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2024_37_ESE_AM: The role of aquifer hydrodynamics on CO_2 storage: quantifying impact on fresh water resources

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Geological CO_2 storage is an important transitional technology to limit global warming to <1.5C (IPCC 2005). CO_2 is injected into porous and permeable sediments containing saline water at depths of ~3km. Ideally these saline aquifers have good communication over 10s of km to maximise pressure dissipation. However, this means that there is a greater risk that CO_2 storage at one location may affect fresh-water resources located in shallower aquifers in the same sediments (such as the Latrobe aquifer, Gippsland Basin, Australia) or in higher strata if there is migration and leakage via faults (IEA, 2011; Birkholzer et al. 2009). The pressure increase associated with CO_2 storage might push saline water up dip into zones of fresh water.

At present saline water influx, resulting from freshwater extraction, is managed by reducing the rate of freshwater extraction. Further influx from CO_2 storage elsewhere in the aquifer might affect the rate of freshwater extraction further with consequent adverse impacts on agriculture and industry as well as access to drinking water. This risk will be increased if the aquifer is hydrodynamic due to processes such as ongoing meteoric recharge, basin uplift or subsidence or past petroleum production. CO_2 injection will modify the direction and rate of this hydrodynamic flow.

To date there has been limited research investigating the impacts of CO_2 on associated freshwater aquifers, partly because conventional modelling tools are not fit for purpose. Basin/migration modelling tools have been designed to model geological processes related to hydrocarbon generation on migration on length scales of 100km and from surface down to source rock depth (~5km). They simulate time scales of 1000s of years. Conversely reservoir simulations focus on fine scale behaviours in volumes of ~20km across and ~100m thick over time scales 10s of years. Hydrogeologic models tend to focus on shallower subsurface flows and their interactions with surface processes (e.g.. river drainage) on similar length scales to basin models.

This project will develop a workflow and algorithms to integrate hydrogeologic, basin and reservoir modelling approaches to enable resolution of the movement of CO_2 within the aquifer, model the dynamics of aquifer flow and evaluate communication across the basin. The approach will be used to assess the potential impacts of CO_2 storage on fresh-water resources and the most important rock, fluid and basin characteristics influencing these impacts. Based on this, methods for mitigating any adverse impacts will be proposed. The study will use geological data provided by the project sponsor.