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Methane point source detection and quantification from high-resolution satellite observations and deep learning methods

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Methane (CH_4) is the second most important anthropogenic greenhouse gas (GHG) in terms of its overall effect on climate radiative forcing. The atmospheric residence time of methane is considerably shorter than that of carbon dioxide, but its warming potential significantly stronger. Methane is produced from natural sources such as wetlands, and as a result of human activities, such as the oil and gas industry. A small number of anomalously large anthropogenic point sources are a major contribution to the total global anthropogenic methane emission budget, thus early detection of such sources has great potential for climate mitigation.

Methane satellite observations are now possible from a number of instruments with very high spatial resolution which allow to map methane emission plumes from individual emission sources. In this work, we explore the capabilities of three satellites with different specifications, spatial coverage and spatial resolutions ranging from metres (WorldView-3; multi-spectral) to tens of metres (PRISMA; hyperspectral) to kilometres (TROPOMI; hyperspectral). This leads to different capabilities for detecting and quantifying methane point sources that can complement each other. Thanks to its good coverage, TROPOMI Level 2 XCH4 data (from IUP Bremen) allows to locate areas with methane anomalies which can then be further analysed with targeted PRISMA and WorldView-3 (WV-3) observations to quantify methane emissions from small point sources.

In our work, we use a fast data-driven retrieval algorithm to derive methane column enhancements from PRISMA and Worldview-3, combined with a statistical method to identify methane plumes and the well-established Integrated Mass Enhancement (IME) method to derive emission flux rates. We developed a simulation framework to characterise and test our approach. This makes use of synthetic methane plumes generated with the Large Eddy Simulation extension of the Weather Research and Forecasting model (WRF-LES) that have been embedded into WV-3 or PRISMA images. To further advance the plume detection methods and to allow automatisation, we have developed a deep learning model for WV-3 or PRISMA based on the WRF-LES simulations.

In this presentation, we will describe and characterise our plume detection method for three

satellite systems covering a wide range of spatial resolutions and we will introduce our deep learning approach. Both methods have been applied to case studies with a focus on emissions from coal mining in South Africa and Australia which we will use to discuss and contrast the different methods and satellite systems.