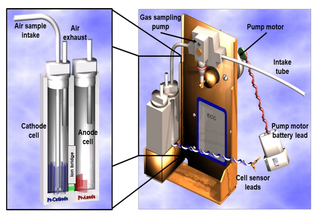
Long Term WMO-GAW Ozonesonde QA/QC and Data Quality Improvements: The 25th Anniversary of the Juelich Ozone Sonde Intercomparison Experiment (JOSIE)

Smit, H.G.J. [(1)], A.M. Thompson, B.J. Johnson, J. Davies, D.W. Tarasick, J.C. Witte, R. Stuebi, R. Van Malderen, R.M. Stauffer, H. Voemel, P. von der Gathen, D.E. Kollonige, S.J. Oltmans, F.J. Schmidlin, B. Hoegger, G. Morris, R. Kivi, T. Nakano, R. Querel, A. Piters, and many more members of the JOSIE-ASOPOS-O3SDQA Teams

(1) Institute of Energy and Climate Research: Troposphere (IEK-8)
Forschungszentrum Jülich (FZJ), Jülich, Germany (contact: h.smit@fz-juelich.de; https://wccos-josie.org)

Quality Assurance (QA) of Ozone Sonde (O3S) Data



- Longest time series of vertical ozone distribution
- Cost efficient for process studies
- Important to validate (i) satellites on their long-term stability (ii) weather and air quality forecastings
- Small changes of instrument or operating procedures can have large impact on data quality
- Trend assessments show need for homogenity of data

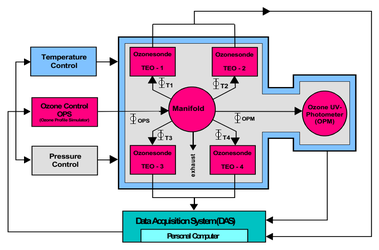
O3S-DQA
Ozone Sonde Data Quality Assessment

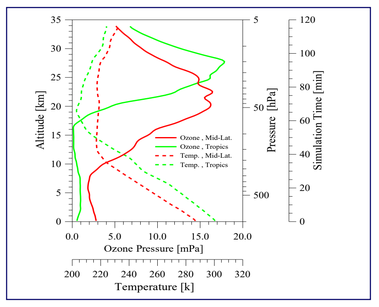
JOSIE
Jülich Ozone Sonde Intercomparison Experiment

ASOPOS
Assessment for Standard Operating Procedures for Ozone Sondes

➡ Standard operating procedures (SOP's) and Homogenisation of O3S data records can improve precision & overall uncertainty better than ±5%

Activities at World Calibration Centre for Ozone Sondes



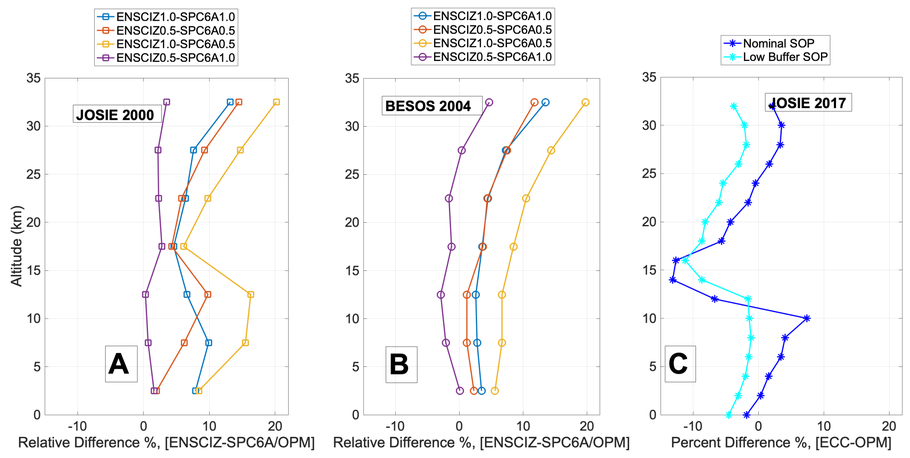


The facility enables control of pressure, temperature and ozone concentration and can simulate quasi realistic flight conditions of ozone soundings to Z=35 km
A dual beam UV-photometer serves as a reference (uncertainty better than ±5 %)

- **JOSIE 1996:** QA-Operation
  - ➢ *Operating procedures of crucial importance*
- **JOSIE 1998:** QA-Manufacturers
  - ➢ *Differences between manufacturers*
- **JOSIE 2000:** QA-Procedures
  - ➢ *Differences between sensing solutions*
- **ASOPOS 2001:** Evaluation of JOSIE 2000
  - ➢ *Definition of provisional SOP's*
- **BESOS 2004:** Testing of provisional SOP's in the field
  - ➢ *Agreement of field and laboratory results*
- **ASOPOS 2004:** Evaluation JOSIE & BESOS
  - ➢ *Unanimous agreement on SOP's*
- **ASOPOS 2009:** Approval SOP's by WMO
  - ➢ *GAW Report No. 201 (2011)*
- **JOSIE 2009-2011:** QA-Manufacturers
  - ➢ *Calibration functions (in preparation, 2022)*
- **O3S-DQA Activity 2011-2018-2023:**
  - ➢ *Homogenisation long term O3S records*
- **JOSIE 2017/SHADOZ:**
  - ➢ *QA-Tropical profiling capabilities*
- **ASOPOS 2.0 (2018-2021):** Upgrade of SOP's
  - ➢ *GAW Report No. 268 (2021)*

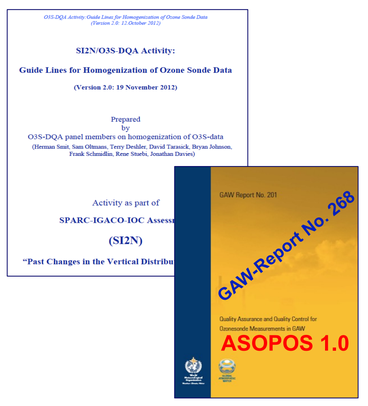
Different Manufacturers & Different Sensing Solution Types

Comparison SPC-6A & ENSCI-Z @ SST1.0 (1.0% & 1.0 Buffer) and @ SST0.5 (0.5% KI & 0.5 Buffer)

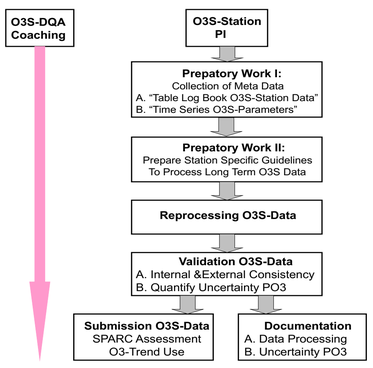


- ➢ Consistent results over 25 years: relative differences with reference (OPM) are minimal (< 1-3 %) for SPC-6A @ SST1.0 or ENSCI-Z @ SST0.5
- ➢ BESOS: Precision of ECC-O3 sondes can be 3 % when strictly the same SOP's are used, which is consistent as observed in JOSIE 1998, 2009/2010)
- ➢ JOSIE: When not same SOP's then enhanced precision is the limiting factor in the troposphere only 5-10 % overall uncertainty can be achieved

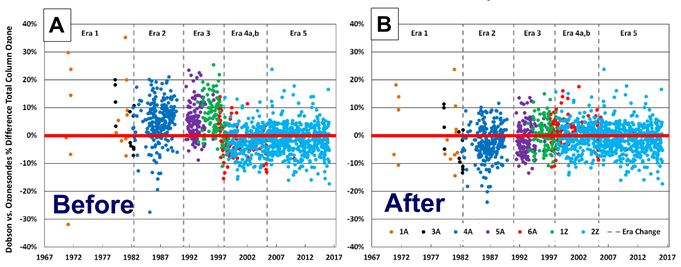
O3S-DQA: Homogenisation of Long-Term Ozone Sonde Data



1. Homogenisation of long-term ozonesonde time series of the sonde stations in the global network.
2. Determination of uncertainty budget for each ozonesonde measurement.
3. Documentation of the homogenisation process and the quality of ozone sonde measurements including the uncertainty of each ozone sonde measurement



Comparison Total Ozone Columns derived from ozonesondes and in-situ Dobson Spectrometer



➢ Overall uncertainty of long term ozonesonde records improved from 10-20% down to 5-10%

ASOPOS (2016-2021): Ozonesonde Measurement Principles & Best Operational Practices

Base for ASOPOS 2.0:

- Results from JOSIE 2009/2010
- Results from Homogenisation (O3S-DQA)
- Results from JOSIE 2017-SHADOZ

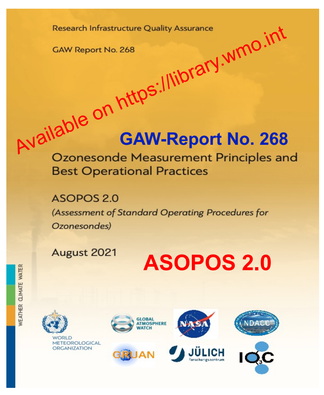
Published in peer reviewed literature:

A.) on O3S Performance:

- JOSIE 2017-SHADOZ: *Thompson et al., BAMS, 2019*
- Uncertainty Budget: *Tarasick et al., ESS, 2021*
- Resolving fast and slow time response: *Voemel et al., AMT, 2020*
- Total Column Ozone Drop : *Stauffer et al., GRL, 2020*

B.) on Homogenisation:

- Tarasick et al., *AMT, 2016*
- Van Malderen et al., *AMT, 2016*
- Witte et al., *JGR 2017, 2018-A &-B, 2019*
- Thompson et al., *JGR, 2017*
- Deshler et al., *AMT, 2017*
- Sterling et al., *AMT, 2018*
- Ancellet et al., *AMT, 2022*
- *……and still ongoing……..*



Key outcomes:

- ➢ More strict and unified Standard Operating Procedures (SOP's)
- ➢ Recommendations on sensing solution type (SST) and ECC sonde type (SPC-6A or EN-SCI) stay the same as in ASOPOS 1.0.
- ➢ Stations are requested in general not to change operations.
- ➢ Uncertainty budget analysis with overal uncertainty to archive.
- ➢ Extensive list of metadata such that data can be reprocessed.
- ➢ Data Quality Indicators
- ➢ Base for improved data processing (resolving fast and slow time responses: Time Delays Resolving Methodology (TDRM)
- ➢ Practical and unified guidelines for SOP's, Meta data, Uncertainties and Homogenisation to achieve overall uncertainty better than 5 %

Outlook (WCCOS-JOSIE.ORG)

- Implementation recommendations of ASOPOS 2.0 into the global ozonesonde network: webinars and regional on-line workshops for station operators).
- Implementation meta data plus uncertainties (incl. data flagging) into the data archives.
- Future JOSIE activities in collaboration with Royal Meteorology Institute (RMI) of Belgium (Uccle).
- Development and implementation of new data processing of Time Delays Resolving Methodology (TDRM) in the global network.
- NRT-data delivery: Expand the number of global stations (> 40).
- Development of new automatic data quality screening tools.
- Regular JOSIE-QA activities to derive the ozonesonde calibration functions to keep the 5% uncertainty stable on the long-term.