Monitoring Surface CO_2 Fluxes During Two Shallow Subsurface CO_2 Releases

Jennifer L. Lewicki[1], Marc L. Fischer[2], Laura Dobeck[3], and Lee Spangler[3]

[1] Earth Sciences Division, Ernest Orlando Lawrence Berkeley National Laboratory, 1 Cyclotron Rd, Berkeley, CA, 94720 USA, jllewicki@lbl.gov
[2] Environmental Energy Technology Division, Ernest Orlando Lawrence Berkeley National Laboratory, Berkeley, CA, 94720 USA
[3] Department of Chemistry and Biochemistry, Montana State University, 108 Gaines Hall, PO Box 173400, Bozeman, MT, 59717 USA

The ZERT project's shallow release facility on the Montana State University campus provides the opportunity to test field methods to detect and quantify potential CO_2 leakage from geologic storage sites. CO_2 release experiments were conducted from a ~100-m long horizontal well installed at ~2.5 m depth, sub-water table, within a sandy cobble. The well was separated into six zones by inflatable packers, from which 0.1 t CO_2 d^{-1} was released for ten days starting 07/09/2007 (Release 1), and 0.3 t CO_2 d^{-1} was released for seven days starting 08/05/2007 (Release 2). We measured soil CO_2 fluxes using the chamber method on grids repeatedly on a daily basis and net CO_2 fluxes continuously using the eddy covariance technique. Based on chamber measurements near the well, CO_2 breakthrough at the surface occurred on day two of Release 1. The spatial distribution and magnitude of leakage fluxes reached quasi-steady state by day six. Fluxes returned to near those measured at background locations two days following the end of Release 2. Spatial patterns in chamber CO_2 fluxes were strongly related to well design. Estimates of total, background (soil respiration), and leakage CO_2 discharges (t d^{-1}) based on chamber measurements showed that during Release 1, background CO_2 discharge was relatively high but declined at nearly the same rate as leakage discharge increased, leading to little change in total discharge. Conversely, during Release 2, background soil respiration remained low relative to leakage discharge.

Because the comparatively large spatial footprint of the eddy covariance measurements averages over both background and well locations, CO_2 leakage signals were difficult to detect by eddy covariance during Release 1, while during Release 2, signals were clearly detectable. Our results emphasize the influence of background CO_2 flux variations on the ability to detect leakage signals.