EMISSION OF GREENHOUSE GASES FROM NATURAL AND HUMAN-CHANGED COLD SOILS: RESULTS AND PROSPECTS

S. GORYACHKIN[1], D. KARELIN[1,2], A. DOLGIKH[1], A. POCHIKALOV[1], V. SHISHKOV[1], E. ZAZOVSKAYA[1], N. BADMAEV[3], YU. TSYBENOV[3], A. KULIKOV[3], P. DANILOV[4], G. SAVINOV[4], A. DESYATKIN[5], R. DESYATKIN[5]

[1]Institute of Geography, Russian Academy of Sciences, Moscow, Russia

[2]Moscow State University, Moscow, Russia

[3]Institute of General and Experimental Biology, Siberian Branch of Russian Academy of Sciences, Ulan-Ude, Russia

[4]North-Eastern Federal University, Yakutsk, Russia

[5]Institute of Biological Problems of Cryosphere, Siberian Branch of Russian Academy of Sciences, Yakutsk, Russia

Keywords: ARCTIC, ULTRACONTINENTAL AREAS, PERMAFROST SOILS, CARBON DIOXIDE, METHANE, FLOW MEASUREMENTS, MONITORING, SUBCONTINENTAL TRANSECT

INTRODUCTION

The interest to the Arctic and other cold regions of Eurasia, as the most vulnerable ecoregion, was always high. This interest is especially intensified in the current period of pronounced human-affected climate change, as a result of increased industrial and agricultural emissions of greenhouse gases. The Eurasian cold regions are critical to earth's climate not only through the balance of greenhouse gases between ecosystems and atmosphere, and changes of surface albedo, but also due to vast reserves of greenhouse gases stored in the permafrost. In recent years, the scientific focus turned not only on the global impacts of human activity, but also to figure out how different forms of local anthropogenic impacts could affect greenhouse gas emissions, and how this influence is comparable to the influence of global climate changes. In addition, it is important to establish a net of circumpolar monitoring stations of soil emissions of biogenic greenhouse gases in the Arctic. With this purpose in 2014-2017 we organized the field measurements of emissions of soil biogenic greenhouse gases and related parameters in the key Arctic locations under the influence of the main local anthropogenic factors.

In 2017 we also organized the greenhouse gases measurements across more than 3000-km subcontinental transect in the cold ultra-continental region of Eurasia from Baikal to Oimyakon (the Pole of Cold of the Northern Hemisphere). The measurements of soil emission in ultra-continental areas previously were mainly gained from scarce monitoring stations (Takakai, 2008; van Huissteden, 2008).

METHODS

The method is based on direct measurements of CO2 by gas analyzer. On all the plots, opaque plastic cylinders (chambers) of 11.5 cm in the inner diameter were inserted into the soil to a depth of 5–10 cm and left there for two hours before the measurements. The time of separate measurements was about 1–3 min. An infrared closed path gas analyzer LI_COR 6200 (Lincoln, Nebraska USA) was used. This analyzer gives estimates of the CO2 flux with an accuracy of 0.1 ppm in the range from 0 to 2000 ppm.

The flow of methane was measured by accumulative method on site for 1 -3 hours by gaseous chromatography.

The soil temperature (at the depth of 10 cm) and air temperature (0.5 m above the soil surface at each of the base cylinders) were determined with a portable electronic thermometer Checktemp_1 (the accuracy of 0.1°C; temperature range from –50 to +150°C) produced by Hanna Instruments. The volumetric soil water content inside the cylinders was measured with a field reflectometer HH2 Moisture Meter equipped with a ThetaProbe ML2x sensor (±1% accuracy) produced by Delta_T Devices Ltd. Each time, the volume of the closed chamber was carefully measured with an accuracy of about 1 cm3. It was possible to include all the major well-known specific types of human impact to measure emissions in those geographic areas.

RESULTS

Our results on the field measurements of emissions of soil biogenic greenhouse gases and related parameters in the key Arctic locations under the influence of the main local anthropogenic factors were already published (Goryachkin *et al.,* 2015; Karelin *et al.,* 2016). Briefly, it was found that the total area of land occupied by buildings, infrastructure, roads, cropland, and human-disturbed lands has increased in all administrative regions of the Arctic zone of Russia by 6% for the period 2000-2013. The biggest increase of the disturbed area is observed in the regions of active exploitation of oil and gas resources. The natural arctic ecosystems being modified by local human activity, could demonstrate for a long time a rates different from the background soil emission of biogenic greenhouse gases. The relative differences of CO_2 soil emissions between the sites with different type of anthropogenic impact are constantly persisted. North-boreal ecosystems (soil complexes) are more stable in this respect, as compared to tundra ecosystems. Anthropogenic CO_2 soil emission may exceed or be below the natural background level, depending on the form or varying degree of human impact, or weather conditions. However, in all cases, when the vegetation cover is absent, they result in a net source of carbon dioxide to the atmosphere. This is especially true for active sites of human settlements.

The results gained in ultra-continental areas are under calculation yet and will be presented at the conference.

PROSPECTS

We see prospects *(a)* to monitor of CO_2 emissions and primary production at selected observation sites in the key geographical subzones and regions and for the main types of anthropogenic impacts in the Arctic, *(b)* to obtain data on other major biogenic greenhouse gases (nitrous oxide and methane) at all selected key sites, *(c)* to expand the spatial coverage of soil emission estimates; include into analysis of new geographic sub-zones and soil types in the Arctic and cold continental areas, *(d)* to calculate for each monitoring site a spatial assessments of soil emissions including all local human impacts with use of remote sensing data, *(e)* to apply a new distant methods for estimation of net primary production rates (based on LAI and NDVI), and chamber estimates of net ecosystem fluxes of CO_2, methane and N_2O using closed-path technique.

One more prospect is to measure greenhouse gases in different kinds of ecotones: tundra-forest, forest-bog, forest-cold grassland. Ecotones are the zones of ecosystem transformations due to climate change.

CONCLUSIONS

There is still a big gap in the data on greenhouse gases emission from cold soils of Arctic and ultra-continental regions. It is worth to combine the monitoring in well-equipped stations and field conditions along long transects in short times in order to find climate-induced difference of gas flows.

The human-changed soil areas are growing in cold areas and this process results in increase of emission of greenhouse gases from cold soils to the atmosphere.

The prospect of studies on greenhouse gas emission is the cooperation of different specialists and the developing of the large database on the cold soil greenhouse gases emission. That could be the good basis for the modelling and forecast of climate change. The role of PEEX could grow for the study of such kind.

ACKNOWLEDGEMENTS

The research was supported by the Program "Searching basic studies for the development of the Arctic zone" of the Presidium of the Russian Academy of Sciences and the project 17-05-41157 of the Russian Geographic Society and Russian Foundation for Basic Research.

REFERENCES

Goryachkin S.V., Karelin D.V., Dolgikh A.V., Lyuri D.I., Shishkov V.A., Zazovskaya E.P. (2015). The Role of Anthropogenic Activities in CO2 and CH4 Emission from Soil to Atmosphere in Polar Regions of East Europe. *Report Series in Aerosol Science,* **163**. 167-171.

D.V. Karelin, E.P. Zazovskaya, V.A. Shishkov, A.V. Dolgikh, I.G. Sharkunov, A.V. Pochikalov, A.A.Karpov, E.V. Antonov and S.V. Goryachkin. (2016). The emissions of biogenic greenhouse gases from arctic and north boreal soils due to the different types of anthropogenic land use at local and regional scales: prospects and dynamics. *Report series in aerosol science*, **180**. 215-222.

Takakai F., Hatano R., Desyatkin A.R., Lopez C.M.L., Desyatkin R.V., Fedorov A.N. (2008). Influence of forest disturbance on CO_2, CH_4 and N_2O fluxes from larch forest soil in the permafrost taiga region of eastern Siberia. *Soil Science and Plant Nutrition*. **54.** 938-949

van Huissteden J., Dolman A.J., Maximov T.C., Kononov A.V. (2008). Summer Soil CH4 Emission and Uptake in Taiga Forest Near Yakutsk, Eastern Siberia. *Agricultural and Forest Meteorology*. **148** (12), 2006-2012.