# AC297r Fall 2019
# Mid-term Summary
## Optimal Real-time Scheduling for Black Hole Imaging

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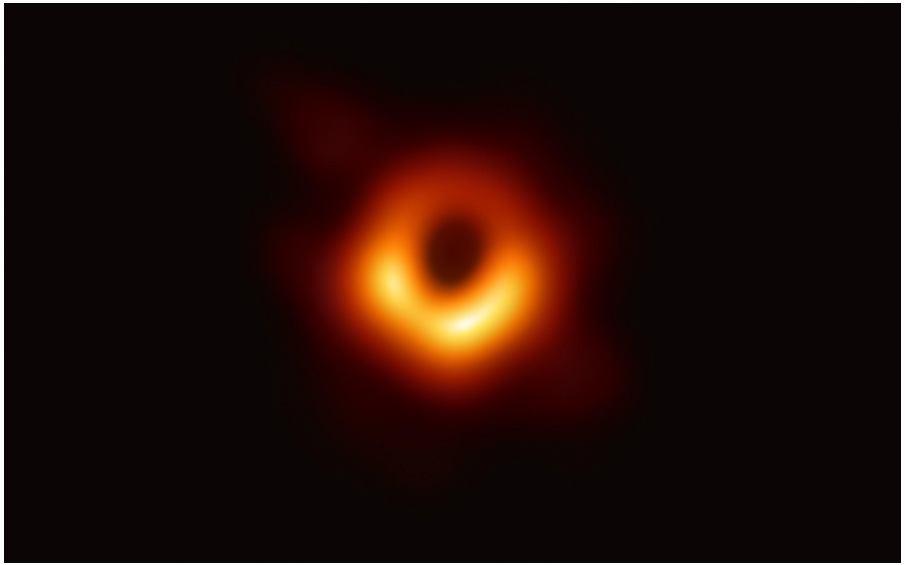
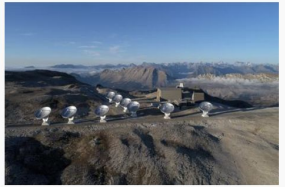
# Background

The Event Horizon Telescope is an international collaboration capturing images of black holes using a virtual Earth-sized telescope.

Event Horizon Telescope



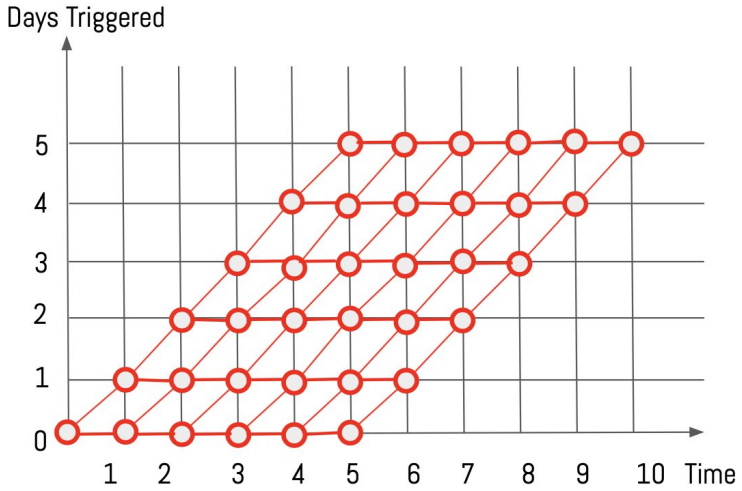
# Introduction



# Problem Statement

We are going to build a model that can:

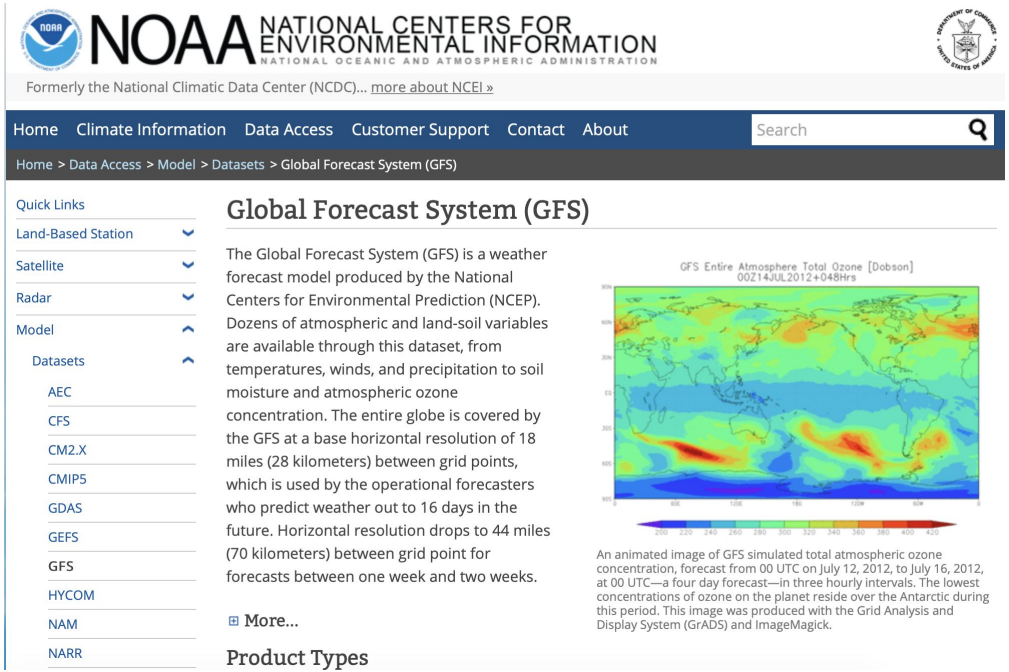
1. In total, choose 5 days from a 10-day window
2. On each day, determine the optimal strategy for future remaining days
3. If possible, provide a confidence level on its suggestion
4. Also provide the second optimal strategy



# Motivations

1. Improve the decision making process
2. Increase the chance of capturing the black hole

# Data Source




GFS provides:

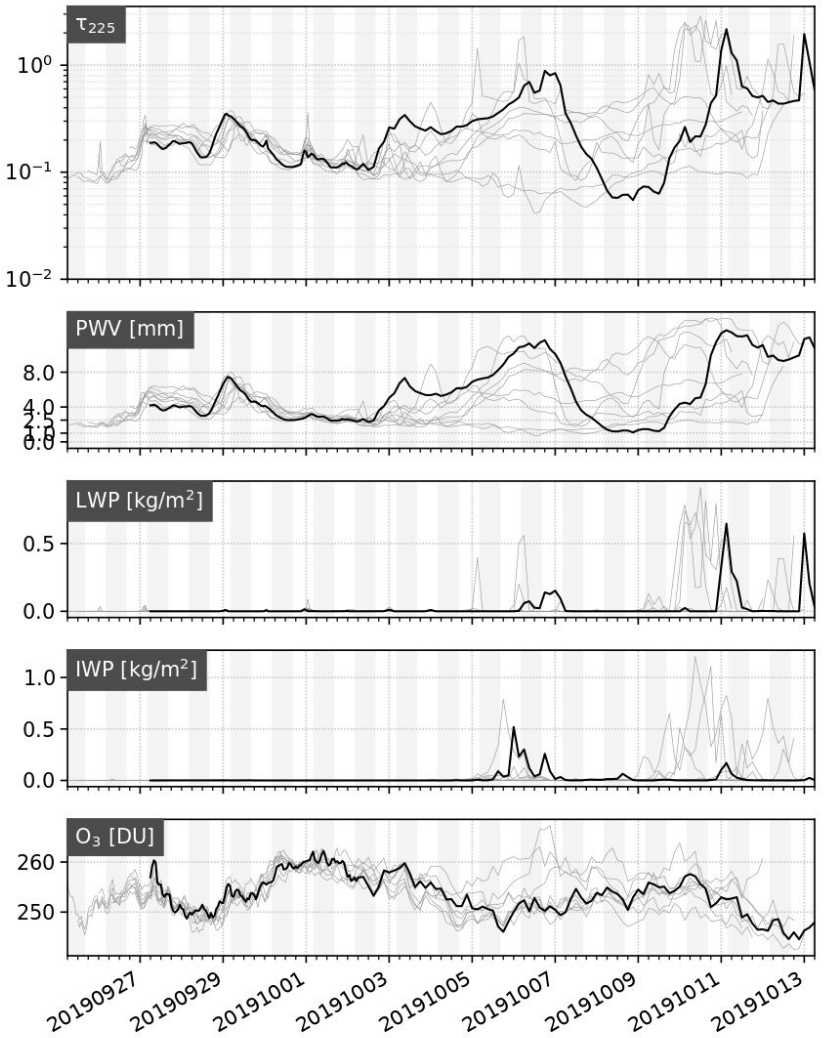
- Atmosphere's condition
- Layer-by-layer
- All over the globe

We pull data every 6 hours specifying:

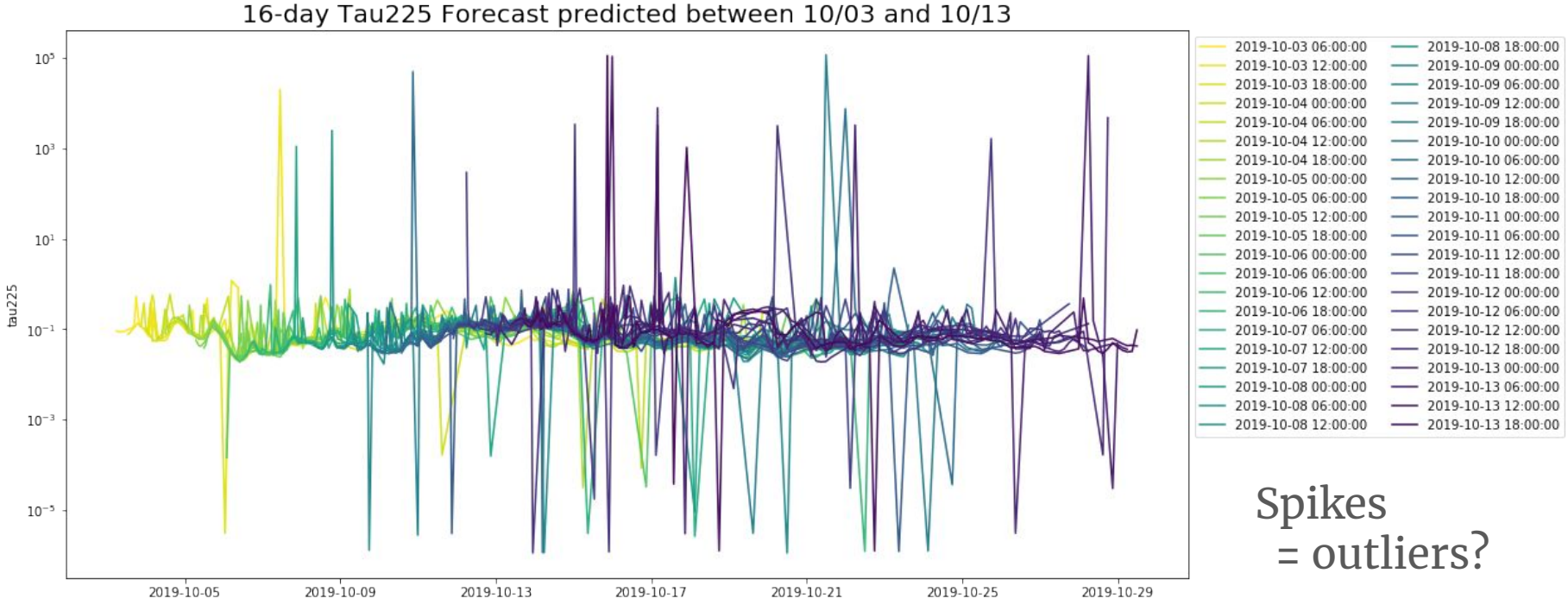
- Longitude
- Latitude
- Altitude

# EDA

- Every 6 hours, we get 16-day atmosphere forecast from GFS.
- First 5-day forecast is pretty accurate.
- Variables: **Tau_225**(absorption directly above head, the lower the better), **PWV, LWP, IWP** (amount of water in different forms), **O3**



# EDA




Spikes
= outliers?

# Model Design

1. Reward Function
2. Uncertainty Measurements
3. Optimization
4. Model Evaluation

f(i)
reward at a single telescope i.

F(f(i))
Total rewards for all telescopes

Measure performance based on real weather afterwards.

Compare with:

1. Best path afterwards
2. Human-made decision

# Baseline Model

1. Reward Function

$$f_i(\tau 225) = -\tau 225$$

$$F = \sum_{i}^{N_{telescope}} w_i f_i$$

where $w_i$ is the weight for each telescope (total GBytes data sent from the telescope used by EHT ).

2. Uncertainty Measurement：

None

# Example - optimization

| Day1 | Day2 | Day3 | Day4 | Day5 | Day6 | Day7 | Day8 | Day9 | Day10 |
|---|---|---|---|---|---|---|---|---|---|
| 19.03 | 13.93 | 16.24 | 16.38 | 18.80 | 12.99 | 17.02 | 19.03 | 18.81 | 14.06 |

# Example

| Day1 | Day2 | Day3 | Day4 | Day5 | Day6 | Day7 | Day8 | Day9 | Day10 |
|---|---|---|---|---|---|---|---|---|---|
| 19.03 | 13.93 | 16.24 | 16.38 | 18.80 | 12.99 | 17.02 | 19.03 | 18.81 | 14.06 |

# Example

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| Day2 | Day3 | Day4 | Day5 | Day6 | Day7 | Day8 | Day9 | Day10 |
|---|---|---|---|---|---|---|---|---|
| 18.82 | 11.04 | 19.07 | 13.06 | 14.46 | 15.90 | 18.37 | 16.98 | 18.30 |

| Day1 | Day2 | Day3 | Day4 | Day5 | Day6 | Day7 | Day8 | Day9 | Day10 |
|---|---|---|---|---|---|---|---|---|---|
| 19.03 | 13.93 | 16.24 | 16.38 | 18.80 | 12.99 | 17.02 | 19.03 | 18.81 | 14.06 |

| Day2 | Day3 | Day4 | Day5 | Day6 | Day7 | Day8 | Day9 | Day10 |
|---|---|---|---|---|---|---|---|---|
| 18.82 | 11.04 | 19.07 | 13.06 | 14.46 | 15.90 | 18.37 | 16.98 | 18.30 |

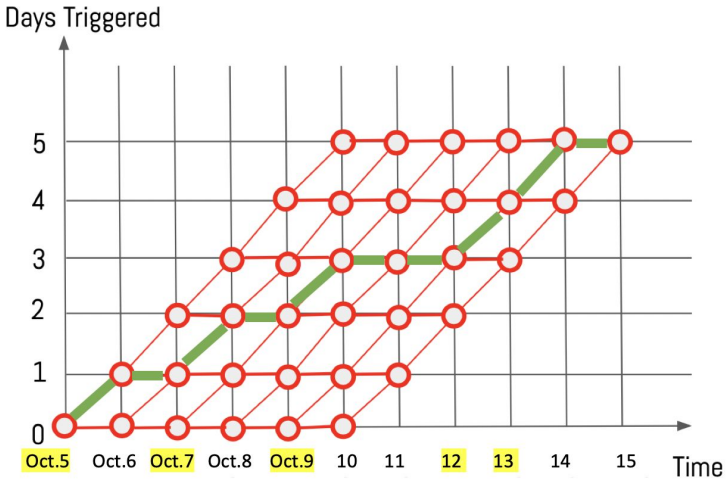
| Day3 | Day4 | Day5 | Day6 | Day7 | Day8 | Day9 | Day10 |
|---|---|---|---|---|---|---|---|
| 10.21 | 17.67 | 14.48 | 11.21 | 19.31 | 16.50 | 11.41 | 12.22 |

| Day4 | Day5 | Day6 | Day7 | Day8 | Day9 | Day10 |
|---|---|---|---|---|---|---|
| 18.97 | 17.30 | 17.83 | 17.42 | 14.64 | 16.43 | 12.25 |

# Baseline Model – evaluation

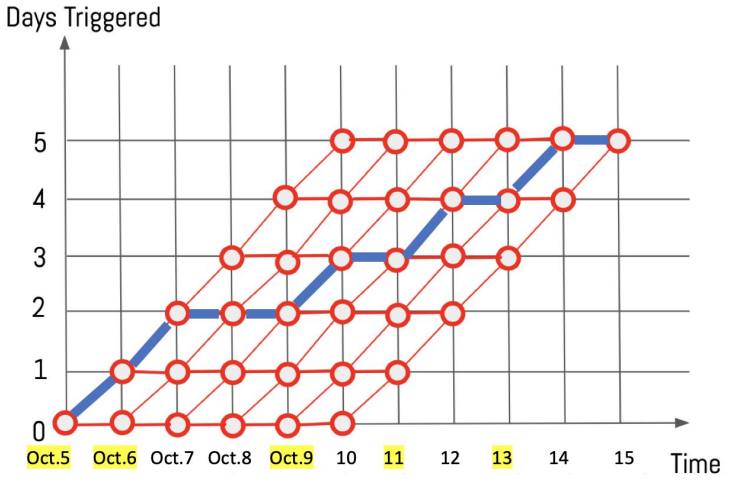
**Choose 5 days From Oct.5 - Oct.14, 2019**

Path suggested by Baseline




Total Reward: - 4,260,444

Ground-truth Best Path Afterwards




Total Reward: - 54,244

# Next Steps

## Adding Uncertainty Measurement

Possible Directions:

1. Discount Factors
2. Probabilistic Distribution

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# Final Deliverables

- A python package implementing an optimal real-time scheduling algorithm


- Proper documentation explaining the algorithm.
- Nice to have: visualization of the path

# Timeline

| Date | Tentative Schedule |
| --- | --- |
| 10/18/2019 | - Midterm Presentation<br>- Short Report to EHT<br>- EDA<br>- Baseline Model with evaluation |
| 10/25/2019 | - Second meeting with EHT<br>- Get to understand files even more<br>- Brainstorm uncertainty measurement |
| 11/1/2019 | - Experiment with different reward functions<br>- Incorporate uncertainty into the model |
| 11/8/2019 | - Third meeting with EHT<br>- Experiment with different uncertainty methods |

# Timeline

| | |
|---|---|
| 11/15/2019 | - Milestone 3 Presentation<br>- Short report to EHT<br>- Find ways to incorporate visualization into the output |
| 11/22/2019 | - Build visualization around the output<br>- Build GUI |
| 12/6/2019 | - Finalize the advanced model<br>- Get ready to ship the package |
| 12/9/2019 | - IACS showcase |
| 12/11/2019 | - Final presentation |
| 12/12/2019 | - Final deliverables (slides, blog, self- and peer-evaluations) |

# Thank you!

10.15.2019