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STUDY OF SMALL SATELLITE CONSTELLATION FOR HIGH-RESOLUTION GREENHOUSE GAS MONITORING

Abstract

The seriousness of the climate crisis has called for international efforts to drastically reduce greenhouse gas (GHG) emissions. This has been seen through international treaties, such as the Paris Agreement, in which 196 parties have committed to limit the global temperature increase well below 2 degrees Celsius above pre-industrial levels, and the Global Methane Pledge, which counts over 110 countries that have pledged to cut their methane emissions by 30% during the present decade.

In order to evaluate the success of these objectives, precise greenhouse gas monitoring is necessary. In-situ networks can provide accurate surface measurements, but offer very sparse coverage and must

therefore be complemented by satellite data. Many earth observation satellites, such as JAXA's GOSAT and ESA's Sentinel-5P, measure greenhouse gas using passive spectrometers that observe reflected solar light. However, these instruments are blind in high-latitude dark regions, suffer from low measurement sensitivity in the lower troposphere and are affected by undetected aerosol layers and thin ice clouds. This hinders measurements in northern areas or for offshore operations, notably in the oil and gas industry, which is a sector that presents both high emissions and high uncertainties.

This paper aims to improve the capacity of existing GHG monitoring systems by presenting a cost-effective conceptual small satellite constellation mission design based on a novel payload for active remote sensing of CO_2, CH_4 and N_2O with high temporal and spatial resolution. First, this paper presents a review of current small satellite missions and industrial needs to determine the mission requirements and current gaps in GHG emission monitoring. The mission parameters, such as the satellites' footprint, swath, observation frequency and revisit rate, are then derived to ensure high quality of data collection and temporal resolution. Finally, the proposed spacecraft design is presented, which is equipped with an active LiDAR (Light Detection and Ranging) instrument in combination with a passive spectrometer supported by enhanced fusion algorithms and the latest state-of-the-art satellite architecture, enabling increased sensitivity to GHG independently of surface contrast, sunlight, cloud coverage or atmosphere composition.