

UC Davis

UC Davis Previously Published Works

Title

Detection and Characterization of a Smoke Plume from Canadian Forest Fires during the Pittsburgh Supersite Experiment

Permalink

<https://escholarship.org/uc/item/5x0312x7>

Authors

Bein, KJ

Zhao, Y

Wexler, AS

et al.

Publication Date

2023-12-10

Peer reviewed

Detection and Characterization of a Smoke Plume from Canadian Forest Fires during the Pittsburgh Supersite Experiment

K.J. Bein, Y. Zhao, A.S. Wexler
University of California Davis

N.J. Pekney, C.I. Davidson
Carnegie Mellon University

M.V. Johnston
University of Delaware

Motivation and Hypothesis

Forest fires are very common during the summer throughout the United States and Canada and are known to produce both gas and particulate phase air pollution. Depending on the size and duration of the event, forest fires can be significant contributors to local, regional and even global air quality. Long range transport of smoke plumes from these fires is of major interest due to the possibility of transport from less populated wilderness areas and national parks to largely populated urban and residential areas. Elevated levels of PM, both mass and number, associated with these episodes could potentially increase health risks for those who are exposed. In the current work, we examine the detection of smoke plumes from a series of boreal forest fires in the Canadian province of Quebec which blanketed the eastern US for several days. Over a three day period (July 6th – 8th, 2002) during the Pittsburgh Supersite experiment, these smoke plumes were detected and measured by a single particle mass spectrometer, RSMS-3, and a high-volume sampler.

Satellite Imagery

I. Fires begin - July 5th, 2002



II. Smoke is transported south - July 6th



III. Smoke blankets most of the east coast, including Pittsburgh, PA - July 7th

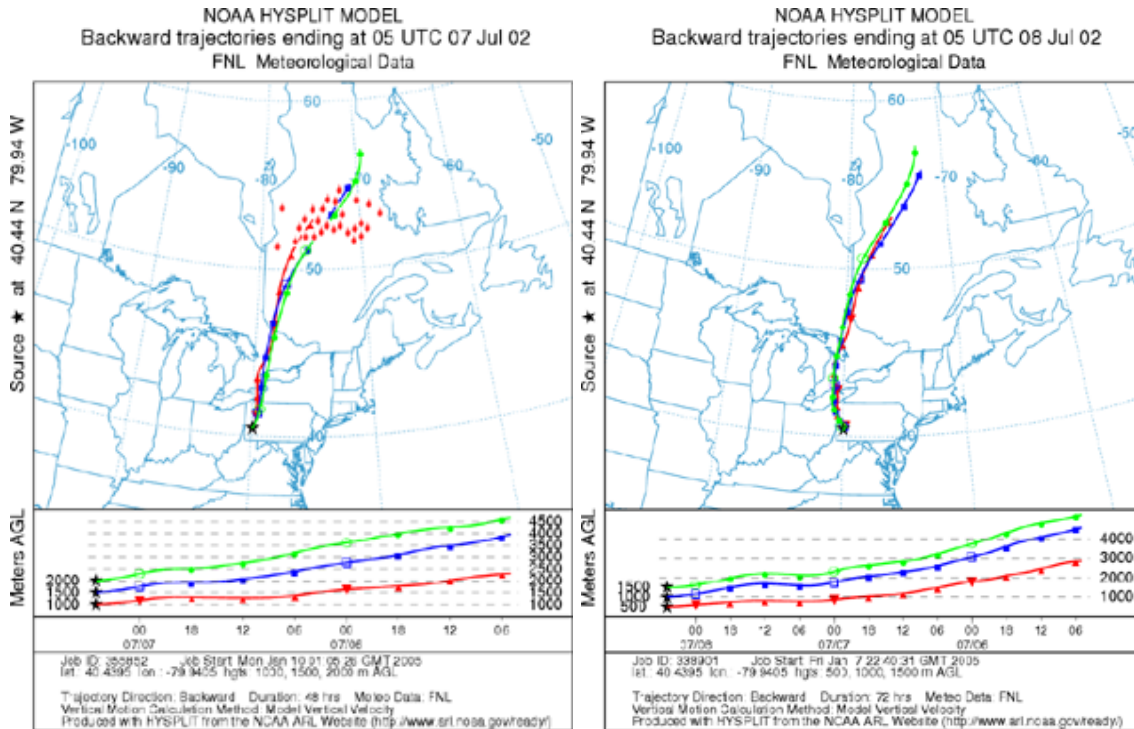


IV. Smoke begins moving out over the Atlantic - July 8th



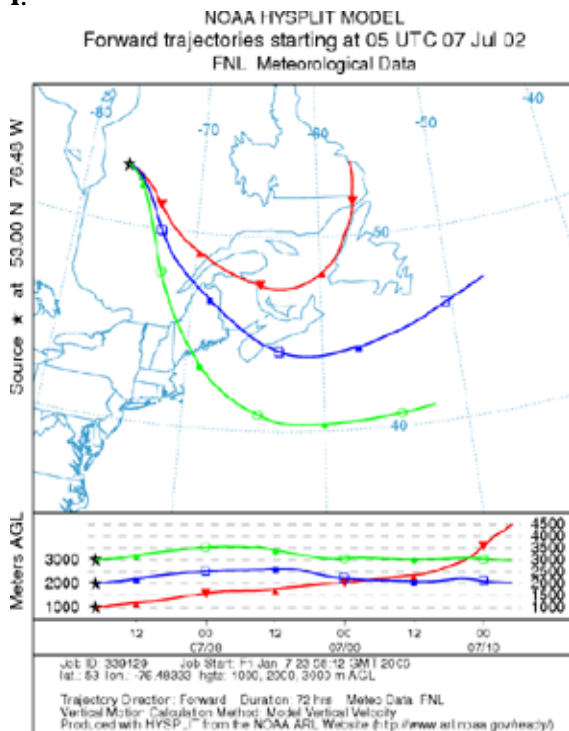
- Images taken by MODIS on the Terra satellite and are available at <http://visibleearth.nasa.gov/>

Transport - HYSPLIT Trajectories



i.

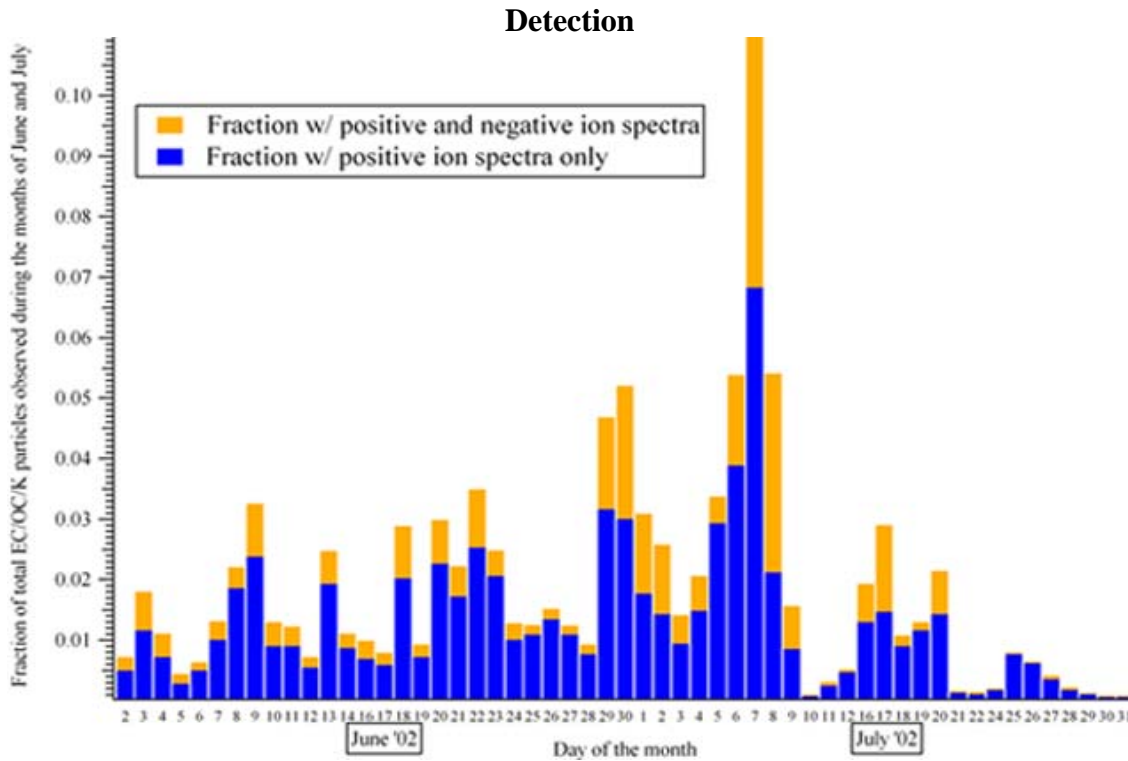
ii.



iii.

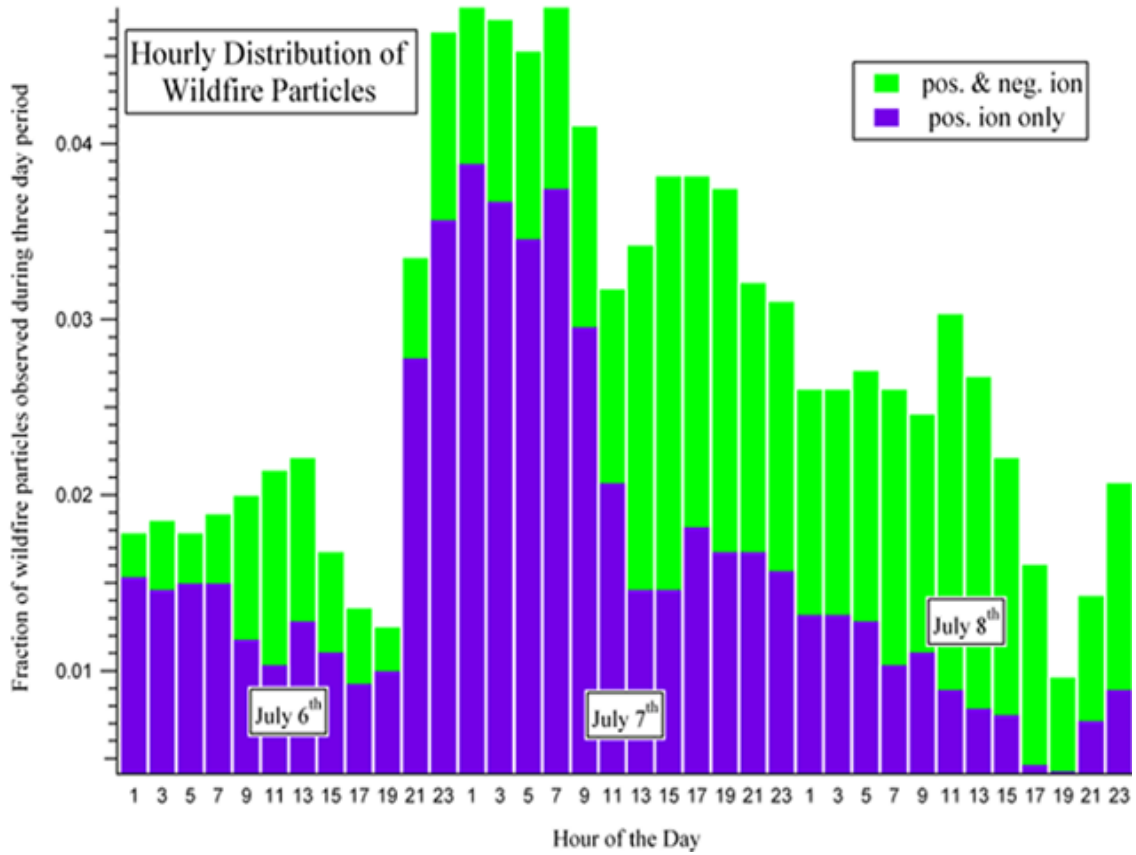
- Figures i. and ii. are 72 hour back trajectories beginning on 07/05/02, 00 EST, and 07/06/02, 00 EST, respectively.

- Wildfires were initiated by lightening early in the morning on the 5th.
- Smoke was initially injected into a 2-6 km altitude layer (Colarco et al., 2004.)
- Figures i. and ii. indicate that smoke from fires burning on the 5th reached Pittsburgh late on the 6th and continued arriving on the 7th and 8th due to burning on the 6th.
- In both figures, notice the strong subsidence from the injection height, above the fires, to boundary layer height above Pittsburgh.
- Figure iii. is a 72 hour forward trajectory beginning on 07/07/02. It indicates that smoke from fires burning on the 7th was carried SE over the Atlantic Ocean, rather than Pittsburgh, suggesting that the 8th is the final day Pittsburgh was affected by this event.

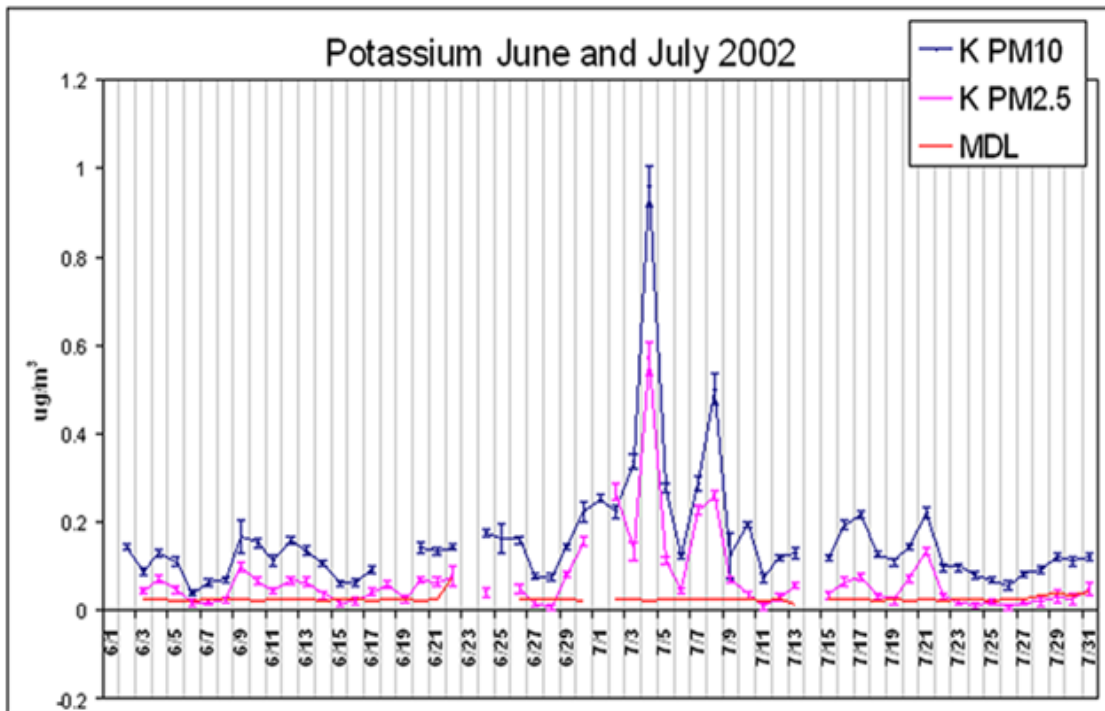


iv.

- Figure iv. shows the daily distribution of the EC/OC/K particle class, a common single particle fingerprint for biomass burning, over the months of June and July. Notice the elevated level of EC/OC/K particles detected on July 6th, 7th and 8th, corresponding to the time of the Quebec wildfires.
- The EC/OC in these particles is associated with the combustion of organic matter while the potassium is a critical trace nutrient found in almost all plants and trees. In addition to single particle data, potassium is used as a biomass burning tracer in the analysis of samples collected from filter based techniques as well.



v.



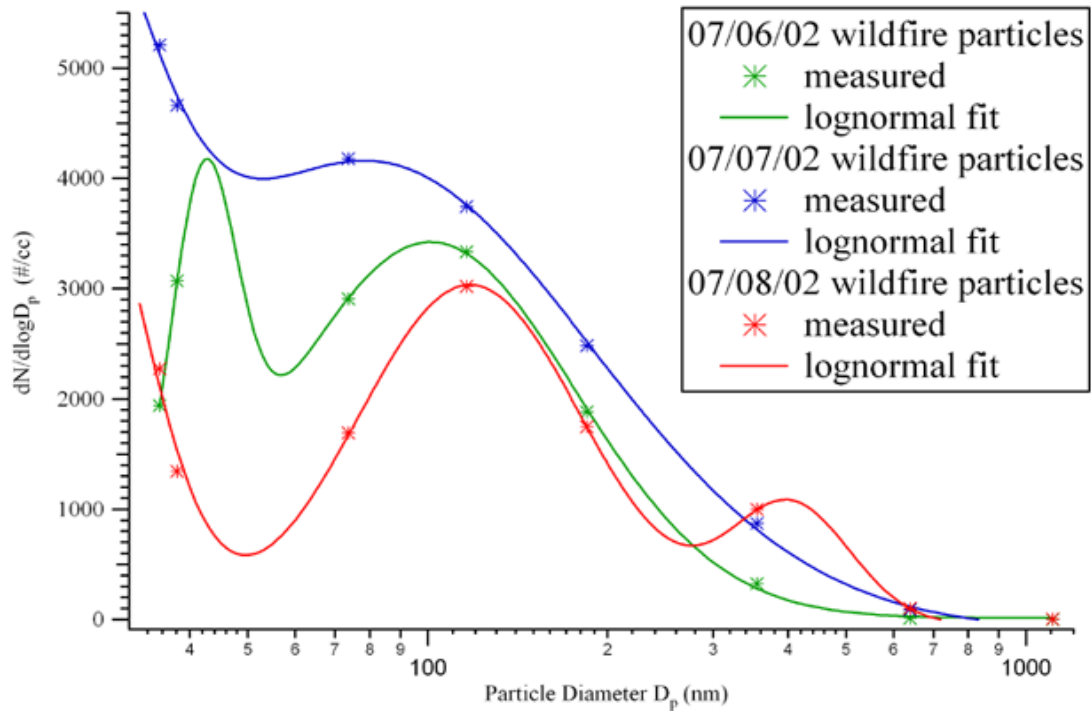
vi.

- Figure v. shows the hourly distribution of the EC/OC/K particle class over a three day period beginning 07/06/02. Notice that elevated levels of EC/OC/K particles begin arriving late on the 6th and continue through to the 8th, corresponding exactly to the indications of the HYSPLIT trajectories.

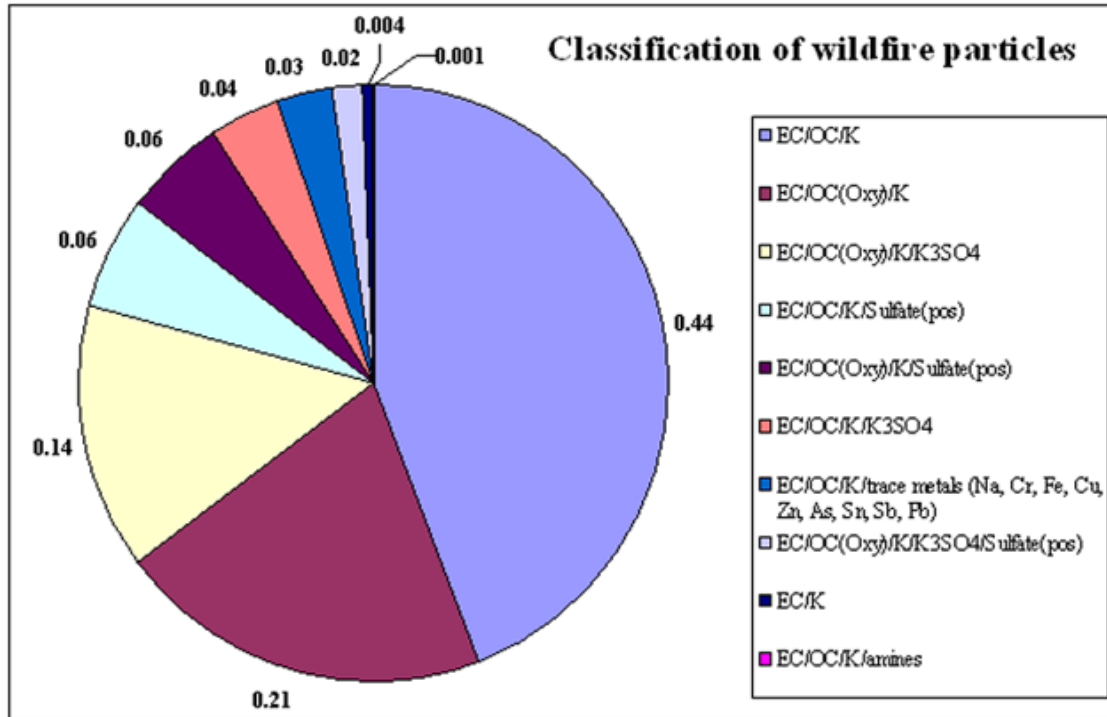
- The plot in figure vi. is the daily distribution of 24 hour PM10 and PM2.5 potassium mass concentrations, as determined by ICP-MS analysis of hi-vol samples, over the same two month period as figure iv. Notice the significantly larger concentrations of potassium on July 7th and 8th.

Particle Characteristics

I. Size and composition



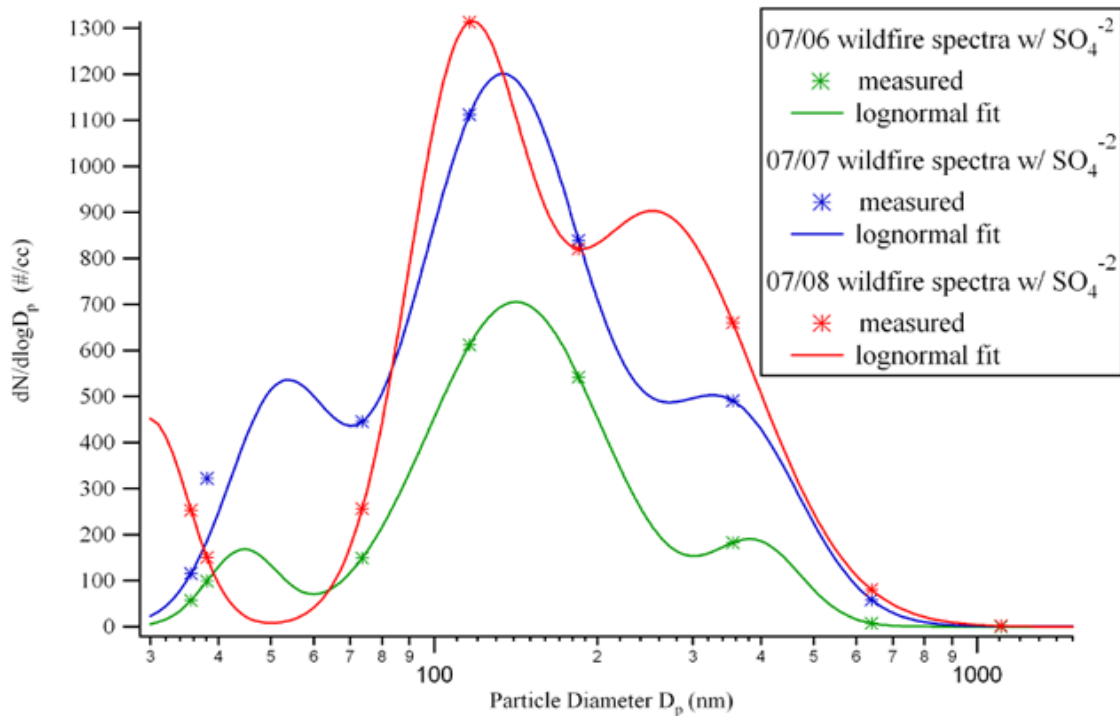
vii.



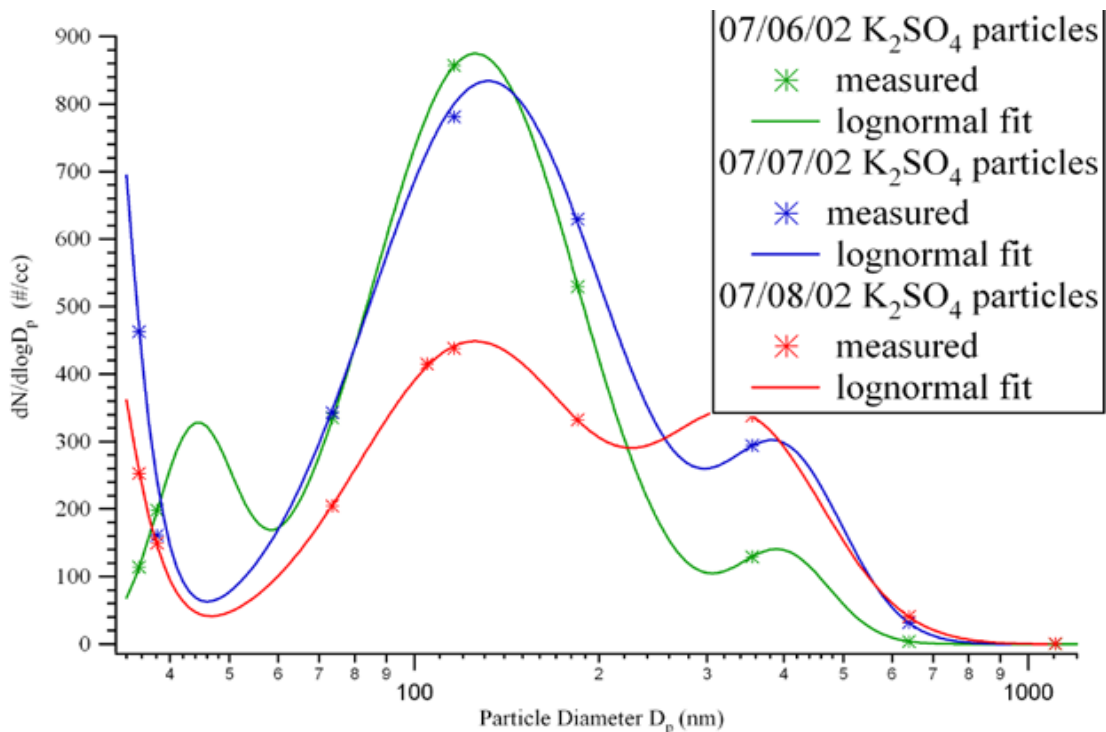
viii.

- Figure vii. shows the number distributions for wildfire particles measured on July 6th, 7th and 8th and figure viii. depicts the distribution of these particles amongst the identified wildfire particle classes.

II. Atmospheric processing



ix.



x.

- Figures ix. and x. show the number distributions for wildfire particles containing sulfate in the negative spectrum and potassium sulfate in the positive, respectively, as measured on July 6th, 7th and 8th. The sulfate in these particles is formed from the oxidation of SO₂ emitted from sources other than the fires, such that it is a secondary component and a significant number of sulfate containing particles indicates long range fire smoke transport.

Conclusion

- Over a three day period from July 6th - 8th, 2002, the Pittsburgh area was largely affected by smoke plumes originating from a series of wildfires in Quebec, Canada. This has been confirmed by satellite imagery, HYSPLIT trajectories, single particle measurements and hi-vol data.

Acknowledgements

Environmental Protection Agency for funding this research

References

Colarco et al., Transport of smoke from Canadian forest fires to the surface near Washington, D.C.: Injection height, entrainment, and optical properties, *J. Geophys. Res.*, 109, D06203, 2004.