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A review of physical modelling and numerical simulation of long-term geological storage of CO_2

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ABSTRACT

Numerical simulations are essential to the understanding of the long-term geological storage of CO_2. Physical modelling of geological storage of CO_2 has been based on Darcy's law, together with the equations of conservation of mass and energy. Modelling and simulations can be used to predict where CO_2 is likely to flow, to interpret the volume and spatial distribution of CO_2 under storage conditions, and to optimise injection operations. The state of the art of physical modelling and numerical simulation of CO_2 dispersion is briefly reviewed in this paper, which calls for more accurate and more efficient modelling approaches. A systematic evaluation of the numerical methods used and a comparison between the streamline based methods and the grid based methods would be valuable. Multi-scale modelling may prove to be of great value in predicting the long-term geological storage of CO_2, while highly accurate numerical methods such as high-order schemes may be employed in numerical simulations of CO_2 dispersion for local transport calculations.

Contents

1. Introduction

The potential role of carbon abatement technologies in reducing greenhouse gas emissions has gained much increased recognition and importance internationally in recent years [1–4]. Early rapid deployment of carbon dioxide (CO_2) capture and storage (CCS) technologies is now recognised as an important issue in meeting climate change mitigation targets and providing a serious option worldwide. The development and deployment of CCS technology can have a profound impact on the energy sector including energy policies [5–7]. The geological storage of CO_2 currently represents the best and likely the only short-to-medium term option for significantly enhancing CO_2 sinks, thus reducing net carbon emissions into the atmosphere [8]. CCS can be effectively integrated into various energy systems. For instance, a liquefied energy chain for transport and utilisation of natural gas for power production with CCS was investigated [9–12]. Other investigations included integration of carbon capture onto electric power generation for offshore operations [13], power generation combining solid oxide fuel cell and oxy-fuel combustion for carbon capture [14], as well as an industrial test and techno-economic analysis of carbon capture in a coal-fired power station [15]. As it stands, CCS is the only industrial scale process capable of capturing large quantities of CO_2 at source and burying it beneath the earth's surface.

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