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science for a changing world

The Proposed North American Land Change Monitoring System

United States, Canada, and Mexico

U.S. Department of the Interior
U.S. Geological Survey

Background

- Developed from initial meetings between USGS and Canadian Center of Remote Sensing to develop new Annex agreement (Project Annex #17)
- Calls for collaboration on Remote Sensing and Land Cover to provide continental compatibility of land cover and land cover change information at different spatial and temporal scales
- Initial discussions were held with all 3 nations during the North American Land Cover Summit meeting held in Washington DC in September, 2006 to form an agreement on future collaboration
- A follow-up meeting to produce the vision and framework of a North America Land Change Monitoring system was held in Ottawa, Canada November 29-30, 2006 with representatives from all 3 nations.

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North American Land Change Monitoring System,

Guiding Principals

- Land cover products will require multi-agency and multi-national efforts to meet spatial and temporal demands (potential examples include Multi-Resolution Land Characteristics Consortium in the United States and the Land Cover Community of Practice in Canada)
- Proposed products are flexible enough to be useful to a large majority of clients, simple and understandable, and able to meet multiple needs at multiple resolutions.
- Products will require agreement on protocols spanning spectral information, accuracy, models, algorithms, terrain corrected standardization, accuracy protocols, etc..
- New products must be relevant and not being produced by other entities.
- Initial products will be developed in 2007, leveraging as many existing resources as possible;
- The ultimate goal is a dynamic land cover change monitoring system, updated on an annual basis and be a critical sustainable information source for users of land cover change products across the continent.

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So Far Agreed to in Principle…..

- Develop annual 250m products and 5-year 30m products
- Build on rigorous image normalization
- Two scales of imagery (~250 m and ~30m) need to be sensor independent
- Standardized projection (Lambert Azimuthal Equal Area)
- Standard Classification System modeled after U.S. Anderson system
- Decision Tree/Regression Tree software classification
- Mapping Zone approach (not political boundary)
- Seamless continental data

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Potential General Products

- 2005,2006,2007 North American MODIS image composite @ 250m – 10 day?
- 2005 North American MERIS image composite
- Synthesis of 30 m best available base land cover for Canada, U.S. and Mexico
- 2005,2006,2007 North American thematic land cover product @ 250m
- North American fractional land cover products – TBD @ 250m
- 2005-2006, 2006-2007 North American spectral change, land cover thematic change, and fractional vegetation change products @ 250m

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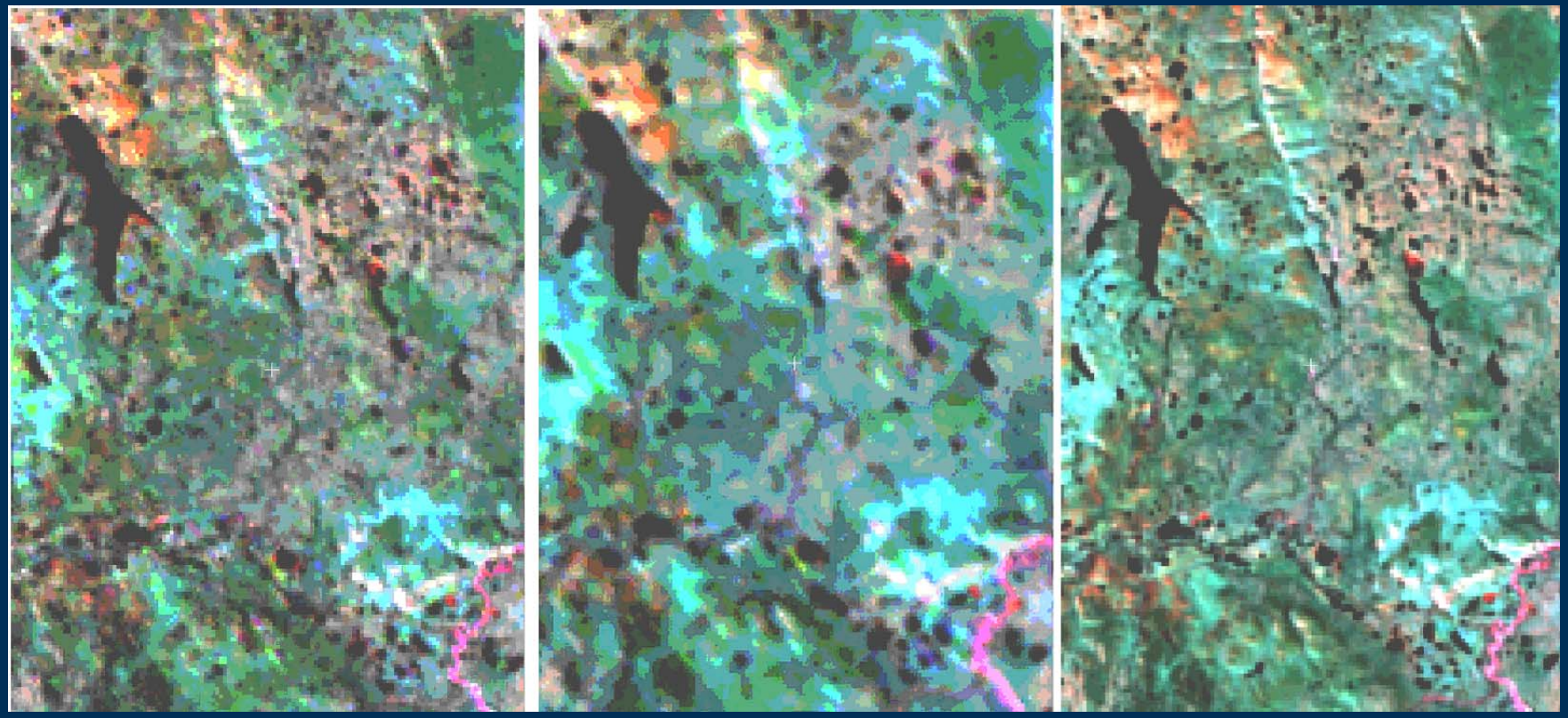
Example of Canadian “sharpening” results from 500m MODIS bands



250m

500m

Landsat scaled
To 250m

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Overview of MODIS pre-processing

- Acquire MODIS data (7 bands including 2 @ 250m and 5 @ 500m (2.6 gig per band)
- Downscale channels 3-7 at 500 m to 250 m resolution using algorithm developed by Trishchenko et al, (2006)
- Reproject using algorithm developed by Khlopenkov et al., (2006) to handle off-nadir issues
- Screen cloud, cloud shadow, and snow/ice
- Composite scenes to 10 day interval
- Perform Atmospheric Correction (SMAC) developed by Rahman and Dedieu (1994).
- Perform BDRF Normalization

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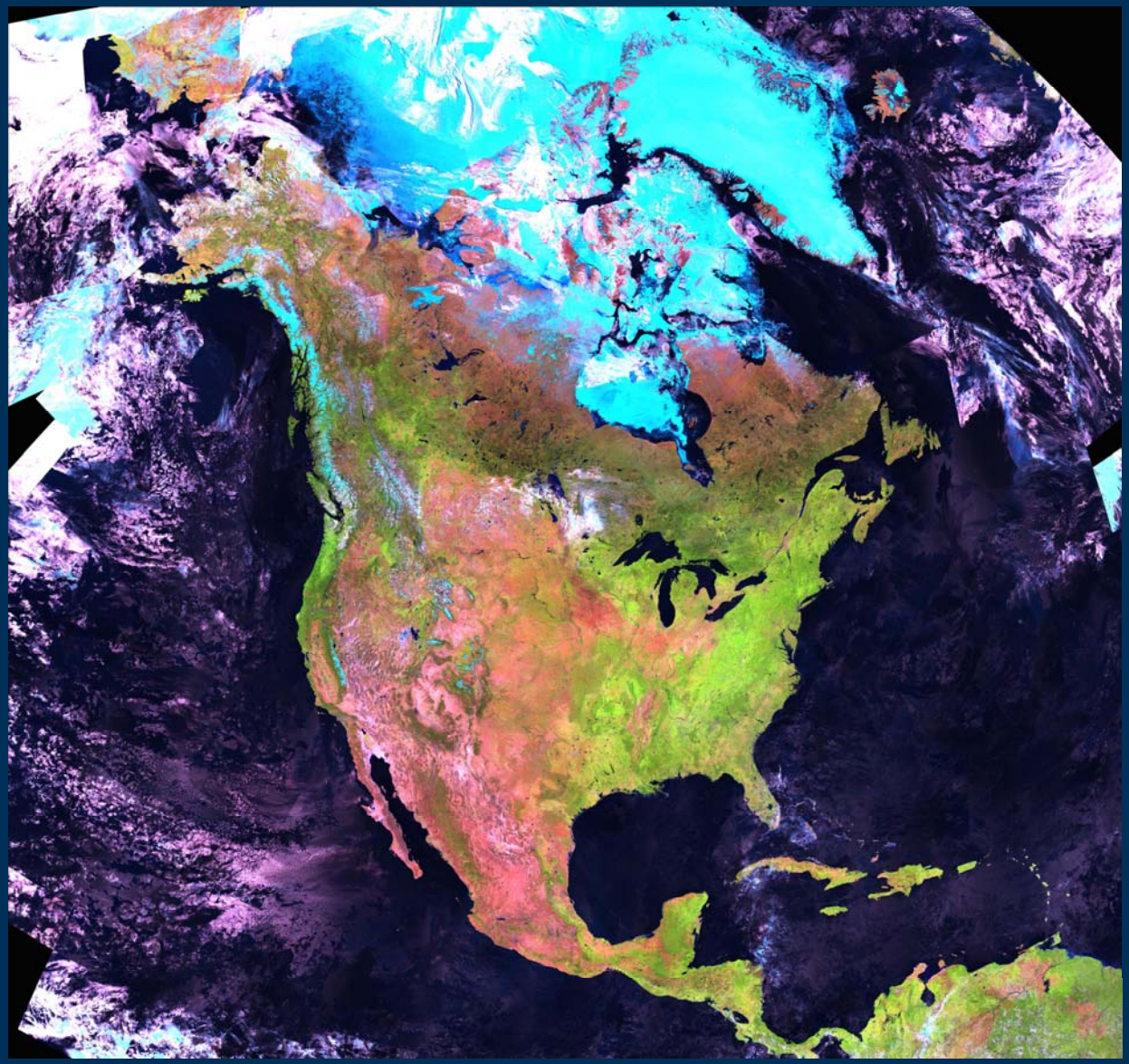
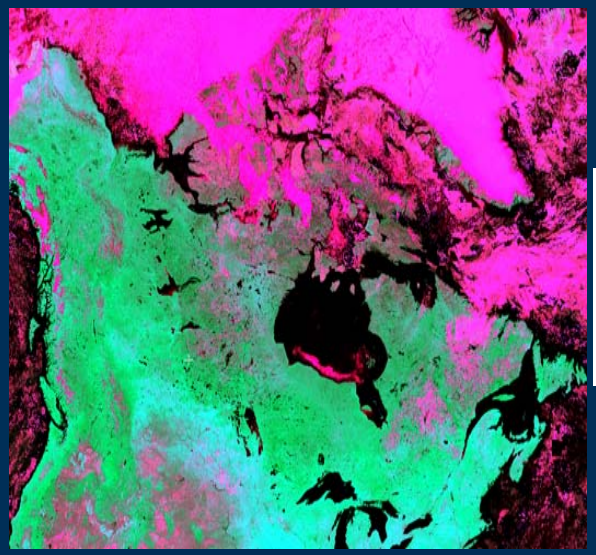
MODIS 250m North America composite

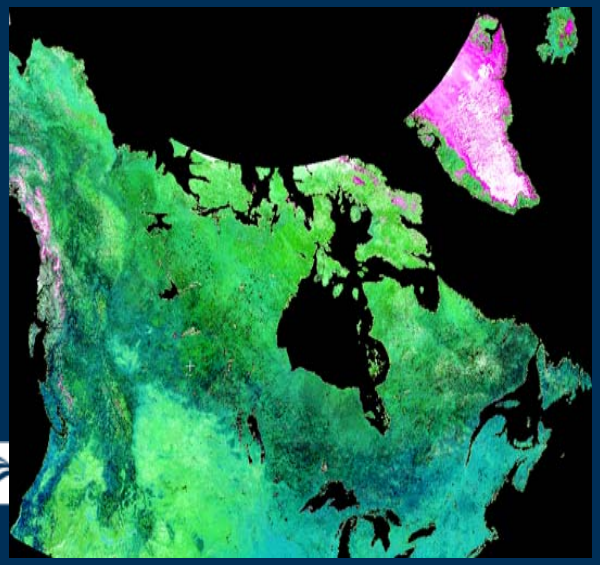


Source: NRCan/ESS Program LUCIA
Project: National Land Cover Characterization

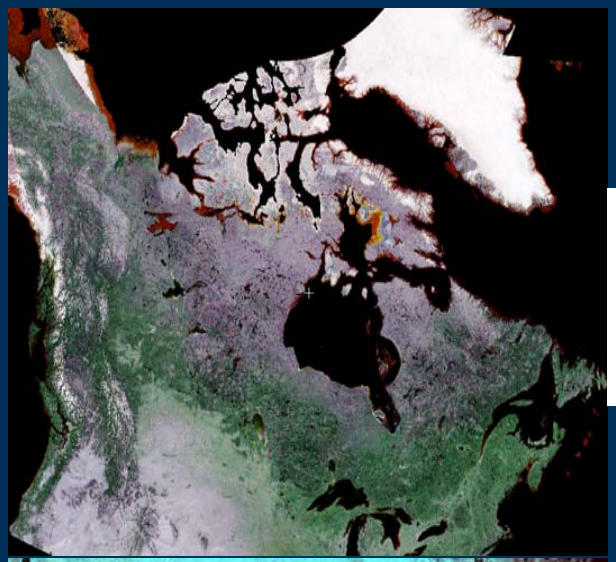
Canadian examples of longer term satellite data sets



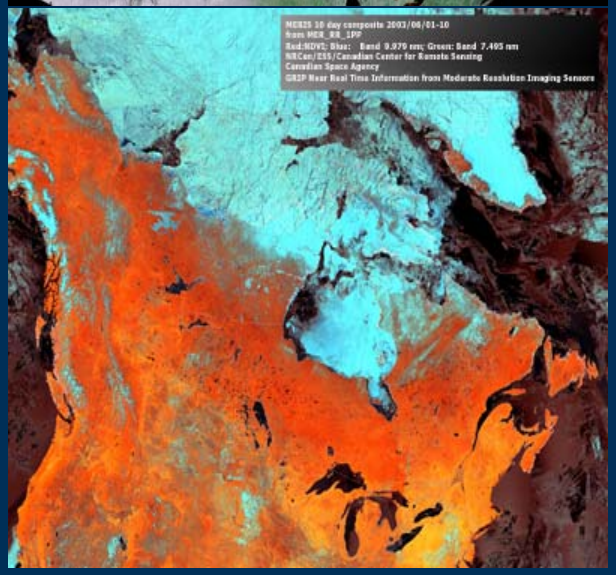
AVHRR
NOAA
1 km
Period:
1982-2006



SPOT/VGT
VITO
1km
Period:
1998-2004

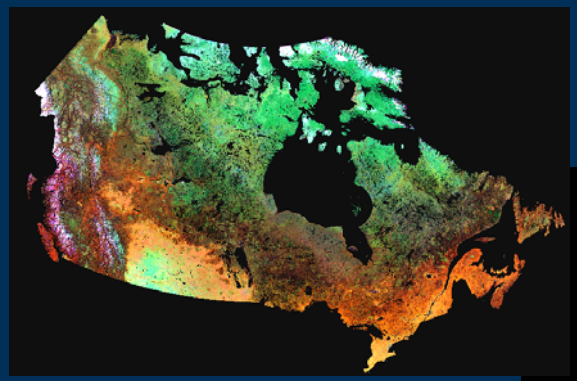


MODIS
NASA
1; 0.5; **0.25 km**
Period:
2000-2004



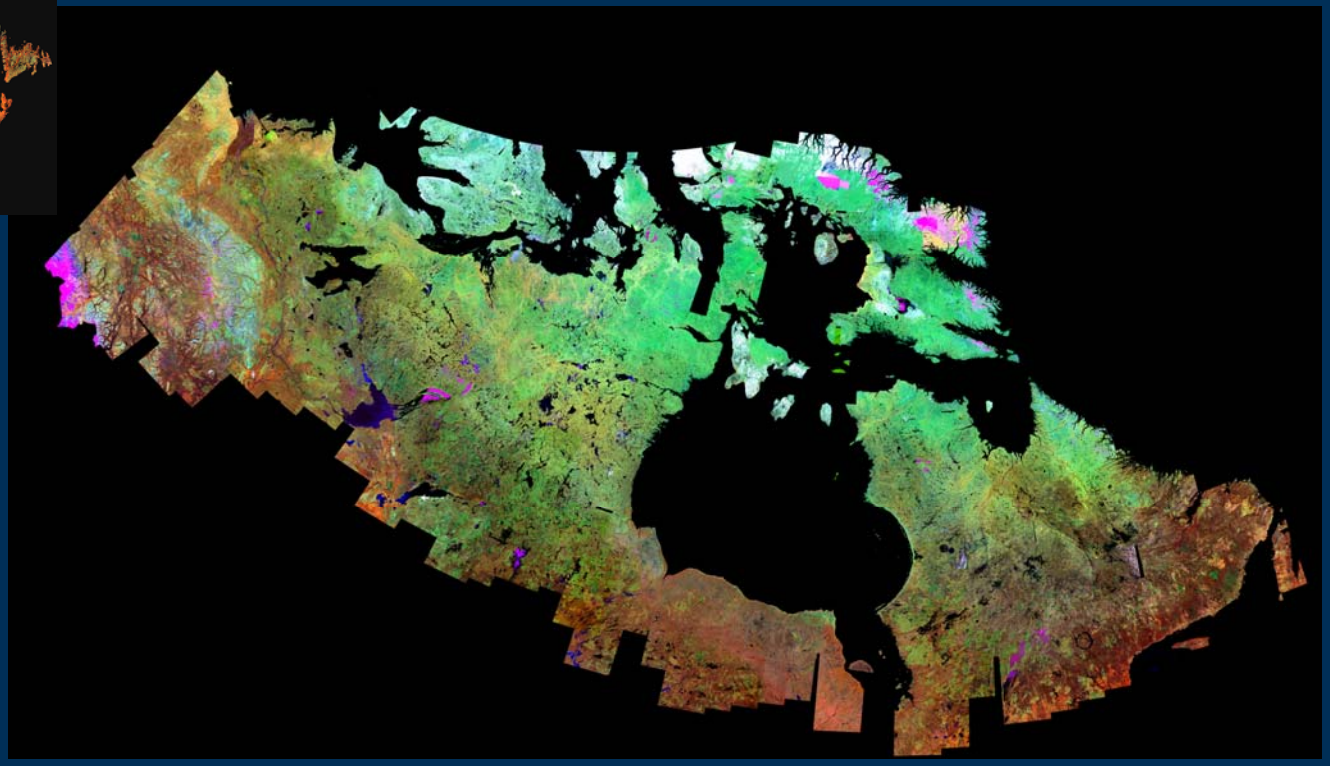
MERIS
ESA
1; **0.3 km**
Period:
2000-2004

Canada radiometric normalization



1km SPOT VGT
Year 2000

90m Landsat ETM+ 446 scenes, Circa 2000



Olthof, I., D. Pouliot, R. Fernandes and R. Latifovic (2005). Landsat ETM+ radiometric normalization comparison for northern mapping applications. *Remote Sensing of Environment*, *95*, 388-398.

Olthof, I., Butson, C., Fernandes, R., Fraser, R., Latifovic, R., & Orazietti, J. (2005). Landsat ETM+ mosaic of northern Canada. *Canadian Journal of Remote Sensing*, *31*, 412-419.

Potential General Products

- 2005,2006,2007 North American MODIS image composite – 10 day?
- 2005 North American MERIS image composite @ 300m
- Synthesis of 30 m best available base land cover for Canada, U.S. and Mexico
- 2005,2006,2007 North American thematic land cover product @ 250m
- North American fractional land cover products – TBD @ 250m
- 2005-2006, 2006-2007 North American spectral change, land cover thematic change, and fractional vegetation change products @ 250m

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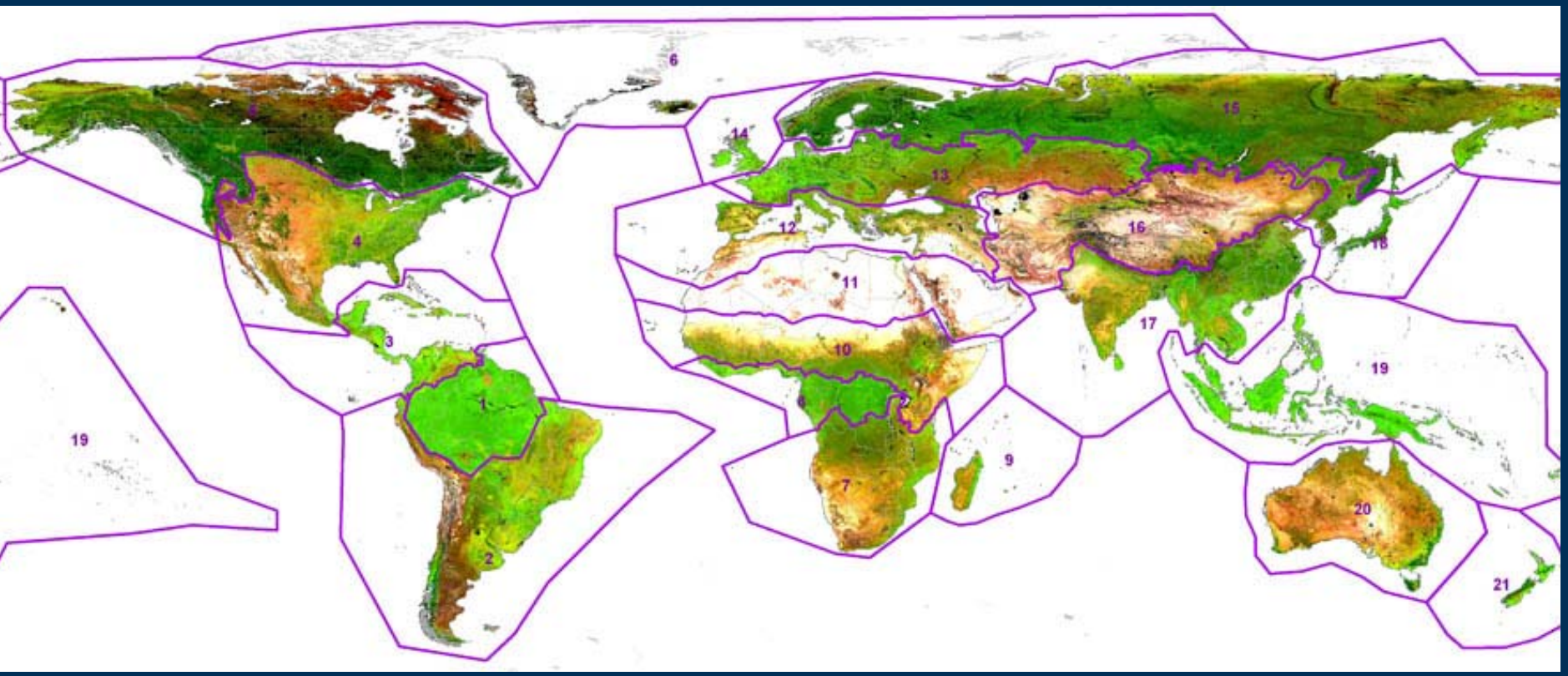
Globcover



- A joint project funded by ESA and being implemented by a consortium led by Medias France
- Global land-cover map for the year 2005 using MERIS 300 m data
- USGS is responsible for developing classification system, interpreting, and validating the data for North America

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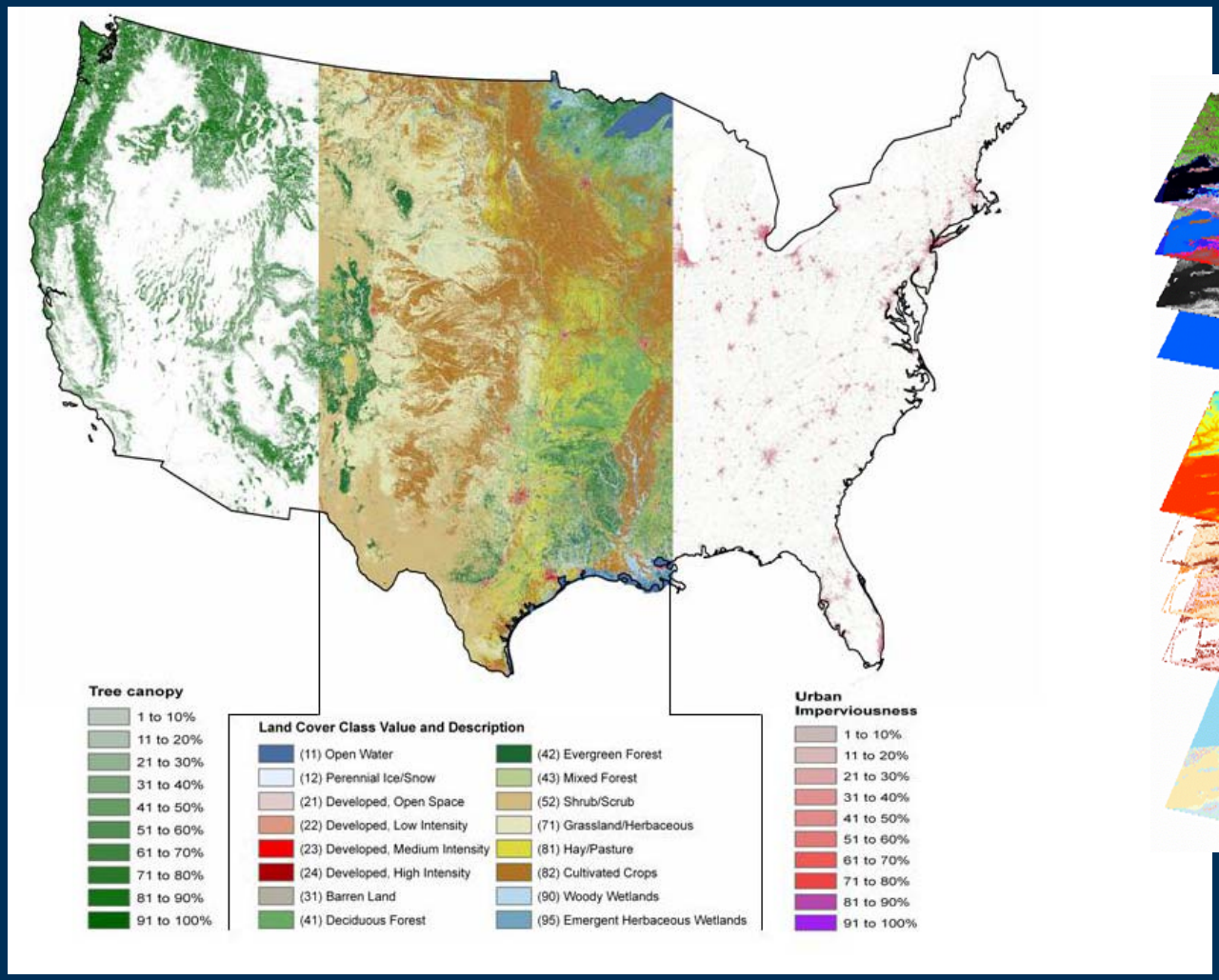
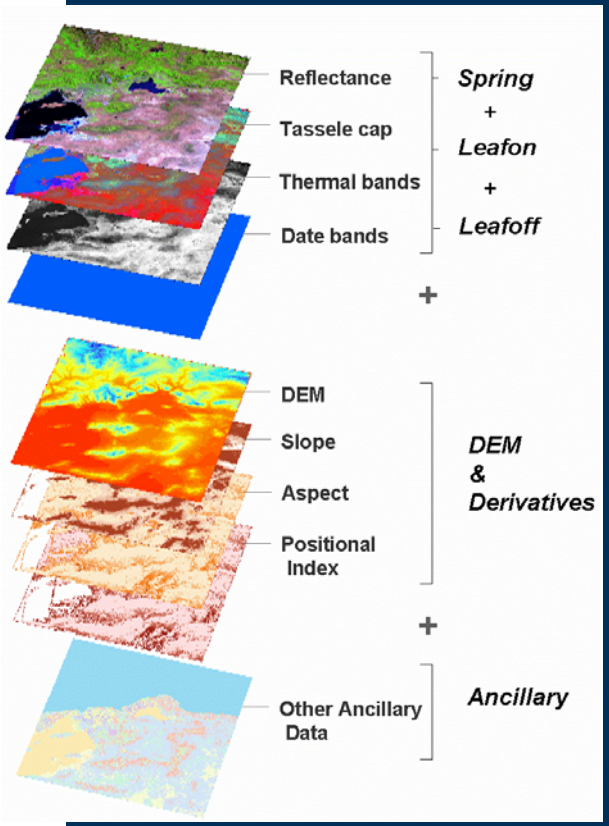
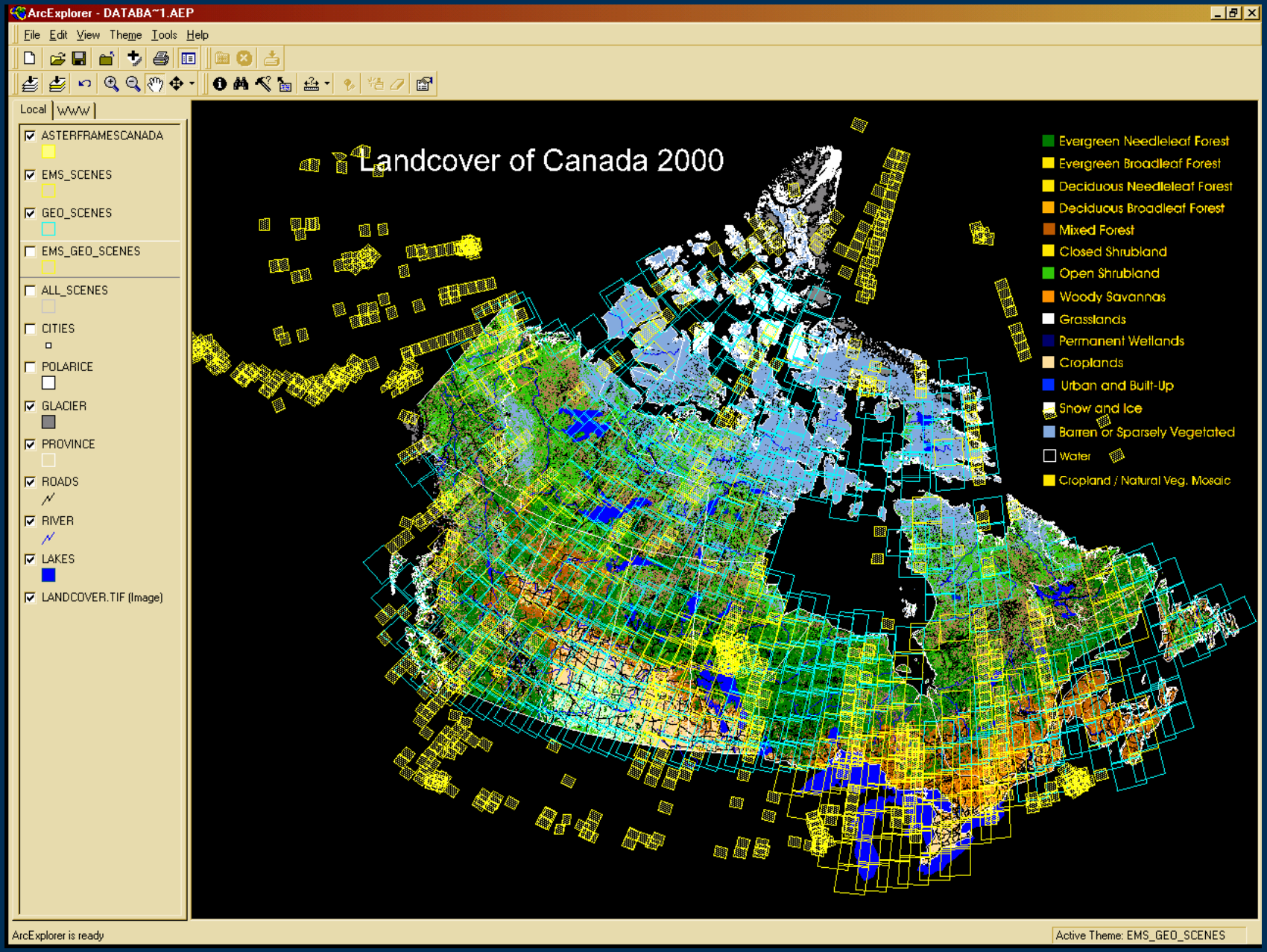
U.S. has NLCD 30m Landsat products to build on

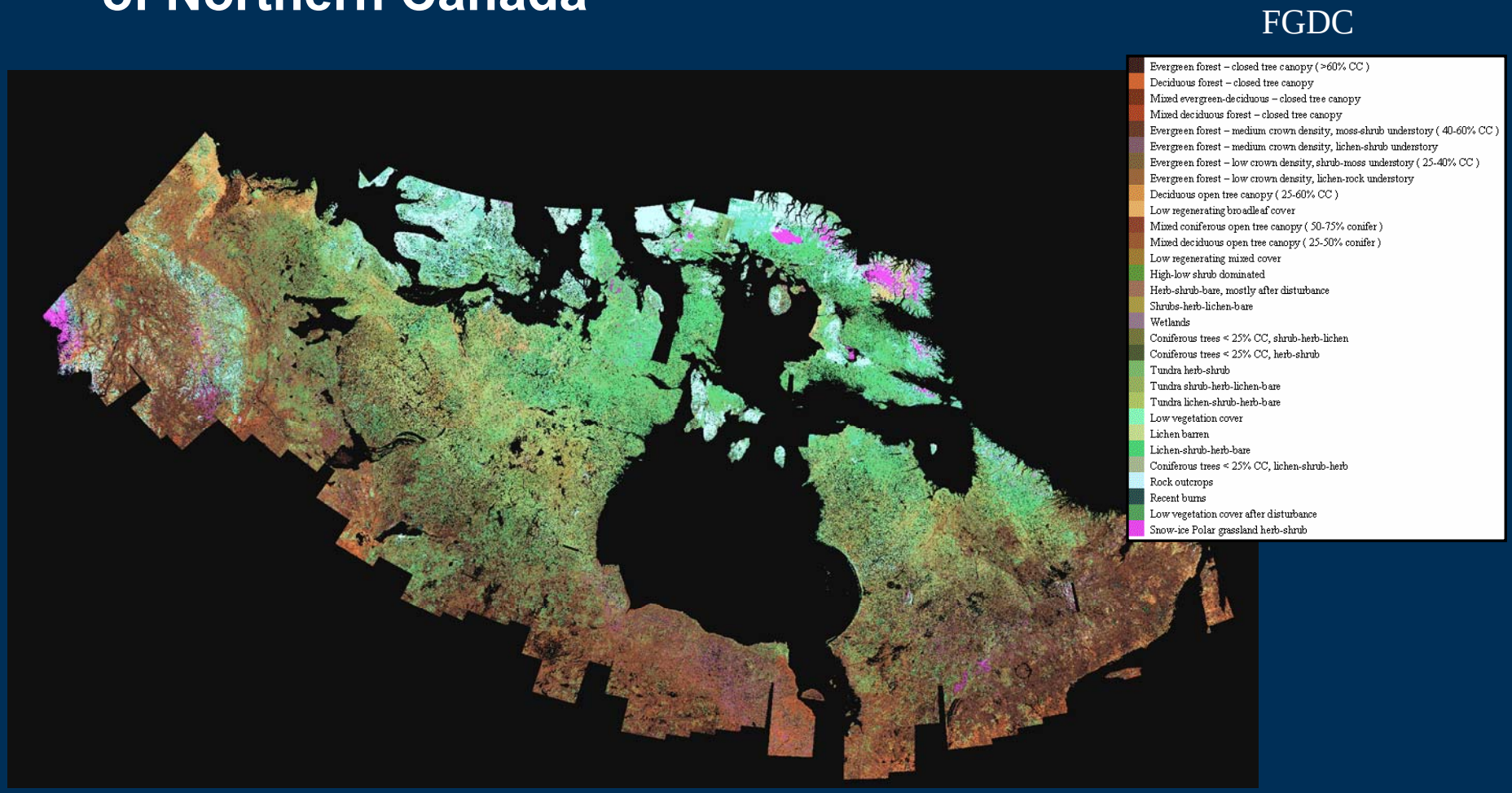




Canada has a variety of 30m land cover available

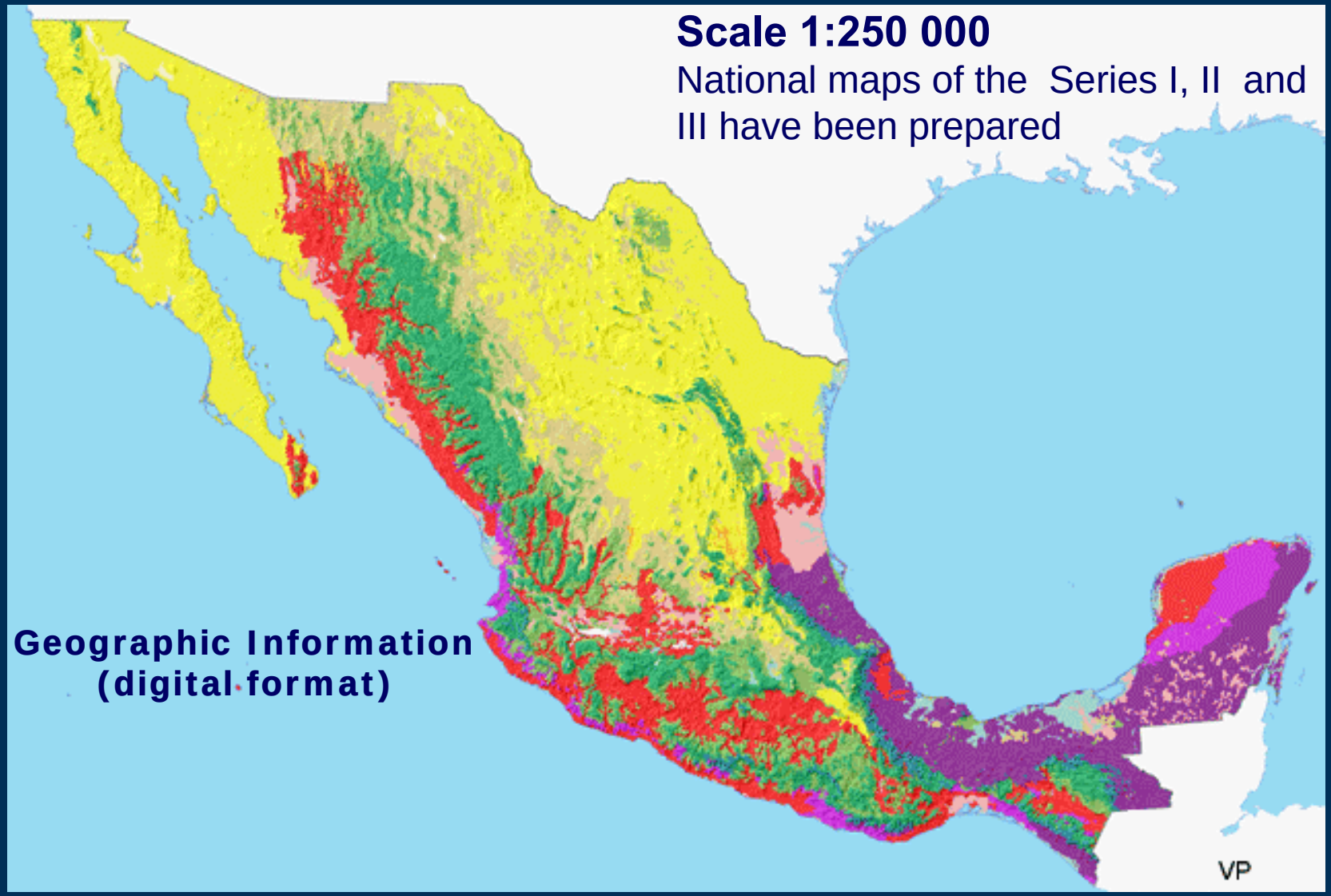


And some circa 2000 Landsat ETM+ 90m land cover of Northern Canada

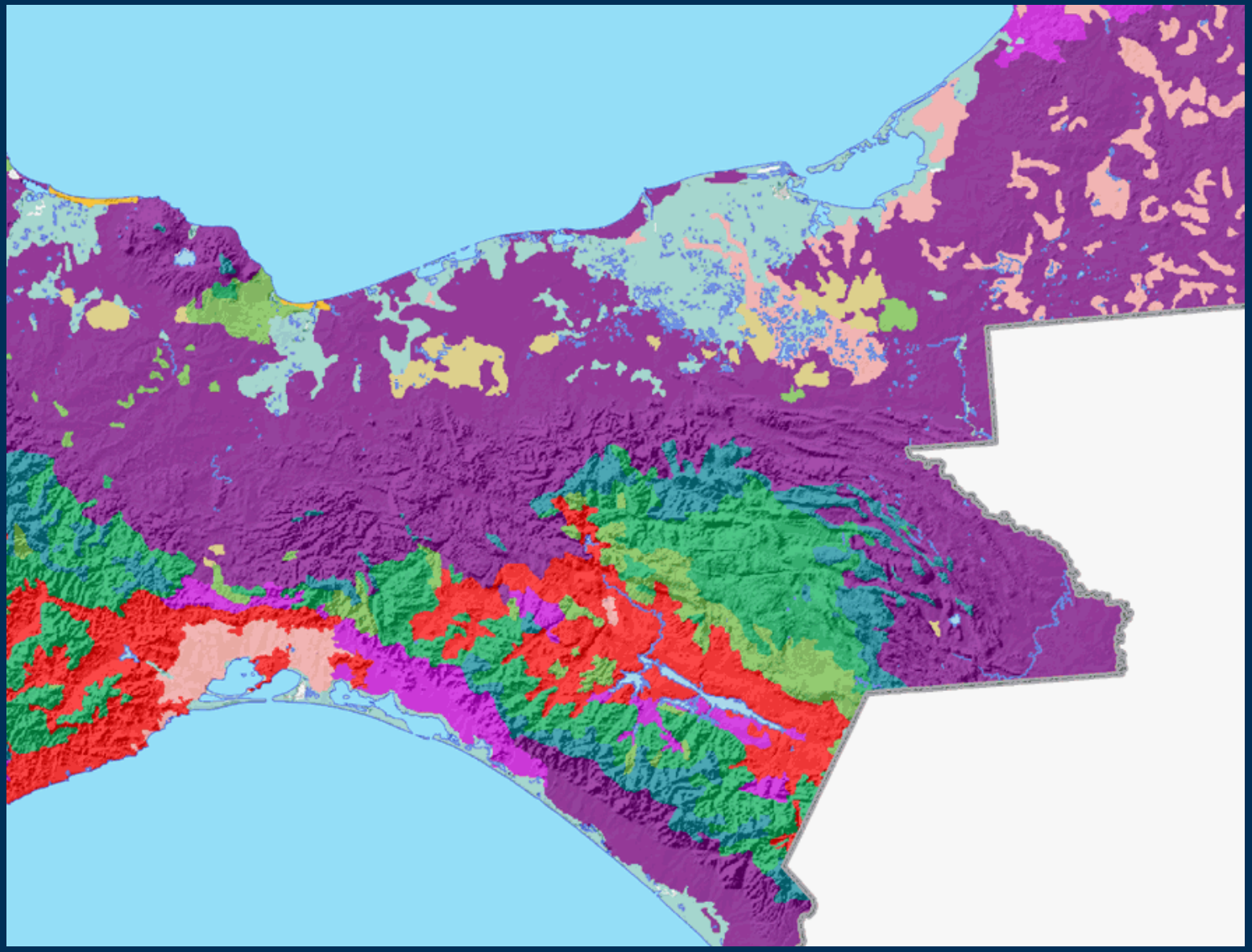


Olthof, I., C. Butson and R. Fraser (2005). Signature extension through space for northern landcover classification: a comparison of radiometric correction methods. *Remote Sensing of Environment.*, *95*, 290-302.

The National Institute of Geographic Statistics and Information of Mexico (INEGI) has Landsat derived land cover



Primary Vegetation ▶ Series I (80´s) ▶ Series II (90´s) ▶ Series III (2005)



Southern Mexico

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LAND COVER OF NORTH AMERICA

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Natural Resources Canada / Ressources naturelles Canada

Canada Centre for Remote Sensing / Centre canadien de télédétection

UNEP

EUROPEAN COMMISSION JOINT RESEARCH CENTRE

GLC 2000

GLOBAL LAND COVER 2000
LAND COVER OF NORTH AMERICA

Global Land Cover 2000 (GLC 2000) is being implemented by the Joint Research Center of the European Commission in collaboration with a network of partners around the world. The main objective of the project is to produce a consistent and reliable land cover database of the world for the year 2000. The North American land cover database has prepared jointly by the U.S. Geological Survey (USGS), EROS Data Center and the Canada Centre for Remote Sensing using the PROBA 2000 dataset.

VEGA 2000 is a dataset of 28 months (1 Mar 1999 – 31 Dec 2000) of pre-processed daily global data acquired by the VEGETATION instrument on board the SPOT 4 satellite. Detailed descriptions of the land cover data set and the methodology used can be found at this web site: http://bioweb.vgt.vito.be/BIOWEB/Pub/C1-2000.htm

The partner digitize major land cover types of the region with a backdrop of relief shading derived from the GTOPO30 global elevation dataset. (http://edc.usgs.gov/geninfo/gtopo30.html).

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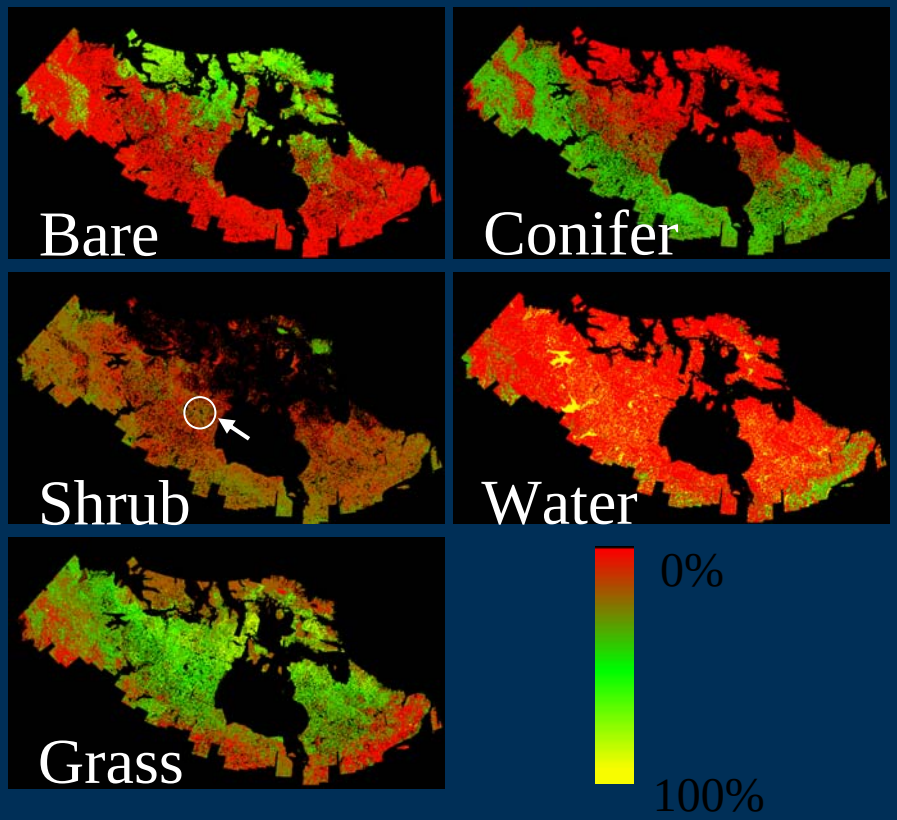
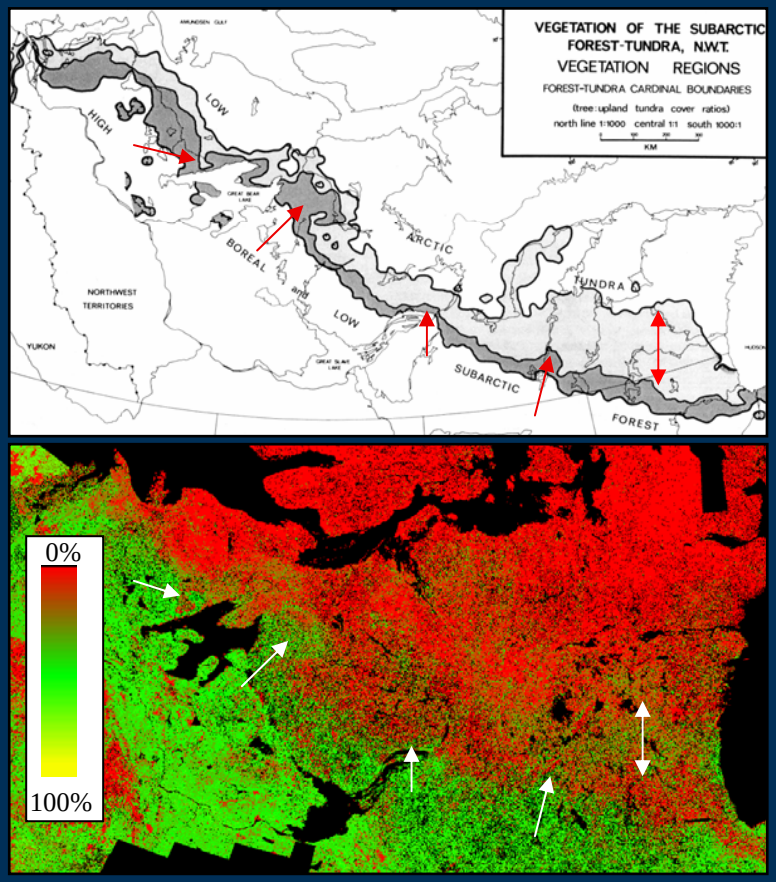
Fractional maps





Comparison of Canada's forest-tundra ecotone mapped using 1,314 air photos (1:50,000) and extensive ground truthing (from Timoney et al., 1992) and the fractional conifer map derived using 90m resample Landsat imagery. The middle line in the upper panel represents a 1:1 tree:tundra cover ratio and the dark and light shaded areas represent 1000:1 and 1:1000 ratios, respectively. The arrows show matching patterns of interest.

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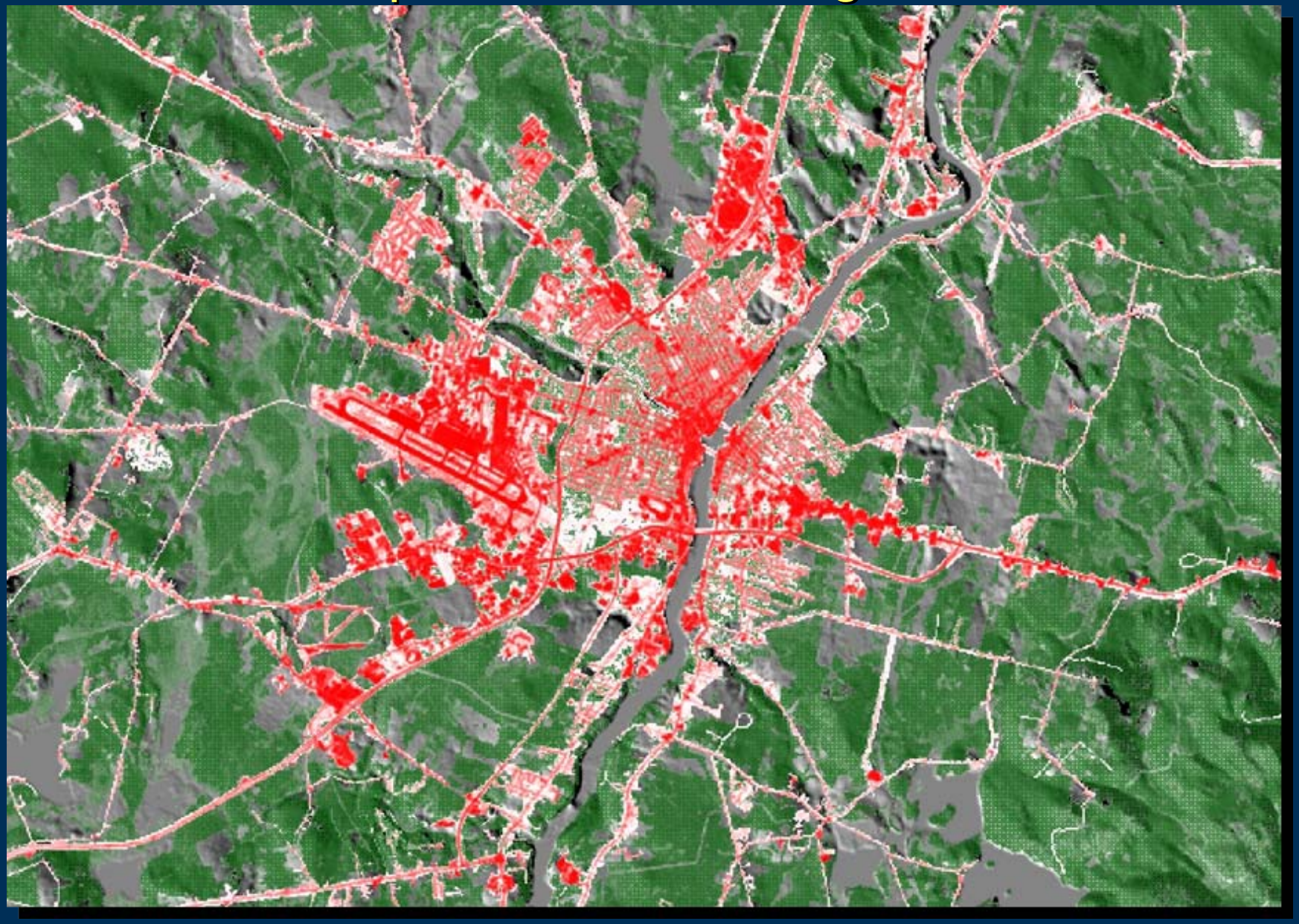
NLCD 2001 Database Applications: Tree Canopy and Imperviousness,Bangor, Maine



Possible fractional themes:

MODIS Potential Continuous Field Land Cover Fractions				
SDS	**Units**	**Data Type**	**Fill Value**	**Valid Range**
Percent Tree Cover	Percent	8-bit unsigned integer	251 bad data 253 water 255 interrupted space	0 - 100
Percent Broadleaf	*percent*	*8-bit unsigned integer*	*252*	*0 - 100*
Percent Needleleaf	*percent*	*8-bit unsigned integer*	*252*	*0 - 100*
Percent Evergreen	*percent*	*8-bit unsigned integer*	*252*	*0 - 100*
Percent Deciduous	*percent*	*8-bit unsigned integer*	*252*	*0 - 100*
Percent Nontree Vegetation	Percent	8-bit unsigned integer	251 bad data 253 water 255 interrupted space	0 - 100
Percent Shrubs	*percent*	*8-bit unsigned integer*	*252*	*0 - 100*
Percent Crops	*percent*	*8-bit unsigned integer*	*252*	*0 - 100*
Percent Other Herbaceous	*percent*	*8-bit unsigned integer*	*252*	*0 - 100*
Percent Bare	Percent	8-bit unsigned integer	251 bad data 253 water 255 interrupted space	0 - 100
Percent Ice	*percent*	*8-bit unsigned integer*	*252*	*0 - 100*
Percent Bare Ground	*percent*	*8-bit unsigned integer*	*252*	*0 - 100*

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Potential change products

- Change will be updated annually for North America at 250 m and regionally at 30 m on an approximate 5 year interval.
- Abrupt changes are often detectable annually as they occur within a single season. Gradual changes are best detected over longer time periods specific to the cause of the change
- Ultimate change product candidates will balance operational achievability, cost and need

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Types of Potential Change to Consider

(changes are spatially and temporally scale dependent)

Abrupt	Gradual
Fire Severe insect or disease damage Biomass harvesting (agriculture, forest, other) Storm damage (severe winds, ice accumulations, flooding) Land slides Drought Industrial development Urban development	Vegetation succession Regeneration post disturbance Pollution effects on vegetated ecosystems Continuous low to moderate insect defoliation Consistent long term hydrologic changes Permafrost changes –active layer increase\decrease, subsidence Costal\shoreline erosion Gradual within “pixel” change

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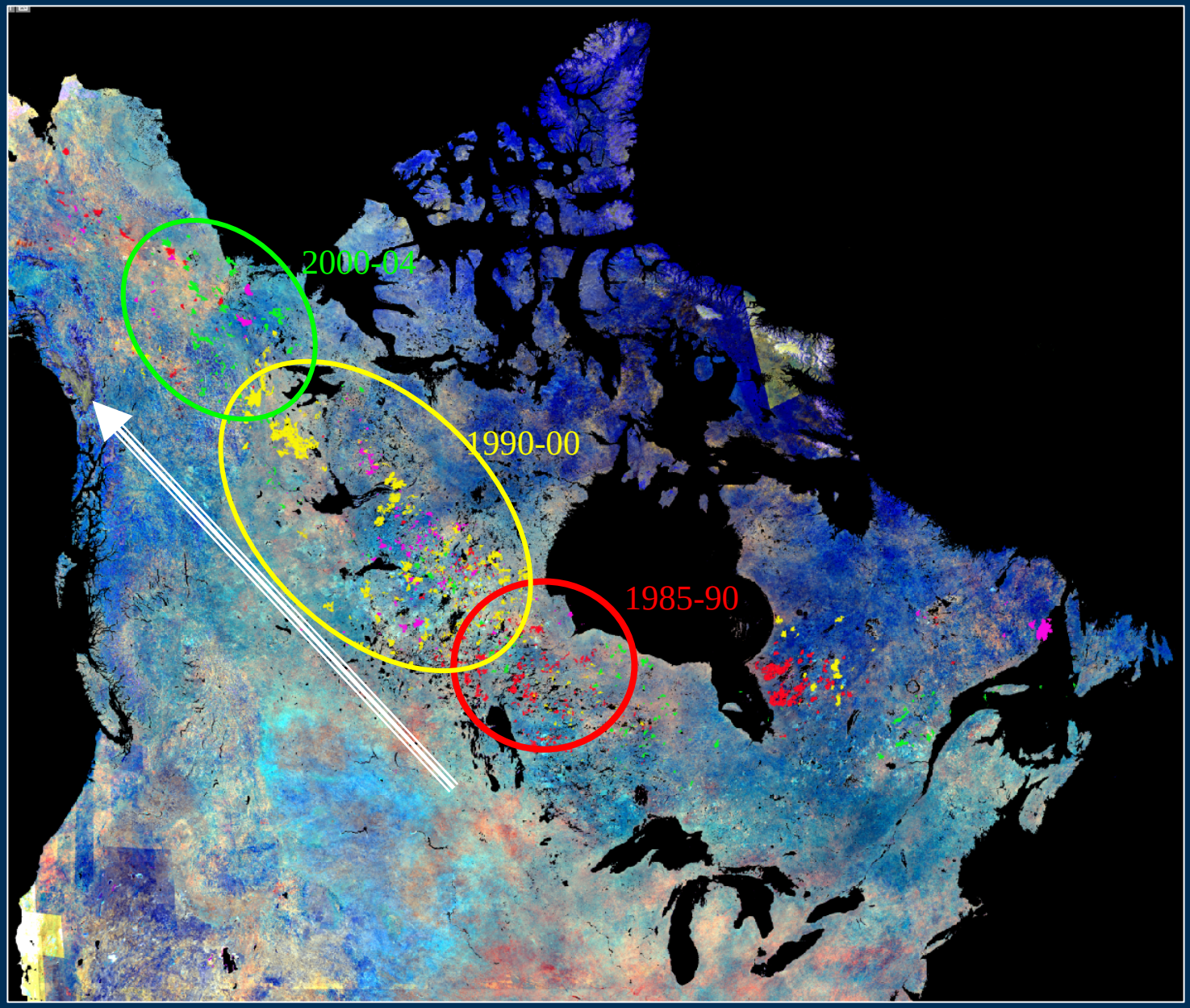
Table 7: List of change indices for evaluation.

Change Method	Image Features	Reference
Peak of season differences	(Red); (NIR); (SWIR)	Coppin et al., 2004
Peak of season ratios	(Red); (NIR); (SWIR)	Coppin et al., 2004
Peak of season cross-correlation analysis	(Red, NIR, SWIR)	Koelin and Bissonnette, 2003
Peak of season change vector analysis	(Red, NIR, SWIR)	Lambin, 1996; Nackaerts et al., 2001
Temporal change vector analysis	(SR = NIR/Red); (IR = NIR/SWIR); (Other VIs)	Lambin, 1996
Temporal template comparison	(SR = NIR/Red); (IR = NIR/SWIR); (Other VIs)	Latifovic, 2005
Temporal variance differences based on temporal coefficient of variation	(SR = NIR/Red); (IR = NIR/SWIR); (Other VIs)	Fraser et al., 2005
Bi-temporal correlation analysis	Red	Latifovic, 2005; Im and Jensen, 2005
Peak of season texture differences based on coefficient of variation	Red	Latifovic and Pouliot, 2005; Fraser et al., 2005

*Brackets identify groups of image feature to evaluate for each index.

Boreal forest fire spatial and temporal pattern 1985-2004



1985-90

1990-95

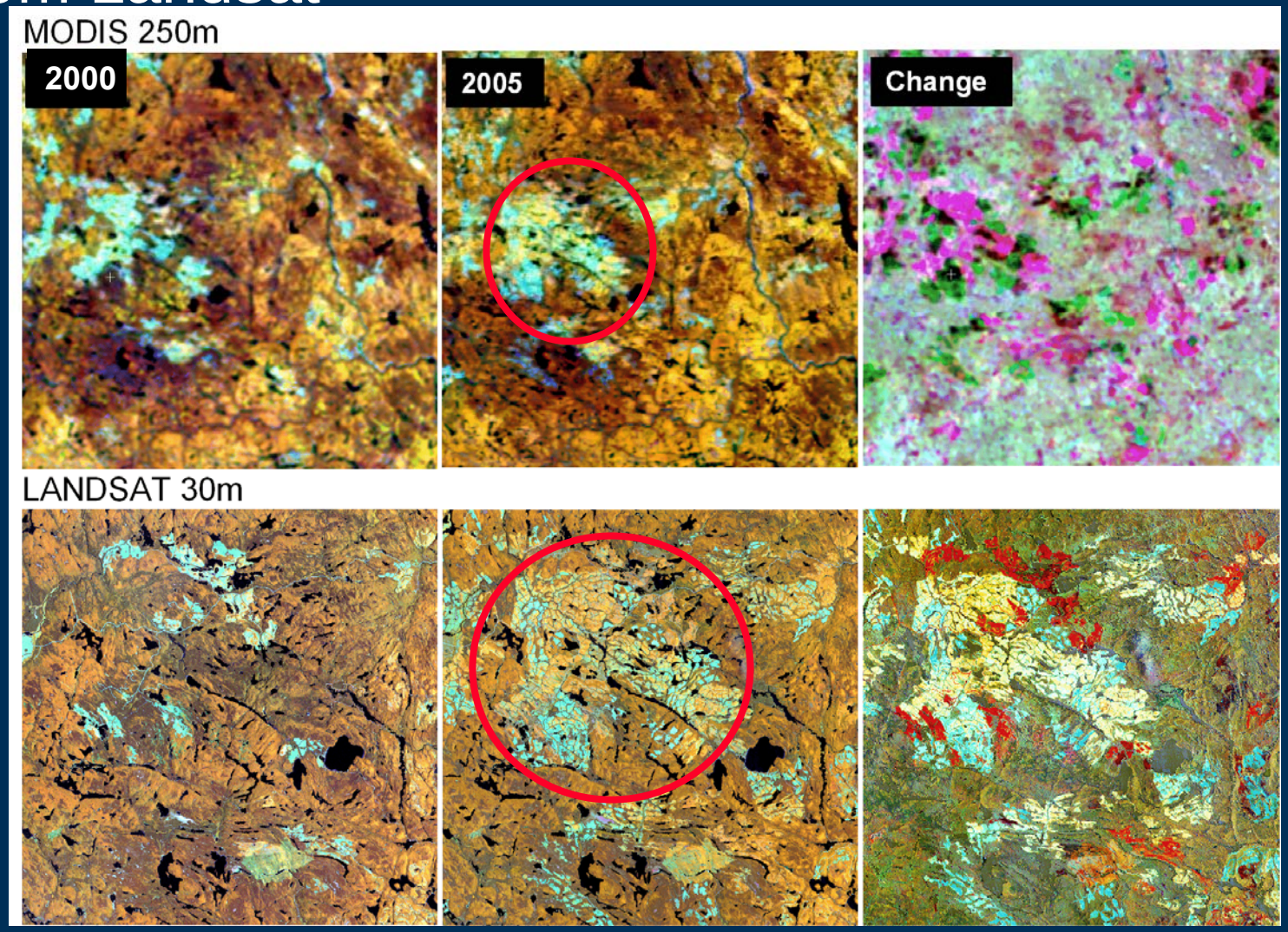
1995-00

2000-04

Cycles present areas with more frequent fire occurrence during the time step.

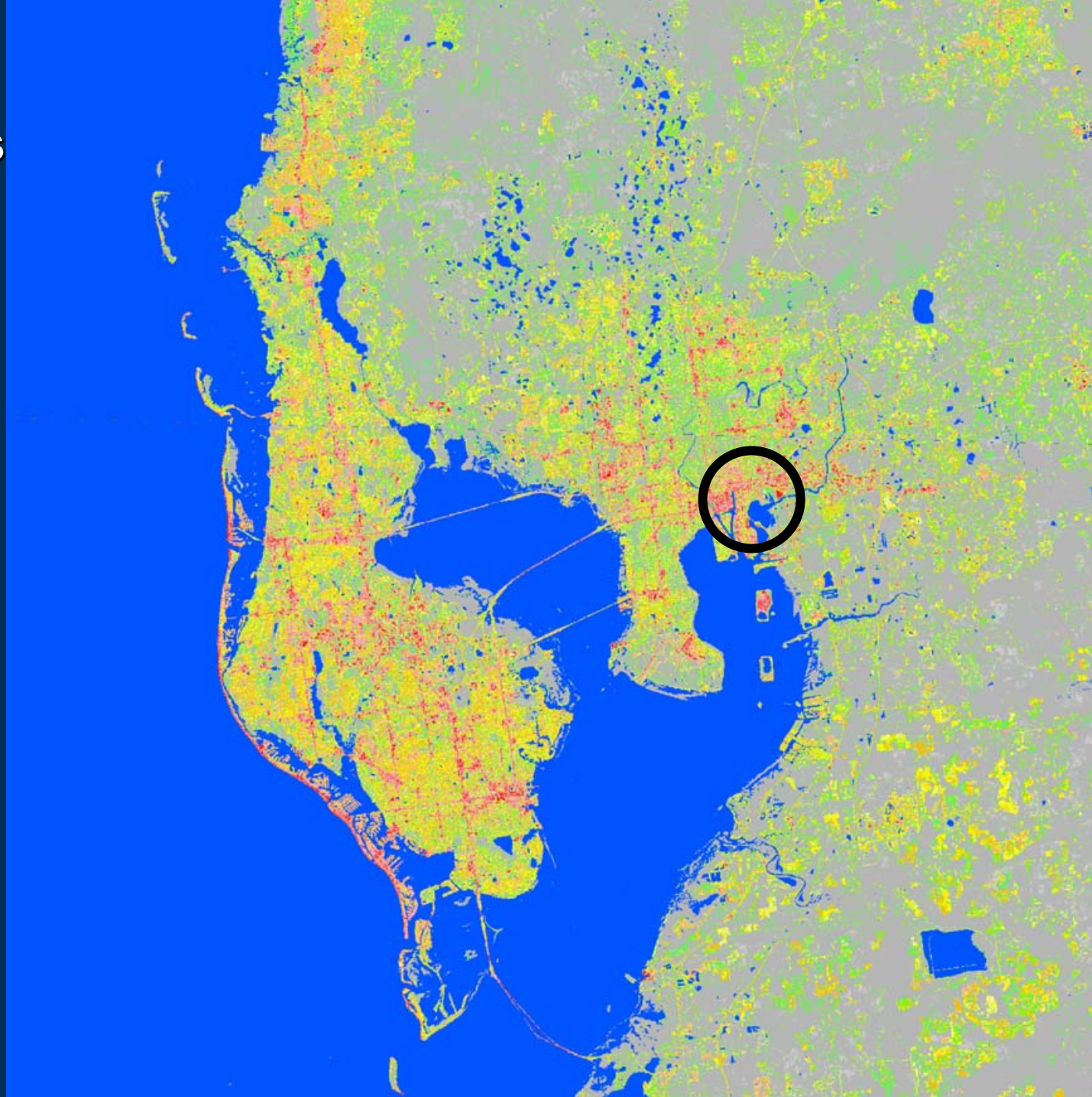
Source: R.Latifovic NRCan/ESS 2005

Comparison of change derived from 250 Modis vs 30m Landsat



Source: NRCan/ESS Program LUCIA
Project: National Land Cover Characterization

Tampa Bay Imperviousness 1991



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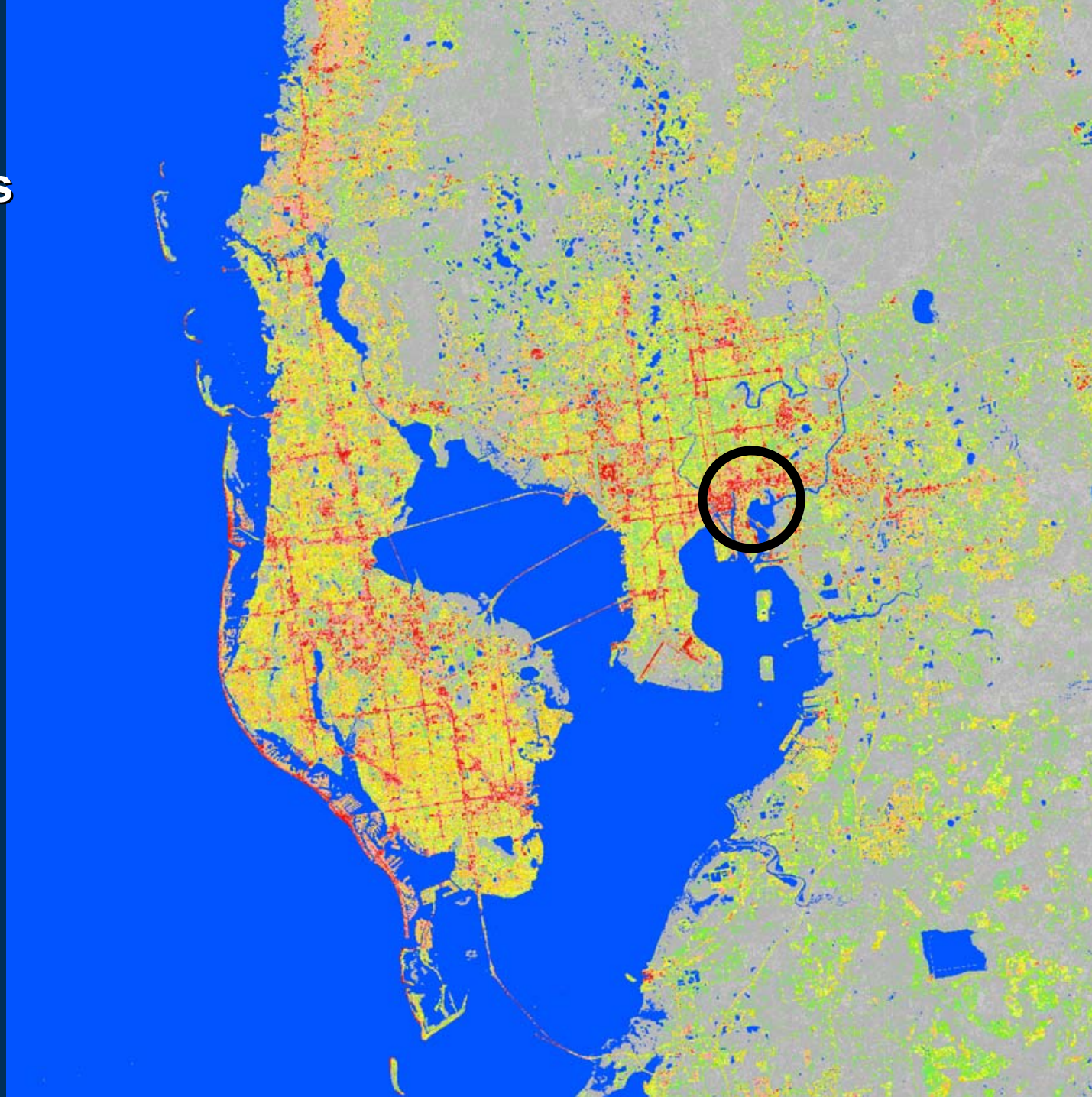
Tampa Bay Imperviousness

2002



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Timeline Goals

- March 23rd Complete initial draft of technical plan and circulate for review
- April 12th - Tri-national meeting in Mexico to begin plan formalization
- June – Complete new draft of technical plan
- August – Examples of initial proof of concept products circulated
- October – Funding and assignments in place to advance project to next phase

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