The Impact of Climate Change to Electric Transmission Assets
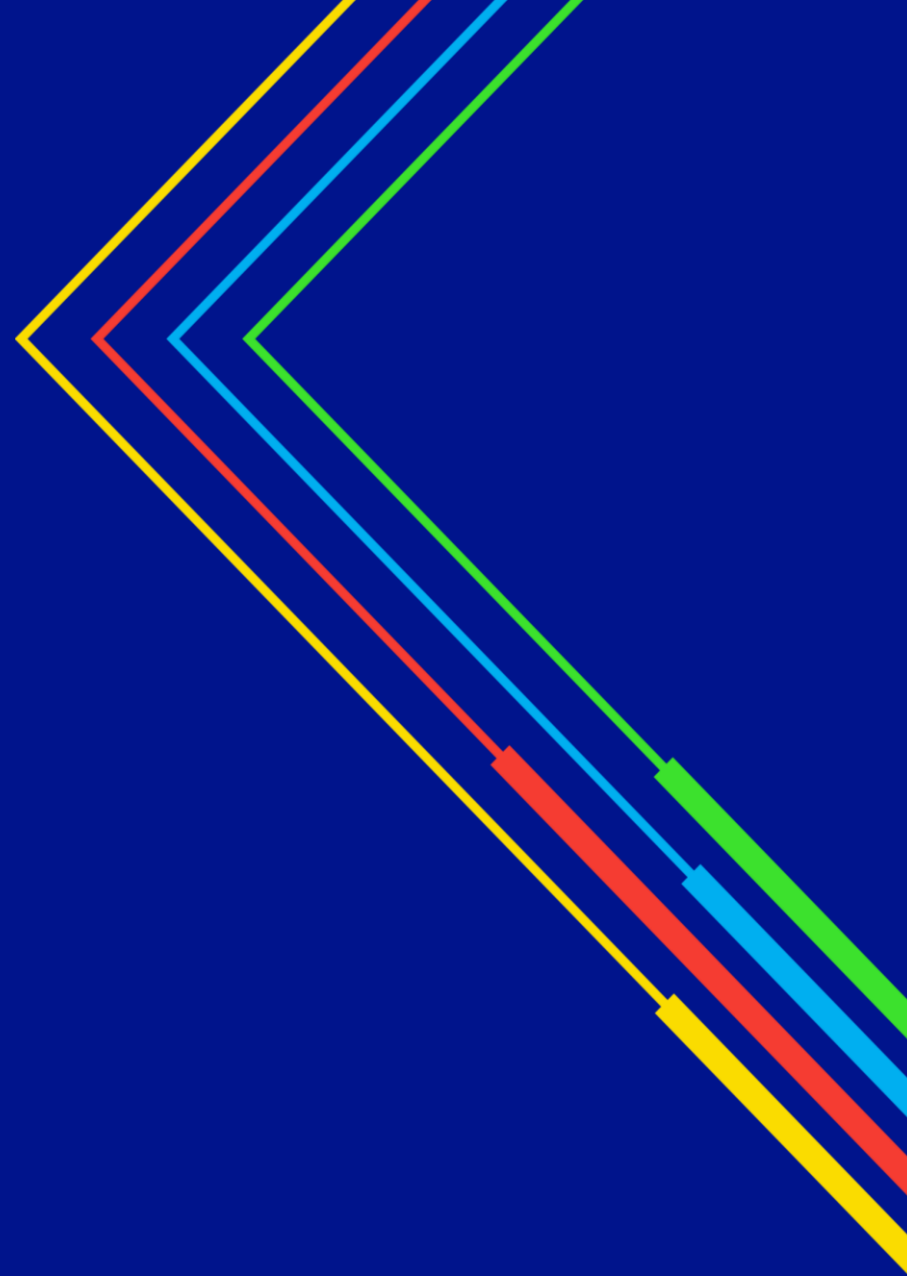
Srikant Vadali
Manager, Data Science

Pavel Ozhogin
Director, Data Science
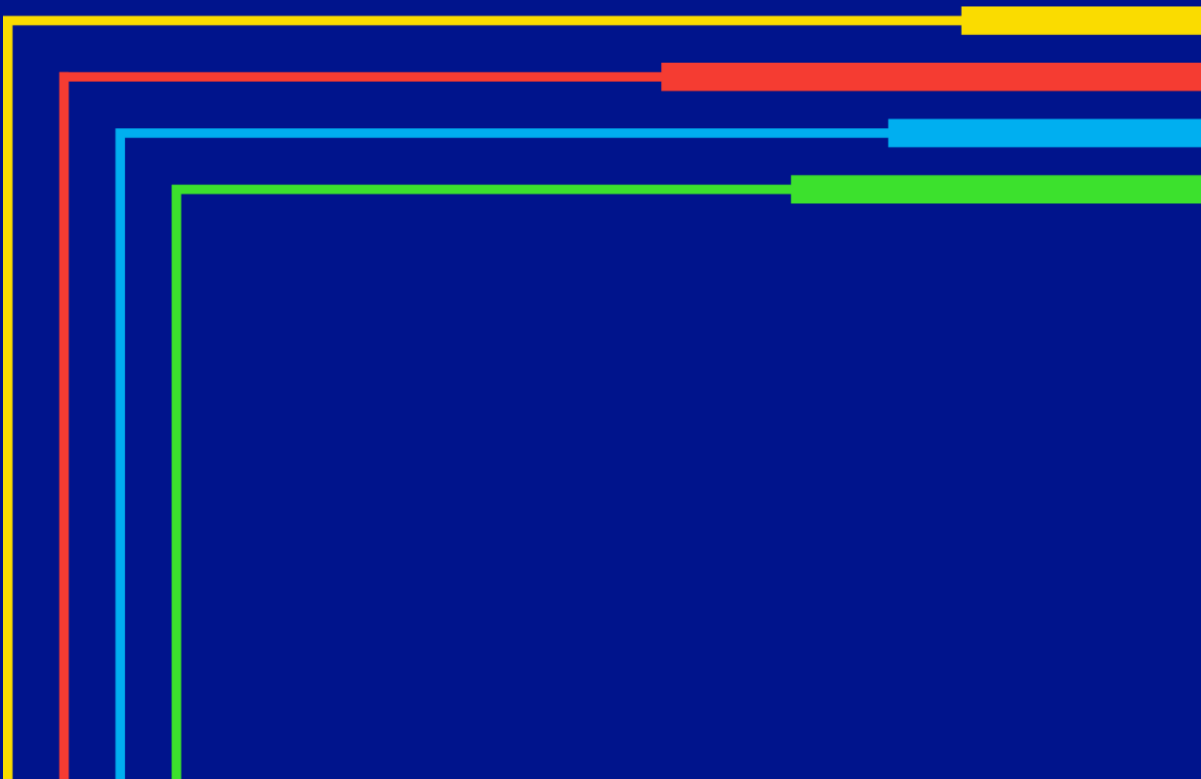
Oct 19, 2022

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Agenda

1. About National Grid

2. The Problem

3. The MIT Study

4. Technical Details

5. 1-in-100 Wind Speeds / Icing Analysis (Note: Data obfuscated)
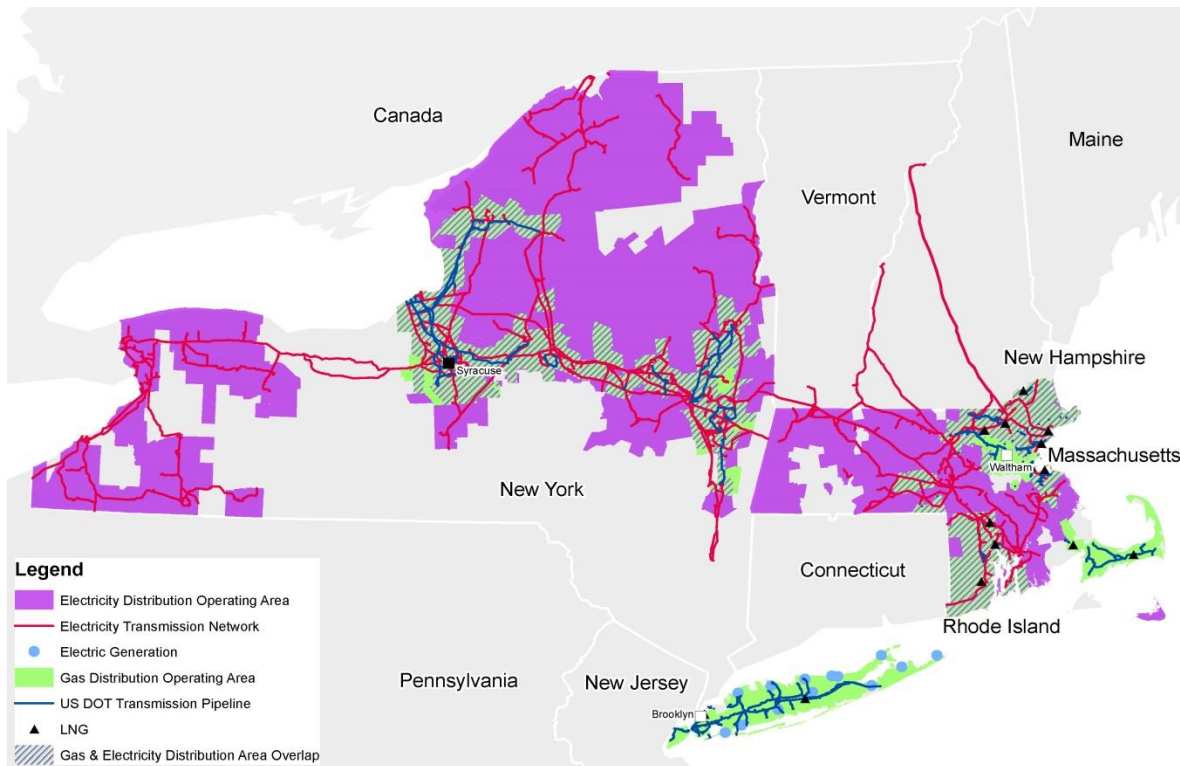
6. Analysis Implications

7. Key Lessons Learned

1

About National Grid

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About National Grid

National Grid is a US energy company, delivering electric, gas, and clean energy to communities in NY, MA, ~~and RI.~~

Legend
- ■ Electricity Distribution Operating Area
- ─ Electricity Transmission Network
- ● Electric Generation
- ■ Gas Distribution Operating Area
- ─ US DOT Transmission Pipeline
- ▲ LNG
- ▨ Gas & Electricity Distribution Area Overlap

Residential & Commercial customers by region:

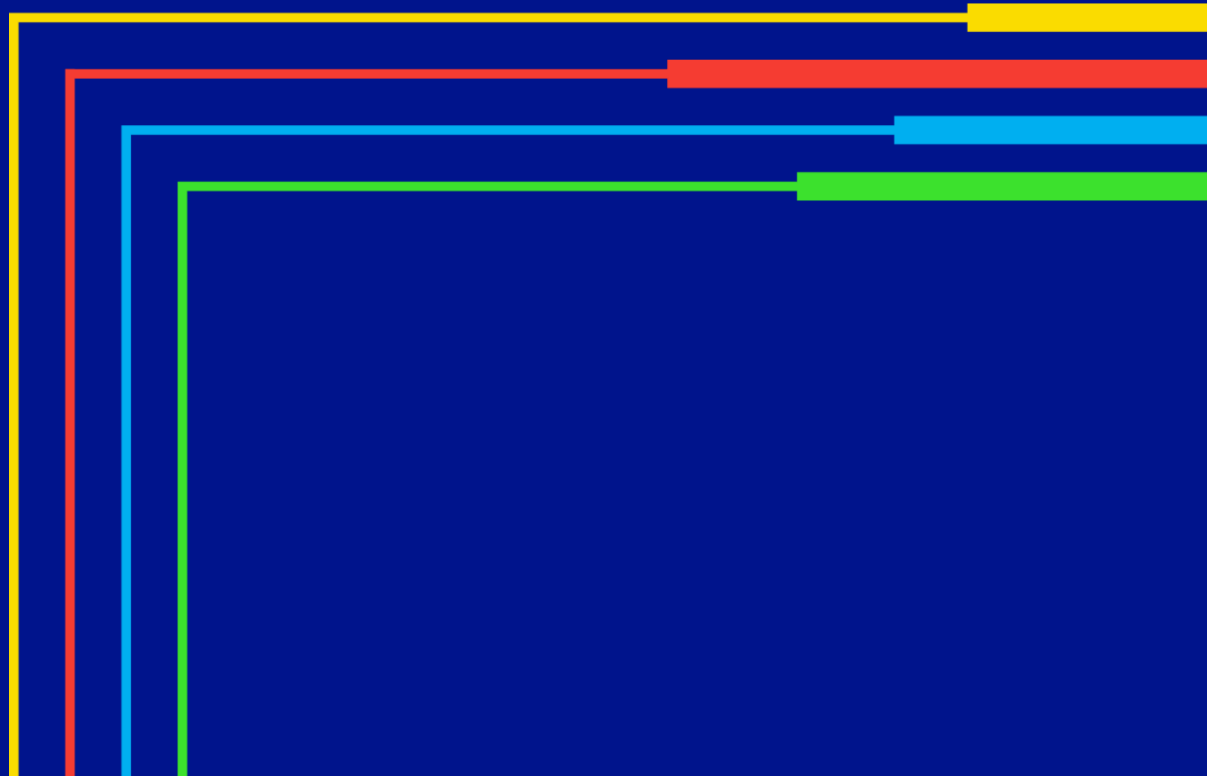MA 1.9 million (32%)

RI ~~0.5 million (8%)~~

NY 3.6 million (60%)
UNY 1.7 million
LI 0.6 million
NYC 1.3 million
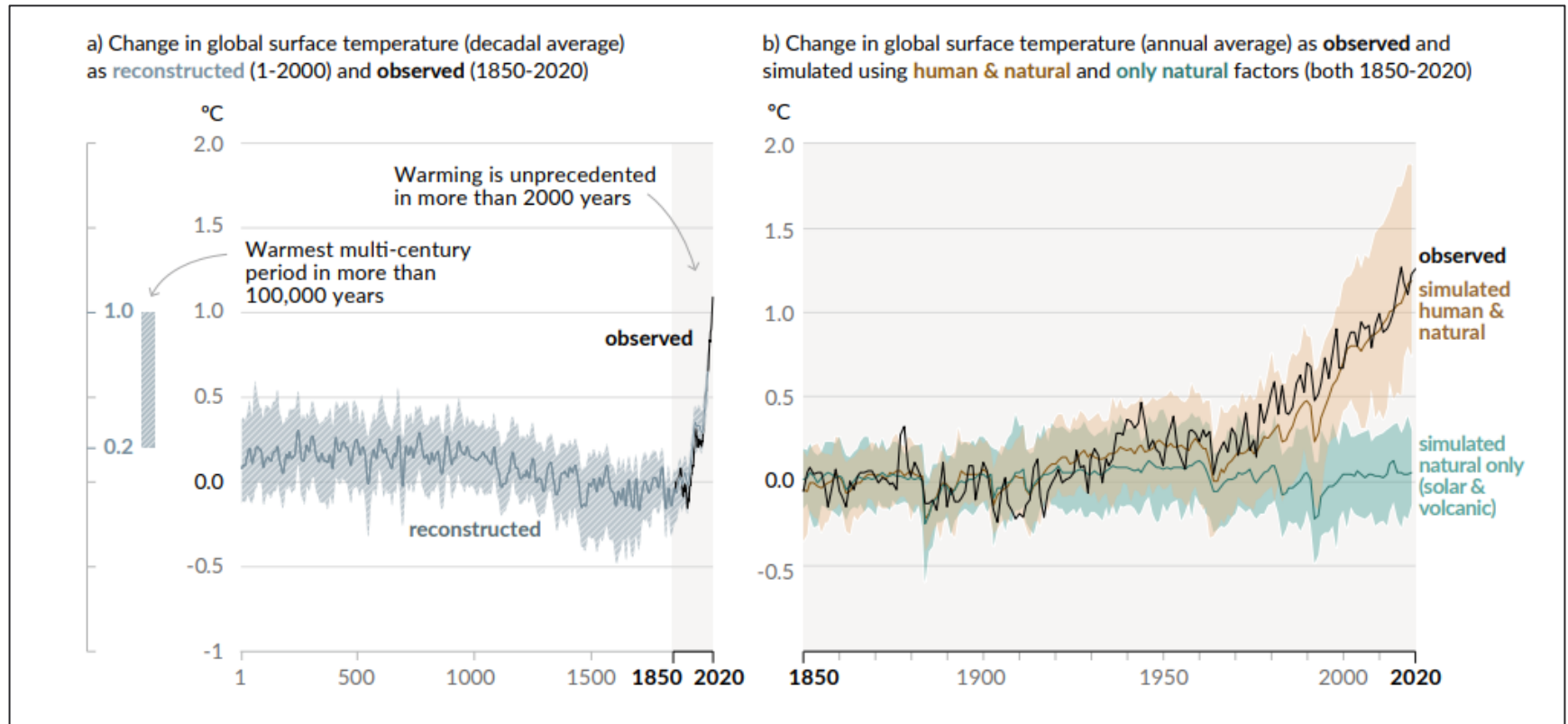
2

The Problem

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Climate Change

(Source: Intergovernmental Panel on Climate Change, Sixth Assessment Report finalized on Aug 6, 2021.
https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM.pdf)

a) Change in global surface temperature (decadal average) as reconstructed (1-2000) and observed (1850-2020)

b) Change in global surface temperature (annual average) as observed and simulated using human & natural and only natural factors (both 1850-2020)

Summary of Our Analysis

- Primary:

  - For each asset characterize 1-in-100 years extreme events.

  - Roll-up asset level analysis to identify circuits to focus on based on asset-level extreme events.

  - 1-in-100 year probabilities:

    - Percent of circuits which will see wind speeds greater than […] mph.

    - Percent of circuits which will see radial icing greater than […] inches.

- Secondary:

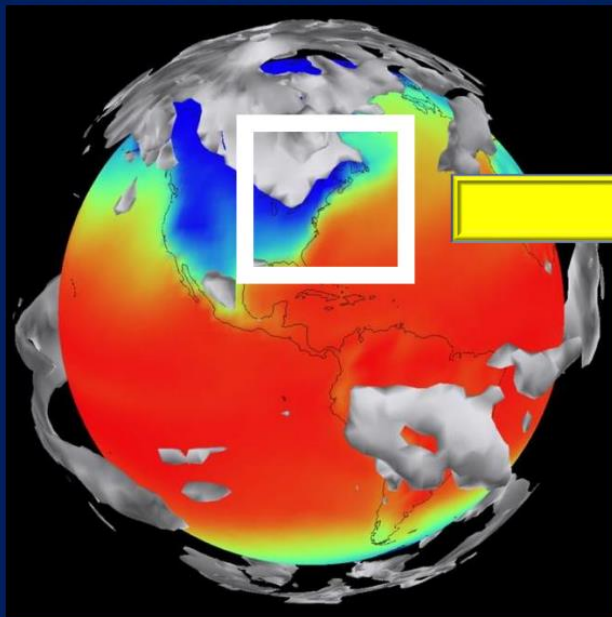 - For each asset characterize chances of observing extreme events over its lifetime.

By Circuit: 1-in-100 Wind Speed Extreme Events
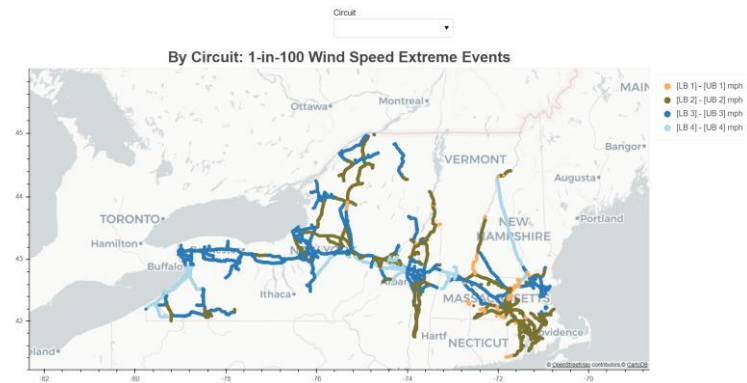
3

The MIT Study

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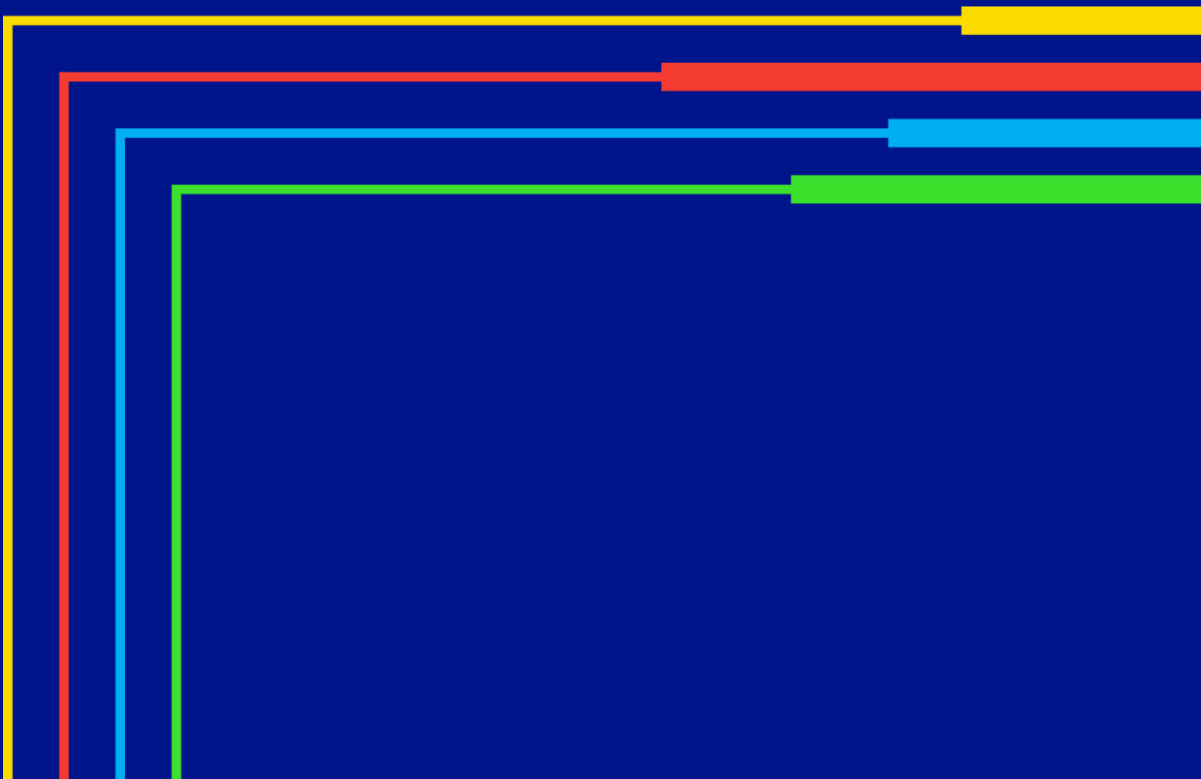
Methodology

High Resolution Modeling
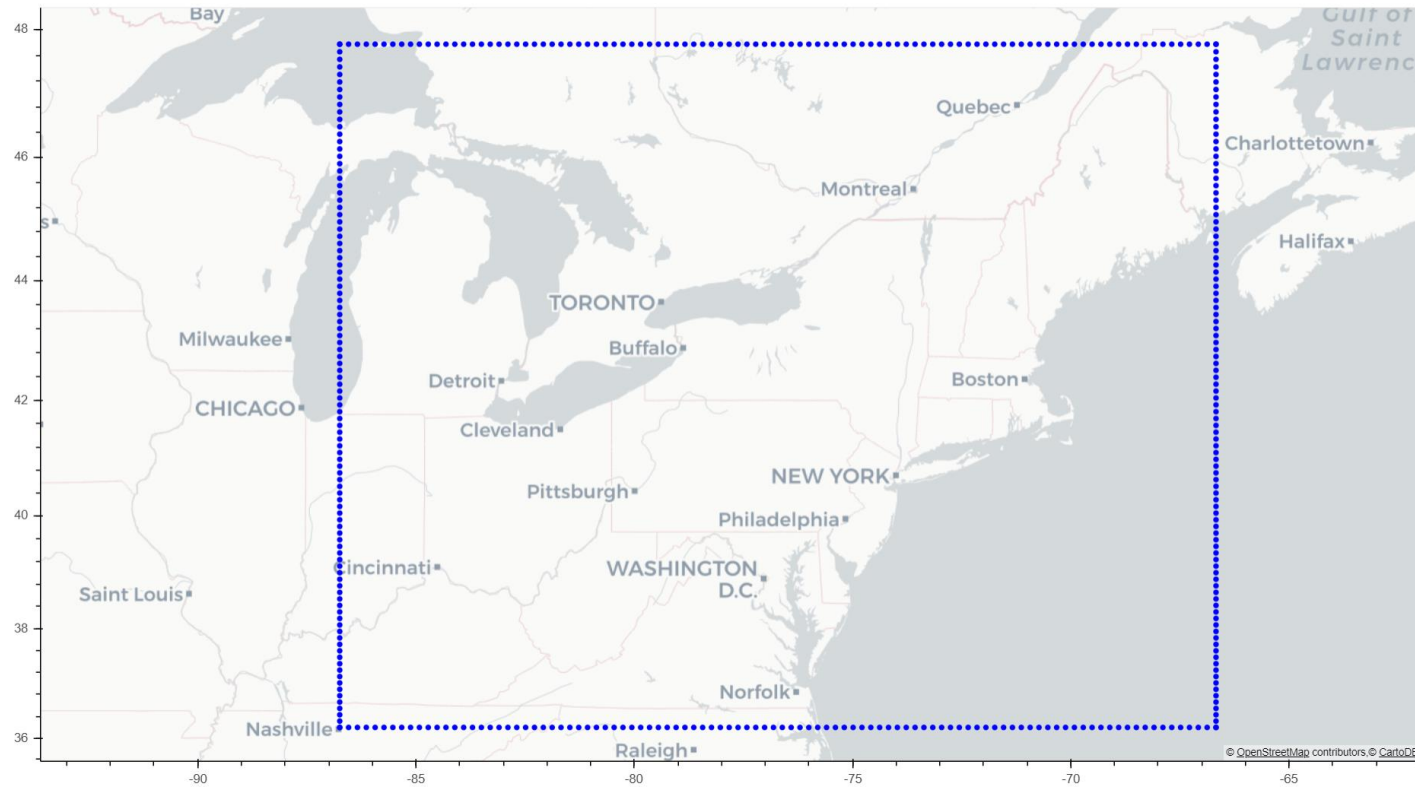
Global Climate Model → Regional Climate Model

3 km
9 km
27 km

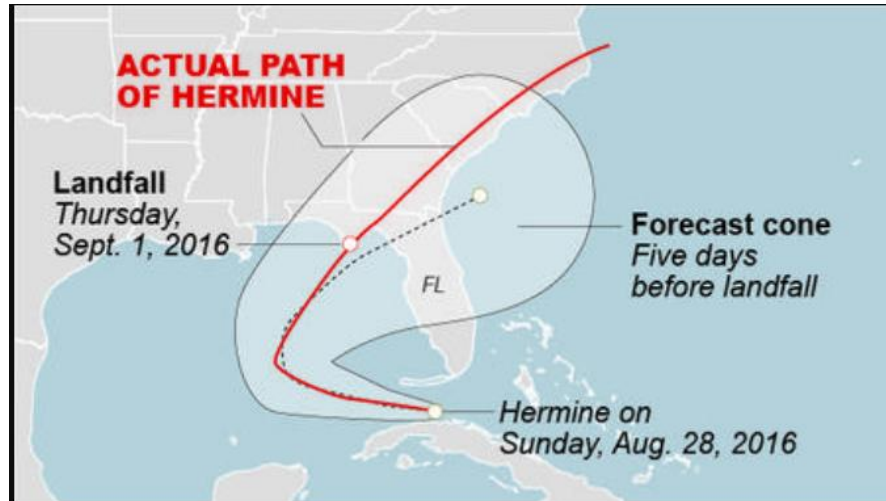- MIT used RCP 8.5 scenario to make projections.

MIT Study: Weather Simulations for 2025 – 2041

- Granularity of Data

  - 3 km grid

  - Hourly

- 65 TB

Caveats to Analysis
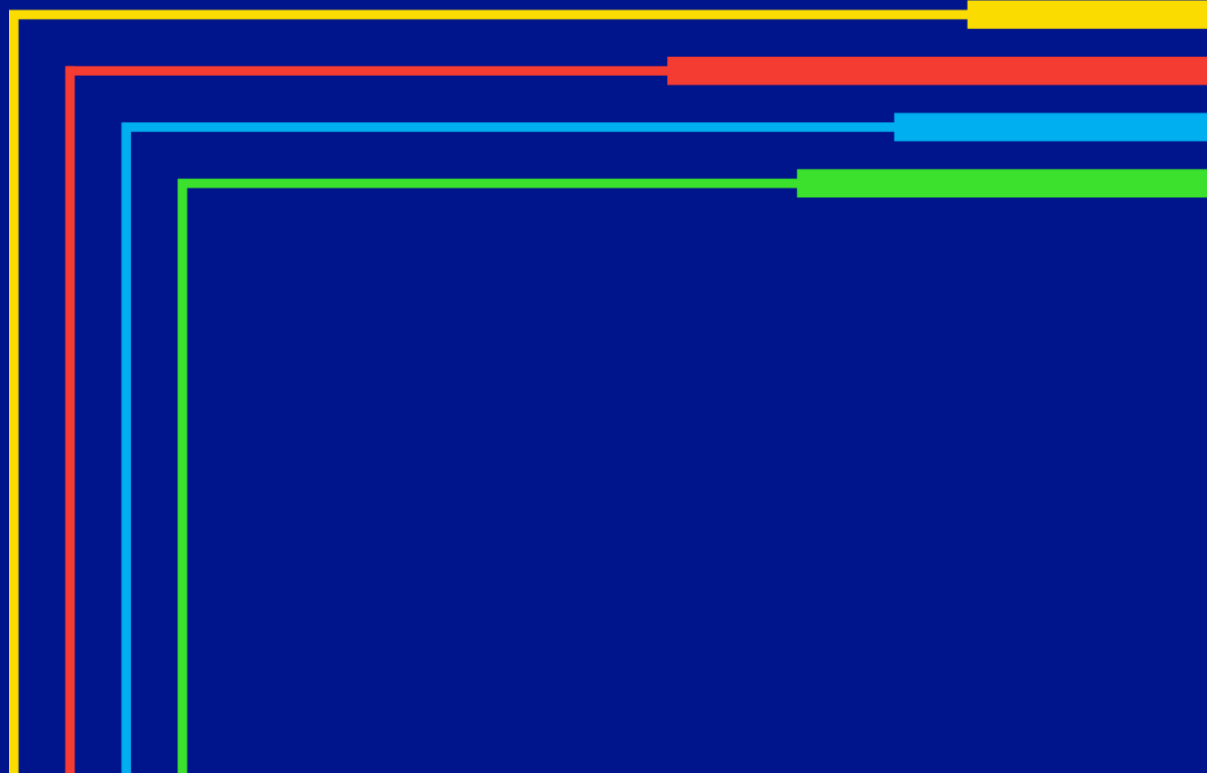
National Hurricane Center's Forecast

- Forecasts are always uncertain.

  - The further out you go the higher the actual error is likely to be.

  - Extreme event analysis mitigates the issue.

- Sustained Wind Speeds vs Wind Gust

  - MIT data does <u>not</u> have wind gusts.

# 4

Technical Details

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Data

- Variables Available: Wind Speed, Temperature, Radial Icing, Snowfall

- Worked with Engineering to convert Wind Speed to Wind Gust

- MIT datasets in netCDF format.

  - Read using Python package "xarray"

- Storage: Azure Corporate Cloud, 63 TB

Data Processing: Technical Details

- Processed data saved in Parquet format instead of CSV files.

  - Columnar, compressed data storage.

  - Pandas has built-in support for Paruqet (pd.read_parquet())

  - Requires PyArrow or FastParquet to be installed.

  - Parquet is compatible with Spark as well.

- Compute: Azure VM (256 GB VM, 32 processor)

  - Used Python's multiprocessing module to parallelize computations.

# Data Processing: Technical Details cont'd
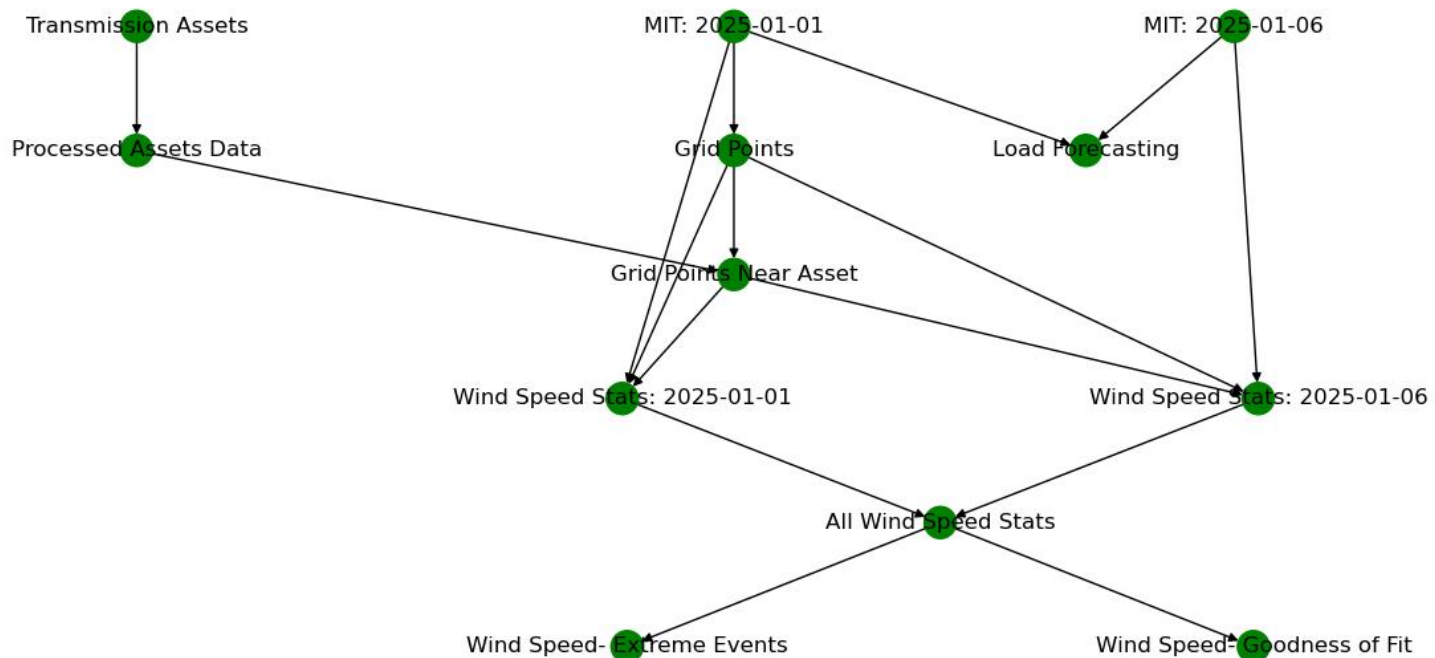
Data Processing: Technical Details cont'd
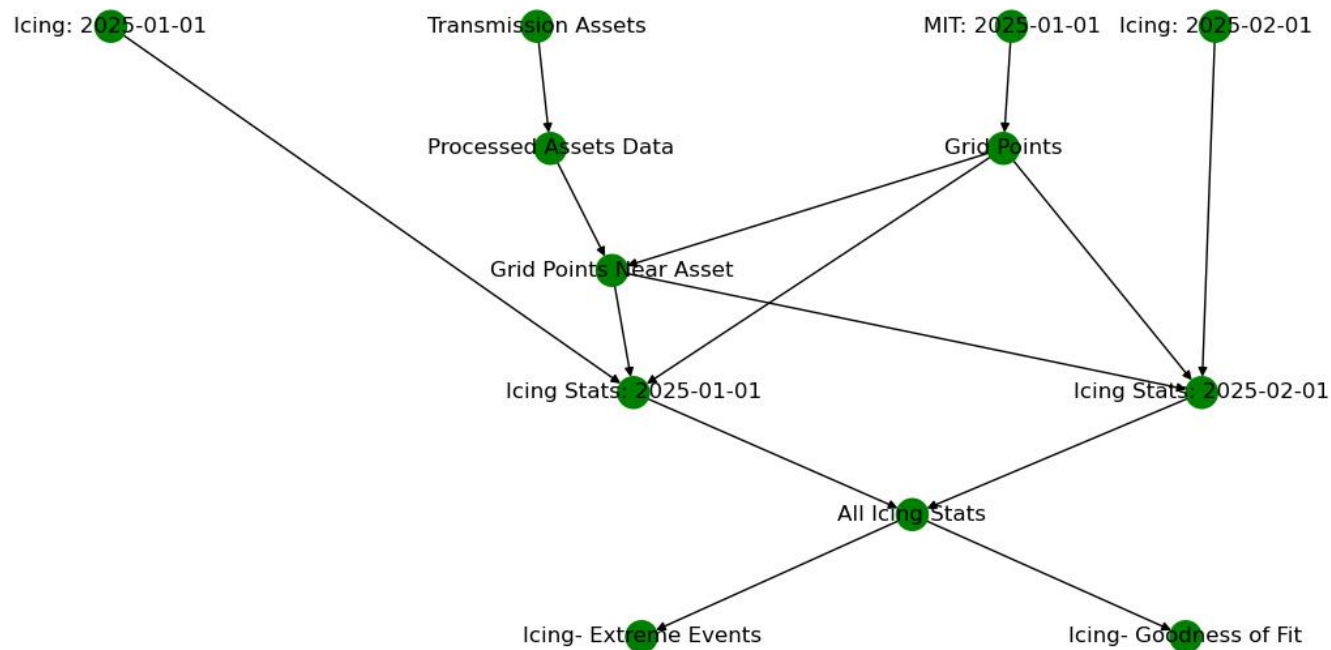
Extreme Event Analysis

- What is a 1-in-100 wind speed at an asset location?

  - $\text{Prob}(\text{Annual Maximum Wind Speed} \geq x) = 0.99$

- Challenge: Only 17 years of data!

  - Percentiles not good enough.

- Our Approach

  - Use hourly data to get <u>daily maximum</u> wind speeds at asset location.

  - Fit a statistical distribution to the <u>daily maximum</u> wind speeds (Gumbel distribution)

  - Use the distribution of <u>daily maximums</u> to calculate 1-in-100 <u>annual maximum</u> wind speeds.
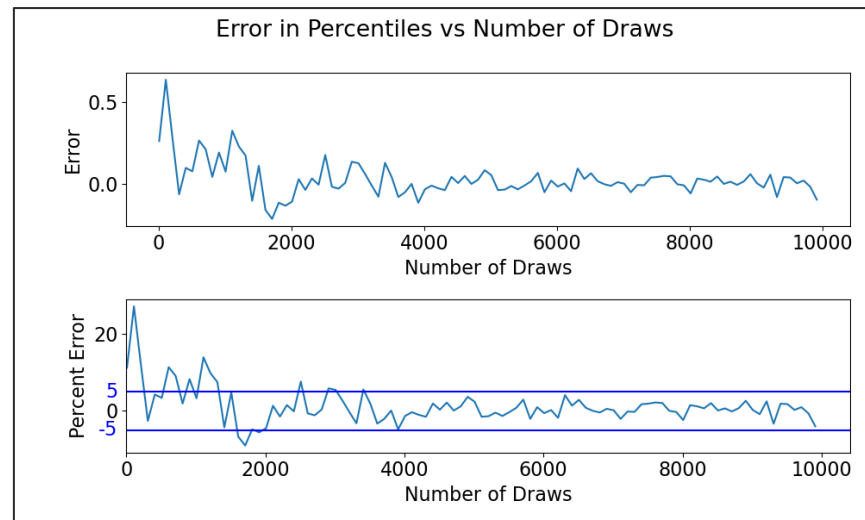
The Math

- What is a 1-in-100 wind speed at an asset location?

  - $\text{Prob}(\text{Annual Maximum Wind Speed} \geq x) = 0.99$

- Distributions: Gumbel, LogNormal

- Estimate using daily maximums and roll-up to annual.

  - Daily Maximum: $\qquad\qquad\qquad X_i$

  - Annual Maximum: $\qquad\qquad Y = \max(X_1, X_2, \cdots, X_n) \qquad (n = 365)$

- If $X_i \sim$ Gumbel(μ, β) then $Y \sim$ Gumbel($\mu + log(n)\beta, \beta$).

- If $X_i \sim$ LogNormal(μ, σ^2) then ????

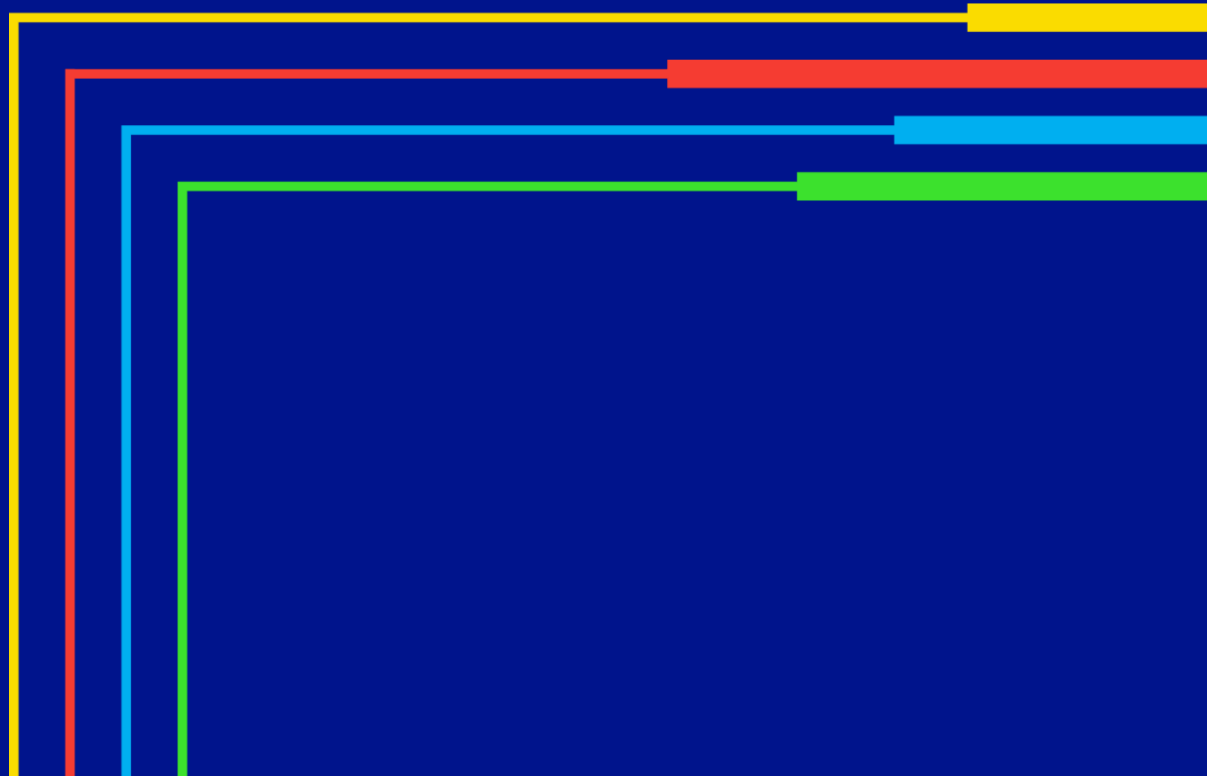# The Math Cont'd

- $X \sim \text{LogNormal}(\mu, \sigma^2)$ and $Y = \max(X_1, X_2, \ldots X_n)$. Solve $F_Y(y) = 0.99$

- $F_Y(y) = \left(F_X(y)\right)^n$.

- Thus, solve $\left(F_X(y)\right)^n = 0.99$

- $y = F_X^{-1}\left(\exp\left(\frac{\log(0.99)}{n}\right)\right)$

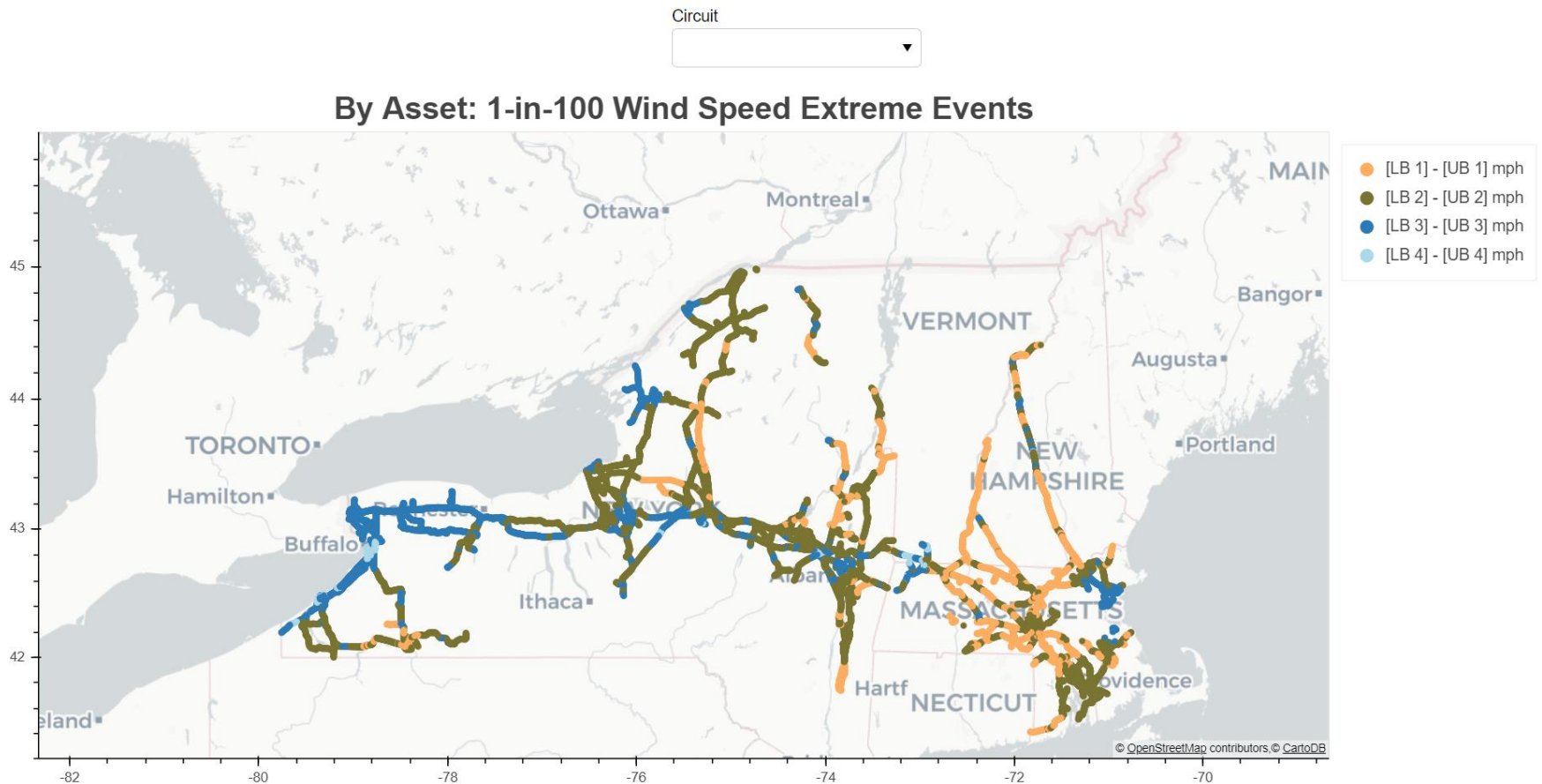- SciPy Stats has F_X^{-1} for LogNormal and for Gumbel.

5

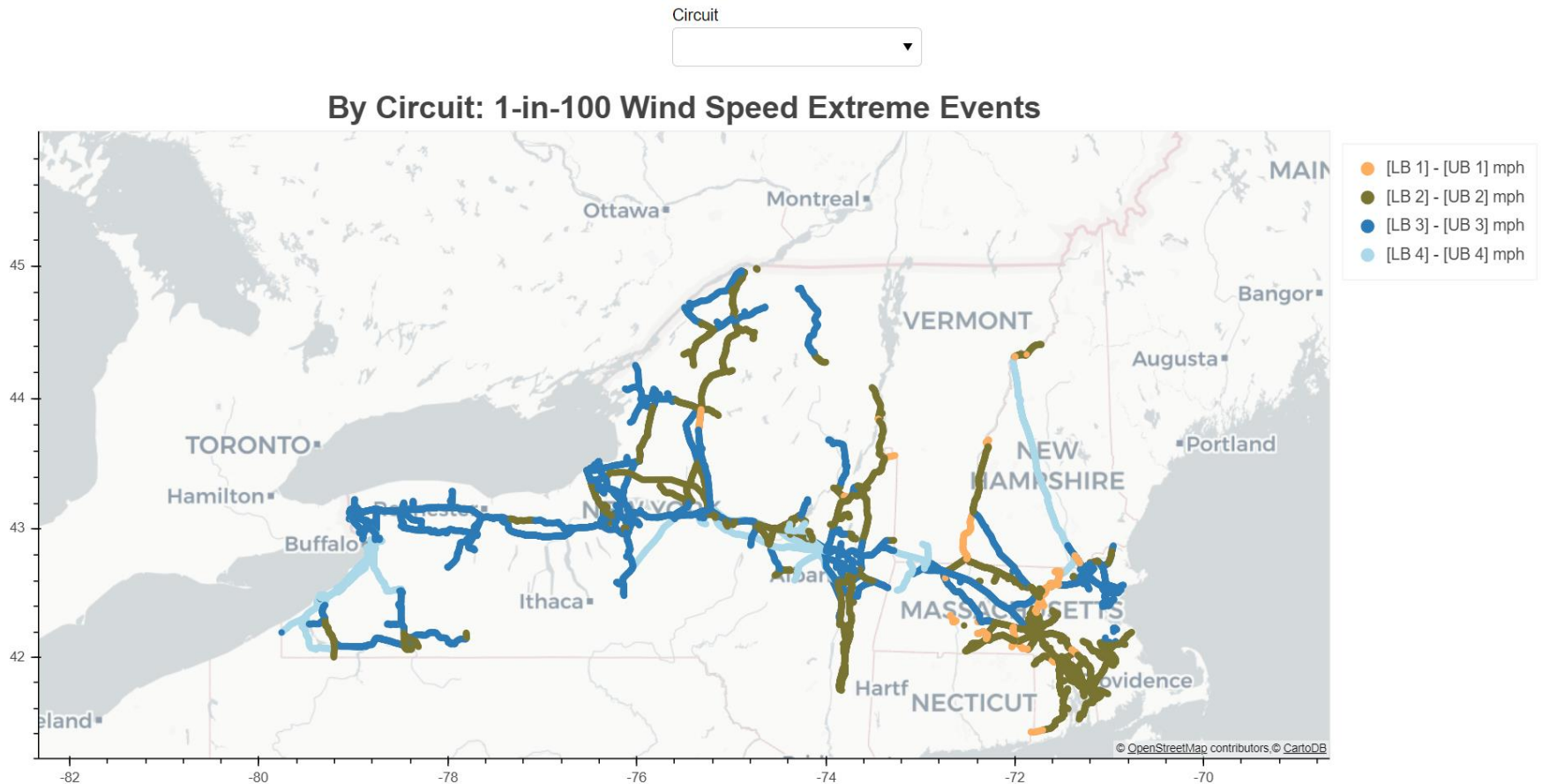## 1-in-100 Wind Speeds and Radial Icing
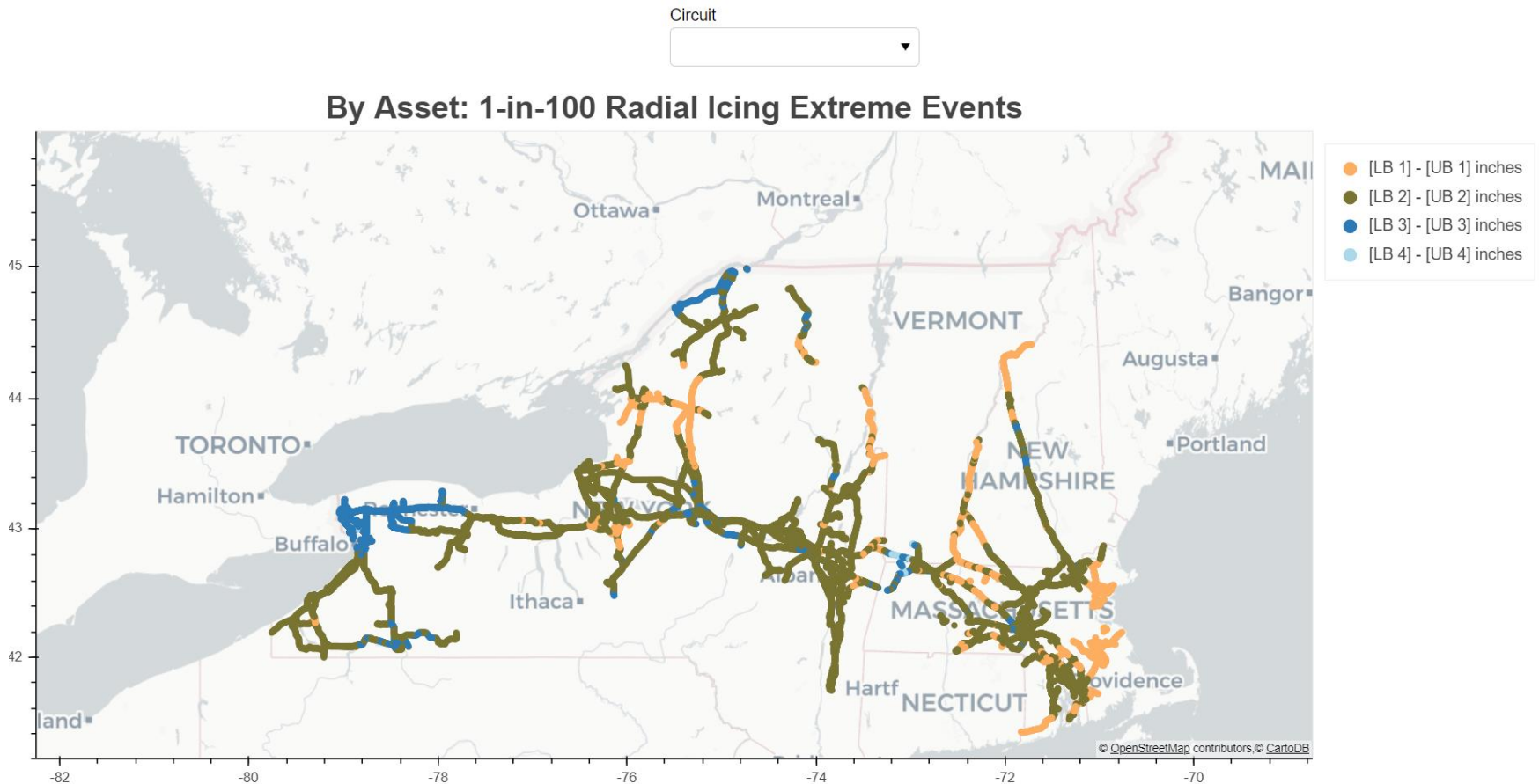
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Geographical Distribution of 1-in-100 Wind Speeds by <u>Asset</u>

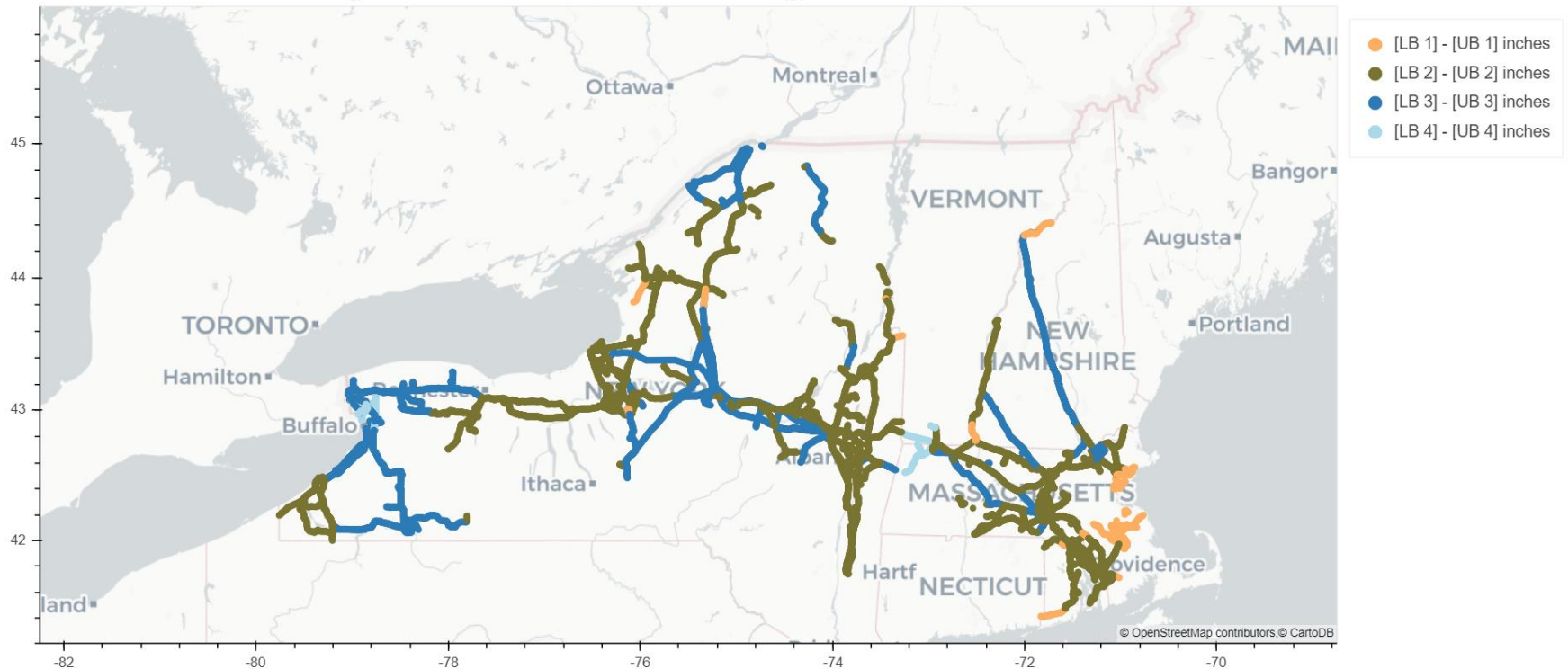# Geographical Distribution of 1-in-100 Wind Speeds by <u>Circuit</u>

Geographical Distribution of 1-in-100 Radial Icing by <u>Asset</u>

By Asset: 1-in-100 Radial Icing Extreme Events

Circuit

Legend:
- [LB 1] - [UB 1] inches
- [LB 2] - [UB 2] inches
- [LB 3] - [UB 3] inches
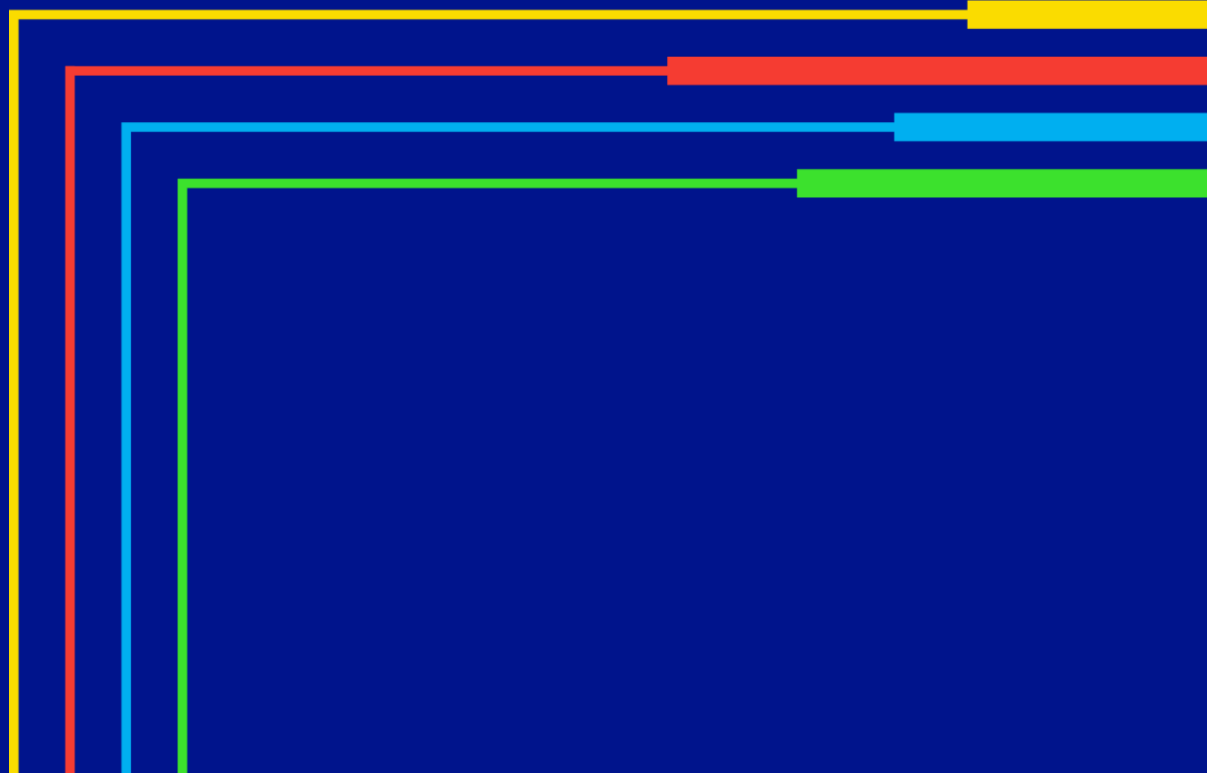- [LB 4] - [UB 4] inches

Geographical Distribution of 1-in-100 Radial Icing by Circuit

6

## Analysis Implications

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Analysis Implications

- Prioritizing asset development projects.

- Influence design standards

    - Revise existing standards?

    - Region specific standards?

- Impact on design/peak day scenarios for Gas and Electric load forecasting.

- Assess potential vulnerabilities and help business develop resilience plans.

    - NY Public Service Law § 66(29)

        - Climate Change Vulnerability Study (Due: 9/2023)

        - Climate Change Resilience Plan (Due: 11/2023)

7

Key Lessons Learned

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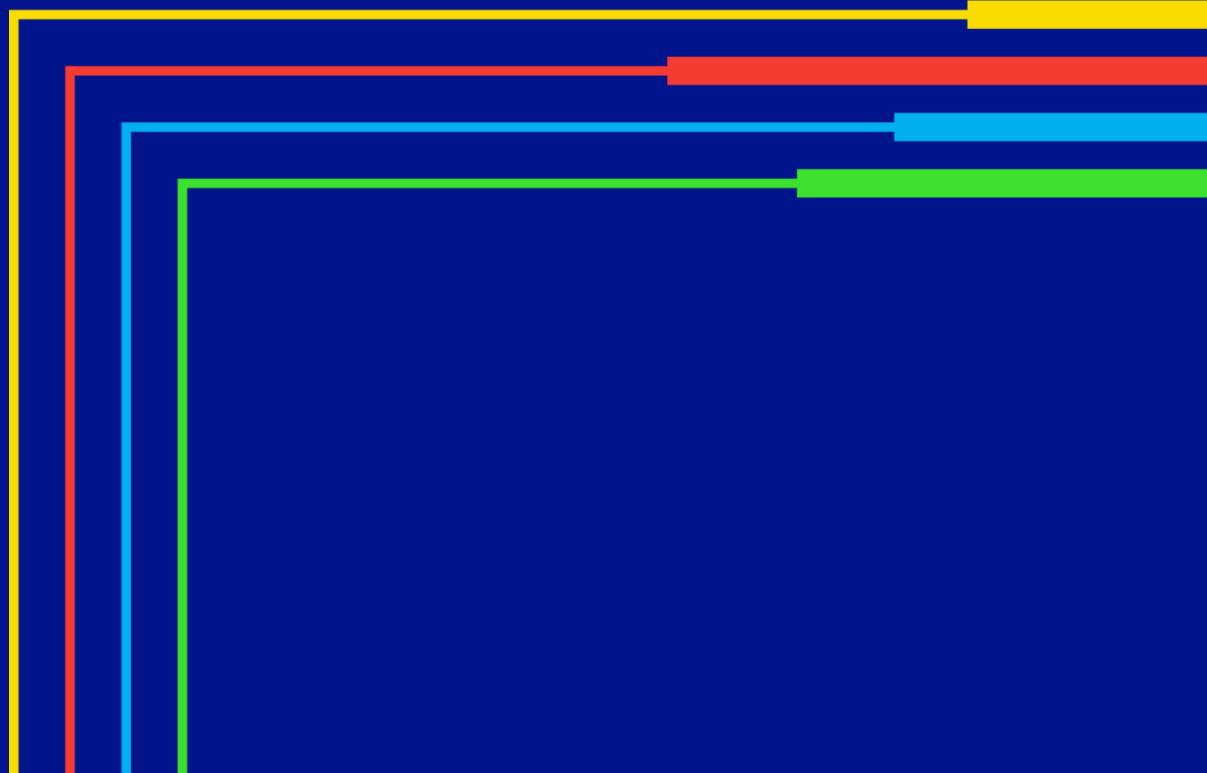
Lessons Learned

1. Engage with Engineering, Standards teams early on.

   • Decide what variables and at what granularity are an absolute must have.

   • Make up some numbers and ask them to put together a rough outline of the analysis steps they will perform.

2. Data volume

   • Mockup some data and ensure that cloud resources can deal efficiently with data volume.

   • Collaborate closely with IT to ensure that cloud resources are deployed as per spec and on time.

3. Involve Stakeholders

   • Regular project updates

   • Roadshows

   • Collaborate at project end to tweak analysis output as needed.

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