electronics. A radar is used to automatically disable the transmitter when aircraft are nearby [1]. The lidar was deployed at Chebogue Point in the Canadian Atmosphere-Biosphere Observations Trailer (CABOT) Observatory, which provides a fully-equipped 12-m long transportable platform for atmospheric measurements.

2. OBSERVATIONS

The lidar aerosol backscatter ratio measurements for 11-13 July 2004 are given in Fig. 1. The measurements show highly structured aerosol layers that extend up to 8 km in altitude on July 11. In the following days the top altitude for aerosols decreased, reaching only as high as 4 km altitude on July 13.

The source for the aerosols was determined using daily aerosol optical depth maps from the MODIS instrument aboard the TERRA satellite. The aerosol cloud was tracked back to intense forest fires burning in Alaska and the Yukon Territory earlier in July. The MODIS observations indicate that the transport between Alaska and Nova Scotia took approximately 10 days time, and

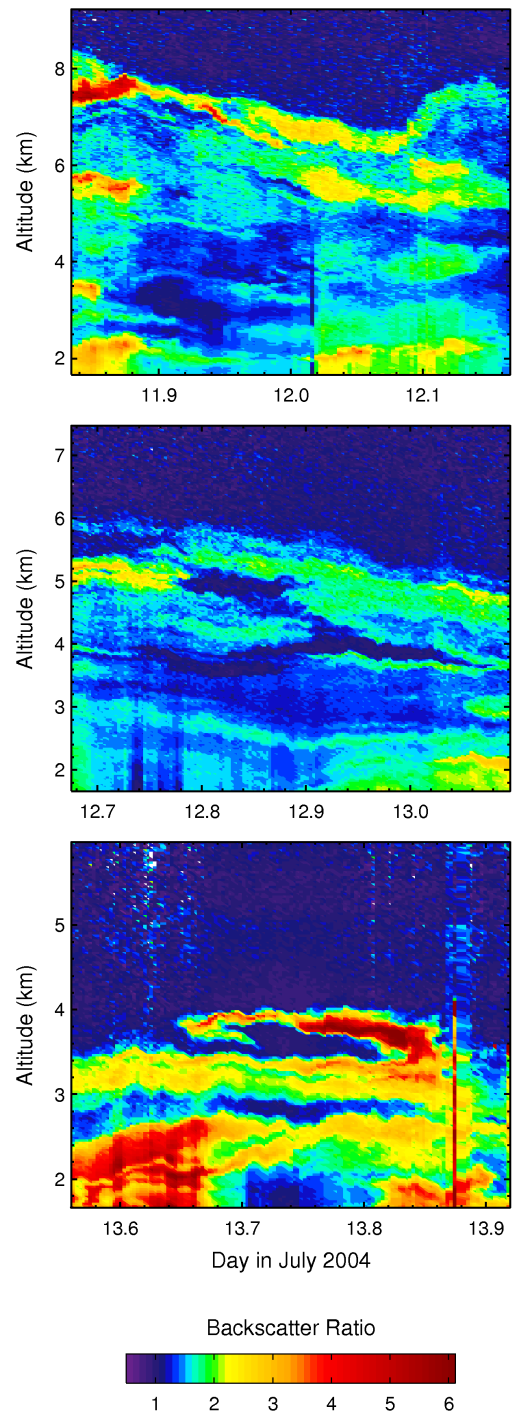

Fig. 1. Lidar aerosol scattering ratios at 532 nm wavelength measured at Chebogue Point from 11-13 July 2004.

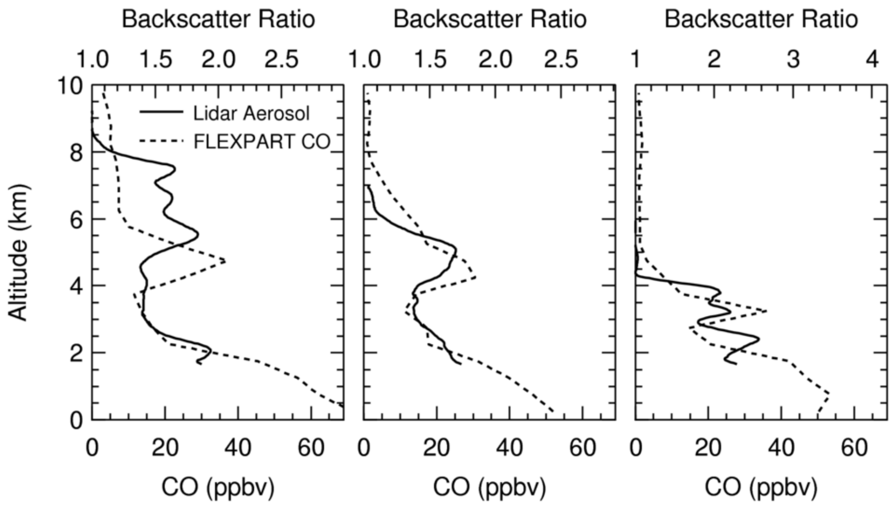

Fig. 2. Lidar aerosol backscatter ratios and Alaskan forest-fire CO predicted by FLEXPART for 11 July, 12 July, and 13 July 2004.

so the measurements are indicative of aged aerosols.

Using the Raman lidar technique, we measured the optical properties of the aerosols for 11 and 12 July. The aerosol optical depths above 1.5 km for each day were found to be 0.25 and 0.1, and the lidar ratios were determined to be 86±7 sr and 98±7 sr, respectively. The measured lidar ratios were relatively high, indicating very dark/absorbing aerosols. The optical depths are lower than the 0.7±0.2 and 0.35±0.1 measured using a co-located CIMEL sun photometer due to the fact that lidar measurements were not obtained below 1.5 km altitude.

3. MODELING

The fires represented an unprecedented burning of North American boreal forest, and the University of Wisconsin lidar system found aerosols from the Alaskan fires to reach above 13 km altitude [2]. In order to more firmly establish the forest fires as a source for our aerosols and to determine the reason for the lower altitudes observed at Chebogue Point, we employed the FLEXPART Lagrangian parcel dispersion model [3] to simulate the transport. Convective injection of forest fire emissions was parameterized based on the observed area and intensity of the forest fires. The initial injection column for emissions extended up to 2 km and the parameterization was allowed to mix the airmass to greater altitudes.

A comparison between the measurements and simulations is given in Fig. 2. The lidar backscatter ratio measurements are averaged for each day, and smoothed so that the vertical resolution matched the modeled results.

As seen in Fig. 2., the measurements and the model agree well, confirming that the observed aerosols originated from the Alaskan wildfires. The best agreement was found on July 12 and 13. On July 11 the main features of the measurement were simulated, although the top simulated aerosol altitude was lower than that observed. This appears to be due to somewhat insufficient convection in the model, since the back-trajectory retroplumes produced by FLEXPART indicate that the air up to about 8 km altitude originated from Alaska. At higher altitudes the airmass originated from well over the Pacific Ocean at more southern latitudes. Thus, the top altitude for aerosols observed at Chebogue Point was limited by differential advection rather than the actual top injection height by pyro-convection.

This paper reports measurements from the Dalhousie Raman Lidar's first campaign. Subsequent measurements have been obtained in Halifax, Nova Scotia, and in Pemberton, British Columbia, Canada. See http://aolab.phys.dal.ca/ for more information.

5. REFERENCES

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