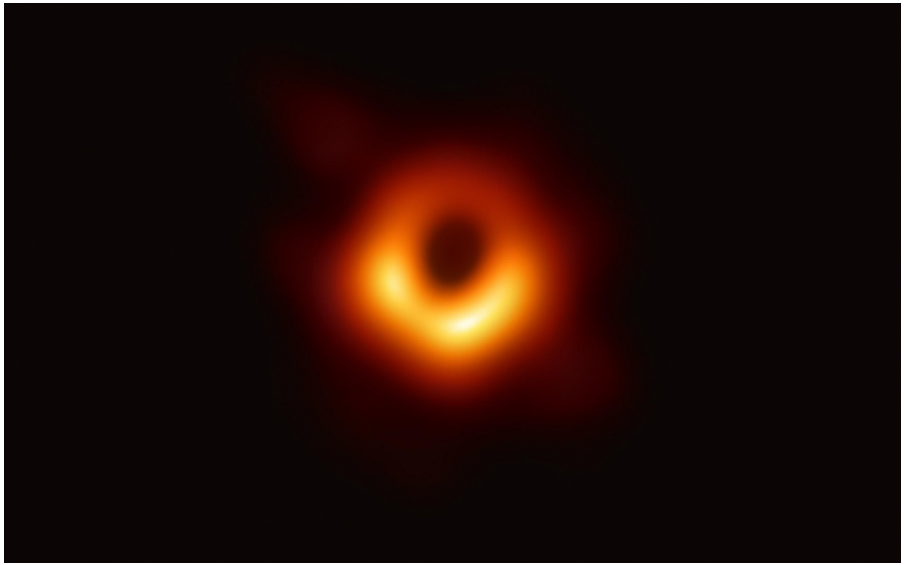
AC297r Fall 2019
Mid-term Summary
Optimal Real-time Scheduling for Black Hole Imaging

EHT Group: Queena, Shu, Yiming
Advisor: Cecilia

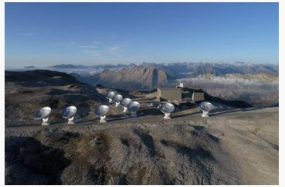
Background

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

Event Horizon Telescope



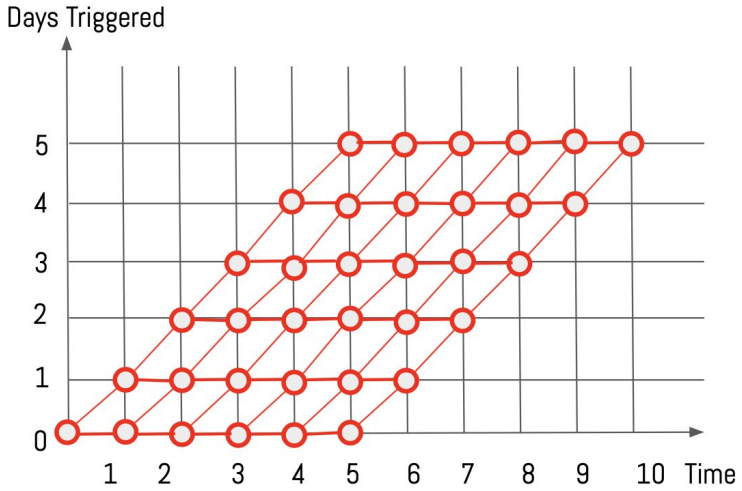
Introduction



Problem Statement

We are going to build a model that can:

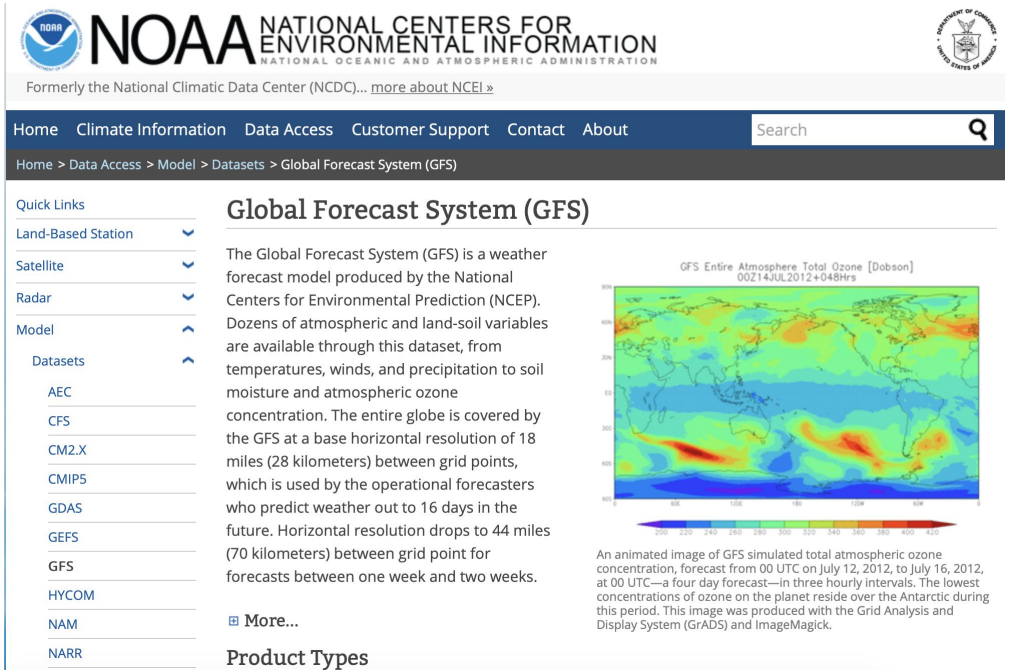
1. In total, choose 5 days from a 10-day window
2. On each day, determine the optimal strategy for future remaining days
3. If possible, provide a confidence level on its suggestion
4. Also provide the second optimal strategy



Motivations

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

Data Source



GFS provides:

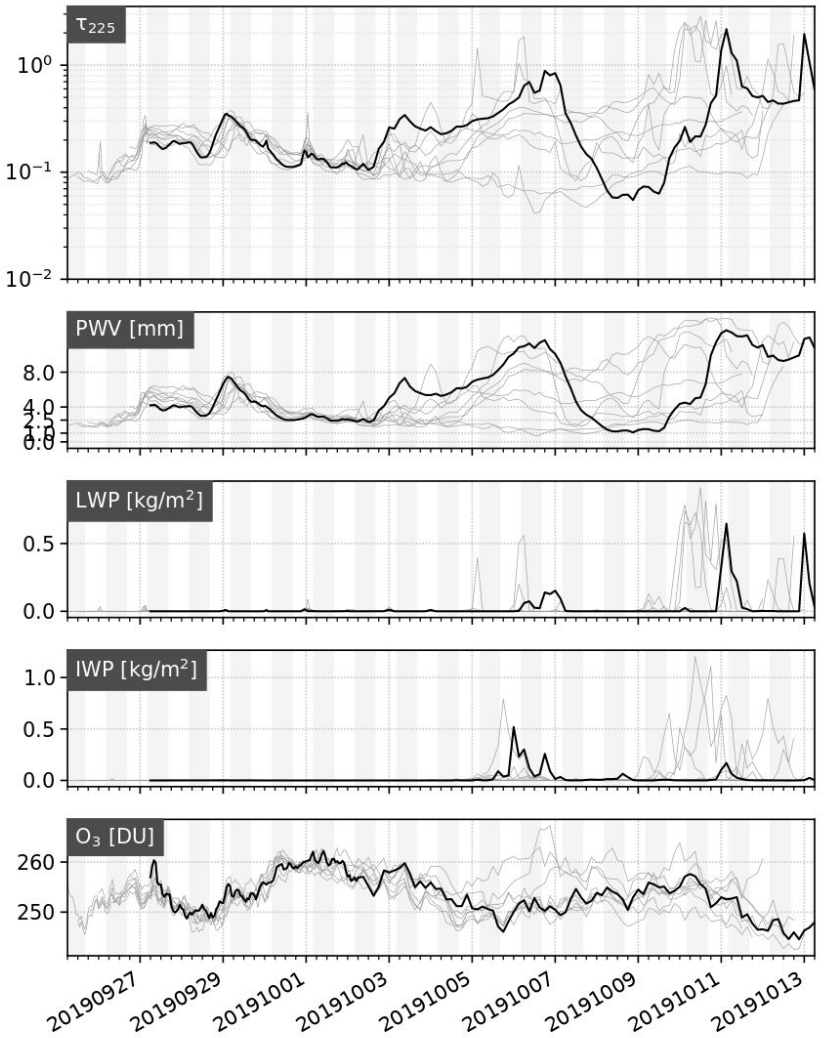
- Atmosphere's condition
- Layer-by-layer
- All over the globe

We pull data every 6 hours specifying:

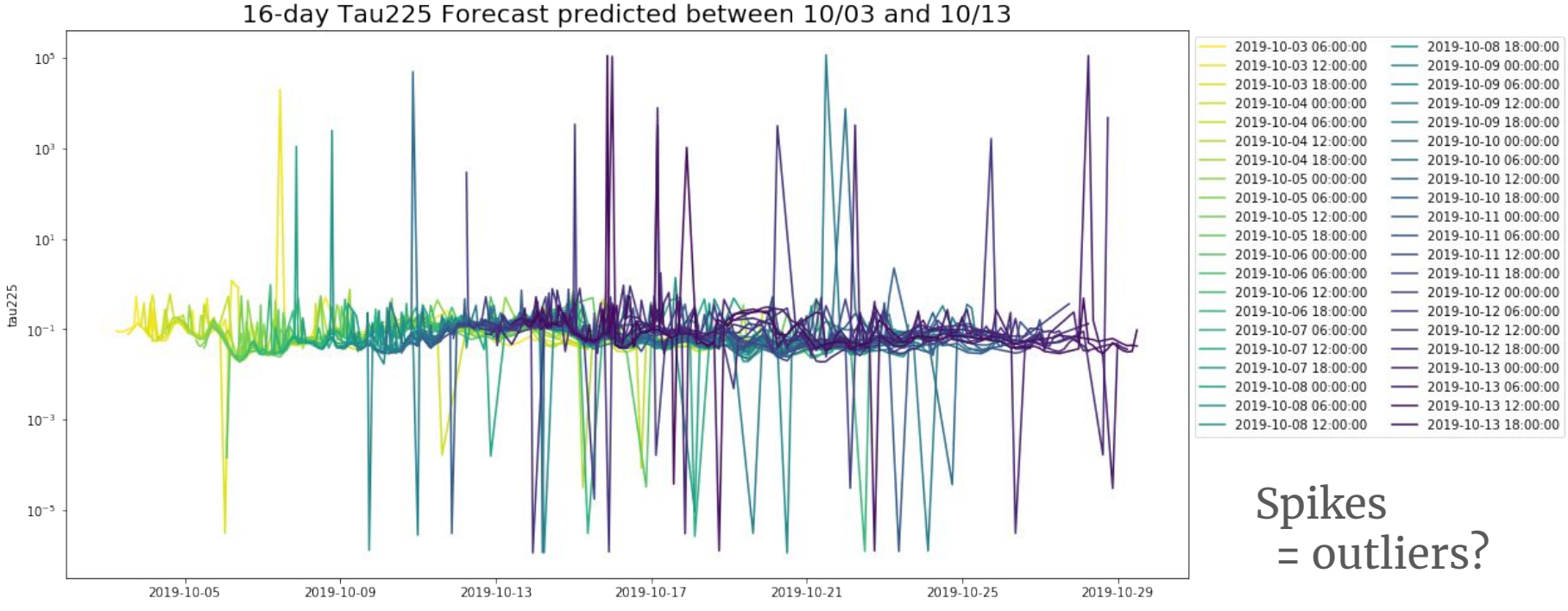
- Longitude
- Latitude
- Altitude

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. Between Models
2. Best path afterwards
3. 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

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

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

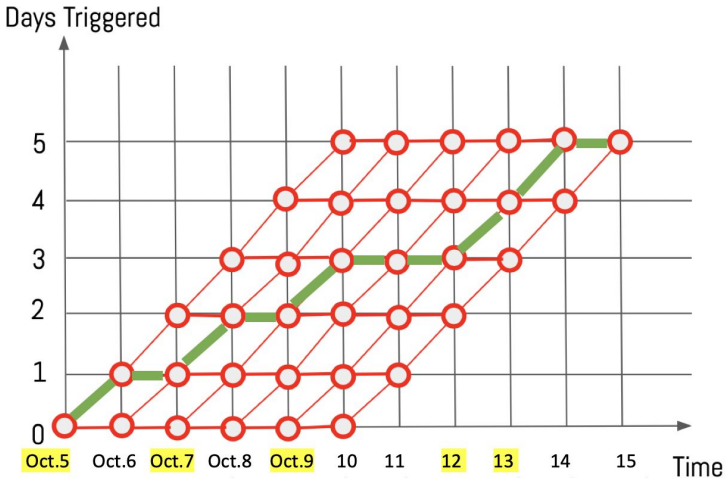
Day3	Day4	Day5	Day6	Day7	Day8	Day9	Day10
10.21	17.67	14.48	11.21	19.31	16.50	11.41	12.22

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

Baseline Model – evaluation

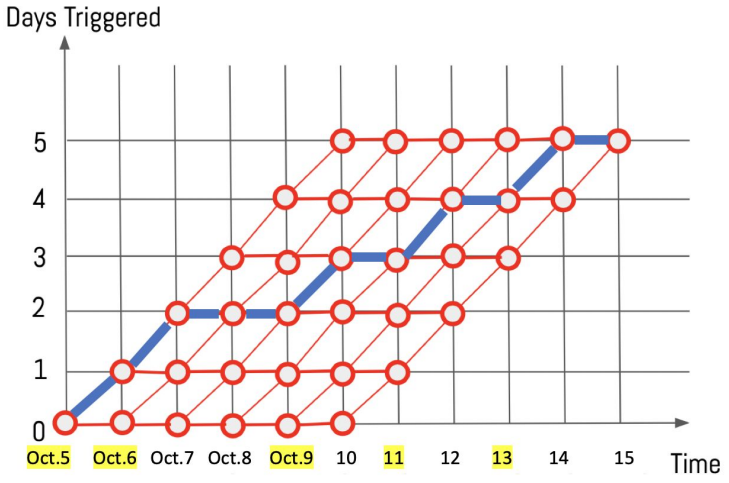
Choose 5 days From Oct.5 - Oct.14, 2019

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 - Short Report to EHT - EDA - Baseline Model / Evaluation - Experiment with different reward functions
10/25/2019	- Second meeting with EHT - Get to understand files even more - Brainstorm different uncertainty measurement - Experiment with different reward functions
11/1/2019	- Experiment with different uncertainty measurement
11/8/2019	- Third meeting with EHT - Experiment with different uncertainty measurement - Find more optimization ways

Timeline

11/15/2019	- Milestone 3 Presentation - Short report to EHT - Find ways to incorporate visualization into the output
11/22/2019	- Build visualization around the output - Build GUI
12/6/2019	- Finalize the advanced model - 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