**WRITTEN STATEMENT OF**
**ALEXANDER E. MACDONALD, PH.D.**

**DIRECTOR, NUMERICAL WEATHER PREDICTION**
**SPIRE GLOBAL, INC.**

**"WEATHER PRODUCTS AND TECHNOLOGIES OF THE PRIVATE SECTOR"**

**BEFORE THE**
**SUBCOMMITTEE ON ENVIRONMENT**
**HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY**
**U.S. HOUSE OF REPRESENTATIVES**

Chairman Bridenstine, Ranking Member Bonamici, and Members of the Committee, it is a distinct honor to testify again before the House Committee on Space, Science and Technology. I retired from the National Oceanic and Atmospheric Administration (NOAA) in January after over 40 years as an Air Force officer and federal executive. I am now employed by Spire Global, Inc., a company that plans to use small, sophisticated satellites to bring revolutionary improvements to weather observing. It is fascinating to see the differences and similarities between my federal service and work in a private company.

When I was a young officer giving weather briefings to Air Force pilots, the information we had was poor. The tremendous progress we have made since then is testimony to the visionaries who believed in science, observations, and computers to deliver better forecasts, but mainly to the nation for its support of the weather community. Recent successes, forecasting of blizzards and hurricanes days in advance, show that we have come a long way, while some recent busts or near misses show we can do better. I believe that the best route to continued improvement of weather prediction must be based on the right combination of public and private contribution to weather observing and modeling.

There was a time when almost all weather infrastructure was developed, purchased and operated by the federal government. However, during recent decades, we have seen a vibrant and growing private sector weather role, including providing weather forecasts to users, creating observing systems, and running state-of-the-art weather models. The reason for the growth of commercial weather businesses is the increasing skill of weather prediction, which generates products that are valuable in the marketplace and can generate revenue. This can lead to enhancements of weather capabilities if policies are in place that encourage the innovation and investments that the commercial sector can bring, while maintaining the crucial services of government, such as assuring public safety. Conversely, it is conceivable that existing policies would carry on with enough inertia from the past that these new commercial opportunities would be lost.

It is good to provide examples. Twenty years ago, operational numerical weather prediction was the exclusive purview of government. I am proud to say that I was among the people who encouraged the development of a regional community model, the Weather Research and Forecasting model, which was developed between the National Center for Atmospheric Research

and NOAA. Now that model is used by the National Weather Service, and worldwide in many commercial applications. More recently, the Panasonic Corporation announced that its global weather model was the most skillful in the world – its "anomaly correlation" was better than the European Center for Medium Range Weather Prediction (ECMWF), the US model, and all the others. This is an exciting advance, but it did not occur out of thin air. They started with NOAA's Global Forecast System model, and made improvements, added data from aircraft, and invested in a large development staff over 10 years. The US has a community modeling approach, which helped enable the Panasonic team to create their model. US policy should assure that the primary foundational modeling capabilities, including both research and operations, be supported in NOAA and the federal sector, while allowing commercial companies to use community capabilities to create the best observing and modeling they can.

The situation is similar for satellite observing systems. While many believed the rockets and satellites would always be the sole purview of government, it is obvious now that the private sector brings a dynamism and complementary advantages to the space business. A great example of this is the company I work for, Spire. This is a small start-up with an immense ambition - build and deploy dozens of small cubesats to do jobs that were previously only done by big, expensive satellites. To me, it's a repeat of the evolution from main-frame computers to PCs in the 1980s. We have experience with the contribution of "Radio Occultations" to weather prediction because of our experience with the COSMIC program. Spire proposes to have a large constellation of satellites that we plan can deliver tens of thousands of Radio Occultations by late next year, with a goal of 100,000 "COSMIC 1 quality" ROs per day. This is the equivalent of a radiosonde balloon providing accurate temperature and moisture soundings for every degree of latitude and longitude every 12 hours over the whole globe! As someone who has been involved with weather modeling for 40 years, I believe this could be the biggest advance yet in weather observations.

It is important to add, however, that the global weather observing system that we have put in place among the international community, led by the US, must be preserved and enhanced. The COSMIC 2 program has a significantly enhanced Radio Occultation (RO) system that would show the direction RO should go in the future, and provide a base of data available under WMO 40. The NOAA GOES R and JPSS satellites have a fabulous suite of sensors that are necessary for weather prediction and our global Earth system science needs.

My closing thought is that we are on the threshold of big improvements in weather predictions. I hope to see the skill we now have on hurricanes and major snowstorms at three days, be extended to five days before I really retire! The new satellite observing systems funded by governments, complemented by the capabilities coming available in the commercial sector (including RO, geostationary hyperspectral and other systems) will make the full system more robust. If we had a major disruption in our JPSS schedule, federal and commercial Radio Occultation satellites could save the day.

It is gratifying to be in a country that can mix the advantages of private and public capabilities as effectively as the US does. We have an opportunity to do just that in the weather arena.

# Alexander E. “Sandy” MacDonald

Dr. Alexander E. (Sandy) MacDonald retired from over 40 years of federal service in the National Oceanic and Atmospheric Administration, on January 3, 2016. He was a Senior Executive since 1990 and President of the American Meteorological Society in 2015. He retired after 10 years as Director of NOAA’s largest research laboratory, the Earth System Research Lab in Boulder, Colorado. He was Chief Science Advisor for NOAA’s research line, and it Deputy Assistant Administrator from 2006 to 2012. He was Director of NOAAs Forecast Systems Laboratory from 1988 to 2005. He is the inventor of NOAA’s Science On a Sphere, an educational exhibit now in over 130 museums worldwide. He worked with Vice President Al Gore to start the GLOBE Program in 1994. He is the recipient of four Presidential Rank Awards.

Dr. MacDonald recently published (January 25, 2016) an article in *Nature Climate Change*, titled **“Future cost-competitive electricity systems and their impact on US $CO_2$ emissions”** that was ranked in the 99$^{th}$ percentile of impact by *Altimetric*. The article presents results that show the US could reduce its carbon dioxide emissions by up to 80% by 2030, by implementing a High Voltage Direct Current transmission network. The article presents a solution to greenhouse gas emissions that could be implemented now with existing technology, and would be also be feasible in other major economies such as Europe, China and India.

On April 4, 2016 he joined Spire Global, where he is leading a group that is developing global weather models and advanced energy solutions.

**Contact**
alexander.macdonald@spire.com

**Curriculum Vitae**

## EDUCATION

Ph.D. in Meteorology (Minor in Computer Science), University of Utah, 1975
M.S. in Meteorology, University of Utah, 1973
B.S. in Mathematics/Physics, Montana State University, 1967
USAF Weather Course Certificate in Meteorology, St. Louis University, 1968

## PROFESSIONAL EXPERIENCE

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| **2006 - 2016** | Deputy Assistant Administrator, Laboratories and Cooperative Institutes, OAR<br>Director, Earth System Research Laboratory, NOAA |
| **1988 - 2006** | Director, Forecast Systems Laboratory, NOAA |
| **1983 - 1988** | Director of the Program for Regional Observing and Forecasting Services (PROFS), Environmental Research Laboratory (ERL), NOAA |
| **1980 - 1982** | Chief of PROFS, Exploratory Development Group, ERL, NOAA |
| **1975 - 1980** | Techniques Improvement Meteorologist in the Scientific Services Division, Western Region National Weather Service, NOAA in Salt Lake City |
| **1973 - 1975** | University of Utah - Research Fellowship |
| **1971 - 1973** | University of Utah - Instructor, Synoptic Meteorology Laboratory |
| **1967 - 1971** | Officer, U.S. Air Force |

## MEMBERSHIP IN PROFESSIONAL SOCIETIES

President, American Meteorological Society, 2015
American Meteorological Society
National Weather Association

## RESEARCH INTERESTS

Dr. MacDonald has published in atmospheric modeling, statistics, dynamics, and meteorological systems. His interests are applications of science and technology to improve operational forecasting.

## ACTIVITIES

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| **2005** | Patent #6,937,210, "Projecting Images on a Sphere", Alexander E. MacDonald |
| **2002** | Patent #6,421,010, "Atmospheric Sondes and Method for Tracking", Russell B. Chadwick and Alexander E. MacDonald |
| **1994** | Executive Committee Member, AMS; AMS Fellow |
| **1993** | Developed GLOBE Program (a Vice-Presidential Initiative) |

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| **1992** | Councilor, AMS three-year appointment |
| **1983 - Present** | Lecturer at numerous AMS chapters throughout the United States. |
| **1987 - Present** | Member, AMS Committee on Aviation, Range, and Aerospace Meteorology |
| **1984 - Present** | Member, Panel on Mesoscale Research, NRC |
| **1988 - Present** | Fellow with the Cooperative Institute for Research in the Atmosphere - Colorado State University |

## AWARDS

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| **2009** | Presidential Rank Award - Distinguished |
| **2007** | Presidential Rank Award - Meritorious |
| **2001** | Presidential Rank Award - Meritorious |
| **1997** | Presidential Rank Award - Distinguished |
| **1993** | Gold Medal - Leadership in Technology Transfer |
| **1980** | Bronze Medal - Accomplishments in NWS AFOS Program |