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Building a Stronger Weather and Climate Enterprise:
Keeping the Economy Moving

Betsy Weatherhead, U. Colorado and George Frederick, Vaisala, Inc., co-chairs

AMS Summer Community Meeting
August 8-11, 2011
Boulder Colorado

Did you know?

Weather is responsible for roughly 20% of all trucking delays, costing in excess of $3 billion per year. (Dan Krechmer, Cambridge Systematics, Inc.).

Weather applications are the second most popular used "apps" on mobile devices—more popular than social networking, maps, music and news. (Barry Myers, AccuWeather).

Public Service of Colorado has realized a $3.1M annual savings due to recent improvements in weather forecasts for wind renewable energy. (Keith Parks, Xcel Energy).

Forty years ago the average three-day forecast of hurricane landfall was off by 400 miles; today our average forecast is almost down to eighty miles. The prospect is real that we will make as much progress in the next ten years as we have in the past forty. (Alexander E. MacDonald, NOAA).

Heat waves kill more people than floods, lightning, tornados and hurricanes combined (1995-2004); forecasting and communicating these risks saves lives. (Christopher Uejio, NCAR/CDC).

The US economic activity (GDP) varies by up to plus or minus 1.7% due to weather variability, resulting in impacts as large as $485 billion of the $14.4 trillion 2008 GDP. (Jeff Lazo, NCAR).

There are 70,000 new cases of potentially deadly skin cancer (melanoma) every year. A new mobile application developed by university scientists helps individuals know when they've been exposed to too much ultraviolet radiation. (Craig Long, NOAA/NWS).

These and other interesting aspects of weather were discussed in Boulder, Colorado where the public, private, and academic sectors involved with providing weather services came together through the American Meteorological Society (AMS) and its Commission on the Weather and Climate Enterprise. Over 200 participants convened to discuss areas of common and pressing interest with a particular focus this year on the critical data needs and the economic value of meteorological services to society. The community recognizes that national and global economies have been reeling in recent times from major setbacks from various causes—not the least of which are those created by weather, water, and climate phenomena, from significant tornado outbreaks, to the fallout from the tsunami that brought devastation to Japan. The entire weather, water, and climate enterprise has much to offer in recovering and building vibrant global economies. At stake are hundreds of billions of dollars in economic productivity,

protection of valuable resources and the safety of countless lives.

Particular areas of interest in our community meeting this summer included:

- Economic value of the public and private efforts on weather
- Meteorological data
- Transportation
- Renewable energy with emphasis on offshore wind and solar energy
- Environmental information services
- Carbon and greenhouse gas information products
- Human health
- Water resources with emphasis on drought and floods.

More detailed information on each of these subjects follows. This summary provides an overview of the highlights and crosscutting themes of the meeting, as well as the consensus recommendations from those convened. The meeting provided insight toward the next steps of coordinated, effective action and cooperation across all sectors of the enterprise to address these issues.

Value of the Enterprise
The economic value of the enterprise was examined from a number of different perspectives related to improved forecast skills that result in saved lives and property as well as direct economic impacts. The economic value differs by sector and in all cases relies on estimates as to loss that would have occurred if current forecasts were not as precise. Sectors affected by the economics of current meteorological activities include transportation, energy, agriculture, human health, and commerce.

The enterprise is working – based on NOAA's foundational forecasts and private sector development
Across sectors, key to the successful use of meteorological information to save lives, protect property, and improve the economy is providing users with information that is tailored to their needs and allows actions to be taken. To this end, a large number of successful companies are using NOAA's fundamental meteorological data and foundational forecasts to provide tailored forecasts to private users. This close and symbiotic relationship is allowing the most effective and efficient delivery of meteorological information in the world. The continuation of NOAA's ability to provide foundational forecasts will certainly impact the success of this important industry. The growth of these private companies, as well as the success of the individuals and industries that rely on the tailored forecasts requires expanded capabilities to access NOAA's data and weather products to meet the growing demand.

National meteorological needs are transforming
Many of the industries that rely on meteorological information are undergoing transformations that will result in an even stronger reliance on weather information. Automobiles will soon be collecting and sharing a variety of information that can inform others about the safety of road conditions. Increased energy demands and changes to renewable energy will require increasingly precise forecasts within the lowest layers of the atmosphere. Increases in transmittable diseases, as well as skin cancer and asthma, require closer collaboration between health officials and meteorologists to develop effective information for those at risk.

There is a growing need for weather information
The combined efforts of public, private, and academic sectors are successful and extremely efficient for addressing current needs. As societal demands for more accurate, immediate and tailored information increase, the coordinated efforts of the enterprise community is likely to be of even greater value. In all likelihood, the transportation, energy, and human health demands for meteorological information will

grow in the future, as their needs increase and change. The current model of NOAA providing foundational data and forecasts while private companies meet the needs of individual industries will likely continue to work for most commercial uses of meteorological information. For public health and safety, continued collaboration between government agencies, academia, and private companies will likely address the future requirements.

Observational basis of forecasts are at risk
There is considerable concern across a variety of sectors that rely on meteorological forecasts that many of the observational datasets will no longer exist. There is specific concern about a potential gap in satellite coverage in the coming years. There is equal concern about the large cost of satellite development, launch and maintenance, as well as any cost overruns that may occur. The enterprise is prepared to evaluate and prioritize, but such a prioritization will take some time because of the number of sectors that will be affected and the range of options that would need to be examined.

Requirements to support economic growth
As the economy grows, demands for energy and water will continue to increase. The enterprise is mobilizing to address the future needs, including forecasts relevant to conventional, solar and wind energies, as well as the increasing estimates of future water resource availability. In many cases, this planning is coordinated at a state or federal level, with direct impact to local municipalities. Fundamental ongoing research supports these needs, with industry and federal governments becoming increasingly involved in requesting new information for both short-term and long-term planning.

S***ummary***
The primary message that clearly resonated in all sessions of this meeting is that the joint efforts of academia, industry, and the public sectors are working efficiently and effectively to meet the current needs. While many aspects of society are changing, the demand for reliable and available meteorological information will continue to grow. The ability of the enterprise to meet these demands will have a direct impact on the economic health, environmental growth, and appropriate environmental stewardship of the nation.

We, as co-chairs of the meeting, will be available to answer questions and continue discussions on any of the points made within these meeting documents. Progress on all recommended priorities will be addressed at the 2012 AMS Summer Community Meeting.

Respectfully,

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More detailed information about the 2011 American Meteorological Society's Summer Community Meeting is available on-line at www.ametsoc.org or contact Dr. Betsy Weatherhead, incoming Chair of the AMS Board on Enterprise Communication, Betsy.Weatherhead@colorado.edu

Meteorology and the Economy: Session Summary

The weather enterprise will face significant challenges in upcoming years due to constricting federal budgets at a time when the data it provides will only become more important to societal needs and provide benefits not previously recognized. The panel was charged with looking at the user community, trends within the community, and the need to recognize how our community must advocate for its programs and their relevance in the upcoming budget debates.

The panel consisted of:
Ed Johnson, Director of the National Weather Service Office of Strategic Planning and Policy,
Brian Bell, Vice President and General Manager of Global Science and Technology, Inc.,
Berrien Moore III, Vice President, Wx and Climate, Oklahoma University, College of Atmospheric & Geographic Sciences,
Barry Myers, Chief Executive Officer of AccuWeather,
Jeff Lazo, Director of Societal Impacts Program at the National Center for Atmospheric Research.

The panel was chaired by Scott Rayder of ITT Geospatial Systems, Inc.

The panelists provided information on the current estimates of value of weather information to the public sector and made the following points:

- Weather forecasts and products are vital to economic activity in the US and relied on by individuals across the country. Weather apps are the second most popular application on mobile devices, ahead of social media, music and news (games are the only category that are more popular than weather apps).
- The community needs reliable and repeatable numbers that we can all speak from as to the size and reach of the community. The US economic activity (as estimated by the GDP) varies by up to plus or minus 1.7% due to weather variability, resulting in impacts as large as $485 billion of the $14.4 trillion 2008 GDP. Initial estimates of the size of the combined enterprise and specifically, the size of the private sector in delivering services that protect life and property in a value-added manner indicate a very high return for investment.
- Many new players are entering the weather market, including small companies that have big plans for how they create, market, and distribute weather information. These companies are growing and have the potential for further growth as either providers of observations, value-added forecasts, or both. The current value of all forecasts is estimated at $31.5 billion per year. Virtually all of these companies rely on forecasts or data from Department of Commerce's National Oceanic and Atmospheric Administration (NOAA).
- New technologies such as the mesonets (stationary and mobile) could very well revolutionize future weather applications. We are in an era where every hand held-device is now a conduit to get information as well as an observing platform. These innovative data collection practices are offering improvements in targeted forecasts such as those needed for improving energy efficiency and supporting alternative power providers.
- Partnerships between government, academia, and the private sector will enable meteorological products that are supplied to the country in the most efficient manner. The market will pick the winners and losers in the larger weather market. The current demand for improved forecasts exceeds the delivery. Of households surveyed, most

indicated a willingness to pay between $12 and $14 per year additionally for improved forecasts. The enterprise is actively fostering new collaborations aligning the best expertise from the private sector and government.

Following the presentations, there were a number of excellent questions and comments. Generally, they all acknowledged the need to build from the current analysis of the economic benefit of the enterprise to a comprehensive analysis. Initial studies all support that the public values weather services and is willing to pay for further improvements on weather services. The demand for these products is fostering a growing and successful industry that relies on NOAA data and foundational forecasts from the National Weather Service (NWS) for success.

Further information on the panelists' presentations can be found at http://www.ametsoc.org/boardpges/cwce/docs/2011-08/agenda.pdf and the embedded hyperlinks.

Meteorology and the Economy: New Priorities

Weather affects many sectors of economy from agriculture to transportation, human health to energy usage and water resources. The enterprise of public, private, and academic efforts is supplying expert advice to inform both weather-dependent industries and the general public. Every study to date shows that the economic returns on investment for all weather-related activities are quite high with annual returns averaging from 2.2 to 6.5. Few other government-private partnerships are as successful at saving lives, expanding the economy, and adding jobs. In the coming years, efforts are needed to more completely identify the value of the meteorological enterprise and determine the areas in which further improvement will add most significantly to the economic value for this country.

TOP LINE OBJECTIVE: Weatherproof the Nation

1st YEAR GOALS (2011-2012):

- Establish a dedicated effort both within NOAA and the private sector to review all studies that analyze the economic impact of weather and the economic value of weather forecasts.
- Quantify the size and growth of the private sector in terms of economic activities, tax revenue generated (is NWS a Federal "profit" center?), and new jobs created from adding value to current NOAA/NWS products and data.
- Determine whether there are any immediate problem areas with respect to meteorological services that are hindering current US economic growth (i.e., longer range forecast capability, resolution, etc.).

THREE-YEAR GOALS (2014):

- Identify what products and services are vital to private industry today and what hard challenges will need to be addressed in the future.
- Carry out new studies to estimate the economic value of current forecasting capabilities within both the public and private sectors.
- Develop metrics for economic success to estimate impacts of current, improved, and diminished forecast skills to all major sectors affected by meteorological services, including but not limited to transportation, disaster management, agriculture, human health, energy usage, energy production, water resources, and manufacturing.
- Engage the private sector to identify methods for improvement of private sector's role in meeting US' needs for meteorological services.
- Establish a priority list for observations, measurements, and services currently provided by government agencies to be targeted spending cuts.

FIVE-YEAR GOALS (2016):

- Identify ”emerging’ areas where improved forecasting capabilities can be used beyond alternative energy as well as in new applications.
- Determine key measurements that are needed for supporting required forecasts at current levels and what new technologies could provide a generational “leap-ahead” capability.
- Evaluate metrics for economic success of changes in services.

All activities should be carried out in a transparent fashion, with leadership from NOAA, involvement of private and academic communities and coordination by AMS.

Meteorology and Data Needs: Session Summary

Weather data needs have largely received secondary attention so far compared to climate observations as the Federal Government focused on synoptic scale observations. A few mesoscale observation networks (Mesonets) have emerged. A recent National Research Council report noted that the existing mesoscale observations are sparse, often lack critical metadata attributes and vertical coverage, and the data are not accessible from a centralized location.

The panel consisted of:
Fred Carr, University of Oklahoma,
Brenda Philips, University of Massachusetts,
Marty Ralph, NOAA's Earth System Research Laboratory,
Yuanfu Xie, NOAA's Earth System Research Laboratory.

The session was chaired by James Stalker of Regional Earth System Predictability Research, Inc.

The panelists focused on two of the most powerful tools to identify weather data needs: Testbeds and Observing System Simulation Experiments (OSSEs)

- James Stalker noted that weather observations will always be sparse and the weather data needs unfilled, unless robust model data are fully integrated with observations.
- Fred Carr reviewed various definitions of testbeds and produced a list of desirable characteristics for testbed selection.
- Fred Carr also pointed out urban areas should be prime testbed targets as more people will be impacted and benefit from such efforts. Fred's takeaway: Let's get started and begin to form multi-sector partnerships.
- Brenda Philips talked about her team's efforts to produce high spatial/temporal lower boundary layer observations using X-band radar systems, integrated with other observation platforms, over the Dallas/Fort Worth area and showed how such observations can be used by weather forecasters, emergency managers, and end users.
- Brenda Philips also talked about how their experiences can be useful in designing future testbeds for other urban areas. Brenda's takeaway: Recognize the critical importance of end user needs.
- Marty Ralph provided an overview of the NOAA Hydrometeorology Testbed and how those testbed efforts resulted in not only the identification of the so-called atmospheric rivers but how such rivers remotely monitored could be used to effectively diagnose/forecast, for example, extreme precipitation events.
- Marty Ralph also pointed out that satellite data are critical for quantitative precipitation forecasts but such data do not include wind information; wind information was obtained from profilers and numerical weather prediction models instead. Marty's takeaway: One size does not fit all, when it comes to testbed planning.
- Yuanfu Xie introduced the concept of OSSEs using simple schematics. He pointed out how "synthetic" observations are generated from a Nature Run for use in the data assimilation of those observations into an operational model. When the two model results are compared, the impact of one or more types of observations can be quantified.

- Yuanfu Xie showed OSSE results of unmanned aerial system observations on hurricane track forecasts. Yuanfu's takeaway: OSSEs offer a powerful and cost effective tool.

Discussions focused on the effectiveness, cost consideration, and general applicability of OSSEs. The discussion highlighted both benefits and limitations of OSSEs. The overall sense of the audience was that the OSSE tool showed promise and should receive full consideration as part of the process of identifying weather data needs. Also, the existing Dallas/Fort Worth area testbed efforts were considered a great step in the right direction with respect to building a Nationwide Network of Networks. The chair had hoped to generate discussion on funding sources for observation networks (e.g., volunteer coop stations) and funding allocation between satellites and other observation platforms, if time permitted.

Further information on the panelists' presentations can be found at http://www.ametsoc.org/boardpges/cwce/docs/2011-08/agenda.pdf and the embedded hyperlinks.

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Meteorology and Data Needs: New Priorities

In order to identify future weather data needs effectively and to fully take advantage of the existing weather and climate data, the Weather and Climate Enterprise must understand and cater to the needs of all stakeholders. Critically important changes will need to be made and traditional roles will need to be redefined as necessary, for the success and longevity of the Enterprise.

1st YEAR GOALS (2011-2012): The Weather and Climate Enterprise Clearly Understands Multi-Sector Roles

- The American Meteorological Society (AMS), NOAA, universities, private sector partners, and weather data users continue the dialog initiated in Boulder to sharpen the weather and climate enterprise value proposition/message and publish a report.
- A new committee, or an existing committee (e.g., AMS' Nationwide Network of Networks group), consisting of members from the AMS, NOAA, private sector, and users should be formed to prioritize the enterprise weather data needs and develop an implementation strategy.
- A new committee, consisting of members from the AMS, NOAA, private sector, and users, will identify all stakeholders by name, including funding entities (e.g., Congress, private investors), develop a database, and invite them all to a meeting.
- The Enterprise will strive for consensus among all stakeholders with respect to their needs, roles, responsibilities and formally publish the details of the agreement on the AMS website for the record.

THREE-YEAR GOALS (2012-2014): Establish a Fully Functional Nationwide Network of Networks or an Equivalent

- Form a new entity, consisting of members from all stakeholders, or formalize the AMS' Nationwide Network of Networks concept that will define an optimal surface and upper air mesoscale network density for the entire country.
- The Entity will further define specific observation data needs within each network through testbeds/models, using as many recommendations already made.
- The Entity, by closely working with all sector partners, will attempt to determine the commercial benefits and revenue streams from all observations.
- The Entity will facilitate privatization of NOAA-owned networks and data dissemination functions where appropriate.
- NOAA will re-examine its role within the broader weather and climate enterprise and produce significantly stronger contributions than ever before.
- NOAA will focus on low-return-on-investment, high-impact, high-risk weather and climate research functions so the other sectors may take on functions suited to them.

FIVE-YEAR GOALS (2016): The Weather and Climate Enterprise Becomes Competitive Globally and Keeps the U.S. Scientific Edge in the World of Earth System Sciences

- The Enterprise, upon recommendation by a committee, will look to produce Earth system models to produce more of the weather data used by all sectors and consumers and facilitate a true paradigm shift.
- Specifically, the Enterprise will work toward supplementing the current/(weak) Starry-Sky picture of sparse observations (stars) with an All-Stars-Sky picture of model-derived weather and climate information plus observations (stars).
- The Enterprise will utilize robust models to drive cost effective observational campaigns and maximize the impact of diminishing funding sources for observations.
- The Enterprise will deliver highly improved forecasts that will save lives and property by developing better initial conditions, schematically described by the All-Stars-Sky picture.

All activities should be carried out in a transparent fashion, with leadership from NOAA, involvement of private and academic communities and coordination by AMS.

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Meteorology and Renewable Energy: Session Summary

Energy is on the national stage with the president stating in his State of the Union Address and articulating in his "Blueprint for a Secure Energy Future" his bold challenge for our nation - to generate 80% of our electricity from a diverse set of clean energy sources. A diverse portfolio of renewable energy technologies must make significant contributions if we are to meet this goal.

The AMS Summer Community Meeting had two sessions on renewable energy. The first was on the economic and technical challenges to achieve high penetrations of photovoltaic energy on the nation's electrical grid.

Keith Parks (Xcel Energy Services) started the session off with a keynote address, which described some of the challenges associated with renewable integration, as well as charting some of the most cost-effective solutions. These solutions included:

- Renewable energy forecasts should drive integration decisions
- Renewable energy can be dispatchable given reasonable operating and market rules
- Fossil fuel plants can be modified for flexible duty (turned down to lower minimums), and
- New facilities can be chosen with flexibility and system integration in mind – to provide more than just cheap power.

Keith also indicated that improved weather forecasts have resulted in a $3.1M annual savings for his company.

The panel for the solar energy session consisted of:
John Manobianco, MESO, Inc,
Richard Perez, SUNY Albany,
Kevin Lynn, U.S. Department of Energy,
Mark Ahlstrom, WindLogics, Inc.

The session was chaired by Andy Stern of NOAA.

The session began with discussions on the technical and forecast challenges for integrating commercial-scale solar energy at the near term and at the day(s)-ahead scale. The session then segued to discussing both cost barriers and new market rules for large-scale solar deployment.

Challenges to forecasting solar energy persist at all timescales and require additional (and accessible) observations, and improved modeling to better characterize the three-dimensional structure and evolution of cloud scale phenomena along with improved calibration and validation of satellite-based products. The end goal of lowering the total cost of solar energy will require a combination of improved forecasting, increased penetration level, and more cost-effective technology (e.g., lower cost for solar panels and balance of plants).

The second energy panel focused on common data needs for the offshore wind energy industry.

The panel for the offshore wind energy session consisted of:
Jeff Freedman, AWS Truepower,
Will Shaw, US Department of Energy/Pacific Northwest National Laboratory,

Angel McCoy, Department of the Interior, Bureau of Energy Management, Regulation and Enforcement,
Len Pietrafesa, North Carolina State University – retired,
David Green, NOAA/National Weather Service.

The session was chaired by Andy Stern of NOAA.

A common theme during the session was the acknowledgement that there are very few turbine-level observations available in the coastal environment to observe the true wind resource. Most efforts to assess the wind resource are performed by extrapolating wind observations from buoy sensors near the ocean surface or from temporarily erected meteorological towers. These observations would be used by the spectrum of participants from government agencies responsible for lease permits and foundational forecasting to academic institutions for research and developers for finance, siting, construction and operational activities.

There are a number of activities that are underway to better prepare the community for eventual wind farm development. This includes several Memoranda of Understanding between NOAA, Department of Energy and Department of the Interior. Research projects are planned for the state coastal waters of the Carolinas. The Department of Energy is attempting to assemble a coalition to develop an offshore energy reference station to test and operate sensors to measure both wind and waves (for future marine hydrokinetic applications). And, the AMS is conducting an Annual Partnership Topic with an aggressive schedule to capture data and modeling needs.

Further information on the panelists' presentations can be found at http://www.ametsoc.org/boardpges/cwce/docs/2011-08/agenda.pdf and the embedded hyperlinks.

Meteorology and Solar Renewable Energy: New Priorities

The panel discussing solar energy at the 2011 American Meteorological Society Summer Community Meeting was asked to formulate a list of possible actions that could move the solar energy industry forward in the next few years. Here is what was proposed:

1st YEAR GOALS (2011-2012):

- Improve the management and availability of observational data for locations near solar plants. Develop a framework to administer and maintain a secure repository for business proprietary observations.
- Provide improved global forecast products – in particular, focus on improving radiative quantities such as cloud cover prediction, which is the largest irradiance modulator.
- Improve availability of solar variables from current NOAA models. For example, some elements may not be included in public distributions, or methods of downloading model grids may be cumbersome for solar forecasting purposes.

THREE-YEAR GOALS (2012-2014):

- Improve the models in terms of data assimilation and physical parameterizations (radiation and cloud physics).
- More integration studies are needed to address higher penetration levels on the grid (including distributed PV which presents different challenges than central PV).
- Improved nowcast/forecast data (beyond 3 hours) would enhance the confidence of utilities and developers.
- Have NOAA's High-Resolution Rapid Refresh model become operational at NOAA'S National Centers for Environmental Prediction.
- Ground-source validation of satellite-based radiation measurements to +/- 5% uncertainty.

FIVE-YEAR GOALS (2016):

- Set up and manage a testbed where changes to solar forecasting methods can be evaluated to determine if irradiance/solar power forecasts actually improve.
- Work to have NOAA's National Centers for Environmental Prediction's Global Forecast System model at least achieve parity for day(s)-ahead solar resource predictions as compared with European and Canadian global models.
- National ground-source network of solar radiation measurements at five-minute intervals to +/- 5% uncertainty.

All activities should be carried out in a transparent fashion, with leadership from NOAA, involvement of private and academic communities and coordination by AMS.

Meteorology and Off-shore Wind Renewable Energy: New Priorities

The panel discussing offshore wind energy at the 2011 American Meteorological Society Summer Community Meeting was asked to formulate a list of possible actions that could move offshore wind energy forward in the next few years. Here is what was proposed:

1st YEAR GOALS (2011-2012):

- Catalog and assess the relevance, value, and representativeness of existing observation networks of atmospheric and oceanic (surface and sub-surface) measurements and platforms for offshore wind energy applications.
- Detail the gaps in measurements and the adequacy of modeling needed to assess the atmosphere/ocean environment from the sea floor to the top of the marine atmospheric boundary layer.
- Develop accurate mapping of extreme event probability distributions (e.g., winds, waves, and icing).

THREE-YEAR GOALS (2012-2014):

- Development of a U.S.-based reference facility to validate new, more cost effective offshore measurement technologies (such as floating lidar) for resource assessment.
- Improvement of forecast and resource assessment model physics to accurately represent hub-height winds (accounting for e.g., sea state, stratification, and coastal effects).
- Development of an integrated data archive or portal to allow access to all forms of information needed to plan, deploy, and operate offshore wind plants. This could include use of non-disclosure agreements for the sharing of business proprietary observations.

FIVE-YEAR GOALS (2016):

- Establish additional observation deployments, enhancement of existing networks, strategic placement of remote sensing platforms, and enhanced modeling efforts that can better capture the structure of the marine atmospheric boundary layer and necessary surface and sub-surface conditions. This would include the deployment of coastal radar and other volumetric scanning systems to operationally provide cost-effective, accurate wind fields offshore.
- Institute long-term plans for addressing identified gaps in data and capabilities (definition of new data needs, topical priorities, timelines, and investment levels).

All activities should be carried out in a transparent fashion, with leadership from NOAA, involvement of private and academic communities and coordination by AMS.

Meteorology and Transportation: Session Summaries

Weather significantly impacts safety, mobility, and the economy on the nation's transportation system. The solution to these problems is a combination of advanced weather monitoring and forecasting, translating weather information into transportation-based decisions, and using Intelligent Transportation Systems as the means to communicate across all transportation users and operators. There were two transportation sessions, loosely divided into the two themes of data needs and the economy. The first session highlighted cutting-edge national initiatives aimed at improving the provision of weather data for transportation uses. The second session highlighted specific needs and uses of transportation-related weather information. Specifically, this session highlights needs and gaps in the provision of this information for various public and private sectors, as well as the role of sector-specific weather information on the economic bottom line of various transportation users.

During the first session we heard from Shelley Row, Bill Mahoney, Brenda Boyce, and Dan Berler, each covering different aspects of data. In particular, we heard about the emerging capabilities to observe weather and road conditions from vehicles. Shelley Row presented such capabilities from the perspective of transportation policy by Shelley Row. Bill Mahoney highlighted the findings of a new AMS Annual Partnership Topic report that documented the potential of such observations to the weather community. Brenda Boyce and Dan Berler spoke about technical advancements to process and apply these observations. The key point from this session was a call to action to the weather enterprise to get engaged in the Safety Pilot effort at the U.S. DOT to push for weather and road condition data from the instrumented vehicles. If the weather enterprise sees potential in these observations, we need to make our voice be heard. This includes approaching the automakers. It also includes approaching the U.S. DOT, which not only includes the Intelligent Transportation Systems' Joint Program Office, which Shelley Row directs, but also the National Highway Traffic Safety Administration

During the second session, we heard from Dave Barjenbruch, Dan Krechmer, Doug Bremicker, and Dave Cunningham. These four speakers complemented the first four, focusing on uses of the data and the applications being developed to better meet the needs of end users. Key points from this session included:

- Public weather providers (i.e., the NWS) see public safety and mobility as a key part of their mission, and are making the most of the data available to them to feed into their products (e.g., watches and warnings).
- Private weather providers are developing a host of tailored road weather products to meet user needs. And this need is very strong, as captured in a survey which found that weather is the third most requested type of information in the vehicle/smartphone.
- Other road users such as the trucking industry also see a major impact from weather-related delays – e.g., 12-25% of all trucking delays are caused by weather, and weather delays cause an estimated $3.1M /yr for the 50 largest cities.
- Road weather observations have played a key role in improvements of weather forecasts, along with improved communications.
- Modeling is still a key part of this world in terms of opportunities for improvement. This includes boundary layer modeling, pavement temperature modeling, and using probabilistic forecasts, etc.

Following the presentations, there were a number of excellent questions and comments. Generally, all comments acknowledged the need to continue working on the issue of providing

meteorological information to support transportation needs. In particular, the need for timely, accurate, and relevant information that is targeted to the individual end users in the transportation environment was reiterated and bolstered. In addition, all partners in the weather enterprise have a role to play, and need to work together and more closely with the transportation community to address the needs.

Further information on the panelists' presentations can be found at http://www.ametsoc.org/boardpges/cwce/docs/2011-08/agenda.pdf and the embedded hyperlinks.

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Meteorology and Transportation: New Priorities

Communicating Weather and Road Conditions to/from Vehicles
During the first transportation session, an opportunity was presented to the community to get engaged in U.S. DOT efforts to improve the observation and dissemination of weather and road condition information by building upon vehicle-based wireless communication capabilities. Such technology developments are significant focus of the U.S. DOT Intelligent Transportation Systems (ITS) program, and there is a window of opportunity to capitalize on that from a weather perspective. In order for the weather enterprise (especially the NWS) to truly reduce the costs of high impact events, they will have to work more closely with the full breadth of public safety officials, not just emergency managers. In addition, products will have to be developed to enable more effective decision making by this disparate community.

1st YEAR GOALS (2011-2012):

- Define a "home" within the AMS structure to own this subject and develop a work plan.
- By the end of the year, refine the work plan to identify major milestones over the next 3-5 years
- Build the relationships with the key constituents, including: U.S. DOT (ITS Joint Program Office, FHWA, and the National Highway Traffic Safety Administration), automobile manufacturers, communications industry, application developers, etc.
- Document required vehicle-based data elements most needed by the weather community and develop concepts of operations (ConOps) that describe how the observations could be used by the weather community to support both the transportation and weather enterprises.
- Participate in the U.S. DOT Safety Pilot – a major effort to develop, test and evaluate the connected vehicle concepts.
- Participate in other U.S. DOT connected vehicle and road weather management efforts.
- Support the transition of Clarus from a research environment to an operational environment.
- Engage the aviation weather community to better meet their needs as well as identify opportunities for coordination.

THREE-YEAR GOALS (2012-2014):

- Participate in demonstrations that test and evaluate the concept of observing weather and road conditions from vehicles and disseminated advanced weather and road condition information to a broad constituency of users.
- Document the utility of vehicle-based observations for improved services to both transportation users (e.g., improved weather-related alerts to drivers) and the weather users (e.g., improved wind forecasts). This is based on the concept of operations developed above.

- As part of this effort, focus on strengthening the working relationships between NWS Forecast Offices, the private sector weather providers, and the state and local departments of transportation.
- Develop a plan to go from research to operations for weather-related vehicle-based observations.
- Conduct quantitative assessment(s) of the economic impacts of weather on the transportation system.

FIVE-YEAR GOALS (2016):

- Work across the transportation and weather communities to deploy the plan to go from research to operations for weather-related vehicle based observations.
- Document and develop a 2nd round of concepts to use of the data given the experiences learned during the 1st round.
- Revisit/refine the AMS/Weather Enterprise's relationship with the transportation community.

All activities should be carried out in a transparent fashion, with leadership from NOAA, and U.S. DOT, involvement of private and academic communities, and coordination by AMS.

Meteorology and Greenhouse Gases: Session Summaries

There is an increasing demand for accurate and reliable greenhouse gas measurements. One of the primary goals for these efforts is to separate natural sources from man-made sources. To meet this demand, NASA has a planned satellite to be launched in 2013 to augment their existing satellite efforts to measure greenhouse gases. The Europeans and Japanese have satellites in operation measuring greenhouse gases globally. Recently, the private sector has become involved in measuring at the surface, with plans to expand broadly throughout the world. Both the satellite communities and the private sector efforts are relying on NOAA to provide the reference standards and the baseline measurements. The United Nation's World Meteorological Organization relies heavily on NOAA for its data management and quality control system. All parties intend to strengthen collaboration in the future to craft a truly global measurement network.

The panel consisted of:
Dr. Tim Stumhofer of the Greenhouse Gas Institute,
Dr. Pieter Tans of the NOAA Environmental Research Laboratory,
Mr. Bob Marshall, founder and CEO of Earth Networks,
Dr. Charles Miller, of the NASA Jet Propulsion Laboratory,
Mr. Eric Webster, of ITT,
Dr. Andy Jacobson, of NOAA ESRL and the CIRES at the University of Colorado.

The sessions were chaired by Lori Bruhwiler of NOAA's Earth System Research Laboratory.

Main points covered by the speakers were:

The panel discussed the necessity for very accurate measurements throughout the network in order to reach the goal of identifying sources of greenhouse gases. Maintaining accuracy requires two components; that every monitoring network is tied in a traceable manner to standards established by the United Nation's World Meteorological Organization (WMO) standards and that there is a system enabling ongoing comparisons between different networks and different methodologies. NOAA, as hosts of the WMO calibration facility for greenhouse gases, is the standard for calibration and supplies reference standards to the private sector as they participate in the WMO network. NOAA regularly compares different methodologies. Their role will likely expand with the increase in satellite and private sector demands.

A new method for taking small samples of air, called AirCore, has been developed within NOAA and is being further developed for operational use by SWRI. The method to sample and measure a chemical vertical profile of the atmosphere from the surface to 100,000 ft. uses a light weight very long tube, closed at one end, that empties and fills passively upon ascent and descent. The column of air preserves the chemical composition encountered during descent, stored like a tape recorder along the length of the tube.

Discussion was focused mainly on two issues; the current lack of enough global observations to adequately constrain carbon flux estimates, and the lack of market forces to drive robust participation by the private sector. Panelists agreed that monitoring greenhouse gas emissions is of critical importance to economic development, and expressed the intent to assure high-quality measurements through close cooperation.

NOAA ESRL has well established collaborations with numerous private sector, academic and international partners, and maintains the international WMO calibration scales for greenhouse

gases. Leveraging the observing partnerships is a cost-effective way to accomplish goals that are absolutely necessary for improving our understanding of climate, developing accurate predictions, and managing the future of our planet. The primary issues we must understand over the coming decade are (1) the potential for Earth System feedbacks to accelerate the buildup of greenhouse gases in the atmosphere and (2) the need to ensure that greenhouse gas management strategies are working – at regional, national, and global scales. This requires understanding both human and natural systems, an impossible task without enhanced observations.

Further information on the panelists' presentations can be found at http://www.ametsoc.org/boardpges/cwce/docs/2011-08/agenda.pdf and the embedded hyperlinks.

Meteorology and Greenhouse Gases: New Priorities

The number and type of greenhouse gas measuring organizations is expanding and will likely continue to expand in the coming years. The private sector using new technologies, and satellites using a variety of approaches are joining the currently established WMO network. Because of the changing community, as well as the likely new applications of greenhouse gas data, expanded efforts at assuring high-quality and traceable comparability are essential. NOAA, NASA, and Earth Networks as well as international partners are all poised to work together towards these goals. The intentions will not materialize into better measurements without new efforts to support the necessary collaborations.

1st YEAR GOALS (2011-2012):

- Build on the current agreement to share data between NOAA and Earth Networks by developing a clear plan for data sharing.
- Develop a plan to move AirCore measuring systems from research to operations.
- Establish collocated NOAA flask measurements at Earth Networks sites.

THREE-YEAR GOALS (2012-2014):

- Expand intercomparison methods that currently go on between international laboratories to include the newly planned Earth Networks measurements.
- Carry out weekly AirCore launches to better understand the operational aspects of AirCore.
- Develop measurement capabilities to analyze retrieved AirCores beyond the current methane and carbon dioxide capabilities.
- Establish a method for comparing NOAA, Earth Networks data with NASA's planned satellite measurements.

FIVE-YEAR GOALS (2016):

- Develop the techniques necessary to interpret flask samples for chemical fingerprints, which will help determine the source of greenhouse gases.
- Build capacity for scientists in developing countries to make high-quality greenhouse gas measurements.

All activities should be carried out in a transparent fashion, with leadership from NOAA, involvement of private and academic communities and coordination by AMS.

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Meteorology and Human Health: Session Summary

The intersections between hydrometeorology and public health are multifaceted, and transcend boundaries across the physical, genetic, biological, and socioeconomic worlds. The "worlds" are so closely linked that improvements in environment and health monitoring can ripple positive benefits for the nation's socioeconomic issues. For example, an exemplary heat-healthcasting system in Philadelphia, PA saves many lives each year, and results in an estimated $153M annual economic savings.

A panel of experts on this intersection between hydrometeorology and public health presented some current successes and ideas for the future at the AMS Summer Community Meeting.

The panel consisted of:
Dr. Georges Benjamin, Executive Director, American Public Health Association
Dr. Ben Beard, Chief of Bacterial Diseases, Centers for Disease Control,
Dr. John Balbus, Senior Advisor, Nat'l Institutes of Environmental Health and co-chair to Climate Change and Human Health Group with the United States Global Change Research Program,
Dr. Christopher Uejio, NCAR/Centers for Disease Control post doctoral fellow,
Mr. Craig Long, Meteorologist, NWS,
Mr. Tim Dye, Senior Vice President, Sonoma Technology, Inc.

Wendy Marie Thomas, Meteorologist, AMS Policy Program served as moderator. The presentations highlighted the value of ***Early Warning Systems*** to human health and the economy:

- **Protecting and preparing health infrastructure:** Hospitals and medical centers in vulnerable areas need forecasts on multiple time scales, from hours to decades. Emergency response equipment requires accurate near-term (days) forecasts of severe events. For example, it takes around a week to prepare medical ships, like the ones that serviced victims of Hurricane Katrina.
- **Disease early warning systems**: Current public health practices for many diseases tend to be reactive rather than proactive. More robust environmental data can lead to more accurate forecasts on annual, seasonal, monthly, and diurnal timescales for diseases like vector-borne infectious diseases. Mortality from heat stress (the leading weather-related fatality) can be greatly reduced through combined use of weather forecasts and geographically arrayed socioeconomic and infrastructure data.
- **Promoting healthy activity:** The United States and much of the world are facing epidemics of obesity, diabetes, and related complications. Weather conditions are an important barrier to physical activity. Incorporating positive weather messages for physical activity into weather alert programs could help motivate healthier behaviors and outcomes.
- **Preventing skin cancer:** Melanoma is the fifth most common form of cancer in the United States. This disease costs the nation ~$1.9B per year (2006 data) for the ~70K new cases that occur annually. NOAA has a productive relationship with the EPA to warn the public of the dangers of ultraviolet radiation. Long-term monitoring of ultraviolet radiation at the surface is essential for climate monitoring and forecast validation.

- **Air quality alerts:** Particulate matter (most notably PM2.5) and surface ozone cause respiratory and cardiovascular symptoms and illnesses. Public-private partnerships under the AIRNow program, spanning 130 federal, state, and local agencies and the private sector (Sonoma Technology, Inc) produce national information products. This cooperative effort saves an estimated $38M in national healthcare costs.

The panelists were in broad agreement that the current data products are giving a strong benefit to human health and safety, and that there were several, well-identified new products that could be addressed for strong returns on investments.

Further information on the panelists' presentations can be found at http://www.ametsoc.org/boardpges/cwce/docs/2011-08/agenda.pdf and the embedded hyperlinks.

Meteorology and Human Health: New Priorities

Weather conditions have strong impacts on human health, including stressors, such as heat waves and transmission of disease such as through ticks or person-to-person transmission. Current meteorological products are useful in informing the public on some basic issues, such as heat stroke and ultraviolet radiation. Additional meteorological products could offer significant advancements in our understanding of weather-related human health issues as well as savings to health care and preservation of human lives. Priorities for the coming years are as follows:

1st YEAR GOALS (2011-2012): Strengthen the Framework for Partnerships

- Create a policy framework, formed by NWS Strategic Planning and Public Affairs, that rewards the current service-modernization of NWS in return for making the government work more effectively and increasing the return of public benefit in the form of better health and economic savings.
- Identify three top research priorities and goals in the United States. At least one of these priorities should be a fast "winnable and measurable project" that can be utilized to showcase partnership benefits to the nation.
- Establish a channel within the NWS Road Map that brings environment and health data to local decision-makers (beyond Emergency Managers) such as public health practitioners and teachers.
- Train research and operational meteorologists for effective cross-discipline communication with public health and medical communities.

THREE-YEAR GOALS (2014): Moving from Extraordinary to Ordinary

- Move Enterprise weather forecasts beyond static variables (e.g., temperature, pressure, wind direction), to a more applied content –for example warnings of when both heat and high particulate content occur for those with specific disorders (like pulmonary diseases).
- Establish multiple cross-agency partnerships on health with Department of Defense, NASA, Dept. of Interior, US Geological Survey, and others.
- Jointly create (between NOAA, Centers for Disease Control and Prevention, and National Institutes of Health) Centers of Excellence that are at the forefront for developing new, better models that integrate environment and health information. These partnerships should also advance joint Masters in Public Health, MS/PhD meteorology degrees.
- Develop K-12 education curriculum among NOAA, Centers for Disease Control and Prevention, National Institutes of Health, and the associated professional society partners, like American Public Health Association and AMS, to educate and inform the next group of national leaders and decision-makers.
- Issue joint NOAA/Centers for Disease Control and Prevention research grants that include weather and health components in the findings.
- Create post doc fellow positions for dual-degreed Masters in Public Health and MS/PhD meteorologists at NWS.

FIVE-YEAR GOALS (2016): Solidifying

- The implementation of the efforts above should culminate in significant savings of human health care costs, quality of life and lives saved. An assessment of their impact should be created and reviewed for further evaluation.
- Establish a new deputy NWS director position for Environment and Health applications.

All activities should be carried out in a transparent fashion, with leadership from NOAA, involvement of private and academic communities and coordination by AMS.

Meteorology and Water Resources: Session Summaries

Hydrological information, from flood warnings to drought forecasts, is becoming an increasingly important part of public planning and private concerns. This session focused on how the enterprise may deliver information on hydroclimate across time scales, including information on floods and drought. Across two sessions, discussions included: the observations needed to support water resource management, what's needed from NOAA by private sector providers and consultants to support their business development, and the economic value of hydroclimate observations and products. The goal was to help define the roles of NOAA, the private sector, and universities with respect to hydroclimate services. The themes of observations and data networks, the economic value of hydroclimate observations, data services, and products were woven through the session. The two sessions were loosely divided into the two themes of hydroclimate information needs for long-term planning and management by the public and private sectors, and observation and data needs for hydroclimate services. With speakers from several aspects of the private sector, government programs, and universities, the session highlighted the needs and current gaps for developing water resource services by the enterprise as a whole.

The first session included Dan Walker, Ben Harding, John Rehring, and Dave Easterling. During the second session, we heard from George Smith, Tim Schneider, Ilse Gayl, Rene McPherson, and Kevin Stewart. The two talks focused on federal efforts that may provide new products to serve hydroclimate needs. Schneider discussed the new interagency Integrated Water Resources Science and Service program, which has a goal of producing collaborative science, services and tools to support water management and adaptation, including high-resolution gridded water resource information for North America derived from observations and models. Dave Easterling discussed the ongoing development of a new probable maximum precipitation product that estimates changes in future extreme precipitation, parallel to the existing product of NWS, based on climatology that is widely used in the engineering and planning community.

Key points were:

- A call to action to work with private sector companies involved in climate-sensitive businesses, because they have interest in climate. These include commodities businesses, and a wide range of water-intensive industries, with the major challenge of siting and designing infrastructure with lifetimes out to mid-century and beyond. Working with these communities means also working through professional networks such as the American Society of Civil Engineers.
- A proposal for how to meet the long-range hydroclimate projection needs of companies such as civil engineering firms that serve water-intensive industries as well as the public sector.
- An example of the use of hydroclimate information in a statewide water supply planning framework.
- A paradigm shift is taking place in the availability of information, the kinds of information, how we access it.

Further information on the panelists' presentations can be found at http://www.ametsoc.org/boardpges/cwce/docs/2011-08/agenda.pdf and the embedded hyperlinks.

Meteorology and Water Resources: New Priorities

Extreme weather events -- including floods and drought -- were among the extreme weather events of the first half of 2011 that caused eight $1 billion-plus disasters, according to NOAA. These events threatened public safety, burdened aging water infrastructure, and had significant economic consequences. Hydrologic forecasts on multiple time scales are a key tool in decision making because of influence on energy prices, assessing crop potential, long-range drought assessment, transportation risk management, food security, industrial infrastructure investment and as a macro-economic enabler or limiting factor.

Federal funding for hydrology research has waned since the 1970s–80s. The nation faces significant challenges in hydrologic extremes and water information including:

- Some of NOAA's probable maximum precipitation estimates used by water agencies for dam safety analyses have not been updated since the 1960s, and the federal guidelines for Flood Flow Frequency Analysis have not been revised since 1981. Neither of these documents addresses hydroclimate non-stationarity.
- Inadequate understanding of the potential changes in future water supply for major river basins.
- Need for information to make decisions regarding infrastructure, both capital assets and new investments by the private sector as well as the governments at all levels.
- More complete information on the current state of water in the landscape.
- Dynamic maps with forecasted flood inundation on multiple time scales.

1st YEAR GOALS (2011-2012):

- Establish a dedicated effort within NOAA to better understand precipitation and weather conditions that can lead to flooding, and foster transition of scientific advances and new tools into forecasting operations. Outputs of this effort would support efforts to balance water resource demands and flood control.
- Consolidate access to existing water-related data from various federal, state, and tribal agencies by establishing a water.gov inter-agency portal similar to drought.gov.

THREE-YEAR GOALS (2014):

- Identify what products and services are vital to supporting planning and managing water-intensive industries (e.g. commodities, and siting and infrastructure design) for both current and future needs.
- Develop a comprehensive database of projected natural flows under various climate change scenarios at the scale of NOAA River Forecast Center forecast points and other points of interest, using an ensemble of downscaling methods and hydrology models to capture key known uncertainties.
- Engage other agencies such as The Federal Emergency Management Agency to provide science to support their process to explicitly incorporate "future conditions hydrology" in

the national flood insurance program's flood hazards mapping, and other agencies (including Bureau of Reclamation, US Geological Survey, Environmental Protection Agency) to identify gaps and the state of the science for handling hydroclimate uncertainty.

- Update and revise precipitation frequency estimates, flood frequency analyses, and probable maximum precipitation – to include subsequently observed data and new analytical approaches.
- Complete studies of changes in precipitation and other hydrologic extremes under various climate scenarios.
- Engage the private and academic sectors in identifying methods for improvement of private sector's role in meeting US needs for water management services.
- Encourage organizations to implement metadata and standards recommended by the AMS' Nationwide Network of Networks ad hoc committee report.
- Encourage organizations to contribute hydroclimate observations into a centralized system as promoted by AMS' Nationwide Network of Networks report.
- Encourage AMS membership from a wider group of data and science providers, including US Geological Survey, ARMY Corps, US Department of Agriculture, and the Environmental Protection Agency.
- Validate downscaled regional climate projections for precipitation using historical observations with a focus on different precipitation regimes across the nation.
- Conduct an inventory and gap analysis of all US hydrologic observations and determine whether the datasets are public, protected or available for restricted use.

FIVE -YEAR GOALS (2016):

- Fully implement the Integrated Water Resources Science and Services
- Identify priorities sectors for improvement of hydrology forecasting capabilities.
- Determine key observations that are needed for supporting required forecasts.
- Evaluate metrics for economic success of changes in services.

All activities should be carried out in a transparent fashion, with leadership from NOAA, involvement of private and academic communities and coordination by AMS.

Building a Stronger Weather and Climate Enterprise: Keeping the Economy Moving

Co-Chairs: Betsy Weatherhead and George Frederick

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Participating Organizations

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