Understanding Our Home Planet: NASA s Role in Studying Global Climate Change
Remarks of NASA Administrator Daniel S. Goldin
To the 80th Annual Meeting of the American Meteorological Society
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Good evening everyone. Thank you for being here tonight as we kick off the 80th annual meeting of the American Meteorological Society.

I asked Ghassem Asrar, the head of NASA s Earth Science Enterprise, to schedule this talk, because I am concerned there is too much of a time lag between the R&D that we do and integrating it into what you do as much as much as 10 or 15 years.

You can t make progress if you re afraid to take risks. You can t make progress if you re afraid of failure. Failure must be an absolute part of any scientific endeavor. When we shoot for and get 100 percent success, we set goals that are so mediocre that we don t deserve the resources we re getting.

To be quite frank, I am highly frustrated about what, from my perspective, is the recalcitrance I see for doing difficult things.

And then I hear all the horror stories to which I say, so what.

We ve got to push the boundaries of science and technology to achieve our dreams. There is no reason we should be limited to 3 and 4 day forecasts with reliability and accuracy that s not where it could be.

Those forecasts should ultimately be 12 or 14 days for weather. There s no reason we shouldn t be able to do better hurricane prediction. There s no reason we shouldn t be able to get at climate predictions on a seasonal to annual basis.

And I m here to tell you that this is where NASA wants to be in the next decade. The American people expect no less.

Those who are reluctant to push the boundaries of science and technology are taking away from the future of our country and of all the people on the planet.

That s why I m here tonight.

Before I begin my main remarks, I want to salute Ron McPherson for providing outstanding leadership to this distinguished organization. Your commitment has helped keep the American Meteorological Society as one of the world s premier scientific organizations.

When I first received the invitation to speak to you, I was a little confused. I knew you d be meeting in Long Beach. I just wasn t sure which one.

Would it be Long Beach, New York, home of Gino s Pizzeria and occasional snowfall on the beach?

Would it be Long Beach, Washington, home of razor clams and fog and rain on the beach?

It was a real dilemma for me for about 10 seconds.

Once I realized I was going to a meeting of the American Meteorological Society, I knew it would be Long Beach, California, the place where warm and sunny today, warm and sunny tomorrow is more than a weather forecast. It s a way of life.

And even though it s sunny and warm in January, I know the weather in Long Beach isn't always so benign. Phenomena like El Ni o can really have a dramatic impact here.

But what does that have to do with NASA?

For many people, NASA conjures up images of astronauts, spacewalks, rocket plumes, and distant galaxies.

What most people don t know is that our efforts to open the space frontier are largely based on our quest to understand our own planet.

While the highly visible space-based missions are taking place, we are also working to understand global climate by using space-based labs to improve life on Earth.

That s why I'd like to spend most of my time tonight talking about the climate and three key areas NASA is studying: climate forcing, climate response, and the processes connecting the two.

Earth scientists have already identified key climate forcing agents. Trace gas increases, including carbon dioxide, are best known, but others such as atmospheric ozone changes, atmospheric aerosols, changes in land cover and land use, and solar irradiance all contribute to climate forcing.

NASA s perspective from space is not only useful in understanding some forcing agents, it s essential. Take solar irradiance, the external force on Earth s climate, for example. There's no way to measure it other than getting above the atmosphere, and we've been doing this with satellites for some 20 years now.

In contrast to our previous concept of the "solar constant," these measurements have conclusively shown that the total solar irradiance varies in synchronization with the 11-year sun spot cycle. Recent satellite measurements have shown that most of the solar variability occurs at ultraviolet (UV) and shorter wavelengths, which influence both the ozone chemistry and temperature of the upper atmosphere.

The Active Cavity Radiometer Irradiance Monitor satellite (ACRIMSAT) that was launched last month will continue this measurement record, overlapping with the ACRIM instrument flying since 1991 aboard the Upper Atmosphere Research Satellite. And the Solar Radiation and Climate Experiment mission (SORCE) planned for 2002 should ensure continuity far into this decade.

Clouds and aerosols are still the biggest unknowns among forces acting on climate. But we re working hard to understand them. Just last month we launched the Terra satellite to target these unknowns.

Terra will measure cloud and aerosol properties, such as size, distribution and reflectivity, to determine how they absorb or scatter solar radiation. Terra will also provide near-daily measurements of the global biosphere to identify sources and sinks of carbon.

This information will help us get at the biggest unknown in climate change the role of clouds. And it will help us understand the largest forcing factor that humans influence the amount of carbon cycling through Earth s land, atmosphere and oceans.

Even as we learn more about forcing factors, we need to understand how the climate system will respond to them. Of course, the first thing everyone thinks about is global temperature changes. The data we re collecting right now is good, but I think we all would like our data sources to be much better.

We want to turn warm and sunny today, warm and sunny tomorrow into warm and sunny today, warm and sunny 14 days from now, with an even better degree of accuracy.

And we re moving in that direction. At the end of this year, we plan to fly a suite of atmospheric temperature sounding instruments we believe is the best ever, including the Armospheric Infrared Sounder (AIRS) and the Advanced Microwave Scanning Radiometer (AMSR).

These instruments should give our scientists some incredible data to study, and it should help us work toward better, smaller, lighter, and simpler temperature profiling instruments for our future operational satellites like the National Polar-orbiting Opertional Environmental Satellite System(NPOESS).

But there's a lot more to climate response than just temperature. And as we move beyond temperature, we realize just how little we actually know. Take precipitation. You'd think we'd know how much precipitation falls around the world, but historically that just isn't true.

It's no big challenge over well-developed inhabited land areas. Just about any grade school kid can tell you how much it rains near his or her school. In fact, through the Global Learning and Observations to Benefit the Earth (GLOBE) program, NASA helps support lots of school kids around the world who are doing just that.

But over the oceans, in unpopulated land areas, over tundra and ice regions, precipitation measurements are not so obvious. For some strange reason, we can t convince researchers to sit in boats in the middle of the Pacific looking at rain gauges.

Some satellites are helping in this area, and we got a major boost from the Tropical Rainfall Measurement Mission (TRMM) that we launched with our Japanese partners in 1997. It has dramatically increased our knowledge of rainfall over the tropical oceans. In addition, research forecasts done this fall using TRMM data demonstrated much better tracking of some of this year's devastating east coast hurricanes, including Dennis and Floyd.

The TRMM satellite only covers tropical and low-to-mid latitudes, so we still don't have adequate coverage of much of the rest of the Earth. Right now, we re working with our international partners to figure out the best way to achieve global coverage in the future.

Beyond more comprehensive precipitation measurements, ocean surface wind is another big issue. The implications for applied meteorology are obvious here hurricane forecasting and El Nino predictions among others and some of our current satellite systems are helping. The NASA Scatterometer (NSCAT) that flew on Japan's Advanced Earth Observation Satellite (ADEOS) and last year s Quick Scatterometer (QuikSCAT) are already providing a lot of useful information. And we'll fly another scatterometer on the Japanese ADEOS-2 satellite to continue this measurement.

The results from these scatterometers have really been astounding. They show us how storm systems are embedded within the larger atmospheric flow. For instance, we can look at a hurricane within the context of the entire Atlantic Ocean or the entire globe. We might learn how specific weather patterns impact hurricane development and movement, and that has incredible implications for advanced warning and forecasting.

Add in the information on ocean surface winds and precipitation rates, and the scientific benefits become even greater. The more we learn about storm strength, momentum, and wind vectors, the greater our ability to make extremely precise movement predictions.

One challenge we haven't been able to meet just yet is direct atmospheric wind measurements. We had a program in place to do it as a technology demonstration using the Space Shuttle. Unfortunately, we had to halt that particular program, because it wasn't progressing. The development approach wasn t working from a cost standpoint, so we had to move on. It was a tough but necessary decision.

That certainly doesn't mean we're not interested in wind measurements. Believe me, we'd LOVE to do tropospheric wind measurements. We've solicited new ideas from industry, and NASA and NOAA are now considering our future course of action. This program could end up as a "data buy" from the commercial sector if there's someone out there willing to do the job to our specifications for a customer base extending beyond the government.

Our course is not set in stone. You could help us out by letting the NASA/NOAA team hear your ideas too.

And there are several other climate responses we are also studying, including El Nino frequency, ecosystem dynamics, sea level, and ice sheet mass. We are employing the same strategy of coordinated satellite and in-situ measurements and modeling activities in an effort to understand them.

Just two months ago, a NASA-sponsored research team from the University of Washington reported the average draft of Arctic sea ice its thickness from the ocean surface to the bottom of the ice pack has declined by 4.3 feet over the past few decades.

Next year, we will launch the Ice, Clouds and land Elevation Satellite (ICEsat), which will use a laser altimetry system to map the topography of the world s ice sheets to a precision of better than 10 cm. When combined with data from QuikSCAT and international satellites, ICEsat data will help us understand how the Earth s polar regions respond to climate change.

One of the things that makes the climate business so difficult is that most every climate system response can be a forcing factor as well. So there aren t really any hard and fast categories.

And we can't just measure things and store data. We have to thoroughly analyze the data we collect and really understand what we re looking at. That s an incredibly complex job, because there are so many variables in the climate.

Now we have had weather models of varying sophistication for years. And they have been helpful in increasing our understanding of the climate. But if we are to move into a future where meteorology becomes even more effective, improving safety and enhancing life, our modeling and simulation systems need to be even better than they are today.

These computational models are critical tools for both the scientific and operational communities. They help us analyze data and they enhance our ability to understand it. If the models can adequately represent what's happened in the past, then we can use them with some confidence to simulate the future.

For instance, we are looking at climate conditions for several years prior to the last El Nino and entering those conditions into a model that combines ocean height, temperature and surface wind data. We ve already shown that the signs were there 15 months in advance. That system could help us to develop a tool to predict the timing and intensity of future El Nino events. Just imagine what that would do for farmers, fishermen, or trans-oceanic shippers.

That s the kind of incredible impact you can have. Mind boggling when you think about it, isn t it?

Our computational model capability must be fast yet flexible and accurate yet understandable.

Modeling is particularly challenging because of the amount and the diversity of data to be ingested. Our EOS satellites will return 500 Gigabytes per day when fully deployed, and when we add all the processed data products, the total reaches over one and a half terabytes per day.

Think about that for a second. One and a half terabytes is somewhere in the neighborhood of 300 million pages of text OR as many as one and a half million images, and that s just one day s worth of data.

Now imagine that much data coming in every day, 365 days a year.

The bottom line for NASA is that the data of different types -- temperature, altimetry, winds, and more — must be integrated into models in a meaningful way. This requires increasingly powerful computational tools. And I don't just mean faster computers, but also advanced software that will convert large, diverse data streams into readily interpretable information. This will help us distinguish natural from human induced changes.

To that end, NASA has expanded a partnership agreement with Silicon Graphics to develop advances in super computers. Current off-the-shelf computers cost too much and don t have the computing capacity we need. So in the heart of Silicon Valley, the NASA team at Ames Research Center has worked with Silicon

Graphics to successfully develop and test the largest single image super computer in the world.

And guess what has happened? Once Silicon Graphics developed the machine with NASA, we received the prototype and beta-tested it. And as Silicon Graphics developed the next generation machine for us, industry began buying the machine we developed previously.

When the new, better computer is available, probably about a year from now, industry will have access to the one we re using today. So Silicon Graphics develops a product based on NASA needs and technology, and they pay for the product development. We get the latest, cutting-edge technology first, and Silicon Graphics has the opportunity to expand its markets.

But we need to go even further. We need computers that operate more like human brains a million times faster and a million times more power efficient than today s machines.

We need systems that can react, learn and adapt to changing conditions, leaving their human counterparts free to be creative thinkers.

We at NASA are already working on such technologies. They are the key to an incredible future.

Just imagine the possibilities of combining improved observing power with advanced communications and information technology.

In the remote sensing equation, it could mean on-board computing to allow transmission of tailored information products directly to a user s desktop at no more than the cost of today s international telephone call.

Or maybe even observing systems that can recognize climate conditions that will result in a category 5 hurricane before the storm has even formed.

Looking ahead, it’s clear that we want to be able to address the questions of climate change and weather. It’s really the same question - after all, climate is really nothing more than the integral of weather.

And climate isn’t so much about means as it is extremes. While it’s nice to talk about a mean climate condition or variation, what people really care about are the things that have a direct and dramatic impact on them - heat waves, droughts, severe storms, floods, cold spells, and the like.

Characterizing the frequency, duration, and severity of future climatic extremes will be crucial for both science and public policy. We re making progress on the science, but we re not there yet. But NASA is committed to making prudent investments of resources, people, and infrastructure to help develop and demonstrate the prediction capability of the future.

In addition, NASA will meet its commitment to provide a 15 year climate data record. Between 1999 and 2002, some 25 launches will carry instruments to orbit as components of our Earth Observing System. And we continue in part through collaboration with NOAA in the converged weather satellite program, or NPOESS.

In parallel, we are extending our rainfall measurements from the tropics to the whole globe. We will make new global measurements of soil moisture and sea surface salinity, filling in key pieces of the puzzle for the water cycle.

We foresee a time when two satellites one at Lagrange Point 1 and another at Lagrange Point 2 will provide continuous views of the full disk of the Earth in both day and night. These two sentinels would be linked to a constellation of small, smart satellites in LEO and GEO.

This system would convey enormous advantages in spatial and temporal resolution, and it would enhance our understanding of global-scale climate changes.

Let me be perfectly clear here. We have to look at the entire Earth as a single dynamic climate system. What happens on the other side of the planet impacts what happens here in the United States.

Meteorology is just like that. No single field within your profession should exist in a vacuum.

My challenge to you is to find ways to work together even more effectively. Find ways to integrate the work of short-term and longer-term researchers with the contributions of broadcast meteorologists and those doing data analysis, and the development of satellite systems.

As we combine the meteorological community s multi-disciplinary approach with advanced observing systems, computing & communications systems, and realistic models, we can dramatically increase our understanding of the links between climatic forcing factors and the climate system s response.

We can begin to establish the climate/weather connection; that is, the impact of climate change on the frequency, intensity and distribution of severe weather events. We will be able to help NOAA and other agencies answer the questions important to people:

When will the next El Nino be?
What will the weather be in two weeks?

What temperature and precipitation pattern can we expect this growing season?
What impact will climate change have on my region of the country over the next 25 years?

I m talking about technologies that will revolutionize the work of the American Meteorological Society s members. But that revolution and the incredible impact it will have on people s lives won t mean much if the public doesn t get the word.

Scientific research isn't just for scientists. The public spends a lot of money on it. They expect more than products, they expect understandable results. And they expect scientists to spend time clearly communicating those results.

Meteorologists already have an established pathway for communicating with the public, which could provide leverage to the broader Earth Science community. So I ask you - and for the NASA scientists here, ask is probably too gentle a word - to think hard about how you can best inform the public of the work that you're doing.

You've got wonderful stories to tell. Don't be afraid to tell them.

As the public sees more and more benefit to the work you do, their support will only increase.

Not every place in the world enjoys the warm and sunny today, warm and sunny tomorrow weather that Long Beach does, but every person on the planet benefits from the incredible work the members of the American Meteorological Society do.

Your efforts in research, forecasting, data analysis, and the development of satellite systems enhances people s lives. We at NASA are proud to be a part of your team.

Thank you very much.