BAYESIAN PREDICTION OF CONSOLIDATION SETTLEMENT USING AUTOENCODER NEURAL NETWORK AND SURROGATE MODEL

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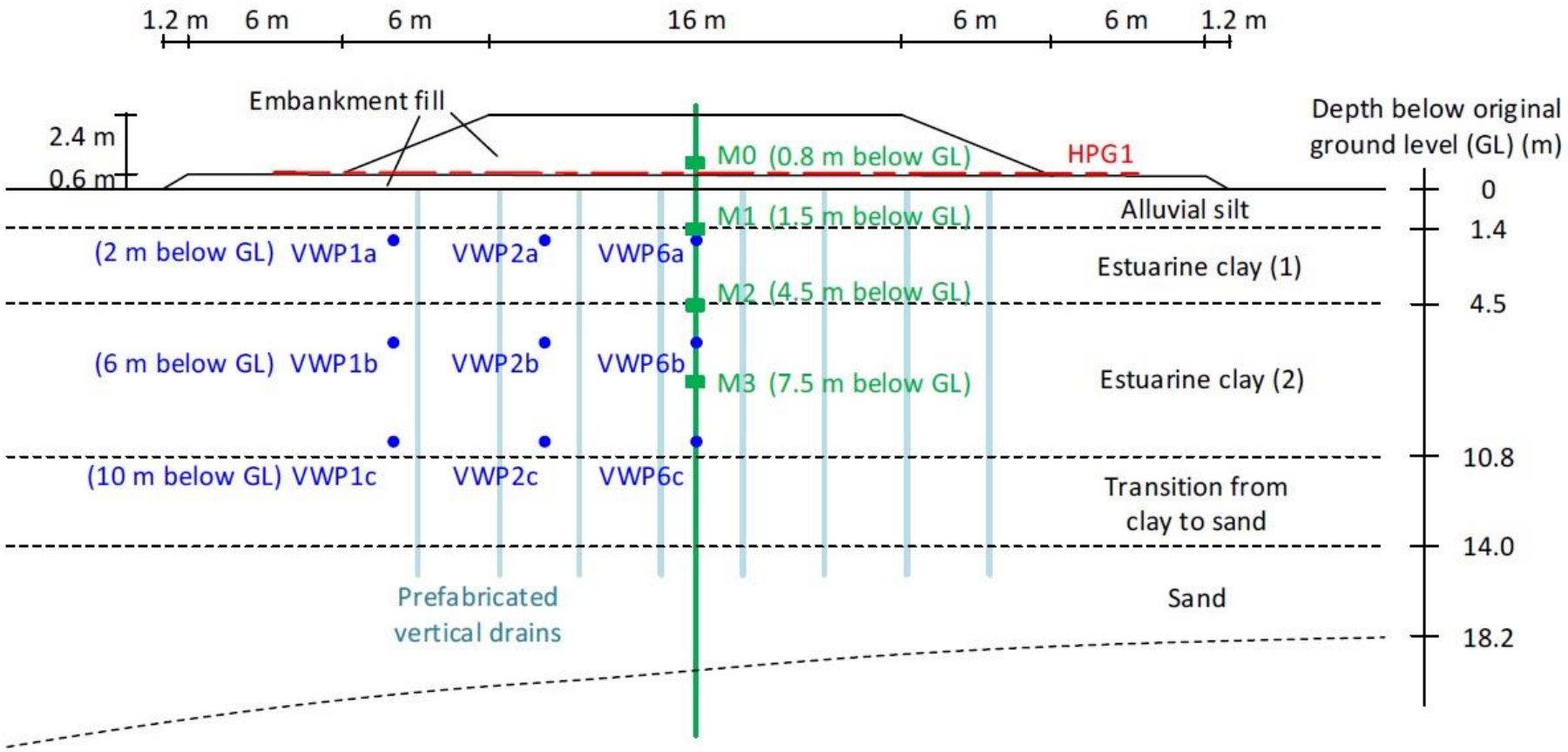
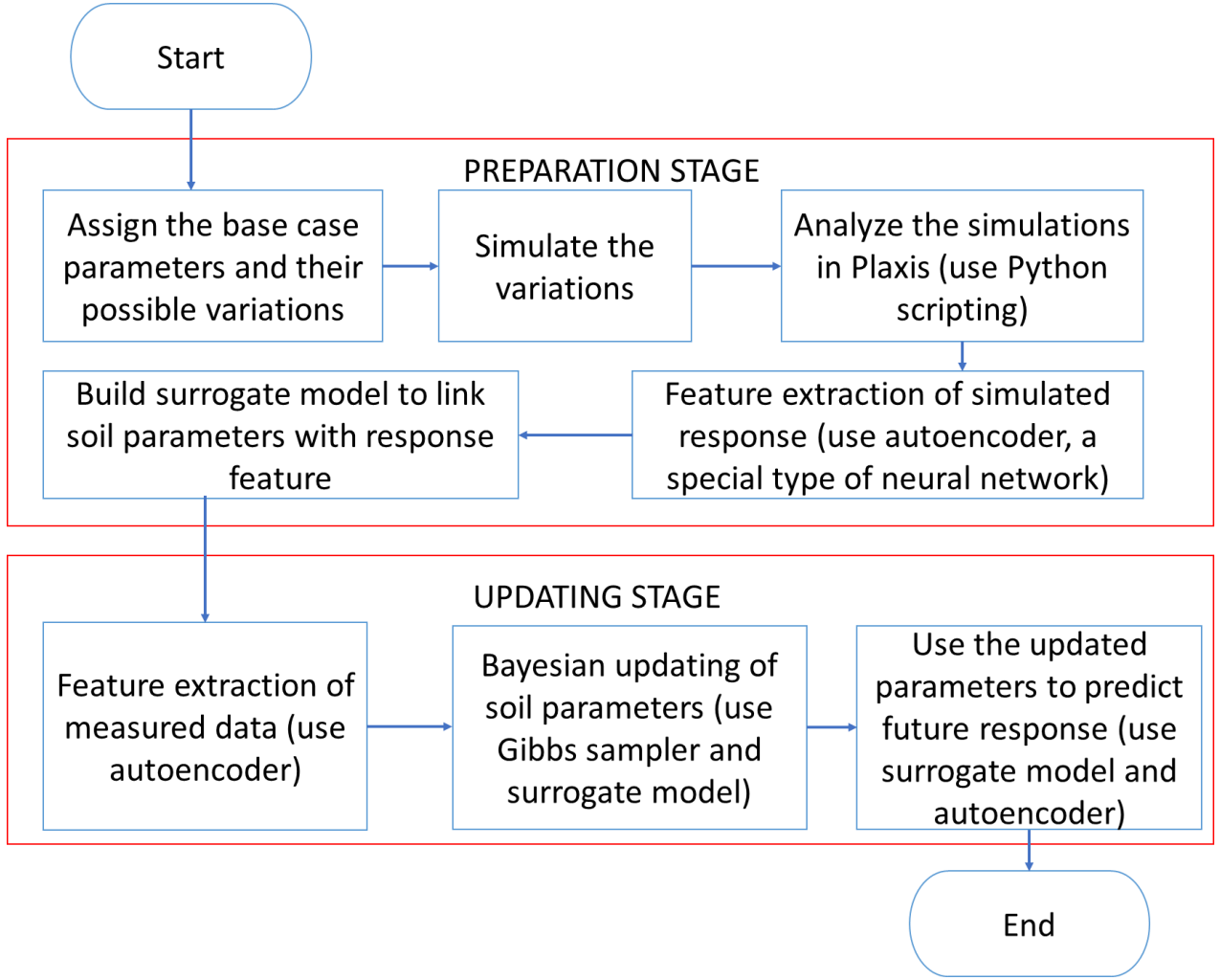
CROSS-SECTION OF PROBLEM GEOMETRY

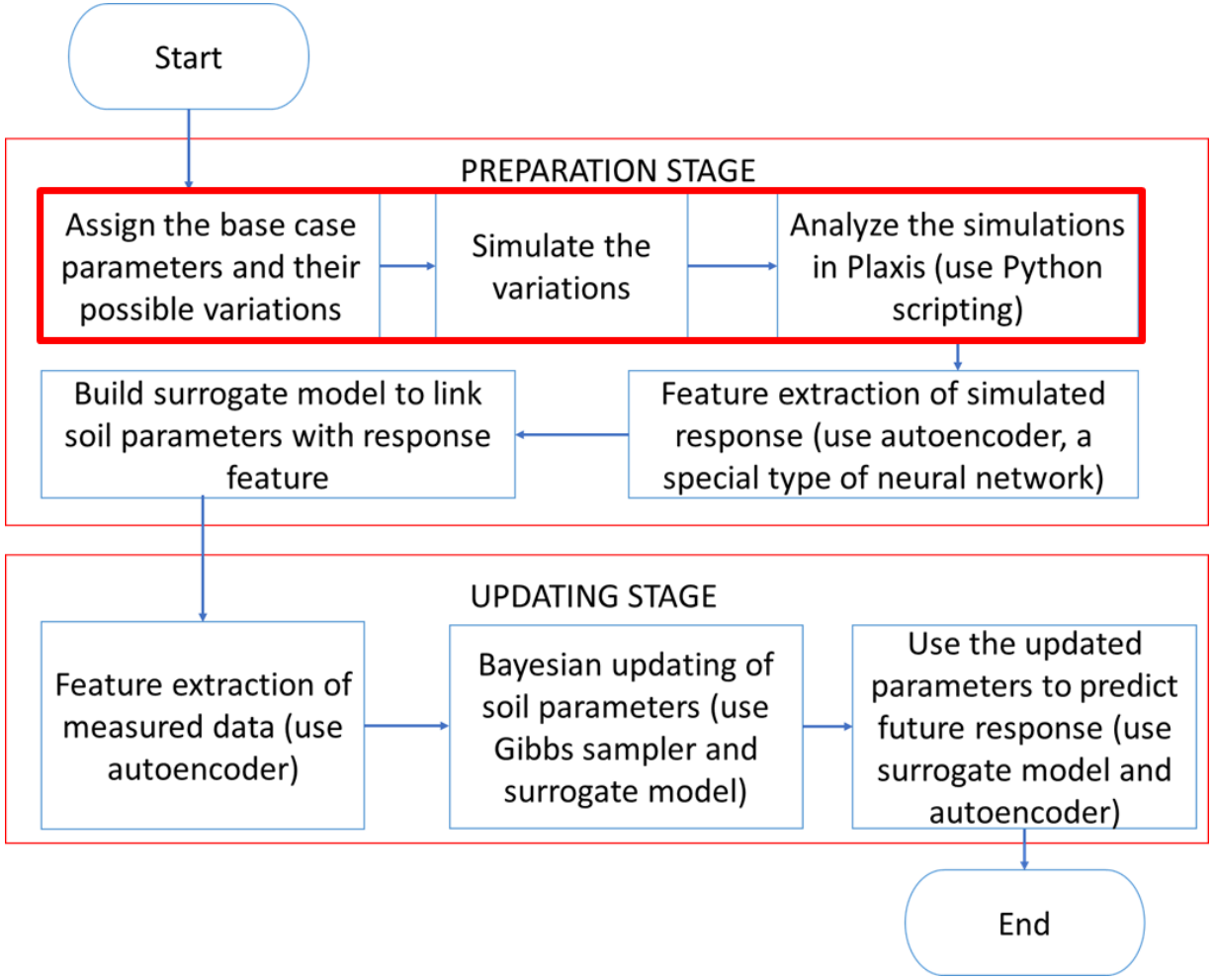


PROJECT FRAMEWORK

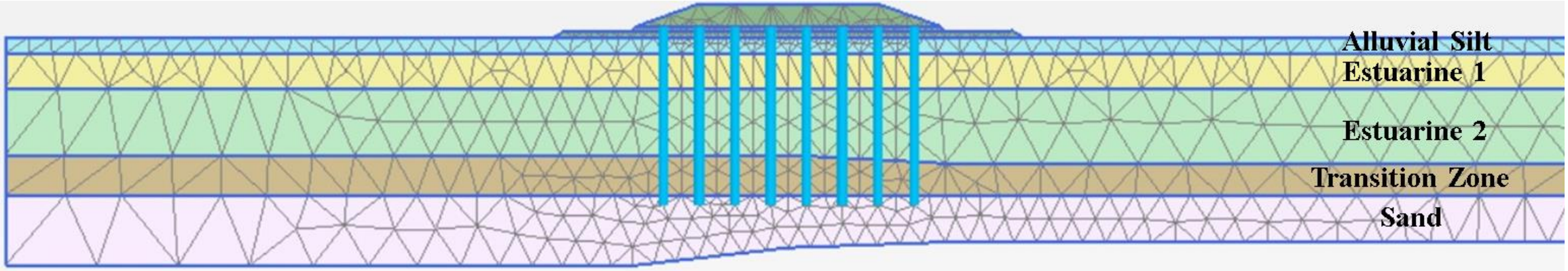


PRELIMINARY WORK

- Created Plaxis model of embankment case
- Produced range of values of soil parameters
- Ran simulations for different combinations of soil parameters
- Transposed raw data into graphs



PLAXIS MODEL OF EMBANKMENT CASE



RANGE OF SOIL PARAMETERS

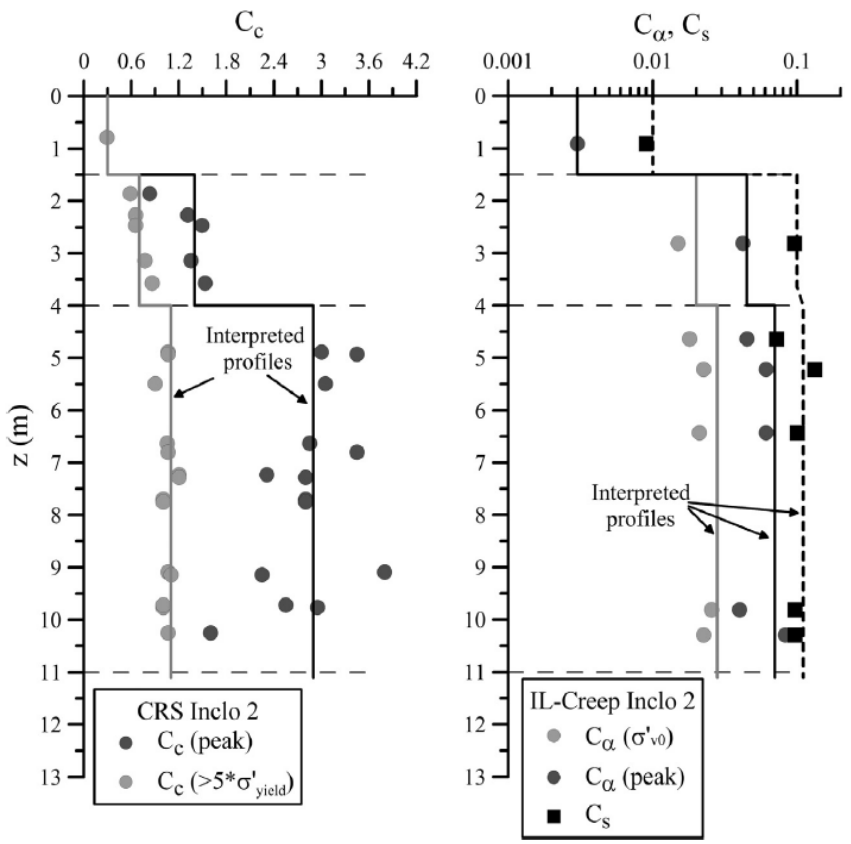


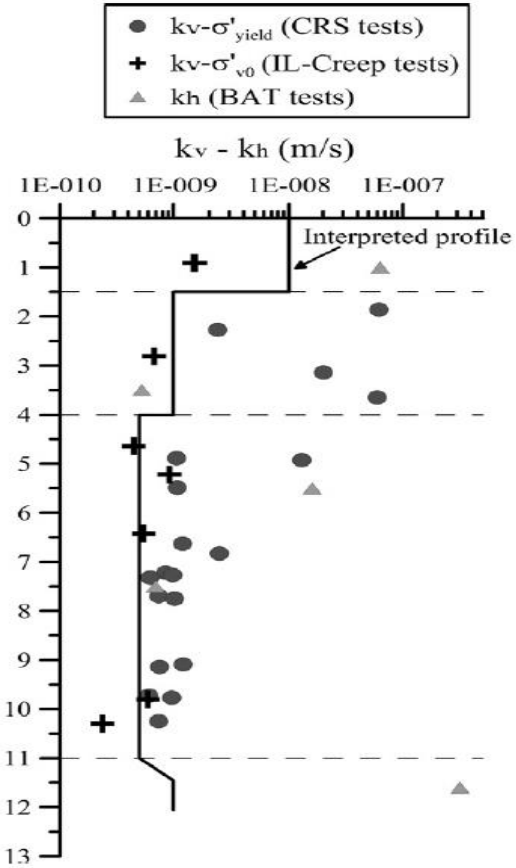
Fig. 4. Profiles of compression, recompression and creep indices. adapted from [2]

Range of values C_c & C_α (Kelly et. al., 2018)

$$\lambda^* = \frac{C_c}{2.3(1+e)}$$

$$\mu^* = \frac{C_\alpha}{2.3(1+e)}$$

Formula for λ* and μ* from Plaxis soft soil creep model



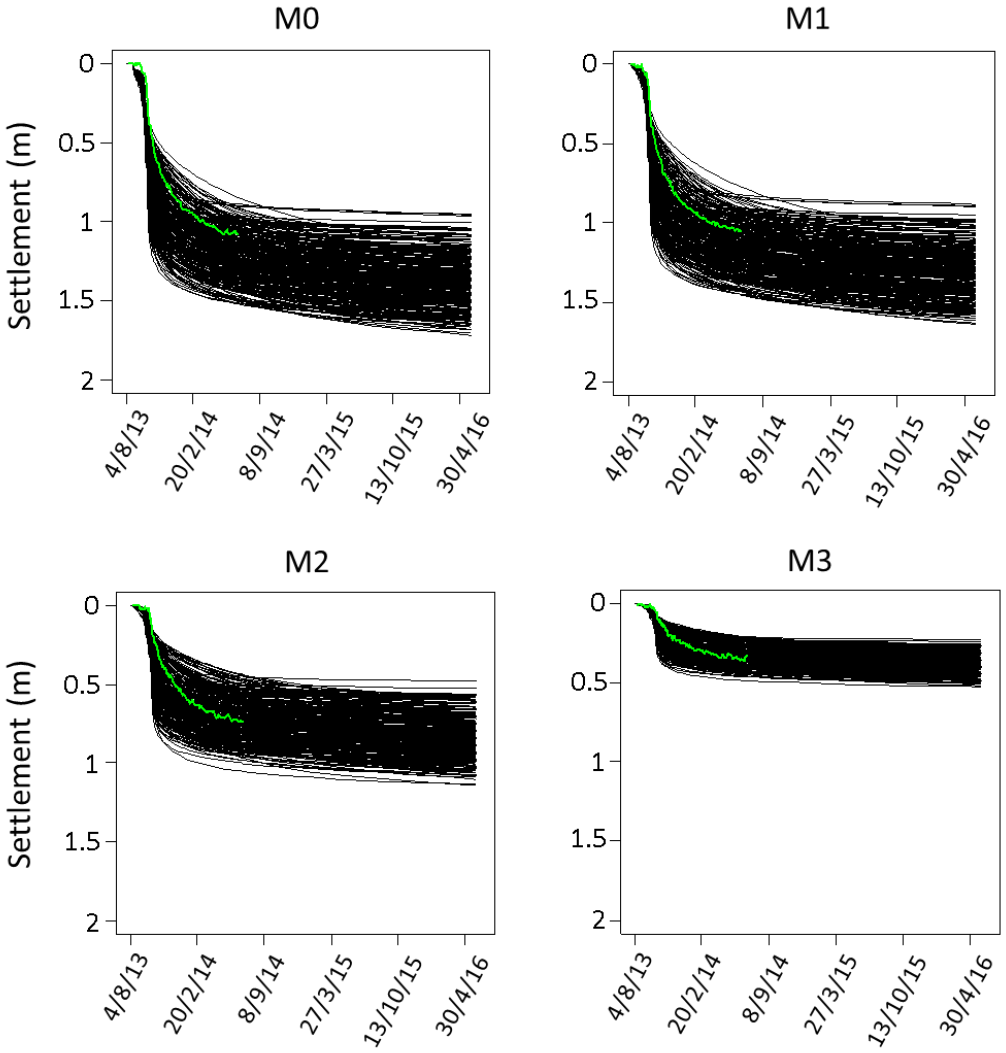
Range of values of k_h (Kelly et. al., 2018)

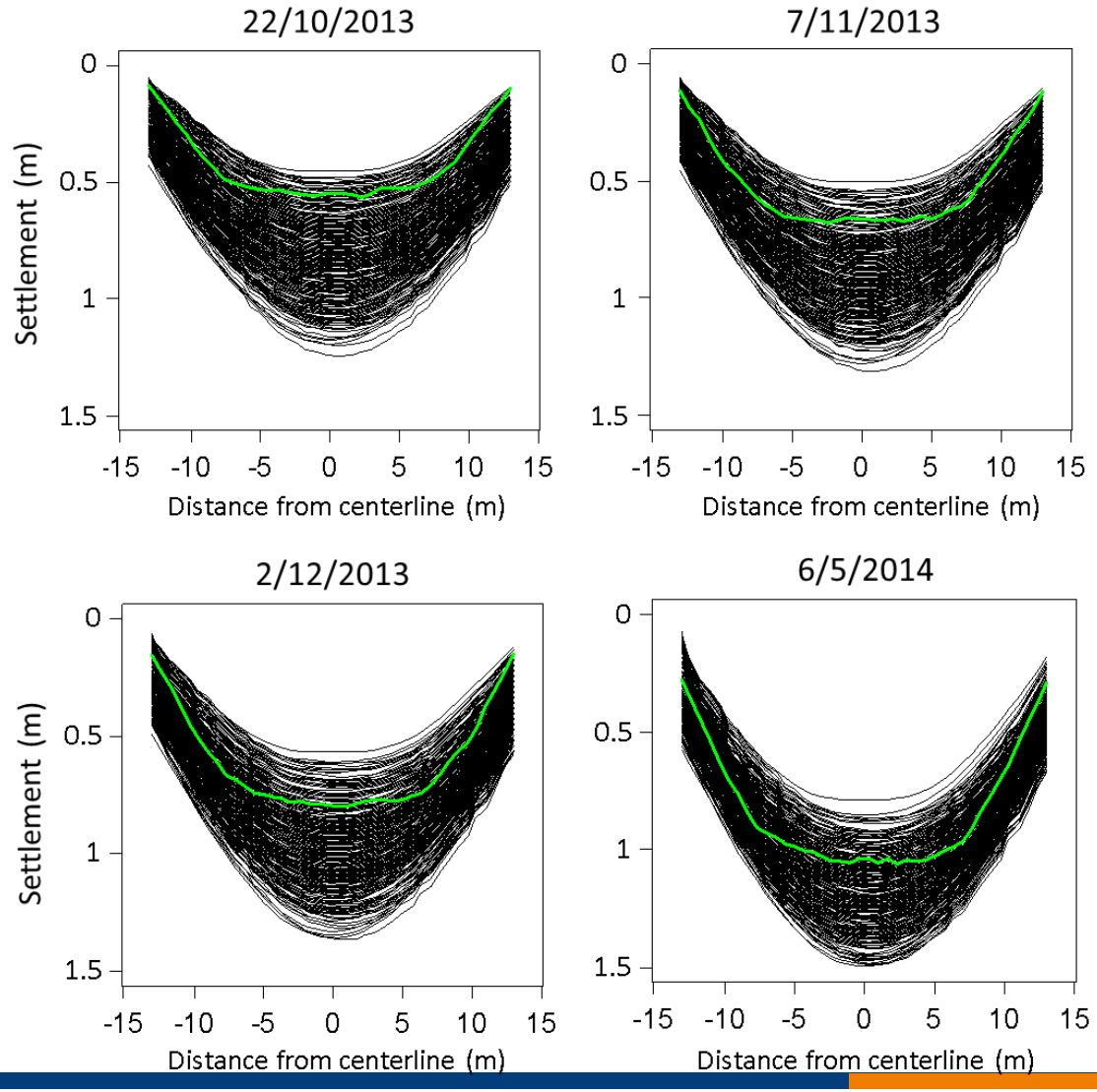
RANGE OF SOIL PARAMETERS

- Based on range of soil parameters, 300 soil combinations are selected by Latin hypercube sampling
- 300 runs of embankment case based on the 300 soil combinations

Parameter	Minimum	Maximum
λ* Alluvial Silt	0.03	0.1
λ* Est(1)	0.08	0.36
λ* Est(2)	0.075	0.38
λ* Trans	0.02	0.1
μ* Est(1)	0.00217	0.011
μ* Est(2)	0.002	0.013
$\log_{10}k_h$ Est(1)	-4.46	-1.88
$\log_{10}k_h$ Est(2)	-4.46	-1.88

SOIL SETTLEMENT GRAPHS





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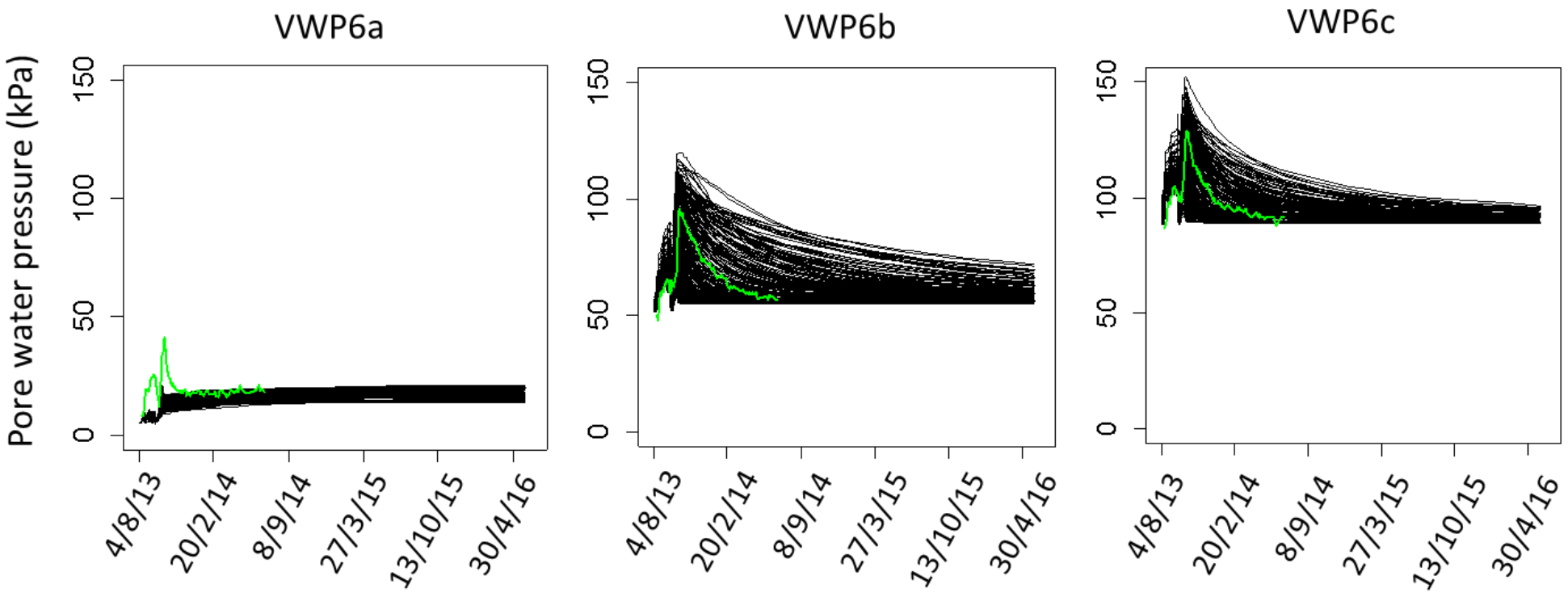
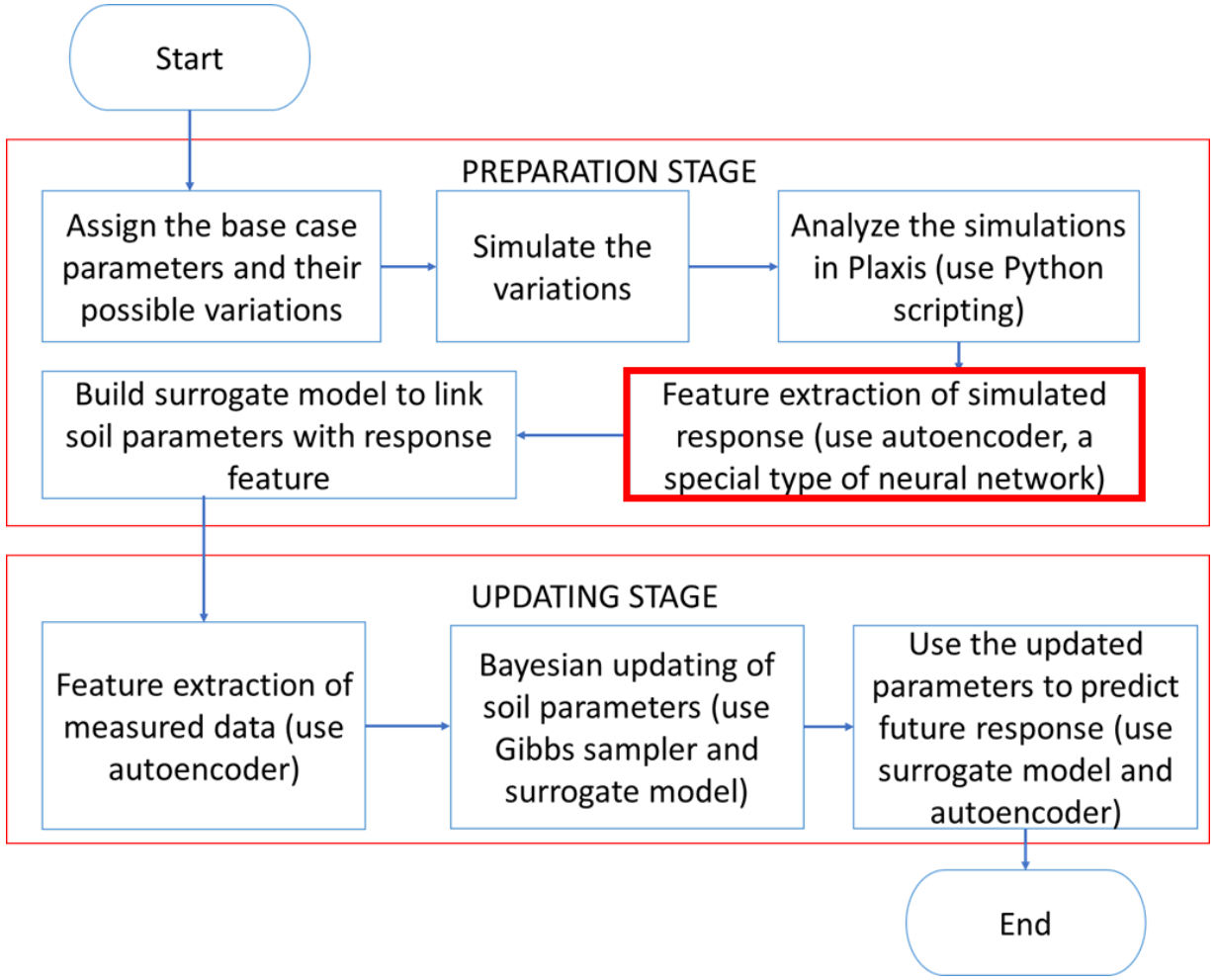
TOTAL PORE WATER PRESSURE GRAPHS



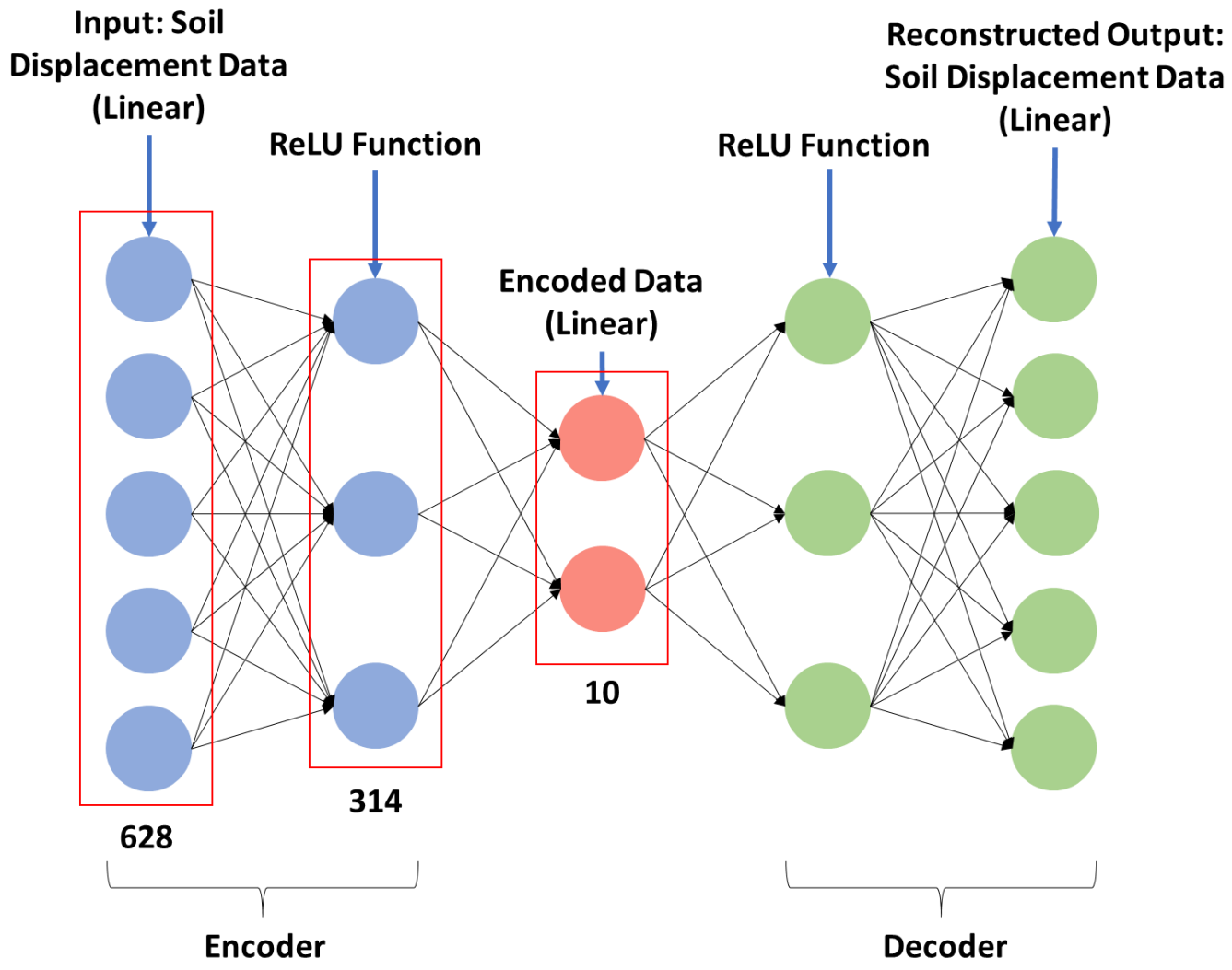
FEATURE EXTRACTION OF SIMULATED RESPONSE

- Raw data from will be compressed using an autoencoder
- Each simulation has 628 settlement data points



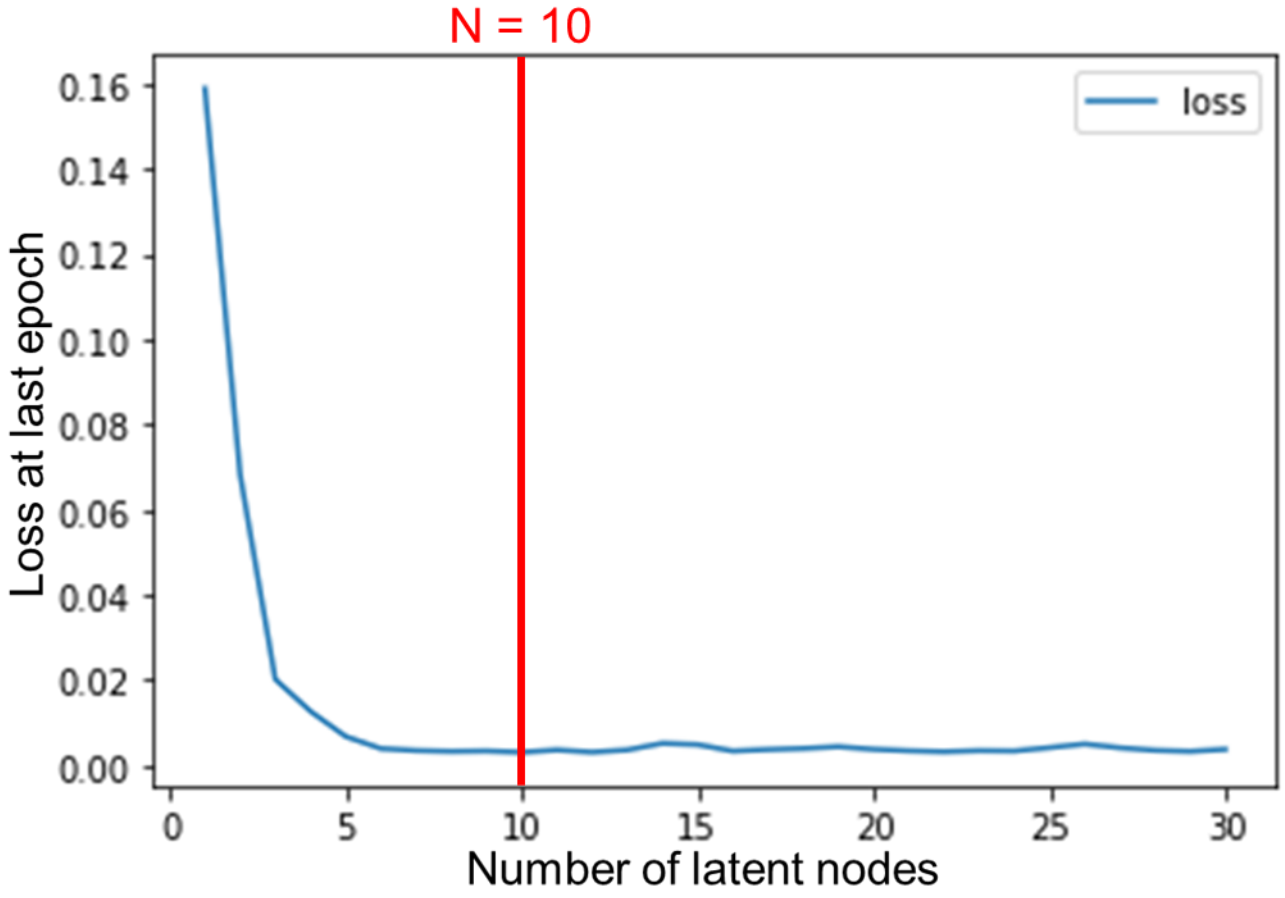
FEATURE EXTRACTION OF SIMULATED RESPONSE

- 300 simulations of 628 data points
- Shape of Input: (300, 628)
- ReLU: Rectified Linear Unit

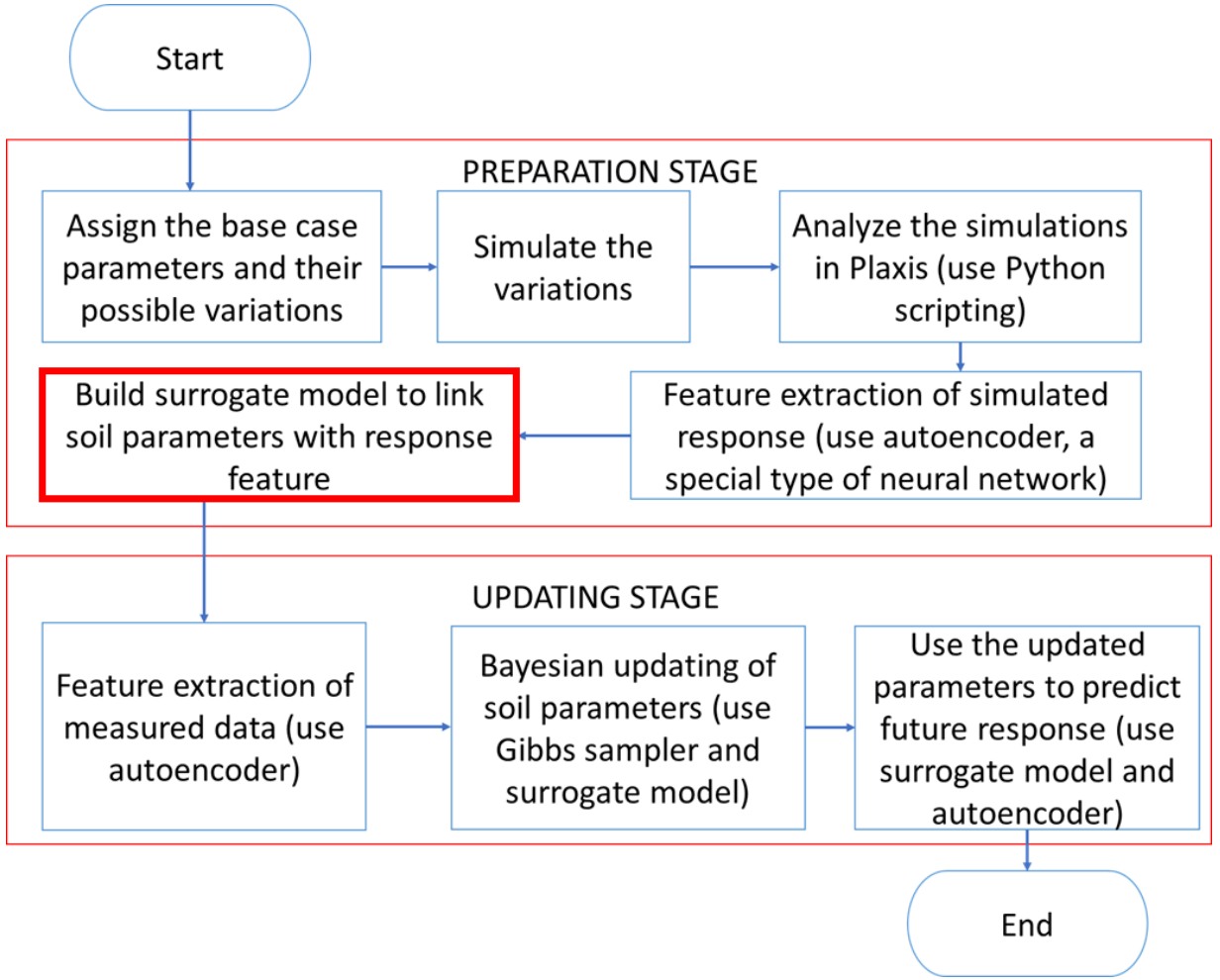


FEATURE EXTRACTION OF SIMULATED RESPONSE

- Refers to the percentage of error of the last epoch for each latent node
- Number of iterations are decided based on trial and error till loss converges



SURROGATE MODELLING

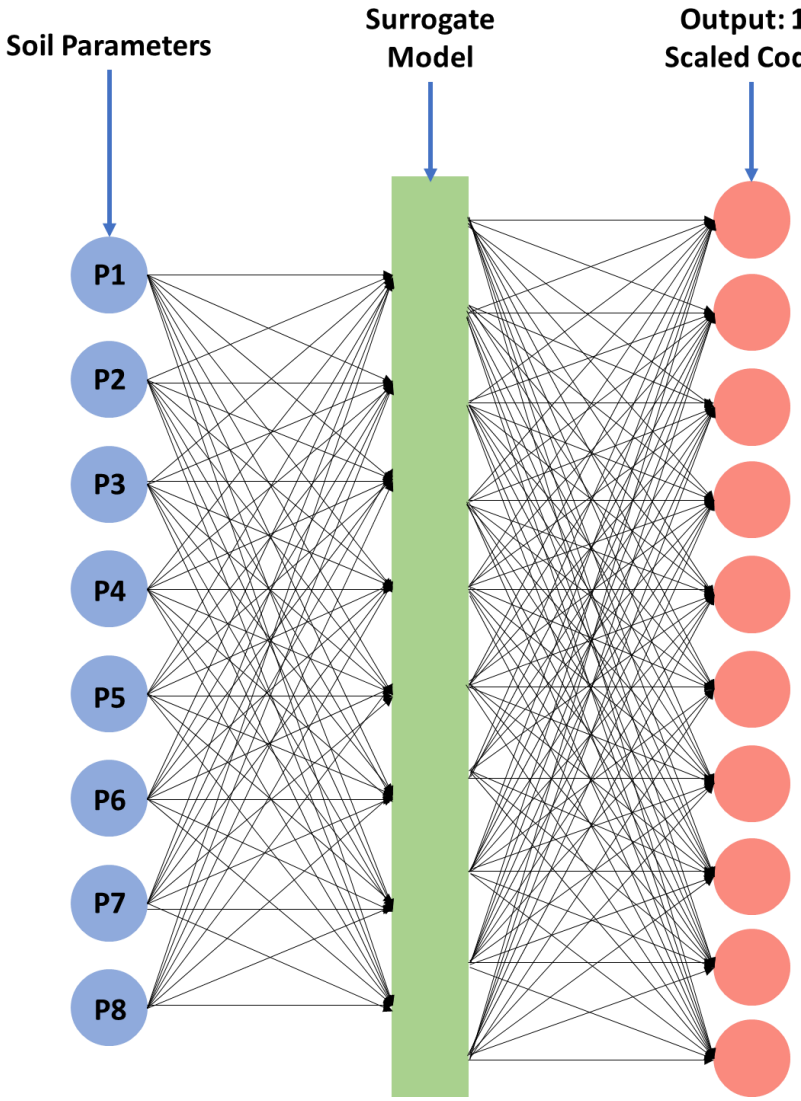


SURROGATE MODELLING

- 8 soil parameters, scaled to within a range of -1 and 1
- Equation of surrogate model:

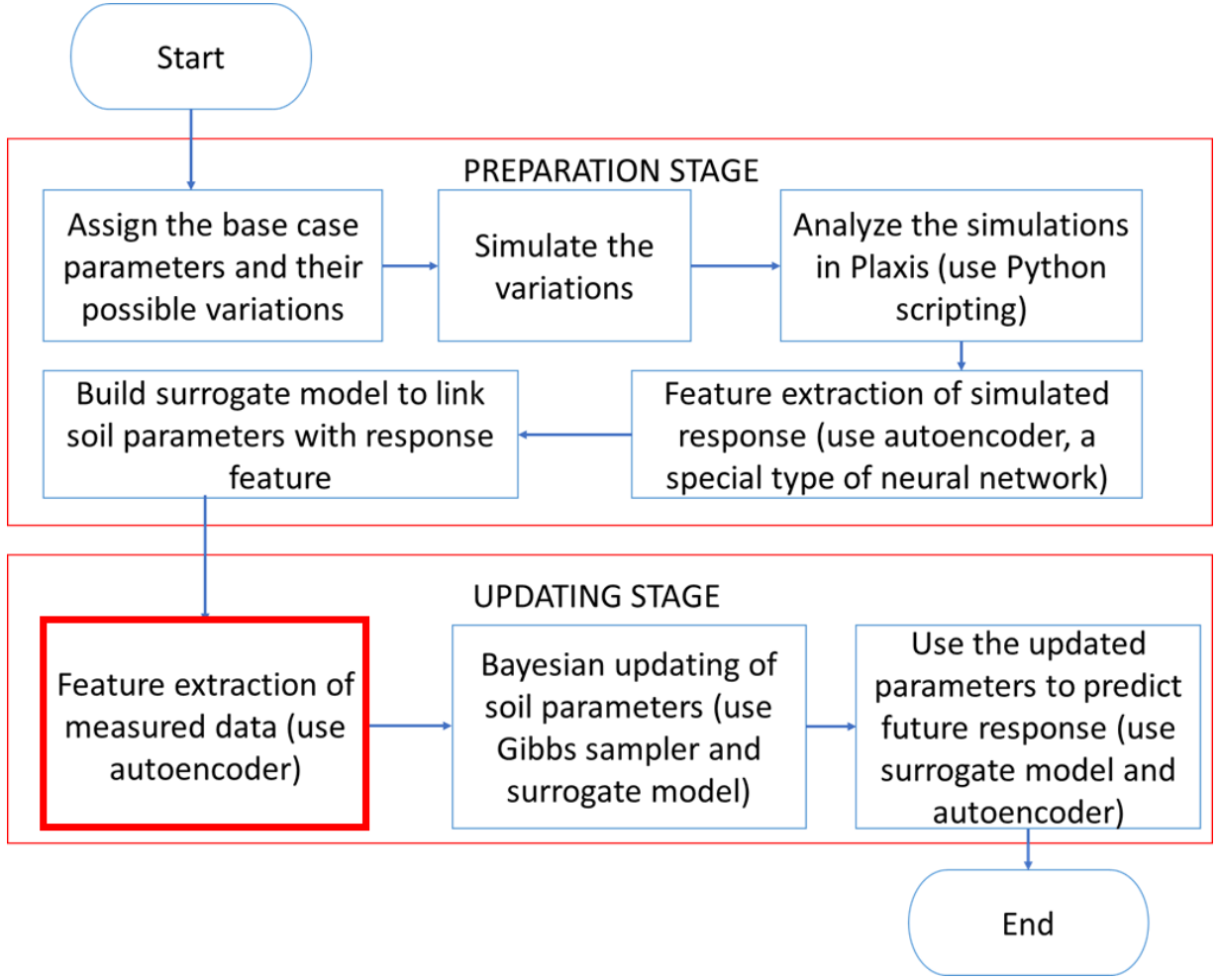
$a_0+a_1*p_1+ a_2*p_2+ a_3*p_3+$
$\ldots+a_9*(p_1^2)+a_{10}*p_2*p_1+a_{11}*(p_2^2)+a_{12}*p_3*p_1+$
$\ldots+a_{43}*p_8*p_7+a_{44}*(p_8^2)$

- Output: 10 codes scaled to within a range of -3 and 3
- Average value of accuracy for output = 0.924254



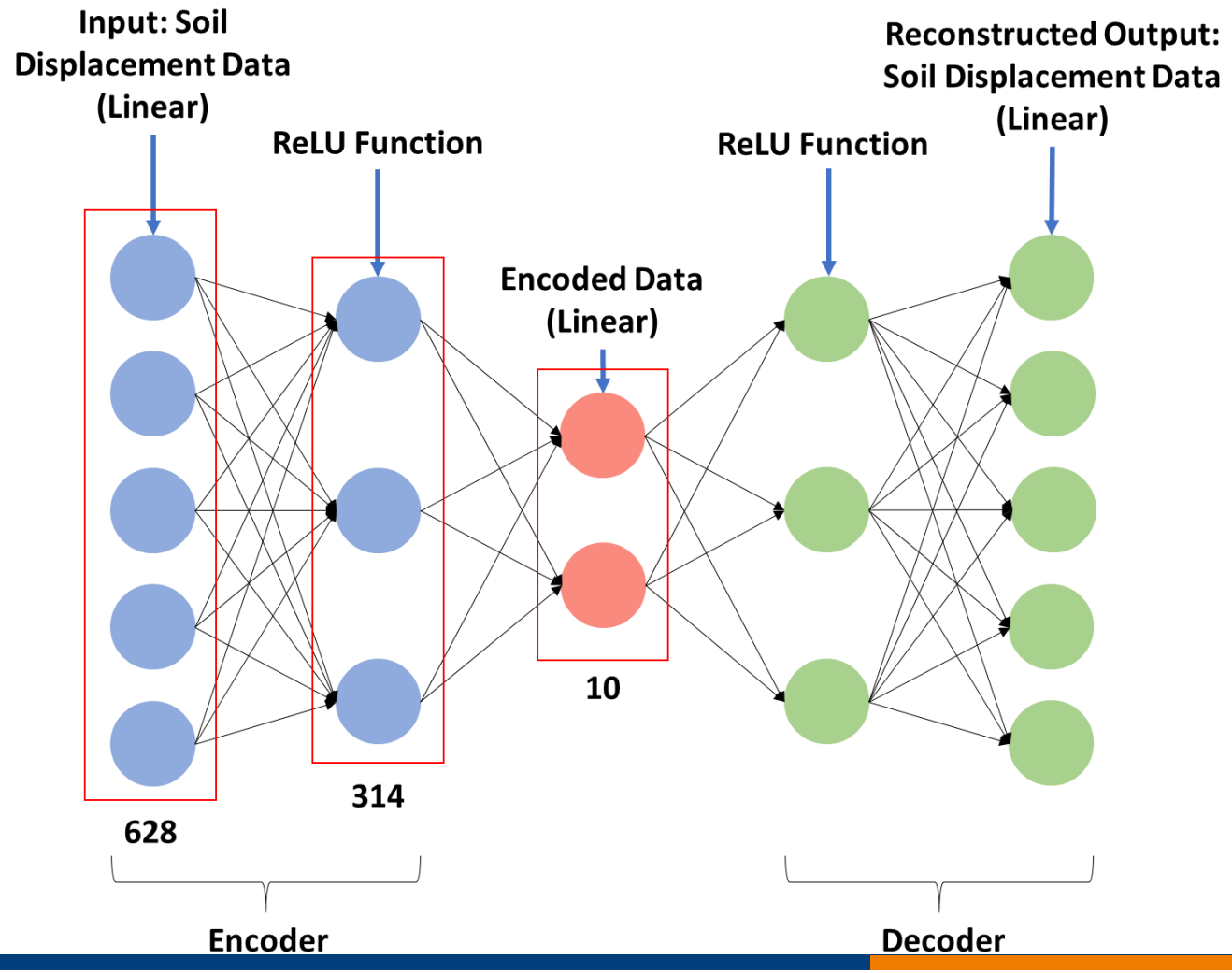
FEATURE EXTRACTION OF MEASURED DATA

- Retrieved from the synthetic data from the contest question
- Extracted using the same autoencoder script developed earlier for simulated response

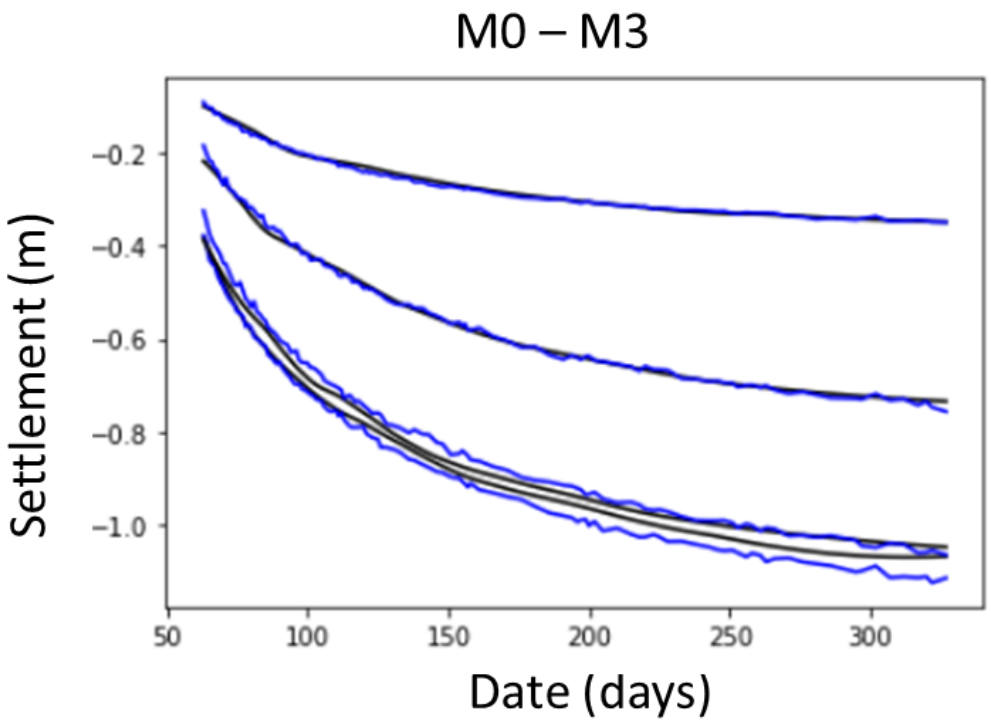


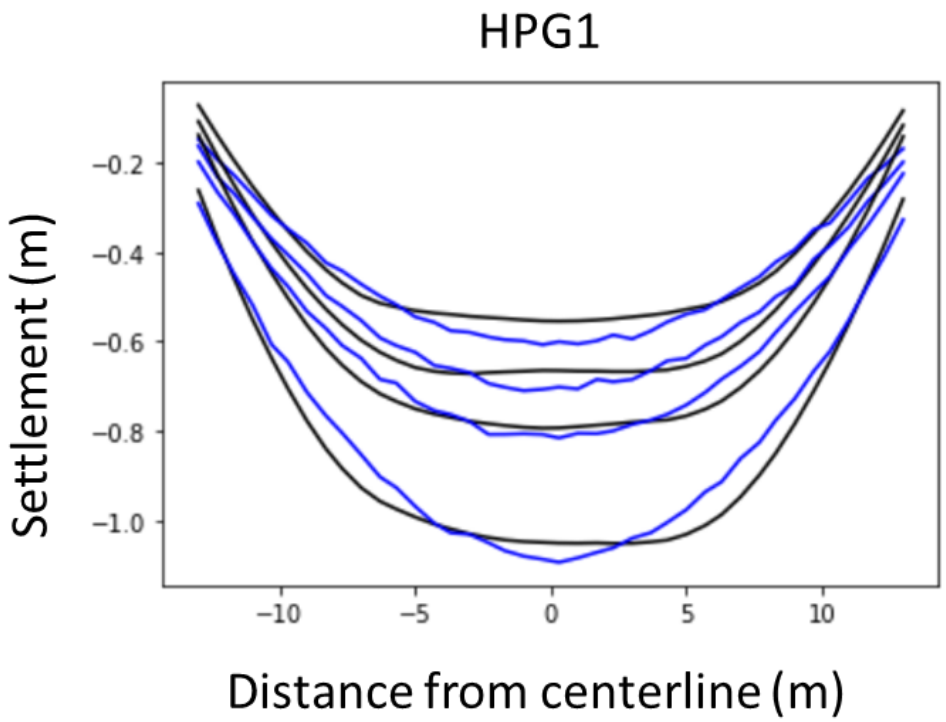
FEATURE EXTRACTION OF MEASURED DATA

- Using the same autoencoder script developed earlier for simulated response
- Shape of Input: (1, 628)
- Code from latent nodes is scaled to fit a range between -3 and 3



FEATURE EXTRACTION OF MEASURED DATA



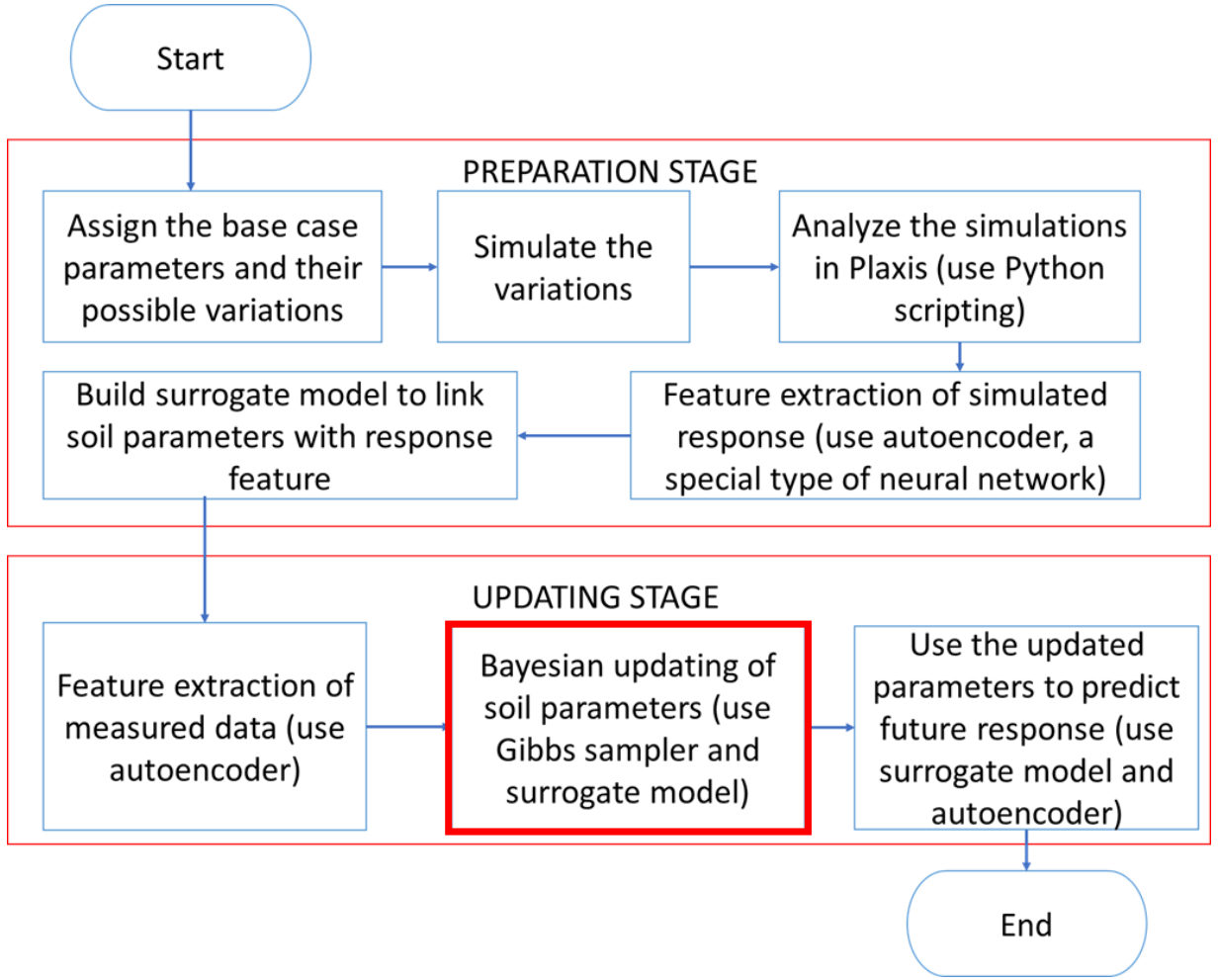


Black Line: Actual Data

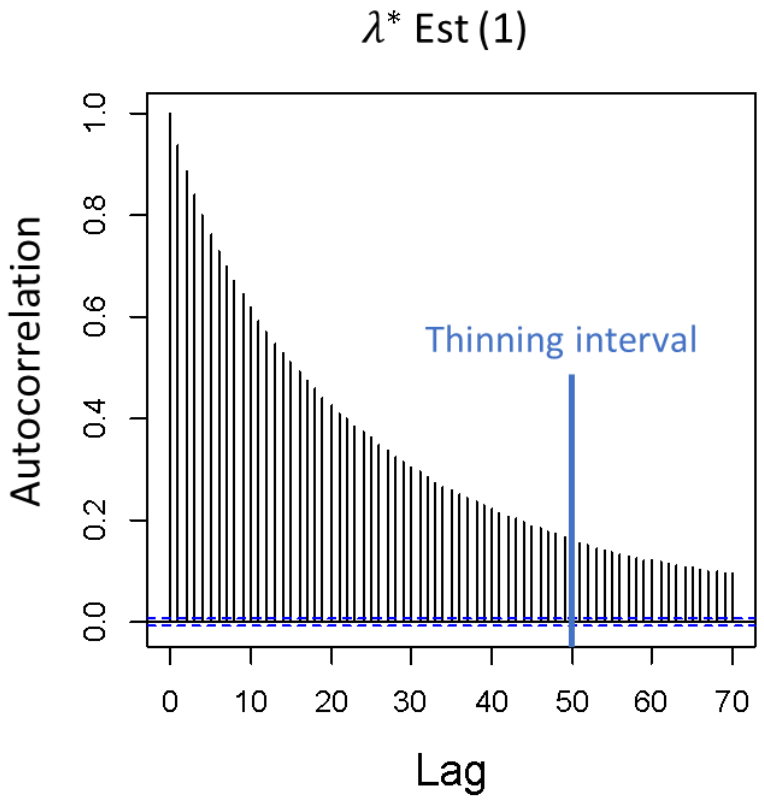
Blue Lines: Reconstructed Data from Autoencoder

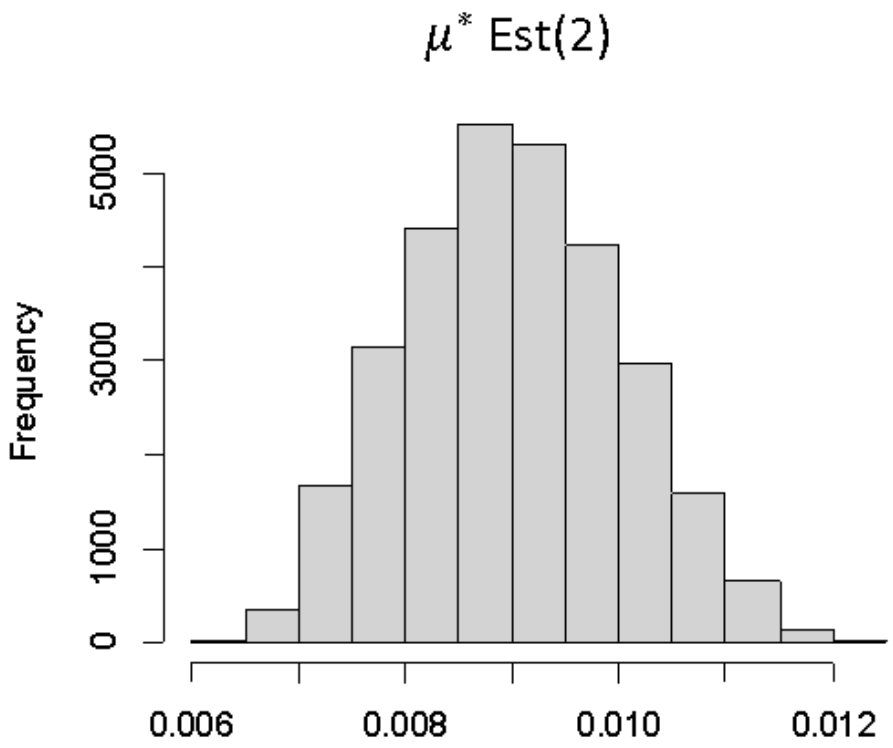
BAYESIAN UPDATING OF SOIL PARAMETERS

- Utilises both Gibbs sampler and surrogate model
- Gibbs sampler: Generate samples from the updated distribution of soil parameters



BAYESIAN UPDATING OF SOIL PARAMETERS



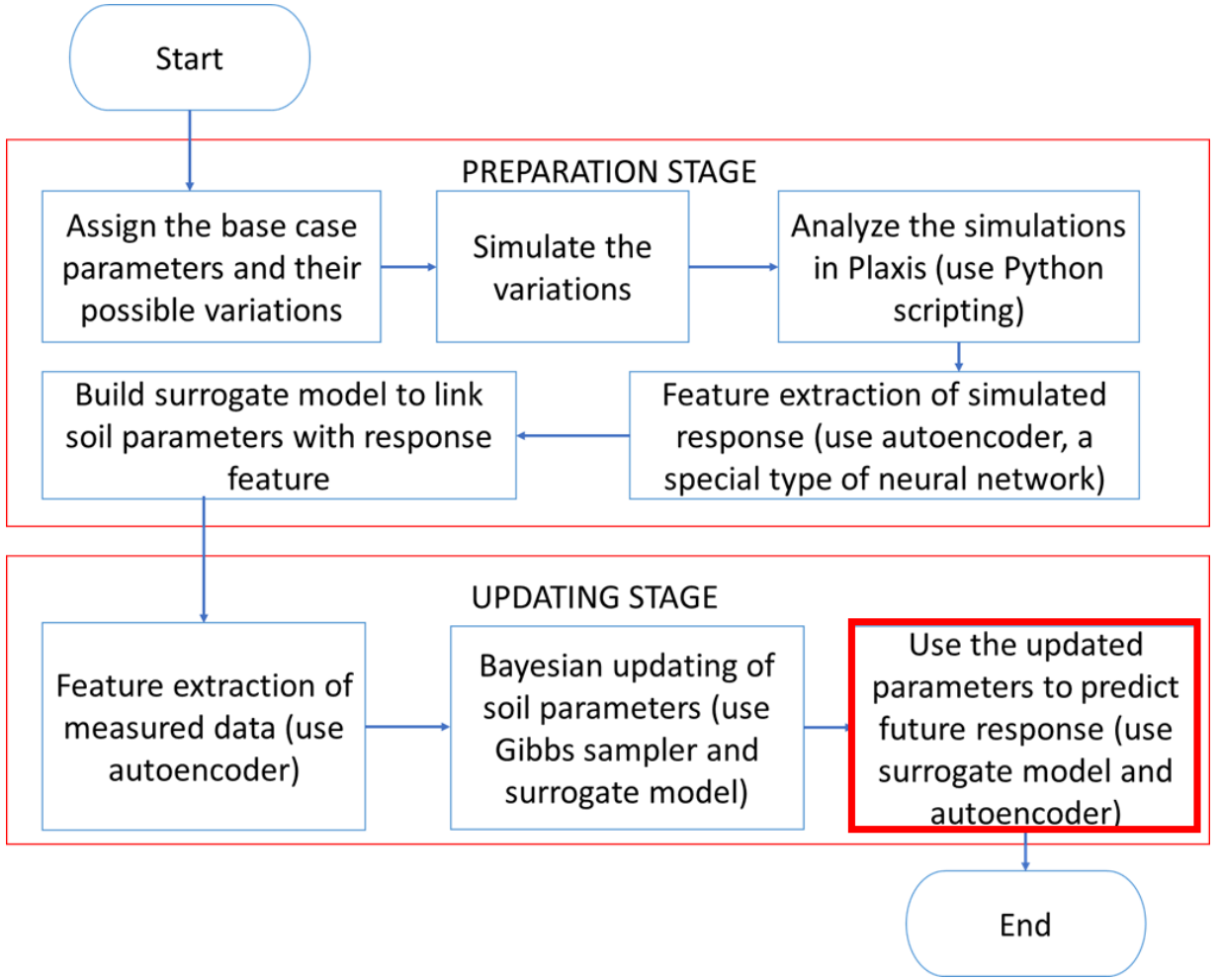


BAYESIAN UPDATING OF SOIL PARAMETERS

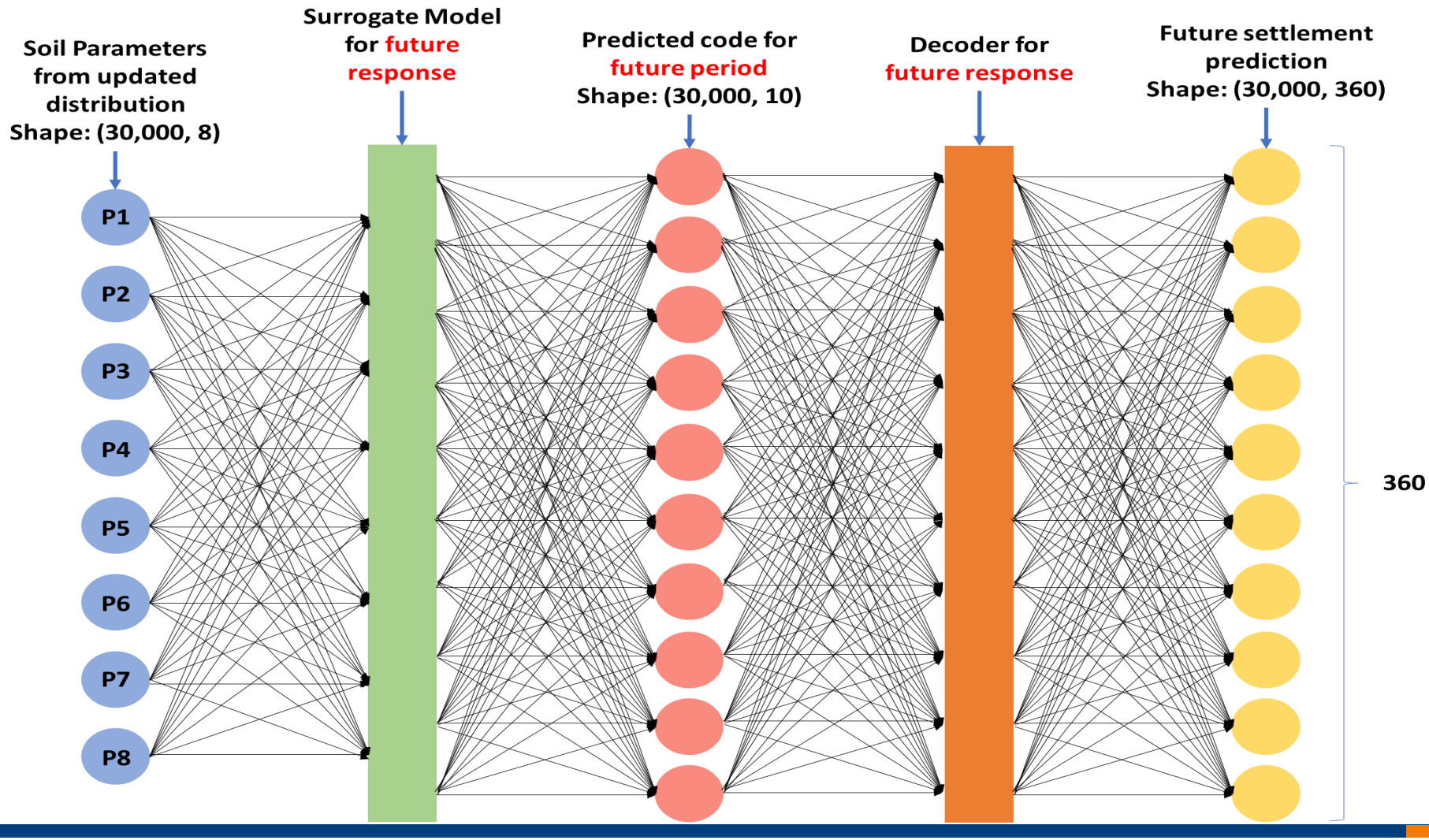
Parameter	Updated mean	SD before update	Updated SD
λ^* Alluvial Silt	0.062	0.020	0.024
λ^* Est(1)	0.11	0.081	0.023
λ^* Est(2)	0.35	0.088	0.024
λ^* Trans	0.055	0.023	0.023
μ^* Est(1)	0.0062	0.0025	0.0018
μ^* Est(2)	0.0090	0.0032	0.0010
$\log_{10}k_h$ Est(1)	-3.68	0.745	0.164
$\log_{10}k_h$ Est(2)	-3.79	0.745	0.032

Soil Parameters after Bayesian Updating

PREDICTION OF FUTURE RESPONSE



PREDICTION OF FUTURE RESPONSE



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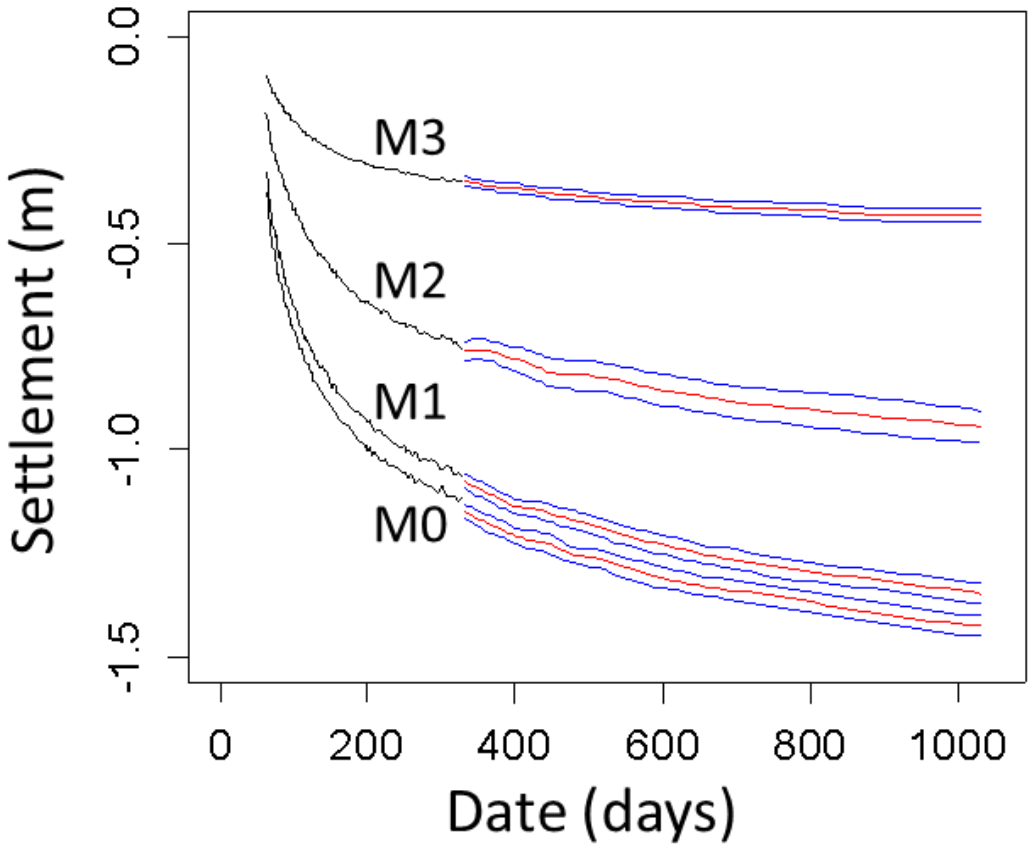
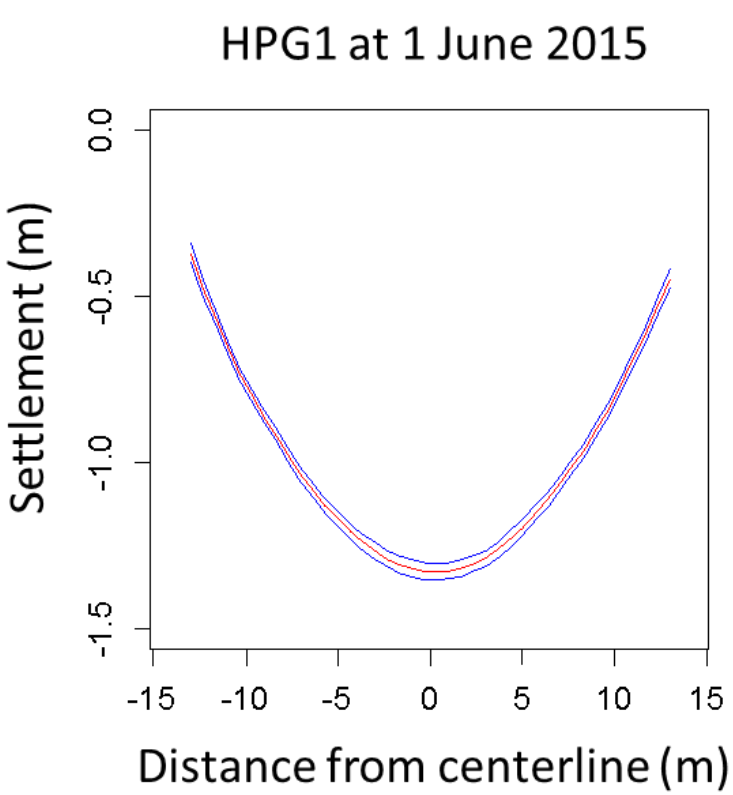
RESULTS OF PREDICTION OF FUTURE RESPONSE

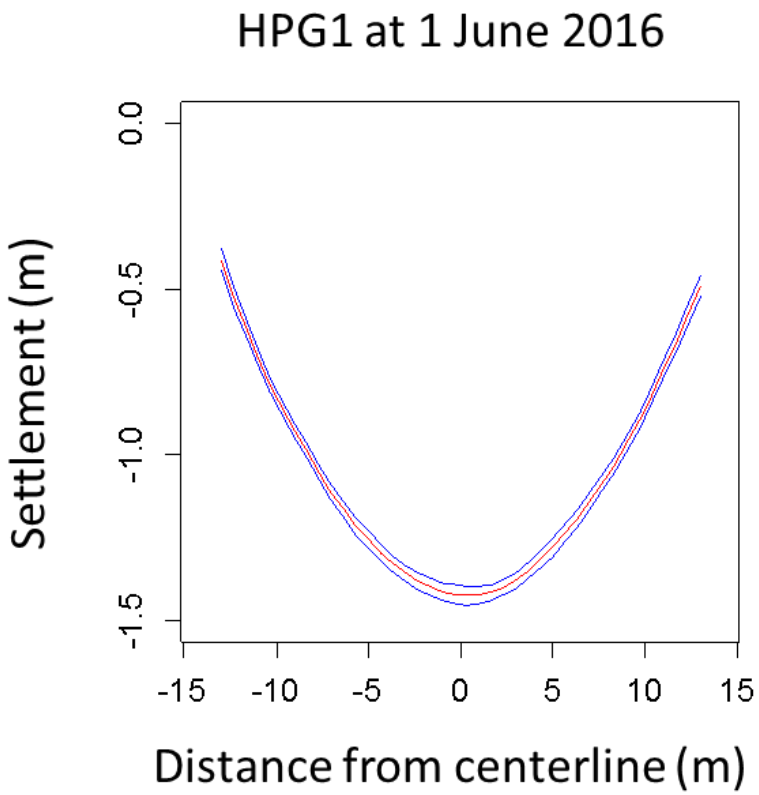
95% confidence level prediction interval (mean $\pm$ 1.96SD). Smooth by loess



RESULTS OF PREDICTION OF FUTURE RESPONSE

95% prediction interval (mean ± 1.96SD). Smooth by loess





RESULTS OF PREDICTION OF FUTURE RESPONSE

95% prediction interval (mean $\pm$ 1.96SD)

	1 June 2015	1 June 2016
M0	[1.334m, 1.364m]	[1.382m, 1.439m]
M1	[1.212m, 1.268m]	[1.318m, 1.368m]
M2	[0.831m, 0.917m]	[0.914m, 0.995m]
M3	[0.401m, 0.427m]	[0.419m, 0.455m]
Centre of HPG1	[1.305m, 1.356m]	[1.393m, 1.452m]

ACKNOWLEDGEMENTS

- Dr. Taeseo Ku

  for his supervision and acting as my advisor in this research.

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  for his supervision and guidance in this research.

- Dr. Man Kong Lo

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- Dr. Siang Huat Goh

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THANK YOU