

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

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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

- 1 Climate Analysis**
  - Overview on Delhi Climate
  - Dataset Description
    - Correlations and Autocorrelations
  - Modelling and Forecasting
    - Bass Model
    - Linear Regression
    - ARIMA
    - ARIMA & GAM
    - Monthly Smoothening
    - Models Comparison
- 2 Basic Necessities Price Analysis**
  - Dataset Description
    - Correlations and Autocorrelations
  - Modelling and Forecasting
    - ARIMA
    - GAM
- 3 Conclusions**

# 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	<b>hot to very hot</b> ; very low to moderate humidity; <b>low precipitation</b>
Monsoon	July, August, September	hot, pleasant during rains; <b>high to very high humidity</b> ; <b>heavy precipitation</b>
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

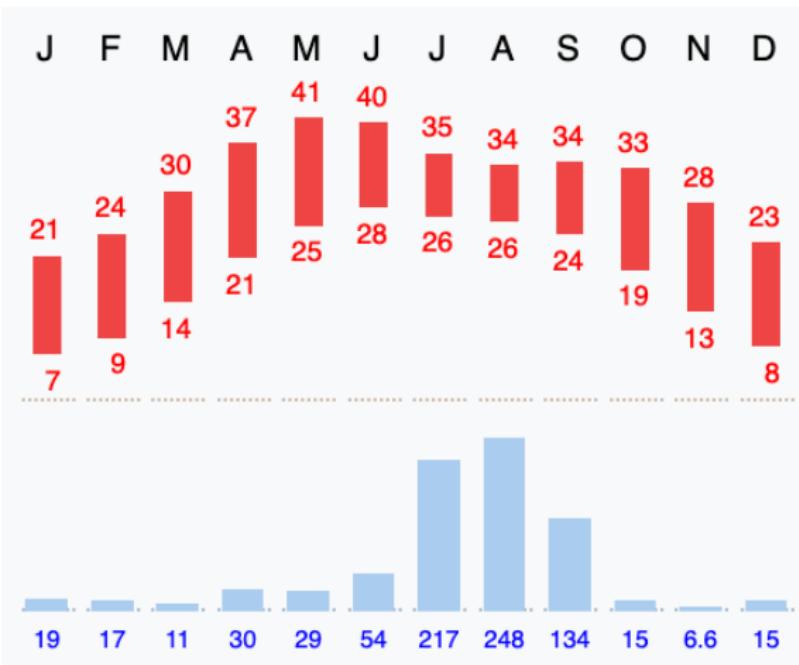


Figure: Average max. and min. temperatures in °C and Precipitation totals in mm

# 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

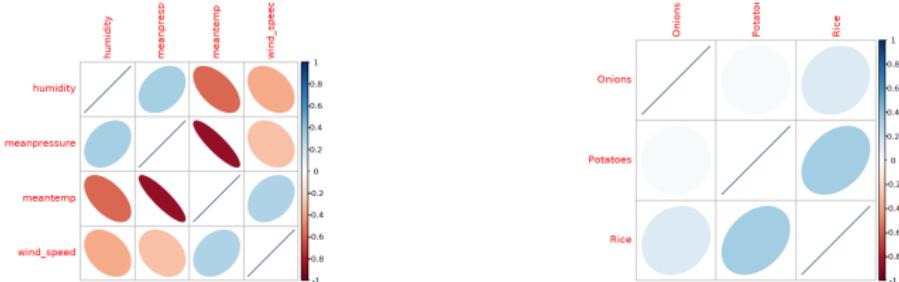
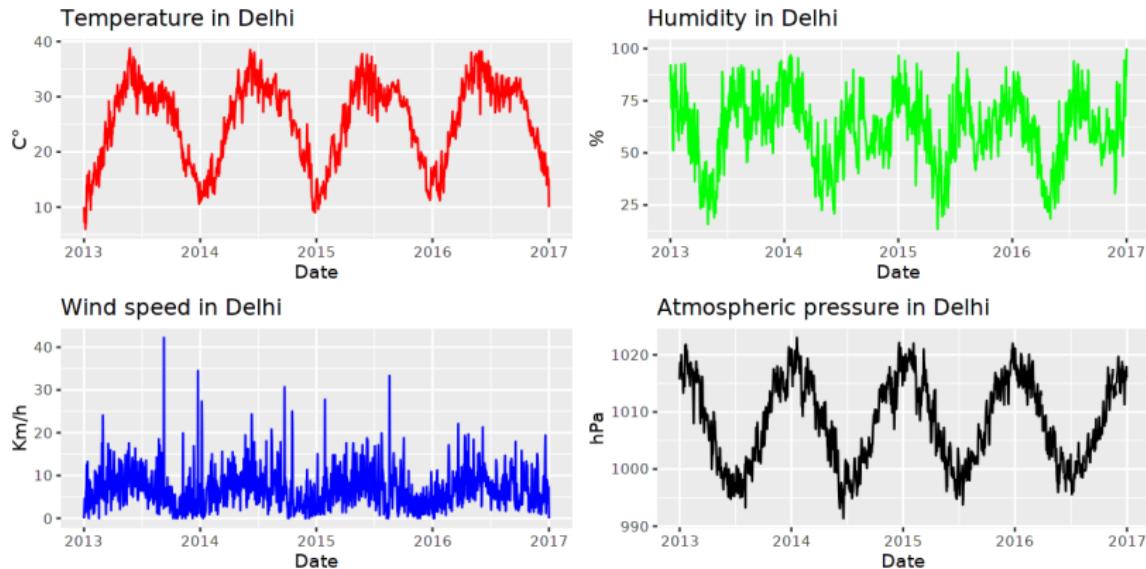


Figure: Correlations matrices between time series

# 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

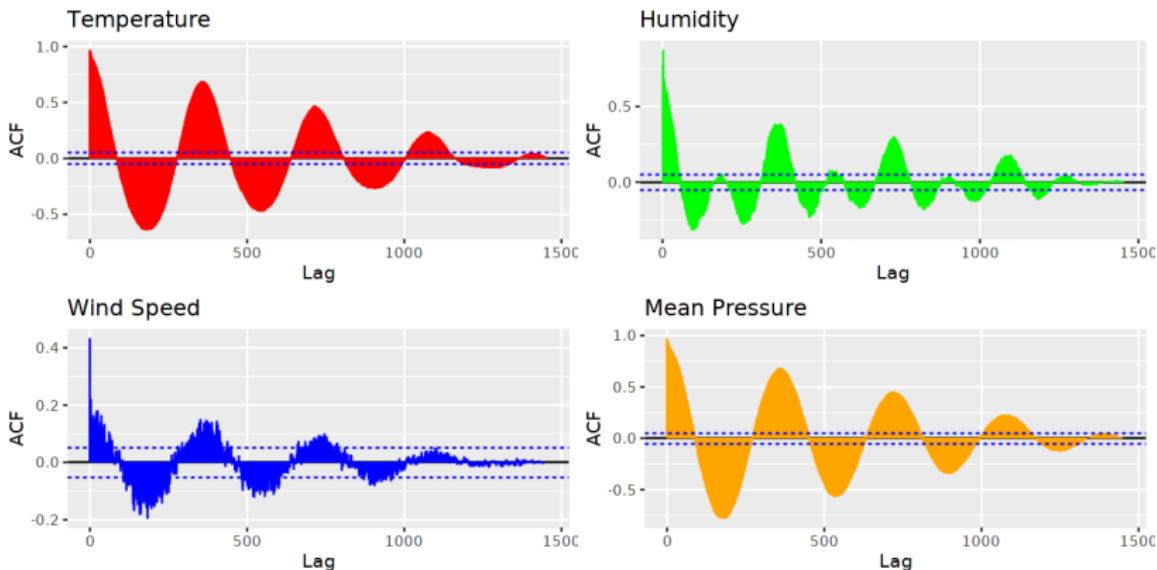


Figure: Autocorrelation functions of the weather time series



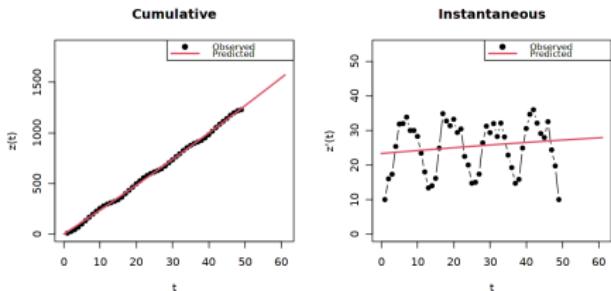
# Models

We are going to use the following models:

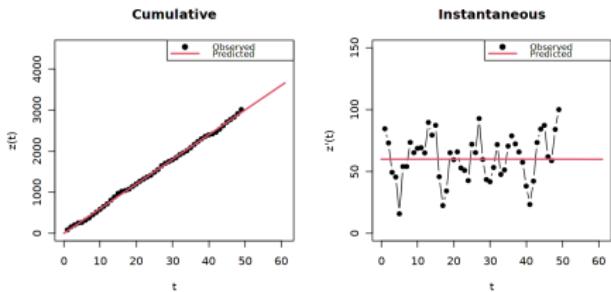
- Bass Model
- Linear Regression
- Generalized Additive Model (GAM)
- ARIMA Model

# 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

# Linear Regression - Weather



Model with trend and seasonality

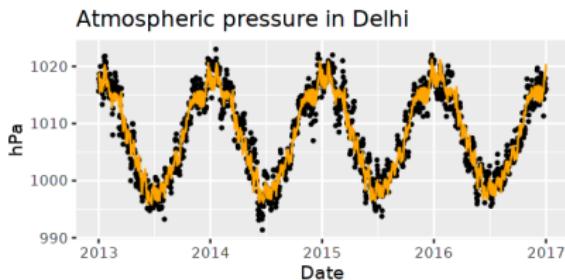
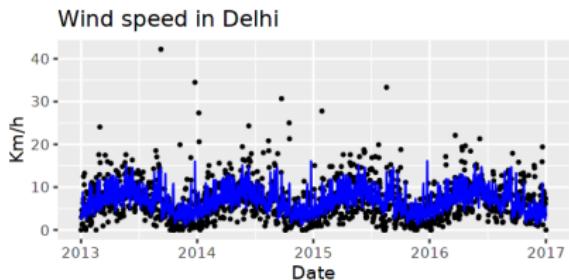
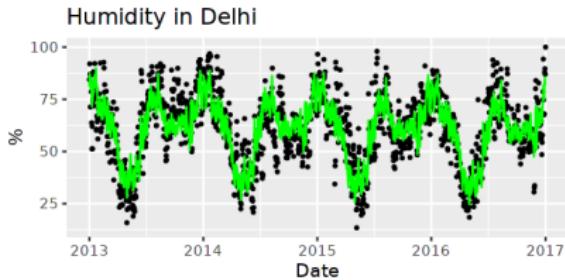
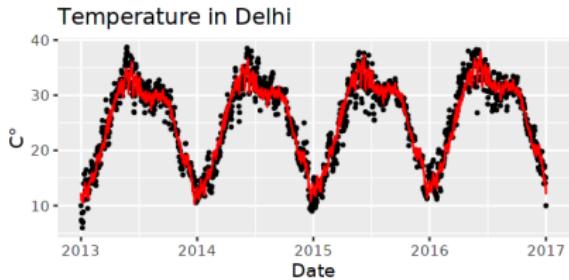


Figure: Linear Regression

# Linear Regression - Weather

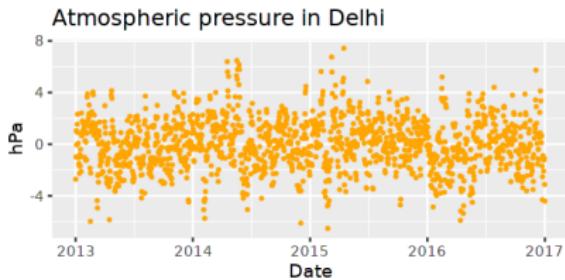
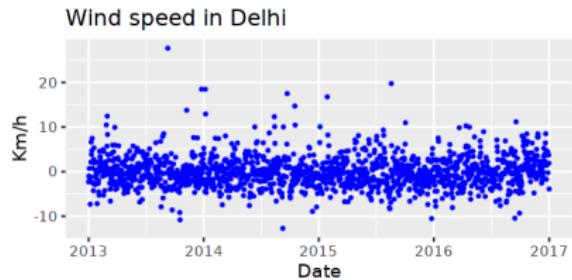
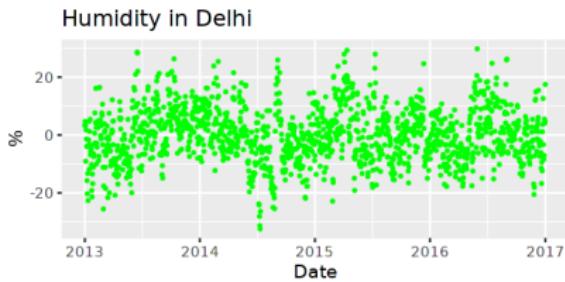
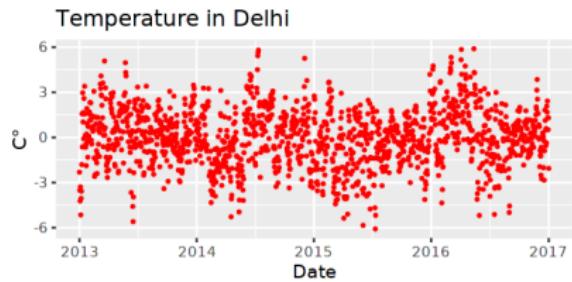
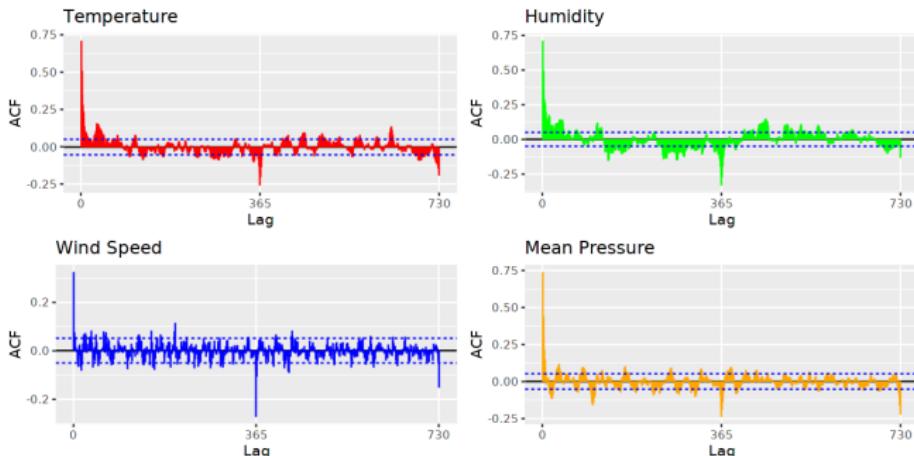


Figure: Linear Regression Residuals

# 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

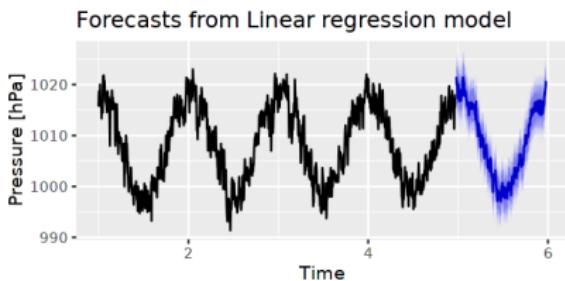
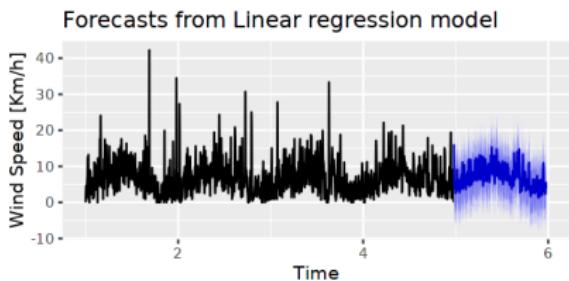
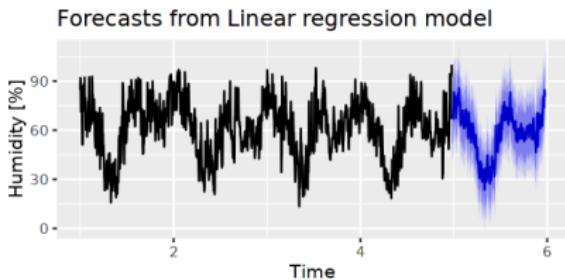
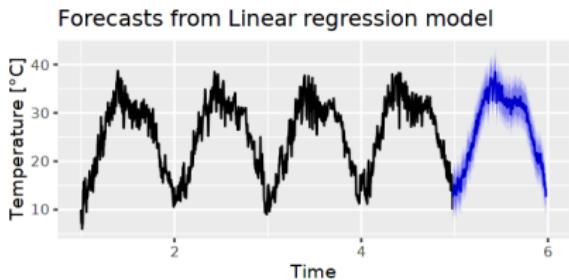
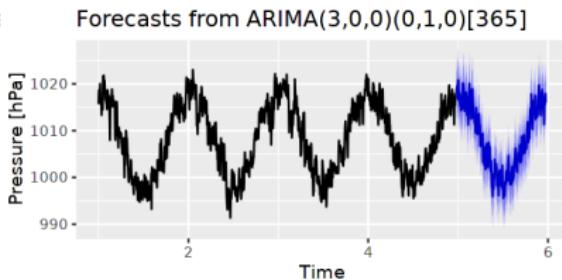
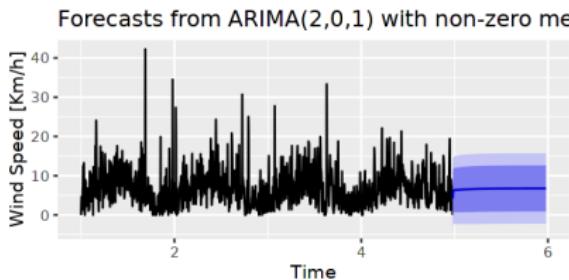
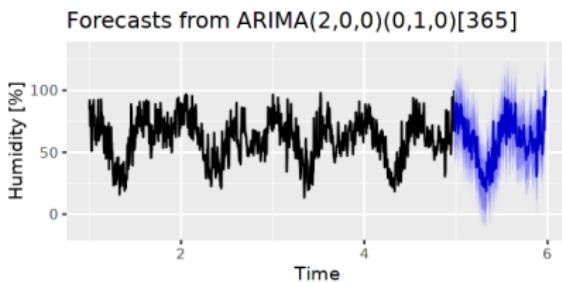
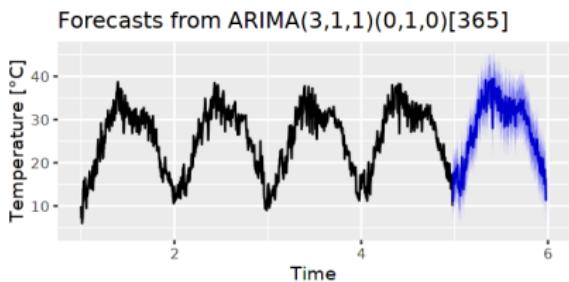


Figure: Linear Regression forecasts

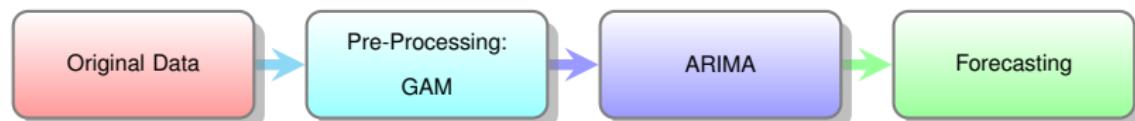
# ARIMA Models - Weather



**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 **dependencies** of each time series on the others and on the time+seasonality and then **add** all the **contributions**.

# GAM - Weather

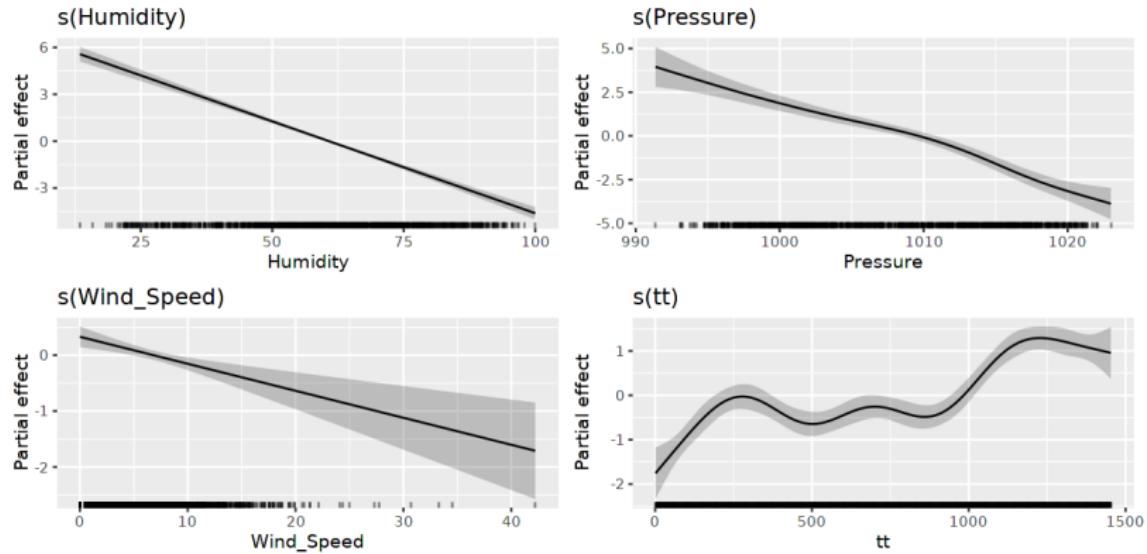
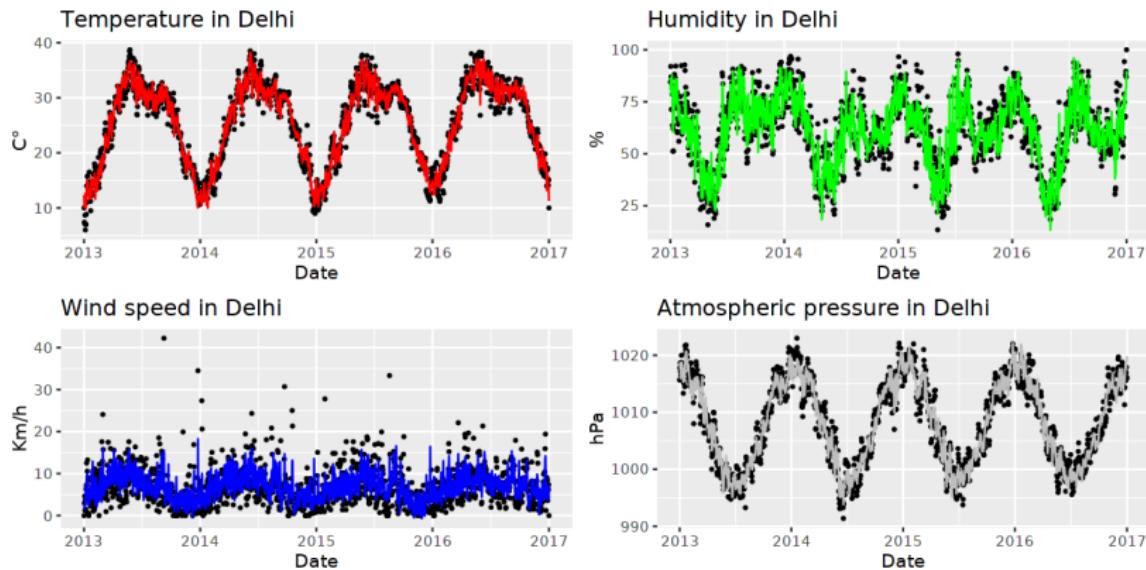


Figure: Generalized Additive Model on the temperature time series

# GAM - Weather



**Figure:** Time series with GAM regression

# ARIMA Models - Weather

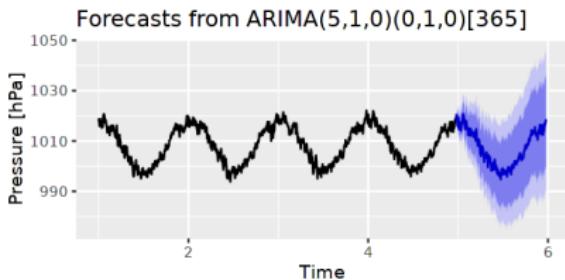
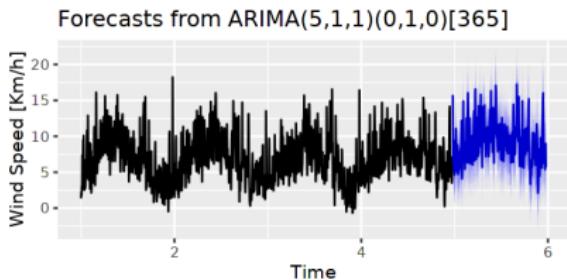
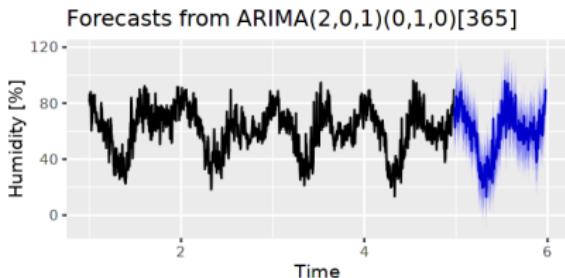
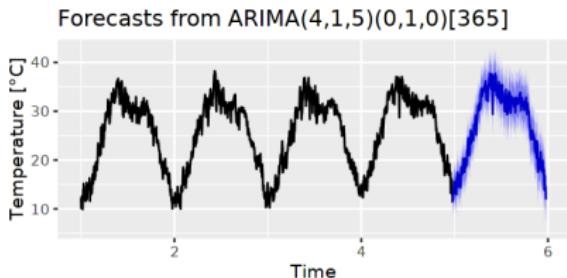


Figure: Forecast with ARIMA on GAM data

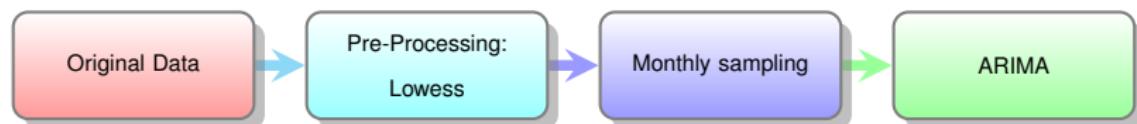
# ARIMA Models - Weather

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

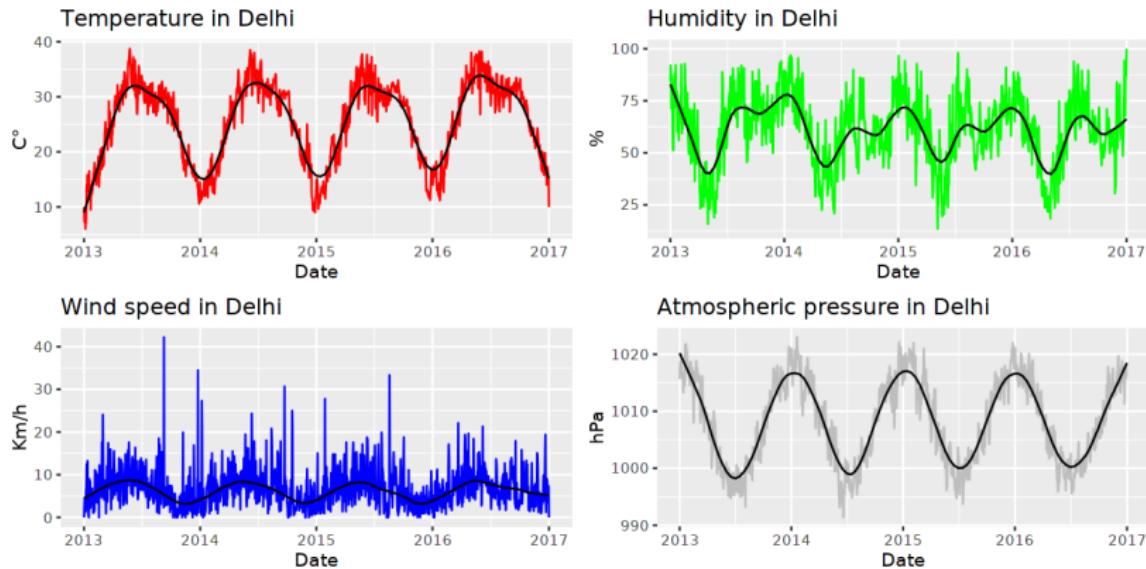
# Sampling

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

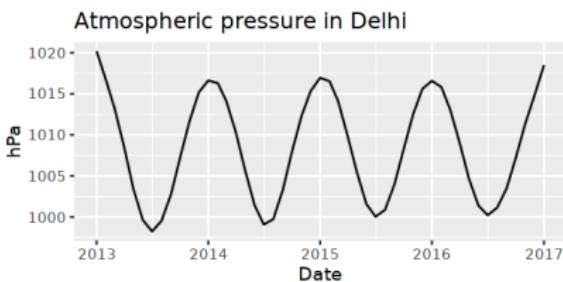
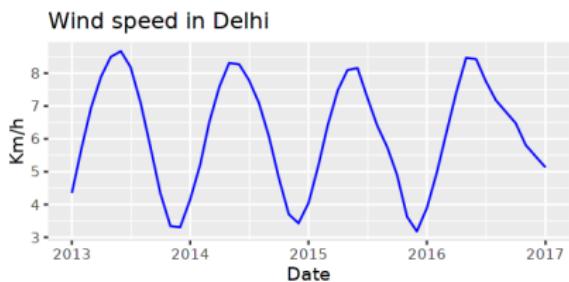
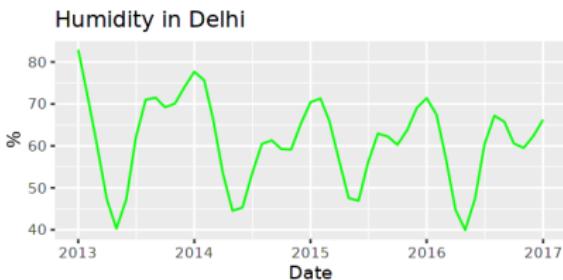
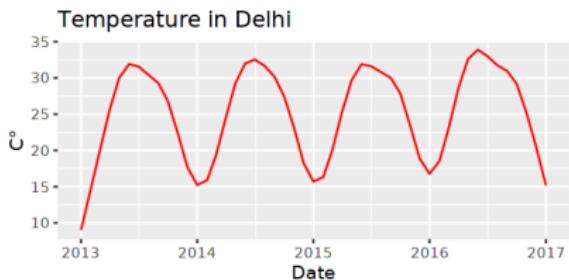


Figure: Smoothed time series

# ARIMA Models - Weather

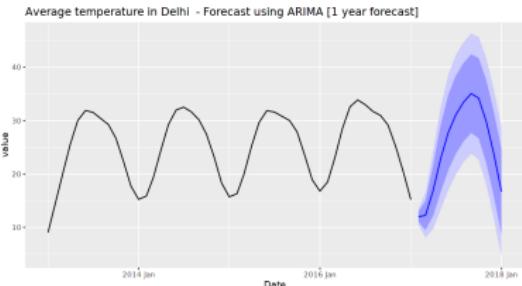


Figure: ARIMA(2,0,2)(0,1,0)[12]

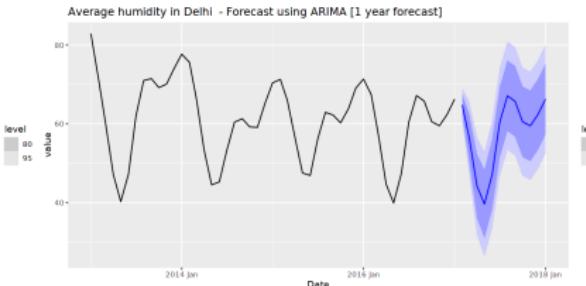


Figure: ARIMA(1,0,2)(0,1,0)[12]

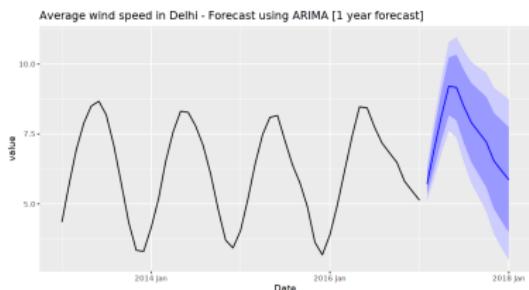


Figure: ARIMA(0,1,1)(0,1,0)[12]

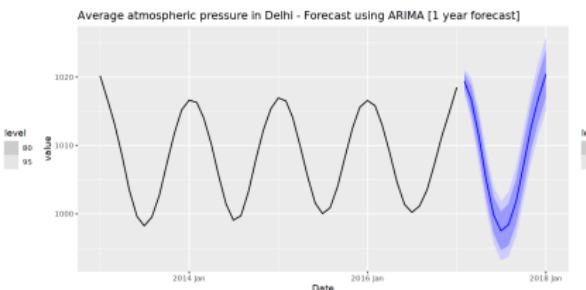


Figure: ARIMA(2,0,0)(0,1,0)[12]

# Basic Necessities Price Analysis



**Figure:** Potatoes, Rice and Onions

# Basic necessities time series

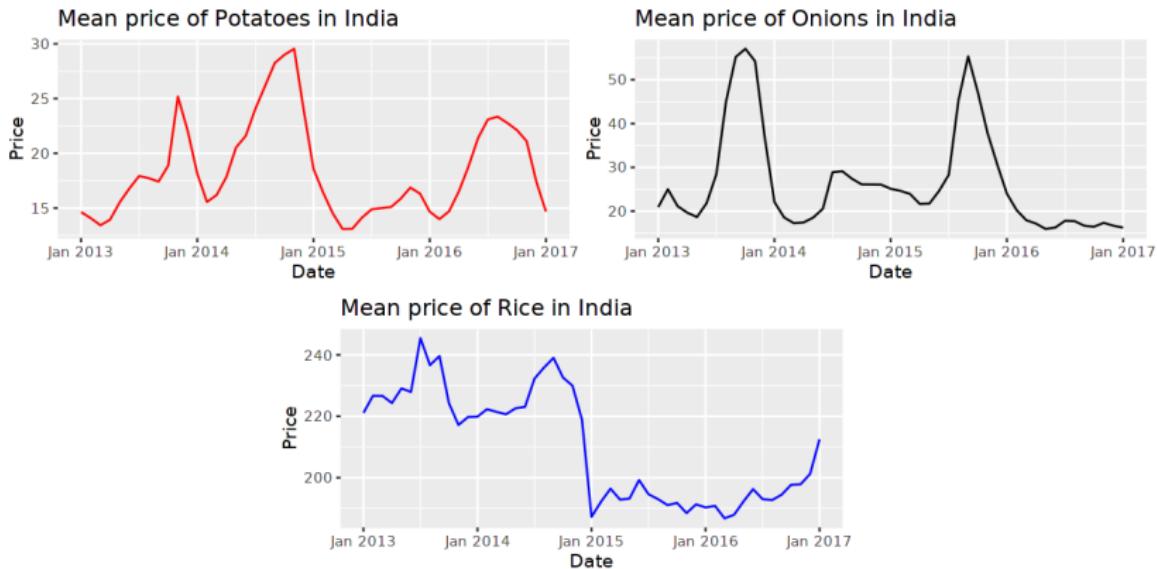
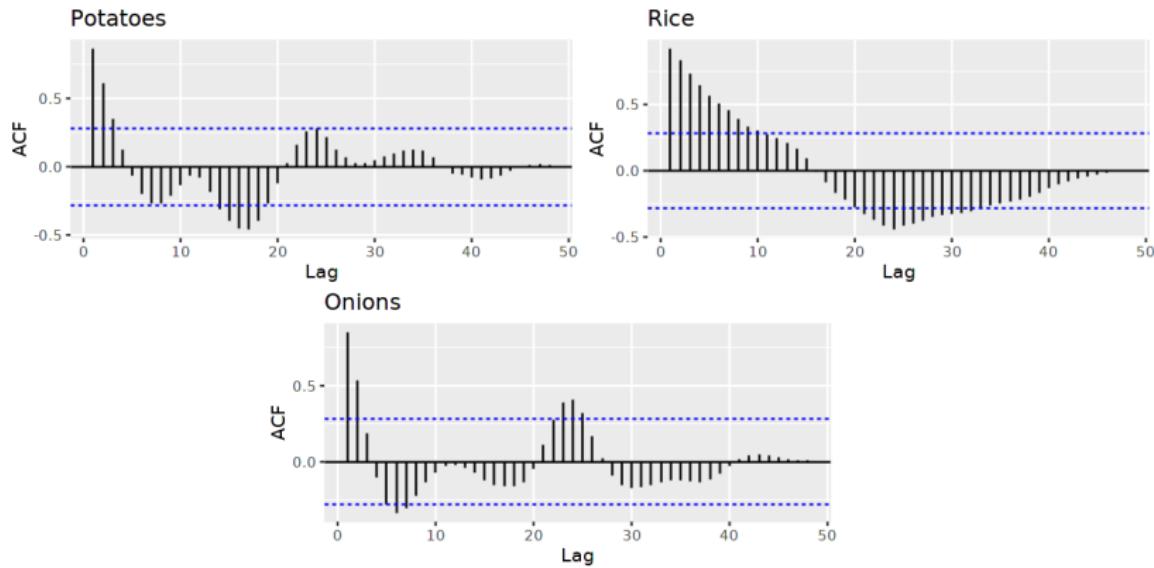


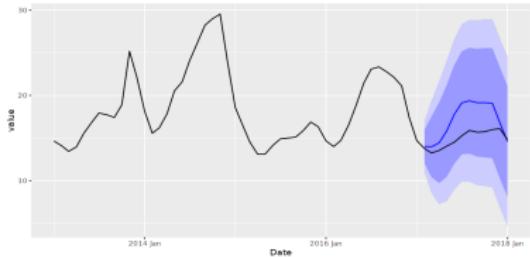
Figure: Data collected from 2013 to 2017 in India.

# Basic necessities time series

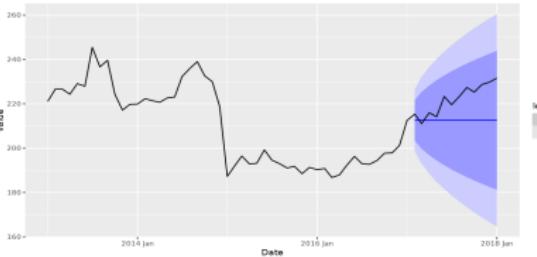


**Figure:** Autocorrelation function of the basic necessities time series

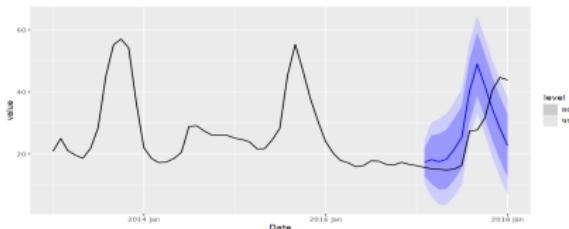
# ARIMA - Basic necessities



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

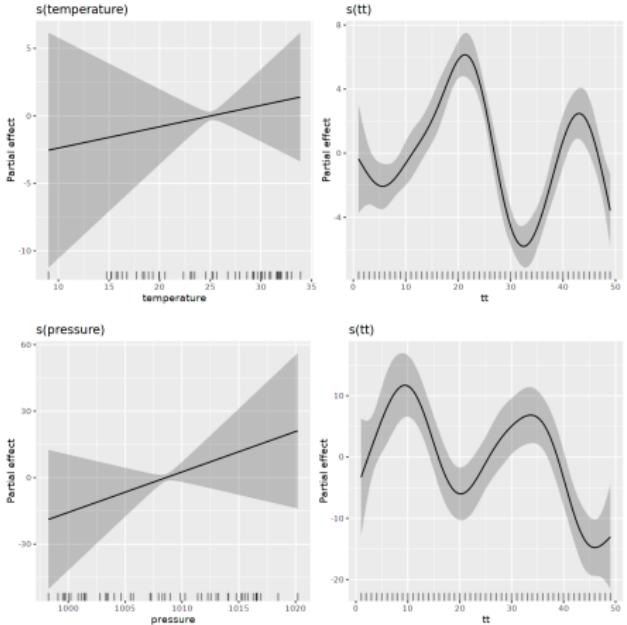


**Figure:** Rice  
ARIMA(0,1,0)



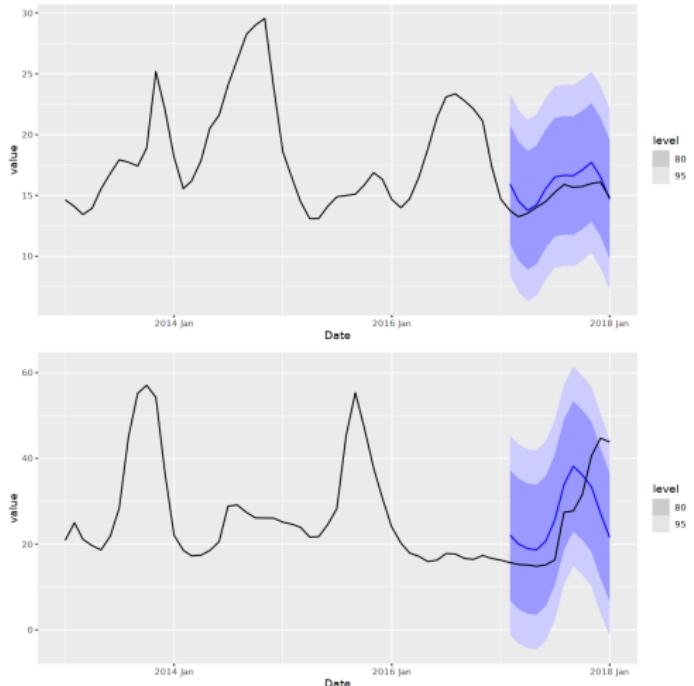
**Figure:** Onions  
ARIMA(1,0,1)(1,1,0)[12]

# 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

# ARIMA - Basic Necessities



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

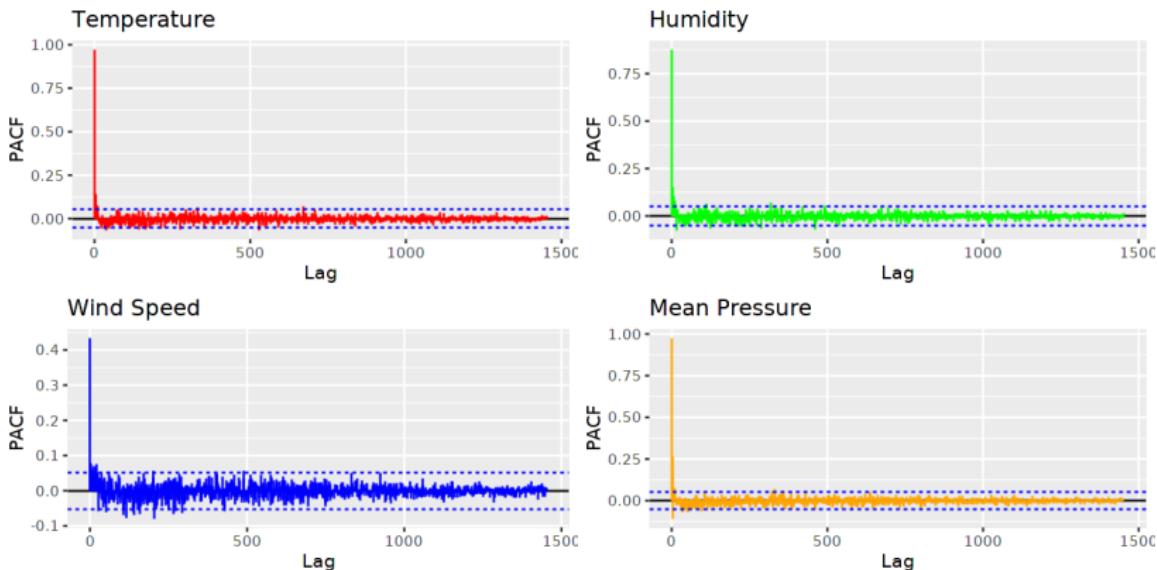
- We studied the weather time series and found that the best model among the ones we used is ARIMA performed on the GAM preprocessed data.
- We studied the correlations between the basic necessities time series and the weather data.
- We succeeded in improving the basic necessities forecasts by imposing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

# Conclusions



Thank you for your attention!

# Weather time series



**Figure:** Partial Autocorrelation function of the weather time series

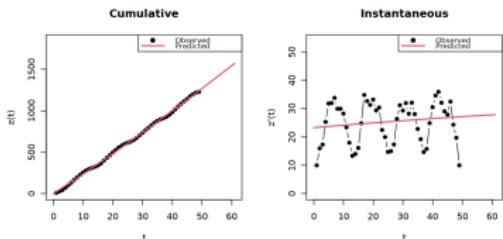
# Bass Model - Weather

		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

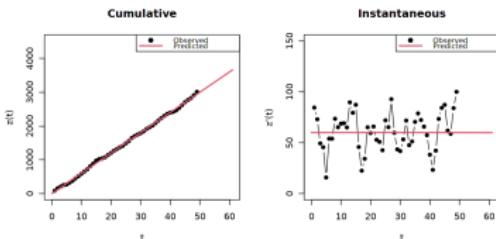
Table: Coefficients of the Bass Model

# Bass Model - Weather

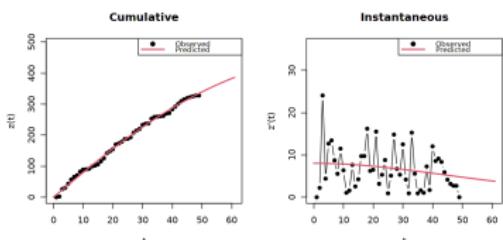
## Temperature



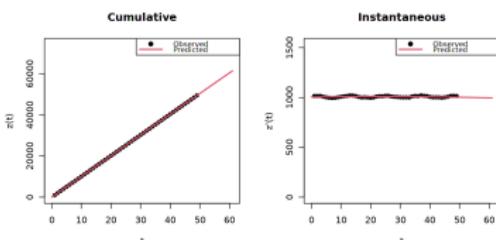
## Humidity



## Wind speed

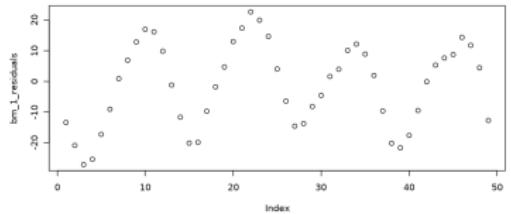


## Pressure

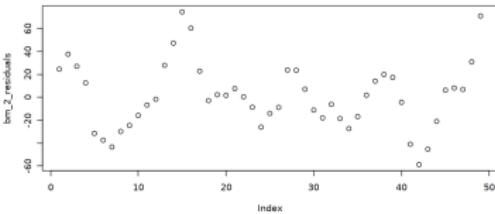


- We can see that we can not adapt the Bass model to our data

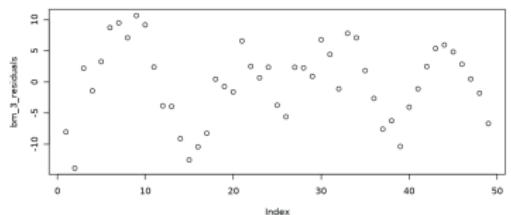
# Bass Model - Weather



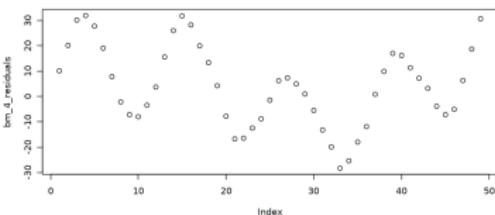
Temperature



Humidity



Wind speed



Pressure

Table: Residuals of the Bass Model

# GAM - Weather

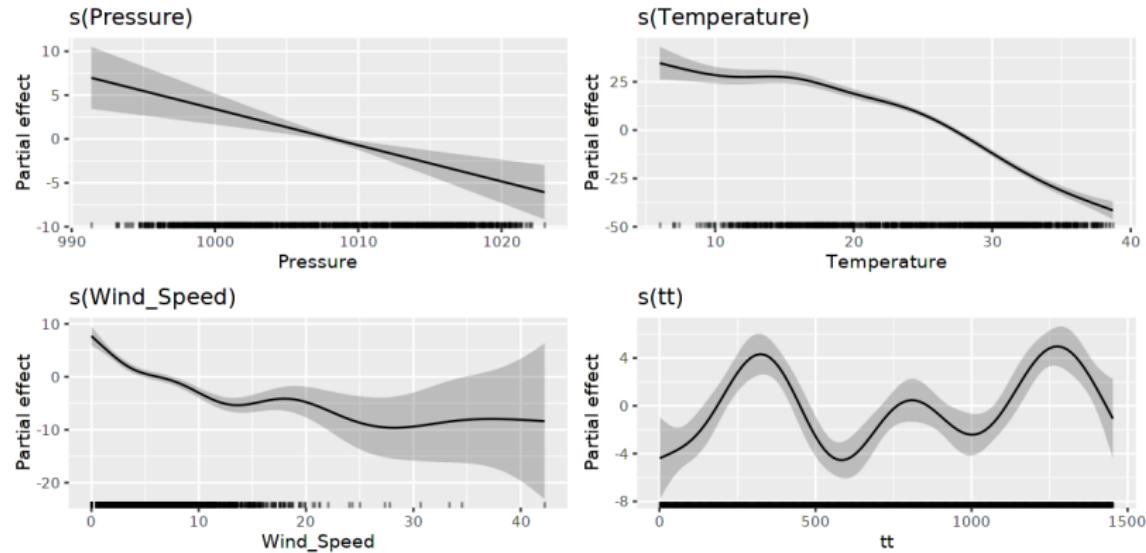
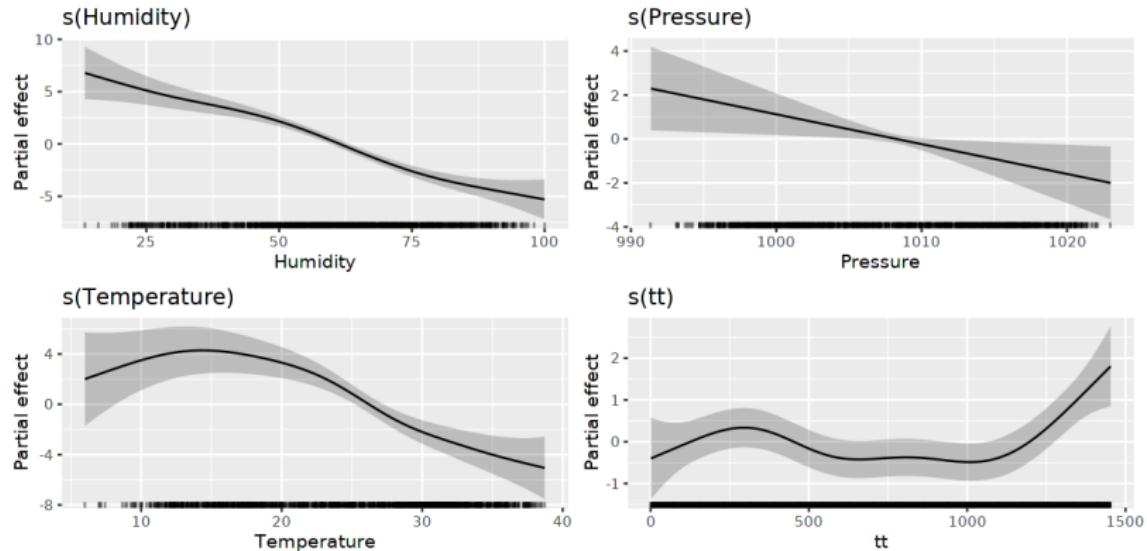


Figure: Generalized Additive Model on the humidity time series

# GAM - Weather



**Figure:** Generalized Additive Model on the wind speed time series

# GAM - Weather

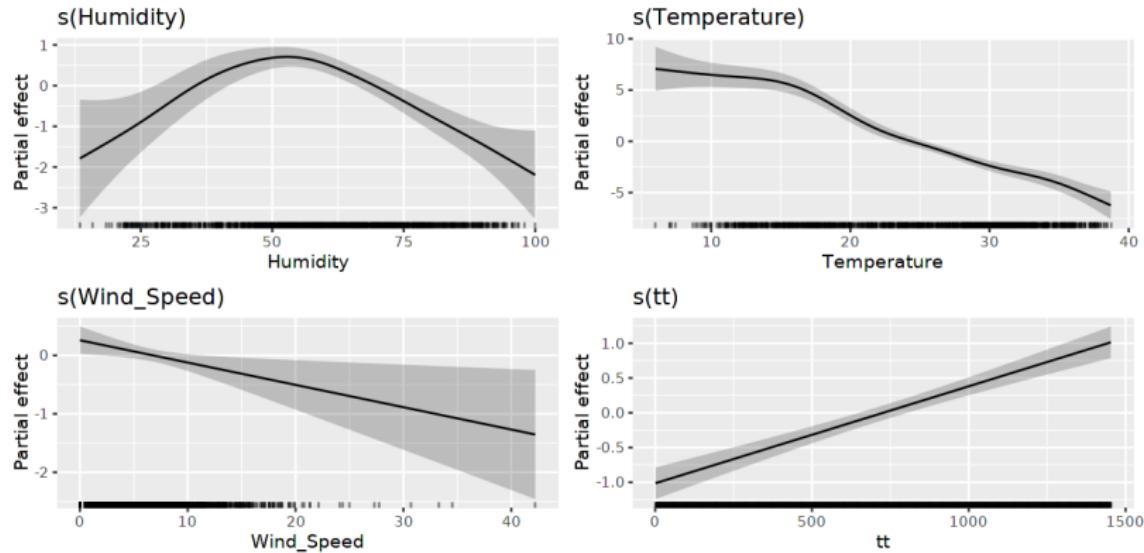


Figure: Generalized Additive Model on the pressure time series

# Monthly data residuals - Weather

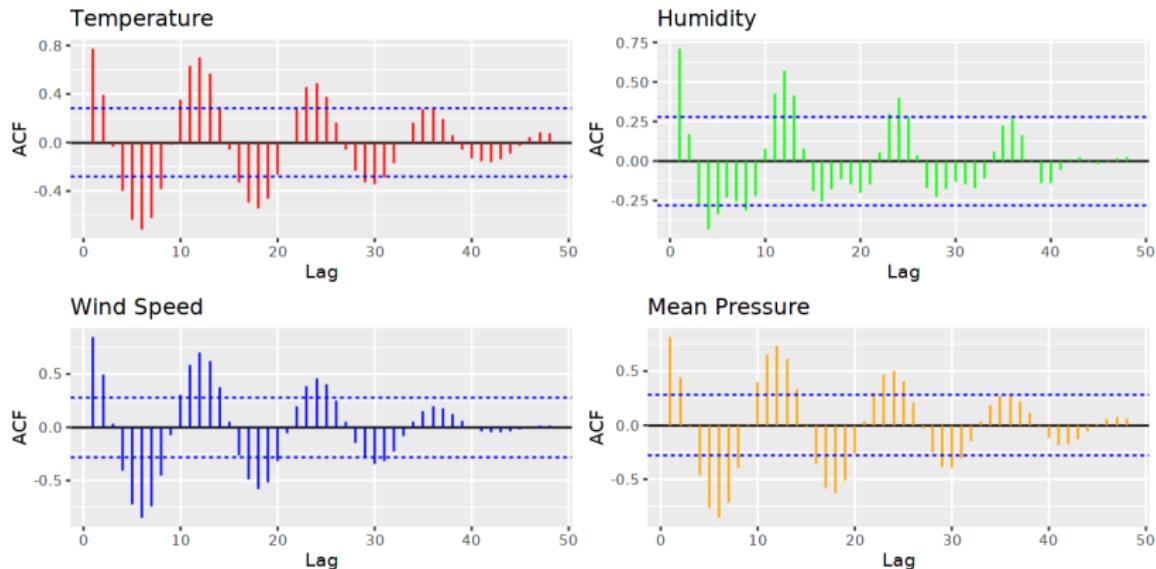


Figure: Autocorrelation function of the smoothed time series

# GAM - Basic necessities

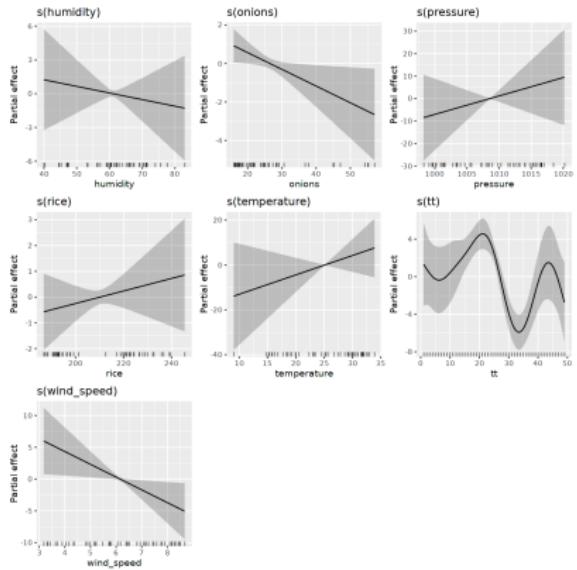


Figure: GAM Potatoes

# GAM - Basic necessities

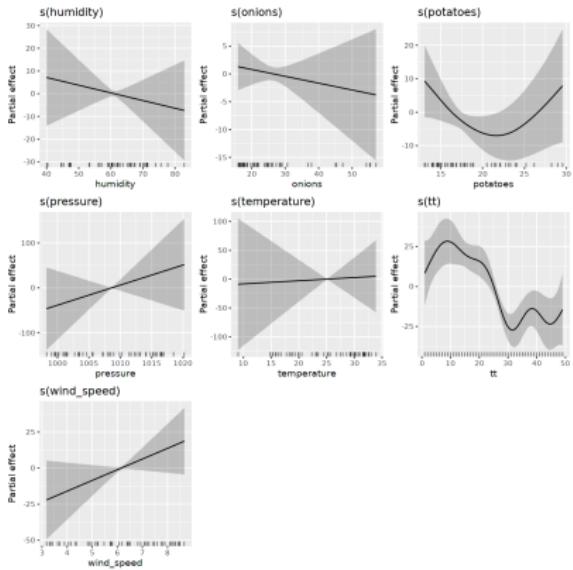


Figure: GAM Rice

# GAM - Basic necessities

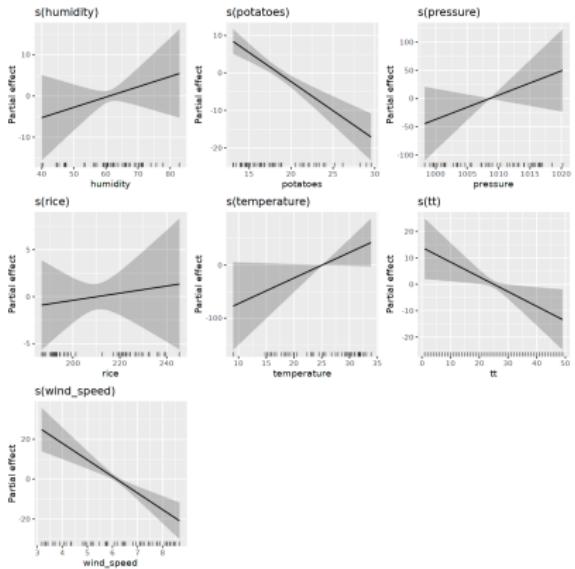


Figure: GAM Onions