Forecasting Extreme Site Power Fluctuations Using Fast Fourier Transformation

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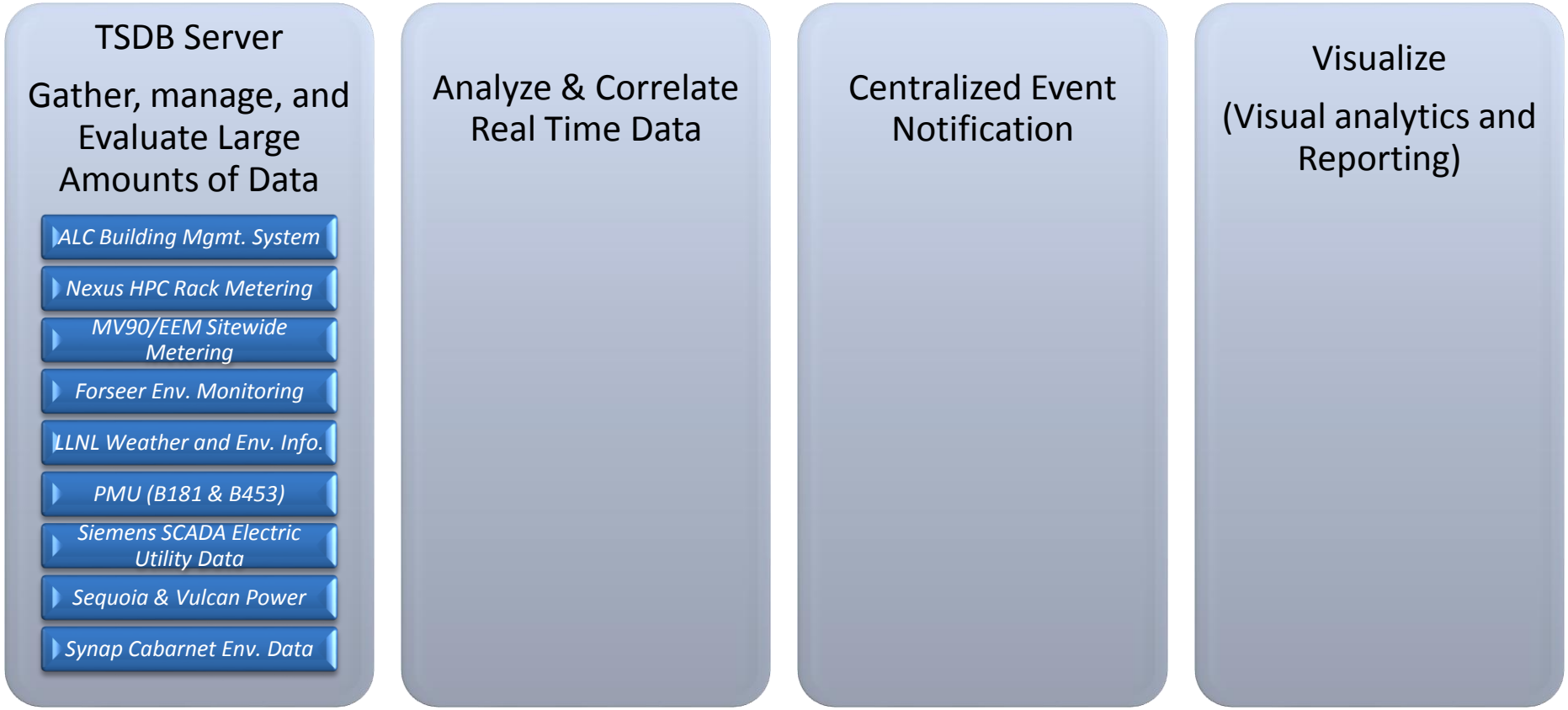
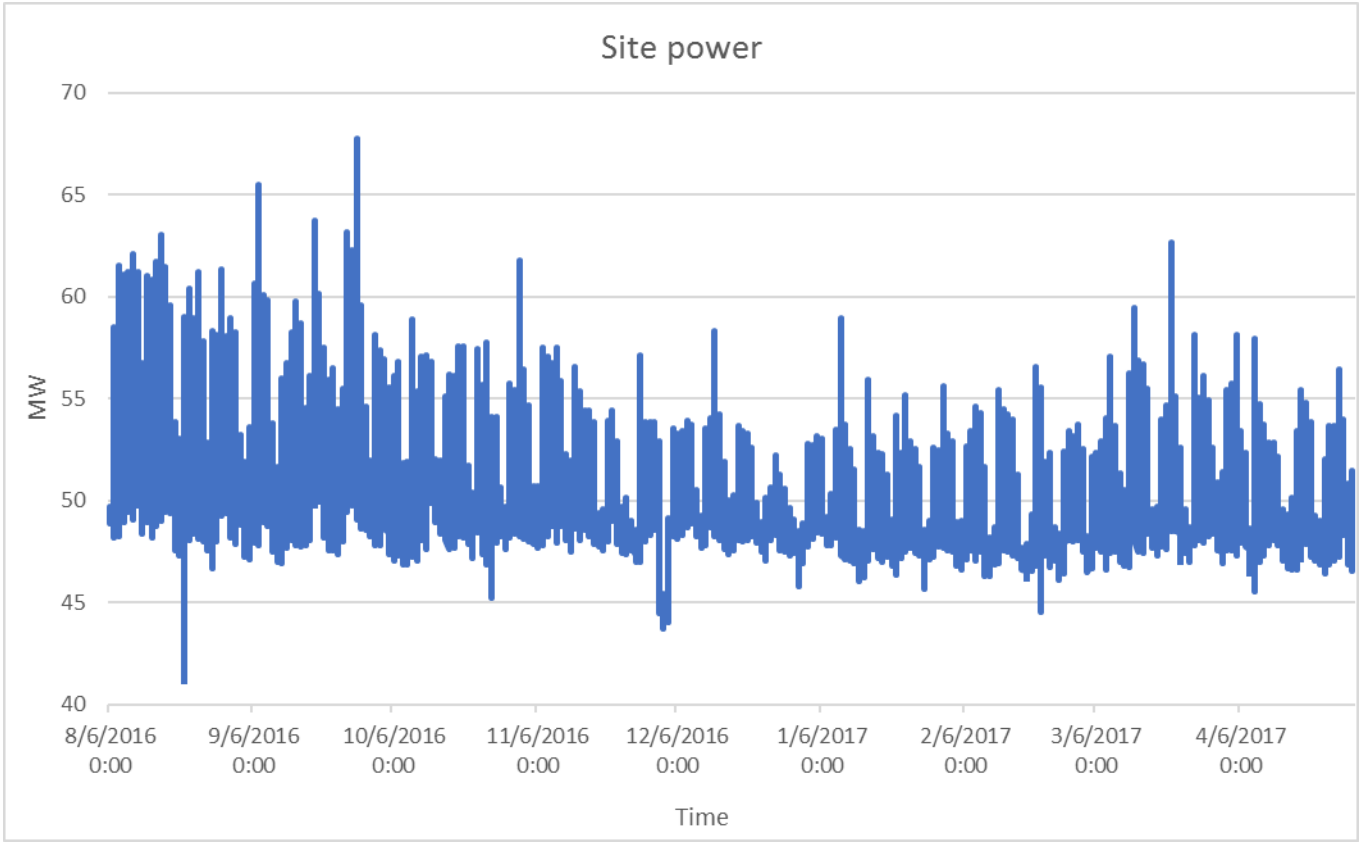
The question?

- WAPA (our energy provider) wanted to be notified when the site's total energy consumption goes up/down by 750 KW over a 15 minutes window

We collect data to support facility operations and research

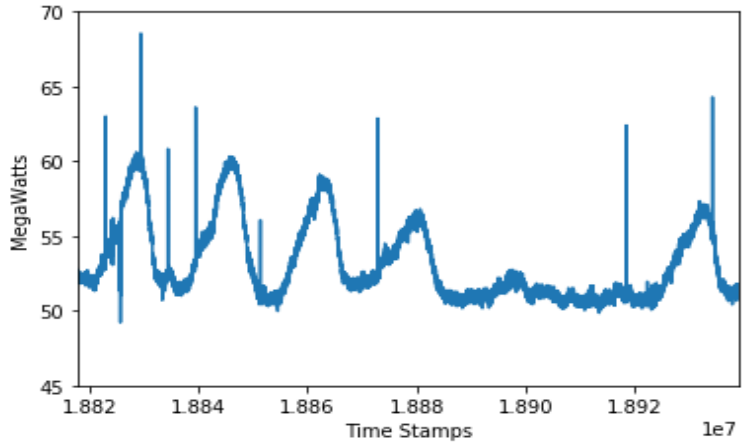


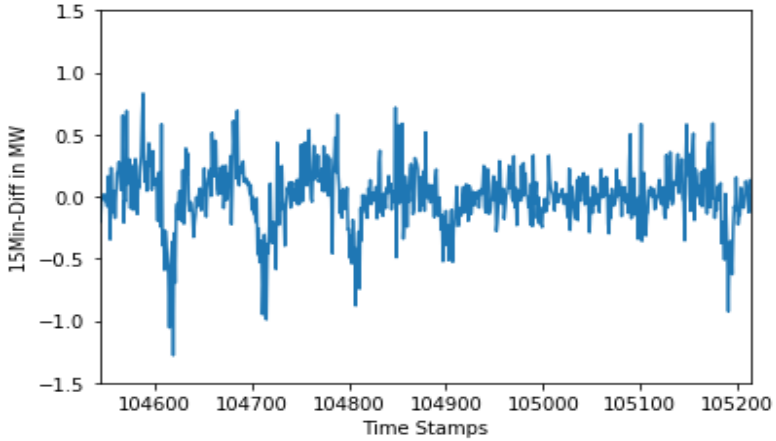
Site power data



Site power data shows periodic and large amplitude power spikes

Generated alerts using real time data from our server





- Time stamp every 5 Sec
- Take the average over 15 minutes window(non rolling)
- Take the Difference from last average
- if the difference is greater than +/-750KW an alert is sent

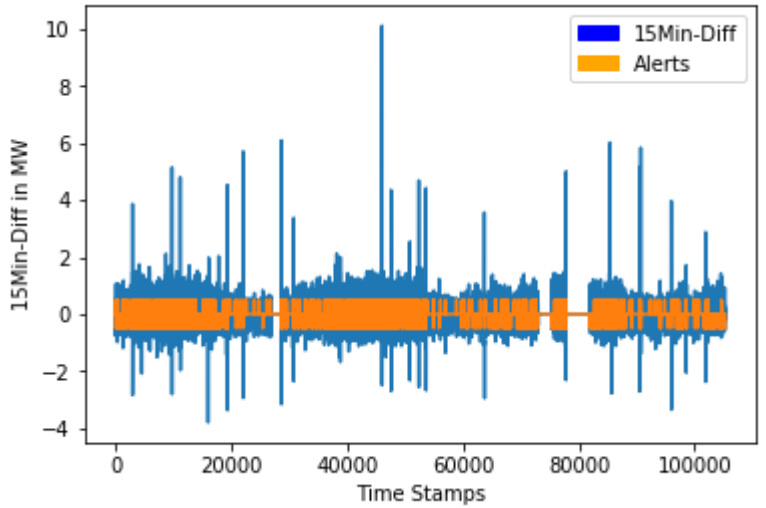
WAPA's scheduling team response:

- "they're not as helpful to me (but may be to others) since they usually happen during real-time. We preschedule LLNL load on 2-6 day ahead basis."

How much of and how far in the future can we predict these alerts?

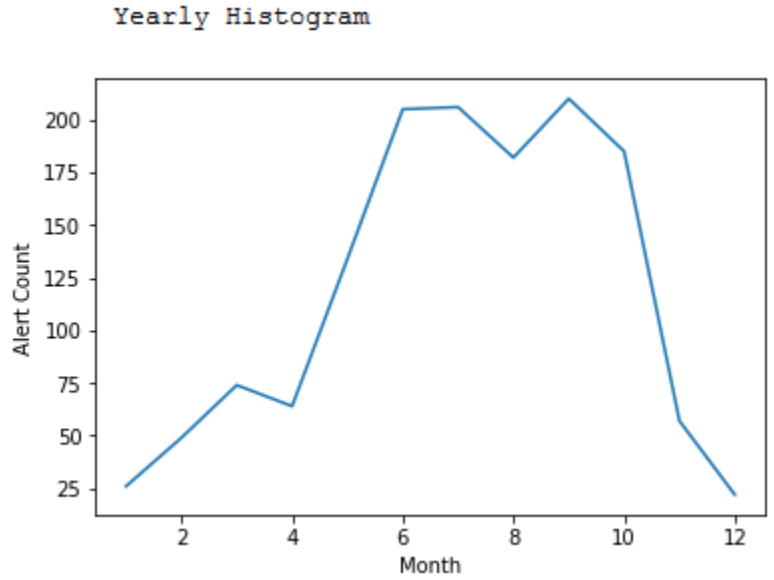
We generated alerts using data for the past 3 Years

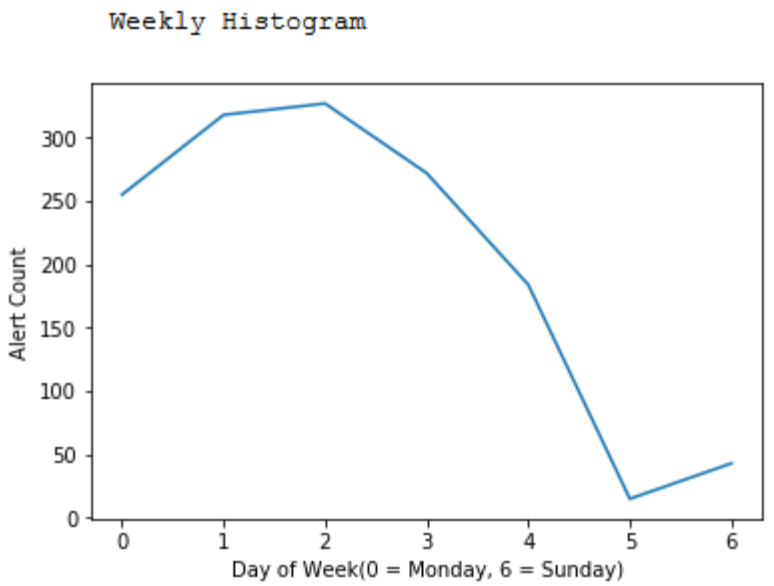
- Used the same algorithm to calculate the alerts:
  - Calculated the past 3 years of differences and alerts
  - Flagged alerts with +/- 1
    - Blue: Differenced power
    - Orange: Alerts
- Visually you can spot a yearly cycle
  - Missing data is not helping, but the first two years are correlated



Explore the use of the temporal structure in the data to predict extreme events.

Alert Histogram Breakdown(Month and Week)



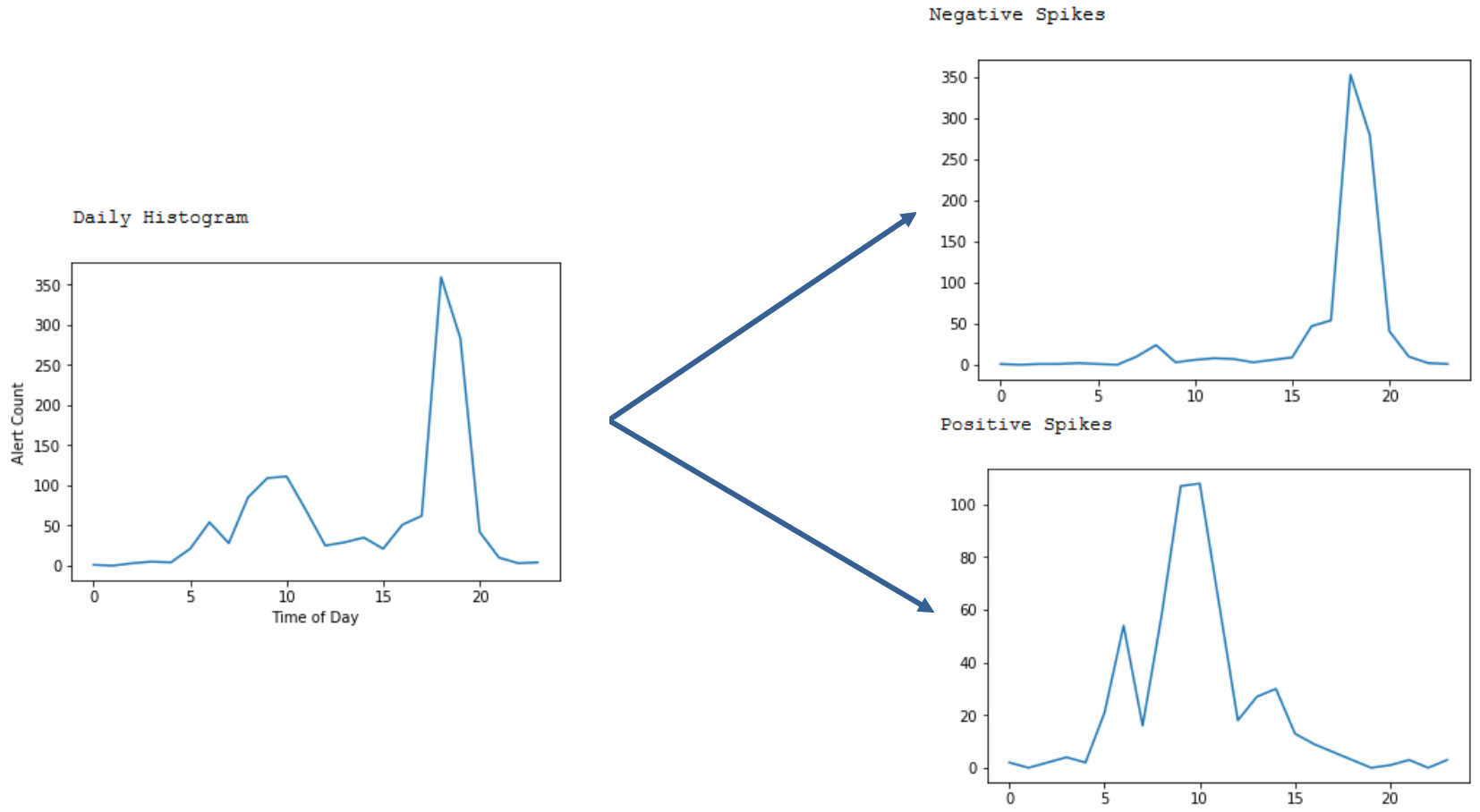


1-12 : Jan - Dec

0-6 : Mon-Sun

There are repeated patterns across months and weeks, what about days?

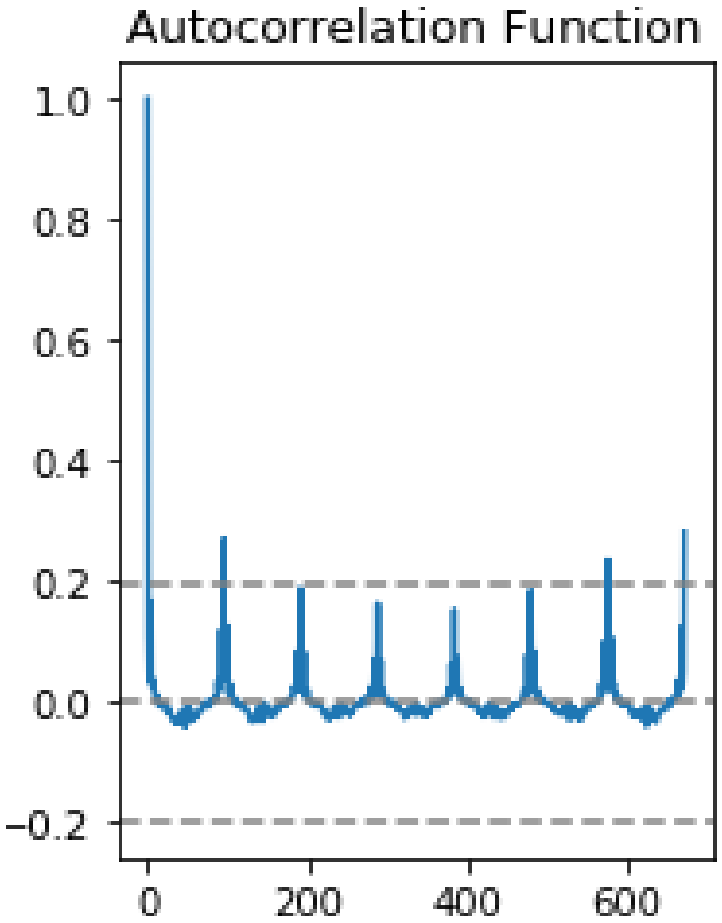
Alert Histogram Breakdown(Daily)



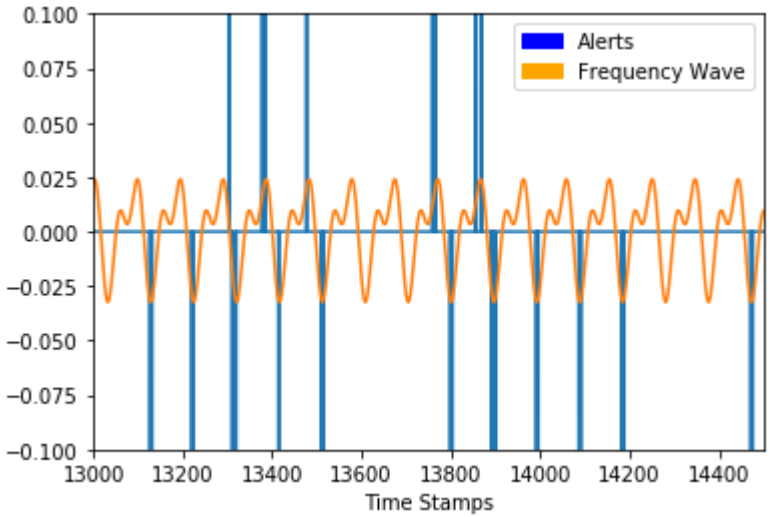
Negative peaks dominating the end of the day and positive peaks dominating the morning hours

Is their any periodicity in the signal?

- We used autocorrelation tests to test seasonality and determine the cycles:
  - Seasonality(yearly, weekly and daily)
  - Daily and weekly correlation on alerts



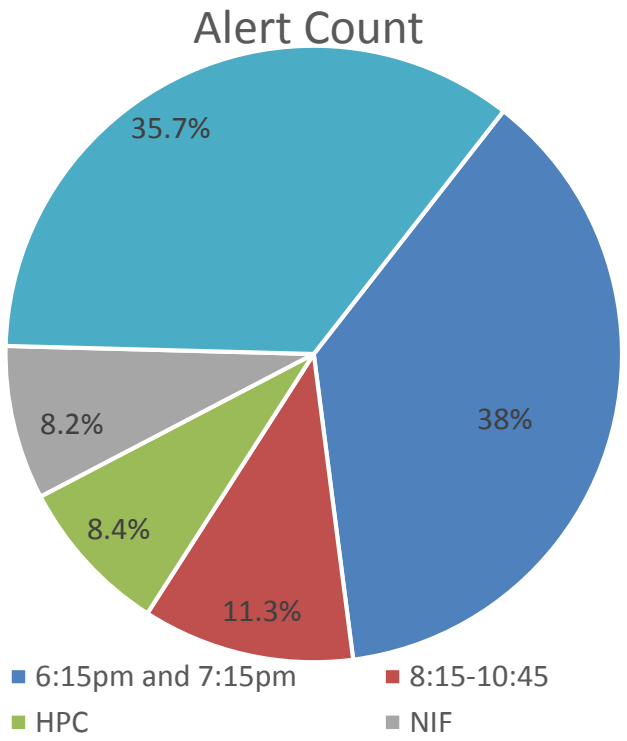
Using Fast Fourier's Transform we confirm the times for the spikes



- Two main events
  - —Positive alerts
    - Mornings from 8:15am – 10:45am
    - Accounting for 18% of total alerts
  - —Negative alerts
    - At 6:15pm and 7:15pm
    - Accounting for 38% of total alerts

Alert Breakdown

- N = 1414 total alerts
- NIF
  - 1124 total spikes
  - 116 alerts
  - 10.3% of total NIF shots triggered an alert
  - 8.2% of total alerts
- HPC(Vulcan and Sequoia)
  - 119 unique spikes and alerts (8.4%)
- 6:15, 7:15, NIF, and HPC(unique)
  - 769 alerts (54.4%)



How Accurate is the Fourier Transform?

- Tested accuracy of different time windows found from the Fourier Transform
  - Mornings from 8:15am-10:45am
  - Evenings at 6:15pm and 7:15pm
- Test N = 20908
  - Alerts = 159 (0.8%)
  - None = 20749(99.2%)

6:15pm and 7:15pm (98.3% accuracy)

		Actual	
Guess		Alert	None
	Alert	62(38)	250
	None	97	20499

8:15AM-10:45AM,6:15pm and 7:15pm (90.5% accuracy)

		Actual	
Guess		Alert	None
	Alert	94(61%)	1934
	None	65	18820

6:15pm and 7:15pm (weekdays, Spring-Fall) (99.1% accuracy)

		Actual	
Guess		Alert	None
	Alert	53(33)	87
	None	106	20662

How much are we willing to trade accuracy for total alerts accounted for?

How Accurate is Machine Learning?

Random Forest 99.2%

	Actual	
Guess	Alert	None
Alert	30(19)	31
None	129	20718

Gaussian Naïve Bayes 99.2%

	Actual	
Guess	Alert	None
Alert	0	0
None	159	20749

- Train/Test = 80%/20%
- Test N = 20908
  - Alerts = 159 (0.8%)
  - Nothing = 20749(99.2%)
- File Format
  - Month
  - Day of Week
  - Time of day
  - Class

Though the overall accuracy is greater it doesn't help much with predicting alerts.

Summary

- Cyclic events (predictable)
  - Employees schedule(54%)
    - Mornings from 8:15am-10:45am(18%)
    - Evenings from 6:15pm and 7:15pm(38%)
  - Summer versus winter
    - Prepare for more events during the summer
- Planned schedule
  - NIF(8.2%)
  - Schedule maintenance?
- Random
  - HPC jobs (8.4%)
  - PDF to predict events

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