Extreme Weather Forecasting Using Machine Learning

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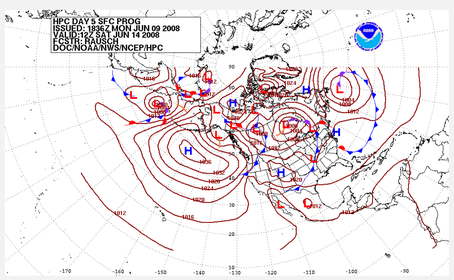
Abstract

Large AI/ML models have achieved record performance predicting extreme weather events by analyzing large meteorological datasets. The technique detects patterns that signal severe weather, aiming to enhance early warnings and disaster preparedness. This project utilized the APL Collab to test run the state-of-the-art weather models and gained great insights.

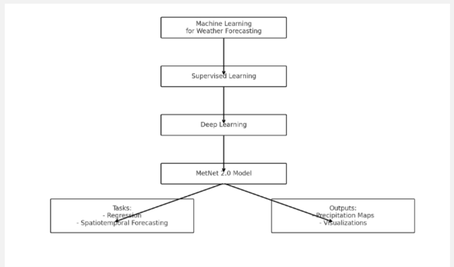
Introduction

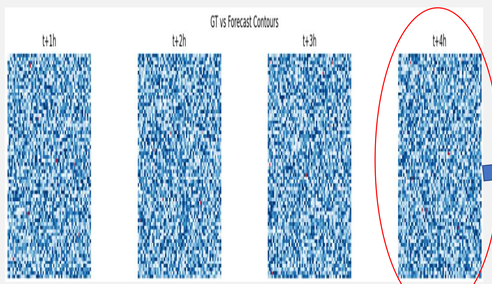
Extreme weather events like hurricanes and floods pose serious risks. Traditional forecasts can miss complex patterns. This project applies machine learning to large datasets to improve predictions and support better preparedness.



Methodology

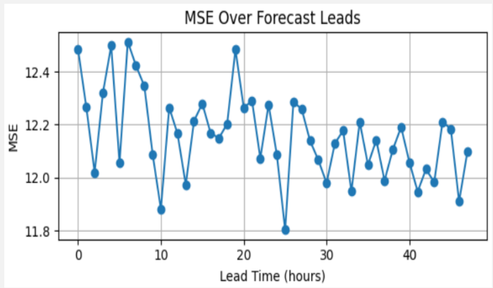
- Researched multiple machine learning models for weather forecasting.
- Initially explored FourCastNet before selecting MetNet 2.0 for its use of dilated convolutions for high resolution precipitation forecasts up to 12 hours ahead.
- Adapted Hugging Face dataset for efficiency.
- Optimized RAM usage by adjusting batch and sample sizes, clearing cache, and testing with smaller datasets.
- Used AI tools for debugging and refining code.
- Gained technical skills through hands-on experimentation.



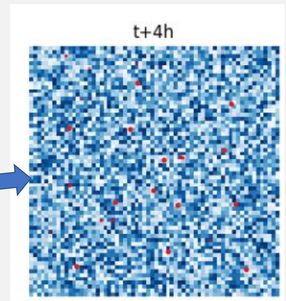


Results

- Successfully ran MetNet 2.0 to forecast precipitation over multiple time steps.
- Visualized results by comparing ground truth precipitation maps with model forecasts.
- Added contour overlays to highlight forecasted high-precipitation regions.
- Plotted side-by-side comparisons for each forecast lead time.
- Calculated and graphed Mean Squared Error (MSE) to assess accuracy over time



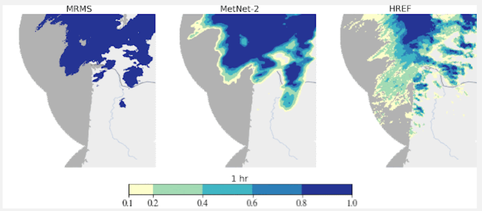
- **Blue** = real rainfall intensity.
- **Red outlines** = model-predicted heavy rain.
- **Overlap** = correct forecast.



Visually, these plots help you quickly see where the model succeeds or fails spatially and in intensity.

Conclusion

- Machine learning offers a powerful tool for improving extreme weather forecasting.
- With enough resources, MetNet 2.0 makes detailed multi-step predictions.
- Visuals and error metrics show strong potential for early warnings.
- Future work could enhance accuracy, add data, and boost efficiency.



Acknowledgement

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