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THE MARTIAN ATMOSPHERIC GAS EVOLUTION (MAGE) EXPERIMENT

Abstract

Methane observation at Mars over the past two decades has revealed a dynamic geochemical system of distinct plumes (up to 45 ppbv) as well as diurnally- and seasonally-varying background seepage (¿1 ppbv). The sources and sinks for this methane are unclear due largely to the difficulty in obtaining frequent (hourly or better) methane measurements. To better characterise the behaviour of methane, there is a need for near-surface, high-frequency, and low resource measurements. Current spectrometers on the surface of Mars (e.g. SAM-TLS aboard the Curiosity/Mars Science Laboratory rover) are limited in their ability to perform such measurements. We are developing a small, low-power, autonomous, surface observatory capable of taking high-frequency, sub-ppb level trace gas measurements.

The Martian Atmospheric Gas Evolution (MAGE) instrument is based on Off-Axis Integrated Cavity-enhanced Output Spectroscopy (OA-ICOS) technology developed by ABB Inc. The ICOS spectrometer is capable of the frequent, sub-ppb measurements that are needed to characterize trace gases including methane. ABB is currently developing a version of this instrument that is optimized for the martian environment through a Canadian Space Agency grant. While OA-ICOS technology is comparable to Cavity-Ringdown Spectroscopy (CRDS), it presents several advantages for space missions, these include (1) resistance to vibrations, temperature and pressure changes, (2) a larger dynamic range for analysed gases, and (3) simpler back-end electronics. In comparison to existing surface spectrometers such as SAM-TLS, its effective path length of up to 100 km improves sensitivity by as much as 10 000x, and it does not require the resource-intensive CO2 scrubbing of the SAM-TLS to make sub-ppbv measurements.

We have used existing ICOS spectrometers over two summers in the high Canadian Arctic (Umingmat Nunaat (Axel Heiberg Island), Nunavut, Canada), a terrestrial analog to Mars. The instrument could

observe background levels of methane over various time scales, as well as localising methane point sources based on wind direction under natural conditions. The instrument is also scheduled to be deployed on a stratospheric balloon flight in summer 2025, where it will demonstrate its behaviour at Mars-like pressures and temperatures. Both locations demonstrate the suitability of ICOS technology in characterizing methane in Mars analogue environments.