# Price of basic necessities in relation to the climate in Delhi

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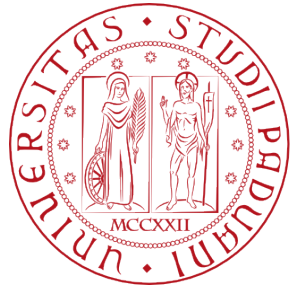


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# Objective



- Improving forecasts about the price of goods using weather analysis. Specifically:
  1. Studying and modelling the time series of the Delhi climate
  2. Make first forecasts about the price of goods
  3. Combing the two analysis

# Outline

# Climate factors in Delhi



Monsoon


Sand Storm

Himalaya

Thar Desert

# Climate factors in Delhi



| Season | Months | Properties |
|---|---|---|
| Spring | February, March | warm days, cool nights, pleasant; low to moderate humidity; moderate precipitation |
| Summer | April, May, June | **hot to very hot**; very low to moderate humidity; **low precipitation** |
| Monsoon | July, August, September | hot, pleasant during rains; **high to very high humidity**; **heavy precipitation** |
| Autumn | October, November | warm days, cool nights, pleasant; low humidity; low precipitation |
| Winter | December, January | cool days, cold nights; moderate humidity; medium precipitation |

# Climate factors in Delhi

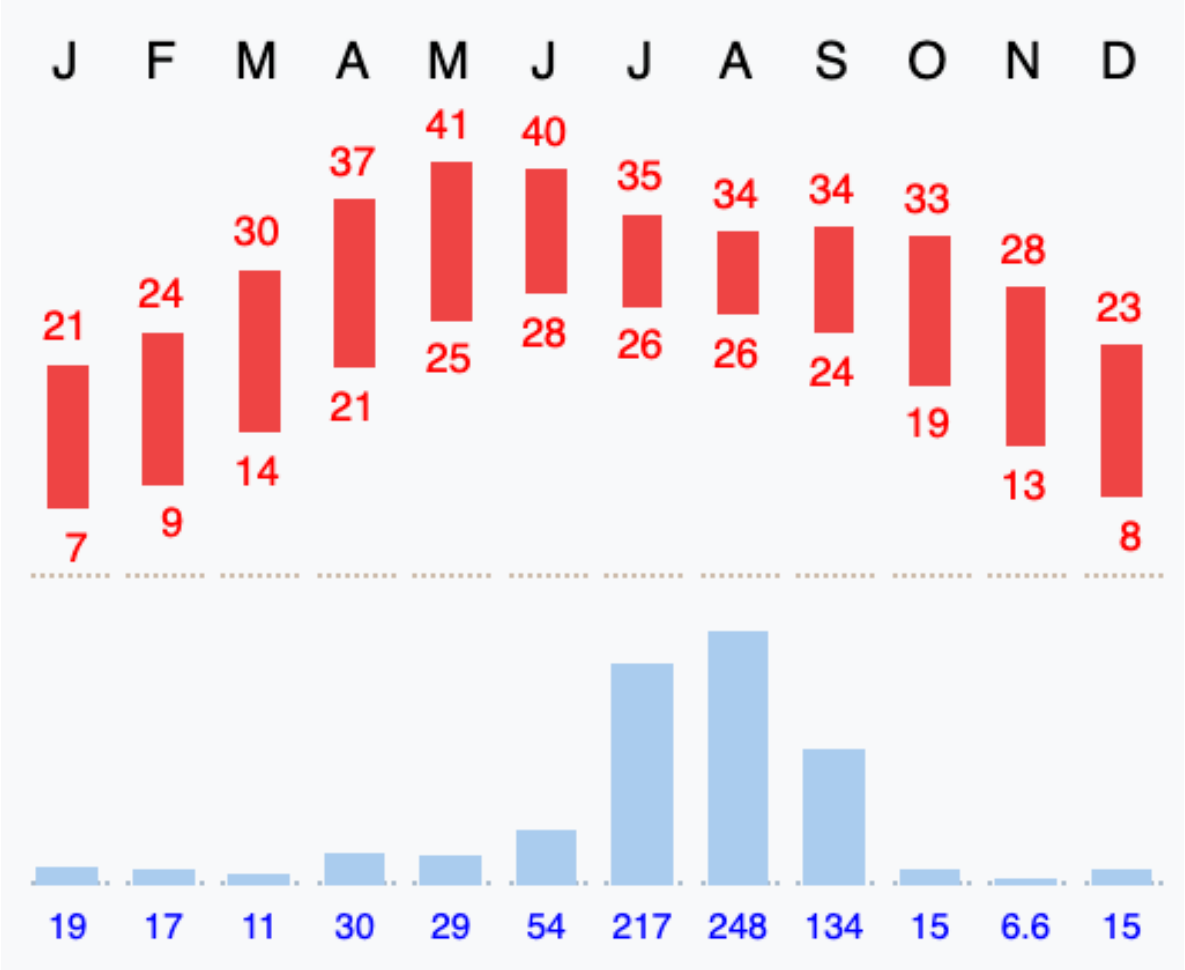



Figure: Average max. and min. temperatures in ℃ and Precipitation totals in mm

# Overview of the dataset

| Time series | Unit | Time step | Mean | St. dev. |
|---|---|---|---|---|
| Temperature | ° C | 1 day | 25.47 | 7.36 |
| Humidity | % | 1 day | 60.77 | 16.78 |
| Wind Speed | Km/h | 1 day | 6.80 | 4.57 |
| Pressure | hPa | 1 day | 1008.27 | 7.44 |
| Potatoes | ₹ | 1 month | 18.51 | 4.42 |
| Rice | ₹ | 1 month | 210.24 | 18.16 |
| Onions | ₹ | 1 month | 26.50 | 11.56 |

Table: Overview of the dataset

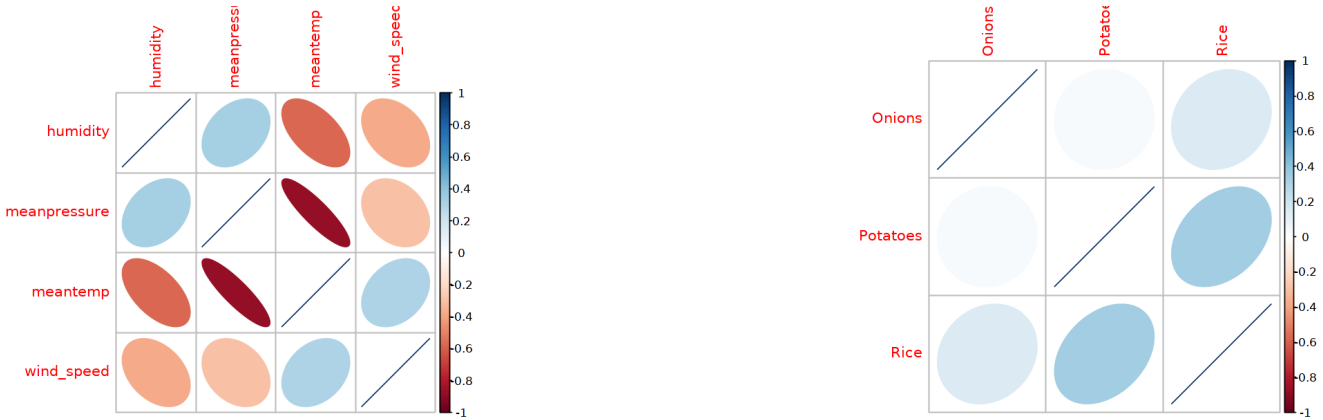



Figure: Correlations matrices between time series

# Weather time series - Data Plot



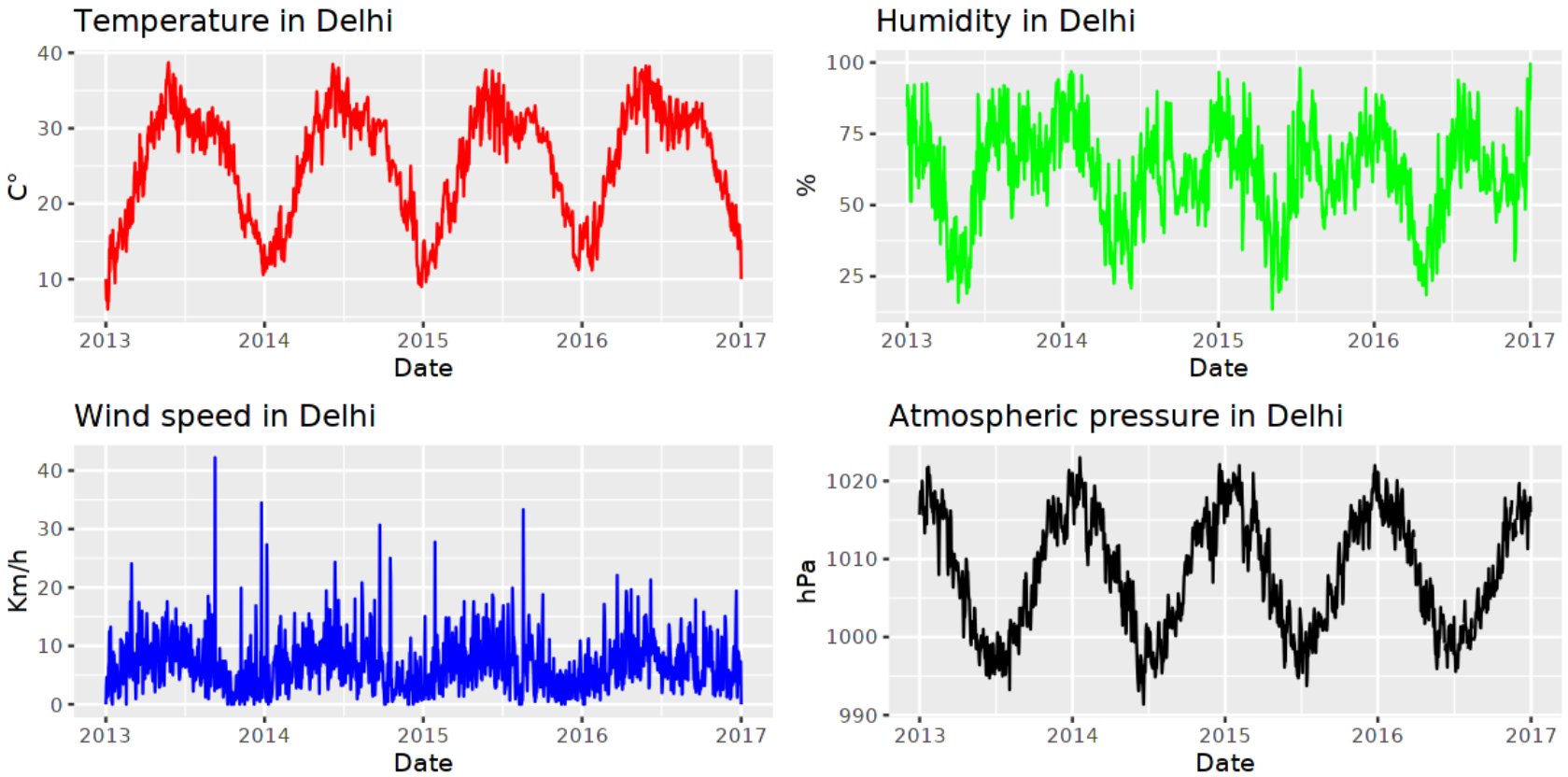



Figure: Data collected from 1st January 2013 to 31th December 2016 in the city of Delhi, India.

# Weather time series - ACF

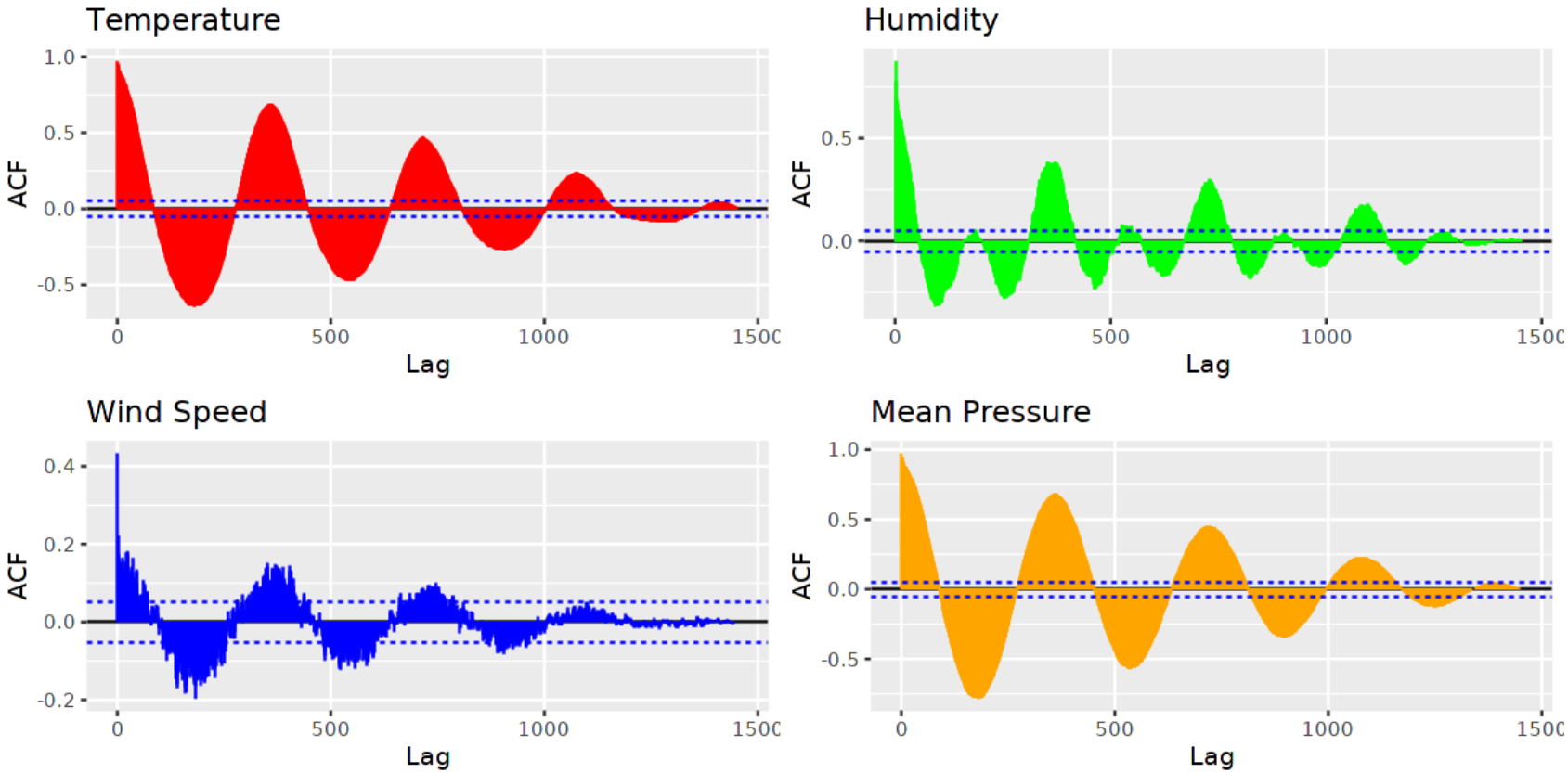



Figure: Autocorrelation functions of the weather time series

# Models



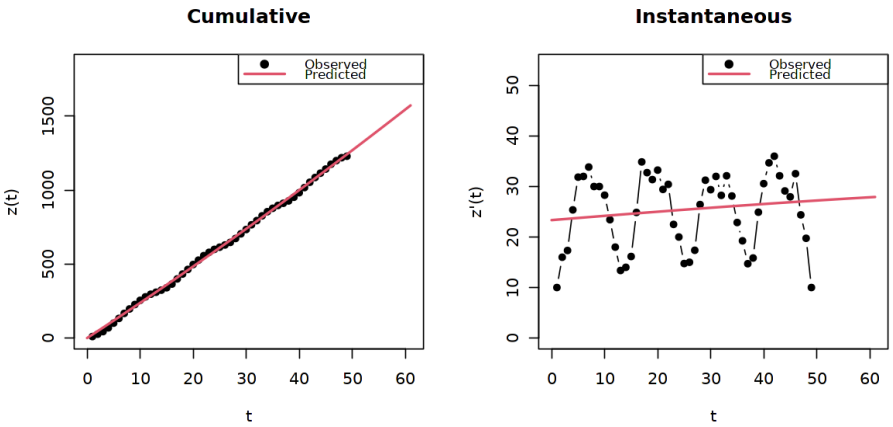
We are going to use the following models:

- Bass Model
- Linear Regression
- Generalized Additive Model (GAM)
- ARIMA Model

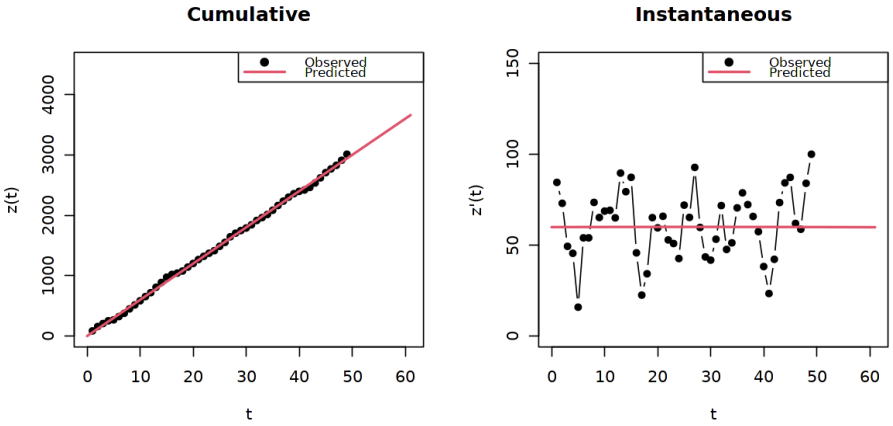
# Bass Model - Weather



## Temperature




## Pressure




- This is not a diffusion process
- There are no Innovators or Imitators
- There is no market cap
- We are fitting through the seasonal trend

## Model with trend and seasonality

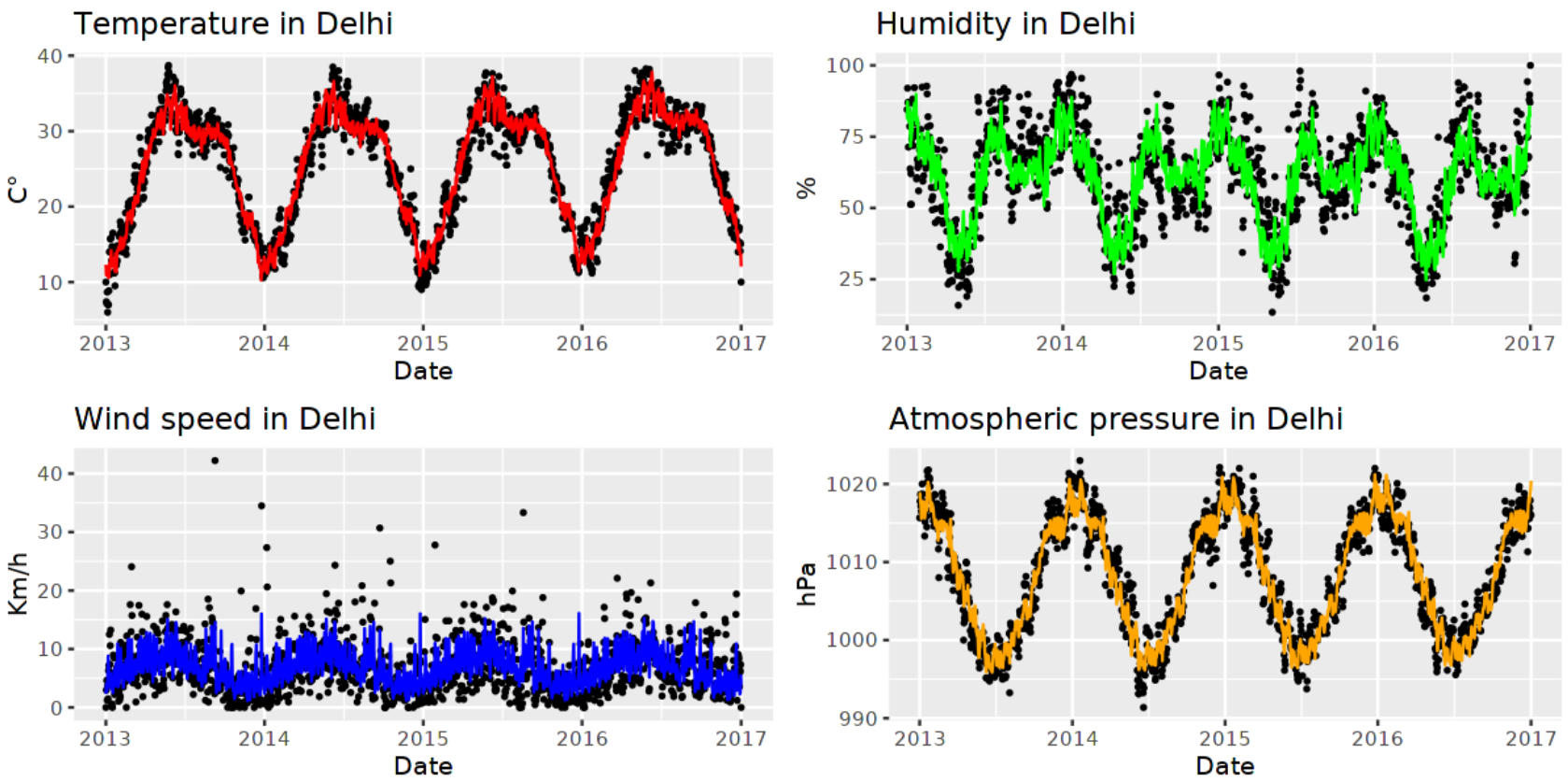



Figure: Linear Regression

# Linear Regression - Weather

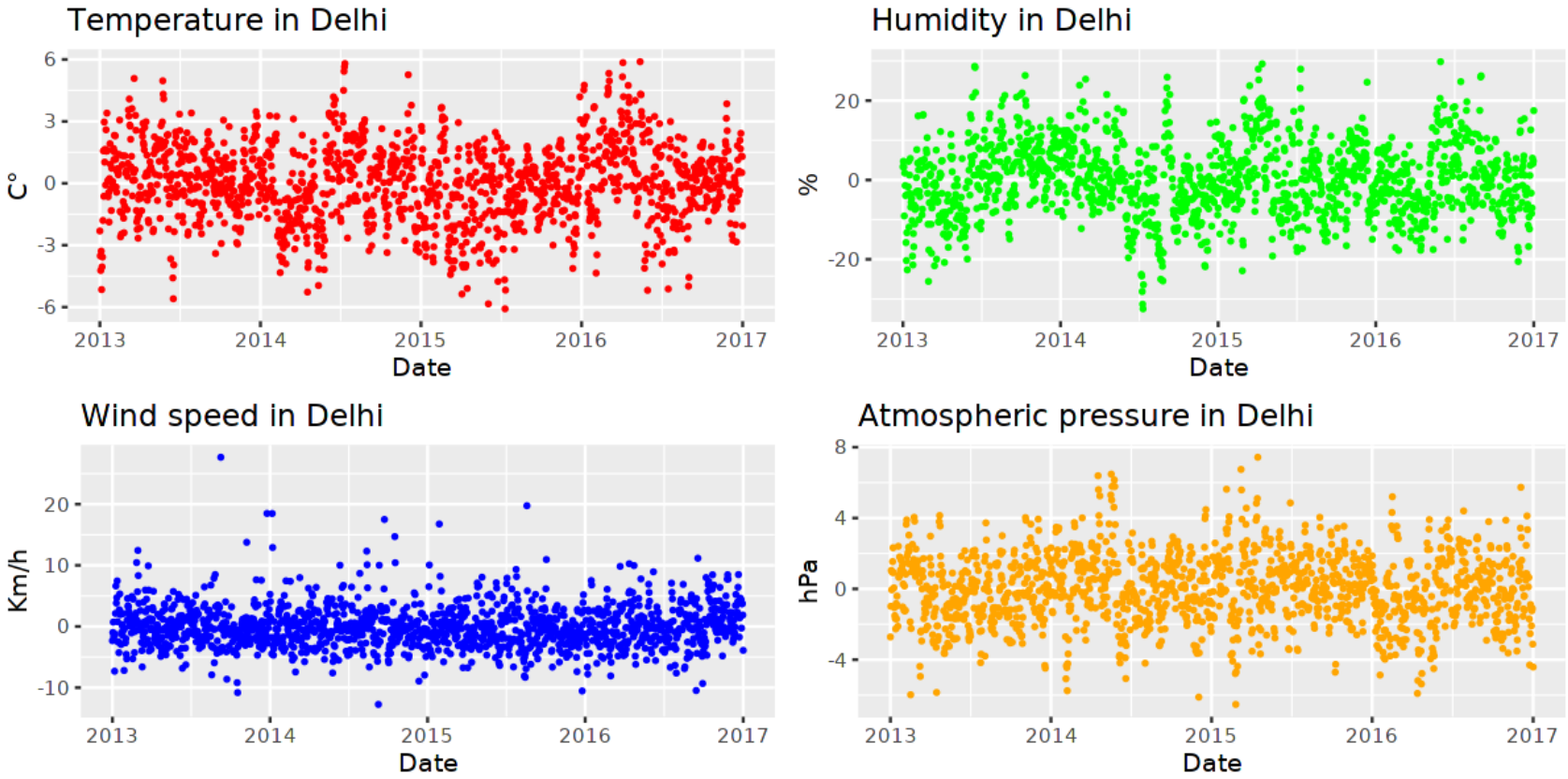



Figure: Linear Regression Residuals

# Linear Regression - Autocorrelation



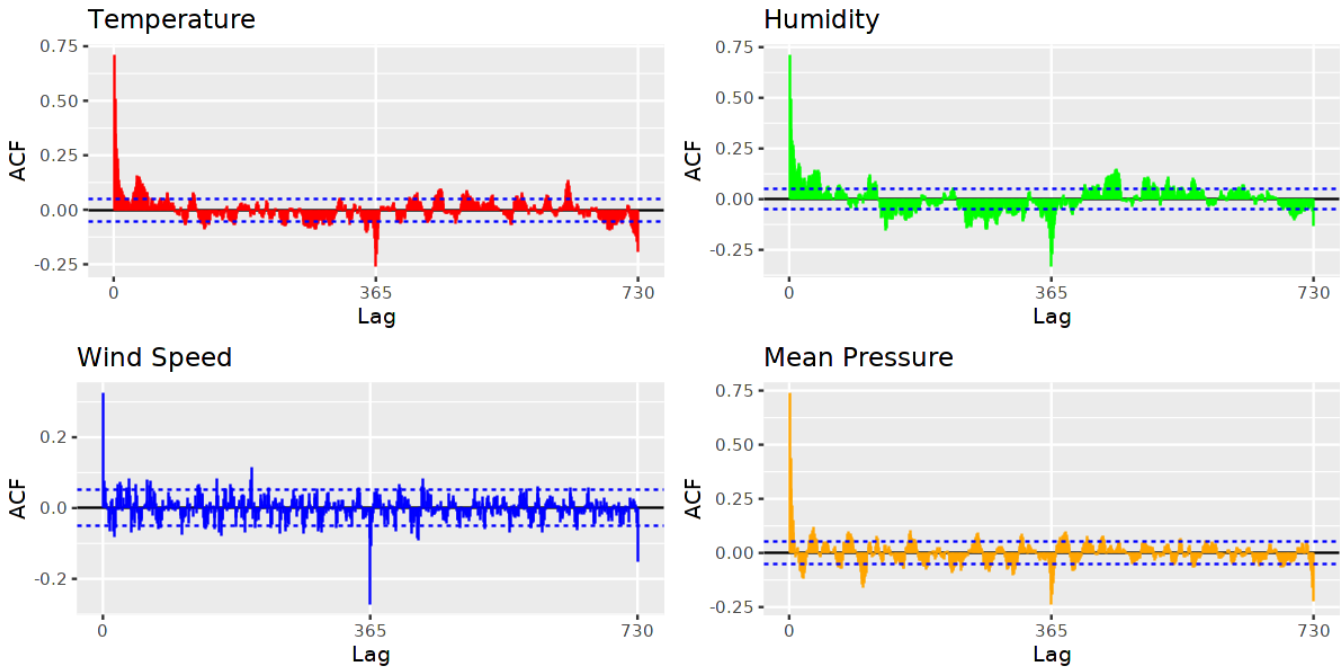



Table: Durbin Watson test results with alternative hypothesis: true autocorrelation is not 0

| | DW | p-value |
|---|---|---|
| Temperature | 0.57772 | $< 2.2 \cdot 10^{-16}$ |
| Humidity | 0.57421 | $< 2.2 \cdot 10^{-16}$ |
| Wind Speed | 1.3483 | $< 2.2 \cdot 10^{-16}$ |
| Pressure | 0.51699 | $< 2.2 \cdot 10^{-16}$ |

# Linear Regression - Weather

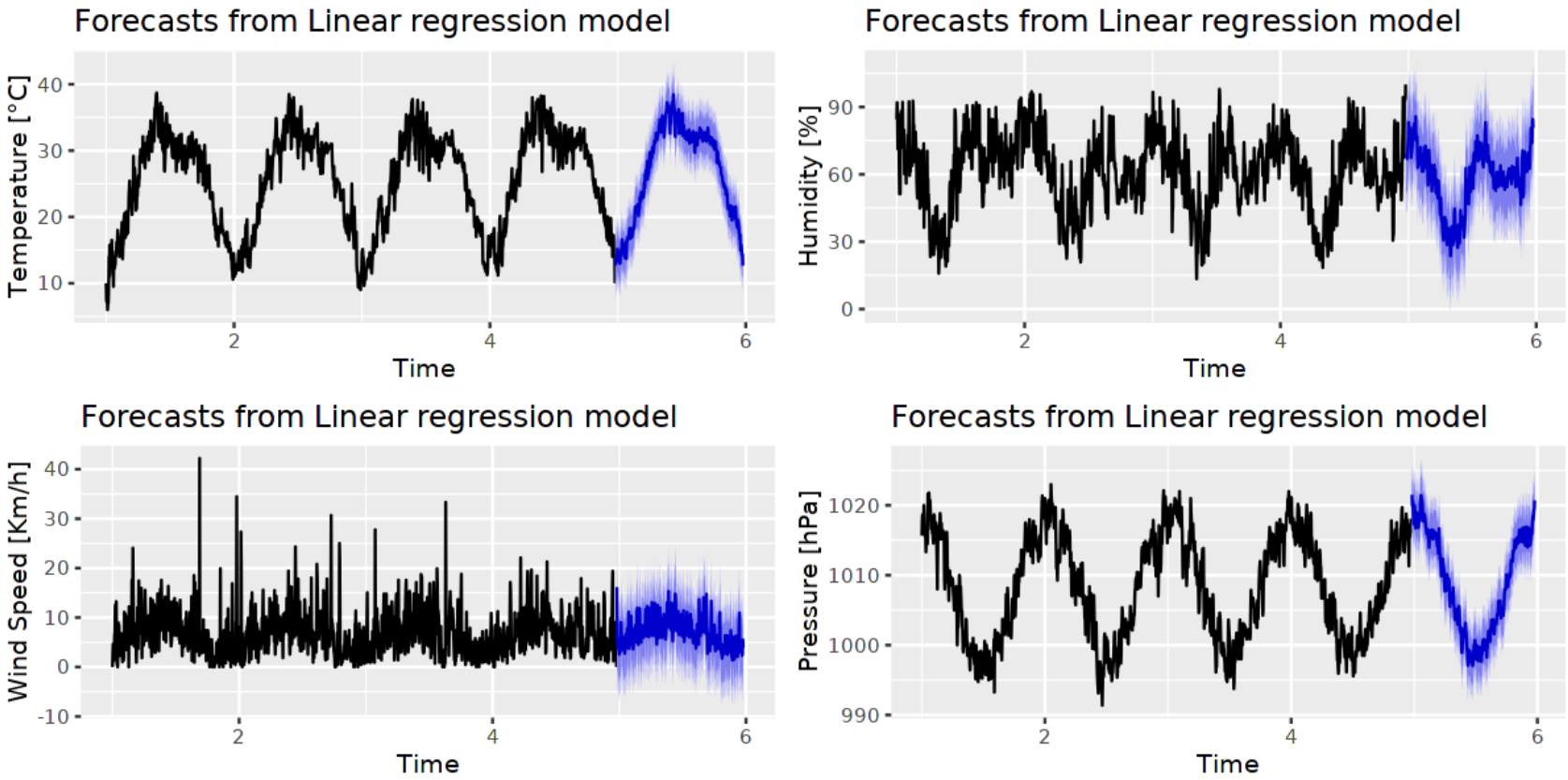



Figure: Linear Regression forecasts

# ARIMA Models - Weather

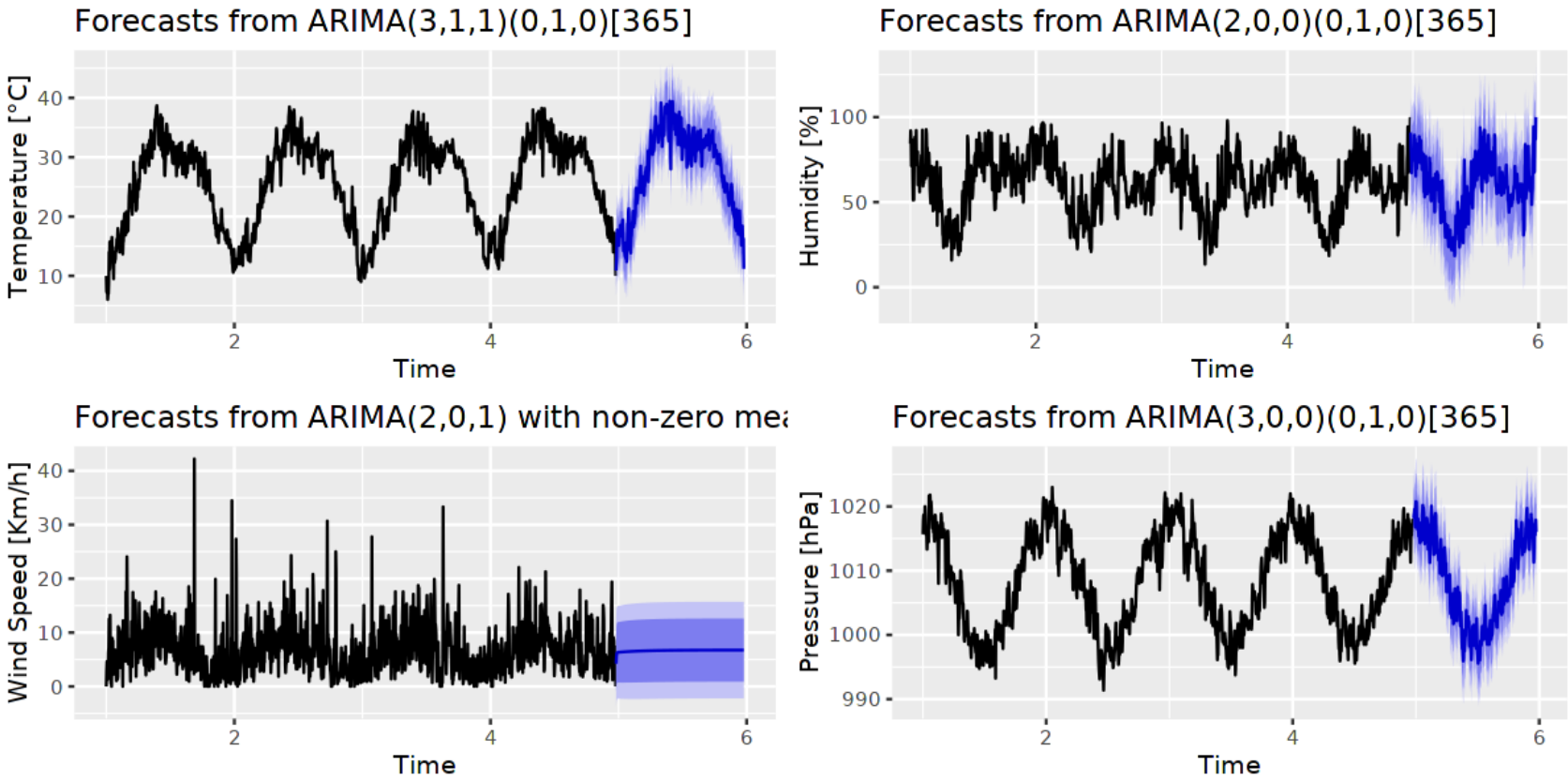
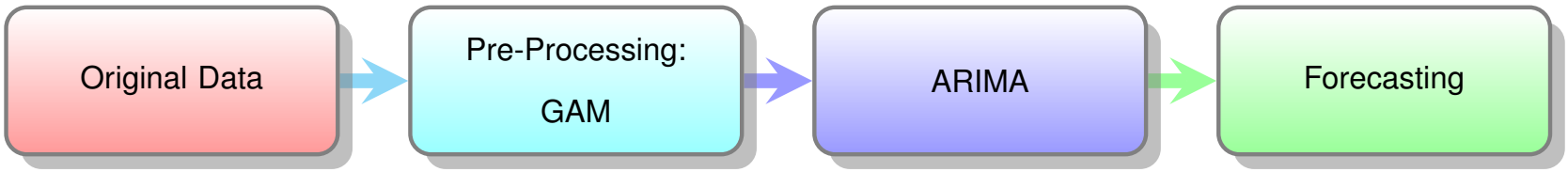



Figure: Forecast with ARIMA on original data

# Preprocessing

Without a **pre-processing** the `auto.arima` function is not able to perform a good forecasting on the wind speed.




GAM: we investigate the **dependecies** of each time series on the others and on the time+seasonality and then **add** all the **contributions**.

# GAM - Weather

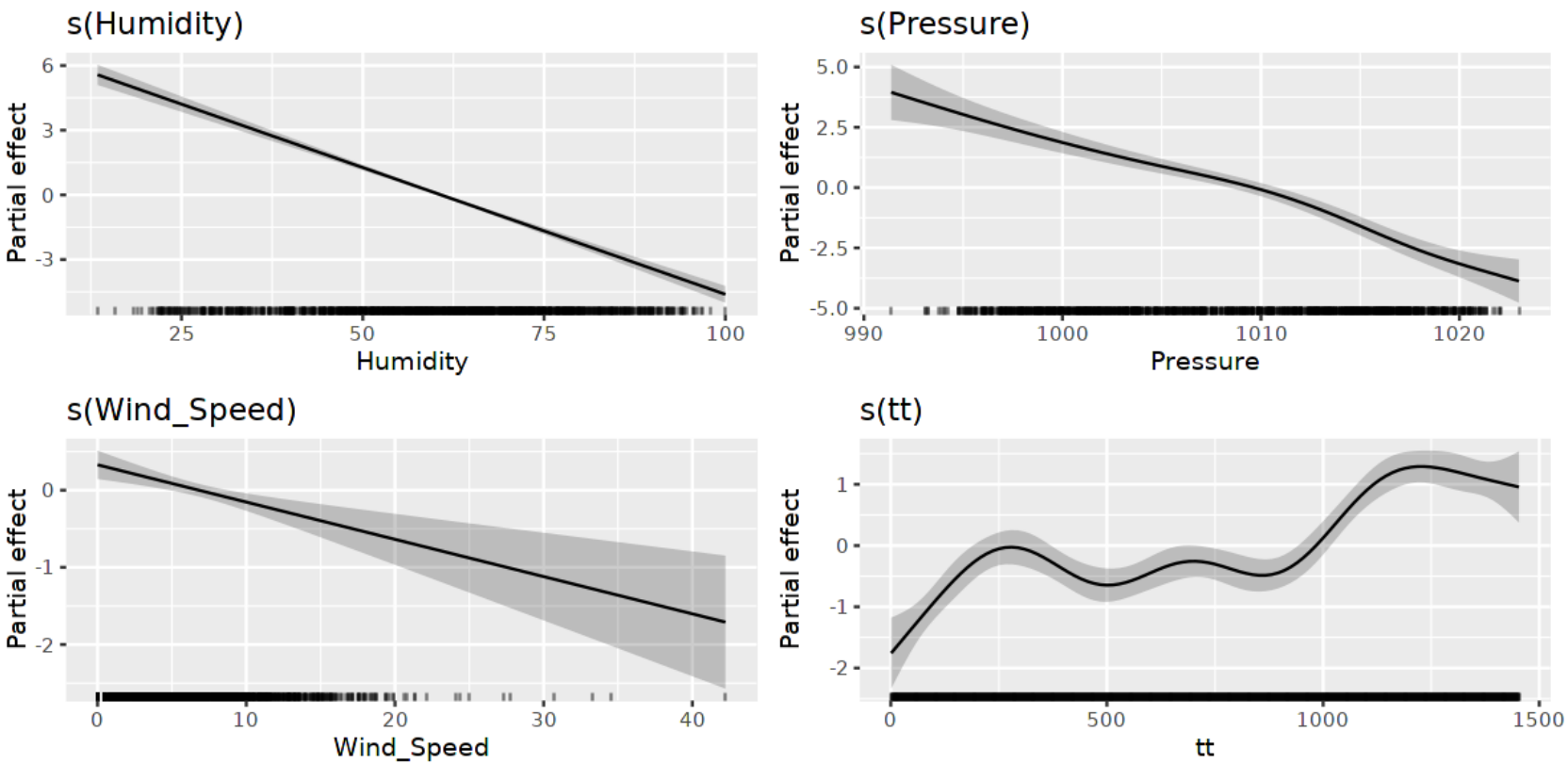



Figure: Generalized Additive Model on the temperature time series

# GAM - Weather



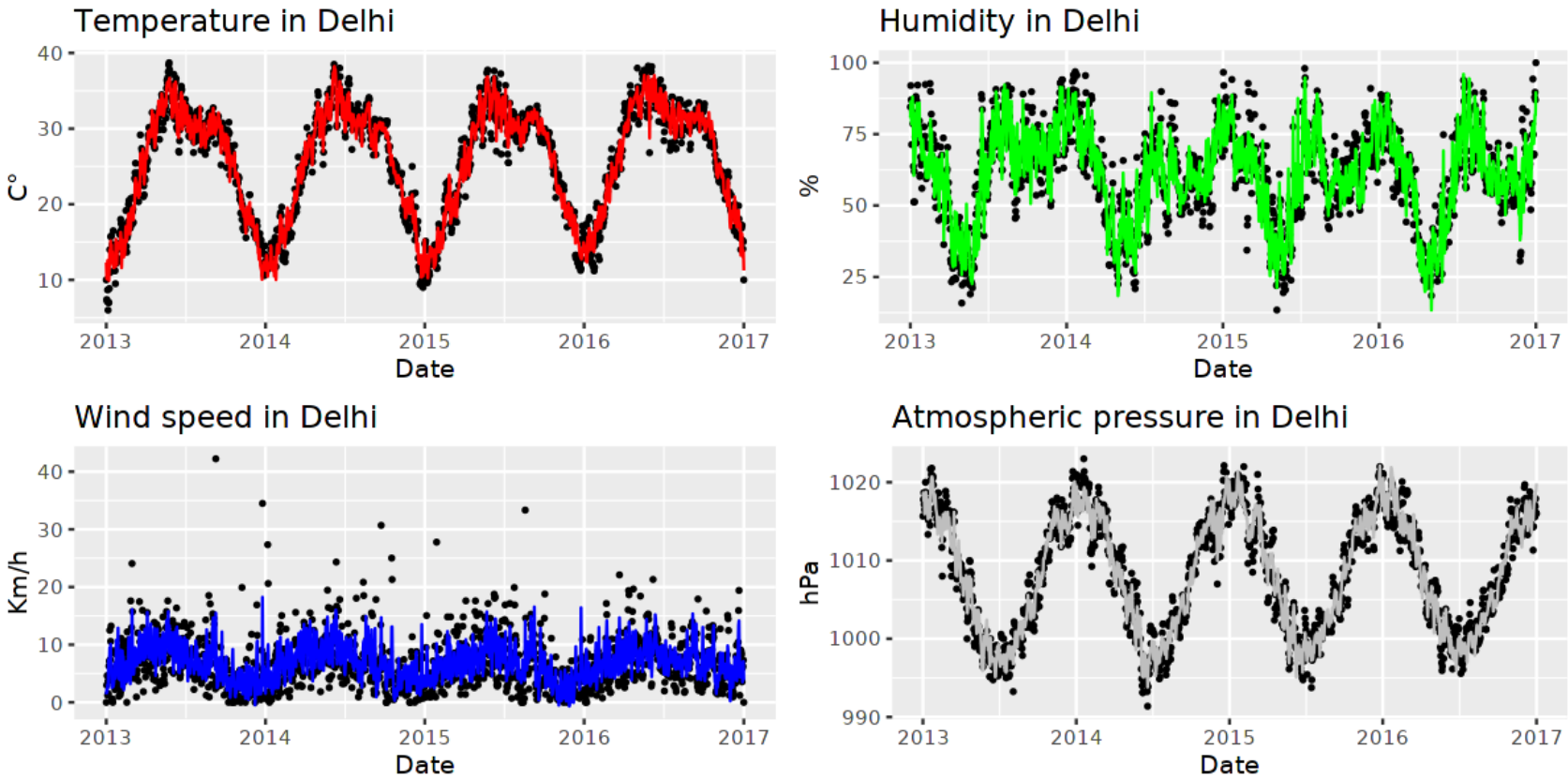



Figure: Time series with GAM regression

# ARIMA Models - Weather

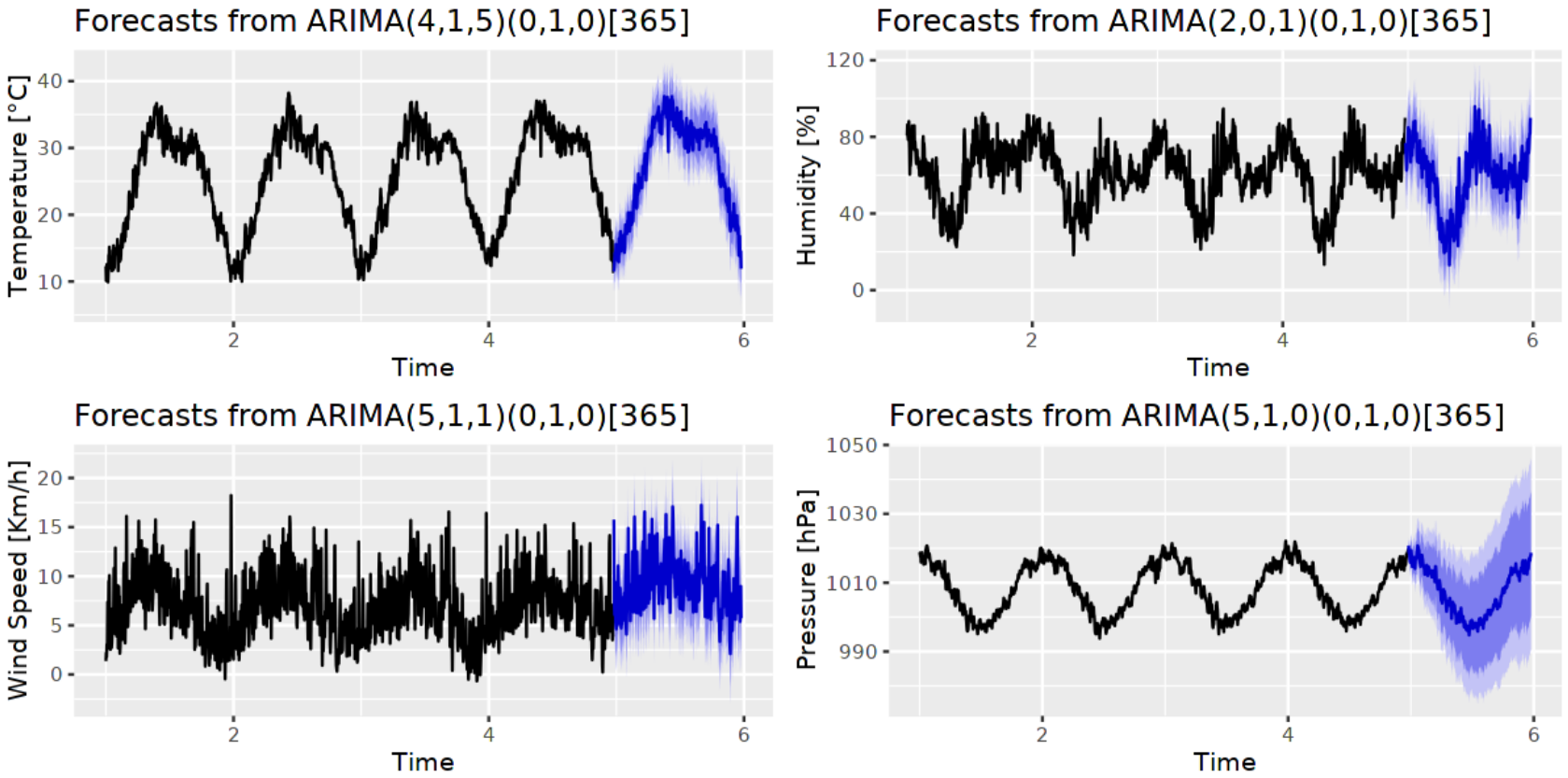



Figure: Forecast with ARIMA on GAM data

# ARIMA Models - Weather



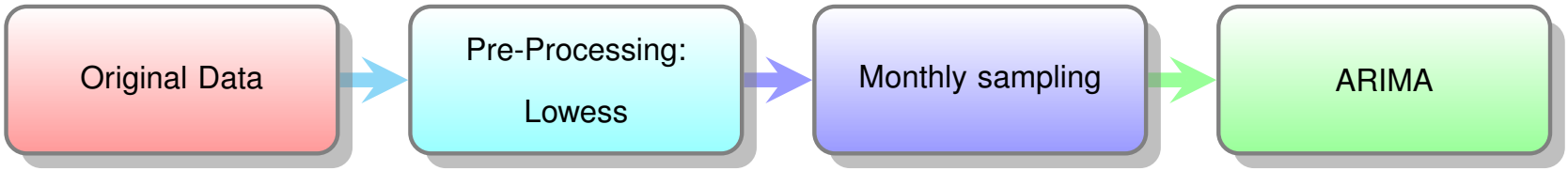
| Series | Model | ME | RMSE | MAE | ACF1 |
|---|---|---|---|---|---|
| Temperature | Linear Regression | 1.002 | 1.611 | 1.271 | .381 |
| | ARIMA | .684 | .842 | .743 | .572 |
| | ARIMA GAM | .574 | .622 | .695 | .465 |
| Humidity | Linear Regression | -3.686 | 9.132 | 7.026 | .239 |
| | ARIMA | -1.365 | 1.956 | 1.469 | .389 |
| | ARIMA GAM | .298 | .894 | .752 | .471 |
| Wind | Linear Regression | .434 | 4.321 | 3.559 | .064 |
| | ARIMA | 4.241 | 12.654 | 9.245 | .098 |
| | ARIMA GAM | .125 | .789 | .645 | .158 |
| Pressure | Linear Regression | .772 | 2.055 | 1.710 | .497 |
| | ARIMA | .124 | 1.245 | .883 | .512 |
| | ARIMA GAM | .374 | .617 | .521 | .328 |

Table: Main statistics on forecasting on the test set

# Sampling



We have monthly data on goods prices so we need **monthly data**. Before **sampling**, we need to **smoothen** the daily records.




After doing a locally weighted regression we take the first day from each month.

# Lowess - Weather

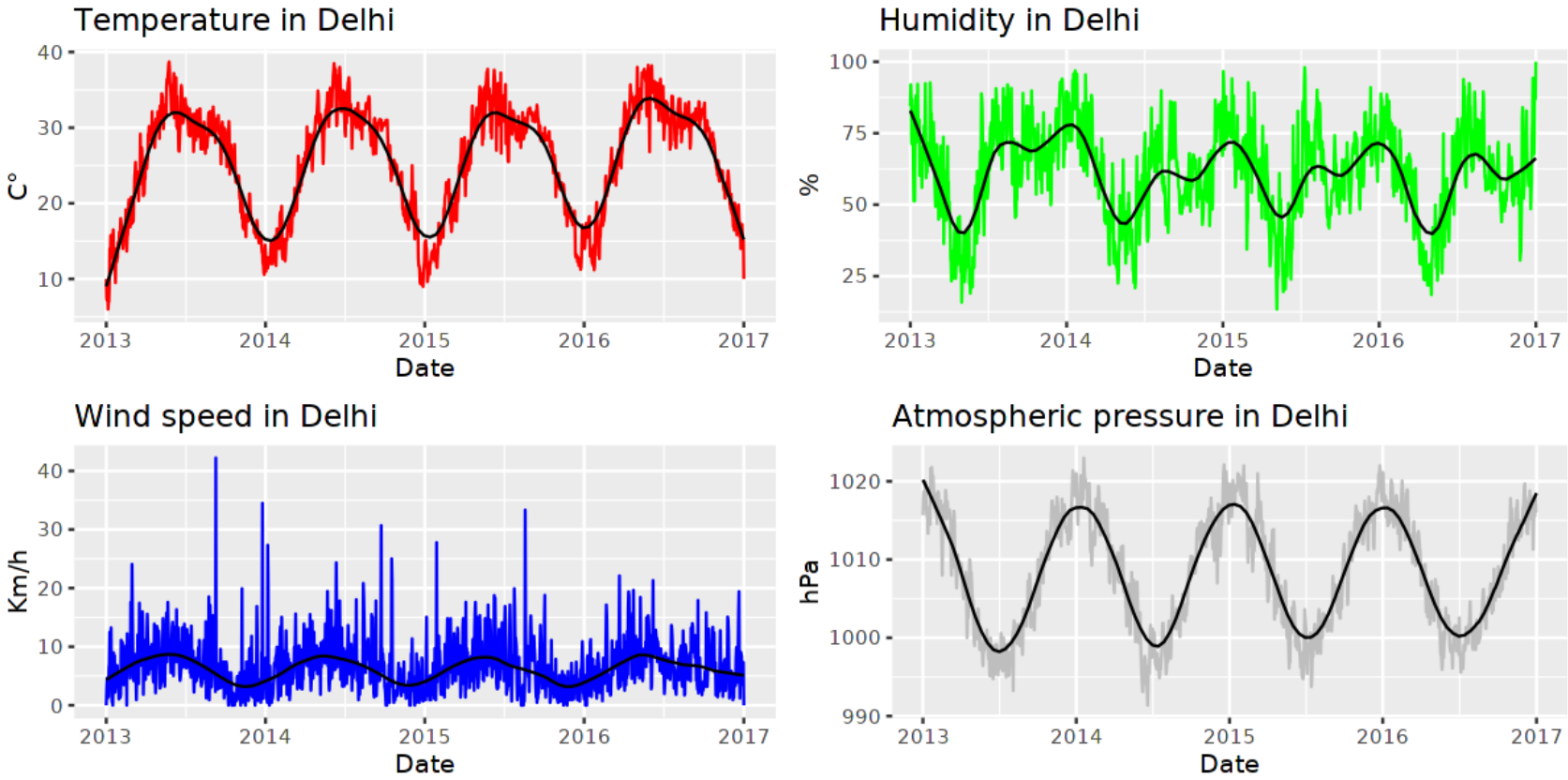



Figure: Original time series, with Locally Weighted Regression

# Lowess - Weather

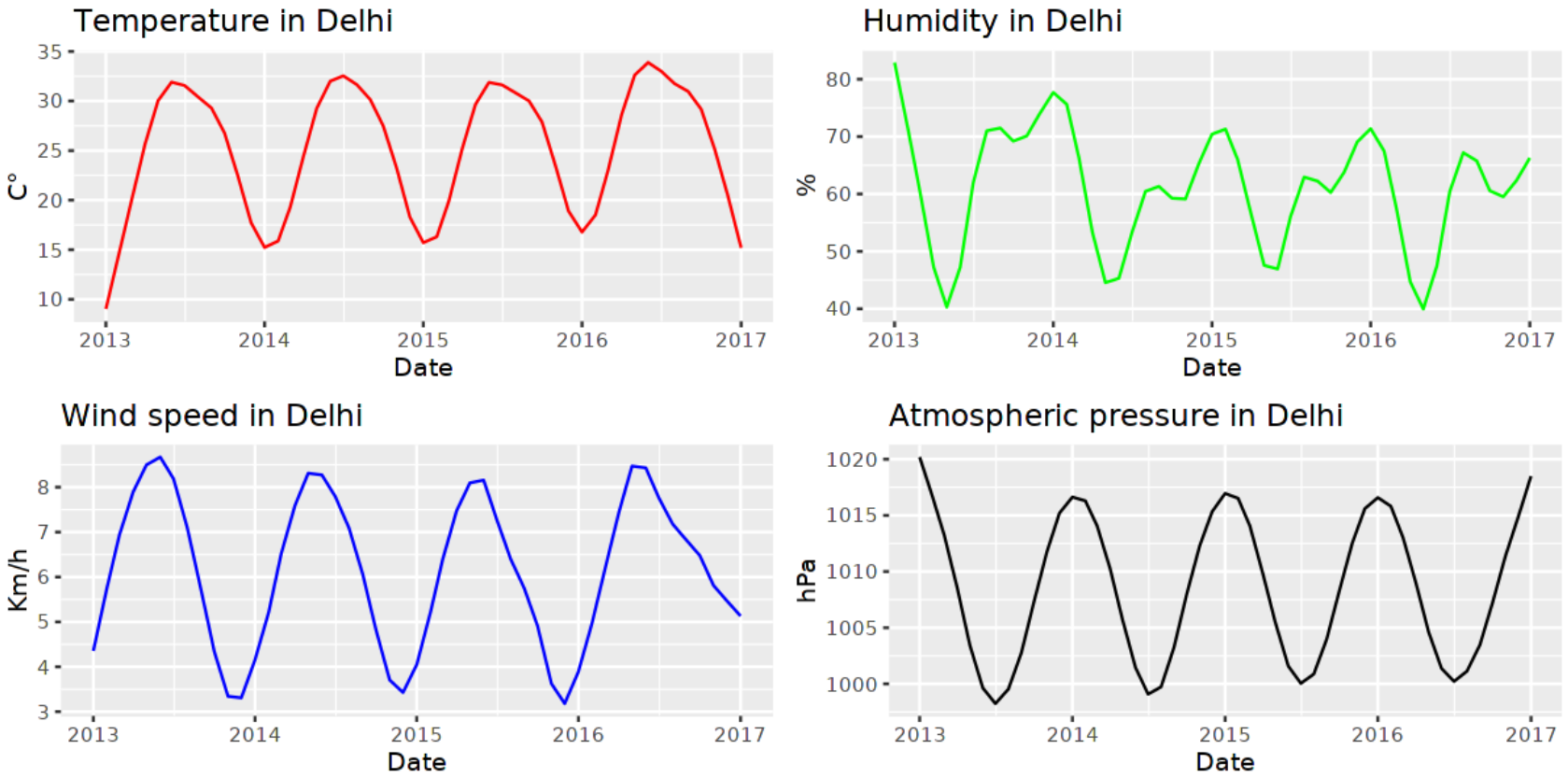



Figure: Smoothed time series

# ARIMA Models - Weather



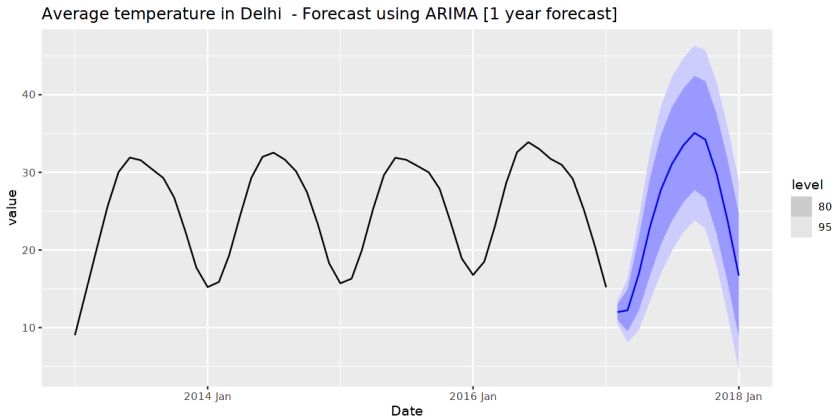



Figure: ARIMA(2,0,2)(0,1,0)[12]

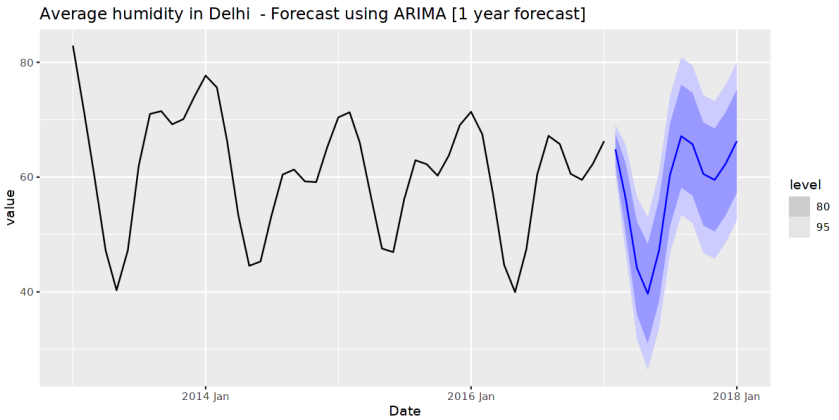



Figure: ARIMA(1,0,2)(0,1,0)[12]

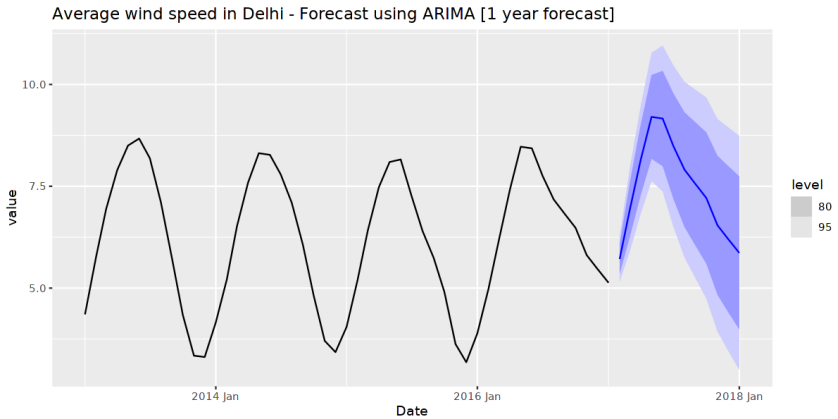



Figure: ARIMA(0,1,1)(0,1,0)[12]

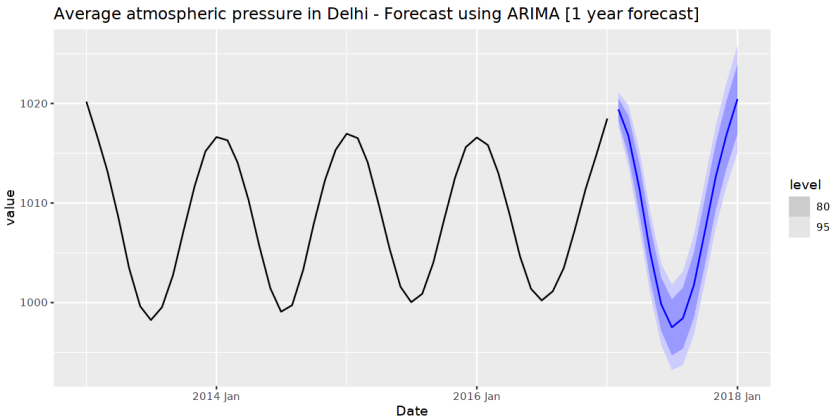



Figure: ARIMA(2,0,0)(0,1,0)[12]

# Basic Necessities Price Analysis



Figure: Potatoes, Rice and Onions

# Basic necessities time series

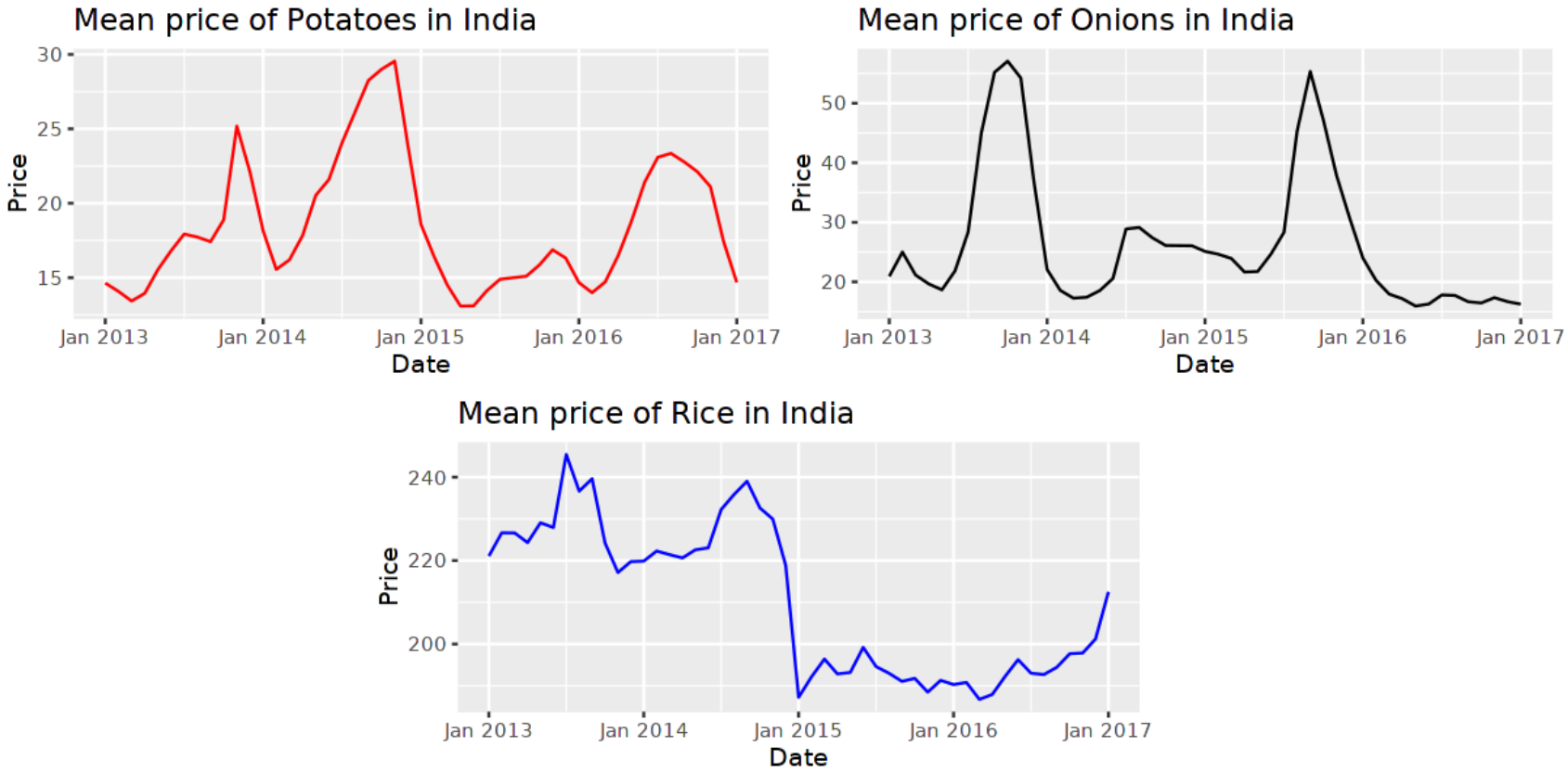



Figure: Data collected from 2013 to 2017 in India.

# Basic necessities time series

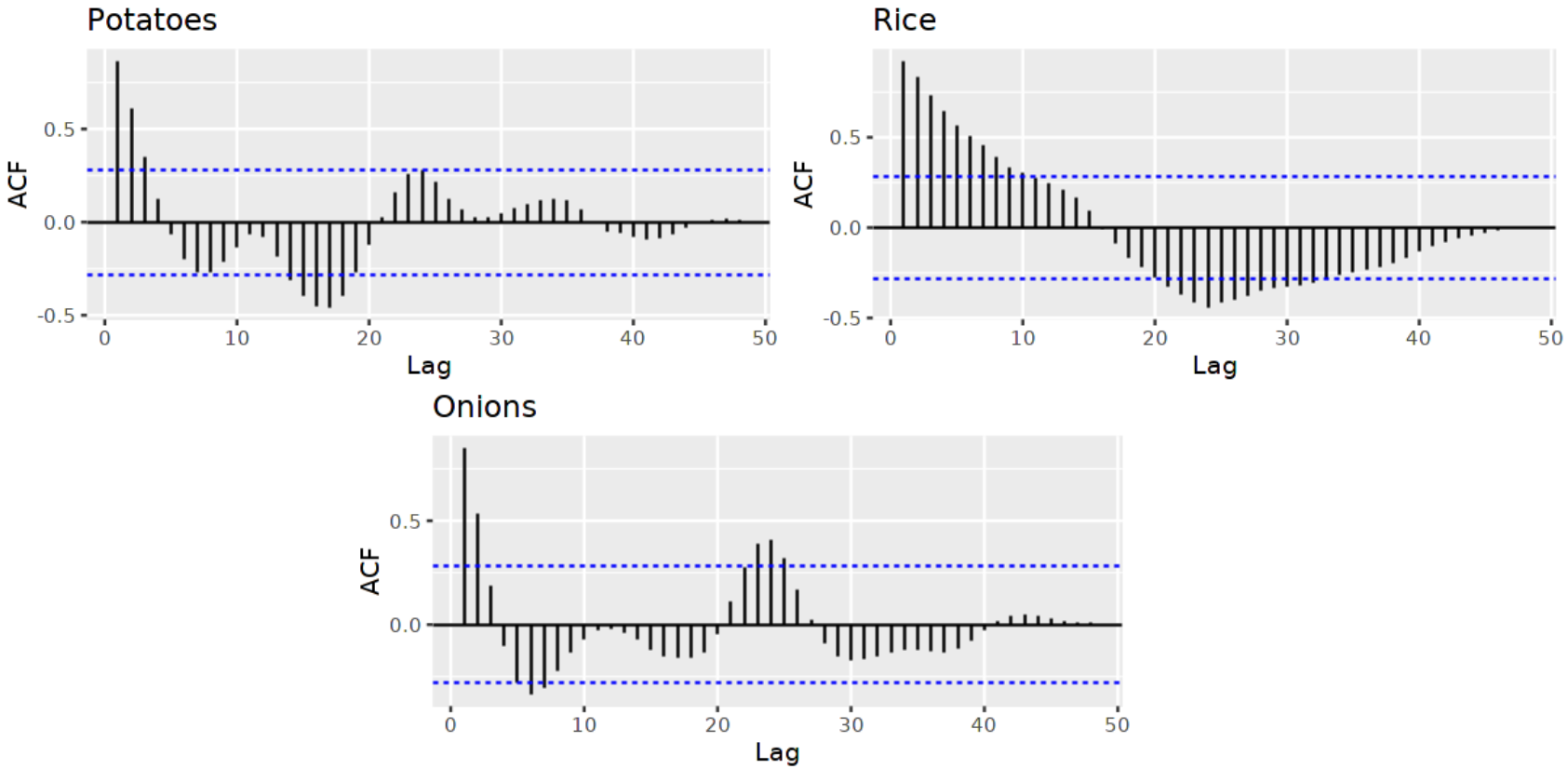



Figure: Autocorrelation function of the basic necessities time series

# ARIMA - Basic necessities

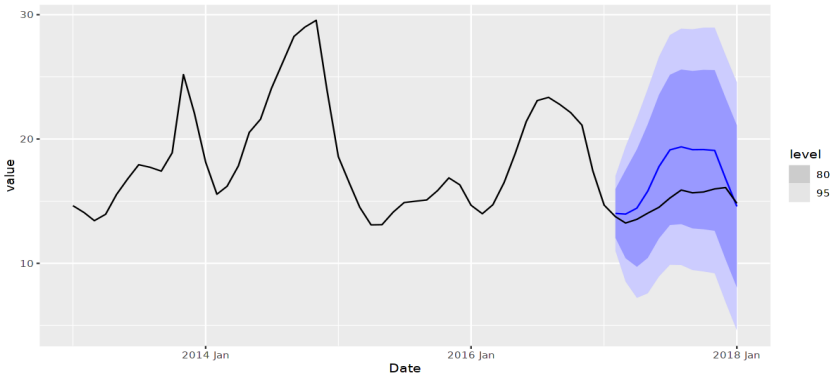



Figure: Potatoes
ARIMA(1,0,2)(1,1,0)[12]

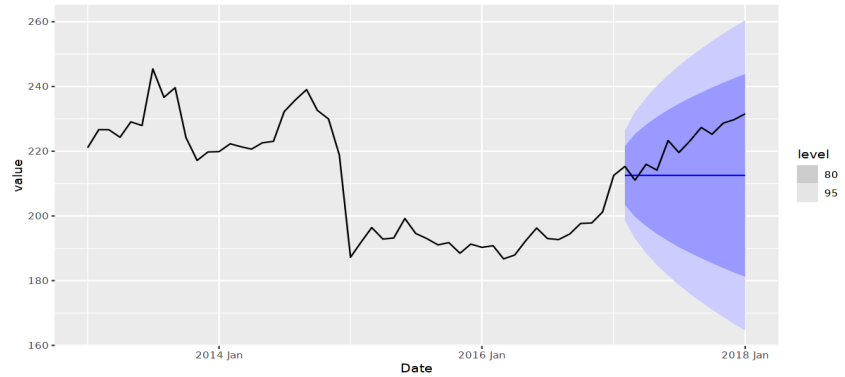



Figure: Rice
ARIMA(0,1,0)

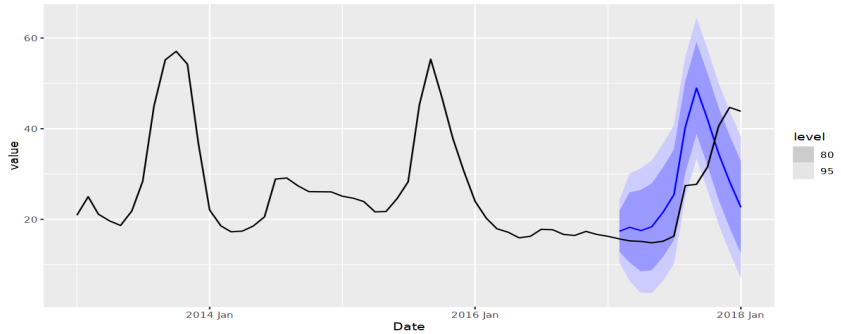



Figure: Onions
ARIMA(1,0,1)(1,1,0)[12]

# GAM - Basic necessities

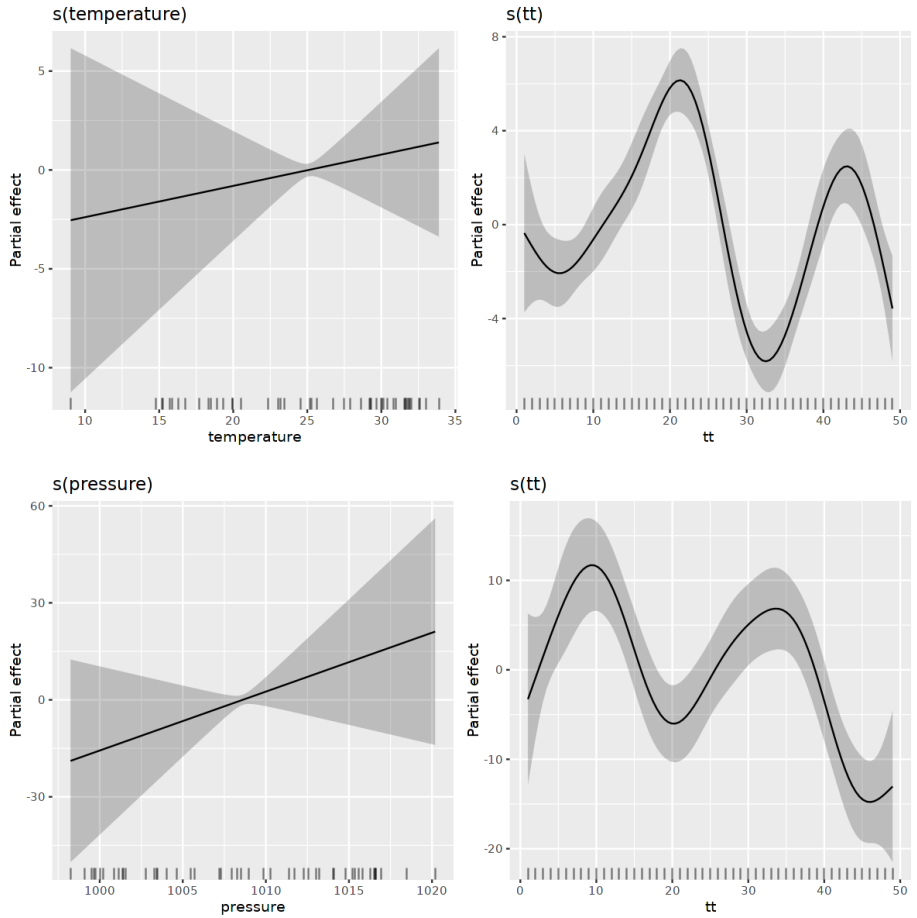
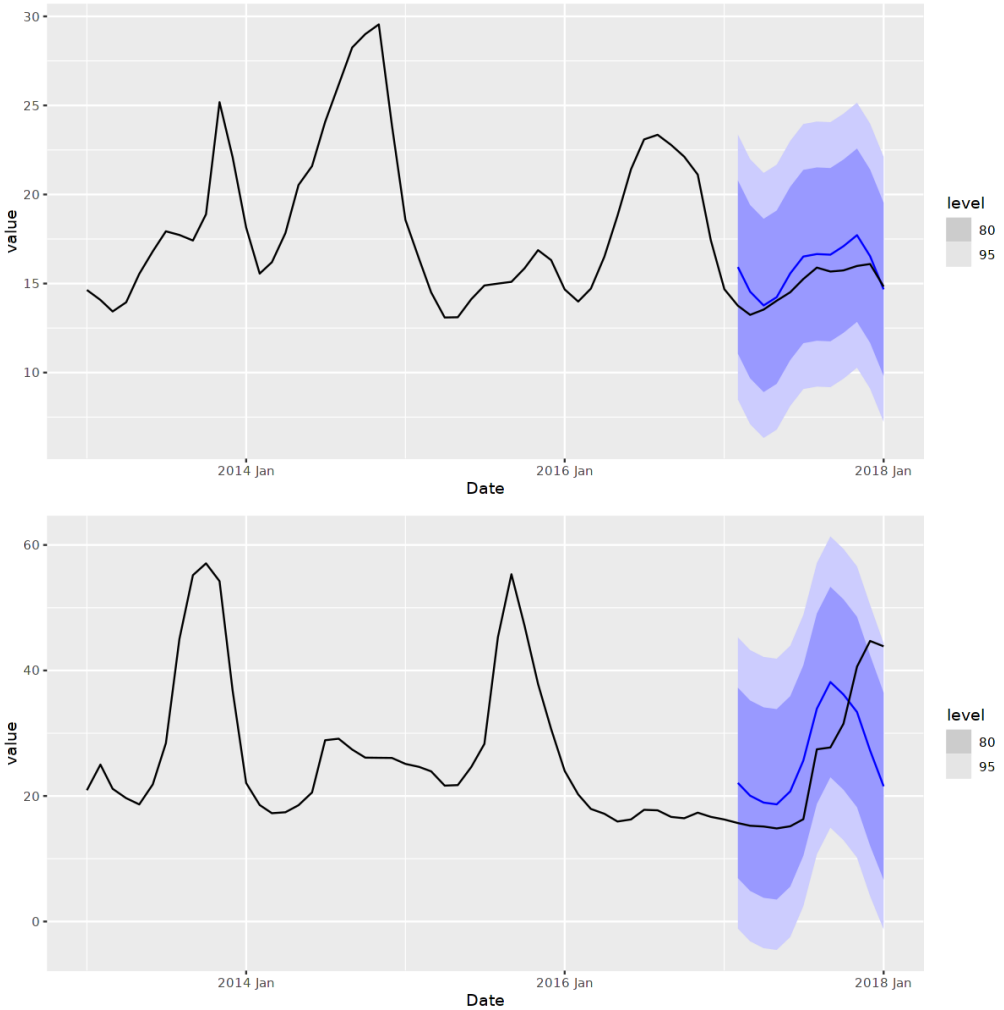



Figure: GAM plots of Potatoes - Temperature  Onions - Pressure

# ARIMA - Basic necessities




Fit ARIMA imposing fixed:

- Temperature parameters for potatoes
- Pressure parameters for onions

| Model | ME | RMSE | MAE | ACF1 |
|---|---|---|---|---|
| ARIMA | -2.061 | 2.520 | 2.103 | 0.623 |
| ARIMA Weather | -0.942 | 1.145 | 0.968 | 0.215 |

Table: ARIMA model metrics on the test set for the **potatoes** time series

| Model | ME | RMSE | MAE | ACF1 |
|---|---|---|---|---|
| ARIMA | -2.265 | 11.679 | 9.542 | 0.627 |
| ARIMA Weather | -0.692 | 10.156 | 8.523 | 0.631 |

Table: ARIMA model metrics on the test set for the **onions** time series

# Conlcusions



- We studied the weather time series and found that the best model among the ones we used is ARIMA performed on the GAM preprocessed data.
- We studied the correlations between the basic necessities time series and the weather data.
- We succeeded in improving the basic necessities forecasts by imposing the parameters of the ARIMA weather analysis.

Thank you for your attention!

# Weather time series

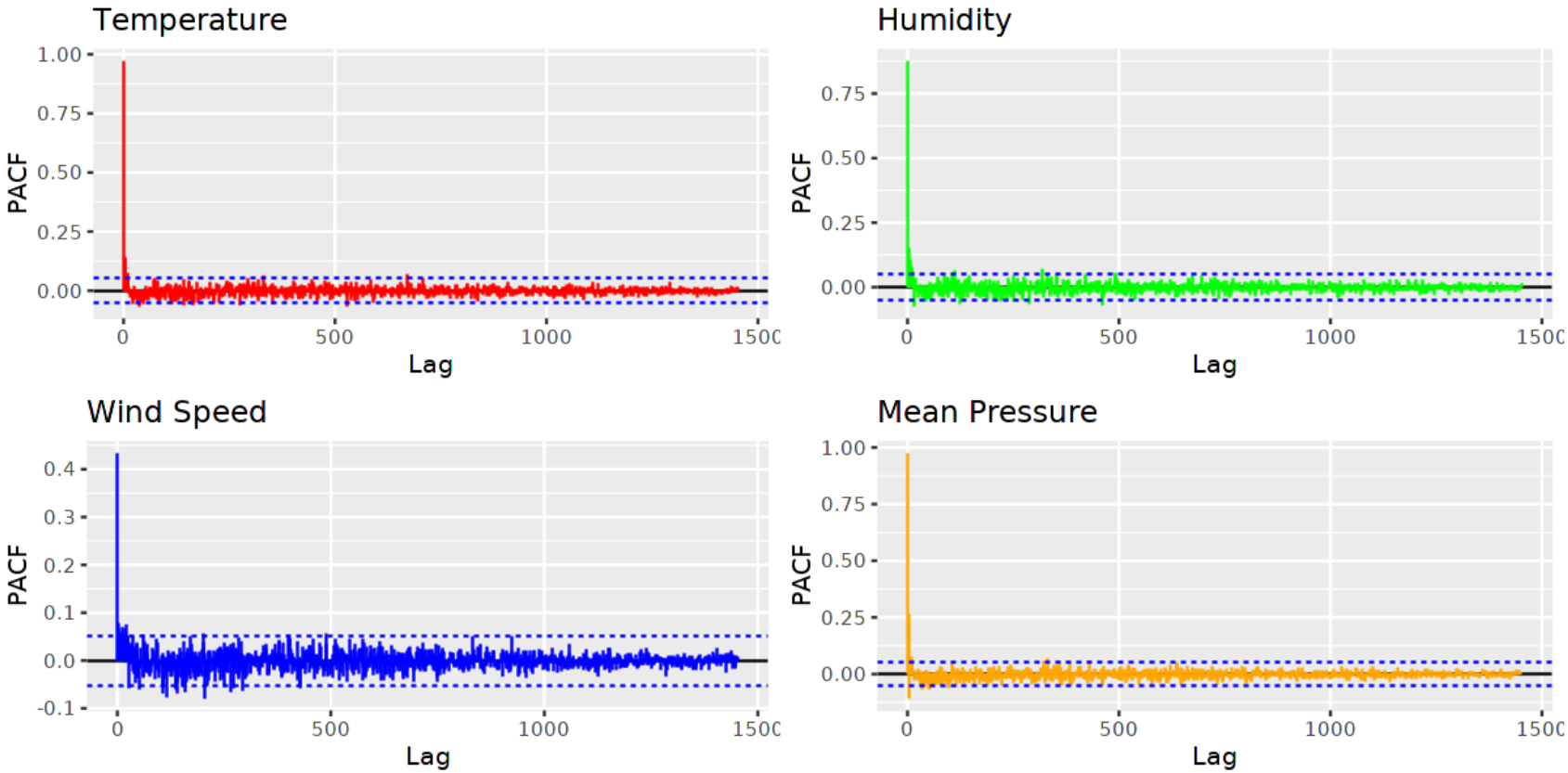



Figure: Partial Autocorrelation function of the weather time series

# Bass Model - Weather

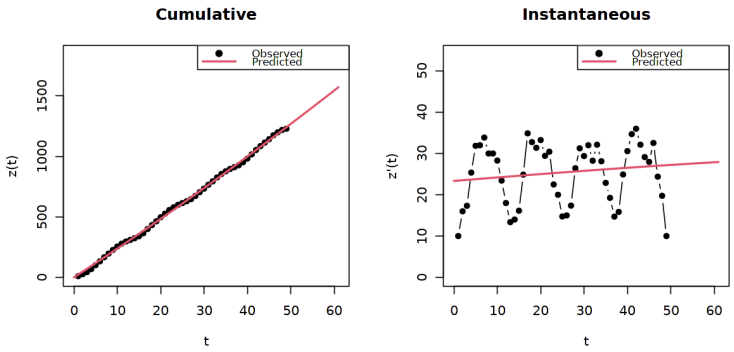


| | | Estimate | Std.Error | Lower | Upper | p-value |
|---|---|---|---|---|---|---|
| T | m | 1.38e+04 | 8.88e+04 | -1.60e+05 | 1.88e+05 | 0.877 |
| | p | 1.67e-03 | 1.07e-02 | -1.92e-02 | 2.26e-02 | 0.876 |
| | q | 5.20e-03 | 1.43e-02 | -2.28e-02 | 3.32e-02 | 0.718 |
| H | m | 4.12e+04 | 5.90e+05 | -1.12e+06 | 1.20e+06 | 0.945 |
| | p | 1.45e-03 | 2.11e-02 | -4.00e-02 | 4.29e-02 | 0.946 |
| | q | 1.57e-03 | 2.42e-02 | -4.58e-02 | 4.90e-02 | 0.948 |
| W | m | 529.92 | 79.54 | 3.74e+02 | 685.80 | 2.93e-08 |
| | p | 0.015 | 0.001 | 1.18e-02 | 0.019 | 2.73e-11 |
| | q | 0.015 | 0.008 | 4.27e-04 | 0.030 | 4.96e-02 |
| P | m | 3.57e+05 | 4.15e+04 | 2.76e+05 | 4.38e+05 | 3.76e-11 |
| | p | 2.82e-03 | 3.30e-04 | 2.17e-03 | 3.46e-03 | 4.76e-11 |
| | q | 3.23e-03 | 4.31e-04 | 2.39e-03 | 4.08e-03 | 1.67e-09 |

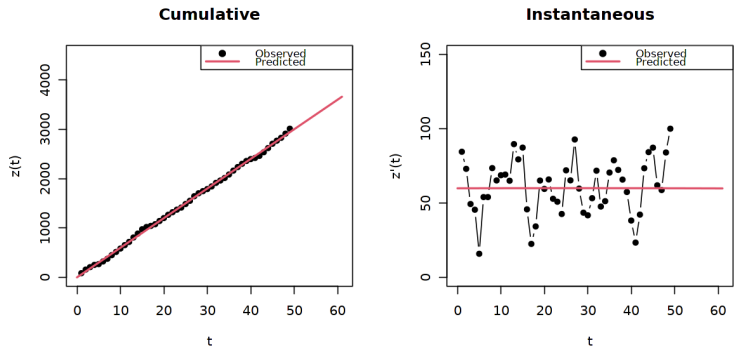
Table: Coefficients of the Bass Model

# Bass Model - Weather

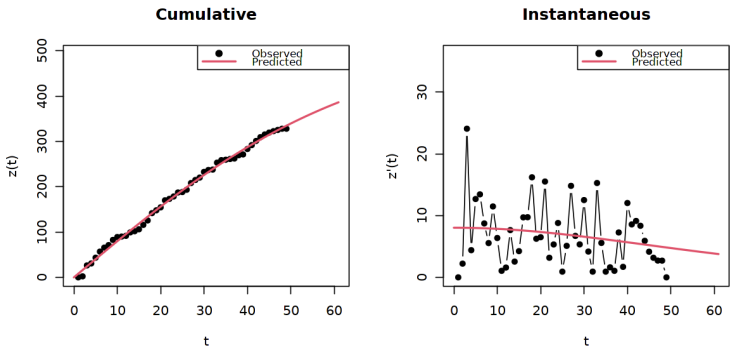
## Temperature



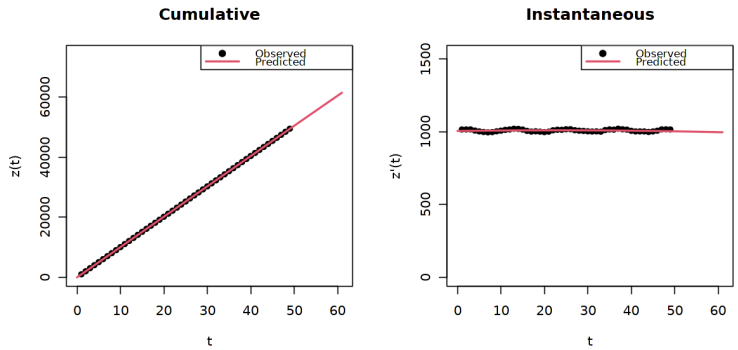

## Humidity




## Wind speed

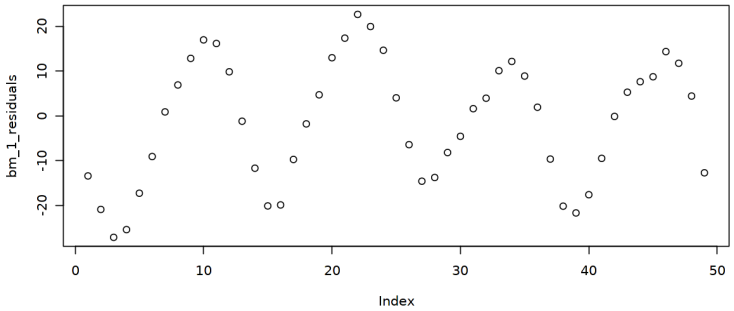



## Pressure

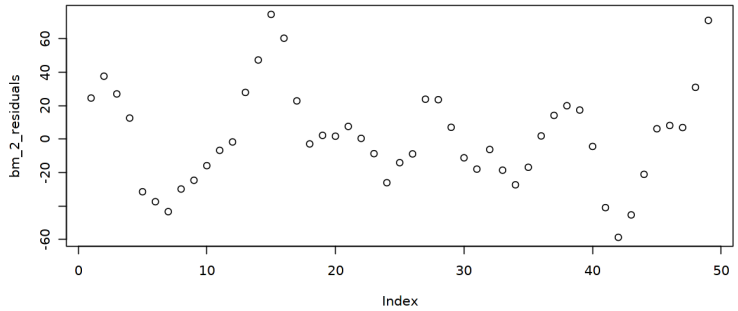



- We can see that we can not adapt the Bass model to our data

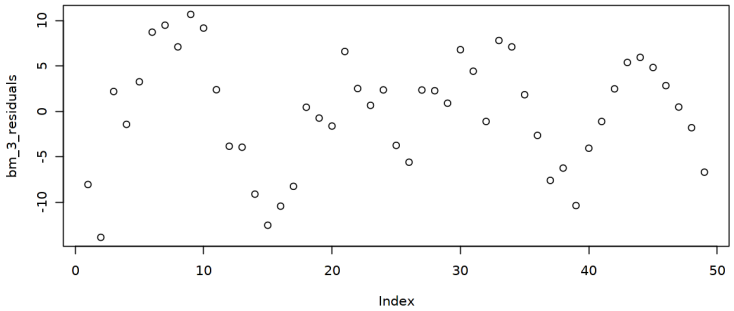
# Bass Model - Weather



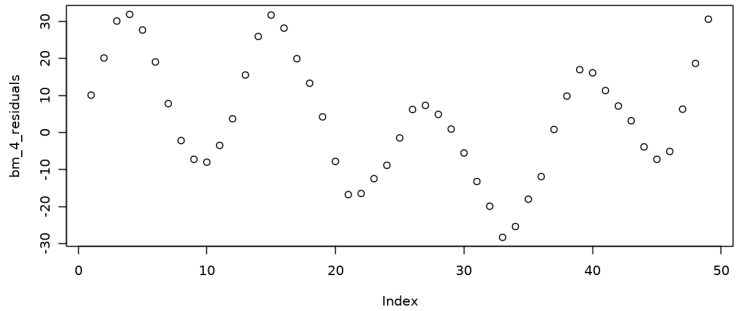

Temperature




Humidity




Wind speed




Pressure

Table: Residuals of the Bass Model

# GAM - Weather

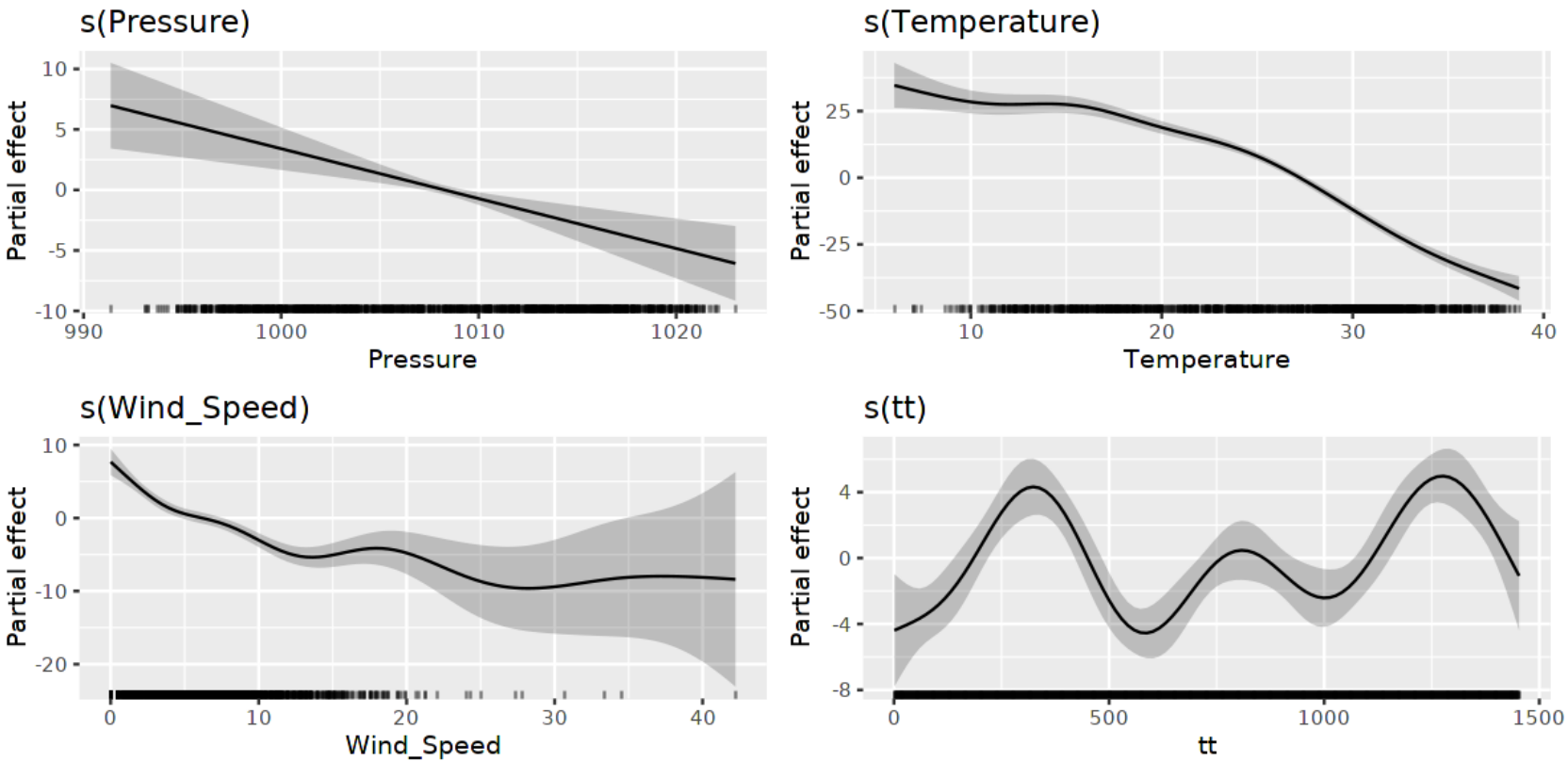



Figure: Generalized Additive Model on the humidity time series

# GAM - Weather

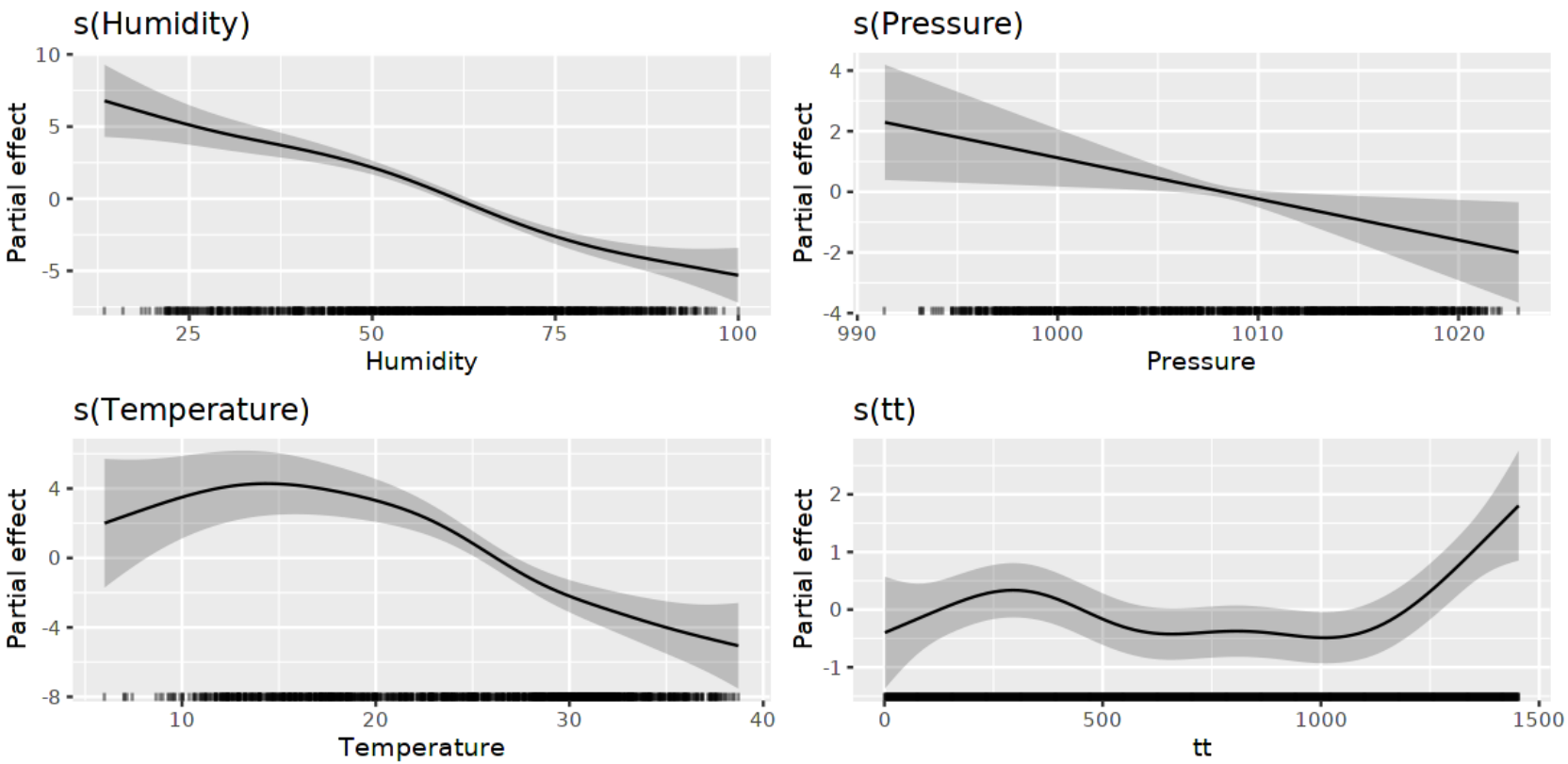



Figure: Generalized Additive Model on the wind speed time series

# GAM - Weather

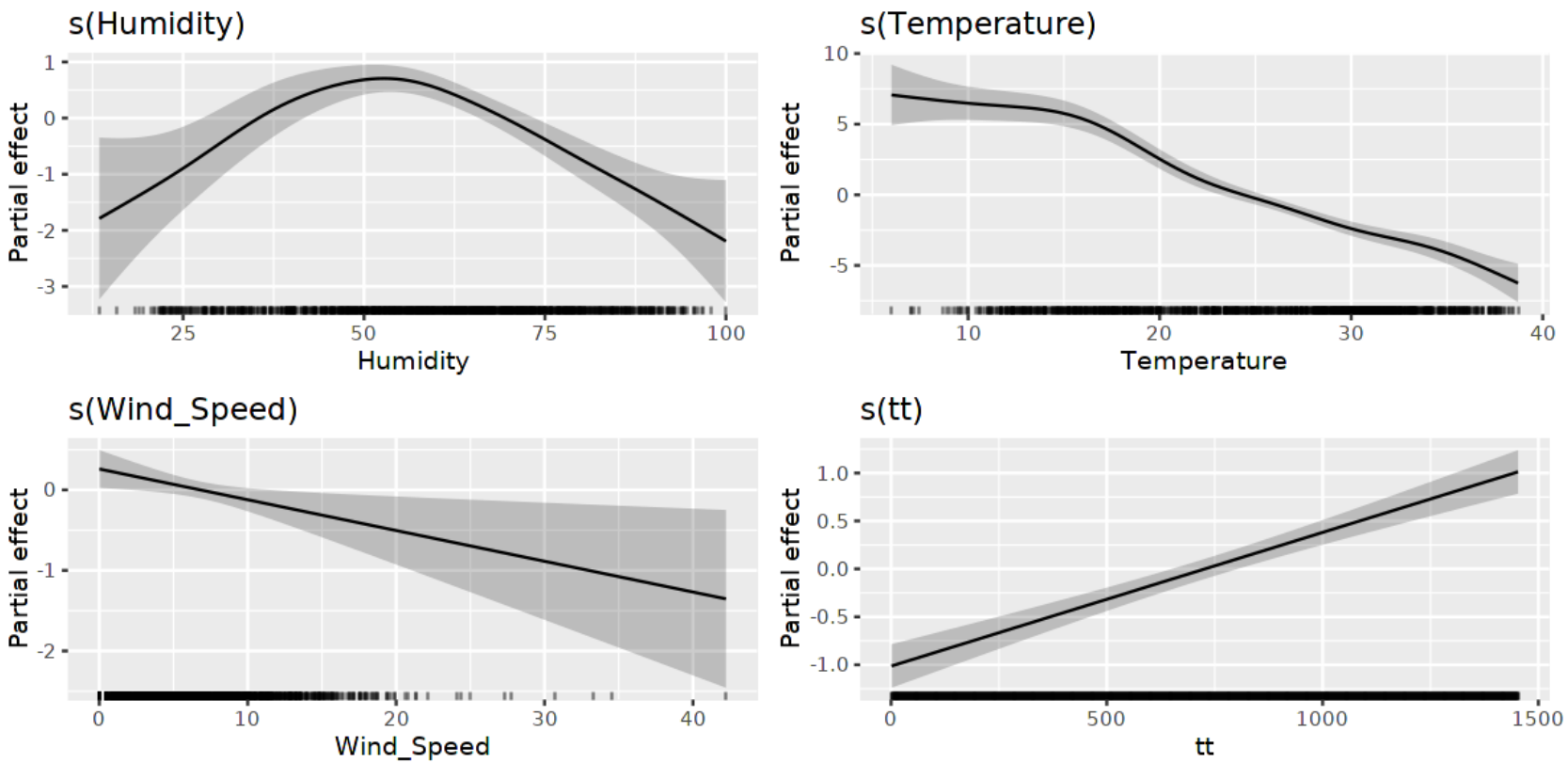



Figure: Generalized Additive Model on the pressure time series

# Monthly data residuals - Weather

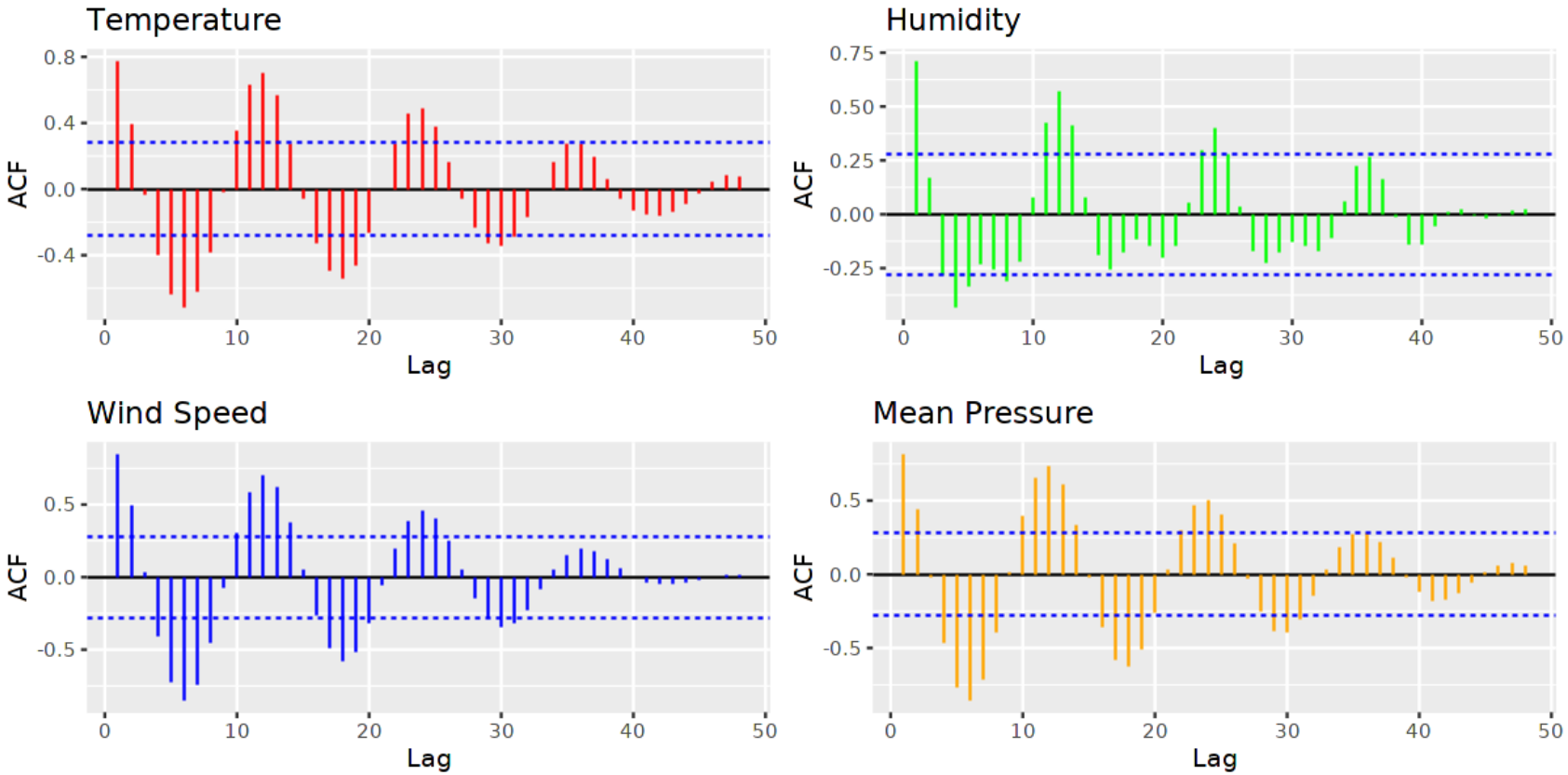



Figure: Autocorrelation function of the smoothed time series

# GAM - Basic necessities

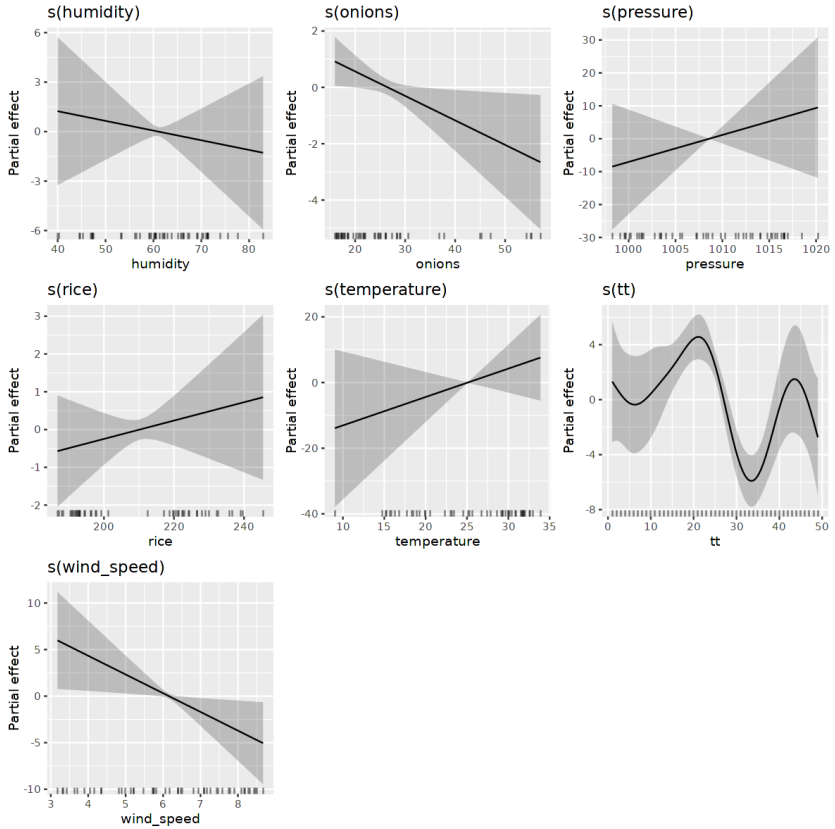



Figure: GAM Potatoes

# GAM - Basic necessities

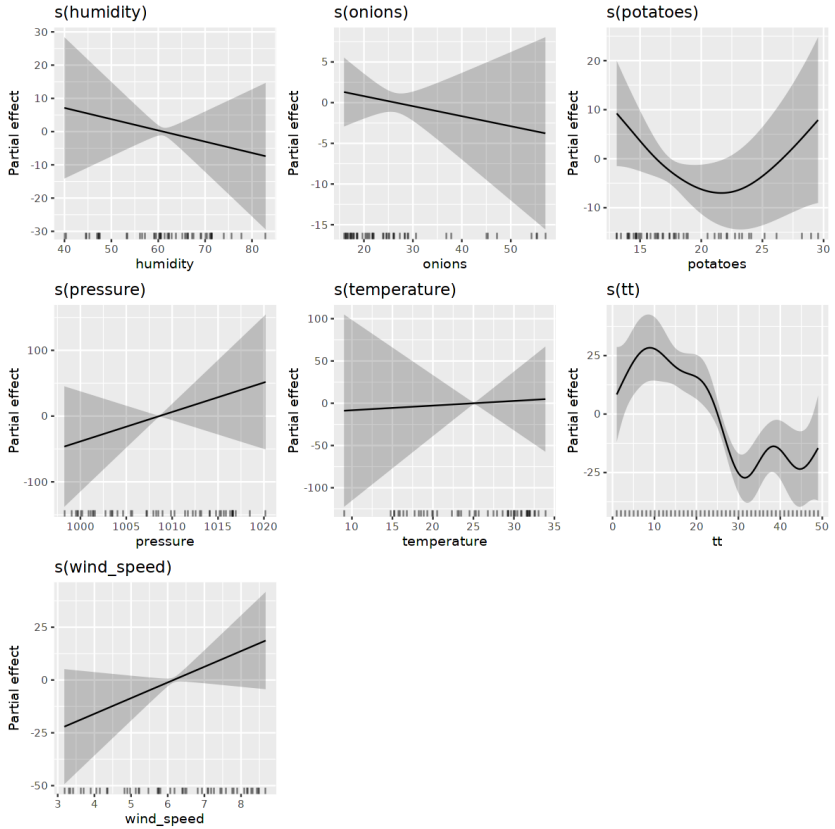



Figure: GAM Rice

# GAM - Basic necessities

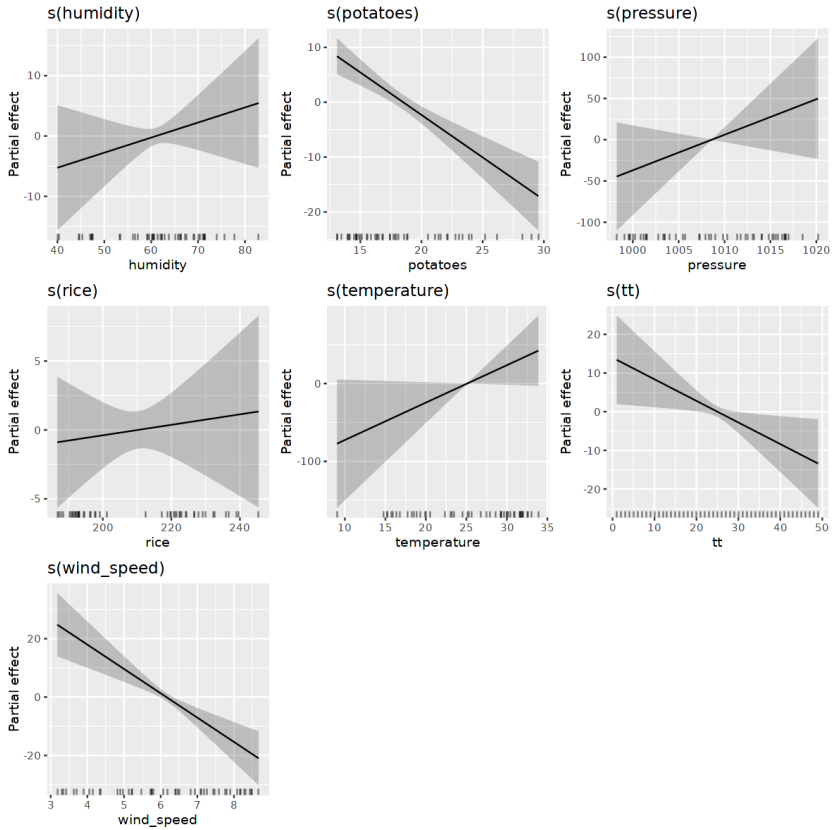



Figure: GAM Onions