Day and night characterization of smoke aerosols during the BORTAS experiment

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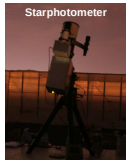
Introduction

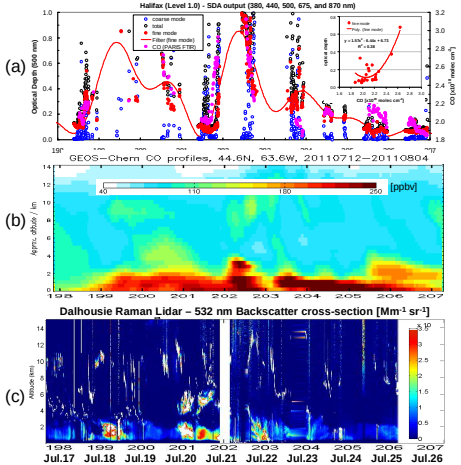


During the summer of 2011 the BORTAS (BOReal forest fires on Tropospheric oxidants over the Atlantic using Aircraft and Satellites) field campaign was carried out over eastern Canada and the western Atlantic (Palmer et al., 2013). Both passive and active optical measurements were carried out at Halifax using ground-based Sun / Star Photometry and backscatter Lidar analysis. We employed these ground-based measurements along with supporting information such as CO column concentration (ground-based FTIR), CALIPSO (satellite-based) Lidar profiles, MODIS imagery, chemical transport modeling (GEOS-Chem), and HYSPLIT back-trajectories to characterize the optical impact of smoke plumes over Halifax during an extended series of smoke events that lasted from 17-26th July 2011 and traceable to forest fires in western Ontario.

Analysis Overview

The principal objective of this communication is to demonstrate the spatial and temporal coherence of various ground-based, satellite and modelling sources of information. In particular we seek to show that retrievals of fine mode optical depth (AOD) at 500 nm [using the SDA technique of O'Neill et al. (2003)] confirms the presence of (fine mode) smoke and that the variation of this parameter is roughly coherent with lidar backscatter coefficient profiles, lidar depolarization ratio profiles, satellite imagery and vertical & integrated profiles of measured and modelled CO. We also illustrate the importance of day-night continuity of optical depth measured using a combination of a sunphotometer and a starphotometer.

Fine / coarse AOD retrievals at Halifax during BORTAS (17th Jul. - 26th Aug. 2011)



The figures above show, for the part of the BORTAS campaign corresponding to heavy smoke at Halifax: (a) components of the AOD variation at 500 nm derived from AEROCAN CIMEL sunphotometer at Dalhousie University (black for total AOD, red for fine mode (sub-micron) AOD, blue for coarse mode (super-micron) AOD). The red solid curve represents a boxcar filter applied in the Fourier domain. The purple filled circles represents columnar CO variation as obtained by PARIS FTIR (the insert graph shows a scattergram of daily averaged CO vs fine mode optical depth) (b) CO concentration profiles (ppbv) as predicted by the GEOS-Chem model (c) Lidar profiles of backscatter cross-section acquired by the Dalhousie Raman Lidar (DRL).

Illustration of Smoke plume over Halifax

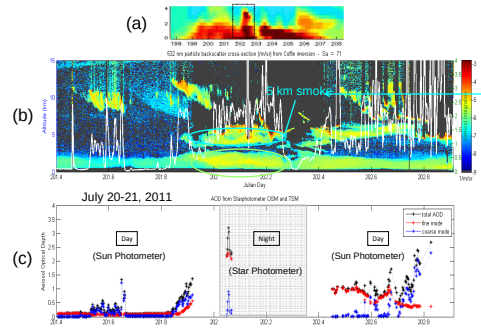
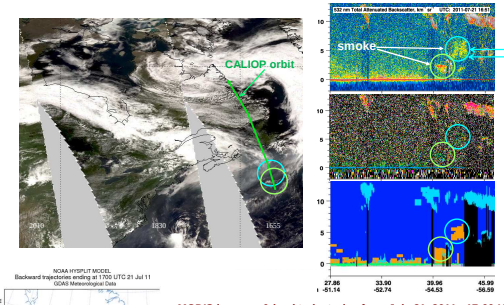
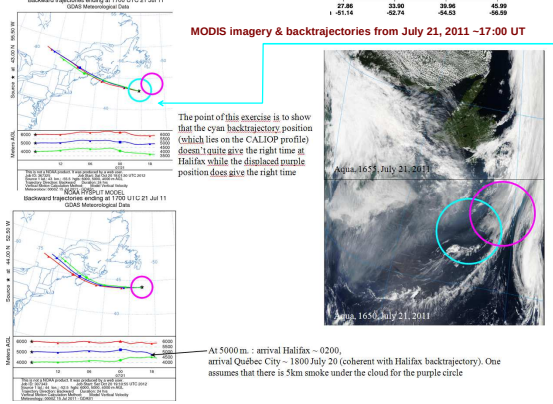


Illustration of day-night-day continuity: (a) GEOS-Chem CO profile with a rectangle showing the period of the smoke plume illustration; (b) DRL profile showing 2 plumes at ~1 km and 5 km altitude (around 202.1 or 02:40 UT July 21). The white solid curve is the estimated DRL optical depth; (c) Day (sunphotometer) and night (starphotometer) retrievals of total, fine and coarse mode OD. The utility of the nightime retrievals is evident since we succeeded in capturing the strong fine mode incursion due to the 1 km and 5 km plumes.

PARASOL & CALIOP Imagery, July 21, 2011, ~15 h after Halifax smoke events (nominally taken at 02:00 UT)



MODIS imagery & backtrajectories from July 21, 2011 ~17:00 UT

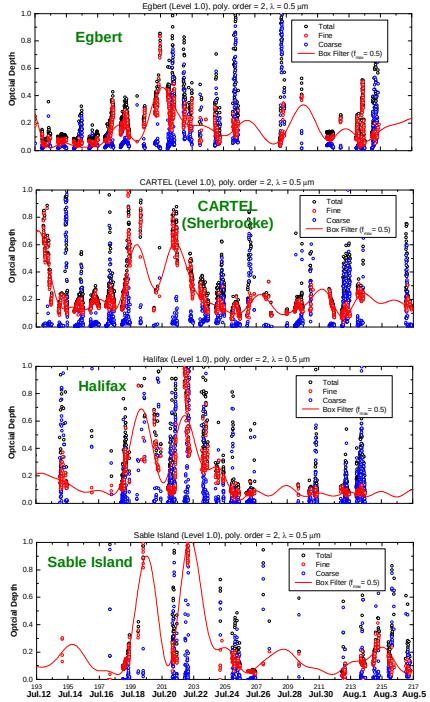


The point of this exercise is to show that the cyan backtrajectory position (which lies on the CALIOP profile) doesn't quite give the right time at Halifax while the displaced purple position does give the right time

At 5000 m. : arrival Halifax ~ 0200, arrival Québec City ~ 1800 July 20 (coherent with Halifax backtrajectory). One assumes that there is 5km smoke under the cloud for the purple circle

PARASOL, CALIOP, MODIS and backtrajectory evidence for the dynamics of the 5 km smoke plume. The three CALIOP profiles next to the PARASOL imagery on the left, show, from top to bottom, attenuated backscatter coefficient (km^{-1}), depolarization ratio and particle-type classification. Note the low depolarization ratios for the two CALIOP plumes (a signature for smoke) and the assignment of an aerosol class to those two plumes.

Retrievals of fine and coarse mode AOD for AEROCAN Sites



SDA Fine and coarse mode retrievals during the BORTAS campaign (12th July – 5th August 2011) showing the dominance of fine mode optical depth variation at four Canadian AEROCAN / AERONET sites. The diurnal (convex shaped) variation at CARTEL (Sherbrooke) is probably an artifact due to contamination of the optics.

Case study of 21st July Smoke Event at Halifax and Sable Island

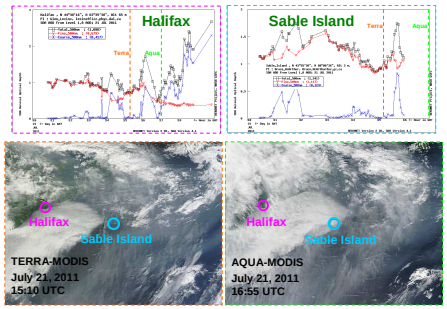
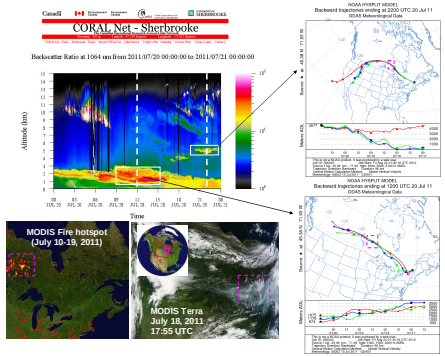


Illustration of SDA retrievals on July 21, 2011 at Halifax and Sable Island along with corresponding Terra and Aqua images, which shows the impact of smoke.

Lidar profile & back-trajectories at Sherbrooke



Example of backtrajectory analysis from smoke plumes at the CORALNet Sherbrooke (CARTEL AEROCAN / AERONET) site and MODIS imageries showing the source of the smoke plumes.

Conclusions

Preliminary analysis indicates a physical coherence between these diverse data elements including day / night continuity of the submicron (smoke) optical depths derived from the sun and star photometer spectra and covariance between the passively derived optical depths and those from the Raman lidar (further analysis is required to cloud screen the lidar data in order to provide a approximate analogue to the fine / coarse mode separation of the sunphotometer and starphotometer data).

References

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Acknowledgements

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