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Earth Observations, Digital Footprints and Machine-Learning: Greenhouse Gas Stocktaking for Climate Change Mitigation

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Introduction & Background

Methane (CH₄) is a powerful greenhouse gas, leaving both a physical and digital footprint from natural (40%) and human (60%) sources. Its atmospheric concentration has increased from 722 ppb before the industrial age to 1,922 ppb in recent times. Because of its global warming potential, measuring and monitoring CH₄ is crucial to mitigating the impacts of climate change. However, large uncertainties exist in “bottom-up” inventories (a product of activity data based on counts of components, equipment or throughput, and estimates of gas-loss rates per unit of activity for different land uses) reported to the United Nations Framework Convention on Climate Change, making it difficult for policymakers to set emission reduction targets.

To address this, we employ causality-constrained machine learning (ML) to combine different gas observations from satellite sensors onboard the TROPOspheric Monitoring Instrument (which measure a digital footprint of human methane-generating behaviour) with outputs from chemical modelling. These are linked with datasets from the national statistics office, meteorology office and a comprehensive survey on quality of life in the emission field, to improve bottom-up estimates of CH₄ emissions at the Earth’s surface.

Objectives & Approach

The research uses mixed methods for collecting and analysing both qualitative and quantitative data for multidisciplinary processing strategies for monitoring CH₄ emissions locally and regionally. It also assesses whether additional “digital footprint” variables besides the well-known chemical sources and sinks can be studied to improve our understanding of the CH₄ budget.

We have conducted an “analytical inversion” of satellite observations of CH₄ to obtain emission fluxes. These represent the dependent variable for our ML model, in combination with 22 independent variables (co-occurring trace gases, meteorological fields, land use, land cover, population, livestock, and data from a survey of quality of life from the Gauteng City-Region Observatory, covering a broad range of socio-economic, personal and political issues) with near-real-time Earth observation data, to aid the development of a causality-constrained ML model for the prediction of CH₄ fluxes.

Relevance to Digital Footprints

We make use of not only satellite imagery, but socio-economic, demographic, and environmental data, and repurpose it for environmental sustainability in the context of mitigating climate change. We are creating unique resources in documenting rapid changes in emissions.

Conclusions & Implications

This research will make important contributions to developing countries with limited resources, enabling them to contribute to the global stocktake towards net-zero by helping policymakers identify geographic regions that are major emitters, enabling them to put measures into place to mitigate emissions.

