

## Can machine learning learn prediction and improve?

- Interferometric synthetic aperture radar (InSAR) is a powerful tool to detect deformation and movement of the Earth's surface.
- Machine Learning (ML) algorithm could extract or predict deformation. ML could detect spatial correlation and trend when input with large volume of data. (Brengman et. al. 2021, Anantrasirichai et. al. 2018)
- An estimation of tropospheric could be calculated with auxiliary information from weather model parameters and additional with GPS. However, it is limited by spatial and temporal resolution. (Bekaert et. al. 2015)
- Incorporate spatial stochastic Global Atmospheric Models (GAM) consists of spatial stochastic properties which have weighting in GAM parameters. (Cao et. al. 2021)

Geostatistics / Kriging	Linear Interpolation	Desired Method
Advantages: <ul style="list-style-type: none"><li>Make prediction with spatial correlation.</li></ul>	Advantages: <ul style="list-style-type: none"><li>Quick and simple</li></ul>	Ideal: <ul style="list-style-type: none"><li>Be able to imply topography, weather model parameters into prediction</li><li>General approach and does not involve complex physical model</li></ul>
Disadvantages: <ul style="list-style-type: none"><li>Assumes isotropic and second-order stationarity. We do not want to have too much assumption.</li></ul>	Disadvantages: <ul style="list-style-type: none"><li>Too simple and not precise.</li><li>Physical properties are not linear and may not be able to make good prediction.</li></ul>	

## Motivation

- Investigate using statistical analysis and machine learning to improve the tropospheric corrections base on GAMs.
- Develop a spatial correlation models from weather model parameters (Temperature (T), Pressure (P), and Water vapour (e)), line of sight (LOS), and digital elevation model (DEM) without other auxiliary data (e.g. GNSS).
- Explore the use of spatial correlation and Deep Neural Networks (DNNs) to improve the interpolation scheme and downscale the GAMs to InSAR resolution.

## Methods

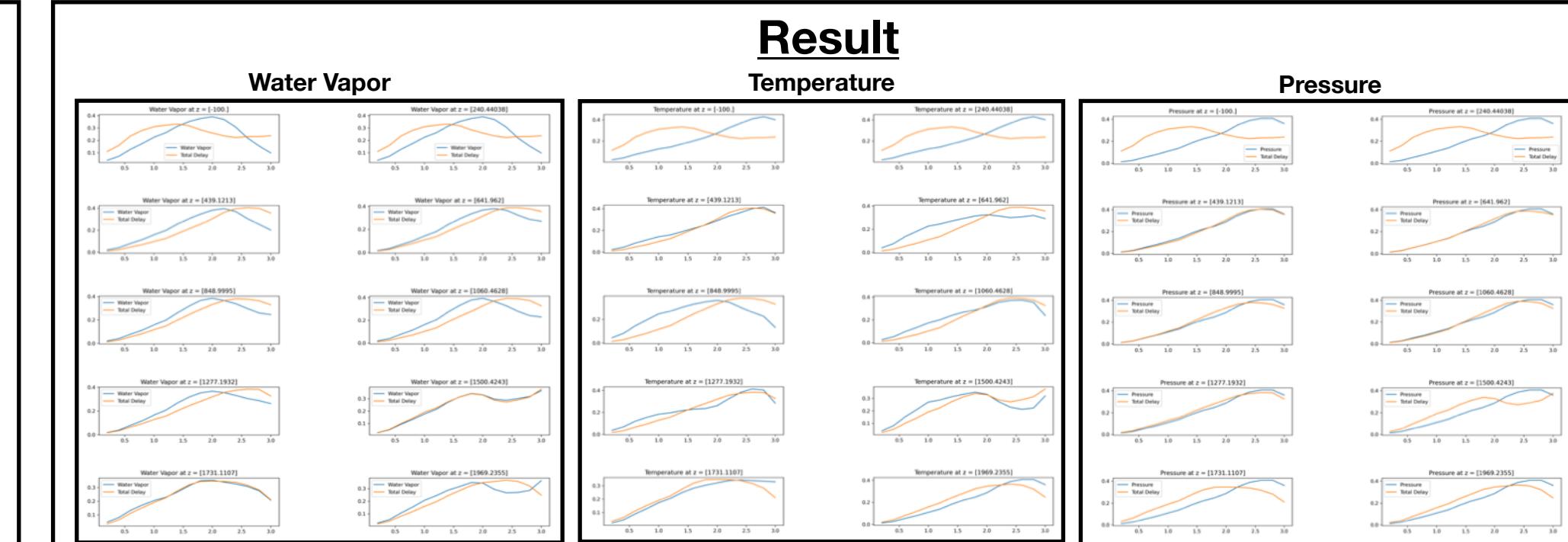
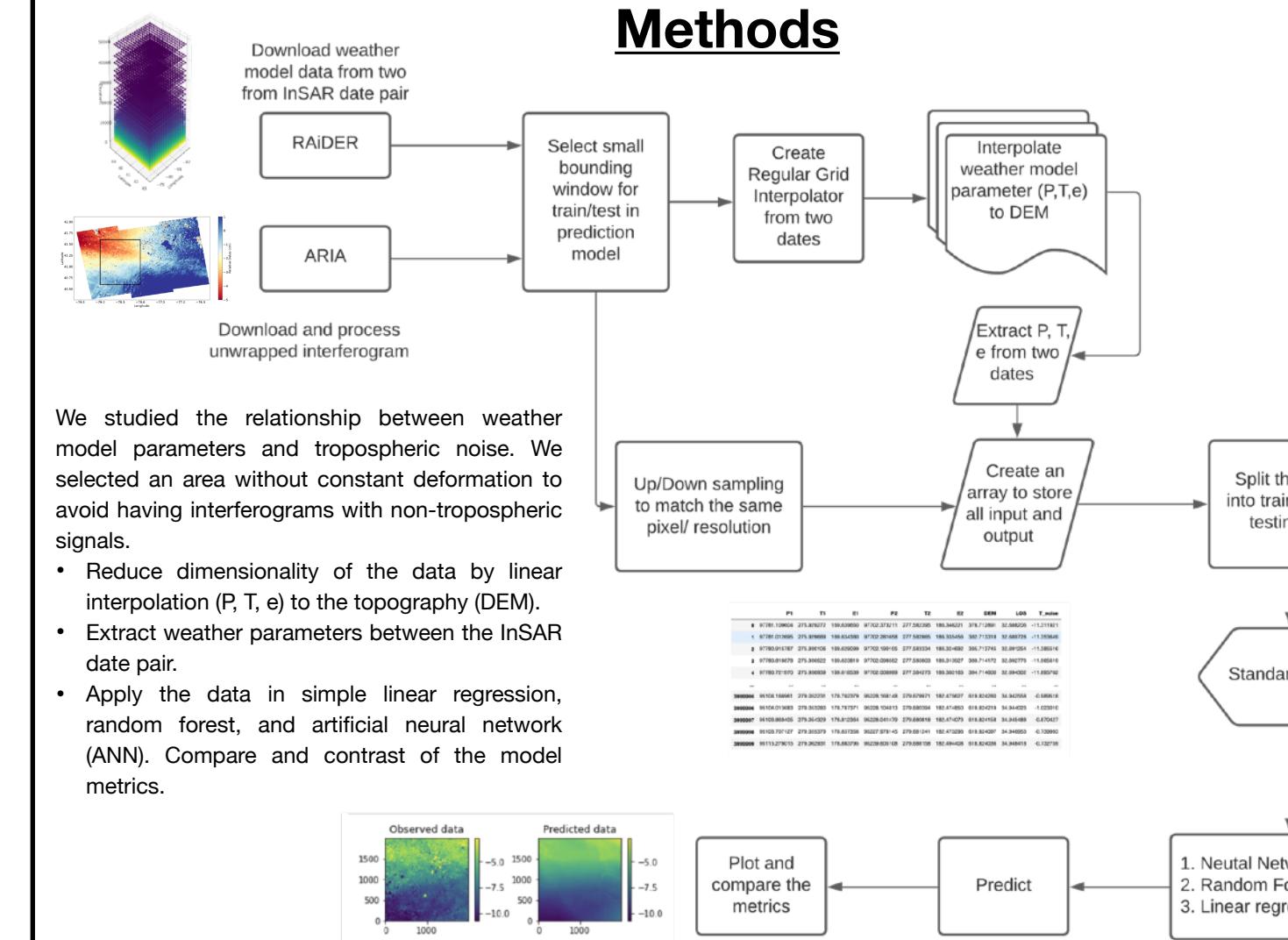
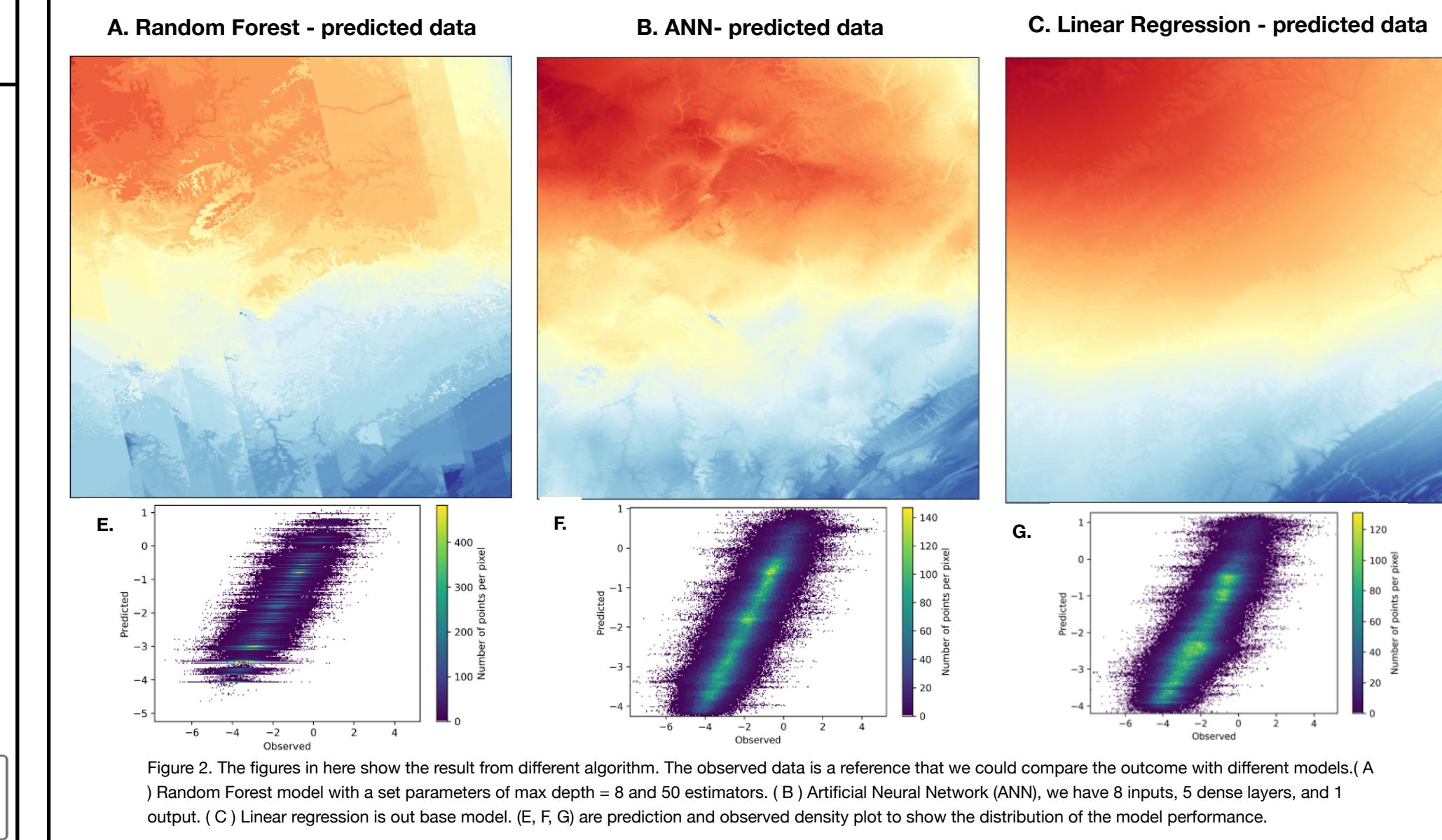
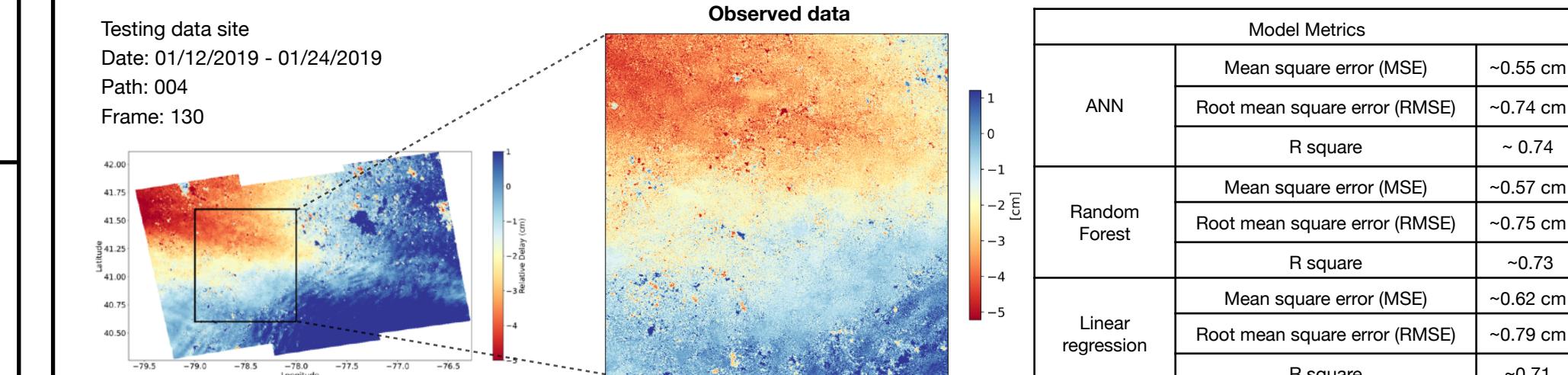


Figure 1. The semi-variance show in each weather model parameters with comparison to point-wise delay at each elevation level.

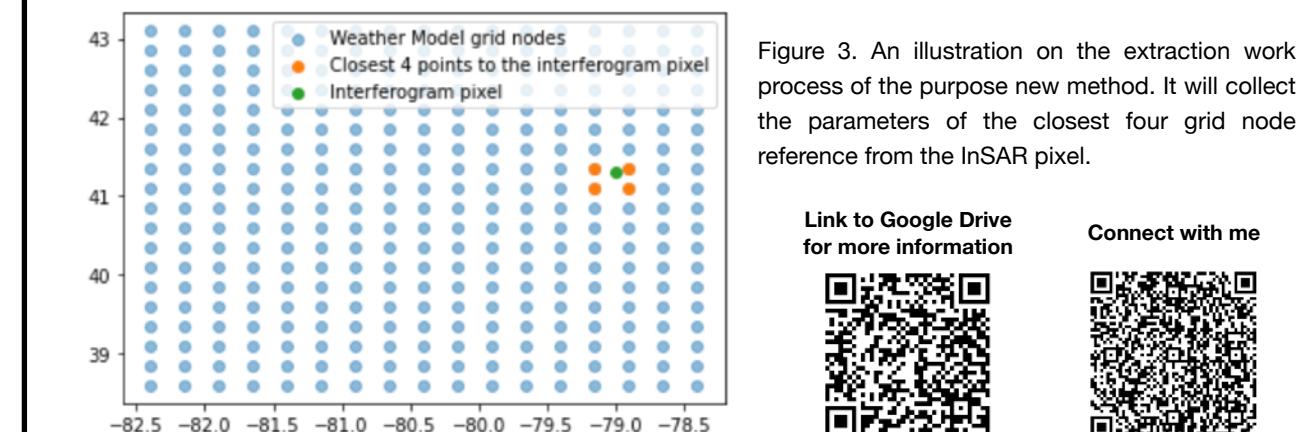


## Discussion

- Pressure, Temperature, Water vapor have strong correlation with point-wise delay. Except at the surface, It shows a good trend between point-wise delay and weather model parameters. (Figure 1.)
- Atmospheric delay at the low elevation have constant spatial correlation.
- Flaws in data extraction method. We used linear interpolation method to reduce the dimension of the data from 3D to 2D. With an assumption of atmospheric interference is the strongest on the ground, some spatial correlation may be lost. Preprocessing of the training data. The current state of art is using standard scaler to normalize the data for training. It might not be the optimal preprocess for the data.
- ANN model could explain about 74% of the tropospheric noise in the study area. It could estimate a general trend of noise in an area.
- We are able to use weather parameters to achieve a good level of tropospheric noise prediction without the involvement of heavy InSAR processes.

## Future Work

- Experiment on an alternative method which involve extraction of weather parameters from four closest weather model nodes reference from the InSAR pixel. Extract data from all 38 elevation levels. Conceptually it could avoid the involvement of linear interpolation. (Figure 4 and scan QR code for more information.)
- Perform PCA analysis to narrow down the parameters.
- Fine-tuning the hyper-parameters for training.
- Collect more variety of data in different time frame during the year to improve prediction accuracy.
- Apply this method at a global scale.



## Reference

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- <https://github.com/dbekaert/RAiDER>
- <https://github.com/aria-tools/ARIA-tools>