Land Surface Characterization

Monitoring land cover and land cover change

Canadian Centre for Remote Sensing

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Workshop of ABCC Program
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ABCC Project Title

Regional scale land cover characterization

Expected Results and Objectives

EO based methodology for producing highly consistent annually updated land cover time series at regional scale to support environmental status and trends assessments and ecosystem process modeling.

Outcome(s) and Potential Impact

Improved EO techniques for monitoring land cover change provide consistent and accurate multi year land cover information.
Better understanding of cause – effect relation /land cover change – global change

Timeframe for Activities & Stage(s) Completion Date(s)

- data collection and processing;
- methodology development;
- land cover change mapping;
- analysis and synthesis.

Study area

Canada coverage

Data Collection Plan & Timetable

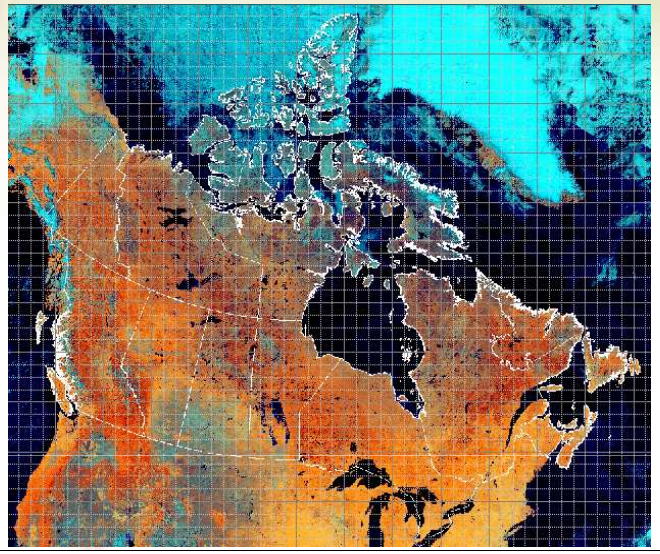
1999-2010 data record from MODIS, Landsat-TM, and other higher resolution images.

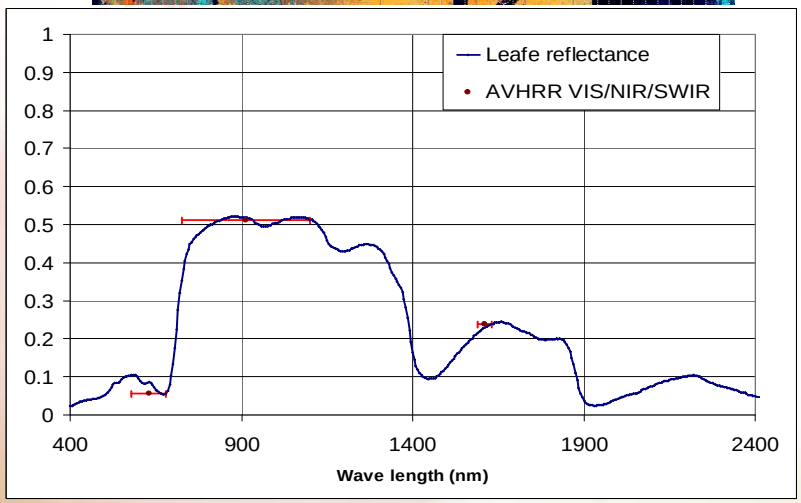
Data collection and processing

- Long Term Satellite Data Record
- Medium resolution coverage
- Cal\Val ground truth data

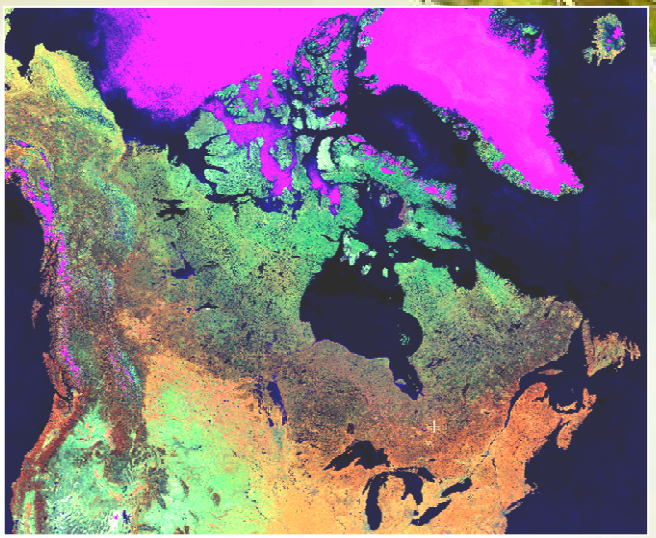
Long Term Satellite Data Record

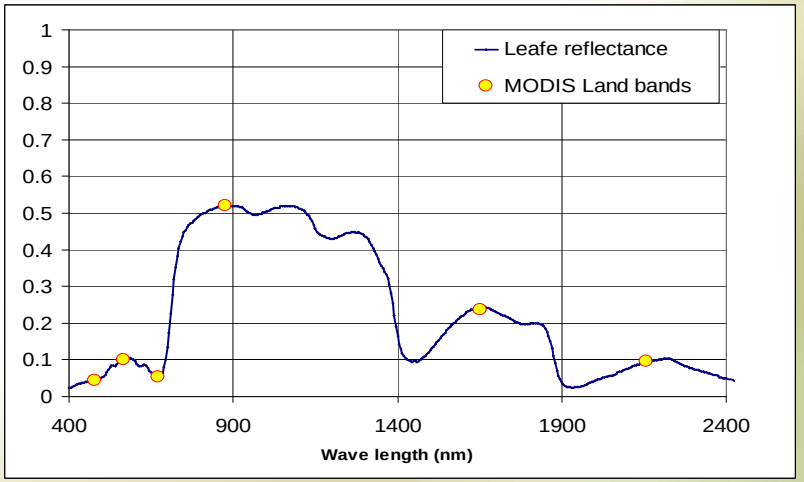
AVHRR NOAA 1km
Record: **1982-2009**
Transition: **MetOp 2006-2020**





MODIS NASA 0.25 km
Period: **2000-2009**
Transition: **NPOESS,VIIRS**

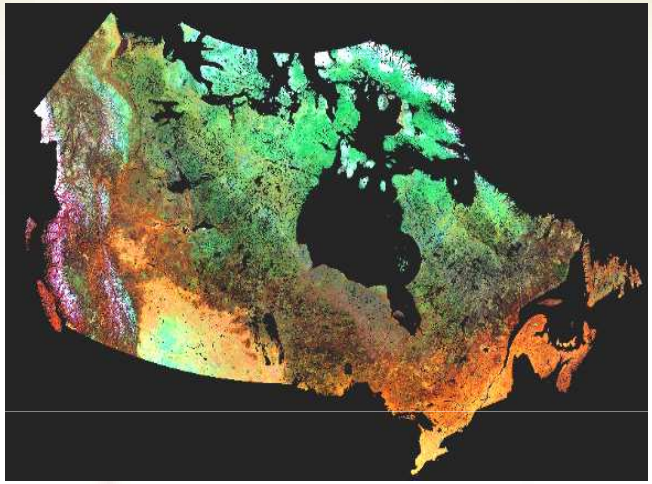


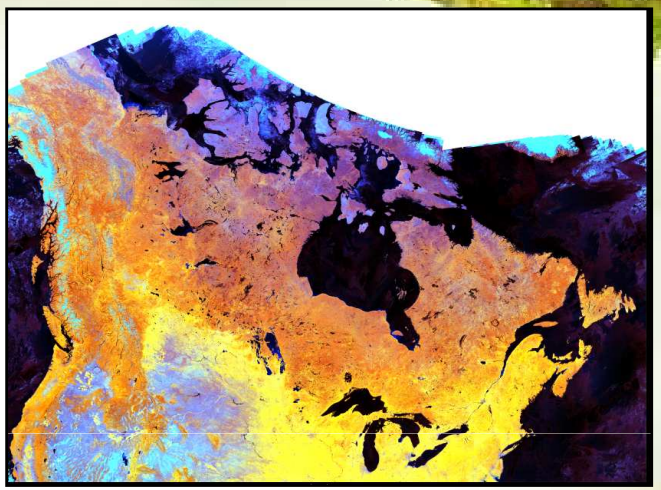


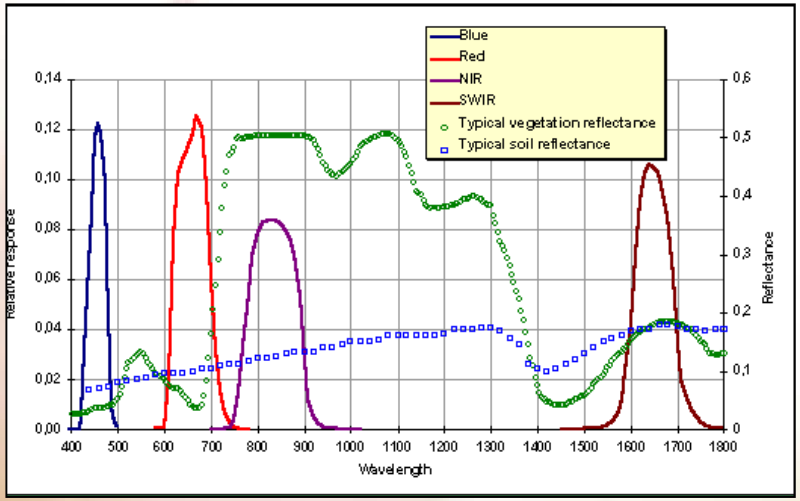
Long Term Satellite Data Record

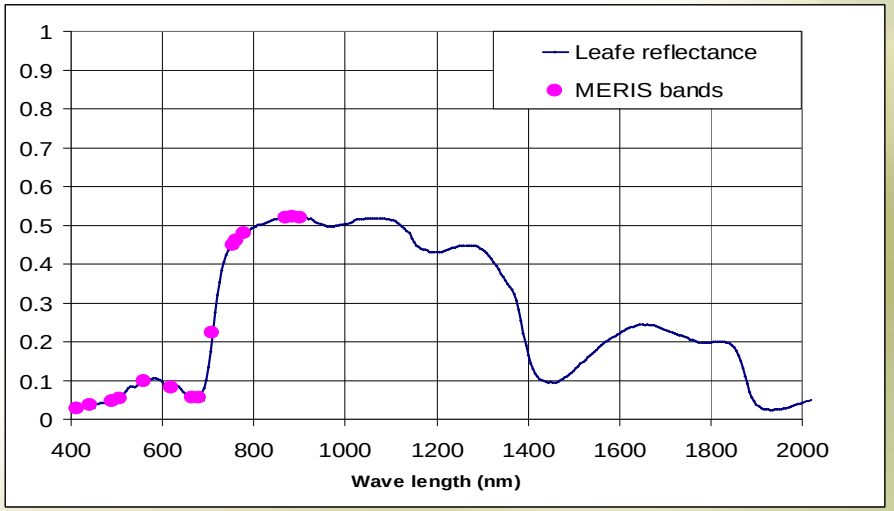
SPOT/VGT 1 km
Period: **1998-2009**
Transition**: PROBA, SENTINEL 3 2012**

MERIS ESA 1,0.3km
Period: **2008-2009**
Transition: **SENTINEL 3 2012**









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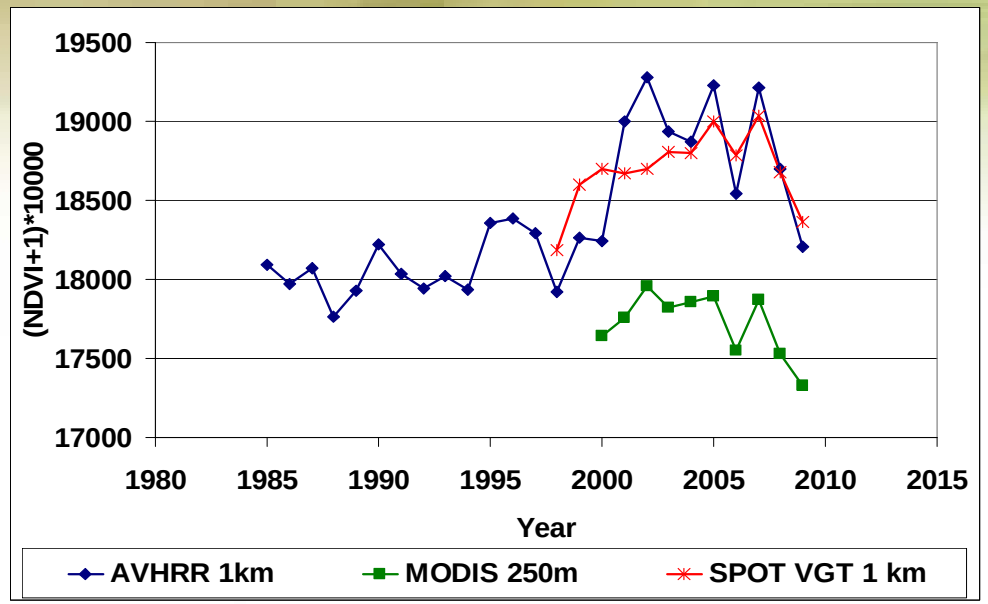
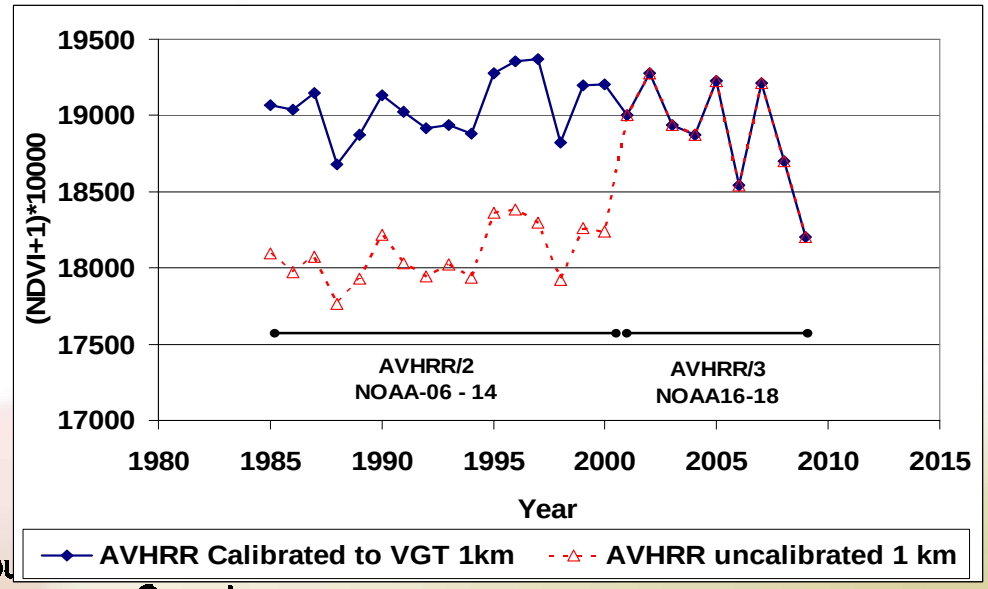
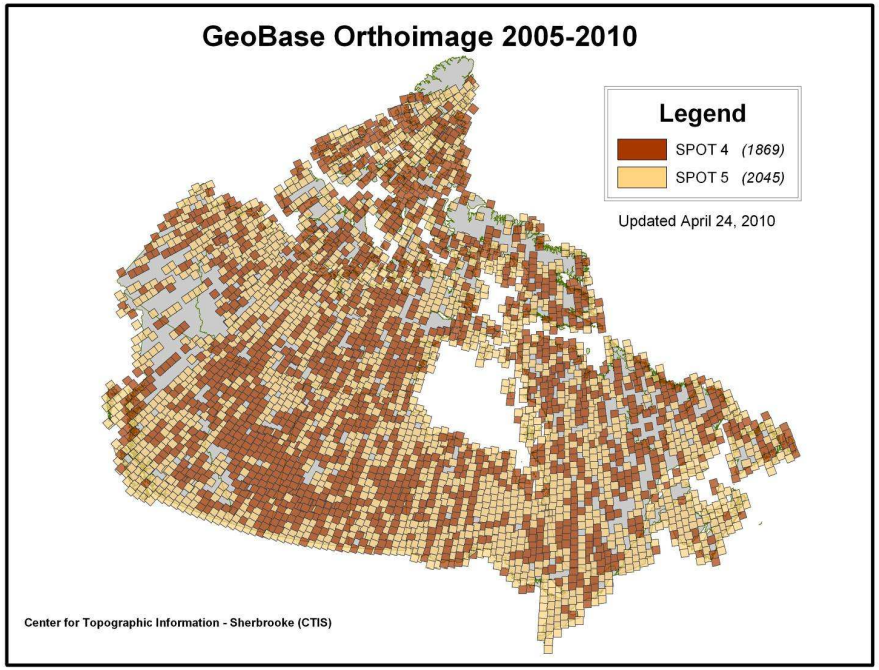
Cross calibration for multi sensors applications

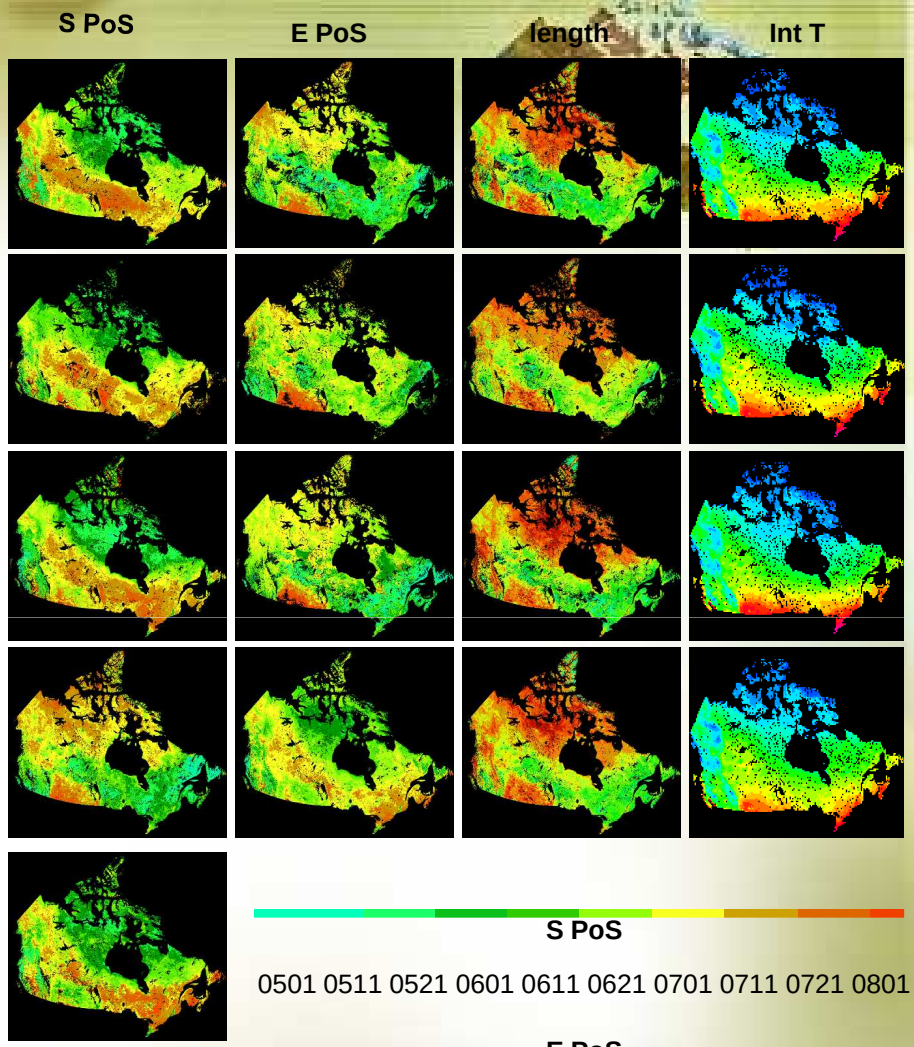




Medium resolution coverage



- 2005-2010 SPOT 4-5 ortho data from CTI GeoBase
- Determine annual length of Peak of Season (PoS) from AVHRR for 2005-2009
  - Lowess smoothed 10-day NDVI
  - 95% threshold of max NDVI
- Filter SPOT scenes to include only PoS
- Normalize to long-term median composite from 1 km VGT



S PoS

0501 0511 0521 0601 0611 0621 0701 0711 0721 0801

E PoS

0721 0801 0811 0821 0901 0911 0921 1001 1011 1021

length

30 40 50 60 70 80 90 100 110 120 130 140 150 160 170

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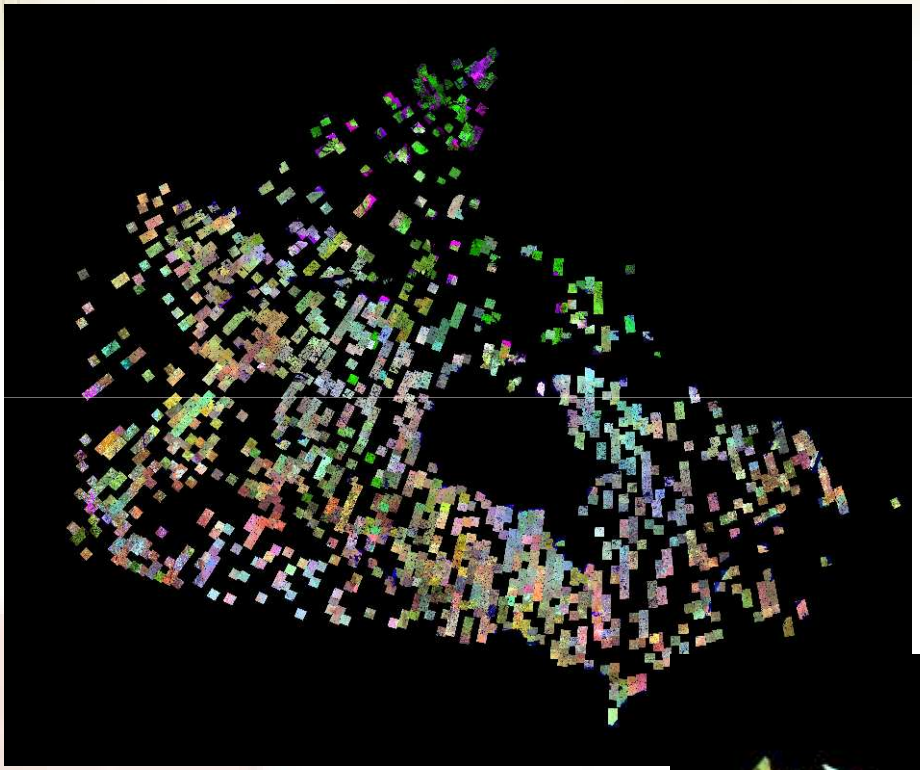
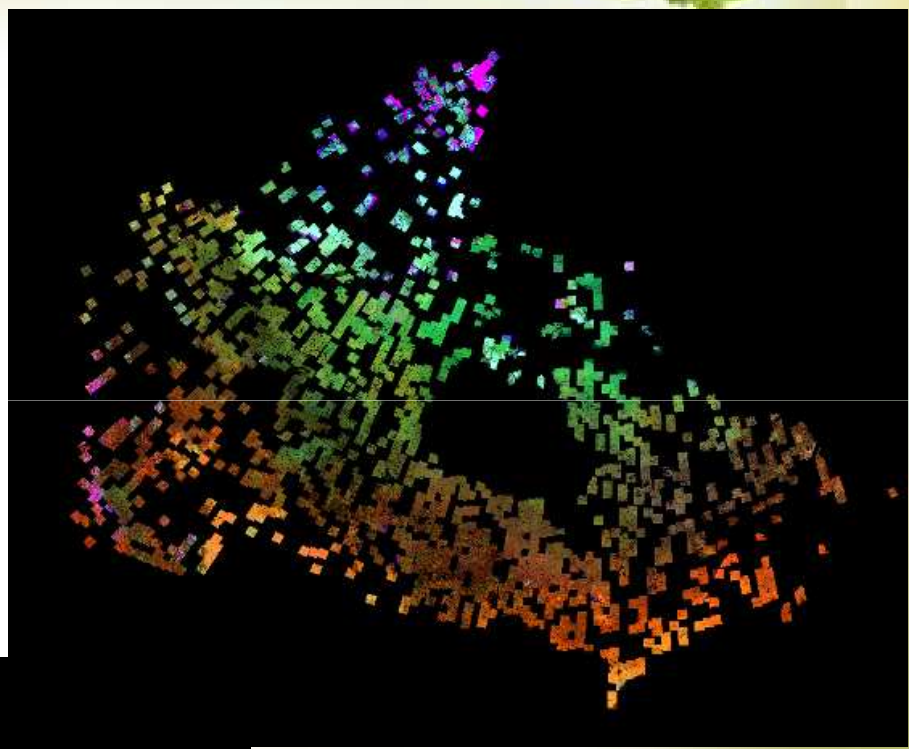
Medium resolution coverage

1383 normalized SPOT 4-5 scenes, each acquired within peak-of-season window for its corresponding location in Canada, are included in the current database.
This sample represents approximately 42% of Canada's landmass (excluding water).



Selected SPOT 20m scene



Normalized SPOT 20m scene

1km SPOT VGT 9-year median
R, NIR, SWIR

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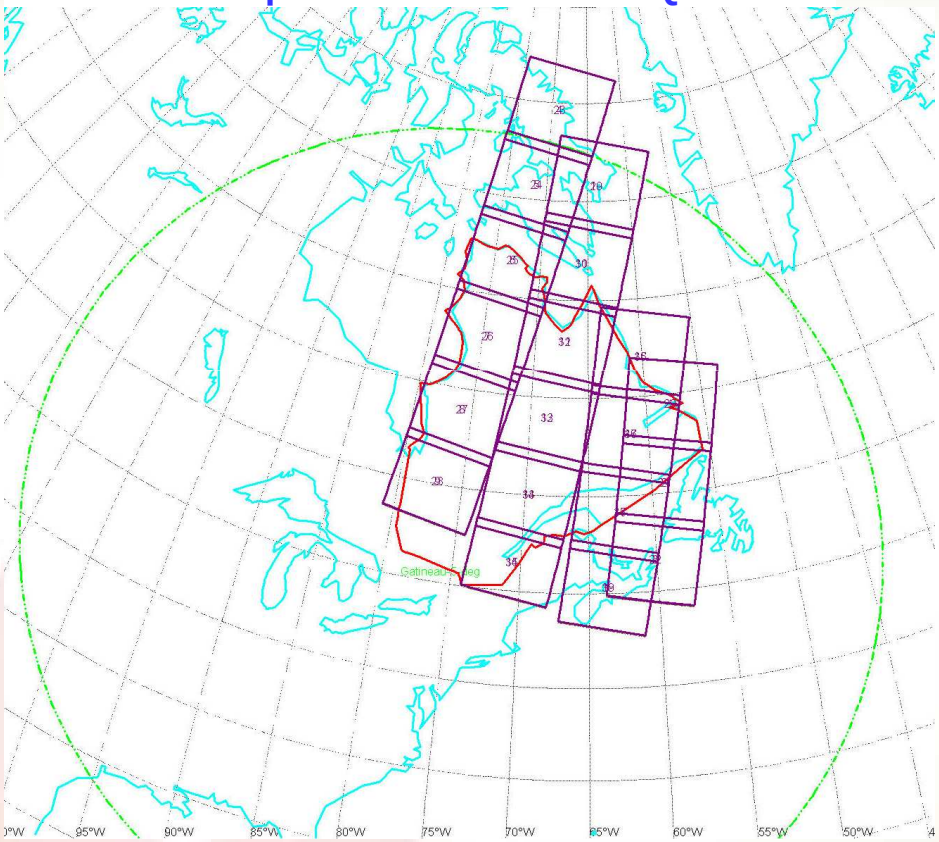
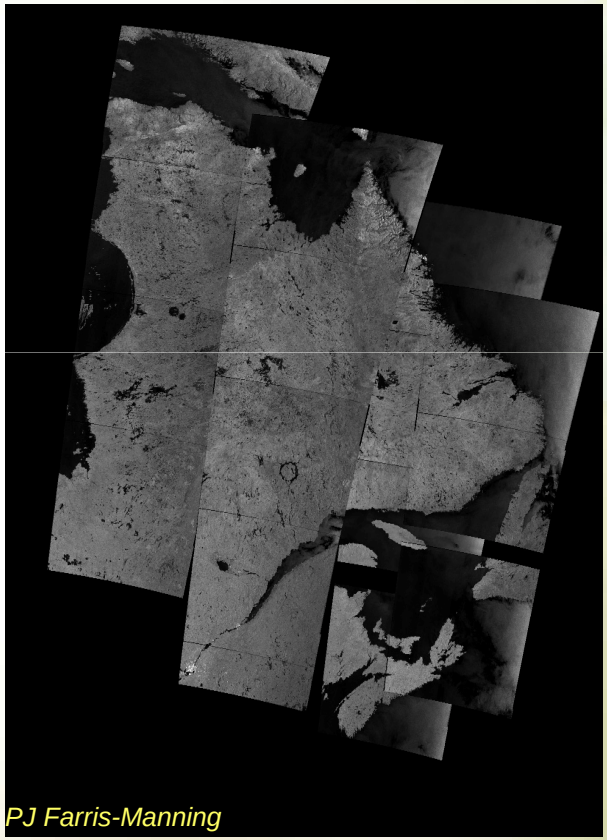
ScanSAR Wide A Coverage in Dual Polarization

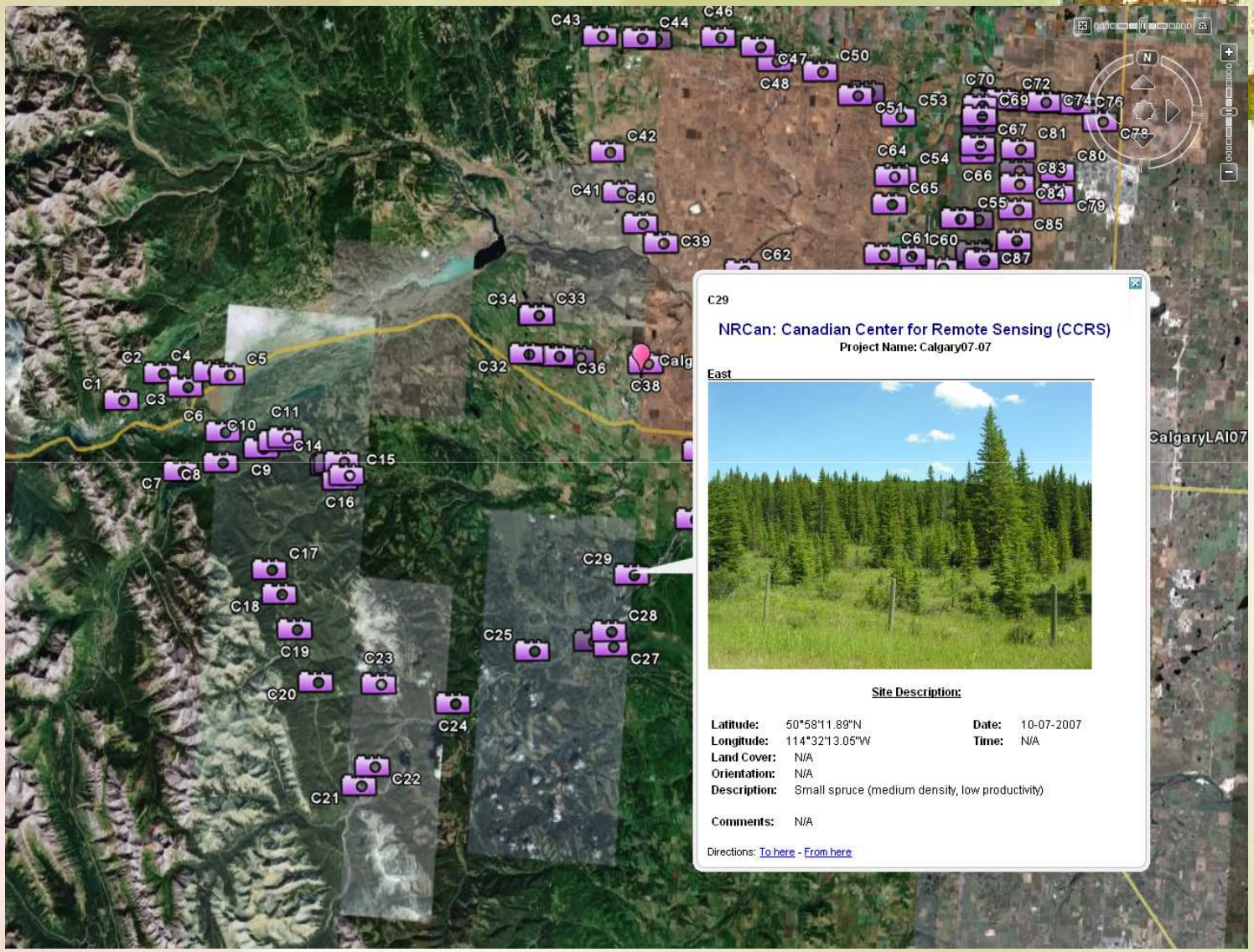
Planned Acquisition –Province of Quebec



First Acquisition – Aug 19-22, 2010



Ground truth data



Land cover characterization: methodology development

- Land cover time series
- Abrupt land cover change (annual change)
- Gradual land cover change (multi year change)

Land Cover Monitoring System

Integrated earth observation data sources

Land cover time1 → *Change detection abrupt and long term* → *Map update* → Land cover time 2

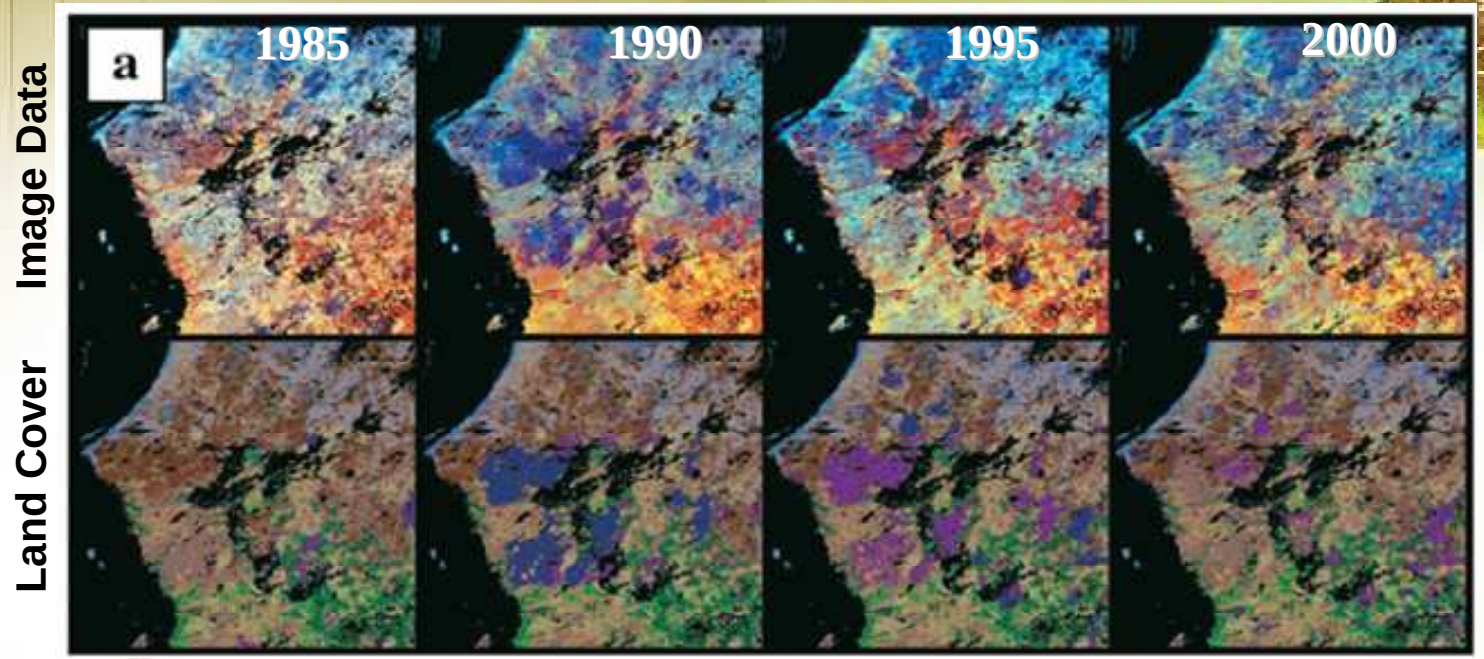
Low spatial and high temporal resolution (yearly update)

Calibration\Validation\Sampling

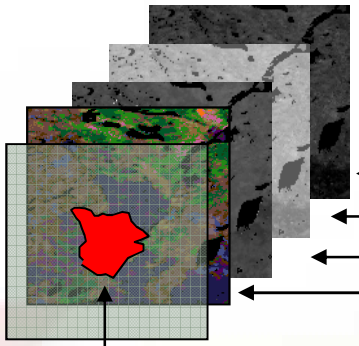
Land cover time1 → *Change detection abrupt and long term* → *Map update* → Land cover time 2

High spatial and low temporal resolution (5 to 10 year update)

Land cover time series trough land cover update



Inter-map consistency = 93 %



AVHRR Composite data (Red, NIR, NDVI) for year to be updated

Land cover map to be updated

Change Area

1	High Density Needleleaf Forest
2	Med Density Needleleaf Forest
3	Med Density Northern Forest
4	Low Density Southern Forest
5	Low Density Northern Forest
6	Decidous Forest
7	Mixed Needleleaf Forest
8	Mixed Uniform Forest
9	Mixed Hetergenous Forest
10	Mixed Broadleaf Forest
11	New Disturbance
12	Old Disturbance
13	Transition Tree Shrubland
14	Wetland Tree Shrubland
15	Wetland Medium Density Shrubs
16	Grassland

Land Cover Change

Abrupt (1-5 years)	Progressive\Gradual (> 5 years)
• Fire • Biomass harvesting (agriculture, forest, other) • Storm damage (e.g. severe winds\ice) • Permanent flooding • Land slides • Drought • Urban development	• 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

Change Detection Methodology

1) Radiometric normalization

↓

2) Change features:

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

↓

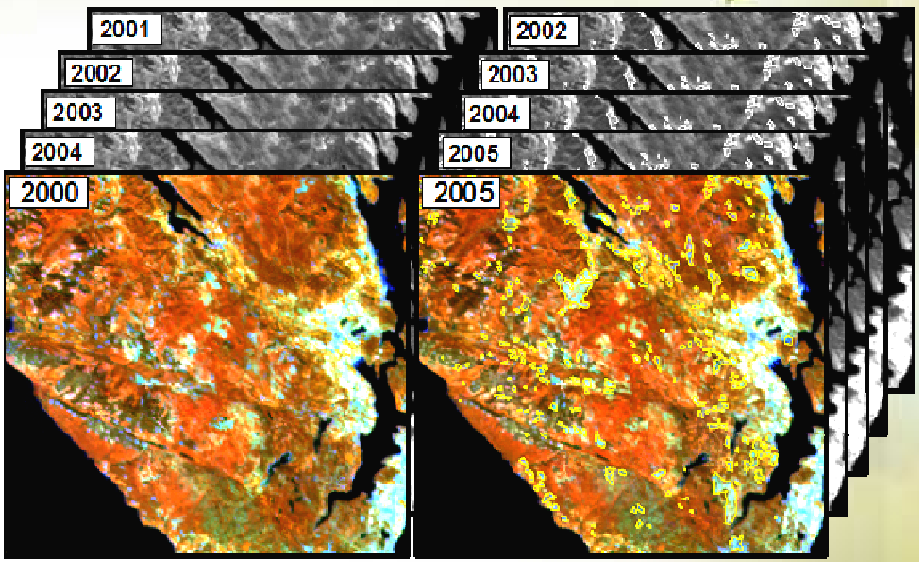
3) Bootstrap feature selection

↓

4) Decision tree change classification – annual change results

↓

5) Change persistence evaluation

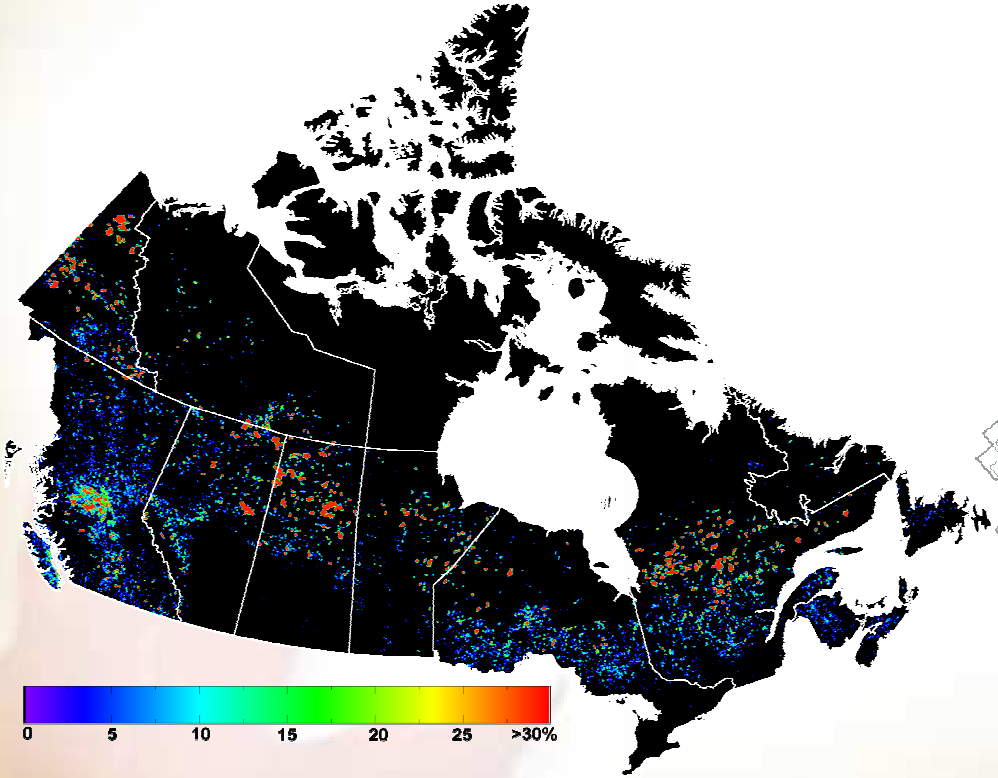


Disturbances

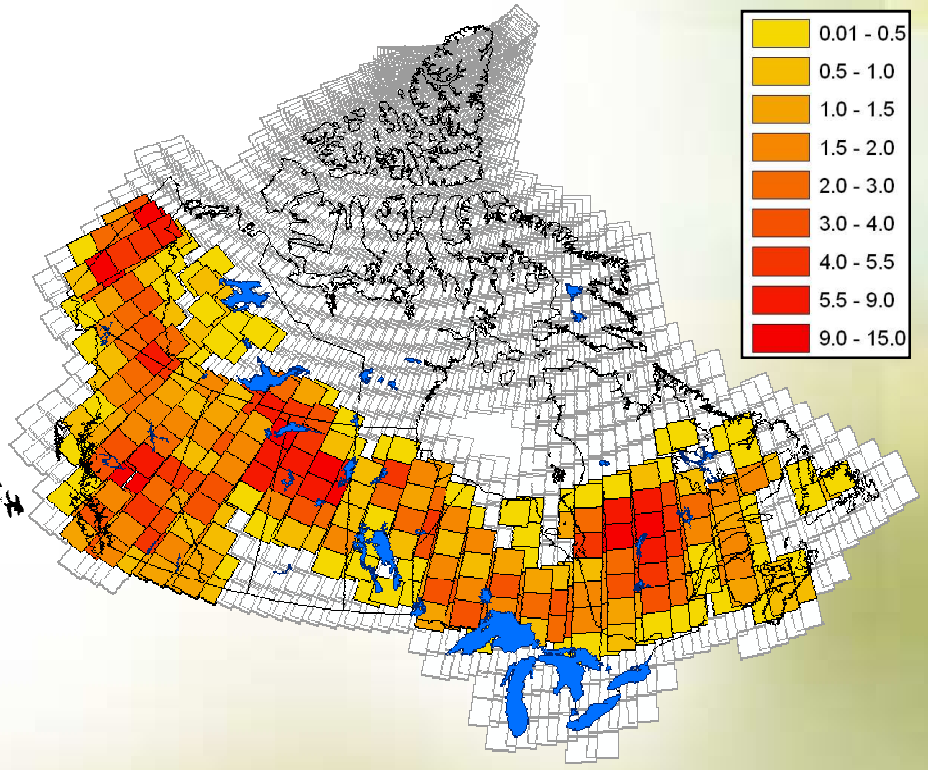
Pouliot, D., R. Latifovic, R. Fernandes, and I. Olthof. (2009). Evaluation of annual forest disturbance monitoring using a static decision tree approach and 250 m MODIS data. RSE, 113:1749-1759.

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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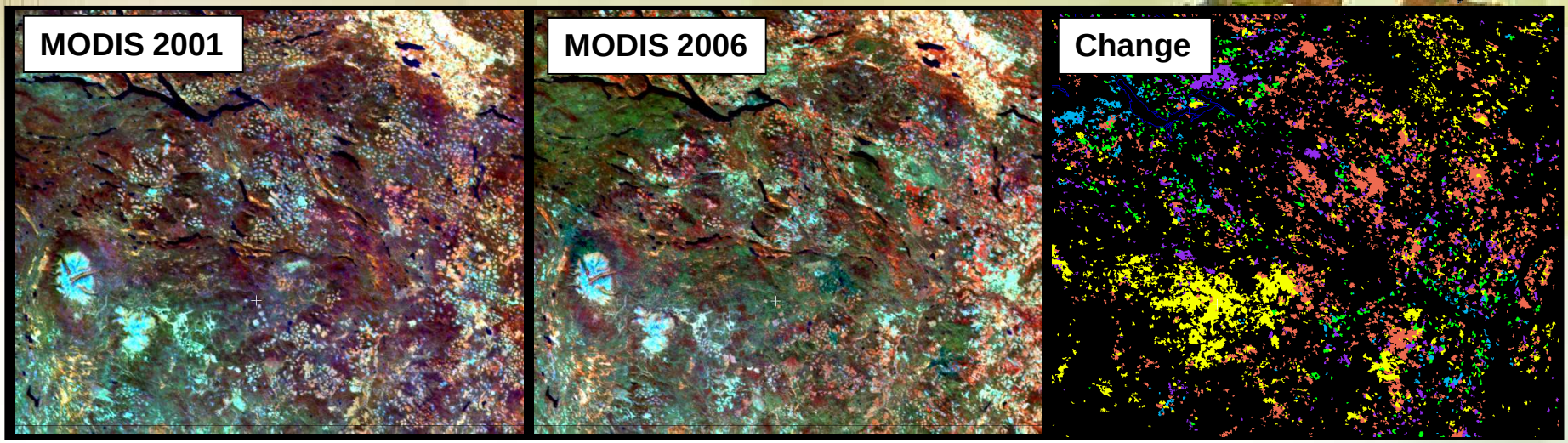
Decision Tree Change Detection: *Mountain pine beetle damage*



Disturbance year

- 2006
- 2005
- 2004
- 2003
- 2002

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

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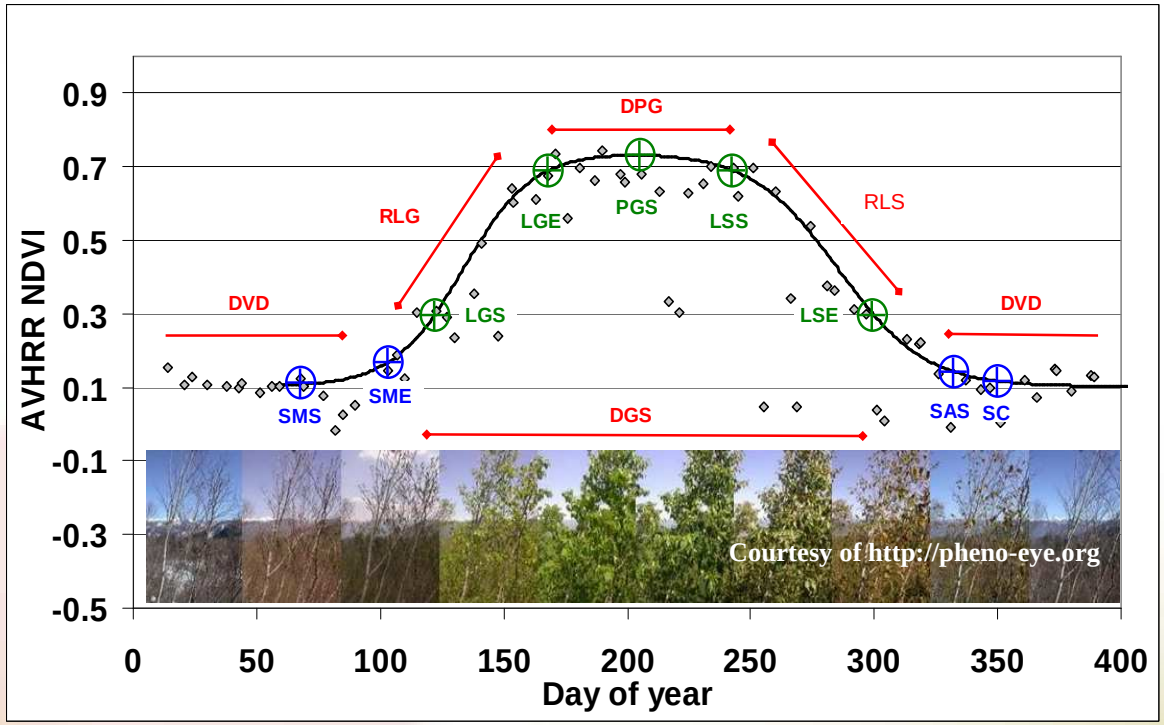
Seasonal change

- A system based on moderate to coarse resolution high temporal frequency EO data for monitoring seasonality events and features of snow, ice, and vegetation completing existing in situ networks.



DVD – Duration of vegetation dormancy

RLG – Rate of leaf growth

DPG – Duration of peak growing season

DGS – Duration of the growing season

RLS – Rate of leaf senescence

LGS – Leaf growth start

LGE – Leaf growth end

PGS – Peak of growing season

LSS - Leaf senescence start

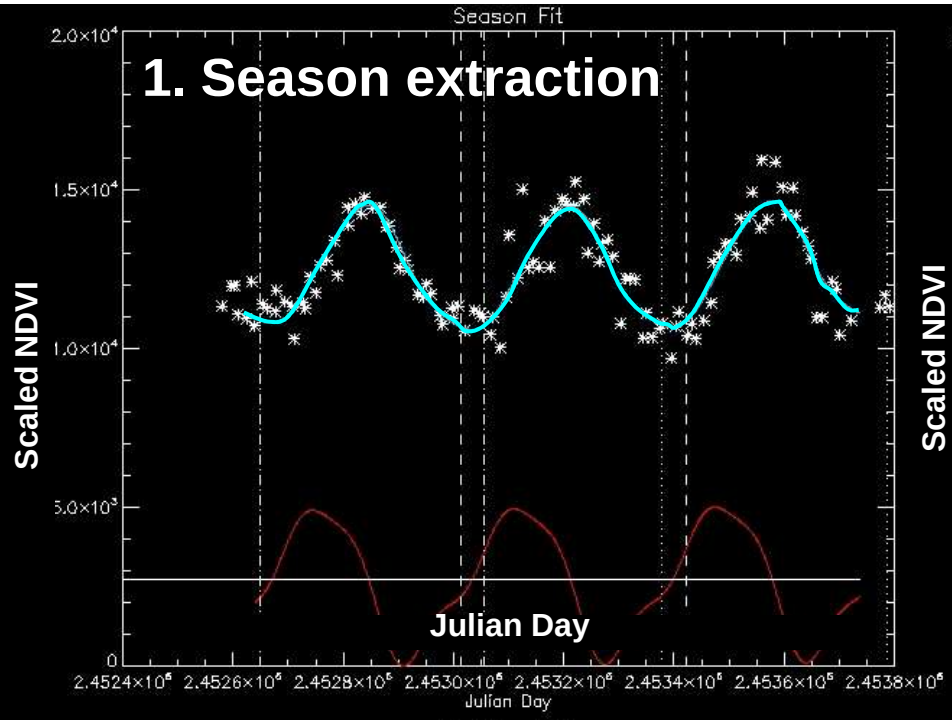
LSE - Leaf senescence end

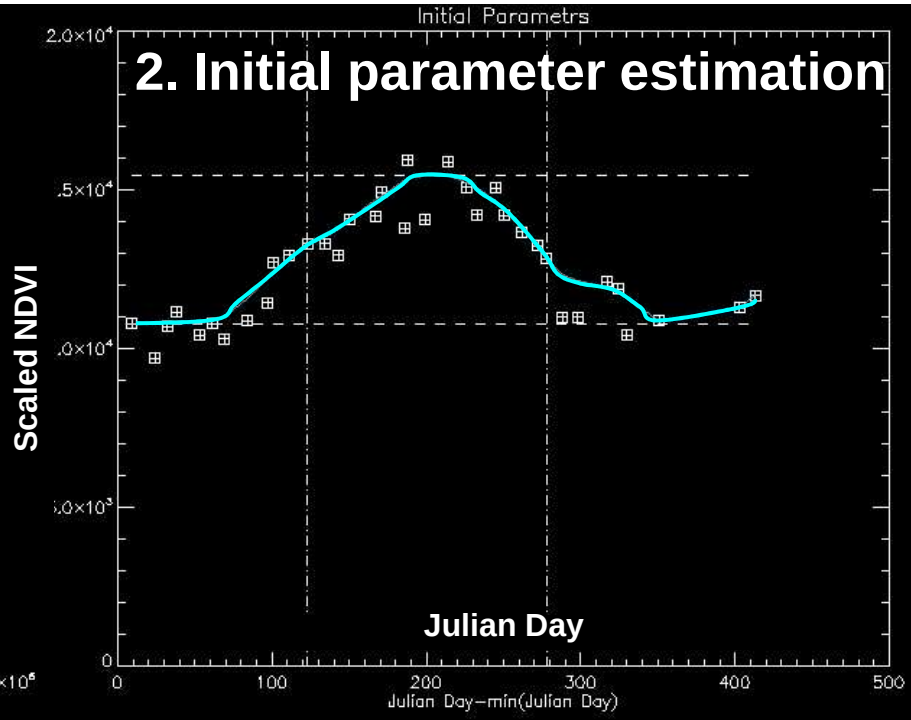
SMS – Snow\ice melt start

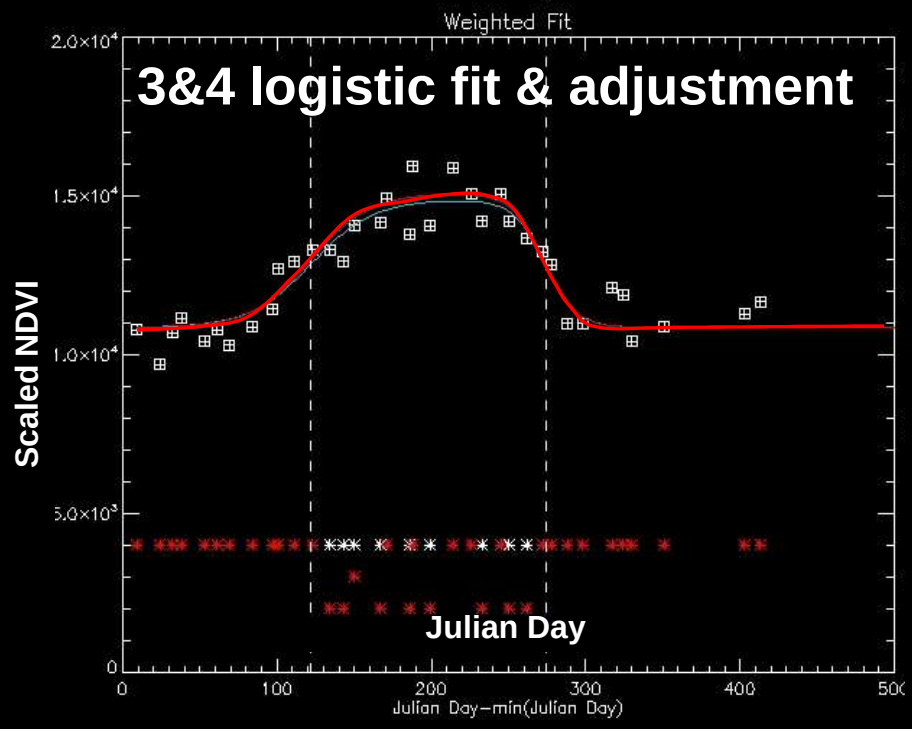
SME – Snow\ice melt end

SAS – Snow\ice accumulation start

SC – Snow covered







1. Time series is divided into seasons based on the least squares polynomial and harmonic basis fit of Jönsson and Eklundh (2004) Computers and Geosciences, 30:833-845.
2. Initial Lowess filter is applied to estimate logistic function parameters.
3. Double logistic function is fit:

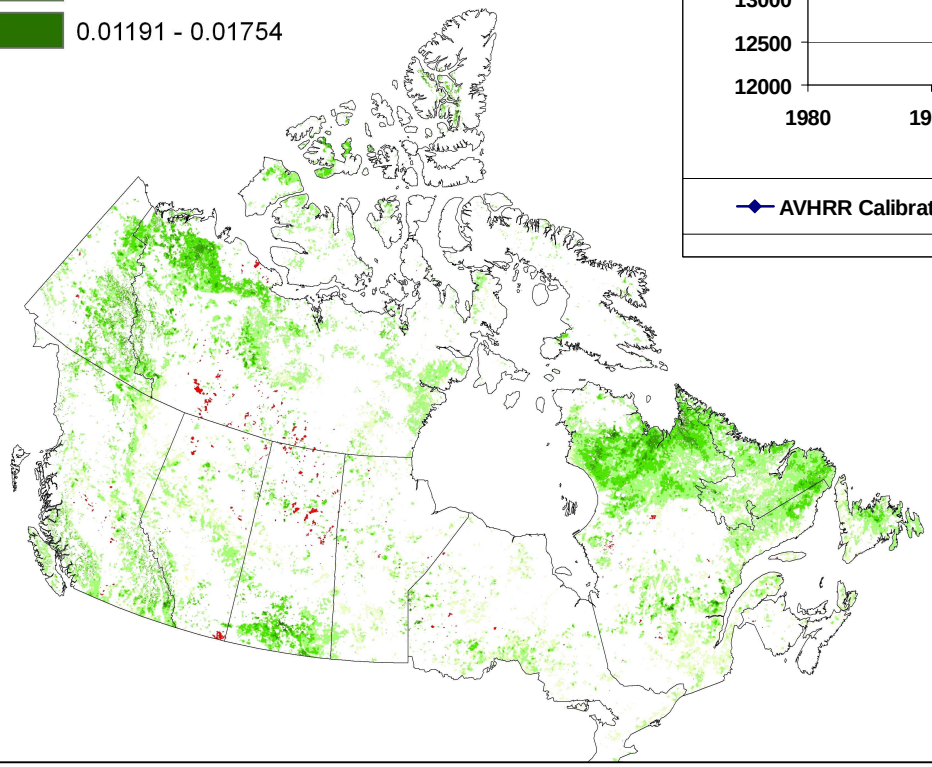
$$NDVI(t) = NDVI_{mn} + \frac{(NDVI_{mx} - NDVI_{mn})}{\left(1+e^{-s_1\times(t-i_1)}\right)+\left(1+e^{s_2\times(t-i_2)}\right)}$$

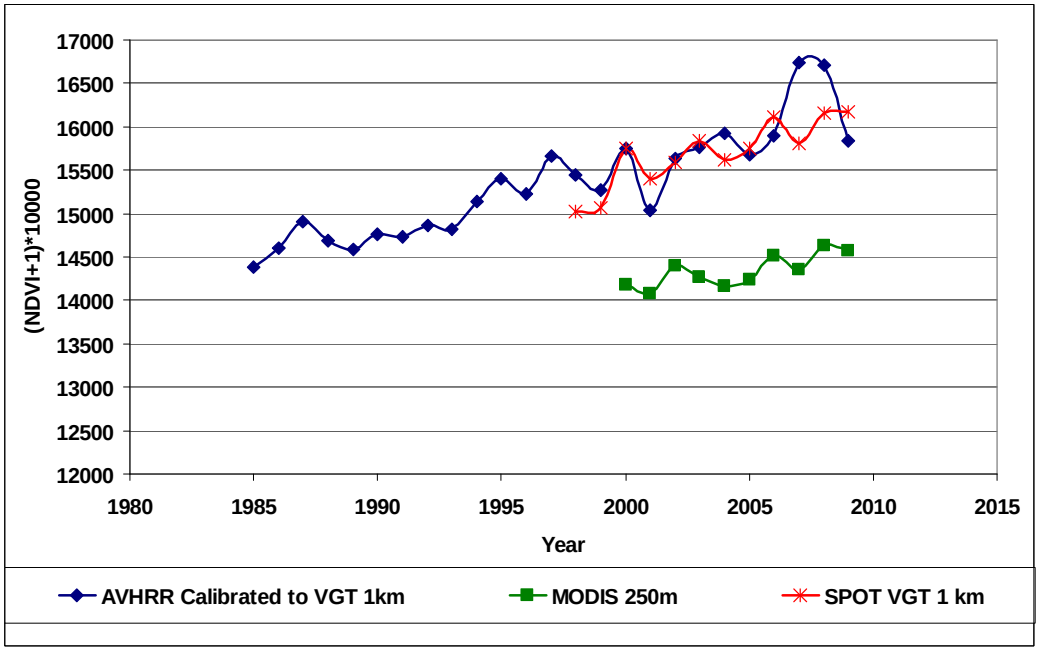
4. Weights are adjusted through an iterative process to adjust fit to upper envelope.

Gradual land cover change (multi year change)

ΔNDVI/Year

- -0.02711 - 0.00000
- 0.00000 - 0.00301
- 0.00301 - 0.00524
- 0.00524 - 0.00746
- 0.00746 - 0.00968
- 0.00968 - 0.01191
- 0.01191 - 0.01754

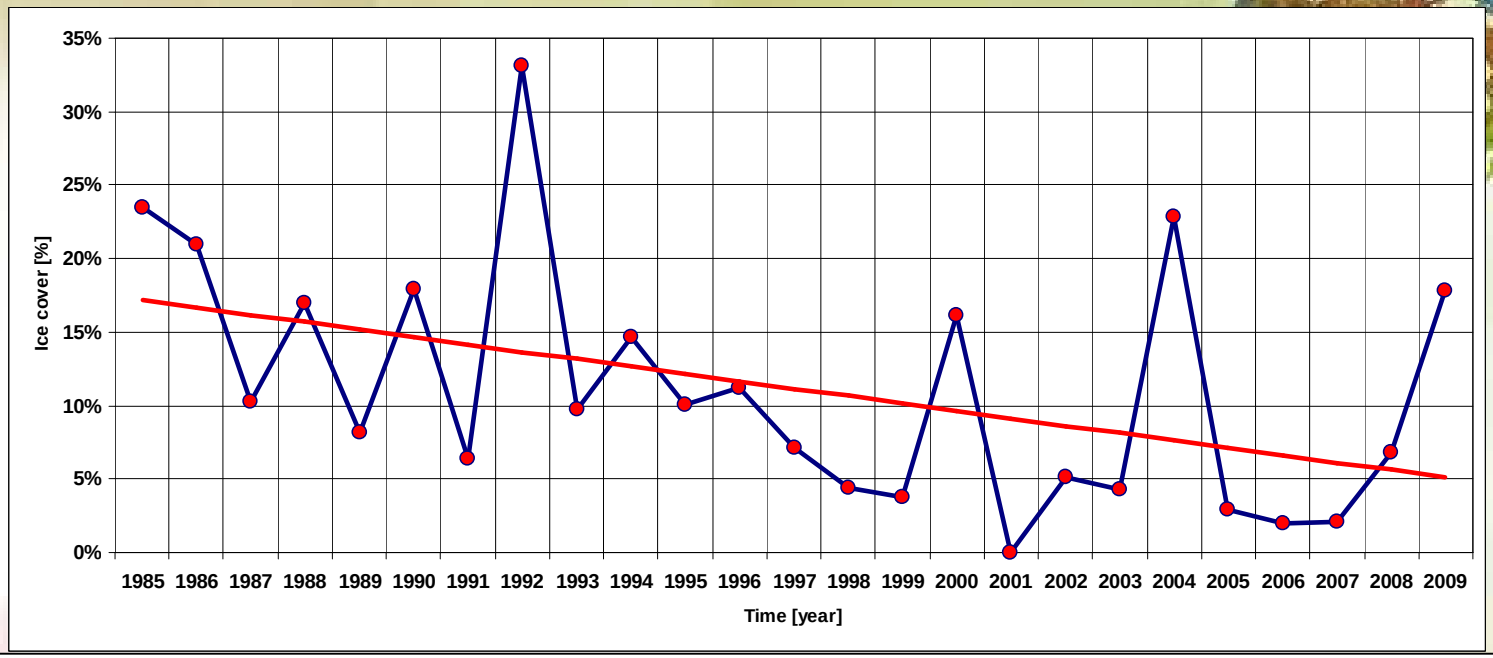


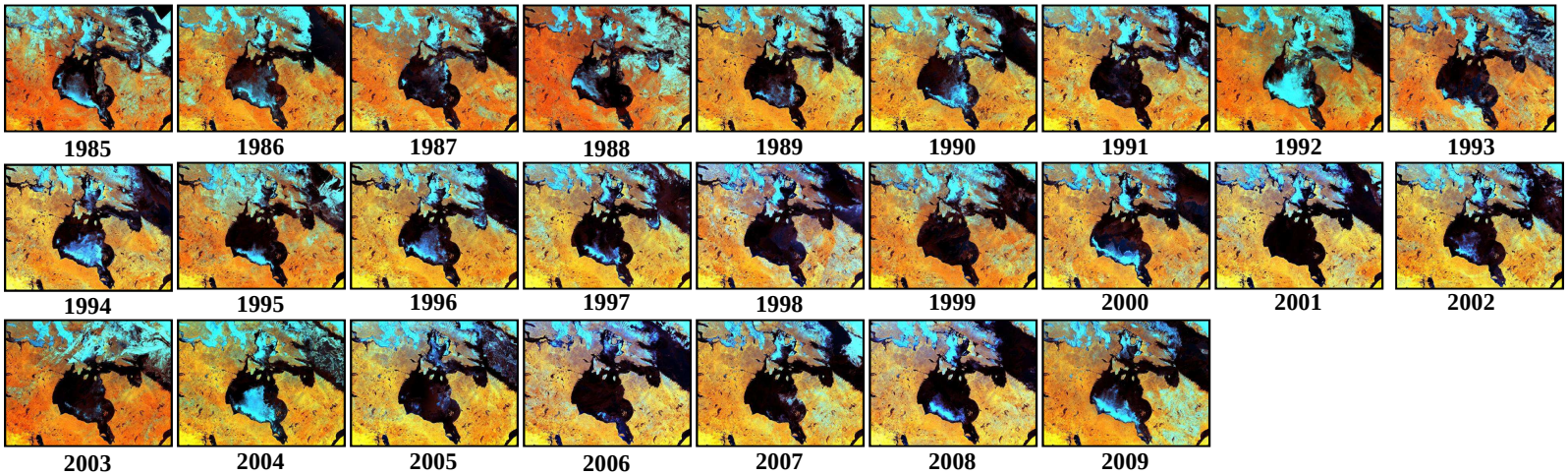


Pouliot, D., R. Latifovic, and I. Olthof. (2008).Trends in vegetation NDVI from 1 km AVHRR data over Canada for the period 1985-2006. International Journal of Remote Sensing, in press.

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

Trend analysis sea ice extent in Hudson and James Bay





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, 31:324- 621 348.

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.