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Detection of CO_2 leaks from carbon capture and storage sites to the atmosphere with combined CO_2 and O_2 measurements

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One of the main issues in carbon capture and storage (CCS) is the possibility of leakage of CO_2 from the storage reservoir to the atmosphere, both from a public health and a climate change combat perspective. Detecting these leaks in the atmosphere is difficult due to the rapid mixing of the emitted CO_2 with the surrounding air masses and the high natural variability of the atmospheric CO_2 concentration. Instead of measuring only the CO_2 concentration of the atmosphere, its isotopes or chemical tracers that are released together with the CO_2, our method uses O_2 measurements in addition to CO_2 measurements to detect a leak from a CCS site.

CO_2 and O_2 are coupled in most processes on earth. In photosynthesis, plants take up CO_2 and release O_2 at the same time. In respiration and fossil fuel burning, O_2 is consumed while CO_2 is released. In case of a leak from a CCS site, however, there is no relationship between CO_2 and O_2. A CO_2 leak can therefore be distinguished from other sources of CO_2 by looking at the atmospheric CO_2-O_2 ratio. A natural increase of the CO_2 concentration is accompanied by a drop in the O_2 concentration, while an increase in the CO_2 concentration caused by a leak from a CCS site does not have any effect on the O_2 concentration.

To demonstrate this leak detection strategy we designed and built a transportable CO_2 and O_2 measurement system, that is capable of measuring the relatively minute (ppm's variations on a 21% concentration) changes in the O_2 concentration. The system comprises of three cases that contain the instrumentation and gas handling equipment, the gas cylinders used as reference and calibration gases and a drying system, respectively. Air is pumped to the system from an air inlet that is placed in a small tower in the field. At the conference, we will demonstrate the success of leak detection with our system by showing measurements of several CO_2 release experiments, where CO_2 was released at a small distance from the air inlet of our instrument.