Methyl Halide Emissions From Experimental Fires With Southern African Biofuels

Collaborative Research: Biomass Burning Emissions Over Southern Africa.

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MPI work shops and staff , MPI

and everybody who is & will be collaborating….

Please also visit this poster: Keene et al., A51A-0043

AGU Fall Meeting, 10-14 December 2001

Research Objectives

To model halogen-, nitrogen-, sulfur- and carbon fluxes to the atmosphere over southern Africa during the dry season.

1. Sampling of representative biofuels from
    * Etosha National Park, Namibia
    * Kruger National Park, South Africa
    * Miombo Network in Zambia, Malawi

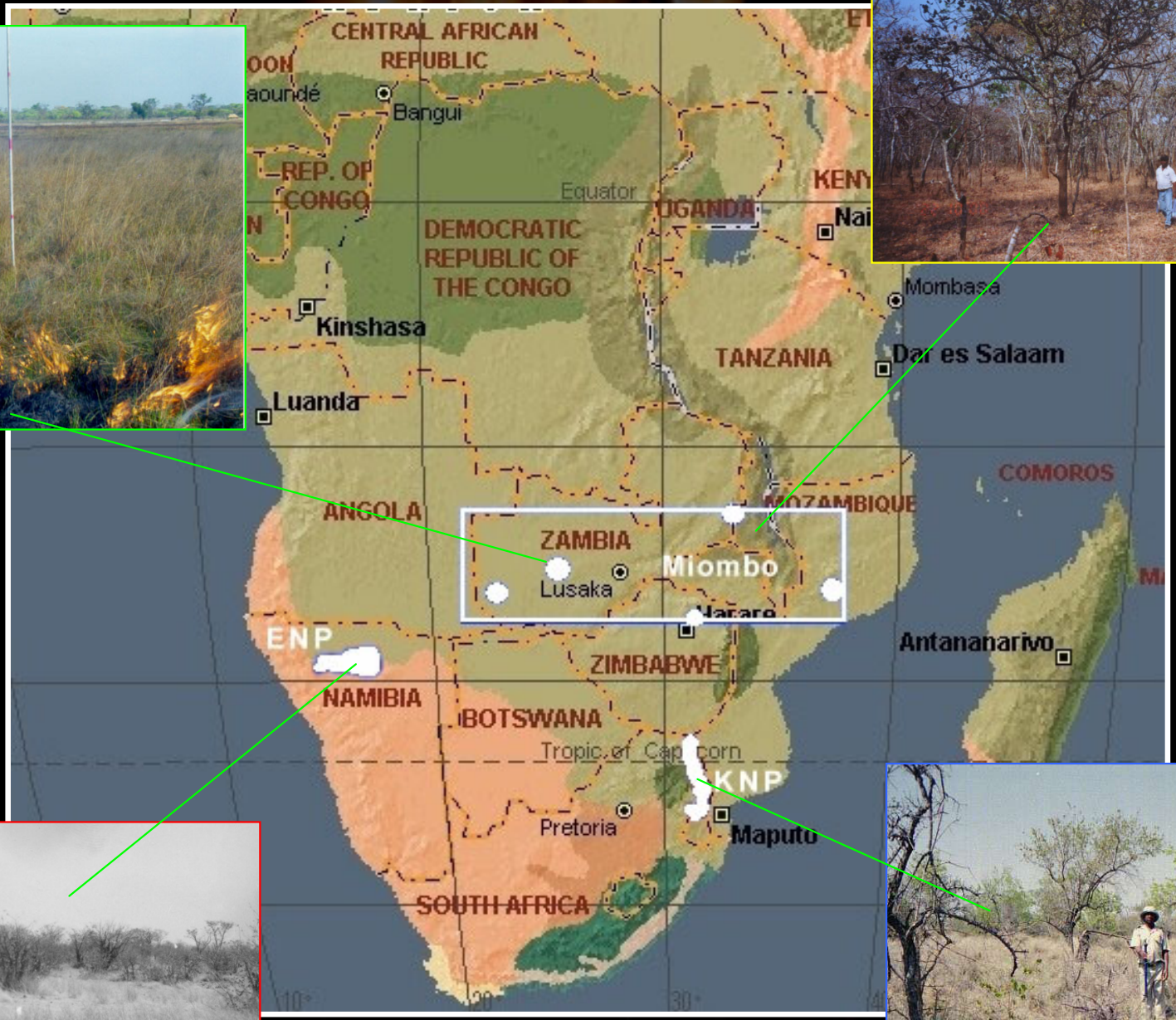
2. Burning biofuels under semi-controlled conditions & measuring emissions of C, N, Halogen, S containing species.

3. Analyzing the biomass & ash for C, N, Cl, Br, I, S, P, Ca, K of

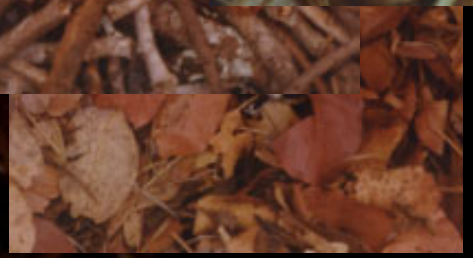
4. Mass balance for each individual fire and group of experiments. Developing algorithms (e.g., based on burning efficiency) to predict biomass burning emissions.

5. Collaborating with SAFARI-2000 investigators to estimate regional emissions

1. Fuel Sampling



1. Biofuel & Experiment Summary



Total of 60 experiments with 8 basic fuel types, 6 fuel regions, 4 fire types, varying moisture and other parameters.

Kruger National Park, South Africa (KNP)
* 23 experiments with these fuels:
  * 17 savannah grass, 8 twigs and branches, 1 litter

Etosha National Park, Namibia (ENP)
* 11 experiments with these fuels:
  * 5 savannah grass, 3 shrubs, 2 branches, 1 litter

Miombo Network, Malawi (MAL)
* 17 experiments with these fuels:
  * 4 savannah grass, 3 branches, 2 brush/shrubs, 2 litter, 4 agricultural waste, 2 charcoal

Miombo Network, Zambia (ZAM)
* 6 experiments with savannah grass

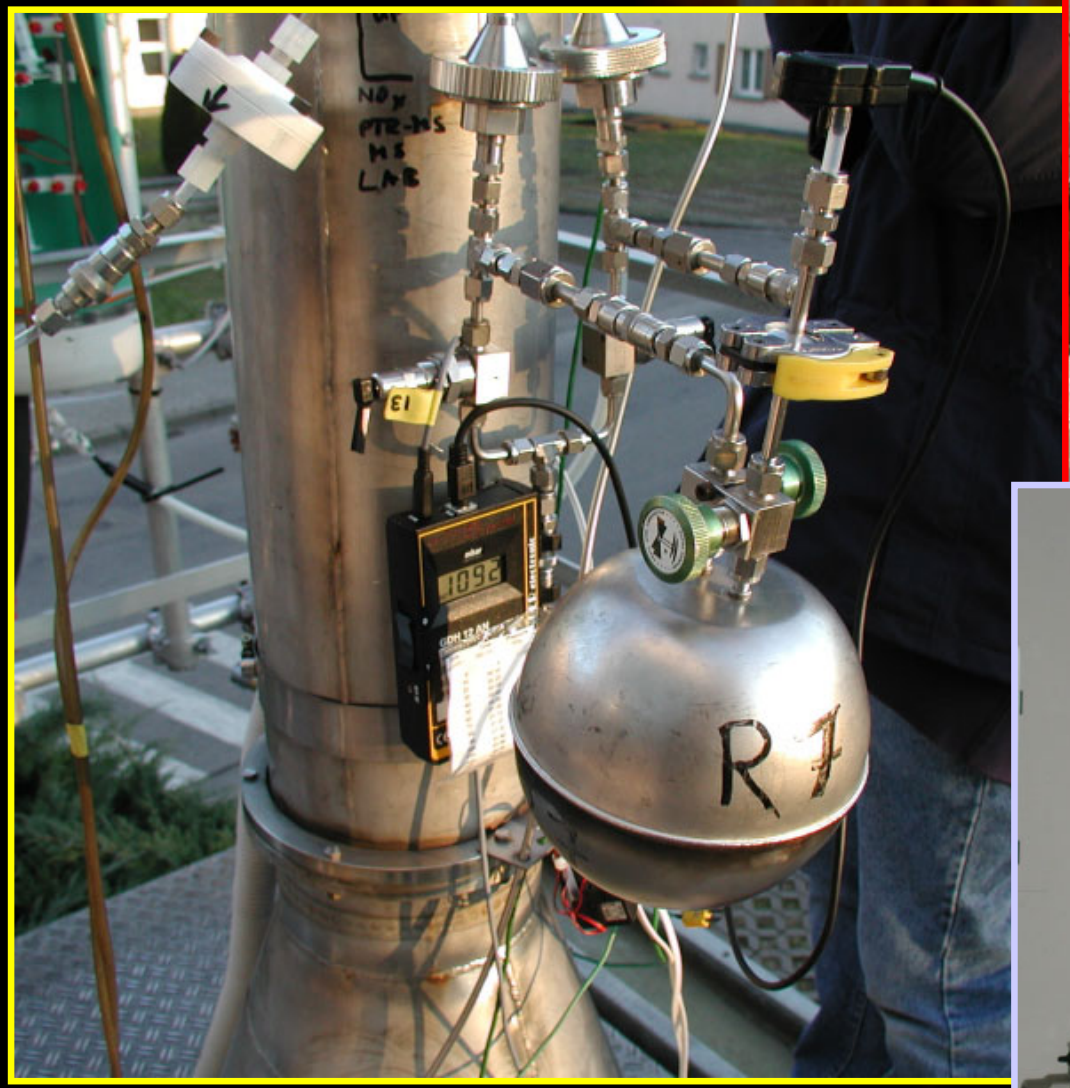
India (IND)
* 2 experiments with dried cow dung cakes (one stove, one open)

Alaska (ALA)
* 1 experiment with peat

2. Burning Facility

2. Burning Facility – partially controlled fires

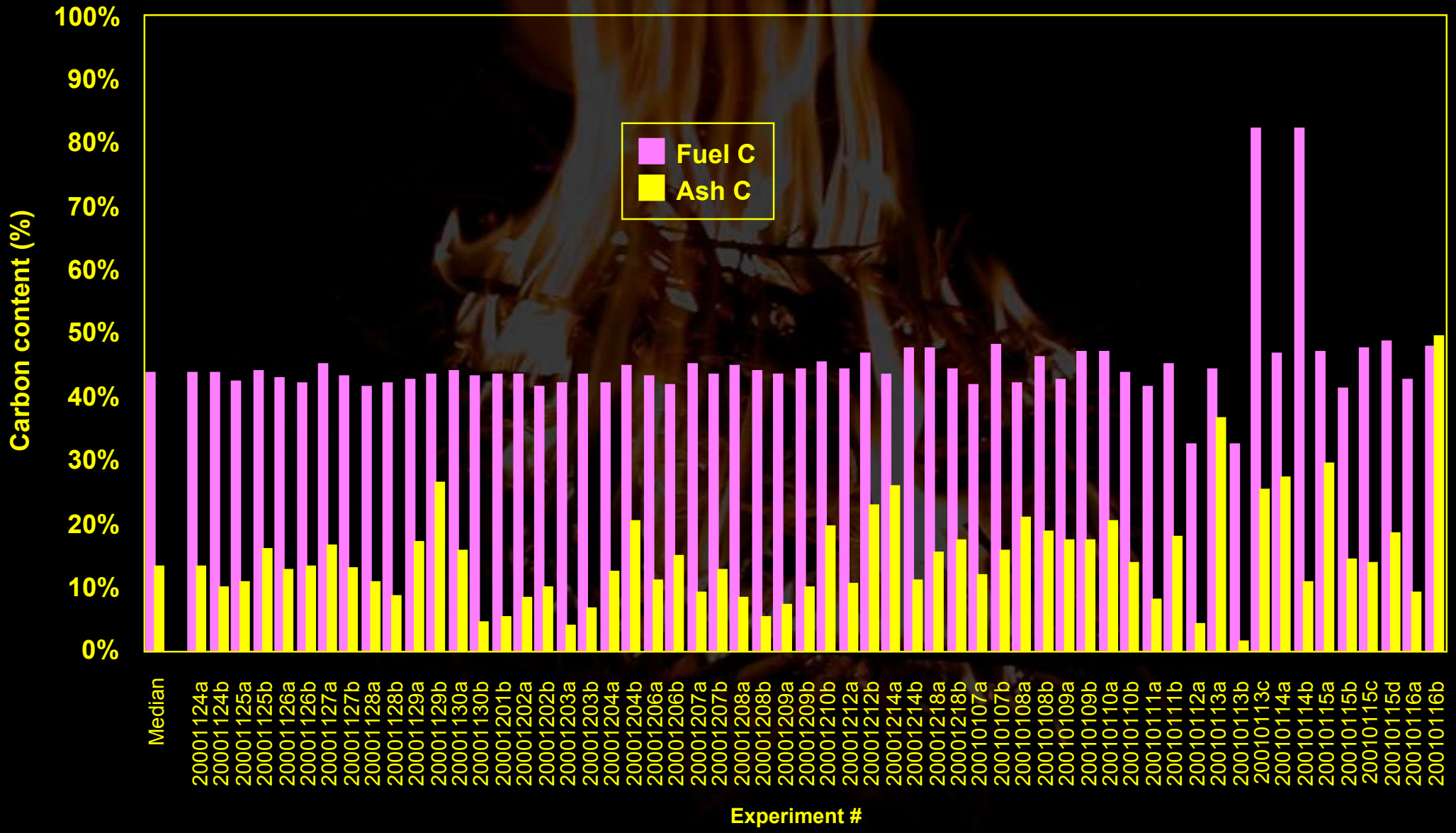
2. Flask Sampling & GC/MS



2. Other instruments

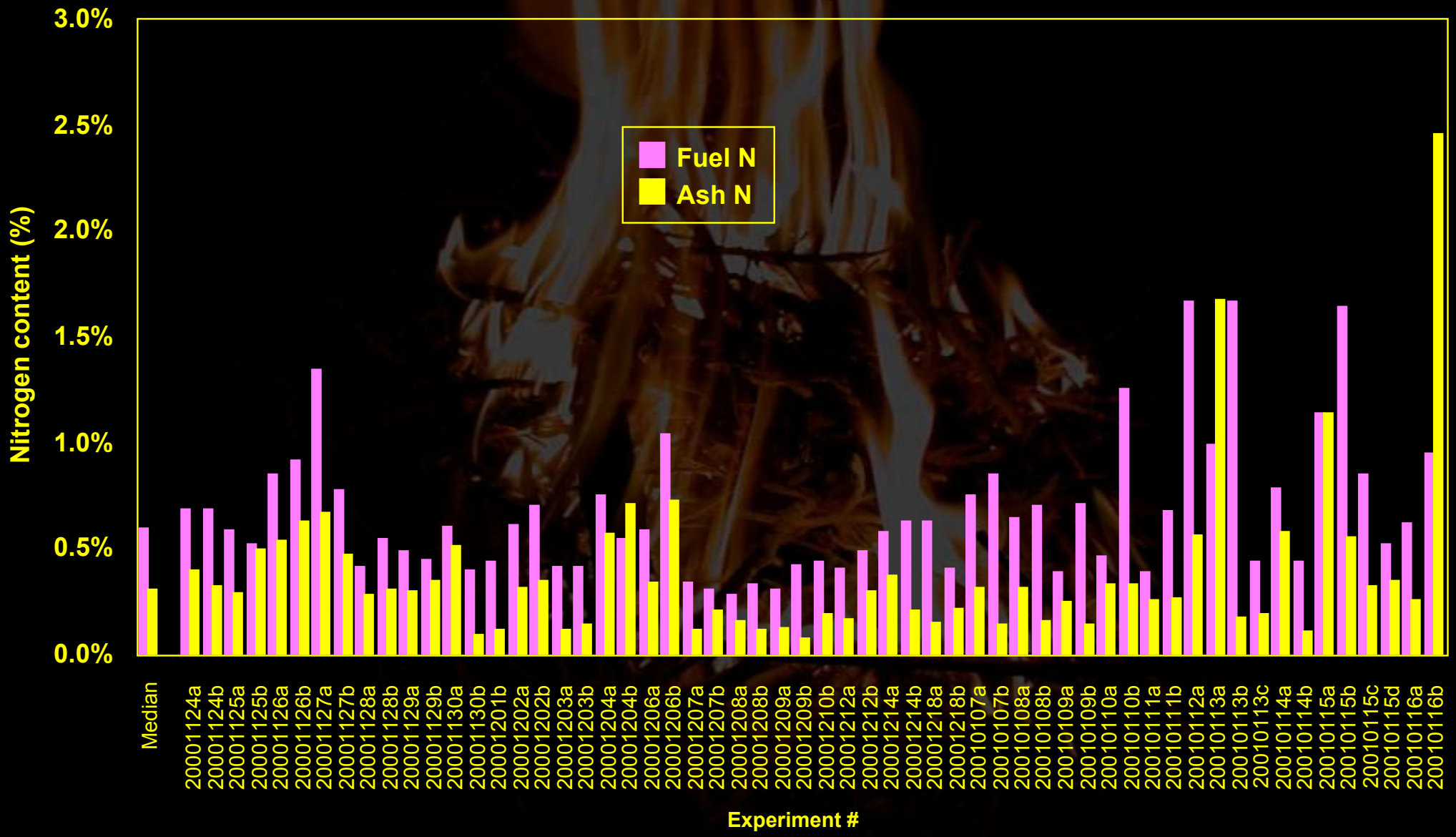
Continuous monitors: CO_2, CO, NO_X *
Temperatures: Stack top, stack middle, fuel *
Air speed: stack top *
Scale 0-30 kg, 1 g resolution *
16-channel data acquisition system *
Base air flow provided by fan on top *

3. Elemental Analyses - Carbon contents



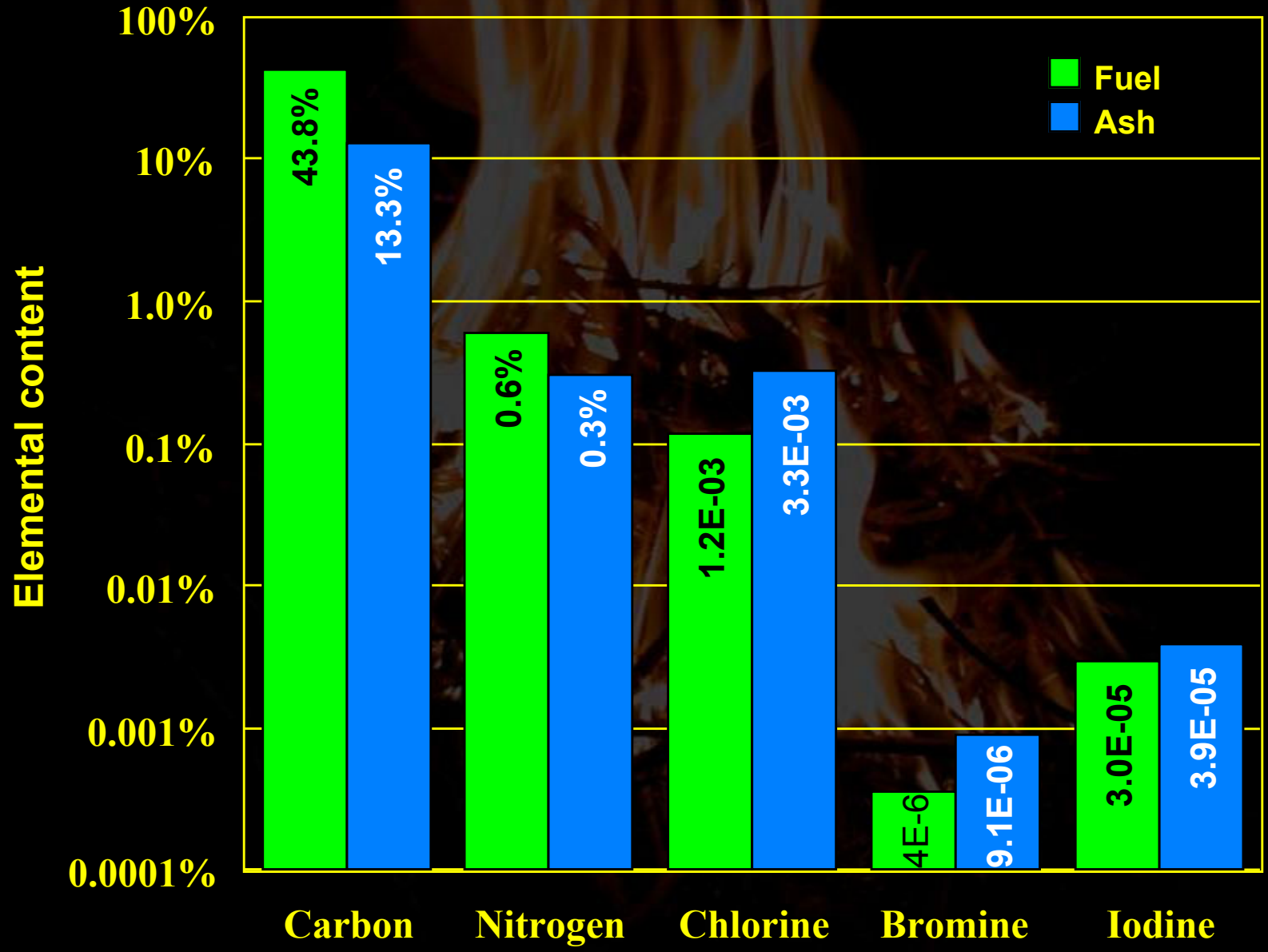
Very uniform fuel carbon content, ash more variable

3. Elemental Analyses - Nitrogen contents



Both fuel and ash nitrogen content vary widely – same applies to halogen contents

3. Elemental Analyses – Fuel and Ash comparison



Ash depletion of C & N; enrichment of halogens

4. Mass Balances – Percent Emitted Element

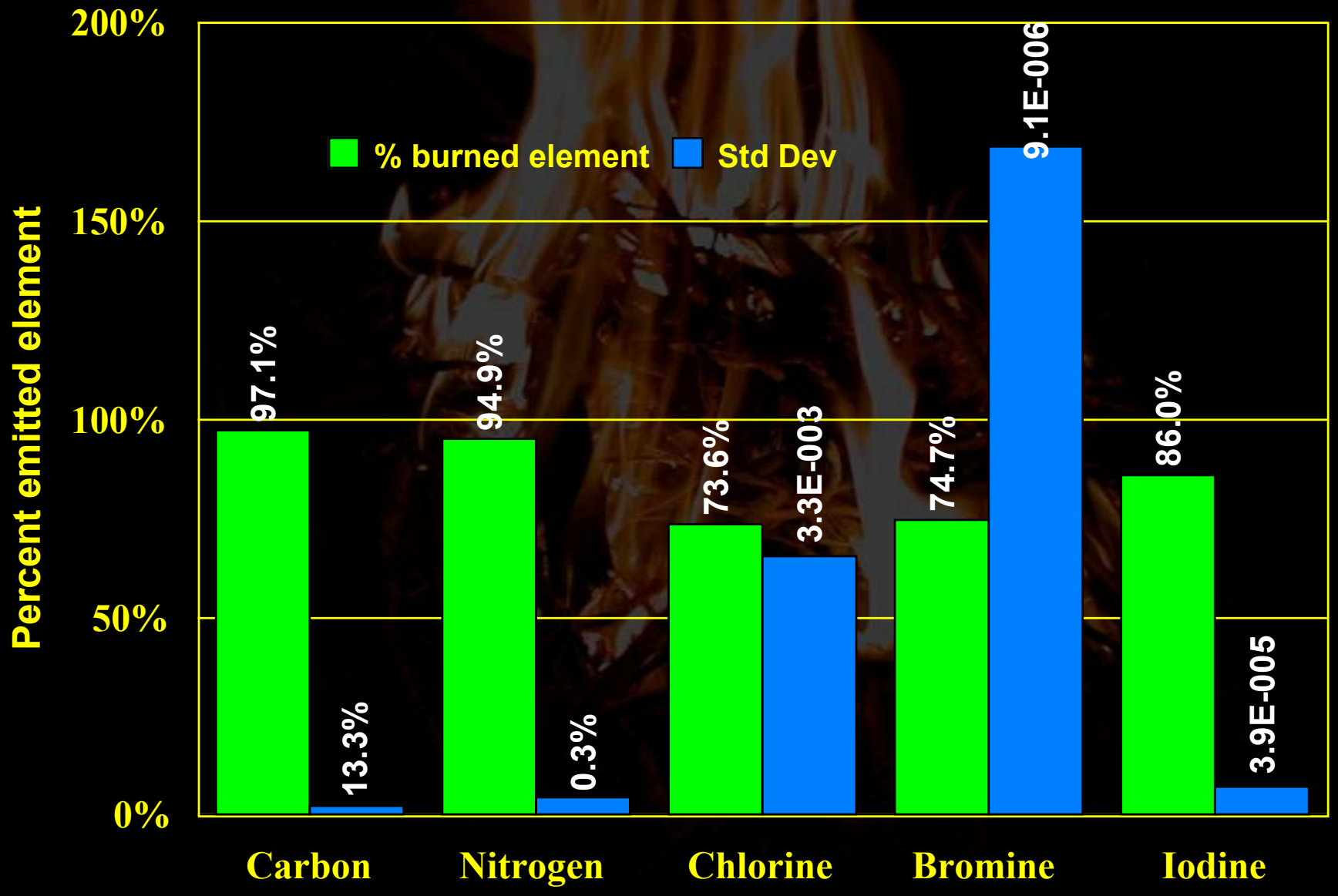
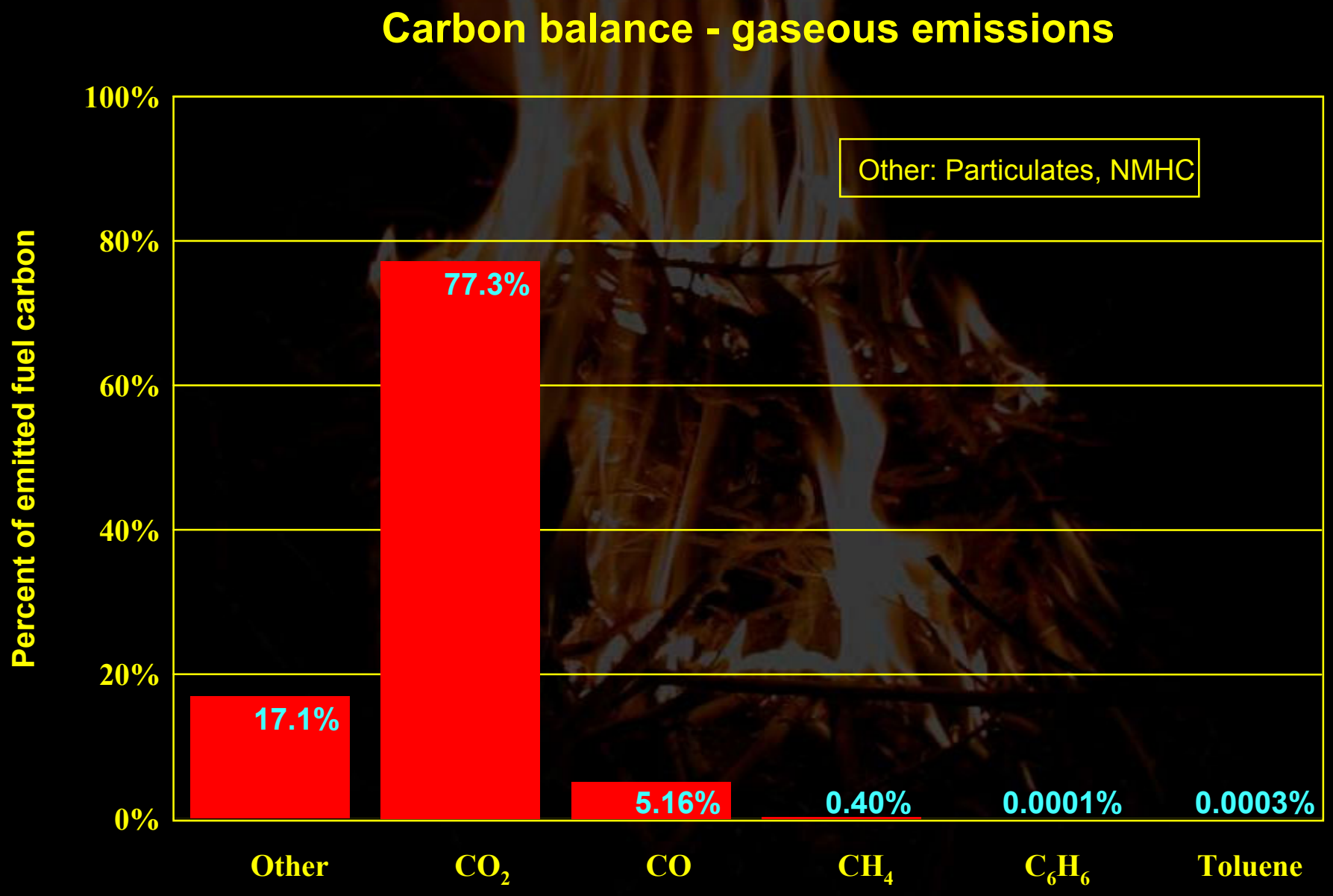


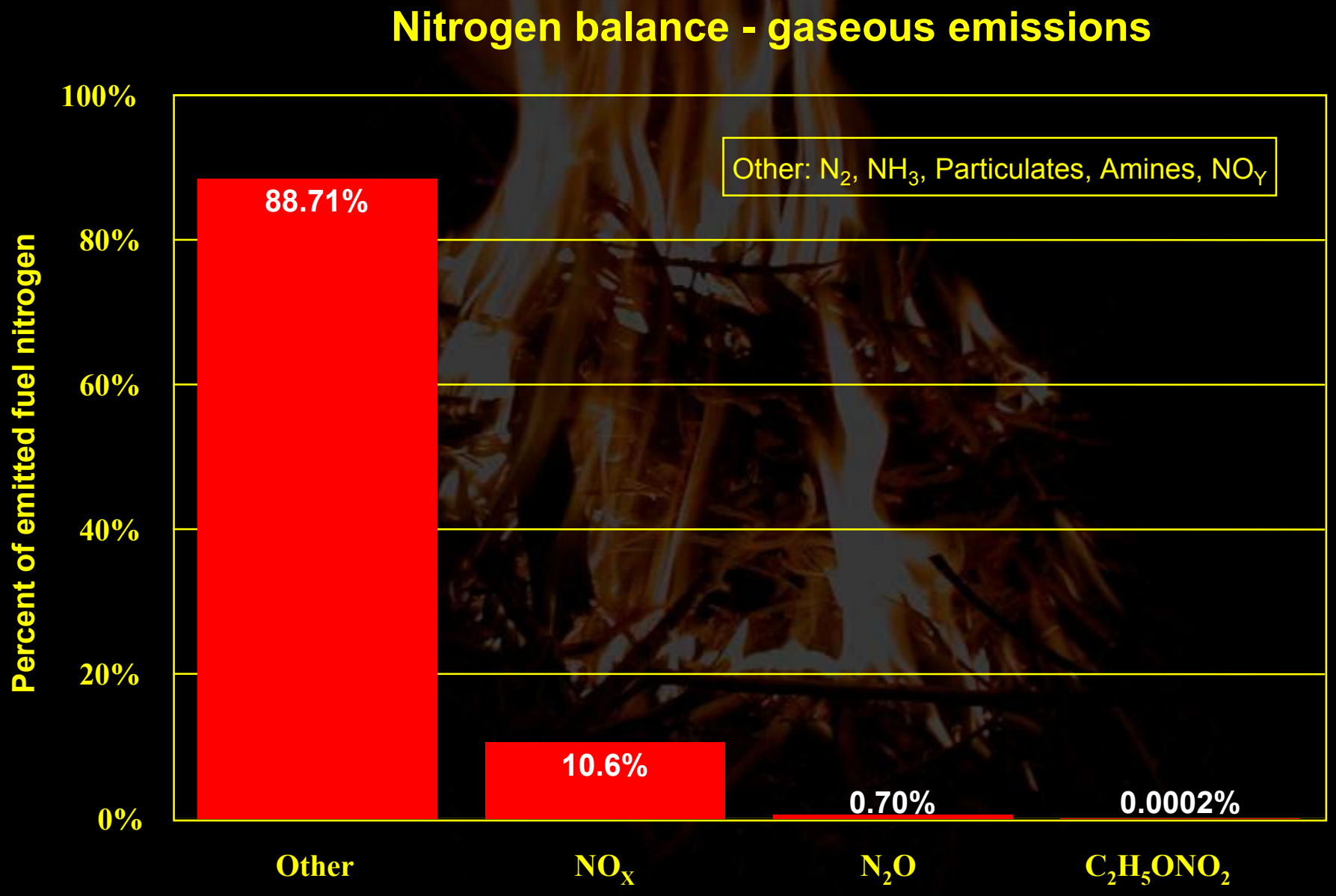
Table of measured halogen gases (GC/MS)

Compound		Mixing Ratios (ppt)			Number of flasks		% of flasks	Comments
		Ambient	Calgas	Flasks	above ambient	total	above ambient	
Chlorine								
Fluoro-carbon-12	CFC-12	572	560	792	2	177	1%	
Chloro-methane	CH3Cl	563	567	316616	172	178	97%	
Chloro-ethane	C2H5Cl	3.3	1	221	155	175	89%	
Fluoro-carbon-11	CFC-11	278	266	22	5	180	3%	
Dichloro-methane	CH2Cl2	211	46	843	44	172	26%	
Trichloro-methane	CHCl3	47	12	1291	144	178	81%	
1.1.1. Trichloro-ethane	CH3CCl3	43	51	167	12	175	7%	co-elution
Tetrachloro-methane	CCl4	105	99	223	13	175	7%	C6H6 o'load
Trichloro-ethene	C2HCl3	18	1	21	28	177	16%	
Tetrachloro-ethene	C2Cl4	27	14	63	38	178	21%	
Bromine								
Bromo-methane	CH3Br	9.2	16	2361	162	173	94%	
Chloro-bromo-methane	CH2ClBr	1.2	1.3	160	109	117	93%	
Dibromo-methane	CH2Br2	1.2	1.5	30	86	176	49%	
Tribromo-methane	CHBr3	2.1	4.1	47	72	175	41%	
Iodine								
Iodo-methane	CH3I	1.1	1.1	42	163	166	98%	
Diiodo-methane	CH2I2	0.8	1.2	22	138	156	88%	
Iodo-ethane	C2H5I	4.7	1.8	298	29	31	94%	
Nitrogen								
Ethyl nitrate	C2H5ONC	3.6	6.6	795	160	169	95%	
Carbon								
Benzene	C6H6	2.7	1	2053	163	165	99%	
Toluene	Toluene	11	1.1	2270	163	169	96%	

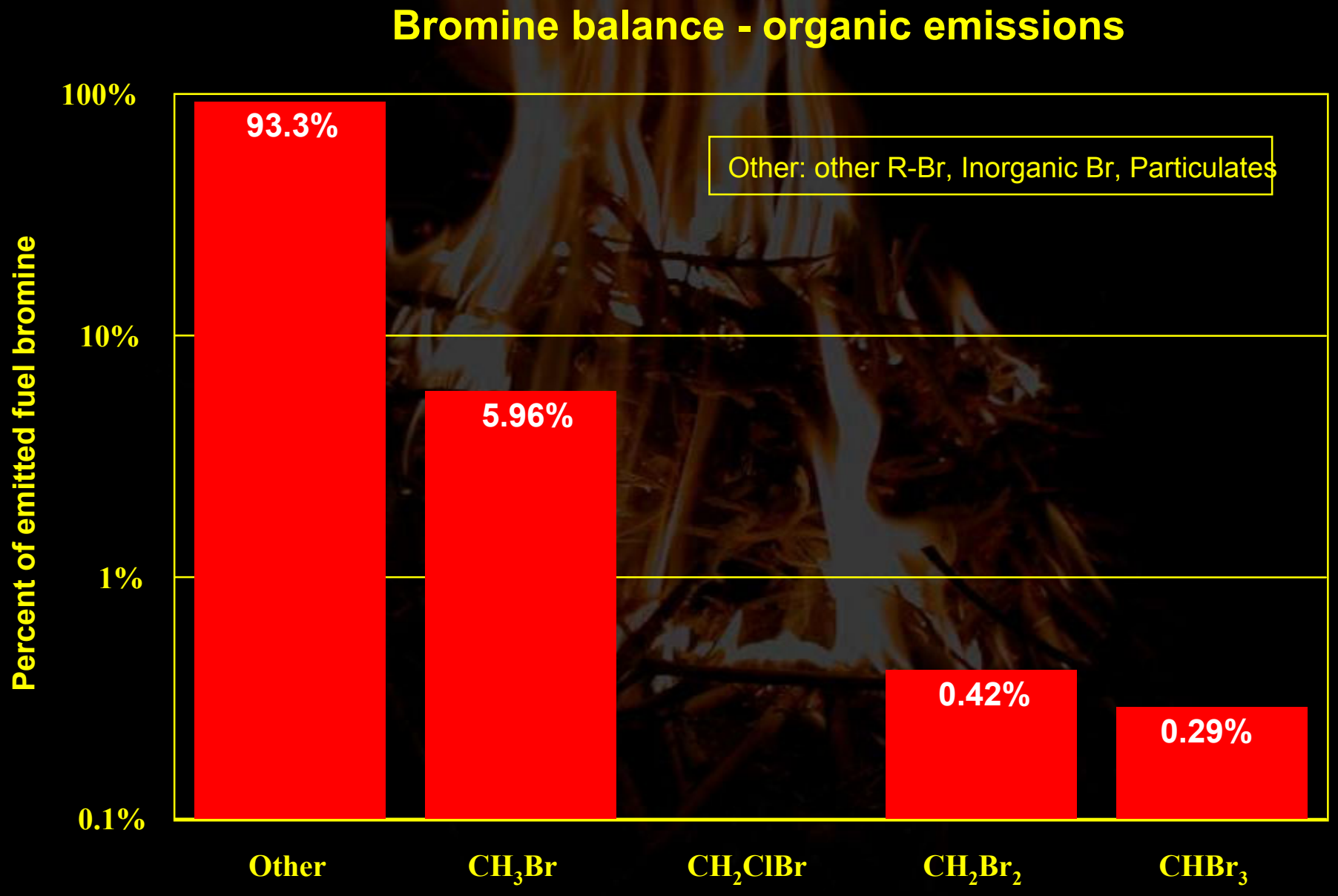
Emissions – Carbon gases



Emissions – Nitrogen Gases

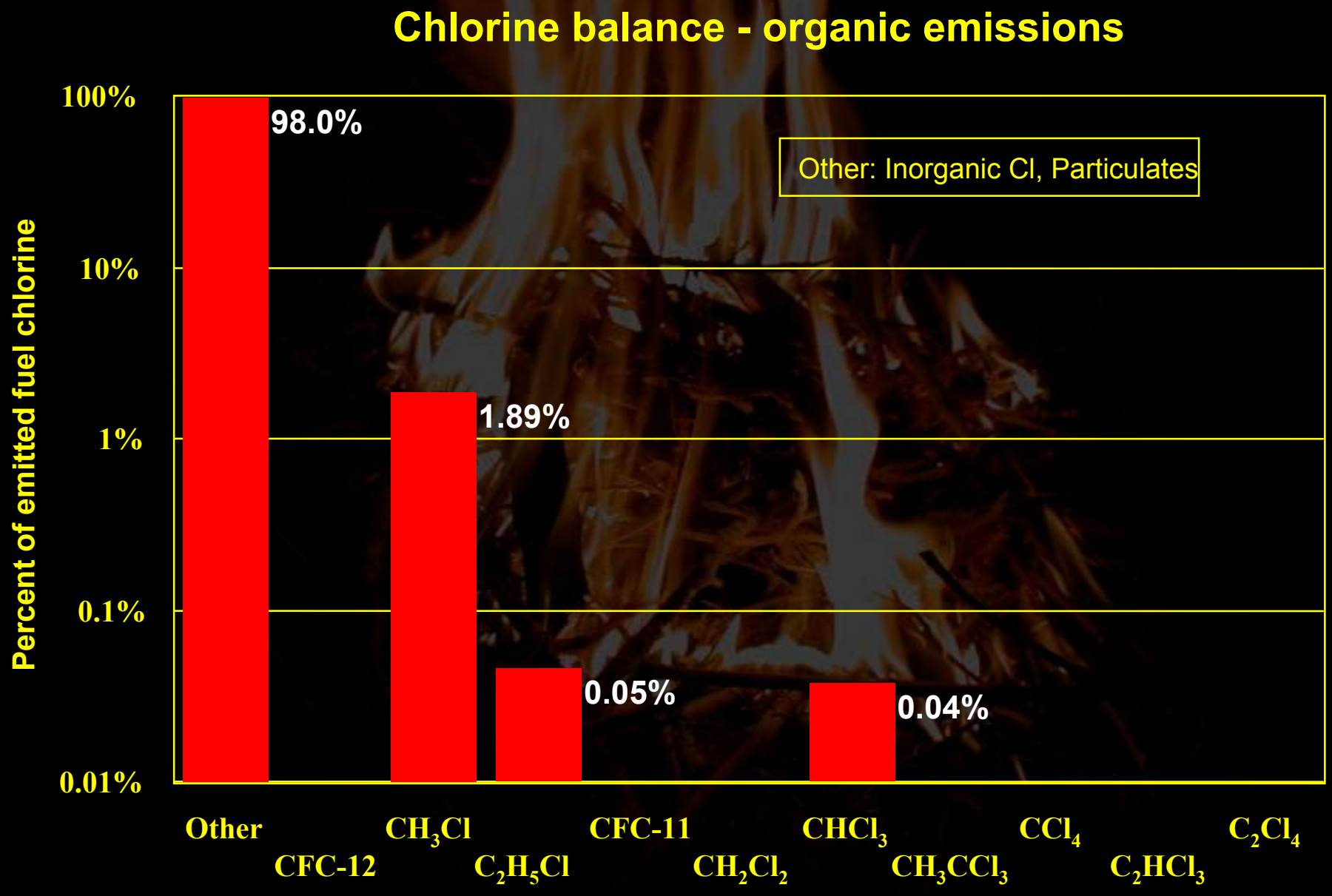


Emissions – Bromine Gases

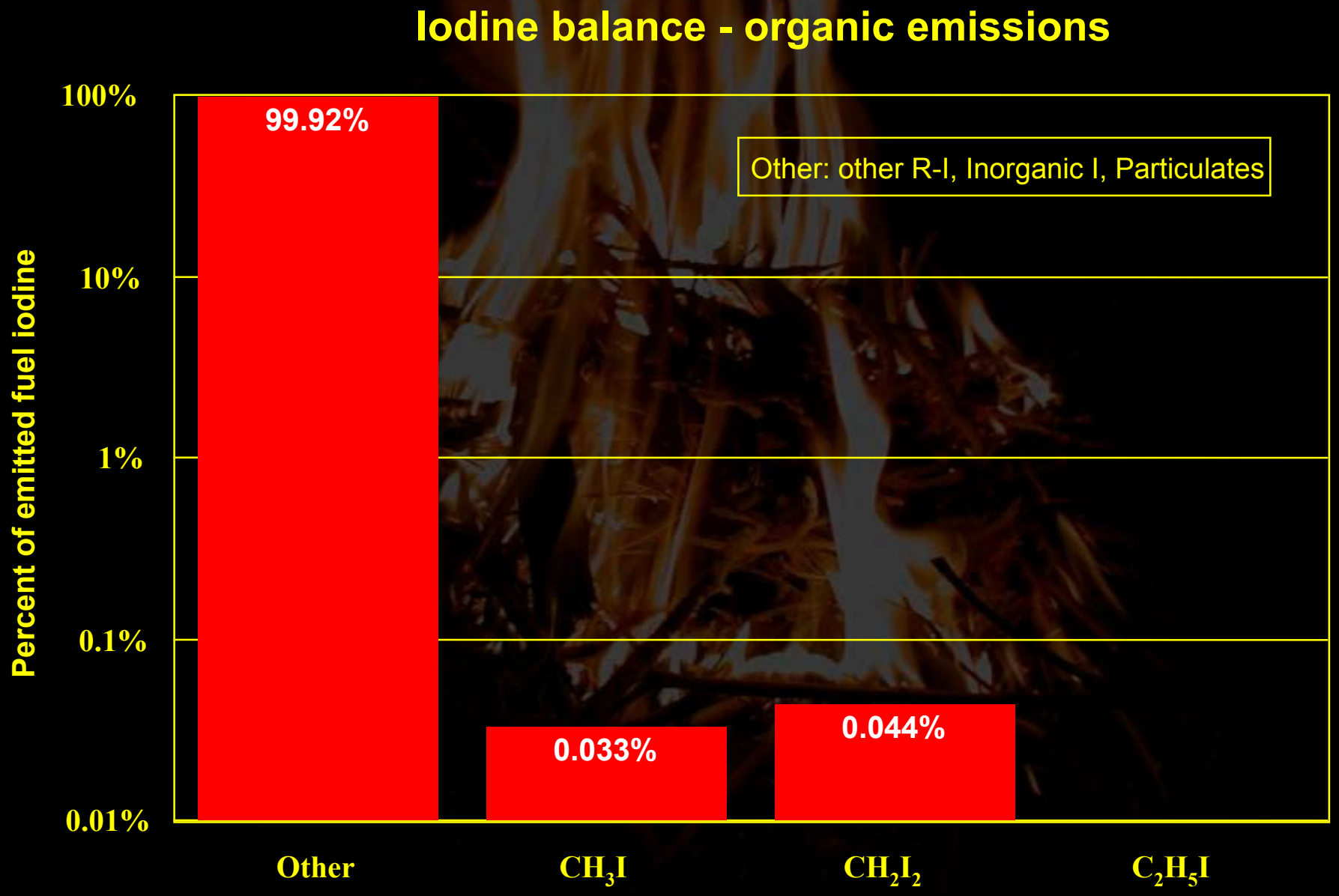


Significant uncertainty in Br mass balance: detection limit of elemental analysis

Emissions – Chlorine Gases



Emissions – Iodine Gases



Large uncertainty in Iodine mass balance: detection limit of elemental analysis

5. Regional Emissions Estimates

Several possible implemenations:

* Logan / Yevich database for rigid, 1°x1° biomass burning emissions as done in Lobert et al. (JGR, 1999)

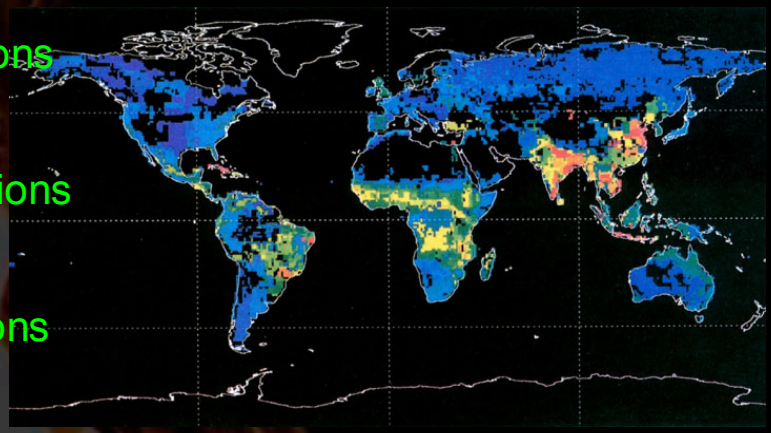
Emission from Southern Africa (south of equator; w/out Madagascar)

Carbon emissions
6.03E+14 gC / yr 16.2% of global carbon emissions

Chlorine emissions:
8.96E+11 gCl / yr 12.8% of global chlorine emissions

CH3Cl emisisons
8.74E+10 gCl / yr 13.7% of global CH3Cl emissions

Inorganic Cl emissions
8.09E+11 gCl / yr 12.7% of global inorg. chlorine emissions



* Christelle Hely: detailed model for Miombo / Zambia (early 2002)

* Tobias Landmann: detailed model for Kruger NP (Spring 2002)

* Stefania Korontzi: detailed model for southern Africa (Summer 2002)

Tidbits to take home…..

- Experimental, partially controlled fires with a wide variety of real-world fuels from four regions in southern Africa (+dung & peat)
- Complete mass balance for each fire enables better emissions estimates
- Mass balances for C, N, Cl, Br, I, S, P
- Carbon:
  - uniform fuel content, slightly variable ash content
  - about 90% of emitted carbon can be explained
- Nitrogen:
  - very variable fuel & ash content
  - only about 1/3 of the fuel nitrogen can be recovered with major species. Significant portion is N_2
- Halogens:
  - very variable fuel & ash content
  - only a few percent of fuel halogens can be explained withorganic emissions
- Suspense: for major portions of emissions, see poster A51C-0043
- Regional integration of emissions to come during 2002…