Appendix V – Ozonesonde Instruments

Balloon-borne ozonesondes first became practical for atmospheric monitoring in the 1960s when it was recognized that the potassium iodide (KI) method worked well as the ozone sensor. The instrument was inexpensive, lightweight and only needed a small pump to bubble ambient air into a KI solution thereby producing an electrical current proportional to ozone, and a weather radiosonde to transmit the data to a ground station [Brewer & Milford, 1960; Komhyr, 1964, 1967, 1969]. These "in situ" instruments are unique in providing high-resolution ozone profiles from ground level to the lower stratosphere, with maximum altitudes at balloon burst near 30-35 km.

Over the last 40 years, ozonesonde development and improvement has been the result of many intercomparison projects involving different ozonesonde types and reference instruments [Attmannspacher and Dütsch, 1970; 1981; Barnes et al., 1985; Hilsenrath et al. 1986; Kerr et al., 1994; Beekmann et al.,1994; 1995; Komhyr et al., 1995a; 1995b; Reid et al., 1996; Boyd et al., 1998; Johnson et al., 2002; Fioletov et al. 2006; Terao and Logan, 2007; Smit et al., 2007; Deshler et al., 2008; Stübi et al. 2008]. The most recent laboratory [Smit et al., 2007] and field [Deshler et al., 2008] experiments have shown that ozonesondes provide very reproducible and consistent results when the Standard Operating Procedures (SOPs) are consistently followed. The variability (precision) between sondes is estimated to be ± 0.1 mPa in the troposphere and ± 0.2 mPa (± 2%) in the stratosphere. Therefore, the ozonesonde has been accepted and proven as a reliable NDACC instrument suitable for long-term measurements of ozone vertical profiles.

The peculiarity of ozonesondes is that every instrument is new and flown only once even though, some stations do re-use recovered sondes after a careful cleaning and laboratory performance checks. Therefore, the notion of a reference/standard instrument has to be interpreted differently than for other types of instruments. In the case of ozonesondes, the main emphasis is on the (SOPs) for preparing the instruments for flight, and on the data processing.

Quality Criteria for the Evaluation of New Ozone Sounding Station

Long term monitoring networks of ozone sounding stations as well as project-dedicated networks have developed optimal practices over the years. Within these networks three different types of ozonesondes are still employed: electrochemical concentration cell (ECC), Brewer Mast (BM), and the Japanese KC sonde.

ECC ozonesondes are now the most widely used ozonesonde type. Two companies produce ECC sondes, Science Pump Corporation (SPC) and ENSCI Corporation. The two manufacturers each recommend slightly different operating procedures. These recommendations have been improved using the expertise gained in the operational ozonesonde networks, such as NDACC and by comparisons organized by the World Meteorological Organization (WMO). The resulting SOPs are described in GAW report n° 201 available at:

http://www.wmo.int/pages/prog/arep/gaw/documents/FINAL_GAW_201_Oct_2014.pdf.

For stations that have not followed the SPC and ENSCI recommendations regarding the KI solution concentration, a publication describing a method to correct the systematic bias introduced is in preparation (Deshler et al. in preparation).

Presently only one station (Hohenpeissenberg) is still using BM ozonesondes operationally. A document defining the SOPs for the Brewer-Mast ozonesonde has been available since 1976, which defines the different steps to complete proper and reproducible ozone profiles. The Japanese sonde KC92 [Kobayashi et al., 1966; Fujimoto et al., 2004] has being replaced by ECC sondes by the Japanese Meteorological Agency. No other stations have used KC sondes.

Under the WMO umbrella, there is a network of global ozone sounding stations, which partially overlaps the NDACC network. The WMO has assigned the role of the world calibration center for ozonesondes (WCCOS) to the Research Center in Jülich. The primary goals of the WCCOS are to promote understanding of the instrument, to establish well-documented SOPs, and to assess differences in instrument manufacturers and in variations of SOPs in use. The WCCOS along with NDACC investigators were instrumental in establishing the guidelines behind the presently recommended SOPs in a document that is cross-linked from the NDACC ozonesonde web site. WCCOS continues to periodically test the quality of ECC ozonesondes provided by the two manufacturers. The NDACC ozonesonde working group endorses the role of the WCCOS and there is a good collaboration between NDACC and WCCOS. A new Jülich Ozonesonde Intercomparison Experiment (JOSIE 2017) is scheduled for the end of 2017.

The manufacturers of ozonesondes produce a consistent product with well-established characteristics. Therefore, the evaluation of candidate ozonesonde stations to be accepted into the NDACC network will be primarily based on their compliance with recommended standards for instrument operation and data analysis. These recommended standards are available in the SOPs for BM or ECC sondes. These guidelines are not meant to discourage new experimental work through which important scientific contributions to our understanding of ozonesonde characteristics can be made. However, in cases where a station wishes to deviate from the SOPs for either practical or scientific reasons, the NDACC requires that the station PI(s) document such changes to the Ozonesonde Working Group representatives and in the NDACC data archive, and provide results showing the consequences of the change compared to standard ECC ozonesonde operation as defined in the SOPs.

Data File format for the ozonesonde NDACC Archive

At its 2009 meeting in Jülich, Germany the NDACC Ozonesonde WG decided on a data file format to be used when submitting data to the NDACC Data Host Facility. The format was based on the NASA/AMES 2160 format and efforts have been taken to standardize this format among all NDACC stations in order to

avoid the need for a multiplicity of readers to access NDACC ozonesonde data. The relevant documents are posted on the ozonesonde working group web site. Thus, NDACC investigators are encouraged to submit all their data using this format, and, although not required, to consider resubmitting any earlier data that may have been submitted under a different format.

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