Massively parallel simulation of Geologic CO_2 storage on the Earth Simulator

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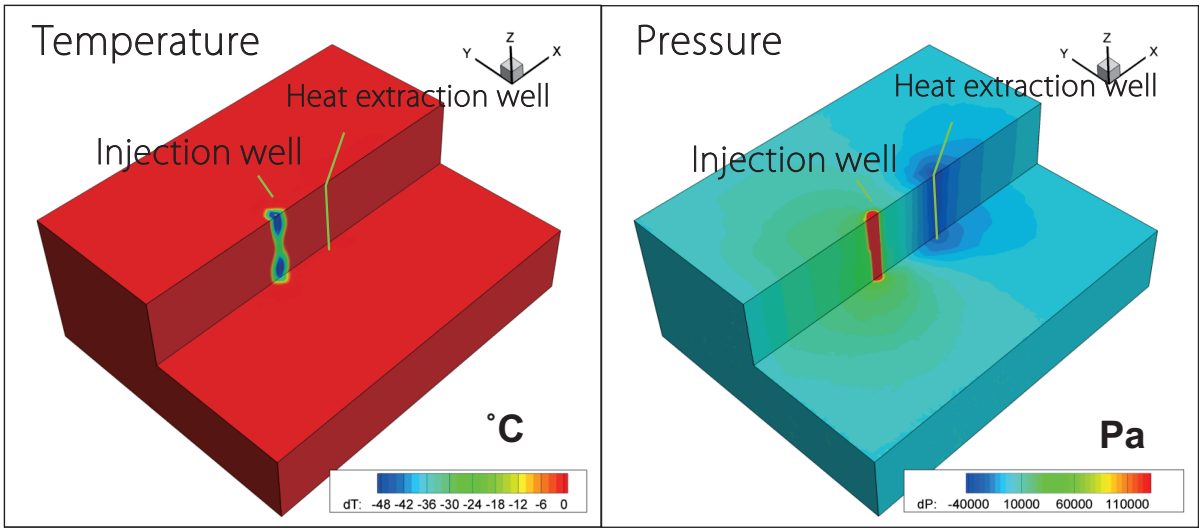
Abstract

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. A parallelized general-purpose hydrodynamics code TOUGH2-MP has been used on scalar architectures where it exhibits excellent performance and scalability. However, on the Earth Simulator (ES2), which is a massively parallel vector computer, extensive tune-ups were required for increasing the vector operation ratio. In this year, the performance of the modified TOUGH2-MP code on ES2 was investigated and presented for some illustrative numerical simulations of long-term fate of CO_2 stored in reservoirs.

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



(a) Temperature change (b) Pressure change

Figure 1 A numerical simulation is conducted to evaluate the performance of modified TOUGH2-MP code for an enhanced geothermal injection–production (heat extraction) system in a sandstone fluvial deposit. The model is developed in CLASTIC project and contains more than 6 million grid blocks. Water or CO_2 will be considered as a working fluid for the heat extraction.

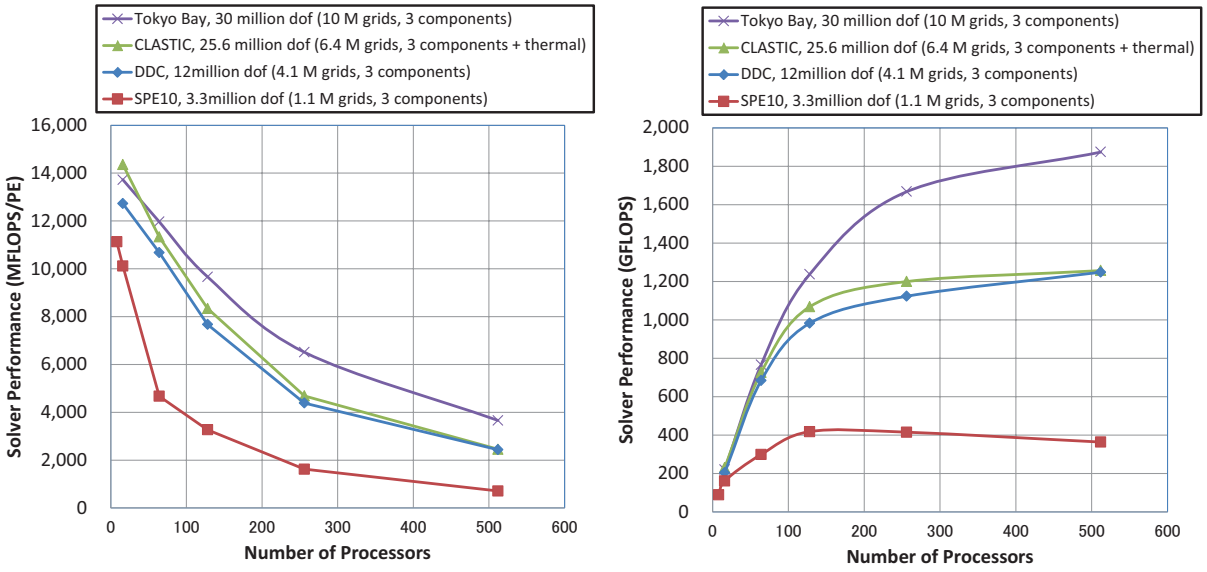


Figure 2 Computation performance of the new solver of TOUGH2-MP on the Earth Simulator. The modified code is about several tens times faster than the original code with Aztec solver. The speed of the new solver is 10-14 GFlops/PE (10-14% of peak performance; VOR > 99.5%).