Hazards Watch: Reducing the Impacts of Disasters Through Improved Earth Observations -- Summary of a Workshop, October 22, 2003, Washington, DC

National Research Council

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HAZARDS WATCH

REDUCING THE IMPACTS OF DISASTERS THROUGH IMPROVED EARTH OBSERVATIONS

SUMMARY OF A WORKSHOP
OCTOBER 22, 2003
WASHINGTON, DC

A SUMMARY TO THE
DISASTERS ROUNDTABLE

BY
RICHARD SYLVES, UNIVERSITY OF DELAWARE
AND HELEN WOOD, NOAA

NATIONAL RESEARCH COUNCIL
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FOREWORD

The Disasters Roundtable (DR) seeks to facilitate and enhance communication and the exchange of ideas among scientists, practitioners, and policymakers concerned with urgent and important issues related to the understanding and mitigation of natural, technological, and other disasters. Roundtable workshops are held three times a year in Washington, D.C. Each meeting is focused on a specific topic or issue and is free and open to the public. The Disasters Roundtable Steering Committee identifies topics, creates agendas, and recruits expert speakers for Roundtable events. For upcoming meetings, please visit http://dels.nas.edu/dr.

The Disasters Roundtable Steering Committee is composed of seven appointed members and sponsoring ex-officio members. The appointed members are William H. Hooke, chair, American Meteorological Society; David Applegate, American Geological Institute; Ross B. Corotis, University of Colorado, Boulder; Ann-Margaret Esnard, Cornell University; Susan K. Tubbesing, Earthquake Engineering Research Institute; Ellis M. Stanley, Sr., Emergency Preparedness Department of the City of Los Angeles; and Richard T. Sylves, University of Delaware. The ex-officio members are Lloyd Cluff, Pacific Gas & Electric; Dennis Wenger, National Science Foundation; Timothy Cohn, U.S. Geological Survey; Stephen Ambrose, National Aeronautics and Space Administration; Margaret Lawless, Federal Emergency Management Agency; James Russell, Institute for Business and Home Safety; and Helen Wood, National Oceanic and Atmospheric Administration. The DR staff includes William Anderson, director; Patricia Jones Kershaw, staff associate; and Kemi Yai, project assistant (until Jan. 2004) and Byron Mason (as of February 2004).

This document presents the rapporteur's summary of the workshop discussions and does not necessarily reflect the views of the roundtable members or other participants. Thanks to Professor Richard Sylves of the University of Delaware and Dori Ackerman and Michael Loucks of GRS Solutions for providing their notes from the workshop.

For more information on the Roundtable visit our website: http://dels.nas.edu/dr or contact us at the address below.

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This summary has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the NRC's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published summary as sound as possible and to ensure that the summary meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this summary:

Ronald T. Eguchi, ImageCat, Inc., Long Beach, California

Inez Fung, University of California, Berkeley

Responsibility for the final content of this summary rests entirely with the authors and the institution

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DISASTERS ROUNDTABLE

HAZARDS WATCH: REDUCING THE IMPACTS OF DISASTERS THROUGH IMPROVED EARTH OBSERVATIONS

OVERVIEW

How can we use our ability to observe the Earth's natural systems to create a disaster-resilient society and what challenges and limits remain in earth observation efforts? This question was explored by a variety of speakers and participants at the 9th Disasters Roundtable (DR) workshop entitled Hazards Watch: Reducing Disaster Losses through Improved Earth Observations on October 22, 2003 at the Keck Center of the National Academies. This topic was chosen by the Disasters Roundtable Steering Committee to take advantage of the momentum created by a July 31, 2003 Earth Observation Summit. This United States-hosted ministerial summit of 33 nations plus the European Commission and 21 international organizations was formed to promote the development of an integrated, comprehensive, coordinated, and sustained Earth observation system or systems among governments and the international community to understand and address global environmental and economic challenges. The DR workshop was designed to address the opportunity for reducing disaster losses by making the most of the technologies available through Earth observing systems, which produce highly-valuable information for policy makers and emergency managers. They represent an important tool for providing both current and long-term information necessary in decision support and in disaster prevention and mitigation. Earth observing technologies have already helped improve and advance the national warning system in the United States and an internationally integrated Earth observing system (IEOS) promises similar advances in planning and warning efforts of all nations. IEOS implementation planning is attempting to chart a course for the next 10 to 20 years that will help address major problems on the planet.

INTRODUCTION AND FRAMEWORK

What is an Earth Observation System? Earth observation refers to measurement and monitoring of the state of the Earth and its processes. An Earth observation system is a system of monitoring networks linked to create data and information for a variety of uses, including the mitigation of natural disasters (Lautenbacher, 2003). Earth observations are used in climate monitoring, search and rescue operations, property protection, and as stated above, disaster mitigation, to name a few. There are many components of an Earth observation system such as seismology for earthquakes, geodesy for precise measurement of the Earth's surface and shape, geomagnetism for solar storms that can damage billions of dollars worth of electrical grids and communications assets, and volcanology for detecting vertical movement at the Earth's surface and warning of eruptions. Specific technologies include the use of unmanned aerial vehicles and moored buoys for atmospheric profiling and measurements.

Earth observation systems are instrumenting the Earth for improving our knowledge of how the Earth's systems function, how they change, and what the implications are for society. Governments and decision-makers around the world now understand that these larger science questions are linked to other pressing social and economic needs. They now understand the potential an IEOS has to make major contributions to improving our understanding of the planet to ultimately save lives, property, and improve economic well-being.

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Although issues related to IEOS are not new, they are now receiving high-level attention that is creating momentum on this subject. This workshop was designed to take advantage of the momentum to explore and emphasize the potential IEOS has for disaster reduction.

VISION

Vice Admiral Conrad C. Lautenbacher, Jr., U.S. Navy (Ret.), Administrator, National Oceanic and Atmospheric Administration (NOAA), has been leading the U.S. effort to develop an IEOS. He participated in the July 2003 Earth Observation Summit, one of the first political summits of its kind. Lautenbacher delivered the keynote address at this workshop.

Lautenbacher stated that producing a successful IEOS will take time and cooperation at the political level. The Earth Observation Summit represents a new phase of cooperation among nations. The nations involved sent high-level representatives to participate, including five cabinet-level secretaries from the United States. Despite current open disagreements among world leaders in some areas, nations were able to put aside their difficulties to attend this event.

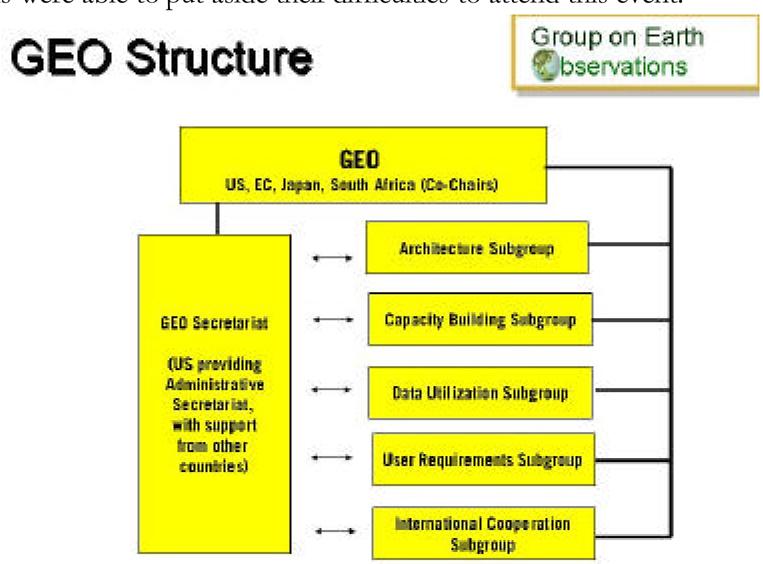

Figure 1 Structure of the Group on Earth Observations.
SOURCE: Presented by Greg Withee.

Earth Summit Mechanics. The declaration adopted at the first Earth Observation Summit recognized the need to move forward in the development of Earth observation systems, reaffirmed the need for data and information for sound decision-making, set forth principles for long-term cooperation in meeting these goals, and committed to improving Earth observation systems and scientific and technical support in developing countries. It also established an intergovernmental ad hoc group on Earth Observations (GEO) to develop a 10-Year Implementation for achieving a comprehensive, coordinated, and sustained Earth observation system. GEO met for the first time during the two days following the Summit and invited governments and international and regional organizations sponsoring existing Earth observing networks to participate. The GEO agreed to an ambitious schedule for developing a framework for a ten-year plan to be ready for the second ministerial conference on Earth observations in Tokyo in Spring 2004. The actual draft plan is to be available by the third ministerial conference in late 2004 to be hosted by the European Union. GEO members elected four co-chairs: Admiral Conrad Lautenbacher (U.S. Navy Ret.), NOAA

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Administrator of the United States; Director General Achilleas Mitsos of the Directorate General for Research of the European Commission; and Mr. Akio Yuki, Deputy Minister of Education, Culture, Sports, Science, and Technology (MEXT) of Japan. The group also established a fourth co-chair, from South Africa, to represent the developing country perspective—South Africa will announce their representative in the near future.

Lautenbacher acknowledged that Earth observing system technology is not new, but is an ongoing effort begun early in the Space Age that integrates existing science and technology. An IEOS will achieve its maximum potential if leaders recognize and support its larger multinational and global focus. IEOS encourages multi- and inter-disciplinary research and can be a catalyst for earth scientists to work together on a unifying topic.

The Value of IEOS. Earth observing systems make it possible to monitor the planet in full, when not long ago Earth monitoring was geographically limited and intermittent. An IEOS carries enormous potential to aid in climate extremes research and prediction, flood watch and warning, agriculture, transportation management, and energy management and distribution. COSPAS-SARSAT[1], a system that rides on Earth observing satellites of several countries to support search and rescue aided tracking, has already assisted in saving over 15,000 lives worldwide since it became operational in 1982 (NOAA, 2003). Researchers can and have used Earth observing system data for scientific and economic advancement, sustainable development, and population growth impact studies. Natural disasters put 30 to 40 percent of America's $10 trillion economy at risk. Due to their use of data gathered by these observation systems, seasonal forecasts are now more accurate and this has had significant effects for agriculture and fishing.

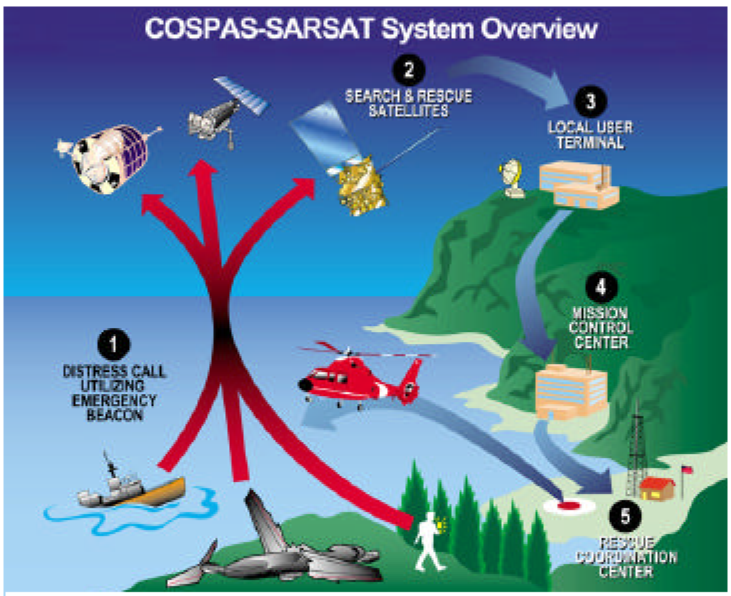

Figure 2 The Search and Rescue Satellite Aided Tracking (SARSAT) system uses NOAA satellites in low-earth and geostationary orbits to detect and locate aviators, mariners, and land-based users in distress. SOURCE: NOAA National Environmental Satellite, Data, and Information Service. http://www.sarsat.noaa.gov/

Earth Observations at Work for Disaster Reduction. Hurricane Isabel struck the east coast and adjacent inland areas of the United States in mid-September 2003. Earth observations from existing satellite systems, combined with advances in science, modeling, and data gathering, predicted the track of

[1] COSPAS-SARSAT is an acronym for an international search and rescue system. Cospas is an acronym for the Russian words "Cosmicheskaya Sistyema Poiska Avariynich Sudov," which mean "Space System for the Search of Vessels in Distress."Cosmicheskaya Sistyema Poiska Avariynich Sudov." SARSAT stands for Search and Rescue Satellite-Aided Tracking (NOAA, 2003).

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Isabel with much greater accuracy than had ever been achieved for previous hurricanes. Forecasters were able to predict where Isabel's land fall point would be, within a 90 mile range of error, 72 hours before the hurricane struck land. After impact, the U.S. Army Corps of Engineers, using Earth observing technologies, examined every square mile of coast affected by Isabel for damages, facilitating speedy repair and recovery, particularly along the hard-hit North Carolina coast.

ACHIEVING INTEGRATED EARTH OBSERVATIONS: CURRENT STATUS

There are 73 satellites used for Earth observations currently in orbit, thousands of ground level networks, and hundreds of airborne information collectors. Terabytes of data are being produced by these instruments every day. Much of this information feeds weather centers and research laboratories and has proven useful for managing natural disasters (see Table 1). The challenge for enhancing future capabilities of Earth observations for disaster management is in increased cooperation among international data providers in order to achieve the scale, frequency of measurements, and speed of response, which are required to face diverse and time-critical disasters (CEOS, 2003).

GLOBAL IMPLICATIONS OF EARTH OBSERVATION SYSTEMS FOR DISASTER REDUCTION

Salvano Briceño heads the Inter-Agency Secretariat of the International Strategy for Disaster Reduction (UN/ISDR). The UN/ISDR is a small inter-agency group assigned the task of helping partners interested in disaster reduction to work together. It attempts to further the efforts initiated through the United Nations during the International Decade for Natural Disaster Reduction (1990-1999). The ISDR goals are to reduce risk and vulnerability, to help public authorities commit to disaster reduction, to advance multi-disciplinary research, to promote the creation and maintenance of disaster resilient communities, to foster regional outreach programs aimed at disaster reduction, and to partner in risk reduction efforts. The ISDR office works in conjunction with United Nations task for110
ces advancing civil societies via advocacy, coordination, information management, and education. The United Nations supports space (satellite) applications, i.e., IEOS, for disaster reduction and has action teams aiding in disaster management.

Increasing poverty compounded by growing population concentrations in urban areas cause increased vulnerabilities, especially in developing nations. IEOS has the potential to reduce disaster vulnerability and recurring disaster losses by providing data for applications that can identify vulnerable populations and areas, thus changing the disaster culture from reaction to prevention and mitigation. IEOS information will advance both scientific and humanitarian goals. (See Rao, 2000 for a specific discussion of how India is using Earth observations for preparedness, mitigation, and recovery.)

NOAA's ROLE IN MAKING IEOS HAPPEN

Gregory Withee, Assistant Administrator for Satellite and Information services at the National Oceanic and Atmospheric Administration (NOAA), is the current chair of the Committee on Earth Observation Satellites (CEOS). The CEOS encompasses the world's government agencies

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TABLE 1 Current Capabilities of Earth Observation Satellites for use in Disaster Management

HAZARD	USE OF EO SATELLITES
Hurricanes & tornadoes	Weather satellites are used extensively for detection and tracking of storms and contribute effectively to the forecasting capability. Recent satellite missions providing more detailed and frequent measurements of sea surface wind speed and tropical rainfall mapping have significant improved forecasts.
Volcanic eruptions & earthquakes	In-situ and Global Positioning System (GPS) satellites provide valuable information on seismic and volcanic activity. EO satellites provide complementary data in support of disaster mitigation and response: interferometry techniques of radar sensors are used to monitor fault motions and strain, and signs of Earth surface deformation and topographic changes. Very high resolution sensors are used to map damage assessment, direct response efforts, and aid reconstruction planning. Satellite data is the primary information source employed by the 9 Volcanic Ash Advisory Centres operational world-wide which issue volcanic ash cloud warnings, an essential information source for international aviation safety.
Wildfires	A number of satellites now contribute routinely to each stage of wildfire hazard management world-wide, including: fire risk mapping using land cover and fire fuel assessments, moisture data, digital elevation maps, and meteorological information – all derived from satellite; fire detection and early warning; fire monitoring and mapping; burned area assessment.
Oil spills	Synthetic Aperture Radar (SAR) data is used as the basis for ocean surveillance systems for oil slick detection, to provide enforcement and monitoring capabilities to deter pollution dumping. The SAR data is processed within 1-2 hours of the satellite overpass and used by pollution control authorities to cue aircraft surveillance. Surveillance systems are currently operational in Norway, and Denmark, and under trial in the Netherlands, Germany, and the UK. SAR data and optical data are also used to develop information in support of major coastal oil spills, to assist in mapping pollution extent and managing the response.
Drought	Currently, multichannel and multi-sensor data sources from geostationary satellites and polar orbiting satellites are used routinely for determining key monitoring parameters such as: precipitation intensity, amount, and coverage, atmospheric moisture and winds. Instruments with spectral bands capable of measuring vegetative biomass are also used operationally for drought monitoring. The Famine Early Warning System (FEWS) in Africa, for example, exploits operational use of satellite technology to reduce the incidence of famine in sub-Saharan Africa by monitoring the agricultural growing season. Monitoring is carried out through 'greenness maps' derived every 10 days from the AVHRR instrument, and from rainfall estimates.
Floods	Earth observation satellites are used for the development of flood impact prediction maps, contributing measurements of landscape topography, land use, and surface wetness for use in hydrological models. Weather satellites provide key information on rainfall predictions to assist flood event forecasting. Since optical observations are hampered by the presence of clouds, SAR missions (which can achieve regular observation of the earth's surface, even in the presence of thick cloud cover) are frequently used to provide near real-time data acquisitions in support of flood extent mapping.

SOURCE: CEOS, 2003.

responsible for civil Earth observation satellite programs, along with agencies that receive and process data acquired remotely from space. As chair of CEOS, Withee plays an active role in the International Global Observation Strategy (IGOS), a world partnership established to provide an

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over-arching strategy for conducting observations relating to climate and atmosphere, oceans and coasts, the land surface and the Earth's interior. The partners, through IGOS, build upon the strategies of existing international global observing programs, and upon current achievements, in seeking to improve observing capacity and deliver observations in a cost-effective and timely fashion (IGOS, 2000).

NOAA advances the ocean and atmospheric part of IEOS through its products and services. NOAA's work involves positioning Earth observing satellites and working with data consumption centers. Atmospheric scientists, ecologists and environmental scientists, geoscientists, and others attempt to integrate their research aims in order to produce "one story" to the President and the Office of Management and Budget. IEOS is ideal in this comprehensive effort because it facilitates in situ land and ecosystem monitoring, volcanic and tsunami warning systems, and a host of other Earth observing activities. Withee suggested that it would be valuable to introduce disaster management support groups to IEOS. IEOS data streams could be processed to help others address landslides, earthquakes, droughts, volcanoes, ocean storms, and oil spills. Withee advocated "on demand" satellite tracking and image acquisition in times of disaster.

To demonstrate how IEOS can assist in managing and reducing natural disasters, Withee described the extensive amount of data and information required to fully understand a disaster event such as flooding. Precipitation estimates and severe storm index sequences are used for warnings of severe storms such as tornadoes (CEOS, 2003). A single system cannot provide all the data necessary to understand the present and future impacts of a disaster event; all data, including archived data from other systems, can aid in response and recovery. Withee illustrated a case in which an international agreement, the International Charter: Space and Major Disasters, was activated to provide satellite observation of various disasters such as earthquakes, volcanic eruptions, landslides, floods, ocean storms, and oil spills.

IEOS officials will need to understand the requirements of their information users in order to make IEOS work. They will also have to help others increase their ability to use IEOS-supplied data in optimum ways. Some of this might be accomplished through the United Nation's World Meteorological Organization.

WMO'S EXPERIENCE IN INTEGRATING GLOBAL OBSERVING SYSTEMS

As Secretary-General of the World Meteorological Organization (WMO), **Michel Jarraud** presented the WMO's role in an IEOS.

The WMO performs extensive global observations in support of climate, hydrological, and meteorological activities. These observations range from in situ sensors to radars and space-borne systems. A major goal of the WMO efforts is to integrate these systems, which are a major contribution to disaster mitigation efforts. Integration includes data collection, worldwide free and unrestricted exchange and dissemination of data and products to a wide range of users including governments.

The goals of the WMO go beyond making observations. The WMO's Global Observation System (GOS) supports forecasting as well as climate research, and contributes to better risk evaluation and management. GOS enables improved study of disaster-related phenomenon possible. The most obvious benefits of GOS are the safeguarding of life and property through the forecasting, detection and warning of severe weather phenomena such as local storms, tornadoes, and extratropical and tropical cyclones. (WMO, 2003).

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GOS provides vertical structure analysis of the atmosphere as well as better monitoring of the Earth's surface. It is made up of observing facilities at stations on land and at sea, and on aircraft, meteorological satellites and other platforms. These facilities are owned and operated by the 185 member countries of WMO and international satellite agencies. Aircraft observational data collection is growing quickly. Argo, a broad-scale global array of temperature/ salinity profiling floats, currently deployed under the responsibility of the Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM), comprises about 900 buoys, with a goal of eventually reaching at least 3000.

The WMO coordinates several other international programs that contribute to Earth observations. The Global Atmospheric Watch (GAW), a worldwide network of strategically located global, regional and national monitoring stations coordinated by the WMO, monitors atmospheric chemistry including greenhouse gases, aerosols and pollutants. The World Hydrological Cycle Observing System (WHYCOS) aims to provide a global picture of the hydrological cycle and to promote global exchange of hydrological data. Also, the WMO has a fast expanding space-based component of its Global Observation System. It integrates data from 3 constellations of satellites (polar orbiting, geostationary as well as research and development environment satellites). WMO has initiated a major WMO Space Program which will contribute to a wide range of disaster prevention and mitigation activities.

WMO's work involves four stages: reviewing user requirements, examining existing and planned observation systems, conducting critical reviews to assess capabilities and how successfully requirements have been met, and producing guidance for WMO members on satellite-related technological developments as well as on changes in relevant existing meteorological and hydrological operation systems. WMO promotes thematic integration of atmospheric climate, oceans and terrestrial data in a constantly evolving manner in order to adapt proactively to a fast changing environment.

The following points emerged during the discussion:

Challenges in Research and Development: Continued research on Earth observations is essential to achieve a fully integrated international Earth observation system. In order to attain funding for research, it is necessary to educate the public about the societal benefits of the research. Equipment costs for Earth observations systems consume a large portion of the total research budget, but program managers work to make it all fit together so that researchers get precisely what they need and research products are disseminated in the best way possible. The recent Summit has helped policymakers around the world recognize the value of expanding their research budgets so their researchers and policymakers make good use of the wealth of information provided to them by the Earth observation system.

Questions that need to be addressed in the near future are:

- How can existing funding be used more effectively?
- How can the system be sustained in the future?
- How can future observations be attained for the same cost as today's observations?

IEOS and Disaster Reduction: IEOS has a wide range of applications in disaster reduction; however, it is difficult to integrate information across all needs. Disasters need to transpire in order to demonstrate the ability of IEOS to aid in disaster reduction. Some success stories have been published by WMO and others on how Earth observing system data has aided in climate research

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and disaster management. The recently published UN/ISDR "Living with Risk" report demonstrates some of what has been done using this data.

IDENTIFYING CRITICAL EARTH OBSERVATIONS GAPS AND OPPORTUNITIES RELATED TO DISASTER REDUCTION

Charles Groat, Director of the U.S. Geological Survey (USGS), provided his views on Earth observation systems gaps and opportunities.

A combination of spatially and temporally diverse systems (e.g., archived, in situ, and remote sensing) are required to characterize environmental developments that contribute to or affect natural hazards. Such monitoring is conducted for both scientific as well as operational purposes (mitigation or post-facto).

Although many new systems have been implemented over the last ten years, one decade is an inadequate timeframe for fully understanding many of the phenomena under scrutiny. The lack of long-term observations is a crucial gap in knowledge in many cases.

Gaps also exist in the integration of in situ sensor data with data from other observations. For example, records from a combination on such sensors along with NASA interferometric radars (Interferometric Synthetic Aperture Radar or InSAR, (USGS, 2004a)) revealed 15 cm of uplift since 1998, but no seismicity, in the Three Sisters volcanoes area in Oregon. InSAR measurements brought to light this change in an area which had not erupted for 1500 years—this was only noted because long-term records of the area existed. As a result, various in situ instruments were put in place to monitor this region more carefully. On the other hand, in situ sensor data dissemination is providing new user opportunities. Examples include the near real-time USGS Stream Gauging Network, which provides potential flood alert data directly to home users via the Internet. The problem with the network is how to sustain it. Stream gauging efforts are sometimes lost due to funding decreases by cooperating agencies. Consistent funding is vitally important for progress to be made.

Strain gauges, whose data are forwarded directly to civil and emergency authorities via ShakeCast, an automatically generated computer map of the severity and distribution of ground shaking that is available via the Internet within 5-10 minutes after an earthquake, are coupled with Advanced National Seismic System (ANSS) seismometers. There are currently 500 ANSS sensors located in buildings and on bridges in a few select cities, while approximately 7500 are needed to cover many vulnerable locations. Budget constraints have delayed wider distribution.

Opportunities exist to apply Earth observations to construction engineering in order to avoid disaster losses. During the November 2002 Denali Earthquake (magnitude 7.9), the Alaskan Pipeline shifted eighteen feet but did not rupture. The pipeline crossed a zone where seismic movement had been predicted and accounted for in the design and reinforcement of the pipeline. Based on long-term geologic data and records of the Denali Fault, the pipeline was designed and built to withstand a magnitude 8 earthquake.

Concluding his remarks, Dr. Groat suggested that our Earth observation tool box must include in situ monitoring, long-term records, and spatially diverse records to enhance our ability to respond to natural hazards.

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Dr. Terry Egan, Manager, Mitigation, Analysis & Plans Unit, Emergency Management Division, Washington (State) Military Department, discussed the challenges of applying Earth observation data to hazards in his state.

Emergency managers provide pre-disaster alerts and warnings, coordinate resources in disaster or emergency circumstances, assist in disaster planning, assist in disaster exercises, and grant financial aid to localities. In a disaster situation, emergency managers are the center and leaders of mass activity. The more information an emergency manager has to work with, the more prepared the manager will be to handle the event. Unfortunately, emergency managers are often constrained in utilizing Earth observation data because they lack adequate resources. Many who work in emergency management are not trained to analyze Earth observation data, nor do they have the time, energy, or funding to integrate observation systems into their work products. Emergency managers need real time data, high resolution images, true-color imagery, and user-friendly, site specific data packages. Emergency managers need the assistance of remote sensing experts to locate a disaster event. Egan sees a need for federal government funding for state and local emergency management applications in remote sensing.

Washington State has received a three-year grant from NASA that aims to help emergency managers use remote sensing products to address hazard planning and disaster mitigation. They have also retained the assistance of the University of Washington's remote sensing lab for training to use remote sensing data for emergency management. Washington has been able to use partnerships such as these to leverage resources. (See NRC, 2003 for a discussion of using remote sensing in state and local government).

Egan reported on data integration successes in Washington State with the use of LANDSAT (a U.S. satellite used for observing Earth's land surface), Advanced Very High Resolution Radiometer (AVHRR), and Moderate Resolution Imaging Spectroradiometer (MODIS) data combined with state, local and tribal data.

Dr. Susan Conard, Vegetation Management and Protection Research, USDA Forest Service, discussed gaps in wildfire disaster management. She highlighted critical issues related to wildfire in an integrated Earth observation system. Her work involves field reference data, LANDFIRE geographic information system analysis, methods, and map deliverables.

Federal agencies spend about $1.6 billion on fire suppression for the approximately 5.4 million acres of federal land that burns annually.

IEOS data helps in providing a baseline for monitoring trends, measuring effects of natural disturbances and fire management activity, and devising plans and building predictive models. EOS data is used in fuel classifications, fuel condition measures, fire hazard threat measurement, in identifying resource values at risk from fire, in building basic data layers, and in mapping wildland fire occurrence. Fire weather inputs, landscape mapping, fire behavior models and behavior, infrastructure data, and data on the urban/wildland interface all draw from EOS in various ways.

Challenges of using IEOS data for wildfire management include linking data across scales, collecting various types of data over various time periods and with varying spatial resolutions. The continuity of observations is sometimes interrupted when satellites move out of range. Seasonal factors, fire activity periods, incident management demands, fire severity and smoke haze sometimes

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make use of EOS supplied information difficult. Before 1999, no national spatial data base on fire and fuels existed. Today there is LANDFIRE, a multi-agency, inter-disciplinary research and development activity designed to develop a consistent and accurate methodology capable of producing geospatial data of vegetation conditions, fire fuels, risks, and ecosystem status at the national, regional, and local scales for implementation of the National Fire Plan. LANDFIRE may lead to a national fires and fuel database. However, maps are not refined to cabin level. Thirty meter resolution is needed to capture buildings and structures.

Dr. Conard advocates historical analysis of fire regimes to examine the rate of change and flammability changes over time. LANDSAT images help in identifying habitats of endangered species, zones of invasive species, vegetation changes, and insect population changes. Weather, wind patterns, humidity, and other variables are essential during fire season. Video from the Fire Consortia for Advanced Modeling of Meteorology and Smoke (FireCAMMS), a coordinated group of regional cooperative centers for high-resolution simulation modeling of weather, fire and smoke, provide timely, high resolution data to support prescribed fire planning, wildland fire response, and smoke modeling and prediction.

Concurrent observations from satellites, planes, and ground sources help map fire parameters and improve fire behavior models. Earth observations help emergency responders anticipate burn area conditions (e.g., slopes, erosion potential, slides).

THE WAY FORWARD: DEVELOPING A 10 YEAR PLAN OF INTEGRATED EARTH OBSERVATIONS

Helen Wood, Senior Advisor for Satellite Systems and Service presented an introduction to the closing session. She provided advice for executing a ten-year plan:

- Speak out as a community.
- Ask for the ideal data, be realistic, and ask for the data that is high priority.
- Do not assume that a system will be sustained – make it a requirement.

Richard Anthes, President, University Corporation for Atmospheric Research (UCAR), spoke on accelerating the transition from research to operations.

More and better observations, improved models with higher resolution, ensemble forecasts, and more powerful data assimilation methods have advanced weather research and improved forecasts rapidly over the past decade. Increasing numbers of sensors produce terabytes of data daily. It is necessary for models to keep pace with the influx of raw data and transform the observations into information because raw data alone is useless to most end users. Combining the many observations from an IEOS to produce analyses and useful information that users will trust, employ and understand, is essential for success. (NRC, 2003a).

Anthes outlined the following obstacles to progress when transitioning from research to operations in Earth observations:

- Cultural differences between research and operational communities
- Organizational and personality issues
- Inadequate communication and coordination between players
- Inadequate financial or educated human resources

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- Absence of effective and standing process for planning and follow-through
- Inflexibility of "the system" to quickly incorporate new ideas
- Inadequate scientific knowledge or technological capability

Anthes suggested that the payoff to surmounting these difficulties is immense, and that an organized mechanism to accelerate the transition of research to operations is needed.

Dr. Ghassem Asrar, Associate Administrator for Earth Science, NASA, spoke on the evolution of the current set of observing networks.

NASA has many Earth observing satellites in orbit; some in geostationary orbits and others on polar orbits. These NASA satellites make it possible to analyze the Earth in a holistic way. Ground-based in-situ observing network sensors and remote sensing by satellite make it possible for resource managers and business people to better manage resources.

Diversity and quality of observations is important. Striving for better calibration and consistency should be a goal of the IEOS. NASA's Earth Science Research Satellite users seek to understand processes; they do not just collect raw data or build models. NASA researchers look for pathways from research to operational systems and recognize that satellites not do the entire job of Earth observation. For this reason, policymakers must reinvigorate ground-based and in situ Earth observation networks.

Asrar supports the adoption of standards and protocols regarding data policies. All Earth observation data producers and consumers should share data. The key to success is thinking flexibly. Asrar hopes that the evolution and pervasiveness of IEOS mimics that of telecommunications.

IEOS will aid in the reduction of natural disasters through:

- Enhanced Ocean Activity Wide Swath remote sensing now makes it possible to measure ocean eddies.
- Ocean wind surface measurements produce a view of the entire globe once every other day.
- Synoptic observation couples atmospheric chemistry analysis with climate science research.

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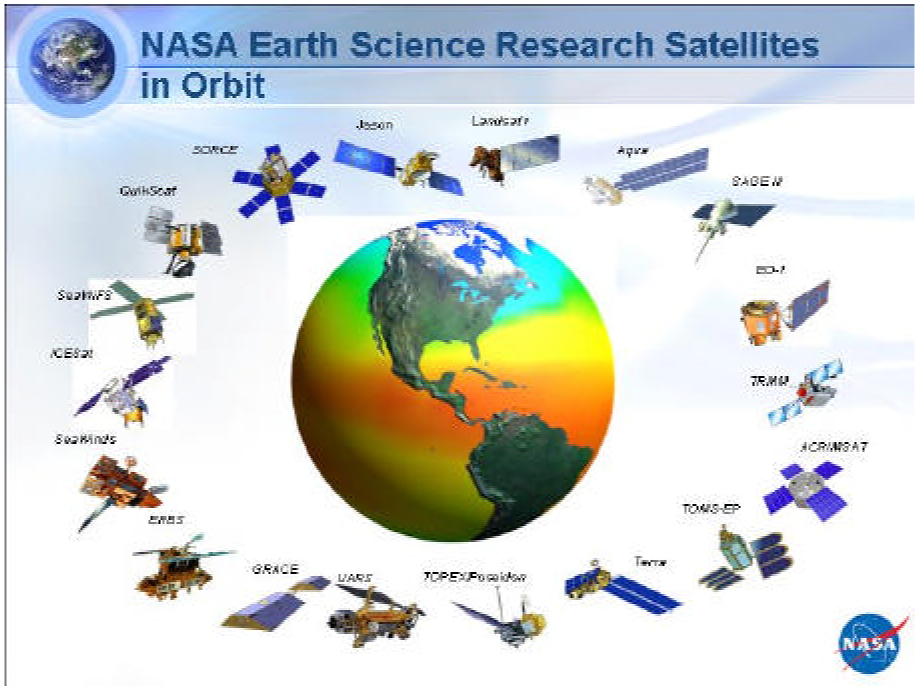

Figure 3 NASA Science research satellites in orbit. SOURCE: Presentation by Ghassem Asrar.

Standards and protocols are areas needing the most improvement now – not new systems. Original data can be on the order of Petabytes (10^{15}), but direct human consumption is on the order of Megabytes (10^{6}). The primary challenges include, but are not limited to, the following:

- Data policies
- Limiting scope of observations
- Maintaining and ensuring data quality
- Cost
- Security

Dr. William Gail, Director, Advanced Programs for Earth Science, Ball Aerospace & Technologies Corp was the final speaker of the day, presenting a briefing entitled "Curves on the Road to an Integrated Earth Observation System."

The justification for IEOS resides in its value as an environmental treaty compliance monitor, contributions to a wide variety of businesses and commercial ventures, weather and climate forecasting value, decision support value to governments, and the ability to reduce vulnerability to natural hazards.

The IEOS is part of a larger environmental information infrastructure which is facing growing demands from users and an increasing need for coordination and enhancement.

An IEOS contains roles for the public, private, and academic sectors. The public sector promotes stewardship and long-term planning; academia promotes creativity and

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challenges institutional routines; and the private sector advances efficiency through free market behavior and the profit motive.

Gail raised several questions regarding the planning for EOS. Are we planning adequately for unanticipated data and information needed for IEOS? Will policy needs in 40+ years be adequately supported by the long-term datasets we initiate today? Will climate change itself alter what needs to be observed and compel IEOS operators to refashion observing systems? Development of the IEOS should incorporate non-deterministic planning, including use of contingency-based and scenario-based planning tools. IEOS users should be sure the systems they develop are flexible and amenable to evolution. Gail emphasized that IEOS has tremendous potential to shape how to mitigate, prepare for, respond to, and recover from future natural disasters.

SUMMING UP

During this workshop, participants discussed and examined how an IEOS would work and how current Earth observations contribute to the mitigation of natural dsasters. As noted by Ghassem Asrar, for the first time in history we have the scientific expertise and the technological capability to study and understand the underlying processes of Earth system change, and to dramatically improve forecasts of natural disasters. These capabilities alone cannot create an integrated system—international cooperation is imperative. IEOS experts and leading officials in over 30 nations are working together to put forward a plan to implement IEOS effectively. The challenges of taking terabytes of data and translating them into practical application will be great, but when IEOS is implemented the payoffs will be in lives saved, in people and property protected, and in significantly better informed management and stewardship of the world's environment and natural resources.

For updates on the current status and future plans of IEOS please see the Earth Observation Summit homepage.

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REFERENCES

Committee on Earth Observation Satellites (CEOS). 2003. Earth Observation Handbook: 2003 Update. Online: http://www.eohandbook.com/index.html. Accessed: February 19, 2004.

IGOS. 2000. The Integrated Global Observing Strategy Partnership Process. Revised 27 December 2000. http://www.igospartners.org/. Accessed: February 17, 2004.

Lautenbacher, C. 2003. "An Integrated Earth Observation System—A Public-Private Partnership" Oceanology International Americas, 2003 Conference. New Orleans, June 4 2003. http://www.noaa.gov/lautenbacher/oceanology.htm Accessed: November 24, 2003.

National Research Council. 2003. Using Remote Sensing in State and Local Government: Information for Management and Decision Making. National Academies Press, Washington, D.C.

National Research Council. 2003a. Satellite Observations of the Earth's Environment: Accelerating the Transition of Research to Operations. National Academies Press, Washington, D.C.

NOAA. 2003. Search and Rescue Satellite-sided Tracking. Online: http://www.sarsat.noaa.gov/. Accessed Nov. 20, 2003.

Rao, D. P. 2000. Disaster Management. GIS Development Applications. Online: http://www.gisdevelopment.net/application/natural_hazards/overview/nho0004.htm. Accessed February 19, 2004.

USGS. 2004. Landfire. http://www.landfire.gov/ Accessed: February 17, 2004.

USGS. 2004a. What is InSAR? USGS Earthquake Hazards Program—Northern California. Online: http://quake.wr.usgs.gov/research/deformation/modeling/InSAR/whatisInSAR.html.

World Meteorological Organization (WMO). 2003. Purpose of GOS. Online: http://www.wmo.int/web/www/OSY/gos-purpose.html Accessed: February 17, 2004.

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APPENDIX A

HAZARDS WATCH: REDUCING DISASTER LOSSES THROUGH IMPROVED EARTH OBSERVATIONS

A DISASTERS ROUNDTABLE WORKSHOP

October 22, 2003

The National Academies
Room 100
500 Fifth Street
Washington, DC

AGENDA

8:30 AM **WELCOME AND INTRODUCTIONS**
William H. Hooke, American Meteorological Society; Chair, Disasters Roundtable

8:40 AM **INTRODUCTION OF WORKSHOP OBJECTIVES**
Helen M. Wood, National Oceanic and Atmospheric Administration; Chair, Subcommittee on Disaster Reduction; Member, Disasters Roundtable

8:50 AM **THE VISION FOR AN INTEGRATED EARTH OBSERVATION SYSTEM: OPPORTUNITIES FOR DISASTER REDUCTION**
Conrad C. Lautenbacher, Jr., National Oceanic and Atmospheric Administration; Co-Chair, Group on Earth Observations

10:00 AM **BREAK**

10:15 AM **ACHIEVING INTEGRATED EARTH OBSERVATIONS: CURRENT STATUS**
Presentations and moderated discussion on the successful use of Earth observations in current international disaster reduction efforts.
Moderator: **Ron Birk**, National Aeronautics and Space Administration
Sálvano Briceño, Secretariat on International Strategy for Disaster Reduction

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Gregory Withee, National Oceanic and Atmospheric Administration; Chair, Committee on Earth Observation Satellites
Michel Jarraud, World Meteorological Organization

11:20 AM **CURRENT STATUS: QUESTIONS AND DISCUSSION**

12:00 NOON **LUNCH BREAK**

1:00 PM **IDENTIFYING CRITICAL EARTH OBSERVATION GAPS AND OPPORTUNITIES RELATED TO DISASTER REDUCTION**
Presentations and moderated discussion on the critical gaps in current Earth observation strategies and systems.
Moderator: **Gene Whitney**, Office of Science and Technology Policy
Charles "Chip" Groat, U.S. Geological Survey
Terry Egan, Washington Military Department
Susan Conard, USDA Forest Service

2:30 PM **CRITICAL GAPS AND OPPORTUNITIES: QUESTIONS AND DISCUSSION**

3:00 PM **BREAK**

3:15 PM **THE WAY FORWARD: DEVELOPING A 10 YEAR PLAN FOR INTEGRATED EARTH OBSERVATIONS**
Presentations and moderated discussion of key outcomes, and the related implementation planning.
Moderator: **Helen M. Wood**, National Oceanic and Atmospheric Administration; Chair, Subcommittee on Disaster Reduction; Member, Disasters Roundtable
Richard Anthes, University Corporation for Atmospheric Research; Chair, NRC Committee on NASA-NOAA Transition from Research to Operations
Ghassem Asrar, National Aeronautics and Space Administration
William Gail, Ball Aerospace and Technologies Corp.

4:20 PM **THE WAY FORWARD: QUESTIONS AND DISCUSSION**

4:50 PM **CLOSING REMARKS**
William H. Hooke, American Meteorological Society; Chair, Disasters Roundtable

5:00 PM **ADJOURN**

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APPENDIX B

LIST OF WORKSHOP ATTENDEES

Gary Adkins, ORBIMAGE
Benigno Aguirre, University of Delaware
Dori Akerman, GRS Solutions
William Anderson, The National Academies
Kasse Andrews-Weller, U.S. Air Force
Richard Anthes, University Corporation for Atmospheric Research
David Applegate, American Geological Institute
Joan Aron, Science Communication Studies
Ron Birk, National Aeronautics and Space Administration
Michael Blanpied, U.S. Geological Survey
Donald Blick, Raytheon
Cameron Bouchard, Office of Critical Infrastructure Protection and Emergency Preparedness (OCIPEP), Canada
Salvano Briceno, United Nations International Strategy for Disaster Reduction
Art Charo, The National Academies
Lloyd Cluff, Pacific Gas and Electric
Timothy Cohn, U.S. Geological Survey
Susan Conard, U.S. Department of Agriculture Forest Service
Jim Cooper, Earth Satellite Corporation
Ross Corotis, University of Colorado
Harvey Dahljelm, ITT Industries
Christina del Castillo, International Activities Office
Julie Demuth, The National Academies
Sheldon Drobot, The National Academies
Jon Duncan, Consortium of Universities for the Advancement of Hydrologic Science, Inc. (UCAR)
Terrance Egan, Washington State Emergency Management
Ron Eguchi, ImageCat
Ann-Margaret Esnard, Cornell University
Peter Folger, American Geophysical Union
William Gail, Ball Aerospace
John Gaynor, National Oceanic and Atmospheric Administration
Don Geis, Geis Design Research Associates
Kathleen Gohn, U.S. Geological Survey
Kay Goss, Electronic Data Systems Corporation
Chip Groat, U.S. Geolo gical Survey
Edward Gross, StormCenter Communications
Chuck Hakkarinen, National Oceanic and Atmospheric Administration
Michael Hales, National Oceanic and Atmospheric Administration
Robert Hamilton, The National Academies
Juerg Hammer, World Institute for Disaster Risk Management, Inc. (DRM)
Elliot Harkavy, EGH & Associates
Steve Harrison, Northrop Grumman Space Technology
Colleen Hartman, National Oceanic and Atmospheric Administration
Tom Hassler, Virginia Emergency Management Association
Rosalind Helz, U.S. Geological Survey
Tom Hickey, Raytheon
William Hooke, American Meteorological Society
Herbert Jacobowitz, Short & Associates, Inc.
Michel Jarraud, World Meteorological Organization
Steve Johnson, ITT Industries
Edwin Jones, Lawrence Livermore National Laboratory
Patricia Jones Kershaw, The National Academies
Sang-Seon Kim, Korean Embassy

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Alcira Kreimer
Keelin Kuipers, National Oceanic and Atmospheric Administration
Mary Ann Kutny, National Oceanic and Atmospheric Administration
Randolph Langenbach, Federal Emergency Management Administration
Conrad Lautenbacher, Jr., National Oceanic and Atmospheric Administration
William Leith, U.S. Geological Survey
John Longenecker, National Oceanic and Atmospheric Administration
Michael Loucks, GRS Solutions, Inc.
Kevin Lynott, National Oceanic and Atmospheric Administration
Caren Madsen, National Oceanic and Atmospheric Administration
Jon Malay, Lockheed Martin Corporation
Robert Mason, U.S. Geological Survey
Margaret McCalla, Office of the Federal Coordinator for Meteorological Services and Supporting Research
James McGuire, Integrated Program Office
Carolyn McMahon, American Meteorological Society
Linda Moodie, National Oceanic and Atmospheric Administration
Ugo Morelli
Richard Murnane, RPI/BBSR
Andrew Negri, National Aeronautics and Space Administration
Tom Nett, Mitretek
Richard Ohlemacher, National Oceanic and Atmospheric Administration
John Perry, Federal Emergency Management Association
Patricia Rainey, The Boeing Company
Jon Robinson, Raytheon ITSS, LLC
Havidán Rodríguez, University of Delaware
Gary Salisbury, Ball Aerospace
William Schroeder, ESRI
Randy Showstack, Eos
Alan Sielen, The National Academies
Julie Siler, EDS
Charles Stahl
David Starr, National Aeronautics and Space Administration
Amanda Staudt, The National Academies
Joe Steller, National Institute of Building Sciences
Gayle Sugiyama, Lawrence Livermore National Laboratory
Richard Sylves, University of Delaware
Lisa Vandermark, The National Academies
Gene Whitney, Office of Science and Technology Policy
Pai-Yei Whung, National Oceanic and Atmospheric Administration
Joel Widder, Lewis-Burke Associates LLC
Gary Wilson, Ball Aerospace
Gregory Withee, National Oceanic and Atmospheric Administration
Helen Wood, National Oceanic and Atmospheric Administration
Richard Wright
Kemi Yai, The National Academies
John Young, American Council for the United Nations University

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