Series of measurements from new possible validation site at Kourovka

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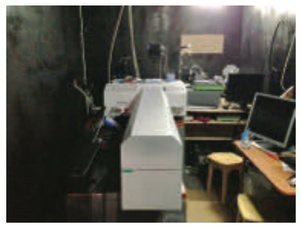
Ural Atmospheric Fourier Station at Kourovka

The Kourovka observation site (Ural Atmospheric Fourier Station, 57.038N, 59.545E, 270 m elevation) is located in forest with background atmospheric condition. Ural Atmospheric Fourier Station (UAFS) is equipped with Fourier interferometer Bruker Optics IFS-125M (maximum spectral range 420-25000 cm^{-1}, maximum resolution 0.0035 cm^{-1}) conjugated with solar tracker A547N. UAFS aims to remote sounding of GHGs in the atmosphere and validation of satellite data. Number of atmospheric spectra in the NIR range (4000-11000 cm^{-1}) had been recorded since summer of 2010 to summer 2013.

Altogether with solar irradiance spectra the following parameters are measured at surface continuously: atmospheric pressure, air temperature, relative humidity, speed and direction of wind, concentration of water vapor, water isotopes ratio using Gill Instruments MetPak-II meteorological station and Picarro L2130-i water vapor isotopic laser analyzer. Recent simulations of ECHAM5-wiso demonstrated that that UAFS as a reference site for climate change study is indicative for whole Western Siberia (Butzin et al., 2013, Gribanov et al., 2013)

Remote sensing of Carbon Gases at Kourovka



The spectrometer was realigned in summer 2012 with the help of TCCON community. The site is automated to provide remote control of the instrument. Measurements are performed during the days under clear sky conditions.

Interferograms are recorded in DC-mode. Raw interferograms are then processed by a special software, which performs phase correction and low-pass filtering of the signal (Keppel-Aleks, G. et al, 2007). This approach improves the retrieval from measurements recorded under conditions with significant amounts of cloud cover or aerosol.

Measurements are performed in Near Infra-Read region (4000-11000 cm^{-1}) with 0.02 cm^{-1} resolution that makes possible an retrieval of mean concentrations of multiple species in vertical atmospheric column.

About 1500 spectra has been recorded since summer 2012 at the Ural Atmospheric Fourier Station.

Retrieval of Carbon Gases dry-air mole fractions derived by standard TCCON software (GFIT) using standard set of spectral windows is shown at Fig. 1.

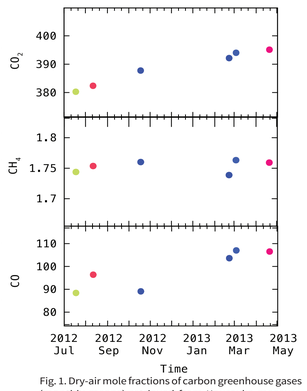


Fig. 1. Dry-air mole fractions of carbon greenhouse gases (monthly means) retrieved from Kourovka measurements recordered since summer 2012 until May 2013.

GOSAT

Intercomparison with standard GOSAT L2 products for dry-air mole fractions of CH4 and CO2 from observation spots around Ural Atmopheric Fourier Station (Fig. 2) was performed using measurements of 2010-2011 years before re-alignment of the spectrometer and measurements of July 2012.

Time series of GOSAT and Kourovka data are represented at Fig. 3. GOSAT retrievals show sistematically higher values of about 5 ppm for CO_2 and 0.04 ppm for CH_4. Monthly mean data shows significant correlation of 0.99 for XCO2 and 0.88 for XCH4, but the slope in both cases is aproximately 1.58.

However the amount of data-points is very limited and further investigation is needed. Collocated measurements are required.

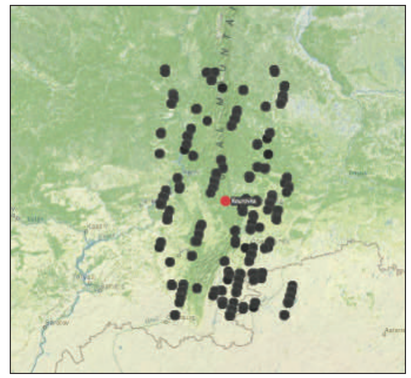


Fig. 2. GOSAT observation spots around the site, which were used for intercomparison

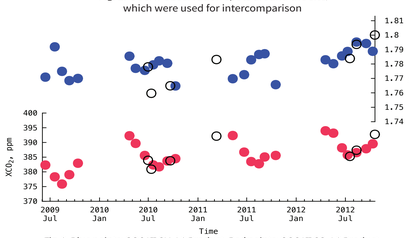


Fig. 3. Blue points: GOSAT CH_4 L2 Product, Red points: GOSAT CO_2 L2 Product. Black Circles: Retrieval using Kourovka measurements (CO_2 values are shifted by +5 ppm, CH_4 values by +0.04 ppm)

Precipitation sampling

Precipitation sampling was organized at the site since middle of October 2012.

Liquid sample WS-CRDS analyzer PICARRO L2130-i installed at the Climate and Environmental Physics Laboratory in Yekaterinburg is used for isotopic analysis of collected samples.

Preliminaty results of dD and dO measurements are represended at Fig. 4.

Intercomparison of measured and ECHAM5-wiso model data (ECHAM5-wiso) is in progress.

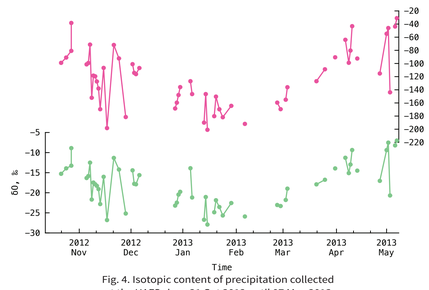


Fig. 4. Isotopic content of precipitation collected at the UAFS since 21 Oct 2012 until 07 May 2013

Remote sensing of water vapour isotopologues at Kourovka

Retrieval of the species of interest was done by GFIT (ver.2012) software. Retrieving quantities are total number of molecules in atmospheric column. For inversion Gfit uses the algorithm of profile scaling. Vertical profiles of the temperature and the water vapour for the region of the site are taken from NCEP/NCAR reanalysis. Vertical profiles for the other gases are taken from standard GFIT atmospheric model.

As a database of spectral line parameters GFIT 'kludged' linelist was used, which is based on Hitran 2008 (Rothman et al. 2010) with some additions and empirical tuning (Wunch et al. 2012). Minor corrections of line intensities were applied to eliminate systematic shifts of the retrieved values. Time series of retrieved columnar mean values of dD and dO are shown at Fig. 5.

To check the sensitivity of the retrieval to the a-priori assumptions another retrieval run with straight dD and dO a-priori profiles equal to zero was performed. Fig 6. shows a scatter plots between values using two different a-priories. This reveals that the retrieval is mostly insensitive to a-priori.

Concentrations ratio of different isotopologues is expressed in terms of delta-values:

$$\delta^x A = \left(\frac{(n_x/n_a)_{sample}}{(n_x/n_a)_{standard}} - 1 \right) * 1000‰$$

where $(n_x/n_a)_{sample}$ is measured ratio of less abundant isotopologue to the most abundant, and $(n_x/n_a)_{standard}$ is a standard ratio.Vienna Standard Mean Ocean Water (VSMOW) standard was used for $^{18}O/^{16}O$ = 2005.2*10^{-6} and for D/H = 155.76*10^{-6} ratios.

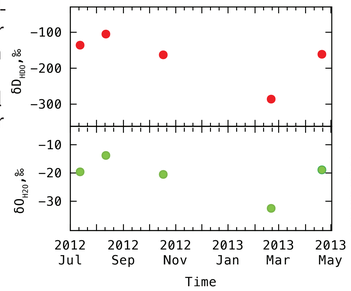


Fig. 5. dD and dO retrieval from Kourovka Measurements

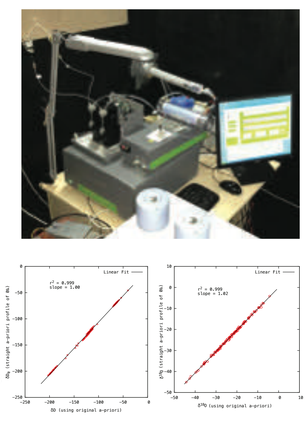


Fig. 6. Water vapour retrieval sensitivity test

PICARRO WS-CRDS in-situ measurements

The instrument was installed in March 2012 at the same pavilion with Bruker IFS. Air temperature around 18°C is maintained in the room. O'Brien optical quality stainless steel tubing of 3/8-inch diameter is used for sampling line in order to minimize water vapour absorption (Tremoy et al., 2012). Air input is installed at 7.8m height above ground and protected against precipitation by a hard cover and against insect by a net.

A response of the instrument is sensitive to humidity. Calibration functions were determined by measurements of reference water samples at different humidity levels (from 1000 to 20000 ppm) and applied to measurements.

Time series of the site temperature and in-situ measurements of dD, dO and H2O are represented at Fig. 7.

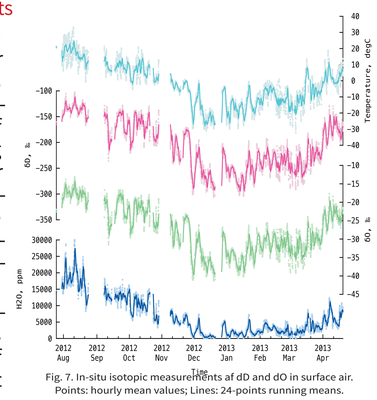


Fig. 7. In-situ isotopic measurements af dD and dO in surface air. Points: hourly mean values; Lines: 24-points running means.

References:

Butzin, M., Werner, M., Bastrikov, V., Bonne, J.-L., Bréon, F.-M., Cattani, O., Gribanov, K., Jouzel, J., Masson-Delmotte, V., Rokotyan, N., Zakharov, V. Changes of temperatures and of the water isotopic composition in Western Siberia during the last five decades - Results from a transient simulation combined with new observations from Kourovka Observatory. Geophysical Research Abstracts, Vol. 15, EGU2013-10425, 2013, EGU General Assembly 2013.

Keppel-Aleks, G., Toon, G. C., Wennberg, P. O., and Deutscher, N. M. (2007). Reducing the impact of source brightness fluctuations on spectra obtained by Fourier-transform spectrometry. Applied Optics 46, 4774-4779. Available at: http://www.ncbi.nlm.nih.gov/pubmed/17609726.

K. Gribanov, J. Jouzel, V. Bastrikov, J.-L. Bonne, F.-M. Breon, M. Butzin, O. Cattani, V. Masson-Delmotte, N. Rokotyan, M. Werner, and V. Zakharov. (2013). ECHAM5-wiso water vapour isotopologues simulation and its comparison with WS-CRDS measurements and retrievals from GOSAT and ground-based FTIR spectra in the atmosphere of Western Siberia. Atmos. Chem. Phys. Discuss., 13, 2599-2640, 2013, available at http://www.atmos-chem-phys-discuss.net/13/2599/2013/, doi:10.5194/acpd-13-2599-2013

Rothman LS, Gordon IE, Barbe A, Benner DC, Bernath PF, Birk M, et al. The HITRAN 2008 molecular spectroscopic database. Journal of Quantitative Spectroscopy and Radiative Transfer. 2009;110(9-10):533-572.

Tremoy, G., Vimeux, F., Mayaki, S., Souley, I., Cattani, O., Risi, C., Favreau, G., and Oi, M.: A 1-year long record of water vapor in Niamey (Niger) reveals insightful atmospheric processes at different timescales, Geophys. Res. Lett., 39, L08805,1055 doi:10.1029/2012GL051298, 2012.

Werner, M., Langebroek, P. M., Carlsen, T., Herold, M., Lohmann, G.: Stable water isotopes in the ECHAM5 general circulation model: Toward highresolution isotope modeling on a global scale, J. Geophys. Res., 16, D15109, 2011.

Wunch, D., G. C. Toon, J.-F. L. Blavier, R. A. Washenfelder, J. Notholt, B. J. Connor, D. W. T. Griffith, V. Sherlock, and P. O. Wennberg (2011), The Total Carbon Column Observing Network, Philos. Trans. R. Soc. A, 369(1943), 2087–2112, doi:10.1098/rsta.2010.0240.

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