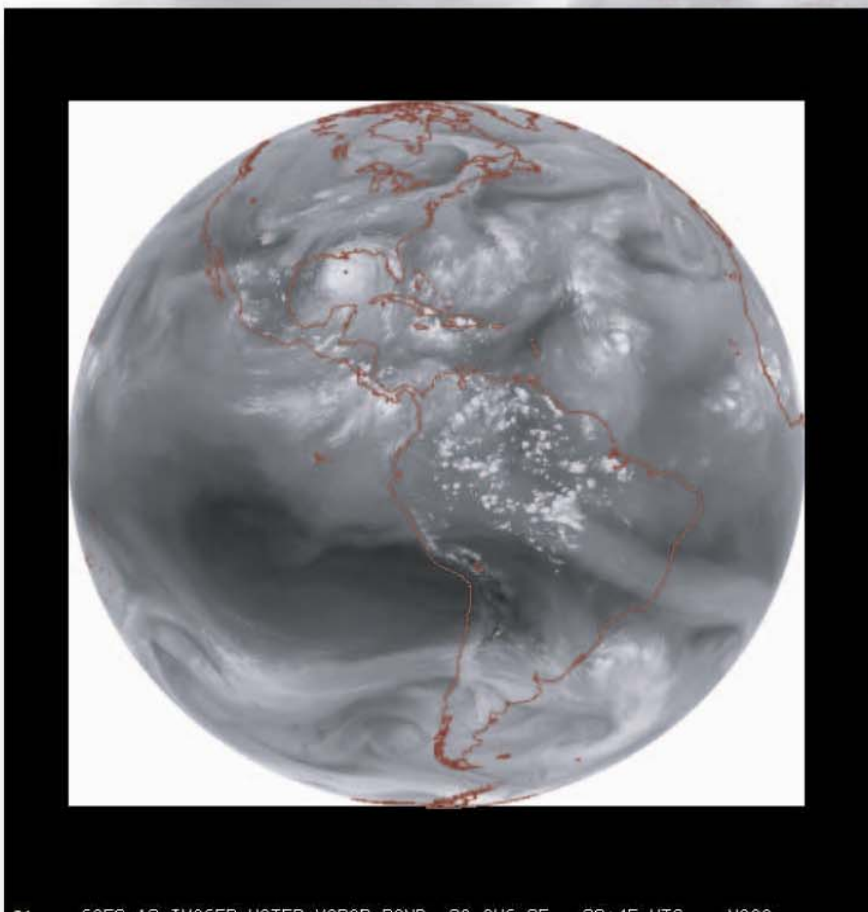
4TH GOES USERS CONFERENCE

May 1–3, 2006
Broomfield, Colorado

CONFERENCE REPORT



U.S. Department of Commerce (DOC)
National Oceanic and Atmospheric Administration (NOAA)
National Environmental Satellite, Data, and Information Service (NESDIS)

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Foreword

The NOAA Geostationary Environmental Operational Satellite (GOES) R-series is in the early stage of development — with first launch now scheduled for the 2014 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 4th GOES Users' Conference in Broomfield, Colorado in May 2006.

The goals of the conference were to:

- Improve communication between NOAA and the GOES user communities
- Inform users on the status of the GOES-R constellation, instruments, and operations
- Promote understanding for the various applications of data and products from the GOES-R series
- Seek ways/define methodologies to ensure user readiness for GOES-R

Many useful recommendations were made during this conference that NOAA will consider as we develop the future series. These recommendations are documented in this report and will greatly help NOAA maximize user readiness for GOES-R.

NOAA sponsored this conference with the support and cooperation of the American Meteorological Society, the National Aeronautics and Space Administration, the National Institute of Standards and Technology (NIST), the National Weather Association, and the World Meteorological Organization. We would like to 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. We appreciate everyone's support of this critical satellite program.

Mary E. Kicza

Mary E. Kicza
Assistant Administrator for
Satellite and Information Services

EXECUTIVE SUMMARY

Over 350 satellite data users gathered in Broomfield, Colorado, May 1–3, 2006 for the 4th Geostationary Operational Environmental Satellites (GOES) Users' Conference. The conference was designed to help GOES data users prepare for various applications of data and products from GOES-R. Data users described the importance of the data for various applications in the user community. Attendees also discussed the "hows" of acquiring data and improving communication between NOAA and the user community. The Co-Chairs for the Conference were Gary Davis, Director, Office of Systems Development, and James Gurka, GOES-R acting Chief Scientist, NOAA Satellite and Information Service.

GOES-R, slated to be launch-ready in late 2014, will provide critical atmospheric, oceanic, climatic, solar, and space data. Current plans call for the satellite to house an advanced imager, a lightning mapper, a solar imager, solar irradiance sensor, and a space environment monitor. The new satellites will provide the user community (national and international government agencies, private weather companies, academic institutions, aviation, and agriculture communities) with significantly more data. Since the conference, the Hyperspectral Environmental Suite (HES) has been deferred with the earliest HES launch on GOES-T in 2019. The report reflects these changes.

The need for an advanced satellite for weather forecasting, and the need for the Advanced Baseline Imager have been well documented and publicized. Attendees not only heard more details about the weather forecasting applications of satellite data, but also about the crucial need for advanced instruments for other applications, including fisheries, space weather, and aviation applications. In order to solidify GOES-R requirements, the need for making their product and interface requirements known in a timely fashion was stressed to the users.

The user community, as well as officials from other Federal agencies, expressed their appreciation for the vast amount of data and information that is readily available on the Internet. Kush K. Malhotra, an information technology specialist with the Government Accountability Office, said he successfully accessed the GOES website and navigated through the materials that are posted. He stated the tremendous amount of posted information should significantly aid in his agency's understanding of the GOES-R system.

Users at the conference 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 NESDIS. The recommendations will be evaluated, discussed, and implemented to the extent possible.

The conference was sponsored by NOAA's Satellite and Information Service in cooperation with the American Meteorological Society, the National Weather Association, and the National Institute of Standards and Technology. Plans call for this important communication with the user community to continue, and for the next GOES Users' Conference to be held in New Orleans in January 2008 at the annual meeting of the American Meteorological Society.

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1. OVERVIEW

Over 350 satellite data users gathered in Broomfield, Colorado, May 1–3, 2006 for the 4th Geostationary Operational Environmental Satellites (GOES) Users' Conference. The conference was designed to help GOES data users prepare for various applications of data and products from GOES-R. Data users described the importance of the data for various applications in the user community. Attendees also discussed the "hows" of acquiring data and improving communication between NOAA and the user community. The Co-Chairs for the Conference were Gary Davis, Director, Office of Systems Development, and James Gurka, GOES-R acting Chief Scientist, NOAA Satellite and Information Service.

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Since the conference, the Hyperspectral Environmental Suite (HES) has been deferred with the earliest HES launch on GOES-T in 2019. The report reflects these changes. The original presentation slides may be found at: ftp://ftp.osd.noaa.gov/ in the "Fourth GOES-R User conf" folder.

2. SESSION 1 – WELCOME AND KEYNOTE

2.1. Introduction

Jim Gurka, Co-chair, welcomes the participants.

Gary Davis, Director, Office of Systems Development, and James Gurka, GOES-R acting Chief Scientist, NOAA Satellite and Information Service, welcomed the attendees to the 4th GOES Users' Conference.

They said the purpose of the conference was to have discourse, listen and learn so that the next series of satellites is even more successful.

2.2. Conference Goals

(L to R) Speakers Mark Mulholland and Mary Kicza, Co-chair Gary Davis, and Speaker Anthony Comberiate

Mark Mulholland, NOAA/NESDIS Senior Program Advisor, described the goals of the conference:

- Continue to improve communication between NOAA and the GOES user communities
- Inform users on the status of the GOES-R constellation, instruments, and operations
- Promote understanding for the various applications of data and products from the GOES-R series
- Seek ways/define methodologies to ensure user readiness for GOES-R.

NOAA's aim is to:

- Ensure our users gain maximum benefit from the current GOES spacecraft
- Help our users prepare for the next generation of GOES spacecraft

2.3. GOES Program Status, Mary Kizca

Mary Kizca, Deputy Assistant Administrator, NOAA's Satellite and Information Service, presented an overview of NOAA's geostationary satellites, including a history. GOES was developed and launched by NASA but, once operational, was turned over to NOAA for day-to-day administration. The GOES program grew out of the successful use of geostationary weather satellites with the experimental SMS-1 and -2. Geostationary satellite experiments began in 1966. The early satellites had limited operational capability: they observed the Earth only 10% of the time and monitored cataclysmic weather events. GOES-4 through -7 added vertical sounding. GOES-7 carried an experimental search and rescue payload providing near-instantaneous detection of emergency distress signals. The current series of satellites, GOES-8 through -12, has been operational since 1994. These satellites are three-axis stabilized spacecraft with a separate imager and sounder. This formation provides simultaneous imaging and sounding 100% of the time in visual and infrared channels. The satellites also relay data from in-situ sensors to users throughout the western hemisphere: free-floating balloons, buoys, and remote automatic data collection stations located around the world.

GOES-N through GOES-P, the next generation to be launched, have the following capabilities:

- Simultaneous and independent imaging and sounding
- Improved pointing accuracy and less thermal distortion
- Flexible scan control allowing for improved short-term weather forecasts in local areas
- Improved power subsystem permiting uninterrupted operations during eclipse periods

The current GOES operational status is:

- GOES-9: Launched May 23, 1995. GOES-9 is a back-up spacecraft located at 155° West Longitude. It is partially mission capable and nearing end of life.

- GOES-10: Launched April 25, 1997. GOES-10 is operational as GOES-West at 135° West Longitude. It will begin a drift maneuver to 60° West Longitude in support of South American coverage following successful GOES-N launch and checkout.
- GOES-11: Launched May 3, 2000. GOES-11 is an on-orbit spare located at 105° West Longitude. It will be a replacement for GOES-10 at 135° West Longitude location following GOES-10 drift and GOES-N launch and checkout.
- GOES-12: Launched July 23, 2001. GOES-12 is operational as GOES-East at 75° West Longitude. Its sounder filter wheel is running slower than normal – ground software modification under consideration.
- GOES-N, now GOES-13, was launched soon after the conference on May 24, 2006. GOES-O is planned for launch April 2008, and GOES-P, October 2009.

2.4. GOES-R Program Overview, Anthony Comberiate

Anthony Comberiate, GOES-R System Program Director, defined the GOES constellation as two operational satellites and an on-orbit spare. The GOES mission is to satisfy national operational environmental requirements for 24-hour observation of weather, earth's environment, and solar and space environment. The GOES I-M (8-12) series has been operational since 1994. The GOES-N launch is planned for 2006 (subsequently successfully launched on May 24, 2006 – ed.) and GOES-O and -P are being built. The GOES-R series is needed to replace the GOES-N series, with an expected launch no earlier than 2014 and will be a part of the U.S. contribution to Global Earth Observation System of Systems (GEOSS). Mr. Comberiate noted that NOAA's satellites are named with letters on the ground, and re-named with numbers once achieving orbit.

Several general assumptions have been made about GOES. The satellites orbit the Earth in a geostationary orbit. The East position is 75° W Longitude; the West position is 135° W Longitude (may be changed to 138° - Ed). The central position, 105° W Longitude, is used for storage and contingency operations. The inclination is –0° +0.5°.

The GOES-R mission life is 7.5 years operational. In addition there will be 7.5 years combined terrestrial and on-orbit storage, with up to 5 years for either.

Mr. Comberiate described the system architecture and presented a status report on the GOES-R series. GOES-R will have significant improvement in technology over GOES-I and GOES-N series. The Imager will have:

- 5X improvement in geographic coverage rate
- 30 second repeats for severe weather threats
- 4X improvement in horizontal resolution
- 3X increase in channels

In addition the satellite will have the ability to detect lightning. There will be continuous coverage of total lightning flash rate over land and water.

Several GOES-R contractors have been selected. System Program Definition and Risk Reduction (PDRR) will be performed by Boeing, Lockheed Martin, and Northrop-Grumman. The System Acquisition Contract will be competitively awarded in May 2008. Instrument contracts have been awarded to ITT, BAE, Ball Aerospace, and Lockheed Martin Advanced Technology Center.

GOES-R Baseline Instruments have been identified to meet users' requirements:

- The Advanced Baseline Imager (ABI). This instrument monitors and tracks severe weather; images clouds to support forecasts. It will provide substantial improvements in spatial coverage as well as spectral and temporal resolution.
- Solar Imager, Solar Irradiance Sensor, and Space Environmental In-Situ Suite (SEISS). The solar imager images the sun and the solar irradiance sensor measures solar output to monitor solar storms. The SEISS measures magnetic fields and charged particles. It provides for early warnings for satellite and power grid operations, telecom services, astronauts, and airlines.
- Geostationary Lightning Mapper (GLM). This instrument detects lightning strikes as an indicator of severe storms, a capability that previously existed only on polar satellites.

Mr. Comberiate said that GOES-R has gotten off to a good start. (Ed. Note: The program completed the program definition and risk reduction phase in April 2007). The Request for Proposals should be released by the fall of 2007, with the goal of having an award by spring 2008. The acquisition and operations phase of the new series will need to be started as soon as possible. In closing, Mr. Comberiate told the attendees, "We need timely user inputs to solidify GOES-R requirements."

2.5. Keynote Address: Advances in Geosynchronous Observations of the Earth and Atmosphere, Dr. Paul Menzel

Dr. Paul Menzel delivers the Keynote Address.

Dr. W. Paul Menzel, NOAA/NESDIS, Chief Scientist in the Center for Satellite Applications and Research, gave the keynote address on "Advances in Geosynchronous Observations of the Earth and Atmosphere." He noted that geostationary satellites were introduced on December 6, 1966, when the Applications Technology Satellite (ATS-1) was launched. ATS-1's spin scan cloud camera provided full disk visible images of the Earth and its cloud cover in 20 minutes. With geostationary coverage, "the clouds moved – not the satellite" according to Verner Suomi; Ted Fujita took full advantage in estimating atmospheric motion vectors from time sequences of carefully geo-located images. ATS-1 was followed by a color version, ATS-3, in November 1967, which produced the first color movie of the planet. But there still was a dark night without an infrared imaging capability.

The success of the ATS led to NASA's Synchronous Meteorological Satellite (SMS) in 1974, an operational prototype dedicated to meteorology. SMS-1 and -2 and subsequent NOAA GOES provided:

- Multispectral imagery at 1-km spatial resolution in the visible and 7 km in the infrared window channel
- Weather Facsimile (WEFAX) providing low resolution GOES images and conventional weather maps to users with low-cost receiving stations
- Data Collection System (DCS) relaying data from remote platforms to a central processing facility

In 1977, the European Space Agency (ESA) launched Meteosat, which provided visible, infrared window, and water vapor imagery – these first-ever water vapor image loops changed how we view the Earth.

By 1980, the GOES evolved to the Visible Infrared Spin Scan Radiometer (VISSR) Atmospheric Sounder (VAS), expanding the multispectral imaging capability to atmospheric temperature and moisture sounding. In partnership with NASA, as part of the Operational Satellite Improvement Program, a sounding demonstration was accomplished. The time continuous monitoring of atmospheric stability, possible with VAS, revealed locations of subsequent severe weather.

In April 1994, GOES-8 was launched on a three axis stable platform (enabling better signal to noise in the measurements) and expanded to separate imaging and sounding instruments (allowing operational soundings for the first time). The GOES-8 through -12 satellites showed numerous improvements over their predecessors:

- Atmospheric motions were captured in much greater detail, which helped with hurricane trajectory forecasts
- Improved IR window cloud temperatures helped to estimate rainfall
- Sea surface temperatures every hour enabled attempts at current tracking
- Multispectral detection of volcanic ash and its motion
- Monitoring fire size and temperature
- Atmospheric temperature and moisture profiles useful for numerical weather prediction.

In 2002, EUMETSAT launched the Spinning Environmental Visible and InfraRed Instrument, SEVIRI, with 12 spectral channels that have set the standard for multispectral applications (i.e., monitoring a dust outbreak associated with a cold front in northern Africa; volcanic eruption near Madagascar; industrial pollution in Eastern Europe).

With GOES-R in the next decade, NOAA is evolving its geostationary remote sensing capabilities to faster imagers with more spectral bands complemented by high spectral resolution sounders later in the series. EUMETSAT is doing the same with their Meteosat Third Generation program. Japan, China, India, and Russia are improving their geostationary satellites as well.

In summary, Dr. Menzel said that we have been on the geostationary road for 40 years. The geostationary remote sensing capability has had many positive consequences: it has saved thousands of lives and millions of dollars from the ravages of storms; it has made meteorological satellite data routinely available to nations around the globe; and, in conjunction with improvements in numerical weather prediction, it has helped to improve forecast skill significantly. The creative mind of Verner Suomi enabled geostationary weather observations; that technology has become the cornerstone of worldwide remote sensing today.

3. SESSION 2 – GEOSTATIONARY SATELLITES AS A PART OF GEOSS (INTERNATIONAL)

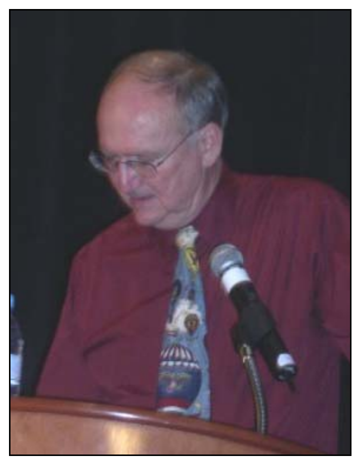
3.1. WMO Activities/GEOSS Plans, Dr. Don Hinsman, WMO Space Programme Office

Dr. Don Hinsman speaks on WMO activities.

Dr. Donald Hinsman, Director of the World Meteorological Organization (WMO) Space Program, presented "The WMO Space Programme Implementation Activities" relevant to the Global Earth Observation System of Systems. He described the current status of the expanded space-based component of the World Weather Watch's Global Observing System (GOS) including access by WMO Members to new data streams from research and development space missions and their impacts for operational use. Activities of particular note are the establishment of an Integrated Global Data Dissemination Service (IGDDS) and a High Profile Training Event planned for October 2006. The expected two orders of magnitude increase in satellite data by 2020 will require efforts by WMO to implement a data dissemination service that provides data access for all WMO Members. Dr. Hinsman described matters arising from the Group on Earth Observations (GEO) on the establishment of a Global Earth Observation System of Systems (GEOSS) and its associated 10-Year GEOSS Implementation Plan. WMO is hosting the GEO Secretariat in Geneva. The WMO Space Programme will be one of the core contributors to the space component of GEOSS.

3.2. Plans for China's Satellite Program, Dr. Jim Purdom, Colorado State University/CIRA

The geo-plans for China were summarized briefly by Dr. James Purdom, Colorado State University/Cooperative Institute for Research in the Atmosphere. The second Chinese geostationary meteorological satellite, FY-2C, was launched on June 2004 carrying GOES Imager-like spectral bands at 1-km (visible) and 5-km (IR) resolution. The satellite is spin stabilized and stationed at 105° E. FY-2D, planned for launch in November 2006, will continue this imaging capability. 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)



Dr. Jim Purdom speaks on China's plans.

3.3. Plans for EUMETSAT's Satellite Program, Ernst Koenemann, EUMETSAT

Ernst Koenemann, Director of EUMETSAT's Programme Development Department, noted that there are now two Meteosat Second Generation (MSG) spacecraft in geostationary orbit – Meteosat-8 since August 2002, and Meteosat-9 since December 2005. Both carry the 12-channel imager SEVIRI and a global earth radiation budget (GERB). Two more MSGs will follow. Mr. Koenemann also summarized the planning underway for Meteosat Third Generation (MTG). EUMETSAT is concluding (with ESA as partner) their user needs identification and feasible mission analysis. The candidate observation missions that have survived to date include:

- A Combined Imager that supports nowcasting and very short term forecasting with high resolution fast imagery enhancing full disk high spectral resolution imagery supplanting the MSG SEVIRI mission
- An Infrared Sounder (IRS) with 1700 channels of 0.6 cm^{-1} resolution sampling 700 to 2175 cm^{-1}, mission focused on atmospheric dynamics.

3.4. Plans for India's Satellite Program, Dr. P. C. Joshi, Indian Space Research Organization

Dr. P. C. Joshi, Head of the Atmospheric Sciences Division of the Satellite Applications Center for the Indian Space Research Organisation (ISRO), presented India's plans for geostationary environmental satellites. India launched INSAT-3A in April 2003. Kalpana, a geostationary satellite dedicated to meteorological applications, was launched in September 2002 carrying an imager with visible (2 km), thermal IR (8 km), and water vapor (8 km) channels and a 1-km CCD array at 0.7, 0.8, and 1.6 microns. Both of these satellites are operational for India. INSAT-3D launch is planned for 2007; the payload will include a 6-channel imager and a 19-channel sounder.

3.5. Plans for Japan's Satellite Program, Naotaka Uekiyo, Japan Meteorological Agency

Naotaka Uekiyo, Senior Scientific Officer for the Satellite Program Division of the Japan Meteorological Agency (JMA), gave an update on the status of the Multi-functional Transport Satellite (MTSAT). MTSAT-1R was launched in February 2005 and was followed by MTSAT-2 in February 2006. MTSAT-1R and MTSAT-2 are multi-purpose satellites with both aeronautical and meteorological missions that are planned to serve Japan's needs through the rest of the decade. The 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
- New ranging system using a turn-around HRIT signal at CDAS.

A follow-on to MTSAT-2 is being planned for 2013; a SEVIRI-like imager and a hyperspectral sounder are being discussed.

3.6. Plans for Korea's Satellite Program, Dr. Hee-Hon Lee, Department of Meteorological Satellites, Korean Meteorological Agency

Dr. Hee-Hon Lee, Director of the Department of Meteorological Satellites for the Korea Meteorological Administration (KMA), 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 weather such as storm, flood, yellow sand, etc.
- Extraction of data on long-term change of sea surface temperature and cloud.

COMS will carry a 5-channel meteorological imager (visible, 4, 6.7, 11, and 12 microns) and an 8-channel ocean imager (visible and NIR channels). Dr. Lee noted that COMS would be launched in late 2008.

3.7. Plans for Russia’s Satellite Program, Dr. Valery Evdokimov, Russian Federal Service for Hydrometeorological and Environmental Monitoring

Dr. Valery Evdokimov, Head of the Remote Sensing and Oceanographic Satellites Data Archiving Department for the Scientific and Research Center “Planeta” of the Russian Federal Service for Hydrometeorology and Environmental Monitoring, presented their geostationary plans for GOMS Electro N1, which will be launched to geostationary orbit at 76° E in 2007. Electro N1 will carry a two-channel visible and IRW imager. GOMS Electro N2 satellite will follow in 2009, and will carry on a three axis stable platform the 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).

The primary mission objectives for GOMS Electro 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 the hydro-meteorological data from national and international platforms (DCPs) to the main and regional forecasting centers
- Helio-geophysical measurements at geostationary orbital altitude
- 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.

3.8. Considerations for GOES-R Readiness in Canada, Mike Manore, Meteorological Service of Canada

Mike Manore, Director of the Canadian Ice Service for Environment Canada, was recently appointed project lead for Environment Canada's Space-Based Monitoring (SBM) Project. The SBM Project will be responsible for coordinating and implementing Environment Canada's infrastructure for satellite reception and access to satellite data products, including the operational requirements for the Meteorological Service of Canada (MSC). Mr. Manore presented some thoughts on Canadian user preparedness for GOES-R. The MSC relies on geostationary data for operational weather nowcasting/forecasting, 4-D VAR assimilation of radiances and winds in NWP, and environmental monitoring of sea ice, volcanic ash, drought/flood, and fires. Research is conducted to optimize algorithms for Canadian environments. Preparations for GOES-R include familiarization with the new data formats to upgrade reception facilities, user training to utilize the enhanced capabilities, and optimization of algorithms for local application. Mr. Manore noted that Canadian contributions to global observing would be complementary to geo (e.g., SAR) but not include geostationary satellites.

The session concluded with the observation that the Global Observing System is truly an international enterprise and that evolution of the geostationary component as outlined in the presentations represents a significant increase in observing capability.

4. SESSION 3 – INFORMATION BRIEFINGS: BASELINE INSTRUMENTS

The session regarding information briefings on the GOES-R baseline instruments was chaired by Steven Hill and Tim Schmit. The myriad of applications was described from the baseline instruments on the GOES-R series.

Breakfast before start of Session 3

4.1. Advanced Baseline Imager (ABI), Tim Schmit, NOAA/NESDIS

Tim Schmit, Speaker and Co-chair

Tim Schmit, NOAA/NESDIS Center for Satellite Applications and Research (STAR), described the next generation geostationary satellite imager, which will offer a continuation of current products and services and enable improved and new capabilities. The Advanced Baseline Imager on GOES-R has been designed to meet user requirements covering a wide range of phenomena. As with the current GOES Imager, the ABI will be used for a wide range of weather, oceanographic, climate, and environmental applications. The ABI will improve upon the current GOES Imager with more spectral bands, faster imaging, higher spatial resolution, better navigation, and more accurate calibration. The ABI expands from five spectral bands on the current GOES imagers to 16 spectral bands in the visible, near-infrared, and infrared spectral regions. There will be an increase of the coverage rate leading to full disk scans at least every 15 minutes. ABI spatial resolution will be 2 km for the infrared bands and 0.5 km for the 0.64-μm visible band. ABI will improve every product from the current GOES Imager and will introduce a host of new products. Current products include: retrieved Atmospheric Motion Vectors (AMVs), Quantitative Precipitation Estimates (QPEs), cloud parameters, clear-sky radiances, and surface (skin) temperature; and detection and characterization of fires, volcanic ash, fog and (experimentally) cloud-top information. ABI will also provide cloud-top phase/particle size information and much improved snow detection, aerosol and smoke detection for air quality monitoring and forecasts. Other new products include vegetation monitoring and upper-level SO_2 detection.

4.2. Geostationary Lightning Mapper – Description and Applications, Dennis Boccippio, NASA, and Joe Schaefer, NOAA/NWS

A description and applications of the Geostationary Lightning Mapper (GLM) were given by Dennis J. Boccippio, NASA Marshall Space Flight Center, with Joseph T. Schaefer, NOAA National Weather Service Storm Prediction Center, as co-author. This key instrument on GOES-R will provide real-time measurements of lightning activity over the full disk. The GLM will be an optical system that will detect in-cloud (IC) as well as cloud-to-ground (CG) lightning flashes with high efficiency, both during the day and at night. In February 2006, formulation contracts to evaluate potential equipment architectures and to assess potential performance requirements were let to Lockheed Martin Space Systems, Ball Aerospace, and ITT Industries. Preliminary estimates of the performance capabilities and possible advanced capabilities for the GLM such as sub-pixel resolution and IC versus CG identification were given. It is anticipated that the GLM data will have immediate applications to aviation weather services, climatological studies, and severe thunderstorm forecasts and warnings. Ongoing risk reduction activities include the Tropical Rainfall Measuring Mission (TRMM) lightning imager, and several Earth-based lightning mapping arrays that are used in an experimental mode by several NWS Offices. The operational potential of total lightning data was illustrated by reviewing several of the papers presented at the 2005 Southern Thunder Alliance Workshop, which brought together government, university, and industry to discuss the use of total lightning observations to improve the nowcasting and warning of severe weather. (See http://weather.msfc.nasa.gov/sport/2005_southern_thunder_agenda.html.) It was noted that more data would be collected for a given point on the Earth after only two weeks of GLM operations than has been collected from TRMM to date.

4.3. Hyperspectral Environmental Suite (HES) Sounder, Paul Menzel, Chief Scientist, NOAA/NESDIS/STAR

The sounder intended for the GOES-R series was described by Dr. W. Paul Menzel, NOAA/NESDIS, Chief Scientist in the Center for Satellite Applications and Research (STAR). Operational high-spectral-resolution infrared radiance measurements from the geostationary perspective were to be introduced on GOES-R with the Hyperspectral Environmental Suite (HES) – Infrared. These advanced sounders will have over one thousand channels with spectral widths of less than a wavenumber, while the current GOES sounders have only 18 bands with spectral widths of tens of wavenumbers. The HES-IR will improve upon the current GOES sounders by expanding the hourly spatial coverage, increasing the vertical temperature and moisture sounding resolution, capturing atmospheric motions at many more levels, and penetrating 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-IR will accomplish hemispheric Disk Soundings (DS) and Severe Weather Mesoscale (SW/M) soundings. DS will provide better than 10-km spatial resolution; selected spectral coverage between 4 and 15 μm will be accomplished every hour for the full disk (out to 62-degrees local satellite zenith angle). SW/M will cover a 1000 x 1000 km area in 4 minutes at 4-km spatial resolution for the infrared (IR) bands; SW/M will be directed to regions where severe thunderstorms, hurricanes, or severe winter storms are pending or where numerical forecast models have low confidence (enabling targeted observations). HES-IR will be able to multiplex DS and SW/M functions. While budgetary and risk issues prevent the incorporation on GOES-R, it is hoped that the HES will be available later in the series.

4.4. GOES-R Coastal Waters Imaging and the COAST Risk Reduction Activities, Curtiss Davis, Oregon State University

Curtiss O. Davis, Oregon State University, spoke on the GOES-R Coastal Waters Imaging and the Coastal Ocean Applications and Science Team (COAST) Risk Reduction Activities. Coastal waters are highly dynamic. Tides, diurnal winds, river runoff, upwelling and storm winds drive currents from one to several knots. Three-hour or better sampling is required to resolve these features, and to track red tides, oil spills, or other features of concern for coastal environmental management. To provide this capability, NOAA hopes to include Coastal Waters (CW) imaging as part of the Hyperspectral Environment Suite (HES) later in the GOES-R series. The HES-CW will image the U.S. coastal waters once every three hours, with selected regions hourly. It will have approximately 375-m spatial resolution and the high signal-to-noise ratio necessary for coastal imaging. To prepare for HES-CW NOAA has formed the COAST team, whose goals are to ensure that ocean applications and science requirements are met, and to help NOAA prepare for the immediate use of the data when HES-CW is launched. The presentation described the HES-CW requirements, planned products, and the COAST planned risk reduction activities to prepare for the use of HES-CW data.

4.5. Solar Imaging and Space Environment In-Situ Suites, Dr. Howard J. Singer, NOAA/NWS, Space Environment Center

Dr. Howard J. Singer, Chief of the Science and Technology Infusion Branch at NOAA's Space Environment Center, described how GOES-R Solar and Space Environment Data would serve society. The Space Weather Week (SWW) user conference, which was held the week before this GOES-R conference, was attended by about 350 users of NOAA space weather forecasts. The SWW users indicated strong support for the forecasts and products that rely almost solely on the GOES space environment sensors. Instrumentation on GOES-R to monitor the highly variable solar and near-Earth space environment continues a long history of space weather observations from the GOES program. These observations are used to protect life and property of those adversely impacted by space weather conditions.

Dr. Howard Singer describes the Solar Imaging and Space Environment In-Situ Suites.

The expanded services in the GOES-R era will improve support of forecasters at NOAA's Space Environment Center; customers in other government agencies, such as DoD and NASA; commercial users of space weather services; and international space environment services. This expansion of services is enabled both by the modest, incremental improvements to the GOES space weather instruments and by substantial improvements in understanding the physics of space weather.

The instruments that contribute to the new services and products include: the Solar Imaging Suite (SIS), that will measure solar X-rays and solar EUV radiation (Ed note: instead of a suite there will be individual sensors: the Solar UV Imager (SUVI), and the Extreme UV/ X-Ray Irradiance Sensor (EXIS)); a solar coronagraph (SCOR) that is part of the SIS suite of instruments, and is currently designated as a pre-planned product improvement instrument; and the energetic particle instruments, called the SEISS (Space Environment In-Situ Suite), that will provide multiple measurements characterizing the charged particle population, including measurements of the electron, proton, and heavy ion fluxes. Finally, Earth's magnetic field will be measured by a magnetometer (MAG), which is part of the spacecraft procurement. Algorithm and model development are proceeding to make maximum use of the data to be returned by these instruments. The products supported by these instruments will contribute to the global Earth and solar observations that are used in NOAA's operations to continuously specify and forecast conditions in the space environment.

5. SESSION 4 – USER READINESS ISSUES AND BREAKOUT SESSION REPORTS – ISSUES I: CONOPS, ARCHIVE, DATA DISTRIBUTION, NUMERICAL WEATHER PREDICTION (NWP)

5.1. U.S. Air Force Readiness for GOES-R: GOES-R Data Exploitation Activities, Thomas Coe, Air Force Weather Agency

Mr. Thomas E. Coe, Strategic Center Programs Division, Air Force Weather Agency (AFWA), described AFWA's mission as: Arming our Nation's forces with essential air and space environmental intelligence, training, and technical services to ensure battlespace awareness and decision superiority, anytime, anywhere. The mission has an operational focus, which places support to operational applications as the top priority for development resources. The enduring principles are:

- Worldwide data collection and dissemination of products and services
- Precise specification of battlespace environment – to determine tactics, equipment assignment, etc.
- Real-time cloud analyses and forecasts

AFWA provides backup operations for several NOAA operations, including the Storm Prediction Center, Aviation Weather Center, National Volcanic Ash Advisory Center, Environmental Modeling Center, and the Space Environment Center.

AFWA's mission is focused on combat decision makers and deployed forces. The forecasts are mission-specific rather than wide-area, general forecasts. The main concern is the impact to the mission. Mr. Coe said that AFWA collects and ingests all data possible to create over 600,000 products for dissemination to users worldwide. The systems, models, and applications include:

- Satellite Data Handling System (SDHS)
- Cloud Depiction and Forecast System, Second Generation (CDFS II)
- Satellite Image Display/Analysis System (SIDAS)
- Space WX Analysis & Forecast System (SWAFS)
- Mesoscale Model Version 5 (MM5)
- Land/Surface Model (AGRMET)
- Joint METOC Broker Language Databases

Mr. Coe discussed the notional NPOESS architecture. This represents both a driver and an opportunity to relook the way in which satellite data are stored and used. Every type of satellite data will be sent to a landing zone on the central storage array; an applications platform will convert the data into standardized databases and place them in a central delivery area for use by all (AFWA) systems. Currently AFWA has to modify each system to process new data types and formats; after this change, AFWA will be able to ingest new data streams without modifying each processing system.

Mr. Coe described the anticipated benefits of NPOESS data and GOES-R data at AFWA. He said that AFWA expects significant improvement in Numerical Weather Prediction accuracy with the dramatic increase in available vertical channel data. AFWA will use almost all of the planned GOES-R Environmental Data Records, with emphasis on:

- The future Hyperspectral Environmental Suite – vertical temperature and moisture profiles, cloud-top temps; cloud tuning
- Geostationary Lightning Mapper

- Space Weather: Space Environment In-Situ Suite; Solar Instrument Suite; Magnetometer
- Rapid Scan Winds – Improved tropical storm fixing

5.2. GOES-R Opportunity for the U.S. Navy, Thomas Lee, Naval Research Laboratory

Mr. Thomas Lee, Naval Research Laboratory, Monterey, said that the improved spatial resolution of GOES-R would result in numerous improvements. We will see improved detail in cloud top heights, and better cloud/snow detection. GOES-R will have new dust capabilities similar to MODIS. In true color, we cannot see a dust storm because it is the same color as the land below it. The GOES-R red channel near-IR will show clear dust and smoke presence and source regions, starkly contrasted from the ground. GOES-R will provide improved temporal coverage required by the Navy.

Satellite winds from GOES-R Advanced Baseline Imager (ABI) will be improved in the following ways:

- More frequent – shorter time intervals available
- Higher spatial resolution – better cloud edge detection
- Increased spectral bands – improved cloud height detection
- Improved signal to noise – better target detection and tracking
- Superior navigation/registration – reduced wind vector error

5.3. Understanding the Importance of Satellite Data to Operational Fisheries Management, Cara Wilson, NOAA/NMFS

Dr. Cara Wilson, NOAA National Marine Fisheries Service, described the importance of satellite data to operational fisheries management. Satellite data are needed to describe most ocean features that are important to ecosystems. Many temporal events such as upwelling, oil spills, El Niño events, and harmful algal blooms can be easily measured by satellite data. Ocean color data, such as will be provided from the future HES-CW, provide measurements of chlorophyll and primary productivity, which quantify the base of the marine food chain. No other biological component of the marine ecosystem is accessible to satellite remote sensing.

Examples of the uses of the data include:

- Timing of the spring bloom and haddock survival
- Characterizing habitat of living marine resources
- Discovering habitat: Large recurrent chlorophyll blooms were discovered with satellite data in the middle of the oligotrophic Pacific gyre. The blooms occur within the target area of several fisheries, including albacore and swordfish, but their impact on higher trophic levels is not known. Satellite imaging is helping us to understand more about such blooms and how to understand effects.
- Forecasting Right Whale distribution to mitigate ship-strike mortality
- Harmful Algal Bloom (HAB) detection
- Cruise support

Dr. Wilson quoted a recent letter from Bill Hogarth, NOAA Assistant Administrator for Fisheries, to Greg Withee, NOAA Assistant Administrator for Satellite and Information Services. "The increased spatial and temporal resolution of data from the Hyperspectral Environmental Suite – Coastal Waters imager (HES-CW) on GOES-R will greatly improve our ability to characterize and monitor coastal regions for better management of ecosystems and fisheries. Environmental satellite data are essential to efficiently fulfill the National Marine Fisheries Service's legislated mandates (i.e., the Magnuson-Stevens

Act, the Marine Mammal Protection Act, and the Endangered Species Act) to monitor and manage living marine resources and their habitat." Mr. Hogarth noted that the U.S. commercial fishing industry contributes approximately $32 billion to the U.S. gross national product, and recreational fishing contributes an additional $25 billion.

Dr. Wilson said that it could be difficult to access and manipulate the large depository of existing satellite data. Efforts are underway to address this:

- New live access server (LAS) and browser at the West Coast CoastWatch Node provide access to multiple satellite datasets, in a variety of formats, including IOOS-compatible OPeNDAP technology.
- Four NMFS scholarships were given this year to attend a 2-week satellite course at Cornell University.
- A 3-day course for NMFS and National Ocean Service participants on accessing and using satellite data is being planned for Aug. 22–24 at Oregon State University in Corvallis, Oregon.

Dr. Wilson said that resources managers want the following:

- High quality datasets
- Temporal, spatial resolutions compatible with management activities and ecosystem dynamics
- Long, consistent, time series
- Flexible, easy access to data – (OPenDAP, LAS, CWBrowser etc.)
- Subsetting, and slicing capabilities
- Multiple file formats
- "One-stop shopping" for multiple datasets

5.4. Third GOES-R Users' Conference Recommendations: User Readiness Issues James Gurka, NOAA/NESDIS

James Gurka, GOES-R acting Chief Scientist, NOAA Satellite and Information Service, discussed recommendations from the Third GOES Users' Conference that related to risk reduction, education and training, and the proving ground concept. Recommendations on risk reduction included the following:

- Provide test data sets well in advance of operations
- Leverage NPP synergy and experiences
- Develop and validate new or improved products before launch
- Form expert teams for each core sensor; involve the end users at the local level
- Re-package products to support multiple levels of users
- Engage existing organizations (e.g., JCSDA)
- Establish a focused coastal and ocean user group
- Use simulated data sets to test and validate data processing and distribution systems
- Ensure sufficient overlap with GOES-N series for in-orbit validation
- Organize a coordinated field campaign to use in-situ measurements for validation
- Test GOES-R system end-to-end before launch

Mr. Gurka said that some of the issues being addressed at this 4th GOES Users' Conference concern CONOPS, archives, data distribution, and Numerical Weather Prediction (NWP). In terms of CONOPS, there are questions:

- ABI/HES continuous full disk vs. mesoscale. The decision-making process includes a question as to the location and number of areas (possibly making multiple measurements). There is also an issue of prioritization/conflict resolution. For example, is there sufficient full disk for winds? What should be the degree of automation?
- Automated selection of clear areas, including HES soundings and HES coastal waters imaging.

Mr. Gurka reminded the attendees that the 5th GOES Users' Conference would be held in New Orleans, Louisiana, January 23-24, 2008. It will be held in conjunction with the 88th American Meteorological Society (AMS) Annual Meeting. The GOES Conference supports the AMS Meeting Theme: Enhancing the Connectivity between Research and Operations for the Benefit of Society.

NOTE: *In the conference, after presentations were given on CONOPS, archival, data distribution and numerical weather prediction, four breakout groups were formed to discuss those issues. For clarity, this report is organized so that each presentation is immediately followed by the report of that breakout group.*

5.5. CONOPS

5.5.1. GOES-R Instrument CONOPS Considerations, Tim Walsh, NOAA, GOES-R Program

Mr. Tim Walsh, NOAA, GOES-R Program, presented an overview on GOES-R Instrument CONOPS considerations. He described: today's constellation, typical scanning scenarios, tasking impacts, special tasking, ABI and HES modes, trade studies, and points to consider. Today's constellation is:

- GOES-8 was deorbited 5/2/04; currently it is 350 km high
- GOES-9 is in a slow drift east
- GOES-10 is operational at 135° West
- GOES-11 ZAP Storage 105° West
- GOES-12 is operational at 75° West

The current scanning scenarios are: routine, full-disk, and rapid scan operations. Routine scanning involves a 3-hour sequence. A full disk scan is followed by five half-hour sequences that include extended Northern Hemisphere, CONUS, and Southern Hemisphere scans. A full-disk scenario involves full disks every half hour (with band-by-band calibration and stars). Rapid scan operation (RSO) doubles CONUS coverage (to 4X per half hour), drops Southern Hemisphere coverage, and provides a full disk scan every 3 hours for synoptic coverage. Super Rapid Scan Operations (SRSO) is a subset of RSO that provides up to 1-minute scanning over specified areas.

GOES-R ABI scan mode 3 has interwoven observations that accomplish:

- A mesoscale (located anywhere in the full disk) every 30 seconds
- A 5000 km x 3000 km CONUS every 5 minutes
- A full disk observation every 15 minutes (due to the interruptions)

Scan mode 4 has uninterrupted observation of the full disk – a full disk in 5 minutes.

Future Hyperspectral Environmental Suite (HES) tasks would include:

- HES -Disk Sounding (HES-DS): 62° LZA/hour coverage rate at 10-km spatial resolution

- HES -Severe Weather / Mesoscale (HES-SW/M): 1000 km x 1000 km / 4.4 minutes coverage rate at 4-km spatial resolution
- HES -Coastal Waters (HES-CW): U.S., Exclusive Economic Zone coverage (400 km wide) by length of U.S. coastline (~ 6000 km) in 3 hours at 375-m spatial resolution

Trade studies are currently underway that may impact instrument tasking. The "NOAA GOES-R Solicitation No.: DG133E-05-RP-1034, Contract Data Requirements List (CDRL), March 22, 2005" states:

- "Perform a trade study to utilize spacecraft and instrument data to perform "smart tasking" of on-board science payloads. Investigate the integration of sensor fusion and "tip off" techniques to dynamically task the ABI, HES and/or other instruments."
- "Identify and assess techniques which eliminate or greatly reduce the time that the Level-1b data products are out of specification as the result of spacecraft maneuvers. Spacecraft maneuvers include: momentum management, yaw flip and stationkeeping. Describe advanced concepts that may be used to increase operational availability."

During the system Program Definition and Risk Reduction (PDRR) phase, which ended in April 2007, information from these trade studies were utilized to update Functional and Performance specifications for the space and ground segments.

Mr. Walsh presented the following questions for consideration:

- How will RSO tasking requirements change given the vastly improved temporal resolution of ABI?
- Will the sort of dynamic tasking used today really even be necessary given the frequency of an ABI mode-3 scenario?
- How does the system utilize science or engineering data to maximize effective science data recovery? – Inter- or intra-platform data utilization
- What process should be used in determining the observational priorities for the instruments, particularly ABI and HES?
- How much automation is acceptable to the operational NOAA organizations (NWS, OSDPD and OSO) and to the users?

Mr. Walsh emphasized to the attendees, "This stage in the GOES-R developmental process is an excellent time to field your questions, comments and feedback."

5.5.2. Breakout Session Report on CONOPS

Doris Hood, NWS Spaceflight Meteorology Group at Houston, Texas, presented the findings for the breakout group on CONOPS. The attendees were asked to share their thoughts on several topics to help prioritize change requests.

CONOPS breakout group

- ABI operational mode already defined
- Define and prioritize users and their respective requests
- Set up rules and business practices to anticipate decisions before event occurs
- Identify events that would drive automated changes to the standard schedule
- Life and property take precedence over scientific pursuits

The session looked into the following questions:

1. *Should the requests for operational modes be prioritized and either granted or rejected by one single point of contact in order to maintain a swift and efficient process? If yes, where should this authority lie? If no, please provide alternative solutions.*

- A single point of contact for operational mode prioritization is most effective / efficient.
- SDM is still the logical choice; requires automation to support the decision process.

2. *Please provide suggestions on the process of issuing requests for GOES-R operational modes.* Suggestions included the following:

- Assume question addresses overall semi-permanent scan modes
- Post-launch review of products and system capabilities to refine operational modes
- ABI and HES probably have different request processes
- Create senior user advisory group to address new requirements for operational scan mode

3. *Please provide suggestions on the synergistic use of GOES-R and NPOESS for your application*.
Suggestions included:

- Synergistic coverage of severe weather
- Schedule GOES-R coverage to coincide (time and location) with NPOESS coverage – NPOESS cannot choose its time of coverage of an area
- Prioritization of NPOESS product generation could be driven by GOES-R event tip-offs.

4. *What other questions or issues would you like the group to address regarding CONOPS?*
Other questions and topics that the group would like to address include:

- If orbit location is off, fixed grid format is still desirable rather than blacking out invalid pixels, and still archive limb data
- Geostationary microwave sounder is an unfunded requirement; still desirable?
- HES CONOPS is hard to develop due to the uncertainties of the HES instrument configurations based on budget and schedule uncertainties.
- At 2008 GOES-R Users' Conference, define strawman schedule for instrument operations.

5.6. Archival

5.6.1 Data and Products Archival in the GOES-R Era, Rick Vizbulis, NOAA/NESDIS

Mr. Rick Vizbulis, NOAA's CLASS Project Manager, discussed the "Role of CLASS in GOES-R." The Comprehensive Large Array-data Stewardship System (CLASS) is a Web-based data archive and distribution system for NOAA's environmental data. It is an evolving system that will support additional "campaigns," broader user base, and new functionality as implementation continues for the next 10 years. CLASS is the principal IT system supporting NOAA's responsibility as an environmental data steward. CLASS concurrently supports both ongoing operations and new requirements implementation.

The vision of CLASS is to:

- Eliminate the various "stove-pipe" systems and produce a unified "enterprise" data access system
- Centralize NOAA's numerous data systems for environmental data access
- Create a single portal
- Retain, as much as possible, portions and modules of existing legacy systems
- Be cost effective

NOAA's National Data Centers and their worldwide clientele of customers look to CLASS as the sole NOAA IT infrastructure project in which all NOAA's current and future environmental data sets will reside. CLASS provides permanent, secure storage, and safe, efficient data discovery and access between the Data Centers and the customers.

CLASS services for GOES-R are:

- CLASS will provide archive and access (AA) services to GOES-R to meet specific program needs found in the GOES-R Mission Requirements Document (MRD)
- Archive Level 0 and derived data products and metadata
- Provide retrospective data distribution
- Archive and access needs not met by CLASS will be provided by the GOES-R Acquisition and Operations (A&O) contractor

CLASS is one of three GOES-R infrastructure interfaces. CLASS is tied to almost every GOES-R structure interface (other than satellite itself). As we move forward and define roles, we will need to look at all interface areas.

According to Section 3.7.1 of the GOES-R Mission Requirements Document (MRD):

- Accommodate ingest function up to GOES-R data rates approaching 100 Mb/s
- Provide user access via the Internet using a standard web browser
- Support searches for data of interest based on source, instrument, time, and location and provide browse images as a search aid
- Provide electronic delivery via "pull" (CLASS system will notify the requester that the requested files are available at a specified FTP site and the user has a specific number of days in which to retrieve the files before they are purged) or "push" FTP accounts (CLASS system will automatically attempt to push the requester's files to the requester's system as soon as the files have been retrieved)
- Support subscription service with either "push" or "pull" delivery; "bulk orders" for large orders having file sizes or numbers of files beyond certain established parameters; or requests for media (such as CD or tape)
- GOES data products will be archived and distributed in their native formats (since they are much smaller in volume relative to the GOES data)
- Data to be archived include Level 0 and derived data products. CLASS will allow users to subset the GOES data, e.g., geographic sub-setting within user-specified spatial, spectral, or temporal limits or a reduced resolution data set using sub-sampling techniques. CLASS will also allow the User to specify alternative data formats, e.g., GVAR (or future GRB), NetCDF or McIDAS area files

Mr. Vizbulis presented a status report on CLASS. The GOES-R Program Office and CLASS Project Office recognize the GOES-R system dependency on CLASS to meet its mission and to ensure success are working closely to:

- Verify and document what services CLASS will provide in the GOES-R time frame that will meet GOES-R requirements
- Finalize the CLASS interface control document with GOES-R as an applicable document for the GOES-R Acquisition and Operations (A&O) Request –For Proposal (RFP)
- Ensure funding will be available to support GOES-R specific CLASS development efforts

5.6.2. Breakout Session Report on Data Archive and Access

Bill Emery of the University of Colorado at Boulder presented the findings of the breakout group on Data Archive and Access. The session looked into the following questions:

1. *What centrally produced derived products do you need to have archived?*
   - Keep all Level 0 data
   - Easy to get and subset: data type; time; place
   - Product generation optimized: generate on the fly, or archive the product
   - Decide how to optimize accessibility

2. *What locally produced derived products do you need to have archived?*
We need to define a process for determining which products are worthy of archive and might become standard/operational products. An earlier CDR report from NRC addresses this process. An overarching question is whether CLASS should be a gateway or repository for worldwide products? How does CLASS fit in GEOSS?

3. *After products are re-processed (e.g., for climate applications), should all previous versions of the products remain in the archives?*
The group felt that it was not necessary to keep all previous versions of the products in the archives. In many cases it is quicker and more efficient to re-generate the data set than to retain the previous version. Usually the re-processing resulted from just fixing a bug, so the previous versions are not needed.

4. *What metadata is required?*
The group said that as much metadata as possible should be archived and accessible. Metadata is generated by the science team; metadata should be easily and efficiently searchable.

5. *Should NWS forecast offices have a limited capability for temporary archiving of GOES-R data and products? If limited local archiving is desirable, how long? (one week, one month?)*
The group felt that the forecast offices should answer the question. The question is line-service specific.

6. *Should AWIPS or AWIPS follow-on system be able to directly access GOES-R data and products from CLASS? What about other operational systems?*
The group also felt that another group should address this question. It was noted that CLASS is not a real-time system.

7. *Should CLASS have the capability to generate local climatological studies or should CLASS simply provide the imagery that local offices can use to develop their own climatology?*
The group said that CLASS should provide the capability to subset the data to generate the climatology. CLASS should not do the climatology, but data should be sub-settable (in more than one way) so others can do the climatology.

8. *What ABI data formats might CLASS make available? (NetCDF, McIdas area?)*
The question was changed to, "What data formats should CLASS support?" The response was:

- NetCDF, McIdas area, GRiB, GEO TIFF, HDF5
- Need tools to make formats useful to users
- User ability to select delivery format
- What is the role of CLASS in servicing and maintaining conversion tools?

9. *Should each data format from CLASS allow options for (calibration) conversion into a number of geophysical units? If so, which ones?*
Yes, if it is not too complicated. It should be made easy to use with many different geophysical products.

10. *For your applications, do you think the ABI data before or after spatial re-gridding should be archived?*
The question was answered as follows:

- Keep Level 0 data
- Be able to generate either 1A or 1B data from Level 0 data
- Responsibility of each product user to analyze demand and cost/complexity to determine level of data needed
- CLASS should work with producers to determine which products should be archived vs. recreated

11. *What other questions or issues would you like to have the group discuss?*
   - There is a need to create a phenomenology database to capture events in space and time with a name of the event that can be searched in the archive
   - Determine data structure during development
     - Use; application; user expectationData stewardship
     - User advisory group
     - Science from Data Centers
     - When to remove or what to reprocess
     - Try to involve less sophisticated users

5.7. Data Distribution

5.7.1. Data Distribution, Tom Renkevens, NOAA/NESDIS

Tom Renkevens, NOAA/NESDIS, Office of Systems Development, discussed GOES-R data distribution. He identified observational requirements and outlined the GOES-R baseline instruments to meet user requirements. These are:

- Advanced Baseline Imager (ABI): monitors and tracks severe weather; images clouds to support forecasts
- Solar UV Imager (SUVI), the Extreme UV/ X-Ray Irradiance Sensor (EXIS) and Space Environmental In-Situ Suite (SEISS): images the sun and measures solar output to monitor solar storms (SIS); measures magnetic fields and charged particles (SEISS); enables early warnings for satellite and power grid operations, telecom services, astronauts, and airlines
- Geostationary Lightning Mapper (GLM): detects lightning strikes as an indicator of severe storms

With the improved GOES-R instruments, the available environmental data will grow by a significant amount. The user community has expressed interest in receiving the full GOES-R environmental data stream (GFUL). In consideration that GFUL distribution might not be feasible to all users, NOAA has defined a subset of the GFUL data stream termed the GOES Re-Broadcast (GRB). The content of the GRB data stream should meet the needs of most users and will be dependent on the design solution; i.e., technology, coverage, and cost.

The Mission Requirements Document (MRD) states that key data users include, as a minimum, NOAA's National Weather Service, including: NCEP Units of TPC in Miami, SPC in Norman, AWC in Kansas City, OPC, HPC, CPC, EMC in Camp Springs, SEC in Boulder, NCEP Modeling Centers in Fairmont West Virginia, NWSTG in Silver Spring and its backup at TBS, DoD in AFWA in Omaha, FNMOC in Monterey, NESDIS in Camp Springs and Suitland; other portions of NOAA; academia."

The MRD says that CLASS will distribute data and products to a wide variety of users ranging from scientists doing weather and environmental research, to school children doing homework, to other interested parties wanting a satellite image of a recent storm in their area. Users will access the CLASS site via the Internet using a standard web browser. The system will enable users to search for the data of interest based on source, instrument, time, and location and will provide browse images as a search aid. Future enhancement to CLASS will potentially enable more advanced search capabilities such as natural language processing, browse animations, and category searches, e.g., "tornados" or "clear days."

Mr. Renkevens said that the large increase of GOES-R data might prevent the entire set of Level 1b data, called GFUL, from being rebroadcast. A subset of these data, GRB, will be transmitted to the GOES-R satellite for rebroadcast to all users. Key users will receive GFUL data by TBD method.

Mr. Renkevens outlined data distribution issues:

- Data rate increases:
    - Rebroadcast: > 17 Mb/s (GRB) vs 2.1 Mb/s
    - Level 1b: > 100Mb/s (GFUL) vs 2.1 Mb/s
    - Level 2/3 products: approx 1.5 Gb/s vs < 4.7 Mb/s
    - Number of products: > 160 vs 41
- Data distribution considerations under study:
    - Distribution methods for GFUL
    - Development of a product generation (PG) system that will meet production processing timelines and product latencies.
- Contents of GRB under study:
    - Level 1b and/or Products
- Support of various data formats (MRD ID#6494)
    - "The PD shall process product formats including, at a minimum (TBR), GIF, Text, BUFR, GRIB, Binary, JPEG, NetCDF, and McIDAS files or their replacement file formats."
    - Other potential formats are under discussion
- Some current distribution methods include: GVAR Direct Readout, NOAAPORT, McIDAS, Unidata IDD

Mr. Renkevens described the current GVAR direct readout system, NOAAPORT distribution and evolution, and McIDAS evolution. New, advanced instruments, such as those on NPOESS and GOES-R, will require more powerful functionality. NOAAPORT and AWIPS are moving to a Service Oriented Architecture (SOA), and will have the ability to increase data rates in their DVB-S system. The candidate transition system for the future of McIDAS is proposed as the Integrated Data Viewer (IDV), based on SSEC's VisAD package. The IDV has a data model that is inherently capable of working with standard data types both now and in the future. It was developed for education community by Unidata and is designed to replace McIDAS at universities. Unidata's IDD (Internet Data Distribution) has proven data delivery of over 500Mb/s without introducing product latency.

The great amount of information from the GOES-R series will offer both a continuation of current products and services, and provide improved or new capabilities. NOAA needs to continue to work with users and PDRR contractors to shape requirements and define GRB content.

5.7.2. Breakout Session Report on Data Distribution

John L. (Jack) Beven, NOAA/NWS National Hurricane Center, presented the breakout group's thoughts on Data Distribution. The session looked into the following questions:

Data Distribution breakout group

1. *Please list the pros and cons of the following options for data and product distribution for your applications:*

- GOES Rebroadcast
    - Pros: support mobile users; highly reliable; "you get it all"; easy method, timely
    - Cons: more complicated than current; increased hardware costs; "you get it all"

- Commercial Rebroadcast
  - Pros: cheaper hardware; expandable; in mix with other GEOSS partners; won't need transmitter on satellite; multiple on-orbit resources; no spectral limits; can decrease disk size; significant bandwidth
  - Cons: high cost to access; lose link to legacy hardware; is additional failure point; added latency Internet
  - Pros: cheap and easy; flexible; many providers
  - Cons: same data sent multiple times; not real time; reliability problems; access outside United States; can't handle bandwidth; wide variability of access; reliance on commercial internet
- TV Broadcast
  - Con: a step backwards
- Land Line Distribution
  - Pros: high reliability; real time; flexibility; full data set
  - Cons: high costs; doesn't address enough customers (especially outside United States)
- Updated NOAA-Port
  - Pros: For specific users works well (e.g., field forecaster); cheaper than L-Band; hardware already in place; scalable
  - Cons: has only N. American mission; select user group; more expensive than EUMETCAST; currently carries only Level 2 products

2. *What infrastructure changes are needed in your organization to be able to handle the data and products that you need from GOES-R?*

- Many users are still assessing what GOES-R means for their organization
- Users need very complete information put out ahead of time
  - Internet page dedicated to GOES-R in multiple languages
  - Need increased access to conferences for more users especially foreign users (may need financial support to attend)
- Will likely need upgrades of systems
  - Some may require financial assistance

3. *What is the proper ratio between the amount of data "pushed" versus "pulled"?*

- Depends on the distribution method and user needs (e.g., operational missions would be predominantly pushed)
- Need way to receive selective data that may vary with use

There is no really good answer because the applications between pushing and pulling are different across agencies, and within the same system. They are not mutually exclusive. A possible solution would be to create a system that "pushes" all real-time data to a remote server. Allow users to "pull" select data subsets using their own client software.4. *What is your desired balance between Level 1b radiance data and Level 2 derived products in the GRB?*

- Most users (such as forecasters, researchers, etc.) prefer greater amounts of 1b data
- Foreign user preferences will depend on their level of sophistication
- A consideration: Given different latency requirements of Levels 1b and 2, does it still make sense to mix them in the GRB?

5. *For your application, what amount of lossy data compression could be allowed, especially the 0.5 km visible band?*

- First choice is no loss due to compression
- Allowable amount depends on how good a compression you come up with

- Don't discard data before you know what you need
- Users need more information to better answer this question
- Consider providing comparison information about what different derived products look like at various compression rates as well as studies around ratios between compression rates and loss. Then, gather user feedback about what amount of data compression is allowable

6. *Should the GLM data be part of the GRB?*
   - Most users believe GLM data should be part of the GRB
   - Reasons
     - Users have wanted hemispheric lightning data for a long time
     - Data could be integrated into many other products
     - Low volume of data
   - User questions
     - Are there any trade-offs?
     - Does it have to be included with the GRB? Are there other options?

7. *For your application, do you need access to the raw data before re-sampling?*
   - Many users need raw data before re-sampling
     - Firefighters need this information
   - Need to consider real-time vs. retrospective needs
     - Researchers need it to calibrate equipment and for research activities

8. *For HES/CW and ABI/SST product distribution, is CoastWatch your preferred source of products, or would you prefer some other arrangement? If other, please elaborate.*
   - Most agree that CoastWatch is best
   - Current Internet sites provide this information
   - Users would like to see GOES-R HES-CW and ABI-SST added to existing NESDIS sites.
   - Meteorologists would want the HES and ABI to support the production of CoastWatch products

9. *What other questions or issues would you like to have the group discuss?*
   - Important Consideration: Prepare users well and far in advance so that they are ready
   - The way EUMETSAT distributes data currently, is that something that can be done with GOES-R? GOES-R will do pretty much the same thing as EUMESTSAT: put all satellite data into single data stream; also considered adding GRB into stream as well; once data processed by facility, goes to ABM processor to commercial vendor, Internet, landline, partners, etc. in DDDS format.

5.8. Numerical Weather Prediction

5.8.1. Numerical Weather Prediction (NWP) – Readiness for the Next Generation of Satellite Data Assimilation, John Le Marshall


Dr. John LeMarshall describes NWP plans for the future.

John Le Marshall, Joint Center for Satellite Data Assimilation (JCSDA), discussed "Numerical Weather Prediction (NWP) – Readiness for the Next Generation of Satellite Data." A vast amount of satellite data are used in NWP. There has been a 5-order magnitude increase in satellite data over the past 10 years, with an enormous volume of data expected with NPOESS and GOES-R.

The JCSDA is a joint center that has elements from NASA, NOAA, the U.S. Navy, and the U.S. Air Force. The mission of the JCSDA is to accelerate and improve the quantitative use of research and operational satellite data in weather climate and environmental analysis and prediction models. The vision is a weather, climate, and environmental analysis and prediction community empowered to effectively assimilate increasing amounts of advanced satellite observations and to effectively use the integrated observations of the Global Earth Observing System of Systems (GEOSS).

Over the past three years, the JCSDA has been developing a balanced program to support future operational data assimilation in NASA, NOAA and the DoD. Due deference to the science priority areas has facilitated this balance. The current and future satellite programs including GOES–R have been examined to develop a strategy to prepare for efficient implementation of satellite data as they become available. A very important activity for the Center is planning in relation to the form of the next generation assimilation systems to be used by the partners. Current strategic planning and development involves the use of the 4D variational approach. The GOES-R program and users will benefit from this activity, which will enable the JCSDA partners to use GOES-R data soon after launch.

The short- to medium-range goals of the JCSDA are:

- Increase uses of current and future satellite data in Numerical Weather and Climate Analysis and Prediction models
- Develop the hardware/software systems needed to assimilate data from the advanced satellite sensors
- Advance common NWP models and data assimilation infrastructure
- Develop a common fast radiative transfer system (CRTM)
- Assess impacts of data from advanced satellite sensors on weather and climate analysis and forecasts (OSEs, OSSEs)
- Reduce the average time for operational implementations of new satellite technology from two years to one.

JCSDA science priorities are:

- Science Priority I – Improve Radiative Transfer Models
- Science Priority II – Prepare for Advanced Operational Instruments
- Science Priority III – Assimilating Observations of Clouds and Precipitation
- Science Priority IV – Assimilation of Land Surface Observations from Satellites
- Science Priority V – Assimilation of Satellite Oceanic Observations
- Science Priority VI – Assimilation for air quality forecasts

Mr. LeMarshall listed some of JCSDA accomplishments. These include:

- Common assimilation infrastructure at NOAA and NASA
- Community radiative transfer model V2 released
- Common NOAA/NASA land data assimilation system
- Interfaces between JCSDA models and external researchers
- Operational implementations include snow/sea ice emissivity model; MODIS winds; AIRS radiances; and new generation, physically based sea surface temperature analysis.
- Preparation for advanced satellite data such as METOP (IASI/AMSU/MHS), DMSP (SSMIS), COSMIC GPS data, EOS AMSR-E, GIFTS, GOES-R
- Impact studies of POES MHS, EOS AIRS/MODIS, Windsat, DMSP SSMIS…on NWP through parallel experiments.

Mr. LeMarshall discussed JCSDA's GOES-R risk reduction related activity involving preparation for data assimilation:

- GOES-R Instrument Radiative Transfer Modeling – Community Radiative Transfer Model (CRTM)
- Risk Reduction Instrument Studies, OSSEs –AIRS

Data Assimilation Research/Risk Reduction using Heritage Instruments- AIRS, MODIS, HIRS, AVHRR, IASI, GOES

- Participation in Calibration/Validation and preparation for early data access
- Development of assimilation methodology for GOES-R data etc. (3D VAR, 4D VAR.)
- Preparation of the numerical forecast systems (GFS, WRF, HWRF…) to use GOES-R data
- FY 2012 – Data Assimilation system prepared for use of GOES-R data

5.8.2. Breakout Session Report on Numerical Weather Prediction

James Partain, NWS Alaska Region, presented the breakout group's thoughts on Numerical Weather Prediction (NWP). The session looked into the following questions:

1. *How do you think GOES-R data will help fulfill the vision for significantly improved forecasts by 2020?*

Improved temporal, spatial, and spectral resolution will lead to improved environmental forecasts of high-impact events:

- Improved moisture flux information (including 3D winds)

Anticipated improvements help frame, and are framed by, what the observing system will look like in 2015

- Question can be answered by stating as "To improve forecasts by 2020, we need to…, and GOES-R contributes as follows:…"
- History shows us that many benefits of planned GOES-R capabilities cannot be anticipated

2. *What studies are needed to ensure that operational NWP models will be ready to accept and use data from GOES-R?*

The group said that a well-vetted (and funded) science plan is needed.

- Role and sequence/planning of running OSSEs (including optimal use of GOES and non-GOES datasets). We must have common framework for OSSEs such that they are all consistent.
- Error covariance matrices in observations (radiance comes first). Most difficult area is cloudy radiances/covariances.

- Distinguish and determine instrumental, representativeness error (including ozone, chemicals, dust, and tropospheric CO_2)
- Engineering question: spatial vs. spectral, including cloud data
- How to get better at using temporal and discontinuous information? Discussions have not addressed temporal benefits of GOES-R. We need to study this further.

3. *What sample data sets should be used to simulate GOES-R data (model output, NPP, NPOESS, NASA research satellites, MSG/MET-8) in the numerical models prior to the launch of GOES-R?*

We should leverage existing high spectral and temporal datasets:

- AIRS (to represent grating systems)
- IASI (to represent interferometers)
- SEVIRI (to represent multispectral/temporal)
- MODIS
- NAST-I
- NPP/VIIRS/CRIS
- Surface emmisivity
- Remote sensing from aircraft
- Computer-simulated atmospheres for OSSEs (including precipitation, clouds, and other “real” parameters)

4. *What additional hardware/software/communications are needed for NWP to prepare for GOES-R?*

- New procurement modes and priorities are needed – now.
- Much greater computational capacity needed to conduct the OSSEs, etc. (and/or new paradigms, like compression)
- Achival capability of the results of the assimilation and research. The data that come out of NWP will need to be stored/archived for climatological studies. Also includes software to retrieve and use data and metadata.
- Regional vs. national modeling, public vs. private sector assimilation
- Need for better, faster, more specific short-wave radiative transfer models
- How will data be going to partners/users; role of NOAA, contractors and vendors; security issues for partners
- Need to go beyond current hardware procurement schedules in order to meet demands of this project.

5. *What work needs to be accomplished so the high spatial and temporal information on GOES-R will be included in regional/mesoscale models?*

We need to utilize GOES-R data in truly mesoscale analysis and forecast models (e.g., including non-linearities). We need to make a transition away from traditional adjoint model (3D/4D VAR) to models that can more accurately handle non-linearity. Linearizing equations in order to assimilate non-linear properties (e.g., clouds) hurts the retrievals. Physics are non-linear, and are represented as such in retrievals. However, assimilation is traditionally linear in a 3D VAR system.

- Current variational analysis schemes cannot capture the mesoscale detail and non-linear processes
- New, creative (e.g., hybrid) approaches will need to be developed to deal with mesoscale non-linearity
- Better understanding of how to use the data over land (and in the lower troposphere), e.g., surface emissivity, skin temperature

6. *What other questions or issues would you like to have the group discuss? GOES-R and: Nowcasting, Instrument Design, Socio-economic Impacts*

- Other products that aren't specifically NWP (e.g., by-products of assimilation, nowcast/watch/warning information) – natural tie-in to Decision Aids
- Channel selection for instrument design and data assimilation (NWP community should have some input)
- How long after satellite launch will it take to measure the impacts of the data (e.g., science leading to social impacts)?

7. *How can NOAA assist you with these issues?*
The group recommended resources and requirements for program stability, and funding for computational and communications capacity. The group said that a firm target for requirements would be most welcomed.

6. USER READINESS ISSUES AND BREAKOUT SESSION REPORTS – ISSUES II: PROVING GROUND/RISK REDUCTION, ALGORITHM DEVELOPMENT, DECISION AIDS, USER EDUCATION/OUTREACH

6.1. Introduction by James Gurka

Jim Gurka presents User Readiness Issues

James Gurka, GOES-R acting Chief Scientist, NOAA Satellite and Information Service, presented a review of user readiness issues.

The primary goal for education and training is to ensure that all data are fully utilized immediately following the start of operations. Major training venues include schools, universities, workshops, conferences, and the Internet. Training must be tailored to meet unique user needs. Decision aids are needed to focus user attention. Possible GOES-R decision aids include:

- Rapid de-stabilization indicated on HES Sounder products
- ABI cloud patterns or moisture profiles markedly different from NWP
- Satellite-derived winds markedly different from NWP
- Alert for fog/low cloud formation
- Enhanced V detection
- GLM indication increasing lightning flash rate

For algorithm development, there is reduced risk through development of the Algorithm Working Group.

NOTE: *In the conference, after presentations were given on proving ground/risk reduction, algorithm development, decision aids and user education/outreach, four breakout groups were formed to discuss those issues. For clarity, this report is organized so that each presentation is immediately followed by the report of that breakout group.*

6.2. Algorithm Development

6.2.1. Plan for Algorithm Development, Mitch Goldberg

Mitch Goldberg, NESDIS Center for Satellite Applications and Research (STAR), gave a presentation on algorithm development. He described how the Algorithm Working Group and STAR work together. The mission of STAR is to provide NOAA with scientific research and development that transitions state-of-the-art satellite data systems, products, and services to operations for use by land, atmosphere, ocean, and climate user communities. Examples of success stories are: POES/GOES Operational Processing Systems; AIRS and IASI Operational Processing Systems; and unique MODIS Processing – Polar Winds.

STAR's core functions include:

- Developing algorithms and prototype software systems that are transitioned into the production of operational environmental satellite products
- Monitoring, characterizing, and improving instrument calibration
- Validating and analyzing products in support of all NOAA mission goals
- Supporting the development of future satellite instruments and their requirements specifications

Mr. Goldberg said that 86 observational requirements were originally identified for GOES-R. The Algorithm Working Group supports the GOES-R program by providing essential components:

- Instrument trade studies
- Proxy dataset development
- Algorithm development and testing
- Product demonstration systems
- Development of Cal/Val tools
- Integrated Cal/Val enterprise system
- Sustained radiance and product validation
- Algorithm and application improvements
- User readiness and education

The mission of the GOES-R Algorithm Working Group (AWG) is to develop, demonstrate and recommend end-to-end capabilities for the GOES-R ground segment and to provide sustained life cycle validation and product enhancements. STAR has the lead in the selection process. The group consists of representatives from the government (NOAA, NASA, DoD, and EPA), industry, and academia, including NOAA's cooperative institutes.

Various teams have been formed or planned. The application teams are responsible for planning and executing the activities to develop, assess, select, and recommend candidate algorithms. The development teams are responsible for testing candidate algorithms in a scalable operational demonstration environment. The anticipated outcome is that the recommended and demonstrated algorithms are delivered to the System Prime, with all supporting materials such as test plans, software, and implementation documentation.

Mr. Goldberg described the planned algorithm delivery schedule:

- 04/06 to 05/07 – Algorithm Development Phase
- 05/07 to 09/07 – Demonstration Phase
- 09/07 to 02/08 – Documentation Phase

6.2.2. Breakout Session Report on Algorithm Development

David Kitzmiller, of the NWS Office of Hydrologic Development, reported for the breakout group on Algorithm Development. An algorithm is defined as a set of decisions and equations that objectively converts data to a desired product. It starts with a series of calculation steps (the scientific algorithm) that then needs to be documented and placed in robust code and validated with test data, including identifying error characteristics of the output. The goals of algorithm development are to: optimize the development process; provide efficient transition from the algorithm developers to operations; and engage the users. The session looked into the following questions:

1. *What groups (beyond the system prime contractor and NOAA/NESDIS/ORA) should be represented on the AWG teams? (B) Should there be other potential AWG teams?*
The group said to add users and international partners to appropriate AWGs. (B) Potential new AWGs are decision support and visualization.

2. *What do each of you perceive as the greatest risks for complete data usage on "Day 1" in the area of algorithm development?*
Day 1 is the first day of full operations after the intensive on-orbit calibration and checkout period. The greatest risks were identified as:

- Lack of input early on from nontraditional users so that the products do not meet their needs for sampling, format, interface, compatibility with their data systems, etc.
    - Potential Solution: Do outreach to nontraditional users (such as local emergency managers, scientists in other disciplines)
- Data not of advertised quality
- Data not certified by other agencies (e.g., FAA) and therefore cannot be used for their requirements
- Algorithms delivered from AWG will lack maturity
- Incompatibility of operating systems

3. *What type of test beds and documentation are recommended to demonstrate GOES-R algorithms meet mission requirements? And how should radiances and products be validated after GOES-R is launched?*
The test bed is to be defined by the algorithm working groups and users to meet their requirements for algorithm development.

Post launch validation of GOES-R is to be conducted by the AWGs. The algorithm validation plan should be developed and discussed with the users before launch. Intensive validation experiments and long-term validation for the life of the system should be included.

4. *What test beds are recommended to allow users to prepare for the utilization of GOES-R products and how far in advance?*
The group recommended that:

- AWG produce the Test Bed
    - Engage the user group in the design and data used in the test bed
    - Provide at least one season of proxy data in the test bed.
    - Include all data types the user community uses
    - Deliver test bed to users at least 2 years before launch

- Use open standards and platforms for the test bed and data systems.
- If possible, provide data from on-orbit checkout (operate instruments for 3-6 months prior to on-orbit storage) to the users through the test bed.

5. *What do users need, and when?*
The top four points in this regard are:

- Test Beds 2 years before launch
- Add a user readiness team to the AWGs
  - User forums
- Comprehensive performance analysis over full range of conditions
- If possible, provide real data from the checkout period prior to on-orbit storage to the users through the test beds.

6. *How should improvements to the algorithms be implemented?*
The group recommended that:

- It was noted that the Satellite Product Services Review Board (SPSRB) is the mechanism in place in NOAA for this process.
- AWG responsible for validation of products and implementing improvements as necessary.
- Evaluate impact on users. User needs are a guide for deciding to implement improvements.

7. *Will the algorithms and/or software be available to the user communities? What about the international communities?*
The group recommended that algorithms' source code and documentation be widely available. They should be available to the international community; they are important for international collaboration (GEOSS).

8. *What other questions or issues would you like to have the group discuss?*
The group noted that test beds would require substantial funding from the receiving agencies in order to use them and prepare to use the data. Users should be involved throughout in the process of algorithm development, testing, validation, and improvement.

6.3. Proving Ground/Risk Reduction

6.3.1. Proving Ground/Risk Reduction, Dr. Kevin Schrab

Dr. Kevin Schrab describes proving ground and other risk reduction activities.

Dr. Kevin J. Schrab, NOAA/NWS Office of Science and Technology, outlined his presentation to include: GOES-R risk reduction overview; proving ground concept overview; interaction between the two; and thoughts for the breakout session.

GOES-R Risk Reduction (R3) enables efficient adoption of GOES-R data and products into NOAA services. Within six months of routine operations there will be:

- Validation of radiometric GOES-R performance
- Unique first time ever imagery
- Examples of improved derived products for weather and coastal ocean nowcasting
- Case studies of NWP impactWithin one year, there will be operational utilization of GOES-R data and early products. R3 enables: Collaborations among participating organizations; GOES-R

products and associated testing to evaluate impact and quality; strategy for data assimilation, forecasting, and nowcasting tests; and the resources needed to conduct these science preparations.

R3 provides the necessary elements for early GOES-R utilization. These include:

- 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
- Cost effective use of GOES-R for improved coastal ocean, weather and water, climate, and commerce and transportation, and ecosystems applications

The focus areas are:

- For FY04-FY08: data compression; hyperspectral instrument characterization; algorithm development; and data assimilation
- For FY09-FY10: technique development for merging data from a composite observing system; and user training
- For FY11 and beyond: preparations for GOES-R product demonstrations

Currently the only true full integration takes place at WFO and NCEP centers. Unanticipated results of testing can cause disruption to operations, and it may overtax the operational system(s). The proving ground concept provides integrated testing of the following in NWS operations: software, hardware, strategies, and concepts. All changes (technological or procedural) undergo rigorous integrated testing. Testing is done at staged, critical design and development points to ensure problems are identified early. The NWS Proving Ground would provide an efficient method to test and evaluate changes suggested by R3.

6.3.2. Breakout Session Report on Proving Ground/Risk Reduction

Tom Renkevens, NOAA/GPO, presented the conclusions for the breakout group on Proving Ground/Risk Reduction. The proving ground concept will help to identify issues so that the beginning of operations for GOES-R goes smoothly. The current concept is to fund three full-time people to coordinate with three NWS forecast offices (one person per forecast office for FY08 through FY16), to test and apply algorithms for hyperspectral data from polar orbiters, and decision aid tools for both present generation GOES products, MSG/MET-8 products, and hyperspectral polar-orbiting data. Algorithms will be developed by the Algorithm Working Group (AWG) in conjunction with the system prime. The candidate algorithms will be tested in real time and post event, with data from any available operational satellites, including NPP, NPOESS, MSG, GOES, and NASA research satellites.

Proposed locations for proving ground offices are: Boulder, Colorado (with CIRA personnel); Milwaukee/ Sullivan, Wisconsin (with CIMSS personnel); Huntsville, Alabama (Short-term Prediction, Research and Transition Center – SPoRT) and Anchorage, Alaska (to take advantage of polar satellite expertise, and rapid updates from polar satellites at high latitudes).

The session looked into the following questions:

1. *What suggestions or feedback do you have on the proving ground concept to help ensure it will contribute to a successful beginning of operations for GOES-R?*

- Cross representation is needed between AWG and proving ground
- Need good communication for work at each of three national data centers
- Mission objectives of proving ground need to be communicated
- Working level users involved early; get forecasters involved at conceptual level
- All eight breakout topics need to be distilled: made part of proving ground as appropriate
- Need to gain broad support within disciplines of NOAA
- Use lessons learned from NPOESS, GOES I-M
- Include an RFC/WFO as one of the proving grounds

2. *Any lessons learned from the WSR-88D proving grounds that could benefit this effort?*

- Other examples of testbeds that have already worked are: SPoRT, Joint Hurricane Testbed, Hazardous Weather Testbed, Hydromet Testbed. We should get lessons learned from them, and explore using them. SPoRT has been successful getting MODIS data into AWIPS.
- Set up focus areas, projects for each year
- Need a plan that is shared, communicated for areas to be tested
- Projects need to use operational equipment, data
- Bottom up approach to get users involved early and often

3. *What other datasets could be leveraged in this proving ground for GOES-R applications before the GOES-R launch?*

- Numerous options are already available
- Decision aid tools are needed to call forecaster attention to GOES-R. Include Decision Aid tools in Proving Ground! Do that with today's data/products.
- Fly GIFTS as risk reduction for HES. Can we fly GIFTS with ABI?
- How can we consolidate various sources?
- ABI products might be considered first
- Education and outreach will be needed to let users know what is available
- An information delivery problem exists in that the existing data are not put into a common format. We need to look broader now to pull all data together.

4. *What potential uses would you see for the Weather Event Simulator?*

- Funding to keep it current. It is a well-proven tool, but equipment upgrade is needed.
- Needs to evolve with AWIPS. If AWIPS evolves, then WES needs to evolve as part of proving ground. If new tools or data are introduced, we need to be able to use them with WES. WES is a very good interactive tool that would work well with satellite data for GOES-R.
- Good for evaluating GOES-R proxy data prior to GOES-R launch. Could use AIRS or other proxy data in WES to simulate the timeliness of GOES-R data, and also to use some of the current data sets that are not being used today. This could then create advocates in the NWS if they see utility in the use of these data sets.
- Provides opportunity for use of lesser known/applied datasets in practice applications
- Testing of decision aids

5. *How can lessons learned from the proving ground be best communicated to you?*
   - Present information at future GOES-R Users' Conference
   - Have the three NESDIS personnel from the proving ground make reports/presentations to NWA, AMS, and other professional user conferences and at NWS workshops. (Marine, Hydro, etc.)
   - Need to also go to other users (DoD, FAA, NOS, etc)
   - Dedicated Web site to display/animate such data

6. *What other questions or issues would you like to have the group discuss?*
   - Will verification statistics and NWS/NOAA goals be included in the prioritization of proving ground projects? Maybe look at GPRA goals.
   - How will coordination with AWG, education groups, etc. actually work? Need to get all who are involved in breakout groups together – industry, academia, and the government, and need to involve A&O contractor
   - How will data be available in the proving ground? Other resources, capabilities (non-AWIPS) might be used initially.
   - AWIPS needs to consider GOES-R product and data requirements. Planning for AWIPS must consider future specific GOES-R data/products/imagery requirements in the field.

6.4. Decision Aids

6.4.1. Decision Aids for Aviation, David Johnson, National Center for Atmospheric Research

David Johnson, a scientist at the National Center for Atmospheric Research, is program lead for NASA's Advanced Satellite Aviation-weather Products initiative. In his presentation on Decision Aids for Aviation, he said that weather product development teams were established by the Federal Aviation Administration (FAA) to respond to identified critical aviation needs. The teams are studying oceanic weather, in-flight icing, turbulence, and convective weather. The FAA and the National Weather Service have established a formal joint review and evaluation process of potential products. Mr. Johnson said that the FAA needs rapid access to all observations and model output, including satellite observations.

FAA's flight information regions extend across a substantial swath of the Pacific Ocean, Atlantic Ocean, and the Gulf of Mexico. The United States aviation geographic areas of responsibility expand over a substantial part of the globe. He said that GOES provides great coverage, except in polar areas and Alaska. For these areas, data from NOAA's polar-orbiting operational environmental satellites (POES) are critical for some applications.

Mr. Johnson discussed the GOES-R instruments, focusing on the Geostationary Lightning Mapper (GLM). The GLM is unique in giving a whole new capability from geostationary orbit. It is not just a replacement for the ground-based systems, but rather gives a unique, large area coverage total lightning observation.
Climatologically, lightning is most common over land areas. In addition, it is uniquely valuable in identifying which convective clouds over the ocean have the most intense updrafts. From an aviation perspective, GLM will <u>for the first time</u> give us a way to identify the convective systems that present the greatest risk to aviation. Because of the critical need for this data, the FAA has submitted a letter of support for the inclusion of the GLM on the GOES-R series of satellites.

Mr. Johnson described hazards to aviation, including severe weather, turbulence, icing, volcanic ash, and solar or geomatic events. With GOES-R we will see improved identification of areas of likely severity with satellite data, particularly by focusing in on smaller features. In test flights, extra satellite data are proving to be of great value in assessing the Current Icing Potential (CIP). For volcanic ash, we need different ways of detecting volcanic eruptions without false alarms, which are very costly to aviation.

6.4.2. Breakout Session Report on Decision Aids

Decision Aids breakout group

Phillip Zuzolo, a meteorologist with Boeing, presented the findings from the breakout group on Decision Aids. The session looked into the following questions:

1. *Please make a list of other decision aids that will be needed for GOES-R.*

- What are the types of decision aids?
    - Satisfy internal operations to the GOES-R system and secondarily to facilitate system automation
    - Key products or derived products from satellite data
    - Sophisticated/derived decision aids combine information from system(s) and sensors
- What is the purpose of decision aids? Optimize usage of GOES-R data and system benefits to users and society
    - Unknowns still exist: needs of the users and the application of the decision aids are in the definition/formulation phase
    - GOES-R is an evolutionary system and requires a continuing user education process
    - Example: Current use of satellite data in AWIPS. Needs to be addressed for the GOES-R era of satellite data tsunami.
- What are the levels of Decision Aids?
    - Provide internal users (NOAA) ability to develop products to deliver to end users
    - Provide end users timely access to products (decision aids defined as products) and satisfy diverse, competing users' needs: FAA, DoD, agriculture (standard defaults could help)
- Key consideration: how users interface with the GOES-R system
- Information access will be a driver: synergy with other space systems and ground sites will provide additional information
    - Decision aids expected to be combinations of different sensors
- Other issues:
    - How to identify priorities (e.g., future scanning strategies)
    - Need to identify some baseline scenarios, then look at baseline Deltas regarding priorities

2. *What groups are already building decision aids?*

- NESDIS Algorithm Working Group is currently in a lead position
- National Centers for Environmental Prediction
- National Severe Storms Laboratory
- National Hurricane Center
- Aviation Decision Aids – NCAR and NASA funded by FAA

- Department of Defense – AFWA, FNMOC, NRL, etc.
- Volcanic Ash Advisory Center
- CIMSS (pre-storm environment decision aids)
- NASA-SPoRT Center, Huntsville, Alabama
- Department of Agriculture, USGS, Department of Transportation
- Private sector
- How much should be done by a national or local agency vs. a private agency?
    - There are clear definitions of what NOAA does vs. private
    - The Government is responsible for life/property/health
    - Private supplies value added information or products
    - Access to data
    - Interruptions to data will affect the private sector

2. *Any lessons learned from the WSSR-88D experience?*
    - Decision aids have an operational purpose – event identification and enabling a temporally dependent mitigation strategy
    - Autonomous algorithms that generate products and tools that are built into the system and alert users that something may be happening (will be equivalent to L2 and L3 of satellite products)
        - Where possible, autonomous operations can help optimize large data volume systems
    - Need for real-time access to Level 1B, calibrated/navigated data – need to archive these data
    - Development of NOAA teams for continued improvement evolution of process
    - Design decision tools based on the end users feedback to meet their needs – Involve users throughout the process
    - Users' training – focused training sessions on the needs of specific users and locations
        - Timing of the training is important relative to operational implementation
        - There should be a large "bottom up" component – get input from the users on how it impacts them
    - Regional differences: key to effective training and operational implementation of decision aids
    - "More is never enough" – Users wanted more frequent and finer resolution

4. *What research is needed to better develop these decision aids?*
    - How to expedite image processing to identify signatures preceding the development of hazardous events
    - Development of automated tools providing information to decision makers and end users
        - Include confidence levels associated with each product/region
    - Development of implementation plans
        - Methodology to move research applications to operations
        - Example: AWIPS implementation process
    - Quality control – incorporate tuning and validation into the research process
        - A proving ground concept
    - Develop a process to incorporate systems/science/user expertise from different disciplines
        - Severe weather
        - Coastal Waters
        - Agriculture
        - Other decision aid topical areas

5. *What other questions or issues would you like to have the group discuss?*

- Develop criteria to prioritize the GOES-R system as a whole
  - Objective methodology and focus group to prioritize geographically separated system priorities when critical events are occurring
- Key considerations: Life and property, safety, resources, etc.
  - Needs to be governed by NOAA, DoD, and other users (private sector) and need to integrate with the GOES-R CONOPS
- Consideration of GOES-R system modes for critical event needs and also how the sensors interact
  - ABI scan modes
  - GLM
  - SEISS, SIS
- How will NOAA reach out to more users to get their inputs and educate them about the benefits of GOES-R:
  - Website with comments/bulletin board capability
  - Organized focus groups
  - Need to consider attendance by NOAA at conferences sponsored by specific user groups such as energy, agriculture, etc.
- Set user expectations regarding benefits and capabilities of what the GOES-R system will provide
  - User understanding of system benefits now rather than later
  - We need to deliver the message of "What's the payoff?"

6.5. User Education and Outreach

6.5.1. User Education/Outreach, Anthony Mostek, National Weather Service

Anthony Mostek presents user education and outreach issues.

Anthony Mostek, NOAA/NWS, discussed NOAA's education and training efforts. NOAA operations are transitioning from forecasts of weather, water, and climate to environmental forecasting/warning, including monitoring of all hazards. We must understand Earth as a whole system, to include coupling atmospheric, terrestrial, oceanic, and space processes. We need to add the key role played by the World Meteorological Organization, pulling together satellite programs around the world.

We are working to build an effective "system-of-systems" infrastructure – a system of observing systems. NOAA has recently established an observing system architecture effort. The first step was to inventory our observing networks. We found that we have 99 separate observing systems measuring 521 different environmental parameters. We also found that we have room to optimize the system. We are now identifying where duplication exists, and where critical gaps remain. Understanding and cataloguing user requirements will be a major part of this effort. If we can develop an integrated system, fully wired and networked together without duplication, we then have the freedom to install needed new observing stations as well as add new sensors to current platforms. In addition, and most importantly, user data will be easier to process, distribute, and archive in an accessible and affordable manner.

The NOAA Observing Systems Architect Office is responsible for maintaining baseline NOAA Observing Systems Architecture and developing target (10-20 years) architecture. The NOAA Observing Systems Council (NOSC) is the principal advisory body to the Under Secretary for NOAA's Earth observation and data management (end-to-end) activities. It is also the principal coordinating body for NOAA to the White House Committee on Environment and Natural Resources (CENR) Subcommittee on Earth Observations in developing an international, comprehensive, coordinated and sustained Earth observation system.

GOES-R requirements allocations and system architecture will be reviewed for conformity to NOAA architecture. The training program (division in NWS) needs to be included in all phases of research, requirements and development. We need a NOAA proving ground to ensure operational readiness of everything introduced into mission critical areas. Trainers must be fully integrated with developers, evaluators and program managers.

The changing role of the forecaster/analyst provides a major challenge for all of us. We need to make sure that the forecaster is ready for the ongoing rapid increase in data/products and in the decision making process.

Training is evolving in all areas: stakeholders, partnerships, weather simulations, structured courses such as Satellite Hydro Meteorology (SHyMet), and education innovation. Stakeholders at all levels must be involved, from directors to entry level. NOAA's partnerships include:

- Cooperative Institutes (VISIT & COMET)
- Labs, Academia, DoD, Federal/State/Local
- WMO – Virtual Laboratory for Satellite Training with Centres of Excellence
- NOAA/EUMETSAT Joint Training

Weather simulations are evolving to environmental simulations. The challenge is to get more satellite data into the simulations. Structured courses include the Advanced Warning Operations Course (AWOC) and SHyMet Courses.

The transfer of training into performance requires management support. Mr. Mostek presented an education and training proposal with the following properties:

- Need NOAA Satellite Training Team (NSaTT)
- Rapid changes in NOAA operations – all environmental services
- Address needs across NOAA and partners
- Bridge and coordinate research-to-operations across all mission goals
- SHyMet Courses – develop training for new products – blended training model
- Support all NOAA missions

Mr. Mostek urged the attendees to help NOAA meet the challenge by participating in the User Education and Outreach Breakout Group. He said that the experience would be postitive and well worth the attendees' time.

6.5.2. Breakout Session Report on User Education and Outreach

Don Moore, NOAA/NWS, presented results from the breakout group on User Education and Outreach. The session looked into the following questions:

1. *What is the target audience for user education? Outreach?*
A distinction was made between education and outreach: education means training those who use the data, such as forecasters, researchers, developers, etc. Outreach is targeted to all ages, all disciplines, internationally: the public, media, and the weather community. Training and education are crucial for managers and decision-makers. The target audiences for user education and outreach need to be defined and prioritized. From the user education standpoint, some sort of alpha products/proving ground access is needed before further definitions of requirements can be provided. Tapping into the communication and media instruction for outreach is crucial; we need to expand on existing opportunities and connections.

2. *What are the key issues for your organization's environmental satellite user training, education and outreach programs?*
Key issues involve:

- Funding
- Tools – this includes the technology for data display, manipulation and research, as well as tools for delivering the training itself
- Volume of Data – at least an order of magnitude increase in data, so we must ensure a path exists to the user as soon as the data begins to flow, and identify the necessary data

3. *How would explicitly adding training, education and outreach into the NOAA satellite planning budgets benefit your work?*
Currently, funding for training appears to be available only at the high program level. Specific training funding at the project level is not available. There is a need for a NOAA/NESDIS Training Coordinator to tie NOAA offices together and eliminate redundancy. This would help facilitate the One-NOAA goal put forth by retired Navy Vice Admiral Conrad C. Lautenbacher, Ph.D., Undersecretary of Commerce for Oceans and Atmosphere. The University of Oklahoma, Norman, OK Doppler radar training system is an example. A group is needed to be responsible for training people in the variety of satellite data and data from the Global Observing System. This training needs to include the operational community. NOAA-specific training is important to build a base of future employees in the private sector. Key decision makers also need to be trained on the needs of the user community. A formal outreach could assist in user feedback to the current GOES-R process. Unified input is needed from targeted user groups such as NWS-NESDIS, FAA-NESDIS training requirements coordinator; this needs to occur at the PPBES level in the NOAA budgeting process. Also needed is an integrated plan to perform outreach. Expanded information on the Proving Ground plan needs to be communicated to the lower levels. The integrated plan needs to cover the program level to the specific outreach level, and it needs to be time phased. The integrated plan also needs to cover user training, from pre-launch simulations to real data training once instrument characteristics are known after launch. The timing of the training is also important – too much simulated training too far in advance of data availability will not be useful.

4. *How might junior and high school students become involved/excited about GOES-R? How might university students become involved/excited about GOES-R?*
Internships and outreach at the high school and university level are important. Actual hands-on presentations from academia and industry at the high school and college level can generate more enthusiasm than job fair presentations, which are traditionally more passive and less focused. This needs to happen earlier in students' college careers so that choices can be made early on. The focus should be on broader issues than GOES-R for the lower level education and can be more streamlined at the college level. Other examples include ready-made lesson plans for teachers, summer training and science programs for both teachers and students, and even basic education at the grade school level. Traveling programs and programs in science museums, such as the Earth Systems Research Lab Science on a Sphere, have also been successful. Interactive multi-media are the key to engaging people. Things such as the Science/College Scholastic Education program within regional WFOs need to be reinstated. The

NASA/GLOBE program is another example. A large number of resources exist, but there is not enough marketing to make this information available to the broader public and education system.

5. *What other questions or issues would you like to have the group discuss?*
Using all of existing assets, such as current satellites in storage, is important. The ESA is an example of a working model. Not using current resources is a serious negative example to users. This capability needs to go into the design level of the satellite and operations. Some degree of formal conversation on this topic would be useful. Users have to be educated on the sparing philosophy and be able to provide feedback on the cost/benefit of the philosophy. Tiered training should be targeted toward the various user groups. There needs to be an integrated plan. We need to identify the broadening GOES-R User Community

7. POSTER PRESENTATIONS

Sixty-three posters were presented at the 4th GOES Users' Conference. A wide range of topics was covered, including the following:

- Baseline instruments (ABI, HES, GOES-N)
- Other instruments (MEO, GEOStar, GEM)
- Forward modeling, assimilation and numerical weather prediction
- Atmosphere/Land/Trace Gases (clouds, aerosols, fires, and hazards)
- Ocean/Coastal
- Communication, data flow (data compression, etc.), training and visualization

The poster abstracts and electronic copies of many of the posters are available on the ftp site ftp://ftp.osd.noaa.gov/Goes-R/. The poster abstracts follow.

7.1. Atmosphere/Land/Trace Gases (clouds, aerosols, fires, hazards, etc.)

Aerosol Research from Geostationary Satellites: Results, Challenges and GOES-R Outlook

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Most satellite remote sensing studies rely on polar orbiting platforms to map the spatial distribution of aerosols and infer aerosol properties. However, geostationary satellites are powerful tools for mapping the diurnal variation of aerosols. Our previous studies over Central America, South America, Africa, and Asia indicate that mapping the diurnal variation of aerosols is important for air quality and climate studies. In this paper we discuss the methods that have been used to study biomass burning, dust and pollution aerosols from the current generation of geostationary satellites. We also outline the challenges that we face and provide the framework for studying aerosols from the GOES-R.

Air Quality Products from NOAA's GOES-R Advanced Baseline Imager (ABI) and Hyperspectral Environmental Suite (HES)

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The use of remotely sensed aerosol data for surface air quality monitoring and forecasting has evolved tremendously in the last decade. NOAA/NESDIS has been active in developing near real time satellite products for air quality applications from its operational satellites for users such as the Environmental Protection Agency (EPA) and the NOAA/National Weather Service (NWS). Satellite derived aerosol optical depths and PM2.5 (particles smaller than 2.5 m in median diameter) emissions in near real time are currently being used by the NWS in air quality forecast verification and in air quality modeling to improve forecasts. In the next decade, during GOES-R era, air quality products such as aerosol and trace gas data will be available over the North American domain at a refresh rate of 5 to 60 minutes from GOES-R Advanced Baseline Imager (ABI) and Hyperspectral Environmental Sounder (HES). Under the GOES-R Algorithm Working Group (AWG), there is an application team for aerosols/air quality/atmospheric chemistry. Members of this team are currently planning to develop various air quality products (aerosol optical depth, particle size, aerosol type, carbon monoxide, methane, ozone, sulfur dioxide, fires, trace gas and aerosol emissions) over the Americas at temporal resolution ranging from 5 to 60 minutes. These products are expected to become operational after the launch of GOES-R in 2013. We will describe the ongoing algorithm and product development work and discuss potential applications of these products.

An Objective Nowcasting Tool that Optimizes the Impact of GOES Derived Product Imagery in Very-Short-Range Forecasts

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Many future instruments (e.g., Wind Profilers networks, automated aircraft reports and the Hyperspectal Environmental Sounder planned for GOES-R) have the capability of resolving atmospheric features beyond today's capabilities in both time and space. Although these data are expected to generate improvements in numerical forecast guidance out to 48 hours and beyond, a greater benefit from these high-time-frequency and detailed data sources may come from their use in real time objective nowcasting systems designed to assist forecasters with identifying rapidly developing, small-scale extreme weather events.

These nowcasting systems 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 will 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 retaining the accuracy of individual observations and preserving the large gradients seen in these data through time. Speed, however, will be of the essence, since in many cases the detailed information provided in the observations is extremely perishable.

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. 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 extremely computationally efficient (since the inertial advective terms no longer dictate that the model time step must be a function of grid spacing), 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. Tests of the system using idealized jet streaks as initial conditions have provided new understandings of regimes where turbulent overturning (CAT) is likely and how very narrow dry bands form in water vapor imagery.

Real data tests are currently being conducted at CIMSS – with the goal of identifying details of the environments associated with the onset of significant weather events several hours in advance. The tests use full resolution (10 km) derived layer moisture products from the GOES-10/12 sounders to update and enhance operational RUC forecasts. Initial tests are focusing on the use of multi-layer GOES Derived Image Product (DPI) moisture data, with the long-term goal of providing a basis for using GOES-R and NPOES data when they arrive. In order to show consistency for operational forecasters between observations and nowcast products, results of the DPI nowcast tests are presented in the form of forecast satellite images. Examples will demonstrate the ability of the LaGrangian system to capture and retain details (maxima, minima and extreme gradients) that are important to the development of convective instability 3-6 hours into the future, even after the IR observations themselves may no longer be available in the areas of severe weather due to cloud development.

Analysis of High Resolution Infrared Images of Hurricanes from Polar Satellites as a Proxy for GOES-R

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The AVHRR on the NOAA satellites and the MODIS on NASA's Aqua and Terra satellites have 1-km sub-point resolution infrared (IR) imagery. A set of this imagery for tropical cyclone cases is being collected to use as a proxy for what will be available from GOES-R. Using McIDAS software, the resolution is reduced to the 2 km planned for GOES-R and further reduced to 4 km, consistent with the IR resolution of current series of GOES satellites.

When color-enhanced IR window channel AVHRR and MODIS images are compared with corresponding lower resolution IR images, some cloud top features with intense hurricanes are clearly seen in the higher resolution images that are not well observed with geostationary images. Cyclonically curved thin cold lines are seen at times in addition to transverse bands aligned perpendicular to the outflowing winds.

The objective Dvorak technique (ODT) uses IR pixel temperatures to provide hurricane intensity estimates. Sensitivity tests are used to illustrate the impact of spatial resolution on the intensity estimates for several hurricanes. 1-km resolution Mercator remaps of AVHRR and MODIS images are degraded to 2- and 4-km resolution images by spatial pixel averaging. Since one of the measurements that contribute to the ODT estimate is the IR eye temperature, the sensitivity of ODT to IR resolution is influenced by eye size. The influence of the resolution on the subjective Dvorak technique is also being investigated.

Automated Cloud Detection with the GOES-R Advanced Baseline Imager

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European Meteosat Second Generation (MSG) multispectral imager data provide a useful surrogate for investigating cloud-detection improvements anticipated with the upcoming GOES-R Advanced Baseline Imager (ABI). The MSG Spinning Enhanced Visible and Infra Red Imager (SEVIRI) has 12 bands positioned in the visible, near-IR, shortwave IR, midwave, water-vapor, and thermal infrared (out to the 13.3-µm CO_2 absorption wing) that are well suited for cloud detection over confounding backgrounds such as deserts, snow and ice, and boundary-layer inversion regions. They are also helpful with detecting dust and volcanic ash. The ABI has bands at or near all the SEVIRI bands, so that ABI-like retrievals are well simulated using SEVIRI data samples.

Radiative transfer theory helps with understanding the types of cloud signatures that can be expected in multispectral radiance datasets. However there is no substitute for studying descriptive imager data to assess the type and strength of multispectral signatures for fog, low clouds, snow and ice cover, thin and thick cirrus, and cumulonimbus at varying times of day and over a collection of different land-surface types. We demonstrate in this poster a SEVIRI multispectral imaging capability that is designed to afford the user a means for determining quantitatively the magnitude of cloud radiative signatures, for the purpose of exploiting them digitally in automated cloud-detection algorithms.

Automated Weather Analysis and Hazard Products from GOES-R at NESDIS

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The Satellite Services Division, NESDIS, plans to fully employ the specialized GOES-R Advanced Baseline Imager (ABI) and Hyperspectral Environmental Suite (HES) data to improve its analyses of significant environmental hazards. The generation of GOES-R will bring with it a wealth of vastly improved remotely sensed environmental data never seen or utilized. With the suite of the ABI and the HES, physical scientists will be able to create a vast array of atmospheric, land, and ocean based products to improve the analysis and prediction of many of Earth's environmental processes. Physical scientists in the field will be able to measure critical levels of the atmosphere – its motion, temperature, moisture, and chemical content – to produce environmental forecasts to effectively safeguard life and property with unprecedented accuracy and timeliness. GOES-R will also provide improved products of ocean currents, sea level temperatures, sea surface patterns, and biological parameters; information that is required for policy makers to act. Land managers and scientists can use critical measurements of the surface of the earth to manage fires, locate vegetation, predict drought, and measure snow and ice cover.

The poster will show how physical scientists at NESDIS will employ improved GOES-R ABI and HES data to improve the accuracy and quality of its automated products to better support the NWS and other federal and state agencies.

Characterization of GOES Aerosol Optical Depth Retrievals During INTEX-A

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A multi platform/sensor approach of using satellite, *in situ*, and model data is being increasingly considered to address science objectives such as determining the state of air quality over the United States. The 2004 Intercontinental Chemical Transport Experiment-North America (INTEX-NA) and NOAA's New England Air Quality Study (NEAQS) field campaigns provided an opportunity to assess the role of satellite data in extending the spatial dimension to study problems such as contribution of long-range transport to regional air quality. NOAA/NESDIS provided near real time aerosol optical depth (AOD) product derived from GOES-12 Imager to aid in the planning of aircraft/ship flight deployment. GOES AODs, available at 30-minute interval during the sunlit portion of the day and covering Contiguous United States (CONUS) at 4 km X 4 km spatial resolution, were provided with one-hour time lag to the field. GOES AOD data were integrated with other satellite imagery to determine how the weather systems were transporting pollutants and which location is ideal to sample with aircraft instrumentation.

The GOES AOD algorithm is a single-channel retrieval that uses look-up tables created using a continental aerosol model. This includes assumptions about aerosol type, size distribution, and refractive index. However, variations in aerosol type and size can occur due to space and time dependent variations in sources of pollution (e.g., forest fires, urban/industrial, dust) resulting in uncertainies in retrieved AOD product. In this study we analyzed GOES AOD measurements with specific focus on uncertainties related to assumptions of one single type of aerosol model across the whole CONUS. Evaluation of GOES AODs by comparing with AERosol RObotic NETwork (AERONET) and MODerate Imaging Spectrometer (MODIS) is an ongoing effort at NOAA/NESDIS. However, measurements of vertical extinction profiles, aerosol size distributions and type made during the field campaign provide an additional source of data to determine uncertainties in GOES AOD product for scenarios where atmospheric aerosol loading is dominated by different aerosol types. We present results on: (1) the assessment of GOES AOD variations on different temporal (diurnal, daily, and monthly) and spatial (local and regional) scales, (2) improvements to GOES AOD product when data are reprocessed with look-up tables created using observed aerosol type, (3) the applicability of operational GOES AODs in supporting future field campaigns for air quality monitoring, and (4) discuss the potential improvements possible with GOES-R Advanced Baseline Imager (ABI) due to its multiple channels in the visible and infrared.

Comparison of Current and Future GOES Fire 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 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 characterization of fire size, temperature, and radiated power. In recent years there has been increased interest in the possibility of directly relating the total fire radiated energy of a fire determined from observed 3.9-micron radiances to the released emissions. This presentation focuses on comparisons of the GOES Imager and future ABI derived fire characterization capabilities using the Dozier technique and as determined from fire radiated power (FRP). Simulations will be performed using MODerate-resolution Imaging Spectroradiometer (MODIS) observations of fires in the U.S.A.

Enhancement of Satellite-based Precipitation Estimates using the Information from the Proposed Advanced Baseline Imager (ABI), Part I: Use of MODIS Channels for Rain / No Rain Separation

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A key weakness of using infrared (IR)-based information from satellites to estimate rainfall is the difficulty in differentiating raining clouds from cold cirrus clouds, since the two have very similar signatures in the thermal infrared (10.7-μm) band. Efforts have been made to resolve this issue by using data from other spectral bands, such as is done in the GOES Multi-Spectral Rainfall Algorithm (GMSRA). However, the potential for improvement is limited by the relatively small selection of bands on the current-generation GOES imager, particularly since the highly important 12.0-μm "split window" band was replaced with another channel beginning with GOES-12.

With several proposed channels that are sensitive to cloud particle phase and size, the Advanced Baseline Imager (ABI) presents an opportunity to improve the discrimination of raining from nonraining clouds. For instance, work by other authors has shown that the combination of 8.5-, 11-, and 12-μm data is useful for determining cloud phase. In this work, MODIS data are used as a proxy for selected ABI channels to quantitatively demonstrate their potential impact on rain/no rain discrimination, with a focus five MODIS channels: 6.5, 8.5, 11.0, 12.0, and 13.4 μm.

Enhancement of Satellite-based Precipitation Estimates Using the Information from the Proposed Advanced Baseline Imager (ABI), Part II: Retrieval of Cloud Droplet Size and Water Equivalent

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Cloud droplet effective radius (DER) and liquid water path (LWP) are two key parameters to quantify the effects of clouds on the exchange of energy and water. Additionally, DER and LWP can be used to characterize the characteristics of precipitation (i.e., growth/decay phase, liquid content, etc.) and provide useful information into physical precipitation retrieval schemes. Traditionally, satellite retrievals of cloud DER are based on satellite reflectance measurements from a single near IR channel, plus visible and thermal IR data. They cannot describe the vertical variation of DER from the cloud top to cloud base. When computing cloud LWP from cloud optical depth and DER, the latter is effectively assumed to be a constant. Chang and Li [2002, 2003] proposed an algorithm that can retrieve the vertical profile of cloud DER and cloud LWP using multi-channel measurements at 3.7, 2.1, and 1.6 μm. These channels are very similar to those that will be on the GOES-R Advanced Baseline Imager (ABI).

In this investigation, the multi-channel algorithm is applied to NASA Moderate Resolution Imaging Spectroradiometer (MODIS) on the Aqua satellite, which also carries Advanced Microwave Scanning

Radiometer (AMSR-E). The microwave observations of AMSR-E contain information on precipitation and LWP. By analyzing the products of MODIS and AMSR-E, we will show the vertical variation of cloud DER and its application in characterizing the precipitation process, in particular, in "warm rain" regimes. Case studies along the U.S. west coast where such processes can contribute to significant rainfall will be presented. Finally, the impact of the inhomegeneity of cloud DER on the satellite retrieval of cloud LWP will also be discussed.

Estimates of Biomass Burning Particulate Matter (PM2.5) Emissions from the GOES Imager

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Aerosol emissions from biomass burning are one of the major sources of uncertainties in air quality forecasts using models such as the Community Multi-scale Air Quality (CMAQ). To reduce the uncertainties in air quality forecasts, we developed an algorithm that can provide near real time PM2.5 emissions for biomass burning events. Static inputs to the algorithm include emissions factors and a new fuel dataset that we developed using MODIS land cover type, leaf area index, and percent vegetation cover at a spatial resolution of 1 km. Dynamic inputs to the algorithm include GOES Wild_Fire Automated Biomass Burning Algorithm (WF_ABBA) fire product with a temporal resolution of 30 minutes and fuel moisture derived from weekly AVHRR vegetation health condition. We tested the performance of the algorithm using fire data from 2002-2004 across the United States. We will present analysis and evaluation of these emissions data and discuss the potential improvements to algorithm for GOES-R Advanced Baseline Imager (ABI) due to enhanced capabilities of the ABI.

Evaluation of GOES-12 Sounder Single FOV and 3x3 FOV Retrievals of Total Precipitable Water Over the ARM SGP Site

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Total Precipitable Water (TPW) is a very useful value for forecasters to determine atmospheric stability and the probability of convection and severe weather. The current GOES Sounder provides the capability to retrieve water vapor profiles and TPW hourly over CONUS with a 10-km spatial resolution. Historically, retrievals have been performed on 3x3 field-of-view (FOV) area. However, the desire to improve product spatial resolution as well as assimilating derived water vapor into numerical models has led to single FOV (SFOV) retrievals. These SFOV retrievals may also provide insight into what improvements increased spatial resolution of future GOES instruments may provide.

The U.S. Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) program Southern Great Plains (SGP) site is centrally located in Lamont, OK. Among other instrumentation, this site contains a Microwave Radiometer (MWR) and rawinsonde launches are performed on a daily basis. These instruments may be used to derive TPW. In addition to the central site, four other boundary facilities also contain MWR instruments, however, rawinsonde launches are not regularly performed at these sites.

The purpose of this study is to evaluate the retrievals of TPW from the GOES Sounder with those retrieved from ground-based instruments such as the MWR and rawinsonde. Both SFOV and 3x3 satellite retrievals from 2004, 2005, and 2006 are included in this comparison. Results are examined for all five of the ARM SGP sites: Lamont OK, Hillsboro KS, Morris OK, Purcell OK, and Vici OK. Results are presented that highlight both the seasonal and diurnal variability of TPW, and the satellite retrieval algorithm's ability to capture this variability. Our study shows that the satellite retrievals outperform the forecast that is used as the first guess in the retrieval procedure. SFOV retrievals have a slightly higher RMS and Bias against the MWR than the 3x3 FOV retrievals, but the SFOV products provide better spatial coverage, and thus may better preserve the spatial gradients of water vapor.

GOES-R ABI New Product Development: Focus on Fog and Atmospheric Dust

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An extensive effort is being undertaken to work towards new and improved products that will be available when GOES-R is launched. Focus at the Cooperative Institute for Research in the Atmosphere (CIRA) has been on product development for the Advanced Baseline Imager (ABI). Not only will existing products be improved due to the increased (spatial, temporal, spectral, and radiometric) resolutions of the ABI, but new products will be developed that would not have been possible from the current selection of GOES Imager and Sounder bands. In order to emulate the GOES-R ABI bands, various existing satellite imagery are being utilized. In particular, the experimental imagery from the EOS (Earth Observation System) Terra and Aqua MODIS (Moderate-resolution Imaging Spectrometer) instruments cover all but two of the spectral bands that will be available on the ABI. In addition, Meteosat Second Generation (MSG) data provide temporal resolution to the development of new and improved products.

Preparations for GOES-R for applications to forecasting mesoscale weather events, including severe storms, tropical cyclones, lake effect snowstorms, fog, and atmospheric dust are well underway. Data from existing operational and experimental satellites are used to create new image products or improve existing products. GOES-R is briefly reviewed, and examples of a risk reduction activity for mesoscale applications will be presented, with a focus on the detection of fog and atmospheric dust outbreaks.

GOES-R Hyperspectral Data Applications

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This paper summarizes the potential applications of hyperspectral remote sensing data from the Geostationary Series R (GOES-R) satellite system. Hyperspectral applications for GOES-R remotely sensed data will provide much needed information concerning the spectral signatures of a variety of environmental phenomena, including severe weather, ecosystem, and other phenomena with societal impacts. The information provided by hyperspectral applications will pioneer efforts to identify, track, and mitigate hazardous weather and other environmental events. These events can produce hazardous situations for society, structures, and the ecosystem. Hyperspectral data can be used for environmental planning, transportation and other relevant NOAA mission applications. In cases of potential harm or hazard to the ecosystem, the hyperspectral data will help to identify the type of hazard and the weather situation contributing to the event. With the detailed information provided by the hyperspectral suite, earlier warnings will be produced to aid evacuation or other mitigation techniques in affected areas. The focus of applications presented in this paper is on the societal benefits of publicly available hyperspectral data.

Hurricane Intensity Estimation from GOES-R Hyperspectral Environmental Suite Eye Sounding

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The Hyperspectral Environmental Suite (HES) sounder planned for GOES-R will have much improved horizontal and vertical resolution than the current GOES sounder. For hurricanes with relatively clear eyes, it may be possible to monitor hurricane intensity from these soundings. AIRS data is being used as a proxy for the HES, and the temperature and moisture retrievals (from the AIRS science team algorithm) in hurricane eyes are being collected. Using an upper boundary condition from a global model analysis, these soundings can be integrated downward to estimate the surface pressure. Results from six soundings from Hurricanes Lili (2002) and Isabel (2003) show that the method is very promising provided the eye is large enough. Because the horizontal resolution of the HES is better than what is currently available from AIRS, the technique should work even better for GOES-R.

Improved Aviation Weather Diagnostics and Forecasting Using Future Generation GOES-R Data

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Hazardous weather conditions for the aviation industry are produced by a diverse set of atmospheric phenomena, ranging from mountain wave induced turbulence, volcanic ash detection, and newly developing and mature convective storms. Each category of these aviation hazards has unique temporal, spatial, and spectral characteristics that can be exploited to produce optimal aviation-weather diagnostics and forecasts.

The suite of instruments included on the next generation GOES-R satellite will collect an unprecedented array of measurements of the Earth's atmosphere, which can be combined to improve aviation safety and efficiency. Higher temporal and spatial resolution measurements by the GOES-R ABI can be used to better monitor and forecast rapidly evolving phenomena such as convective storms and their associated mesoscale flows. Higher spectral resolution measurements from GOES-R HES can be used to observe and characterize the structure of turbulent mountain and convectively induced gravity waves as well as the composition of volcanic ash plumes.

The focus of this presentation is to demonstrate the potential capability of the GOES-R ABI and HES instruments for improved monitoring of hazardous aviation weather. This will be done through the use of current generation aircraft-based, geostationary, and polar-orbiting instrumentation that have similar characteristics and capabilities to instruments proposed to fly on GOES-R. This research has been conducted as part of the Advanced Satellite Aviation-weather Product (ASAP) and Satellite-based Nowcasting and Aviation Applications Program (SNAAP) at UW-CIMSS, which is focused on using current and future generation satellite instrumentation to study and better understand hazardous aviation weather phenomena.

Improvements in the GOES-R ABI for Cloud Remote Sensing Relative to GOES-I-P Imagers

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The GOES-R ABI imager will offer the geostationary cloud remote sensing community many new capabilities including improved spectral, spatial and temporal information. Many of these new capabilities are designed for non-cloud remote sensing capabilities such as vegetation and aerosol properties estimation. However, the new capabilities also greatly enhance the traditional cloud remote sensing mission of the GOES imagers. This poster will demonstrate many of these improvements in cloud products using data from the SEVIRI instrument on the European Meteosat Second Generation (MSG) series of geostationary satellites. For example, we will demonstrate the improvement in cirrus cloud properties from additional infrared channels on ABI relative to the CO_2 slicing approach used on the current GOES-NOP imagers and the split-window approaches used on the GOES I-M imagers.

Mapping Snow from Geostationary Satellites: Getting Ready for GOES-R

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Since 1966 NOAA/NESDIS has been conducting interactive mapping of snow cover using satellite imagery. Increasing demand for higher spatial and temporal resolution of information on the snow cover for numerical weather prediction and climate models stipulates the development of automated satellite-based mapping techniques. These techniques are initially intended to complement the interactive product and facilitate the work of a human analyst, but eventually are expected to replace the interactive technique.

Availability of measurements in the visible, middle-infrared and infrared spectral bands from the current Geostationary Operational Environmental Satellite (GOES) Imager allows for an automated identification and mapping of snow. Enhanced observing capabilities of the Advanced Baseline Imager (ABI) onboard GOES-R will allow for improved retrievals of atmosphere, land surface and ocean properties and in particular, improved retrievals of snow and ice cover. Enhancements in snow and ice mapping are expected primarily owing to additional spectral channels centered in the near-infrared, short-wave infrared and split-window infrared bands; however a higher rate of observations and better navigation may also be beneficial and may facilitate the snow/ice monitoring.

In this poster we present the current operational and experimental automated snow and ice products for the Western Hemisphere derived at NOAA/NESDIS from GOES data. GOES-based retrievals are validated using other remote sensing products and surface observations. We also investigate potentials to improve snow detection and mapping with the Advanced Baseline Imager (ABI) onboard GOES-R. In this latter research Meteosat Second Generation (MSG) SEVIRI instrument is used as prototype for ABI. The MSG snow-mapping algorithm is presented and the results of snow cover monitoring with SEVIRI data over Europe for the last two winter seasons are evaluated.

Ozone Detection with the Advanced Baseline Imager

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The current GOES Sounder provides total column ozone (TCO) estimates on an hourly basis throughout its coverage region. The GOES-R Advanced Baseline Imager (ABI) will share this capability thanks to overlaps in spectral coverage, most importantly through the inclusion of the 9.6 µm band, the most significant region of ozone absorption of upwelling radiation. ABI lacks some spectral coverage that the GOES Sounder does have, and as a result does not represent an improvement over current abilities nor will there be a substantial degradation in capabilities. ABI has higher spatial resolution (2 km vs 10 km IGFOV) and higher spatial and temporal coverage (full disk every 15 minutes vs a region roughly the size of the United States every hour), features that can be exploited to improve the ozone estimates. Additionally data from models and other sources can be used to improve upon the estimates further. The ABI ozone algorithm will be based upon the algorithm used for the current GOES Sounder, and the work to adapt that algorithm is being supported by the GOES-R Aerosol Algorithm Working Group.

Remote Sensing of Aerosol from the GOES-R Advanced Baseline Imager (ABI)

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Real time monitoring of aerosol optical depth from the Geostationary Operational Environmental Satellite (GOES) data have been routinely conducted at the National Oceanic and Atmospheric Administration (NOAA). The current algorithm uses only a single channel to retrieve aerosol optical depth (AOD), provides no information on particle size, uses a fixed aerosol model and estimates the surface effect with large uncertainty that leads to inaccurate AOD for certain times and regions. The GOES-R Algorithm Working Group (AWG) Application Team (AT) for aerosol at the NOAA Center for Satellite Applications and Research (STAR) has currently started developing methods that address some of the shortcomings of the current GOES aerosol algorithm. This is done by taking advantage of the new capabilities offered by the Advanced Baseline Imager (ABI) onboard GOES-R. These capabilities are similar to the multispectral observations currently provided by the Moderate Resolution Imaging Spectroradiometer (MODIS) flown on the NASA Earth Observing System (EOS) satellites, and to those that will be available from the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Visible/Infrared Imager/Radiometer Suite (VIIRS). In addition, ABI on GOES-R will expand the frequency and coverage of aerosol remote sensing that can support a wide range of weather and environmental applications including the monitoring of air quality. The ABI aerosol algorithm being designed at STAR relies on the heritage of and the lessons learned from the MODIS and VIIRS aerosol algorithms. In this paper the current and planned work on aerosol remote sensing are described. Specifically, examples of estimating the visible surface reflectance from the near infrared ABI channel, adaptation of time-space-dependent most-probable aerosol models for prescribing aerosol microphysics, and simulation of clear ABI channel radiances using MODIS-derived atmosphere and surface products.

Retrieval of Land Surface Infrared Charateristics from Simulated HES Radiances

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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 km from a high altitude aircraft platform. Likewise, the EOS Aqua platform with the Atmospheric InfraRed Sounder (AIRS) instrument is being 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 are being 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. MODIS global derived infrared emissivities have also been used to create a global gridded database for spectral regions important for HES sounder simulations. A 24-hour data simulation of a candidate HES sensor has been created at 8-km spatial resolution that combines realistic surface emissivities and WRF model surface temperatures and atmospheric state profiles with an infrared radiative transfer model to compute TOA simulated HES radiances. This simulated dataset is being used in the development and testing of the time dependent surface temperature and emissivity algorithm.

Study of Total Column Ozone Retrieval from the Current GOES Sounder

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The radiances measured by the current Geostationary Operational Environmental Satellite (GOES) Sounder provide hourly information for atmospheric temperature and water vapor profiles as well as total column ozone. Ozone concentration is estimated using the ozone absorption channel at 9.7 µm and several other channels. In this study, a newly developed statistical regression procedure is presented that uses infrared radiance measurements from GOES Sounder channels 1 – 15 (14.7 – 4.5 µm) to estimate total column ozone. The regression coefficients were generated from a nearly global training data set containing 6408 atmospheric temperature/moisture/ozone profiles along with physically assigned surface emissivities and surface skin temperatures. The associated radiances were calculated from a fast forward radiative transfer model. Two retrieval schemes were investigated; one integrating a retrieved ozone profile and another retrieving total column ozone directly. The direct total column ozone retrieval showed a better result in our simulation study and was further applied to GOES Sounder radiance measurements. GOES-8 Sounder ozone estimates in 1998 and 1999 showed root-mean-square difference (RMSD) of 3% ~ 6% with collocated Total Ozone Mapping Spectrometer (TOMS) Level 2 ozone measurements onboard the Earth Probe satellite. A case study of 10 May 2005 GOES-12 ozone retrievals and the Ozone Monitoring Instrument (OMI) total ozone Level 2 products from on the EOS Aura satellite showed a similar difference. The seasonal and latitudinal retrieval biases were also investigated and a bias adjustment was applied to improve the GOES Sounder ozone product.

Synergism of ABI and HES for Atmospheric Sounding and Cloud Property 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. However, the presence of clouds affects the sounding retrieval and needs to be dealt with properly. The ABI is able to provide clear sky infrared (IR) radiances at 2 km spatial resolution, and cloud properties at 0.5 ~ 2 km spatial resolution. The combined ABI/HES system offers the opportunity for new or better atmospheric and cloud products. For example, collocated ABI can provide HES sub-pixel cloud characterization (mask, amount, phase, layer information, etc.), and be used for HES cloud-clearing for partly cloudy HES footprints when ABI and HES have a close viewing angle and time match. In addition, when ABI and HES have different viewing angles, combined clear ABI radiances and cloudy HES radiances within a HES footprint may provide direct sounding when ABI and HES have close time match. The effects of parallax need to be considered. 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.

In order to derive soundings from combined ABI and HES radiances under HES partly cloudy footprints where no microwave-sounding data is available, an optimal cloud-removal or cloud-clearing algorithm is developed. The bias and the standard deviation between the convoluted cloud-cleared brightness temperatures (BTs) and MODIS clear BT observations is less than 0.25 K and 0.5 K, respectively, over both water and land for most MODIS IR spectral bands, reveals the potential operational use of imager/sounder for cloud-clearing. The ABI/HES cloud-clearing requires ABI and HES have a close viewing angle and time match. In the case of different viewing angles but with close time match, an algorithm for direct sounding from combined ABI clear IR radiances and HES cloudy radiances within HES footprint is being developed. Initial results of direct sounding from combination of MODIS/AIRS are promising.

Trade-off Study for the Hyperspectral IR Sounder for a Geostationary Satellite

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Trade studies have been carried out on spectral resolution, spectral coverage, and signal-to-noise ratio for a hyperspectral infrared (IR) sounder on the geostationary satellite. The science requirement of the hyperspectral IR instrument design is to achieve high vertical resolution with 1 K for temperature retrieval accuracy and 10% for relative humidity retrieval accuracy in the lower atmosphere. The data density method is applied for the vertical resolution analysis, and a nonlinear physical iterative scheme is used for the retrieval simulation. The impact of spectral coverage, signal-to-noise ratio, and spectral resolution on the vertical resolution as well as the sounding retrieval accuracy is investigated. Results show that by fixing the proper spectral coverage, a hyperspectral IR sounder with proper signal-to-noise ratio can achieve the required science performance. Synergy of microwave sounder and infrared sounder can improve the vertical resolution compared to either instrument alone. Furthermore, trade studies of retrieval accuracy between different instrument design options are explored to demonstrate capabilities and also provide the proper methods for the future instrument studies. In addition, the spatial resolution, temporal resolution, and detector optical ensquared energy (DOEE) for advanced geo IR sounder are also studied. These studies and results are very relevant to the next generation of geostationary IR sounder such as Hyperspectral Environmental Suite (HES) on GOES-R slated to be launched in late 2012 and the Meteosat Third Generation (MTG) infrared sounder (IRS) in 2015.

Use of Shadows to Retrieve Water Vapor in Hazy Atmospheres

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Techniques aimed at retrieving water vapor from satellite data of reflected near-infrared solar radiation have progressed significantly in recent years. These techniques rely on observation of water vapor attenuation of near-infrared solar radiation reflected by the Earth's surface. Ratios of measured radiances at wavelengths inside and outside water vapor absorbing channels are used for retrieval purposes. These ratios partially remove the dependence of surface reflectance on wavelength and are used to retrieve the total column water vapor amount. Hazy atmospheric conditions, however, introduce errors into this widely used technique. A new method based on radiance differences between clear and nearby shadowed surfaces, combined with ratios between water vapor absorbing and window regions, is presented that improves water vapor retrievals under hazy atmospheric conditions. Radiative transfer simulations are used to demonstrate the advantage offered by this technique.

Using Meteosat-8 SEVIRI as Surrogate for Developing GOES-R Cloud Algorithms

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The GOES-R Advanced Baseline Imager (ABI) represents a significant step in the spectral imaging capabilities of geostationary satellites. While theoretical studies are necessary for preparing algorithms for the new sensor, the real world often operates in disagreement with our rather simplified characterizations of the surface and atmosphere. Thus, it is essential that the cloud retrieval algorithms being developed are applied to data that is as close to the ABI as possible. Currently, the Moderate Resolution Imaging Spectroradiometer (MODIS) on Aqua and Terra and the Scanning Enhanced Visible and Infrared Imager (SEVIRI) on Meteosat-8 are most similar to the proposed ABI. The latter provides the same type of sampling as GOES-R; therefore, it should be the main source for testing new ABI-based algorithms. This paper describes the development of SEVIRI data for testing new algorithms and the initial testing of current geostationary satellite cloud retrieval methods. The initial steps include calibration of the SEVIRI against their MODIS counterparts to ensure that model-based retrievals can be used confidently with the SEVIRI data. A set of algorithms currently being applied in real time to GOES-10/12 are used to analyze the SEVIRI data after calibration. The results of these analyses are presented along with initial comparisons to similar parameters derived from active remote sensing sites in Europe and Africa. Potential improvements making use of additional channels not available on current GOES imagers are discussed.

Using NAST-I in Support of GOES-R Proxy Data

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High quality and realistic proxy data that represent a large variety of atmospheric and surface conditions are critical for the design of a new instrument and its data processing algorithms. The NPOESS Airborne Sounder Testbed – Interferometer (NAST-I) has been successfully operating on high altitude aircraft (i.e., ER-2 and Proteus) since 1998. NAST-I was designed to provide radiometric measurements similar to those being obtained from present and future satellite sensors such as the AIRS, the HES, the GIFTS, the IASI, and the CrIS. NAST-I provides high-spatial resolution and high-spectral resolution (0.25 cm^{-1}) measurements within the spectral region of 645–2700 cm^{-1}. Because of its spectral resolution and coverage, it is an ideal instrument for generating proxy data for new sensor development. The NAST team has developed state-of-art inversion algorithms to deal with both clear and cloudy conditions. NAST-I is aimed at providing high quality and realistic proxy data for the GOES-R Algorithm Working Group. NAST-I data have been used to support GIFTS and CrIS; samples of these activities are presented. The plan for NAST-I to fulfill GOES-R proxy data requirements is addressed.

Validation of GOES-R Total Precipitable Water (TPW) Using GPS derived TPW

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The data and products from GOES-R will be used in conjunction with next generation surface, air and space-based observing systems to play a critical role in NOAA's weather and water, climate, commerce and transportation, and ecosystems missions. To insure the highest data quality, especially for numerical weather prediction (NWP) and climate applications, techniques to monitor the instruments, detect problems, and take corrective actions in near real-time must be developed and implemented. Based on preliminary studies conducted by the authors, we propose the use of surface-based Global Positioning System (GPS) receivers as part of the system to continuously monitoring total precipitable water (TPW) under all weather conditions as an effective and low cost way to monitor and assess GOES-R Hyperspectral Environmental Suite (HES) long-term sensor performance and retrieval accuracy. The strategy would be to form coincident pairs of GOES-R HES and GPS TPW observations within prescribed space and time windows over CONUS. Currently a network of about 400 GPS receivers, providing TPW measurements every 30 minutes for NWP and regional forecasting applications, is available to do this. Through international cooperation in the hemisphere, the network can be expanded to cover most of North America. The temporal resolution of GPS total water vapor measurements combined with the large number of GPS receivers and the spatial and temporal resolution of the GOES-R observations allow us to form a large number of coincident GOES-R HES-GPS TPW pairs. The robust statistical comparison of GOES-R HES and GPS TPW pairs can be used to validate the GOES-R HES water vapor data and retrieval process. Experience in using GPS to validate AIRS water vapor data indicates that GPS is also sufficiently accurate (1 mm RMS) to act as an independent check on satellite water vapor channel radiances and derivatives. In addition, GPS water vapor products will be used to complement other GOES-R water vapor validation studies, including those based on match-ups to radiosonde, microwave water vapor radiometer, and lidar data.

7.2. Baseline Instruments

ABI Delivers Significantly Increased Capabilities over Current Imagers

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The Advanced Baseline Imager (ABI), designed and built by ITT Space Systems Division, provides significantly increased capabilities over our current GOES Imager. This poster will describe the on-orbit operation of our instrument and compare it to the current GOES Imager. The details of Scan Modes 3 & 4 will be explained and operational flexibility summarized.

The following will be addressed:

- Requirements:
  - Top-level comparison of ABI to Imager requirements: coverage, channels, resolution, and data rate

  - Scan Mode 3 & 4 requirements
    - Scene definitions
    - Timing requirements
  - Channel requirements: center wavelength, bandwidth, spatial resolution, dynamic range, SNR & NEdT, etc.
- System Design:
  - Comparison of ABI to Imager operations: scan pattern, scan rate, full disk collection
  - Calibration scenes: space looks and blackbody
  - INR scenes: stars
  - Mode 3 text description and time-time diagram
  - Mode 4 text description
  - On-orbit flexibility: scan direction, space look side, sun avoidance, scene & timeline concept
- Level 1B data rate:
  - Scene size by channel resolution and for 16-channel set
  - Mode 3 & 4 data rates

Algorithm Working Group Space Weather Team Activities and Plans

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The Space Weather (SWx) Team of the Algorithm Working Group (AWG) was formed in January 2006 to address algorithm development and readiness for the Solar Imaging Suite (SIS), Space Environment /In Situ/ Suite (SEISS), and magnetometer. Membership draws on NOAA's Space Weather Program and includes representation from the NCEP Space Environment Center (SEC) and from the NESDIS National Geophysical Data Center (NGDC). Expertise spans the range from instrument scientists to forecasters to archivists. This poster presents an overview of current SWx forecasting and products. It also addresses the Team's initial plans for the assessment of current operational SWx algorithms, the incorporation of new or different GOES-R sensor capabilities into algorithms, and the actual development and validation of GOES-R algorithms.

GOES-N Sounder and Imager Data and Products

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The Geostationary Operational Environmental Satellite (GOES) sounders and imagers have provided quality hourly radiances and derived products over the continental U.S. and adjacent oceans for approximately 10 years. The products derived from the sounder include: temperature and moisture profiles; Total Precipitable Water vapor (TPW); atmospheric stability indices, such as Convective

Available Potential Energy (CAPE) and Lifted Index (LI); cloud-top properties; and (experimentally) total column ozone. Some of the products derived from the imagers include: retrieved Atmospheric Motion Vectors (AMVs); Quantitative Precipitation Estimates (QPEs); cloud parameters; clear-sky radiances; surface (skin) temperature; and detection and characterization of fires, volcanic ash, fog and (experimentally) cloud-top information. The GOES-N sounder and imager will continue these missions. The GOES-N/O/P instruments will be similar to the GOES-8 through GOES-12 instruments with an imager channel lineup similar to GOES-12, but will be on a different spacecraft bus. The new bus will allow improvements both to the navigation and registration, as well as improved radiometrics. Radiances from GOES-N+ will be less noisy, due to a colder detector temperature. The first satellite of this new series, GOES-N, will be launched no sooner than mid-May of 2006.

The various data and product enhancements will be monitored during the NOAA post-launch science test, which follows the NASA-led engineering check-out. As with other GOES NOAA check-outs, there are three primary goals for the GOES-13 (N) science test. The first goal is to assess the quality of the GOES-13 radiance data. This will be accomplished by comparisons with other satellite measurements, investigating the consistency with forward model calculations, and by calculating the signal-to-noise ratio. The second goal will be to generate products from the GOES-13 sounder and imager data streams and compare them to products derived from other satellites, as well as other ground-based observations. The third goal is to investigate and measure the impact of the new satellite bus on instrument performance and product quality, manifested through the expected improvements in navigation, calibration, and data availability.

GOES-R ABI Solar Bands Calibration

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Currently, there is no sensor on geostationary orbit that performs onboard calibration for the visible and near infrared (VIS/NIR) channels. Unlike the thermal infrared and microwave channels, which acquires "hot" reference from a blackbody, onboard calibration of the VIS/NIR channels normally requires "bright" reference from the sun. Unlike the sun-synchronized orbit adopted by most polar-orbiting environmental satellites, for which the sun geometry nearly repeats every orbit, the sun geometry for sensors on geostationary orbit changes daily and seasonally. All these impose challenges to the design and operation of the Advanced Baseline Imager (ABI) for GOES-R, which will have onboard calibration for its VIS/NIR channels. This poster will discuss these challenges in some detail, analyze some data from current GOES to illustrate the role of sun geometry for geostationary sensors, and demonstrate the importance of calibration for the successful execution of the GOES-R program.

GOES-R and NOAA's Mission Goals

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The great amount of information from the GOES-R series will offer both a continuation of current products and services, but also allow for improved or new capabilities. These products, based on validated requirements, will cover a wide range of phenomena that cover NOAA's four primary mission goals. This includes applications relating to: weather, ocean, coastal zones, land, hazards, and space weather. The geostationary perspective offers a rapid refresh rate and consistent view angles. The Advanced Baseline Imager (ABI), Hyperspectral Environmental Suite (HES), Geostationary Lightning Mapper (GLM), Solar Imaging Suite (SIS), Space Environment In-Situ Suite (SEISS), and Magnetometer (MAG)) 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-Coastal Waters 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 provide improved observations needed for a host of applications. Information from each component of the GOES-R system will help meet NOAA's mission 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 (All instruments);
4. Support the Nation's commerce with information for safe, efficient, and environmentally sound transportation (GLM, ABI, HES, SIS, SEISS).

New Sounding Products from the Next Generation of Geostationary Environmental Operational Satellites

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The Advanced Baseline Imager (ABI) and the Hyper-spectral Environmental Suite (HES) instruments on the next generation of Geostationary Environmental Operational Satellite's (GOES-R series) provide the opportunity for improved sounding algorithms in extreme weather situations. We will describe the activities within sounding application team of the GOES-R Algorithm Working Group (AWG) to merge the hyperspectral experience from polar satellites, such as the Atmospheric Infrared Sounder (AIRS) and

Infrared Atmospheric Sounding Interferometer (IASI), with the high spatial and temporal sampling of GOES sounding products.

Simulated Datasets for Next Generation Geostationary Imager Studies

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In order to facilitate simulation studies, for example data compression studies, for the GOES-R Advanced Baseline Imager (ABI), data comprised of current satellite instruments have been staged. The primary datasets consist of MODerate-resolution Imaging Spectroradiometer (MODIS) data, which can be used to spatially simulate most bands on the ABI. An advantage of using actual satellite observations is that the small-scale features are more realistic than those simulated from numerical models. Several datasets of high spatial resolution MODIS containing visible, near-infrared (IR) and IR images have been spatially reformatted and posted for community use. MODIS data are recorded at 12 bits for all bands and stored as 16-bit scaled integers after being converted to radiances. For these sample datasets, bit depth was reduced from 16 to expected values for ABI, which will vary between 10 and 14 for different bands. These example data sets include weather and environmental phenomena such as fire and smoke, mountain waves, dust storms, and clouds. MODIS data have been quality controlled to reduce striping, averaged to appropriate ABI spatial resolution, subset to an even number of fields of view (FOVs) over the area of interest (so that compression ratios can be extracted out to a greater number of FOVs), and corrected for planned bit depth. Sample METOSAT-8 SEVIRI (Spinning Enhanced Visible and Infrared Imager) data, from EUMETSAT, have also been posted. There are 11 spectral bands for 3 sequential times for those interested in simulating compression of full disk images. There has been no post-processing on these images; raw METOSAT-8 data is 10-bit. Finally, unaltered GOES-12 Imager Full Disk images have also been staged. There are 5 spectral bands for 2 separate images. The times are representative of a "night" and "day" case. ABI can also be simulated using high spectral resolution data, such as those from the Atmospheric InfraRed Sounder (AIRS), by convolving with mock ABI spectral response functions; representative spectral response functions have also been staged. Each of these datasets has advantages and disadvantages in how they represent what will be obtained from the ABI. Data and additional information are available on the World Wide Web: http://cimss.ssec.wisc.edu/goes/abi/

Outgoing Longwave Radiation Diurnal Variation from GOES Observations

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We are developing a suite of algorithms similar to those developed for the High-resolution Infrared Sounder (HIRS) that will retrieve the longwave radiation budget variables using Advanced Baseline Imager (ABI) and Hyperspectral Environmental Suites (HES) radiance measurements onboard the GOES-R satellite. The planned products include the outgoing longwave radiation (OLR) at the top of the atmosphere, the atmospheric layer longwave cooling rate, and the downward longwave radiation at the Earth's surface, whereas the OLR is the primary product. Past research at the CICS has adapted the multispectral OLR algorithm to GOES Sounder and Imager instruments. GOES Sounder OLR was validated against the Cloud and Earth's Radiant Energy System (CERES) broadband observations with expected accuracy. Both GOES Sounder and Imager OLR data have been used in the study of the OLR diurnal variations and demonstrated the need of sufficient temporal sampling for daily to monthly integral purposes. GOES-R OLR will have the advantages of accuracy as well the spatial coverage with temporal sampling that is expected to be better than with the GOES Sounder and Imager combined. In this paper we compare the climatological all-sky monthly diurnal cycles derived with HIRS OLR data with the diurnal variations observed by the GOES Sounder and Imager, as surrogate to the GOES-R. We discuss the implications regarding the representativeness of the empirically derived diurnal model and its impact on the HIRS OLR climate data record.

Using Aircraft-based NAST Interferometer Data to Perform HES Trade-off Studies

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The National Polar-Orbiting Operational Environmental Satellite System (NPOESS) Airborne Sounder Testbed Interferometer (NAST-I), which flies on high altitude aircraft, provides radiometric measurements with continuous spectral coverage between 645 – 2700 cm^{-1}, (approximately 15.3 to 3.7 μm) with a spectral resolution of 0.25 cm^{-1} and a nominal spatial resolution of 2.6 km from an aircraft altitude of 20 km. The instrument properties of the NAST-I make it ideal for simulating the spectral coverage, spectral resolution, and spatial resolution of the IR-sounding component of the Hyperspectral Environmental Suite (HES), which is slated to be a part of the next generation geostationary observing system GOES-R series. While, the exact HES instrument specifications have not yet been finalized, NAST-I interferograms can be convolved to accurately simulate any of the proposed HES spectral resolution definitions. In addition, given the continuous coverage of the NAST-I measurements from 3.7 – 15.3 μm, the spectral coverage of the HES can also be fully represented with the NAST-I. In this study, NAST-I measurements are used to simulate HES measurements, and profiles of temperature, moisture, and ozone are retrieved using a statistical regression technique. The retrieval results are compared to in-situ rawinsondes and dropsondes in an effort to assess the impact of the HES instrument characteristics on the sounding products in general, and the ability to meet product accuracy specifications.

7.3. Communication, Data Flow, Training and Visualization

Data Analysis and Visualization Tools for Advanced Imagers and Sounders

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University of Wisconsin, SSEC/CIMSS

New multispectral Imager and hyperspectral Sounder instruments being developed for future operational satellites will exceed the design capabilities of current data analysis tools and limit the visualization capabilities now available. Innovative techniques for developing algorithms, analyzing data and visualizing results with these new data are under development. The Unidata program is developing the Integrated Data Viewer (IDV), a reference application based on SSEC's VisAD Java library for interactive visualization and analysis of numerical data. SSEC is collaborating with Unidata to provide the multispectral and hyperspectral data functionality to be found in GOES-R for the IDV. SSEC has also created a plan to transition the current McIDAS-X users into this IDV/VisAD-based system. These new data analysis and visualization tools will provide a powerful and flexible environment for developing algorithms and new visualizations that are required for interrogating data from future sensors, while allowing current McIDAS users to carry forward their heritage software and products. This poster will summarize the project, its goals and provide examples from current users.

Direct Readout Systems for Current GOES and GOES-R Users

Richard A. Anstett
Lockheed Martin

The Lockheed Martin MetDAS direct readout system provides forecasters the ability to conduct real-time analysis of worldwide high-resolution meteorological satellite data by means of secure client-server transactions. These systems receive and quickly process all channels available from the current GOES imager and the METEOSAT Second Generation 12-channel imager. They provide the ability to retrieve, analyze and distribute the data in a timely manner. Users may access the systems over the internet with the Windows client application, choose single channel imagery or multispectral products, such as aircraft icing, volcanic ash, dust storm, snow cover or a number of other pre-defined products, and retrieve the imagery for analysis, manipulation and re-distribution. Users may accomplish these actions on an ad-hoc or scheduled basis. This method of operations gives users the capability to sift through large amounts of real-time high-resolution data, and move only what is required, making an efficient use of bandwidth, local storage, and time. The system processes both current direct broadcast services and the EUMETCast digital video broadcast service, and is expandable to accommodate future satellites such as GOES-R.

GOES-R Proxy Data Management System

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For the development of operational-certified GOES-R product algorithms and processing systems, the GOES-R Algorithm Working Group (AWG) program requests a high quality of proxy data for algorithm developments, testing and assessments. The requested proxy data will be initially integrated from the AWG funded projects to the NOAA cooperative institutes and other government laboratories, processed and managed through a high performance data management system operated at the Office of Research and Applications. The central tasks in the proxy data management system will be the delivery of simulation and observation-based GOES- R Level1B data, the development of visualization tools for various formats of proxy data, and the design of a GOES-R Observing System Simulation Experiment (OSSE) framework for demonstrating the potential impacts of GOES-R data on NWP forecasts.

Lossless Compression Studies of Grating Spectrometer Data for NOAA GOES-R Hyperspectral Environmental Suite

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Grating spectrometer is a possible sensor option for the next-generation GOES-R Hyperspectral Environmental Suite (HES). Lossless compression is desired to avoid potentially significant degradation of the meteorological products inferred from the HES data in the mathematically ill-posed retrieval problem. To support the GOES-R data compression studies for the possible grating-type HES sounder, we present various state-of-the-art 2D and 3D lossless compression methods using the grating-type Atmospheric Infrared Sounder (AIRS) data. We also demonstrate DSP-based compression methods for satellite onboard implementation.

Lossless Compression Studies of Interferometer Data for NOAA GOES-R Hyperspectral Environmental Suite

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Interferometer is a possible sensor option for the next-generation GOES-R Hyperspectral Environmental Suite (HES) sounder. Given the unprecedented amount of 3D data that will be generated by the HES each day, the use of robust data compression techniques will be beneficial for data transfer and archival. To support the GOES-R data compression studies for the possible interferometer-type HES sounder, we investigate various 2D and 3D lossless compression methods using the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Airborne Sounder Testbed-Interferometer (NAST-I) data. Preliminary work shows lossless compression ratios above 4 are obtainable for this class of data.

NOAA CLASS Project

Frederick Vizbulis[1] and Robert Rank[2]
[1]Ground Systems Division, Office of Systems Development
[2]CLASS Manager, New Campaigns, Office of Systems Development

This poster will describe the current status of GOES data within the CLASS system along with added capabilities either in the development or planning stages.

NOAA has developed the Comprehensive Large Array-data Stewardship System (CLASS) to archive and make accessible the data from current satellite-based (e.g., Polar-orbiting Operational Environmental Satellites - POES, Geostationary Operational Environmental Satellites - GOES, Defense Meteorological Satellite Program - DMSP) and ground-based (e.g., Next Generation Weather Radar - NEXRAD) observing systems. It also is being structured to handle the large increases in data that will come from additional satellites (e.g., European Meteorological Operational satellites - MetOp, National Polar-orbiting Operational Environmental Satellite System - NPOESS, NPOESS Preparatory Project - NPP, and Earth Observing System - EOS satellites). Finally, it must be capable of supporting current in situ data sources (e.g., Automated Surface Observing System - ASOS).

GOES data are now available through CLASS. It was placed into operations on December 1, 2003 and has been archiving and making these data accessible since then. The data can be searched in a variety of ways, including data type, satellite, date and time range, and spatial coverage. Data can be delivered in several different formats; including McIDAS area format, NetCDF, GIF, JPEG, and raw GOES Variable format (GVAR). The National Climatic Data Center has been archiving the more than 234TB of historical data to make it available to researchers, scientists, and the general public. Currently, more than 85TB have been ingested into CLASS and are accessible online.

GOES operational capabilities:

- GOES data archival and access was put into operations on December 1, 2003
- Available data formats are: McIDAS area format, NetCDF, GIF, JPEG, and raw GVAR
- Spatial resolutions are: 1 km, 4 km, 8 km, and 16 km (approx. at subsatellite point)
- Bands:
    - Imager bands 1-5 for GOES08/09/10
    - Imager bands 1-4,6 for GOES12
    - 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 (i.e., GOES-8, GOES-9, GOES-10, GOES-12)
    - Date and time range
    - Spatial coverage using a bounded box or entering lat/long coordinates
    - Dataset name
- Historical data available online:
    - Block 11 data starting in 1994
    - GOES Imager starting in 1994
    - GOES Sounder starting in 1996
- Dual site operations – Suitland, MD (OSD) and Asheville, NC (NCDC)
- Ingesting historical data

Current development activities:

- Planning for ingest of additional historical GOES data – SMS01-02 and GOES1-7, scheduled to start in May 2006
- Transferring CLASS operational site from Suitland to Boulder, CO (NGDC) – scheduled for Fall 2006
- Implementing capability to deliver data on physical media, e.g., DVD, tape – scheduled for Spring 2006
- Implementing APIs for data access

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

Preparing for GOES-R: Old Tools with New Perspectives

Bernadette H. Connell
CIRA/Colorado State University, Fort Collins, Colorado

Creating products to aid in feature identification for weather forecasting and hazards requires knowledge of the spectral signatures of the features. How do the (hyper) spectral signals of clouds (water, ice, thin, thick), land surfaces, water surfaces, volcanic ash, and dust differ and how does that affect products that rely on channel differencing? Examples discussing some of these features will be shown using GOES, MODIS, and AIRS imagery. Who would have thought that full-disk hyperspectral imagery on a GOES satellite could be possible and so beneficial to image interpretation?

Satellite Meteorology Education and Training for GOES-R+: Leveraging Current Activities and Lessons Learned

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[3]NOAA/NWS

The Cooperative Program for Operational Meteorology, Education and Training (COMET®) receives funding from NESDIS and the NPOESS Integrated Program Office (IPO) to specifically support education and training efforts in the area of satellite meteorology. For COMET's partnership with NESDIS, the focus is on the integration of geostationary and polar-orbiting remote sensing data into operational applications and forecast processes by including examples and training in all COMET learning materials. COMET also provides updates and revisions to previously released satellite meteorology modules when sensor modifications or new capabilities come online, and is currently in the process of planning learning activities that address user readiness for the next generation GOES-R+ satellites.

COMET's focus over the last few years has been on highlighting and demonstrating the future capabilities, applications and relevance of the NPP/NPOESS system to operational forecasters and other user communities. By partnering with subject matter experts at the Naval Research Laboratory and working closely with various user communities, COMET strives to stimulate greater utilization of both the training materials and current polar-orbiting satellite data observations and products. For the NPOESS effort an additional Web-based resource is available, the NPOESS Userport training portal. The Userport Web site (meted.ucar.edu/npoess) provides links to polar-orbiting satellite multimedia learning resources and real-time data for forecasters, scientists, students, faculty, and anyone interested in learning more about the spacecraft, data processing, products, and applications.

This poster presentation will review COMET's ongoing satellite training efforts with an emphasis on the Userport Web site, recent training modules, and discussion of how similar approaches could be adapted for GOES-R+ training and user readiness efforts. Recent training modules will be highlighted and visitors will be able to see the Userport and Meted Websites, along with select NRL Web resources that demonstrate specific future remote sensing capabilities by leveraging real-time data from various operational and research sensors.

Supplementary URLs: http://meted.ucar.edu/topics_satellite.php, http://meted.ucar.edu/npoess, http://www.nrlmry.navy.mil/nexsat_pages

7.4. Forward Modeling, Assimilation, and NWP

A Statistical Assessment of Mesoscale Model Output using Computed Radiances and GOES Observations

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Geostationary Operational Environmental Satellite-R (GOES-R) and National Polar-Orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project (NPP) risk reduction activities involve the advance creation of synthetic imagery and using them to develop new products in advance of satellite launch. It is important to analyze the performance of our models when reproducing actual weather events in order to assess the usefulness of any of the products developed before satellite launch. Also such comparisons can be used to quantify model error statistics for data assimilation purposes. We will present results from such statistical comparisons performed using multiple simulations of severe weather that were performed as part of the GOES-R risk reduction project. CSU Regional Atmospheric Modeling System (RAMS) was used to model severe weather while a state-of-the-art forward observational operator was used to compute the observable satellite radiances.

A Technique for Computing Hydrometeor Effective Radius in Bins of a Gamma Distribution

Lewis D. Grasso and Manajit Sengupta
CIRA/Colorado State University, Fort Collins, Colorado

As part of the Geostationary Operational Environmental Satellite R (GOES-R) and National Polar-Orbiting Operational Environmental Satellite System Preparatory Project (NPP) risk reduction activities at the Cooperative Institute for Research in the Atmosphere (CIRA), we have proposed to create synthetic imagery in advance of the launch of an instrument. To produce synthetic imagery in ice clouds, scattering of solar radiation in ice crystals has to be accounted for while computing brightness temperatures. Scattering and absorption properties of inhomogenous ice crystals can be computed using anomalous diffraction theory. Also geometric ray tracing methods can be used to compute the same optical properties. This paper discusses the results arising from using different computation methods as well as the impact of different averaging methods to account for crystal size distribution; for example, computing the effective radius within bins of a gamma distribution of particle sizes.

CIMSS Forward Model Capability to Support GOES-R Measurement Simulations

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A critical part of planning for GOES-R implementation is the development of forward radiative transfer (RT) models to compute top-of-atmosphere (TOA) radiances in an end-to-end system. Generation of these radiances is important in developing new products and algorithms, such as atmospheric profile retrievals, cloud and aerosol property retrievals, and wind retrievals, and are essential in the preparation of GOES-R data for data assimilation.

Toward this effort, the Cooperative Institute for Meteorological Satellite Studies has built a forward RT modeling system for rapidly computing 2-D TOA thermal radiances in all weather conditions for the Hyperspectral Environmental Suite (HES) and certain channels on the Advanced Baseline Imager (ABI). The system consists of two main components: a fast band model for computing layer gas optical depths and a multiple scattering RT model that parameterizes cloud reflection/transmission properties. The latest ice scattering properties based on rigorous calculations are used in generating the RT model databases. Weather Research Forecast (WRF) model simulations supply the necessary atmospheric and cloud fields for which radiances are computed. Capabilities of the RT model system will be discussed in detail along with its current performance and planned improvements.

CIMSS NWP Modeling Capability to Support GOES-R Measurement Simulations

Jason Otkin, Erik R. Olson, Hung-Lung Huang, Steve Wanzong, Chian-Yi Lui, Robert Knuteson, and Leslie Moy
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Numerical model output from high-resolution Weather Research and Forecasting (WRF) model simulations are used to produce simulated atmospheric profile datasets that are subsequently employed for GOES-R forward radiative transfer model and retrieval algorithm development. The simulated datasets, which are treated as the "truth" atmosphere, are passed through the forward radiative transfer model to generate simulated top of the atmosphere (TOA) radiances over a broad spectral range. Atmospheric motion vectors and temperature and water vapor retrievals generated from the TOA radiances are then compared with the original model simulated atmosphere to assess the accuracy of the wind and retrieval algorithms. Case study results demonstrate that the WRF model is able to realistically simulate mesoscale cloud, temperature, and water vapor structures present in the real atmosphere. The realism of the simulated datasets indicates that TOA radiances derived from WRF model output can serve as an effective alternative for real radiances observed by infrared sensors. Representative examples of TOA radiances, atmospheric motion vectors, and temperature and water vapor retrievals are shown to illustrate the use of the simulated datasets.

Ensemble Data Assimilation of Simulated Brightness Temperature Observations

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An ensemble-based data assimilation approach, recently developed at Colorado State University and entitled Maximum Likelihood Ensemble Filter (MLEF), is being applied to evaluate the impact of future GOES-R observations. The MLEF algorithm is designed to simultaneously estimate several different components of an augmented control variable (initial conditions, model error and empirical parameters). The algorithm also provides uncertainties of all estimated variables, defined in terms of flow-dependent analysis and forecast error covariance matrices. Of particular importance for the GOES-R applications is the built-in capability of the MLEF algorithm to calculate information content of different observations. This capability is used with the ultimate goal to estimate value added of the future GOES-R observations.

We have applied the MLEF algorithm to assimilate simulated 10.35 μm brightness temperature observations using Colorado State University Regional Atmospheric Modeling System (CSU-RAMS). Experimental results for the case of hurricane Lili will be presented and discussed.

GOES-R Observation System Simulation Experiment Framework

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On board the next generation of NOAA Geostationary Operational Environmental Satellite (GOES)-R, the Hyperspectral Environmental Suite (HES) and Advanced Baseline Imager (ABI) are slated to be launched in late 2012. These two sensors will provide enhanced spatial, temporal information for atmospheric soundings and clouds, trace gas estimation, and surface property retrieval. Among these products, the atmospheric temperatures and moisture winds are extremely valuable for hurricane model simulation. An Observation System Simulation Experiments (OSSE) framework is designed to assess the impact of GOES-R measurements on numerical weather prediction.

Our previous studies have indicated that atmospheric temperature data obtained from AMSU measurements can significantly improve hurricane forecast. With the additional atmospheric wind information provided by GOES-R data, it is expected more positive impacts will be made on hurricane prediction. Our first task is to compare the effectiveness of two different kinds of data variational (DVAR) scheme. The first method directly assimilates GOES-R radiance with the 4DVAR scheme. The second method is so-called hybrid variational scheme (HVAR), in which the atmospheric temperatures and winds are derived from a 1DVAR model, and then assimilated with the 4DVAR.

Modeling GOES-R 6.185-10.35 µm Brightness Temperature Differences Above Cold Thunderstorm Tops

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[2]CIRA, Colorado State University, Fort Collins, Colorado

The Advanced Baseline Imager (ABI) aboard the GOES-R series will have channels centered at 6.185 µm and 10.35 µm, which are within the water vapor absorption and atmospheric window regions of the spectrum, respectively. Previous studies have shown that positive brightness temperature difference values between these two bands are occasionally observed above cold thunderstorm tops. These positive values may be associated with water vapor absorption in the relatively warm lower stratosphere. This study uses an observational operator to simulate radiances at these two channels. Sensitivity tests are performed to demonstrate that brightness temperature differences depend primarily on the strength of the tropopause inversion, and to a lesser extent the amount of water vapor above cloud top. Additionally, it will be shown that an optically thin cloud layer above a deep cumulonimbus can also affect brightness temperatures. Studies of this nature are extremely important in preparation for the launch of GOES-R.

Recent OSS Radiative Transfer Model Improvements and Application to Sounding

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The Optimal Spectral Sampling (OSS) method models band averaged radiances as weighted sums of monochromatic radiances. The method is fast and accurate and has the advantage over existing techniques in that it is directly applicable to scattering atmospheres. Other advantages conferred by the method include flexible handling of trace species, the ability to select variable species at run time without having to retrain the model, and the possibility of large speed gains by specializing the model for a particular application. The OSS method is used in the NPOESS operational retrieval algorithms for the CrIS and CMIS sensors. It is also currently being implemented in the Joint Center for Satellite Assimilation (JCSDA) Community Radiative Transfer Model (CRTM), and a version of OSS is currently under development for direct inclusion within MODTRAN™ as an alternative to the current band models. This poster discusses recent updates to the speed and accuracy of OSS and identifies new developments relevant to atmospheric sounding in clear and cloudy regions.

Synthetic GOES-R and NPP Imagery of Mesoscale Weather Events

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Development of satellite products that are used by the operational community usually occurs after a satellite is placed into orbit. As a result, the operational life span of a satellite can be reduced due to the time required for product development. As part of the Geostationary Operational Environmental Satellite R (GOES-R) and National Polar-Orbiting Operational Environmental Satellite System Preparatory Project (NPP) risk reduction activities at the Cooperative Institute for Research in the Atmosphere (CIRA), we have proposed to create synthetic imagery in advance. That is, produce synthetic imagery before the sensor is placed into orbit. Creating not only synthetic satellite images, but also products in advance has the potential to extend the operational life span of future satellites. As a result, our first goal was to demonstrate that synthetic images can be produced. A brief overview of the procedure followed by examples of synthetic GOES-R and NPP images will be presented.

7.5. Ocean, Coastal

Assimilating HES-CW Imagery and Products into an Ecological Prediction System of Chesapeake Bay

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[3]University of Maryland, Department of Atmospheric and Oceanic Sciences
[4]University of Maryland, Department of Mathematics

Coastal ocean monitoring and prediction is an important national and NOAA goal. In order to accomplish this, we feel that an integrated modeling and data assimilation approach that links the atmosphere, land and coastal waters and employs in-situ, modeled, and satellite derived data is required. The next generation of Geostationary Operational Environmental Satellite (GOES-R) represents a major source of remotely sensed data that can be used in achieving this national and agency ecosystem monitoring and prediction goal. In particular, the Hyperspectral Environmental Suite – Coastal Waters (HES-CW) capability will provide data of unprecedented spatial, temporal and spectral resolution that will provide synoptic measurements of the coastal zone that, in conjunction with in-situ observations, can be used to both validate coupled biological-physical ecosystem models and to initialize them for regional ecological forecasting. The Satellite Climate Studies Branch, along with its co-located partners of the Cooperative Institute for Climate Studies and the Earth System Science Interdisciplinary Center, are implementing a fully integrated, ecological model of the Chesapeake Bay and its watershed that will assimilate appropriate HES-CW products. The poster will provide an overview of the project, briefly describing the Regional Ocean Modeling System (ROMS), the regional coupled biological – physical ecosystem model that will be employed to predict environmental conditions in the bay, and our plans to use the Localized Ensemble Kalman Filter in order to maximize the amount of information that can be assimilated into the ecological prediction system from satellite-derived measurements.

NOAA National Ocean Service (NOS) Requirements for GOES-R Ocean Color Capability

Varis Ransibrahmanakul[1], Richard Stumpf[1], and John J. Pereira[2]
[1]NOAA National Ocean Service, N/SCI, Silver Spring, Maryland
[2]Requirements, Planning and System Integration, E/OSD1, Silver Spring, Maryland

NOAA is committed to providing the public with relevant and timely information on coastal water conditions. A long record of surface chlorophyll and turbidity data can be used to partially characterize coastal conditions. Characterization, in turn, enables more effective fishery management, as well the enhanced ability to detect anomalous events (i.e. algal blooms). Where direct measurements prove costly, surface chlorophyll and turbidity can be estimated indirectly from the spectral characteristics from satellite ocean color sensors: SeaWiFS and MODIS. It should be noted that the total signal the satellite receives is dominated by the atmosphere. In order for GOES-R, a NOAA operational satellite, to be able to correct for atmospheric interferences and estimate surface chlorophyll and turbidity in coastal areas, at the minimum, the following wavelengths are required: 412, 443, 490, 510, 530, 550, 580, 610, 645, 667, 678, 720, 750, and 865 nm. The poster will describe and justify the need of each band.

Outreach at the Cooperative Institute for Oceanographic Satellite Studies

Ted Strub and Amy Vandehey
CIOSS, College of Oceanic and Atmospheric Sciences, Oregon State University

Outreach is an integral activity at the Cooperative Institute for Oceanographic Satellite Studies (CIOSS), the newest cooperative institute sponsored by NOAA/NESDIS. CIOSS addresses outreach to the scientific community through workshops related to its four Research Themes: Satellite Sensors and Techniques, Ocean-Atmosphere Fields and Fluxes, Ocean-Atmosphere Models and Data Assimilation, and Ocean-Atmosphere Analyses.

CIOSS addresses outreach to the general public through its fifth theme, Outreach, consisting of: Formal Education; Informal Education; and Data Products and Access. Improved data products and data access are primarily accomplished through collaborations with the NOAA CoastWatch / OceanWatch program. Formal Education is addressed through the SMILE program. CIOSS is helping the Science and Math Investigative Learning Experiences program to develop its high school curriculum and activities in the thematic areas of Oceanography and Remote Sensing. The SMILE program consists of weekly, afterschool “club” activities, leading to a culminating “High School Challenge” event, attended by students in the 12 participating Oregon school districts. Informal Education is addressed at the Public Wing of the Hatfield Marine Science Center. CIOSS is helping HMSC to build an interactive public display that will highlight the use of remote sensing is to monitor the coastal ocean off Oregon and in other coastal locations. This poster presents the details of these outreach and education (formal and informal) activities.

Physical Retrieval for Precise Satellite SST Measurements – GOES-R Risk Reduction Study

Eileen Maturi[1], William Smith, Sr.[2], and Stanislav V. Kireev[2]
[1]NOAA/NESDIS, Camp Springs, Maryland
[2]Hampton University, Hampton, Virginia

A physical algorithm is developed to allow precise sea surface temperatures to be derived from a combination of satellite Hyperspectral Sounder (HS) and Multi-spectral Imager (MI) data as one of the GOES-R Risk Reduction studies. The physics of the algorithm involves the formulation of the radiative transfer equation, including the surface emission, the upwelling atmospheric emission, and the surface reflected sky radiation. The accuracy goal is 0.2 C, which requires the solution to accurately account for the surface emissivity and reflectivity and the atmospheric temperature, water vapor, and trace gas contributions to the observed upwelling radiance. In order to account for these contributions, high spectral resolution HS radiance spectra, as will be measured by future operational satellites, are required. However, HS observations will be at a spatial resolution where cloud contamination will often affect the measured radiance spectra. Under these conditions, low spectral, but high horizontal, resolution radiances, from a companion MI must be used both to detect HS cloud contamination and to infer the sea surface temperature in geographical regions where the HS data are affected by partial cloudiness. The multi-sensor sea surface temperatures are combined in such a manner that the transition from clear field of view HS to partly cloudy HS field of view MI sea surface temperature determinations is relatively seamless (i.e., partly cloudy HS fields of view MI determinations possess approximately the same accuracy as the HS clear fields of view). This characteristic is accomplished by adjusting the partly clouded HS field of view MI sea surface temperature for local difference in the HS and MI sea surface temperatures obtained for surrounding HS clear sky fields of view. This poster provides a description of the multi-sensor algorithm and presents results from applying this algorithm to Aqua satellite AIRS (HS) and MODIS (MI) measurements. These algorithms will be applied to the GOES-R HES and ABI data to achieve a precise sea surface temperature in the GOES-R era.

7.6. Other Instruments (MEO, GEOStar, GEM, etc.)

Advanced Technologies for the GOES-R Series and Beyond

Gerald. J. Dittberner
NOAA Satellites and Information Service

NOAA is exploring advanced technologies for future NOAA satellite systems, including non-moving microwave sounders, innovative constellations, and novel technologies for viewing the polar regions all the time, 24 hours a day, 7 days a week.

Microwave sounders could be of great value in helping the GOES-R series satisfy unmet requirements for vertical profiles through clouds. NOAA has invested in understanding a concept being developed by NASA's JPL called the Geostationary Synthetic Thinned Aperture Radiometer (GeoSTAR). JPL's working engineering model of GeoSTAR, has been operated both in an antenna range or calibration purposes and through the atmosphere demonstrating that the concept of a non-moving interferometric microwave sounder is a real possibility to GOES-R and beyond.

Another idea is a constellation of satellites at Medium Earth Obit (MEO) altitudes, here described as circular orbits at 11,000 km altitude. Consider the vision of being able to observe the environment anywhere on the Earth, at any time, with any repeat look frequency, and being able to communicate these measurements to anyone, anywhere, anytime, in real time. Studies suggest that a constellation of MEO satellites occupying equatorial and polar orbits (inclination = 90 degrees) could, in principle, accomplish this task.

Also new on the horizon is solar sail technology. NOAA has been looking at solar sails as providing a propulsive system that could be used to maintain a satellite in a position closer to the Sun than L1. L1 is that point between the Earth and the sun where the gravitational forces of the Earth and the sun are equal. The sail would allow the increased gravitational force from the Sun to be balanced by the propulsive force of the solar sail. This capability could increase the lead time for measuring and predicting the impact of solar events. Solar sails could also allow a satellite to be positioned over the Earth's polar regions continuously, filling a critical gap in current orbital observations and services.

GeoSTAR: A P3I Payload for GOES-R

Jorn Lambrigtsen
Jet Propulsion Laboratory (JPL)

The Geostationary Synthetic Thinned Aperture Radiometer (GeoSTAR) is an exciting new concept for a microwave sounder, intended to be deployed on GOES-R. This will fill a serious gap in our remote sensing capabilities of long standing – a key capability that NOAA is book keeping at the top of its list of "pre-planned product improvements" for GOES-R – i.e. the most urgently needed additional payload, which is expected to be added to the baseline as soon as funding has been allocated and programmatic issues resolved. Although real-aperture GEO microwave sounders have been proposed over the years, only GeoSTAR is capable of meeting the measurement requirements and is therefore now the leading candidate. A ground-based proof-of-concept prototype has been developed at the Jet Propulsion Laboratory, under NASA Instrument Incubator Program sponsorship, and is currently undergoing tests and performance characterization. Initial tests have been very successful, and images of the sun transiting through the field of view – the first successful imaging with a 2D aperture synthesis system – demonstrate that the system is very stable and that aperture synthesis is a feasible approach. This development constitutes a breakthrough. The initial space version of GeoSTAR will have performance characteristics similar to those of microwave sounders currently operating on polar orbiting environmental satellites, but subsequent versions will significantly outperform those systems. In addition to all-weather temperature and humidity soundings, GeoSTAR will provide continuous rapid-update rain mapping, tropospheric wind profiling, measurement of convective intensity and real time storm tracking. These observations will significantly enhance our ability to assess, track and predict hurricanes and other severe storms. With the aperture synthesis approach used by GeoSTAR it is possible to achieve very high spatial resolutions without having to deploy the large mechanically scanned parabolic reflector antenna that is required with the conventional approach. GeoSTAR therefore offers both a feasible way of getting a microwave sounder with adequate spatial resolution in GEO as well as a clear upgrade path to meet future requirements. GeoSTAR offers a number of other advantages as well, such as 2D spatial coverage without mechanical scanning, system robustness and fault tolerance, operational flexibility, high quality beam formation, open ended performance expandability, and is easily accommodated without interfering with other payloads. The technology and system design required for GeoSTAR are rapidly maturing, and it is expected that a space demonstration mission can be developed in time for the first GOES-R launch if funding is made available, and it could be flown as an Instrument Of Opportunity on GOES-R or GOES-S. It will be ready for operational transition 1-2 years after that. Although the GeoSTAR team has been closely collaborating with the NOAA Office of System Development, there are programmatic barriers that make it difficult for NOAA to sponsor the development of new-technology payloads. Traditionally this has been the role of NASA, and both organizations are working on finding ways to implement a workable "research to operations" model without negatively impacting their other objectives. GeoSTAR is a good candidate for this model, and it is expected to go forward as a joint NASA-NOAA space mission within the next decade.

Geostationary Passive Microwave Observation System Simulation Experiments

Albin J. Gasiewski[1], Bob L. Weber[2], Alexander G. Voronovich[3], and Jian-Wen Bao[3]
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[3]NOAA Earth System Research Laboratory, 325 Broadway, Boulder, Colorado

Passive microwave sounding and imaging from geosynchronous orbit was first studied in the mid-1970's, although initial proposals using microwave channels below 220 GHz required prohibitively large antennas. Studies during the early 1990's suggested that antenna size and costs could be significantly reduced while retaining good spatial resolution by using key submillimeter-wavelength water vapor and oxygen bands. It was with this notion that the Geosynchronous Microwave Sounder Working Group (GMSWG) was convened to develop a model for a practical submillimeter-wave geosynchronous microwave (GEM) sounder and imager.

The current GEM concept is based on a ~2-meter steerable Cassegrain reflector antenna and fast-scanning subreflector. GEM will be capable of either intensively observing specific areas near severe weather or obtaining synoptic information over an extended environment. The low-mass scanning subreflector provides a means of high-resolution imaging of ~200-km wide swaths on a regional basis, while the main reflector's momentum-compensated steering mechanism provides the ability to scan the swath over the Earth's disk. A total of up to 44 channels within the AMSU-A (50-57 GHz) and AMSU-B (183.310 GHz) bands and near the 118.750-GHz O_2 line, the 340 GHz transmission window, the 380.197 GHz water vapor line, and the 424.763 GHz O_2 line are considered in the baseline system design. The subsatellite spatial resolution at the highest frequency channel is ~12 km after beam deconvolution. A tradeoff between penetration depth and spatial resolution exists for the GEM channel set. The GEM system is also the basis for the GOMAS (Geostationary Observatory for Microwave Atmospheric Sounding) sensor being studied within the European community, although for GOMAS an antenna of ~3-m diameter is used to improve spatial resolution at the higher latitudes of interest for Europe.

During the mid-1990's an alternate means of geostationary microwave imaging and sounding based on aperture synthesis was proposed. Aperture synthesis relies on precision measurements of the coherence function in an aperture plane made using a set of receivers and cross correlators, along with subsequent application of a Fourier transform to obtain the angular radiation field. As implemented in geostationary orbit the system would use a Y-shaped array of antenna and receiver elements along with several tens of thousands of one-bit digital correlators to synthesize a full-disk image of the Earth's brightness temperature. The system would require no moving components to provide ~25-km subsatellite spatial resolution at 183 GHz, but impose tradeoffs in sensitivity, spectral coverage, calibration accuracy, and spaceborne hardware complexity. The JPL GeoSTAR concept is based on implementing this technique at the two primary AMSU bands (50-57 and 183 GHz), with possible inclusion of the 89-GHz AMSU window channel.

In order to assess the operational capabilities of each of these systems for forecasting applications a set of observation system simulation experiments (OSSEs) using the two (real and synthetic aperture) concepts are being conducted by the University of Colorado's Center for Environmental Technology in conjunction with NOAA. An assessment of the two system concepts requires that the simulated data be considered in the context of the intended operational application, specifically, for the forecasting needs of the U.S. National Weather Service. To this end, the primary driver of a geostationary microwave system is to improve forecasting of severe weather, and specifically precipitation. While nowcasting of atmospheric rain and cloud water content, along with temperature and moisture fields are important, the ultimate application of geostationary microwave data will be attained by driving a numerical weather prediction model with geostationary microwave brightness imagery. To this end the spatial and temporal sampling capabilities of the two candidate systems, along with the spectral and spatial ranges of their data, need to be carefully considered.

Since the two system concepts provide distinct types of brightness information the assessment is best carried out in the framework of radiance assimilation into a numerical weather prediction model. In this talk we present the status of the geostationary microwave OSSE effort with a focus on forward radiative transfer modeling studies of upwelling radiation fields from a simulated landfalling hurricane. The information content of the simulated imagery and the potential for using such imagery to drive regional numerical weather prediction models using direct radiance assimilation will be discussed. A 2D-var scheme for locking the precipitation state variables of a numerical weather prediction model onto simulated geostationary satellite brightness imagery will be presented.

GOES to the Pole

Lars-Peter Riishojgaard[1] and Dennis Chesters[2]
[1]UMBC-GSFC
[2]NASA-GSFC

One of the most surprising fallouts from MODIS is the highly successful application of feature-tracking winds over the polar regions in global assimilation and forecast systems. This has demonstrated that high-latitude wind observations can have a very substantial impact on forecast skill – even though these observations are only obtained over a very limited region and from an orbit that is far from optimal for this purpose in terms of coverage, timeliness, etc. The positive impact of these winds generally extends well into the lower latitudes (outside the observed region), and the impact tends to be largest when the forecast skill is lowest. Much of the success of the MODIS winds is attributed to the 6.7-µ water vapor channel imagery that provides the vast majority of the wind vectors.

An atmospheric imager flying in a Molniya orbit is proposed as a pathfinder for a high-latitude extension of the GOES-type imagery and as a natural MODIS follow-on mission from a satellite winds perspective. The Molniya orbit is a highly eccentric inclined orbit with a stable high-latitude apogee. Due to the second Kepler law of planetary motion, the satellite spends about two thirds of the time near its apogee where it provides a quasi-geostationary perspective centered over the high latitudes. This will extend the rapid-repeat rate imagery coverage all the way to the pole and will enable the near-real time (30 minutes or better) production of high-latitude feature tracking winds, also based on clear-sky water vapor imagery.

The apogee height of the Molniya orbit is within 10% of the geostationary orbit height, and most of the available geostationary technology in terms of spacecraft, instrumentation, communications, and feature tracking can therefore be reused with only minor modifications. The image technology being developed for GOES-R could be used to produce temporally and spatially coherent images for the regions poleward of 55-60 degrees that are not well covered by the geostationary observatories, with very similar quality.

Science Workshop to Explore R&D Instrument Options on GOES-R

Dennis Chesters[1], Paul Menzel[2], and Stan Wilson[3]
[1]NASA/GSFC
[2]NOAA/University of Wisconsin
[3]NOAA/NESDIS

A one-day workshop was held on 17 November 2005 at NASA-GSFC to explore the benefits of placing an R&D instrument on the GOES-R series of NOAA's operational satellites in the next decade.

NOAA has remote sensing requirements that are not met by the suites of instruments proposed for GOES-R, particularly for observing in cloudy/stormy regions with (necessarily large) microwave sensors. NASA's strategic plans call for observations of the diurnal and regional physical processes that drive atmospheric chemistry, weather and climate. Many of these interests overlap, but at present, there is no NOAA-NASA agreement for an R&D instrument on GOES-R.

The workshop explored options for proposing new geo-enabled science measurements with the potential to become operational on GOES-R. At the workshop, nine scientists and engineers from GSFC, JPL, universities, and industry proposed to monitor: (1) temperature, water vapor and precipitation profiles by passive microwave imaging and sounding, (2) tropospheric chemistry and aerosols, (3) coastal waters, (4) photosynthesis, (5) carbon monoxide, and (6) the solar corona.

These categories are roughly in order of decreasing impact on the GOES-R mission and decreasing instrument maturity. Each scientist described his/her data product and how it fills a science/operational need, justified a GOES viewpoint as being good for observation, made a connection with NASA and NOAA agency requirements, presented a strawman instrument, identified the critical technologies in the instrument, and estimated the size, mass, power, data rate, pointing, east/west station requirements. It was evident that several exciting possibilities are available.

APPENDIX 1. CONFERENCE AGENDA

Fourth GOES Users' Conference
"Preparing for a New Era"
May 1–3, 2006
Omni Interlocken Resort Hotel
Broomfield, Colorado
(Broomfield is located approximately 10 miles southeast of Boulder, Colorado)

Conference Goal: *Help Users Prepare for GOES-R*

Conference Objectives:

1) Seek ways/define methodologies to ensure user readiness for GOES-R;
2) Continue to improve communication between NOAA and the GOES user communities;
3) Inform users on the status of the GOES-R constellation, instruments, and operations;
4) Promote understanding for the various applications of data and products from the GOES-R series;

Expected Outcomes: to gather and document user feedback on:

- Data and product distribution options
- GOES-R ReBroadcast options
- Prioritizing scan mode change requests
- Archiving centrally or locally produced derived products
- CLASS data formats
- Studies needed to ensure that operational NWP models will be ready to accept and use data from GOES-R
- The proving ground concept, to help ensure it will contribute to a successful beginning of operations of GOES-R
- Perceived risks for complete data usage on "day 1" in the area of algorithm development
- Needs for GOES-R related decision aids to forecasting and warning services
- Promoting user education at all levels: k-high school, academia, management
- Contributions of GOES-R to GEOSS

And to provide the user community an update on GOES-R status and capabilities

May 1 (Monday): Omni Hotel
Session 1: Welcome and Keynote
Co-Chairs: Gary Davis and Jim Gurka

11:00 am	Registration (and poster set up)
LUNCH	(on your own)
1:00 pm	Introduction (logistics, conference format etc) – Jim Gurka, NOAA/NESDIS
1:10 pm	Welcome/ Opening Remarks/ Conference goals – Mark Mulholland, NOAA/NESDIS
1:20 pm	GOES Program status – Mary Kicza, NOAA Deputy Assistant Administrator for Satellite and Information Services
1:40 pm	GOES-R Program Overview – Tony Comberiate, NOAA/NESDIS
2:00 pm	Keynote Address: Advances in Geosynchronous – Dr. Paul Menzel, Chief Scientist, Observations of the Earth and Atmosphere NOAA/NESDIS/STAR

2:30 pm Dialog with speakers
3:00 pm BREAK

Session 2: Geostationary Satellites as a part of GEOSS
Co-Chairs: Dr. Paul Menzel and Eric Madsen

3:15 pm WMO Activities/GEOSS Plans – Dr. Don Hinsman, WMO Space Programme Office
3:30 pm Plans for China's Satellite Program – Dr. Jim Purdom, CSU/CIRA
3:45 pm Plans for EUMETSAT's Satellite Program – Ernst Koenemann, EUMETSAT
4:00 pm Plans for India's Satellite Program – Dr. P. C. Joshi, Indian Space Research Organization
4:15 pm Plans for Japan's Satellite Program – Naotaka Uekiyo, Japan Meteorological Agency
4:30 pm Plans for Korea's Satellite Program – Dr. Hee-Hon Lee, Department of Meteorological Satellites, Korean Meteorological Agency
4:45 pm Plans for Russia's Satellite Program – Dr. Valery Evdokimov, Russian Federal Service for Hydrometeorological and Environmental Monitoring
5:00 pm Considerations for GOES-R Readiness in Canada – Mike Manore, Meteorological Service of Canada
5:15 pm Dialog with International Speakers – All
5:30 pm Introduction to posters – Tim Schmit, NOAA/NESDIS
6:00 pm Icebreaker and Poster viewing

May 2 (Tuesday): Omni Hotel
Session 3: Information Briefings: Baseline Instruments
Co-Chairs: Tim Schmit and Steven Hill

8:00 am Registration/continental breakfast
8:30 am Announcements (as necessary) – Jim Gurka, NOAA/NESDIS
8:35 am Advanced Baseline Imager (ABI) – Tim Schmit, NOAA/NESDIS
9:00 am GOES Lightning Mapper – Description – Dennis Boccippio, NASA and Applications – Joe Schaefer, NOAA/NWS
9:20 am Hyperspectral Environmental Suite (HES) Sounder – Dr. Paul Menzel, Chief Scientist, NOAA/NESDIS/STAR
9:45 am GOES-R Coastal Waters Imaging and the – Curt Davis, OSU COAST Risk Reduction Activities
10:05 am Solar Imaging and Space Environment In-Situ SuitesHoward Singer NOAA/NWS
10:25 am Dialog with speakers – All
10:35 am BREAK

Session 4: GOES-R User Readiness – Issues I
CONOPS, Archive, Data Distribution, Numerical Weather Prediction (NWP)
Co-Chairs: Tim Walsh and Ken Carey

10:50 am Third GOES-R Users' Conference Recommendations – Jim Gurka, NOAA/NESDIS, User Readiness Issues
11:00 am GOES-R Instrument CONOPS Considerations – Tim Walsh, NOAA/NESDIS
11:20 am Data and Products Archival in the GOES-R era – Rick Vizbulis, NOAA/NESDIS
11:40 pm Data Distribution – Tom Renkevens, NOAA/NESDIS
12:00 pm LUNCH (on your own)
1:15 pm NWP – Readiness for the Next Generation of Satellite – John Le Marshall, Joint Center for Satellite Data Assimilation

1:35 pm US Air Force and Navy Readiness for GOES-R – Thomas Coe, Air Force Weather Agency and Thomas Lee, Naval Research Lab
1:55 pm Understanding the Importance of Satellite Data to – Cara Wilson, NOAA/NMFS Operational Fisheries Management
2:15 pm Dialog with speakers – All
2:30 pm BREAK and Poster Viewing

Session 5: Breakout Sessions (User Readiness Issues I)
CONOPS, Archive, Data Distribution, Numerical Weather Prediction (NWP)
Jessica Hartung – IWS

This year, attendees will meet in breakout groups according to their interest in a particular breakout topic not according to professional disciplines. This will provide more in-depth responses to each question, as the groups will have approximately two hours to discuss one of the topics. The speaker who presented on that breakout topic will join the group to provide expertise and guidance in addition to the professional facilitator and technical lead.

Registration for breakout groups will be available online at time of registration or can be completed at sign-in at the Omni Hotel during the morning of Day 1. Participants are able to join only one breakout group per day. The following are the breakout groups for Session 5. They are numbered according to the standard numbering scheme on NIST's conference registration web site.

Breakout Group Outline

Day 2, Breakout Session 1	Concept of Operations
Day 2, Breakout Session 2	Archive
Day 2, Breakout Session 3	Data Distribution
Day 2, Breakout Session 4	Numerical Weather Prediction

Breakout Session groups that are large (above 30) will be separated into two groups. For example, if 60 participants register for CONOPS, then there will be a CONOPS I group with 30 participants and a CONOPS II group with 30 participants.

3:00 pm Breakout Sessions: Concept of Operations, Archive, Data Distribution, Numerical Weather Prediction
5:30 pm Session closes
5:30–6:00 Breakout sessions presenters meet with facilitators to prepare presentation
6:30 pm Conference Dinner
Dinner Speaker: Mike Nelson, Chief Meteorologist, KMGH-TV (Denver)

May 3 (Wednesday): at Omni Hotel
Session 6: User Readiness –- Issues II
(Proving Ground, Algorithm Development, Decision Aids, and User Education and Outreach)
Co-chairs: Tony Mostek and Kevin Schrab

8:00 am Registration/continental breakfast
8:30 am Review of user readiness issues – Jim Gurka, NOAA/NESDIS

8:40 am Plan for Algorithm Development – Mitch Goldberg, NESDIS/ORA
9:00 am Proving Ground/Risk Reduction – Kevin Schrab, NOAA/NWS
9:20 am Decision Aids for Aviation – David Johnson, NCAR
9:40 am User Education/Outreach – Tony Mostek, NOAA/NWS
10:00 am Dialog with session 6 speakers – All
10:15 am BREAK and POSTER REMOVAL

Session 7: Breakout Session II (User Readiness Issues II)
(Proving Ground, Algorithm Development, Decision Aids, and User Education and Outreach)
(Jessica Hartung – IWS)

See note with Session 5. The following are the breakout groups for Session 7. They are numbered according to the standard numbering scheme on NIST's conference registration web site.

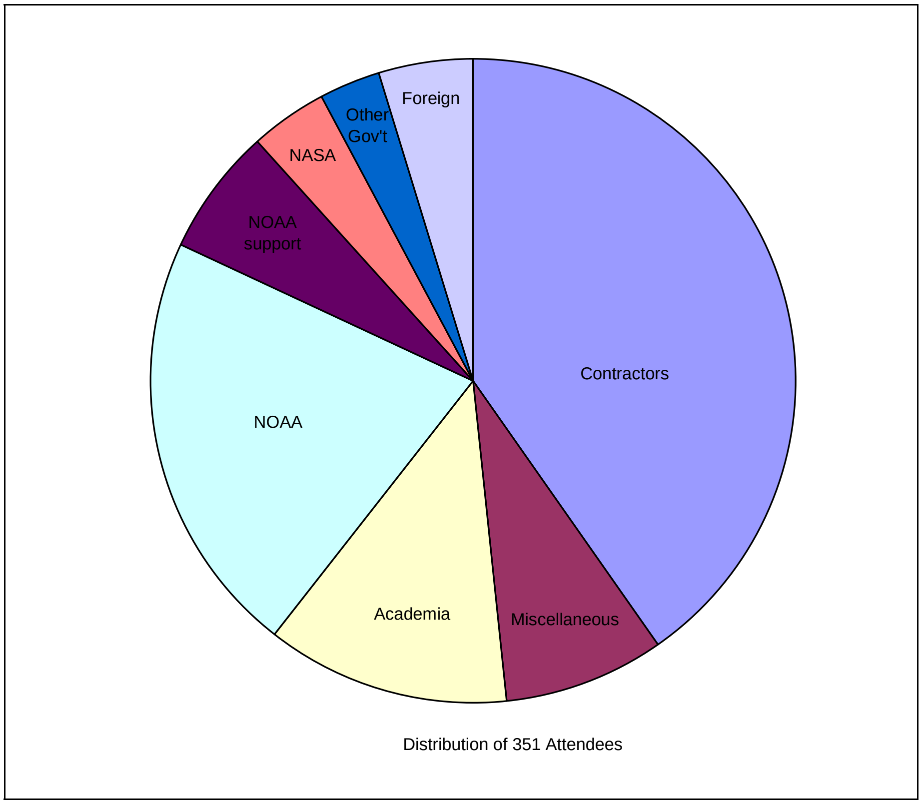
Breakout Group Outline

Day 3, Breakout Session 5	Proving Ground/Risk Reduction
Day 3, Breakout Session 6	Algorithm Development
Day 3, Breakout Session 7	Decision Aids
Day 3, Breakout Session 8	User Education/Outreach

10:45 am Breakout sessions: Proving Ground, algorithm Development, Decision Aids, User Education
12:00 pm LUNCH (on your own)
1:15 pm Breakout sessions continue
3:00 pm BREAK and final report preparation
3:30 pm Breakout Sessions I and II reports
4:45 pm Closing Remarks

APPENDIX 2. ATTENDEE REPRESENTATION

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



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

APPENDIX 3. GLOSSARY

ABI	Advanced Baseline Imager
ABS	Advanced Baseline Sounder
ADEOS	Advanced Earth Observing Satellite
AFWA	Air Force Weather Agency
AGRMET	Land/Surface Model (Air Force)
AIRS	Atmospheric Infrared Sounder
AMS	American Meteorological Society
AMSU	Advanced Microwave Sounding Unit
AMV	Atmospheric Motion Vector
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
ATS	Applications Technology Satellite
AWC	Aviation Weather Center
AWIPS	Advanced Weather Information Processing System
CCD	Charge-Coupled Device
CDR	Climate Data Record
CG	Cloud-to-ground
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
COAST	Coastal Ocean Applications and Science Team
COMS	Communication, Ocean, and Meteorological Satellite (Korea)
CONOPS	Concept of Operations
CONUS	CONtinental United States
CPC	Climate Prediction Center
CSU	Colorado State University
CrIS	Cross-track Infrared Sounder
CW	Coastal Waters
CWSA	Commercial Weather Services Association
CWSU	Center Weather Service Unit
DCP	Data Collection Platform
DCS	Data Collection System
DoD	Department of Defense
DS	Disk sounding
ENVISAT	ENVIronmental SATellite
EOS	Earth Observing System
ESA	European Space Agency
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FAA	Federal Aviation Administration
FNMOC	Fleet Numerical Meteorology and Oceanography Center
GCOM	NASDA mission
GEM	Geostationary Microwave
GEOSS	Global Earth Observaton System of Systems

GERB	Global Earth Radiation Budget
GIFTS	Geostationary Imaging Fourier Transform Spectrometer
GIFTS-IOMI	Indian Ocean METOC Imager
GLM	Geostationary Lightning Mapper
GOES	Geostationary Operational Environmental Satellite
GOMS	Electro Russian Satellite
GOS	Global Observing System
GPS	Global Positioning System
GVAR	GOES Variable Format
HAB	Harmful Algal Bloom
HES	Hyperspectral Environmental Suite
HPC	Hydrometeorological Prediction Center
IASI	Infrared Atmospheric Sounding Interferometer
IC	In-cloud
IDV	Integrated Data Viewer
IGDDS	Integrated Global Data Dissemination Service
IOO	Instrument of Opportunity
IOOS	Integrated Ocean Observing System
IR	InfraRed
IRIS	Improved Resolution and Image Separation
IRS	Infrared Sounder
ISCCP	International Satellite Cloud Climatology Project
JCSDA	Joint Center for Satellite Data Assimilation
JMA	Japan Meteorological AgencyKMA Korea Meteorological Administration
LAS	Live access server (NMFS)
LZA	Local Zenith Angle
MAG	Magnetometer
METEOR	Russian meteorological satellite
MM5	Mesoscale Model Version 5 (Air Force)
MODIS	MODerate-resolution Imaging Spectroradiometer
MRD	Mission Requirements Document (GOES-R)
MSC	Meteorological Service of Canada
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
NCEP	National Centers for Environmental Prediction
NESDIS	National Environmental Satellite, Data, and Information Service
NGDC	National Geophysical Data Center
NIR	Near InfraRed
NIST	National Institute of Standards and Technology
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NOSC	NOAA Observing Systems Council
NOSA	NOAA Observing System Architecture
NPOESS	National Polar-orbiting Operational Environmental Satellite System

NPP	NPOESS Preparatory Project
NRC	National Research Council
NRL	Naval Research Laboratory
NWA	National Weather Association
NWP	Numerical Weather Prediction
NWS	National Weather Service
NWSTG	National Weather Service Telecommunication Gateway
OAR	Office of Oceanic and Atmospheric Research
OFCM	Office of the Federal Coordinator for Meteorological Services and Supporting Research
ONR	Office of Naval Research
OPC	Ocean Prediction Center
OSDPD	Office of Satellite Data Processing and Distribution
OSO	Office of Satellite Operations
OSSE	Oriented Scintillation Spectrometer Experiment
PDRR	Program Definition & Risk Reduction
PFEL	Pacific Fisheries Environmental Laboratory
PPBES	Planning, Programming, Budgeting and Execution System
PPI	Office of Program Planning and Integration
SAR	Search And Rescue
SBM	Environment Canada's Space-Based Monitoring Project
SCOR	Solar coronagraph
SDHS	Satellite Data Handling System (Air Force)
SDM	Satellite Data Manager
SEC	Space Environment Center
SEISS	Space Environmental In-situ Suite
SEVIRI	Spinning Environmental Visible and InfraRed Instrument
SIDAS	Satellite Image Display/Analysis System (Air Force)
SIS	Solar Imaging Suite
SMS	Synchronous Meteorological Satellite
SPC	Storm Prediction Center
SSEC	Space Science and Engineering Center (U. Wisconsin)
SST	sea surface temperature
STAR	Center for Satellite Applications and Research (NOAA/NESDIS)
SWAFS	Space WX Analysis & forecast System (Air Force)
SW/M	Severe Weather Mesoscale (soundings)
SWW	Space Weather Week
Terra	the EOS flagship satellite (EOS AM)
TPC	Tropical Prediction Center
TRMM	Tropical Rainfall Measuring Mission
UAV	Unmanned Aerial Vehicle
UCAR	University Corporation for Atmospheric Research
USGS	U.S. Geological Survey
VAR	Variational (as in 4-dimension variational assimilation)
VAS	VISSR Atmospheric Sounder
VIS	Visible
VISSR	Visible Infrared Spin Scan Radiometer
WEFAX	Weather Facsimile
WFO	NWS Forecast Office
WMO	World Meteorological Organization

APPENDIX 4. GOES-R LINKS

GOES-R Program

Official GOES-R Program Page – https://osd.goes.noaa.gov//
GOES-R Users' Conferences – http://www.osd.noaa.gov/announcement/index.htm
NASA GOES Project – http://goespoes.gsfc.nasa.gov/goes/index.html
NASA GOES Project science http://goes.gsfc.nasa.gov/

Instruments

ABI Documentation from NASA – http://goespoes.gsfc.nasa.gov/abihome.htm
ABI Research Home page – http://cimss.ssec.wisc.edu/goes/abi/
ABI Mock Spectral Response functions – ftp://ftp.ssec.wisc.edu/ABI/SRF/
The CIMSS Hyperspectral Environmental Suite (HES) Page – http://cimss.ssec.wisc.edu/goes/HES/

NESDIS

Office of Systems Operation (OSO) – http://www.oso.noaa.gov/goes/
Office of Systems Development (OSD) – http://www.osd.noaa.gov/
National Polar-orbiting Operational Environmental Satellite System (NPOESS) – http://www.ipo.noaa.gov/
NESDIS Satellite Services Division (OSDPD) – http://www.ssd.noaa.gov/
Operational Significant Event Imagery – http://www.osei.noaa.gov/
NESDIS Satellite Product Overview Display Control Center – http://osdacces.nesdis.noaa.gov/controlcenter.cfm
GOES Products and Services Catalogue, 4th Edition (2002) – http://www.orbit.nesdis.noaa.gov/smcd/opdb/goescat_v4/
Comprehensive Large Array-data Stewardship System (CLASS) – http://www.osd.noaa.gov/class/index.htm
STAR, formerly ORA – http://www.orbit.nesdis.noaa.gov/star/index.html

National Weather Service (NWS)

National Weather Service Home – http://www.nws.noaa.gov/
NOAAPORT User's Page – http://www.nws.noaa.gov/noaaport/html/noaaport.shtml
Interface Control Document (ICD) for AWIPS – National Environmental Satellite, Data and Information Service (NESDIS) – http://www.nws.noaa.gov/noaaport/document/icd_ch4.pdf

National Centers for Environmental Prediction (NCEP)

NCEP Office of the Director – http://www.ncep.noaa.gov/director/
Aviation Weather Center (AWC) – http://aviationweather.gov/
Climate Prediction Center (CPC) – http://www.cpc.ncep.noaa.gov/
Environmental Modeling Center (EMC) – http://www.emc.ncep.noaa.gov/
Hydrometeorological Prediction Center (HPC) – http://www.hpc.ncep.noaa.gov/
NCEP Central Operations – http://www.nco.ncep.noaa.gov/
Ocean Prediction Center (OPC) – http://www.opc.ncep.noaa.gov/
Space Environmental Center (SEC) – http://www.sec.noaa.gov/index.html
Storm Prediction Center (SPC) – http://www.spc.noaa.gov/
Tropical Prediction Center (TPC) – http://www.nhc.noaa.gov/

University of Wisconsin Space Science & Engineering Center (SSEC)

SSEC – http://www.ssec.wisc.edu/
Cooperative Institute for Meteorological Satellite Studies (CIMSS) –

http://cimss.ssec.wisc.edu/
Man Computer Interactive Data Access System (McIDAS) – http://www.ssec.wisc.edu/mcidas/
Advanced Satellite Products Branch (ASBP) – http://cimss.ssec.wisc.edu/aspb/

Colorado State University
Cooperative Institute for Research in the Atmosphere (CIRA) – http://www.cira.colostate.edu/
Regional and Mesoscale Meteorology Branch (RAMMB) – http://rammb.cira.colostate.edu/

Oregon State University
Cooperative Institute for Oceanographic Satellite Studies (CIOSS) – http://cioss.coas.oregonstate.edu/CIOSS/

Training
Cooperative Program for Operational Meteorology, Education, and Training (COMET) – http://www.comet.ucar.edu/
VISITview – http://www.ssec.wisc.edu/visitview/
International Virtual Lab – http://oislab.eumetsat.org/VLab/

GOES
GOES-8 – http://cimss.ssec.wisc.edu/goes/goes8/
UW CIMSS GOES Gallery – http://cimss.ssec.wisc.edu/goes/misc/interesting_images.html
NWA Satellite Imagery list – http://www.nwas.org/committees/rs/nwasat.html
SXI – http://www.sec.noaa.gov/sxi/index.html

Miscellaneous
NOAA – http://www.noaa.gov/
AMS – http://www.ametsoc.org/
NWA – http://www.nwas.org/

APPENDIX 5. CONFERENCE COMMITTEE AND OUTREACH TEAM

Conference Committee

Kenneth Carey	NOAA/NESDIS, Office of Systems Development
Dennis Chesters	NASA/Goddard Space Flight Center
Dane Clark	Short & Associates, Inc.
Curtiss Davis	Oregon State University
Mark DeMaria	NOAA/NESDIS, Center for Satellite Applications and Research
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
James Gurka	NOAA/NESDIS Office of Systems Development
Jessica Hartung	Integrated Work Strategies
Donald Hillger	Colorado State University
Bonnie Kim	Integrated Work Stragegies
Anna King	Integrated Work Strategies
Wendy McBride	National Institute of Standards and Technology
Eric Madsen	NOAA/NESDIS, Office of International Affairs
Tony Mostek	NOAA/NWS
John Pereira	NOAA/NESDIS, Office of Systems Development
Dick Reynolds	Short & Associates, Inc.
Kevin Schrab	NOAA/NWS Office of Science and Technology
Tim Schmit	NOAA/NESDIS, Center for Satellite Applications and Research
John Shadid	NOAA/NESDIS
Justine Short	Short & Associates, Inc
Steve Short	Short & Associates, Inc.
Howard Singer	NOAA/NWS Space Environment Center
Patricia Viets	Short & Associates, Inc.
Tim Walsh	NOAA/NESDIS Office of Systems Development
Marnie Williams	Integrated Work Strategies

Outreach Team

Lisa Botluk	NOAA/NESDIS, Legislative Affairs
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
Garner Yates	NOAA Legislative Affairs
Dick Reynolds	Short & Associates, Inc.
Patricia Viets	Short & Associates, Inc.
Jane Whitcomb	NOAA/NESDIS, NPOESS Integrated Program Office