INL/RPT-24-76949-Revision-0

Development of Multiresolution Capabilities for HERON - FY23 (M4)

July 2024

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Changing the World's Energy Future

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IES
Integrated Energy Systems

Development of Multiresolution Capabilities for the Holistic Energy Resource Optimization Network (HERON) tool
A progress update

Prepared for: U.S. Department of Energy
Office of Nuclear Energy

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Report highlights

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Purpose of the study

Context

- INL researchers work on technoeconomic analyses of IES, e.g. maximizing net present value of components operating in a grid.
  - Determine optimal capacities of components and strategies for resource dispatch.
- Analyses rely on simulation tools that require time series data as inputs (e.g. pricing data, load profiles, wind speeds, solar irradiance, etc.).
- But simulations contain a degree of uncertainty due to the unpredictability of complex markets or weather events.
- Within simulations, dynamics occur on multiple timescales: important fast dynamics can get dominated by other larger, slower dynamics.
  - E.g., seasonal market trends vs. a quick contingency event due to power plant outage

Objectives and impact

- Generate better synthetic time histories that are statistically representative of training datasets.
- Understand the underlying dynamics in a multi-timescale time series.
- Couple seasonal, day-ahead and real-time optimization with greater computational efficiency.
- This will provide better decision-making for markets at different time scales.

IES
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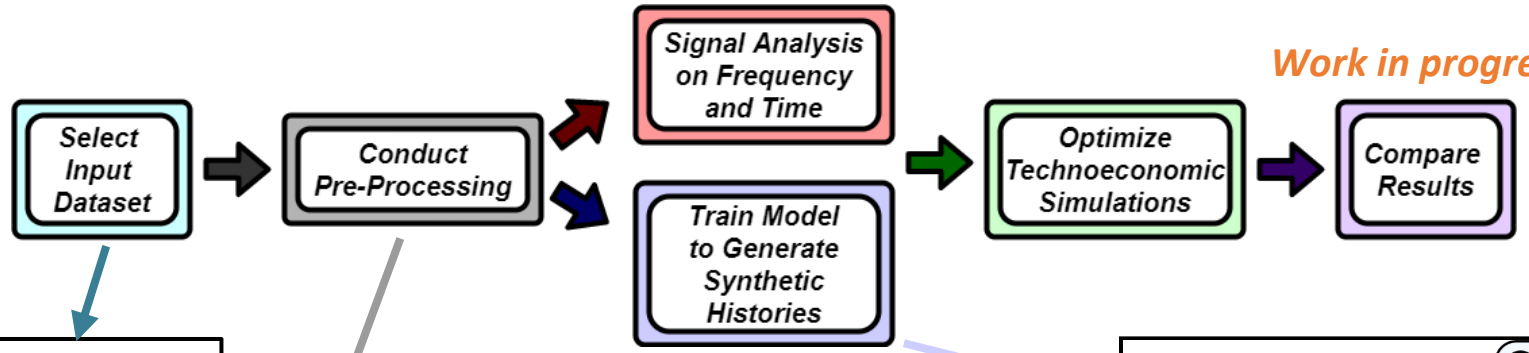
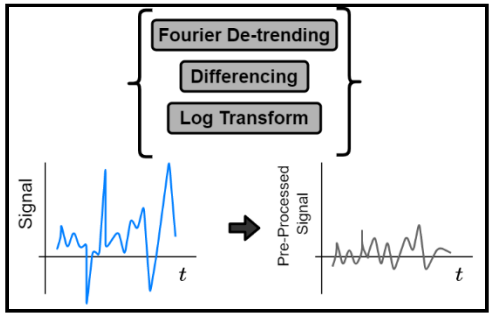
Methodology

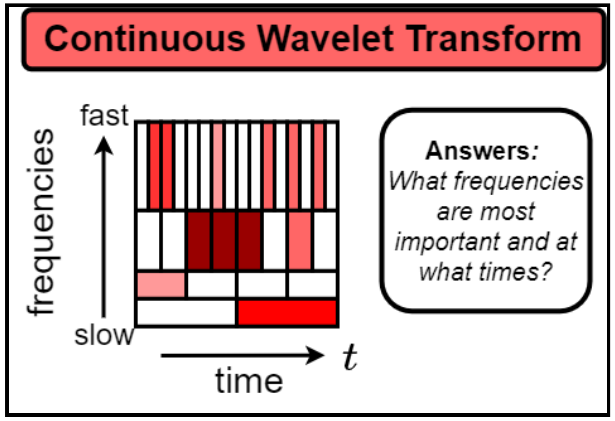
Work in progress.



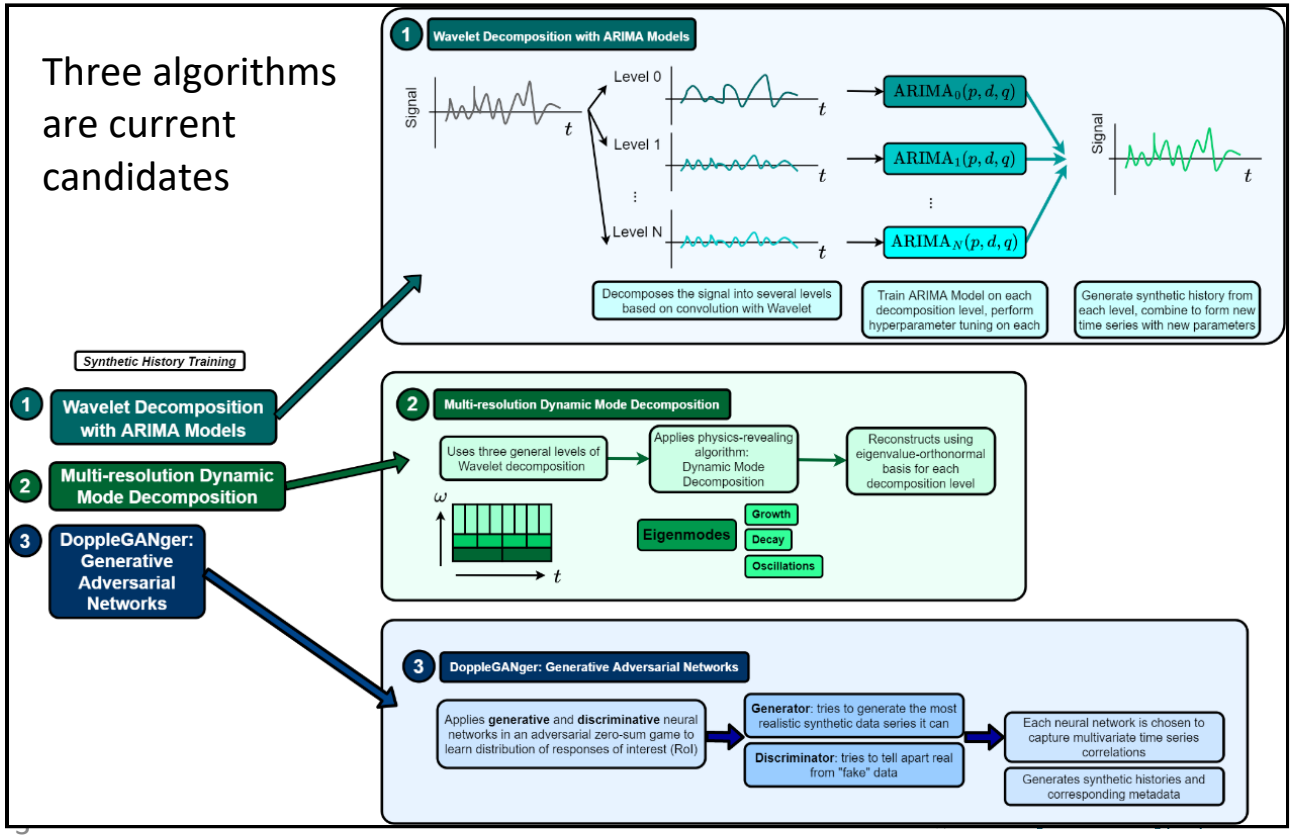
E.g.:

- **Hourly grid load**
- **Hourly wind, solar profiles**
- **Hourly day ahead market (DAM) pricing data**



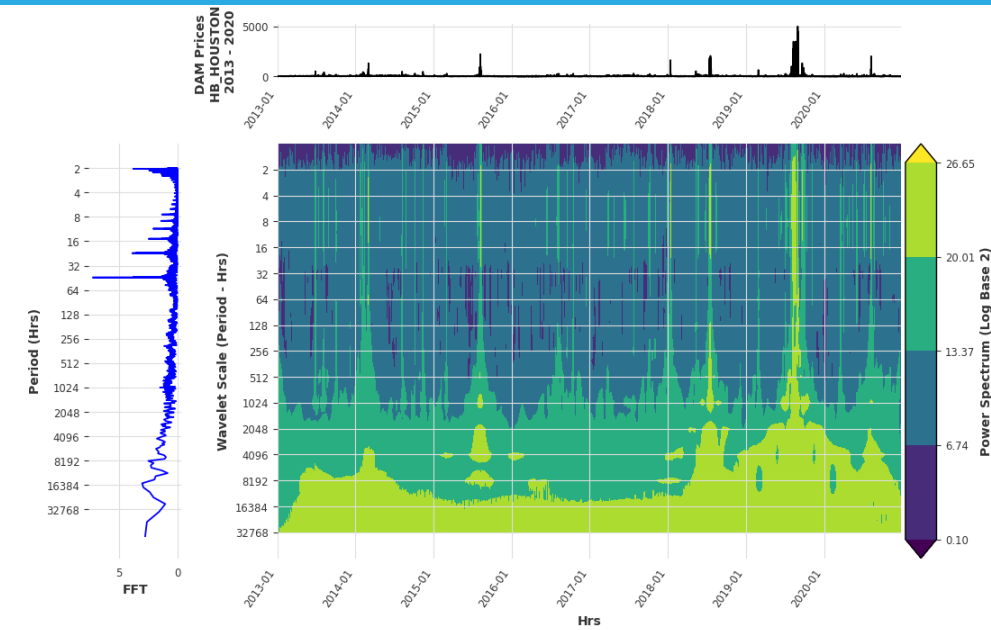


Three algorithms are current candidates

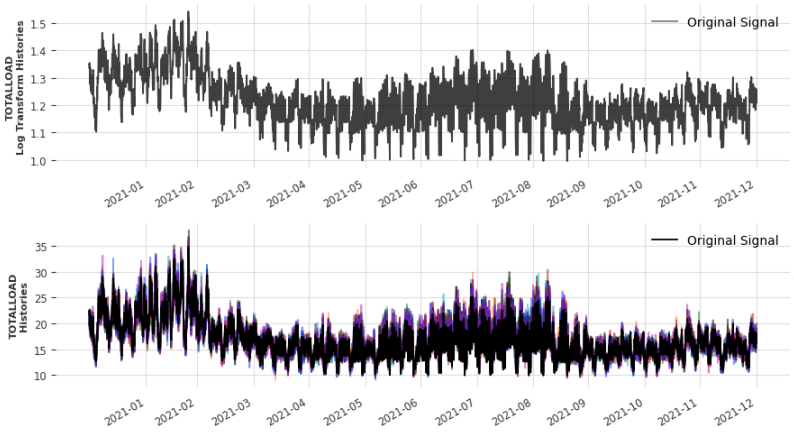


Main results and conclusions

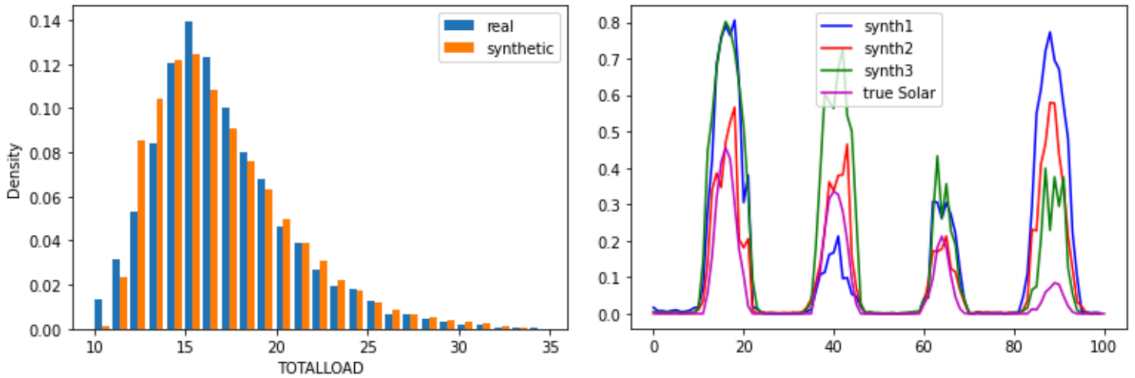
- Showed that Wavelet ARIMA decomposition methods can be used to analyze signal and determines which frequencies are most important at what time periods.
- Demonstrated usage of 3 new algorithms for synthetic history training and generation:
  - Trained a model using two datasets, applying log transform first (nested ARIMA models based on decomposition levels).
  - Generated Dynamic Mode Decomposition.
  - Generated DGAN (DoppelGANger where GAN is generative adversarial networks) time series.



Power spectrum of Houston day-ahead market prices



Synthetic Histories from NY 2021 Loading data



Trained and generated new synthetic signals. Histograms show that model captures rare events (tails)

Next steps

- Generate better synthetic time histories:
  - Create metrics for comparing synthetic histories.
  - Improve capture of extreme spikes in training data.
  - Implement within INL's Risk Analysis Virtual Environment (RAVEN) for users.

- Understand the underlying dynamics in a multi-timescale time series
  - Apply clustering algorithm on Continuous Wavelet Transform

- Couple seasonal, day-ahead and real-time optimization with greater computational efficiency
  - Conduct optimization of simulations for multiple timescales (e.g., seasonal, day-ahead, etc.)