International Forest Fire News (IFFN) No. 32 (January – June 2005, 83-89)

Contribution of GOFC/GOLD-Fire to Fire Monitoring in the Russian Federation

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Introduction

The Global Observation of Forest Cover/Global Observation of Landcover Dynamics (GOFC/GOLD) program is providing international coordination to put in place the long-term observing systems needed for global environmental monitoring (http://www.fao.org/gtos/gofc-gold/index.html). Environmental monitoring requirements include satellite and ground observations for global change scientific research, as well as for natural resource management and the associated policy and decision support systems. The obstacles to improved use of satellite data for fire monitoring are common to many countries. It is recognized that the range of global observations necessary to understand and monitor earth processes, to assess human impacts and support natural resource management, exceeds the capability of any one country and therefore necessitates an international program (Ahern et al. 2001).

GOFC/GOLD was formed under the Committee on Earth Observation Satellites (CEOS) to bring together data providers and information users to improve access to and use of satellite and ground based observations on forests and fire. GOFC/GOLD is part of the Global Terrestrial Observing System (GTOS), which is sponsored by the International Global Observing System (IGOS) Partners, including the United Nations Environment Program (UNEP), the United Nations (UN) Food and Agriculture Organization (FAO) and the World Meteorological Organization (WMO) (Figure 1). GOFC/GOLD is currently helping GTOS secure the global observation needed for carbon, biodiversity monitoring and natural resource management. The secretariat for GTOS is hosted by the UN/FAO, the secretariat for GOFC/GOLD is hosted by the Canadian Forest Service. GOFC/GOLD has a special relationship with the international space agencies through the Committee on Earth Observation Satellites (CEOS).

Through a series of international workshops, the GOFC/GOLD-Fire Implementation Team (http://gofc-fire.umd.edu/) has developed a set of program goals that cover the broad range of perceived observation needs of the fire community (Justice et al., in press):

1) To increase user awareness by providing an improved understanding of the utility of satellite fire products for resource management and policy within the United Nations system, at international national and local levels.

2) To encourage the development and implementation of standard methods for Fire Danger Rating suited to different ecosystems and to enhance current fire early warning systems. To facilitate the use of remote sensing data and the development of a global fire danger monitoring system that can be used to supplement existing national and regional systems.

3) To establish an operational network of fire product validation sites and protocols, providing accuracy assessment for operational fire products and a test-bed for new or enhanced products, leading to standard fire products of known accuracy.

4) To enhance fire data product use and access, for example by developing operational multi-source fire data and combined with GIS data and making these available over the Internet.

5) To develop an operational global geostationary fire network providing observations of active fires in near real time.

6) To establish operational polar orbiters with fire monitoring capability. Providing i) operational moderate resolution long-term global fire data and products to meet user requirements and distributed ground stations providing enhanced regional products. These products should include fire danger, fuel moisture content, active fire, burned area and fire emissions, ii) operational systematic high resolution data (c. 30m) acquisition allowing fire monitoring and post-fire mapping and assessments. Thereby continuing the long-term records from Landsat and SPOT.

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7) To create emissions product suites, developed and implemented to provide annual and near real-time emissions estimates including the associated input data sets.

To achieve its goals, GOFC/GOLD-Fire has developed strategic partnerships with a number of international programs, including the CEOS Working Group on Land Product Validation (WG/LPV), the CEOS Disaster Management Support Group (DMSG), the International Geosphere-Biosphere Program's (IGBP) International Global Atmospheric Chemistry (IGAC) Biomass Burning Experiments (BIBEX) program, the European Association of Remote Sensing Laboratories (EARSeL) Special Interest Group (SIG) on Forest Fires and the UN International Strategy for Disaster Reduction (ISDR) Working Group 4 (WG4) on Wildland Fire. The latter is helping to increase the awareness of fire issues, strengthen fire monitoring within the UN System, to improve national collation of fire information and the standardization of national reporting and articulation of the information needs of policy makers with respect to fire information.

The Northern Eurasian Regional GOFC/GOLD Fire Network

A major role of GOFC/GOLD is to provide a coordinating mechanism for national and regional activities by developing a number of regional networks of data providers, data brokers and data users. Strong networks of resource managers and scientists provide the key to sustained capability for improving the observing systems and ensuring that the data are being used effectively. Wherever possible these networks are building on existing regional structures and activities. A series of workshops are being held to provide a strong voice for regional needs and foster lateral transfer of technology and methods within and between regions. The networks are enhanced and strengthened through a partnership with UN/ISDR/WG4, involving policy makers and fire managers associated with the UN System and building on the existing organizational structures to develop and implement the regional fire agendas. This UN program, facilitated by the Global Fire Monitoring Center (GFMC; http://www.fire.uni-freiburg.de/), is bringing together fire managers to help develop and implement the regional fire policies.

One of the GOFC/GOLD networks are currently being developed is the Northern Eurasian Regional Information Network (NERIN). This network is recognized as one of the major data providers for the emerging Northern Eurasian Earth Science Partnership Initiative (NEESPI). Current members of the network include the Center for Forest Ecology and Productivity (CFEP) and the Space Research Institute (SRI) (both in Moscow), the Institute of Atmospheric Optics (IAO; Tomsk), the Sukachev Forest Institute (SFI; Krasnoyarsk) and the Institute of Solar and Terrestrial Physics (ISTP; Irkutsk). These institutes have been generating satellite-based products of active fires and burned areas from the Advanced Very High Resolution Radiometer (AVHRR) and from the Moderate Resolution Infrared Spectroradiometer (MODIS) aboard the polar orbiting NOAA and NASA Earth Observing System Terra and Aqua satellites, respectively. Network members have also been working towards other GOFC/GOLD-Fire goals, such as the development of fire danger rating systems or the use of new technology for fire monitoring. Through partnerships at local, regional and national level, the network of satellite data providers collaborates closely with the Arial Forest Protection Service Avialesookhrana (AFPS). The immediate goal of is the intercomparison and validation of fire information from various sources within the framework of an integrated data system.

Members of the network have a history of collaboration with international partners, particularly in the United States, Canada, Europe and Japan. One of the major partners in the US is the University of Maryland, whose contribution to the activities includes two major areas. First, the MODIS science team has been assisting in acquiring raw MODIS data and MODIS fire products for near-real time dissemination and use by fire management agencies within Russia. Second, a rigorous a-posteriori analysis of satellite-derived fire products is being carried out to ensure proper quality assessment of the data for emission estimates and other scientific analysis.

The Workshop was an ideal forum for further discussions among the network participants and for steps towards the inclusion of institutions and researchers located in the Russian Far East to formally participate in the network activities.

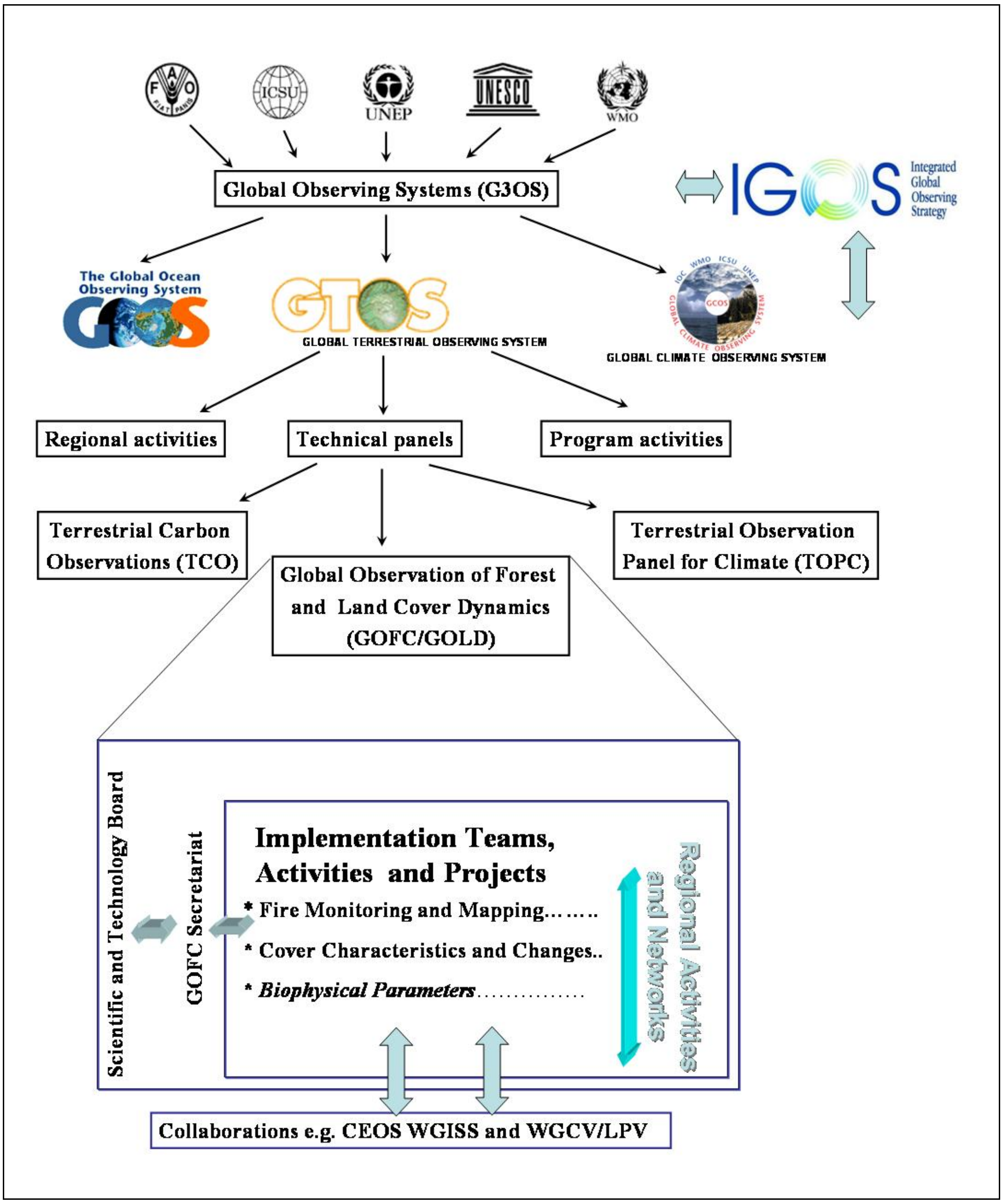


Figure 1. Organizational status of GOFC/GOLD

Product comparison and validation

For data products to be used in numerical models or in a decision-making framework, it is critical for users to understand their reliability and accuracy. Up until recently, satellite fire products and national fire statistics have been generated with little or no indication of accuracy. National fire statistics are compiled and reported using different methods and approaches making a quantitative comparative assessments and identification of trends extremely difficult. The CEOS WG/LPV and GOFC/GOLD are promoting the development of quantitative methods for quality assessment and to determine the accuracy (validation) of global, regional and national satellite fire products and maps (Roy et al. 2002; Morisette et al. 2002). This involves comparison with other airborne or satellite products and analysis of independent ground observations of known accuracy. Validation of global products is a labor intensive and costly activity and there are real advantages in international cooperation, sharing costs and resource between national and regional programs. A number of test sites are being established around the world as a focus for fire product validation (Justice et al. 2000). The primary challenge for GOFC/GOLD in this area will be to promote standardized national data collection and reporting and encourage satellite data providers to assess the accuracy of the products that they are delivering. Involvement of the user community in design of the information products and the accuracy assessment process is highly desirable. It is important for satellite data providers to recognize that quantitative product validation is not an option but an integral part of the data and information delivery system and must be included as part of the overall mission costs.

Both of the two major sources of fire data in Russia, AFPS and the satellite-based fire products, have their strengths and limitations. AFPS can provide accurate, high resolution data at all weather conditions, but only over a limited coverage area, and according to its mandate, only over forests. Satellites can provide observations over a wider area regardless of the land cover type, but cloudiness hampers detection of active fires. This is less a problem when burned areas are detected, when only a few clear scenes are needed for a successful mapping. However, issues related to sensor limitations and algorithm imperfections remain.

There have been attempts to directly compare total burned area estimates from AFPS and satellites and large discrepancies have been found (Conard et al. 2002). Here we present our analysis of data from 2001 over the Irkutsk airbase coverage area, using the fire product generated at SFI (Sukhinin 1999). This product includes cumulative active fires as well as directly mapped burned areas. Figure 2 shows the comparison of size distributions of burned scars. Total areas from AVHRR and AFPS are also shown. It is clearly visible that most fires in the AFPS database are smaller than 100 hectares. AVHRR data, on the other hand, have no burn scars smaller than the nominal resolution of the AVHRR pixel (~1 km^2). Note, however, that this does not indicate that satellites cannot detect fires smaller than that threshold; many of those fires are included in the 100-500 ha bin. Multiple individual small fires within one AVHRR pixel are represented as one single fire. The tendency of the AVHRR product to merge multiple fires into single clusters is also illustrated by several large fires which were not reported by AFPS.

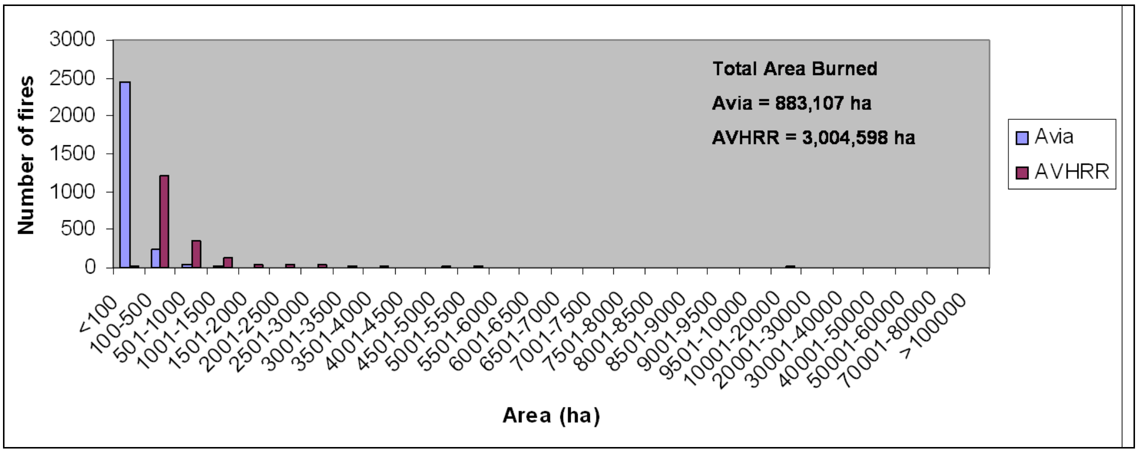


Figure 2. Size distribution of burned areas as reported by AFPS and AVHRR

The AVHRR data presented in Figure 2 include all fires within the coverage area, including fires over non-forested land surface. We used the 1-km AVHRR land cover classification dataset (Hansen et al. 2000) to determine the extent of burning over various land cover types. As it can be seen in Figure 3, the majority of the fires occurred over woodland and wooded grassland. In fact, if we calculate the sum of the burned areas over only the four “forest” land cover types (evergreen needleleaf, deciduous, deciduous broadleaf and mixed), the result (692,580 ha) is close to that reported by AFPS.

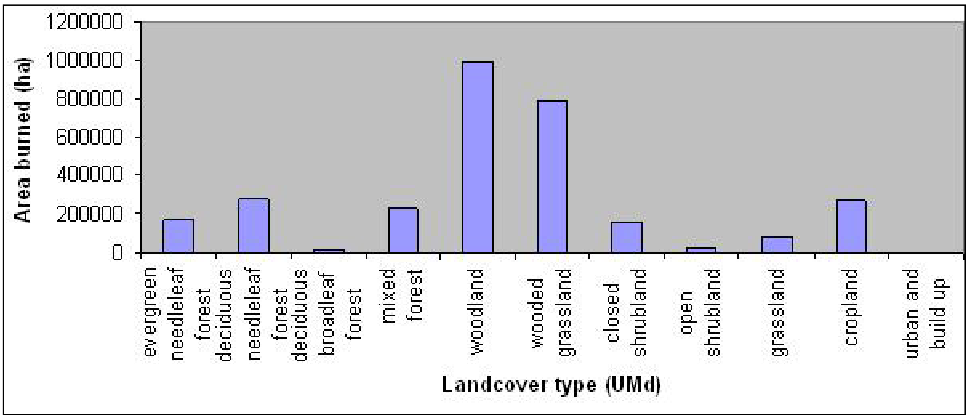


Figure 3. Distribution of burned areas derived from AVHRR over land cover types

Of course, definitions of "forest" used by AFPS and the satellite-based classification schemes are not compatible. We also computed total burned areas from AVHRR as a function of tree cover percentage from the University of Maryland continuous vegetation cover product (DeFries et al. 2000). From Figure 4 it can be seen that the best match between the two datasets is when we consider AVHRR burned areas over pixels with more than ~ 55% fractional tree cover.

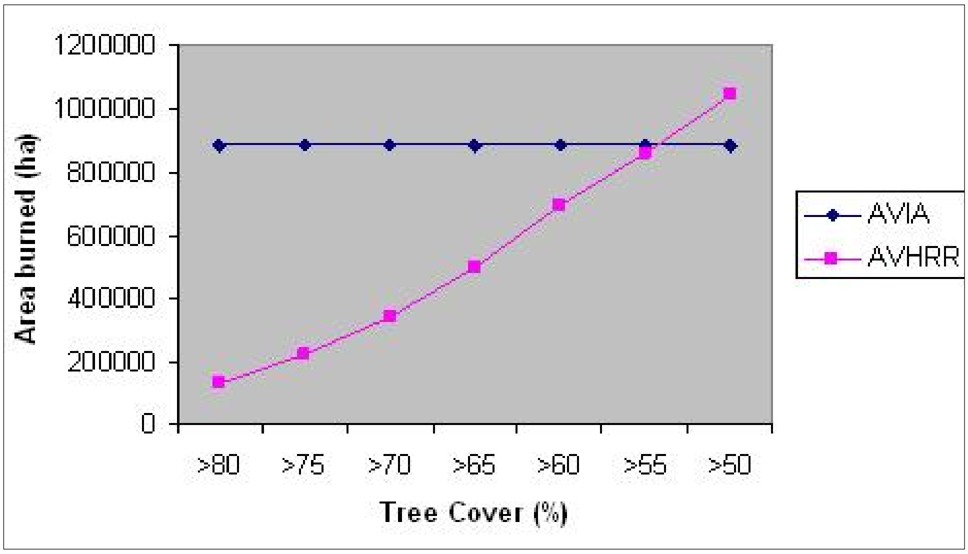
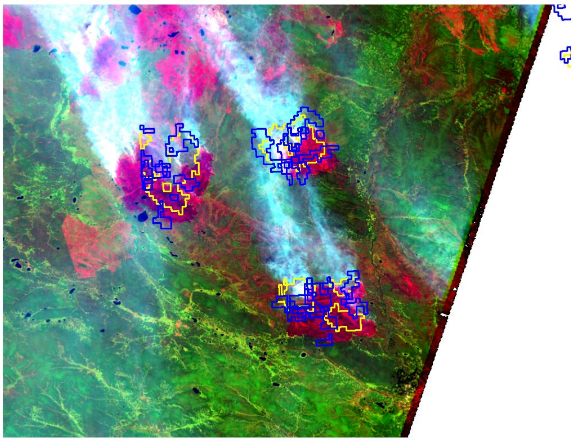


Figure. 4. Total burned area from the AVHRR product as a function of tree cover percentage. The blue horizontal line represents the total area reported by AFPS.

With the help of high resolution satellite imagery, such as Landsat/ETM+ (Enhanced Thematic Mapper) data, such total statistics can be compared to independent, more accurate estimates. High resolution imagery is also useful for the geospatial validation of the data. Figure 5 shows examples of comparisons between fire products from CFEP/SRI (Bartalev et al. 2001), SFI and Landsat/ETM+. Direct comparison of AFPS and satellite data has proven to be difficult because AFPS data are available only as center locations and areas (i.e. no perimeters) and because of the often large inconsistencies in the locations of fires reported by AFPS and mapped by satellites.



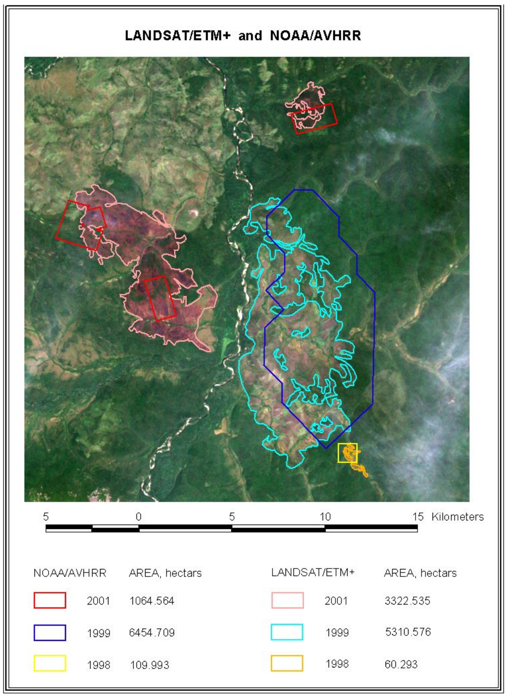


Figure 5. Landsat/ETM+ imagery with active fires and burned areas from AVHRR products generated at CFEP/SRI (left; 07/23/02, WRS 125_016) and SFI (right; 06/20/01, WRS 139_22).

Conclusions

Various data sources of biomass burning in Russia are often incompatible due to differences in reporting and coverage, often as a consequence of the inherent differences in observing systems. Similarly, many of the requirements of the fire management and the scientific communities are also different, such as timeliness and form of delivery of the information. However, proper quality assessment is essential for both optimizing resource usage in the everyday fire management practice and for improving our scientific knowledge related to atmospheric emissions, land cover change, or other aspects of the Earth System. This indicates the interdependence between the various data user and data provider communities. Local and regional fire management agencies can provide invaluable source of fire data for the validation and calibration of satellite-based products developed by the science community. High-quality, more reliable satellite products, in turn, can assist the managers in making strategic planning decisions. These arguments prompt the convergence of the various products into one integrated system where the best use of each can be made in a complementary fashion.

Acknowledgements

Thanks go to Drs. A. Sukhinin (SFI), E. Lupyan (SRI), D. Ershov (CFEP) and their colleagues for making their satellite-based products available. Part of the work presented in this paper was supported by the NASA New Investigator in Earth Sciences program.

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