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Preferential flow pathways revealed by field based stable isotope analysis of CO_2 by mid-infrared laser spectroscopy

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A newly developed and commercially available isotope ratio laser spectrometer for CO_2 analyses has been tested during a 10-day field monitoring campaign at the Ketzin pilot site for CO_2 storage in northern Germany. The laser instrument is based on tunable laser direct absorption in the mid-infrared. The instrument recorded a continuous 10-day carbon stable isotope data set with 30 minutes resolution directly on-site in a field-based laboratory container during a tracer experiment. To test the instruments performance and accuracy the monitoring campaign was accompanied by daily CO_2 sampling for laboratory analyses with isotope ratio mass spectrometry (IRMS). The carbon stable isotope ratios measured by conventional IRMS technique and by the new mid-infrared laser spectrometer agree remarkably well within 2σ analytical precision (<0.3 ‰. This proves the capability of the new mid-infrared direct absorption technique to measure high precision and accurate real-time table isotope data directly in the field. The injected CO_2 tracer had a distinct δ13C value that was largely different from the reservoir background value. The laser spectroscopy data revealed a prior to this study unknown, intensive dynamic with fast changing δ13C values. The arrival pattern of the tracer suggest that the observed fluctuations were probably caused by migration along separate and distinct preferential flow paths between injection well and observation well. The new technique might contribute to a better tracing of the migration of the underground CO_2 plume and help to ensure the long-term integrity of the reservoir.