Milestone 1
AC297r Fall 2019

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Problem Statement

Goal: maximize the number of good photos of Black Hole

- Only choose 5 days from a 10-day window
- Find the optimal strategy for the future remaining days
  - Confidence level
  - Second optimal strategy

Scope of Work

Final deliverables:

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

- Proper documentation explaining the algorithm.

Learning Goals

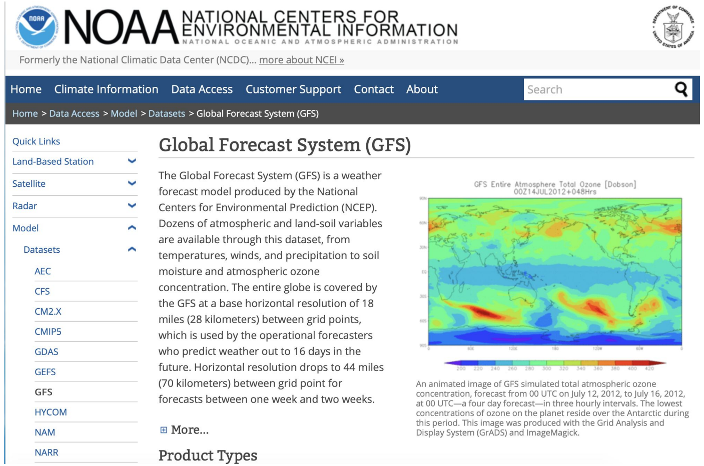
1. Domain Background

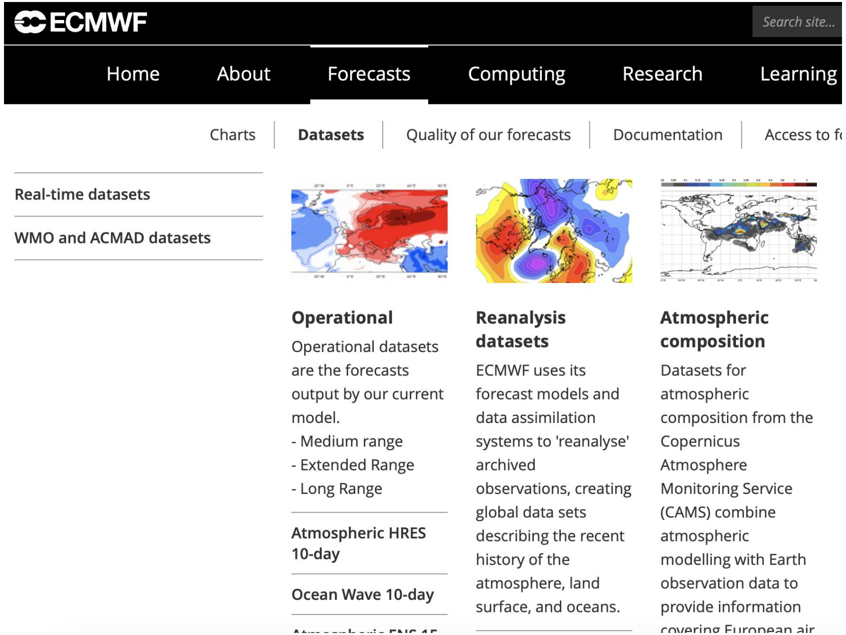
    Translate the EHT scheduling problem into data science language.

    Comprehend the requirements and define our own problem.

2. Potential Optimization Methods

Data Sources





Getting Data

- Global Forecast System (GFS)
  - Atmosphere’s condition
  - Layer-by-layer
  - All over the globe

- Github Repository: Smithsonian/sma-met-forecast
  - Scripts to download data every six hours
  - Need to modify each telescope’s longitude, latitude, altitude

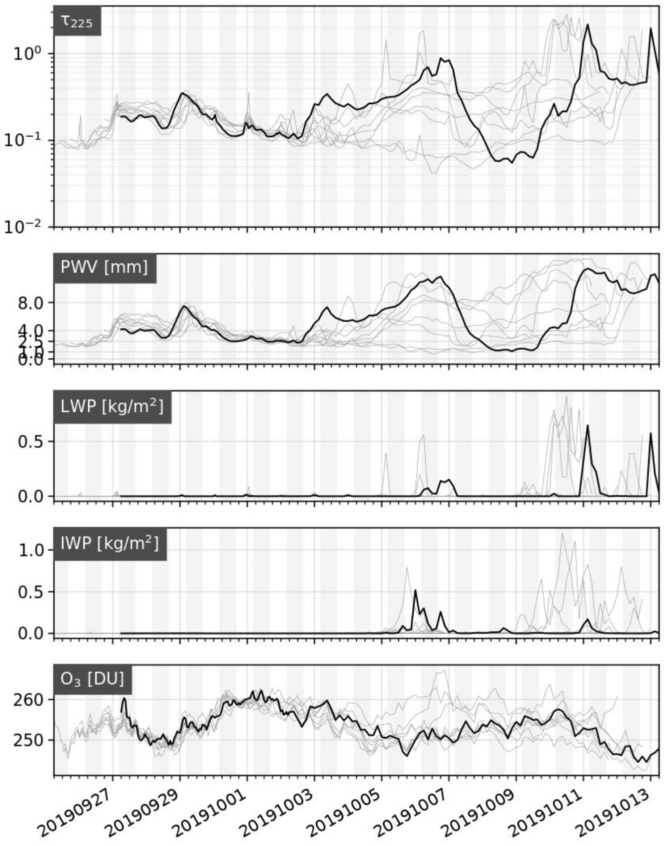
EDA

GFS makes forecast every 6 hours.

Every forecast covers prediction of atmosphere for the future 16 days.

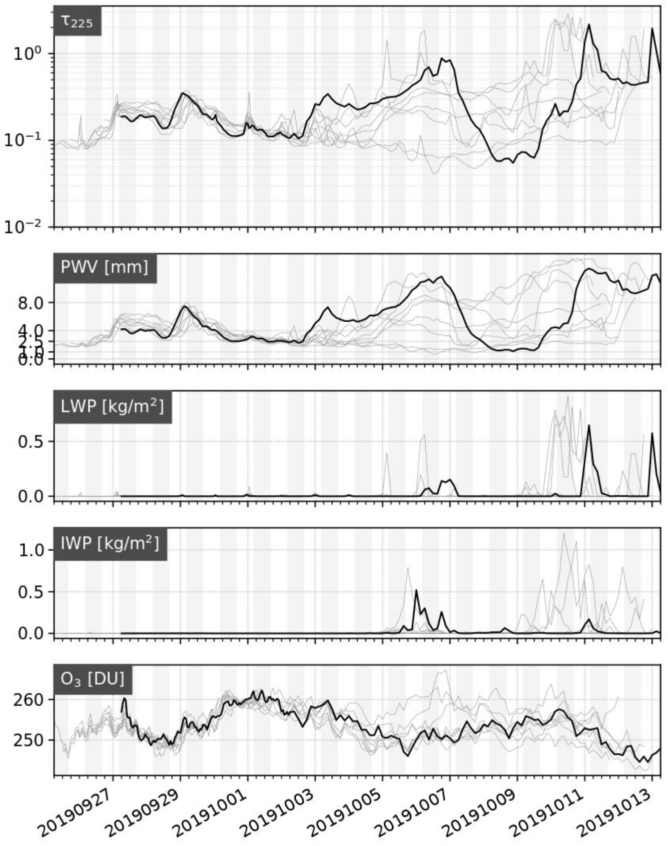
First 5 days: more certain, hourly

6 days +: more variance, 3-hourly



Forecast is for the SMA at 19.824 deg. N, 155.478 deg. W, 4080.0 m altitude. Dates are UT with major ticks at 00:00. Shading indicates local night. The current forecast is plotted in black; the prior 48 hours' forecasts are in grey.

Atmospheric state data are from the NOAA/NCEP Global Forecast System (GFS), with data access provided by the NOAA Operational Model Archive and Distribution System (https://nomads.ncep.noaa.gov). Optical depth is from am v.10.0 (https://doi.org/10.5281/zenodo.640645).



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Variables:

Tau-225: absorption directly over-head

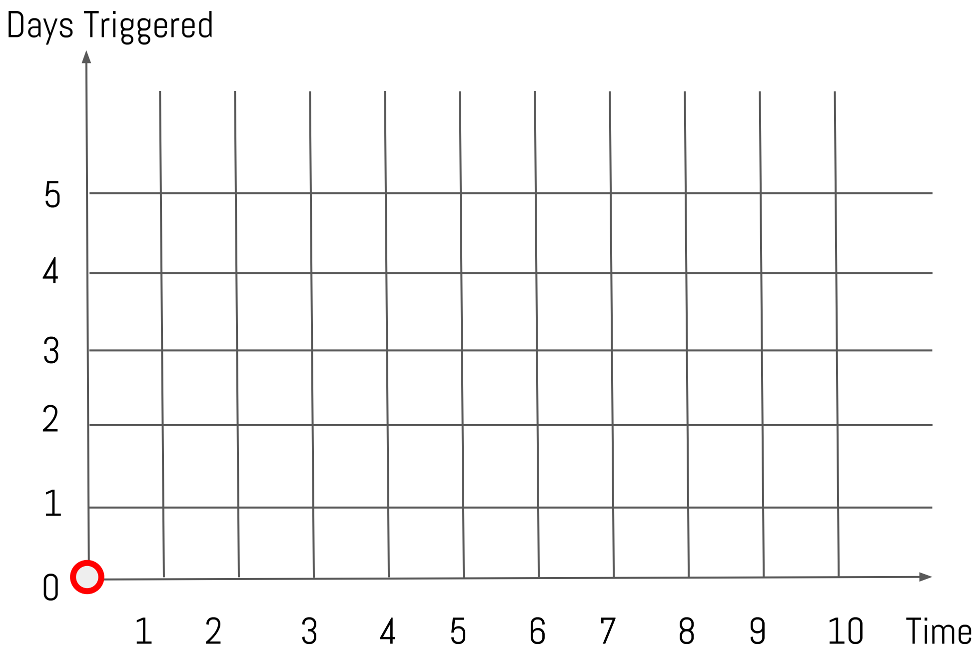
PWV(precipitable water vapor): the depth of water in a column of the atmosphere, if all the water in that column were precipitated as rain.

LWP(Liquid water path): the total amount of liquid water present between two points in the atmosphere

IWP(Ice water path)

Ozone

Formulate our problem



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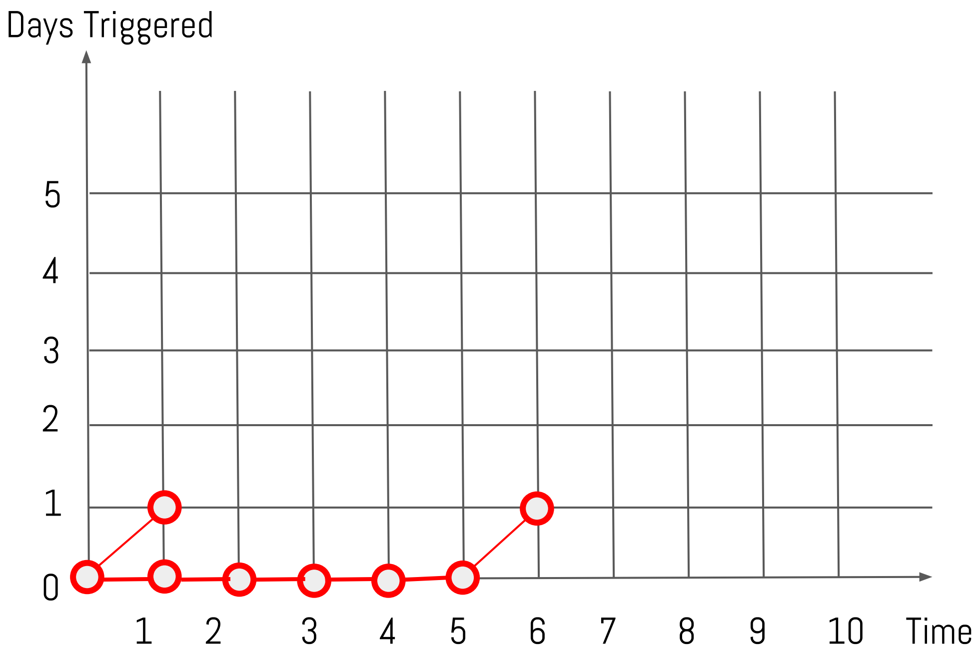

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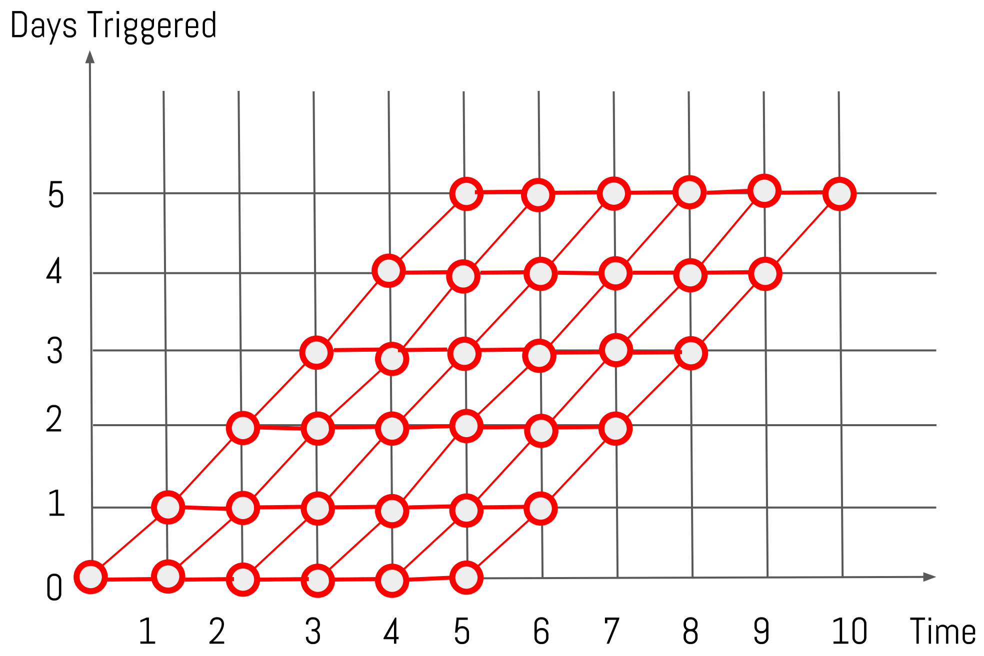

Model Design

1. **Reward Function**
2. **Uncertainty Measurement**
3. **Optimization**
4. **Model Evaluation**

Model Design

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For single telescope f
For whole telescopes F

Model Design

1. Reward Function
2. **Uncertainty Measurement**
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Possible ways:

- Discount factor
- Probabilistic distribution

  ……..

Model Design

1. Reward Function
2. Uncertainty Measurement
3. **<u>Optimization</u>**
4. Model Evaluation

Possible ways:

- Dynamic Programming
- (Reinforcement Learning)

……..

Model Design

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4. **Model Evaluation**

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 size of telescope i

Baseline Model

2. Uncertainty Measurement：

None

3. Optimization

Simplified from 2-dimension to 1-dimension

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

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

Future Plan

- Take more features to the reward function:
  - Other weather prediction index
  - Telescope condition: angle, schedule
- Ways to incorporate uncertainty:
  - Discount variable
  - Probabilistic distribution

Collaboration Infrastructure

model building (together)

 - > implementation (divide & conquer)

- > model improving (together)

- > implementation (divide & conquer) - …

Logistics

- Regular Tuesday class, meetings with Pavlos
  - Also meet when needed
- Regular check-in with EHT (bi-weekly)
  - Shep, Scott, Alex, Lindy
- Version control: Github
- Communication: Wechat, Emails