

Applications of Signal Processing in Power Systems Research at LLNL

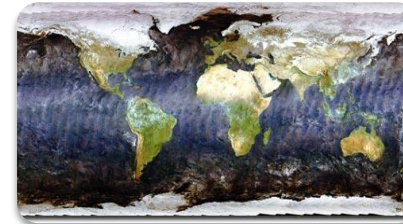
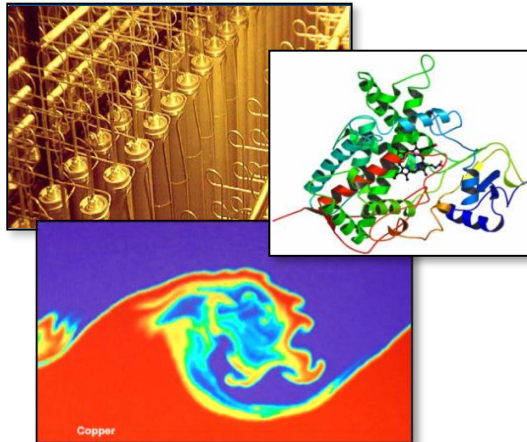
Philip Top
Emma Stewart

May 15, 2019



Data Science is the discipline of transforming data to knowledge

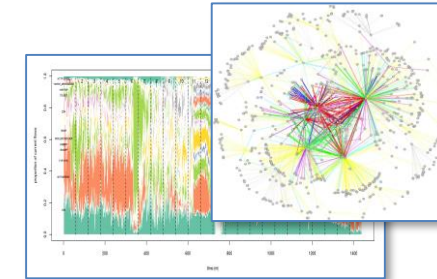
Critical complex systems



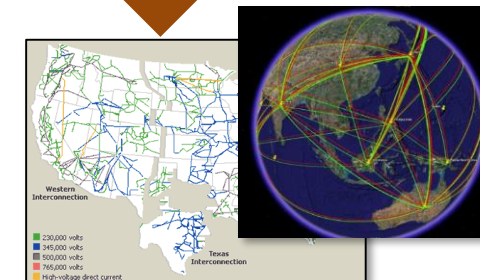
Managing large, distributed data



New data-intensive computing architectures



Learning patterns of behavior in the data



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



Chemical



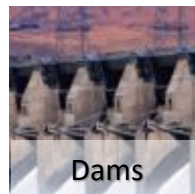
Commercial



Communications



Manufacturing



Dams



Defense



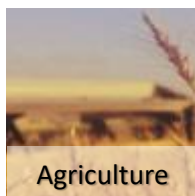
Emergency



Energy



Financial



Agriculture



Government



Healthcare



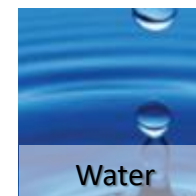
Information



Nuclear



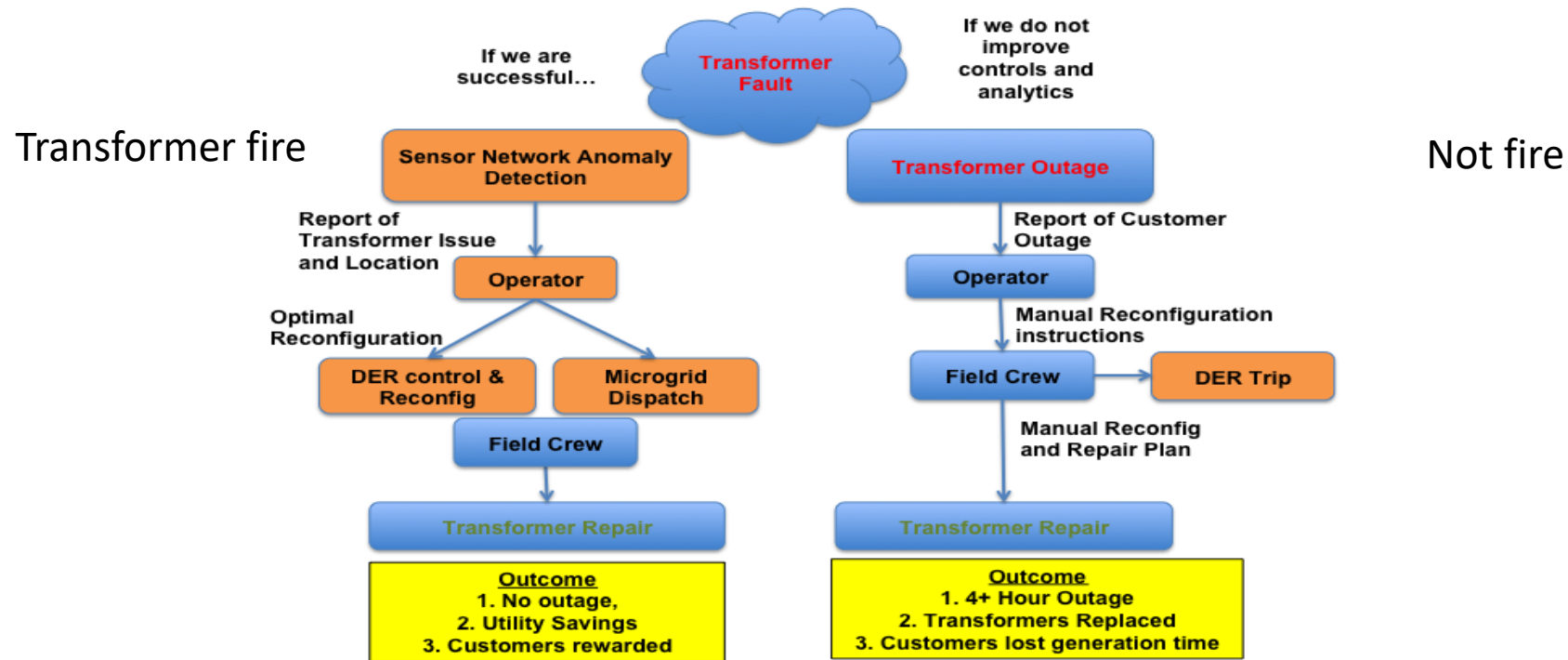
Transportation



Water

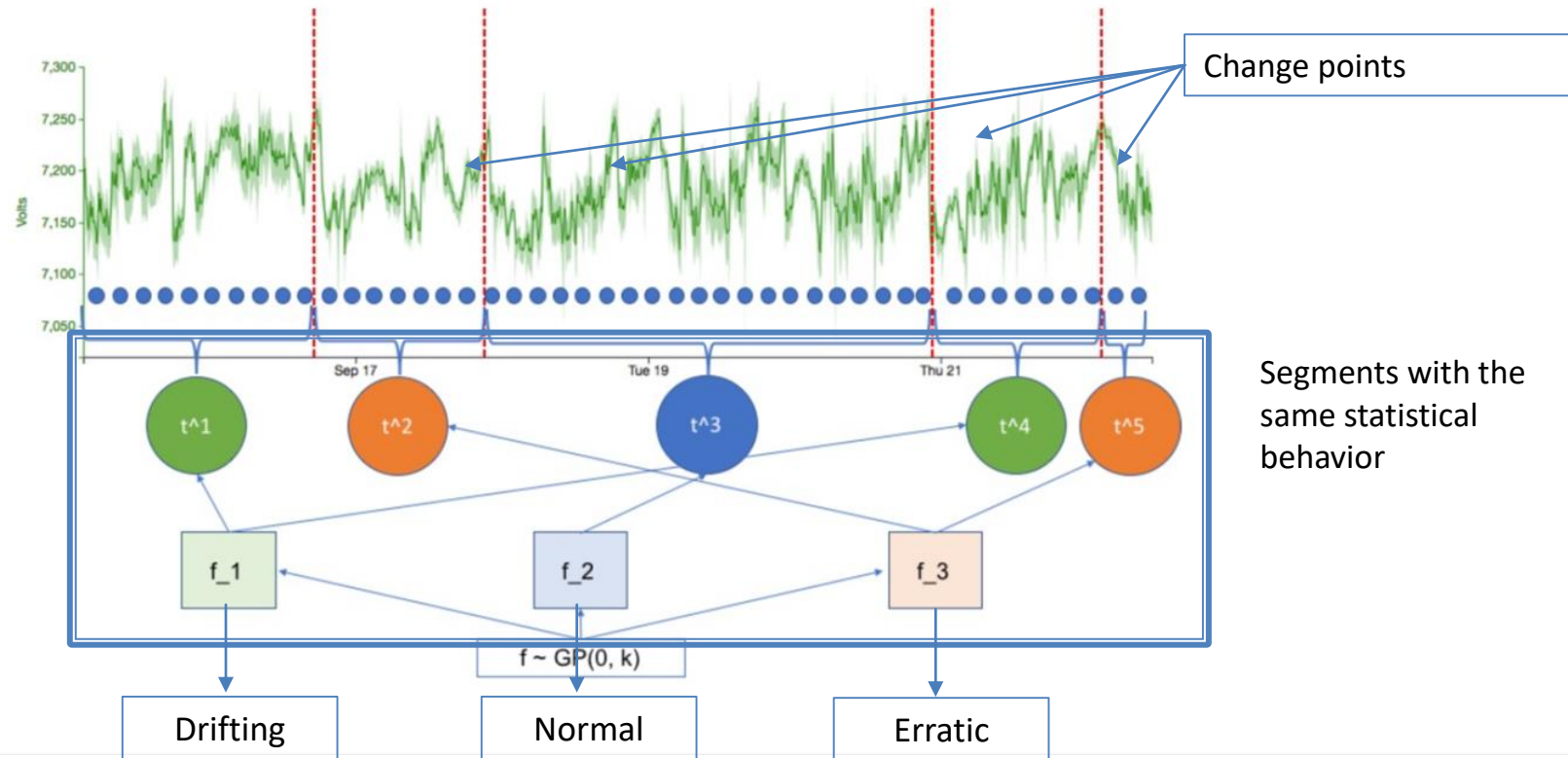
Problem: Transformer failure prediction in smart grids

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

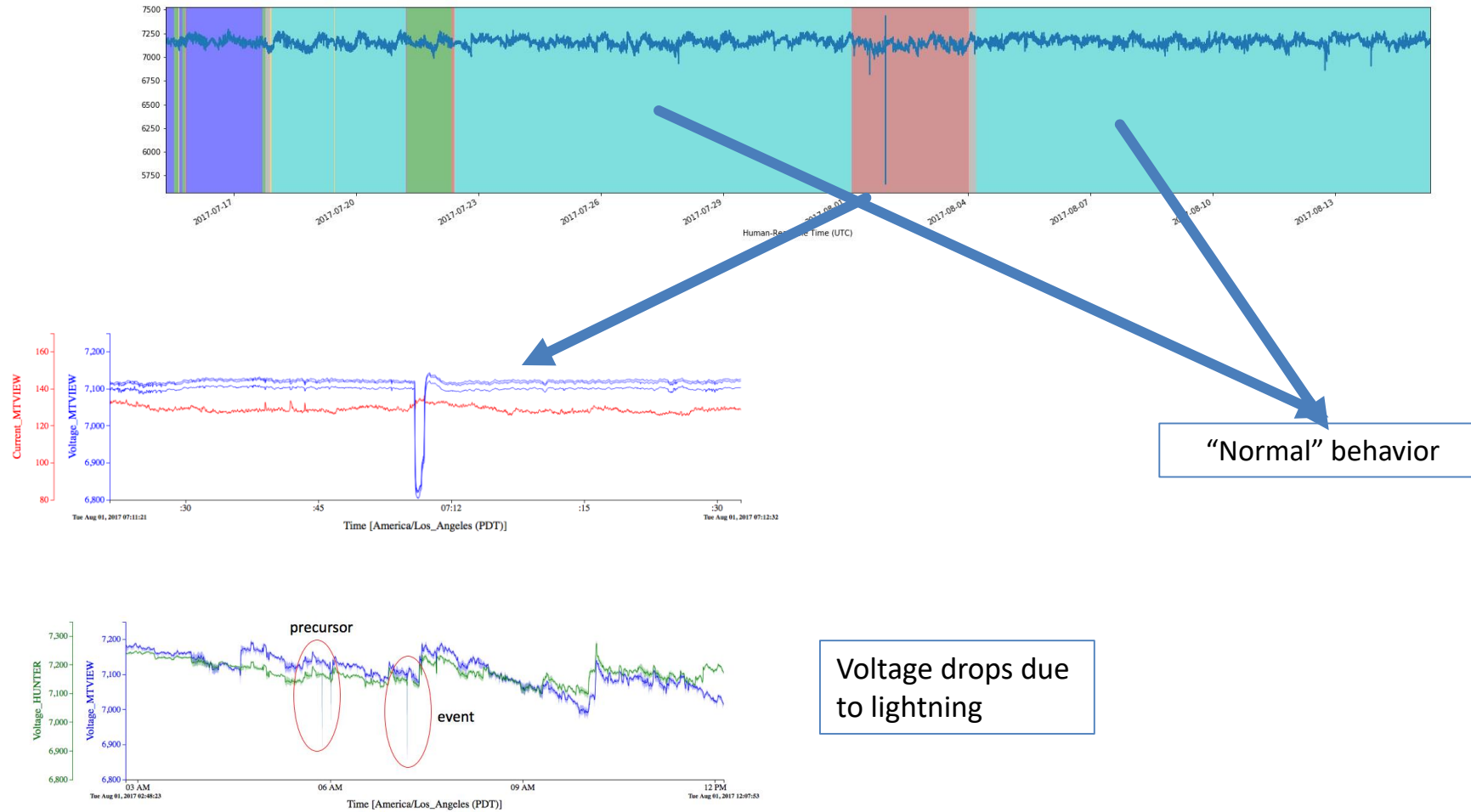


Discovering risky behavior in power grid through Machine Learning

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

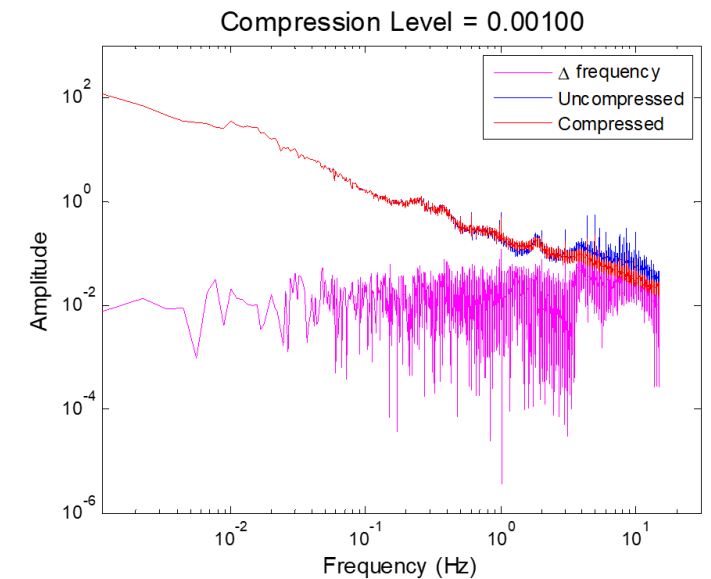
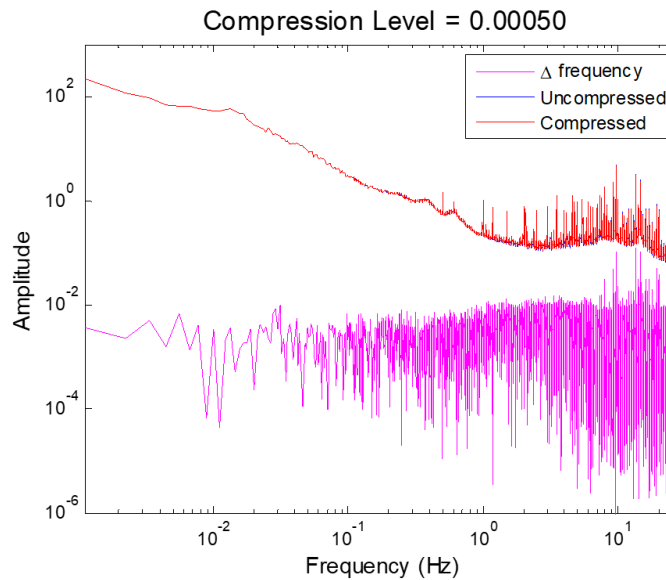
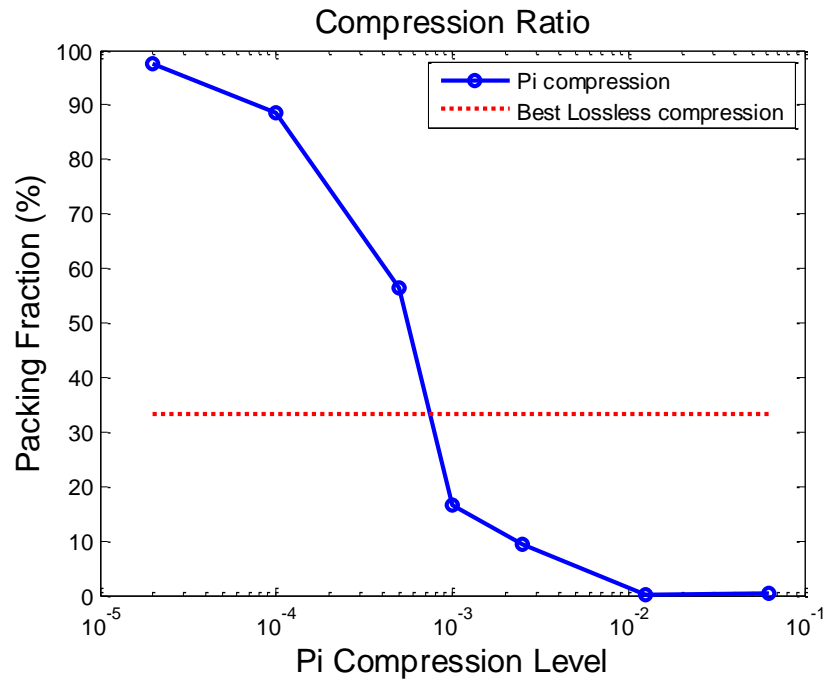


Fingerprints discovered in data



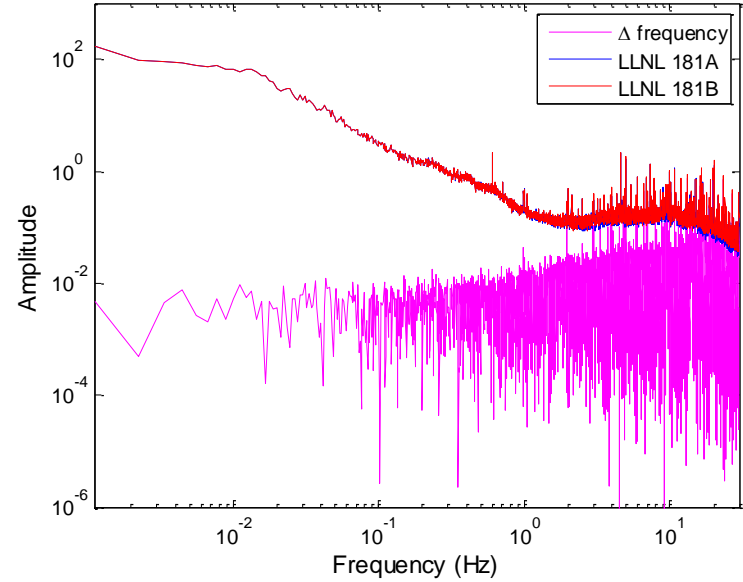
Data Compression

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

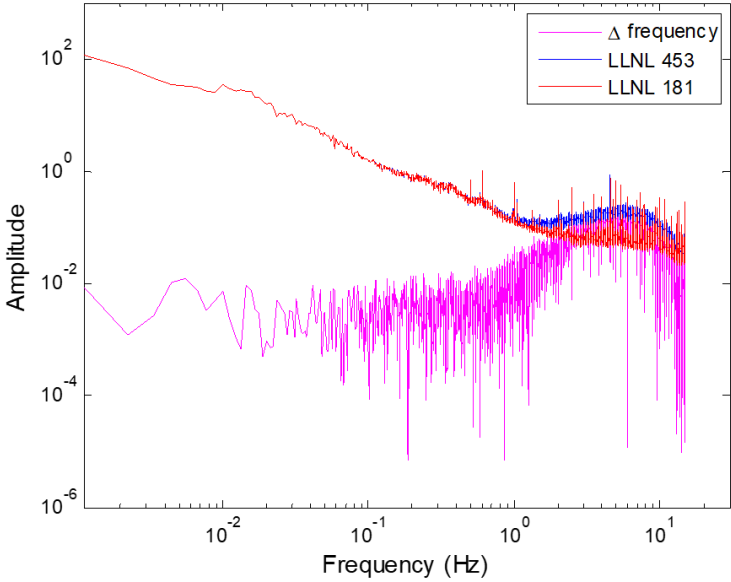


Signal Deviation

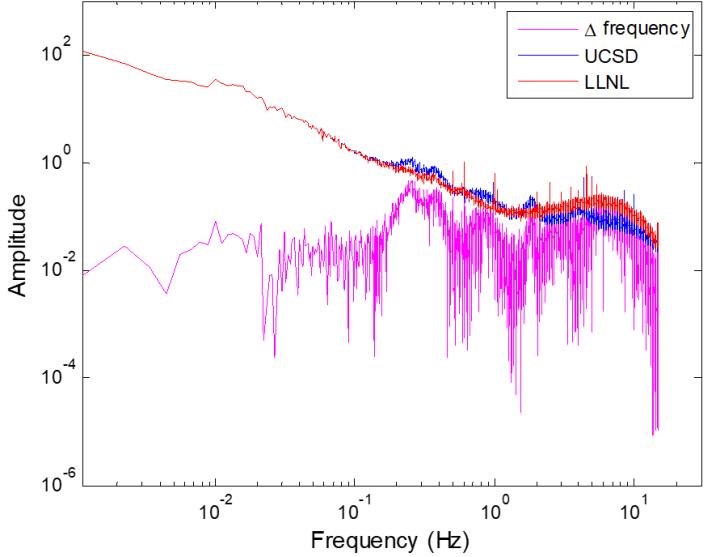
LLNL 181A vs LLNL 181B



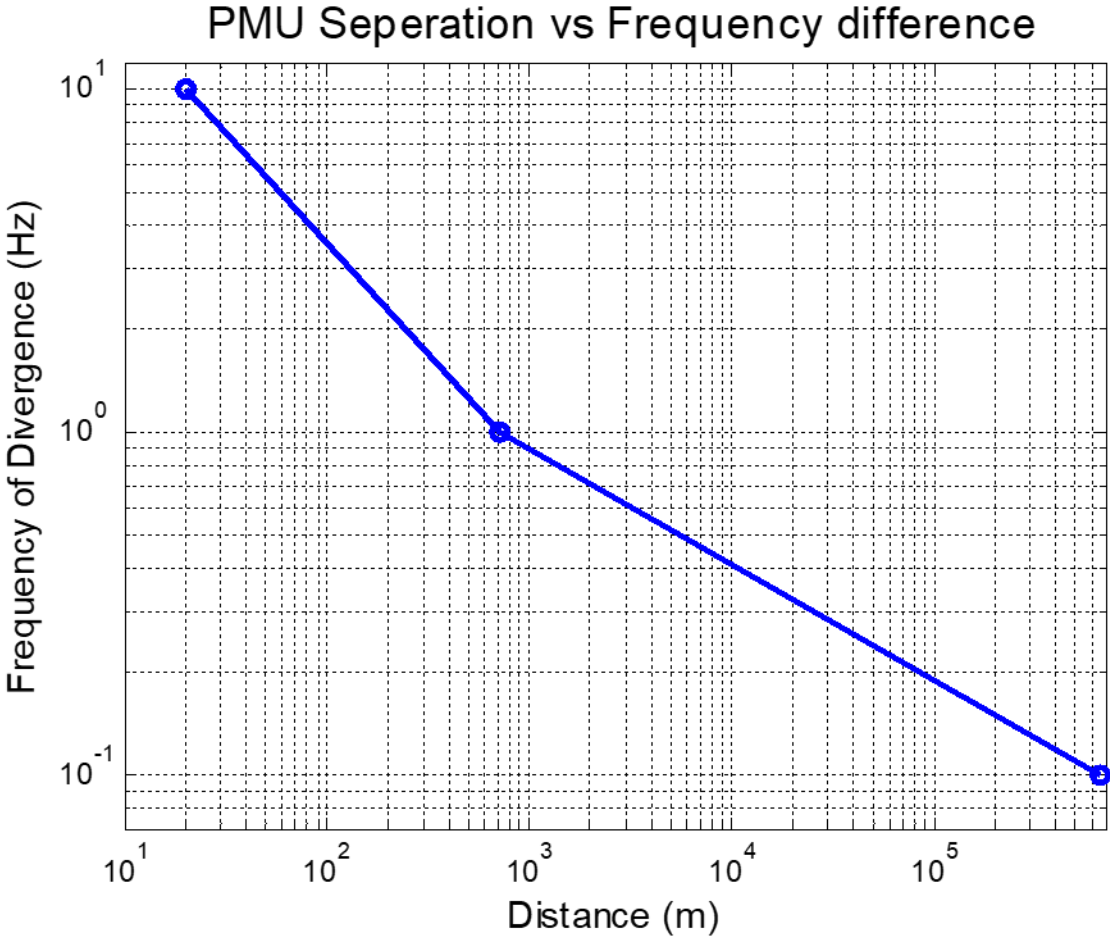
LLNL 453 vs LLNL 181



UCSD vs LLNL



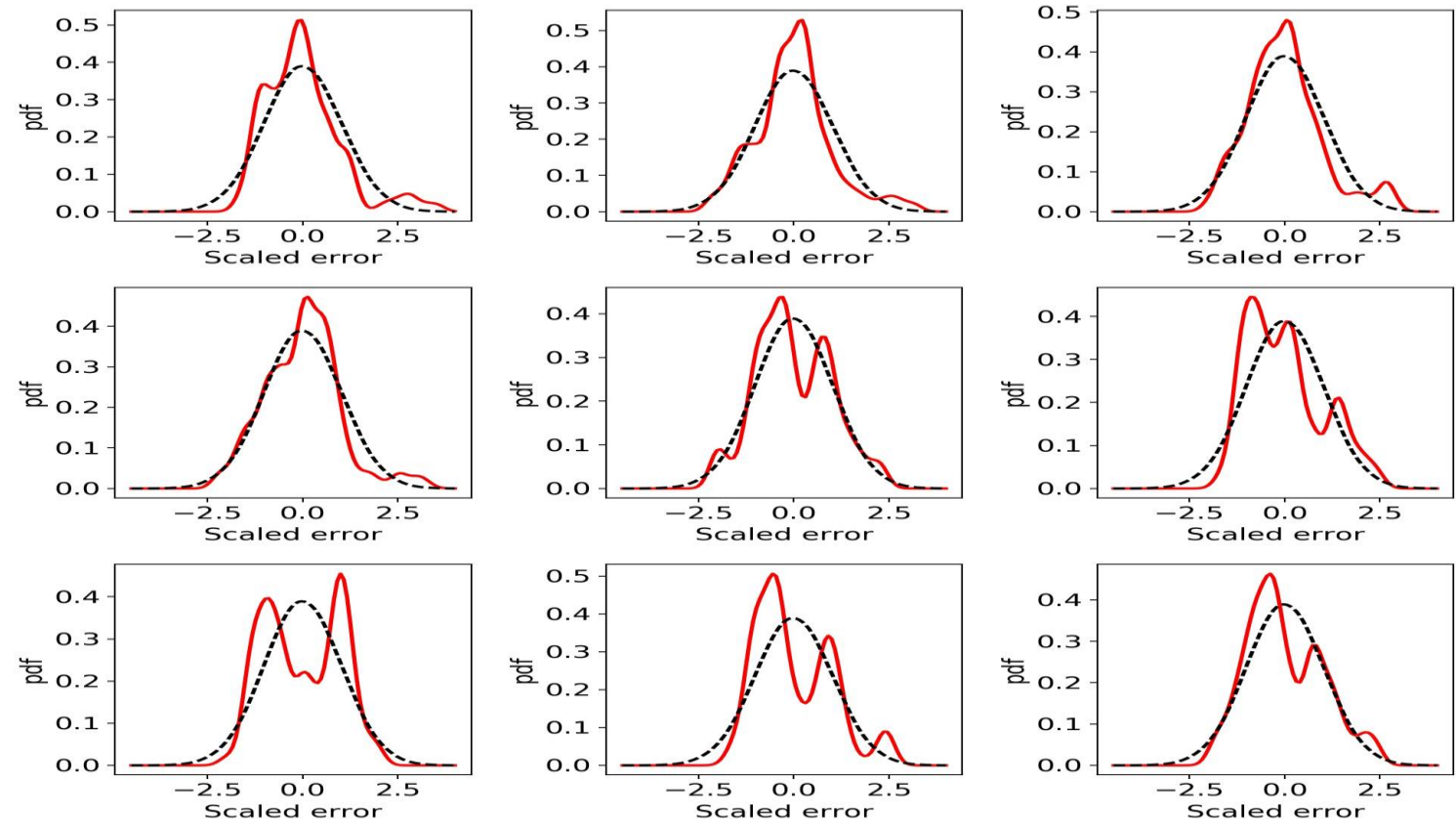
Signal Deviation



PMU Noise

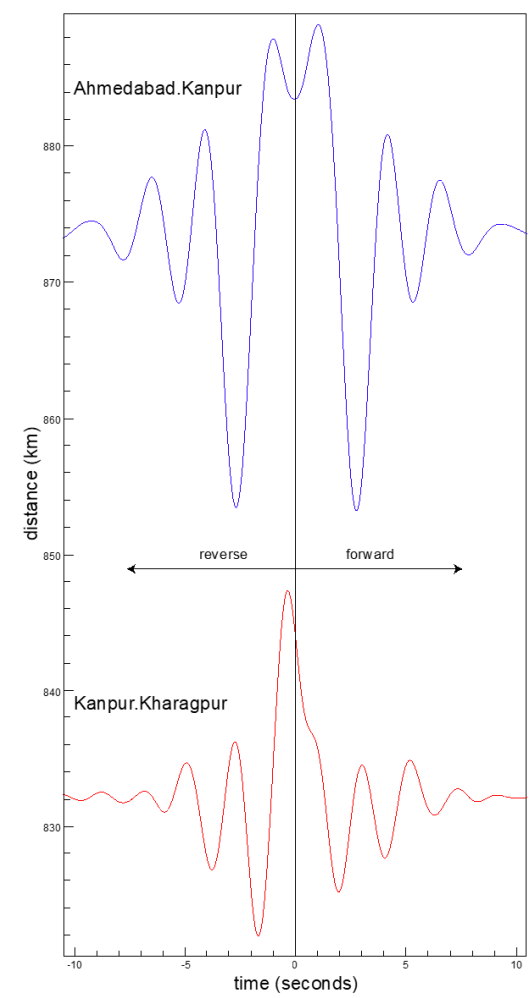
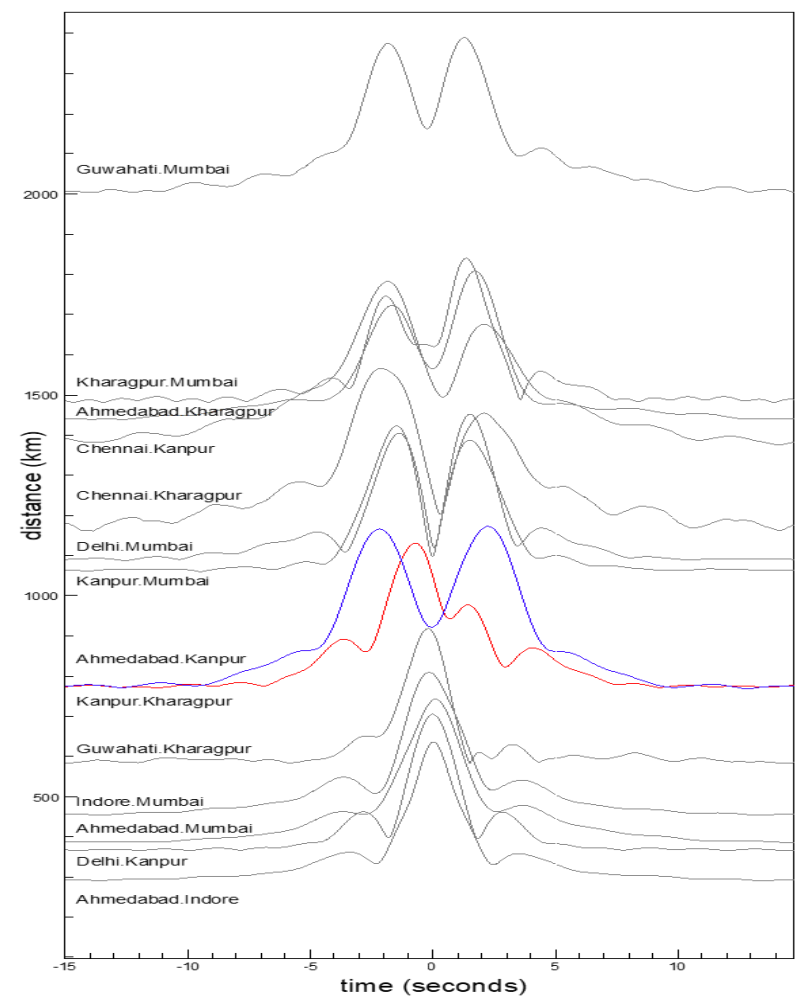
Can Huang, Mert Korkali, Charanraj Thimmisetty,
Xiao Chen, Emma Stewart, Vaibhav Donde, Charles
Tong

- 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.**

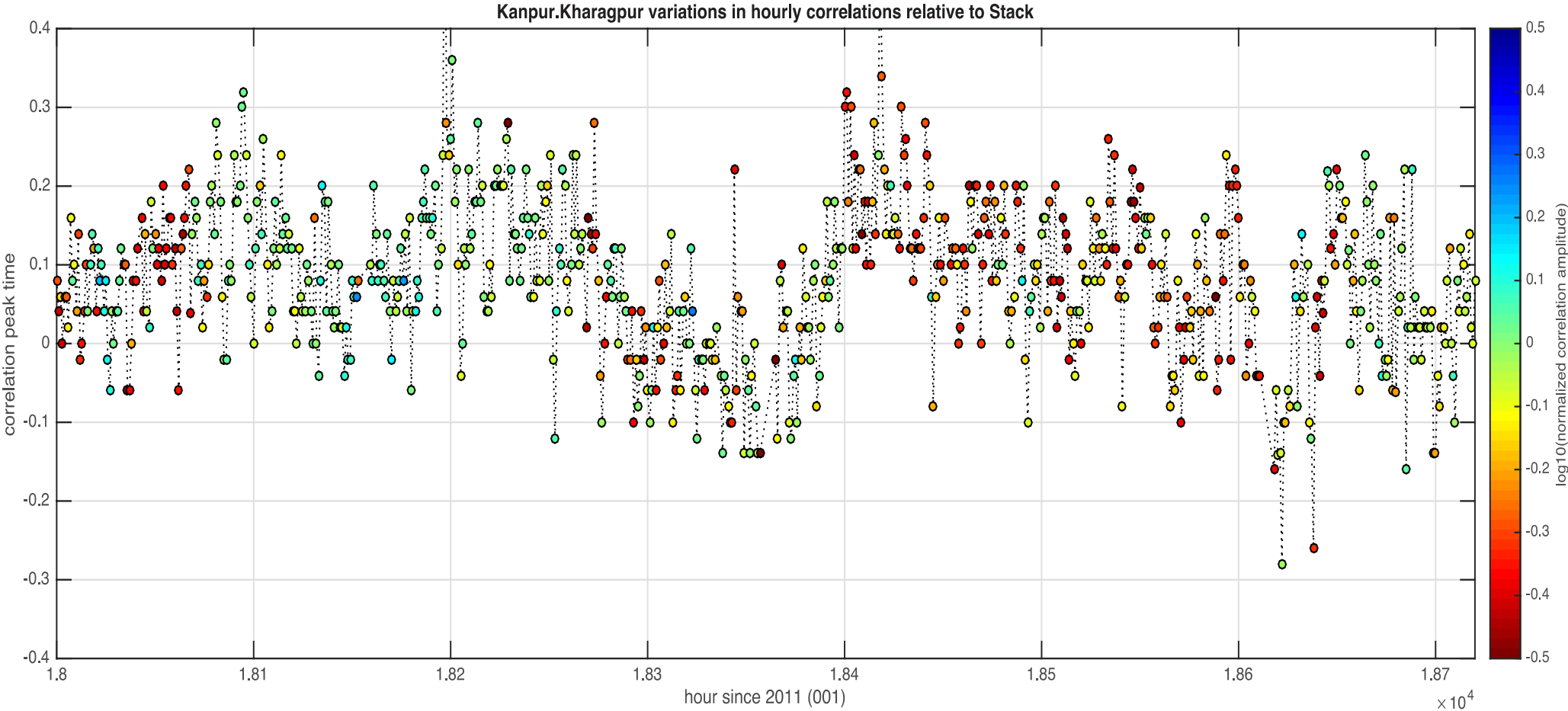


Ambient Noise Correlation

Eric Matzel, Philip Top



Ambient Noise Correlation



Other Areas of Signal processing with Power Systems

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



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