HYPERSPECTRAL IMAGING FOR LARGE-AREA MONITORING OF CARBON DIOXIDE GEOLOGIC SEQUESTRATION SITES

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Hyperspectral imaging will be used in both a greenhouse study and a controlled outdoor research experiment to analyze the viability of remote sensing to be used as a monitoring tool for subsurface carbon storage sites. The Intergovernmental Panel on Climate Change (IPCC) has postulated that at current rates average global temperatures will rise 1.4ºC (2.5ºF) to 5.8ºC (10.4ºF) between 1990 and 2100 (IPCC, 2000). The contemporary global climate crisis demands mitigation technologies to curb atmospheric greenhouse gas emissions. Carbon dioxide is the most critical of all the greenhouse gasses due to its overall relative abundance as an insulating gas in our atmosphere. The U.S. Department of Energy is investigating a variety of avenues to sequester atmospheric carbon dioxide for long periods of time. One carbon capture and storage (CCS) technology is geologic sequestration. Geologic carbon sequestration takes point source emissions from stationary power plants and drilling operations to capture and purify the carbon dioxide for storage in deep subsurface geologic formations (Lawrence Livermore National Library, 2005).

Accompanying this technology is the inherent responsibility to monitor these large-scale carbon dioxide reservoirs for leaks to ensure safety to local environments and inhabitants, as well as to alleviate global warming. In 1986, a carbon dioxide gas bubble exploded in

Lake Nyos in Western Cameroon resulting in over 1,800 deaths (Kling et al., 2005). On Mammoth Mountain, CA, a snow cavern collapsed around a volcanic vent killing three ski patrollers from asphyxiation (UCSB--Office of Public Affairs, 2006). These are evidence of the potential hazard that accompanies storing large quantities of carbon dioxide deep within the earth. Cost-effective, large-scale monitoring of surface leaks for proposed geologic sequestration sites will be required to ensure site safety and to keep targeted carbon sequestered for climate change mitigation.

It has been postulated that periodic airborne campaigns utilizing remote sensing technology can offer relatively low-cost, broad coverage methods for monitoring large land areas to detect carbon dioxide leaks expressed as plant stress at the surface (Keith et al., 2009). Because plants are the predominant ground cover at sequestration sites, they can act as an early warning mechanism to signal operational inefficiencies in hazardous leak scenarios. Remote sensing technology has the potential to detect leaks before they are recognized with human sensory perception. Hyperspectral imaging, in particular, might discern subtle changes in relative reflectance of plants in response to elevated soil carbon dioxide concentrations via energy detection in numerous, narrow bands throughout the electromagnetic spectrum. Elevated carbon dioxide levels in soil are known to cause anoxic conditions in plant roots, whereby oxygen is displaced at the roots, disrupting plant respiration and causing acidification of the ground water and inducing a stress response (Noomen & Skidmore, 2007).

The extent to which hyperspectral imaging can be utilized to detect soil carbon dioxide concentrations will be analyzed in a greenhouse experiment that addresses two key questions: 1) How fast can a leak be detected? & 2) How small of a leak can be detected? Plants will be subjected to three carbon dioxide leakage rates to mimic geologic sequestration leak scenarios and hyperspectral images will be obtained bi-weekly for a month once plants reach maturity. While it has been determined that elevated gas levels in soil corresponded to discernable hyperspectral plant stress signals in Maize plants, other physiological factors, such as water stress, that could lead to similar spectral responses were unexamined (Noomen & Skidmore, 2009; Noomen et al., 2008). This study will identify discrete reflectance channels that are indicative of a carbon dioxide-induced plant stress response. Concurrently, the spectral responses of these plants will be compared to those of plants subjected to water-stress conditions to determine how plant physiological responses may vary spectrally. Lessons learned from the greenhouse experiment will inform an airborne hyperspectral imaging campaign in a controlled, outdoor leakage experiment to assess the capability of hyperspectral remote sensing in a real-world context (Keith et al., 2009).

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