Louisiana EPSCoR

ESTABLISHED PROGRAM TO STIMULATE COMPETITIVE RESEARCH VOL.13 NO.2

Precise Weather Forecasting via Intelligent and Rapid Harnessing of Big Data

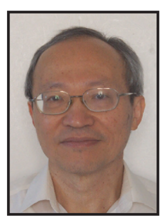
The National Weather Service estimates that about one-third of the U.S. economy – some $3 trillion – is sensitive to weather and climate, ranging from agriculture, to transportation, to communication, and even to energy and utility sectors. There are clear signs that weather-induced disasters have caused the growing losses of property, production, and life in Louisiana lately. According to the most recent decennial National Climate Assessment report (released in 2014), Louisiana may see billions of dollars in increased disaster costs resulting from the combined effects of global warming and natural processes, by 2030. The climate crisis is already an everyday reality, especially when it comes to hurricanes and flooding in the state.

The Precise Regional Forecasting via Intelligent and Rapid Harnessing (PREFER) research team received a $5 million multi-state interdisciplinary research award in 2020 by the National Science Foundation under its Research Infrastructure Improvement Track-2 Focused EPSCoR Collaboration (RII Track-2 FEC) program to address the stark problem of national importance caused by frequent extreme weather and climate events.

Dr. Nian-Feng Tzeng with University of Louisiana at Lafayette (UL Lafayette) leads the project and brings together collaborative research teams from five institutions in Louisiana, Alabama, and Kentucky. The co-principal investigators are Sytske Kimball with University of South

Western Kentucky University undergraduate students are instructed on the instrumentation of a Kentucky Mesonet station.

Alabama (USA), Xu Yuan with UL Lafayette, Stuart Foster with Western Kentucky University, and Richard Day with the U.S. Geological Survey (USGS). The PREFER team also has nine other investigators: Li Chen, Hassan Najafi, and Paul Darby from UL Lafayette, Lu Peng from Louisiana State University, Tom Johnsten and David Bourrie from USA, Mathieu Kourouma and Lynette Jackson from Southern University, and Eric Rappin from WKU.

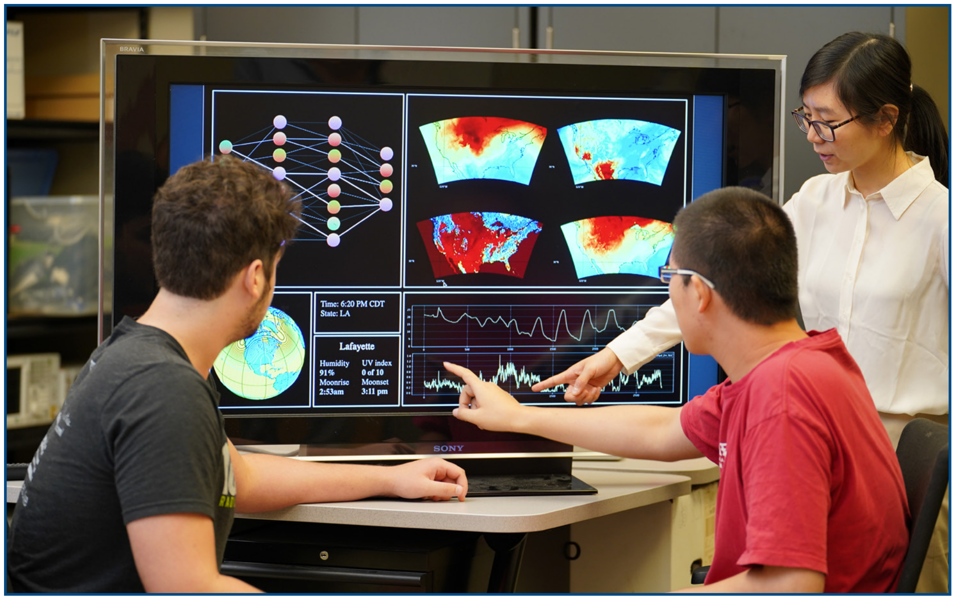


Dr. Nian-Feng Tzeng

This project contains both fundamental research and experimental activities built upon and expanding earlier work of team members in the disciplines of computer science and engineering, meteorology, hydrology, and electrical & computer engineering.

Lately, the hurricane season has become longer and we are seeing more named storms. For example, late-season hurricane Zeta that made landfall near Cocodrie, Louisiana, on October 28, 2020 is now known as the latest calendar year major hurricane to make landfall in the continental U.S. To better mitigate or even avoid potential harm and losses, precise regional weather prediction in finer spatial and temporal scales is highly desirable. It is achieved by deploying innovative neural networks (NNs) based on machine learning, which approximates the complex functions of input and output relationships based on data.

The prediction NNs take both computed atmospheric data sets and ground observation weather readings as inputs for improving meteorological and hydrologic forecasts. The computed atmospheric data sets are made available for public use in a 3-km resolution with hourly updating. Ground observation weather readings, like temperature, wind speed and direction, pressure, precipitation, etc., are obtained by weather stations. Clusters of weather stations deployed in target areas are called "Mesonets," which are ground observational data gathering facilities under the National Mesonet Program covering all 50 states. There are two Mesonets involved in this project, the South Alabama Mesonet and the Kentucky Mesonet.



UL Lafayette faculty researcher, Dr. Chen Li, standing, and student participants Christopher Aucoin, left, and Yihe Zhang, center, discuss NN model training.

With the aid of near surface weather parameter readings from Mesonet stations, the NN-based models have been shown to exhibit more precise weather forecasting (than without the readings) in a high temporal resolution (in minutes, rather than in an hour) over a target region of interest. Aiming at short-term and fine spatial resolution predictions, this research team aims to greatly enhance meteorological forecasting and flash flood predictions.

Landfalling tropical systems can lead to flooding and wind damage in some areas while not affecting others. Precise forecasting through the NN models spearheaded by this research project allows for emergency management to determine critical evacuation regions and preparation in the event of approaching storms. This immediate regional "nowcasting" involves complex data sets, including hydrological measures on rivers/streams by streamgages deployed and maintained by USGS. For better flood stage prediction for this project, water gauges are to be installed over a low-lying area near the Vermilion River in Lafayette. Together with the streamgages, the water gauges will enable investigation into the backwater wetland storage capacity to mitigate river flooding and wetland ecological restoration.

Intelligent bigdata harness results from proper NN models, which require preparation with algorithms from huge datasets for precise regional forecasting. The time it takes to "train" NN models for regional predictions is very long, and the research team is investigating various computing methodologies for accelerating this process. "This research project is distinct in that it not only addresses an important problem of national importance, but also is expected to facilitate wide neural network applications to diverse domains, resulting in technical innovations in computer systems," said Dr. Tzeng.

More details on this project can be found at: https://prefer-nsf.org.

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