POSTER ABSTRACTS – 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 five 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 five 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 Derive 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 goals 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 contributes 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-um CO2 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 Hyper-spectral 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 are 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 Contigous 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 which 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.

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 3.7um, 2.1um, and 1.6um. 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 U.S. 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, 4 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 5 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 (2km vs 10km 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 which 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 kilometers 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 ~ 2km 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 improved 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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Lockheed Martin

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 which represents 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.

POSTER ABSTRACTS – Baseline instruments (ABI, HES, etc.)

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 details, 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 which 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 hyper-spectral 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.

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 multi-spectral 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.

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 world wide web: http://cimss.ssec.wisc.edu/goes/abi/

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.

POSTER ABSTRACTS – Communication, Data flow, Training and Visualization

Data Analysis and Visualization Tools for Advanced Imagers and Sounders

Thomas Achtor, Tom Whittaker, and David Santek
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New multi-spectral Imager and hyper-spectral 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 multi-spectral and hyper-spectral 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 multi-spectral 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 levele1B 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

Bormin Huang[1], Alok Ahuja[1], Yagneswaran Sriraja[1], Hung-Lung Huang[1], Mitch D. Goldberg[2], Timothy J. Schmit[2], and Roger W. Heymann[2]
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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

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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 is 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. It 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 has 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: 1km, 4km, 8km, and 16km (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

<u>Preparing for GOES-R: Old Tools with New Perspectives</u>

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

Patrick Dills[1], Thomas Lee[2], Tony Mostek[3], and Sherwood Wang[1]
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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

POSTER ABSTRACTS – Forward modeling, Assimilation, and NWP

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

Manajit Sengupta[1], Lewis D. Grasso[1], Daniel T. Lindsey[2], and Mark DeMaria[2]
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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 in homogenous 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 distributions. 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

Tom Greenwald[1], Hung-Lung Huang[1], Dave Tobin[1], Ping Yang[2], Leslie Moy[1], Erik Olson[1], and Xuanji Xu[1]
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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 are 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
University of Wisconsin-Madison/SSEC/CIMSS

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

Tong Zhu[1] and Fuzhong Weng[2]
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[2] NOAA/NESDIS, Camp Springs, Maryland

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 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 extent 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.

POSTER ABSTRACTS – Ocean, Coastal

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

Christopher W. Brown[1], Raghu Murtugudde[2,3], Joaquim Ballabrera[2], Jiangtao Xu[2], John Quah[4], and Eugenia Kalnay[2,3]
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[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

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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 for 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

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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.

POSTER ABSTRACTS – 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 seven 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 anytime, 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 P^3I 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

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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 ~3m 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 or 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 two the 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

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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 6.7μ 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

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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 a 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.