Poster Abstracts, 3/9/04

1) Using ABI to help HES for atmospheric sounding and cloud retrieval

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Abstract

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

2) ABI cloud mask study using MODIS data

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Abstract

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

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

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Abstract

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

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

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

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

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

4) Study of the Hyperspectral Environmental Suite (HES) on the GOES-R and beyond

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Abstract

High spectral resolution infrared radiances from the Hyperspectral Environmental Suite (HES) on Geostationary Operational Environmental Satellite (GOES-R and beyond) will allow for monitoring the evolution of atmospheric profiles and clouds. The HES is currently slated to be launched in 2013. HES, together with the Advanced Baseline Imager (ABI) will operationally provide enhanced spatial, temporal

and vertical information for atmospheric soundings and clouds. Trade-off studies have been done on the spectral coverage, spectral resolution, spatial resolution, temporal resolution, band-to-band co-registration and signal-to-noise ratio. HES data applications investigated include sounding temperature/moisture retrievals, trace gas estimation, cloud retrieval and surface property retrieval. The accuracy and vertical resolution of atmospheric temperature, moisture and trace gas associated with HES are investigated. These will be contrasted with capabilities from current sensors.

5) Quantization Noise for GOES-R ABI Bands

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Abstract

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

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

6) Using GOES-R to help fulfill NOAA's Mission Goals

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

7) Calibration of the reflective channels of the ABI with a full-disk ratioing radiometer

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

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

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

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

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

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

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Abstract

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

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

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

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

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Abstract

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

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

11) Applications of ABI and HES on GOES-R for monitoring of ocean temperature and color

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Abstract

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

displayed at different spatial and temporal scales, allow rapid evaluation and application of the present satellite observations of the oceans.

12) **Using GOES-R to Help Monitor SO_2**

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Abstract
Sulfur Dioxide (SO_2) is often associated with volcanic eruptions. This is important for aviation interests. Given the correct spectral coverages, satellites can monitor the location and changes of volcanic ash plumes. Geostationary satellites offer a rapid refresh rate and constant viewing angle. The Advanced Baseline Imager (ABI) and the Hyperspectral Environmental Suite (HES) on GOES-R will enable a much improved monitoring of the upper-level SO_2 distribution and evolution from the geostationary perspective. The ABI will have 16 spectral bands, compared with five on the current GOES Imagers. Most importantly for SO_2 detection, there will be spectral bands at 8.5 and at 7.34 µm. The ABI will improve the spatial coverage from nominally 4 to 2 km for the infrared bands, as well as almost a five-fold increase in the coverage rate. The HES will be able to provide higher spectral resolution observations (on the order of 1 cm^{-1}, compared to 20 cm^{-1} on today's broadband sounders) with spatial resolutions of between 4 and 10 km. More importantly, the high spectral resolution observations will offer a more detailed view for better monitoring the end of the life cycle of thinner volcanic dust clouds. This will be demonstrated with data from the NASA AIRS instrument and these high spectral resolution observation convolved with mock ABI spectral response functions to simulate what will be possible spectrally from the ABI. To date, it has not been decided which side of the water vapor continuum that the HES will observe. Of course, the longwave side would be needed for optimum SO_2 monitoring in the 7.3 µm absorption region.

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

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

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

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

14) <u>**Use of High Spectral Resolution Infrared Observations by Ground-based, Aircraft, and Satellite Instruments to Simulate HES Radiances over a Land Site**</u>

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Abstract

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

15) **GOES R and the Global Carbon and Water Cycle**

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Abstract

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

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

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

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

16) **Applications of the HES Coastal Water Imager**

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Abstract

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

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

Gary P. Ellrod [1], Jung-Sun Im [2]

[1] Office of Research and Applications (NOAA/NESDIS), Camp Springs, Maryland
[2] IM Systems Group, Camp Springs, Maryland

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

18) **<u>Projected Impacts of ABI Data on Satellite-Based Precipitation Estimation Part I: Enhanced Temporal Resolution</u>**

Robert J. Kuligowski
NOAA/NESDIS Office of Research and Applications, Camp Springs, MD

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

19) **<u>Projected Impacts of ABI Data on Satellite-Based Precipitation Estimation Part II: Additional Spectral Information</u>**

Robert J. Kuligowski
NOAA/NESDIS Office of Research and Applications, Camp Springs, MD

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

20) **<u>Outgoing Longwave Radiation Products from GOES-R as part of the Global Observing System</u>**

Hai-Tien Lee[(1)], Arnold Gruber[(2)] and Robert G. Ellingson[(3)]

[(1)] University of Maryland, Cooperative Institute for Climate Studies (CICS), Earth System Science Interdisciplinary Center (ESSIC), Computer and Space Sciences Building, Room 4115B, College Park, Maryland 20742. Email: LEE@ESSIC.UMD.EDU.
[(2)] NOAA/NESDIS, Cooperative Institute for Climate Studies, Earth System Science Interdisciplinary Center, 2207 Computer and Space Sciences Building, Room 4115D, College Park, Maryland 20742
[(3)] Florida State University, Department of Meteorology, Tallahassee, Florida 32306

Abstract:
The outgoing longwave radiation (OLR) at the top of the atmosphere is a very important radiation parameter for earth's radiation budget study as well for weather/climate model validation purposes. Accurate OLR measurement can lead to improvement of numerical weather and climate prediction and thus enhance our understanding of the weather and climate system. NOAA has been producing OLR estimates operationally using narrowband radiance observations from the Advanced Very High Resolution Radiometer (AVHRR) onboard the Polar Orbiting Environmental Satellites (POES) since late 1970's and has added another operational OLR product using High-resolution Infrared Sounder (HIRS) data since 1998. The AVHRR OLR product has been used in many climate monitoring and assessment purposes. NASA conducted earth radiation budget studies with the Earth Radiation Budget Experiment (ERBE) and the Cloud and Earth's Radiant Energy System (CERES) experiments onboard various satellites, primarily polar orbiters. Recognizing that the combination of limited temporal sampling by polar orbiters and diurnal variation can cause large interpolation errors, analysis methods that employ geostationary satellite observations were developed for CERES and HIRS OLR. Past studies have found that the use of geostationary observations can reduce the ERBE-like mean instantaneous interpolation rms errors by 50%. The Geostationary Earth Radiation Budget (GERB) experiment onboard EUMESAT's Meteosat Second Generation (MSG) satellites measures the short- and long- wave radiation from the Earth every 15 minutes and it will provide strong synergy with OLR estimated from polar orbiters in addressing the diurnal

variation issues. Similarly, we propose to use GOES-R's Advanced Baseline Imager (ABI) to provide high temporal sampling of OLR that is compatible with ERBE/CERES to reduce the interpolation errors in the OLR estimates made with polar orbiters. Past efforts at CICS have successfully adapted the HIRS OLR algorithm to the GOES Imager and Sounder instruments. Currently, the GOES Imager OLR is operationally produced under the full disk GOES Surface and Insolation Project (GSIP) (A. Heidinger, personal communication). We will use the GOES Imager OLR from GOES 10 and 12 to demonstrate the values and benefits of this proposed product, particularly as to how it supplements the global observing system.

21) **Simulation of the spectral bands on the Advanced Baseline Imager (ABI)**

Mathew M. Gunshor*, Timothy, J. Schmit[@], Kristopher B. Karnauskas*

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Abstract

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

22) **Operational Air Quality Monitoring from GOES Imager**

S. Kondragunta, A. I. Prados, and I. Laszlo
NOAA/NESDIS Center for Satellite Applications and Research

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

performance, a discussion on planned improvements to the current algorithm, and a discussion on further improvements possible with the GOES-R Advanced Baseline Imager (ABI).

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

Patrick Minnis, L. Nguyen, D. F. Young, W. L. Smith, Jr.
Atmospheric Sciences, NASA Langley Research Center, Hampton, VA 23692 USA

Abstract

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

24) The Imager-Sounder Paradigm Revisited

Joe Criscione, Jim Bremer, Don Chu
Swales Aerospace

Abstract:
The possibility of having two GOES satellites over each coast was originally proposed for scheduling flexibility, but it also affords the opportunity to redefine the instruments. The traditional imager/sounder partitioning of requirements could be replaced with a full-disk/region-of-interest partitioning with extraordinary benefit to the coastal waters imaging and the severe weather/mesoscale sounding observations. These gains are possible because the region-of-interest instrument could be flown on its own spacecraft and that instrument would not require a scan mechanism. Eliminating the scan mechanism enables a doubling of the instrument aperture at a reduction in cost/complexity with order of magnitude improvements in performance. This proposed instrument architecture coupled with the distributed architecture would better exploit the benefits of geostationary orbit with some impact to the full-disk sounding requirements.

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

Jaime M. Daniels[@], Wayne Bresky[+], Chris Velden[*], and Antonio Irving#
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Abstract

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

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

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

26) **Cloud and Aerosol Properties using High Spectral Resolution Infrared Measurements**

Steve Ackerman
Cooperative Institute for Meteorological Satellite Studies (CIMSS), University of Wisconsin-Madison
Madison, WI 53706, U.S.A

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

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

Peter Romanov, Dan Tarpley
Office of Research and Applications, NOAA/NESDIS, Camp Springs, MD

ABSTRACT

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

28) **Smooth transitions toward GOES-R: Simulation of high temporal resolution imagery using advanced morphing algorithms**

Anthony J. Wimmers*
*Cooperative Institute for Meteorological Satellite Studies (CIMSS)
University of Wisconsin-Madison, Madison, WI 53706, U.S.A.

Abstract

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

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

29) Aerosol Correction for NPOESS VIIRS Sea Surface Temperature

Dorlisa L. Hommel[1], Richard J. Sikorski[1], Yunyue Yu[1], Thomas P. DeFelice[1], Phillip Ardanuy[1], Doug May[2], Wallace McMillan[3]

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2. Remote Sensing Branch, Naval Oceanographic and Atmospheric Research Laboratory, Stennis Space Center, Mississippi, USA
3. Physics Department, UMBC, 1000 Hilltop Circle, Baltimore, MD, USA

Satellite sea surface temperature (SST) retrieval has been available for nearly three decades. The effects of high aerosol concentrations on SST retrievals are not well characterized and are a significant concern in the Visible/IR Imager/Radiometer Suite (VIIRS) retrieval algorithm. VIIRS will fly as a primary sensor on the National Polar-orbiting Operational Environmental Satellite System (NPOESS) program. The first opportunity for VIIRS will be as a payload on the NPOESS Preparatory Project (NPP), currently scheduled for launch in 2006, which provides a great opportunity to investigate this problem. This study utilizes VIIRS proxy imagery and VIIRS aerosol products to study this source of error. Preliminary results will be presented at the meeting. A comparison between the aerosol-corrected SST's and non-corrected SST's indicates that the VIIRS aerosol products are useful for applying aerosol correction in the SST retrieval.

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

Mark Conner, Gary Gustafson, Francis Bieker[1], Bruce Thomas[2] and Thomas Kopp[2]
Atmospheric and Environmental Research (AER), 131 Hartwell Avenue, Lexington, MA 02421-3126
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Abstract

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

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

existing GOES imager, describe the rapid prototyping facilities that are in use today, and overview cloud algorithm upgrades that are potentially supported by the ABI.

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

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

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

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

32) **A System Design for Storing, Archiving, and Retrieving Hyperspectral Data**.

Ralph G. Dedecker*, Tom Whittaker*, Ray K. Garcia*, Robert O. Knuteson*
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Abstract

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

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

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

33) **<u>Environmental product VErification and REmote SEnsing Testbed utility for HES</u>**

Jay Marmo and Jerome Luine
Northrop Grumman Space Technology, Redondo Beach, CA 90278

Abstract

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

34) <u>Advanced Spacecraft Stellar Inertial Attitude Control Technology to Enhance the Quality of NOAA's GOES Weather Data</u>

Loren Slafer
Boeing Satellite Systems

Abstract

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

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

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

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

To meet this never-before achieved 10 microradian bus pointing for GOES N-P, BSS created many innovative solutions including: a method to account for the star tracker's non-Gaussian, non-white spatial dependent errors in the Kalman filter design to optimize SIAD performance, a 45-degree star tracker boresight orientation to attenuate star tracker high spatial frequency error, a time-matching technique to minimize attitude error between star tracker based attitude and gyro based attitude introduced during

spacecraft slews, use of an equalized star catalog to minimize on-board catalog size while enhancing SIAD performance, and a Kalman filter implementation with weighted measurement noise covariance matrices.

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

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

35) **GOES-R Data Fusion for Atmospheric HazMat Detection, Dispersion and Concentration Models – A Case Study in Northeastern Iran Using MODIS and AIRS Data**
Gary Alexander, Kevin M. Lausten, Mary Tutzu, Brenda Zuzolo, Phil Zuzolo
The Boeing Company, Springfield, VA 22153, U.S.A.

The Hyperspectral Environment Suite (HES) and Advanced Baseline Imager (ABI) on GOES-R will provide near real time observation and quantification of catastrophic atmospheric events, both at the Earth's surface and in the near-surface regime. ABI's high spatial (0.5km) and temporal resolution (30 minutes, Full Disk) will provide the capability to not only discern dangerous event locations, but also define multiple clear atmosphere (cloud, smoke, and obscurant free) viewing windows for the HES. Algorithms using the high spectral and temporal resolution of the HES will enable identification of many gaseous materials harmful to human health. In addition, parameters such as relative humidity, wind speed/direction, and cloud particle size, required as inputs for accurate dispersion modeling, can be determined from HES data. The data products can be used in conjunction to create models for the distribution of harmful materials, assisting decision makers in evacuations, remediation/containment actions, and post-event decontamination activities. The synergistic relationship of these sensors is maximized by their collocation. A case study over Northeastern Iran, incorporating high spatial resolution MODIS data with high spectral resolution AIRS data will illustrate the efficiency and effectiveness of an integrated approach.

36) **Synergistic Approach to Aerosol Observations Using the Hyperspectral Environmental Suite (HES) and the Advanced Baseline Imager (ABI) On GOES-R**
Gary Alexander, Kevin M. Lausten, Mary Tutzu, Brenda Zuzolo, Phil Zuzolo
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Abstract:
The Hyperspectral Environment Suite (HES) and Advanced Baseline Imager (ABI) on GOES-R allow for the most accurate observation and quantification of aerosol optical properties. Aerosols can affect climate by scattering or reflecting solar radiation, and by altering cloud microphysics, cloud brightness, and precipitation. The high spatial (.5 km) and temporal (30 minutes, Full Disk) resolution of the ABI allows for up to date cloud masking capabilities and the accurate location of multiple clear atmospheric windows. The high spectral (TBD) and radiometric resolution functionality of the HES enables algorithms to acquire valuable aerosol information. Such products as aerosol optical thickness (AOT), particle size, and relative humidity (RH) can be calculated over oceans and ideal continental regions in near real time due to the co-location of the ABI and HES. The Moderate Resolution Imaging Spectroradiomter (MODIS) and

Atmospheric Infrared Sounder (AIRS) instruments relate well to the ABI and HES, respectively, and are used in this study to display a synergistic relationship between sensors to develop aerosol products.

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

Danielle Forsyth, Thetus Corporation

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

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

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

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

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

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

38) Current GOES Data Capability Within The CLASS System And New GOES Capabilities in Development Or Planning Stages.

Richard G. Reynolds, Chief, Ground Systems Division, Office of Systems Development, NESDIS
Carlos Martinez, Vice-President, TMC Technologies, Inc.

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

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

GOES operational capabilities:

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

Current development activities:

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

Supports the following NOAA Strategic Goals:

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

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

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

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

* The EVE Science Team:
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A. Jones, D. Judge (University of Southern California)
J. Lean, J. Mariska, D. McMullin, H. Warren (Naval Research Laboratory)
G. Berthiaume (MIT – Lincoln Labs)
S. Bailey (University of Alaska – Geophysical Institute)
T. Fuller-Rowell, R. Viereck (NOAA – Space Environment Center)
J. Sojka (Utah State University)
K. Tobiska (Space Environment Technologies)

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

Raymond K. Garcia, Maciej J. Smuga-Otto, Hung-Lung Huang, Paolo Antonelli
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Abstract

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

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

Christopher C. Schmidt, Jun Li

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Abstract:

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

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

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

42) **Design of a Compression Algorithm for GOES Data.**

Irina Gladkova [1], Leonid Roytman [1], Mitch Goldberg [2], John Weber [1]
[1] City College of New York, [2] NOAA/NESDIS

Abstract

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

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

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

Paul Ruscher

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

One of our most popular features is daily weather satellite discussions, done during the school year. These features were added after the old NESDIS regional satellite discussions were discontinued in the 1990s. In addition, we have a complete history of the U. S. Weather Satellite program online. We also participate in the GLOBE program, and have developed a separate educational outreach program for schools with automated weather stations, called REALM.

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

44) **Using GOES-R for Land Surface Temperature Estimation**

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Abstract

The Advanced Baseline Imager (ABI) and the Hyperspectral Environmental Suite (HES) will provide a vast improvement in the current capability in monitoring the land surface temperature (LST). LST is a critical product from GOES and is used in defining the lower boundary condition in numerical weather prediction models. The current GOES N-P series of imager lacks a 12 um channel which complicates the estimation of the LST. In addition, the lack of hemispheric scanning of the GOES N-P sounder limits the ability of using sounder channels to assist in the LST generation. All of these limitations will be removed with GOES-R. This poster will present the current state of LST generation with GOES N-P within the NESDIS Office of Research and Applications and will give preliminary results on the improvements expected with GOES-R.

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

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

of sensor data using a common retrieval algorithm. In this poster we will present an overview of the NPOESS-CrIMSS algorithms, describe the OSS method and discuss specifics about the implementation that maximize flexibility for transition to future sensors. Retrievals using AIRS measurements and simulated GOES-HES measurements will also be presented.

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

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

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

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

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

Gary Jedlovec[1], Stephanie Haines[2], Ron Suggs[1], Tom Bradshaw[3], Jason Burks[3], and Kevin Schrab[4]
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Abstract:

Imagery and derived products from MODIS, on NASA's Terra and Aqua satellites, are being used operationally by several NWS Forecast Offices to assist in the preparation of short-term forecasts. A subset of MODIS channels with spectral characteristics similar to those planned for the GOES-R ABI are obtained in real-time by the NASA/MSFC, as part of the Short-term Prediction Research Transition (SPoRT) program. The data are reformatted, sectorized, and disseminated to Forecast Offices for operational use directly in AWIPS. Several images generated from more than one channel, such as true and false color composite imagery and a 11-3.9 micrometer "fog" image, are produced from the real-time data stream. Additionally, a number of products, such as lifted index, land surface temperature and cloud phase, generated either from EOS institutional or NASA/MSFC in-house algorithms, are made available to the offices in near real-time.

This transition activity, from research to operations, serves to prepare forecasters for the next generation of satellite observing capabilities through real-time, hands-on applications to their forecast problems. The SPoRT program provides training on the new data and products and their applications. Forecasters provide immediate feedback on product improvement and an assessment of the value of the new data or product. The poster will present examples of this transition and preliminary assessments on the utility of the EOS products for improving short-term forecasts.

48) **Application of Principal Component Analysis (PCA) to AIRS Data**

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Abstract

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

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

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

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

49) **The Case for the Green Band on ABI**

Christopher C. Schmidt

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

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

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

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

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Abstract

The current GOES Wildfire Automated Biomass Burning Algorithm (WF_ABBA) has provided diurnal information on wildfires, prescribed burns, and agricultural fires for the Western Hemisphere since the year

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

51) **On The Spatial And Spectral Requirements To Effectively Resolve The Coastal Ocean Environment**

W. Paul Bissett, Daniel Dye, Sharon DeBra, and David D. R. Kohler
1Florida Environmental Research Institute, Tampa, FL USA

Abstract

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

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

52) **SST retrieval using scene dependant two band and three band multi-window algorithms for the GOES-R Advanced Baseline Imager (ABI)**

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

Abstract

Retrieval of Sea Surface Temperature (SST) in tropical or sub-tropical regions within the 0.2C errors needed for accurate climatology is complicated by corrections due to atmospheric corrections for water vapor. This effect is magnified by large satellite zenith angles where the water vapor path increases. Present

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

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

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

54) Regional and Global NWP Data Denial Experiments

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Abstract

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

initiated that use the Global Forecast System (GFS).

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

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

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

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

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

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

56) **<u>The Advanced Satellite Aviation-Weather Products Initiative for Diagnosing and Nowcasting Weather Hazards for Improved Aviation Safety</u>**

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

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

57) **<u>Improvement in Groundbased Infrared Hyperspectral Retrieval of Thermodynamic Profiles</u>**

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The United States Department of Energy's Atmospheric Radiation Measurement (ARM) program has funded the successful development of the Atmospheric Emitted Radiance Interferometer (AERI) instrument during the past decade. This has led to a hardened, autonomous system that measures downwelling infrared (IR) radiance at high-spectral resolution. Seven Hyperspectral AERI systems have been deployed around the world as part of the ARM program. The initial goal of these instruments was to characterize the clear-sky IR emission from the atmosphere for thermodynamic profiling, thus a temporal sampling was chosen (8-10 min per spectrum) to minimize random noise in the AERI observations. Recent research emphasis has been placed on the improvement of vertical resolution and temporal sampling on AERI derived atmospheric boundary layer thermodynamic profiles and cloud property retrievals.

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

58) **<u>Lossless Data Compression Studies for NOAA Hyperspectral Environmental Suite</u>**

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Timothy J. Schmit and Roger W. Heymann
NOAA, National Environmental Satellite, Data, and Information Service

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

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

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

60) **Preparing for GOES-R+ - Critical Role of A Vibrant Continuous Learning Program**

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