JOSIE-1996: Executive Summary of Jülich Ozone Sonde Intercomparison Experiment

The 1996 WMO International intercomparison of ozone sondes under quasi flight conditions in the environmental simulation chamber at Jülich.

Herman G.J. Smit and Dieter Kley

[*WMO Global Atmosphere Watch report series, No. 130 (Technical Document No. 926), World Meteorological Organization, Geneva, 1998*]

The state of knowledge regarding long term trends of tropospheric as well as stratospheric ozone is limited due to inadequate global coverage of ozone sounding stations, poor assurance of data continuity and questionable homogeneity of data (WMO-Scientific Assessment of Ozone Depletion: 1994). Particularly, there is an urgent need for improved data quality which must be achieved by intercalibration and intercomparison of existing ozone sonde types as well as agreement through procedures for data processing and analysis (WMO-report No. 104, 1995).

In order to assess the performance of the different types of ozone sondes used within GAW (=Global Atmosphere Watch) and GLONET (=Global Ozone Network) an international intercomparison experiment of ozone sondes, **JOSIE (=Jülich Ozone Sonde Intercomparison Experiment)** was conducted from 5 February to 8 March 1996 in the environmental simulation chamber of the World Calibration Center for Ozone Sondes (WCCOS) at the Forschungszentrum Jülich, Germany. A controlled environment plus the fact that the ozone sonde measurements could be compared to an accurate UV-Photometer as a reference experiments are essential elements for addressing questions that arise from previous field intercomparisons. JOSIE, sponsored by the WMO (=World Meteorological Organization) as part of QA/SAC (=Quality Assurance/Science Activity enters)-program of GAW and hosted by the Forschungszentrum Jülich, was attended by eight ozone sounding laboratories from seven countries. The performance of four different ozone sonde types such as Electrochemical Concentration Cell (ECC) of two different manufacturers, Brewer/Mast (BM-original), Indian (modified BM-type) and Japanese (KC79/96), that are in routine operation in GAW/GLONET and additionally the prototype version of the Swiss BM-hybrid was assessed. Thus, all major types of ozone sondes were compared under controlled conditions.

In order to determine precision, accuracy and response of the ozone sondes as a function of sonde type, altitude, and ozone level, the different ozone sonde types were tested under a variety of conditions and compared with an accurate UV-photometer. Special attention was paid to the influence of pre-launch procedures on in-flight performance. In addition it was investigated how and how much the data analysis is affected by certain procedures such as background signal correction and total ozone column normalization.

Name [No.]	Participating Organization	Ozone Sonde Type	Participants
MOHp [1]	Meteorological Observatory Hohenpeissenberg, Germany	Brewer-Mast (original of Mast Comp.)	Hans Claude (PI) Uwe Köhler Martin Adelwart
CMDL [2]	NOAA-Climate Monitoring & Diagnostic Laboratory, Boulder, USA	ECC/ENSCI-1Z (EN-SCI Corp.)	Brian Johnson (PI) Sam Oltmans
FZJ [3]	Forschungszentrum Jülich/ICG-2, Germany	ECC/SPC-6A (Science Pump Corp.)	Manfred Helten (PI) Wolfgang Sträter
IMD [4]	Indian Meteorological Department, Pune, India	Indian (Brewer-Mast type)	S. K. Srivastava (PI) P. N. Mohanen
ASP [5]	Swiss Meteorological Institute / Aerological Station Payerne, Switzerland	Ozone Sensor: Brewer-Mast (original of Mast-Comp) Pump: Teflon (ENSCI Corp.)	Bruno Hoegger (PI) Gilbert Lefrat Bertrand Henchoz
AES [6]	Atmospheric Environmental Service, Ontario, Canada	ECC/SPC-5A (Science Pump Corp.), ECC/ENSCI-1Z (EN-SCI Corp.)	James Kerr (PI) David Tarasick Jonathan Davies
CNRS [7]	Centre Nationale de la Recherche Scientifique, Paris, France	ECC/SPC-5A (Science Pump Corp.)	Claude Vialle (PI) Gerard Velghe
JMA [8]	Japan Meteorology Agency, Tokyo, Japan	Japanese KC79 (MEISEI-Comp.)	Masanori Shitamichi (PI) Hiroshi Kaneko

Table: *List of participating research institutions with the ozone sonde types used (PI = Principal Investigator)*

All sondes tracked the simulated ozone profiles quite well within scale lengths larger than 200 m, even under extremely low ozone concentrations, as they occur in the tropical troposphere. Precision and accuracy are altitude dependent and varied in size for the different participating laboratories. For all sondes, the relative precision is best in the middle stratosphere. A best precision of (3-5)% was achieved by the ECC-type ozone sondes. Conversely, the Non-ECC types of ozone sondes (Brewer-Mast, Indian and KC79), exhibited a somewhat lower precision of about (5-15)%. In the troposphere, the Non-ECC type sondes showed a somewhat lower precision compared to the ECC sondes.

JOSIE showed that the ECC-type sondes perform best with regard to precision and accuracy if operated by the procedures described by Komhyr (1986) such that, in the troposphere and lower/middle stratosphere up to 35 km altitude, the precision is within ± (3-4)% and the accuracy about ± (4-5)%. JOSIE showed that the different performance characteristics of the ECC-sondes (CMDL [2] and CNRS [7]) was caused by the use of different operating procedures. JOSIE clearly demonstrated that even a small change of the operating procedures can have a significant impact on the overall performance of the sonde and that caution has to be taken before any change of operating procedures of sondes.

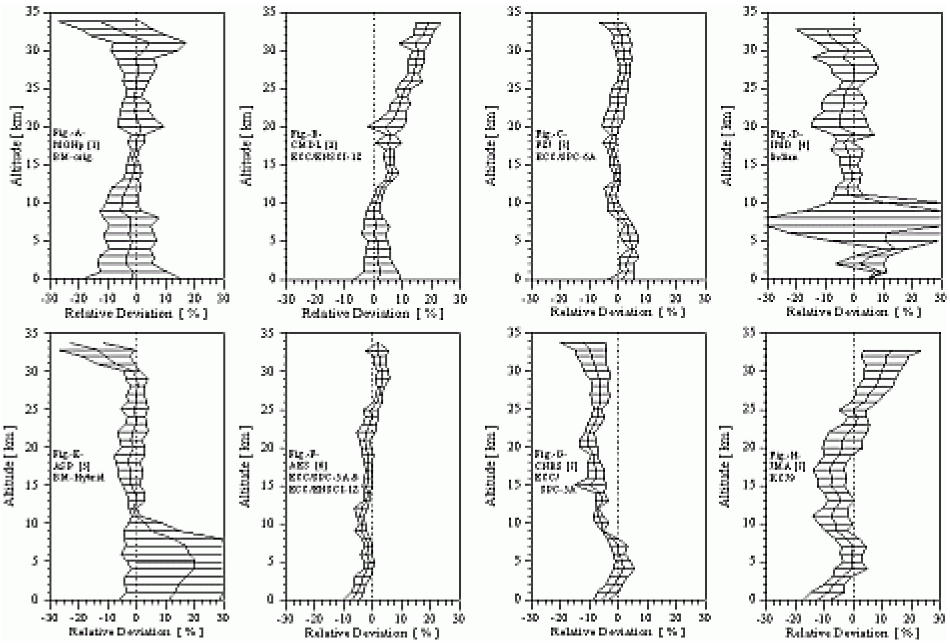

***Figure of Summary of JOSIE-results**:*
Average (thick line) plus/minus one standard deviation (thin line) of the relative deviations of the individual sonde readings from the UV-photometer for each participating sounding laboratory obtained from six simulation runs (4 mid-latitudinal + 2 tropical profiles). Tropospheric parts of tropical profiles below 20 km are excluded.

The performance of the non-ECC type sondes showed in general higher variability and larger deviations from the UV-photometer measurements than the ECC and that the behavior of the different Non-ECC-sonde types is quite different. The original BM-sonde operated by MOHp exhibited a precision of about ± (3-5) % and an accuracy of about ± 5% in the stratosphere up to 30 km altitude while, in the troposphere, the precision was somewhat lower with values of about ± 10 % and the accuracy was ± (10-13) %. The BM-Hybrid/ASP gave good performance in the lower stratosphere (precision » ± 4% and accuracy » ± 5%) up to 30 km. However, in the troposphere the sonde was suffering a low precision (» ± 18%) and low accuracy (» ± 33%). The KC79/JMA-sonde tended to underestimate ozone in the troposphere (precision » ± 6% and accuracy » ± 10%) and lower stratosphere (precision » ± 5% and accuracy » ± 10%) and to overestimate ozone above 25 km altitude (precision » ± 7% and accuracy » ± (11-18)%) The Indian/IMD sonde showed a precision of about ± (4-8)% and an accuracy ± (6-13)% in the lower stratosphere, with decaying performance above 30 km altitude. In the troposphere the sonde showed strong fluctuations and deviations from the UV-photometer.

Although all individual normalization factors range between 0.9 and 1.1, the variability (standard deviation) of the ECC-sonde types with values of 0.02 for three of the four ECC-stations is significantly smaller than the variability of the other types of sondes, at values of (0.07-0.10). The normalization factors for the Non-ECC-type sondes are closer to unity than usually achieved during field operation at the sounding site.

The observed larger variability among ozone sonde measurements in the middle stratosphere is mainly caused by uncertainties in the pump efficiency and by the amount of evaporating sensing solution. Significant differences (more than 5-10 % at 5 hPa) were observed between the various experimental methods used to determine the pump flow efficiency at lower pressures. JOSIE indicated that the sensitivity of the ECC-sonde increases during flight due to evaporation caused changes of the concentrations of the sensing solutions. However, the process is not understood in detail and more investigations are necessary to study this effect, particularly in relation to the initial concentrations of the sensing solutions, the actual temperature of the sensing solution and the pump flow efficiency correction which also has an important influence on the sonde performance.

The determination of tropospheric ozone profiles by ozone sonde measurements is sensitive to the methods of background/offset signal processing. This point, being of general importance, becomes critically important for the measurement of tropical ozone profiles. A strong recommendation for further research is to get a better understanding on the origin and evolution of the background signals during flight.

The JOSIE-results show that the achievement of good precision and high accuracy is strongly dependent on sonde type and handling. Non-ECC types need more preparation efforts to obtain results similar to those from well prepared ECC-sondes. The observed differences between the ECC-sonde types are mostly due to differences in the preparation and correction procedures applied by the different laboratories. JOSIE clearly demonstrates that there is an urgent need for the homogenization of the standard operating procedures (SOP) for pre-launch preparation and post-flight data processing. Further, there is a need for research to get a more fundamental understanding of the influences of instrumental factors such as background signal, sensing solution, pump flow efficiency and their uncertainties on the data quality of ozone soundings. In addition, the use of the total ozone normalization as a correction factor has to be re-evaluated for the tropospheric as well as for the stratospheric part of the measured ozone profile.

JOSIE brought valuable information about the performance of the different ozone sonde types and the influence of the operating procedures for preparation and data correction applied by the participating laboratories. JOSIE showed also that there is a need to validate ozone sondes on a routine basis. Ozone sondes have gone through some modifications since they were first manufactured, which adds uncertainty to trend analysis. Routine testing of newly manufactured ozone sondes on a regular basis, following a standard operating procedure, will help to ensure more confidence in observed trends in the future. A pre-requisite thereby is the standardization of the preparation procedures and data correcting methods in the near future, but also a better and more detailed documentation of the procedures and methods applied in the past at the different long term ozone sounding stations.

References

WMO report No. 104, Report of the fourth WMO meeting of experts on the quality assurance/science activity centers (QA/SACs) of the global atmosphere watch. Jointly held with the first meeting of the coordinating committees of IGAC-GLONET and IGAC-ACE at Garmisch-Partenkirchen, Germany, 13-17 March 1995, *WMO TD.No. 689*, *World Meteorological Organization, Geneva,*1995

Komhyr, W.D., Operations handbook - Ozone measurements to 40 km altitude with model 4A-ECC-ozone sondes, NOAA Techn. Memorandum ERL-ARL-149, 1986.