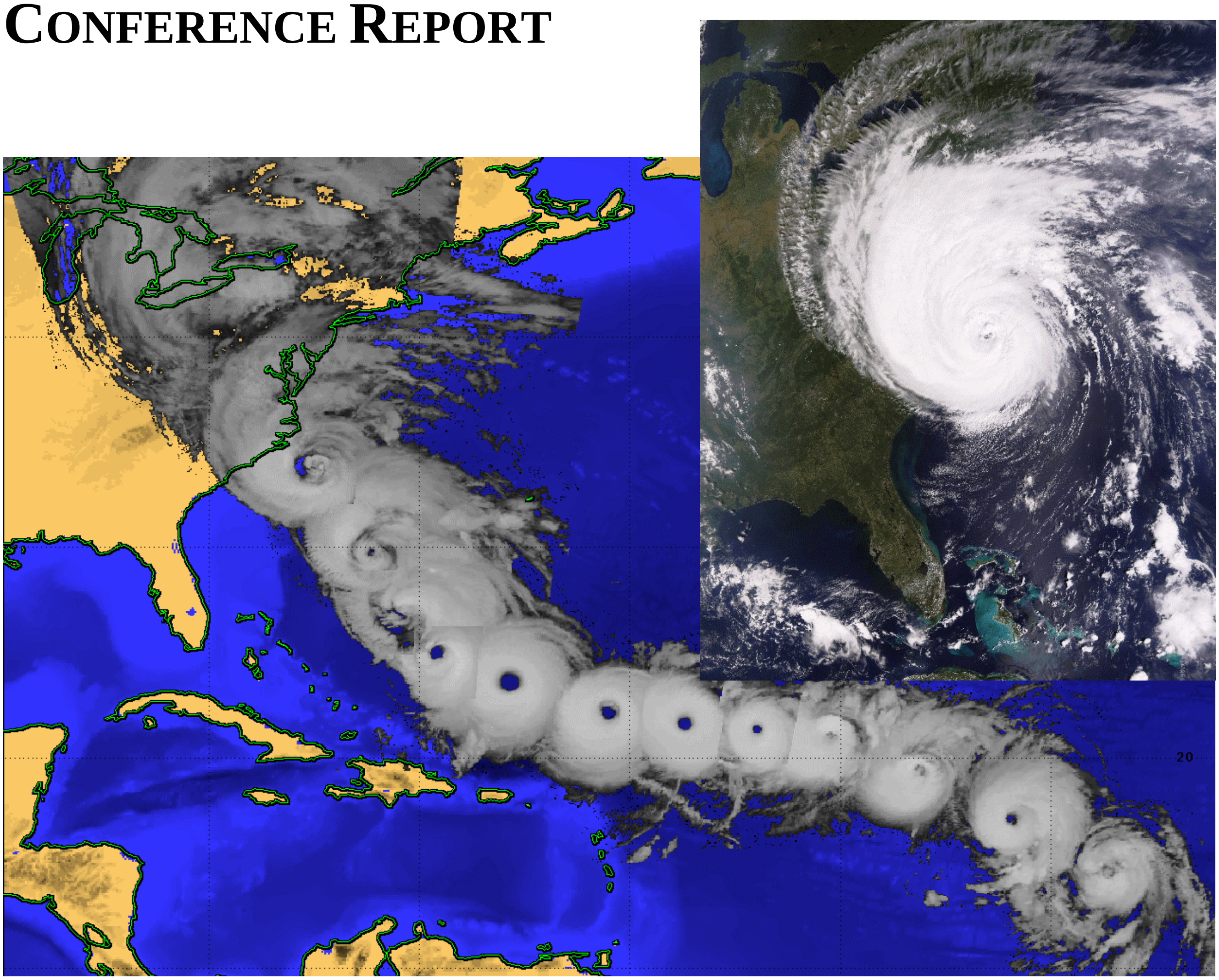
3RD GOES-R USERS CONFERENCE

May 10–13, 2004
Broomfield, Colorado

CONFERENCE REPORT



U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Environmental Satellite, Data, and Information Service

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National Environmental Satellite, Data, and Information Service (NESDIS)

Foreword

The NOAA Geostationary Operational Environmental Satellite (GOES) R-series is in the early stage of development — with first launch now scheduled for the 2012 timeframe. NOAA is conducting a number of outreach efforts to exchange information with the user community to ensure user readiness when GOES-R becomes operational. To further this user coordination, NOAA held the 3rd GOES Users' Conference in Broomfield, Colorado in May 2004.

The goals of the conference were to:

Inform users on the status of the GOES-R constellation, instruments, and operations;
Refine potential user applications for data and products from the GOES-R series;
Seek ways to help the user communities prepare for GOES-R;
Address user and societal benefits of the GOES-R series as an integral part of the Global Observing System; and
Continue to improve communication between NOAA and the GOES user communities.

These goals were well attained since many useful recommendations were made that NOAA will consider as we develop the future series. These recommendations are documented in this report. This input is also especially timely since we are developing requirements for GOES-R data distribution and archive and will be documenting and validating these requirements during this year and next. These requirements form the basis for various technical studies and cost/benefit analyses.

The conference was sponsored by NOAA with the support and cooperation of the American Meteorological Society, the Marine Technology Society, the National Aeronautics and Space Administration, the National Institute of Standards and Technology, the National Weather Association, and the World Meteorological Organization. We thank all conference participants especially the invited speakers, the program committee, NIST personnel for the logistic support, and all those who provided valuable suggestions for improving the future GOES program.

Gary K. Davis
Director
Office of Systems Development

EXECUTIVE SUMMARY

More than 330 GOES satellite users gathered in Broomfield, Colorado, May 10–13, 2004, for the 3rd Geostationary Operational Environmental Satellites (GOES)-R Users Conference. The meeting provided users with the status of the future GOES-R satellite constellation, instruments, and operations. Satellite data users from government, industry, and academia made presentations and gave their recommendations for the next generation of environmental satellites to the National Oceanic and Atmospheric Administration's National Environmental Satellite, Data, and Information Service (NESDIS).

The third generation of GOES will provide critical atmospheric, oceanic, land, climatic, solar and space data. The satellite will host an advanced imager, lightning mapper, solar imager, a space environment monitor, and a hyperspectral environmental suite, including the capabilities for atmospheric sounding and coastal waters imaging. GOES-R, planned for launch in 2012, will revolutionize weather forecasting and environmental monitoring.

The overall theme of the conference was user readiness: NOAA intends to ensure that the user communities are fully ready when GOES-R becomes operational. "User" refers to anyone who needs and uses GOES-R data to do their job and make decisions. This includes NOAA offices, federal, and non-federal agencies as well as a host of users in the private sector.

User readiness includes planning, preparation, risk reduction, and training. The readiness functions include delivery mechanisms, product readiness, education and training, and planning, budgeting, and reporting. Several factors contribute to the complexity of ensuring user readiness. The user communities are diverse, with unique operational and programmatic needs. The readiness functions need to be planned, organized, scheduled, and budgeted. Comprehensive coordination, monitoring, and reporting are required.

The approach being taken by NOAA/NESDIS is to organize and facilitate planning with extended GOES teams, and to document and manage "end-to-end" user readiness needs. The preliminary schedule includes requirements definition in 2004, planning and coordination beginning in 2005, and beginning preparations for operational integration in 2006.

The goals of the conference were to:

1) Inform users on the status of the GOES-R constellation, instruments, and operations;
2) Refine potential user applications for data and products from the GOES-R series;
3) Seek ways to help the user communities prepare for GOES-R;
4) Address user and societal benefits of the GOES-R series as an integral part of the Global Observing System; and
5) Continue to improve communication between NOAA and the GOES user communities.

These goals were met through the use of focused sessions and breakout group meetings.

The conference was organized into sessions on: Information Briefings; GOES-R as a Component of the Global Observing System; and Ensuring User Readiness for GOES-R in 2012. Four sessions addressed NOAA's mission goals:

- ***Understand climate variability and change to enhance society's ability to plan and respond***
- ***Protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management***

- ***Support the Nation's commerce with information for safe, efficient, and environmentally sound transportation***
- ***Serve society's needs for weather and water information.***

Users provided feedback on special applications of GOES, including weather, climate, coasts and oceans, space weather, transportation, hydrology and water resources, air quality and fires. Special breakout sessions enabled attendees to organize their thoughts and provide feedback and recommendations to NOAA/NESDISA facilitator and a technical lead served each group. Participants provided feedback in the following areas: needs for data and product distribution; user community training; NOAA/NESDIS preparation for GOES-R; GOES-R risk reduction; and user readiness timelines. Some recurring themes underlying the breakout sessions included: managing the increase in data volume, systems integration, expanding user input opportunities, serving varied user needs, visibility of the program, and quality verification methods.

Attendees underscored the need for user training, outreach, and education, and that training must be tailored to meet the unique needs of each user community. They noted that new and varied applications of GOES data are continuously emerging, thus the need for a seamless transition from the GOES N-P series to the GOES-R series. They expressed a need for a central location on the Internet for up-to-date technical, scientific, and programmatic information with on-demand access data, and for users to review feedback and maintain communications with one another.

The participants stressed that experts from NOAA should be available to brief other agencies on GOES-R plans, and that NOAA should also balance U.S. needs with international user needs, removing any unnecessary delays in data availability to international users.

Among the many ideas put forth by the participants to support the GOES-R risk reduction approach were developing early definitions of products and services, developing prototype products well in advance, and showing comparisons of products/data between the current GOES and future GOES-R series. These measures would help eliminate surprises in information formats and structures.

Over 60 poster papers focusing on GOES-R potential applications, GOES-R as part of the Global Observing System, and the smooth transition to GOES-R were offered. This conference report will be placed online when available. Presentations, poster abstracts, and the conference agenda are available at: http://www.osd.noaa.gov/announcement/index.htm.

The conference was sponsored by NOAA with the support and cooperation of the American Meteorological Society, the Marine Technology Society, the National Aeronautics and Space Administration, the National Institute of Standards and Technology, the National Weather Association, and the World Meteorological Organization.

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1. GOALS, THEMES AND RECOMMENDATIONS

More than 330 GOES satellite users participated in the 3rd Geostationary Operational Environmental Satellites (GOES)-R Users Conference, May 10–13, 2004. Goals had been established to provide users with the status, applications, preparations, and benefits of the future GOES-R satellite constellation, instruments, and operations. Certain themes were raised during the discussions and recommendations and are described below.

Coastal and Oceans Applications Breakout Group

1.1 Goals and Themes

The goals of the conference were to:

1) Inform users on the status of the GOES-R constellation, instruments, and operations;
2) Refine potential user applications for data and products from the GOES-R series;
3) Seek ways to help the user communities prepare for GOES-R;
4) Address user and societal benefits of the GOES-R series as an integral part of the Global Observing System; and
5) Continue to improve communication between NOAA and the GOES user communities.

To address these goals, the conference was organized into sessions on: Information Briefings; GOES-R as a Component of the Global Observing System; and Ensuring User Readiness for GOES-R in 2012; and four additional sessions addressed NOAA's mission goals:

- ***Understand climate variability and change to enhance society's ability to plan and respond***
- ***Protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management***
- ***Support the Nation's commerce with information for safe, efficient, and environmentally sound transportation***
- ***Serve society's needs for weather and water information***.

The primary focus of the conference was user readiness: NOAA intends to ensure that the user communities are fully ready when GOES-R becomes operational. The themes underlying the breakout sessions included: managing the increase in data volume, systems integration, expanding user input opportunities, serving varied user needs, visibility of the program, and quality verification methods.

1.2 Recommendations

The last day of the conference featured breakout sessions. NOAA/NESDIS regards the recommendations that resulted from the breakout sessions as the most important information from the meeting. Attendees selected the session they wished to attend, and the groups provided recommendations to NOAA. A facilitator and a technical lead served each group. The breakout sessions were: Weather Applications; Climate Applications; Coastal and Ocean Applications; Safe and Efficient Transportation; Hydrological Applications; and Air Quality/Fires.

Participants in each of the breakout sessions were asked questions relevant to specific topics. Their responses are provided in some detail below. Some recurring themes included managing the increase in data volume, systems integration, expanding user input opportunities, serving varied user needs, visibility of the program, and quality verification methods.

1.2.1 Needs for Data and Product Distribution

Please discuss your needs for data and product distribution, archiving and access, for example, timeliness, metadata, etc.

Users recommended that data, including raw data for reprocessing and derived products, be easily accessible, free, and easily processed through a user-friendly interface, in real time (e.g., "off-the-shelf" products). Users need on-demand access to metadata and archived data, including current algorithms. Metadata must include geospatial information, acquisition time, information on product accuracy and stability, information on sensors and collection platforms, and algorithms used to produce the products. NOAA must consider that while some users have a wide variety of needs, and a wide variety of capabilities to process large amounts of satellite data, others may need just the information from GOES-R, but not necessarily all the data. Participants also recommended thinking beyond just the traditional rebroadcast (directly from the satellite) for GOES-R. The GOES-R rebroadcast should be one component of the solution for data and product distribution. The solution set for distribution methods should allow for future advances in communication technology. NOAA should also balance U.S. needs with international user needs, removing any unnecessary delays in data availability to international users. Users also stressed the need for a seamless transition from the GOES N-P series to the GOES-R series, and for rapid access to "thumbnails" of available products across all systems and platforms. Finally, the latest plans for data and product distribution should be made available on the web to allow for continued user inputs.

1.2.2 User Community Training

When should training begin for the user communities? What methods of training should be used? What kind of general education will be needed? What early training and outreach do you foresee?

The primary goal recommended by the users for training was to ensure that all data are used fully and quickly following the first launch in the GOES-R series. The common theme among users was that training and education should begin early, with the major arenas being schools, universities, workshops, conferences, and online. In addition to addressing both the end users' and the developers' needs, training should address how products complement each other as well as provide applicability to real world problems. Considering the wide variety of types of users with varying needs, training must be tailored to meet the unique needs of each user community. Some specific groups cited with unique needs include: NWS forecasters; FAA meteorologists; coastal service centers; air quality modelers; climatologists; broadcast meteorologists; university faculty; researchers; industry users, including value-added companies and instrument builders; international community (in coordination with the WMO); middle and upper level NOAA management; K-12 students; and the general public. The proving ground concept that was successful in paving the way for the WSR-88D radar in the NWS should be employed for GOES-R. This will mean stationing extra personnel at selected NWS forecast offices or national centers, and NOS coastal service centers to develop and test high spectral resolution prototype GOES-R products generated from research and operational satellites. COMET should be used to provide education for the professional meteorologists and oceanographers. We should also learn from what EUMETSAT has accomplished in online documentation for image interpretation. Topics for education and training should include: strengths and limitations of the products; new capabilities and algorithms; and both quantitative and qualitative uses of the products.

1.2.3 NOAA/NESDIS Preparation for GOES-R

At this conference, some of the ways NOAA/NESDIS can help your organization prepare for GOES-R were identified. Please identify those that are most important to you. Please identify other forums where GOES capabilities need to be discussed and explored. How do you suggest we interact with these opportunities? Are there other ways NOAA/NESDIS can help?

Respondents recommended that NOAA/NESDIS help organizations prepare for GOES-R by maintaining two-way communication with the users and developers, both with the big picture and the details, and include an online mechanism for users to review feedback and maintain periodic communications with one another. NOAA should provide thorough and up-to-date GOES-R references on the Internet in one location, informing users both within and outside of NOAA of updated plans for instruments and products, including information on the value of the products to the user communities. Additional items of importance are the development and validation of products, carrying out risk reduction efforts and milestones, and including quality indicators within the metadata.

Forums for discussing GOES-R capabilities, GOES-R status, product and algorithm development, risk reduction activities, and other relevant specifics, and providing valuable opportunities for information exchange include international venues, organized focus groups, satellite conferences and remote sensing workshops/virtual conferences, AMS meetings, academia, and stakeholders' meetings. Experts from NOAA should also be available to brief other agencies on GOES-R plans. For climate applications, users suggested the development of a climate and education outreach program.

1.2.4 GOES-R Risk Reduction

NOAA is considering future "Risk Reduction" at one or more of its offices to provide a "proving ground" or test bed for prototype operations to ensure that new algorithms, products, and services are validated prior to integrating into official NOAA operations. This approach is patterned after NOAA's NWS Modernization risk reduction operations used earlier to validate and perfect technologies and future services prior to integrating into official operations. What recommendations do you have on how the GOES-R Risk Reduction approach could assist your organization's GOES-R transition to future operations?

Among the many ideas put forth by the participants to support the GOES-R risk reduction approach were: developing early definitions of products and services; developing prototype products well in advance, showing comparisons of products/data between the current GOES and future GOES-R series, providing test data sets in advance, leveraging NPP synergy and experiences for GOES-R preparation; and providing GOES-R data and ground simulators for local data handling. These measures would enable user evaluation and feedback; thereby eliminating surprises in information formats and structures. Training would also be required.

To prepare optimal processing of GOES-R data, users felt that NOAA/NESDIS should form expert teams (or science teams) for each core sensor and involve the end user at the local level, both within and outside the government. Users also recommended that sufficient data reduction be packaged to support different operational user classes. NOAA/NESDIS ought to take advantage of existing organizations like the Joint Center for Satellite Data Assimilation and establish a focused coastal and ocean user group. Simulated data should be provided to test and validate data processing and distribution systems i.e., data storage and data rates. Users recommended organization of a "coordinated field campaign" as necessary to obtain "*in situ*" measurements to exercise "validation processes" and algorithm research panels, and to insure user involvement with scenario-based appreciation (e.g., fire fighting, storm surge and precipitation-caused flooding). Users stated that the GOES-R system should be tested end-to-end before launch. NOAA/NESDIS should provide sufficient time of overlap and length of time for planning, development, operational integration, and add a timeline for development and integration of algorithms and products, and realistic prototype operations. Algorithm research and development activities must be conducted at "sensor formulation phase" and at sufficient level.

To reduce future risk the climate users group recommended: beginning production of near real-time Climate Data Records (CDR) to monitor the current state of the climate system and any short-term variations; plan for reprocessing, archiving, and distribution of CDRs to create long-term records that are a consistent, seamless, high quality time series with minimized bias; and lastly, establish a test bed for all components of the end-to-end GOES system, acquisition to archive.

1.2.5 User Readiness Timeline

Please review this basic timeline for addressing the major segments of user readiness. What additional primary activities would you recommend be included?

In general users would recommend the inclusion of the following in the timeline:

1) Add simulations to the timeline;
2) Implement a user input for sensor requirements and systems operations;
3) Test end-to-end GOES-R system before launch;
4) Define products and applications now; and,
5) Add a timeline for development and integration of algorithms and products, and realistic prototype operations.

2. OVERVIEW OF PRESENTATIONS

Dr. Gerald Dittberner, NOAA/NESDIS, Advanced Technology Lead, welcomed the participants to the conference on behalf of Gary Davis, director of the NOAA/NESDIS Office of Systems Development, and outlined the goals of the conference. The goals were to: inform users on the status of the GOES-R constellation, instruments and operations; refine potential user applications for data and products from the GOES-R series; seek ways to help the user communities prepare for GOES-R; address user and societal benefits of the GOES-R series as an integral part of the Global Observing System; and to continue to improve communication between NOAA and the GOES user communities.

Dr. Dittberner explained that participants would learn about GOES-R, and about NOAA's plans to assist the users to prepare for GOES-R, and then be asked to describe their plans and applications and how NOAA can assist them.

2.1 Keynote Address

Brig. Gen. David L. Johnson, NOAA Assistant Administrator for Weather Services, presented the keynote address: "A Vision for Environmental Services in the GOES-R Era." General Johnson described the vision as moving NOAA into the 21st Century scientifically and operationally, in the same interrelated manner that we observe and forecast, while recognizing the link between our global economy and our planet's ecology. General Johnson noted that users' needs continue to evolve, and science and technology continue to advance.

General Johnson said that we must understand the Earth as a whole system, coupling atmospheric, terrestrial, and ocean processes. Analyses must be holistic, taking into account the entire system. Analyses begin with observations. Today, NOAA has a decentralized observing responsibility with 99 observing platforms and 521 environmental parameters. Earth observing systems are increasing in number, including international observations and private networks. Integrated observing systems are needed, with an effective "system-of-systems" architecture. This would enhance performance, continuity, and interoperability across NOAA.

To understand the environment, we need certain data. The sensors of the future will provide the data, and we need concrete plans to make the data available. General Johnson noted that the National Centers for Environmental Prediction provide warning and forecasting services, and are a major user of GOES data. In the future, the mission will include air quality forecasts for the United States. The forecasts will include ozone in the North East by 2005, ozone nationwide by 2009, and aerosols by 2012.

The vision for aviation services is to support the Federal Aviation Administration's safe and efficient National Airspace System. Low ceiling and visibility warnings would be issued about 6 hours in advance for specific airports; turbulence and icing warnings would be issued for flight corridors about 5 hours in advance.

The vision for climate services is an end-to-end system of integrated global information of key atmospheric, oceanic, and terrestrial variables. Reliable probabilistic forecasts would be issued. Climate variability and change would be predicted at time and space scales relevant to ecosystem models.

For hydrologic services, the vision is to provide high-resolution water and soil moisture information and forecasts; increase flash flood warning time to about 1 hour for counties; and provide reliable surface and sub-surface water quality forecasts.

For public weather services, the vision is: through teamwork, to reach every person in the nation with information when and where needed; to satisfy customer and partner requirements for consistent, timely, and accurate weather services, products, forecasts, and warnings; and to support evolving national needs.

In concluding, General Johnson outlined demands for the year 2022. Environmental services will include space weather, terrestrial weather, estuaries, oceans, coasts, atmosphere, air quality, fresh water, soil moisture, and snow pack. General Johnson told the attendees that America needs their input in order for the future of environmental forecasting and monitoring to be successful.

2.2 Vision of an Integrated Global Observing System

Michael Crison, NESDIS, Director for Requirements, Planning, and Systems Integration, gave a presentation titled "Vision of an Integrated Global Observing System" on behalf of Gregory W. Withee, NOAA Assistant Administrator for Satellite and Information Services, who was not able to attend. Mr. Crison described the strategy for a global observing system. Data, including remotely sensed and *in situ* data, would be used in Earth system models. High performance computing, communication, and visualization would be used in issuing predictions. Society will benefit from policy and management decisions based on input from decision support systems. Feedback from users will optimize value and reduce data gaps.

A successful global observing system must be comprehensive, sustained, and integrated. A comprehensive system consists of physical, chemical, and biological systems. It encompasses *in situ*, mobile, airborne, and satellite observations. It also includes a broad range of spatial and temporal scales. A sustained system consists of future, current, and predecessor systems. It includes a sustained research and development program feeding into an evolving long-term operational program. In an integrated system, multiple platforms will be orchestrated to serve one or more missions, including weather, climate, disasters, solar weather, land, ocean, coastal, and water missions. Such a system will be more efficient, more effective, and will ensure sustainability.

Mr. Crison described the implementation concept for an integrated global observing system. The concept is complex, involving a requirements process that includes external sources and other government agencies. The process involves architecture development, Federal program/system development, and Federal systems deployment and operations phases, as well as commercial development, deployment, and operations phases. Mr. Crison said that GOES is an integral part of the Integrated Global Observing System.

2.3 The Future of NOAA Coastal and Ocean Services in the GOES-R Era

Dr. Mary Culver, NOAA Coastal Services Center, compared NOAA's vision in 1996 with the vision of today in order to determine what the differences might be in the GOES-R era. In 1996 the vision was for: customer service; continuous operational observing capabilities; reliable assessments and predictions; integrated approaches to environmental management; partnerships; and new technology development. Examples of the tools and technology used in 1996 to accomplish this vision included: installing NEXRAD Doppler radars; moving to GPS-based reference stations; analog cameras; awaiting SeaWIFS launch; international GOOS in its fifth year; limited Internet and e-mail; and the then-recent launch of GOES-9.

Currently, the priority themes for the National Ocean Service (NOS) are very similar to NOAA's vision for 1996. In large part, the similarity is due to the fact that the NOS customer needs have not significantly changed during that time period. Dr. Culver defined NOS customers as state and local resource managers, who have a responsibility to effectively manage the coastal zone. To address coastal issues, end users want regional data for local interpretation; all information easily accessible and available in one place; validation of information provided; and analysis provided by experts.

Since 1996, the tools and technology to address NOS customer needs have advanced. In 2004 they include: hand-held GPS units; digital cameras; online access to data, imagery, and training; SeaWIFS and MODIS sensors; and routine use of e-mail and cell phones. As an example of the progress that tools and technology can provide, we can map coral reefs at higher resolution than before; in 2007 we will have accomplished full shallow-water coral mapping.

Surveys of coastal states indicate that over the next 5 years, the important issues for NOS customers will be: land use; habitat change; nutrient enrichment; sediment management; environmental contamination; non-indigenous species; coastal hazards; and ocean management. Remote sensing, monitoring, and models are the primary technology needs that were identified to monitor these areas. The challenges to using remote sensing in coastal areas include managing the tradeoff between obtaining imagery quickly (timeliness) and obtaining highly accurate imagery; higher spatial resolution in order to obtain data in bays and estuaries; and parameters such as coastal ocean color, shallow-water bathymetry, and salinity.

Dr. Culver noted that the needs of NOS customers will be met in the future by data sources such as NPOESS and GOES-R satellites and high-resolution satellites and airborne sensors from the commercial sector. The data flow of the future will be enormous, and integration of the available data is the key.

NOS activities are driven by the needs of the coastal managers. The issues that they manage do not change quickly; however, technology does. To apply the data to coastal issues, we will need an integrated ecosystem-based approach to protect the environment and effectively manage resources. To address the range of users in coastal management, we will need the capacity to tune the rate of data acquisition, management, and analysis to the time scale of the decision-making. We will also need to close the gap between new scientific understanding and technology that will be gained in the future and the formulation and implementation of scientifically sound environmental policies.

2.4 Science Evolution in the GOES-R Era

Mitch Goldberg, NOAA/NESDIS/ORA, Chief, Satellite Meteorology and Climatology Division, said that emerging requirements addressing the nation's present and future environmental concerns are driving new requirements in science, applications, sensor technology, and data utilization. The wealth of information and applications will require new partnerships between government, industry, and academia. GOES-R will be a critical part of a larger and continuously evolving integrated observing system that will require extensive research and applications activities. These activities will require new ways of doing business, such as Scientific Data Stewardship.

Mr. Goldberg said that science evolution is driven by the increasing need for information. More information has resulted in the need for better observations. Evolving observations result in more capabilities. Mr. Goldberg discussed capabilities of the Atmospheric Infrared Sounder (AIRS) and compared them with capabilities of the Advanced Microwave Sounding Unit (AMSU). He noted that AIRS performance is much better than AMSU, even in partly cloudy conditions.

Better observations require more and accurate science algorithms. These include radiances, atmospheric soundings, winds, clouds, surface, composition (trace gas and aerosol), radiation budget, and data and product access and visualization.

The increasing growth of satellite data has resulted in new interagency organizational structures. These include the Joint Center for Satellite Data Assimilation, which was created to accelerate the use of satellite data in numerical weather predictions. The center is a partnership between NOAA, NASA, DOD, scientists, and academia.

Air quality is an evolving requirement. Air quality satellite objectives are to: monitor intercontinental/regional dust pollution and transport; identify sources of pollution; and improv forecasting of air pollution events so mitigating strategies can be applied in advance.

Data compression is likewise an evolving requirement. The volume of hyperspectral data is huge. Data compression can have applications in areas such as downlink, rebroadcast, and distribution/archive.

2.5 Monitoring Air Quality in the GOES-R Era

Dr. Deborah Mangis, Environmental Protection Agency (EPA), Assistant Lab Director, National Exposure Research Lab, N.C., gave a presentation titled "U.S. Environmental Protection Agency: A User Perspective Focused on Air Quality Assessments and Forecasts." Dr. Mangis noted that the EPA uses remote sensing data for a variety of applications including research, air quality, water quality and watershed modeling, land cover mapping, emergency response, and monitoring regulatory compliance, to name a few. Her presentation focused on air quality.

Air quality is important for numerous reasons. Aerosols such as $PM_{2.5}$ (particulate matter) can induce respiratory disease and cancer, reduce visibility, and impact the climate. Ozone can induce respiratory disease and damage crops. For society, poor air quality results in 60,000 deaths per year and costs the nation $143 billion per year.

Several regulations relate to air quality. Under the Clean Air Act, the EPA Administrator is required to periodically review and revise National Ambient Air Quality Standards (NAAQS) in accordance with the latest state of the science. The EPA and NOAA signed a Memorandum of Agreement (MOA) for air quality forecasting in May 2003.

Meteorological, trace gas, and aerosol satellite measurements can be used for assessment and monitoring and enhance the agency's traditional focus on regulatory policy. The EPA is extending into new air quality applications through the EPA/NOAA partnership. The EPA is also connecting to other science areas including public health tracking.

For air quality modeling, certain parameters are needed. The meteorological parameters include vertical profiles of state variables, surface characteristics, and clouds. The information is used for data simulation during meteorological model simulation and meteorological model evaluation as an air quality driver. Most uses of satellite data for air quality will require assimilation into global and/or regional transport models.

The chemical parameters for air quality include key chemical species directly related to NAAQS with high resolution. The information is used for data assimilation during air quality model simulation; operational and diagnostic model evaluation; emissions inventory verification; and evaluation of policy changes.

The current derived tropospheric satellite data are from low-earth orbit (LEO) satellites. For such data from a geostationary platform, there are several considerations. LEO is good for climate and global monitoring once per day. However, air quality requires hourly observations, making geostationary the appropriate platform. Ozone, aerosols, and precursors change rapidly during the day.

Dr. Mangis concluded by stating that the Advanced Baseline Imager will be very useful for air quality, and additional MODIS-like bands would be very useful. For the Hyperspectral Environmental Suite, the EPA would like to see carbon monoxide and ozone retrievals in infrared, both day and night. New instrumentation would allow improved air quality forecasting.

2.6 Recommendations from 2nd GOES Users Conference

Recommendations from the 2nd GOES Users Conference were presented by, James Gurka, NOAA/NESDIS, GOES Program Requirements, Timothy Schmit, NOAA/NESDIS/ORA, Advanced Satellite Products Team, and Dick Reynolds, Short & Associates, Inc. Since the conference, many of the recommendations were acted upon by NOAA/NESDIS, Mr. Gurka noted. There were a number of changes and additions to the current baseline plan due to user comments. Some of these changes include the faster Imager scanning, number of Advanced Baseline Imager (ABI) channels, the coastal waters task, and a 4-km Hyperspectral Environmental Suite (HES) mode.

For instruments, the recommendations were for improved spatial resolution, spatial coverage, temporal resolution, spectral resolution, and radiometric accuracy. For the ABI, attendees recommended at least 12 imager channels, and an additional four channels to meet the requirements of a large cross section of users; full disk Imager coverage every 5 minutes; and rapid scan capability for severe weather events.

For the HES, attendees recommended near full disk every hour; 4-km footprint for the Sounder; rapid scan option for the Sounder; detection of temperature inversions; and soundings in cloudy areas.

Attendees of the 2nd conference also recommended that NOAA explore the feasibility of a passive microwave instrument in geosynchronous orbit. They also strongly recommended a lightning mapper. They recommended that data from experimental satellites be used operationally to prepare for GOES-R, and that visible channels must be calibrated. They noted that for climate applications, calibration is critical.

For marine ecosystems and fisheries, they recommended validated pre- and post-launch radiometric calibration in all bands; spatial resolution of about 100 meters for coastal zones; and appropriate channels for suspended sediment, chlorophyll a, land/water boundary, and sea surface temperatures.

For numerical modeling, they recommended a 1-hour to 90-minute refresh rate for mesoscale models; 15-minute refresh for severe storms and aviation applications, and a 1- to 2-km spatial resolution for the Weather Forecast Model by 2012.

To bring research into operations, they recommended that funding for research and development for new products should be part of the satellite acquisition budget. They recommended improved collaboration between research and operations for developing new satellite products. They further recommended for operations, a blend of data and products from operational and research satellites.

They recommended that training should begin immediately after system requirements are defined and the infrastructure can be put into place. They recommended continued communication between NOAA and the user community, and suggested various forums for the exchange of information.

Mr. Gurka noted that many recommendations have been incorporated into GOES-R notional baseline instruments. Recommendations on user readiness issues have provided foundations for plans. Finally, he said that NOAA will continue to communicate updates of GOES-R plans to users and seek input from user communities.

2.7 GOES-R, Fractals and the Butterfly Effect, or How GOES-R Can Save Civilization

William H. (Bill) Hooke, Senior Policy Fellow and Director of the Atmospheric Policy Program, American Meteorological Society, gave a captivating presentation at the conference dinner on Wednesday. He demonstrated the role of GOES-R and the role of those gathered at the conference in the greater scheme of things. Our job, he noted, is to serve the world in 2012 and beyond.

Science and technology are moving forward in a relatively short period of time. Likewise, the science of meteorology has changed dramatically. Throughout history, mankind has operated on three principles: the assimilative capacity of the atmosphere is infinite; the climate is unchanging; and weather is unpredictable. In the span of a century, meteorologists have shown the opposite: the assimilative capacity of the atmosphere is finite; the climate changes, sometimes abruptly; and weather is more predictable than we had thought.

Policy makers rely on scientists to provide good data and information. Currently, there are about 20 unsolved global issues, including global warming, biodiversity, fisheries depletion, and deforestation, to name a few. In the coming 20 years, environmental issues will take center stage in policy making. We can expect a future marked by adverse climate variability; natural extremes beyond our handling capacity; environmental and social catastrophes; declining margins; and ineffective top-down strategies.

The good news is that GOES-R can change outcomes throughout the larger system. The GOES-R program can bring end users to the table and reshape the policy landscape. New policy tools are needed for addressing the costs/benefits of meteorological science and services, and for studying the impact of different market mechanisms. International data sharing needs to be assessed, as does the segmentation of weather providers. There is a need for long-term continuity and prioritization.

The American Meteorological Society is helping the community meet these needs. This is being accomplished through programs such as: the Policy Forum Series; the Summer Policy Colloquium; Congressional Science Fellows; and policy research. Likewise, GOES-R will play an important role in resolving global concerns.

3. INFORMATION BRIEFINGS

3.1 GOES Program Overview and GOES-R System Architecture

Steven Kirkner, NOAA/NESDIS, GOES Program Manager, discussed the GOES mission, challenges, requirements, improvements, benefits, baseline, and program management. The GOES mission satisfies national operational environmental requirements for 24-hour observation of weather, Earth's environment, and the solar and space environment. To meet these requirements, NOAA continuously maintains operational satellites at two locations, 75 degrees West, and 135 degrees West, with an on-orbit spare ready to replace one. The GOES I series (GOES-8 through GOES-12) is the current operational series. The GOES-N series (13 through 15) is under contract; the GOES-R series, the follow-on continuity program to the GOES-N series, is under design.

The GOES program supports NOAA's strategic objectives, including ecosystem, climate, weather and water, and commerce. For the ecosystem, we must determine the environmental impacts of chaotic processes, such as diurnal ocean color as a function of tides. For climate, we need to provide the diurnal signal for climate prediction and analysis. For weather and water, real-time weather data are needed to accurately track and analyze severe weather events. For commerce, we need to provide uninterrupted hemispheric observations and products for safe and efficient transportation and commerce systems. The challenge lies in maintaining data continuity to support these objectives.

GOES-R must be operationally available (launched and checked out) by mid-fiscal year 2013 to provide coverage in the event of a failure of GOES-O or GOES-P.

Another challenge is to maintain a balance between user benefits and costs. Evolving user needs must be balanced with an affordable cost of the system. Complete life cycle end-to-end costs must be included in upfront planning to ensure decision makers have a full understanding of the system cost. Architectures, including ground systems, must be developed to effectively handle large volumes of data required by users.

To address these challenges, the GOES program has adopted various strategies. Trade studies are being performed against requirements. Multiple architecture options are being evaluated. End-to-end system architecture is being defined. The acquisition approach is being structured with adequate design and risk reduction, and with development phases for spacecraft, instruments, and ground systems. Life cycle cost targets are being developed, as are assessments of user utility and cost benefit analyses.

To meet requirements, NOAA is maintaining extensive user involvement, including GOES and other conferences. The GOES-R Program Requirements Document has been coordinated with other federal and international agencies and incorporates all NOAA line office and mission goal team requirements. The Mission Requirements Document translates operational requirements into system acquisition requirements.

Mr. Kirkner described GOES system improvement, comparing GOES I/P with the GOES-R notional baseline. All instruments will provide considerable spatial, spectral, and temporal improvements. In addition, GOES-R will host a lightning mapper. These improvements will allow NOAA more capability to: characterize ocean color; measure climate-relevant changes; improve severe weather trajectories and moisture/thermal knowledge; and improve the forecast accuracy of fog, ice, and wind.

3.2 Introducing the Advanced Baseline Imager (ABI)

Timothy Schmit, NOAA/NESDIS/ORA, Advanced Satellite Products Team, said that the Advanced Baseline Imager (ABI) is the next generation operational geostationary imager—its era will begin in 2012. Mr. Schmit noted the limitations of the current GOES imager, including: missing spectral bands; low spatial resolution; scan conflicts between regional and hemispheric areas; and outages due to eclipses and other causes.

Mr. Schmit compared the ABI with the current GOES imager. The ABI has improved spectral coverage, with 16 bands rather than the current 5 bands. Spatial resolution is improved in both visible and infrared bands. Spatial coverage is improved—the ABI will provide four full disk images per hour, compared with the current one image every 3 hours. Twelve images of the Continental United States will be taken every hour, compared with the current four per hour. On-line calibration and low light imaging will be available; they currently are not.

The ABI will have 16 bands. These will provide coverage of the following: daytime aerosols over land; daytime clouds, insolation, winds; daytime vegetation and aerosols over water; daytime cirrus clouds; daytime cloud water, snow; day land/cloud properties; surface and cloud/fog at night; high- and mid-level atmospheric water vapor, winds, rainfall; lower-level water vapor, winds, and upper-level SO_2; total water; total ozone, turbulence, winds; surface properties, low-level moisture and cloud; sea surface temperature; ash; and air temperature and cloud heights and amounts.

The ABI will also improve fire detection and characterization useful for air quality monitoring and forecasting. It will also better define mountain waves, which will aid turbulence forecasting for aviation weather forecasting.

3.3 The Next Generation Operational Geostationary Sounder

Dr. Paul Menzel, NOAA/NESDIS, Chief Scientist, Office of Research and Applications, described the road leading to the development of the Hyperspectral Environmental Suite (HES), starting with IRIS in 1969, and looking toward the future with the Cross-track Infrared Sounder, the Geostationary Imaging Fourier Transform Spectrometer, and HES. He noted that future GOES satellites will address all four key remote sensing areas. These are: spatial resolution, spectral coverage and resolution, temporal resolution, and radiometric resolution.

Dr. Menzel said that observations from polar-orbiting satellites every 4 hours are not frequent enough to monitor atmospheric instability. GOES hourly observations are necessary to help track atmospheric changes and cloud formation. GOES-R temporal improvements will make it possible to see convective development. HES, with over one thousand channels of spectral widths of less than a wavenumber, will increase the vertical temperature and moisture sounding resolution, capture atmospheric motions at many more levels, and penetrate the boundary layer to depict small scale temperature and moisture changes. Improvements will be realized in nowcasting, short-range weather forecasting, and longer-range numerical weather prediction. HES will be able to see the emergence of temperature and moisture inversions in clear skies; thus marking severe weather potential and possible fog formation. High-spectral-resolution sounder radiances will also improve cloud-top pressure estimates. This will be possible because the right balance of spatial, temporal, spectral, and radiometric capabilities will have been realized.

HES applications are being investigated with simulated and real data. Combining HES and ABI data for better atmospheric and cloud retrievals is also under investigation with Moderate Resolution Imaging Spectroradiometer (MODIS) and Atmospheric InfraRed Sounder (AIRS) measurements from Earth Observing System's (EOS) Aqua platform. These early investigations are confirming that GOES-R will be able to detect water vapor as never before by identifying small-scale features of moisture vertically and horizontally. It will track atmospheric motions much better by discriminating more levels of motion and assigning heights more accurately. It will characterize life cycles of clouds, distinguish between ice and water clouds, and identify cloud particle sizes. It will measure surface temperatures by accounting for emissivity effects. It will also distinguish atmospheric constituents with improved certainty. These include volcanic ash, ozone, and possibly methane, plus other trace gases.

Dr. Menzel concluded by noting that there is still another decade of opportunity to evolve GOES sounder utilization; the full potential of this broadband radiometer remains to be realized. GOES-Sounder improved applications plus HES simulations will prepare for timely GOES-R utilization after launch.

3.4 Hyperspectral Environmental Suite (HES)/Coastal Waters (CW)

Dr. Christopher Brown, NOAA/NESDIS, Office of Research and Applications, discussed the need and capability for coastal water imaging with the HES on GOES-R. HES/CW offers significant potential to collect high temporal and spatial resolution observations, on a continuing basis, to meet both operational and research applications.

Dr. Brown noted that the current satellite observations do not satisfy all of NOAA's needs. The current suite of existing earth imaging systems lacks the combination of spectral, spatial, and temporal characteristics to investigate short-lived events in the coastal ocean and on land. NOAA's National Ocean Service requires ocean color products with spatial resolution of 300 meters or better. NOAA's Fisheries requires observations with high temporal and spatial resolution to improve measurement and modeling of small-scale phenomena such as migration pathways for salmon fisheries.

Polar-orbiting satellites lack the repeat coverage to investigate important short-term marine, atmospheric, and terrestrial processes. The solution lies in the HES/CW imaging. Visible and near infrared imaging of the HES/CW from geostationary orbit will provide radiometrically sensitive observations of high spatial and temporal resolution and will fill an existing gap in the time-space domain of available observations obtained from existing space-borne sensors. The purpose will be to monitor and assess disasters, severe environmental events, and natural hazards in coastal waters of the United States. It will also be used to investigate the response of marine and terrestrial ecosystems to short-term changes.

The HES/Coastal Waters will enable broad-scale and long-term monitoring of coastal ocean areas to ensure science-based coastal resource management and decision-making. The multi- to hyperspectral observations, on a continual basis, will meet both operational and research needs and applications. HES/CW imaging will also enhance the performance and capabilities of GOES capabilities.

The HES/CW can be used in a survey mode to provide routine coverage of coastal waters in the U.S. exclusive economic zone (EEZ) at least every 3 hours and a localized mode to observe events of interest. The HES/CW will provide more details, enable water type classification, and resolve the tidal cycle in a single day. For coastal ocean applications, it has the potential to detect, monitor, and predict the location of hazardous material, such as harmful algal blooms; to assess water quality and clarity; to locate and appraise the health of shallow water corals; to appraise changes in local bathymetry; to initialize and validate coastal models; and to quantify the response of marine ecosystems due to short-term changes in the environment. For terrestrial applications, the HES will enable scientists to evaluate vegetative stress, and to locate and assess fine-scale storm track damage.

3.5 GOES Lightning Mapper Sensor

Dr. Hugh Christian, senior lightning researcher at the Global Hydrology and Climate Center at NASA's Marshall Space Flight Center in Huntsville, Alabama, gave a presentation on lightning detection, and the GOES Lightning Mapper Sensor. Both low inclination and near polar-orbiting satellites have been in use for lightning detection. The Lightning Imaging Sensor (LIS) aboard the Tropical Rainfall Measuring Mission and the Optical Transient Detector (OTD) are examples of polar-orbiting or low-earth orbiting missions.

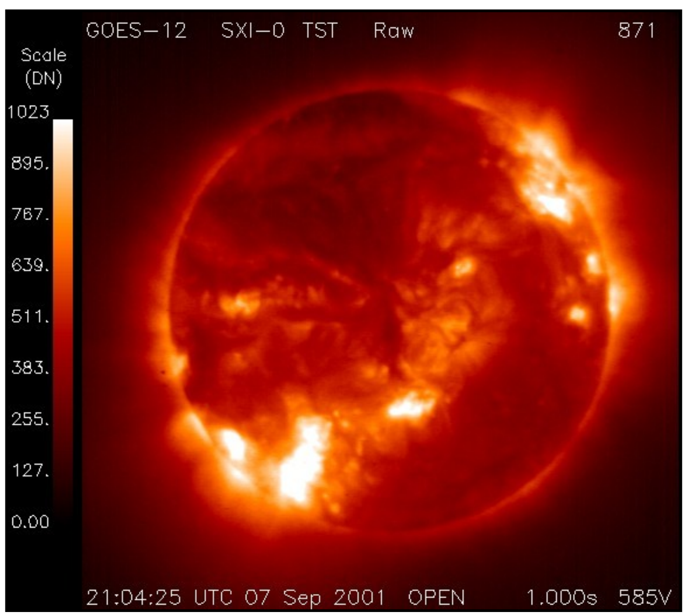
Dr. Christian discussed the climatology of lightning. Global lightning is modulated on annual and diurnal time scales, as well as seasonally and interannually. The Northern Hemisphere summer dominates lightning strikes. The deep tropics have about twice the amount of lightning as the subtropics.

Dr. Christian told attendees it is important to observe lightning in forecasting. He compared the total lightning flash rate tendency relative to tornadoes. The lightning flash rate is directly correlated to storm intensity: the higher rate implies a stronger storm. Lightning signatures, combined with other assets used by the National Weather Service, can be used to: separate intensifying from weakening storms; identify storms in the process of becoming severe; quickly determine the most intense storms in a complex system; improve warning times; and reduce false alarm rates.

From the geostationary vantage point, we can observe storm evolution. Lightning sensing from geosynchronous orbit is used for climate monitoring, storm development, ice-phase precipitation estimates; severe weather nowcasting; data assimilation and model inputs; and atmospheric chemistry.

The Lightning Mapper Sensor aboard GOES-R will be an extension of the LIS/OTD technology, with products available in near real time. The technique to be used has been successfully demonstrated; performance goals are readily realizable; all technology issues have been resolved; and all major sub-systems are nearing completion.

3.6 Supporting Space Weather Users with the Space Environment Sensor and Solar Imaging on GOES-R



Dr. Howard J. Singer, Chief, Research and Development Division, NOAA Space Environment Center, Boulder, Colorado, said that GOES Space Environment Monitor (SEM) measurements provide crucial data to our nation and the world for commercial and government applications and for understanding the space environment. NOAA’s services must expand to meet the needs of our nation’s increasing use of and reliance on the space environment. User input has provided the necessary guidance to define GOES-R SEM instrumentation; GOES-R SEM activities are in the formulation phase.

Dr. Singer discussed space weather and described solar flares, coronal mass ejections, the magnetosphere, and the ionosphere. The GOES SEM contributes to the mission of the

Space Environment Center (SEC) and to NOAA's mission goals. The SEC is the nation's official source of space weather alerts and warnings. SEC monitors and forecasts the Earth's space environment; it provides accurate, reliable, and useful solar-terrestrial information. It also conducts and leads research and development programs to understand the environment and improve services. It plays a leading role in the space weather community; advises policy makers and planners; and fosters a space weather services industry.

The GOES SEM consists of the following sensors: Energetic Particle Sensor; Magnetometer; X-ray Sensor; and on GOES-12, the Solar X-ray Imager. GOES N/O/P will have two magnetometers operating simultaneously; Energetic Particle Sensors that will have more look-directions; X-ray Sensor; EUV Sensor, a new instrument with five wavelength bands; and a Solar X-ray Imager.

GOES-R SEM will provide improved specification of spacecraft surface charging and single event upsets. It will provide improved monitoring of critical physical processes affecting energetic particles, and will provide improved quality covering the full solar dynamic range. It will also allow improved height resolution in calculations of thermospheric heating rates, critical components in the modeling of the ionosphere and thermosphere. The GOES-R Solar X-ray Imager will have improved spatial resolution, double sensitivity, and an increased dynamic range.

The Coronagraph will detect Earth-directed coronal mass ejections up to 2500 km/s. The instrument will allow answers to questions similar to those asked about hurricanes: Did a coronal mass ejection (CME) occur? Will the CME hit the Earth, thus causing a geomagnetic storm? When will the storm begin? How strong will the storm be? How long will the storm last?

Dr. Singer discussed user involvement in establishing the instrumentation on the GOES-R SEM. Space Weather Week is an annual event at SEC. In April 2004, attendees from industry, academia, and government numbered 250.

Dr. Singer also discussed the Halloween Storms of October/November 2003. The SEC issued its first Service Assessment, detailing alerts and warnings, and various impacts. The impacts included: six power plants took mitigating action; 76 percent of NASA's Earth and science missions that were surveyed were affected; and the ADEOS-2 spacecraft was lost. There were numerous impacts to aviation, and GOES energetic particle data were used for airlines alerts and warnings.

For the future, SEM measurements will also be needed for space exploration near the Earth and under the radiation belts for Shuttle and International Space Station operations; for lunar missions, and for missions to Mars and beyond.

3.7 GOES-R Geostationary Microwave Sounder (GMS)

Michael Madden, The Aerospace Corporation, discussed the GOES-R Geostationary Microwave Sounder (GMS). A passive microwave sounder has been identified as a Pre-Planned Product Improvement (P^3I). The sounder will compliment the Hyperspectral Environmental Suite (HES), and will provide high-resolution temporal and spatial coverage. A passive microwave sounder was identified as a critical need at the 2nd GOES Users Conference. This type of sounder is based on Advanced Microwave Sounding Unit (AMSU) experience; it would use the same frequency bands and increases the utility of infrared sounders. NOAA requires hourly updates. This sensor will provide moisture and temperature retrievals that lead to precipitation.

NOAA and NASA are looking at two promising technologies, with the first launch planned for 2015: Geostationary Microwave (GEM) and Geostationary Synthetic Thinned Aperture Radiometer

(GeoSTAR). The GEM features a 2-meter solid dish antenna design, five bands, 43 channels, and 16- to 140-km resolution, CONUS coverage in 90 minutes, and 1500 x 1500 km in 15 minutes. It was designed by NOAA's Environmental Technology Laboratory and MIT.

GeoSTAR features a sparse aperture radiometer, three bands, 10 channels, 25- to 50-km resolution, with no moving parts, and provides full disk coverage in 60 minutes. It was designed by NASA's Jet Propulsion Laboratory.

3.8 How GIFTS Helped Pave the Way for HES

Dr. Paul Menzel, NOAA/NESDIS, Chief Scientist, Office of Research and Applications, discussed the Geostationary Imaging Fourier Transform Spectrometer (GIFTS), and how it has helped to pave the way for the Hyperspectral Environmental Suite (HES).

GIFTS represents a revolutionary step in observing from geostationary orbit. It is designed to deliver 16,000 4-km soundings every 11 seconds from spectra at 0.6 cm^{-1} resolution. It will have consistent and accurate calibration and signal-to-noise ratios of several hundred. It has "raised the bar" for the GOES-R HES. GIFTS will feature: two 128 x 128 Infrared focal plane detector arrays with a 4-km footprint; one 512 x 512 visible focal plane detector array with a 1-km footprint; field of regard 512 km x 512 km at satellite subpoint; and 10-second full spectral resolution integration time per field of regard.

Seven key technology demonstrations will help pave the way from GIFTS to HES. These are: imaging FTS; long wave IR detectors; active cooling; light-weight optics; high-speed analog to digital conversion; active pixel sensory; and a star tracker. Dr. Menzel summarized the status of GIFTS sensor module and test readiness as follows: the subsystem critical design reviews have been conducted, and the system design is nearly complete; all key New Millennium technologies will be delivered within months; the system needs to be assembled and tested to prove the thermal/mechanical design and the Imaging FTS enabling technology; and test facilities are ready. He noted that completion of the GIFTS Engineering Development Unit is highly desirable: it would provide the demonstration of several key technologies working together; the identification of the risks during integration; and characterization of the full system. Completion of these demonstrations will provide many useful lessons as risk reduction for the GOES-R HES.

GIFTS products include: water vapor; temperature; carbon monoxide concentration; ozone concentration; surface temperature and emissivity; clouds; and aerosol concentration and depth. Several science areas need to be investigated to move from GIFTS to HES. These include: using the shortwave side of the water vapor band; hyperspectral simulations; winds tracking in retrievals; soundings in thin cirrus; and outreach/education. Geo-GIFTS remains very desirable; flight opportunities, including international partnerships, should continue to be explored.

3.9 Instrument Synergy

Dr. James F. W. Purdom, of the Cooperative Institute for Research in the Atmosphere, discussed satellite instrument synergy. This synergy maximizes the utilization of the nation's civil space-based remote sensing observation capabilities in the GOES-R era. Maximizing utilization of GOES-R's capabilities needs to be addressed in three areas: (1) intra-satellite: maximizing the utilization of the instruments on each GOES-R series satellite with respect to other instruments on that satellite; (2) intra-system: maximizing the utilization of the instruments on each GOES-R series satellite with respect to other GOES-R series satellites; and (3) inter-system: maximizing the utilization of the instruments on each GOES-R series satellite with respect to the fixed observing satellites in low earth orbit.

Dr. Purdom said that synergy is in its infancy: we are entering an age of multi-platform and multi-sensor products, but we're not there yet.

The observing needs and capabilities of any system drive requirements. Resolution requirements are: temporal, which will improve with GOES-R; spatial, which will improve from 1 km to 250 m; and spectral, such as the different bands on the ABI. These will allow us to observe phenomena with greater information content. New products will emerge, based on mathematical analysis of multi-channel images, every 5 minutes or less.

The initial goal is to integrate NPOESS and GOES-R by 2012.

Each observing system has distinctive characteristics: polar is global and fixed, while geostationary is quasi-hemispheric and adaptive. Selected sensors will operate over very similar spectral region. The challenges are dynamic tasking and adaptive sensing for intra-satellite, intra-system, and inter-system.

Adaptive observational needs of NWP and nowcasting help define sensor activity/application. Nowcasting requires detailed information on mesoscale thermodynamic structure of the atmosphere—cloud type and vertical wind shear. Nowcasting severe convection requires frequent imaging and sounding that can only be provided by geostationary satellites.

GOES-R is unique in spectra, space, and time. The spatial and temporal domains of the phenomena drive the spectral needs as a function of space, time, and signal to noise. Products such as, ocean color from polar satellites may be inhibited by clouds. We should use two or three different views, taking advantage of when polar and geostationary systems are viewing at the same time. Using the two systems together would result in a more accurate product.

GOES-R will play a role in climate. Climate products require long term, stable and accurate sensor measurements. We can track the diurnal cycle spectrally.

The satellite system in the GOES-R era will lead to improvements. We can expect improved prediction accuracy from improved observations and the ability to observe the previously unobserved. These will be realized particularly when we capitalize on the adaptive observing nature of the geostationary system in synergy with the fixed polar system.

3.10 Future Integrated Satellite Architecture

Michael Crison, NESDIS, Director for Requirements, Planning, and Systems Integration, said that the vision of an integrated global system is for one that is comprehensive, sustained, and integrated. Today's integrated satellite constellations consist of a GOES system, and a polar-orbiting system of DMSP and POES satellites. The future integrated satellite observing system will include GOES-R, NPOESS, METOP, specialized satellites, and other satellite sources. Our system architectures must be constructed with this in mind.

GOES-R architecture alternative studies started with user needs to determine the appropriate architecture in developing a notional baseline system. New and non-traditional ideas are being studied. A medium earth orbit (MEO) would be at 10,400 km with a 6-hour period. The MEO Walker constellation would involve eight satellites in eight planes: four in equatorial orbit, and four in polar orbit. The benefits of MEO are: near real-time global coverage with a relatively small number of the same type of satellites; one/third the orbit of GEOS with the potential to reduce instrument apertures; and a robust constellation, providing the capability of repositioning satellites to reduce the impact of on-orbit failures. GOES-R architecture studies show that MEO is probably not viable as a GOES-R 2012 candidate. However, it has great potential for the future beyond GOES-R.

The challenges are to balance between operational capability and affordability; understand the science to accommodate the new orbits; and to develop new instrument designs and architectures. The future opportunities involve integrated satellite architectures providing improved linkages to NOAA, national, and international observing systems and better support to operational users.

3.11 The Imager/Sounder Paradigm Revisited

Dr. Joe Criscione, Swales Aerospace, discussed the Imager/Sounder paradigm on GOES satellites. The intrinsic benefits of geostationary sensors are to provide high-temporal sampling of the full disk and to provide intense sampling of a specific region of interest. The high-temporal sampling of the full disk provides an excellent way to observe change and flux; the intense sampling is ideal for observing rare or significant events such as severe weather, coastal waters, and natural and man-made disasters.

The current architecture for the GOES-R system partitions requirements between an imager and a sounder. Dr. Criscione presented an architecture that partitions requirements based on a full-disk instrument and a region-of-interest instrument with each instrument performing both imaging and sounding. The proposed architecture can be flowed down to the distributed spacecraft architecture and enable the spacecraft to do the scanning for the region-of-interest instrument. By eliminating the scanner, the region-of-interest instrument can have a much larger aperture and achieve an order-of-magnitude improvement in the Coastal Waters Imaging and the Severe Weather/Mesoscale Sounding. The only caveat is that the spectral resolution in the full disk soundings will be reduced in order to perform the soundings at the same refresh rate as the full-disk imaging.

Dr. Criscione addressed some rationale for maintaining finer H_2O spectral resolution as opposed to chasing CO_2 resolution for the full disk soundings. Dr. Criscione discussed the feasibility of adding approximately 100 H_2O channels to the ABI as well as a 60-cm aperture for HES and the ability of a spacecraft to do instrument pointing.

In conclusion, Dr. Criscione said that the proposed architecture involves the same costs and risks. It would achieve gains by optimizing the spacecraft/instrument systems and balance full disk sounding needs and instrument complexity. He reiterated that an order-of- magnitude improvement would be realized in both mesoscale soundings and coastal waters. During the question and answer period, it was also noted that this paradigm shift would not meet several validated requirements. A point was also made that for the next generation series, maybe the paradigm shift should be to scan only with hyperspectral sensors and then build broad spectral band images from those.

4. GOES-R AS A COMPONENT OF THE GLOBAL OBSERVING SYSTEM

4.1 The Role of Geostationary Environmental Satellites in the WMO Space Program

Dr. Donald Hinsman, head of the World Meteorological Organization (WMO) Space Program, presented a summary of the current space-based component of the Global Observing System (GOS). He introduced the WMO Space Programme and noted its goals were to: (a) promote high-quality satellite-related continuing education to keep the knowledge and skill of Members' operational and scientific staff up to date with the latest technological innovations, and to provide the competence and skills needed in related fields, such as communications with users, and (b) review the space-based components of the various observing systems throughout WMO programmes and WMO-supported programmes, towards the development of an integrated WMO global observing system that would encompass all present WMO observing systems.

Dr. Hinsman further gave a vision of the capabilities of the GOS in 2020, which include: 30-minute warning of very destructive weather events; 1- to 12-hour forecast of severe weather events; 5-day hurricane track prediction to +/-30 km; 10- to 14-day weather forecast; 12 month regional rain rate including monsoon forecasts; 15- to 20-month El Niño prediction; and 10-year climate forecasts. Dr. Hinsman concluded by noting that the evolution of the geostationary component of the GOS would be a key contributor.

4.2 Meteosat Second Generation (MSG) Products

Dr. Ken Holmlund of EUMETSAT gave a presentation highlighting the new operational capabilities of the Meteosat Second Generation (MSG), now called Meteosat-8. The Meteosat Product Extraction Facility has expanded their suite of products to include: Atmospheric Motion Vectors; Calibration Monitoring; Clear Sky Radiance; Climate Data Set; Cloud Analysis; Cloud Top Height; Global Instability; ISCCP Data Set; GPCP Precipitation Index; Total Ozone; and Tropospheric Humidity.

Dr. Holmlund also noted the important role of the Satellite Applications Facilities in developing and producing new products. These centres of excellence for processing of satellite data complement the production of standard meteorological products derived from satellite data centrally (at EUMETSAT) and also distribute user software packages. He finished by showing many examples of the exciting new MSG data and products.

4.3 Plans for EUMETSAT's Third Generation Meteosat (MTG) Geostationary Satellite Program

Dr. Rolf Stuhlmann summarized the EUMETSAT planning process underway for Meteosat Third Generation (MTG). The stages of preparation include: needs identification and mission analysis; feasibility; preliminary definition; detailed definition; production, and testing; and utilization. EUMETSAT is engaged (with ESA as partner) in the first stage; this will conclude in 2005 when they have established agreed high level user needs and priorities, identified and assessed relevant observing techniques, extracted relevant mission requirements, and performed technology, sensor and system level concept studies.

Dr. Stuhlmann noted that at present, based on the assessment of observing techniques, five candidate observation missions have been identified for MTG. (1–3) Three distinct imagery missions dedicated to operational meteorology, with emphasis on nowcasting and very short term forecasting including High Resolution Fast Imagery (HRFI) as an enhancement of the MSG HRV-channel mission; Full Disk High Spectral resolution Imagery (FDHSI) as a successor to the MSG SEVIRI mission; and Lightning Imagery (LI); (4) An Infrared Sounding (IRS) mission focused on operational meteorology, with some potential relevance to atmospheric chemistry; and (5) A UV/Visible sounding (UVS) mission dedicated to atmospheric chemistry.

4.4 Routine Use of METEOSAT Rapid Scans

Hans-Peter Roesli presented numerous examples of the rapid scan imagery available from the Meteosats; these included dissipation of fog in the Alpine valleys, dust storms in Africa, high winds in the Alps, tropopause folds or stratospheric intrusions in the ozone and water vapour images, and water cloud changing phase to ice cloud. The uniqueness of a geostationary perspective is amply illustrated in these examples.

4.5 Plans for Japan's Geostationary Satellite Program – Multi-functional Transport Satellites

Hitomi Miyamoto from JMA gave an update on the status of the Multi-functional Transport Satellite (MTSAT). Preparations are almost complete for MTSAT-1R launch. (It had been planned to launch MTSAT-1R in the first quarter of 2004, but due to the failure of a Japanese H-2A rocket in 2003, this was postponed, and by the second half of 2004 new launch dates will be announced). MTSAT-1R and MTSAT-2 are multi-purpose satellites with both aeronautical and meteorological missions. Main changes from GMS-5 to the MTSAT series are: four infrared channels including a 3.7 micron channel and one visible channel; low-resolution digital image data disseminated by LRIT to SDUS; image data disseminated to MDUS by HiRID whose format is compatible to that of Stretched-VISSR of GMS-5; introduction of HRIT in addition to HiRID in order to disseminate image data at original resolution (4 km for IR and 1 km for VIS) and at original quantization levels to MDUS; and new ranging system using a turn-around HRIT signal at CDAS.

4.6 Plan of Geostationary Satellite (COMS) Program in Korea

Dr. Hyo-Sang Chung spoke about Korea's plans for a Communication, Ocean, and Meteorological Satellite (COMS). COMS would have satellite communication, ocean monitoring, and weather monitoring missions. The last two missions include: monitoring of marine environments around the Korean peninsula; production of fishery information (chlorophyll, etc.); monitoring of long-term/short-term change of marine ecosystem; continuous monitoring of imagery and extracting of meteorological products with high-resolution and multispectral imager; early detection of special weathers such as storm, flood, yellow sand, etc.; and extraction of data on long-term change of sea surface temperature and cloud. He noted that the timetable for COMS is completion of system design in 2004, completion of detailed design in 2006, system assembly and test in 2007, and launch and operation of COMS in 2008.

4.7 Future Plans of India's Geostationary Meteorological Satellite Programme

Dr. Ramesh Bhatia presented India's plans for geostationary environmental satellites. India launched INSAT-3B in March 2000 as the first of the INSAT-3 series. INSAT-3C followed on January 24, 2002. METSAT, a geo dedicated to meteorological applications, was launched in September 2002 carrying an imager with Vis (2 km), IRW (8 km), and WV (8 km) channels and a 1-km CCD array at 0.7, 0.8, and 1.6 microns. INSAT-3D launch is planned for 2006; this payload will also include a 19-channel sounder.

4.8 Summary of Other International Plans

The geo-plans for China and Russia were summarized by, Dr. Paul Menzel, NOAA/NESDIS, Chief Scientist, Office of Research and Applications. The second Chinese geostationary meteorological satellite, FY-2B, was launched on June 25, 2000. The satellite is spin stabilized and stationed at 105^{o} E. FY-2C, planned for launch in October 2004, will carry the current GOES Imager spectral bands at 1-km (VIS) and 5-km (IR) resolution. FY-4 (the second generation of Chinese geostationary meteorological satellite series) is being planned; several changes are under consideration including: three-axis stabilization; VIS/IR satellite (A series: 2012) and microwave satellite (B series: 2015); more powerful imager and lighting mapper; sounding capability (spectrometer); enhanced ground control capability; and enhanced application and services systems. FY-4 is in definition and pre-configuration stages; the first satellite is scheduled to be developed during 2006–2012, and launched after FY-2E (2012).

Russian geo-plans are for GOMS Electro N2 satellite to be designed for a 3-axis stabilized platform. The key payload will consist of Multi-Scanning Unit (MSU-G), a scanning radiometer-imager with 10 channels in VIS and IR similar to MSG SEVIRI (spectral bands include 0.5-0.65; 0.65-0.80; 0.8-0.9; 3.5-4.0; 5.7-7.0; 7.5-8.5; 8.2-9.2; 9.2-10.2; 10.2-11.2; 11.2-12.5 microns). The spatial resolution in sub-satellite point will be about 1 km (VIS) and 4 km (IR). GOMS/Electro N2 launch to geostationary orbit at 76^{o} E is planned for 2006. The primary mission objectives for GOMS Electro N2 are: continuous observation of the Earth within a radius of 55–60 degrees centered at the sub-satellite point, providing simultaneous images of cloud cover and the Earth's surface in 10 spectral channels of visible and infrared range; collection and retransmission of the hydro-meteorological data from national and international platforms (DCP) to the main and regional forecasting centers; helio-geophysical measurements at geostationary orbital altitude; and dissemination through the satellite of various information products (image fragments, charts and numerical data) from the main and regional centers to national and foreign users' receiving stations.

4.9 Qualitative Design: The Right Way to Develop the Composite Observing System

Dr. Sandy MacDonald from the NOAA Forecast Systems Lab spoke about the importance of designing a complete system (e.g., observing subsystems must be treated as part of a composite system and not as stand alone systems). In his view, the strategic triad for global observing consists of satellites, Unmanned Aerial Vehicles (UAV), and surface observations. He noted that considerable progress has been made toward performing credible simulations of observing capabilities at continental and global scales. He then presented the example of the potential impact of space-based lidar winds on weather prediction using results from recent experiments at the NASA Data Assimilation Office.

5. ENSURING USER READINESS FOR GOES-R IN 2012

5.1 GOES-R User Readiness, Planning, and Development

James Gurka, NOAA/NESDIS, GOES Program Requirements, discussed “GOES-R Series User Readiness, Planning and Development.” The goal is for the user communities to be fully ready when GOES-R becomes operational. He defined “user” as anyone who needs and uses GOES-R data to do their job and make decisions. This would include NOAA offices, other federal and non-federal agencies, as well as the private sector.

User readiness includes planning, preparation, risk reduction, and training. The readiness functions include delivery mechanisms, product readiness, education and training, and planning, budgeting, and reporting. There are several factors contributing to the complexity of ensuring user readiness. The user communities are diverse, with unique operational and programmatic needs. The diverse readiness functions need to be planned, organized, scheduled, and budgeted. Comprehensive coordination, monitoring, and reporting are required.

The approach being taken by NOAA/NESDIS is to organize and facilitate planning with extended GOES teams, and to document and manage “end-to-end” user readiness needs. The preliminary schedule includes requirements definition in 2004, planning and coordination in 2005, and preparing for operational integration in 2006.

Mr. Gurka pointed out the breakout sessions at this conference would provide user recommendations on the planned scope and approach, priority items and strategies, schedule and future recommendations, and coordination mechanisms and contacts.

5.2 NOAA User Readiness – Lessons Learned

Dr. Elbert (Joe) Friday, Professor of Meteorology at the University of Oklahoma, gave a presentation on “NOAA User Readiness—Lessons Learned.” He said that users must act now to identify their requirements for GOES-R. The time limit of meeting the GOES-R schedule is quickly approaching, and users cannot wait until tomorrow. Users must look at the requirements, data expectation, and what is promised by NOAA/NESDIS.

Dr. Friday said that users must decide what they really need, not what they really want. Budgeting constraints often mean that what users want is not affordable. Users must pay attention to the reviews of requirements. Often there is a quick turnaround time to comment, but users must be ready to comment, and must do so.

Requirements are often portrayed incorrectly, sometimes too detailed, other times too general. Requirements must be described with a level of specificity that is useful, and contractors’ hands must not be tied. The Statement of Requirements should represent all users, including the international community. Users have users (end users), and their needs must be included in the process. Dr. Friday said that for GOES-R, NOAA is doing a good job in working with users to determine what is needed.

Users and developers must be intrinsically linked, Dr. Friday said. This is especially important with regard to requirements and product delivery. To prevent miscommunication, it is vital to maintain continued communication throughout the entire process. Prioritization needs to be a higher priority. NOAA must have a total commitment up and down the line, from the user community involved in setting requirements generating desire through the development process.

Dr. Friday reminded attendees that, "risk happens." Of whatever can go wrong, a large percentage will go wrong. Early recognition is vital, so that everyone involved can identify potential risks. Two-way communication will prevent some of the risks that might otherwise become problems.

5.3 A Committee Study of End-to-end Utilization of Operation Environmental Satellite Data: A Vision for 2010 and Beyond

Dr. H. L. Allen Huang, of the Cooperative Institute for Meteorological Satellite Studies, and chair of the Committee on Environmental Satellite Data Utilization (CESDU) described CESDU's challenges. These include: the likely multiplicity of uses of environment data; likely interface between data provider and range of users; implication of multidirectional interfaces; critical factors that may drive the evolution of data management responsibilities; and findings and recommendations in enhancing the optimal utilization of operational environmental data.

For data utilization issues, Dr. Huang focused on the upcoming decade of environmental observation. In the next 10 years, we face the need for capability to support 100 new satellites and orders of magnitude more data. However, there are no integrated plans to utilize these data and transfer these benefits to society.

Dr. Huang identified the top ten ways reported to his committee to ensure that remotely sensed data are not used. These are:

- Provide data in formats that most potential users find difficult to handle (e.g., HDF rather than GeoTIFFs)
- Make sure the projection cannot be read by existing commercial image processing system (e.g., ISIN rather than SIN)
- Make the interfaces difficult to use especially the ordering ones
- Ensure that directories, catalogs and ordering mechanisms are as varied as possible
- Keep changing format of data and meta-data
- Deliver data in very large unit sizes
- Make sure users have lots of data processing to do once they receive the data sets
- Make sure that when orders are invalid users are not informed
- Have different data policies depending on which data are being provided
- Ensure the products are based on old out-moded algorithms

Dr. Huang described ECMWF's experience in using environmental satellites for research and operations. They have been used for numerical weather prediction and seasonal interannual prediction and environmental monitoring. The deliverables from focused earth system modeling data assimilation and monitoring are socially and politically important. We must constantly make the case for the necessary resources to exploit huge investments in satellite technology.

For the future, the challenge remains: how to take advantage of strength of all observing systems while avoiding their weaknesses. This issue requires more attention from the satellite community to provide resources needed to make full use of all data in numerical prediction. The bottom line is we need a fully funded, end-to-end process from satellite design to development, procurement to data utilization.

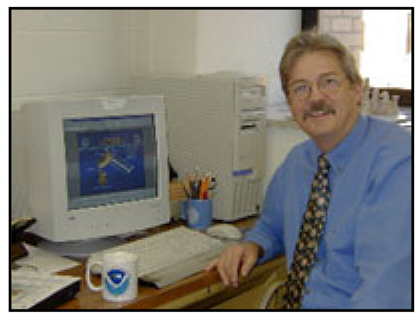
The presentation identified the challenges for satellite data utilization. These include: better use over land; better use in clouds; better exploitation of spatial and temporal gradients; data compression; inter-satellite calibration consistency; and early coordinated efforts for new sensors.

5.4 Existing Data Sets to Point the Way to GOES-R

Dr. Steve Ackerman, Director of the Cooperative Institute for Meteorological Satellite Studies, said that the development of GOES-R algorithms, products, and their accompanying data support systems will take several years. Given the current operational and research satellites now in orbit, and the high spectral resolution research instruments available in field campaigns, ample research data sets are available to develop, test, and implement Day 1 algorithms, to study data assimilation issues, to create a robust demonstration plan, and to design the hardware systems to support these efforts, and thus lower the risk of the GOES-R program.

Dr. Ackerman discussed the philosophy of data sets, and described where they fit in. He described observations from aircraft, ground, and satellite. Data sets must address science needs, including theoretical studies, measurement concepts, retrieval algorithms, and spacecraft instruments. We must design new methods, theories, and aircraft observations. We must improve the current capabilities for new and existing products. We must inspect existing measurements including calibration and validation. We must also bring new users to address user needs.

5.5 Risk Reduction for GOES-R Product Development



Dr. Paul Menzel, NOAA/NESDIS, Chief Scientist, Office of Research and Applications, presented GOES-R risk reduction activities. An end-to-end plan has been developed that addresses the following: user requirements; instrument requirements; tradeoffs between instrument design and science requirements; instrument calibration and validation; ground system/archive design and implementation; algorithm and product development; operations; and education and outreach.

The plan provides the necessary elements for early GOES-R utilization, including: capable informed users; flexible inventive providers; pre-existing data infrastructures; informative interactions between providers and users; knowledge brokers that recognize new connections between capabilities and needs; champions of new opportunities in high positions; well-planned transitions from research demonstrations to operations; and cost-effective use of GOES-R for improved applications.

The plan enables efficient adoption of GOES-R data and products into NOAA weather and climate services. Within 6 months of operation, there will be calibration and validation; unique first time imagery; examples of improved derived products; and case studies for numerical weather prediction impact. Within 1 year, operational use of GOES-R data and early products are envisaged.

The plan embraces all multispectral and hyperspectral experiences for GOES-R preparation. Aircraft, LEO, GEO-GIFTS and simulated data will be used for science preparation. The plan goes from FY 04 through FY 12.

Dr. Menzel noted that there are several challenges for improved utilization of remote sensing data, including that anticipated from HES. These include: better use over land; better use in clouds; better use in coastal regions; exploitation of temporal and spatial gradients measured by satellite instruments; improved data compression techniques; intersatellite calibration consistency; early demonstration projects before operations; synergy with complementary observing systems; and sustained operations of oceans and atmosphere, and ultimately of climate.

5.6 GOES-R Data Distribution

Timothy Schmit, NOAA/NESDIS/ORA, Advanced Satellite Products Team, said that data distribution is very important. There are a large number of current GOES Variable Data (GVAR) reception sites with more to be added. GVAR is the format of the rebroadcast data stream for the current GOES series. These include fixed and mobile sites. There is a wide range of current user needs. GOES-R instrument data rates increase by about two orders of magnitude over current instruments. Data compression can help reduce data rates while preserving information.

We think we know the following: the data downlink most likely will be in the X-band; data re-broadcast most likely will be in the L-band; the GOES-R rebroadcast format will most likely be different from today's GVAR; there will be some form of satellite rebroadcast; a tunable range of data compression options is ideal; and data compression techniques will continue to improve.

The future GOES rebroadcast system (GRB) is an extension of the GVAR system for the GOES-R era. The GRB is a payload service, separate from any direct service. The GRB will not realistically be able to transmit from the GOES satellite all level 1b data without data compression. Data compression can have applications in downlink, rebroadcast, distribution, and archive.

Several assumptions have been made concerning GRB. All users and applications are not known. Users will expect a similar or higher level of service than currently available. Communications capabilities will continue to evolve. NOAA should send out as much information (as opposed to data) as possible while balancing the cost of dissemination with the goal of maximizing the usefulness of the information.

NOAA/NESDIS is investigating Alternative Dissemination Methods (ADM) for distribution of weather and environmental data by means of Internet, Commercial Space Communications, and Dedicated Landline. The ADM methods of communication are separate from communication methods used in Direct Readout, which is a rebroadcast from government satellites. A Broad Agency Announcement for future geostationary satellite architecture is currently underway.

5.7 Comprehensive Large Array-data Stewardship System (CLASS)

Richard G. Reynolds, NOAA/NESDIS, CLASS Project Manager, presented an overview and plans for the CLASS system. NOAA's national data centers and their worldwide clientele of customers look to CLASS as the sole NOAA IT infrastructure project in which all current and future large array environmental data sets will reside. CLASS provides permanent, secure storage, and safe, efficient access between the data centers and the customers.

CLASS is a Web-based data archive and distribution system for NOAA/NESDIS environmental data. CLASS provides access to the user community for data sets. CLASS is an extension of a 1995 operational system, the Satellite Active Archive (SAA), and the migration from SAA to CLASS is complete, with CLASS coming online in a dual-site configuration in April 2004. CLASS currently supports POES, DMSP, and GOES data sets as well as RadarSat and SeaWiFS. It will support additional campaigns in the future to incorporate more data sets and expanded functionality.

Numerous accomplishments have been made to date. The overall design of the architecture is in place. Key system documentation has been prepared. CLASS established operational, integration and test, and development environments in Suitland, Maryland. Three Web sites have been consolidated into one Web-based user interface. The ingest system has been enhanced to be independent of file type. Baseline systems have been delivered to Suitland and Asheville, North Carolina, and are operational. CLASS is working with NASA to define initial requirements to archive EOS/MODIS Level 0 data. A CLASS Developers Workshop was completed in March 2004.

In summary, Mr. Reynolds said that the CLASS software release includes dual site configuration, operational April 2004. All retrospective GOES data will be available on CLASS in 2005. CLASS is a robust and active program, able to achieve objectives. Reprocessing is and continues to be a part of the implementation of CLASS beginning in 2006. The GOES-R campaign does have funding, through the GOES-R Program, and CLASS will start to work actively implementing GOES-R compatibility and capabilities in mid-2007.

5.8 User Education and Training

Tony Mostek, NOAA/NWS, Training Division, discussed the need for an end-to-end cycle for user education and training for NOAA's satellite programs. Analysis and forecast operations are evolving. The forecast process is changing the role of forecasters and data processing. We must understand the Earth as a whole system including holistic analyses, ecosystem-based management, and coupling atmospheric, terrestrial, and ocean processes. An integrated observing system should tie all systems together with a system-of-systems infrastructure.

A proving ground is needed for requirements testing training. Other agencies, such as the Army and NASA, have demonstrated the utility of proving grounds. In NOAA, the current state of affairs is that testing takes place in operations. The desired state is that testing should take place in a proving ground between the programs and operations areas. Desirable characteristics of the proving ground are: it should focus on operational testing; it should be requirements driven; it should be fully integrated; it should involve both experienced testers plus field users; there should be a cross-cutting of test team resources; the test team should be independent; and there should be distributed test sites.

Training should be included in the research and development process. NOAA should develop a proving ground to ensure the operational readiness of new hardware, software, and data. Under the current system, there is still a long, slow complex transfer to get new products from development to operations. A proving ground would help by bringing together the various systems, checked out in terms of assessment, performance and training capability before general release.

Training similar to the Satellite Hydrological and Meteorological (SHy Met) course would be appropriate for GOES-R. The goal would be to prepare NOAA users for new products within new forecast processes. The training fits nicely within the proving ground concept. The training could accommodate the major increases in NOAA's satellite programs. It would also link with the NOAA Strategic Plan for integrated global environment observing, and a bridge should be built to coordinate research-to-operations across all mission goals.

5.9 NOAA Observing System Architecture (NOSA)

Eric Miller, NOAA's Acting Observing Systems Architect, said that NOAA's Strategic Plan calls for the development of an integrated global environmental observation and data management system. He presented background information on NOAA decisions that have been made, including: establish Observing Systems Council; establish NOAA Observing Systems Architect; implement a system that is matrix managed within NESDIS; implement observing systems architecture toolset across NOAA; document baseline NOAA Observing System Architecture; and develop target (10-20 years) NOSA.

A Strategic Direction for NOAA's Integrated Environmental Observation and Data Management System has been published

Architecture establishes a semantic bridge between the mission and technology. An observing system architecture is analogous to a building blueprint. The GOES-R satellite system cuts across all goals and therefore fits into the overall architecture. The GOES-R Statement of Needs states that a replacement satellite is required by the end of 2012 to maintain continuity. User requirements have led to improved sensors. The Statement of Needs supports NOAA's strategic goals.

The GOES-R end-to-end approach involves implementing a process to identify and validate user requirements. The end-to-end system includes: space and launch segment; command, control, and communications; product generation and distribution; archive and access; and user interface and assimilation. NOAA is working with NASA to develop a joint process for major system acquisition approval.

NOAA's Information Service's enterprise for 2020 involves: engaging, advising, and informing our users; monitoring and observing; assessing and predicting; understanding and describing the environment; and getting back to our users. The future holds "Information on Demand," in which information is provided via the Internet to defense, civil, commercial, private, and international sectors.

6. NOAA'S FOUR MISSION GOALS

James H. Butler, Acting Director, NOAA Strategic Planning, presented an overview of NOAA's four mission goals. NOAA's mission is to understand and predict changes in the Earth's environment, and to conserve and manage coastal and marine resources to meet our Nation's economic, social, and environmental needs.

NOAA's goals are to:

- Understand climate variability and change to enhance society's ability to plan and respond
- Protect, restore, and manage the use of coastal and ocean resource through ecosystem-based management (e.g., habitat restoration, corals, protected areas, coastal resource management, invasive species, and others)
- Support the Nation's commerce with information for safe, efficient, and environmentally sound transportation
- Serve society's needs for weather and water information

The strategic planning process involves stakeholders such as users, constituents, employees, and partners who give information and feedback to NOAA. NOAA develops a strategic plan that guides our work. Mission goal teams are formed for ecosystems, climate, weather and water, and commerce and transportation. The outcomes are achieved through execution of programs, which support the goals and are evaluated by stakeholders. [Didn't he say anything about GOES? I remember something like "GOES-R will be used to support all the mission goals, especially the weather and water one."] In addition, Mr. Butler pointed out there are many cross-cutting priorities, including satellite acquisition, which support all the other programs in many ways.

NOAA's cross-cutting priorities initiatives are: an integrated global environmental observation and data management; environmental literacy, outreach, and education; sound, reliable, state-of-the-art research; international cooperation and collaboration; homeland security; and organizational excellence.

The mission goals and priorities connect through the Planning, Programming, Budgeting, Execution, System (PPBES) process, and an ongoing process that involves feedback throughout the entire cycle.

6.1 Understand Climate Variability and Change to Enhance Society's Ability to Plan and Respond

6.1.1 Report from NESDIS Data Users Conference

Kenneth Knapp, of the National Climatic Data Center (NCDC), presented a report on the NESDIS Data Users Conference, which was held June 11–12, 2003. About 375 people attended the conference, representing commercial, research, NESDIS, and other government agencies. The goals of the conference were: to review current products, archive, and data access; inform users about future capabilities, plans, and data sets; assess user needs and societal benefits; and solicit user opinions.

NESDIS asked eight core questions regarding these issues and received 570 answers, which were later consolidated to 180 recommendations, which are being tracked internally at NCDC. The top three recommendations involved: integrating multiple data sources; ensuring the overall user community has input into decisions concerning archive data; and maintaining human customer interface. Other recommendation topics included access, new services, feedback, data, archive, and standards. NOAA's goal for FY 04 is to have action plans for 50 percent of the recommendations. As of April, NOAA has plans for about 37 percent.

A follow-up workshop titled "NOAA Data Users Forum: Surface Weather and Climate Observations and Data" was held June 2–4, 2004.

6.1.2 Overview of NOAA Climate Observational Requirements

Herbert Jacobowitz, of Short & Associates, Inc., gave an overview of climate observational requirements for GOES-R. Climate observations from GOES are important for several reasons. Climate forcing has a strong diurnal component, which can take advantage of the frequent observations made from GOES during a given day. Also, these frequent observations from GOES make possible more accurate daily averages. The region observed on Earth is viewed from the same direction from the satellite. Intercalibration with polar satellites is possible.

Climate observational requirements have a scientific basis. Scientists need to measure small climate change signals, such as global temperature and solar irradiance in order to monitor the Earth's climate. We need to determine the long-term stability of the climate variables that need to be measured. They may be estimated by first noting that climate models predict doubling CO_2 in 70 years, leading to a climate forcing, whose magnitude can be approximated. The required long-term stabilities can then be estimated by measuring how much should climate variables change to offset the forcing.

The new instruments on GOES-R, the Advanced Baseline Imager (ABI) and the Hyperspectral Environmental Suite (HES), will play an important role in monitoring climate. The ABI has 10 infrared and 6 visible/near infrared channels; the number of channels on the HES will be about 1,600.

General requirements for GOES-R are to: minimize orbit drift; maintain some satellite overlap; replace satellites prior to failure; conduct thorough pre-launch characterization of instruments; conduct adequate on-board calibration; plan for product reprocessing; ensure access to products; continue observations on decommissioned satellites; include *in situ* observations; monitor network performance; and finally to preserve and exploit the full scientific value of the data through scientific data stewardship.

Some climate variables are dependent on geostationary observation. Specific requirements are: atmosphere, including clouds, precipitation, water vapor, CO2, earth radiation budget, radiances, temperature, and winds; land, including skin temperature and snow cover; ocean, including sea surface temperature and ocean color; and for space, total solar irradiance.

The requirements process is a NOAA-wide process with regional and global perspective. It is dependent on science requirements stated in numerous source documents. There is a formal validation and approval process. The GOES-R product requirements document is a living document that will be updated periodically.

6.1.3 GOES-R Support to Future Climate Monitoring Needs

Mitch Goldberg, Chief, Satellite Meteorology Climatology Division, NOAA/NESDIS Office of Research and Applications, discussed GOES-R support to future climate monitoring needs. No one can overemphasize the critical nature of climate. Up to 40% of the nation's $10 trillion economy is affected by weather and climate. The economic impact of El Nino in 1997–98 is estimated to be about $25 billion. We may see a 1 percent decrease in the U.S. gross domestic product by 2100, according to global warming projections.

There are several major goals in climate studies, to: improve predictions of climate variability and change; improve prediction of recovery of the stratospheric ozone layer; improve prediction of CO_2 out to

100 years; develop credible ecological forecasts due to global climate change; understand how water cycle dynamics will change in the future; and better understand and quantify the role of aerosols.

The vision of the U.S. Climate Change Science Program is: the nation and the global community empowered with the science-based knowledge to manage the risks and opportunities of change in the climate and related environmental systems. The goals are to: improve knowledge of the Earth's past and present climate; improve quantification of forces that control climate; reduce uncertainty in climate projections; understand sensitivity and adaptability of ecosystems and humans to climate; and explore the uses and limits of knowledge to manage risks and opportunities of climate variability and change.

The NOAA Strategic Plan for climate calls for building an end-to-end system of integrated global observations of key atmospheric, oceanic, and terrestrial variables. GOES-R will be part of this system. It will complement NPOESS by resolving the diurnal cycle and its long-term changes by providing more daily opportunities to obtain visible and infrared observations non-degraded by cloud cover; by monitoring rapidly changing and rare climate phenomena; and serving as a calibration anchor for all NPOESS satellites.

NOAA is responsible for scientific data stewardship. The goal regarding satellites is to ensure satellite observations and products are processed and used in a scientifically defensible manner, for real-time assessments and predictions of climate and retrospective analyses, re-analyses, and reprocessing efforts. This stewardship includes careful monitoring of the observing system performance, generation of climate data records (CDR), climate research and applications, and archive and distribution of data. NESDIS is formulating a plan for developing CDRs.

6.1.4 GOES-R and the Data Center of the 21st Century

Kenneth Knapp (for John Bates), of the National Climatic Data Center (NCDC), said the Data Center of the 21st Century will have four primary functions, the Four A's: acquire, archive, access, assess. He showed a reference model for an Open Archival Informational System (OAIS), which describes the archive and its interaction with three necessary components: the producer, which provides the information to be preserved; management, which sets the overall policy as one component within a broader policy domain; and the consumer, who interacts with the archive system to query and retrieve information.

Human-to-human interactions are the essence of a data center. Negotiations are required to achieve submission agreements with data producers and determine use-case scenarios with customers. Technology then enables the implementation of the agreements and scenarios. Management interactions provide the primary source of funding and guidelines for resource utilization. Management conducts regular performance reviews, determines pricing and distribution policies, and participates in conflict resolution involving producers, consumers, and internal administration.

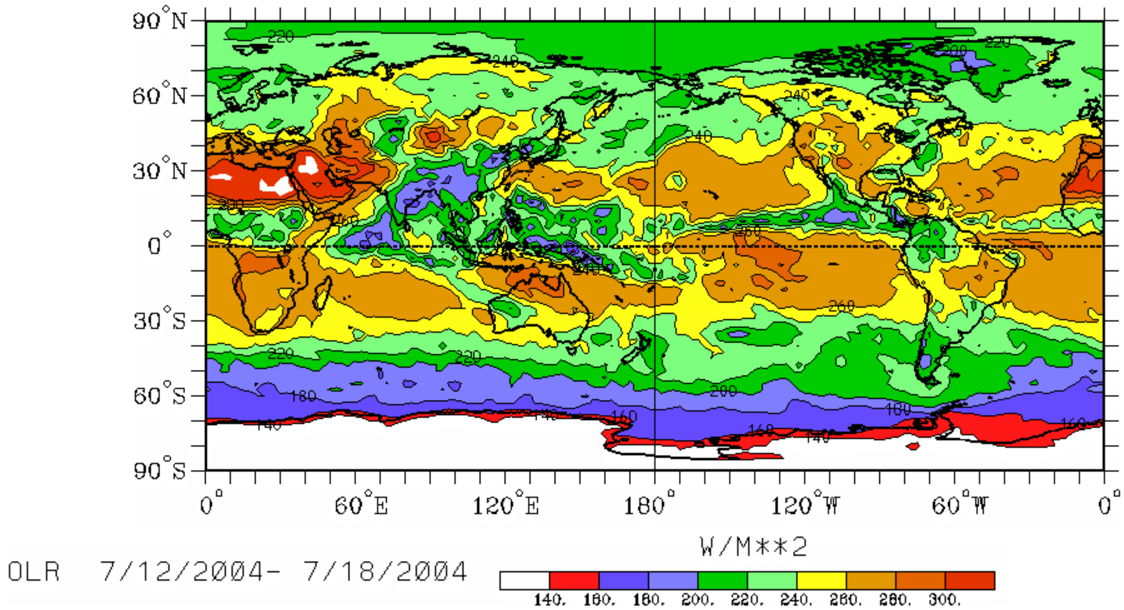
In the past, NOAA had no data submission agreements. NOAA is developing a new data submission process under which providers produce products supported by validated science requirements and request those products be archived and made available to a designated community by the archive.

However, a lack of metadata is the Achilles Heel of long-term archiving. Metadata is important because representation information is required to transform digital bits into information. This rich representation information can be provided by the data producer only. Currently producers do not supply this, leading to a loss of how to interpret data objects.

Data center consumer interactions involve consumer expectations that are rapidly changing. Consumers want to solve problems across a wide range of disciplines. Consumers want, and expect, easy data discovery, 24 x 7 access, and metadata. The Information Technology revolution will continue to shape consumer expectations. In short, data centers must respond to increasing consumer demand for more information.

6.1.5 GOES-R Support to Future Long-Wave Radiation Products

Hai-Tien Lee, of the University of Maryland's Cooperative Institute for Climate Studies, presented background on longwave radiation, information on satellite measurements and products, and potential of GOES-R longwave radiation products.



Outgoing longwave radiation (OLR) is the primary area of focus. Operational OLR products issued by NOAA/NESDIS are utilized by NOAA's Climate Diagnostics Center, NOAA's National Centers for Environmental Prediction, and others, for routine diagnostics of climate variations and evaluation of numerical weather prediction model performance. Satellite measurements and products are important for global monitoring of OLR. The satellite is a unique tool. Both polar-orbiting and geostationary satellites are used in OLR measurements. The Advanced Very High Resolution Radiometer aboard NOAA's polar-orbiting satellites has been used since 1979 to produce OLR products. The imager aboard GOES is also used for OLR products starting recently. Current OLR products include AVHRR OLR, HIRS OLR, ERB WFOV, ERBE WFOV, ERBE Scanner, CERES, ScaRaB, and GERB (first Earth's radiation budget from a geostationary satellite).

The potential of GOES-R longwave radiation products include: using validated multispectral OLR algorithm; being directly adaptable to ABI and ABS/HES; studying OLR diurnal variation effects; validating weather prediction model in regional scale with higher temporal resolution; blended polar-orbiting/geostationary OLR products; and other radiation products including DLR and heating rate.

6.1.6 Role of GOES in International Climate Programs

Professor Tom Vonder Haar, of the Department of Atmospheric Science at Colorado State University and Director of the Cooperative Institute for Research in the Atmosphere, said that GOES is a cross-cutting program to support all four of NOAA’s goals, including climate understanding, assessment, and prediction. GOES also supports regional climate studies over the Western Hemisphere, and is part of an international climate study via collaborative systems with other GOES and polar-orbiting satellites. Under the World Climate Research Programme, GOES data provide major input to GEWEX and to CLIVAR.

The GOES program, GOES satellites and scientists analyzing observations from GOES have made outstanding, internationally recognized contributions to climate research and monitoring. Many new opportunities will arise, as GOES-R becomes part of NOAA's "System of Systems" of Environmental Satellites. New climate opportunities for GOES include new cloud/aerosol property and variability research from multispectral data; and support the development and tests of regional climate models using key diurnal measurements of clouds, water vapor, temperature, and winds.

Professor Vonder Haar discussed the SINERGEE project, which exploits the synergy between the UK Met Office operational Numerical Weather Prediction model and GERB and SEVIRI on Meteosat-8. The Met Office performs simulations of broad-band fluxes and narrow-band radiances, in parallel with main run of forecast model. Model output and satellite data are available for analysis within about 24 hours of observation time. The Met office forecast and climate models are very similar in regard to their cloud and radiation components.

GOES-R, the Meteosat-8 series, and other new Geos will support many U.S. and International Climate objectives, especially with their improved calibration, long-term stability, and advanced instrument characterization.

6.2 Protect, Restore, and Manage the Use of Coastal and Ocean Resources Through Ecosystem-based Management

6.2.1 The Cooperative Institute for Oceanographic Satellite Studies

Dr. Ted Strub, Director of the Cooperative Institute for Oceanographic Satellite Studies (CIOSS), described the institute as a new collaboration between the NOAA/NESDIS' Office of Research and Applications and Oregon State University's College of Oceanic and Atmospheric Sciences. The program began formally on April 1, 2003. The initial period is for 5 years. The overarching goal is to develop, improve, and evaluate methods of ocean remote sensing and ocean-atmosphere modeling.

CIOSS activities include the development and improvement of techniques to use satellite data to investigate the ocean, and evaluation of existing and proposed satellite sensors. CIOSS also studies ocean-atmosphere fields and fluxes, develops models of oceanic circulation and methods of data assimilation for those models. Dynamic analyses of data sets derived from satellites, models and/or *in situ* observations increase our understanding of the physical and biological processes in the ocean-atmosphere system, on a wide range of scales.

CIOSS provides outreach, education, and training, to include formal and informal education for students, researchers, resource managers, and the public. The central educational themes concern oceanography and the use of remotely sensed data sets and numerical models, to learn more about the ocean and ocean-atmosphere interactions. Dr. Strub described SMILE, which stands for Science and Math Investigative Learning Experiences, an educational program that works with teachers in Oregon public school districts with large numbers of students who are traditionally under-represented at universities, especially in the fields of science and mathematics.

6.2.2 Harmful Algal Blooms and GOES-R

Richard P. Stumpf, of NOAA's National Ocean Service, described harmful algal blooms (HAB) and GOES-R. There is a need for monitoring HABs, as they can affect shellfisheries and people eating shellfish and endangered marine mammals such as manatees. They also can cause respiratory problems and affect tourism.

A system to monitor and forecast harmful algal blooms will soon be fully operational by NOAA/NOS in the Gulf of Mexico. The system involves a collaboration among federal, state, and commercial sectors. GOES-R data will be used in models, field samples, and testing of impacts.

HAB detection and monitoring includes ecological and optical methods. Ecological methods are used to detect new blooms (Karenia), upwelling variability, and other factors. Optical methods allow discrimination of Karenia or dinoflagellates from diatoms, blue greens. GOES-R additional bands will improve these methods.

GOES-R enhancements include improved averages (cloud clearing), better determination of optical properties, and additional benefits to ecology, such as diurnal variation. GOES-R will provide higher resolution, improved detection in bays and near coast. Additional bands will provide atmospheric correction for turbid water and absorbing aerosols, and improved bio-optical algorithms for chlorophyll estimates and dinoflagellate discrimination.

6.2.3 Potential Applications of GOES-R Data in Support of NOAA Fisheries Missions

Cara Wilson, of NOAA's Pacific Fisheries Environmental Laboratory, said the NOAA fisheries mission is to provide stewardship of the Nation's living marine resources through science-based conservation and management and to promote healthy ecosystems. NOAA Fisheries is involved in defining Large Marine Ecosystems (LME) and working towards developing guidelines for their stewardship. The U.S. Exclusive Economic Zone extends out into the waters surrounding the United States. The mandate for fisheries covers the entire economic zone of the United States. It is a large region, and fish do not, of course, respect boundaries.

There are numerous economic benefits of the U.S. Exclusive Economic Zone. Landings by U.S. commercial fisheries average 4.3 million metric tons, valued at about $3.4 billion. U.S. recreational fisheries provide food and recreation to over 17 million Americans, who spend $20 billion per year on angling.

The rationale for satellite remote sensing in fisheries involves understanding the changing ocean. Variations in marine environmental conditions affect distribution, abundance and availability of living marine resources. Variations affect the vulnerability and catchability of fish stocks.

Numerous ocean features are important to fisheries. These include: ocean fronts, boundaries, and edges; mesoscale circulation patterns; convergence zones; subsurface thermal structure; ocean surface winds; ocean currents; and wave heights. Temporal events important to living marine resources include HABs, oil spills, El Niño events, and regime shifts.

Fisheries use satellite data for various applications, including optimizing sea-going fisheries activities. Satellite sea surface temperatures (SST) are currently being used by NOAA Fisheries to mitigate interactions between endangered sea turtles and longline fisheries. Satellite data are also used to define essential habitats (lobster and salmon) for incorporation into an ecosystem approach to management.

GOES-R will provide other potential Fisheries applications. Ocean color used in conjunction with SST will be an important component in defining and monitoring essential fish habitat. The temporal resolution of existing satellite-derived products used in marine resource management can be improved to better account for regional ocean dynamics. Higher temporal and spatial resolution satellite data will enhance the development and implementation of new products for management of coastal fisheries (e.g., Pacific Salmon and Atlantic Lobster fisheries).

6.2.4 Naval Research Applications for GOES-R Data

Dr. Robert Arnone, of the Ocean Science Branch of the Naval Research Laboratory (NRL), said that Naval operations rely on the intelligent use of the ocean environment. NRL is meeting new challenges through evolving algorithms. New ocean color algorithms include salinity, bottom type classification, water depth, improved optical properties, particle size distribution, water mass tracking, and river plume dispersion. Applications include: water mass calculation approaches for optical signatures; diver visibility and vulnerability; target detection; laser systems performance; bathymetry and hazard detection; CHARTS (laser hydrography); data fusion; and data assimilation.

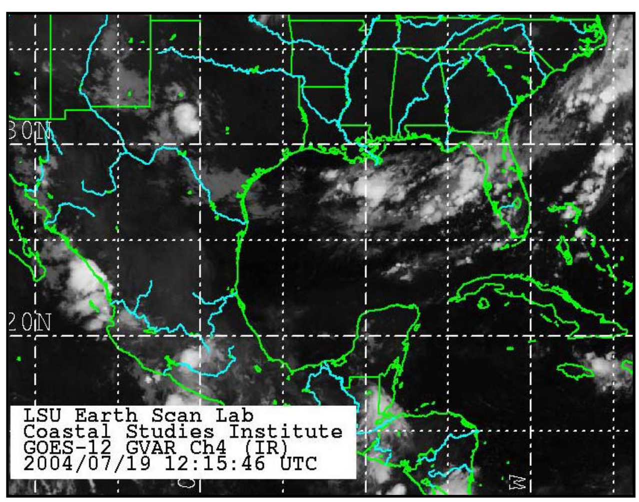
Technology is evolving toward Remote Sensing Optical Oceanography. Advances are based on calibration and sensor characterization. New products are being developed beyond chlorophyll; there are currently about 65 research bio-optical properties.

NRL is tracking optical signatures of coastal waters. The spectral differences of satellite optical properties define water masses. There are unique bio-geo optical provinces. Scientists are looking into how the optical character changes with particle scattering, biological activity, and colored dissolved organic matter. Multiple images, three per day, allow scientists to study the satellite consistency of ocean products.

In summary, Dr. Arnone said that "Ocean Color" is preparing for GOES-R. Scientists have demonstrated the need and utility for temporal coverage required in coastal zones (hours or less). They have demonstrated high spectral needs in coastal regions.

6.2.5 Gulf of Mexico Coastal Marine Applications Using GOES-R Data

Nan D. Walker, Earth Scan Laboratory, Coastal Studies Institute and the Dept. of Oceanography and Coastal Sciences, School of the Coast and Environment, Louisiana State University, presented a talk on Gulf of Mexico Coastal Marine Applications Using GOES-R Data. Significant advances in ocean surveillance have occurred as a direct result of the radiometric improvements in the GOES I-M imager. Frequent coverage (at least 48 images/day) over large ocean areas has led to the development of new techniques for detecting and tracking ocean features on very short time scales. The Gulf of Mexico provides a particular challenge due to clouds and high water vapor loading during 4–5 months of the year (May–September). However, the frequent image updates, low noise in the mid-IR channel (3.9 µm), and application of night-time measurements have provided SST accuracy of ~0.5 ºC, "de-clouded" images, and image animations that are used to detect, track, and study ocean features such as the Loop Current, eddies, and upwelling events even during summer months. This information is needed in real time



by decision makers in the oil and gas industry, for oil spill response activities, and for the prediction of harmful algal bloom growth and movement.

The opportunity now exists, with ongoing discussions of future GOES imager characteristics, to significantly improve upon the surveillance of physical, biological, chemical, and geological properties and processes of coastal marine ecosystems. Most coastal research can be enhanced by inclusion of remote sensing measurements at the appropriate spatial scales and wavelength regions. Coincidentally, gradients are largest along the coast due to seaward fluxes of land-derived suspended sediments, pigments (CDOM), and nutrients that fuel phytoplankton and harmful algal blooms. In the northern Gulf of Mexico, visible (0.44, 0.49, 0.55, and 0.66 µm) and near infrared (0.86 µm) measurements are essential to discriminate CDOM, chlorophyll *a* and suspended sediments in coastal waters.

The "true color" products from MODIS, SeaWiFS, and OCM over the Gulf of Mexico are being used to map and track optically distinct water masses, while individual channels are used to quantify chlorophyll *a* and suspended sediment concentrations. Physical/biological interactions, associated with Mississippi and Atchafalaya River discharges, contribute in complex ways to the location and severity of hypoxia (oxygen < 2 mg/l) on the Louisiana shelf. Satellite imagery provides a capability for the regional assessment of phytoplankton as well as the surveillance of river and coastal circulation on the shelf and cross-margin transport into the deeper Gulf of Mexico. During summer, the visible channels are essential for tracking river water, as thermal signatures are weak or non-existent in coastal areas. Spatial scales of 0.5 km or less are essential for the effective application of remote sensing in estuaries and coastal bays and lakes, where eutrophication and pollution problems are common and becoming more frequent. In Louisiana, remote sensing measurements will help to understand physical and biological impacts of river diversions, which could assist with the development of effective management strategies for their operations.

6.2.6 Coastal Ocean and Carbon Measurements from Geostationary Orbit

Janet Campbell, Principal Investigator, University of New Hampshire, gave a presentation on Coastal Ocean Carbon Observations and Applications (COCOA): A Proposed Earth System Science Pathfinder (ESSP) Mission Concept. The ESSP program is a component of NASA's Earth Science Enterprise (ESE) that addresses unique, specific, highly focused mission requirements in Earth science research. The ESSP program is an innovative approach for addressing global change research by providing periodic "windows of opportunity" to accommodate new scientific priorities and infuse new scientific participation into the Earth Science Enterprise.

Coastal missions have been proposed in the past, including the Navy's Coastal Ocean Imaging Spectrometer (COIS) on NEMO; and NASA and NOAA teamed up to propose a Special Events Imager (SEI). At this conference, users heard about plans for the GOES-R Hyperspectral Environmental Suite (HES). This would feature 400 km x 400 km viewing geometry with two modes, survey and local.

Both geostationary and hyperspectral are needed for the ideal coastal mission. The reasons to support hyperspectral are: the optical complexity of coastal waters; bottom albedo as additional signal; heterogeneous aerosol properties; chlorophyll fluorescence as valuable signal; and the potential to differentiate algal functional groups. The case for geostationary can be made based on the short time scales associated with coastal processes.

The proposed COCOA mission is being developed by JPL and a team of scientists. COCOA is a geostationary coastal carbon mission to be proposed as an Earth System Science Pathfinder mission. It would quantify the carbon pools and pathways of the coastal ocean.

Engineering teams at JPL conducted feasibility studies in the summer of 2003. They selected a geostationary orbit at 100^o to 90^o W longitude because it provided the greatest amount of annual revisit time for the coastal United States. COCOA will have two modes of operation, the synoptic mode, which would image the entire U.S. coastal zone 4–6 times per day, and the experimental and event mode, which would be used to intensively image regions during science experiments or during significant events

6.2.7 Animation of GOES Images for the Detection of Ocean Features

Richard Legeckis, of the NOAA/NESDIS Office of Research and Applications, gave a demonstration of composite images of sea surface temperature based on the GOES thermal infrared measurements. When daily composite images are viewed rapidly in a movie format, it is possible to separate the slowly moving ocean patterns from the rapidly moving clouds. The animations reveal the motions associated with large warm currents, such as the Gulf Stream, as well as the cool Pacific equatorial currents related to upwelling and La Niña. The advantage of the GOES is that the high frequency of daily observations provides a continuous link between the interactions of the atmosphere and oceans. The capability to resolve both atmospheric and oceanic motions is a distinct advantage when one tries to interpret and verify predictions made from computer models of weather and climate.

GOES-R advances will feature: the Advanced Baseline Imager with higher resolution, better cloud detection, elimination of gaps in present products, and three infrared channels. The Hyperspectral Environmental Suite Costal Water Imager will provide co-located color and infrared, hyperspectral visible and near infrared, and 150–300 meter resolution. The color images will continue to provide a view of the coastal oceans even during summer months when warm surface waters can eliminate the temperature gradients associated with ocean currents.

6.2.8 Surface Current Mapping Off California with Radiometry and Altimetry

Dr. Bill Emery, of the University of Colorado, said the goals are: to use near real time system to produce updates of the mesoscale surface circulation in the California Current Region; to use six to eight AVHRR BT images per day (requires automation) to evaluate passive microwave sea surface temperature (SST) and ocean color imagery for similar current calculations; to merge BT with altimeter data from Topex, Jason, ERS-1, and ERS-2 satellites using the Optimal Interpolation Technique; and to characterize the variability in time and space of the region's mesoscale coastal surface currents.

The tools used for this include: Maximum Cross Correlation (MCC); SST imagery from AVHRR and AMSR; ocean color imagery from MODIS; cloud filters; image navigator (Georegestration); quality filters; composites; and optimal interpolation.

For Maximum Cross Correlation, patterns are identified using cross correlations depicted in the first and second template boxes. The position of the template in the first image is fixed; correlations are computed as the template in the second image is moved to different positions within a dashed line. The template position with the greatest cross correlation indicates the most likely displacement of the feature.

To choose the areas, choose the template window in the first image to have enough points to give a 95% significant correlation. Choose the size of the search window in the second image large enough to be able to represent the maximum velocity between the images. Filter the vectors for significant (high) correlations and for spatial coherence using a next-neighbor filter. Overlap the resulting vector windows to produce a high-resolution spatial velocity field from the 1-km resolution imagery.

There are several sampling issues. Altimeters are accurate, but the space between even the tandem mission tracks is too large to adequately resolve the mesoscale. Satellite imagery provides a 1-km spatial sample that is unfortunately frequently obscured by clouds. We need to determine if we can combine the best attributes of both altimetry and imagery to produce accurate, timely and well-resolved maps of coastal surface currents. We need to determine if these methods can be used to compute a historical climatology as well as real-time updates for various applications needing accurate and high-resolution maps of coastal surface currents.

To be useful for the MCC calculation, the infrared and color images must be geolocated as accurately as possible (to within 1 km). It is relatively easy to correct for geometric distortions, but it is also necessary to correct for satellite attitude variations and for timing errors. The MCC method itself can be used to create a method to automatically correct the images. Once the geometric corrections have been made, the MCC method is used to perform the final corrections for satellite attitude and timing.

Optimal Interpolation (OI), also called Objective Analysis, was first introduced to oceanography by Bretherton (1976). OI makes an estimate of a variable from a weighted linear combination of observations at irregular locations. Weights are chosen so that the estimate has the minimum expected ensemble mean square error. Mapping to a stream function is justified because mesoscale circulation is strongly geostrophic, and hence weakly divergent. Mapping to a non-divergent stream function serves to largely filter out ageostrophic components of flow in the direct observations of velocity.

In comparing MCC with altimetry, we see that altimetry reveals geostrophic flow only. MCC data are interpreted as a total velocity that may include ageostrophic processes that advect thermal patterns. Even though thermal images are plagued by clouds, it has been shown that in certain regions the volume of MCC data can rival that of a satellite altimeter (Bowen et al., 2001). MCC intermittently achieves higher resolution than altimetry. MCC has more observations near the coast, where the thermal gradients are pronounced, complementing altimeter data sampling. There are problems with merging. Even in some 3-day fields there will be very few MCC vectors, and the OI merged vector velocities will depend primarily on the altimeter data.

In conclusion, Dr. Emery said that a GOES imager could provide the rapid repeat imagery needed to effectively find cloud-free image segments needed for MCC surface current mapping. Super resolution makes it possible to have a useful spatial resolution at GEO without a huge telescope.

6.3 Support the Nation’s Commerce with Information for Safe, Efficient, and Environmentally Sound Transportation

6.3.1 Navy Operational Applications of GOES-R Data

Dr. Richard Crout, of the Naval Meteorology and Oceanography Command's Satellite Programs office, described the Navy's current use of geostationary information; advantages of GOES-R for the Navy; potential uses of GOES-R for the Navy; and Navy issues.

Currently six regional centers collect real-time down-link from GOES and Meteosat satellites. The imagery is looped to derive mesoscale “weather.” The imagery is used in conjunction with other data products to produce annotated imagery products. Super Rapid Scan Operations can show the evolution of a thunderstorm.

The Fleet Numerical Meteorology and Oceanography Center (FNMOC) assimilates sea surface temperature and multi-level atmospheric wind speeds and direction into global and regional numerical weather prediction models. FNMOC focus products include: visible, infrared, and water vapor imagery; connective cloud top heights; simplified dust enhancements; and model and wind vector overlays.

The Joint Typhoon Warning Center uses data on tropical cyclone location, intensity, determination, and current path. The Naval Oceanographic Office uses multi-channel sea surface temperature and ocean features analysis. The National Ice Center uses Great Lakes and U.S. East Coast ice coverage.

The Navy will realize several advantages with GOES-R data, including data from the Advanced Baseline Imager (ABI) and the Hyperspectral Environmental Suite (HES). Multispectral capabilities of GOES-R ABI and HES will allow better discrimination of en route hazards such as fog, dust, smoke, volcanic ash, etc. There will be improved cloud type determination for numerical model initialization. The Navy is also looking to use the shortwave channels for ocean color applications. New IR and near-IR bands on ABI will allow discrimination of sea ice from clouds.

The Navy is looking at the potential atmospheric and oceanographic uses for GOES-R data. Atmospheric uses include true color imagery, sea surface temperature, dust and volcanic ash, cloud temps and levels, cloud/snow discrimination, cirrus cloud detection, cloud phase, rainfall estimates, wind speed and direction, hurricane intensity, biomass burning and smoke, fog, and aircraft icing potential. The oceanographic uses include: true color imagery, sea surface temperature, and ocean optical parameters.

The Navy has several issues concerning GOES-R. There is a concern about being overwhelmed, and a need to get on NOAA port. There are concerns about: the communications architecture; support at Naval Air Stations from Aviation Hubs at Norfolk and San Diego; Southern Hemisphere support; Navy research and development; and risk reduction for future geostationary systems.

6.3.2 Joint Ice Center Applications of GOES-R

Dr. Richard Crout, of the Naval Meteorology and Oceanography Command Satellite Programs office, described the role of the National Ice Center, the Nation's and the Defense Department's single interagency for operational ice analysis and forecasting. The agency represents a cooperative effort between the Navy, NOAA, and the Coast Guard. Its mission is to provide the highest quality strategic and tactical ice services tailored to meet the operational requirements of U.S. national interests, and to provide specialized meteorological and oceanographic services to U.S. Government agencies.

Government customers include all branches of the Department of Defense; U.S. Government agencies such as NOAA, the Coast Guard, and the Department of the Interior. The scientific community in government and academic institutions use the data; and the data are available to industry on the World Wide Web.

The National Ice Center uses GOES data primarily in the Great Lakes region. The strength of GOES data is the frequency of imagery; the weaknesses are relatively coarse resolution, lack of ice/cloud discrimination, and only 5 channels. The National Ice Center relies primarily on RADARSAT and data from the NOAA Polar-orbiting Operational Satellite's Advanced Very High Resolution Radiometer for the resolution that is needed.

Improvements in sea ice detection will be realized with GOES-R. The Advanced Baseline Imager (ABI) will have improved resolution. It will greatly improve the capacity for ice/cloud discrimination. It will provide updates every 5 minutes, which is useful for operational tracking of ice evolution and motion. The new 10.35-micron channel will be able to see through thin low-level clouds to see some ice floes on foggy days.

6.3.3 Navy Ionospheric and Thermospheric Imaging from Geostationary Orbit

Stefan Thonnard of the Naval Research Laboratory gave the presentation for Dr. Robert P. McCoy, of the Office of Naval Research. The Navy is permanently forward deployed and critically dependent on space for communication, navigation, surveillance, space tracking, satellite meteorology and oceanography, and satellite ocean altimetry. These can be degraded or denied by ionospheric weather. Space weather (including solar storms and ionospheric bubbles) can greatly affect HF communications and GPS navigation, especially in polar regions.

The Naval Space Command provides an Alternate Space Control Center for U.S. Space Command as part of the space surveillance network. The command detects, tracks, identifies, and catalogs man-made objects in space. The Naval space weather theme is, "Learn from the meteorologists." The Navy uses various data sources for assimilating the ionospheric model. These include DMSP, SSIES, SSULI, SSUSI, and GPS.

The Navy is developing optical instruments (UV Limb Sounder, UV Spectrographic Imager, geo-coronal imager) to monitor the ionosphere that could be deployed on future geostationary satellites. Some of these instruments were planned for the GIFTS-IOMI project, which is now in jeopardy. One current experiment is the Ionospheric Mapping and Geocoronal Experiment (IMAGER), an extreme and far-ultraviolet camera. One of the science objectives is to study the dynamics of global ionospheric irregularity structures and scintillation regions. Another was to serve as synergistic science with GIFTS/IOMI. Mr. Thonnard said that additional ground truth and calibration are needed.

6.3.4 GOES-R Support to Aviation Route Planning

Warren Rodie, NOAA/NWS, Meteorologist in Charge, Central Weather Service Unit (CWSU), Denver, Colorado, said that CWSU provides expert meteorological consultation forecasts and advice to Air Route Traffic Control to ensure the safe and efficient flow of air traffic throughout the National Air Space. GOES imagery is used to support this effort.

Mr. Rodie said that two-thirds of delays in aviation are weather related, causing a loss of about $4 billion per year; of this $1.7 billion could be avoided. Technology should be there to reduce the impact of weather on the aviation industry. We are currently working toward regional aspect, then local.

With the advent of GOES-R, there is no product to train on. CWSU receives what is sent by the weather office, such as a channel map, icing, and low cloud-forming product. Denver needs support on wind. We need better information and prediction for landings. Plans are made based on weather predictions—if weather doesn't happen as forecasted, much fuel is wasted in rerouting aircraft.

GOES-R fits in with impacting weather. Satellite products and their limitations need to be examined. These include ceilings and visibilities, turbulent wind, thunderstorms, and icing. For the future, our hopes, dreams and desires should be considered in GOES-R requirements. The current inability of CWSU to receive all of the available satellite information via a distributed system could be a future concern for full utilization of GOES-R that must be addressed.

6.3.5 GOES-R: Bringing Critical New Capability to Automated Weather Aviation Products

Paul H. Herzegh, of the National Center for Atmospheric Research (NCAR), gave a presentation entitled "GOES-R: Bringing Critical New Capability to Automated Weather Aviation Products." He described the flow of product development from testing through operational delivery and presented an overview of FAA-sponsored automated weather products that are in process or planned. These products include: volcanic ash (planned); turbulence; icing; ceiling and visibility; convection; winds; and space weather (a possible future effort). The operational users of current or future products include the FAA Flight Services Stations; airline meteorology departments; airport operators; air traffic support; pilots; commercial aviation weather services; and volcanic ash centers.

GOES-R will play a significant role in these products, and the talk illustrated a few of the GOES-R impacts. For example, the GOES-R Advanced Baseline Imager (ABI) and Hyperspectral Environmental Suite (HES) products will improve the likelihood of fielding a turbulence product. The geo lightning mapper will allow critical improvement to convective nowcasting; forecasting diagnosis of severe oceanic convection; convective storm evolution; and possibly give early alerts of volcanic eruptions. Ceiling and visibility products and in-flight icing products will also be critically improved by GOES-R data.

Volcanic ash detection will be improved by GOES-R. In this area the enabling properties of GOES-R are: the ABI spectral data for detection of ash and upper level SO_2, the improved spatial and temporal resolution of the ABI, HES/ABI satellite winds for plume tracking, temperature/wind profiles for plume height, capability for improved CO_2 slicing for plume heights, and others.

NCAR is currently working with academia, MIT Lincoln Lab, Colorado State University, and others to develop these aviation products.

6.3.6 GOES-R Contributions Toward More Effective Combat Force Projection

Captain Brian Kabat, Air Force Weather Agency (AFWA), Offutt Air Force Base, Nebraska, described Air Force Weather mission areas, and the importance of GOES-R to this mission. AFWA, as part of the joint team, delivers accurate, relevant, and timely environmental information, products, and services anywhere in the world. AFWA directly impacts decision superiority by enhancing predictive battlespace awareness and enabling commanders at all levels to anticipate and exploit the battlespace environment, from the mud to the sun.

Geostationary products from GOES and other satellites provide support at the strategic, operational, and tactical levels. AFWA customers include the intelligence community, National Command Authorities, Unified, Specified and Joint Commands, Air Force and Army warfighters, and base and post weather units. AFWA also provides backup for NOAA's Storm Prediction Center, Aviation Weather Center, National Volcanic Ash Advisory Centers, Environmental Modeling Center, and the Space Environment Center.

GOES-R will support the Air Force's force projection, moving people and equipment across the globe, and supporting them while deployed. The primary benefits of GOES-R will be scan strategy, improved capabilities, and new capabilities. Benefits will be realized in the areas of volcanic ash detection monitoring, land surface modeling, global satellite cloud analysis, thunderstorms, space weather forecasting, cyclone reconnaissance, resource protection, and homeland defense. The new capabilities will include low-light imaging and data from the lightning mapper. Low-light imaging from the Advanced Baseline Imager (ABI) could extend the usable visible imaging period 2–3 hours, allowing better detection of fog and other significant features (fires, aurora, etc). AFW is interested in in-cloud lightning for flight safety reasons.

The Air Force is particularly looking forward to improved geographic coverage from the GOES-R (ABI). The Air Force has extensive missions in South America, which is observed infrequently by GOES during Rapid Scan operations. The Air Force global cloud analysis will also greatly benefit from the elimination in coverage gaps.

6.3.7 GOES Data Collection System (DCS) in the GOES-R Era

William E. Brockman, Short & Associates, Inc., described the GOES Data Collection System (DCS) as a data relay system used for transmission from ground-based sensors through satellite to receiving station. It has been carried on board NOAA geostationary satellites since the 1970s. One reason it is important is that operations from remote locations are very expensive.

Currently, the system supports 20,000 platforms. The observation period is nominally 6 hours, the message size is 200 bytes, and data throughput is 100/300/1200 selectable. The current users are domestic and international government agency users exclusively. The principal users are: NOAA line offices; U.S. Geologic Survey; Army Corps of Engineers: USDA Forestry Service; national, state, and Canadian fire agencies; Bureau of Land Management; national, state, and local water resource agencies; and international hydromet services.

The requirements process involved a survey of current and potential users in which NOAA requested statements of requirements. The requirements were organized into a spreadsheet and then converted into a database, and then validated by interview and formal review process.

For this presentation, Mr. Brockman organized the requirements into categories coinciding with position in the biosphere. These include: observing in the water; observing on the surface of the water; observing on land; observing in the atmosphere; and other services, including support of NOAA ships with e-mail, Internet/intranet, safety, security, and quality of life/entertainment. The threshold requirements number of platforms for all categories is 89,000. The objective is 158,000. Projections for the GOES-R suggest that an increase in data volume will require a somewhat faster transmission rate.

Mr. Brockman told the users to stay engaged to their requirements. Keep the requirement system up to date, and understand where system design is going to take advantage of hardware evolution.

6.4 Serve Society's Needs for Weather and Water Information

6.4.1 GOES-R Support to Weather Forecast Offices

Dr. Gary Hufford, of NOAA's National Weather Service Alaska Region Headquarters, discussed GOES-R support to Weather Forecast Offices. He is exploring the possibility of using remote sensing techniques to help with solar radiation measurements needed to calculate snowmelt.

GOES-R has applications with its greater number of channels and high resolution for forecasting snowmelt and streamflow in those areas where snow is a major source of water for the region. We need to be able to recognize snow against land, cloud, and water. They chose a recumbent neural network to determine these classifications. Dr. Hufford said his office studied three basins in the Sierra Mountains of California, which gave them an opportunity to look at high and low elevations and those on basins on the windward and leeward sides of the mountains. They determined the classification scheme for cloud, snow cover, land, and water every hour of the day for the 3 months of major snow melt.

Dr. Hufford said they improved on the measurement of snowmelt and that information was used in a simulated streamflow model. They then compared the model results to actual streamflow observations in the three basins. The use of direct solar radiation measurements from GOES data allowed for up to 27% improvements in streamflow estimations. A demonstration effort was used to calculate at a base resolution of 1 km. With the higher resolution of GOES-R, we will see an even greater improvement in exactly what snowmelt is doing. As water resources become less and less, accurate mesurements of snowmelt and streamflow will be critical to water ressource managers. A side benefit of the demonstration is that the technique can be used for flooding potential.

Typically, basin averages, not 1-km data, are taken, so the researchers had to work with the system. There is a need for updated hydrological models that can handle direct input at higher resolutions in preparation for GOES-R data.

6.4.2 GOES-R Benefits for Numerical Weather Prediction

Ralph Petersen, Senior Scientist at the Cooperative Institute for Meteorological Satellite Studies at the University of Wisconsin-Madison Space Science and Engineering Center, said that the improved spectral, spatial and temporal coverage of GOES-R Imagers and Sounders will be critical in meeting many future numerical weather prediction (NWP) goals. GOES is also a major source of information to forecasters domestically and in other parts of the Northern Hemisphere.

GOES-R will be used for synoptic scale NWP, mesoscale NWP, and objective nowcasting. The GOES-R impact on weather forecasts is likely to be greatest in the first 3 days. It is important to remember that forecasters use real-time image products.

Before GOES-R can be used successfully, we need to determine how to deal with the incredibly huge amount of data from Advanced Baseline Imager (ABI) and Hyperspectral Environmental Suite (HES), with their rapid refresh rates.

Emerging new users need frequent updates and fast turn-around. They expect higher spatial and temporal accuracy and confidence. For GOES use in mesoscale NWP, model simulations provide good guidance tools, but the real atmosphere is much more complex than model simulations can currently accommodate. In many cases, we won't know what is there until GOES-R sees it. In the 0- to 6-hour objective nowcasting range, forecasters will not be able to look at all observations individually. Instead, we need to provide forecaster tools that preserve data closely and appear similar to other GOES observation composites, like the Derived Product Images.

Preflight preparation of the Atmospheric Infrared Sounder (AIRS) was good, but GOES-R needs to be better. We must do supporting research and development now! We must include the total infrastructure, such as ground receivers and data ingest systems. Applications development and data system emulations must be used. Without a sufficiently funded applications program, the needs of the end users won't be met.

6.4.3 The NOAA Hydrology Program and Its Requirement for GOES-R

Pedro J. Restrepo, NOAA/National Weather Service (NWS), Senior Scientist, Office of Hydrologic Development, described NOAA's hydrology program, its future, and its observation requirements. The NWS hydrologic service delivers products in three different ways: national, major river basin, and forecast points. The NWS River Forecast System involves a calibration system, ensemble stream-flow prediction system, operational forecast system, and an interactive forecast program.

Hydrologic applications of satellite data include: multi-sensor precipitation estimates; freezing level and potential evaporation observations and forecasts; data assimilation; temperature and precipitation forecast grids for use with distributed models; land surface input variables for atmospheric and hydrologic models; and snow cover and snow water equivalent.

Dr. Restrepo looked into the future of NOAA's hydrology program. He discussed high-resolution distributed hydrologic modeling, including high-resolution observations of precipitation, temperature, snow cover, snow water equivalent, and soil moisture. He described hydraulic models, high-resolution observations of river and reservoir/lake stage; and the Community Hydrologic Modeling System; mud slide models; and water resources.

Water resources are any of the Earth's range of natural waters that are of potential use to humans. The themes and objectives of NOAA's water resources programs include:

- Socio-economic needs and benefits, involving multidisciplinary social science studies with demonstrations of product/service benefits;
- Water resource data assimilation, which involves Doppler radar dual polarization and satellite quantitative precipitation, snow, satellite vegetation, soil moisture, evaporation, tides, estuary water quality;
- Fresh water forecasting, involving high spatial resolution water resources information grids, daily to seasonal probabilistic forecasts; and improved forecast information for extreme events (floods and droughts)
- Estuary-fresh water ecosystem predictions: fresh water forecast information incorporated into assessments of ecosystem stress; routine predictions of coastal water conditions.

NOAA's hydrology program requirements, threshold, and objectives were described for precipitation, snow cover, snow water equivalent, soil moisture, radiation parameters, vegetation cover, wind, air temperature, skin temperature, humidity, channel characteristics, and flood mapping.

6.4.4 GOES-R Support to Future NWS Weather Applications

Dr. Frank P. Kelly, NOAA/National Weather Service (NWS) Office of Science and Technology, discussed the potential GOES-R contributions to integrated observing systems and improving the user end of the end-to-end process. For integrated observing systems, the potential is to: improve temporal, spatial, and spectral resolution; obtain observations of new environmental elements; integrate multi-purpose observing systems and networks within an extensible enterprise architecture; determine where GOES-R data can complement the current and planned systems.

The objectives are to: deliver required improvements in observational capabilities; build an effective "system-of-systems" infrastructure; and establish efficient business processes. Increasing the temporal resolution involves goals and thresholds for both the Imager and Sounder. NOAA also needs to alleviate the current full disk versus mesoscale conflict and provide better monitoring and detection of significant weather events. Increasing the spatial resolution and the spectral resolution also involves goals and thresholds for the Imager and Sounder. Increased spectral resolution will allow discrimination among different parameters, and better vertical resolution in profiles.

GOES-R can measure an increased number of parameters: lightning (land and ocean), solar (energetic particles, auroral boundary, neutral density profile, etc.), cloud characteristics (particle size distribution, phase, etc.). GOES-R can better measure key parameters: fog, winds, stability, sea surface temperature, ozone, aerosols, profiles, soil moisture, vegetative type/greenness, etc.

To improve the user end of the end-to-end process, NOAA needs to develop strategies for dissemination, display/application, assimilation, and training. For improved dissemination, coordination and collaboration among NWS and NESDIS is necessary to ensure a cost effective solution is chosen. An Integrated Work Team should be formed to deal with dissemination issues. For display/application, collaboration among NESDIS, OAR (FSL), and NWS is needed. An Integrated Work Team should be formed. For assimilation, collaboration between NESDIS and NCEP is needed to ensure optimal use of new data. Incorporate this into the Joint Center for Satellite Data Assimilation. For training improvements, training should be included in the overall GOES-R budget. Training material for blended learning should be developed, including distance learning, residence workshops, and teletraining.

6.4.5 Value of Future GOES to United States Air Force Operations

Dr. John Zapotocny, Chief Scientist, Air Force Weather Agency (AFWA), said Air Force Weather, as part of the Joint team, delivers accurate, relevant, and timely environmental information, products, and services, anywhere in the world. Air Force Weather directly impacts decision superiority by enhancing predictive battlespace awareness and enabling commanders at all levels to anticipate and exploit the battlespace environment, from the mud to the sun.

AFWA provides backup for NOAA's Storm Prediction Center, Aviation Weather Center, Volcanic Ash Advisory Centers in Washington, D.C. and Anchorage, Alaska, National Centers for Evironmental Prediction regional modeling, and Space Environment Center. AFWA's customers include the Intelligence Community, National Command Authorities, Air Force and Army Warfighters, and Base/Post Weather Units. The organization includes a Strategic Center at Offutt Air Force Base, Nebraska, eight worldwide squadrons, and about 219 combat weather teams.

GOES-R will cover many of the areas of responsibilities. The Air Force will have very high use of GOES-R data. For the Advanced Baseline Imager (ABI), AFWA has similar interests and priorities as other users of new ABI capabilities, including aviation forecasting, severe weather, detection of aerosols, thin cirrus, and volcanic ash. ABI interests include automated cloud depiction and fine-scale numerical modeling improved by direct radiance assimilation to specify cloud and moisture patterns.

AFWA has long experience with low-light visible imaging on DMSP, which provides visible cloud images into twilight and with lunar illumination (>25%). Low-light imaging on GOES can extend useful visible data by 2–3 hours/day. If sensitive enough, nighttime fires or other anomalous lights can be detected.

For space environment monitoring, Air Force Weather has a mission to provide space weather analyses, forecasts, and warnings to DoD operators and decision makers. There is a continued reliance on X-ray and energetic particle sensors for real-time warnings. The Solar X-Ray Imager (SXI) has improved AFW capabilities for monitoring and forecasting solar events. The Advanced Baseline Sounder will provide RAOB-quality soundings with very high temporal and spatial resolution.

The Special Events Imager (SEI) provides high-resolution (300 m) multispectral depiction of short-term events such as volcanic plumes, dust, fog, floods, clouds, etc. There is a reasonably short reaction time. The SEI offers details and temporal coverage not available from other satellites.

The AFW interest in intra/inter-cloud (IC) lightning for flight safety, and the Lightning Mapper is a tremendous asset. Thunderstorm forecasts are required for areas outside of current detection equipment. Most systems detect only cloud-to-ground (CG) strikes in or near CONUS. AFWA needs IC lightning detection, and coverage beyond CONUS.

AF Weather often forecasts for regions with limited conventional data and relies heavily on satellite observations. Reduced scanning of South America has negative impacts on forecasting ability. U.S. Southern Command users cannot receive data for their areas of responsibility. Southern Hemisphere cloud analyses and forecasts have reduced input data. Full-disk every 15 min meets MJCS 154-86 DoD requirements.

Strategic Center Users require best data available and more flexible antenna size and complexity. Deployed users need lightweight, portable, rugged equipment for remotely deployed units lacking reach-back connectivity. The receive antenna should not require tracking and should be easily aligned. Low-rate Imagery Transmission is likely to be the signal of choice. Data will also be available via network reach-back (JMIST concept). There will be key downlink nodes with HRIT ingest/processing capability stage data for network access.

6.4.6 GOES-R Support to U.S. Army Weather Applications

Dr. Donald Hoock, of the U.S. Army Research Laboratory, White Sands Missile Range, N.M. provided an overview of the Army user's requirements for GOES-R. Eleven Army battlefield functional areas need GOES-R information including: special operations forces, infantry, intelligence, aviation, logistics, air defense, Nuclear, Biological & Chemical (NBC) defense, combat engineers, field artillery, armor, and signal. The U.S. Air Force is tasked to provide the Army with the majority of its daily operational weather information, including METSAT, so Air Force GOES-R requirements highly overlap those of the Army.

Air Force personnel have traditionally been assigned to Army tactical operations centers at the higher echelons (division and above). As Combat Weather Teams they currently use the Army's Integrated Meteorological System (IMETS) to provide forecast products, decision aids, alerts and warnings to commanders across the Army Battle Command System. IMETS is currently tasked mainly for mission planning based on mid- to long-range forecasts of 24–120 hours. IMETS METSAT map overlays are very useful to forecasters and military commanders alike and have always been part of the IMETS system requirements.

However, the new DoD-wide Transformation programs are significantly expanding Army weather requirements, making METSAT remote sensing even more vital in the GOES-R era. The latest Army operational requirements documents, ranging from the highest level Force Operation Capabilities (FOC) to the lowest echelon Future Combat Systems (FCS) all emphasize expanded weather requirements. For example, weather for current mission execution and for short-term 0–6 hour planning must now be supported in a highly dynamic and mobile operating environment. This requires exploiting real-time, *in situ* forward-deployed sensors and remote sensing for more accurate, up-to-date information. Current weather updates are needed to confirm or correct the forecasts and red-amber-green weather impact decision aid status, even while en route and on the move. The IMETS functionality will be merged into the Army's Distributed Common Ground Station—Army (DCGS-A), an intelligence analysis system, and with other Air Force forecasting workstation applications into a Joint Environmental Toolkit (JET) workstation.

GOES-R and other METSAT sensors will thus provide critical information to JET and DCGS-A. Today's relatively large tactical METSAT ground terminals used by the Air Force and Army are being replaced with small GOES receivers and low rate direct readout terminals. These will provide small forward units with direct receive capabilities that can back up the high rate METSAT EDR database to be broadcast to the Army from Air Force direct readout ground stations over the military's future Global Information Grid. They will provide space weather forecasts that are critical to Army communications. The future GOES-R Hyperspectral Environmental Suite and Advanced Baseline Imager will also provide excellent support to Army artillery systems that require vertical temperature and moisture profiles. METSAT data also support prediction of acoustic propagation, radar ducting, location of obscuring battlefield smoke and dust, and the transport of chemical, biological, radiological and nuclear contaminants. In addition to supporting the Army's future artillery systems, there are also METSAT data requirements for the Corps of Engineers mobility and hydrology models, and for Army Test and Evaluation range operations and range safety.

Quantitative requirements for specific METSAT data parameters are being staffed through the Army and will be published soon. Army weather information systems may look different in the GOES-R era than they do now, but METSAT requirements will remain solid.

7. POSTER PRESENTATIONS

1) Using ABI to help HES/ABI for Atmospheric Sounding and Cloud Retrieval

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The Advanced Baseline Imager (ABI) and the Hyperspectral Environmental Suite (HES) on GOES-R and beyond will enable improved monitoring of the distribution and evolution of atmospheric thermodynamics and clouds. The HES will be able to provide hourly atmospheric soundings with spatial resolution of 4 ~ 10 km with high accuracy using its high spectral resolution measurements. However, presence of clouds affects the sounding retrieval and needs to be dealt with properly. The ABI is able to provide at high spatial resolution (0.5 ~ 2 km) a cloud mask, surface and cloud types, cloud phase mask etc, cloud top pressure (CTP), cloud particle size (CPS), and cloud optical thickness (COT). The combined ABI/HES system offers the opportunity for atmospheric and cloud products improved over those possible from either system alone. The key steps for synergistic use of ABI/HES radiance measurements are (1) collocation in space and time, and (2) ABI cloud amount, type, and phase determination within the HES sub-pixel. The Moderate-Resolution Imaging Spectroradiometer (MODIS) and the Atmospheric Infrared Sounder (AIRS) measurements from the Earth Observing System's (EOS) Aqua satellite provide the opportunity to study the synergistic use of advanced imager and sounder measurements. The combined MODIS and AIRS data for various scenes are analyzed to study the utility of synergistic use of ABI products and HES radiances for better retrieving atmospheric soundings and cloud properties.

2) ABI Cloud Mask Study using MODIS Data

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The Advanced Baseline Imager (ABI) cloud mask is a very important product needed for use in generating the atmospheric soundings, cloud parameters, clear-sky radiances, and surface properties from ABI radiances. ABI cloud mask information collocated with Hyperspectral Environmental Suite (HES) data not only enables cloud detection within a given HES footprint, but also helps cloud-clearing processing using ABI/HES data. The cloud mask algorithm is the operational Moderate-Resolution Imaging Spectroradiometer (MODIS) algorithm developed at the Space Science and Engineering Center (SSEC), which uses several cloud detection tests to indicate the level of confidence that clear skies are being observed. The algorithm has been adjusted to the currently selected ABI spectral bands, and uses ABI spectral bands to maximize reliable cloud detection and to mitigate past difficulties experienced by sensors with coarser spatial resolution or fewer spectral bands. The algorithm identifies several conceptual domains according to surface type and solar illumination including land, water, snow/ice, desert, and coast for both day and night. Once a pixel has been assigned to a particular domain (defining an algorithm path), a series of threshold tests attempt to detect the presence of clouds in the ABI field-of-view (FOV). Each cloud detection test returns a level of confidence that a pixel is clear, ranging in value from 0 (low) to 1 (high). The ABI cloud mask algorithm has been tested with MODIS data from both day and night. The ABI and MODIS cloud masks are compared for both similarities and differences due to spectral differences between the two instruments.

3) Study of the Hyperspectral Environmental Suite (HES) on the GOES-R and Beyond

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High spectral resolution infrared radiances from the Hyperspectral Environmental Suite (HES) on Geostationary Operational Environmental Satellite (GOES-R and beyond) will allow for monitoring the evolution of atmospheric profiles and clouds. The HES is currently slated to be launched in 2013. HES, together with the Advanced Baseline Imager (ABI) will operationally provide enhanced spatial, temporal and vertical information for atmospheric soundings and clouds. Trade-off studies have been done on the spectral coverage, spectral resolution, spatial resolution, temporal resolution, band-to-band co-registration, and signal-to-noise ratio. HES data applications investigated include sounding temperature/moisture retrievals, trace gas estimation, cloud retrieval, and surface property retrieval. The accuracy and vertical resolution of atmospheric temperature, moisture, and trace gas associated with HES are investigated. These will be contrasted with capabilities from current sensors.

4) Advance Mesoscale Product Development for GOES-R Using Operational and Experimental Satellite Observations

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Although the scheduled launch of GOES-R is almost a decade away, advance preparation is necessary now to maximize the useful lifetime of this new series of satellites. The high time resolution of GOES-R makes it highly desirable for mesoscale weather events such as severe storms and tropical cyclones. Observations that are similar to subsets of what will be available from GOES-R are being collected from operational and experimental satellites for severe weather and tropical cyclone cases. Observations include those from the current GOES, AVHRR, MODIS, and AIRS. The Advanced Baseline Imager (ABI) will have much higher spatial resolution than the current GOES satellites, and the AVHRR and MODIS data are being used to evaluate the utility of this higher resolution capability. Another major advance on GOES-R will be the Hyperspectral Environmental Suite (HES) that has the potential to provide atmospheric temperature and moisture soundings with a much higher vertical resolution than those currently available. Soundings from the AIRS instrument have been obtained for several case studies of mesoscale weather events, and are being evaluated by comparison with *in situ* observations. Examples of potential applications of the ABI and HES to severe weather and tropical cyclone forecasting will be presented.

5) Applications of Simulated GOES-R Observations for Advance Product Development for Mesoscale Weather Forecasting

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In preparation for GOES-R, we are developing a method to simulate satellite observations using a cloud-scale numerical simulation model and radiative transfer models. In short, a numerical cloud model is used to simulate mesoscale weather events, including severe storms and tropical cyclones. A second model is used to calculate the brightness temperatures of the clear and cloud sky scenes from the model simulations. This procedure allows for advanced product development for severe weather (precipitation estimation, updraft diagnosis products) and tropical cyclones (intensity estimation). The development of products in advance of the satellite launch extends the useful life of the satellite system. Examples of this method for severe storm and tropical cyclone case studies will be described.

This modeling framework is also being used to prepare for assimilation of GOES-R observations. For this purpose, simulated observations are generated by sub-sampling the model initial condition based upon current day observing system capabilities, which are then used as input to a data assimilation system. The simulated observations can be supplemented by additional data that will be available from GOES-R. The potential impact of the GOES-R data on forecasts can be estimated by comparing the forecasts with and without the supplemental simulated observations to the original model prediction. The plans and model framework for this study will be described.

6) Projected Impacts of ABI Data on Satellite-Based Precipitation Estimation Part I: Enhanced Temporal Resolution

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The Advanced Baseline Imager (ABI) on the GOES-R series of satellites will provide much more frequent imagery than is available from the present generation of GOES—every 5 minutes over the CONUS as compared to every 15 minutes at present. Given the rapid life cycle of convective precipitation, the capability to estimate precipitation from satellite data would be enhanced by the improvement in temporal resolution. This is demonstrated using 5-minute GOES-11 data obtained when the satellite was active in support of the International H_2O Project (IHOP) during the summer of 2002.

7) Projected Impacts of ABI Data on Satellite-Based Precipitation Estimation Part II: Additional Spectral Information

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In the GOES-R era, the number of available Imager channels is planned to increase from 5 on the current generation Imager to 16 on the Advanced Baseline Imager (ABI). Many of these channels contain information pertinent to cloud and precipitation processes because of their sensitivity to cloud-top particle phase and size. In this work, MODIS data are used as a proxy for selected ABI channels to demonstrate their potential impact on precipitation estimates. This impact is particularly notable in discriminating non-raining cirrus clouds from raining cumulus clouds and thus reducing the overestimation of precipitation that frequently occurs with satellite-based techniques.

8) Space-Time Characteristics of the Diurnal Variation of Rainfall over the United States and Adjacent Oceans Obtained from GOES

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Hourly precipitation estimates from GOES, along with the NOAA Stage IV radar rainfall estimates, are used in this study to look at the diurnal variations of rainfall over the United States and adjacent oceans. The GOES based rainfall estimates correspond to GOES Multi-Spectral Rainfall Algorithm (GMSRA) and the Operational Hydro-Estimator (HE). The HE is based on a radar-calibrated relationship between 10.7-μm brightness temperature and rainfall rate. GMSRA uses data from all five GOES channels to produce rainfall estimates. The objective of this research paper is to analyze the diurnal variations of rainfall in terms of small spatial scale changes over the United States during August 2003. GOES data provide direct and continuous information on diurnal variation of cloudiness and rainfall. Preliminary results for the month of August 2003 indicate large amplitude diurnal harmonic in the southeastern United States, in southwest Mexico near Baja California and over the Gulf Stream off the East coast of the United States. These results are consistent between rainfall estimation techniques and compare well to analyses of hourly radar-rain gauge data.

9) Near Real-Time Cloud and Radiation Products from GOES-R ABI

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The Advanced Baseline Imager (ABI) on GOES-R will provide data that will greatly enhance the retrieval of cloud properties and the estimation of radiative fluxes within the atmosphere and at the surface. These products have a variety of applications. A suite of algorithms, currently applied to 30-min GOES-9/10/12 data for the Atmospheric Radiation Measurement (ARM) and the NASA Advanced Satellite Aviation Products (ASAP) programs and to continuous Moderate-Resolution Imaging Spectroradiometer (MODIS) data for the Clouds and Earth's Radiant Energy System (CERES) Project, will be adapted to match the ABI spectral bands for application to 15-min GOES-R data. The algorithms first identify each pixel as cloudy or clear. Surface skin temperature and albedo are retrieved for each clear pixel. Cloud-top and base heights and temperature are estimated for each pixel along with the cloud phase, effective particle size, and liquid or ice water path. Groups of clear and cloudy pixels are then combined at a prescribed scale (20–50 km) and used to compute the surface and top-of-atmosphere radiation budget for the clear and cloudy parts of the group with input from the cloud retrievals and numerical weather analyses/forecasts. The products are currently being used to diagnose aircraft icing conditions, validate mesoscale and general circulation model predictions of clouds and radiative fluxes, and develop climatological statistics over selected parts of the globe. A variety of other applications are envisioned for the future including solar energy, agriculture, weather forecasting, and contrail diagnosis for flight rerouting. The current methodologies are limited by the resolution and spectral suite on the current GOES imagers. The availability of additional solar and infrared channels as well as enhanced spatial resolution will permit better cloud, phase, and height determination plus improved detection of multilayered clouds. Channels similar to those on the ABI are being used by CERES and are being tested in a geostationary mode using the 3-km resolution Spinning Enhanced Visible and Infrared Imager (SEVIRI) on Meteosat-8. Examples of the near real time products from the various satellites and the improvements that can be accomplished with GOES-R are presented.

10) Atmospheric Motion Vectors from the Current GOES-I/M Series with an Eye on Opportunities with the Future GOES-R/U Series

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Atmospheric motion vectors (AMV), derived from the current GOES-I/M series of satellites, continue to provide invaluable wind information to the meteorological community. AMVs obtained from tracking features (i.e., clouds and moisture gradients) are used for: i) Improving numerical weather prediction (NWP) analyses and forecasts; ii) Supporting short term forecasting activities at National Weather Service (NWS) field offices; and iii) Generating tropical and mesoscale wind analyses.

The future Advanced Baseline Imager (ABI) planned for the GOES-R/U series of satellites offers exciting new capabilities that should directly benefit and improve the derivation and quality of the AMVs. These new capabilities include continuous scanning with no loss of imagery due to eclipse or conflicting scanning schedules, higher resolution (spatial and temporal) imagery, and improved navigation. The future Hyperspectral Environmental Suite (HES) planned for the GOES-R/U series will offer increased spectral resolution, which will enable increased vertical resolution of the derived AMVs.

Today, areas of active AMV research include the generation, validation, and impact assessment of rapid scan winds derived from high temporal frequency imagery, error characterization and improvement of tracer height assignment, and improved utilization of AMVs in NWP systems. This research will lay the scientific foundation so that the anticipated improvements in AMVs in the GOES-R era can be realized. This poster will highlight many of these active AMV research topics.

11) Cloud and Aerosol Properties using High Spectral Resolution Infrared Measurements

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High spectral resolution infrared measurements provide increased capabilities over imaging radiometers for detecting clouds and aerosols and for characterizing their optical properties. A variety of research groups have been developing algorithms for detecting clouds and aerosols using high-spectral resolution infrared measurements. The goal has been to apply these algorithms to current and future hyperspectral sensors on polar orbiting and geostationary satellite platforms with a view to improving our understanding of the Earth's hydrological cycle and energy budget. This paper reviews the advantages and disadvantages of using high-spectral resolution infrared observations to detect cloud and aerosol and, where feasible, retrieve their microphysical properties. Presented is an overview of these algorithms and a demonstration of their capabilities as applied to aircraft (HIS/S-HIS/NAST-I) as preparation for GOES-R

12) Smooth Transitions Toward GOES-R: Simulation of High Temporal Resolution Imagery using Advanced Morphing Algorithms

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"Morphing" is a term that describes a broad category of digital image algorithms used to create smooth, seamless transitions between two or more images. In satellite imagery, morphing can be used to simulate image sequences at a temporal resolution that is higher than the original instrument capabilities. This makes morphing a necessary tool for visualizing the 5-minute full disk updates planned for the GOES-R Advanced Baseline Imager (ABI) channels, and indicates a future role that morphing can play in further enhancing the temporal quality of ABI imagery in post-processing. Before the GOES-R deployment, morphing could be used to create realistic 5-minute full disk simulations from existing GOES or Meteosat Second Generation imagery to prepare for the data-delivery requirements of GOES-R. After deployment, morphing could be used to create <5 minute resolution "interpolations" of ABI imagery in rapidly developing events, and could be used to repair sectors corrupted by operational errors.

A simulation of 5-minute resolution full-disk imagery produced by morphing GOES-12 images will be presented. A regional-scale example using morphed images from the Moderate Resolution Imaging Spectroradiometer (MODIS) will also be presented in order to demonstrate the infrared ABI bands at full 2-km resolution.

13) GOES-R ABI Impacts on Operational Cloud Analysis at AFWA

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For over three decades the Air Force Weather Agency (AFWA) has produced an operational global cloud analysis product based on analysis of polar-orbiting satellite observations from DMSP and TIROS. In June of 2002 the existing nephanalysis model underwent a significant upgrade that included addition of data from the international constellation of geostationary environmental satellites (i.e., GOES, Meteosat, and GMS). Understandably, this resulted in major improvements of timeliness, accuracy, and coverage over mid-latitudes to the tropics. New algorithms were developed specifically to exploit the high temporal refresh and, where applicable, the multispectral capabilities of the respective sensors. The most capable of the extant systems are the GOES five-channel imaging sensors with their frequent updates (15 minutes over much of the coverage areas) and true multispectral capabilities.

While analysis of GOES data provides a vastly superior cloud analysis relative to the legacy two-channel polar-orbiting algorithm, there remain limitations that negatively impact overall accuracy. These include loss of continuity across the day/night terminator; discrimination of low cloud/fog over problematic backgrounds such as ice, snow, desert, and sun-glint; detection and accurate characterization of transmissive cirrus, particularly during daytime; complete identification of multi-layer cloud systems; and correct classification of ice, water, and mixed-phase clouds. Satellite limitations such as eclipse outages, sensor noise, and reduced spatial coverage during rapid-scan also affect the operational products. On-going research to utilize the high spectral resolution of new and upcoming sensors such as MAS, MODIS, VIIRS, and the GOES-R ABI have shown promise toward addressing the known weaknesses associated with existing sensor systems. Existing rapid prototype facilities at AFWA provide an optimal environment for evaluating new sensor data and processing algorithms prior to incorporation into the operational system. The imminent introduction of 12-channel SEVIRI data from an operational Meteosat-8 is expected to provide a first indication of how well the AFWA operational model can adapt to an expanded sensor capability. In our poster we will present real-world examples of current algorithm performance using the existing GOES imager, describe the rapid prototyping facilities that are in use today, and overview cloud algorithm upgrades that are potentially supported by the ABI.

14) Lessons Learned from NASA's ECS Program

Jennifer Wallace
Raytheon

In the early 1990s, NASA launched an ambitious effort to build and operate a series of earth observing satellites through its Mission To Planet Earth. As part of that effort, NASA built the Earth Observing System Data and Information System (EOSDIS) Core System (ECS), which provides the Command, Control, and Communications (C3) components and the Science Data Processing Segment (SDPS) for the Terra, Aqua, Aura, and Landsat-7 satellites. ECS has been operational since 1999 and processes, archives, and distributes data for the largest repository of on-line civil earth observations in the world. This paper discusses lessons learned in the development and operation of ECS, and how they may apply to the development and operation of the GOES-R system, the next-generation Geostationary Operational Environmental Satellite system.

15) Improvements on Volcanic Plume Detections by GOES-R vs. Current GOES and MODIS Data Products

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The Hyperspectral Environment Suite (HES) and Advanced Baseline Imager (ABI) on GOES-R allow for the most accurate observation and quantification of aerosol optical properties. Aerosols can affect climate by scattering or reflecting solar radiation, and by altering cloud microphysics, cloud brightness, and precipitation. The high spatial (.5 km) and temporal (30 minutes, Full Disk) resolution of the ABI allows for up to date cloud masking capabilities and the accurate location of multiple clear atmospheric windows. The high spectral (TBD) and radiometric resolution functionality of the HES enables algorithms to acquire valuable aerosol information. Such products as aerosol optical thickness (AOT), particle size, and relative humidity (RH) can be calculated over oceans and ideal continental regions in near real time due to the co-location of the ABI and HES. The Moderate Resolution Imaging Spectroradiomter (MODIS) and Atmospheric Infrared Sounder (AIRS) instruments relate well to the ABI and HES, respectively, and are used in this study to display a synergistic relationship between sensors to develop aerosol products.

16) Regional and Global NWP Data Denial Experiments

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While the impact of data from GOES-R in numerical weather prediction models is difficult to quantify at this point in time, it is reasonable to assume that the impact will be at least as large as that seen from current instruments in geostationary orbit. In fact, the improved spectral, temporal and spatial resolutions of the data should ideally lead to even greater model forecast impacts. Currently, the impact of *in situ* and remotely sensed observations is being studied quantitatively at CIMSS via model data denial experiments, using both regional and global models supplied by NCEP. The regional work has been ongoing for several years, using NCEP's Eta Data Assimilation/Forecast System (EDAS). Recently, global studies have been initiated that use the Global Forecast System (GFS).

In the most recent regional work, the impact of *in situ* rawinsonde data and remotely sensed geostationary and polar orbiting satellite data routinely used in the EDAS was studied for extended length time periods during four seasons. The case studies chosen consisted of 15-day periods during Fall 2001, Winter 2001/2002, Spring 2002 and Summer 2002. The model runs included a control run, which utilized all data types routinely used in the EDAS, and three experimental runs in which either all rawinsonde, GOES or POES data was denied. Differences between the experimental and control runs were then accumulated over the 15-day periods and analyzed to demonstrate the 24 and 48-hr forecast impact of these data types in the EDAS. The diagnostics were computed over both the entire horizontal model domain, and within a subsection covering the continental United States and adjacent coastal waters (extended CONUS).

The 24-hr domainwide results showed that a positive forecast impact was achieved from all three data sources during all four seasonal time periods. Cumulatively, the rawinsonde data had the largest positive impact over both the entire model domain and extended CONUS. However, GOES data had the largest contribution for several fields, especially moisture during summer and fall. In general, GOES data also provided larger forecast impacts than POES data, especially for the wind components and moisture.

In terms of global modeling studies, Observing System Experiments (OSE) with NCEP's Global Forecast System (GFS) are currently being conducted to evaluate the impact of various operational observing systems on NCEP's global forecasts. Both winter and summer 6-week periods are being evaluated, with the last 4 weeks being used to generate forecast impact statistics. In this work, the NCEP Global Data Assimilation System (GDAS) is being run at the full operational resolution of T254 (55 km) and 64 levels vertically. Currently, all Advanced Microwave Sounder Unit (AMSU) and High-resolution Infrared Radiation Sounder (HIRS) observing system data are being evaluated by denying each system separately in the GDAS. Both systems for these data consist of instrumentation on NOAA-15, -16 and -17. In addition, denial experiments for each AMSU instrument are planned. The impact statistics computed include the percent change in root mean square (rms) for sea level pressure, and mandatory level (100-1000 hPa) relative humidity, temperature, and zonal wind. In addition, geopotential height anomaly correlation at 500 and 1000 hPa for both the Northern and Southern Hemispheres is being evaluated, and tropical rms vector errors at both 200 and 850 hPa will be calculated. Results indicate that the largest forecast difference between the control experiment and the denied experiment is obtained when denying AMSU data, and the differences observed to this point are significantly larger than those seen in the HIRS denials. The AMSU impact is as large as a 40% improvement in state fields on mandatory pressure levels, and an anomaly correlation improvement of 0.1 for 500-hPa heights at forecasts longer than 8 days.

17) An Objective Nowcasting Tool that Optimizes the Impact of Geostationary Satellite Observations in Short-Range Forecasts

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Future geostationary hyperspectral instruments, such as the HES planned for GOES-R, will have the sensitivity necessary to resolve atmospheric features above and beyond the capabilities of today's geostationary sounders. Although HES data will most likely generate improvements in numerical forecast guidance out to 48 hours and beyond, a greater benefit may come from the use of HES data in real time objective nowcasting systems designed to assist forecasters with identifying rapidly developing, small-scale extreme weather events. Such a system will need to detect and retain extreme variations in the atmosphere, incorporate large volumes of high-resolution asynoptic data from satellites and other high-resolution systems, and be computationally very efficient. Accomplishing this may require numerical approaches and techniques that are notably different from those used in numerical weather prediction where the forecast objectives cover longer time periods. The nowcasting systems will need to place an emphasis on the accuracy of individual observations and retaining the large gradients seen in these data through time, and thereby serve as a means of frequently updating more traditional numerical prediction models.

The basis for a new approach to objective nowcasting is presented that uses LaGrangian techniques to optimize the impact and retention of information provided by multiple observing systems. The system is designed to detect extreme variations in atmospheric parameters and preserve vertical and horizontal gradients observed in the various data fields – with the goals of identifying details of the environments associated with the onset of significant weather events several hours in advance. Analytical tests of such an approach have been performed to determine the ability of the method to retain gradients and extremes in meteorological fields. These tests show that the technique is computationally efficient, is able to retain sharp gradients and observed maxima and minima, and has the capability of providing timely updates to forecast guidance provided by operational forecast models. Initial real data tests are currently being conducted with a proof-of-concept prototype are being tested at the Cooperative Institute for Meteorological Satellite Studies (CIMSS), University of Wisconsin using full resolution (10 km) derived layer moisture products from the GOES-10/12 sounders. Initial tests have focused on the use of multi-layer GOES moisture data. Results of these tests will be shown which focus on the ability of the proposed system to capture and retain details important to the development of convective instability 3–6 hours into the future, even after IR observations in the areas of severe weather may no longer be available due to cloud development.

18) Realistic Performance Expectations for the Natural Color Rendering Capabilities of GOES-R

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Operational applications involving satellite imagery interpretation benefit greatly from the ability to present information from a complex scene in a reference frame inherently familiar to the human analyst—natural (or "true") color. A prime example of this benefit was demonstrated recently during Operation Iraqi Freedom, when natural color high resolution imagery products created in near real-time from the Moderate Resolution Imaging Spectroradiometers (MODIS) aboard the National Aeronautics and Space Administration (NASA) Earth Observing System (EOS) Terra and Aqua satellites over southwest Asia were in such high demand that the Commander, Naval Meteorology and Oceanography Command (CNMOC) funded the installation of X-band receiving stations at Navy Regional Centers in Bahrain (Arabian Gulf) and Rota (Spain) to support operational requirements for real-time imagery. The 250 m spatial resolution natural color imagery brought a paradigm shift to feature interpretation capability and, by extension, the operational utility of these data to the warfighter. Navy Aerographer's Mates (AG) used the information to track weather across the southwest Asia theater of operations for the purposes of tactical decision making, including strike/reconnaissance mission planning, ship and aircraft routing, and weapons/sensor selection.

The wealth of additional information provided by natural color as compared to standard 8-bit grayscale imagery (where only a small fraction of these shades are optically differentiable by the human eye) or false color composites (where additional training is often required) bolsters the interpretive ability of even the most trained satellite imagery analysts. The omission of the 0.555-micrometer (green) band upon the GOES-R series limits the ability to produce geostationary versions of the same high quality natural color depictions as those demonstrated currently upon low-earth-orbiting platform radiometers (including MODIS, Sea View Wide field-of–view Sensor (SeaWiFS), Ocean Color Mapper (OCM), Feng Yun 1D, and the Medium Resolution Imaging Spectrometer (MERIS, aboard Envisat)) and what will be available during a timeframe contemporary to GOES-R upon the National Polar Orbiting Environmental Satellite System (NPOESS) constellation.

Any attempts to reproduce natural color from GOES-R must therefore resort to numerical approximations for synthesizing the missing green channel. The complex spectral behavior of earth scenes in the visible band precludes simple linear techniques for the approximation of 0.555 micrometer by available nearby narrowband red, blue, and near infrared channels. So, instead statistical look-up-tables (LUT) representative of the full dynamic range of observations for a given region over time are required. Using MODIS as a model for GOES-R, this paper demonstrates various approximation techniques (including the application of general LUTs, zone-dependent LUTs, and simple channel averages) and quantifies the performance/limitations of each with respect to unapproximated natural color results. The pre-computed LUTs have been applied to independent datasets as a realistic determination of expected synthetic natural color product performance. Preliminary findings indicate the most significant departures occur for shallow and/or suspended-particle-laden waters found most commonly in littoral zones, islands, and atolls—areas where the GOES-R Hyperspectral Environmental Suite's (HES) Coastal Imager will provide a compensatory role in regions scanned by the HES-CW.

19) The Case for the Green Band on ABI

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The most widely used and most efficient processor of sensor information in the world utilizes an array of detectors that are sensitive to radiation from the visible portion of the spectrum. While the processor in question is capable of functioning without some or all of this radiance information, extra cost and effort is required to make up for the loss. There are currently over 6 billion of these processors in existence, and new ones are coming online every day.

While often referred to as merely a "qualitative" product, natural color imagery from the Moderate Resolution Imaging Spectroradiometer (MODIS) has proven to be highly desired by scientists, the military, commercial enterprises, and the general public alike. While no requirements from a select pool of users specified a 0.55 μm ("green") band on the Advanced Baseline Imager (ABI), the omission of that band, and subsequent loss of natural color (also known as true color or "red, green, and blue") imagery capability, will incur extra cost and effort to generate the pseudo-color imagery that will function as a replacement. Look-up tables (LUT) have the greatest capability thus far to represent green utilizing information from the red, blue, and 0.86 μm (near infrared) bands that are planned for ABI. The LUTs fail under certain circumstances to produce acceptable results and by necessity result in a loss of data resolution. LUTs also incur costs related to their generation and application, costs that will be shouldered by every agency and commercial entity that desires an approximation of natural color imagery. Whereas natural color images are readily interpreted by everyone from a 5-year-old child to the President of the United States, pseudo-color images will require training in order to demarcate the limitations of the images to users who must make decisions based on what they see. From a quantitative, derived product standpoint, some algorithms that could benefit from a green band have been overlooked, particularly with respect to aerosol optical depth. Examples of ABI images made from LUTs and of quantitative products made using the green band will be simulated from MODIS.

The ultimate end user for any publicly funded satellite program is the public. Discounting the positive impact that high-resolution natural color imagery could have upon the perception of the utility of the GOES series should not be dismissed out of hand. Natural color imagery is the primary and most effective method of outreach for earth and space science, and that imagery has always proven to be the most effective in that regard as it is in the form that our minds were built to understand. What is called "good enough" today will be seen as flawed when tens of thousands of users, accustomed to MODIS and similar platforms, begin to discover the inadequacies of pseudo-color imagery.

20) The Future of Infrared Geostationary Ozone Detection: HES and ABI

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The GOES I-M series of satellites are endowed with an ozone sensitive band located at 9.6 μm. Estimates of hourly, 10 km resolution total column ozone are possible utilizing the ozone band and the other Sounder bands at 4 μm and longer wavelengths via a linear regression technique. GOES I-M ozone estimates have allowed for the detection of features that reflect both synoptic and mesoscale dynamics. Current GOES Sounder estimates lack the temporal and spatial resolution to routinely detect mesoscale airmass exchange events, such as those that cause clear air turbulence, though case studies have shown that it is possible to do so on occasion.

While the Imager on GOES I-M does not have the ability to assist the Sounder in ozone detection, GOES satellites carrying the Hyperspectral Environmental Suite (HES) and the Advanced Baseline Imager (ABI) will have two instruments capable of generating ozone values, both separately and in concert with one another. ABI, while achieving less accuracy than the current GOES Sounder, has a high refresh rate with Continental United States (CONUS) scans every 5 minutes and full disk scans every 15 minutes at a resolution of 2 km. HES is capable of achieving much higher accuracies (relative to current GOES and ABI) at 4 km resolution, yet at a lower refresh rate. HES and ABI could be used synergistically to achieve high accuracy and high temporal and spatial resolution ozone retrievals that will allow rapid and accurate detection of ozone features that could lead to identification of events such as clear air turbulence.

Simulations of HES, ABI, and GOES ozone regression techniques have been compared and illustrate the advantages of the GOES-R platform over current GOES.

21) Applications of the Advanced Baseline Imager for Fire Detection and Characterization

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The current GOES Wildfire Automated Biomass Burning Algorithm (WF_ABBA) has provided diurnal information on wildfires, prescribed burns, and agricultural fires for the Western Hemisphere since the year 2000 for hazard support activities and for documenting and evaluating the impact of biomass burning on the environment. The international environmental monitoring and scientific research communities have stressed the importance of utilizing operational satellites to produce routine fire products and to ensure long-term stable records of fire activity for applications such as land-use/land-cover change analyses and global climate change research. The Advanced Baseline Imager on GOES-R and beyond will enable continued analysis of fire activity throughout the Western Hemisphere with significant improvements in fire detection and sub-pixel fire characterization. Full disk coverage every 15 minutes and CONUS every 5 minutes will ensure that even short-lived burning can be monitored. With the improved spatial resolution on ABI in the infrared bands (2 km), the minimum detectable fire size burning at an average temperature of 750 K will be approximately .04 ha with the size increasing to .08 ha at 50 °N. The elevated saturation temperature of 400 K in the 3.9-micron band limits the number of saturated fire pixels to less than 10% of all observed fires. Simulations of enhanced GOES ABI fire monitoring capabilities will be demonstrated using MODerate-resolution Imaging Spectroradiometer (MODIS) observations of fires in the Western U.S.

22) Transition from NPOESS-CrIMSS toward GOES-HES: Algorithm Overview and Initial Results

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The Hyperspectral Environmental Sensor (HES), scheduled for flight on GOES-R, will dramatically enhance atmospheric, surface and cloud characterization capabilities from the geostationary platform. The proposed channel set and spectral resolution for HES are similar to both AIRS, which is presently on the EOS-Aqua platform, and the Cross-track Infrared Microwave Sounder Suite (CrIMSS), which will fly on the NPP and NPOESS platforms. We have developed an algorithm to generate temperature and moisture soundings operationally from microwave and infrared sounders using a physical retrieval method. This algorithm, based upon well-known minimization methods but optimized for the new generation of high spectral resolution instruments, is the basis for the CrIMSS temperature and moisture profile retrieval algorithm. The algorithm is extremely flexible and is designed to allow for the retrieval of surface properties and/or trace gas profiles in addition to temperature and moisture profiles. For test and verification it has been applied to simulated CrIMSS data, along with actual NAST-I, AIRS and AMSU measurements. For example, as an on-going, daily algorithm validation effort at AER, global retrievals of NOAA-16 AMSU data are compared with co-located radiosonde measurements. The key to the flexibility of the retrieval algorithm is in the forward radiative transfer model, the Optimal Spectral Sampling (OSS) method. This is a state-of-the-art, fast radiative transfer model that allows for tuning of model accuracy to meet user run-time requirements. Specific features incorporated into OSS eliminate the need for re-training the model when performing phenomenology studies, such as retrieval of trace gases, or to vary the instrument spectral characteristics. This feature also allows for a straightforward transition of the algorithms from current sounder configurations to HES and provides a mechanism for the inter-comparison of sensor data using a common retrieval algorithm. In this poster we will present an overview of the NPOESS-CrIMSS algorithms, describe the OSS method and discuss specifics about the implementation that maximize flexibility for transition to future sensors. Retrievals using AIRS measurements and simulated GOES-HES measurements will also be presented.

23) EOS Data in NWS Forecast Offices: A Test Bed for GOES-R Applications

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Imagery and derived products from MODIS, on NASA's Terra and Aqua satellites, are being used operationally by several NWS Forecast Offices to assist in the preparation of short-term forecasts. A subset of MODIS channels with spectral characteristics similar to those planned for the GOES-R ABI are obtained in real-time by the NASA/MSFC, as part of the Short-term Prediction Research Transition (SPoRT) program. The data are reformatted, sectorized, and disseminated to Forecast Offices for operational use directly in AWIPS. Several images generated from more than one channel, such as true and false color composite imagery and an 11-3.9 micrometer “fog” image, are produced from the real-time data stream. Additionally, a number of products, such as lifted index, land surface temperature and cloud phase, generated either from EOS institutional or NASA/MSFC in-house algorithms, are made available to the offices in near real-time. This transition activity, from research to operations, serves to prepare forecasters for the next generation of satellite observing capabilities through real-time, hands-on applications to their forecast problems. The SPoRT program provides training on the new data and products and their applications. Forecasters provide immediate feedback on product improvement and an assessment of the value of the new data or product. The poster will present examples of this transition and preliminary assessments on the utility of the EOS products for improving short-term forecasts.

24) The Advanced Satellite Aviation-Weather Products Initiative for Diagnosing and Nowcasting Weather Hazards for Improved Aviation Safety

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A new NASA effort, the Advanced Satellite Aviation Weather Products (ASAP) initiation, has been developed to provide satellite derived meteorological products and expertise to the Federal Aviation Administration (FAA) weather research community. University of Wisconsin-Madison SSEC/CIMSS has been tasked to provide satellite information to the NCAR-based Aviation Weather Research Program's (AWRP) 11 Product Development Teams (PDT).

Satellite derived products that ASAP will develop and provide to the AWRP PDTs will be value-added information for forecasting/nowcasting aviation hazards such as those caused by low ceiling/visibility, convection, turbulence, icing, volcanic ash, and wind shear. Much of the satellite data provided to NCAR will be infused into each PDT's unique system for diagnosing a particular hazard. For ASAP in 2004 and beyond, UW will collaborate with the University of Alabama in Huntsville and NASA's Marshall Space Flight Center. This collaboration will bolster UW's ASAP activities by offering expertise in data mining, pattern recognition, as well as through introduction of other remote sensing data sets (e.g., lightning). Phase 2 of ASAP activities will include incorporation of hyperspectral satellite data (AIRS, CrIS, and HES) products into the FAA PDT's aviation hazard algorithms. This poster will present an overview of current ASAP research and products.

25) Improvement in Groundbased Infrared Hyperspectral Retrieval of Thermodynamic Profiles

Wayne F. Feltz[1], Hugh B. Howell[1], David D. Turner[2], Ralph G. Dedecker[1],
Harold M. Woolf[1], Robert O. Knuteson[1], Hank Revercomb[1], and Kris Bedka[1]
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The United States Department of Energy's Atmospheric Radiation Measurement (ARM) program has funded the successful development of the Atmospheric Emitted Radiance Interferometer (AERI) instrument during the past decade. This has led to a hardened, autonomous system that measures downwelling infrared (IR) radiance at high-spectral resolution. Seven Hyperspectral AERI systems have been deployed around the world as part of the ARM program. The initial goal of these instruments was to characterize the clear-sky IR emission from the atmosphere for thermodynamic profiling, thus a temporal sampling was chosen (8-10 min per spectrum) to minimize random noise in the AERI observations. Recent research emphasis has been placed on the improvement of vertical resolution and temporal sampling on AERI derived atmospheric boundary layer thermodynamic profiles and cloud property retrievals.

Results indicate that the AERI derived temperature profiles more accurately represent strong surface based temperature inversions common through nocturnal radiative cooling with a higher vertical resolution line-by-line fast model. AERI retrieval results from the International H_20 Program (IHOP) demonstrate that improved vertical resolution of temperature within the lowest 1 kilometer of atmosphere has been achieved implementation of a new more accurate and higher vertical resolution fast model. The University of Wisconsin-Madison deployed an AERI instrument in its mobile AERIBago in 40-second rapid-scan mode during the CRYSTAL-FACE experiment in southern Florida. Temperature and moisture retrievals from the rapid-scan data also demonstrate fluctuations in the boundary layer thermodynamic profile that are lost due to averaging with the nominal sampling strategy. This poster will present AERI thermodynamic retrieval progress with applications directly linked to future GOES-R HES derived meteorological products.

26) The Development of Hyperspectral Sounder Simulator and Processor (HSSP) for HES

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In preparation for GOES-R Hyperspectral Environmental Suite (HES) operation, and to conduct its risk reduction activities, CIMSS is developing models, algorithms, software and knowledge bases to ensure optimal use of GIFTS and AIRS measurements. Through these efforts CIMSS is characterizing an end-to-end system demonstration that will enable an early assessment of the operational benefit and optimal utilization of geostationary hyperspectral sounding measurements.

This poster paper reviews the comprehensive simulation and processing chain from NWP modeling of the atmosphere, through the simulation of top-of-atmosphere radiances, to the retrievals from those radiances of atmospheric soundings, winds, clouds, and earth surface properties. The Hyperspectral Sounder Simulator and Processor (HSSP) under development at CIMSS will permit the simulation of HES measurements for physically consistent four-dimensional (4-D) atmosphere-earth-system states. HSSP will deliver simulations simultaneously in extended coverage area with spectral, spatial and temporal resolutions improved compared to current simulation capability. A significant outcome is the opportunity that HSSP will afford engineers and scientists to fully assess HES potential early in the development cycle.

27) Quantization Noise for GOES-R ABI Bands

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Certain specifications are set for the GOES-R Advanced Baseline Imager (ABI). Two of those specifications are allowable instrument noise and the instrument maximum scene temperature for each band. As a result of those specs, other characteristics of the ABI data stream (GOES Re-Broadcast or GRB) can be determined. One of those characteristics is the bit-depth or number of bits used to represent the radiances measured by the ABI. This, in turn, determines the quantization of the measured radiances and the quantization “step” or the minimum change that can be described in the digitized scale. The desire is that this quantization step per count be much less than the actual radiance noise in order to not put an artificial limit on the radiance noise of the ABI. Calculations are made, and results will be presented on the minimum number of bits needed to capture the desired range of temperatures as well as exceed the noise spec for each ABI band. Of course, it may turn out that the maximum number of bits needed for any band will be used for all bands. For example, the current GOES instruments have 10-bit for the Imager and 13-bit for the Sounder.

Among the ABI bands, the 3.9 µm band is of primary interest because of its greater sensitivity to warm temperatures and the desire to capture very hot scene temperatures for detection and characterization of hot spots (e.g., forest and range fires). Thus, this shortwave infrared (IR) band has a specified instrument maximum scene temperature of 400 K, much greater than the specified temperatures for the other ABI bands. Due to the finer field-of-view size of the ABI (compared to the current GOES imager), this hotter saturation temperature is needed. However, of the IR bands, this band suffers the most from increasing noise (in temperature units) at low scene temperatures, as a result of the basic physics of the Plank equation for shorter wavelengths. Of course, this same shortwave band is also used for cloud characterization on the cold temperature end. Temperature noise in this band is much greater at low temperatures than that for the other ABI bands and can be an undesirable feature of the increased instrument maximum scene temperature. In particular, this band seems to require a 15-bit scale to meet ABI specifications, but that would still result in a quantization noise per count step of 2.1 K @200 K. Thus, it appears that a higher-resolution scale, or a 16-bit scale in this case, is more desirable, resulting in a quantization noise per count step of 1 K @200 K.

28) Calibration of the Reflective Channels of the ABI with a Full-disk Ratioing Radiometer

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The Advanced Baseline Imager (ABI) will fly on the GOES-R series of geosynchronous weather satellites. These satellites will be three-axis stabilized to maintain a constant orientation with respect to the Earth. Each ABI will scan the Earth's surface, requiring approximately 5 minutes to make a full-disk image that covers most of one hemisphere in six solar reflective channels and ten thermal infrared (TIR) channels. The ABI will be required to have an onboard apparatus to perform full-aperture, end-to-end calibration on all of its channels. The TIR channels will be calibrated by viewing a full-aperture blackbody.

The reflective channels, ranging in wavelength from 470 nm to 2.26 µm, may be calibrated by viewing sunlight that is attenuated to the level of the full Earth albedo, either by diffuse reflection from a Lambertian radiator or by transmission through a perforated screen. We propose an alternative technique in which the ratio between the solar irradiance and the full-disk irradiance is measured by a small ratioing radiometer with spectral channels matched to those of the ABI. This value of the full-disk irradiance is then compared to the value derived from a full-disk image made simultaneously by the ABI. This technique works best from geostationary orbit, where the viewing geometry remains constant throughout the ABI's full-disk scan and where the full disk subtends a relatively small solid angle, in comparison to low-Earth orbit.

A small integrating sphere with two pinhole apertures can be placed on the nadir-facing surface of a GOES satellite and equipped with baffles and with spectral channels that are matched to the reflective channels of the ABI. One pinhole can be equipped with a baffle that restricts its field-of-view (FOV) to a circle approximately 18^o in diameter, centered at nadir, allowing it to view the Earth's full disk continuously throughout its daily cycle. The second, smaller pinhole can be equipped with a baffle that restricts its FOV to about 1^o in the East-West direction and +/-25^o in the North/South direction. In this configuration, the full direct solar irradiance, integrated over the smaller pinhole, will be added to the Earth's irradiance during an interval of about 2 minutes once each night. If the cross-section of the pinhole that views the Sun is approximately 100 times smaller that that of the Earth-viewing pinhole, then the solar flux in the sphere during this brief solar-viewing interval will approximate the flux due to the full-disk at noontime.

Detectors in the integrating sphere with spectral channels matched to those of the ABI can measure the ratio of the full-disk irradiance to the direct solar irradiance, independent of the detector's gain, the filter's transmittance, and the sphere's reflectivity. Intervals when direct solar or lunar irradiance enters the Earth-viewing pinhole aperture can be disregarded, and the irradiance of other planets and stars is negligible. ABI channels 1, 2, and 3 operate at wavelengths of 470 nm, 640 nm, and 860 nm. The corresponding channels in the full-disk radiometer can use silicon detectors and can operate at ambient temperature, or slightly below it. ABI channels 4, 5, and 6 operate at wavelengths of 1.38 µm, 1.61 µm, and 2.26 µm. The detectors for the corresponding channels in the full-disk radiometer will require some cooling.

In addition to calibrating the ABI, this full-disk radiometer on a GOES-R satellite can make stable, long-term measurements of the daily and seasonal variations in the albedo. The ongoing series of GOES-R satellites enables cross-calibration between GOES East and GOES West and transfer from decommissioned satellites to new satellites, valuable capabilities for climatic studies. This proposed instrument can be small and light, has no moving parts, can be hard-mounted to the nadir-viewing face of the spacecraft, requires minimal electrical power, and has a low data rate. It can operate without interrupting the ABI's data taking operations and without inserting any obstructions into the ABI's field of regard.

29) Environmental product VErification and REmote SEnsing Testbed utility for HES

Jay Marmo and Jerome Luine
Northrop Grumman Space Technology, Redondo Beach, California

Northrop Grumman Space Technology's Environmental product VErification and REmote Sensing Testbed (EVEREST) is a tool that has been developed by NGST at its Environmental Sensing Center in Redondo Beach, CA. EVEREST produces simulated sensor data sets derived from detailed sensor performance models, platform characteristics and simulated earth surface and atmospheric scenes. This high fidelity modeling and simulation testbed is currently supporting the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Program. Current capabilities and planned upgrades can aide HES users developing applications and data products to meet NOAA's strategic goals. Users may also benefit from the EVEREST's simulation capability to evaluate the impact of sensor performance characteristics or post-processing techniques on potential applications and algorithms. In this poster we will describe the EVEREST's current and future capabilities and its potential utility to HES users.

30) Advanced Spacecraft Stellar Inertial Attitude Control Technology to Enhance the Quality of NOAA's GOES Weather Data

Loren Slafer
Boeing Satellite Systems

In January 1998, Boeing Satellite Systems (BSS) of El Segundo, CA, began development of a unique spacecraft bus design concept for the next-generation Geostationary Operational Environmental Satellites, GOES-N, GOES-O, and GOES-P. The goal of this new design was to substantially improve the quality of NOAA's GOES weather data. The key features of this design concept included a stellar inertial attitude determination (SIAD) control system which is integrated directly with the imager and sounder on a precision optical bench to have the bus design focus on 'flying the instruments' for the next-generations of GOES.

This new GOES N-P design enables the precision spacecraft performance that will be required for the GOES-R high-resolution instruments. The goal of the GOES program's design features was to improve the spacecraft performance using SIAD to:

- Enhanced instrument accommodation
- Significantly improved image navigation and registration (INR) performance
- Provide extensive on-board autonomy for reduced ground interaction
- Provide ability for the instruments to perform service quickly after orbit control operations (after a 10 minute housekeeping period)
- Maintain continuous environmental and storm warning systems with an enhanced ground resolution (1.5 km ground resolution at nadir) and to monitor the Earth's surface and space environmental conditions.

The BSS developed SIAD system uses star measurements provided by star trackers (3-for-2 redundancies), spacecraft rates measured by Hemispheric Inertia Reference Unit (HIRU), and a 6-states Kalman filter implemented in the spacecraft control processor to determine spacecraft 3-axis attitude. It has the advantage of two orders of magnitude improvement in accuracy over existing earth/sun sensor-based attitude determination systems.

To meet this never-before achieved 10 microradian bus pointing for GOES N-P, BSS created many innovative solutions including: a method to account for the star tracker's non-Gaussian, non-white spatial dependent errors in the Kalman filter design to optimize SIAD performance, a 45-degree star tracker boresight orientation to attenuate star tracker high spatial frequency error, a time-matching technique to minimize attitude error between star tracker based attitude and gyro based attitude introduced during spacecraft slews, use of an equalized star catalog to minimize on-board catalog size while enhancing SIAD performance, and a Kalman filter implementation with weighted measurement noise covariance matrices.

The Imager and Sounder are collocated with the stellar inertial attitude sensors on a common base plate supported by structural flexures and attached to the nadir panel. Reaction wheels are mounted to the aft corners of the spacecraft main body. The single panel solar array provides a clear field of view (FOV) for the Imager and Sounder coolers, maximizing their radiometric performance.

The benefits of the precision SIAD control system design for the improved GOES weather data was discussed by the Boeing team with Joe Friday, Director, U.S. National Weather Service, 1988–1997. His ideas for improved weather data was that the improvements in the data quality over the present system will continue to allow the National Weather Service to improve its ability to protect the life and property of the nation's citizens. The main benefits of improved spacecraft performance for improved data quality described by Joe Friday include improvements in the ability to detect and locate weather events including flash flood situations, typhoon tracking, valley fog, and hazards to aviation. The present capabilities are not sufficient to distinguish between adjacent valleys in rough terrain, or meet the FAA goals for aircraft safety. The additional objectives of enhanced spacecraft performance include improving weather and flood forecasts. NWS goals for flash floods anticipate improvement with GOES N-P to 60 minutes lead-time with false alarm rates improved. NWS goals for severe storms anticipate improvement with GOES N-P to 20–25 minutes lead-time. False alarm rates will improve. There will be improved air traffic control, separating aircraft from weather thunderstorms and rain cells.

31) Thetus Publisher, Data Management Software for Satellite and other Scientific/Research Data

Danielle Forsyth
Thetus Corporation

Current data management systems and practices have not kept pace with data production. Data is isolated in silos with incomplete metadata. When metadata has been captured, it has not been made available for users to search. Metadata has not continued to evolve as data processing continues. Automated notification has not been done to notify researchers and data users when specific data is available. There has been no scientifically defensible record of data processing throughout the data lifecycle.

Thetus developed a new data management solution tuned for scientific and research data management to address these problems. One of the company's early customers was the College of Oceanic & Atmospheric Science (COAS) at Oregon State University. They needed to bring order to their NASA MODIS satellite direct broadcast data streams and make subsets of the data available to internal and external researchers and the public. They needed a system that would support the on-going discovery inherent to satellite data and they needed to be able to track this data as it was fused with other data sets.

Thetus automated the data processing workflow (automatically generating products), tracked the metadata throughout the data lifecycle and provided researchers and Web users with a seamless way to search, retrieve and understand satellite data and its relationship to other remotely sensed data.

The Thetus Publisher is a solution for proactive ontology-based classification of data and a rich metadata search and retrieval. Ontologies provide a structure for understanding and relating metadata from varied sources. COAS used Thetus to build a MODIS Satellite data ontology. This ontology can be readily shared with other Satellite data collection organizations who want to start with a geospatial semantic description. By sharing ontologies between organizations and using them to keep metadata and process information at the sites where it can best be maintained, the Publisher provides an extensible framework for data management, searching and notification, data routing and storage management.

Using the RDF standard and providing the web service interfaces also means that the ontology and data classification descriptors can be made available to other data processing sites and, if the sites agree on an ontology, all sites can reference classification elements between systems. A major advantage to the RDF/OWL versus a rigid schema approach is that the assertions and annotations associated with any data or dataset can continually evolve as advances are made in scientific analysis methods or additional information about the dataset is discovered. This approach enables greater collaboration between the diverse communities using satellite and other geospatial data streams, including communities outside the research community.

The poster will describe and demonstrate satellite (MODIS and AVHRR) and coastal radar data and metadata processing, automated retrieval of up-to-date processing algorithms and cross-site data search. The advantages of automated processing and metadata management will be shown through the search interface, data provenance reporting, automated user notification and selective data re-processing. Migration of data and metadata to new generations of satellite data collection systems (i.e., GOES-R) will be presented.

32) Utilization of GOES-R Measurements at NESDIS for the Real-Time Analysis and Monitoring of Environmental Events

John Paquette and Brian Hughes
NOAA/National Environmental Satellite, Data, and Information Service

The Satellite Services Division (SSD) intends to improve its suite of hazards products through the application of GOES-R data and products. The spectral channels that are currently only available from NOAA's Polar-orbiting Operational Environmental Satellites (POES), along with other essential channels to sense more of the earth's environment, will be available from the GOES-R Advanced Baseline Imager (ABI).

Due to its high spatial and temporal resolutions, the use of the GOES ABI and Hyperspectral Environmental Suite (HES) data and products at the SSD is paramount to support near real-time analyses of significant global hazard events including tropical cyclones, heavy precipitation, volcanic ash, and fires and smoke. SSD's analysis of snow and ice will also benefit from the use of the ABI. In the next series of GOES, starting with GOES-R, SSD plans to fully exploit the increased number of spectral channels (16) and the improved temporal resolution (full disk scan every 5 minutes) and spatial resolution of the ABI (.5 km for visible channel and 2 km for infrared channels). In accordance with NOAA's strategic goals of serving society's needs for weather and water information and supporting the nation's commerce with information for safe and efficient transportation, it is SSD's fundamental goal to improve its products for the National Weather Service's advanced warning and forecast services and other federal and state agencies. As aforementioned, derived products from the HES (GOES-R Sounder) will also be utilized by SSD to complement the analyses of environmental events, particularly volcanic ash detection and heavy precipitation.

33) Current GOES Data Capability Within the CLASS System and New GOES Capabilities in Development or Planning Stages.

Richard G. Reynolds[1] and Carlos Martinez[2]
[1]Chief, Ground Systems Division, Office of Systems Development, NESDIS
[2]TMC Technologies, Inc.

NOAA has developed the Comprehensive Large Array-data Stewardship System (CLASS) to archive and provide access to the data from current satellite-based observing systems [e.g., Polar-orbiting Operational Environmental Satellites (POES) and Geostationary Operational Environmental Satellites (GOES)] and ground-based observing systems [e.g., Next Generation Weather Radar (NEXRAD)]. CLASS is also being designed to handle the significant increases in data volume that will come from planned satellite launches [e.g., National Polar-orbiting Operational Environmental Satellite System (NPOESS), NPOESS Preparatory Project (NPP), and Earth Observing System (EOS) satellites]. Finally, CLASS will ultimately be capable of supporting current *in situ* data sources [e.g., Automated Surface Observing System (ASOS)].

Current GOES data is now available through CLASS and has been since December 1, 2003. The data can be searched in a variety of ways, including by data type, satellite, date and time range, and spatial coverage. GOES data can be delivered in several different formats, including McIDAS area format, NetCDF, GIF, JPEG, and raw GVAR. Plans are being formulated to backfill some or all of the more than 200 terabytes of historical GOES data to make it available to researchers, scientists, and the general public.

GOES operational capabilities:

- GOES data archive and access capability became operational on December 1, 2003
- Available data formats are: McIDAS area format, NetCDF, GIF, JPEG, and raw GVAR.
- Spatial resolutions are: 1km, 4km, 8km, and 16km. (approx. at subsatellite point)
- Bands are: Imager bands 1-5/6, Sounder bands 1-19
- Search capabilities include:
  - Coverage (e.g., CONUS, Full disk, Northern or Southern Hemisphere)
  - Satellite schedule (e.g., routine, rapid scan, super rapid scan)
  - Data type (e.g., Block 11, imager, sounder)
  - Satellite (e.g., GOES-8, GOES-9, GOES-10, GOES-12)
  - Date and time range
  - Spatial coverage using a bounded box or entering lat/long coordinates

Current development activities:

- Dual site operations
  - Suitland, MD (OSDPD) and Asheville, NC (NCDC)
  - Planned to be operational March 15, 2004
- Planning for ingest of historical GOES data
- Statistical analysis of Imager data
- New Global Imaging GOES ingestors replacing data feed from University of Wisconsin
- Evaluating GOES products

Supports the following NOAA Strategic Goals:

- Understand climate variability and change in order to enhance society's ability to respond
- Serve society's needs for weather and water information
- Support the Nation's commerce with information for safe and efficient transportation

34) <u>A System Design for Storing, Archiving, and Retrieving Hyperspectral Data</u>.

Ralph G. Dedecker, Tom Whittaker, Ray K. Garcia, and Robert O. Knuteson
University of Wisconsin-Madison, Space Science and Engineering Center, Cooperative Institute for Meteorological Satellite Studies (CIMSS), University of Wisconsin-Madison, Madison, Wisconson

Hyperspectral data and products derived from instrumentation such as GOES-R HES, AIRS, CrIS, and GIFTS will impose storage and data retrieval requirements that far exceed the demands of earlier generation remote sensing instrumentation used for atmospheric science research. Efforts at the University of Wisconsin - Space Science and Engineering Center (UW-SSEC) are underway to develop a new architecture designed to address projected real time and research needs.

The large volume of data collected and products produced from hyperspectral instrumentation will require large distributed storage devices employing several servers. The hardware infrastructure must be implemented to allow component augmentation, replacement, and maintenance without undue demands to modify user applications. User applications will need tools to simplify locating data files. User data selection facilities for retrieving specific information from storage devices for calibration, analysis, instrument inter-comparison, or reference purposes will also be necessary due to the large data volume and standardized data formats and data delivery schemes will be important.

This poster will outline a prototyped infrastructure for data archiving and cataloging, data storage, metadata search and query, and retrieved data delivery schemes to be utilized for real time operations and by research users.

35) ISCCP Data at NCDC: A [Not So] New Climate Resource

Kenneth Knapp and John Bates
NCDC/NOAA, Asheville, North Carolina

The International Satellite Cloud Climatology Project data is archived at the National Climatic Data Center. The various ISCCP data levels—subsampled satellite data (e.g., B), cloud products (e.g., C1), and pixel-level cloud products (e.g., DX)—provide global observations every 3 hours from July 1983 to present. In particular, the B1 level data is a high-resolution dataset that has yet to be used for research. ISCCP B1 data is made up of Geostationary observations from JMA's GMS series, EUMETSAT's Meteosat series, and the NOAA GOES series of geostationary satellites. The fulldisk imagery—subsampled to ~10 km—includes visible and infrared observations, but also may include water vapor (e.g., from Meteosat), the full suite of channels from GOES-8 through 12, and most recently all 12 channels of Meteosat-8 (formerly, Meteosat Second Generation, MSG). Until recently, access to B1 data was limited by a lack of documentation and software support. However, recent efforts by NCDC now provide information on reading, navigating and calibrating the B1 data. This allows climatological research from the B1 data at high spatial and temporal resolutions.

36) Applications of ABI and HES on GOES-R for Monitoring of Ocean Temperature and Color

Richard Legeckis, Christopher W. Brown, Timothy Mavor, and Paul S. Chang
NOAA/NESDIS, Office of Research and Applications, Silver Spring, Maryland

The planned combination of the Advanced Baseline Imager (ABI) and the Hyperspectral Environmental Suite (HES) Coastal Water Imager on GOES-R will enable the hourly and daily estimation of co-located sea surface temperatures (SST) and ocean color (surface chlorophyll). This will allow monitoring of the variability of ocean fronts, surface currents, eddies, as well as coastal and equatorial upwelling. The co-location of the SST and color observations will provide the first multispectral view of the ocean surface from a geostationary platform. Efforts will be made to combine GOES-R data with observations from other geostationary satellites, such as the Meteosat Second Generation (MSG-4), as well as from polar satellites such as NPOESS. The blended polar and geostationary products will increase the cloud-free coverage of the Atlantic and the Pacific Oceans. This should improve our ability to monitor El Nino and La Niña cycles as well as ocean areas that tend to spawn hurricanes. Furthermore, to improve estimation of SST in persistently cloudy ocean areas, GOES-R products will be merged with all-weather microwave measurements that penetrate cloud cover and provide estimates of SST. To achieve this blended SST capability, the U.S. National Ocean Partnership Program (NOPP) is sponsoring the Global Ocean Data Assimilation Experiment (GODAE). Due to the increased complexity of products, it will be a challenge to provide an image product architecture which allows for flexible product generation to meet the needs of different users. A product system should provide a feedback loop so GOES-R products can be modified in near real time to meet evolving environmental or satellite instrument system conditions. In effect, the satellite product producers and the product users have to be part of an integrated, flexible system that is capable of responding to change. The poster provides examples of the present GOES and MSG SST products and SeaWiFS ocean color observations. Animations of large quantities of satellite images, displayed at different spatial and temporal scales, allow rapid evaluation and application of the present satellite observations of the oceans.

37) Preparing for GOES-R+ - Critical Role of a Vibrant Continuous Learning Program

Anthony Mostek[1], Mark DeMaria[2], and Jim Gurka[2]
[1]NOAA/NWS
[2]NOAA/NESDIS

As NOAA begins building the next generation of GOES, it may appear that there is plenty of time to get operational users prepared for the arrival of the new data and products. However, with the complex and evolving nature of NOAA's operational environmental monitoring and forecast programs, it is critical that a vibrant and continuous learning program is already in place. To get NOAA users ready, the poster will review the progress being made on the Satellite HydroMeteorology (SHyMet) course. The SHyMet course will begin in 2005 and will continue well into the GOES-R+ era. The SHyMet course will evolve to incorporate new advances in both polar and geostationary platforms. The SHyMet course is the final step in the development of a "Proving Ground" system for NOAA operations. The "Proving Ground" will ensure that any new products, techniques or algorithms are completely checked out and that there is comprehensive training in place.

38) Applications of the HES Coastal Water Imager

Christopher W. Brown[1], Michael Ondrusek[1], and Richard P. Stumpf[2]
[1]NOAA/NESDIS, Office of Research and Applications
[2]NOAA/NOS, National Centers for Coastal Ocean Science

The Coastal Water Imager (CWI) is a proposed component of the Hyperspectral Environmental Suite (HES) that would be flown on the Geostationary Operational Environmental Satellite R Series (GOES-R) to acquire multispectral to hyperspectral visible – near infrared images of the Earth's surface at high spatial (150–300 meters) and temporal (every 3 hours or better) resolution. Its data would fill an existing gap in the time-space domain of available observations obtained from existing space-borne sensors. In its survey mode, CWI will improve our ability to monitor the coastal ocean (out to the Exclusive Economic Zone) of the U.S. East Coast from Texas to Maine by providing observations of this region at least three times a day. Cloud filtering, through compositing of these multiple images, will also increase the amount of surface area exposed on a daily basis. In its localized mode, the repeated collection of CWI data from a selectable region (ca. 400 km x 400 km) at high frequencies will permit short-term processes and events of the ocean, land, and atmosphere to be detected, monitored, and quantified. These observations will enable the investigation of the dynamic coastal ocean and the study and tracking of ephemeral events in the terrestrial and atmospheric environments, including storm development, volcanic ash plumes, and pollutants. The poster will describe a few of the many applications of the CWI.

39) Multi-Spectral Infrared Sea Surface Temperature Algorithms for GOES-R

David Hogan, William Gallery, Scott Zaccheo, and Xu Liu
Atmospheric and Environmental Research, Inc., Lexington, Massachusetts

The advanced imaging and sounding capability planned for GOES-R can provide improved sea surface temperatures (SST) with benefits to diverse applications including weather forecasting, climate, fisheries and shipping. The additional channels, higher spatial resolution and lower noise of the Advanced Baseline Imager will lead to improvements in SST generated by standard multi-channel regression approaches. The Hyperspectral Environmental Sensor (HES) can provide dramatically improved characterization of the atmospheric and surface state and offers the possibility of highly accurate, physically based SST determination.

We investigate two algorithm approaches for Sea Surface Temperature (SST) for GOES-R: (a) multi-channel regression-based approach using only channels from an imaging sensor; and (b) physical retrieval, combining high spatial resolution infrared imaging data with high spectral resolution sounder data. The regression algorithm employs multiple channels in thermal infrared wavelengths from 3.7 to 12 μm. The Non-Linear SST (NLSST) algorithm (the current operational POES SST algorithm used with the AVHRR) is compared to several alternative algorithms. These alternative algorithms include use of the 8.5 μm channel (to improve tropical SSTs) and corrections for aerosols. The combined imager/ sounder algorithm applies a two-step physical retrieval algorithm. First an iterative physical retrieval algorithm is applied using only the HES data to derive a low spatial resolution specification of the atmospheric and sea surface state. Then a second physical retrieval is performed by adding the ABI infrared radiances. The physical retrieval algorithm employs an iterative, non-linear optimal estimation technique. This physical retrieval algorithm is shown to result in reduced measurement uncertainty because of the improved atmospheric correction compared to multi-channel regression algorithms.

These analyses were performed using a comprehensive algorithm test-bed at AER. This test-bed includes end-to-end modeling tools, sensor simulators, extensive environmental databases, state-of-art radiative modeling tools, interactive analysis software and real-time satellite data feeds. The radiative transfer modeling used in this work includes a wind and angle-dependent ocean emissivity model and an ocean reflectivity model that calculates solar reflection from a wind-ruffled ocean surface. The latter effect is essential for accurate assessment of the use of mid-wave infrared channels in the daytime.

40) On The Spatial and Spectral Requirements to Effectively Resolve the Coastal Ocean Environment

W. Paul Bissett, Daniel Dye, Sharon DeBra, and David D. R. Kohler
Florida Environmental Research Institute, Tampa, Florida

The anticipated Hyperspectral Environment Suite (HES) sensor on the GOES R will provide a revolutionary new tool to the fields of ocean and climate monitoring. This sensor will provide continuous data streams necessary for effective monitoring, management, and forecasting in the near-shore coastal environment. Previous, multispectral satellite sensors have contributed greatly to the biological, chemical, and physical characterization of the open ocean. However, in the coastal zone, the spatial and spectral resolution of these satellites have been insufficient to resolve the complicated commingled signals of bottom reflectance, suspended sediments, and other non-phytoplankton optical properties from the bio-optical signals of CDOM and phytoplankton pigments. High resolution HyperSpectral Imagery (HSI) offers the promise to deliver the needed spectral and spatial resolution to characterize the coastal zone, as well as the high signal-to-noise ratio required to adequately remove atmospheric interference, which is currently unavailable from space-borne satellite sensors.

The Florida Environmental Research Institute, in collaboration with the Naval Research Laboratory, has been operating the Portable Hyperspectral Imager for Low-Light Spectroscopy (PHILLS) in a variety of coastal ocean environments, ranging from clear tropical environments to turbid estuarine waters. The spectral resolution required to separate the water-quality and organic material from bottom type and bathymetry is approximately 10 nm in these near-shore waters. The spatial resolution required to resolve these optical constituents, as well as to resolve physical circulation features such as tidal fronts and river plumes, ranges from meters to 100's of meters within 20 km of the shoreline. In this paper, we describe the required spectral and spatial resolution to effectively resolve important coastal ocean features, e.g. Harmful Algal Blooms, as well as product generation and data delivery systems for high resolution HSI data streams.

41) Insight on HES Coastal Water Imager Inwater Turbidity Product based on MODIS Observations

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Terra MODIS 250 m observations are being applied to a Suspended Sediment Concentration (SSC) algorithm under development for coastal case 2 waters. This new product provides insight into possible contributions to coastal monitoring by the HES Coastal Water Imager. The SSC product algorithm applies an atmospheric correction to isolate the remote sensing reflectance in the MODIS 650 and 865 nm bands. The atmospheric correction is based on MODIS observations in the 500 m 1.6 and 2.1 µm bands. Similar spectral bands will be on the Advanced Baseline Imager (ABI) on GOES-R. The HES-CW will have more spectral bands and be at a finer spatial resolution than the ABI. The ABI will afford much improved spatial and temporal coverages. Together the ABI and HES-CW may be useful complements to capture fine spatial detail and temporal variability in an SSC product. SSC estimates from remote sensing reflectance are based on accepted inherent optical properties of sediment types known to be prevalent in the U.S. Gulf of Mexico coastal zone. The MODIS SSC product along the U.S. Gulf Coast gives a first look at possible information content of HES Coastal Water Imager observations. The influence of spatial resolution will be examined.

42) SST Retrieval Using Scene Dependant Two Band and Three Band Multi-window Algorithms for the GOES-R Advanced Baseline Imager (ABI)

Barry Gross, Leona Charles, Min Min Oo, Fred Moshary, and Samir Ahmed
Optical Remote Sensing Lab, City College of New York; NOAA-CREST

Retrieval of Sea Surface Temperature (SST) in tropical or sub-tropical regions within the 0.2 C errors needed for accurate climatology is complicated by corrections due to atmospheric corrections for water vapor. This effect is magnified by large satellite zenith angles where the water vapor path increases. Present operational algorithms work on near water free bands at ~ 10 µm and 11 µm under the assumptions that the water vapor path is small enough for linear corrections. However, this approximation degrades for large water vapor paths and non-linear corrections need to be applied. Improvements under these conditions may be expected to occur if data from a water vapor sensitive channel is included which will allow more robust water vapor removal. In addition, particularly over sub-tropical and tropical regions, strong correlations exist between total column water vapor (TCWV) and SST which may be used to improve retrievals. In this presentation, a comparative sensitivity study between algorithms developed for the ABI channels 14 (11.2 µm), 15 (12.3 µm) bands comparable to operational AVHRR are compared to algorithms including the use of an extra water vapor channel 16 (13.3um) as well as “smart” algorithms using correlation relations between SST and TCWV is performed and significant improvements are seen. Algorithms are based on a physical retrieval method employing Radiative Transfer derived channel radiances sampled from TIGR atmospheric profile data base.

43) SST Product Development/Enchancement for GOES-R

Eileen M. Maturi
NOAA/NESDIS/ORA/ORAD

GOES-SST products have been operational since December 2000 and are already widely used by the scientific community. There has been an active program of improvements to the GOES-SST processing,

including the adoption of radiative-transfer based retrieval methods. The recent development of daytime algorithms which do not require the 12 µm split-window channel was promoted specifically to ensure continuity of this popular product into the GOES-M-Q era. The latest development is a new cloud detection methodology based on fast radiative transfer calculations and the application of Bayes' probability theorem, raising the prospect of being able to propagate cloud detection confidence information into SST error estimates on a pixel-by-pixel basis within each scene.

Most of the recent work has been carried out by University of Edinburgh (UoE) under contract to NESDIS/ORA. UoE has collaborated with Météo-France for geostationary SST products over the North Atlantic derived from GOES-8 data and are currently collaborating with them for MSG/SEVIRI. A merged MSG and GOES-12 SST product has been developed by University of Edinburgh and Météo-France as part of the Eumetsat Ocean & Sea-Ice Satellite Applications Facility (OSI-SAF). UoE have also generated retrieval algorithms for GOES-9 SST products enabling their generation by NESDIS until the platform is replaced by MT-SAT.

Preparation for GOES-R will require continuing the high-accuracy retrieval of SST by testing, evaluating and implementing as appropriate alternative retrieval methodologies as may benefit SST production. Specifically, the requirements are: i) to ensure operational product continuity; ii) maximize return on GOES-R investment by continuing to develop the SST product on current geostationary sensors with similar capabilities. This will include retrieval algorithm development for MSG and MT-SAT. Radiative-transfer techniques will be applied to the MSG and MT-SAT for determining retrieval coefficients to sensors planned for operational processing at NESDIS: SEVIRI on MSG and the infrared imager on MT-SAT. Validate on all available *in situ* match-up data and optimize algorithm derivation as required, including adjustments to sensor characteristics and radiative transfer models.

This also permits expansion in geographic coverage, adding to the value of GOES-R observations.

SST data from all the geostationary satellites will be inputs to the new blended POES/GOES product for global sea surface temperatures. With MT-SAT, MSG and GOES-E & W, rapid repeat observations of SST, covering the important diurnal cycle will be available for most of the globe. The proposed move of GOES-10 to the Indian Ocean could permit complete global coverage up to ±60° latitude.

44) Operational Air Quality Monitoring from GOES Imager

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We conducted a pilot study to demonstrate the usefulness of GOES Aerosol and Smoke Product (GASP) in operational air quality monitoring. NOAA/NESDIS has been retrieving near real-time column aerosol optical depths in the visible channel from GOES for the past 3 years (http://orbit-net.nesdis.noaa.gov/crad3/gasp/RealTime.html). We focused on three different scenarios under which air quality can deteriorate – dust storms, forest fires, and urban/industrial pollution. We reprocessed GASP retrievals with the best calibration available for pollution episodes of June 2001 (dust storm), forest fires (July 2002), and urban pollution (June 2003). Positive correlations between GASP and particulate pollution measured near the surface (PM2.5, particulate mass of particles < 2.5 microns in median diameter) suggest that GOES aerosol retrievals can be used to monitor and track pollution transport. Despite their ability to detect pollution, GASP retrievals have an offset when compared to Moderate Resolution Imaging Spectroradiometer (MODIS) aerosol optical depths, and the offset is different for GOES-8 and GOES-12. Based on our analysis of the three episodes, we find that the major limitations of the current GOES imager are uncertainties in estimates of surface reflectance, calibration, and aerosol model assumptions. We will provide an analysis of the spatial and temporal features present in the GASP retrievals, comparisons to ground-based and MODIS observations, an assessment of the retrieval algorithm performance, a discussion on planned improvements to the current algorithm, and a discussion on further improvements possible with the GOES-R Advanced Baseline Imager (ABI).

45) Volcanic Ash Detection Capabilities from GOES-R Based on Experiments Using NASA Moderate Resolution Imaging Spectroradiometer (MODIS) Data

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The advanced GOES-R satellite (scheduled for launch in 2012) will have greatly improved capabilities, such as a sixteen channel Imager, better geographic coverage, faster imaging rates (full disk every 15 minutes), and higher resolution (0.5 km visible, 2.0 km Infrared (IR)). The proposed suite of IR channels on the GOES-R Imager features a number of spectral bands that have been shown to be useful for volcanic ash detection based on prior research. While some of the proposed IR bands have been available on prior GOES (3.9, 10.7 and 12.0 µm for example), there are several new bands proposed (such as those centered near 7.3, 8.6, and 9.7 µm), with which users have had little prior experience. Also, the 12.0 µm band will be restored, following an absence of nearly 10 years (beginning with GOES-12 in 2003). Recent experiments have been conducted using data from NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) instruments on Aqua and Terra spacecraft, which have 1 km resolution IR channels similar to those proposed for GOES-R. Using data sets for several recent volcanic eruptions, optimum detection was obtained from a three-channel combination of Band 29 (8.5 µm), Band 31 (11.0 µm) and Band 32 (12.0 µm). Since Band 29 is affected by absorption from airborne sulfur dioxide and sulfates, in addition to volcanic ash, its use improves the likelihood of observing airborne volcanic clouds. Comparisons with current GOES products show significant improvements. Color composite versions of this product have also been developed which incorporate visible (0.6 µm) and near-IR (1.6 µm) bands to assist users in interpretation. Test images of this three-band algorithm are being generated using near real-time MODIS data by the NESDIS Interactive Processing Branch for evaluation by the Washington Volcanic Ash Advisory Center (VAAC) for selected regions under their responsibility. The Hemispheric coverage and rapid updates of this type of image product from GOES-R should result in significantly better monitoring of active volcanoes by the next decade.

46) Using GOES-R to Help Monitor SO_2

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Sulfur Dioxide (SO_2) is often associated with volcanic eruptions. This is important for aviation interests. Given the correct spectral coverages, satellites can monitor the location and changes of volcanic ash plumes. Geostationary satellites offer a rapid refresh rate and constant viewing angle. The Advanced Baseline Imager (ABI) and the Hyperspectral Environmental Suite (HES) on GOES-R will enable a much improved monitoring of the upper-level SO_2 distribution and evolution from the geostationary perspective. The ABI will have 16 spectral bands, compared with five on the current GOES Imagers. Most importantly for SO_2 detection, there will be spectral bands at 8.5 and at 7.34 µm. The ABI will improve the spatial coverage from nominally 4 to 2 km for the infrared bands, as well as almost a five-

fold increase in the coverage rate. The HES will be able to provide higher spectral resolution observations (on the order of 1 cm^{-1}, compared to 20 cm^{-1} on today's broadband sounders) with spatial resolutions of between 4 and 10 km. More importantly, the high spectral resolution observations will offer a more detailed view for better monitoring the end of the life cycle of thinner volcanic dust clouds. This will be demonstrated with data from the NASA AIRS instrument and these high spectral resolution observation convolved with mock ABI spectral response functions to simulate what will be possible spectrally from the ABI. To date, it has not been decided which side of the water vapor continuum that the HES will observe. Of course, the longwave side would be needed for optimum SO_2 monitoring in the 7.3 µm absorption region.

47) Using GOES-R to Help Fulfill NOAA's Mission Goals

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The great amount of information from the GOES-R series will both offer a continuation of current product and services, but also allow for improved or new capabilities. These products, based on validated requirements, will cover a wide range of phenomena. This includes applications relating to: weather, ocean, coastal zones, land, hazards, solar and space. The geostationary perspective offers a rapid refresh rate and constant viewing angles. The Advanced Baseline Imager (ABI), the Hyperspectral Environmental Suite (HES), the Geo Lightning Mapper (GLM), the space and solar instrument suites (Solar Imaging Suite (SIS) and the Space Environment In-Situ Suite (SEISS)) on GOES-R will enable much improved monitoring compared to current capabilities. The ABI will have 16 spectral bands, compared with five on the current GOES imagers. The ABI will improve the spatial coverage from nominally 4 to 2 km for the infrared bands, as well as almost a five-fold increase in the coverage rate. The HES-IR will be able to provide higher spectral resolution observations (on the order of 1 cm^{-1}, compared to 20 cm^{-1} on today's broadband sounders) with spatial resolutions of between 4 and 10 km. The HES-CW will allow high spatial resolution measurements in the visible/near infrared region. These measurements will be used for unique observations of the land and coastal regions. The GLM will offer unique lightning observations over the land and sea for both nowcasting and NWP (Numerical Weather Prediction) applications. The solar and space observations will mean improved observations needed for a host of applications. Information from each component of the GOES-R system will help meet NOAA's mission goals. What follows are the four main mission goals and the primary GOES-R instruments that will help meet the goals: (1) Protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management (HES, ABI); (2) Understand climate variability and change to enhance society's ability to plan and respond (ABI, HES, GLM, SIS, SEISS); (3) Serve society's needs for weather and water information (ABI, HES, GLM); (4) Support the Nation's commerce with information for safe, efficient, and environmentally sound transportation (GLM, ABI, HES, SIS, SEISS).

48) Simulation of the Spectral Bands on the Advanced Baseline Imager (ABI)

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The Advanced Baseline Imager (ABI) expands the capabilities for short time interval multispectral observations on the next generation Geostationary Operational Environmental Satellites (GOES) –R platform. This instrument will be used for a wide range of applications including weather, oceanography, numerical weather prediction, climate, natural hazards and hydrology. The ABI will have 16 total spectral bands; three in the visible, three in the near infrared and 10 in the infrared spectral regions, compared with five total bands on the current GOES imagers. These additional bands will enable improved and new products. The ABI will also improve the spatial resolution from nominally 4 to 2 km at nadir view for the infrared bands and increase the temporal coverage rate five-fold. Mock spectral response functions have been created for all bands and are available for other interested parties. Studies are underway in preparation for GOES-R using forward model calculations in both real and simulated atmospheres with weighting functions created to compare to similar bands on other instruments such as the current GOES Imagers. Simulated images of ABI bands are created daily from direct broadcast AIRS and MODIS data received at the University of Wisconsin-Madison. These are posted in near real-time to the World Wide Web. Simulations of ABI spectral and spatial advances are presented using data from aircraft (AVIRIS) and research satellites (AIRS, and MODIS).

49) Use of High Spectral Resolution Infrared Observations by Ground-based, Aircraft, and Satellite Instruments to Simulate HES Radiances over a Land Site

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The Hyperspectral Environmental Suite (HES) on GOES-R and beyond will enable improved monitoring of the temporal evolution of land surface temperature and infrared surface emissivity. The HES is expected to provide hourly top of atmosphere radiance observations with a spatial resolution of better than 10 km and a spectral resolving power of greater than 1000. The University of Wisconsin is using existing observations from ground-based, aircraft, and satellite platforms to develop a simulation of the outgoing surface radiation of a land site in North Central Oklahoma. The Department of Energy Atmospheric Radiation Measurement Program Southern Great Plains (DOE ARM SGP) site is being used because of the extensive network of atmospheric profiling measurements routinely collected at that site. High spectral resolution infrared observations from the ground-based UW Atmospheric Emitted Radiance Interferometer (AERI) have been made of the time rate of change of surface emitted thermal radiance at this site but only for select land cover types. Similar aircraft observations have been made of the DOE ARM SGP site by the UW Scanning High-resolution Interferometer Sounder (S-HIS) at a spatial resolution of about 2 kilometers from a high altitude aircraft platform. Likewise, the recently launched EOS Aqua platform with the Atmospheric InfraRed Sounder (AIRS) instrument has been used to obtain high spectral resolution satellite observations at a spatial resolution of about 15 km. The combination of these instruments with the 1 km observations of the Moderate-Resolution Imaging Spectroradiometer (MODIS) and the infrared channels of the current GOES instrument are being used to simulate what would be observed by a future geostationary infrared spectrometer. These simulations will be used to develop algorithms for the generation of effective land surface emissivity and effective land surface temperature products derived from the geostationary observations anticipated in the GOES-R time frame.

50) GOES R and the Global Carbon and Water Cycle

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Land vegetation affects weather, weather affects vegetation, and by monitoring land vegetation with the HESS instrument planned for GOES R, we can improve weather forecasts as well as our understanding of linkages between climate and the global carbon cycle.

The global carbon and water cycle are intimately linked through land vegetation physiological processes. Land surface vegetation exerts strict controls on land-atmosphere exchanges of carbon, water and energy as result of biological processes evolved to optimize the plant's allocation of light, nutrients and water for survival. The land-atmosphere mass and energy balance is in turn intimately linked to meteorological processes influencing resource availability, including precipitation rates and boundary layer structure, to name two examples, which in turn feedback strongly to plant photosynthetic rates, respiration and in the longer term, through vegetation succession, the structure of the landscape.

The importance of these land surface-atmosphere processes to atmospheric dynamics are recognized, and are represented in atmospheric general circulation and global carbon cycling models by a general class of models called Surface-Vegetation-Atmosphere Transfer (SVAT) models. SVATs attempt to represent vegetation physiology and soil hydrology using different schemes, all generally requiring knowledge of instantaneous downwelling Photosynthetically Active Radiation (PAR), the capacity of the vegetated surface to absorb PAR (Fpar) and finally the rate at which the vegetation converts the absorbed photons to carbon, the plant light use efficiency (LUE). Together, these process rates are linked physiologically to evapotranspiration. Through these processes the mass and energy budget over vegetated surfaces is controlled primarily by just these three variables.

Tower eddy-correlation measurements in a large number of ecosystems show that the mass-energy budget of a vegetated surface is quite variable on a diurnal scale since these three controlling variables can vary considerably over time scales of just seconds. Over the past 20 to 30 years, a number of satellite methodologies have been developed to measure PAR and Fpar globally. However LUE has been traditionally modeled as a function of vegetation type, soil moisture, nutrient availability, air temperature and humidity to which plant LUE responds. The physiological processes related to LUE are not always completely represented in the models, and in any case, the input variables are quite difficult to measure at the large geographic scales required for general circulation and carbon cycling models. In just the last 10 years, a growing body of literature has recognized that variations in LUE induced by environmental stress, is manifest by changes in leaf pigments and in leaf and canopy optical properties. These changes can be measured remotely using multispectral sensors that can measure changes in plant reflectance at 531 nm, and 570 nm. The HES GOES R is planned to include both a 531 and 570 nm band, hence is suitable for monitoring changes in plant LUE, thus changes in the surface energy and mass budget induced by plant stress, and ultimately the effects of feedbacks between the atmospheric boundary layer and vegetation on weather. These measurements should significantly improve weather forecast accuracies as well as our understanding of the links between carbon and climate. This poster presents a brief history of these developments, as well as recent advances in algorithms for using narrow-waveband spectrometers for measuring surface-atmosphere carbon dioxide exchange over vegetated surfaces.

51) Automated Snow Mapping And Monitoring With Goes Imager: Perspectives For GOES-R

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Observations from geostationary satellites have long been used to map and monitor snow cover. Availability of measurements in the visible, middle-infrared and infrared spectral bands from GOES Imager allows for an automated identification and mapping of snow. In this presentation we will describe the retrieval technique and demonstrate current operational and experimental automated snow and ice products derived at NESDIS from GOES data. These products include snow and ice cover, snow fraction and estimates of the snow depth over non-forested areas. GOES-based retrievals will be compared with other remote sensing products derived from different instruments and with surface observations. We will discuss perspectives to improve snow detection and mapping with the Advanced Baseline Imager (ABI) onboard GOES-R. The key factor in the improvement is a broader and more detailed spectral coverage of ABI as compared to the current GOES Imager. MODIS data will be used to assess the effect of additional spectral information in ABI measurements on the accuracy of future snow products.

52) Distributed Computing for the Extraction of Meteorological Products from the GIFTS Imaging Interferometer

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Faced with the challenge of terabyte-scale data volumes specified by forthcoming imaging infrared interferometers, such as those planned for the Hyperspectral Environmental Suite (HES), and the necessity for timely delivery of meteorological products derived from these data, we are conducting design studies and prototyping a distributed data processing system capable of meeting throughput and latency requirements. We summarize methodologies and technologies appropriate to near-real-time extraction of products, including atmospheric vertical temperature and moisture profiles as well as wind vector fields, from data to be delivered by the Geosynchronous Imaging Fourier Transform Spectrometer (GIFTS).

53) EXPLORES! – A K-12 Educational Outreach Program for NOAA GOES and POES Satellites Products

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This poster will outline the goals and accomplishments of the international EXPLORES! program, which has been deployed in six states and in Mexico. The program began in 1992 as a way to bring NOAA direct readout (APT and WEFAX) into the K-12 classroom, and continues with the delivery of real-time digital data into the classroom today (HRPT and GVAR). EXPLORES! is adapting to the newer satellite constellations, and also has developed a K-12 curriculum that is tied to Florida state science standards as well as National Standards. A distance learning course on using geoscience imagery, including NOAA satellite data, in the classroom will be piloted during summer 2004. We also maintain the international weather satellite professional and enthusiast list, WXSAT-L.

One of our most popular features is daily weather satellite discussions, done during the school year. These features were added after the old NESDIS regional satellite discussions were discontinued in the

1990s. In addition, we have a complete history of the U. S. Weather Satellite program online. We also participate in the GLOBE program, and have developed a separate educational outreach program for schools with automated weather stations, called REALM.

The EXPLORES! program has operated a site on the World Wide Web for teachers forcussing on satellite meteorology and tropical weather (in response to a request from for our Florida teachers) since 1995; it is available at http://www.met.fsu.edu/explores/.

54) The SDO EUV Variability Experiment (EVE): Research to Operations

F. G. Eparvier, T. N. Woods, and the EVE Science Team*

The EUV Variability Experiment (EVE) on the upcoming NASA Solar Dynamics Observatory mission has four primary science objectives: (1) Specify the solar EUV irradiance and its variability on time scales from seconds to years; (2) Advance current understanding of how and why the solar EUV irradiance varies; (3) Improve the capability to predict (nowcast and forecast) the EUV irradiance variations; and (4) Understand the response of the geospace environment to solar EUV variability and the impact on human endeavors. This poster will describe the EVE science plans, going beyond accurate and precise irradiance measurements to encompass improvements in models of the sources of solar EUV and the effects on the Earth's atmosphere. EVE has the ultimate goal of improving space weather operations and will provide a transition to the future of space weather monitoring systems.

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55) Lossless Data Compression Studies for NOAA Hyperspectral Environmental Suite

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The Hyperspectral Environmental Suite (HES) aboard the next-generation Geostationary Operational Environmental Satellite (GOES)-R in 2012 will provide critical atmospheric, oceanic, land information. The sounder will have high spectral resolution (over one thousand channels), high temporal resolution (1 hour), high spatial resolution (less than 10 km), and hemispheric coverage. Given such a high volume of data, the use of robust data compression techniques will be beneficial to data transfer and archive. Unlike hyperspectral imaging data compression, hyperspectral sounding data compression is desired to be lossless or near lossless to avoid potentially significant degradation of geophysical retrievals. Several state-of-the-art lossless compression schemes are studied, including 3D wavelet-based EZW and SPIHT, 2D wavelet-based JPEG2000, 2D predicton-based CALIC and JPEG-LS, and the 1D block-sorting-based Burrows-Wheeler transform (BWT). A novel data preprocessing technique is utilized to improve the compression gain for each scheme. Their compression ratios for the AIRS hyperspectral sounding data are presented.

56) **Lossy Data Compression and Retrieval Impact Studies for NOAA Hyperspectral Environmental Suite**

Bormin Huang[1], Alok Ahuja[1], Hung-Lung Huang[1], Timothy J. Schmit[2], and Roger W. Heymann[2]
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The Hyperspectral Environmental Suite (HES) aboard the next-generation Geostationary Operational Environmental Satellite (GOES)-R in 2012 will scan the Earth nearly five times faster than the current GOES. The sounder will provide the user community with about one hundred times the amount of data currently provided. It will have higher spectral resolution (over one thousand channels) and high spatial resolution (less than 10 km). Given the unprecedented volume of data HES will generate, the use of robust data compression techniques will be beneficial to data transfer and archive. Hyperspectral sounding data compression is desired to be lossless or near lossless to avoid potentially significant degradation of atmospheric state and surface property retrievals. Lossy compression of hyperspectral sounding data via JPEG 2000 and JPEG-LS is presented. The impact of lossy compression on the retrieval of atmospheric temperature and absorbing gases profiles is studied for various compression ratios.

57) Design of a Compression Algorithm for GOES Data.

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We are developing a novel approach for the compression of the next generation GOES sounding data that includes over 2,000 channels and arranged in granules that consist of 135 scan lines containing 90 cross-track footprints per scan line resulting in total 135 x 90 footprints.

The proposed algorithm is based on adaptive clustering procedure that extracts the characteristic features of the sensor measurements. The clustering is performed recursively and at each iteration. The set of features is modified so that the classification performance is maximized. Several elements of the proposed algorithm are similar to (available in the literature) pattern recognition approaches and the vector quantization techniques. The challenge is to derive an organic compression scheme that is the most appropriate for the sounder data. Hence, the main objective of the project is to incorporate a priori knowledge of the physical characteristics of the sounder data into compression process in order to achieve an optimal compression ratio. Our overall strategy is to use the data itself as the prime driver in the search for the optimum solution.

58) NASA Technology Applicable to GOES-R Onboard Compression, Error Control Coding and Digital Modulation (3 posters)

Pen-Shu Yeh and Wai Fong
NASA/GSFC Code 567

Advanced technology development in data compression, error control coding and digital modulation conducted at NASA's Goddard Space Flight Center is targeted towards future missions requiring high-speed data throughput on a constrained bandwidth channel. Each development is implemented on a high-speed radiation tolerant flight hardware platform. In-depth analysis of algorithms is performed to ensure optimal implementation and to achieve the highest performance. .

In the data compression area, a new tunable compression scheme applicable to both push-broom and frame instrument has been developed for imaging and higher-dimensional data. The algorithm has been selected by the CCSDS with the release of the recommendation expected summer 2004. The algorithm allows a user to select fixed rate compression or quality-controlled compression from high compression ratio to lossless mode. Flight integrated circuit specified at over 20 Msamples/sec is under development.

To improve the efficiency of channel coding, new bandwidth efficient error control coding scheme, specifically the Low Density Parity Check (LDPC) code, has been developed to effectively double the bandwidth utilization as compared to the concatenated Reed-Solomon and Convolutional codes. The code does not exhibit any error floor with BER down to 10^{-10}, a requirement dictated by the need to transport compressed data reliably. This LDPC code has been proposed to CCSDS as a candidate for a new channel coding standard. Flight LDPC coders of block length 8-k and 4-k bits has been designed to operate at over 1 Gbps.

To satisfy the spectral mask recommended by the Space Frequency Coordination Group (SFCG) and improve bandwidth efficiency, CCSDS has published a set of new digital modulation schemes including Filtered-OQPSK, GMSK, 8PSK-TCM for future missions. The narrow spectrum is achieved by filtering the channel symbol to produce side-band suppression. A multi-function digital modulation integrated circuit is being developed for space missions with a target rate of over 300 Mbps (Filtered-8PSK). A testbed built on an FPGA implementation has demonstrated 40 Msps throughput and verified spectral performance.

This presentation gives only a top-level description of the three technology developments that are applicable to the GOES-R mission. Details of each will be provided in the poster.

59) Application of Principal Component Analysis (PCA) to AIRS Data

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Observations from high spectral resolution Atmospheric InfraRed Sounder (AIRS) are now routinely provided in near real-time to the NWP community by NOAA/NESDIS.

The main benefits of high spectral resolution infrared data are vastly improved information of the temporal and spatial structure of key atmospheric parameters, such as temperature, moisture and clouds, which are needed to significantly improve real-time, weather forecasting, and climate monitoring and prediction capabilities. Also important trace gases such as ozone, carbon dioxide, carbon monoxide, and methane can be derived. Our processing of AIRS data is also providing important risk reduction activities for future sensors, including GOES-R

A very important part of our AIRS processing is to apply Principal Component Analysis (PCA) to the original AIRS 2000+ channel radiances. PCA is used for detector monitoring and noise filtering/estimating, channel recovery and radiance reconstruction, and for deriving profiles of temperature, moisture, ozone and other geophysical parameters. Since PCA has the ability to reduce the dimensionality of a dataset while retaining most of the information, investigations are being done on its applications to AIRS data compression and archiving. Data compression is one of the key issues for GOES-R.

Our research and prototyping will allow us to provide valuable information and lessons learned to the GOES-R effort. Some examples of each application, along with the details on the generation and application of eigenvectors, will be presented at the meeting.

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APPENDIX 1. CONFERENCE AGENDA

Third GOES-R Users Conference
May 10–13, 2004
Omni Interlocken Resort Hotel
Broomfield, Colorado

Goals for Conference:
1) Inform users on the status of the GOES-R constellation, instruments, and operations;
2) Refine potential user applications for data and products from the GOES-R series;
3) Seek ways to help the user communities prepare for GOES-R;
4) Address user and societal benefits of the GOES-R series as an integral part of the Global Observing System;
5) Continue to improve communication between NOAA and the GOES user communities

May 10 (Monday): Omni Hotel
Session 1: Welcome and Keynote
Co-Chairs: Gary Davis, NOAA/NESDIS and Gerry Dittberner, NOAA/NESDIS

11:00 am	Registration (and poster set up)
LUNCH	(on your own)
12:45 pm	Introduction (logistics, conference format, etc.) – Jim Gurka, NOAA/NESDIS
12:50 pm	Welcome/ Opening Remarks/ Conference goals – Gary Davis, NOAA/NESDIS
1:05 pm	Keynote Address: A Vision for NOAA's Weather and Water Services in the GOES-R Era – Brig. Gen. D.L. Johnson, NOAA/NWS
1:35 pm	Vision of an Integrated Global Observing System – Greg Withee, NOAA/NESDIS
2:05 pm	The Future of NOAA Coastal and Ocean Services in the GOES-R Era – Mary Culver, NOAA/NOS
2:25 pm	Science Evolution in the GOES-R era – Mitch Goldberg, NOAA/NESDIS
2:45 pm	Monitoring Air Quality in the GOES-R Era – Deborah Mangis, EPA
3:00 pm	Recommendations from 2nd GOES Users Conference – Jim Gurka, NOAA/NESDIS
3:15 pm	BREAK

Session 2: Information Briefings
Co-Chairs: Mike Crison, NOAA/NESDIS, and Tim Schmit, NOAA/NESDIS

3:30 pm	GOES Program Overview & GOES-R System Architecture – Steve Kirkner, NOAA/NESDIS
4:00 pm	Introducing the ABI (Advanced Baseline Imager) – Tim Schmit, NOAA/NESDIS
4:30 pm	TheNext Generation Operational Geostationary Sounder – Paul Menzel, NOAA/NESDIS
5:00 pm	HES/Coastal Waters – Chris Brown, NOAA/NESDIS
5:30 pm	Questions/Discussion Integrated Work Strategies
5:40 pm	End of day 1

May 11 (Tuesday): Omni Hotel
Session 2 Information Briefings (Continued)
Co-Chairs: Mike Crison, NOAA/NESDIS & Tim Schmit, NOAA/NESDIS

8:00 am	Registration/ continental breakfast (and poster set up)
8:30 am	Announcements (as necessary) – Jim Gurka, NOAA/NESDIS
8:40 am	GOES Lightning Mapper Sensor – Hugh Christian, NASA/MSFC

9:00 am	Supporting Space Weather Users with the Environment Monitor and Solar Imaging on GOES-R – Howard Singer, NOAA/OAR/NWS
9:20 am	GOES-R GEO Microwave Sounder (GMS) – Mike Madden, The Aerospace Corporation
9:40 am	How GIFTS helped pave the way for HES – Paul Menzel, NOAA/NESDIS
10:00 am	BREAK
10:20 am	Instrument Synergy –Jim Purdom, CIRA
10:50 am	Future Integrated Satellite Architecture – Mike Crison, NOAA/NESDIS
11:10 am	The Imager/Sounder Paradigm Revisited – Joe Criscione, Swales Aerospace
11:30 am	LUNCH (on your own)

Session 3: GOES-R as a component of the Global Observing System
Co-chairs: Paul Menzel, NOAA/NESDIS and Jim Purdom, CIRA

1:00 pm	The Role Of Geostationary Environmental Satellites In The WMO Space Program – Don Hinsman, World Meteorological Organization
1:20 pm	Meteosat Second Generation (MSG) Products – Ken Holmlund, Meteorological Operations Division, EUMETSAT
1:40 pm	Plans For EUMETSAT's Third Generation Meteosat (MTG) – Rolf Stuhlman, Meteorological Geostationary Satellite Program Operations Division, EUMETSAT
2:00 pm	Routine Use of METEOSAT Rapid Scans – HansPeter Roesli, Swiss Meteorological Service
2:20 pm	Plans for Japan's Geostationary Satellite Program – Hitomi Miyamoto, Meteorological Multi-Functional Transport Satellites Satellite Center, Japan Meteorological Agency
2:40 pm	BREAK
3:10 pm	Plan of Geostationary Satellite (COMS) Program in Korea – Hyo-Sang Chung Meteorological Research Institute, Korea Meteorological Administration
3:30 pm	Feature Plans of India's Geostationary Meteorological Satellite Programme Ramesh Bhatia, Additional Director General of Meteorology, India Met Department
3:50 pm	Summary of other International Plans – Paul Menzel, NOAA/NESDIS
4:10 pm	Qualitative Design: The Right Way to Develop the Composite Observing System Sandy MacDonald, NOAA/OAR
4:40 pm	Poster Previews – Tim Schmit, NOAA/NESDIS
5:00 pm	Discussion and wrap up – Integrated Work Strategies
5:15 pm	Poster session and icebreaker

May 12 (Wednesday): at OMNI Hotel
Session 4: Ensuring User Readiness for GOES-R in 2012
Co-Chairs: Joe Friday, University of Oklahoma, and Tony Mostek, NOAA/NWS

7:15 am	Continental Breakfast
8:30 am	GOES-R User Readiness Planning – Jim Gurka, NOAA/NESDIS
8:40 am	NOAA User Readiness – Lessons Learned – Joe Friday, University of Oklahoma
9:10 am	A Committee Study of End-To-End Utilization of Operational Environmental Satellite Data: A Vision for 2010 and Beyond – Allen Huang, CIMSS
9:30 am	Existing Data Sets to Point the Way to GOES-R – Steve Ackerman, CIMSS
9:45 am	Risk Reduction for GOES-R Product Development – Paul Menzel, NOAA/NESDIS
10:05 am	GOES-R Data Delivery – Tim Schmit, NOAA/NESDIS
10:20 am	BREAK
10:45 am	Comprehensive Large Array-data Stewardship System (CLASS) – Richard Reynolds, NOAA/NESDIS
11:05 am	User Education And Training – Tony Mostek, NOAA/NWS
11:25 am	NOAA Observing System Architecture (NOSA) – Eric Miller, NOAA/NESDIS

11:45 am Overview of NOAA's Four Mission Goals – Jim Butler, NOAA/PPI
12:00 pm LUNCH (on your own)

1:00 – 3:00 pm
SESSION 5A: Understand climate variability and change to enhance society's ability to plan and respond
Co-Chairs: Mitch Goldberg, NOAA/OAR, and Gerry Dittberner, NOAA/NESDIS
Introduction – Gerry Dittberner, NOAA/NESDIS
Report from NESDIS Data Users Conference – Kenneth Knapp, NOAA/NESDIS
Overview of NOAA Climate Observational Requirements for GOES-R - Herb Jacobowitz, Short & Associates Inc.
GOES-R Support To Future Climate Monitoring Needs – Mitch Goldberg, NOAA/NESDIS
GOES-R and the Data Center of the 21st Century – Kenneth Knapp, NOAA/NESDIS
GOES-R Support To Future Long-Wave Radiation Products – Hai-Tien Lee, CICS
Role of GOES in International Climate Programs – Tom Vonder Haar, CIRA

3:15 – 5:15 pm
SESSION 5B: Protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management
Co-Chairs: Ricardo Letelier, CIOSS, and John Pereira, NOAA/NESDIS
The Cooperative Institute for Oceanographic Satellite Studies –Ted Strub, CIOSS
Harmful Algal Blooms and GOES-R – Rick Stumpf, NOAA/NOS
Potential Applications of GOES-R Data in support of NOAA Fisheries Missions – Cara Wilson, NOAA/NMFS/PFEL
Naval Research Applications for GOES-R data – Bob Arnone, NRL
Gulf of Mexico Coastal Marine Applications Using GOES-R Data – Nan Walker, Louisiana State University
Coastal Ocean & Carbon Measurements From Geostationary Orbit – Janet Campbell, University of New Hampshire
Animation of GOES images for the Detection of Ocean Features – Richard Legeckis, NOAA/NESDIS
Mapping ocean Surface from Sequential Surface Temperature Imagery – Bill Emery, Univ. of Colorado

1:00 – 3:00 pm
SESSION 6A: Support the Nation's commerce with information for safe, efficient, and environmentally sound transportation
Co-Chairs: Bob Winokur, U.S. Navy/Oceanographer & Gary Ellrod, NOAA/NESDIS
Navy Operational Applications of GOES-R Data – Dick Crout, CNMOC
Joint Ice Center Applications of GOES-R Dick Crout, CNMOC
Navy Ionospheric & Thermospheric Imaging from Geostationary Orbit – Stefan Thonnard, NRL
GOES-R Support to Aviation Route Planning – Warren Rodie, NWS/CWSU
GOES-R Support for Volcanic Ash Avoidance – Paul Herzegh, UCAR
GOES-R Contributions Toward More Effective Combat Force Projection – Brian Kabat, AFWA
GOES Data Collection System (DCS) in the GOES-R Era – Bill Brockman, Short & Associates

3:15 – 5:15pm
SESSION 6B: Serve society's needs for weather & water information
Co-Chairs: Frank Kelly, NOAA/NWS & Don Gray, NOAA/NESDIS
GOES-R support to Weather Forecast Offices – Gary Hufford, NWS/ARH
GOES-R benefits for NWP – Ralph Petersen, CIMSS
The NOAA Hydrology Program and its Requirements for GOES-R – Pedro Restrepo/NWS
GOES-R support to Future NWS Weather Applications – Frank Kelly, NWS

GOES-R support to Air Force Weather Applications – John Zapotocny/AFWA
GOES-R support to U.S. Army Weather Applications – Don Hoock/U.S. Army

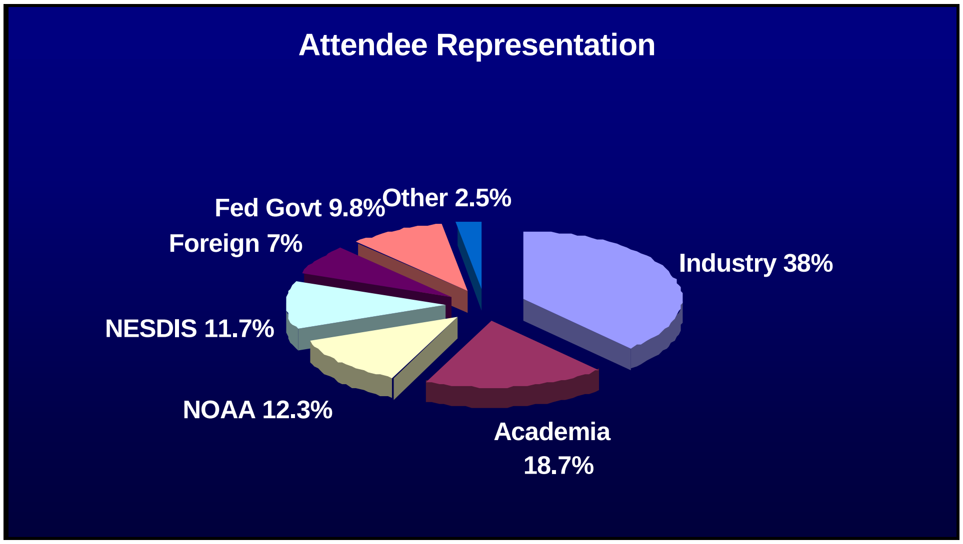
6:15 pm Conference Dinner
Dinner Speaker: Bill Hooke, Senior Policy Fellow and Director of the Atmospheric Policy Program, American Meteorological Society

May 13 (Thursday): at Omni Hotel
Breakout Sessions
Facilitator: Jessica Hartung

7:30 am	Continental Breakfast
8:30 am	Introduction to feedback process (Jessica Hartung)
9:00 am	Breakout sessions begin (Facilitators and Technical Leads)
	Weather Applications (Tim Schmit and Gary Hufford)
	Climate applications (Paul Try and Mitch Goldberg)
	Coastal and Ocean Applications (Chris Brown and Rick Stumpf)
	Safe and Efficient Transportation (Gary Ellrod and Dick Crout)
	Hydrological Applications (Pedro Restrepo and Mark DeMaria)
	Air quality/Fires (Ken Carey and Shobha Kondragunta)
10:30 am	BREAK
10:45 am	Breakout sessions resume
12:00 noon	LUNCH (on your own)
1:30 pm	Highlights from each breakout group Group representatives
3:00 pm	Closing remarks – Gerry Dittberner, NOAA/NESDIS
3:30 pm	Adjourn

APPENDIX 2. ATTENDEE REPRESENTATION

Attendee representation spanned various fields across several different user groups. The chart below illustrates the attendee distribution.



Notes:

Academia includes:

- The National Center for Atmospheric Research (NCAR)
- The University Corporation for Atmospheric Research (UCAR)
- The Cooperative Institute for Research in the Atmosphere (CIRA)
- The Cooperative Institute for Meteorological Satellite Studies (CIMSS)
- Other colleges and universities

The Federal Government includes:

- The National Aeronautics and Space Administration (NASA) and contractors
- Department of Defense agencies and contractors

APPENDIX 3. GLOSSARY

ABI	Advanced Baseline Imager
ABS	Advanced Baseline Sounder
ADEOS	Advanced Earth Observing Satellite
AFWA	Air Force Weather Agency
AIRS	Atmospheric Infrared Sounder
AMS	American Meteorological Society
AMSU	Advanced Microwave Sounding Unit
AO	Announcement of Opportunity
Aqua	NASA Earth Science satellite mission named for the large amount of information that the mission will be collecting about the Earth’s water cycle
ARH	Alaska Regional Headquarters
CICS	Cooperative Institute for Climatic Studies
CIMSS	Cooperative Institute for Meteorological Satellite Studies
CIOSS	Cooperative Institute for Oceanographic Satellite Studies
CIRA	Cooperative Institute for Research in the Atmosphere
CLASS	Comprehensive Large Array-data Stewardship System
CNMOC	Naval Meteorology and Oceanography Command
CONUS	CONtinental United States
CrIS	Cross-track Infrared Sounder
CWSA	Commercial Weather Services Association
CWSU	Center Weather Service Unit
DCS	Data Collection System
DoD	Department of Defense
ENVISAT	ENVIronmental SATellite
EOS	Earth Observing System
ESA	European Space Agency
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
GCOM	NASDA mission
GEM	Geostationary Microwave
GIFTS	Geostationary Imaging Fourier Transform Spectrometer
GIFTS-IOMI	Indian Ocean METOC Imager
GOES	Geostationary Operational Environmental Satellite
GOS	Global Observing System
GPS	Global Positioning System
GVAR	GOES Variable Format
HES	Hyperspectral Environmental Suite
IASI	Infrared Atmospheric Sounding Interferometer
IOO	Instrument of Opportunity
IR	InfraRed
IRIS	Improved Resolution and Image Separation
ISCCP	International Satellite Cloud Climatology Project
METEOR	Russian meteorological satellite
MODIS	MODerate-resolution Imaging Spectroradiometer
MSFC	Marshall Space Flight Center
MSG	Meteosat Second Generation
MTG	Meteosat Third Generation
MTSAT	Multi-functional Transport Satellite
NASA	National Aeronautics and Space Administration

NASDA	Japanese Space Agency
NCAR	National Center for Atmospheric Research
NCDC	National Climatic Data Center
NESDIS	National Environmental Satellite, Data, and Information Service
NGDC	National Geophysical Data Center
NIST	National Institute of Standards and Technology
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NOSA	NOAA Observing System Architecture
NPOESS	National Polar-orbiting Operational Environmental Satellite System
NPP	NPOESS Preparatory Project
NWA	National Weather Association
NWP	Numerical Weather Prediction
NWS	National Weather Service
OAR	Office of Oceanic and Atmospheric Research
OFCM	Office of the Federal Coordinator for Meteorological Services and Supporting Research
ONR	Office of Naval Research
PFEL	Pacific Fisheries Environmental Laboratory
PPI	Office of Program Planning and Integration
SEC	Space Environment Center
SEVIRI	Spinning Environmental Visible and InfraRed Instrument
SST	sea surface temperature
Terra	the EOS flagship satellite (EOS AM)
UAV	Unmanned Aerial Vehicle
UCAR	University Corporation for Atmospheric Research
WMO	World Meteorological Organization

APPENDIX 4. CONFERENCE COMMITTEE AND OUTREACH TEAM

Conference Committee

Jim Gurka, ***Chair***	NOAA/NESDIS Office of Systems Development
Kenneth Carey	NOAA/NESDIS, Office of Systems Development
Dennis Chesters	NASA/Goddard Space Flight Center
Mark DeMaria	NOAA/NESDIS, Office of Research and Applications
Gerald Dittberner	NOAA/NESDIS, Office of Systems Development
Gary Ellrod	NOAA/NESDIS, Office of Research and Applications
Don Gray	NOAA/NESDIS Office of Systems Development
Jessica Hartung	Integrated Work Strategies
Eric Madsen	NOAA/NESDIS, Office of International Affairs
Tony Mostek	NOAA/NWS
John Pereira	NOAA/NESDIS, Office of Systems Development
Anna Poulsen	Integrated Work Strategies
Dick Reynolds	Short & Associates, Inc.
Tim Schmit	NOAA/NESDIS, Office of Research and Applications
Steve Short	Short & Associates, Inc.
Patricia Viets	Short & Associates, Inc.
Michael Young	Short & Associates, Inc.

Outreach Team

Jim Gurka, ***Chair***	NOAA/NESDIS, Office of Systems Development
Dave Clark	NOAA/NESDIS, National Geophysical Data Center
Jean Fitch	NOAA/NESDIS, NPOESS Integrated Program Office
Robert Hansen	NOAA Constituent Affairs
John Leslie	NOAA/NESDIS Public Affairs
Kathy Martin	NOAA/NESDIS, National Geophysical Data Center
Eric Madsen	NOAA/NESDIS, International Affairs
Caren Madsen	NOAA Intergovernmental Affairs
Craig Montesano	NOAA Legislative Affairs
Dick Reynolds	Short & Associates, Inc.
Janice Sessing	NOAA/NESDIS, Legislative Affairs
Pete Steurer	NOAA/NESDIS, National Climatic Data Center
Patricia Viets	Short & Associates, Inc.
Jane Whitcomb	NOAA/NESDIS, NPOESS Integrated Program Office