

To Observe and Protect: How NOAA Procures Data for Weather Forecasting

STATEMENT OF

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Introduction

Thank you, Mr. Chairman and Members of the Subcommittee for this opportunity to testify on the importance of continuing innovation to improve weather forecasting and warnings.

I am Dr. Berrien Moore, Vice President of Weather and Climate Programs at the University of Oklahoma, as well as Director of the National Weather Center and Dean of the University's College of Atmospheric and Geographical Sciences. These positions are a new role for me; I have been at Oklahoma only since June 2010; therefore, I am a "later" rather than a "sooner". I appear, today, largely because of my responsibilities as the Director of the National Weather Center; however, this said, the views expressed in today's testimony are my own

I am very appreciative of this opportunity to discuss the continuing need to use more sophisticated observation systems to help improve weather forecasting by integrating state and local surface data – known as mesoscale observations – or "Mesonets" – to help improve the reliability, accuracy and speed of local near-term weather forecasting. Mesonets are critical in helping to protect life and property before severe weather events, providing precious additional warning time that can often mean the difference between life and death. In addition, mesonet observations are increasingly important for the critical functioning of key parts of our national economy – including agriculture, commercial aviation, renewable energy generation and the management of the electric grid. Mesonets are also well suited for use by fire fighters, first responders, and emergency managers before, during, and after weather disasters.

History and Evolution of the Mesonet Concept

Weather has a greater impact on our society than ever before. This includes impacts to the lives and property of our citizens and to our economy. 2011 had the highest number of storms with damage in excess of a billion dollars in the history of recorded weather data. To provide the most accurate forecasts and warnings for weather, dense high quality observations are required. Without observations

of the atmosphere, quality forecasts and warnings are not possible. Meteorological observations on the mesoscale (i.e., local/county scale) are of particular importance as evidenced by the fact that the vast majority of severe weather life and property losses are associated with mesoscale events such as tornados, thunderstorms, hurricanes, fronts and squall lines.

The mesonet concept was founded on the Southern Great Plains where severe weather, which can materialize with little warning and often times overwhelming intensity, is very common. Tornado Alley, which is loosely defined as the Plains states between the Rocky and Appalachian Mountain ranges, encounters more of these storms than anywhere else in the nation. In 1990, University of Oklahoma and Oklahoma State University joined forces with the Governor of the State of Oklahoma, with an investment of approximately \$3 million, and deployed what today is a 120-station statewide network, which includes detailed weather observations in every one of Oklahoma's 77 counties. At each site, the environment is measured by a set of instruments located on or near a 10-meter-tall tower. The measurements are packaged into "observations" every 5 minutes, and then transmitted to a central facility every 5 minutes, 24 hours per day year-round. The Oklahoma Climatological Survey (OCS) at OU receives the observations, verifies the quality of the data and provides the data to Mesonet customers. It only takes 5 minutes from the time the measurements are acquired until they become available to the public.

The data quality and the assurance procedures exceed National Weather Service standards.

As a member of the National Mesonet Program Alliance, OU and the Oklahoma Mesonet demonstrate the strength of the National Mesonet Program. We provide a state of the art observational weather network, paid for and largely maintained with non-federal funds,¹ with surface (in situ) weather observations that are reported more frequently and with more localized predictive value than those provided by the National Weather Service due to the location and density of the network sensors. Taken together, the data from the National Weather Service and the Oklahoma Mesonet compliment and strengthen the predictive value of each network's information, making for a powerful partnership. It is an ideal model in these fiscally constrained times on how best to leverage investment from multiple entities to maximize the delivery of high quality information at a reasonable cost benefiting taxpayers and communities that depend upon more accurate weather forecasts.

Use of Mesonet data, including applications on virtually all smart phones embraced by millions of consumers, reflects recent advances in electronics technology. These advancements have also enabled the weather sensors to become smaller, faster, more accurate, more reliable and less expensive. Networking of the sensors via the Internet and wireless networks has enabled dense surface based observation networks to proliferate rapidly, building upon the original concept developed in Oklahoma. Environmental parameters, which were once not practical to observe at the surface, are now measured routinely. As a result, they are now used in critical decision making. In some cases, these breakthroughs

¹ For instance, in FY 2011 the state provided slightly more than \$1,897,000; USDA, Army Corps of Engineers, and DoE provided \$210,000; the Government of Quebec \$44,900; the Noble Foundation of Oklahoma \$5,000; media and other users \$40,000, and NOAA provided via Earth Networks, \$189,294—not quite 8% of the budget.

in surface based network technology potentially obviate the need to observe these parameters from space, where the costs and risks to do so are far higher. Generally, anything that can be observed from the surface should be observed at the surface due to the extremely high costs and risk factors inherent in any satellite based system.

But does this mean that we do not need our weather satellite system? Certainly not—as important as the Oklahoma Mesonet is, it tells us little about the oceans; about other parts of the planet, or for that matter, the upper part of the Oklahoma atmosphere. Weather is global; the interests of the United States—including its businesses and its citizens are global, and hence the US weather observing system must be global. The weather observing system must be a network of networks—satellites, aircraft, balloons, and ground-based mesonets.

Today, there are literally dozens of mesonet networks that range in size from a few dozen locations in a particular state or region to those in the commercial realm that can range from hundreds in number to more than 8,000 stations for the top commercial weather network. Most of these stations meet World Meteorological Organization (WMO) standards and are integrated with weather data from global sources, to deliver precise, accurate weather information directly to users around the world.

The concept of a national mesonet has been validated scientifically on a number of occasions, most notably in the path finding report issued in 2009 by the National Academy of Sciences, *From the Ground Up: A Nationwide Network of Networks*.² The report's key finding is very powerful—it also shows that proactive work needs to be done:

“...the status of U.S. surface meteorological observation capabilities is energetic and chaotic, driven mainly by local needs without adequate coordination. While other providers act locally to satisfy particular regional monitoring needs, the federal government is unique in its capacity to act strategically and globally in the national interest. An overarching national strategy is needed to integrate disparate systems from which far greater benefit could be derived and to define the additional observations required to achieve a true multi-purpose network that is national in scope, thereby fully enabling mesoscale numerical weather prediction and other applications.”

I would like to note one other conclusion in the Report that is directly relevant to today's hearing (emphasis added):

Several steps are required to evolve from the current circumstance of disparate networks to an integrated, coordinated NoN [Network of Networks]. First, it is necessary to firmly establish a consensus among providers and users that a NoN will yield benefits in proportion to or greater than the effort required to establish it. *This consensus-building step is essentially political*, requiring agreement in principle at various levels of

² *Observing Weather and Climate from the Ground Up: A National Network of Networks* National Research Council, 2009; http://www.nap.edu/openbook.php?record_id=12540

public and private participation, which leads to the collaborative development of an implementation plan. The key elements of a NoN are twofold: (1) the provision of services and facilities that enable individually owned and operated networks to function, more or less, as one cohesive network, and (2) the provision of new observing systems or facilities to enable national objectives. The first is largely separable from the second, since considerable benefit may be achieved from improved functionality with existing observational assets.

The National Mesonet and A Weather-Ready Nation

Last fall, NOAA launched a new campaign to engage communities, scientists and emergency response leaders to embrace a new vision for weather forecasting and response known as the Weather-Ready Nation. OU and the National Weather Center hosted the first NOAA workshop on the topic last December.

NOAA's Weather-Ready Nation is about building community resilience in the face of increasing vulnerability to extreme weather and water events. Record-breaking snowfall, cold temperatures, extended drought, high heat, severe flooding, violent tornadoes, and massive hurricanes have all combined to reach, as mentioned earlier, the greatest number of multi-billion dollar weather disasters in the nation's history.

The devastating impacts of extreme events can be reduced through improved readiness, which is why the Weather-Ready Nation initiative is so important. Through operational initiatives, NOAA's National Weather Service is proposing to transform its operations to help America respond. In the end, emergency managers, first responders, government officials, businesses and the public will be empowered to make fast, smart decisions to save lives and livelihoods.

America will only become a "Weather-Ready Nation" if we increase the number of observations used to make meteorological forecasting more accurate and precise, and then work with the public and local decision makers to act on those improved forecasts.

The objective of weather and climate observing systems is to provide critical information on the current state of the atmosphere, oceans, and the terrestrial systems in a timely manner such that informed decisions can be made. This information will result in a better understanding of global weather patterns, which will lead to better decisions in hazardous weather such as floods, drought and winter weather or tropical storms. Each of these can affect large areas and many sectors of the economy over prolonged periods of time. Observing systems are also essential for short-fuse decisions (i.e., thunderstorms) for weather events that occur quickly and dramatically impact people, property and critical assets on the timescale of minutes.

Supporting these varying decisions and timescales requires various types of observation platforms, including mesonets as well as space based satellite systems. When seamlessly integrated, these complementary resources provide the foundation upon which an entire nationwide decision support system is built. These data are critical inputs to and required for the establishment of situational

awareness, the generation of forecasts, as well as the subsequent dissemination of warnings and alerts for the protection of life, infrastructure and optimization of weather sensitive market sectors.

Because surface measurement technologies have only matured over the last decade, NOAA has built its observational forecasting largely on the basis of information from satellites and radar. As the Administrator recently testified, NOAA gets more than 90 percent of its weather data from satellites. The \$5 billion investment to upgrade NOAA's own automated surface observing system (ASOS) over the last two decades, when combined with radar and satellite information, has significantly improved weather accuracy. But even the 1,200 stations that make up the NWS/FAA ASOS network, situated largely at commercial airports, are often times not enough. As we saw with the 2004 Baltimore Water Taxi incident or with the more recent severe weather events in Joplin, Tuscaloosa and the Indiana State Fair, there are gaps in the system because of the location and frequency of the NWS' own observational sensors that prevent even the most dedicated forecaster from detecting a storm's intensity or direction soon enough to give the public sufficient warning to avoid the loss of life.

Rather than have the Federal Government embark upon an expensive effort to upgrade its own ASOS network, mesonets have evolved as a means to dramatically improve the scale of observations at a fraction of the price of further federal efforts. In Oklahoma, our current federal support from the National Weather Service as part of the National Mesonet program represents less than 8% percent of the financial support necessary to maintain our network. The State of Oklahoma provides almost 80% of the budget. The total investment from state, federal, private sector and other sources enable us to make sure that our weather and climate stations have state of the art measurement sensors and are serviced continuously by technicians that make sure stations are working and in good order, and who conduct comprehensive calibration and preventive and reactive maintenance. This same approach is used currently by the other members of the National Mesonet Program Alliance, which includes private sector partners, universities and state governments, each of which maintain their own proprietary network.

While NOAA receives observations from thousands of non-federal weather stations today, the mesonet stations stand out because they generally provide data whose quality and precision exceeds that of observations provided by the NWS/FAA ASOS sensors. Prior to transmitting their data to customers, mesonet partners put the observations through quality assurance steps, including comparative analysis and range checks, to guarantee that the measurements reported by these networks are accurate. The mesonet partners' other lines of business enable them to support maintenance of their networks so that the effective cost to the Federal Government for access to these observations is pennies on the dollar, with no capital outlay by NOAA.

The current National Mesonet Program Alliance provides billions of observations annually to the National Weather Service from approximately 8,000 stations located in 26 states. I have included a map that outlines the number and configuration of stations by state.

New emerging sensor technology that measures total lightning and the boundary layer of the atmosphere are representative examples of what can and should be added to the current network, as well as more in situ surface, coastal and mobile stations. Total lightning – which measures important cloud-to-cloud lightning rather than just cloud to ground lightning, has proven effective in increasing warning lead times for thunderstorms by as much as 100 percent over existing technology. Likewise, emerging profiler technology, which measures conditions in the surface boundary layer, must also be an important part of any emerging mesonet strategy. The boundary layer is that part of the atmosphere that directly feels the effect of the earth's surface. Its' depth can range from just a few meters to several kilometers depending on the local meteorology. Turbulence is generated in the boundary layer as the wind blows over the earth's surface and by thermals, such as those rising from land as it is heated by the sun. Turbulence redistributes heat, moisture, pollutants and other constituents of the atmosphere. As such, turbulence plays a crucial role in modulating the weather (temperature, humidity, wind strength, air quality, etc) as we experience it, living on the surface. Expanding the profiler coverage with increased federal support would be especially valuable—this is a win-win decision.

Current and Potential Users of the Mesonet

While predicting severe weather is the most frequent use of mesonet data, there are a number of other critical applications that were noted by the National Academy in *From the Ground Up*: energy security, transportation, water resources, and food production. The report's authors concluded that the development of a surface based National Mesonet, with comprehensive data collection, quality control and dissemination capabilities, will provide the critical information needed to improve short and medium term weather forecasting (down to local scales), plume dispersion modeling, and air quality analyses. It increases the capabilities of the atmospheric community, but substantially improves the decision making for many key sectors of the economy and end user constituencies including energy, agriculture, homeland security, disaster management and emergency response (including wildfire management), insurance and economic forecasting, transportation, education, recreation and scientific research.

Energy Benefits

NOAA has stated that weather & climate data creates value for energy companies, as they make decisions to generate, buy or sell energy across regional power grids. A study by (Centrec, 2003) found that for every \$1 that energy companies spend in acquiring NOAA climate station data they receive a potential benefit savings of \$495 in related costs (i.e. not having to implement their own observing system to collect the data).³ This yields a \$65 million benefit when extrapolated across the entire US energy market, and the cost-benefit (value) ratio is likely to increase in time, as a national mesonet is implemented. This is particularly true for portions of the renewable energy sector like wind generation.

³ Centrec Consulting Group, LLC, 2003: *Investigating the Economic Value of Selected NESDIS Products, 2003: Benefits of meteorological services. A report to National Environmental Satellite, Data, and Information Service (NESDIS). Centrec Consulting Group, Savoy, IL, page 2.*

Transportation Benefits

The transportation industry is very sensitive to changes in weather and climate conditions. The impacts of adverse weather, annually, on the Nation's highway system and roads are significant: 7,400 weather-related deaths; 1.5 million weather-related crashes; more than 700,000 weather-related injuries; and \$42 billion in economic losses.⁴ Delays caused by adverse roadway weather conditions have reached nearly 1 billion hours per year. Department of Transportation statistics also show that adverse weather was a factor in nearly 25% of total highway crashes. A national mesonet can help address the lack of roadway weather data and analysis by integrating weather observations nationally, and into multi-use formats that do not presently exist. The result being near-real time data sets that can be used for numerous surface transportation and environmental applications (e.g. input to weather and climate models; data for improved traffic management and road maintenance decisions; traveler information services; and data to improve weather and hydrologic warnings and forecasts). This greater capacity to understand weather and climate data near major U.S. roadways will result in saved lives and more efficient commerce. Commercial aviation is particularly weather dependent and the estimated benefits in routing efficiency, lower fuel costs, on-time performance and passenger safety and convenience envisioned by the FAA's proposed NexGen system will be dramatically enhanced by the availability of mesonet data integrated into the forecasting and predictive systems used by the aviation industry.

Water Resources Benefits

Water resource management is concerned with controlling river and lake water levels as contained in reservoirs often as part of a network of dams. This was one of the central reasons why the Oklahoma Mesonet was created. Water managers monitor how seasonal or annual changes in climate (e.g. drought, El Niño-Southern Oscillation) may affect the water levels to conserve for domestic, hydroelectric, industrial, and agricultural use throughout the year. Flooding and drought add to the challenges that water managers, city officials and emergency managers must take into consideration when making decisions. The National Hydrologic Warning Council projects that NOAA information and data provide for economic benefits of \$240 million/year in mitigating flood losses, and an additional \$520 million/year in benefits for water resource users including: hydropower, irrigation, navigation, and water supply.⁵ A robust mesonet would increase these benefits for water resource users.

Food Production Benefits

The agriculture industry has long relied on NOAA weather and climate information to improve planning and decision-making in yielding crops. Environmental factors such as seasonal precipitation, drought vulnerability, mean & extreme temperatures, and the length of the growing season (i.e. the last spring and first fall freezes) - help to determine which type of crop will be most profitable in a specific region.

⁴ Department of Transportation, Bureau of Transportation Statistics, 2007: *National Transportation Statistics*, Washington, DC, [502 pp.]

⁵ National Hydrologic Warning Council, 2002: *Use and Benefits of the National Weather Service River and Flood Forecasts*. NOAA NWS National Hydrologic Warning Council, Silver Spring, MD, page 4.

However, over the course of a season, a farmer must make crop planning and management decisions at different time scales. For example, a widespread agricultural freeze for nearly two weeks in a previous January, in which overnight temperatures over a good portion of California dipped into the 20's, destroyed numerous agricultural crops and caused \$1.4 billion in estimated damage/costs.⁶ A national mesonet can assist a particular region by providing information, which may aid in operational decisions such as irrigation, the optimal time to apply pesticides, when to plant and harvest crops, etc. From what I have seen, there is not a farmer in Oklahoma that does not use the Oklahoma Mesonet—I have noticed that Congressman Frank Lucas has the Oklahoma Mesonet on his computer and looks at it many times a day—and he is also a farmer.

Another important climate information resource is the U.S. Drought Watch, which provides updated information on the presence and severity of U.S. drought. Information from the Drought Watch assists the agricultural community in adapting to drought conditions, which may result in improved planning and substantial economic, environmental, and social benefits. Drought conditions cost an estimated \$6-8 billion annually across all sectors of the economy, making it, on average, one of the most costly of all natural disasters affecting our Nation.⁷ To mitigate the impacts of drought, a national mesonet can provide an integrated, interagency drought monitoring and forecasting system for the Nation.

Major Benefits For Severe Weather Prediction

With the more intensive patterns of severe weather which Americans have faced in recent years, there are three primary reasons why a national mesonet is essential for the nation's weather enterprise moving forward.

First, use of mesonet data will substantially increase warning times. Data captured using total lightning and other mesonet data during last April's Super Outbreak of storms showed that these observations increased warning times on average by 13 minutes, nearly double the current National Weather Service standard. This leap in advance warning is potentially transformational in how weather observations are reported and can be acquired for modest sums in contrast to the upgrading of the ASOS network to achieve the same objective which would cost billions. Expanded warning times are a matter of life and death.

Second, mesonet data will enable forecasting and warnings to be far more targeted than the warnings of today. Mesonets provide far more detail of local weather patterns. As such, mesonet data enables forecasters and their computer models to evaluate a storm's surrounding environment with far greater certainty over far smaller tracts. This "micro-targeting" of storms means that communities can have a much more precise idea of a storm's longevity and severity. This means alerts can likely go to a smaller

⁶ Lott, N., Ross, T., Houston, T., and A. Smith, 2008: *Billion dollar U.S. weather disasters, 1980-2008*. Factsheet. [NOAA National Climatic Data Center, Asheville, NC, 2 pp.]

⁷ Federal Emergency Management Agency (FEMA), 1995: *National Mitigation Strategy: Partnerships for Building Safer Communities*, Federal Emergency Management Agency, Washington, D.C., 40 pp.

subset of a region or community so that they can better internalize the imminence of the threat that faces them.

Third, a national mesonet will lead to a significant reduction in the vexing problem of false alarms where today a large area is notified of a potential severe weather event, but because the weather pattern only touches a small portion of the region, the alert is ignored, giving a false sense of security to those in the destructive path of a storm. This “social behavior” challenge is one of the most difficult challenges identified by NOAA in its effort to achieve a Weather-Ready Nation. Some of the most recent tragedies we have witnessed from severe weather were in part caused because portions of the affected population ignored the warnings provided.

To achieve these benefits, however, we must have leaders with vision, and the desire to work for coordinated and continued investment. The National Mesonet Program was begun by Congress – in the wake of the Baltimore Water Taxi incident – because it saw the need for a public private partnership where NOAA could acquire the additional data and services it needs at a fraction of the cost of owning the network assets. The return required for the network deployment costs are amortized over a variety of market segments; the costs and risks are shared.

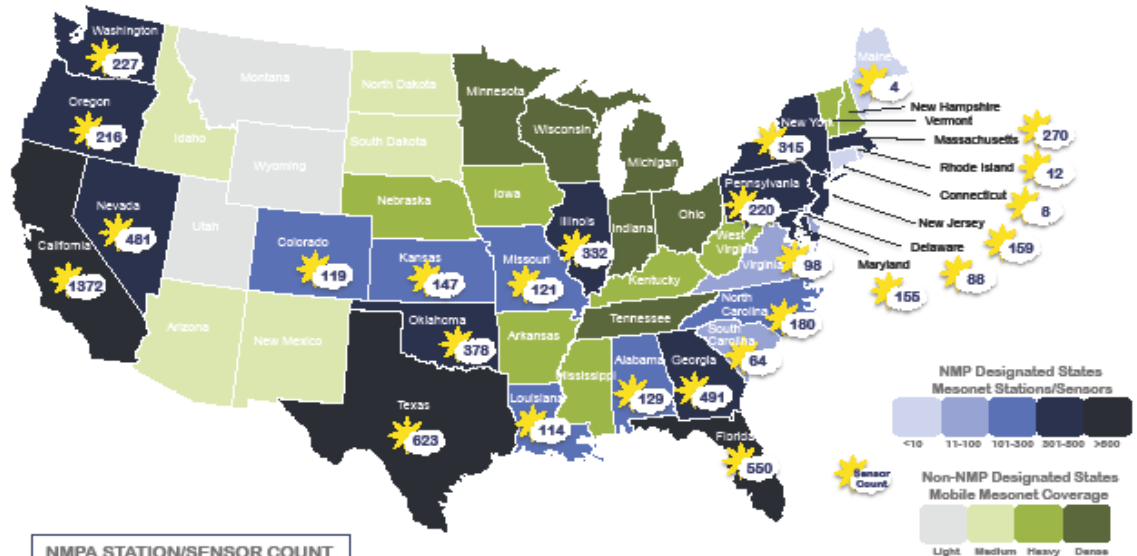
The National Mesonet Program has suffered from inconsistent investment patterns. The fiscal year 2012 NOAA appropriation for the national mesonet was just \$12 million, a 40 percent reduction from the enacted appropriation for the program in fiscal year 2010. At a minimum, Congress should return to the fiscal year 2010 level of \$20 million, but should respectfully consider continued expansion of the program so our nation can truly have comprehensive coverage. A comprehensive national mesonet allows for the introduction of the new technologies that are essential for a Weather-Ready Nation.

This Committee, working with your colleagues on the Appropriations Committee, can sustain this public-private partnership. I strongly recommend that you take the steps necessary to make sure that the National Mesonet Program is restored to its 2010 levels in this year’s budget, and that NOAA and the Administration be strongly encouraged to include it in future budgets so we can save more lives and more communities and become the Weather Ready Nation to which our country aspires.

In the National Weather Center in Norman, Oklahoma, the University of Oklahoma and the Oklahoma Mesonet are particularly close partners with our colleagues and neighbors at NOAA’s Storm Prediction Center, the NOAA Norman National Weather Service Forecast Office, the NOAA National Severe Storms Laboratory, and the NOAA Warning Decision Training Branch. Our collective efforts – requiring a daily, joint commitment of time, people and funding – help save lives and improve the quality of those lives. The pioneering efforts on the Oklahoma Mesonet have set the gold standard for how mesonets can lead to great decisions saving lives, property, and money. By investing in the National Mesonet Program we can significantly improve our understanding of the world around us, allowing for more accurate and specific weather forecasts and warnings, and can truly reach our goal of being a Ready-Weather Nation.

Appendix A

National Mesonet Program Alliance Non-Federal Stations & Sensors



NMPA STATION/SENSOR COUNT	
In-situ 10m & below	2,341
Soil temp & moisture	706
Solar radiation	2,304
Winds above 10m	1,132
Road surface temp	1,530
Total Assets	8,013

Note:
 Observations acquired in states shaded blue are required as part of the National Mesonet Program.
 Observations acquired in states shaded green are not required, but provided as additional observations via mobile mesonet