Massively parallel simulation of Geologic CO_2 storage on the Earth Simulator

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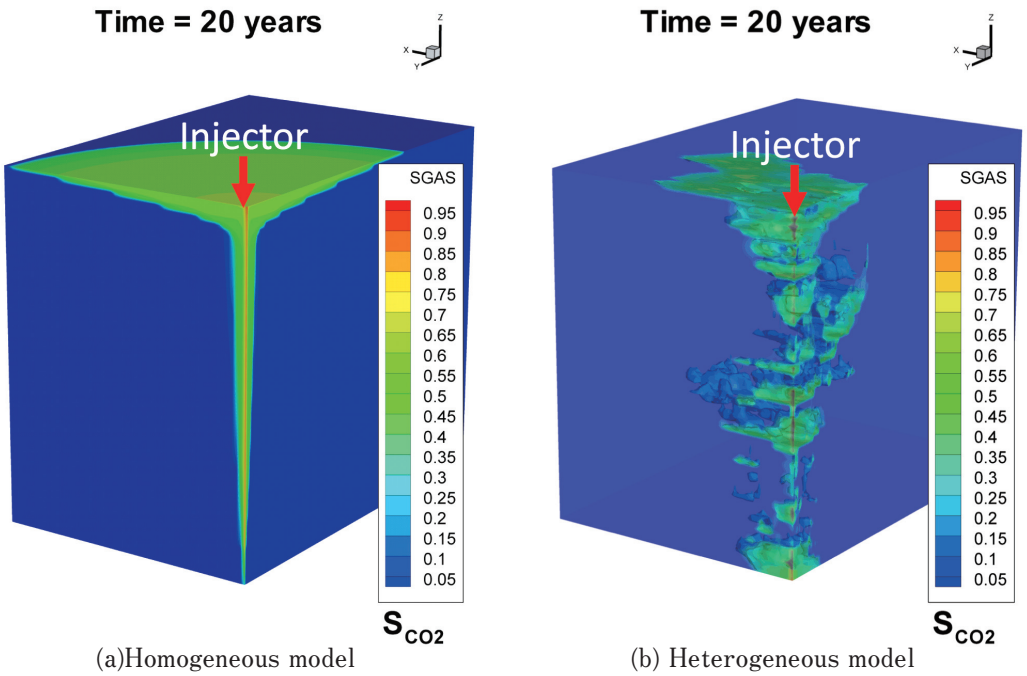
Abstract

CCS (carbon dioxide capture and storage) is a promising approach for reducing the greenhouse gas content in the atmosphere, through capturing carbon dioxide (CO_2) from large emission sources and injecting it into reservoirs (such as deep saline aquifers). Large-scale storage projects will likely involve very long-term storage of huge amounts of CO_2, potentially exceeding hundreds of millions of tonnes (Mt). This study intends to demonstrate potential benefits of massively parallel computing technology for simulating geologic CO_2 storage for important scientific and engineering topics. In this year, uncertainties due to grid resolution effects are investigated for two topics: 1) CO_2 behaviors in highly heterogeneous geologic formations; 2) diffusion-dissolution-convection process that may cause gravity instability greatly enhancing convective mixing of dissolved CO_2 in storage reservoirs in long-term.

Keywords: large-scale simulation, CCS, CO_2, global warming, groundwater



(a)Homogeneous model (b) Heterogeneous model

Figure 1 CO_2 plume spreading from the injection well in homogeneous (left) and heterogeneous (right) model. The heterogeneous model represents irregular nature of sand/shale distribution in the reservoir, while the hydraulic properties (porosities and permeabilities) are averaged and uniformly assigned in the homogeneous model. Obviously CO_2 tends to migrate in sand portions with higher permeability, suppressing the gravity override (i.e., less-dense CO_2 flows over denser groundwater)

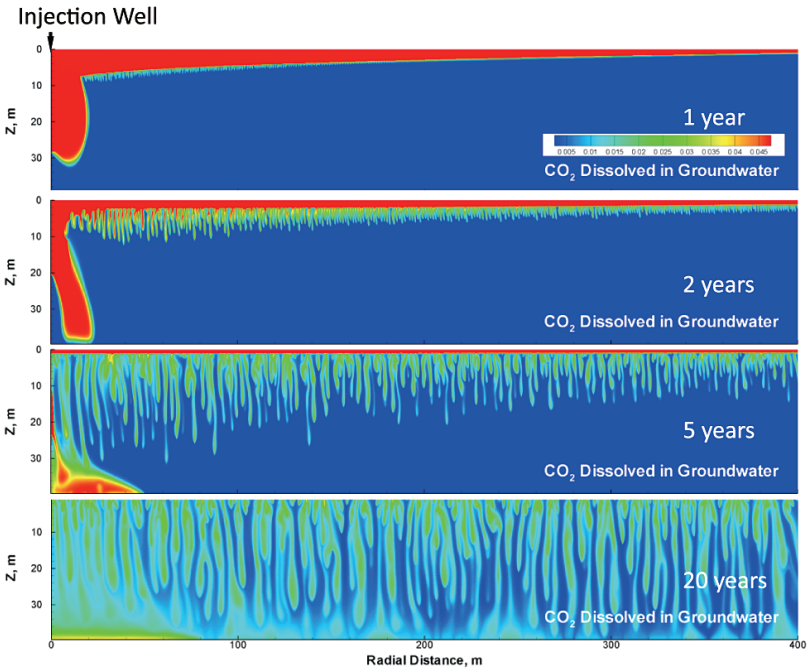


Figure 2 A preliminary simulation result of diffusion-dissolution-convection process in a radially symmetrical model at a reservoir-scale. CO_2 is injected in supercritical state with the rate of 100kt/year for one year. Due to the gravity convection, CO_2 dissolution in groundwater is greatly enhanced and eventually the supercritical CO_2 disappears.