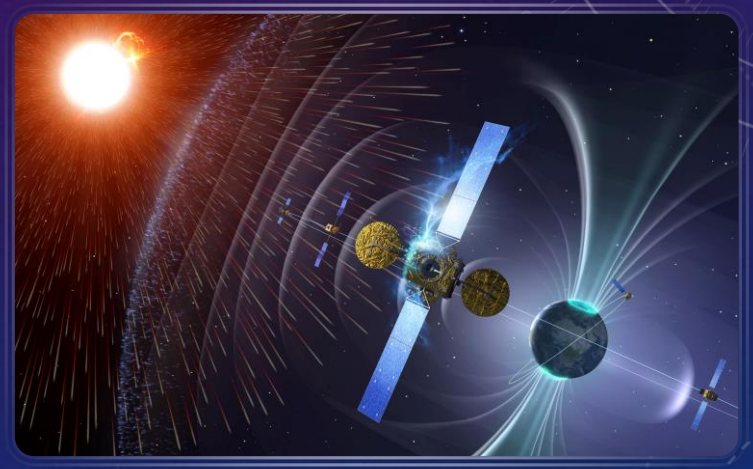
NASA SPACE APPS CHALLENGE

SINGLE EVENT UPSET PREDICTOR

ADAM MCMULLEN

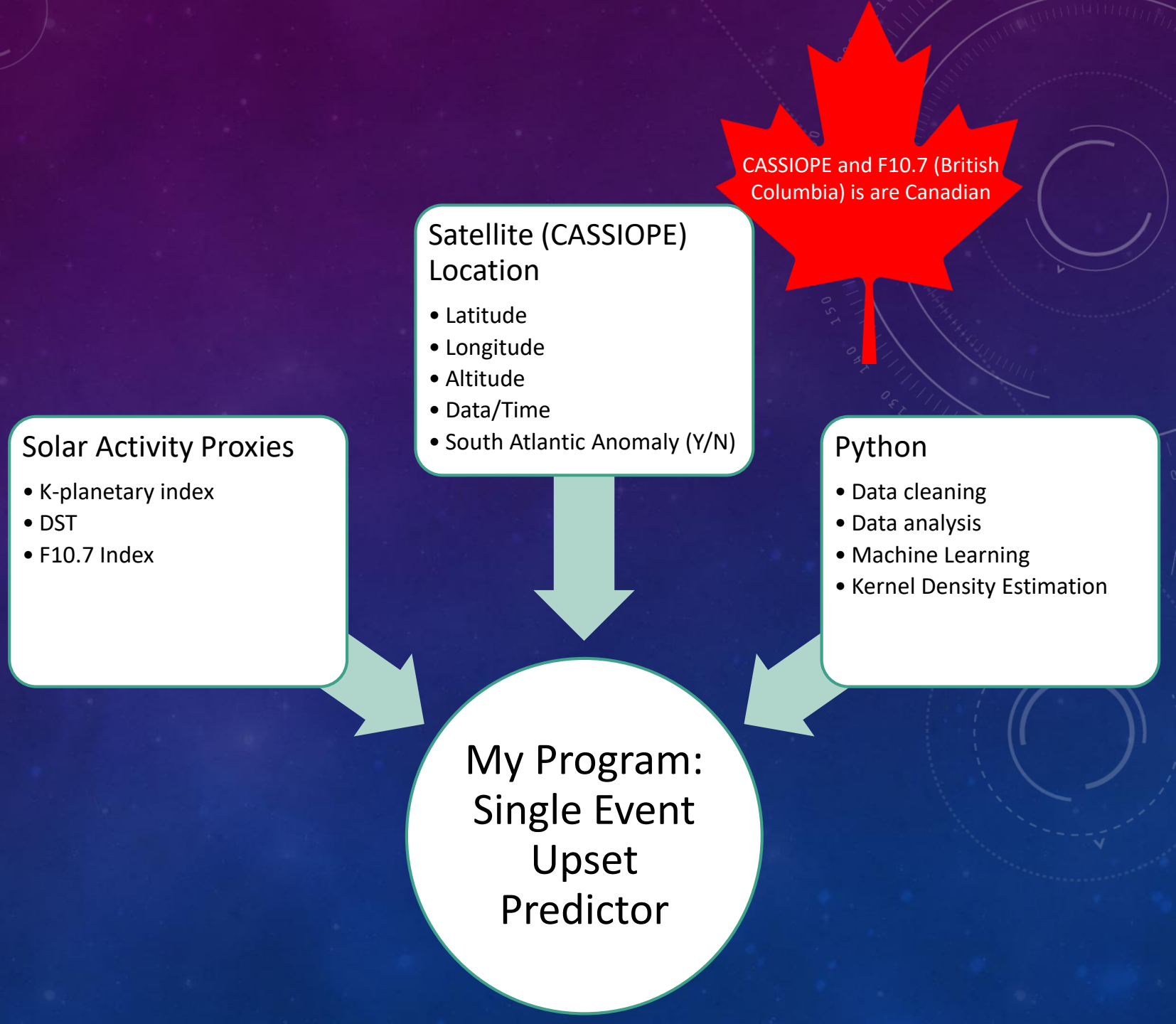
PROBLEM

- High levels of solar activity creates a lot of charged particles and radiation that travel to Earth
- These particles can damage satellite electronics via a Single Event Upset (SEU) which can lead to data losses



SOLUTION

- From CSA website:
- Space Radiation Danger Problem:
- **Challenge description:** This challenge consists of establishing a risk scale of space-weather caused satellite resets, which is the risk of satellite computers shutting down because of strong radiation in space. To this end, data on single-event upsets taken directly from the Canadian satellite CASSIOPE needs to be meshed with multiple open space weather datasets to determine what factors cause the upsets, and devise a way to estimate the risk that the satellite would be affected by space radiation a day in advance, enabling better satellite operations



DATA INPUTS

- This project incorporated:
  - Local satellite local time
    - Hour
    - Year
  - Satellite location
    - Latitude
    - Longitude
    - Altiude
    - Whether satellite is in south Atlantic anomaly
  - Solar activity indices
    - K-plantary
    - F10.7
    - DST

Note that sat speed is redundant to alt (keplers 3rd law)
X,Y,Z coords are redundant to lat, long,alt


```
[' Latitude (deg)',' Longitude (deg)',' Altitude (km)','Year','LocalTime','kp','f10','dst','SAA']
```

RESULTS

Machine Learning Accuracy	Correct Classification	Incorrect Classification
Non-SEU	250	0
SEU	0	5

- Two predictive tools were developed
- Both took the same data as inputs (see last slide)

1. Machine Learning Classifier
    1. Had a 100% false negative rate for classifying SEUs (it said everything was non-SEU)

```
Machine Learning model predictions on test set:
['Non-SEU' 'Non-SEU ' 'Non-SEU ' 'Non-SEU ' 'Non-SEU ' 'Non-SEU ' 'Non-SEU ' 'Non-SEU
']
```

2. Probability of a SEU with Kernel density estimation and histogram

```
Machine Learning model predictions on test set:
['Non-SEU' 'Non-SEU ' 'Non-SEU ' 'Non-SEU ' 'Non-SEU ' 'Non-SEU ' 'Non-SEU ' 'Non-SEU ']

# KDE method
# The probability of the test events being SEUs is ['0.0', '95.2', '0.0', '37.8', '15.7', '0.0', '2.9', '0.0'] %
# The probability of the test events being Non-SEUs is ['100.0', '4.8', '100.0', '62.2', '84.3', '100.0', '97.1', '100.0'] %
#
# Histogram method
# The probability of the test events being SEUs is ['5.6', '13.5', '1.2', '4.5', '5.1', '7.8', '0.0', '0.0'] %
# The probability of the test events being Non-SEUs is ['94.4', '86.5', '98.8', '95.5', '94.9', '92.2', '100.0', '100.0'] %
```

HOW TO USE THIS NEW TOOL

FUTURE WORK

- Don’t run out of time :) in hackathon
- Create a likelihood based model incorporating ionizing particle (electron, proton) fluxes