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THE 1991 WMO OZONE SONDE INTERCOMPARISON

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ABSTRACT

The WMO ozone sonde intercomparison was held at Vanscoy, Saskatchewan from May 13 to May 24, 1991. The purpose of the intercomparison is to evaluate the performance of various ozone sonde types used operationally in the Global Ozone Observing System and to ensure that the accuracy and precision of the measurements are sufficient to detect long-term trends in stratospheric ozone. The intercomparison was sponsored by WMO and hosted by the Atmospheric Environment Service (AES) of Canada. It was attended by scientists from six countries: Canada, Finland, Germany, India, Japan and USA.

A total of 10 balloon payloads were launched each carrying 7 or 8 sondes for a total of 67 successful ozone sonde flights. The payloads were carried to altitudes between 35 and 40 km where the flights terminated by balloon burst. Results of the profile measurements made during the series of flights are used to determine statistically meaningful evaluations of the different sonde types. A description of the payload and the different ozone sondes is given. Preliminary results of the profile measurements and an evaluation of the performance of the sonde types are presented.

1. INTRODUCTION

A variety of types and manufacturers of ozonesondes are currently used operationally in the Global Ozone Observing System (GO_3OS) and there is concern that the accuracy and precision of measurements differ from one sonde type to another. An ozone sonde intercomparison was held with the goal of evaluating the various ozonesonde types to ensure that their measurements are comparable with each other and that they are of sufficient quality to detect long-term trends in stratospheric ozone.

The WMO organized and provided financial support for the comparison and the Atmospheric Environment Service (AES) of Canada hosted it. The comparison was held at Vanscoy, Saskatchewan from May 13 to May 24, 1991. The participants included scientists from six countries: Canada, Finland, Germany, India, Japan and USA.

The intercomparison was held at Vanscoy, which is the site that the AES has used for launching large experimental payloads. The facility was readily adapted for launching and recording multi-ozonesonde payloads. The intercomparison was held in May when the day-to-day variability of ozone is large and, therefore, a wide range of ozone conditions could be expected.

2. DESCRIPTION OF SONDES

An ozonesonde is a self-powered ozone sensor which is usually used as a supplement to a standard meteorological radiosonde. The ozonesonde samples ambient air to determine its ozone content and provides as output an electronic signal which is related to the amount of ozone in the air sample. The output signal from the ozonesonde is read (often through an electronic interface) into the radiosonde where the data are transmitted by radio to the ground receiver along with the regular meteorological data record.

Four different types of ozonesondes were represented at the intercomparison: the electrochemical concentration cell (ECC) sensor, the Brewer-Mast sensor, the Indian sensor and the RSII-KC79 sensor. The ECC sensor was used by the participants from Canada, Finland and USA. The Brewer-Mast sensor was used by the participants from Germany. The Indian sensor was used by the participant from India. The RSII-KC79 sensor was used by the participants from Japan and is integrated into a combined radiosonde/ozonesonde package. Most of the ozonesonde profile data which are reported routinely to the World Ozone Data Center (WODC) are measured by these four types of ozone sensors. The type of ozonesondes used by each participant is summarized in Table 1.

In operation the different types of ozone sensors are linked to radiosondes, often through an interface. The interface digitizes the signal from the ozone sensor so it can be included as part of the data record on the recently developed automated digital radiosondes. There are many combinations of ozone sensors, interfaces and radiosondes which are used operationally. The primary objective of the intercomparison reported here is the evaluation of the performance of the ozone sensors. It is also useful to compare ozone profiles derived from data which are transferred through different radiosondes and processed by different recording and analysis procedures. Information regarding the type of ozonesonde, radiosonde, data logging and analysis used by each country is summarized in Table 1.

3. DESCRIPTION OF THE BALLOON PAYLOAD

The ozonesonde packages from all countries were attached to a single balloon payload which is shown schematically in Figure 1. Up to eight sondes were suspended with a minimum separation of approximately one meter around the perimeter of an octagonally shaped frame. The frame is collapsible, light-weight (< 2kg) and sufficiently robust. The command and telemetry package and batteries were positioned at the center of the support frame. The payload systems were designed to be recovered after a flight and reflown with a new set of ozonesonde/radiosonde packages. Two payload systems were made in order to allow the preparation and checkout of a second set of ozonesondes while the first set was being recovered. This minimized the time interval between flights.

A special telemetry package was developed to accommodate the requirement of simultaneously transmitting the data from several sondes. This package consists of an eight-channel voltage controlled oscillator (VCO). A VCO channel reads the voltage output from either a radiosonde or an ozonesonde, transmits the information by telemetry to the ground receiver which replicates the voltage level at one of eight work areas. A test flight on May 1, 1991 demonstrated that the signals received at the ground through the VCO system were identical to those received in parallel through a regular 1680 MHz radiosonde and ozonesonde transmission. The resulting ozone profiles derived from the flight data recorded by both systems were essentially identical.

The participants were given the option to fly their ozonesonde either with or without a supporting radiosonde. The capability to telemeter the output from a radiosonde directly to the ground station using the standard radiosonde frequencies was available for only three sondes. The remaining sondes on the payload used the VCO system. When an ozone sensor was flown without a supporting radiosonde the signal from the ozonesonde was fed into the VCO. When both ozonesonde and radiosonde were flown the output from the radiosonde was fed to the VCO and the radiosonde transmitter was disabled. The ozonesonde, interface, radiosonde and telemetry configuration used by each of the participating countries are summarized in Table 1.

The 403 MHz radiosonde channel was used for an omega navigation sonde to determine payload position for calculations of winds.

The overall weight of the payload including the support frame, ozonesonde/radiosonde packages, telemetry package and power supply was about 20 kg. The payloads were flown on plastic balloons ranging in size from 140,000 to 500,000 cubic feet. The relatively light-weight payload was easily hand-

	OZONE SENSOR	INTER-FACE	RADIO SONDE	TELEMETRY CHANNEL	DATA LOG	DATA ANAL
CAN	ECC	N/A	VIZ	1680 MHz (VCO # 7)	Ana.	Man.
FIN	ECC	Vaisala	Vaisala	405 MHz (VCO # 7)	Dig.	Auto
GER	Brewer /Mast	N/A	N/A	VCO # 5 (VCO # 2)	Ana.	Man.
IND	Indian	N/A	N/A	VCO # 6 (VCO # 7)	Ana.	Man.
JAP	RSII-KC79	N/A	N/A	VCO # 5 (VCO # 7)	Ana.	Man.
USA	ECC	TMAX	Vaisala	401 MHz (VCO # 7)	Dig.	Auto

TABLE 1: Summary of the ozonesonde, interface, radiosonde and telemetry channel used by each country. The type of the transmitted data signal (analog or digital) and the data analysis procedure (automatic or manual) are also indicated. The telemetry channel in brackets indicates the channel used by that country when a second sonde was flown.

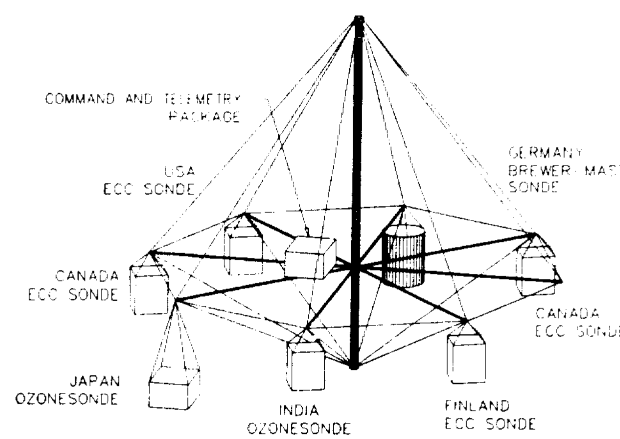

Fig. 1: Schematic diagram of ozone sonde payload.

launched by two people provided the surface wind was less than 10 knots.

The transmitted radio signals from the payloads were received at the ground and distributed to the work areas of the participants. This allowed the participants to display and record their data with their normal operational equipment and the data could be analyzed using their normal methods and procedures. The data was recorded on magnetic tape to allow playback of data for reanalysis, if necessary. It also enabled the participants to analyze data from their second ozonesonde which was flown on some of the flights.

4. DATA ACQUISITION

The participants prepared their ozonesondes using their normal pre-flight calibration and preparation procedures. When a participant's ozone sensor was ready for flight it was integrated on to the payload. The signals were checked through the telemetry and data distribution systems in order to ensure that the proper signals were being received at the appropriate work area. After signals had been checked on an individual basis, they were checked with all sondes on the payload operating in order to test for interference and cross-talk. When the all-up tests had been completed with verification from all participants that their sensors were operating correctly and the proper signals were being received at the work areas, the payload was ready for flight.

FLT NUM	DATE MAY 1991	START TIME (CST)	FLIGHT LENGTH (MIN)	MAX HEIGHT (KM)	TOTAL OZONE (DU)	TWO SNDS	GOOD PROS
1	14	22:16	99	37.0	346	Can	7
2	15	21:43	129	37.9	354	USA	7
3	16	04:55	120	39.8	331	Fin	7
4	16	21:05	110	37.0	321	*	3
5	17	01:41	122	36.0	325	Ind	7
6	19	05:57	116	37.2	334	Jap	7
7	19	21:30	115	38.8	374		6
8	20	20:51	112	38.4	365	Can USA	8
9	21	07:29	114	36.1	367	Fin Ind	8
10	22	21:10	118	38.8	374	Jap	7

TABLE 2: Summary of the ozonesonde flights during the intercomparison. The date, time of launch, flight duration, maximum altitude, total ozone, two sonde assignment and number of successful profiles are given. Time is in central standard time (CST) which is six hours behind GMT. Total ozone is in Dobson Units using the Bass-Paur absorption coefficient scale effective January 1, 1992. The "*" denotes a flight during which the VCO telemetry system failed and for which profile data for those sondes using the VCO system (Germany, India and Japan) are unavailable.

The balloon payload was designed to accommodate physically up to eight sondes and the telemetry system to accommodate up to eleven sondes. This allowed the opportunity for two sondes from one or two countries to be flown on each flight. Two sondes were flown by different groups on a rotational basis for different flights.

A total of 10 balloon payloads were launched between May 14 and May 22, each carrying 7 or 8 ozonesondes for a total of 67 successful ozonesonde profile measurements. Most of the flights were launched during the sunrise or sunset period when low surface winds allowed good launch opportunities. The payloads were carried to altitudes between 35 and 40 km where the flights were terminated by balloon burst. The payloads were recovered, refurbished and prepared for re-flight with unused ozonesondes usually within 24 hours. The launch times, flight durations, maximum altitudes, number of good profiles and country assignments for the two-sondes are summarized in Table 2.

Data from the intercomparison were submitted "blindly" to a "data custodian" who served as an objective recipient of the data and who had no direct involvement in the preparation of the ozonesondes or the analysis of the ozone profile data. The participants were asked not to compare or discuss their data with other groups during the intercomparison. Shortly after each flight the data were submitted to the data custodian together with a rating as to whether the data were thought to be good, average or poor. The data custodian reviewed the data as they were submitted in case there were severe problems (e.g. gross differences from the other data sets or extremely noisy data) so that the problem could be corrected for subsequent flights.

The participants analyzed their flight data using their normal analysis procedures. To reduce the effort involved in comparing sonde results, the participants submitted their data as floppy diskette files.

Ground-based ozone measurements were made with the Brewer and Dobson instruments to support the ozone profile measurements made by the ozonesondes. The ground-based measurements consisted of both direct sun total ozone measurements and Umkehr profile measurements. The total ozone measurements were required to normalize the sonde profile measurements using standard correction procedures. The Umkehr profile measurements were compared with the sonde profile measurements. The ground-based total ozone values valid for the ten flights are listed in Table 2. These values are on the Bass-Paur absorption coefficient scale. During the campaign the weather was not very favourable for Umkehr measurements which require clear zenith sky conditions over a three hour period after sunrise or before sunset.

5. RESULTS

Results for flight #1 on May 14 are shown in Figure 2. This example shows the nature of the variations of the vertical profile of ozone (top diagram) as well as the variations between the different sondes (bottom diagram).

The profiles were evaluated using a common pressure and temperature profile as measured by the Canadian radiosonde using a hypsometer measurement for pressure. The profiles were then normalized using the ground based total ozone measurements.

For all ten flights there were 3 or 4 ozone profiles measured with the ECC sonde (used by Canada, Finland and USA). On each flight the simultaneous data from the other three sonde types were compared with the mean ECC profile. The average ratios of the other measurements to ECC measurements and the standard deviations for the ten flights are shown in Figure 3.

6. CONCLUSIONS

Ten intercomparison flights were made between May 14 and May 22, 1991. Data from these flights are analyzed for evaluation of the quality of ozone profile measurements. Preliminary comparison indicate that the profile measurements show agreement of the order of 10% to an altitude corresponding to 10 mb in pressure. Possible systematic differences were observed. A thorough analysis of the results from the comparison are to be reported in a WMO publication.

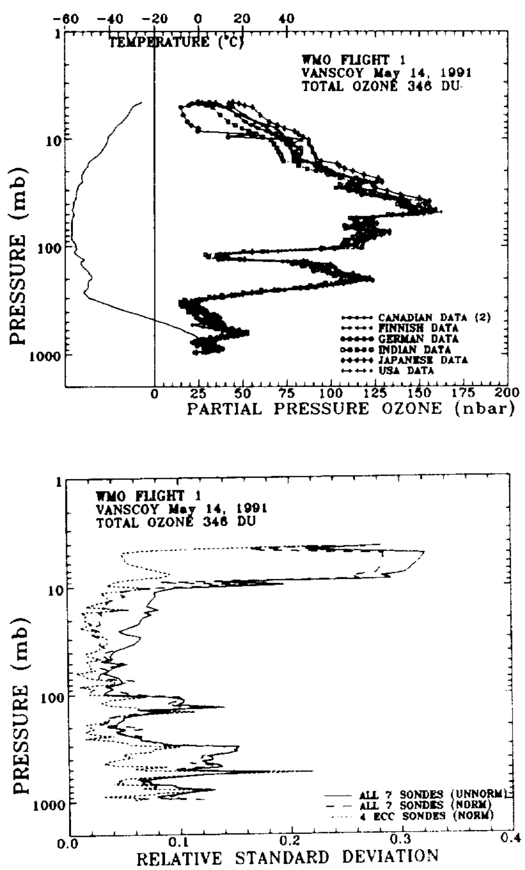

Fig. 2: The measured profiles for flight 1 of May 14, 1991. The top diagram shows the profiles of the individual ozone and the mean of four temperature measurements.

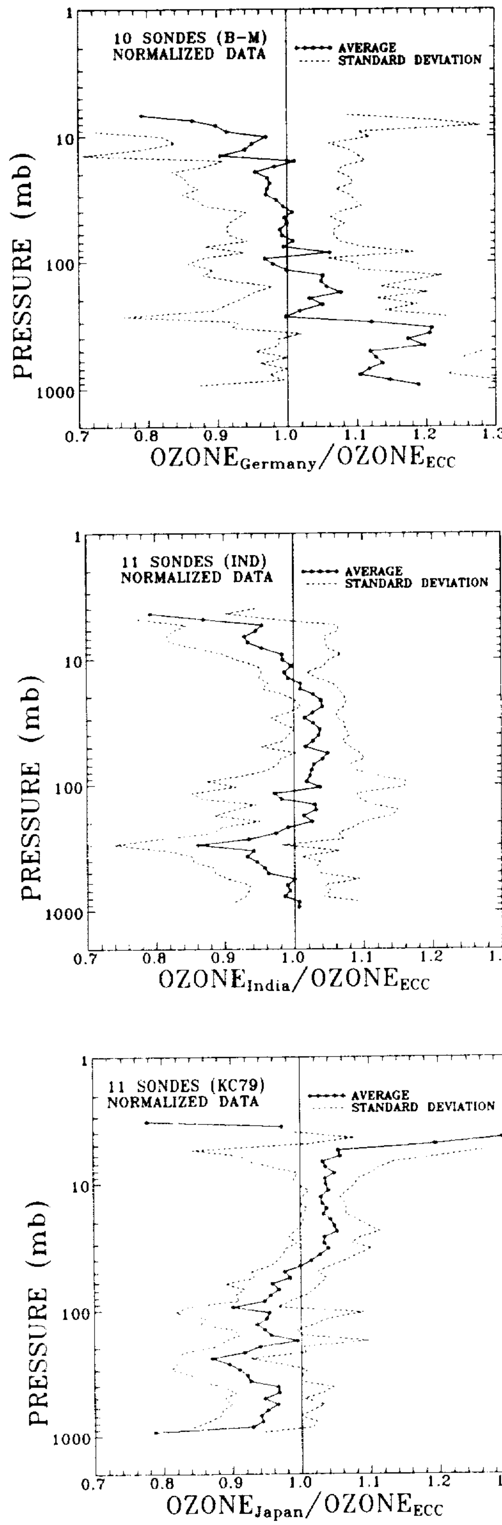

Fig. 3: Ratios of measurements made by the Brewer-Mast sonde (top), the Indian sonde (middle) and the Japanese KC79 sonde (bottom) to the flight-averaged simultaneous ECC sonde measurements. Means and standard deviations of the 10 flights are shown.