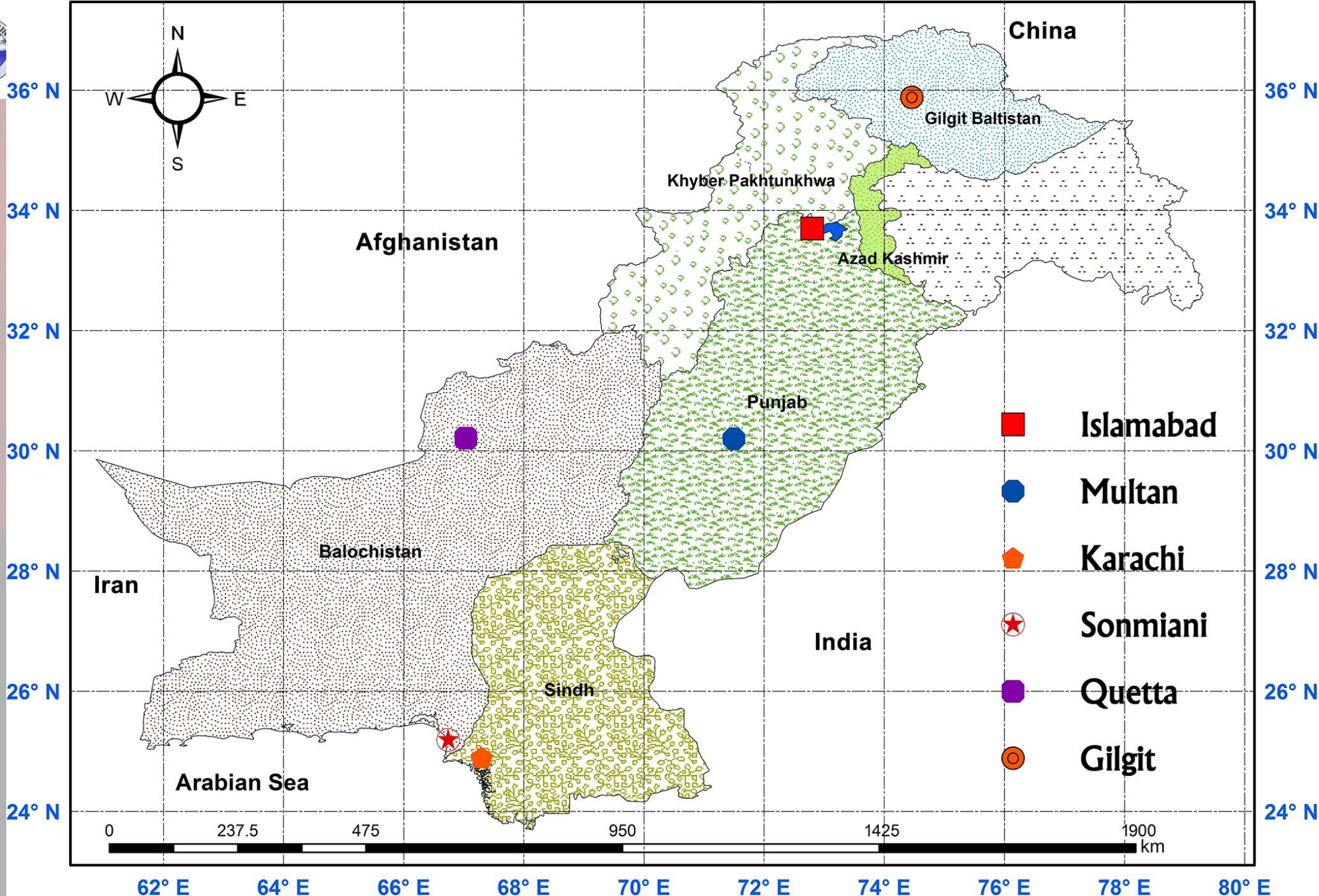


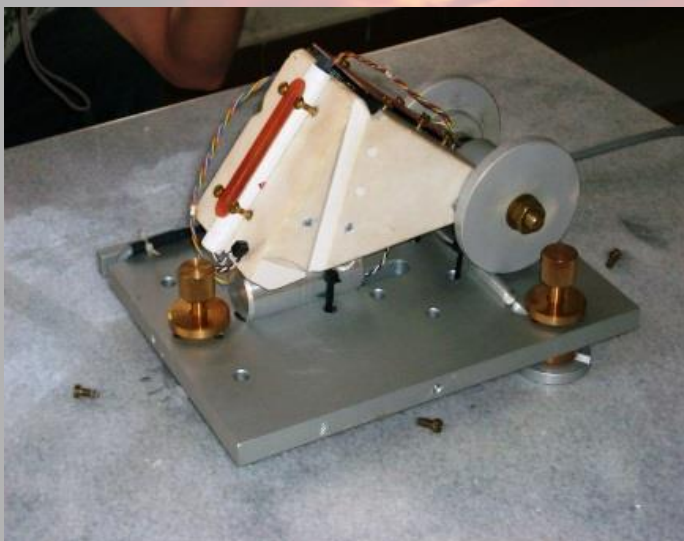
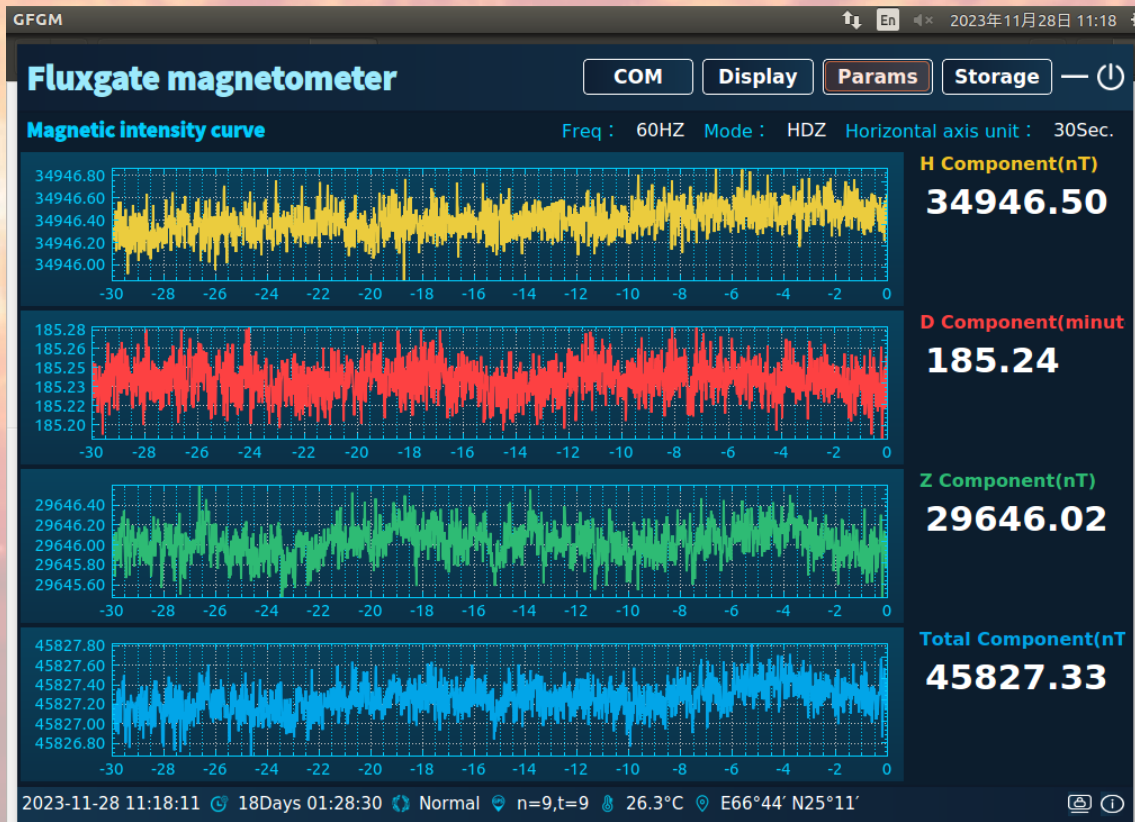
Predicting daily foF2 over Pakistan using machine learning

Muhammad Ayyaz Ameen
Pakistan





Some Instruments



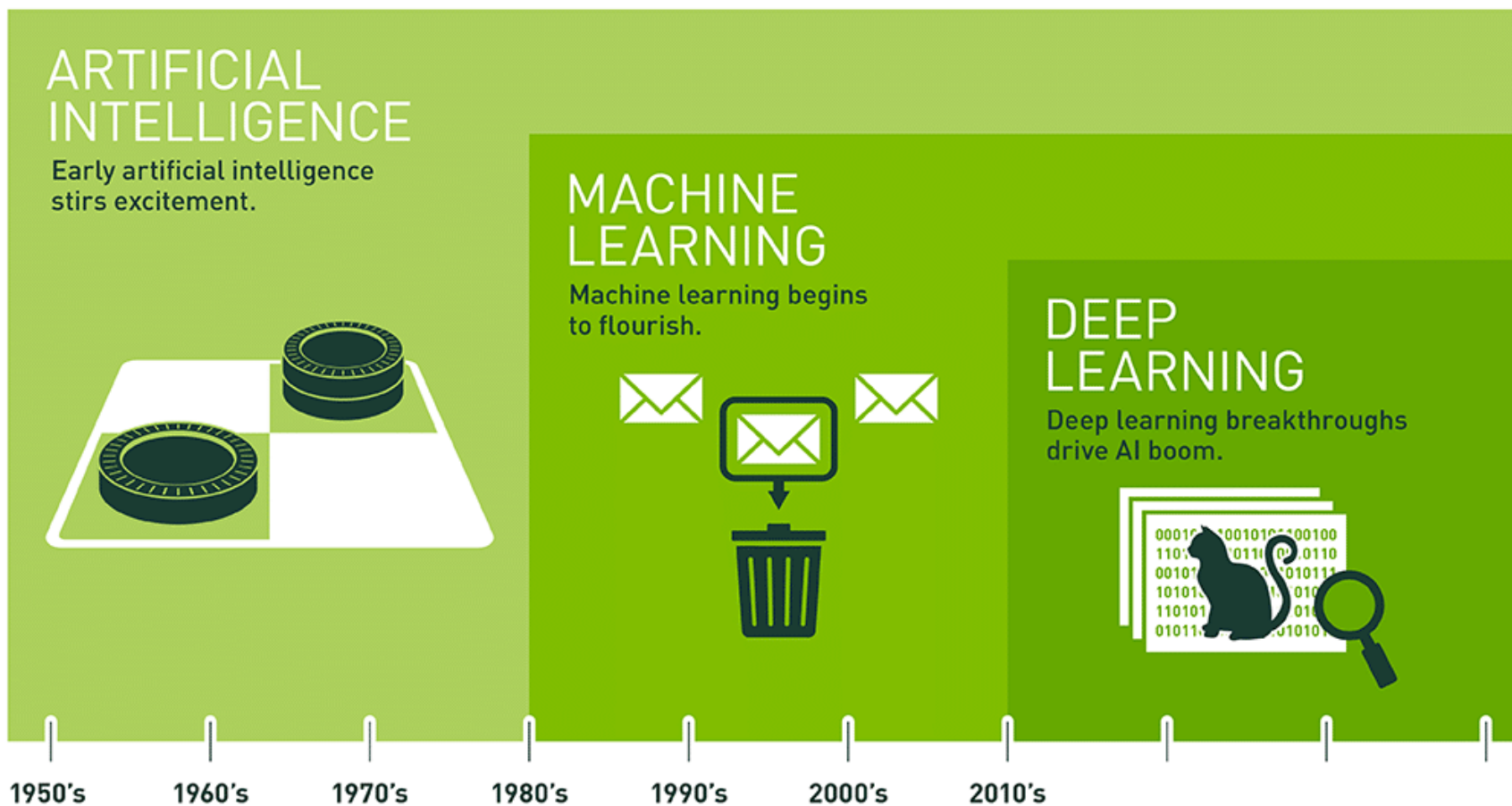
Ionospheric variations

- Ionosphere **may vary** with:
 - altitude
 - latitude
 - longitude
 - time
 - season
 - solar cycle and
 - magnetic activity

Need to model ionosphere!

- Ionosondes taking snapshots signals round the clock
- GNSS receivers using trans-ionospheric 24/7
- Physical and empirical understanding of ionosphere
- Our Earth acts as a global radio observatory
- Machine learning may be useful

Artificial Intelligence

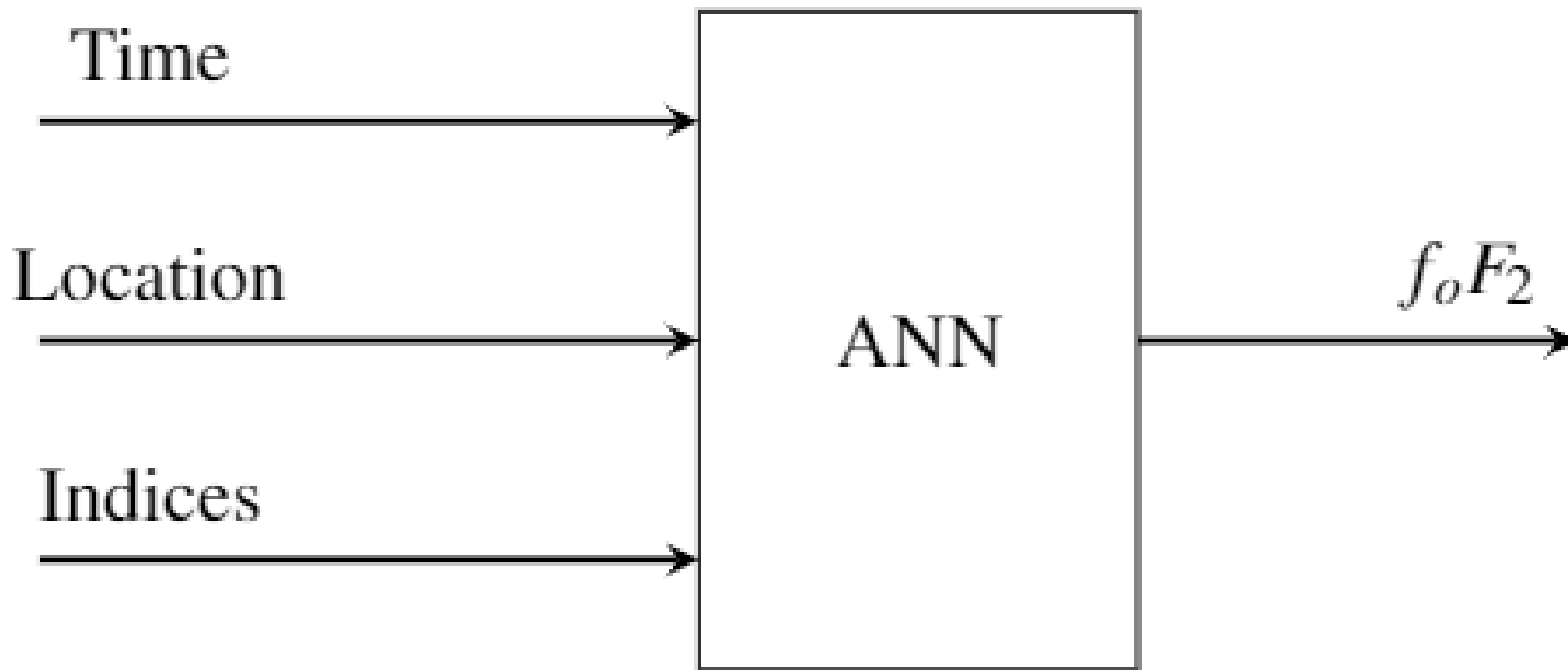


Since an early flush of optimism in the 1950s, smaller subsets of artificial intelligence – first machine learning, then deep learning, a subset of machine learning – have created ever larger disruptions.

Ingredients of the algo using machine learning

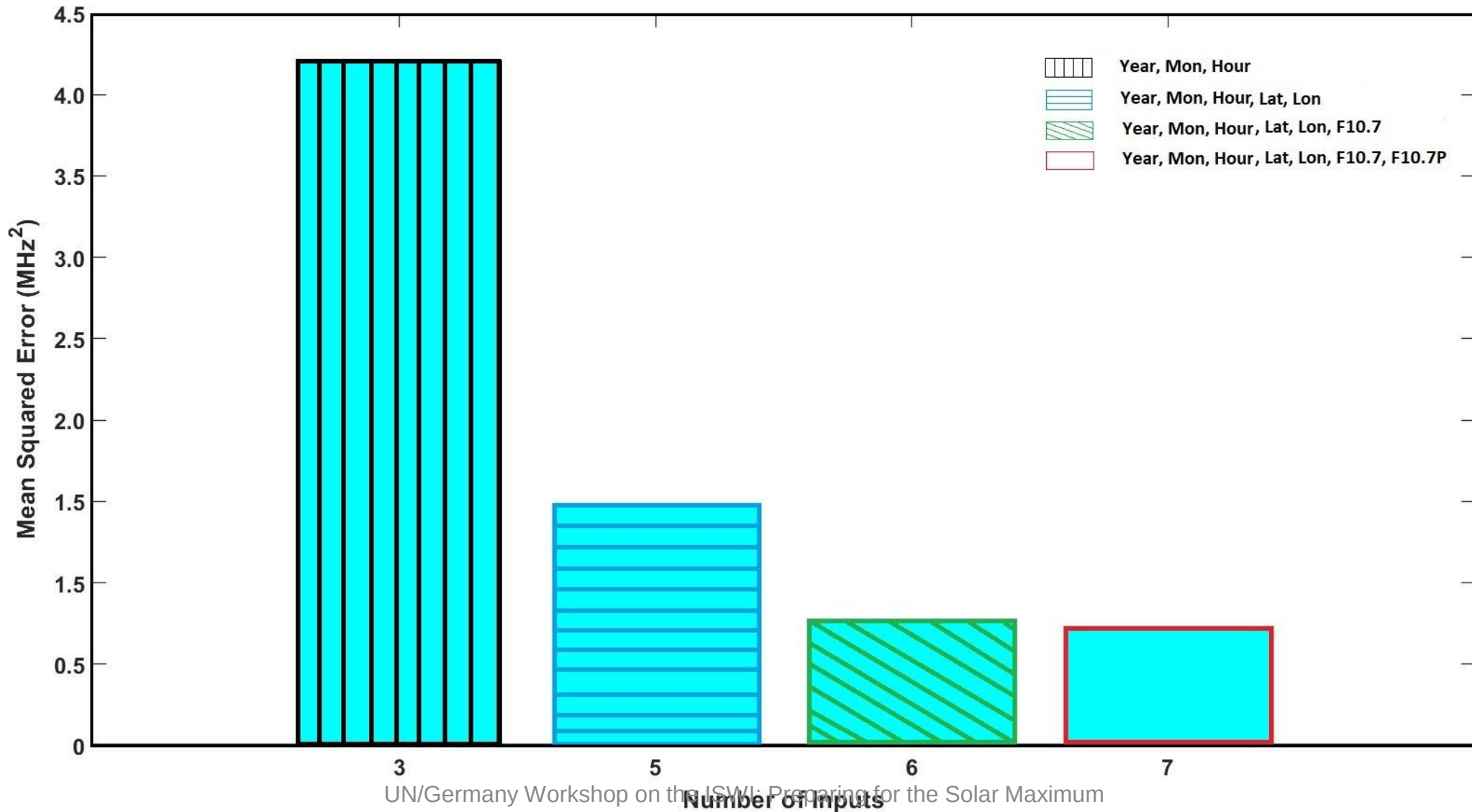
- Data
- Target output
- Input space
- Activation function
- Loss function
- Neurons
- Layers
- Epochs

Gray box model approach



Climatological model of foF2

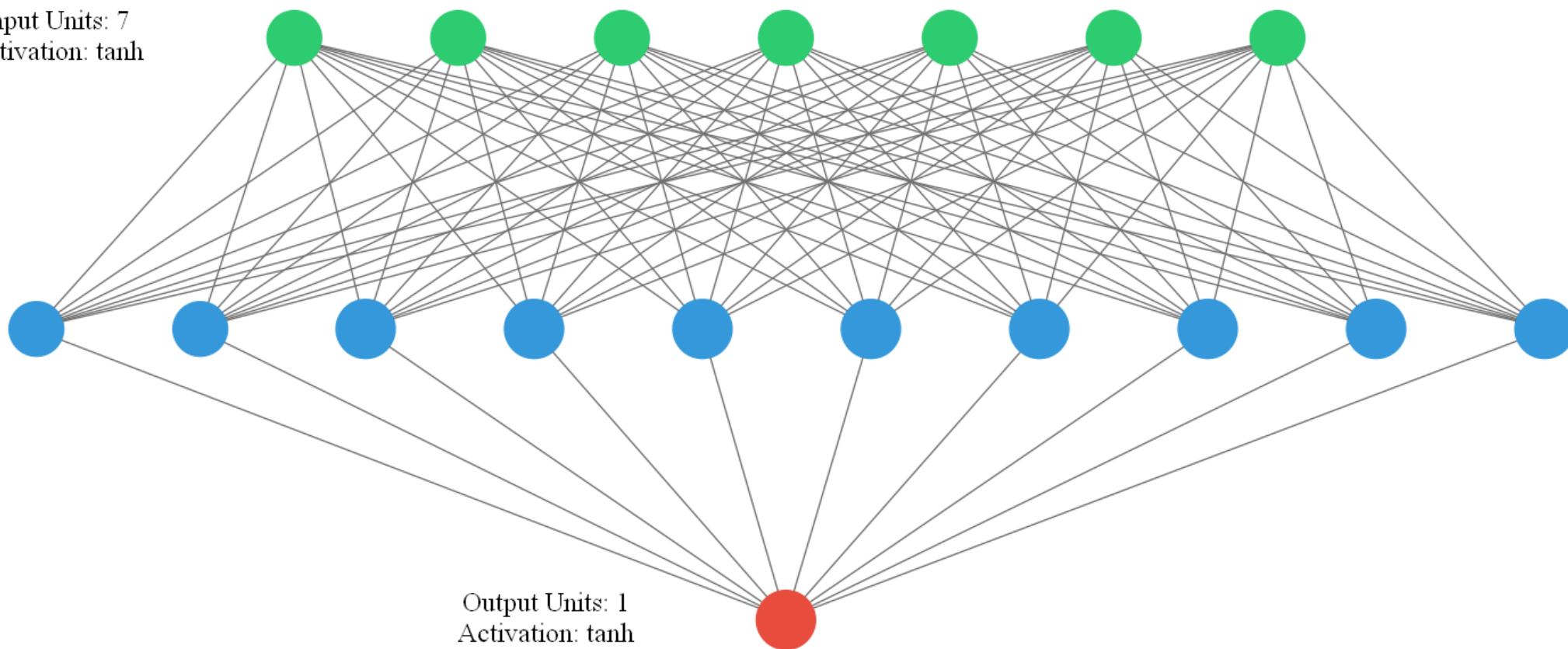
Input space to predict foF2



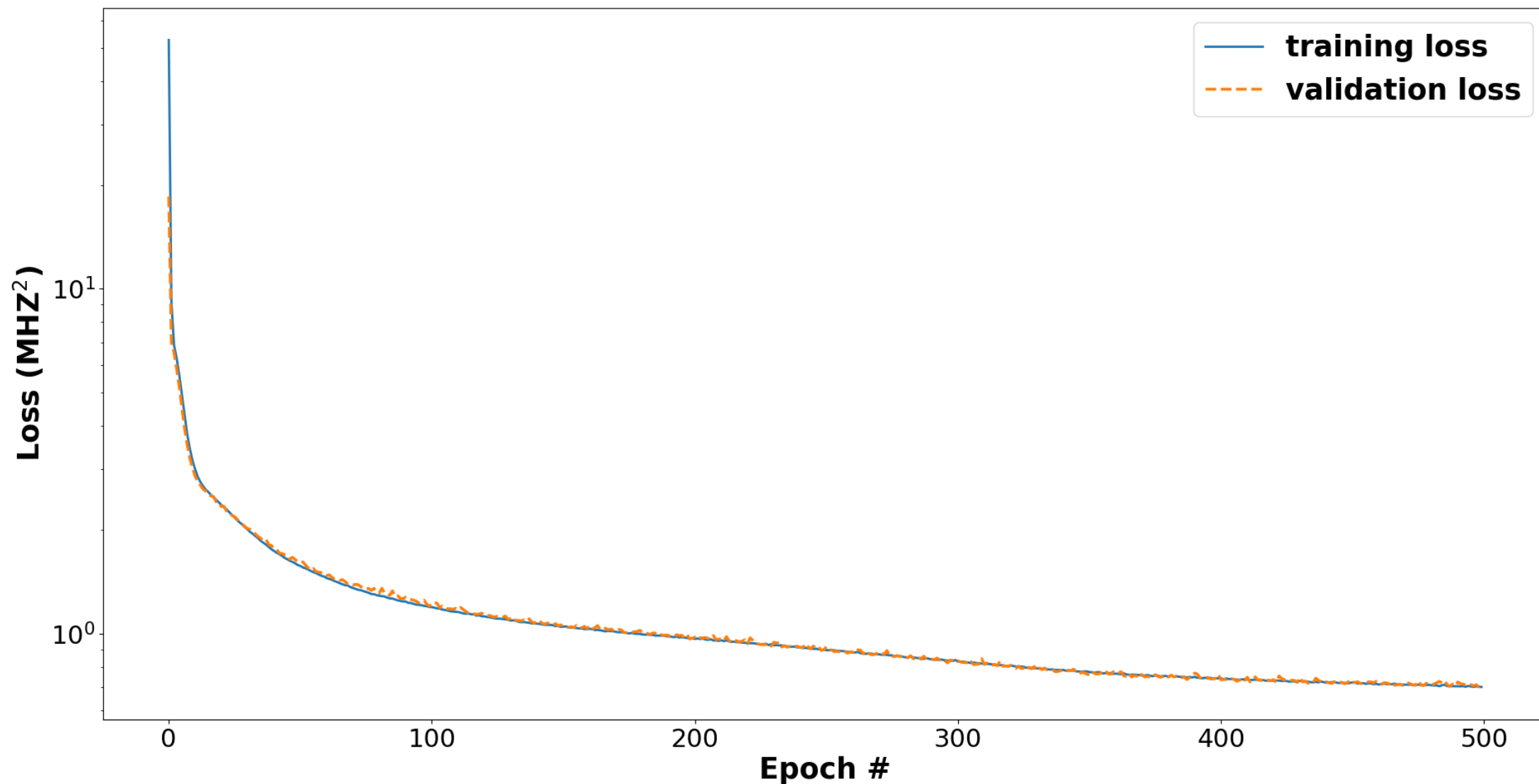
ANN architecture

Input Units: 7
Activation: tanh

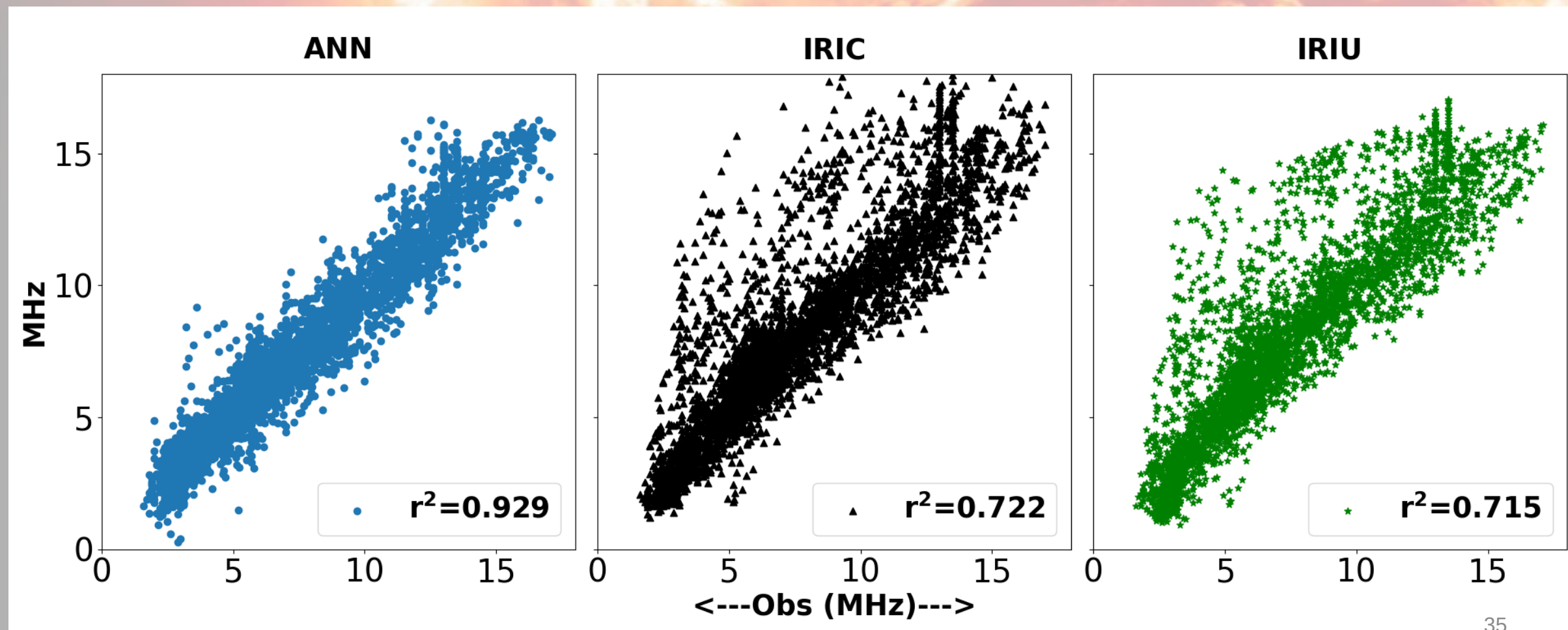
Units: 96 (+86 more)
Activation: tanh



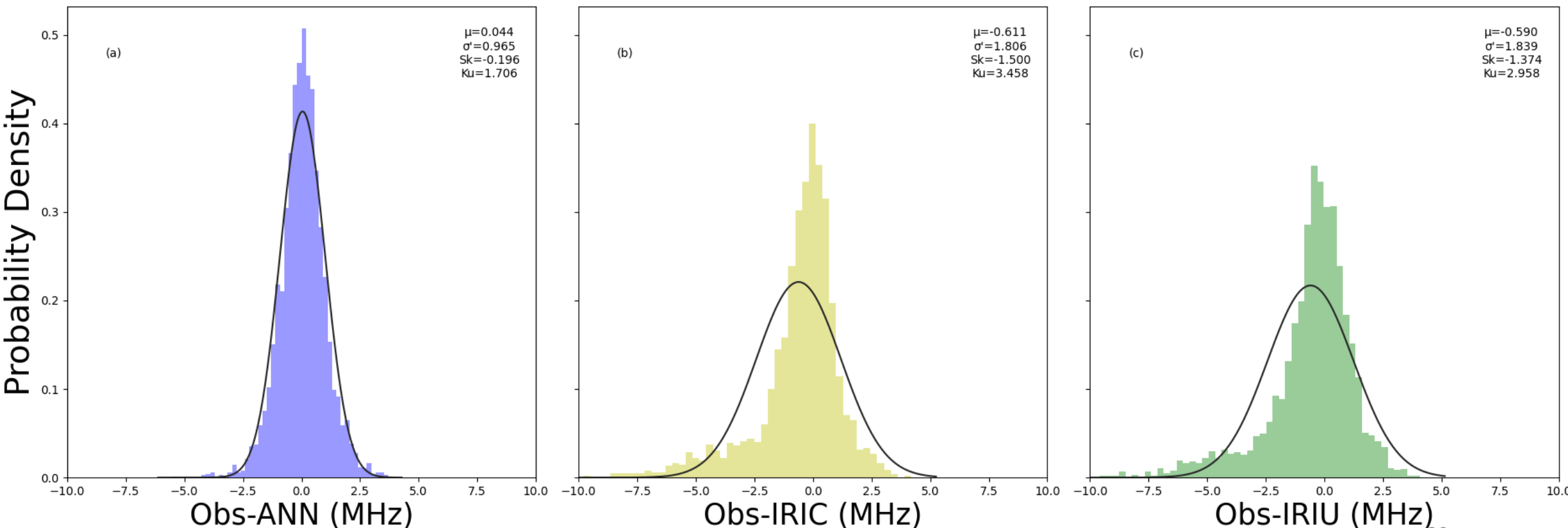
Learning & Generalization



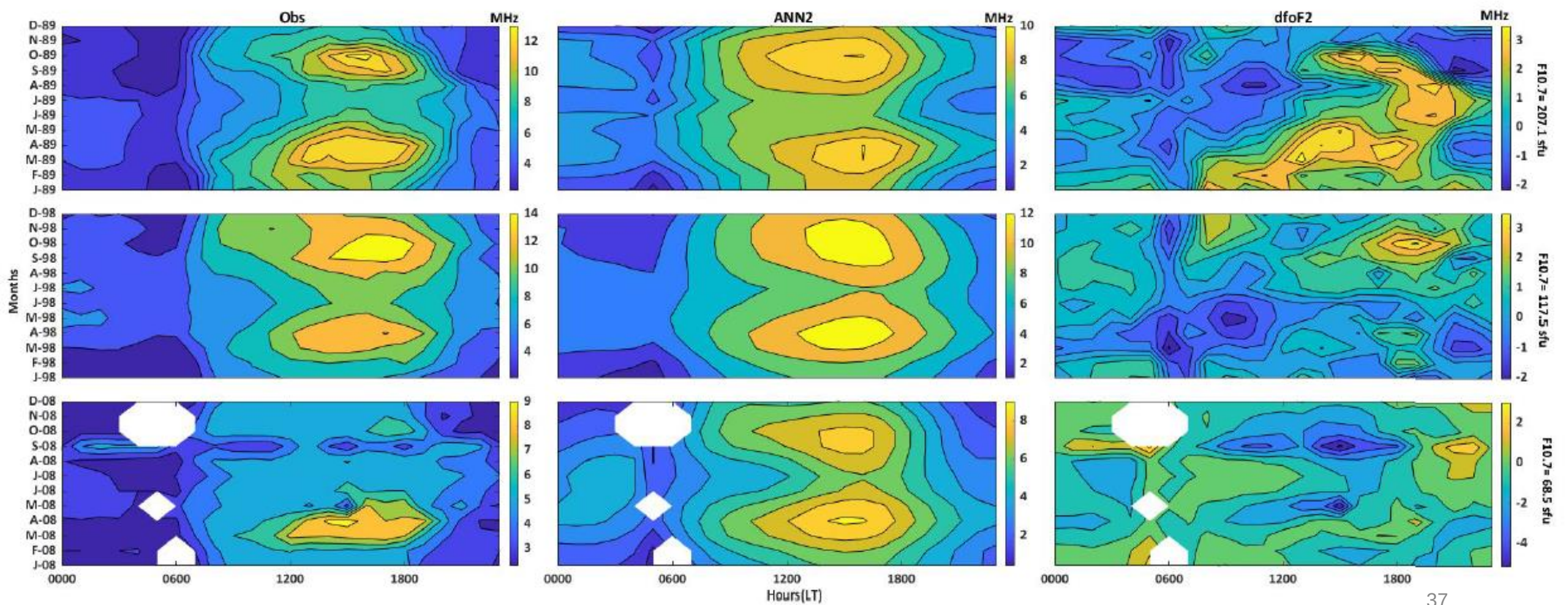
Observations vs models



Error estimations



Model results over Karachi (northern crest of EIA)



Space weather (daily hourly) model of foF2

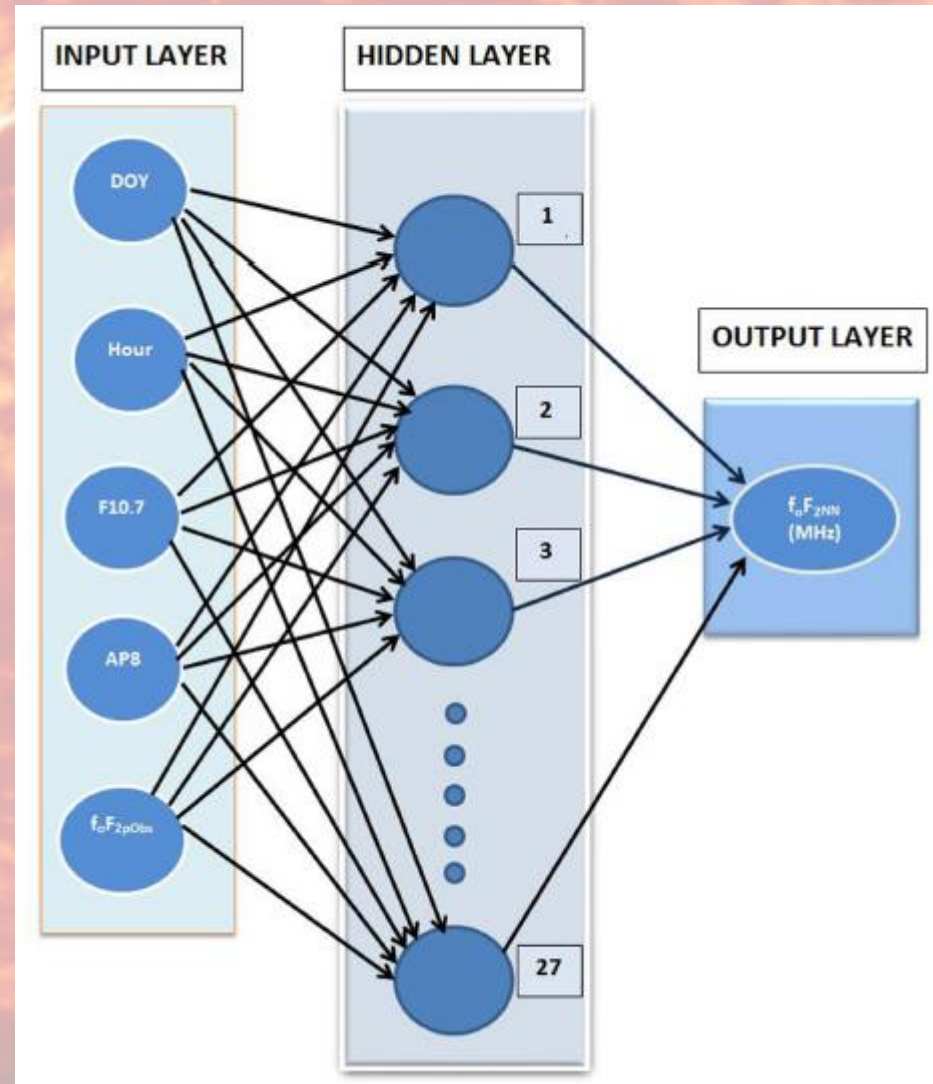
At the northern crest of EIA

Availability of data points at Sonmiani station between 2018–2021.

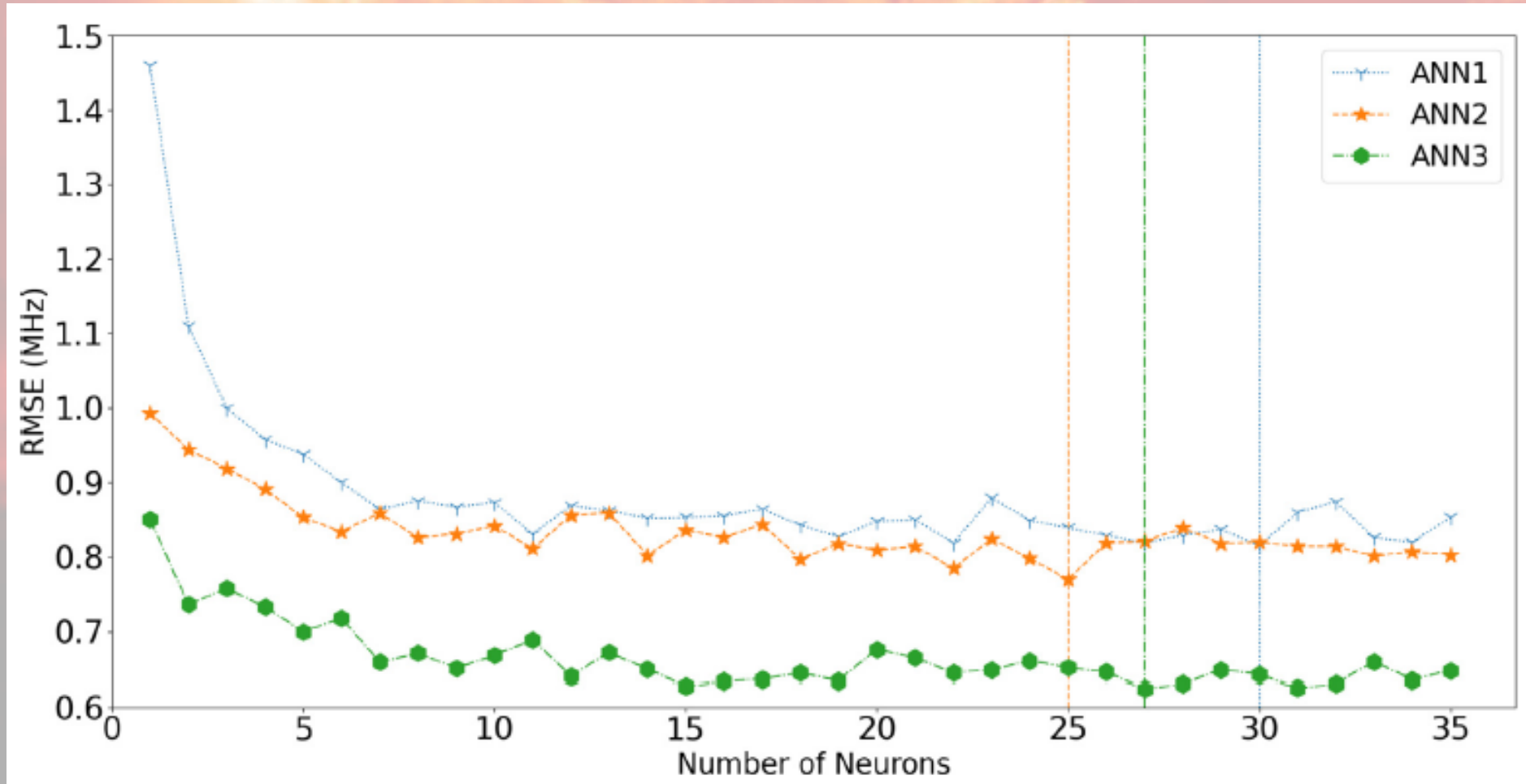
Dataset Type	Period	Possible Data Points	Available Data Points
Train Data	2018–2020	26304	18858
Test Data	2021	8760	6942

Implemented ANN models with different inputs.

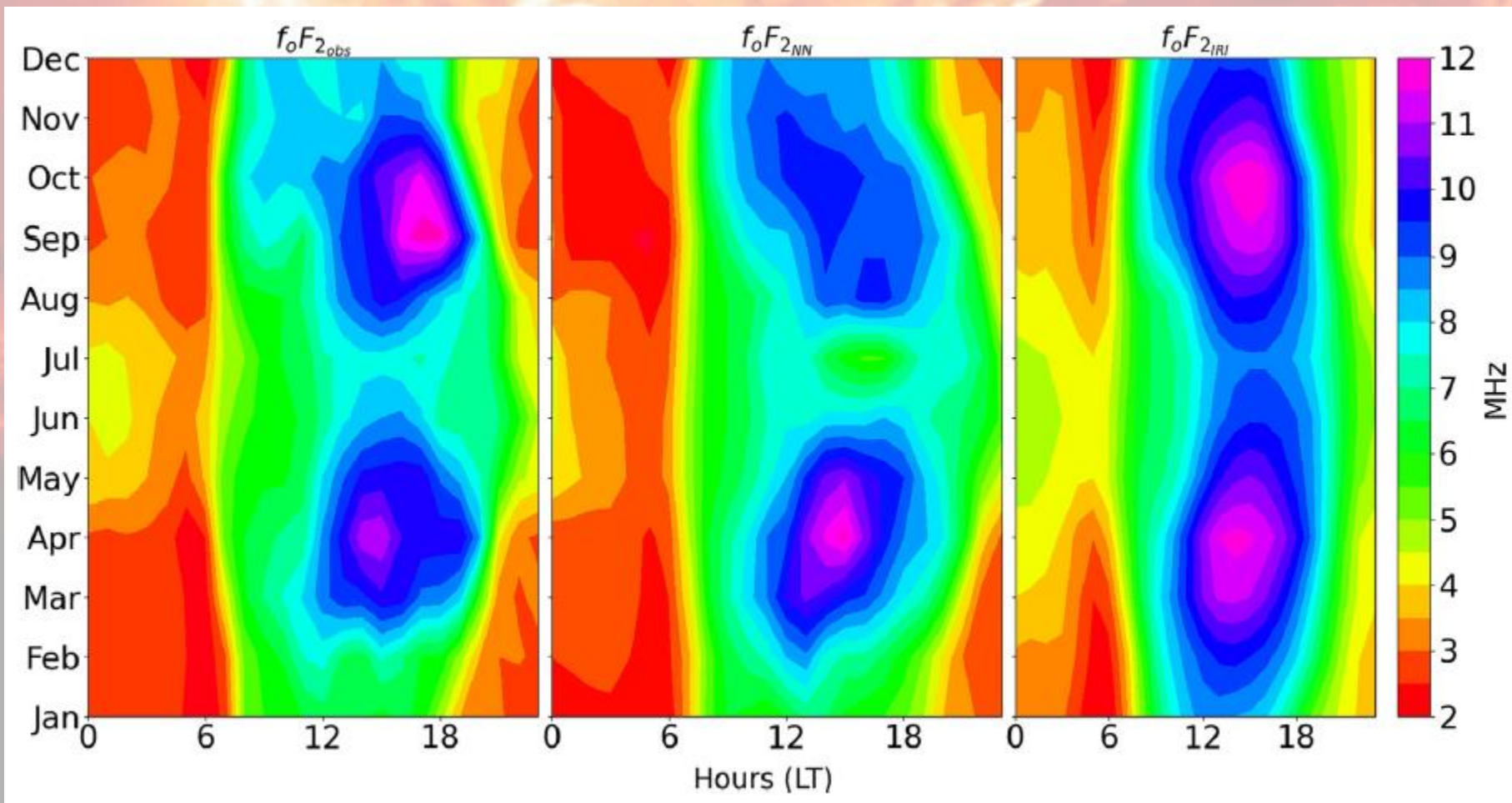
Model Name	Inputs
ANN1	DOY, Hour, F10.7, AP8
ANN2	DOY, Hour, F10.7, AP8, f_oF_{2pRI}
ANN3	DOY, Hour, F10.7, AP8, f_oF_{2pObs}



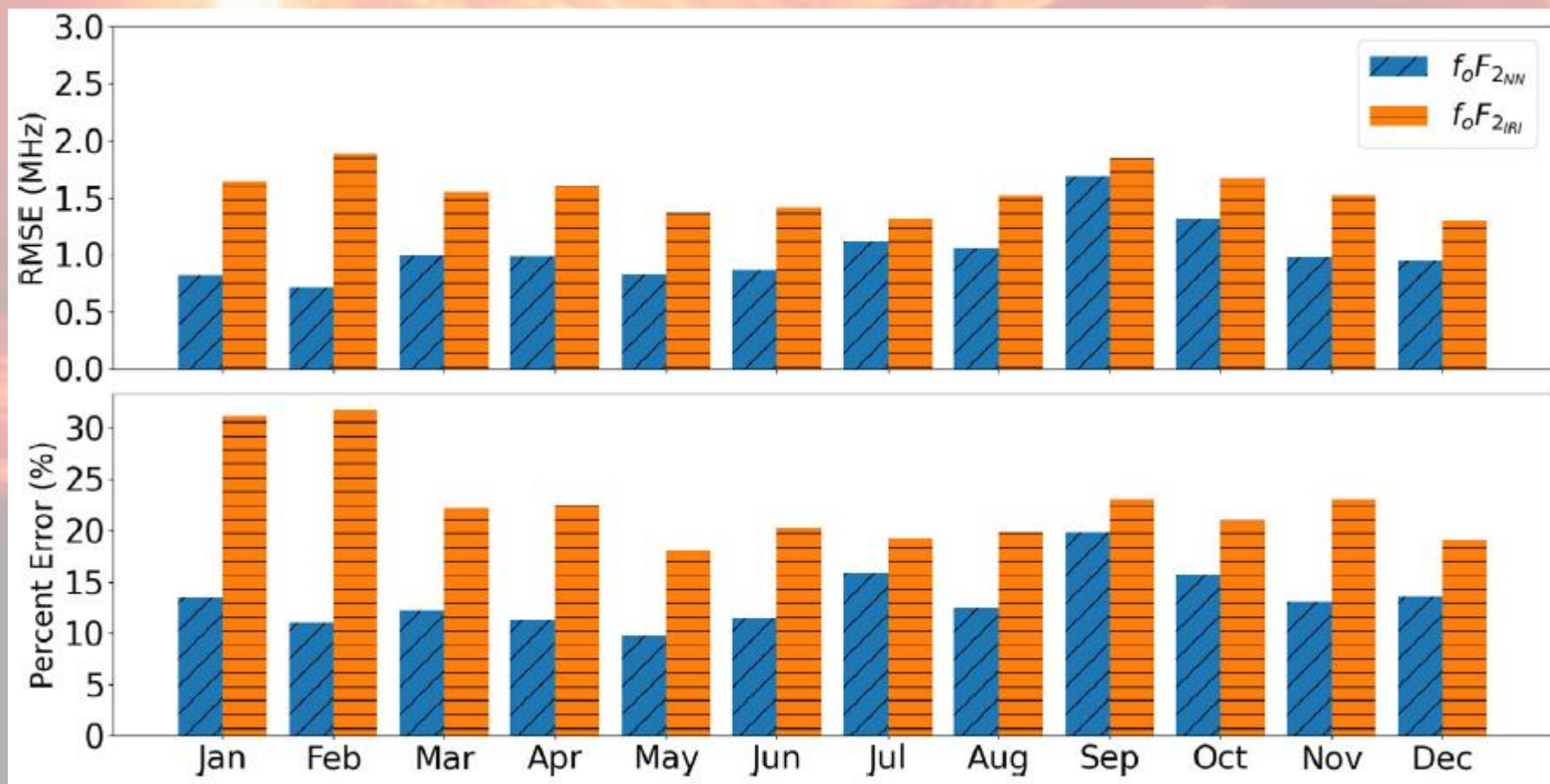
Learning & Generalization



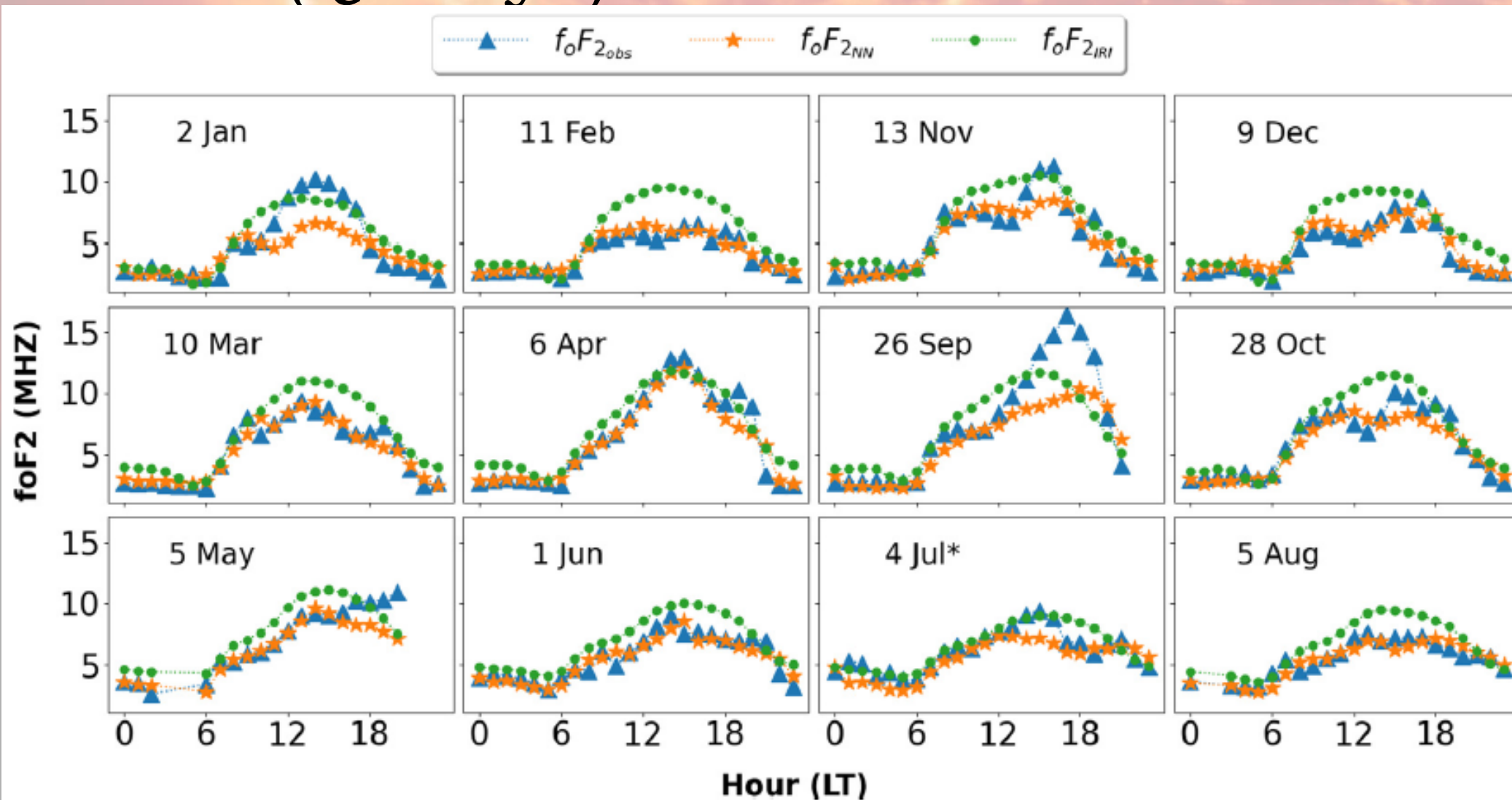
Results (Monthly variations)



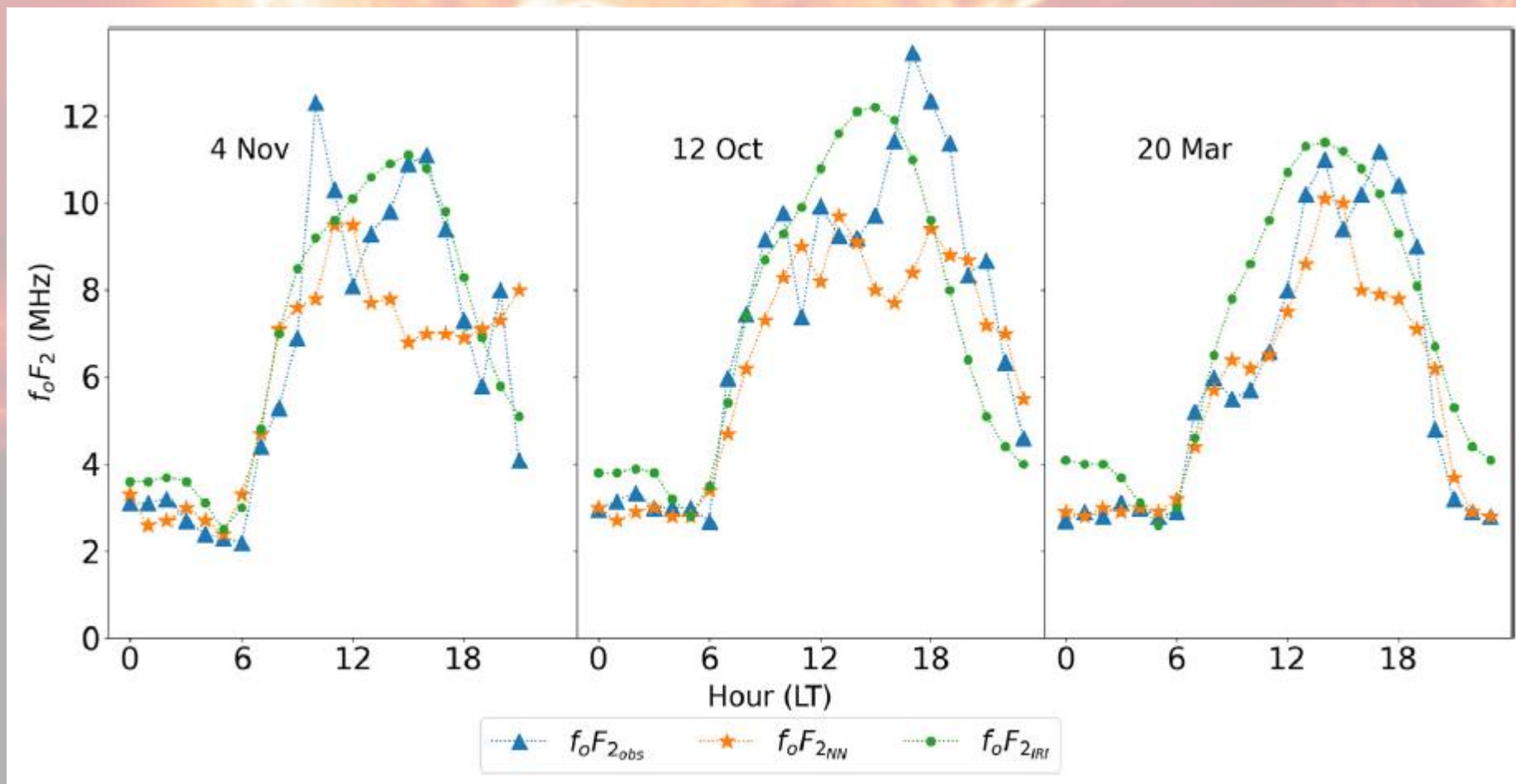
RMSE & PE(%)



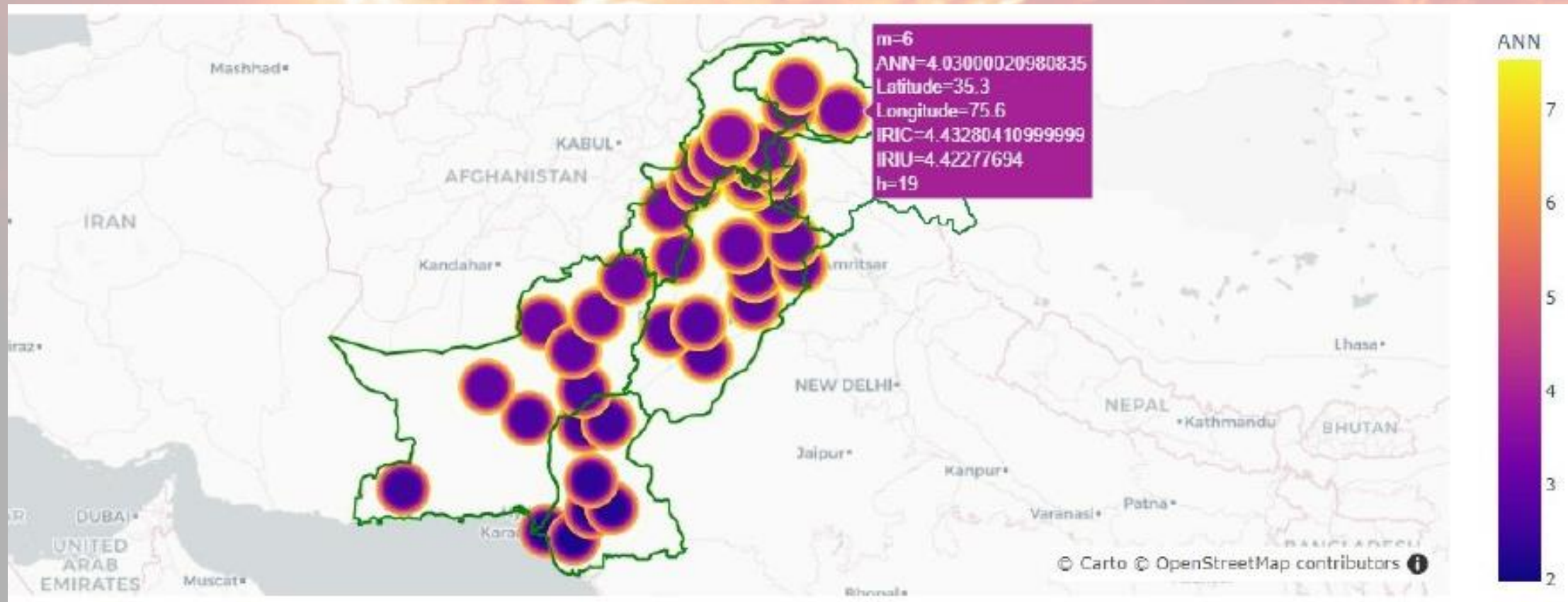
Results (Q-Days)



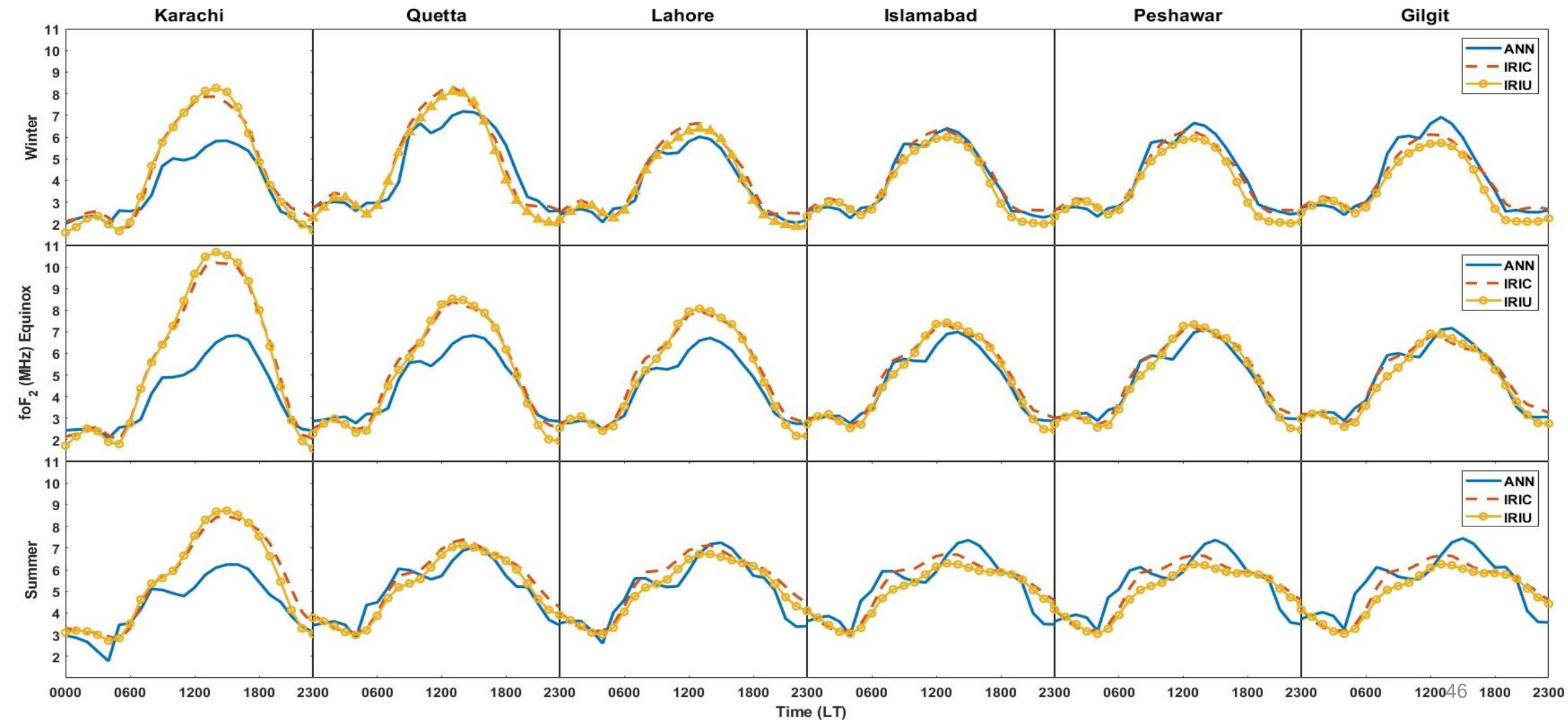
Results (D-Days)



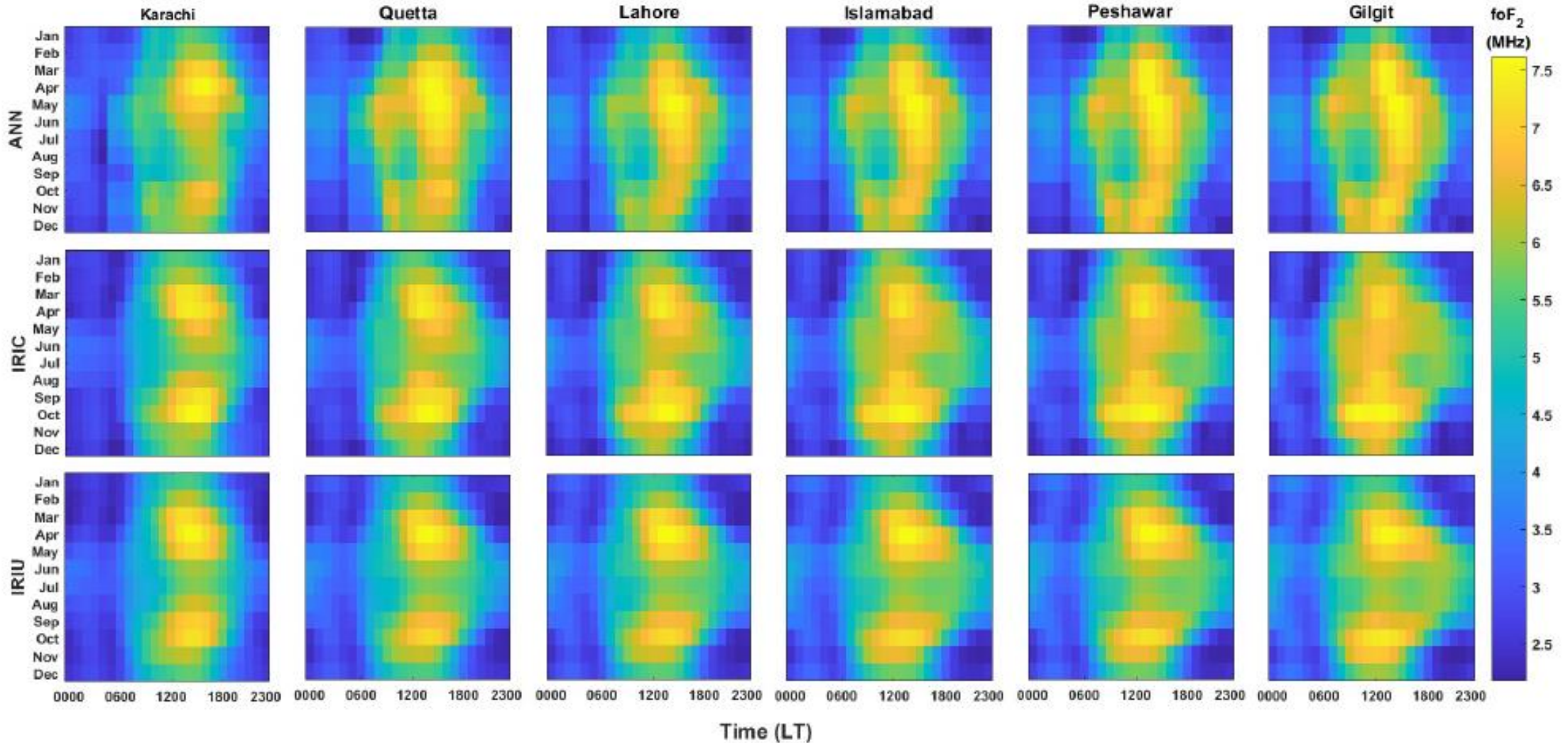
Spin-off



Preliminary results (biteouts)



Preliminary results (monthly variations)



Conclusion

- Our ML models use limited computation power
- They are simple in terms of its design
- The accuracy of the prediction could have been increased at the cost of extra neurons and a hidden layer
- This was avoided to limit the processing time and chances of over/under-fitting
- To move forward, a comprehensive model is under construction considering all available daily hourly data of foF2 from Pakistan

Thank You!