Understanding Ozone Photochemistry in Siberian Boreal Fire Plumes using TES and OMI observations

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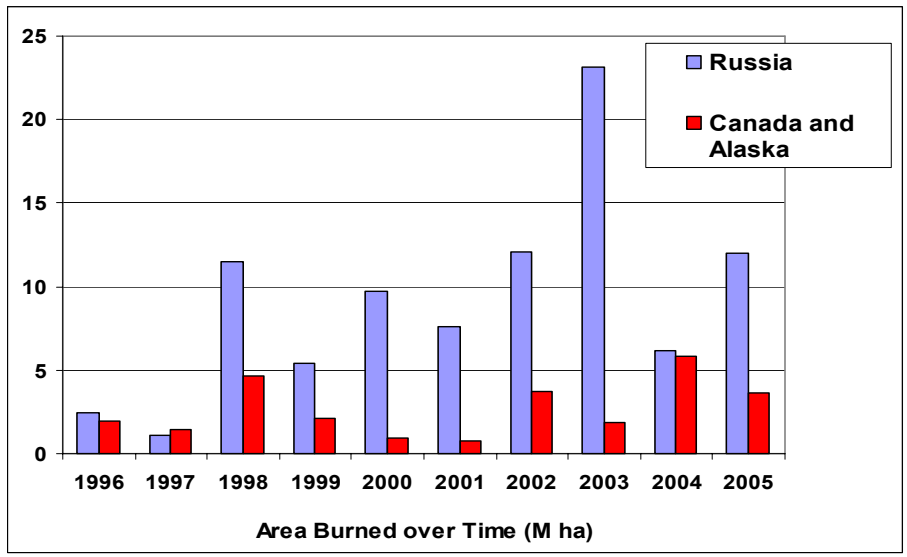
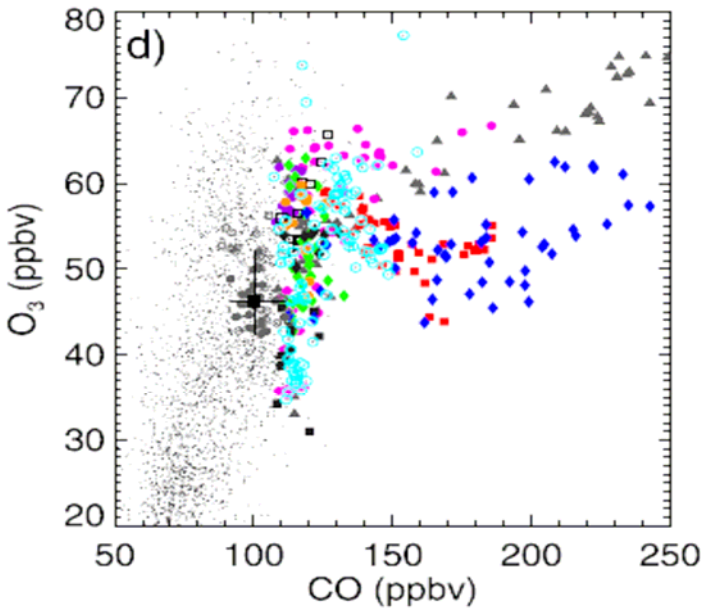
Introduction

- Dramatic increase in the size of Siberian fires in the last decade.
- Quantify the impact of boreal fires on tropospheric ozone.
- However, understanding how boreal fires impact tropospheric ozone is difficult as the ozone production in smoke plumes is highly variable (Mauzerall et al., 1998, Lapina et al., 2006, Martin et al., 2006, Real et al., 2007).



J. Crawford, LaRC

Tower Measurements of North American Smoke Plumes



O_3 / CO ratios
M. Val Martin, 2006

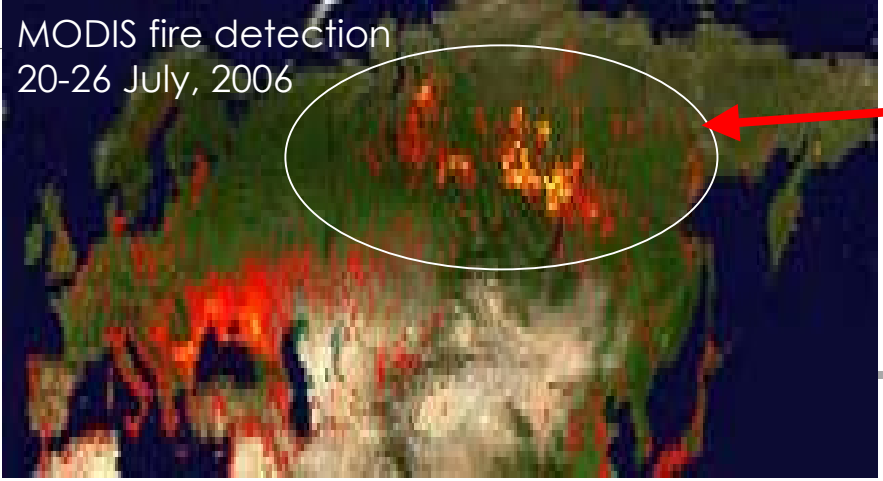
Black Dots show ozone and CO for "background" air

Colored Dots show ozone and CO for different smoke plumes

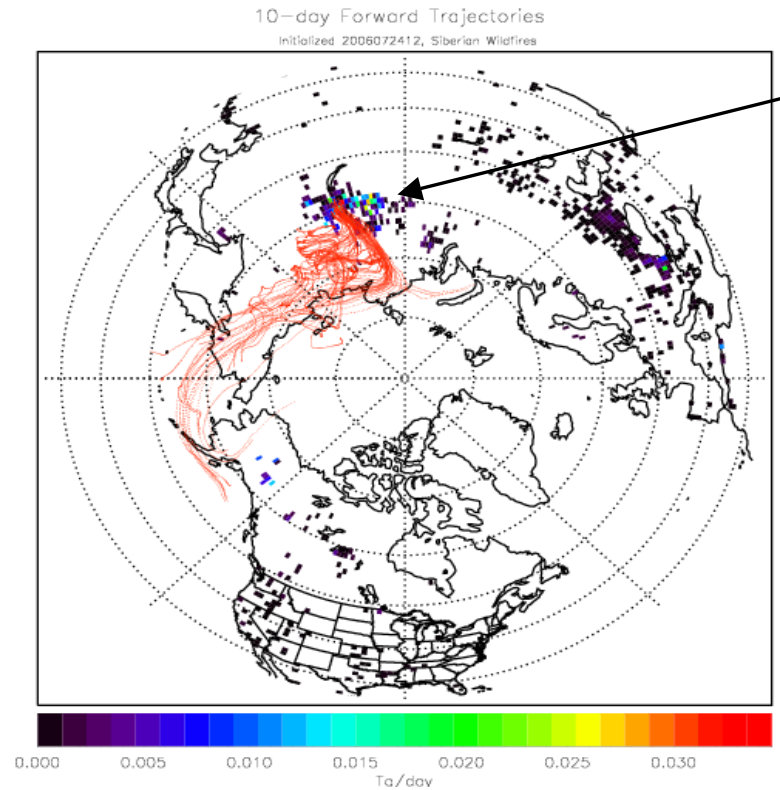
❖Ozone and CO not necessarily correlated in smoke plumes.

❖Ozone in smoke plumes is highly variable ranging from 35 PPB to 75 PPB.

To explore furthermore ozone photochemistry within smoke plumes, this study in the present context, uses satellite observations for Siberian boreal fires event 2006



- The July 2006 Siberian forest fires presents a unique opportunity for studying the ozone photochemistry and evolution in boreal fires using space-based measurements.



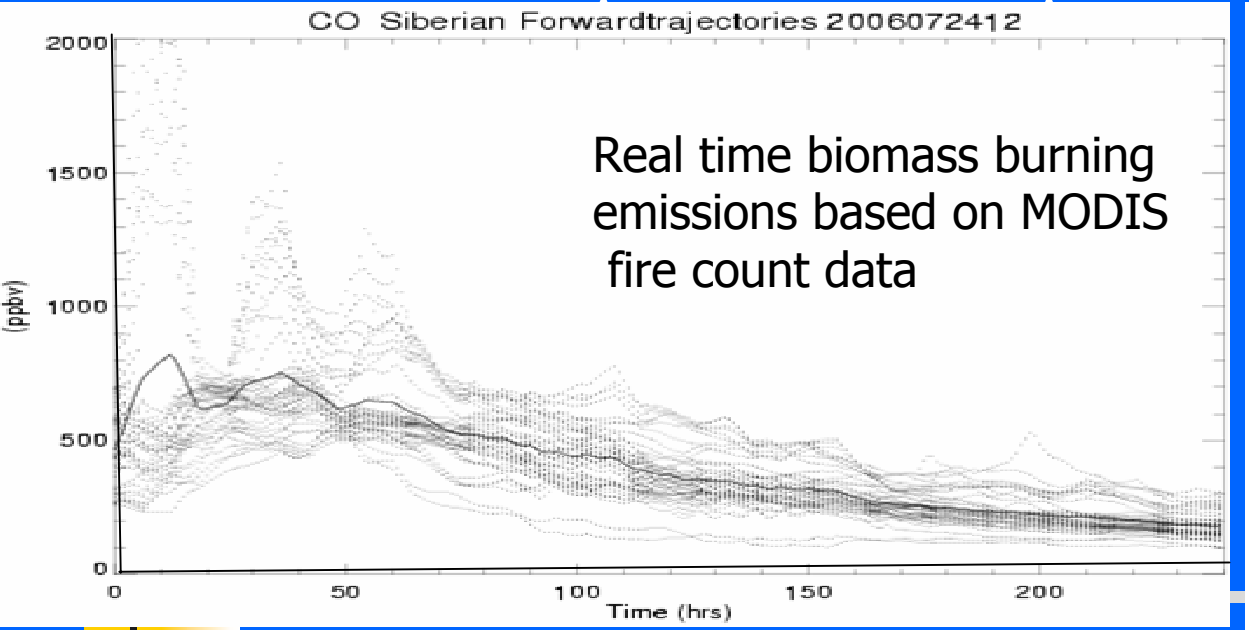
- Ten-Day forward trajectories show plume stretches from Eastern Europe to across the Pacific

Satellite data

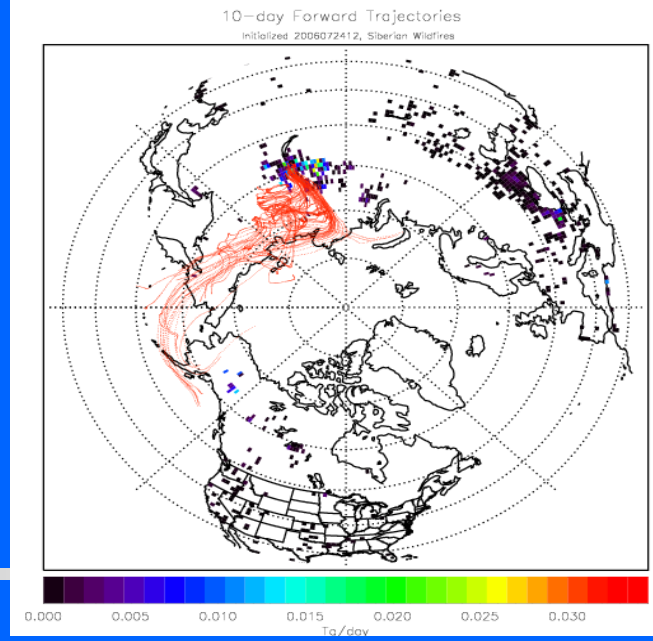
TES makes several observations of ozone and CO in the Siberian fire plume between July 15 and mid-August every other day.

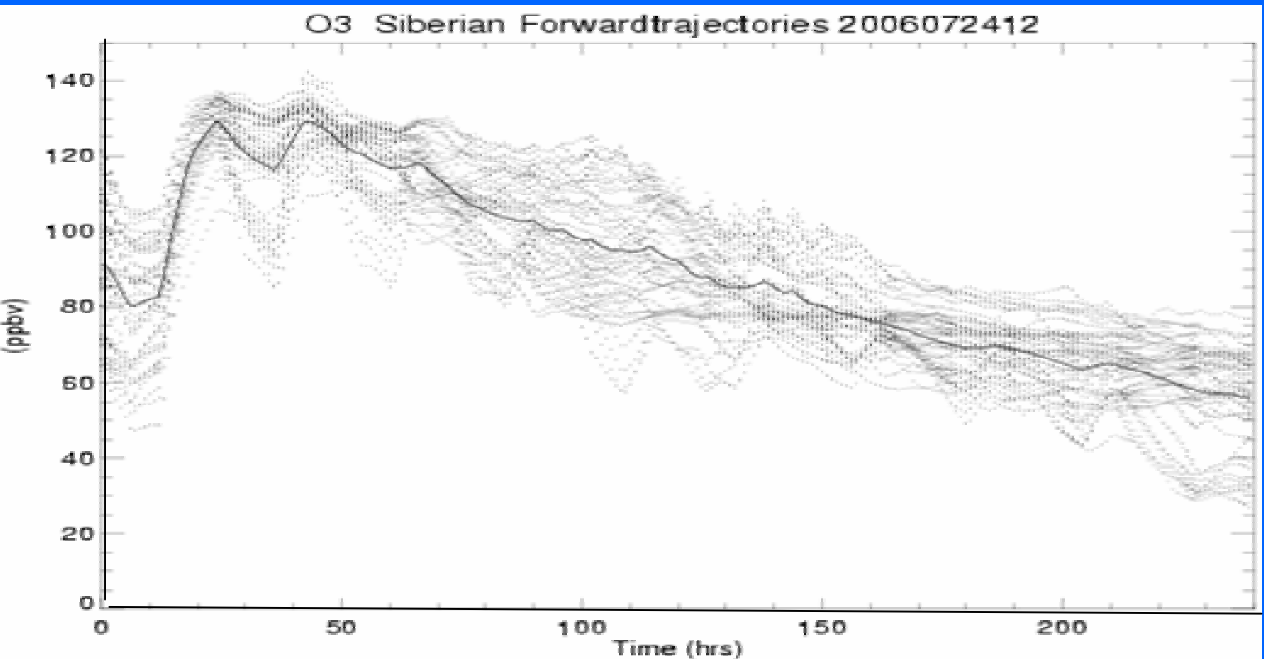
10-day forward trajectories (red) from peak Siberian wildfire emissions on July 24th, 2006. Daily wild fire emissions (Tg/day) from RAQMS real-time emissions are shown as colored dots in Siberia.

What do models expect for ozone production in Boreal Fires?



Real time biomass burning emissions based on MODIS fire count data



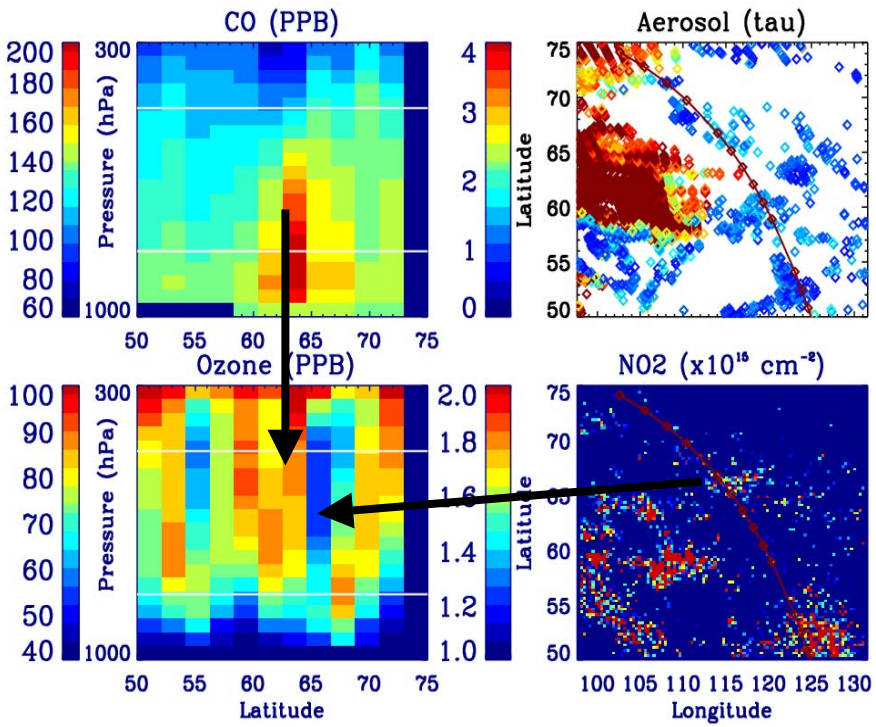


R.H.S-The 10 day forward trajectories as shown in global map. The same trajectories are being shown as a function time in L.H.S.

Significant photo-chemical production of ozone (>120 PPB) at fire source with additional production along the plume as well as mixing as we move away from fire source with time

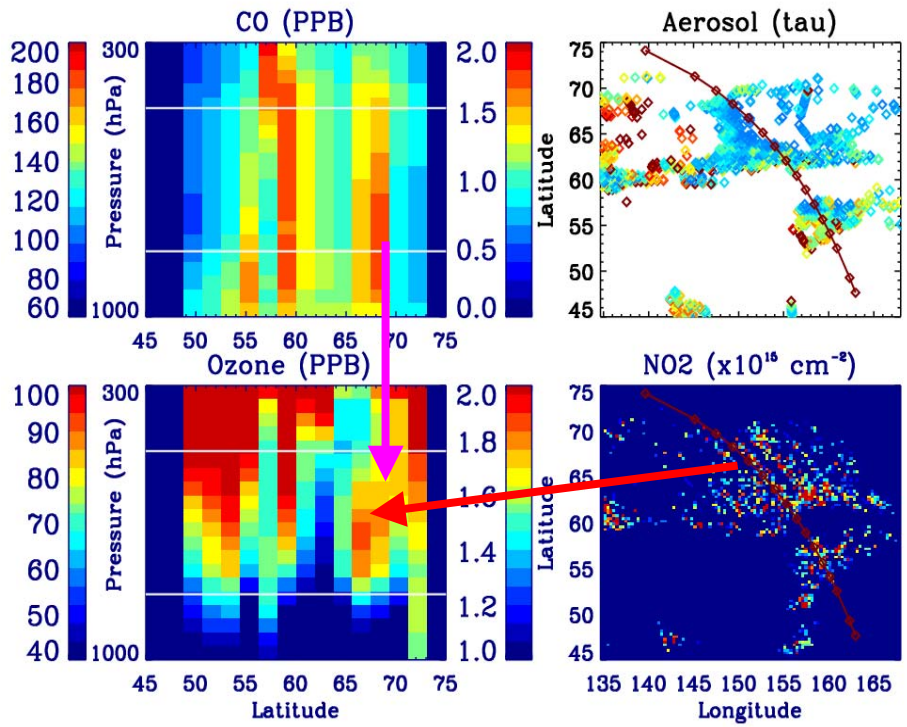
Satellite Observations of Enhanced Ozone in Boreal Fire Plume

O_3, CO, aerosol and NO_2 near Fire source



TES OMI

O_3, CO, aerosol and NO_2 in Aged Smoke Plume

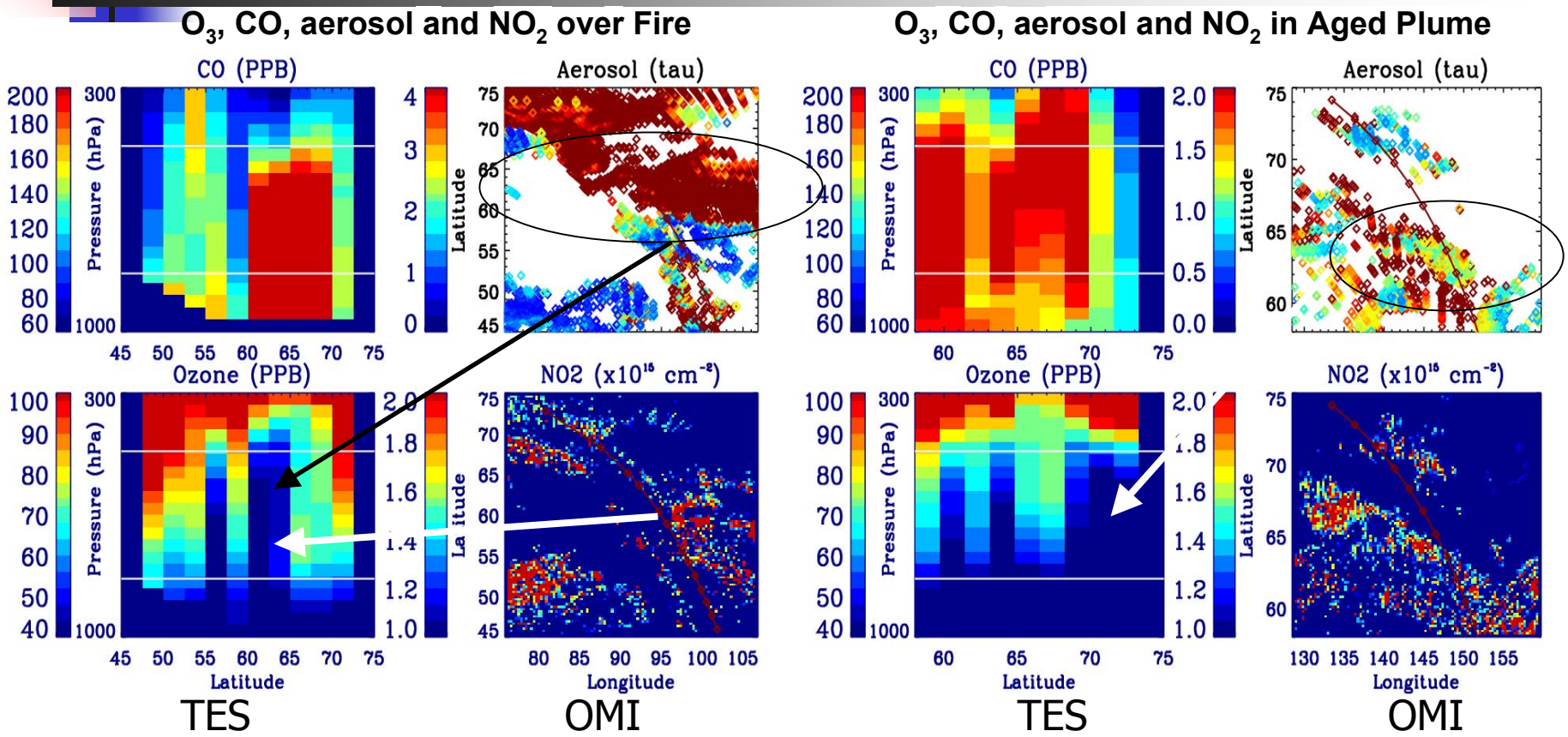


TES OMI

TES observes a significant production of ozone with a related high CO and NOx emissions but in the presence of low aerosols amounts in both fresh and aged plume conditions.

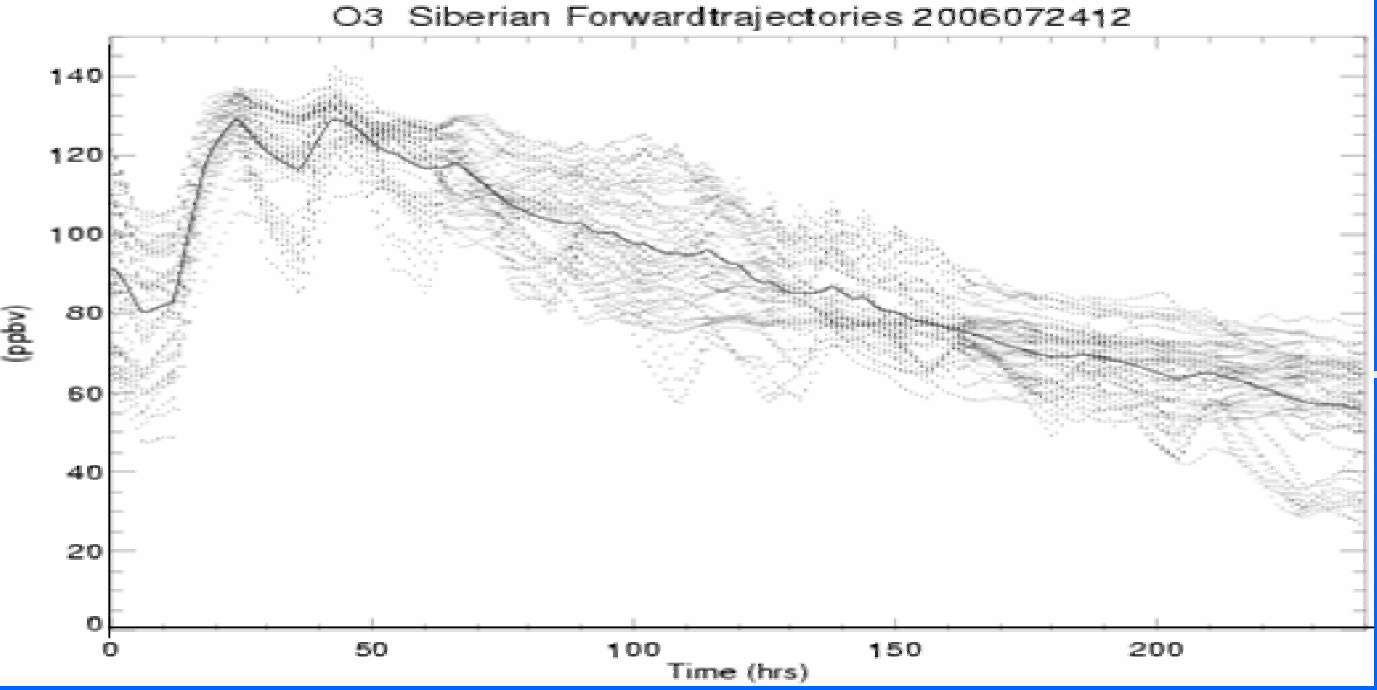
Enhanced ozone (> 90 PPB) in fresh and aged plume consistent with RAQMS model prediction

Observations of Relatively Low Ozone in Boreal Fire Plume

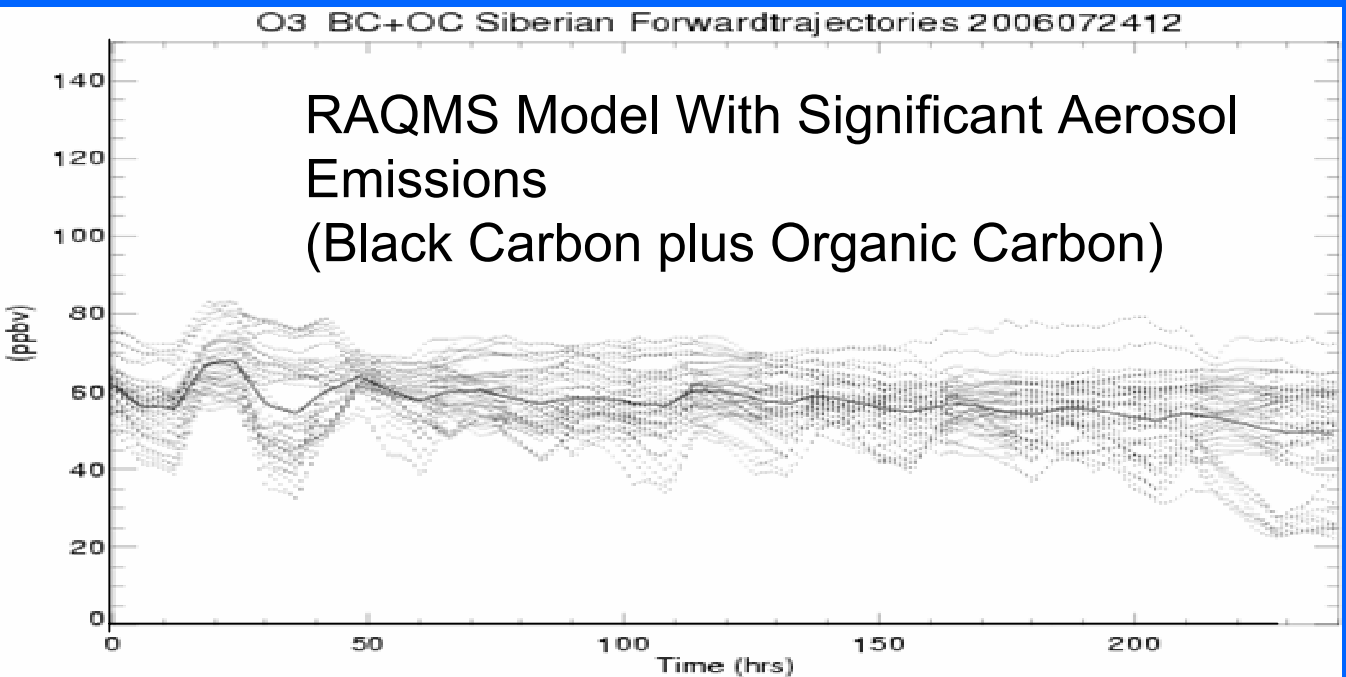


In contrast, TES also observes a relatively low ozone under similar conditions of high CO and NOx emissions but with optically thick aerosols amounts for both over fire and aged smoke plumes cases.

Hypothesis: Are aerosols inhibiting the ozone photo-chemistry in the smoke plume ?



O3 drops from 140 PPBV to ~60 ppbv with aerosols inhibiting photolysis



However, current model does not replicate low ozone observations of about 30 - 40 PPB

Summary

- Ozone production in smoke plumes is highly variable some plumes show strong ozone enhancement and others show relatively low ozone.
- Aerosols have a significant impact on the ozone photochemistry of boreal fires.
- Additional production along the plume plus mixing of air parcels also needed to characterize ozone in boreal fire plumes.

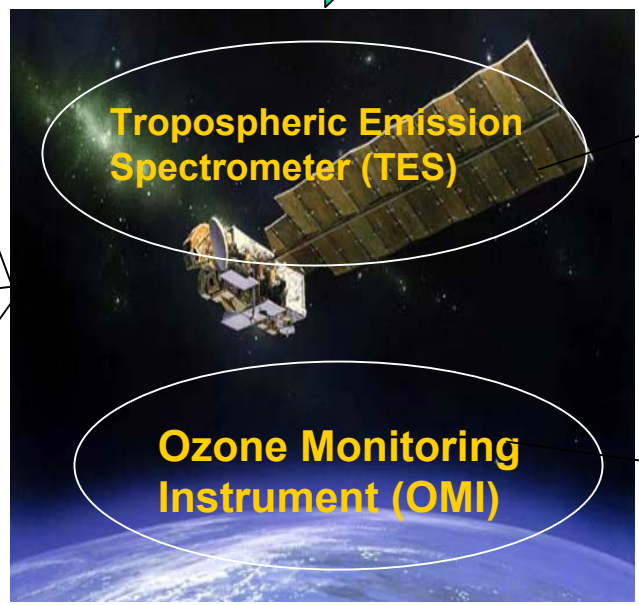
Methodology

Analysis Data
Examine co-located observations

1) Identify aged and fresh plume observations using enhanced CO values (CO > 120 PPB)

2) Connect these enhanced values to fire source using back/ forward trajectories

3) Examine ozone chemistry, and evolution in boreal smoke plume.



CO
ozone

colocated observations

Aerosol Optical depth and NOx

4) Use RAQMS model to describe evolution of ozone production and loss in boreal smoke plume and relate these processes to TES and OMI observations.