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Global sensitivity analysis of a low permeability media gas flow model with multiple transport mechanisms

Thursday, 3 June 2021 20:00 (1 hour)

Methane is recognized as a potential energy source in the transition to carbon free energies. Appropriate modeling approaches to quantify methane migration in low permeability geomaterials can assist the appraisal of the feasibility of a methane recovery project. Wu et al. (2016) proposed a model enabling one to estimate the total mass flow rate of the gas as the sum of key processes, including (i) a surface diffusion and two weighted bulk diffusion components, (ii) slip flow, and (iii) Knudsen diffusion. In its isothermal form and taking pressure gradient as boundary condition, the model relies on 10 parameters. These are typically estimated through laboratory-scale experiments. Considering the mechanisms involved, such experiments are costly, time demanding, and their results are prone to uncertainty. The latter is also related to the intrinsic difficulties linked to replicating operational field conditions at the laboratory scale as well as to the desired transferability of results to heterogeneous field scale settings. Due to our still incomplete knowledge of the key mechanisms driving gas movement in low permeability geomaterials and the complexities associated with the estimation of model parameters, model outputs should be carefully analyzed considering all possible sources of uncertainty. In this sense, sensitivity analysis approaches may be used to enhance the quality of parameter estimation workflows, upon focusing efforts on parameters with the highest influence to target model outputs. We rely on two typical global sensitivity analysis approaches (i.e., Variance-based Sobol approach and Morris method) to analyze the behavior of the aforementioned gas migration model targeting low permeability media. Because of the complexity of the physical processes represented in the model and the typical frequency distributions of pore size in caprocks, the sensitivity analysis is performed in two differing settings, each corresponding to a given range of variability of characteristic pore sizes. When considering porous systems with pore size ranging between 2 and 100 nanometers, results based on Sobol indices identify (in decreasing order of importance) pore radius, porosity, pore pressure, and tortuosity as the parameters whose uncertainty significantly imprints model output uncertainty. Similar results are obtained through the analysis of the Morris indices, these identifying the pore radius parameter as the one with the highest contribution to non-linear (or interaction) effects on the model output. For tighter porous media (i.e., with pore size comprised between 2 and 10 nanometers), the Sobol indices analyses identify (in decreasing order of importance) pore pressure, porosity, blockage/migration ratio of adsorbed molecules, and pore radius as the most influential model parameters. The role of the blockage/migration ratio of adsorbed molecules suggests that surface diffusion is a dominant gas transport mechanism in these scenarios. The Morris approach identifies the same parameters as important, albeit in a different order of importance.

Time Block Preference

Time Block A (09:00-12:00 CET)

References

Wu, K., Chen, Z., Li, X., Guo, C., Wei, M., 2016. A model for multiple transport mechanisms through nanopores of shale gas reservoirs with real gas effect-adsorption-mechanic coupling. International Journal of Heat and Mass Transfer 93, 408-426. doi: 10.1016/j.ijheatmasstransfer.2015.10.003

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