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1. Introduction

Greenhouse gases are the main driver of the ongoing global warming which has developed into one of the major issues for our modern world. Although the lifetime being around 10 years in the atmosphere, methane is the most potent greenhouse gas. Oil production, natural gas utilization and farming produces majority of the antropogenic methane emissions. However, contribution of the natural methane emission sources, such as wetlands, is not yet fully uderstood.

2. Measurement technique

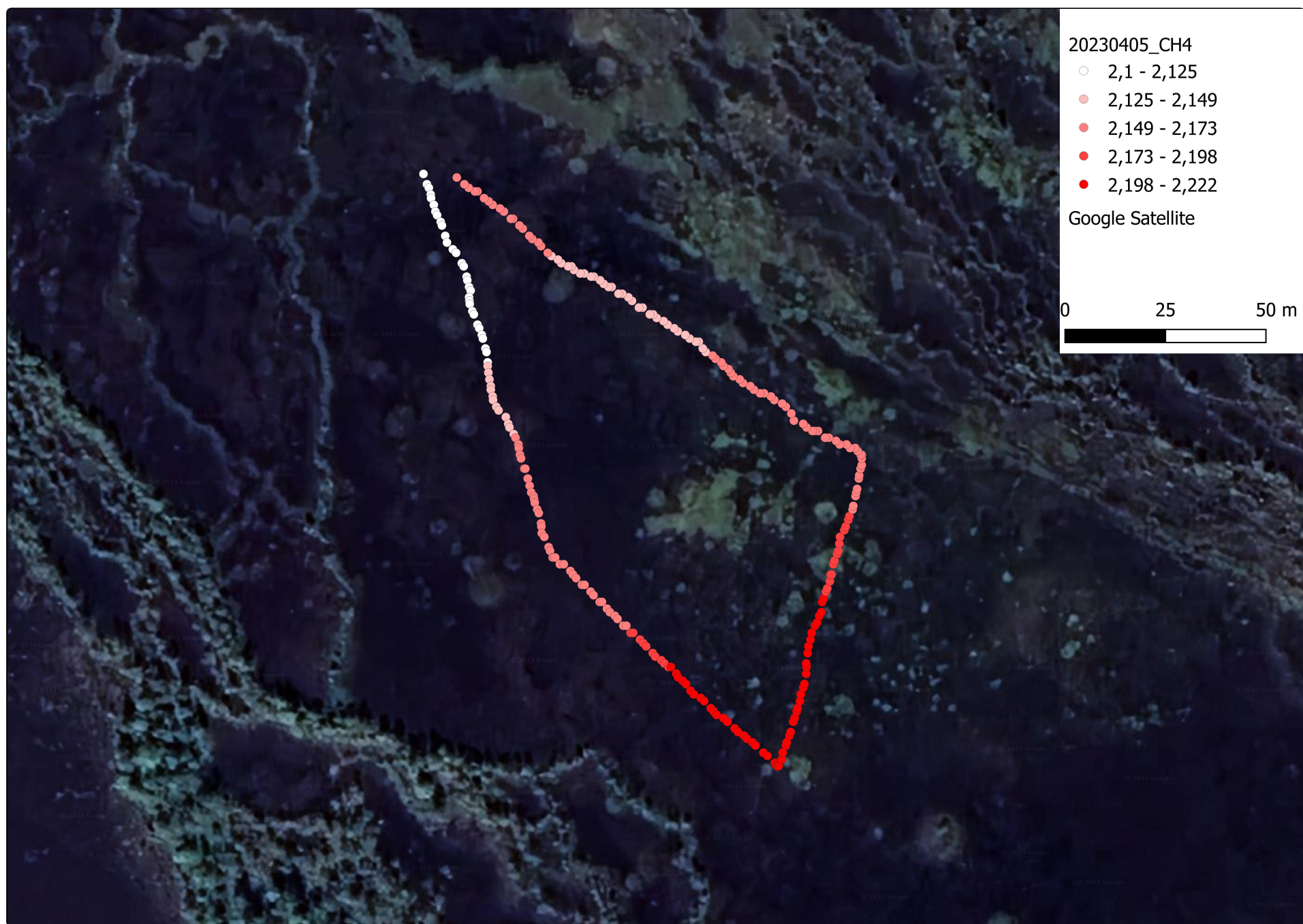
In this research, we studied methane emissions from Halssiaapa wetland near Sodankylä, especially focusing emission during early spring and late fall. Capturing methane plumes is done by utilizing **AirCore** atmospheric sampling system.

Drone equipped with AirCore is capable of flying about **11 minutes** before the gas collecting chamber is full and ready to be analyzed. Atmospheric conditions heavily affect the quality of measurements, such as wind conditions and mixing ratio.



3. Data visualization

An example drone flight over wetland on 5th of April 2023. Clear methane enhancements can be seen and it is likely that emissions originate from the wetland.



4. Theoretical modeling

Behavior of local-scale methane concentration c can be roughly described using convection-diffusion equation $D \nabla_x^2 c(\mathbf{x}, t) - \mathbf{v}(\mathbf{x}) \cdot \nabla_{\mathbf{x}} c(\mathbf{x}, t) + S(\mathbf{x}) = 0$ which includes **diffusion**, **convection** and **source** terms

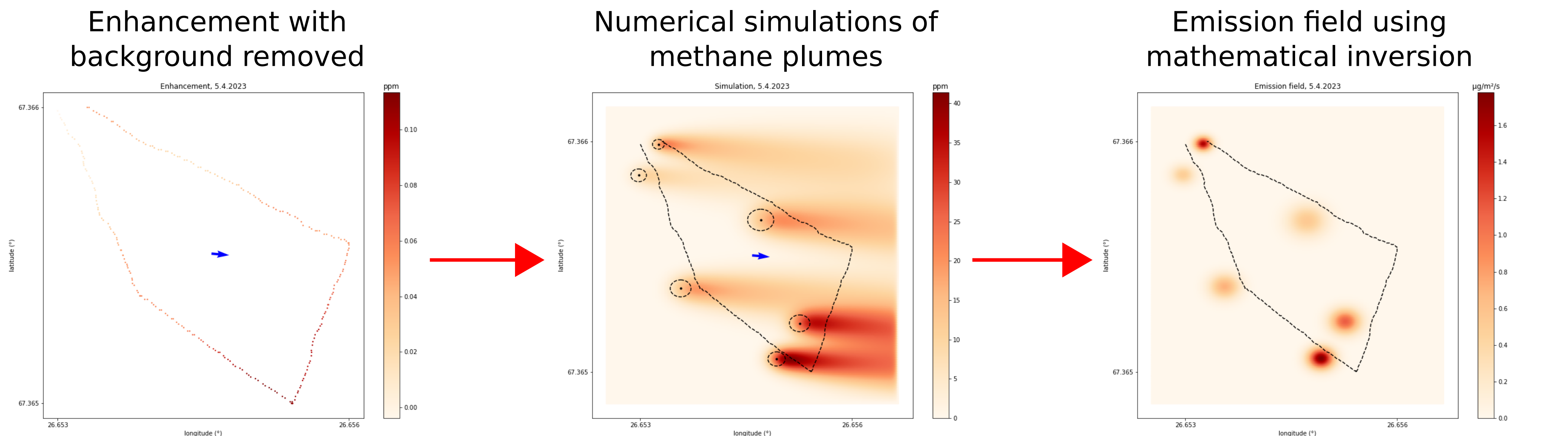
Special case (solution) of the conv-diff for a single source at (0,0,0) is the Gaussian plume model given by

$$c(x, y, z) = \frac{Q/u}{\pi \sigma_y(x) \sigma_z(x)} \cdot e^{-\frac{y^2}{2\sigma_y^2(x)}} \cdot e^{-\frac{z^2}{2\sigma_z^2(x)}}$$

which includes the **emission rate**, **wind speed** and both **horizontal and vertical spreading** of the plume with respect to the downwind direction x

Methods for estimating emissions from the observed data include the inverse Gaussian plume approach (IGA) and integrated mass enhancement (IME)

5. Results and conclusions



Recent in-situ measurements show that there should be clear point sources but pin-pointing them using a single drone flight is difficult. Mixing of methane due to wind and limited amount of data propose many challenges. Moreover, source location and emission rate are highly correlated so finding out these unknowns together reliably is extremely difficult.

K. Vinković et al., Evaluating the use of an Unmanned Aerial Vehicle (UAV)-based active AirCore system to quantify methane emissions from dairy cows, Science of The Total Environment, Volume 831, 154898, <https://doi.org/10.1016/j.scitotenv.2022.154898>

A. Karion et al., AirCore: An Innovative Atmospheric Sampling System, Journal of Atmospheric and Oceanic Technology, Volume 28: Issue 11, <https://doi.org/10.1175/2010JTECHA1448.1>