3RD WORKSHOP ON CLOUD ORGANISATION AND PRECIPITATION EXTREMES
ICTP

Electrical activity prediction in the WRF-ELEC model using ML

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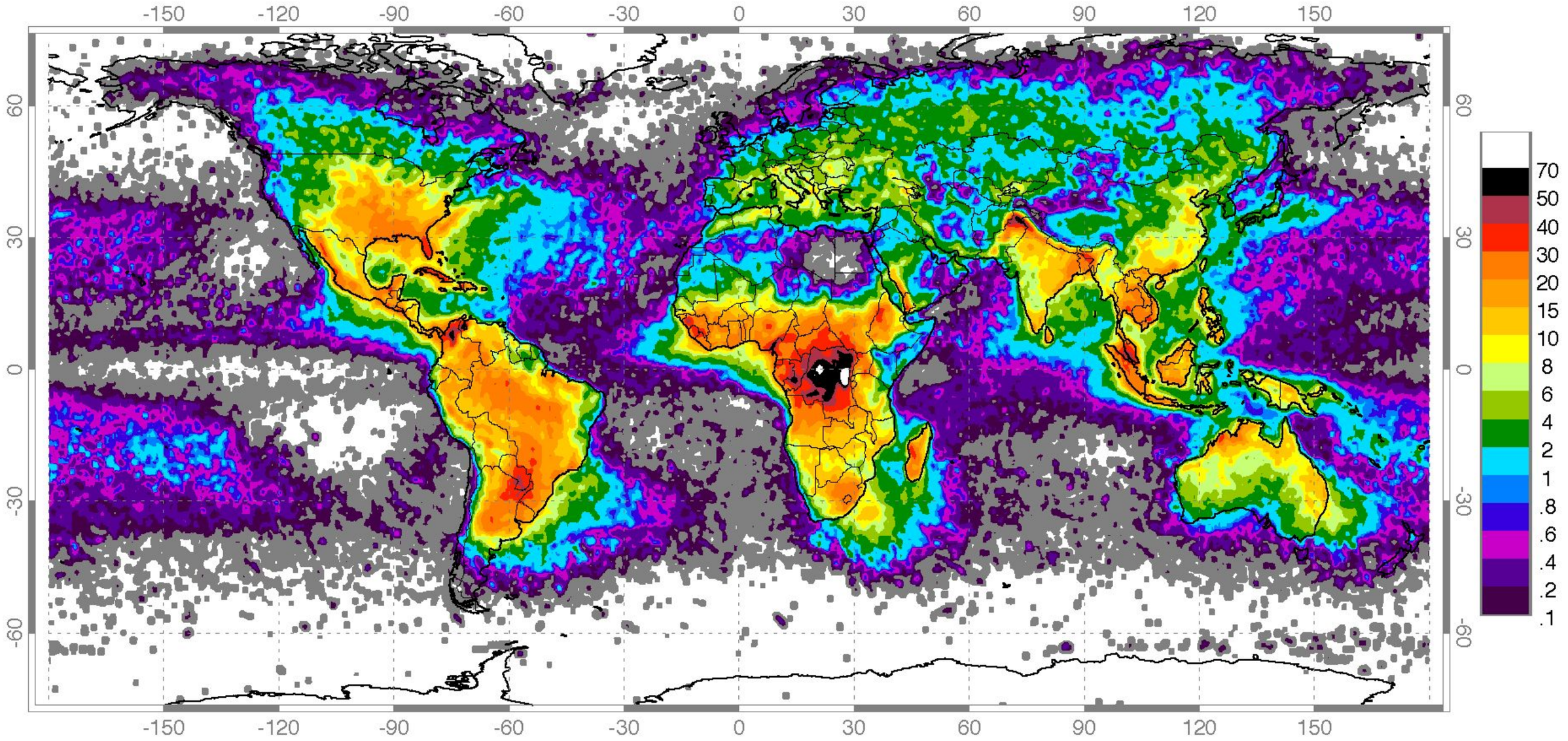
Summary

1. Why do we study electrical activity?
2. WRF and WRF-ELEC models
3. ML techniques
4. Results
5. Conclusions
6. Future studies

GLOBAL MAP OF LIGHTNING FREQUENCY [FLASHES/KM2/YR].



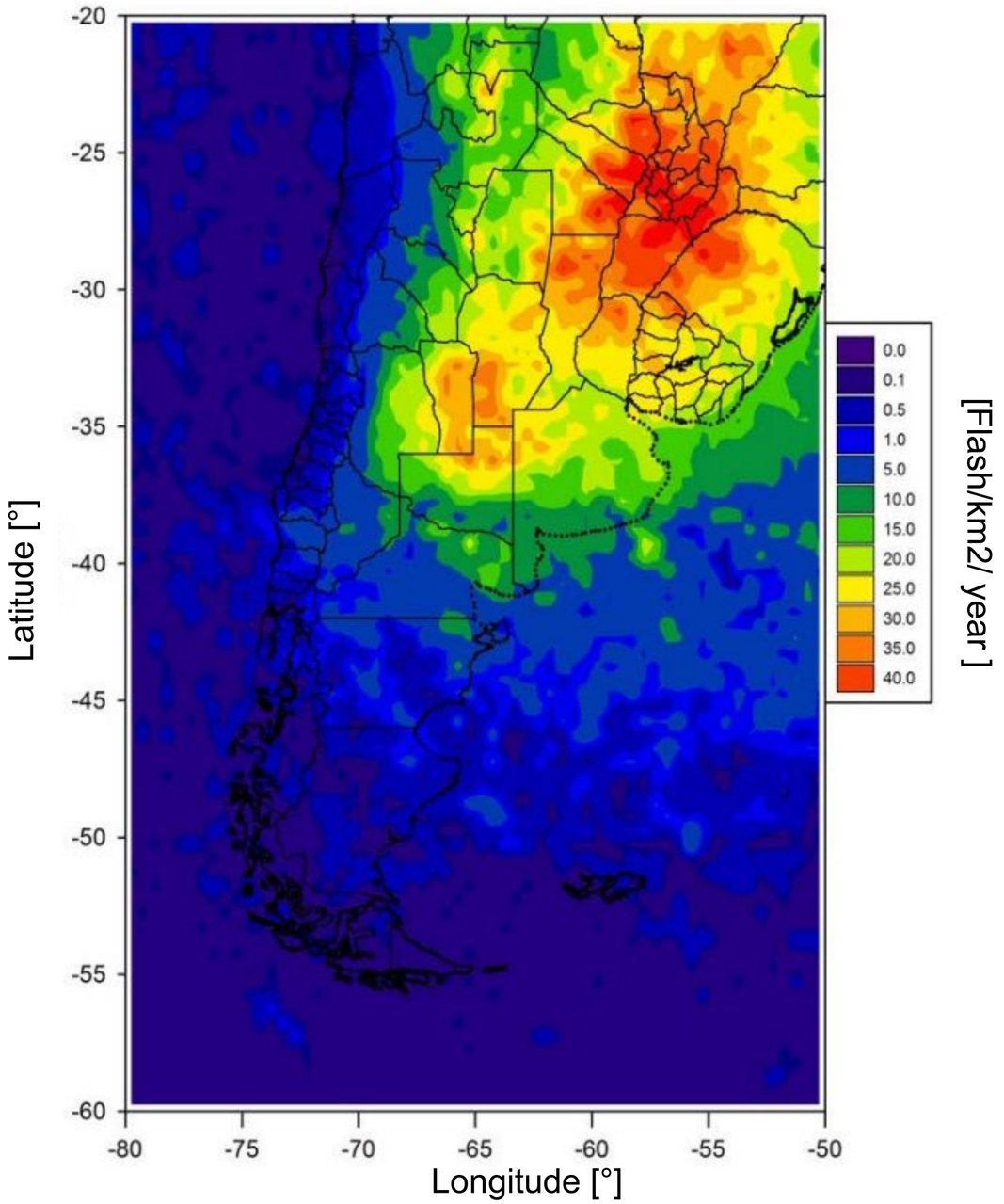
NASA/GHRC/NSSTC LIGHTNING TEAM

SOUTH - SOUTH AMERICA

- Is the region between 20° & 60°S latitudes and betweeen 50° & 80° W longitudes.
- Due to local climate, precipitations in Center and North of Argentina are mainly generated by thunderstorms (Liu et al., 2010).
- The annual map of Thunderstoms Days (Tds) shows an absolute maximum located in northwestern Argentina with values greater than 100 Td/year (Bertoni et al., 2022).

FLASH RATE

- As figure shows, central region have relevant electrical activity with 25 flashes per km2 per year, while northwest area shows more than 40 flashes per km2 per year (Nicora et al., 2014)

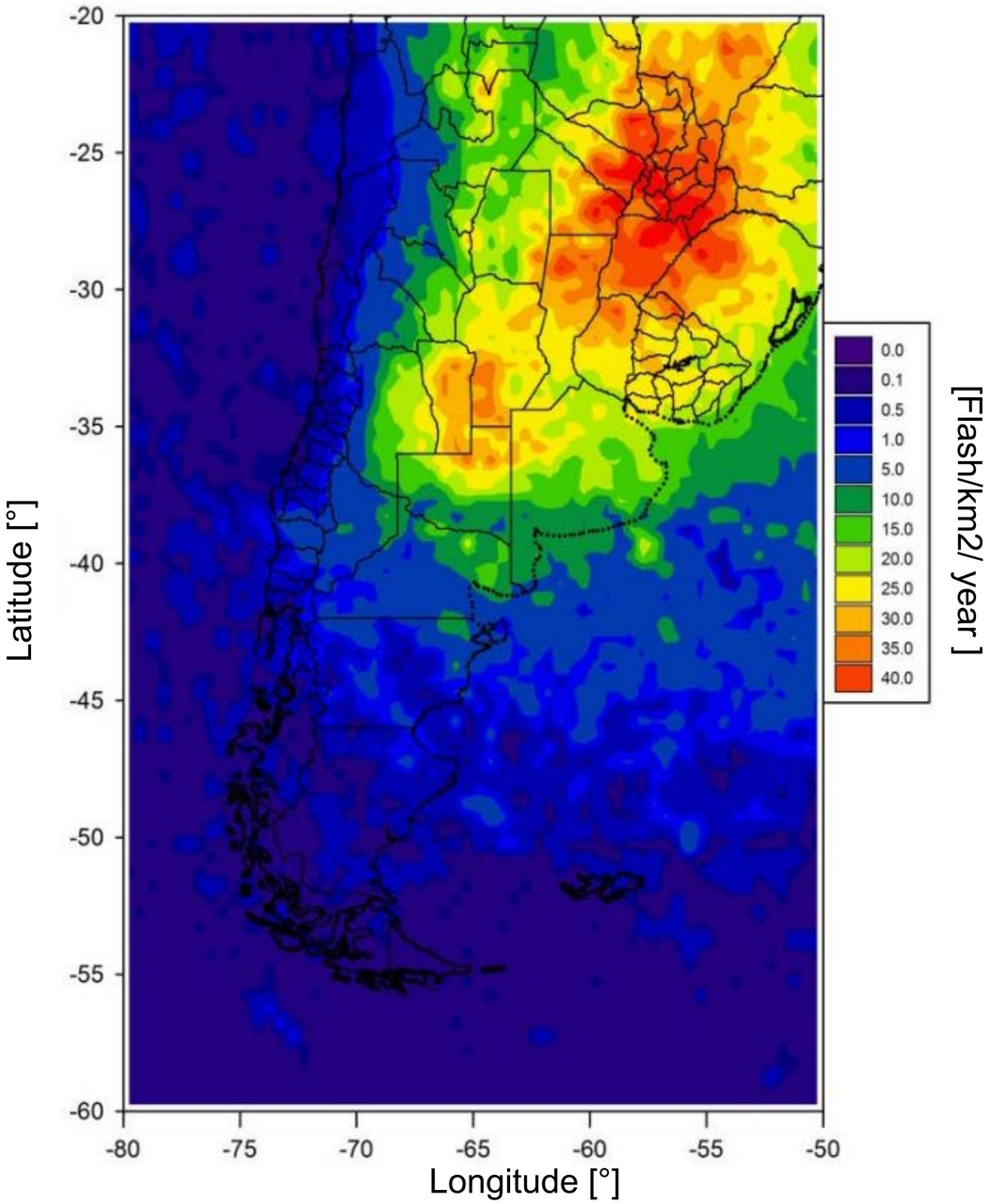


ELECTRICAL ACTIVITY AS A PROXY

Research indicates a correlation between electrical discharges and the microphysics and dynamics of thunderstorms. Correlations with severe weather events have also been identified.

- Updraft maximum (Deierling and Petersen, 2008).
- Precipitation ice mass (Deierling and Petersen, 2008).
- Updraft volumes (Schultz, et al., 2017)
- Graupel mass (Carey et al., 2019)
- CTT and hail precipitation (Borque et al., 2020)

Then, it could be possible to predict severe events from electrical activity.



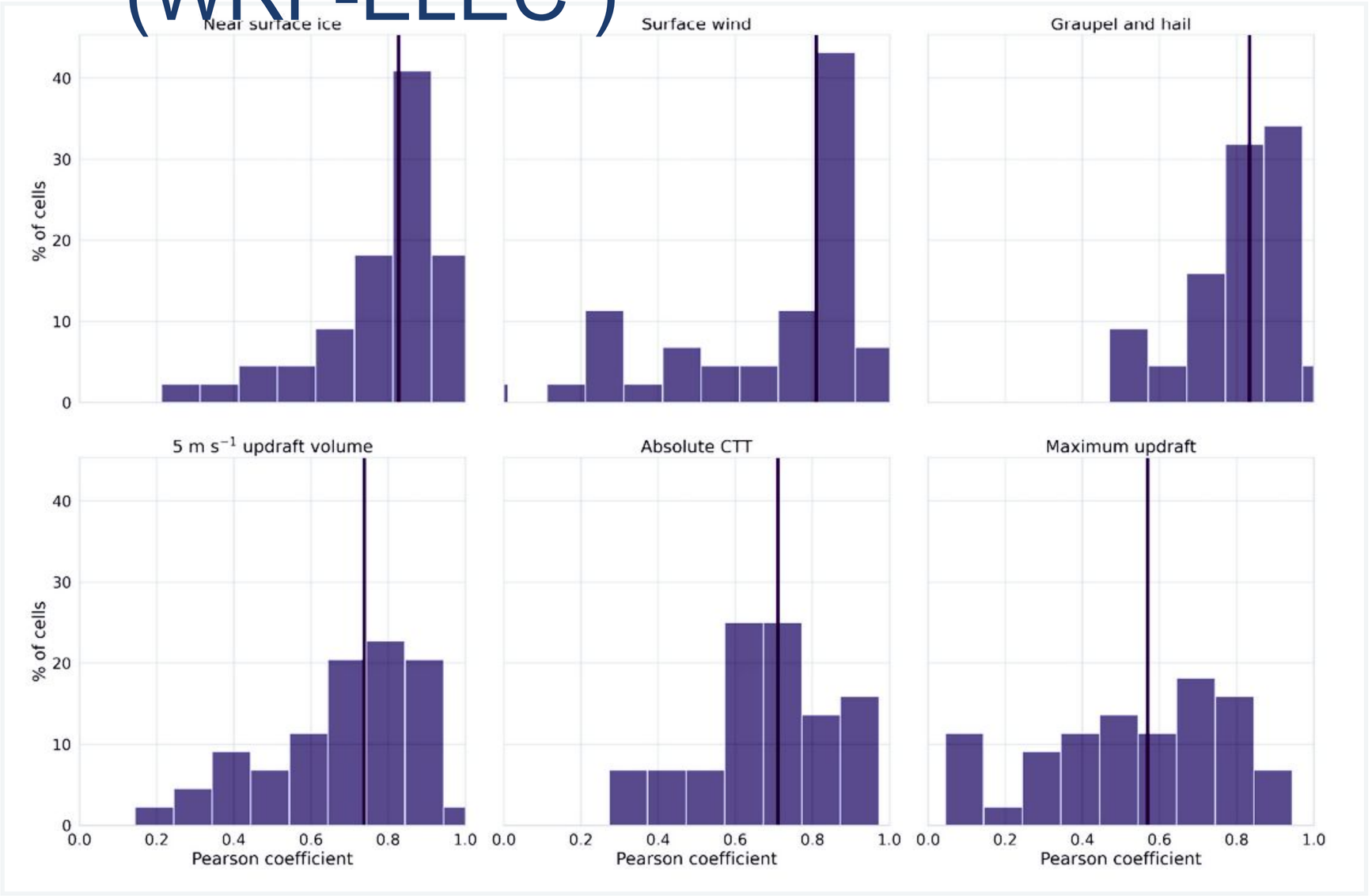
WRF / WRF-ELEC models

- WRF is a mesoscale forecast model and assimilation system developed by numerous institutes and centers in the U.S.

- WRF-ELEC is a storm electrification package for the WRF model which explicitly represents the charge and discharge processes of the clouds (Fierro et al., 2013).

Correlations with electrical activity (WRF-ELEC)

Histograms for maximum Pearson correlation coefficients between the LIGHT variable and: near-surface ice, surface wind, graupel + hail mixing ratios, 5 m/s updraft volume, CTT and maximum updraft. Vertical lines indicate median value at each case.



LUQUE ET AL., 2023

WRF-ELEC

Only works with WRF 3.9.1.
Last WRF is 4.5.1

ML MODEL

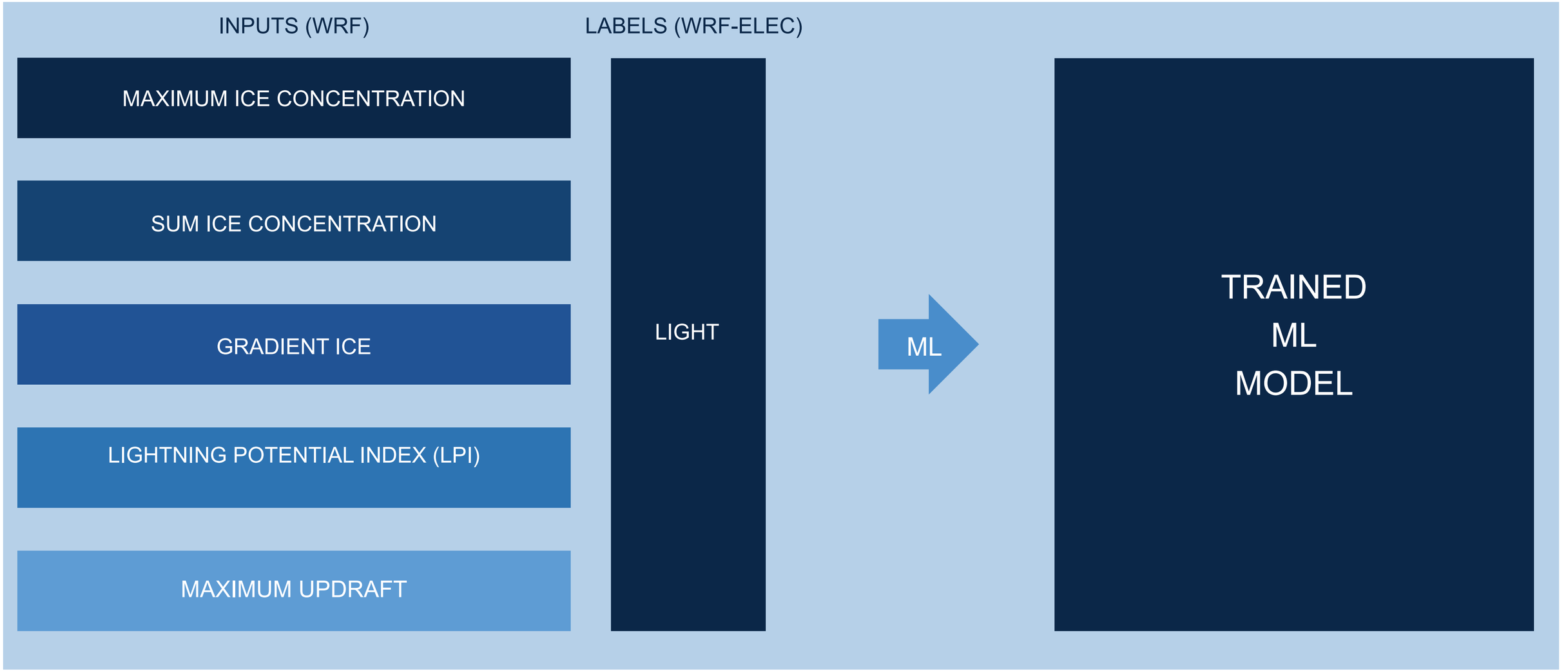
Uses WRF to create dataset.
ML with Python.

Models

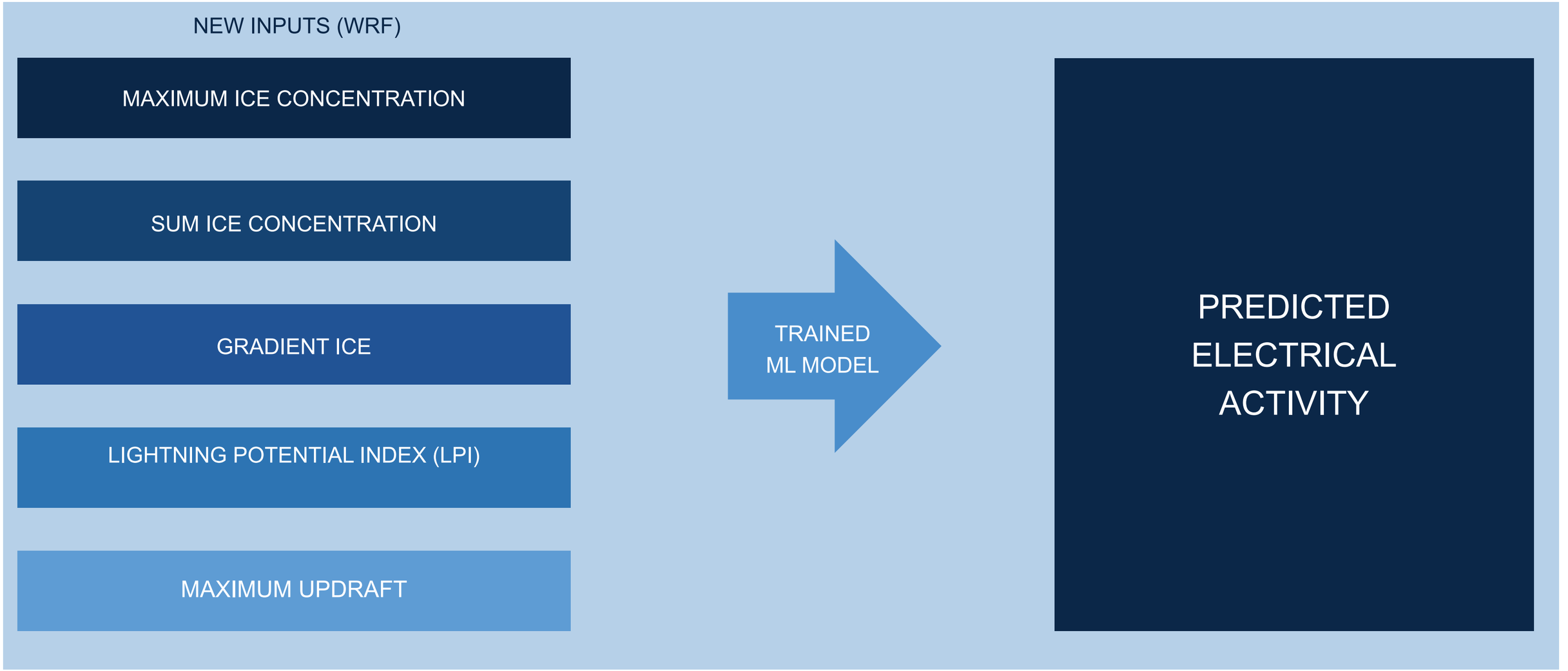
RANDOM FOREST
is an ensemble learning method for classification, regression and other tasks that operates by constructing a multitude of decision trees at training time.
For regression tasks, the mean or average prediction of the individual trees is returned.

NEURAL NETWORKS
are a branch of machine learning models that are built using principles of neuronal organization. Artificial neural networks can be described as models with at least two layers: one input and one output, as well as, in most cases, other intermediate layers (hidden layers).

Dataset and training

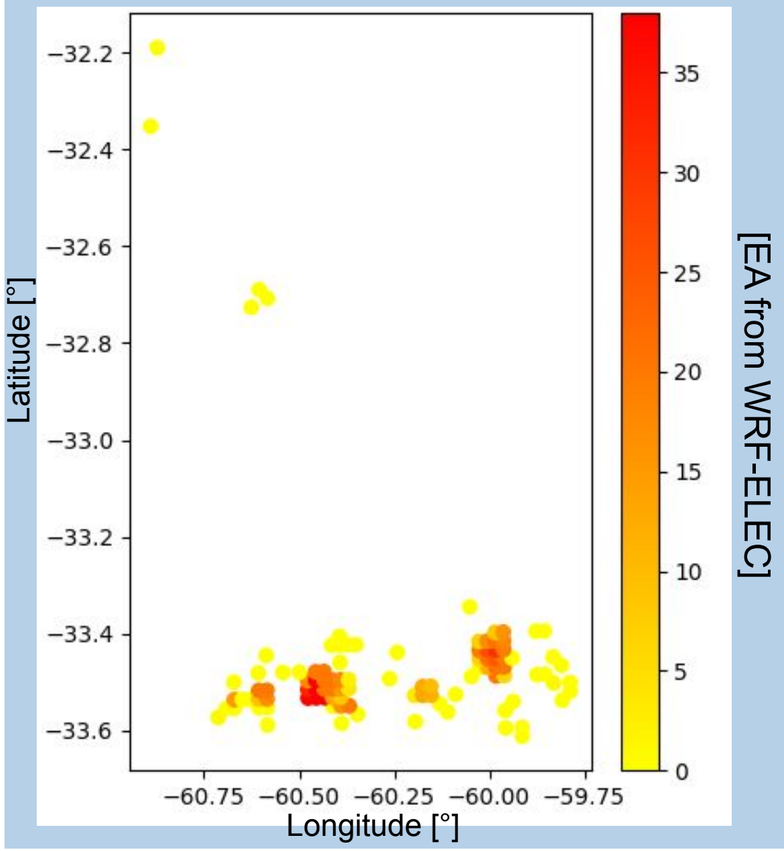


ML implementation



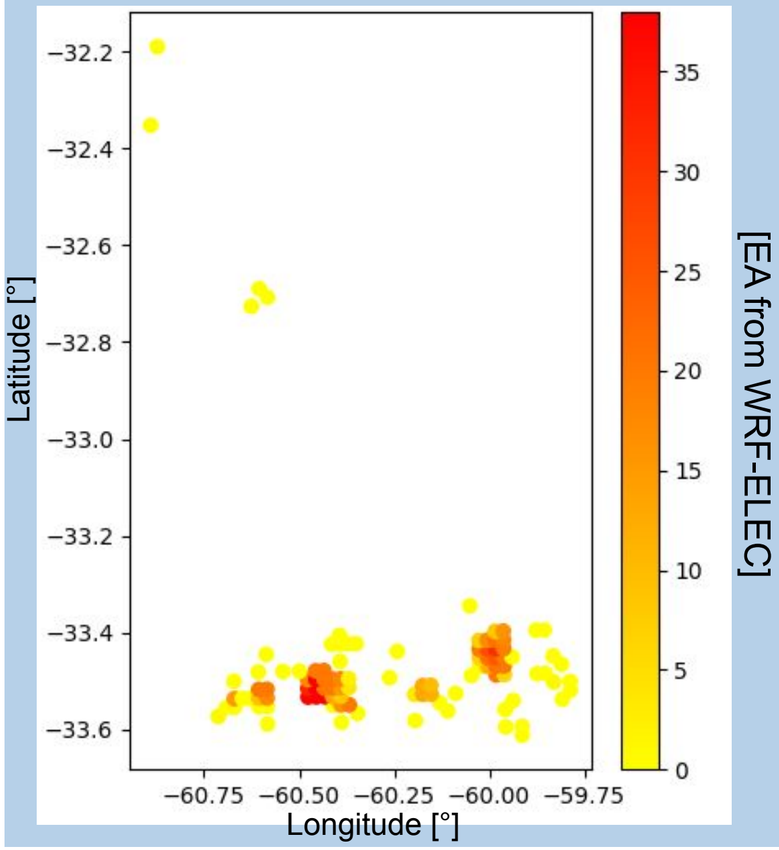
Results

WRF-ELEC SIMULATED ELECTRICAL ACTIVITY

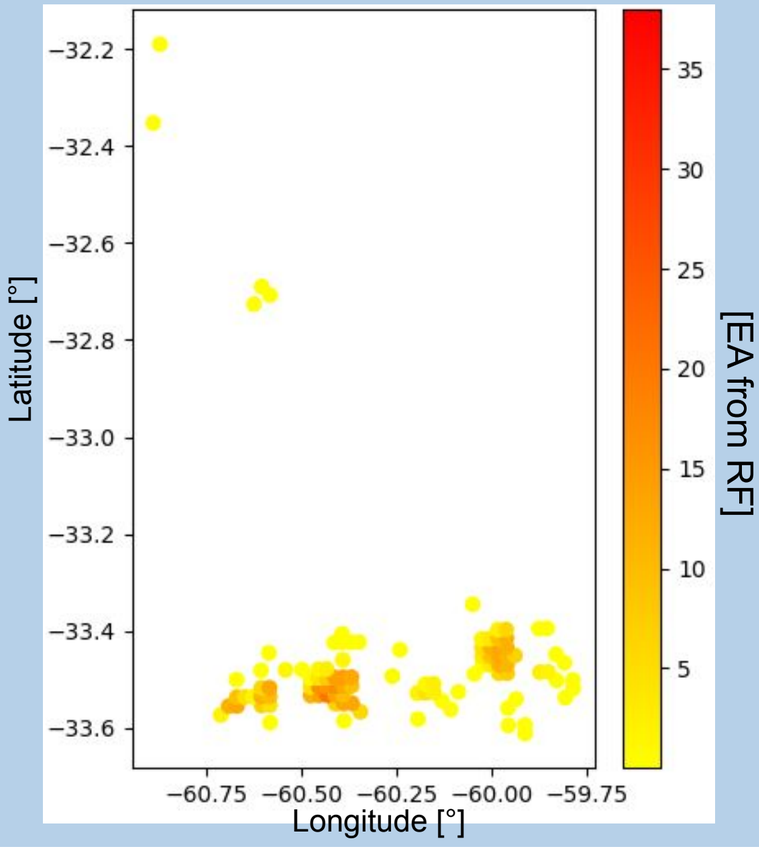


Results

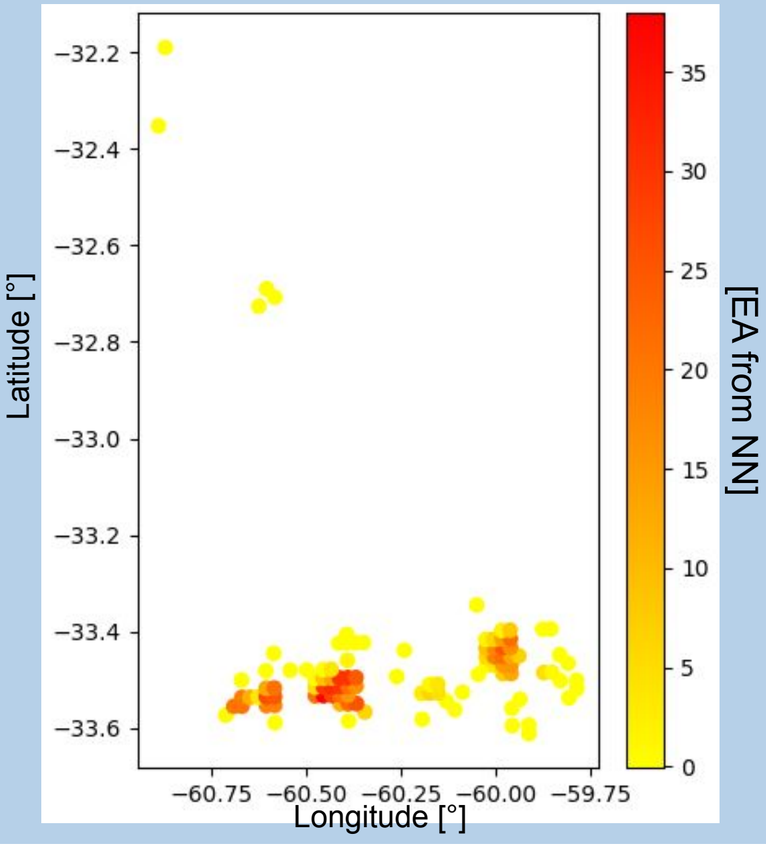
REAL ELECTRICAL ACTIVITY



RANDOM FOREST



NEURAL NETWORKS



Conclusions

- BOTH ML MODELS REPRODUCES SUCCESFULLY THE LOCATION OF DISCHARGES SIMULATED BY WRF-ELEC.
- NN SHOWS BETTER PERFORMANCE THAN RF MODEL WITH VARIANCES OF 0.67 AND 0.6, RESPECTIVELY.
- TAKING INTO ACCOUNT THE PRESENT RESULTS, ML MODELS DEVELOPED HERE COULD BE USE AS AN ALTERNATIVE TO WRF-ELEC MODEL.

Future studies

- IMPLEMENT MORE COMPLEX MODELS SUCH AS CONVOLUTIONAL NEURAL NETWORKS.
- EXTEND STUDIES TO OTHER SOURCES OF LIGHTNING INFORMATION SUCH AS WWLLN INCLUDING NOT ONLY WRF DATA BUT ALSO RADAR DATA.

Thank you!