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KEYNOTE DINNER ADDRESS TO
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I would like to thank Dr. Charlie Kennel, Director and Dr. Lisa Shaeffer of SCRIPPS, CNES, Christine Bernard of the French Embassy, and everyone involved in the organization, including Robert and Linda Bernstein of SeaSpace Corporation that supported this evening's event, for inviting me to participate in this exciting workshop on space and environment.

I also wanted to take the opportunity to acknowledge Dr. David Halpern, whom many of you know as your colleague. He is detailed from NASA JPL to the Office of Science and Technology Policy to be the lead for climate science and global change research and for our activities in oceans. We felt that these are such important scientific issues that we wanted to make sure we had a key discipline researcher in our office.

Today's topic is relevant and timely and contributes greatly to the ongoing policy and research discussion on observation systems, not just for understanding climate change, but also other environmental issues and for health. Any discussions must include members of academia, industry, and the international community. I want to applaud the organizers for bringing what I believe are the right groups together in order to reflect the diversity, richness, and robustness of space and environment research and the importance of partnership for all these endeavors.

We live in a remarkable age. When I first went to NASA, I was aware that Cassini was about to safely fly by earth on its orbit that was being propelled by nuclear power, but I did not know what its scientific purpose was. It was therefore interesting to learn, when space scientists came to brief me, that Cassini was going to Saturn, and was going to fly between the rings and take samples, in order for us to better understand what was going on. I was so amazed at what our technology can do in this era! There's also amazing technology on the many platforms that allow us to look down on the Earth. Dr. Mary Cleave, who is Deputy Associate Administrator in NASA's Earth Science Enterprise and a former astronaut, told me once that if we could have looked down at the Earth before we named it, we would have called it "Ocean"!!! Because of today's spatial observation posts, we fully comprehend the extent to which the ocean covers the majority of the planet.

Today I want to discuss three major anniversaries, in order to consider the many ways in which the past directs the present and the future. First, I would like to congratulate SCRIPPS on its 100th anniversary -- I think it is September 26th. Second, I would like to draw your attention to the 25th anniversary of a new era in both Earth and ocean sciences, an era when it became clear that space was important for advances in meteorology and oceanography. I am going to pause for a moment and give you some background while you catch your breath, because this is an after-dinner speech and I just jumped 75 years in one sentence! In 1978 we launched SeaSat, which demonstrated that the sea surface height topography and the surface wind velocity could be

measured with a satellite. Then TIROS-1, the next-generation Television Infra-Red Operational Satellite, carried the first instruments to adequately record sea surface temperature. Nimbus 7 showed how ocean color measurements provide estimations of phytoplankton, while LandSat-3 recorded images of the Earth surface, and GOES-3—all of that was launched 25 years ago in 1978. It clearly demonstrated the importance of satellite observations and it showed that utilizing radiation, microwave, visible, and infra-red frequencies could open the world of discoveries and understanding about our oceans and about our Earth.

When people look back 25 years from now, they are going to see that these last three years have also been a landmark for observations. There have been 16 missions launched since 1997, and that is not counting the six operational satellites developed by NASA for NOAA. What has also become clear today is that we are still missing many of the measurements that we need.

This year is also the 10th anniversary of always knowing where we are with accuracy of a few meters. Fast forward from 1978 to June 26, 1993 when the US completed the constellation of the 24 earth observing satellites known as the global positioning system, GPS. This basically revolutionized oceanography because it enabled the latitude and longitude of a measurement to be easily determined to tens of meters. It revolutionized environmental science, in general, since accurate geospatial measurements are the heart of their scientific progress.

What many of you may not be aware of is that GPS has also impacted my own field of neuroscience. We no longer need to spend NIH dollars supporting research on trying to locate the neurological site that inhibits men from asking directions along with the site that accounts for their love of gadgets. These sex differences have almost vanished now that GPS is found in cars and golf carts!

Interestingly, GPS was not developed with this application in mind. This incredible new technology was made possible by a combination of scientific and engineering advances, particularly the use of atomic clocks to seek answers about the universe. This is what the U.S. government does; invest in a strong science and technology profile, invest in basic science, in discovery science, and continue to support innovation. In addition to mission investments, discovery also referred to as curiosity-driven science is important because you do not know where it is going to end up. In this case it ended up with something that changed all of our lives.

The sixties and the seventies witnessed the establishment of strong and successful inter-agency processes. These involve NASA, NOAA, USGS—all agencies who are here today—along with the National Science Foundation, which supports our basic research profile in these areas. It was during this period that NASA designed and launched the Earth Observing Satellites, NOAA operated weather satellites to improve our weather forecasting, and USGS managed the land data archives. NASA had the science mission, for the necessary purpose of environmental research. The agencies worked in harmony, and our role at the OSTP is to make sure that they are still holding hands.

We had a breakthrough in satellite technology and knowledge during the past 25 years, which from the early 1970's allowed us to begin focusing on a major challenge, climate. The enactment of the national climate program after 1978 really accelerated the climate science era. At first concentration was on inter-annual variations of flood, drought, and agricultural harvest.

By the 70's and the 80's, the carbon dioxide measurements, recorded by Dr. David Killian from SCRIPPS, demonstrated the steady rise of carbon dioxide in the atmosphere, the annual breathing of the Earth, the influence of El Nino on the atmospheric CO_2, and the issue concerning the storage of half of the CO_2 emitted to the atmosphere. These are very important issues and, as we saw this afternoon, we are still tackling these scientific areas.

Around the same time, in the late 1970's, NASA was continually evolving in terms of finding its mission. Indeed, after the successful landing on the Moon, exploring, and bringing back samples, they orchestrated a series of meetings around the country to get advice on NASA's purpose for humankind. One of these meetings was actually held at the Institute of Geophysics and Planetary Physics here on the SCRIPPS campus. What resulted was a consensus to study Earth as a planet to advance the science of global habitability. Indeed, any study of Earth as a planet requires the unique perspective of space observational systems.

NASA agreed and decided to start a unique enterprise, to host a complex interdisciplinary science program to understand the global ecosystem on time scales of several decades. What they did is start "The Mission to Planet Earth", with your own Dr. Charles Kennel as the first director. The complexity of the problem of understanding the changing global environment has been demonstrated in many forms. Indeed, the United States, with France and other international partners, accepted the challenge to understand "global" change. And if the challenges were easy to solve, then the topics of today and tomorrow's seminar would be very different. Global means international. In terms of global climate, I should acknowledge the strong contributions of our international partners. We have heard a number of times today about Topex Poseidon, and that is because Professor Walter Munk of SCRIPPS said it was one of "most successful ocean experiments of all time". It has been my pleasure to share a table with Dr. Jean-Louis Fellous (and I apologize for the pronunciation but I only had 4 years of French!) and he was, for nearly 20 years, the main person responsible on the French side for this spectacular instrument which is now followed by its follow-on observatory, Jason.

I've spent most of this talk dealing with past anniversaries and accomplishments, but now we must look to our future and talk about our "grand environmental challenge.'' We must involve all of our partners in this challenge. We need an integrated global observation system, in which *in-situ* and remotely sensed biological, chemical, and physical observations are dynamically assimilated in the global models of the Earth ecosystem for prediction of many environmental phenomena for the benefit of all. This challenge requires all of our tools from observations, models, interpretation, databases, and also the quest for new knowledge to improve the predictive systems. It is important that the United States, France, and international communities have already established successful anchor points. We have improved the one- to five-day weather forecast, and also the prediction of the phase of the three- to seven-year El Nino and La Nina oscillations. France's Mercator Project in the North Atlantic is another excellent example of what needs to be done globally. The prediction of long-term climate and its change, however, is still very much in its infancy.

David Halpern wanted me to mention the example of the new NASA Orbiting Carbon Observatory, OCO, which is being readied for launch in 2007. This is going to provide accurate measurements of the column abundance of CO_2 in the Earth's atmosphere, and monthly global

maps of atmospheric CO_2 abundance will enable scientists to observe changes over time and location. It is very important that we start getting these measurements. It will make possible the interpretation of CO_2 sinks and the relative roles of uptake of atmospheric CO_2 by the ocean and terrestrial biosphere, as well more thoroughly understand the "missing" CO_2. It is also going to require improved tools, higher resolution climate models, improved super computing power, and increased knowledge about a large number of phenomena, to discover what we need to know for decision support. We are living and working at a very important time, and I challenge us now to stop dreaming about the integrated global observational systems and just "get on with it"! Every researcher in this room, as well as each of your colleagues elsewhere, has been working for many years to establish the integration of global to regional to local scale observations; to establish the integration of atmosphere, ocean and land observations; to establish the integration of *in-situ* and satellite observations; and to assimilate the observations in four dimensions of east-west, north-south, vertical directions, and in time. We talked through the "alphabet soup" of organizations like GTOS (Global Terrestrial Observing System), GCOS (Global Climate Observing System), GOOS (Global Ocean Observing System), IGOS (Integrated Global Observing Strategy), and others. They all have reports upon reports saying that we need an integrated global observation system. So to move forward and to create one, the United States' Departments of Commerce (NOAA), Energy, and State, are taking a major lead, and with the help of NASA, USGS, NSF, and the Department of Defense's Office of Naval Research, to host an Earth Observation Summit in Washington this summer. We are envisioning a high-level event which will serve as a foundation for reenergizing the Earth observing community. In the past 20 years, intergovernmental cooperation on space missions for oceanography has become the norm—I have mentioned Topex/Poseidon and Jason as examples, but also ARGOS and SeaWiFS—and we need to continue in this direction. Vice-Admiral Lautenbacher will say more about this tomorrow when he speaks. We envision, at the international level, bringing together senior government and non-government leaders for science, technology, and environment, who are involved in Earth observations from land, to the sea, to the air. Our desire is to sign a declaration supporting space-based, aerial, and *in situ* observations in an integrated framework that will enable nations to detect, understand, and address the changes in Earth systems and processes. We feel that this is very important.

Our generation has continued the quest for discovery. We now have incredible tools for observations and predictions to characterize the complex nature of climate change. New technologies always promise to advance our understanding, but now is the time for us to utilize recent advances, not only in space but by land, by sea, and by air, to conquer the challenges of environmental prediction and enjoy the adventure of new discovery. Something that I often say in Washington and I am going to say here is that we want our scientific opportunities and policies to drive our budgets, not our budgets to drive our policies. I believe the time is now.

On that note, I want to say thank you. It has been an incredible day, and I look forward to tomorrow.