Predicting hot spots and hot moments of biogenic gas accumulation and release in a subtropical ecosystem using airborne ground-penetrating radar (GPR)

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Peat soils are major terrestrial carbon stores and large natural producers of biogenic greenhouse gases (e.g., methane and carbon dioxide). These gases accumulate in the soil matrix to be subsequently released to the atmosphere, therefore directly influencing climate change. While recent advances have been made with regards to the prediction of carbon fluxes, many uncertainties still exist to properly understand the spatial distribution of hot spots and hot moments for the accumulation and release of biogenic gases. This can be attributed to the limitations in terms of effective non-invasive methods that can be deployed at scales of measurement relevant for the imaging and identification of such hot spots. This project intends to test a prototype ground-penetrating radar (GPR) unit mounted on a small unoccupied aircraft system (sUAS) to efficiently identify the presence of hot spots and hot moments in subtropical peat soils of the Everglades and explore how certain physical (i.e. soil structure) and biochemical properties (i.e. metabolic pathway) may influence its dynamics. As a preliminary phase, a series of measurements both at the laboratory and field scales were performed to test the ability of GPR to identify contrasts in relative dielectric permittivity associated with variable soil biogenic gas content for different antenna ground couplings (i.e. variable air gaps). Measurements were performed in soils from the Grassy Waters Preserve, a 60 square km wetland ecosystem near West Palm Beach (FL) that represents a pristine remnant of the historical Greater Everglades system. At the laboratory scale, a high frequency antenna was suspended over a peat monolith (extracted from the same site) using a custom-made rail system that allowed for the antenna to move autonomously and monitor changes in dielectric permittivity associated with biogenic gas build up and release at high temporal resolution. At the field scale, an array of antennas (with

frequencies ranging from 160-750 MHz) suspended from a wooden frame were also tested to determine the antenna frequency with the best compromise between resolution and depth of penetration when targeting hot spots for gas accumulation. Preliminary results are consistent at showing the potential of GPR for efficiently imaging hot spots for gas accumulation in a variety of settings, and therefore show promise for expanding scales of measurement via airborne/drone GPR.