Applications of Signal Processing in Power Systems Research at LLNL

Philip Top
Emma Stewart

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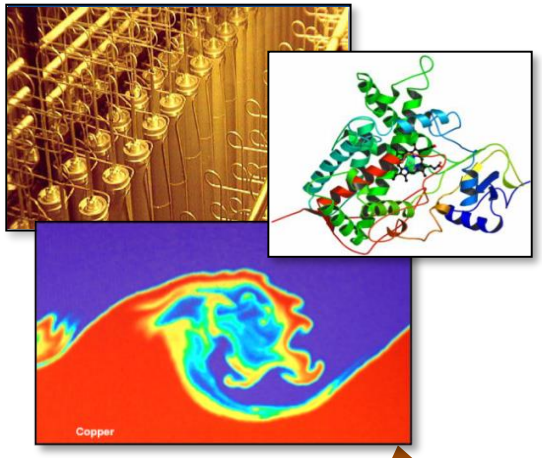
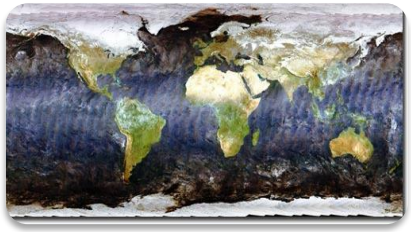
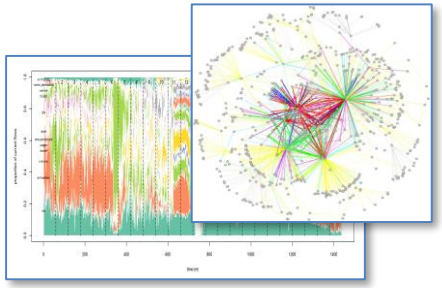
Data Science is the discipline of transforming data to knowledge

Critical complex systems



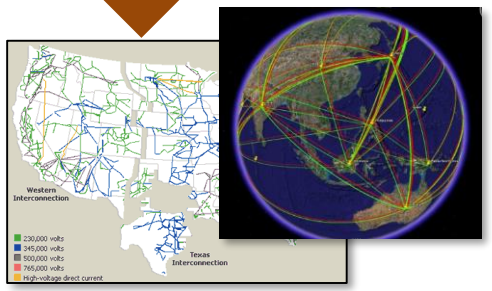


Managing large, distributed data



Learning patterns of behavior in the data

New data-intensive computing architectures



Predictive models with quantified uncertainties

Applications in
- **Detection and intervention**
- **Resilience and security**
- **Design optimization**

Cyber and Infrastructure Resilience Program

Mission:

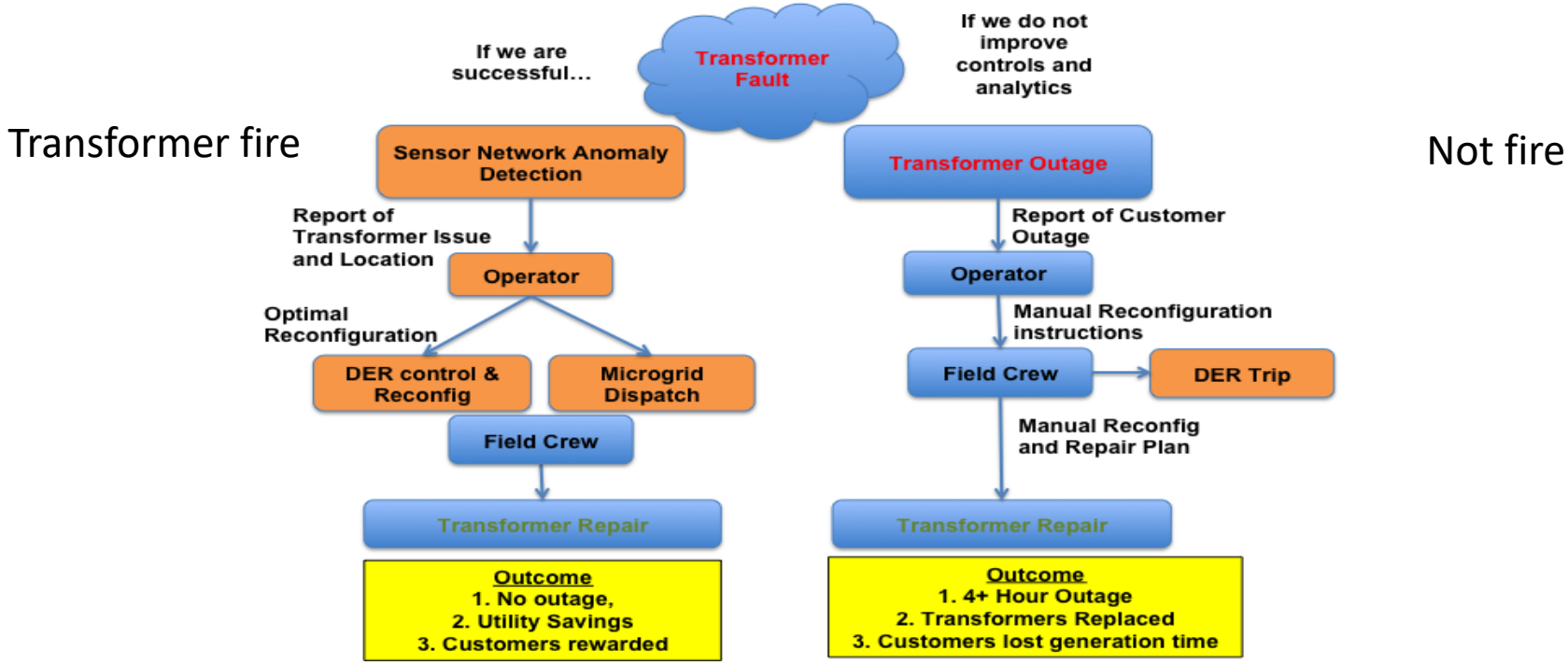
Produce technologies and solutions that ensure the sustainable and resilient functioning of our national infrastructure – both physical and virtual – in the face of cyber, physical and environmental challenges

We build towards a future where:

- *Energy is supplied by **100% renewable sources**, eliminating both negative impact on the environment as well as reliance on foreign powers for energy*
- *Our infrastructure systems are **intelligent and self-healing**, making them resilient to cyber and physical disruption*
- *National borders are fully secure to illegal activity, but appear **transparent to legitimate commerce***
- *Clean water is **abundant** and available where it is needed*

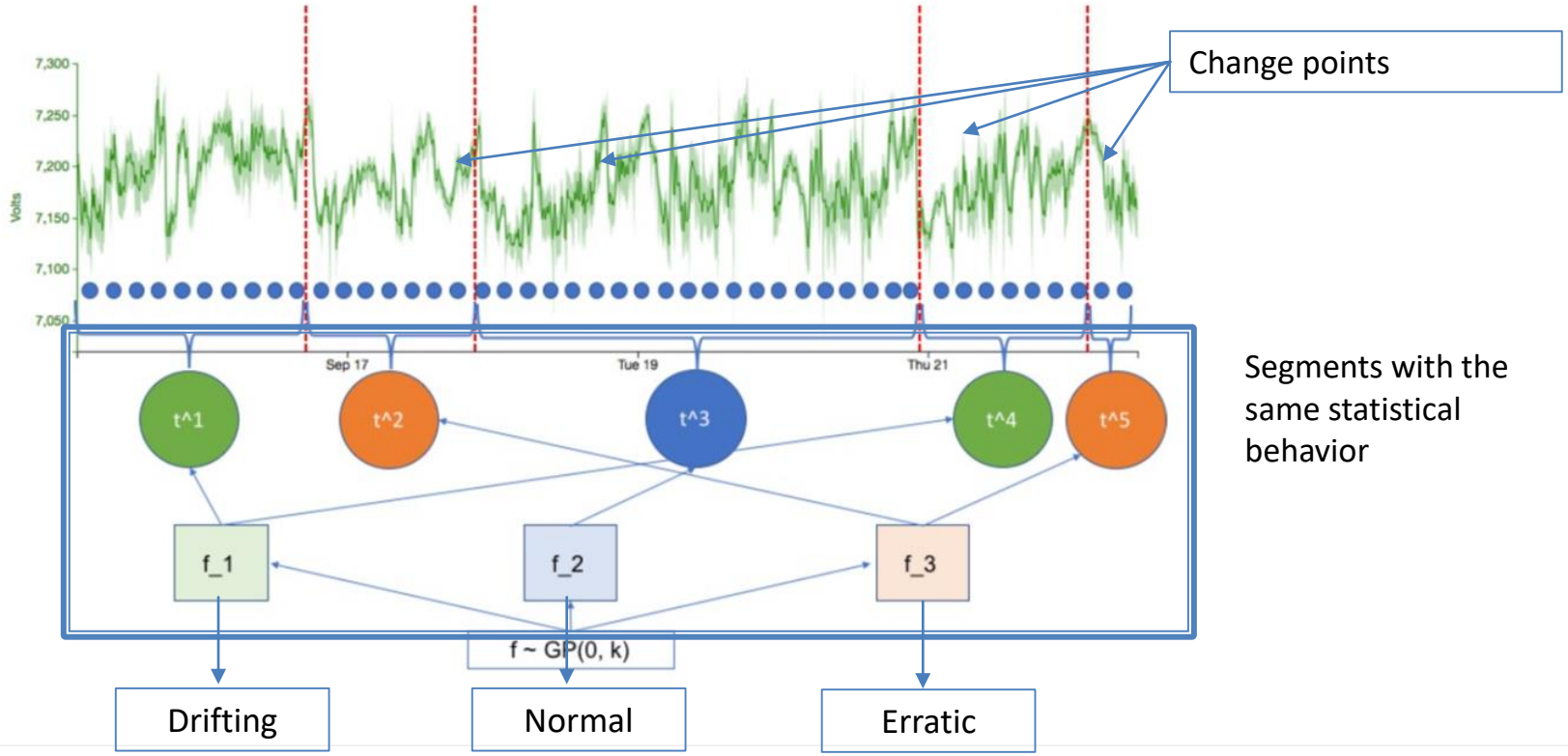
Problem: Transformer failure prediction in smart grids

- Predict transformer failures/repair strategy accurately, quickly, and economically, based on disparate temporal multimodal data

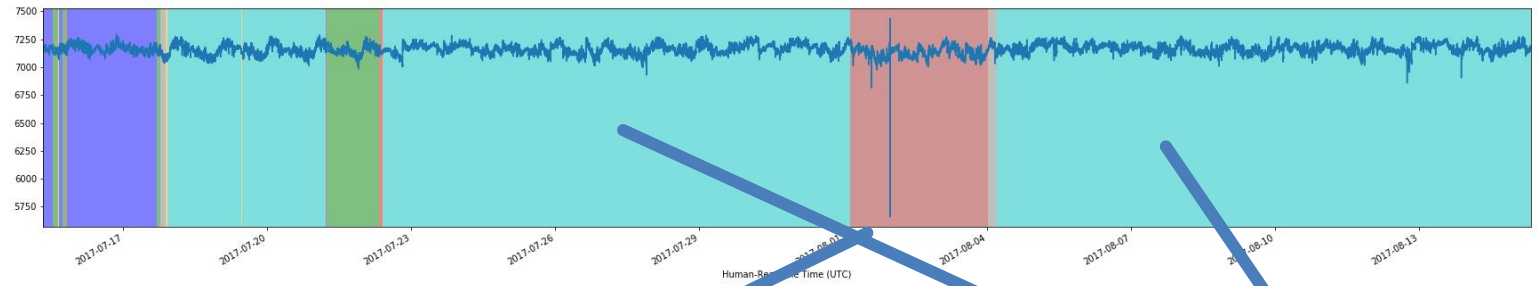


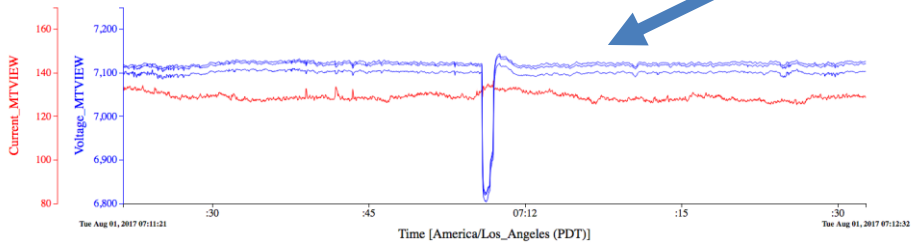
Discovering risky behavior in power grid through Machine Learning

- Few examples of transformer failure / erratic behavior
- Approach the problem as unsupervised learning task: From micro PMU measurements, we want to learn

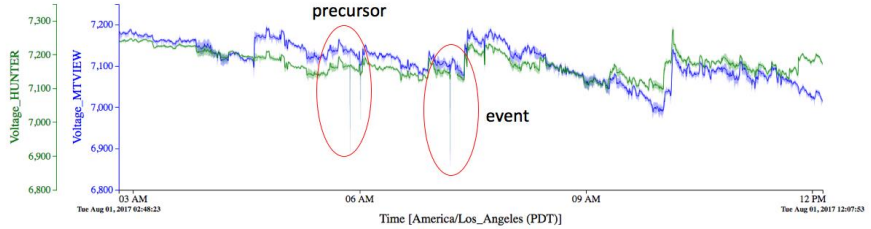


Fingerprints discovered in data





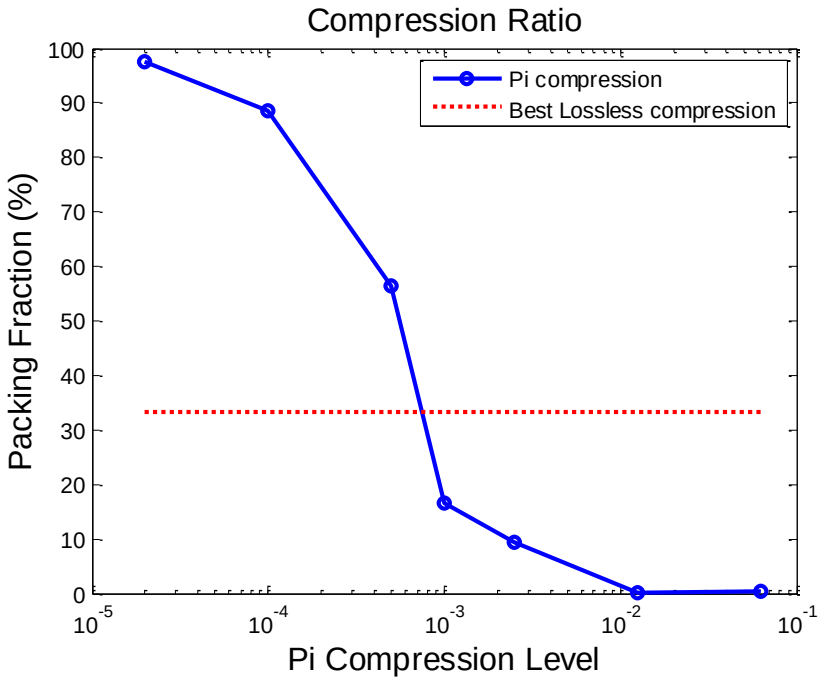
"Normal" behavior

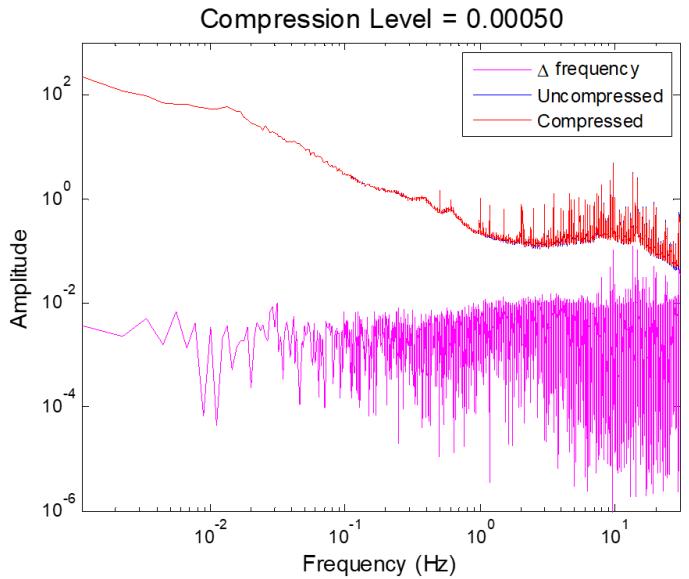


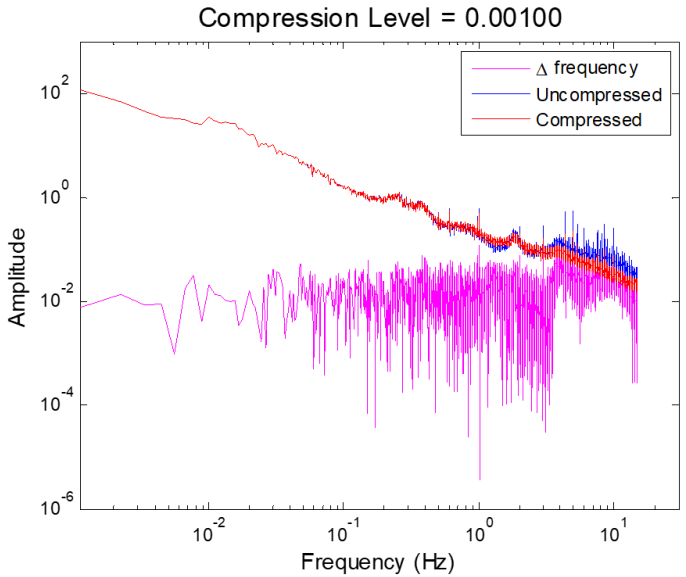
Voltage drops due to lightning

Data Compression

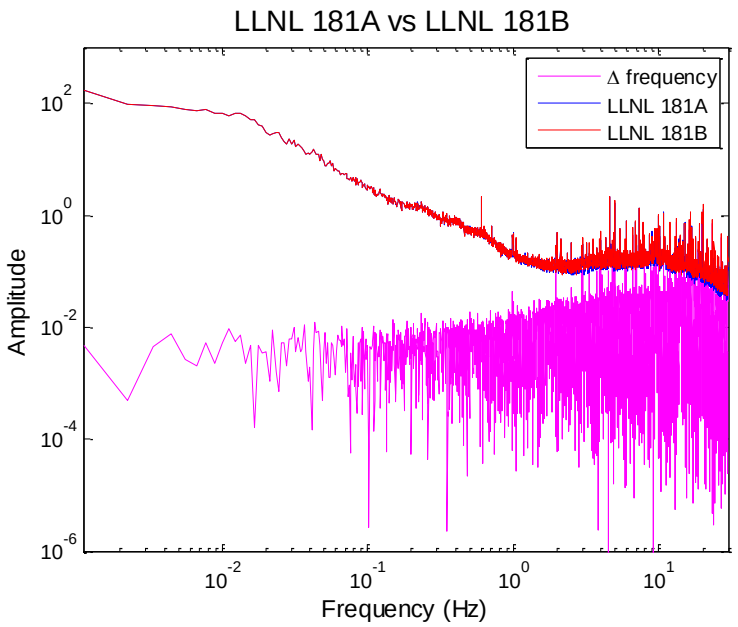
- Lots of data- to reduce size it can be compressed
- How does compression affect the data?

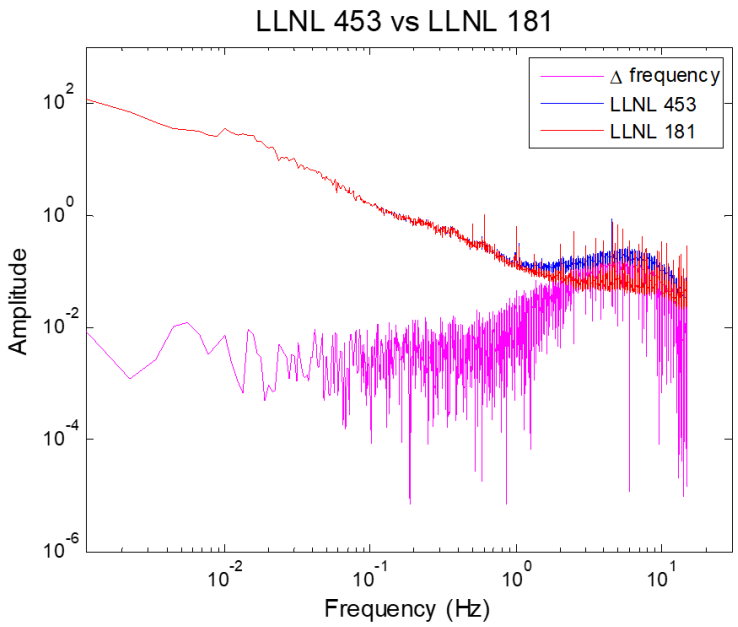


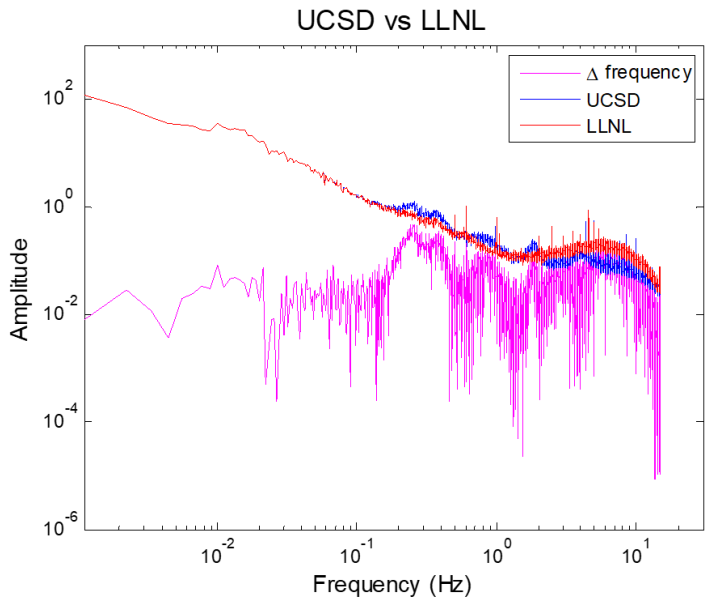




Signal Deviation







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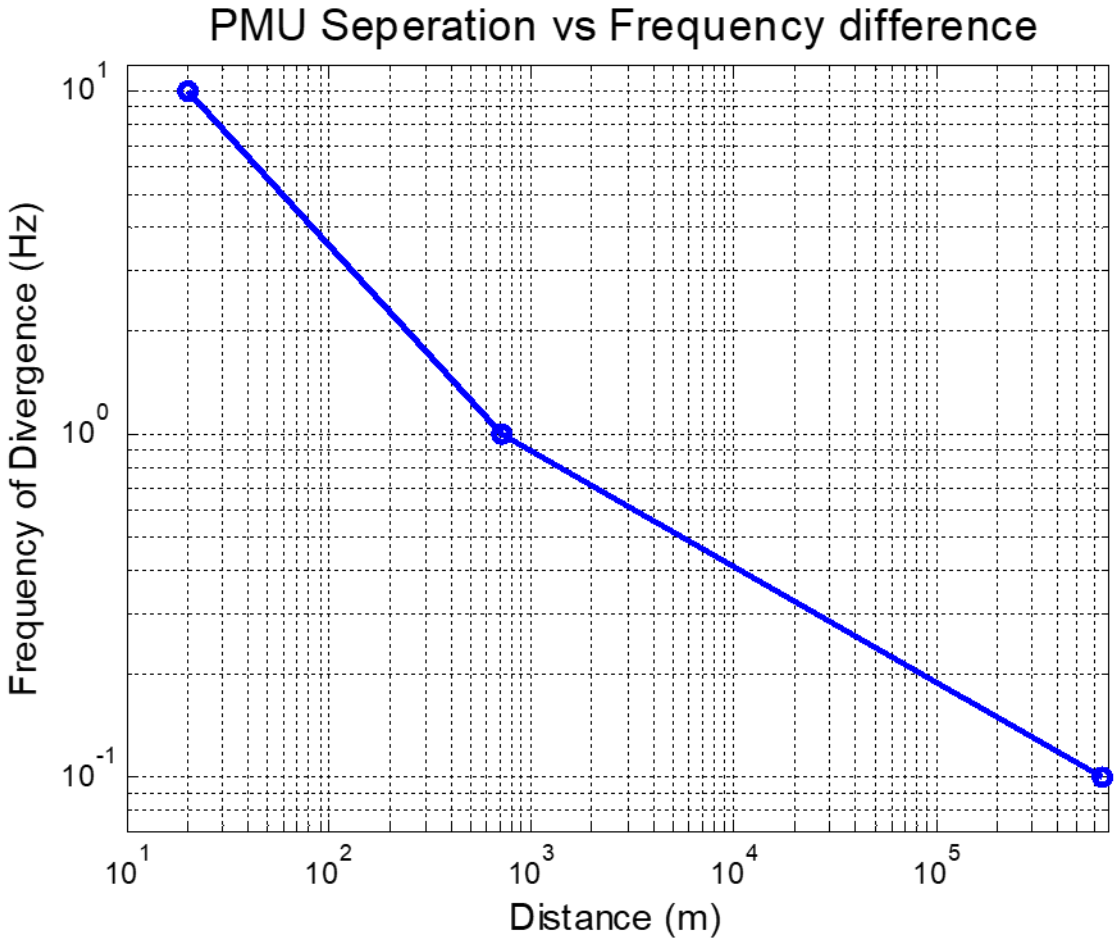


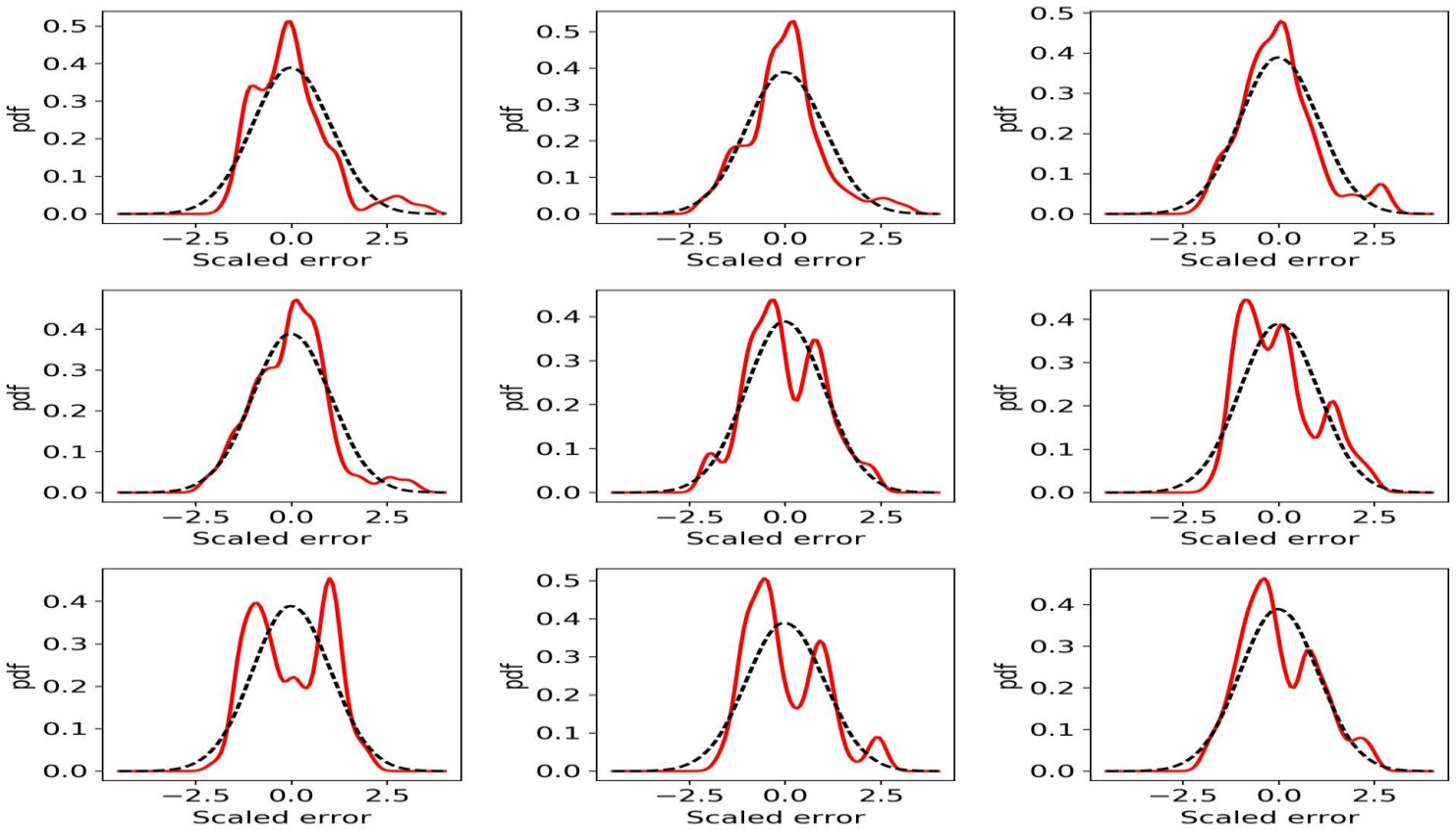
PMU Noise

Can Huang, Mert Korkali, Charanraj Thimmisetty, Xiao Chen, Emma Stewart, Vaibhav Donde, Charles Tong

- Is the noise Gaussian
  - Short run? No
  - Long run? Its close

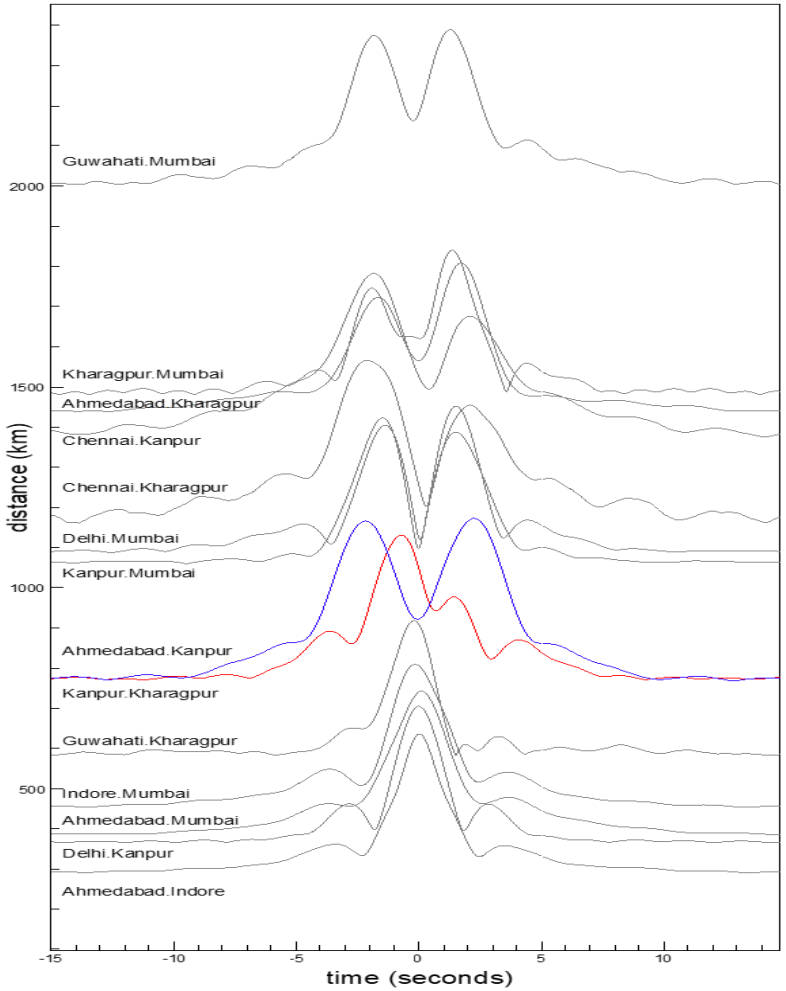
- Figure: δ_{Error} distribution for L1 for time frame

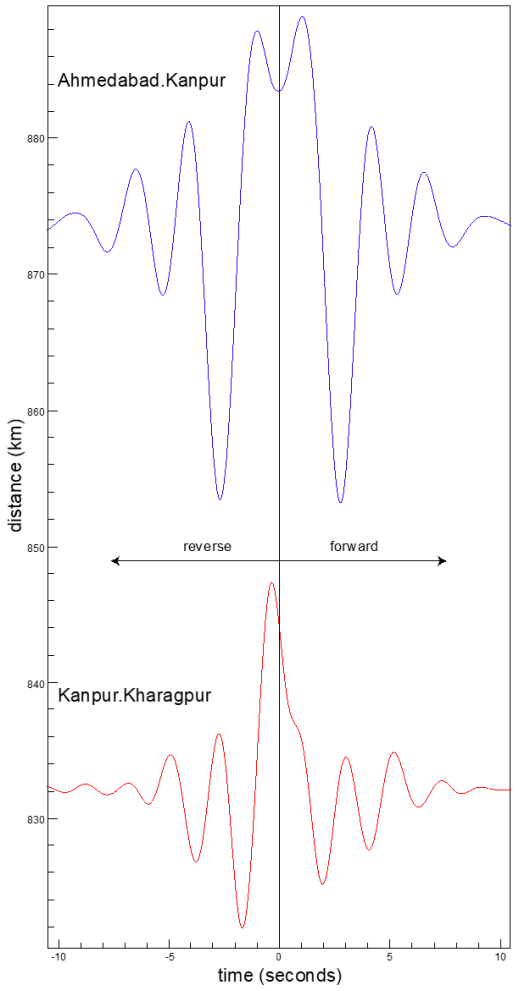
- **2 sec**, each distribution has **240** samples; 9 subplots corresponds to sample **0-2, 2-4, .. 16-18 secs.**



Ambient Noise Correlation

Eric Matzel, Philip Top





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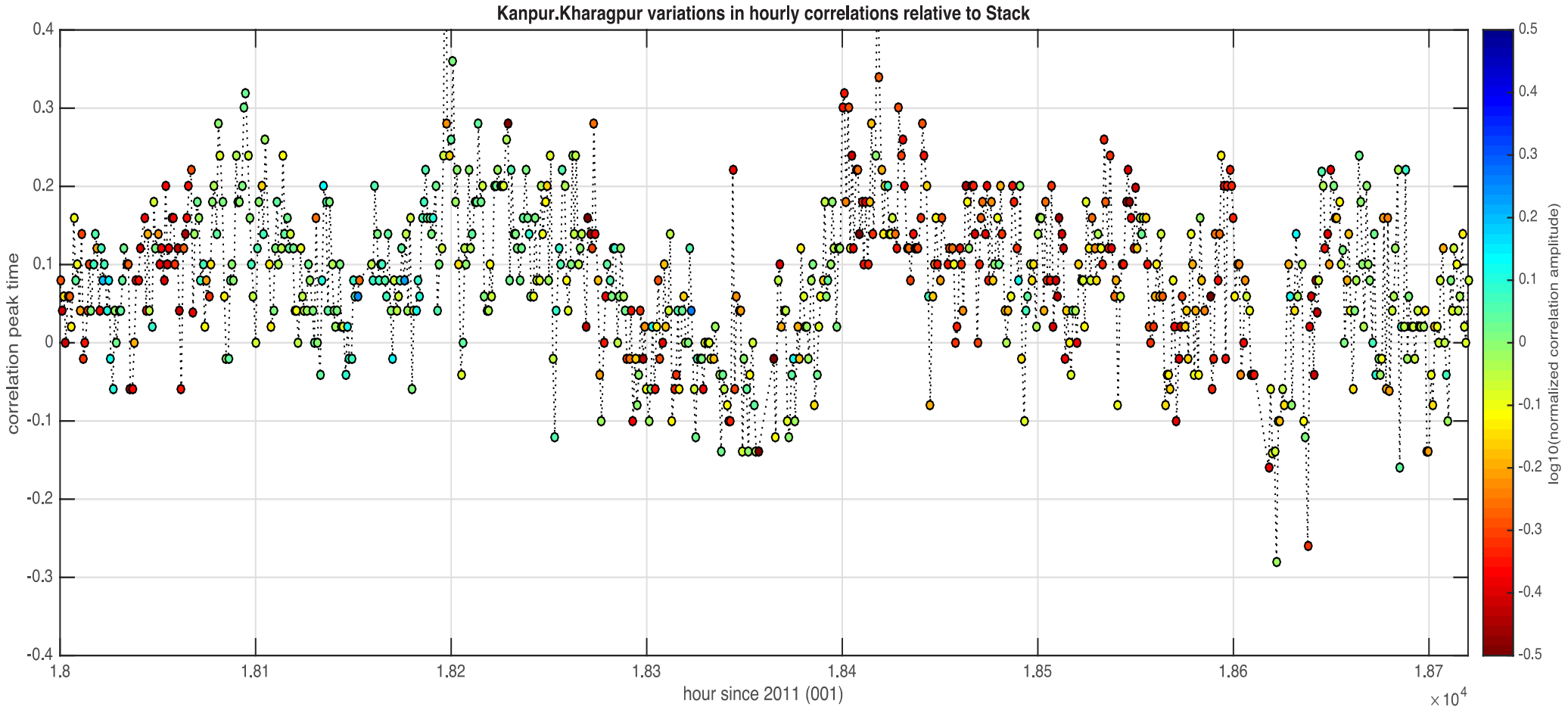

Other Areas of Signal processing with Power Systems

- Data Analysis
- Machine learning for dynamic models
- Control theory
- Model Validation