Publications of the Institute of Geophysics, Polish Academy of Sciences
Geophysical Data Bases, Processing and Instrumentation
vol. 455 (P-5), 2025, pp. 245–246
DOI: 10.25171/InstGeoph_PAS_Publs-2025-141
40th International Polar Symposium – Arctic and Antarctic at the Tipping Point, 4–7 November 2025, Puławy, Poland

Innovative Warning System for Methane Emissions in Polar Areas

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1. INTRODUCTION

The Arctic plays a critical role in the global climate system, acting as both a carbon sink and a significant source of greenhouse gas emissions, particularly methane. Methane is released from thawing permafrost, Arctic wetlands, and thermokarst lakes. These emissions may intensify under global warming, creating a feedback loop that accelerates climate change (Bartosiewicz 2020). A comprehensive understanding of this process requires robust, long-term datasets characterizing both the magnitude and variability of methane fluxes.

2. MONITORING SYSTEM DEVELOPMENT

We have developed and implemented an innovative, cost-effective early warning system for detecting methane emissions in the Arctic (Kot and Bartosiewicz 2025). The system utilizes a low-energy tunable laser sensor integrated with an Eddy Covariance (EC) instrument located on the Fuglebergslett plain near the Polish Polar Station in Hornsund, Spitsbergen. The EC tower, equipped with an IRGASON sensor, provides high-frequency measurements of gas fluxes, water vapour, and meteorological variables. This setup allows for detailed analysis of gas exchange dynamics between the surface and the atmosphere in extreme Arctic conditions.

3. FIELD IMPLEMENTATION AND DATA ANALYSIS

The system is further enhanced by remote visualization using a miniaturized methane sensor mounted on an ROV, enabling spatial and discrete methane concentration measurements in the vicinity of the EC installation. This facilitates the identification of local emission sources and

the characterization of the spatiotemporal variability in fluxes. Special focus is given to thermokarst wetlands, which are emerging as key methane emitters due to organic matter decay and the release of subsurface reservoirs triggered by permafrost degradation (Bartosiewicz 2020).

4. INTEGRATION AND OUTLOOK

The integration of Eddy Covariance data with mobile ROV-based sensing offers a comprehensive monitoring solution, contributing significantly to our understanding of Arctic methane emissions and their climate feedback mechanisms.

References

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Received 3 September 2025
Accepted 20 October 2025