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Enhancing a high-fidelity nonlinear solver with reduced order model for induced seismicity

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Even though geologic carbon storage could reduce carbon emissions to the atmosphere and mitigate the impact of climate change, there are potential seismic risks and uncertainties associated with a GCS operation. Hence, we need to understand this process better before it becomes a reliable technology. However, the system of partial differential equations used to describe an induced seismicity event is highly nonlinear. Subsequently, we need substantial computational resources to approximate this system, making this process unsuitable for handling large-scale uncertainty quantification in which an extensive set of simulations must be explored. Kadeethum et al. [1] have illustrated the use of reduced order modeling (ROM) to enhance full order modeling (FOM) solvers. In this study, we apply the framework to an induced seismicity high-fidelity solver (coupled hydro-mechanical (HM) processes) proposed by Chang et al. [2]. Our goal is to investigate the improvements of ROM-assisted FOM performance with emphasis on (1) computational cost reduction and (2) a convergence rate. Our systematic approach is:
1. Substitute the high-fidelity hydro (H-FOM) solver with the low-fidelity hydro (H-ROM) model but still use high-fidelity mechanics (M-FOM) solver: H-ROM-M-FOM.
2. Substitute the M-FOM solver with low-fidelity mechanics (M-ROM) model: H-FOM-M-ROM.
3. Use HM-FOM with HM-ROM initialization.

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[1] Kadeethum, T., O'Malley, D., Ballarin, F., Ang, I., Fuhg, J. N., Bouklas, N., … & Yoon, H. (2022). Enhancing high-fidelity nonlinear solver with reduced order model. Scientific Reports, 12, 20229.

[2] Chang, K. W., Yoon, H., & Martinez, M. J. (2022). Potential seismicity along basement faults induced by geological carbon sequestration. Geophysical Research Letters, 49(13), e2022GL098721.

Participation

In-Person

References

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