

@penCHORD_UoE
@peninsula_ARC



Module 9 : Forecasting
Session 9B : Forecasting with Prophet
Elliott Coyne

"With Iberia, you are more"



#hsma5isalive

What we'll learn this afternoon...

PROPHET

Forecasting at scale.

<https://facebook.github.io/prophet/>

Python & R

Great for daily
level forecasting in
health services!

Motivation for Prophet

- Old ideas implemented in a nice, easy to use package
- Offers 'modern business' forecasting at the *daily* level
 - (but can be used at lower i.e., hourly /higher i.e., weekly levels)
 - Multiple levels of seasonality e.g. weekly, annually, special events/holidays (aka 'spiky events')
- Forecasting and time series expertise is limited
 - Lots to do but not enough people to do it (using classical methods, requiring lots of detailed analysis to decide exactly which forecasting method should be used)
 - Facebook's data science view: tunable automatic forecasting is the answer
 - Simple to explain methods

A motivating time series from health

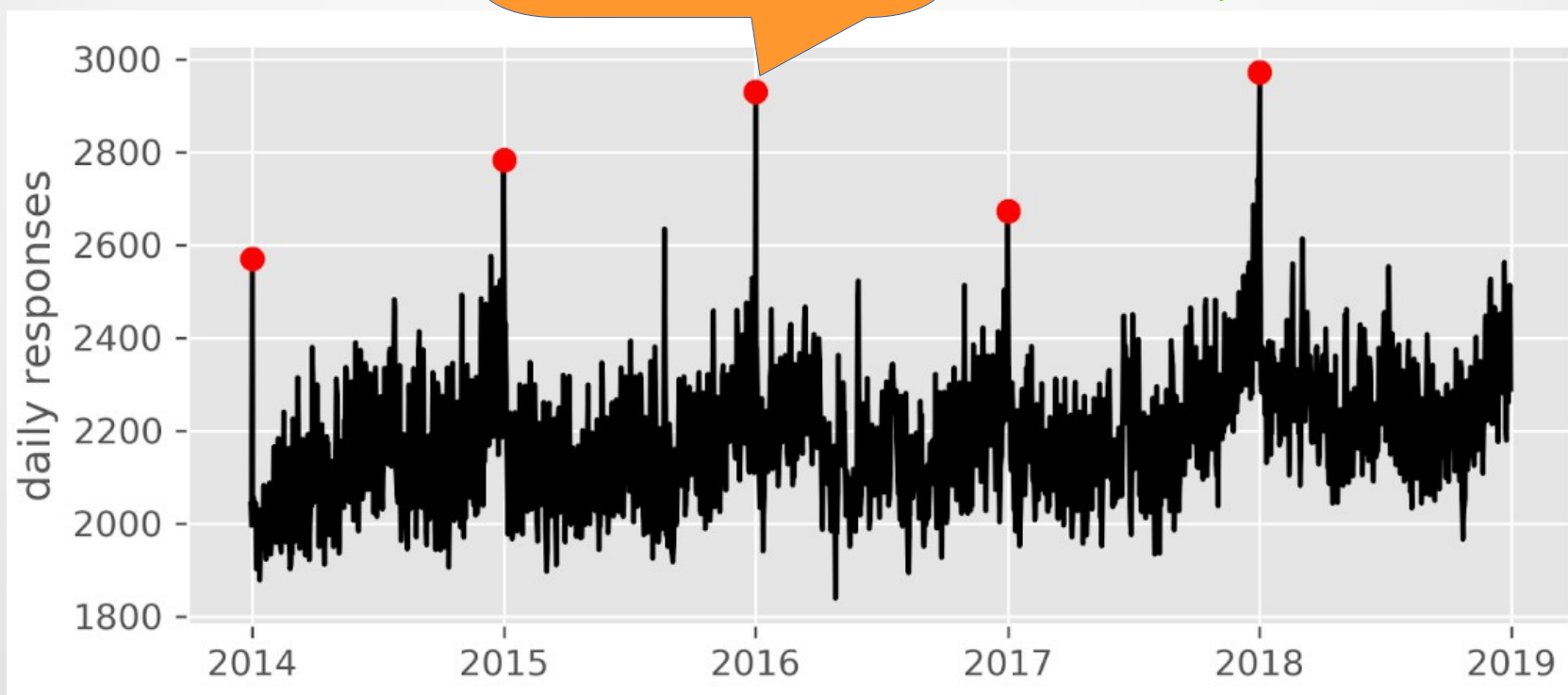


Is there a trend?

Is there a cyclical pattern?

New Year Day = Predictable 'Spike' in demand

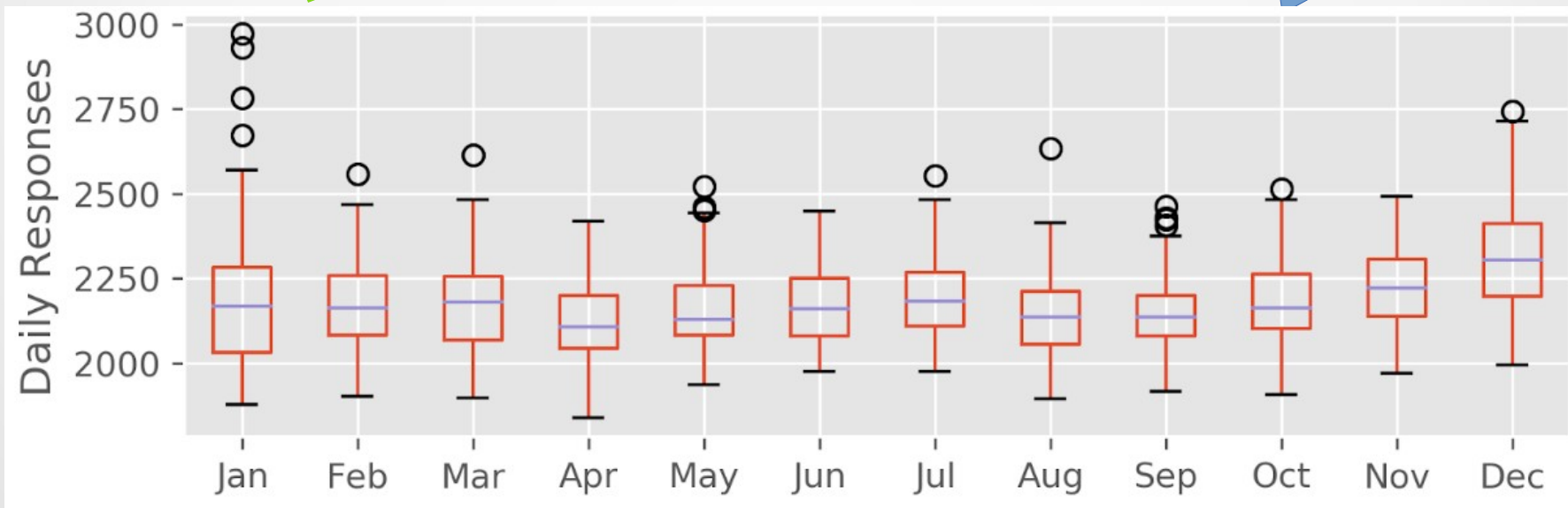
Real project: Daily # calls that resulted in 1+ dispatches of ambulances



Seasonality (1)

Box Plots to see monthly variation in data ignoring trend

What do medians tell us?



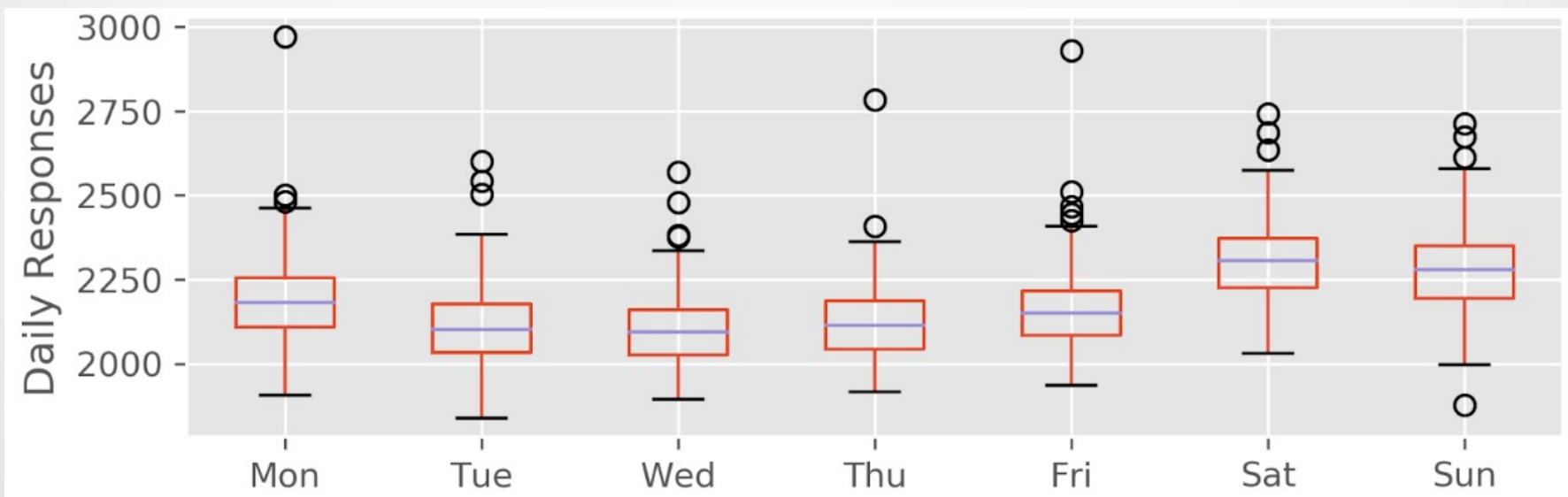
Not familiar with B&W Plots? <https://asq.org/quality-resources/box-whisker-plot>

Seasonality (2)

Box Plots to see daily (DoW) variation in data

What do medians tell us?

Any other observations?



Prophet

Simply add these components together...

...can be non-linear!



Additive model

trend

+

seasonality

+

holidays

+

i.i.d. errors

Whitening of Errors....

Trying to remove all the autocorrelations and patterns within errors – therefore leaving errors that are uncorrelated

Independent Identically Distributed errors
Prophet goes against other forecasting literature

Trend

- Piecewise linear model (i.e. change trend within data at certain points) or
- Logistic model (i.e. taper off over time i.e., not just continually up over time)

Trend points automatically detected via a Bayesian approach

Large number of points selected then used to update its parameters to decide if those trend points are real or not. Then left with just a few genuine change points within the data

Seasonality

- Seasonality also autodetected by Prophet
- Can have seasonality at different time intervals in data i.e.....
 - Month of year
 - Modelled by fourier series (sin + cosine curves fit to data) [EXAMPLE HERE](#)
 - Day of year
 - Also modelled by fourier series
 - Day of week
 - Modelled by 'dummy' variables (aka 'categorical variables' i.e. 1 or 0, *c.f.* regression)

Holidays

- Built in holidays and special events (UK, and overseas)
 - E.g. Christmas, Easter holidays or St Patrick's days
- But flexible and can handle any dates
 - Possible to add in your own
- Again modelled as dummy variables

Additional Regressors

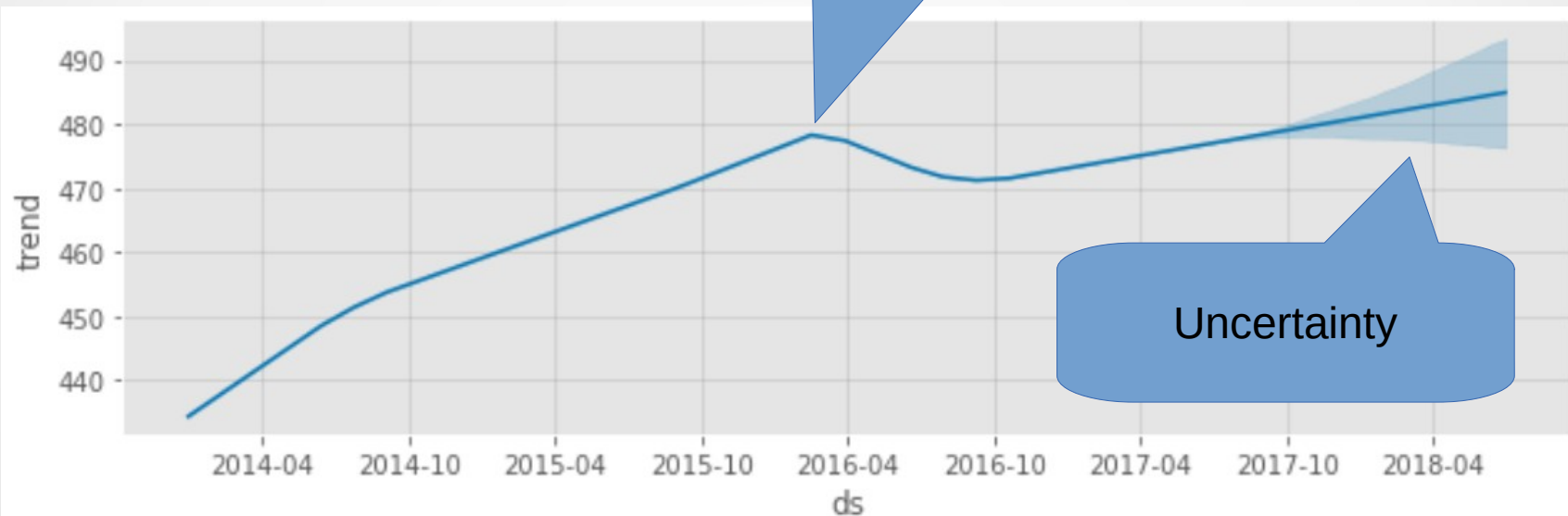
- The additive structure of Prophet actually allows for additional regressors
- In health this might include:
 - Weather
 - Air quality
 - Performance of other related health systems
 - Lagged combinations of the above

But always remember that to forecast you will need forecasts of your additional regressors! Not always straightforward

Outputs: Decomposition - Trend

Ambulance Data...

Not completely
linear



Uncertainty

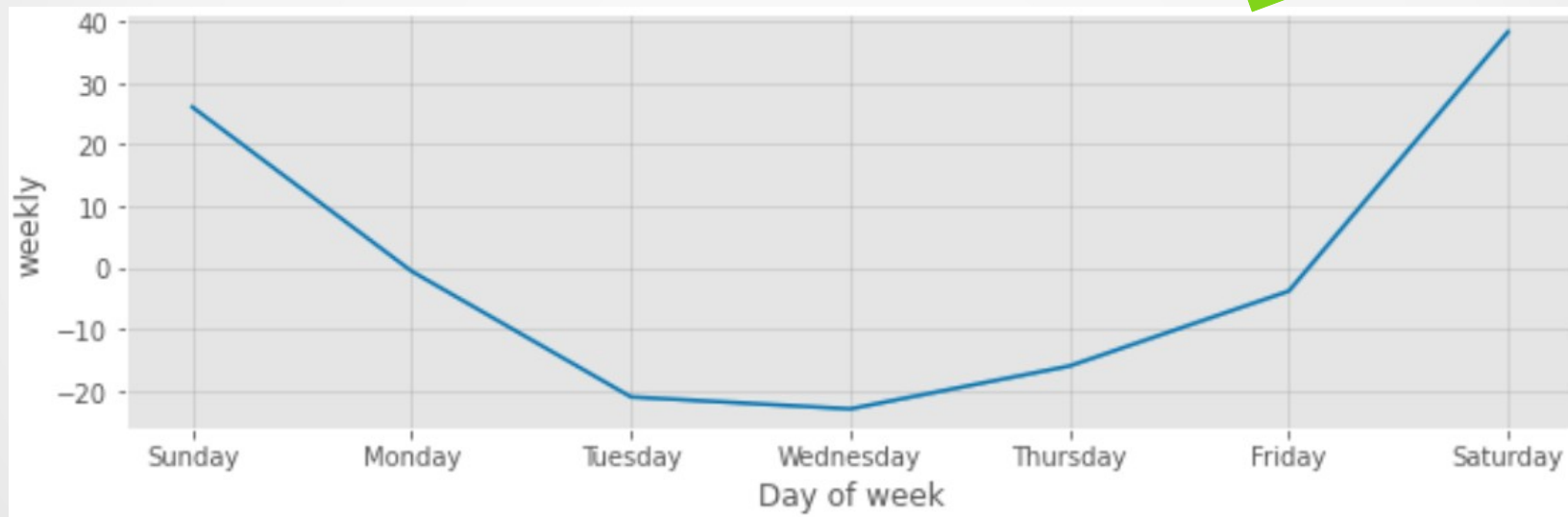
A smooth trend with little variable implies that it will be similar in the future...

Smooth trend reduces uncertainty.

Where there lots of change points then you'll see a wider PI

Outputs: Decomposition – DoW Seasonality

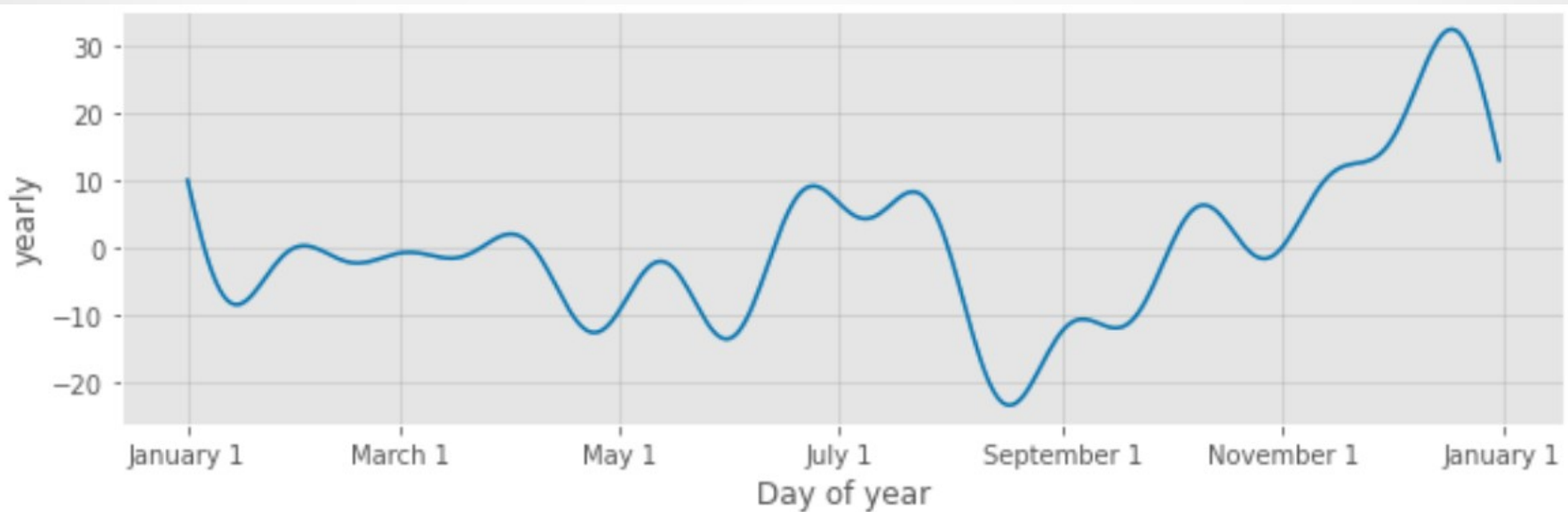
Dummy variables fitted to the model



Remember our Box Plots by Day of Week? Weekends compared to mid week

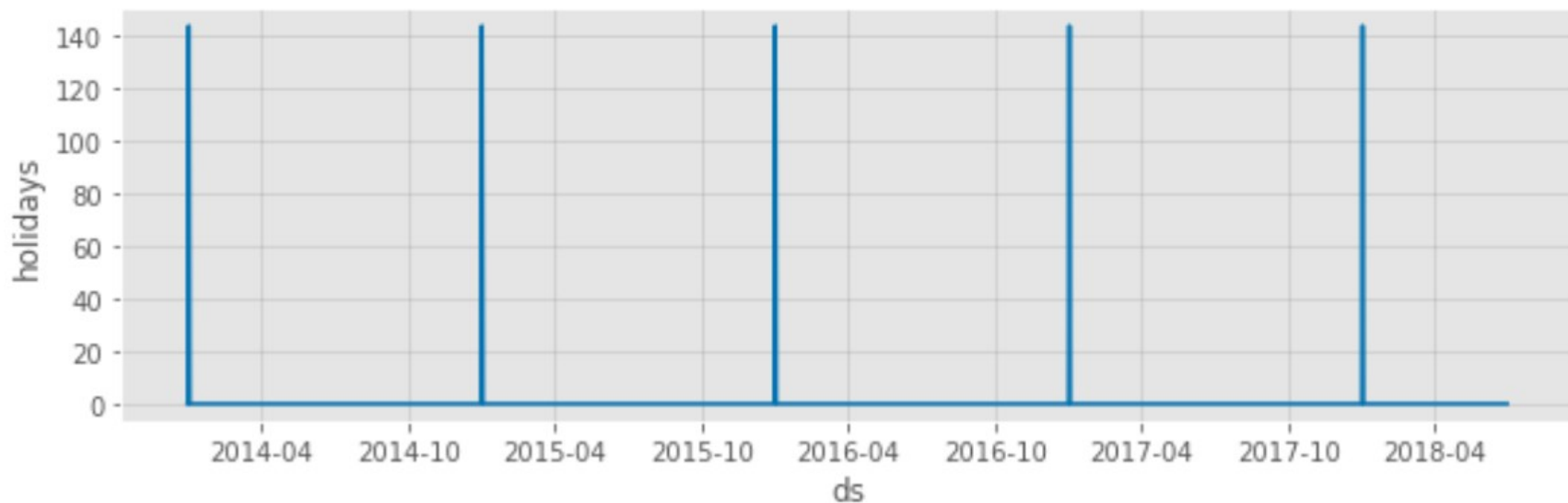
Outputs: Decomposition – Monthly Seasonality

Fitted by pairs of sin & cos waves (fourier series)



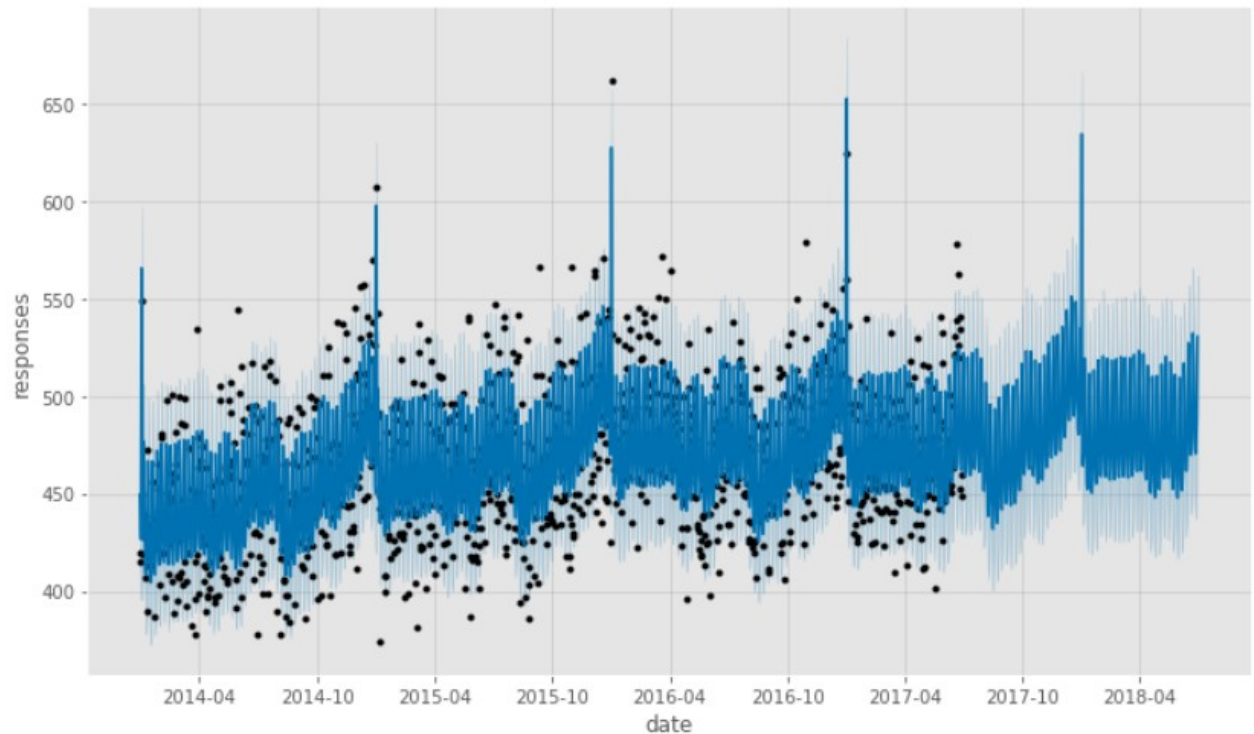
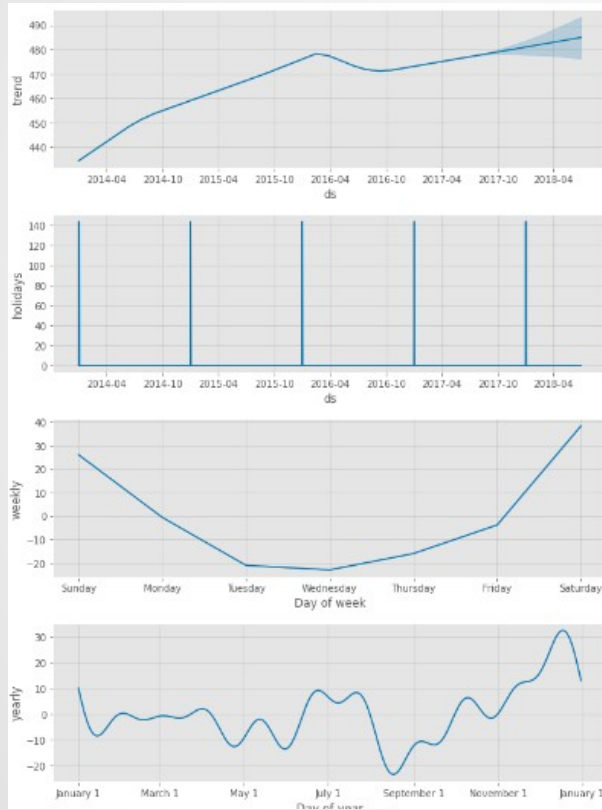
Outputs: Decomposition – Holidays

New Years Days are
+140 calls extra



Prophet applied to Ambulance Example

Lets see it in a lab...



Fitted Model

Forecast

Lets see some code...

We'll now look at three code along notebooks

- Data preprocessing
- Building a basic Prophet model
- Adding holidays and special events

This will be followed by a 15 minute comfort break.

...Before attempting Practical in your PSGs