Rainfall Runoff Modelling Using Artificial Neural Network

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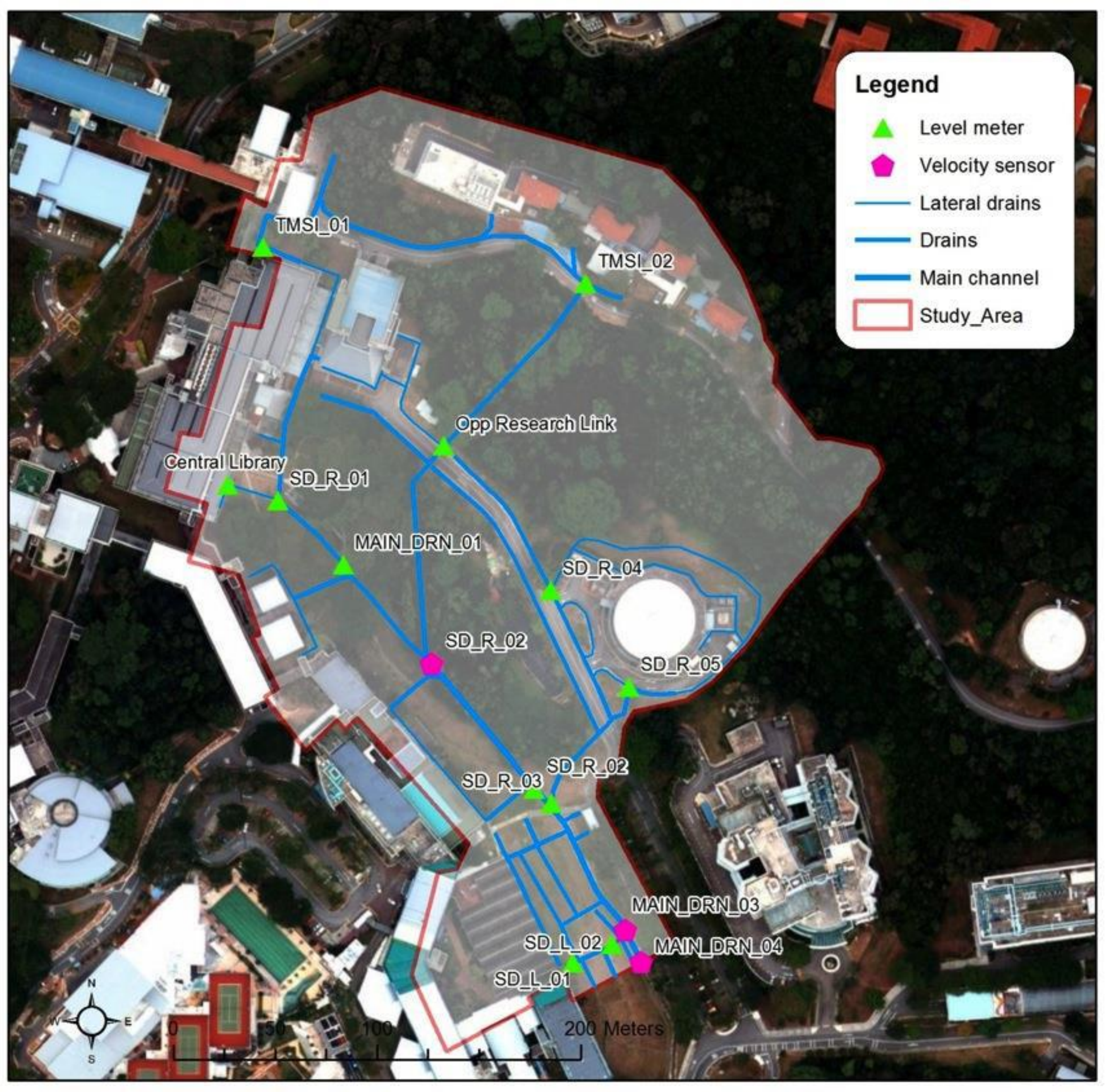


- 10. 20 and 60- min Forecast of flow rates at Main Drain 04
- Discuss forecast accuracy as function of lead time

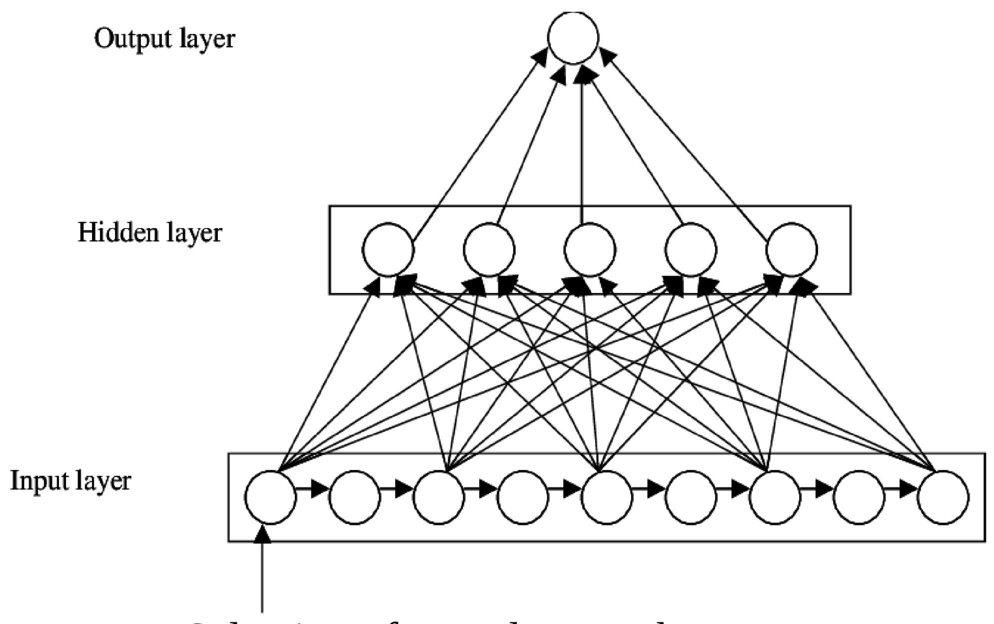
Artificial Neural Network (ANN)

- ✓ "Universal Approximator"
- ✓ No mathematical model required
- ✓ Pattern recognition and non-linear modelling

Correlation Factor

	Q_MD01	Q_MD02	Q_CTRLIB	Q_OPPRL	Raincum	Duration
Rainfall	0.707215	0.795895	0.884045	0.750784	-0.126774	0.216596

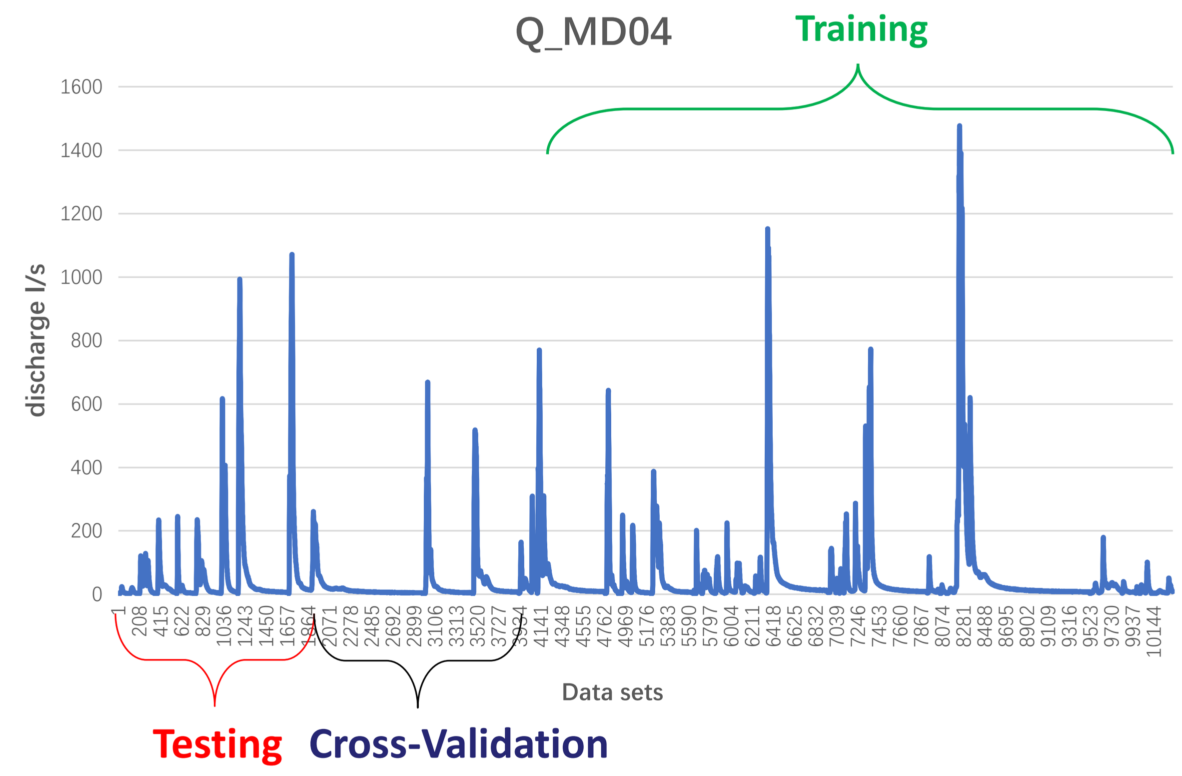
Selection of input and output parameters – Correlation Analysis



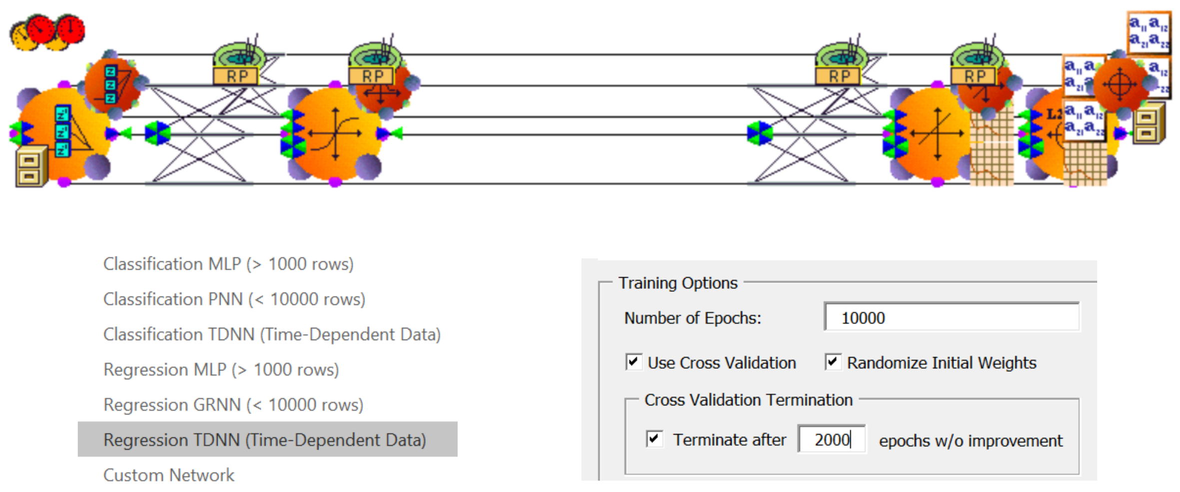
Selection of neural network structure

Time-Delayed Neural Network (TDNN)

- Select a window of events for training
- Recognize time difference

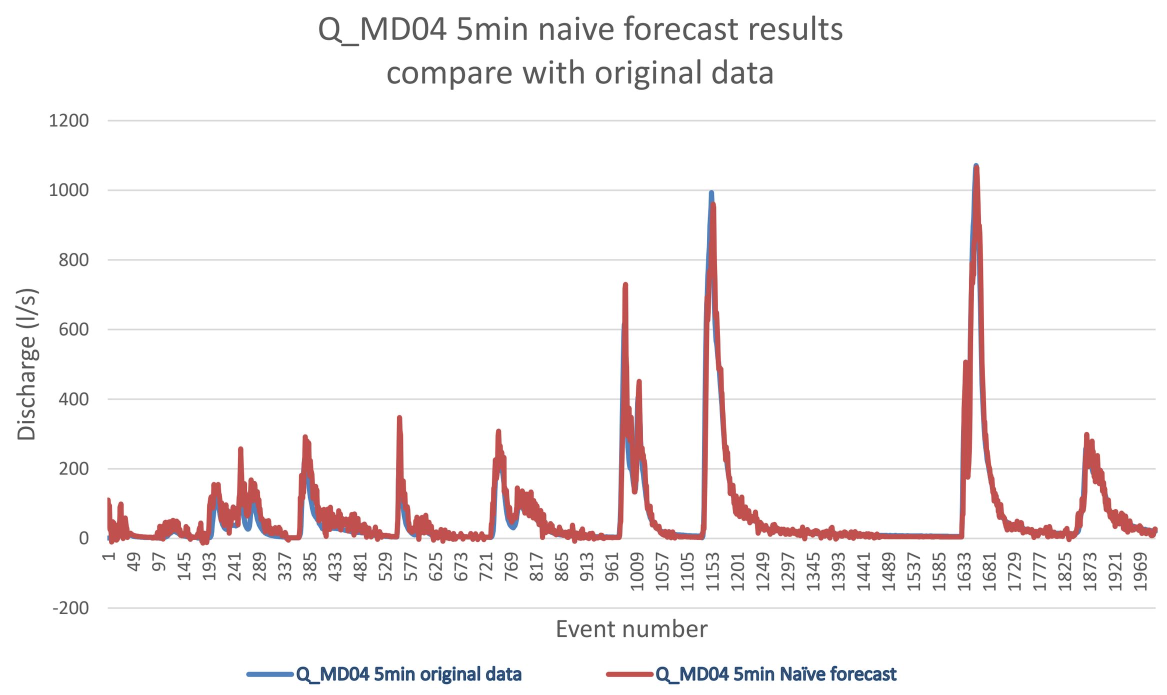


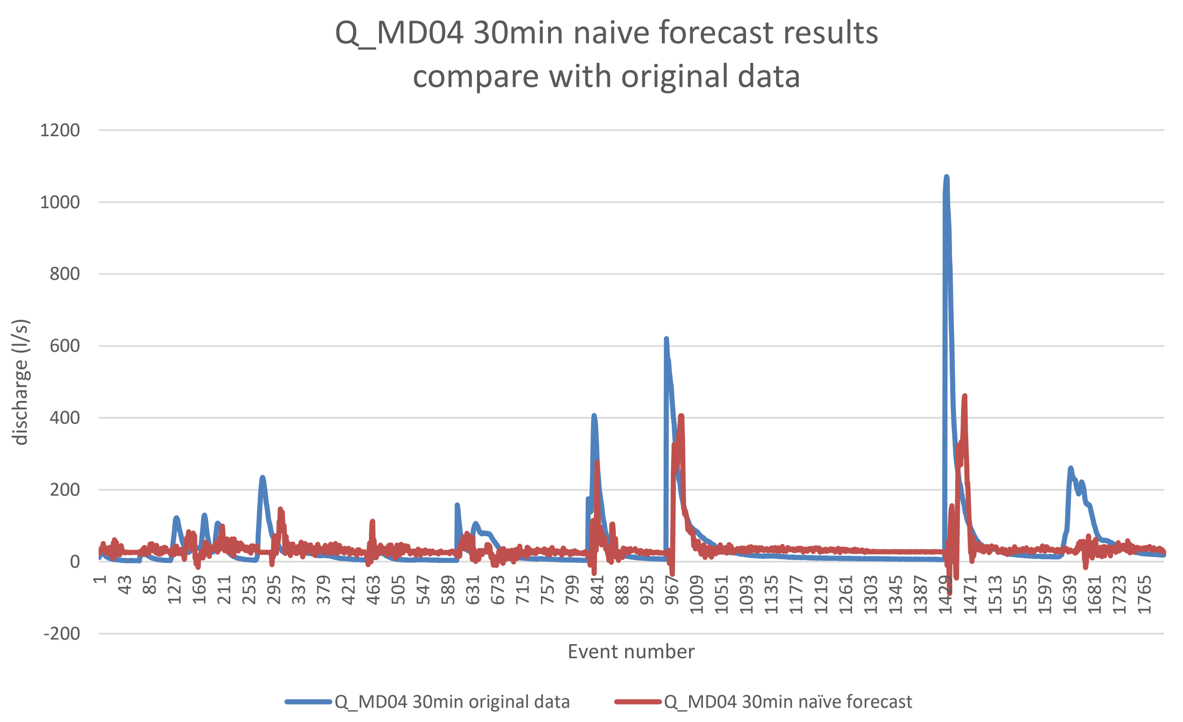
Selection of respective data sets



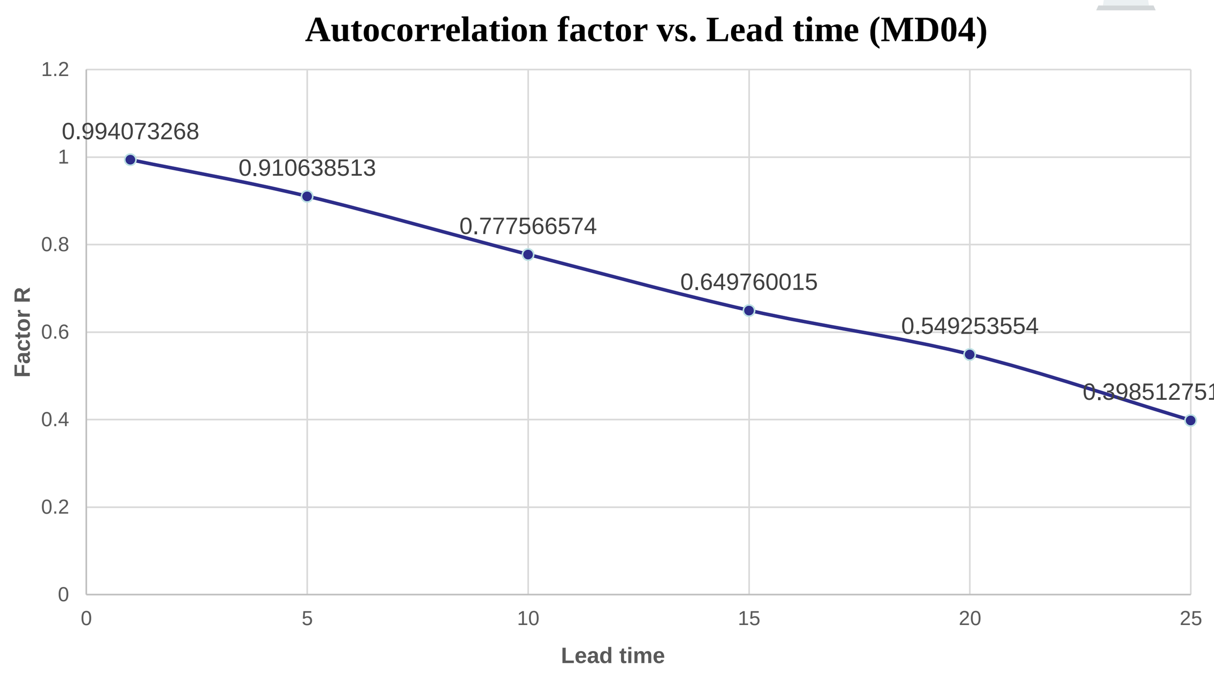
Naïve forecast

- Last period's trend → Next period's forecast
- Without processing the data in advance
- Benchmark against more sophisticated methods



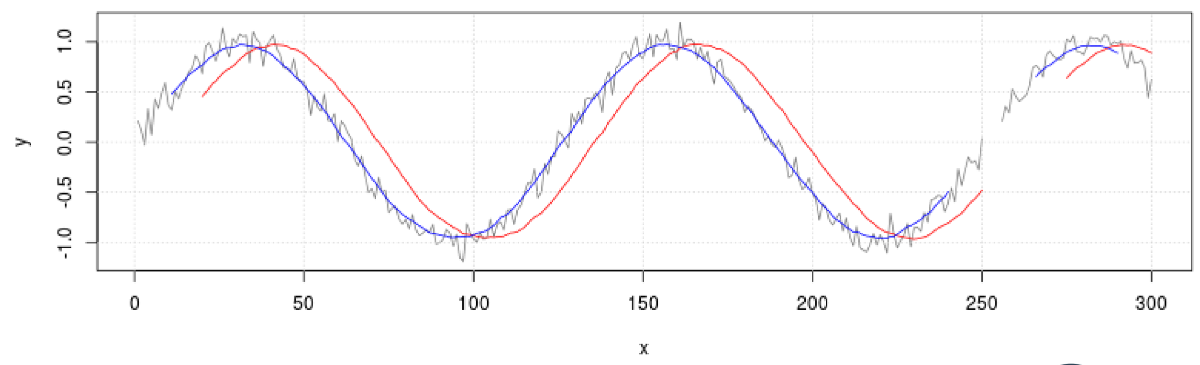


Quality of forecast deteriorates with time.
How can we improve?



$$Q(t+n) = Qt + \widehat{dQ}$$

Simple Moving Average

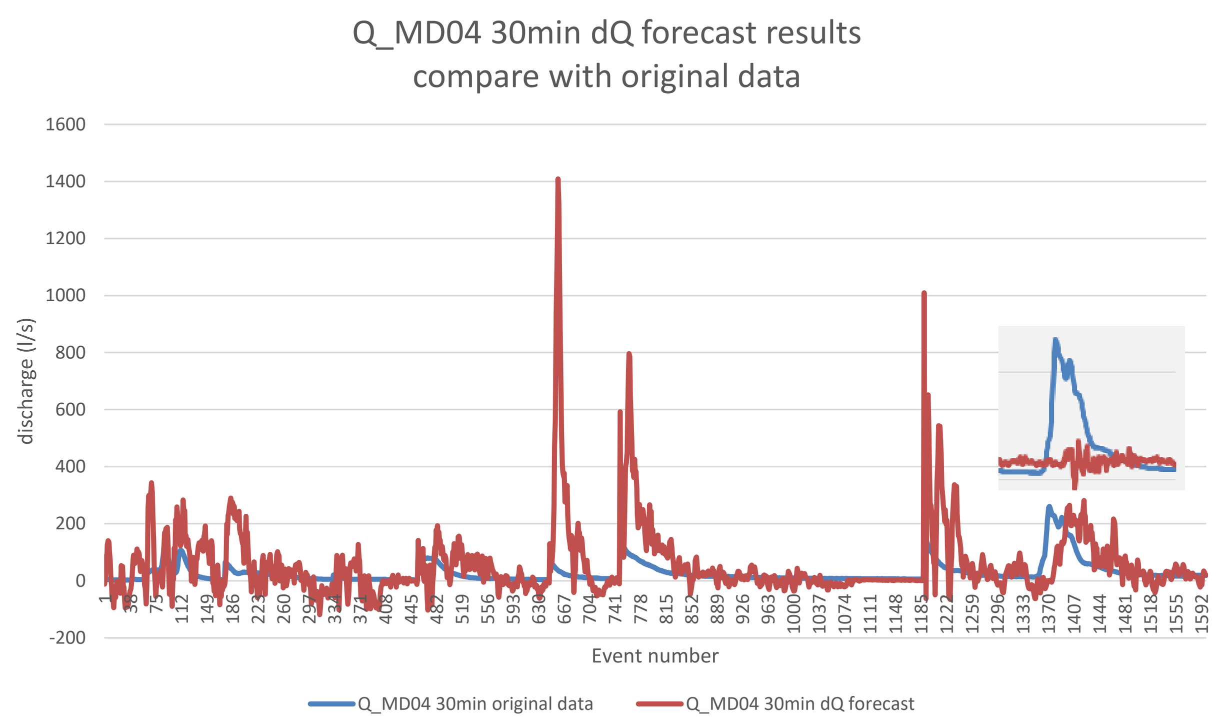


- No information about abnormal data
- Define a better trend of flow
- Filter out potential "noise"

$$\text{SMA} = \frac{A_1 + A_2 + A_3 + \cdots + A_n}{n}$$

Improvement based on dQ method
dQ+SMA method

dQ Method



Box Cox Transformation

- ANN responses well against normalized data
- Improve quality of forecast
- Named after *George Box* & *Sir David Roxbee Cox* in 1964.

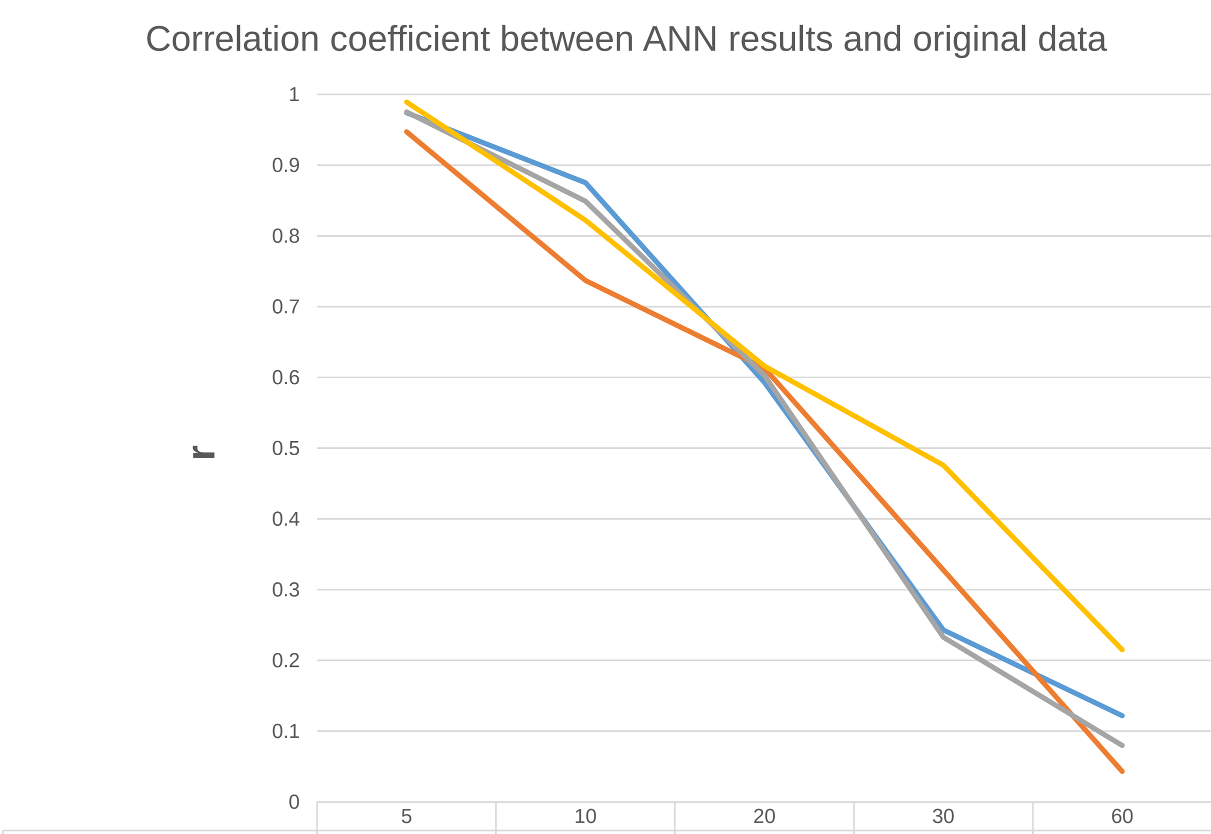
$$y(\lambda) = \begin{cases} \dfrac{y^{\lambda}-1}{\lambda}, if\ \lambda \neq 0 \\ \log y, if\ \lambda = 0 \end{cases} \qquad y(\lambda) = \begin{cases} \dfrac{(y+\lambda_2)^{\lambda_1}-1}{\lambda_1}, if\ \lambda_1 \neq 0 \\ \log\,(y+\lambda_2), if\ \lambda_1 = 0 \end{cases}$$

For positive y values — For 0 & negative y values

$$(\lambda) = 2, 1, 0.5, -0.5, -1$$

Box Cox Transformation applied for both
Original data and dQ data

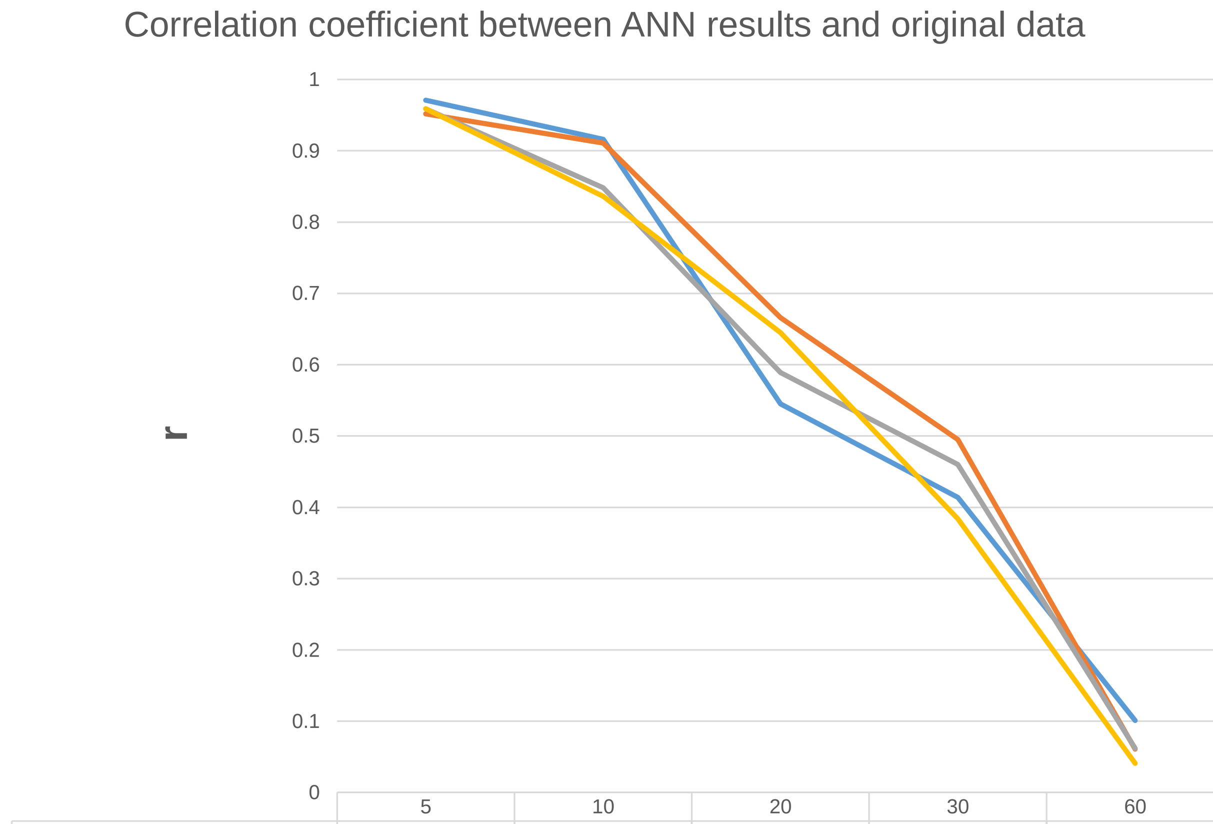
Results and Comparison



	5	10	20	30	60
naïve forecast	0.974	0.875	0.593	0.243	0.122
Box Cox Q forecast (λ=2)	0.947	0.737	0.613	0.328	0.043
Box Cox Q forecast (λ=1)	0.975	0.849	0.603	0.233	0.08
Box Cox Q forecast (λ= 0.5)	0.989	0.822	0.616	0.476	0.215

Limitations of naïve forecast

- No real forecast ability
- Relies on numerical values of historical data
- Unable to find the underlying pattern
- Usually does not respond to any random variations
- Use as reference for more complex methods



	5	10	20	30	60
dQ+SMA forecast	0.971	0.916	0.545	0.414	0.101
Box Cox dQ forecast (λ=2)	0.952	0.911	0.666	0.495	0.061
Box Cox dQ forecast (λ=1)	0.959	0.848	0.589	0.460	0.062
Box Cox dQ forecast (λ= 0.5)	0.959	0.836	0.645	0.384	0.041

The two methods have respective
advantages and limitations

- Capturing general trend
- Capturing peak values
- Time and effort required to produce good results
- Improvement in quality of forecast

dQ+SMA Method

- Trend is captured at high accuracy
- Peak values may not be very accurate
- Could be used to forecast baseflow/subsurface flow
- Difficult to determine the window period
- Too short → lose general trend / Too long → undesirable lag

Box Cox dQ Method

- Peak is captured at high accuracy
- Forecast of low magnitude values my not be very accurate
- Could be used to forecast flooding cases
- Difficult to determine the optimal lambda (λ) value
- Requires time and effort

Recommendation & Future works

- Test dQ+SMA Method with multiple window periods
- Test Box Cox dQ Method with different λ values
- Collect more hydrological data to validate results
- Limitation of forecast is catchment concentration time
- Test and verify the results using rainfall forecast
- Apply the method to larger catchment area in Kent Ridge
- Apply the method to different catchment areas

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