ANOMaLY: A Real-Time Globalized System for Effective Regional Mitigation of Agricultural Nitrous Oxide Emissions

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Nitrous oxide (N2O) is one of the largest contributors to the greenhouse effect (265x more greenhouse forcing than CO2) and is the largest contributor to ozone depletion in the 21st century. Over 70% of anthropogenic N2O is emitted directly from agriculture and soil management, and previous studies have observed that these emissions spike in localized spatiotemporal events. The system developed in this project identifies these events in real-time across the globe, allowing for fast and effective mitigation measures to be put in place to quickly reduce total emissions. Sentinel-2 imagery was correlated with soil chemical data gathered by the author from 7 farms across North Carolina over 6 months (1200+ samples taken) and used to extract novel spectral indices that approximate soil NH4+ and NO3- (R2 = 0.53, 0.46). Existing data was paired with soil chemical data using the new spectral indices and was used to build an informed model that integrated partial differential equations modeling microbial nitrogen kinetics into a neural network architecture. This informed model explained ~80% of variation in regional N2O a large improvement over previous models explaining only ~30% of variation. Due to this system using real-time satellite and climate data, localization of regional-scale flux hotspots can be achieved at nearly any place and time on Earth. At maximum capacity, this system can localize over 55% of total anthropogenic N2O emissions and is generalizable to various agricultural gas-based pollutants. Additionally, the world's first spatiotemporally linked soil nitrate and ammonium dataset was developed for this project.