Predicting Fire Dynamics Using a Convolutional Neural Network

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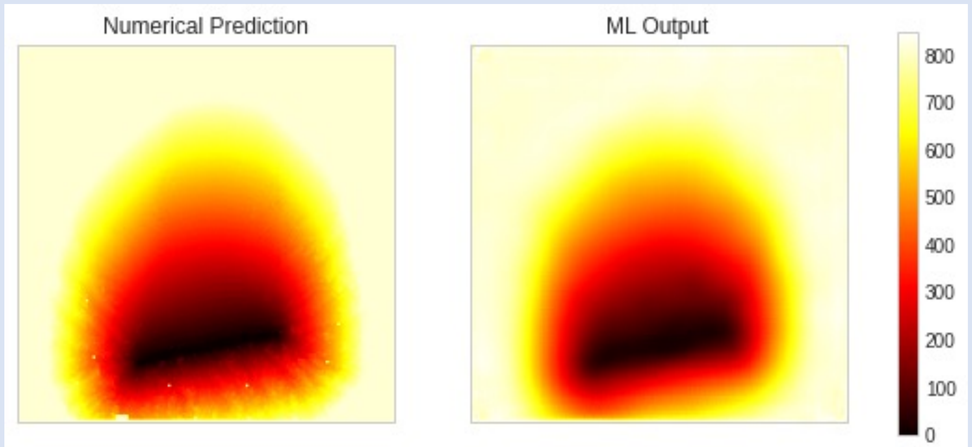
ABSTRACT

This project seeks to create a Machine Learning (ML) model using a Convolutional Neural Network that can accurately predict fire spread and fire dynamics. A physical model to predict fire dynamics was created using MATLAB as a control/comparison to the ML model that was created and run through a Python Script and TensorFlow.

CONCLUSIONS

These findings suggest that a Machine Learning model using Convolutional Neural Networks is able to accurately predict fire dynamics and fire spread. Further research should be conducted to develop a machine learning model that could predict fire spread on a larger scale while taking more variables into account such as fire leaps, fuel material, while striving for faster run times and greater accuracy.

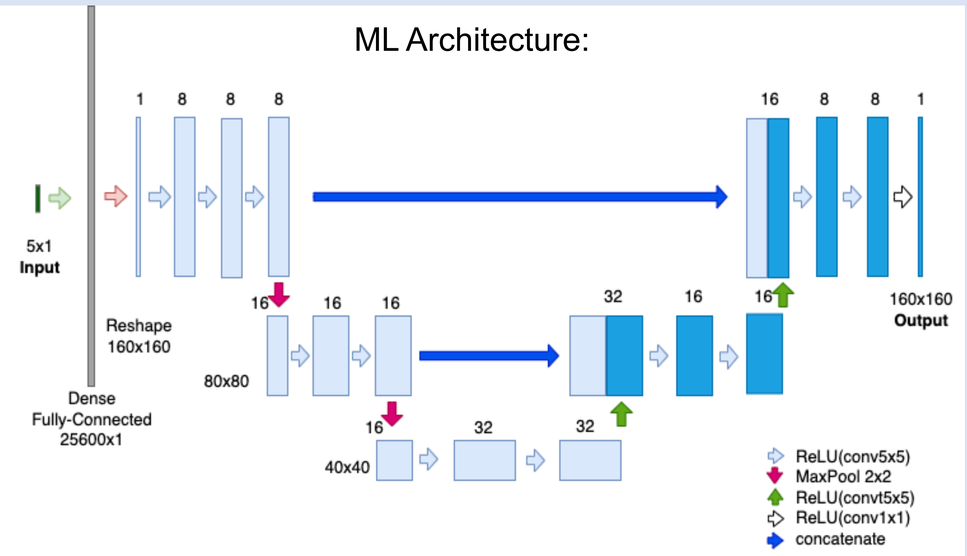
Physical Model's Prediction vs. ML Model



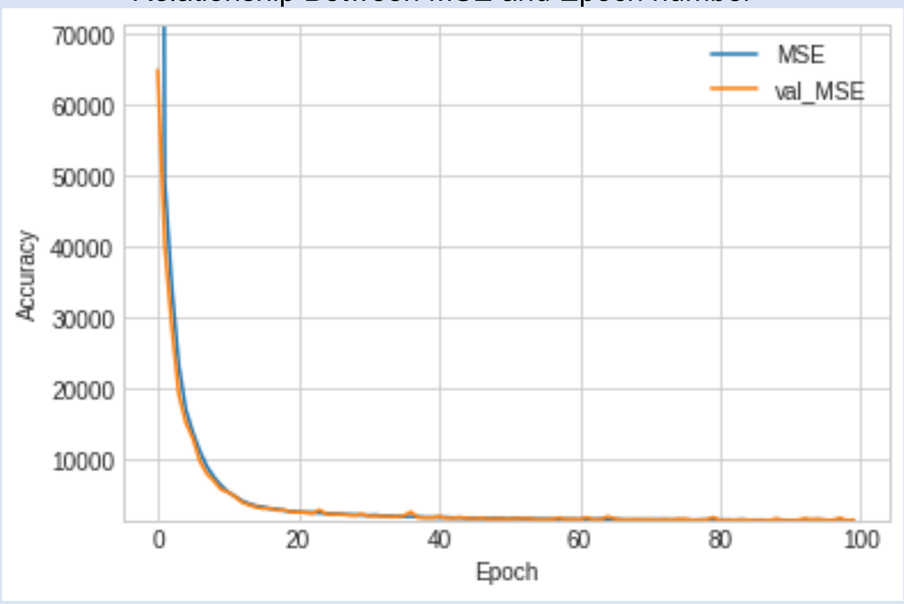
REFRENCES

- Sharples, Jason J., and James E. Hilton. "Modeling Vorticity-Driven Wildfire Behavior Using Near-Field Techniques." *Frontiers in Mechanical Engineering*, 2020
- Quaife, Bryan, and Kevin Speer. "A Simple Model for Wildland Fire Vortex–Sink Interactions." *Atmosphere*, 2021,
- Hilton, J. E., et al. "Incorporating Convective Feedback in Wildfire Simulations Using Pyrogenic Potential." *Environmental Modelling & Software,* 2018
- Finney, Mark, et al. *Wildland Fire Behaviour: Dynamics, Principles and Processes*. CSIRO Publishing, 2021

ML Architecture:



Relationship Between MSE and Epoch number



# of Epochs	Learning Rate	# of Trainable Parameters	Time per Epoch	Batch Size
100	0.0001	219,761	~12 sec	20

METHODS

- The fire dynamic map (first arrival map) was predicted by a numerical physical-based model using MatLab. A collection of these samples would later serve as the training and test sets for the ML model
- MatLab files for datasets were sent to the RCC via SSH to the remote supercomputer
- The samples were combined randomly and divided as: 80% of samples to be used for training the model (training set, 4250), and 20% for testing the model (test set, 1000)
- Using Python and TensorFlow on Google Colab, these datasets were learned and trained through the ML model to receive outputs.
- After the model is trained it produces predictions of fire spread maps and we can make plots of the maps.
- Further datasets are still being created, and the ML model's hyperparameters are still being altered for ideal efficiency/accuracy.