Performance assessment for crystalline host rock: effects of discrete fracture network realization variability

Paul E. Mariner, Emily R. Stein, Eduardo Basurto, and Michael A. Nole
pmarine@sandia.gov, Sandia National Laboratories, Albuquerque, NM, USA

Problem

- Discrete fracture network (DFN) generation introduces substantial aleatory (random) uncertainty.
- ***What are the effects of DFN realization variability on repository performance?***
- ***How can these effects be minimized?***

Method

- Generate DFN realizations based on fracture set properties at Forsmark (Joyce et al. 2014) using dfnWorks (Hyman et al. 2015)
- Map to equivalent porous medium grid of generic crystalline repository reference case (Stein et al. 2017; Mariner et al. 2016)
- Run 50 realizations of epistemic uncertainties (Table 1) for each DFN realization using **PFLOTRAN** (Hammond et al. 2011; Lichtner and Hammond 2012) and ***GDSA Framework*** (pa.sandia.gov)
- Analyze results

Table 1. Epistemic uncertainties assumed and propagated.

Parameter	Lower bound	Upper bound	Distribution
Used nuclear fuel (UNF) fractional dissolution rate (rateUNF) (yr^{-1})	10^{-8}	10^{-6}	Log uniform
Glacial permeability (kGlacial) (m^2)	10^{-16}	10^{-13}	Log uniform
Buffer porosity (pBuffer)	0.3	0.5	Uniform
Damaged rock zone (DRZ) permeability (permDRZ) (m^2)	10^{-19}	10^{-16}	Log uniform
Buffer permeability (permBuffer) (m^2)	10^{-20}	10^{-17}	Log uniform
log of mean waste package fractional degradation rate at 60°C (rateWP) (yr^{-1}) *	-5.5	-4.5	Uniform

* Uncertainty among waste packages about the sampled log mean rate is assumed to be normally distributed with a standard deviation of 1.

Discrete Fracture Network

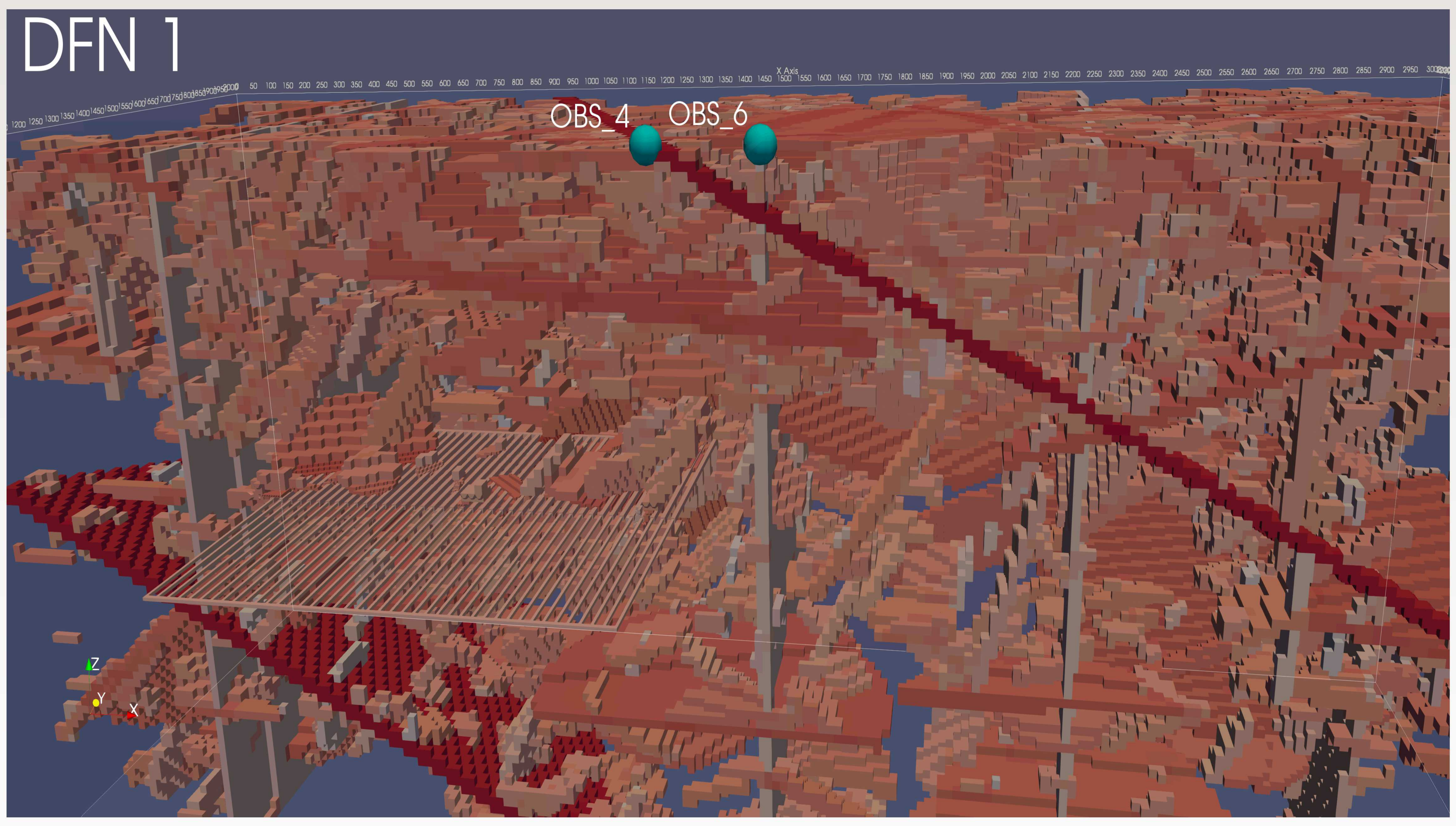

Figure 1. Cut-away of DFN 1 realization mapped to porous medium grid, showing the far half of the repository and model domain. Fractures of the DFN realization are shown in orange. Unconnected fractures are removed. Five deterministic fracture zones, three sub-vertical (gray) and two with a dip of approximately 30 degrees (red), are common to each DFN realization. Observation points 4 and 6 are located above the midline of the repository where the deterministic fracture zones intersect the top boundary.

Results

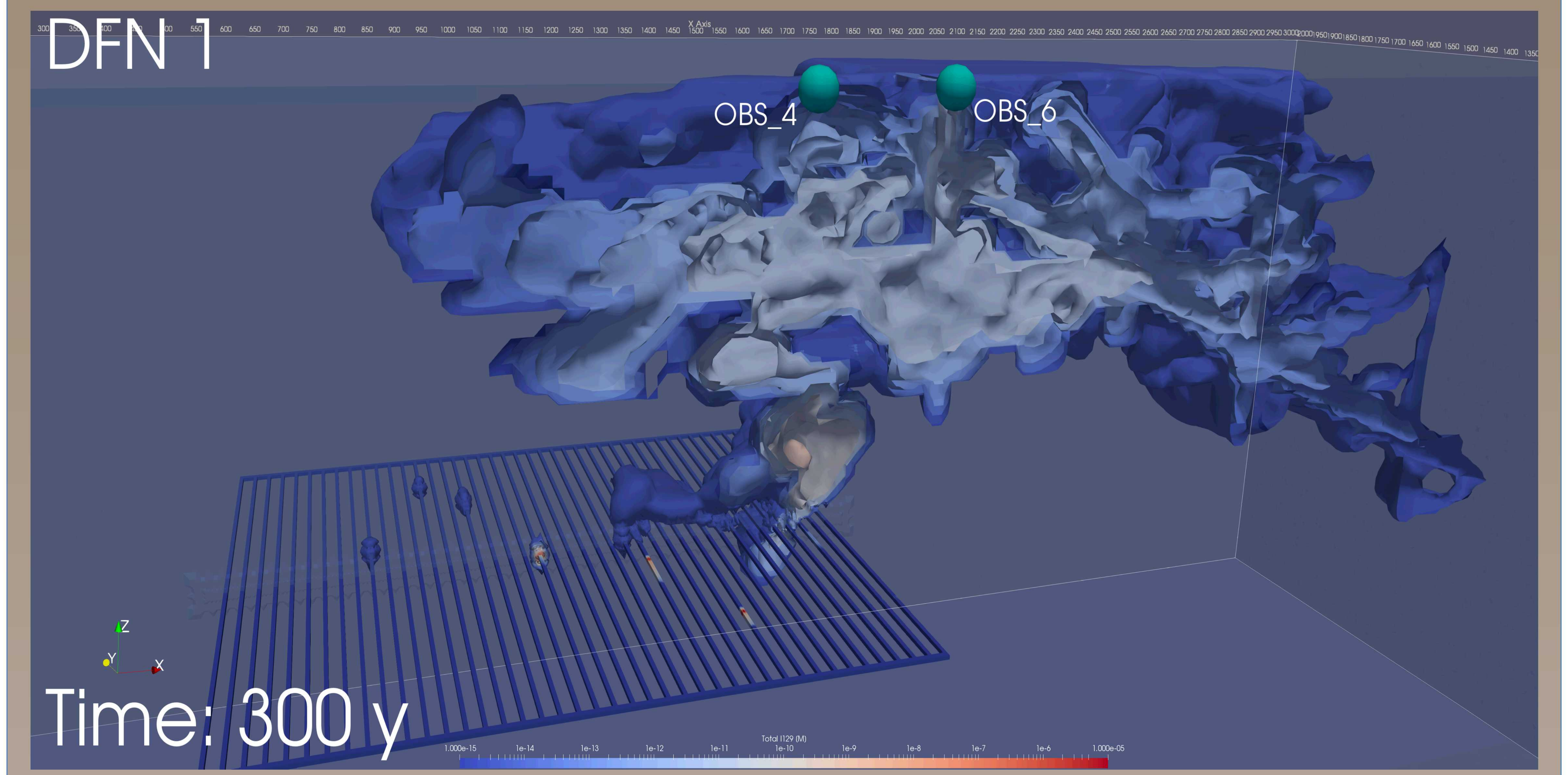

Figure 2. I-129 concentration contours for DFN 1 at 300 years.

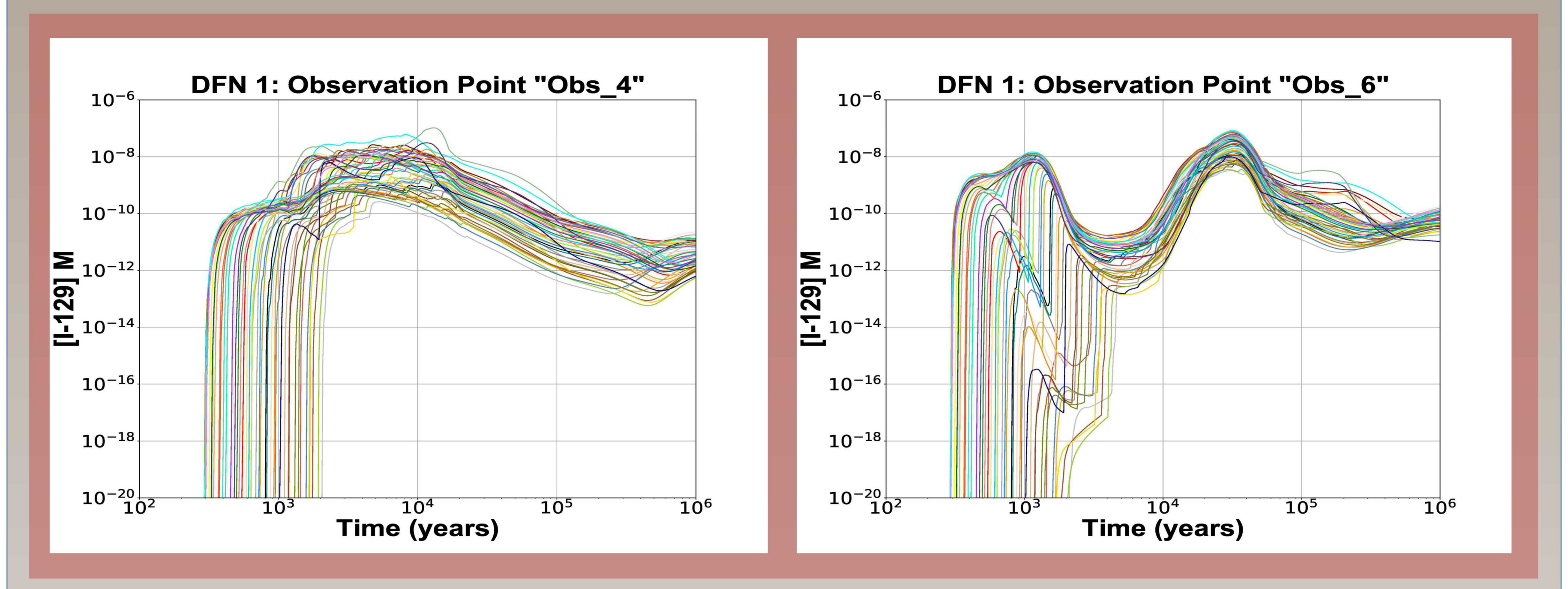

Figure 3. I-129 concentrations over time at OBS_4 and OBS_6 for DFN 1.

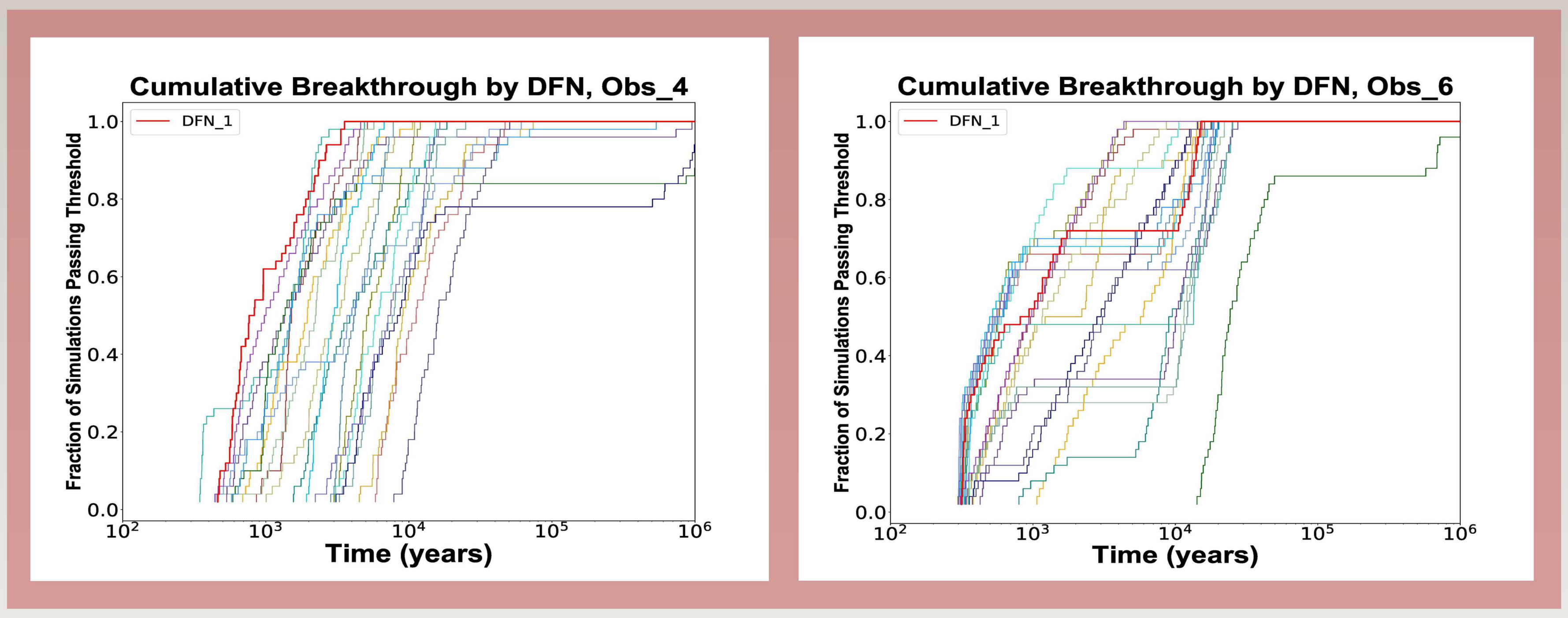

Figure 4. Cumulative occurrence of breakthrough (>10^{-10} M) for each DFN at observation points (DFN 1 in red).

Conclusions

- Breakthrough time variation at OBS points owe primarily to:
  - Uncertainty in waste package degradation rate
  - Uncertainty in spatial locations of connected fractures
- Results support (1) avoiding waste emplacement near connected fractures intersecting the repository and (2) sealing the drift and damaged rock zone in the vicinities of those fractures.

References

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