Proceedings Papers: 28th International Symposium on Remote Sensing of Environment,
27-31 March 2000, Cape Town, South Africa

SHADOZ (Southern Hemisphere ADditional OZonesondes): An Ozonesonde Network and Resource for Remote Sensing Research and Education

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Abstract - Balloon-borne ozone instrumentation (ozonesondes), launched at fixed sites, is used to study local patterns in stratospheric and tropospheric ozone and to provide validation for satellite ozone products and model calculations of ozone. A paucity of coordinated ozonesonde data in the southern hemisphere tropics is being remedied in a 3-year project of coordinated ozonesondes launches at 10 sites. The data are available to the scientific community at the SHADOZ website at NASA/Goddard. Stations and their operational characteristics, with examples of ozone observations, are given. One expectation of SHADOZ is that wide dissemination of data and interaction with users and field projects will leverage local funding to maintain infrastructure and operations. SHADOZ data are well-suited for educational projects in which students learn about regional ozone patterns.

I. NEED FOR TROPICAL OZONESONDE DATA

In the past 5 years, new tropical tropospheric ozone data products have been developed from TOMS and other satellites [Fishman and Brackett, 1997; Hudson and Thompson, 1998; Thompson and Hudson, 1999]. During this period, chemical-transport models have been developed that calculate ozone profiles. There is a lack of ozone profile measurements in the tropics and substropics for evaluation of these data sets. In the southern hemisphere, at least a dozen stations have operated ozone profiling instrumentation (ozonesondes) in the past decade but not consistently over time.

In 1998, NASA's Goddard Space Flight Center, NOAA/ CMDL (Climate Monitoring and Diagnostics Lab) and international sponsors, began a 3-year project to collect a consistent data set by augmenting ozonesondes at southern hemisphere tropical sites. In exchange, the stations make the ozone and temperature profile data available to the scientific community as quickly as possible at the SHADOZ website at NASA/Goddard[1].

[1] http://code916.gsfc.nasa.gov/Data_services/shadoz

II. SHADOZ SITES AND OPERATIONS

Stations in SHADOZ include four islands in the Pacific: Fiji, Tahiti, Galapagos and American Samoa. Two sites are in the Atlantic: Natal (Brazil) and Ascension Island. Three other sites span Africa (Nairobi and Irene, South Africa) and the Indian Ocean (Réunion Island, Watukosek in Java, Indonesia). Table 1 lists the locations of all SHADOZ sites[2]. Figure 1 shows an example of a typical sounding from Ascension Island (8°S, 14°W)[3].

Table 1.

SHADOZ Sites

Station	Latitude (deg.)	Longitude (deg.)
Pago, Pago, American Samoa	-14.23	-170.56
Papeete, Tahiti	-18.00	-149.00
San Cristóbal, Galapagos	-0.92	-89.60
Natal, Brazil	-5.42	-35.38
Ascension Island	-7.98	-14.42
Irene, South Africa	-25.25	28.22
Nairobi, Kenya	-1.27	36.80
La Réunion Is.	-21.06	55.48
Watukosek, Java Indonesia	-7.60	112.70
Suva, Fiji	-18.13	178.40

[2] SHADOZ is supported by NASA's ACMAP Program and the TOMS project. Individual SHADOZ sites are also supported by in-country agencies and universities, NOAA, NASA/WFF, NASDA (Japan), SAWB (S. Africa), INPE (Brazil), and the Swiss Meteorological Agency.

[3] Profile taken by the US Air Force and processed by Wallops Flight Facility group.

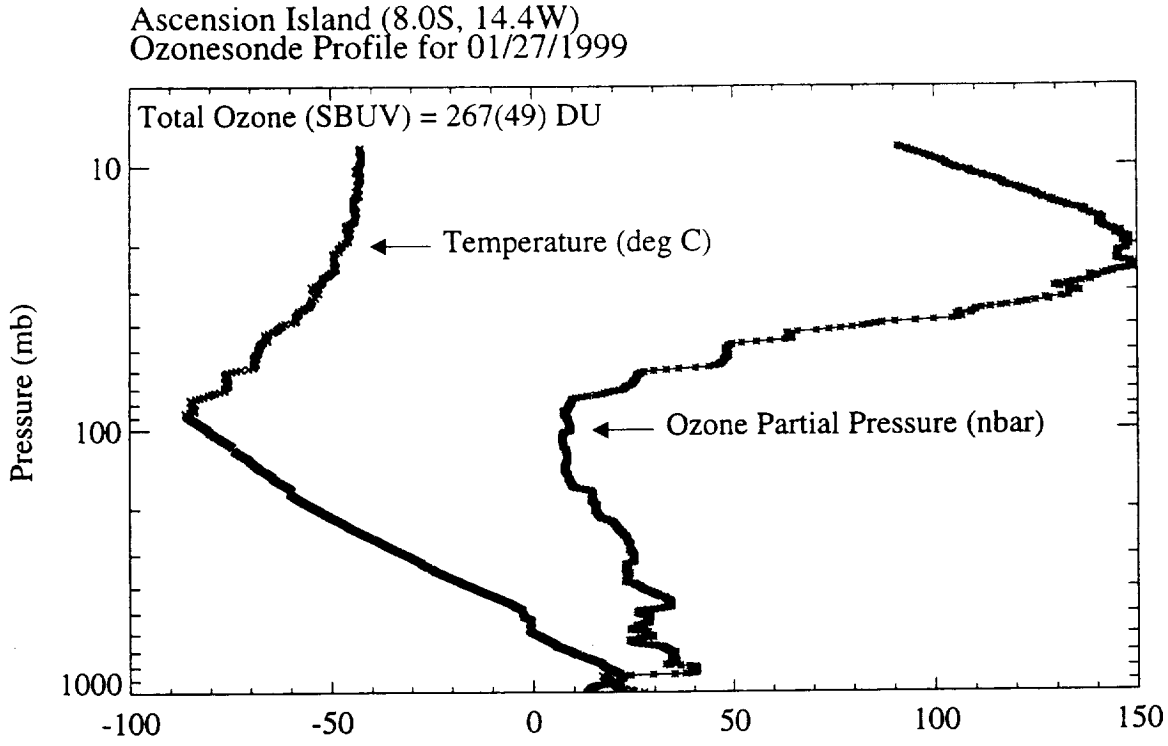

Figure 1. Typical ozonesonde profile viewable on SHADOZ website shows ozone and temperature profiles from the surface to 7 mb. Ozone is measured by the electrochemical concentration cell (ECC) method.

Current sampling at all stations is once-per-week or twice a month, and usually mid-week. Balloon-borne ozonesondes are coupled with a meteorological radiosonde to transmit air pressure and temperature, dew point, and ozone to a ground receiving station.. All SHADOZ stations use ECC (Electrochemical Concentration Cell) type sensors; Java converted to this system in August 1999. Model of sonde, preparation techniques, and processing methods vary. Differences in data acquisition and handling make it difficult to interpret discrepancies between total ozone from SHADOZ ozonesondes and total ozone from co-located Dobson spectrometers or from satellite overpass measurements (e.g., TOMS). SHADOZ scientists will participate in the next JOSIE (Jülich Ozonesonde Intercomparison Experiment, Germany) to help resolve differences in techniques by conducting tests with various ozonesonde sensors and cell solutions in pressure- and temperature-controlled chambers.

III. EXAMPLES OF SHADOZ OZONESONDE DATA

Researchers are using SHADOZ data to learn more about interannual and seasonal variability in ozone over southern hemisphere tropical locations by comparing current and previous observations [e.g. Diab et al., 1996; Kirchhoff et al., 1996; Taupin et al., 1999; Fujiwara et al., 1999].

Total ozone integrated from the all the sondes launched at two SHADOZ sites in 1998, Ascension Island (8S, 14.4W) and American Samoa (14S, 171W) are shown in Figure 2a. These sites are chosen as representative of the tropical Atlantic and subtropical Pacific. In both cases, the highest column total ozone values (> 240 DU; one Dobson Unit = 2.69 x 10^{16}molec/cm^2) occur most consistently between Days 230 and 300 (late August through October). The lowest column values are in April and May (~Days 100-150).

A comparison of integrated tropospheric ozone at Ascension and Samoa (Figure 2b) shows much greater contrast over the two stations than for total ozone. The tropospheric ozone difference averages ~15 DU with the period of smallest difference occurring at ~Day 130 (early May; Figure 2b). One factor contributing to low ozone at Samoa and generally over the Pacific in early 1998 was the latter phase of the El Niño that modified

normal circulation patterns. Higher-than-normal convection during this period brought low ozone surface air up into the entire column, decreasing the amount of total ozone and tropospheric ozone for more than two months of 1998 (Days 1-70 in Figure 2b).

Elevated tropospheric and total ozone over the Atlantic, most prominent at Ascension Island in August through October (Days 200-300 in Figure 2), is attributed to accumulation of ozone produced from the pollution of savanna burning over the southern African and South American continents. In addition to the photochemical source, this ozone feature, which appears annually, [Thompson and Hudson, 1999] is caused by subsidence and recirculation of stable layers, rich in ozone, over the south Atlantic.

Further insight into tropospheric ozone patterns comes from examining sonde vertical structure. Figure 3 shows the individual profiles for the February and July 1998 sondes at Samoa and Ascension, with the mean profile in bold. February 1998 was a month of great variability at both stations, although the tropopause and upper troposphere appear to be more uniform at Samoa. There are very clean upper tropospheric layers (ozone < 20 ppbv mixing ratio) at both sites; surface values are lower in February than in July at both locations. The more nearly uniform high ozone associated with transport of biomass burning ozone is seen in the July 1998 Ascension sounding. The marine boundary layer at Ascension is still relatively unpolluted (30 ppbv mixing ratio or less) and appears to uncoupled from the polluted layers in the free troposphere.

SHADOZ will complement intensive field campaigns from time to time with ozonesonde augmentation in exchange for SHADOZ data. In 1999 this was done at the Kaashidhoo Observatory (Maldives-5N, 73E) during

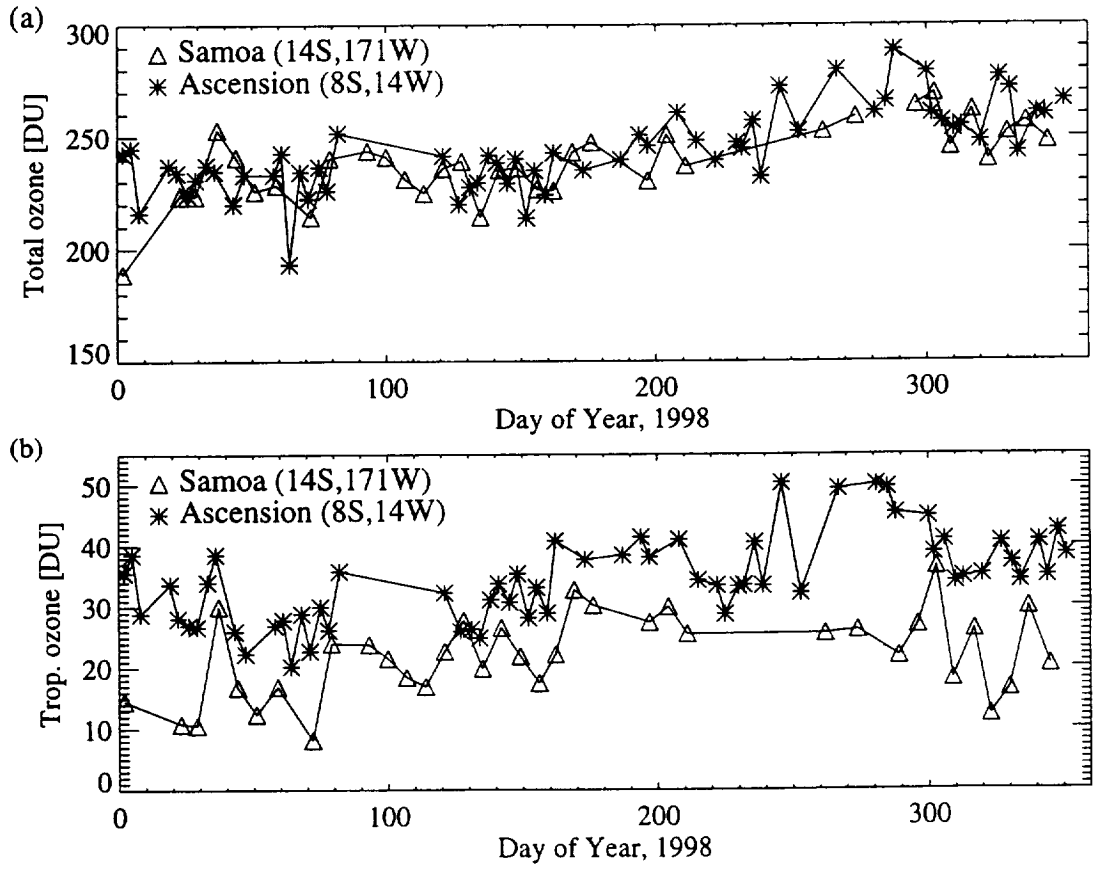

Figure 2. (a) Integrated ozone column from sondes launched in 1998 at Am. Samoa and Ascension Is. SHADOZ data are used. Archived data go from surface to 7mb or balloon burst, whichever is lower. Above 7mb, extrapolation is based on SBUV climatology. (b) Same as (a) except integrated column ozone covers surface to tropopause.

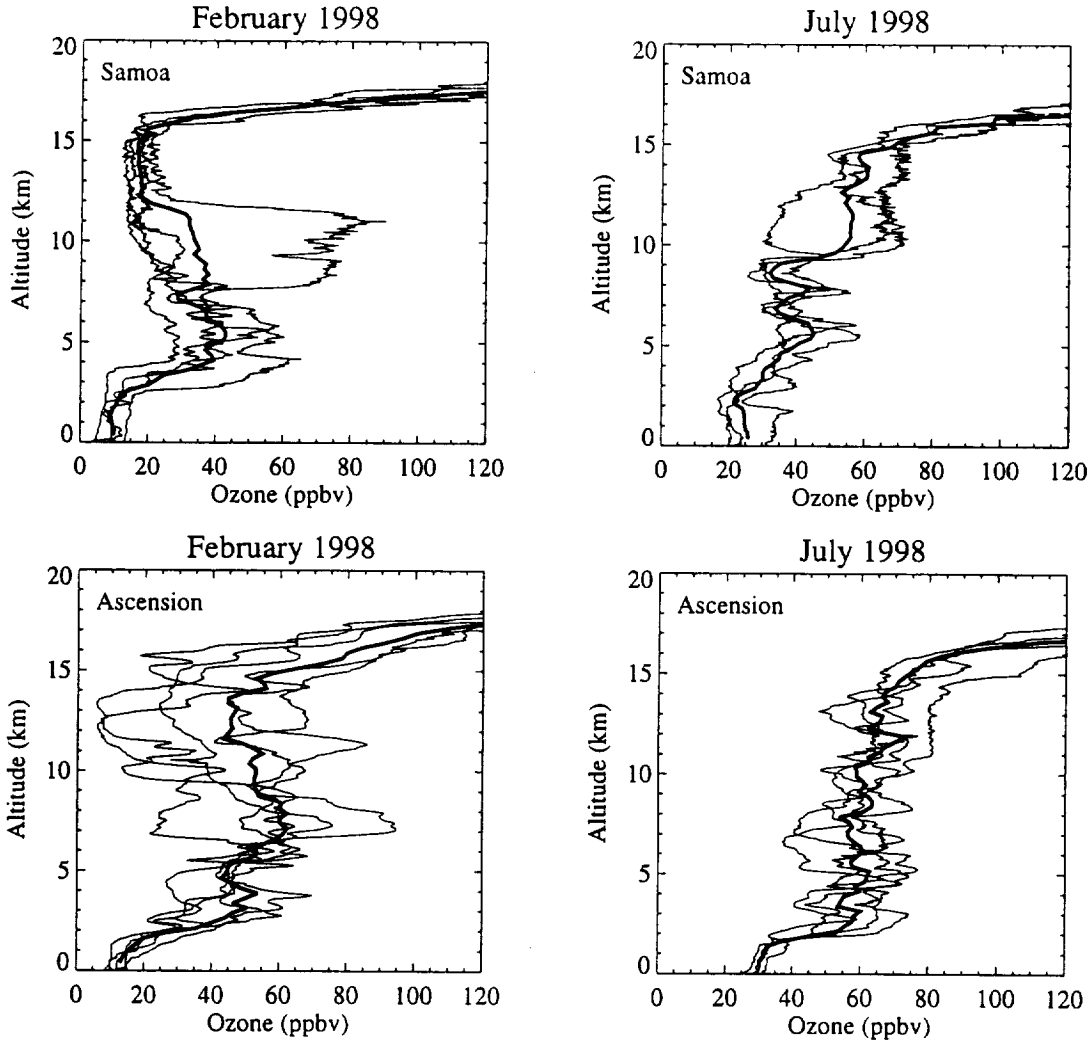

Figure 3. Individual soundings, 0-20km, at Ascension Is. (8S, 14W) and Am. Samoa (14S, 171W) for two months in 1998. Quarter-km averages appear in bold

INDOEX (Indian Ocean Experiment) and for SOWER (Stratospheric Ozone and Water in the Equatorial Region) at Christmas Island (2N, 157W). In 2000, as part of the SAFARI-2000 experiment and the Southern African Validation for EOS (SAVE), SHADOZ will enhance ozonesonde launches in South Africa.

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