LEDAPS

Landsat Ecosystem Disturbance Adaptive Processing System

A North-American Disturbance Record from Landsat: Overview and Update

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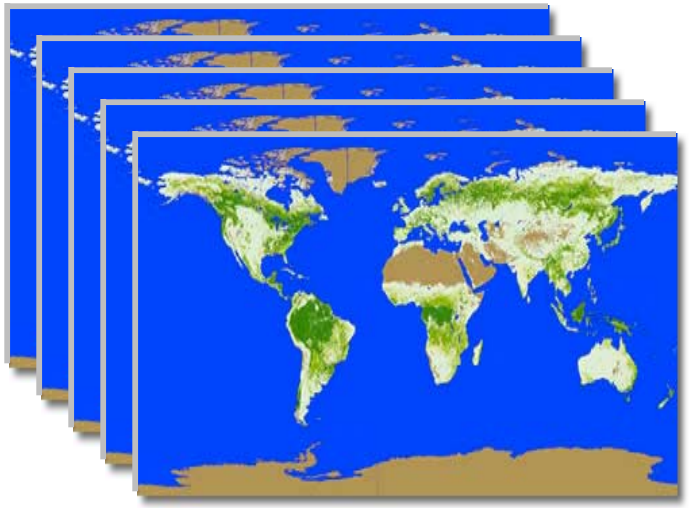

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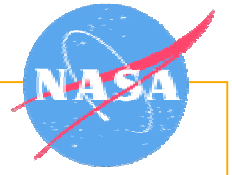


Science Context and Project Overview

The Role of the Landsat Archive

• 30+ year Landsat archive essential for assessing land-cover change, disturbance, and above-ground biomass at fine resolution over long periods of time…

BUT

… There has never been an effort to create continental records of surface reflectance and change from the Landsat archive

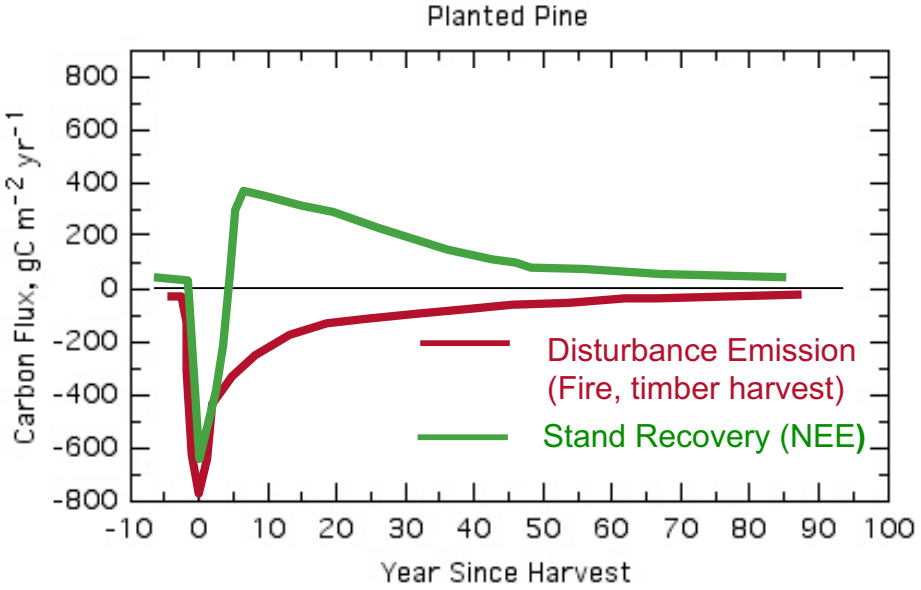
• SDB/EarthSat GeoCover product provides a *geometrically* corrected archive for this purpose

- 1975, 1990, 2000 epochs
- Orthorectified to map base
- Mostly clear scenes, mostly centered on peak-NDVI
- 30-80 m spatial resolution

Why Map Disturbance with Landsat?

7km

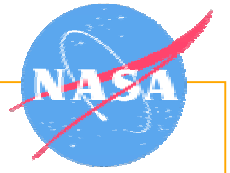
1985 1988 1999



- Disturbances (fire, harvest, insect damage) emit C to atmosphere

- Regrowth following disturbance governs forest age structure and hence net ecosystem exchange (NEE) with atmosphere

Scaling Up to Continental Carbon Models



Landsat, Inventories

Disturbance History

Inventories, Lidar, Radar

Biomass

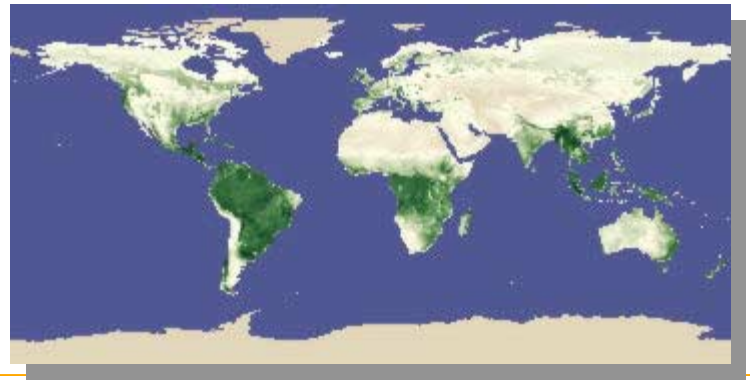
MODIS

Biophysics, Productivity

Climate

Ecosystem Productivity Models

Atmospheric CO2 Fluxes *(gridded, global, monthly)*



LEDAPS

The Landsat Ecosystem Disturbance Analysis Adaptive Processing System (LEDAPS) will…

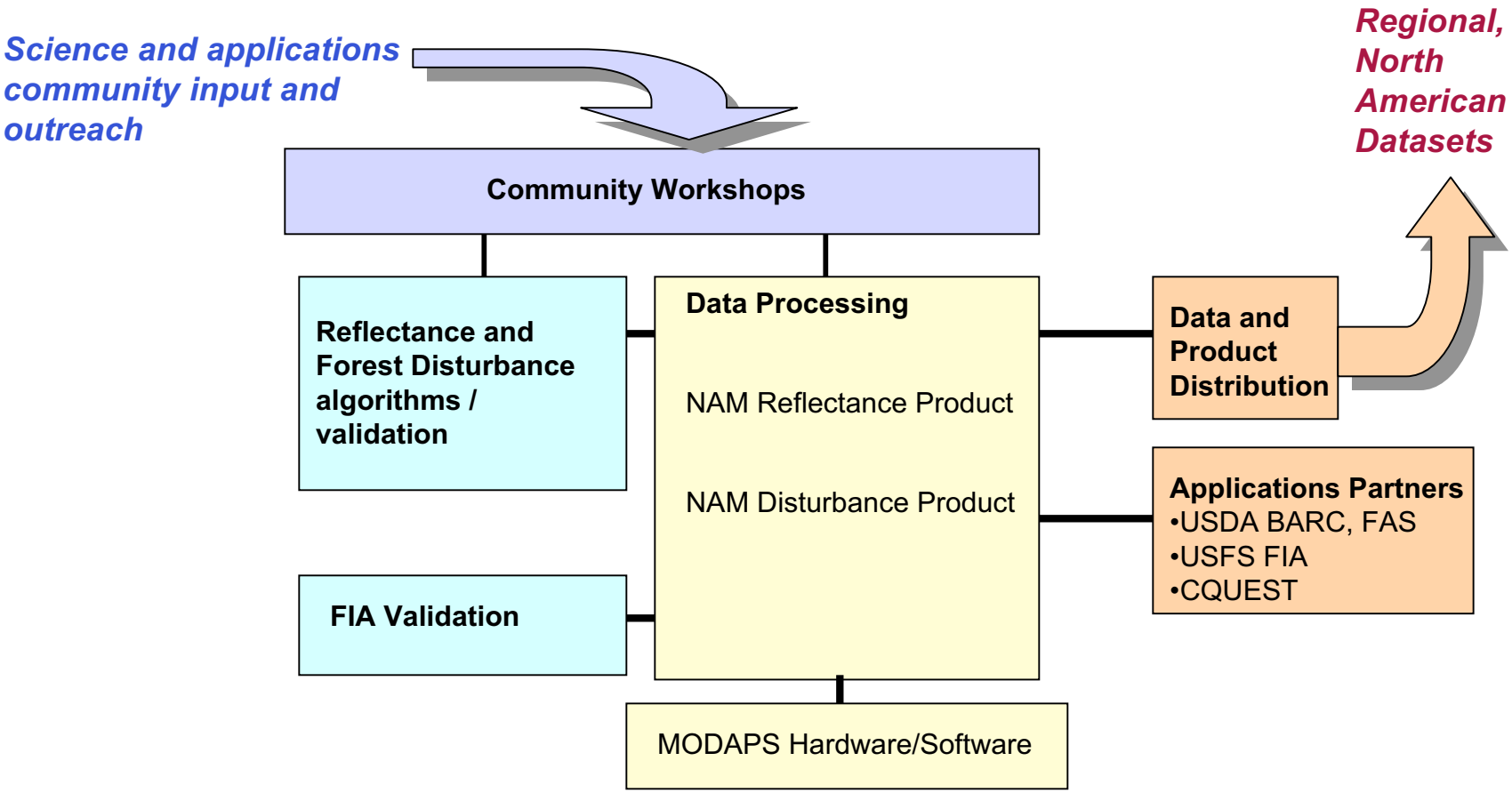
- *Create decadal surface reflectance (SR) images from the North American Landsat GeoCover archive for the period 1975-2000*

- *Analyze these SR images for forest disturbance, recovery, and conversion, and distribute continental products to science an applications communties*

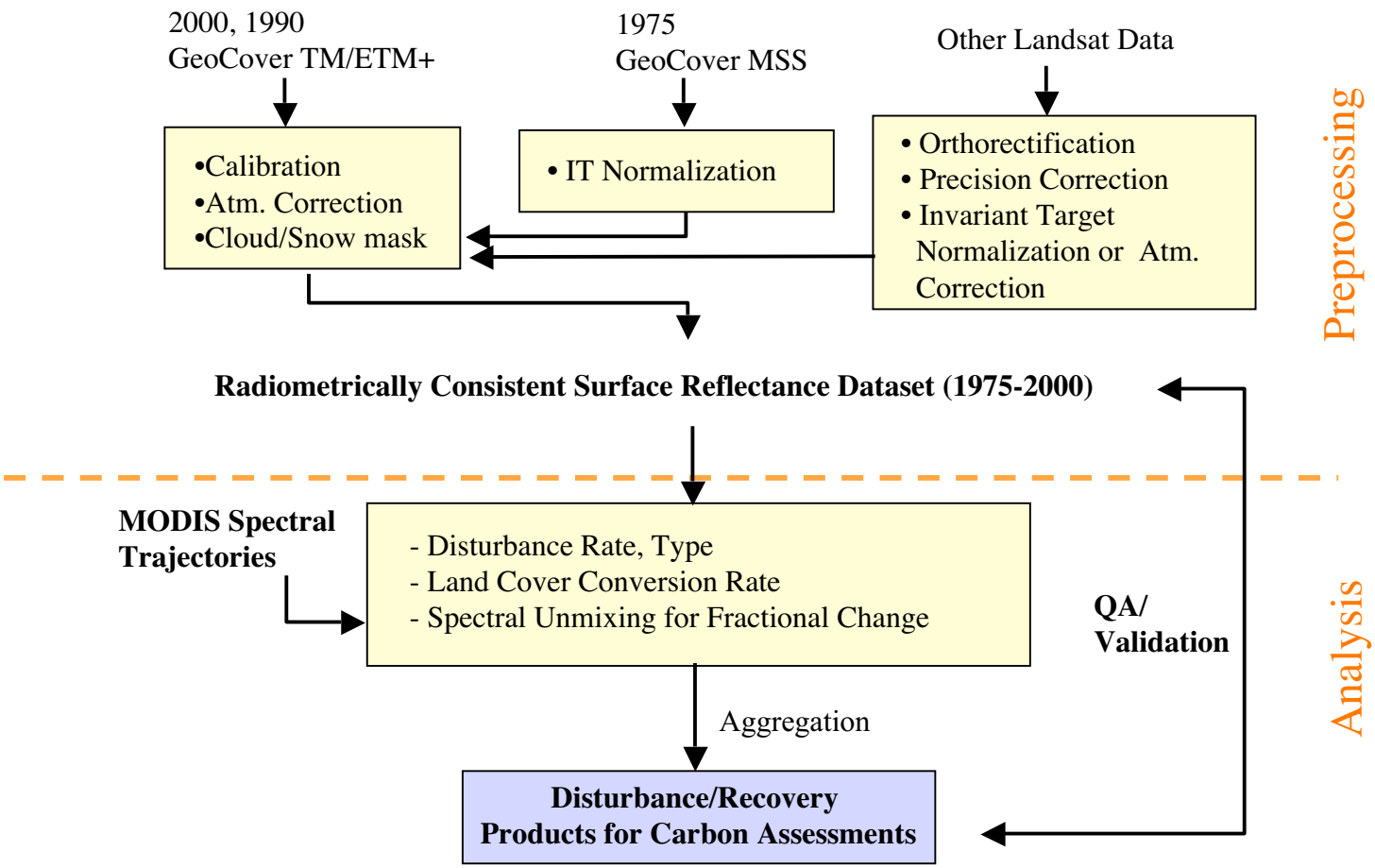
- *Work with remote sensing and carbon science communities to tailor processing to meet science needs*

- *Work with representatives of USDA, USDA Forest Service, Canadian Forest Service to evaluate applications utility of SR and disturbance database for carbon management and agricultural monitoring.*

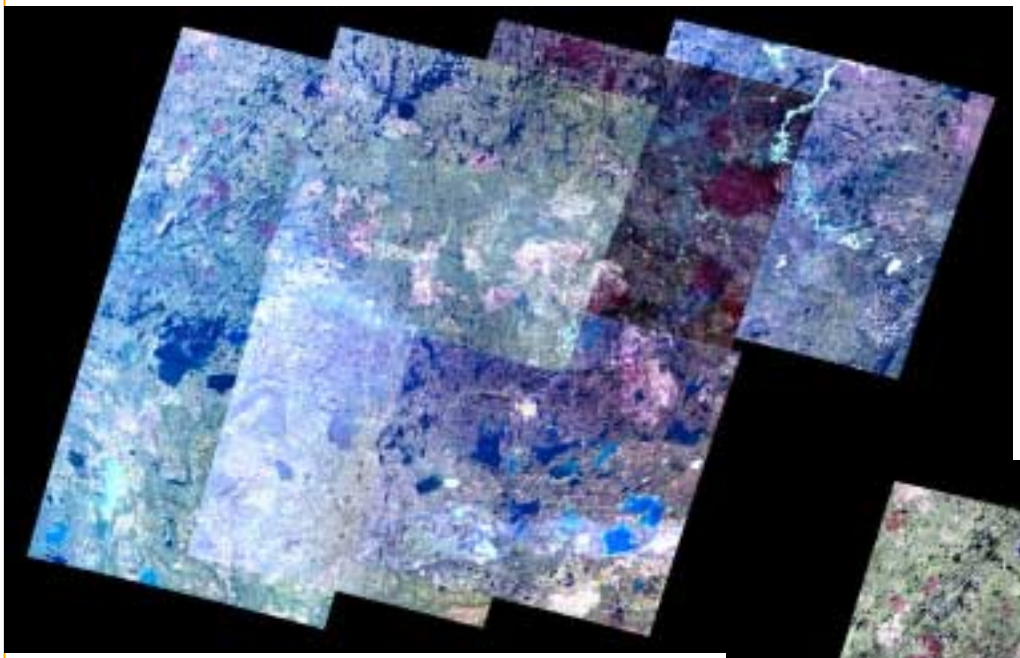
Proposed LEDAPS Project Elements



LEDAPS Processing Overview



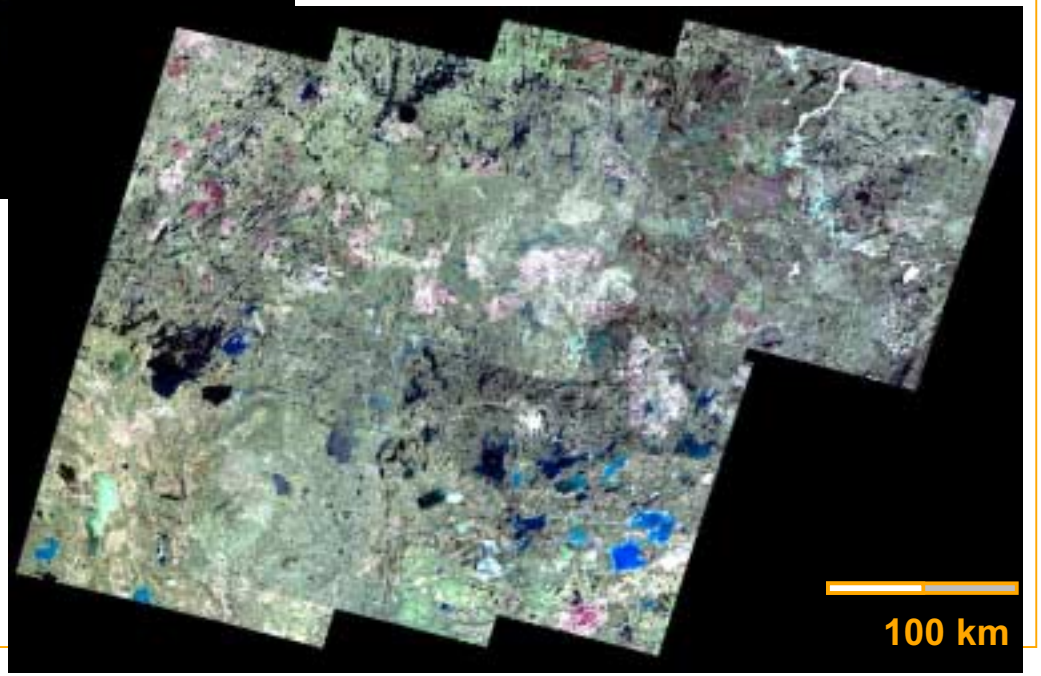
Landsat-5: Atmospheric Correction

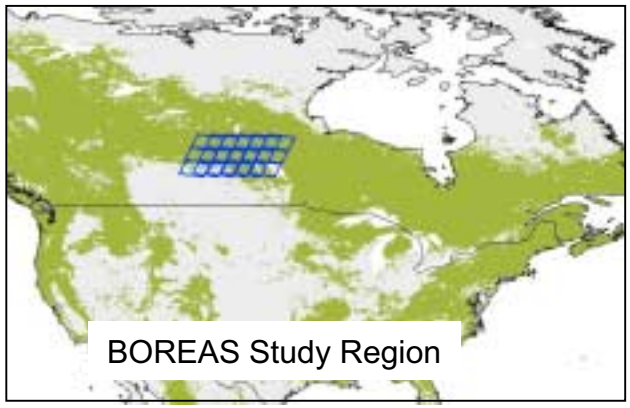


1990's Landsat-5 mosaic

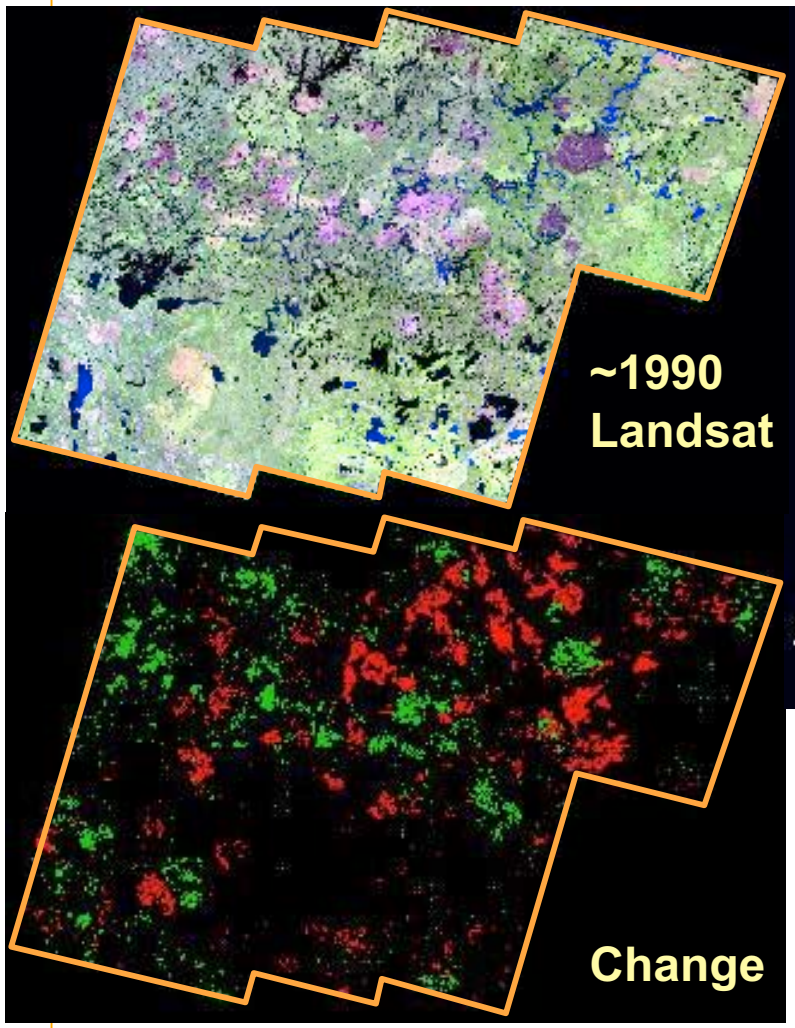
← TOA reflectance

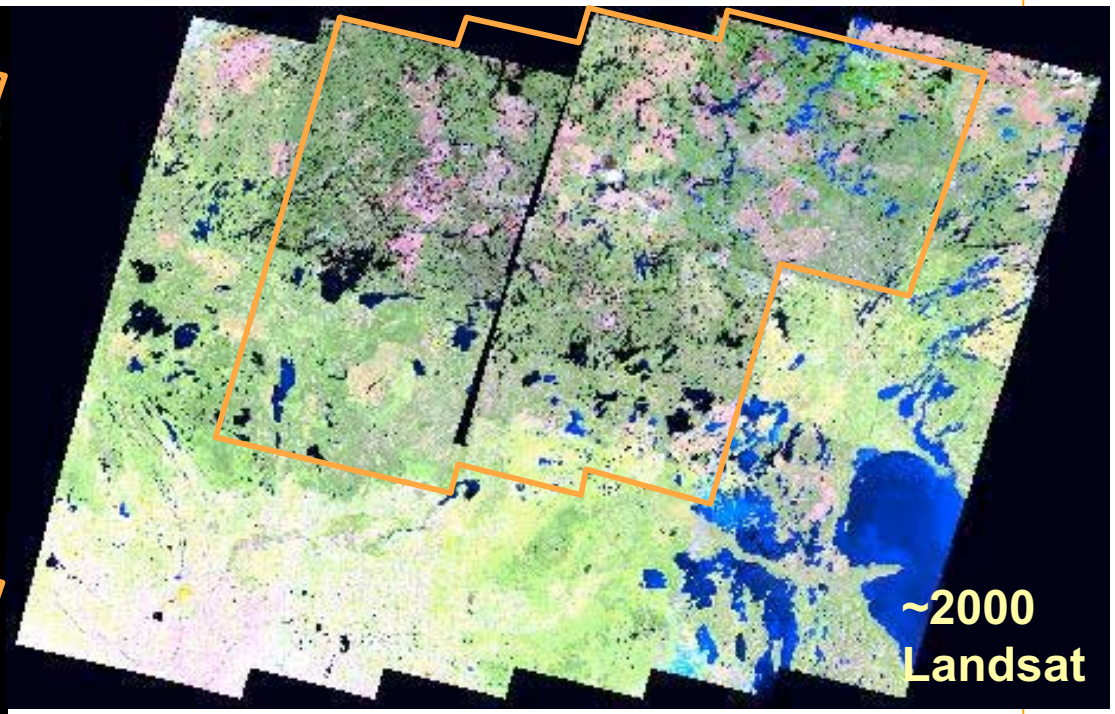
Surface reflectance ↓





Mapping Regional Disturbance



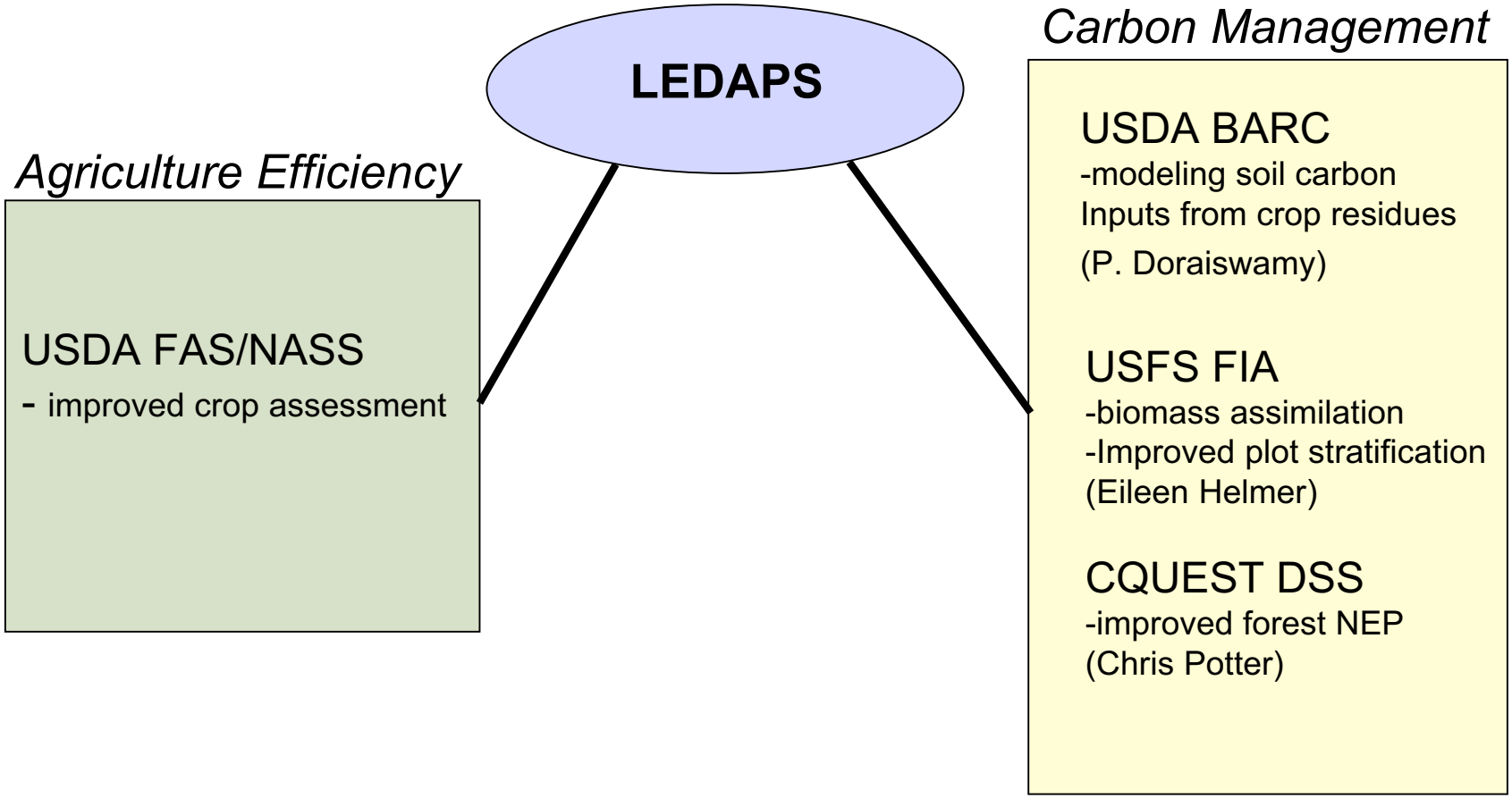


1990-2000:

- **1.03 Mha burnt, logged (5.8% of area)**
- **0.89 Mha in early regrowth (4.9% of area)**

Note: these results are illustrative and not validated

Applications Partners



LEDAPS Schedule and Milestones

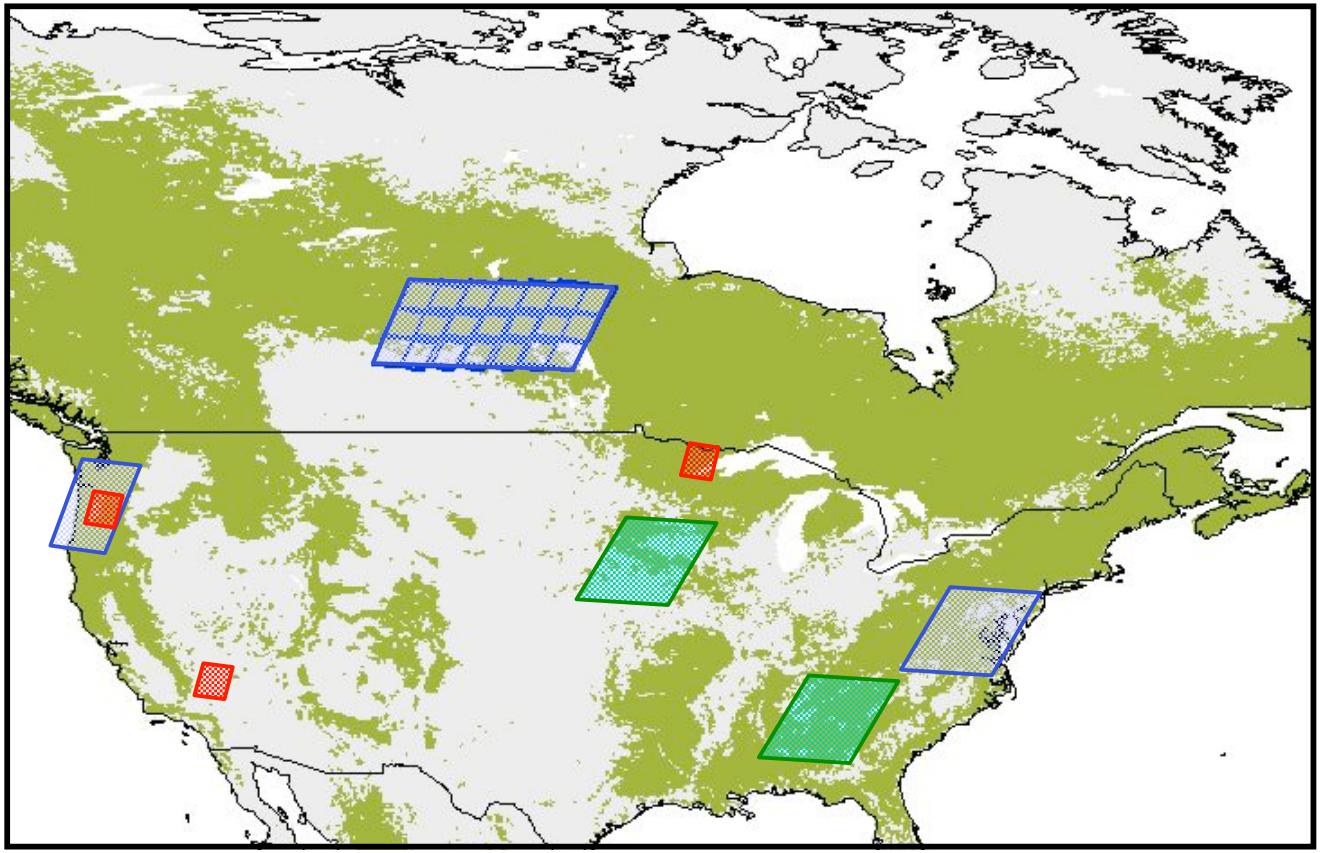
Surface Reflectance Products:

Beta (regional): March 31, 2004 (ETM+)
Provisional (NAM): March 31, 2005
Validated (NAM): March 31, 2006

Disturbance / Forest Cover Change:

Beta (regional): September 30, 2004
Provisional (NAM): September 30, 2005
Validated (NAM): March 31, 2007

Initial (Beta) Reflectance Products

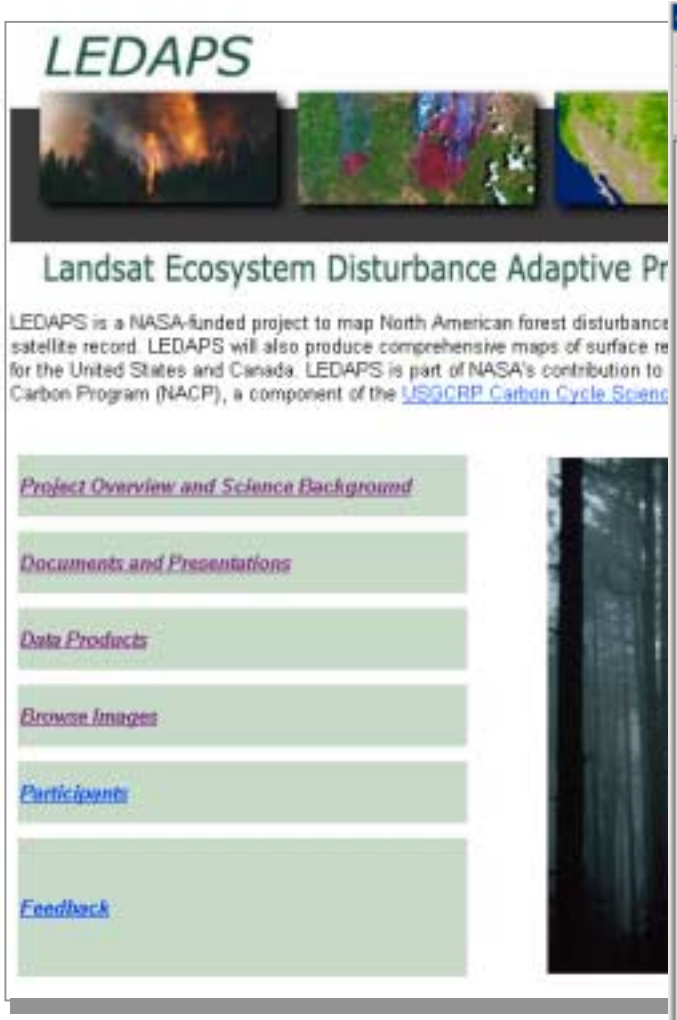


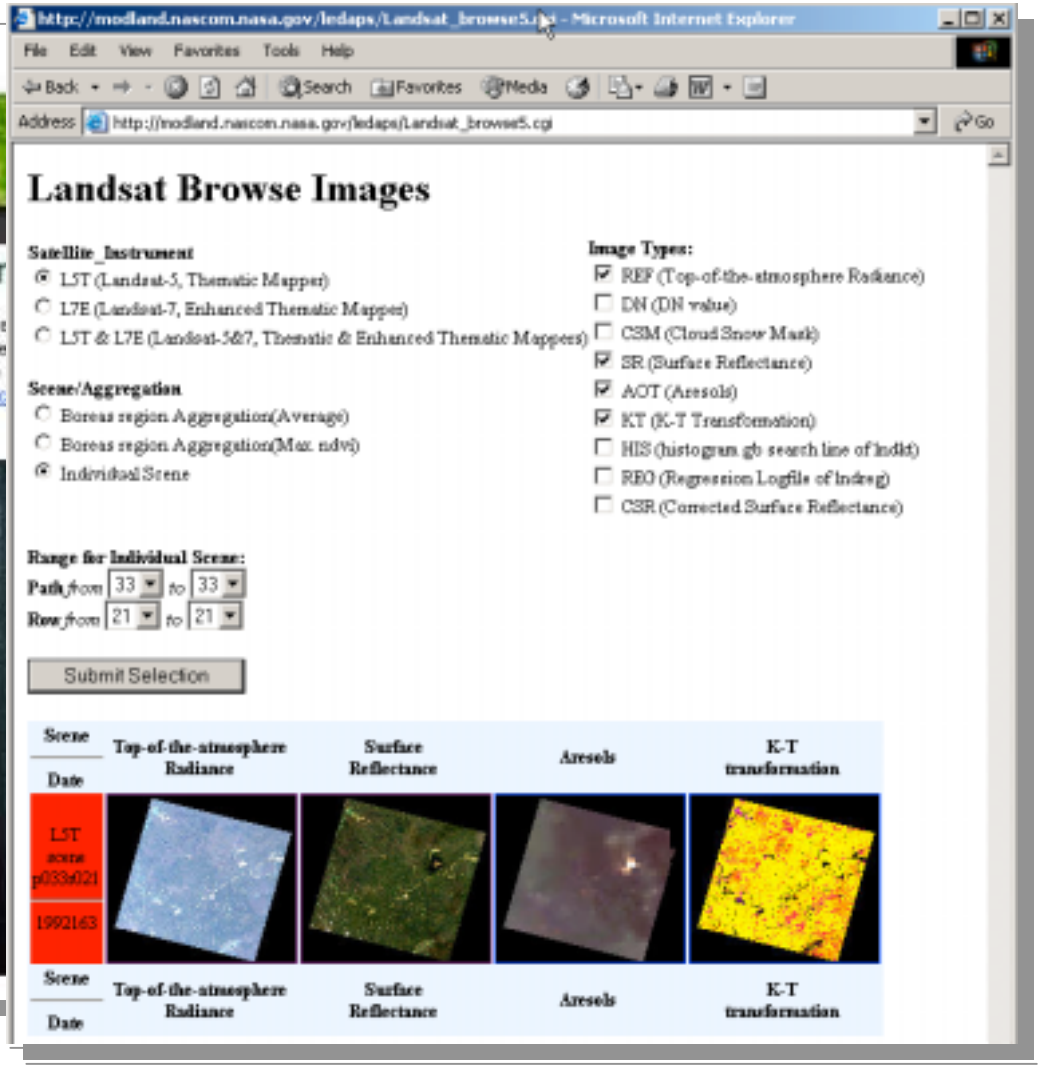
SR Validation

Collaborators

Large-Area/Disturbance

LEDAPS Web Page





http://modland.nascom.nasa.gov/ledaps/ledaps.html

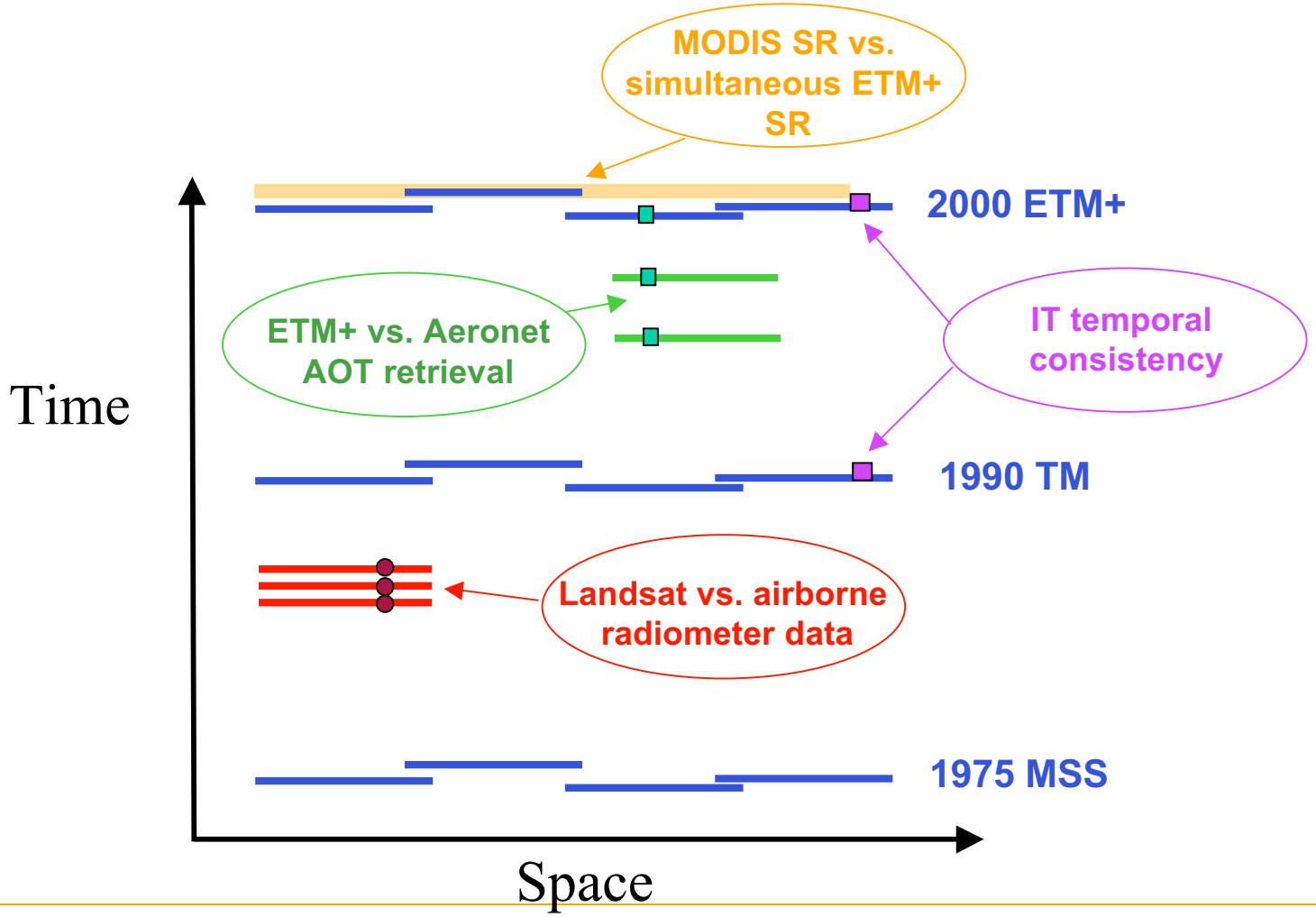
LEDAPS

Project Status Update

- *Surface Reflectance Validation*
- *Disturbance Algorithm Development*
- *Community Outreach*

Recent Progress – SR Validation

Four SR Validation Approaches…



Recent Progress – SR Validation

Initial Results:

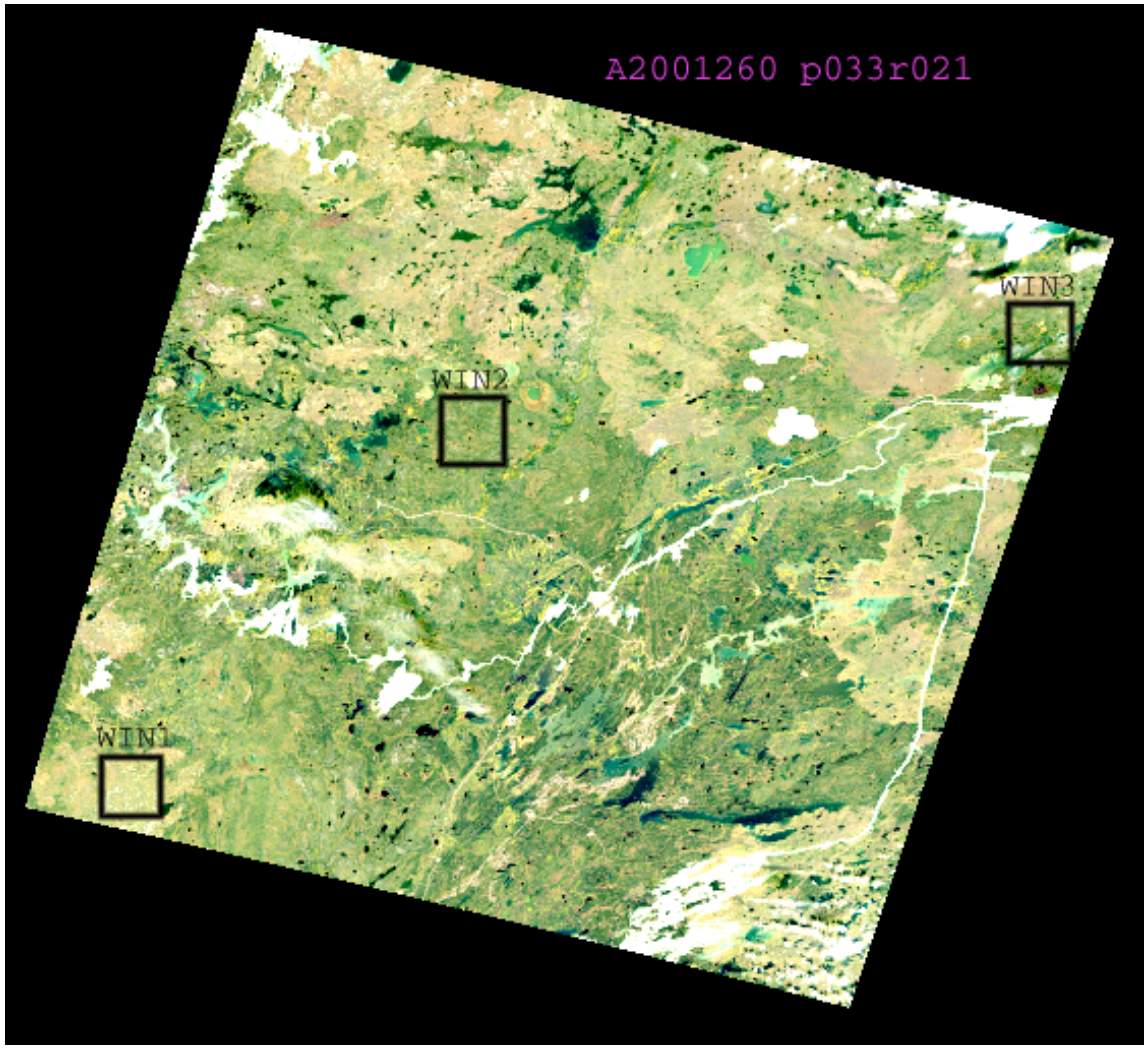
- Landsat TM/ETM+ SR differs from MODIS SR because of dark-target aerosol estimation algorithm

- When using a common aerosol map, MODIS and ETM+ agree to within bandpass differences and MODIS uncertainty:
  For vegetated target, Δ= ~0.5% visible, ~1-2% NIR

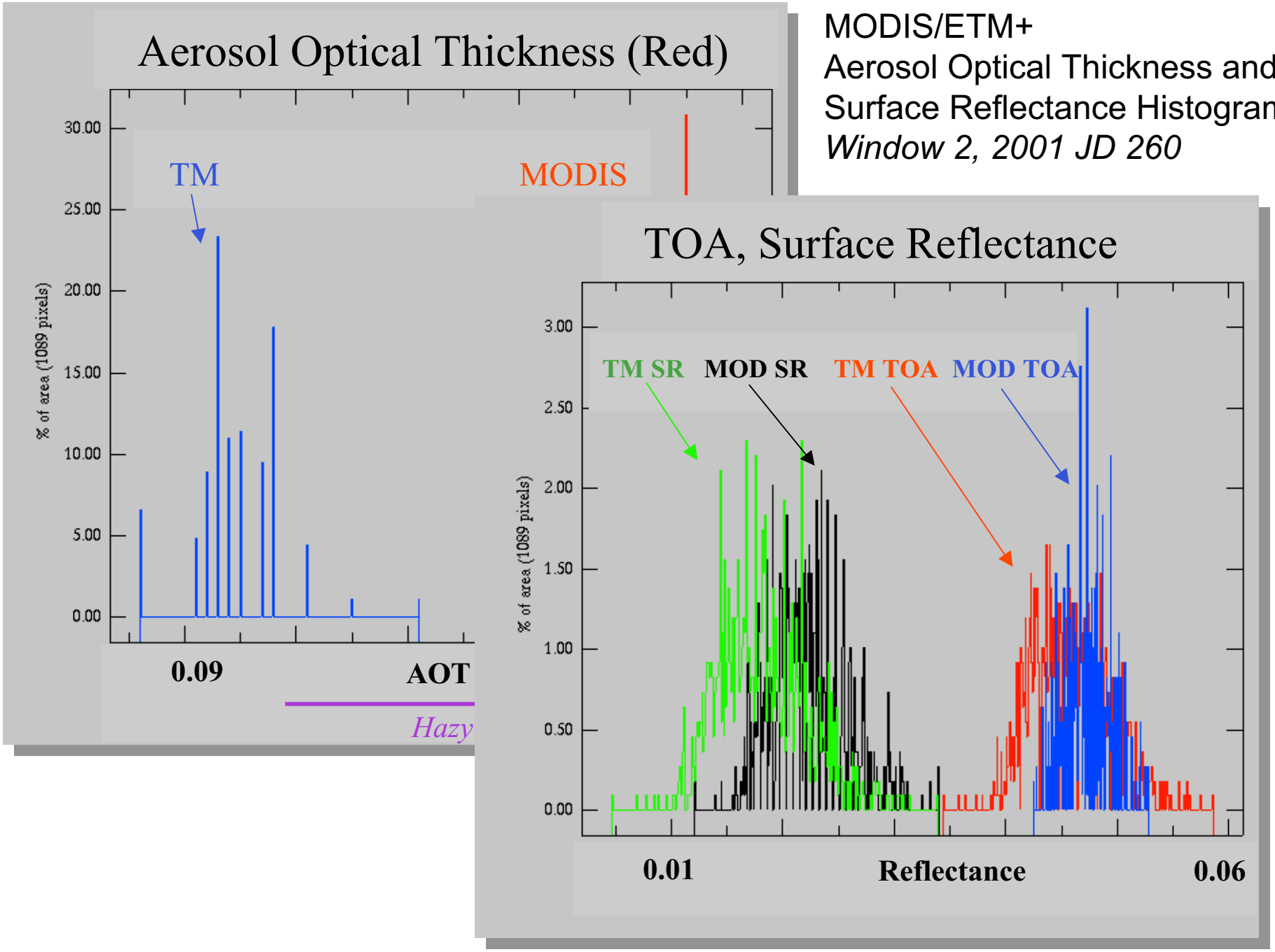
- L5 TM / BOREAS MMR comparisons give good agreement, but L5 TM / OTTER SE590 comparisons give very poor agreement

- Landsat-5 calibration procedure being revised
  3 different processing streams for 1990 GeoCover product (EDC NLAPS, CCRS NLAPS, EOSAT) – need to recover original processing files from EarthSat and back out original calibration

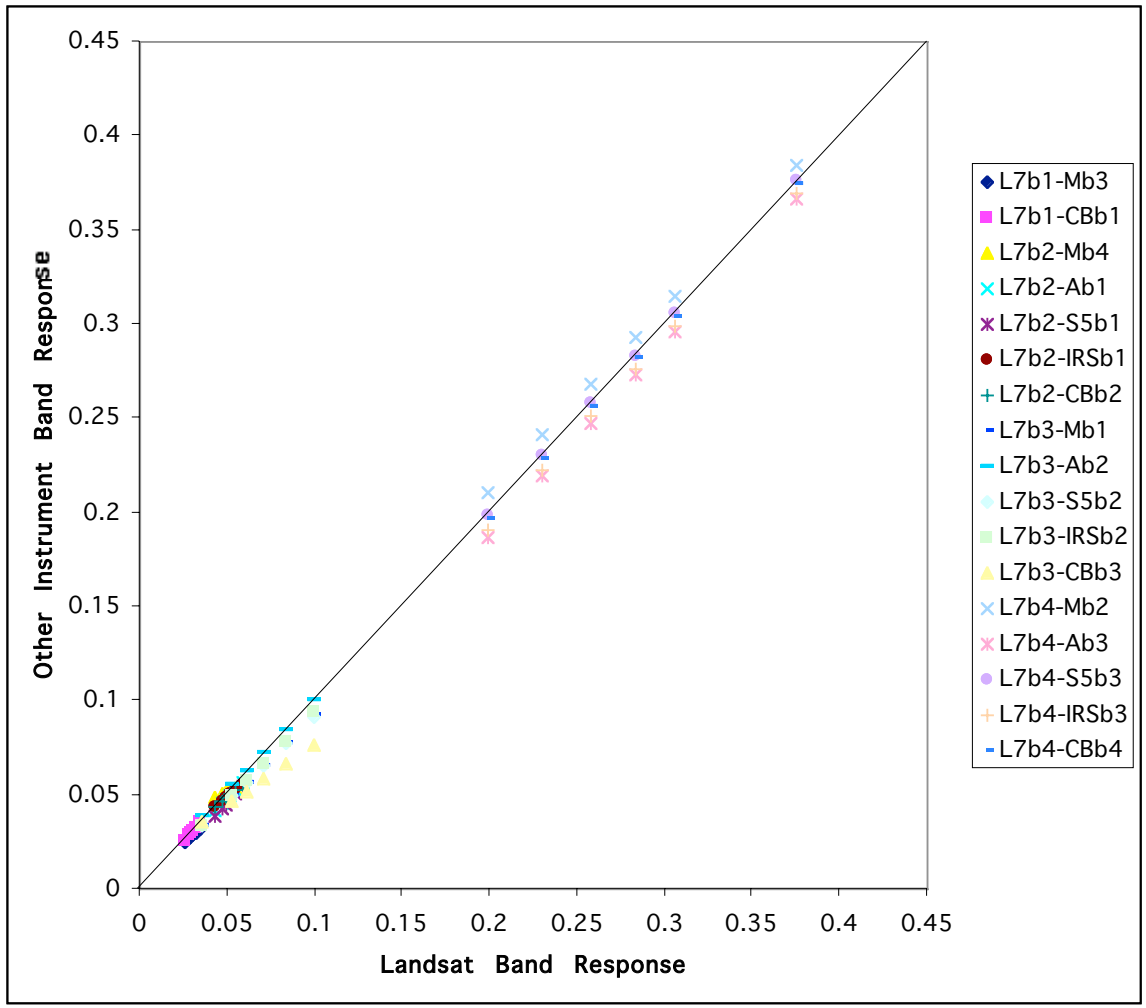
Example: BOREAS SR Validation



MODIS/ETM+
Aerosol Optical Thickness and
Surface Reflectance Histograms
Window 2, 2001 JD 260



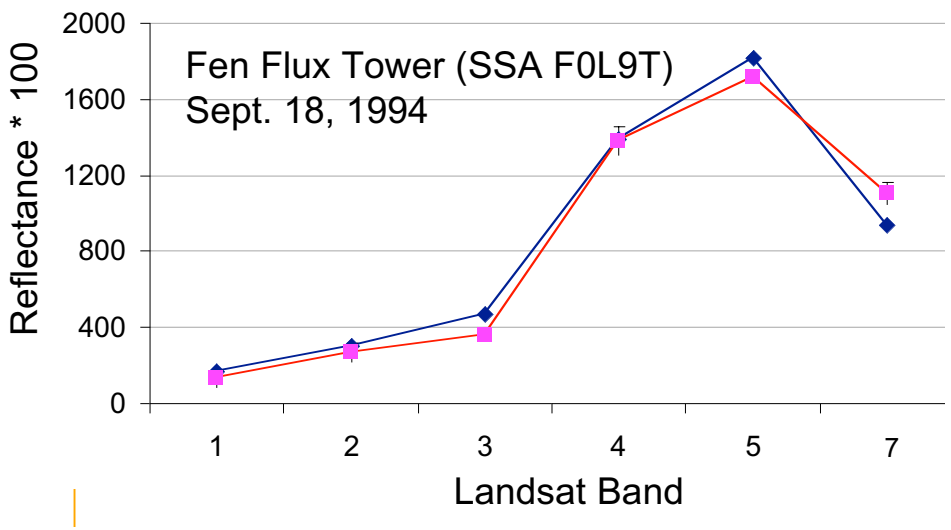
SR "Error" Due to Bandpass

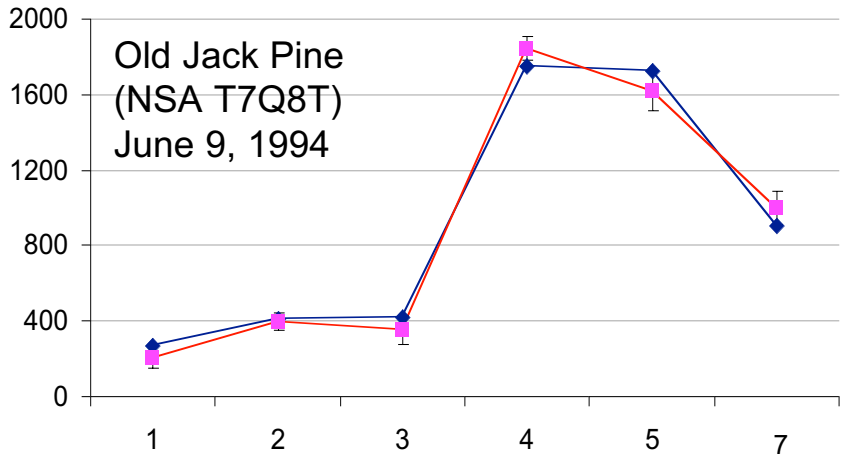


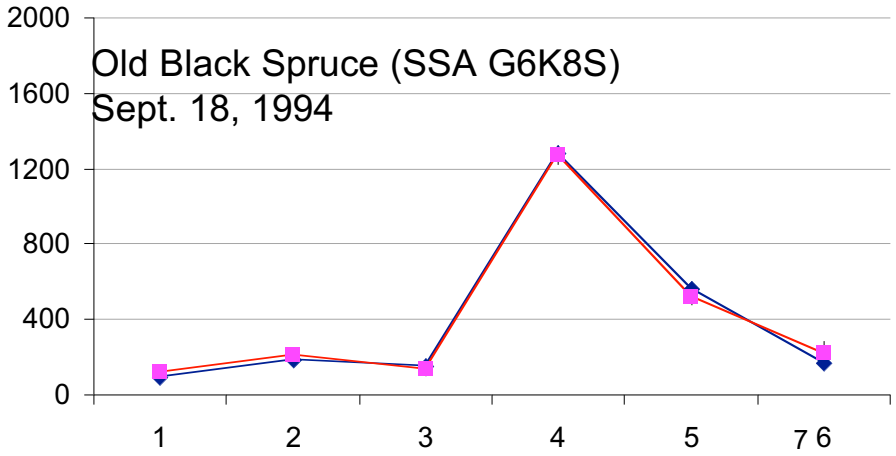
L7 = Landsat-7
CB = CBERS
IRS = IRS
M = MODIS
A = Aster
S = Spot

Assumes typical vegetation spectrum

Boreas MMR vs. Landsat Reflectance





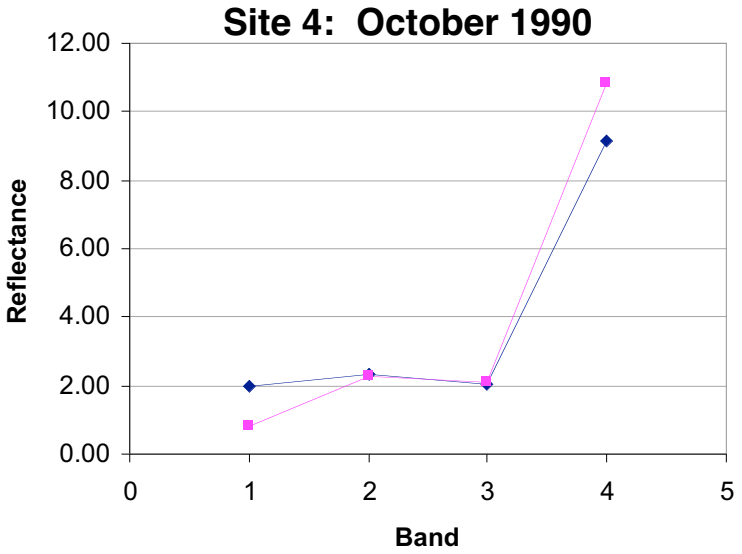


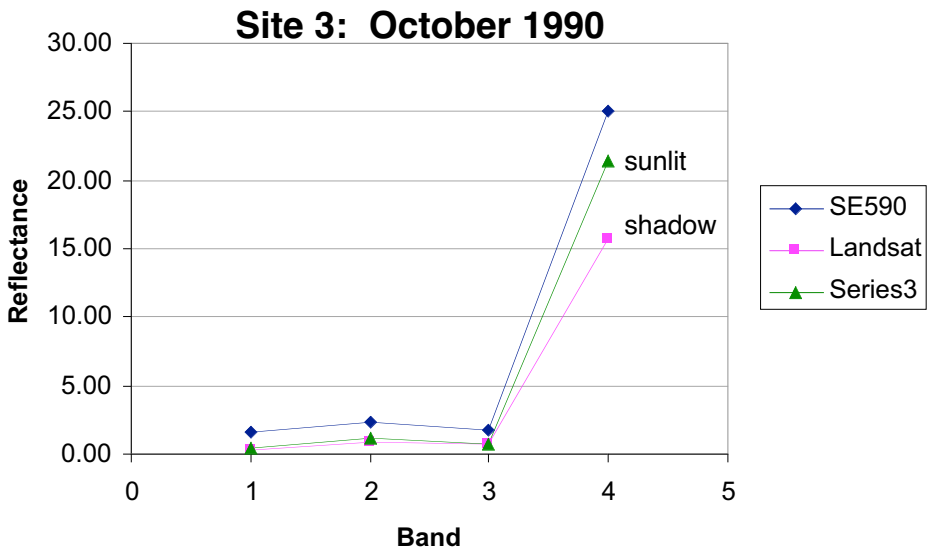
Helicopter MMR data

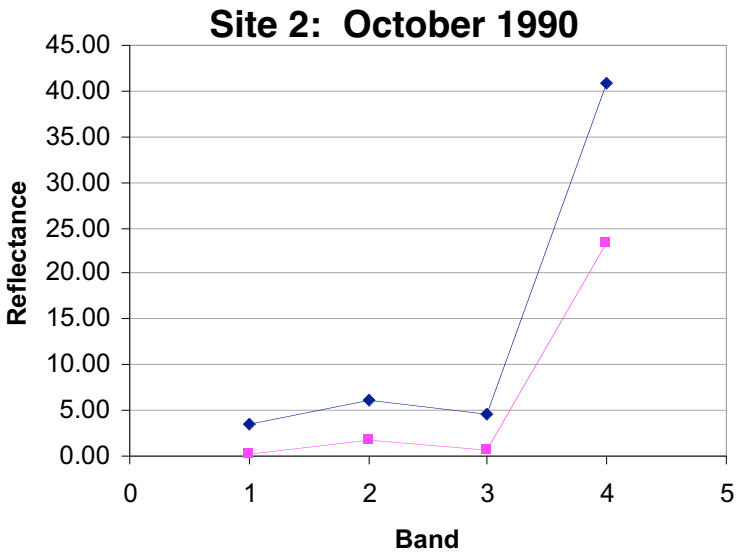
Landsat-5 TM Surface Reflect.

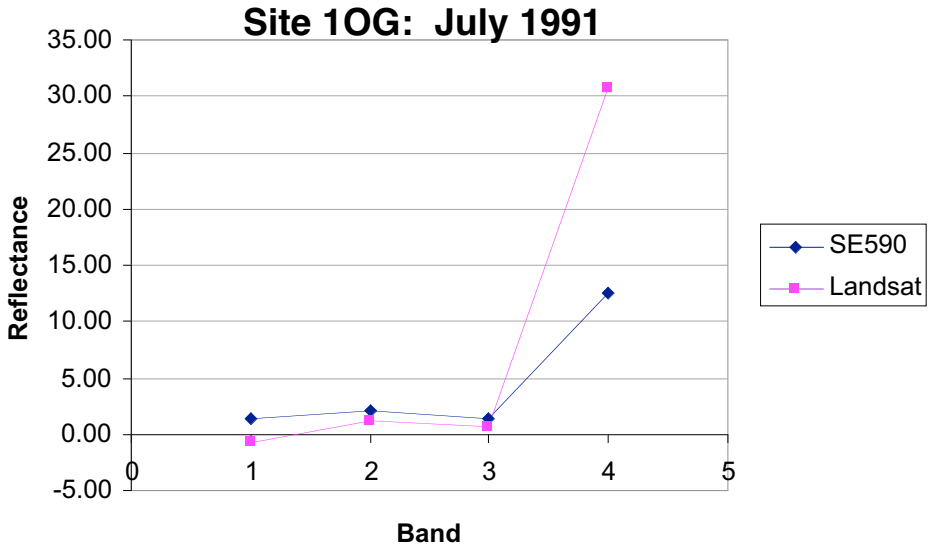
Error bars = +/- 1 std dev within 3x3 pixel window of center

Otter SE590 Ultralight Data









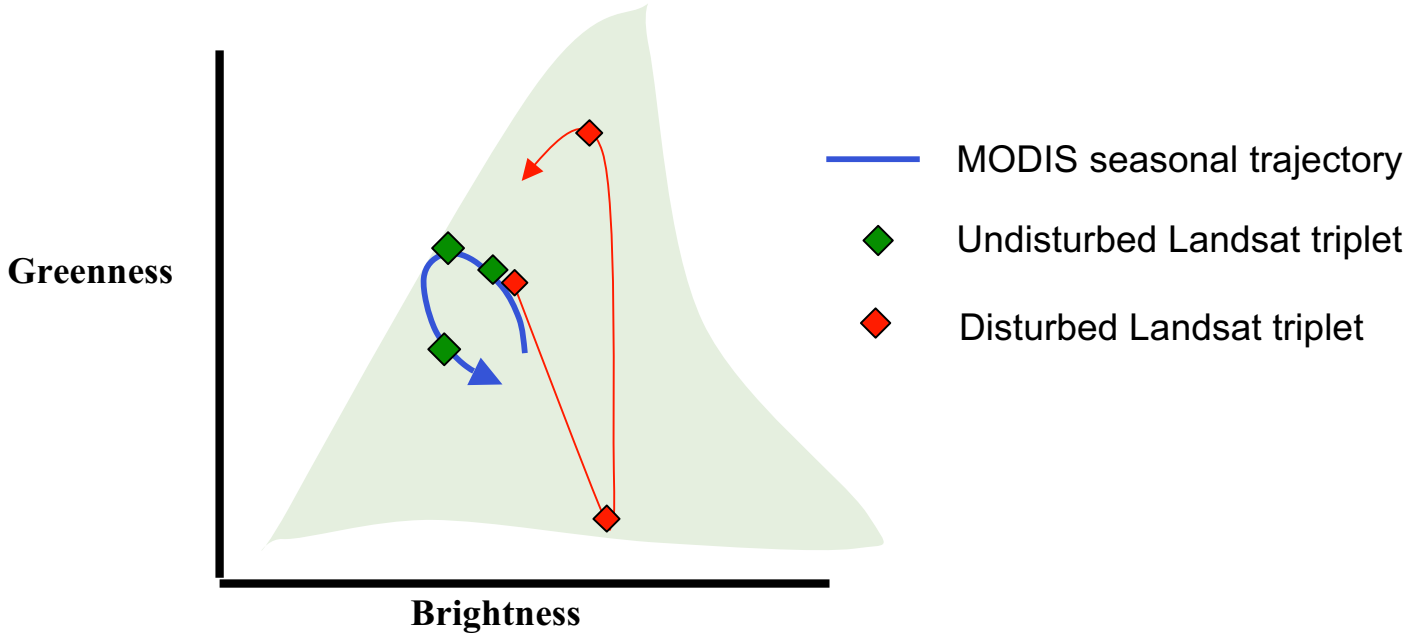
Recent Progress - Disturbance Mapping

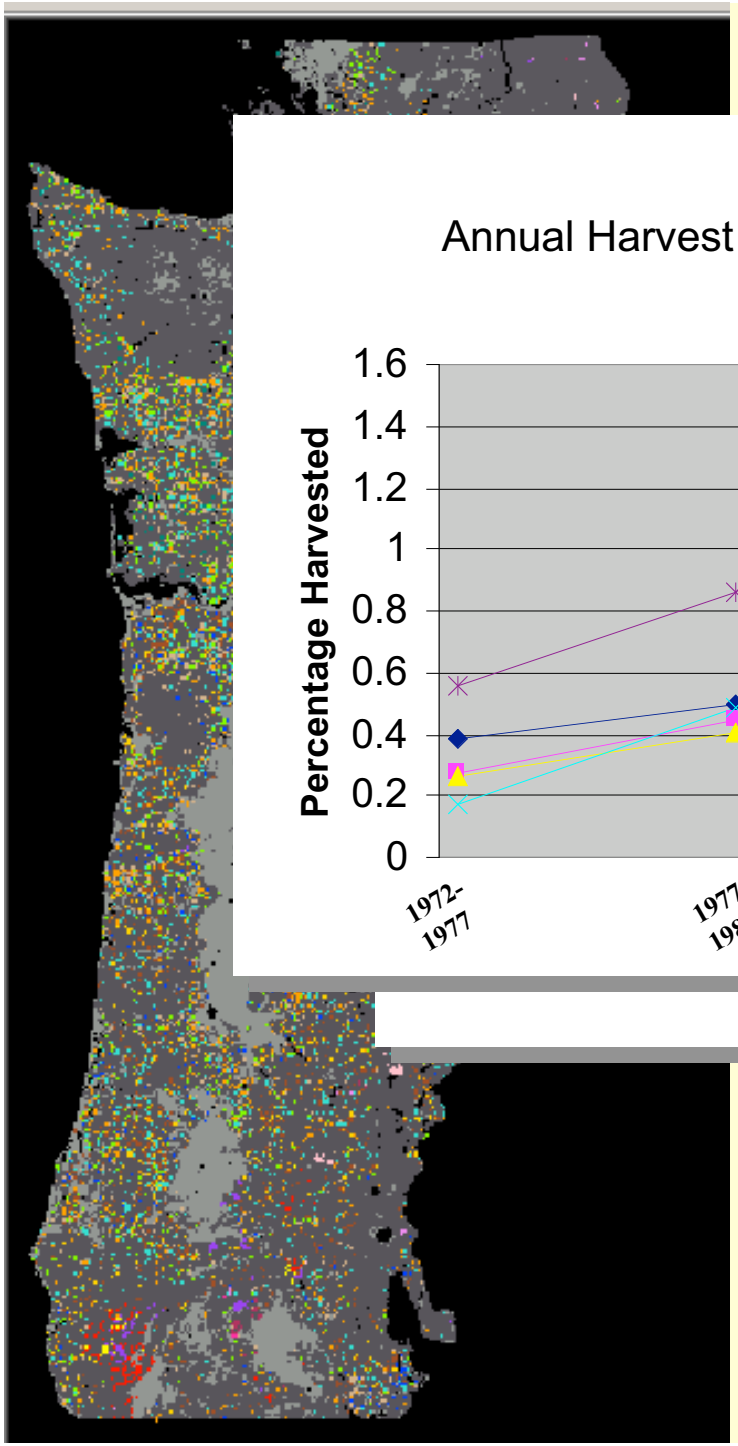
Initial Concept:

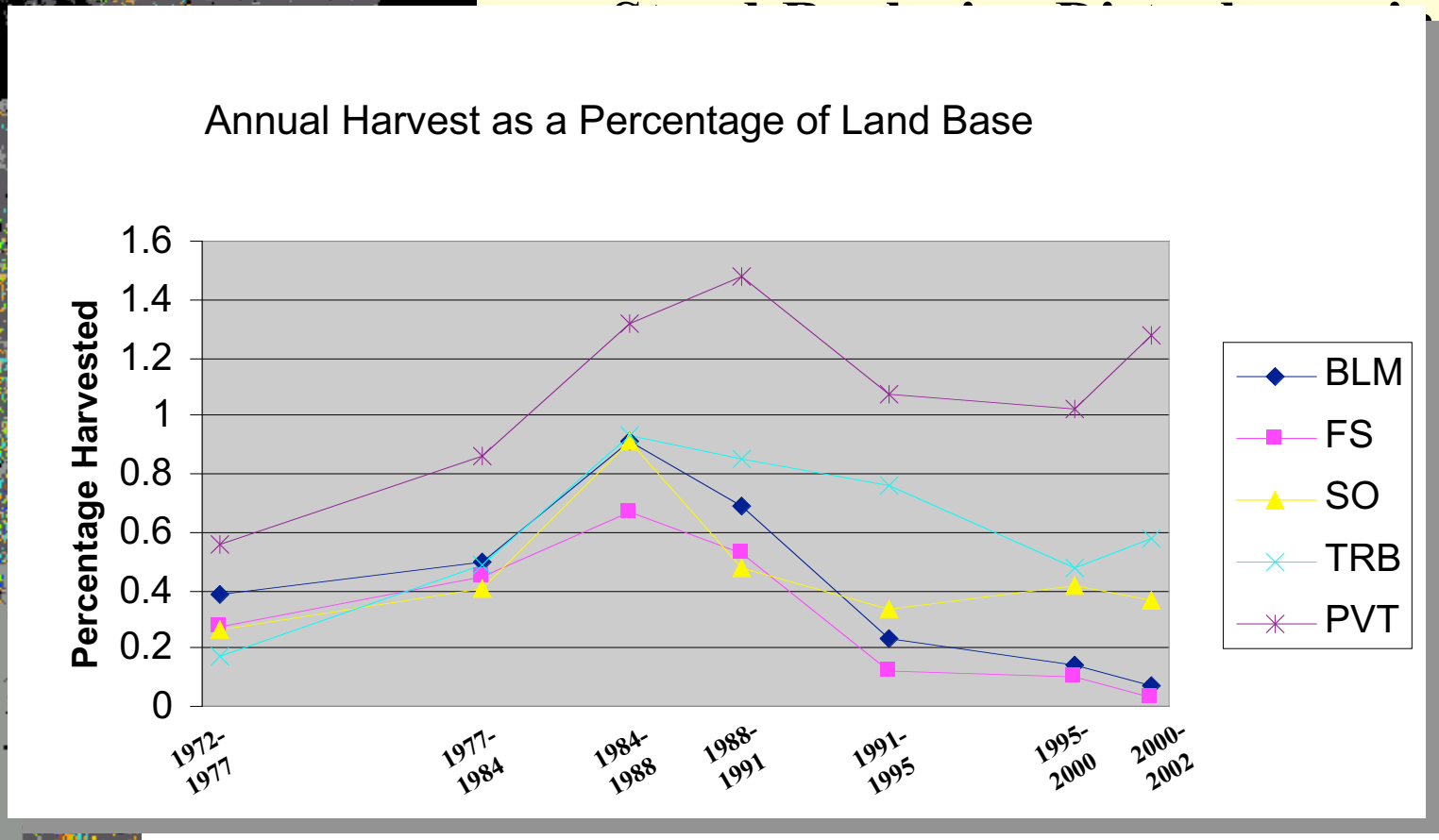
- **Objective: map areas of significant biomass loss or gain (stand-clearing disturbance; young regrowth)**

- **Stratify by ecoregion and stand type (e.g. conifer, hardwood, mixed)**

- **Evaluate actual spectral trajectories against "expected" trajectories derived from MODIS for mature forests.**



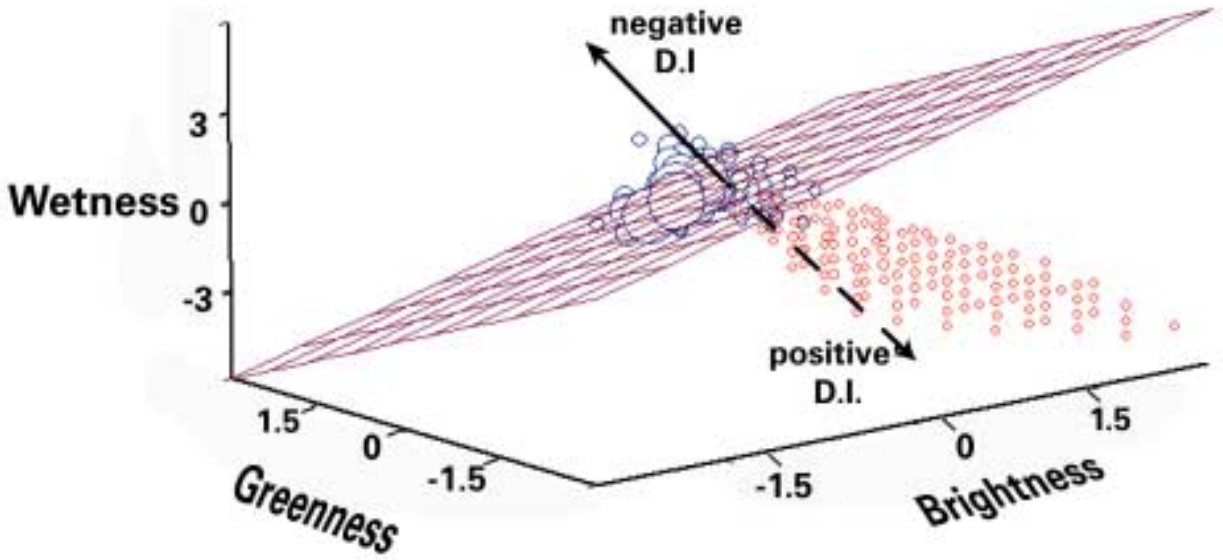




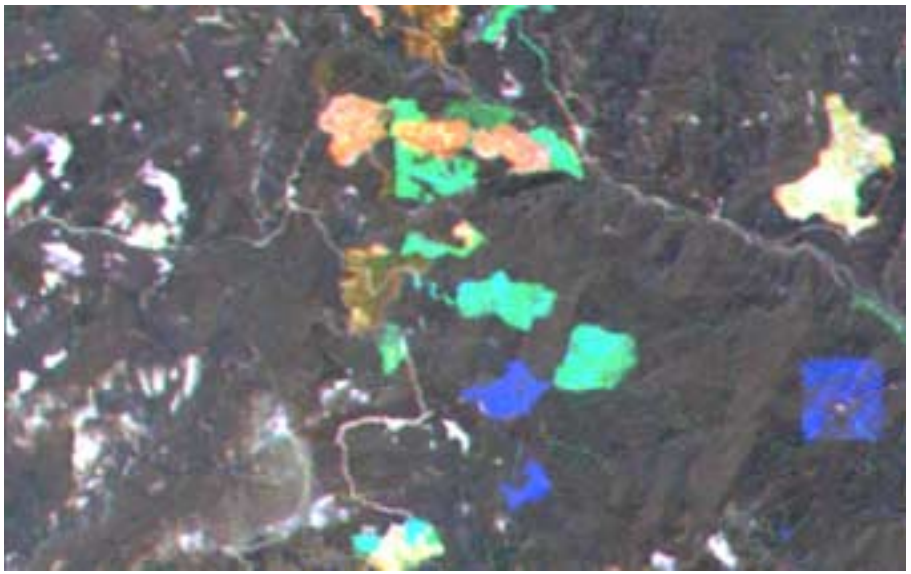
1996-2000

2000-2002

Disturbance Index: $Brightness_{rescaled} - (Greenness_{rescaled} + Wetness_{rescaled})$



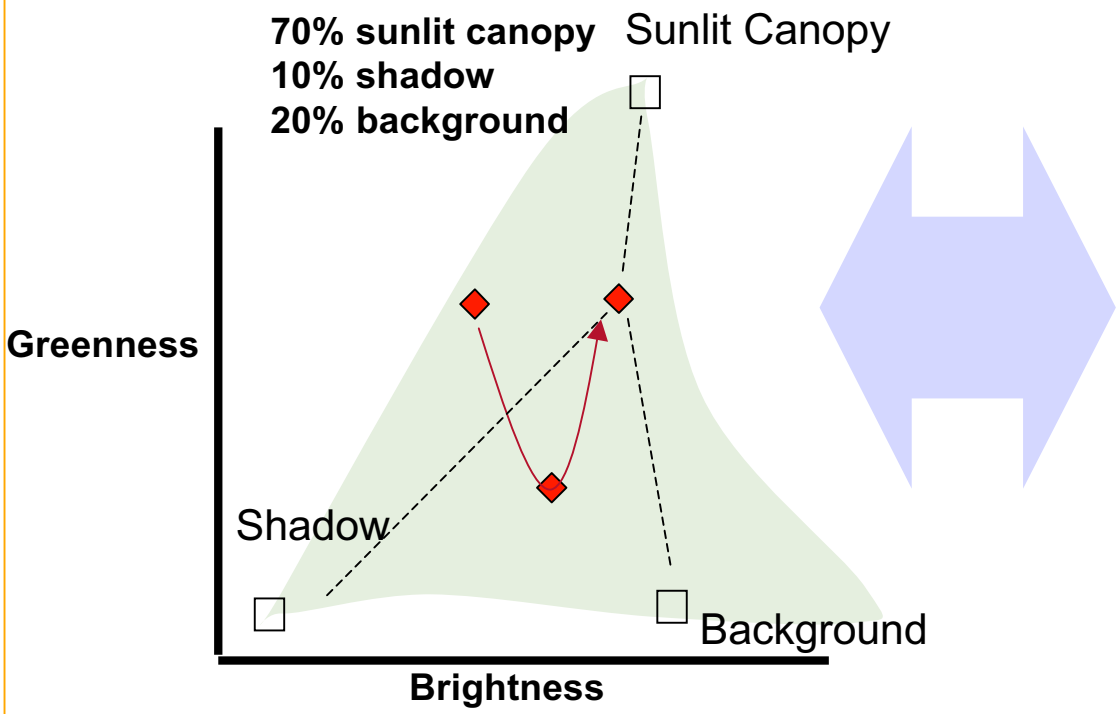
Disturbance Index is a simplified approach for mapping areas of decreased canopy cover and shadow



Multi-date disturbance index composite (RGB), Western Oregon

Recent Progress - Disturbance Mapping

Future Directions: Relation of spectral trajectories to forest structure trajectories using spectral unmixing, canopy reflectance models, and/or forest inventory data



Canopy Reflectance Modeling

Forest Inventory Data

Recent Progress – Community Outreach

- AGU, December 2003 - talk
- NASA LCLUC Meeting, January 2004 – poster
- FluxNet Canada Meeting, March 2004 - poster
- IGARSS, September 2004 – submitted
- EOS Transactions – late 2004?

-FIA NE Station Meeting (Feb 5, 2004)
- Met with Chip Scott, NE Station Director
- MOU for plot-level data (Mid-Atlantic)

- FIA HQ Meeting (Feb 19, 2004)
- Met with Andrew Gillespie, FIA National Director
- Discussed FIA role in NACP

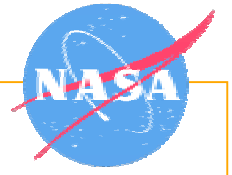
-Agreeed to provide SR timeseries for FluxNet Canada sites and to work with CCRS on cross-validation (Robert Fraser, Hank Margolis, Andre Boudin)

-Future collaboration with Carol Wessman to evaluate SW woody biomass

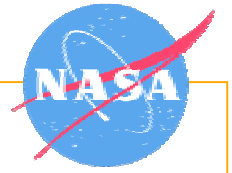
Summary: Issues

- Technical issues slowing release of TM, MSS data
  - *Landsat-5 calibration tougher than expected*
  - *Need to pin down correct AOT estimation for Landsat*
- Programmer absent December ’03 – February ’04

Summary: Bright Spots



- Basically on-schedule, on-budget and no show stoppers
- Growing list of collaborators, good collaboration with USFS FIA
- Disturbance mapping concepts promising
- Good synergy with other projects
  - *AVHRR/ MODIS processing (Masuoka)*
  - *UMD Terrestrial Ecology project (Goward)*
  - *CQUEST (Potter)*
  - *LDCM Data Blender project*
  - *Current Carbon NRA proposals*
    - *Integration of NACP data sources for Carbon modeling*
    - *National assessment of disturbance through FIA integration and Landsat*
    - *Modeling disturbance-driven C fluxes for SE US and Canada*



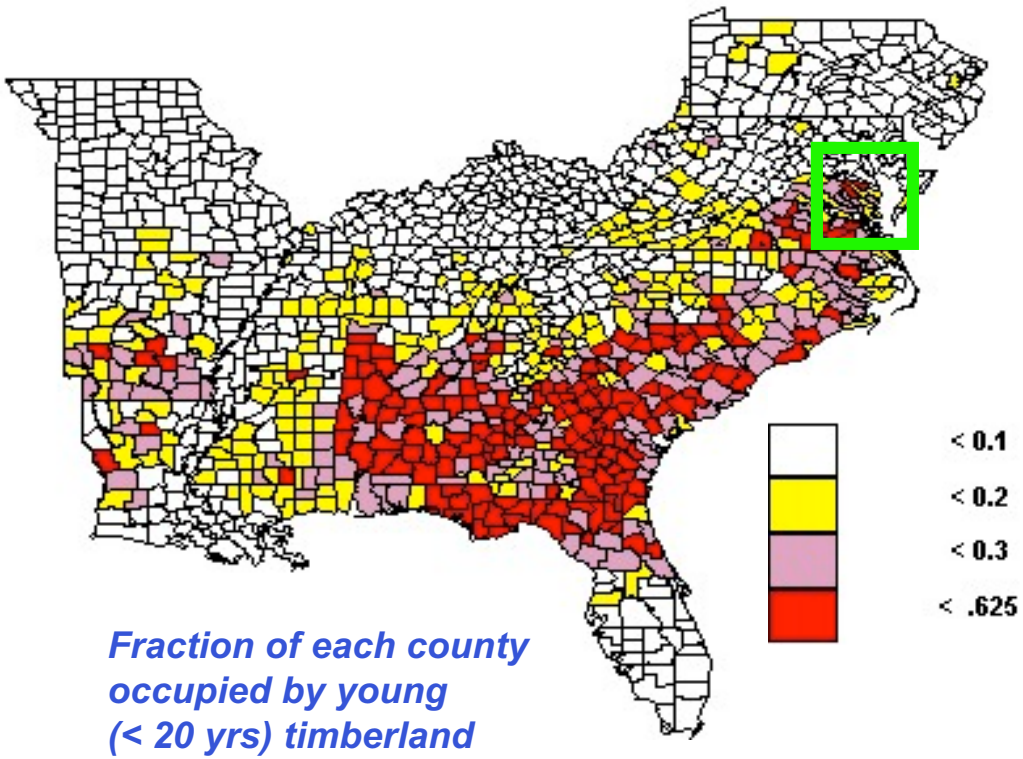
Coming Attractions…

Modeling Disturbance-Driven NEP: Central Virginia

Southeast United States locus of rapid-rotation, “industrial” forestry
= ***rapid, continual disturbance***

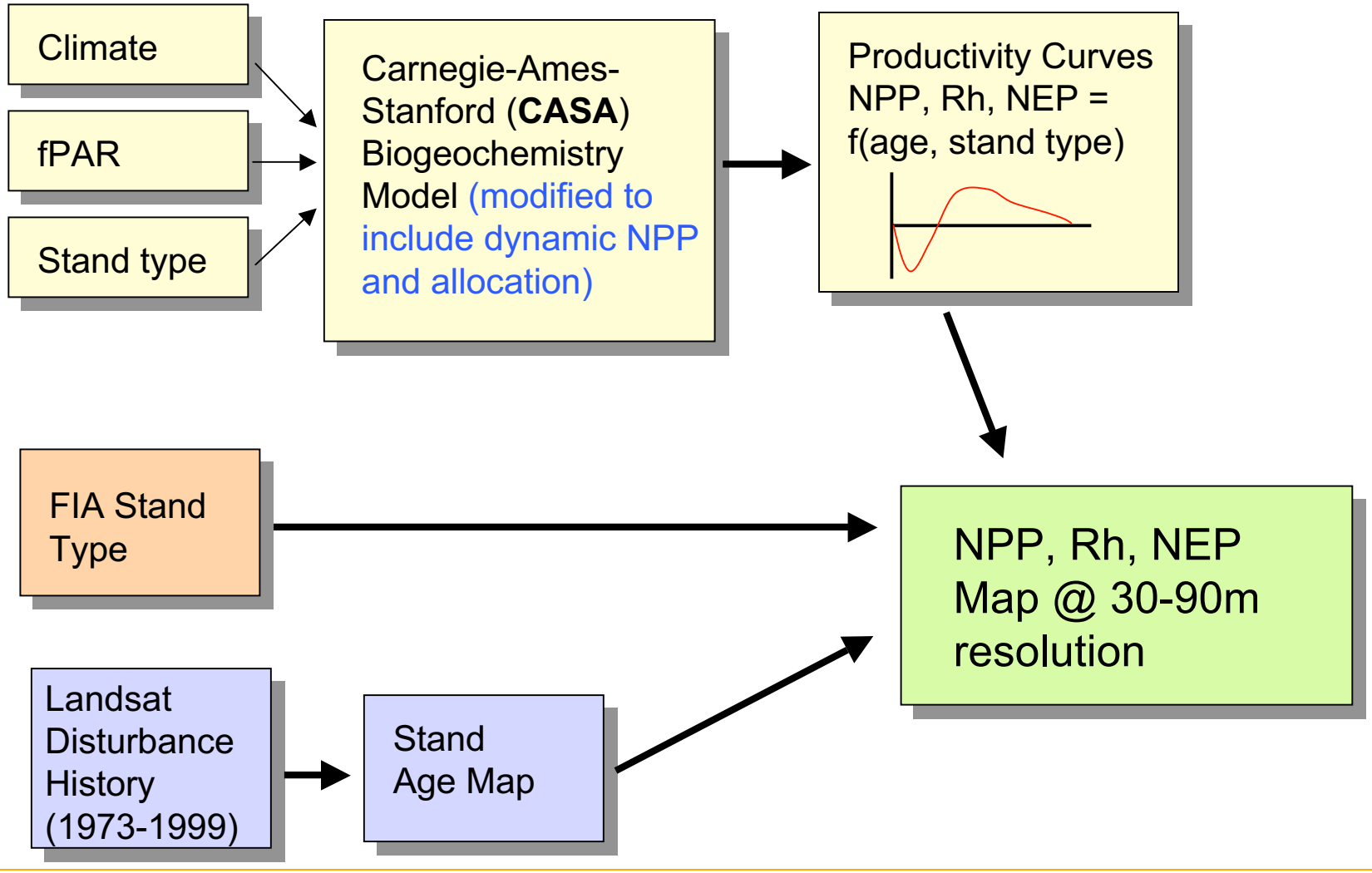
- Objectives: Can we use Landsat disturbance history and CASA to map regional NEP?

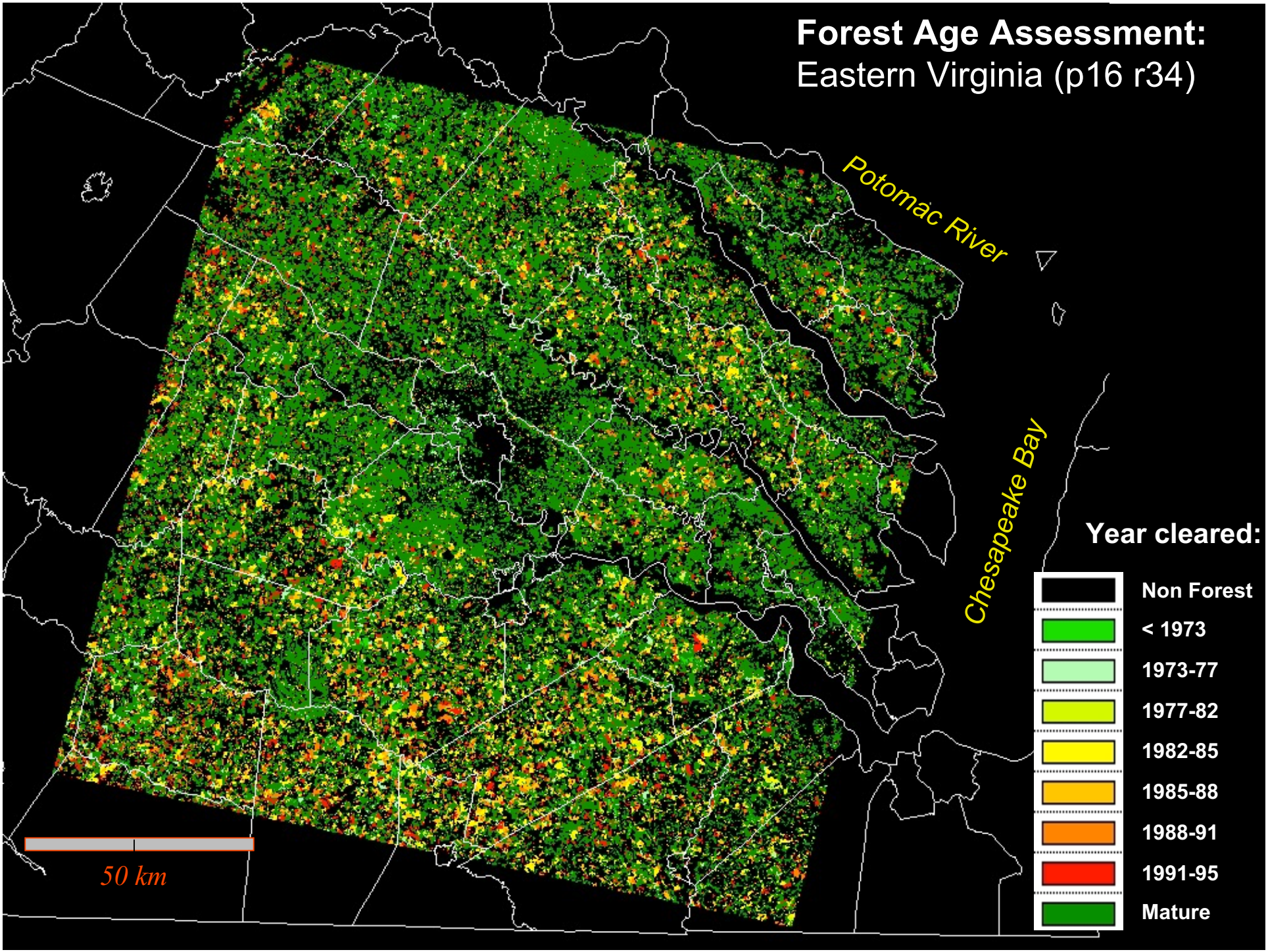
- How does disturbance-driven NEP variability compare to that driven by climate variability?



Fraction of each county occupied by young (< 20 yrs) timberland

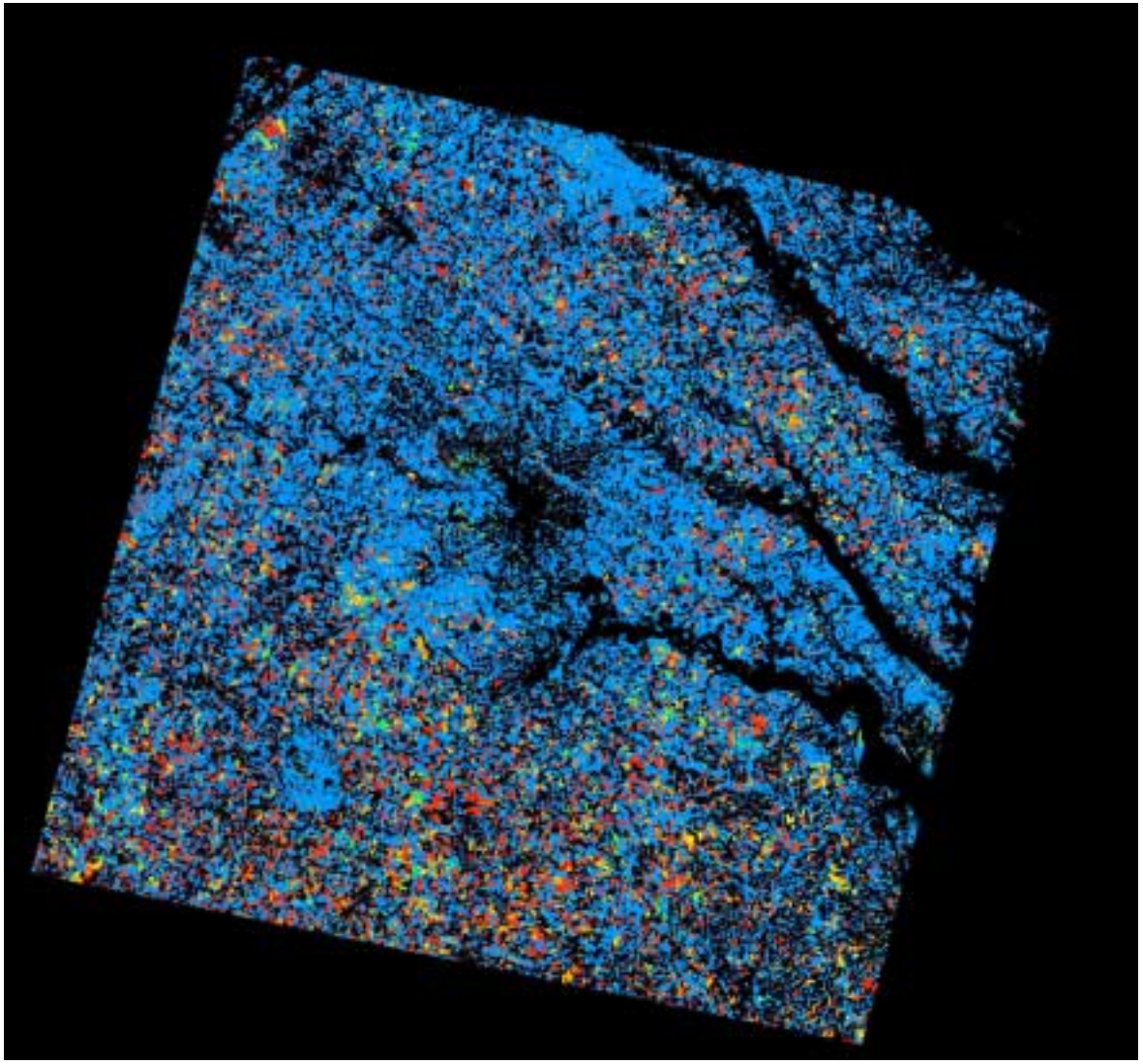
Study Overview




Forest Age Assessment:
Eastern Virginia (p16 r34)
Potomac River
Chesapeake Bay
Year cleared:
Non Forest
< 1973
1973-77
1977-82
1982-85
1985-88
1988-91
1991-95
Mature
50 km

CASA Productivity Curves

Net Ecosystem Productivity



VA Mean Forest NEP =
192 g C / m^2 yr

Equivalent SE USA
NEP = 0.10 Gt C /yr

FIA-based SE USA
NEP = 0.08 Gt C/yr
(Turner et al., 1995)

Future Directions: Collatz/Margolis/Masek NACP Proposal

-Compare NEE estimates with FluxNet chronosequences in disturbed ecosystems (SE United States, Canada)

-Evaluate climate-driven NEP variability vs. disturbance-driven NEP variability

-Evaluate inventory-based biomass vs. model-based biomass

Provide regional “bottom up” assessments of NEE that can be compared with “top down” atmospheric inversions