Measurement, Modeling, and Analysis of CO_2 in the Near-Surface Environment for Geologic Carbon Sequestration Verification

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Abstract. To ensure that geologic CO_2 storage is effective, monitoring of storage sites is necessary to verify that CO_2 is not leaking from the storage formation and seeping out of the ground. Numerical simulations show that CO_2 concentrations can reach high levels in the shallow subsurface even for relatively low leakage fluxes. However, once CO_2 seeps out of the ground, winds are effective at dispersing CO_2. This suggests that measurement and monitoring to detect incipient or low-level CO_2 leakage and seepage should be made in the near-surface environment, with focus on the shallow subsurface. In natural ecosystems, near-surface CO_2 fluxes and concentrations are controlled by a variety of biologic and hydrologic processes. Technologies for monitoring CO_2 in the near surface include the portable infrared gas analyzer, the accumulation chamber, and the eddy covariance method. To detect low-level seepage within natural background variability, we propose an approach that integrates detection and monitoring with statistical analysis and modeling. The proposed strategy initially focuses on measurements of CO_2 subsurface concentrations and surface fluxes in the storage area and in a control area. Based on statistical analysis of the data, areas with "high-probability" CO_2 anomalies can be analyzed using more expensive chemical and isotopic methods. Integrated analysis of all data will definitively determine if the CO_2 is derived from a deep fossil fuel source consistent with a geologic CO_2 storage site, the spatial extent of the anomaly, and the total CO_2 emission rate.