Multi-event analysis of Lidar and Sunphotometer observations acquired at a site in Southern Canada (steps towards a regional climatology)

Environment Canada / Environnement Canada

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Objective: To characterize regional aerosols at a rural / urban site (Egbert, Ontario) using active and passive remote sensing techniques. This is part of a more long term objective to characterize the key link between sunphotometry AODs and lidar backscatter coefficient profiles, the lidar (backscatter to extinction) ratio(S_a)

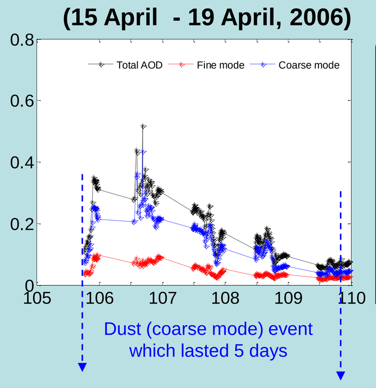
Instruments used: CIMEL Sunphotometer (AEROCAN/AERONET network), ALIAS (Aerosol LIdar for Atmospheric Studies)

Remote sensing imagery products used: MODIS (Aqua and Terra), Aerosol Index (OMI), HYSPLIT Back Trajectories

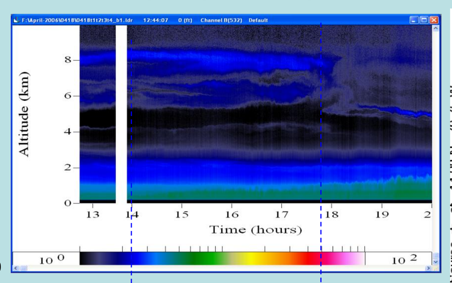
Models employed: HYSPLIT (Hybrid Single Particle Lagrangian Integrated Trajectory Model)

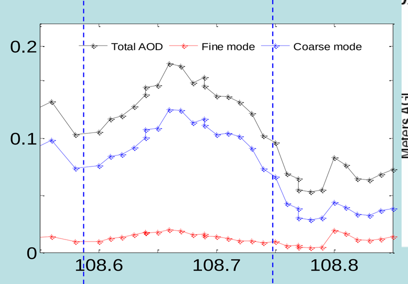
1. Long range transport of dust aerosols

AODs from CIMEL Sun Photometer (15 April - 19 April, 2006)

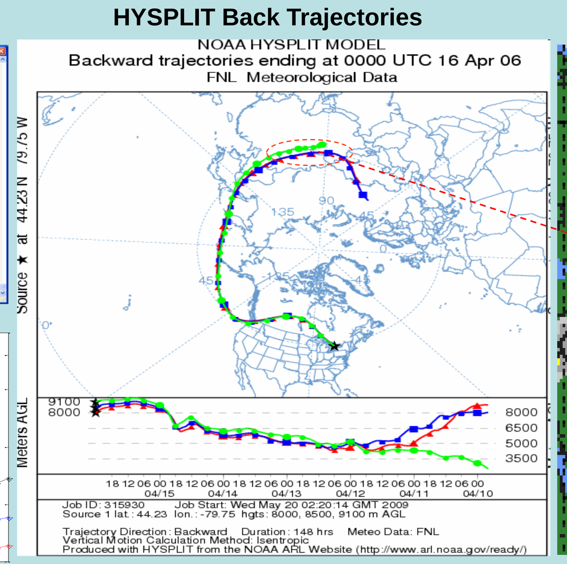


Lidar backscatter ratio (18 April, 2006)

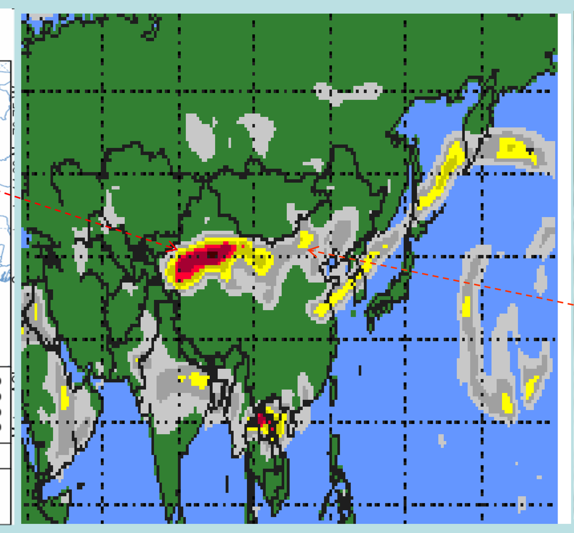




HYSPLIT Back Trajectories



OMI Aerosol Index (13 April 2006)

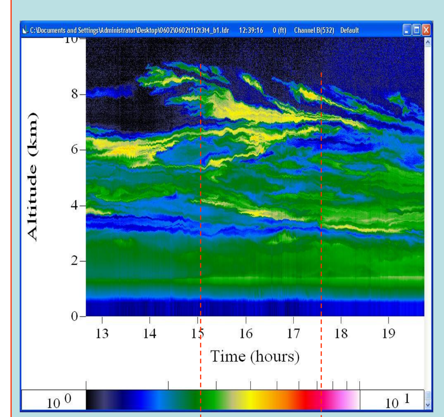


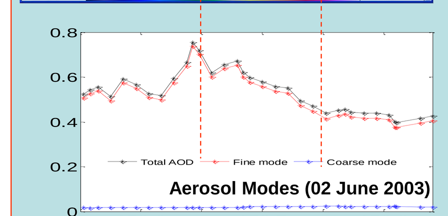
MODIS Terra 04/13/06 05:00 UTC

•Lidar profile shows a plume around 8 km which was consistent with trajectories going back to the Gobi and Taklimakan desert region. The dust plume originated from intense dust storm activity over the Gobi and Taklimakan desert near China. The coarse mode (super-micron) optical depth was dominant for at least 5 days.

2. Long range transport of smoke aerosols

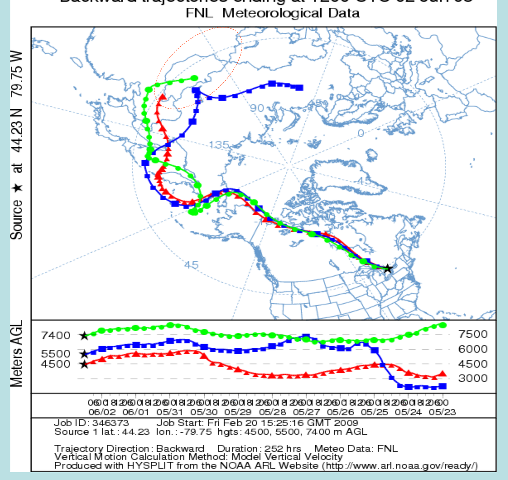
Lidar backscatter ratio (2 June 2003)



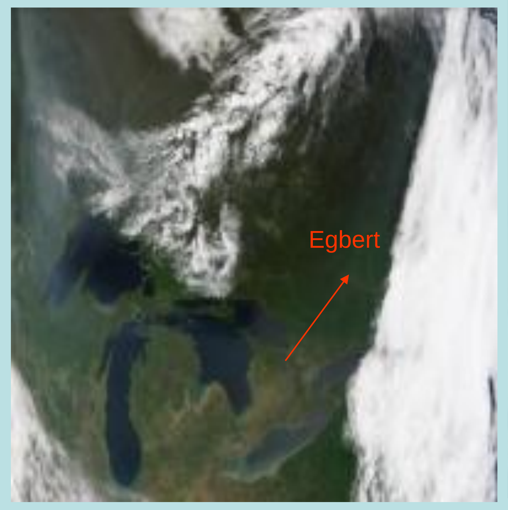


Aerosol Modes (02 June 2003)

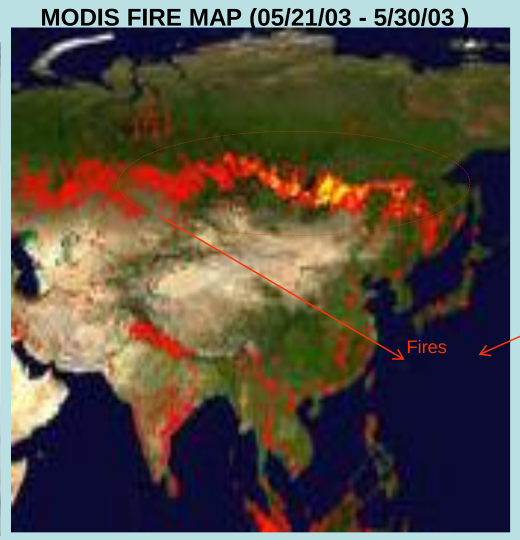
HYSPLIT Back Trajectories



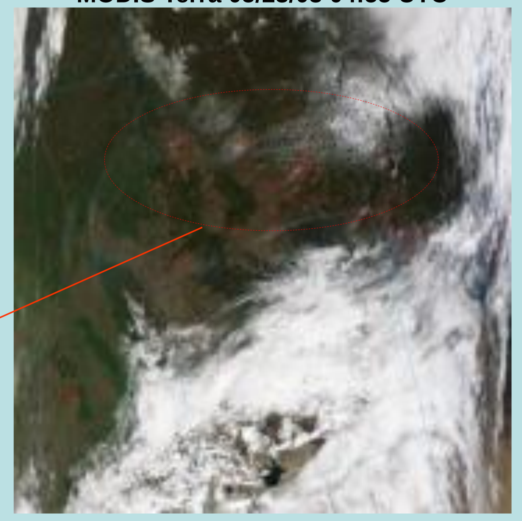
MODIS Terra 6/02/0315:30 UTC



MODIS FIRE MAP (05/21/03 - 5/30/03)



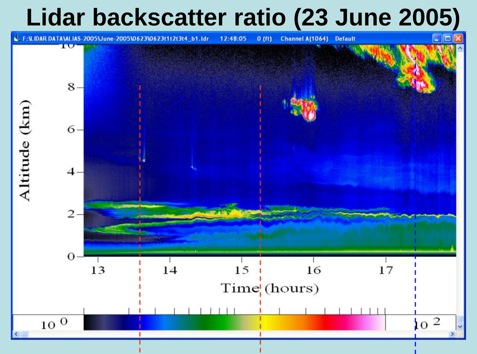
MODIS Terra 05/23/03 04:55 UTC

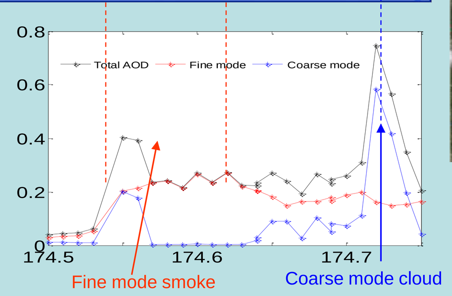


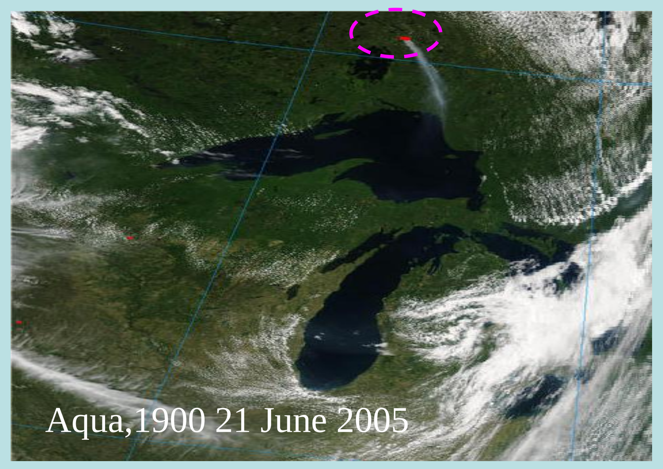
•Lidar profile shows a plume between 6 and 8 km which was coherent with trajectories going back to southern Siberia. The smoke originated about ten days earlier from intense forest fires in Siberia. The fine mode (sub-micron) optical depth was dominant on June 02, 2003.

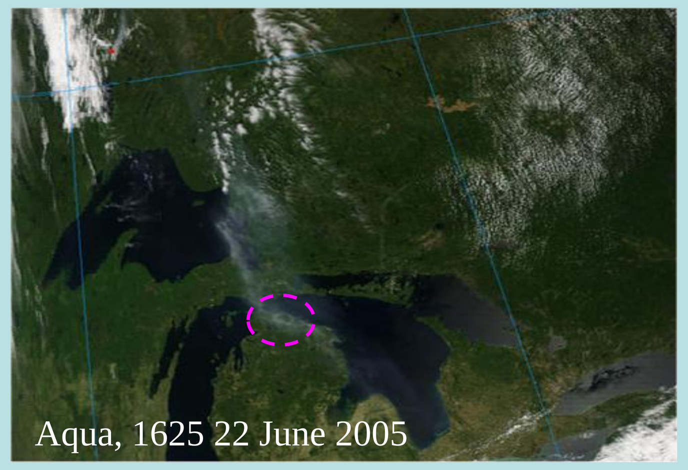
3. Regional transport of smoke aerosols

Lidar backscatter ratio (23 June 2005)

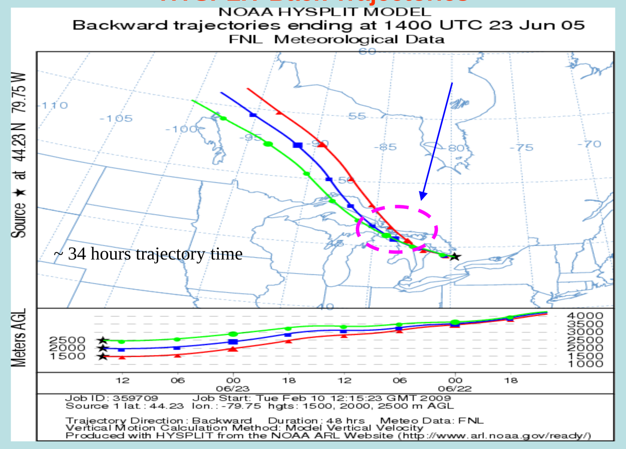








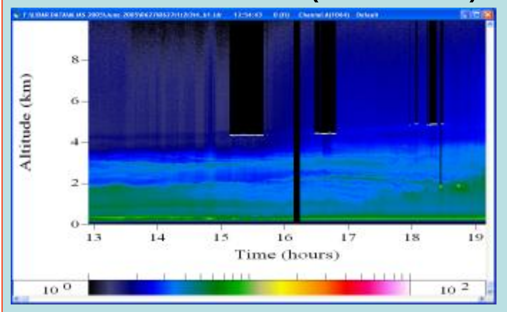
HYSPLIT Back Trajectories

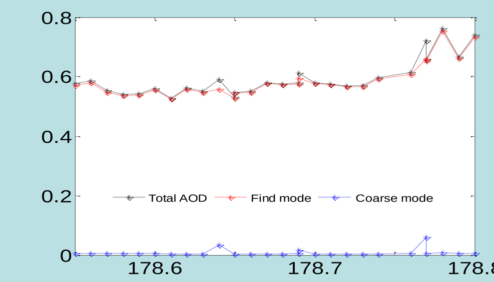


HYSPLIT Back Trajectories and MODIS Terra image suggesting that the smoke originated from forest fire activity near Lake Nipigon in Northwestern Ontario on June 21-23, 2005.

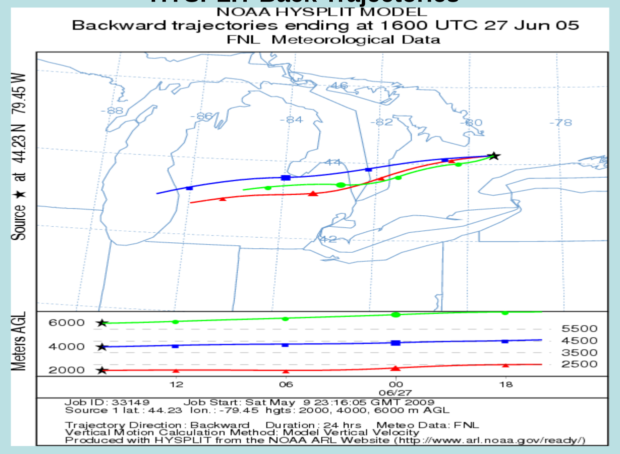
4. Pollution event

Lidar backscatter ratio (27 June 2005)

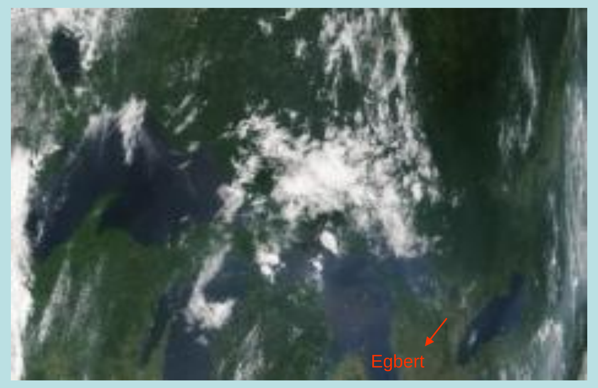




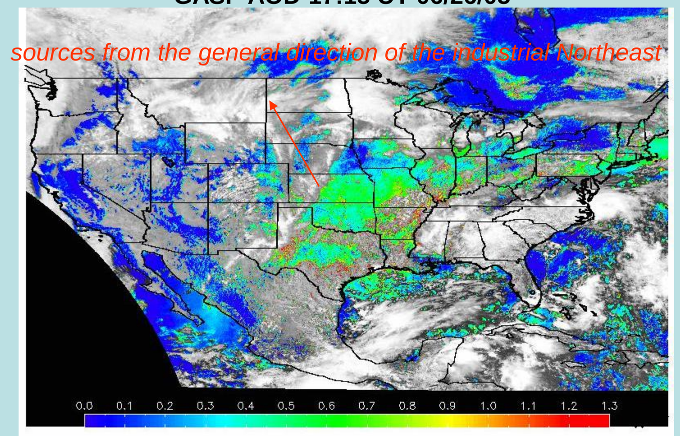
HYSPLIT Back Trajectories



MODIS Terra 06/27/05 16:40 UTC



GASP AOD 17:15 UT 06/26/05



• The event is fine-mode dominated with both fine and total AODs ~ 0.6 and both fine and total α values remaining constant throughout the day at around 1.5 (the latter value is typical of large fine-mode particles).

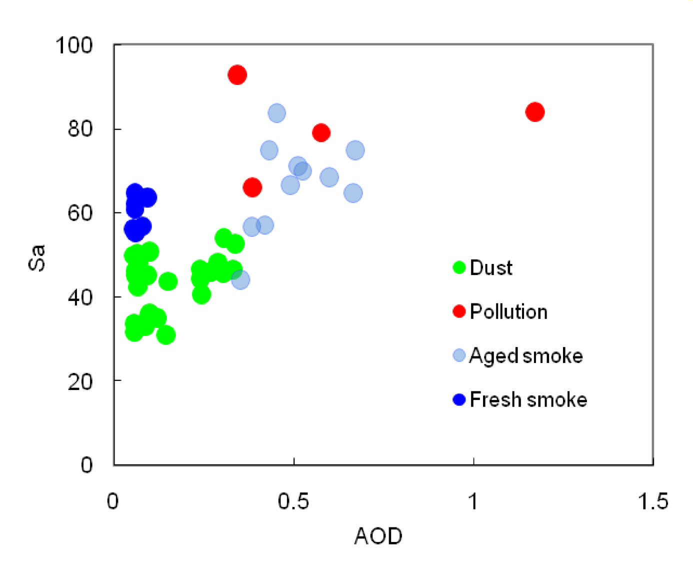
Extinction-to-backscatter ratios(Sa) for key aerosol types (linking the sunphotometry and the lidar profiles)

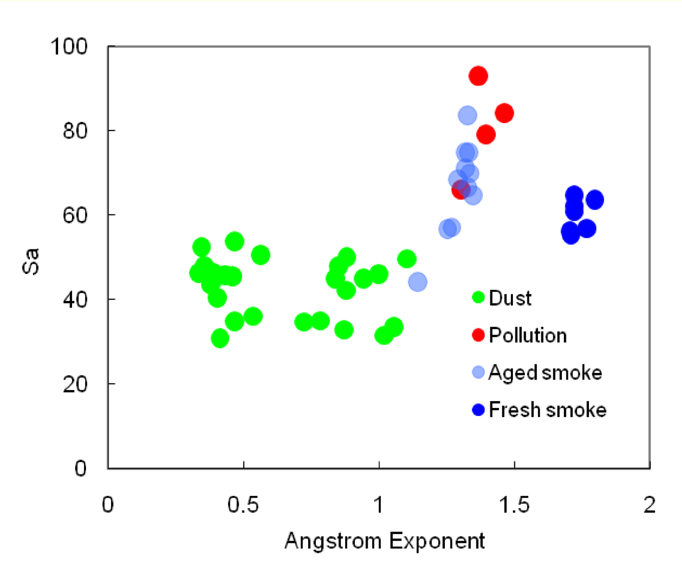
The lidar (extinction-to-backscatter) ratio is the key to linking sunphotometer AODs with integrated profiles of lidar backscatter coefficient (the next step in our analysis). They were computed for key aerosol types of dust, aged smoke, fresh smoke and pollution events at 0.5 µm on the basis of selected retrievals of aerosol properties from AEROCAN/ AERONET over Egbert. The Lidar ratio has been calculated from the following equation(Muller et al., 2003; Dubovik et al., 2006)

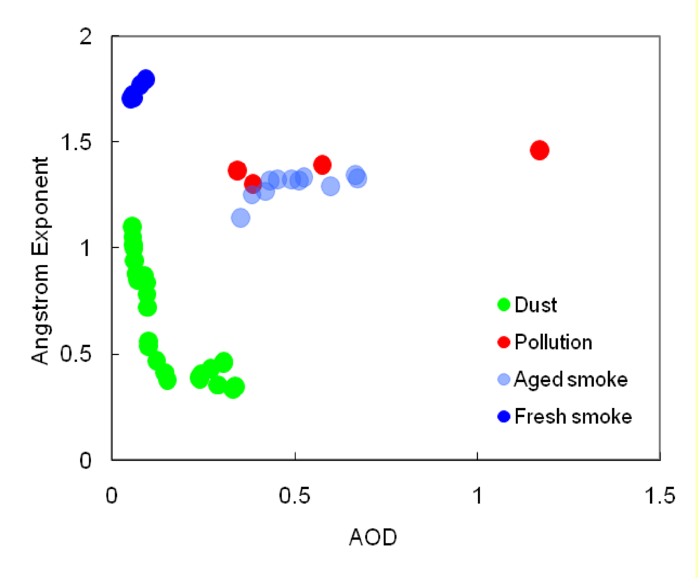
$$S_a(\lambda) = \frac{4\pi}{\omega_{0,a}\, p_a(\cos\pi)}$$

•Low mean values of the lidar ratio, S_a, at 0.5 µm for desert dust ($<S_a> \cong 43$ sr) aerosols are clearly distinguishable from biomass burning (Aged smoke: $<S_a> \cong 67$ sr and Fresh smoke $<S_a> \cong 60$ sr) aerosols and pollution ($<S_a> \cong 81$ sr).

where $p_a(\cos\pi)$ is the backscattering value of the aerosol phase function. $\omega_{0,a}$ is the single-scattering albedo. p_a at 500nm was calculated through the linear interpolation of Dubovik inversion values at 440 and 676nm.







•Our next step will be to investigate the utility of further dividing the classification scheme into coarse and fine mode domains.

Table.1 : Summary of Aerosol Optical Parameters for key aerosol types (Retrieved From AEROCAN/AERONET)

Type	Sa	α	AOD	Source Region
Dust	42.89±7	0.65±0.26	0.16±0.1	Asia
Pollution	80.58±11	1.38±0.07	0.62±0.38	Regional smog
Aged Smoke	66.59±11	1.30±0.06	0.5±0.1	Forest fires in Siberia
Fresh Smoke	59.95±4	1.73±0.03	0.07±0.02	Relatively fresh smoke aerosols from northern Ontario

•The results indicate that Sa can be coarsely classified using the Angstrom exponent and the AOD.

Conclusions

- ➢A combination of ground-based measurements coupled with remote sensing imagery products and back trajectories were used to characterize a variety of aerosol events.
- ➢ This yielded contributions to a climatology of S_a values (the essential link between sunphotometry and integrated lidar backscatter coefficient profiles)
- ➢Long term goal: a measure of the variability in S_a for key aerosol types would be useful for inverting global lidar observations (notably CALIOP).