Monitoring of methane emissions in the Arctic by laser sensing to assess climate change

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Over the past 100 years, the rate of temperature in the Arctic increases almost twice higher than the average rate of warming of the planet (IPCC, 2007). Identifying methane anomalies responsible for the temperature increase, by hiking trails in the Arctic requires great human labor. It is necessary to use lidar methods for search and identification of methane from permafrost.

The Arctic is an essential component in the Earth's ecosystem, affecting its energy balance, atmospheric and oceanic circulation, freshwater, sea level, storage and release of large amounts of greenhouse gases, the economy, infrastructure, health, culture and identity, as well as the lives of millions of people.

Currently Arctic dramatic changes due to global warming, in addition, it is influenced by globalization and cross-border pollution . Feedback mechanism between the surface and the Arctic climate system will enhance the warming effect, while the ground ice in the Arctic is increasingly contributing to global sea level rise. Need to keep track of all the changes taking place in the Arctic, document them, to simulate changes in the cryosphere and their consequences. Permafrost temperature and thickness of the active layer , in spite of some differences in certain regions, have generally increased throughout the Arctic . [1]

According to preliminary estimates by the year 2100 there will be a wide degradation of permafrost across the Arctic has many effects.

Deconservation less than 0.1% the amount of organic carbon buried in the upper 100 m layer of permafrost (about 10,000 Gt of carbon in the form of CH_4) may lead to a doubling of atmospheric methane, radiation activity is about 20 times higher than that of CO_2. [1]

Identifying methane anomalies hiking routes in the Arctic requires great human labor, and therefore ineffective. Is also ineffective visual observation using air transport and sampling.

Despite the obvious importance of the problem is now practically no methods of isolation , containment and remote diagnostics methane anomalies , although technically such a possibility is quite realistic. Lidar aerial photography characterized by high mobility allows to detect a signs of methane with negligible concentrations (not less than 0.0001 %) for considerable distances (hundreds of meters) from the terrestial surface.

Development and introduction of new physical methods of nonlinear increase detection sensitivity allows for rich and practically inexhaustible possibilities of laser sensing information to create highly effective and competitive technologies search of methane emissions in the Arctic. Its advantages over traditional (indirect), for example, the physicochemical - the following: remote, noncontact, the possibility of continuous areal and profile scanning with simultaneous determination of a wide range of chemical elements and compounds , as well as high sensitivity and speed of detection (10^{-6}s). [2,3]

Automated on-board lidar installed capacity will allow methane emissions, qualitative and quantitative parameters of anomalies. According search shooting may be identified pockets of methane, monitor changes in the concentration levels, thereby obtaining the necessary data for climate modeling and prediction of the degree of "global warming". Also is possible to estimate the environmental and engineering conditions of design, construction and operation of wells, pipelines, etc.

[1] Bruhwiler, L.M. and E. Matthews, Can we reconcile our understanding of the atmospheric methane budget over the past decades with atmospheric observations EOS Trans. AGU, 88, (52), Fall Meet. Suppl. Abstract B52C-03, 2007. S. V.

[2] Alimov ; S. V. Kascheev ; D. V. Kosachev ; S. B. Petrov ; A. P. Zhevlakov «Multifunctional lidar for needs of oil-and-gas pipes» Proc. SPIE 6610, 66100B (2007).

[3] S. Alimov, D. Kosachev, O. Danilov, A. Zhevlakov, S. Kashcheev, A. Mak, S. Petrov, and V. Ustyugov, "Aviation Raman lidar with ultraspectral resolution," J. Opt. Technol. 76, 199-207 (2009).