Operational Integration of Direct Readout Technology: Example-based Frameworks for Decision Support

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Introduction

Direct readout (DR) data receiving and processing capabilities have expanded significantly throughout the globe since the NASA Earth Observation System (EOS) established direct broadcast functionality, following the launches of the Terra (1999) and Aqua (2002) satellites. Dependence on MODIS imagery and derived data products received and processed at more than 125 X-band ground receiving stations worldwide (NASA Direct Readout Laboratory, 2008) underscores the value of DR technology for operational requirements associated with resource and disturbance monitoring. In particular, the ability to conduct near-real time, high frequency regional and global monitoring of wildfire and associated atmospheric conditions has enabled and enhanced decision support systems (DSS) used in wildfire management and disaster response. While direct broadcast data transmission and receiving are well documented and supported, both in terms of satellite mission operations and commercial data receiving and processing technology, the mechanisms in place at individual ground stations to generate, analyze, and distribute derived products are unique to their operational objectives and processing environments.

This paper intends to describe a conceptual framework for data acquisition, processing, and distribution into strategic and tactical DSS used for wildland fire management. Two specific examples are presented to demonstrate existing operational environments that successfully leverage DR technology to obtain near-real time data and information products. The examples illustrate how DR technology has been adapted to accommodate different information needs and uses in settings with different information technology infrastructure. As significant as the differences are the elements of commonality, particularly in the reliance on science processing algorithms that relate back to the mission science programs. While specific to wildland fire, these examples describe frameworks that may also be adaptable to other rapid response and longer term monitoring information needs.

Conceptual Framework for Operational Integration

The principal determination for utilization of DR data and derived information originates from decision support information needs that typically include synoptic, high frequency observations of disturbance events. There is no standard model for integrating DR technology into this kind of operational environment. A number of factors determine the data processing and information flow mechanisms that are implemented to feed DSS, including sensor type, data availability and latency, processing systems and support, and IT infrastructure. However, there are fundamental elements of an operational DR system that outline a conceptual framework for integration into decision support. These elements can be distilled into four categories: Data, Processing, Products, and Operational Use. Figure 1 illustrates the conceptual relationship of key elements that comprise the process of moving from DR data acquisition to incorporation of information into a DSS. This conceptual framework is based on current NASA EOS and NOAA direct broadcast and data processing systems. It emphasizes data redundancy, minimal product latency, and a high level of availability typically required for rapid response decision support. It also illustrates an operational model intended to meet a range of information needs over broad geographic extents. The examples presented in the body of this paper describe two unique manifestations and scales of implementation of this conceptual framework. The North American example describes an operational system that is broad in scope and extent with numerous architectural elements, while the South African example describes system that is more operationally independent and targeted to a specific information need over a smaller geographic extent.

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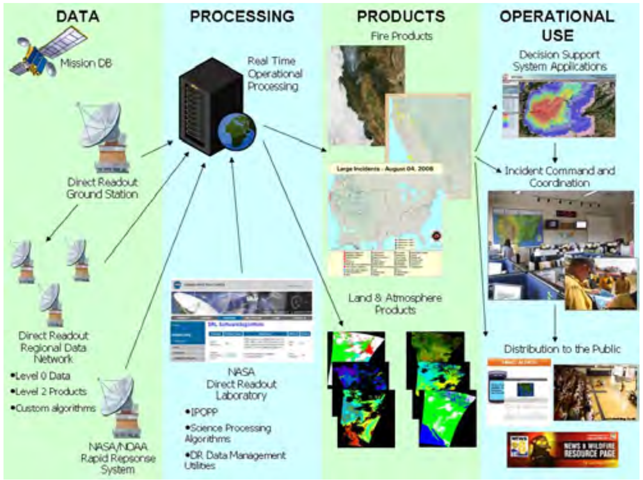

Figure 1 A conceptual framework for the use of direct read-out technology to support operational information needs in a wildand fire decision support environment

Data

The foundational element of operational integration of DR is data acquisition. As previously stated, satellite mission operations (including direct broadcast management) and the commercial technology to receive direct broadcast transmissions are well documented and not within the scope of this paper. However, data access and redundancy are critical for operational reliance on DR-based information. It is assumed here that a ground receiving station is the core of data access. A single station, however, does not provide data redundancy or the ability to generate information over large (continental and global) extents. Increasingly, regional data networks have been established (i.e. Sentinal Asia, North American MODIS Active Fire Network) to leverage multiple ground receiving facilities, expanding aerial coverage and ensuring data access in the event of facility failure. Finally, integration of the NASA Goddard Space Flight Center (GSFC) MODIS Rapid Response system further augments data redundancy and ensures access to EOS data in the event of DB failure. Recent interruptions in MODIS DB functionality on the Terra satellite have underscored the criticality of additional data redundancy from mission data acquisition.

Processing

Several standard science processing algorithms developed by the MODIS Science Team are available to the DR community for generating a series of land, atmosphere, and ocean information products. The NASA Direct Readout Laboratory (DRL) has been instrumental as a central access portal for DR data processing technology and as a liaison between NASA mission scientists and the operational applications community. Access to available science processing algorithms for the direct readout processing environment, as well as Level 0 and Level 1 data, and Level 2 science products produced by DRL's ground station is available at: http://directreadout.sci.gsfc.nasa.gov. It is estimated that the majority of DR facilities receiving MODIS data and operationally using DR data and products rely on the output products from science processing algorithms as the basis for the information products that are integrated into DSS. It is not currently known how many custom processing algorithms are used in operational settings but variants of standard science products and custom products are in use as witnessed in the example frameworks described.

Products

The basis for a near-real time product availability stems from the official science products generated by the EOS mission science teams and made available to the DR user community through the NASA DRL. Data processing and product generation at operational facilities has largely been accomplished through the development of unique processing environments that focus on local implementation of standard science processing algorithms, often aided by informal assistance from various NASA entities. A near-term advance in the availability and support of a standard data processing system will come in the form of the International Polar Orbiter Processing Package (IPOPP) (NASA Direct Readout Laboratory, 2008), developed and supported by NASA DRL, the NOAA Integrated Program Office (IPO) and the Cooperative Institute of Meteorological Satellite Studies (CIMSS) of the University of Wisconsin. The IPOPP will offer a complete processing system for the production of near-real time NASA science products by operational DR processing facilities. The IPOPP will also be the primary mechanism to address science product continuity across existing NASA EOS missions and their transition to NPOESS. The transition from EOS to NPP and NPOESS is a significant issue for consistent operational use of DR based products, especially concerning their use in DSS.

While the emphasis herein is on standard science products, custom and value-added products have been and will be increasingly critical components in operational settings, particularly as reliance on DR products expands and interest in addressing information needs originates from DSS managers and product end users. As illustrated in a report on the recent international DR workshop held in Mexico City (Schwind and Quayle, 2007), several custom land products are currently generated and distributed. It can be expected that information need and scientific initiative will continue to push custom products into the DR environment, underscoring the importance of continued communication and collaboration between DR facilities/ networks. The Mexico City report documents the formation of the International Land Direct Readout Coordination Committee (ILDRCC) (http://landdirectreadout.org) that will provide a forum and communication node for the DR user community. This is expected to be a primary mechanism to address issues including global and regional information needs/priorities, custom DR algorithms and associated calibration/validation issues. The ILDRCC will also provide a formal interface with NASA and other space agency mission scientists and program managers to address issues of concern in the DR community.

Example Framework: North America

USDA Forest Service

Wildland fire management is a significant issue for the U.S. Department of Agriculture Forest Service and other federal and state land management agencies in the United States. The past decade in the United States has witnessed an increasing trend in area burned due to wildland fires with an annual average of over 2.6 million hectares (National Interagency Coordination Center, 2008). The management of these fires is affected by a host of complicating factors including increased fuel loads, forest health conditions and climate extremes increasing the potential for larger, more catastrophic fires; encroachment of urban development into areas prone to recurring fire activity creating significant hazards for human populations and structures; and, the availability and prioritization of suppression resources to contend with multiple, simultaneous fire events. As a result, the Forest Service and other federal land management agencies expend more than $3 billion (US) annually on wildland fire suppression and related activities (United States Government Accountability Office, 2008).

To facilitate improved strategic and tactical management of active wildland fires, U.S. land management agencies routinely leverage daily fire assessment information acquired using both airborne and spaceborne remote sensing technologies. High temporal, synoptic image data acquired by the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor onboard the NASA Earth Observing System (EOS) satellite platforms, Terra and Aqua, provide a critical and comprehensive source of daily fire intelligence information. The technical capabilities of MODIS effectively identify current fire activity over large geographic areas multiple times daily, and also characterize the effects of wildland fires.

The USDA Forest Service MODIS Active Fire Mapping Program was implemented in 2001 to leverage daily MODIS data for comprehensive operational fire detection and monitoring. In order to minimize the latency of data availability to users and consequently increase the effectiveness of the information provided by MODIS, the program leverages direct readout technologies to acquire image data directly from both MODIS instruments. MODIS image data are rapidly processed to generate a daily suite of near real-time fire geospatial data and mapping products and provided to the Forest Service and other U.S. land management agencies in the continental United States, Alaska and Hawaii. In addition, as a result of collaboration initiated during the 2003 fire season by several fire management agencies in western Canada, the program also currently provides operational MODIS fire detection and monitoring for all of the provinces and territories of Canada.

Data Access/Data Network

The MODIS Active Fire Mapping Program is operated by the Forest Service Remote Sensing Applications Center (RSAC) located in Salt Lake City, Utah. RSAC operates an X-band antenna and ground station at its facility collecting MODIS direct broadcast data from both Terra and Aqua. RSAC has been receiving and processing MODIS direct readout data operationally since early 2002. The geographic location of the RSAC antenna enables the Forest Service to provide near real-time MODIS coverage for the majority of western North America. To facilitate near real-time MODIS data coverage for the balance of the United States and Canada, RSAC also leverages direct readout data collected by other ground stations throughout the United States. This data sharing network includes the NASA Direct Readout Laboratory (DRL), the University of Wisconsin Space Science and Engineering Center (SSEC), and the University of Alaska-Fairbanks Geographic Information Network of Alaska (GINA) (Figure 2). Selected swath-based Level 0 Production Data Sets (PDS) and Level 2 science data products from each of these ground stations are continually relayed to RSAC and integrated for further processing.

Direct readout data acquired by the MODIS Active Fire Mapping program are also augmented with selected five-minute Level 0 MODIS granules from the daily MODIS data stream via NASADRL, and Level 2 MODIS data products from the NASA MODIS Rapid Response Project (Descloitres, 2002). The MODIS data provided by these programs, typically on a 2-4 hour post-acquisition delay, provide redundancy to the direct readout network, data coverage in the limited areas of North America where direct readout coverage is not available, and provide uninterrupted, timely access to comprehensive MODIS data in the event of intermittent or extended absence of Terra or Aqua direct broadcast capabilities.

Direct Readout Science Data Algorithms/ Integration

RSAC operates a fully automated system at its facility for processing near real-time Level 0 MODIS data

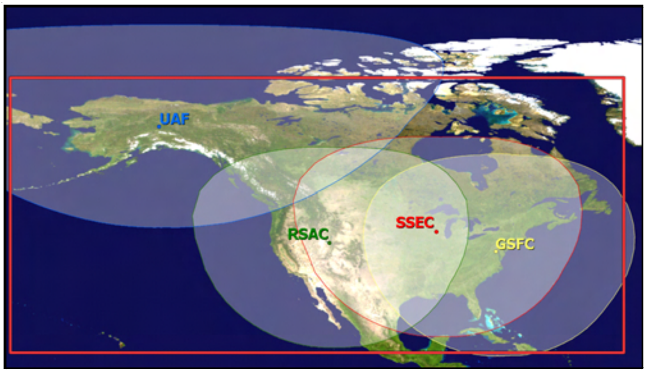

Figure 2 Direct readout data sharing network utilized by the USDA Forest Service MODIS Active Fire Mapping Program. Direct readout data coverage provided by the USDA Forest Service Remote Sensing Applications Center (RSAC), the University of Alaska-Fairbanks Geographic Information Network of Alaska (UAF), the University of Wisconsin Space Science Engineering Center (SSEC) and NASA Goddard Space Flight Center (GSFC) facilitates near real-time fire detection monitoring for nearly all of North America

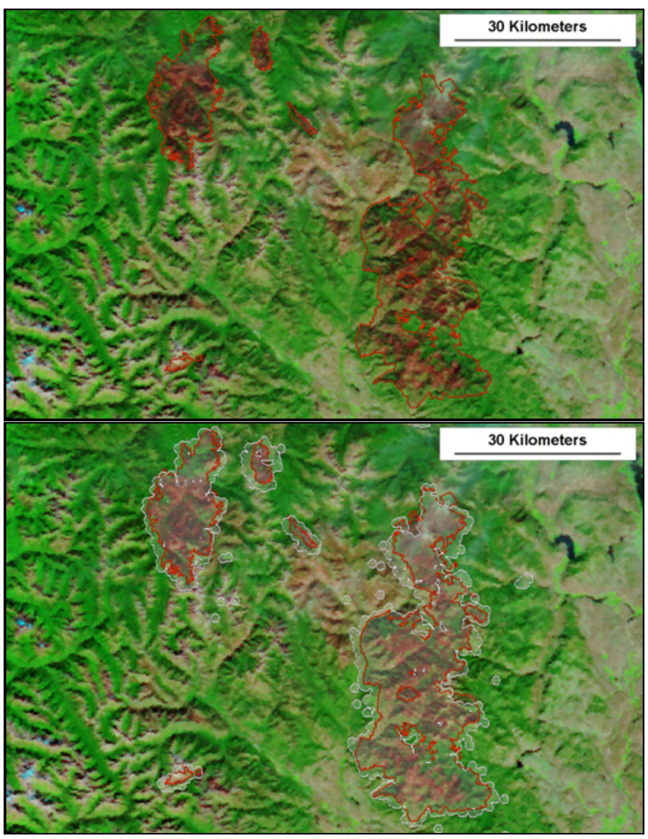

Figure 3 September 28, 2006 False color composite Terra MODIS image of 2006 forest fire areas in north-central Washington state. Red lines in the top graphic depict interagency fire perimeters delineated by GPS and other high resolution assets. White-shaded and outlined polygon areas in bottom graphic illustrate the spatial correspondence of cumulative year 2006 1-kilometer MODIS fire detection data relative to fire perimeters and post-fire reflectance data

for the United States and Canada. The system integrates the latest direct readout data processing technologies and land science algorithms provided by NASA DRL, the MODIS Land Science Team, and the NASA MODIS Rapid Response System. The system ingests the Level 0 MODIS data from RSAC and the direct readout data network to generate several higher level MODIS products including the Level 2 MODIS fire and thermal anomalies product (MOD14/MYD14) (Giglio, 2005).

The direct readout version of the MOD14/MYD14 algorithm produces the same output as the official Level 2 science product distributed by the NASA Land Processes Distributed Active Archive Center (LP DAAC). The MOD14/MYD14 algorithm identifies and characterizes actively burning fires detectable at the time of overpass by MODIS at a spatial resolution of one-kilometer (Giglio et al, 2003). As described by Giglio and others (2003), in the initial processing stage of the algorithm, potential fire pixels are identified based on the 4µm band brightness temperature and the difference in the brightness temperatures of the 4µm and 11µm bands. These pixels are further screened to identify pixels containing large and/or relatively hot fires using 4µm brightness temperature thresholds established for global operational fire detection. Subsequent contextual analysis is conducted on the potential fire pixels to identify smaller and/or cooler burning fires, and verify detections identified from absolute threshold tests.

Numerous technical and environmental factors at the time of satellite overpass can affect the probability of a fire being detected by MODIS including sensor view angle, solar zenith angle, fire size and characteristics, biome type, and atmospheric conditions and obscurations (Giglio et al, 2003). However, based on qualitative assessments using available ground truth information, the global MODIS fire detection algorithm performs adequately for detecting and monitoring fire activity in the variable environmental conditions present throughout the United States and Canada (Figure 3).

In addition to the MODIS fire detection product, RSAC also generates and distributes additional operational MODIS direct readout land and atmosphere data products for fire monitoring and resource management. These products include surface reflectance, land surface temperature, vegetation indices, aerosol optical depth, and several cloud products. As part of its effort to utilize the latest in direct readout technologies and to prepare for processing direct broadcast data from the National Polar-orbiting Operational Environmental Satellite System (NPOESS) sensor missions in the future, RSAC is generates these MODIS direct readout products using the International Polar Orbiter Processing Package (IPOPP). IPOPP is a new direct readout processing package produced and distributed by NASA DRL and will facilitate direct readout data processing and product continuity between the EOS and

NPOESS eras. IPOPP currently generates a suite of Level 2 MODIS land, atmosphere and ocean science products for the direct readout environment, and it will eventually produce Level 2 environmental data records (EDRs) for the Visible Imager and Infrared Radiometer Suite (VIIRS) onboard the NPP and NPOESS platforms.

RSAC is also actively coordinating with NASA DRL and MODIS science team members to transition and implement additional fire-related MODIS science products into the IPOPP data processing framework such as live fuel moisture assessment and burned area delineation. The new direct readout science products will benefit not only the MODIS Active Fire Mapping Program, but also the global direct readout community.

Geospatial Product Generation and Distribution

Direct readout data products and imagery generated from the latest MODIS acquisitions are integrated with available contextual geospatial data and information provided by fire management agencies in the United States and Canada. These data sources include fire intelligence information reported by wildland fire incidents, observed and forecasted fuels and weather conditions, land cover, urban areas, transportation networks, topography, hydrologic features, administrative unit and political boundaries, and fire detection data from other satellite sensors. MODIS fire mapping products and contextual data are operationally integrated, processed and analyzed in a completely automated processing system developed by RSAC. The processing system generates a suite of enhanced, value-added fire mapping and visualization products, and data provisioning services made available to users via the program's website at http://activefiremaps.fs.fed.us.

The homepage of the MODIS Active Fire Mapping Program website contains maps for the United States and Canada depicting the approximate geographic location of current large wildland fire incidents. The incident location maps are updated each day based on the latest fire intelligence information provided by fire reporting agencies in both countries. Below the maps is a news information block that reports MODIS fire mapping information to users such as product descriptions, MODIS instrument status, and other relevant program announcements.
MODIS Active Fire Mapping products and geospatial data for the United States and Canada are categorized into logical groups and accessible via separate web pages on the site. Each product webpage can be accessed from any location in the site via links provided in the left margin. MODIS Active Fire Mapping product/data categories are described below.

Regional Fire Detection Maps: Poster-sized regional MODIS fire detection maps for the United States and Canada in JPG and PDF format depicting cumulative and recent fire activity detected by MODIS. Fire detection data are displayed on a topographic base map with current large wildfire incident labels, urban areas, major transportation networks, hydrography and political boundaries. Maps are updated throughout the day as fire conditions warrant in each region with the latest data from both Terra and Aqua MODIS acquisitions (Figure 4).

Interactive Fire Detection Map Viewers: Web-based interactive MODIS fire detection map viewers available for four geographic regions, the continental United States, Alaska, Hawaii and Canada. Each map viewer allows users to integrate additional geospatial data layers not available in the regional fire detection maps. Additional layers include cumulative and current fire detection data acquired by the Advanced Very High Resolution Radiometer (AVHRR) and Geostationary Operational Environmental Satellites (GOES), observed and forecasted weather and fuel conditions, fire weather watches and warnings, federal administrative boundaries, political boundaries, detailed transportation and hydrographic network, topographic maps, and MODIS and LANDSAT imagery (Figure 5). Fire detection and fire weather data layers are updated hourly.

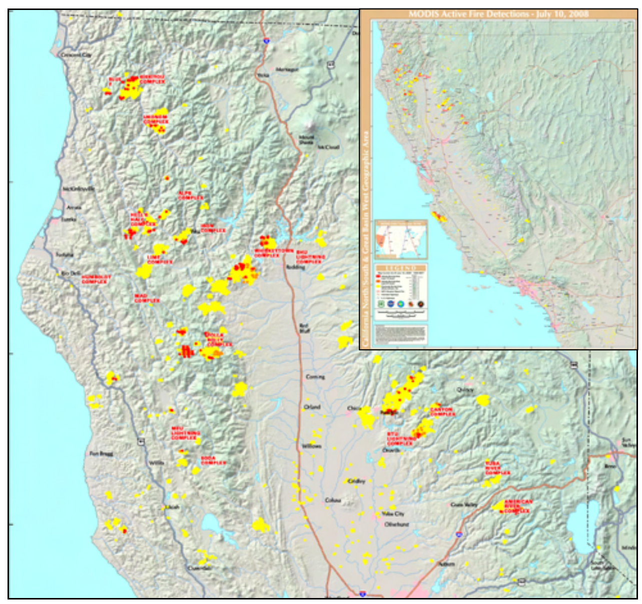

Figure 4 MODIS-detected fire activity for northern California on a July 10, 2008 MODIS Active Fire Map. MODIS Active Fire detection maps are generated for nearly 40 geographic areas throughout North America including California and Nevada (inset). The maps display the cumulative of fires for the current year and highlight recent fire activity. Cumulative fire detections are indicated in yellow. Fire activity detected in the last 24 hours is in orange; fire activity in the last 12 hours in red.

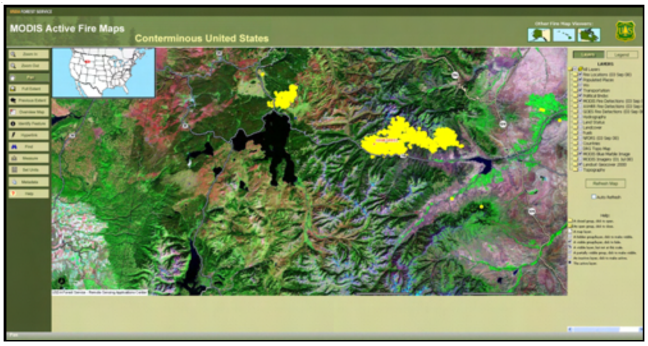

Figure 5 MODIS Active Fire Mapping Program interactive fire detection map viewer centered on the Yellowstone National Park area of northwest Wyoming

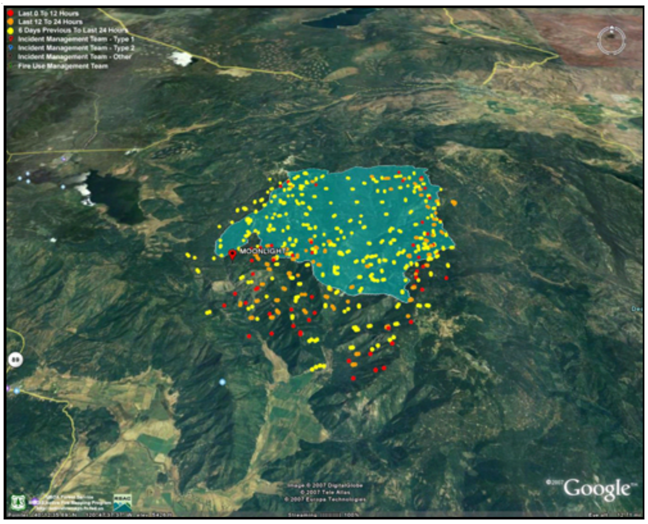

Figure 6 MODIS Active Fire Mapping Program Keyhole Markup Language map file of MODIS fire detection data displayed in Google Earth. Virtual globe applications enhance MODIS data product visualization and facilitate integration of relevant fire information such as current incident information and fire perimeter data

MODIS Fire Detection GIS Data: Annual GIS data of MODIS fire detections available as individual datasets for the continental United States, Alaska, Hawaii, Canada and all of North America. Detection data for the current calendar year are based on the data provided by the MODIS Active Fire Mapping Program and are updated hourly. Data for previous years are extracted from the latest version of the MODIS MOD14 data record provided by the LP-DAAC. All datasets are available in standard GIS formats and provided with thematic metadata.

Keyhole Markup Language Map Files and Web Map Services: Regional KML maps for the continental United States, Alaska, Hawaii and Canada depicting MODIS fire detection activity for the past week. Fire detection data are characterized with pertinent attributes such as by date and time of occurrence and measured fire radiative power (FRP) (Figure 6). For each geographic region, a Web Map Service (WMS) containing fire detection data for the entire MODIS data record is also provided. Fire detection data for the KML and WMS maps are updated hourly.

MODIS Reflectance Images: Daily MODIS corrected reflectance subsets for the United States and Canada generated from daytime MODIS observations. The georeferenced subsets are generated from the MODIS multi-spectral data used for land surface remote sensing (MODIS bands 1 through 7) resolution-sharpened to a spatial resolution of 250 meters. Subsets are generated following each Terra and Aqua MODIS observation and accessible in a variety of standard image formats readily supported by most geographic information system (GIS) and remote sensing software applications (Figure 7).

Current Detection Information: Mapping and analytical summaries of MODIS detections occurring in the United States and Canada in the last 12 hour period. Fire detections occurring in the last 12 hours are analyzed hourly in the context of the latest fire weather warnings/watches, fire danger ratings, land cover classifications, administrative boundaries and proximity to urban areas. Results are provided as viewable national scale maps and detailed analytical summaries from geospatial overlay analyses.

Operational Use of Direct Readout MODIS Fire Products

Near real-time MODIS fire products facilitated by direct readout technologies are used widely throughout the Forest Service, other land management agencies and the general public. The MODIS Active Fire Mapping Program's fire mapping products and geospatial data support several fire management objectives and decision support applications including:

1) Strategic planning and allocation of available national and regional fire suppression resources based on the observed severity and extent of current fire activity across the nation.
2) Daily mission planning and targeted prioritization of higher resolution airborne remote sensing assets used for tactical fire mapping support at the local incident scale.
3) Spatial fire behavior systems/models that require explicit data depicting the location and extent of fire activity and used to characterize the probability of fire spread and identify resources at risk.
4) Detection and monitoring of fire activity in remote areas/non-response zones where allocation of assets is limited.

5) Monitoring propagation of smoke from wildland and prescribed fire activity and its effects on local and regional air quality, visibility, and sensitive ecosystems.
6) Monitoring threat of fire activity to critical infrastructure.
7) A source of current fire mapping information for the general public, particularly for communities threatened by current wildland fires.

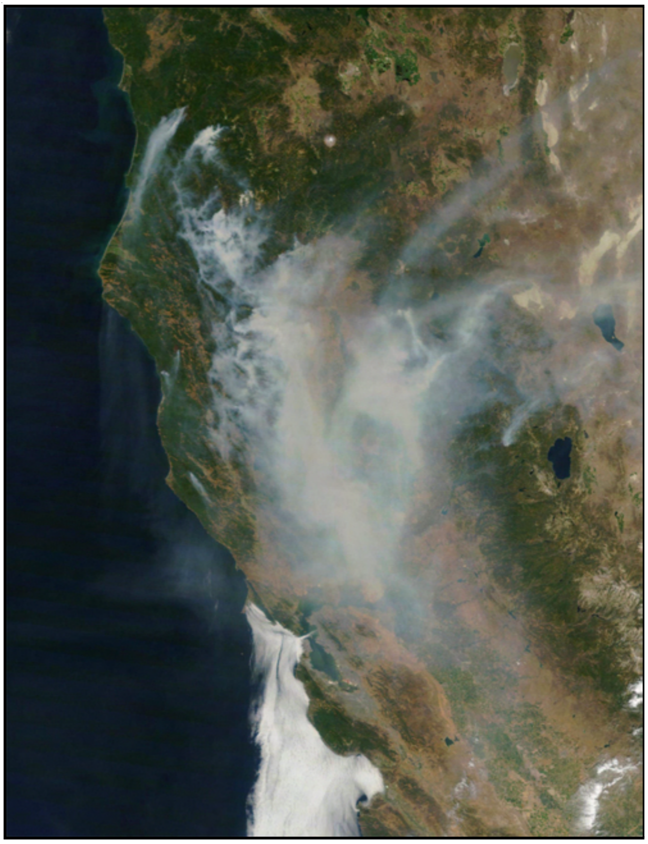

Figure 7 July 10, 2008 Terra MODIS image subset of northern California generated from direct readout data acquired by the USDA Forest Service MODIS ground station. The true-color composite highlights the smoke emitted from the severe fire activity ongoing in the region.

Figure 8 Grass fire underneath power lines

Example Framework: South Africa

CSIR and Eskom

During the 2004 fire season, South Africa's largest power company Eskom, and South Africa's biggest science council (CSIR) implemented a novel satellite-based fire alert and information system (AFIS) to help combat line faults caused by fires underneath transmission lines. The quality of electricity supply through transmission lines are severely affected (in the form of line faults) by natural phenomena such as, bird streamers (excrement), lightning, fires and air pollution. Line faults cause short but significant interruptions in the power supply which have major financial implication for factories running continuous production processes (Vosloo, 2005). Eskom operates approximately 28 000 km of transmission lines in South Africa, most of which crosses through fire prone biomes. Consequently, large parts of the transmission grid are exposed to grass and bush fires (Figure 8), especially during the dry winter period of June to October. The north eastern parts of South Africa have a summer rainfall season resulting in very dry and windy conditions during the winter period making it ideal for the outbreak of large fires. Similarly, the western and southern Cape have a Mediterranean climate resulting in rain in the winter months, which results in South Africa having 2 distinct fire seasons in the north eastern and southern parts of the country.

The South African Advanced Fire Information System (AFIS) is the first near real-time satellite-based fire monitoring system in Africa and incorporates satellite fire detection information from both the Terra and Aqua MODIS satellites as well as the Meteosat Second Generation (MSG) geostationary satellite from Eumetsat providing a continuous view of Southern Africa.

Data Access/Data Network

The CSIR is operating two MODIS receiving stations, one from the Satellite Application Centre (SAC) outside of Johannesburg and a second station on the CSIR campus in Pretoria operated by the Meraka Institute. The two stations are approximately 70 km apart but are connected on a 1 Gbit network to enable fast data transfers. Both stations are making use of the Sediba processing system which is an in house developed MODIS processing system based on open source software. Once data is received and processed products are uploaded to a central server on the 1Gbit network from where the AFIS server will upload the relevant products. If one receiving station goes down the second station will automatically provide the relevant products to ensure a continuous data stream.

Direct Readout Science Data Algorithms/ Integration

The MODIS DRL algorithms have been integrated in to the Sediba processing system to enable the generation of standard MODIS DB products. The raw data (level-0 files) are transferred from the receiving stations to processing servers by using FTP into a specific directory structure. The processing servers are responsible for processing data from L0 to level-1b using the MODIS L1DB code. Once level-1b products are generated numerous L2 and L3 products can be created within minutes. The standard products created by the processing servers are the MOD/MYD 14 fire product, the MOD/MYD 09 corrected surface reflectance, MODIS Burned Area (Giglio/CSIR) and true colour imagery. Additional products such as Land Surface Temperature and Atmospheric products can be produced on request.

AFIS currently relies on contextual algorithms for hotspot detection using the two MODIS sensors and the SEVERI sensor aboard the geostationary MSG satellite. Though the SEVERI provides almost near real time hotspot detection, it can only resolve large hotspots (five hectares – Prins, 2001), whereas MODIS can resolve hotspots less than a hectare in size (Giglio, L. et al. 2003).

The CSIR is running a customized version of the MOD/MYD 14 collection 5 code. Modifications were made to the threshold tests to enable the detection of smaller cooler fires within Southern Africa. Day time channel 21 thresholds have been reduced to 305º K while night time thresholds have been reduced to 295º K. Similarly the channel 21 – 31 difference has been reduced to 7º K from the default 10º K. Additional to the threshold changes an Industrial No-Burn mask was also build in to the algorithm to exclude large industrial plants that emit lots of heat which causes false detections.

Geospatial Product Generation and Distribution

The AFIS system (Figure 9) is based on both satellite and terrestrial data sources in order to create a sensor web of information. Processing servers derive relevant products that are fed in to the main AFIS server on the South African Research Network (SANREN).

The AFIS system has three main outputs:

Online mapping system: The online mapping system is based on Google Web tools and display active fire information from MODIS and MSG in near real time. Additional to the active fire information additional inputs include hourly updated automated weather station data as well as daily fire danger maps.

Fire Alert Service: The alert system is based on cell phone SMS and email messages automatically generated whenever a fire is within a pre-defined distance of a point, line or polygon. As soon as a fire is detected within 3 km of any of the 28000 km of transmission lines within South Africa an SMS or email alert is automatically generated and send directly to the persons phone responsible for that portion of the line (Figure 10)

WFS and GEONETCAST services: The AFIS system provides MODIS active fire products as web feature services. The raw ASCII files with the position of active fires are also distributed through the GEONETCAST system to enable any person with Eumetcast reception station to receive the MODIS fire data without needing assess to the internet.

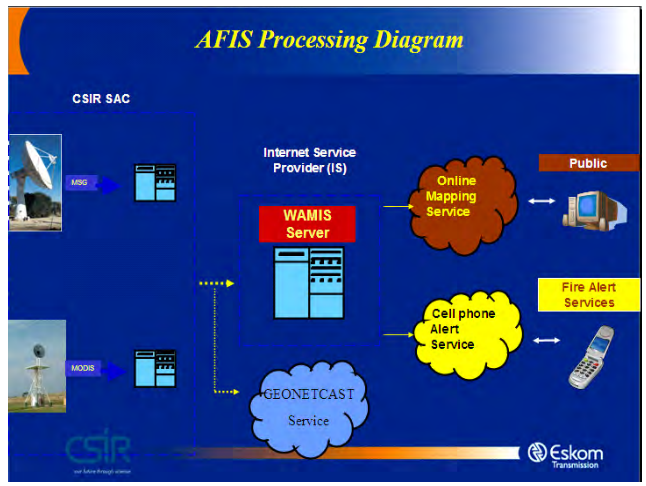

Figure 9 AFIS processing diagram

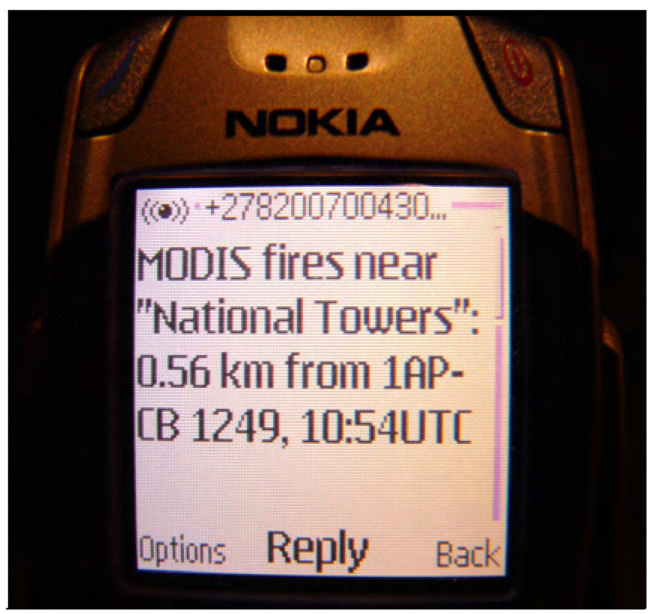

Figure 10 SMS alert message

Operational Use of Direct Readout MODIS Fire Products

AFIS has become an integral part of Eskom's transmission line monitoring and management system and provides staff with an estimated 5000 alert messages per month during the peak fire season. Fire alerts are also provided to the Working on Fire (WOF) program and regional Fire Protection Associations (farmers and fire brigades) to enable the fire suppression agencies to react to fires in quick time. The technology can however still be improved with MODIS and MSG still missing more than 50% of all the fires along power lines that cause line faults (Frost and Vosloo, 2007).

MODIS active fire maps are also displayed once a week on National Television with the evening weather report during the fire season (Figure 11).

Figure 11 MODIS fire report TV

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