The advanced fire information system

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The South African Advanced Fire Information System (AFIS) is the first near real-time satellite-based fire monitoring system in Africa. It was originally developed for, and funded by, the electrical power utility Eskom, to reduce the impact of wild fires on regional electricity supply.1 Fires underneath the 28,000 km of power lines can cause flashovers which severely affect electricity supply. The loss of life and destruction of property caused every year by wildfires further emphasised the need to develop an operational, early warning fire information system that could alert the disaster management, firefighting, farming and forestry communities on the location and trajectory of blazes, as well as capturing information on the frequency and distribution of fires for researchers. In 1999 the Terra polar-orbiting satellite was launched, with Aqua following in 2002. Both have a MODIS sensor on board that can detect fires with high precision four times a day. These data are coupled with observations from Meteosat Second Generation (MSG), a geostationary weather satellite that provides slightly coarser and less sensitive fire location information every 15 minutes. Eskom implemented AFIS in June 2004, scanning every 15 minutes within a buffer of 5 km along all transmission lines, searching for any fire hotspots. With the detection of a fire, e-mail and SMS text messages are immediately sent to affected parties. AFIS was first implemented using propriety GIS technology, but has now been reengineered as an Open Geospatial Consortium-compliant Sensor Web application which is currently being developed.

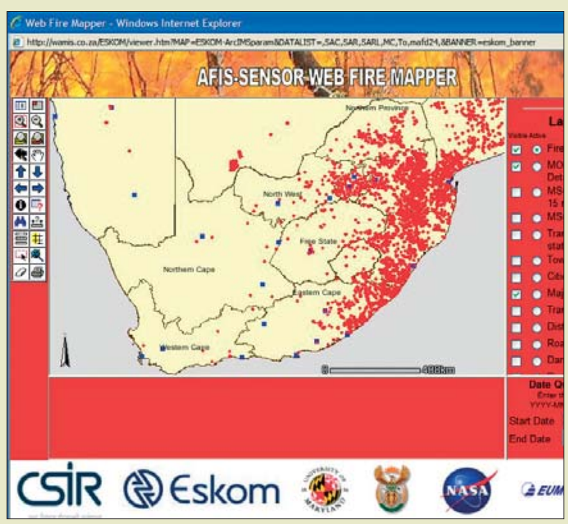
Hotspot detection

AFIS currently relies on contextual algorithms for hotspot detection using the two MODIS sensors and the SEVERI sensor aboard the geostationary METEOSAT-8 satellite. Though the SEVERI provides almost near real-time hotspot detection, it can only resolve large hotspots (five hectares or more in extent), whereas MODIS can resolve hotspots less than a hectare in size.

The hotspot detection algorithm was originally developed for the Advanced Very High Resolution Radiometer (AVHRR) sensor flown aboard the TIROS satellites. The algorithm uses the short wave infrared and thermal bands to discriminate fire pixels from background pixels. The algorithm first classifies a pixel according to a fixed threshold, e.g. $T > 310K$, to identify potential fire pixels, and the remaining pixels are called background pixels. The neighbourhood of this pixel is then searched for background pixels, growing the neighbourhood if necessary to ensure that at least 25 per cent of the neighbourhood pixels are background pixels. From this set

Advanced fire warnings

The MODIS active fires are incorporated into the weather report once a week on national television



The AFIS web mapper enables people to view fire locations via the Internet

A grass fire burning underneath an Eskom transmission line

of background pixels, the mean and standard deviation statistics are calculated from the difference between the mid-infrared and thermal band. The pixel under consideration is then classified as a hotspot if its mid-infrared value exceeds the background mean by some multiple of the standard deviation. A similar test is performed on the mid-infrared and thermal band difference.

Hotspot detection success rate

The success of AFIS as a management tool within Eskom is measured by its ability to detect fires close to transmission lines before flashovers occur. MODIS was able to detect an average of 44 per cent of all flashover fires during 2003-2005, while MSG detected 46 per cent of all flashover fires during the same period. By combining the detection accuracy of MODIS and MSG within one system (AFIS), the detection rate rose to 60 per cent.2 The statistics of the MODIS and MSG detections clearly demonstrate the limitations of each of these sensors as a detection tool on its own. The MODIS sensor was able to detect many of the smaller fires, but due to its infrequent revisit time, was unable to detect short-duration fires. The MSG sensor struggled to detect smaller fires but picked them up when they grew big enough to be seen by the current algorithm. The 2 per cent higher detection accuracy calculated for MSG with its lower resolution and less advanced detection algorithm shows the importance of frequent observations.

In order to further improve the detection rate a new, more sensitive non-contextual hotspot algorithm is under development for the SEVERI sensor. The basic approach is to build a general model of the diurnal cycle of the thermal and infrared bands, and then to fit this model to the observed data of the last 24 hours. The model can then be used to generate accurate estimates of the expected background temperatures. If a statistically significant difference between the current observed temperature and the predicted background temperature is observed, then the pixel in question is classified as a hotspot. The first implementation of this algorithm relied on a Kalman filter to provide the estimates of the background temperature. Initial results indicate that this method is significantly more sensitive, particularly in cases where the background temperature is below 300K e.g. early morning.

Extending AFIS functionality

The intention is to shift the emphasis from simple fire detection to more sophisticated fire risk management. This requires a good understanding of what controls wild fire behaviour. The Meraka Institute is currently building domain ontology for wild fires. The ontology will capture key concepts in the wild fire domain such as combustion properties, fuel load, burning regime, fire weather, fire suppression methods and topographical controls. The aim is to use the Sensor Web to observe specific fire-related phenomena described in the wild fire ontology and employ machine reasoning to determine fire risk and issue more useful fire alerts.