Reducing Canada's vulnerability to climate change

Satellite Monitoring of Land Cover Change and Disturbance for Improving Carbon Budget Estimates in Canada

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Background

Land cover / land use change (LCLUC) and natural disturbances have a significant impact on emissions and removals of greenhouse gases in Canada. These modifications to the terrestrial carbon budget must be reported under the United Nations Framework Convention on Climate Change and Kyoto Protocol for the 2008-2012 commitment period. The Carbon Sequestration Project in the ESS Climate Change Program includes an activity on "Satellite monitoring methods and products for improving national biological carbon budget estimates." Two components of this activity are designed to improve the level of available information on carbon budget changes due to LCLUC and disturbance: (i) national-level, coarse resolution resolution change detection; and (ii) long-term, fine resolution change detection in Canada's North.

National Level Coarse Resolution Change Detection

Objectives

- Develop a satellite-based technique to identify large-scale (> 5-10 km^2), inter-annual changes from LCLUC and disturbance
- Provide a coarse-filter approach to detecting major areas and the timing of changes a national scale. Such areas could then be investigated in more detail using fine resolution change detection, such as that being conducted under the CFS EOSD initiative
- Major changes of interest include wildfires, forest harvesting, severe insect defoliation, and flooding.

Methods

This Change Screening Analysis Technique (Change-SAT) uses change metrics derived from 1-km multi-temporal satellite imagery (reflectance, temperature, texture) and ancillary spatial variables (proximity to active fires and roads, forest tenures, slope). A Canada-wide training and validation change dataset was created based on analysis of multi-temporal Landsat imagery, forest fire surveys, and insect defoliation surveys. A two-step model was created that uses logistic regression and a decision tree classifier. An optimal change/no-change threshold is applied to the logistic regression probability of change output. A decision tree classifier then predicts the most likely type of change based on the trajectory of the change metrics.

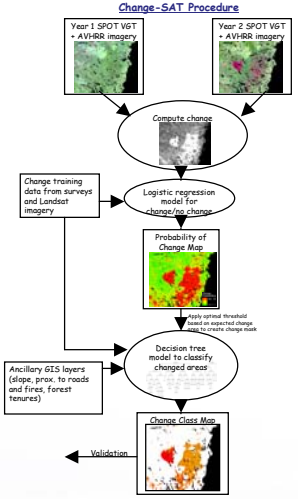
Results

Change-SAT was tested over 1998-2000 using an independent validation sample of 555 pixels. Overall accuracy was 82%, while commission error for unchanged pixels was 2%. A low commission error is especially important to identify a relatively small proportion of changed pixels over a vast area such as Canada, since even a 2% error will lead to more than 8 million ha of falsely mapped change pixels (i.e. 418,000,000 ha forested area × 2%).

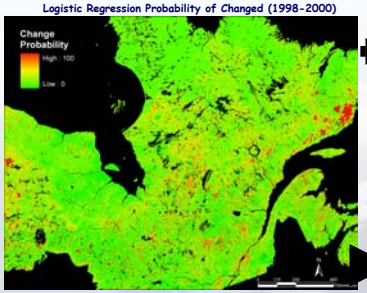
Change Detection Error Matrix

	No change	Burned	Flooded	Defoliated	Clearcut	User's Accuracy
No change	130	19	13		29	68%
Burned	2	109	1	14	13	78%
Flooded			6			100%
Defoliated		5		119	3	94%
Clearcut	1				88	99%
Producer's Accuracy	98%	82%	30%	89%	66%	82% Overall

Change-SAT Procedure

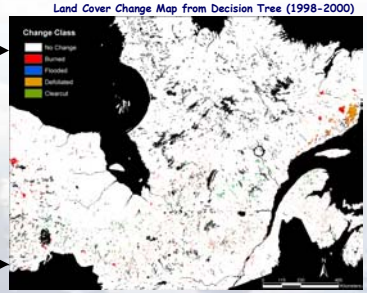


Logistic Regression Probability of Changed (1998-2000)



Threshold Map then Classify Changed Areas

Land Cover Change Map from Decision Tree (1998-2000)



Fine Resolution Change Detection in Canada's North

Objective

- Quantify vegetation changes by land cover type along the forest-tundra boundary in northern Manitoba from 1979-2001

Methodology

Landsat imagery was acquired over Churchill, Manitoba during the summer growing seasons of 1979, 1991, 1993 and 2001. Image-to-image registration was performed on all of the datasets in order to geometrically match the images into a similar spatial domain. Radiometric calibration coefficients were then used to map top-of-atmosphere reflectance over all spectral bands. Next, a land cover map was generated based on the 2001 imagery through a supervised spectral clustering technique, resulting in 6 spectrally separate classes. Using the land cover map as the main input, a cross-correlation analysis was performed on the green, red and near-infrared spectral bands for each year. Change maps based on z-score statistics were then derived for each year to show 'most-changed' regions per land cover type.

Results

As shown in Fig.1, between 1979-2001 most of the changes (highlighted in red) are due to the regeneration of old burns. Between this time, heath cover showed the highest proportion of changed pixels while sphagnum larch and recent burns were also relatively high. Between 1991-2001 the heath class revealed the highest proportion of changed pixels (23.8%) while regenerating forests showed the lowest proportion of changed pixels (14.7%). From 1993-2001 a large area in the lower portion of the change map in Fig.1 shows the presence of a regenerating burn. With this in mind, table 1 shows that heath cover and recent burns are the two land cover classes that have the highest proportion of changed pixels.

[Brook, R.K. and Kenkel, N.C. 2002. A multivariate approach to vegetation mapping of Manitoba's Hudson Bay Lowlands. *Int. J. of R.S.* Vol. 23, pp. 4761-4776.]

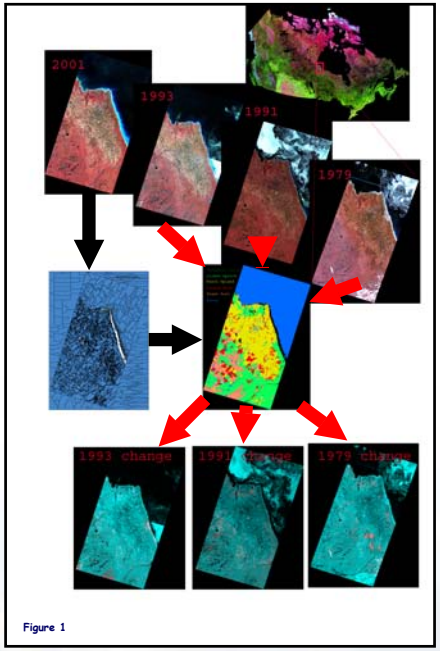


Figure 1

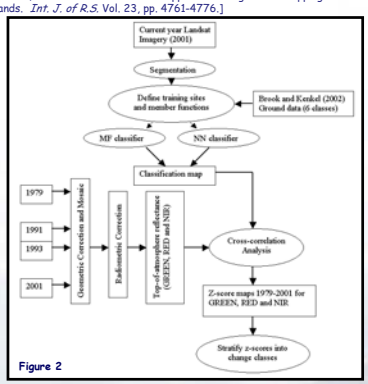


Figure 2

Table 1

	LAND COVER CLASS											
	HEATH		RECENT BURN		REGEN FOREST		SPHAGNUM LARCH		LICHEN SPRUCE			
YEAR	TOTAL (KM^2)	CHANGE (%)	TOTAL (KM^2)	CHANGE (%)	TOTAL (KM^2)	CHANGE (%)	TOTAL (KM^2)	CHANGE (%)	TOTAL (KM^2)	CHANGE (%)		
1979	4434	25.4	972	24.1	1425	15.1	102	25.0	3476	13.4		
1991	15754	23.8	3410	18.9	4715	14.7	418	20.7	13650	17.5		
1993	15616	26.4	3361	22.4	4523	16.8	400	16.1	13339	13.0		

Conclusions

The LCLUC and disturbance mapping techniques demonstrated in this poster should provide valuable information for improving estimates of Canada's terrestrial carbon budget. The large-scale, interannual change detection performed by Change-SAT is aimed at providing a coarse filter approach to guide more detailed analyses of change. The fine resolution, northern change detection will provided more detailed, long-term change information for ecosystems particularly sensitive to the effects that climate change will have on carbon balance.