

TIME SERIES

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ABOUT ME

Moscow State University | Bachelor's degree
in Economics

University of Toronto | Master's degree in
Statistics

Sber, Liquidity Risk Department | Data
Scientist

Yandex, e-com market | Data Scientist

Dodo Pizza | Product Analyst

Wildberries, A/B-testing platform |
Analyst - Developer

LECTURE PLAN

1. Definition
2. Application
3. AR, MA, ARMA processes
4. ARCH-GARCH
5. Trend-seasonal decomposition
6. Forecasting and confidence intervals

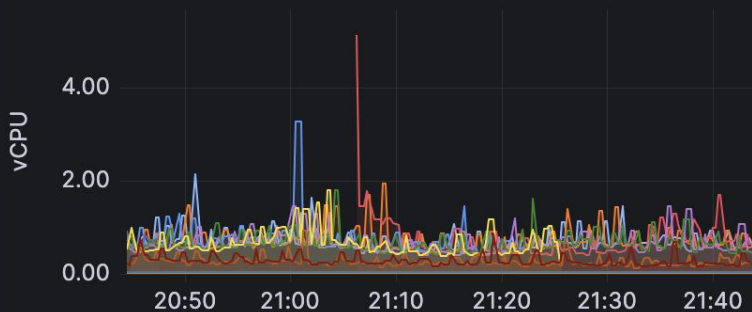
TIME SERIES | DEFINITION

Time Series - is a sequence of data points that occur in successive order over time.

Gross domestic product per capita in India



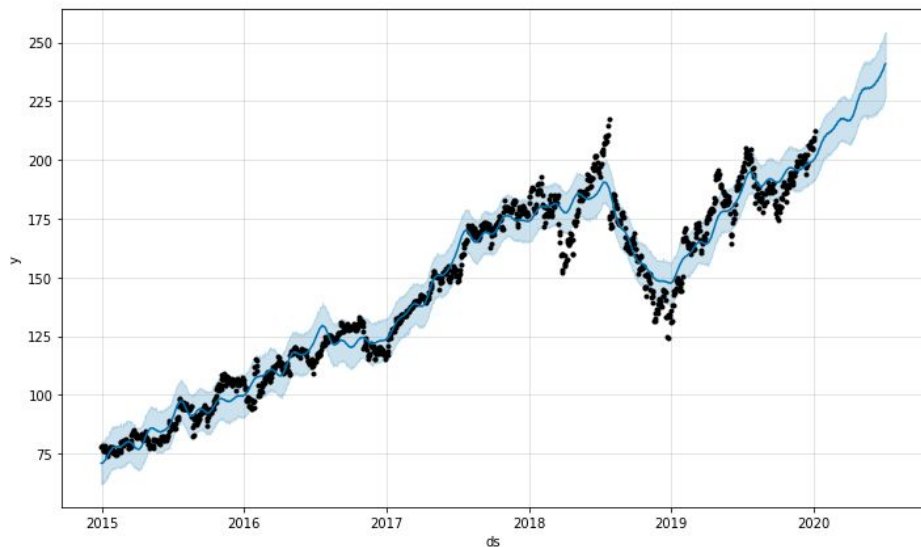
CPU usage



Год	ВВП в текущих ценах, млрд руб.
2022	151 455.6
2021	135 295.0
2020	107 658.2
2019	109 608.3
2018	103 861.7
2017	91 843.2
2016	85 616.1
2015	83 087.4
2014	79 030.0
2013	72 085.7
2012	68 103.4
2011	60 114.0
2010	46 308.5

WHY DO WE NEED TO MODEL TIME SERIES?

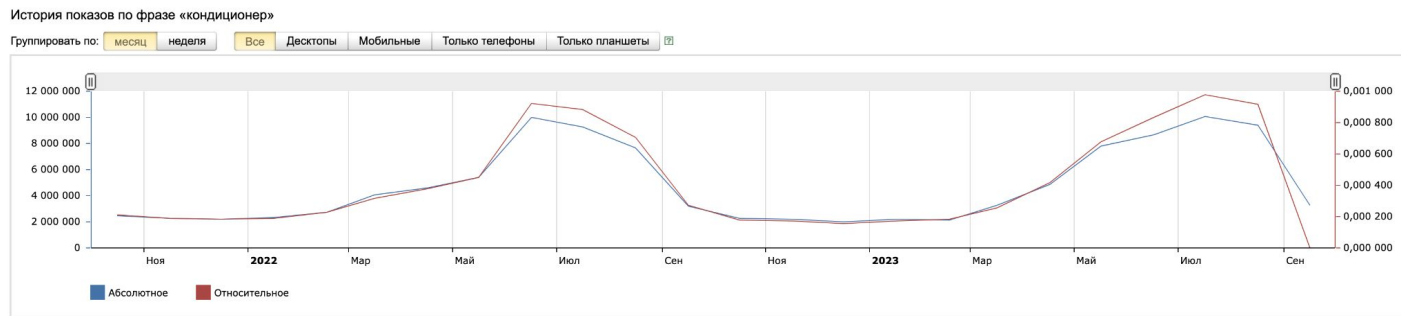
For real-life Time Series a theoretical model can be estimated. Time series model approximates real-life process for studying and forecasting.



An example of a forecast of Time Series using a mathematical model. Realization in fb-prophet.

PROPERTIES OF TIME SERIES

- Periodicity (seconds, minutes, hours, days, months, years etc.)
- Seasonality (same patterns that repeat over time.
Example: demand on AC-systems)
- Trend (some stable tendention over time)
- Stationarity/Non-stationarity
- Heteroscedasticity/Homoscedasticity



EXAMPLES

★ Мониторинг Revenue Главная web

[Refresh](#)[Edit Source](#)

counter_id

4

interval

19/11/23



06/12/23

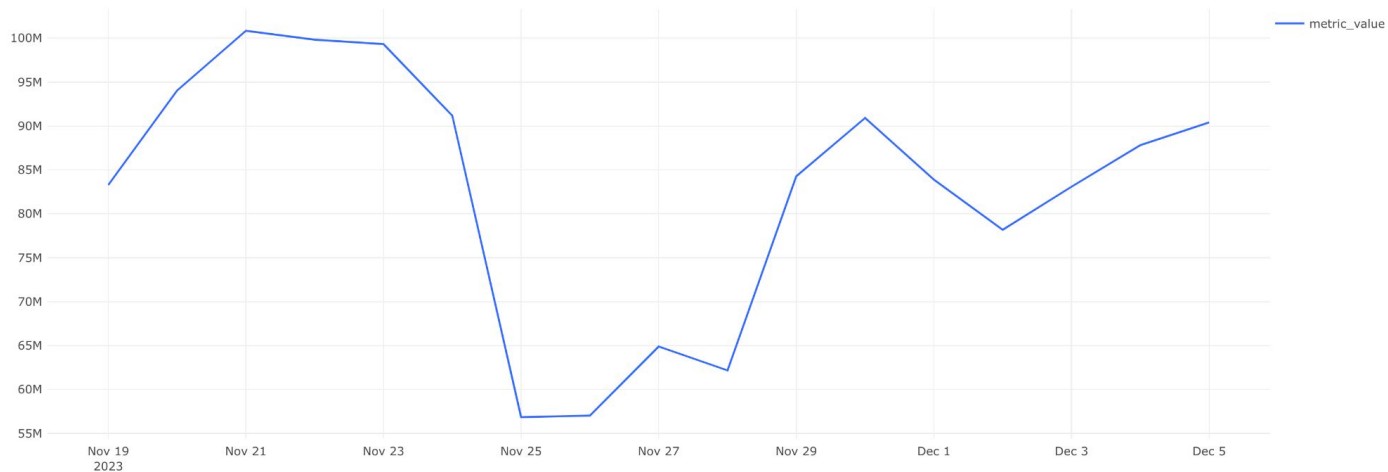


Table

Процентное изменение выручки на главной ×

Выручка с главной ×

+ Add Visualization

[Edit Visualization](#)

17 rows 15 seconds runtime

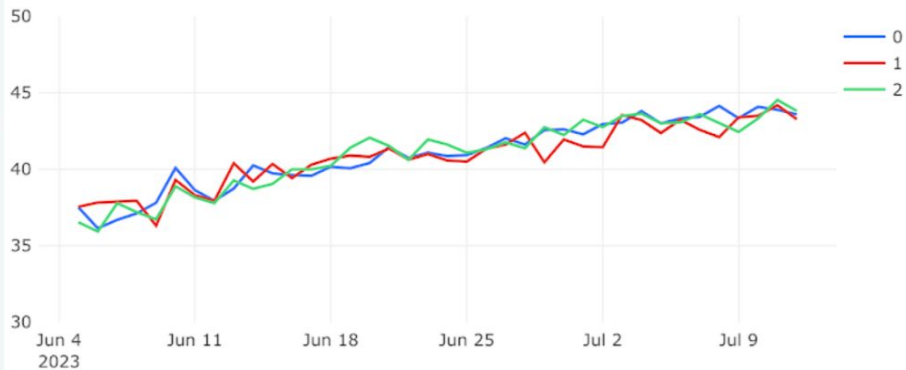
Refreshed 2 days ago

EXAMPLES

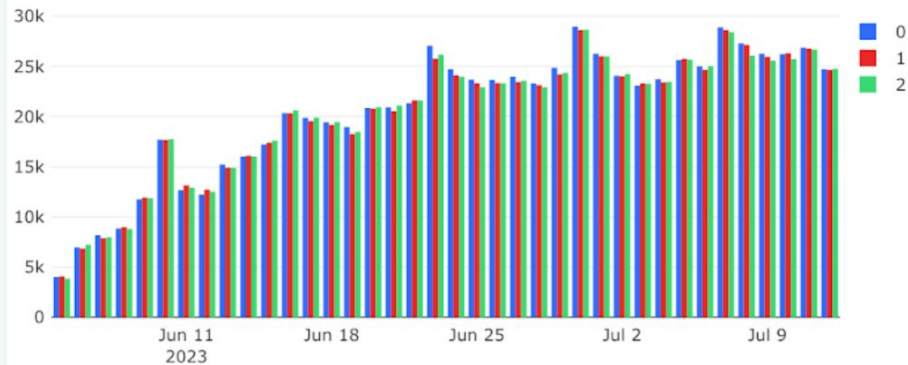


EXAMPLES

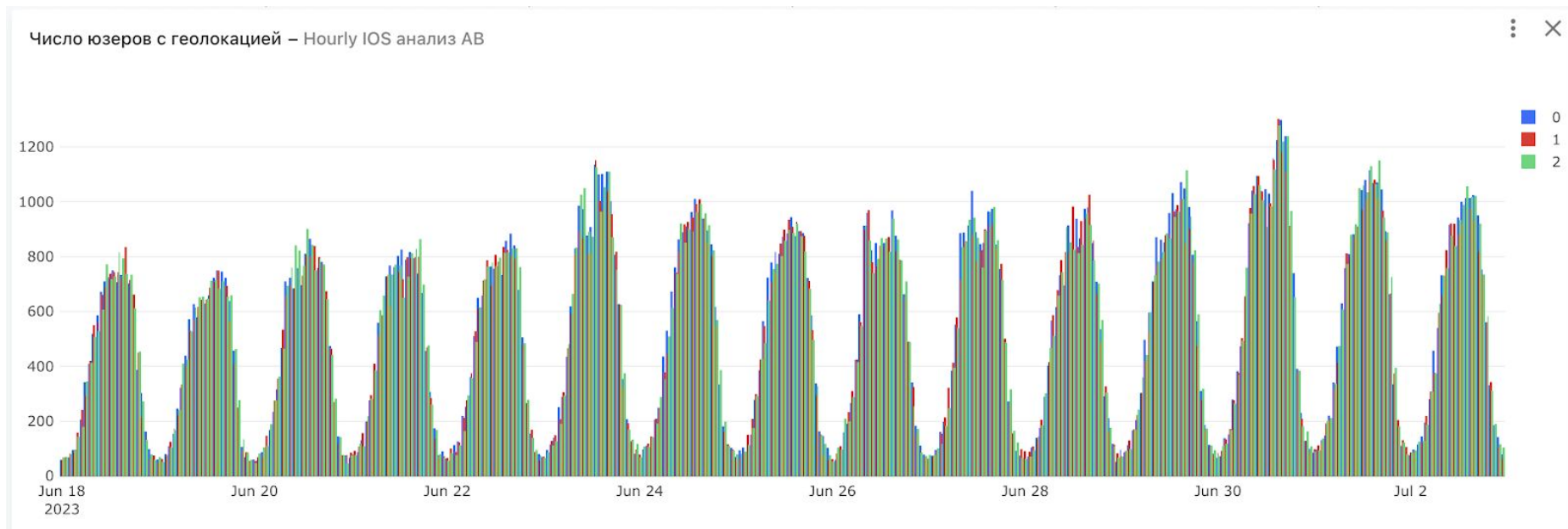
Процент юзеров с геолокацией – IOS анализ AB



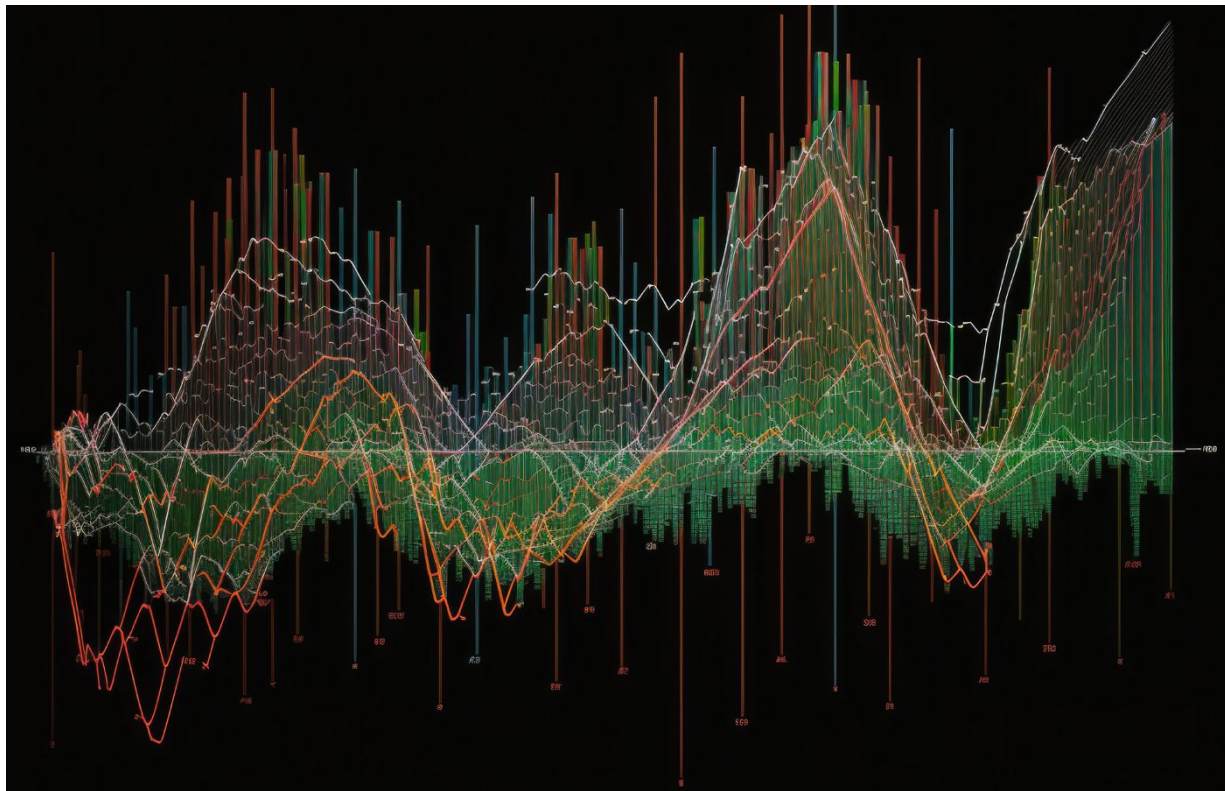
Число уникальных юзеров – IOS анализ AB



EXAMPLES

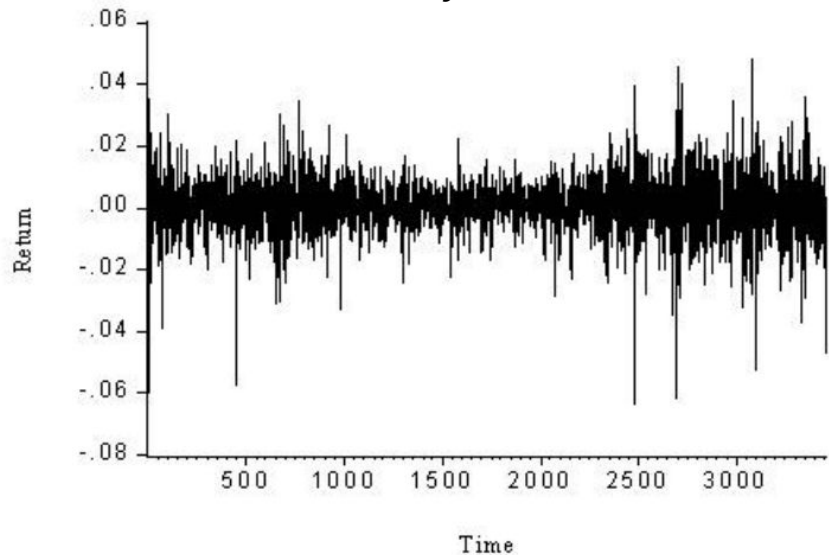


EXAMPLES



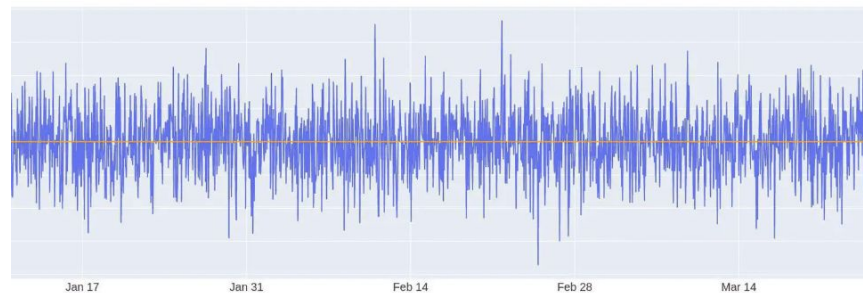
HETEROSCEDASTICITY/HOMOSCEDASTICITY

Heteroscedasticity



Variance is NOT stable over time

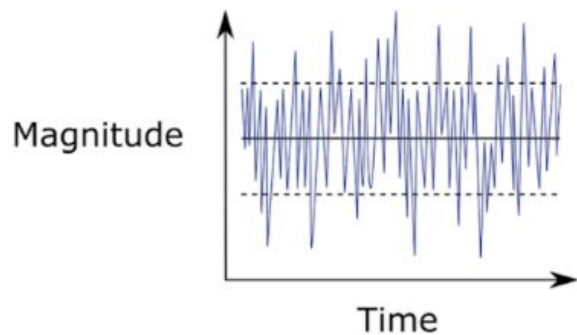
Homoscedasticity



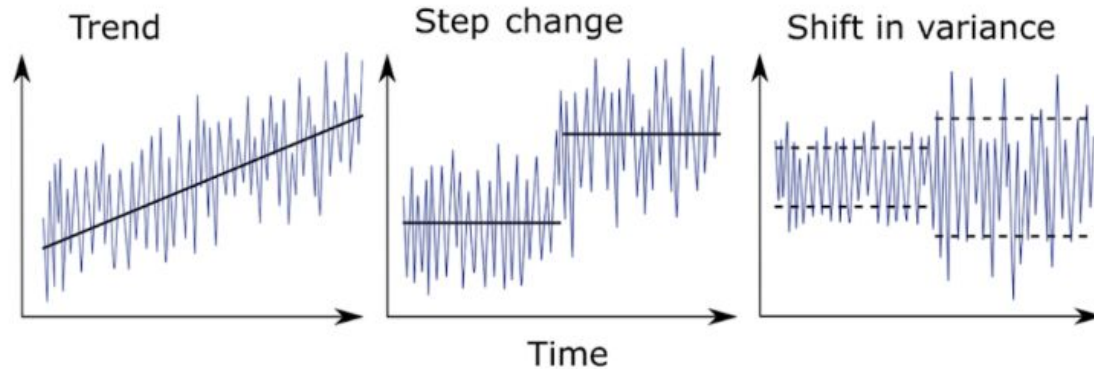
Variance is stable over time

STATIONARITY/NON-STATIONARITY

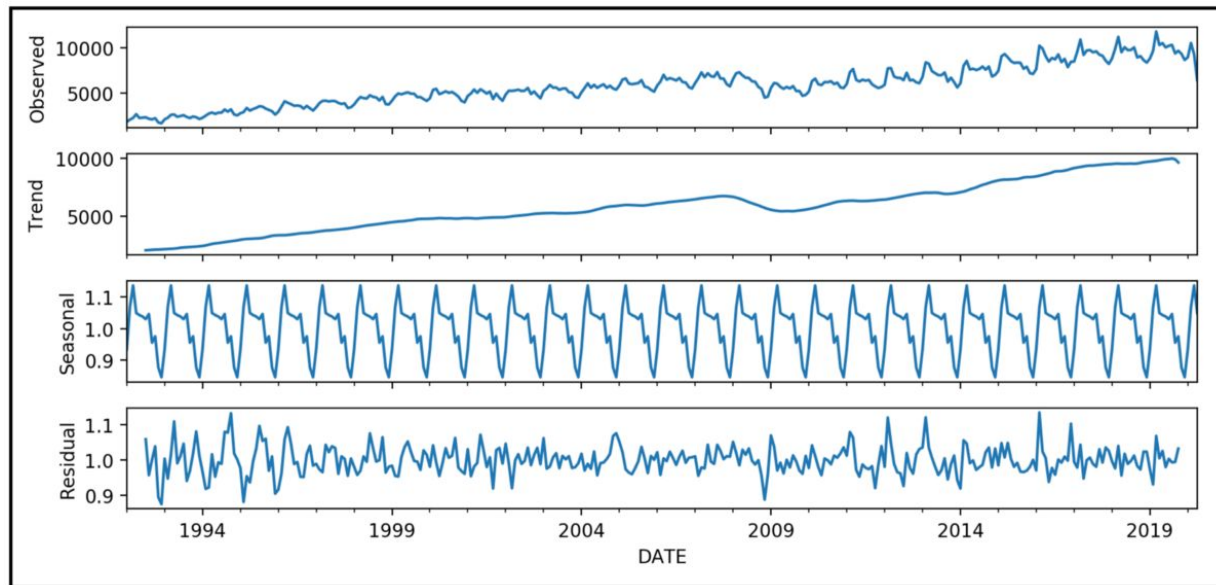
(a) Stationary



(b) Nonstationary



TREND, SEASONALITY AND SHOCKS



Временной ряд можно представить в виде декомпозиции на несколько отдельных временных рядов:

- тренд
- сезонность
- шоки/выбросы

TREND, SEASONALITY AND SHOCKS

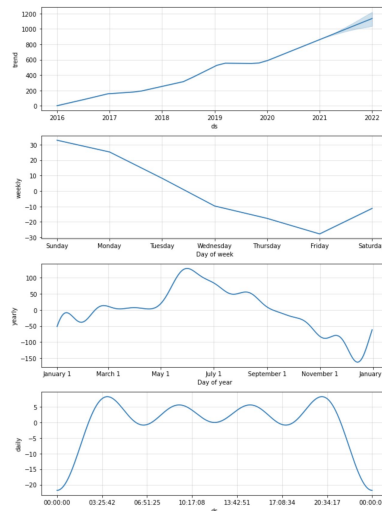
Additive Decomposition

$$Y_t = T_t + S_t + E_t$$

Y_t - observation value at time t ,
 T_t - trend component
 S_t - seasonal component
 E_t - shock component

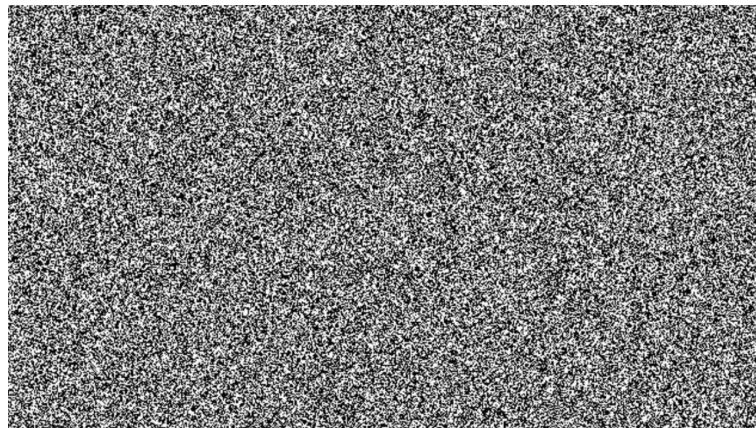
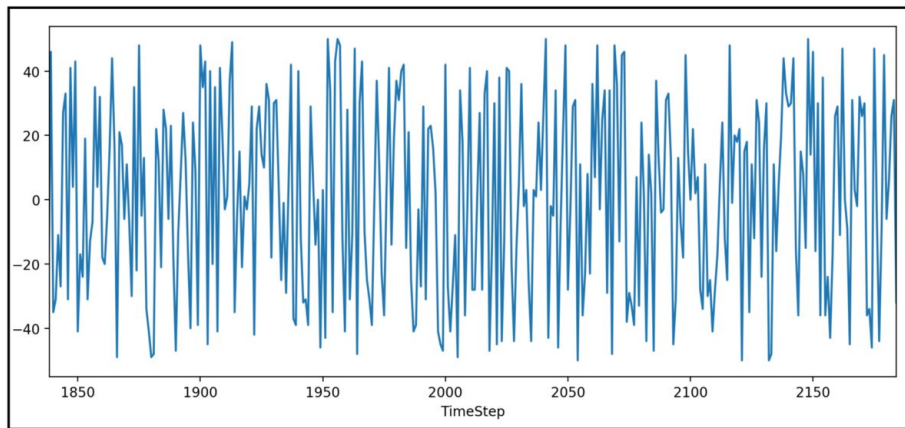
Multiplicative Decomposition

$$Y_t = T_t * S_t * E_t$$



WHITE NOISE

White noise is a process $e_1 \dots e_t$ of independent equally distributed random variables that has a zero mean and finite variance



AR(p) - AUTO-REGRESSION PROCESS

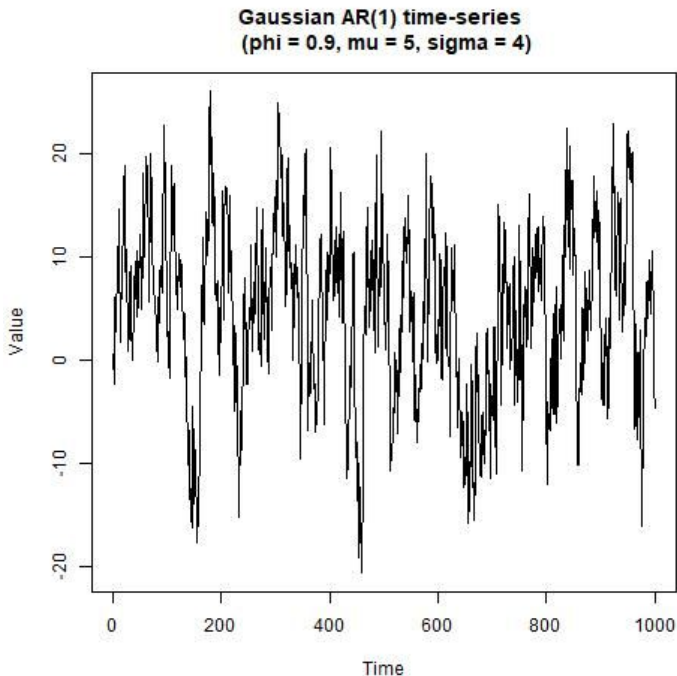
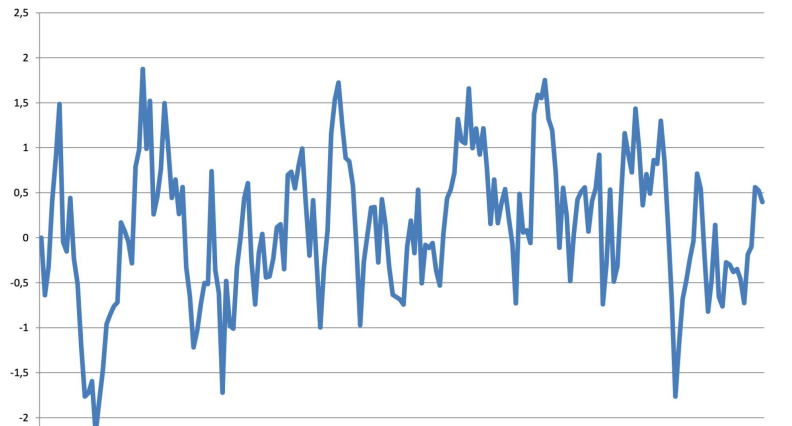
$$X_t = \sum_{i=1}^p \varphi_i X_{t-i} + \varepsilon_t.$$

A process with values that follow the formula

AR(1) - FIRST ORDER AUTO-REGRESSION

It is an example of auto-regression of order $p=1$.

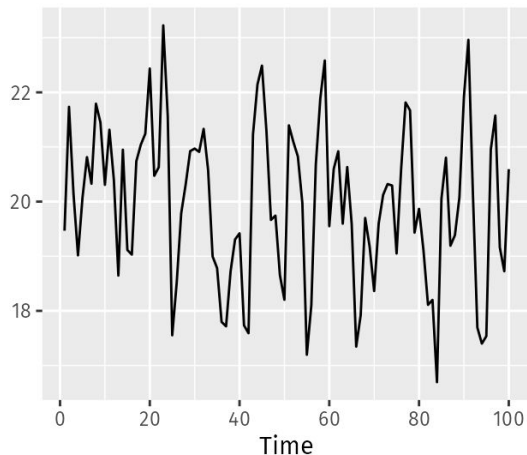
$$y_t = \delta + \theta y_{t-1} + \varepsilon_t$$



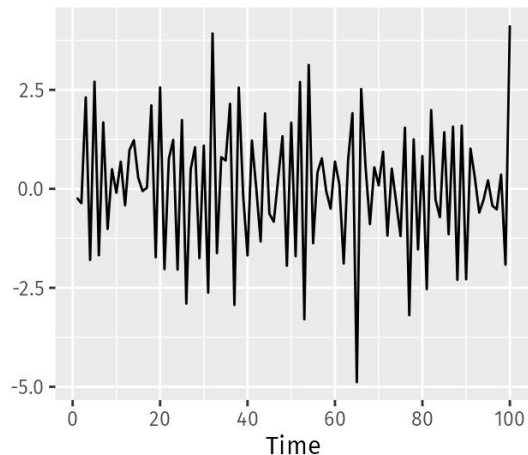
MA(Q) - MOVING AVERAGE PROCESS

$$MA(q) : Y_t = \mu + \epsilon_t + \sum_{i=1}^q \theta_i \epsilon_{t-i}$$

MA(1)



MA(2)



FBPROPHET EXAMPLE

Insert example with electricity