Development of Unmanned Aerial Vehicle Spectrometer (UAV-MS) Systems for Calibration and Validation of Satellite Remote Sensing Data using In-Situ Volcanic Plume analysis

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The advancements of small unmanned aerial vehicles (UAV), along with the development of a variety of sensor packages, have enabled in situ and proximal remote sensing measurements of volcanic plumes. Using Costa Rican volcanoes as a Natural Laboratory, the University of Costa Rica as host institution, in collaboration with NASA and JPL, is continuing with an initiative to develop field-deployable unmanned airborne MS systems to perform volcanic gas & ash plume research and in-situ volcanic monitoring and gas composition analysis in conjunction with orbital assets and state-of-the-art models of plume transport and composition.

Several small and miniature mass spectrometer based systems (named *ULISSES*) have been integrated for different UAV platforms and lab tested. The different ULISSES MS versions are then combined with temperature, pressure, relative humidity, electrochemical cell SO2, and GPS sensors payload that have been already UAV deployed into the active plume of Turrialba volcano in Costa Rica, generating 3D plots of SO2 concentration near the volcano while simultaneously, remote sensing data is collected from the ASTER and OMI space borne instruments and compared with the in-situ data. The first UAV Mission deployment performed in March of 2013 demonstrated a path to study and visualize gaseous volcanic emissions using mass spectrometer and gas sensor based instrumentation in harsh environment conditions to correlate in situ ground/airborne data with remote sensing satellite data for calibration and validation purposes

The latest ULISSES MS version involves the use of miniature turbo pump from Creare Inc, similar to the ones used by the Mars Science Lab (MSL) of the Curiosity Rover; and the Transpector XPR3 Miniature Quadruple MS (1.8cm rods, $r_o < 0.38$mm) from Inficon, capable to operate in the mtorr vacuum range.

The deployment of such technologies improves on our current capabilities to detect, analyze, monitor, model, and predict hazards presented to aircraft by volcanogenic ash clouds from active and impending volcanic eruptions.