Towards Improving Infrasound Station Data Availability with State-of-Health Encoded Feature Clustering

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Bryant Chow[1]

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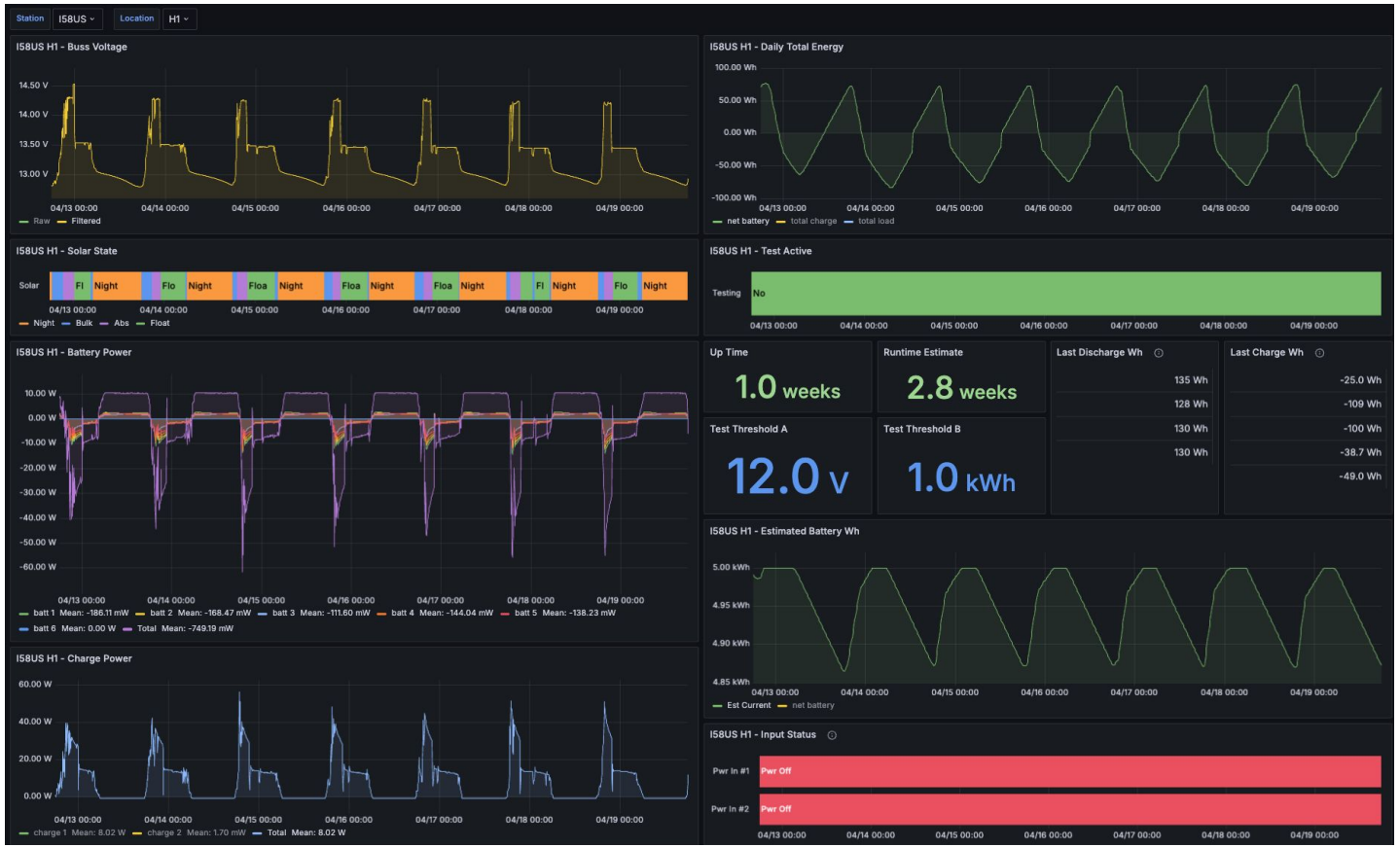
University of Alaska Fairbanks

ITW 2024



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Cleared for release

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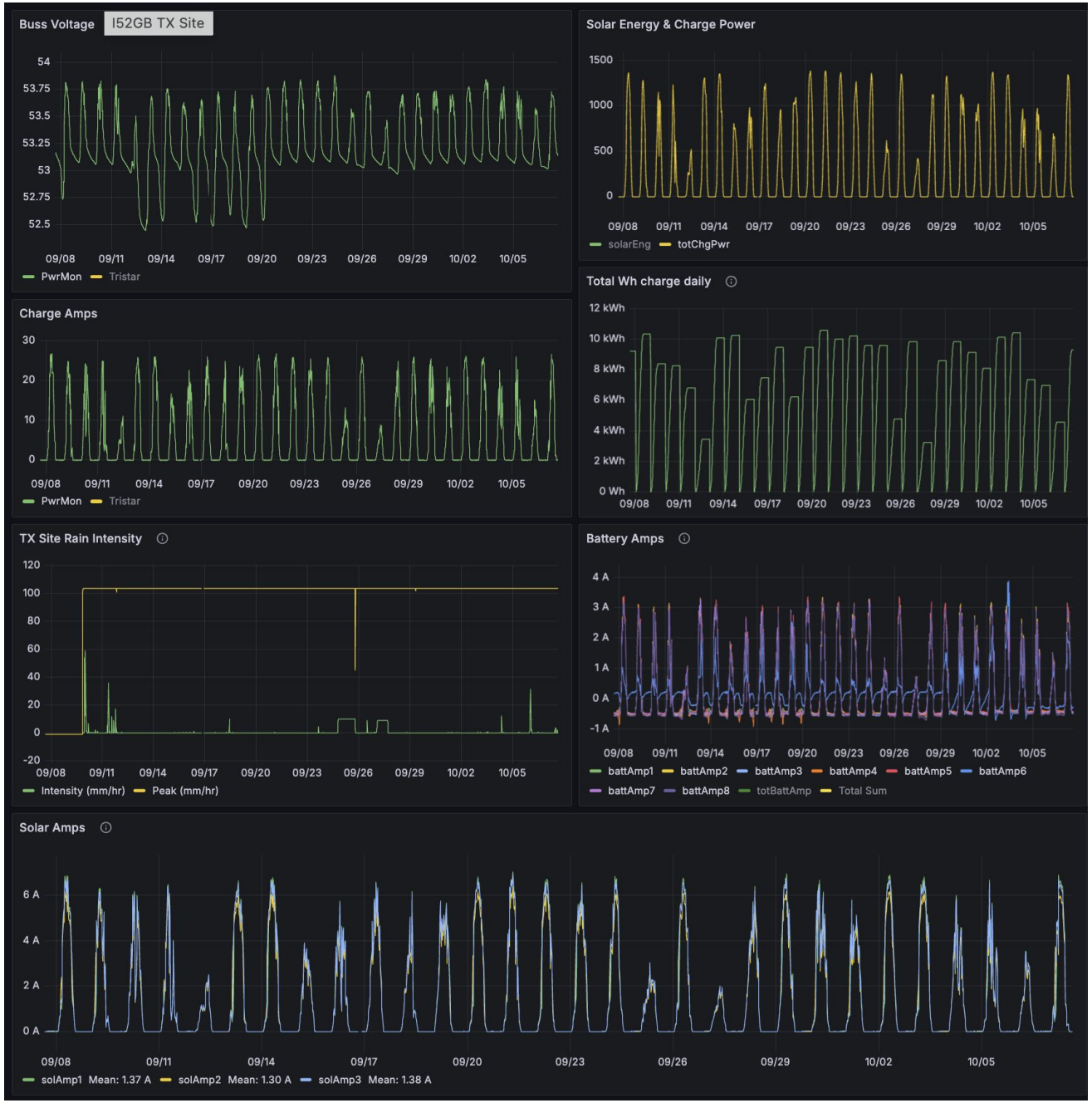
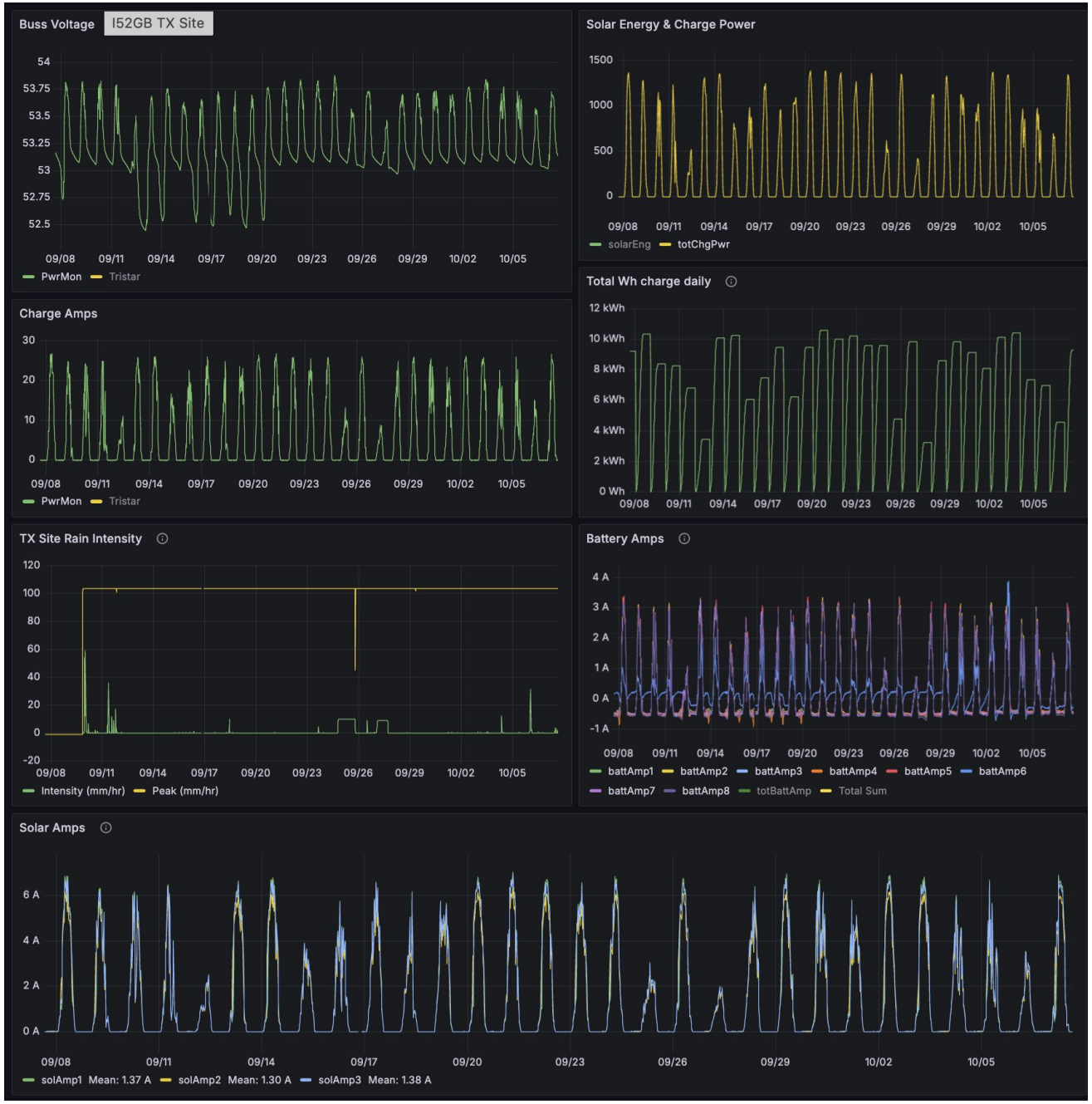
Motivation

- **Station uptime is a top priority; we want to develop better ways to detect and predict outages**
- Engineering team collecting state-of-health (SOH) data from WATC Powerhubs



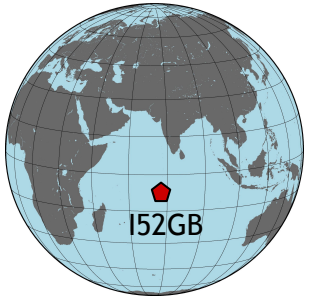
Motivation

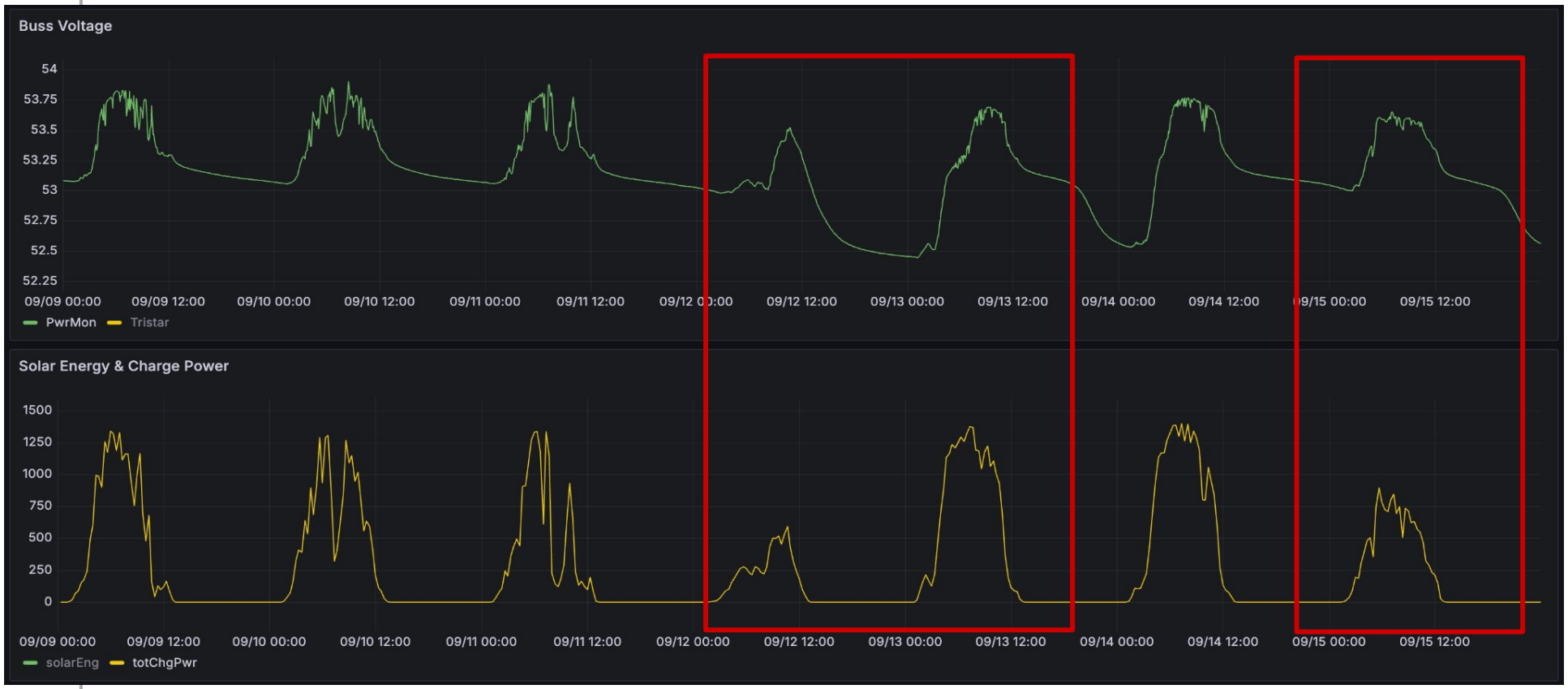
- **Station uptime is a top priority; we want to develop better ways to detect and predict outages**
- Engineering team collecting state-of-health (SOH) data from WATC Powerhubs
- Potential to enhance analysis and response with machine learning



Input Data

- Looking specifically at I52GB because of known charging issues
- Desired output model should be sensitive to both Buss Voltage and Charge Power

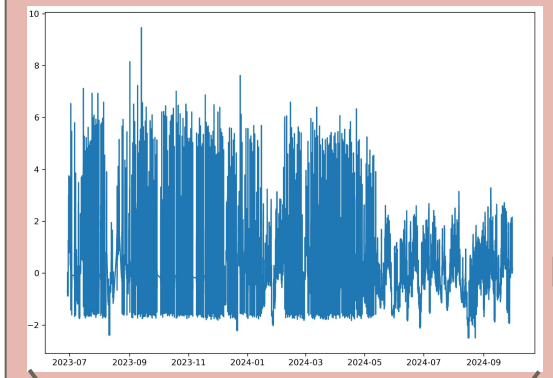


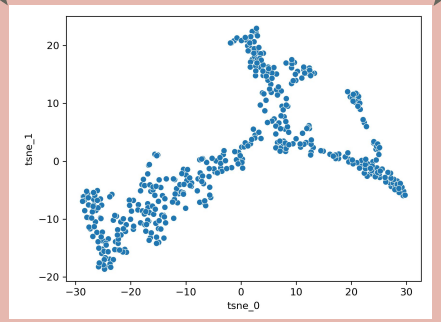


Workflow

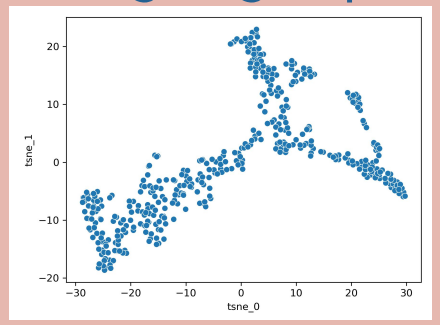
Train

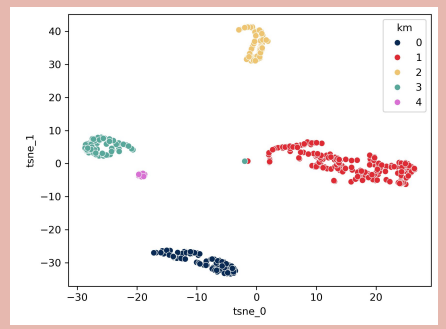
Autoencode: Transform data into lower-dimensional latent features





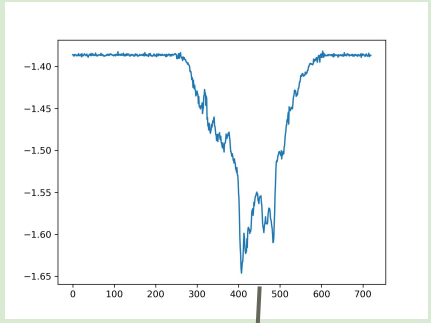
Cluster encoded features into meaningful groups

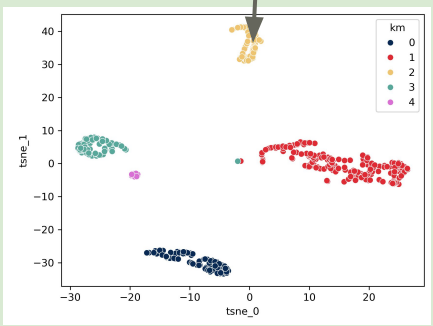




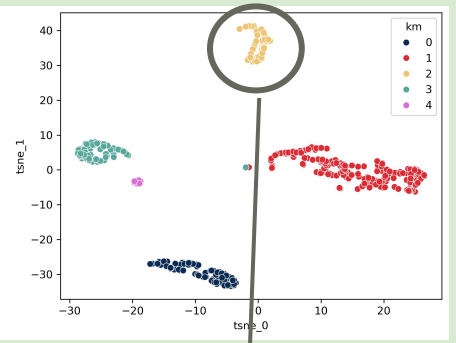
Operationalize

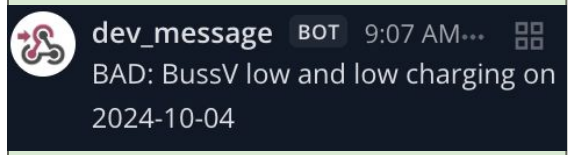
Fit previous day to already trained model



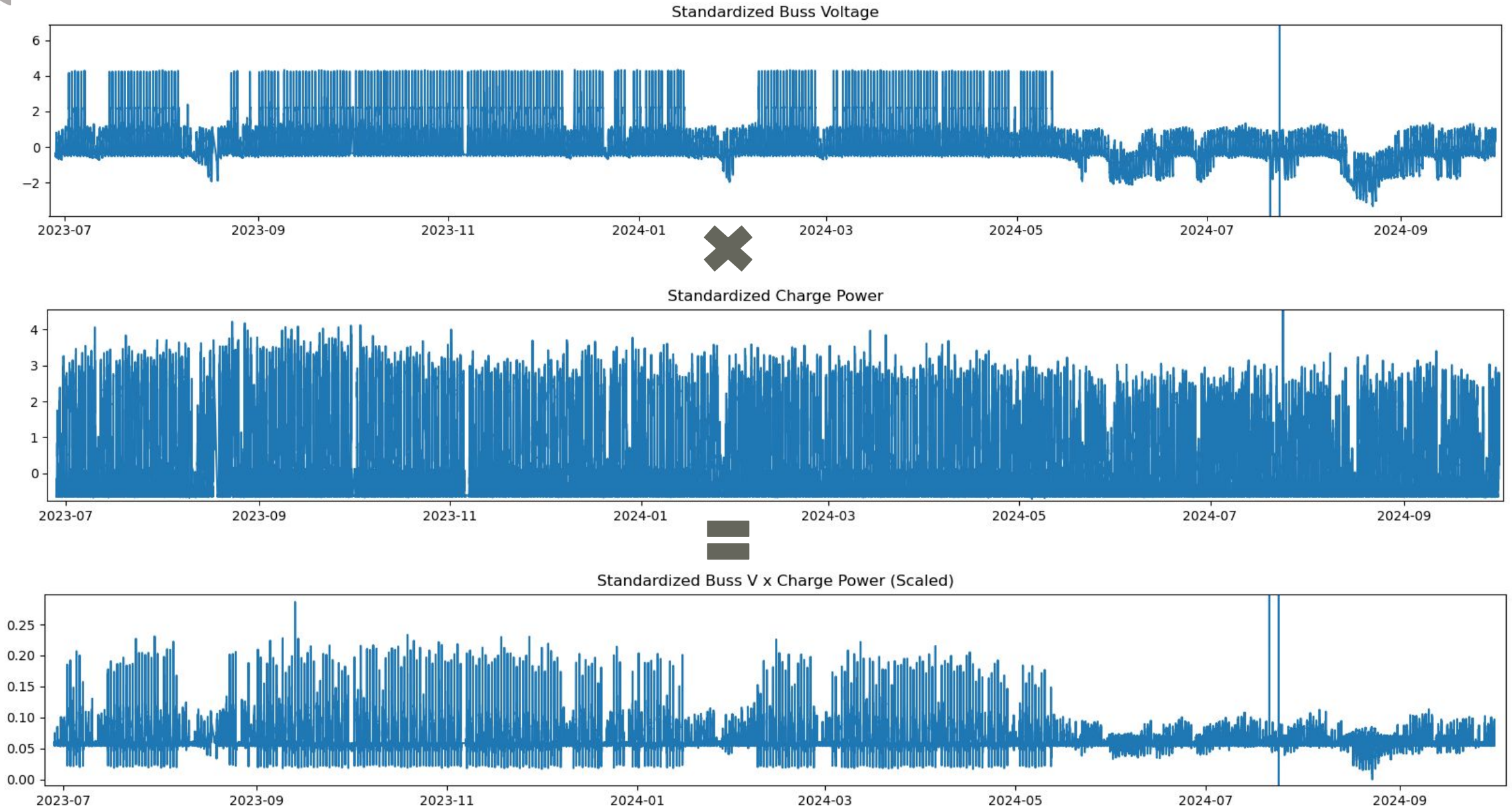


Notify engineers of model's interpretation of previous day

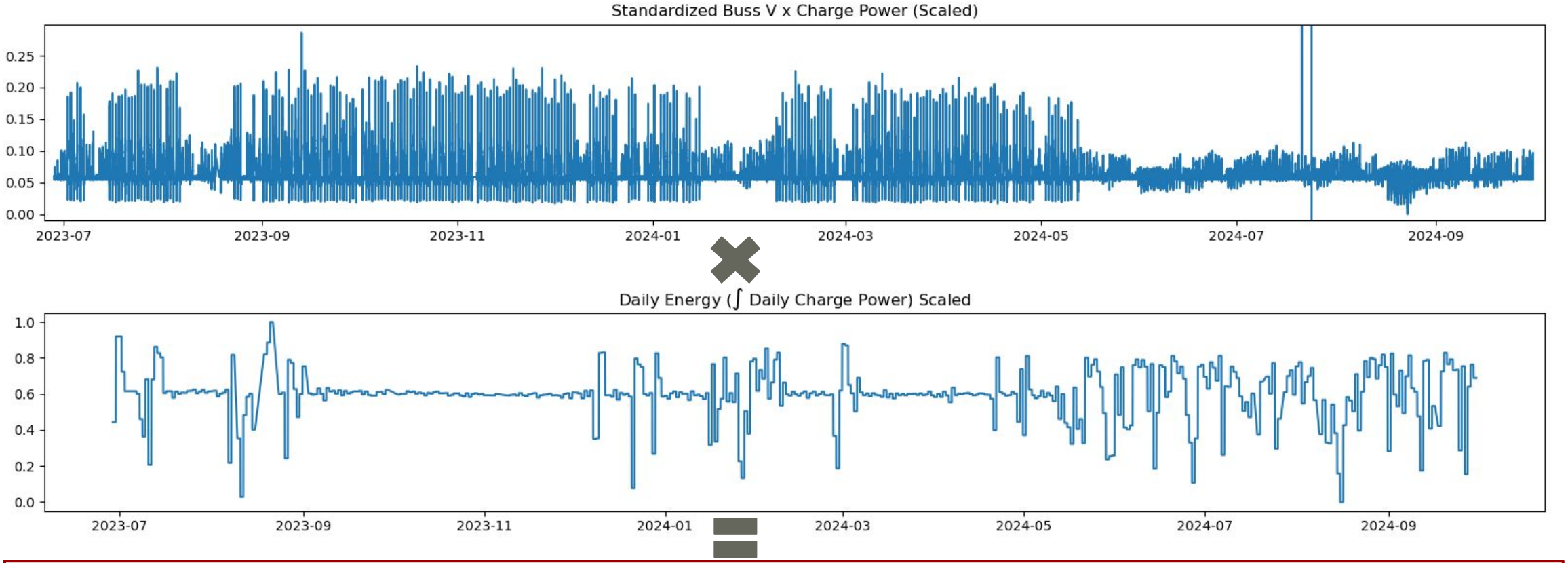




Input Data

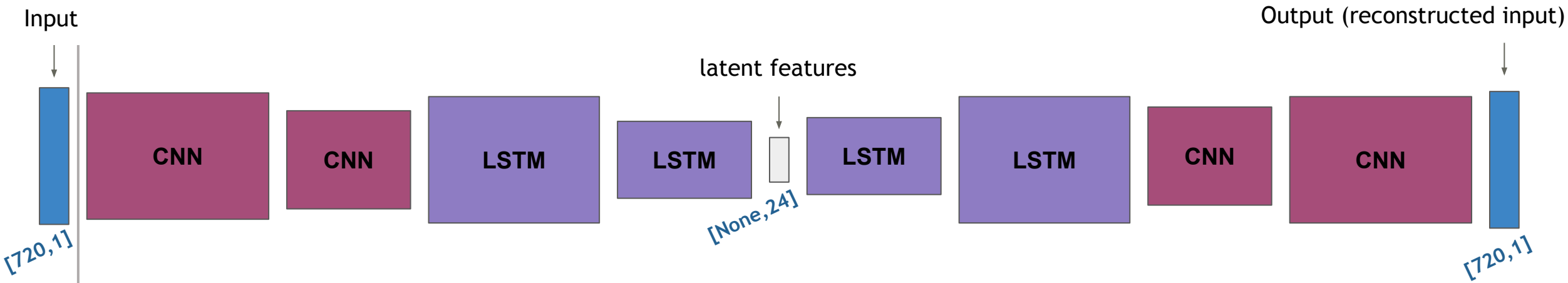

Standardized Buss Voltage
6
4
2
0
−2
2023-07
2023-09
2023-11
2024-01
2024-03
2024-05
2024-07
2024-09
Standardized Charge Power
4
3
2
1
0
2023-07
2023-09
2023-11
2024-01
2024-03
2024-05
2024-07
2024-09
Standardized Buss V x Charge Power (Scaled)
0.25
0.20
0.15
0.10
0.05
0.00
2023-07
2023-09
2023-11
2024-01
2024-03
2024-05
2024-07
2024-09

Input Data


Standardized Buss V x Charge Power (Scaled)
0.25
0.20
0.15
0.10
0.05
0.00
2023-07
2023-09
2023-11
2024-01
2024-03
2024-05
2024-07
2024-09
Daily Energy (∫ Daily Charge Power) Scaled
1.0
0.8
0.6
0.4
0.2
0.0
2023-07
2023-09
2023-11
2024-01
2024-03
2024-05
2024-07
2024-09
Model Input (Standardized)
8
6
4
2
0
−2
2023-07
2023-09
2023-11
2024-01
2024-03
2024-05
2024-07
2024-09

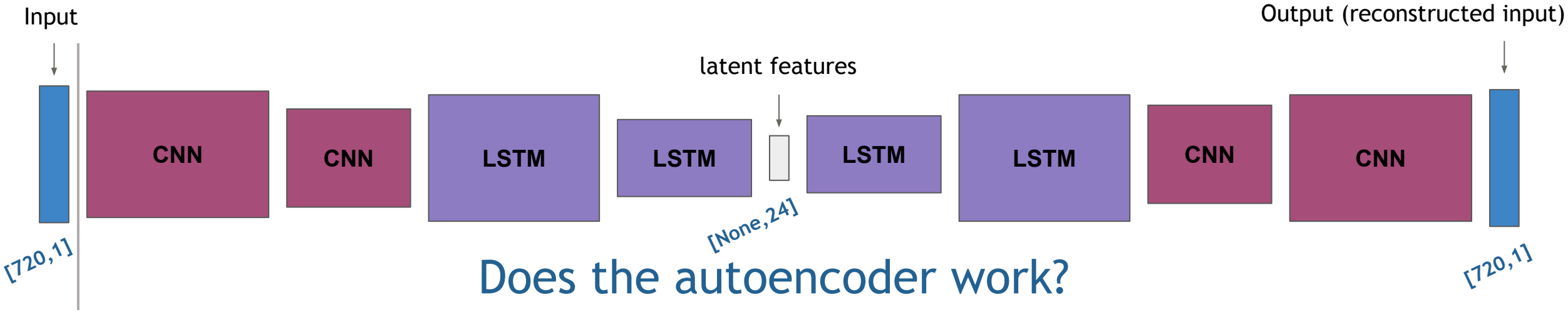
Latent Feature Extraction - Autoencoding

- Self-supervised learning - **no labels needed!**
- Representation learning - learns to transform raw data into a meaningful, lower dimensional representation (latent features)
- Learning is based on ability to reconstruct original data from latent features

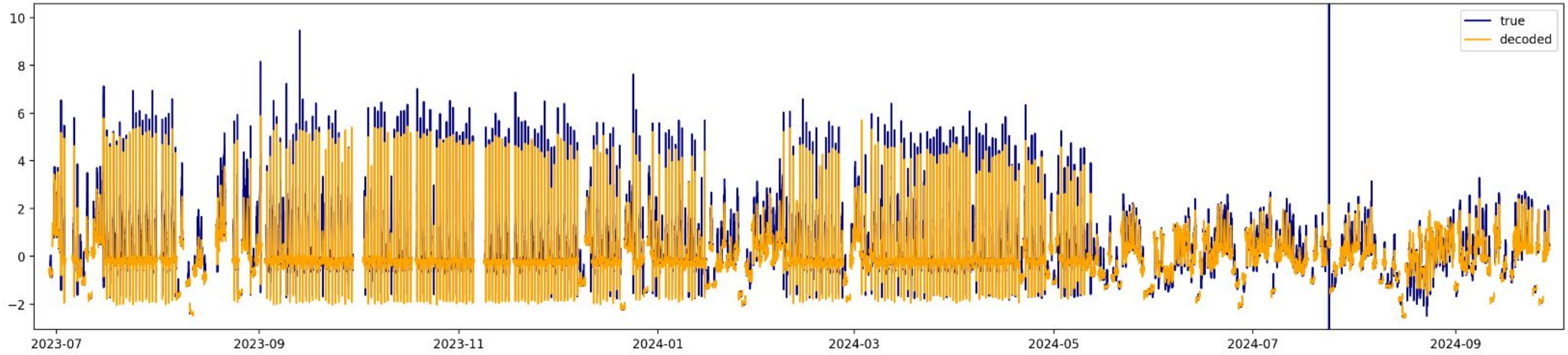


Autoencode ➡ Cluster ➡ Fit ➡ Notify

Latent Feature Extraction - Autoencoding



Does the autoencoder work?



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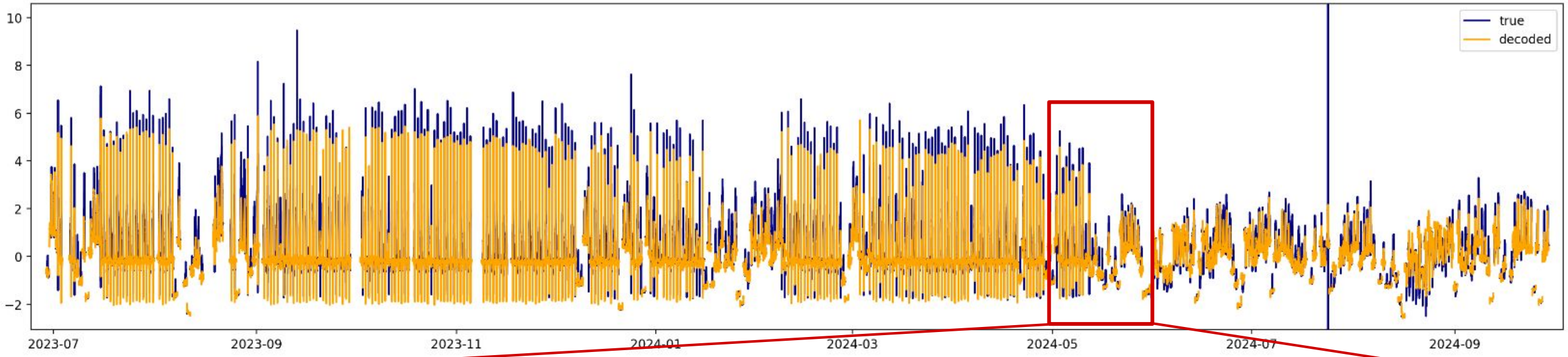

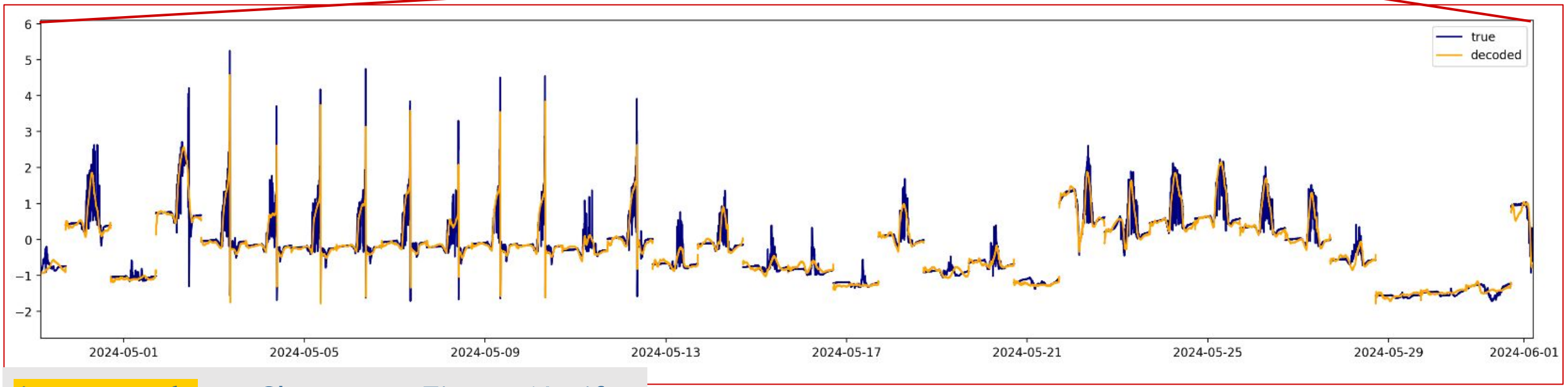

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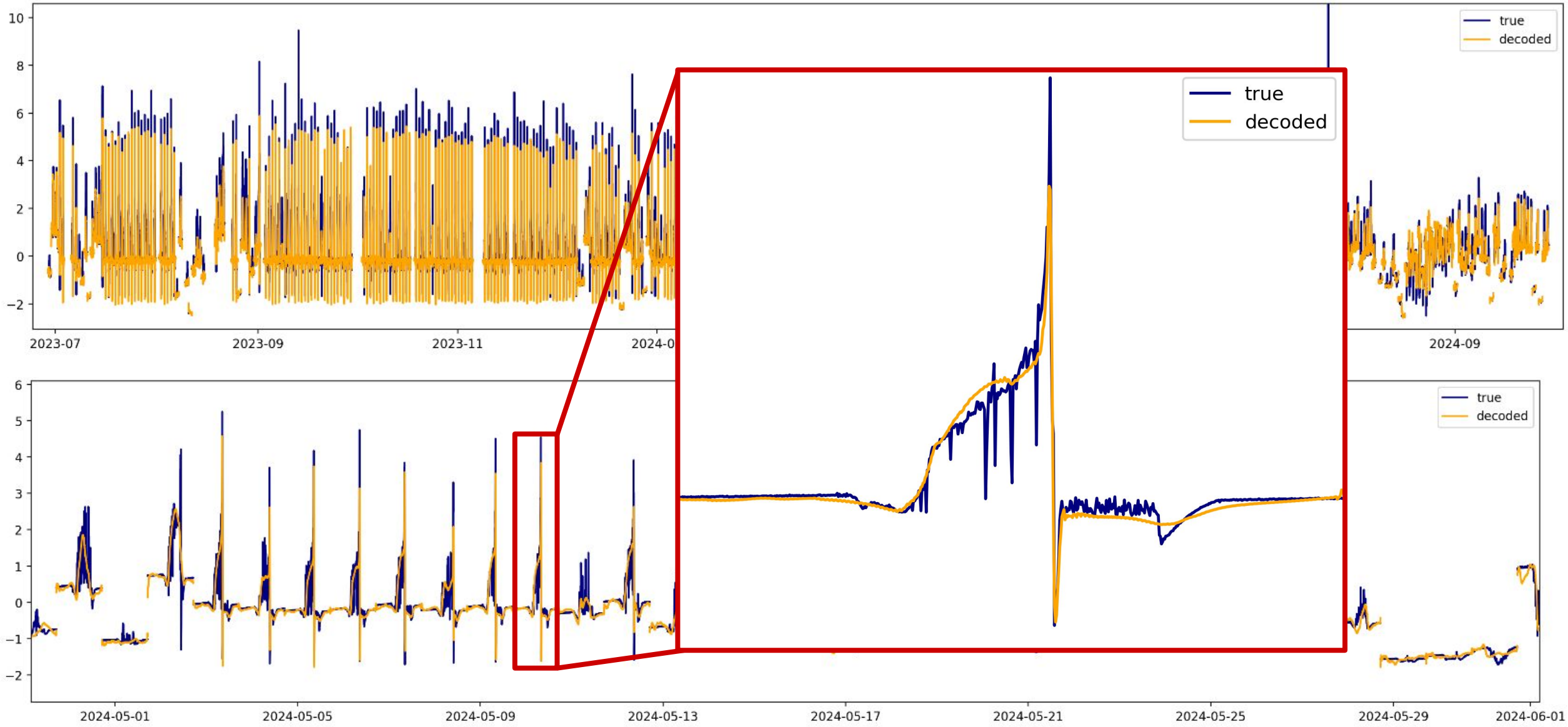
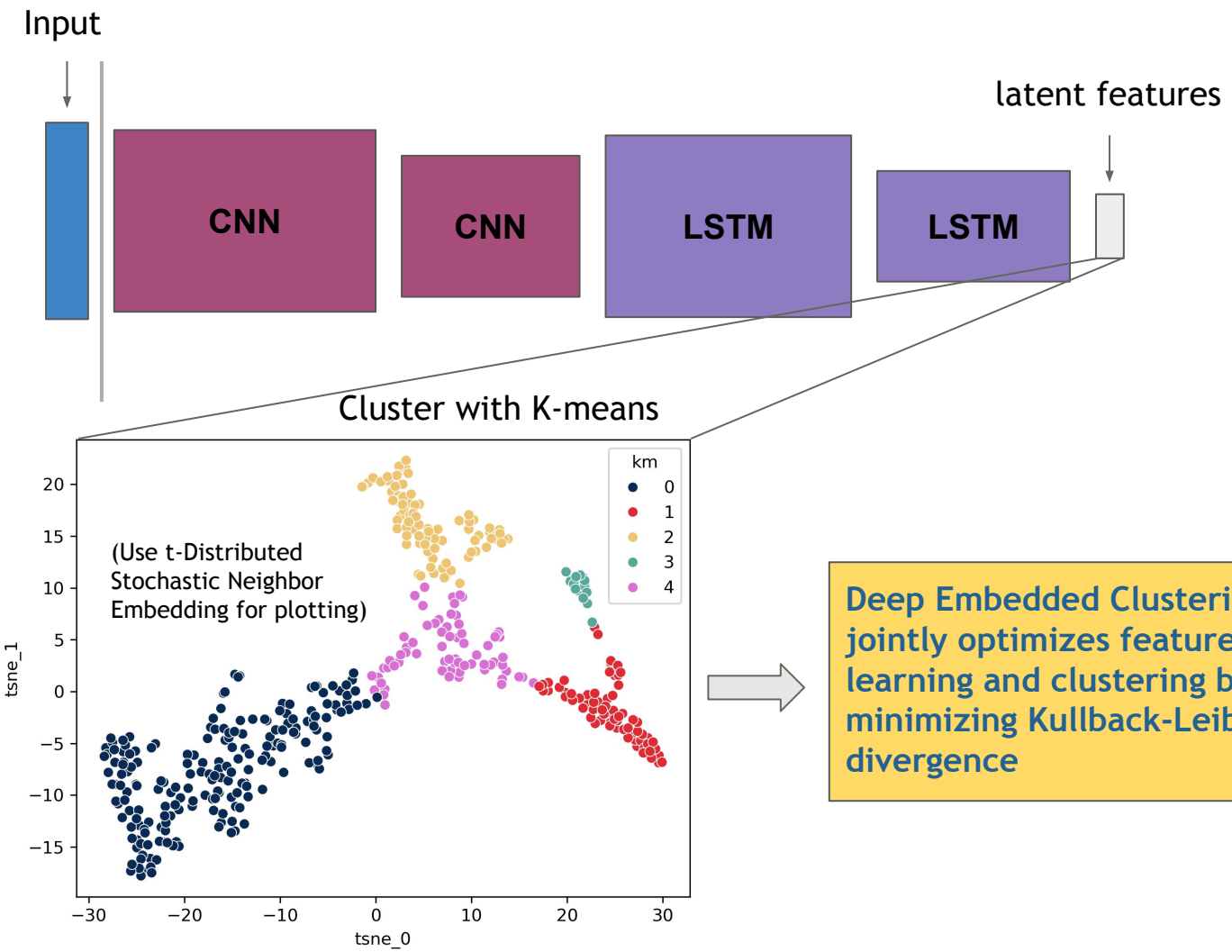


Autoencode ➡ Cluster ➡ Fit ➡ Notify

Latent Feature Extraction - Autoencoding



communications earth & environment

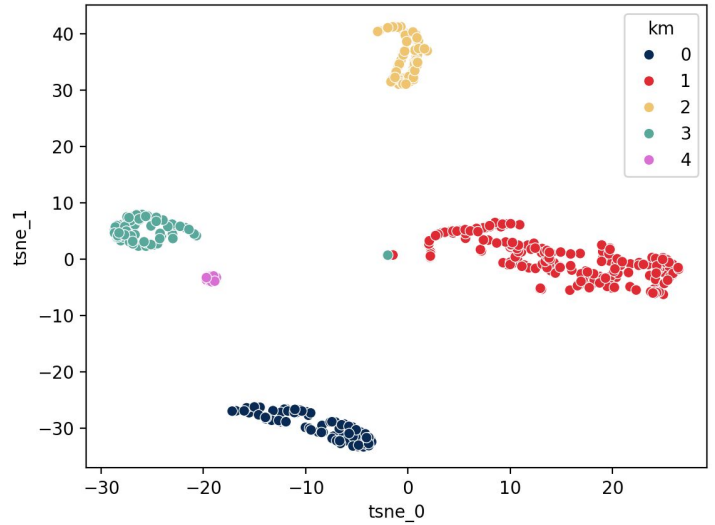
ARTICLE

https://doi.org/10.1038/s43247-023-01166-w OPEN

Tremor clustering reveals pre-eruptive signals and evolution of the 2021 Geldingadalir eruption of the Fagradalsfjall Fires, Iceland

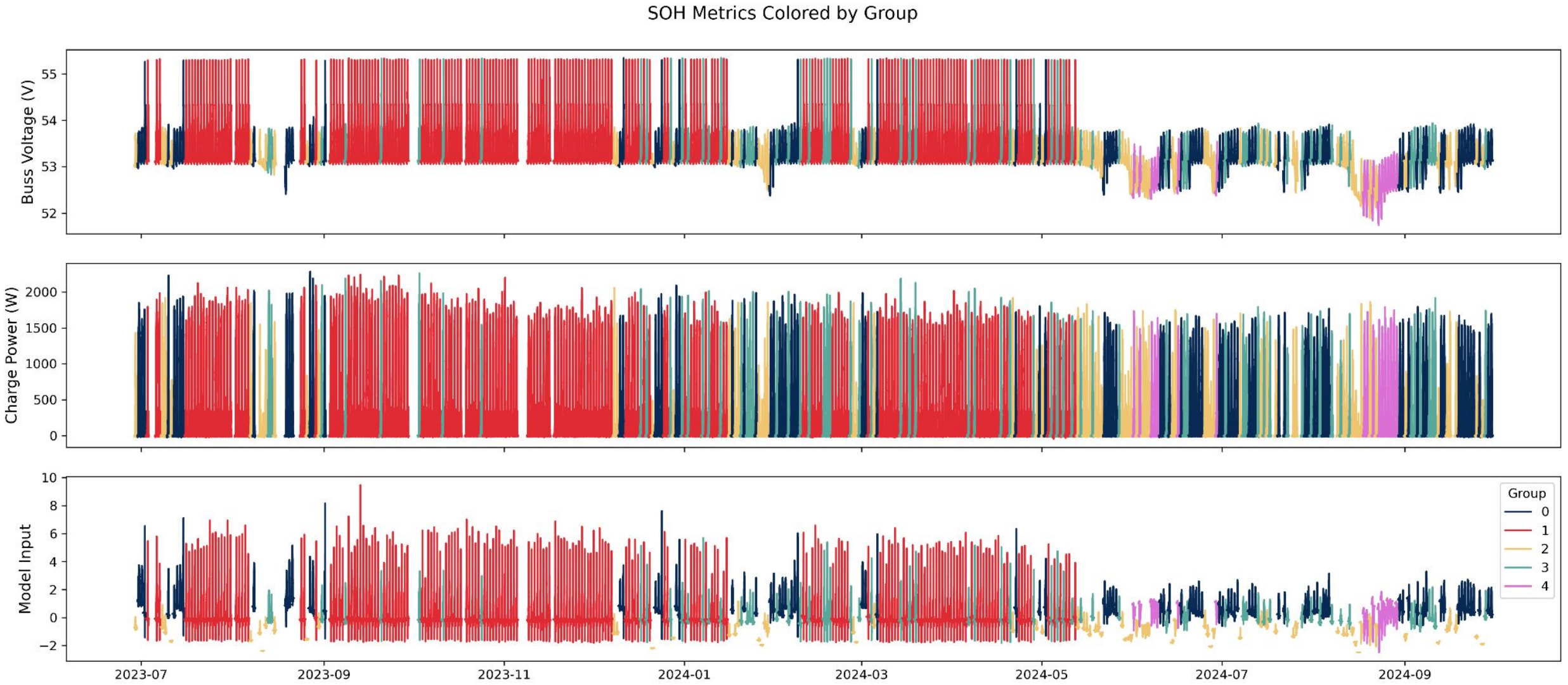
Zahra Zali[1,2]✉, S. Mostafa Mousavi[3], Matthias Ohrnberger[2], Eva P. S. Eibl[2] & Fabrice Cotton[1,2]

Deep Embedded Clustering - jointly optimizes feature learning and clustering by minimizing Kullback-Leibler divergence

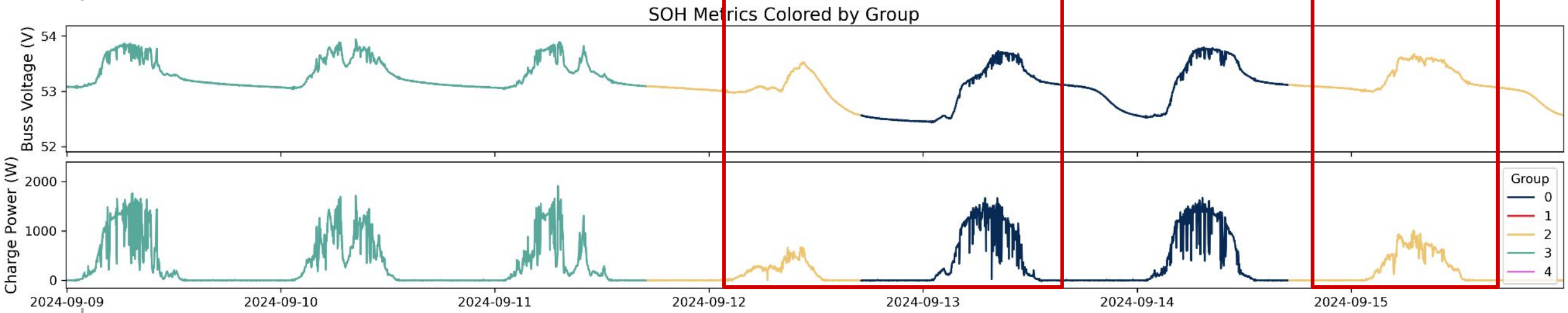


Autoencode ➡ **Cluster** ➡ Fit ➡ Notify

What are the “meaningful groups”?

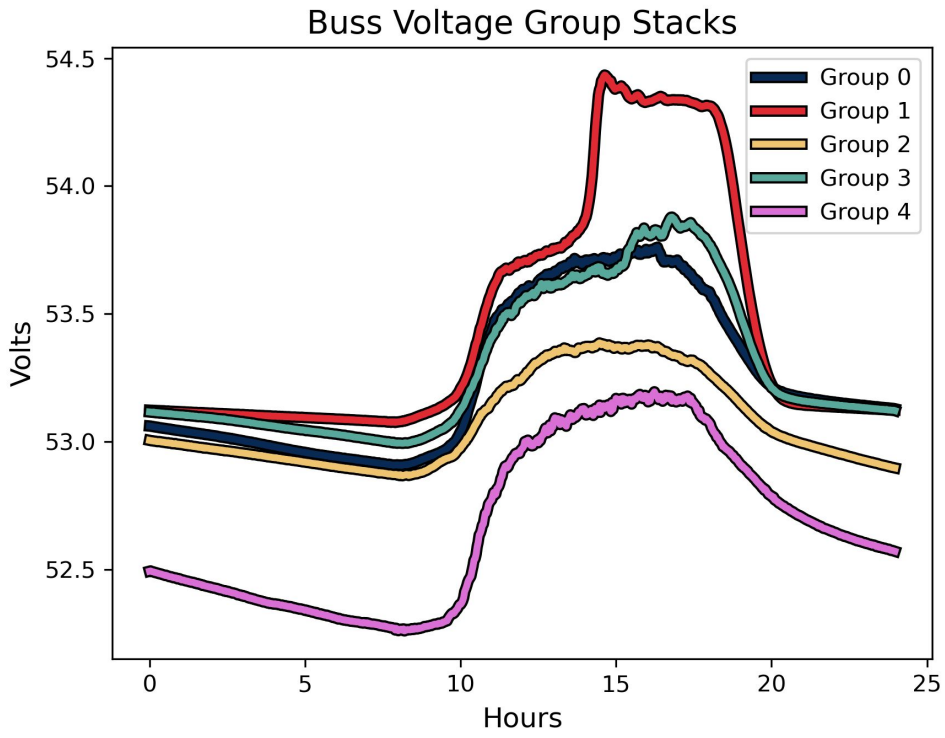


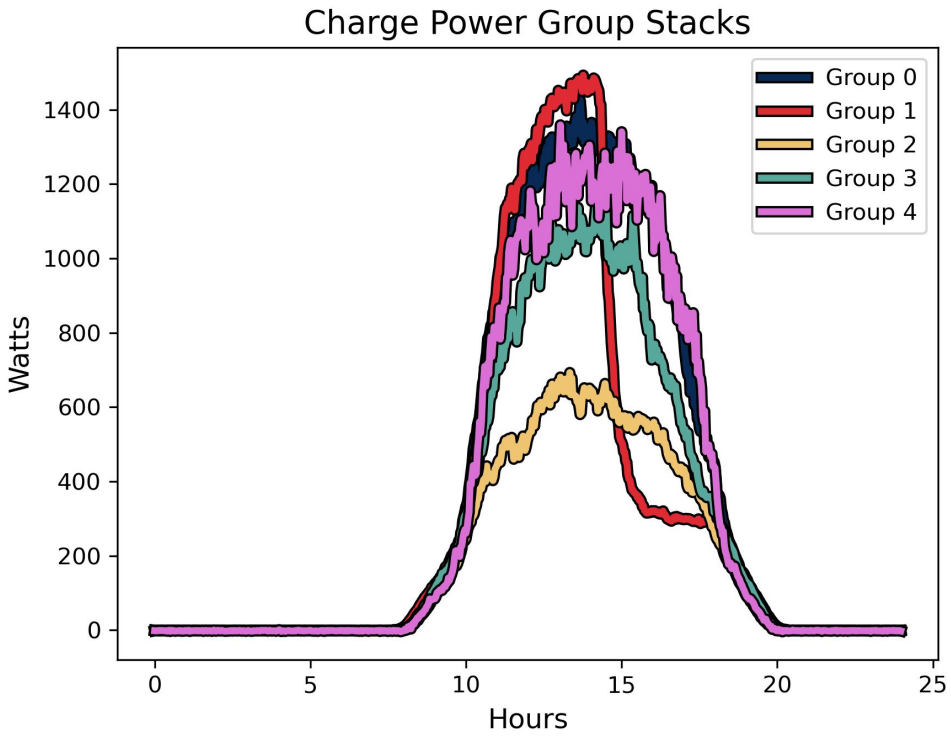
Autoencode ➡ **Cluster** ➡ Fit ➡ Notify



Autoencode ➡ **Cluster** ➡ Fit ➡ Notify

- Group 1 - GOOD: Good charging, battery hit or close to float (red)
- Group 2 - BAD: BussV low and low charging (yellow)
- Group 3 - FAIR: BussV moderate, good charging (turquoise)
- Group 0 - OK: BussV low, good charging (dark blue)
- Group 4 - POOR: BussV low, good charging yesterday (pink)

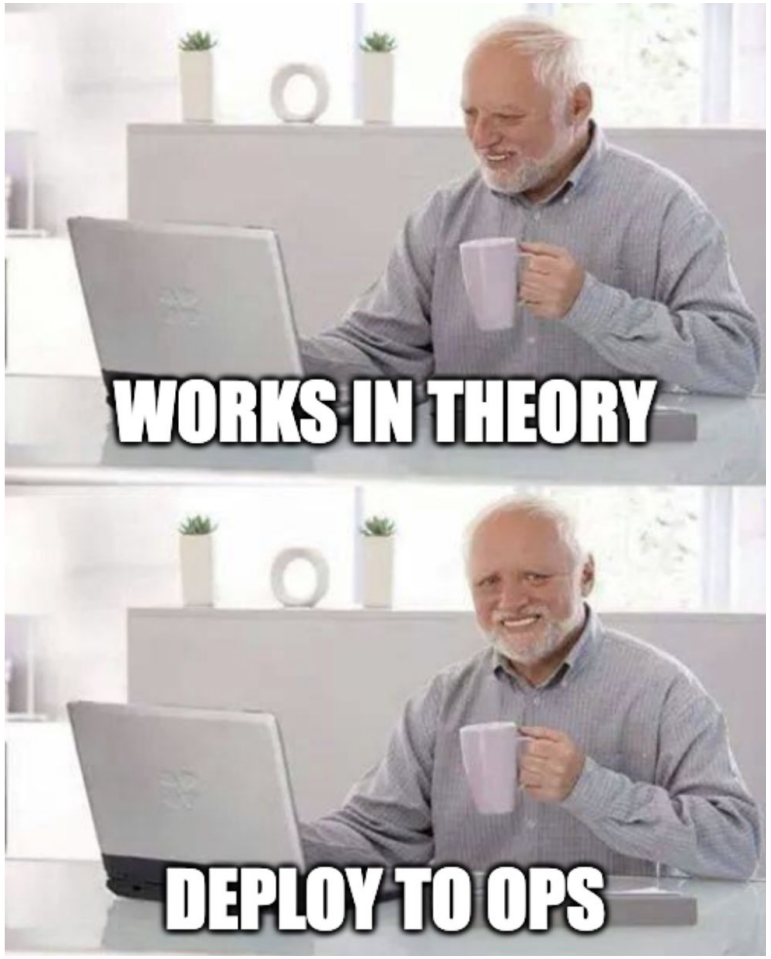




Autoencode ➡ **Cluster** ➡ Fit ➡ Notify

Operationalize

- Every morning, script loads in previous 24 hrs of Buss V and Charge Power data at I52GB TX site
- Fit data to decoding model to extract latent features
  - If fit is poor, day will be classified as “abnormal”
  - If fit is good, fit latent features to clustered model



Autoencode ➡ Cluster ➡ Fit ➡ Notify

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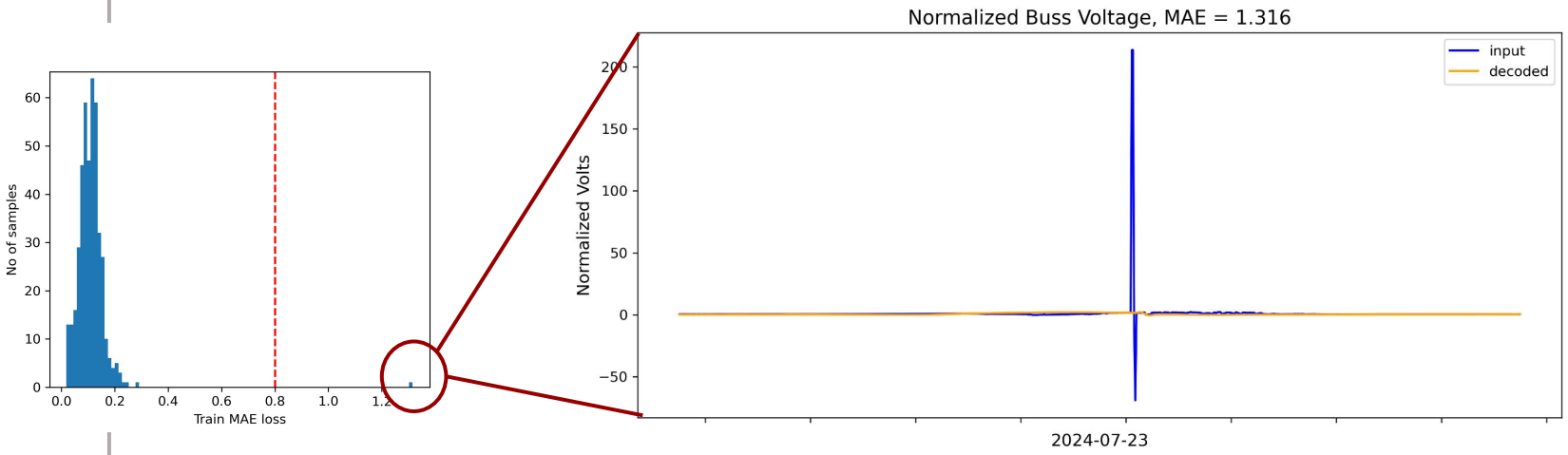

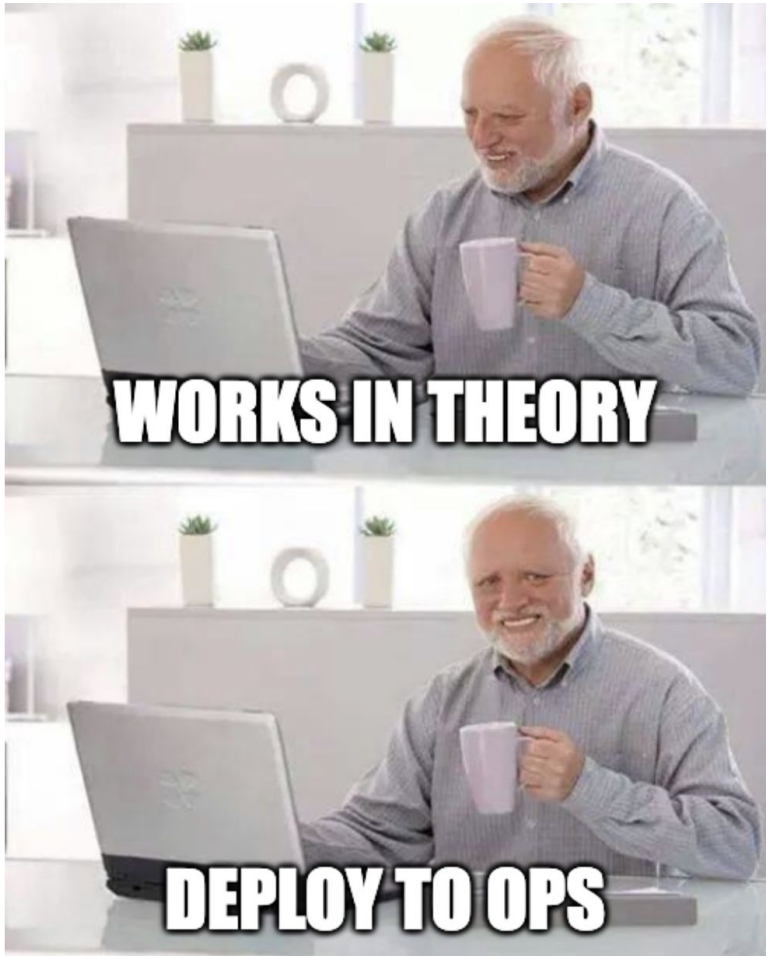

Autoencode ➡ Cluster ➡ **Fit** ➡ Notify

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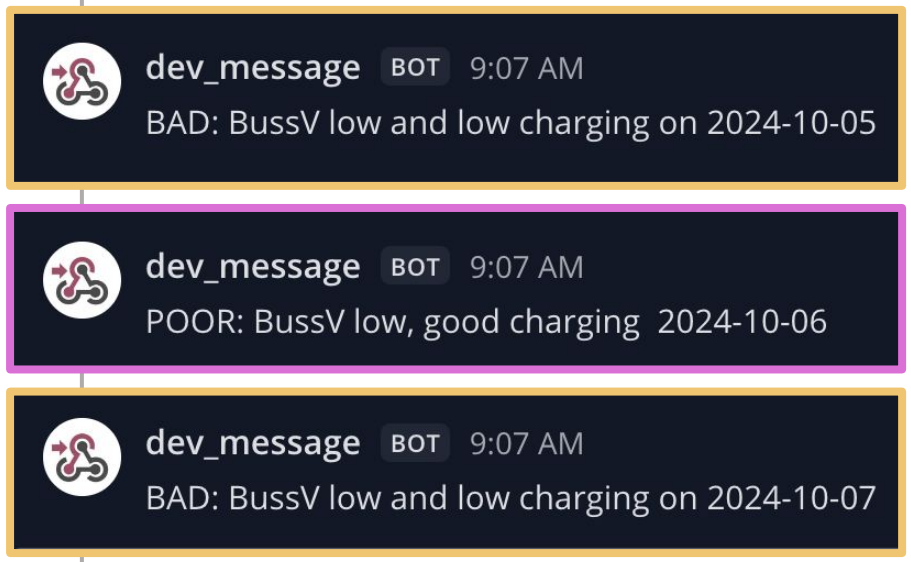
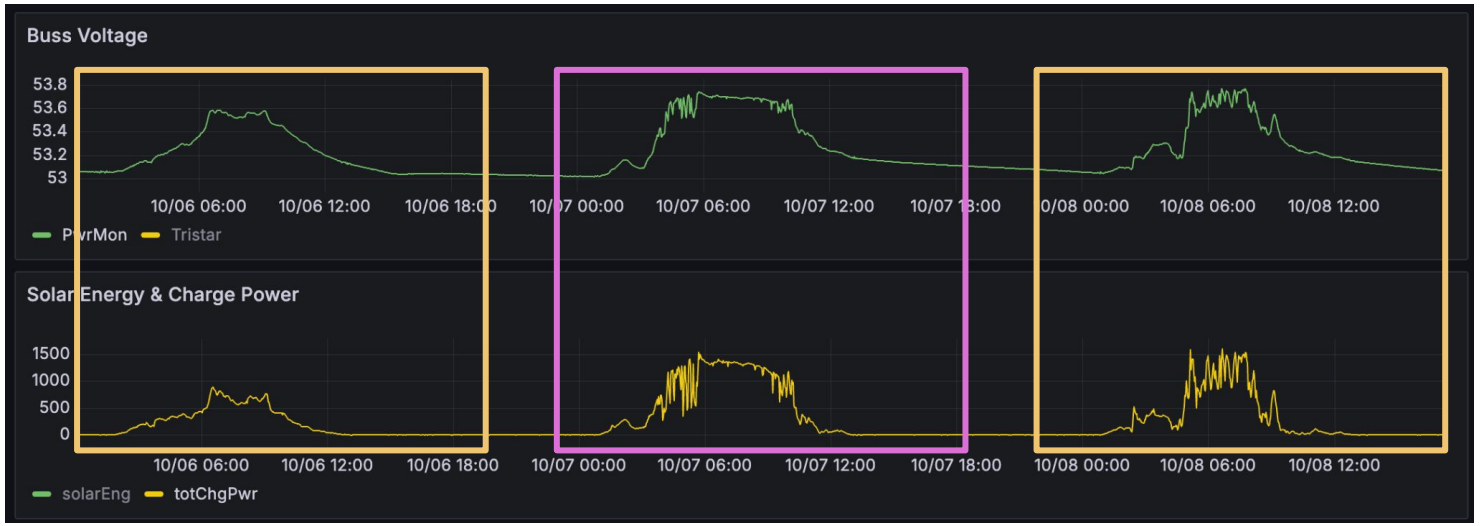
- Message sent to instant messenger

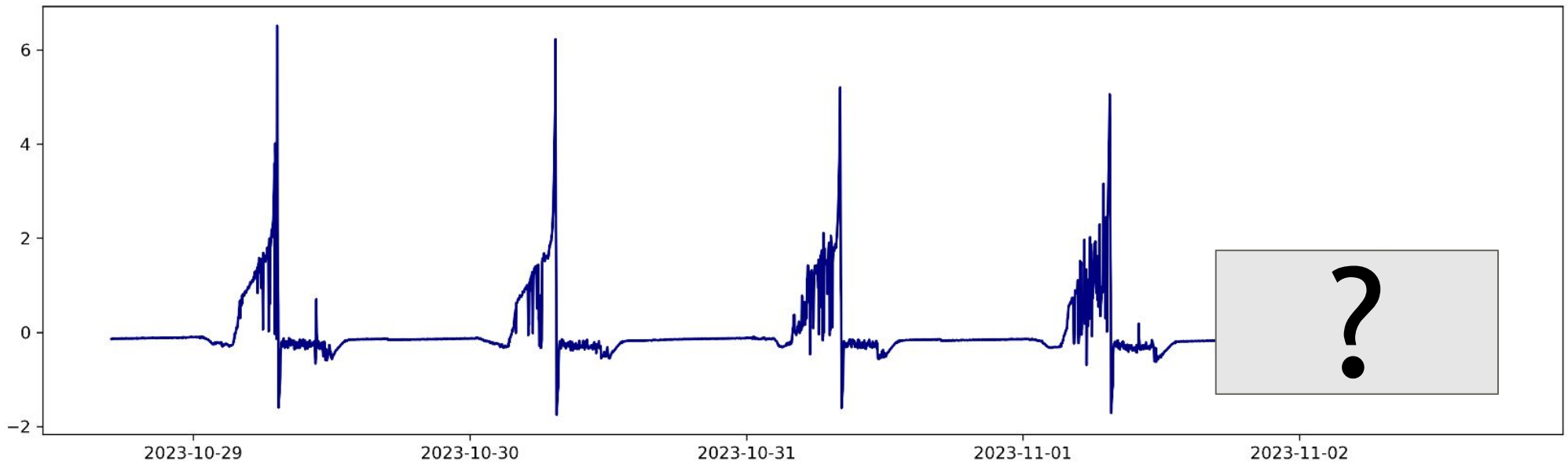




Autoencode ➡ Cluster ➡ Fit ➡ **Notify**

Moving forward - Predictive Model

- Look at past four days of input and predict what following day will look like



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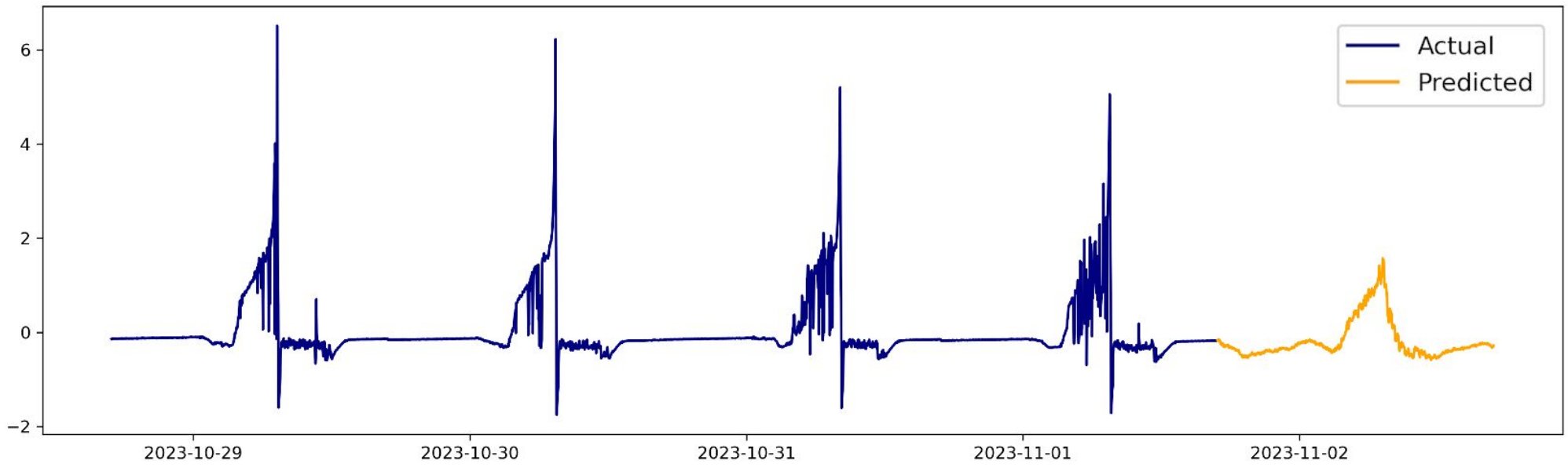

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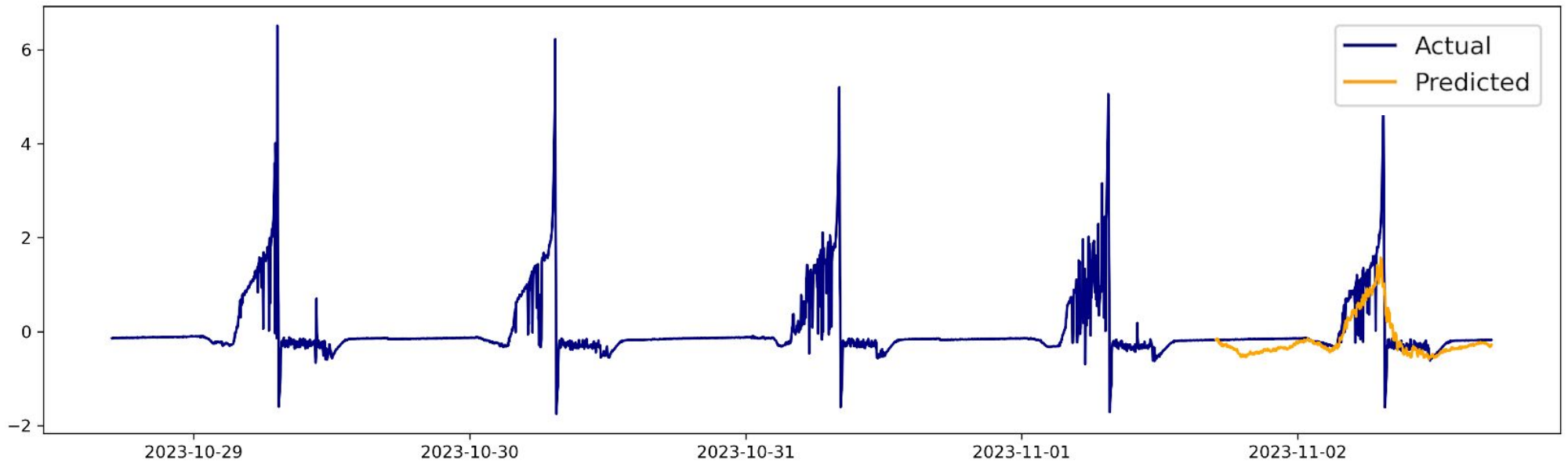
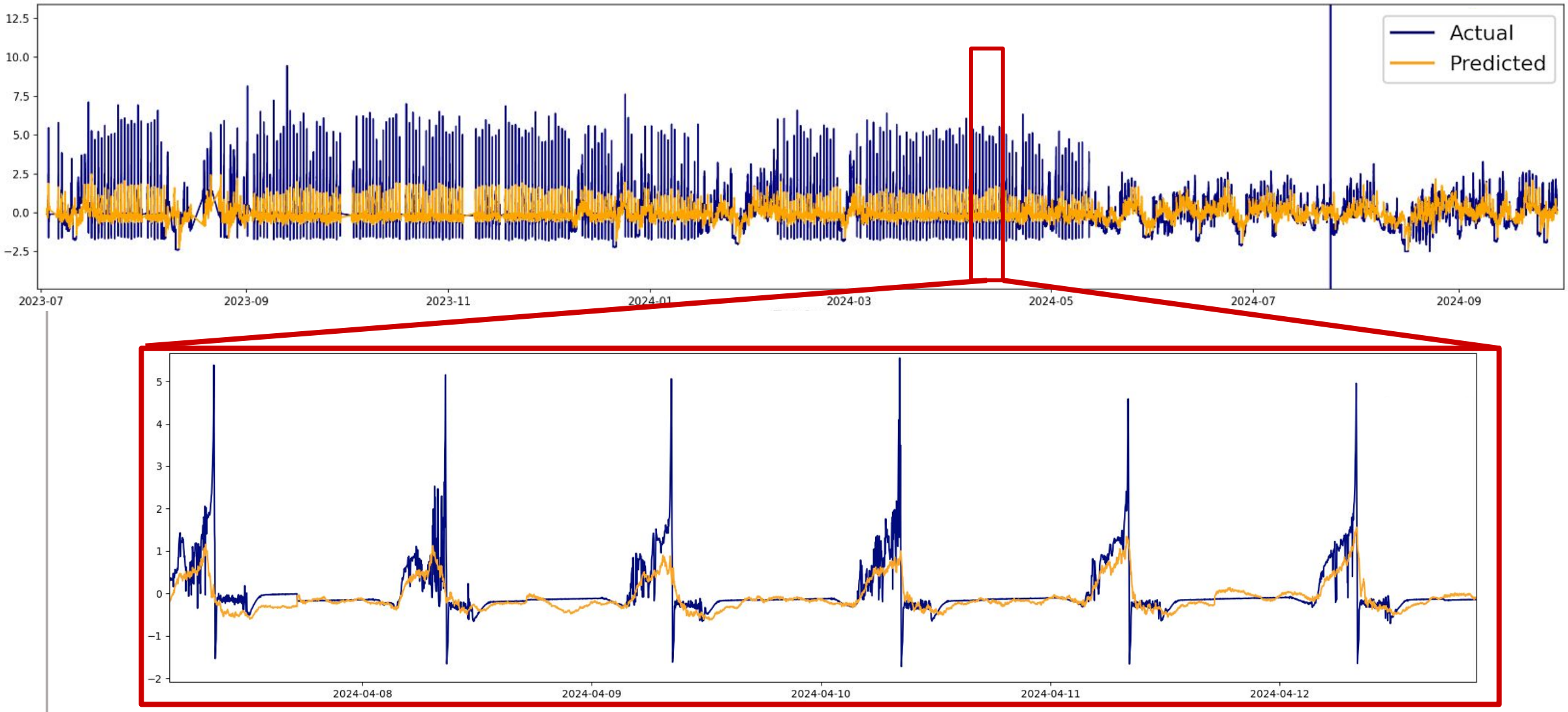


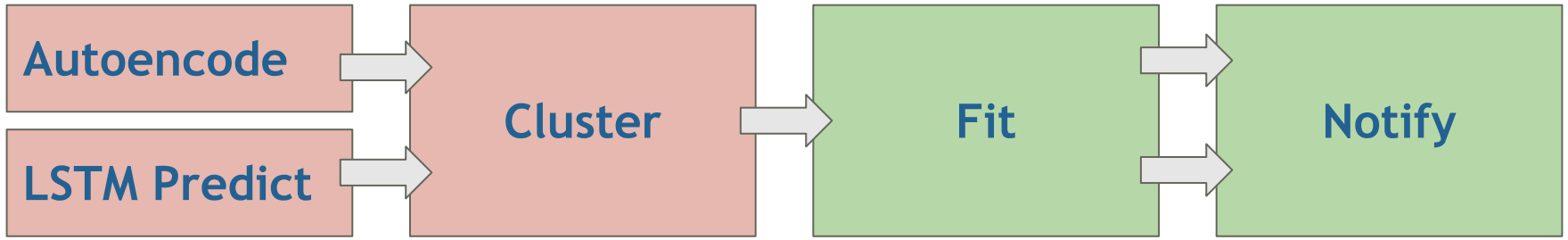
Moving forward - Predictive Model

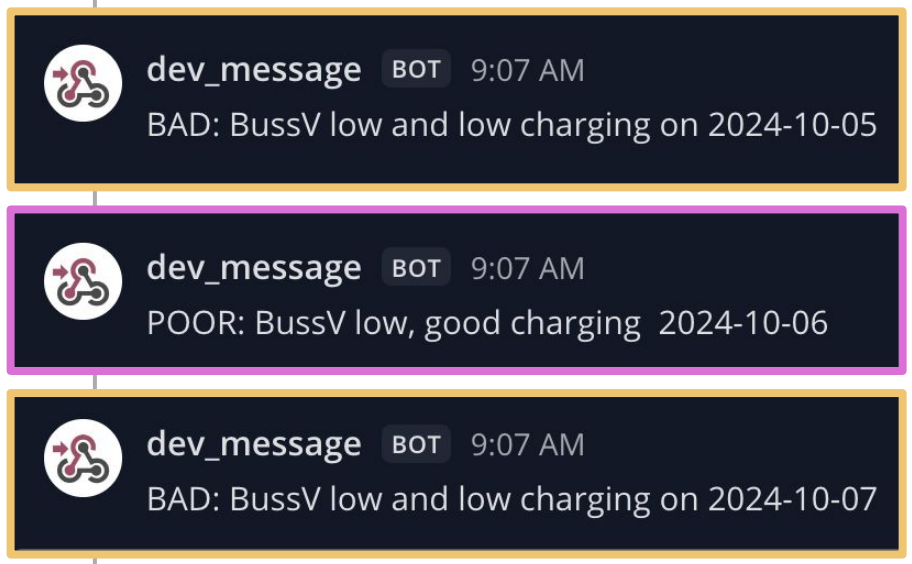


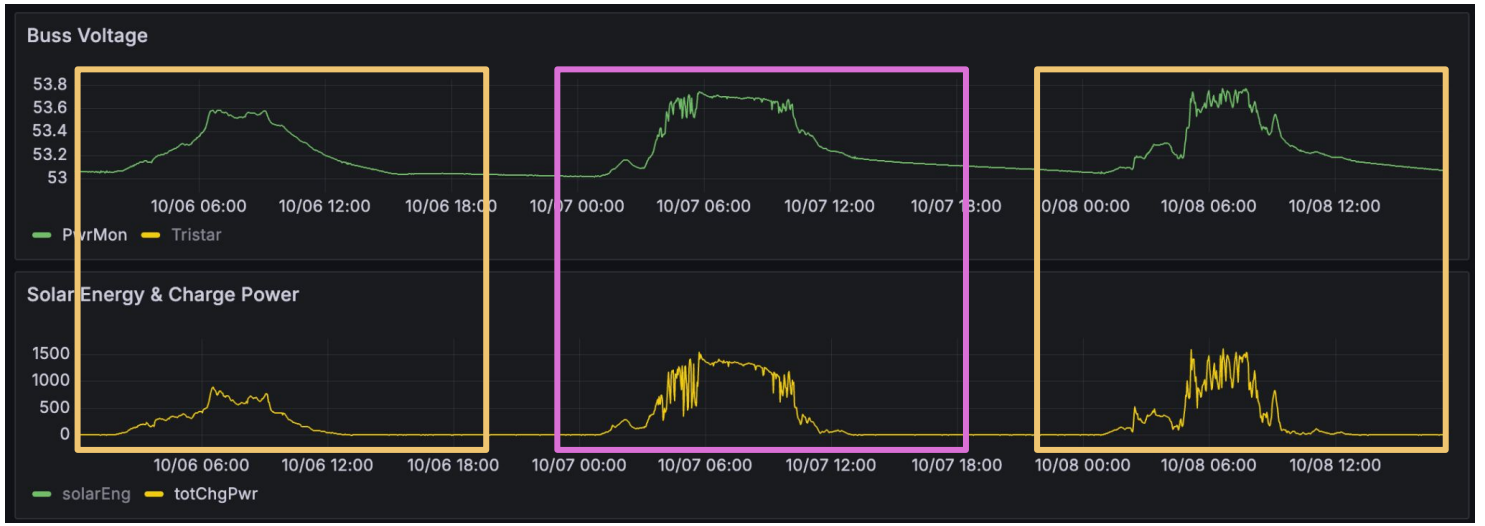
Moving forward - Predictive Model

Moving forward - Predictive Model

Use Long Short-Term Memory Model to predict input for following day, fit to model, and predict the group of the following day

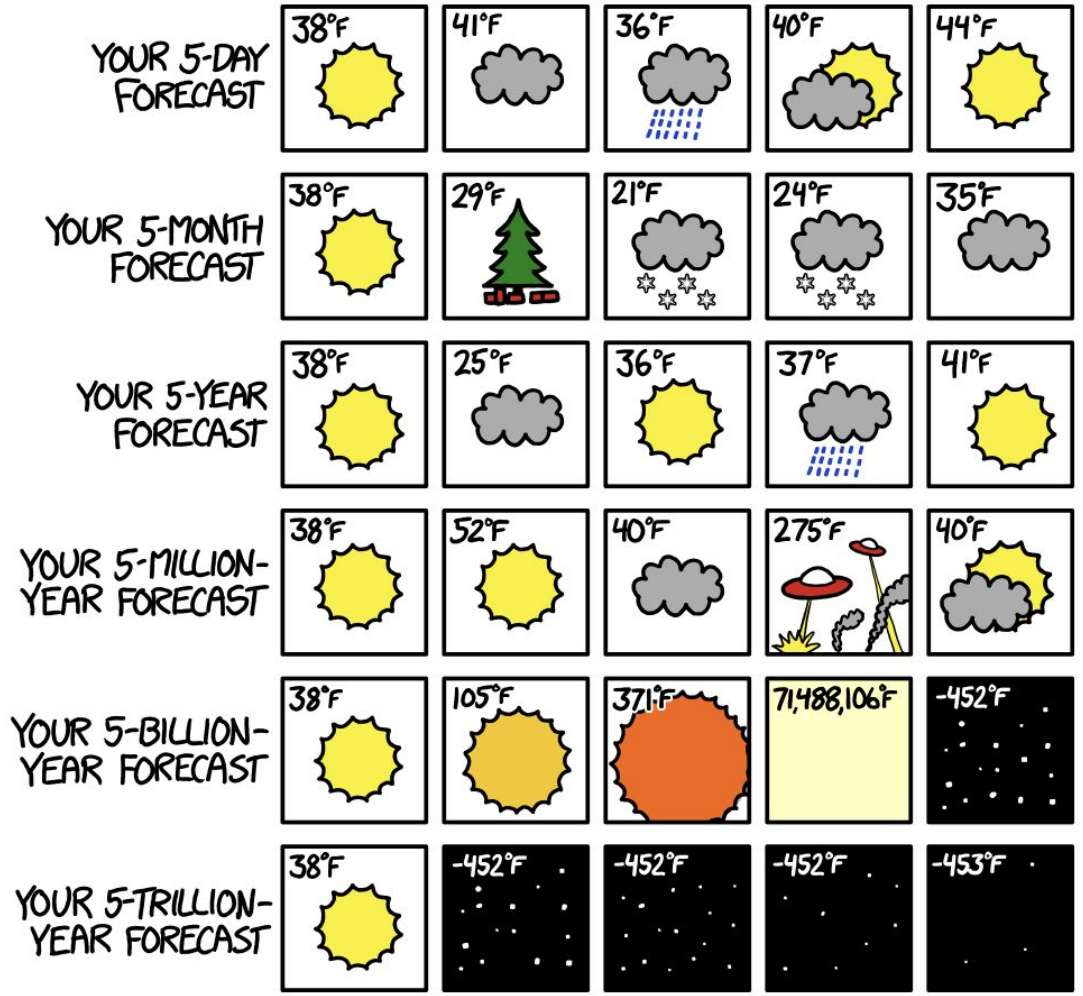






And tomorrow will be...

Thank you! Questions or Comments?



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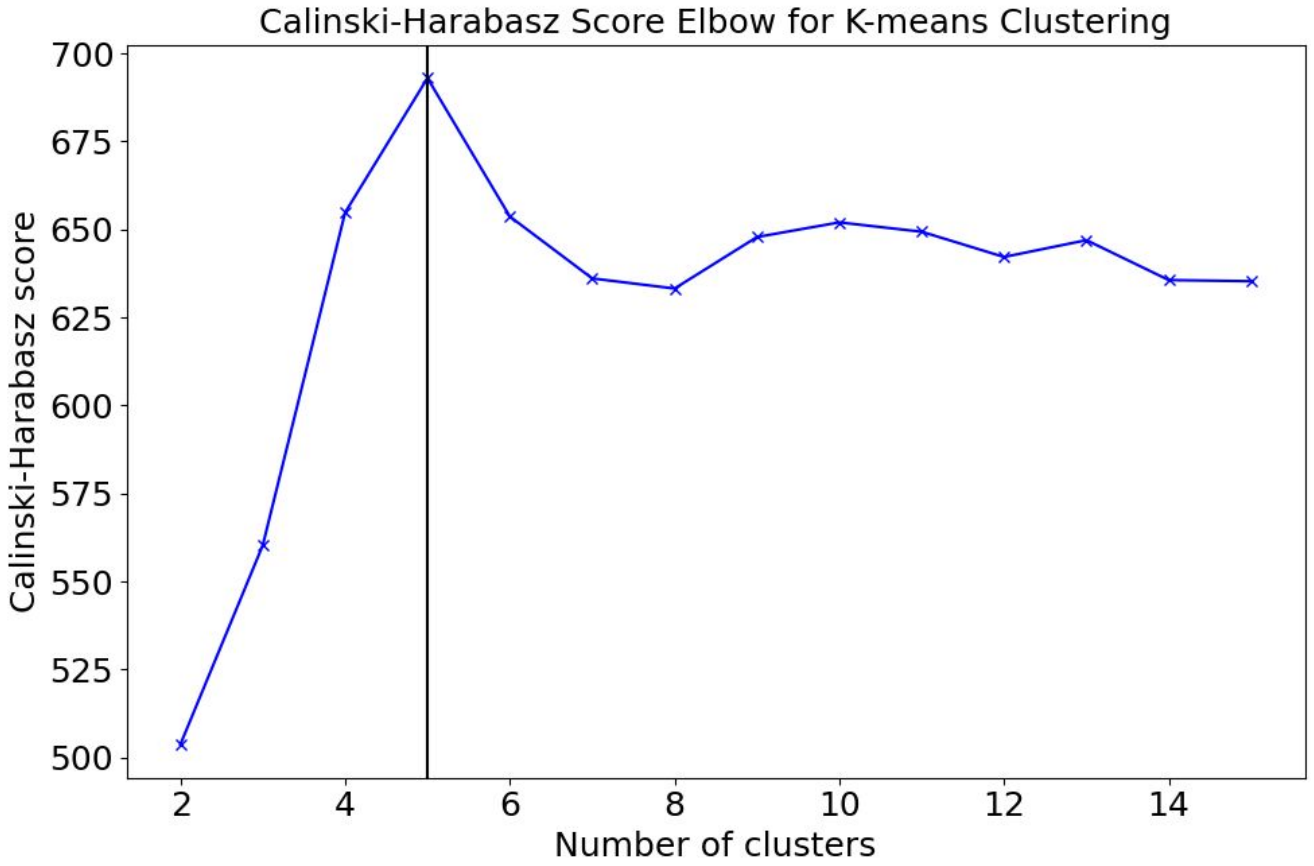
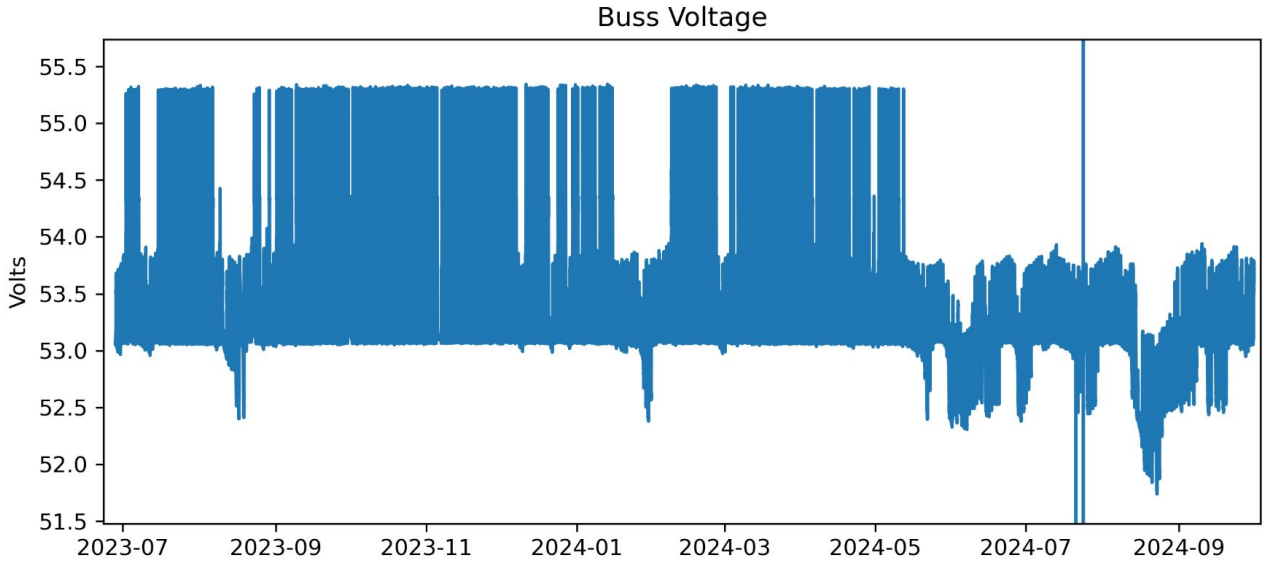
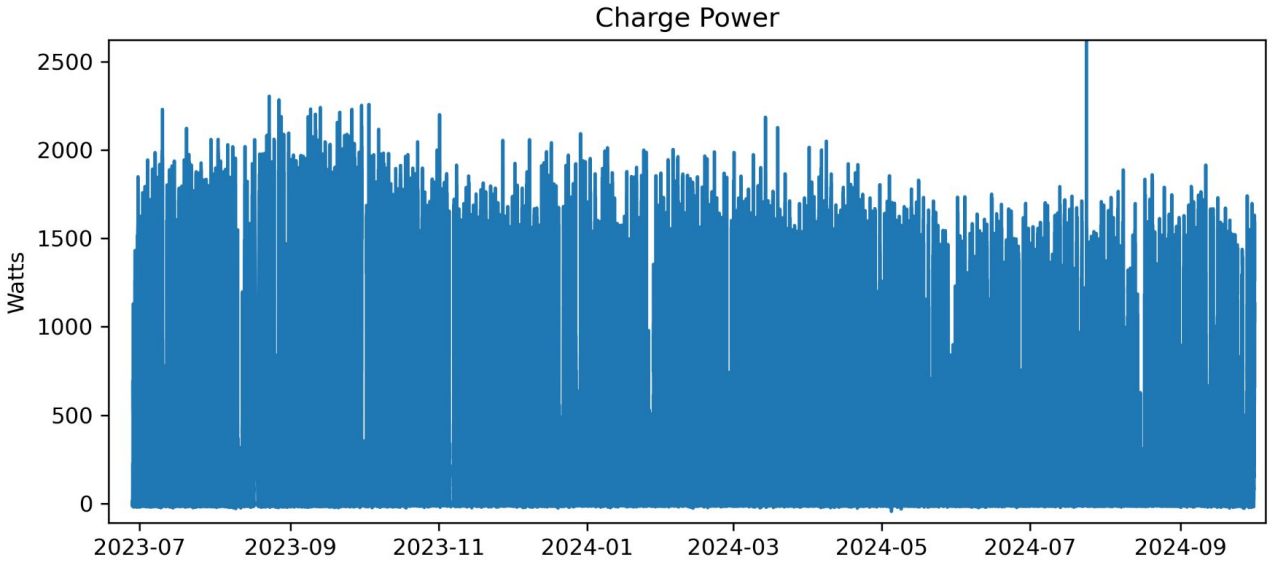
Extra Slides



Calinski-Harabasz Score: ratio of the sum of between-cluster dispersion and within-cluster dispersion


Buss Voltage
Volts
55.5
55.0
54.5
54.0
53.5
53.0
52.5
52.0
51.5
2023-07
2023-09
2023-11
2024-01
2024-03
2024-05
2024-07
2024-09


Charge Power
Watts
2500
2000
1500
1000
500
0
2023-07
2023-09
2023-11
2024-01
2024-03
2024-05
2024-07
2024-09

Input Data and Feature Crossing