NYS Mesonet
UNIVERSITY AT ALBANY

Building Resiliency to High Impact Weather:

The New York State Mesonet

UNIVERSITY AT ALBANY
State University of New York

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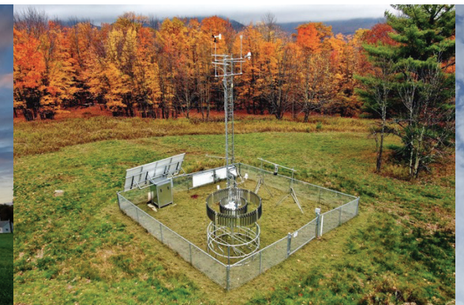
The NYS Mesonet: A Vision Fulfilled

"As the gold standard of weather observation networks in the US, the New York State Mesonet has fulfilled our vision and beyond. With every county now equipped with 24/7 weather monitoring capability, the 181 sites feed critical data to emergency managers, utilities, transportation managers, and pilots, and today make New York the most observed state in the nation. Warnings are faster, emergency response more proactive, and infrastructure more resilient. Real-time Mesonet data are optimizing farm production, power grid utilization, and water management. The billions of observations collected and archived thus far are being used in commerce for insurance, engineering, and litigation, and for breakthrough research in studies on air quality, Legionnaire's disease, and renewable energy. The New York State Mesonet has proven itself transformational, and with a multi-fold return on investment, provides the groundwork for even greater potentials yet to come, in education, research, emergency preparedness, and more. We ask for your joint participation and support in this exciting endeavor!"

— Dr. Christopher Thorncroft
Director, Atmospheric Sciences Research Center
Director, NYS Mesonet and Center of Excellence in Weather and Climate Analytics

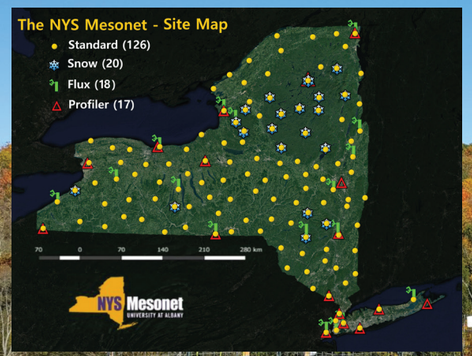


A Remarkable Feat of Engineering

After Superstorm Sandy killed nearly 300 people and caused $70 billion in damages to New York State in 2012, Governor Andrew Cuomo established the NYS Mesonet to provide real-time, comprehensive environmental data to boost emergency preparedness during high-impact weather events. The University at Albany was chosen to design and deploy the most sophisticated weather monitoring system in the world.

Before the NYS Mesonet, New York had only 27 automated weather stations. Today, it boasts 181 stations spaced an average 17 miles apart across the state, hosting 1,825 sensors and gathering over 1 million observations every day, with more than one billion observations to date. During all kinds of weather, the solar-powered NYS Mesonet transmits data via the University at Albany to users across the state and nationally. It is the most comprehensive, best-in-class statewide mesonet in the United States.

But it's not only about sensors and data. The NYS Mesonet is staffed by meteorologists, engineers, computer scientists, instrumentation experts, climate experts and weather forecast experts. Their broad expertise makes the NYS Mesonet a key weather partner for state and national institutions like the National Oceanic and Atmospheric Administration (NOAA), the National Weather Service (NWS), the NYS Division of Homeland Security and Emergency Services (DHSES), the Department of Transportation (DOT), the Department of Environmental Conservation (DEC) and the Department of Health (DOH).



The Gold Standard Mesonet

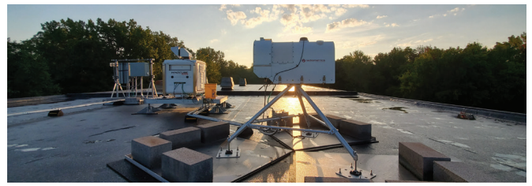
"With 17 unique 'profiler' stations that offer advanced metrics on atmospheric data, it's the most expansive and advanced mesonet in the country." — *USA Today*, March 25, 2020

The NYS Mesonet is widely recognized as the nation's new gold standard for statewide mesonets, with state-of-the-art quality control and pioneering technology. Below are some of the NYS Mesonet's features:

- Deployment of best-in-class instrumentation and sensors, providing unparalleled technological capability, resiliency and data quality.
- Advanced profilers to capture above-the-ground, three-dimensional data for early warning and better weather forecasts—a first for any state in the nation.
- True statewide mesonet coverage with at least one station sited in every county based on meteorological and strict scientific criteria.
- Standardized deployment of instrumentation and sensors at each station, along with a maintenance program with standardized protocols, criteria and processes to ensure optimum accuracy and reliability.
- Rigorous data quality assurance of instrumentation and sensors through a state-of-the-art calibration and validation program.

FOUR NETWORKS

Four different networks, all designed, deployed and operated by the NYS Mesonet, capture discrete types of meteorological data, analyzed and quality controlled by world-class meteorologists:



Courtesy of Timothy D. Keegan, Jr.

- The **126-station Standard network** measures surface temperature; humidity; wind speed and direction; precipitation; atmospheric pressure; soil temperature and moisture; and snow depth. Cameras collect real-time images to aid situational awareness. Solar monitoring sensors provide the solar energy industry and utilities with real-time observations that reduce cost. Precipitation measurements aid fire weather monitoring, field irrigation and flash flood prediction.

- **17 Profiler sites** collect aboveground vertical profiles of wind velocity, temperature and relative humidity, in some cases as high as the stratosphere. These cutting-edge instruments provide the only continuous, long-term observations of the atmosphere above ground in the state, crucial for informing weather forecasters and numerical weather prediction modelers about how the atmosphere is evolving.

- **18 Flux stations** directly measure incoming and outgoing shortwave and longwave radiation; ground heat flux; sensible and latent heat; and carbon dioxide in a wide range of land types, including vineyards, orchards, farmland, forests and urban areas.

- **20 Snow monitoring stations** across the Adirondacks, Tug Hill and Catskills measure snow depth and the amount of water contained in snowpacks—a potential flooding hazard in the spring. Equally important, nearly all hydropower generation in New York State depends on rain and snowfall; NYS Mesonet observations help assess the availability of hydropower.

Severe and Extreme Weather

"Data from the NYS Mesonet now help mitigate the harmful effects from these high-impact events and help prepare New Yorkers with greater lead times and more accurate predictions."

— Albany Weather Forecast Office (WFO), National Weather Service

New York has experienced increased frequency of extreme weather over the past 50 years, consistent with anthropogenic climate change. This trend is expected to intensify as the planet continues to warm.

Before the establishment of the NYS Mesonet, New York State suffered more than $85 billion in damages from weather-related disasters like Hurricane Sandy, Tropical Storm Lee and Northeast flooding. New Yorkers lost their homes, their businesses, and their communities, due in part to a lack of information about what was happening in real-time.

Today, institutions designed to keep New Yorkers safe and prosperous use the NYS Mesonet's real-time data to heighten their situational awareness and enhance the protection and well-being of the public. The National Weather Service tracks storm evolution using NYS Mesonet data, providing earlier and more accurate warnings. NOAA's operational prediction models ingest NYS Mesonet data, which enable more accurate, more reliable forecasts. The NYS Division of Homeland Security and Emergency Services uses real-time NYS Mesonet data to coordinate state- and county-level preparedness and response to severe weather events. Utilities depend on the NYS Mesonet during high-impact weather events to make emergency decisions that minimize disruption and ensure the delivery of power. The NYS Department of Environmental Conservation accesses NYS Mesonet data to monitor air pollution and dam safety during extreme events. The NYS Mesonet provides weather data to counties that lack routine, automated weather stations altogether, filling critical gaps in coverage while enhancing local officials' ability to make informed public safety decisions.

Emergency Management

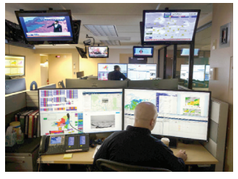
"The National Weather Service's mission is to protect life and property. We rely on NYS Mesonet data to execute this mission."

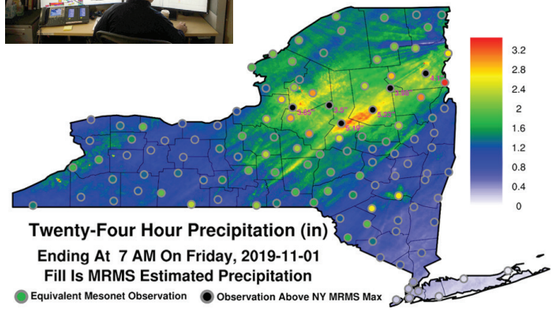
— Raymond G. O'Keefe, Meteorologist in Charge, Albany WFO, National Weather Service

The NYS Mesonet amasses real-time weather data and transmits it directly to the National Weather Service and the NYS Division of Homeland Security and Emergency Services. The National Weather Service incorporates the data into their operational prediction models to issue more timely warnings. Based on those warnings and the NYS Mesonet data, the NYS Division of Homeland Security and Emergency Services prepares emergency response and recovery operations.

IMPACT OF THE NYS MESONET

On October 31, 2019, as young New Yorkers voiced dismay about an incoming storm that would cancel their trick-or-treating, the NYS Mesonet recorded extremely high rainfall rates (inches per hour) and strong winds across several remote locations. These observations were forwarded to the National Weather Service in near real-time, warning the agency of potential flash flooding. Had it not been for the critical observations of the NYS Mesonet, they would have delayed issuing, or perhaps missed entirely, crucial flood and high wind warnings to individuals, parents and communities at-large on that unusually warm and scary Halloween night.





"Over 5 inches of rain in that area seen in NY State Mesonet observations is running off into rivers and creeks causing major flooding and mud slides... NY State Mesonet profilers show 50+ mph winds at about 2000-5000 feet in western NY and areas downwind of Lake Ontario..."

— Albany WFO, National Weather Service

On August 4, 2020, Tropical Storm Isaias tracked northwards across New York State, causing extreme rainfall and winds that resulted in flash floods and a significant number of power outages. The National Weather Service made extensive use of the NYS Mesonet data during this event to improve forecasts and warnings that would protect the life and property of citizens.

"Tannersville's Mesonet was closely monitored and played a key role in the determination to issue a flash flood warning at 3:45 p.m. yesterday. All Mesonet observations (especially rainfall and wind) were monitored throughout the day and played an essential role in our situational awareness of Tropical Storm Isaias."

— Raymond G. O'Keefe, Meteorologist in Charge, Albany WFO, National Weather Service
August 5, 2020

Utilities

"The impact of weather on an electric utility is substantial, and the observations from the NYS Mesonet have helped create a more robust operational picture in Central Hudson, both during and after large-scale restorations."

— Ian Smith, System Coordinator Emergency Management, Central Hudson Gas & Electric Corporation

The difficulty of keeping customers supplied with energy during storms forces utilities to make consequential decisions. Should more crews be added? How many, and from where? What other steps would limit the number and duration of outages?

Weather data provided by the NYS Mesonet help utilities look critically at lead time and storm-induced challenges, such as road closures and poor conditions that can prevent deployment of first responders, crews and materials. Weather data can also be used to determine when to activate emergency operations centers.

Renewables

"We need to be able to forecast the impact of this intermittent resource on the electric grid. The mesonet gives our control room operators more visibility into real-time changes in solar production."

— Emilie Nelson, Executive Vice President, New York Independent System Operator

In June 2019, Governor Cuomo signed one of the nation's most aggressive pieces of legislation aimed at mitigating climate change. The Climate Leadership and Community Protection Act (CLCPA) requires New York State to produce 100 percent carbon-free electricity by 2050, among other goals. To meet this challenge, New York's renewable power infrastructure will need critical data to better quantify the potential of its renewable resources; improve forecasting of power production; and more effectively assess the performance of renewable power plants. The NYS Mesonet was designed to protect New Yorkers from harm, but a by-product of its 24/7 weather surveillance is a trove of rich weather observations and data necessary to meeting the CLCPA's ambitious goals.

The NYS Mesonet's Standard network directly measures wind, solar radiation and precipitation, as well as severe weather, directly enhancing New York's ability to monitor its renewable resources. The Profiler network monitors winds aloft, a critical aid for evaluating wind turbine power plant performance. The Snow monitoring network tracks snowpack, crucial to determining current and future production of hydropower generators, nearly all of which are built on New York's streams and rivers.

"By providing better spatial and temporal weather granularity across New York—in both real-time and historically—the world-class NYS Mesonet will enable wind and solar projects to be optimally sited and more efficiently integrated into the state's electrical generation mix."

— Bruce Bailey, Founder and former CEO, AWS Truepower

Environmental Conservation

"The NYS Mesonet has become a powerful tool in the state's fight to combat the existential threat of climate change. Data provided by the NYS Mesonet inform DEC researchers and state policies and programs designed to prepare and protect our communities from air pollution, severe storms, wildfires and floods. With data from the NYS Mesonet, DEC experts have a fuller understanding of, and are better prepared to mitigate our climate challenges."

— Basil Seggos, Commissioner,
New York State Department of Environmental Conservation (DEC)

WATER

The NYS Mesonet leads the world in monitoring water transfer between land and air. The U.S. Department of the Interior; U.S. Geological Survey; NYS Department of Environmental Conservation; NYC Department of Environmental Protection; and NWS River Forecast Centers are just a few of the entities that routinely use NYS Mesonet data in their hydrological monitoring and forecast operations. Using NYS Mesonet data, these institutions research and track algal blooms; model New York City's water supply; survey public water supply levels; test models of interactions between water and ecological systems; and evaluate reservoir seepage.

AIR

The United States Environmental Protection Agency and New York State Department of Environmental Conservation make regular use of NYS Mesonet temperature, humidity and wind data to monitor air quality. NYS Mesonet Profiler data have been used to track smoke from Canadian fires, essential information for accurate air quality warnings. A NYSERDA-funded study uses NYS Mesonet Standard and Profiler data to record air pollution emitted from New York City. For another study, the NYS Mesonet deploys low-power, low-cost air quality monitoring sensors across the New York City Metropolitan area.

FIRE

Both the National Weather Service and DEC are committed to fire safety and enhanced ability to predict weather that fosters wildfires. To aid their mission, the NYS Mesonet fills in gaps in what is currently a data-sparse DEC fire-monitoring network. Fire conditions can change rapidly across space and time due to changes in recent rainfall, soil moisture, topography, vegetation and other factors, and the NYS Mesonet is perfectly suited to measure these. NYS Mesonet weather forecast experts coordinated with the National Weather Service Albany Office to create preliminary fire weather danger maps during the Breakneck Ridge fire on March 9, 2020. These maps are now shown on the National Weather Service website.

CLIMATE CHANGE

When NYS Mesonet stations were constructed in 2014, they were built as permanent facilities to monitor long-term (30+ year) changes in weather. Today, the NYS Mesonet provides stable, high-quality measurements documenting long-term trends in weather and climate. An additional network of stations is being deployed across New York City to monitor climate changes across the urban landscape.

Transportation

"When striving for continuous improvement in Snow and Ice Operations, it's imperative to measure what's happened at the local level in order to prepare for what comes next at the local level. The weather data and related products provided by the NYS Mesonet have helped optimize Snow and Ice Operations for NYSDOT and is a game changer for both pre-storm preparedness and post-storm performance analytics."

— Joe Thompson, NYS Department of Transportation Snow and Ice Program Manager

As high-impact events like flooding, winter storms and hurricanes become more severe, New Yorkers face increasing dangers on the road. Real-time NYS Mesonet data on snow and rainfall rates, storm direction and wind speeds enhance situational awareness at the NYS Department of Transportation and NYS Thruway Authority, where they aid operational decision making about road closures and conditions on state roadways.

The NYS Department of Transportation also uses NYS Mesonet data to research best practices for improving safety and lowering maintenance costs. Additional weather stations were installed along the NYS Thruway to minimize winter travel disruptions during high-impact weather events and ensure safe and open travel for commerce during the height of the winter season. To reduce ecological impacts, the NYS Mesonet is working with state transportation agencies and authorities, local governments and private businesses to reduce salt usage while improving road safety. Additional research uses NYS Mesonet data to quantify road safety during heavy rain and snow.

Other agencies use NYS Mesonet data to solve transportation-related problems. Local airports monitor NYS Mesonet data for routine aircraft operations; state police utilize NYS Mesonet camera data for planning their flight operations; and the Metropolitan Transportation Authority employs NYS Mesonet data for hazardous weather planning and response.

Health

"The NYS Mesonet is a powerful tool for improving public health disease surveillance, epidemiological investigations, and longitudinal studies of environmental health threats. The spatial and temporal granularity of the data—not to mention the easy access and great service—have allowed us to gain a more refined understanding of everything from transmission patterns in Legionnaires' disease to the impacts of climate change on health."

— Ursula Lauper, NYS Department of Health

Weather and climate have a profound impact on human health. Data from the NYS Mesonet are foundational to groundbreaking research on wide-ranging issues involving New York public health, conducted by the EPA, NYS Department of Health and NYS Department of Environmental Conservation. NYS Mesonet data have helped scientists recognize Legionnaires' disease as driven by weather and climate; understand tick behavior as a function of climate; and better predict hospital admittance as a function of high-impact weather events. These projects are already yielding scientific breakthroughs with medical applications: For example, using NYS Mesonet data, the NYS Department of Health has found that the bacterium *Legionella* prefers dark, humid and wet conditions and is repelled by direct sunlight and dry conditions.

Now, with the onset of the global COVID-19 pandemic, a new research effort is underway. Researchers will incorporate the full reach of NYS Mesonet data into a model, together with COVID-19 case and hospitalization data, to empirically estimate the impact of weather and seasonality on the risk of SARS-CoV-2 transmission. The results of these research endeavors, and others like them, will save lives and promote the wellness of the public at large through enhanced public health guidance, protective actions, medical treatments and other remedies.

Agriculture

"NYS Mesonet meets an important need for professional quality-controlled weather data across New York State. The Network for Environment and Weather Applications (NEWA) relies on these real-time data streams from the NYS Mesonet to help agricultural users make well-informed crop management decisions to mitigate the economic and environmental costs of production."

— Dan Olmstead, Extension Associate, NEWA Coordinator, New York Integrated Pest Management Program

Weather doesn't impact farmers only on a given day; it affects every aspect of a farm throughout the entire life of the enterprise. Having more high-quality weather data enables farmers to correlate specific weather patterns and other information with past successes or failures; better manage current practices; and anticipate, strategize and plan for uncertain future weather behavior. NYS Mesonet data are used directly by farmers to optimize planting and harvesting times; aid insurance claims and reduce insecticide use.

The NYS Mesonet collaborates with Cornell University's Integrated Pest Management Program to distribute critical real-time information to hundreds of farmers statewide to optimize pest management and maximize crop yields. Farmers can now rely on local weather information from nearby NYS Mesonet stations—essential tools for ensuring that the state's agriculture remains competitive and profitable.

K-12 and Higher Education

"My teaching has been taken to the next level. Working with the NYS Mesonet team has given me an experience that I can bring back to my students; I've created four new lessons to investigate soil properties incorporating NYS Mesonet data."

— Crystal Perno, Science Teacher, Acadia Middle School

The NYS Mesonet data are used extensively across K-12 schools, colleges and universities for education and research. Some one dozen colleges and universities, and another dozen K-12 schools, directly host NYS Mesonet stations. These schools and others access data for educational activities. As part of its Education and Outreach program, the NYS Mesonet also promotes general public education through the publication of quarterly newsletters and public lectures. Guest visitors and lecturers teach students about the NYS Mesonet and provide essential expertise for scientific inquiry. NYS Mesonet experts have reached hundreds of learners of all ages across the state.

Through collaborations with teachers and academia, NYS Mesonet staff are working to develop a statewide curriculum and set of programs to integrate Mesonet data into regular STEM teaching. These partnerships will provide endless opportunities for K-12 students and teachers to take advantage of rich, real-time weather data relevant to their daily lives—data collected from their own "backyards"—to build knowledge and skills in earth science and other STEM fields. As such, the NYS Mesonet offers an open, data-intensive, networked infrastructure that science educators can use to support authentic scientific practices as advocated by the Next Generation Science Standards (NGSS).

In higher education, the NYS Mesonet provides unique internship opportunities, enabling undergraduates to take advantage of an immersive research experience at the NYS Mesonet Operations Center. Students are exposed to hands-on learning, working directly with data under the supervision of field technicians and data and computer scientists.

For graduate students and professors, the NYS Mesonet data are a source of endless research opportunities. With more than one billion weather observations already archived, the NYS Mesonet provides a unique foundational dataset for theses and dissertation topics. Utilizing these data, fundamental research has been funded by the National Science Foundation, the National Oceanic and Atmospheric Administration, the Department of Energy, the National Aeronautics and Space Administration and the New York State Energy Research and Development Authority, and these externally funded activities continue to grow annually.

Business and Private Enterprise

New York is more economically sensitive to weather variability than any other state in the nation, according to a study led by the National Center for Atmospheric Research.

— J. Lazo, M. Lawson, P. Larsen and D. Waldman, *Bulletin of the American Meteorological Society*, 2011

Our physical safety and economic well-being depend in good part on access to weather information. Managing weather's impact on the supply and demand of goods and services is of critical importance to our economy and our health. High-quality weather information, as provided by the NYS Mesonet, is thus critical for understanding and mitigating against adverse weather.

Hundreds of private businesses have reached out to the NYS Mesonet in search of high-quality information. Forensic meteorologists employ local NYS Mesonet data for "slip and fall" court cases. Civil engineers utilize years of archived NYS Mesonet data to design water management systems for cities. And landscape engineers use NYS Mesonet data to build golf courses.

In collaboration with the University at Albany's Center of Excellence (COE) in Weather and Climate Analytics, the NYS Mesonet has formed research collaborations with a wide range of private businesses to push the boundaries of atmospheric-related technologies.

Access to weather information underpins human comfort, mobility, economic prosperity and social progress. Smart weather solutions driven by artificial intelligence (AI) and machine learning (ML) show economic benefits to all major economic sectors supported by the COE, including transportation, insurance and agriculture.

The energy industry needs smart weather solutions that integrate renewable energy into the existing grid, identify energy supply and demand needs, and predict weather-driven power outages. Together with the COE, the NYS Mesonet provides solutions for these needs, which only continue to increase; as renewable energy rapidly replaces carbon-based power generation, the energy industry is transforming its business models. The NYS Mesonet and COE are also supporting innovative start-ups working in such areas as forensic meteorology, renewable energy, weather risk management and weather warnings to name but a few.

What It Takes to Run

"The NYS Mesonet is a game changer."

— Louis Uccellini, Director,
National Weather Service

The NYS Mesonet is a game changer, but it doesn't run itself. Its 181 stations need consistent and loving care to protect them from ongoing threats to their continued operation. The list of what can go wrong is long: lightning, ice, overgrowth, severe winds, rust, flooding, wildfires, sensor drift and wildlife. Without routine maintenance and calibration efforts, the quality of the data degrades.

The NYS Mesonet's people are crucial to maintaining this vitally important resource. A dozen staff dedicated to network operations drive 100,000 miles annually to maintain and repair over 1,800 sensors. To date, technicians have followed up on nearly 10,000 "trouble tickets." In-house staff maintain the million lines of software code required for data ingest, quality control, archiving and dissemination.

The NYS Mesonet relies on income from public and private sources. The federal government provides support via the National Mesonet Program. Given the service provided to the state, there is also a need for state support. Finally, given the economic impact of weather data, a significant fraction of support is anticipated to come from commercialization of data and related products. In this respect, the NYS Mesonet leads the nation in sustaining a statewide mesonet through public and private monies.

What's Ahead

"As the world's changing climate continues to produce increased frequency and intensity of extreme weather events, the need for a weather-ready state and nation has never been greater. As part of New York's response to this existential threat, Governor Andrew Cuomo directed the University at Albany's world-class atmospheric scientists to build the New York State Mesonet—the most advanced weather observation system of its kind in the United States. Headquartered at UAlbany, the Mesonet provides unprecedented real-time, on-the-ground and above-the-surface weather observations to help safeguard and protect New Yorkers' lives and property. As we prepare for a future with more devastating hurricanes and tropical storms, flooding and severe winds, and extreme heat and heavy snowfall, we are proud that the NYS Mesonet will play a critical role in keeping our communities safer."

— Havidán Rodríguez, President, University at Albany

The future impact of the NYS Mesonet is virtually unlimited. Today, the weather data it collects already make New York State safer and more resilient in the face of extreme-weather events. As we move forward, integrating the NYS Mesonet into UAlbany's nation-leading Weather and Climate Enterprise will enable the NYS Mesonet to position New York State as a national leader in statewide weather observing systems, resiliency and commercial applications.

The NYS Mesonet is looking forward to more data, additional partnerships, greater integration of data into operations, new apps and increased research and development. Here's a taste of what's to come:

- Creation of agriculture-focused maps and products for the farm community.
- Adoption of NYS Mesonet mobile app for truck operators.
- Use of NYS Mesonet–driven models for optimized winter road operations.
- Integration of NYS Mesonet data with indoor heating/cooling systems.
- Development of more operational products for NOAA.
- Integration of NYS Mesonet data into statewide education curricula.
- Use of NYS Mesonet data for placement and operation of wind and solar farms.

NEW HOME FOR THE NYS MESONET

In 2021, the NYS Mesonet and UAlbany's entire Weather and Climate Enterprise, along with the new College of Emergency Preparedness, Homeland Security and Cybersecurity, and the University's business development and commercialization operation will be co-located in a new $180 million, 240k sq. ft R&D center known as ETEC on the Harriman Campus. The synergies and opportunities to leverage the power of the NYS Mesonet will be far-reaching across research, training and economic development.

Growing the NYS Mesonet is more than an idea whose time has come. It's a reality that enhances New York State's economy, generates new opportunities for everyday New Yorkers, and paves the way for a cleaner, brighter world.

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