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Above-canopy drone detection of elevated CO_2 gradients from volcanic gas seeps in a Costa Rican rainforest.

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Persistent volcanic CO_2 gas seeps are commonplace on the broad slopes of active volcanoes and often devoid of acid gases due to subsurface scrubbing. Small variations in excess diffuse soil CO_2 flux can be diagnostic for volcano monitoring and early warning applications. At many tropical volcanoes, however, these sites are difficult to find and access due to dense vegetation and the vast terrain of volcanic landscapes. Satellite remote sensing techniques lack the sensitivity and spatial resolution needed to detect these seeps, but airborne techniques offer solutions for routine or spot investigations of CO_2 fluxes from these otherwise hidden gas seeps.

We reviewed the requirements for deploying small unmanned aerial systems (sUAS) for these environments and integrated the best suited sensor in a fixed-wing sUAS specifically designed for autonomous operations and long endurance in extreme environments, without causing significant disturbance of the sampled air. Test flight results on the flanks of Turrialba volcano in Costa Rica above forest canopies covering known moderate gas seeps demonstrate the detection and mapping capabilities of above-canopy elevated CO_2 gradients. The strong detection capabilities and high detector signal stability resulted from key system design elements including RF shielding, mechanical stabilization, and calibration procedures. This highly robust system is readily applied for diffuse volcanic CO_2 emission studies on active volcanoes covered by dense vegetation. Future studies may benefit from this system, which is specifically designed to detect, map, and track diffuse volcanic CO_2 gas seeps and their atmospheric gradients, on the forested flanks of tropical volcanoes.