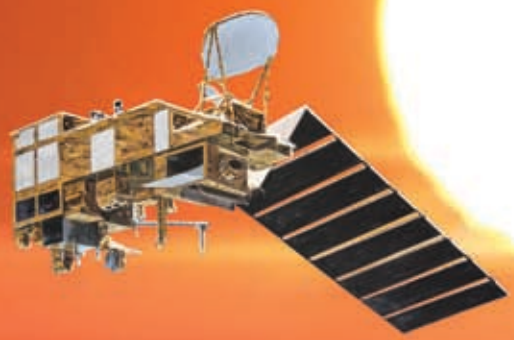
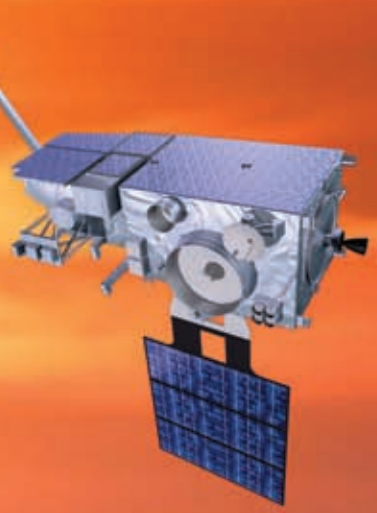
ENVIROCAST

Increasing the Environmental IQ of America





Technology for Global Environmental Change

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Technology for Global Environmental Change

Dave Jones

" The temperature record is clearer, the sea level record is clearer, more amounts of ice are melting and disappearing than people thought they would be able to document…the temperatures are going up just about everywhere, except for Antarctica…The sea ice and the ice over Greenland is not only shrinking horizontally but shrinking vertically and the ice thickness in the Arctic sea is getting thinner." These are the comments by Dr. Ralph Cicerone, President of the National Academy of Sciences when interviewed by Bob Ryan, Chief Meteorologist with NBC4 TV in Washington, DC about the latest IPCC report on Climate Change.

Sea ice on September 21, 2005, the date at which the sea ice was at its minimum extent in the northern hemisphere. The amount of sea ice coverage that is below the average minimum coverage is about the size of Texas. Should it continue during the summer months, new navigation routes may be opened for a short time creating new trade opportunities. New challenges for responding to emergencies in these remote areas will also emerge. (Image courtesy NASA GSFC Scientific Visualization Studio)

Now more than ever satellite savvy nations around the world need to focus on providing extensive coverage of the earth and its environment so scientists can answer key questions and people can understand how the changing climate will impact their lives and the lives of their children, grandchildren and great grandchildren.

Dr. Cicerone continues, "We can adapt to slow changes if we understand and can anticipate them. We are going to have trouble adapting when there is a sudden, large change, especially one that we didn't predict...there is going to be a big difference in the way the world responds to climate changes."

Rich countries will be able to adapt faster by employing technologies and innovation while poorer countries will be left to adapt at much slower paces, which could result in massive problems such as food shortages, widespread disease outbreaks and incredible vulnerability to the sea when coastal storms threaten.

"Scientists have to keep working on the extreme events, the severe storms, where they are moving and how intense will they be in terms of winds and rainfall…the science has to keep working at those predictions of extreme events over smaller areas." says Dr. Cicerone.

NOAA's Global Change Research Program has identified a similar key question that needs to be answered through additional research. Their question: How are extreme events, such as droughts, floods, wildfires, heat waves, and hurricanes, related to climate variability and change?

And just as important a question: Can these extreme events be predicted with enough lead-time to save lives and property?

That is where future earth observing satellite systems come into play. Scientists are now confident that our climate will continue to warm and this warming may lead to an increase in the severity and frequency of storms such as hurricanes, floods, droughts and severe weather. Warming on a global scale is thought to lead to more extreme weather events such as colder cold-air-outbreaks, stronger storms, heavier snows, hotter heat waves, longer droughts and more tornados. These kinds of weather extremes have a much higher impact on the economy than before, especially if these events are not anticipated and occur where people continue to migrate, such as the coastline.

Weather and climate sensitive industries, both directly and indirectly, account for about one-third of the Nation's GDP [$4 trillion in 2005 dollars] ranging from finance, insurance, and real estate to services, retail and wholesale

Local villagers cross a flood plain on the road to Xai-Xai some 100 kilometers (60 miles) from the Mozambique capital Maputo, Thursday Feb. 24, 2000, after floodwaters swept away the road which links the north of the country with Maputo. Rapid changes in weather and climate will make it difficult for poorer nations to adapt due to a lack of technology and resources. (Image Courtesy AP Worldwide Images)

trade and manufacturing.[1] It is critical that technology be developed to constantly improve weather and climate forecasts. As a result, more property will be protected and more lives will be saved.

Because we are all affected by the changes in weather and climate we need to have confidence that forecasts will be accurate. Accurate forecasts depend on accurate and frequent observations from many locations, not just in the United States, but everywhere. As the demand for weather and climate forecasts increases, more forecasts will depend on direct output from weather forecast models with less human intervention. This increasing reliability on automated forecasts demands constant improvements on the observing systems, the data assimilation systems and the numerical weather forecast models that process all of that data.

Satellites offer the widest coverage at increasingly better resolutions. It doesn't make sense (financial or practical) to place buoys in the ocean every square mile in order to get good observations out at sea. The maintenance costs

1 Dutton, John A., Opportunities and priorities in a new era for weather and climate services, Bulletin of the American Meteorological Society, September 2002, volume 83, no.9, pp 1303-1311

Coastal storms may be getting stronger. As the earth warms many scientists believe that people around the world will experience more extreme weather events such as heavier snowstorms, longer droughts, hotter heat waves and colder blasts of arctic air. During the El Nino event of 1997-1998 large waves pounded Malibu, CA and caused significant damage to coastal communities. (Image Courtesy AP Worldwide Images)

alone would be astronomical, not to mention the navigational hazards that would exist. That is indeed why we have satellites, so they can gather critical observations in areas where scientists need data the most, over the open oceans.

The nation cannot afford any gaps in satellite coverage, as this would affect weather forecast model predictions significantly. Today, 99% of the observations that go into most NOAA computer weather forecast models come from satellites. Satellites are orbiting today, providing the necessary data and information required to keep our nation safe, however, improved satellites are being built now to further improve climate and weather predictions.

There is an important need to maintain continuity of operations in order to keep the data flowing consistently into the models. There is also a great need to advance capabilities in satellite observations in order to improve climate and weather services to the nation. Because of these needs (and others), NOAA is moving forward building the National Polar Orbiting Environmental Satellite System (NPOESS), the most advanced polar-orbiting satellite data collection system ever produced. In addition, NOAA is also planning GOES-R, the most advanced geostationary environmental early warning system ever assembled.

Northrop Grumman is the government's NPOESS partner and the company is building on its successful history and its ability to construct highly reliable, durable, peak performing spacecraft to serve the scientific community. That history is a cornerstone of the company's capabilities. The unique network of data distribution systems for NPOESS, called SafetyNet™ built by Northrop Grumman's partner Raytheon will enable 77% of global NPOESS data to reach the processing centrals within 15 minutes and 95% within 28 minutes. This innovative capability will result in a data latency improvement of 400-500% over current 120-150 minutes it takes for today's polar orbiting series to deliver the data.

So the weather forecast models and data assimilation systems will get the data faster than ever before which really defines the total end-to-end system. SafetyNet™ will be acting like a supercharged delivery service that will lead to early alerts and advanced warnings of potential life-threatening weather developments.

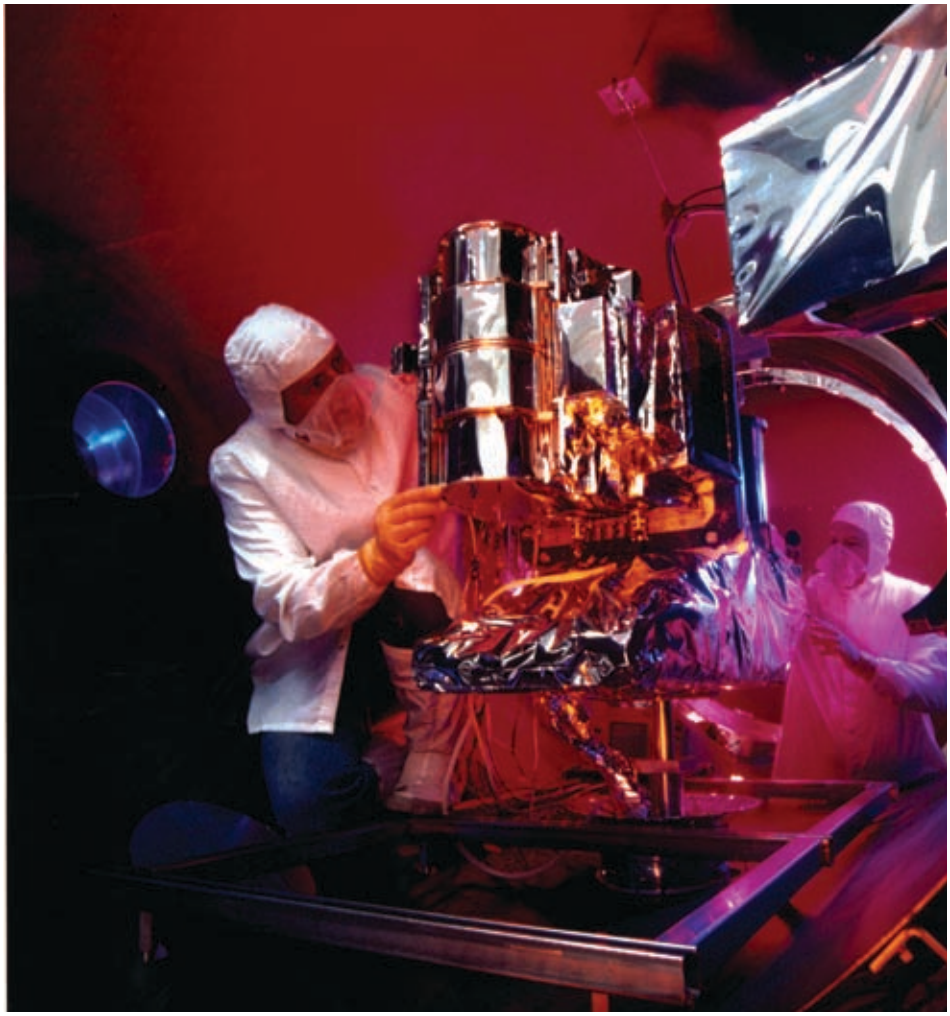
This kind of quality and reliability will keep the nation moving forward with advancements in numerical

Picture to the left: NOAA's vision of an improved observing system considers satellites, planes, unmanned aerial vehicles (UAVs), balloons, buoys, ships, undersea observatories and ground sensors and improved radar systems. Additional data means more observations which could lead to improved weather and climate forecasts. NOAA's challenge is to identify what the best, most cost efficient combination of observation platforms will result in the largest improvement in forecasts. This is known as an "analysis of alternatives." (Graphic courtesy NOAA)

weather prediction while maintaining continuity in data collection.

NOAA and Northrop Grumman are working closely together to make sure the sensors placed on NPOESS are the most advanced operational sensors that have been proven through Northrop Grumman's missions serving the research and operations communities today. NPOESS will collect and deliver the data necessary to enable significant advances in weather prediction so people can be prepared for rapid changes in weather conditions. This would not be possible if it weren't for the history of instrument building and calibration activities that were done in the past.

Northrop Grumman built 6 Earth radiation budget sensors for NASA, 2 on EOS/Terra, 2 on EOS/Aqua, 1 on TRMM (no longer operating), and 1 in storage waiting for NPOESS C1. Arguably the most accurately calibrated broadband radiometers ever flown, the CERES (Clouds and the Earth's Radiant Energy System) sensor has 3 spectral bands 0.3 to 3.5 um (solar reflective measurement), 8 to 12 um (measure surface thermal emission), and 0.3 to >50 um (total channel to measure entire radiance of the earth).



CERES was being assembled in the Northrop Grumman Space Technology thermal vacuum chamber in Redondo Beach, CA. To ensure the highest quality data, CERES' sensors have been precisely calibrated using standards traceable to the National Institute of Standards and Technology. A Northrop Grumman extreme-precision calibration facility provides unique calibration capabilities. CERES is operating on both Terra and Aqua satellites.

The key has been the absolute radiometric calibration at <1% for the short wave band, <0.3% for the long wave band and <0.5% for the total band radiometers. To get these accuracies required development of a sophisticated thermal vacuum calibration facility, developed by Northrop Grumman.

These channels scan the earth at approx 30 km spatial resolution, horizon to horizon, every orbit, every day, over many years. By measuring the reflected sunlight and thermal emission over the Earth vs time scientists can determine if the Earth is warming or cooling over any given period of time. In particular, the key is to measure the "cloud forcing function", that is, the effect of various cloud types on heating/cooling. High altitude cirrus clouds allow sunlight in but tend to limit thermal emission causing heating. Cumulus clouds have the opposite effect.

Northrop Grumman also built the Earth Radiation Budget Experiment (ERBE) scanning sensors that flew in the early/mid 1980's and the measurements are traceable back to that period in time via Northrop Grumman's calibration hardware in Redondo Beach, CA.

Dr. Leo Andreoli, Director of Northrop Grumman's Environmental Systems says, "We built NASA's Aqua satellite to accommodate sensors measuring the earth's water cycle, climate and weather. A different set of sensors were placed on an Aqua–identical spacecraft named Aura. Aura observes the composition, chemistry and dynamics of the earth's atmosphere, ozone, air quality and climate. Both Aqua and Aura missions are operating very well on orbit. We are now in the process of developing the National Polar–orbiting Operational Environmental Satellite System (NPOESS) to carry on most of these measurements. These systems are collecting the important information about our changing planet and contributing to major advancements

in weather prediction. Because of this, we believe Northrop Grumman is also best qualified to build GOES-R."

When launched, NPOESS will be the most sophisticated Earth-observing system in the world supplying critical information for timely and accurate weather forecasts. This is what is needed as described by many operational meteorologists. It takes a dedicated team to build such a sophisticated system. Looking back at the history of satellites, Northrop Grumman has a very impressive track record.

"From the mid 1960s to today, the satellites that were built at Northrop Grumman have delivered over $5 billion of extra life and value in orbit," says Andreoli.

Built to Last

As the prime contractor for NPOESS, Northrop Grumman has a history of outperforming design life expectations. The most impressive example is the Pioneer series of explorer spacecraft with Pioneer 6, 7, 8 and 10 still operating nearly 40 years later.

The Earth Observing System (EOS) satellites Aqua and Aura which focus on the multi-disciplinary study of atmosphere, oceans and land surface – and their relationship to changes in the Earth system – were built by Northrop Grumman and are working well today. Northrop Grumman designed and developed both spacecraft, payload accommodations, integrated instruments, validated space vehicles and supported launches and on-orbit checkout along with instrument activation once the satellites were in orbit.

This kind of reliability is important in today's budget climate. The longer satellites and sensors operate in orbit the more consistent climate and weather records become. One thing that severely impacts climate monitoring is any type of gap in coverage. With three more Defense Meteorological Satellites and one more NOAA POES satellite in storage and ready for launch, the Integrated Program Office (IPO) and Northrop Grumman are confident that NPOESS will be ready to step in to maintain continuity of operations once those satellites are launched, operational and winding down their life cycle. As climate changes and the possibility of more intense weather and environmental events it is essential to have leadership from a company that delivers quality spacecraft and the team to deliver and maintain NPOESS and GOES-R well into the 21st century.

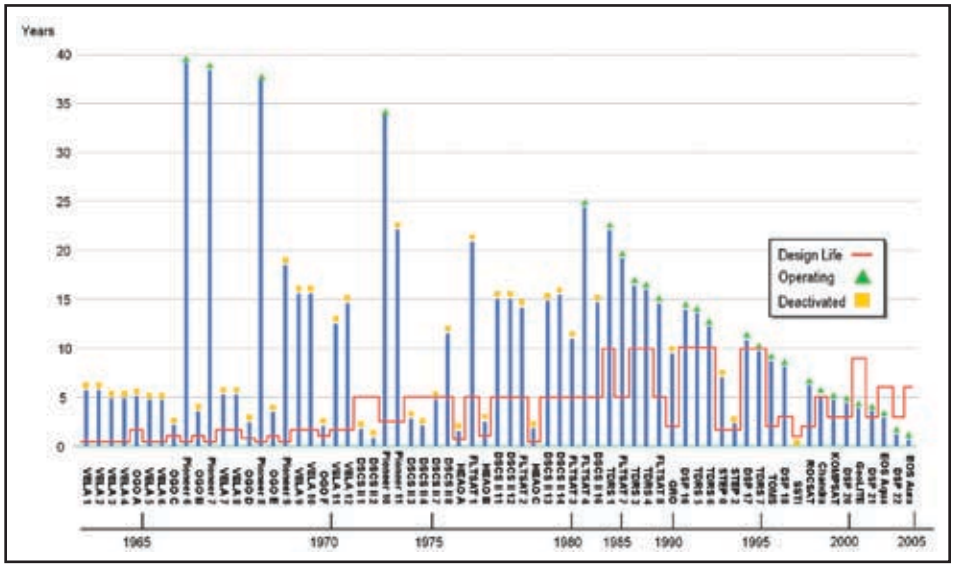
Weather vs. Climate Prediction

Numerical weather prediction modelers and data assimilation experts don't just want data, they want useful data to process in order to improve the accuracy of weather forecasts. The challenge of improving weather and climate forecasts is different.

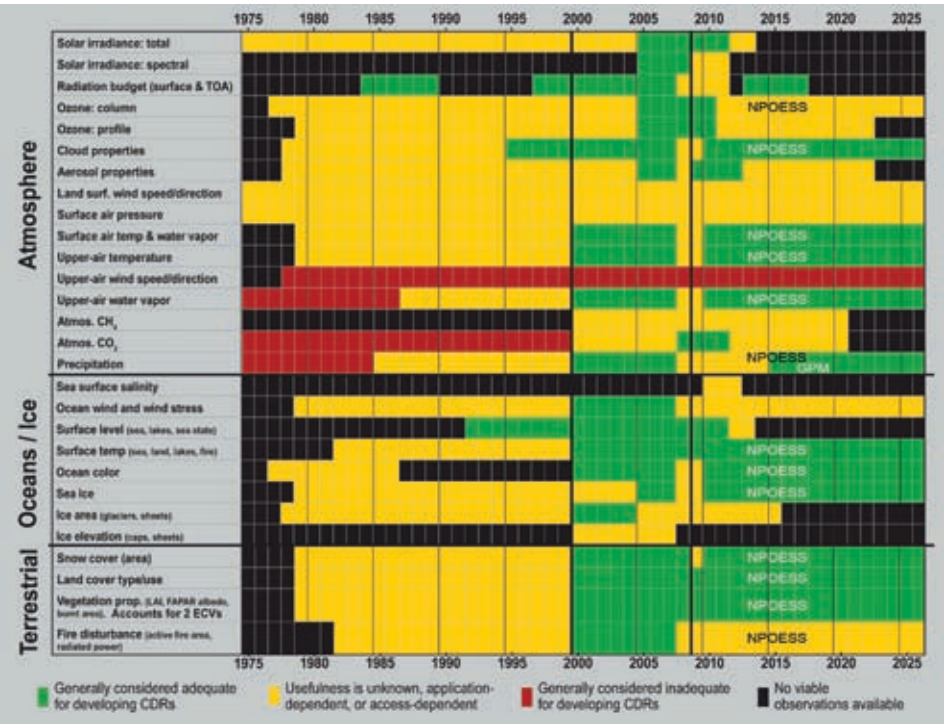
Climate forecasts are made for larger areas well into the future and are done with global models with very good accuracy. You will not see a point specific climate model forecast for San Francisco 50 years ahead of time, for example. That would be a weather forecast valid 50 years into the future and that is quite impossible.

Climate models give us an idea of what general weather patterns might be well into the future for large areas of the nation and the globe, they do not predict specific weather conditions in any given city on any particular day. Weather forecast models do accomplish point forecasts out to 5 days fairly accurately. When the models attempt to forecast beyond 7 days, the point forecast really falls apart in many cases.

There are key variables that need to be measured when dealing with climate observing and prediction. In its effort to measure key climate parameters, NPOESS will deliver more than half of the essential climate variables (ECV) necessary to monitor changes in climate. This is significant as most of the essential climate



Northrop Grumman has an incredible history of outperforming design life expectations. This chart shows just how many missions exceeded design life expectations. The additional time, shown beyond the red line, has resulted in an additional $5 billion of extra life and value in orbit.



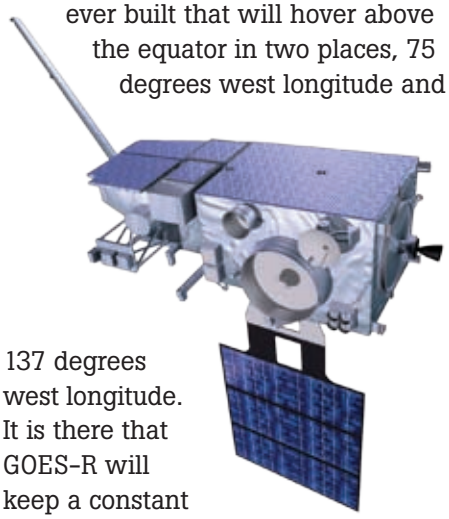
NPOESS will deliver 14 Essential Climate Variables (ECVs) when launched in 2013. A 15th ECV will be added when NASA launches the Global Precipitation Mission (GPM) and the two satellites can work together to produce the precipitation ECV.

variables are being measured by research satellites that will probably not be functioning when NPOESS launches around 2013. Most research satellites have lifetime expectations of 5–7 years. At this time, it is not clear what plans the government has for developing future research or operational satellites that will monitor all of the ECVs over a long-term. NPOESS, however, will contribute 14 of the identified 26 Essential Climate Variables with a 15th contribution to precipitation when combined with measurements from the planned Global Precipitation Mission (GPM).

GPM, while currently in the formulation phase at NASA, will measure precipitation globally and aid scientists in improving global predictions of climate, improving the accuracy of weather and precipitation forecasts, and providing more frequent and complete sampling of the Earth's precipitation.

From NPOESS to GOES-R

From 22,300 miles above the earth, GOES-R will continuously monitor the nation and is planned to be the most advanced geostationary operational environmental system ever built that will hover above the equator in two places, 75 degrees west longitude and 137 degrees west longitude. It is there that GOES-R will keep a constant eye on the tropics and the nations of the western hemisphere, including most importantly, the United States. Rapid imaging capability will not allow any weather development to go unnoticed and GOES-R will be able to zoom into special areas of interest to monitor developing storms closely. Meteorologists will see small clouds form as low level swirls way in advance of the next major hurricane while imagery used by NWS meteorologists will result in warnings of approaching storms that will alert people to take cover and protect their lives.



GOES-R image courtesy of Northrop Grumman

Through its history of building earth observation systems Northrop Grumman applies advances in technologies and lessons learned from NPOESS to provide significant risk reduction for GOES-R that will ensure cost and performance are met. Addressing and improving the prediction of climate, hazards and weather are critical tasks that will keep this nation safe and informed. That is what NOAA is doing right now to save lives and property and Northrop Grumman is standing side by side with NOAA to tackle the challenges ahead to provide environmental security to every person in this nation.

About the Author

Dave Jones is founder, president & CEO of StormCenter Communications, Inc. (www.stormcenter.com) in Ellicott City, MD. StormCenter focuses on "Raising the Environmental IQ of America™" through innovative technologies and programs in partnership with public and private companies across the nation. He is also a director on the board of the Foundation for Earth Science, a 501 (c) 3 corporation in Northern Virginia. Dave can be reached via dave@stormcenter.com.

At Northrop Grumman, the progress we make daily on NPOESS is crucial to bringing this next generation of low earth orbiting environmental satellites into service. NPOESS' state-of-the-art technology will deliver more accurate information in minutes, rather than hours, enabling decision makers to act quickly reducing potential loss of human life and property. In partnership with the Department of Commerce, the Department of Defense and NASA, the Northrop Grumman team is committed to developing a highly reliable national weather forecasting capability that saves lives and protects our economic well-being.

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