Satellite Anomaly Prediction

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The Data Mine

INTRODUCTION

Background:

- Satellites are essential for gathering and sharing data worldwide, supporting critical operations for governments, private organizations, and individuals. However, these satellites frequently experience technical challenges often triggered by space weather.
- Space weather can be loosely defined as events caused by the expulsion of particles from the Sun.
- Space weather includes events such as solar flares, coronal mass ejections, solar wind, sunspots, etc.
- Current anomaly responses are reactive.

Motivation:

- It is essential that satellites in orbit work properly in the atmosphere.
- Disruptions to satellite systems or damage to satellites can be very expensive.
- Preventing anomalies is crucial to the continued ability to send satellites into space.
- Space weather is difficult to accurately predict in long term.
- By using space weather conditions we can predict satellite anomalies and minimize cost.
- Therefore, satellite operators have a strong incentive to invest in building a predictive model for satellite anomalies to help minimize costs.

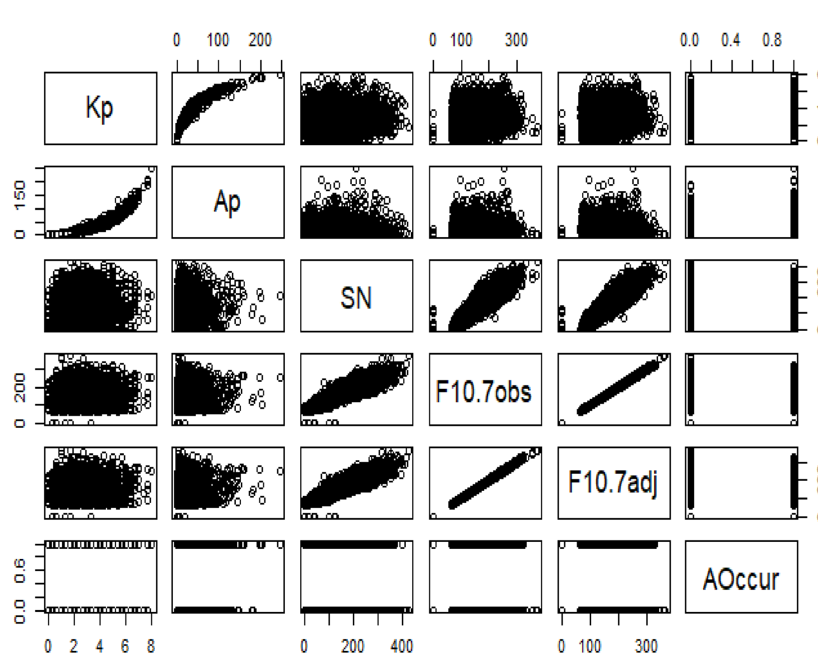
RESEARCH AND RESULTS

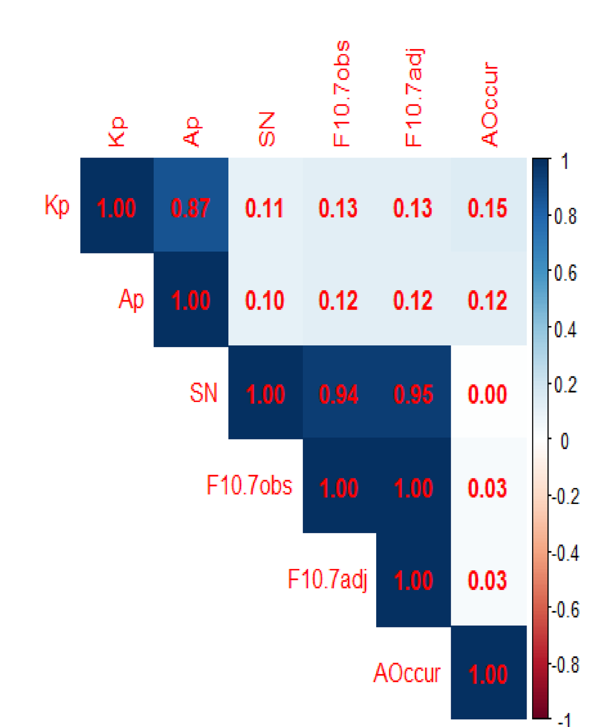
Logistic Regression Model

- Statistical method used to predict the probability of an anomaly occurring using the day's Kp Index and transformed Total Sunspot Number.
  - Yeo Johnson transformation was performed on Total Sunspot Number to normalize the data instead of removing outliers.
- Randomly selected 75% of the data as the training set and the remaining as the testing set.
- Classification threshold was 50%.
- Model's accuracy is 79.47%.
- Classification Error Rate is 20.53%.
- False Positive Rate is 20.53%.
- False Negative Rate is 25.00%.
- False Discovery Rate is 99.50%.
- False Omission Rate is 0.04%.

DATA

- Dataset used to train models to predict satellite anomalies was created by joining 2 datasets
- First dataset was exported from National Oceanic and Atmospheric Administration Satellite Anomalies and had specific data on the cause and type of satellite anomalies and satellite details
- Second dataset was exported from Helmholtz Centre for Geoscience and included daily weather conditions.
- Datasets were joined by shared dates to determine whether an anomaly occurred that day.
- 11,688 observations from 1963-1994 are in the dataset, with 13 variables describing space weather and satellite anomalies
- Notable variables are:
  - Date
  - Mean Kp value
  - Mean Ap value
  - SN (Daily Total Sunspot)
  - AnomalyCount (total number of anomalies)
- Location of satellite was not included





FUTURE GOALS

- Identify the particular type of anomaly occurring using multi-class models
- Improve the accuracy of the models to be more reliable
- Forecast future space weather conditions

FUTURE DEFINITION OF SUCCESS

Ability to predict satellite anomalies reliably enough to be able to devise strategies to avoid operational disruptions and reduce economic losses

ACKNOWLEDGEMENTS

Andrew Jossi, Will Biancarelli, Sienna Amorese, Monica Ball, Dan Hirleman, Jessica Jud, Hector Falcon and the Space ISAC team

Data Mine of the Rockies Spring 2025