

The GOFC–GOLD Fire Implementation Team Workshop Summary

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The Global Observation of Forest and Land Cover Dynamics (GOFC–GOLD) Fire Implementation Team (IT) workshop was held at the European Space Research Institute (ESRIN), European Space Agency (ESA), Frascati, Italy on March 23–25, 2010. The workshop reviewed the current state of global fire observations and identified the priorities and next steps in the area of fire science and applications. The workshop brought together 40 participants, including representatives from international, government, and non-government organizations. Workshop participants identified the need to: continue and improve global product validation; blend geostationary and polar-orbiting fire products ensuring global coverage; develop community consensus on fire essential climate variables; develop procedures for establishing dynamic data continuity between sensors; improve fuel type and moisture content data for assessing fire danger and early warning and risk; organize training programs to build regional expertise; and improve data availability and product dissemination for enhanced understanding of human–climate–fire relationships.

Introduction

GOFC–GOLD is an organization focused on international coordination of enhanced Earth observations. Its overall aim is to improve the quality and availability of space-based and *in situ* observations at regional and global scales and to encourage the production of ap-

propriate, timely, and validated information products. Originally developed as a pilot project by the Committee on Earth Observation Satellites (CEOS) as part of their Integrated Global Observing Strategy, GOFC–GOLD is now a panel of the Global Terrestrial Observing System (GTOS). The essence of the GOFC–GOLD implementation strategy is to develop and demonstrate operational monitoring at regional and global scales by conducting pilot projects and developing prototype products in three different themes: land cover characterization and change, fire mapping and monitoring, and biophysical processes.

The GOFC–GOLD Fire Mapping and Monitoring Implementation Team (Fire IT) is composed of experts from national and international space agencies, governmental, and non-governmental environmental organizations and universities. The Fire IT aims to refine and articulate international observation requirements and encourage the use of satellite-derived fire products and information from existing and planned systems for global change research, fire management, and policy decision-making. This includes identifying the observation priorities and needs of the fire community, facilitating collaborative research in recognized priority areas, periodic identification of critical observation gaps, promoting the use of spaceborne assets for fire research, provision and validation of fire products, improved data distribution,



The GOFC–GOLD Fire IT Workshop participants

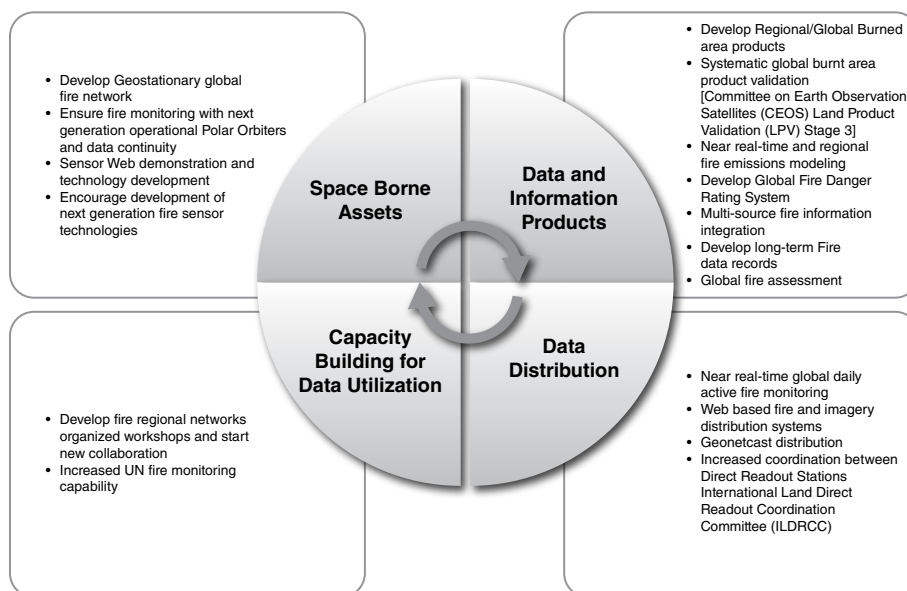


Figure 1. GOFC-Fire IT emphasis areas and sub-tasks

and capacity building. The Fire IT is actively pursuing these goals and the associated sub-tasks— see **Figure 1**— through international and national contributory projects, involving regional experts and strategic partnerships with the relevant international organizations.

The Workshop

The Italy 2010 Fire IT meeting followed previous IT meetings that were held in Thessaloniki, Greece (2008) and Montreal, Canada (2005). The meeting was organized around several focus areas: polar satellite active fire and burned area products; the Global Geostationary Fire Network; fire product validation; the Fire Disturbance Essential Climate Variables (ECVs) of the Global Climate Observing System (GCOS); data continuity; the Global Fire Early Warning System; global fire emissions estimation; Fire in the United Nations Reduced Emissions from Deforestation and Degradation (UN-REDD) Program; fire observations from new and planned instruments; the Global Fire Assessment; and the regional fire network status and direct broadcast initiatives. For each focus area, two experts from the team were identified to present an overview on the topic, assessing the status and future needs, followed by group discussion.

Opening Remarks

The meeting started with an introductory welcome address from the host **Olivier Arino** [European Space Research Institute (ESRIN)]. Arino highlighted the ESA's activities and emphasized the importance of long-term global systematic Earth observations for climate research. In this context, he presented the upcoming ESA Sentinel missions and ESA's planned free and open data policy.

Chris Justice [University of Maryland—*Fire-IT Co-chair*] then provided an overview on the GOFC–GOLD Fire IT organizational structure and function and the details on regional fire network activities. Justice emphasized the importance of product accuracy assessment and described the activities of the CEOS Land Product Validation (LPV) sub-group. He presented some of the current obstacles for fire science, including the fragility of product continuity, inconsistent fire product validation, and varying data policies. Justice also highlighted some opportunities including new algorithms and application areas, new and planned missions [e.g., NPOESS Preparatory Project (NPP)/Joint Polar Satellite System (JPSS); Sentinels; Landsat Data Continuity Mission (LDCM); and Deformation, Ecosystem Structure (DesDynI)], and using the current satellite record to develop a comprehensive Global Fire Assessment and explore the relationships between fire, climate, and global change.

Johann Goldammer [Freiburg University—*Fire-IT Co-chair*] presented an overview of the global fire networks, the Global Fire Monitoring Center, and GOFC–GOLD, and how they have been serving users at both the global and regional scale. Goldammer emphasized the Global Fire Early Warning System and international efforts to strengthen regional fire network activities, and noted that regionally focused studies are needed since the role of fire in many ecosystems remains poorly understood.

Science Presentations

David Roy [South Dakota State University] reviewed active fire and burned area products generated from polar-orbiting satellites. Roy summarized the current GOFC–GOLD requirements for these products. For ac-

tive fire these include: 1-km global with 24-hr detection summaries, burned area: 500-m global with monthly statistics; and 30-m regional products periodically. He also highlighted the potential product generation benefits of data fusion approaches using both polar and geostationary satellite data. Roy stated that to date, fire product developers have not definitively demonstrated the accuracy and consistency of their products and that limited product comparison and validation exercises have revealed significant discrepancies in area estimates, timing, and location. He reiterated the need for systematic fire product validation and the importance of making the resulting accuracy information comprehensible to non-scientists including policy makers. Roy stressed that consensus community-endorsed validation is of increasing importance as satellite products are getting easier to generate—driven by factors including space agency support for free satellite data, decreasing computer costs, increasing computer processing and storage capabilities, and the proliferation of satellite direct-broadcast reception systems.

Ivan Csizsar [National Oceanic and Atmospheric Administration (NOAA)] highlighted the global geostationary network activities. Csizsar presented details on the NOAA/National Environmental Satellite, Data, and Information Service (NESDIS) Wildfire Automated Biomass Burning Algorithm (WF ABBA) wildfire product, its validation, and long-term data records over South America. Csizsar demonstrated the utility of a probabilistic approach for correction for cloud obscuration. This approach could reduce omission errors (43–59%) over areas affected by clouds. Csizsar described the international coordination efforts to develop the Geostationary Fire Network and the activities within the Coordination Group of Meteorological Satellites (CGMS) to specify user requirements for fire detection on operational geostationary systems. Plans include the incorporation of fire detection from the Multi-Functional Transport Satellite-2 (MTSAT-2); the Communication, Ocean, and Meteorological Satellite (COMS); and the Indian National Satellite System-3D (INSAT-3D) satellites into the global system.

Kevin Tansey [University of Leicester] emphasized the need to validate the satellite fire products at a variety of scales. Tansey highlighted that an unbiased estimate of burnt area validation at a coarser resolution is needed to fully characterize the uncertainty. This would need to include a transition from CEOS *Stage 2* Validation (expert-based selection of representative validation sites) to *Stage 3* Validation (model-based statistical sampling). He described the accuracy problems in L3JRC, Moderate Resolution Imaging Spectroradiometer (MODIS) *MCD45*, *GFED2*, and *GFED3* datasets and stressed the need for more comprehensive validation of these products. He also described the CEOS Global Burnt Area Validation Protocol and mentioned that a validation effort through the *Wiki* site has started (*lpvs.pbwiki.com*).

Olivier Arino [ESRIN] described the GCOS Fire Disturbance ECV objectives and requirements (which include achieving high accuracy of 5% error in omission/commission, spatial resolution of 250 m, daily temporal resolution, and stability of 5%). Arino described the variables within the Fire Disturbance ECV [which includes active fires, burned areas, and fire radiative power (FRP)], their status, and requirements as highlighted in the GTOS T13 Food and Agriculture Organization of the United Nations (FAO) document and the NASA White Paper on Fire Earth System Data Records (ESDR). He also described the ESA's Climate Change Initiative and ECV activities stressing the need to explore data fusion methodologies for effective fire monitoring.

Krishna Vadrevu [University of Maryland] provided an overview of the coarse, medium, and high-resolution satellite data useful for fire research and applications and their associated data continuity needs. Vadrevu discussed the potential and limitations of different sensors useful in generating active fires, burnt areas, and FRP products. He summarized the data availability and utility of the NOAA Advanced Very High Resolution Radiometer (AVHRR), Systeme Pour l'Observation de la Terra (SPOT), MODIS, Visible Infrared Imager Radiometer Suite (VIIRS), Landsat, ESA satellites, Indian Remote Sensing satellites (IRS), and China–Brazil Earth Resources Satellite program (CBERS), in fire research.

Bill de Groot [Canadian Forest Service] described the Global Fire Early Warning System (EWS) initiative and how fire danger information can aid in the implementation of fire management action plans and in mitigating or preventing wildfire disasters. De Groot discussed the EWS inputs, which include fire weather/activity products, fire behavior products, and fire management response tools, as well as presented a recent pilot demonstration for Southern Africa. He also highlighted some of the ongoing international collaborative efforts and the need for incorporating satellite observations in the global EWS.

Alessandro Brivio [Institute for Electromagnetic Sensing of Environment (IREA)] highlighted the Burnt Biomass and Satellite Observations (BBSO) activities undertaken as a part of the Global Emissions Inventory Activity (GEIA)/Atmospheric Composition Change the European Network of Excellence (ACCENT) programs. BBSO has two major activities: database generation for global and regional emission inventories, and an inter-comparison exercise for carbon monoxide (CO) emission estimates. Both of these studies recommended using MODIS burnt-area products for emission estimation in herbaceous/shrub/boreal forests; burnt-area and Fire-Radiation-Power (FRP) products for evergreen forests; and MODIS active-fire products for characterizing the temporal distribution of fires at the seasonal scale. Brivio called for enhanced collabora-

tion between different international programs for validation of fire products and emissions estimation.

Danillo Mollicone [FAO] highlighted the UN-REDD mechanism and national REDD activities in some countries. Mollicone pointed out the need for a multi-phased approach involving a variety of datasets for monitoring, reporting, and verification to reduce the errors in REDD projects. He called for increased capacity-building activities in the tropical countries for successful implementation of the REDD mechanism.

Luigi Boschetti [University of Maryland] provided details on the role of fire in REDD and outlined the fire component of the GOFC–GOLD REDD Sourcebook. Boschetti explained that the current version [*Conference of the Parties (COP)-Ver.15*] includes the methods and procedures for monitoring, measuring, and reporting anthropogenic greenhouse gas (GHG) emissions and carbon stocks in the forestry sector. He stressed the need for high-resolution satellite datasets for GHG emissions estimation. Boschetti also emphasized the importance of capacity-building activities from GOFC–GOLD focusing on REDD and involving regional experts for effective REDD project implementation.

Louis Giglio [University of Maryland] provided extensive details on fire observations from new instruments, which included the Sentinel/Sea and Land Surface Temperature Radiometer (SLSTR), NPP/National Polar-orbiting Operational Environmental Satellite System (NPOESS) Visible Infrared Imager Radiometer Suite (VIIRS), Technologieerprobungssträger 1 (TET-1), Global Climate Observation Mission-Second generation Global Imager (GCOM-SGLI), Hyperspectral Infrared Imager (HypIRI), Landsat Data Continuity Mission (LDCM), and Geo-Africa. Giglio highlighted the instruments' potential and limitations for fire mapping and monitoring.

Chris Justice and **Johann Goldammer** provided an overview on the importance of implementing an international Global Fire Assessment and problems associated with finding a donor to fund the initiative. Justice stated that there are now satellite time-series data to quantitatively describe fire at a global scale with national-scale reporting and that useful metrics need to be developed. He recommended an active role for the regional network scientists in providing an interpretation of recent fire trends. Justice stressed the need for a comprehensive Global Fire Assessment, and the need to fund such an assessment.

Everett Hinkley [United States Department of Agriculture (USDA) Forest Service] described the International Land Direct Readout Coordination Committee (ILDRCC) activities, formed under the auspices of GOFC–GOLD in early 2008. ILDRCC acts as a voice

of the international land direct readout community that interfaces with space agencies and science teams responsible for direct broadcast capability, data quality, and official science product development. Emphasis from the ILDRCC is currently focused on the NPP/JPSS VIIRS system but it would like to encourage direct readout from other international sensors. More details about ILDRCC can be found at: landdirectreadout.org.

After the science presentations came a series of overview presentations on the various regional GOFC–GOLD Fire Network activities, including reports from:

- **Check Mbow** [Université Cheikh Anta Diop de Dakar] on fire aspects of the West Africa Regional Network (WARN) activities.
- **Narisara Thongboonchoo** [King Mongkut's University of Technology] on the Southeast Asian Regional Research and Information Network (SEARIN).
- **Magsar Erdenetuya** [National Remote Sensing Center, Mongolia] on fire activities in Mongolia and the emerging Central Asia regional network initiated at Urumqi, China—formally established during the Land Cover Land Use Change Workshop in Almaty.
- **Johann Goldammer** on developments with the UN Global Wildland Fire Network.
- **Isabel Cruz** [National Commission for the Knowledge and Use of Biodiversity (CONABIO)] on the Latin American Fire Network (Red LaTIF) activities.
- **Phillip Frost** [Council for Scientific and Industrial Research] on the Southern Africa Fire Network (SAFNET) remote sensing and fire management activities.

An extended discussion session followed these presentations that focused on identifying key issues and fire research needs. Participants identified nine priority areas for emphasis in the short term (1–1.5 yrs) and long term (2–3 yrs)—see **Table 1**.

Emilio Chuvieco [University of Alcalá] gave an introductory presentation and suggested several priority areas for the GOFC–GOLD Fire IT, which included fire danger/risk estimation, validation of fire products, processing of long-term data records, active participation of regional networks, emission estimations, etc. Chuvieco also emphasized generating new higher-order fire products, including fuel type maps and live fuel moisture content datasets.

Table 1. GOF-C-GOLD Fire IT Priority Areas

Global validation protocols and implementation	Complete the burnt area validation protocol as a part of CEOS calibration/validation sub-group activity. Develop the validation protocol for active fire products.	Implement <i>Stage-3</i> validation for Burned Area through international cooperation.
Global Geostationary Network	Obtain full GEO-SAT agency response to CGMS suggestions. Generate fire products for all GEO network satellites. Enable NRT access. Validate products against data (e.g., higher spatial resolution data). Generate blended “global” geostationary product, including links to global NRT emissions models.	Long-term processing of geostationary fire data from archives. Generate Meteosat active fire/FRP product from early mission years (e.g., 2003 onwards). Validate composite product and ultimately blend in polar-orbiting fire products to ensure global coverage.
Data requirements for global ECV	Conduct user consultation exercise (questionnaire and workshop) with modelers and fire technicians on ECV. Work with GTOS to refine ECV requirements. Propose GOF-C-GOLD Fire to provide ECV oversight.	Develop community consensus Fire ECV products and provide oversight. Revisit VIIRS IORD for Fire.
Long-term data record (LTDR) generation	Complete scoping and assemble 1-km AVHRR archive from LAC and HRTF data. Develop procedures for establishing dynamic continuity between sensors.	Generate LTDRs for active fire and burned area products, including validation datasets and produce continuity products from NPP/JPSS and Sentinel 3.
Global fire danger including early warning and risk	Prepare global fuel type map. Calibrate Fire Weather Index (FWI) over different regions. Organize workshop on fire risk assessment (Coimbra, November 2010).	Prepare databases of field measurements on live fuel moisture content estimation and other Global EWS inputs.
Global fire emissions estimation	Contribute to the BBSO dataset development and model inter-comparison. Organize fuel consumption workshop (regional experts + inventory developers). Comparison of inventories using top-down constraints (CO and aerosols).	Develop experimental datasets on fuel moisture, biomass, fire severity, FRP, combustion completeness. Use LTDRs to produce long-term fire emissions estimates. Explore new input products (e.g., using radar products and emission factors).
Regional network issues, capacity building, accessibility, etc.	Organize training programs for building regional expertise and provide project-based training on data validation and application. Improve data availability and product dissemination. Provide SPOT archive data to African regional networks.	Improve visibility of the regional networks to national end-users and policy decision makers. Prepare training and education materials. Promote training in developing countries on fire data from new missions.
User outreach and feedback	Expand the fire component of the GOF-C-GOLD REDD Sourcebook. Promote the involvement of GOF-C-GOLD regional networks in the REDD process. Develop user friendly products and documentation.	Provide information on fire data and products from new missions. Promote training in developing countries on the use of fire data from new missions. Explore distance-learning outreach modules.
New fire-related missions and products	Initial evaluation of TET-1 data and products. Publish review of fire sensors: instruments, calibration, and data-related data quality.	Development of fused products. Characterization of the NPP/JPSS/VIIRS, Sentinel 3, and new geostationary sensors, data, and products. Use of satellite-based lidar for fuel characterization.

Participants gave priority to the development of international validation protocols for the polar and geostationary active fire products and the need to consider ecosystem type, timing, and biophysical characteristics. The Fire IT agreed to work on implementing *Stage 3* Validation of the fire products, in partnership with CEOS, and to encourage the involvement of regional scientists. The participants emphasized on data fusion methodologies combining multi-resolution data from both the polar and geostationary satellites for effective and timely fire monitoring. Further, they recommended extending GEONETCast data dissemination beyond Africa and with increased bandwidth.

Participants agreed that urgent clarification is needed about roles and responsibilities for product generation of the ECVs and their validation and oversight, as a number of individual organizations are starting to develop them. The question as to what is an acceptable level of accuracy for the fire ECV was raised. While they didn't have a specific answer, the team did reiterate the fundamental need for a well-calibrated long-term data record and an international effort by the CEOS Calibration-Validation (Cal-Val) Working Group to validate fire products from different sensors in a consistent manner. With respect to data and product continuity, participants called for better international coordination of data acquisition and open data sharing for past, current, and future moderate resolution sensors. More emphasis on developing a moderate-resolution satellite constellation with global coverage and near real-time distribution was also recommended to increase the frequency of observations and to enhance moderate-resolution burned area monitoring. For coarse resolution sensors, emphasis should be given to developing common processing and fire products for NPP/JPSS/VIIRS and Sentinel 3/SLSTR with an internationally coordinated *Stage 3* Validation. It was also noted that NOAA has initiated a study to scope the compilation and processing of the historical 1-km AVHRR data from the available Local Area Coverage (LAC) and

High Resolution Picture Transmission (HRPT) available archives worldwide.

The discussion of the fire-danger rating system identified the need for locally calibrated and frequently updated data, improved fuel type and moisture content maps, and improved information on anthropogenic impacts and drivers. With respect to greenhouse gas emissions estimation, participants noted that satellite-derived FRP products have potential to provide useful spatially explicit biomass burned data. Relating to UN-REDD, the team recognized the potential role of reducing fire emissions; some projects are already being developed in this area and there is a need to broaden the GOF-C-GOLD REDD Sourcebook to include accuracy assessment.

Brainstorming discussions revealed that the GOF-C-GOLD regional fire networks are seeking different types of training, including undergraduate and graduate education in remote sensing and Geographic Information Systems (GIS), and training to build regional expertise related to specific programs [e.g., UN-REDD and Intergovernmental Panel on Climate Change (IPCC) National Emissions Inventory]. Participants noted that bilateral training and professional exchanges between the regional networks could help develop regional capacity and that the Global Change System for Analysts, Research, and Training (START) and GOF-C-GOLD should help identify support for such activities. The NASA Land Cover/Land Use Change Program is supporting the GOF-C-GOLD Fire Project Office. Financial support for the workshop was provided by NASA, ESA, the Canadian Space Agency, the GOF-C-GOLD Secretariat, Canadian Forest Service, Natural Resources Canada, START, and the host institutions of the members. The workshop agenda, participants list, and presentations are available at:

gofc-fire.umd.edu/Frascati_Meeting/index.asp. ■

Kudos

The EOS Project Science/Science Mission Directorate (SMD) Support Office submitted outreach products to the Washington, DC chapter of the *Society for Technical Communication's* (STC) "2009-2010 International Technical Publications Competition." This year, the *Ocean Surface Topography Mission's* (OSTM) *Science Writer's Guide* received an **Award for Distinguished Technical Communication** and the book *Our Changing Planet: The View from Space* (Cambridge University, December 2007) received an **Award for Excellence**. The Project Science Office team (and all those who collaborated on these products) are commended for producing high-quality outreach materials that help promote NASA science! For more information on STC's competitions, please visit: www.stc.org.