



Long Term Satellite Data Records for Land Surface Characterization

Canadian Centre for Remote Sensing
Rasim Latifovic, Darren Pouliot and Ian Olthof



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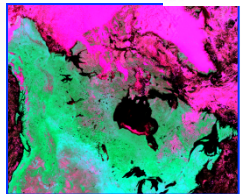
LTSDRs – Long Term Satellite Data Records

Time series of satellite measurements of sufficient length, consistency and continuity to determine terrestrial variability and change.

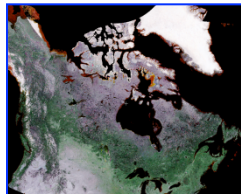
SDRs – Sensor data record.
Time series of calibrated and quality-controlled data organized by sensors

EDRs – Environmental data record.
Terrestrial parameters derived from the SDRs such as albedo, snow cover, land cover, LAI, fAPAR

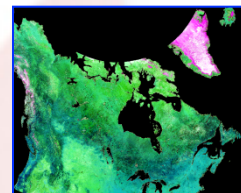
GT – Ground truth.
Data for validation and quality control



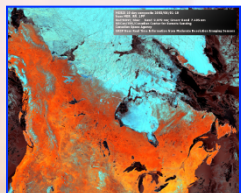
AVHRR NOAA 1 km
Period: **1982-2011**
Transition: **MetOp**
2006-2020



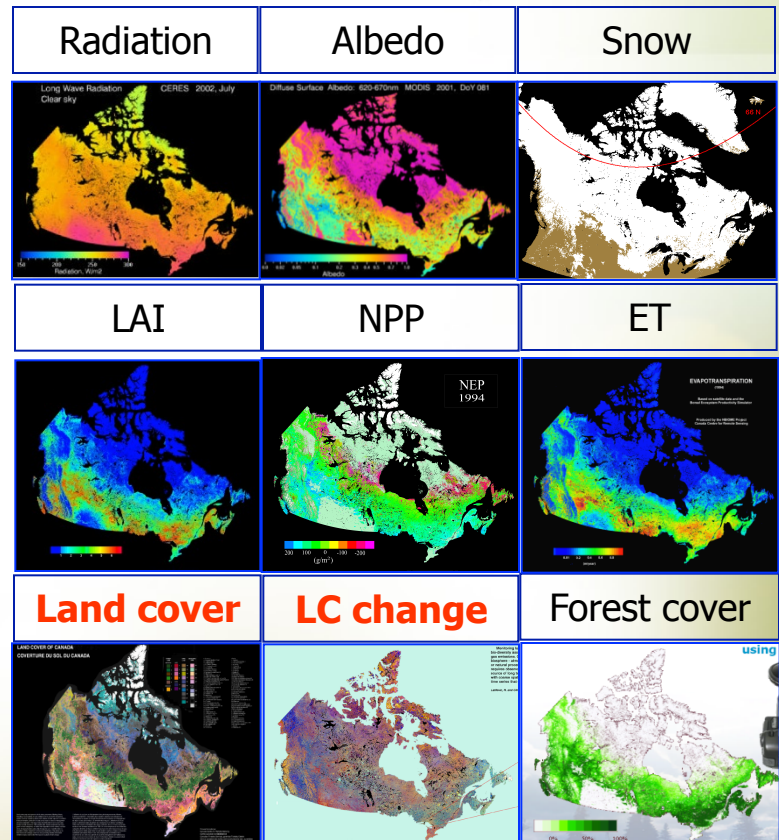
MODIS NASA 1; 0.5; 0.25 km
Period: **2000-2011**
Transition: **NPOESS VIIRS**



SPOT/VGT VITO 1km
Period: **1998-2011**
Transition: **SENTINEL3** 2013



MERIS ESA 1; 0.3 km
Period: **2008-2011**
SENTINEL 3 2012



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Land Cover Change

Abrupt (1-5 years)	Progressive\Gradual (> 5 years)
<ul style="list-style-type: none">• Fire• Biomass harvesting (agriculture, forest, other)• Storm damage (e.g. severe winds\ice)• Permanent flooding• Land slides• Drought• Urban development	<ul style="list-style-type: none">• Vegetation composition change• Re-vegetation of disturbed lands• Pollution related forest decline• Continuous low to moderate insect defoliation• Consistent long term hydrologic changes• Permafrost changes –active layer increase \decrease, subsidence• Coastal\shoreline erosion



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Change Detection Methodology

1) Radiometric normalization



2) Change features:

$Feature_1, Feature_2, Feature_3, \dots, Feature_{167}$



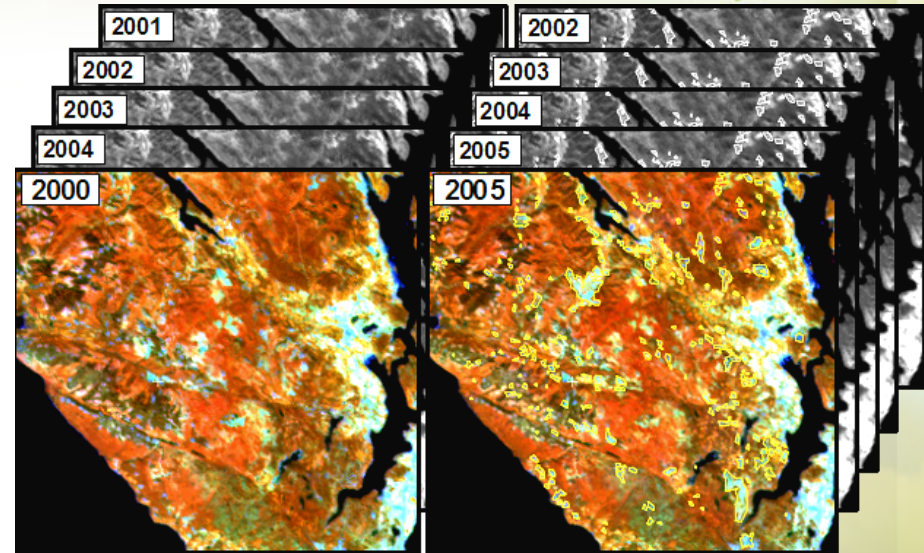
3) Bootstrap feature selection



4) Decision tree change classification
– annual change results



5) Change persistence evaluation



 Disturbances

Pouliot, D., R. Latifovic, R. Fernandes, and I. Olthof. (2009). Evaluation of annual forest disturbance monitoring using a static decision tree approach and 250 m MODIS data. RSE, 113:1749-1759.



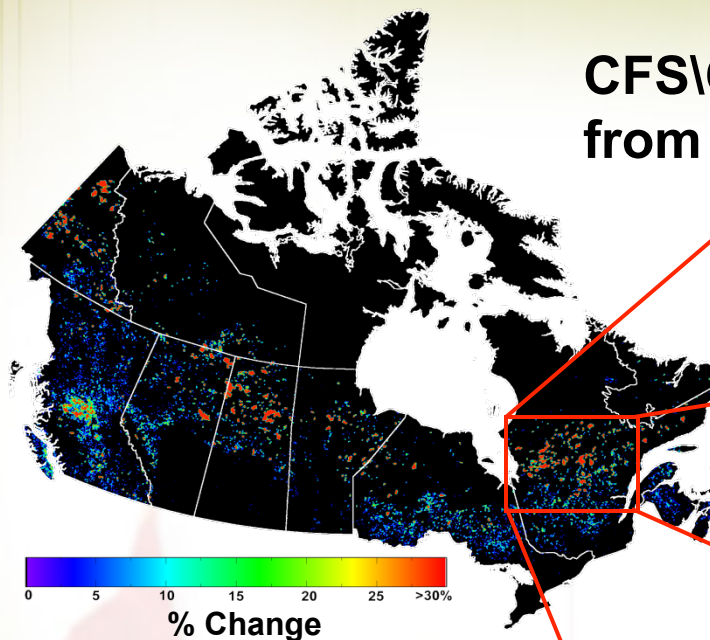
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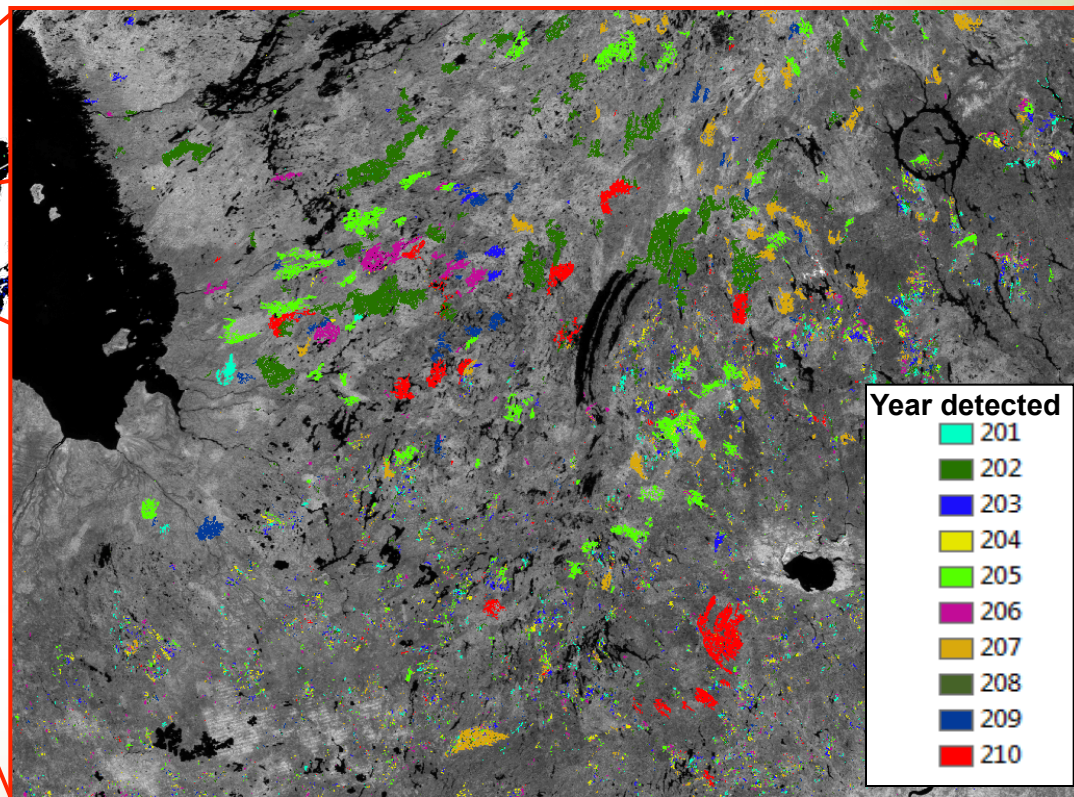
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MODIS Land Cover Time Series Change Detection

CFS\CCRS national forest change product
from 2001-2010 at 250 m spatial resolution.

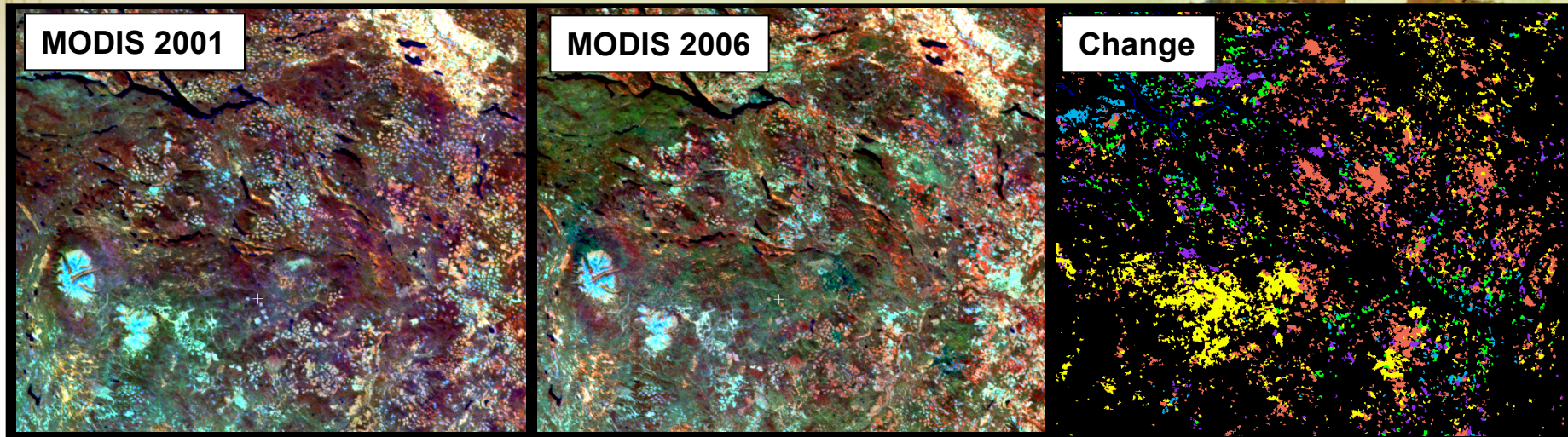


Guindon et al. (2011). An improved method for the annual mapping of forest disturbance across Canada based on MODIS 250m data and decision/regression trees. 32nd Canadian Symposium on Remote Sensing, June 13-16, Sherbrooke, Quebec.



Pouliot, D., R. Latifovic, R. Fernandes, and I. Olthof. (2009). Evaluation of annual forest disturbance monitoring using a static decision tree approach and 250 m MODIS data. Remote Sensing of Environment, 113:1749-1759.

Decision Tree Change Detection: *Mountain pine beetle damage*



Disturbance year

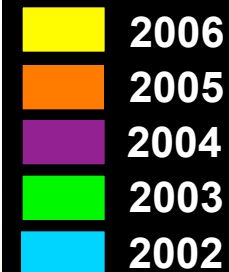


Photo by Lorraine Maclauchlan, Ministry of Forests, Southern Interior Forest Region, Canada



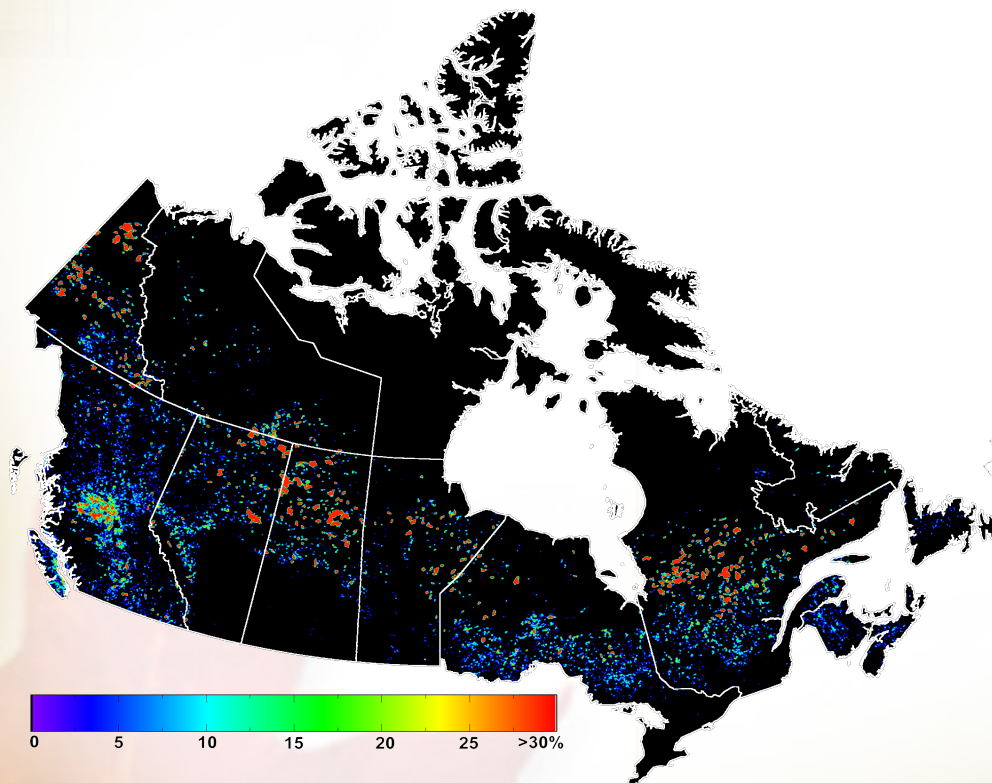
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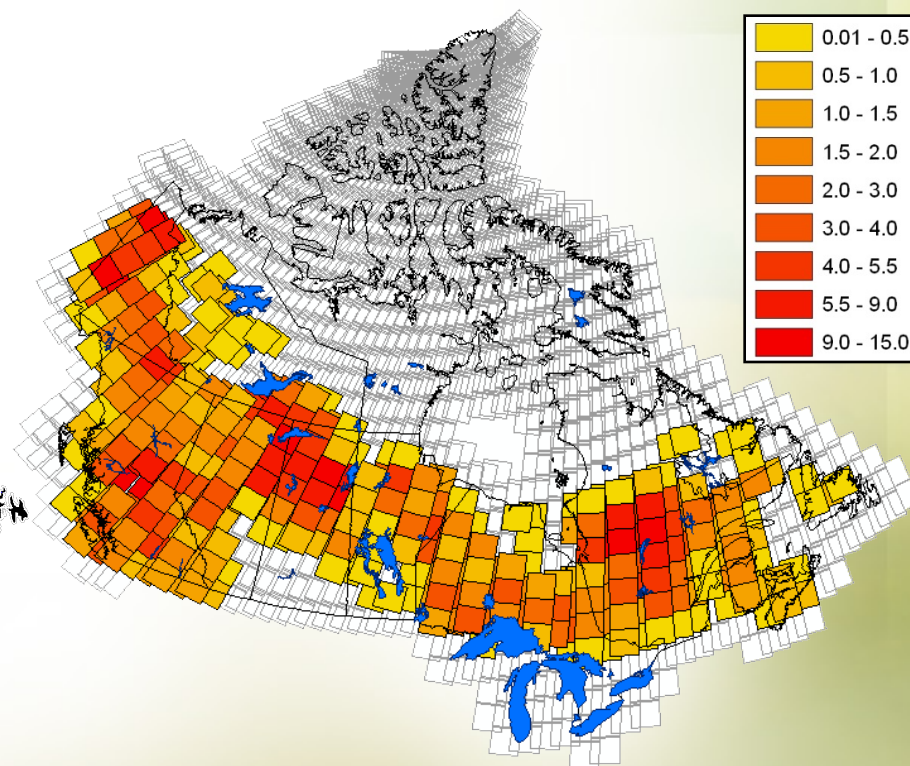
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Abrupt land cover change (annual change)

Fraction of forest change within an 8 km pixel from 2001-2006



Percent forest change within Landsat footprint 2000-2006



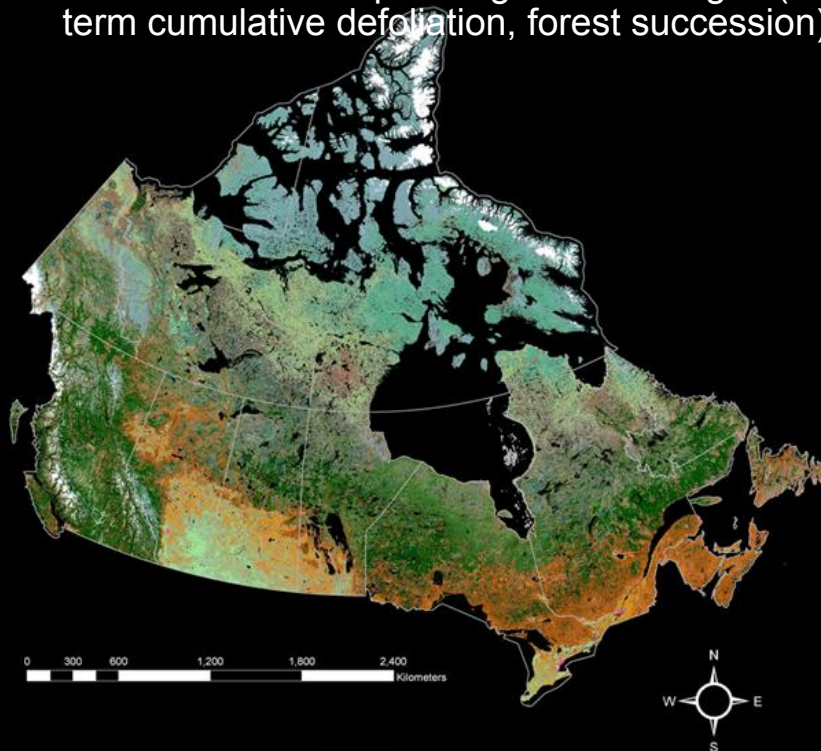
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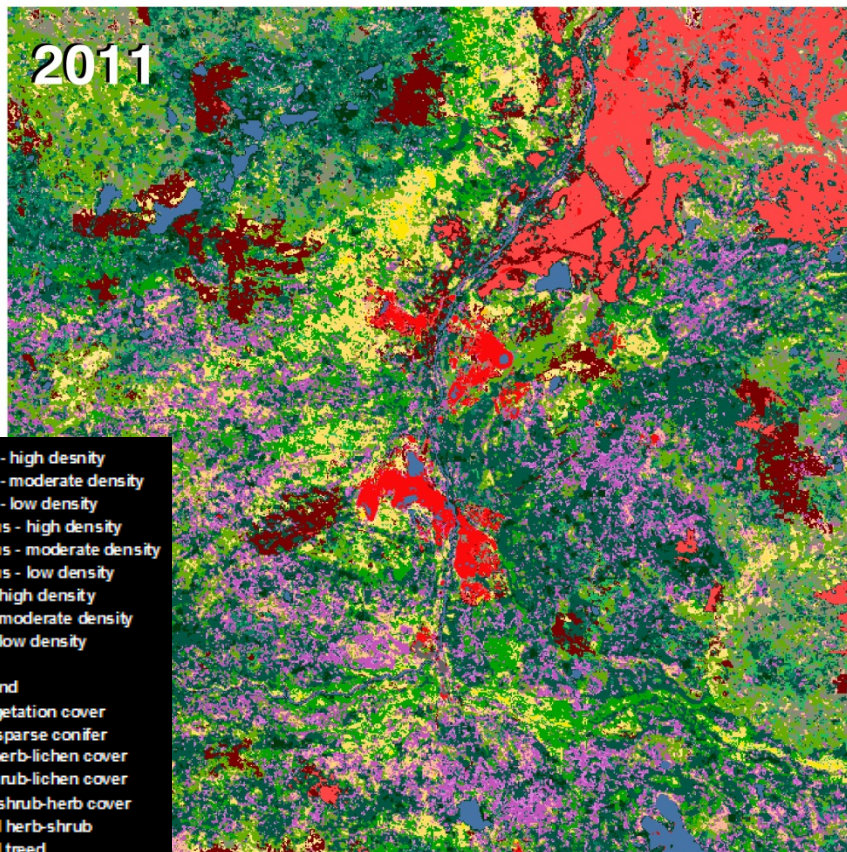
MODIS Land Cover Time Series

- Employ a modified version of the change\vidence based update approach.
- 2005 Land Cover of Canada used as base map ~70-80% accurate depending on assessment.
- Specific legend still to be determined.
- Version 1 will include abrupt changes (e.g. fire, harvesting, sever defoliation, and regeneration of disturbed sites).
- Version 2 will incorporate gradual changes (e.g. long term cumulative defoliation, forest succession).



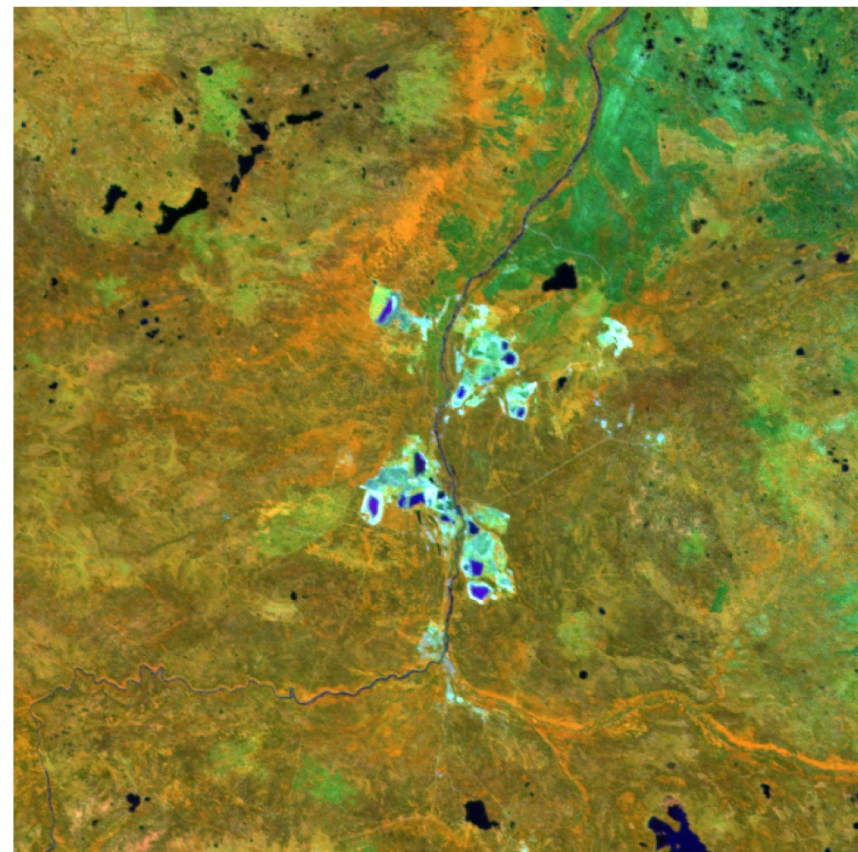
Legend

1. Evergreen needleleaf forest / Close Canopy
2. Deciduous broadleaf forest / Close Canopy
3. Mixed evergreen-deciduous forest / Mature to Old Closed Canopy
4. Mixed evergreen-deciduous forest / Young Closed Canopy
5. Mixed evergreen-deciduous forest / Closed Canopy
6. Evergreen needleleaf forest / Medium crown density / Moss-Shrub Understory
7. Evergreen needleleaf forest / Medium crown density / Lichen-Shrub Understory
8. Evergreen needleleaf forest / Low crown density / Shrub-Moss Understory
9. Evergreen needleleaf forest / Low crown density / Lichen (Rock) Understory
10. Evergreen needleleaf forest / Low crown density / Poorly Drained
11. Deciduous broadleaf forest / Low to Medium Density
12. Deciduous broadleaf forest / Young Regenerating
13. Mixed evergreen-deciduous forest / Mixed coniferous / Low to Medium Density
14. Mixed evergreen-deciduous forest / Mixed deciduous / Low to Medium Density
15. Mixed evergreen-deciduous forest / Mixed deciduous / Low Regenerating Young Mixed Cover
16. Shrubland / High-Low Shrub Dominated
17. Herbaceous vegetation / Temperate or subpolar grassland / Grassland, Prairie Region
18. Herbaceous vegetation / Temperate or subpolar grassland / Herb-Shrub-Bare Cover
19. Herbaceous vegetation / Saturated temperate or subpolar grassland / Wetland
20. Herbaceous vegetation / Temperate or subpolar grassland with a sparse tree layer / Coniferous sparse
21. Herbaceous vegetation / Short sod polar grassland / Herb-Shrub
22. Herbaceous vegetation / Polar grassland with sparse shrub layer / Shrub-Herb-Lichen-Bare
23. Herbaceous vegetation / Polar grassland with sparse shrub layer / Herb-Shrub poorly drained
24. Herbaceous vegetation / Polar grassland with sparse dwarf-shrub layer / Lichen-Shrub-Herb, Bare Soil
25. Herbaceous vegetation / Polar grassland with sparse dwarf-shrub layer / Low vegetation cover
26. Annual graminoid or forb vegetation / Cropland-Woodland
27. Annual graminoid or forb vegetation / Temperate or subpolar annual grassland or forb vegetation / High Biomass Cropland
28. Annual graminoid or forb vegetation / Temperate or subpolar annual grassland or forb vegetation / Medium Biomass Cropland
29. Annual graminoid or forb vegetation / Temperate or subpolar annual grassland or forb vegetation / Low Biomass Cropland
30. Nonvascular Dominated / Temperate or subpolar lichen vegetation / Lichen Barren
31. Nonvascular Dominated / Temperate or subpolar lichen vegetation / Lichen-sedges, moss low shrub wetland
32. Nonvascular Dominated / Temperate or subpolar lichen vegetation / Lichen-spruce bog
33. Vegetation Not Dominated / Consolidated rock sparse vegetation / Rock Outcrops
34. Recent Burns
35. Old Burns
36. Urban and Built-Up
37. Water Bodies
38. Mixes of Water and Land
39. Snow/Ice



- Conifer - high density
- Conifer - moderate density
- Conifer - low density
- Deciduous - high density
- Deciduous - moderate density
- Deciduous - low density
- Mixed - high density
- Mixed - moderate density
- Mixed - low density
- Shrub
- Grassland
- Low vegetation cover
- Tiaga - sparse conifer
- Shrub-herb-lichen cover
- Herb-shrub-lichen cover
- Lichen-shrub-herb cover
- Wetland herb-shrub
- Wetland treed
- Cropland high biomass
- Cropland low biomass
- Mixed cropland and other veg
- Barren
- Urban and built-up
- Water
- Snow and ice

Land Cover



MODIS 250m

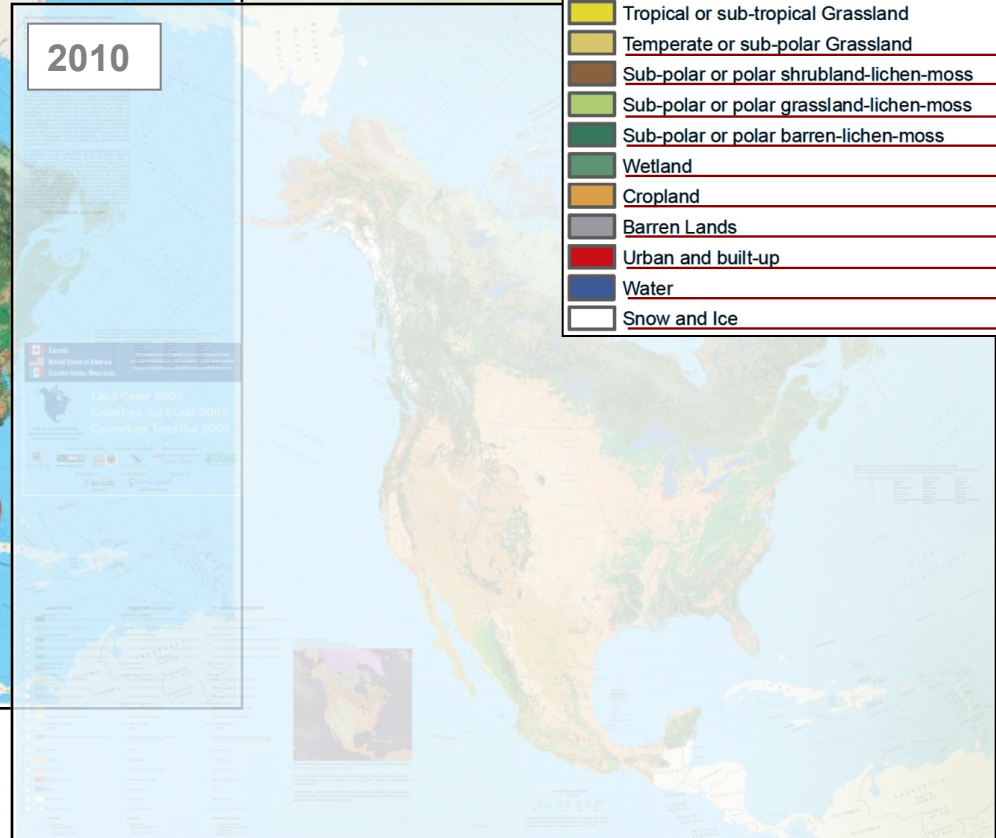


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North America Land Cover Update



North America Legend	
	Temperate or sub-polar needleleaf forest
	Sub-polar taiga needleleaf forest
	Tropical or sub-tropical broadleaf evergreen forest
	Tropical or sub-tropical broadleaf deciduous forest
	Temperate or sub-polar broadleaf deciduous forest
	Mixed Forest
	Tropical or sub-tropical Shrubland
	Temperate or sub-polar Shrubland
	Tropical or sub-tropical Grassland
	Temperate or sub-polar Grassland
	Sub-polar or polar shrubland-lichen-moss
	Sub-polar or polar grassland-lichen-moss
	Sub-polar or polar barren-lichen-moss
	Wetland
	Cropland
	Barren Lands
	Urban and built-up
	Water
	Snow and Ice

2005 land data available from the Commission for Environmental Cooperation (CEC) at:
<http://www.cec.org/Page.asp?PageID=924&SiteNodeID=565>

Latifovic, R., Pouliot, D., Homer, C., Giri, C., Takaki, F., and Ressler, R. (2009). North American Land Change Monitoring System Present and Future. The 30th Canadian Symposium on Remote Sensing – Bridging Excellence. June 22-25, Lethbridge, Alberta, Canada.

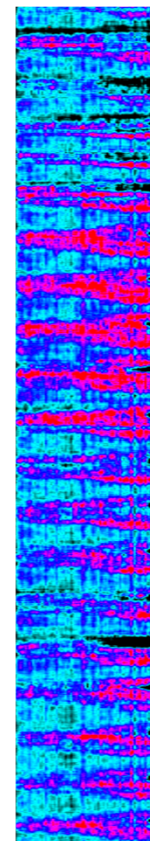
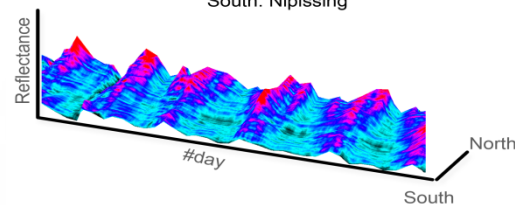
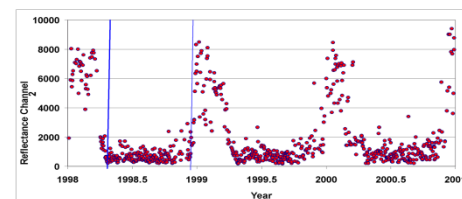
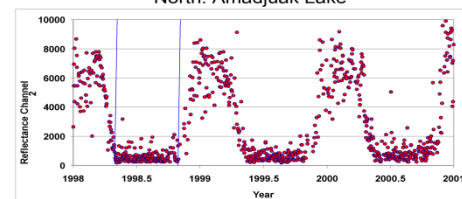
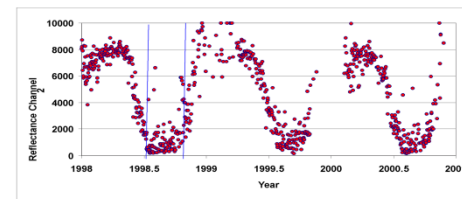
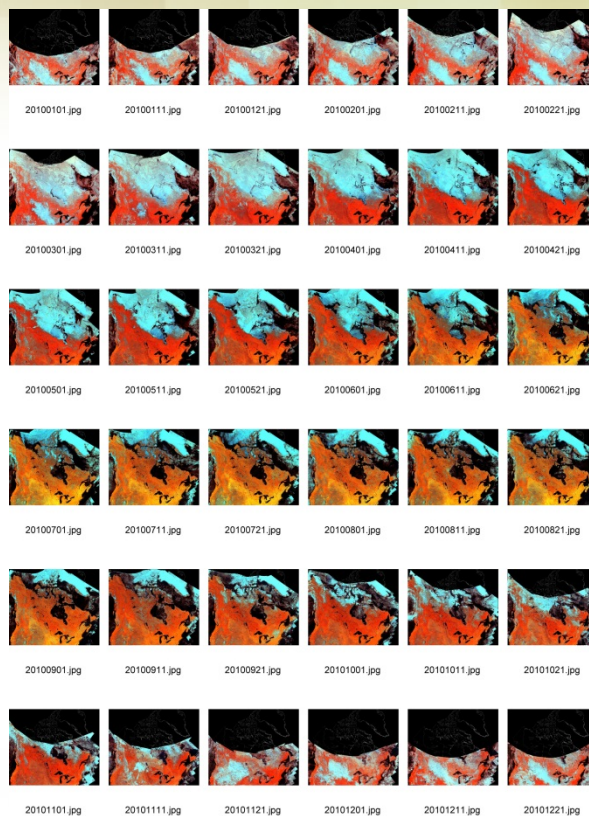
EO monitoring

Temporal scale

- **Daily**
- 10Days
- Monthly
- Annual
- Decade

Spatial scale

- 1000m
- 250m
- 30m



Latifovic, R., Trishchenko, P. A., Chen, J., Park, M. W., Khlopenkov, V. K., Fernandes, A. R., Pouliot, D., Ungureanu, C., Luo, Y., Wang, S., Davidson, A., and Cihlar, J. 2005 Generating historical AVHRR 1-km baseline satellite data records over Canada suitable for climate change studies. *Canadian Journal of Remote Sensing* vol. 31, N5, pp 324-346.



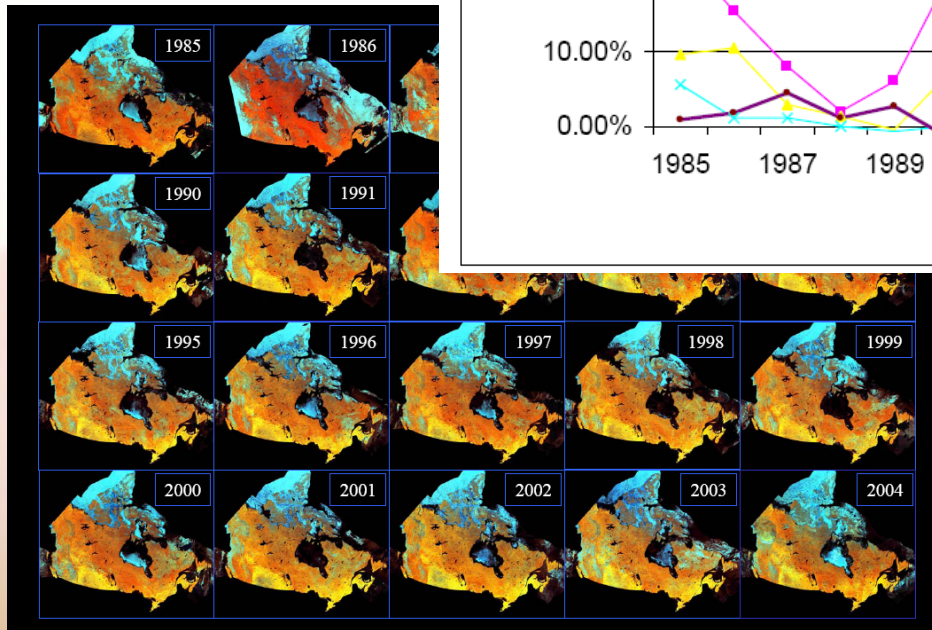
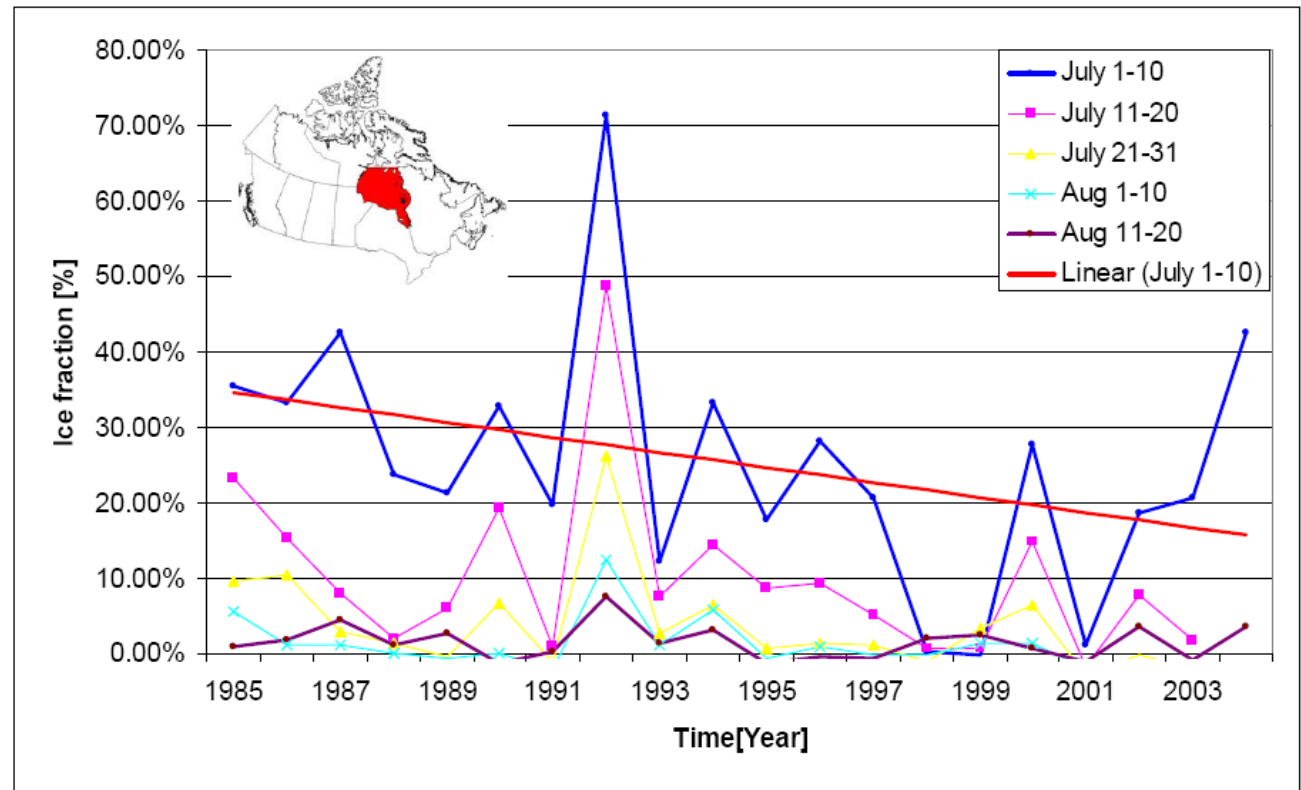
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Gradual change: sea ice

Trend sea ice extent in Hudson and James Bay



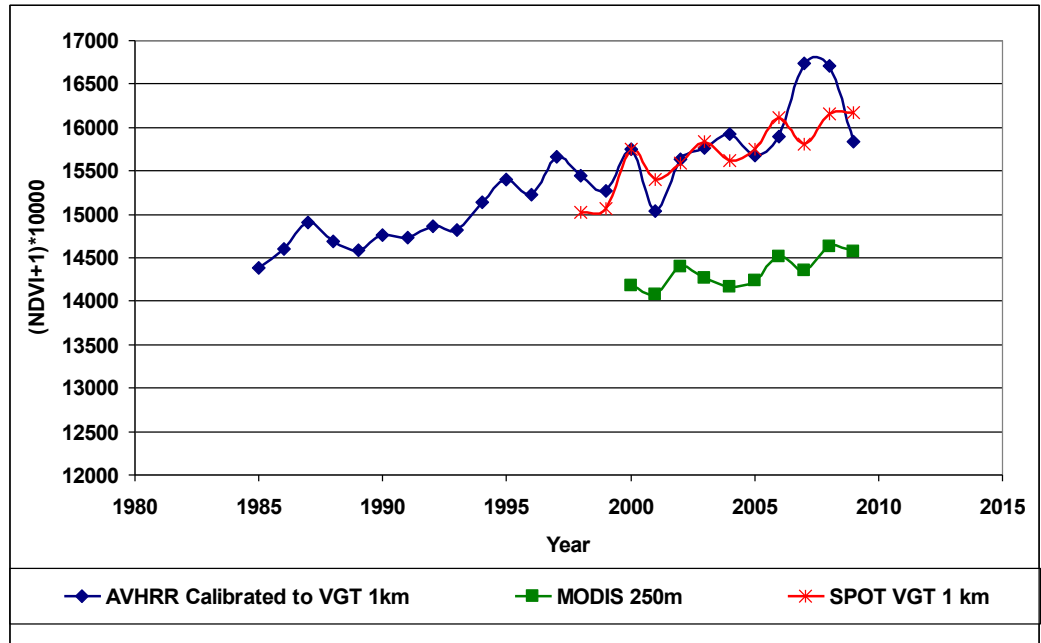
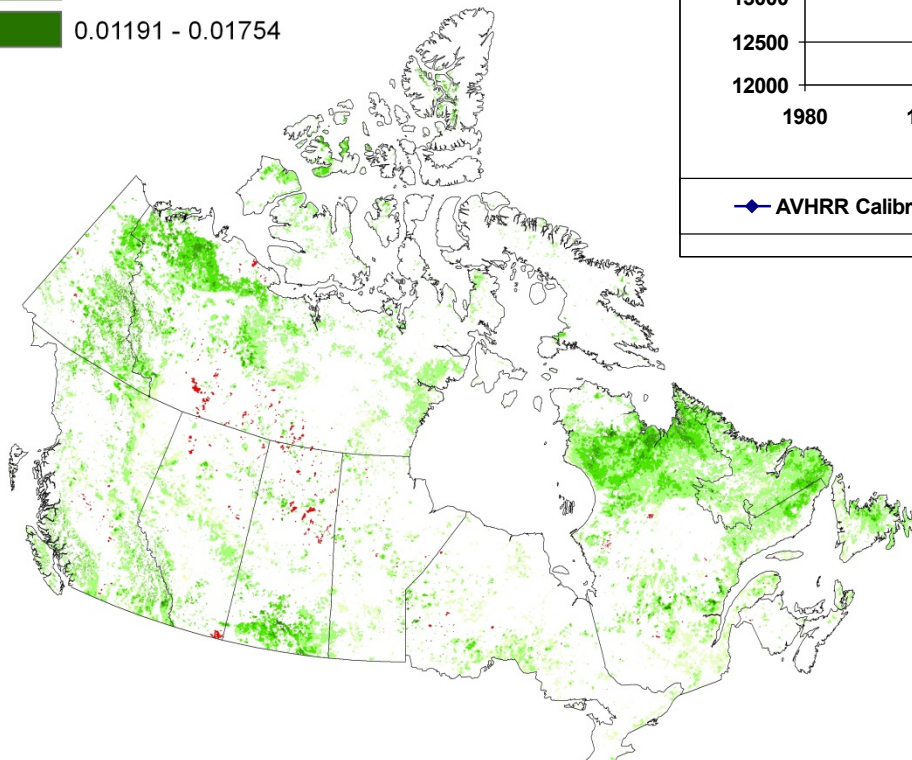
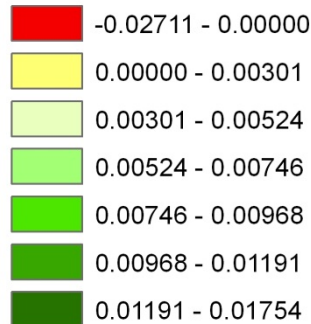
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Latifovic, R., et al., (2005). Generating historical AVHRR 1-km baseline satellite data records over Canada suitable for climate change studies. Canadian Journal of Remote Sensing vol. 31, N5, pp 324-346

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Gradual land cover change (multi year change)

$\Delta\text{NDVI}/\text{Year}$



Pouliot, D., R. Latifovic, and I. Olthof. (2008). Trends in vegetation NDVI from 1 km AVHRR data over Canada for the period 1985-2006. *International Journal of Remote Sensing*, in press.

Sturm, M., C. Racine, and K. Tape (2001). *Increasing shrub abundance in the Arctic*. *Nature*, 411, 546-547.6

Future Development



- **Maintain and improve Long Term Satellite Data Record**
- **Completion of the medium resolution (20m) coverage of Canada**
- **Reference database generation for training and validation**
- **Further development and improvements on land cover change detection and updating methodologies**
- **Testing methods for land cover change monitoring (various options of combining coarse and fine resolution data)**
- **Development or related Canada-scale products at 0.25 km**
- **Enhance collaborative efforts within ABCC involving exchange of data and methods between partners.**

