Fly Testing a Drone-MS Prototype (Drone Based Mass Spectrometer System) at Solfatara Volcano for in situ Volcanic Gas Plume Measurements

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Assessing gas emissions of eruptive volcanoes is a risky task that cannot be performed with portable hand- or backpack-carried gas analysis systems. Sudden explosions or high concentrations of toxic gases make it impossible for scientists and volcanologists to enter an area close to the active crater to make the needed in situ measurements to determine if the nature of the eruptions is magmatic or not. Changes in ratios between chemical species have been observed to be precursors to increasing volcanic activity, therefore there is a need to provide local authorities and researchers the technical capability to continue monitoring chemical emissions, complementing other techniques, to assess the dangers of the ongoing activity. Satellite-based remote sensing and near-field remote sensing instruments are useful to provide gas flux information when is not possible to perform in situ sampling. Not all gases of interest however, can be measured with this method, they still require in situ data validation to provide proper measurements of the gas fluxes emitted by the volcano. Since 2009 the present international collaboration team, together with many other research partners, have been working to integrate in situ gas analysis instrumentation (e.g., miniature mass spectrometers [miniMS] and miniature gas detection payloads [miniGAS] with fixed and rotary wing unmanned aerial vehicles [UAVs]). Our goal is to develop airborne payloads as a way to implement systematic in situ calibration and validation of remote sensing data using volcanic plume measurements, and also to have a tool to characterize volcanic emissions and chemical ratios during bigger eruptions without risking human lives. This task has not been an easy one, since it both involves the development of the new airborne platforms and custom instrumentation, while facing new and more restrictive regulations for the use of UAVs worldwide, imposing limits on where and how to use such platforms. This talk describes the development and flight testing of our first Drone-MS system succesfully integrated into an INGV multi-copter and flown at La

Solfatara Volcano, Italy. This constitutes our latest advance in developing a completely autonomous unmanned aerial system for in situ chemical analysis, which can be used under harsh environmental conditions. The 8kg payload is based on a modified XPR3 miniature quadrupole from Inficon Inc. (1-100amu and capable of operating in the mtorr range), together with the smallest turbo drag pump from CREARE (10^{-4} torr using direct sampling), an embedded PC, and a Lipo battery and telemetry for real-time chemical concentration analysis and 3D mapping of active volcanic plumes. The drone is an ITALDRONE octocopter with 10kg payload capabilities, 1km range and 20min endurance. Other UAV-MS integrations and flight test demonstrations are under way in USA and Costa Rica, pending hardware readiness reviews and flight permits.