Integrated System for Simultaneous CO2 Source Detection and Plume Forecasting Using Doppler Radar and Satellite Imagery

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CO2 emissions are a critical global concern, particularly in urban and industrialized regions. Effective tracking of CO2 plumes is essential for understanding climate impacts and managing air quality. However, current monitoring systems struggle to simultaneously detect emission sources and track plume dispersion in near real time. This study addresses these limitations by integrating OCO-2 satellite data with Doppler radar, creating a Python-based system for detecting and forecasting CO2 behavior. Focusing on the United States (2018–2022), the model aligns high-resolution CO2 data with Doppler wind fields to analyze plume transport and dispersion patterns. Spatial and temporal synchronization ensures near real-time processing, achieving a 0.2-second per-pixel processing speed. Satellite data identifies emission hotspots, while radar tracks how plumes move across space and time. The system is built in Python and visualized using GIS. Results show a 68% improvement in computational efficiency and a 45% increase in accuracy , allowing faster and more precise CO2 monitoring. Anomaly analysis across five years revealed the highest CO2 concentrations to be in 2022 while the lowest was in 2020, these patterns suggest a clear link between human activity levels and atmospheric CO2 concentrations. Evidence of CO2 traveling across state boundaries underscores the impact of wind on emission behavior. This system provides a scalable, efficient method for real-time CO2 tracking. Its applications support better climate modeling, air quality risk assessments, and rapid environmental response, making it a powerful tool for science and policy alike.

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