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Tropospheric Ozone at Cuiabá during SCAR-B and TRACE-A

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Abstract

Ozone soundings at Cuiabá were made during two biomass burning field campaigns: SCAR-B (Smoke, Clouds, Aerosols, Radiation - Brazil) in August-Sept. 1995 and TRACE-A (Transport and Atmospheric Chemistry near the Equator - Atlantic) in September-October 1992). Characteristics of these soundings are summarized by Kirchhoff et al [TRACE-A, 1996a; SCAR-B, 1996b]. The ozone records are compared in terms of mean mixing ratios at each altitude. "Excess ozone," defined as the amount above a climatological, non-burning season ozone profile, is also determined. The magnitude and variability of ozone is explored with respect to AVHRR-derived biomass fire counts available for each year. Trajectories are used to determine the likely origin of high tropospheric ozone layers (60-120 ppbv) observed in the soundings below 5 km. Tropospheric column ozone was slightly higher during SCAR-B than TRACE-A, with all of the difference below 5 km. Transport patterns were not very different for the two experiments, but vegetation fires are more numerous during SCAR-B than TRACE-A. In the upper troposphere the origin of excess ozone is presumed to be deep convective injection of pollution products (CO, NO_x, hydrocarbons) that react to produce ozone.

Introduction

Ozonesondes were launched at Cuiabá (16°S, 56°W) during SCAR-B (August-September 1995) and TRACE-A (September-October 1992). A listing of the sonde dates and launch times is given in Table 1. For further details see Kirchhoff et al. [1996a; TRACE-A] and Kirchhoff et al. [1996b; SCAR-B].

Figure 1 shows SCAR-B (1995) and TRACE-A (1992) ozone, integrated to the tropopause, with the tropopause defined by NMC (now, NCEP, National Center for Environmental Prediction) data. A striking difference between the two data sets is the apparently greater tropospheric column ozone in SCAR-B. The mean for 1992 is 35.2±6.6 DU (Dobson Units, 2.69 x 10^{16} molecule cm^{-2} = 1 DU); for SCAR-B the mean is 43.1±6.1 DU. Most of the additional ozone during SCAR-B is below 5 km. The mixed layer, which was generally capped by a stable layer at ~2-4 km was enhanced by photochemical ozone formation during SCAR-B (e.g. 27 August 1995 in Figure 2a). Integrated ozone below 5 km during SCAR-B was typically lower for those soundings taken before 0900 Local Time on

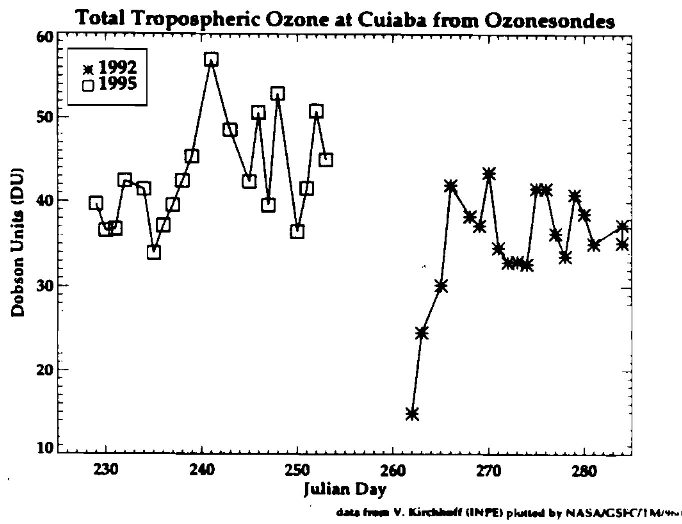

Fig. 1. Column-integrated tropospheric ozone during SCAR-B, 1995, and TRACE-A, 1992 (in DU, to tropopause at 15-16 km).

SCAR-B (e.g. 7 September 1995, Figure 2b) because nighttime surface destruction reduces near-surface ozone concentrations.

The difference between lower tropospheric ozone in the two sets of soundings can be seen in the mean vertical ozone profiles for SCAR-B and TRACE-A (Figure 3). The profiles are very similar except below 5 km (~600 mb).

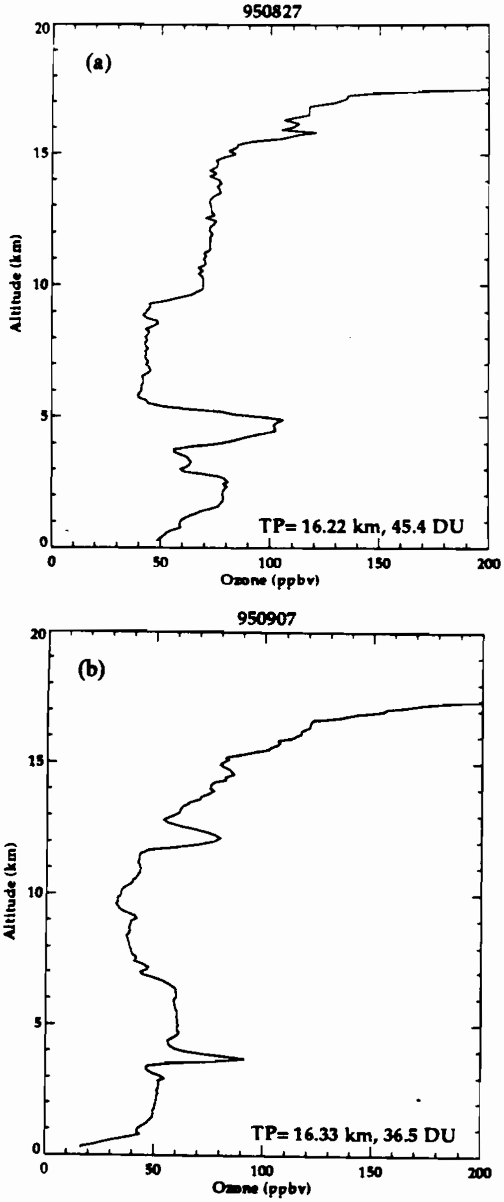

Fig. 2 Ozone soundings during SCAR-B. (a) 27 Aug. 1995, Day 239, midday launch; (b) 7 Sept. 1995, Day 250, early morning launch. See Table 1.

Ozone-Fire-Trajectory Links

Figure 4 shows the profiles with the highest and lowest tropospheric ozone column amounts during SCAR-B. These occurred on 24 August and 5 September 1995, respectively. Nearly all of the ozone of 5 September in excess of that on 24 August is below 5 km. We ran back trajectories with the GSFC isentropic trajectory model to see if there were different transport patterns and possible fire exposure from the two soundings. These were run in clusters centered around the Cuiabá location at a constant potential temperature surface corresponding to 700 mb. The transport patterns of the two sets of air parcels were not greatly different.

AVHRR-sensed fire counts (http://condor.dsa.inpe.br/ult_focos) for the periods of the maximum-ozone and minimum-ozone profiles of SCAR-B are compared. Figure 5 shows fire counts for the SCAR-B and TRACE-A periods in the region that encompasses most of the back trajectories from Cuiabá: 10-20°S, 40-60°W. The higher ozone profile (5 September 1995) corresponds to slightly more vegetation fires in the study region compared to 24 August 1995, but the 7-day averaged fire counts are not sufficiently resolved to discriminate fire exposure of air

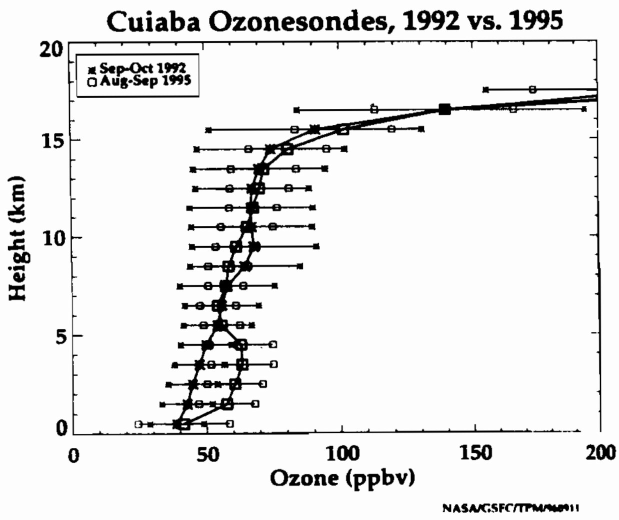

Fig. 3. Mean ozone profile from SCAR-B and TRACE-A soundings (Table 1), with standard deviation.

parcels arriving at Cuiabá in the two data sets. Daily fire counts are needed, as in the analyses for TRACE-A in Brazil and southern Africa [Thompson et al., 1996a,b]. In comparing mean ozone profiles for SCAR-B and TRACE-A, one difference is in the middle troposphere where excess ozone was greater in TRACE-A. One

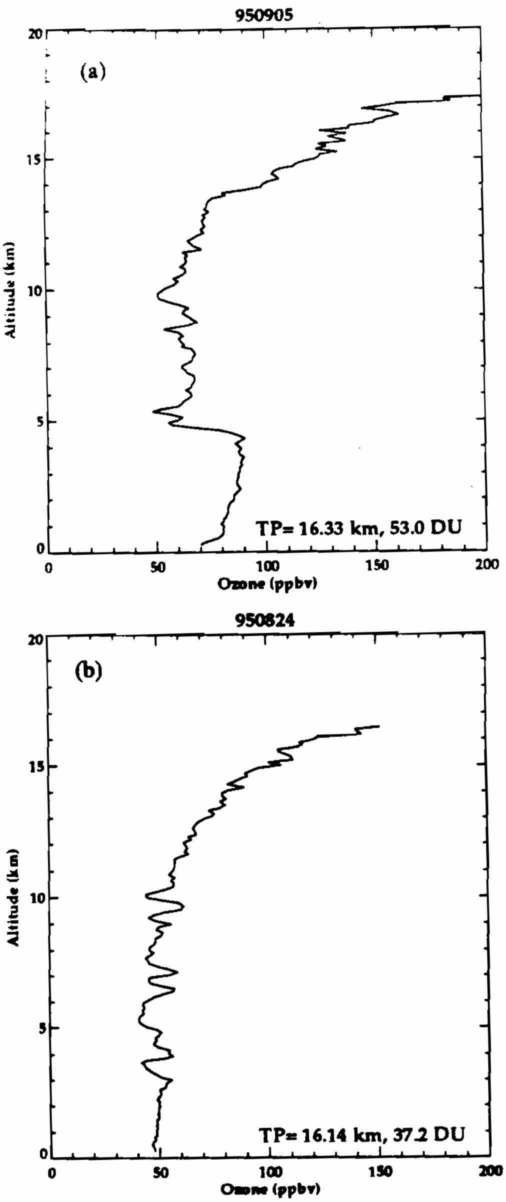

Fig. 4. SCAR-B ozone profiles corresponding to greatest (a) and least (b) column-integrated ozone amounts, on 5 September and 24 August 1995, respectively.

reason may be more deep convection during TRACE-A than SCAR-B. A dedicated set of aircraft flights on 27 September 1992 in TRACE-A [Pickering et al., 1996] demonstrated the effectiveness of convection for transporting boundary-layer pollution from biomass fires and/or industrial to the middle and upper troposphere. Although enhanced upper tropospheric ozone over Cuiabá was not evident from 27-29 September 1992, ozone enrichment downwind of convection was detected over Natal [Thompson et al., 1996a].

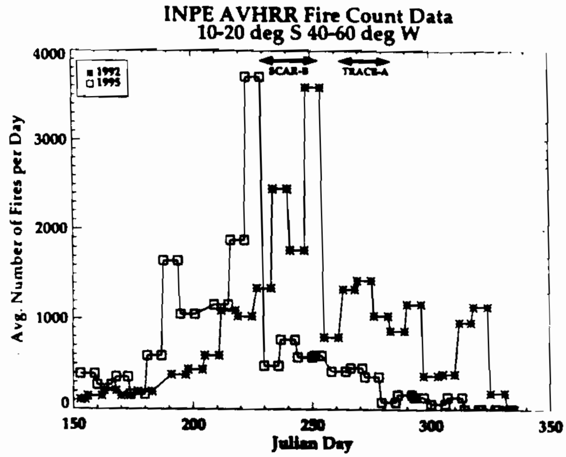

Fig. 5. Weekly-averaged AVHRR fire counts. During SCAR-B, time of day for overpass shifted on 2 Aug. 1995, from NOAA-14 (mid-day) to NOAA-12 (early evening), leading to apparent drop in fire counts.

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Table 1. Cuiabá ozonesondes, TRACE-A (1992) and SCAR-B (1995)

SCAR-B No.	1995 Julian Day, Date	Launch Time (UT)	TRACE-A No.	1992 Julian Day, Date	Launch Time (UT)
1	228, 16 Aug.	1540	1	263, 19 Sept.	1530
2	229, 17 Aug.	1410	2	265, 21 Sept.	1504
3	230, 18 Aug.	1439	3	266, 22 Sept.	1834
4	231, 19 Aug.	1440	4	267, 23 Sept.	1433
5	232, 20 Aug.	1441	5	268, 24 Sept.	1654
6	233, 21 Aug.	1446	6	269, 25 Sept.	1700
7	234, 22 Aug.	1805	7	270, 26 Sept.	1700
8	235, 23 Aug.	1433	8	271, 27 Sept.	1713
9	236, 24 Aug.	1915	9	272, 28 Sept.	1708
10	237, 25 Aug.	1413	10	273, 29 Sept.	1705
11	238, 26 Aug.	1348	11	274, 30 Sept.	1657
12	239, 27 Aug.	1343	12	275, 1 Oct.	1651
13	240, 28 Aug.	1506	13	276, 2 Oct.	1658
14	240, 28 Aug.	--	14	277, 3 Oct.	1657
15	241, 29 Aug.	1518	15	278, 4 Oct.	1604
16	243, 31 Aug.	1000	16	279, 5 Oct.	1629
17	245, 2 Sept.	1246	17	280, 6 Oct.	1856
18	246, 3 Sept.	1453	18	281, 7 Oct.	1705
19	247, 4 Sept.	2216	19	284, 10 Oct.	1412
20	248, 5 Sept.	2037	20	284, 10 Oct.	1618
21	249, 6 Sept.	1910			
22	250, 7 Sept.	0944			
23	251, 8 Sept.	0951			
24	252, 9 Sept.	0950			
25	253, 10 Sept.	1030			