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Data Set Description:
PI: James Rosen and Collaborators (see list below)
Instrument: Backscattersonde
Sites: Laramie, WY; Lauder, NZ; Polar Regions; Natal, Brazil; and other locations. More specific details given under the Instrument History Section below.
Measurement Quantities: Pressure, Temperature, RH, Geopotential height, backscatter at 921 and 495 nm effective wavelengths, ozone partial pressure.

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Reference Articles:
Rosen, J.M., S.J.Oltmans, W.F.Evans, Balloon borne observations of PSCs, frost point, ozone and nitric acid in the north polar vortex, Geophy. Res. Lett., vol. 16, 791-794, 1989.

Rosen, J.M., N.T.Kjome, S.J. Oltmans, Observations of backscatter, particle concentration and frost point in north polar vortex stratospheric clouds, Geophys. Res. Lett. vol 17, 1271-1274, 1990.

Rosen, J.M., N.T.Kjome, S.J. Oltmans, Balloon borne observations of backscatter, frost point and ozone in polar stratospheric clouds at the South Pole, Geophys. Res. Lett., vol. 18, 171-174, 1991.

Rosen, J.M., and N.T.Kjome, The Backscattersonde: a new instrument for atmospheric aerosol research, Appl. Opts., vol. 30, 1552-1561, 1991.

Rosen J.M., N.T.Kjome, V.U.Khattatov, V.V. Rudakov, V.A. Yushkov, Observations of ozone and polar stratospheric clouds at Heiss Island during winter 1998-1989, J. Geophys. Res., vol. 8099-8104, 1992.

Rosen, J.M., N.T.Kjome, H.Fast, V.U.Khattatov, V.V.Rudakov, Penetration of Mt. Pinatubo aerosols into the north polar vortex, Geophys. Res. Lett., vol. 19, 1751-1754, 1992.

Rosen, J.M., N.T.Kjome, S.J.Oltmans, Simultaneous ozone and polar stratospheric cloud observations at South Pole Station during winter and spring 1991, J. Geophys. Res., vol. 98, 12,741-12,751, 1993.

Rosen, J.M., N.T.Kjome, H.Fast, N.Larsen, Volcanic aerosol and polar stratospheric clouds in the winter 1992/93 north polar vortex, Geophys. Res. Lett., vol 21, 61-64, 1994.

McKenzie, R.L., J.M.Rosen, N.T.Kjome, T.J.McGee, M.R.Gross, U.N.Singh, R.F.Ferrare, P.Kimvilakani, O.Uchino, T.Nagai, Multi-wavelength profiles of aerosol backscatter over Lauder, New Zealand, 24 November 1992, Geophys. Res. Lett., vol. 21, 789-792, 1994.

Rosen, J.M., N.T.Kjome, R.L.McKenzie, J.B.Liley, Decay of Mt. Pinatubo aerosol at midlatitudes in the northern and southern hemispheres, J. Geophys, Res., vol. 99, 25,733-25,739, 1994.

Larsen, N., J.M.Rosen, N.T.Kjome, B.Knudsen, Deliquescence and freezing of stratospheric aerosol observed by balloon borne backscattersondes, Geophys. Res. Lett., vol. 22, 1233-1236, 1995.

Larsen, N., B.M.Knudsen, J.M.Rosen, N.T.Kjome, E. Kyro, Balloon borne backscatter observations of type 1 PSC formation: inference about physical state from trajectory analysis, Geophys. Res. Lett., vol 23, 1091-1094, 1996.

Rosen, J.M., N.T.Kjome, N.Larsen, B.M.Knudsen, E.Kyro, R.Kivi, J.Karhu, R.Neuber, I.Beninga, Polar stratospheric cloud threshold temperatures in the 1995-1996 arctic vortex, J. Geophys. Res., vol. 102, 28,195-28,202, 1997.

Rosen, J.M., N.T.Kjome, J.B.Liley, Tropospheric aerosol backscatter at a midlatitude site in the northern and southern hemispheres, J. Geophys. Res., vol. 102, 21,329-21,339, 1997.

Rosen J.M., S.Young, J.Laby, N.Kjome, J.Gras, Springtime aerosol layers in the free troposphere over Australia: Mildura Aerosol Tropospheric Experiment (MATE 98), J. Geophys. Res., vol. 105, 17,833-17,842, 2000.

<u>Unpublished Manuscripts, available on request:</u>

Kjome, N.T., J.M.Rosen, Instructions for the Backscattersonde, June 1995.

Rosen, J.M., Calibration of the University of Wyoming Backscattersonde 1999, December 2000. Includes critical absolute comparisons with lidar, satellite, and optical particle counter measurements. Copy available as separate file appendix to Meta Data File.

<u>Instrument Description:</u>

Backscatter Sensor

Briefly, the sensor measures the locally backscattered light at two wavelengths (effectively at 921 and 495 nm) on a rising and/or descending balloon. Thus, the measurements are representative of the ambient conditions in the vicinity of the payload. The light source is a collimated beam from a 10 jule xenon flash lamp. The distribution of wavelengths and backscatter angles associated with the backscattersonde has been taken into account in modeling the instrument response. The results of the modeling show that there is only a small difference between the response for 180 degree backscatter and the backscattersonde. In addition, the uncertainty associate with the distribution of wavelengths can be essentially eliminated for natural aerosols by selecting 921 and 495 nm as the effective wavelengths.

In principle the backscattersonde can be calibrated in aerosol free air, since the signal strength for this condition is relatively large. In practice, it is not possible to achieve completely aerosol free air, and a somewhat indirect method has therefore been devised (see separate appendix to Meta Data File).

The accuracy of the backscatter values is nominally 1-3% of the reported value with an effective resolution of .5-1%. However, at altitudes above 20 km statistical fluctuations in the backscatter values (due to much smaller scattering) become noticeable and may dominate over the other uncertainties at the highest altitudes. These fluctuations can be reduced by averaging over multiple data frames. Full resolution (30m) data is archived, except where noted in the header.

A more complete description of the backscattersonde, its calibration, and the comparison with other instruments can be found in Rosen and Kjome [1991] and Rosen [2000]. Methodologies and formulas for converting backscattersonde measurements to equivalent measurements from lidar, satellite extinction and mass mixing ratios can be found in Rosen [2000]. Typical profiles can be found in the above published references.

Ozone Sensor

The standard backscattersonde contains an ECC ozone sensor manufactured by Scientific Pump (series 5A) or by EN-SCI (type 1Z). The current output of the sensor (uA) and pump temperature is measured and incorporated as an integral part of the data frame as controlled by the sonde's microprocessor (a modified TMAX board). The ozone sensors are prepared in the same way irrespective of the manufacturer using a 1% solution of KI along with KBr and a pH buffer). The cells are stored in shorted out condition (to reduce background current) for usually 12 hours or more before launch and their time constants (time to drop from 6 uA to 2 uA, starting from 7 uA) are all less than 25 seconds. The flow rate of each pump is measured at ground level before launch. Care has been taken to eliminate RF interference to or from the ozone sensor and associated electronics.

PLEASE NOTE: The ozone measurements are provided as an aid to the interpretation of aerosol backscatter structure and at this time should not be considered as part of the regular ozone database.

Flight Configuration

The backscattersonde is normally suspended on a 50 meter line below the plastic or rubber balloon to eliminate scattered light contamination and spurious particles coming from the balloon envelope.

<u>Algorithm Description:</u>

Backscatter

Using the strobe light reference channels the raw aerosol + molecular voltage signal from the photometers is first adjusted to compensate for the small variations in xenon flash lamp intensity. The scattering ratio =(aerosol + molecular)/molecular is then computed by dividing the adjusted photometer signal by the expected pure air signal as determined from ground calibration and the concurrent in-flight measurements of pressure and temperature.

Ozone

The ozone partial pressure is calculated from the cell current using the following formula:

PPOZ(nb)=.004307*Icell(uA)*Tpump(K)*T100(sec)*FRcorr

where: Icell is the current from the censor cell in uA
T100 is the pre-flight measured time to pump
.1 liters of air.
Tpump is the actual pump temperature in degrees K
FRcorr is the flow rate correction factor given by
FRcorr=1+0.52291*P(mb)^(-0.656288)
where P(mb) is the ambient pressure in mb or hPa

For simplicity, consistency, and for avoiding the possible addition of artifacts to the data, no background current has been subtracted from Icell. Just before launch the background cell current (with the pump running and ozone free air) is typically about 0.01 uA. Our in-flight measurements of ozone cell background indicate that simple corrections to the total current using the pre-assumed or expected background current are not necessarily appropriate.

The flow rate correction represents the average value obtained from 15 sondes in 1989. Rechecks in several succeeding years have yielded similar formulas. The above correction is very similar to the one found by Johnson et al. [Evaluation of ECC ozonesonde performance from recent field and laboratory intercomparisons, in Atmospheric Ozone: Proceedings of the XVIII Quadrennial Ozone Symposium, pp927-930, 1998].

Geopotential Altitude
The following formula is used to compute the increment in altitude between data frame measurements:

DeltaZ(m)=29.425*Tbar(K)*DeltaP(mb)/Pbar(mb)
where
DeltaZ is the increment in altitude (meters)
Tbar is the average interval temperature
DeltaP is the pressure change
Pbar is the average interval pressure

PLEASE NOTE: The value "29.425" may differ in various algorithms used by various groups to compute altitude. The user is invited to review the appropriateness of this number for their application. If necessary revised geopotential altitudes can easily be determined from the temperature and pressure data.

Expected Precision/Accuracy of Instrument:

PTU values for the RS 80 Radiosonde
Pressure:
Resolution 0.01 mb
Accuracy 0.5 mb or 1% of reading, whichever is smaller
(pressures sensors are recalibrated before launch to

ensure this accuracy)

Temperature:
Resolution 0.1 C
Accuracy 0.2 C

Humidity:
Resolution 0.1
Accuracy 2% RH

Geopotential Height
Resolution 1 meter
Errors are due to uncertainty in pressure/temperature measurements, the use of finite increments, the assumption of dry air, and the uncertainty in the constant (29.425) employed in the algorithm given above. If the accuracy of geopotential height is an issue, the user is invited to re-compute this parameter from the basic measurements given in the files using their own modified algorithm.

Ozone Pump temperature
Resolution: 0.1 C
Acuracy: 0.5C

Ozone Partial Pressure
Resolution .01
Accuracy 10% or less

Backscatter Ratio (aerosol + molecular)/molecular
Resolution .001 as reported in data files

Effective Resolution is .5% in the troposphere and grows to larger values near the top of the sounding due to statistical variations associated with too low signal strength. Effective resolution can be improved by averaging over multiple data frames. The effective resolution and improvements thereof can be best determined from plots of the full resolution data and plots of profiles with a variable amount of smoothing. Accuracy 1-3%, partly depending on treatment during shipping and not including low signal statistical effects.

Instrument History:

The first backscattersonde series (Laramie) began in May 1989 following a two year period of development and test flights. The most definitive calibration of the backscattersonde took place during 1999 [Rosen, 2000] and all data reported to the NDSC reflect the 1999 calibration.

Backscattersonde Sounding Inventory (as of February 2001)

Station Name	Lat.	Long.	Altitude (m)	#	Dates
Laramie WY	41.3 N	105.6 W	2160	93	5/89- 9/00
Lauder New Zealand	45.0 S	169.6 E	370	77	2/92- 3/00
Natal Brazil	6.1 S	35.3 W	50	19	11/95-11/00
Cuiaba Brazil	15.0 S	56.0 W	225	3	8-9/95
Mildura Australia	34.2 S	142.1 E	52	4	9-10/98
South Pole Station	90.0 S	0.0 E	2835	11	wntrs 90&91
Table Mountain CA	34.4 N	117.7 W	2260	4	3/97
Boulder CO	40.0 N	105.1 W	1743	3	7/89- 5/90
Alamogordo NM	33.3 N	105.0 W	1280	2	6/90
Vanscoy Canada	52.1 N	106.6 W	50	4	8/91- 9/00
Air sur l'Adour France	43.7 N	00.3 W	79	2	3/94
Gap France	44.5 N	06.0 E	550	1	6/93
Rylsk Russia	51.6 N	34.7 W	200	5	8/89-10,92
Moscow Russia	56.0 N	41.0 E	190	2	6/94
Kiruna Sweden	67.9 N	21.1 E	327	17	11/91- 1/00

Sodankyla Finland	67.4 N	26.6 E	179	36	9/94- 3/00
Thule Greenland	76.5 N	68.8 W	60	32	1/92-12/97
Scorebysund Greenland	70.5 N	21.5 W	60	5	10/94- 2/96
Sondre Stromfjord	67.0 N	50.9 W	50	2	3/95- 1/96
Ny Alesund	78.9 N	11.9 E	10	14	1/96- 3/00
Heiss Is. Russia	80.6 N	58.1 E	10	12	1/89- 3/92
Alert NWT Canada	82.5 N	62.3 W	66	35	1/89- 1/93
Resolute Canada	74.2 N	95.0 W	40	1	10/91
Arkhangel'sk Russia	64.6 N	40.5 E	4	3	1/93- 1/94
Dixon Is. Russia	73.5 N	80.2 E	42	5	1/91- 3/92
Salekhard Russia	66.5 N	67.5 E	160	2	2/99- 1/00
Yakutsk Russia	62.0 N	130.9 E	106	10	1/95- 3/98

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