MetaData File provided: September 1999.
Latest Revision: June 2022.

Data Set Description:

PIs: T. Blumenstock (KIT-IMK), U. Raffalski (IRF)

since 2005:
T. Blumenstock (IMK), U. Raffalski (IRF), Y.Matsumi (STEL)
since March 2001:
T. Blumenstock (IMK), U. Raffalski (IRF), Y. Zhao (STEL)
since Jan 1999:
D. Yashcov(IRF), T. Blumenstock (IMK), Y. Zhao (STEL)
until Dec 1998:
A. Meier (IRF), T. Blumenstock (IMK), Y. Zhao (STEL)

Co-I: Frank Hase (KIT-IMK)

IRF: Institutet foer Rymdfysik (Swedish Institute of
Space Physics), Kiruna, Sweden
IMK: Institute of Meteorology and Climate Research
Karlsruher Institute of Technology (KIT), Karlsruhe, Germany
STEL Solar Terrestrial Environment Laboratory,
University of Nagoya, Japan

Instrument: Fourier Transform Infrared Spectrometer (FTIR)

Site(s): IRF Kiruna
NDACC Arctic site
67.84 S, 20.41 E, 419m above sea level

Measurement Quantities: Vertical column abundances and Profiles of several trace gases above Kiruna (in number molecules per cm2)

Contact Information:

Name: Thomas Blumenstock, Frank Hase
Address: IMK (Institute of Meteorology and Climate Research)
Karlsruhe Institute of Technology (KIT),
Box 3640, 76021 Karlsruhe, Germany,
email: thomas.blumenstock@kit.edu, frank.hase@kit.edu
phone: +49-721-608-22838, -22434
fax: +49-721-608-24742

Name: Uwe Raffalski
Address: IRF Institutet foer Rymdfysik (Swedish Institute of Space Physics)
Box 812, 98128 Kiruna, Sweden
email: uwe.raffalski@irf.se
phone: +46-980-79021
fax: +46-980-79050

Online References:
http://www.imk-asf.kit.edu/english/714.php

Instrument Description:
A Bruker IFS 120HR Fourier Transform Infra-red (FTIR) spectrometer has been operated at the Kiruna site on a continuous basis since Mar 1996. (A mobile Bruker 120-M had been operated at the nearby Esrange site by the IMK group on a campaign basis before March 1996.)
The FTS is operated in solar absorption geometry. The maximum optical path difference achievable is 360 cm corresponding to a spectral resolution of 0.002 cm-1. Normally a resolution of 0.005 cm-1 (opd = 180 cm) is chosen. The 120HR is equipped with two sets of InSb and MCT detectors allowing for solar and lunar absorption spectra. For solar observations the spectral range covered is 650 to 5000 cm-1. The NDACC optical filter set is used.
The Instrumental Line Shape (ILS) is monitored routinely with HBr or N2O gas cell measurements.
Cell spectra are analyzed with the LINEFIT software (F. Hase, 1999).

Algorithm Description:
PROFFIT 9.6 (Hase et al., 2004) is used for the inversion of the spectra. PROFFIT is able to retrieve profiles and vertical column abundances of several species in several microwindows simultaneously. For the profile retrieval the Phillipps-Tikhonov approach is used. For some species the inversion is performed on a logarithmic scale to avoid negative vmr values.

PROFFIT also includes a forward model. The synthetic spectra are calculated using daily pressure and temperature data of the National Center for Environmental Prediction (NCEP). Spectroscopic data are taken from HITRAN 2008 data base.

Expected Precision/Accuracy of Instrument:
The error estimate is given for each data point in the data files.

Instrument History:

| | |
|---|---|
| Mar. 1996 | start-up of the instrument at IRF Kiruna |
| Mar. 1998 | side-by-side intercomparison with the Bruker 120M from NPL |
| Feb. 1999 | new solar tracker system installed |
| July 2001 | new PC; OPUS-OS/2 replaced by OPUS-NT; |
| July 2002 | camera system for cloud observation installed |
| July 2004 | remote control implemented |

| | |
|---|---|
| July 2007 | spectrometer upgraded to 125 HR; basically a new electronics was installed, optics wasn't changed |
| Sept 2010 | camera based camtracker implemented (Gisi et al., 2011) |
| Mar. 2014 | new PC: Win XP => Win 7 |
| Mar. 2017 | low-resolution FTIR spectrometer Bruker EM-27/SUN added for GHG measurements |
| Dec. 2021 | PC: Win 7 => Win 10 |
| Dec. 2021 | Bruker EM-27/SUN shipped back to Karlsruhe; second detector channel for CO added |
| Mar. 2022 | Bruker EM-27/SUN measurements resumed |

Days of observation:

| | |
|---|---|
| 1996 | 27 |
| 1997 | 100 |
| 1998 | 84 |
| 1999 | 84 |
| 2000 | 74 |
| 2001 | 74 |
| 2002 | 95 |
| 2003 | 91 |
| 2004 | 87 |
| 2005 | 79 |
| 2006 | 91 |
| 2007 | 95 |
| 2008 | 59 |
| 2009 | 47 |
| 2010 | 64 |
| 2011 | 79 |
| 2012 | 64 |
| 2013 | 66 |
| 2014 | 70 |
| 2015 | 68 |
| 2016 | 81 |
| 2017 | 73 |
| 2018 | 110 |
| 2019 | 103 |
| 2020 | 105 |
| 2021 | 95 |
| Total | 2065 |

Selected Articles:

Hannigan, J. W., Ortega, I., Shams, S. B., Blumenstock, T., Campbell, J. E., Conway, S., Flood, V., Garcia, O., Griffith, D., Grutter, M., Hase, F., Jeseck, P., Jones, N., Mahieu, E., Makarova, M., De Mazière, M., Morino, I., Murata, I., Nagahama, T., Nakijima, H., Notholt, J., Palm, M., Poberovskii, A., Rettinger, M., Robinson, J., Röhling, A. N., Schneider, M., Servais, C., Smale, D., Stremme, W., Strong, K., Sussmann, R., Te, Y., Vigouroux, C., Wizenberg, T.: Global atmospheric OCS trend analysis from 22 NDACC stations, Journal of Geophysical Research: Atmospheres, 127, e2021JD035764, https://doi.org/10.1029/2021JD035764, 2022.

Franco, B., Blumenstock, T., Cho, C., Clarisse, L., Clerbaux, C., Coheur, P.-F., De Mazière, M., De Smedt, I., Dorn, H.-P., Emmerichs, T., Fuchs, H., Gkatzelis, G., Griffith, D. W. T., Gromov, S., Hannigan, J. W., Hase, F., Hohaus, T., Jones, N., Kerkweg, A., Kiendler-Scharr, A., Lutsch, E., Mahieu, E., Novelli, A., Ortega, I., Paton-Walsh, C., Pommier, M., Pozzer, A., Reimer, D., Rosanka, S., Sander, R., Schneider, M., Strong, K., Tillmann, R., Van Roozendael, M., Vereecken, L., Vigouroux, C., Wahner, A., Taraborrelli, D.: Ubiquitous atmospheric production of organic acids mediated by cloud droplets. Nature 593, 233–237 (2021). https://doi.org/10.1038/s41586-021-03462-x.

Sha, M. K., Langerock, B., Blavier, J.-F. L., Blumenstock, T., Borsdorff, T., Buschmann, M., Dehn, A., De Mazière, M., Deutscher, N. M., Feist, D. G., García, O. E., Griffith, D. W. T., Grutter, M., Hannigan, J. W., Hase, F., Heikkinen, P., Hermans, C., Iraci, L. T., Jeseck, P., Jones, N., Kivi, R., Kumps, N., Landgraf, J., Lorente, A., Mahieu, E., Makarova, M. V., Mellqvist, J., Metzger, J.-M., Morino, I., Nagahama, T., Notholt, J., Ohyama, H., Ortega, I., Palm, M., Petri, C., Pollard, D. F., Rettinger, M., Robinson, J., Roche, S., Roehl, C. M., Röhling, A. N., Rousogenous, C., Schneider, M., Shiomi, K., Smale, D., Stremme, W., Strong, K., Sussmann, R., Té, Y., Uchino, O., Velazco, V. A., Vigouroux, C., Vrekoussis, M., Wang, P., Warneke, T., Wizenberg, T., Wunch, D., Yamanouchi, S., Yang, Y., and Zhou, M.: Validation of methane and carbon monoxide from Sentinel-5 Precursor using TCCON and NDACC-IRWG stations, Atmos. Meas. Tech., 14, 6249–6304, https://doi.org/10.5194/amt-14-6249-2021, 2021.

Blumenstock, T., Hase, F., Keens, A., Czurlok, D., Colebatch, O., Garcia, O., Griffith, D. W. T., Grutter, M., Hannigan, J. W., Heikkinen, P., Jeseck, P., Jones, N., Kivi, R., Lutsch, E., Makarova, M., Imhasin, H. K., Mellqvist, J., Morino, I., Nagahama, T., Notholt, J., Ortega, I., Palm, M., Raffalski, U., Rettinger, M., Robinson, J., Schneider, M., Servais, C., Smale, D., Stremme, W., Strong, K., Sussmann, R., Té, Y., and Velazco, V. A.: Characterization and potential for reducing optical resonances in Fourier transform infrared spectrometers of the Network for the Detection of Atmospheric Composition Change (NDACC), Atmos. Meas. Tech., 14, 1239–1252, https://doi.org/10.5194/amt-14-1239-2021, 2021.

Strahan, S. E., Smale, D., Douglass, A. R., Blumenstock, T., Hannigan, J. W., Hase, F., Jones, N., Mahieu, E., Notholt, J., Oman, L. D., Ortega, I., Palm, M., Prignon, M., Robinson, J., Schneider, M., Sussmann, R., Velazco, V.: Observed Hemispheric Asymmetry in Stratospheric Transport Trends from 1994-2018. Geophysical Research Letters, 47, e2020GL088567, https://doi.org/10.1029/2020GL088567, 2020.

Vigouroux, C., Langerock, B., Bauer Aquino, C. A., Blumenstock, T., Cheng, Z., De Mazière, M., De Smedt, I., Grutter, M., Hannigan, J., Jones, N., Kivi, R., Loyola, D., Lutsch, E., Mahieu, E., Makarova, M., Metzger,

J.-M., Morino, I., Murata, I., Nagahama, T., Notholt, J., Ortega, I., Palm, M., Pinardi, G., Röhling, A., Smale, D., Stremme, W., Strong, K., Sussmann, R., Té, Y., van Roozendael, M., Wang, P., and Winkler, H.: TROPOMI–Sentinel-5 Precursor formaldehyde validation using an extensive network of ground-based Fourier-transform infrared stations, Atmos. Meas. Tech., 13, 3751–3767, https://doi.org/10.5194/amt-13-3751-2020, 2020.

Franco, B., Clarisse, L., Stavrakou, T., Müller, J.-F., Taraborrelli, D., Hadji-Lazaro, J., Hannigan, J. W., Hase, F., Hurtmans, D., Jones, N., Lutsch, E., Mahieu, E., Ortega, I., Schneider, M., Strong, K., Vigouroux, C., Clerbaux, C., Coheur, P.-F.: Spaceborne measurements of formic and acetic acids: A global view of the regional sources, Geophysical Research Letters, 47, e2019GL086239, https://doi.org/10.1029/2019GL086239, 2020.

Vigouroux, C., Bauer Aquino, C. A., Bauwens, M., Becker, C., Blumenstock, T., De Mazière, M., García, O., Grutter, M., Guarin, C., Hannigan, J., Hase, F., Jones, N., Kivi, R., Koshelev, D., Langerock, B., Lutsch, E., Makarova, M., Metzger, J.-M., Müller, J.-F., Notholt, J., Ortega, I., Palm, M., Paton-Walsh, C., Poberovskii, A., Rettinger, M., Robinson, J., Smale, D., Stavrakou, T., Stremme, W., Strong, K., Sussmann, R., Té, Y., and Toon, G.: NDACC harmonized formaldehyde time series from 21 FTIR stations covering a wide range of column abundances, Atmos. Meas. Tech., 11, 5049-5073, https://doi.org/10.5194/amt-11-5049-2018, 2018.

Bader, W., Bovy, B., Conway, S., Strong, K., Smale, D., Turner, A. J., Blumenstock, T., Boone, C., Collaud Coen, M., Coulon, A., Garcia, O., Griffith, D. W. T., Hase, F., Hausmann, P., Jones, N., Krummel, P., Murata, I., Morino, I., Nakajima, H., O'Doherty, S., Paton-Walsh, C., Robinson, J., Sandrin, R., Schneider, M., Servais, C., Sussmann, R., and Mahieu, E.: The recent increase of atmospheric methane from 10 years of ground-based NDACC FTIR observations since 2005, Atmos. Chem. Phys., 17, 2255-2277, doi:10.5194/acp-17-2255-2017, 2017.

Barthlott, S., Schneider, M., Hase, F., Blumenstock, T., Kiel, M., Dubravica, D., García, O. E., Sepúlveda, E., Mengistu Tsidu, G., Takele Kenea, S., Grutter, M., Plaza-Medina, E. F., Stremme, W., Strong, K., Weaver, D., Palm, M., Warneke, T., Notholt, J., Mahieu, E., Servais, C., Jones, N., Griffith, D. W. T., Smale, D., and Robinson, J.: Tropospheric water vapour isotopologue data (H216O, H218O, and HD16O) as obtained from NDACC/FTIR solar absorption spectra, Earth Syst. Sci. Data, 9, 15-29, doi:10.5194/essd-9-15-2017, 2017.

Barthlott, S., M. Schneider, F. Hase, A. Wiegele, E. Christner, Y. González, T. Blumenstock, S. Dohe, O. E. García, E. Sepúlveda, K. Strong, J. Mendonca, D. Weaver, M. Palm, N. M. Deutscher, T. Warneke, J. Notholt, B. Lejeune, E. Mahieu, N. Jones, D. W. T. Griffith, V. A. Velazco, D. Smale, J. Robinson, R. Kivi, P. Heikkinen, and U. Raffalski: Using XCO2 retrievals for assessing the long-term consistency of NDACC/FTIR data sets, Atmos. Meas. Tech., 8, 1555-1573, doi:10.5194/amt-8-1555-2015, 2015.

Vigouroux, C., T. Blumenstock, M. Coffey, Q. Errera, O. García, N. B. Jones, J. W. Hannigan, F. Hase, B. Liley, E. Mahieu, J. Mellqvist, J. Notholt, M. Palm, G. Persson, M. Schneider, C. Servais, D. Smale, L. Thölix, and M. De Mazière: Trends of ozone total columns and vertical distribution from FTIR

observations at eight NDACC stations around the globe, Atmos. Chem. Phys., 15, 2915-2933, doi:10.5194/acp-15-2915-2015, 2015.

Schneider, M., S. Barthlott, F. Hase, Y. González, K. Yoshimura, O. E. García, E. Sepúlveda, A. Gomez-Pelaez, M. Gisi, R. Kohlhepp, S. Dohe, T. Blumenstock, A. Wiegele, E. Christner, K. Strong, D. Weaver, M. Palm, N. M. Deutscher, T. Warneke, J. Notholt, B. Lejeune, P. Demoulin, N. Jones, D. W. T. Griffith, D. Smale, and J. Robinson: Ground-based remote sensing of tropospheric water vapour isotopologues within the project MUSICA, Atmos. Meas. Tech., 5, 3007-3027, doi:10.5194/amt-5-3007-2012, 2012.

Kohlhepp, R., R. Ruhnke, M. P. Chipperfield, M. De Mazière, J. Notholt, S. Barthlott, R. L. Batchelor, R. D. Blatherwick, Th. Blumenstock, M. T. Coffey, P. Demoulin, H. Fast, W. Feng, A. Goldman, D. W. T. Griffith, K. Hamann, J. W. Hannigan, F. Hase, N. B. Jones, A. Kagawa, I. Kaiser, Y. Kasai, O. Kirner, W. Kouker, R. Lindenmaier, E. Mahieu, R. L. Mittermeier, B. Monge-Sanz, I. Morino, I. Murata, H. Nakajima, M. Palm, C. Paton-Walsh, U. Raffalski, Th. Reddmann, M. Rettinger, C. P. Rinsland, E. Rozanov, M. Schneider, C. Senten, C. Servais, B.-M. Sinnhuber, D. Smale, K. Strong, R. Sussmann, J. R. Taylor, G. Vanhaelewyn, T. Warneke, C. Whaley, M. Wiehle, and S. W. Wood: Observed and simulated time evolution of HCl, ClONO2, and HF total column abundances, Atmos. Chem. Phys., 12, 3527-3556, doi:10.5194/acp-12-3527-2012, 2012.

Kohlhepp, R., S. Barthlott, T. Blumenstock, F. Hase, I. Kaiser, U. Raffalski, and R. Ruhnke: Trends of HCl, ClONO2 and HF column abundances from ground-based FTIR measurements in Kiruna (Sweden) in comparison with KASIMA model calculations, Atmos. Chem. Phys. 11, 4669-4677, 2011.

Gisi, M., F. Hase, S. Dohe, and T. Blumenstock: Camtracker: a new camera controlled high precision solar tracker system for FTIR-spectrometers, Atmos. Meas. Tech., 4, 47-54, 2011.

Blumenstock, T., F. Hase, I. Kramer, S. Mikuteit, H. Fischer, F. Goutail, U. Raffalski: Winter to winter variability of chlorine activation and ozone loss as observed by ground-based FTIR measurements at Kiruna since winter 1993/94, International Journal of Remote Sensing, Vol. 30, 4055 - 4064, DOI: 10.1080/01431160902821916, 2009.

Blumenstock, T., G. Kopp, F. Hase, G. Hochschild, S. Mikuteit, U. Raffalski, R. Ruhnke: Observation of unusual chlorine activation by ground-based infrared and microwave spectroscopy in the late Arctic winter 2000/01, ACP, Vol. 6, 897-905, SRef-ID: 1680-7324/acp/2006-6-897, 2006.

Meier, A., C. Paton-Walsh, W. Bell, T. Blumenstock, F. Hase, A. Goldman, Å. Steen, R. Kift, P. Woods and Y. Kondo: Evidence of reduced measurement uncertainties from an FTIR instrument intercomparison at Kiruna, Sweden, Journal of Quantitative Spectroscopy and Radiative Transfer 96, 75-84, 2005.

Hase, F., J.W. Hannigan, M.T. Coffey, A. Goldman, M. Höpfner, N.B. Jones, C.P. Rinsland, S.W. Wood: Intercomparison of retrieval codes used for the analysis of high-resolution, ground-based FTIR measurements, Journal of Quantitative Spectroscopy & Radiative Transfer 87, 25–52, 2004.

Rinsland, C. P, E. Mahieu, R. Zander, N. B. Jones, M. P. Chipperfield, A. Goldman, J. Anderson, J. M. Russell III, P. Demoulin, J. Notholt, G. C. Toon, J.-F. Blavier, B. Sen, R. Sussmann, S. W. Wood, A. Meier, D. W. T. Griffith, L. S. Chiou, F. J. Murcray, T. M. Stephen, F. Hase, S. Mikuteit, A. Schultz, T. Blumenstock: Long-Term Trends of Inorganic Chlorine from Ground-Based Infrared Solar Spectra: Past Increases and Evidence for Stabilization, J. Geophys. Res., 108 (D8), 4252, 2003.

Kopp, G., H. Berg, T. Blumenstock, H. Fischer, F. Hase, G. Hochschild, M. Höpfner, W. Kouker, T. Reddmann, R. Ruhnke, U. Raffalski, Y. Kondo: Evolution of ozone and ozone related species over Kiruna during the THESEO 2000-SOLVE campaign retrieved from ground-based millimeter wave and infrared observations, J. Geophys. Res. 108 (D5), 8308, 2003.

Mellqvist, J., B. Galle, T. Blumenstock, F. Hase, D. Yashcov, J. Notholt, B. Sen, G.C. Toon and M.P. Chipperfield: Ground-based FTIR observations of chlorine activation and ozone depletion inside the Arctic vortex during the winter of 1999/2000, J. Geophys. Res., 107 (D20), 8263, 2002.

Höpfner, M., T. Blumenstock, F. Hase, A., Zimmermann, H. Flentje, S. Fueglistaler: Mountain polar stratospheric cloud measurements by ground based FTIR solar absorption spectroscopy, Geophys. Res. Lett. 28, 2189 - 2192, 2001.

Hase, F., T. Blumenstock, C. Paton-Walsh: Analysis of the instrumental line shape of high-resolution Fourier transform IR spectrometers with gas cell measurements and new retrieval software, Appl. Opt. 38, 3417-3422, 1999.

Blumenstock, T.; H. Fischer, A. Friedle, F. Hase, and P. Thomas: Column amounts of ClONO2, HCl, HNO3, and HF from ground-based FTIR measurements made near Kiruna, Sweden, in late winter 1994, Journal of Atmospheric Chemistry 26, 311 - 321, 1997.

For full list of references please see:
http://www.imk-asf.kit.edu/english/709.php