



HAL
open science

Scalable Parallel Domain Decomposition for Mixed Finite Elements: Application to Analysis of Convective Mixing in CO₂ Storage

Mohammed Adil Sbai

► **To cite this version:**

Mohammed Adil Sbai. Scalable Parallel Domain Decomposition for Mixed Finite Elements: Application to Analysis of Convective Mixing in CO₂ Storage. HPC-EUROPA2 Transnational Access Meeting - HLRS, Dec 2008, Stuttgart, Germany. hal-00590369

HAL Id: hal-00590369

<https://brgm.hal.science/hal-00590369v1>

Submitted on 3 May 2011

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

SCALABLE PARALLEL DOMAIN DECOMPOSITION FOR MIXED FINITE ELEMENTS: APPLICATION TO ANALYSIS OF CONVECTIVE MIXING IN CO₂ STORAGE.

M. A. SBAI¹

¹BRGM, Water Division, groundwater and geochemistry modeling group.
3, Avenue Claude Guillemin, BP 36009, 45060 Orléans Cedex 2, France.
e-mail: a.sbai@brgm.fr

ABSTRACT

Accurate prediction of the long-term fate of carbon dioxide in saline aquifers is a numerical and computational challenge. High permeability rocks are ubiquitous in many sedimentary basins targeted by this technology. In many of such cases, convective mixing of dissolved supercritical CO₂ rich waters with the initial saline waters is likely to occur involving a multiscale time-space dependent problem. Spatial resolutions needed to capture dissolution fingers for practical applications like the first commercial CO₂ injection project in Sleipner (North-Sea) are in the orders of few centimetres. Therefore, efficient and highly scalable parallel decomposition methods need to be developed, hopefully as a black-box simulator, to advance scientific knowledge for such applications in as much to demonstrate the long-term safety of future storage sites. To this end, we implemented a balancing domain decomposition mixed finite elements for second-order elliptic partial differential equations. Problems in this form arise in many other applications including single-phase and multiphase subsurface flow, electrostatics, implicit discretisations of parabolic and hyperbolic equations, and as a subproblem in the application of operator-splitting techniques to advection-dispersion-reaction transport equations. The Balancing Domain Decomposition method, is a substructuring method that involves at each iteration the solution of a local problem with Dirichlet boundary conditions, a local problem with Neumann boundary conditions, and a coarse grid problem to propagate information globally (over all domain processors) and to ensure the consistency of the Neumann problems. Our numerical experiments show that the condition number, consistently with theory, grows at worst like $O\left(1 + \log\left(\frac{H}{h}\right)^2\right)$ in both two and three dimensions, where H is the characteristic subdomain size, and h the characteristic mesh size. Computational results from an MPI message passing parallel implementation on IBM CLX/1024 Linux cluster machine at CINECA demonstrate the scalability properties of the method and show almost optimal linear speed-up for up to 128 processors.

Acknowledgement: This research work is supported by the French Agency for Scientific Research (ANR), and BRGM Research Direction, under contract number ANR-06-CO2-006-01 in the framework of Heterogeneities-CO2 project. Support for a HPC-EUROPA visit program in 2007 at CINECA host in Bologna is gratefully acknowledged.