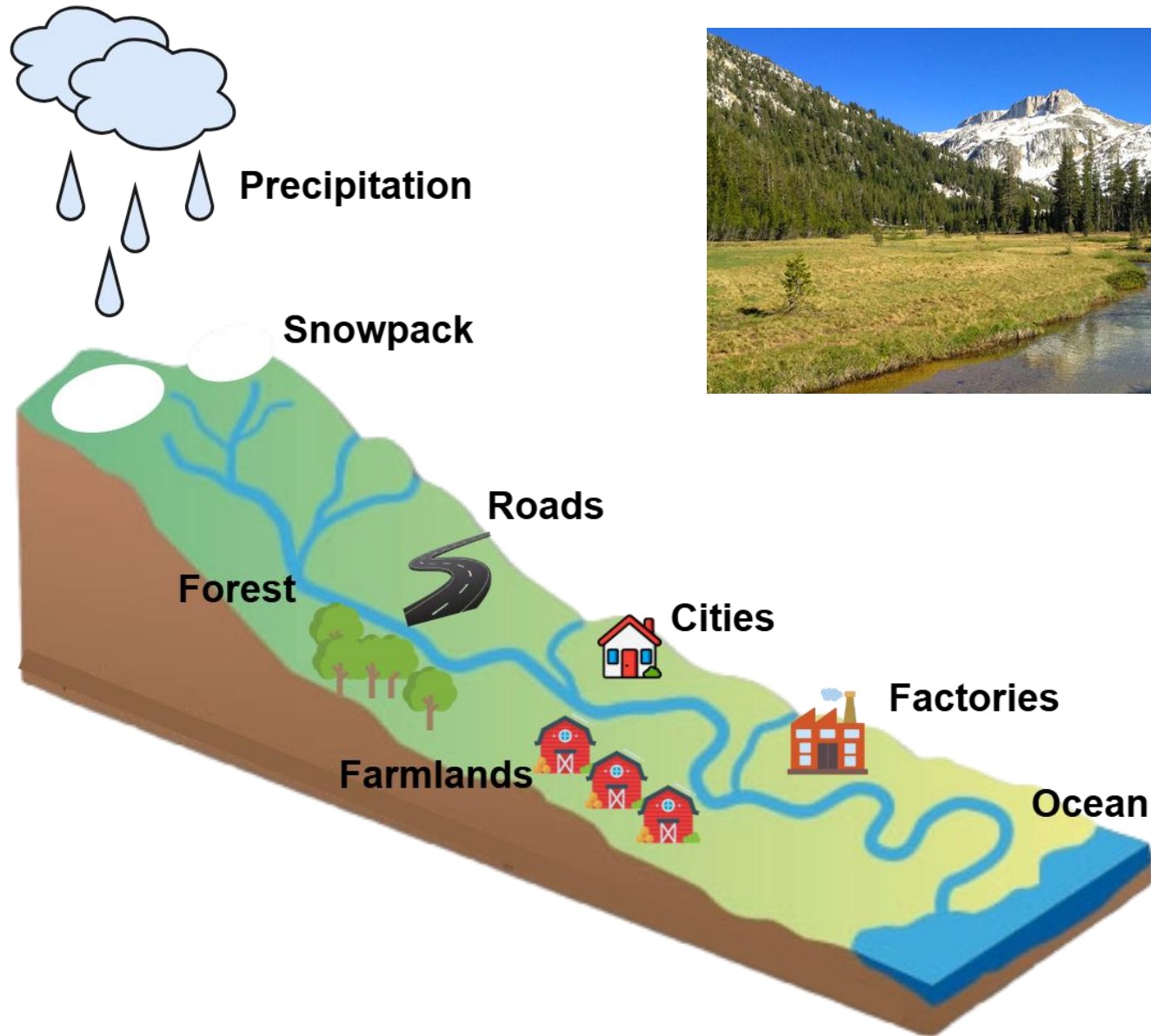




Multilayer perceptron model for predicting conservative solute transport in rivers and streams

Lina Rodriguez, Trilce Estrada, Alexandre Tartakovsky, Kenneth C. Carroll, Timothy Ginn, Ricardo González-Pinzón

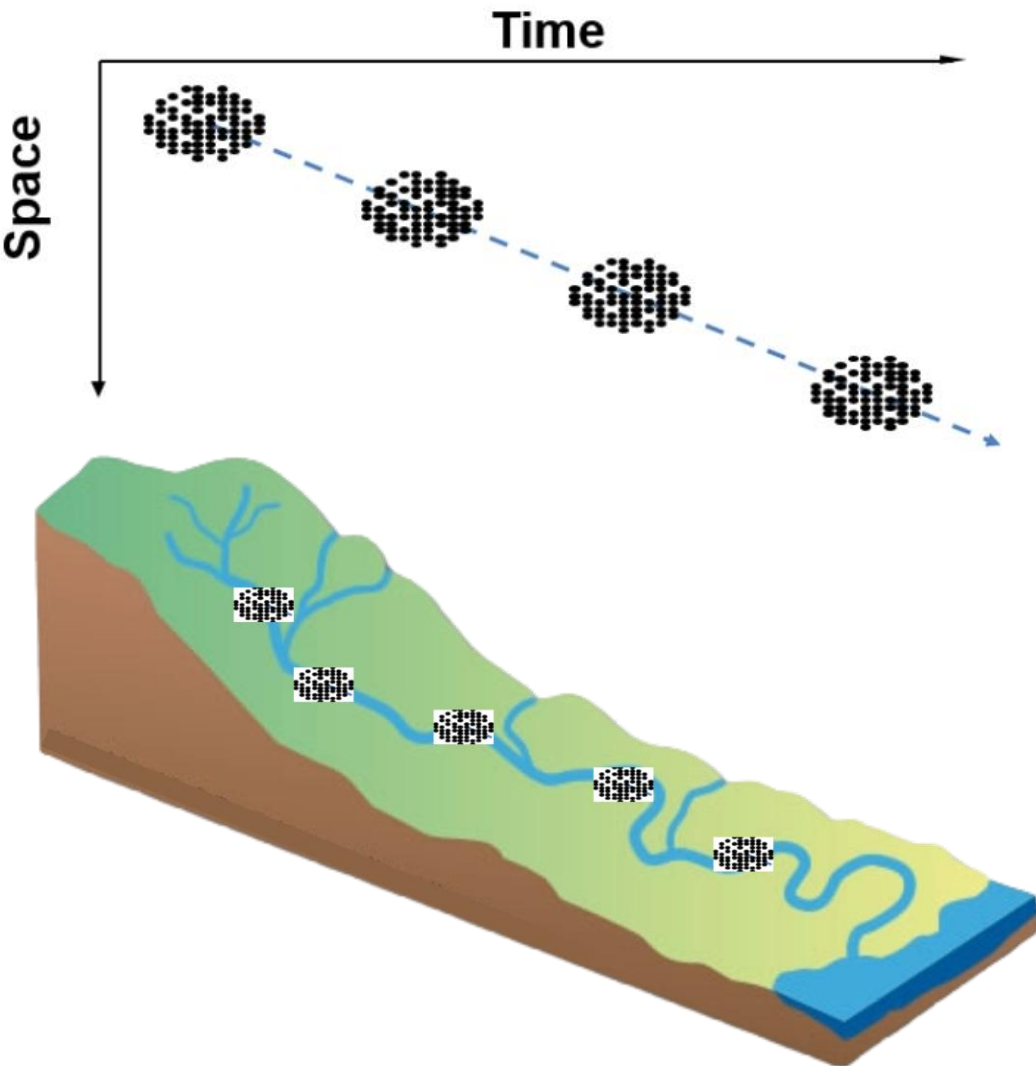
How do rivers and streams work?



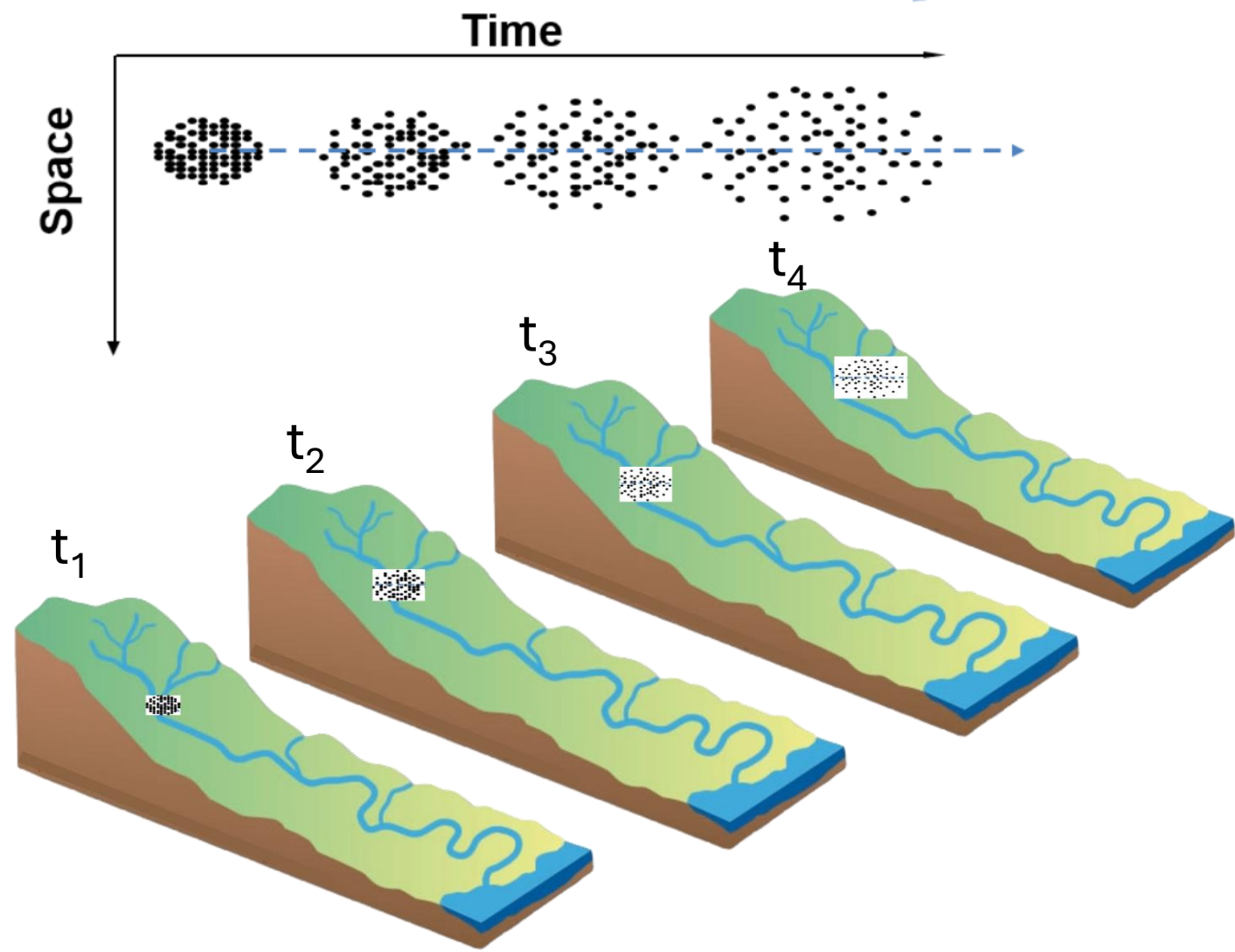
What is solute transport?

$$\frac{\partial c}{\partial t} = D \frac{\partial^2 c}{\partial x^2} - u_x \frac{\partial c}{\partial x} \quad \longrightarrow \quad c(x, t) = \frac{M_{inj}}{2A\sqrt{\pi Dt}} e^{-\frac{(x-ut)^2}{4Dt}}$$

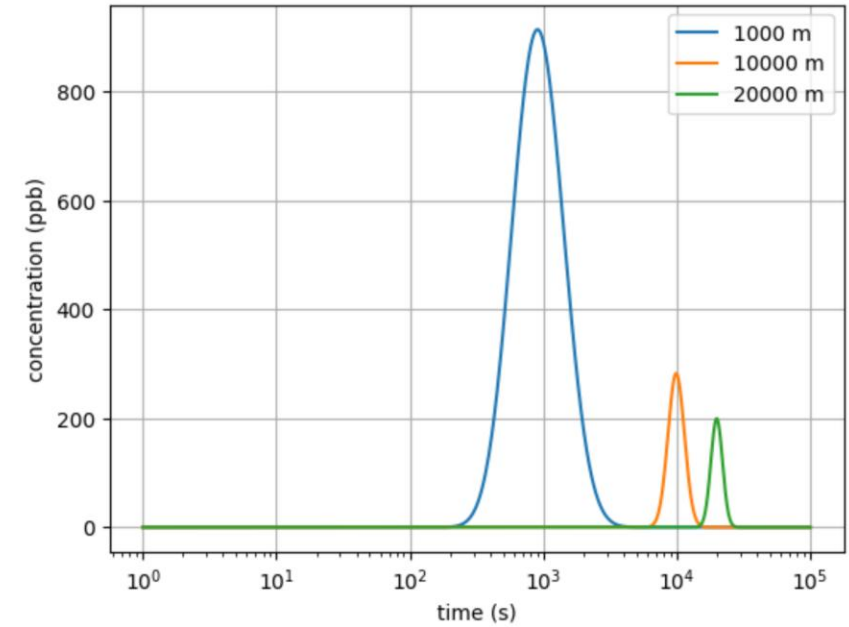
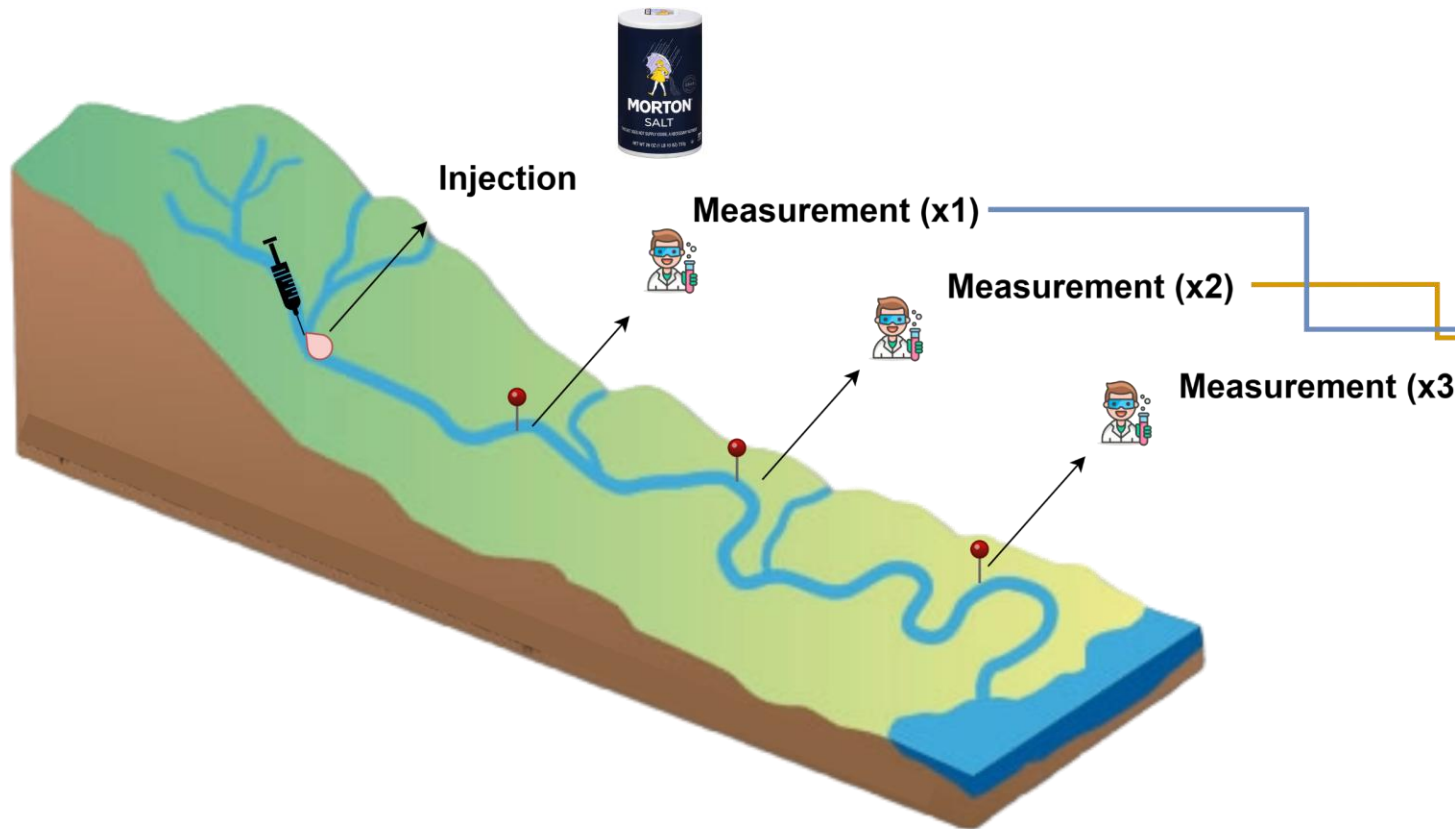
Pure Advection (u)



Pure Dispersion (D)

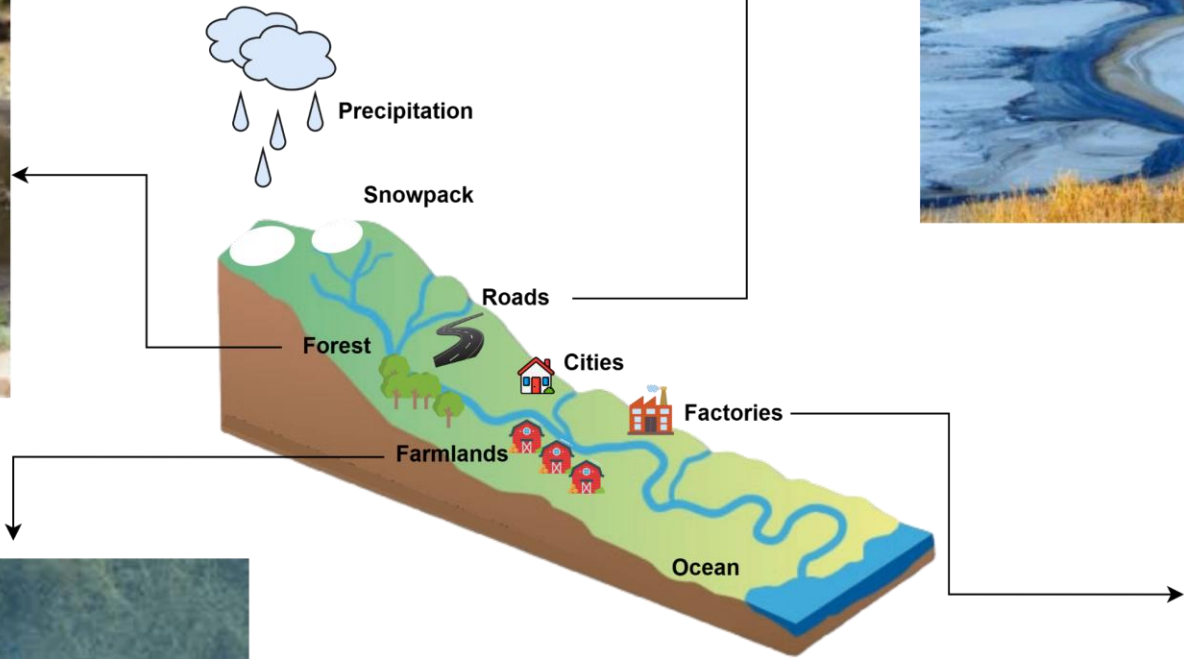


Tracer Injection Experiments

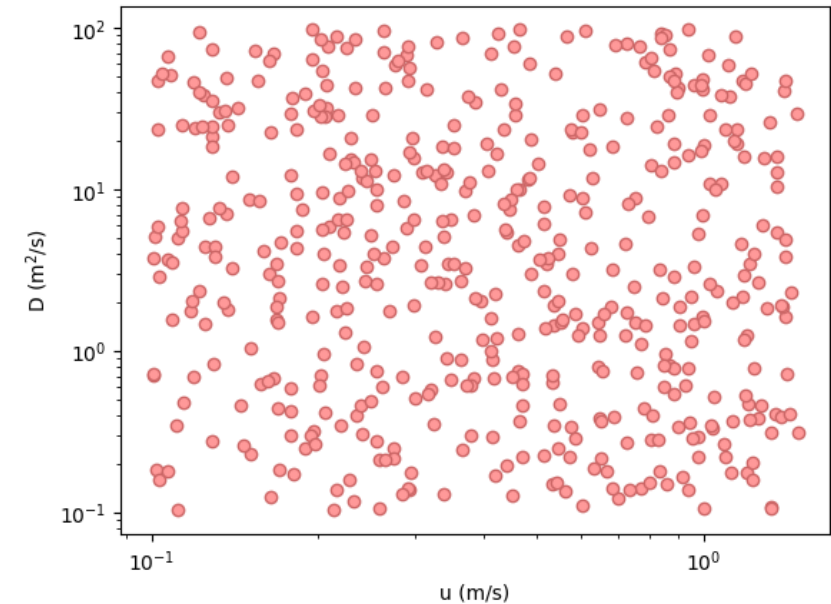
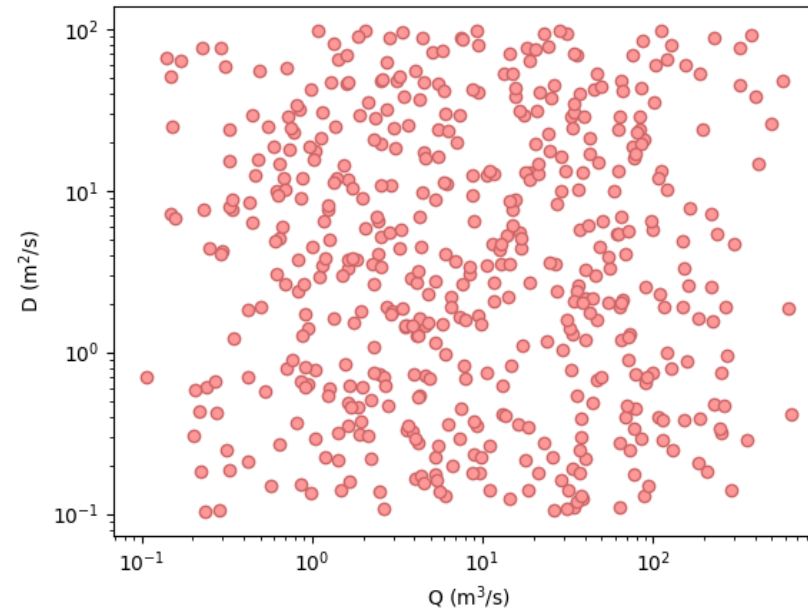
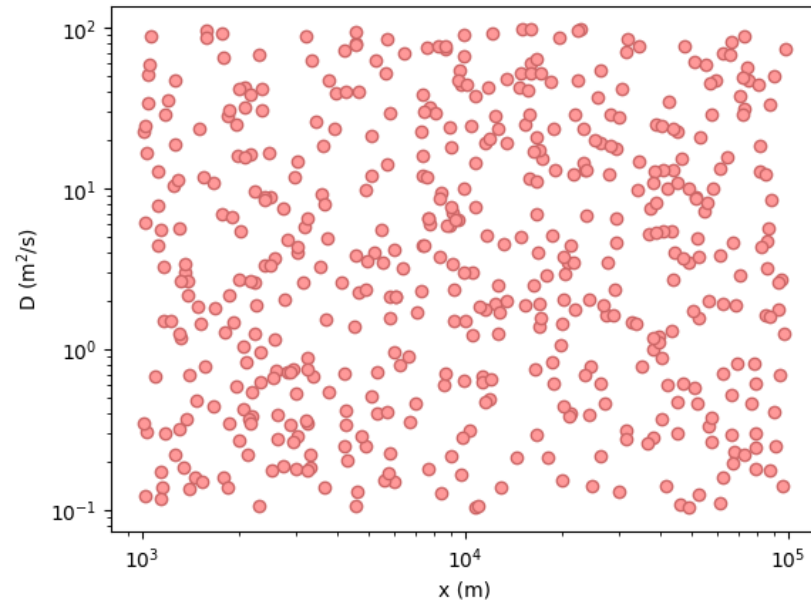


$$c(x, t) = \frac{M_{inj}}{2A\sqrt{\pi Dt}} e^{-\frac{(x-ut)^2}{4Dt}}$$

Why is this important?

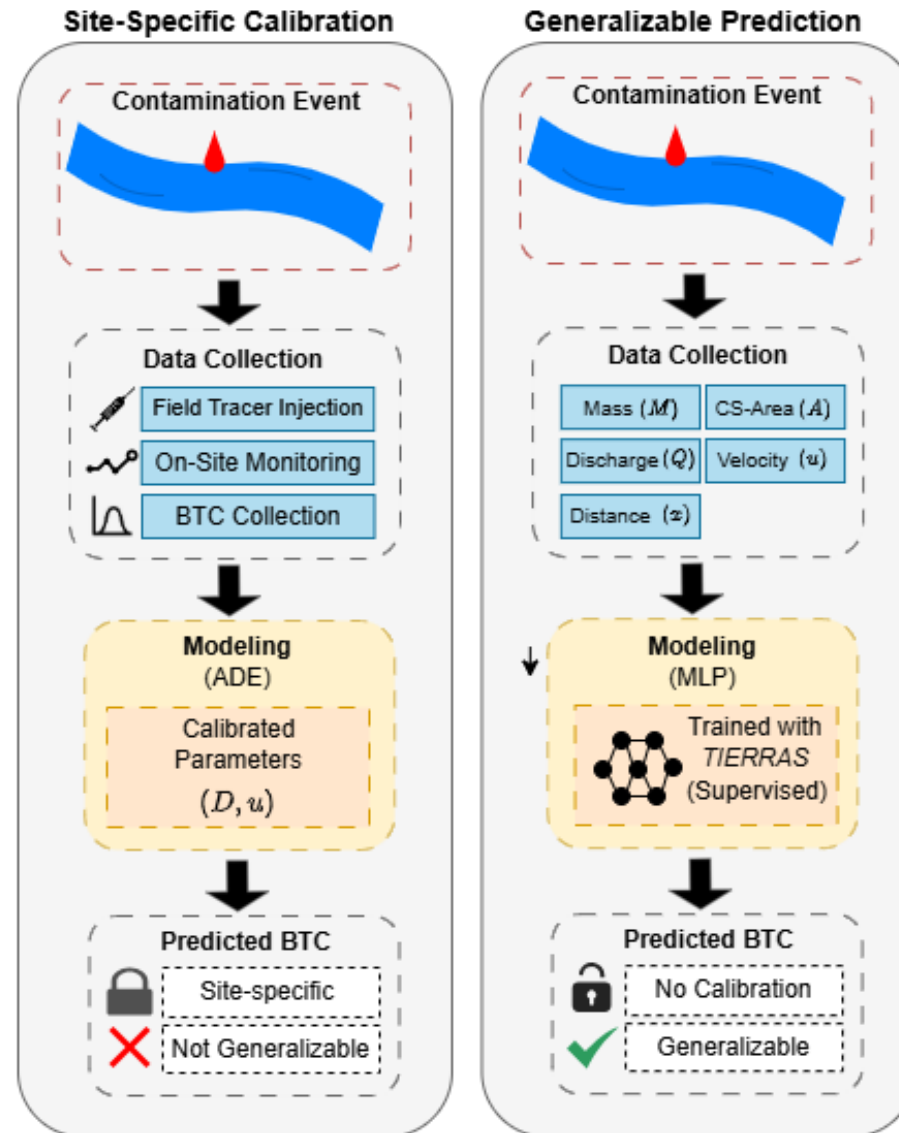


Challenges

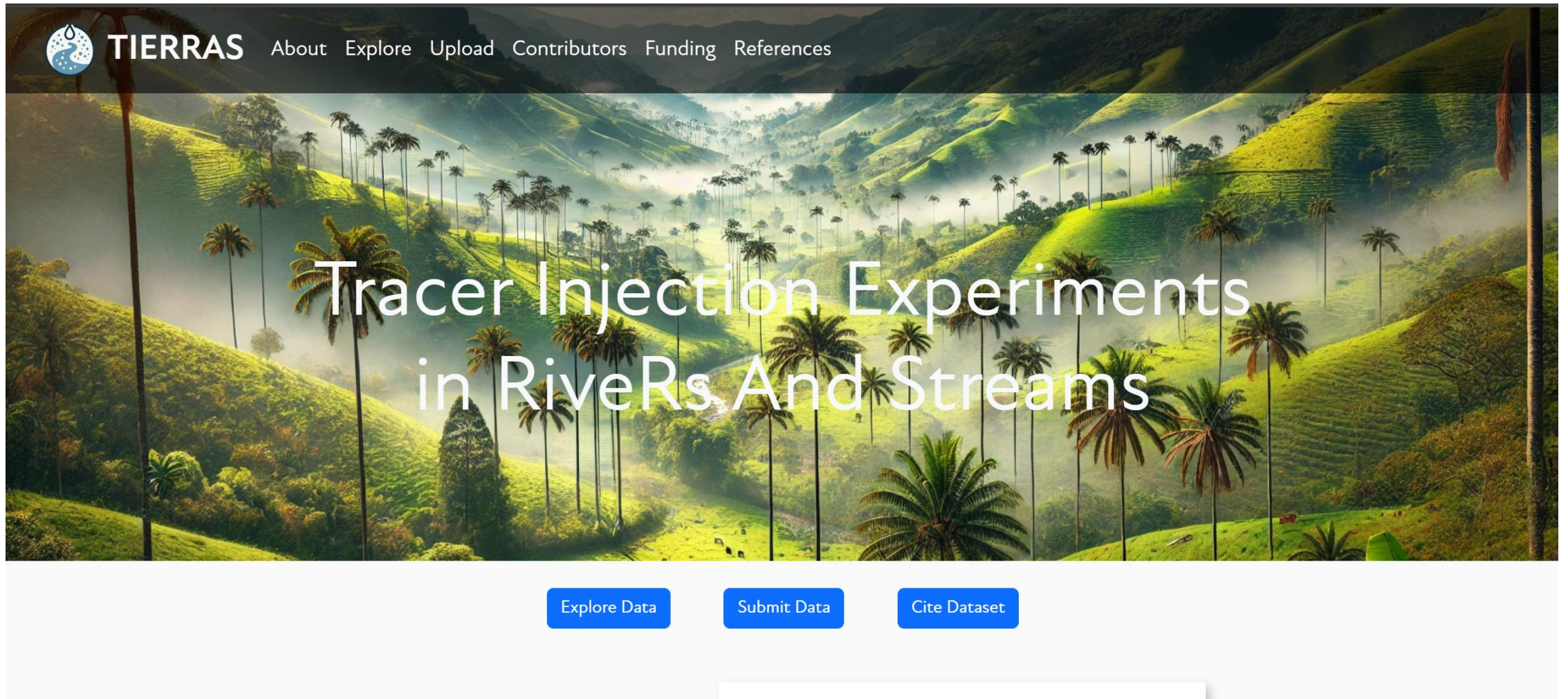


TAKEAWAY: We spend lots of time and money in the field to calibrate models, but the parameters we get only work for that specific site and flow conditions, making this approach not viable for forecasting tasks.

Can machine learning generalize the solute transport problem?



TIERRAS: Tracer Injection Experiments in Rivers and Streams



The image shows the header of the TIERRAS website. At the top left is the TIERRAS logo, which consists of a blue circular icon with a white water drop and a globe, followed by the word "TIERRAS" in a bold, white, sans-serif font. To the right of the logo is a navigation menu with the following items: "About", "Explore", "Upload", "Contributors", "Funding", and "References", all in a smaller white font. The background of the header is a vibrant, high-resolution photograph of a tropical landscape. It features rolling green hills, numerous tall palm trees, and a misty atmosphere. The text "Tracer Injection Experiments in Rivers and Streams" is overlaid in the center of the image in a large, white, sans-serif font. Below the image, there are three blue buttons with white text: "Explore Data", "Submit Data", and "Cite Dataset".

TIERRAS About Explore Upload Contributors Funding References

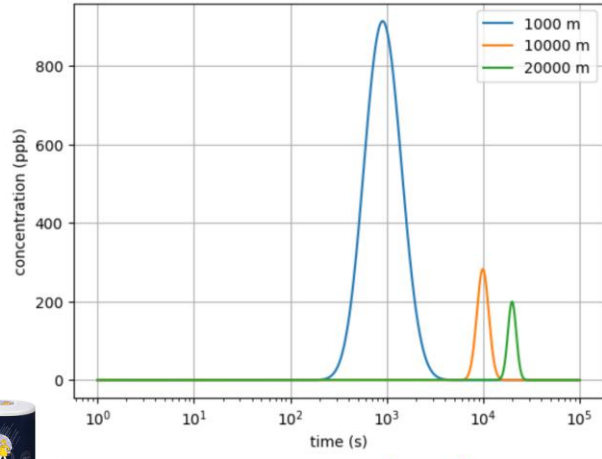
Tracer Injection Experiments
in Rivers and Streams

Explore Data Submit Data Cite Dataset

TIERRAS: Tracer Injection Experiments in Rivers and Streams

- +400 Break Through Curves (BTC)
- +50 rivers

- Discharge ranges from 0.31 to 6824 m³/s

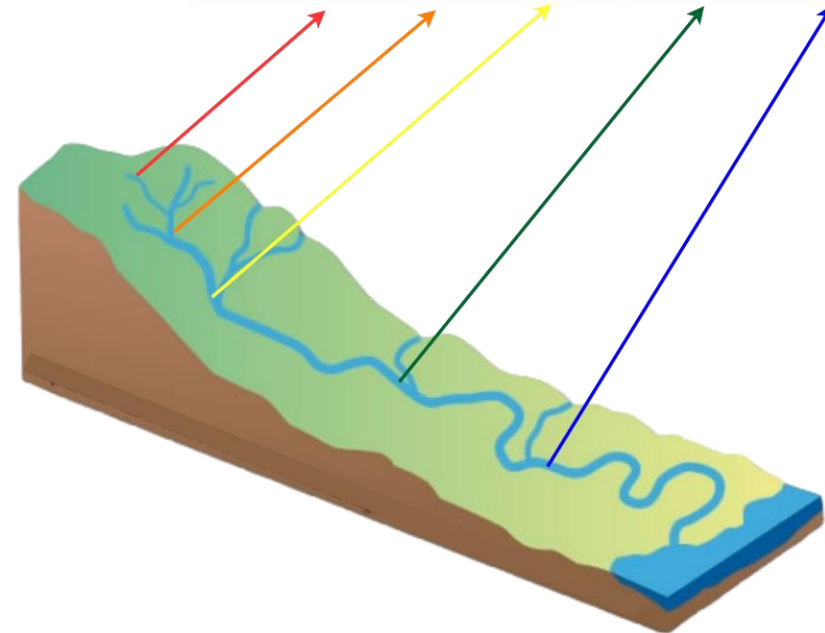
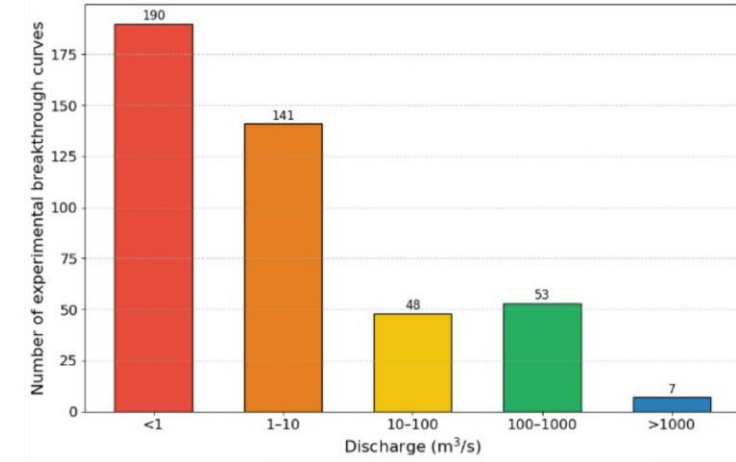
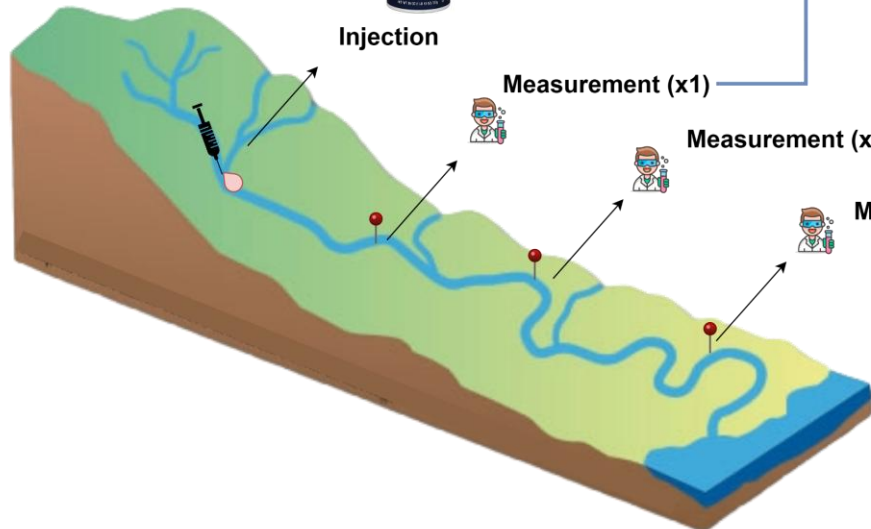


Injection

Measurement (x1)

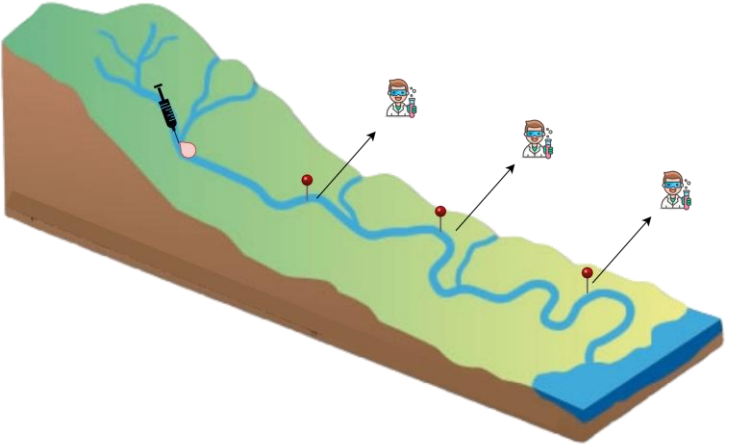
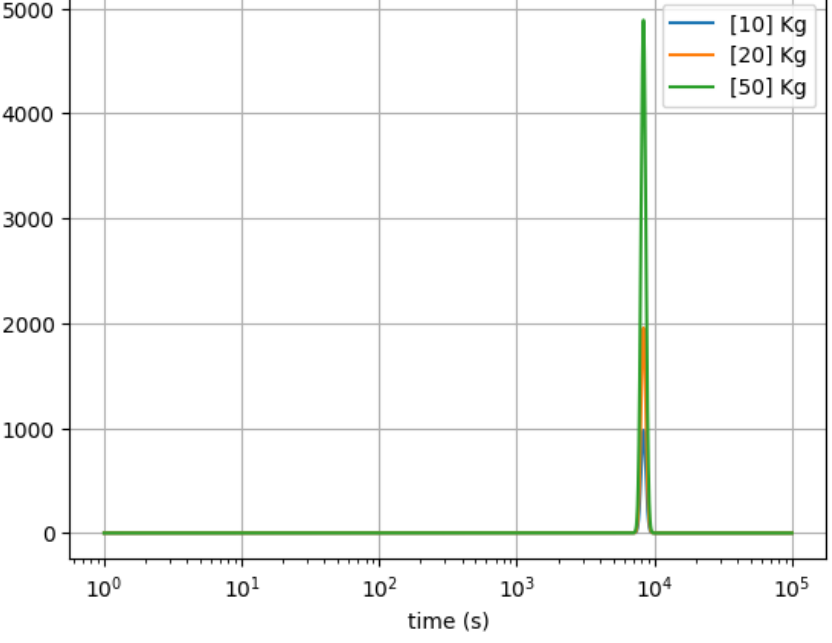
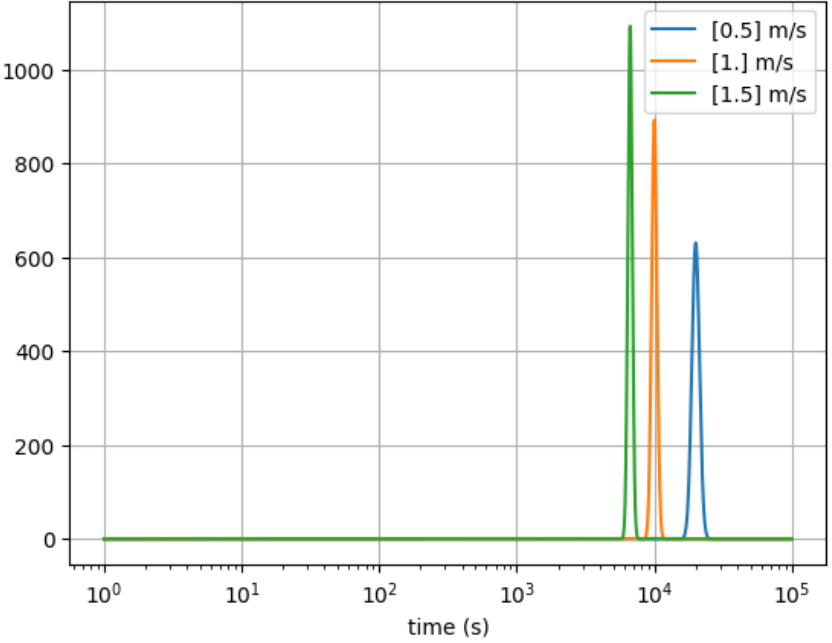
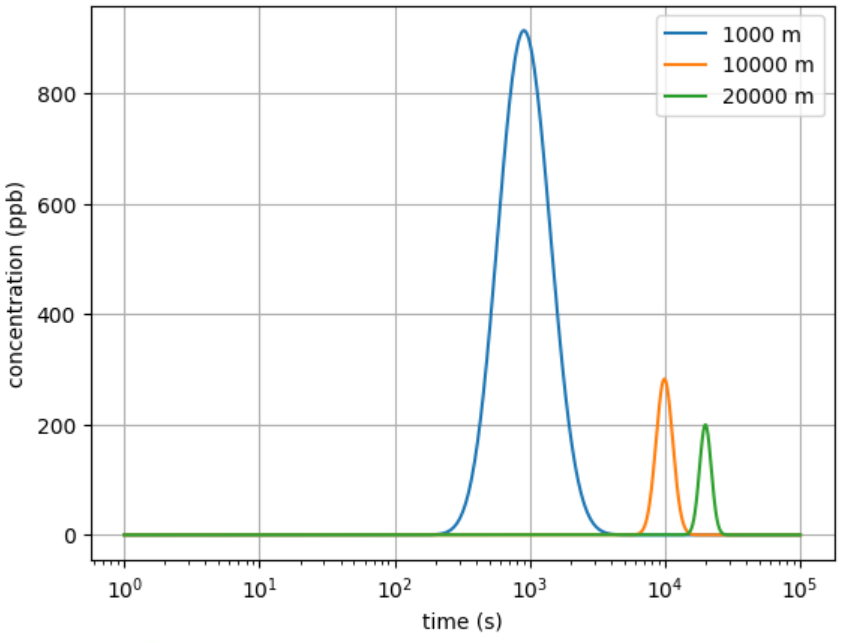
Measurement (x2)

Measurement (x3)

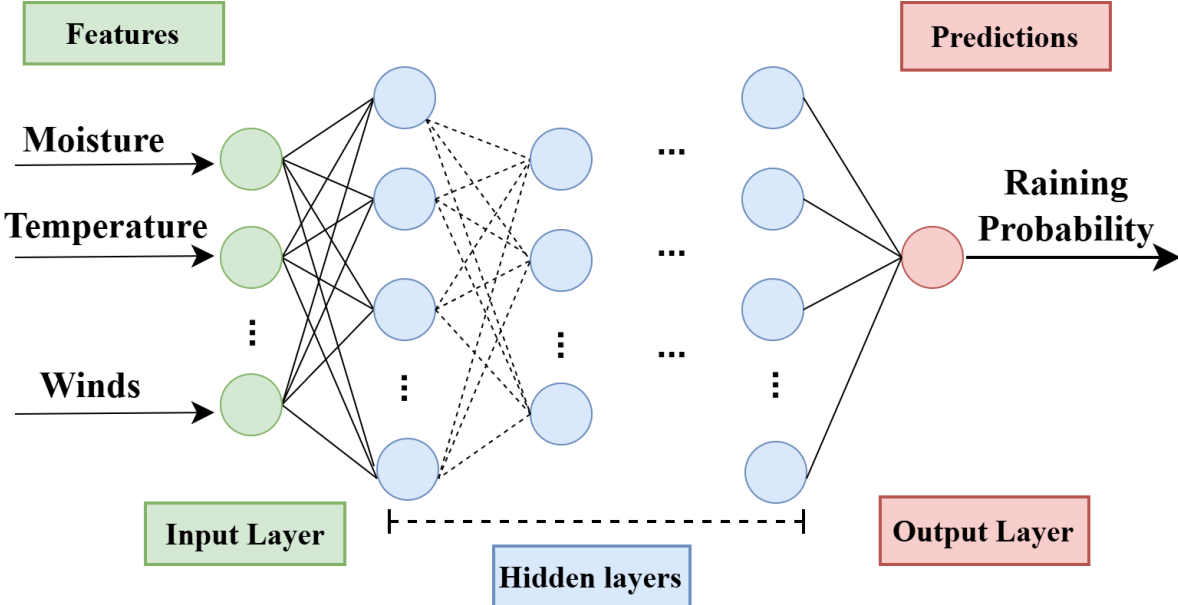
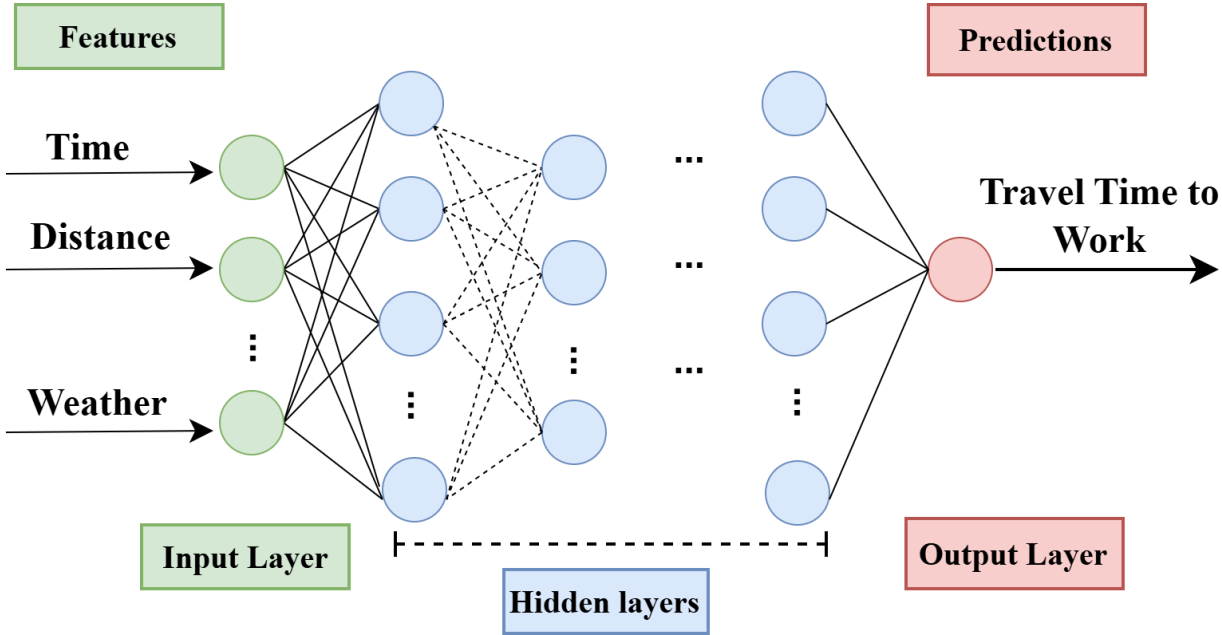


TIERRAS: Tracer Injection Experiments in Rivers and Streams

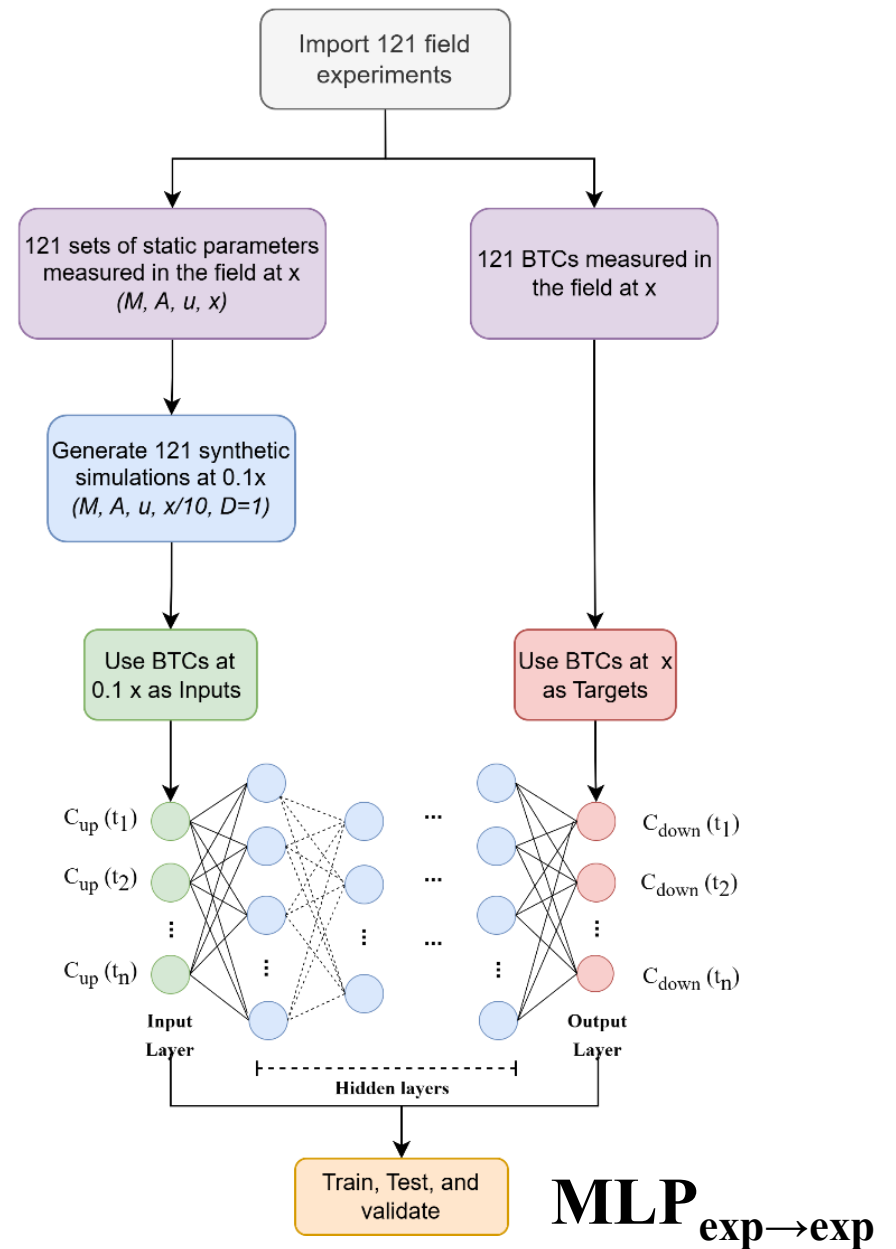
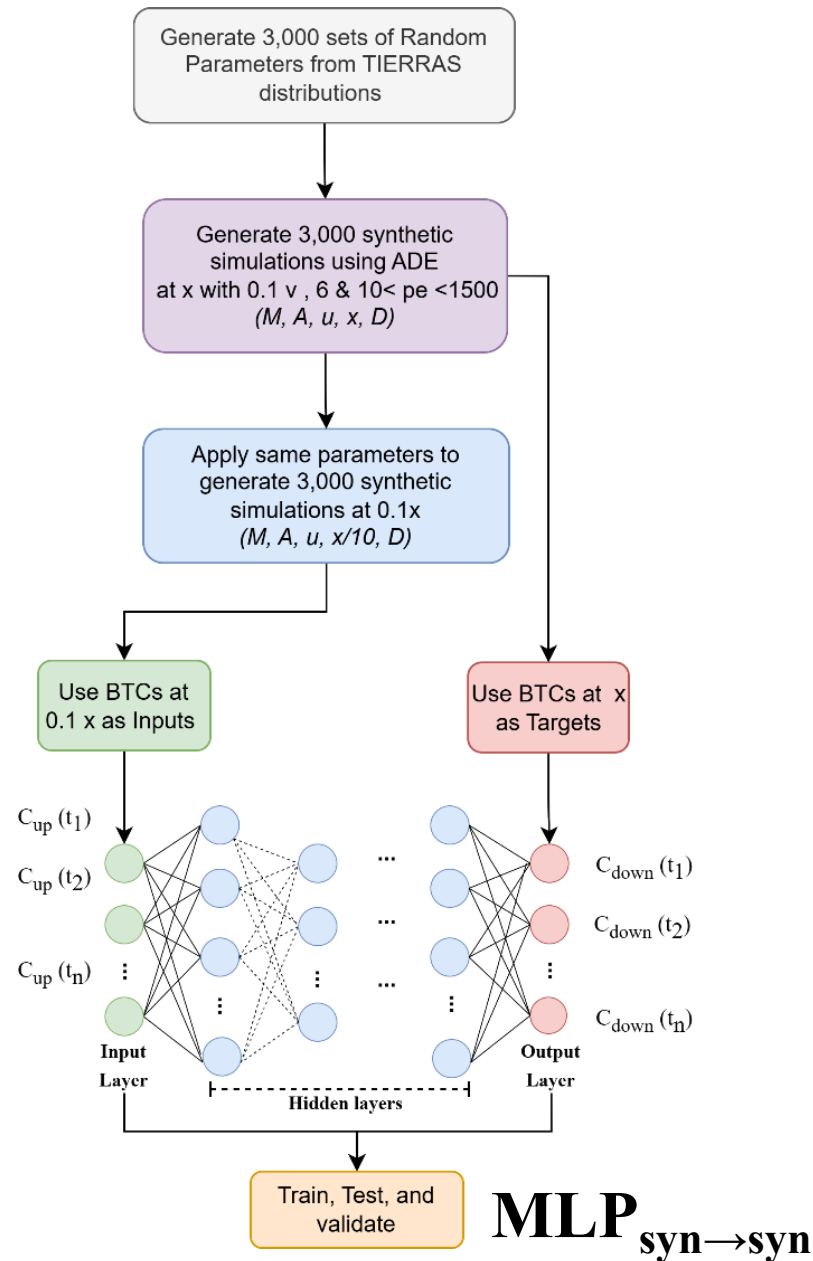
- Distance ranges from 35 to 294500 m
- Velocity ranges from 0.04 to 1.6 m/s
- Mass ranges from 0.01 to 108 Kg



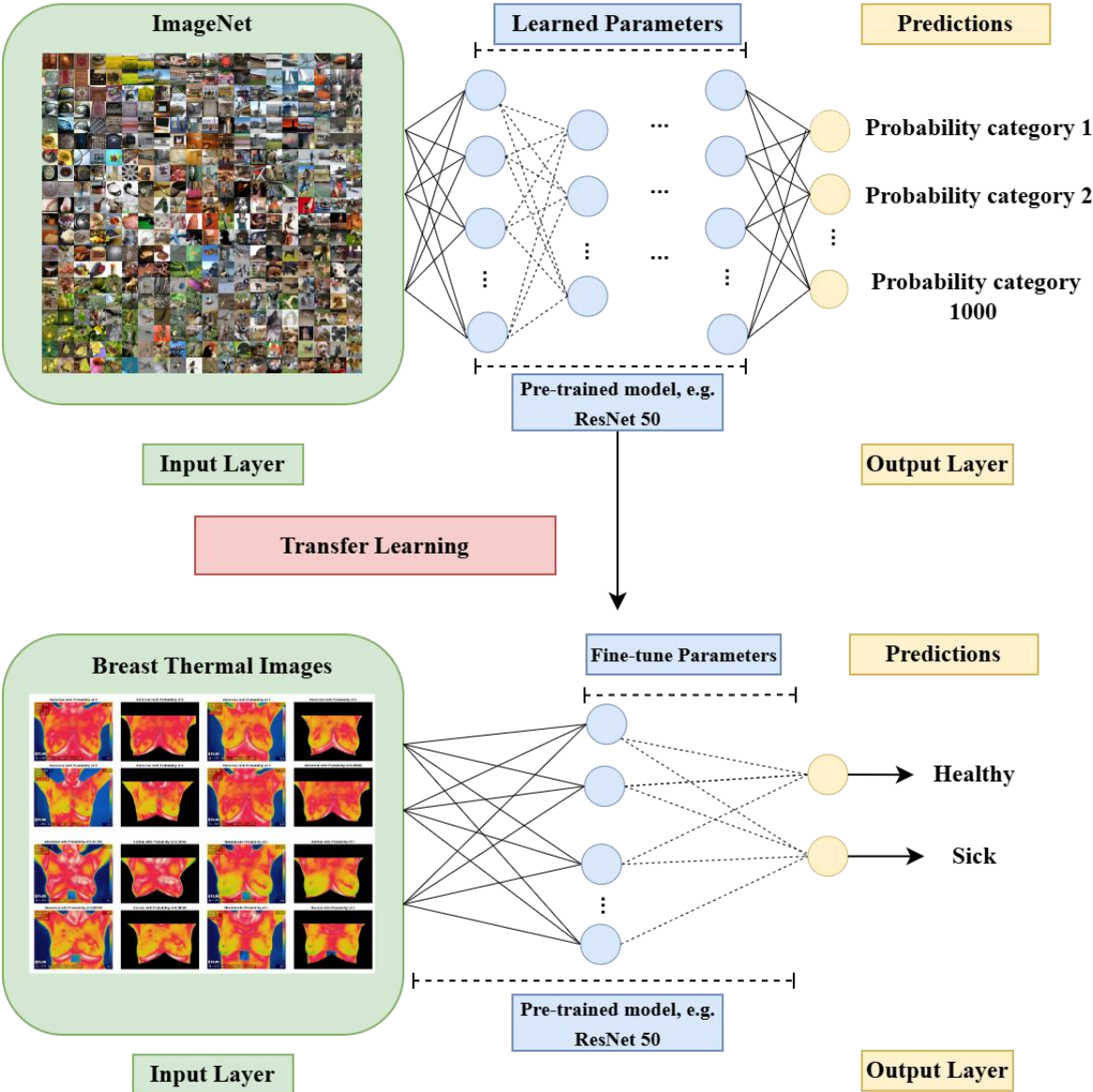
Multilayer Perceptron: How Does It Work?



Multilayer Perceptron: How Do We Apply It?

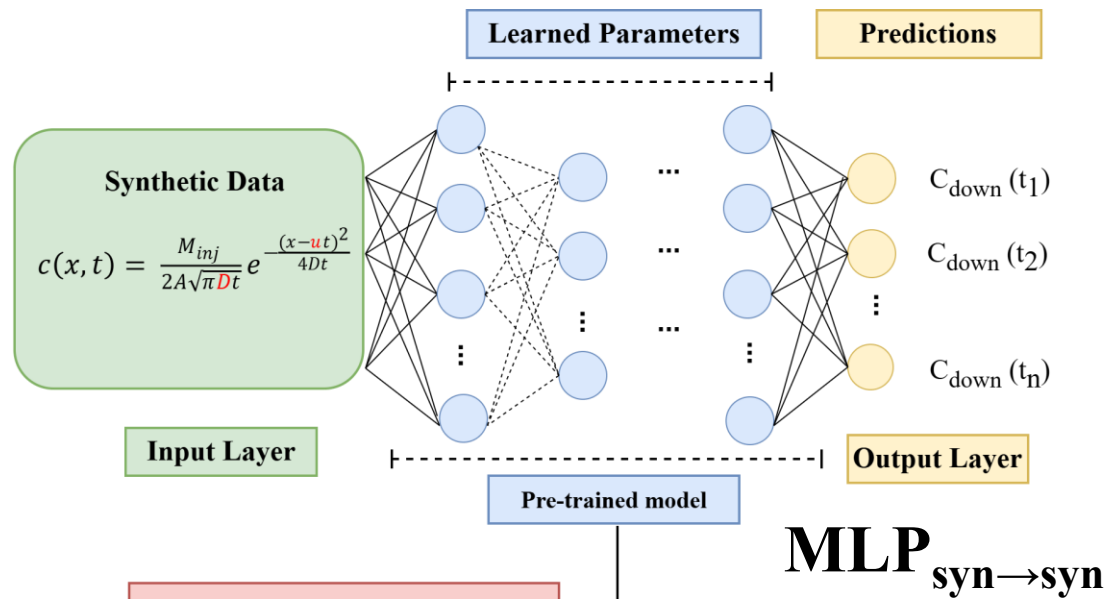


Transfer Learning: How Does It Work?



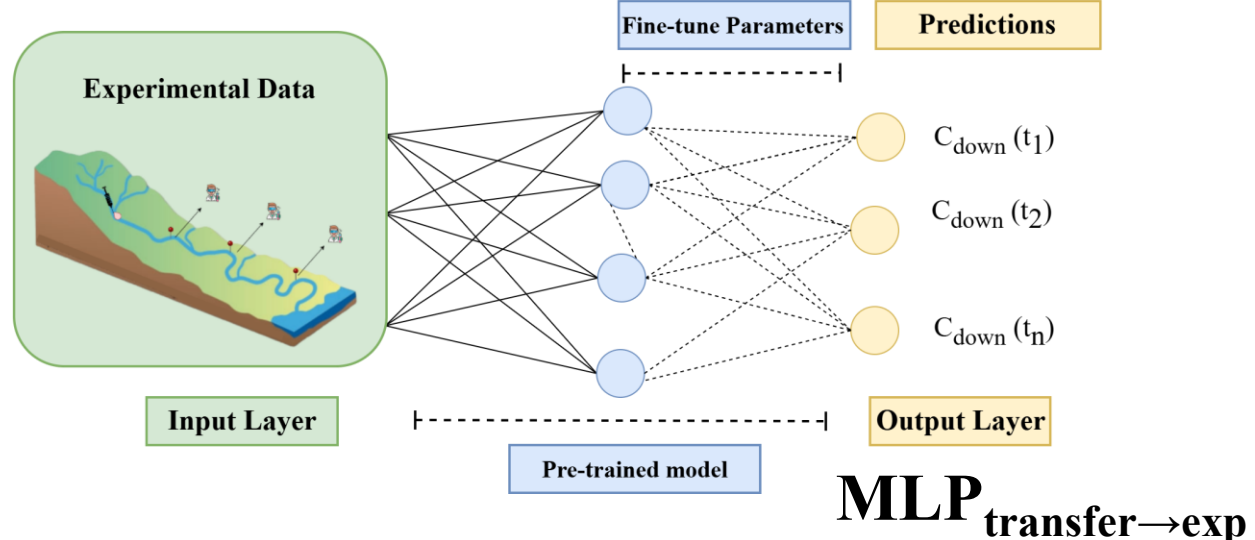
Transfer Learning: How Do We Apply It?

Part 1: Pre-training a physics-based model using synthetic data

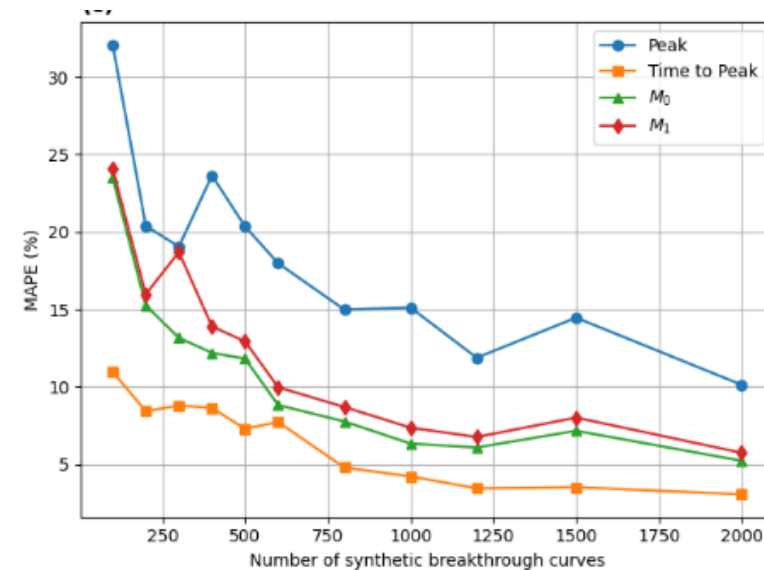
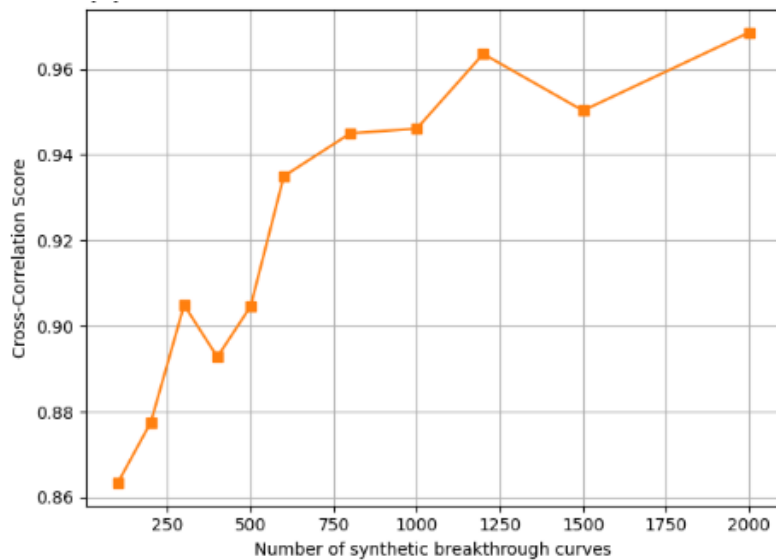
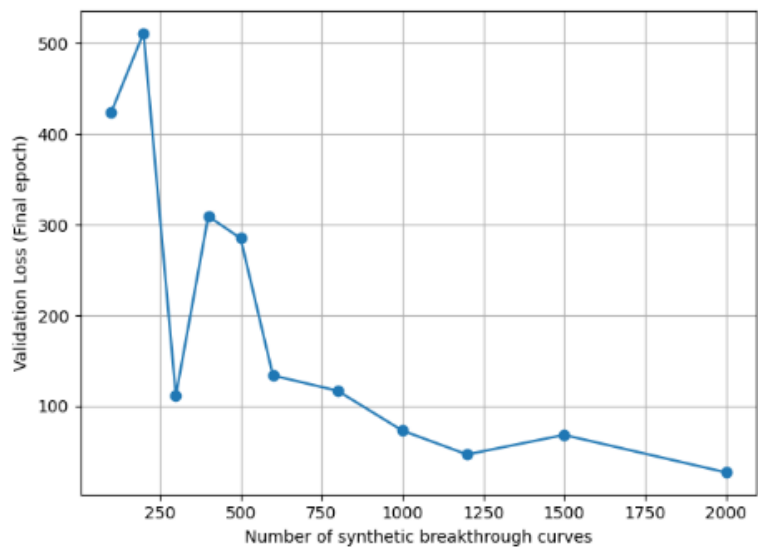


Transfer Learning

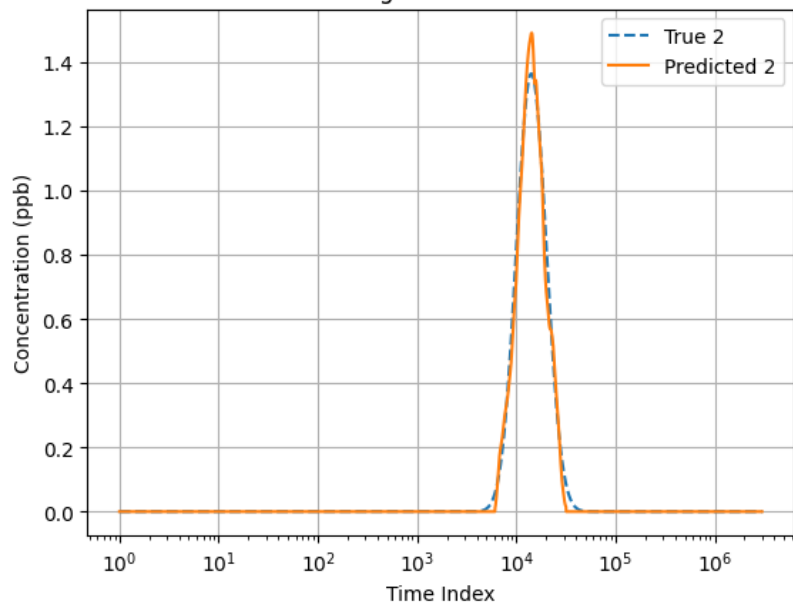
Part 2: Fine tuning a Pre-trained physics-based model with real-world data



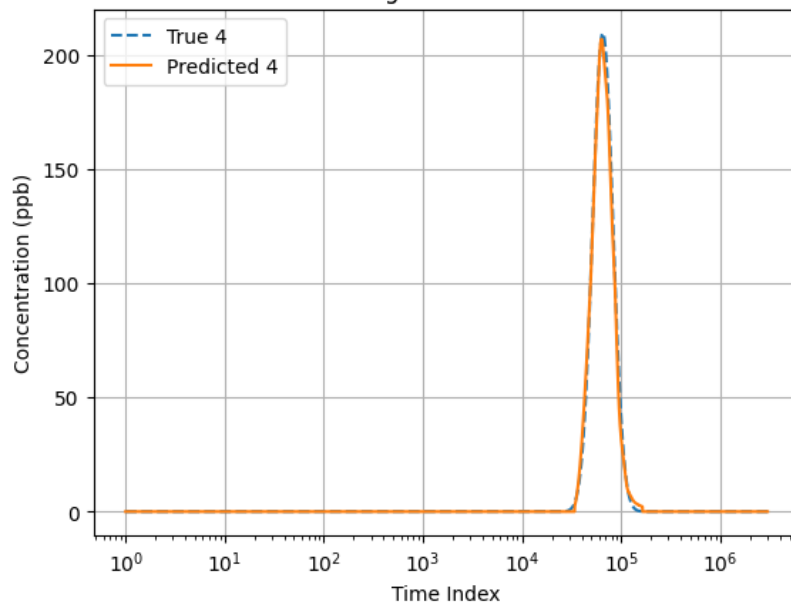
Results MLP_{syn}→_{syn}



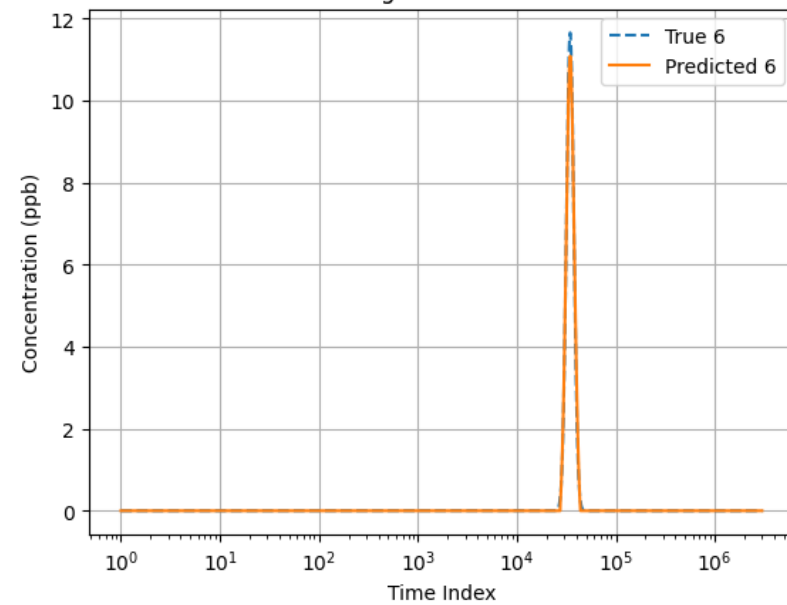
Tested Breakthrough Curves: True vs Predicted



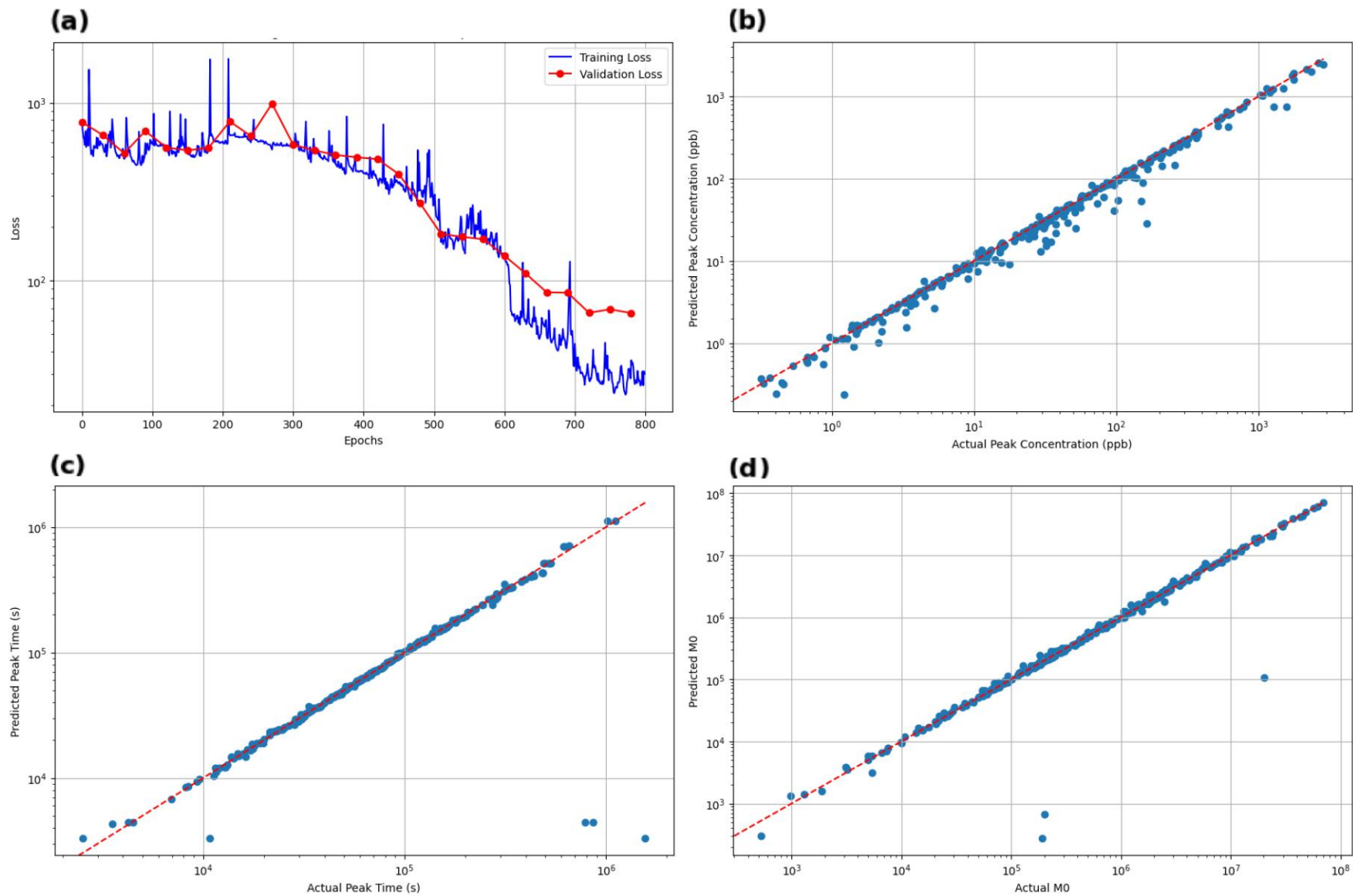
Tested Breakthrough Curves: True vs Predicted



Tested Breakthrough Curves: True vs Predicted

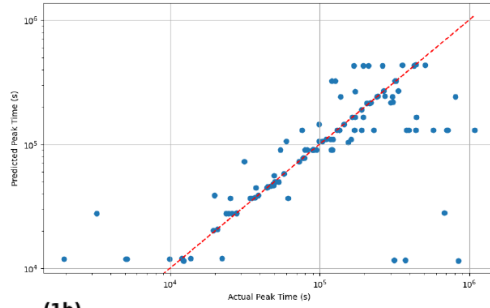


Results $\text{MLP}_{\text{syn} \rightarrow \text{syn}}$

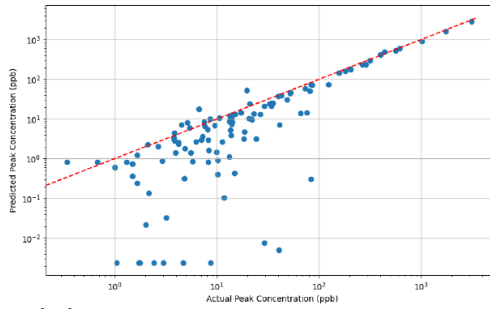


MLP_{exp→exp}

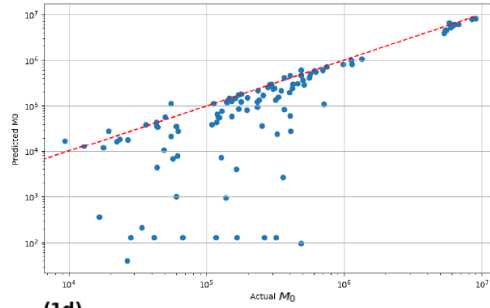
(1a)



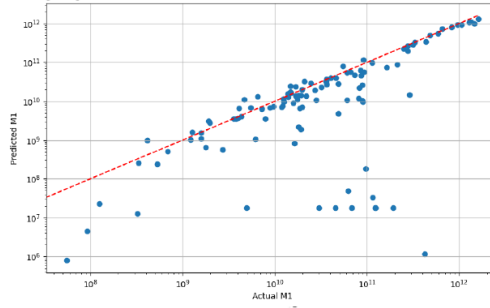
(1b)



(1c)

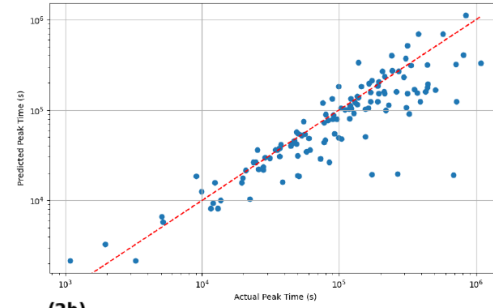


(1d)

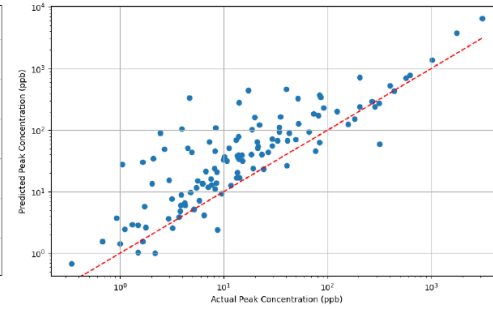


MLP_{syn→exp}

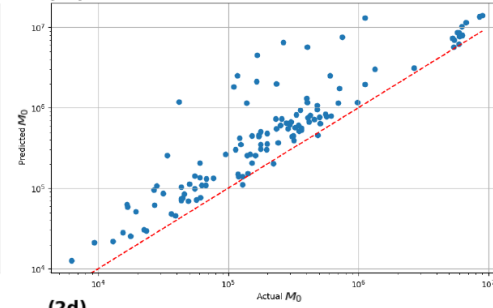
(2a)



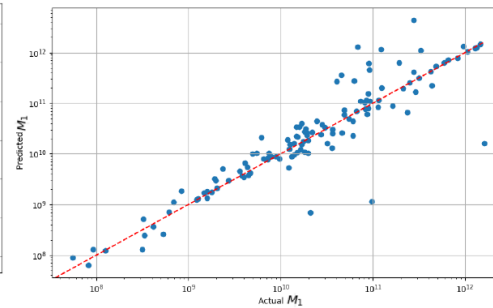
(2b)



(2c)

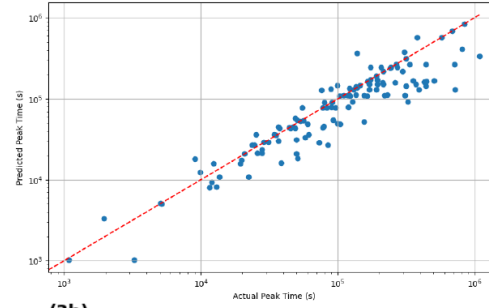


(2d)

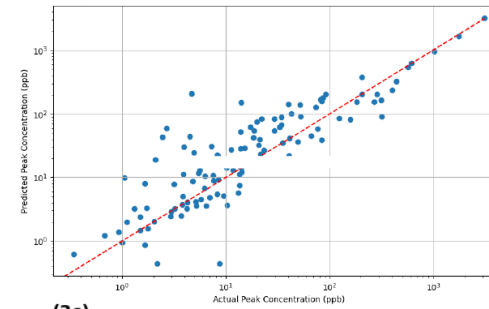


MLP_{transfer→exp}

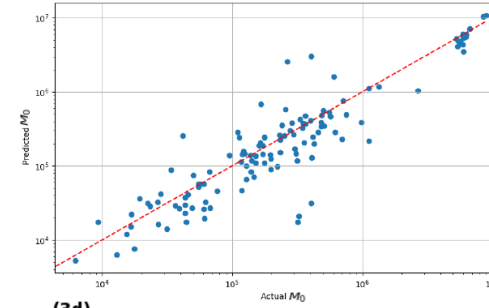
(3a)



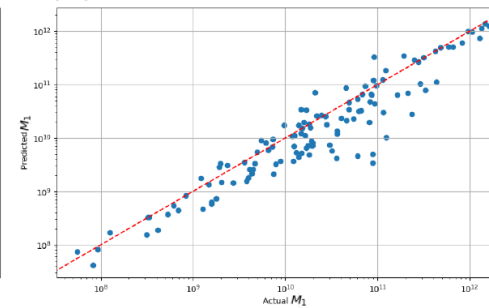
(3b)



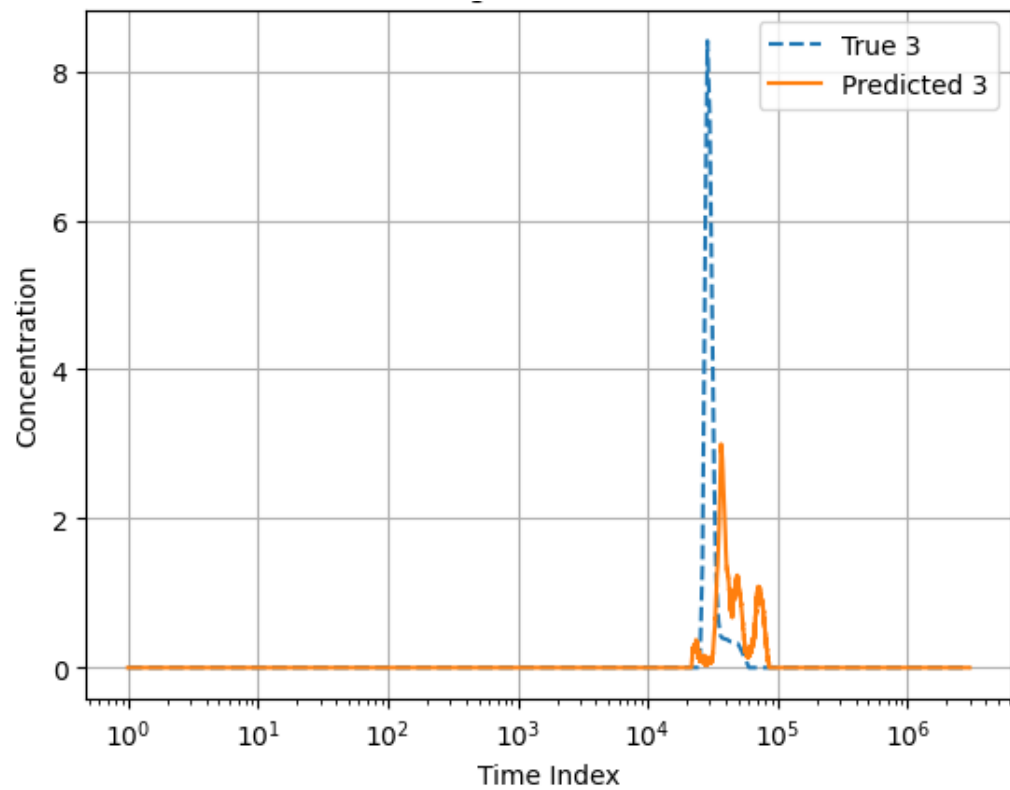
(3c)



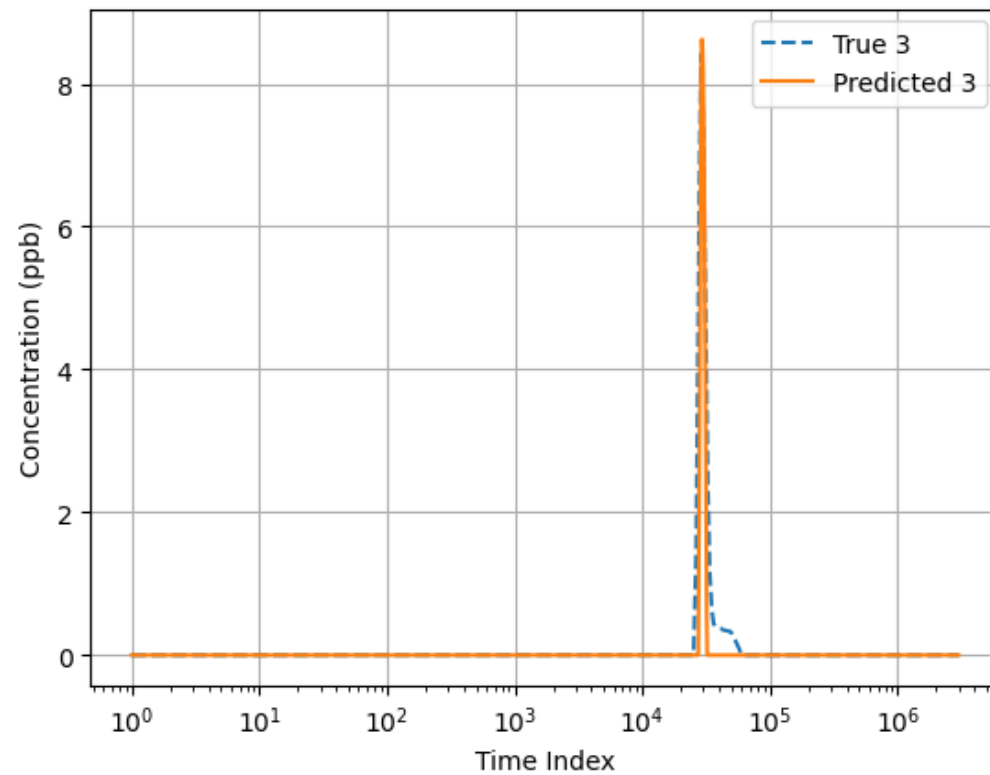
(3d)



MLP_{exp→exp}



MLP_{transfer→exp}



Conclusions



The proposed MLP approach can learn and predict the solute transport behavior across a wide range of hydrologic conditions



Transfer Learning has been shown to be a highly reliable alternative when data is limited



More experiments are needed to improve performance

Thank You

Questions?

