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Mass balance of physics-informed and physics-constrained machine learning

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Background: Physics-informed neural networks (PINN)

$$\min_{\theta} \mathcal{L}(\theta) = \frac{1}{N_u} \sum_{i=1}^{N_u} \|u(\mathbf{NN}(x^i; \theta)) - u^i\|^2 + w \|\mathcal{F}(u(\mathbf{NN}(x; \theta)); p)\|^2$$

weights collocation point # outputs Neural network True value at collocated point penalty Model parameter

- Physics code is solved at collocation points
- Then comparison between real and simulated points is calculated
- Optimization problems become stiff
- Training takes a lot of wall clock time even for a simple problem
- Does not always satisfy mass balance and other mathematical properties of physics code?
- **Our goal is to compute the mass balance in Darcy flow equation for a porous media**
- **Also, find when and when not to use PINN**

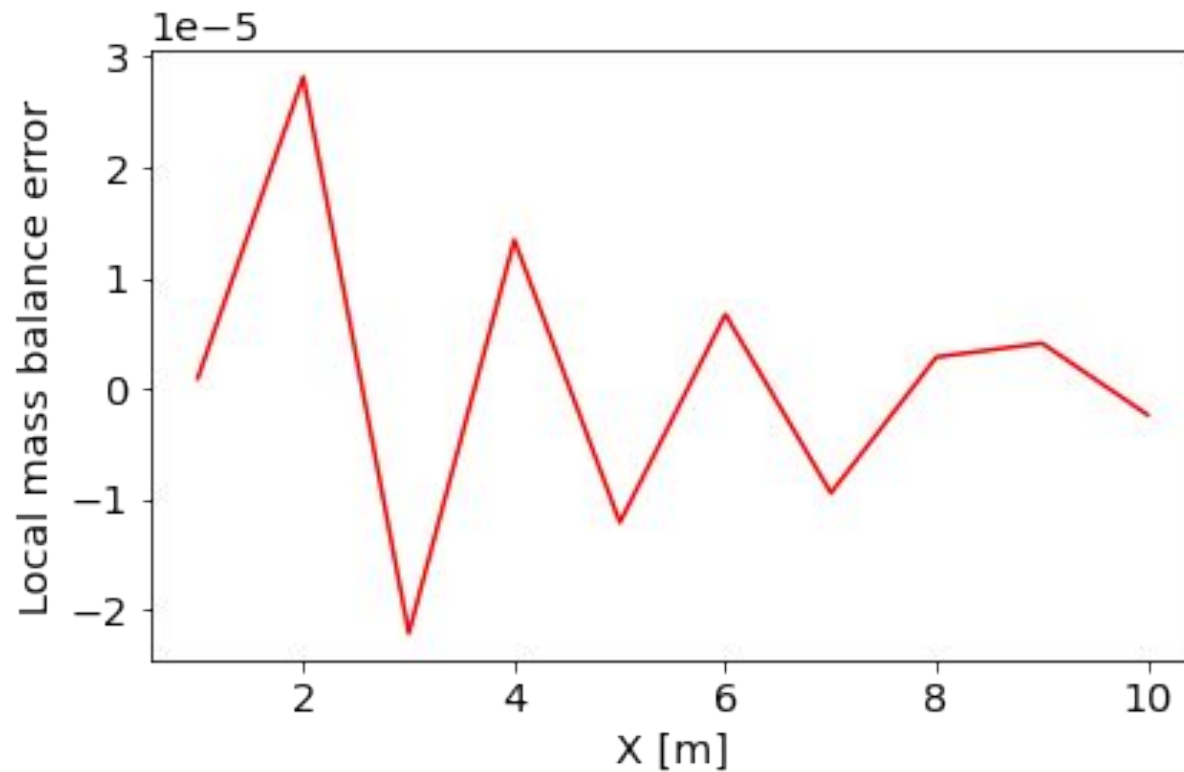
Steady-state Darcy flow model



BC

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Results: Flux



Conclusions

- Mass is not fully conserved
- However, it gives us a good range for parameter search space
- The parameter range can be used in physics model to fine tune the model

Thanks!

Question?