MODIS land team

use of IKONOS data

High Spatial Resolution Commercial Imagery Workshop
March 19 - 21, 2001
Greenbelt, Maryland

Jeff Morisette, SSAI, Code 923 NASA's GSFC
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and the MODIS Land Team

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Outline

- **Overview of MODIS Land team validation activity**
- **The EOS Land Validation Core Sites**
- **Early results using IKONOS data**

SAFARI 2000 & others

MODerate Resolution Imaging Spectroradiometer (MODIS) on board Terra launched 12/19/99

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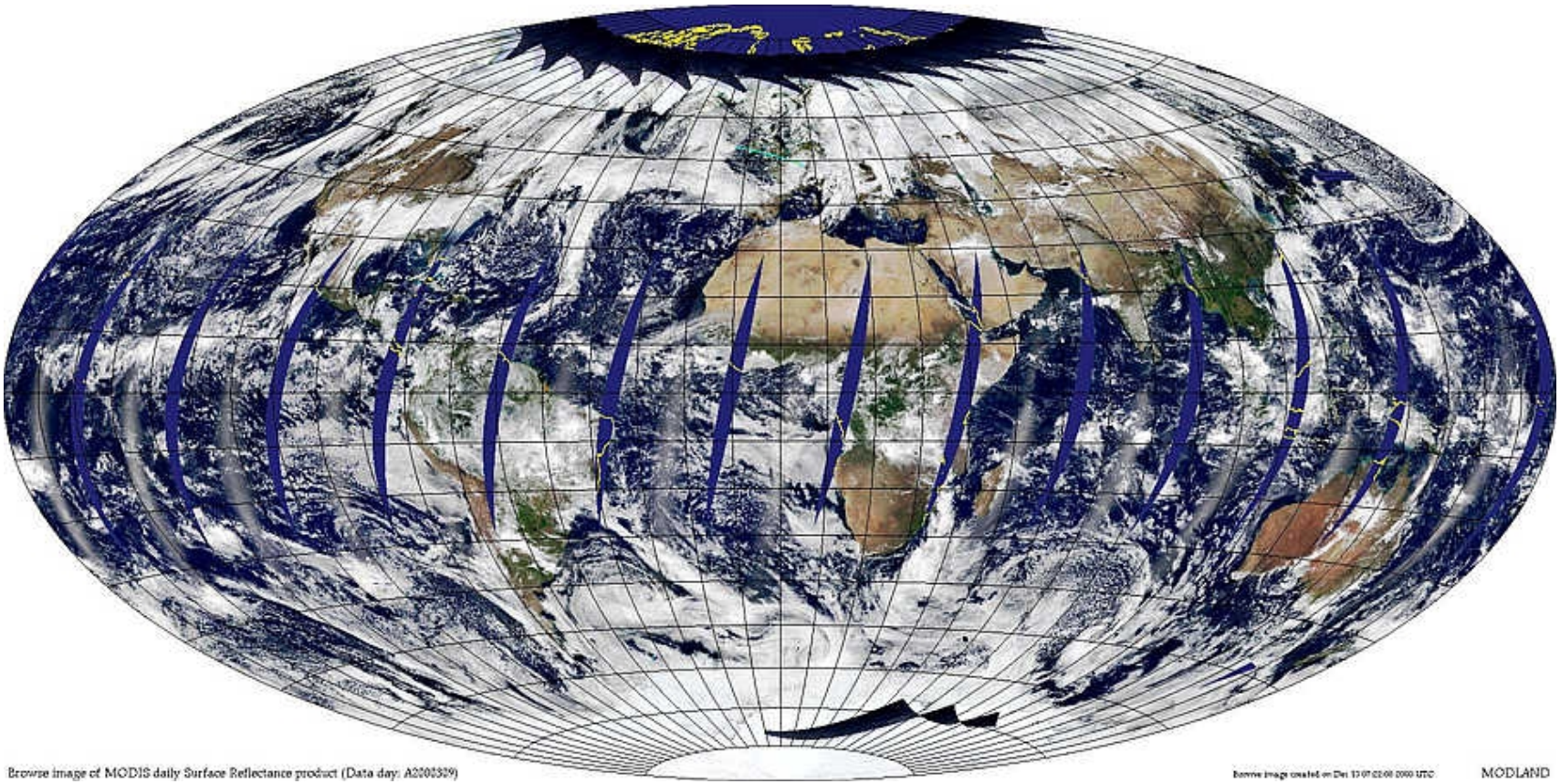
MODIS:
near global coverage daily



Atmospherically corrected land surface reflectance, 11/05/00

http://edcdaac.usgs.gov/modis/dataprod.html

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MODIS Land Products / NASA Earth Science Enterprise Research Themes*

- *Energy Balance Product Suite*
  - Surface Reflectance
  - Land Surface Temperature
  - BRDF/Albedo
  - Snow Cover
- *Vegetation Parameters Suite*
  - Vegetation Indices
  - LAI/FPAR
  - NPP/PSN
- *Land Cover Land Use Suite*
  - Land Cover
  - Vegetation Continuous Fields
  - Vegetation Cover Change
  - Fire and Burned Area

Global Water Cycle and Energy Balance

Biology and Biogeochemistry of Ecosystems and the Global Carbon Cycle

Land Cover and Land Use Change

Atmospheric Chemistry and Aerosols

Applications
Education
Assessments

Validation:

"the process of assessing by independent means the quality of the data products derived from the system outputs"

- CEOS

MODLAND validation home page

http://modarch.gsfc.nasa.gov/MODIS/LAND/VAL

Why we need to validate MODIS land products

- **Good science and resource management require understanding of product accuracy/uncertainty**
- **Explicit statements of uncertainty fosters an informed user community and improved use of data**
- **International environmental protocols and agreements imply findings will be independently evaluated and possibly challenged**
- **As more, and similar, global products are produced by CEOS members, inter-use will require characterization of each product's uncertainty**

MODLAND Validation general operating principles

- the ultimate objective is to characterize products' uncertainty
- utilize independent data with relatively high accuracy and global consistency
- recognize limited resources for both data collection and analysis
- capitalize on the concept that imagery and field data sets can often be used to validate more than one product

Implications of operating principles

- Partnerships with
  - other field programs (e.g., LTERs)
  - science networks (e.g. AERONET, Fluxnet, & SDP)
  - international research efforts (LBA, SAFARI 2000)
  - International planning
    (CEOS working group on Calibration and Validation)
- Development of a set of core validation sites
  - globally consistent data sets
  - provide a foundation for a network that can grow toward global representation.
- Serve a wide range of investigators interested in landscape characterization

Three main components for each product

- **Instruments and imagery needed for reference data**
- **Sites where these data will be collected**
- **Protocol for collecting data and conducting correlative analysis**

  - ***instruments are generally product specific***
  - ***imagery needs are consistent across products***

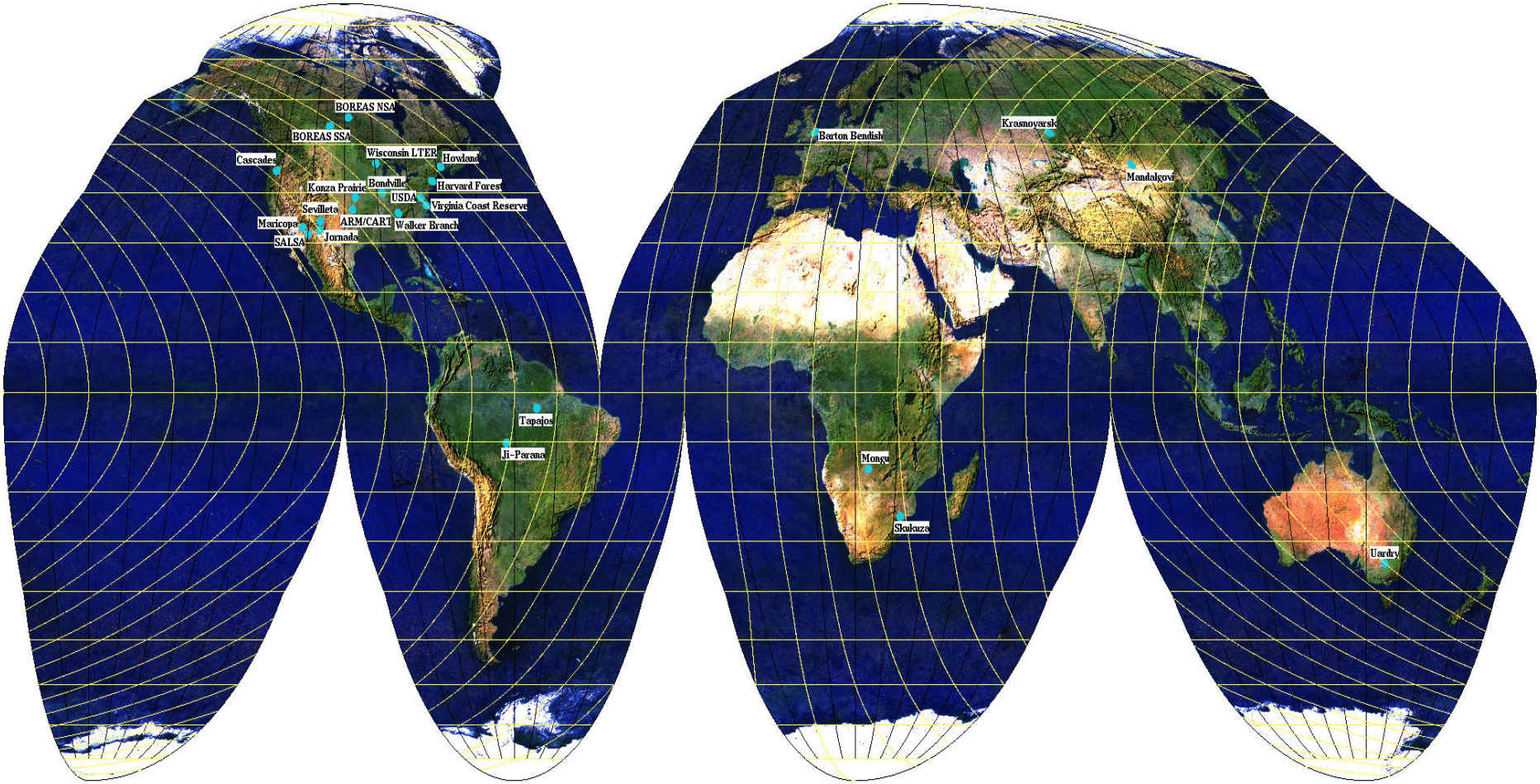
Why MODLAND uses IKONOS data for validation

- **High spatial resolution can help associate field measurements to other satellite data (ETM+ ⟶ MODIS)**

- **High geometric accuracy**

- **Available globally and globally consistent**

EOS Land Validation Core Sites



EOS Land validation core sites – Goode homolosine projection – Black grid: 10 deg. graticule – Yellow grid: MODLAND L3 tiles

Jacques Descloitres (MODLAND / LDOPE) – May 1999

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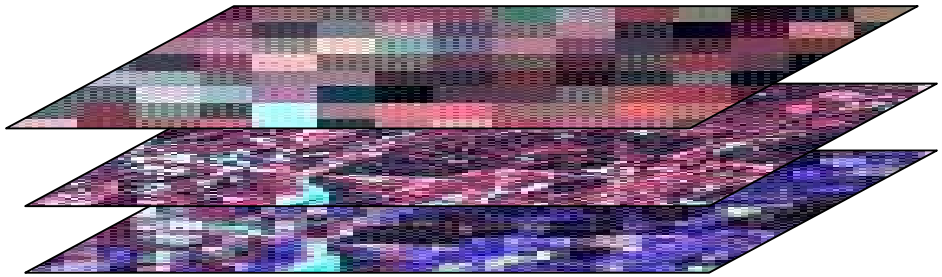
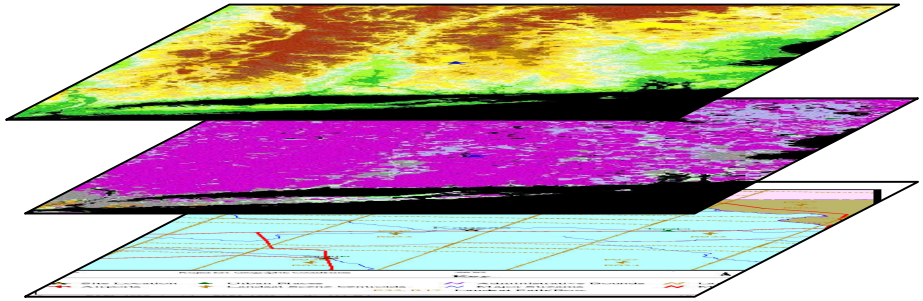
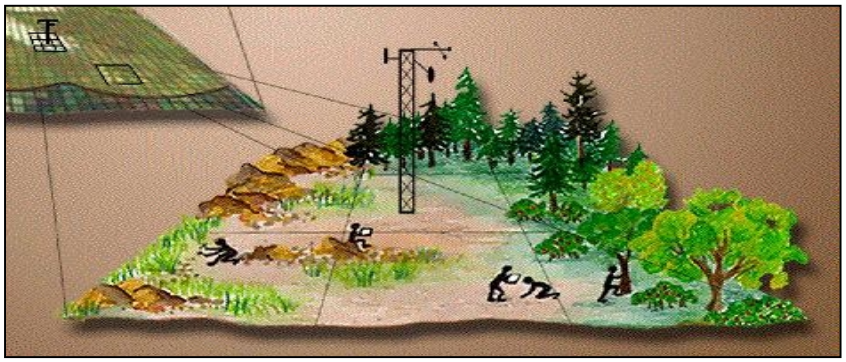
EOS Land Validation Core Sites







Field data graphic courtesy of the BigFoot program

Satellite imagery
- **MODIS Subsets (EDC DAAC)**
- **ETM+ (EDC DAAC)**
- **ASTER data (EDC DAAC)**
- **MISR Local Mode (Langley DAAC)**
- **SeaWiFS Subsets (GSFC)**
- **IKONOS (SDP/GLCF)**
- **"GeoCover '90s TM (SDP)**
- **EO-1**

Ancillary layers and background information such as existing
- **elevation**
- **land cover**
- **reference layer**

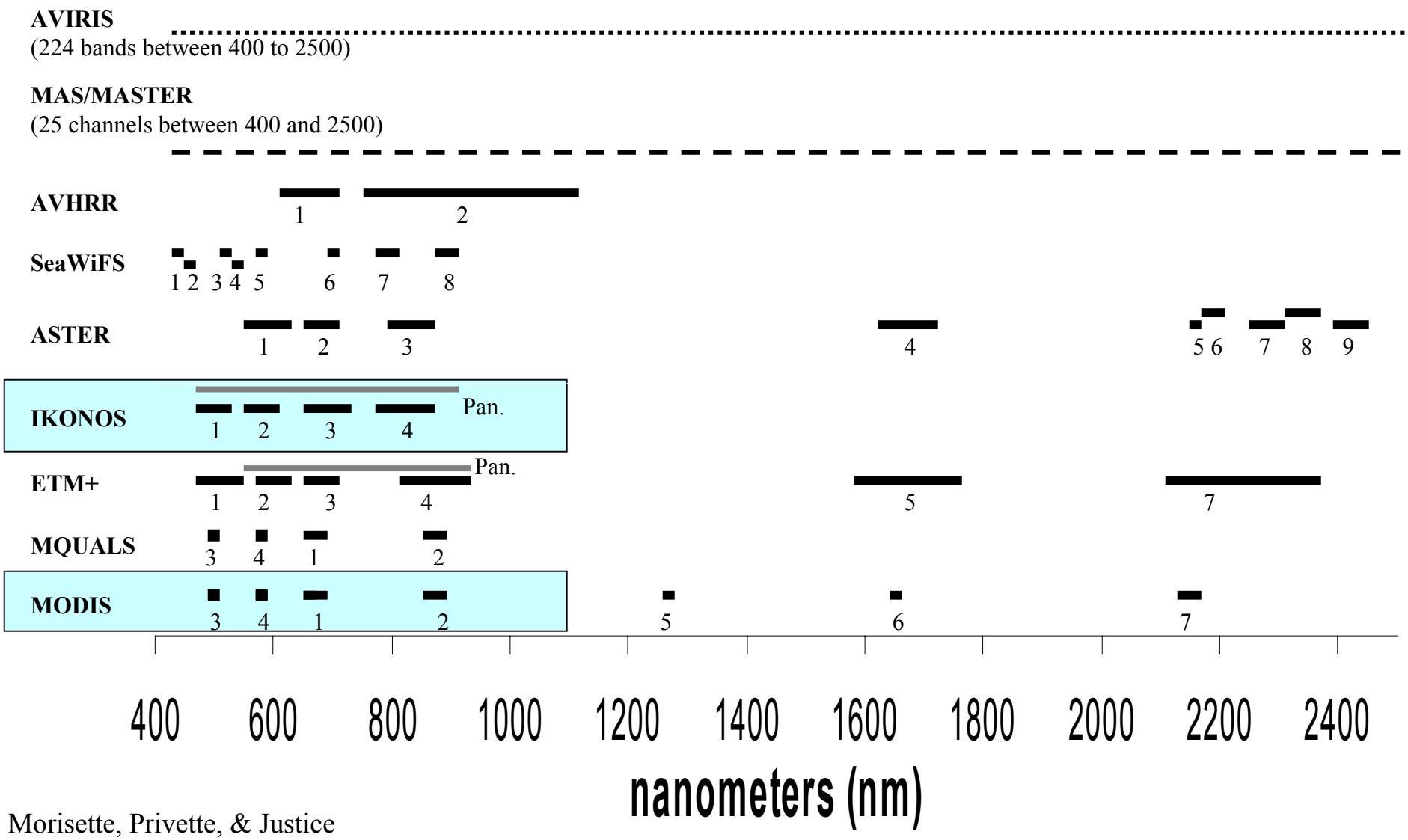
available through UMd ESIP – GLCF

Field and airborne data:
archive and access through
ORNL DAAC's "Mercury System"

AERONET and FLUXNET data

Black: available for all Core Sites
Blue: available for some Core Sites,
Green: not currently available

Spectral bands for imagery utilized by MODLAND validation



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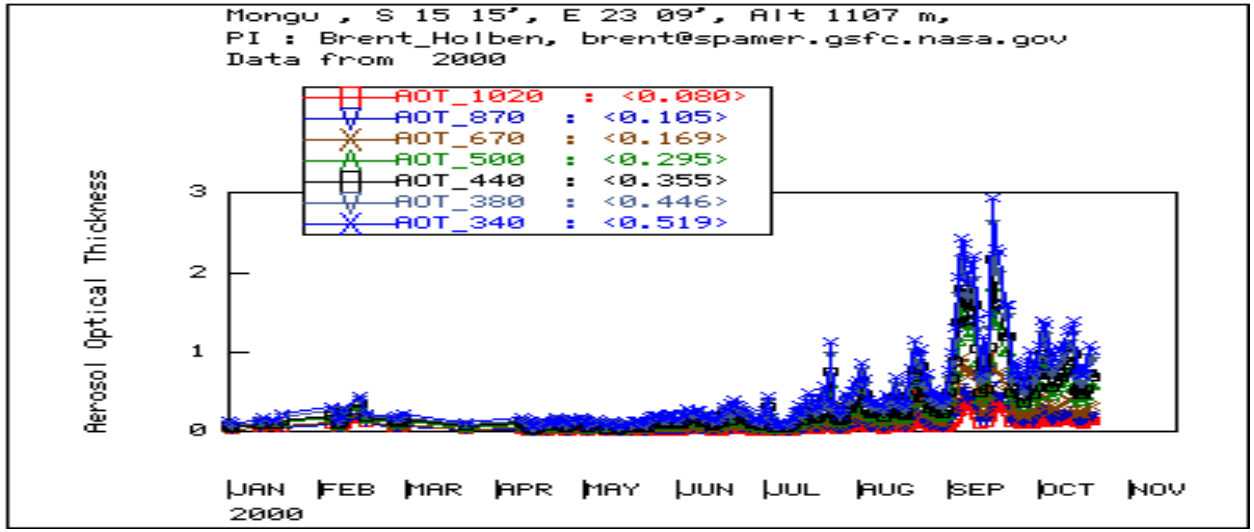
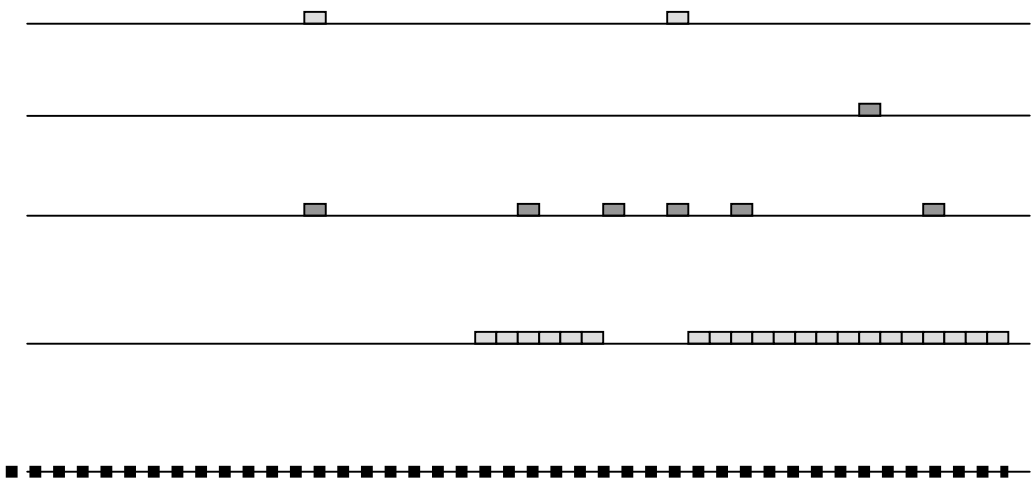
Acquisition frequency: example from MONGU Core Site



AERONET data



IKONOS

ASTER

ETM+

MODIS 8-day Surf. refl.subsets

SeaWiFS (>100 subset for 2000)

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Core Site data summary

	ARM/CART	Barton Bendish	Bondville,IL	BOREAS, NSA	BERMS	Cascades LTER	Harvard Forest	Howland	Ji-Parana	Jornada LTER	Konza Prarie	Krasnoyarsk	Mandolgobi	Maricopa Ag.	Mongu	SALSA	Sevilleta LTER	Skukuza	Tapajos	Uardry	USDA ARS	VCR	Walker Branch	Wisc.Park Falls
MODIS Subsets																								
SeaWiFS subsets																								
Ancillary report (CRESS)																								
Ancillary data (GLCF)																								
ETM+ (with # of acquisitions)			7	3			5			4	5	2	1		7		2		5		5			5
Ikonos		1-DEM		2		1	1	1		2	2	1			2		4				2			
Airborne (MQUALs or ER-2, both)																					AT			
Global Land Cover Test Sites																								
GeoCover: 1990 TM data																								
Aeronet CIMEL (planned)																								
EO-1 coverage - planned																								
ASTER & MISR local mode - planned											1													

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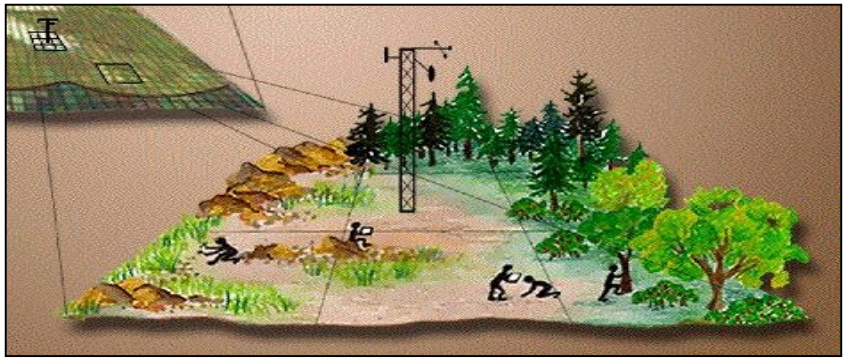
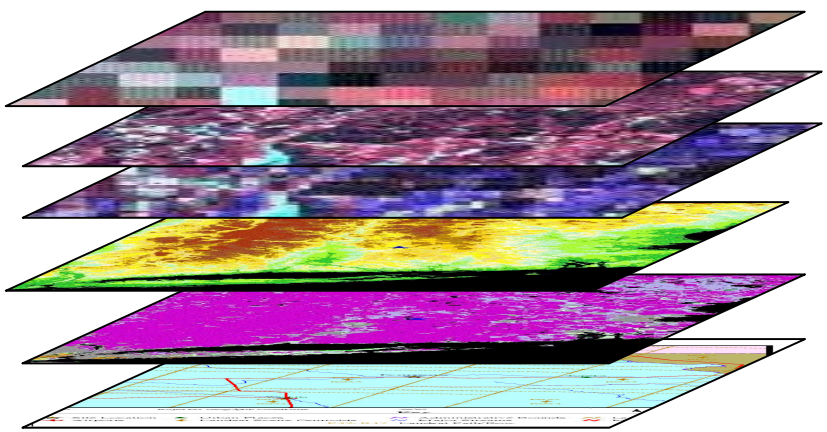
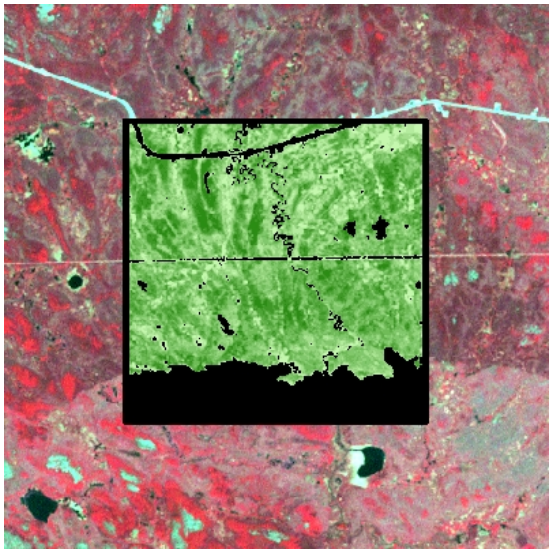
The scaling issue



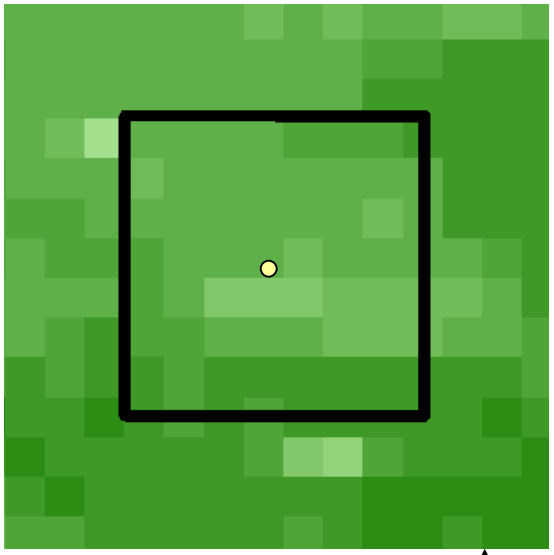
Calibration



Aggregation

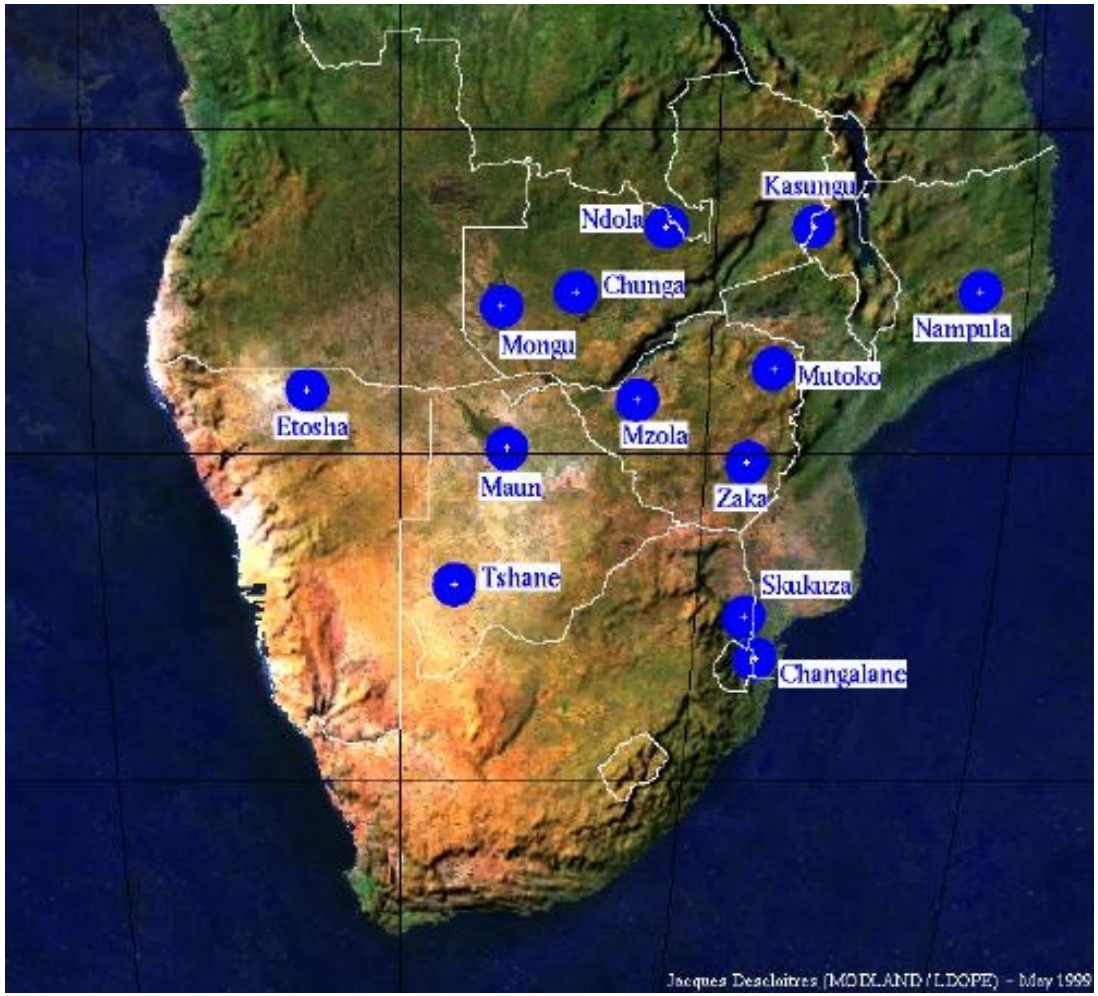


Correlation



Morisette, Privette, & Justice *Some graphics courtesy of BigFoot project*

Southern Africa Fire and Atmosphere Research Initiative: SAFARI 2000



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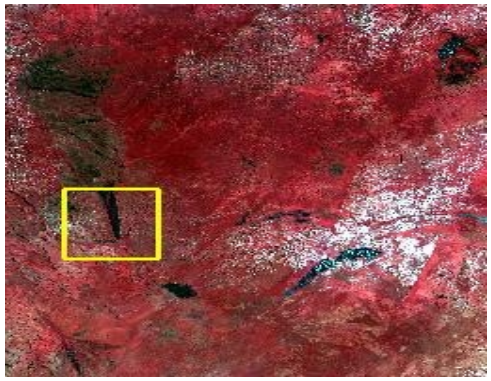
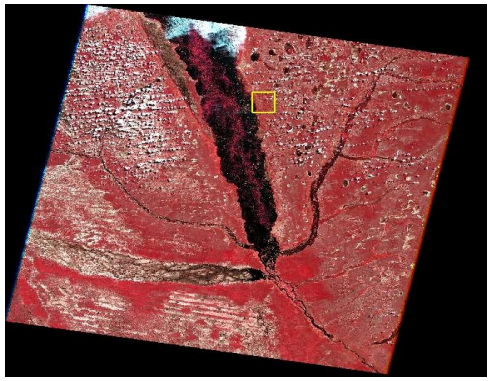
1200km



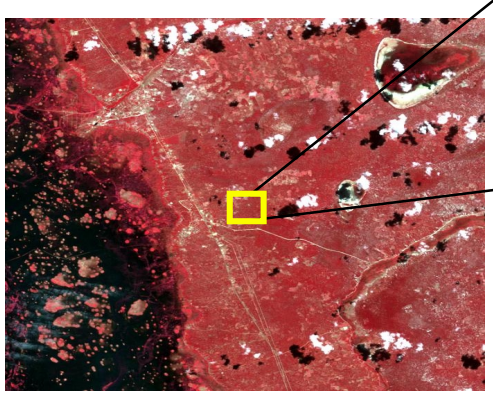
MODIS 1200x1200km^2 tile
yellow box indicates bounding box for ETM+ scene below

~200km

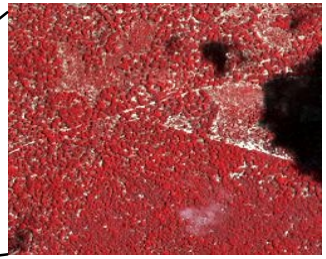


ETM+ scene
yellow box indicates bounding box for IKONOS scene below

11km



IKONOS, close up



1 km

1 km

ETM+, close up

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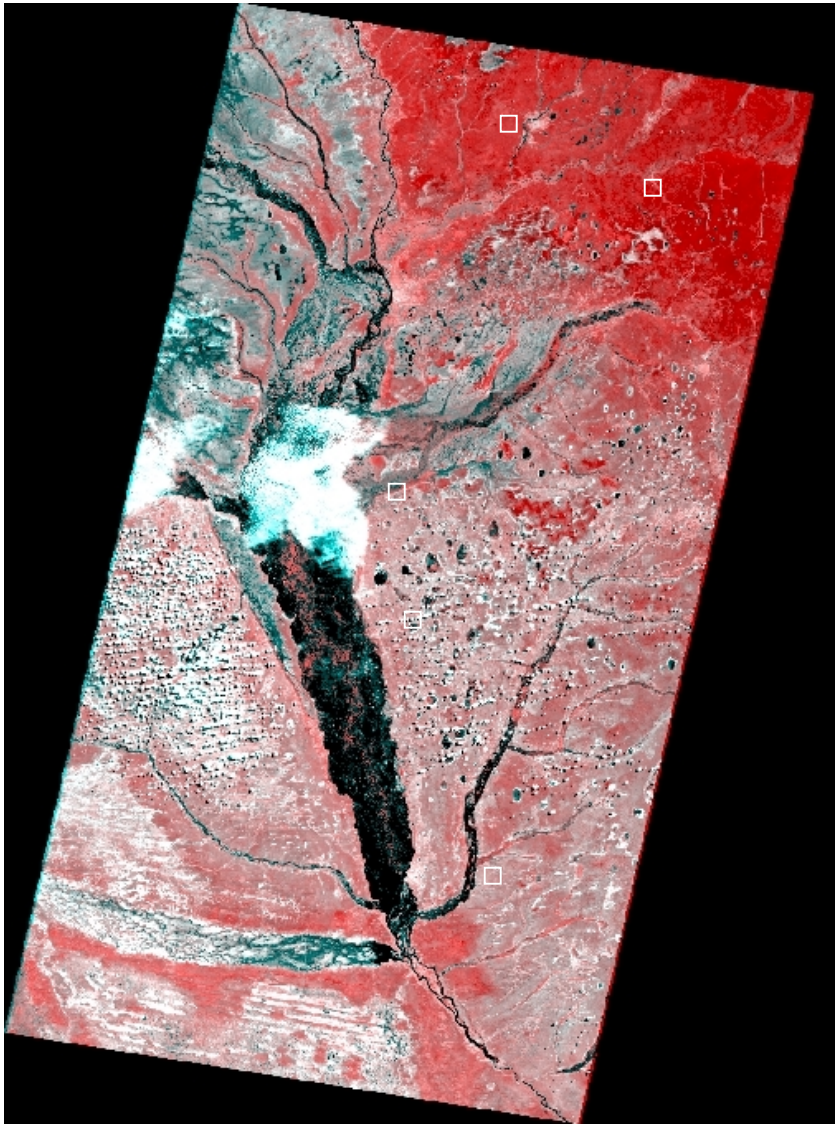
IKONOS use in Western Zambia to Map Tree Cover



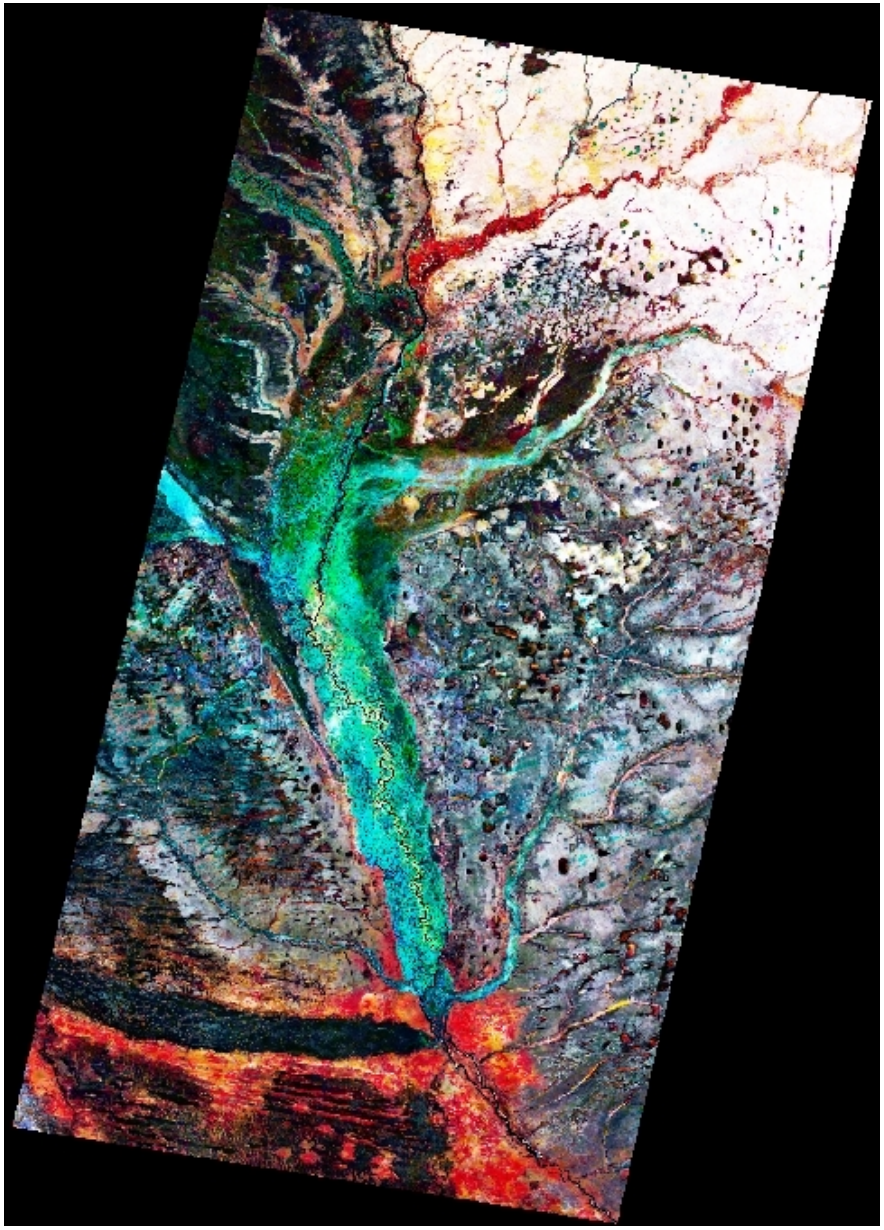
Using IKONOS to "train" ETM+ data

IKONOS acquisitions shown as white squares

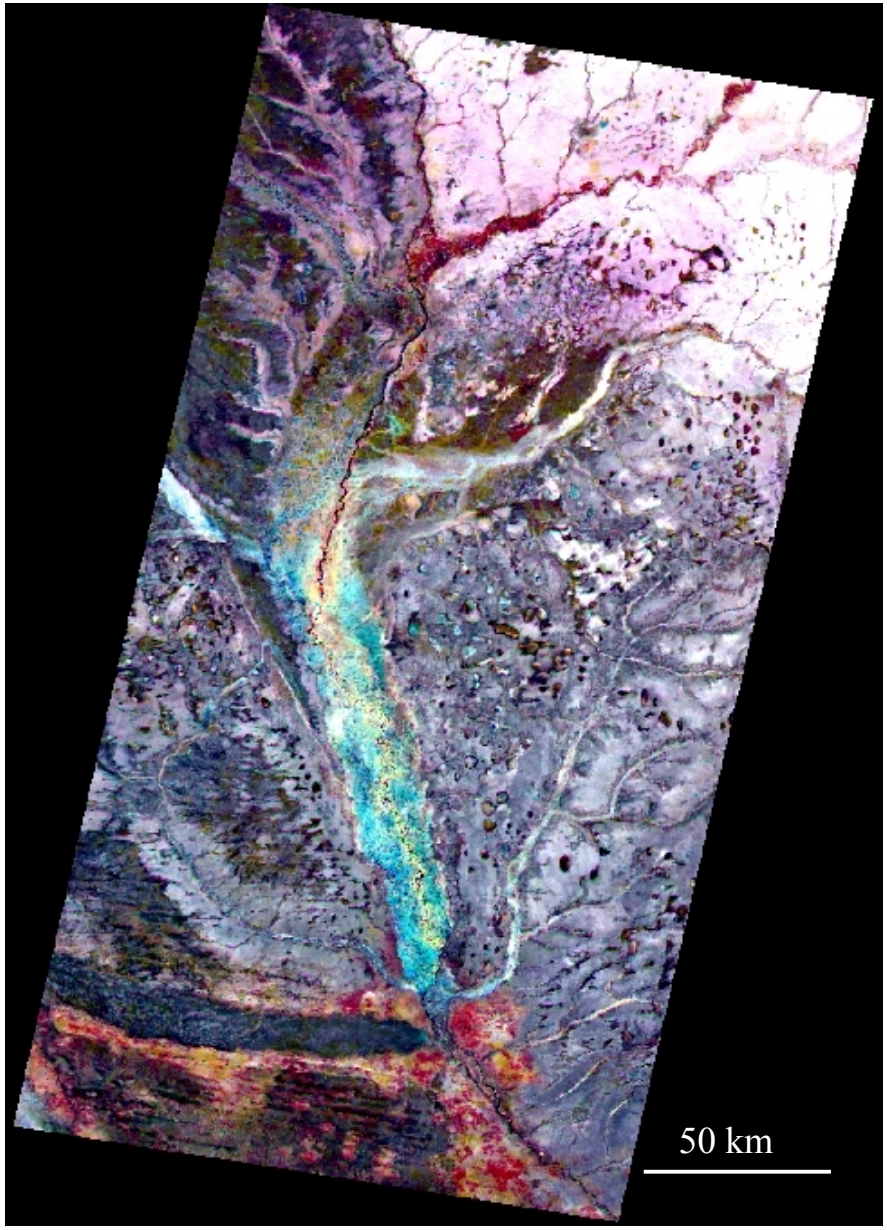
False Color composite for
Zambia
Landsat WRS 175/070-071,
April 4, 2000

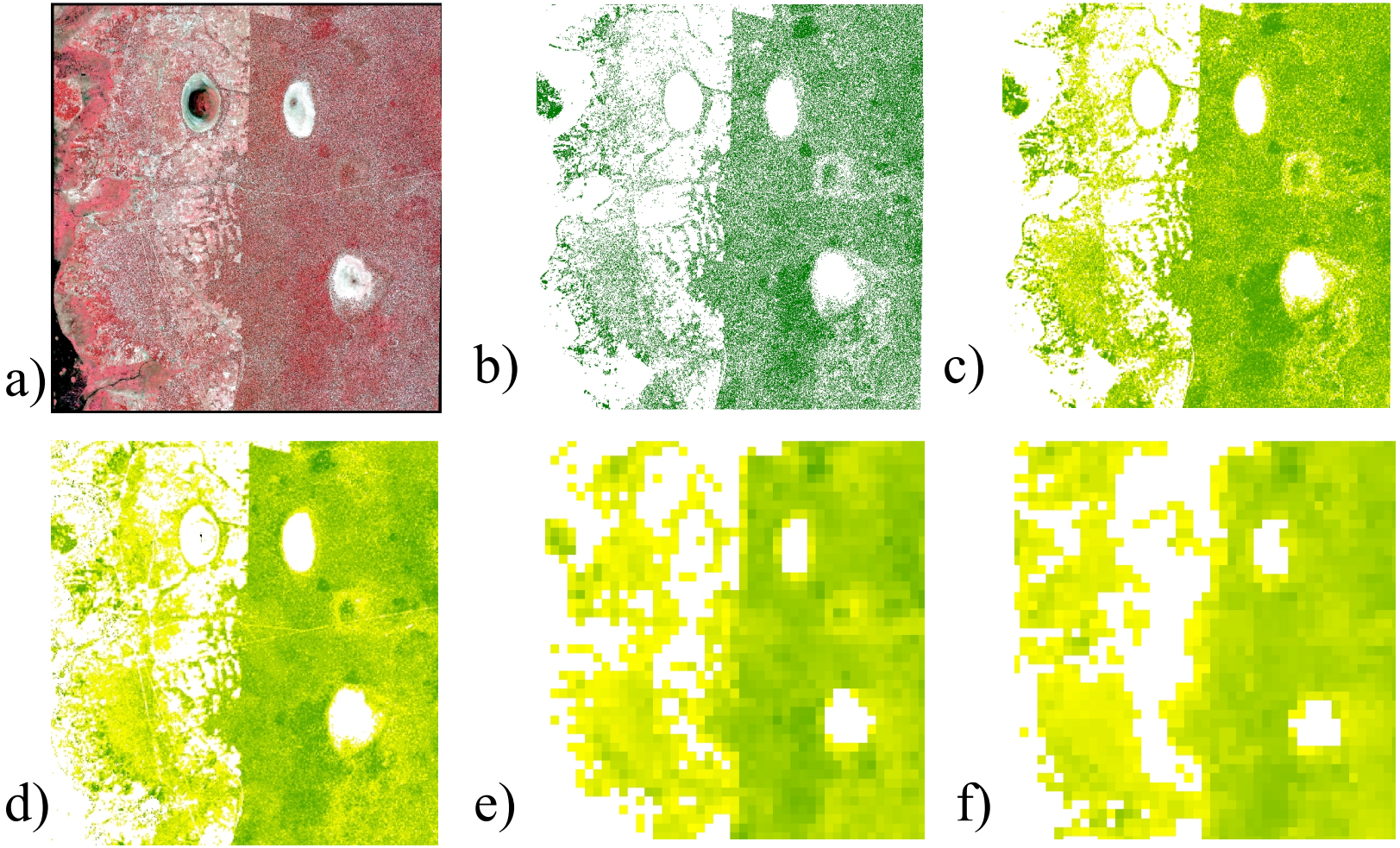
from Hansen, Umd
With Townshend and Defries, UMd

ETM+ NDVI composite,
red=April 4, green=June 29, blue=August 16,
2000

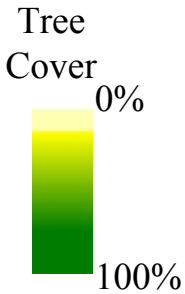


MODIS NDVI composite,
red=May 20, green=June 25, blue=July 27
2000

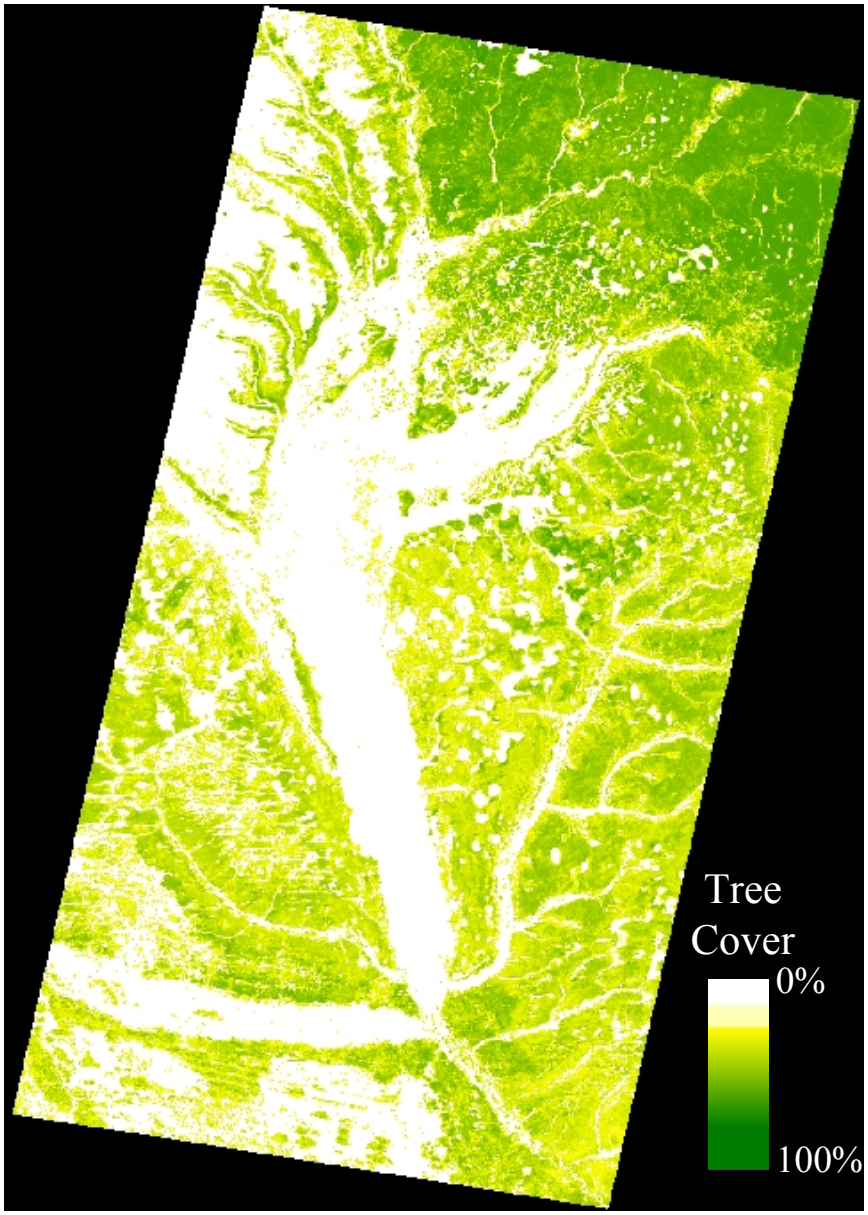




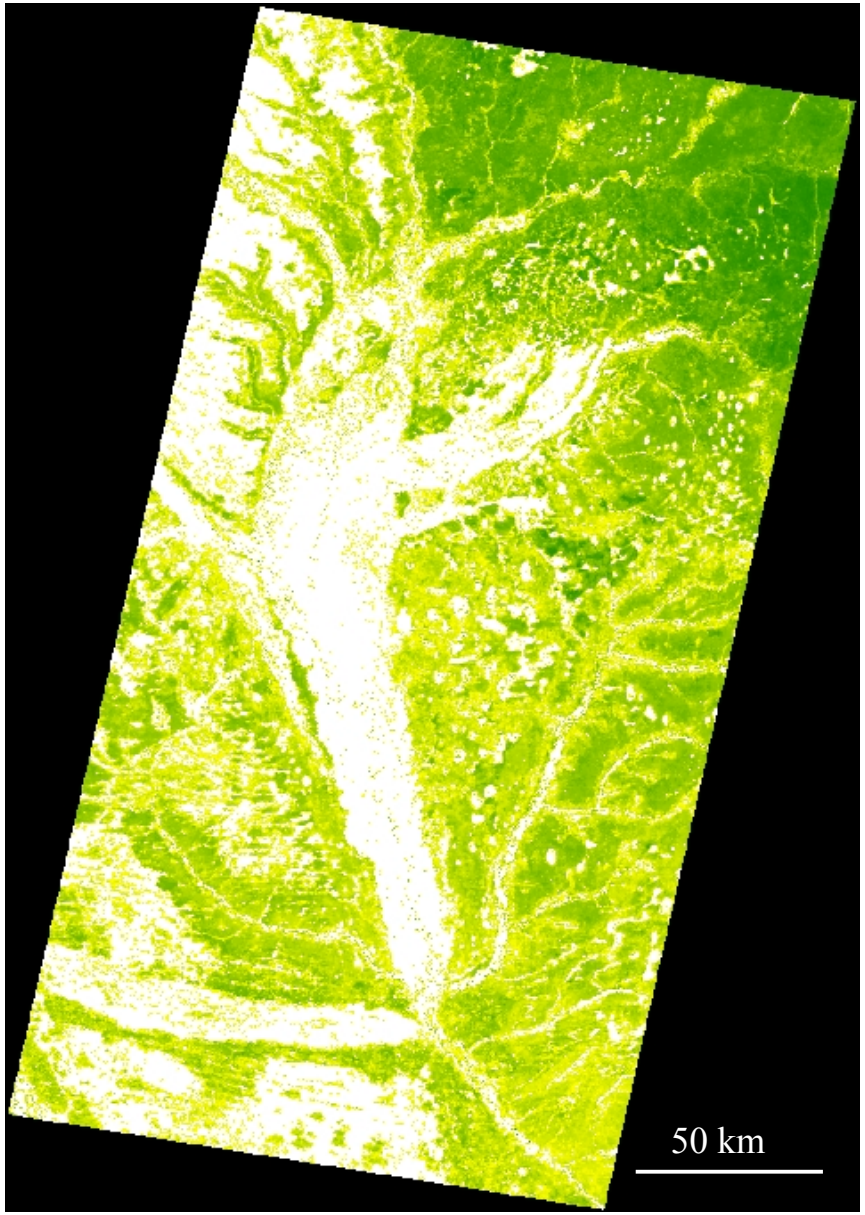
- 4 m IKONOS 4-3-2 combination, 11km by 11km,
- crown cover interpretation,
- aggregated continuous crown cover training at 30 meter resolution,
- ETM canopy cover derived from IKONOS training,
- result aggregated to 250 meter for MODIS validation use,
- MODIS predicted crown cover at 250 meter resolution



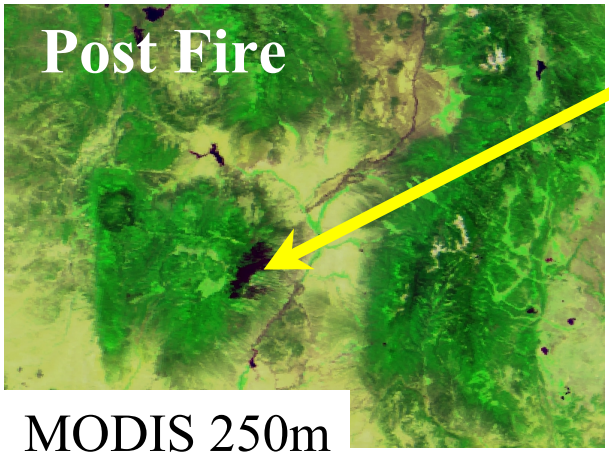
ETM+ crown cover
aggregated to 250 meters



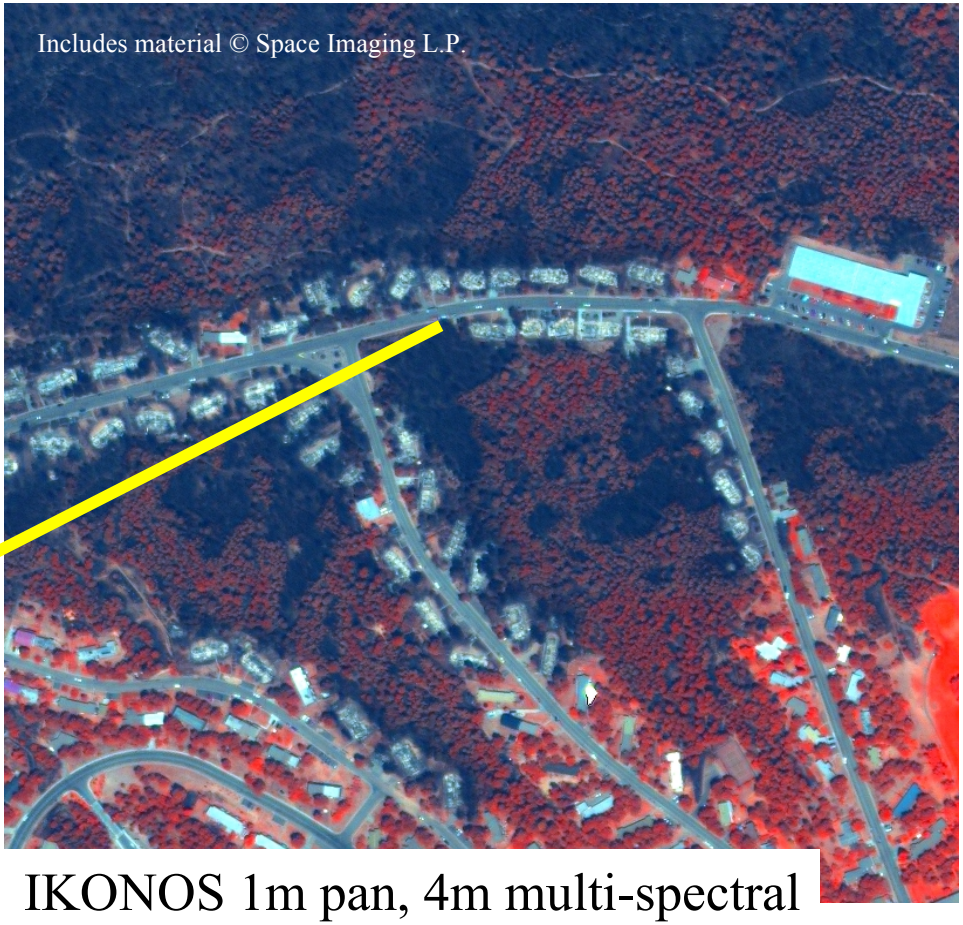
MODIS 250 meter predicted tree cover
using training taken from TM product



Cerro Grande (Los Alamos) Fire: MODIS Land Cover Change



MODIS 250m



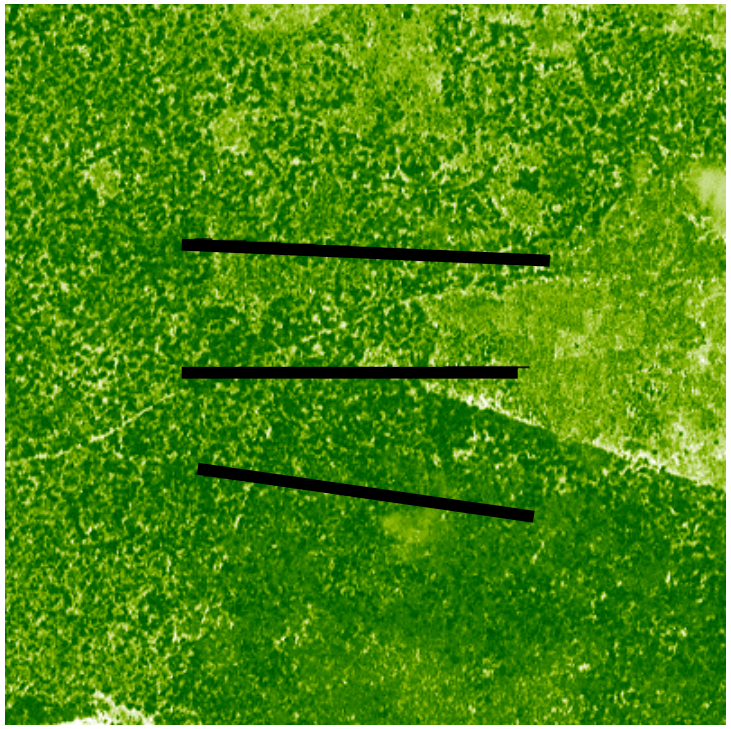
IKONOS 1m pan, 4m multi-spectral

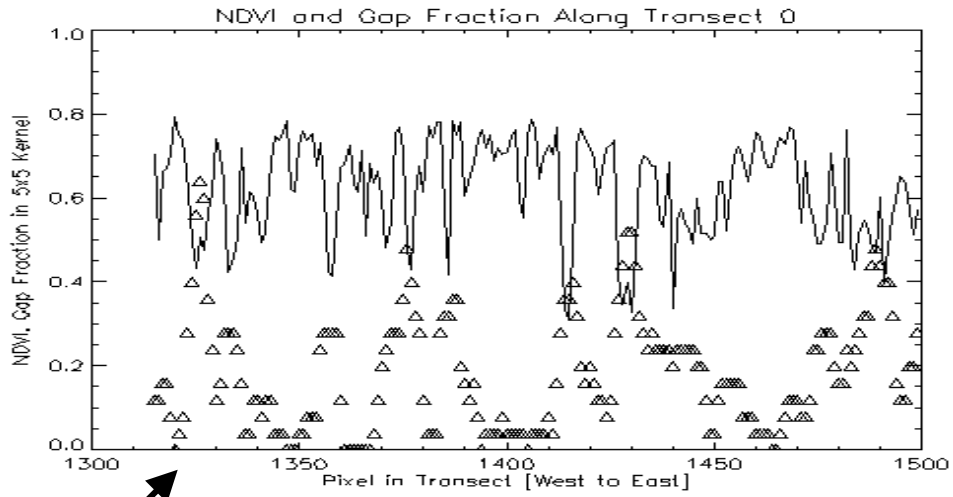
IKONOS provides an important new perspective on land cover change to examine scaling and mixed pixel effects.

Provided by Sohlberg, UMd

Transect Variability Across Forest Border: NDVI and Gaps

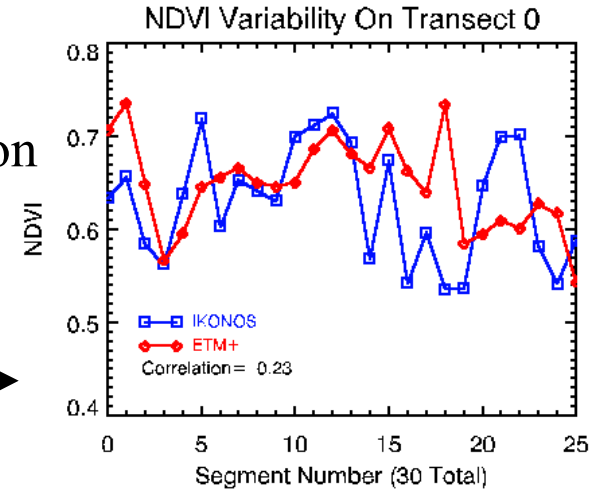
IKONOS NDVI 4 m/pixel





IKONOS:
NDVI vs gap fraction

IKONOS vs ETM+



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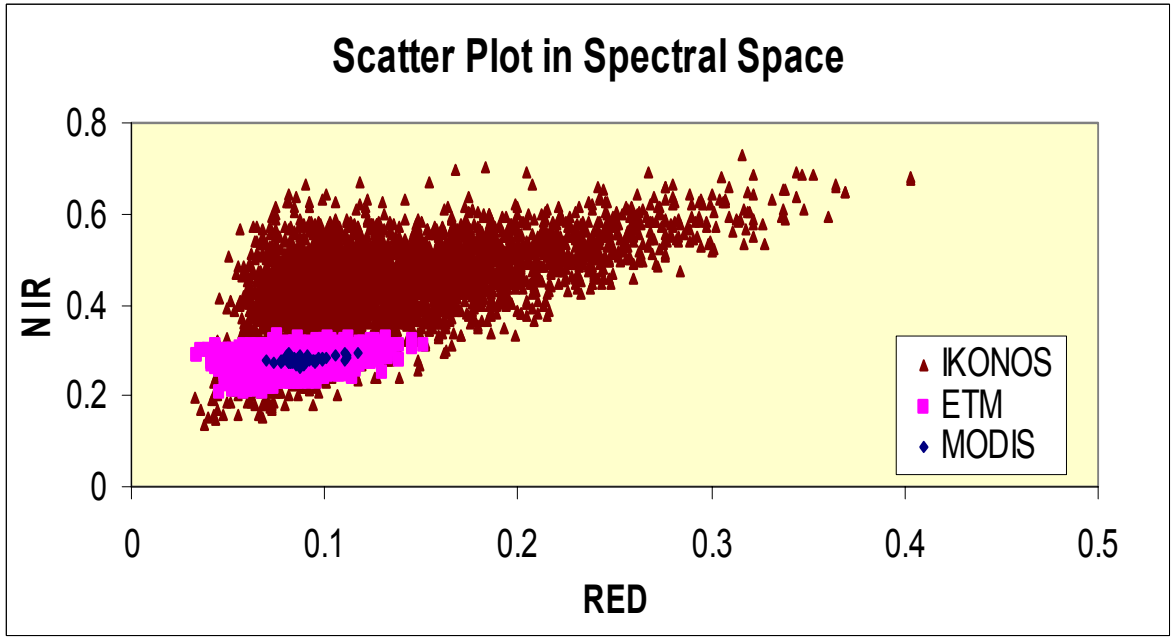
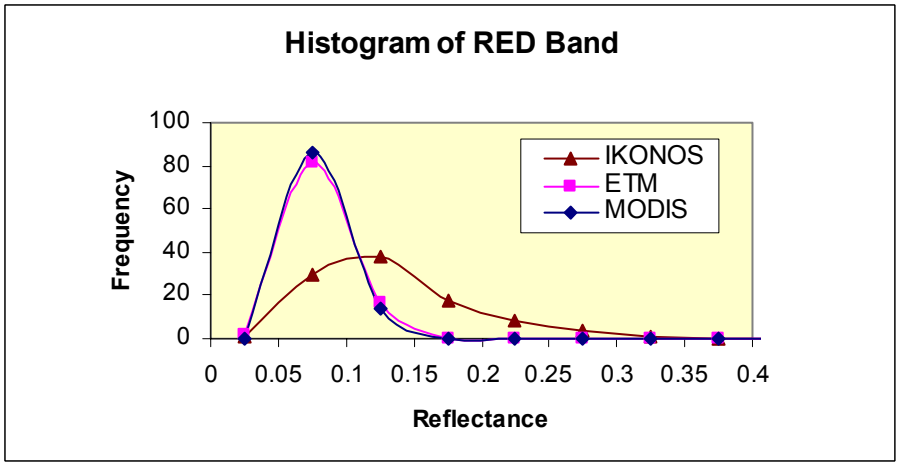
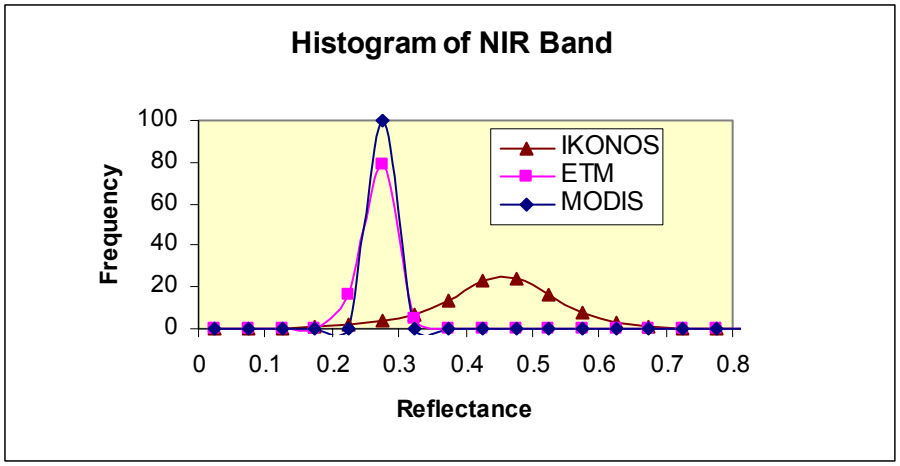
Data from Privette's: Southern Africa Validation of EOS Products

Reflectance Comparisons





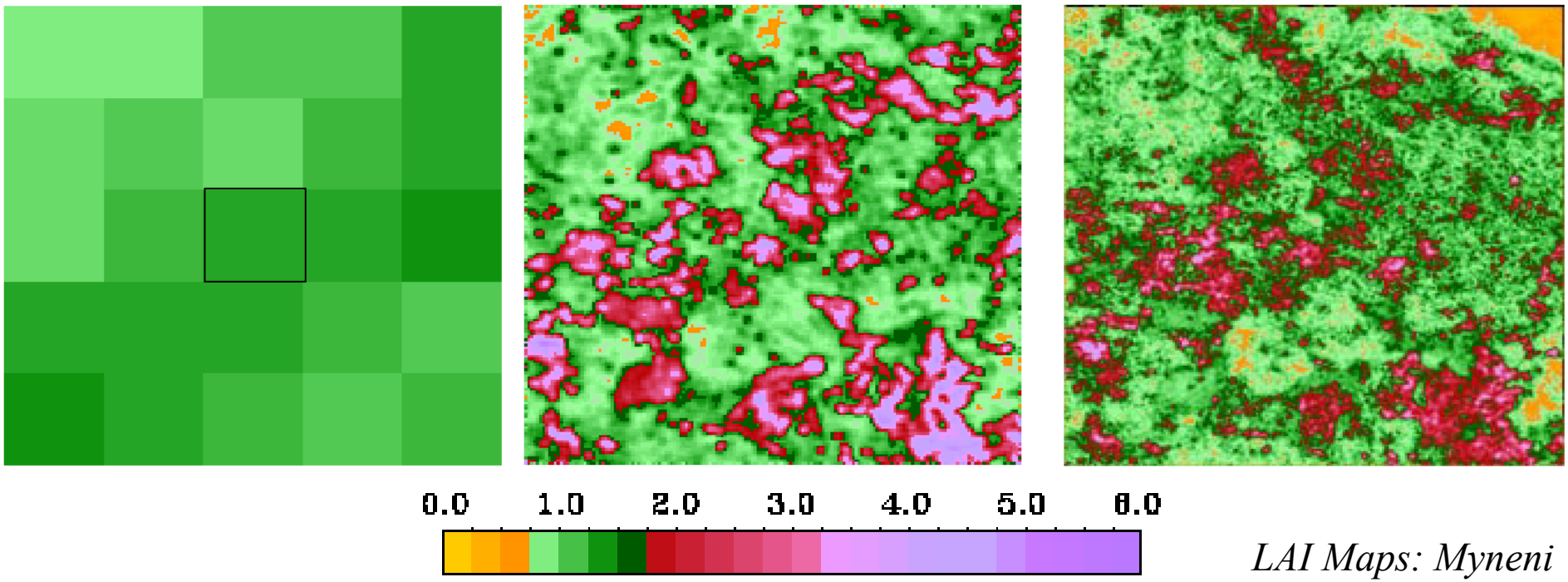


From Myneni et al, BU

Leaf Area Index/FPAR

BU/Myneni et al., LAI Map of a 5 KM Area, from SAFARI 2000

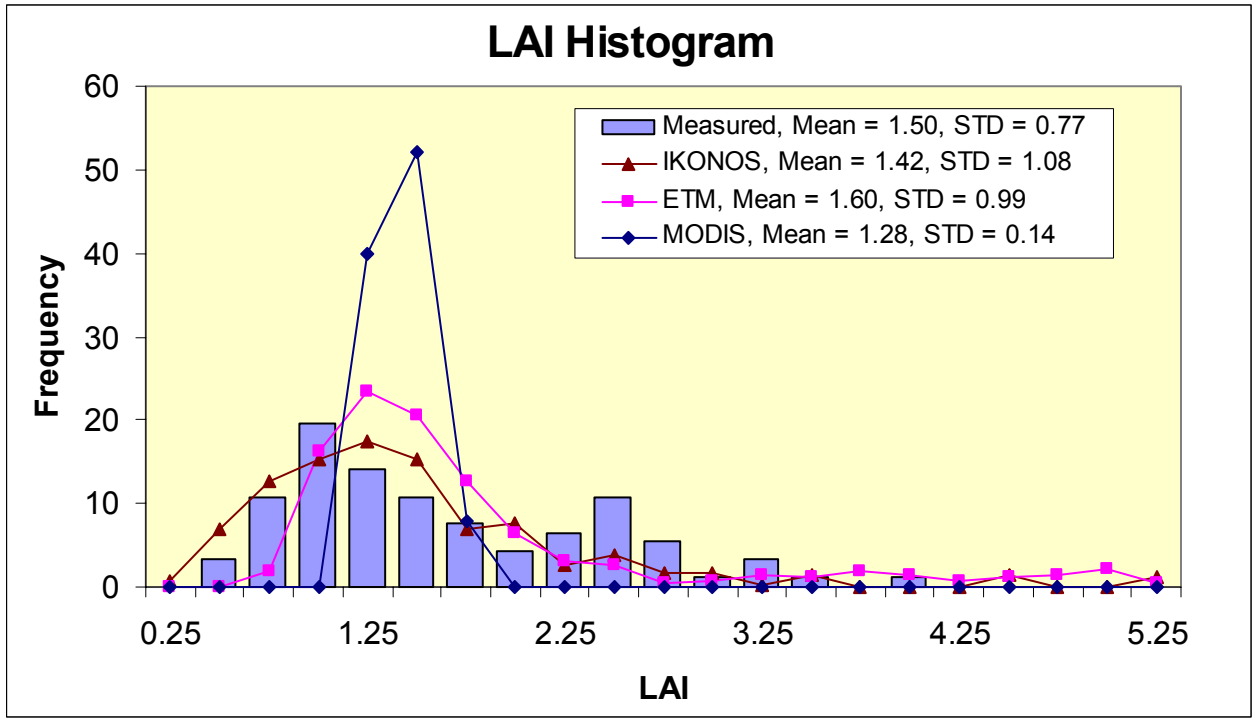
MODIS Retrievals, Apr. 3, 2000 **ETM Retrievals, Apr.3, 2000** **IKONOS Retrievals, Mar. 30,2000**



LAI Maps: Myneni

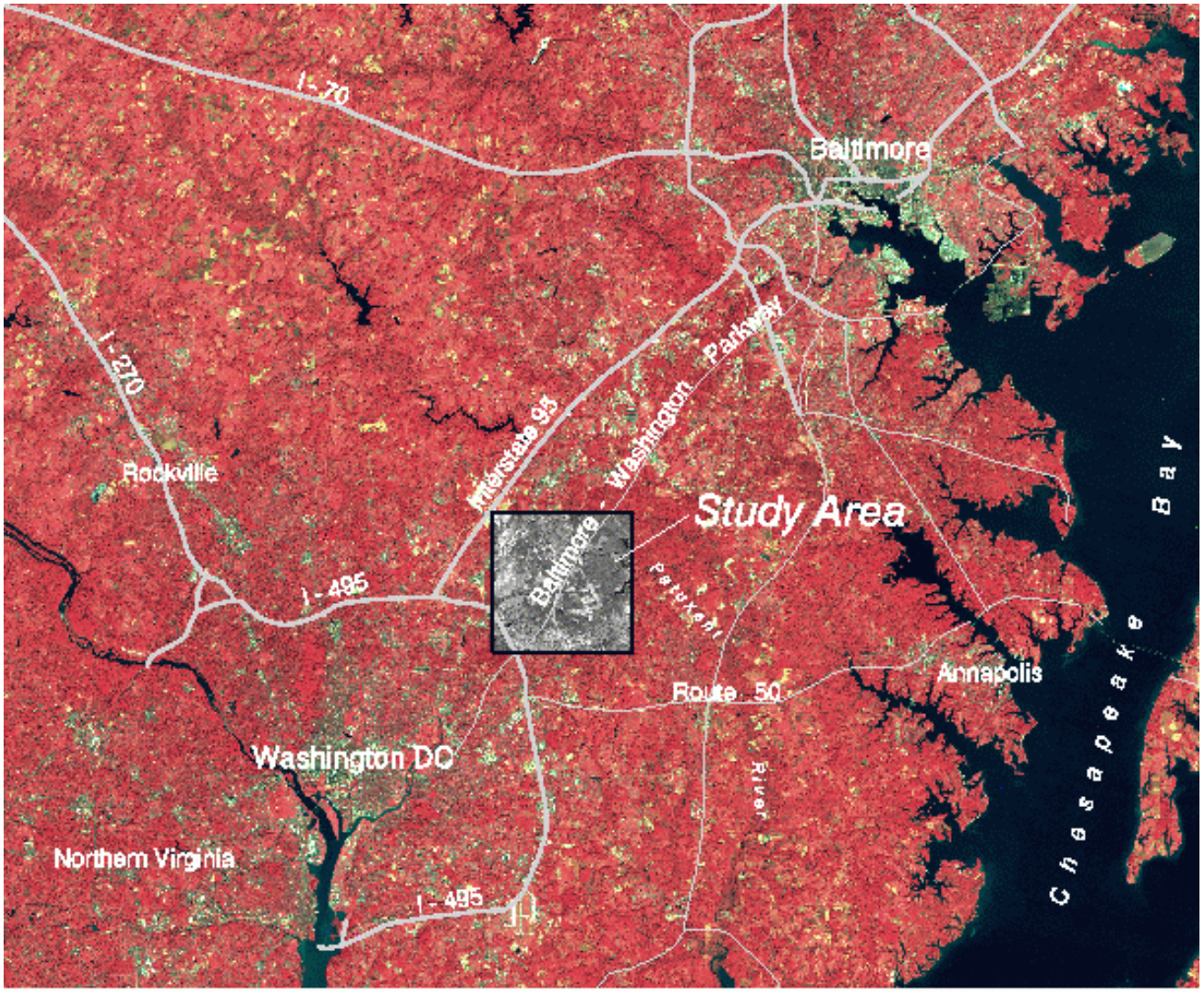
Includes material © Space Imaging L.P.

Histogram of Retrieved LAI



From Myneni et al, BU

USDA BARC: EOS Land Validation Core Site



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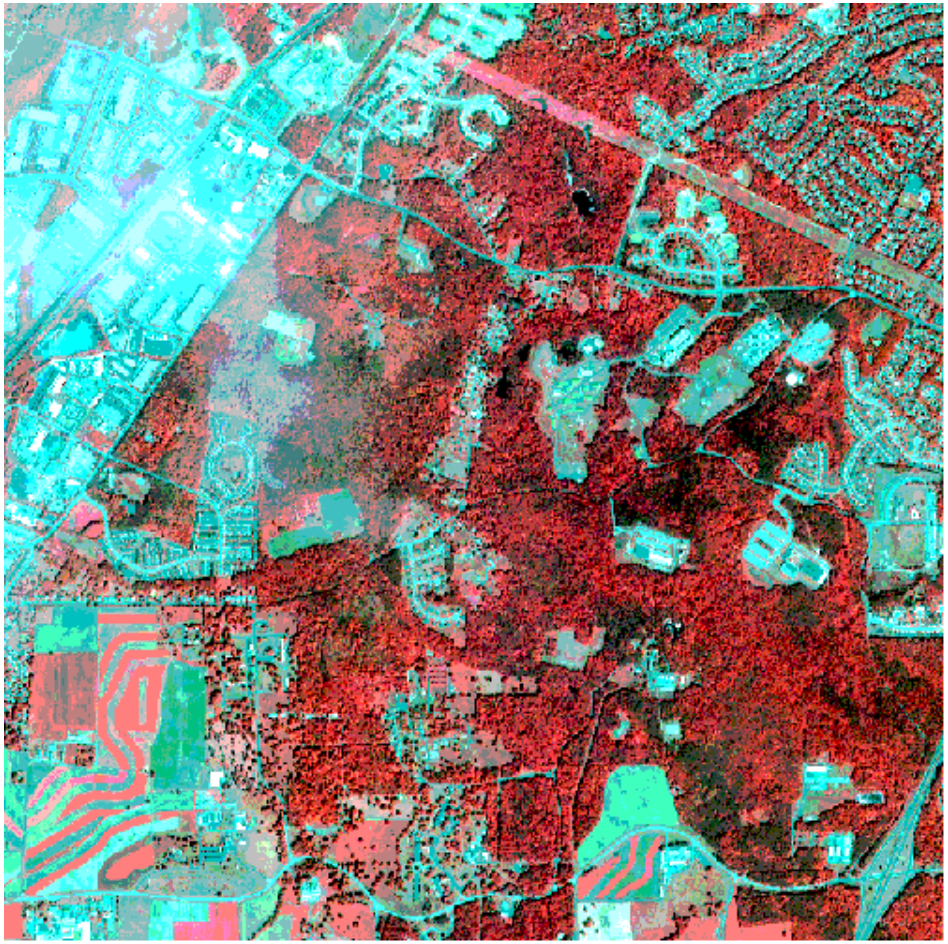
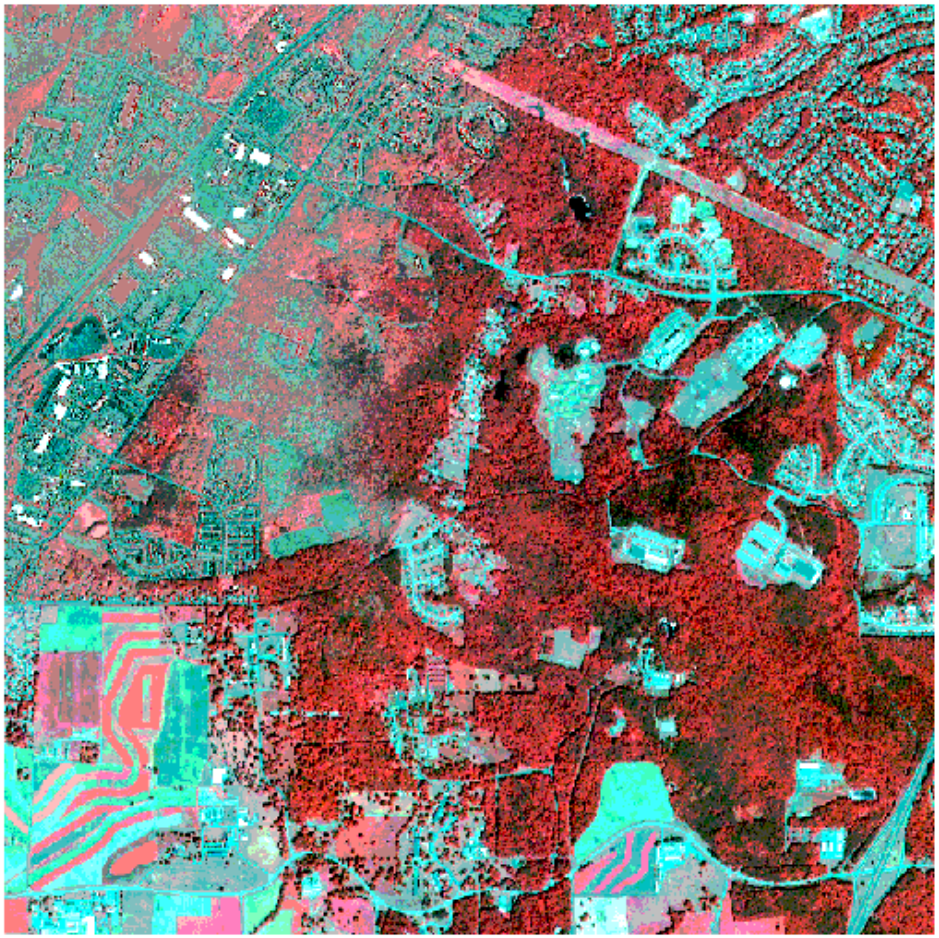
IKONOS imagery of USDA/BARC, June 3, 2000





from Liang, UMd

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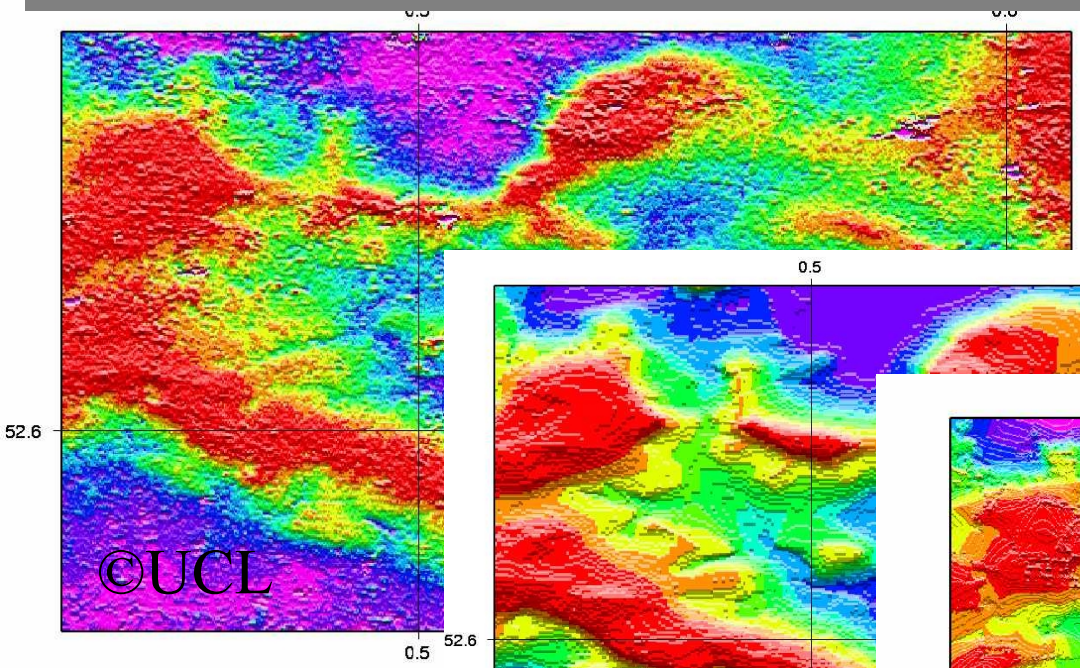
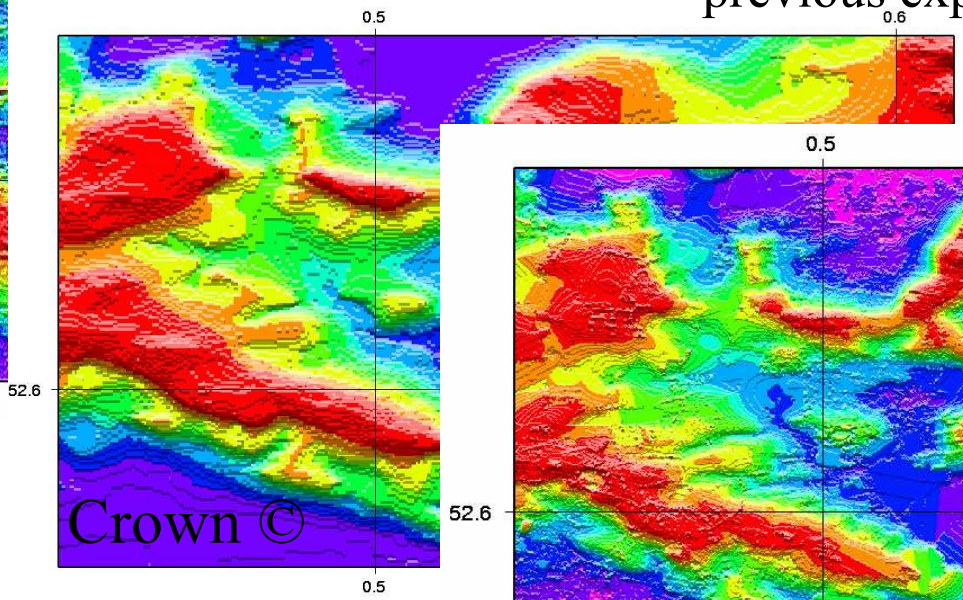
Includes material © Space Imaging L.P.

Stereo IKONOS for landscape 3D modelling for BRDF simulation: DEM intercomparison at 30m

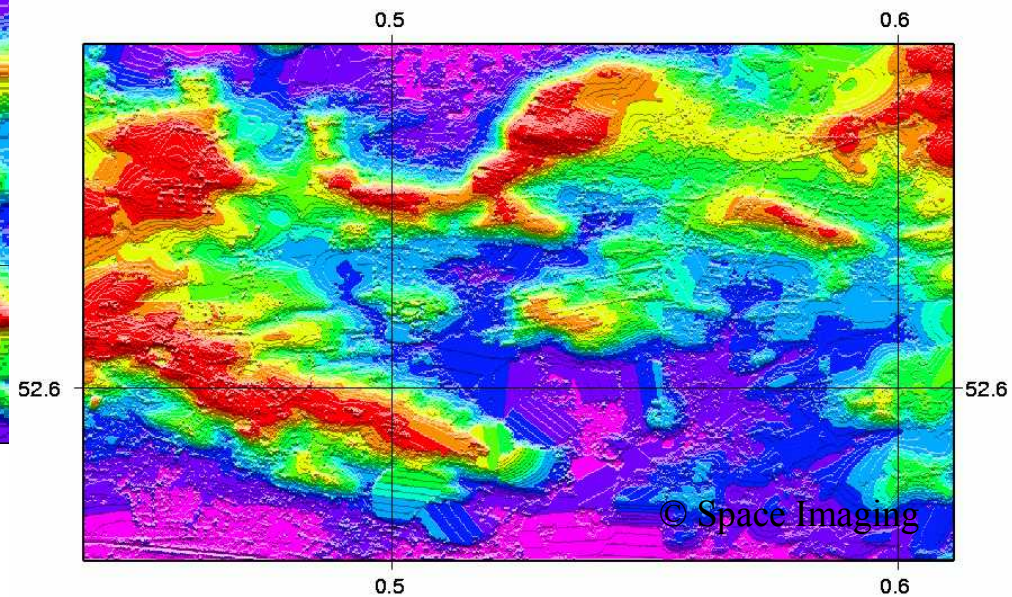
OS-IKONOS=2.25±2m
IfSAR-IKONOS=0.97±3.49m
Expected ±1m based on previous experiments



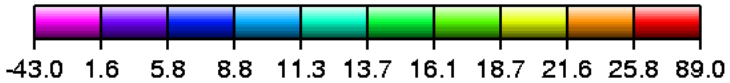
IfSAR



U.K.Ordnance Survey DTM



from Muller, UCL



Large-scale artefacts visible
In IKONOS but morphology good

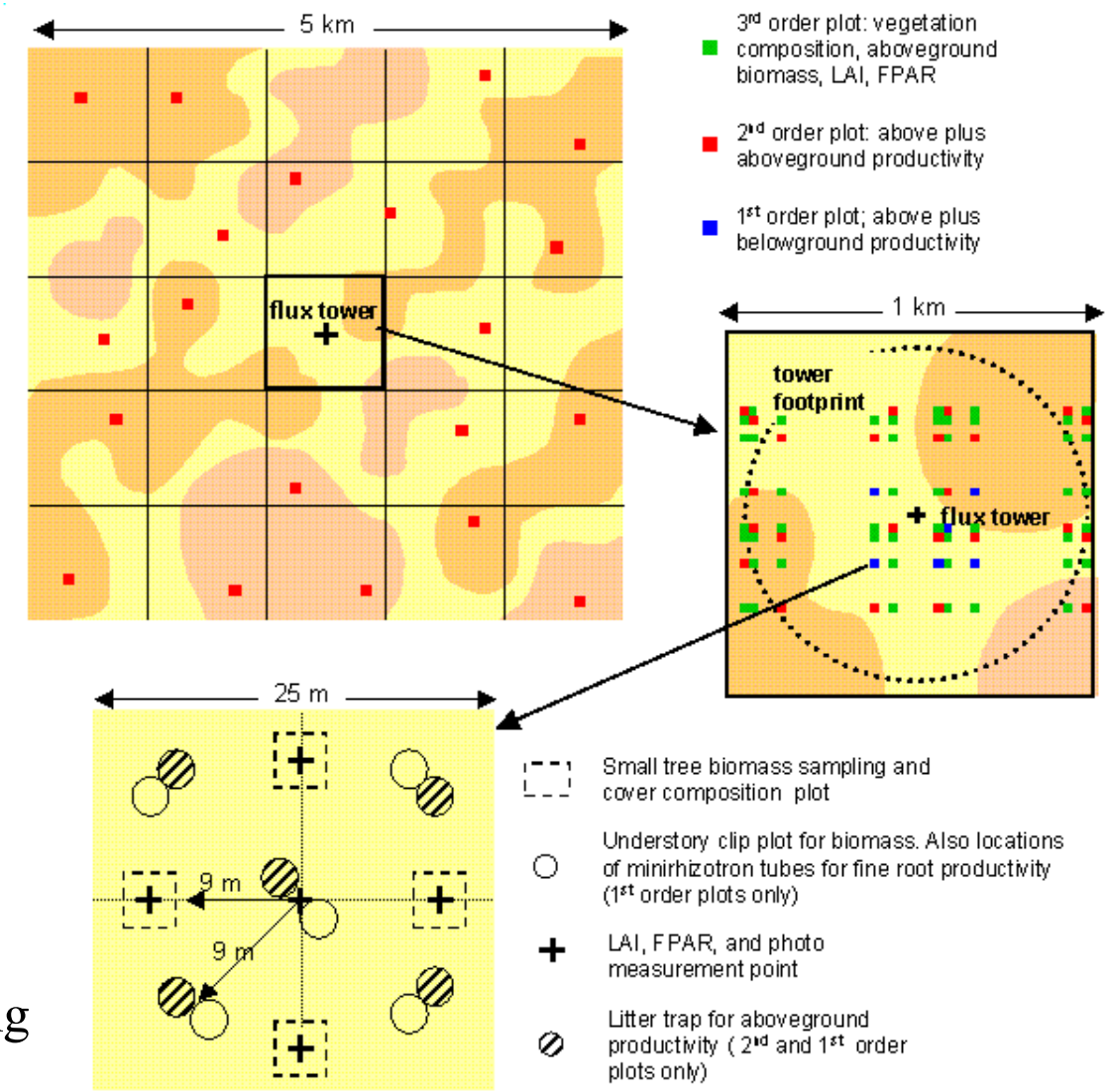
Includes material © Space Imaging L.P.

Stereo IKONOS for landscape 3D modelling for BRDF simulation

- 3D landscape models will be used to simulate a BRDF at aircraft and satellite resolutions given field measurements of BRDF at the canopy level.
- 3D landscape models combined with orthorectified provide a much less ambiguous way to classify land cover types.
- 3D landscape models can be used to measure the Aerodynamic Surface Roughness Length

- **Currently:**
  - **“the most important intermediate step between field data and Landsat.”**
  - **using IKONOS to georeference the ETM+.**
- **Plans:**
  - **Investigate how adding IKONOS into the data analysis improves what can be done using ETM+ alone**

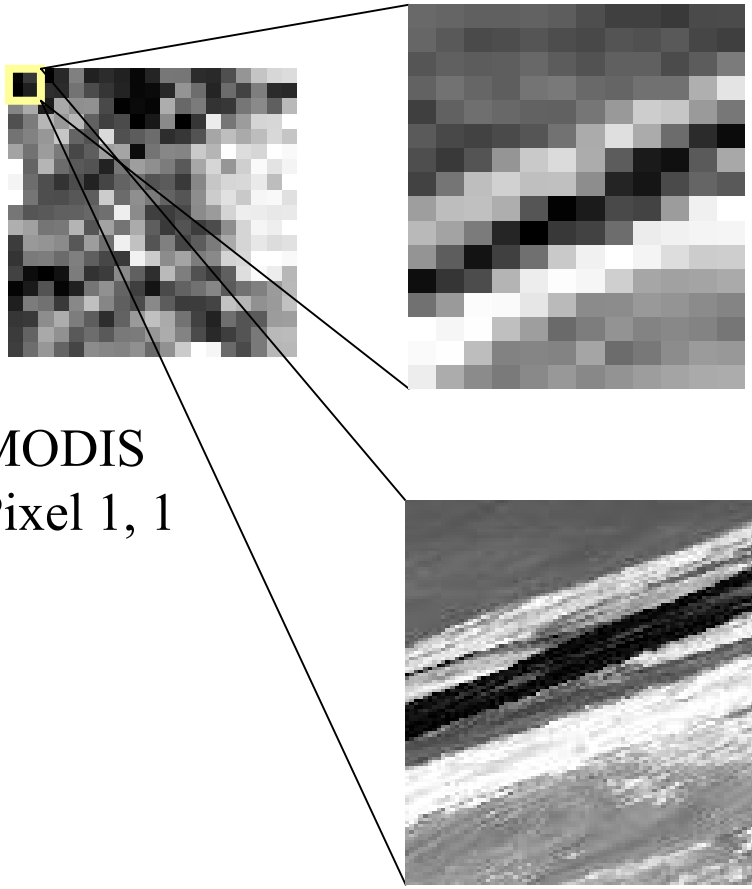
Field-Based Sampling Design



For forest plots, a prism sweep for stem biomass will be made from the plot center

IKONOS to help with sub-ETM- scale sampling

Comparison at Multiple-scales



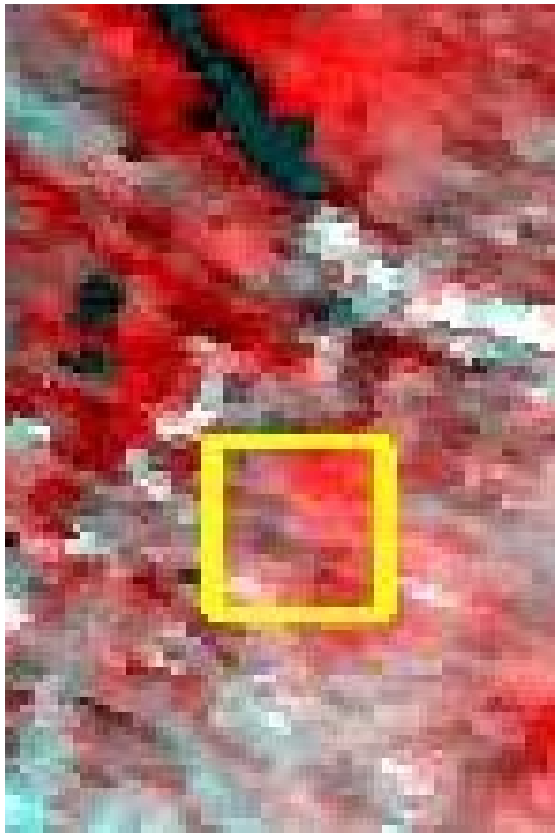
ETM+
14, 16
n=224

MODIS
Pixel 1, 1

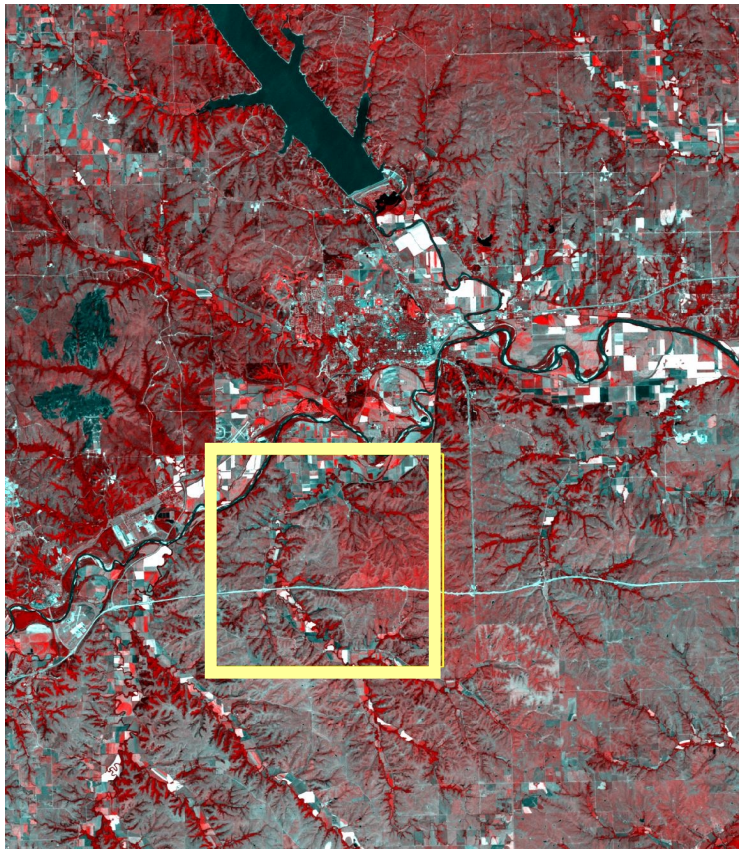
IKONOS
116, 120
n=13,920

Considering all three as variable and subject to errors, consider MODIS pixel relative to the *distribution* from the higher resolution data

IKONOS boundary on MODIS 500m and ETM+



MODIS
8-day composite



ETM+,
Sept. 11

IKONOS,
Sept. 15

Aeronet sun photometer (Meyer)
Vermote et al.'s Six S code
(for ETM+ and IKONOS)

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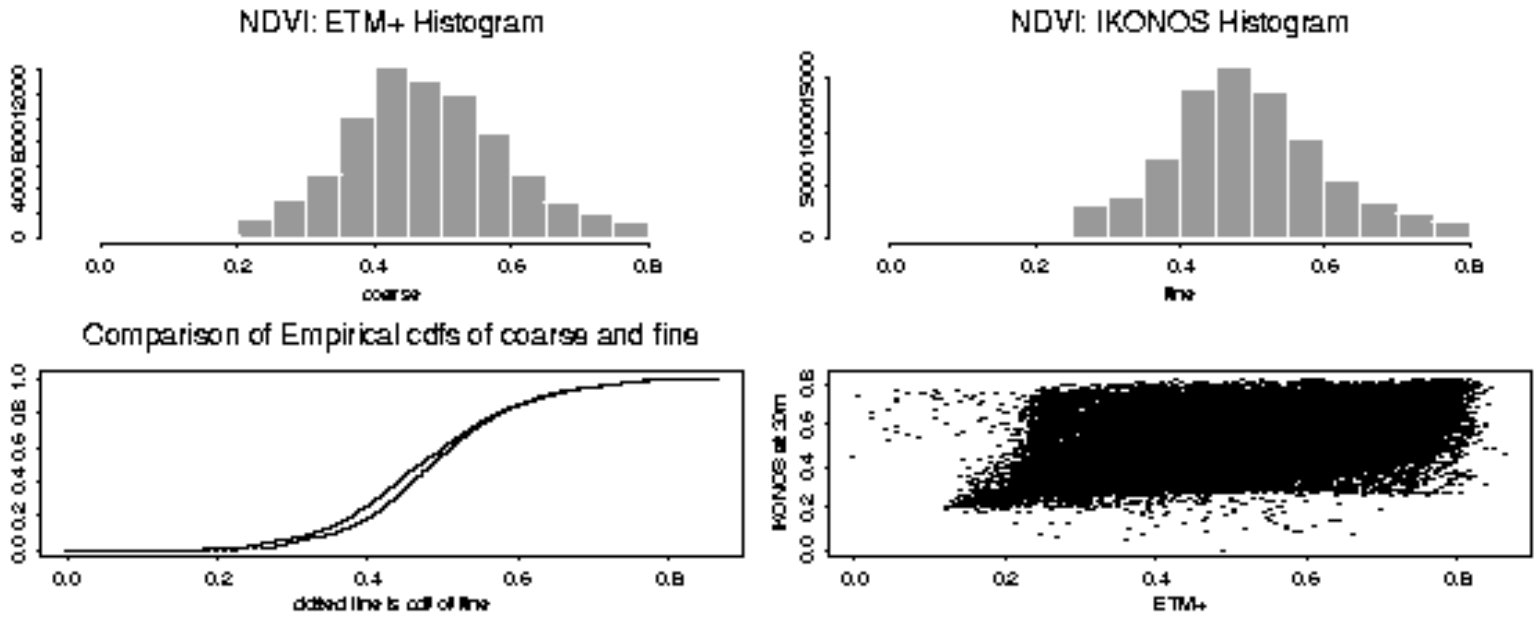
IKONOS vs ETM+: Normalized Difference Vegetation index (NDVI)



Correlation = .5639

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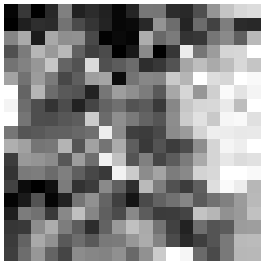
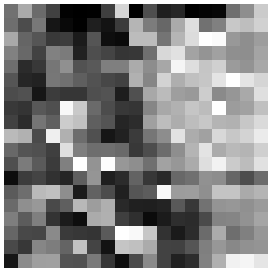
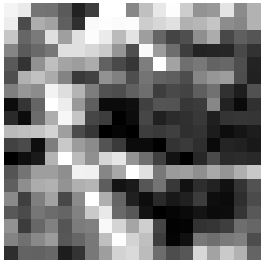
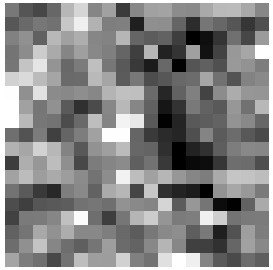
Normalized differences: method to include variability





$$\frac{\text{ETM+} - \text{IKONOS(average)}}{\text{Std. Dev (IKONOS ave.)}} = \text{“z score”}$$





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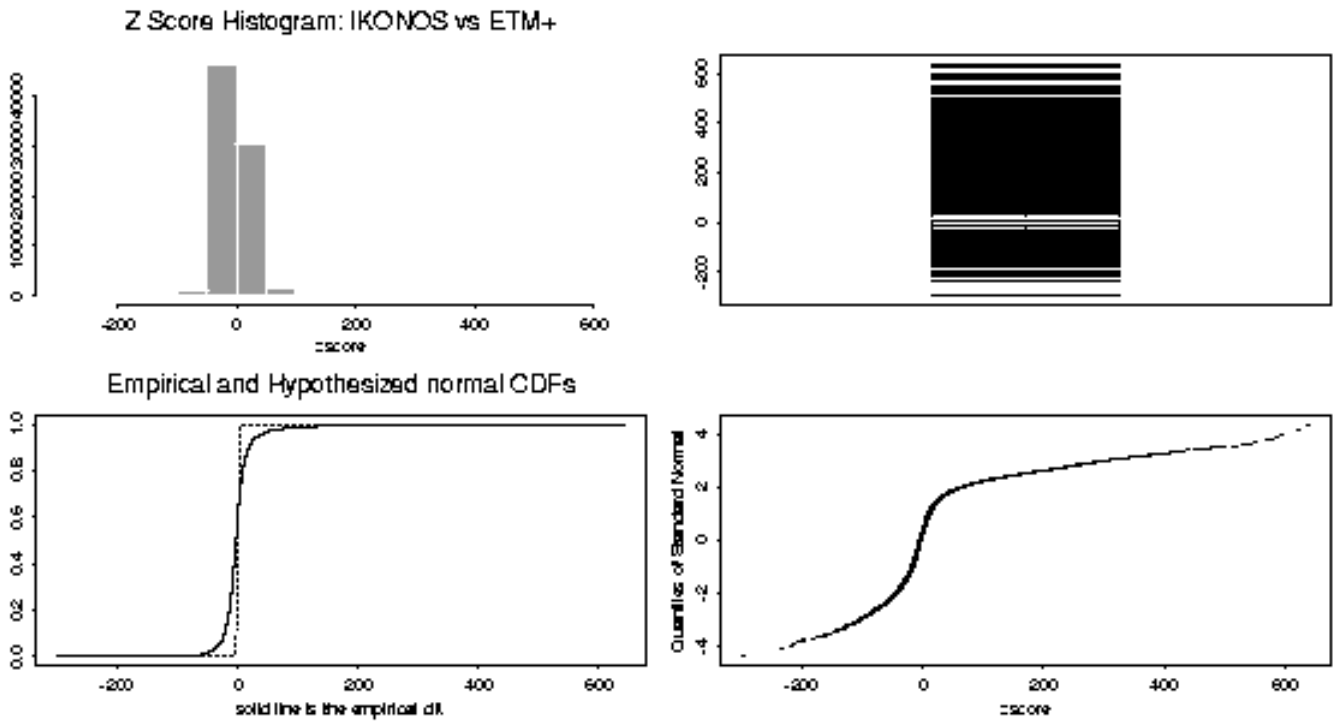
Z score analysis: ETM+ vs IKONOS



IKONOS vs ETM

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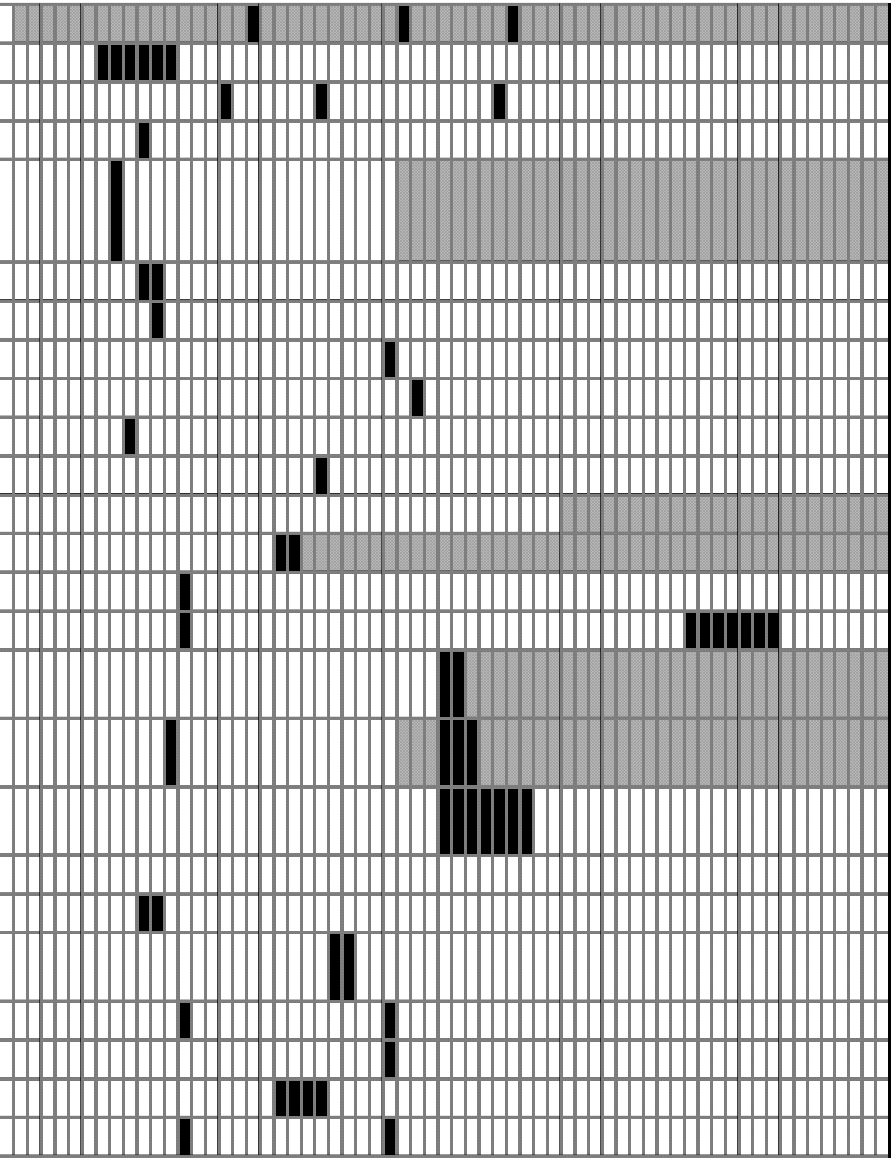
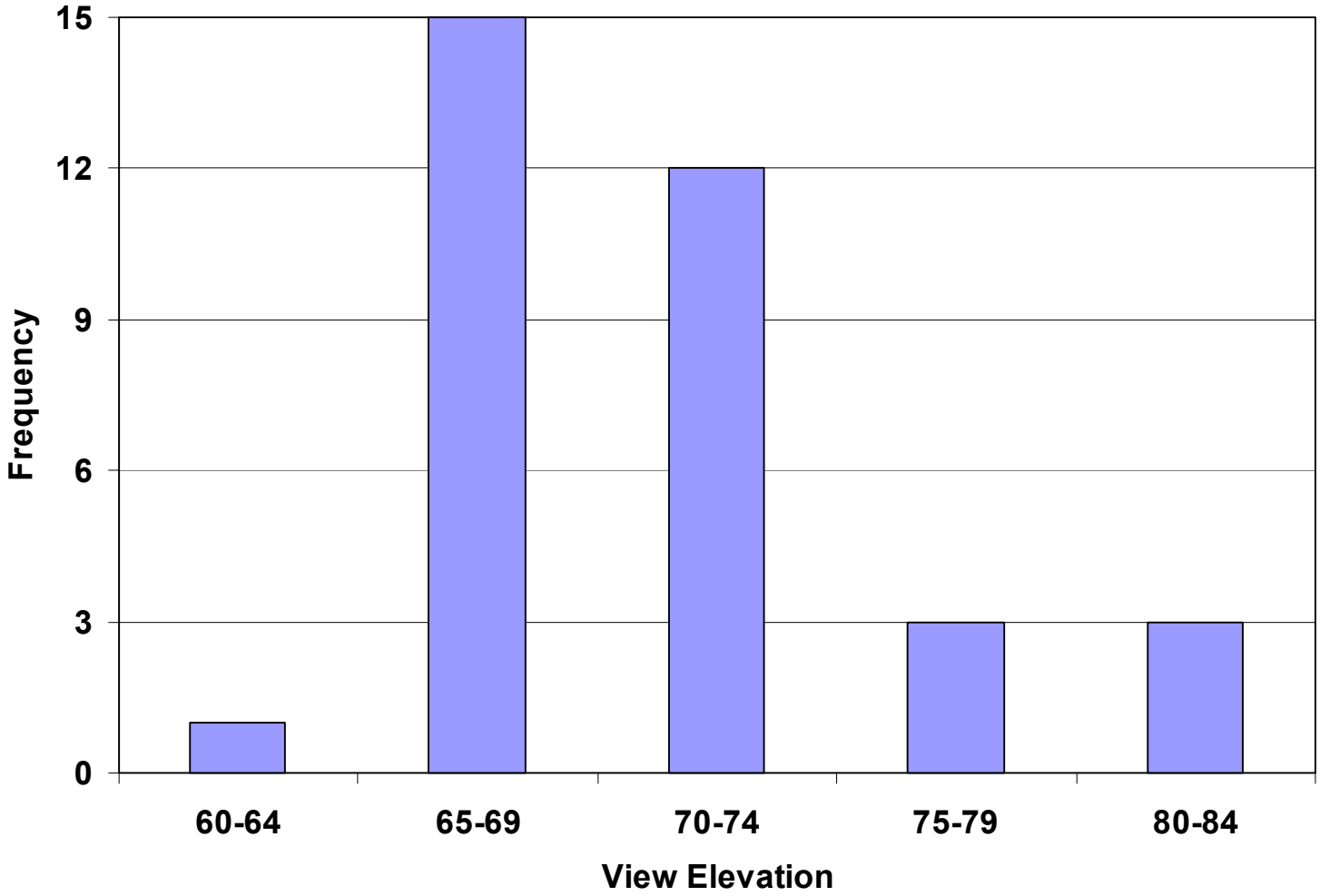
Campaign name	relevant products	2000 j f m a m j j a s o n d	2001 j f m a
BigFoot-Bondville, USA *	Land Cov., LAI/FPAR, NPP		
BigFoot-BOREAS NSA, Canada *	Land Cov., LAI/FPAR, NPP		
BigFoot-Harvard, USA *	Land Cov., LAI/FPAR, NPP		
BigFoot-Konza, USA *	Land Cov., LAI/FPAR, NPP		
Deering-Krasnoyarsk, Russia *	LAI/FPAR		
Deering-Krasnoyarsk, Russia *	LAI/FPAR		
Gower-ParkFalls, USA *	LAI/FPAR, NPP		
Hall-New Hampshire, USA *	Snow & Sea Ice		
Hao-Western US fires	Fire, Veg. Cov. Conversion		
Honda/GLI-Eugene, USA	Surf. Refl., VI, Albedo/BRDF		
Honda/GLI-Jornada, USA *	Surf. Refl., VI, Albedo/BRDF		
Honda/GLI-Konza Prairie, USA *	Surf. Refl., VI, Albedo/BRDF		
Honda/GLI-Mandalgobi, Mongolia *	Surf. Refl., VI, Albedo/BRDF		
Honda/GLI-Missoula, USA	Surf. Refl., VI, Albedo/BRDF		
Honda/GLI-SALSA, USA *	Surf. Refl., VI, Albedo/BRDF		
Honda/GLI-Victoria, Canada	Surf. Refl., VI, Albedo/BRDF		
Hook-Amburla	LST		
Hook-Lake Tahoe *	LST		
Hook-Thangoo	LST		
Hook-Uardry *	LST		
Huete: MQUALS-Brasilia, Brazil	Surf. Refl., VI		
Huete: MQUALS-Jornada, USA *	Surf. Refl., VI		
Huete: MQUALS-Tapajos, Brazil *	Surf. Refl., VI		
Huete: MQUALS-Walnut Gultch, USA *	Surf. Refl., VI		

Liang-USDA Beltsville, USA *	Surf. Refl., Albedo
Li-Southern Ocean cruise	Snow & Sea Ice
Muller-Barton Bendish, UK *	BRDF/Albedo and LAI
Myneni & Privette-Maun, Botswana	LAI/FPAR, Land Cov.
Myneni & Privette-Mongu, Zambia *	Surf. Reflect, VI, LAI/FPAR, BRDF/Albedo, Surf. Temp., Fire, NPP
Myneni & Privette-Okwa, Botswana	LAI/FPAR, Land Cov.
Myneni & Privette-Tshane, Botswana	LAI/FPAR, Land Cov.
Myneni-Harvard, USA *	LAI/FPAR
Myneni-Kejiimkujik, Canada	LAI/FPAR
Myneni-Pandamatanga, Botswana	LAI/FPAR, Land Cov.
Myneni-Ruokolahti, Finland	LAI/FPAR
Nolin-Fort Peck, SURFRAD site	Snow & Sea Ice, Albedo
Nolin-Greenland ice sheet	Snow & Sea Ice, Albedo
Nolin-Turquoise Lake, Colorado	Snow & Sea Ice, Albedo
Nolin-Yampa Valley, Colorado	Snow & Sea Ice, Albedo
Privette-Mongu, Zambia *	LAI/FPAR, BRDF/Albedo, Surf. Temp., Fire, NPP, VI
Privette-Skukuza, S.A. *	LAI/FPAR, BRDF/Albedo, Surf. Temp., Fire, NPP, VI
SAFARI 2000-dry season, Southern Africa *	Fire, VCC
Shi-King's River, Sierra Nevada, CA, USA	Snow & Sea Ice
Townshend- Vegetation Cover Conv., Africa	Land Cov., Veg. Cov. Conversion
Townshend-Appalachian Transect, Eastern USA *	Veg. Continuous fields
Wan-Bridgeport, CA, USA	LST
Wan-Grassland, Chico, CA, USA	LST
Wan-LakeTiticaca, Bolivia	LST
Wan-MonoLake	LST



View elevation angle distribution

34 related acquisitions to-date



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Conclusions

- IKONOS is proving useful as a bridging between field and ETM+ (ASTER) imagery
- Globally consistent data is useful for globally representative validation (i.e. Core Site data suite)
- Solid coordination with Stennis Scientific Data Purchase and Space Imaging
- Infrastructure of MODLAND Validation has helped maximize use of IKONOS scenes
- Radiometric issues need to be resolved for validation activities that utilize radiometric information
- Related publication are forthcoming: MODLAND special issue of Remote Sensing of Environment, SI "Imaging Notes" article, and potential special issue on Land Product Validation

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