Landsat Science Team Meeting, Rochester, June 22-24, 2009

Landsat Science Team PI Progress Report

Feng Gao

ERT Inc. and NASA GSFC

Part I

Mapping Consistent Impervious Type from Multi-temporal Moderate Resolution Sensors

with contribution from Jeff Masek and Yaozhong Pan

Study Area and Data

- One of the fastest economic growth area in China
- Fast population growth rate
- Water pollution in 2007 summer
- Landsat Data Sources

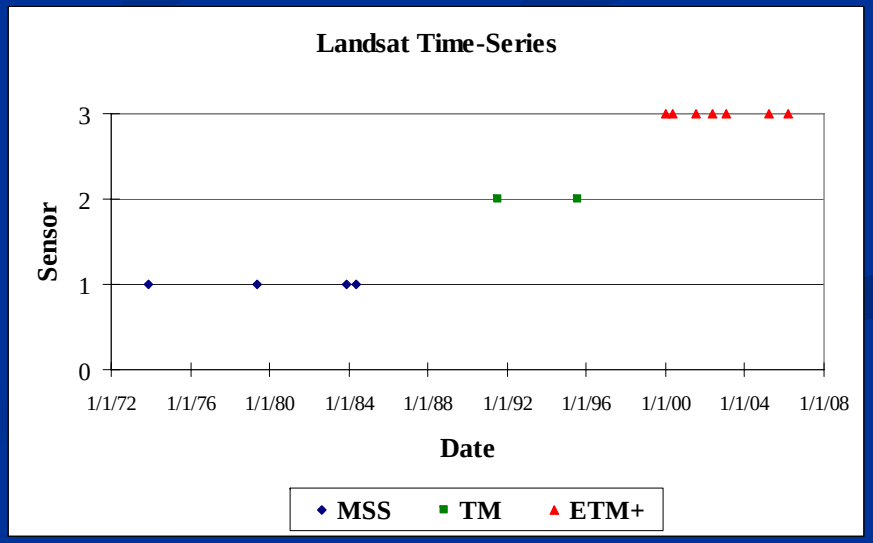
  (WRS-2: path 119, row 38)
  - MSS:

  11/16/1973; 05/25/1979; 11/14/1983; 05/08/1984
  - TM:

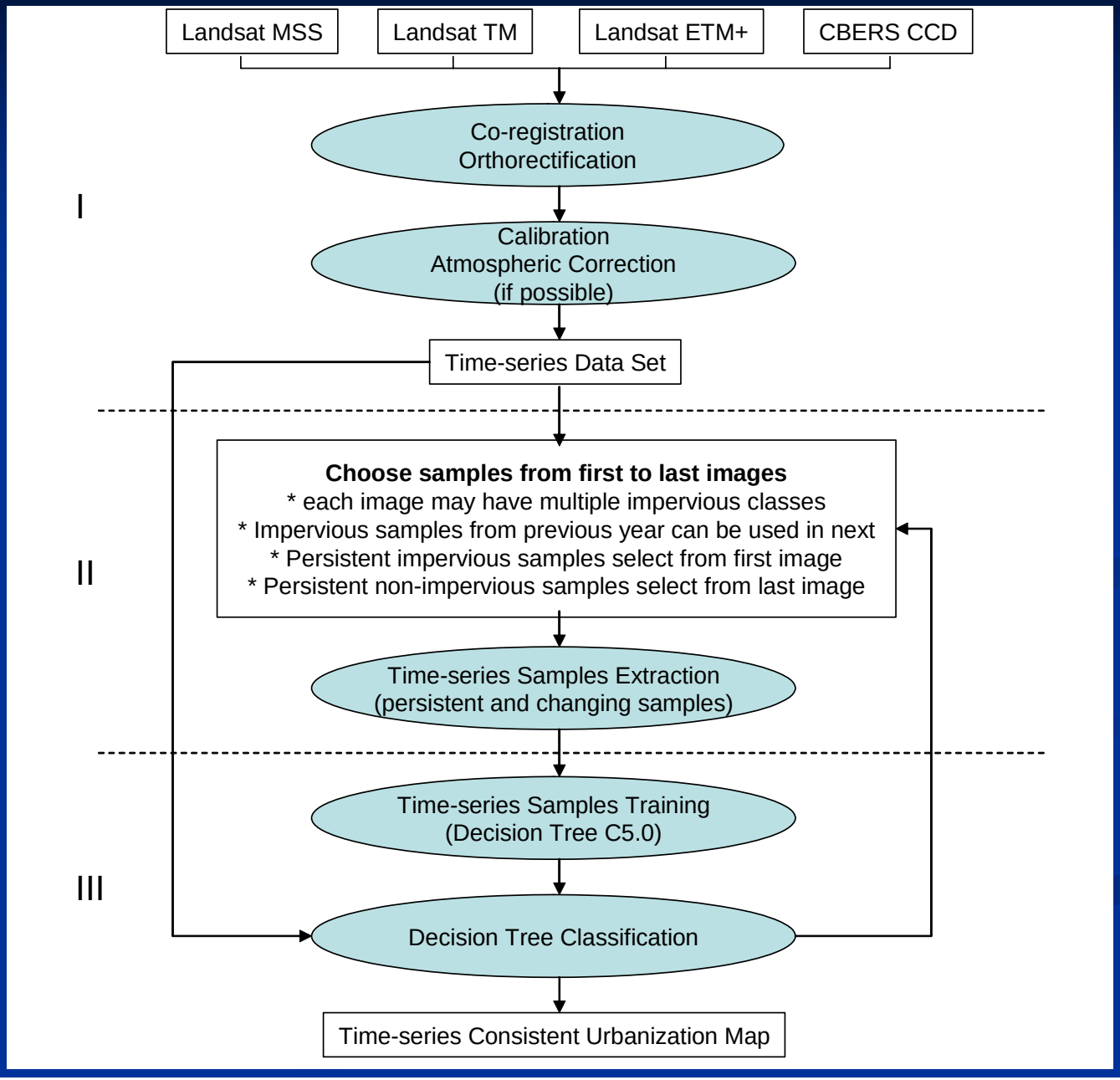
  07/23/1991; 08/03/1995
  - ETM+:

  12/28/1999; 05/04/2000; 07/26/2001; 05/26/2002; 02/06/2003; 03/31/2005; 03/02/2006
- CBERS CCD

  3/3/2006



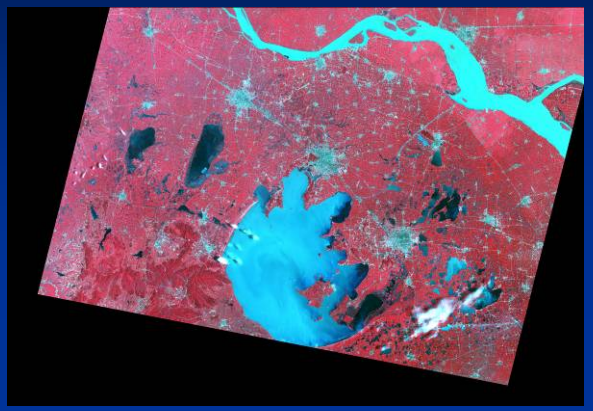
Processing Flow Chart

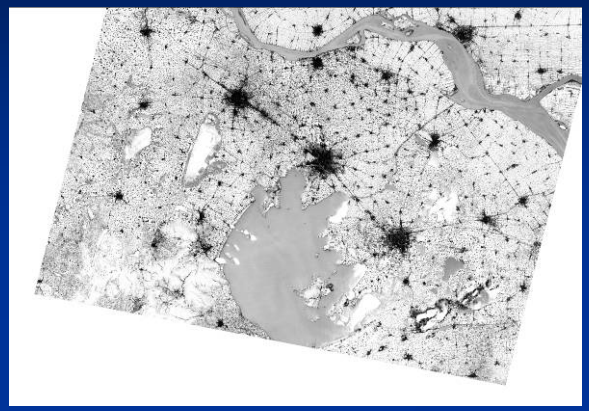


Time-series Impervious Samples

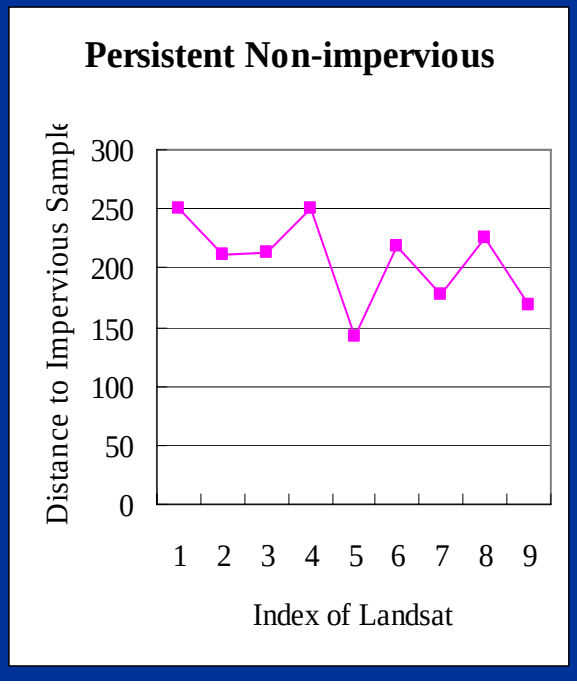
$$s_i = \min\{\frac{1}{m}\sum_{j=1}^{m}(\frac{x_j - \bar{x}_i}{\sigma_i})^2\}$$

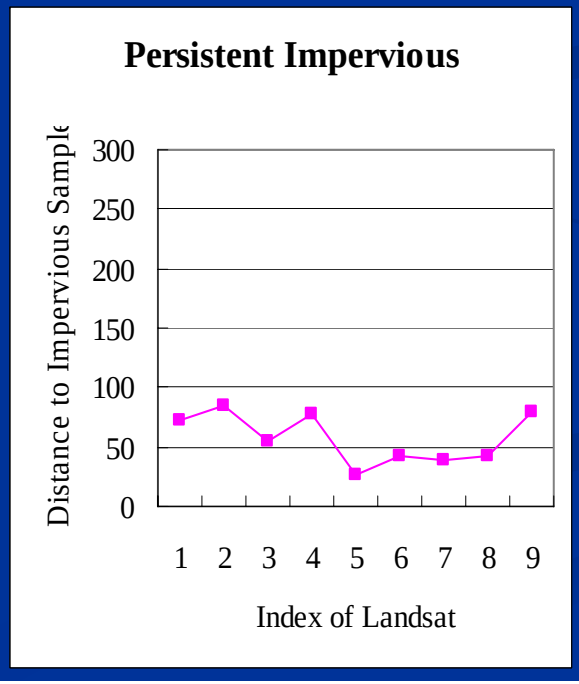
$$s_{\min} = \min\{s_i\}$$

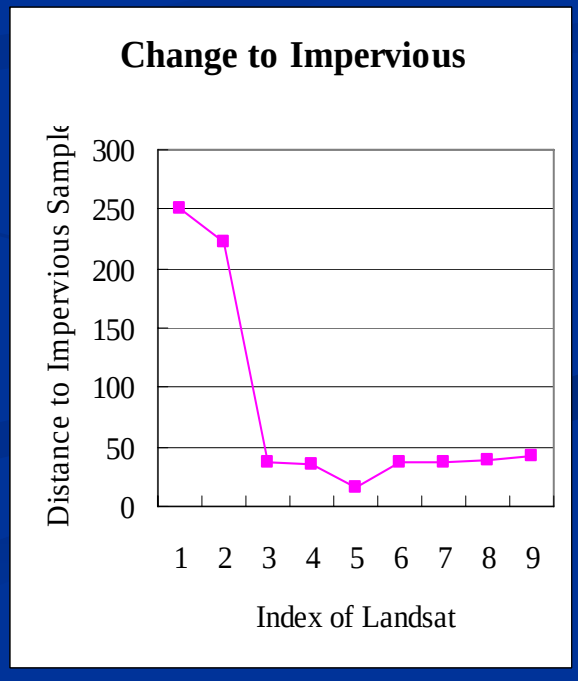


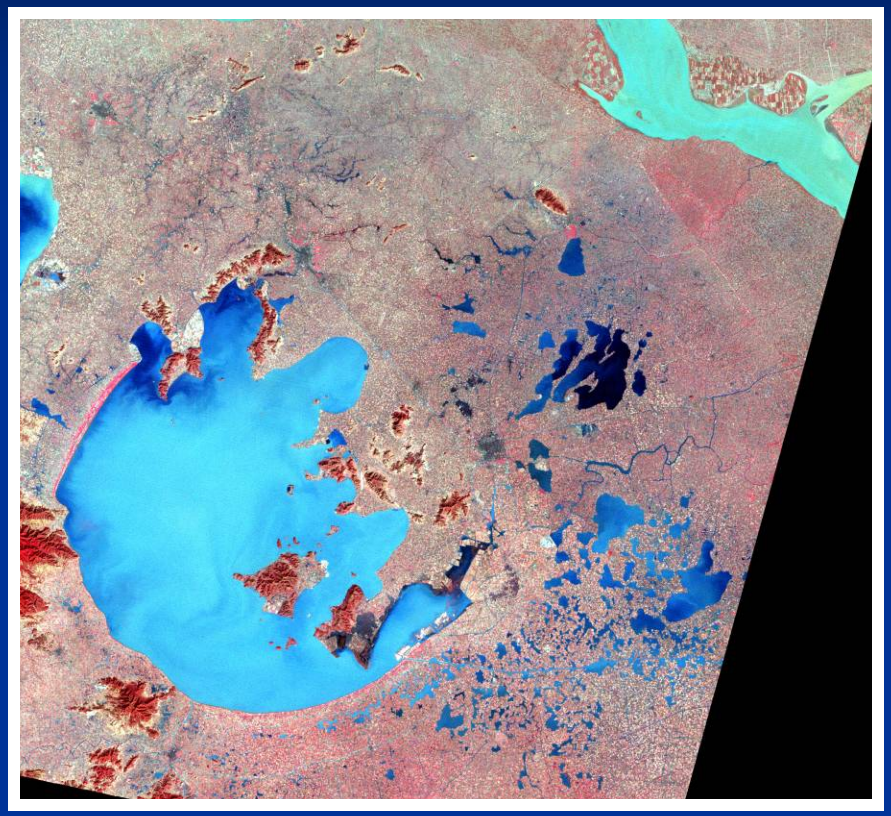


(a)Landsat 5 TM, August 3, 1995 (b) Spectral Distance to Impervious Samples

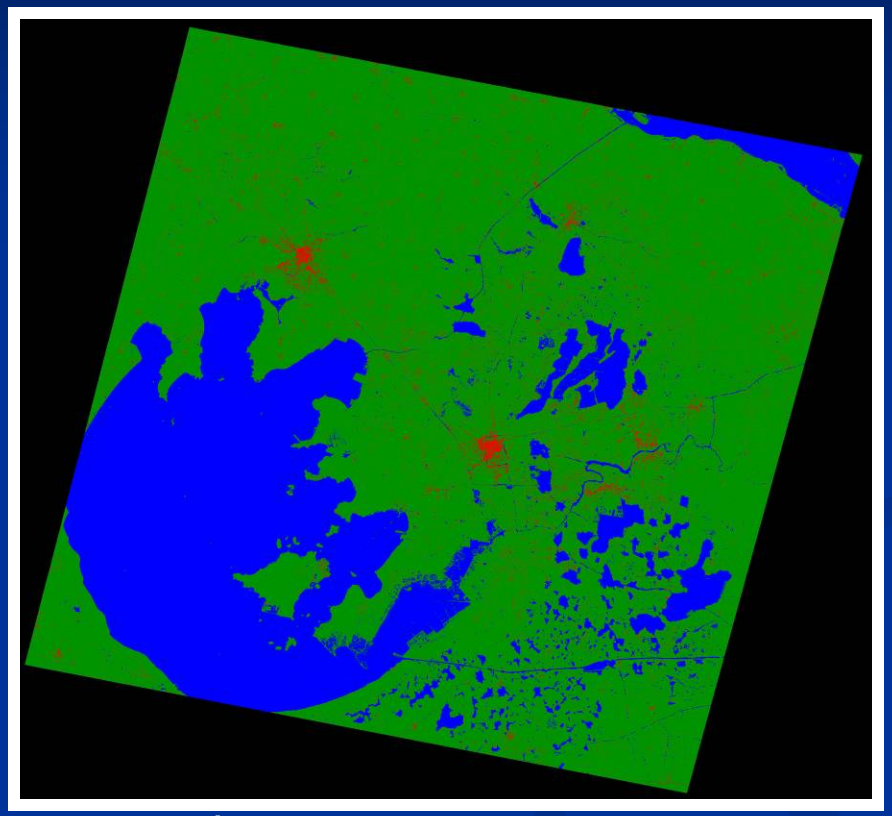




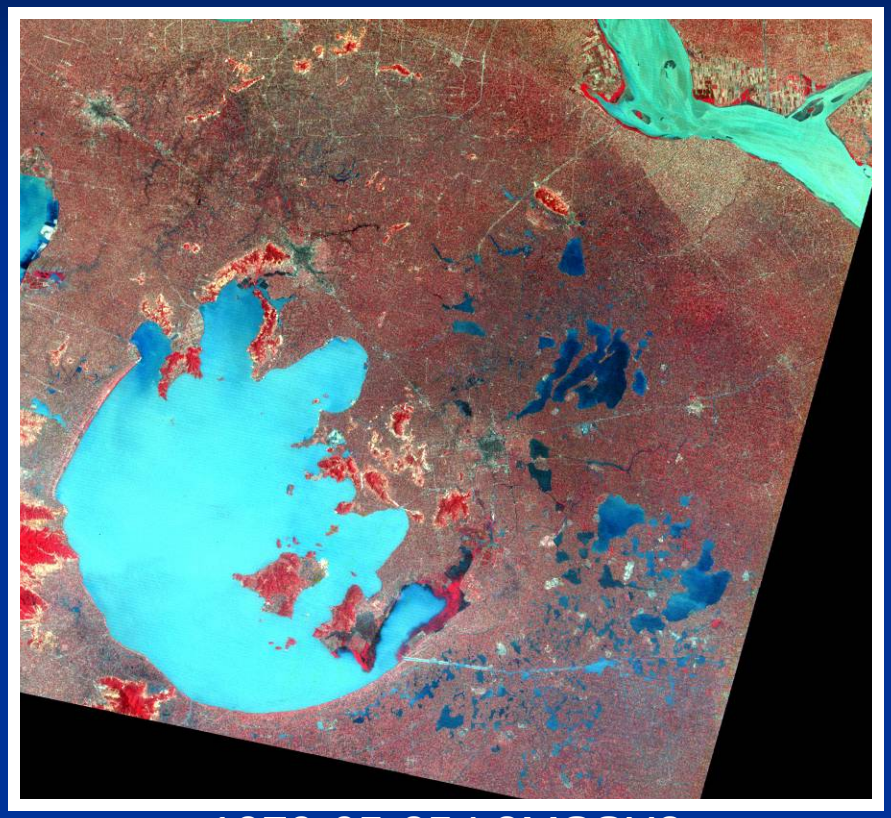




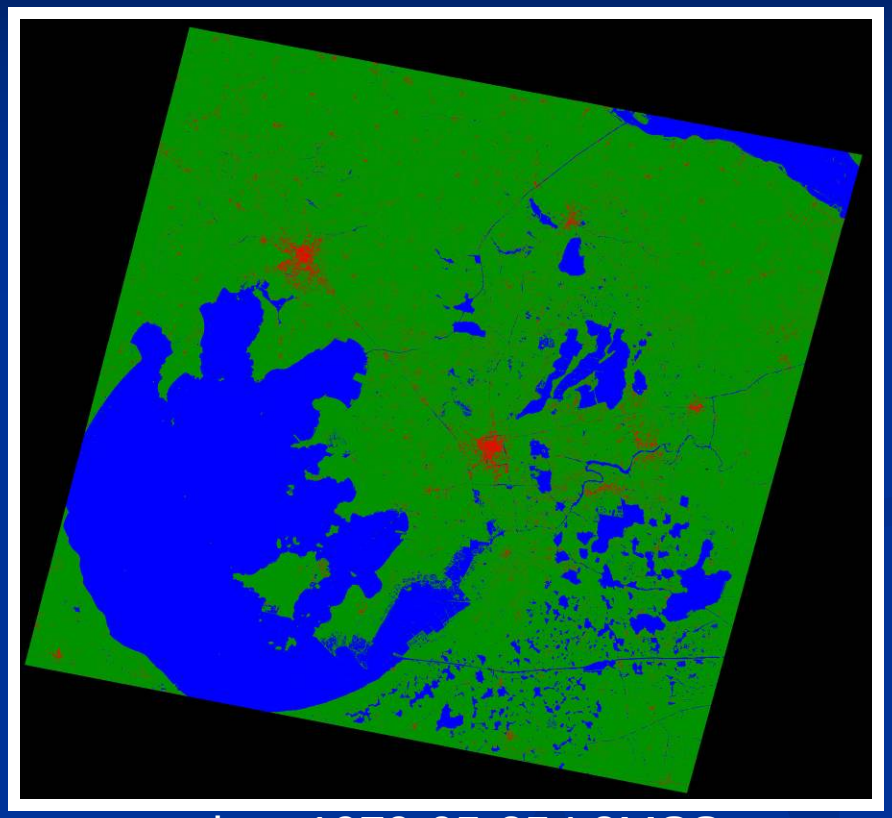
1973-11-16.L1MSSX2



urban.1973-11-16.L1MSS



1979-05-25.L3MSSX2



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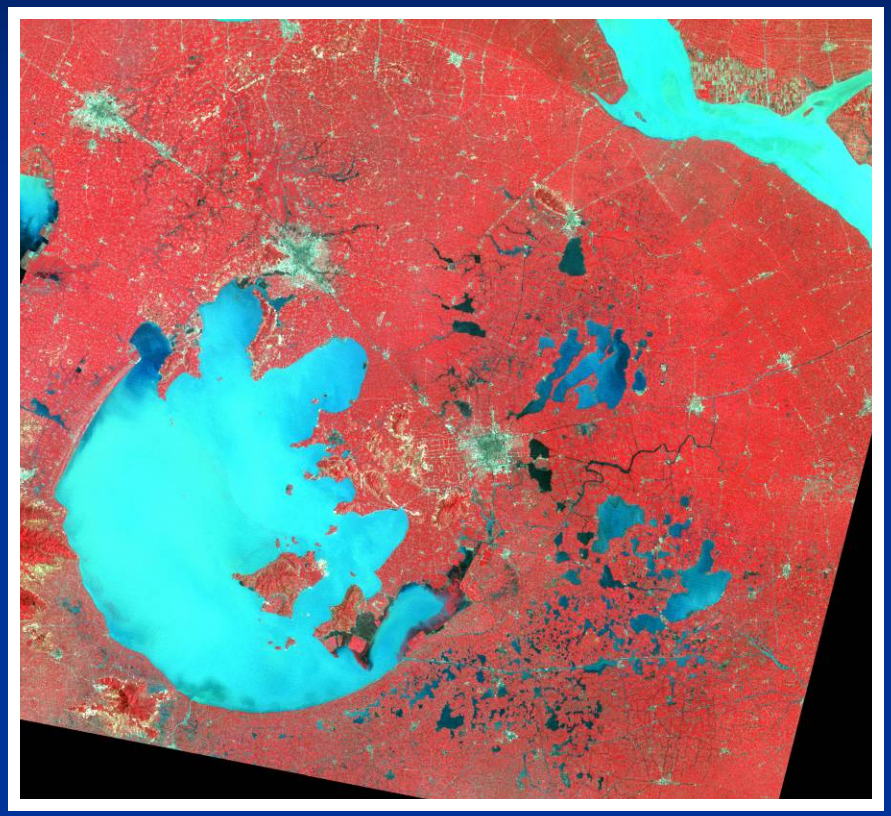
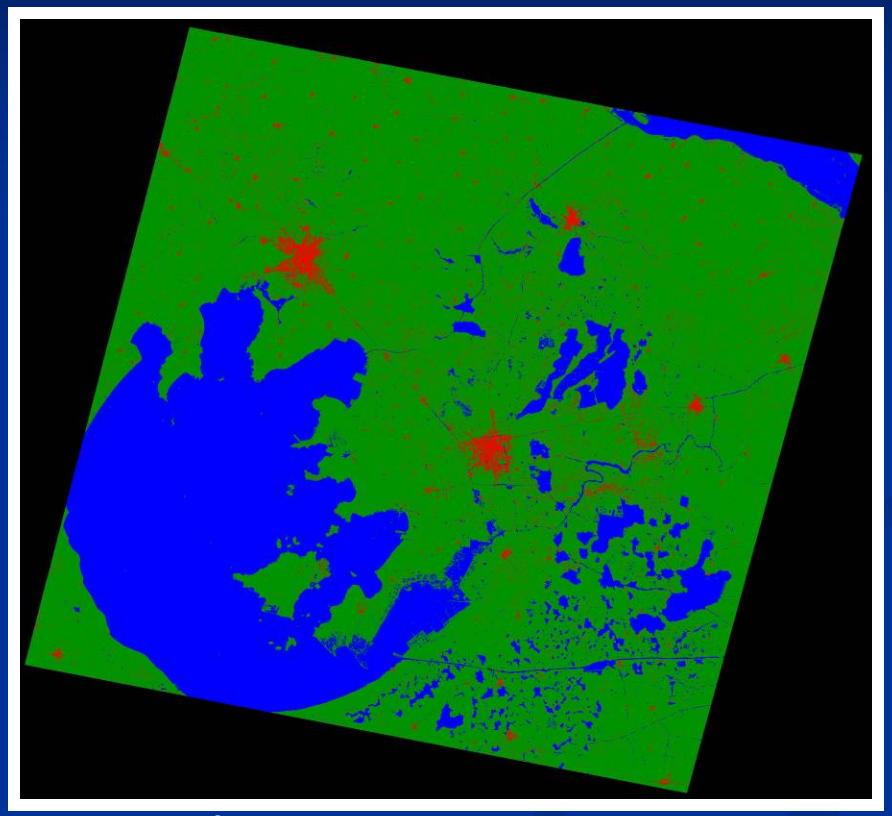


1984-05-08.L4MSSX2



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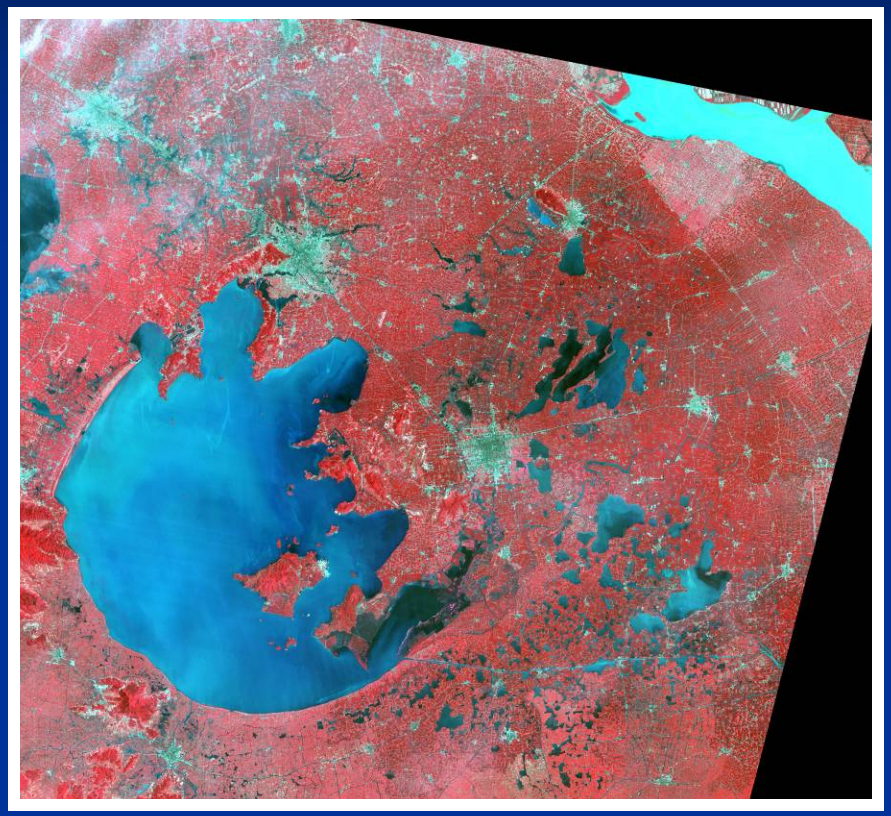
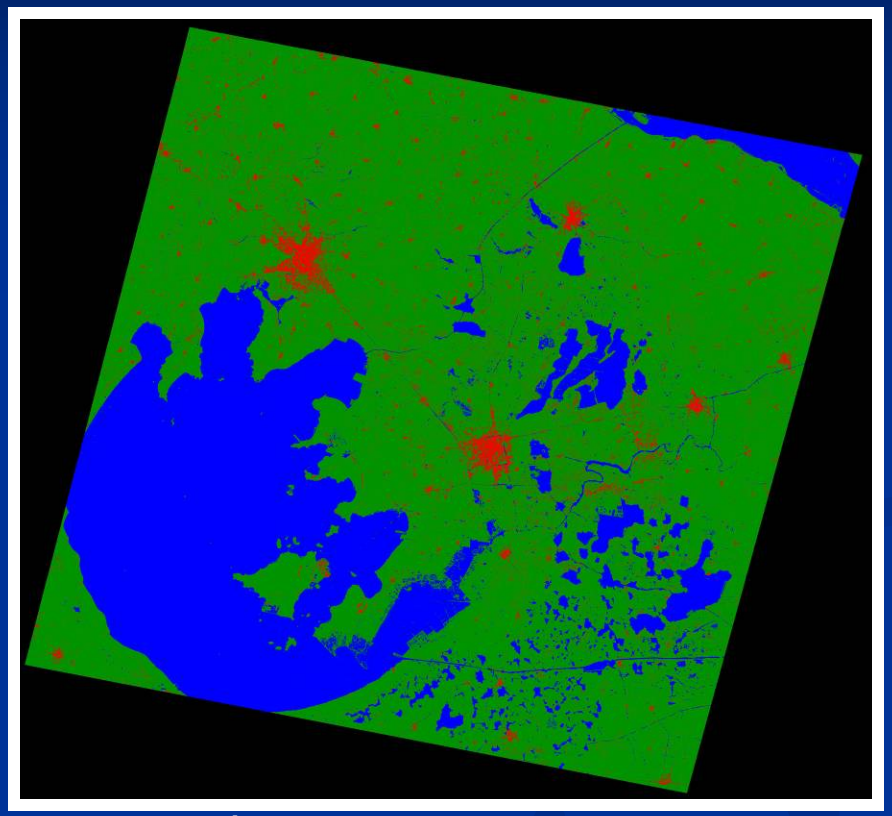


1991-07-23.L5TM



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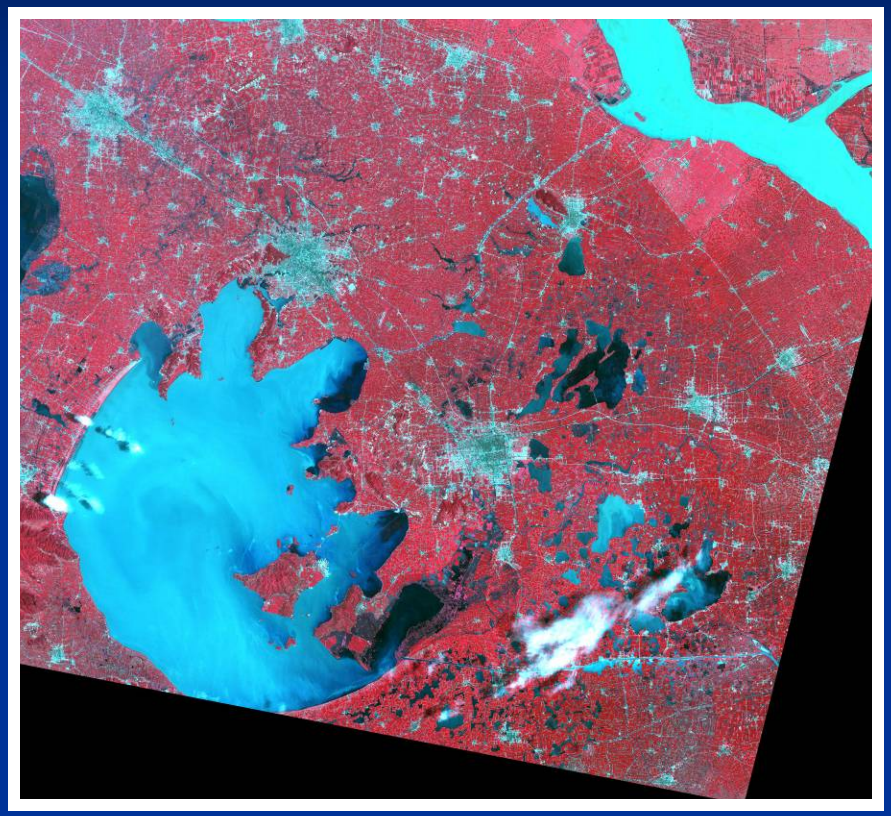
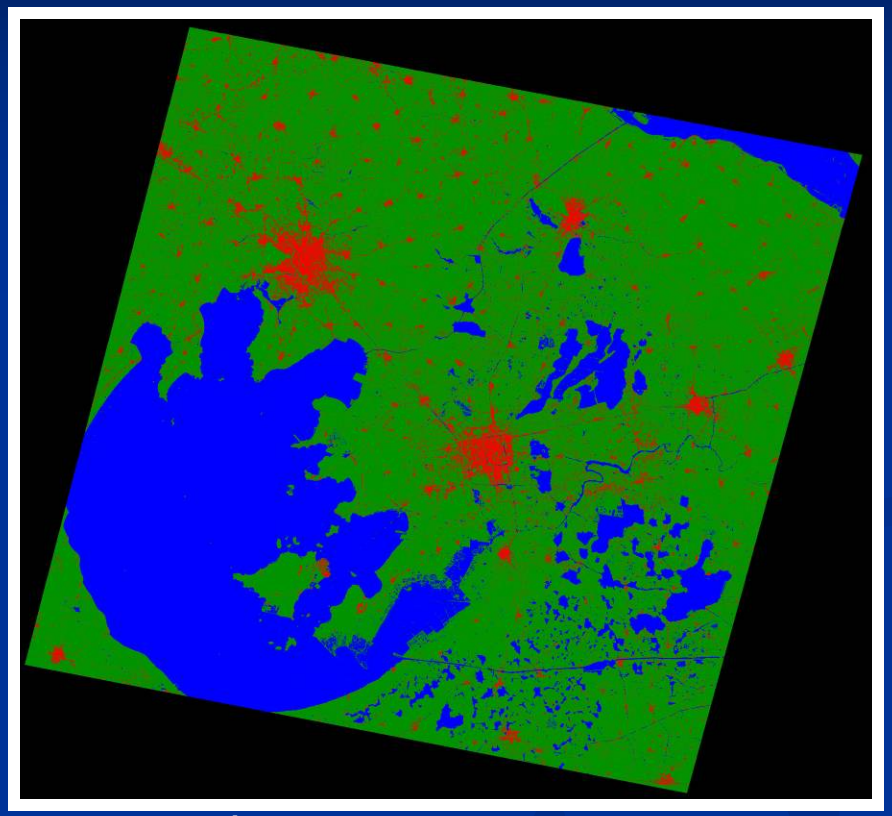


1995-08-03.L5TM



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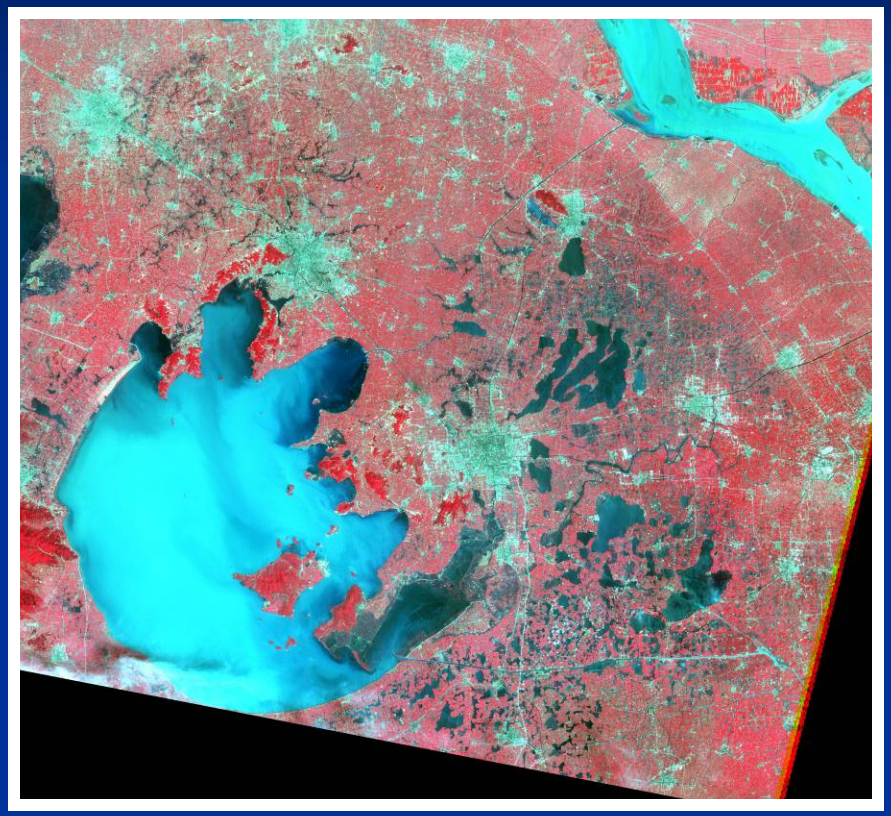
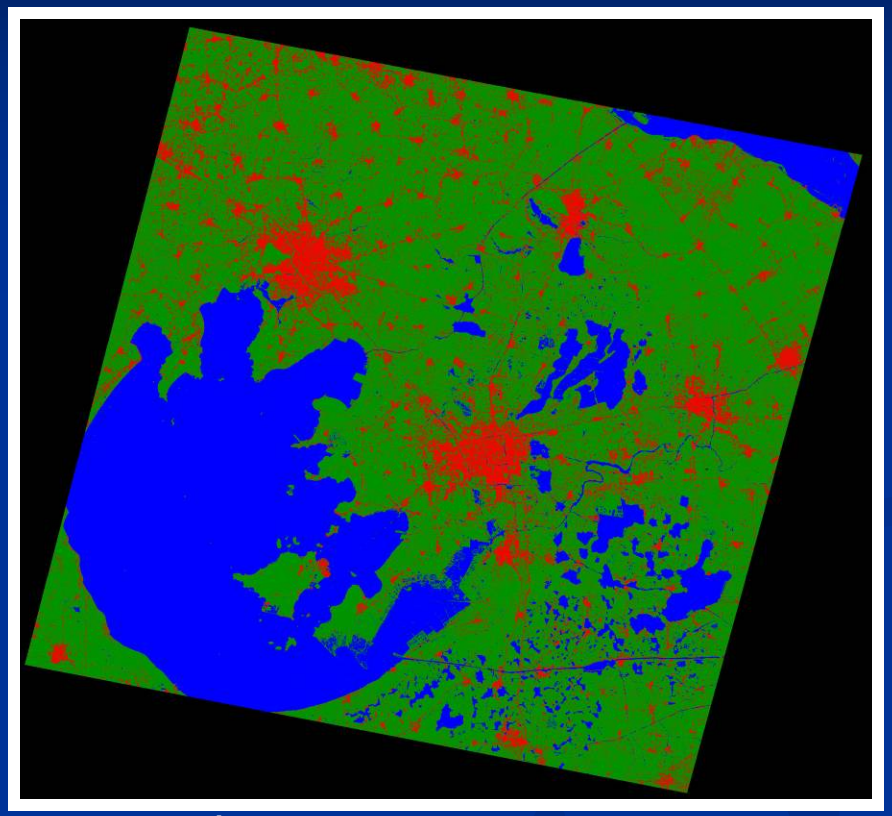


2000-05-04.L7ETM



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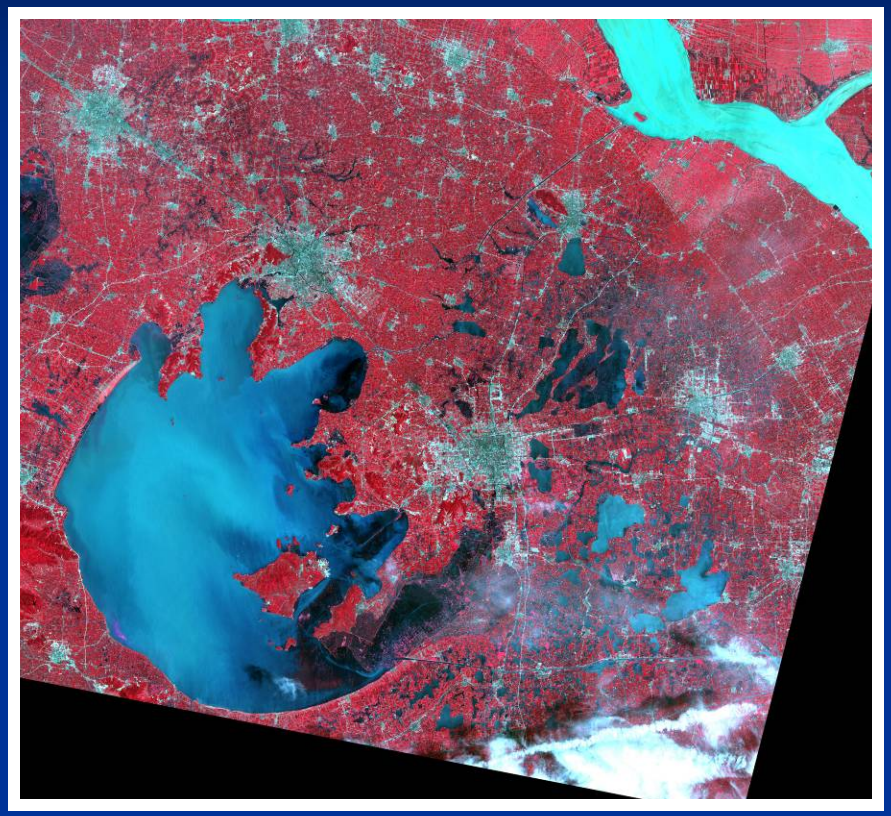
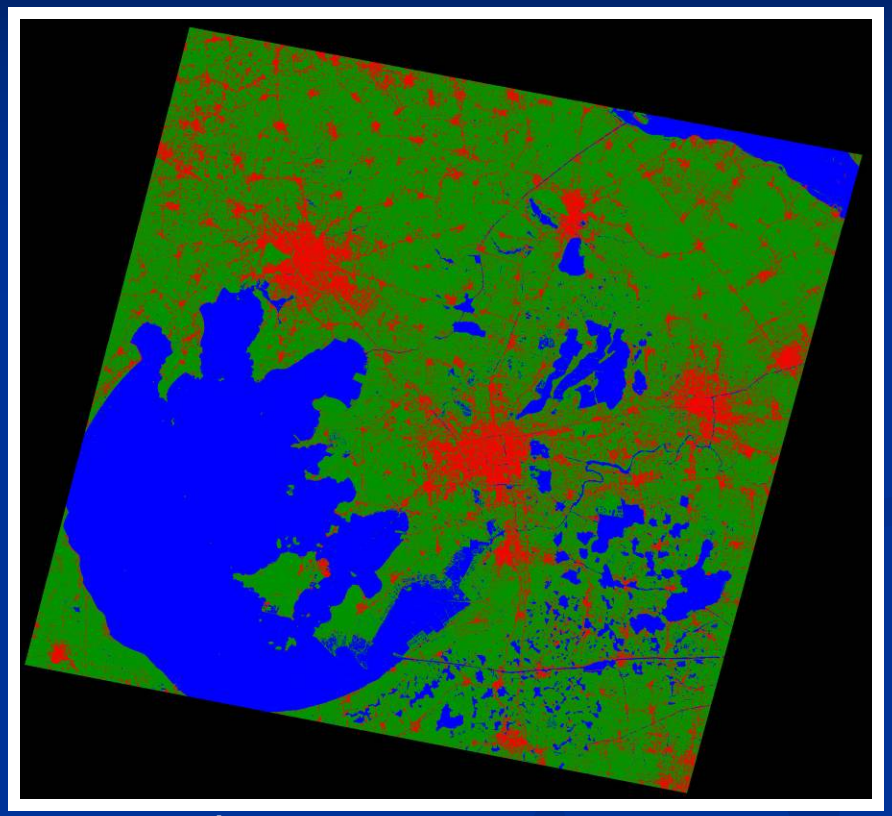


2001-07-26.L7ETM



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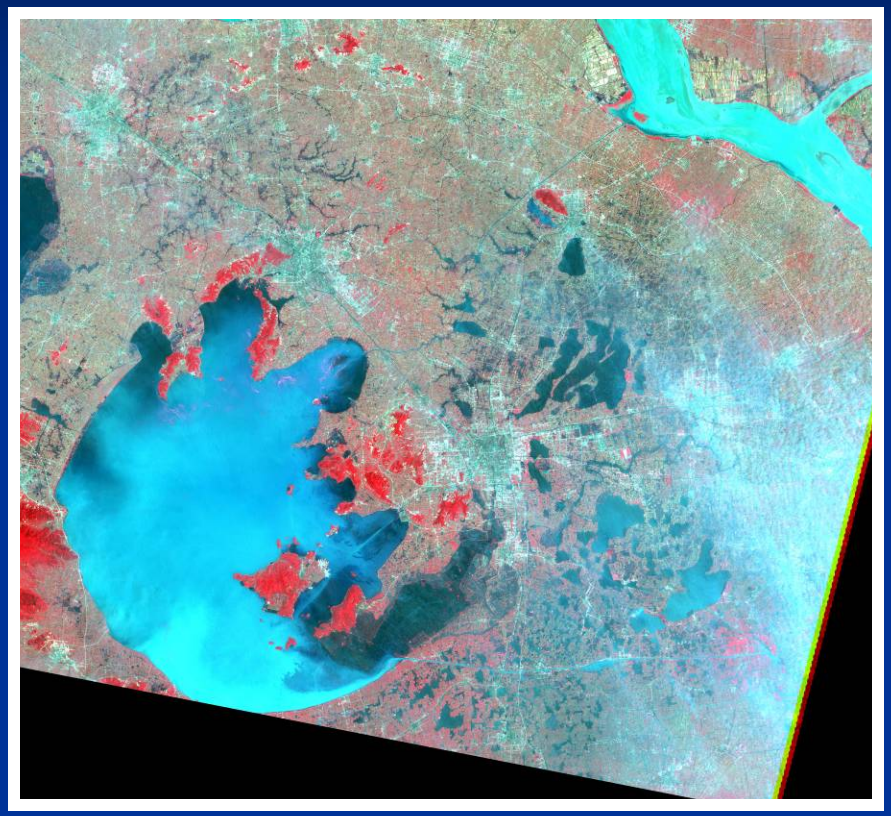
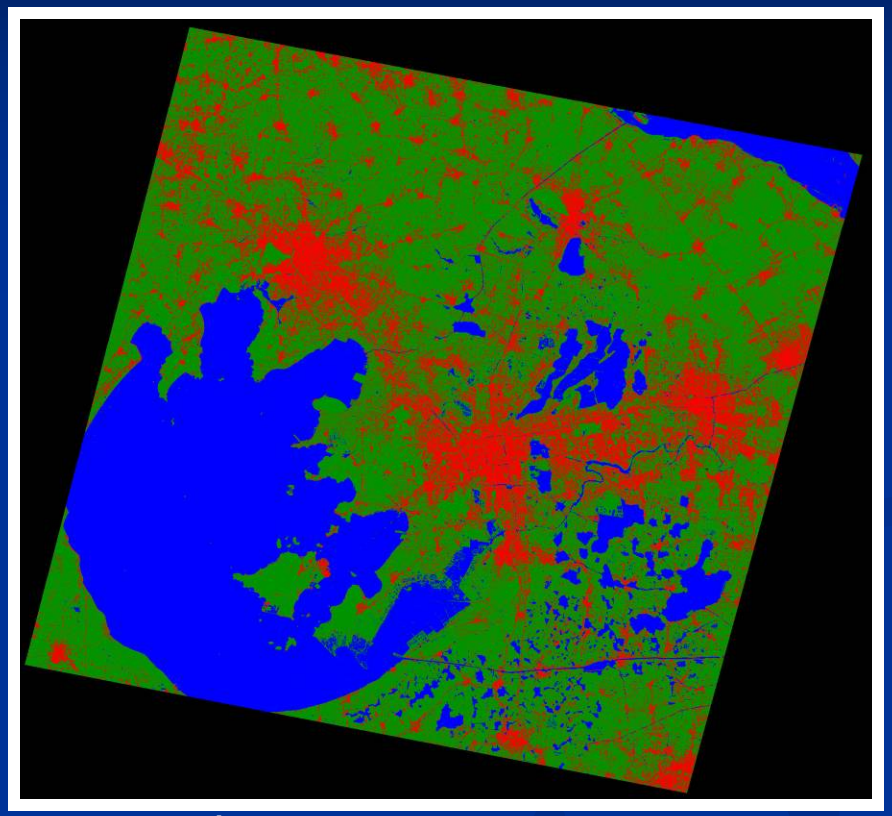


2002-05-26.L7ETM



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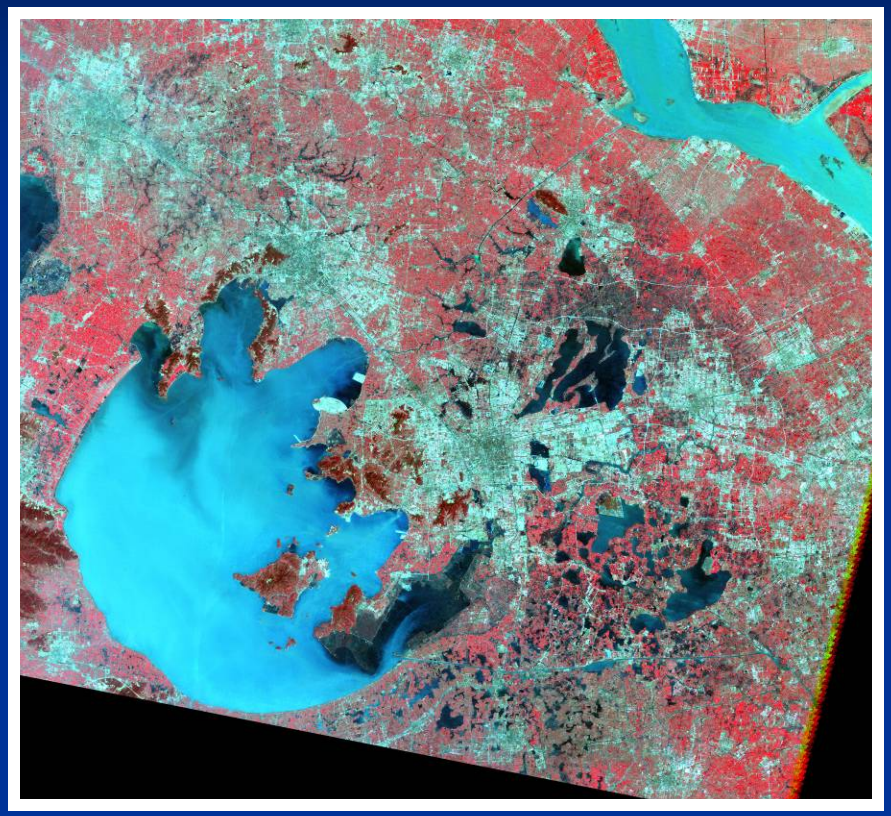
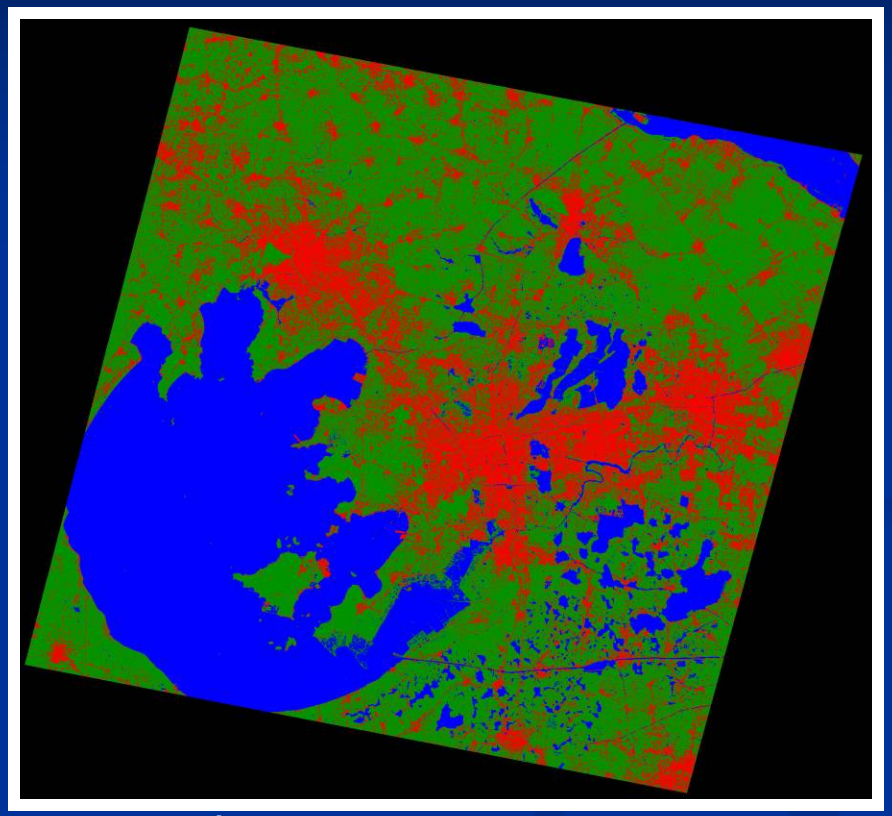
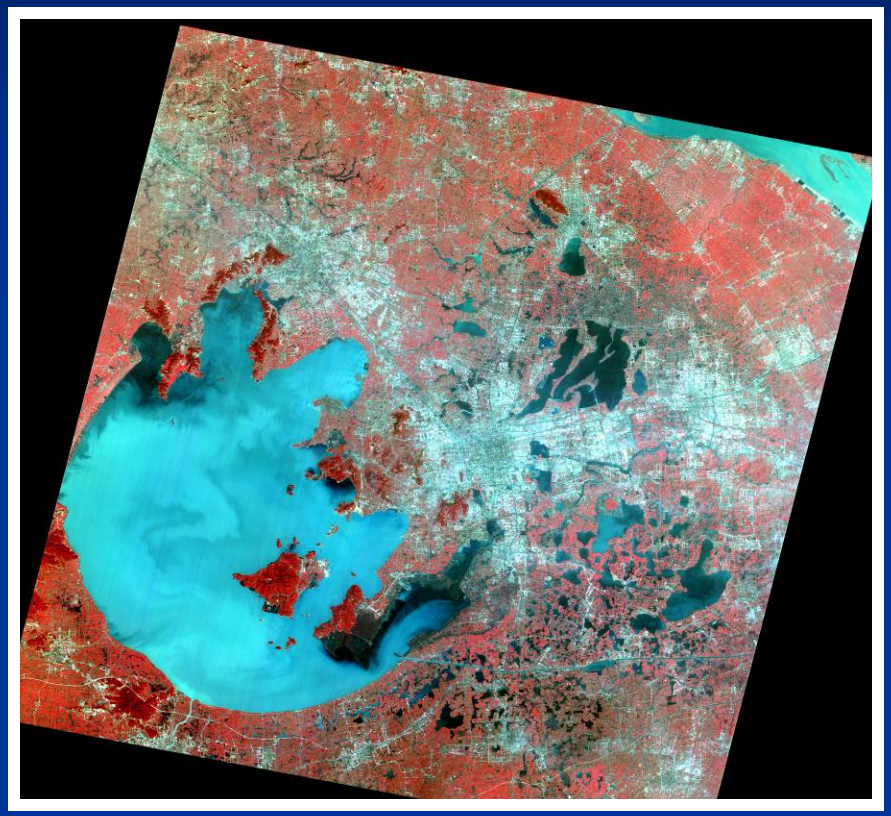


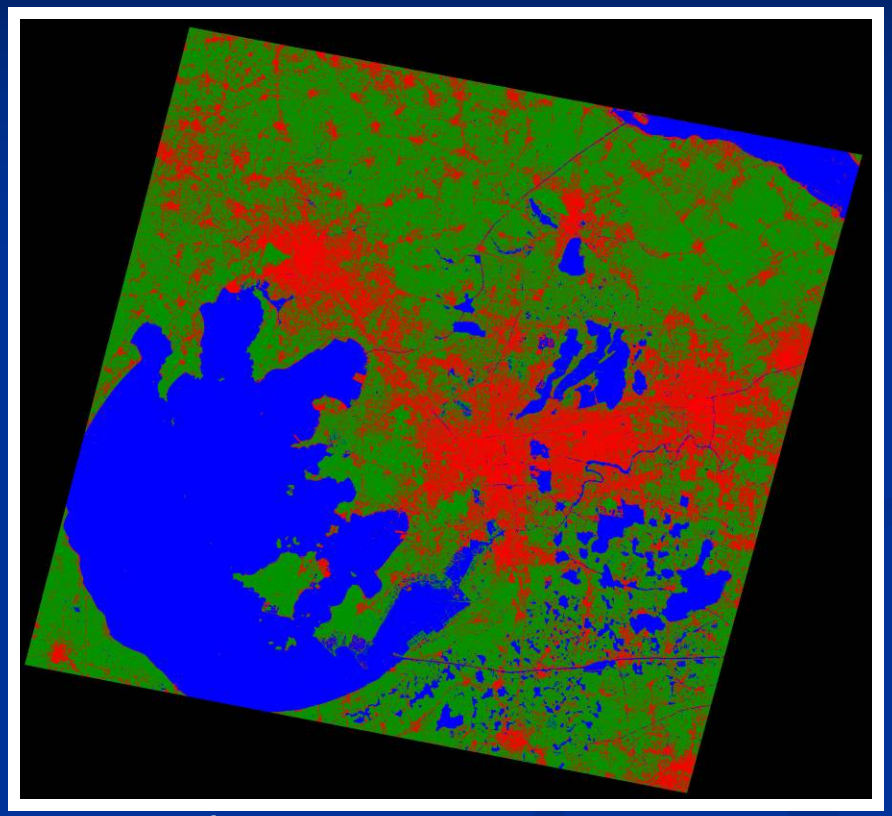
2005-03-31.L7ETM



urban.2005-03-31.L7ETM

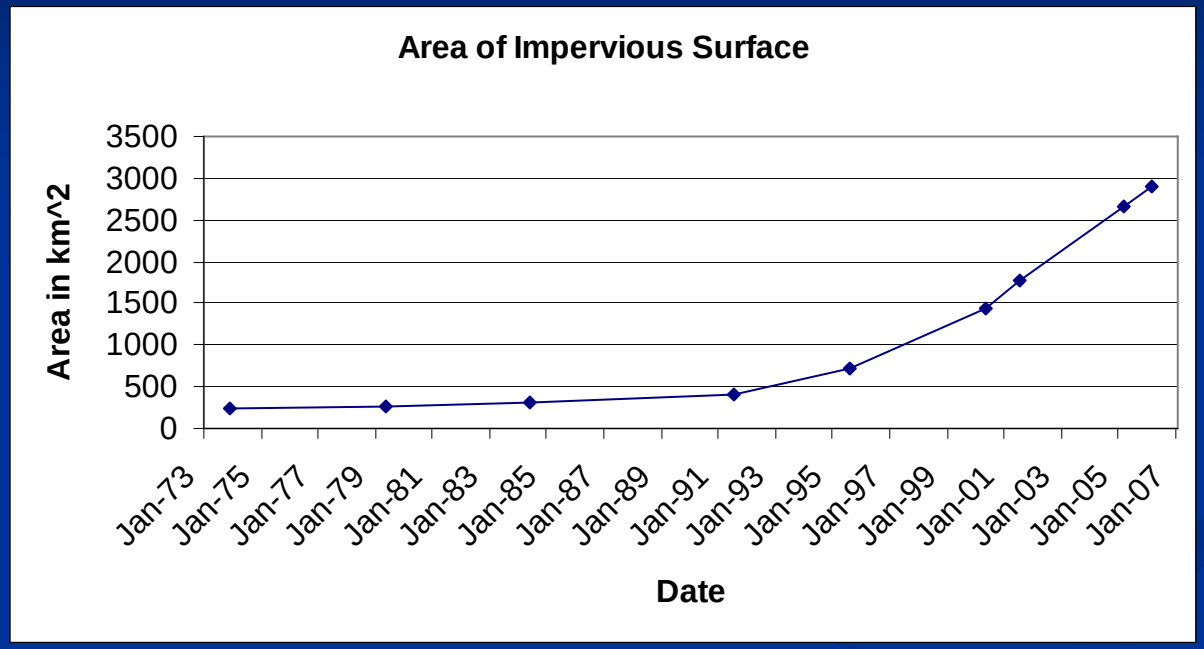


2006-03-03.CBERS



urban.2006-03-03.CBERS

Rate of Urbanization



Translated from the official statement of the Land Bureau of Wuxi City published in the China Society of Territorial Economists "land use in Wuxi city can be summarized in three stages: the first stage (before 1992) is the stable; the second stage (1992-2003) is an expanding stage which can be divided into two sub-stages. The first sub-stage (1992-1999) is initial expanding period. The second sub-stage (2000-2003) is immersive expanding period; the third stage (2004 to present) is expanding control period."

Next Step

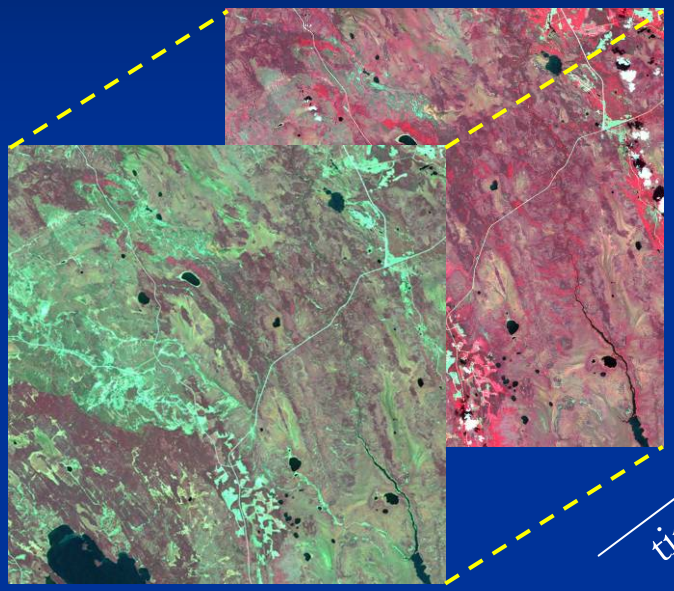
- Validate result
  - Ground truth/aerial photos and statistical results
  - Change study area with good validation data source
- Automatic sample training processing
  - Automated training based 1)spectral signal and texture information from image and/or 2) a priori knowledge from existing thematic maps
  - Training sample database

Part II StarFM Applications

with contribution from Jeff Masek, Jeff Morisette, Robert Wolfe, Thomas Hilker and Michael Wulder

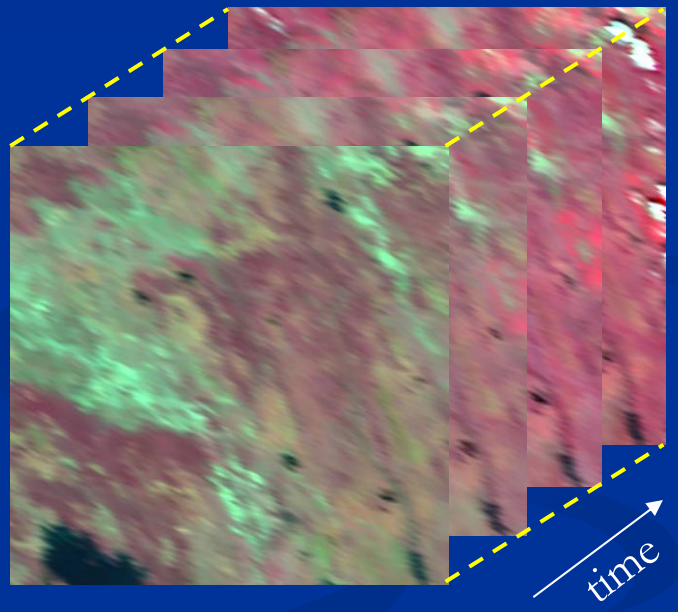
Background

Landsat



- Landsat
  - 30m spatial resolution
  - 16-day revisit cycle

MODIS



- MODIS
  - one or two revisit per day
  - 250m & 500m spatial resolution

Objective - combine the spatial resolution of Landsat with the temporal frequency of coarse-resolution MODIS.

Spatial and Temporal Adaptive Reflectance Fusion Model (StarFM) Implementation

- Standalone version
  - C programming
  - Freely available on the Landsat Ecosystem Disturbance Adaptive Processing System (LEDAPS)

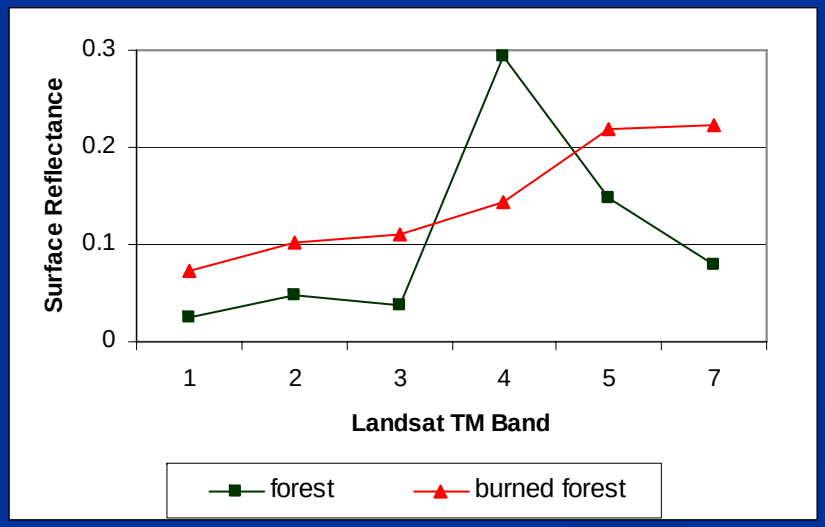
  http://ledaps.nascom.nasa.gov/ledaps/ledaps_NorthAmerica2008.html
  - IDL version from Thomas and Michael

- Web-based service
  - NASA ACCESS Land Cover Community-driven Processing System (PI: Jeff Masek; Co-I: Feng Gao etc.)
  - Automatic processing on MODIS NBAR and Landsat

  http://esipapp05.umiacs.umd.edu:8080/LC-ComPS/

StarFM Application Example I: Burn Severity Mapping

- Burn Severity: degree of changes in soil and vegetation caused by fire
- Useful for forest management: evaluate impacts and plan for vegetation succession

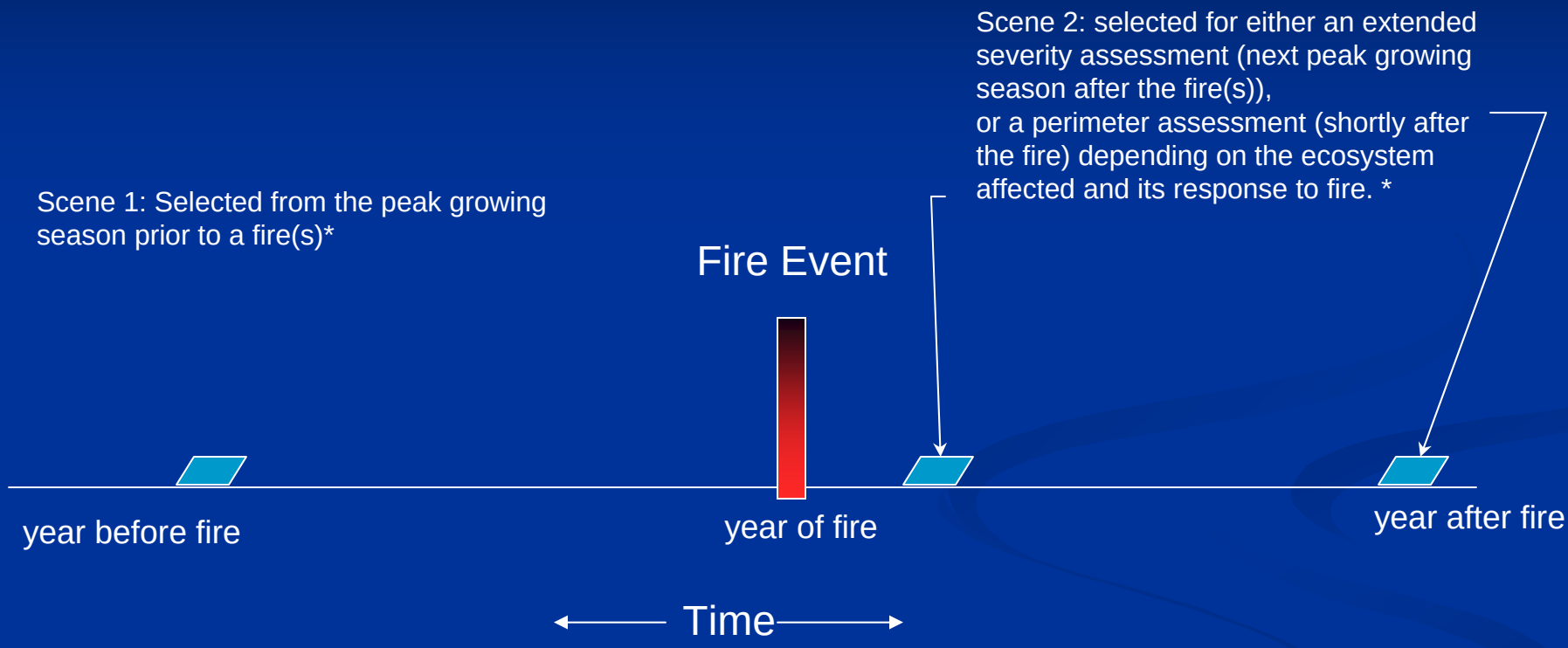


- Remote Sensing Approach
  - Vegetation Index (VI) and changes
  - Normalized Burn Ratio (NBR) and changes (dNBR)

    NBR=(b4-b7)/(b4+b7)

    dNBR = pre_fire_NBR – post_fire_NBR

Current situation: dNBR based on two Landsat scenes

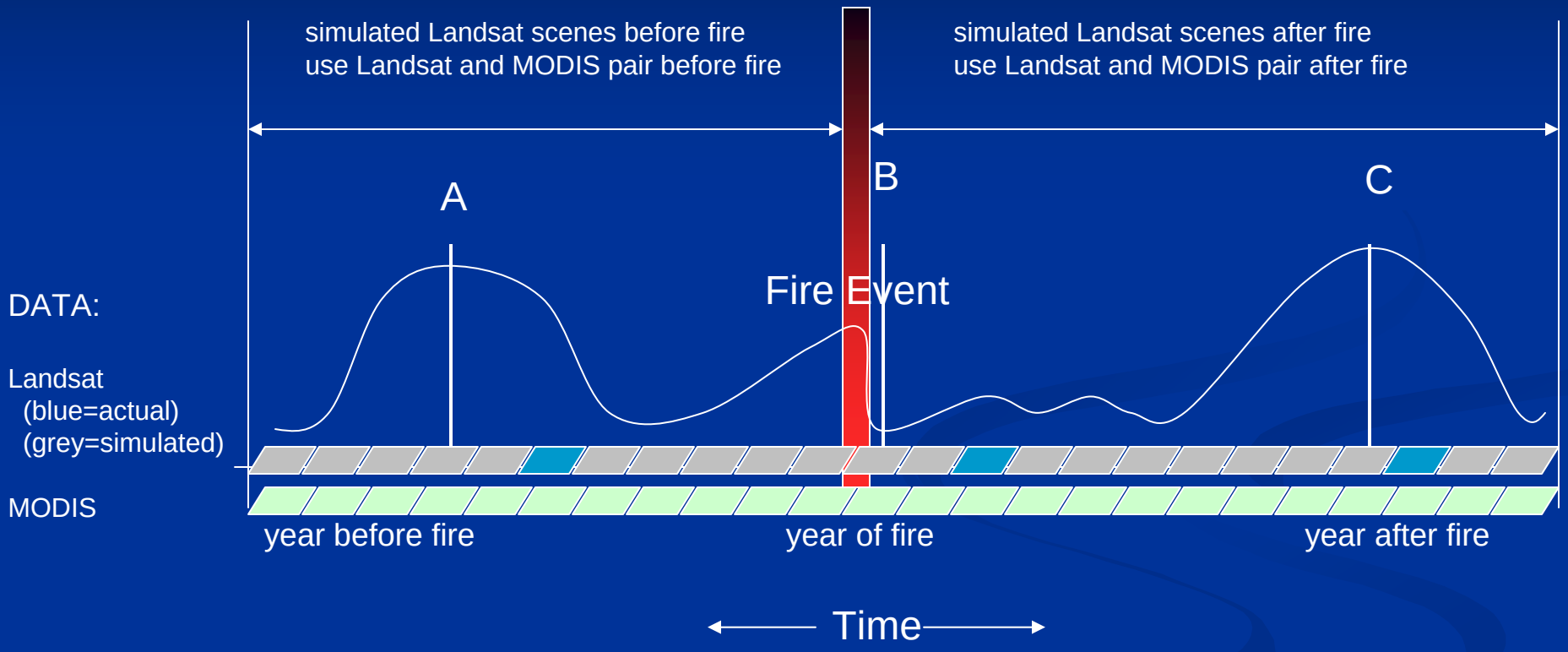


ISSUES:

- peak growing season is not based on quantitative methods
- the specific date for Landsat acquisition is dependent on availability of cloud free data
- different strategies for the timing of scene two imply a lack of standardization of dNBR data.

* From Monitoring Trends in Burn Severity, http://mtbs.gov (US fires 1984-2010)

Annual dNBR based on synthesized MODIS and Landsat product

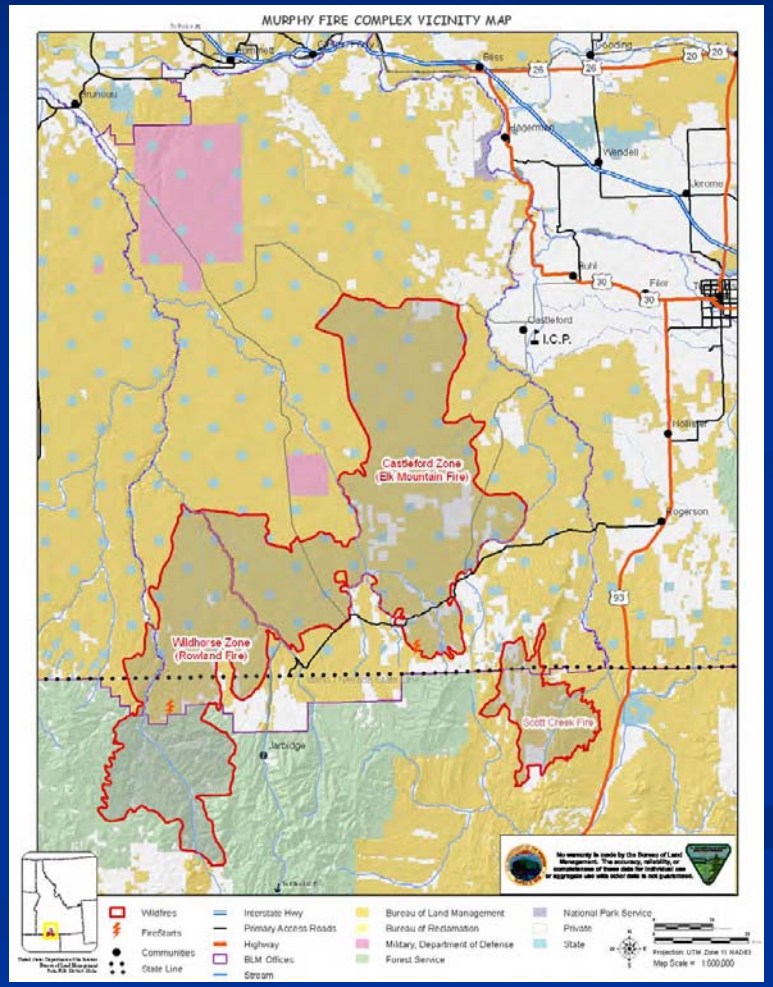


Advantages

- High-frequency metrics adds significant information to enhance ecological analysis
- Algorithm to simulate Landsat data allows the vegetation signal to dictate analysis dates (as opposed to dates determined by cloud free Landsat availability)
- Peak growing season is determined quantitatively from MODIS vegetation record.

Murphy Wildland Fire Complex

- Located in Idaho-Nevada border
- Started in July 16 and 17, 2007 by several lightning and lasted about two weeks
- Grass and sagebrush rangeland
- 1000 square miles burned
- Remote sensing data were used to evaluate burn severity



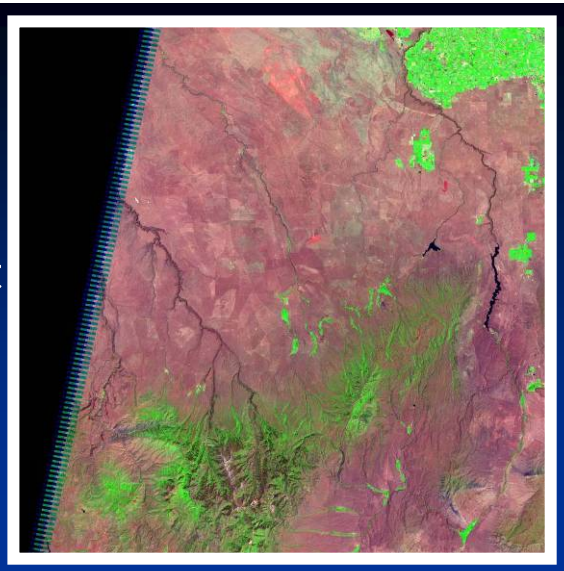
USGS Murphy Fire Reports
(Research Gaps and Limitations)

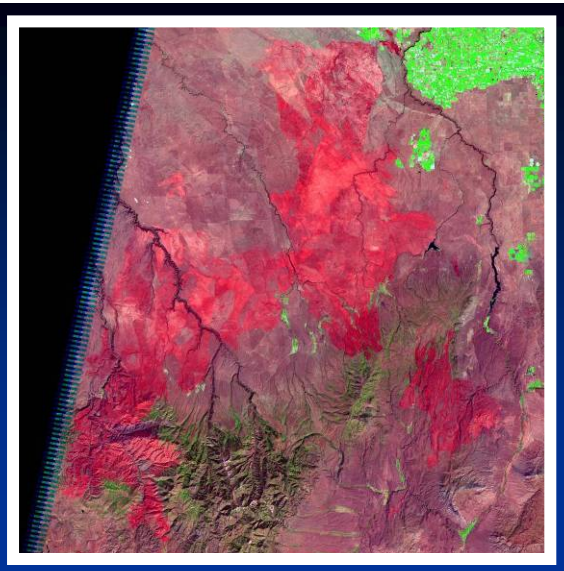
"Additional research into the relationship of dNBR to post-fire soil burn severity and vegetation mortality in shrubland and grassland systems should be pursued."

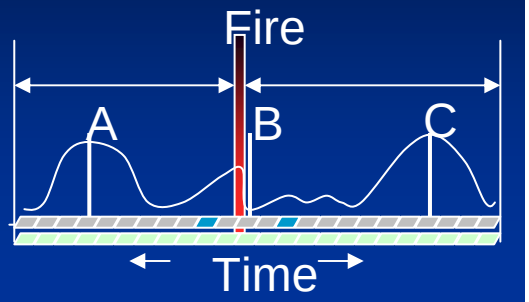
http://pubs.usgs.gov/of/2008/1214/

StarFM for Burn Severity

Landsat TM



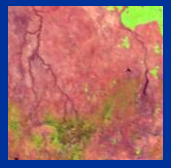


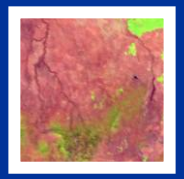


MODIS NBAR

July 7, 2007

Sept. 11, 2007



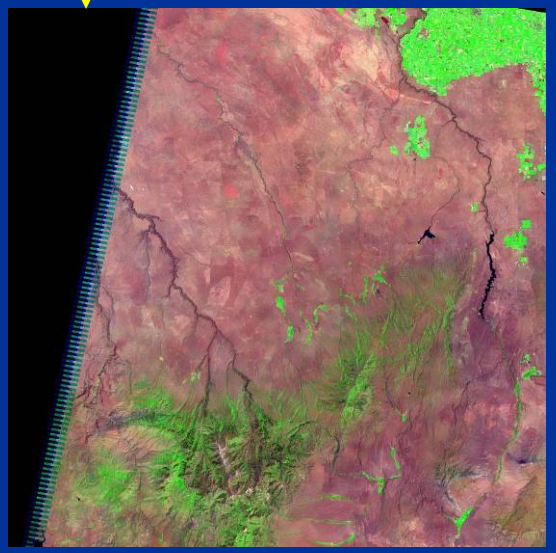


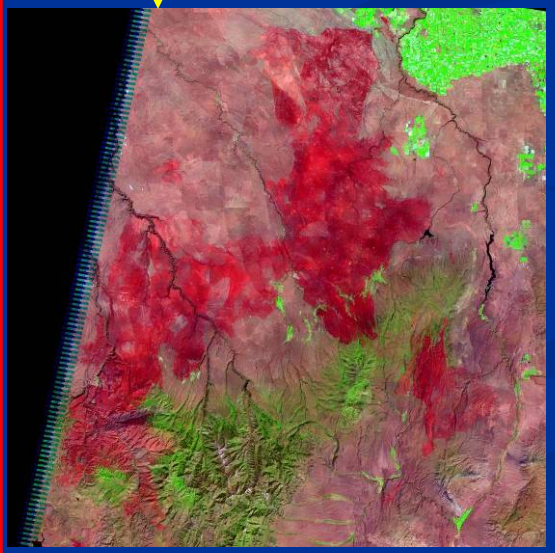
2006201

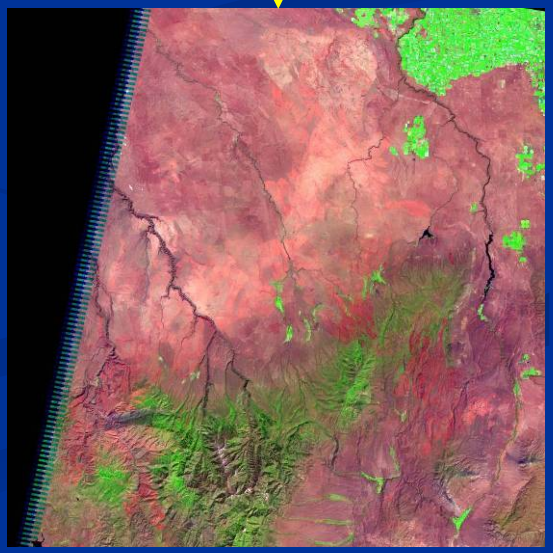
2007201

2008201

Predicted Landsat (July 20 – August 4)





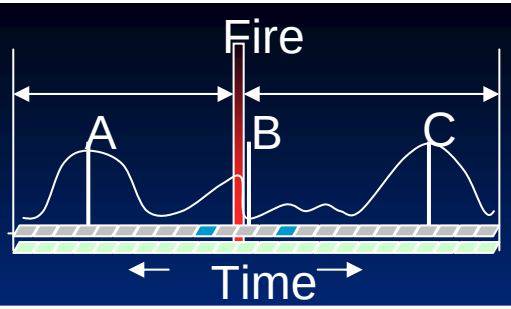


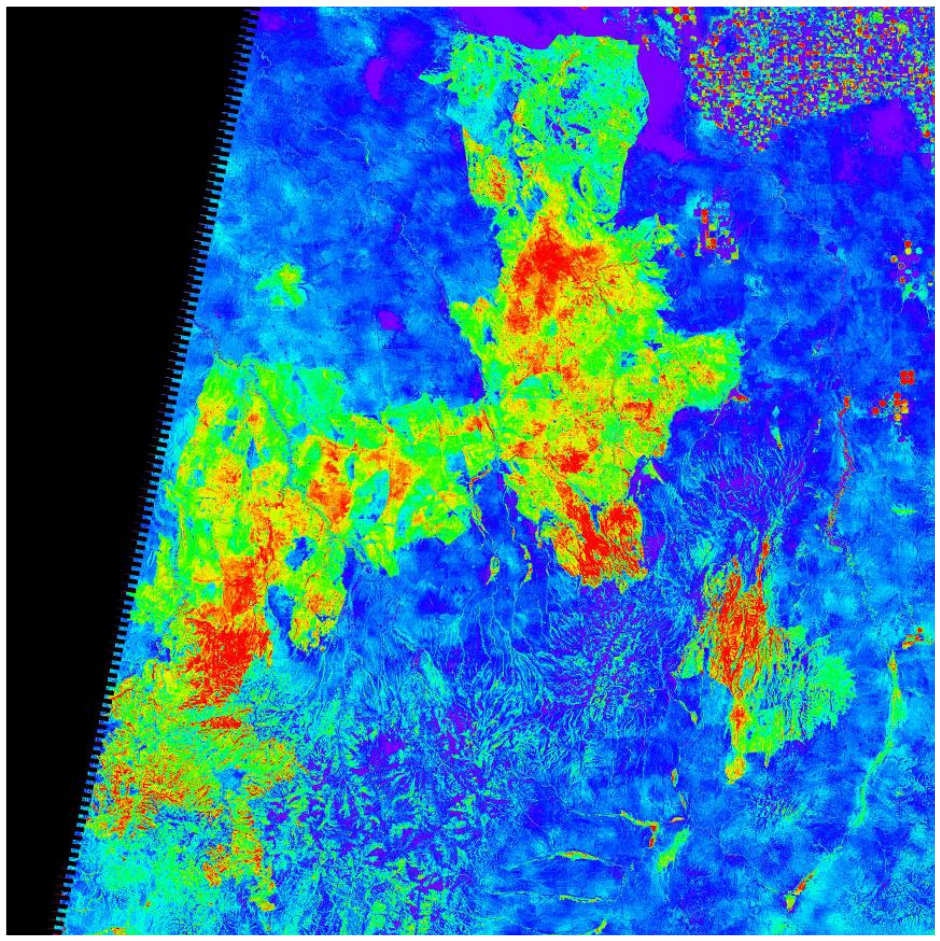
2006201 (A)

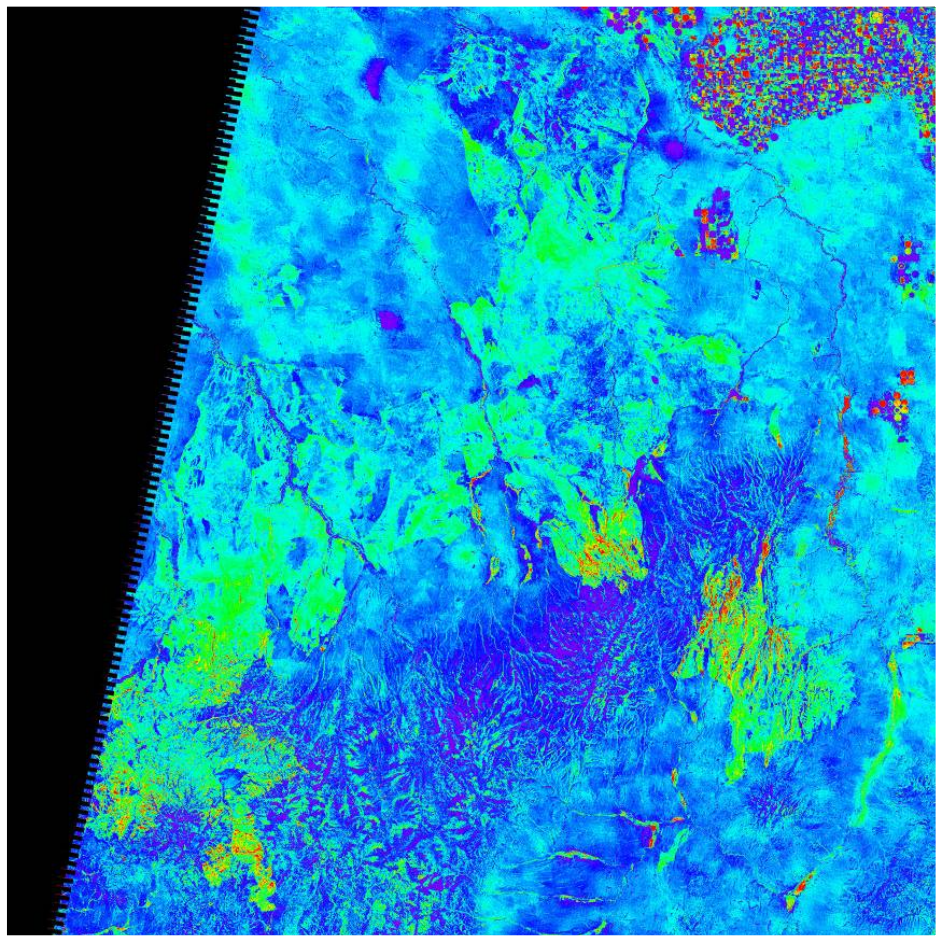
2007201 (B)

2008201 (C)

Annual dNBR on Day 201





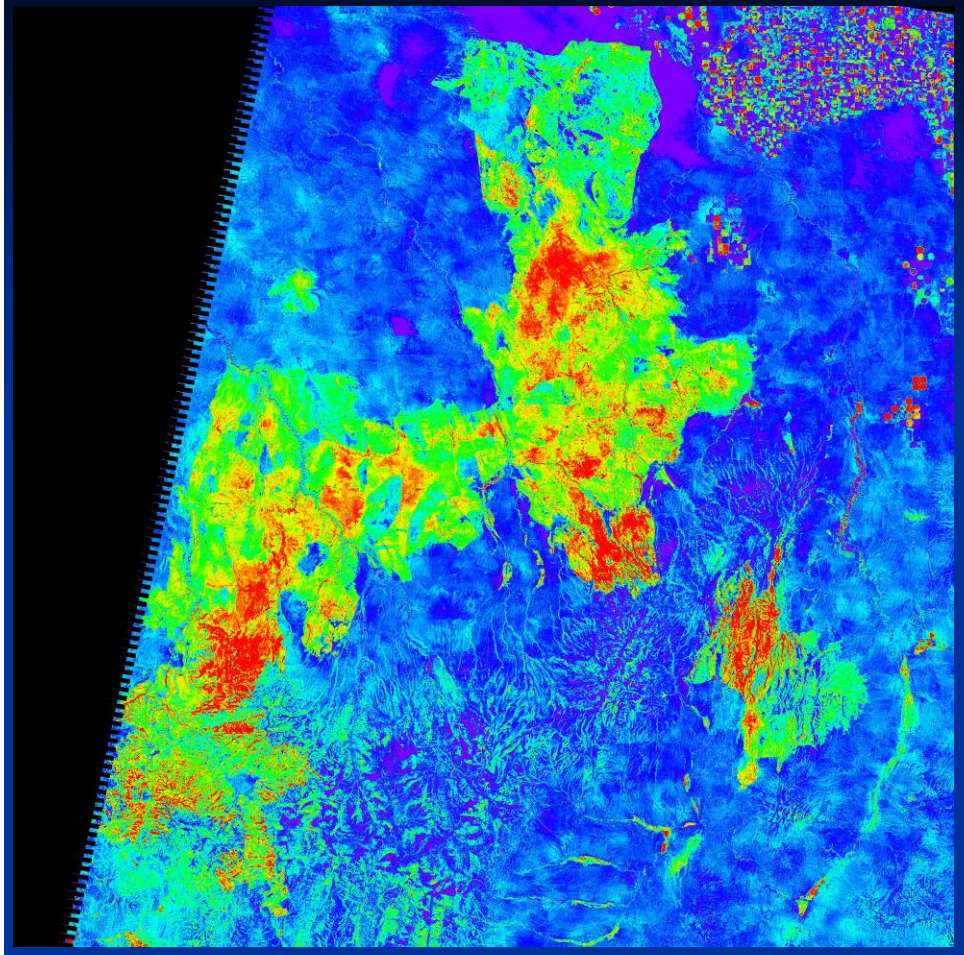


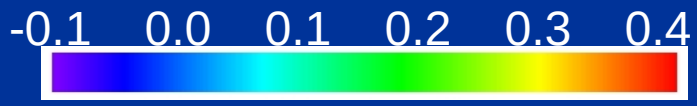
2006201 minus 2007201 (A-B)

2006201 minus 2008201 (A-C)

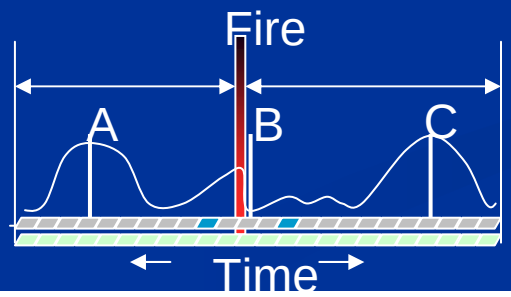
-0.1 0.0 0.1 0.2 0.3 0.4

Annual dNBR (A-B)

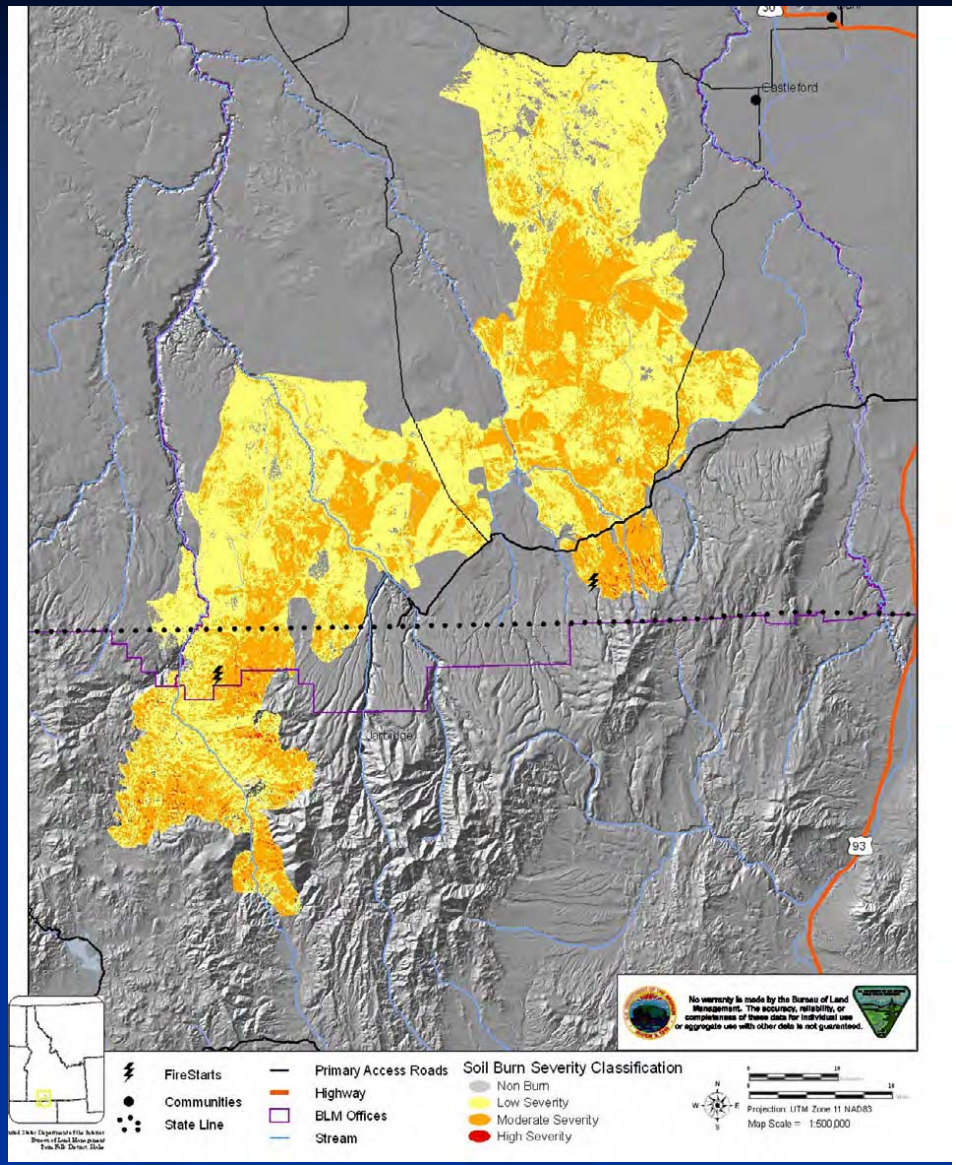




Annual dNBR (2006201-2007201) from simulated Landsat data.

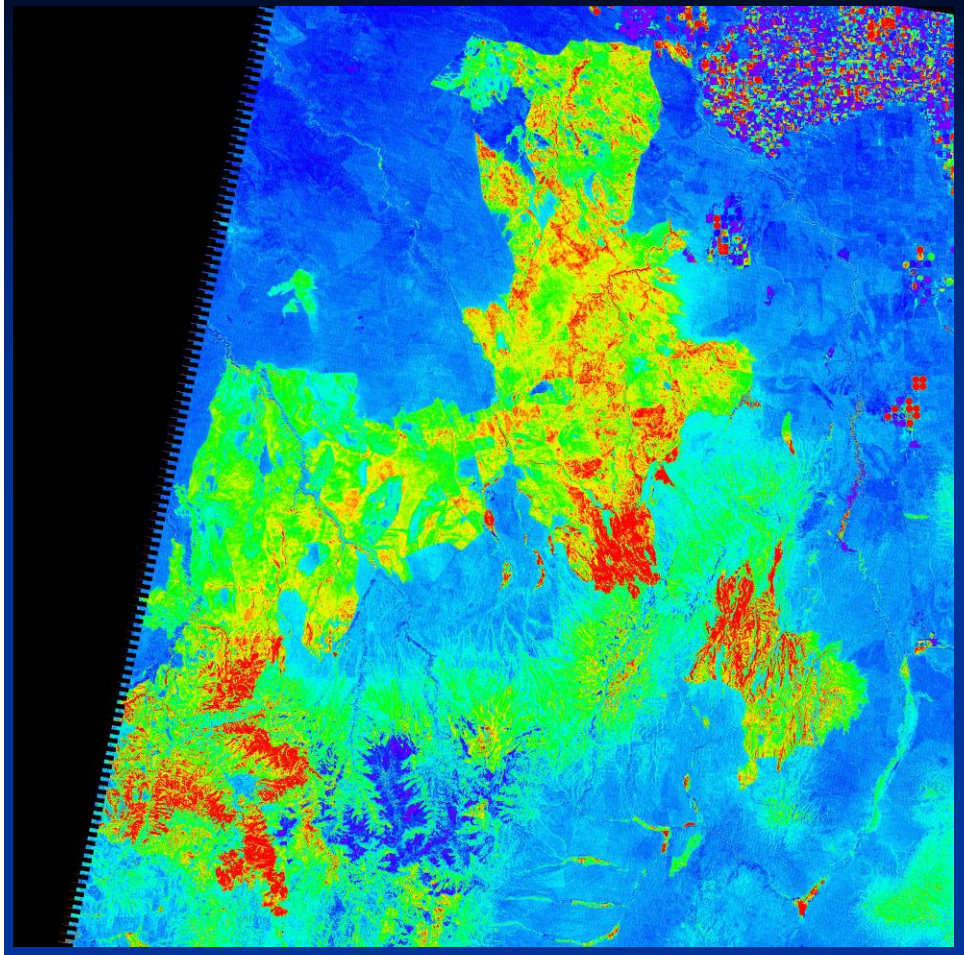


Burn Severity Map



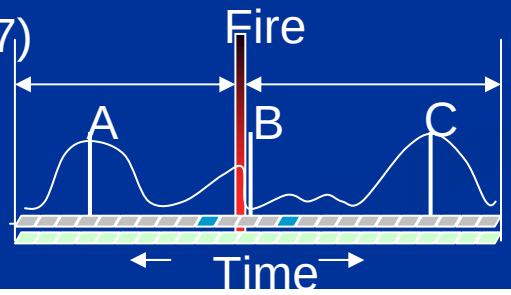
Burn Severity Map from Reports (based on 4 Landsat images and field examinations)

Observed dNBR

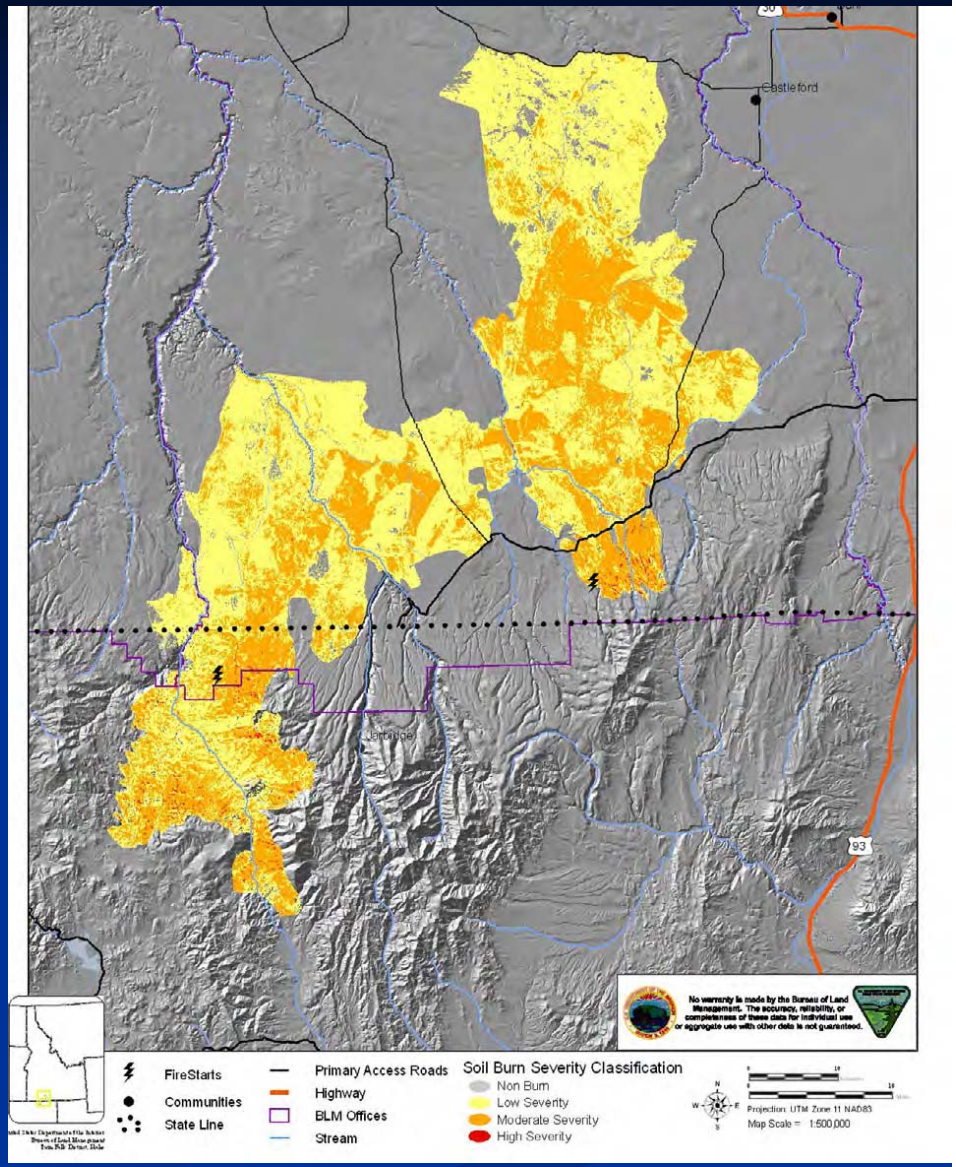


(7/9/2007-9/11/2007)

NOT AN IDEAL DATE!!!

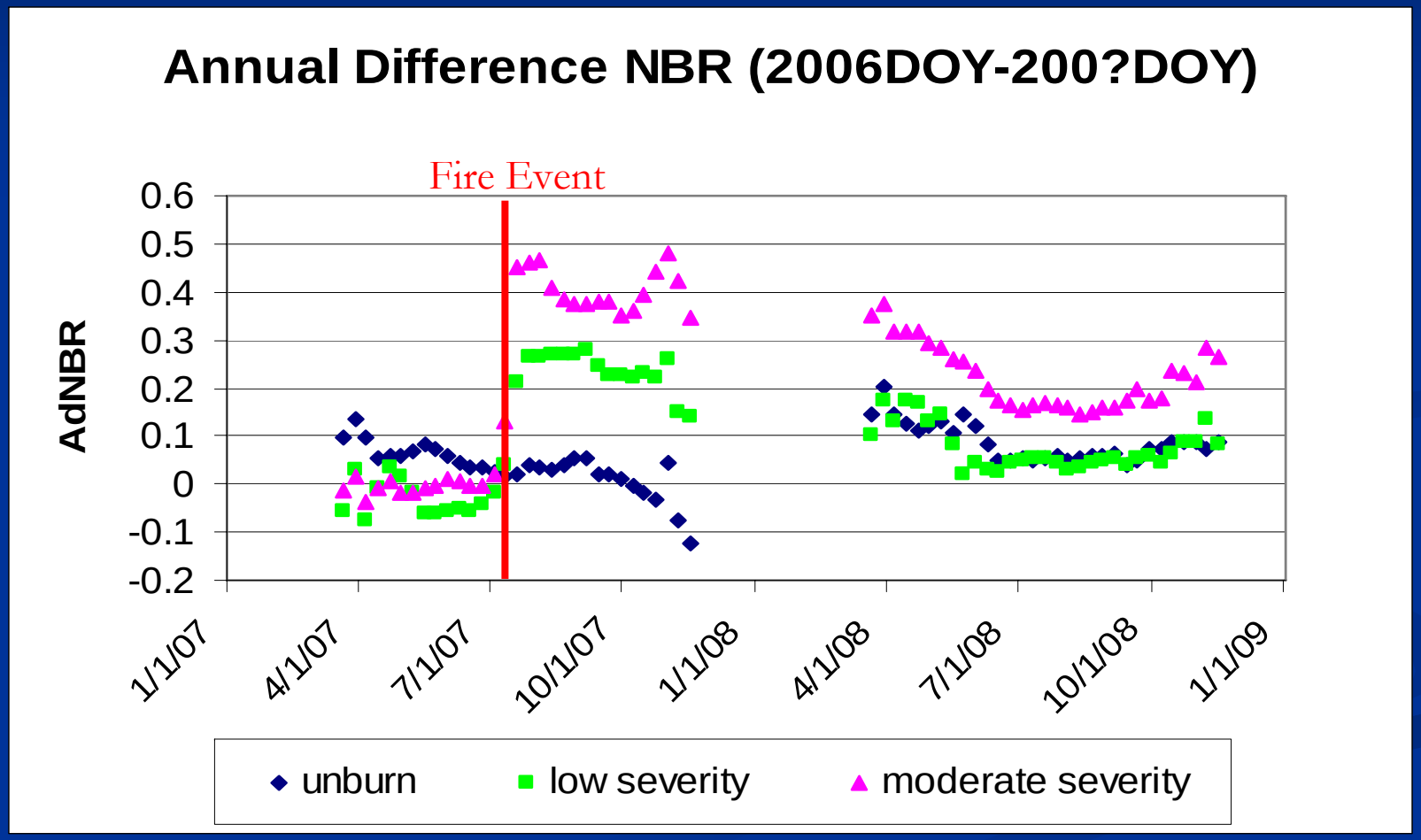


Burn Severity Map



Burn Severity Map from Fire Reports

Annual difference NBR (AdNBR)



Next Step: Evaluation and Validation

StarFM Application II: Forest Monitoring

Canadian Forest Service,

Pacific Forestry Centre

(Thomas Hilker and Michael Wulder)

- Generation of dense time series synthetic Landsat data through data blending with MODIS using the spatial and temporal adaptive reflectance fusion model (STARFM), Remote Sensing of Environment, 2009.

- A new data fusion model for high spatial- and temporal- resolution mapping of forest disturbance based on Landsat and MODIS, Remote Sensing of Environment, 2009.