Leveraging the Enterprise: Strengthening Our Value to Society  
A Summary of the 2014 AMS Washington Forum

Shawn Miller, Editor and Program Committee Chair 
Tom Fahy, Editor

The 2014 AMS Washington Forum Program Committee:  
Mike Anderson, Kris Ebi, Pam Emch, Tom Fahy, Mary Glackin, David Green, Michelle 
Hawkins, John Haynes, Jim Koermer, John Lasley, Renee Leduc-Clarke, Sue Haupt, 
Melinda Marquis, Angel McCoy, Marjorie McGuirk, Matt Parker, Kevin Petty, Gary 
Rasmussen, Tim Schneider, Keith Seitter, Bill Sprigg, and David Titley

Student Rapporteurs:  
Abigail Ahlert, Lorenza Cooper, Jia-Long Fan, Amber Hill, Eric Hout, Amanda Kibbe, 
Timothy Loftus, Faisal Mahmood, Amanda Mitchell, Aisha Murphy, Lynn Montgomery, 
Churchill Okonkwo, Alex Ortiz, Mayra Oyola, Craig Pepper, Keren Rosado, Jose Tirado, 
Kar’retta Venable

This report summarizes the outcomes of the 2014 AMS Washington Forum (AWF). Consistent with the modified Chatham House Rule that was in effect during the event, the names of individual speakers and attribution of individual remarks is not included in this report. Information about speakers and attendees for internal use can be obtained from the AMS staff. The theme of this year’s event was “Leveraging the Enterprise: Strengthening Our Value to Society”. After opening remarks by board and commission leadership, the first session of the 2014 AWF focused on this theme.

Executive Summary

Like it or not, weather defines our world.
• Each year, thousands of lives are lost to weather-related events and accidents.
• Variability in U.S. economic output due to weather-related supply and demand inefficiencies averages more than three percent on a state-by-state basis.
• The anticipation of changing climate is beginning to drive infrastructure and resource planning.

How can we prepare for and respond to these issues? The American Meteorological Society (AMS) holds its annual Washington Forum to address this question. The Forum gathers stakeholders from the public, private and academic sectors engaged in work on weather, water and climate. A key goal is improving the value and efficiency of the enterprise (as the combination of our three sectors is known). This year’s Forum, with the theme Leveraging the Enterprise: Strengthening our Value to Society, was attended by more than 150 members of the enterprise and built upon the momentum of previous years’ events.

Among the many excellent discussions had during the meeting (see back for more detail), the following stand out:
Collaboration involving all three sectors of the enterprise is increasingly important to meeting society’s requirements. Our three sectors coordinate effectively today, but we are exploring deeper collaboration for the future. Commercialization of weather data sources is one example. Working across agencies and across sectors (e.g., health, energy) is becoming a new “normal” for solving problems. All agree the needs and demands for data, information and forecasts are continuing to change, so our enterprise must remain flexible and agile.

Society’s diverse needs are often coupled in poorly recognized ways. Stovepipe disciplines are breaking down as we recognize critical interdependencies. For example, researchers have explored the tight coupling between water and all types of energy production to better inform decision making. This is central to managing growing demands for both water and energy.

Disastrous storms such as Sandy and Typhoon Haiyan provide valuable lessons to help society better prepare for future events. Hurricane Sandy revealed new vulnerabilities in our infrastructure for maintaining public health. It also illustrated how we must prepare for “black swan events”—those that are considered unexpected. For example, an extreme space weather event caused by a solar storm (similar to one experienced in the 1800s) would have significant impacts today due to our dependence on the electrical grid. We need to do more to mitigate and prepare.

Climate impacts are becoming visible, and our enterprise is responding. Among other things, impacts in the Arctic are real. The U.S. is taking on a lead role in responding, both through operations of the U.S. Navy and leadership of the Arctic Council.

This year’s ten interactive panel discussions and three individual presentations, along with the key messages emerging from each, are summarized below.

<table>
<thead>
<tr>
<th>Session/Presentation</th>
<th>Key Messages</th>
</tr>
</thead>
</table>
| Panel 1: Theme Session | • Our enterprise must continue to conduct research to ascertain mechanisms for climate change and help people understand the cause and effect at regional and local scales.  
• All three sectors of the enterprise are critical to its success |
| NOAA and the Weather, Water and Climate Enterprise | • Needs and demands for weather data are continuing to change, so our enterprise must remain flexible and agile  
• Integration of data and information across multiple disciplines will facilitate the meeting of user needs and also lead to richer collaboration |
| Federal Budget Update | • Regardless of where budget negotiations land, the next several years will continue to be challenging with respect to the funding of our enterprise, so we must communicate the value of our enterprise clearly |
| Panel 2: Commercialization of Weather and Climate Data | • While most agree the private sector needs to take on a bigger role in the provision of weather data, the public and private sectors need more time to jointly determine the best path forward |
| Panel 3: Impacts of the Changing Arctic | • Changes in the Arctic are real, and the U.S. is taking on a lead role in responding, both through operations of the U.S. Navy and leadership of the Arctic Council |
| Climate Change and the Wine Industry | • Impacts of climate change are already being seen in the wine industry and will continue to evolve, serving as an excellent and
Summary of the 2014 AMS Washington Forum

| Panel 4: Congressional Staffers | • Approval of HR2413 (the Weather Forecast Improvement Act of 2014) on April 1 indicates the level of importance placed on the weather enterprise by Congress  
• Seasonal forecasts are one of the next major science and policy challenges to address |
| Panel 5: Weather, Climate and Health | • Recent weather events such as Sandy have revealed new vulnerabilities in our infrastructure for maintaining public health  
• Interdisciplinary efforts are vital to better understanding weather and climate impacts on health |
| Panel 6: Space Weather and Carrington Events | • Carrington or similar space weather events are inevitable, and our dependency on the electrical grid and electronic systems makes us more vulnerable than ever; we need to do more to mitigate and prepare |
| Panel 7: Federal Agency Leads | • Interagency and cross-sector engagements are the new normal way of business for solving problems as we move into the future |
| Panel 8: Surface Transportation and Weather | • The public and private sectors are continuing to explore new ways for the surface transportation and weather forecasting communities to provide reciprocal benefits to one another |
| Panel 9: Water-Energy Nexus | • Water and energy are tightly coupled and interdependent as resources to our nation; there is ample room for improved efficiency with both |
| Panel 10: Typhoon Haiyan | • Disastrous storms such as Sandy and Haiyan have provided us with valuable lessons on how to better prepare for these events in the future |

**Theme Session**

The increasing pace of science and technology continues to accelerate capabilities in the atmospheric and hydrologic disciplines. As an outgrowth of public and private-sector investment in weather, climate, and hydrology, new and innovative means have evolved to acquire, integrate, and communicate critical weather, water, climate knowledge and warning information to the public based on these technological achievements. Like the *Fair Weather: Effective Partnerships in Weather and Climate Services* report that was published in 2003, recent studies by the National Academy of Sciences, the National Research Council, the National Academy for Public Administration, and the NOAA-commissioned *JPSS Gap Mitigation: Analysis of Alternatives* report, provide insights on the health and vitality of the Enterprise. These reports show that federal agencies working with their Enterprise partners can produce well-formulated strategies to directly return societal benefits. The greatest national good is achieved when all parts of the Enterprise function to serve business, industry and the public. Building on these reports, the 2014 AMS Washington Forum highlights the Enterprise’s considerable advances in shared research, technology development, observations, data sources, social science research and improved end-user access of shared resources and their benefit to society.

The theme session began with a discussion of the value shift with climate change. Conveying the message that the ice cap has been frozen for three million years and that it will be ice free in Septembers during our lifetime breaks through the polarization of
opinion on climate change. Sea level has been rising for centuries, but has been the same for 8,000 years of our history as a people. Polar ice cap melting shifts our weather patterns, but thermal expansion largely causes the rise in sea level. Changes in shoreline drive property values and affects our decisions on what we do at the coasts. Florida was 100 miles wider at the peak of the last ice age. When people see the clearly defined messages of shoreline, they realize the importance of observing, measuring, and studying the science of weather and water enterprise. Figure 1 illustrates an example of this type of communication.

![Figure 1. Illustration of the impacts of sea level rise.](image)

How far should we raise buildings, or how far inland should we retreat? Nobody ever wants to say that in 30 years we should be elevated three feet or moved back by some measure. What could happen is already evident at high tides along the coasts with real decisions happening now. Most people have an understanding that weather has destabilizing effect. We, as an enterprise, have to help people connect the dots from cause to effect.

The next discussion focused around the tenet that “the greatest national good is achieved when all parts of the enterprise function to serve business, industry and the public.” Within that subtheme, engagement with young professionals was described in the context of the Education Partnership Program, which serves minority students. Projects that involve students include networks (e.g. GRUAN), modeling (e.g. WRF extension for climate services), and observations (e.g. CRUISE). Public, private and academic partnerships are key to moving the enterprise forward to serve the greater good. In the past, private companies gained value through developing and innovating
and commercializing new products and services. Research to operation has a slow pace even while private enterprise has evolved the ability to fund its own research. As resources expand, private enterprise pushes innovative change into the marketplace. So, how can the private sector work with academia? Academia has more flexibility in working with the private sector cooperatively and not competitively. Property and intellectual right issues that inhibit research cooperation with the private sector should be negotiated.

The discussion then shifted to the perspective of the NOAA Corps, which employs aircraft, ships and instruments to engage in missions integrated with other federal partners. For example, ocean flux research over the Arctic Ocean used NOAA instrumented aircraft to record gases, aerosols, and radiation measurements. Deploying buoys in remote regions like the Bering Sea and working closely with fishery scientists, NOAA determines the impact of the physical environment on fish stocks. Collaborating with European meteorology services; NOAA conducts operations for satellite observations. They assess climate change effects on the ocean. Echoing the statement made by the Navy Oceanographer, the biggest national security threat to the United States coastal regions is climate change. Automated flying machines, UASs, drones, are outfitted with sensor packages that apply to a variety of sciences including mammal health, severe storm genesis, and marine sanctuaries monitoring.

Shifting again to the private sector perspective in the weather and climate enterprise, applied technology and consumer interface are two historic roles the private sector plays in the enterprise. The means of communicating to the public come with many questions. Deciding the right mix of weather information products is often a role of private sector meteorology companies. Doing further research on creating products and services is also a function of the private sector that serves American and global societies.

**NOAA and the Weather/Climate Enterprise**

The AMS has a unique and pivotal role because it facilitates open discussion across the sectors. NOAA is America’s environmental intelligence service. A recent climate data initiative event at the White House broached topics such as use of climate data, how use of Government data is a platform for private sector innovation, and that free and open use of Federal data serves a public good. The weather and climate enterprise is unique because the three sectors work together. This is not so in all industries and we tend to take it for granted. The needs of businesses and communities that depend on NOAA and other data will change and continue to change – so our enterprise must be flexible, per the recommendations from the Fair Weather Report.

We need to realize we can’t do it without all three sectors and core agencies (like NOAA) that are healthy and strong. There is changing demand in forecasting needs, and the range of conditions is also changing. We need longer foresight, higher reliability, better geographic focus, and to relate forecasts and risk analysis results to projected impacts. We need to incorporate insight into economic planning and to factor in systemic risks of potential climate change and variability. NOAA acts as the balance.
between the academic and private sectors for these activities, and has listened to the recommendations in the recent NRC and NAPA reports to that end. It is essential to convert our understanding of the planet into something useful for the general population. All of us have an underlying drive to understand this planet and to make that understanding matter. We must use this bond to serve the partnerships that lie ahead.

**Federal Budget Update**

Historically, the U.S. deficit, relative to our economy has peaked in 2009 and is currently projected to level around 4% of GDP within the next decade. In order to mitigate the deficit, steps in legislation were made which include the recovery act, provide short-term stimulus, tax cuts, and support to low-income people to reduce the impact of the recession. These steps are believed to have made the recession less deep. In other words, things could have been a lot worse.

In 2011, funding cuts and Budget Control Act Caps, sequestration, fiscal cliff tax bill, and interest savings have all been contributed to the $4 Trillion in deficit reduction. The session primarily focused on the discretionary side of the budget, recent policy savings to reduce deficits largely come from program cuts (77%). The increase in non-defense discretionary funding is emphasized as modest. Figure 2 shows the latest trends and projections in this area.

![Figure 2. Current trends in non-defense discretionary spending.](image-url)
The budget deficit pattern over the years was depicted and discussed. Since 2001 the deficits have been measured as a share of the economy. How large is the deficit relative to our economy? How much debt does a family have relative to their ability to pay? We measure deficits relative to the economy because it is relative to our ability to pay to meet the interest payment on a particular debt. Data shows that deficits spiked around the recession; on the revenue side, people make less money so they pay fewer taxes; on the spending side, inflation drives costs up. The Nation took steps to mitigate (Recovery Act, provided money for investments, increased tax cuts, increased support for low/middle income people), and these steps did improve the situation somewhat. Moving forward, there is an ongoing budget debate in Washington, D.C. between the Ryan budget and the President’s budget.

The President’s budget has a deficit reduction roughly $1.7 trillion and can be contributed to new revenues, immigration reform, spending cuts, including Medicare. On the discretionary side of the budget, the President considered the Opportunity Growth and Security Initiative. This provides new funding for discretionary non-defense programs. The budget consisted of spending cuts, immigration reform and budgeting of discretion programs that would allow funding to be increased by $56 billion in 2015. The discretionary budget increases Defense by $483 billion above post sequester levels and it cuts the Non-Defense programs by $791 billion below post sequester levels. We have to make important decisions on what we spend money on and how we spend money for revenues.

The Ryan budget was recently released and the details are just emerging. The Ryan budget balances by the 10th year, which is an ambitious target to reduce the deficit, however nothing comes from new revenues. There are modest Medicare cuts in the first 10 years, large cuts in low-income mandatory programs, increases in defense, and larger cuts in NDD than in prior year budget. There is an attraction to this budget plan towards policy makers. A deficit reduction goal is made, however appropriators have the decision and struggle to finalize and delegate which program(s) gets adequate funding. The Ryan budget may or may not pass. Competing budget plans are important because the funding levels are very hard for the appropriators to meet.

An important point was made concerning our national debt and the role it plays in reducing our deficit. There is no question we will need to do further deficit reduction with the end goal for our debt to remain stable. However, stability requires us to meet some principles. We have to make the economy a little stronger and we have to think about the timing of deficit reduction. Whatever deficit reduction choice is made, what spending is cut, it needs to be done on context and priorities.

There was an interest in the room to placing a hard number on the economic value on weather/climate information. Economic policies are helpful. You want things to be concrete. For example, if you can place a dollar amount on the value of weather predictions for shipping routes, there can be a substantial argument made. However, this is not an easy task. Other people are making the same argument. If an argument is made that people need accurate weather prediction for their businesses to grow and protect life and property, then one can argue our economy is overall weaker because
our businesses will not be successful. In order for us to make things happen, we have to make the argument and explain why it is important.

Questions asked by the audience:
Q: What convinces Congress and decision-makers that something is worth investing? If we make good forecasts and the economy grows then is this an aspect of the argument?
A: The government’s decision to increase funding for Defense and Non-Defense programs provided an example of the ability for Congress to show unity. Both parties knew that there would be bigger cuts in the future. Therefore, they felt it necessary to compromise and make a deal. The science community needs to voice their concerns and opinions or they will risk another cut. They need to build a bigger coalition and talk about the importance of the area.
Q: What happens when interest rates increase?
A: The National debt is directly proportional to the deficit. The deficit is relative to the economy and the debt ensures that the economy is stable. So, even though the debt is stable it is predicted to trend up by the end of the decade. Deficit reduction needs to be well timed so the economy can improve and employment can rise. Whatever deficit reduction choices you make it needs to be done in the context of priorities.
Q: Are there any other strategies?
A: Economic impact analyses are helpful.

Commercialization of Weather and Climate Data

Weather and climate observations provide critical information that supports both the research and operational communities. Traditionally, the Federal Government has acted as the primary source for weather and climate data; however, over the past few decades, private sector companies have increasingly played a role in the production and dissemination of these data. The current economic landscape has resulted in an increased focus on more effective, targeted use of available Federal resources. As a result, the Federal Government is under pressure to closely examine and optimize its investment in weather- and climate-related activities, including those associated with development, deployment and operation of observing networks. This may manifest itself in an evolving paradigm where there is more reliance on the private sector for weather and climate data and information. This session built on previous sessions that have examined the topic of the commercialization of weather and climate data, with a focus on the following: the expansion of commercial data providers, the future role of the government in the deployment and operation of observing networks, and challenges associated with the commercialization of weather and climate data.

The discussion began with “Airborne Sensors Data Acquisition: A struggling Business Model.” Only a few commercial airlines buy into the Aircraft Meteorological Data Relay (AMDar) program, equipping their aircraft with weather sensors and transmitting the data to ARINC, who then sends the data to NWS for improving their forecast models. Other airlines that do not undergo the equipment and communications expense, still benefit from the efficiency gained from improved
weather forecast model output. There was to be a meeting later in April 2014 at ARINC to look at improvement to the model. Considerations include 1) letting the private sector handle the entire process and sell the data to end users and 2) giving companies that participate in AMDAR a tax break using the current model.

NCDC is examining and optimizing its investment in climate data by establishing prioritization of data sets based on public and scientific communities’ requirements. Some of the specific priorities identified were: (1) Deep Water Horizon, (2) National Climate Assessment, (3) Global Historically-collected Data, (4) Pathfinder Dataset, (5) Climate Normals, (6) World Magnetic Field, and (7) the Climate Reference Network.

There was some advocating for use of commercial weather satellites. Examples were provided of “outsourcing” satellite data by NASA, FAA, DoD, and the USGS. A balanced approach is recommended, maintaining federal satellites but augmented by commercial ones. NOAA could buy the data and proprietarily protect it without having total ownership of weather satellites.

The legal aspects of commercializing weather/climate data are significant. Currently there is a prohibition on using commercial weather satellites (51 USC 60151). Additionally, the policy of buying data does not align well with business models because the government has to freely distribute the data, even when it pays for it. However, the Weather Forecast Improvement Act just passed in Congress, which would allow and encourage the federal government to consider buying weather data.

In the Q&A session there was considerable discussion over the Weather Forecast Improvement Act (HR 2413) and its encouragement for NOAA to consider buying weather and climate data. There were many concerns about changing NOAA’s long-standing provision of its data for free to all users and its impact on private sector business models. These implications must be addressed before the federal government will fully adopt the practice of purchasing commercial weather and climate data.

Please see the article written from interviews with panel participants and organizers: “Industry and House urge NOAA to use commercial weather data” at http://www.eenews.net/stories/1059997252.

**Impacts of the Changing Arctic**

The future of the Arctic involves less ice, more access, and new fisheries, tourism, and shipping as well as oil, gas, and minerals commerce. The AMS Arctic panel explored the new Arctic regime and speculated on the needs that will arise at the intersection of policy and the weather, water, and climate enterprise. What tools can AMS partnerships offer that people will use to design and operate facilities in the changing weather and climate patterns of the Arctic? What ocean, weather, and climate and environmental observations and monitoring will forecasters and modelers need to predict future arctic conditions and to foresee the Arctic’s impact on the global future? What critical questions do policy-makers need answers for as the United States prepares to chair the Arctic Council in 2015?
The Arctic is a changing maritime environment that is physically changing more rapidly than anywhere else on the planet. There is scientific debate on its impact globally. There is a need for a more robust understanding of changes in the Arctic because of lack of knowledge about potential tipping points that we may be approaching or already have approached. The most recent arctic development is the release of Implementation Plan of Arctic Strategy on January 30, 2014. It focuses on advancing US security interest (infrastructure development, military, arctic domain, freedom on sea and air space, and national energy), responsible arctic stewardship (protecting natural environment), and charting the arctic region, both land and water, and strengthening international cooperation.

The Arctic Council is a high-level intergovernmental forum that addresses issues faced by the Arctic governments and the indigenous people of the Arctic. From 2015-2017 the United States will chair the Arctic Council. Overarching goals of the council are to 1) leave the council better than what it was prior to our chairmanship, 2) make things operate more smoothly and with more predictable funding, 3) focus on research areas we have yet to focus on, and 4) raise public awareness in US of the importance of the Arctic and Alaska since the US is in fact an Arctic nation. Secretary of State John Kerry will start our chairmanship; however, there will be a new administration in 2016, so a new chair will finish out the chairmanship.

Additionally there is concern of Russia’s continued role in the council. Russia is an important contributor to the council given they have the longest shoreline. Out of the 8 countries, Russia is the only country to not agree to the negative impact of black carbon. The other countries have tried for years and years to convince Russia. Headway is being made, however it is very slow. There is a need to focus on black carbon in the Arctic. If we can succeed in inexpensively mitigating black carbon in the Arctic Council countries, then these techniques can be adopted in other areas of the world.

In 2009 the United States Navy published the first Arctic Roadmap. The most recent update was in February 2014. The U.S. Navy’s key missions in the Arctic include ensuing US sovereignty, ensure freedom on the seas, and support the Coast Guard and other partners. It is expected that in the 2020-2030 period, there will be only a minimal increase in shipping in the Arctic. In this decade, surface ship operations in expanding open waters will allow for training and developing experience and expertise in the Arctic environment. By 2030 it is expected that there will be significant operations within the Arctic. Major waterways are expected to be consistently open in summer months. Oil, gas, and mineral exploitation, and production and transportation models, are expected to be established and sustained. See Figure 3 for a summary illustration of these expected changes.
The changing Arctic provides new access to resources in energy, fishing, and mining. This will in turn lead to increased shipping, loss of permafrost, increased area for military operations, and accelerated environmental degradation. Risks associated with increased activity include: vessel pollution/stranding, whale strikes, oil and gas extraction risks, damage and accidents, tourism. We have undeveloped risk reduction measures. Arctic governance needs to be based on good stewardship: preservation, cooperative planning, and responsibility for the Arctic shared by all. Governments need to strengthen abilities of the Arctic Council. Currently the Arctic Council has limited legal power and governments have very little accountability.

The new Earth System Prediction Capability (ESPC) is a multi-agency program whose goal is to develop a unified national “best-in-the-world” operational prediction system, for time scales ranging from 0 hours to 30 years, which will cover weather, climate, oceanography, and ice prediction. So far, the Navy and NOAA have received funding under the ESPC. The Navy is trying to codify this program. There is a need for more observation and data of single year and multiyear ice thickness to further understand melting and movement of ice, especially with increased exploration within the region. Geo-engineering might be necessary to prevent dire consequences in the Arctic such as ocean acidification and ice melt.

There may have to be large-scale geo-engineering in the Arctic during this century. Specifically, an effort to increase the albedo that is currently decreasing because of ice

Figure 3. Anticipated changes in Arctic sea route navigability.
melt may be needed to reduce warming. Secondly, acidification of ocean water is occurring faster in the Arctic than in other oceans, and an attempt to increase the water’s PH Level may be needed to protect marine species whose exoskeletons are susceptible to decomposing at lower PH. A strong Arctic Council could provide the necessary leadership and management for such types of research.

The Arctic Council has served as a “governance incubator” and it has negotiated two legally binding agreements that manage search/rescue and the other issues dealing with oil spill response. In regard to geo-engineering, the informality of the Arctic Council could be an asset. A formal treaty addressing geo-engineering is virtually unimaginable; however, a method of managing geo-engineering experiments by the Arctic Council would seem less impossible.

A challenge of making policy in the absence of sufficient information was discussed. Panelists agreed that the Department of Defense and others have to make decisions in the midst of uncertainty on a regular basis. Decision-makers never have certainly. Putting bounds upon the uncertainty helps. “Uncertainty is not an excuse (for not making policy)”.

**Climate Change and the Wine Industry**

The dinner presentation on Day 1 of the 2014 AWF provided a real-world example of the impacts of climate change. After a brief tutorial on the types of grapes and how wines are made, anticipated latitudinal shifts in ideal regions for wine-making were presented based on the results of the latest internationally coordinated runs of climate models. Some vintners have already begun to secure land in more northern and southern regions based on this type of knowledge.

**Congressional and Executive Staffers**

Both House and Senate staffers pointed to an inherent necessity to initiate conversations among all sectors. The scientific community needs to recognize the economic implications, while policy makers are urged to understand the scientific requirements and current innovations.

Congressional staff from the Science, Space and Technology Committee announced the approval of H.R. 2413, the Weather Forecast Improvement Act, which the House passed that day. The bill prioritizes the need to develop a robust and competitive weather forecasting system -- second to none -- by increasing computational capabilities, creating a better satellite portfolio to meet the need of NWS and DOC (specifically for aging satellite platforms), and the inclusion of research to operation (R20) investments, among others.

Initially, Section 2 of H.R. 2413 made weather forecasting the primary goal among all NOAA offices. The bill had to be modified to accomplish a bipartisan compromise, yet weather forecasting is prioritized. Staffers suggested that one important section was to enable NOAA to purchase commercial satellite weather data. Another is to address forecasting needs through inputs from NWS and private forecasters, sociologists, and
Others. An additional requirement is to identify what technology & resources are currently in existence, but not available to NOAA.

The importance of keeping the NWS employees at “the heart” of this budget was addressed. Budgetary pressure behind the NWS structure motivated the Weather Bill. However, discussions with management at the Weather Service have been difficult. Panel members agreed on the need for increased communications among the research centers of NOAA – NWS, NCEP and OAR. Several examples were addressed in which this relationship has been problematic to include the challenges involved in the approval of the “Sandy Supplemental”.

Additionally, there is a need to establish a relationship between the Department of Commerce and NOAA NWS to develop a seasonal forecast to support farming and transportation activities, particularly during anomalous winters. Complications occurring in the Chicago area the 2013-2014 Winter Season were addressed. Farmers and transportation companies could benefit from having enough lead-time to make corporate decisions, which will require seasonal forecast to be as skillful as short range forecast. A proposed alternative was to improve the transportation infrastructure instead of just focusing in the forecast models. Interagency interaction through the National Transportation Safety Board is imperative and should include national disaster/weather and climate events.

The panel stressed the need of obtaining more feedback and involvement from the community. A recommendation from the participants was to increase the participation of academia in Research-to-Operations (R2O), observations and forecast improvement. The problems addressed by the panel were not limited to impacts to OAR and NWS, but also involved NSF budget challenges to support research vessels and aircraft operations. Involvement of NSF is also important, as it significantly supports academic community. A debate on budgetary cuts in operational science (related to OAR) vs. basic science (NSF) resurfaced, particularly since applied science has been taking a hard cut since 2008. Budgetary cuts in the social sciences were also mentioned as causing a negative impact because it disengages different sectors. The sector was urged to be more proactive to support academic, basic science and basic research.

**Impacts of Extreme Weather and Climate Events on Health**

The extent of human health risks from extreme weather and climate events depends not just on exposure to these events, but also on the status of the public health and health care systems, built environment, and natural environment, and on the capacity of individuals and communities to understand the risk, and avoid, prepare for, cope with, and recover from extreme events. The panelists explored how recent scientific understanding of the magnitude and pattern of possible impacts, and of the effectiveness of measures to communicate and manage risks, can inform local to national policy development.

The presentations in this session revealed a general consensus that climate change and weather has impacts on public health, and more needs to be done to understand the risks, preventative measures, and best practices that would serve to minimize health
impacts. Climate change is expected to exacerbate health impacts in the future due to extreme heat events (and thus increasing the risk for heat related illness), wildfires, poor air quality, dust (increasing the risk for reemerging disease such as Valley Fever), and extreme weather (increasing risk for injury, risk of drowning, waterborne-diseases, damage to infrastructure and health infrastructure). Recent events such as Hurricane Sandy revealed vulnerabilities in urban lifelines and infrastructure (water supply, electricity supply, gasoline supply, pharmacy/drug supply, transportation) that lead to a series of cascading impacts that further compromised health. In order to minimize the health impacts of climate change, we should focus on preventative measures and providing adaptation tools; identifying vulnerable populations (elderly, young, pre-existing health conditions); and addressing factors that make the population vulnerable (urban heat island, income, housing design). Figure 4 illustrates an example of an extreme dust event impacting human health far from the location of the event itself.

Specific needs highlighted by panelists include:

- Identify and address barriers to adaptation (different vulnerable groups will have different challenges)
- Consistent, clear and targeted messaging on health impacts of weather and climate
- Interdisciplinary efforts and risk assessment studies quantifying the public health impact of dust storms
• Improved prediction of extremes (predictions of averages are not enough)
• Collaborations on verification of weather-related deaths through use of the Electronic Death Registration System
• Better understanding of highly complex systems and context specific vulnerabilities

Q&A with the audience:
The merging of weather and climate and health mismatch in time, scale and space was probed. We do bring datasets and collaborations together better than we have been and match emerging technologies (e.g., dust forecasts and climate predictions with health surveillance). This has been done in some cases (NYC inundation maps overlaying deaths during Sandy) but more can be done. Simply using each other’s data is not enough - all need to see the benefits of merging data. We also need continuity on the message that is being communicated.

Researchers can help communicate the importance of sustained funding for climate and health research. Networks and personal connections can help with facilitating collaborations among different disciplines. Research on economic impacts of climate change is needed. Health decision makers want to know the costs of impacts and adaptation options.

As a community we are not doing all we can to better predict air quality and support public preparedness. State and local authorities rely on national guidance from NWS but it has to be a partnership. Budget authorities perceive duplication of efforts but don't recognize the unique roles of each agency and the partnership with states. The Clean Air Act was designed for long term planning, not a tools for quick response to individual events. There is a need to re-evaluate roles because harmful ozone levels are not going away.

**Space Weather Mitigation: Recovering from a Carrington Event**

The Committee on the Societal and Economic Impacts of Severe Space Weather Events by the Space Studies Board of the National Research Council published its last Workshop Report in 2008. They said: “The adverse effects of extreme space weather on modern technology -- power grid outages, high-frequency communication blackouts, GPS disruptions of aircraft flight systems, spacecraft anomalies -- are well known and well documented, and the physical processes underlying space weather are also generally well understood. Less well documented and understood, however, are the potential economic and societal impacts of the disruption of critical technological systems by severe space weather,” like having a re-occurrence of the 1859 Carrington Event. Today Americans are familiar with all types of natural hazards and understand how to prepare and mitigate their disastrous effects. The question must be asked if the government exists to safeguard the people, why hasn’t the federal or state government done more to educate and prepare the public for the dangers of space weather that could potentially cripple electrical power systems on Earth? Why haven’t more studies been conducted to examine the socioeconomic impacts of extreme space weather events and develop risk assessment strategies to deal with severe space weather? It’s a
matter of probability that we will experience another Carrington event. As noted in a June 17, 2011 New York Times op-ed: "What good are space weather alerts if people don’t understand them and won’t react to them?" This panel focused not on solar physics or what is a Coronal Mass Ejection, but how the nation can prepare for an event of this magnitude and what does society do afterwards. How do we recover from another Carrington Event?

Space weather can have a major impact on our daily activities, as shown in Figure 5. Space weather generally refers to conditions on the Sun and in the solar wind, magnetosphere, ionosphere, and thermosphere that can influence the performance and reliability of space-borne and ground-based technological systems and that can affect human life or health. Space weather effects on Earth are not a new phenomenon. In 1989, a severe geomagnetic storm caused the collapse of the Hydro-Quebec grid. The panel focused on largest solar flare event ever recorded in September 1859, known as the Carrington Event (CE). While space weather can affect various technologies (e.g., satellites, GPS) and people, including astronauts and crew or passengers on high flying jets, the panel expressed the biggest threat is on our power grid.

![Figure 5. Space weather impacts on technology and society.](image)

We should begin by rethinking the definition of a CE. For example, we can define a modern CE as a geomagnetic storm. It can cause power blackouts and permanent transformer damage and disturb the ionosphere. There is variability of space weather events that generally correspond to periods of low and high solar activity. Yet we are not completely defenseless. The NOAA Space Weather Prediction Center provides
official watches and warnings of space weather. Industry can then take action based on those products. There are several satellites that provide research and operations support, including NASA’s Solar and Heliospheric Observatory (SOHO) which studies the external and internal structure of the sun to help understand the origins of the solar wind.

Legislation like the Grid Act and Shield Act could spur protection of the grid to geomagnetic storms. However, for various political reasons, this legislation failed to pass through Congress. It would only be a minimum cost to protect the roughly 300 transformers that protect our civilization from functioning in a modern society. The state level governments have been more successful. Maine, Virginia, Florida, New Mexico have taken steps to safeguard the grid and these efforts are continuing at the federal and state level.

The participants questioned how the U.S. could make the space weather threat more of a priority. We need popular support. There are inexpensive and simple procedures that anyone can do to prepare for a long duration black-out event, caused by a space weather storm. The Department of Defense should start planning for something like a CE. Recently, President Obama acknowledged for the first time at the executive branch level that a large geomagnetic storm is a threat. Nonetheless, nothing has been done to harden the grid. During these types of events, the media will tend to promote the aurora phenomenon rather than let the public know the potential threat it can pose.

Impact scenarios of a CE level storm could include power outages in highly populated areas along the east coast (20 – 40 million people). Total economic cost for such a scenario could be in the trillions of USD. A substantial geomagnetic storm can cost more in terms of USD than any major natural disaster witnessed. Space weather prediction is still in its infancy and the consensus among panelists is the need to further develop technology and models to help predict future space weather events. The panel and participants agreed that there needs to be more education and awareness of the potential impacts of geomagnetic storms.

**Federal Agency Leads**

Panelists from four major federal agencies each gave a 10 minute opening statement that looked ahead, provided updates on current weather, water, and climate programs, and provided insights on new science initiatives and directions. The subsequent discussion emphasized topics related to future programs and initiatives that may lead to business or partnership opportunities for AMS Members.

The public health sector is currently involved in bridging the practice of public health with research. There’s a lot of focus on data and developing quantitative results as a tool for creating improvements. The president’s Climate Action Plan is focused on building healthy and resilient communities and creating a resource packet. The timeline they are pushing for is a year. One of the interests for NIH is public health in the context of climate change, a key example of how climate change is a multidisciplinary collaboration. The Climate Change and Human Health Workgroup (CCHHG) was created
in 2009 to further research human health. The MATCH (Metadata Access Tool for Climate and Health) is a database with health information that can be used to study the effects of climate change on health. The Interim Assessment on Human Health is a report on health impacts caused by heat, diseases, and other natural causes that may be influenced by climate change.

The important topics for USGS include developing renewable resources, protecting ecosystems, monitoring water systems, and creating the most accurate form of forecasting. Climate scientists are working with regional partners in academia and federal agencies. USGS has developed great monitoring systems and databases, trying to figure out how to build resilient communities in vulnerable areas. It has also advised for adaptation and strategies for dealing with climate change's impact on communities. USGS does not necessarily involve weather, but its water monitoring capabilities can detect potential floods. The next generation of new monitoring techniques can give a better idea of what occurs with rivers. USGS has worked with the National Weather Service to develop a debris flow early warning system in southern California, which is very vulnerable to landslides, debris flow, and wildfires. USGS looked at the path of Sandy to figure out what type of damage, inundation, and erosion it would cause.

The Earth Science Division of NASA enables research, applied sciences, technology, and a flight element (satellites). 2014 is an active year for satellites, with 5 launches scheduled this year. A launch from February 2014 will allow more accurate precipitation measures. A July 1st launch will increase the accuracy of detecting carbon dioxide. Later in July, RapidSCAT will be launched. In September, a LIDAR system will be launched. Finally in November, SMAP will be launched. Many of the satellites will be kept at the ISS, and 9 additional launches are scheduled from 2015 to 2021. Applied sciences will include applications in health, water, and other disciplines. They are currently working on new technology such as cube satellites.

The National Weather Service is spending their efforts in making a weather-ready nation in which the Impact-based Decisions Support Services is a key component, as shown in Figure 6. Weather-Ready Nation is about building community resiliency and improving the "Last Mile" of forecasting, which involves communicating potential impacts to decision makers. Their connection with the social sciences has grown with the use of social media, refining warning messages, and expanding partnerships. There is also the goal to improve access to data across NOAA and finish the preparation service document. The Integrated Water Resources Science and Services (IWRSS) has a partnership with FEMA and will elevate water resource services and forecasts. Sandy supplemental funds were a major boost to the NWS, and were used to improve the resolution of the GFS, HRRR, HWRF, and other models. Research operations, accelerating the improvement of models, preparing for extreme weather events, and addressing the IDSS for the water community are future goals.
Some Current Capabilities and Future Plans for Surface Transportation Weather Support

Last year’s AWF Transportation Session focused on the need for and the importance of improved weather support for surface transportation, since weather usually causes greater overall human and economic impacts to the nation than all of the combined major meteorological events (e.g. hurricanes, tornadoes, lightning, etc.), which receive most of the attention and resources; broadly outlined recent studies on developments and potential of new technologies; and described some ideas on future opportunities. In keeping with the theme for this year’s Forum, this session followed up on these ideas with a concrete example of a very successful implementation of new mobile observations technology support by the private sector; a discussion of newly developed public sector plans for research, development, and application; and finally a perspective on how the federal government may be of assistance in integrating the new technologies from various sectors and accelerate their use to benefit society.

What if there was an accurate weather forecast that told people how it would impact the transportation system? How would they react differently, if you told them that there was a 20% chance that thousands of people would be stranded on the
roadways because of the deteriorating road conditions due to weather, such in the case of Atlanta this year? “Connected vehicles” and “Mobile Observations” may be the solutions to get real-time road weather data, routing and navigation, and mobility information to the motoring public to improve safety and reduce impacts.

There are on average over 5.8 million traffic accidents in the United States a year of which 23% are weather-related. There are also billions of hours of related travel delays, which can be expensive, waste time and gasoline, and result in generating more greenhouse gases. Basic messages from vehicles can transmit speed, heading, position, acceleration, size, break system status, and other data, which can in turn be used to issue threats and warnings and include weather information that may help in preventing crashes and delays. Other applications may include blind spot/lane changing warnings, do not pass warnings, left turn assist, emergency electronic break light, forward collision warning, and intersection movement assist, which could warn a driver based on wireless messages received from other vehicles. Weather relevant data would allow vehicles to collect data from temperature, windshield wiper use, anti-lock brake use, steering patterns, and speed. Developing these capabilities would need to research across many different disciplines.

Weather Telematics, Inc., currently works with several vehicle fleets to collect a wide range of weather and vehicle information in real-time and provides the ability to communicate with computers on board vehicles. “Telematics” can in general be thought of as an “OnStar” type system that collects information from the vehicles on which they are installed, processes the data, and can relay messages back to the vehicle. Many types of real-time collected, processed, and disseminated information can be meaningful to the public in providing accurate weather alerts in order to direct drivers to the shortest and safest routes. This real-time dynamic weather alert system could help drivers in the decision-making process on whether they should risk driving on a certain road or whether they just need to slow down their speeds. Looking into the future, eventually there probably would be a need to include data from traffic lights and traffic signs based upon car sensor information to help drivers avoid hazards. Weather sensors have been and could be installed on vehicles to collect data like precipitation intensity, air temperature, road temperature, wind speed, relative humidity, pressure, and dew point—many standard weather variables. More than 1500 vehicles outfitted with Weather Telematics equipment generate observations every 5 seconds and result in more timely and representative observations for the motoring public than conventional weather stations. Just this relatively small number of vehicles can provide more than an order of magnitude more observations a small fraction of the cost of the conventional weather observing network. Figure 7 shows an example of how mobile observations of this kind can be used.
It is important that the AMS community understands the magnitude of road weather impacts to people and the economy. On average, there are annually over 6,000 fatalities and over 480,000 injuries from over 1.3 million weather-related vehicle crashes (see http://www.ops.fhwa.dot.gov/weather/q1_roadimpact.htm ). These numbers are an order of magnitude larger than those attributed by the National Weather Service to weather phenomena, such as tornadoes, hurricanes, lightning, etc. The economic impacts due to prevention, damage, and delays are also huge. For example, state and local agencies spend nearly 2.3 billion dollars annually on just snow and ice control operations. We need to decide how much of an affect NowCasting will have compared to forecasting. Mobile weather stations on board could help reduce accidents and save lives and economic resources.

The USDOT Intelligent Transportation System (ITS) Joint Project Office (JPO) has been gathering data to develop a new 5-year strategic plan. The AMS ITS/Surface Transportation Committee and its Mobile Observations Subcommittee have recently sent in recommendations that address research needs in the surface transportation area and many of these specifically address areas to get the most out of mobile observations.

There isn’t really a nationally managed surface transportation program, since most operations/activities are handles by the states. The Federal Highway Administration (FHWA) has a limited budget for research activities and to inform stakeholders of recent developments. Clarus and the Maintenance Decision Support System (MDSS) were two successful FHWA research programs that demonstrated capabilities, which can benefit the road weather community. Clarus is now transitioning into the NOAA Meteorological
Assimilation Data Ingest System (MADIS), which collects, integrates, quality controls, and distributes observations from partnerships with local to national and international data networks. MDSS is now being used by a number of organizations in the road weather community to make road condition determinations. The Pathfinder Project is a current surface transportation weather collaboration project that tries to understand the impacts of weather to reduce accidents. People often need multiple sources, such as the TV meteorologists, mobile alerts, and other contacts to reinforce their decisions before they actually react to a road weather situation. There is a need for a core group in the National Weather Service (NWS) to work across disciplines including aviation weather and surface transportation people to help bridge the gap between weather and climate. There is a need to be working to meet strategic goals set forth in the Weather Ready Nation’s Roadmap to improve products and make more data available to the weather enterprise.

An exciting new opportunity that is underway is the implementation of this mobile surface data in Real Time Mesoscale Analysis (RTMA) and other high-resolution mesoscale weather forecast models. At this time, launching technology and working with parts manufacturers is important because some of these ideas will take years to get onto vehicles. The weather will also be very important down the road for self-piloting vehicles. There will be a mixed intelligence since some cars would have this capability and some cars will not. It is important that the driver remembers that they are driving the car so the warnings and advisories should be directed at the drivers.

In the Congress -- it appears that preventive use of weather is often overlooked and weather-related legislation is often in the form of disaster relief. The last transportation bill consolidated programs and there is no dedicated weather research program and USDOT now has the flexibility on what is funded. There is a new bill being worked that will have more emphasis on innovation and determining the right policies to deal with new technologies. There will probably not be an effort to grow programs, but rather to get more efficiency from existing ones.

Question/Answer Period Summary:

What is the vision that these “telematics” type devices will evolve to a larger number of non-commercial vehicles? The answer was that they are starting to put them on Lexus vehicles, but more widespread use could take 12 to 15 years.

Who is responsible for rulemaking in the USDOT? The rules are generally put in place by the USDOT National Highway Traffic Safety Administration (NHTSA). There are no specific items on weather in their recent announcement on mobile observations.

How will we operate in the transition when some vehicles having the advanced capabilities and some not? The response was that the driver will still have the ultimate responsibility and that “connected vehicle” data only provides information for a driver to make the decision.

What is the relationship between the transportation community and the Center for Disease Control (CDC) with respect to capturing cause of death? The Congress and NHTSA have both worked with the CDC in this area. More collaboration should be encouraged.
How are mobile observations being used for road maintenance and poor road avoidance? It was cited that climate change may exacerbate problems in some areas, but that Boston already has a phone app for identifying pot hole areas and demonstrated that some uses are already underway.

Water-Energy Nexus

Population growth, economic development and the increased demand for energy are stressing U.S. water supplies and causing a dependency on other countries for energy sources. For these reasons, coupled with a changing climate, the need for an integrated approach to science and services for water resources in the energy sector has never been greater, yet our nation’s ability to meet that demand is inadequate. In the Water-Energy Nexus session, panelists discussed threats to our nation’s water resources, interagency coordination to address national outcomes for water and energy, advances in offshore renewable energy development, and the challenges and tradeoffs in the water-energy nexus.

There are opportunities to develop improvements in water quality; improve modeling and synthesis. We need to develop better forecast models to help with the growing thirst for water. Water for energy (e.g., to extract mineral resources, cool thermoelectric power plants) and energy for water (e.g., to pump, treat and deliver water supply, to collect, treat and dispose of wastewater) are both important cycles – see Figure 8. Energy production consumes significant amounts of water. National data obscure state-specific differences in water-related energy use; for example, in California 19% of electricity is for water-related use vs national use of 4%. 80% of the electricity used at water treatment plants is used for pumping. Most of the time energy is not used efficiently at wastewater and water utility plants; cost is a significant barrier to using energy for water-related purposes more efficiently. Saving water saves energy and also reduces carbon emissions.
Figure 8. Water for energy and energy for water.

Significant research and information needs exist, with huge data gaps on how much energy is needed for water heating; no public or private entity collects energy data from water utilities or other end users; data collection and quality control standards are lacking; research is needed on advanced technologies to save water and energy. There needs to be more cooperation between water utility companies and energy companies.

- Most power plants run on water (steam generation and cooling)
- Plants have problems with incoming water being too hot and outgoing being too warm
- Low carbon does not necessarily mean low water usage
- Switching from coal to nuclear does not necessarily decrease water usage.
- Wind and solar decrease water use
- >20% of SW water supply is used for power generation
- More education and outreach are needed

Critical question: Are power plants resilient to future extreme events?

Panel Observations:
- Florida has the highest potential for ocean-energy production in the US
- Small scale tests of ocean-energy production are currently ongoing, but there is a funding gap and we are fighting for resources
- The U.S. is behind Europe on marine-energy technologies
• Projections on water use and availability have the most uncertainties according to recent reports
• Models are not convergent for water use and availability
• Major science issues are modeling and data infrastructure, model resolution
• Mountain snowpack is a huge concern and their resolution needs to be better discerned on the models

Typhoon Haiyan

Typhoon Haiyan was an unprecedented storm. Figures 9 and 10 illustrate the impacts. Making landfall in the Philippines on November 8, 2013 as a Category 5 typhoon, the storm left significant damage in its wake. Additional countries impacted included Vietnam and southern China, as well as Micronesia and Palau. It was the strongest cyclone to hit land in recorded history. While the storm’s 200 mph winds were devastating, it was the two-story-high storm surge that was most destructive - flooding homes, schools, and hospitals. Since 1969, only three storms have had sustained winds close to this magnitude — Hurricane Camille in 1969, Super Typhoon Tip in 1979, and Hurricane Allen in 1980. Typhoon predictions – and related technology – have improved substantially over this time, and the predictions for Haiyan were quite accurate. However, the impacts of this storm were still huge, especially in the Philippines. This panel examined some of the technologies that assisted with the prediction and response to this storm, and how they compared to what was available in past storms – and explored what should happen next in planning for the next super typhoon like Haiyan. The panel discussion also addressed the comparisons in prediction and response to Superstorm Sandy that hit the coast of New Jersey in October 2012. This panel was focused on the technology and innovation surrounding the prediction of and response to Typhoon Haiyan.

The presentations revealed a consensus that there is often a disconnect between the messages that forecasters and emergency managers relay to the public, and how the public interprets the messages. While the technology used to forecast weather events like Haiyan were generally accurate, and there is high confidence in weather predictions, there is still work that needs to be done to improve lead time, accuracy, and specificity. However, the response was the biggest issue. A question was posed about whether we are not focusing enough on the ground impacts associated with high impact weather. Communication to the public needs to be improved beyond knowledge based on the timing and severity of storm to include the impacts and the actions that need to be taken in order to adequately respond to the storm.

In the robust discussion that started after the presentations, a question was asked about the needs of developed versus developing countries for warnings and lead time. The response of the panel varied based on their backgrounds, but the consensus was that developed countries are inherently more prepared due to more infrastructure investment and consistency of messages over time. In developing countries, while advance warning time is helpful, there is a need for greater preparation for navigating and recovering from the damage that will come when major storms hit areas with sub-
standard infrastructure. While advance warning provides the public awareness, it takes efforts over time to convey what warnings can really mean in terms of access to food, water and power as well as other hazards that are inherent after a major storm.

Figure 9. Estimated impacts of Typhoon Haiyan prior to landfall.

Figure 10. Satellite views of impacts of Typhoon Haiyan.