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Mapping the Boreal zone – forest cover and forest cover loss 2000 to 2005

a - South Dakota State University, GIScCE

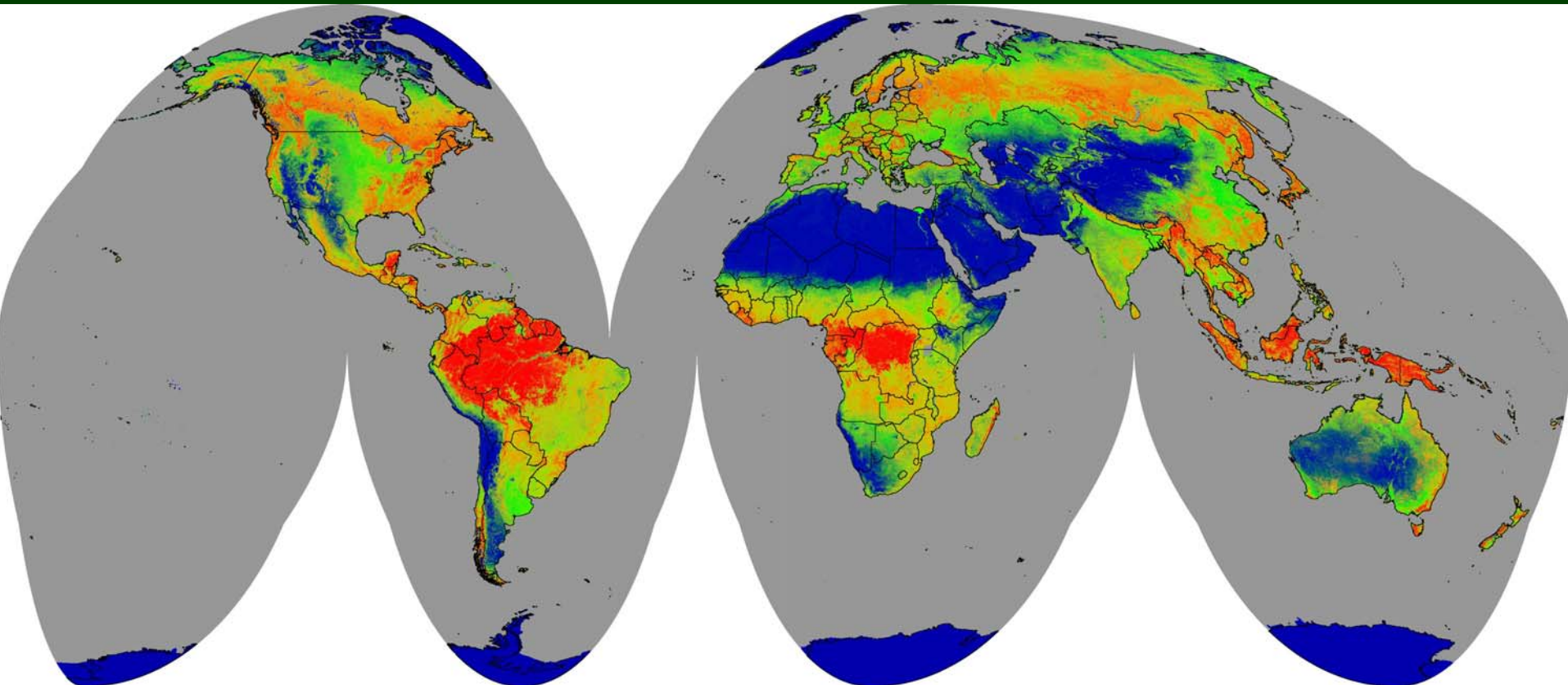
b - State University of New York, SUNY-ESF

c – USGS, EROS Data center

d - University of Maryland



MODIS Vegetation Continuous Fields – 2000



Bare ground

Grass/shrubs/moss

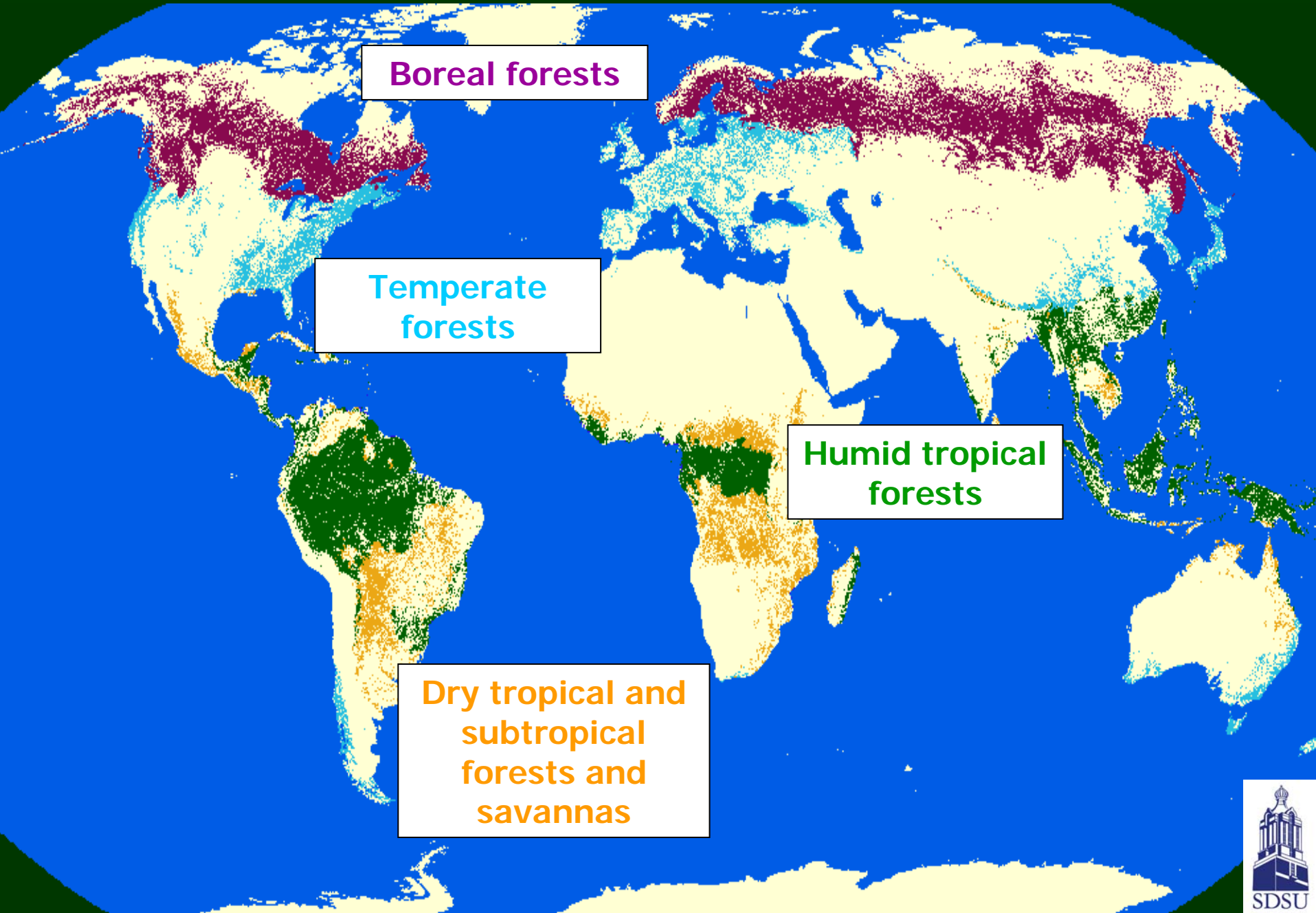
Trees

Percent cover

0%

100%

Major forest biomes of the World



Boreal forests

Temperate forests

Humid tropical forests

Dry tropical and subtropical forests and savannas

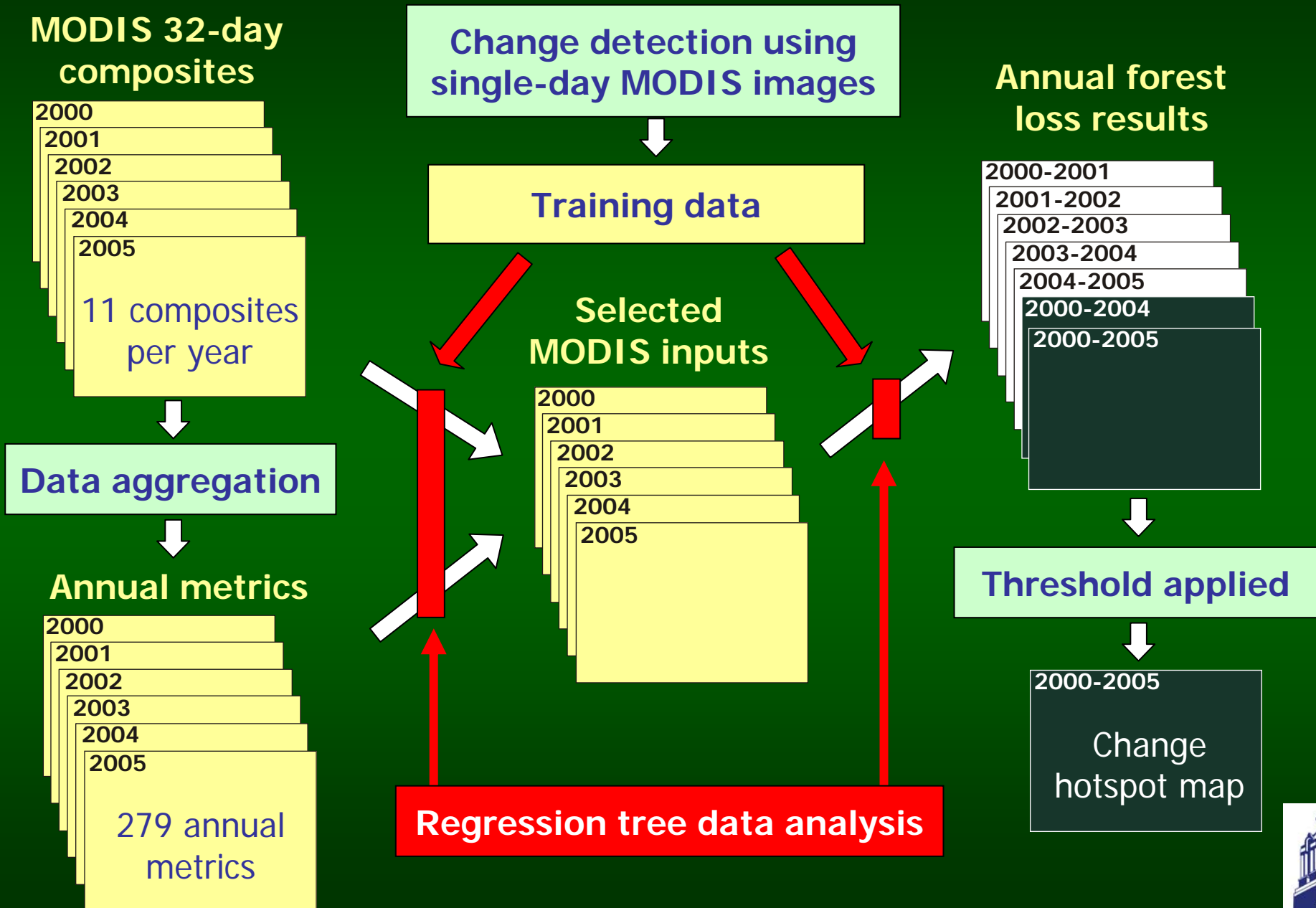
Mapping boreal forest cover and forest cover loss, 2000 to 2005

- Use a sampling approach with Landsat data to estimate area of change
- Employ MODIS to stratify boreal biome into high, medium and low areas of change
- Also use MODIS in the analysis phase via a regression estimator procedure
- Integrated approach enables rapid assessment of biome-scale change with known uncertainty
- The approach employs MODIS data on an annual basis and Landsat data for years 2000 and 2005
- Maps presence or absence of tree cover, disregarding forestry land use definitions

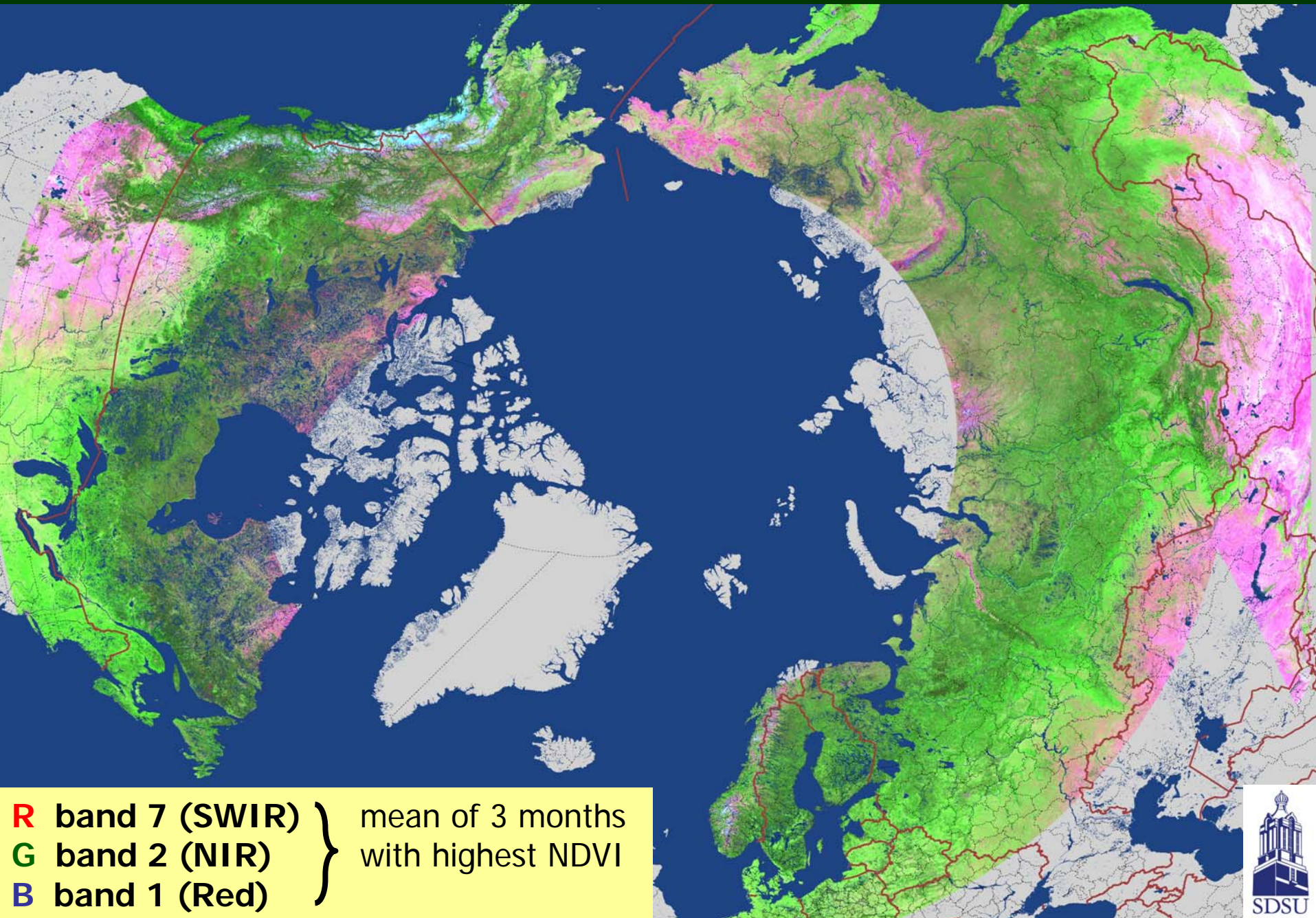
Biome-scale MODIS-based forest cover loss monitoring

- MODIS data time series analysis is based on annual metrics instead of monthly composites alone
- Classification and regression tree (CART) classification algorithm employed as primary tool for intellectual data analysis and change mapping
- Single supervised classification model used for biome-wide annual data analysis
- Sub-pixel percent forest cover change training were used as a dependent variable. Coarse resolution training data set developed from higher resolution imagery

MODIS time-series data analysis

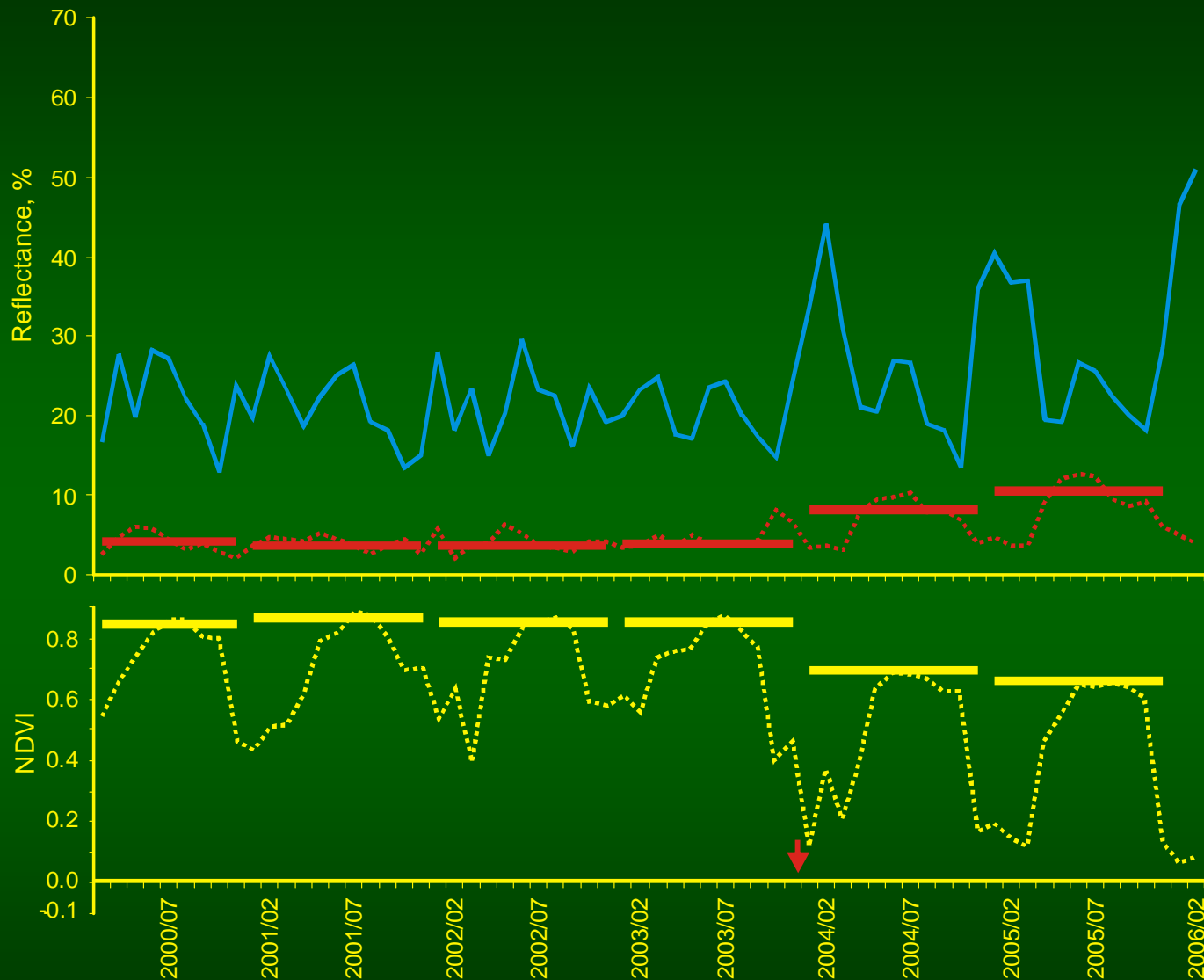


Example of annual MODIS metrics – boreal region



R band 7 (SWIR) } mean of 3 months
G band 2 (NIR) } with highest NDVI
B band 1 (Red)

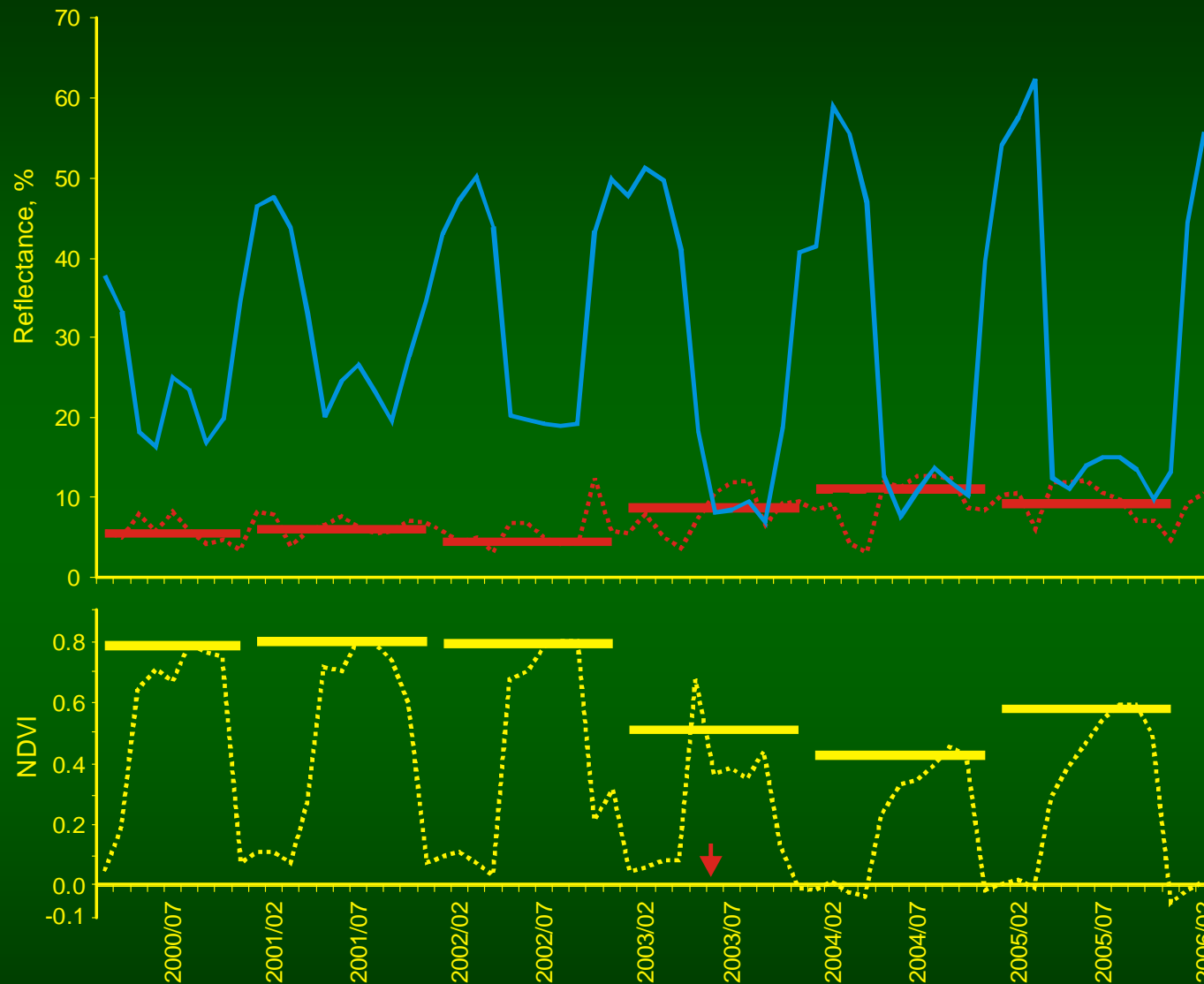
Change signal on MODIS metrics



Area affected
by clearcut
(Québec,
Canada)

- SWIR band
- Mean SWIR-band value for 3 greenest month
- NIR band
- Monthly NDVI
- mean NDVI of 3 greenest month

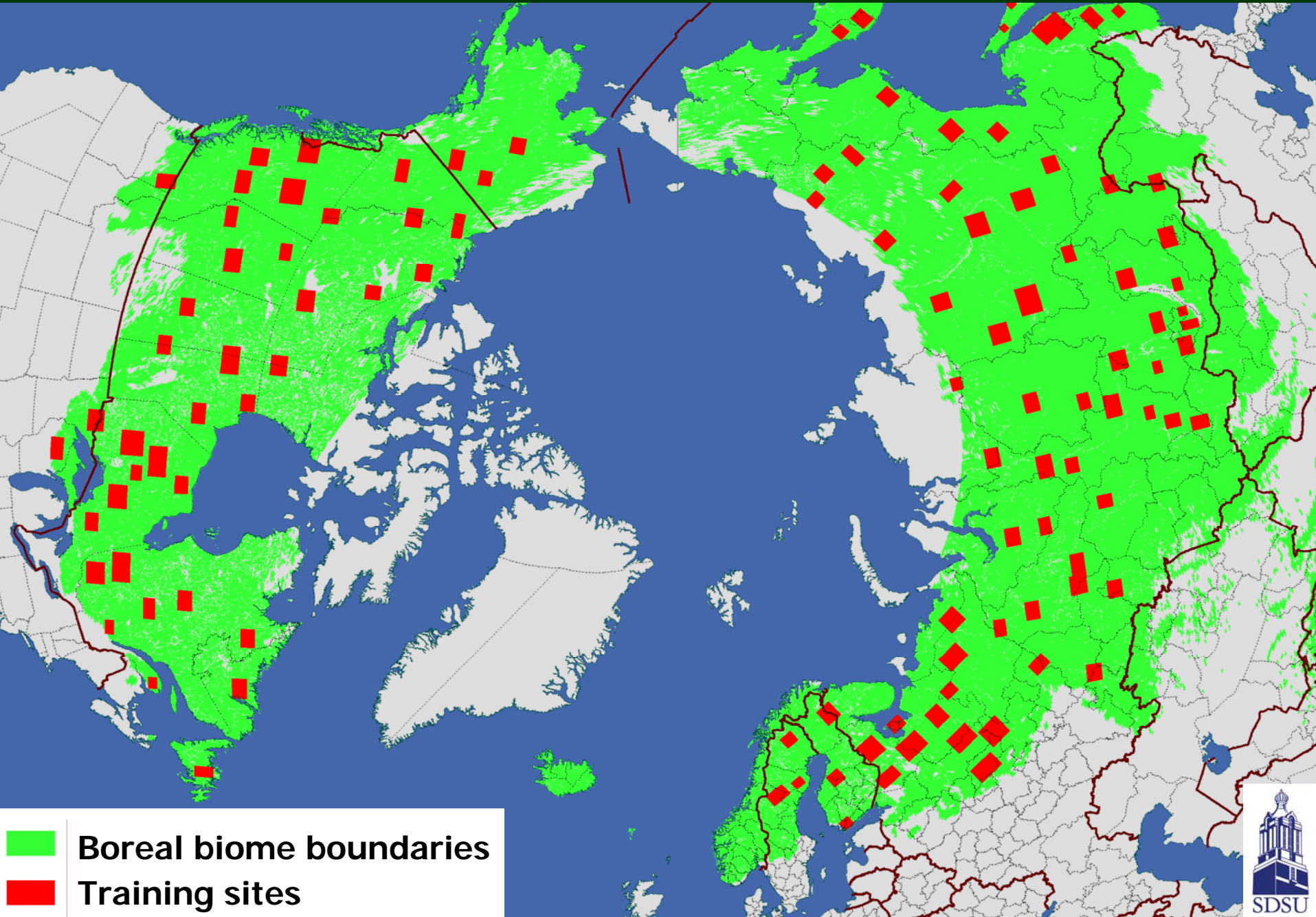
Change signal on MODIS metrics



**Area affected
by stand-
replacement
fire (Québec,
Canada)**



Training sites distribution – Boreal biome

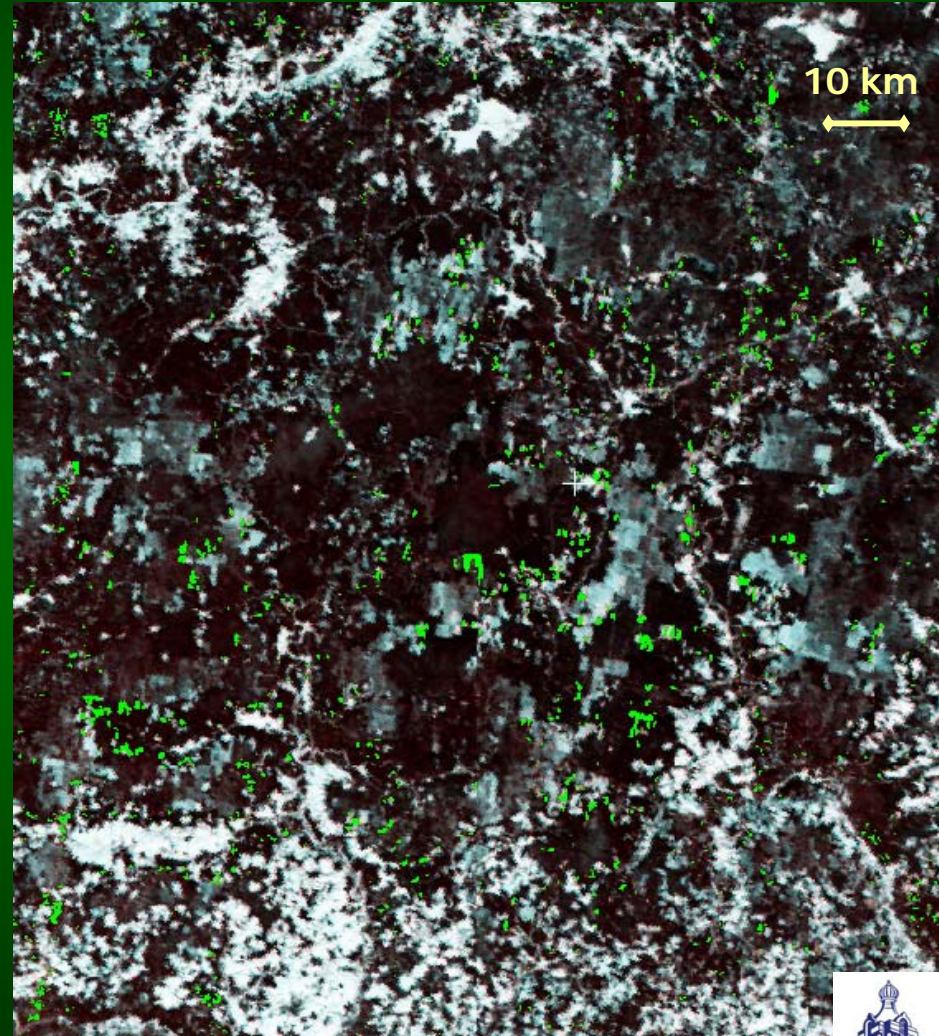
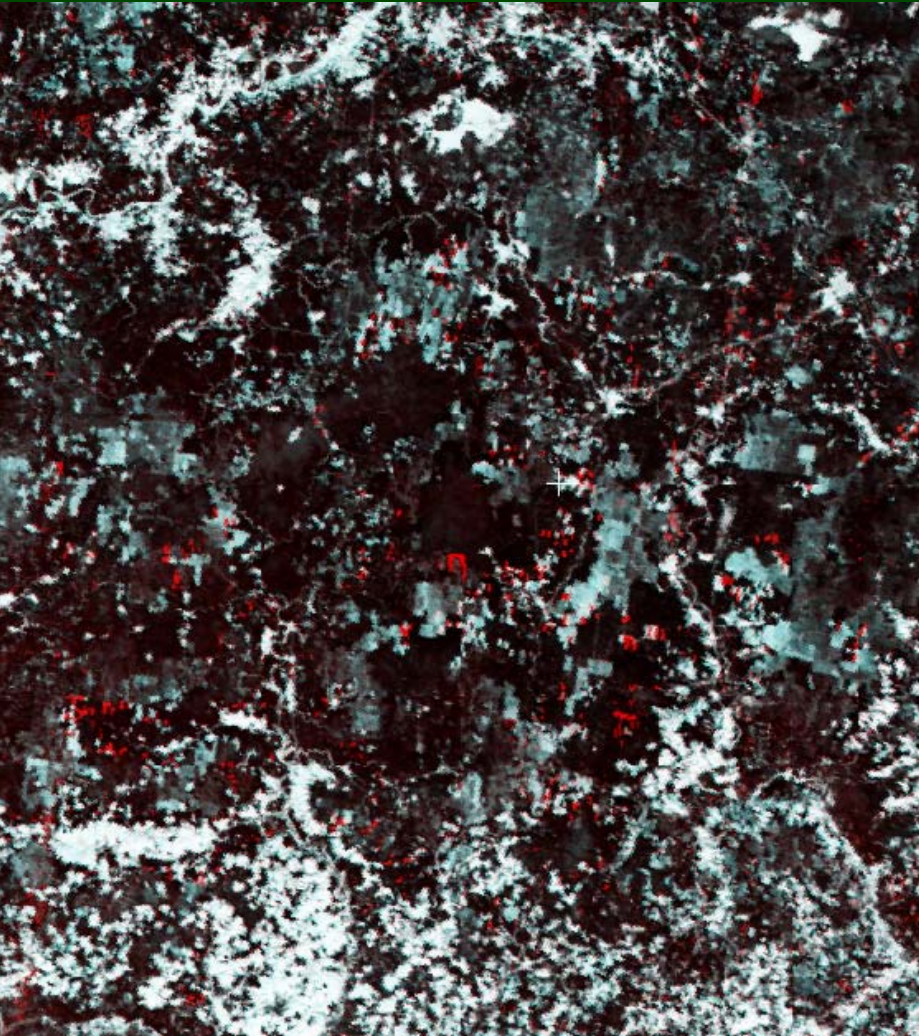


-  Boreal biome boundaries
-  Training sites

Training site example – Boreal biome

MODIS NIR band (250m)
Multi-temporal composite

Classification results



■ Main areas of forest removal

■ Forest cover loss areas

Annual forest cover loss in Alaska (USA) and Yukon (Canada)

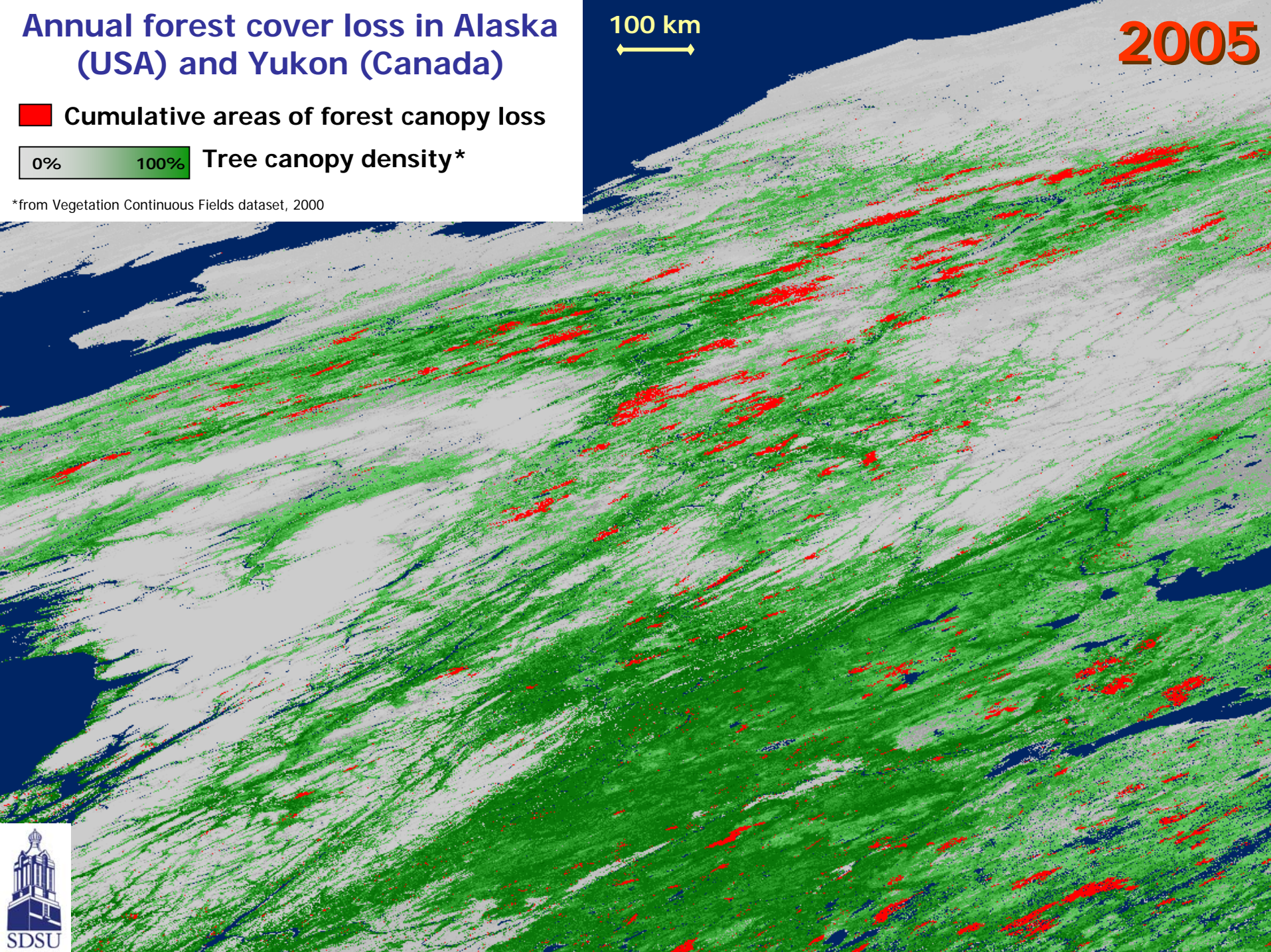
100 km
↔

2005

 Cumulative areas of forest canopy loss

 Tree canopy density*

*from Vegetation Continuous Fields dataset, 2000



Annual forest cover loss in Quebec (Canada)

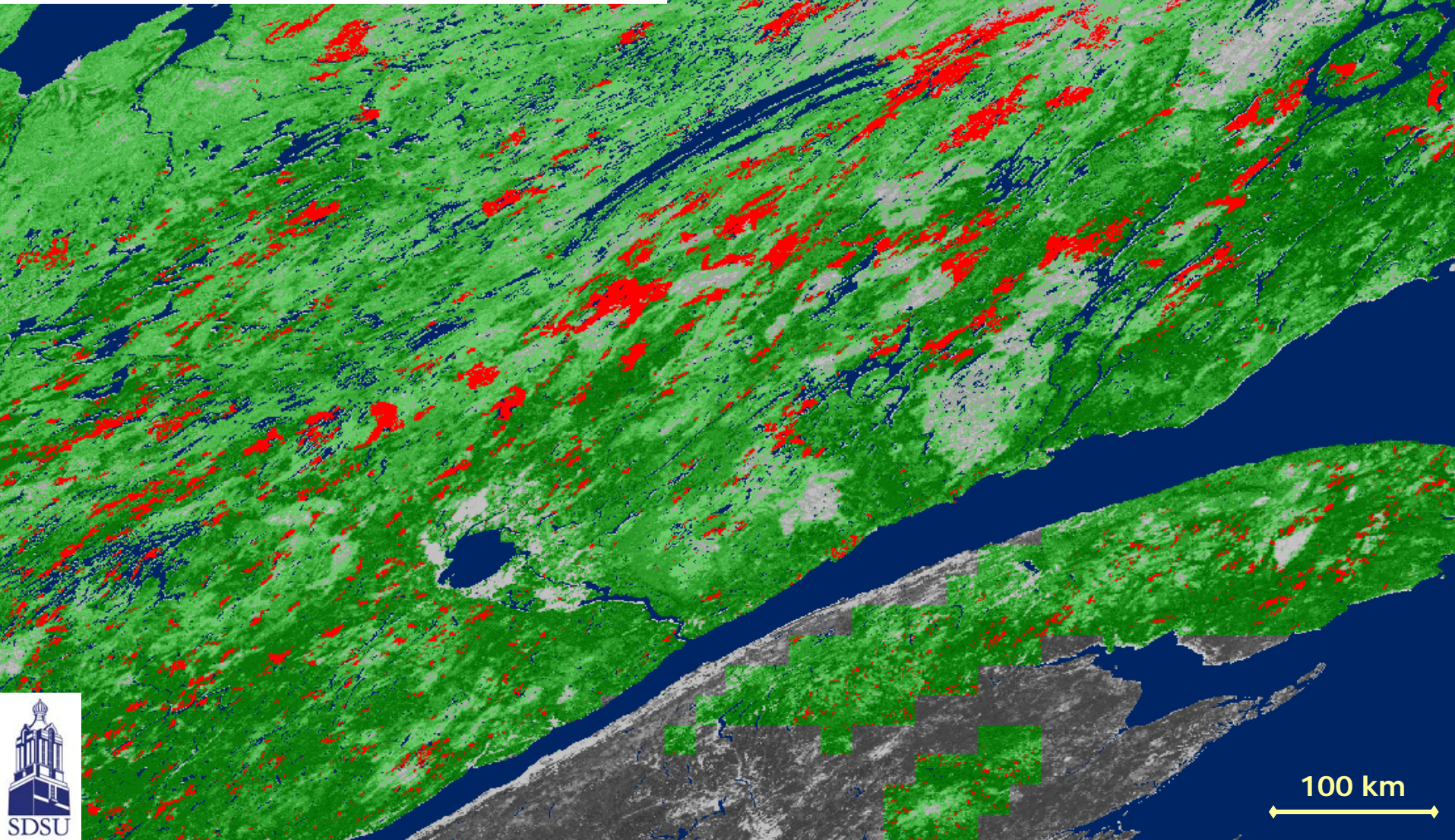
2005

 Cumulative areas of forest cover loss

0%  100%

Tree canopy density*

*from Vegetation Continuous Fields dataset, 2000



100 km

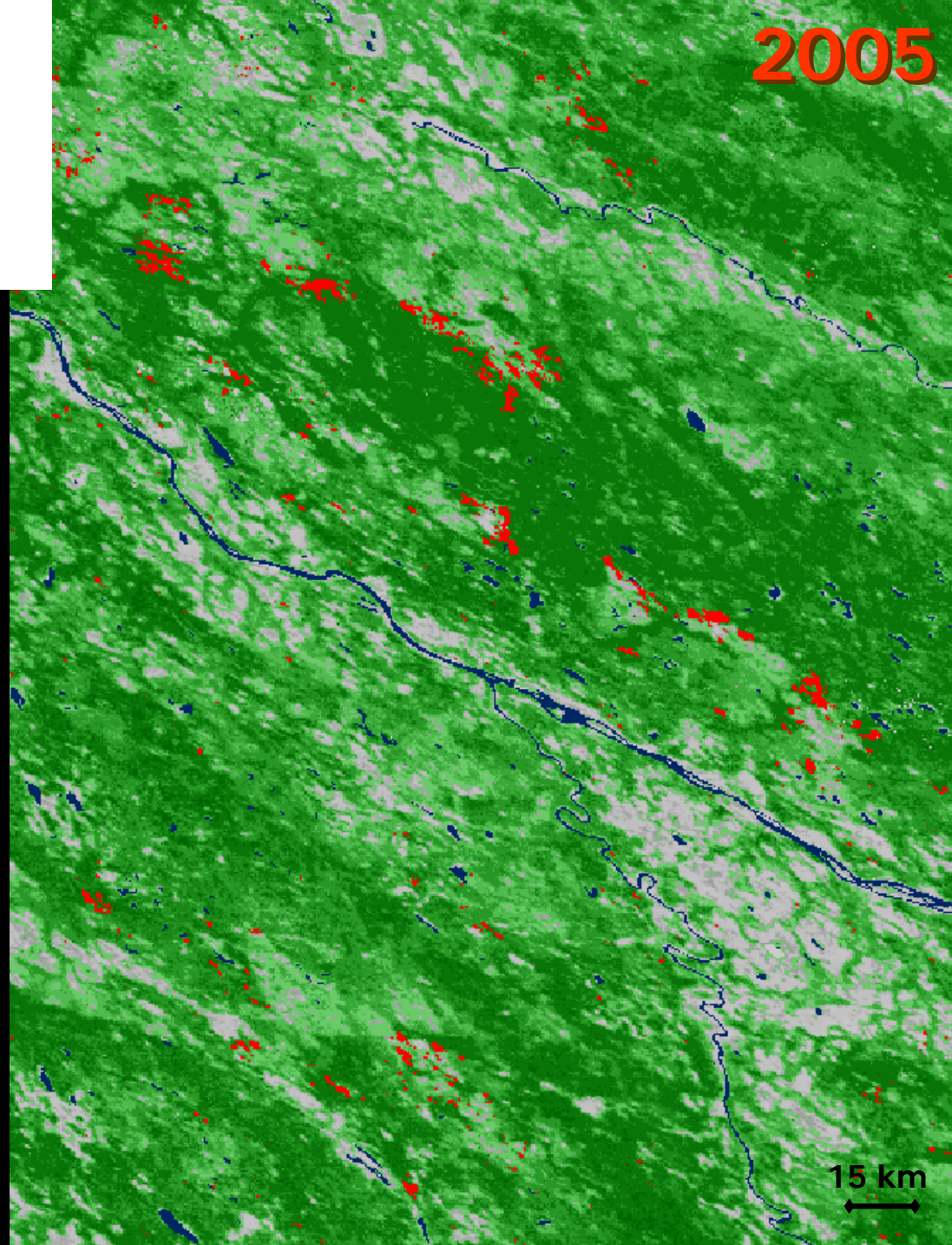
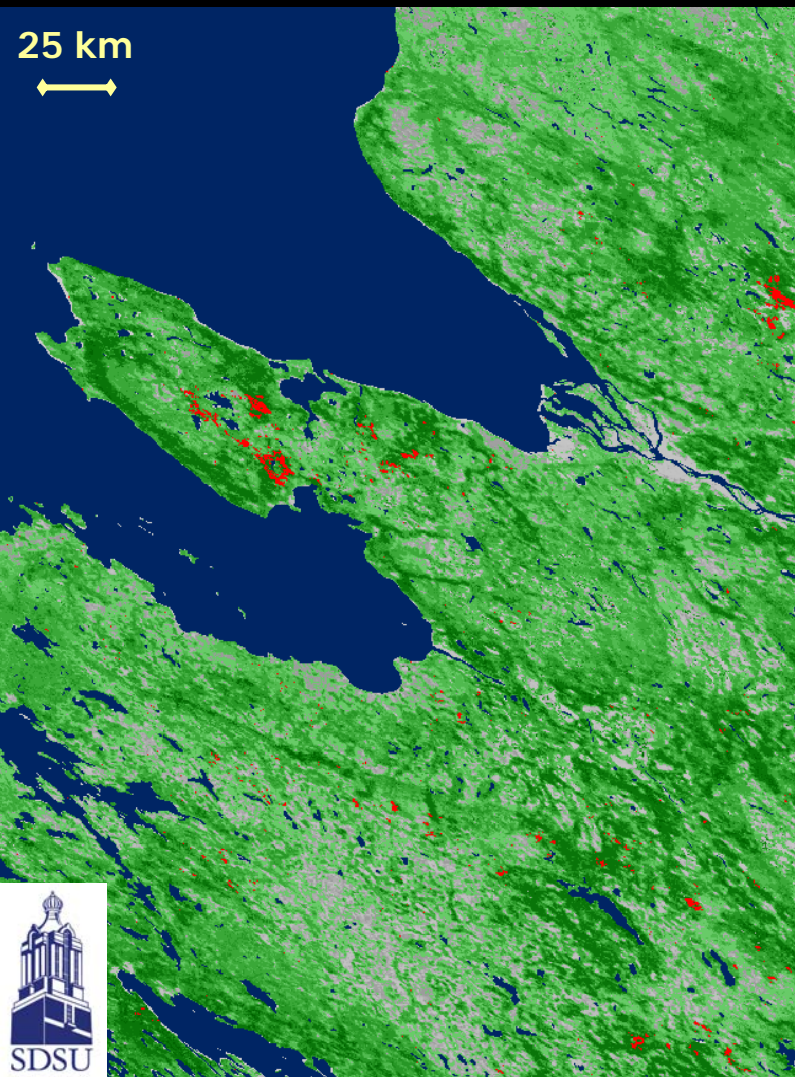
Annual forest cover loss in European Russia

2005

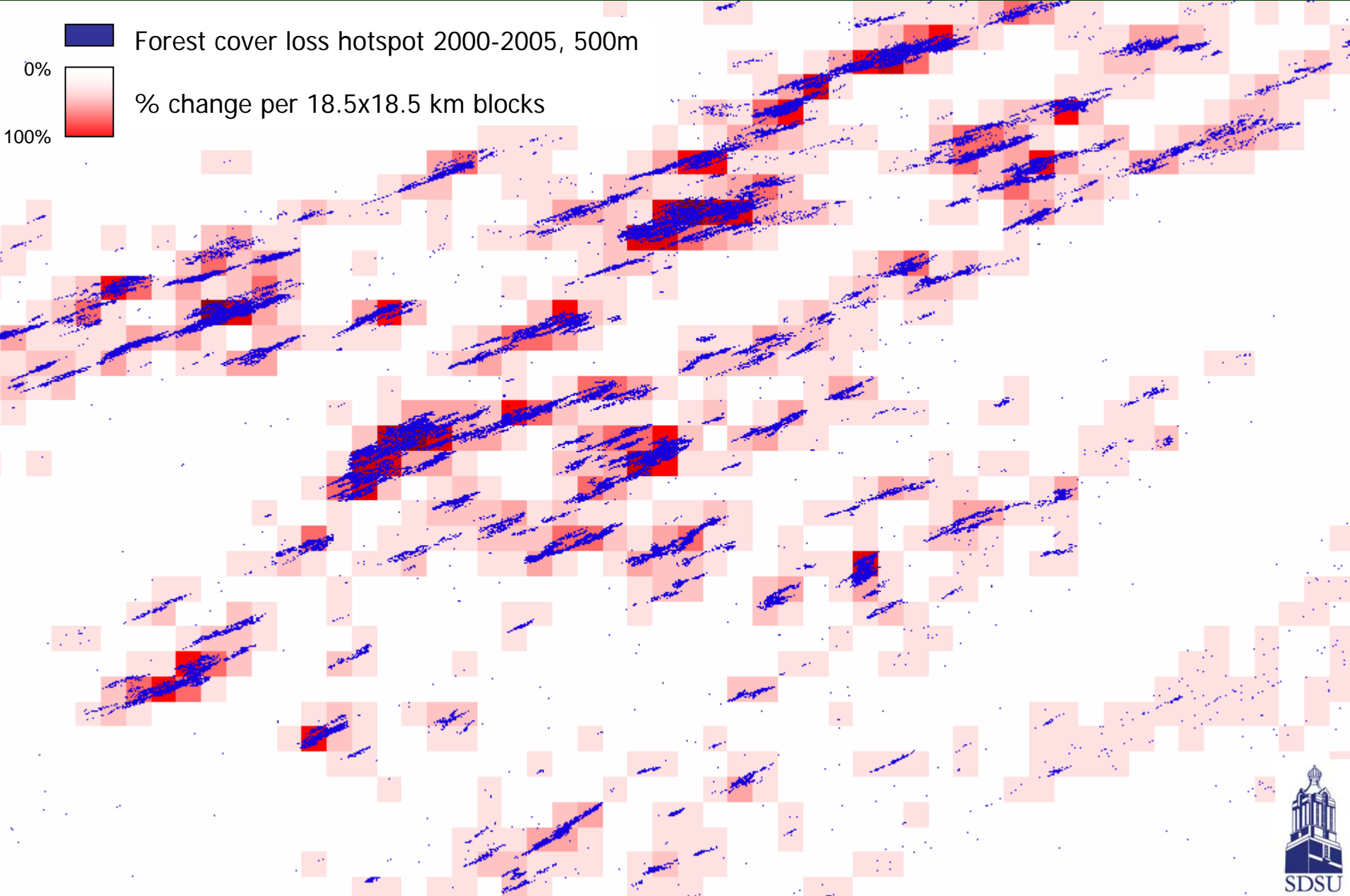
 Cumulative areas of forest cover loss

 Tree canopy density*

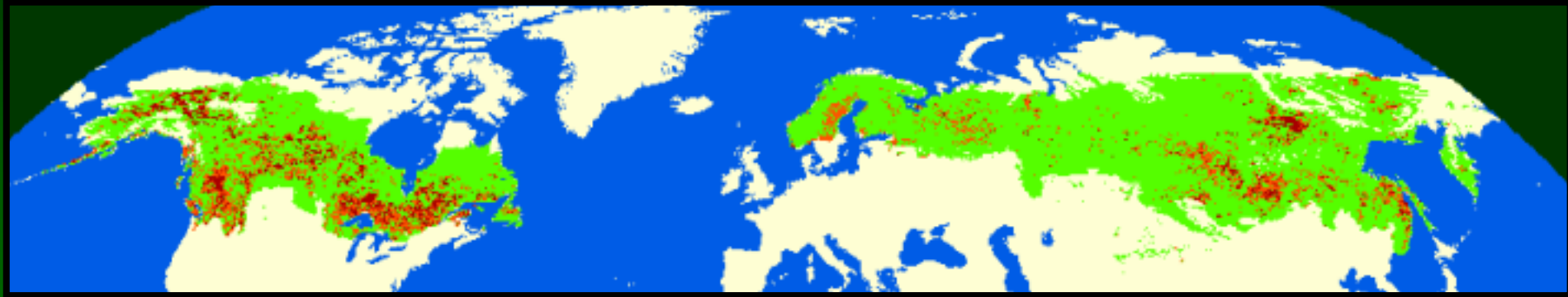
*from Vegetation Continuous Fields dataset, 2000



Average change hotspot for 18.5x18.5 km blocks



Hotspot map change into change likelihood strata



Low change

Medium change

High change

Stratified samples



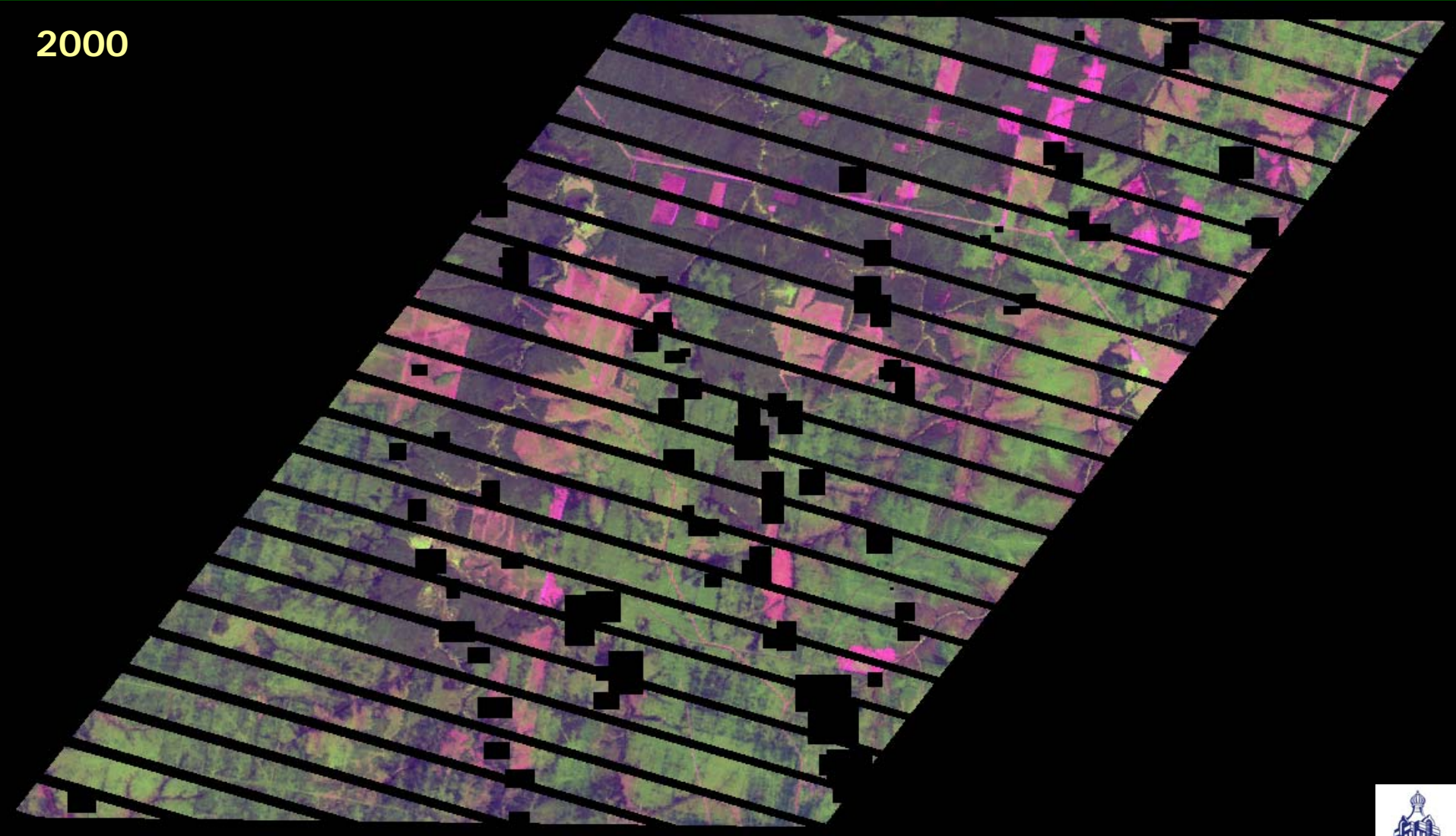
Low change

Medium change

High change

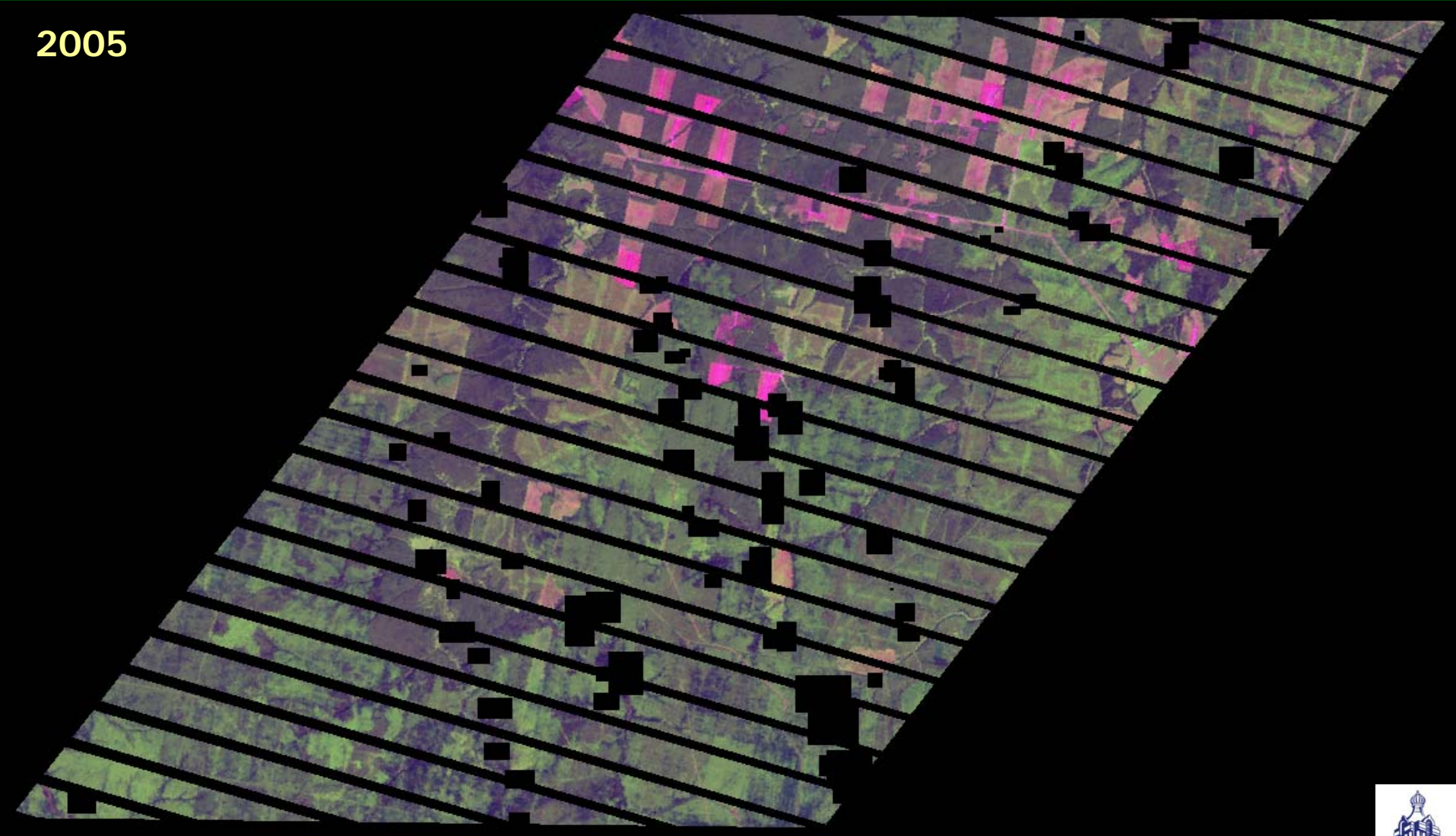
Landsat sample blocks analysis – Boreal biome

2000



Landsat sample blocks analysis – Boreal biome

2005



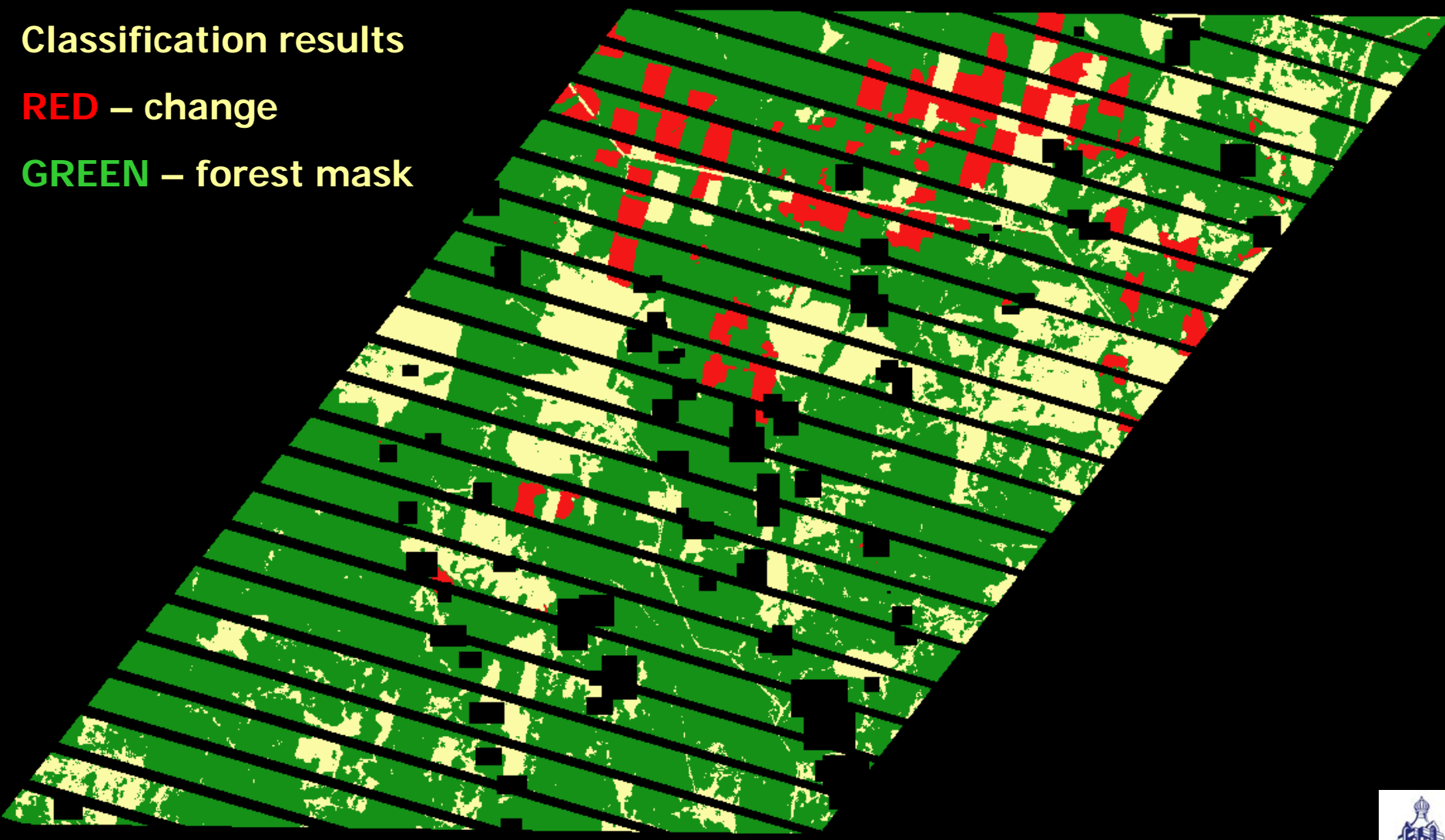
Landsat sample blocks analysis – Boreal biome

Image classification – Change 2000-2005

Classification results

RED – change

GREEN – forest mask



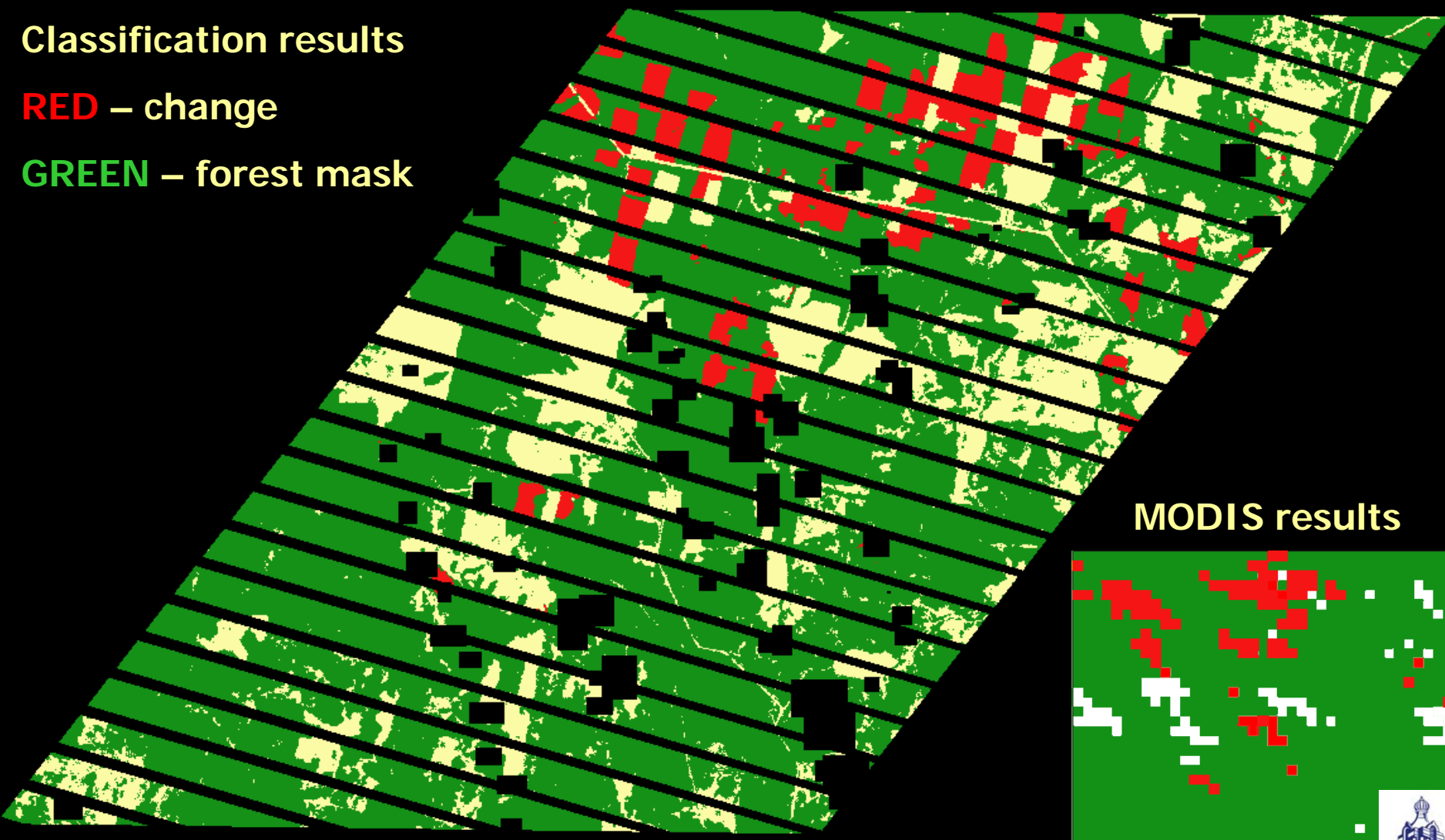
Landsat sample blocks analysis – Boreal biome

Image classification – Change 2000-2005

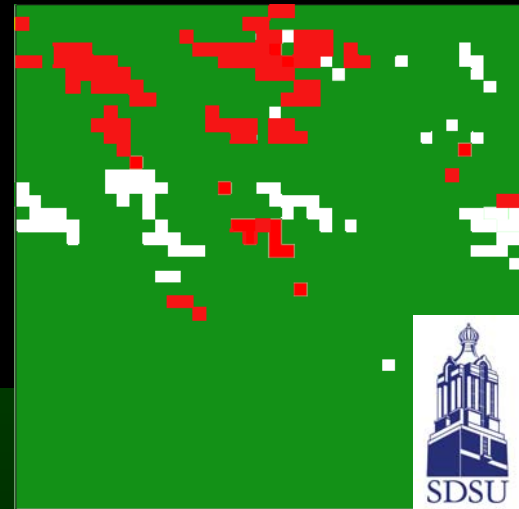
Classification results

RED – change

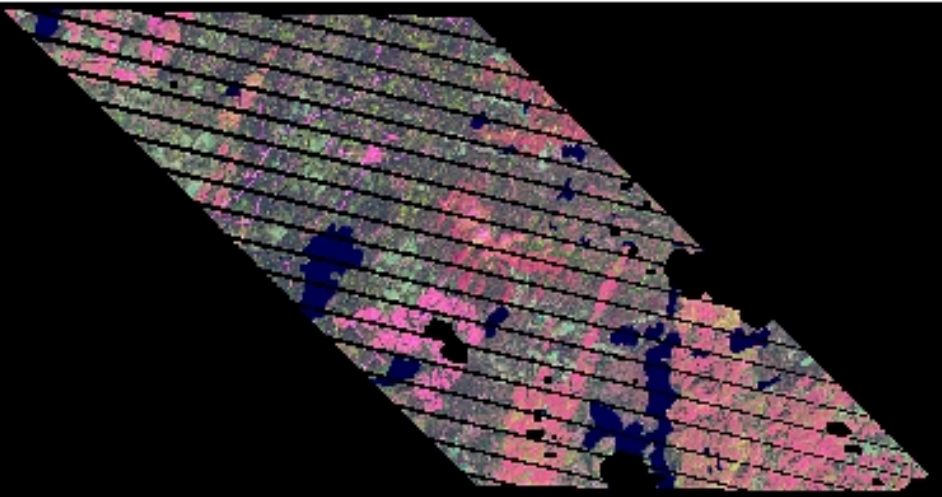
GREEN – forest mask



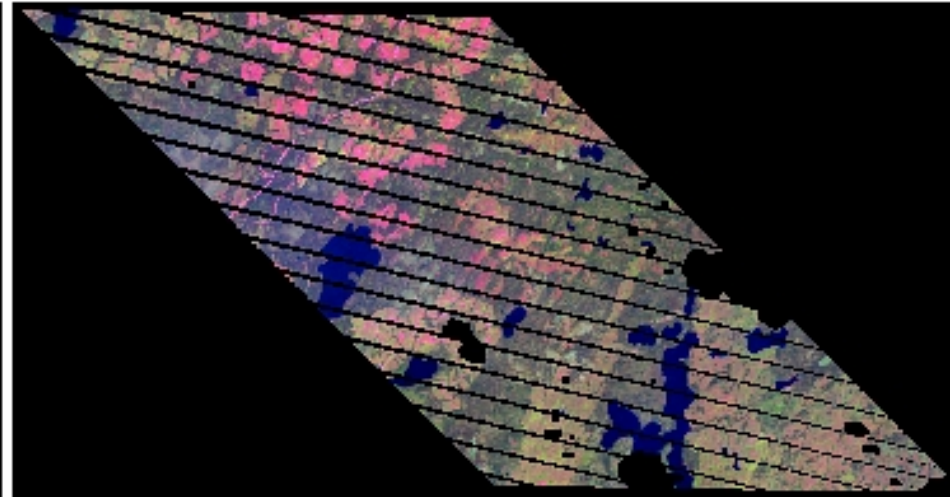
MODIS results



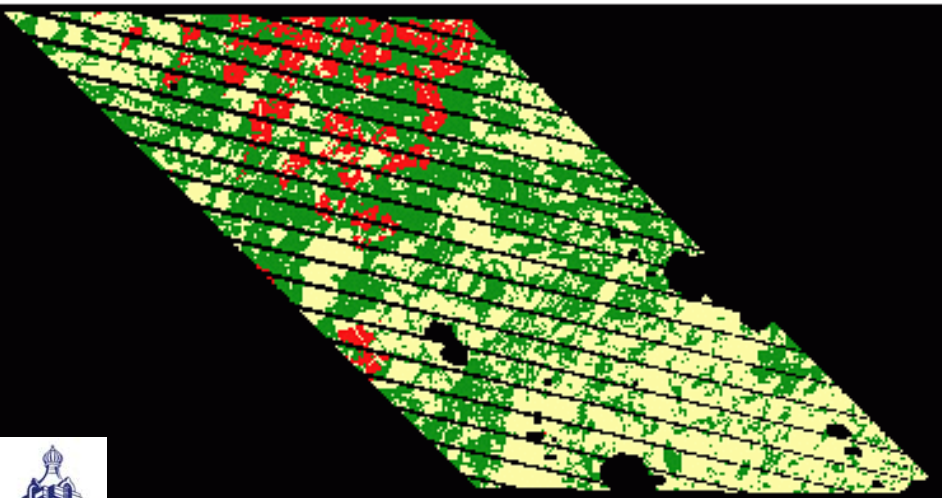
Canada, Quebec (50.25° N; 76.24° W) Stratum: 4



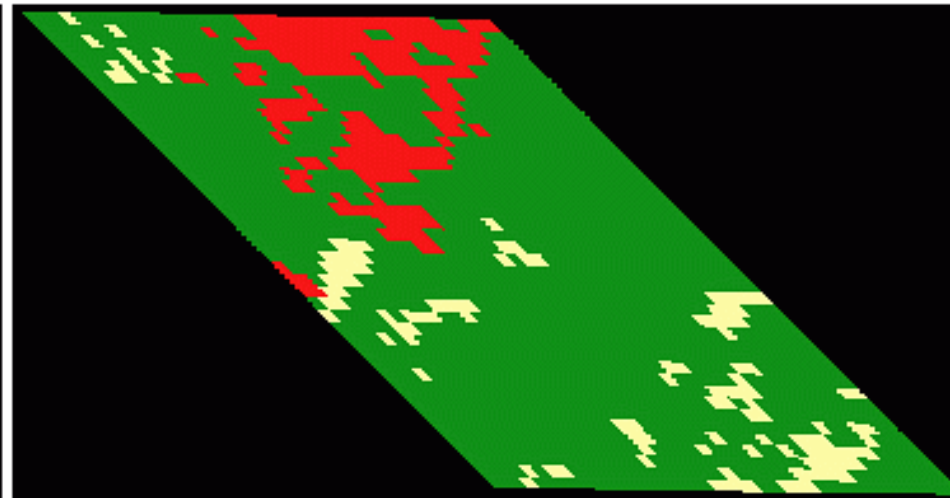
7/12/2000



7/10/2005



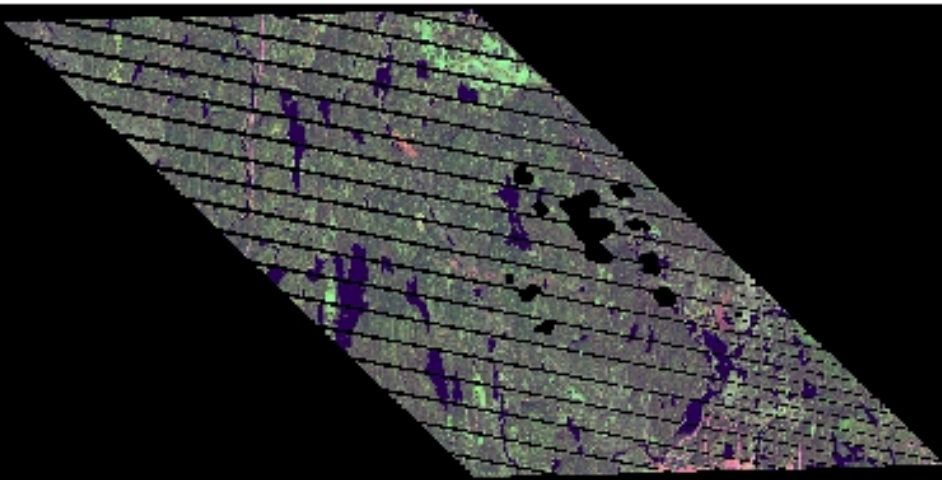
Landsat classification results



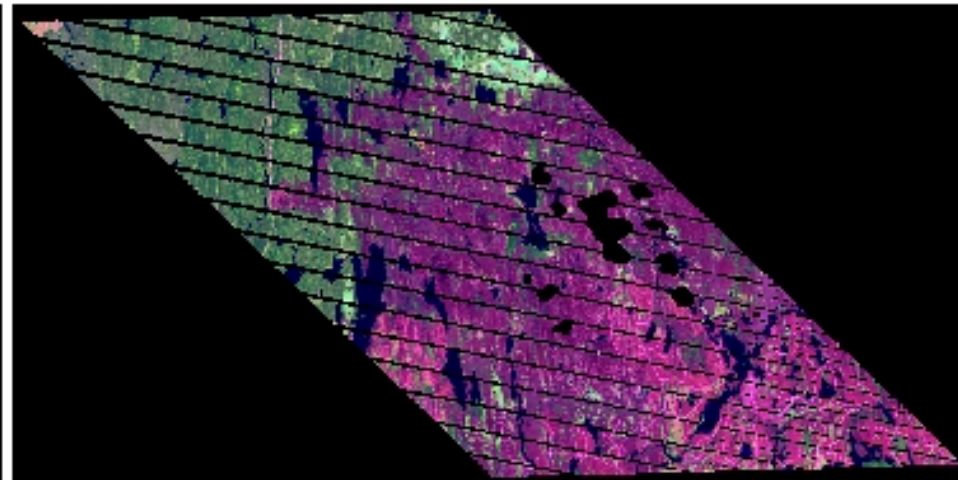
MODIS hotspot map

Red - Forest canopy loss; Green - Forest cover;
Yellow - Non-forest areas; Black - Clouds/No Data.

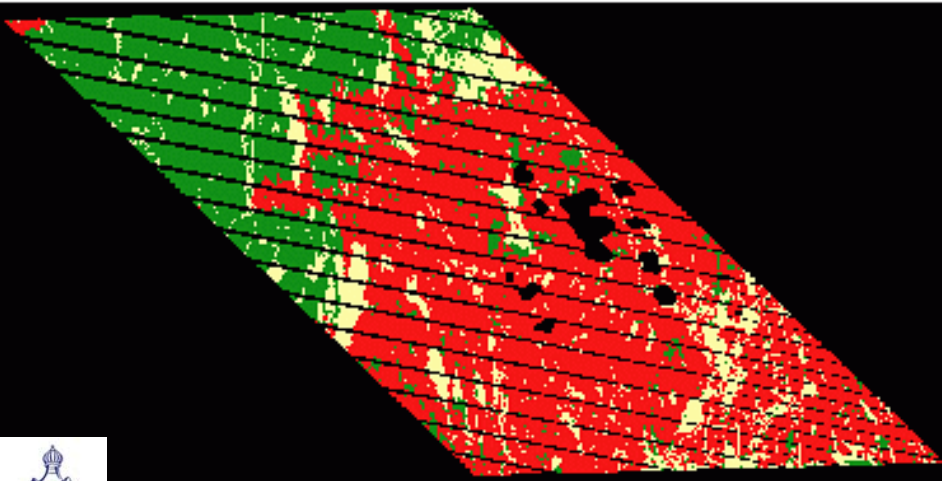
Canada, Quebec (50.08° N; 73.12° W) Stratum: 4



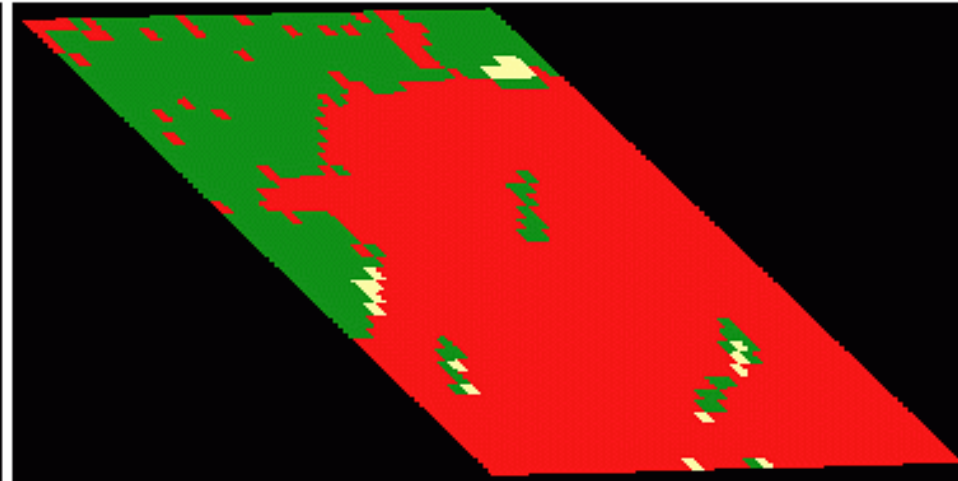
9/19/2001



7/12/2005



Landsat classification results



MODIS hotspot map

Red - Forest canopy loss; Green - Forest cover;
Yellow - Non-forest areas; Black - Clouds/No Data.

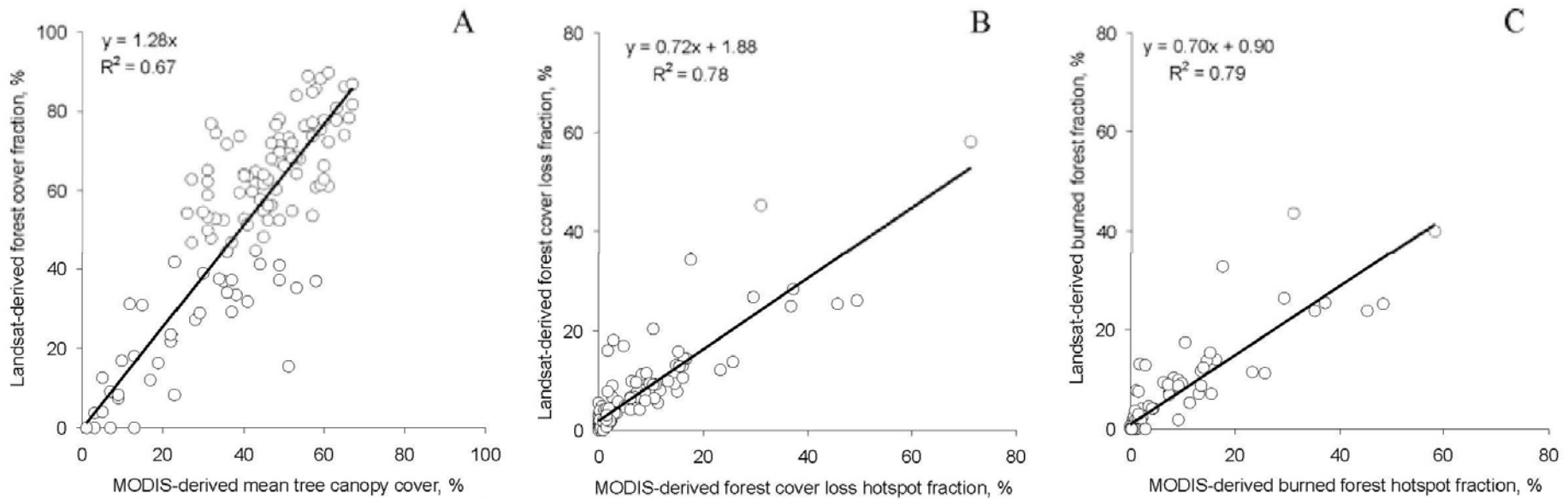
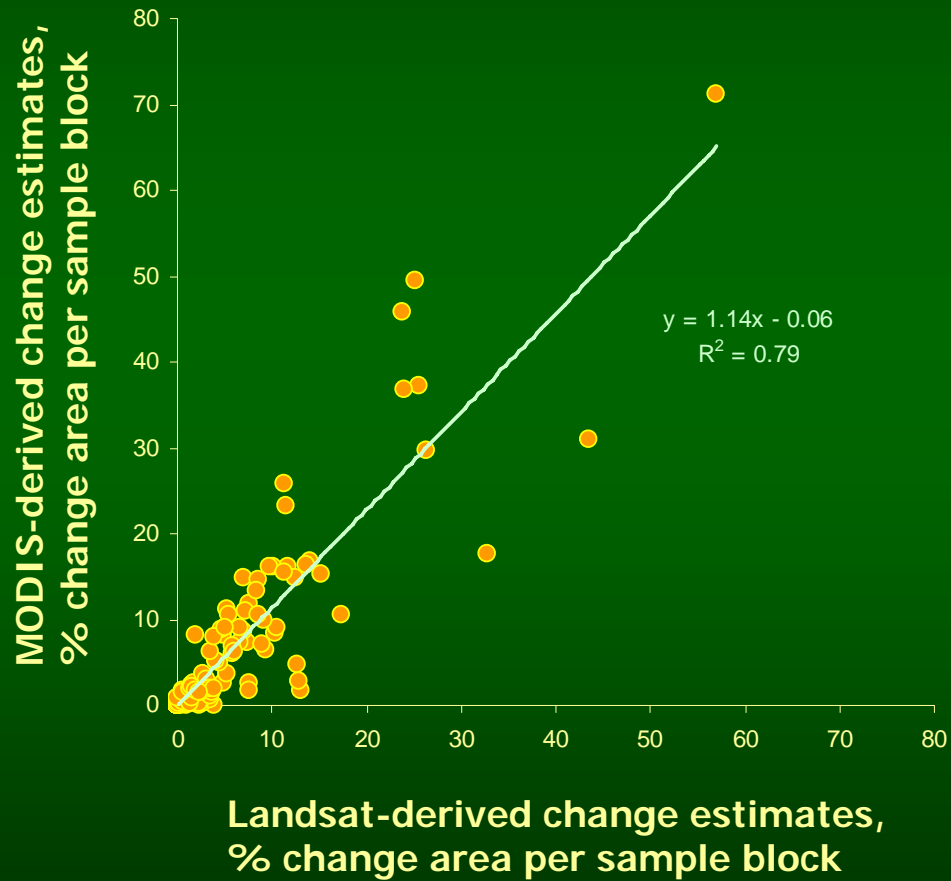


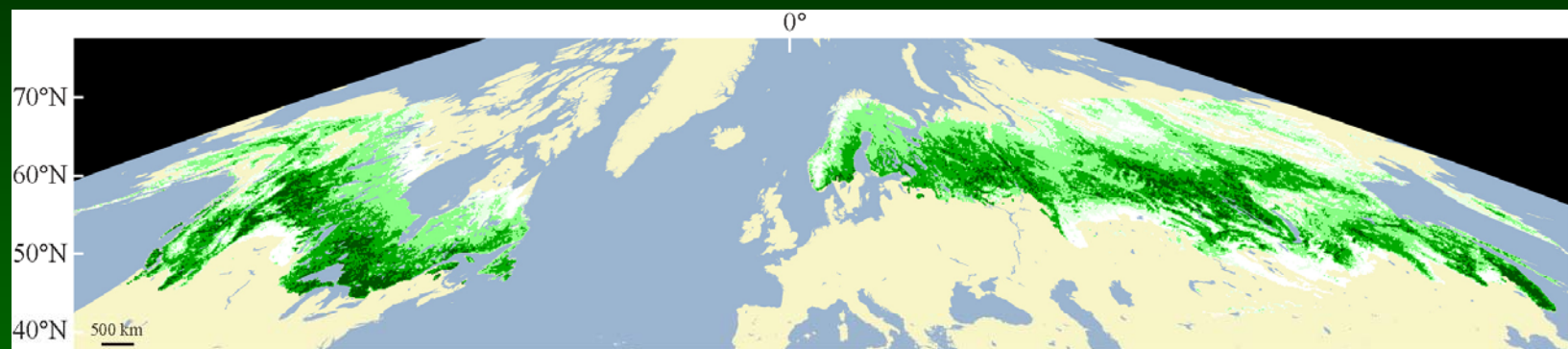
Figure 6. A. Plot of Landsat-derived forest cover fraction versus MODIS-derived mean tree canopy cover (VCF product) per sample block.
 B. Plot of Landsat-derived versus MODIS-derived forest cover loss fraction per sample block.
 C. Plot of Landsat-derived versus MODIS-derived burned forest fraction per sample block.
 (n=118 sample blocks).

Boreal biome

118 sample blocks



Landsat-calibrated forest cover and forest cover loss estimates for Boreal biome



Year 2000 forest cover percent: <10% 10-25% 25-50% 50-75% >75%

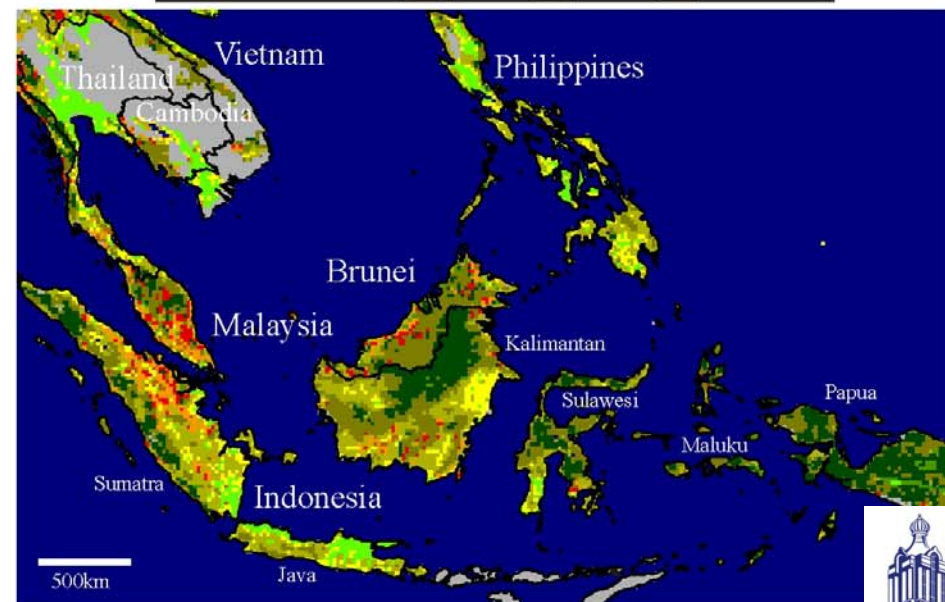
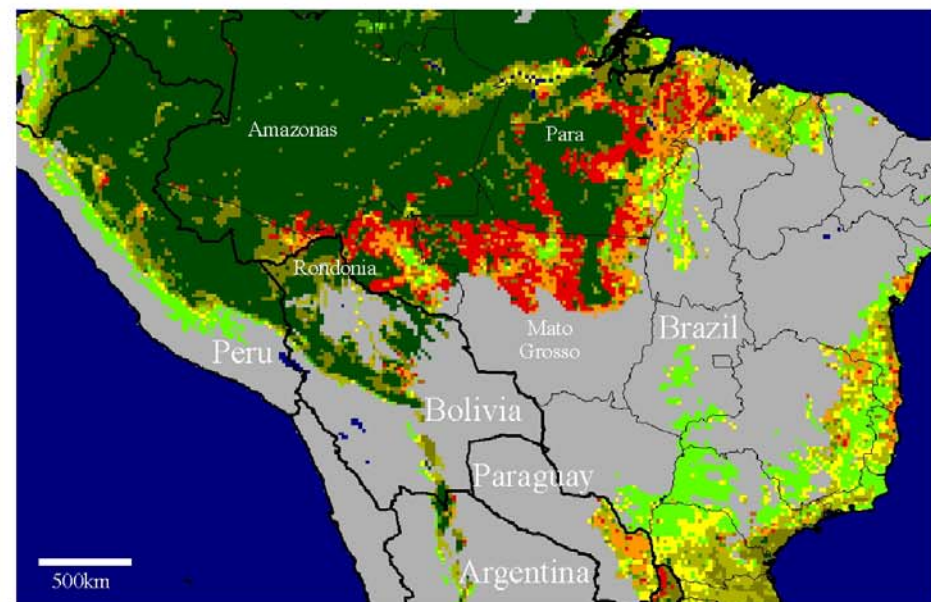
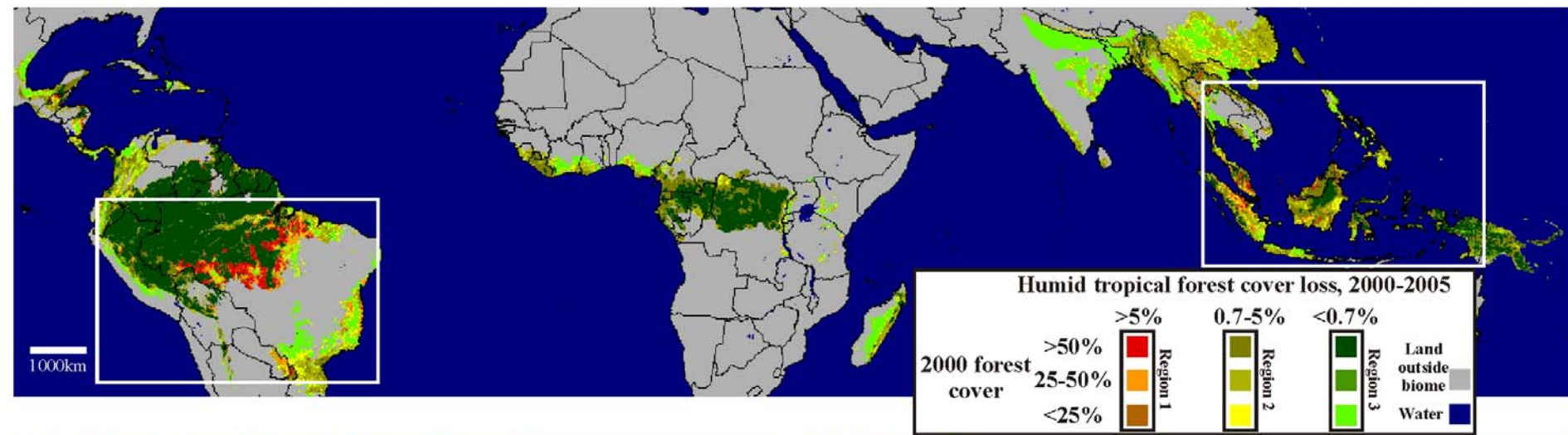


Forest cover loss percent, 2000-2005: <1.5% 1.5-5.0% 5.0-10.0% >10.0%



Burned forest percent of total forest cover loss area: <25% 25-50% 50-70% >75%
(only within blocks with forest cover loss percent above 1.5%)

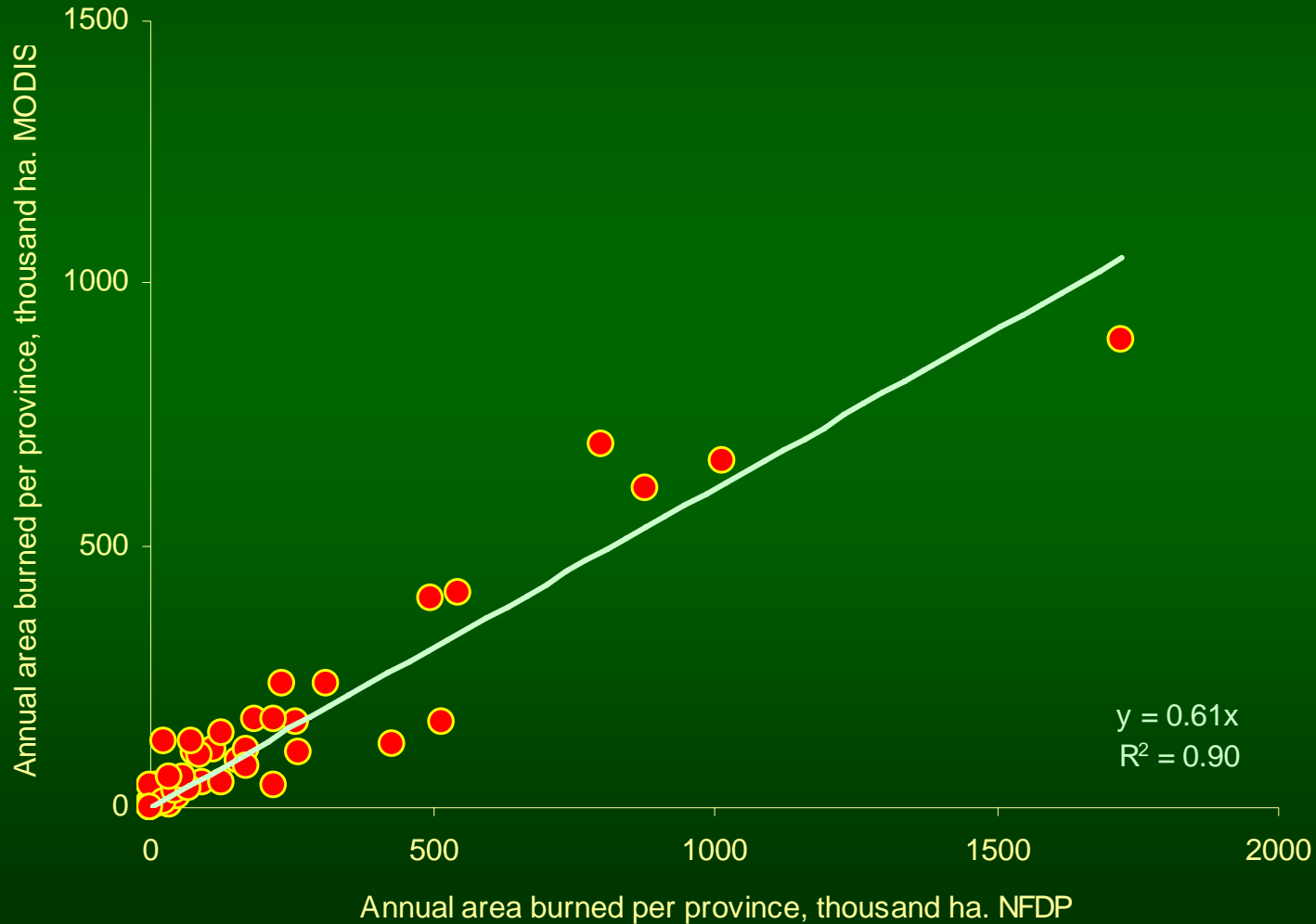
Landsat-calibrated forest cover and forest cover loss estimates for Humid Tropical biome



MODIS change analysis validation using independent datasets

NFDP burned areas data for Canada

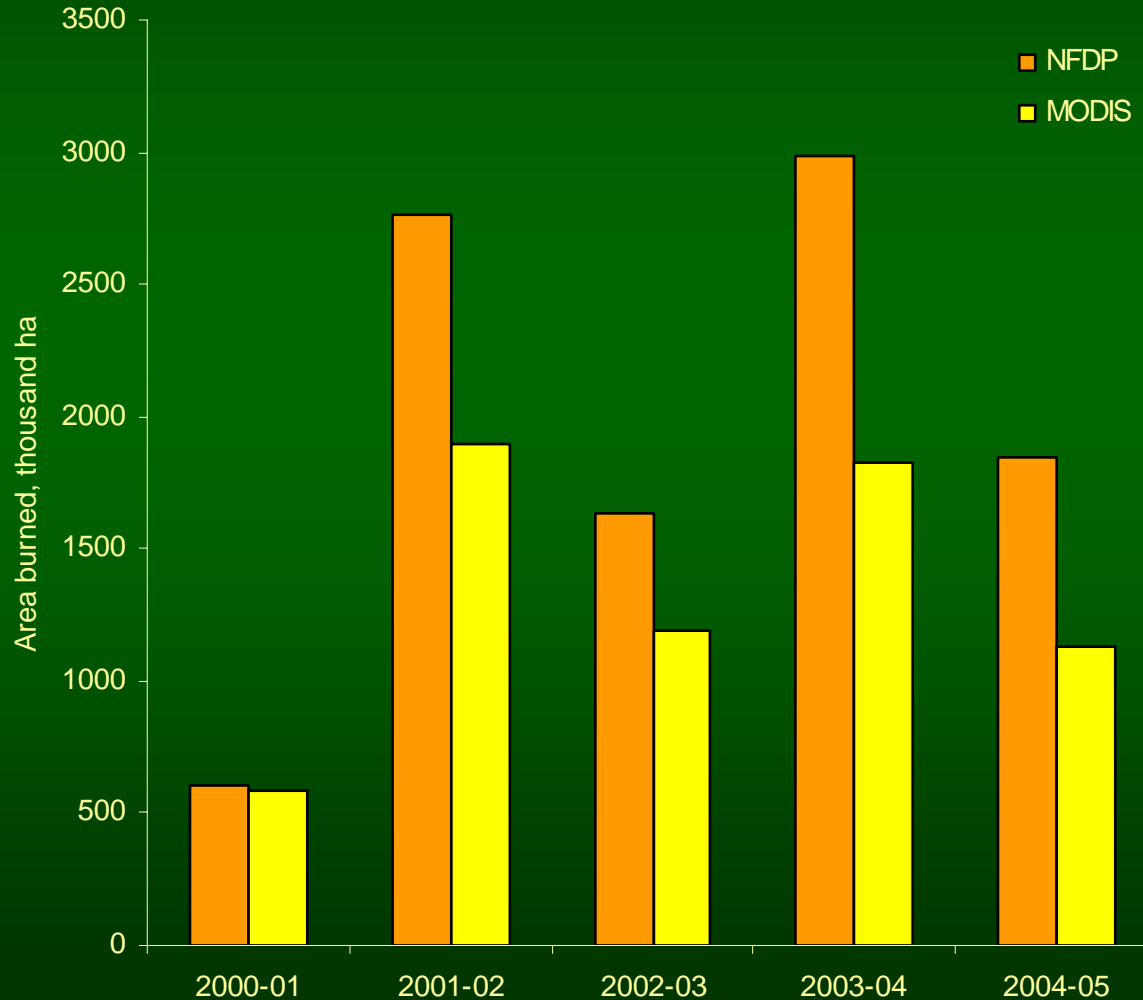
Comparison of annual burned area per province



MODIS change analysis validation using independent datasets

NFDP burned areas data for Canada

Comparison of annual burned area for Canada



Forest cover loss area 2000-2005 for continents and selected countries within the boreal biome

Region	Percent of total biome area	Within-region forest cover loss as percent of land area (s.e.)	Within-region forest cover loss as percent of year 2000 forest area	Percent forest cover loss within the region attributed to fire
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By continent

North America	36.4	2.44 (0.12)	5.63	57.9
Eurasia	63.6	1.17 (0.12)	3.00	60.0

By country

Canada	30.5	2.34 (0.15)	5.28	54.7
Russia	53.7	1.18 (0.19)	2.91	65.2

Biome total		1.63 (0.10)	4.02	58.9
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Biome-wide forest cover loss area estimation, 2000-2005

	Boreal	Humid Tropics
Biome area, million ha	2,150.9	1,962.4
Forest area 2000, million ha	872.3	925.1
% forest loss 2000-2005 (standard error)	1.63 (0.10)	1.39 (0.08)
Area of forest loss 2000-2005, million ha	35.1	27.2
% Forest loss area of forest 2000 area	4.02 2.25 excluding fire	2.36

Conclusion

- A monitoring strategy combining data from sensors at multiple temporal and spatial resolutions offers a feasible and cost-effective methodology to produce timely, precise and internally consistent estimates of biome-wide forest cover loss.
- Results of this analysis illustrate the regional and temporal variability of forest cover loss within the boreal biome and point the way forward for combining such information with available carbon stock data to improve carbon accounting

Next Steps

- Complete temperate and dry tropical biomes
- Investigate other possibilities
 - Estimating tree cover gain
 - 1990 to 2000 using AVHRR as a stratifier
 - 2005 to 2010 continuation of present approach