BAX 442 001 002 - Advanced Statistics - Homework 7
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# HOLT WINTER TIME SERIES MODEL

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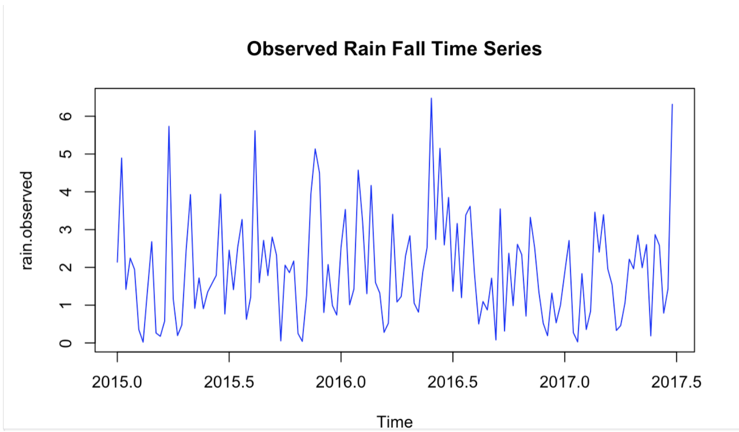
**Objective:**

The purpose of this homework is to apply Holt-Winters forecasting to analyze a weather time series. This involves extracting level, trend, and seasonality components and making forecasts for future periods.

**1. Selection of Weather Time Series**

We selected the variable avg_rainfall_level from data_week.csv for analysis. This variable represents weekly observed rainfall over a given period. The data was converted into a time series object with a frequency of 52 (weekly observations) starting from the year 2015.



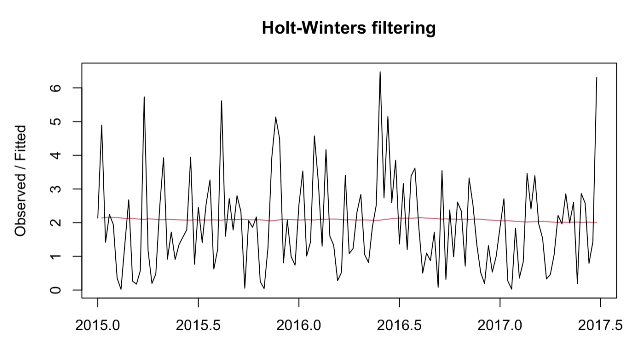

**2. Holt-Winters Model Combinations**

We applied the Holt-Winters method with four different configurations of trend (beta) and seasonality (gamma):

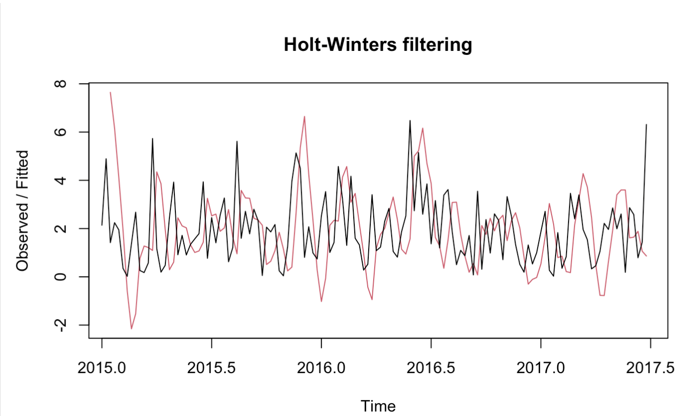
1. **Model 1:** No trend, no seasonality (alpha only)
2. **Model 2:** Trend included, no seasonality (alpha + beta)
3. **Model 3:** Seasonality included, no trend (alpha + gamma)
4. **Model 4:** Both trend and seasonality included (alpha + beta + gamma

Here's a brief explanation of each model:

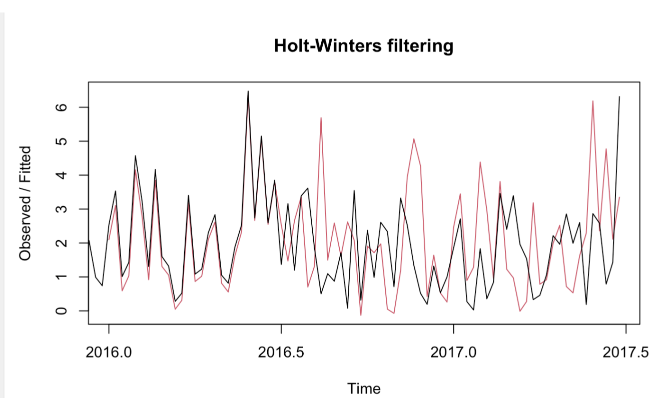
1. **Model 1: No trend, no seasonality (alpha only)**
   - This is a simple exponential smoothing model.
   - It assumes that the time series has no trend or seasonal pattern, only a level that gets updated over time.



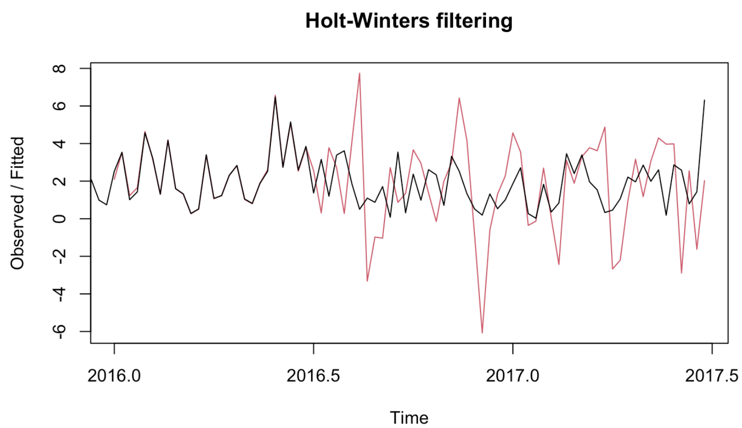

2. **Model 2: Trend included, no seasonality (alpha + beta)**
    - This is Holt's Linear Trend Model.
    - It accounts for both the level (alpha) and a linear trend (beta).
        i. It's useful when the data exhibits an increasing or decreasing trend over time but has no seasonal variations.



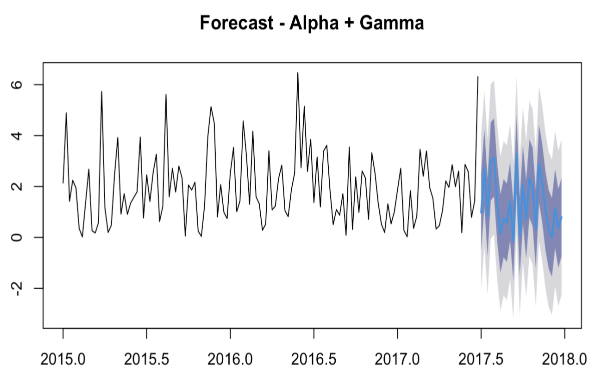

3. **Model 3: Seasonality included, no trend (alpha + gamma)**
    - This is the Holt-Winters Seasonal Model without trend.
    - It captures the level (alpha) and seasonal variations (gamma), but it assumes no consistent trend in the data.

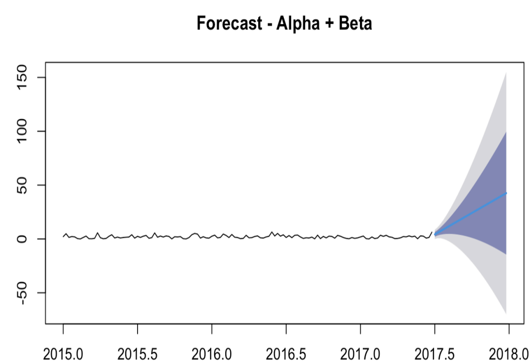


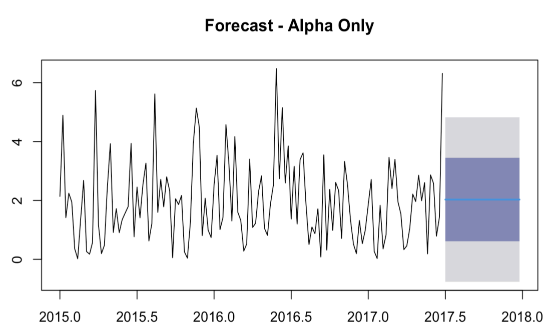
4. **Model 4: Both trend and seasonality included (alpha + beta + gamma)**
    - This is the full Holt-Winters Model, also known as the Triple Exponential Smoothing model.
    - It includes level (alpha), trend (beta), and seasonality (gamma).
    - This model is best suited for time series with both a trend and a repeating seasonal pattern, making it the most flexible among the four.

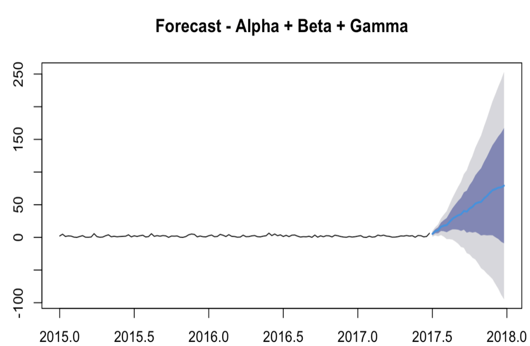



## 4. Predictions and best Model selection



| Model <chr> | AIC <dbl> | BIC <dbl> |
|---|---|---|
| Alpha Only | 468.2576 | 479.7277 |
| Alpha + Beta | 571.5104 | 582.9806 |
| Alpha + Gamma | 422.3119 | 433.7820 |
| Alpha + Beta + Gamma | 513.5700 | 525.0401 |

4 rows

When comparing models using AIC (Akaike Information Criterion) and BIC (Bayesian Information Criterion), lower values are preferred. Both AIC and BIC are used for model selection, where:

- **AIC** is designed to measure the relative quality of a statistical model, balancing the goodness of fit with model complexity (penalizing extra parameters).
- **BIC** is similar to AIC but applies a stronger penalty for complexity, particularly for large datasets.

In the table above:

- The **Alpha + Gamma** model has the lowest AIC (422.3119) and BIC (433.7820) values compared to the other models.
- The **Alpha Only** model has the second-lowest AIC (468.2576), but its BIC (479.7277) is higher, suggesting it might not be as good a choice for complex data.
- The **Alpha + Beta** and **Alpha + Beta + Gamma** models have higher values, meaning they have more parameters but don't improve the fit significantly compared to Alpha + Gamma.

Thus, **Alpha + Gamma** strikes the best balance between fit and complexity, as it has the lowest AIC and BIC values.

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