GOFC-GOLD GLOBAL OBSERVATION OF FOREST AND LAND COVER DYNAMICS

Report on the Joint GOFC/GOLD Fire and CEOS LPV Working Group Workshop on Global Geostationary Fire Monitoring Applications.

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Global Observation of Forest and Land Cover Dynamics (GOFC-GOLD) is a coordinated international effort to ensure a continuous program of space-based and in situ forest and other land cover observations to better understand global change, to support international assessments and environmental treaties and to contribute to natural resources management.

GOFC-GOLD encourages countries to increase their ability to measure and track forest and land cover dynamics by promoting and supporting participation on implementation teams and in regional networks. Through these forums, data users and providers share information to improve understanding of user requirements and product quality.

GOFC-GOLD is a Panel of the Global Terrestrial Observing System (GTOS), sponsored by FAO, UNESCO, WMO, ICSU and UNEP. The GOFC-GOLD Secretariat is hosted by Canada and supported by the Canadian Space Agency and Natural Resources Canada. Other contributing agencies include NASA, ESA, START and JRC. Further information can be obtained at http://www.fao.org/gtos/gofc-gold

Joint GOFC/GOLD Fire and CEOS LPV Working Group Workshop on

Global Geostationary Fire Monitoring Applications

EUMETSAT, Darmstadt, March 23-25, 2004

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Executive Summary

The Global Observations of Forest and Land Cover Dynamics (GOFC/GOLD) project provides a forum for international exchange of information, observation and data coordination, and serves as a framework for establishing long-term monitoring systems. The GOFC/GOLD Fire Mapping and Monitoring Theme is primarily focused on determining international observation requirements and making the best use of products from existing and future satellite systems for fire management, policy decision-making and global change research (see http://gofc-fire.umd.edu/index.asp). A specific goal of the GOFC/GOLD-Fire program is to develop and foster the implementation of a global near real-time operational geostationary fire monitoring network using the GOES, MSG and MTSAT data to monitor fires as they occur and capture the diurnal signature. The GOFC/GOLD Fire program and the Committee on Earth Observation Satellites (CEOS) Land Product Validation (LPV) Working Group held a joint workshop on *Geostationary Fire Monitoring Applications* to address this goal. The workshop was hosted by the EUropean Organization for the Exploitation of METeorological SATellites (EUMETSAT) in Darmstadt, Germany on March 23-25, 2004. More than 35 individuals from 11 countries attended the workshop. Participants included geostationary program managers and representatives from operational agencies, research centers, and universities; algorithm developers; data providers and users; validation scientists; and GOFC regional network representatives.

The overall goal of the workshop was to discuss, plan and coordinate the development and eventual implementation of a global operational geostationary fire monitoring applications system. In addition, this workshop touched on other applications of geostationary satellites for fire risk assessment and post-fire changes in surface characteristics including the use of albedo products. Accuracy assessment was also discussed and is a vital and necessary component in the implementation of a global geostationary fire monitoring network.

Specific objectives and topics of discussion included the following:

1.) review of current and future geostationary satellite sensors (GOES, MSG, MTSAT) and capabilities for active fire detection and pre- and post-fire monitoring applications (e.g. fire risk, surface albedo monitoring, and burned area mapping with MSG HRV);

2.) identification of global/regional user product requirements, specifications, and applications;

3.) review of algorithm development activities, product generation, and availability;

4.) evaluation of the feasibility of a coordinated near real-time global geostationary fire monitoring applications system;

5.) development of a timeline and list of participants involved in the implementation of a global geostationary monitoring system;

6.) identification of validation activities; and

7.) discussion of ways to generate integrated polar and geostationary products for enhanced global monitoring.

The overall assessment of the GOFC/GOLD *Global Geostationary Fire Monitoring Applications Workshop* was that geostationary systems have an important contribution to make to active fire and smoke detection and characterization with applications in fire management, emissions and air quality studies, and global change research. Geostationary systems can provide valuable diurnal information that is complementary to fire products produced by higher resolution polar orbiting instruments. Workshop participants felt that a global geostationary fire monitoring network is technically feasible, but that it must be supported by the operational agencies in order to sustain the activity and produce standardized long-term data records and fire inventories of known accuracy. In order to demonstrate the science and show the benefits and feasibility of a global geostationary fire monitoring network, a demonstration/feasibility project was planned. The focus of the project will be active fire detection, emissions assessment, and intercontinental transport with a strong numerical model data assimilation component. In addition the demonstration phase will be used to identify traditional users and strengthen the input from non-traditional users.

The components of the demonstration plan are as follows and will be supported through current funding mechanisms.

- A rapid scan GOES-10/-12 Wildfire ABBA will be implemented in the U.S. to show the impact of high temporal geostationary fire monitoring capabilities on fire detection and suppression efforts.

- NOAA/NESDIS Office of Research and Applications (ORA) and UW-Madison Cooperative Institute for Meteorological Satellite Studies (CIMSS) will adapt the operational GOES-10/-12 Wildfire Automated Biomass Burning Algorithm (WF_ABBA) to the European Meteosat Second Generation (MSG) Spinning Enhanced Visible and Infrared Imager (SEVIRI) with an experimental version in place by June 2005. UW-Madison CIMSS in cooperation with NOAA/NESDIS/ORA will make the MSG SEVIRI near real-time fire products (fire locations and sub-pixel fire characteristics) available to the EU civil protection and fire service customers during the summer of 2005 to solicit their feedback and support.

EUMETSAT anticipates producing a fire product after the demonstration phase at the end of 2005 at the earliest.

- NOAA/NESDIS/ORA and CIMSS will adapt the WF_ABBA for application with the Japanese Multi-functional Transport SATellite (MTSAT-1R) JAMI after launch.

- The Naval Research Laboratory (NRL-Monterey) will demonstrate the impact of assimilating all available global geostationary fire products (GOES, MSG, MTSAT-1R) into the operational Navy Aerosol Analysis and Prediction System (NAAPS) to diagnose and predict aerosol loading and transport.

- Validation efforts will be performed in coordination with the CEOS LPV working group.

- Results of the demonstration/feasibility project will be documented and publicized to the broad community of data users for evaluation and feedback and to the operational satellite and user agencies. This demonstration is intended as a first step towards future operational implementation of the geostationary network.

Recommendations from the Meeting

1. That the Global Geostationary Fire Demonstration Project outlined in the report be supported by the proposed partners and a small project workshop should be held in 2005 to analyze and evaluate preliminary project results.

2. GOFC/GOLD Fire should hold a results workshop on completion of the project, with a broad user community and operational agency participation to show the results of the demonstration project and formulate plans for operational implementation.

3. As part of the proposed demonstration project a coordination effort is needed between GOFC/GOLD – Fire and the CEOS Land Product Validation Working Group to establish standards and protocols for geostationary fire product validation and reporting.

4. GOFC/GOLD should work to increase the level of involvement of the Japanese Meteorological Agency in this project and in discussions on geostationary fire monitoring.

Workshop co-chairs:

Elaine Prins, NOAA/NESDIS/ORA, Grass Valley, CA, USA
Yves Govaerts, EUMETSAT, Darmstadt, Germany

Overview of the Joint GOFC/GOLD Fire and CEOS LVP Workshop on Global Geostationary Fire Monitoring Applications

The overall goal of the GOFC/GOLD and CEOS Land Product Validation (LPV) Working Group Workshop on *Geostationary Fire Monitoring Applications* was to discuss, plan, and coordinate the development and implementation of a global operational geostationary fire detection and monitoring system. Currently the imager on the U.S. Geostatationary Operational Environmental Satellites (GOES-East and GOES-West) allows for diurnal fire detection and monitoring throughout the Western Hemisphere. The European Meteosat Second Generation (MSG) Spinning Enhanced Visible and Infrared Imager (SEVIRI) launched in 2002 can provide diurnal fire monitoring capabilities in Europe and Africa. In May 2003, the GOES-9 satellite was activated over the Equator at 155°E allowing for hourly full disk fire detection and monitoring throughout the region, including portions of eastern Asia, and excellent coverage of the Western Pacific, Southeast Asia and Australia. The Japanese Advanced Meteorological Imager (JAMI) on the Multi-functional Transport Satellite (MTSAT-1R, launch in 2005) will enable enhanced fire monitoring throughout the region. Together with current and future meteorological and environmental polar-orbiting satellites, this suite of geostationary sensors provides nearly global coverage and will be able to detect, monitor, and characterize sub-pixel fires as they occur with high temporal resolution.

The format of the workshop consisted of three plenary sessions with invited oral presentations focusing on specific topics/objectives, a poster session, and four discussion sessions to further address the goals and objectives of the workshop. The plenary session topics included: the rationale for a global geostationary fire product, an overview of current and near-term geostationary systems for fire monitoring, algorithm development, applications and requirements, current operational geostationary fire monitoring systems, and validation activities. The discussion sessions focused on specific issues as they relate to geostationary fire monitoring applications and the development and implementation of a global geostationary fire monitoring network. The discussion sessions were led by two co-chairs and were guided by a series of questions. A summary report of each of the session discussions is provided below. In some cases the discussion sessions addressed each of the questions individually; in others it was more appropriate to address multiple questions simultaneously.

The four discussion session topics and associated questions are outlined below:

1.) **Global Geostationary Fire Network**;

What are the user requirements, specifications, applications for pre- and post-fire monitoring and active fire detection?
Do current geostationary algorithms meet these needs?
What do we need from future systems?
What are the priorities?

2.) **Global Geostationary Fire Algorithm Development Status**;

What is the status of algorithm development for a global geostationary fire monitoring

system?
What is currently available?
What research is needed?
What are the priorities?

3.) **Global Geostationary Fire Monitoring System Roadmap**; and

What is the feasibility of a coordinated near real-time global geostationary fire monitoring applications system?
What is the timeline?
Who are the participants involved in the implementation of a global geostationary fire monitoring system?
Demonstration plan?
What are the plans for operational multi-sensor data fusion?

4.) **Geostationary Fire Products Validation Plans**

What validation activities need to be done?
Can we tie into larger programs?
What is available?

Discussion Session 1: Global Geostationary Fire Network

(Co-Chairs: Jeffrey Reid (NRL-Monterey), Chris Justice (University of Maryland))

The discussions in this session often addressed multiple questions simultaneously. The summary provided below addresses all four questions and overlapping issues.

What are the user requirements, specifications, applications for pre- and post-fire monitoring and active fire detection?

Do current geostationary algorithms meet these needs?

What do we need from future systems?

What are the priorities?

In the first discussion group, participants conferred on the user requirements of their individual organizations as well as those of the scientific and hazard communities as a whole. From the presentations it was clear in which directions geostationary fire research is headed. Both the global climate science (GC) and fire applications (FA) communities have determined that no one system can meet all of the needs of the highly diverse biomass burning field, but geostationary and polar orbiting systems can be combined synergistically to meet a significant number of the requirements. Most current applications for geostationary fire science are at the local/national/regional levels in areas such as fire hazard monitoring, smoke forecasting, and air quality. Despite these more "localized" applications communities, there are considerable benefits from the development of active human networks, including exchange of experience and methods. It is highly desirable for all observation systems to be consistent on a number of levels including well-documented detection probabilities and data formats and distribution. Indeed, such consistency is required to support the growing requirements for fire climatologies (e.g., GC science and compliance with the Kyoto Protocol) as well as intercontinental transport models of gas and particulate emissions (for air quality, regulation, and climate).

Geostationary systems fill a number of unique user requirements for which they are ideally suited. This is ultimately related to their high temporal scanning frequency (e.g., every 15-30 minutes) compared to polar orbiters (2 times per day). The current GOES system (i.e., Wildfire Automated Biomass Burning Algorithm (WF_ABBA)) has been effective in early fire detection and is currently being evaluated by Environment Canada to identify and monitor fires in remote locations in Quebec, Canada. The WF_ABBA data has also been used in forensic science to assist in determining the time of fire ignition. Geostationary products are more suited for real time fire emissions estimates; because fires are monitored at high temporal resolution, it is easier to develop burning time series for individual fires. Such time series are required for real time air quality/plume transport applications, and are particularly necessary for the monitoring of pollution by intense, short duration agriculture burning. The coarser resolution also has the advantage of reduced brightness temperature saturation in the 4 micron band.

Potential also exists for new systems that can utilize geostationary strengths. Because of the rapid production of geostationary fire products, they have tremendous aptitude for fire hazard assessment and prediction. By combining fire products with high-resolution meteorology data, flare-ups can be monitored and hazards assessed. This is further aided by the geostationary satellites lower propensity for pixel saturation. The inclusion of geostationary smoke optical depth products currently under development by NOAA will also help monitor air quality.

In a number of ways, geostationary algorithms augment current and proposed polar orbiter data sets (such as AVHRR, METOP, MODIS, NPP and NPOESS VIIRS). Polar orbiters have higher spatial resolution than the geostationary platforms but at a cost of temporal coverage. If applied consistently across platforms, the geostationary platforms can be used to determine diurnal cycles of burning activity in individual regions. In post analysis, this can be combined with the polar data to determine more accurate fire climatologies, long-term emissions assessments, and support for international agreements such as the Kyoto protocol.

Currently, the WF_ABBA system based on GOES satellites is the only operational or quasi-operational system providing both fire identification and estimates of sub-pixel fire characteristics. Fire products are generated for GOES-10 and -12 for the Western Hemisphere and it is anticipated that the GOES-9 WF_ABBA over East Asia will become active by summer 2004. European investigators have performed preliminary algorithm development for MSG/SEVERI in the last year, although no definitive product has emerged. Currently the WF_ABBA is slated for transition to this platform as well. The WF_ABBA has fulfilled some of the requirements listed by the panel, although not with the desired fidelity. The WF_ABBA has proven itself for early fire detection in remote regions of Canada and the United States. It has also provided first detection in some populated regions late at night. Fire products from the WF_ABBA have been used to initialize air quality models and have been helpful in mapping fire hazards in other various air quality capabilities. However, the current state of the GOES satellites makes these products only semi-quantitative.

All of the applications discussed above have similar requirements for geostationary fire products. Ultimately, for fire detection, most users would prefer extremely high spatial, temporal, and dynamic precision and accuracy (e.g., 500 m data, 5 minute scan rate, 5 minute turn around, etc....). Such requirements are not likely be technically feasible for the next 15 years. In addition to a geo-located Boolean fire hot spot analysis, reasonable products for currently anticipated systems should include instantaneous estimates of fire temperature, size, and fire radiative power. For next generation geostationary systems, spatial resolution needs to be increased from the current 4-5 km to better than 2 km, and geo-location must be performed to within 1 km. Fire identification should have a specificity of better than 95% (e.g., <5% false alarms) (Final Report of the CEOS Disaster Management Support Group Fire Team). Discussion amongst the group suggested that future systems should have a dedicated 16-bit 4 μm fire channel with a maximum temperature of at least 400 K. Because geostationary applications are geared to near-real time analysis, all fire products are required to support a 30-minute update cycle with a processing time of less than 10 minutes from image acquisition. Global coverage is anecessity. Because different satellites would be used in this global analysis, algorithms should be comparable and preferably the same. Product characterization and intercomparisons will be needed. Data distribution should be consistent between platforms and include web based information delivery and GIS compatibility. To meet the needs of the meteorological community, BUFR (Binary Universal Form for the Representation of Meteorological Data) output would also be beneficial.

Near term priorities can be divided into current system, research and long-term action items. With the demonstration of the WF_ABBA in the Western Hemisphere the porting of this system to other platforms, such as MSG/SEVERI and MTSAT/JAMI for demonstration purposes, should proceed as a high priority. Co-linear development of new systems by the European and Asian communities should be encouraged. Research should be focused on two principle areas. The first is the systematic validation effort required to understand cross platform differences. This is further discussed in discussion session 4 of this report. Second, the development of fire radiance algorithms should be encouraged. Currently, pixel navigation has a large enough uncertainty in deforestation areas to regularly disrupt identification of the ecosystem in which a fire is detected. This has a non-linear effect on fire emission algorithms and causes the greatest uncertainty in determining fire emission rates. It has been hypothesized that fire radiance is closely coupled to total output energy and hence emissions. If these fire radiance algorithms prove fruitful, it may alleviate some of the navigation bias in emission models. To conclude, there was much discussion on long-term priorities.

Clearly, there is the need for a strong lobby from the user community to ensure satellite programs add the necessary fire related capabilities to their missions. A large part of this lobbying must include an education and outreach plan with users and demonstration projects to show how geostationary fire products can help individual fire hazard, air quality, meteorology and global climate science organizations.

Discussion Session 2: Global Geostationary Fire Algorithm Development Status

(Co-Chairs: Louis Giglio (SSAI), Stephane Flasse (Flasse Consulting))

What is the status of algorithm development for a global geostationary fire monitoring system? What is currently available?

Although numerous data products can be derived from geostationary satellite observations, discussions were limited to those products offering clear advantages over other remote sensing satellites and systems. These are:

- active fire detection and characterization, which includes fire timing and location, fire radiative power, instantaneous fire size and average temperature;
- fire weather and diurnal surface temperature;
- long term burnt area via albedo; and
- aerosol optical depth (further evaluation is needed).

The remainder of the discussion was confined to active fire-related products. These products offer the most compatibility with heritage satellite-based fire monitoring systems, and are perhaps the most appropriate in the context of near real-time fire monitoring. In addition, fire detection algorithms are relatively mature. Discussion of current algorithms focused on fire detection, retrieval of sub-pixel temperature and area, and retrieval of fire radiative power.

There are presently at least six active fire detection algorithms intended for use with instruments on-board geostationary satellites. There is a considerable range in their relative maturity. Some are operational and have been applied over large spatial scales (e.g. continental) and multi-year time periods, while others, having been applied on much more limited spatial and temporal scales, are experimental. During the discussion session, the following detection algorithms were identified:

1) the contextual WF_ABBA algorithm of Prins et al., which has been used operationally for some years with the GOES-8 through GOES-12 Imagers;
2) an operational algorithm developed at the University of Hawaii being used with the Imagers on board multiple GOES satellites;
3) an operational algorithm which is part of the RAMSDIS system developed by CSU-Colorado that has been used with the GOES-8 through GOES-12 Imagers;
4) a threshold-based algorithm developed by Setzer et al. for the GOES Imager;
5) an experimental threshold and change detection algorithm for the MSG SEVIRI developed by Telespazio;
6) an experimental threshold algorithm for the MSG SEVIRI developed by the Laboratorio de Teledetección (LATUV).

Current approaches for determining instantaneous estimates of sub-pixel fire temperature and area include the traditional Dozier two-channel method, and an extended five-channel Dozier approach developed by Telespazio.

Current approaches for determining fire radiative power include the original empirical approach of Kaufman et al., as well as the improved radiance-based approach of Wooster et al. One could also use subpixel fire temperature and area estimates to retrieve fire radiative power, although this would introduce additional error sources that are potentially very large.

What research is needed?

The discussion session identified the following ten research areas:

1.) development of fire detection and characterization algorithms;
2.) establishment of detection envelopes and false alarm rates for each instrument (and algorithm);
3.) assessment of geolocation accuracy;
4.) use of ancillary information;
5.) exploiting the superior temporal sampling provided by geostationary satellites;
6.) identifying false-alarm sources;
7.) addressing the SEVIRI cubic convolution resampling issue;
8.) product integration;
9.) fire radiative power;
10) subpixel fire area and temperature.

A discussion of each research area is provided below.

<u>Development of fire detection and characterization algorithms</u>
If different algorithms are needed for each geostationary sensor (which is likely), efforts should be made to make these algorithms behave as consistently as possible. A consensus was reached that any detection algorithm would have to be robust and contextual given the spatial scales over which the algorithms will be applied.

<u>Establishment of detection envelopes and false alarm rates for each instrument (and algorithm) should be developed.</u>
This should include quantifying the dependence of algorithm performance on view angle. From a user perspective, it is also desirable to establish confidence limits for detected fires.

<u>Geolocation accuracy</u>
For the user community a clear characterization of geolocation accuracy is needed for each of the geostationary fire monitoring satellites.

<u>Use of ancillary information</u>
What ancillary information should be used, and how may this information be used in a consistent manner across the different geostationary platforms? If global land cover data sets are required for the fire detection and/or characterization process, how should one deal with the dynamic nature of land cover, and how frequently must such data sets be updated?

Exploiting the superior temporal sampling provided by geostationary satellites
Benefits include a reduction in false alarms (possibly by using statistics of different variables vs. time of day), and high quality estimates of total energy released by individual fires. The latter could in turn be used to help estimate the total biomass combusted by individual fires.

False-alarm sources
This effort should be leveraged on analyst and algorithm developer experience. The final system needs to be automated with a minimum of operator interaction.

SEVIRI cubic convolution resampling issue
Upstream SEVIRI data "cleaning" and remapping must be well understood with respect to the impact on fire monitoring. If necessary, methods of undoing or bypassing these preprocessing steps need to be considered.

Product integration
The proposed network of geostationary fire-monitoring satellites builds upon sensors having different spatial resolutions and radiometric characteristics. In addition, the instrument instantaneous ground field of view (IGFOV) systematically increases as one moves away from the subsatellite point. All of these factors effect the envelope of detectable fires. It is important, therefore, to quantify both detection and false alarm rates for each instrument (and algorithm, if a different detection algorithm is to be used for each instrument). Subsequent efforts should be directed towards devising optimal methods for integrating the observations from the network of satellites in such a way as to maximize their consistency.

Fire radiative power
A better understanding is needed of the energy contributions from the tops of flames vs. regions close to the ground, and how this determines the satellite measured power especially when integrated over the comparatively large sensor footprint. Given the different radiometric characteristics of the different geostationary satellite sensors, it is important to determine what may be done to substitute shorter wavelength channels in the event that the 4 micron channel saturates. Finally, in light of the experimental nature and the current unknown utility of fire radiative power, it would be worthwhile to better understand the role of FRP in modeling.

Subpixel fire area and temperature
It is necessary to quantify the uncertainties in retrieved fire temperature and subpixel area. This is particularly important because earlier work has suggested that the larger IGFOV of geostationary-satellite sensors can cause significant random and systematic errors. The NPOESS Preparatory Project (NPP) Active Fire Environmental Data Record (i.e., product) includes a subpixel fire temperature and area component, and a link should be made to this activity, possibly through the NPP Science Team.

What are the priorities?

Since the primary goal of this GOFC/GOLD activity is to facilitate the implementation of a global fire-monitoring geostationary satellite suite, highest priority should be given to characterizing the individual fire monitoring capabilities of the multiple sensors that will be used

(GOES Imager, MSG SEVIRI, MTSAT JAMI), and, to the extent possible, standardizing these capabilities. For example, although the different spatial resolution and radiometric characteristics of these sensors will, in addition to other factors, preclude identical fire detection and characterization capabilities in all regions, it is nevertheless important to make these characteristics as uniform as possible. Secondly, efforts to standardize product documentation, product metadata, quality-assurance procedures, and data formats are also important and should be undertaken early in the implementation process. Finally, the utility of fire radiative power versus the more common retrieval of average fire temperature and subpixel area needs to be investigated.

Discussion Session 3: Global Geostationary Fire Monitoring System Roadmap

(Co-Chairs: Donna McNamara (NOAA/NESDIS), Yves Govaerts (EUMETSAT))

What is the feasibility of a coordinated near real-time global geostationary fire monitoring applications system?

Technically a global near real-time geostationary fire monitoring system is feasible. To obtain the support of operational organizations, a demonstration phase should take place first, with the NOAA National Environmental Satellite, Data, and Information Service (NESDIS), with its current capability in fire monitoring, taking the lead. The goal of the demonstration will be to show the positive contribution of geostationary fire data to atmospheric modeling (e.g., visibility forecasting), as well as identify traditional users (who have a greater impact on operational organization priorities) and strengthen the voice of non-traditional users. This global coordinated effort should not prevent local, customized users from using geostationary data for specialized applications.

What is the timeline?

The plan is for the WF_ABBA to be adapted to the Spinning Enhanced Visible and Infrared Imager (SEVIRI) data on Meteosat Second Generation (MSG) and implemented on an experimental basis in 2005. EUMETSAT hopes to produce a fire product no earlier than the end of 2005, after demonstration. Although the Japanese Meteorological Agency (JMA) was not represented at the workshop, contacts have been made and plans are underway to adapt the WF_ABBA to the MTSAT JAMI after launch.

Who are the participants involved in the implementation of a global geostationary fire monitoring system?

Although not all of the participants attended the workshop, the following list provides a summary of current and desired participants.

Current:

- NOAA/NESDIS/ORA and UW-Madison Cooperative Institute for Meteorological Satellite Studies (CIMSS) will adapt the WF_ABBA to MSG SEVIRI, followed by the Multi-functional Transport Satellite (MTSAT) (Elaine Prins, NOAA/NESDIS).
- The Naval Research Laboratory (NRL) will demonstrate the impact of global fires detected from geostationary satellites on the operational Naval Aerosol Analysis and Prediction System (NAAPS). (Jeffrey Reid, NRL-Monterey).

The following groups were not represented at the workshop, but their participation is desired and they will be contacted:

- Polish Weather service: adapting Coupled Ocean/Atmospheric Mesoscale Prediction Systems (COAMPS) with demonstration of aerosol component (Piotr Flatau, NRL-Monterey Visiting Scientist).
- Southeast Asia: assign participants in May SEARIN (Southeast Asian Regional GOFC/GOLD Network) meeting.
- Program to address Asian Regional Transboundary Smoke (PARTS): involvement of Specialized Meteorological Center in Singapore and NESDIS/NGDC.
- Australia and Japan: contacts are needed.
- Possible involvement of US/Japanese modeling group in Hawaii.
- AEROCOM Global Aerosol Model Intercomparison (Michael Schulz, LSCE Paris; Stefan Kinne, MPI-Met, Hamburg).
- AERONET (AErosol RObotic NETwork) program at NASA/GSFC (Brent Holben, NASA/GSFC)
- Center for Weather Forecasts and Climate Studies (Centro de Previsão de Tempo e Estudos Climáticos, CPTEC) in Brazil (both GOES and MSG coverage).

Demonstration and Feasibility Plan

NOAA/NESDIS/ORA and UW-Madison CIMSS will adapt the WF_ABBA algorithm to both MSG and MTSAT. NRL-Monterey will assimilate the fire products into the global Naval Aerosol Analysis and Prediction System (NAAPS). Results will be documented and publicized via the GOFC/GOLD Fire Implementation Team. MSG SEVERI fire products will be made available to EU civil protection and fire service customers during the summer of 2005 to solicit their feedback and support. In addition NOAA/NESDIS/ORA will demonstrate GOES Rapid Scan support during a major fire situation in the US to show possible impact of high temporal geostationary monitoring on fire detection and suppression.

What are the plans for operational multi-sensor data fusion?

The first step involves identifying the pluses and minuses of each sensor (polar and geostationary). Groups are currently using multiple sensors in manual data fusion efforts. There is interest in automated data fusion, but no operational groups are ready to do this at this time and further development is needed within the research community. When data fusion is performed, it is likely to be application oriented. Participants felt that once the required information systems are developed, data fusion will follow. Metadata (and consistent formats) will facilitate data fusion.

Discussion Session 4: Geostationary Fire Products Validation Plans

(Co-Chairs: Jeffrey Morisette (NASA/GSFC), Ivan Csiszar (University of Maryland), Elaine Prins (NOAA/NESDIS))

The summary provided below addresses all three questions and overlapping issues.

What validation activities (can) need to be done?

Can we tie into larger programs?

What is available?

The objective of an integrated, global high temporal resolution fire monitoring system from geostationary platforms will be achieved if products from different geostationary platforms can be combined in a relatively seamless fashion. Quantifying the accuracy of the products from each sensor will help ensure proper use when these products are combined. The Committee on Earth Observing Satellites (CEOS) has established the need for proper calibration and validation of satellite-derived products through its Working Group on Calibration and Validation (WGCV). The validation of higher-order land products can be coordinated through the Land Product Validation (LPV) subgroup; for fire detection validation this coordination can include:

1) development of protocols for validation data collection and provision,
2) cost sharing by building on existing validation efforts for fire-related products from polar orbiting satellites,
3) establishing and maintaining consistency for the validation methods of global fire products derived from multiple geostationary platforms, and
4) standards for validation results presentation.

Presentations and discussions at the workshop established the consensus that the most useful fire products from geostationary satellites are active fire detections and fire radiative power retrievals.

Validation of active fire detection products is a two-stage process. The first stage involves the determination of absolute detection capabilities of the given sensor and algorithm. Accuracy metrics are detection probabilities as a function of fire characteristics and observing conditions. The second stage is the determination of commission and omission errors related to the application-dependent population of "fires of interest." Detection probabilities and error rates can be established using reference data from in-situ and high resolution remote sensing observations and radiative transfer simulations.

A unique feature of the geostationary fire products is the capability to map the diurnal cycle of fire activity. Therefore, particular attention needs to be paid to the variability of algorithm performance as a function of local time.

Presentations at the workshop revealed several independent, regional validation activities, representing a wide range of methodologies. While some work quantifying the accuracy of geostationary active fire detection exists, most validation work has been done with polar orbiting active fire and burn scar products. This presents near-term opportunities for geostationary active fire detection validation to share existing and future reference data from polar orbiting validation work.

Those leading the GOFC/GOLD and LPV initiative to validate the MODIS active fire product via high resolution ASTER data agreed to also analyze the WF ABBA product over North and South America. Multiple ASTER/MODIS data sets will allow for analysis across a range of geostationary view angles. It is desirable to consider ASTER/MODIS locations near geostationary sub-satellite points as well as off-nadir locations. For inter-sensor comparisons, the use of common reference data from polar satellites (such as ASTER/MODIS or the experimental BIRD system) can be complemented by direct comparison in regions of geostationary footprint overlap (e.g., Eastern Brazil for MSG and GOES-East). It is important to note that the comparison of geostationary active fire detection with polar data implies a limitation of only considering two times of day.

Another near-term opportunity is to establish a database of gas-flare reference locations. The LPV will work with the GOFC/GOLD fire implementation team to establish a database of persistent thermal anomalies (such as gas-flares) and post these locations on the LPV and GOFC/GOLD Fire Implementation team Internet sites. This gas flares database will provide a reference data set for comparisons of hot spot detection throughout the day, as well as a baseline for long-term monitoring of any changes in product accuracy.

Several science networks or existing programs can be utilized for the purpose of validating geostationary fire-related products. The results of the Smoke Clouds and Radiation (SCAR) experiments and the EOS Validation studies provided keen insights. Ongoing projects that can offer both validation reference data and application and scientific users include:

- The Large-scale Biosphere/atmosphere study in Amazonia (LBA) program (for fire detection/emission modeling)
- The US Forest Service, National Interagency Fire Center, Incident Command databases, Joint Fire Science Program and Burned Area Emergency Response (BAER) teams; and the Canadian Forest Service (for a large amount of reference data and operational perspective)
- Diurnal fire modeling studies for validation applications (e.g. Roger Ottmar, Pacific Northwest Research Station)
- Global Land Products for Carbon Model Assimilation (GlobCarbon) (focus on burnt area, providing indirect validation reference for active fires)
- The Nature Conservancy and Long Term Ecological Research (LTER) sites (for small-scale prescribed burns that can help establish minimum detection limits)
- The European Association of Remote Sensing Laboratories (EARSeL) Forest Fire Special Interest Group (SIG) (Mediterranean Region)
- Southern African Fire Network (SAFNet), Preparation for the Use of MSG in Africa (PUMA) project, Mongolia.

The EOS validation hierarchy is recommended to be adapted to indicate geostationary fire product maturity. The mid- to long-term goal is to achieve at least "Stage 2" validation status and a suite of "provisional" geostationary data products. This requires a proper strategy to sample a wide range of observing and environmental conditions. For a comprehensive product evaluation, radiative transfer simulations may be necessary to complement direct observations. Another long-term goal is to evaluate the detection capabilities for understory burns.

In addition to the validation of active fire detection from geostationary platforms there is the need to validate developmental algorithms such as fire radiative power. To address this need, and resulting from the meeting, there is a plan for collaboration between the LBA-Ecology "inter-project" prescribed burn and fire radiative power research at King's College. This will take place in August of 2004 in the Brazilian state of Mato Grosso and combine the LBA field, airborne, and satellite data acquisition for multiple prescribed burns – including standing forest and pasture areas. These data will be used to assess the accuracy of fire radiative power estimates from GOES-East data for these prescribed burns.

Validation activities and the resulting accuracy estimates should be done in conjunction with fire-related modeling research. It would be helpful to establish error budgets and/or sensitivity analysis of climate/emissions modeling components, including: fire count, area burnt, biomass/fuels, emissions, combustion completeness/burning efficiency, weather, and topography. Having such information will help quantify each models' sensitivity to the various input parameters. This information can help prioritize research efforts toward refining those input parameters causing the most uncertainty in the model output. Some work has been done on this, but more is needed to better establish producer priorities.

APPENDIX

Agenda for GOFC/GOLD Global Geostationary Fire Monitoring Applications Workshop

March 23-25, 2004, EUMETSAT, Darmstadt, Germany

<u>Day 1 – March 23, 2004</u>

Plenary Session 1 (Chair- Yves Govaerts)

13:00 – 13:05	Welcome Remarks (David Williams, EUMETSAT)
13:05 – 13:15	Introduction and Logistics (Yves Govaerts, EUMETSAT)
13:15 – 13:25	Objectives of the Meeting (Elaine Prins, NOAA/NESDIS)
13:25 – 13:40	GOFC/GOLD Fire Project (Chris Justice, University of Maryland)

Rationale for a Global Geostationary Fire Product

13:40 – 14:00	Global Change Research Community (Ivan Csiszar, University of Maryland)
14:00 – 14:20	Policy/Decision Makers (Johann Goldammer, Max Planck Institute)
14:20 – 14:40	**Coffee break**

Overview of Geostationary Systems for Fire Monitoring

14:40 – 15:00	Overview of GOES and MTSAT systems (Elaine Prins, NOAA/NESDIS)
15:00 – 15:20	Overview of the MSG system (Y. Govaerts, EUMETSAT)
15:20 – 15:40	Overview of the MSG/SEVIRI potential for fire applications (Stephane Flasse, Flasse Consulting)
15:40 – 16:00	Active fire detection from geostationary platforms (Louis Giglio, SSAI)

Plenary Session 2 (Chair – Elaine Prins)

Algorithm Development

16:00 – 16:20	Overview of the GOES Wildfire ABBA, Applications, and Future Plans (E. Prins, NOAA/NESDIS; Christopher Schmidt, UW-Madison CIMSS)
16:20 – 16:40	Retrieving fire radiative energy estimates using MSG SEVERI (Gareth Roberts, Martin Wooster, George Perry; Kings College)
16:40 – 17:00	Development of an algorithm to assess the impact of fire on surface albedo (Y. Govaerts, EUMETSAT)
17:00 – 17:20	Estimation of burned areas from fire perturbed albedo (Bernardo Mota; Jose Pereira; Technical University of Lisbon)

<u>Day 2 – March 24, 2004</u>

Plenary Session 2 - Continued

Applications and Requirements (Chair – Paulo Barbosa)

08:30 – 08:50	European user community (Paulo Barbosa, JRC)
08:50 – 09:10	African user community (Philip Frost, CSIR)
09:10 – 09:30	North American user community and applications (Tom Bobbe, USFS)
09:30 – 09:50	Monitoring the summer of 2003 forest fires of Spain and Portugal using MSG (Part 1) (Evaristo Cisbani, Telespazio S.p.A.)
09:50 – 10:10	Monitoring the summer of 2003 forest fires of Spain and Portugal (Part 2) (Jose-Luis Casanova, LATUV)
10:10 – 10:30	**Break**
10:30 – 10:50	Fire Detection by satellite for fire control in Mongolia (S. Tuya, Chiba University)
10:50 – 11:10	GOES fire monitoring for early warning and fire weather applications (C. Schmidt, UW-Madison CIMSS)
11:10 – 11:30	NRL-Monterey FLAMBE fire product data assimilation and aerosol modeling (Jeffrey Reid, NRL-Monterey)
11:30 – 13:00	**Lunch and Poster Viewing**
13:00 – 13:20	User requirements for global atmospheric modeling (Martin Schultz, MPI)
13:20 – 14:30	**Open Discussion Session 1: Global Geostationary Fire Network** (*What are the user requirements, specifications, applications for pre- and post-fire monitoring and active fire detection? Do current geostationary algorithms meet these needs? What are the priorities?*) (**2 co-chairs: Chris Justice, Jeffrey Reid**)
14:30 – 14:50	**Break**

Operational Geostationary Fire Monitoring Systems (Chair – Ivan Csiszar)

14:50 – 15:10	Applications of geostationary data for operational forest fire monitoring in Brazil (Wilfred Schroeder, IBAMA-PROARCO)
15:10 – 15:30	Geostationary hot spot monitoring at the Univ. of Hawaii (Luke Flynn, Univ. of Hawaii)
15:30 – 15:50	NOAA/NESDIS/ORA Hazard Mapping System (Donna McNamara, NOAA/NESDIS)

15:50 – 17:00	**Open Discussion Session 2: Global Geostationary Fire Algorithm Development Status** (*What is the status of algorithm development for a global geostationary fire monitoring system? What is currently available? What research is needed? What are the priorities?*) (**2 co-chairs: Louis Giglio, Stephane Flasse**)
19:00	**Social Event**

Day 3 – March 25, 2004

08:30 – 09:30	**Open Discussion Session 3: Global Geostationary Fire Monitoring System Roadmap** (*What is the feasibility of a coordinated near real-time global geostationary fire monitoring applications system? What is the timeline? Who are the participants involved in the implementation of a global geostationary fire monitoring system? Demonstration plan? What are the plans for operational multi-sensor data fusion?*) (**2 co-chairs: Donna McNamara, Yves Govaerts**)

Plenary Session 3 (Chair – Jeffrey Morisette)

Validation Activities

09:30 – 09:45	Overview of current CEOS LPV multi-sensor validation efforts/plans (Jeffrey Morisette, NASA-GSFC)
09:45 – 10:00	Albedo and burned area product validation efforts (Jeffrey Morisette, NASA-GSFC)
10:00 – 10:20	**Break**
10:20 – 10:40	Overview of validation of active fire products (I. Csiszar, Univ. of Maryland)
10:40 – 11:00	GOES WF_ABBA fire product validation in North and South America (E. Prins, NOAA/NESDIS; Joleen Feltz, UW-Madison CIMSS)
11:00 – 11:20	Geostationary validation possibilities (Tim Lynham, Canadian Forest Service)
11:30 – 12:30	**Lunch**
12:30 – 13:30	**Open Discussion Session 4: Validation Plans** (*What validation activities need to be done? Can we tie into larger programs? What is available?*) (**Co-Chairs: Jeffrey Morisette, Elaine Prins**)

13:30 – 14:00 **Discussion of next steps (Chris Justice)**

14:00 – 15:00 **Wrap-Up**