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SIMULATION OF HIGH RESOLUTION SATELLITE ORBITS TO MAXIMIZE FREQUENCY AND QUALITY OF METHANE EMISSION DETECTION OVER A SOLID WASTE LANDFILL IN RIO DE JANEIRO, BRAZIL

Abstract

In recent years, methane has received significant attention as a powerful greenhouse gas. Although methane has a far higher global warming potential than carbon dioxide, it dissipates from the atmosphere far more quickly, presenting an opportunity for policymakers to mitigate short-term climate change through identification of large anthropogenic emission sources. At the same time, newly launched satellites can remotely sense these sources with higher precision, better spatial resolution, and shorter revisit times than their predecessors. These enhanced capabilities provide advantages such as identification of previously unknown sources and quantification in places where it is expensive or infeasible to install ground sensors or perform aerial flybys. GHGSat is a prominent example of a company that has taken advantage of these new possibilities, operating a growing constellation of methane-detecting satellites since the launch of their demonstration instrument in 2016. Previous work, conducted under NASA's Commercial SmallSat Data Acquisition (CSDA) program, gathered observations from GHGSat's constellation over the main solid waste landfill serving the city of Rio de Janeiro, Brazil between 2022 and 2024. Paired with stakeholder interviews, field visits, and collaboration with the city government, that work revealed both a significant increase in observed methane emissions over the course of a week and potential actions by the operators of the landfill that may have contributed to this variation. The combined results serve as a case study to begin applying the Environment-Vulnerability-Decision-Technology (EVDT) Framework, a Systems Engineering Framework that links natural phenomena, social circumstances, decision-making authority, and technological ability. This paper builds on these results to develop a Systems Engineering analysis that simulates the orbits and access opportunities of current and future satellites by GHGSat and other operators. Software is used to simulate the positions and trajectories of the satellites in relation to the landfill to identify patterns of frequent, high-quality access with low pointing angles. Additional satellites are added, and parameters such as inclination, ascending node, and true anomaly are varied. A trade space analysis illustrates which design features of a methane monitoring constellation are drivers of benefits for municipal landfill operators. A lack of in-situ knowledge of wind speed is a major source of uncertainty in satellite-derived quantification of methane emission plumes, so the analysis evaluates the utility of adding additional sources of wind speed measurement. These new results integrate data from multiple disciplines to provide better clarity on the utility of satellite technology to address urban landfill methane emissions.