The role of forecasting electricity demand in societal decarbonization

Hussain Kazmi, PhD

Overview

- Who makes electricity demand forecasts and why?
- When (and at which aggregation levels) are the forecasts made?
- How to make electricity demand forecasts?
  - Inputs, outputs and function approximation
  - Model evaluations
  - Some lessons from recent competitions

Why make forecasts?

Generation side

The electricity grid

Demand side

The energy transition

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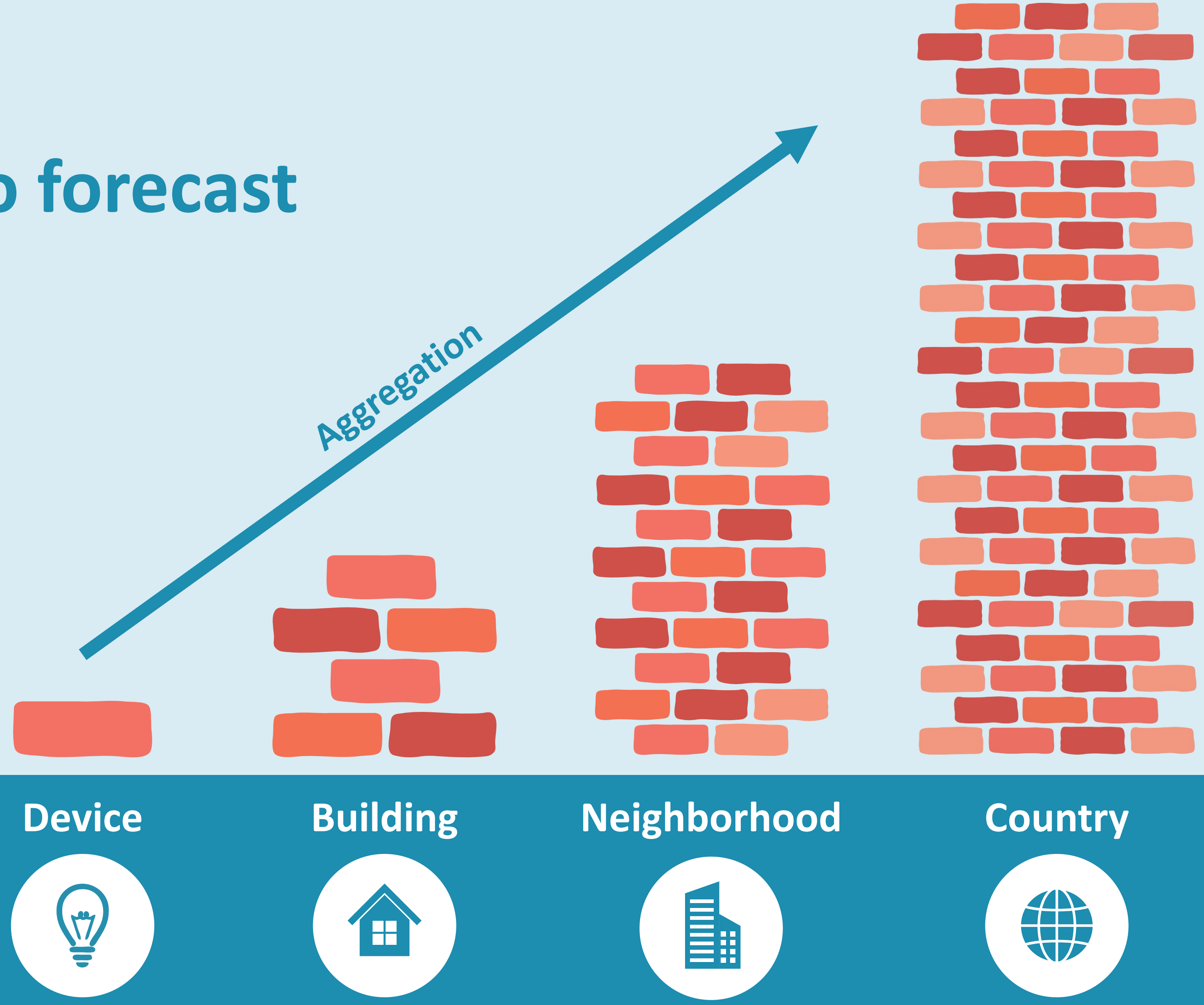
Where to forecast



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Time resolution of datasets

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Forecasting grid load

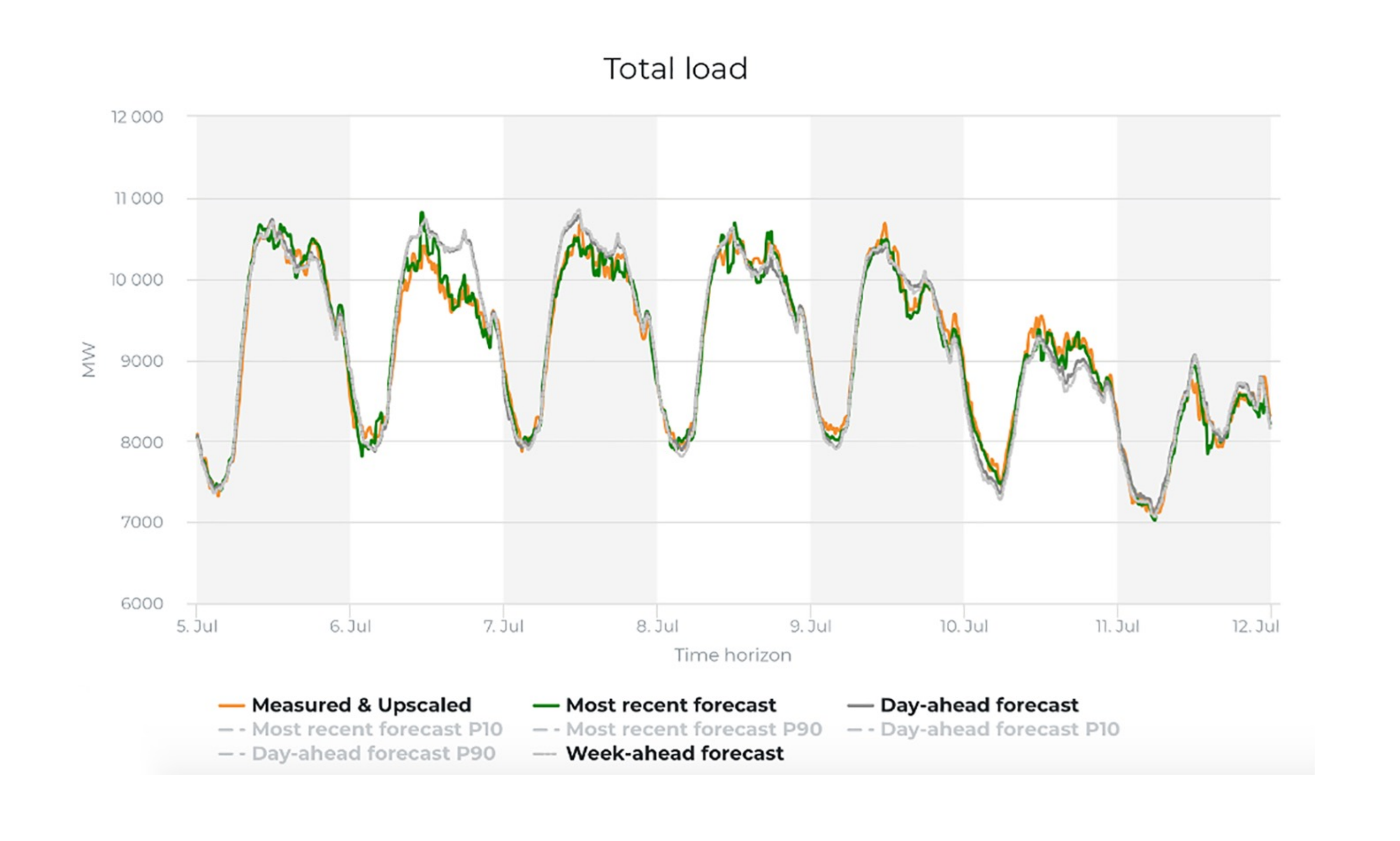

Image source: Elia

Forecasting grid load

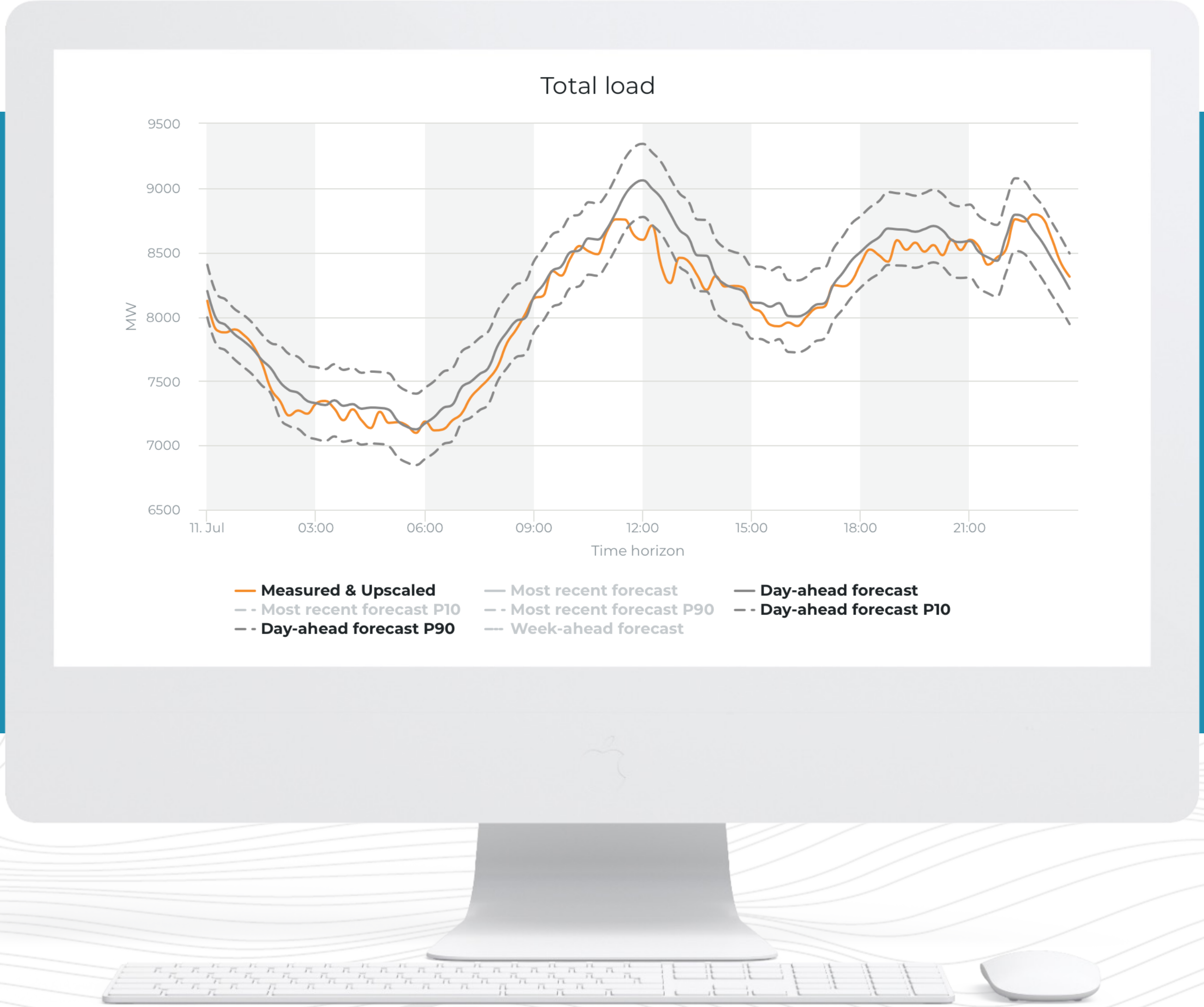

Image source: Elia

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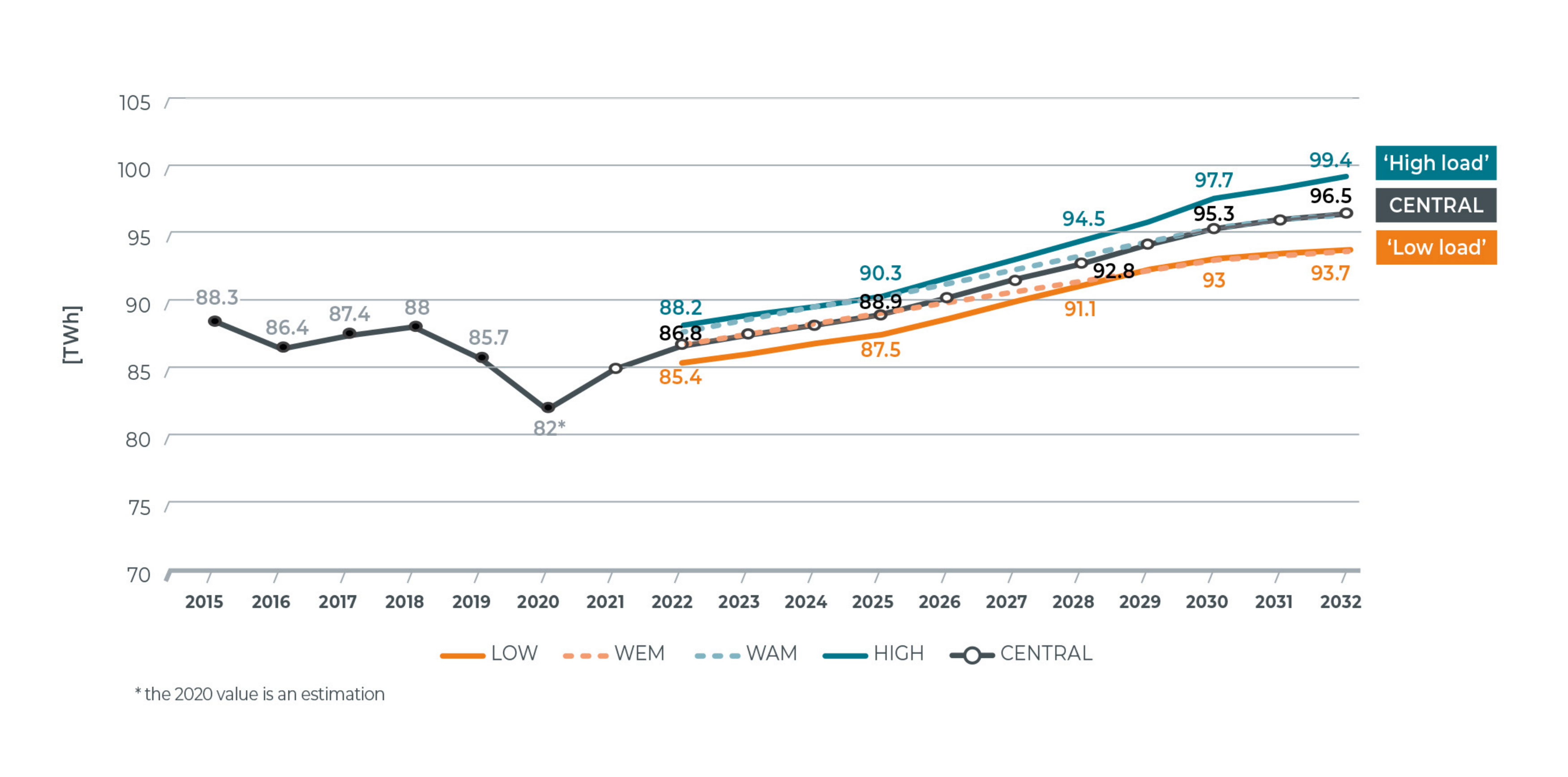
Forecasting energy load



Adapted from Elia Report 2021

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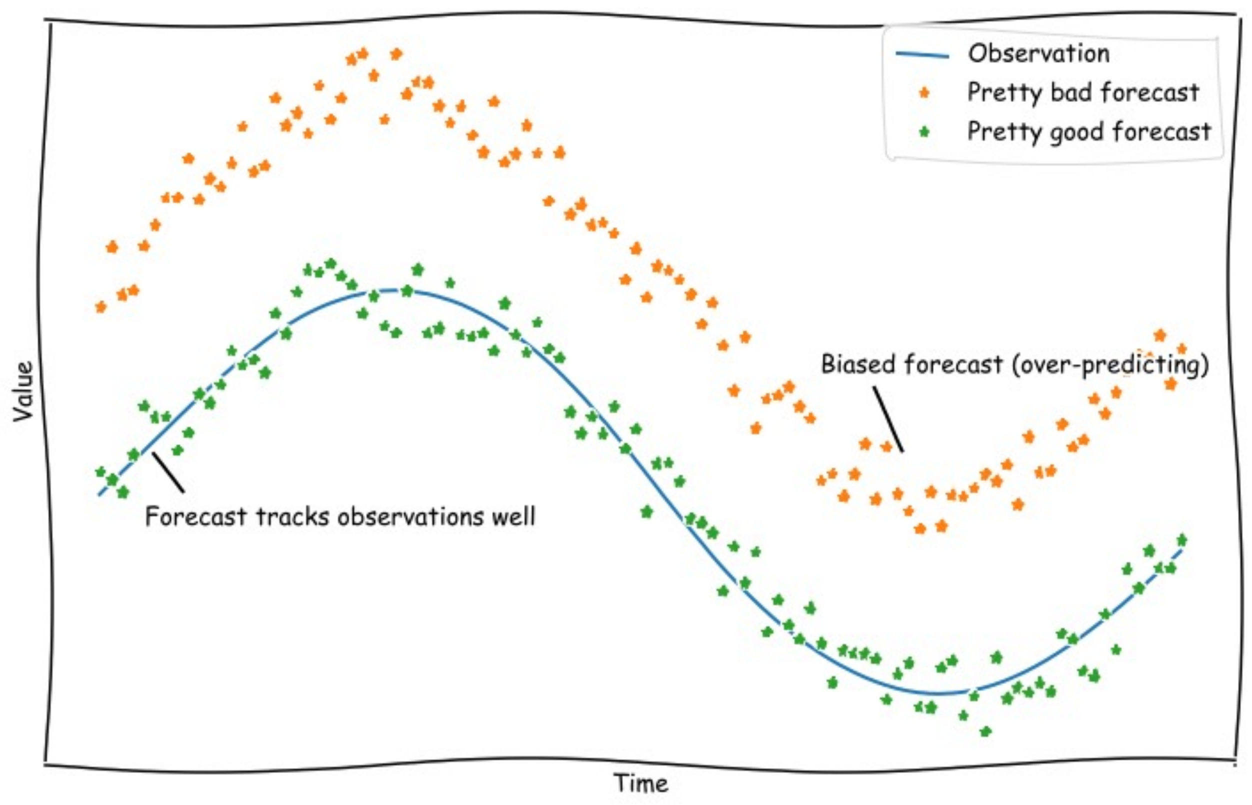
What makes a good forecast?

1. Error metric values

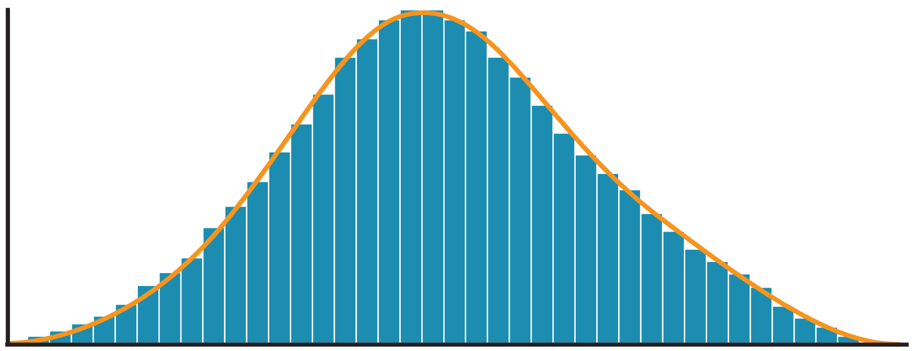


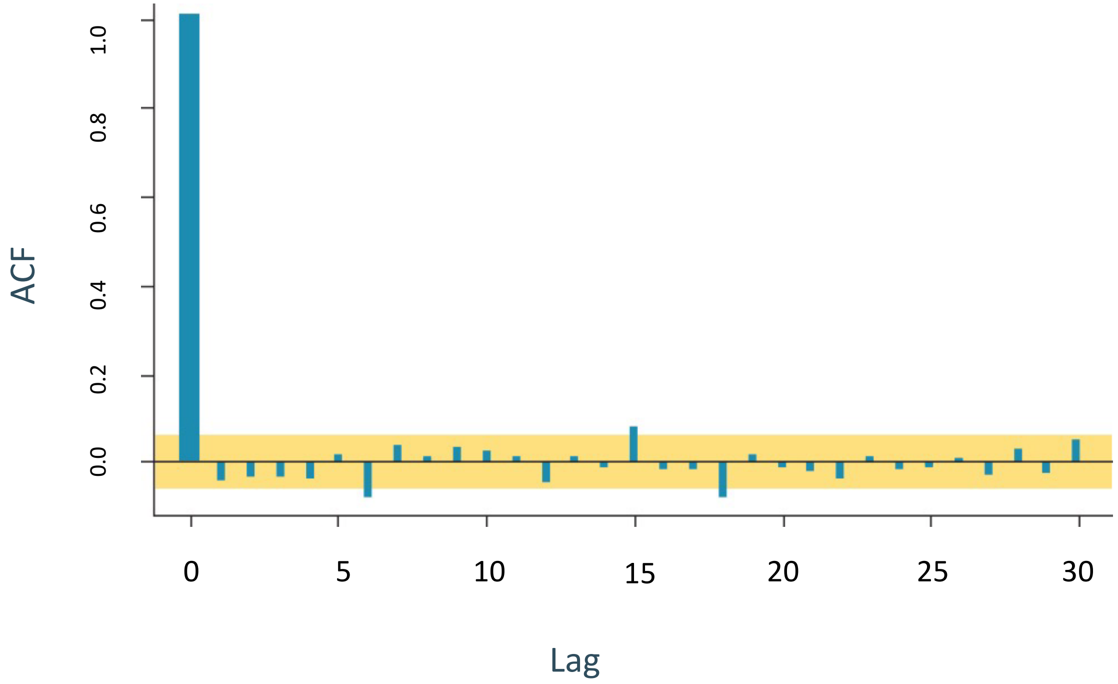
a. Mean absolute error (MAE)
b. Mean absolute percentage error (MAPE)
c. Relative metrics (relative MAE (rMAE), Mean absolute scaled error (MASE))
d. Other measures (R^2 score, AIC / BIC, etc.)

What makes a good forecast?

2. Forecast error distribution

a. Normally distributed residuals
b. Bias-variance trade-off
c. No autocorrelation





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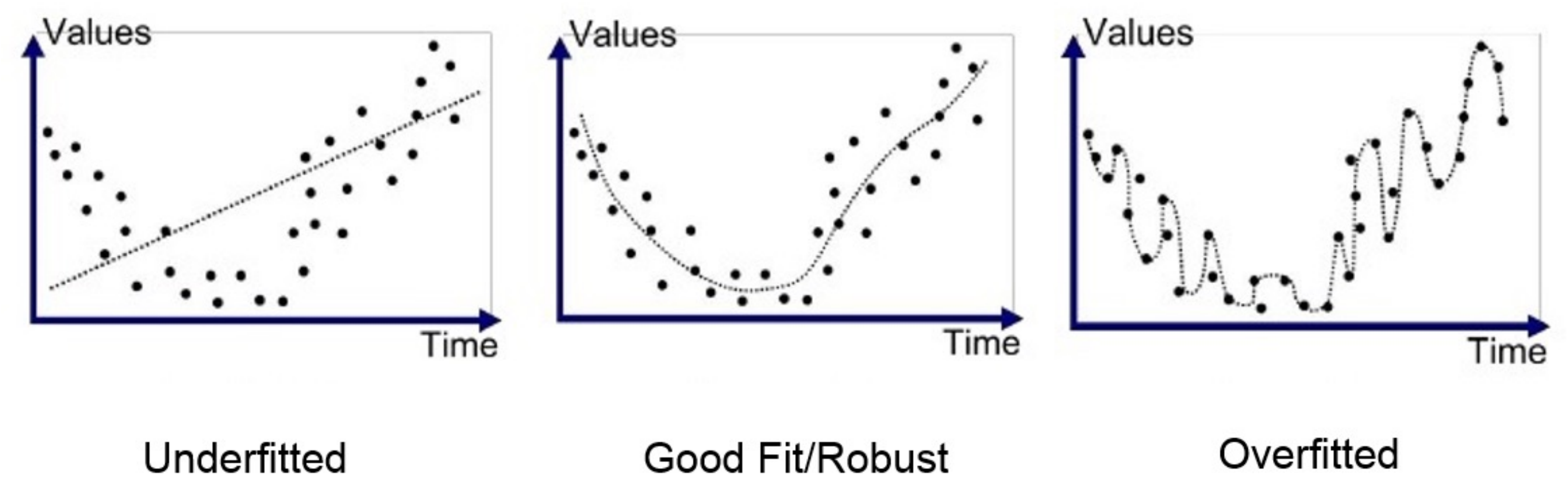
What makes a good forecast?

3. Generalization

a. Training, validation and test error

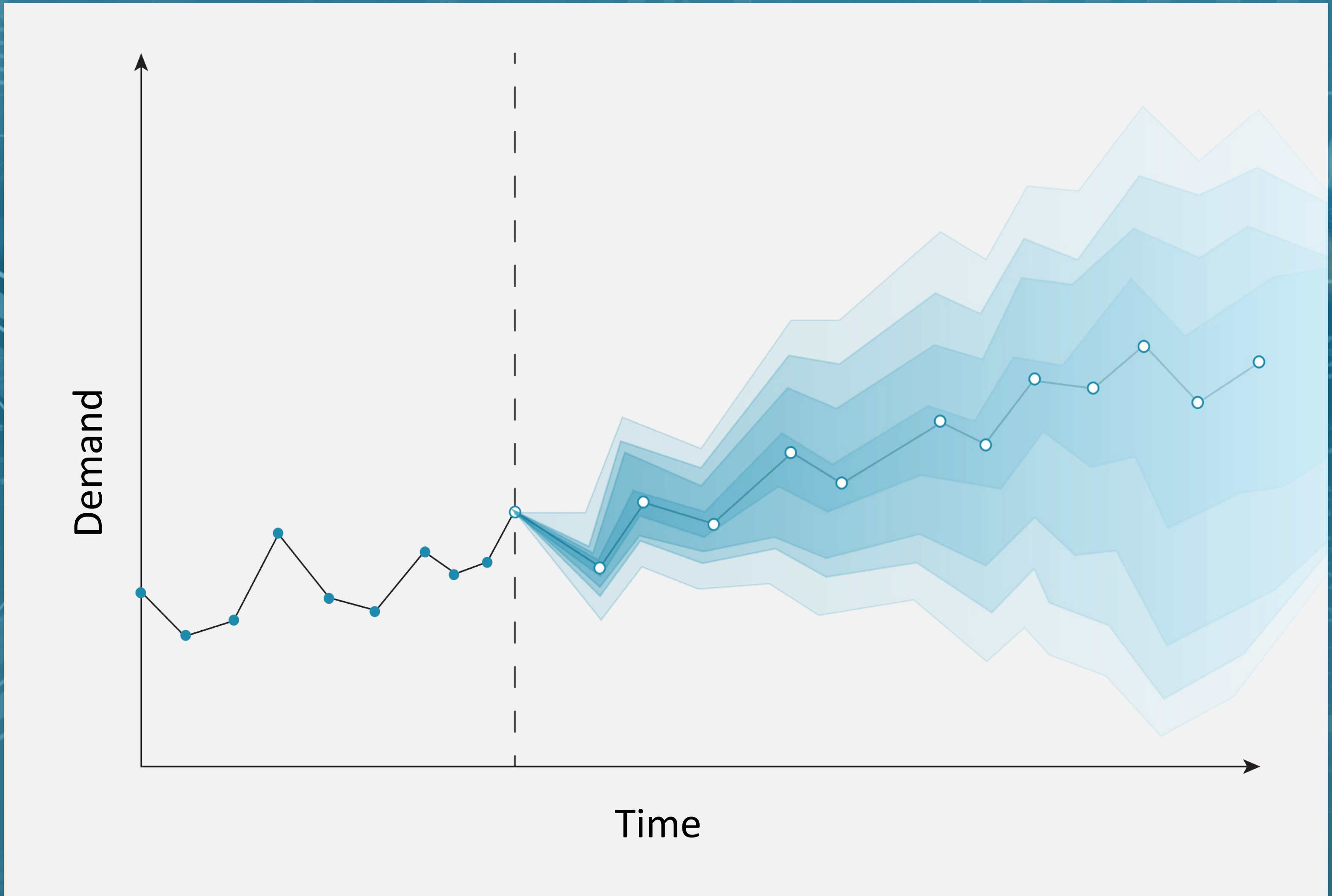
b. Comparison with simple baselines



What makes a good forecast?

4. Scalability and computational complexity

a. Has low training / inference times depending on context
b. Scales well with increasing amount of data and/or features



What makes a good forecast?

5. Uncertainty estimates?

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Establishing a baseline

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Defining a persistence baseline model

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Defining an auto-ml baseline model

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How to build a forecast model

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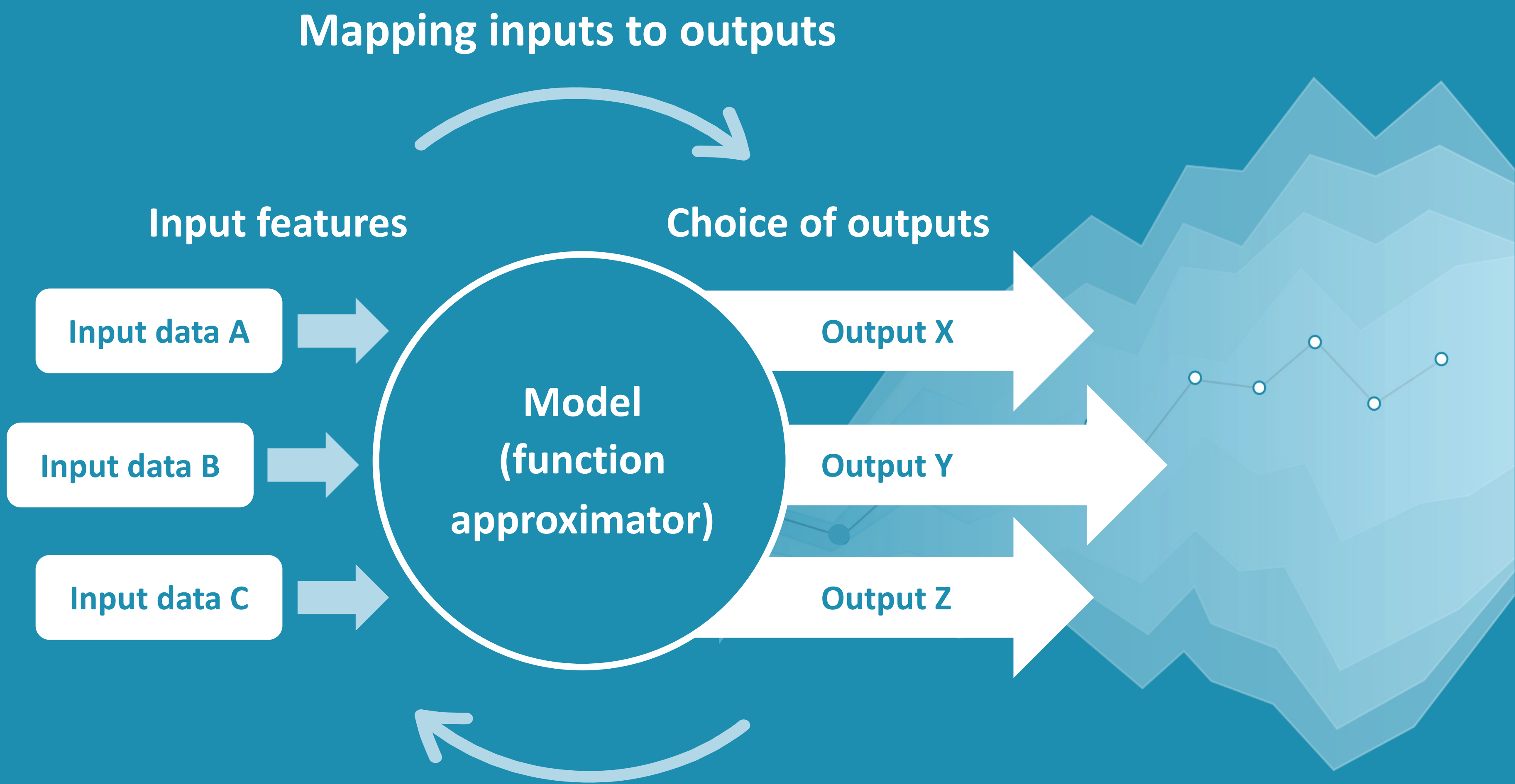
Building a forecast model



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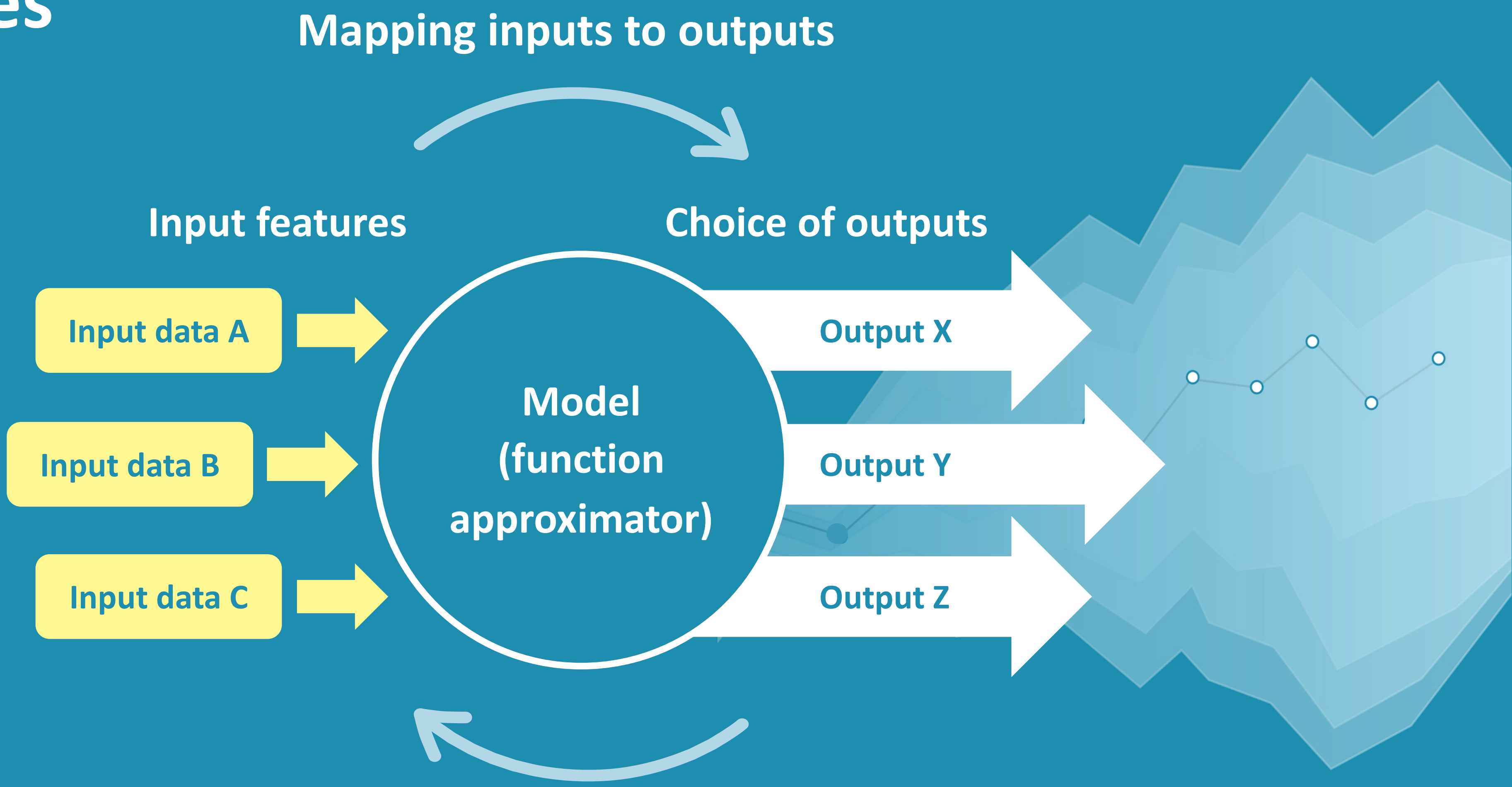
1. Input features for a forecast model

a. Feature selection



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Building a forecast model

1. Input features for a forecast model

b. Sliding and expanding windows

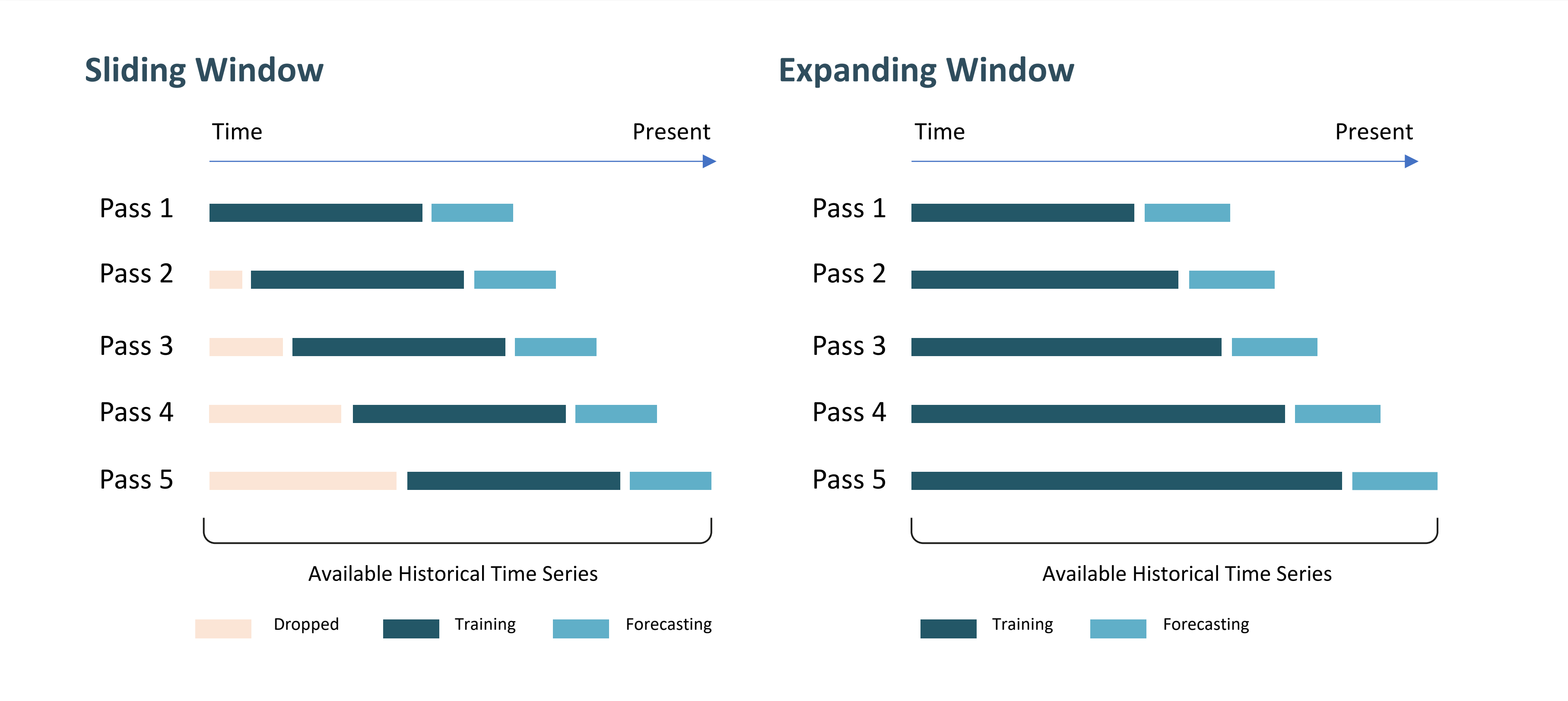

Image adapted from Uber

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Building a forecast model

1. Input features for a forecast model

c. Feature transformations

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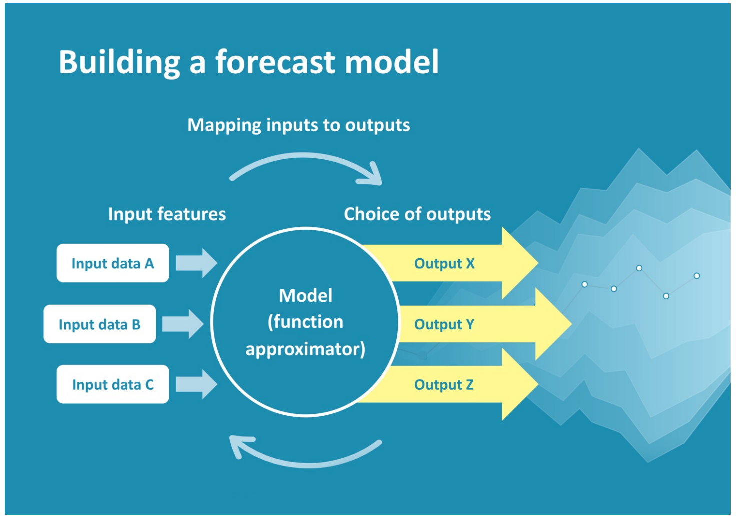
Building a forecast model

2. Choice of outputs

a. Point and interval forecasts

b. Recursive, direct & multi-step forecasts



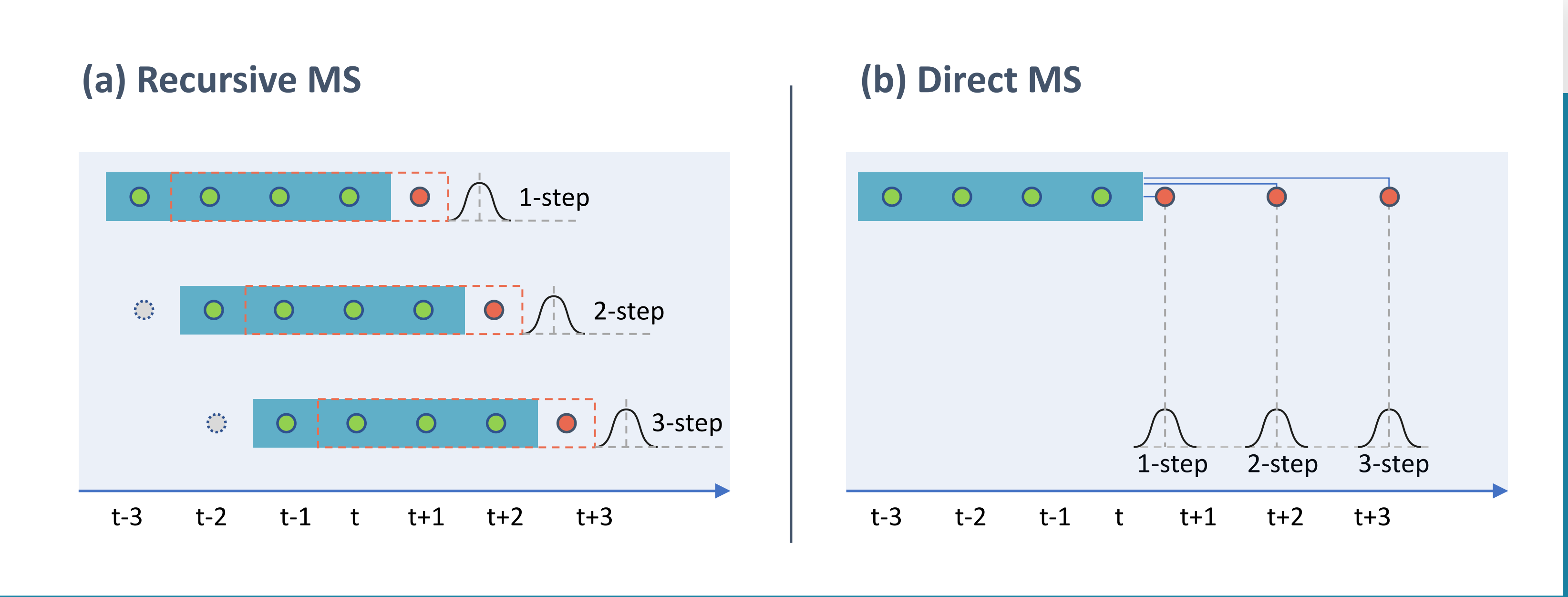


Image adapted from: IEEE

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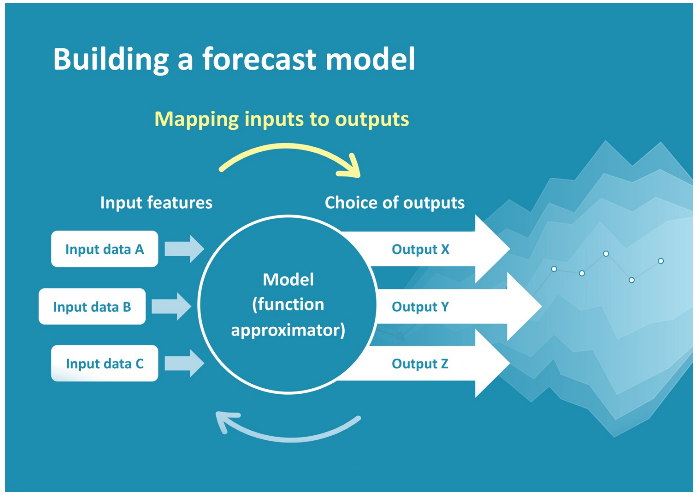
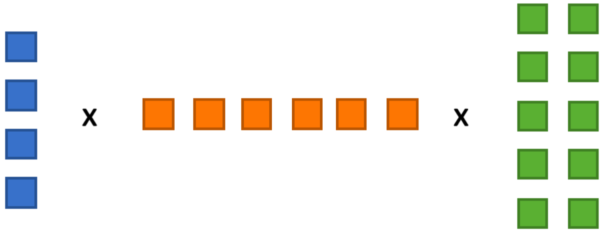
Building a forecast model

3. Mapping inputs to outputs

a. Choice of function approximator





Time series   Time horizon   Ensemble models

Model type	Number of models
Recursive, global model (no ensembling)	1 x 1 x 1 = 1
Recursive, local model (no ensembling)	4 x 1 x 1 = 4
Direct, global model (no ensembling)	1 x 6 x 1 = 6
Recursive, global, ensemble model	**1 x 1 x 10 = 10**
Direct, local model (no ensembling)	4 x 6 x 1 = 24
Recursive, local, ensemble model	4 x 1 x 10 = 40
Direct, global, ensemble model	1 x 6 x 10 = 60
Direct, local, ensemble model	4 x 6 x 10 = 240

Building a forecast model

3. Mapping inputs to outputs

b. Generalization via regularization

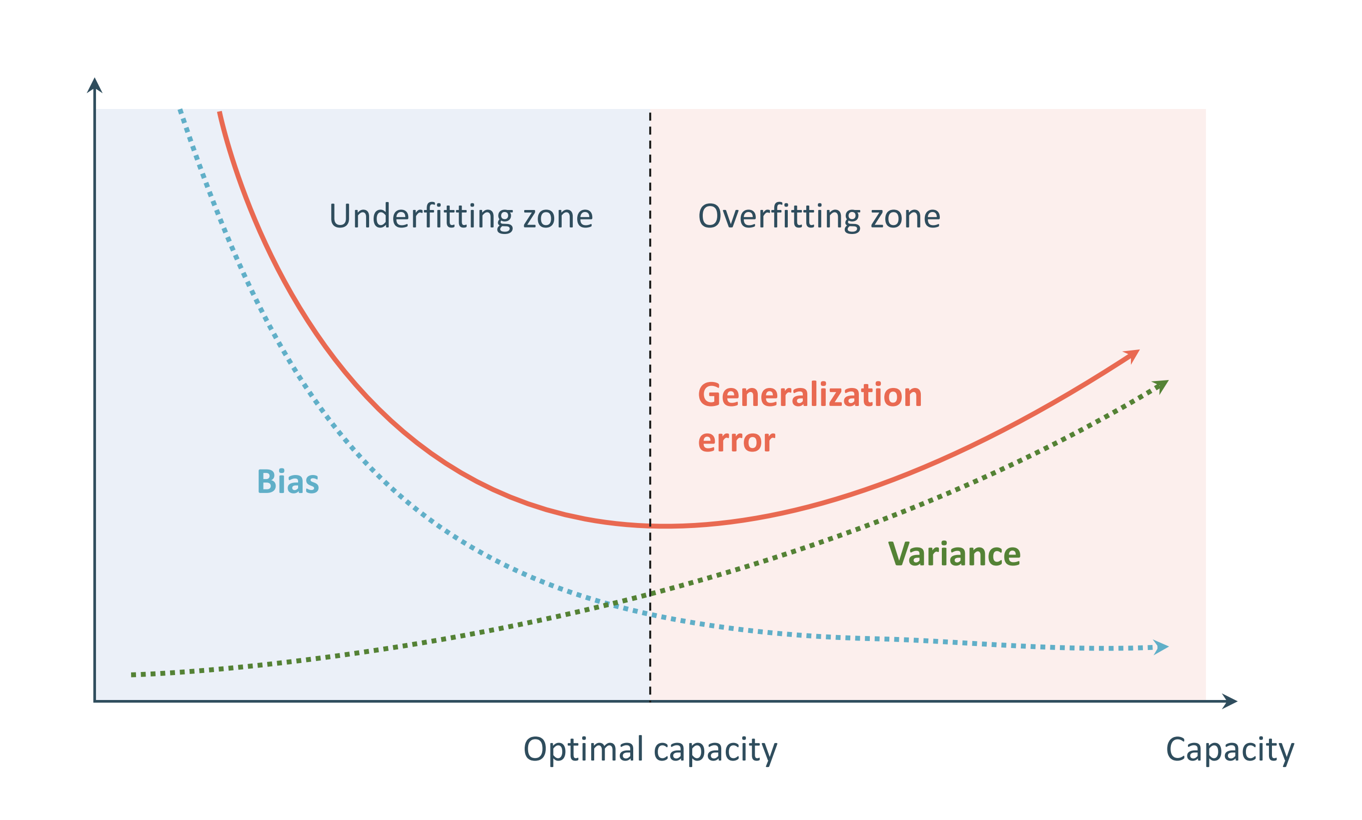


Image adapted from: Deepai

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Model comparisons

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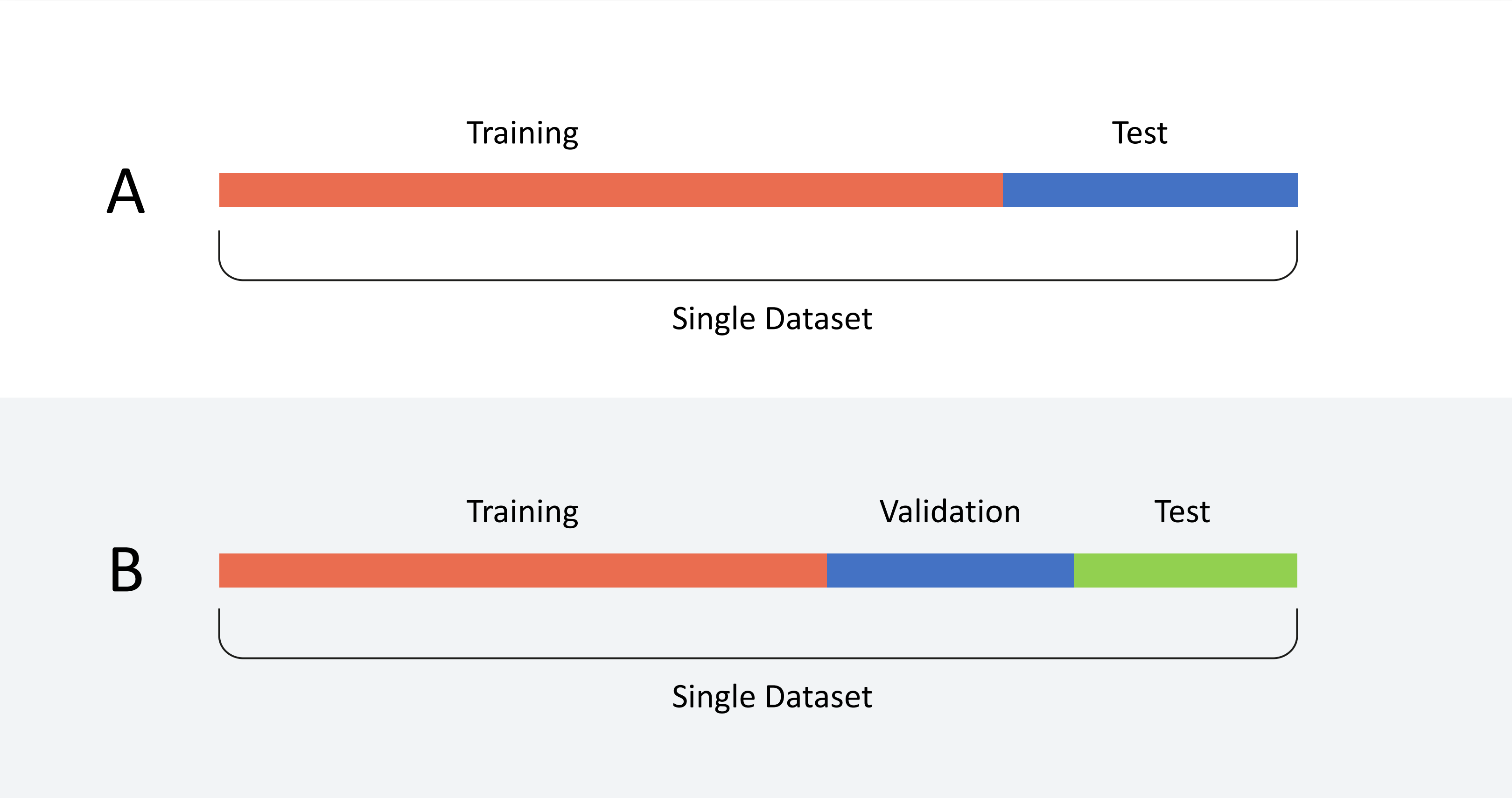
Data splits



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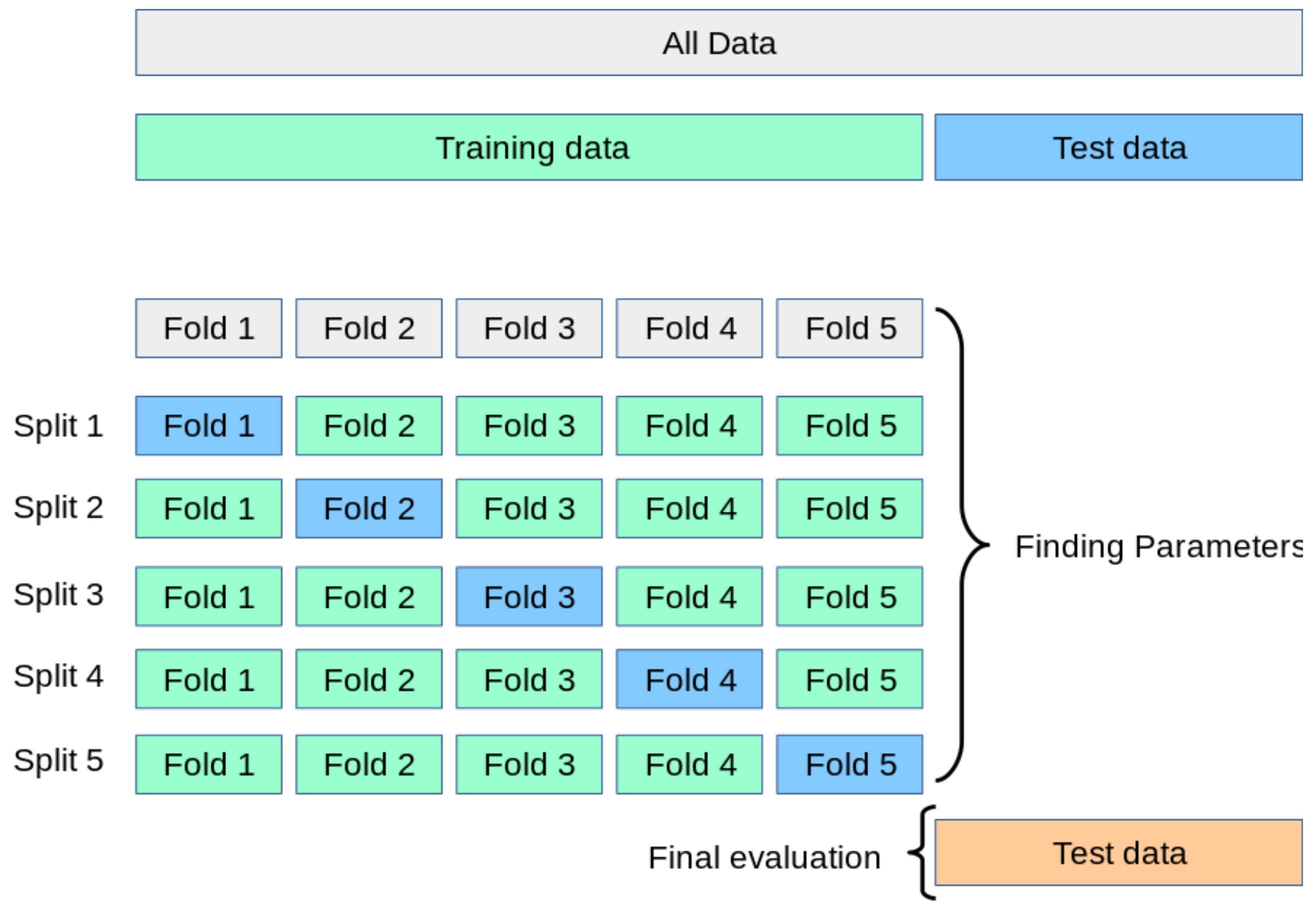
From splitting data to cross-validation

Image source: Scikit-learn



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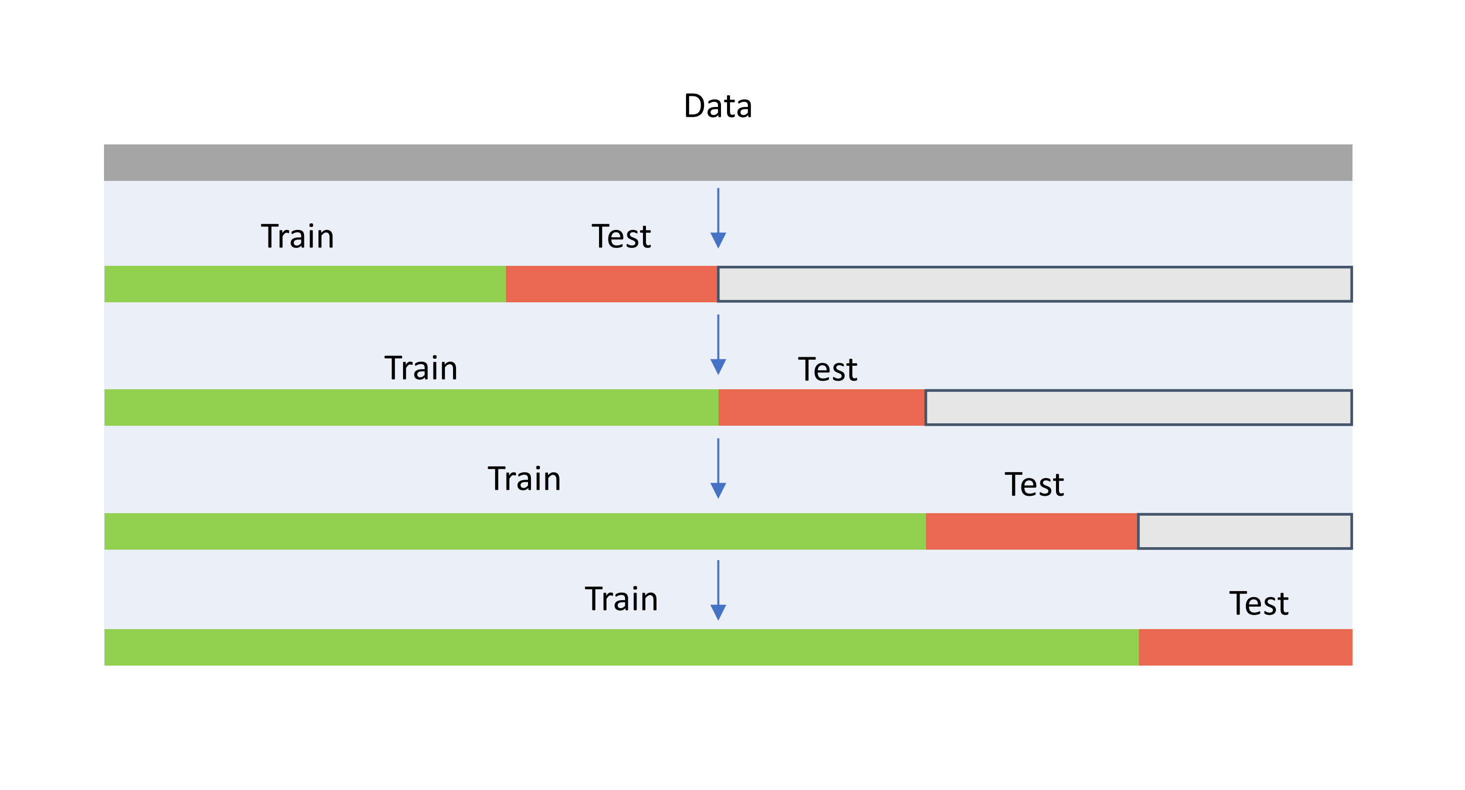
Cross-validation in time series



Some lessons from recent competitions

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The Great energy predictor III challenge

- Preprocessing and data transformations are a critical step
- Gradient boosted models are extremely effective, while out-of-the-box deep learning models tend to underperform

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The post-Covid-19 electricity forecasting challenge

BluWave IEEEDataPort™

- Ensembles increase forecasting accuracy(although they increase complexity)
- Modelling holidays (and special events) well is extremely important
- More generally, understanding concept or data drift is critical

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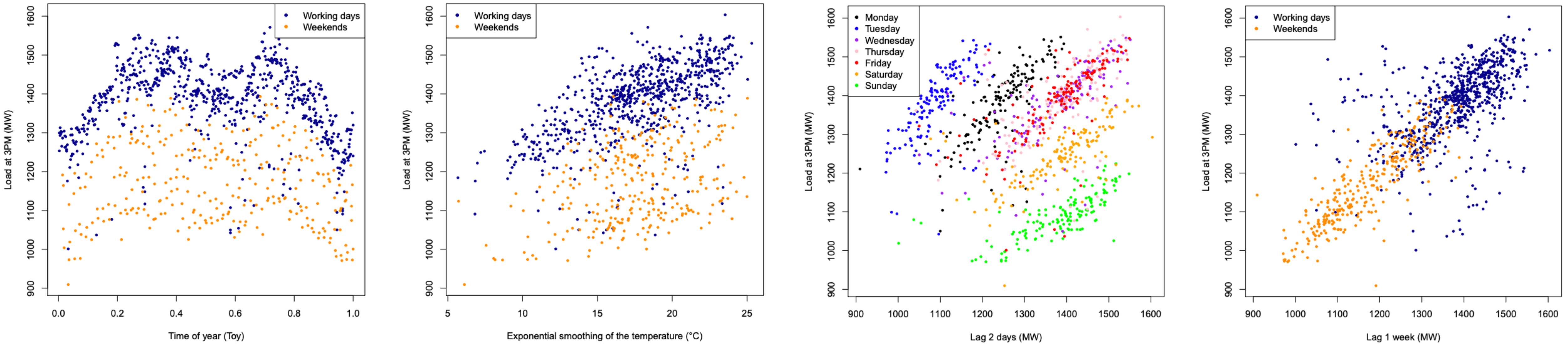
The post-Covid-19 electricity forecasting challenge



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Onwards to the demo

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