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Canadian Forest Service – Great Lakes Forestry Centre

The use of satellites to track forest fires and estimate carbon emissions

INTRODUCTION

Canada is recognized as a world leader in forest fire research and management. Over the past 20 years, the Canadian Forest Service has developed information systems that use advanced technologies such as remote sensing and geographic information systems to monitor and report on forest fire activity at a national scale. Many of these decision support tools have been adapted for use in countries around the globe. Canada is also one of the first countries to have a national system that accounts for annual carbon emissions from wildfires, which fulfills obligations under the United Nations Framework Convention on Climate Change.

Fire is a natural ecological process in Canada's forests; currently, an average of more than two million hectares of forest burn annually. When forests burn, a portion of the trees is consumed and emits carbon dioxide. Researchers convert the CO_2 to carbon using a standard equation based on the atomic weight of the two substances. Once the conversion is made, researchers have an estimate of carbon emissions from fire. Natural decay, insect defoliation, forest harvesting and other disturbances also cause increases in CO_2 released to the atmosphere, and are all included in Canada's Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3) that calculates total carbon emissions from managed forests.

Rapid detection and management of forest fires can save human lives and millions of dollars in property damage. It is expected that wildfire incidence will increase significantly in the decades ahead as temperatures rise due to climate warming. To address these concerns, scientists require the best possible data on which to base their predictions of forest fire impacts, both on the ground and in the atmosphere. Recent advances in satellite technology have provided a new tool to allow more accurate assessment of forest fires in real time.

NATURAL RESOURCES CANADA (NRCAN) ROLE

Two sectors of Natural Resources Canada, the Canadian Forest Service (CFS) and the Earth Sciences Sector (ESS), teamed up in 2003 to develop a Fire Monitoring, Accounting and Reporting System (FireMARS), with support from the Canadian Space Agency (CSA). The system uses satellites, forest fire data and a Canadian ecological fire effects model to track and report on the carbon emissions from wildfires. These emissions estimates are incorporated into an annual report on national forest carbon accounting that is developed by the CFS Carbon Accounting Team (CAT) using the CBM-CFS3. The CAT reports annually to Environment Canada on the release and uptake of forest carbon for all managed Canadian forests.

The data inputs to FireMARS are based partially on the detection and mapping of fires from satellites (Image 1). Remote sensing researchers at ESS developed the satellite fire mapping tools along with other tools

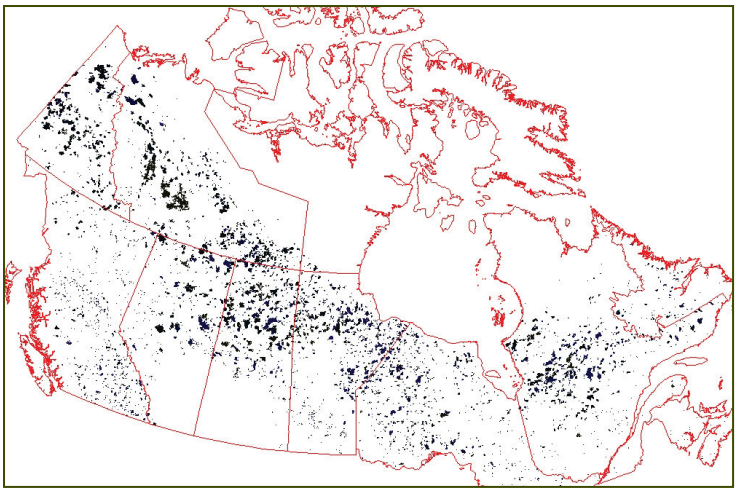

Image 1. Map of Canadian wildfires (greater than 500 ha) for the years 2000-2010 produced from SPOT-VGT satellite data. (source: R. Fraser, NRCan, Canada Centre for Remote Sensing)

that use specialized satellites to detect high-temperature events called hotspots. The Canadian website (http://cwfis.cfs.nrcan.gc.ca/en_CA/index) is updated twice daily with maps showing fires detected by remote sensing. Data on these hotspots, such as the location, size and energy of active fire fronts, provide critical information for forest managers who monitor and manage wildfires.

The FireMARS team is currently working with international partners who are developing complementary satellites, with the goal of improving fire monitoring and reporting around the globe. The plan is to launch 4 polar orbiting satellites. The first, AQUARIUS/SAC-D will be launched in 2011 by NASA and the Argentine Space Agency (CONAE); the second, TET-1, is to be launched by the German Space Agency (DLR) in 2011; the third, Sentinel-3, will be launched by the European Space Agency (ESA) in 2013; and the fourth, VIIRS, will be launched in 2014 by NASA.

The new experimental sensor on the AQUARIUS/SAC-D mission is called the New Infrared Sensor Technology (NIRST). This instrument was developed collaboratively by CSA and CONAE, with CSA designing the heart of the instrument, the thermal infra-red detector. As a collaborator, Canada will receive the NIRST data for free. The NIRST instrument will allow Canadian fire managers to monitor fires that cover as little as 900 m^2 (< 1/10th of a hectare). Detecting wildfires at this scale has immense potential to minimize the damage they cause; early fire attack efforts are critical in containing wildland fires before they get out of control. While only 3% of fires get out of control they account for 97% of the area burned.

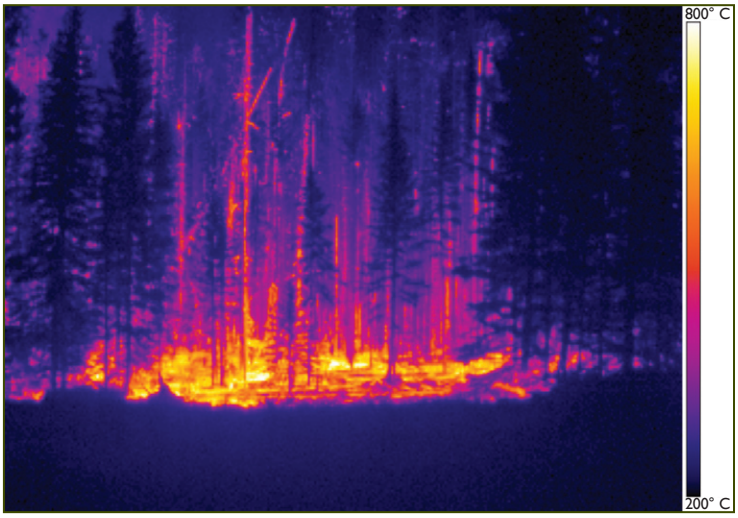

Image 2. An image of a forest fire taken using a thermal infrared (TIR) camera. Temperatures above 600 °C are in yellow, temperatures from 300-600 °C are in red, and temperatures below 300 °C are dark coloured. These data can be used to estimate fuel consumption and carbon emissions from forest fires..

GREAT LAKES FORESTRY CENTRE (GLFC) ROLE

GLFC researchers are working to get better estimates of fuel consumption to improve the estimates of carbon emissions from forest fires. To accomplish this they have teamed up with colleagues from King's College London (KCL) in the UK on a project that aims to use thermal infrared technology for measuring the amount of fuel consumed by forest fires. The KCL group is highly advanced in the application of this technology in remote sensing, and is bringing its expertise to bear in Canadian forest fire research. Previous collaborative studies with this group have shown that the amount of energy radiated from a fire, referred to as Fire Radiative Energy (FRE) and measured using thermal infrared detectors, is directly related to the amount of fuel that burns (Image 2). This earlier research will contribute to the development of new remote sensing tools that use this technology for monitoring the FRE of wildfires.

The UK researchers worked with their CFS counterparts to collect data from two Canadian prescribed burns as part of their efforts to develop this technology. The two burn sites included a 1-ha prescribed burn in Ontario that was conducted in 2007, and an 8,000-ha prescribed burn in Alberta in 2009. This latter burn was organized by the province of Alberta in conjunction with Parks Canada to halt the spread of the mountain pine beetle, and to re-introduce fire for ecological reasons. Researchers capitalized on the fire to gather detailed information on FRE from a 5-ha sub-plot. Prior to the burns the researchers conducted ground sampling to obtain data on the fuel load and fuel type. During the burns, scientists flew over the sites in helicopters and filmed the fires with small hand-held infrared cameras that were equipped with thermal detectors to calculate the FRE.

Canadian scientists plan to use this technology by equipping the satellites used to track fires with infrared sensors similar to the ones on the handheld cameras. The sensors are highly sensitive to thermal energy. In fact, they are 10,000 times more sensitive to thermal energy than to the cooler background forest. One of these sensors will be part of the NIRST instrument on the upcoming AQUARIUS/SAC-D satellite mission. Once these satellites are launched, researchers will be able to collect data on FRE via remote sensing. The information will be used as part of the data input to FireMARS, which will enhance carbon emissions estimates and national forest carbon accounting, and could lead to further research on remote sensing technologies for use in fire monitoring. The technology has application globally in helping reduce the cost of fire management and better protecting forest communities.

CONCLUSION

Forest fire management in Canada is the most expensive forest management activity, costing $500-800 million annually. The use of remote sensing tools not only helps managers to detect fires in the early stages, for timely intervention and reduced suppression costs, but also provides a novel tool for tracking fires and calculating carbon emissions from them. International collaboration is helping Canadian forest fire scientists bring the latest technologies to bear in addressing a global issue, thus maintaining their reputation as world leaders in their field. Such collaboration will improve the accuracy of reporting on carbon emissions from wildfires using remote sensing and facilitate international adoption of this technology. Many African countries have already adopted this technology and are using an operational system for monitoring grasslands fires.

COLLABORATORS

- Province of Alberta (Alberta Sustainable Resource Development)
- Province of Ontario (Ontario Ministry of Natural Resources)
- Parks Canada
- Earth Science Sector, Canada Centre for Remote Sensing
- Canadian Space Agency
- The National Aeronautics and Space Administration (NASA)
- King's College London, UK (KCL)

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