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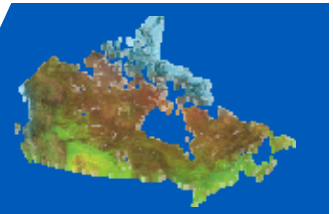

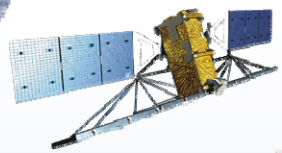

Overview of CFS remote sensing activities with potential linkages with ALOS K&C initiative

A. Beaudoin, R.J Hall, D. G. Goodenough, H. Chen
and many contributors

(© 2011 NRCan/CFS)

15th ALOS K&C Science Team meeting,
Jan. 24-28, Tokyo, Japan

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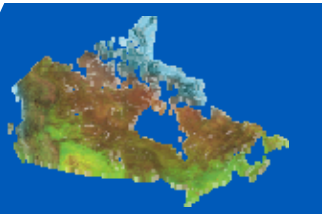
OUTLINE



1. Forest biomass mapping and monitoring in Canada: Status and perspectives related to ALOS K&C

2. R&D for specific forest applications from L-/C- band radar

3. CFS interests in ALOS K&C Initiative

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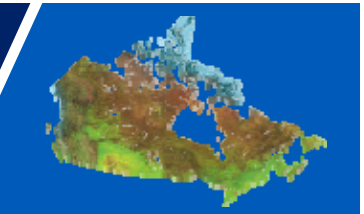
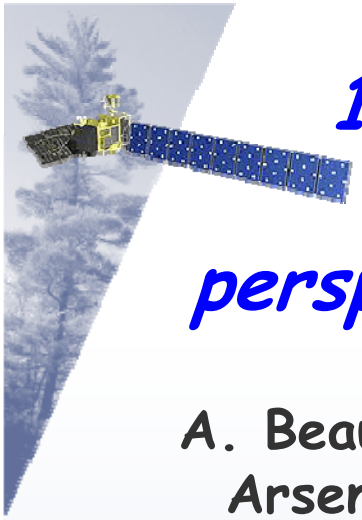
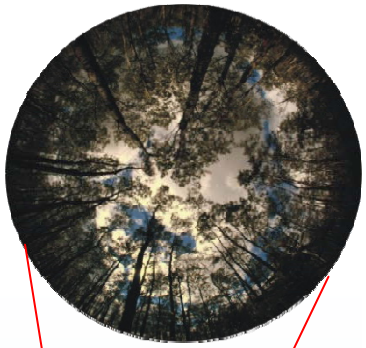




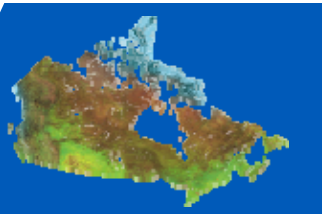
1. Forest Biomass mapping in Canada: needs, status and perspectives related to ALOS K&C *



A. Beaudoin, R.J Hall, L. Guindon, P. Bernier, E.J. Arsenault, R. Skakun, M.A. Wulder, P. Villemaire, D. McKenney, J.E. Luther and M.D. Gillis

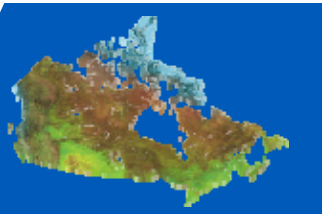
* Adaoted from R. Hall et al. (2010): Approaches for forest biomass estimation and mapping in Canada, IEEE-IGARSS, Jul. 25-30, 2010 Honolulu, Hawaii, USA

1. Importance and needs



- Indicator of carbon (C) in a forest ecosystem.
- Increasing interest from broad range of perspectives: CO_2 uptake, forest productivity, bio-energy initiatives, etc.
- Provide inputs to models: calculate, forecast C budgets.
- To support national and international reporting.

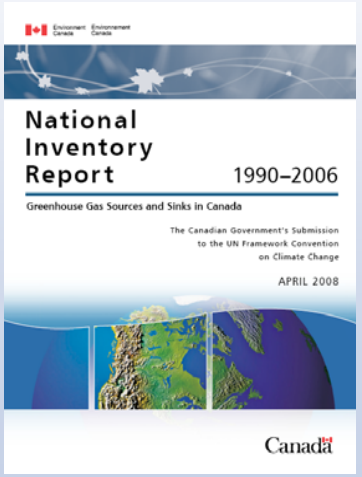
1. Importance and needs



- Inventory data primary source for biomass estimation
- Few inventory ground plots over land mass of Canada
- Data gaps outside of provincial inventories.

National Forest Carbon Monitoring, Accounting and Reporting System (NFCMARS)

- **NFCMARS** reports impacts of resource management, land use change, disturbances on forest carbon stocks.
- Annual reports of GHG emissions to UNFCCC
- Criteria and Indicators Reporting
- Contributes to National Inventory Report produced by Environment Canada



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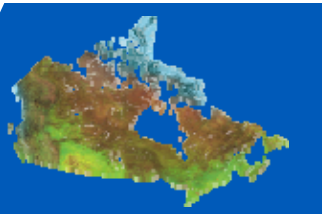
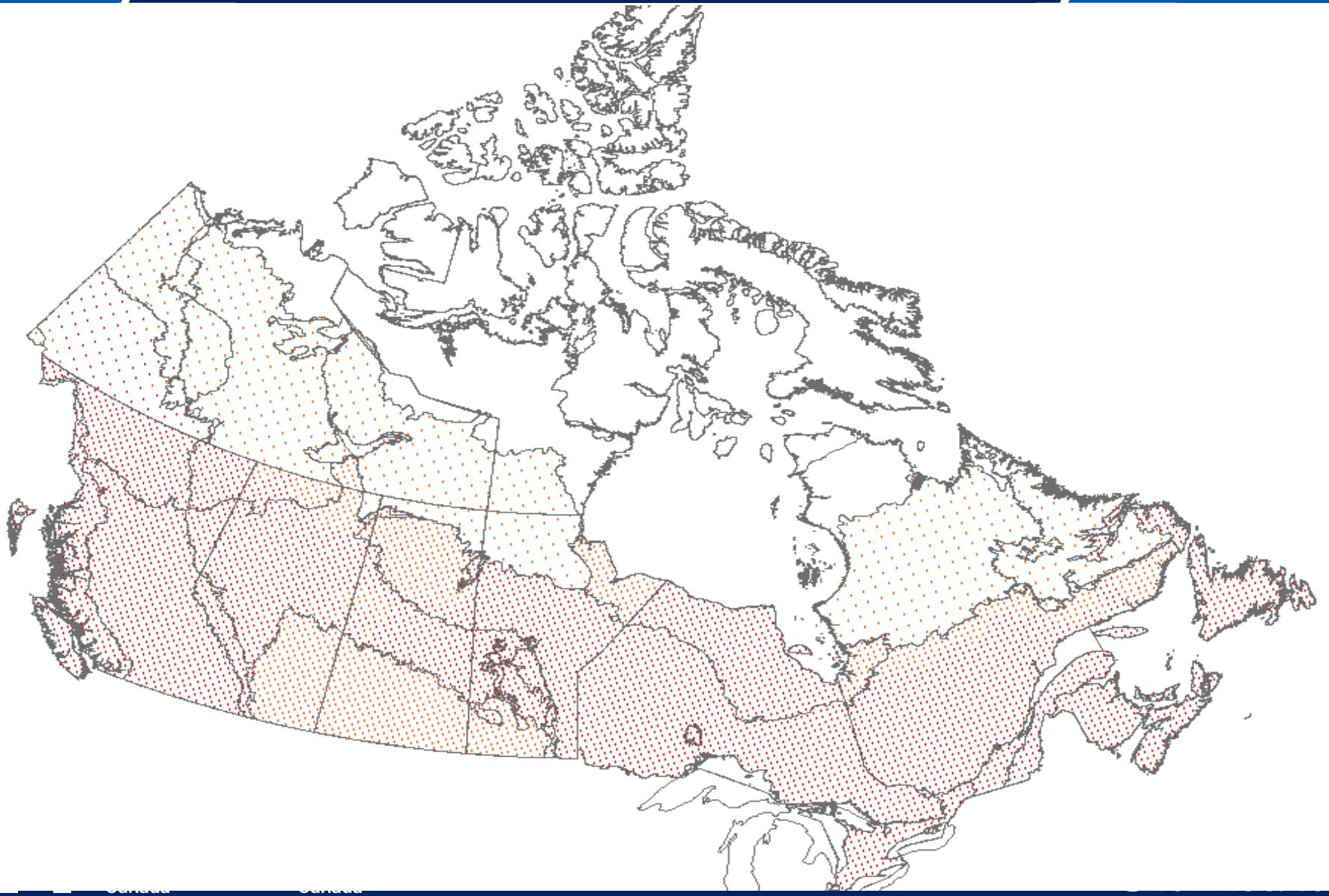
2. Current status: National Forest Inventory (NFI)





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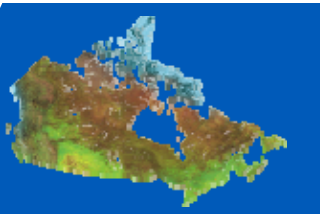
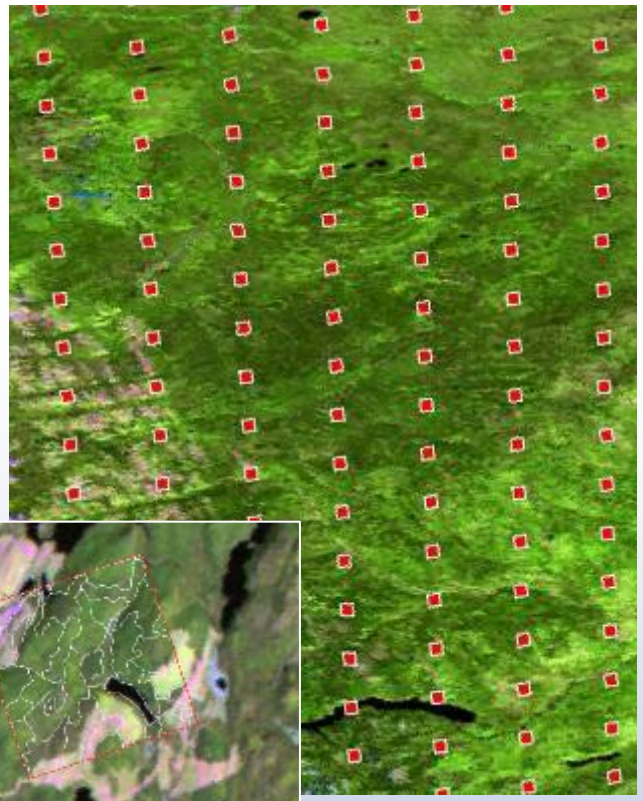


NFI provides a framework for the collection of attributes.

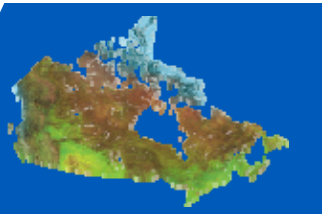
- National systematic sample
- 2km x 2km photo plots spaced on a 20km grid (~20,000)



- **Monitoring Strategy:** a 5-year sample and reporting capability nested within a 10-year remeasurement cycle

Gillis et al (2005)
For. Chron. 81:214-221

2. Current status: Circa 2000 EOSD Biomass



1. Objective: Produce first spatially contiguous forest biomass map of Canada at EOSD Land Cover product tile level (circa 2000).
2. Approach: Integrate CanFI 2001 Age, climate grids to estimate site, Ecozones, NFI models and EOSD land cover to estimate volume and biomass.

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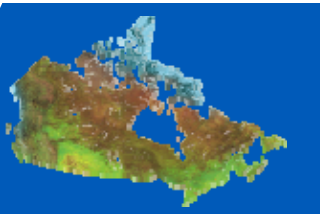
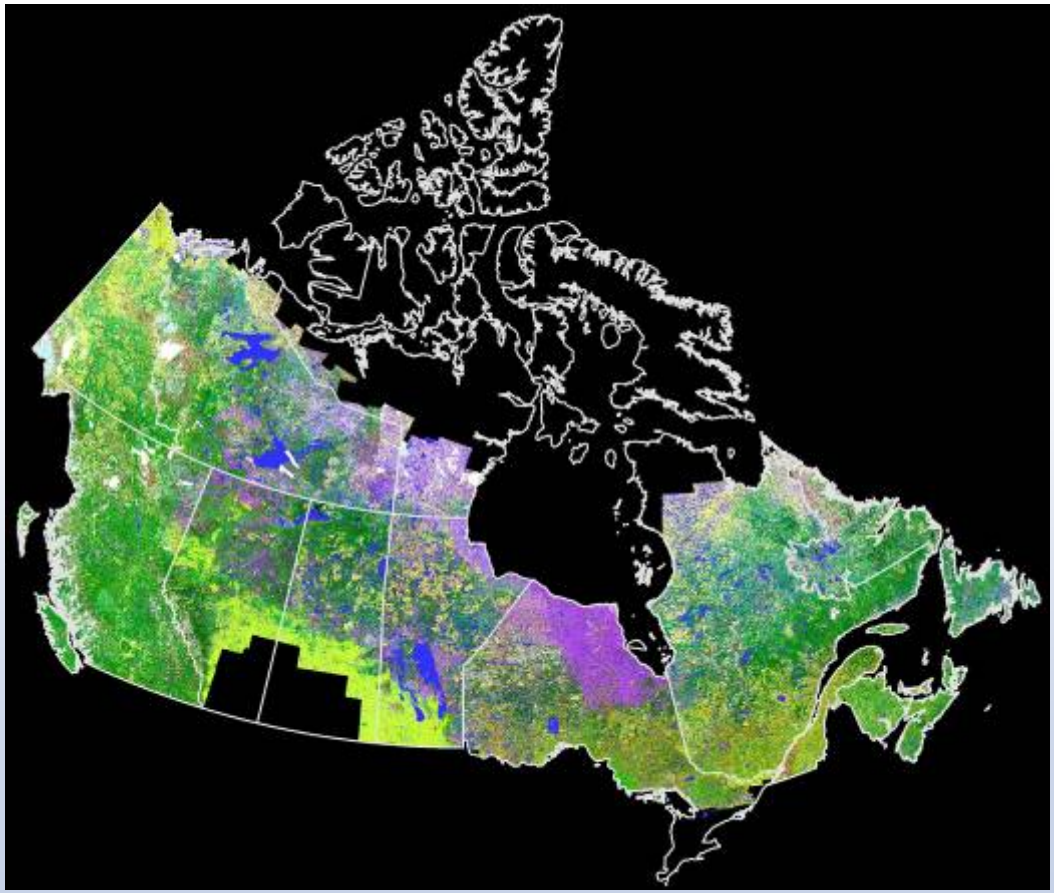
2. Current status: Circa 2000 EOSD Biomass



Earth Observation for Sustainable Development of Forests (EOSD) land cover framework

- Circa 2000 land cover
- 477 Landsat frames
- 610, 1:250,000 maps
- Data posted on:

http://www.saforah.org/



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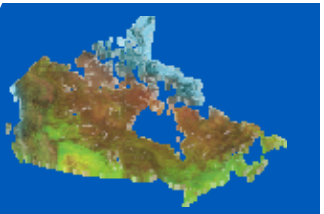
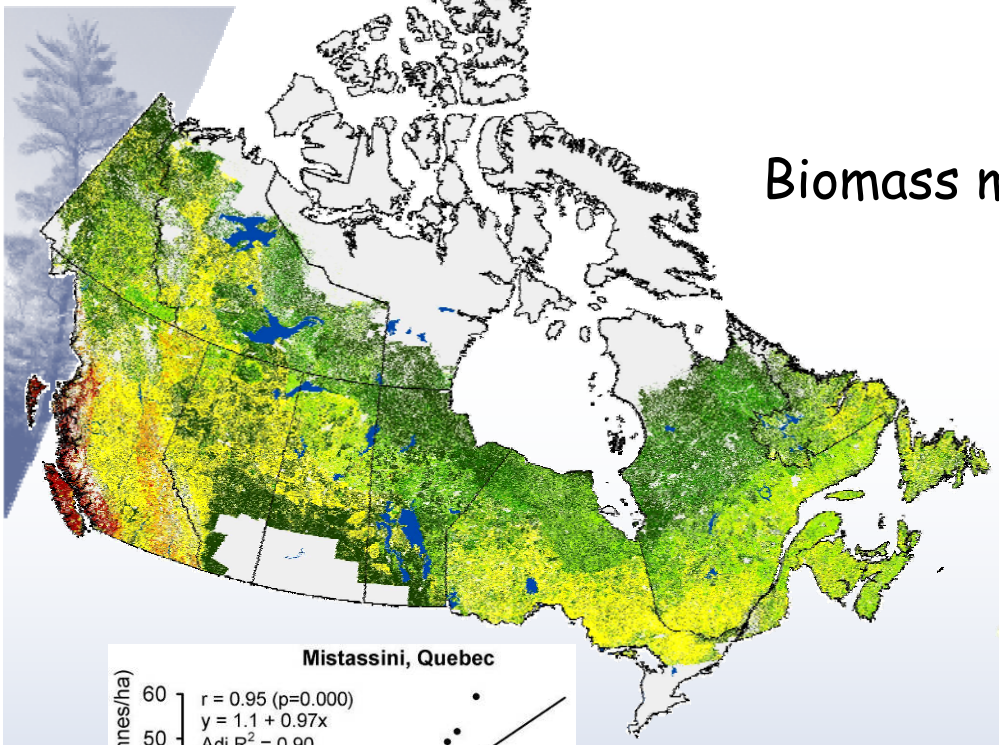
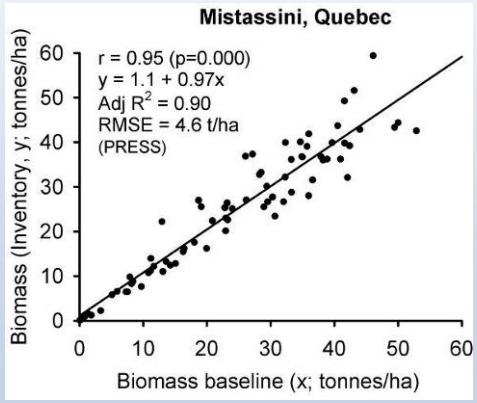
2. Current status: Circa 2000 EOSD Biomass

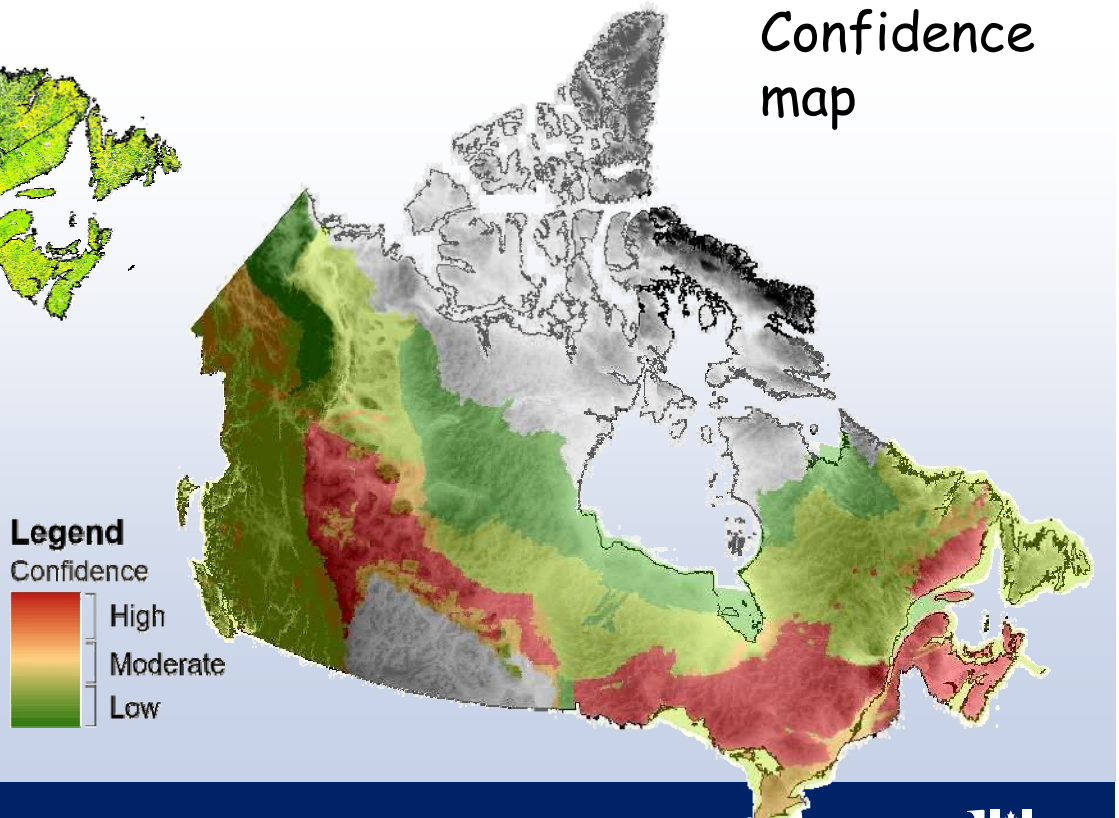




Biomass map



Confidence map



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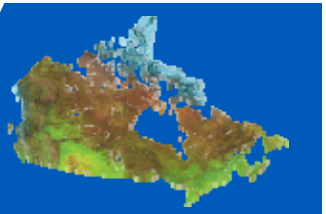
2. Current status: Circa 2000 EOSD Biomass



Limitations:

- Static biomass map for NFI needs without intent to update
- Use of hundreds Landsat scenes to cover Canada
- Coarse resolution estimate of age used to estimate height
- Optimal for coarse grain size > 1 km^2

One solution among others:

- Use med-res (250m) multi-source (optical and radar) coverage of Canada and impute biomass from NFI plots

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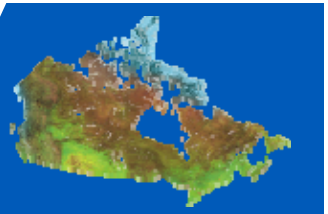
3. Perspectives: 2010+ Biomass from multi-source med-res RS data



Objectives:

- Produce an up-to-date (2010) spatially contiguous forest biomass map of Canada using MODIS-based framework
- Update the biomass map on a regular basis (5-10 years)

Approach:

1. link to CCRS North American Land Change Monitoring System (NALCMS, 250m land cover + change products) as a framework
2. Spatialize biomass from NFI plots at 250m res, using a non-parametric method (RT or kNN) and multi-source RS mosaics: MODIS, PALSAR and Rsat-2, along with climate and topo layers;
3. Update map through estimation in changed areas using MODIS-based change products (CCRS/CFS)

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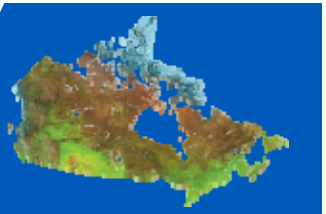
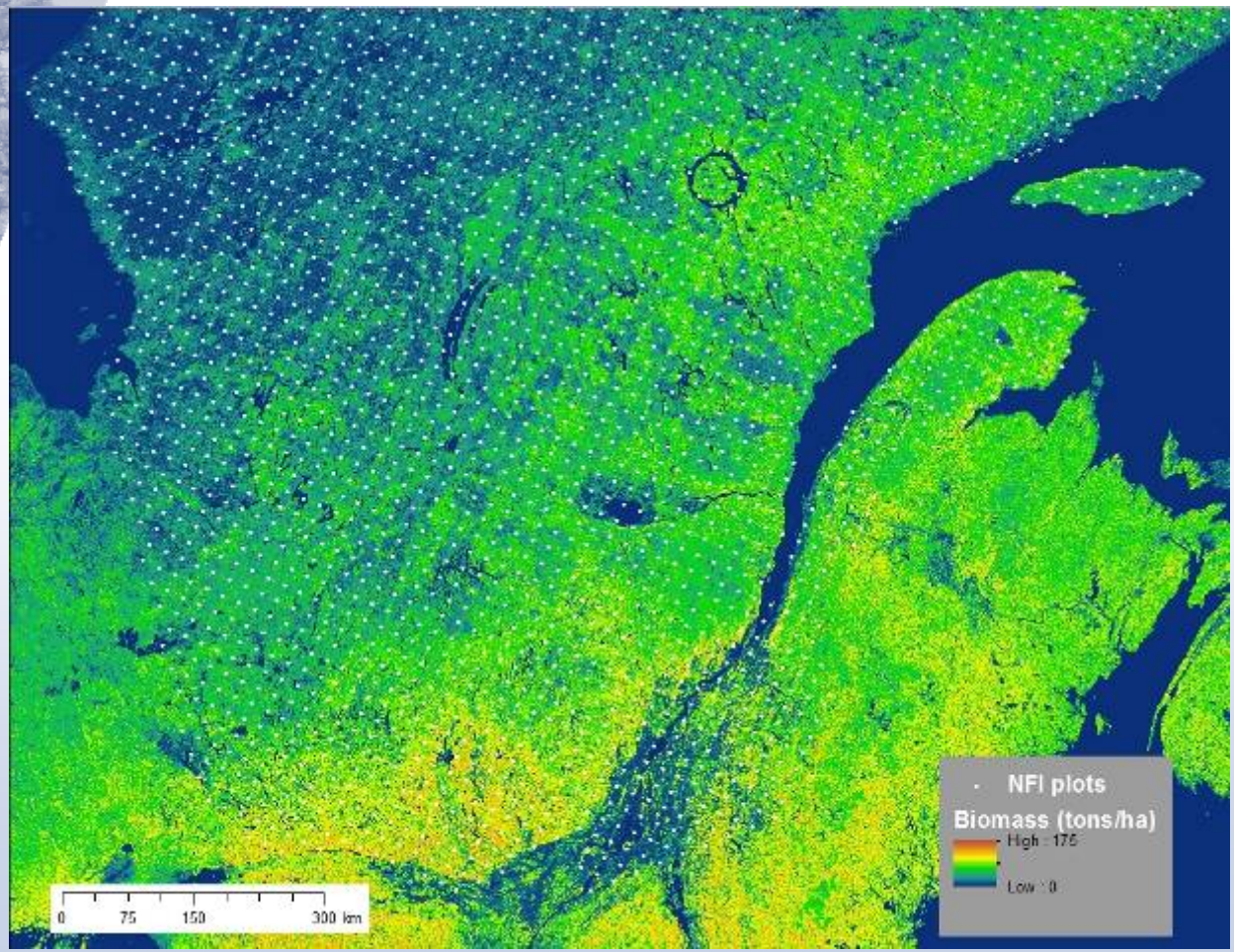


Example: MODIS-based kNN biomass map over Québec (2005)



MODIS: B1, B2, B6 composites, winter and summer, along with indices (CCRS)

Others:
- 7 climatic layers
-3 topo layers
- Forest/non-forest

Accuracy:
- 39% rel. RMSE
- negligible bias

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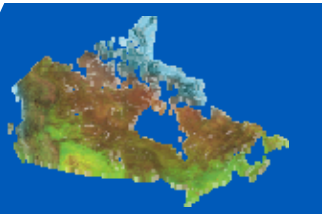
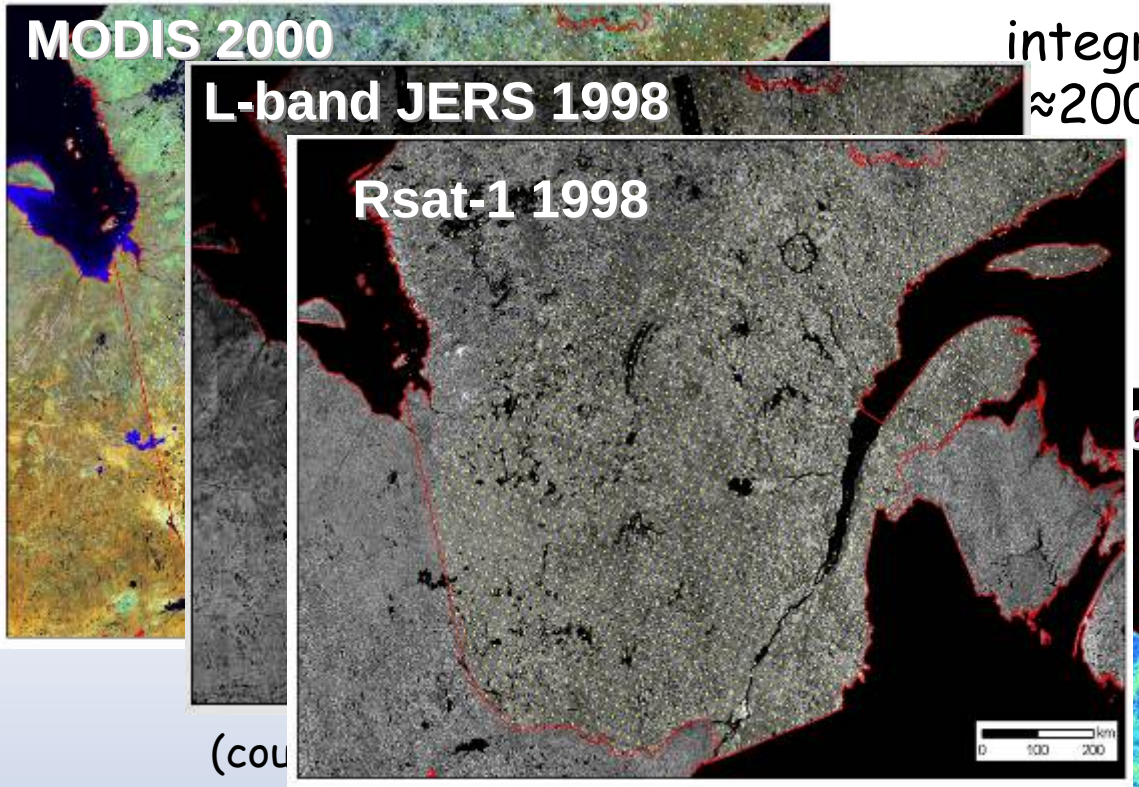
3. Perspectives: 2010+ Biomass from multi-source med-res RS data



Future MODIS and radar mosaics integration for improved imputation
≈2000 illustration; targeted: 2010)



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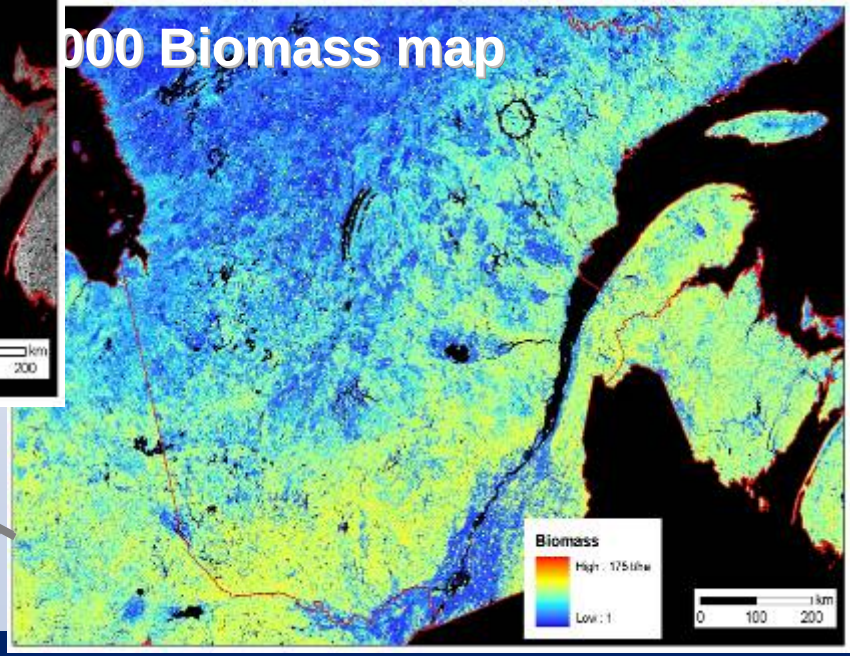
Predictive improvements

KNN or RT



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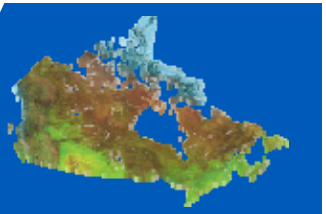
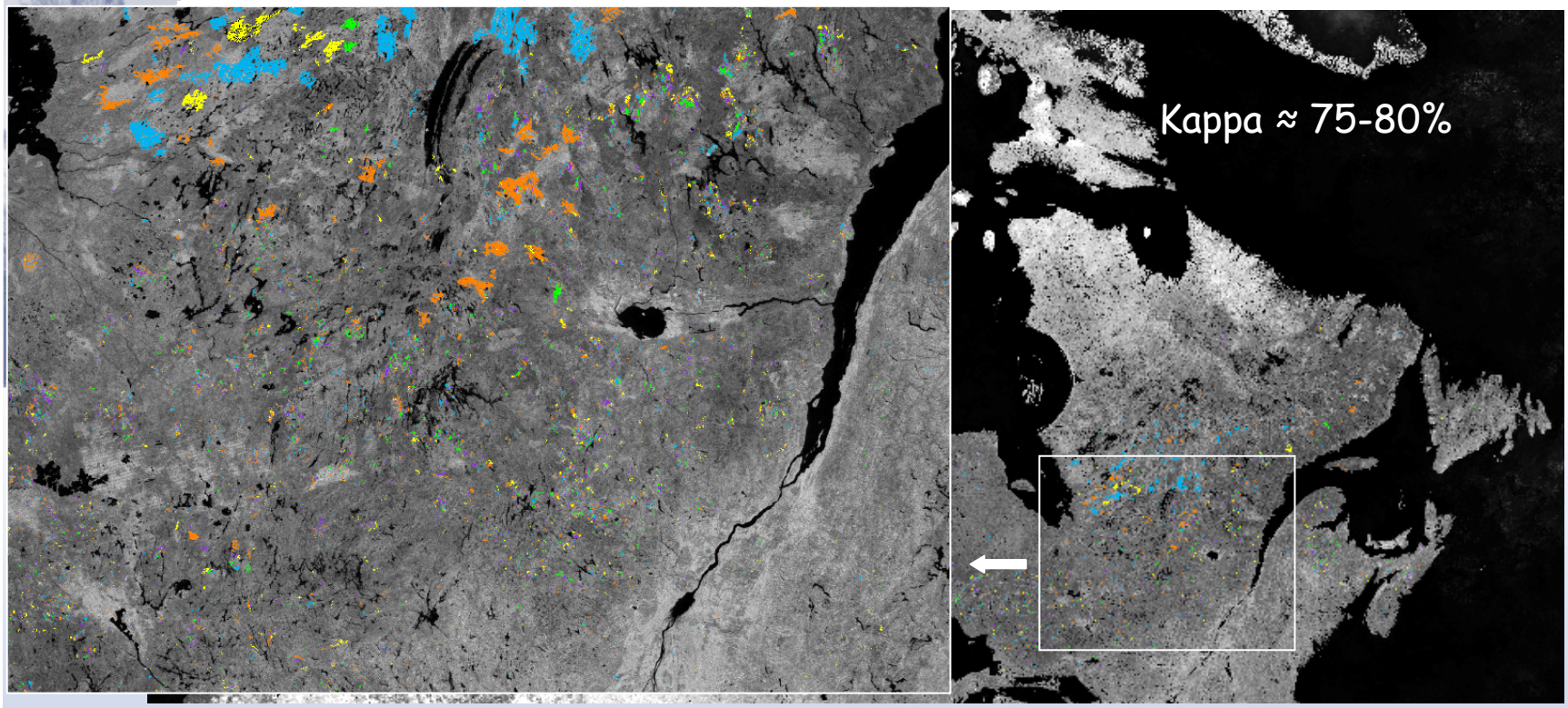


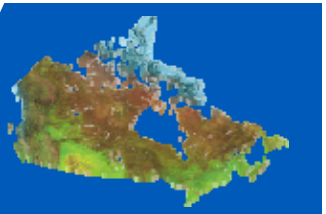
MODIS 2001-2010 annual forest change products



© 2006 CCRS (courtesy D. Pouliot & R. Latifovic)

On-going production beyond 2006 for NALCMS and NFI needs (CCRS/CFS partnership), would provide areas to be updated for biomass

Summary Remarks



1. Wide range of biomass information needs in Canada.
2. Current biomass products include estimates (NFI) and spatial maps (EOSD, ca 2000).
3. Needed : a nat'l biomass mapping and updating methodological framework based on MODIS 250 m along with simple estimation methods ingesting MODIS data and other key predictive layers such as PALSAR mosaics
4. Challenges:
    1. Huge country with inventory data gaps (north)
    2. No single approach is optimal, but needs integrating sensors, in-situ data, and allometric functions.
    3. Validation of large area estimates always a challenge.
    4. Implementation and data source flexibility (ex: MODIS)

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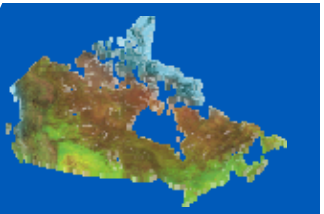

2. R&D for specific forest applications from PALSAR and Radarsat-2

A. Beaudoin, D. G. Goodenough, H. Chen and D. Leckie
(CFS scientists with radar background)

15th ALOS K&C Science Team meeting,
Jan. 24-28, Tokyo, Japan

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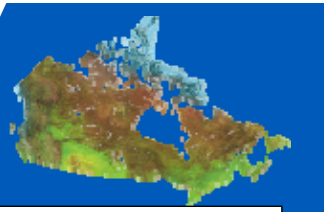
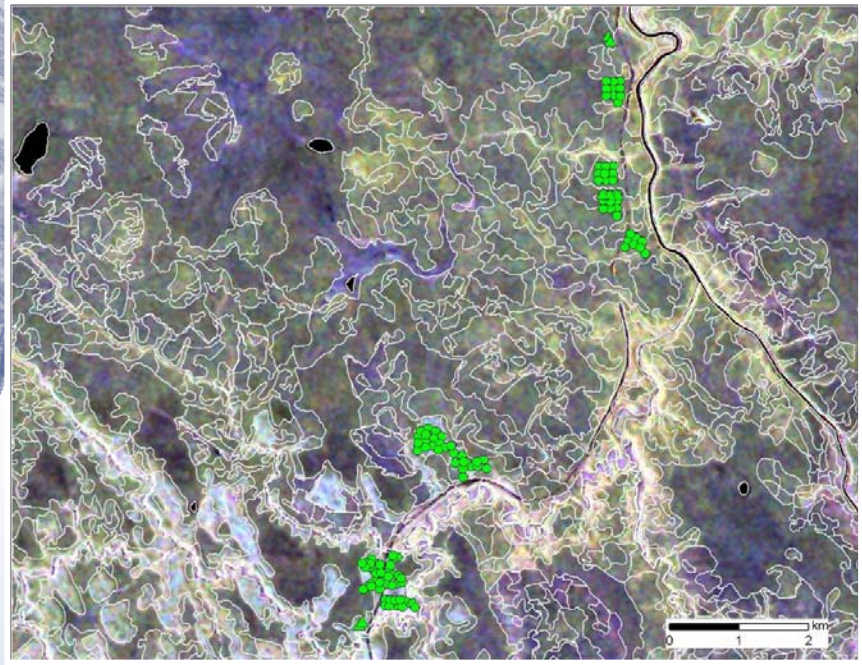
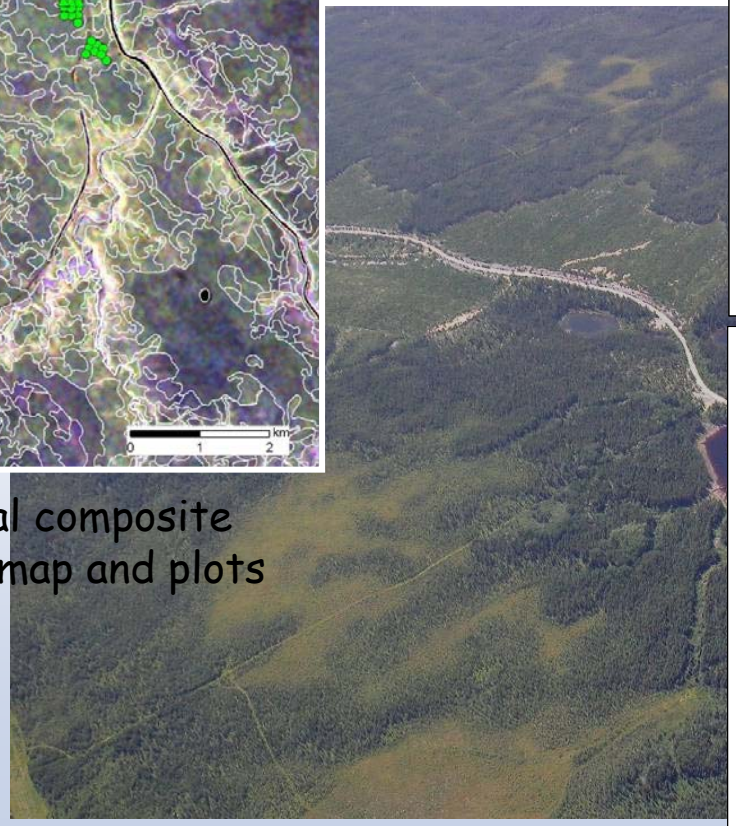
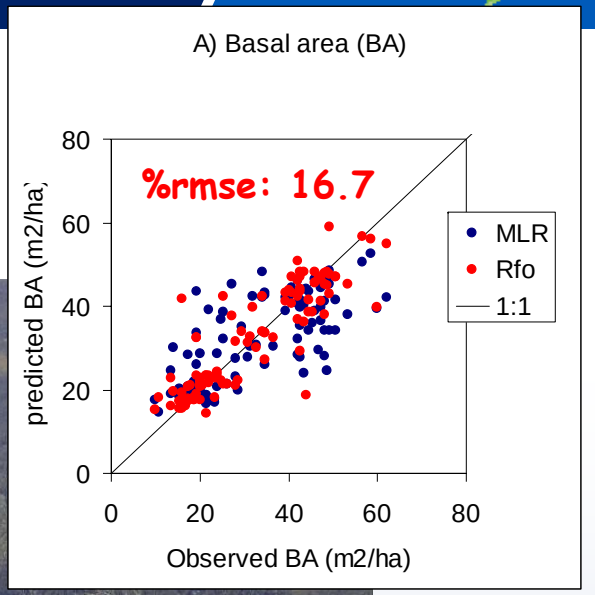
1. Improving forest maps of wet boreal forests with paludification info using L-/C-band radar (A. Beaudoin, LFC)

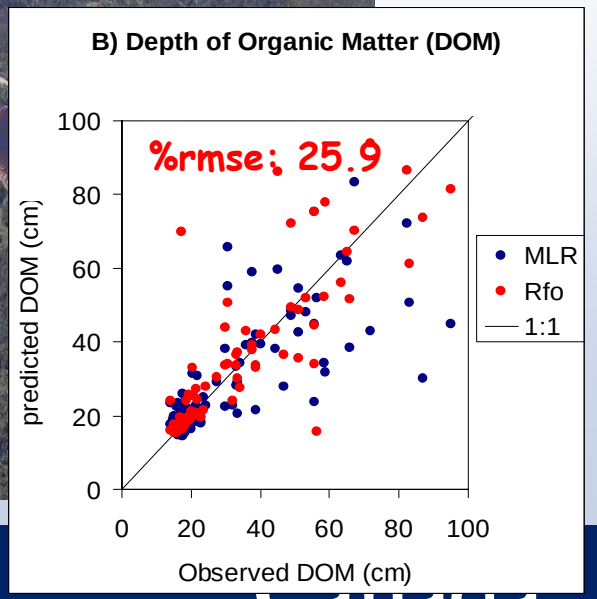




PALSAR FBS HH temporal composite (2008) along with forest map and plots







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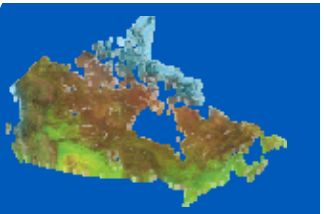
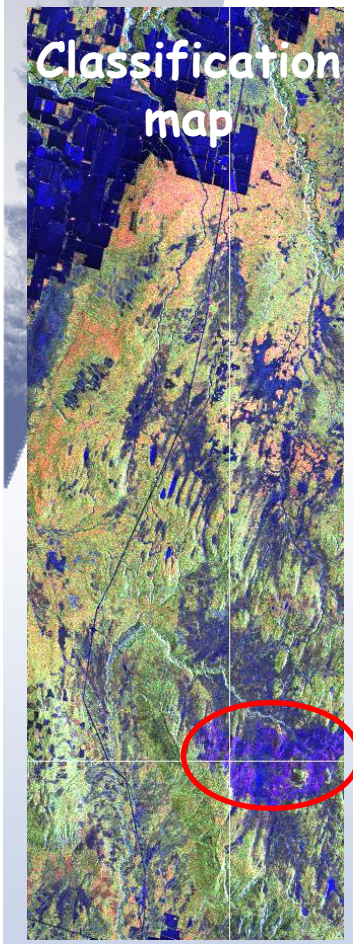
2. Various radar Products for Forestry

(D. G. Goodenough and H. Chen, PFC)



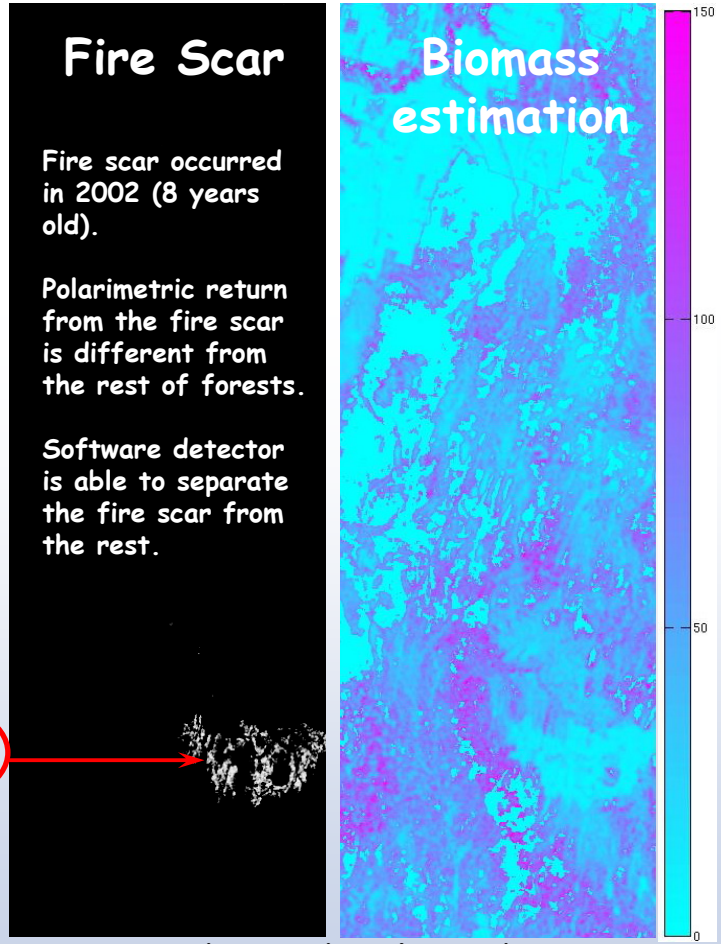


Fire Scar

Fire scar occurred in 2002 (8 years old).

Polarimetric return from the fire scar is different from the rest of forests.

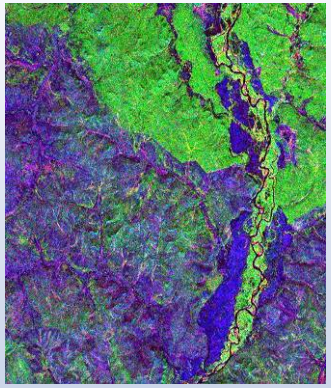
Software detector is able to separate the fire scar from the rest.



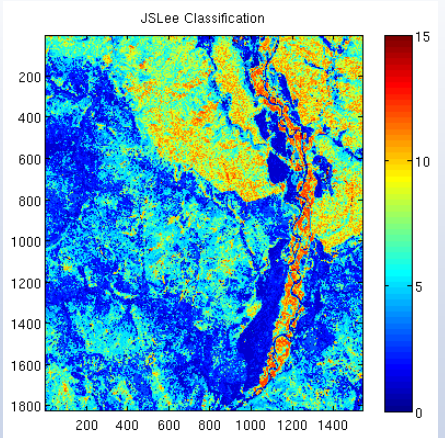
ALOS PALSAR L-band Quad-pol Products
April 6, 2009, Key River, AB

Fire Scar

Fire scar occurred in 2001 (9 years old).

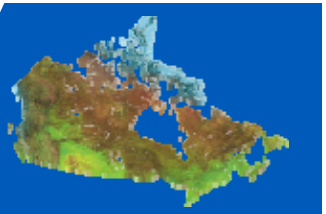


Classification

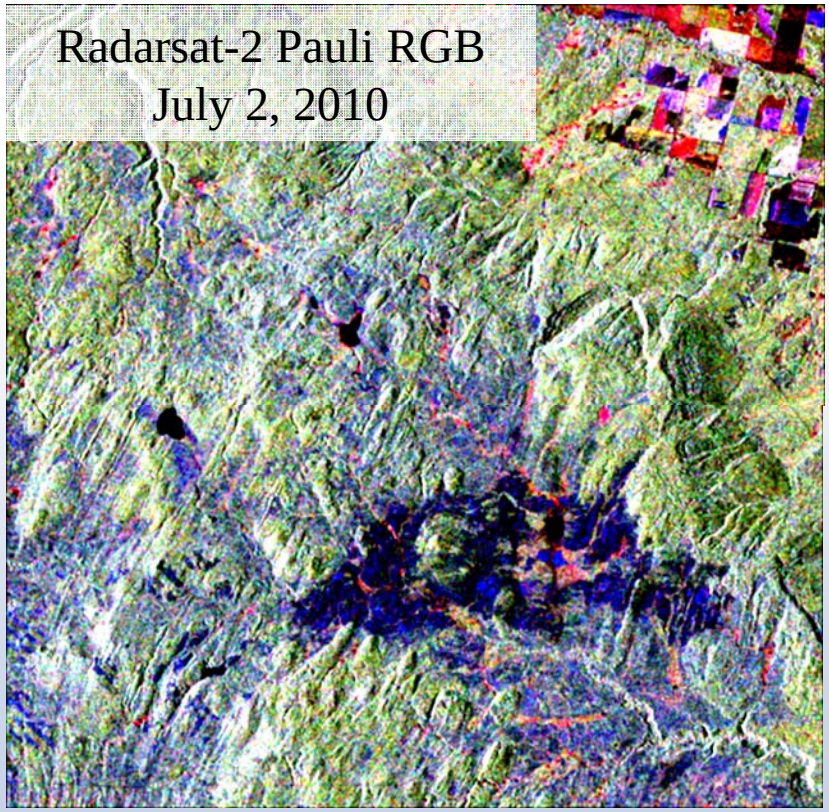


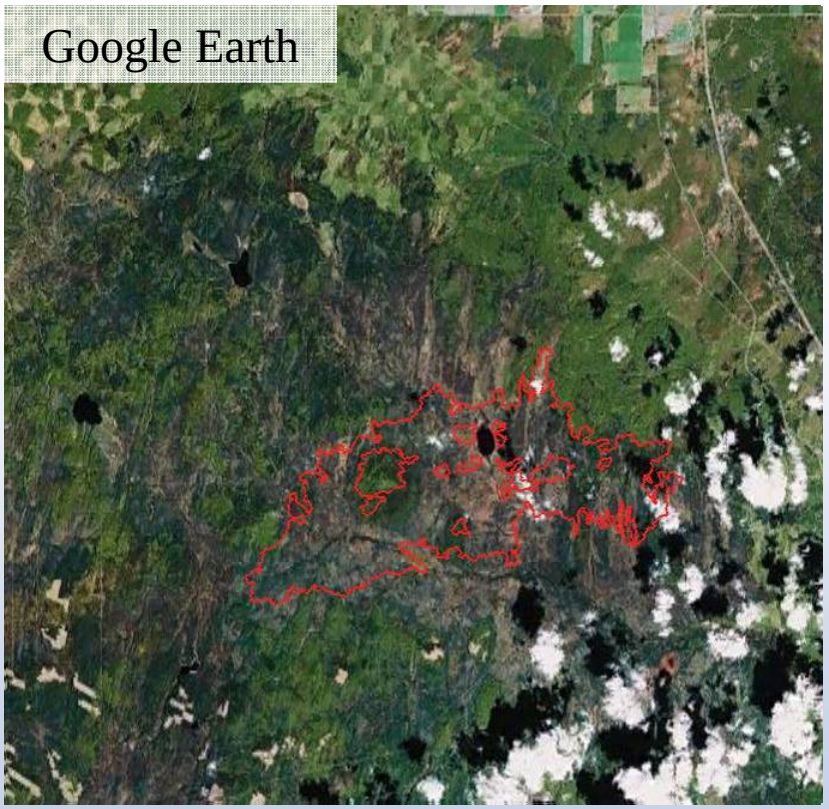
Radarsat-2 C-band Quad-pol Products
October 18, 2009, Ta-He, Northeast China

3. Boreal fire scare mapping from quad-pol radar (D. G. Goodenough and H. Chen, PFC)

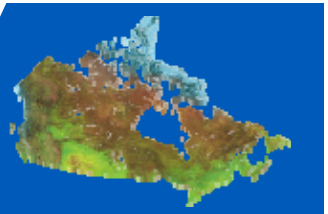


fire scar areas in Key River, AB.



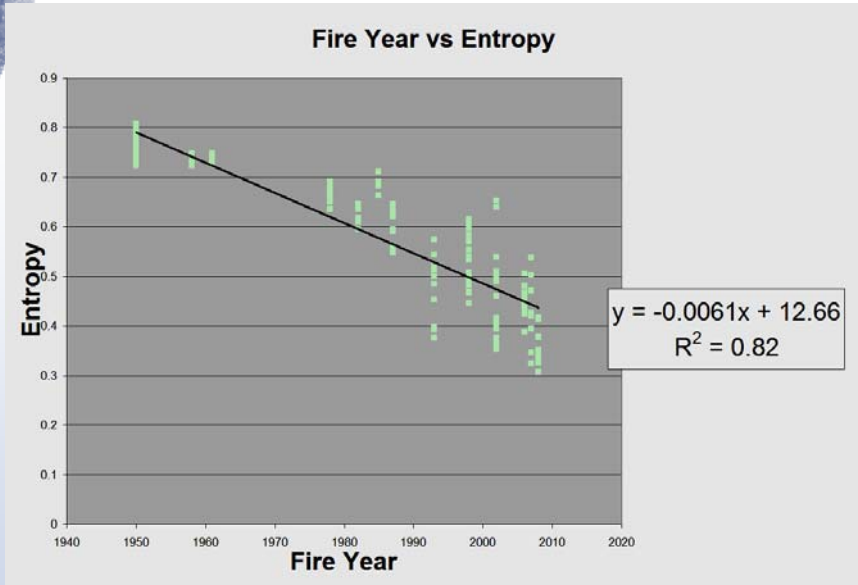


3. Boreal fire scare mapping from quad-pol radar (D. G. Goodenough and H. Chen, PFC)

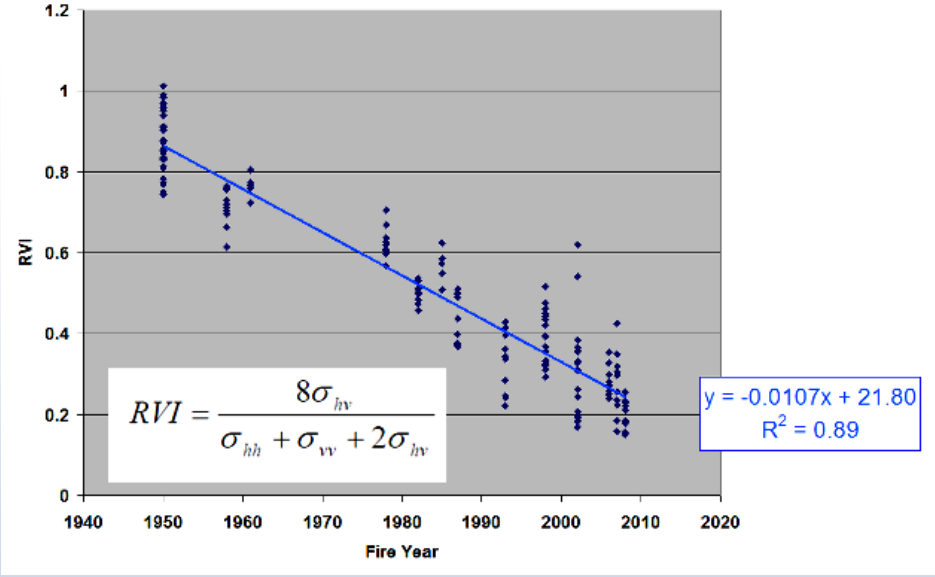


6 PALSAR scenes with 17 fire events from 160 plots showing a trend of fire scar ages → Age of fire scars could be estimated.

Polarimetric approach



Multi-pol approach



Perpsective: map fire scares with age along with biomass losses/gains

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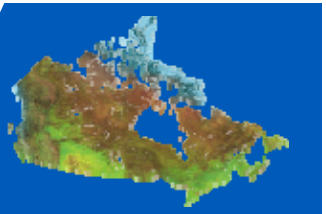
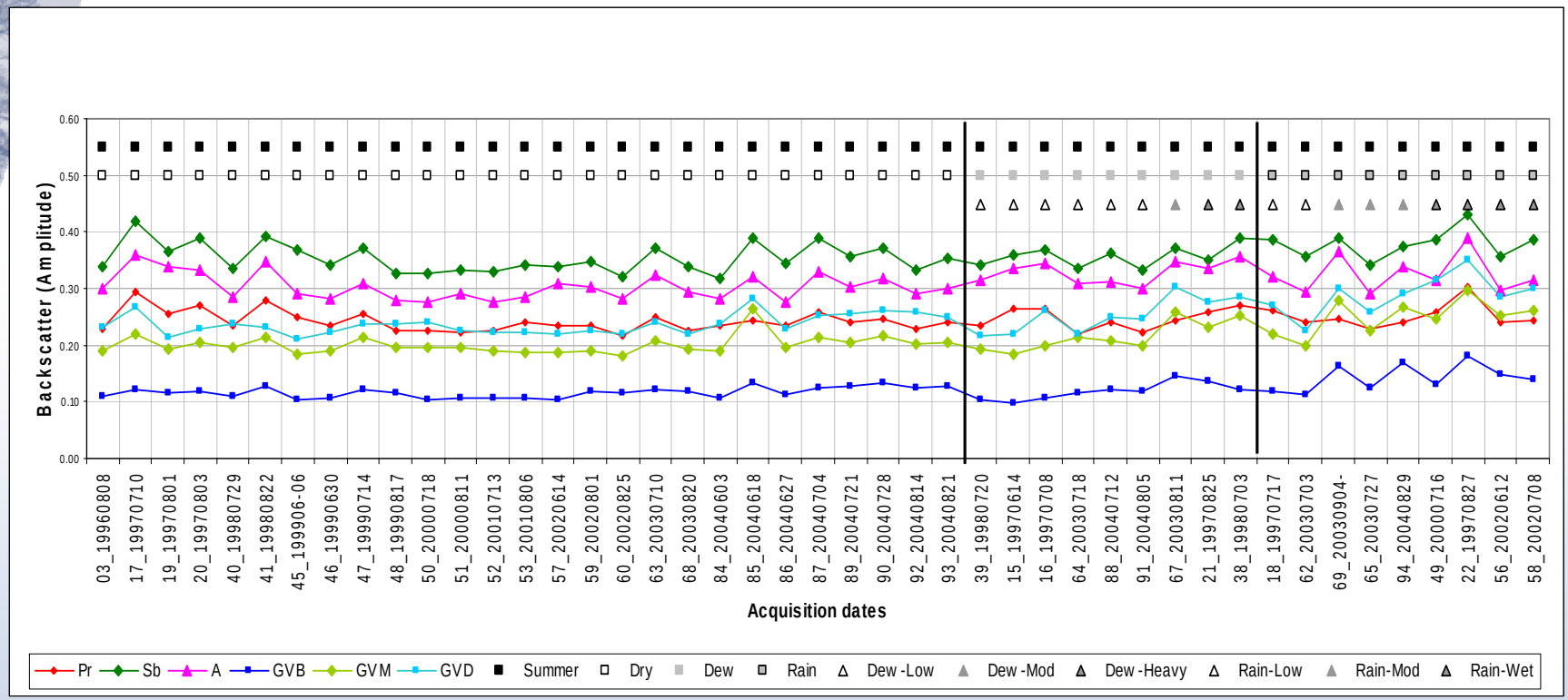
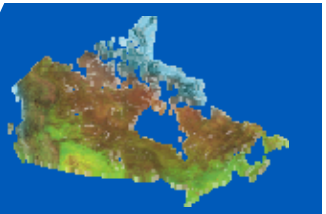
4. Impact of environmental conditions

(D. G. Leckie, PFC)



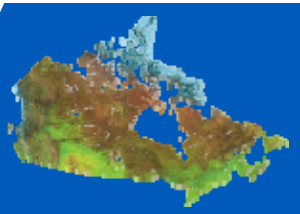


5. Key findings at CFS regarding PALSAR



- **Polarimetric data :**
- Phase information data was utilized in order to get accurate biomass estimation.
- Random Volume Over Ground (RVOG) model was used to estimate maximum ratio of surface-to-volume (μ) as a useful biomass predictor
- Entropy showed to be correlated to fire scares age
- Polarimetry useful for forest and fire scar classification prior to biomass mapping

- **Multi-pol data:**
- Confirmed good correlation with basal area and biomass in wet boreal forests (log transformed); temporal series useful to reduce impact of dry/wet ground or use it for paludification mapping
- New regional application related to the estimation of depth of organic matter (under development, CSA funds)
- Multi-pol L-band radar vegetation index useful for mapping fire scares age



3. CFS interests in ALOS K&C Initiative 3rd phase (2011-2014)

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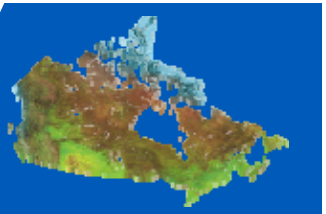
1. Potential activities of mutual interest ?

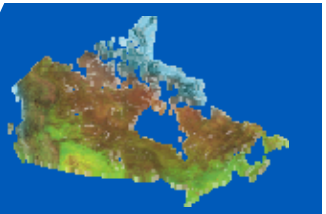


- Test non-parametric methods (kNN, RT) towards mapping biomass of Canada using 2007-2009 PALSAR products (25m HH-HV mosaics and 10 m forest cover) and validate :
  - local/regional level using 25m mosaic data (plot data)
  - national level at 250m resolution (NFI plots)

- Test and validate quad-pol methods to map key forest attributes in boreal regions prone to fires

- Promote and release jointly PALSAR-based biomass and other products along with publications (scientific articles, promotional documents, etc…)

1. Potential activities of mutual interest ?

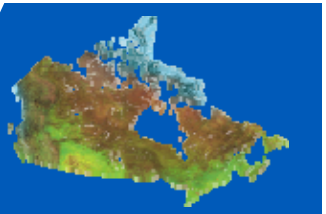


- Provide and exchange scientific knowledge & expertise related to forest remote sensing and JAXA PALSAR for mutual benefits (CFS: Goodenough, Beaudoin, Leckie, Chen; CCRS: Touzi and Fernandes)

- Partner with ALOS K&C team members particularly involved in N. American activities (ex: NASA/JPL) and those in boreal regions for mutual leveraging, if any

- Represent CFS and its contributing partners through A. Beaudoin (CCRS, universities, provinces,…)

2. Challenges



- Limited CFS resources to participate to Int'l initiatives BUT a new project to be submitted to Canadian Space Agency on national biomass mapping could partly support (Leaders; A. Beaudoin and D.G. Goodenough)

- Restrictions on access to Canadian data sets:
  - NFI and provincial inventory plot data can't be released to int'l 3rd parties
  - Other data sets (imagery, value-added products out of imagery, etc) : to be seen, easier depending on provider's data and licensing policies
  - Some CFS research plots : possibly

- Participation to related GEO-FCT not guaranteed (Mexico)

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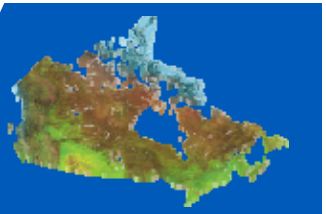
Acknowledgments



- Natural Resources Canada
- Funding support by the Canadian Space Agency
- Numerous provincial, industrial and crown corporations in support of NFI, EOSD land cover and biomass.
- Collaboration with Canada Centre for Remote Sensing for MODIS data and NALCMS change and land cover
- MDA/CSA for Rsat-2 data
- JAXA for PALSAR data

CSA ASC