Diagnosing anthropogenic carbon emissions: A 'carbon dioxide checkup' of Earth's health

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A swarm of drones for coordinated observation. Credit: Dongxu Yang

Since 2020, many countries have pledged their plans for "carbon peak and carbon neutrality". Managing anthropogenic emissions, especially from major industries, is crucial for addressing global warming and promoting sustainable growth. However, existing emission records lack transparency and accuracy due to limited knowledge of CO_2 emissions from cities and key sectors, leading to uncertainty in the global carbon

budget and hindering carbon asset management across industries.

To ensure precise carbon emission data, the 2019 Refinement to the 2006 Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories advocates using atmospheric measurements and inversion techniques for validating and improving emission inventories. Given the complexity of anthropogenic emissions, continuous high-quality monitoring of atmospheric CO_2 concentrations is essential.

Recent research conducted by Dr. Dongxu Yang and his team from the Carbon Neutral Research Centre at the Institute of Atmospheric Physics, Chinese Academy of Sciences (IAP, CAS), is shedding light on the critical issue of anthropogenic carbon dioxide emissions and their impact on the Earth's climate. They conducted a campaign in Shenzhen, Guangdong Province, and Nanning, Guangxi Zhuang Autonomous Region, focusing on monitoring greenhouse gas emissions from urban and vital sectors.

During this campaign, they established the Low-cost UAV Coordinated Carbon Observation Network (LUCCN) equipped with medium-accurate greenhouse gas sensors for CO_2 measurements. LUCCN combines ground-based and UAV-based in-situ measurement instruments, enhancing the detection and quantification capability of point source emissions in three dimensions.

Dr. Yang said that existing and even near future satellite measurements cannot meet the frequent monitoring requirements for anthropogenic emissions due to cloud cover, aerosols, and revisit patterns. Therefore, the development of an adaptable observation network is crucial for accurate monitoring and data collection on greenhouse gas emissions.

Following data collection, conversion of CO_2 concentration data into

emission intensity is essential for validating emission inventories.

The research utilized the UAV-measured data to calculate emission flux using a cross-sectional flux (CSF) method, resulting in a slightly overestimate than the Open-source Data Inventory for Anthropogenic CO_2 inventory (ODIAC) due to data limitations associated with UAV in-situ measurements. ODIAC is a global high-resolution emission data product for fossil fuel CO_2 emissions, originally developed under the Greenhouse gas Observing SATellite (GOSAT) project at the National Institute for Environmental Studies (NIES), Japan. This discrepancy underscores the current challenge of UAV-based measurements.

The study showcases LUCCN's requirements and accomplishments and provides insights for future quantitative research into anthropogenic emissions. Nonetheless, the UAV sampling strategy and emission estimation methods require further exploration.

"We are now developing a measurement-fed-perception self-adaptation network strategy for the LUCCN system to improve monitoring efficiency, and atmospheric inversion will be applied to enhance emission estimates. These tasks are essential for monitoring anthropogenic emissions," said Dr. Yang Dongxu.

The initial findings of the campaign are published in Advances in Atmospheric Sciences.

More information: Dongxu Yang et al, Toward Establishing a Low-cost UAV Coordinated Carbon Observation Network (LUCCN): First Integrated Campaign in China, *Advances in Atmospheric Sciences* (2023). DOI: 10.1007/s00376-023-3107-5