Comparison of the isotopic composition of precipitation and air for three Arctic stations with the results of the ECHAM5-wiso modeling

N. Yu. Denisova, K. G. Gribanov, M. Werner

N. Yu. Denisova, K. G. Gribanov, M. Werner, "Comparison of the isotopic composition of precipitation and air for three Arctic stations with the results of the ECHAM5-wiso modeling," Proc. SPIE 10466, 23rd International Symposium on Atmospheric and Ocean Optics: Atmospheric Physics, 104666T (30 November 2017); doi: 10.1117/12.2288311

SPIE.

Event: XXIII International Symposium, Atmospheric and Ocean Optics, Atmospheric Physics, 2017, Irkutsk, Russian Federation

Comparison of the isotopic composition of precipitation and air for three Arctic stations with the results of the ECHAM5-wiso modeling

N.Yu. Denisova[1], K.G. Gribanov[1], M.Werner[2]
[1]Ural Federal University, Yekaterinburg, Russia
[2]The Alfred Wegener Institute, Helmholtz Center for Polar and Marine Research, Bremerhaven, Germany

ABSTRACT

In order to validate the isotopic model of the general circulation of the atmosphere ECHAM5-wiso, a comparison of the model and experimental data on the isotope composition (δHDO and $\delta H_2{}^{18}O$) of precipitation and water vapor in atmospheric air at the surface for three Arctic observation stations was made. Experimental data on the isotope composition of water vapor were obtained at climate monitoring stations created and maintained by the Climate and Environment Physics Laboratory INS UrFU in Labytnangi and in Igarka, as well as the station located on Samoylov island, supported by the Melnikov Permafrost Institute of SB RAS and the Helmholz centre for polar and marine research, the Alfred Wegener Institute (Germany).

Climate modeling, isotopic composition of water vapor, laser spectrometer.

To validate the general atmospheric circulation model with embedded fractionation of water isotopologues ECHAM5-wiso1, the average daily data on the isotope composition of precipitation and water vapor in atmospheric air at the surface obtained at three monitoring stations in Labytnangi (66.660 ° N ., 66.409 ° E), in Igarka (67.453 ° N, 86.535 ° E) and on Samoylov (72.367 ° N, 126.483 ° E) from the time of installation of these stations until the end of 2016, with the results of the simulation were compared. The model was developed at the Max Planck Institute in Hamburg and supplemented with modules that take into account the isotope fractionation of water in the hydrological cycle[2].

The simulation was performed in the following mode: the spectral resolution was T106 (corresponds to the spatial grid 1.125°x1.125°), the time step was 6 minutes, the simulation started from January 1, 2011, the simulation stopped at January 31, 2016, the nudging mode to the known values of temperature, pressure, divergence and vorticity of the wind. As known values of these parameters, the data of a retrospective analysis of the European Center for Medium-range Weather Forecasts ERA-Interim[3] were used.

Collection of precipitation samples was carried out only at the station in Labytnangi. Fig. 1-3 show the time series of the isotopologues $\delta H_2{}^{18}O$ and HDO, as well as the value of d-excess. The figures show the measurement data (indicated with red dots) and the results of the model experiment performed at the Climate and Environment Physics Laboratory UrFU (green line).

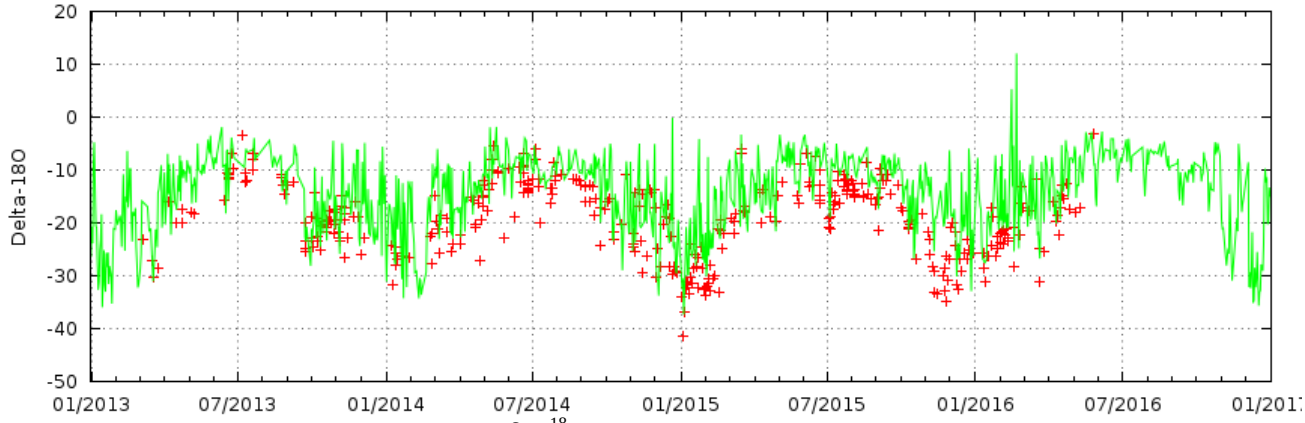

Fig. 1 – The $\delta H_2{}^{18}O$ in precipitation at Labytnangi site

23rd International Symposium on Atmospheric and Ocean Optics: Atmospheric Physics, edited by Gennadii G. Matvienko, Oleg A. Romanovskii, Proc. of SPIE Vol. 10466, 104666T
 · doi: 10.1117/12.2288311

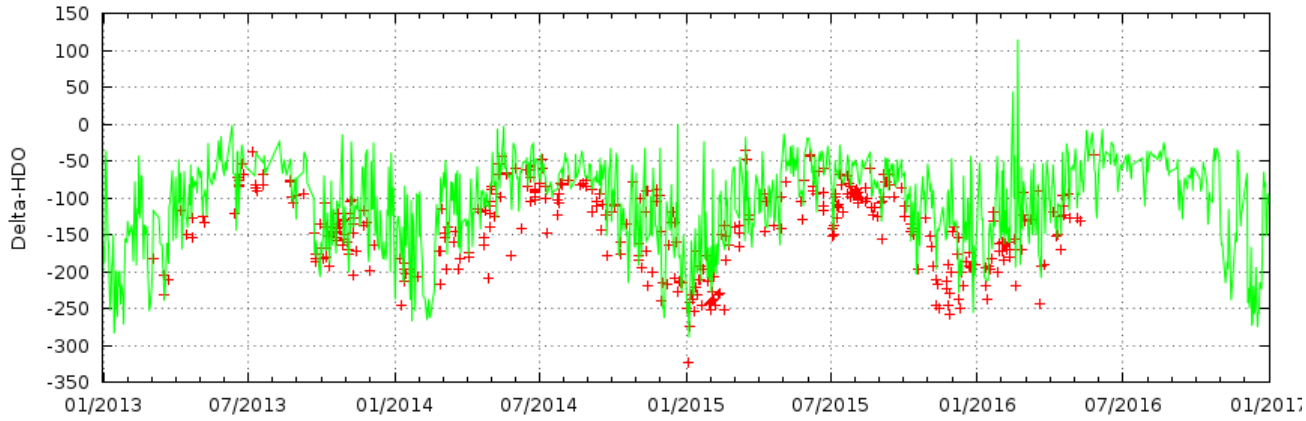

Fig. 2 – The δHDO in precipitation at Labytnangi site

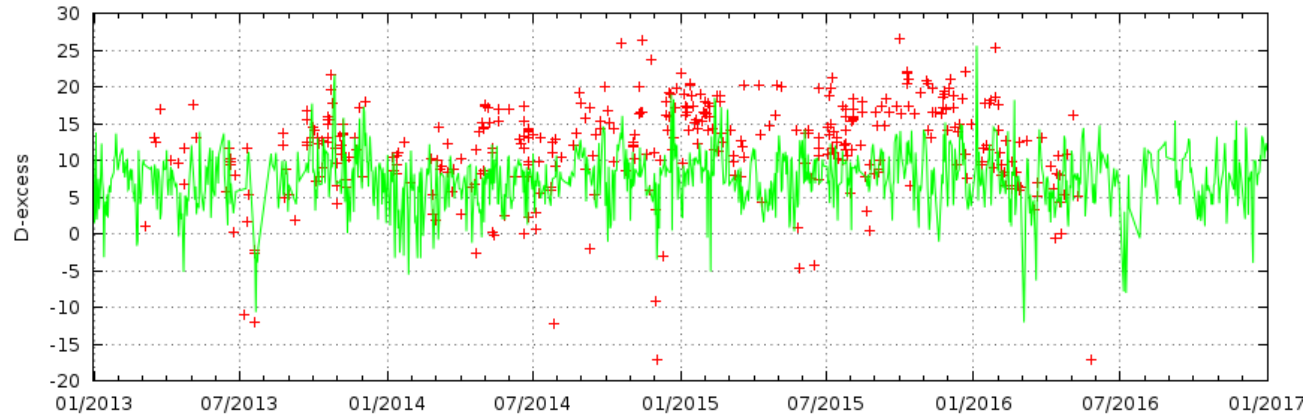

Fig. 3 – The d-excess in precipitation at Labytnangi site

Fig. 4-12 show the relative concentrations of isotopologues (δHDO and δH218O) in atmospheric air at the surface for three observation stations.

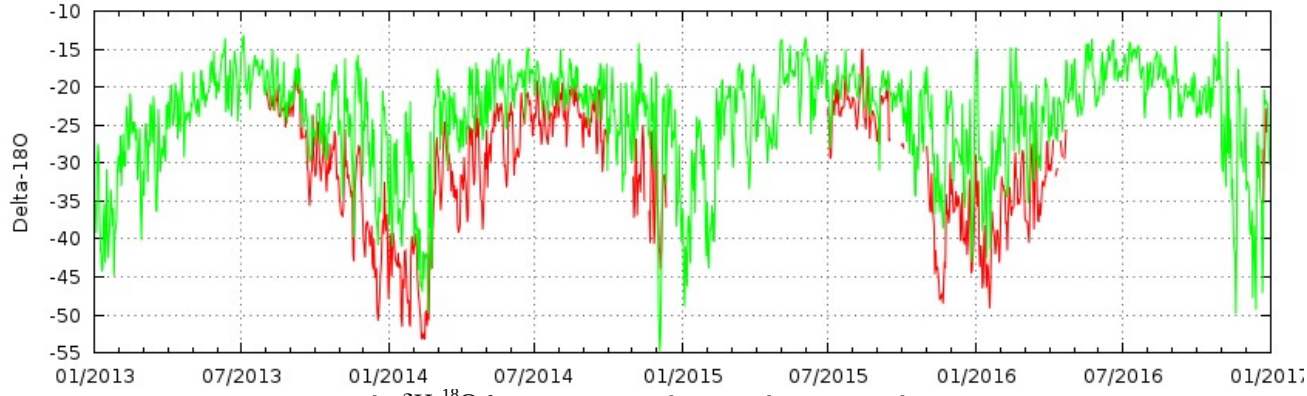

Fig. 4 – The $\delta H_2{}^{18}O$ for water vapor in the atmospheric air at Labytnangi site

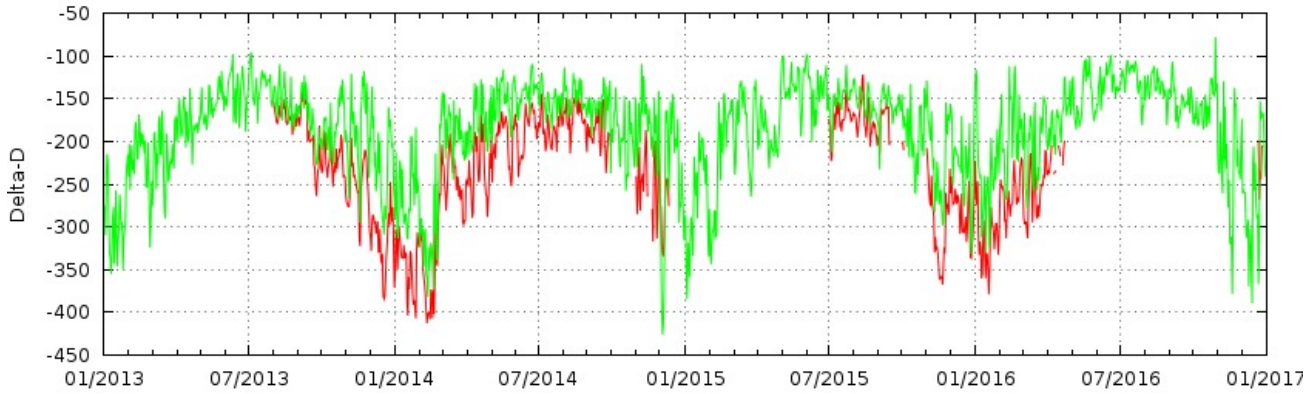

Fig. 5 – The δHDO for water vapor in the atmospheric air at Labytnangi site

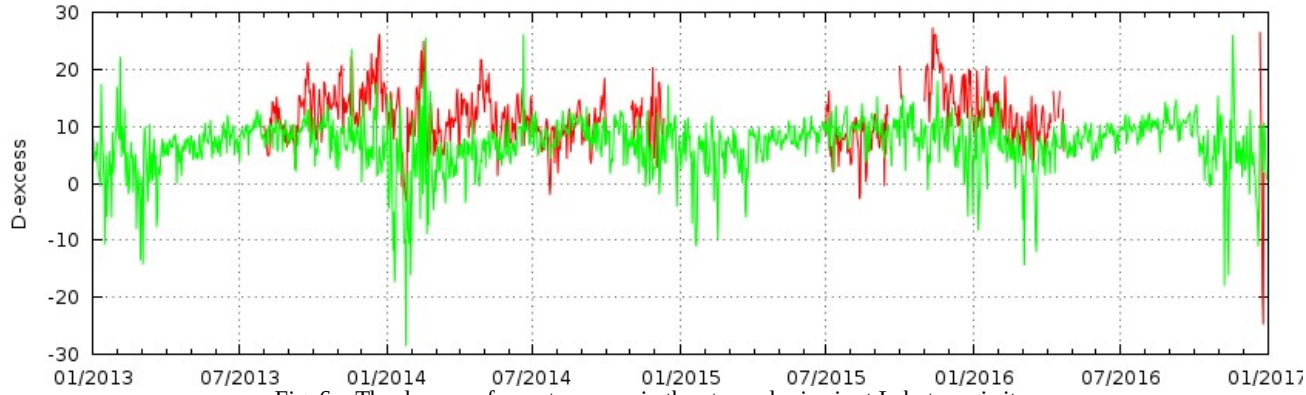

Fig. 6 – The d-excess for water vapor in the atmospheric air at Labytnangi site

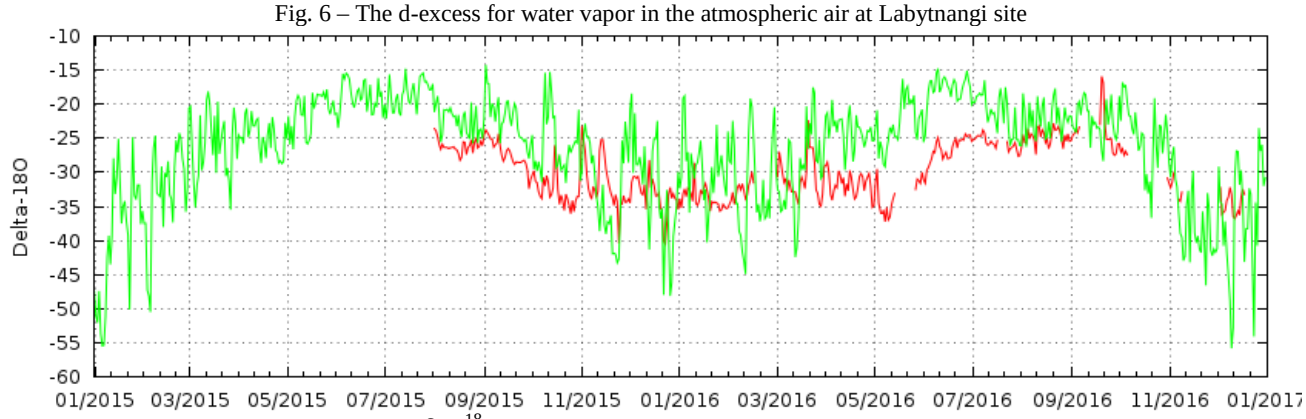

Fig. 7 – The $\delta H_2{}^{18}O$ for water vapor in the atmospheric air ar Igarka site

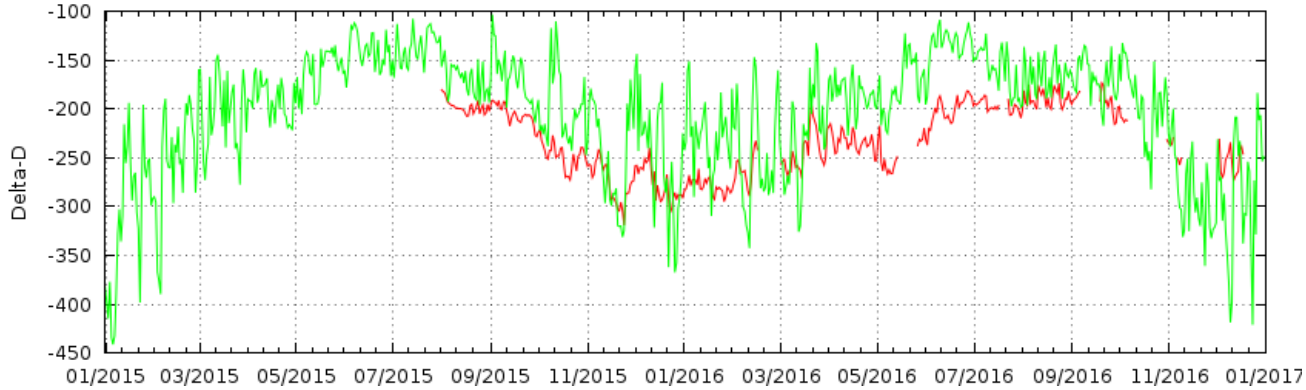

Fig. 8 – The δHDO for water vapor in the atmospheric air at Igarka observation site

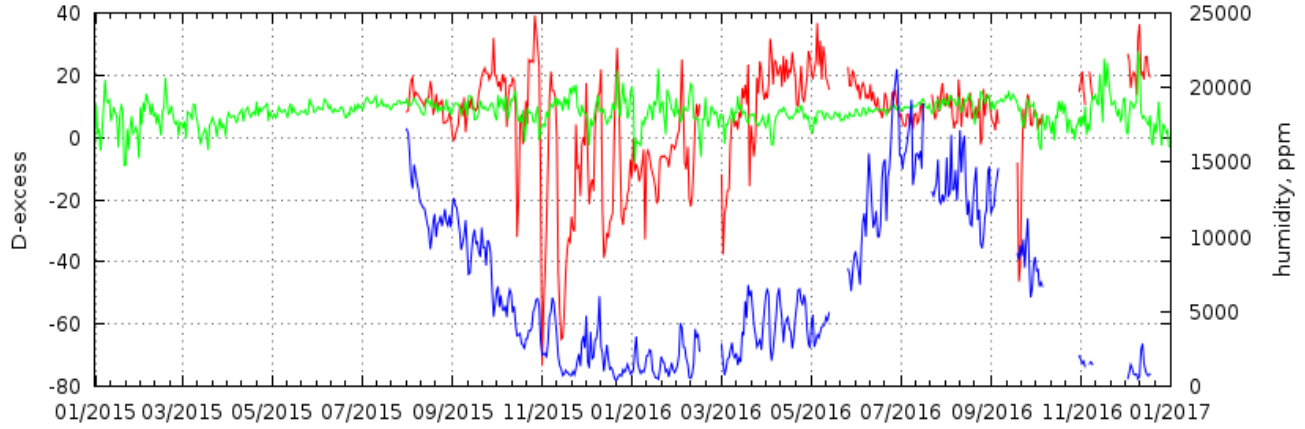

Fig. 9 – The d-excess for water vapor in the atmospheric air and humidity (blue line) at Igarka site

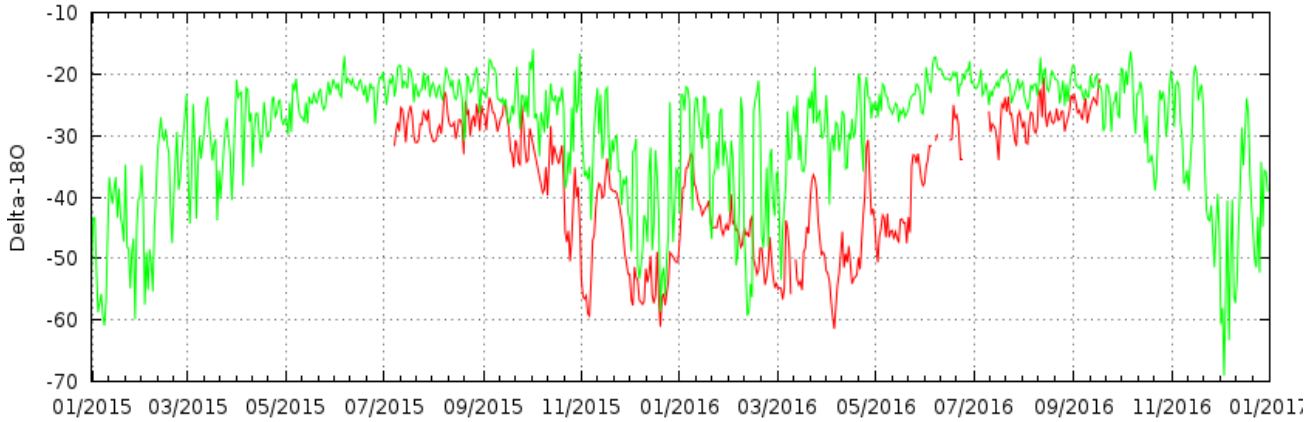

Fig. 10 – The $\delta H_2{}^{18}O$ for water vapor in the atmospheric air on Samoylov island

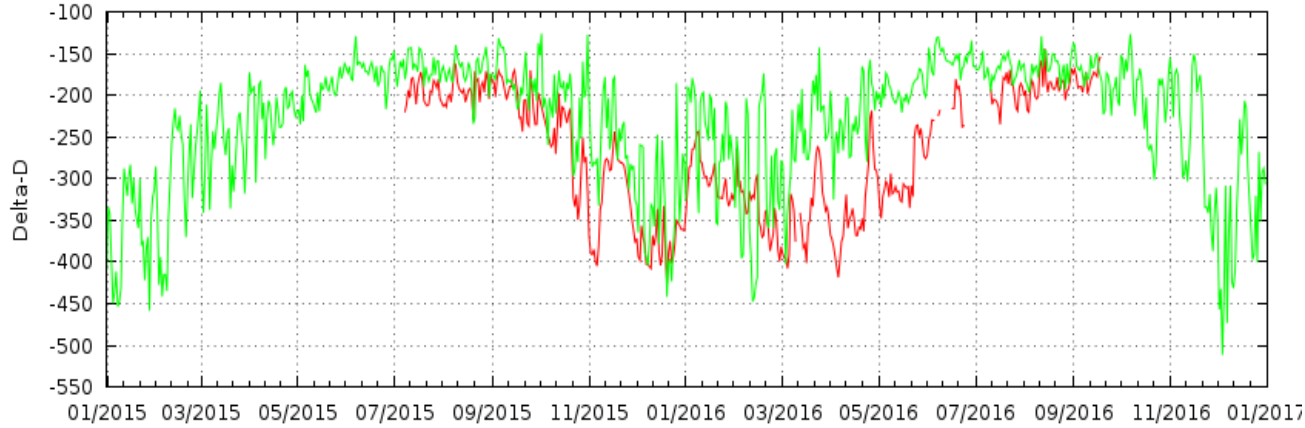

Fig. 11 – The δHDO for water vapor in the atmospheric air on Samoylov island

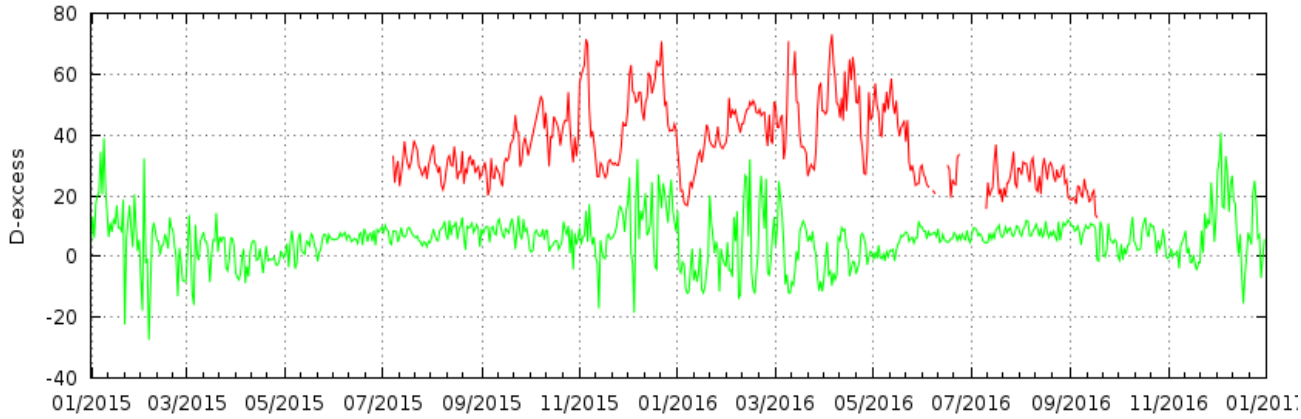

Fig. 12 – The d-excess for water vapor in the atmospheric air on Samoylov island

One can see that the simulation results better represent the measured values in the summer months. This may be due to the fact that winter months are characterized by low air humidity, and the Picarro laser analyzer has a larger measurement errors at low humidity, or because of possible disadvantages of the model. According to the scattering diagrams of the d-excess of $\delta H_2{}^{18}O$ (Fig. 13), it was observed that for the stations located on the island of. Samoylov and Igarka, the points can be divided into two groups having different angles of inclination, which may be due to the mixing of water vapor formed from the river water.

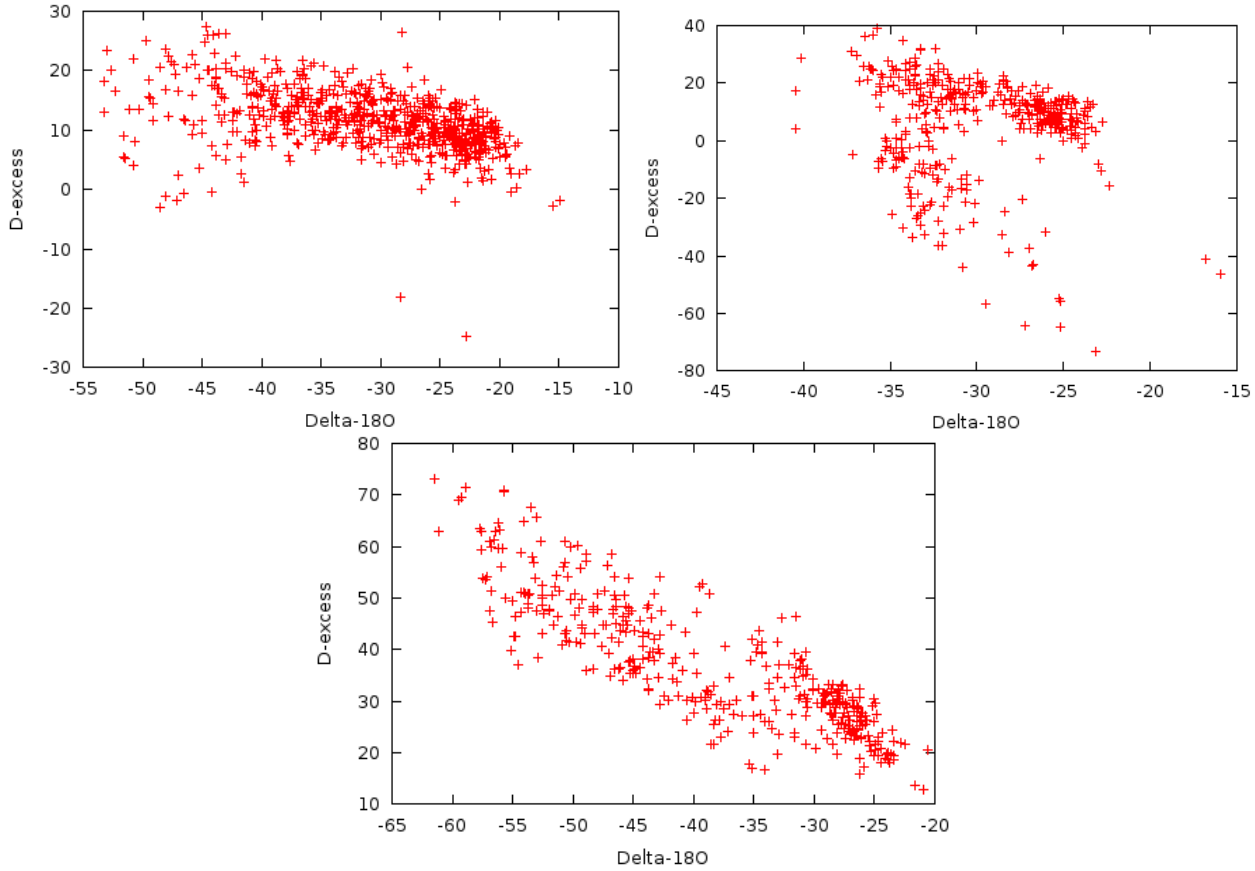

Fig. 13 – Diagrams of scattering of d-excess from $\delta H_2{}^{18}O$ for Labytnangi, Igarka and Samoylov

Acknowledgements: The research was supported by the RFBR grants №16-51-50064, №15-01-05984a and by the government of Russian Federation, contract №02.A03.21.0006, project № 3.6064.2017/8.9.

References:
[1] Roeckner, E. et al. [The atmospheric general circulation ECHAM 5, Part 1, Model description, Report No. 349], Max Planck Institute for Meteorology, Hamburg, Germany (2003).
[2] Werner, M., Langerbroek, P.M., Carlsen, T., Herold, M., and Lohmann, G. "Stable water isotopes in the ECHAM5 general circulation model: toward high-resolution isotope modeling on a global scale", J.Geophys. Res., 16, D15109, doi:10.1029/2011JD015681 (2011).
[3] ERA-Interim: New ECMWF reanalysis products from 1989 onwards. ECMWF Newsletter 110, Winter 2006/7, http://old.ecmwf.int/publications/newsletters/pdf/110_rev.pdf.