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Data Set Description:

PI: Dr. R. Stubi

Instrument: Brewer-Mast Ozone sonde until August 31, 2002
ECC (ENSCI-0.5%) since September 1, 2002

Site(s): Payerne Aerological Station (coord. 6.95 E, 46.80 N)

Measurement Quantities: Ozone partial pressure, Temperature, Pressure, RH (up to 200 hPa), Wind speed, Wind direction, Geopotential Height

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DOI:

Data License:

Reference Articles on ozone sondes:

Claude et al., "Measurements of Atmospheric Ozone Profiles using the Brewer/Mast sonde", Global Ozone Research and Monitoring Project, Report No. 17, 1987.

Staehelin J., Schmid W., "Trend Analysis of the tropospheric ozone concentration utilizing the 20-years data set of the ozone balloon soundings over Payerne", Atmos. Env., Vol 25A, No. 9, pp 1739-1749, 1991.

Smit H., et al., JOSIE: The 1996 WMO International Intercomparison of Ozonesondes under Quasi-flight Conditions in the Environmental Simulation Chamber at Julich, Proc. Quad. Ozone Symp., l'Aquila, Italy, 1996

Tarasick, D.W., J. Davies, K. Anlauf and M. Watt, Response of ECC and Brewer-Mast Sondes to Tropospheric Ozone, Proc. Quad. Ozone Symp., l'Aquila, Italy, 1996

SPARC/IO3C/GAW assessment of the trends in the vertical distribution of ozone, WMO global ozone research and monitoring project, report No. 43, (WCRP_SPARC, report No.1), May 1998

René Stübi, Gilbert Levrat, Bruno Hoegger, Pierre Viatte, Johannes Staehelin, and F. J. Schmidlin, In-flight comparison of Brewer-Mast and electrochemical concentration cell ozonesondes, JGR, VOL. 113, D13302, doi:10.1029/2007JD009091, 2008

C. Schnadt Poberaj, J. Staehelin, D. Brunner, V. Thouret, H. De Backer, and R. Stübi Long-term changes in UT/LS ozone between the late 1970s and the 1990s deduced from the GASP and MOZAIC aircraft programs and from ozonesondes, Atmos. Chem. Phys., 9, 5343–5369, 2009, www.atmos-chem-phys.net/9/5343/2009/

J. Staufer, J. Staehelin, R. Stübi, T. Peter, F. Tummon, and V. Thouret Trajectory matching of ozonesondes and MOZAIC measurements in the UTLS – Part 1: Method description and application at Payerne, Switzerland Atmos. Meas. Tech., 6, 3393–3406, 2013, www.atmos-meas-tech.net/6/3393/2013/

J. Staufer, J. Staehelin, R. Stübi, T. Peter, F. Tummon, and V. Thouret Trajectory matching of ozonesondes and MOZAIC measurements inthe UTLS – Part 2: Application to the global ozonesonde network, Atmos. Meas. Tech., 7, 241–266, 2014, www.atmos-meas-tech.net/7/241/2014/

Terry Deshler, Rene Stübi, Francis J. Schmidlin, Jennifer L. Mercer, Herman G. J. Smit, Bryan J. Johnson, Rigel Kivi, Bruno Nardi, Methods to homogenize electrochemical concentration cell (ECC) ozonesonde measurements across changes in sensing solution concentration or ozonesonde manufacturer, Atmos. Meas. Tech., 10, 2021–2043, 2017, https://doi.org/10.5194/amt-10-2021-2017

Leonie Bernet, Thomas von Clarmann, Sophie Godin-Beekmann, Gérard Ancellet, Eliane Maillard Barras, René Stübi, Wolfgang Steinbrecht, Niklaus Kämpfer, and Klemens Hocke, Ground-based ozone profiles over central Europe: incorporating anomalous observations into the analysis of stratospheric ozone trends Atmos. Chem. Phys., 19, 4289–4309, 2019, https://doi.org/10.5194/acp-19-4289-2019

<u>Conference contribution with Payerne data:</u>

Stubi, R., V. Bugnon, M. Giroud, P. Jeannet, P. Viatte, B. Hoegger and J. Staehelin. Long term ozone balloon soundings series at Payerne: homogenization methods and problems. XVIII Quadrennial Ozone Symposium, 12-21 September 1996, L'Aquila.

Jeannet. P et al., "Ozone trends in the Lower Troposphere Based on Balloon Soundings and Alpine station Measurements", Proc. of the GAW-CH Conference in Zurich, 1998.

Stubi R. et al., "Sensitivity Analysis of the Data Correction: a contribution to theRe-evaluation of the Payerne ozone Sounding Series", Proceedings. Swiss Agency for the Environment, Forests and Landscape (SAEFL). Environmental Documentation No. 110. 1999.

Stubi R. et al., "BM-ECC ozone twin flights: differences between two ozone sonde types", to be published in Proc. of the Fifth European Workshop on Stratospheric ozone, Saint-Jean de Luz 1999.

Stubi, R., C. Ammann, D. Ruffieux, N. Bretz, P. Viatte, G. Levrat, B. Hoegger, F.J. Schmidlin,G. Brothers, W. Michel and P . Moore. BM-ECC ozone twin flights: differences between two ozone sonde types. Stratospheric Ozone 1999. Proceedings of the Fifth European symposium, 27 September - 1 Octobre 1999, Saint Jean de Luz, France. European Commission, Air pollution research report 73, EUR19340, 2000. 734-737

Stubi, R., G. Levrat, B. Hoegger, P. Jeannet, P. Viatte, and J. Staehelin. Comparability between BM and ECC ozone sondes. Atmospheric Ozone. Proceedings of the Quadrennial Ozone Symposium. 3-8 July 2000, Sapporo, Japan. 1657-658.

Stubi, R., G. Levrat, P. Viatte, and B. Calpini. Study of the ECC ozone sondes sensitivity to cathode solution concentration in flight and laboratory conditions. Proceedings of the Quadrennial Ozone Symposium. 1-8 June 2004, Kos, Greece. p. 610-611.

<u>Instrument Description:</u>

At Payerne, the Brewer - Mast (BM) type ozone sonde has been used from 1968 until end of August 2002.

The manufacter was the Mast Keystone Corporation (Reno, Nevada, USA).

Since September 2002, the ECC ozone sondes has been used from ENSCI company. A O.5% KI concentration is used at Payerne

The aerological sondes accompanying the ozone sondes were :

- the Swiss sonde SRS-400 from 1990 to January 2011
- the Swiss sonde SRS-C34 from January 2011 to February 2017
- the Swiss sonde SRS-C50 from February 2017 to march 2018
- the Vaisala sonde RS41 since March 2018

The Swiss sondes mentioned above have been developed by Meteolabor Corporation (Zurich, Switzerland).

The BM sonde differs from the ECC in having a unique chamber with the 3 ccm of KI 0.1% solution and two different electrodes, a platinum cathode and a silver anode. A 0.42 V external polarizing voltage is applied to cancel the current in absence of iodine in the cell. The major difficulty in handling the BM system is the sensitivity of the sonde to the cleaning procedure. Another important difference is the pump made of a steel piston in a plastic body.

The need for a lubrication oil and a larger dead volume result in less good performance than the all Teflon ECC pump. The preparation in Payerne was largely similar to the SOP for the BM sonde published by Claude et al. (ref above). Few adaptations have been done in the cleaning procedure to avoid the use of the harmful HF acid.

A good summary of the ozone sondes systems, their performances and reproducibility/accuracy can be found in the JOSIE and SPARC reports referred above.

The transition to ECC sondes has operational Payerne instrument was operated after an extensive campaign of dual BM - ECC soundings. The analysis of more that 100 dual flights allows to have a clear picture of the difference between the two ozone sonde types. A report is available at MeteoSwiss: R. Stübi, SONDEX/OZEX Campaigns of dual ozone sondes flights: report on the data analysis, Veröffentlichungen Serie, July 2002.

See also:

Stübi, R., G. Levrat, B. Hoegger, P. Viatte, J. Staehelin, and F. J. Schmidlin (2008), In-flight comparison of Brewer-Mast and electrochemical concentration cell ozonesondes, J. Geophys. Res., 113, D13302, doi:10.1029/2007JD009091.

BM ozonesonde algorithm description:

Ozone is calculated as a partial pressure with the standard form:

POZ(nb) = 0.004307 * i * Tp * t * E(p)

where: i is the current from the sensor in uA
- t is the time in seconds to pump 0.100 liters of air through the pump
- E(p) is the pump efficiency correction
- Tp is the pump temperature assumed to be constant (280 K in Payerne) since no measurements of that pump temperature is made in BM sonde

Background current is assumed to be zero in the BM sonde.

The pump efficiency correction E(p) is interpolated from the original table:

Pressure	Correction
5.0	1.300
8.0	1.206
10.0	1.170
15.0	1.120
20.0	1.092
30.0	1.065
40.0	1.047
50.0	1.035
60.0	1.025
70.0	1.022
100.0	1.010
150.0	1.000
1000.0	1.000

The profiles are normalized to the ozone column measured at the Arosa station (9.7 E, 46.77 N, alt. 1850 m) with the Dobson #101. The residual column above the balloon burst is evaluated using the constant mixing ration rule. The mixing ratio is evaluated over the last two hPa, the balloon having reached at least 17 hPa. Between 17 and 30 hPa, the SBUV satellite climatology is used.

The ozone profiles are visually inspected during the ascent by trained people. Glitches in the sensor current and intervals of strong noise are removed. A subsequent visual check is performed when the normalization to the Dobson is performed.

<u>ECC ozonesonde algorithm description:</u>
Ozone is calculated as a partial pressure with the standard form:

$$POZ(nb) = 0.004307 * i * Tp * t * E(p)$$

where: i is the current from the sensor in uA
t is the time in seconds to pump 0.100 liters of air through the pump
E(p) is the pump efficiency correction
Tp is measures pump temperature with the sensor inside the pump body

Background current (ib2) is measured during the "day of flight" sonde preparation.

The pump efficiency correction E(p) is given in ENSCI manuel (Komhyr 94):

Pressure	Correction
3.0	1.240
5.0	1.124
7.0	1.087
10.0	1.066
15.0	1.048
20.0	1.041
30.0	1.029
50.0	1.018
70.0	1.013
100.0	1.007
150.0	1.002
200.0	1.000
1000.0	1.000

The profiles are normalized to the ozone column measured at the Arosa station (9.7 E, 46.77 N, alt. 1850 m) with the Dobson #101 or #062. The residual column above the balloon burst is evaluated using the constant mixing ration rule. The mixing ratio is evaluated over the last two hPa, the balloon having reached at least 13 hPa.
The ozone profiles are visually inspected during the ascent by trained people. Glitches in the sensor current and intervals of strong noise are removed. A subsequent visual check is performed when the normalization to the Dobson is performed.

<u>Expected Precision/Accuracy of Instrument:</u>

PTU values for SRS - 400 Radiosonde valid for the data since 1990:

Pressure:
Resolution 0.1 mb
Accuracy +/- 0.5 mb

Temperature:
Resolution 0.1 C
Accuracy +/- 0.2 C

Humidity:
Resolution 1% RH
Accuracy +/- 2% RH

Geopotential Height:
Uses Pressure and Temperature profile.
Errors due to uncertainty in these values.

Ozone Partial Pressure BM: -----------------
Resolution 0.01 mPa
Accuracy +/- 10% or less depending on altitude (according to the JOSIE report for the Hohenpeissenberg BM sondes similar to Payerne). Smit H., et al., JOSIE: The 1996 WMO International Intercomparison of Ozonesondes under Quasi-flight Conditions in the Environmental Simulation Chamber at Julich, Proc. Quad. Ozone Symp., l'Aquila, Italy, 1996)

The main sources of error are the pump efficiency correction at high altitudes and the background current in the troposphere. The constant pump temperature rule hypothesis is also source of systematic difference. A report on the differences between BM and ECC ozonesondes measured in dual flights will be issued by the end of 2001.

Ozone Partial Pressure ECC:
Resolution 0.01 mPa
Accuracy +/- 3-4 % depending on altitude, sensing solution and manufacturer (ENSCI vs SPC). see ref. on the JOSIE site: http://www.fz-juelich.de/icg/icg-ii/josie/

The main sources of error is the preparation procedure. An international effort to issue Standard Operation Procedure is currently under way (see JOSIE site mentioned above)

<u>Instrument History:</u>

For the period of the NDACC records (from 1991), no significant change has been made in the ozone instrument or algorithm. However, the introduction of a new aerological sonde in April 1990 has introduced a rupture in the ozone sounding series. It is only since 1993 that the ozone measurement has recover the previous quality standard. A statistical correction has been applied on the data.