Weathering Change: Need for Continued Innovation in Forecasting and Prediction

STATEMENT OF

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Introduction

Thank you, Mr. Chairman and Members of the Committee for this opportunity to testify on the importance of continuing innovation to improve weather forecasting and warnings. My name is Bob Marshall, founder and CEO of Earth Networks and I am very appreciative of this opportunity to discuss topics relating to the weather observing and forecasting programs of the National Oceanic and Atmospheric Administration. We thank the Committee for its continuing interest in addressing the complex requirements of observation, prediction, planning and response, and the critical role these efforts play in protecting lives and property.

Earth Networks' particular expertise is in owning and operating large, dense environmental and atmospheric sensor networks. We utilize the data from these observational networks to deliver daily environmental information and alerting to millions of consumers; federal, state and local governments; and the myriad of industries impacted by weather. While we certainly rely on many NOAA services, and incorporate NOAA data and forecasts into our products and services, we have found that the needs of the marketplace (and of government) often require higher resolution solutions and data sets that are more locally targeted and in much greater frequency than NOAA is currently able to provide through its own observing networks. In this manner, existing local networks of this type are able to supplement NOAA's in a unique and powerful public/private partnership.

Weather is having a greater impact on our society than ever before. This includes impacts to the lives and property of our citizens and to our economy. To provide the most accurate forecasts and warnings for weather, dense high quality observations are required, so I will focus my comments on that component of the overall system. Without observations of the atmosphere, quality forecasts and warnings are not possible. And meteorological observations on the mesoscale (i.e., local/county scale) are of the greatest 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, fronts, squall lines, etc.

The need for improvements in observations of this kind are well documented and compelling as recently indicated within the National Research Council report" From the Ground Up: A Nationwide Network of Networks". Among other recommendations, the Council advocated that a first priority be the development of a surface based *National Mesonet,* with comprehensive data collection, quality control and dissemination capabilities, which 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. In this manner, not only will the overall capabilities of the atmospheric community be substantially improved, but decision making will be significantly enhanced across a broad spectrum of market sectors and end user constituencies including energy, agriculture, homeland security, disaster management and emergency response, insurance and economic forecasting, transportation, education, recreation and scientific research.

From an observing perspective, there are a number of specific areas that NOAA weather and climate programs should focus on in order to establish a truly Weather Ready Nation. Three key areas are: (1) a comprehensive and robust observing system; (2) early warning capabilities that leverage key mesoscale observing systems; and (3) strong public-private partnerships. While each of these components could be examined more closely to identify key requirements, assess the current condition of readiness and prescribe appropriate efforts and investments necessary for a more capable domestic program, my testimony today will only touch upon these aspects at a high level. Please note that my recommendations here today are rooted in recent reports from the National Academy of Sciences, national efforts by leading industry associations regarding weather and climate services, as well as my own experiences in leading an organization that interacts with all aspects of the American Weather Enterprise, i.e. public, private and academic interests involved in sourcing and distributing weather information. Finally, I'll also touch briefly upon climate considerations in this regard.

(1) Comprehensive and Robust Observing Systems

The objective of weather and climate observing systems is to provide critical information on the current state of the atmosphere and terrestrial biosphere in a timely manner such that informed decisions can be made at varying time scales. In this context, decisions on the long term may involve potential global temperature changes and sea level rise that require development of climate mitigation and adaptation strategies. Intermediate term decisions may include flood, drought and winter weather or tropical storms expected to affect large areas and many sectors of the economy over prolonged periods of time. Alternatively, short fuse decisions more often entail those relating to convective (i.e., thunderstorm) weather events that while often widespread, occur quickly and dramatically impact people, property and critical assets.

Supporting these varying decisions and timescales requires various types of observation platforms, including surface based in-situ and remote sensing monitoring networks as well as space based satellite systems. When seamlessly integrated, these complementary resources provide the raw data 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. With regard to the latter, it should be noted that the impact of weather on our nation's economy was recently estimated to be as much as $485 billion or 3.4% of the 2008 US gross domestic product. (Lazo, Lawson, Larsen and Waldman, *Bulletin of the American Meteorological Society*, June 2011, (http://www.sip.ucar.edu/publications/PDF/Lazo_sensitivity_June_2011.pdf).

Recent advances in electronics technology have enabled surface based 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. Environmental parameters that were once not practical to observe at the surface are now proven and operational. In some cases, these breakthroughs 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 launch. Satellites should only be considered where ground based sensors are inadequate.

These advances are similar to the advances seen in astronomy. Ten or twenty years ago, the technology available from ground-based telescopes was not adequate to capture data at sufficient resolution for all research purposes; space based telescopes like Hubble were necessary. Now, technological advances have significantly improved the capability of ground-based observations. As a result, we collect from space only that data which we cannot collect from the ground – the two domains complement each other. Like in astronomy, improvements in the technology of ground-based in situ sensors, communications, power management, data handling and storage have all enabled the deployment of cost-efficient sensor networks with a density sufficient to allow applications thought impossible just a few short years ago.

But sometimes a satellite is the appropriate answer. For example, the JPSS satellite is critical to NOAA's ability to forecast weather accurately, especially in the 3-5 day period and longer. This was never more apparent than the terrible southern tornado outbreak from this spring. The NWS was able to predict a very high potential for severe weather in the region many days in advance which helped communities to prepare. Studies have shown that the polar orbiting satellite data was critical to this success. Winter storms forecasts and warnings are also another area where the polar orbiting satellites are critical. In last year's "snow-mageddon", NWS forecasts allowed for up to a week's advanced warning of this storm, which again allowed time for communities to prepare in advance of the severe weather. There is no surface based technology that can provide an alternative for the observations that will be delivered by JPSS. It is critical for JPSS to be funded to prevent a significant decline in forecast and warning accuracy for these type events.

(2) Early Warning Capabilities

As mentioned previously, most severe weather occurs at the mesoscale, i.e., local and regional scale and NOAA/NWS generally does a very good job of generated severe weather warnings to cover this domain. However, while warning lead times correspondingly improved during the NWS modernization that began in the 1980's, during recent years the warning lead times have not improved appreciably. This is a direct reflection of operational observing systems also not significantly improving. With the frequency and severity of weather events increasing and our population growing, further improvements in warning lead times are necessary to better protect life and property. High resolution mesoscale observations enable more accurate and timely forecasts and warnings in the 0-6 hour's timeframe. Fortunately, this committee and the National Weather Service have taken steps toward making this capability operational by appropriating monies for and implementing demonstration programs and pilot projects. For example, the National Mesonet Program championed by Senator Barbara Mikulski after the 2004 Baltimore Water Taxi Incident, involves a broad cross section of weather and climate network operators throughout the country who are supplying comprehensive surface observations and associated metadata from stationary and mobile platforms. But more should be done; we need to move beyond pilot projects to operational implementation.

To this end, I maintain that following the recommendations of the 2008 NRC report From the Ground Up: A Nationwide Network of Networks, and leveraging to the maximum extent existing and proliferating surface observations, be fully implemented as soon as possible. Doing so will significantly enhance NOAA's ability to forecast near-term severe weather and do so in a highly cost-effective manner. This is particularly germane in a year where the nation experienced an historic number of severe weather outbreaks, including destructive Tornado outbreaks in Tuscaloosa, AL and Joplin, MO as well as severe droughts, crippling snow storms and devastating hurricanes in other parts of the country. And the situation is only being exacerbated as our population grows and migrates toward urban and coastal areas. In fact, the previous annual record of 9 individual $1billion weather related catastrophes has been surpassed already in 2011 with a record setting 14 as of today.

Beginning in the 80's, NOAA invested heavily in infrastructure for observing, analysis, visualization and dissemination capabilities which resulted in significant tornado warning lead time improvements from 4-14 minutes. This important and necessary advancement was the outcome of an approximately $4.5 Billion investment. Since then, however, there have only been marginal improvements. What I want to stress is that new and innovative technologies can immediately deliver step-function improvements in early warning times at a fraction of the previous cost. These advancements in sensor technologies are the result of motivated and fully engaged private, academic and state government organizations that have enabled the deployment of dense, surface based observation networks throughout the country.

A specific recent innovation in mesonet technology is the integration of total lightning sensors. For many years, researchers have demonstrated that monitoring cloud flash lightning data at high detection efficiencies would provide insight into early stage convective development and that such total lightning observations could potentially provide significant improvements in storm warnings. But the technology was never available to cover large, continental areas at a reasonable cost. Using innovative new technology, Earth Networks has rapidly and efficiently deployed a continental scale total lightning network on its nationwide mesonet. This network is operational today and is automatically producing severe storm alerts with lead times as much as 30 minutes in advance of NWS Severe Thunderstorm and Tornado Warnings. During the April 25 to 28, 2011 Super Outbreak that killed more than 346 people and included the tornado that tore through Tuscaloosa, AL, Earth Networks total lightning system achieved an average lead time increase of 13 minutes for a broad subset of these events. Similar lead time performance achievements have been repeatedly observed for many other events throughout the country over the past several years and as such, the NWS is currently piloting the technology in 27 field and regional forecast offices.

As mentioned, this type of technology has only been made available on a broad scale and for such purposes during the past couple of years. It should also be emphasized that its cost is only a small fraction of that required to achieve the same from space and was accomplished without consuming a single dollar of taxpayer money. With the Earth Networks total lightning network being fully operational, the need to observe lightning in the future from satellites should be evaluated. The forthcoming GOES-R satellite includes a lightning sensor at a cost of more than $100M. The Earth Networks ground based total lightning network already delivers many of the benefits of the GOES-R satellite lightning sensor including higher resolution and accuracy. This is the kind of issue that should be looked at carefully, so that the government can be assured that a proper cost-benefit analysis has been completed. Even if the GOES-R lightning sensor initiative, scheduled for operations in 2017, is too far along to be shelved the Earth Networks total lightning capability should leveraged immediately to improve severe weather forecasting and alerting as well as to provide ground truth for satellite calibration, forecast validation and after action reports.

I have attached a Power Point presentation to this statement that demonstrates the power and effectiveness of this currently available and cost effective technology.

(3) Public Private Partnerships

Achieving a condition where the nation is adequately equipped to foresee weather related threats and alert the community with sufficient warning lead-times requires vision, coordination and continued investment. It is particularly clear, however, that the federal government cannot achieve this goal alone, particularly in the face of an increasingly difficult budget environment. Therefore, it is imperative that vigorous public-private partnerships be nourished to drive innovation and allow for the appropriate mixture of baseline government provided services and market based offerings. By utilizing the capabilities of private networks, NOAA can acquire the 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. Only this type of partnership will ensure that available government funding is being deployed most effectively and efficiently.

Consistent with the 2003 NRC report entitled Fair Weather: Effective Partnerships in Weather and Climate Services, the NWS has initiated and expanded upon a dialogue with the private sector. These conversations have improved coordination among the sectors by providing greater insight into each other’s respective needs, plans and capabilities. These efforts should be continued and identified synergies should be acted upon with greater urgency in order to rapidly fill the gaps in capabilities and services.

While the federal government is well suited to act globally and nationally, it is limited in its capacity to act locally beyond the provision of oversight and funding support. As such, it is envisioned that a public/private partnership structure, with guidance from the National Oceanic and Atmospheric Administration, facilitate and integrate these disparate networks and delivery of customized services. An organizational model of this type is particularly applicable given that many networks have been deployed by local organizations with local considerations in mind. These stakeholders can react quickly and efficiently, and are uniquely positioned to recommend future network evolution within their domains. These networks are in-place and available today. As such they offer the ability to deliver immediate returns.

(4) Climate Considerations

Before turning to my conclusions, let me comment briefly on another related monitoring initiative that Earth Networks is pursuing.

NOAA is charged with conducting research on the complex carbon cycle and its impact on climate variability. Currently, there are very limited carbon observations available to scientists for this research. NOAA operates about 10 such surfaced based carbon observation sites and there are a few dozen operated by others around the world. The current carbon observation network is limited to global and continental scale measurements and analysis. Many more observations are required to develop a better understanding of the carbon cycle at local and regional scales and to provide measurement, reporting and verification to support international treaties, as well as any regulatory or market-based reductions schema.

Similar to the advances described above, advances in electronics technology have also significantly improved the ability to accurately and reliably measure carbon from the surface. Earth Networks is deploying the largest surface-based greenhouse gas observing network in the world, with 50 sensors planned for the continental United States, 25 in Europe, and 25 distributed around the rest of the globe. Again, with this innovative new technology there is the potential for significant cost savings by increasing investments in ground based carbon measurements relative to satellite-based measurements. Unfortunately, the original Orbiting Carbon Observatory (OCO) satellite launch failed on launch. The cost of that mission was approximately $280 million. A second carbon satellite, OCO2, is being developed at a cost of another $200 million. While all scientists, including those at Earth Networks desire data from both surface and space based platforms, the question is whether this is practical given the current budget constraints. Before funds are fully committed to a new or replacement satellite program, an exhaustive analysis should be accomplished to determine the trade-offs associated with these funding decisions. As the previously referenced National Academies report title intimated, we should always start “from the ground up”.

Conclusion

While NOAA has built up significant observational assets and capabilities over many decades, there remain significant gaps that limit our ability to further improve forecasts and warnings. Further, with budget challenges that will no doubt confront us for the foreseeable future, NOAA's model for acquiring and maintaining critical observations is infeasible. Overall budgets will likely be flat or lower. Satellite program costs are consuming an ever larger proportion of the NOAA budget and the current trajectory is simply not sustainable.

Immediate improvements, however, in forecasting and prediction can be realized by utilizing Public-Private partnerships to enhance existing space and ground based observing platforms. Therefore, specific strategies adopted in this regard should:

- Guarantee annual funding of the National Mesonet in NOAA's budget to fully integrate locally collected mesoscale surface weather data into the forecasting and warning functions at every National Weather Service field office;
- Guarantee that NOAA incorporate continental scale total lightning data into the National Mesonet and into its storm warning capability to achieve a step-function improvement in warning times;
- Fund cost efficient surface based carbon networks to improve local and regional scale climate science;
- Establish a standing NOAA advisory panel whose sole mission is to look at the balance of NOAA's forecasting needs for both weather and climate, and then recommends in a public way how those requirements should be met between the three observational domains of surface, airborne and space based measurements;
- Hold annual Congressional hearings on the state of innovation in forecasting and warning to measure the progress on the important objectives that the public demands and which must be done in a fiscally prudent manner given the challenging economic times.

Through the types of strategies and initiatives that I have highlighted today, the broader weather and climate industry will be able to expedite and support NOAA in establishing a truly Weather Ready Nation.

Thank you for the opportunity to testify today. I would be happy to answer any questions you may have.