

MetaData File provided: September 2018
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Data Set Description:

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Instrument: Eureka Stratospheric Ozone Lidar (SOLID)

Site: Eureka, Nunavut (CANDAC PEARL facility)
NDACC Station Eureka
80.05 N, 86.42 W, 607 m.a.s.l.

Measurement Quantities: Vertical profiles of:
stratospheric ozone in units of [molecules/cm³, ppmv]
stratospheric and mesospheric temperature in units of [K]
tropospheric water vapour in units of [ppmv]

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Reference Articles:

Tikhomirov, A. B., G. Farhani, E. M. McCullough, R. J. Sica, P. F. Fogal, T. Leblanc, and J. R. Drummond. "Ozone Measurements Using the Refurbished Eureka Stratospheric Differential Absorption Lidar". *Canadian Journal of Remote Sensing*. (2019), pp. 1-21. doi: 10.1080/07038992.2019.1651195. url: <https://doi.org/10.1080/07038992.2019.1651195>.

Moss, A., R. J. Sica, E. McCullough, K. Strawbridge, K. Walker, and J. Drummond. "Calibration and validation of water vapour lidar measurements from Eureka, Nunavut, using radiosondes and the Atmospheric Chemistry Experiment Fourier Transform Spectrometer". *Atmospheric Measurement Techniques*. vol. 6, no. 3 (2013), pp. 741-749. doi: 10.5194/amt-6-741-2013. url: <https://www.atmos-meas-tech.net/6/741/2013/>.

Duck, T. J., J. A. Whiteway, and A. I. Carswell. "Lidar observations of gravity wave activity and Arctic stratospheric vortex core warming". *Geophysical Research Letters*. vol. 25, no. 15 (1998), pp. 2813-2816. doi: 10.1029/98GL02113. url: <https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/98GL02113>.

Donovan, D. P., H. Fast, Y. Makino, J. C. Bird, A. I. Carswell, J. Davies, T. J. Duck, J. W. Kaminski, C. T. McElroy, R. L. Mittermeier, S. R. Pal, V. Savastiouk, D. Velkov, and J. A. Whiteway. "Ozone, column ClO, and PSC measurements made at the NDSC Eureka Observatory (80°N, 86°W) during the spring of 1997". *Geophysical Research Letters*. vol. 24, no. 22 (1997), pp. 2709-2712. doi: 10.1029/97GL52828. url: <https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/97GL52828>.

Pal, S. R., A. I. Carswell, J. Bird, D. P. Donovan, T. Duck, and J. Whiteway. "Lidar measurements of the stratosphere at the Eureka and Toronto NDSC stations". *Application of Lidar to Current Atmospheric Topics*. Ed. by Arthur J. Sedlacek III. Vol. 2833. International Society for Optics and Photonics. SPIE, 1996, pp. 28-39. doi: 10.1117/12.258164. url: <https://doi.org/10.1117/12.258164>.

Carswell, A. I., A. Ulitsky, and D. I. Wardle. "Lidar measurements of the arctic stratosphere". *Atmospheric Radiation*. Ed. by Knut H. Stamnes. Vol. 2049. International Society for Optics and Photonics. SPIE, 1993, pp. 9-23. doi: 10.1117/12.163507. url: <https://doi.org/10.1117/12.163507>.

Carswell, A. I., S. R. Pal, W. Steinbrecht, J. A. Whiteway, A. Ulitsky, and T. Y. Wang. "Lidar measurements of the middle atmosphere". *Canadian Journal of Physics*. vol. 69, no. 8-9 (1991), pp. 1076-1086. doi: 10.1139/p91-166. url: <https://doi.org/10.1139/p91-166>.

Refereed Journal Publications:

Kerzenmacher, T. E., K. A. Walker, K. Strong, R. Berman, P. F. Bernath, C. D. Boone, J. R. Drummond, H. Fast, A. Fraser, K. MacQuarrie, C. Midwinter, K. Sung, C. T. McElroy, R. L. Mittermeier, J. Walker, and H. Wu. "Measurements of O₃, NO₂ and Temperature during the 2004 Canadian Arctic ACE Validation Campaign". *Geophysical Research Letters*. vol. 32, no. 16 (2005), pp. 1-5. doi: 10.1029/2005GL023032. url: <https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2005GL023032>.

Donovan, D. P., A. I. Carswell, T. Shibata, J. C. Bird, T. J. Duck, T. Itabe, T. Nagai, S. R. Pal, O. Uchino, and J. A. Whiteway. "Multiwavelength lidar aerosol measurements made at Eureka (80°N, 86°W) during early 1995". *Geophysical Research Letters*. vol. 25, no. 16 (1998), pp. 3139-3142. doi: 10.1029/98GL52328. url: <https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/98GL52328>.

Manney, G. L., J. C. Bird, D. P. Donovan, T. J. Duck, J. A. Whiteway, S. R. Pal, and A. I. Carswell. "Modeling ozone laminae in ground-based Arctic wintertime observations using trajectory calculations and satellite data". *Journal of Geophysical Research: Atmospheres*. vol. 103, no. D5 (1998), pp. 5797-5814. doi: 10.1029/97JD03449. url: <https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/97JD03449>.

Bird, J. C., S. R. Pal, A. I. Carswell, D. P. Donovan, G. L. Manney, J. M. Harris, and O. Uchino. "Observations of ozone structures in the Arctic polar vortex". *Journal of Geophysical Research: Atmospheres*. vol. 102, no. D9 (1997), pp. 10785-10800. doi: 10.1029/96JD03787. url: <https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/96JD03787>.

Donovan, D. P. and A. I. Carswell. "Principal component analysis applied to multiwavelength lidar aerosol backscatter and extinction measurements". *Applied Optics*. vol. 36, no. 36 (1997), pp. 9406-9424. doi: 10.1364/AO.36.009406. url: <http://ao.osa.org/abstract.cfm?URI=ao-36-36-9406>.

Whiteway, J. A., T. J. Duck, D. P. Donovan, J. C. Bird, S. R. Pal, and A. I. Carswell. "Measurements of gravity wave activity within and around the Arctic stratospheric vortex". *Geophysical Research Letters*. vol. 24, no. 11 (1997), pp. 1387-1390. doi: 10.1029/97GL01322. url: <https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/97GL01322>.

Donovan, D. P., J. C. Bird, J. A. Whiteway, T. J. Duck, S. R. Pal, A. I. Carswell, J. W. Sandilands, and J. W. Kaminski. "Ozone and aerosol observed by lidar in the Canadian Arctic during the winter of 1995/96". *Geophysical Research Letters*. vol. 23, no. 23 (1996), pp. 3317-3320. doi: 10.1029/96GL03230. url: <https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/96GL03230>.

Whiteway, J. A. and T. J. Duck. "Evidence for critical level filtering of atmospheric gravity waves". Geophysical Research Letters. vol. 23, no. 2 (1996), pp. 145-148. doi: 10.1029/95GL03784. url: <https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/95GL03784>.

Donovan, D. P., J. C. Bird, J. A. Whiteway, T. J. Duck, S. R. Pal, and A. I. Carswell. "Lidar observations of stratospheric ozone and aerosol above the Canadian High Arctic during the 1994-95 winter". Geophysical Research Letters. vol. 22, no. 24 (1995), pp. 3489-3492. doi: 10.1029/95GL03337. url: <https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/95GL03337>.

Whiteway, J. A. and A. I. Carswell. "Rayleigh Lidar Observations of Thermal Structure and Gravity Wave Activity in the High Arctic during a Stratospheric Warming". Journal of the Atmospheric Sciences. vol. 51, no. 21 (1994), pp. 3122-3136. doi: 10.1175/1520-0469(1994)051<3122:RLOOTS>2.0.CO;2. url: [https://doi.org/10.1175/1520-0469\(1994\)051%3C3122:RLOOTS%3E2.0.CO;2](https://doi.org/10.1175/1520-0469(1994)051%3C3122:RLOOTS%3E2.0.CO;2).

Other Refereed Publications:

Carswell, A. I., D. P. Donovan, J. C. Bird, T. J. Duck, S. R. Pal, and J. A. Whiteway. "Measurements at the Eureka Arctic NDSC Station with a Raman DIAL System". Advances in Atmospheric Remote Sensing with Lidar. Ed. by Albert Ansmann, Roland Neuber, Patrick Rairoux, and Ulla Wandinger. Berlin, Heidelberg: Springer Berlin Heidelberg, 1997, pp. 521-524. isbn: 978-3-642-60612-0.

Donovan, D. P., J. A. Whiteway, W. Steinbrecht, and A. I. Carswell. "Arctic Lidar Measurements of the Middle Atmosphere". Applications of Photonic Technology. Ed. By George A. Lampropoulos, Jacek Chrostowski, and Raymond M. Measures. Boston, MA: Springer US, 1995, pp. 219-222. isbn: 978-1-4757-9247-8. doi: 10.1007/978-1-4757-9247-8_41. url: https://doi.org/10.1007/978-1-4757-9247-8_41.

Ph.D. thesis:

Duck, T. "High Arctic Observations of Strato-mesospheric Temperatures and Gravity Wave Activity". PhD thesis. York University, CANADA, 1999.

Steinbrecht, W. "LIDAR Measurements of Ozone, Aerosol and Temperature in the Stratosphere". PhD thesis. York University, CANADA, 1994.

Instrument Description:

[UVB: Include list of instrument spec's that are or are not met. See UVB instrument validation appendix for list of instrument spec's.]

Transmitter:

Laser	LightMachinery Inc., IPEX-848 (unstable resonator optics)
Laser type	Excimer, XeCl
Wavelength	308 nm
Beam size	10 mm x 22 mm
Beam divergence	0.4 mrad
Pulse width	<20 ns

Repetition rate	198 Hz
Pulse energy	up to 250 mJ
Average power	up to 50 W
Raman cell	1.8 m long, 60 psi, H ₂
Wavelengths	308 nm (generated by laser) 353 nm (Raman, 1st Stokes vibrational in H ₂)
Pulse energy	152 mJ(@308nm), 20 mJ(@353nm)
FWHM	0.3 nm
Beam divergence	0.15-0.20 mrad (65% of energy)

Receiver:

Telescope	1 m, f 2.5, Newtonian
Field of view	0.5-1.0 mrad
Channels	308,353,332,385,405 nm
Bandwidth	0.5-20 nm FWHM
Data acq.	Photon Counting
Range resol.	150 m typically

Optical chopper:

Blade	4-slot
Motor	BLDC (Koford Engineering., LLC)
Speed	8910 rpm
Laser trig.	198 Hz (every 3rd slot)
Control type	PID

Detectors and Signal Processing:

Photomultiplier	Thorn EMI, 9863/350 (308,353,332,385 nm); Hamamatsu H5783P-03 (405 nm)
Amplifier	Phillips 770 (308,353,332,385 nm); Optech Inc. PAD-1G (405 nm)
Discriminator	Phillips 704 (308,353,332,385 nm); Optech Inc. PAD-1G (405 nm)
Counters	3 x Optech Inc. FDC-700M, 2 ch, 8 bit/ch, 700 MHz

Algorithm Description:

[LIDAR: Include information on unit conversion if pressure or mixing ratios appear in the data file.]

A traditional data processing algorithm is used to retrieve ozone and temperature vertical profiles from SOLID backscattered signals. During the data processing the ozone number density profiles from elastic (308/353 nm) and Raman channels (332/385 nm) are merged together and averaged in time in order to generate either a nightly mean ozone profile, or a mean profile over some other predetermined time interval. The backscattered signals from elastic 353 nm and Raman 385 nm channels are used to retrieve temperature in the stratosphere and mesosphere (20-80 km). The ozone and temperature retrieval

software (GLASS) is written in IDL. Detailed description of the GLASS algorithm can be found in Leblanc et al. 2016, AMT, part 1-3.

Expected Precision/Accuracy of Instrument:

Listed in the data files.

Instrument History:

[dates and description of significant changes in instrument or algorithm

Note: a typical winter measurement season in Eureka starts from November and ends in March]

- 1992/1993 - system installation and beginning of measurements.
- 1993/1994 - nitrogen Raman channels installed (332, 385 nm).
- 1994/1995 -
- 1995/1996 -
- 1996/1997 -
- 1997/1998 -
- 1998/1999 - water vapour Raman channel installed (405 nm, January 16, 1999).
- 1999/2000 -
- 2000/2001 -
- 2001/2002 -
- 2002/2003 -
- 2003/2004 - nominal operations by EC (Feb 19 - Mar 8, 2004), data processed with Astro Dial Analysis software Version 1, data archived in AMES format.
- 2004/2005 - nominal operations by EC (Feb 19 - Mar 6, 2005), data processed with Astro Dial Analysis software Version 1, data archived in AMES format.
- 2005/2006 - nominal operations by EC (Feb 18 - Feb 26, 2006), data processed with Astro Dial Analysis software Version 1, data archived in AMES format.
- Feb 2006 - Replacement of filters in Raman and Rayleigh channels on February 18, 2006.
- 2006/2007 - nominal operations by EC (Feb 17 - Mar 6, 2007), data processed with Astro Dial Analysis software Version 1, data archived in AMES format.
- 2007/2008 - nominal operations by EC (Feb 17 - Mar 4, 2008), data processed with Astro Dial Analysis software Version 1, data archived in AMES format.
- 2008/2009 - nominal operations by EC (Feb 8 - Mar 6, 2009), data processed with Astro Dial Analysis software Version 1, data archived in AMES format, original laser (Lu-monics EXCIMER-600) became inoperable at the end of the campaign.
- 2009/2010 - new laser and chiller installed (LightMachinery Inc., IPEX-848; Thermo Fisher Scientific, Neslab HX300), no operations due to funding issues.
- 2010/2011 - no operations due to funding issues.
- 2011/2012 - no operations due to funding issues.
- 2012/2013 - no operations due to funding issues.
- 2013/2014 - development and testing of new chopper (198 Hz, PID control, BLDC), no measurements.

- 2014/2015 - development and testing of ISA-to-USB adapter for Optech Inc., FDC-700M counter boards, new data acquisition software (LabView), secondary optics and servo control system upgrade, no measurements.
- 2015/2016 - SOLID is operational, using all 5 channels, final tuning and optimization performed, test measurements performed.
- Jan 2017 - nominal operations by DAL (Jan 25 - Mar 10, 2017), participation in 2017 Canadian Arctic ACE/OSIRIS Validation Campaign.
- Oct 2017 - nominal operations by DAL (Oct 18 - Nov 10, 2017).
- Feb 2018 - nominal operations by DAL (Feb 07 - Mar 10, 2018), participation in 2018. Canadian Arctic ACE/OSIRIS Validation Campaign.
- Sep 2018 - traditional ozone data retrieval algorithm is applied (GLASS, JPL, Leblanc et al. 2016, AMT, part 1-3), ozone data are achieved in HDF4 at NDACC.
- Oct 2018 - nominal operations by DAL (Oct 21 - Nov 07, 2018).
- Feb 2019 - nominal operations by DAL (Feb 03 - Feb 24, 2019), participation in 2019 Canadian Arctic ACE/OSIRIS Validation Campaign, laser high voltage power supply failure.
- Aug 2019 - replacement of failed laser high voltage power supply, no operations due 24-hour sunlight.
- Nov 2019 - nominal operations by DAL (Nov 11 - Dec 04, 2019).
- Feb 2020 - nominal operations by DAL (Feb 03 - Mar 10, 2020), participation in 2020 Canadian Arctic ACE/OSIRIS Validation Campaign.
- Oct 2020 - no qualified personnel on site due to COVID-19 travel restrictions, fall measurement campaign is suspended.