Deployments of small unmanned airborne vehicles (UAVs) with a variety of sensors enable in situ sampling and proximal remote sensing measurements of volcanic plumes with considerably reduced risk to researchers. Primary goals include the calibration and validation of satellite remote sensing data (e.g., the US-Japan Advanced Spaceborne Thermal Emission and Reflection radiometer--ASTER). We are developing and testing low-cost, field-deployable airborne platforms and instrumentation to conduct volcanic gas and ash plume research in conjunction with orbital observations to validate state-of-the-art retrieval models of plume transport and composition. Costa Rican volcanoes provide natural laboratories for this research because of their relatively benign current behavior, (e.g., at Volcan Arenal for ash sampling and Volcan Turrialba for sulfur dioxide sampling and ash), facilitated access of UAVs to local airspace provided by local authorities, and good technical infrastructure. Several electro-chemical gas sensors, a miniature mass spectrometer, and temperature, pressure, relative humidity, and GPS sensors, were deployed into the active plume of Turrialba Volcano, during ASTER and Ozone Monitoring Instrument (OMI) overpasses over the last year. A variety of airborne platforms were utilized, including manned research aircraft, UAVs, tethered balloons, as well as man-portable in–situ ground truth systems. Initial in situ balloon-borne electrochemical sensor measurements within the Turrialba plume indicate ambient sulfur dioxide concentrations in the range of tens of ppmv within a few kilometers of the Turrialba summit vent. Such concentration measurements are consistent with correlative remote sensing retrievals. Detailed horizontal and vertical sulfur dioxide concentration profiles for Turrialba plumes are currently being constructed.