Forecasting Renewable Jet Fuel Demand in New Zealand: Benchmarking Analysis for Understanding Different Scenarios

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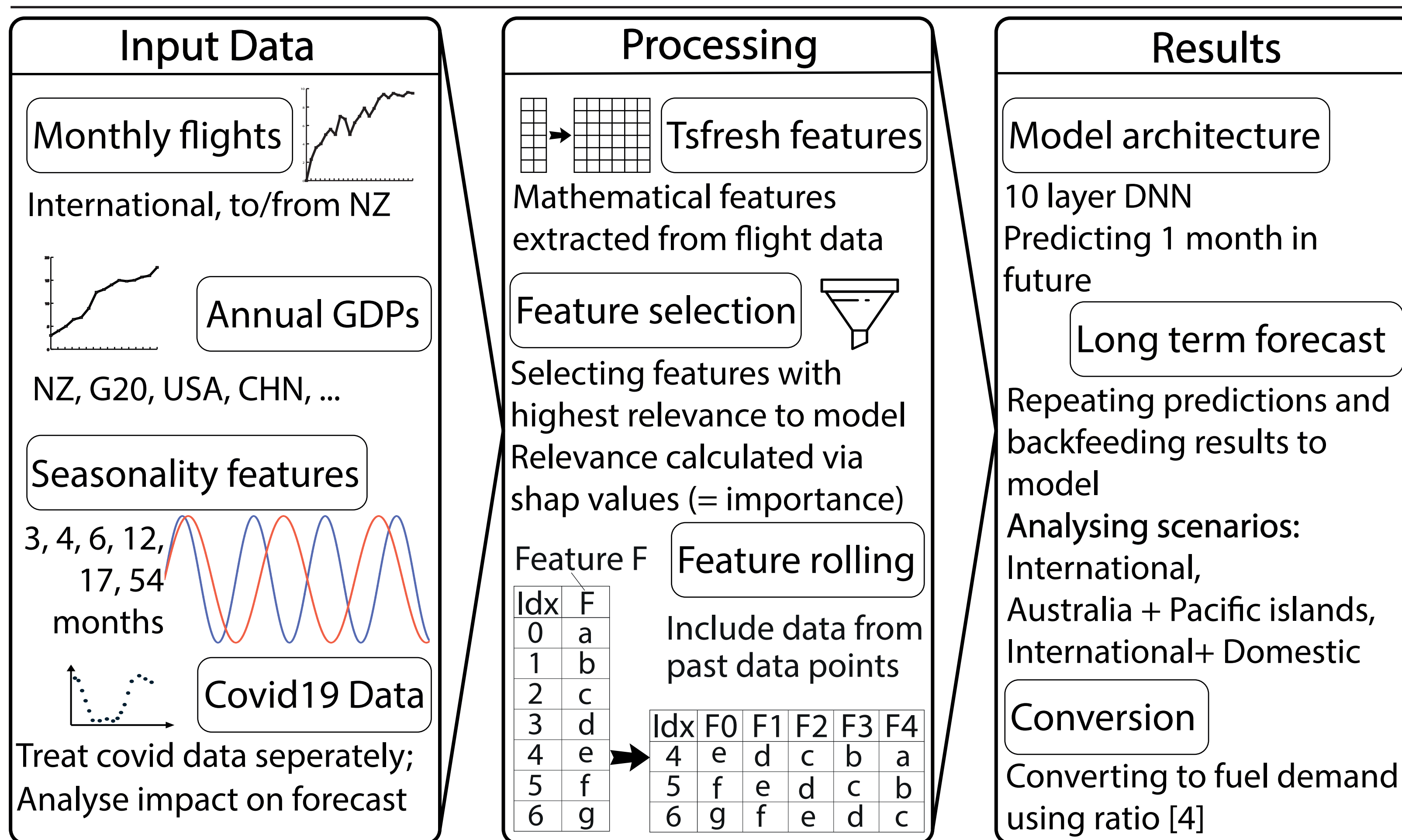simon.stuber@st.oth-regensburg.de

On the road to a fully renewable energy system in New Zealand, new supply chain models must be analysed, taking into account sectors switching to sustainable fuel alternatives. With New Zealand being heavily reliant on aviation for both passenger transportation and freight, future aviation fuel demand needs to be forecasted to provide input data for these models.

In this work, we forecast aviation fuel demand in New Zealand, explore the possibility of forecasted seasonality and analyse the impact of Covid-19 data on our forecast. Our results can be used to analyse future green hydrogen demand in New Zealand using supply chain and energy models.

Input data
- Monthly number of international flights [1]
- Forecasted GDP values [2]
  - Show expected long term growth of worldwide economy
- Mathematical features using tsfresh
- Seasonality features
  - Fourier analysis shows seasonal patterns within 3, 4, 6, 12, 17 and 54 months in flight data

Input Data
- **Monthly flights** — International, to/from NZ
- **Annual GDPs** — NZ, G20, USA, CHN, ...
- **Seasonality features** — 3, 4, 6, 12, 17, 54 months
- **Covid19 Data** — Treat covid data seperately; Analyse impact on forecast

Processing
- **Tsfresh features** — Mathematical features extracted from flight data
- **Feature selection** — Selecting features with highest relevance to model. Relevance calculated via shap values (= importance)
- **Feature rolling** — Include data from past data points

Feature F

Idx	F
0	a
1	b
2	c
3	d
4	e
5	f
6	g

Idx	F0	F1	F2	F3	F4
4	e	d	c	b	a
5	f	e	d	c	b
6	g	f	e	d	c

Results
- **Model architecture** — 10 layer DNN, Predicting 1 month in future
- **Long term forecast** — Repeating predictions and backfeeding results to model. Analysing scenarios: International, Australia + Pacific islands, International+ Domestic
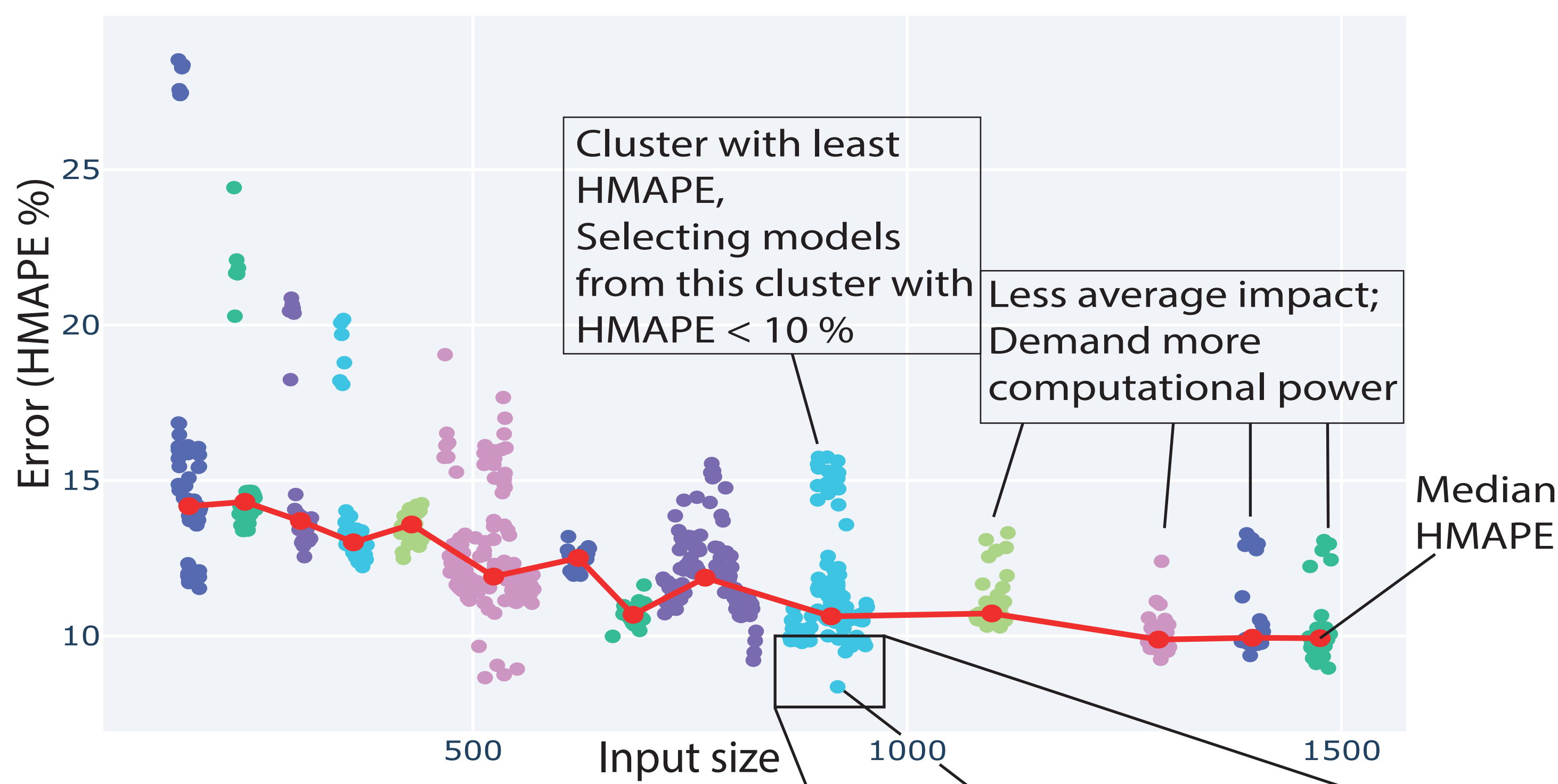- **Conversion** — Converting to fuel demand using ratio [4]

Methodology
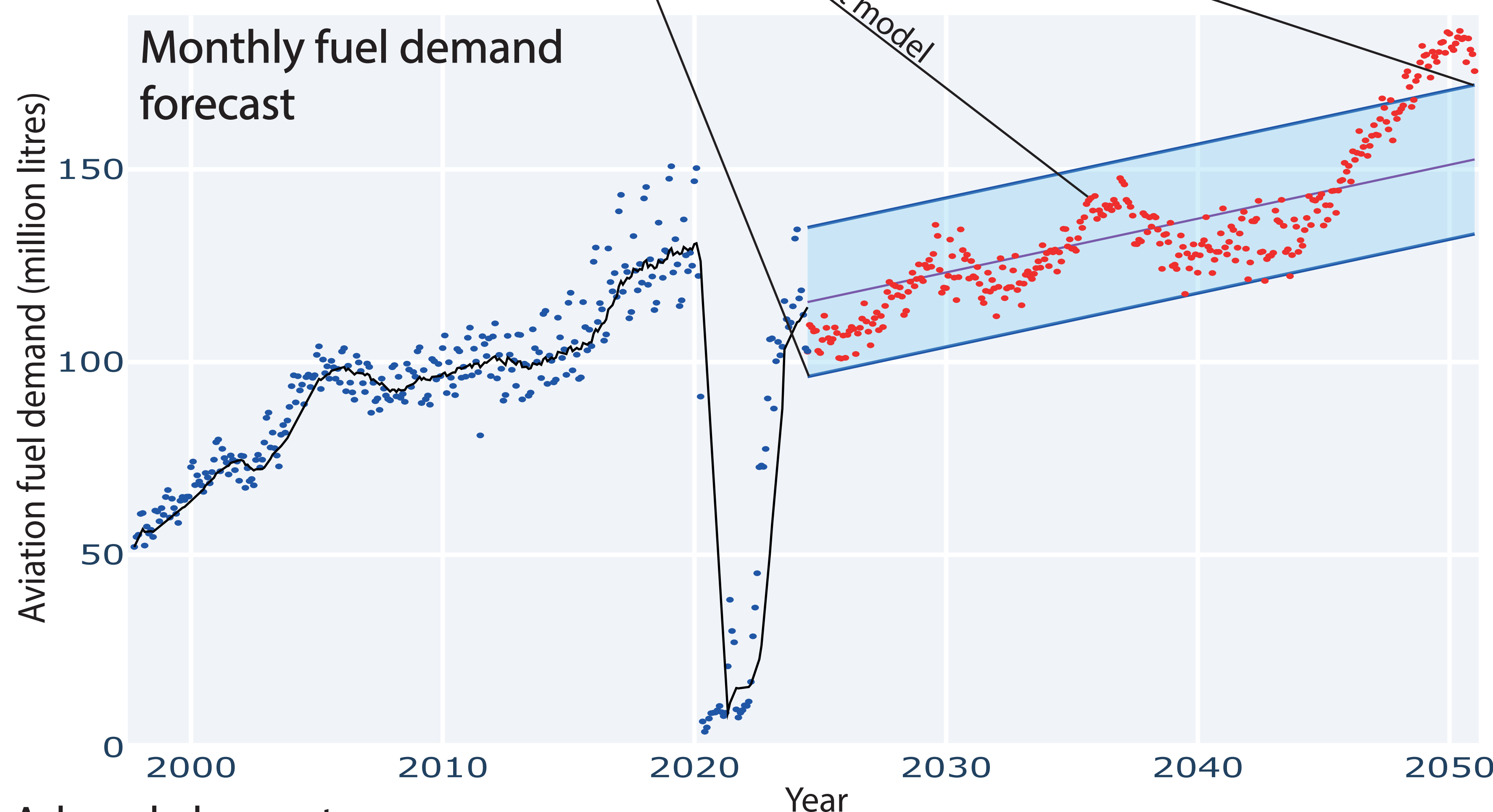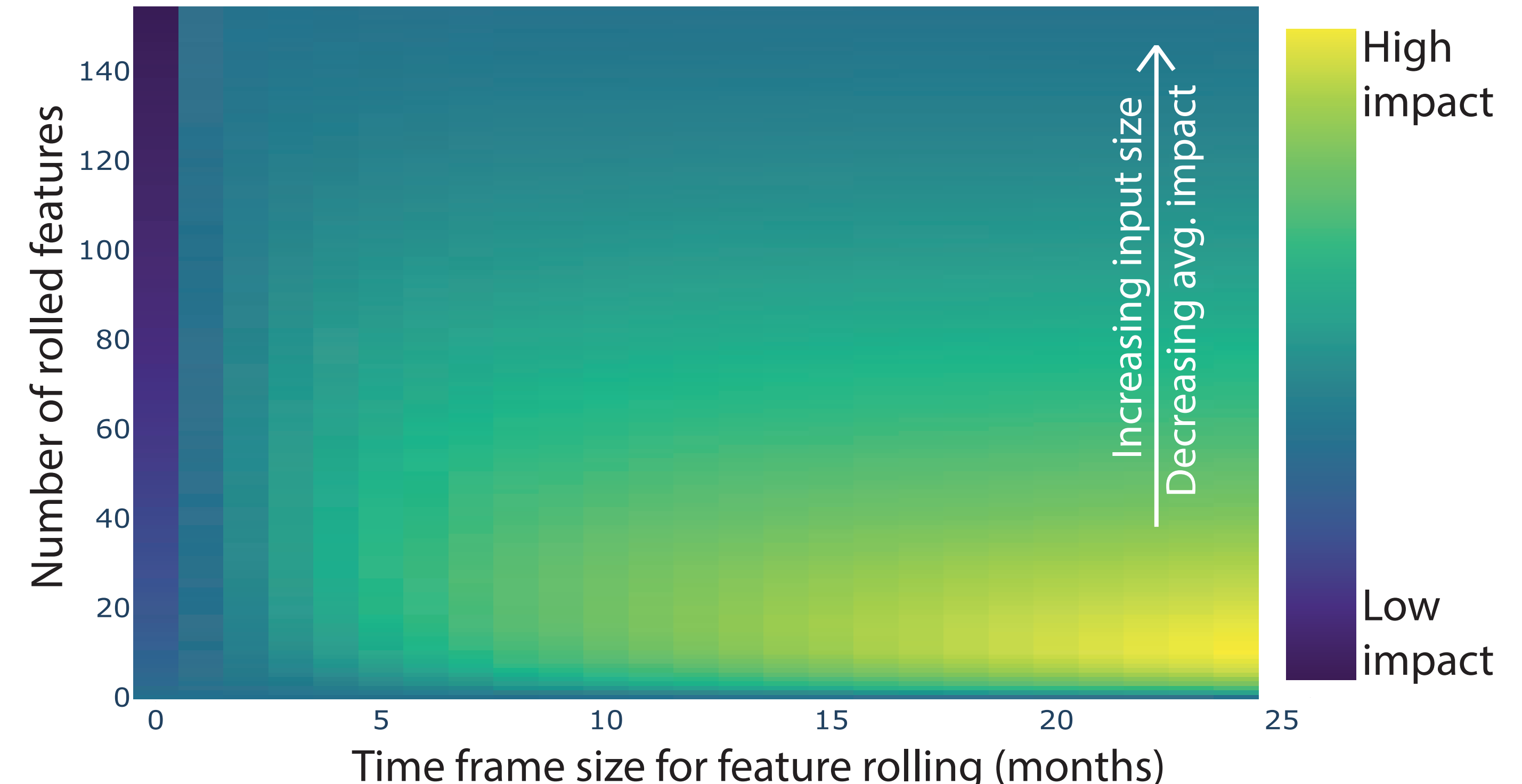The pipeline for forecasting future aviation fuel demand can be seen here. We aim to provide:
- **Increase until 2050**
  - Taking a cluster of models and finding minimum and maximum expected increase
- **Seasonal changes**
  - Seasonality features (sine waves with frequencies of found patterns)
  - Input data includes features from past data points, called **rolled features**
    - The number of rolled features and time frame size impact the total input size
  - Can be used as input for supply chain or energy system models with **higher temporal resolution** (monthly instead of annual)
- **Covid impact analysis**
  - Including covid data after model training using partial training
  - Varying learning rate for covid data to analyse different covid impact rates

To analyse different scenarios in the forecast, the input data can be changed to only include certain regions.
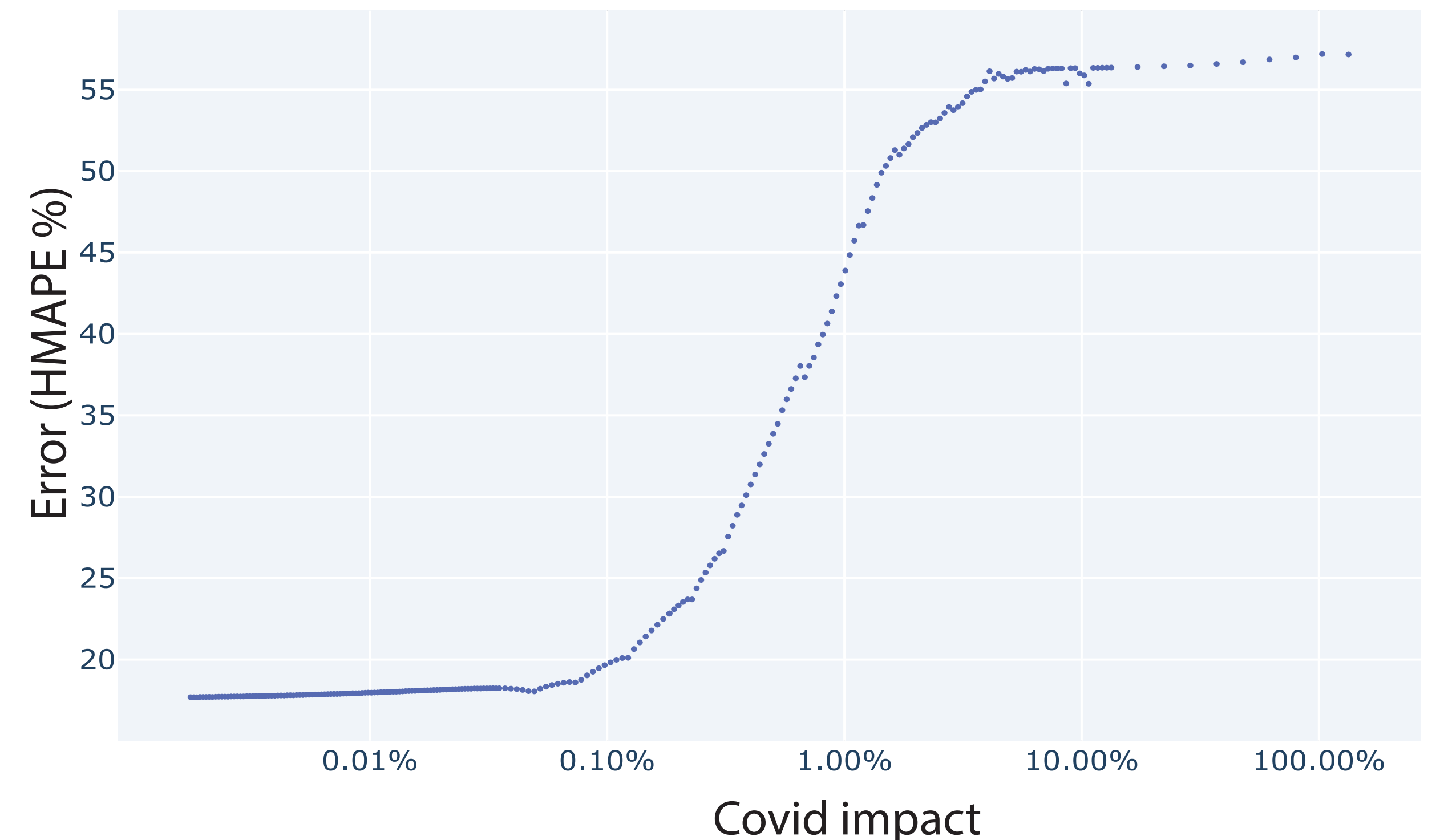
Error over input size

Cluster with least HMAPE, Selecting models from this cluster with HMAPE < 10 %

Less average impact; Demand more computational power

Median HMAPE

Average feature impact with increased feature rolling

Monthly fuel demand forecast

Best model

Post covid error with covid impact

Key takeaways
- Covid-19 data should not be included in model training
- Forecasted scenario: International flights from/to all regions
- Forecasted monthly aviation fuel demand:
  - 2030: 100 - 140 million litres on average
  - 2050: 130 - 170 million litres on average

References
[1]: Stats NZ, Monthly number of international flights, https://infoshare.stats.govt.nz/, (Last accessed: 20.12.2024)

[2]: OECD, Real GDP long-term forecast, https://www.oecd.org/en/data/indicators/real-gdp-long-term-forecast.html, (Last accessed: 20.12.2024)

[3]: Vatankhah Ghadim H., Fallah Ardashir J., Odonkor P., Haas J. Hypotenuse-based absolute percentage error metric: A trade-off between robustness and user-friendliness?. (Working paper)

[4]: Vatankhah Ghadim, H., Peer, R. A. M., Read, E. G., & Haas, J. (2024). How much hydrogen could we need in New Zealand? Understanding the diverse hydrogen applications and their regional mapping. Journal of the Royal Society of New Zealand, 1–20. https://doi.org/10.1080/03036758.2024.2365306, (Last accessed: 30.01.2025)