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Modeling of water isotopes with model echam6-wiso in nudging mode with reanalysis era5

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ABSTRACT

In order to validate the isotopic model of the general circulation of the atmosphere ECHAM6-wiso, modeling in nudging mode with data from reanalysis ERA5 was made. These model data were compared with experimental data on the isotope composition (δHDO and $\delta H_2{}^{18}O$) of water vapor in atmospheric air for stations in Labytnangi and in Igarka created and maintained by the Climate and Environment Physics Laboratory INS UrFU and on Samoylov island, supported by the Trofimuk Institute of Petroleum Geology and Geophysics of SB RAS and the Alfred Wegener Institute (Germany), and with experimental data on the isotope composition of precipitation for the station in Labytnangi.
Keywords: atmospheric general circulation model, water isotopes, reanalysis

1. INTRODUCTION

ECHAM6 is the sixth generation of the general atmospheric circulation model ECHAM, created at the Max Planck Institute for Meteorology in Hamburg[1]. The ECHAM6 model is an atmospheric component of the climate model MPI-ESM, which includes models of the atmosphere, ocean, land and connects them through the exchange of energy, momentum, water and carbon dioxide.

The ECHAM6 model, like the previous ECHAM5, has a nudging mode to known values of air temperature, wind speed and surface pressure. Data from a retrospective analysis ERA5[2] was used as these values in this paper.

Like the ECHAM5 model, ECHAM6 was supplemented with a wiso module that takes into account the isotopic fractionation of water in precipitation and water vapor. This module was developed at the Alfred Wegener Institute of Polar and Marine Research[3], Bremerhaven, Germany.

Climate and Environmental Physics Laboratory UrFU has two observation stations in Russian Arctics: in Labytnangi and Igarka. The station on Samoylov island is supported by the Trofimuk Institute of Petroleum Geology and Geophysics of SB RAS and the Alfred Wegener Institute (Germany). The experimental base of these monitoring stations contains laser spectrometers PICARRO L2130-i (L2140-i) at each station, designed to measure the concentration of water vapor in air and the values of $\delta H_2{}^{18}O$ and δHDO. In addition, each monitoring station is equipped with an automatic meteorological station (Vaisala WXT520), which continuously measures temperature, humidity, pressure, wind direction and strength, as well as the level of liquid precipitation.

To verify the general atmospheric circulation model with embedded fractionation of water isotopologues ECHAM6-wiso, the average daily data on the isotope composition of water vapor in atmospheric air at the surface obtained at 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) with the results of the simulation were compared. The simulation was performed in the following mode: the spectral resolution was T63 (corresponds to the spatial grid 1.88°x1.88°), the time step was 6 minutes, the simulation started from January 1, 2010, 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 ERA5 were used.

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2. RESULTS OF MODELING

Fig. 4-9 show the relative concentrations of isotopologues (δHDO and $\delta H_2{}^{18}O$) in atmospheric air at the surface for three observation stations. The figures show the measurement data (indicated with orange line) and the results of the model experiment performed at the Climate and Environment Physics Laboratory UrFU (blue line).

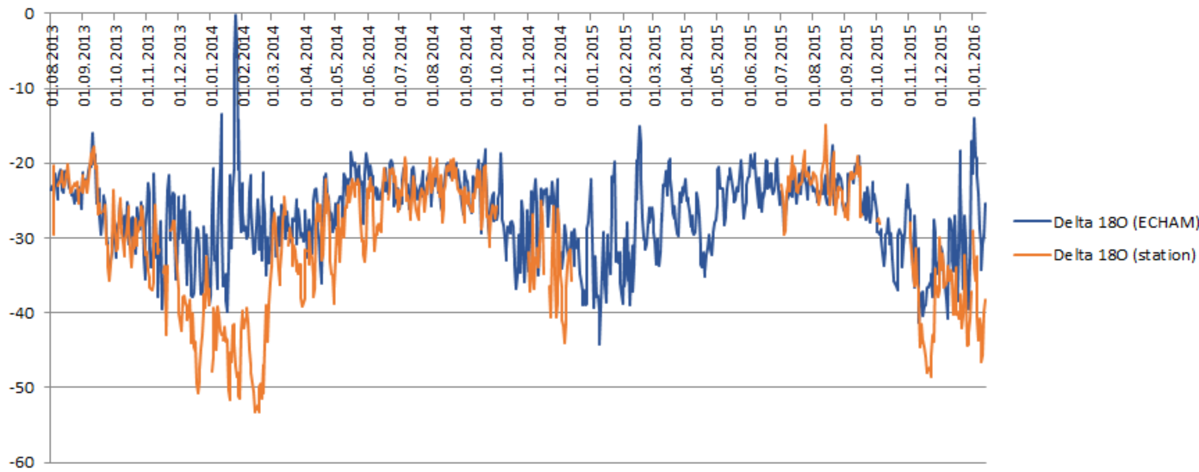

Fig. 1 – The $\delta H_2{}^{18}O$ for water vapor in the atmospheric air at Labytnangi site

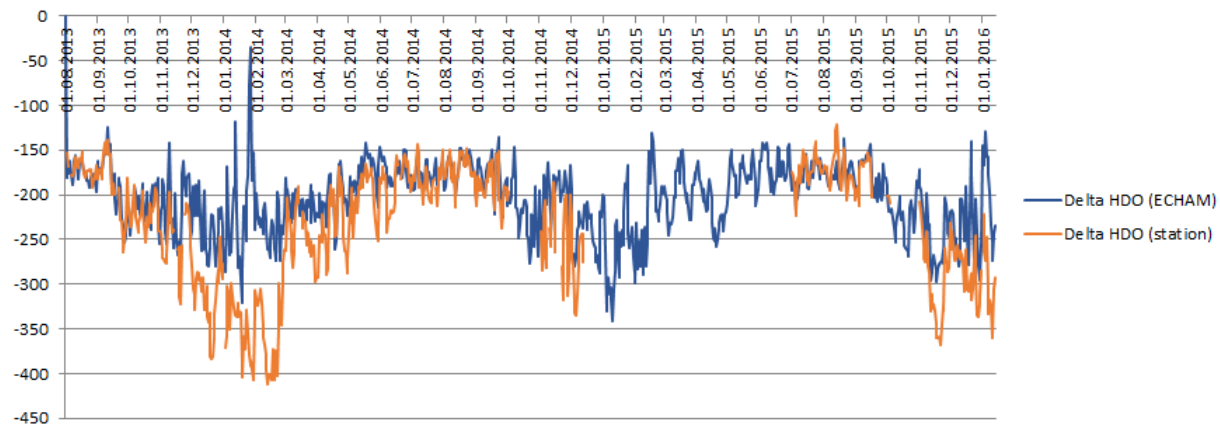

Fig. 2 –The δHDO for water vapor in the atmospheric air at Labytnangi site

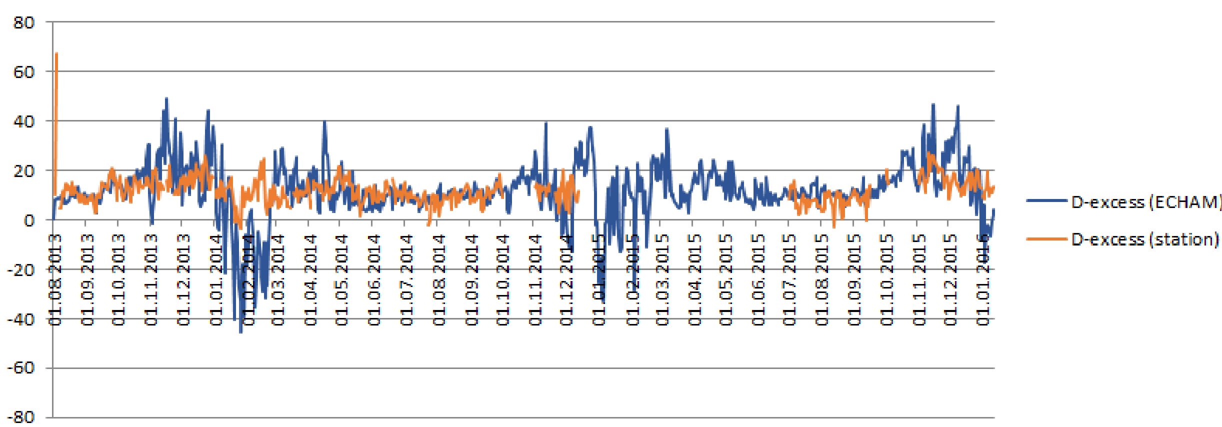

Fig. 3 – The d-excess for water vapor in the atmospheric air at Labytnangi site

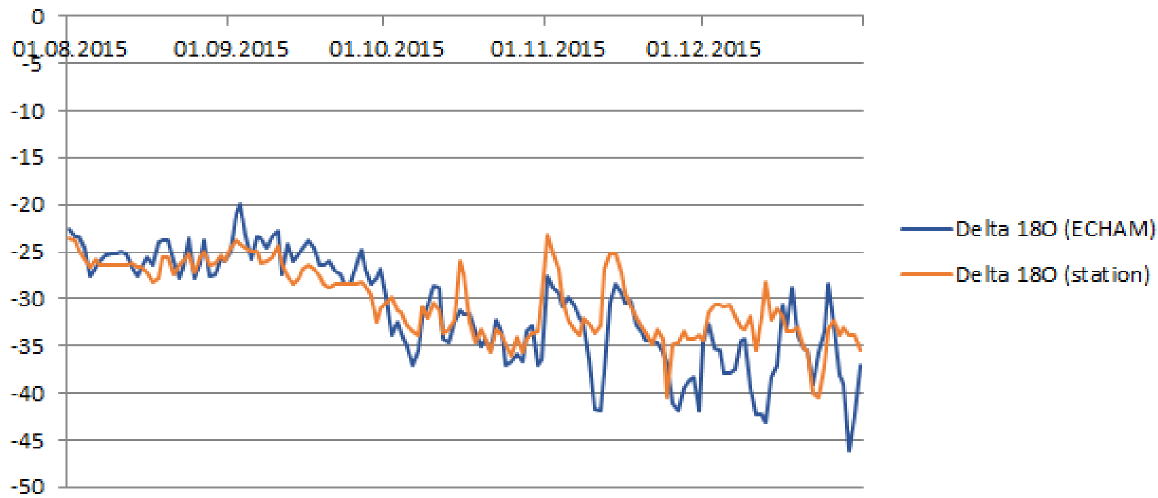

Fig. 4 – The $\delta H_2{}^{18}O$ for water vapor in the atmospheric air ar Igarka site

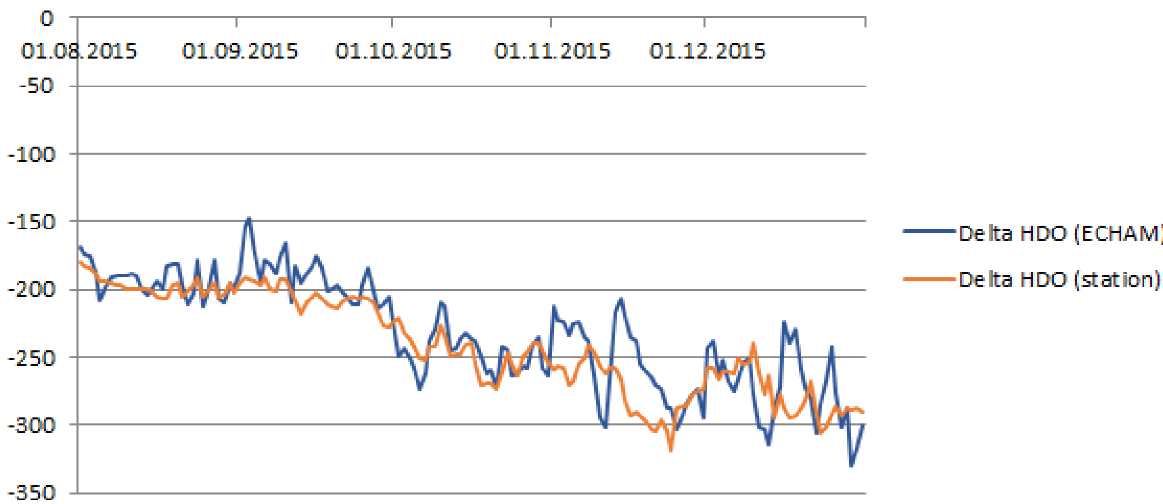

Fig. 5 – The δHDO for water vapor in the atmospheric air at Igarka observation site

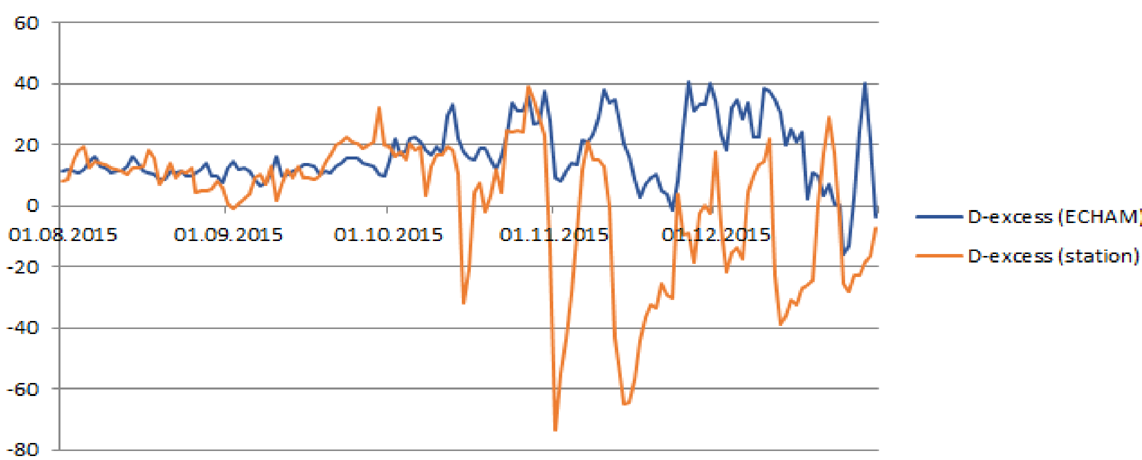

Fig. 6 – The d-excess for water vapor in the atmospheric air and humidity (blue line) at Igarka site

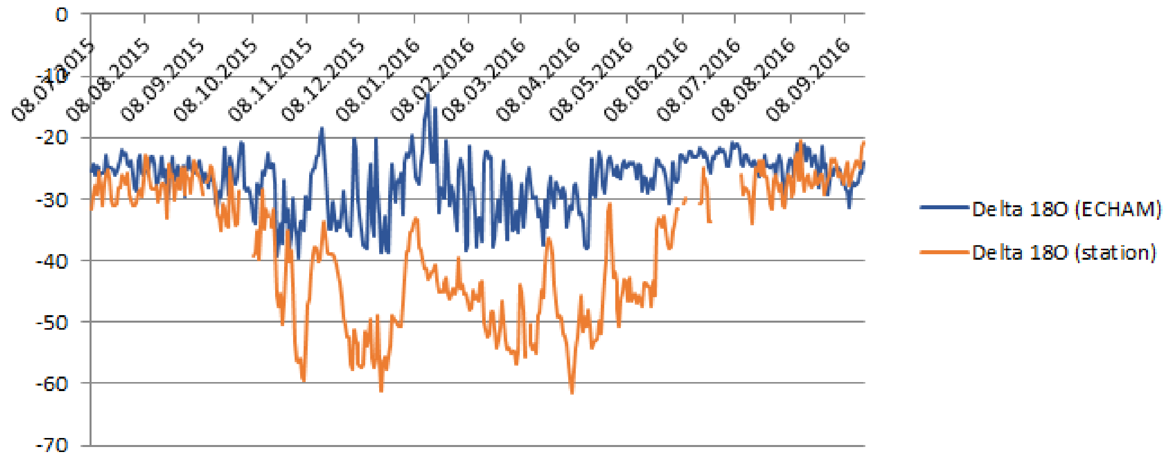

Fig. 7 – The $\delta H_2^{18}O$ for water vapor in the atmospheric air on Samoylov island

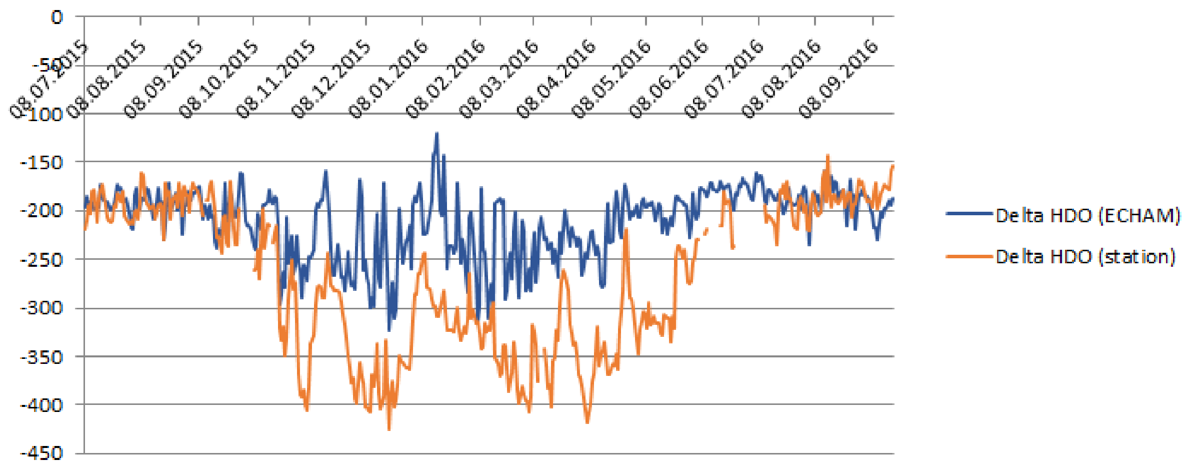

Fig. 8 – The δHDO for water vapor in the atmospheric air on Samoylov island

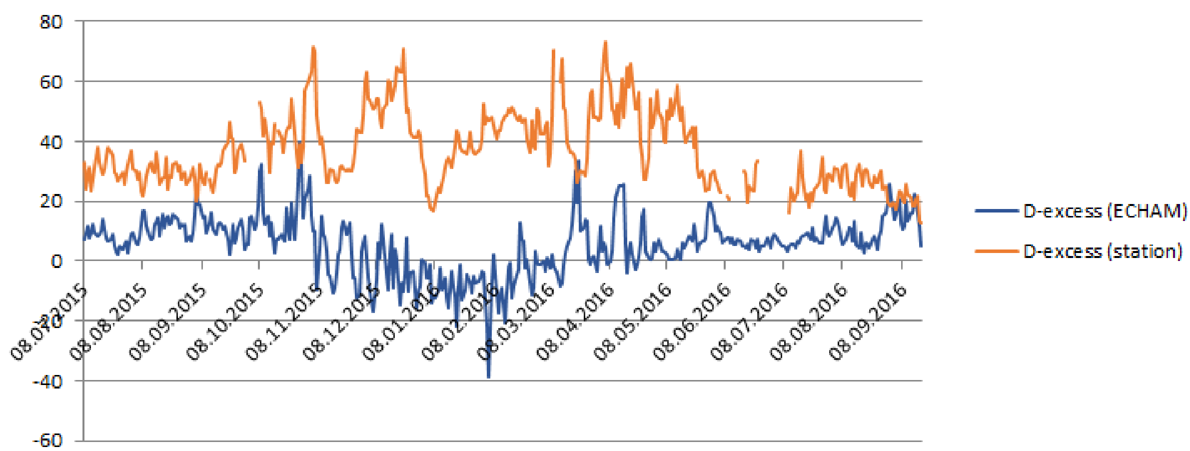

Fig. 9 – The d-excess for water vapor in the atmospheric air on Samoylov island

3. CONCLUSION

Simulation results better represent the measured values in the summer months. There are three possible causes of discrepancies between model and measured data. First, the different scale of the data, the model represents the data averaged over the cell of its grid, and the experimental data are point data. Secondly, at low humidity in cold season, the spectrometer has a high relative error in determining the measured concentrations. This error is especially reflected in the magnitude of the d-excess. Third, climate modeling in itself, in contrast to stochastic numerical weather prediction models, reproduces meteorological values only on average for long time intervals. Thus, for a more correct comparison of model and measured values, it is necessary to continue measurements to obtain multi-decadal data series.

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REFERENCES

[1] Stevens, B., et al. (2013), Atmospheric component of the MPI-ESM Earth System Model: ECHAM6, J. Adv. Model. Earth Syst., 5, 146–172, doi:10.1002/jame.20015.

[2] European Centre for Medium-Range Weather Forecasts. 2017, updated monthly. *ERA5 Reanalysis*. Research Data Archive at the National Center for Atmospheric Research, Computational and Information Systems Laboratory. https://doi.org/10.5065/D6X34W69. Accessed 09.02.2018.

[3] Cauquoin, A., Werner, M. and Lohmann, G., Alfred Wegener Institute (AWI), Helmholtz Centre for Polar and Marine Research. Division Paleoclimate Dynamics, Bremerhaven, Germany. (2017): Modeling of water stable isotopes in the ECHAM6 atmospheric general circulation model: current status and perspectives, EGU General Assembly 2017, Vienna (Austria), 24 April 2017 - 28 April 2017.