

BRAZIL

OBSERVATIONAL ACTIVITIES:

The Ozone Laboratory of the National Institute for Space Research (INPE) was created in 1985 by Dr Wolker W. J.H. Kirchhoff and the coordinator is Dr Plinio C. Alvalá. In the present it is formed by 3 Ph.D.s, 2 engineers, 5 technicians and a few graduate students in special MSc and PhD programs. Our major activity is to make observations of the ozone layer using a network of ground based spectrophotometers, of the Dobson and the Brewer types. We presently operate 2 Dobson stations and 6 Brewer observation sites: Natal and Cachoeira Paulista are Dobson sites; Natal, Cuiabá, Cachoeira Paulista, Santa Maria, La Paz, Punta Arenas (1991 to 2000) and Antarctica are Brewer sites. In addition, ozone concentrations are also measured by the ECC sounding technique on balloons. A long term measurement program at Natal has been operational since 1978. Special field campaigns have also been made at other sites, especially in Amazonia, to study biomass burning effects. More recently, instruments to measure the UV-B radiation have been added to the network.

Table1: The Brazilian Network Instrumentation.

SITE	LAT. (SOUTH)	LONG. (WEST)	DOBSON NUMBER	GUV NUMBER	BREWER NUMBER	PERIOD and TYPE
NATAL BRAZIL	5.84°	35.21°	093 since 1978	9285 - since 1997	110 073	1994-1996 MARK IV 1996 - today MARK IV
CUIABÁ BRAZIL	15.3°	56.1°	-	-	056 081	1991-1997 MARK II 2002-today MARK IV
LA PAZ, BOLÍVIA	16.54°	68.06°	-	-	110	1996-2004 MARK IV
CACHOEIRA PAULISTA BRAZIL	22,68°	45,00°	114 since 1976	9255 - since 1997	124	1997 MARK IV
SAO JOSE DOS CAMPOS BRAZIL	23,2°	45,86°	-	-	056	2000 - 2006 MARK II
SANTA MARIA BRAZIL	29,26°	53,48°	-	-	081 056	1992-1998 MARKIV 2000-2002 MARK II 2006 – 2008 MARK III
PUNTA ARENAS CHILE	53,20°	70,90°	-	-	068	1992-2000 MARKIV
BRAZILIAN ANTARCTIC STATION	62.1°	58.4°	-	9285 - since 1996	068	SPRING 2001 to 2007

Calibration activities

2007 – WMO calibration

In 2007 new calibration was the Brewer #068 and B# 124 in Punta Arenas, Chile. In José dos Campos, Brazil, the Brewers were calibrated: B#163, B#124, B#110 and Natal was the Brewer# 073.

Five Brewer spectrophotometers were calibrated by International Ozone Services Inc. (IOS) in 2004: São José dos Campos (B#056), Cachoeira Paulista (B#124), Cuiabá (B#081), La Paz (B#110) and Natal (B#073).

The Ozone Laboratory participated in international calibration in 1994, in Spain, where the Natal Dobson (093) was shipped with our expert. In 1997 expert Bob Evans, from NOAA, checked the Natal Dobson, on a visit to Natal, but did no adjustments; the Buenos Aires WMO Intercomparison, in December 2001 and 2003 and 2006, has shown that the Natal Dobson (093) did not need any corrections, even doing some work on it, such as electronic repairs/improvements, optics cleaning, and wedge calibrations. The C.Paulista Dobson (114) and a correction was adjusted in 5%.

Three GUV were calibrated in 2001, in Sao Jose dos Campos, Brazil, using standard instrument of Biospherical Instruments Inc. The GUV 9285, is operating in Natal, the GUV 9255, in Cachoeira Paulista and the GUV 9285, in Brazilian Antarctic Station.

RESULTS FROM OBSERVATIONS AND ANALYSIS

Total column ozone observations

Brewer and Dobson spectrophotometers

Ground based total column ozone has been measured continuously at low latitude sites, using Brewer spectrophotometers. In addition, two of these sites also operate Dobson spectrophotometers to obtain total ozone. The tropical Brewer-Dobson sites are Natal (6° S, 35° W) and Cachoeira Paulista (23° S, 38° W). The new Brewer spectrophotometer ozone data set for Natal and Cachoeira Paulista is presented it is compared with the TOMS version 8 (V8), from 1997 to 2005 (june). Only direct sun measurements have been used in this analysis.

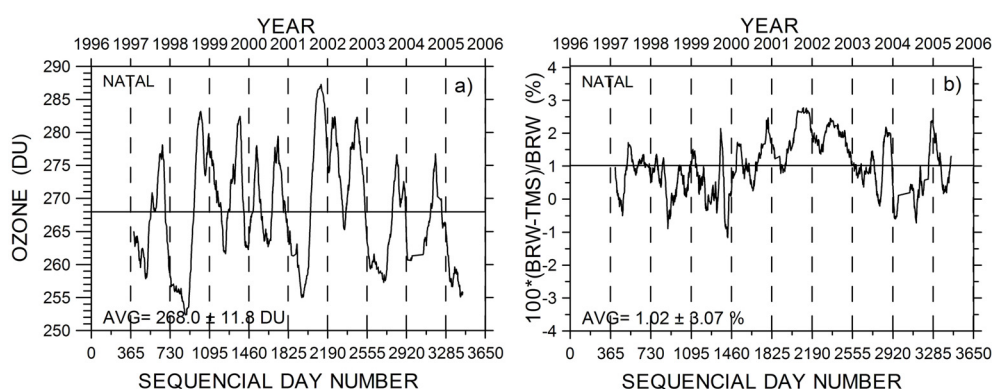


Figure. 1: The figure shows a new 8 years data set of the Brewer, obtained at Natal (a). The data are presented as running means of 31 days and this data varies between minima of 250 and 290 DU, and shows large year to year variability. The fig.1b shows the difference parameter Brewer – Toms (version 8).

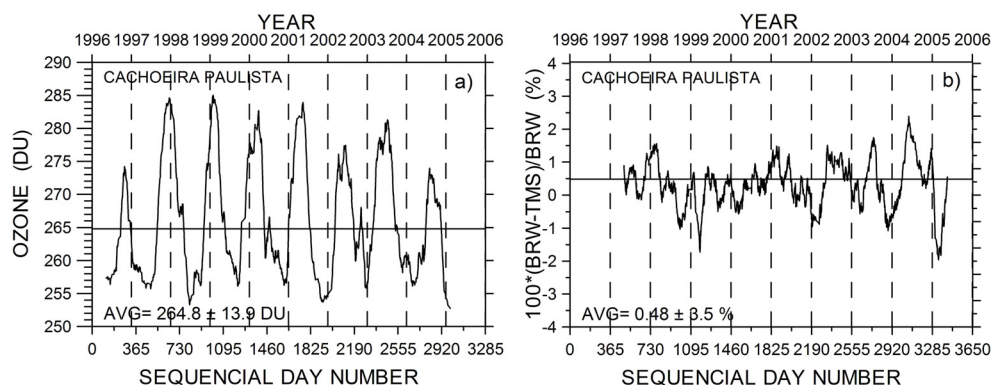


Figure 2: The figure shows a new 8 years data set of the Brewer, obtained at Cachoeira Paulista (a). The data are presented as running means of 31 days and this data varies between minima of 250 and 290 DU, and shows large year to year variability. The fig.2b shows the difference parameter Brewer – Toms (version 8).

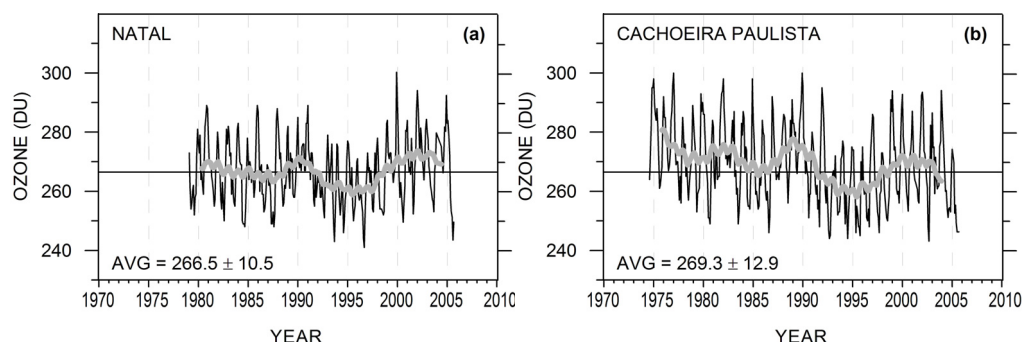


Figure 3: The figure shows a new 26 years data set of the Dobson, obtained at Natal (a) and C.Paulista (b). The data are presented as mensal average (black line) and running means of 15 days (gray line) and this data varies between minima of 240 and 300 DU, and shows large year to year variability. The average is 266.5 DU and the standard deviation is 10.5 at Natal and 269.3 DU at Cachoeira Paulista and the standard deviation is 12.9.

The Tables 2 and 3 give further statistical details of the data sets. The total column ozone data are compared with the Total Ozone Mapping Spectrometer, Toms data, versions 7 and 8. The data set of 6 years (1997 – 2003) is discussed.

Table 2: Monthly Average O₃ data statistics (DU).

STATION NAME	INSTR.	AVERAGE	SIGMA	MIN.	MAX.	# DATA POINTS
NATAL	BRW	268.9	9.6	250.0	290.4	75
	DOB	268.7	10.1	252.3	289.4	66
	TMS7	268.4	8.7	253.2	286.4	76
	TMS8	263.5	8.9	245.8	282.3	77
C.PAULISTA	BRW	265.4	12.3	240.4	289.9	72
	DOB	267.6	12.5	245.6	293.5	71
	TMS7	268.0	11.1	243.9	290.5	77
	TMS8	264.4	12.9	234.5	292.8	77

Table 3: Monthly Averages of the difference parameters: data statistics for $100 \cdot (\text{BRW-DOB})/\text{BRW}$, $100 \cdot (\text{BRW-TMS})/\text{BRW}$ and $100 \cdot (\text{DOB-TMS})/\text{DOB}$, in %.

STATION NAME	DIFFER.	AVERAGE	SIGMA	MIN.	MAX.	# DATA POINTS
NATAL	BRW-DOB	0.2	1.2	-2.4	3.1	55
	BRW-TMS7	0.0	2.1	-4.3	7.9	74
	BRW-TMS8	0.32	1.4	-4.56	3.13	77
C.PAULISTA	BRW-DOB	-1.0	1.6	-4.5	4.5	63
	BRW-TMS7	-1.0	1.5	-5.4	3.7	73
	BRW-TMS8	1.1	3.6	-11.9	8.0	74
	DOB-TMS7	-0.1	1.9	-7.6	3.9	68
	DOB-TMS8	3.18	4.5	-18.1	12.6	74

A new set of ground based total column ozone data is described for the period 1996 to 2004 (May) at the high altitude (3.400 m) site La Paz (16,5° S, 68° W). This station operates a Brewer spectrophotometer. These are compared with the Total Ozone Mapping Spectrometer, Toms, satellite data (version 8).

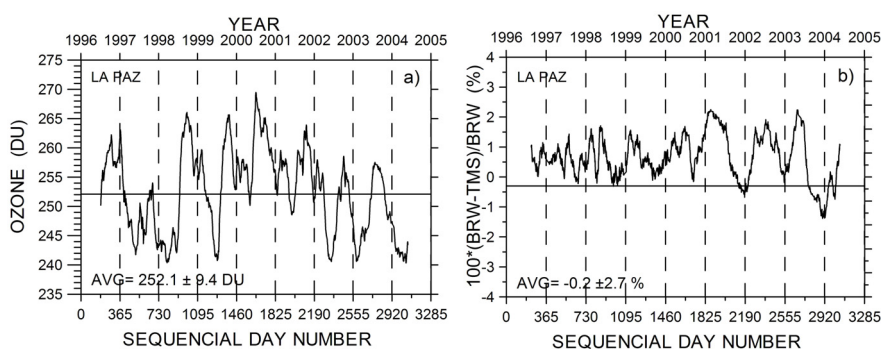


Figure 4: Shows a new 8 years data set of the Brewer, obtained at La Paz. The data are presented as running means of 31 days and this data varies between minima of 235 and 270 DU. The average and the standard deviation are 252.1 ± 9.4 DU (a). The fig. 4b shows the difference parameter Brewer – Toms, version 8. The average difference is slightly negative before 2000 and close to zero after that, with higher deviations.

Ozonesondes

Since 1978, weekly ozonesondes were launched in Natal, Brazil, and campaigns were made in Punta Arenas, Chile (1995, 1997 and 2001), in La Paz, Bolivia (2000) and Brazilian Antarctic Station (1992, 1999, 2003 and 2004).

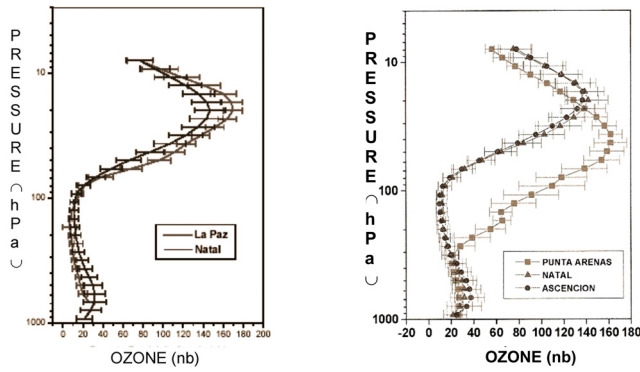


Figure 5: Average ozone profile characterizing the normal profile of ozone concentration, expressed as partial pressure, at Natal, Brazil, Punta Arenas, Chile and compared with ozone profile at Ascension Island. (F. Guarniere, Ph.D. Thesis, INPE 2001).

Results are described from an intense field campaign, at the Brazilian Antarctic Station Comandante Ferraz, on King George Island (62.1° S; 58.4° W) during the Spring of 2003. Ozone was measured using a ground based Brewer spectrophotometer, filter photometers, and the vertical profile was obtained on several days using balloon-borne ECC ozonesondes. In terms of the UV-B index, higher values were seen during 2003: on two occasions the Index passed the level of 9; which is larger than values observed on any previous campaign at the site.

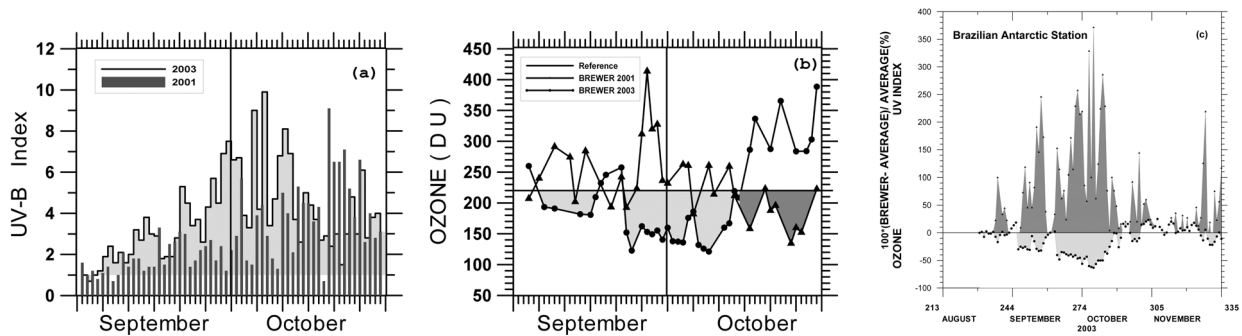


Figure 6: Shows the comparison between the UV-B index (a) and total ozone (b) for September and October, 2001 and 2003. Higher values were seen during 2003 when the ozone hole appeared earlier and the minimum of ozone was present during several consecutive days. The anti correlation for ozone and UVB (%) during the spring of 2003 (c).

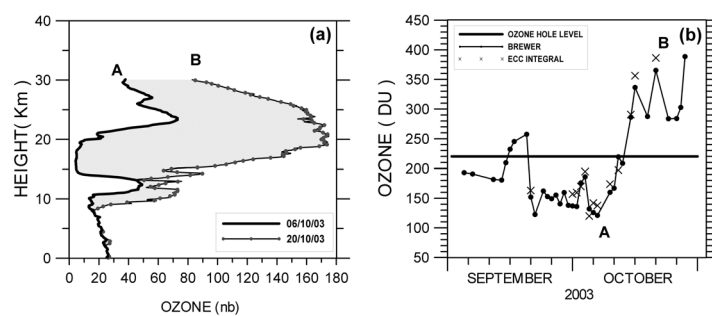


Figure 7: Shows a composite of the vertical profile of the severe ozone hole of October 6, plus a "normal" profile shown for comparison, obtained on October 20. The second panel shows the ozone integrals measured by a Brewer spectrophotometer, plus the ozone integrals from vertical soundings, shown with x sign. The UV-B index observed on this day was 9.9 and the ozone was 121 DU measured with the Brewer spectrophotometer.

DISSEMINATION OF RESULTS

Data Reporting

The Brewer data have been submitted for the WOUDC, since 2004 and the Dobson data since 1978.

Information to the public

The UV forecasts is in web site www.dge.inpe.br/ozonio

Relevant scientific papers

- Kirchhoff, V.W.J.H., R.A. Barnes, and A.L. Torres, *Ozone climatology at Natal, from in situ ozonesonde data*, *J. Geophys. Res.*, **96**, 10899-10909, 1991.
- Kirchhoff, V.W.J.H., Zamorano B, F., and Casiccia S, C.A.R. *UV-B Enhancements at Punta Arenas, Chile*, *J. Photochem. Photobiol., B: Biology*, **38**, 174-177, 1997a.
- Kirchhoff, V.W.J.H., Casiccia S, C.A.R., and Zamorano B, F., *The Ozone Hole over Punta Arenas, Chile*, *J. Geophys. Res.*, **102**, 8945-8953, 1997b.
- Kirchhoff, V.W.J.H., Sahai, Y., Casiccia S., C.A.R., Zamorano B, F., and Valderrama, V., *Observations of the 1995 ozone hole over Punta Arenas, Chile*, *J. Geophys. Res.*, **102**, 16109-16120, 1997c.
- Sahai, Y., V.W.J.H. Kirchhoff and N.M.Paes Leme, *Total ozone trends in the tropics*, *J. Geophys. Res.*, **105D15**, 19823-19828, 2000.
- Kirchhoff, V.W.J.H. and F.L. Guarnieri, *Missing ozone at high altitude: comparison of in situ and satellite data*, *J. Geophys. Res.*, **107D11**, ACH 2-1 to 2-6, 2002.
- Saleska, S.R., V.W.J.H.Kirchhoff, et al., *Carbon in Amazon forests: unexpected seasonal fluxes and disturbance-induced losses*, *Science*, vol.302, no.5650, 1554-1557, 2003.
- Casiccia, C.A.S., V.W.J.H. Kirchhoff, and A. Torres, *Simultaneous measurements of of Ozone and Ultraviolet Radiation: Spring Ozone 2000, Punta Arenas, Chile*, *Atmosph.Env.*, **37**, 383-389, 2003.
- Thompson, A.M., V.W.J.H. Kirchhoff, et al., *Southern Hemisphere Additional Ozonesondes (SHADOZ) 1998-2000 tropical ozone climatology 2. Tropospheric variability and the zonal wave-one*, *J.Geophys.Res.*, Vol.108, No. D2, 10.1029/2002JD002241, 31 January 2003.
- Thompson, A.M., V.W.J.H. Kirchhoff, et al., *J.Geophys.Res.*, *Southern Hemisphere Additional Ozonesondes (SHADOZ) 19982000 tropical ozone climatology 1. Comparison with Total Ozone Mapping Spectrometer (TOMS) and ground-based measurements* *J. Geophys. Res.*, Vol. 108 No. D2, 10.1029/2001JD000967, 30 January 2003.
- Rosen, J.M., R.M. Morales, N.T. Kjome, V.W.J.H. Kirchhoff, and F.R. da Silva, *Equatorial aerosol-ozone structure and variations as observed by balloon-borne backscattersondes since 1995 at Natal, Brazil (6°S)*, *J.Geophys.Res.*, **109**, D03201, doi: 10.1029/2003JD003715, 2004.

PROJECTS AND COLLABORATION

Project in the Brazilian Antarctic Programme: The ozone and UVB radiation over Brazilian Antarctic Station and Punta Arenas, Chile.

Collaboration with the project SHADOZ (Southern Hemisphere Additional Ozonesondes).

Collaboration with the San Andres University, La Paz, Bolivia

Collaboration with the Magallanes University, Punta Arenas, Chile

FUTURE PLANS

Participation in the Internacional Polar Year (YPI) and International Heliophysical Year (IHY).

Study of the Mesosphere, Stratosphere and Troposphere Antarctica and its links South America. (MST- ASA) proposta final - atividade 442

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NEEDS AND RECOMMENDATIONS

It is very important the support for the annual calibrations and maintenance of the Brewer. Financial support for trips techniques and participation in Ozone and UV Meetings, Congresses and Symposium.
