Boreal fire emissions in transported pollution plumes measured at the GEOSummit Station, Greenland

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Introduction

Measurements of ozone (O_3) precursors in conjunction with FLEXPART tracers and trajectory simulations are used to identify polluted air masses transported to the GEOSummit station, Greenland (72.6N,38.5W, 3212 m.a.s.l.) to assess the impact of biomass burning emissions on O_3 levels in the Arctic lower free troposphere.

Measurements

Table 1: Measurements at the GEOsummit site from Jun 2008- Jul 2010

Species	Method	Frequency
NO	O_3 chemiluminescence	10 min
NO_2	NO_2 photolysis (blue LED)	10 min
NO_y	Au-catalyzed reduction by CO	10 min
PAN	Gas Chromatography	10 min
NMHC	Gas Chromatography	~10/day
O_3*	UV Photometric	5 mins

*O_3 data from ERSL/NOAA .
NO_x, NO_y, PAN and O_3 have been filtered by wind direction to remove potential influence from camp pollution. In this work we use hourly-averaged datasets for all species except NMHC

Plume identification

- FLEXPART: A Lagrangian air parcel dispersion model is used to assess transport and events using CO (anthropogenic) and BC (fire) tracers calculated from emission inventories.
- **Biomass burning events:** Periods when the BC fire tracer > 90th percentile (for at least 12 hours) and the mean anthropogenic CO tracer is < 50th percentile.
- Using this plume identification technique we observe **15 biomass burning events** during two years of measurements

Biomass Burning Events

Table 2: Mean enhancements in trace gases measured at GEOSummit site during biomass burning events

BB Event	Period	Length (hrs)	Plume age (days)*	ΔO_3 (ppbv)	ΔPAN (pptv)	ΔNO_y (pptv)	ΔNO_x (pptv)	Primary BB Source
1	25-26 Jul 08	36	8.7	-2.5	-	-	-	Canada
2	16-17 Jul 08	294	14.7	6.6	-12.1	-15.3	0.1	Canada
3	3-15 Aug 08	42	10.8	2.4	35.0	135.1	15.6	Canada
4	19-21 Aug 08	30	8.1	-4.2	-	-	-	Canada
5	14-15 Nov 08	15	11.3	3.2	26.4	54.9	3.9	Canada
6	**1-2 Jun 09**	**21**	**17.2**	**29.4**	**22.4**	**76.9**	**2.0**	**Russia**
7	29-30 Jun 09	18	15.7	4.7	117.0	132.9	16.3	Canada
8	17-18 Jul 09	15	13.1	3.4	39.2	37.7	13.1	Alaska
9	18-19 Jul 09	30	14.6	12.4	70.6	92.2	7.5	Alaska
10	15-17 Aug 09	54	17.6	-4.6	57.1	151.4	35.8	Alaska
11	17-19 Aug 09	39	16.9	1.8	52.2	14.7	7.1	Alaska/Canada
12	7-8 Jun 10	39	12.8	11.9	72.3	54.1	0.1	Alaska/S. Canada
13	25-26 Jun 10	21	13.6	-1.6	44.1	167.6	24.8	Canada
14	14-16 Jul 10	57	15.9	8.0	1.2	25.4	8.8	Canada
15	18-20 Jul 10	54	8.9	10.3	-	194.4	18.0	Canada/Alaska

*Plume age determined from the mean FLEXPART air mass age
Δ indicates the difference between measured and background mixing ratios (background = 20th percentile of each species and varies with season

- The results in the table above demonstrate large variability in the mixing ratios of O_3 and O_3 precursors within the biomass burning plumes.
- From the 15 events identified we observe **positive mean ΔO_3 values** during **11 events** ranging from **1.8** to **29 ppbv**, indicating possible photochemical production of O_3 within these plumes.
- Plots of NMHC ratios allow us to assess the photochemical processing that occur during transport of BB plumes.
- Larger negative NMHC ratios are indicative of aged air masses

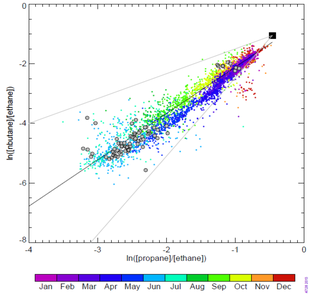

Fig 1. NMHC ratios for measurement period, gray circles indicated ratios during fire events. Sold grey lines indicated kinetic and mixing slopes.

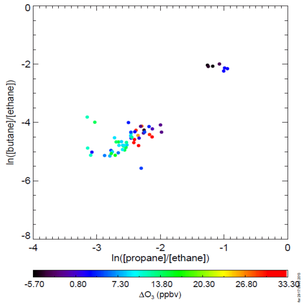

Fig 2. NMHC ratios during BB events, colors represent the O_3 enhancement above background.

O_3 production efficiency

- Within photochemically aged airmasses the levels of O_3 increase with the oxidation products of NO_x such as NO_z ($NO_z = NO_y - NO_x$)
- The slope of O_3 vs NO_z has previously been used to estimate the ozone production efficiency (OPE). Typical OPE values are ~10 in rural areas with lower values observed in urban plumes [1]
- We observe an OPE of 140 ppbv ppbv^{-1} (Fig. 3) indicating possible mixing with high O_3/low NO_z air during transport

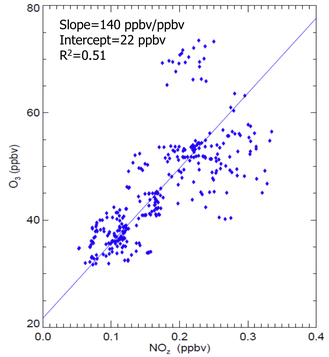

Fig 3. O_3-NO_z correlation for BB events

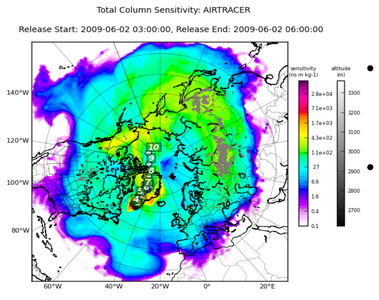

Fig 3. FLEXPART air mass trajectory

- Mixing with background air may explain the high value for ΔO_3 (29.4 ppb) during **Event 6** (Jun 2009) while ΔPAN and ΔNO_y are relatively low.
- Fig 4 shows the air mass trajectory during this event - the plume was transported over the high latitude Arctic region before reaching the site and may have mixed with O_3 rich air from stratospheric airmasses entrained into the troposphere.

Conclusions

- The largest O_3 enhancements are generally observed during periods when the NMHC ratios are lower – indicating aged emissions and greater potential for photochemical processing – however mixing from high O_3 background air may also result in higher ΔO_3 values
- Future work will explore the O_3 production efficiency during BB events and the influence from mixing with background air

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References: [1] Trainer et al., 1993