Application of Machine Learning in Catastrophe Modelling

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Agenda

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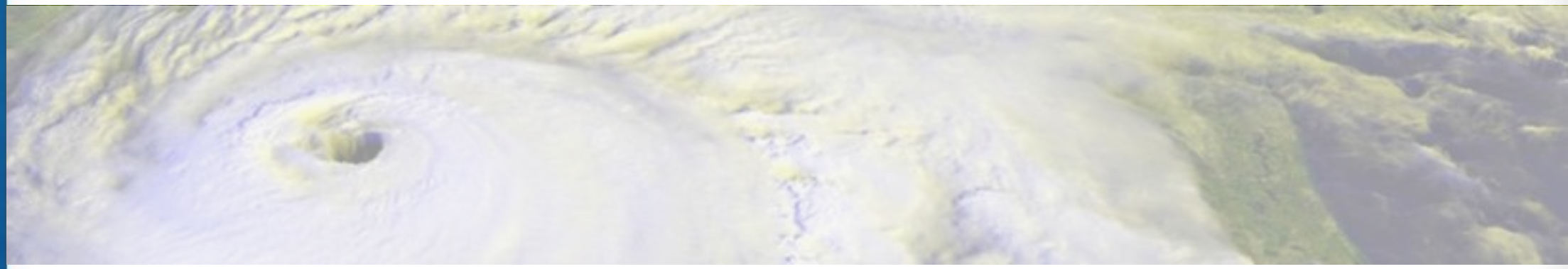
01	*What is CAT Modelling?*
02	*How CAT Model Works?*
03	*Limitations of CAT Models*
04	*Machine Learning in CAT*
05	*Future Scope of Work*
06	*Future with Quantum Computing*

What is Cat Modelling?

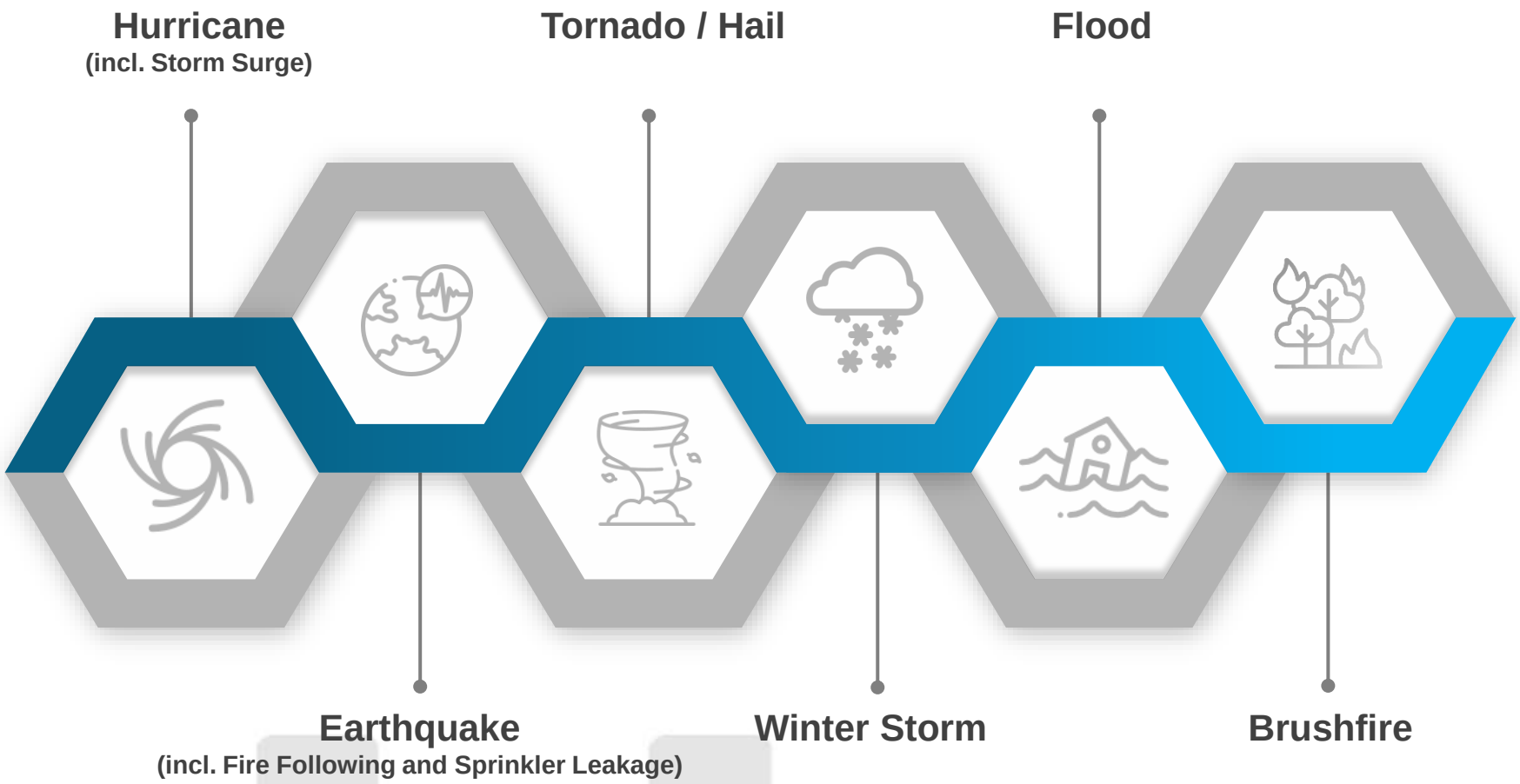


The Process of using Computer-assisted Calculations to Estimate Losses that could be Sustained by a Portfolio of Properties due to a Catastrophic Event like Hurricane, Earthquake etc.

This includes:

- Estimates the Magnitude/Intensity and Location
- Determines the Amount of Damage
- Calculates the Possible Insured Loss

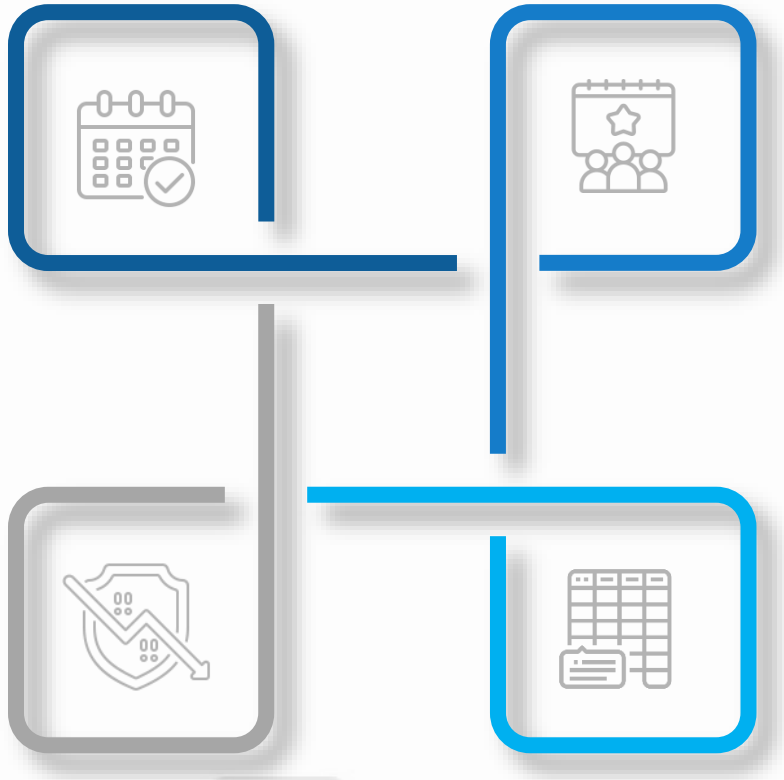
Modeled Natural Catastrophe Perils Include



CAT Models are Designed to Answer:

Where Future Events can Occur?

How Big Future Events can be?



Potential Damage and Insured Loss

Expected Frequency of Events

How CAT Model works?

Exposures

Models start with the exposure distribution (geography, construction, occupancy, etc.)

Vulnerability

This is the amount of damage expected to result from an event based on the exposure characteristics and event intensity

Hazard

Stochastic events are simulated against the exposures. Each event has an associated probability

Financial Perspectives

Finally, varying perspectives of the loss are generated (application of primary insurance conditions and facultative and treaty reinsurance)

Step-by-step CAT Modelling (Example of a Storm)

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User Enters Location Data and Building Characteristics into Model

Model Geocodes Location to its Geographic Coordinates, Identifying Location's Distance to Coast

Stochastic Event Module Defines Event set for Specified Location and Storm Type

Hazard Module Generates Event Information Including Wind Speed and Storm Surge to Determine Hazard Intensity

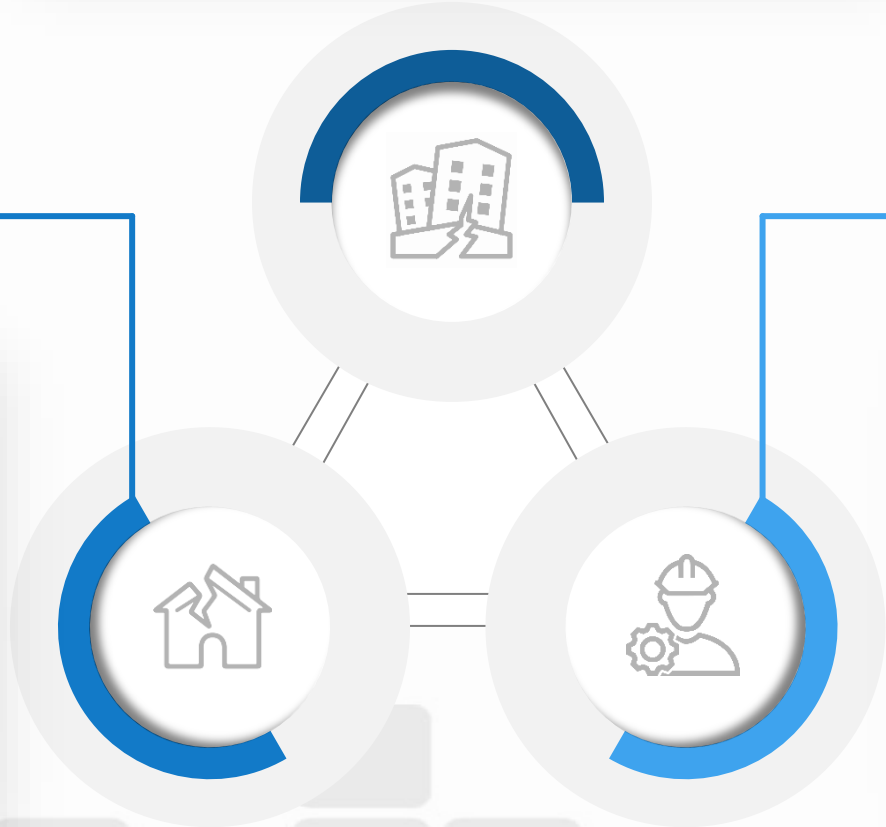
Vulnerability Module Retrieves Hazard Intensity and Generates Average Damage (i.e., mean damage ratio) and Associated Uncertainty Factoring in Building Characteristics (e.g. roof type, construction type)

Based on the Estimated mean Damage Ratio and Uncertainty, Financial Module Calculates Losses based on Building Values and Insurance Policy Terms

Financial Loss is Quantified for Specified Coverage(s) and Line(s) of Business Based on the Mean Damage Ratio and its Variation

Limitations of Conventional CAT Models

Huge Damage Uncertainty is Observed in Hurricane and Earthquake Claims Data



Damage functions are available and Developed for common Structures (houses, buildings, office, warehouse) that have gone through many real disasters. They must be adjusted for unique construction and occupancy

CAT software is Completely Inadequate for Corporate Facility or Building Analysis Without Input from Structural Engineers (such as structural system, anchorage level, etc)

Machine Learning in CAT

Data Collection

Data Custodianship, Curation, Preparation, Annotation, Validation, Ethics, Privacy, Ownership and Open Source

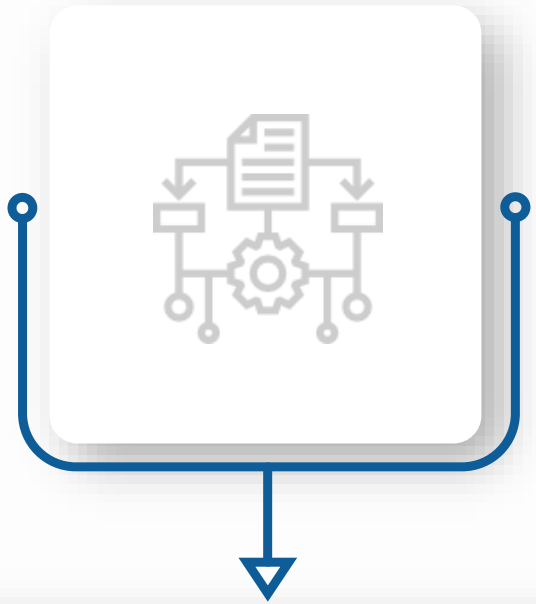
Model Development

Handling of Missing Values in Training data, Problem Formulation, Selection of Machine Learning Method, Performance metrics, and Trustworthiness

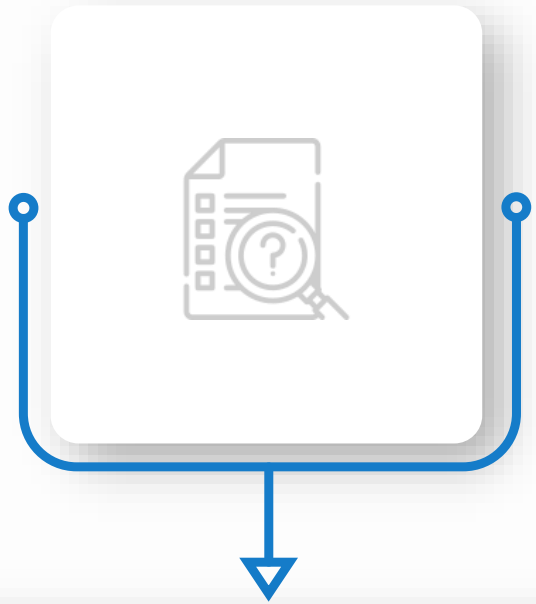
Model Deployment

Real-time Detection Systems for Alerts and Early Warning Systems, Forecast and Hazard Mapping Systems, and Situational Awareness and Decision Support Systems

Why ML/DL is Important?



ML/DL allows the user to Feed a Computer Algorithm an Immense Amount of Data and have the Computer Analyze and make Data-driven Recommendations and Decisions based on only the Input Data



ML/DL Helps sift through Vast Amounts of what may be Competing Data to Find Information that a Human Analyst would not have the Time to Look for

Predictions Using AI

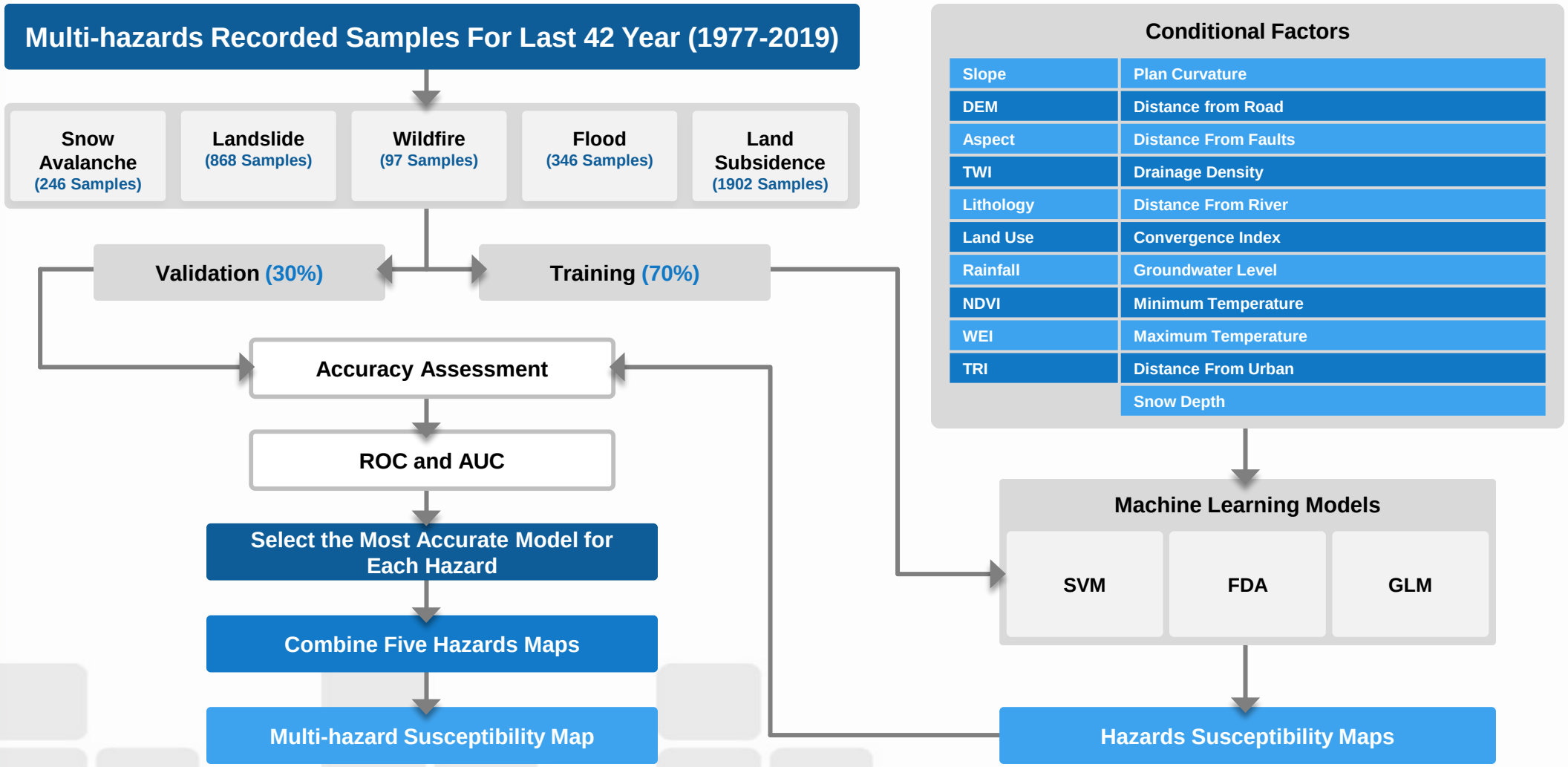
Earthquakes

AI Systems can be Fed with the Information from Seismic Imaging to Train them. The AI Analyzes the Data to Learn about the Patterns of Various Earthquakes and can then Predict where an Earthquake and Aftershock Might Hit

Hurricanes and Tornadoes

AI Systems Monitor Satellite Imagery to Predict the Course of a Hurricane or Tornado. The Technology can also Determine the Force of the Storm.

A ML Framework for Multi-Hazard Modelling in a Mountainous Area



Source: https://www.nature.com/articles/s41598-020-69233-2

A ML Framework for Hurricane Forecasting

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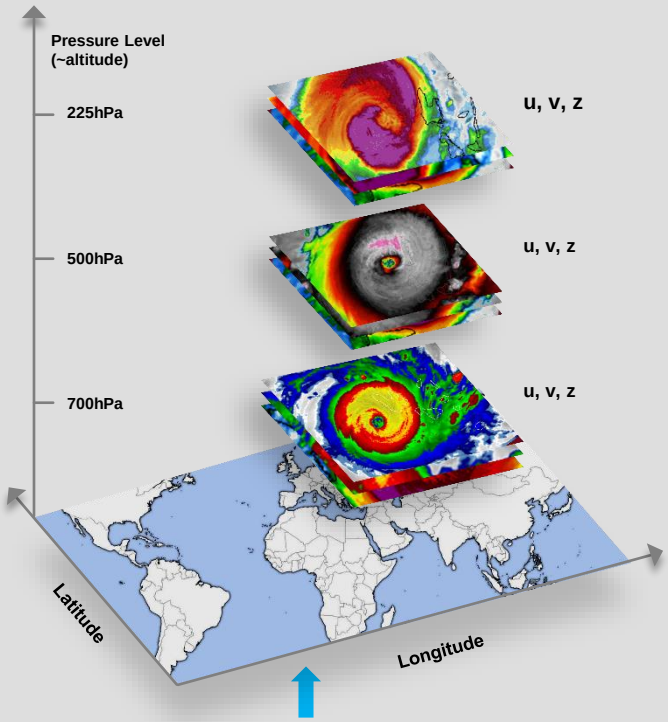
Statistical Features

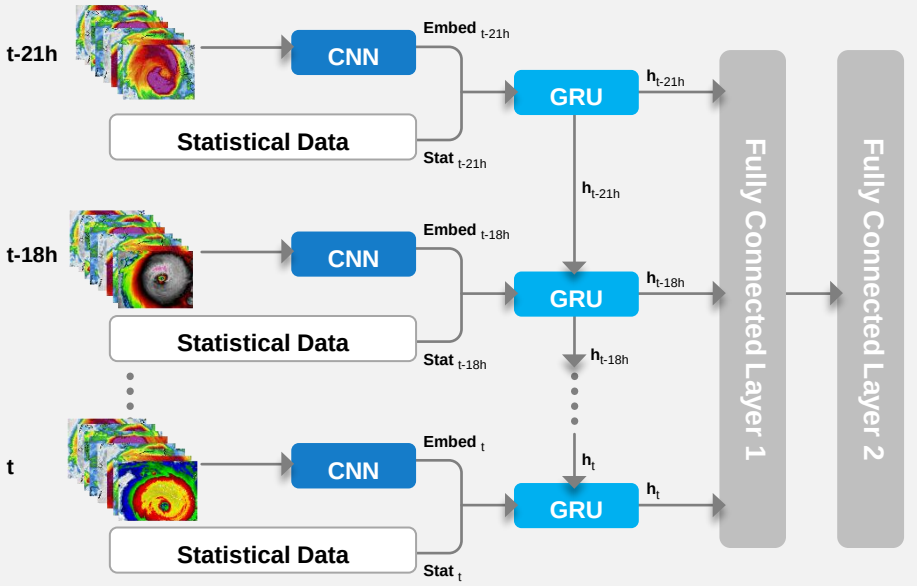
Latitude	Longitude	WMO Wind	WMO Pressure	Distance to Land	Storm Speed	Storm Direction	Storm Displacement Latitude	Storm Displacement Longitude	Basin	Storm Type



Reanalysis Maps

Prediction Pipeline With ML

Combined Feature Extraction Using both Reanalysis Maps and Statistical Features



Hurricane Intensity and Track Forecasting

Predictive models

Random Forest	XGBoost Model	Neural Network

Future Scope of Work in ML/DL

Modeling on Specific Location and Peril :
Like Earthquake and One Region say- India

Develop ANN
(Artificial Neural Network) Mode

Train CNN
(Convolutional Neural Network) algorithm

Using Algorithms Based on PCA
(Principal Component Analysis)/EOF (Empirical Orthogonal Functions)

Compare Developed Model Against the AIR/RMS

Future with Quantum Computing

Quantum computers may be naturally suited to solve certain linear algebra problems such as stress analysis and fluid flow, which are ubiquitous in science and engineering. Many examples of such applications are found in Earth science, specifically with respect to studying climate and weather and to improving our use of energy resources which can change the future.

Greater Capability to do Climate Modeling and Weather Forecasting

Greater capability to solve fluid dynamics-based Simulations Could Facilitate Model Improvements, Allowing Clearer Understanding of likely Future Conditions and Improving mitigation and Adaptation Planning

Grid Safety and Resilience

Improvements in both near-term weather forecasting and longer-term climate predictions achieved with quantum computing could benefit the resilience and reliability of energy systems.

Accelerate Discovery and Development of New Energy Production

(e.g., photovoltaic) and Storage (e.g., battery) Technologies, as well as Improved Strategies for Climate Change Mitigation (e.g., Carbon Capture)

Future with Quantum Computing

Why:

Quantum Computing is a better fit because it has the Potential to Speedily Process vast Amounts of Weather Data and Conduct Analysis that is too Complex for Classical Computers. The Speed of the Algorithms can allow the use of Real Time Data to Impact the Predicting

How:

By Deploying the Quantum Computing Model in the Power Grids, Natural Disasters can be Mitigated

Challenge:

Meeting Computational Needs as the Complexity and Resolution of Simulation and Forecasting Models Grow

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THANK YOU!