Emissions from Forest Fires Near Mexico City

Peter DeCarlo, CU

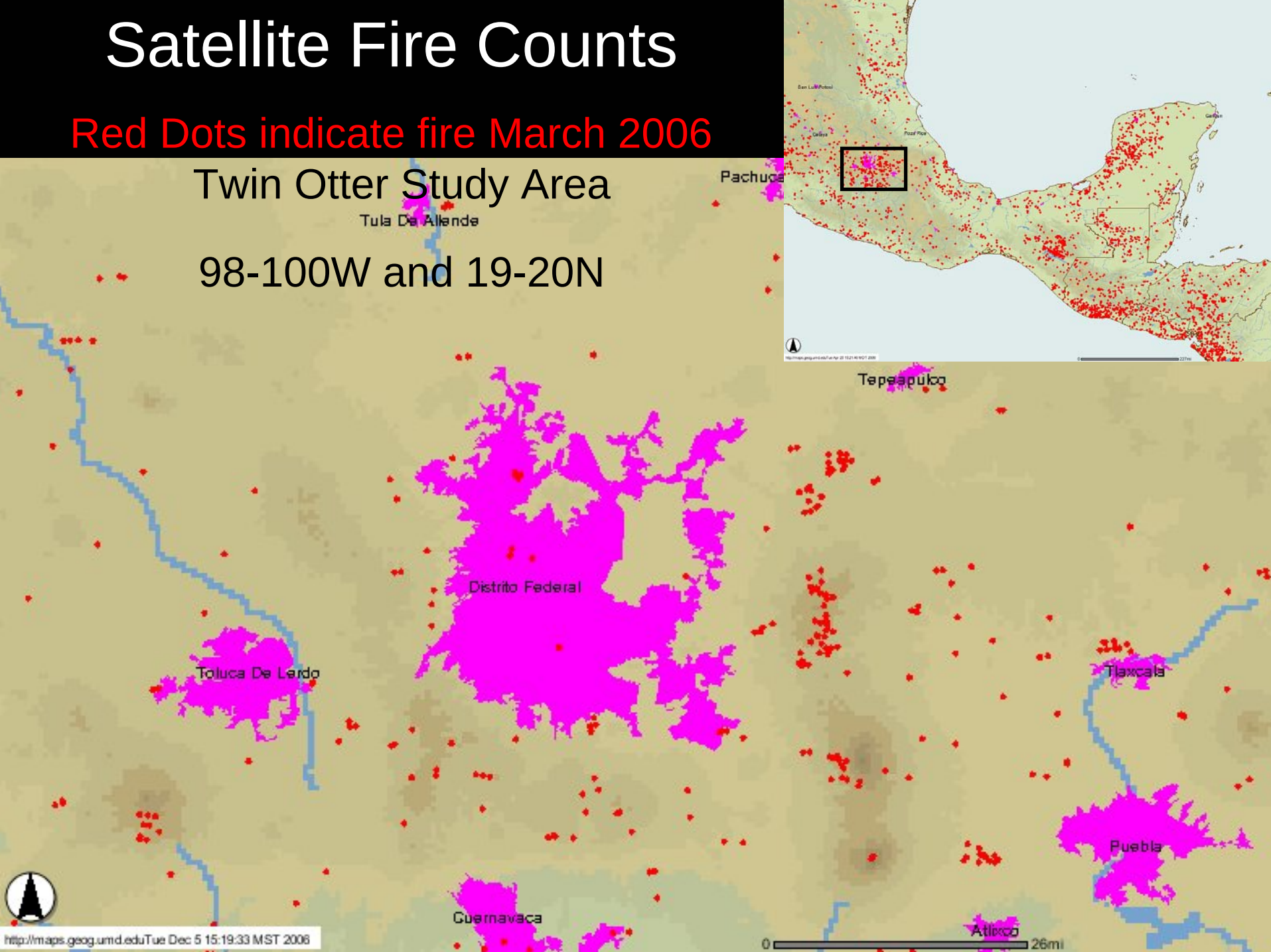
Yokelson, Urbanski, Atlas, Toohey, Alvarado, Fisher, Wold, Campos, Adachi, Buseck, and Hao

Crounse, Wennberg, DeCarlo, Jimenez, Blake, Apel, Emmons, and Campos

Funding: NSF

Satellite Fire Counts

Red Dots indicate fire March 2006



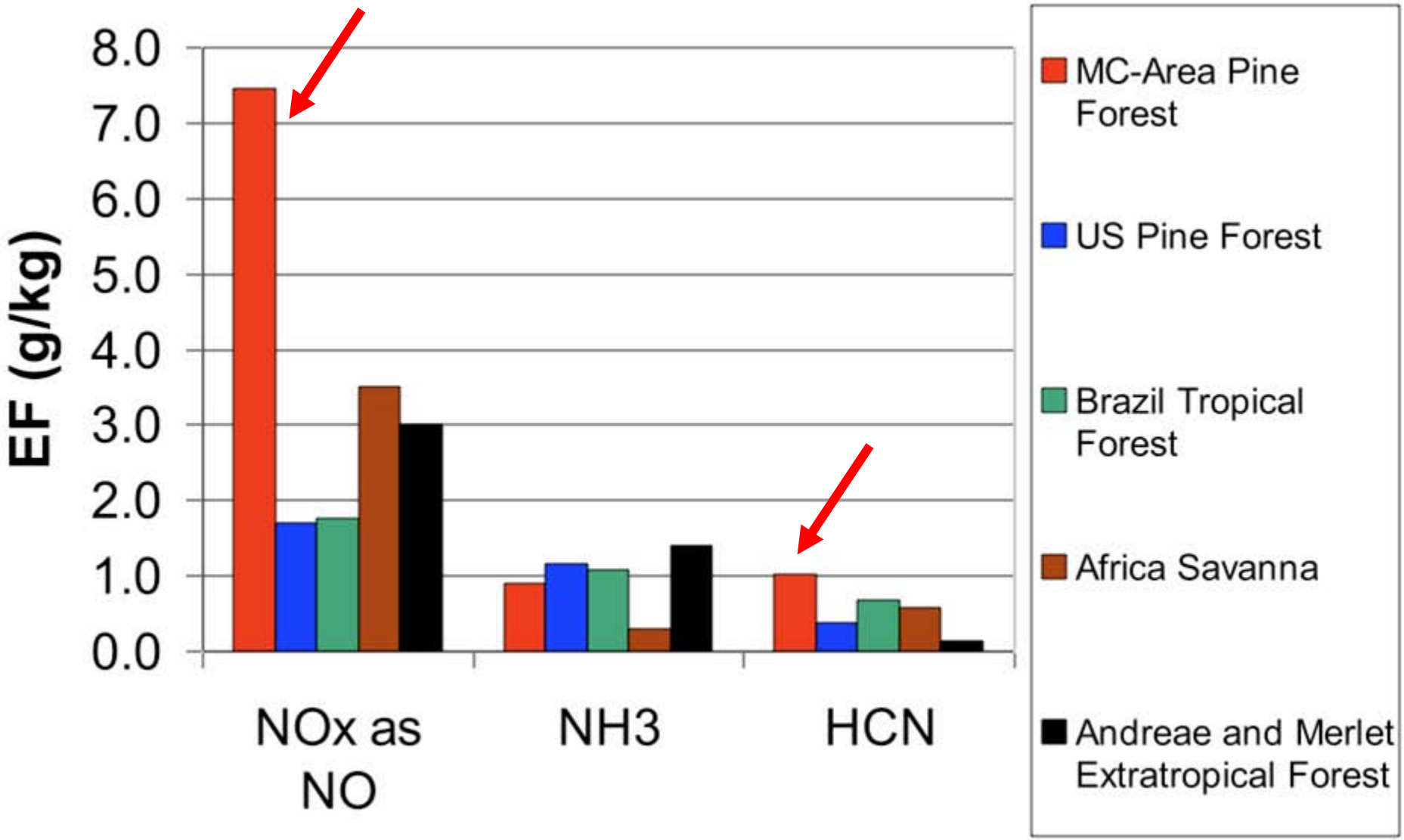
TWIN OTTER SPECIES MEASURED:

Yokelson et al.

- **WAS:** CO_2, CO, CH_4, C_2-C_5 Hydrocarbons
- **AFTIR:** H_2O, O_3, CO_2, CO, CH_4, C_2H_2, C_2H_4, C_3H_6, HCHO, HCOOH, CH_3OH, CH_3COOH, NO, NO_2, HCN, NH_3
- **LICORS:** CO_2, H_2O
- **MPS-3:** TEM Grids (182 - Dust, City, Fire)
- **UHSAS:** PM Size Dist 0-1 μm & PM_1
- **Nephelometer:** $PM_{2.5}$

- Twin Otter measured emissions of 63 fires
  - 8 fires in study area box

Twin Otter Emission Factors



Yokelson et al.

Yokelson et al. Bottom-up Estimate

Fire Contribution to Regional Emissions

MCMA EI: 1/12 annual CO = 0.147 Tg

Burning Period, 12-5. Avg Fire 1h, 145 tons fuel.

Satellite (PM) sees 1/5 fires & Cloud free ½ days

10 X #HS(218) X 145 tons X EFCO = 0.026 Tg

CO: Fire/Urban = 18 % **CO: Fire/Total = 15 %**

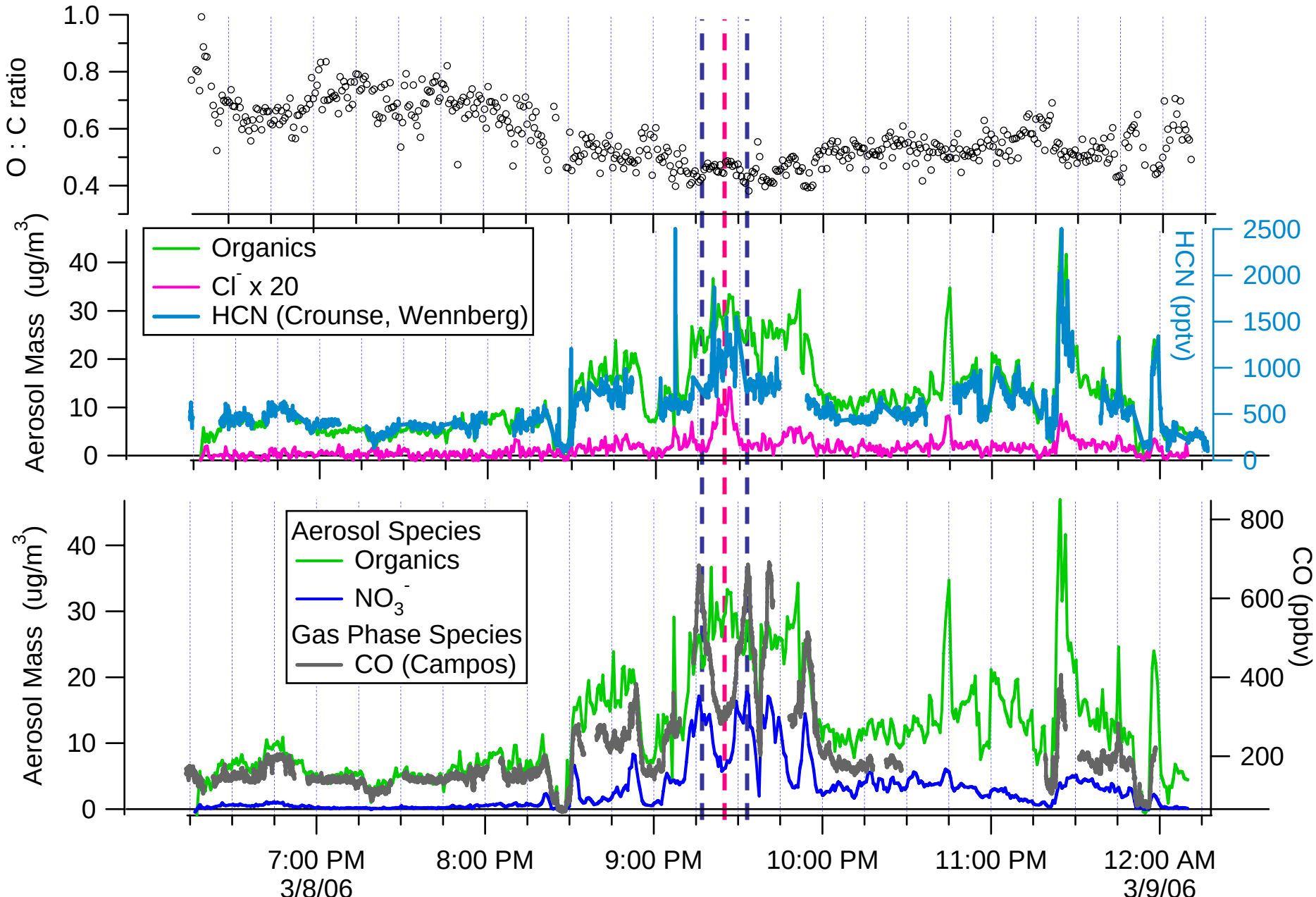
MCMAEI, PM10/CO = 11 g/kg (35-50 g/kg)

FIRES, PM1/CO = 133 g/kg

Fire PM1 / Total PM10 = 68 % (Primary)

Fire PM1 / Total PM10 = 32-40 %

C-130 3/8 flight case study



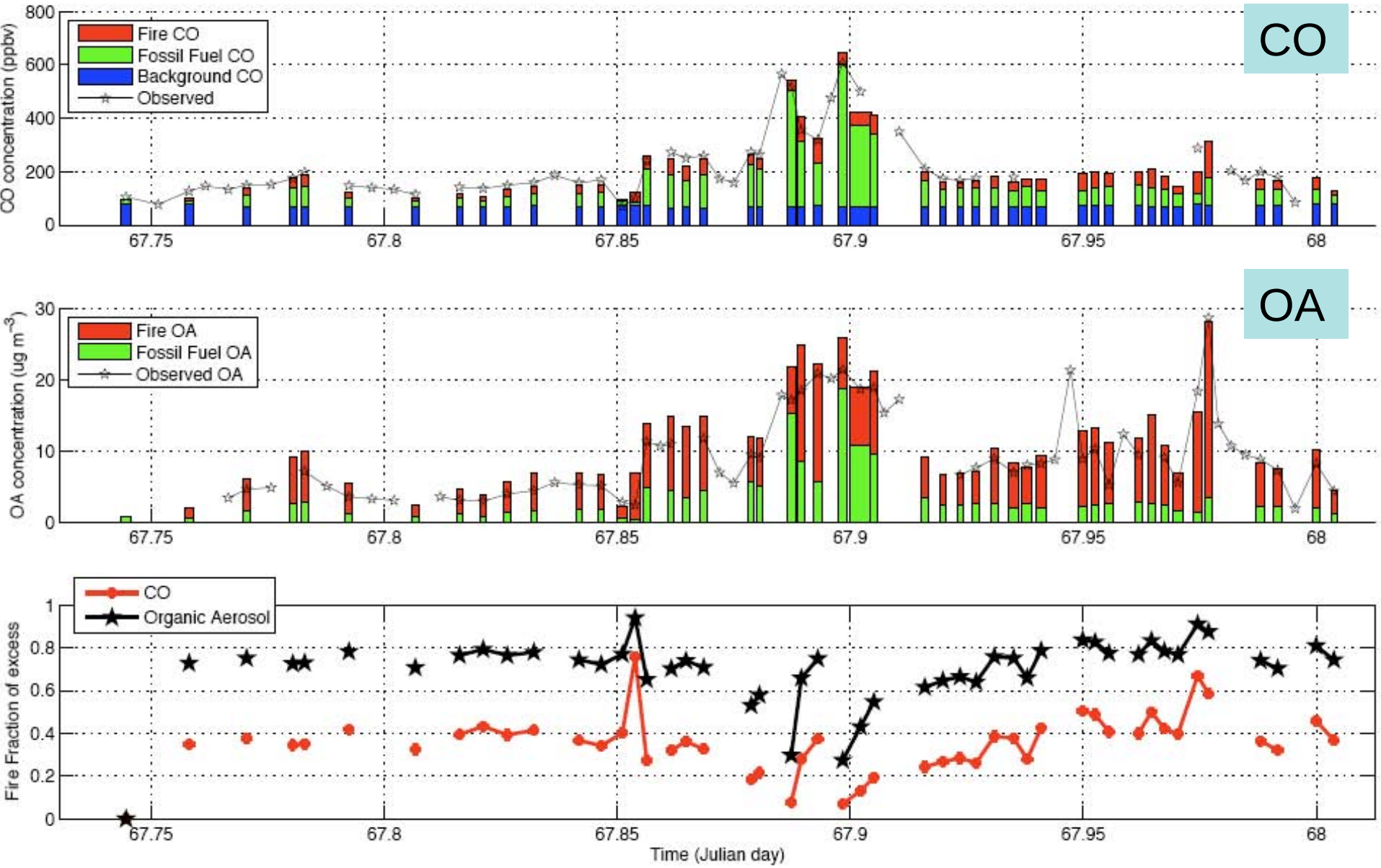
CO, OA, Benzene reconstruction

$$CO_{meas} = CO_{bkgnd} + CO_{ffc} + CO_{bb}$$

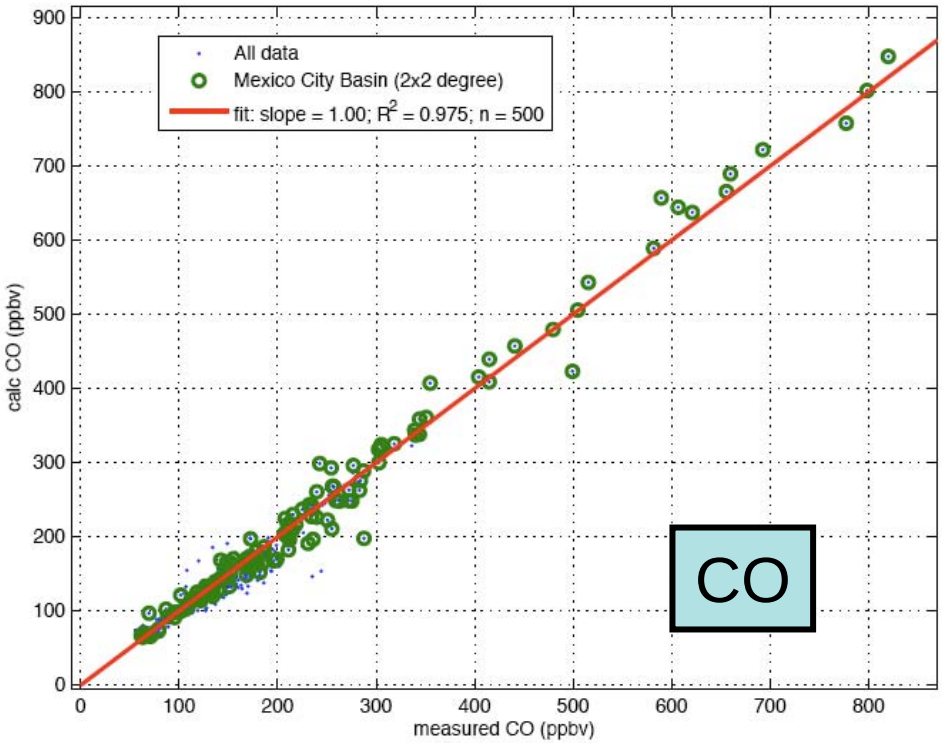
- Tracers for reconstruction
  - HCN for Biomass Burning (bb)
  - Acetylene for Fossil Fuel Combustion (ffc)
- Reconstruct CO based on emission ratios to the tracers
  - Background CO = MOZART - NEI_{tags} + 29ppbv
  - Use cross terms (HCN, C_2H_2 not unique tracers)
- Reconstruct Organic Aerosol and Benzene from CO_{ffc} and CO_{bb}

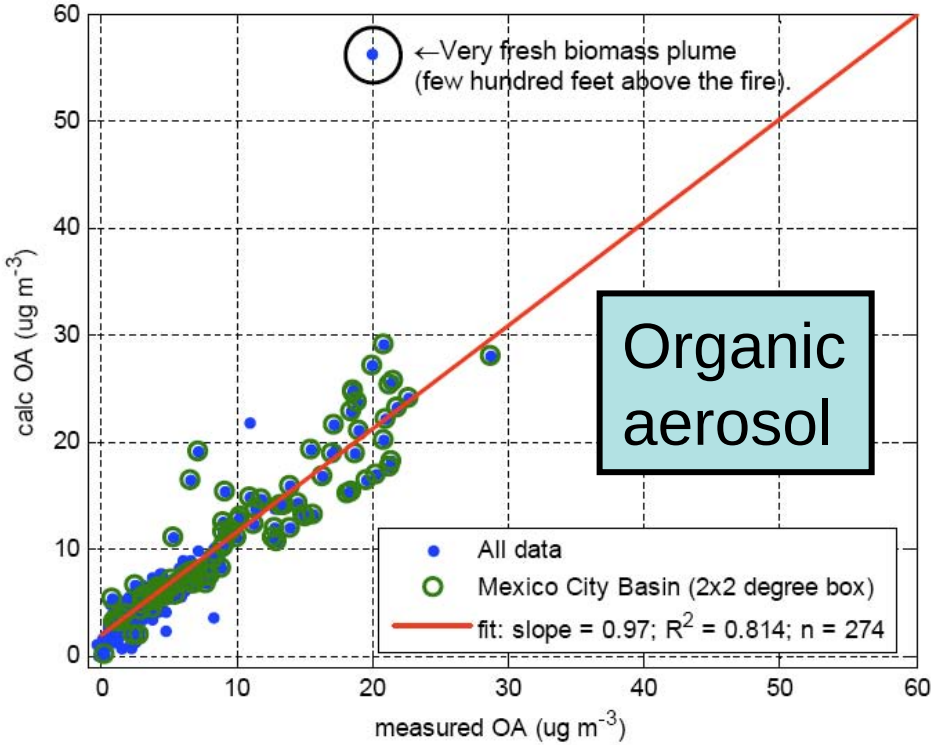
C-130 Crounse et al.

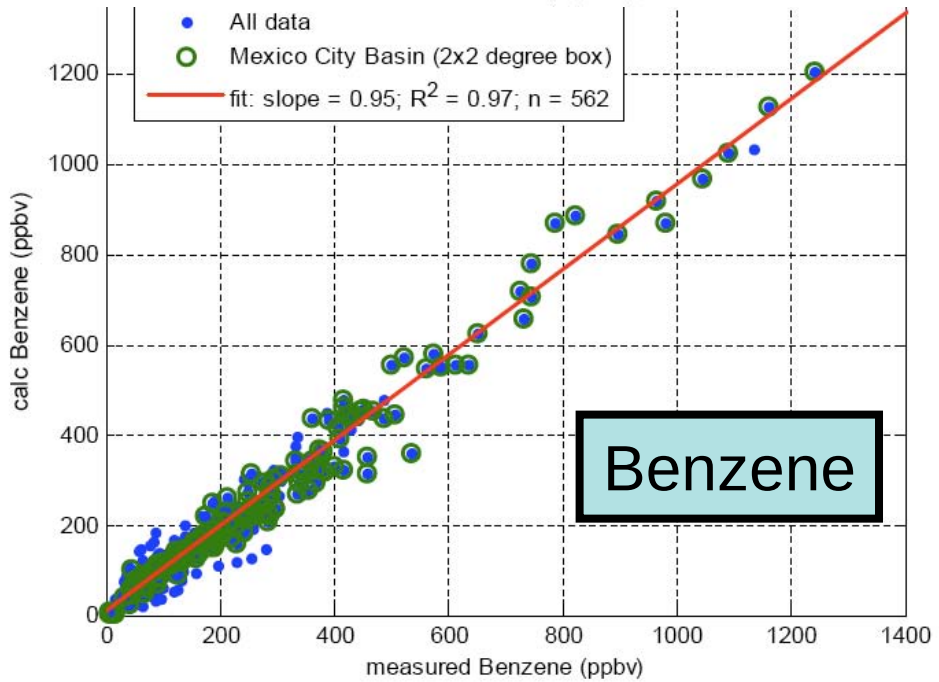
C-130 3/8/06 Flight



C-130 Tracer Reconstructions







Crounse et al.

C-130 Budget Estimates

- From tracer apportionment, mass weighted fire contributions on 2x2 degree box centered on Mexico City are:
- Fire contributions
  - CO ~ 25%
  - Organic Aerosol ~ 62%
  - Total PM_1 ~ 31-38%

- Aerosol fraction from biomass burning ~double what is measured on ground (T0)
  - Expected based on geometry of basin

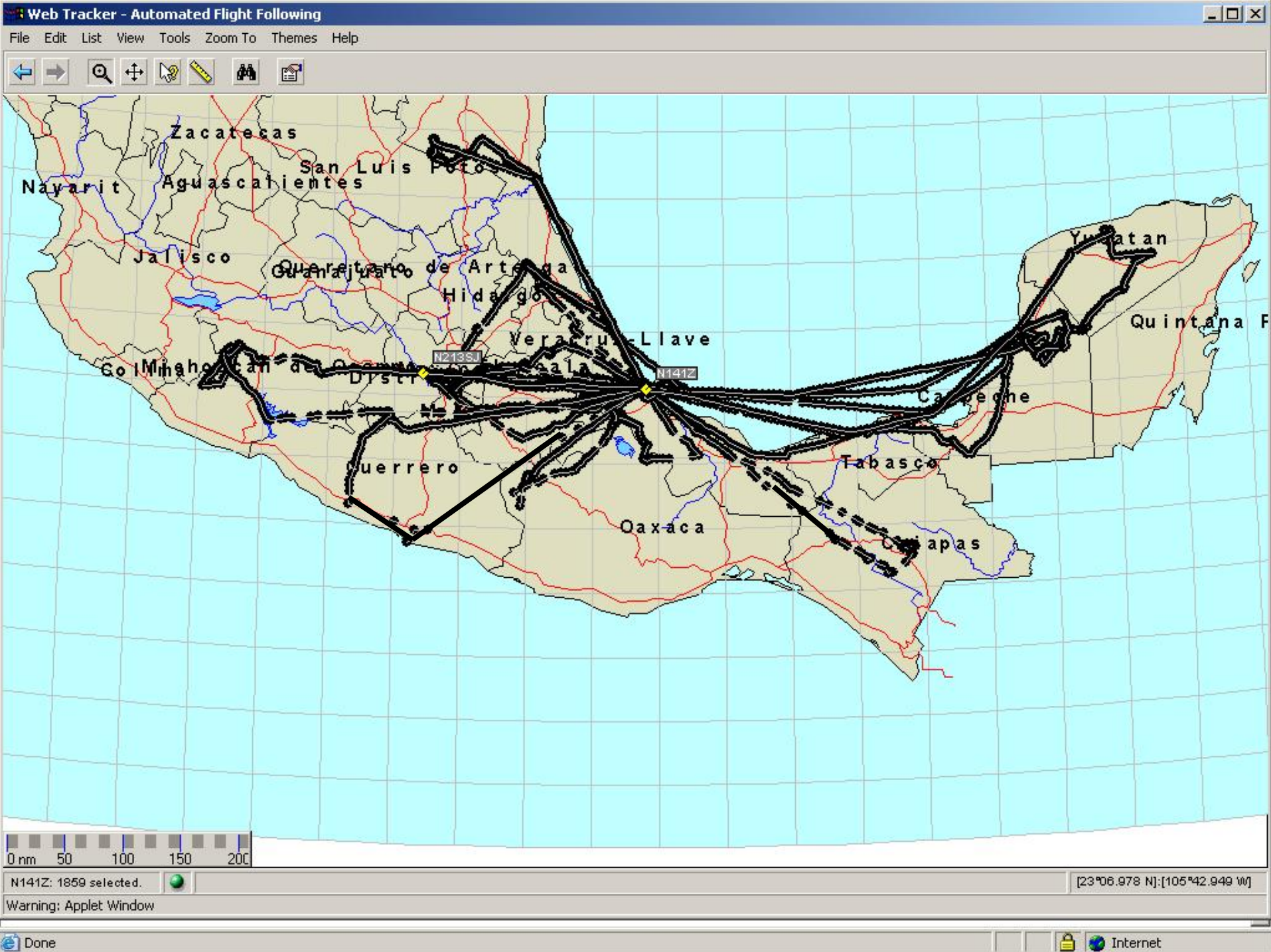
Fire Budgets of CO and OA

	CO from Biomass Burning	Particulates from Biomass Burning
Twin Otter EI estimate	15-23%	68-78% (Primary PM ONLY)
Twin Otter (including SOA)	**15%**	**32-40%**
C-130 Tracer Estimate	**25%**	**31-38%**

Geometric arguments => influence will be larger in the outflow

Extra Slides


N142
U.S. FOREST SERVICE
FIRE


Web Tracker - Automated Flight Following
File Edit List View Tools Zoom To Themes Help
Zacatecas
San Luis Potos
Nayarit
Aguascalientes
Jalisco
Guanajuato
Hidalgo
Veracruz-Llave
Yucatan
Quintana R
N213SJ
N141Z
Campeche
Tabasco
Guerrero
Oaxaca
Chiapas
0 nm 50 100 150 200
N141Z: 1859 selected.
[23°06.978 N]:[105°42.949 W]
Warning: Applet Window
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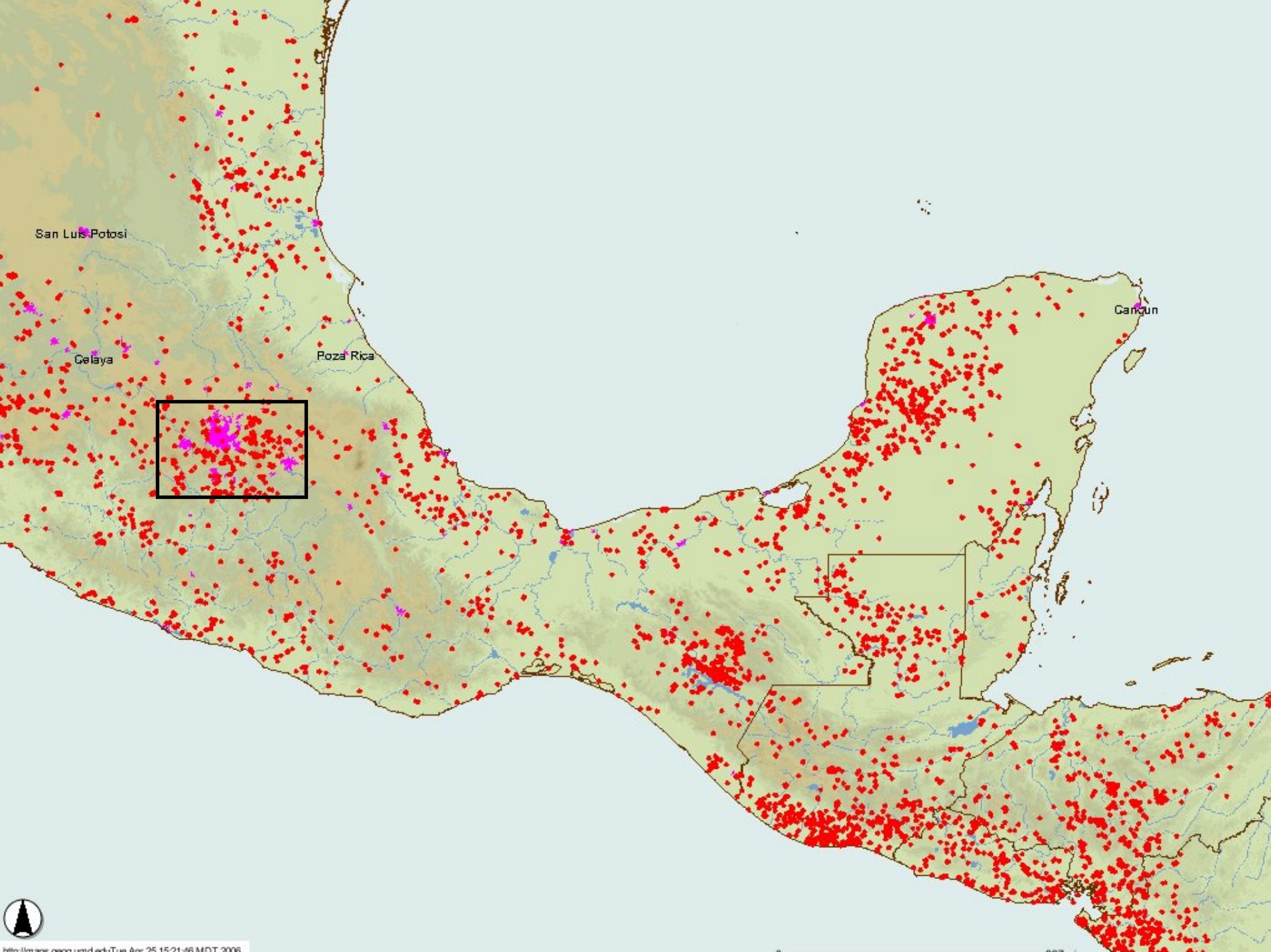
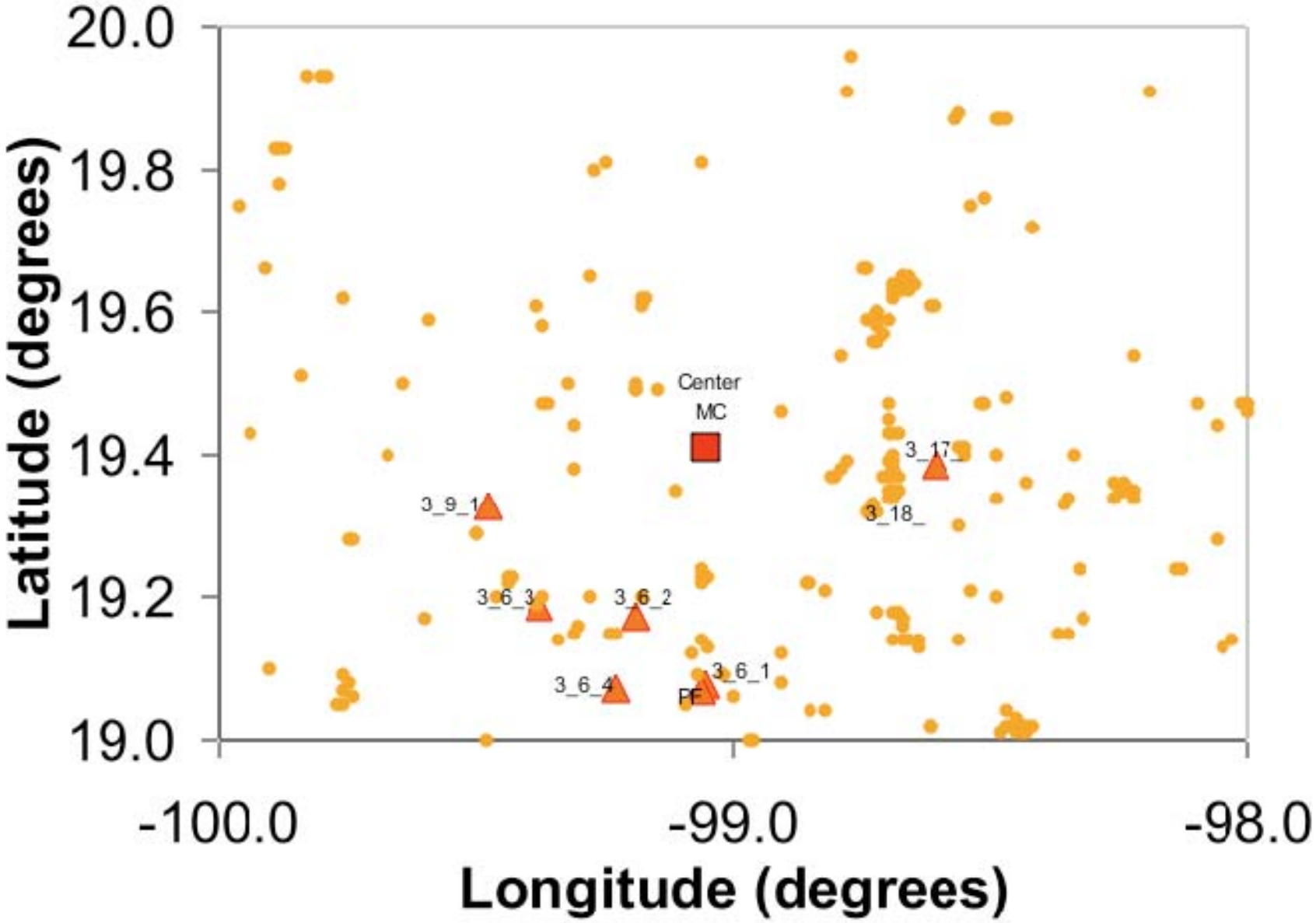

San Luis Potosi
Celaya
Poza Rica
Cancun


20.0
19.8
19.6
19.4
19.2
19.0
Latitude (degrees)
-100.0
-99.0
-98.0
Longitude (degrees)
Center
MC
3_9_1
3_6_3
3_6_2
3_6_4
PF
3_6_1
3_17_
3_18_

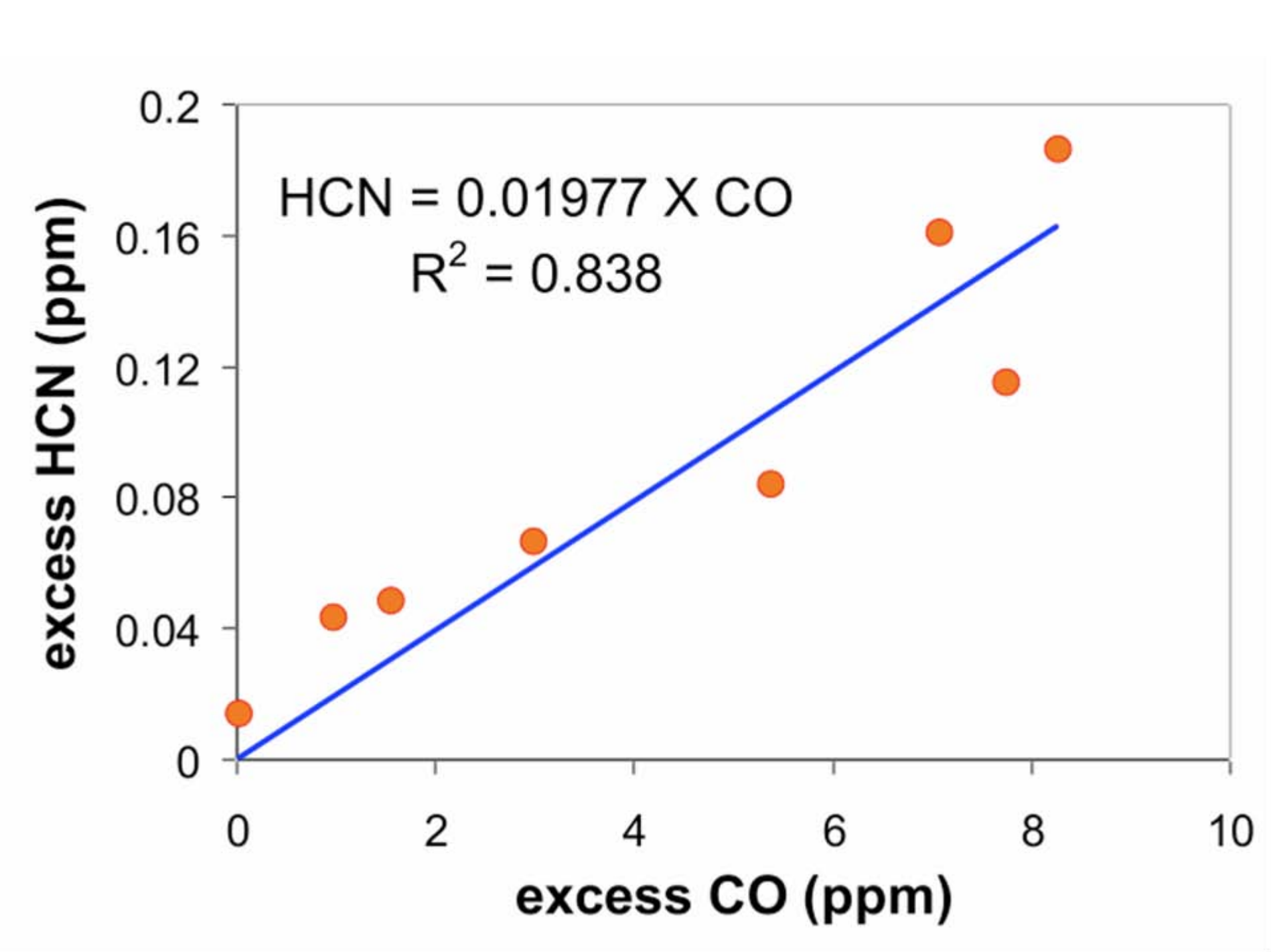
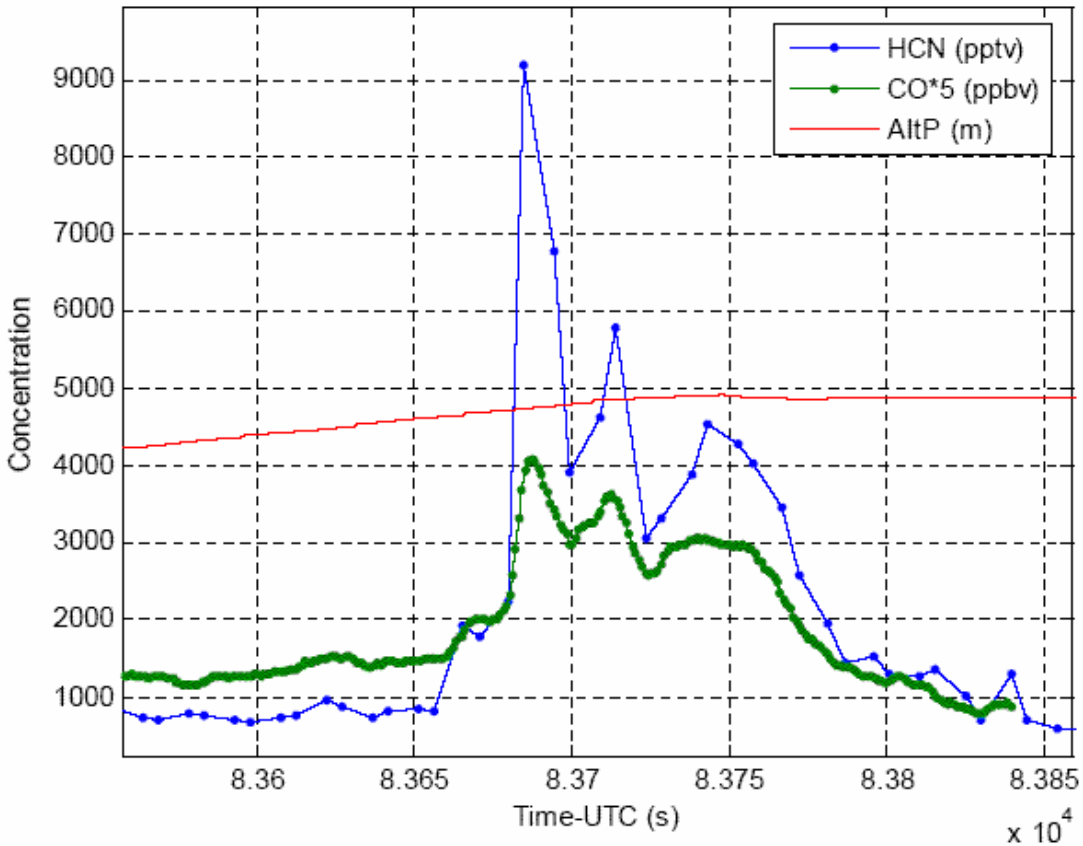

HCN = 0.01977 X CO
R^2 = 0.838
excess HCN (ppm)
0.2
0.16
0.12
0.08
0.04
0
0
2
4
6
8
10
excess CO (ppm)

Table 2. Emission Factors for the pine-savanna forest fires sampled in the mountains surrounding Mexico City in March 2

	March 6th	March 9th	March 17th	March 17th	March 18th	All Fires	All Fires
	Fires 1-4	Fire 1	Planned Fire	Fire 2	Fire 2		
Species	EF (g/kg)	EF (g/kg)	EF (g/kg)	EF (g/kg)	EF (g/kg)	Average	Standard Deviation
CO2	1655	1652	1747	1611	1646	1662	51
CO	83.2	88.6	30.9	112.5	99.2	82.9	31.1
MCE	0.927	0.922	0.973	0.901	0.914	0.927	0.027
NO	6.14	5.88	1.95	2.68		4.16	2.16
NO2	5.51	6.70	3.37	4.54		5.03	1.42
NOx as NO	9.73	10.25	4.15	5.64		7.44	3.01
H2	nm	nm	nm	nm	1.51	1.51	nm
CH4	6.92	5.00	2.81	4.69	5.39	4.96	1.48
C2H4	0.90	0.36	1.38	1.17	0.88	0.94	0.38
C2H2	0.24	nm	0.20	0.12	nm	0.19	0.06
C2H6	0.34	nm	0.35	0.55	1.09	0.58	0.35
C3H6	0.19	nm	0.42	0.48	0.92	0.50	0.30
HCHO	2.37	3.32	3.73	2.55		2.99	0.64
CH3OH	1.48	2.56	1.45	2.77		2.06	0.70
CH3COOH	3.18	6.65	3.61	2.40		3.96	1.86
HCOOH	1.66	4.34	1.83	nm		2.61	1.50
NH3	1.81	0.65	0.30	0.89		0.91	0.65
HCN	1.50	0.32	1.67	0.60		1.02	0.66
propane	0.948	nm	0.141	0.069		0.386	0.488
isobutane	0.119	nm	0.015	nm		0.067	0.074
n-butane	0.326	nm	0.040	nm		0.183	0.202
t-2 butene	0.013	nm	0.030	0.044		0.029	0.016
1-butene	0.042	nm	0.086	0.105		0.078	0.032
isobutene	0.053	nm	0.072	0.118		0.081	0.033
c-2-butene	0.010	nm	0.021	0.031		0.021	0.011
cyclopentane	0.004	nm	0.002	nm		0.003	0.001
isopentane	0.032	nm	0.011	nm		0.022	0.015
n-pentane	0.051	nm	0.018	0.008		0.026	0.023
1,3 butadiene	0.042	nm	0.090	0.069		0.067	0.024
PM1	7.08	7.40	6.83	21.0	13.0	11.05	6.10

Temporary Measurement Key	
	U Miami Cans
	FS Cans
	UC UHSAS
	FS neph
	UM AFTIR

“Tracer”-based Estimate Fire Contribution



C-130 March 10th Data

Twin Otter AFTIR

Study Average

MC-area

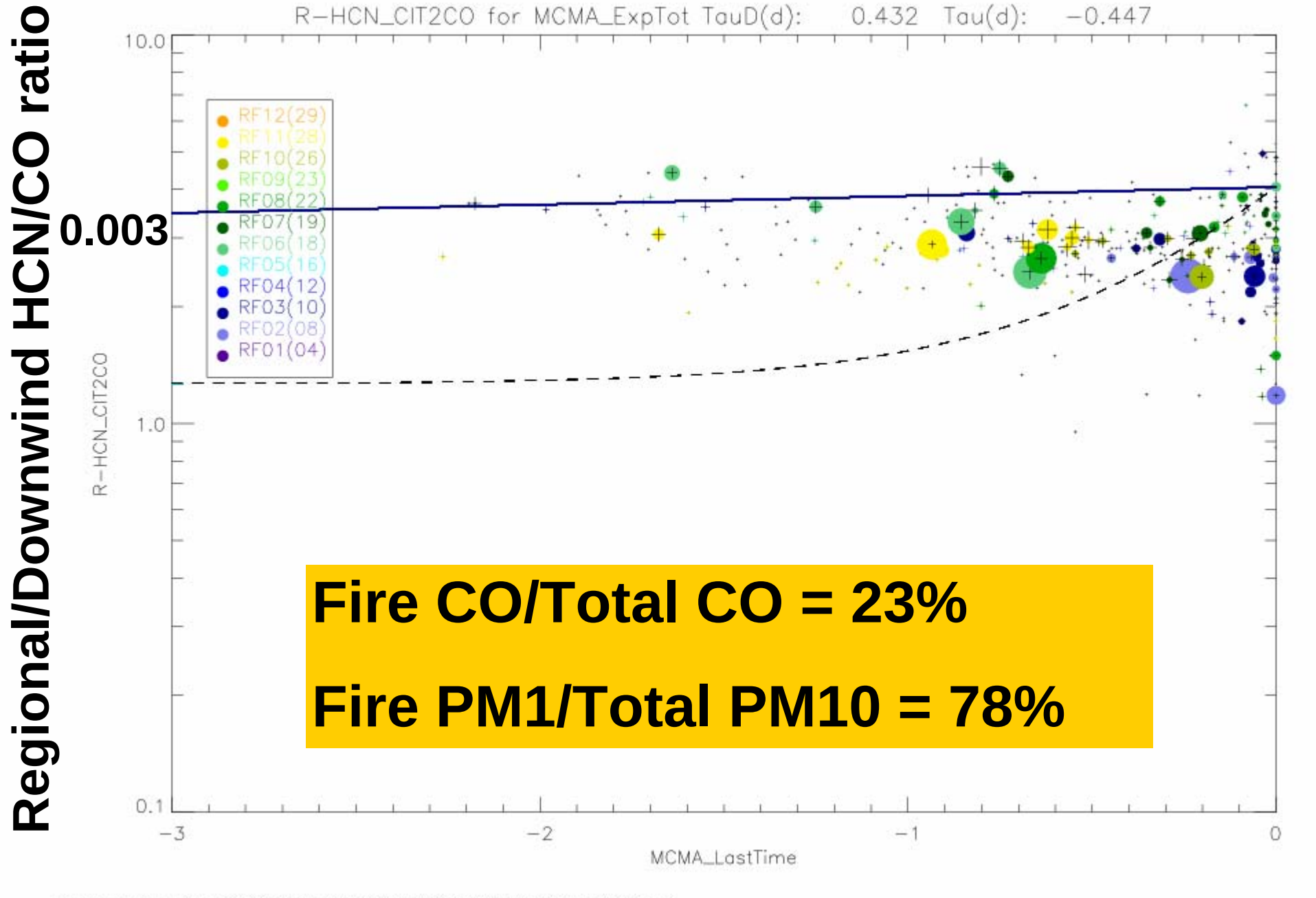
HCN/CO = 0.0128

C-130

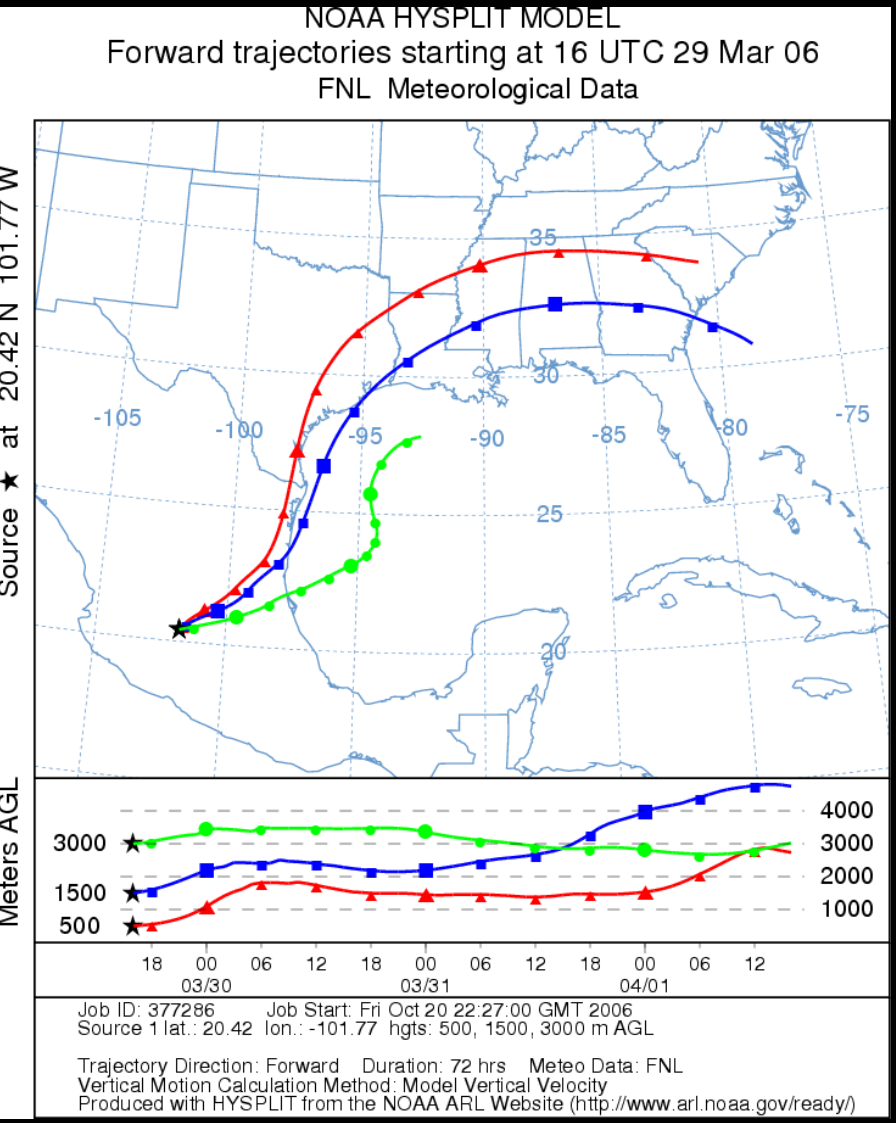
MC-area

HCN/CO = 0.011

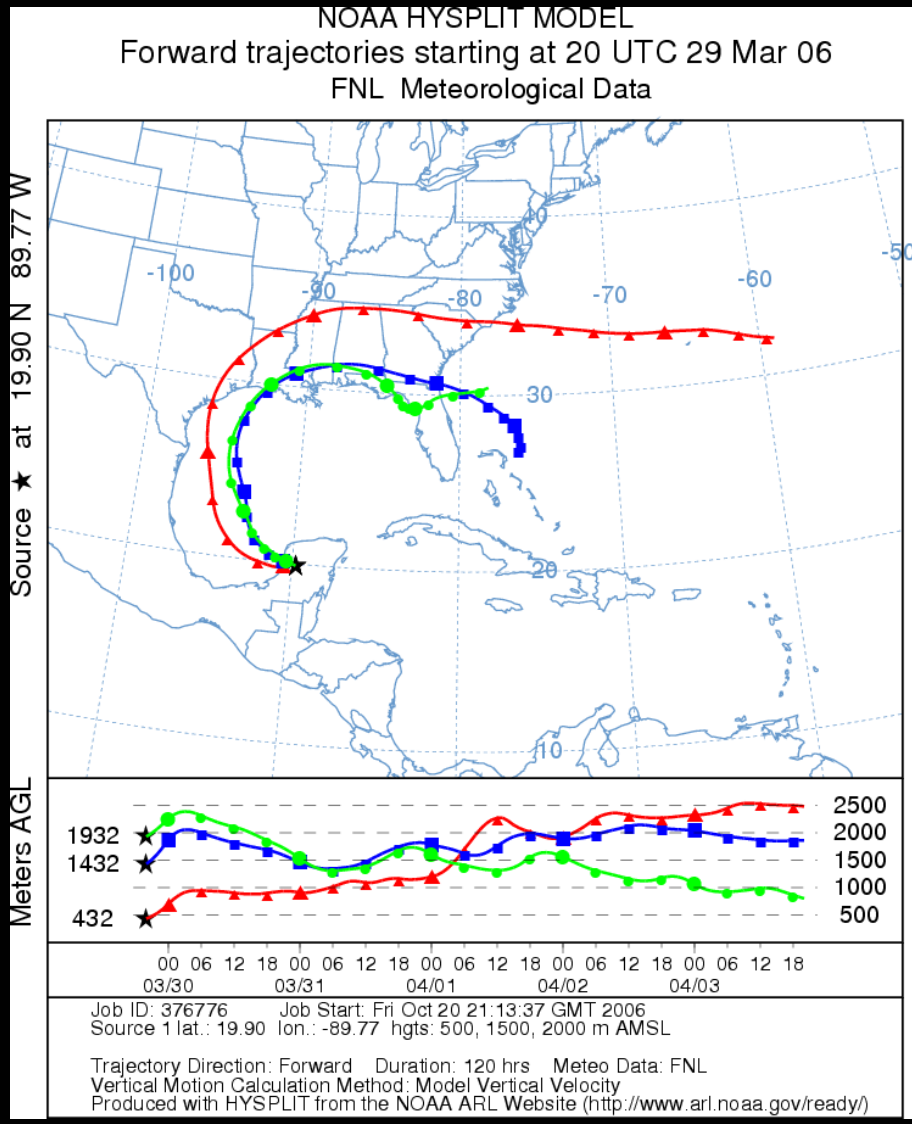
Danny McKenna (NCAR)



~MC Area Forward trajectories



~Yucatan Fire Forward trajectories



Conclusions

- **Mountain Fires produce 15-25% of CO, VOC, NOx in Mexico City Area outflow**
- **Fire emissions impact O3 (dust also) and soa**
- **Mountain Fires produce 70-80% of PM in Mexico City Area outflow (high in OC)**
- **Mexico City Plume and Yucatan (and other) Fires Interact Further on Regional Scale**

FUTURE RESULTS

2006 Twin Otter data Still to be analyzed:

MC DOWNTOWN: 5X; MAR 6, 9, 17, 18, 28

MC OUTFLOW: 5X; MAR 6, 8, 9, 11, 17

MC INFLOW: 6X; MAR 6, 8, 20, 25, 26, 27

VPS: T2 3/9; TAM 3/11; VER 3/8; 21x98 3/8&9

YUCATAN: 3X; MAR 12, 22, 29

CHIAPAS: 3/20

GUERRERO: 3/27

APRIL - MAY 2007 GROUND-BASED MEAS.:
COOKING GARBAGE ETC FIRES: