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Gas Concentration Mapping of Arenal Volcano using AVEMS

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Introduction

The Arenal Volcano Emission Mass Spectrometer (AVEMS) System developed by NASA Kennedy Space Center and National Center for Atmospheric Research (NCAR) using equipment from the COSTAR Project was successfully used for mapping gas emissions from the Arenal Volcano in Costa Rica. The data was generated in conjunction with Landsat 7 ETM+ data in March 2002. The Arenal Volcano Emission Mass Spectrometer is a Edgerton quadrupole mass spectrometer with four quadrupoles with two ionization detectors and a combination of mass spectrometer and vacuum systems. The system was designed to make measurements of the concentration of a contaminant gas along a flight path. The goal of this project was to demonstrate the ability of AVEMS to detect and map gas emissions and airborne volcanic aerosol layers. The system was also designed to make measurements of gas concentrations in real time and to provide data with the potential to be used for modeling purposes.

System Description:

The Arenal Volcano Emission Mass Spectrometer (AVEMS) system is designed for deployment on an aircraft and can be housed in a passenger compartment. The system is composed of a 170 Da quadrupole mass analyzer, a volume of 2000 cm³, a detector, and a control computer. This mass spectrometer was able to detect and measure gases with a sensitivity of 0.1% of the total gas volume. The system also has the ability to measure temperature and pressure.

In situ gas data in this work, consisting of helium, carbon dioxide, sulfur dioxide, and others, were acquired in conjunction with GPS data which was paired with the topography. The data was collected using a combination of GPS and SRTM data. The system was also able to obtain data with remote sensing data. The data was then analyzed to understand the pyroclastic flow behavior in case of a major eruption.

Map Generation and 3D visualizations:

The gas concentration data collected with AVEMS during the different flights contains geographical location attributes (Latitude, Longitude, Altitude) and 3D visualization of volcanic gases. The data is then used to locate spatially the volcanic plume. In order to model the plume location, which is not necessarily visible to the human eye and poorly represented if it is located in two dimensions, digital elevation data obtained by other sensors during the COSTAR 2005 campaign, topographic data generated by the Shuttle Radar Topographic Mapping (SRTM) Mission and remote sensing data from the LANDSAT satellite (both geo-referenced) are combined to produce a 3D model based on the gas concentration data. In this way, characteristics related to the flight path direction and position of the volcanic plume are visible in the 3D model.

Conclusions:

AVEMS demonstrated its usefulness in aerial plume analysis at Arenal Volcano, presently the most active Costa Rican volcano. Several 3D gas concentration visualizations were created for several gases. These 3D maps now serve to model plume direction and variability to predict possible impact on urban area and crops in the area close to the volcano, as well as to be used as a guide for aircraft operation near the volcano. Other applications of AVEMS, used during the COSTAR 2005 campaign included ground tephroclast emission analysis. Also, the concentration of tephra and gas around urban areas was measured at multiple times to provide temporal information as well.

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AVEMS team during COSTAR 2005 Campaign: PRIRAS-CENAT, NASA, KSC researchers and CICANUM UCR students.