Numerical Simulation of a Potential Impact of Large-scale Geologic CO_2 Storage on Regional Groundwater Systems

Project Representative

Hajime Yamamoto

Taisei Corporation

Authors

Hajime Yamamoto [*1], Shinichi Nanai [*1], Keni Zhang [*2], Atsunao Marui [*3], Hitoshi Uehara [*4], Noriaki Nishikawa [*4], Kengo Nakajima [*5]

＊1 Taisei Corporation

＊2 E.O. Lawrence Berkeley National Laboratory

＊3 National Institute of Advanced Industrial Science and Technology

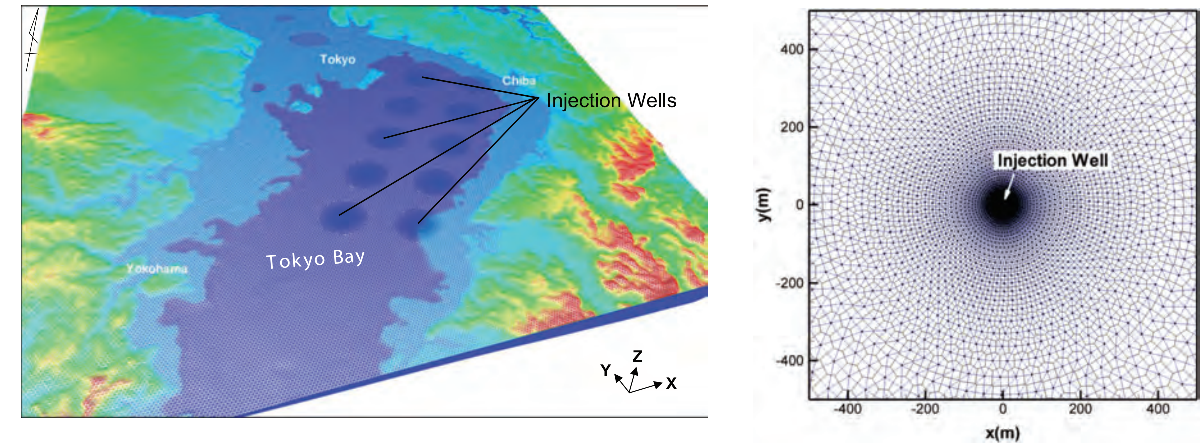
＊4 Japan Agency for Marine-Earth Science and Technology

＊5 The University of Tokyo

Abstract

Large-scale storage of carbon dioxide in saline aquifers may cause considerable pressure perturbation and brine migration in deep rock formations, which may have a significant influence on the regional groundwater system. With the help of parallel computing techniques, we conducted a comprehensive, large-scale numerical simulation of CO_2 geologic storage that predicts not only CO_2 migration, but also its impact on regional groundwater flow. As a case study, a hypothetical industrial-scale CO_2 injection in Tokyo Bay, which is surrounded by the most heavily industrialized area in Japan, was considered, and the impact of CO_2 injection on near-surface aquifers was investigated, assuming relatively high seal-layer permeability (higher than 10 microdarcy). A regional hydrogeological model with an area of about 60 km × 70 km around Tokyo Bay was discretized into about 10 million gridblocks. To solve the high-resolution model efficiently, we used a parallelized multiphase flow simulator TOUGH2-MP/ECO2N on a world-class high performance supercomputer in Japan, the Earth Simulator. In this simulation, CO_2 was injected into a storage aquifer at about 1 km depth under Tokyo Bay from 10 wells, at a total rate of 10 million tons/year for 100 years. Through the model, we can examine regional groundwater pressure buildup and groundwater migration to the land surface. The results suggest that even if containment of CO_2 plume is ensured, pressure buildup on the order of a few bars can occur in the shallow confined aquifers over extensive regions, including urban inlands.

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



(a) (b)

Figure 1 Model mesh showing grid refinement around the injection wells (about 10 million gridblocks in total). (a) A 3D view of the model mesh in this study. Lines are the connections of gridblocks colored by their elevations. (b) Voronoi polygons around the injection wells (black lines) and connections among them (blue lines). Dots are nodal points of the gridblocks.

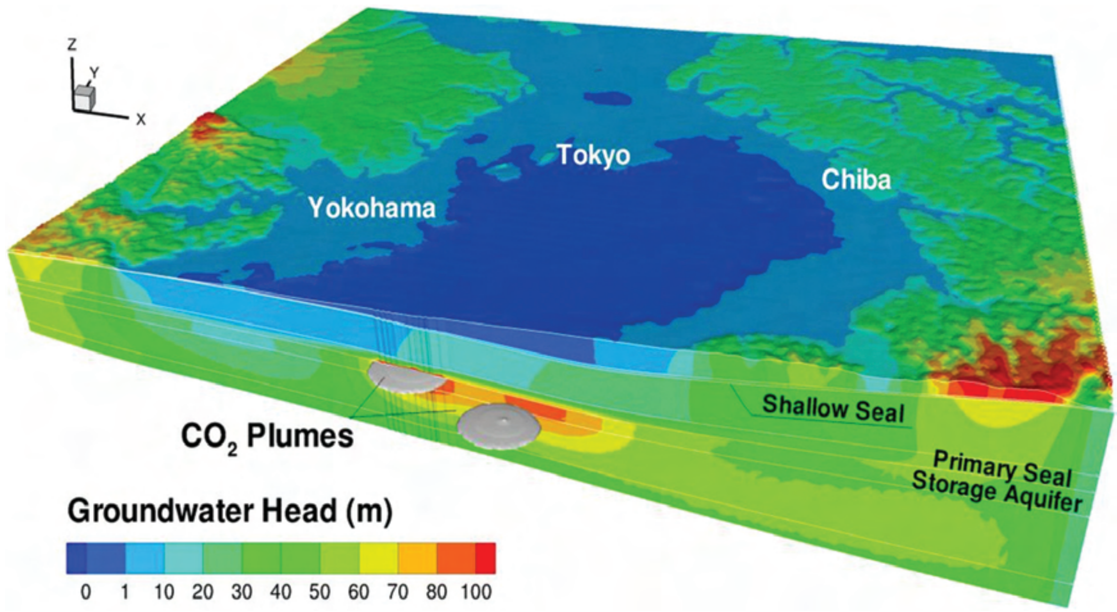


Figure 2 Regional groundwater head distribution after the CO_2 injection. White lines shown on the cross-section are the boundaries of geologic formations. The head distribution that appears on the top of the model is due to the prescribed head condition with land surface elevations (i.e., topography), resulting in high heads (warm color) in mountainous area. It should be noted that the heads in the bay are maintained to the sea level (i.e., z=0m) A couple of CO_2 plumes are shown for a reference (gray colored).