Forecasting disease from univariate time series using naive, ARIMA, exponential smoothing, additive regression, and LSTM models

Client summary

Capstone project for
Springboard Data Science Career Track

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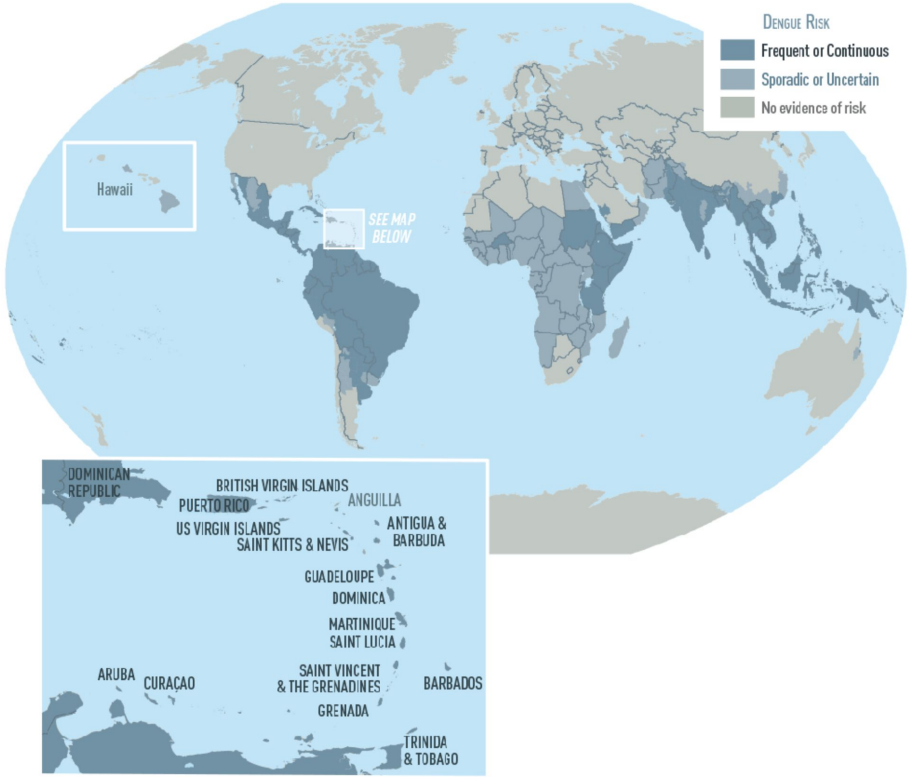
Challenge: Create a multi-year forecast of dengue fever



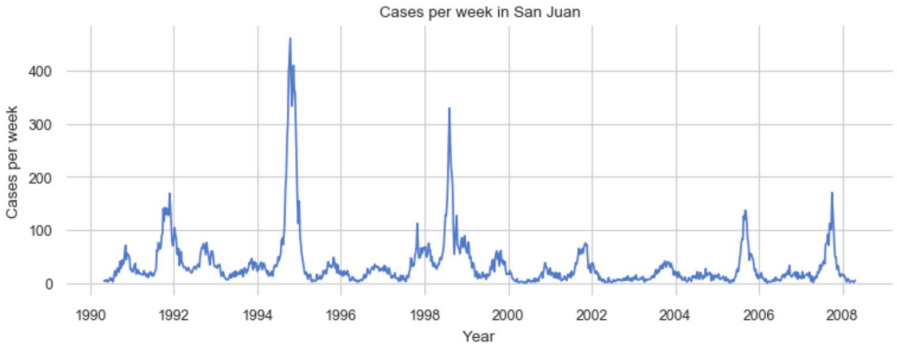
Data: Univariate time series of weekly cases

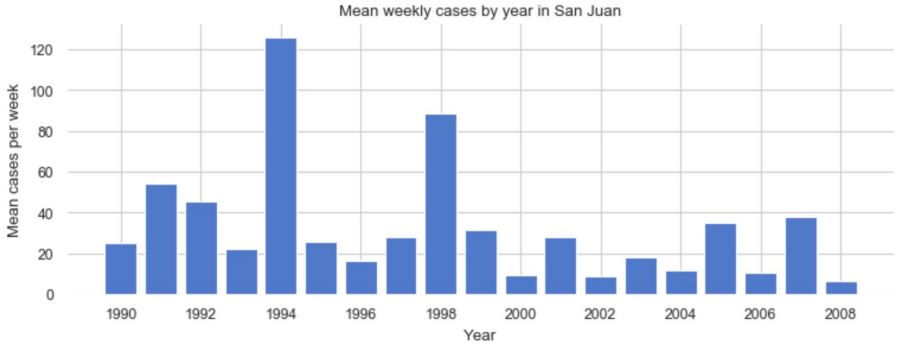
DRIVENDATA

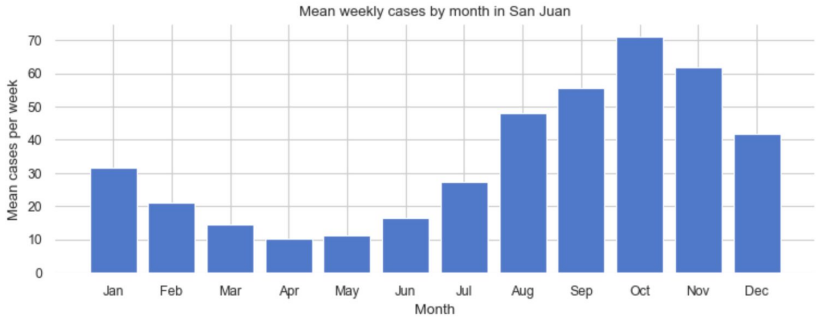
San Juan, Puerto Rico

Iquitos, Peru

Explore: Spikes, slight downward trend and strong seasonality

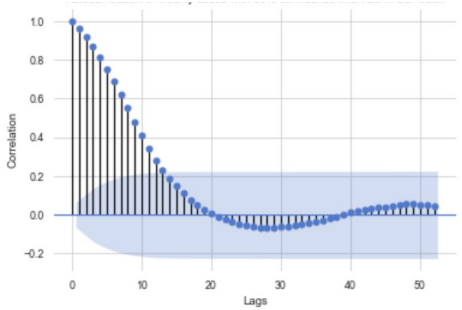




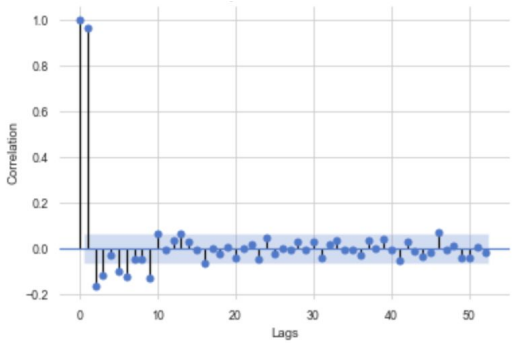


Explore: Time series statistics

- Strong autocorrelation
- Lack of stationarity



Autocorrelation of weekly cases
with 95% confidence interval in San Juan



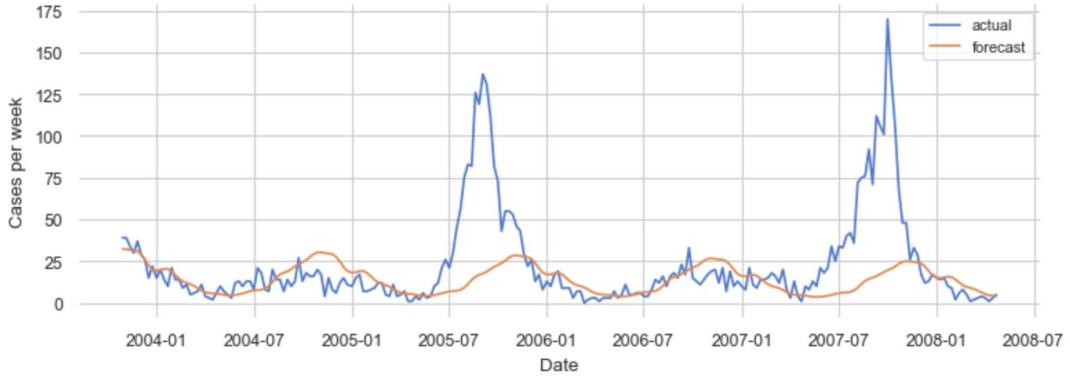
Partial autocorrelation of weekly cases
with 95% confidence interval in San Juan

Models: Additive regression on log-transformed data is best

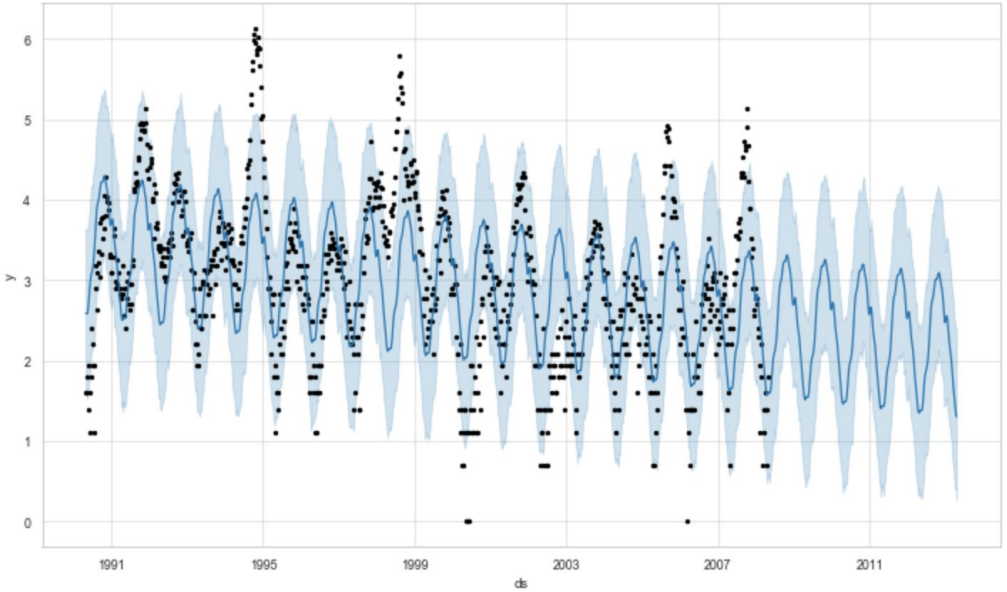
Performance of top-10 models and variations, ranked by MAE, for San Juan

Approach	Summary	Transform	RMSE	MAE	Rank
Additive Regression	Stabilized Trend	Log (x+1)	28.70	14.59	1
Additive Regression	Cap and Floor	Log (x+1)	29.94	14.64	2
Exponential Smoothing	Seasonal ES, a=.5, b=.1, g=0, optimized	Log (x+1)	26.54	15.54	3
ARIMA	SARIMAX (2, 1, 2) x (2, 0, 1, 52)	Log (x+1)	26.61	15.85	4
Exponential Smoothing	Seasonal ES, a=.9, b=.8, g=.1, optimized	None	28.60	17.14	5
ARIMA	SARMIAX (3, 1, 2) x (0, 0, 0, 52)	None	29.48	18.71	6
Exponential Smoothing	Simple ES, a=0	None	34.12	19.09	7
Additive Regression	Stabilized Trend	None	29.20	20.05	8
Naive	Seasonal Naive Method	None	35.95	21.34	9
LSTM	ConvLSTM	Log (x+1)	34.29	21.36	10

Actual and forecast of an additive model using Facebook Prophet with “stabilized trend” arguments on log-transformed test data for San Juan



Final forecast



Facebook Prophet's visualization of the final forecast on a log(x+1) scale for San Juan

Example forecast value:

- Week of August 19, 2008, which is 6 months into forecast period
- Forecast value is 26 cases
- An 80% constant confidence interval
  - Lower bound is 9 cases
  - Upper bound is 72 cases

Lessons and improvements

Lessons from modeling:

- Importance of well-transformed data
- Connection between data and model
- Limits of univariate data
- LSTM’s lack of success

Improvements:

- Better understand business context and domain
- Refine forecast horizon
- Explore additional time-series models
- Leverage multivariate data
- Explicitly predict spikes