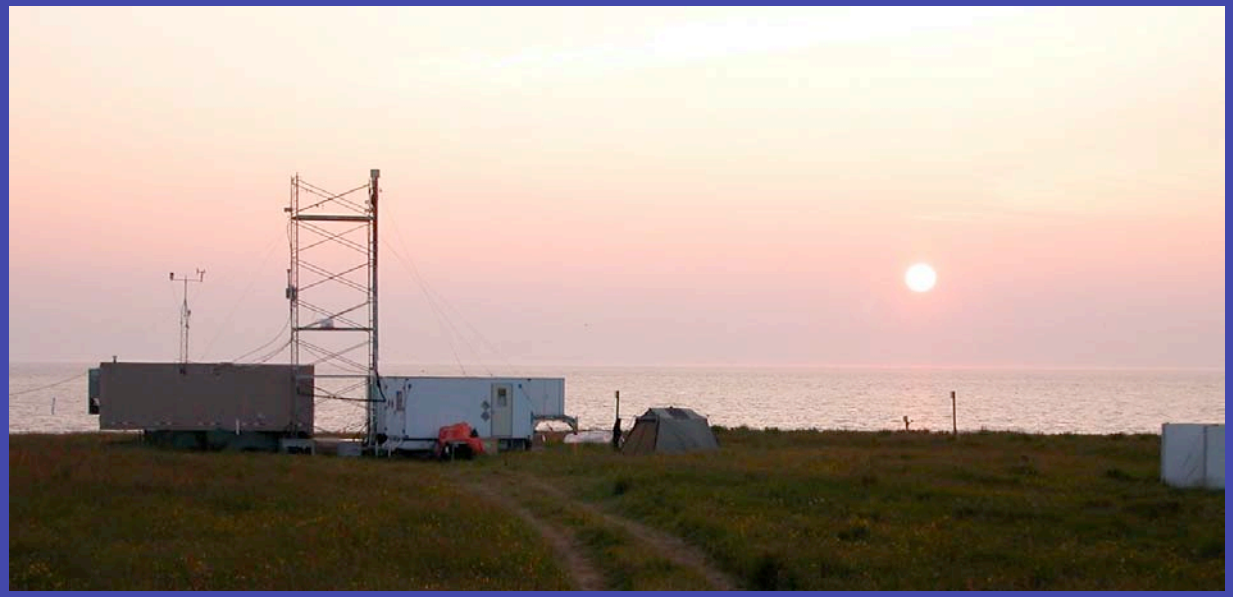
# Chemical Characteristics of Air Pollution Outflow from North America: Early Insights from Nova Scotia 2004



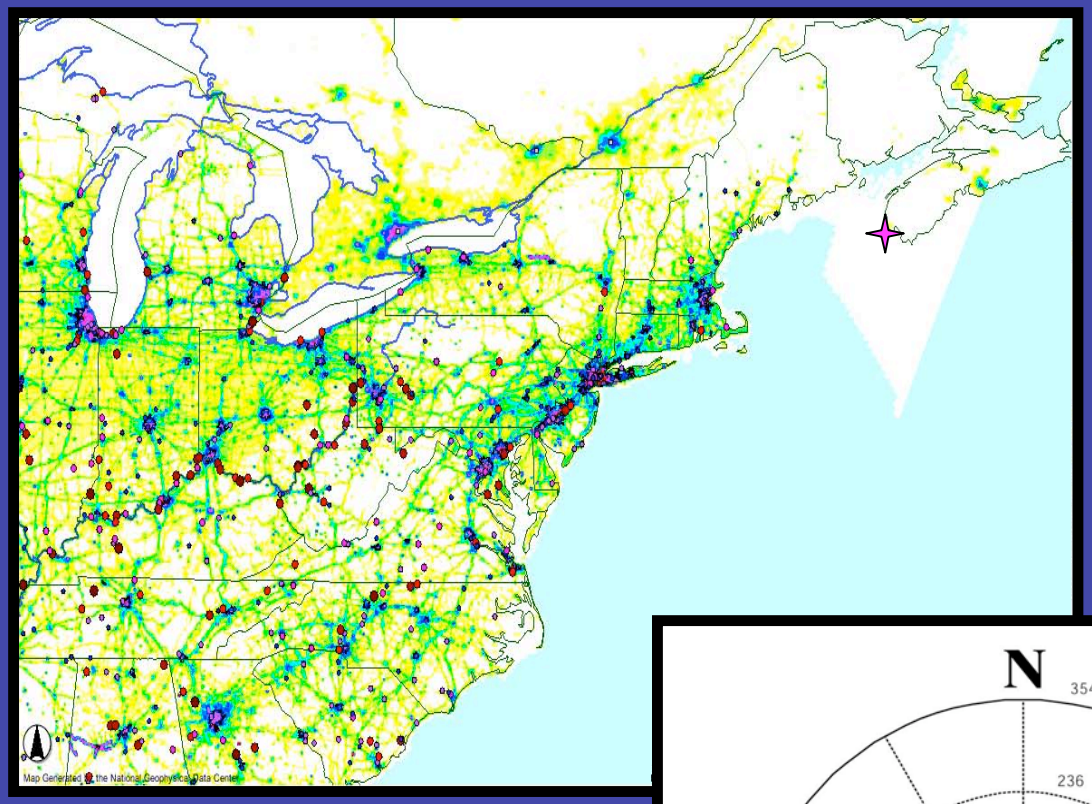
Allen Goldstein

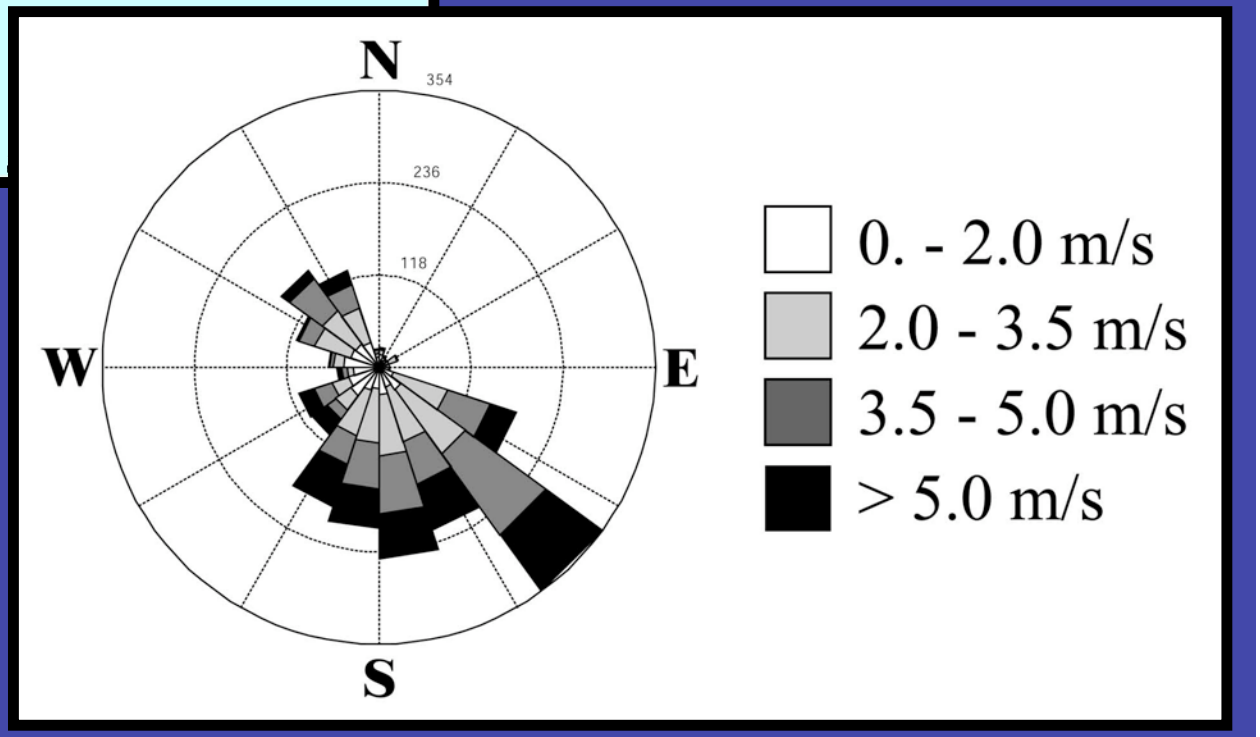
University of California, Berkeley

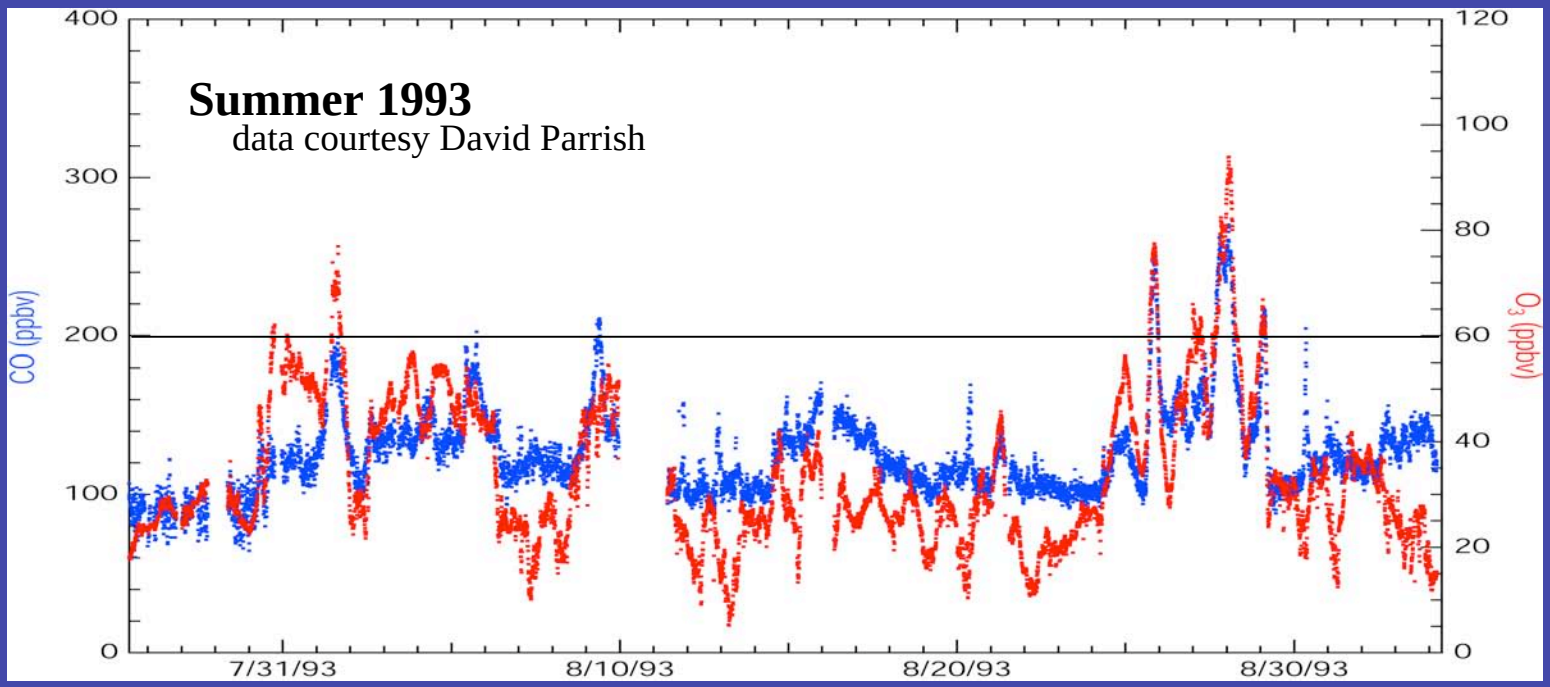
(MOSTLY PREPARED BY DYLAN MILLET)

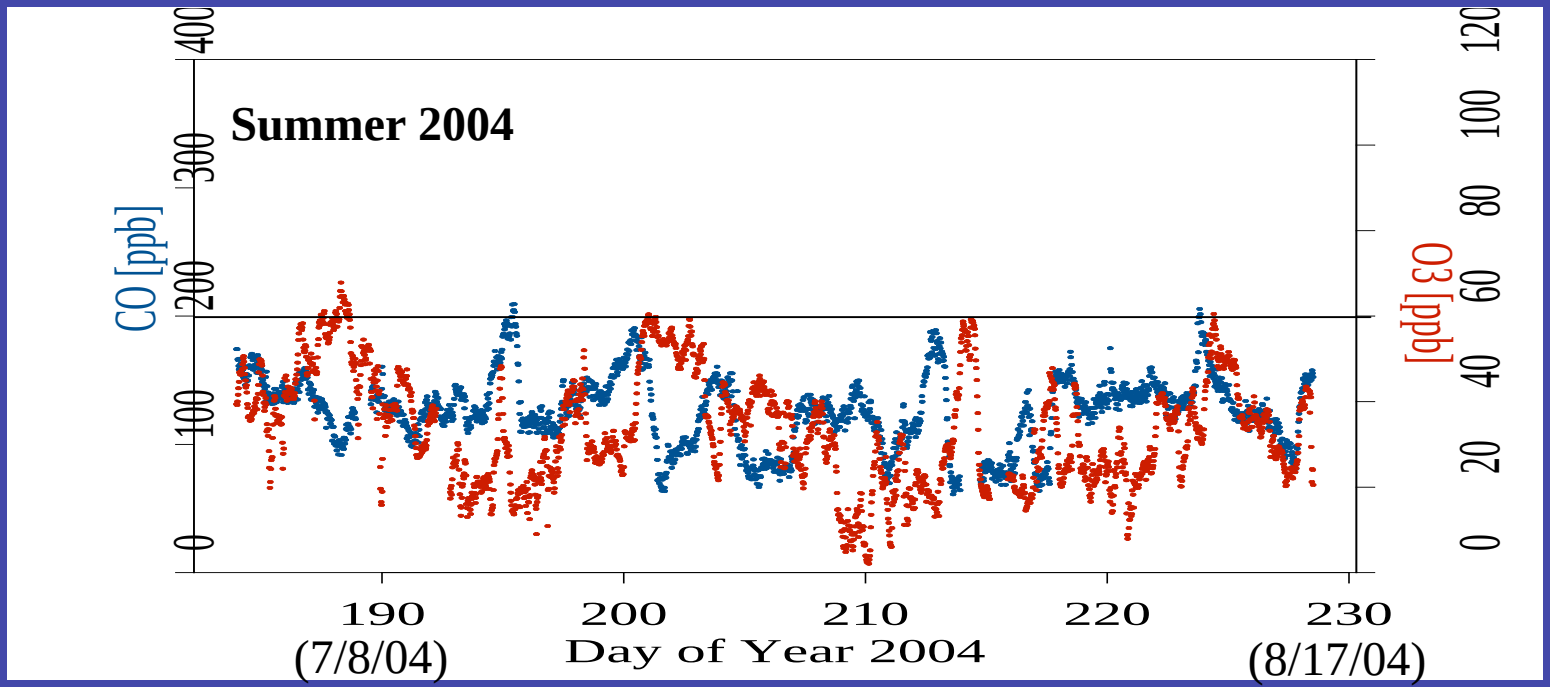
# Outline

1. Site description & comparison to 1993
2. What were the dominant processes/sources impacting atmospheric composition at CP?
3. What can the combination of VOC/TAG/AMS data tell us about organic aerosol sources & chemistry?
4. What can we say about the composition & chemistry of pollution outflow?

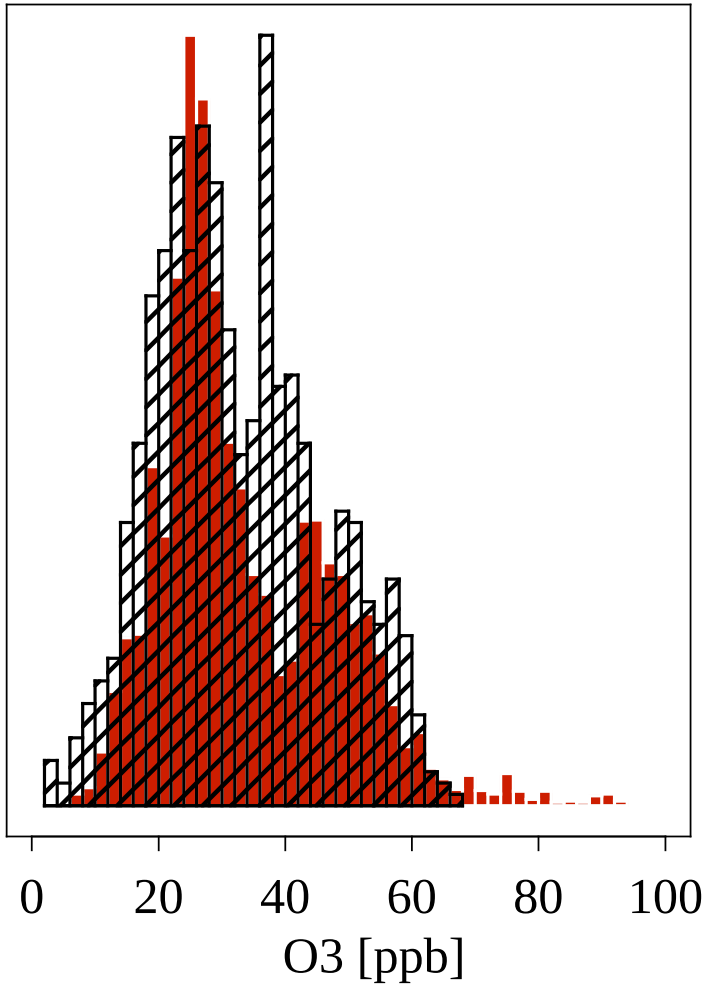

Map Generated @ the National Geophysical Data Center


N
354
236
118
W
E
S
0. - 2.0 m/s
2.0 - 3.5 m/s
3.5 - 5.0 m/s
> 5.0 m/s

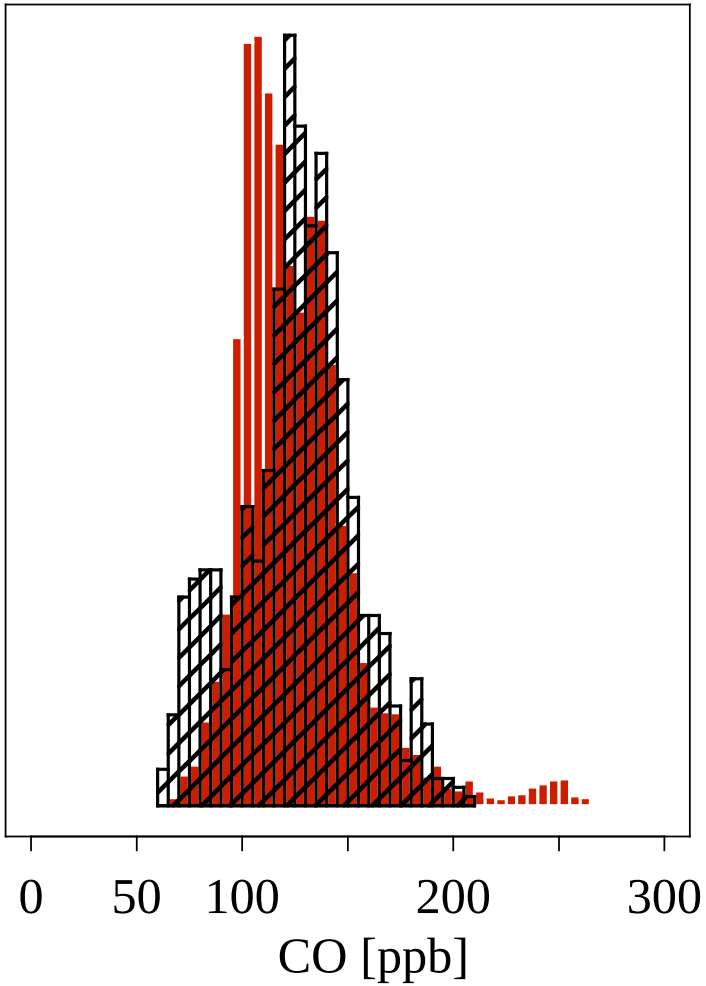

Summer 1993
data courtesy David Parrish
CO (ppbv)
O3 (ppbv)
400
300
200
100
0
120
100
80
60
40
20
0
7/31/93
8/10/93
8/20/93
8/30/93


Summer 2004
CO [ppb]
O3 [ppb]
400
300
200
100
0
120
100
80
60
40
20
0
190
(7/8/04)
200
210
220
230
(8/17/04)
Day of Year 2004

NARE 1993
MEAN O3 (PPB): 34 +/- 14 (RANGE: 5-94)
MEDIAN O3 (PPB): 30
ICARTT 2004
MEAN O3 (PPB): 33 +/- 13 (RANGE: 2-68)
MEDIAN O3 (PPB): 31




NARE 1993
MEAN CO (PPB): 126 +/- 28 (RANGE: 60-270)
MEDIAN CO (PPB): 121
ICARTT 2004
MEAN CO (PPB): 126 +/- 28 (RANGE: 63-206)
MEDIAN CO (PPB): 128



# Factor Analysis

F1: US dominated

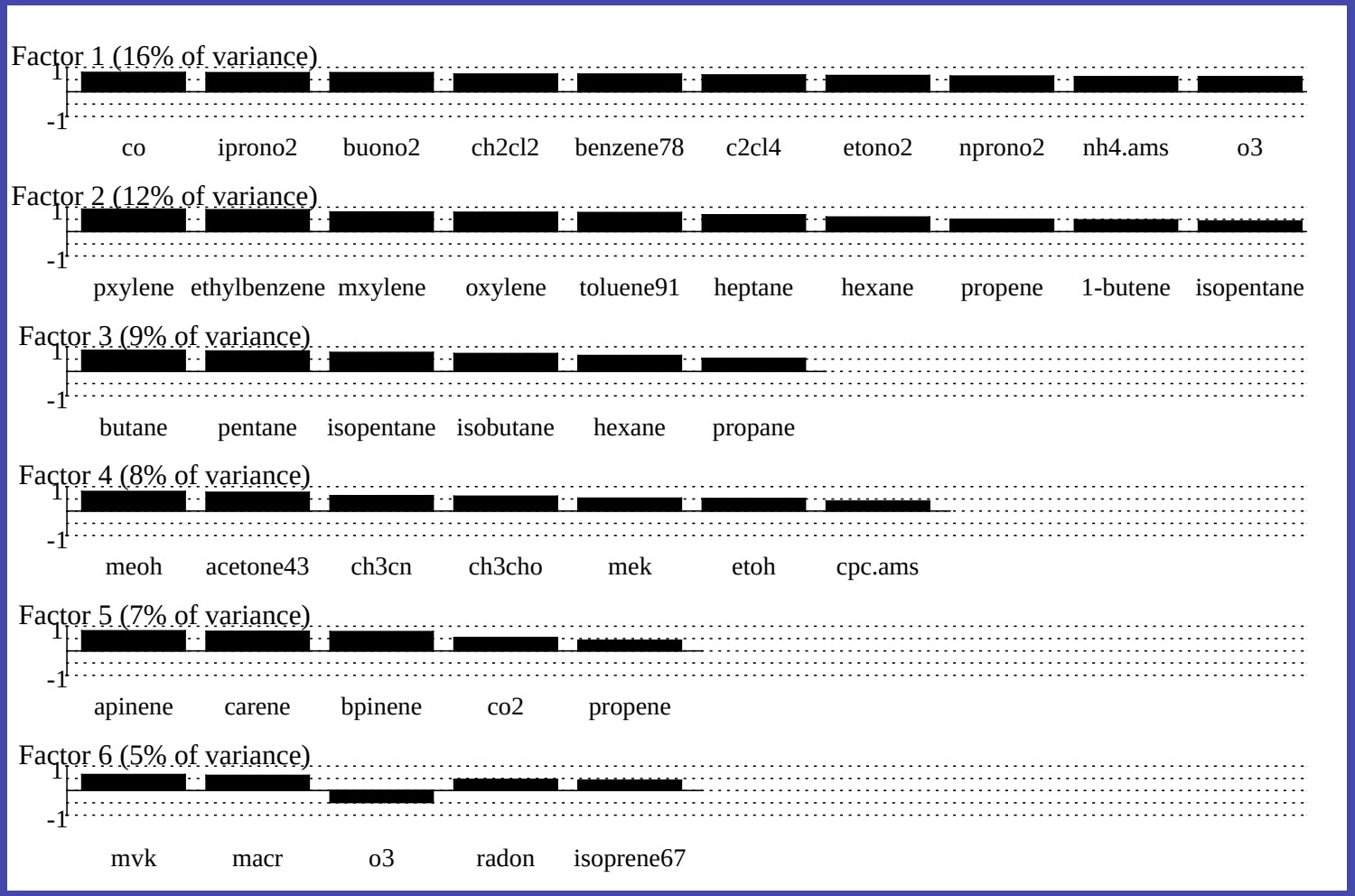
F2: Local combustion

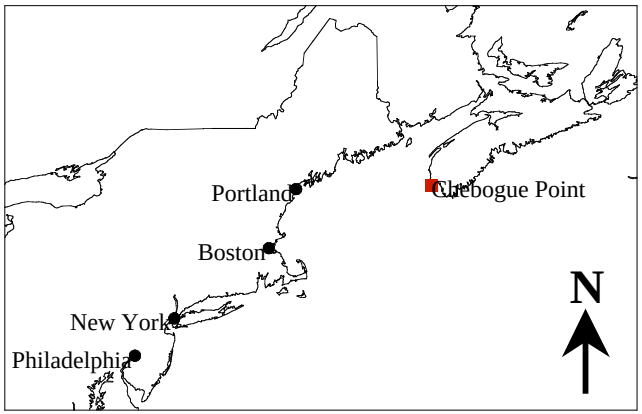
F3: Alkanes

F4: OVOC

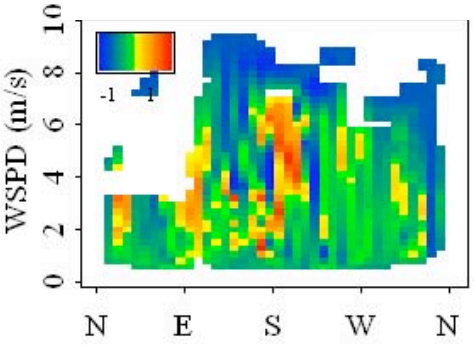
F5: Terpenes

F6: Biogenic OX

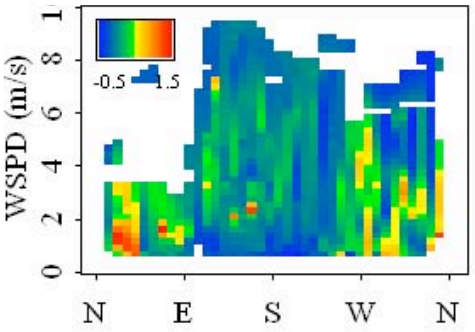




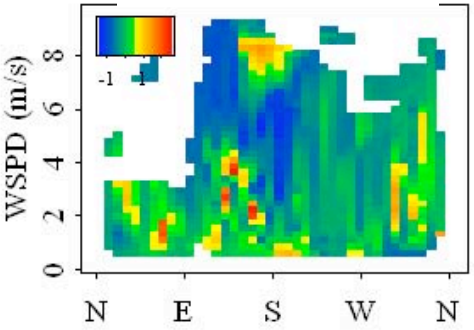

## F1: U.S. dominated



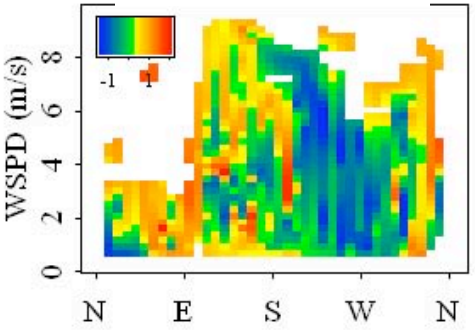

## F2: Local combustion



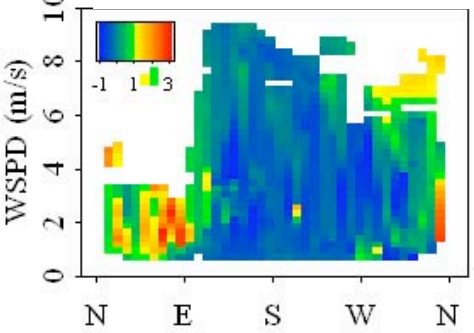

## F3: Alkanes



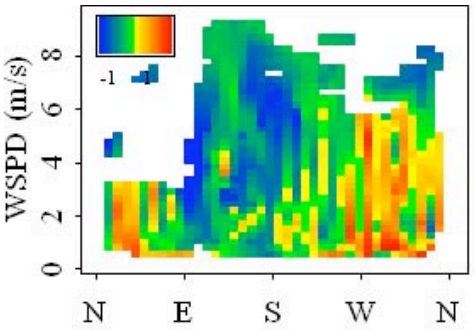

## F4: OVOC




## F5: Terpenes



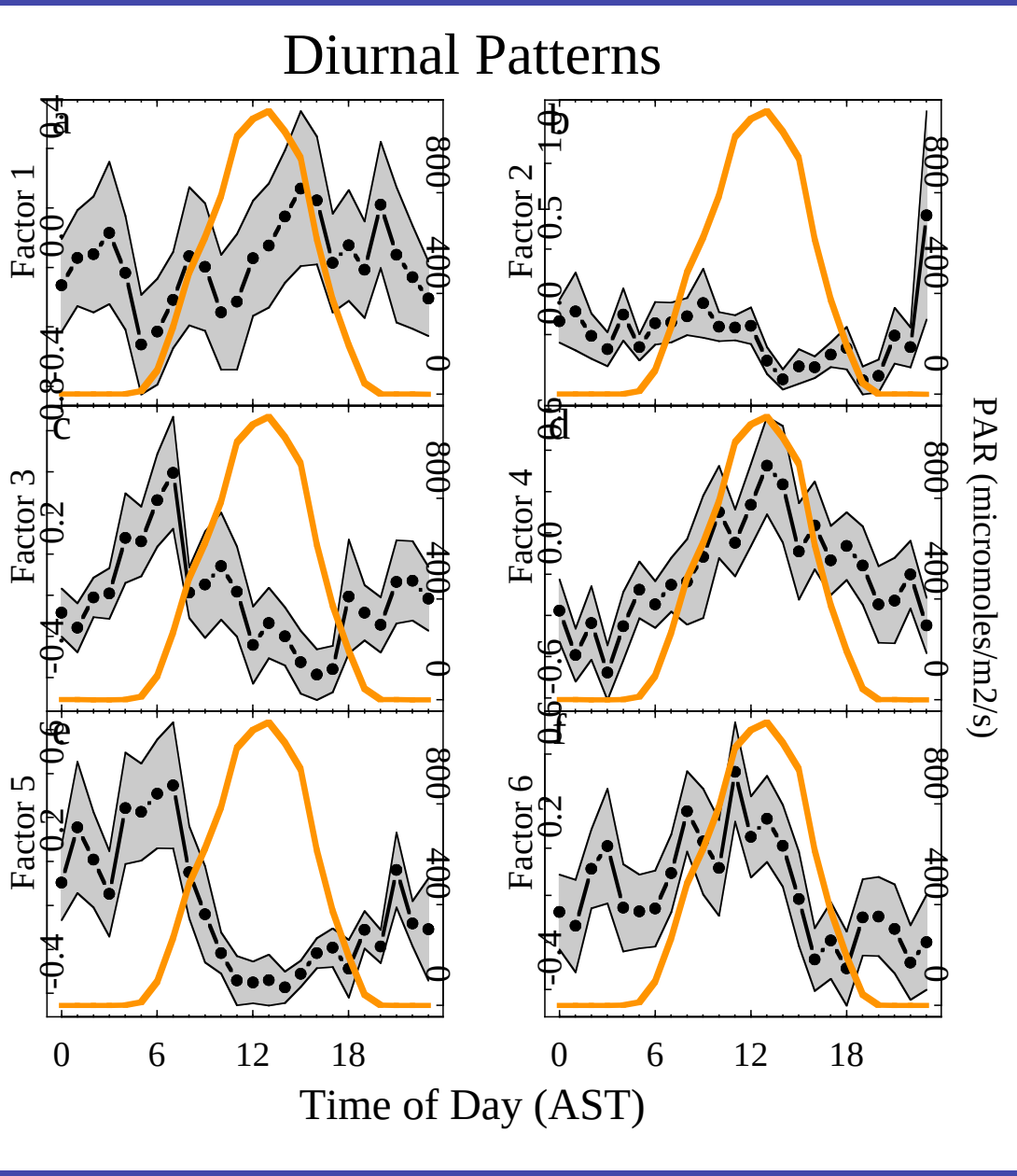

## F6: Biogenic OX



F1: U.S.

F3: Alkanes

F5: Terpenes




F2: Local combustion

F4: OVOC

F6: Biogenic OX

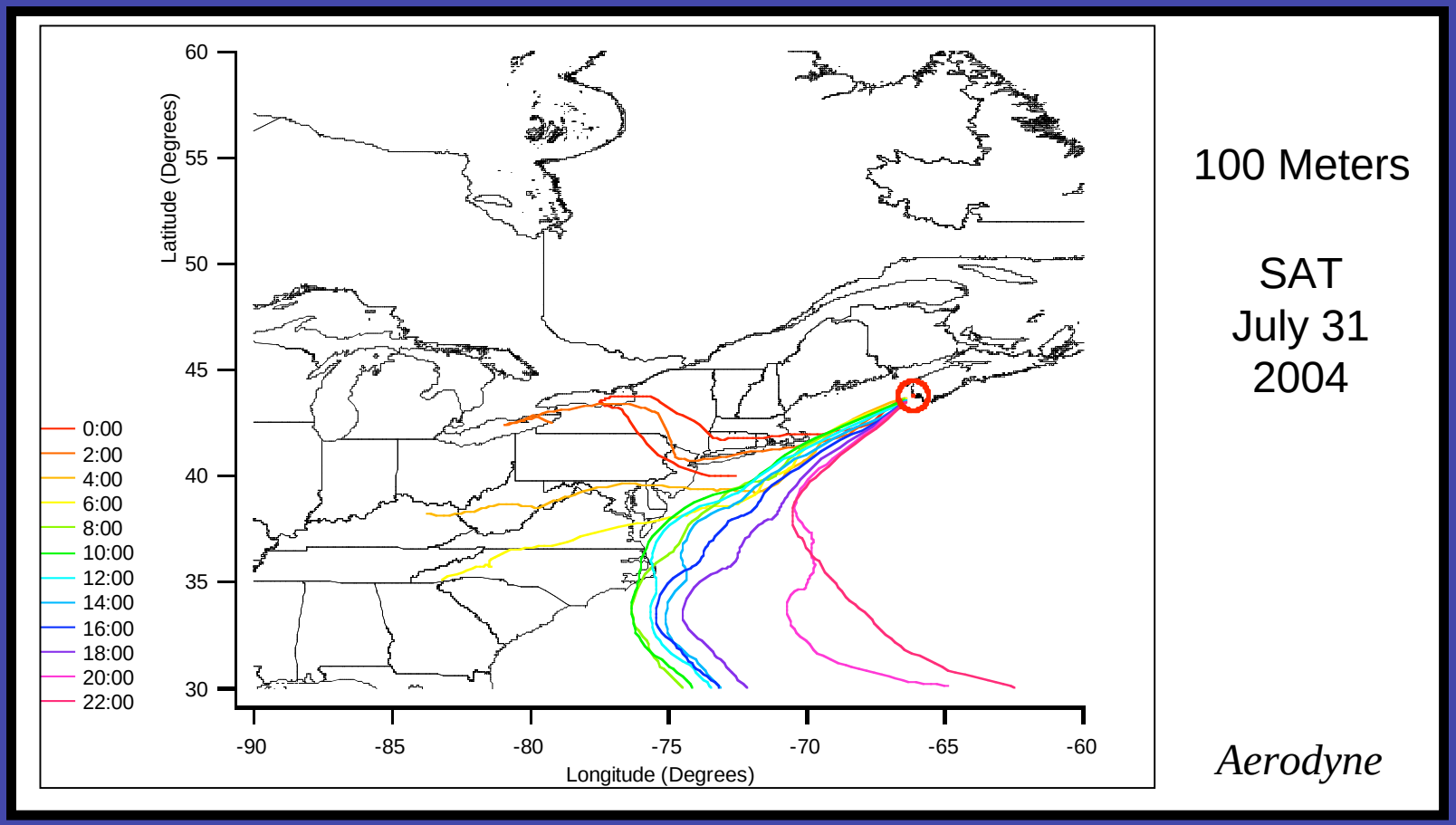
# Eastern U.S. Emissions

F1 (U.S.) can be further split:

- F1a: $1^o$ & $2^o$ gas-phase & particle phase pollution
- F1b: Very high in particulate $SO_4$, $NH_4$, OC, and $O_3$

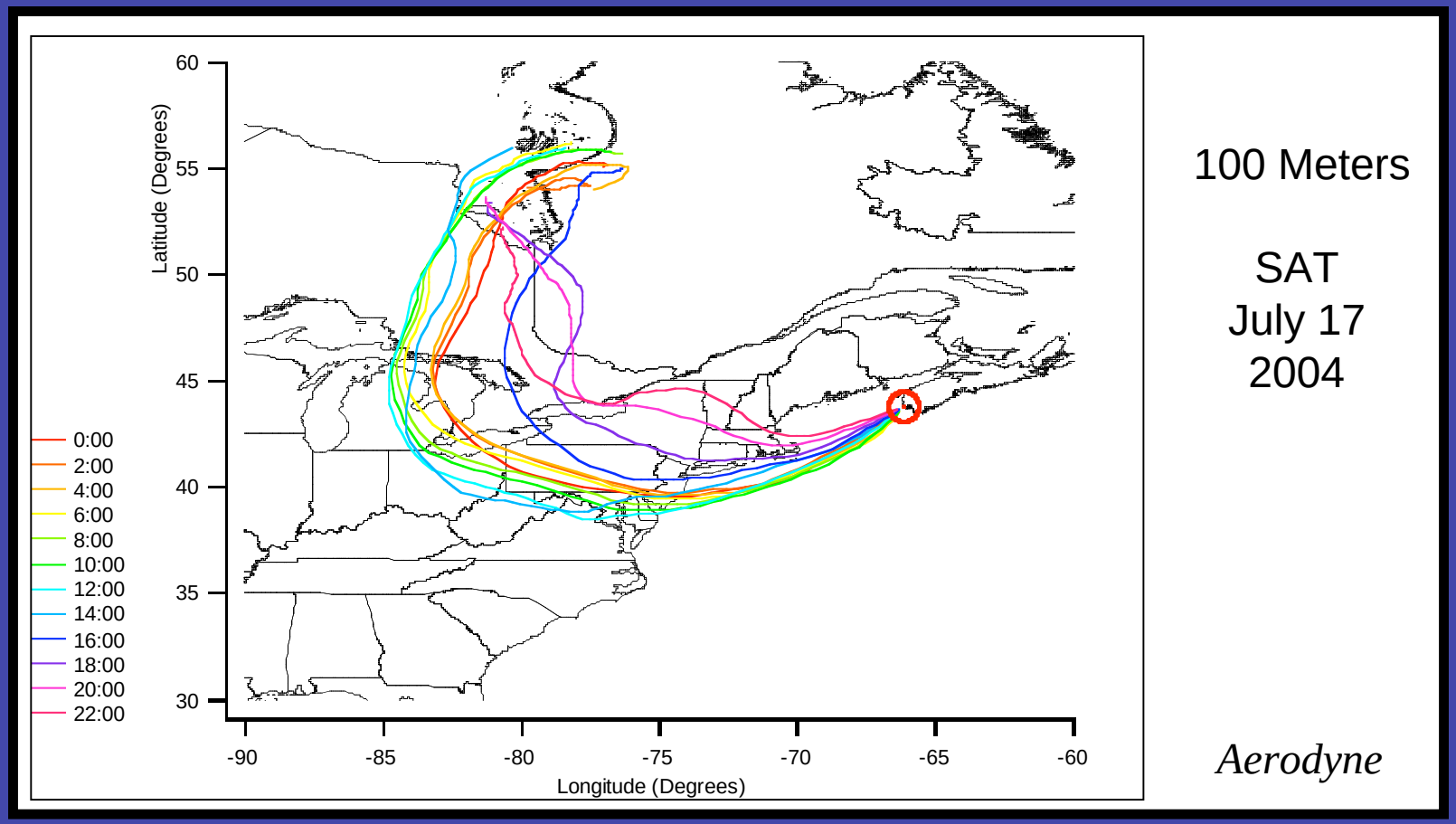
# Eastern U.S. Emissions

## Example 4d back-trajectory for F1a:



# Eastern U.S. Emissions

## Example 4d back-trajectory for F1b:



# Organic Aerosol Chemical Composition

- Total aerosol OC variability driven by:
  - F1a & F1b (US emissions) (most important)
  - Also F4 (OVOCs) & F6 (Biogenic OX)
- Can we get any more detail?

# Online Organic Aerosol Chemical Composition

TAG

(B. Williams, A. Goldstein, S. Hering, N. Kreisberg)

- Individual species provide information on OC source types
  - Insights into OC sources and production mechanisms
- All compounds measured appear highly oxygenated
- Identification and quantification: major challenge when far from sources

# Organic Aerosol Chemical Composition

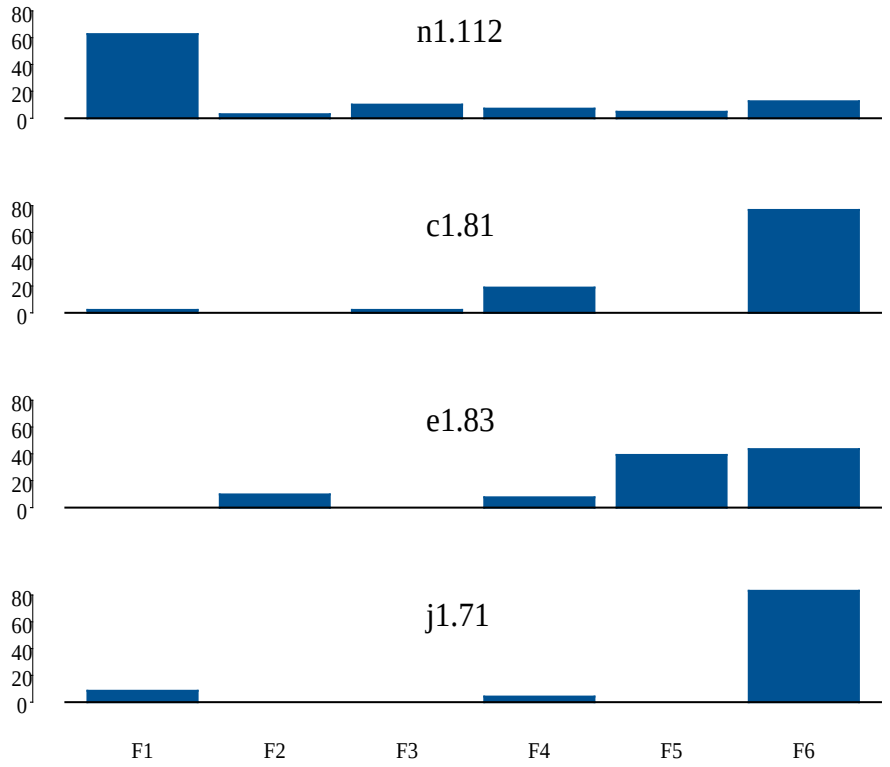
## Multiple regression of OC species with 6 factors:

Tentative Compound ID:

1,6-dioxaspiro[4,4]nonane-2,7-dione ($C_7H_8O_4$) ?

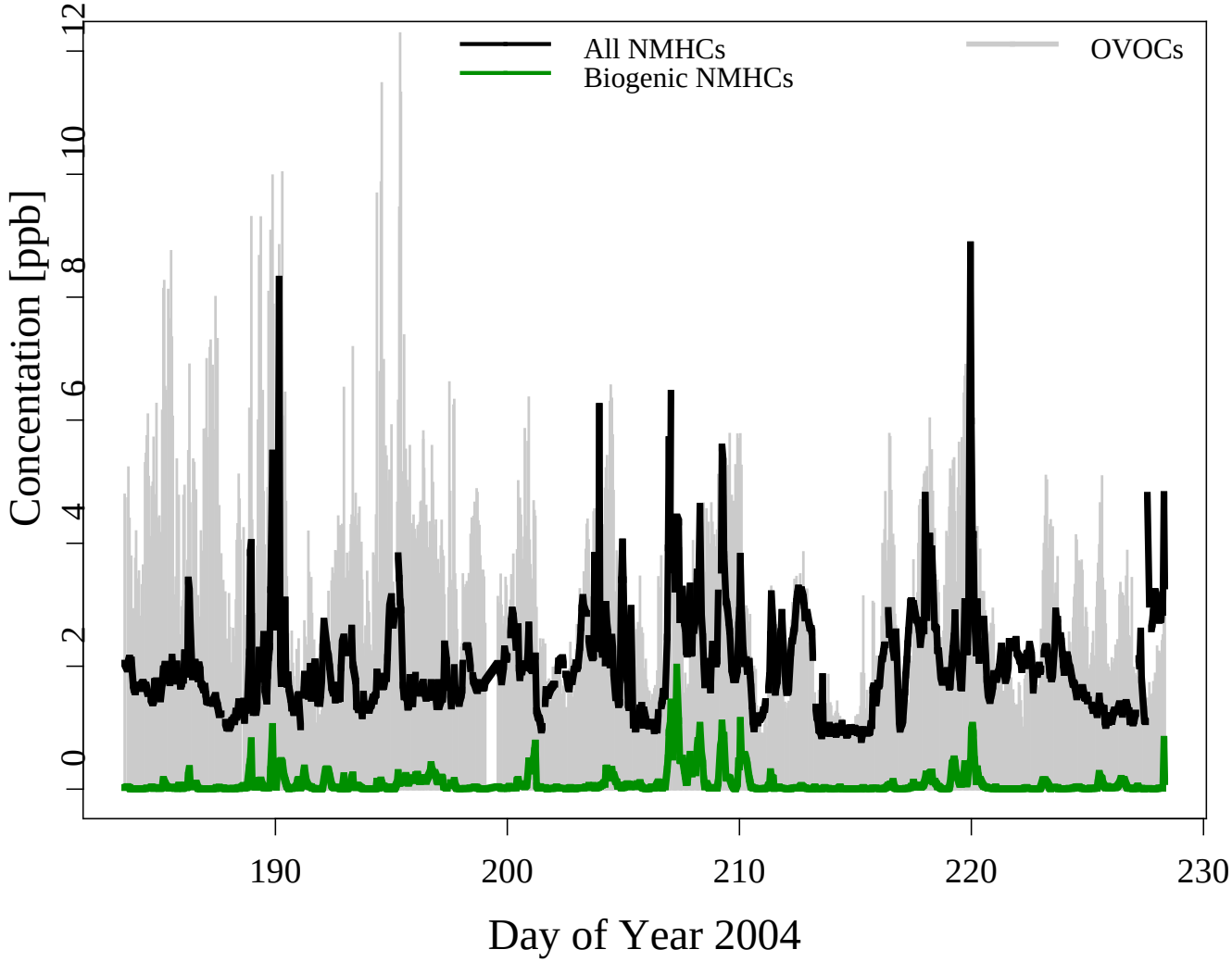
7-anti-methyl-2-oxo-bicyclo[2.2.1]heptane-7-carboxylic acid ($C_9H_{12}O_3$) ?

2,3-pinanediol ($C_{10}H_{18}O_2$) ?

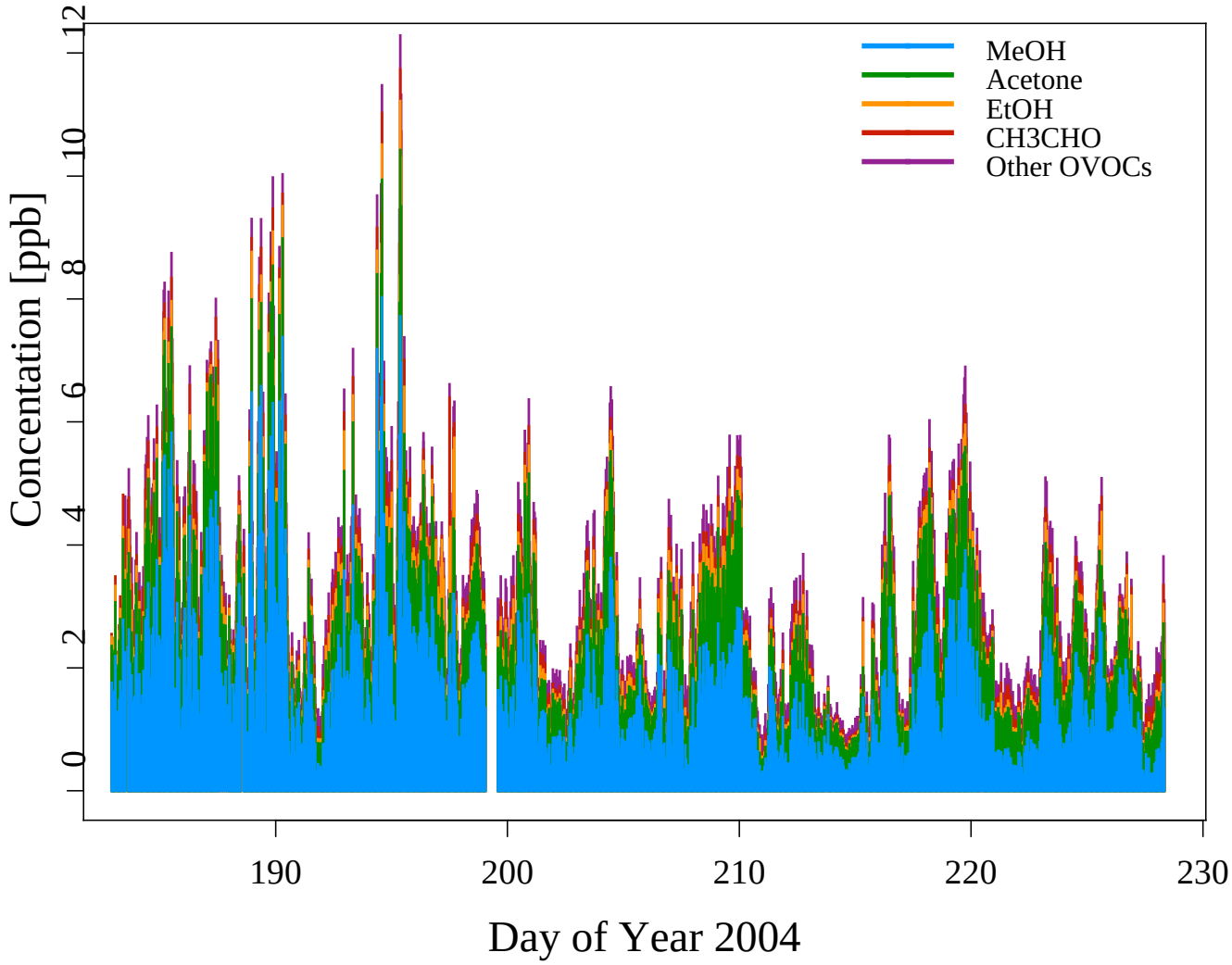



U.S. Alkanes Terpenes
Local comb OVOC Biog OX

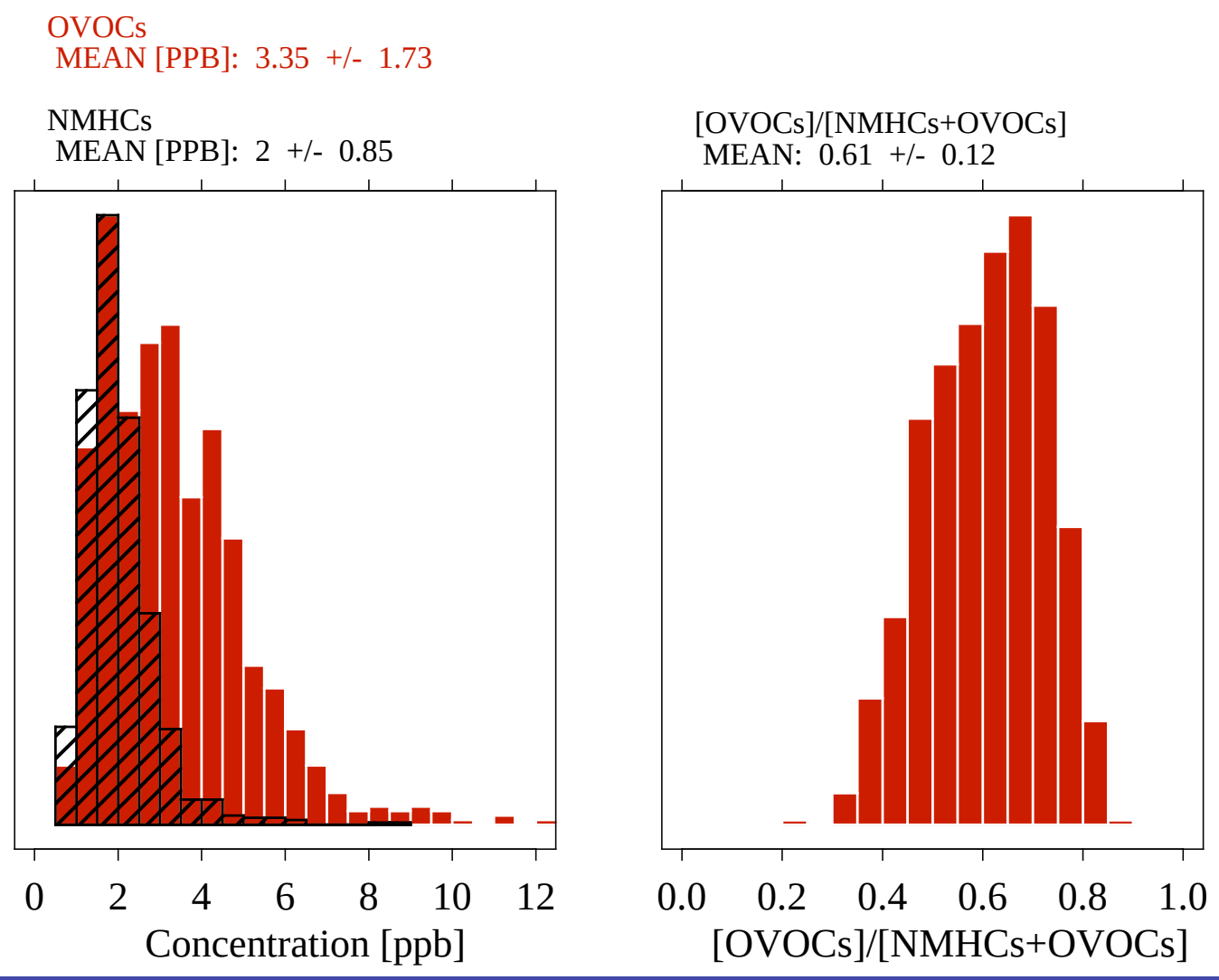
# VOC concentrations



# What About the OVOCs?



# What About the OVOCs?

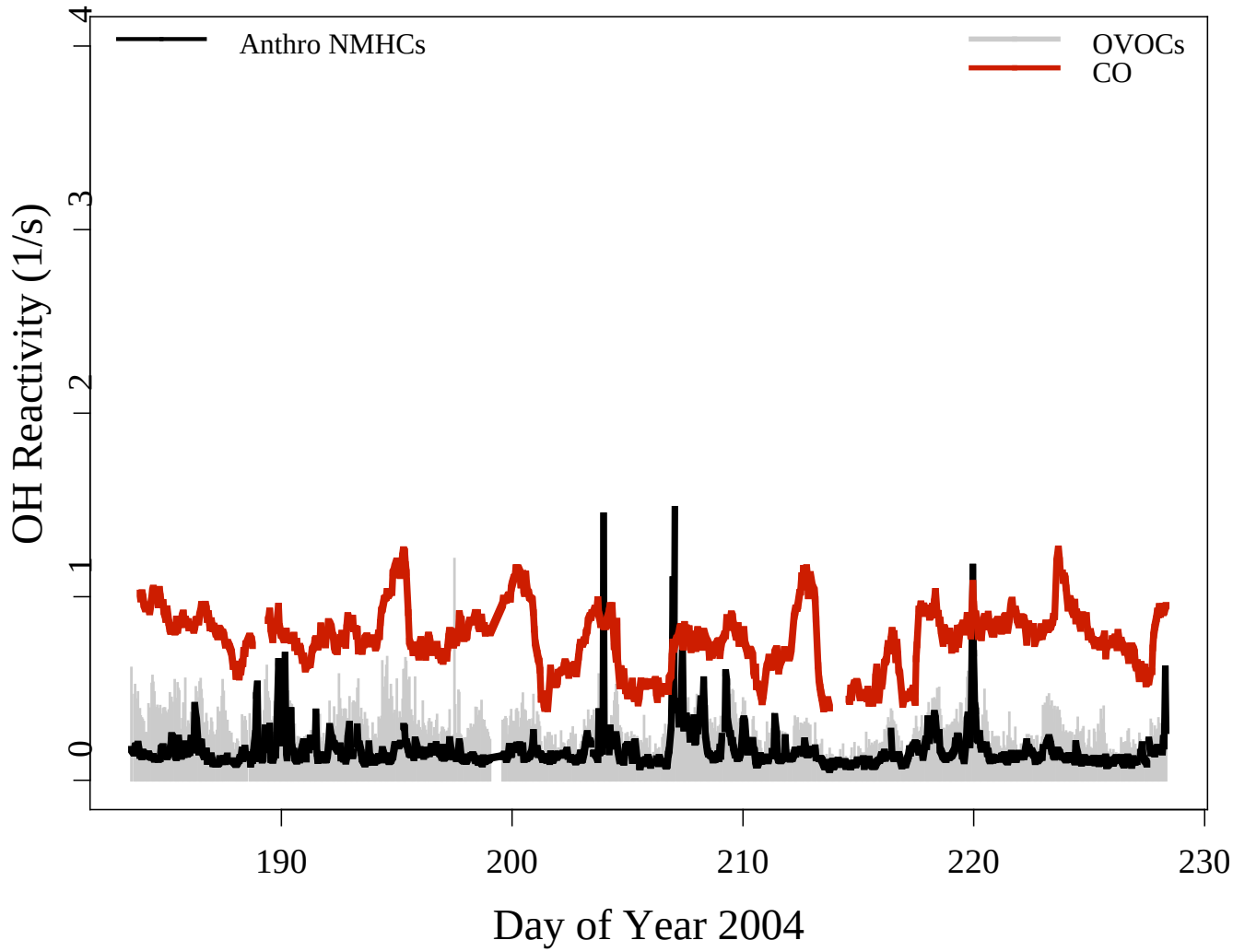


# VOC OH Reactivity

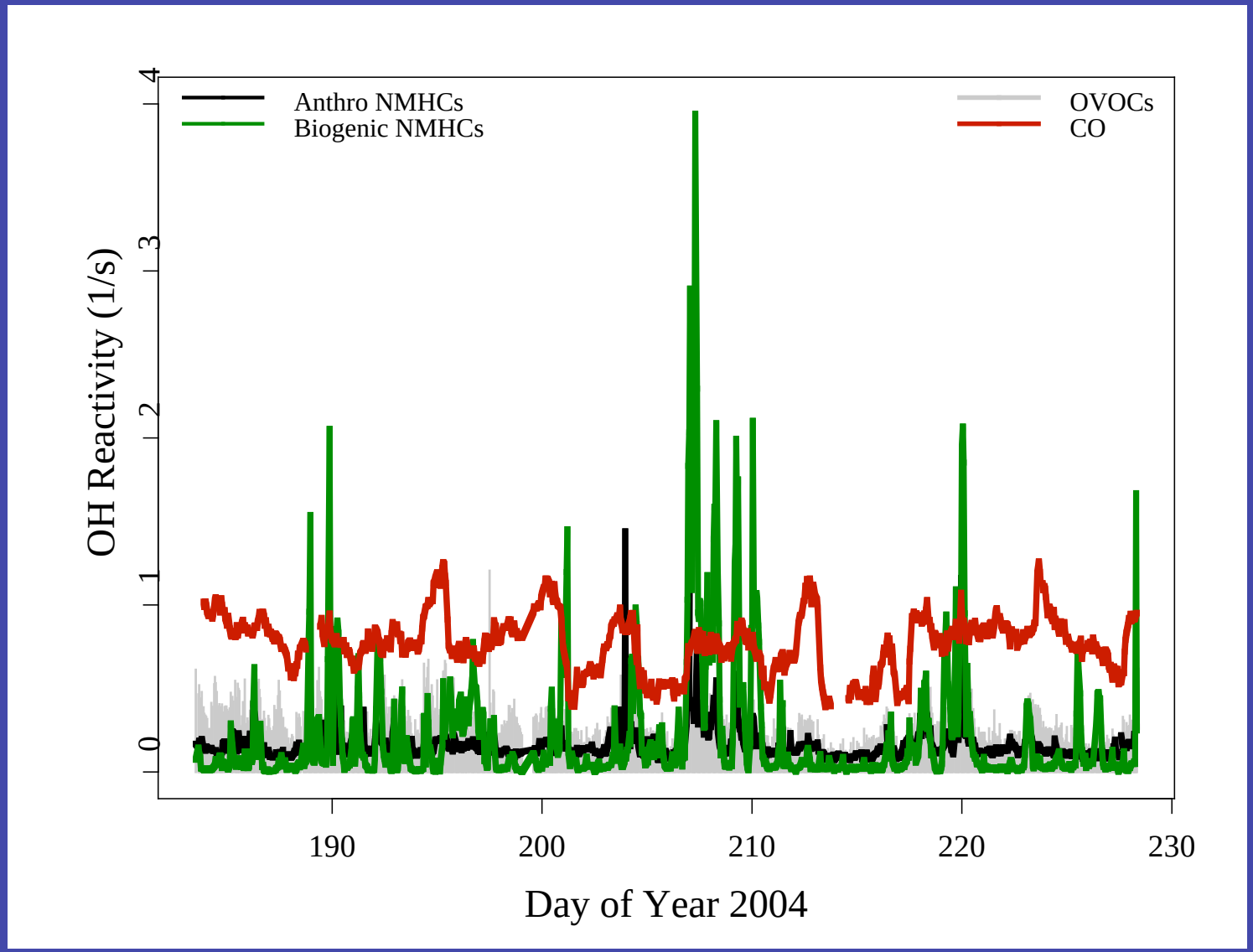
$$L_{OH} = \sum_i k_i [X_i]$$

- Index of the chemical reactivity of an air mass
- Inverse lifetime of OH wrt reaction with the measured compounds
- What are the dominant VOCs competing for OH radicals?

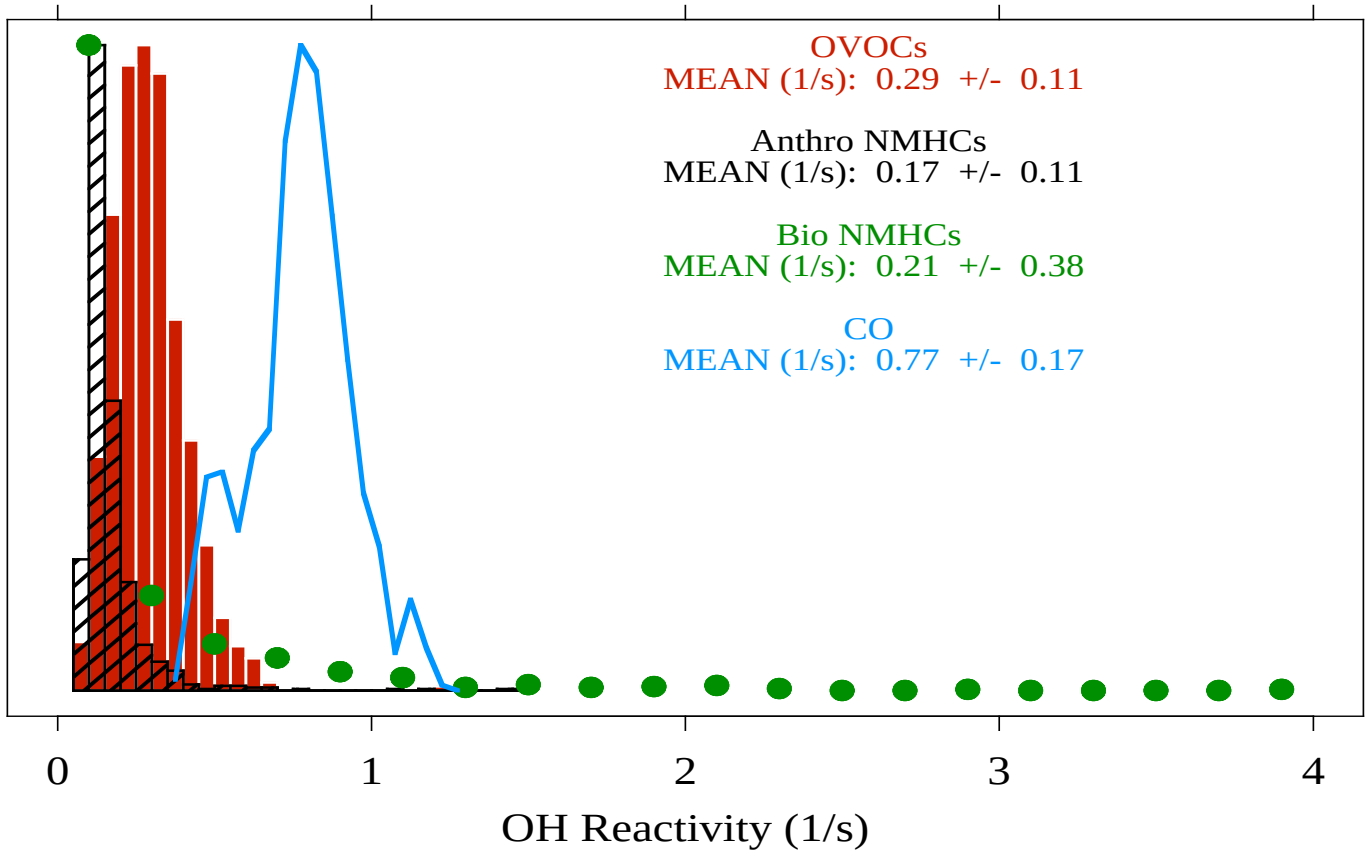
# OH Reactivity



# OH Reactivity



# OH Reactivity



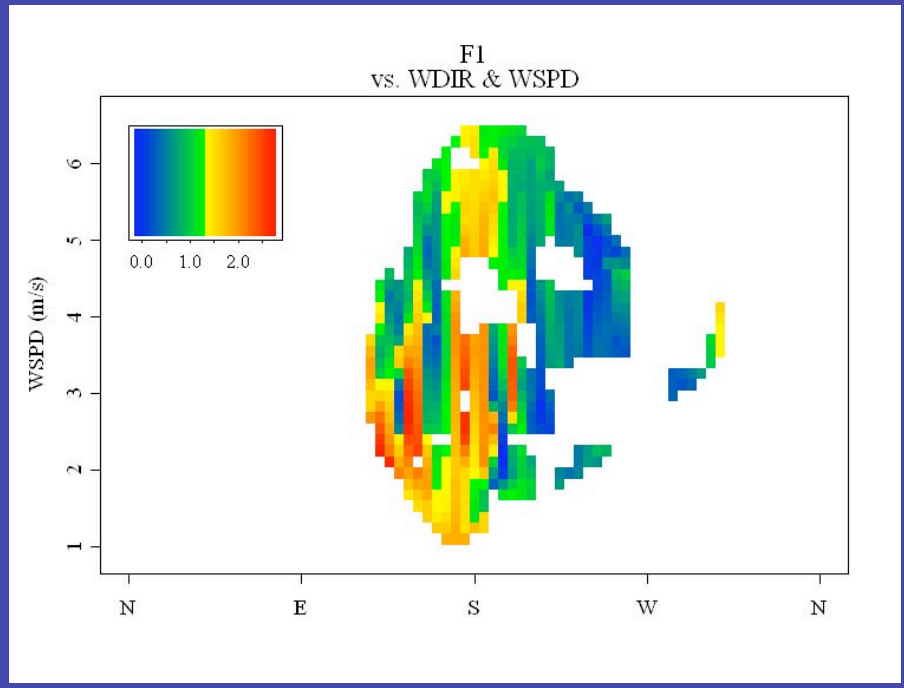
# Filtering for NE US emissions

- Use F1 as a filter for NE US outflow

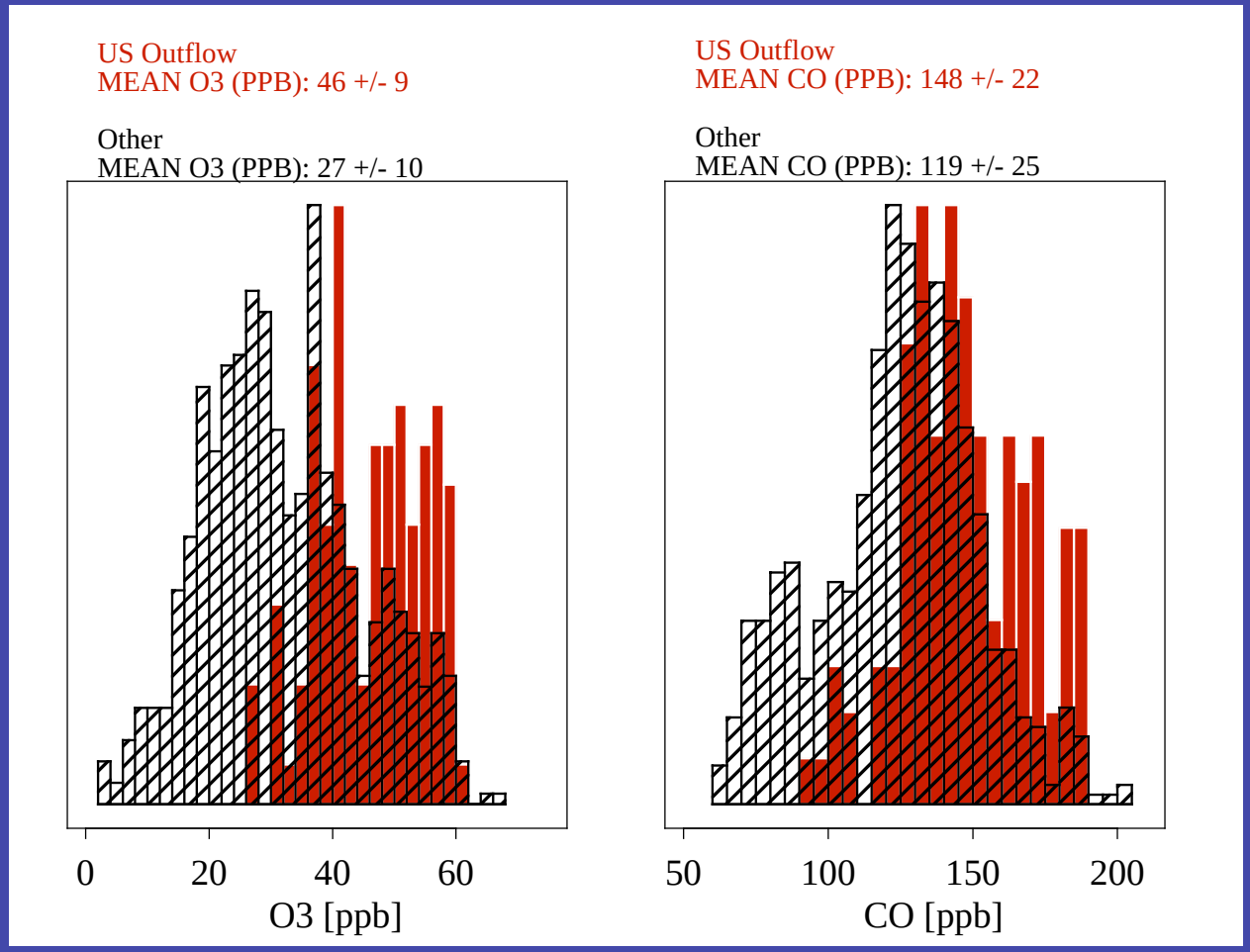
- Choose times when

$$F1 > \sum_{1=2}^{6} Fi$$

(117 / 899 hours; 13%)



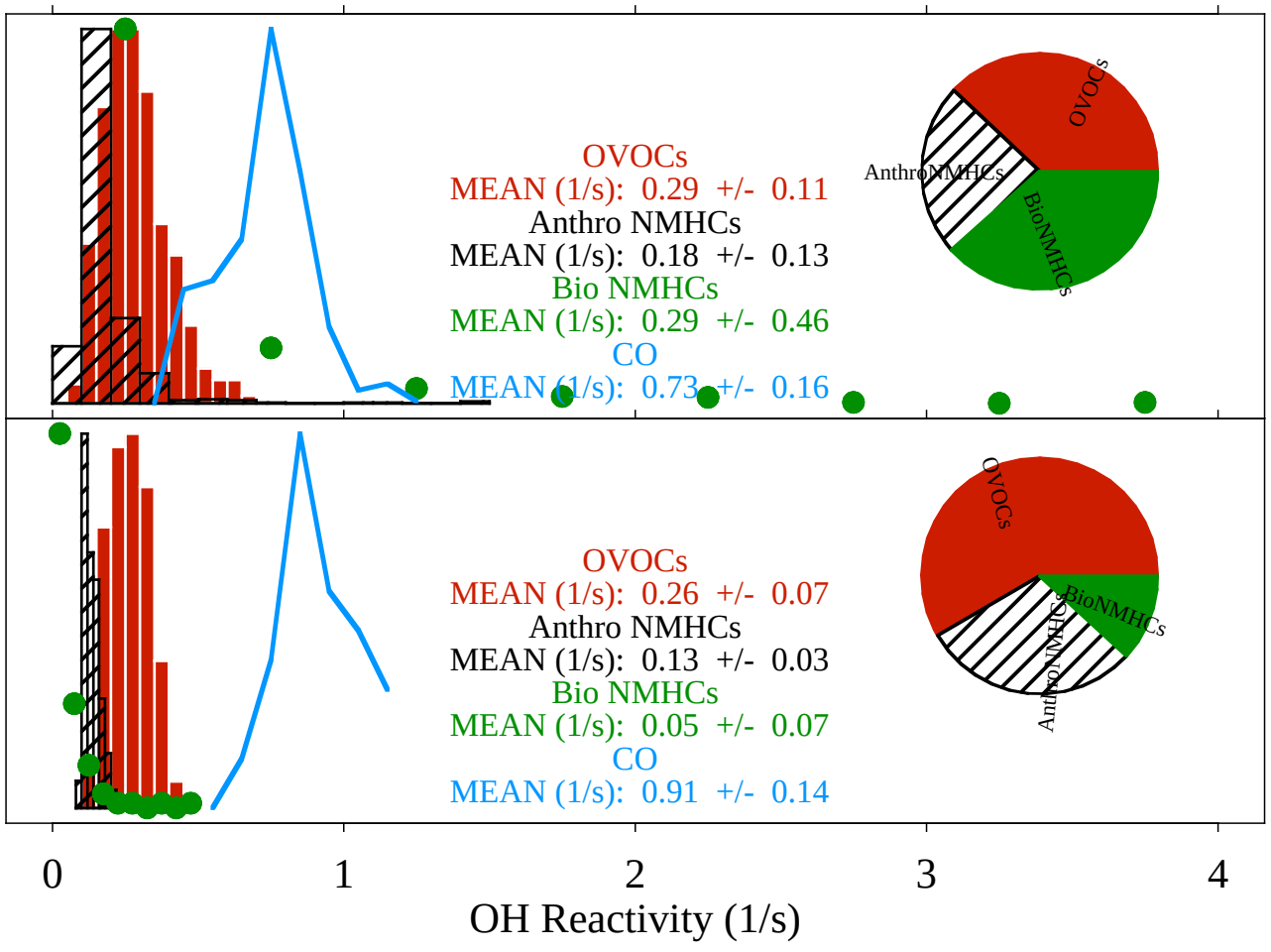
# $O_3$ & CO


US Outflow
MEAN O3 (PPB): 46 +/- 9
Other
MEAN O3 (PPB): 27 +/- 10
0
20
40
60
O3 [ppb]
US Outflow
MEAN CO (PPB): 148 +/- 22
Other
MEAN CO (PPB): 119 +/- 25
50
100
150
200
CO [ppb]

# VOC OH reactivity

**Other periods**

**US outflow**



# Conclusions & Future Work

Conclusions:

1. CO & $O_3$ levels similar to 1993
2. FA provides context & means to segregate data
3. Organic aerosol highly oxygenated
   - NE pollution
   - Oxidation of biogenic precursors
4. OVOCs are ~ 2x as important as NMHCs during NE outflow periods

To do:

- Look in detail for evidence of changes in composition & photochemistry since 1993
- Continue investigation of organic carbon budget and chemistry in gas + particle phase

# Acknowledgements

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Dan Jaffe (UW Bothell)

Funding:

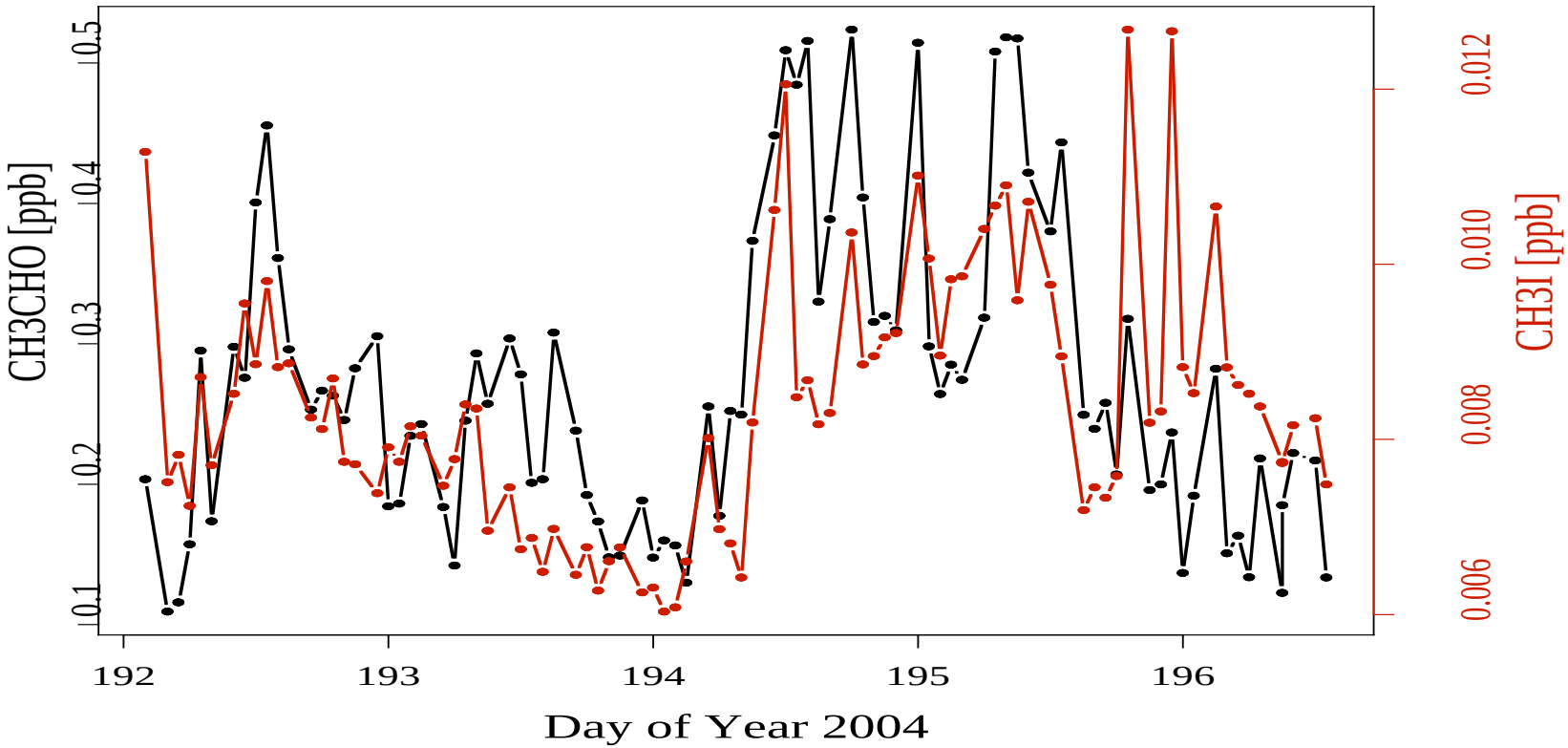
NOAA Office of Global Programs

DOE SBIR Progarm

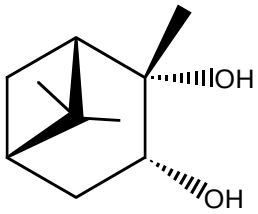
DOE Global Change Education Program

# Oceanic OVOC Source?

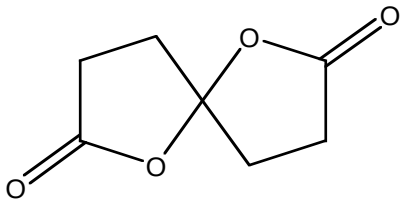
Nothing definitive, but a few hints…



# Aerosol OC Composition




j1.71: 2,3-pinanediol




n1.112: 1,6-dioxaspiro[4,4]nonane-2,7-dione