Long-Range Transport of Smoke from Forest Fires in Alaska and Western Canada in 2004

1. Forest fire plumes during NEAQS-ITCT 2004
2. Model calculations using FLEXPART
3. VOC composition vs. the transport time
NEAQS-ITCT 2004 Experiment

NEAQS
New England Air Quality Study

ITCT (an IGAC task)
Intercontinental Transport and Chemical Transformation

Part of the ICARTT study
International Consortium for Atmospheric Research on Transport and Transformation
NEAQS-ITCT 2004 Experiment

Goals:
1. Regional Air Quality in northeastern U.S.
2. Intercontinental transport of pollution

Means:
*Airborne measurements in July and August 2004 using the NOAA WP-3*

Forest fires in Alaska and Canada!
Forest fires in North America in 2004

Fires late June and early July

Source: Center for International Disaster Information (http://www.cidi.org/wildfire/)
Forest fires in North America in 2004

Additional fires late July
Alaskan/Canadian smoke plume at sunset on July 17, as seen in the 1 km GOES-EAST visible imagery. Forest fire plumes from Alaska and western Canada were regularly observed over the eastern U.S.
Alaskan/Canadians smoke plume at sunset on July 18.
Alaskan/Canadians smoke plume at sunset on July 19.

On July 20 and 21 the WP-3 intercepted the plume here.
Measurements of acetonitrile (CH$_3$CN) clearly show the forest fire plume intercepts.

Plume intercepted over Pennsylvania on July 20

Plume intercepted over Cape Cod on July 21

Measurements of acetonitrile (CH$_3$CN) clearly show the forest fire plume intercepts.
Scatter plots of acetonitrile vs. CO show clear differences between forest fire plumes and urban outflow.

Large acetonitrile enhancements in forest fire plumes.
Scatter plots of acetonitrile vs. CO show clear differences between forest fire plumes and urban outflow. Small acetonitrile enhancements in urban plumes (New York City and Boston).
FLEXPART (Andreas Stohl; http://niwot.al.noaa.gov:8088/icartt_analysis/):
1. Lagrangian particle dispersion model
2. ECMWF and GFS meteorological data
3. Forest fire data from Center for International Disaster Information
4. Injection of emissions at 0-1, 0-3 and 0-10 km

Results from July 9 flight
FLEXPART reproduces observations very well
ECMWF data and 0-10 km injection generally give the best description of the data.
Many of the forest fire plumes were very dry:
1. The plumes have risen to high altitudes
2. Moisture has been removed by precipitation
FLEXPART can be used to estimate the transport time from the source to the time of the measurement

This work: describe the VOC composition of the plumes as a function of transport time
VOC enhancement ratios vs. CO are determined for all plume intercepts.

Results from July 9.
Most VOC enhancements decrease as a function of transport time.

- Benzene in blue removal = 0.028±0.012 day\(^{-1}\)
- Toluene in red removal = 0.20±0.07 day\(^{-1}\)

Ratio between removal rates: 7±4
Ratio between OH rate coefficients: 4.8
VOC removal rate vs. their OH rate coefficient

From a fit of a line to the data:

\[ \text{OH} = (3.2 \pm 0.9) \times 10^5 \text{ molecules cm}^{-3} \]
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Lower than OH climatology (Spivakovsky 2000): 1.75x10^6 cm^{-3} (July, 500 hPa, 52°N)
VOC removal rate vs. their OH rate coefficient

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MEK and acetic acid are removed faster than expected from their reactivity \( \Rightarrow \) wet deposition?
Low OH levels can be explained by:
1. Low humidity and NO$_x$
2. High CO

Role of oxygenated VOCs as source of HO$_x$ remains to be studied.

Results from July 20

Acetonitrile (pptv)
Conclusions

• The low humidity shows that cloud processing has occurred, yet many VOCs are still present
  Compare with Yokelson 2003 and Tabazadeh 2004:
  *Removal of methanol in cloud-processed fire plumes*

• No significant formation of secondary products is observed
  Compare with Jost 2003 and Holzinger 2004:
  *Formation of acetone and methanol in fire plumes*

• The removal of VOCs seems to be slow
  *OH levels in aged fire plumes seem to be low*

• Effects on regional air quality?
  *Smoke was observed at the surface around Boston on July 11*
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