Multi-site CO₂ Sequestration Optimization using a Dynamic Programming Approach

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Abstract. Increased greenhouse gas emissions, resulting from our heavy dependence upon fossil fuels, have been found to be directly related to global warming. During the past 250 years, the average carbon dioxide (CO₂) concentration in the atmosphere has increased from about 280 to 385 ppm with approximately two thirds of this increase occurring in last 60 years. Global warming may lead to adverse conditions such as the melting of polar ice caps, raised ocean levels, as well as, altered weather patterns including higher intensity hurricanes and storms. While technological advances, public education, and enacting policy changes are excellent long-term solutions to this problem, carbon capture and sequestration (CCS) in addition to other short term solutions may provide a bridge to a sustainable future. Unfortunately, leakage of sequestrated CO₂ may contaminate air and water resources as well as adversely affect plant and animal life. These risks must be fully understood and minimized before implementation.

A preliminary decision support system (DSS) has been constructed to optimize CCS at five potential injection sites as to minimize the total cost of CO₂ leakage while meeting a specified sequestered mass target. This DSS uses Microsoft Excel for a graphic user interface (GUI) and database platform but employs CSUDP (a generalized dynamic programming software) as an optimization driver. An analytical leakage algorithm has been integrated into CSUDP’s objective function to estimate leakage costs. Based upon work by Nordbotten (2009), this algorithm quantifies the mass of CO₂ leakage through weak areas (such as abandon oil wells) in the caprock. The resulting DSS uses a wide range of geological, economical, and infrastructural parameters to output optimal CO₂ injection rates as well as injection durations for each site.

With additional effort the presented concept may become a potentially valuable tool for decision makers faced with the task of sequestration site selection. The leakage algorithm must be improved and validated against actual site data and an economic analysis should be performed to define model cost parameters. Also, the inclusion of stochastic dynamic programming would provide further insight in addressing caprock permeability uncertainty.

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