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Damage evaluation for crops exposed to a simulated leakage of geologically stored CO_2 using hyperspectral imaging technology

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Facilities for the geological storage of carbon dioxide (CO_2) as part of carbon capture and storage (CCS) schemes will be designed to prevent any leakage from the defined 'storage complex'. However, even though the risk is of low probability, the precautionary principle requires that near surface environments that might be at risk be thoroughly monitored to detect a leak, were it to happen. Among all currently proposed monitoring methods, only hyperspectral imaging of vegetation stress response allows one to scan large areas rapidly and in detail. Until now, however, only a handful of studies have been carried out on using this novel technology. The aim of the present communication was to characterize the impacts that a simulated CO_2 leak might have on the hyperspectral signature of a Norwegian oats crop.

In order to test the effects of different intensity of leakage, a CO_2 exposure field experiment was designed to create a longitudinal CO_2 gradient. For this purpose a gas supply pipe was inserted at one end of a 6m by 3m experimental plot at the base of a 45 cm thick layer of sand buried 40 cm below the surface under a silt loam plough layer. CO_2 was then injected at a rate of 2l.min-1 just after the oats had germinated at the end of June, and Facilities for the geological storage of carbon dioxide (CO_2) as part of carbon capture and storage (CCS) schemes will be designed to prevent any leakage from the defined 'storage complex'. However, even though the risk is of low probability, the precautionary principle requires that near surface environments that might be at risk be thoroughly monitored to detect a leak, were it to happen. Among all currently proposed monitoring methods, only hyperspectral imaging of vegetation stress response allows one to scan large areas rapidly and in detail. Until now, however, only a handful of studies have been carried out on using this novel technology. The aim of the present communication was to characterize the impacts that a simulated CO_2 leak might have on the hyperspectral signature of a Norwegian oats crop.

In order to test the effects of different intensity of leakage, a CO_2 exposure field experiment was designed to create a longitudinal CO_2 gradient. For this purpose a gas supply pipe was inserted at one end of a 6m by 3m experimental plot at the base of a 45 cm thick layer of sand buried 40 cm below the surface under a silt loam plough layer. CO_2 was then injected at a rate of 2l.min-1 just after the oats had germinated at the end of June, and continued until it was harvested at the end of August. Then soil CO_2 fluxes were recorded at the surface using a (60 x 60 cm) grid sampling pattern.

Hyperspectral images of the experimental plot were taken at different dates during the gassing period using a SPECIM camera with 800 spectral bands, covering the wavelength range 400 – 1000 nm. The change in the reflectance spectra were characterized over time within the plot by the computation of various hyperspectral vegetation indices for small discretized spatial units (i.e. 10 cm by 10 cm square).

The results showed that one month after injection, reduced plant growth, yellowing of the leaves and purple discoloration of the stems were observed just above the injection points were high CO_2 fluxes had been identified. These high CO_2 flux zones were further associated with an increase of the reflectance that occurred in the red region of the spectra indicating a decrease of the chlorophyll content in the plants. To conclude, plant health, as indicated by the hyperspectral signature, was closely related to the leakage pattern, indicating that hyperspectral imaging could be used to identify a CO_2 seepage in an agricultural field.

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