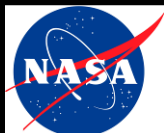


# Recent highlights of the Making Earth System Data Records for Use in Research Environments (MEaSUREs)

## Web-enabled Landsat data (WELD) Project

Funding Started April 10<sup>th</sup> 2008 Finish: April 9<sup>th</sup> 2013



15th Annual LCLUC Science Team Meeting  
UMUC Marriott, Adelphi, Maryland, March 28-30th 2011

# WELD Project Overview



# Timely, accurate, high spatial resolution land assessments have been advocated by and are need to support

- NASA's Land Cover and Land Use Change program
- NASA's Terrestrial Ecology program
- NASA's North America Carbon program
- Global Observation of Forest Cover-Land (GOFC-GOLD) program
- Group on Earth Observations (GEO) Report
- US National Land Imaging Program
- Integrated Global Observing Strategy (IGOS) Report
- U.S. Strategic Plan for Earth Science (CCSP) Earth Science Program
- United Nations Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD)
- Land Use Change Earth System Data Record (LUCES) White Paper
- Numerous federal, state, municipal, academic, commercial and military applications

The capability to support these (now that Landsat data are Free) is unprecedented





# Free Landsat Products at USGS EROS

## Calibrated & Geolocated Digital Numbers

- L1T format
  - geometrically corrected
  - radiometrically calibrated
- Pixel size: *15m/30m/30m*
- Media type: *Internet download only*
- Product type: *L1T (terrain-corrected)*
- Output format: *GeoTIFF*
- Map projection: *UTM*
- Orientation: *North up*
- Resampling: *Cubic convolution*
- DEM: *GLS DEM (SRTM, NED, CDAD, DTED, GTOPO 30)*

# MODIS Land Products

Peer Reviewed, Documented, Systematically Generated, Derived Data Products, Quality Assessed and Validated, Reprocessed Global products, Significant NASA funding

## Energy Balance Product Suite

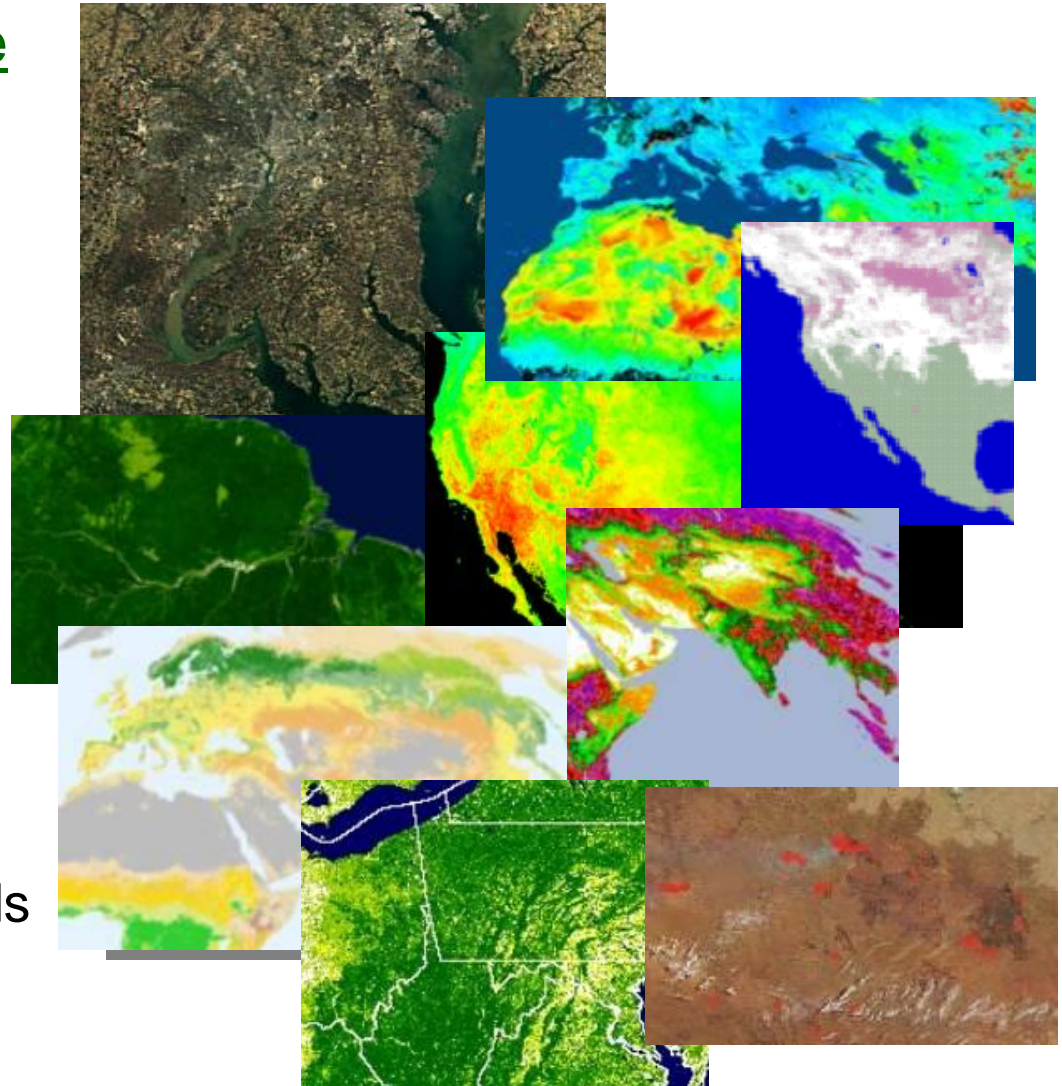
- Surface Reflectance
- Land Surface Temperature, Emmissivity
- BRDF/Albedo
- Snow/Sea-ice Cover

## Vegetation Parameters Suite

- Vegetation Indices
- LAI/FPAR
- GPP/NPP

## Land Cover/Land Use Suite

- Land Cover/Vegetation Dynamics
- Vegetation Continuous Fields
- Vegetation Cover Change
- Fire and Burned Area





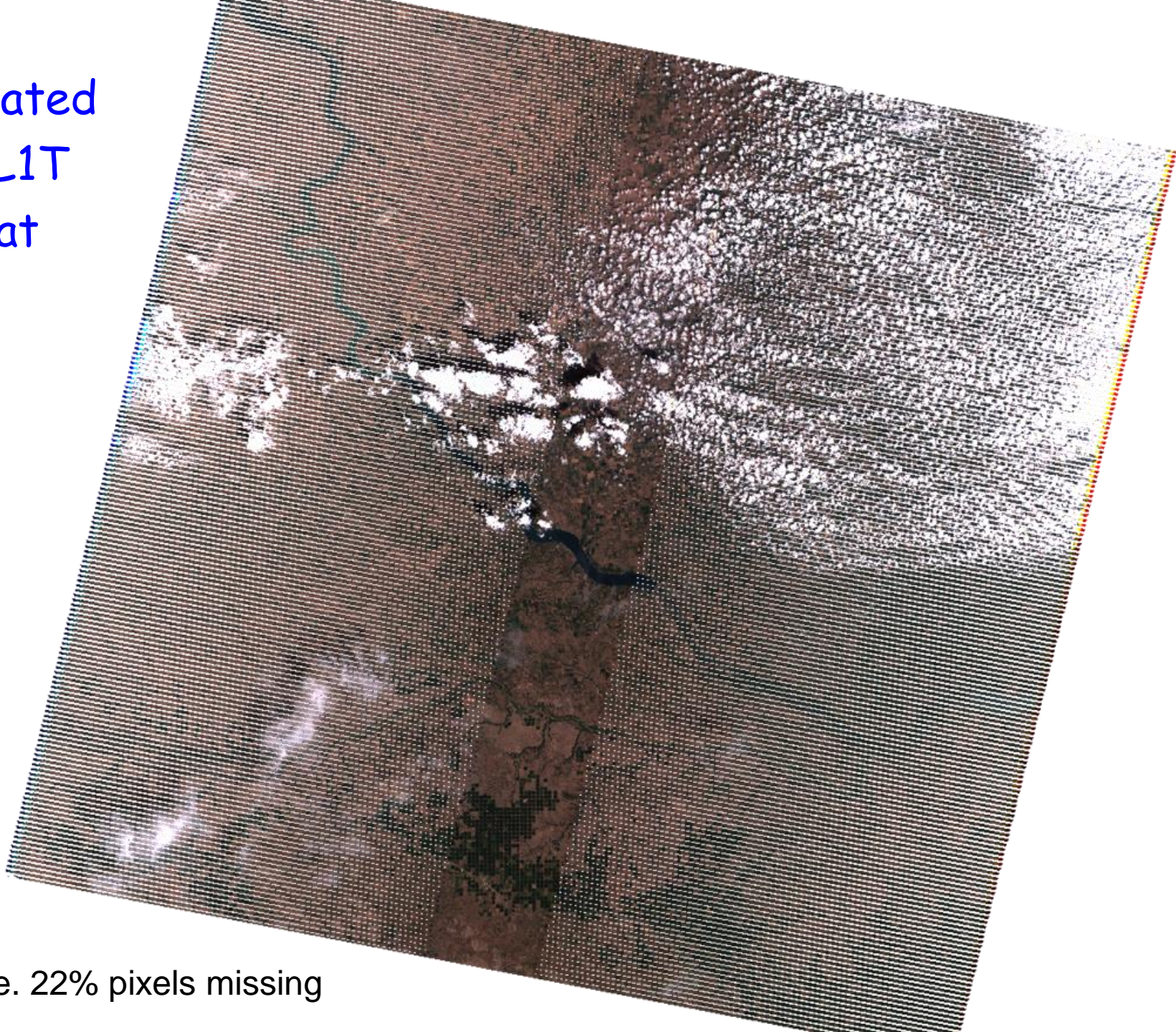
# WELD Project Mission

- Provide a consistent long-term 30m record of the land surface of the Conterminous United States (CONUS) and Alaska for 8 years
- **MODIS-like processing (building on our 10 years MODIS experience)**
  - “seamless” mosaics
  - weekly, monthly, seasonal, annual products to capture land surface change
  - with per-pixel quality assessment information
  - with percent tree, bare ground, vegetation, water information
  - improve the consistency and quality of the Landsat ETM+ data by fusion with MODIS products
- **WELD products designed to facilitate**
  - application without the need for additional processing
  - derivation of higher-level geophysical, biophysical and land cover products
- Fully automated production at SDSU WELD lab
- **Multiple Product Versions i.e. reprocessing**
  - Get it out
  - Get it right
  - Community evaluation
- Distribute from USGS EROS (for free via the internet)

# Current WELD Products



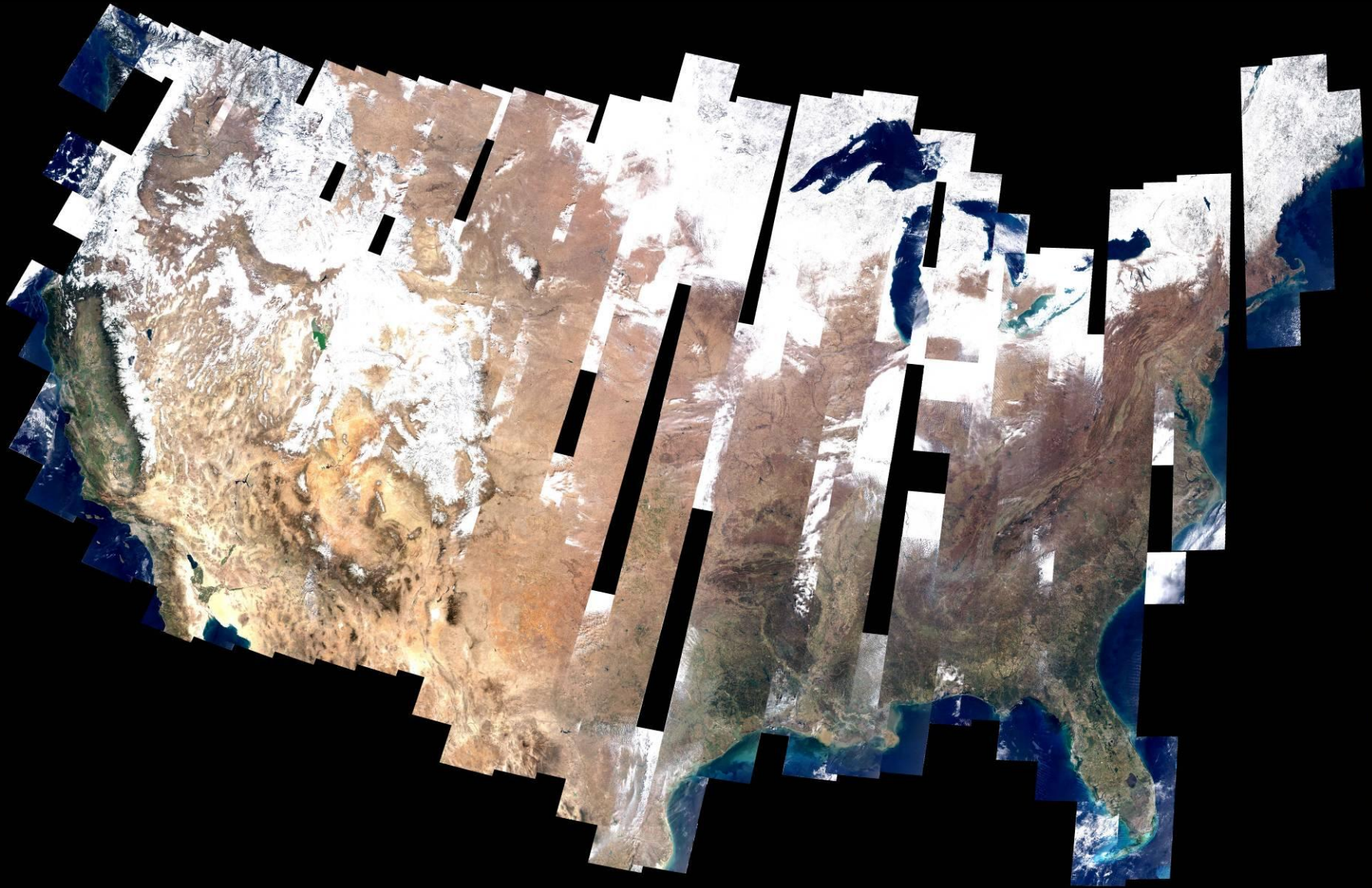
Generated  
from L1T  
Landsat  
ETM+



SLC-off i.e. 22% pixels missing



March 2008 monthly WELD composite  
all L1T acquisitions with cloud cover < 80%





# Landsat ETM+ L1T processed data acquired over 213 Alaska and 455 CONUS path/rows

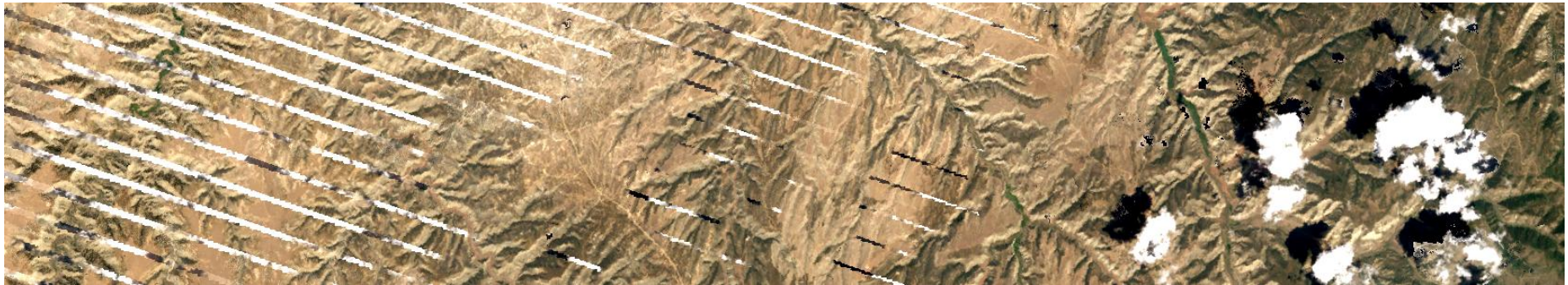


# CONUS July 2008 illustrative movie



# Current (Version 1.5) Product Contents

## 30m TOA Reflectance



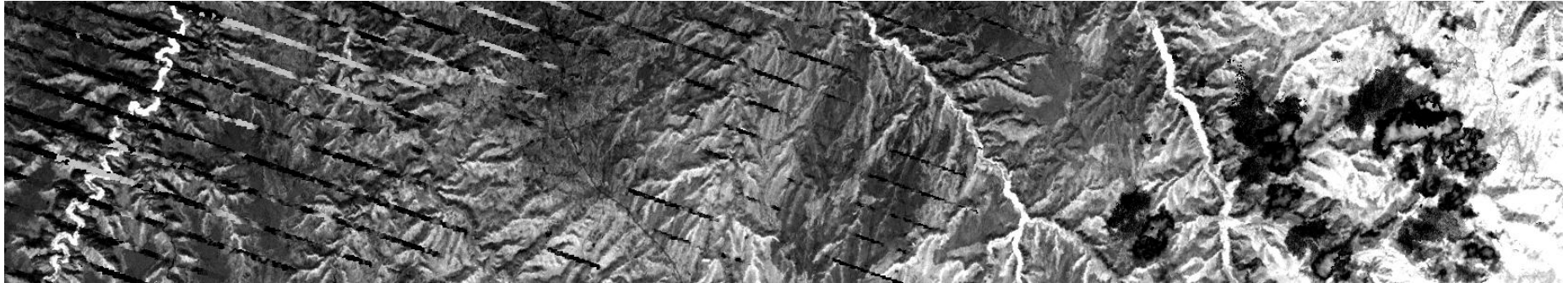
*Band names:*

Band1\_TOA\_REF, Band2\_TOA\_REF, Band3\_TOA\_REF,  
Band4\_TOA\_REF, Band5\_TOA\_REF, Band7\_TOA\_REF

July 2008 monthly WELD composite, 1670 x 300 pixel subset, Utah – Colorado

# Current (Version 1.5) Product Contents

## 30m TOA NDVI



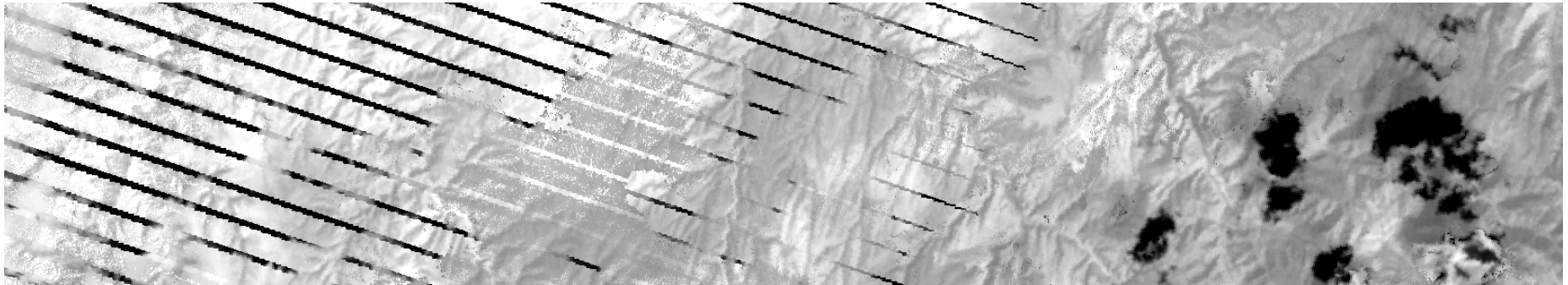
*Band name:*

NDVI\_TOA

July 2008 monthly WELD composite, 1670 x 300 pixel subset, Utah – Colorado

# Current (Version 1.5) Product Contents

## 30m TOA Brightness Temperature



*Band names:*

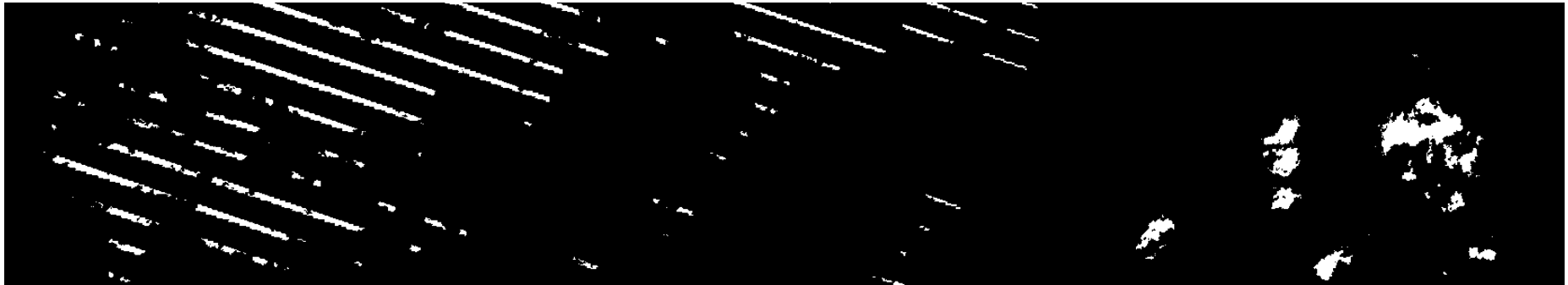
Band61\_TOA\_BT, Band62\_TOA\_BT

July 2008 monthly WELD composite, 1670 x 300 pixel subset, Utah – Colorado



# Current (Version 1.5) Product Contents

## 30m bit packed Band Saturation



(white = saturated in any of the bands)

*Band name:*

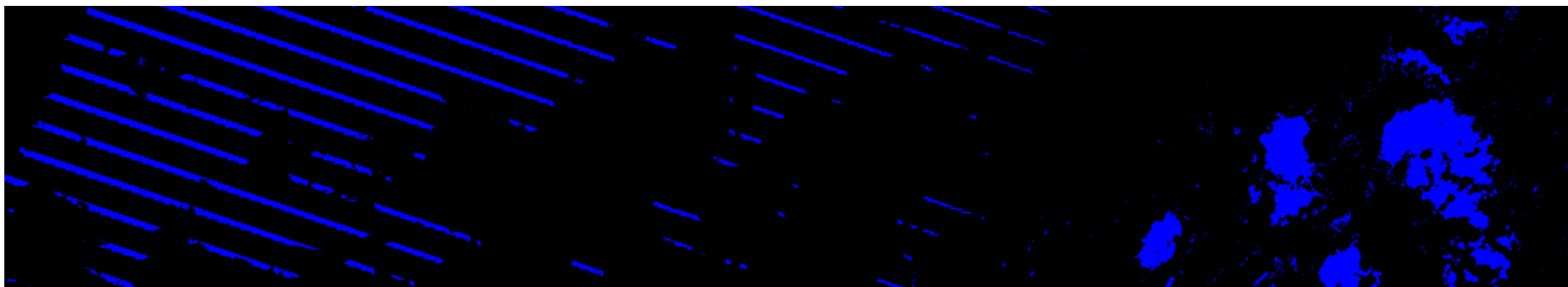
Saturation\_Flag

July 2008 monthly WELD composite, 1670 x 300 pixel subset, Utah – Colorado



# Current (Version 1.5) Product Contents

## 30m ACCA cloud mask



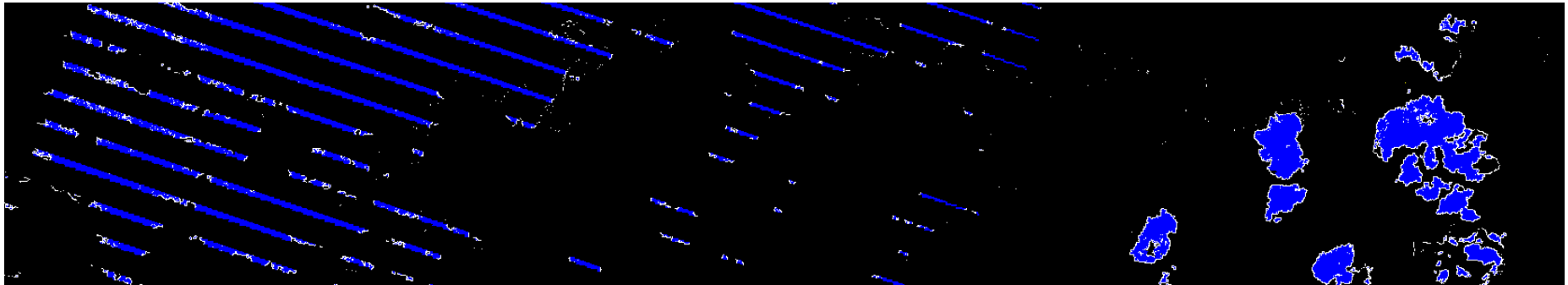
(blue = cloud detected)

*Band name:*  
ACCA\_State

July 2008 monthly WELD composite, 1670 x 300 pixel subset, Utah – Colorado

# Current (Version 1.5) Product Contents

## Decision Tree cloud mask



(blue = cloud detected, white = adj. to cloud)

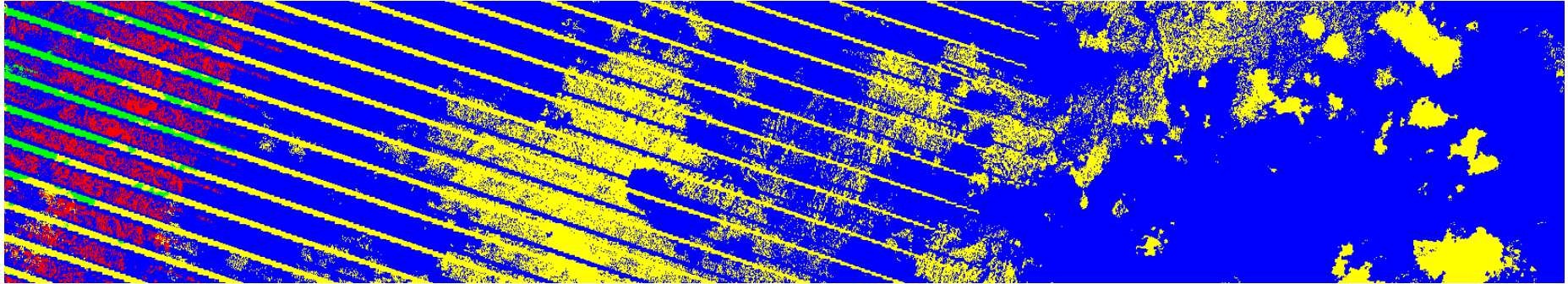
*Band name:*

DT\_Cloud\_State

July 2008 monthly WELD composite, 1670 x 300 pixel subset, Utah – Colorado

# Current (Version 1.5) Product Contents

## Day of year pixel sensed



(blue = July 7, green = July 14, yellow = July 23, red = July 30)

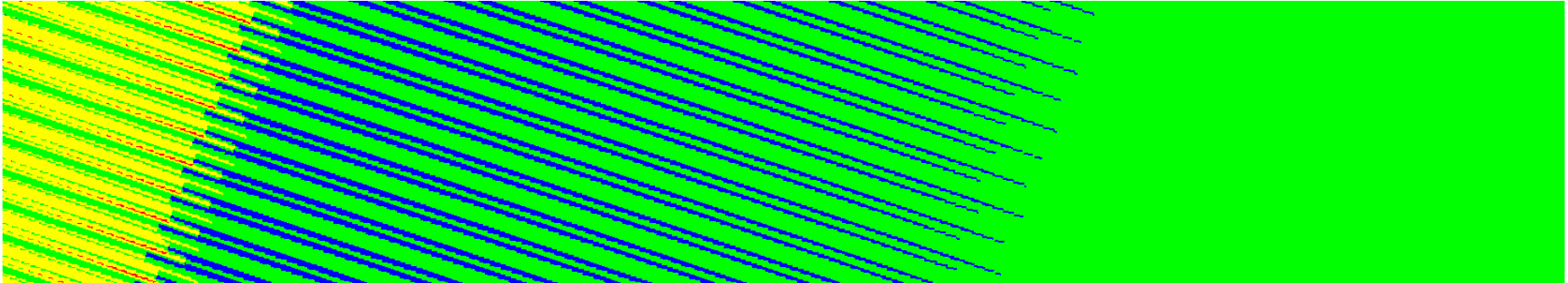
*Band name:*

Day\_Of\_Year

July 2008 monthly WELD composite, 1670 x 300 pixel subset, Utah – Colorado

# Current (Version 1.5) Product Contents

## Number of ETM+ observations



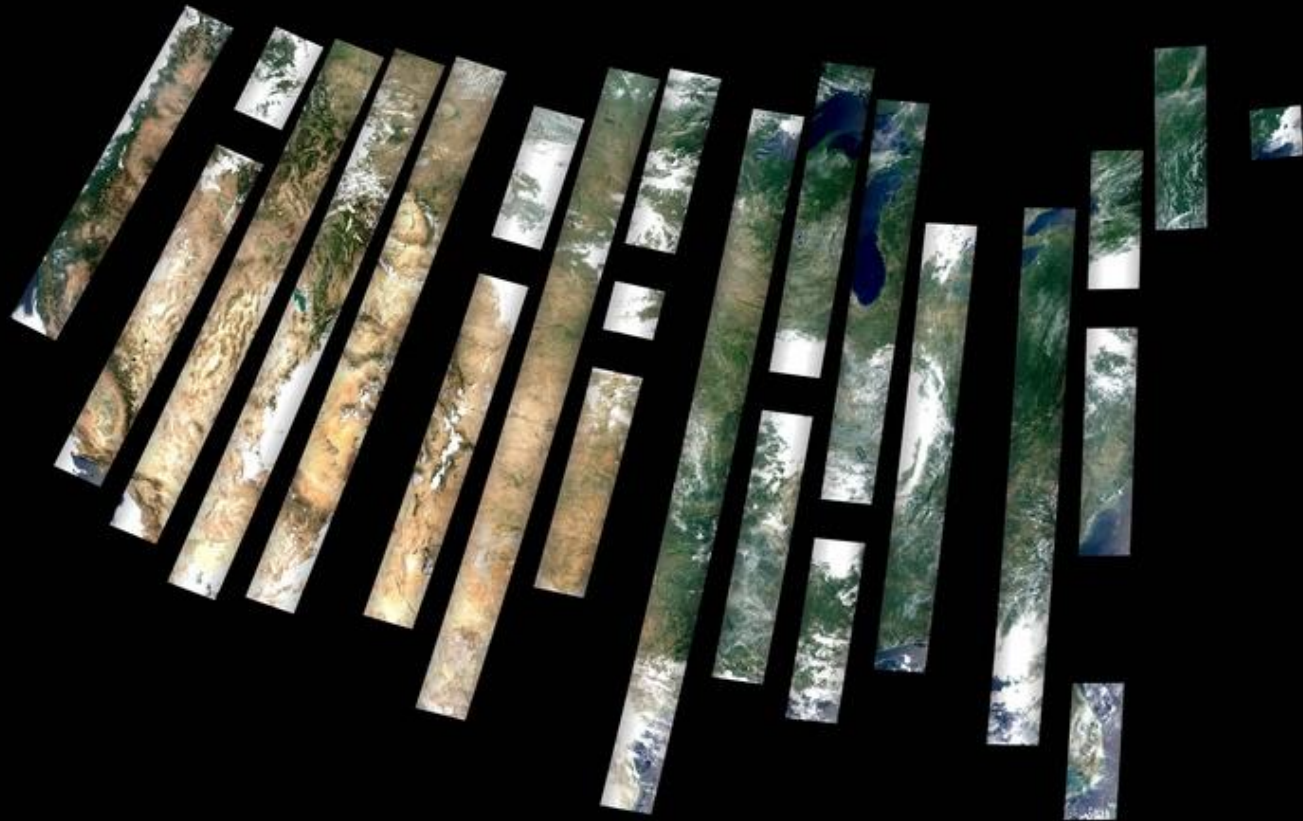
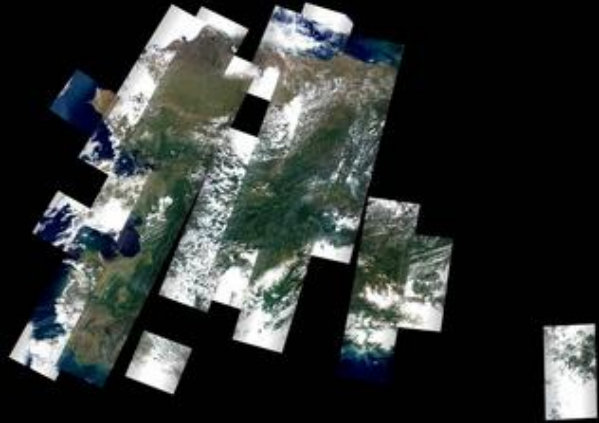
(blue = 1, green = 2, yellow = 3, red = 4)

*Band name:*

Num\_Of\_Obs

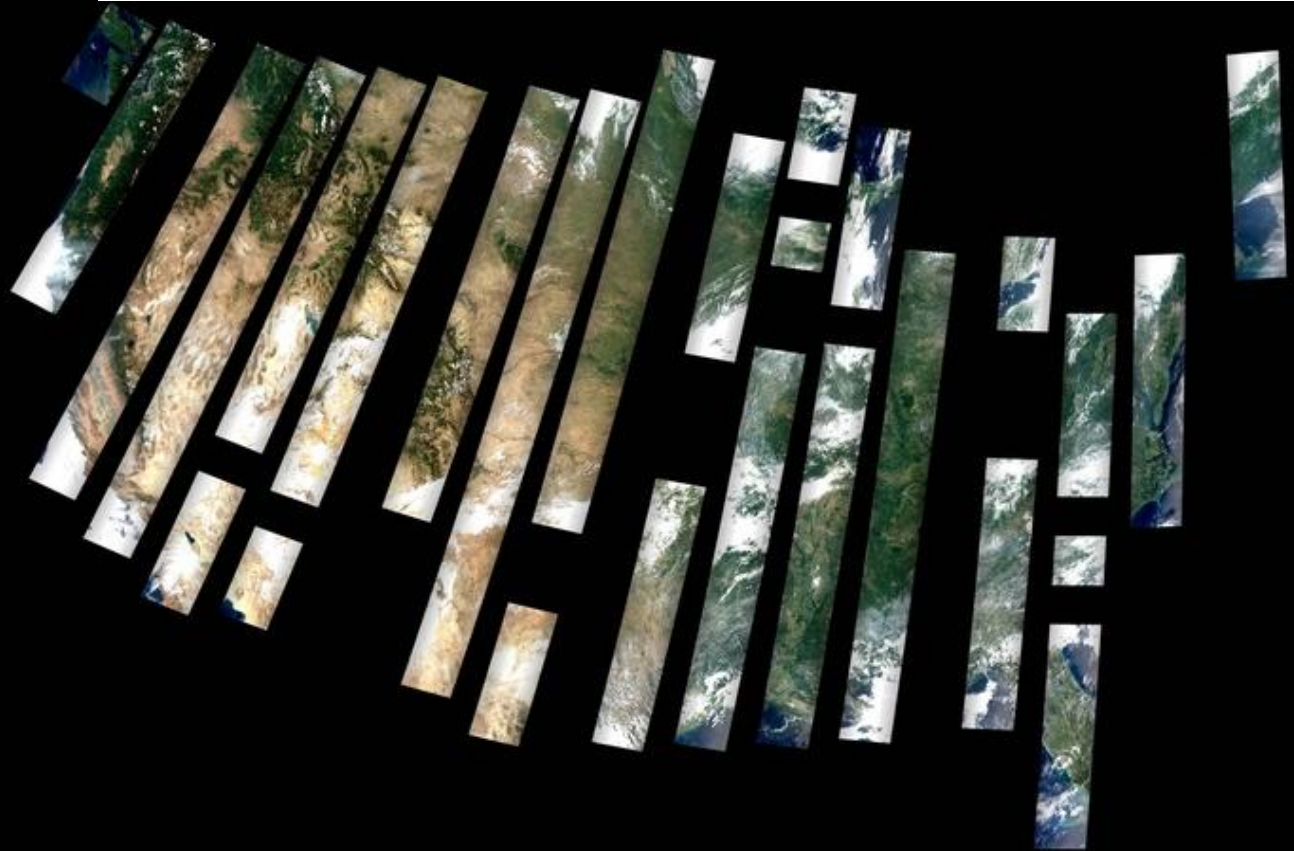
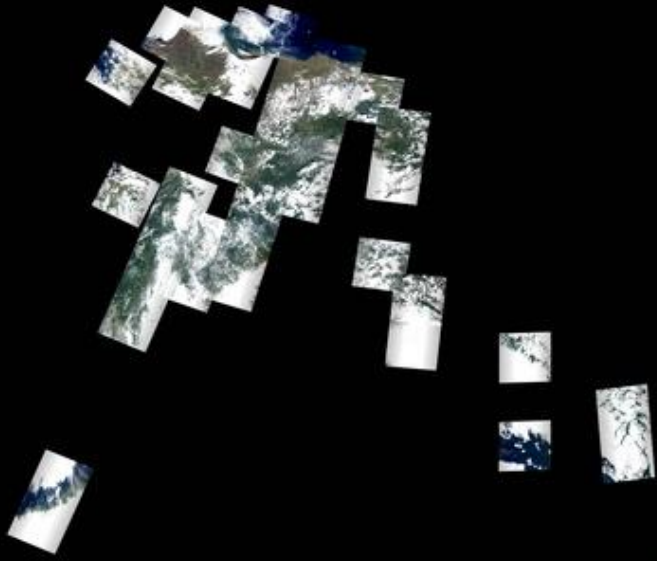
July 2008 monthly WELD composite, 1670 x 300 pixel subset, Utah – Colorado

**Week 27: July 8 - 14 2008**

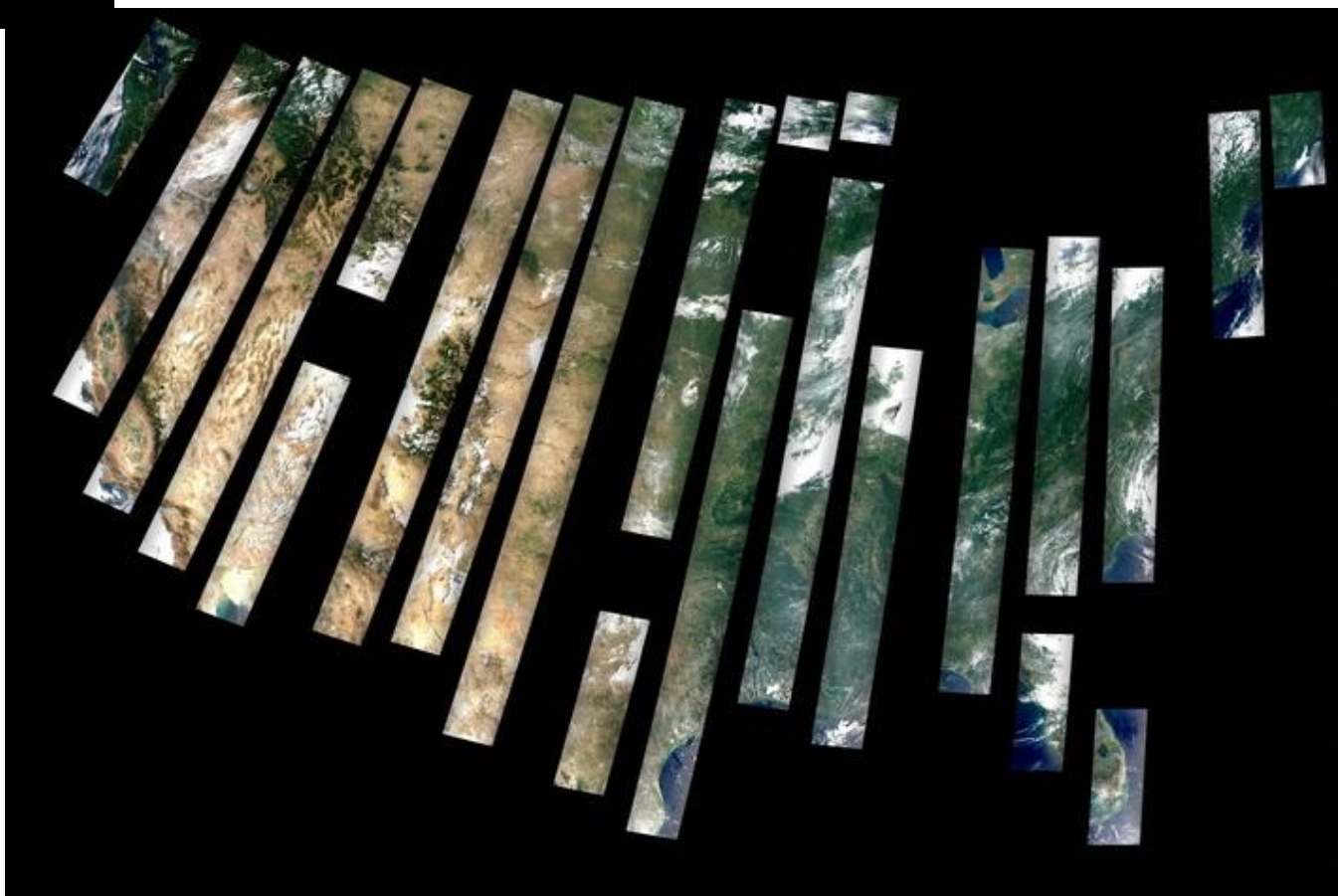
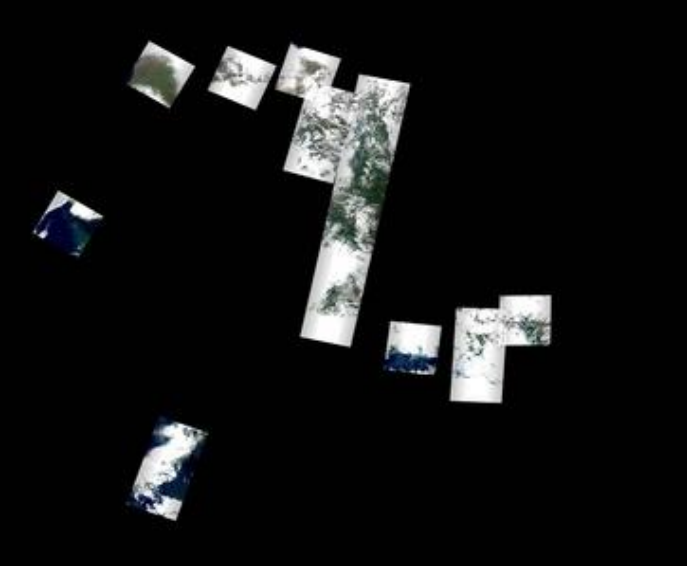




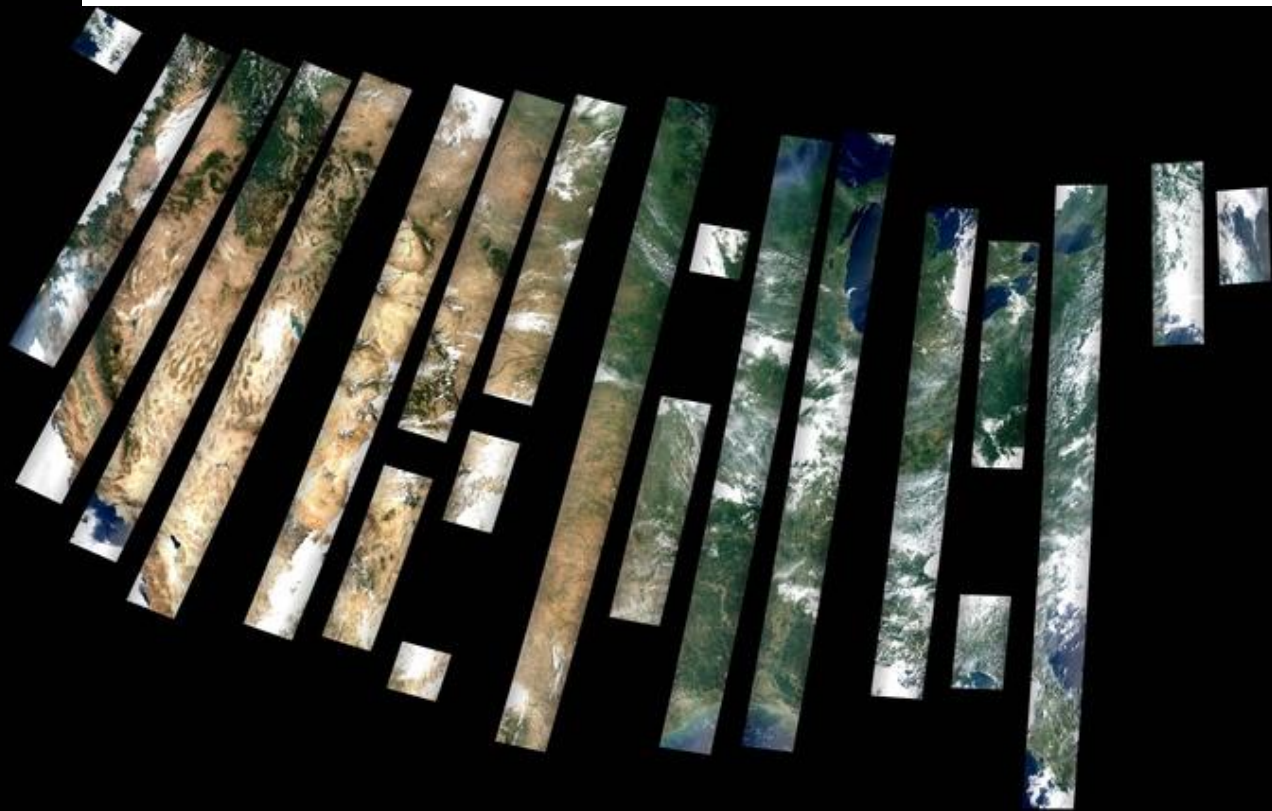
**Week 28: July 8 - 14 2008**



**Week 29: July 15 - 21 2008**

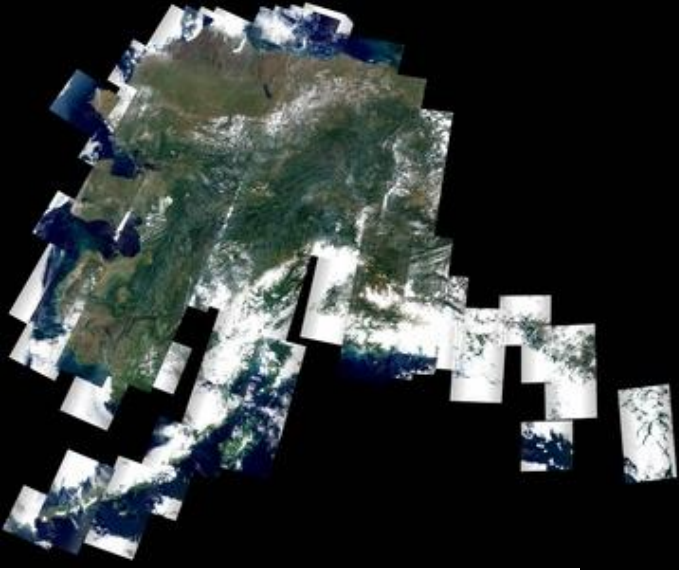


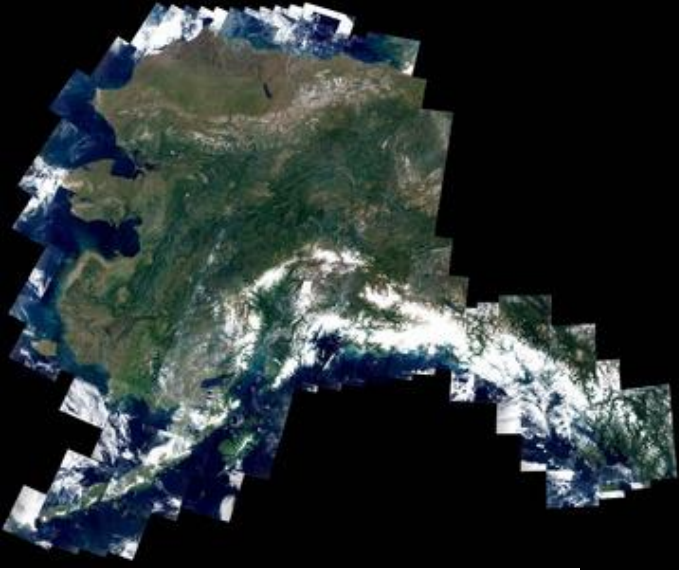
**Week 30: July 22 - 28 2008**





July 2008



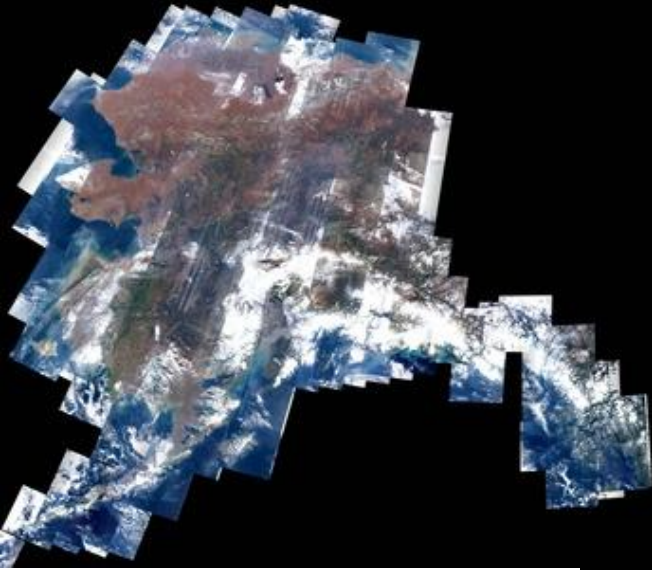


Summer

(June, July, August) 2008

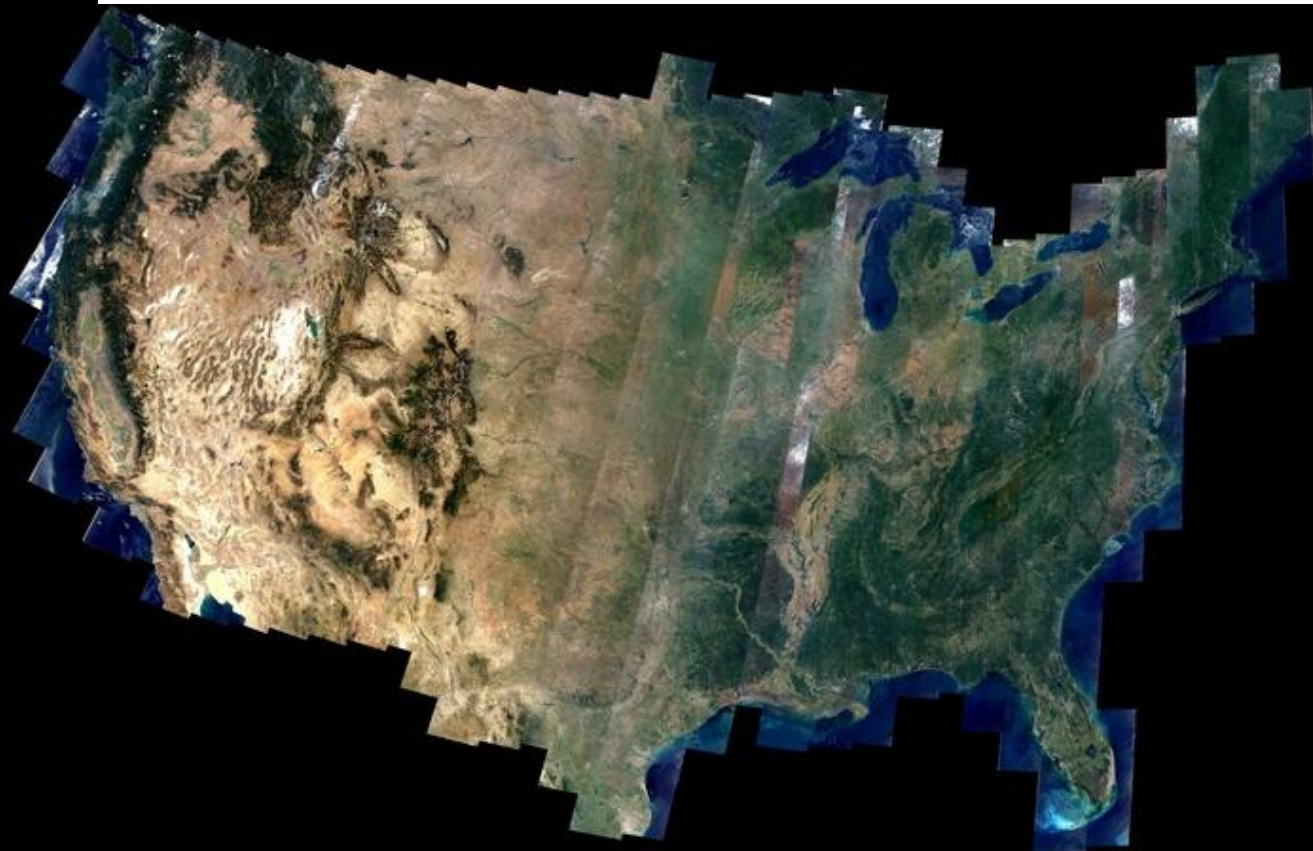






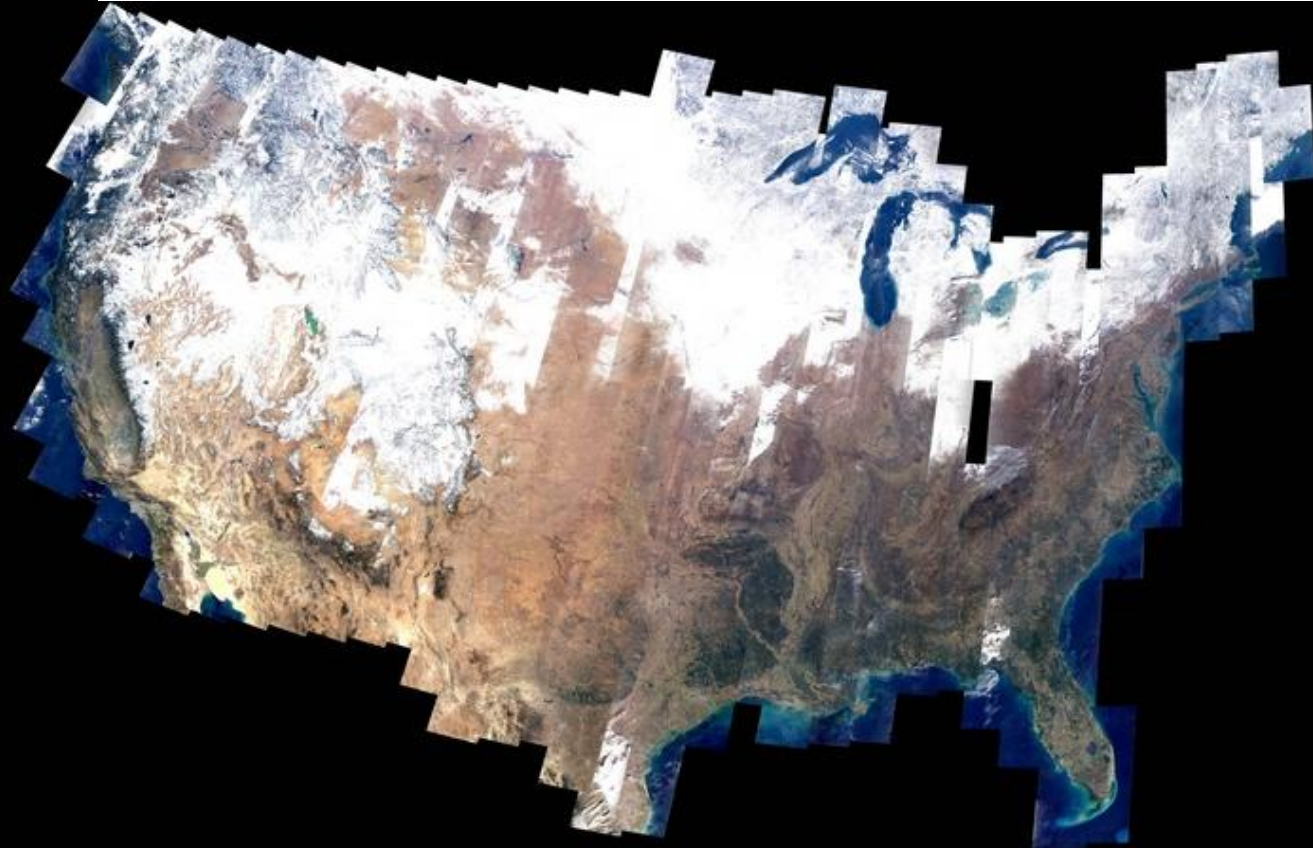
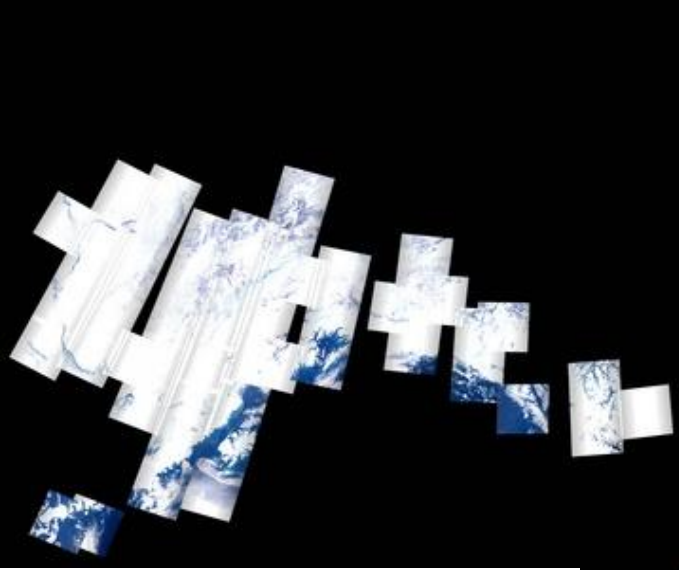
Fall

(September, October, November) 2008

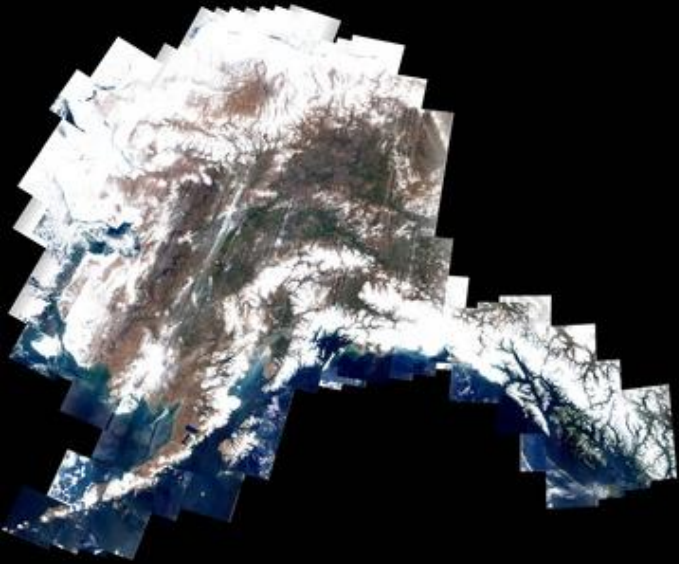


Winter

(December, January, February) 2008/09







Spring  
(March, April, May) 2009





Annual

(December 2009 - November 2008)

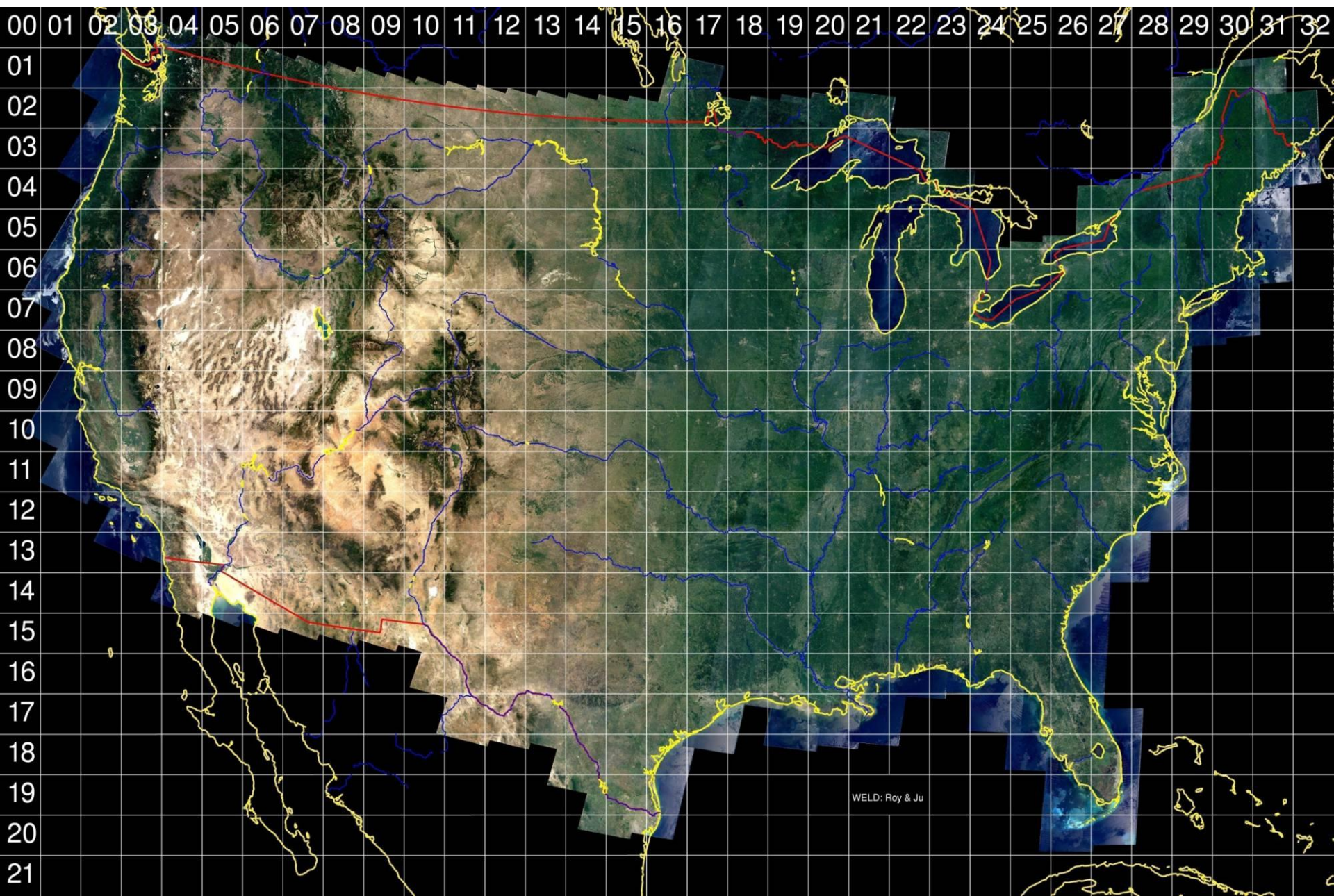
Alaska ~ 1,700 L1T acquisitions / year

CONUS ~ 8,000 L1T acquisitions / year



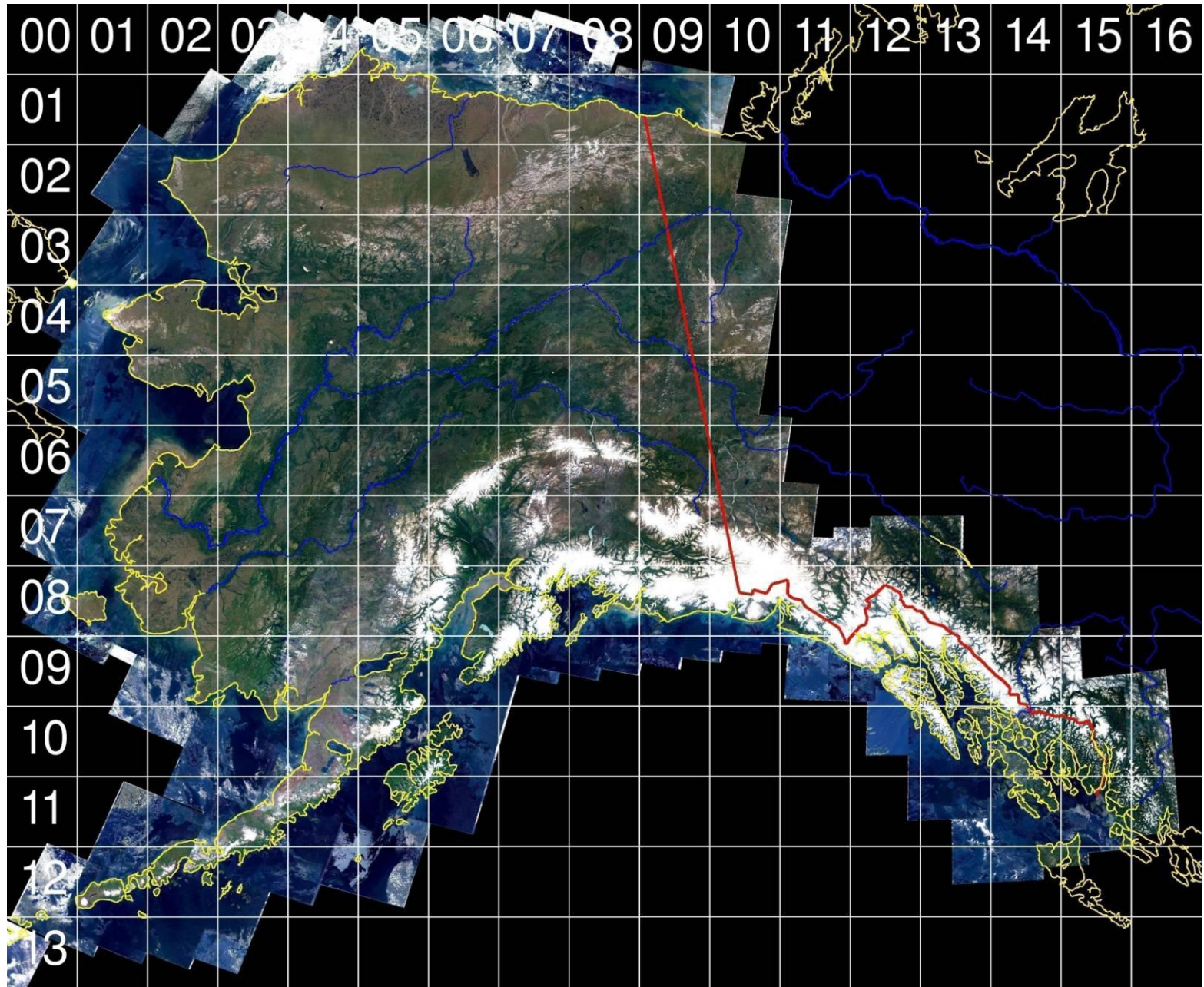


# WELD Tile Map (CONUS has 501 5000x5000 30m pixel tiles in Albers)



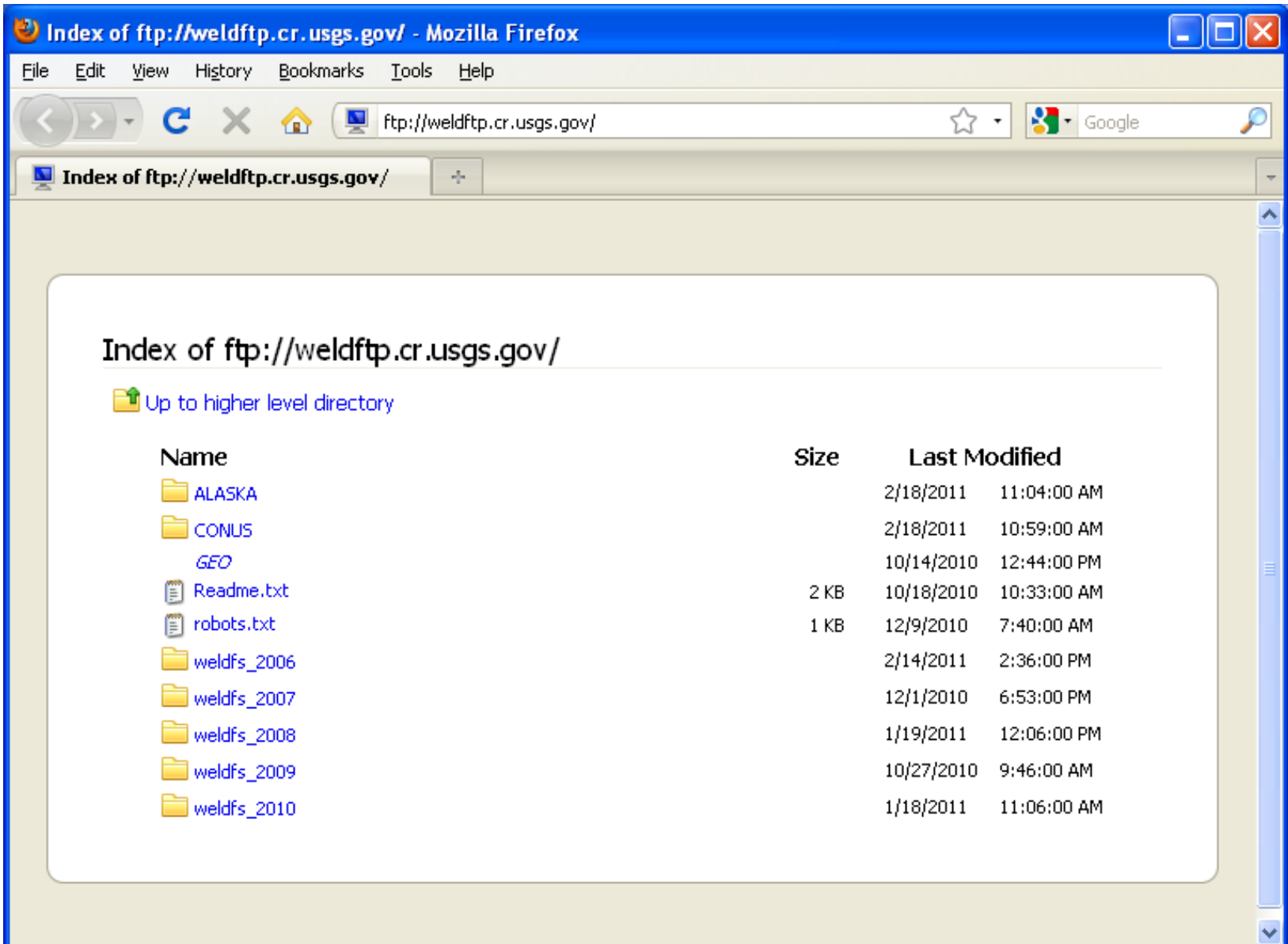


WELD Tile Map (Alaska has 162 5000x5000 30m pixel tiles in Albers )  
~3,100 million 30m land pixels



How to get WELD Products

# 5 Years 2006-2010 Version 1.5 WELD HDF Tiles Available via FTP (4TB/year)



Index of <ftp://weldftp.cr.usgs.gov/>

[Up to higher level directory](#)

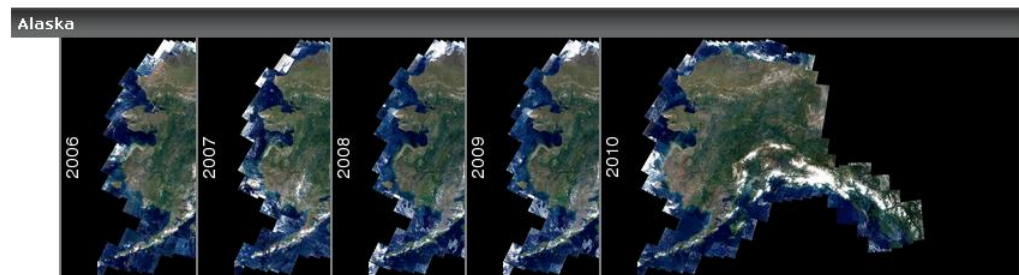
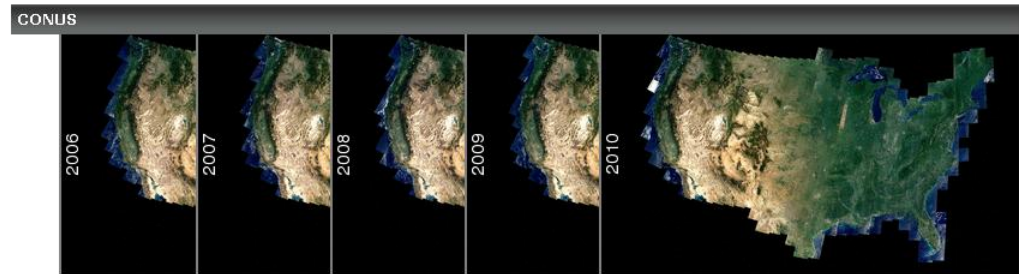
Name	Size	Last Modified
<a href="#">ALASKA</a>		2/18/2011 11:04:00 AM
<a href="#">CONUS</a>		2/18/2011 10:59:00 AM
<a href="#">GEO</a>		10/14/2010 12:44:00 PM
<a href="#">Readme.txt</a>	2 KB	10/18/2010 10:33:00 AM
<a href="#">robots.txt</a>	1 KB	12/9/2010 7:40:00 AM
<a href="#">weldfs_2006</a>		2/14/2011 2:36:00 PM
<a href="#">weldfs_2007</a>		12/1/2010 6:53:00 PM
<a href="#">weldfs_2008</a>		1/19/2011 12:06:00 PM
<a href="#">weldfs_2009</a>		10/27/2010 9:46:00 AM
<a href="#">weldfs_2010</a>		1/18/2011 11:06:00 AM



# WELD: WEB - ENABLED LANDSAT DATA



## Available Years:



<http://weld.cr.usgs.gov/>

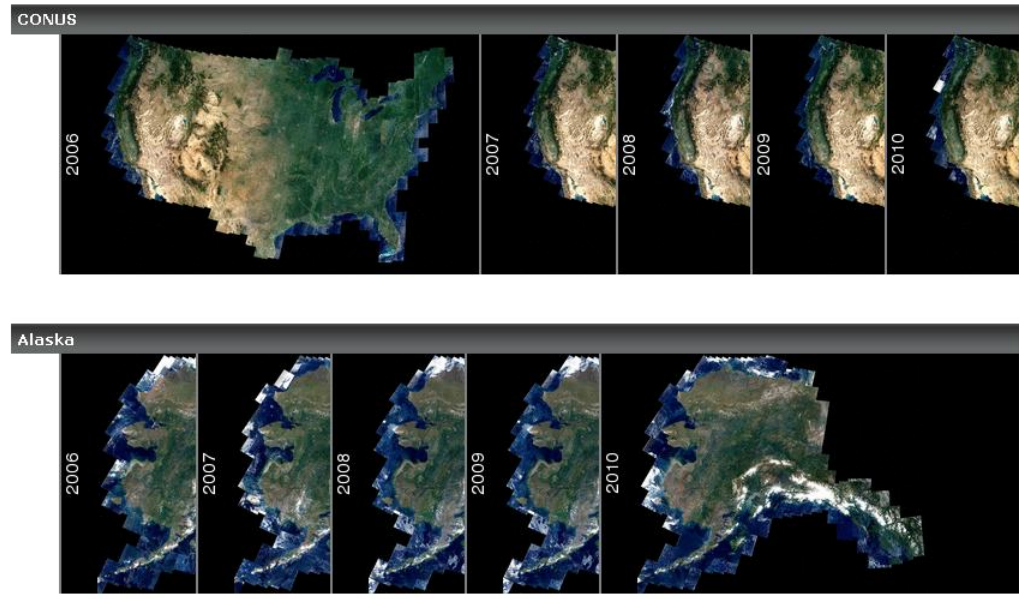
- [Interface Help](#)
- [WELD Product Information](#)
- [Distribution Metrics](#)



# WELD: WEB - ENABLED LANDSAT DATA



## Available Years:



<http://weld.cr.usgs.gov/>

- [Interface Help](#)
- [WELD Product Information](#)
- [Distribution Metrics](#)



# WELD: WEB - ENABLED LANDSAT DATA



CONUS 2006

<< Home

## Annual & Seasonal



## Monthly



## Weekly



[? Interface Help](#)

[? WELD Product Information](#)

[? Distribution Metrics](#)







- Vector
- Zoom In (or double click)
- Zoom Out (or mouse wheel)
- Next Period
- Previous Period

Order Coordinates

- Longitude/latitude
- Albers

**Hold the shift button & drag the mouse to define your order area, or enter the area coordinates below**

Note: In using Long/Lat the coordinates refer to the SW and NE corners of the area

North:

South:

West:

East:

200 km  
100 mi





- Vector
- Zoom In (or double click)
- Zoom Out (or mouse wheel)
- Next Period
- Previous Period

**Order Coordinates**

- Longitude/latitude
- Albers

**Hold the shift button & drag the mouse to define your order area, or enter the area coordinates below**

Note: In using Long/Lat the coordinates refer to the SW and NE corners of the area

North:

South:

West:

East:





- Vector
- Zoom In (or double click)
- Zoom Out (or mouse wheel)
- Next Period
- Previous Period

Order Coordinates

- Longitude/latitude
- Albers

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North:

South:

West:

East:





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- Zoom Out (or mouse wheel)
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- Previous Period

Order Coordinates

- Longitude/Latitude
- Albers

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North:

South:

West:

East:







- Vector
- Zoom In (or double click)
- Zoom Out (or mouse wheel)
- Next Period
- Previous Period

Order Coordinates

- Longitude/Latitude
- Albers

Hold the shift button & drag the mouse to define your order area, or enter the area coordinates below

Note: In using Long/Lat the coordinates refer to the SW and NE corners of the area

North:

South:

West:

East:

Order Data

20 km  
10 mi





- Vector
- Zoom In (or double click)
- Zoom Out (or mouse wheel)
- Next Period
- Previous Period

Order Coordinates

- Longitude/Latitude
- Albers

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North:

South:

West:

East:





- Vector
- Zoom In (or double click)
- Zoom Out (or mouse wheel)
- Next Period
- Previous Period

Order Coordinates

- Longitude/Latitude
- Albers

**Hold the shift button & drag the mouse to define your order area, or enter the area coordinates below**

Note: In using Long/Lat the coordinates refer to the SW and NE corners of the area

North:

South:

West:

East:

20 km  
10 mi





- Vector
- Zoom In (or double click)
- Zoom Out (or mouse wheel)
- Next Period
- Previous Period

Order Coordinates

- Longitude/Latitude
- Albers

**Hold the shift button & drag the mouse to define your order area, or enter the area coordinates below**

Note: In using Long/Lat the coordinates refer to the SW and NE corners of the area

North:

South:

West:

East:





- Vector
- Zoom In (or double click)
- Zoom Out (or mouse wheel)
- Next Period
- Previous Period

Order Coordinates

- Longitude/Latitude
- Albers

**Hold the shift button & drag the mouse to define your order area, or enter the area coordinates below**

Note: In using Long/Lat the coordinates refer to the SW and NE corners of the area

North:

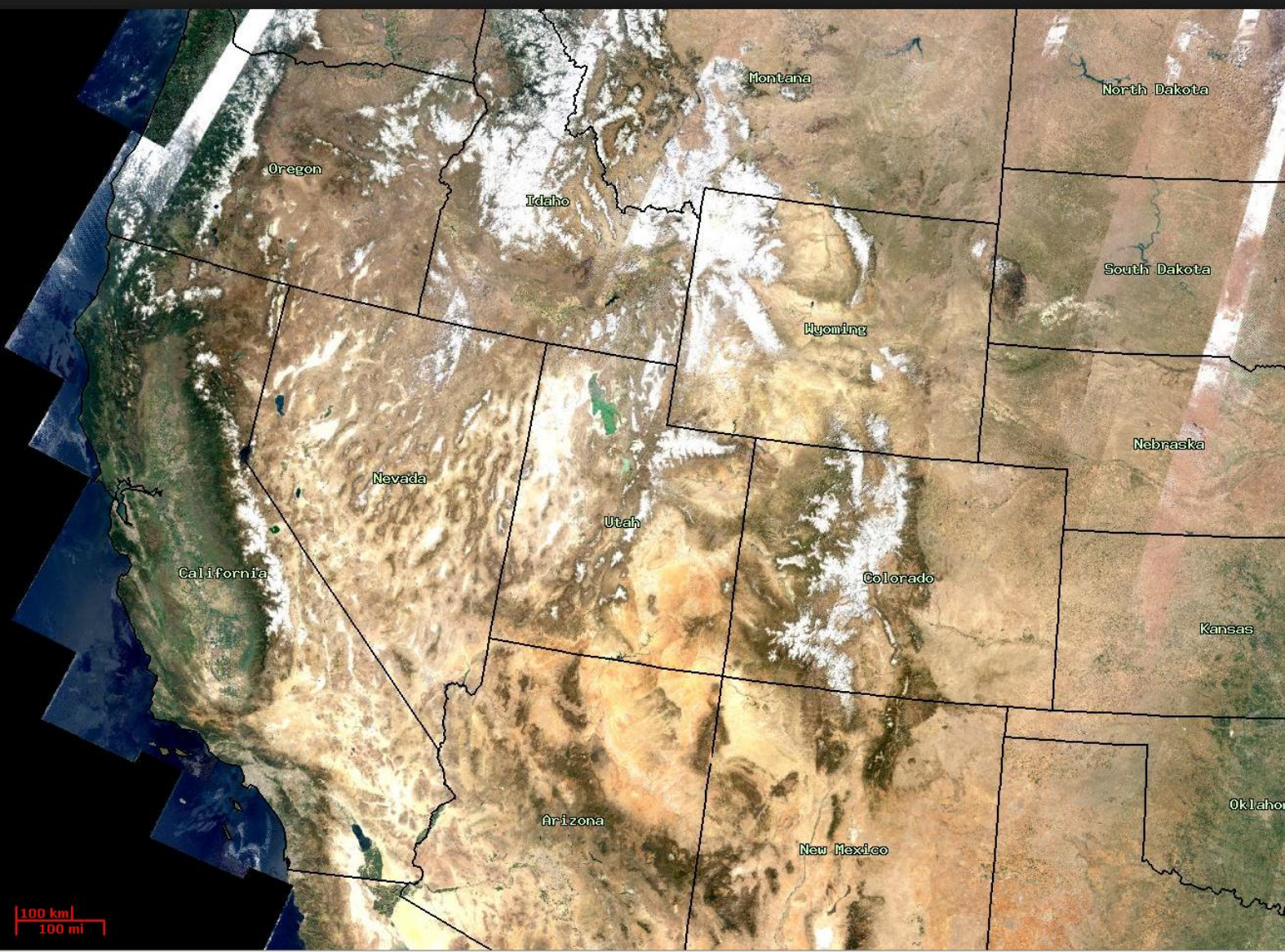
South:

West:

East:







- Vector
- Zoom In (or double click)
- Zoom Out (or mouse wheel)

Order Coordinates

- Longitude/latitude
- Albers

Hold the shift button & drag the mouse to define your order area, or enter the area coordinates below

Note: In using Long/Lat the coordinates refer to the SW and NE corners of the area

North:

South:

West:

East:

Order Data



CONUS: Spring 2008 [ Mar 2008 - May 2008 ]

Home | Interface Help | Back



- Vector
- Zoom In (or double click)
- Zoom Out (or mouse wheel)

Order Coordinates

- Longitude/latitude
- Albers

Hold the shift button & drag the mouse to define your order area, or enter the area coordinates below

Note: In using Long/Lat the coordinates refer to the SW and NE corners of the area

North:

South:

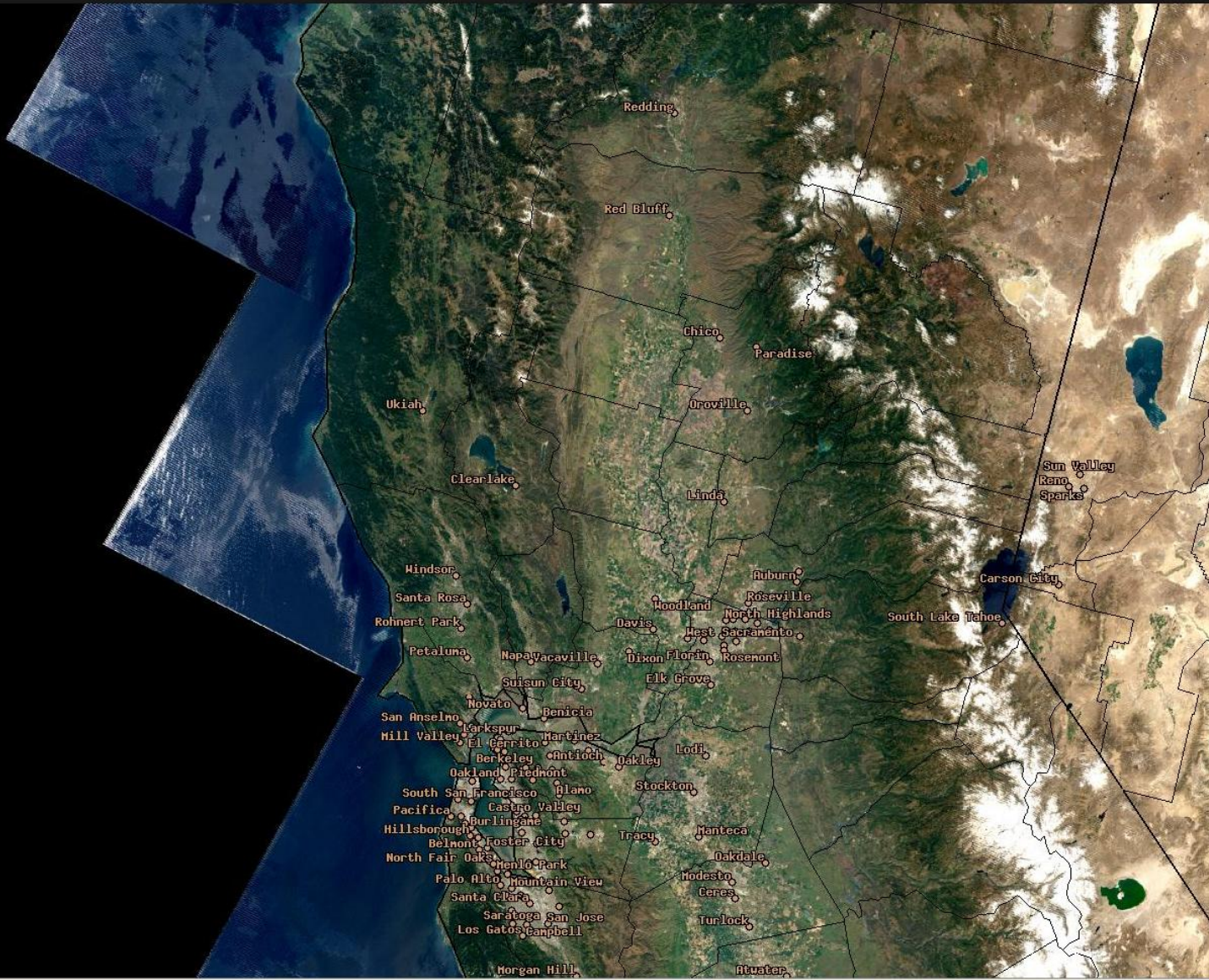
West:

East:

Order Data

50 km  
20  
mi





- Vector
- Zoom In (or double click)
- Zoom Out (or mouse wheel)

Order Coordinates

- Longitude/latitude
- Albers

Hold the shift button & drag the mouse to define your order area, or enter the area coordinates below

Note: In using Long/Lat the coordinates refer to the SW and NE corners of the area

North:

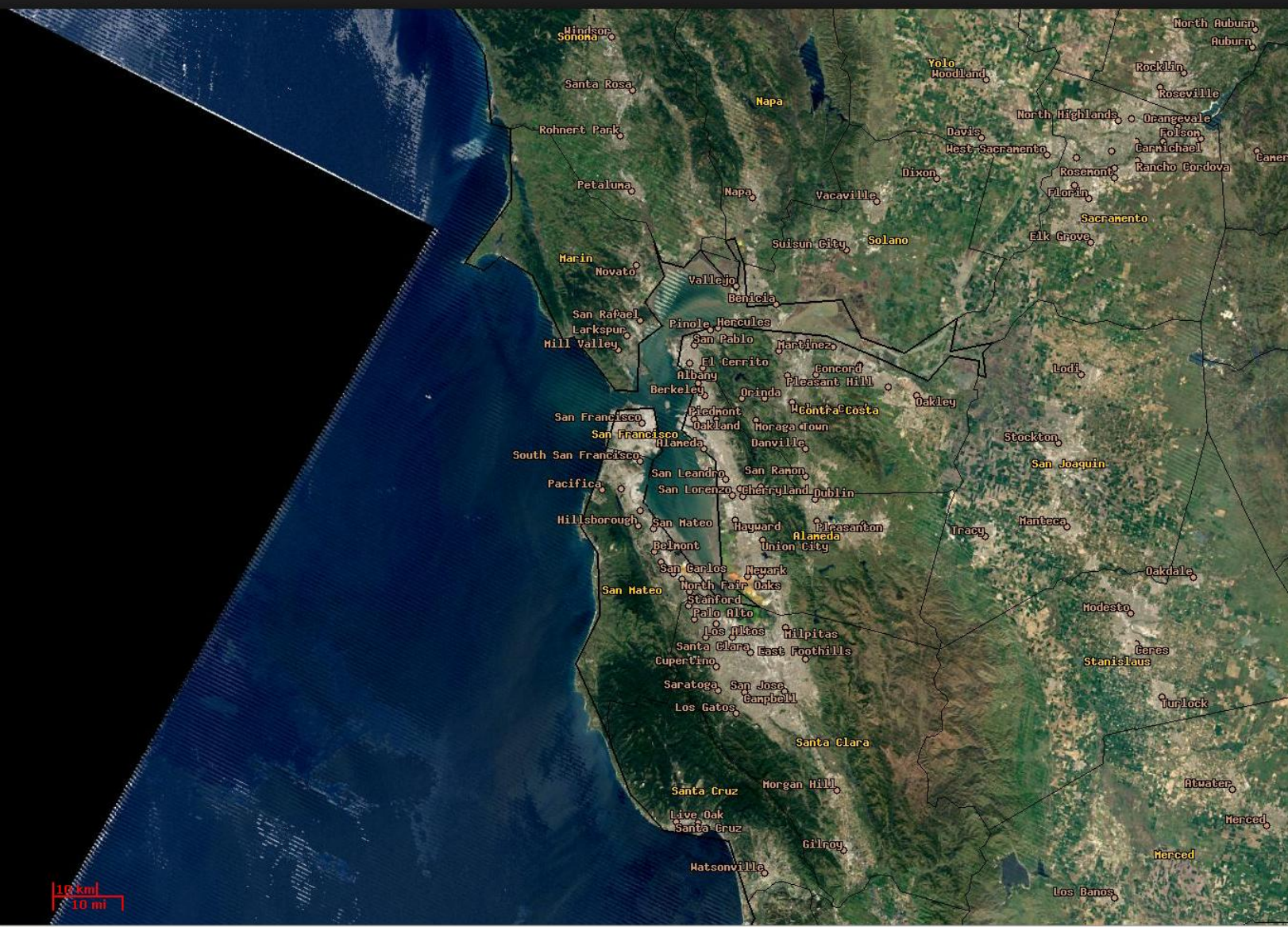
South:

West:

East:

Order Data





- Vector
- Zoom In (or double click)
- Zoom Out (or mouse wheel)

**Order Coordinates**

- Longitude/latitude
- Albers

Hold the shift button & drag the mouse to define your order area, or enter the area coordinates below

Note: In using Long/Lat the coordinates refer to the SW and NE corners of the area

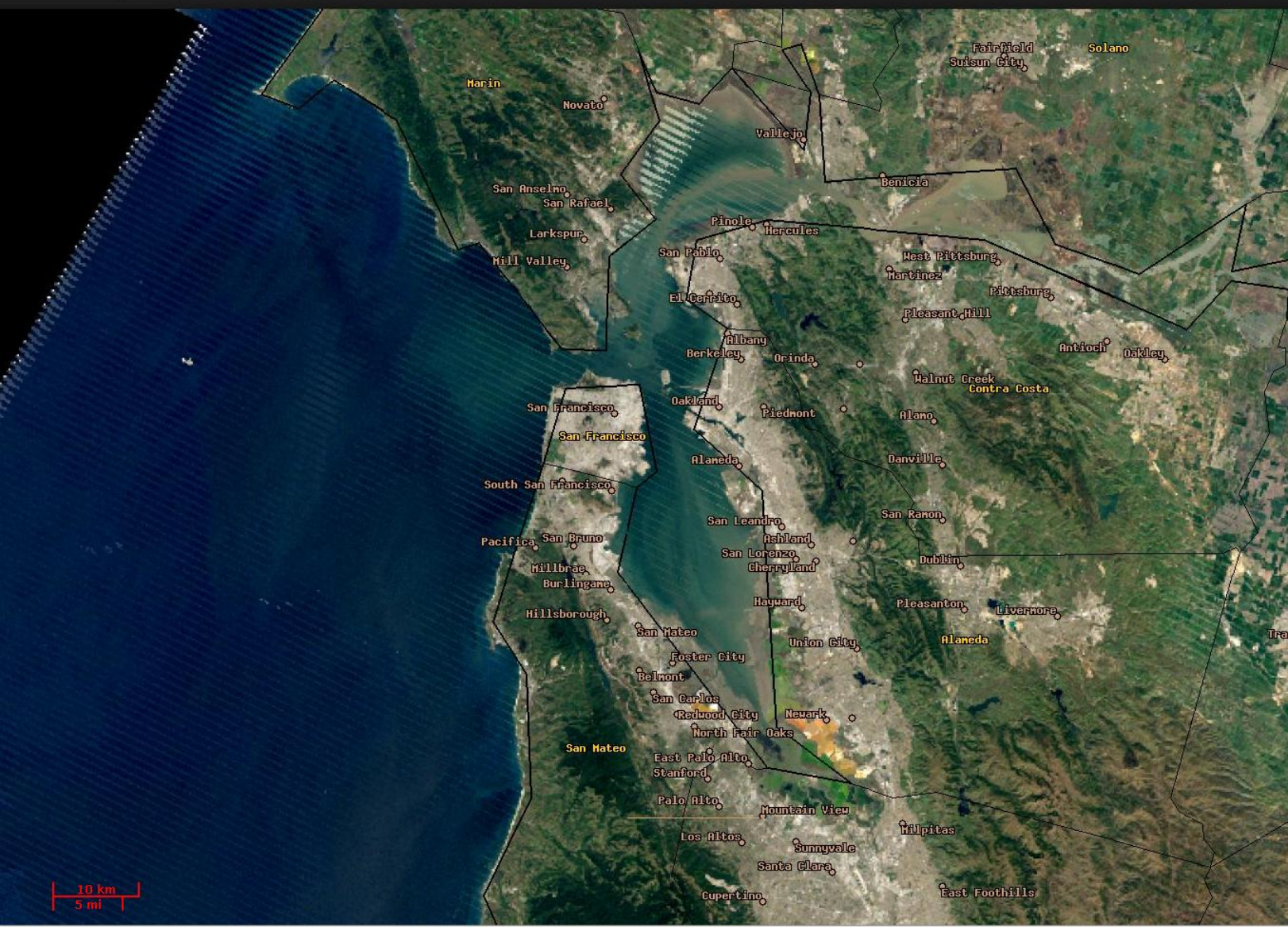
North:

South:

West:

East:





- Vector
- Zoom In (or double click)
- Zoom Out (or mouse wheel)

Order Coordinates

- Longitude/latitude
- Albers

Hold the shift button & drag the mouse to define your order area, or enter the area coordinates below

Note: In using Long/Lat the coordinates refer to the SW and NE corners of the area

North:

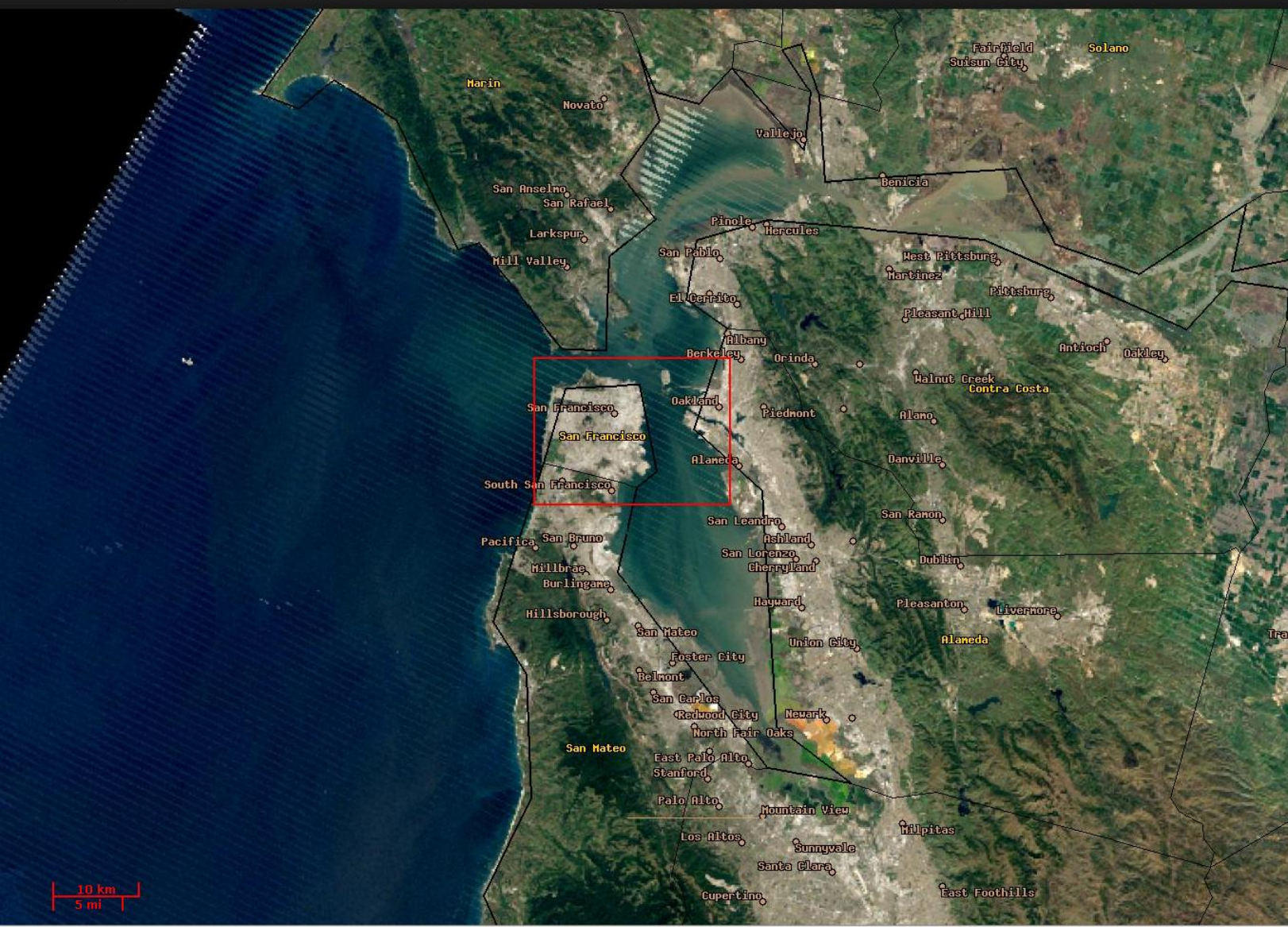
South:

West:

East:

Order Data





Vector  
 Zoom In (or double click)  
 Zoom Out (or mouse wheel)

**Order Coordinates**

Longitude/latitude  
 Albers

Hold the shift button & drag the mouse to define your order area, or enter the area coordinates below

Note: In using Long/Lat the coordinates refer to the SW and NE corners of the area

North:   
 South:   
 West:   
 East:

10 km  
5 mi



You have selected a CONUS region of 7644 x 7644 30m pixels

[<< Home](#)

**You can order this region for the following WELD products:**

- Annual [ December 2007 - November 2008 ]
- Seasonal [ December 2007 - November 2008 ]
- Monthly [ December 2007 - November 2008 ]
- Monthly [ January 2008 - December 2008 ]
- Weekly [ January 2008 - December 2008 ]

**and for the following WELD product bands:**

- All
  - Band1\_TOA\_REF
  - Band2\_TOA\_REF
  - Band3\_TOA\_REF
  - Band4\_TOA\_REF
  - Band5\_TOA\_REF
  - Band7\_TOA\_REF
- All
  - Band61\_TOA\_REF
  - Band62\_TOA\_REF
- All
  - NDVI\_TOA
- All
  - Day\_Of\_Year
  - Num\_Of\_Obs
  - Saturation\_Flag
- All
  - DT\_Cloud\_State
  - ACCA\_State

[Place order >>](#)

[? Interface Help](#)

[? WELD Product Information](#)

[? Distribution Metrics](#)

[X Logout](#)

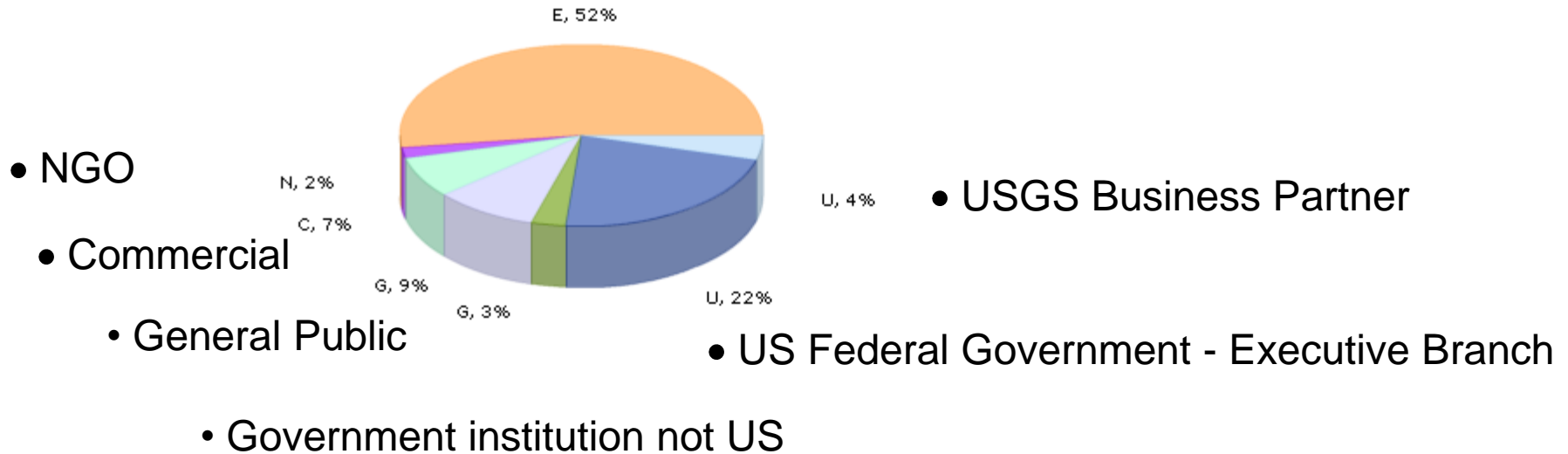
# WELD Product Distribution Metrics

- From USGS EROS Science Processing Architecture Project (ESAP) servers
- Encouraging distribution statistics
  - 90% of the available 20TB WELD version 1.5 data product volume distributed in first 4 months of availability
  - more than 193 users, from 11 countries



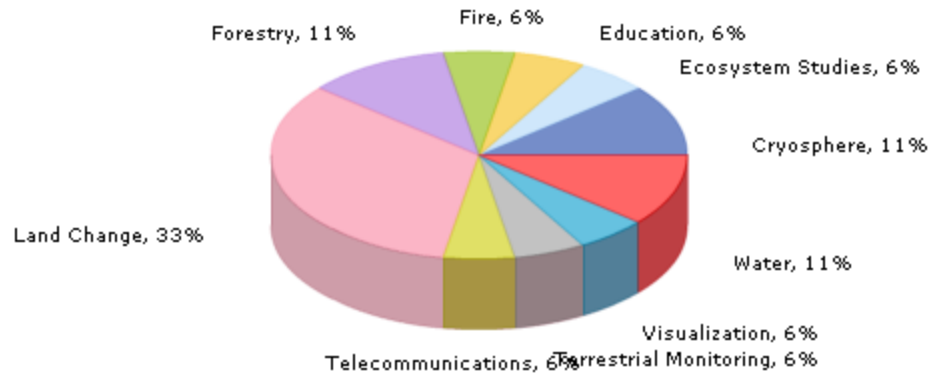
Number of unique users ordered products by Affiliation

- Educational/Academic Research institution



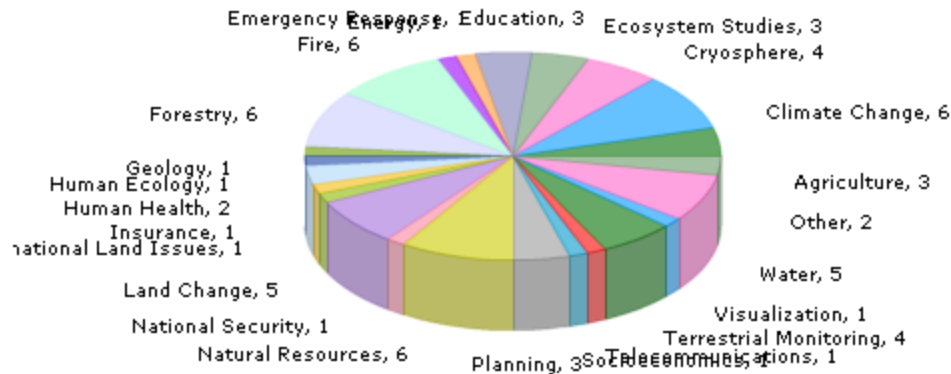
**CONUS and Alaska**

### Number of unique users ordered products by Primary use



## CONUS and Alaska

### Number of unique users ordered products by Secondary use





Planned  
WELD Version 2.0 Algorithms

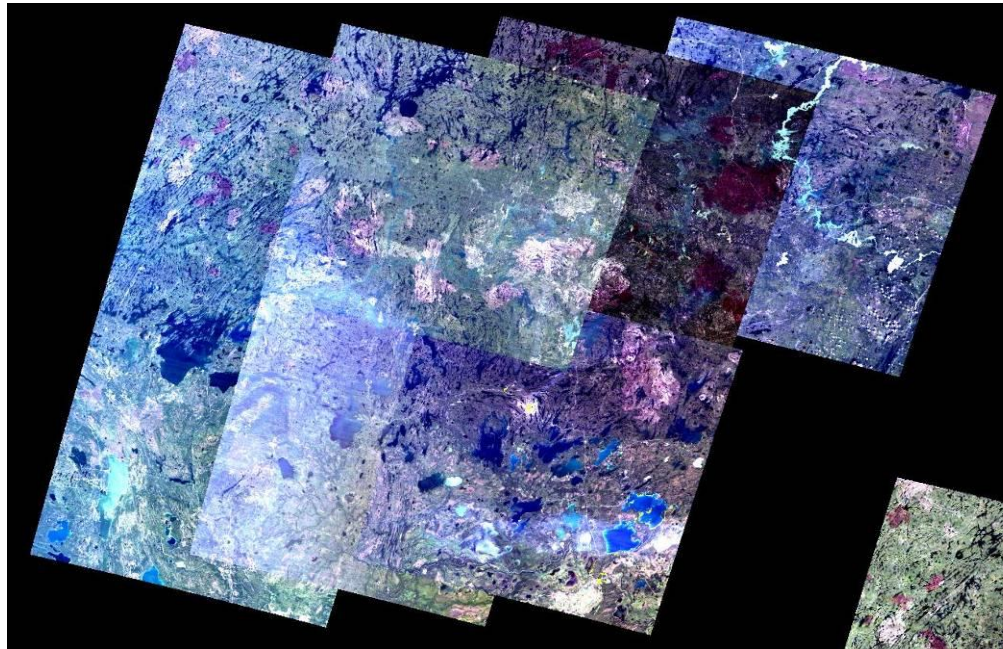
# Planned Version 2.0 WELD Products

## Reprocess with

- Atmospheric Correction of the Top of Atmosphere Reflectance Bands
- Reflective and Thermal Wavelength Gap Filling
- Reflective Wavelength Radiometric Normalization
- Percent Tree, Bare Ground, Vegetation and Water Classification



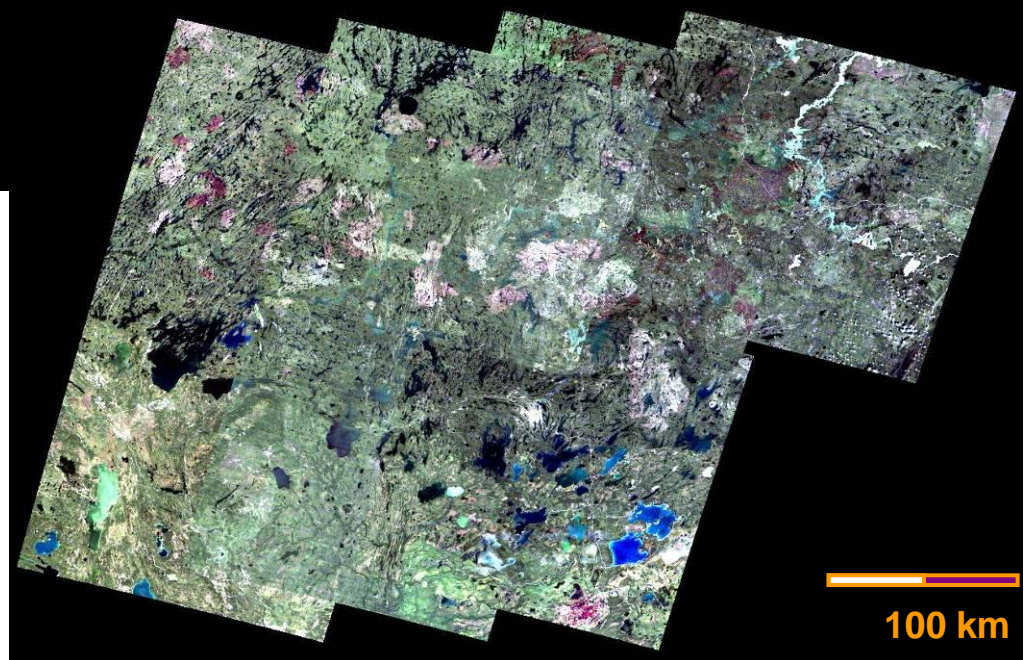
# Heritage: LEDAPS Atmospheric Correction - 6SV



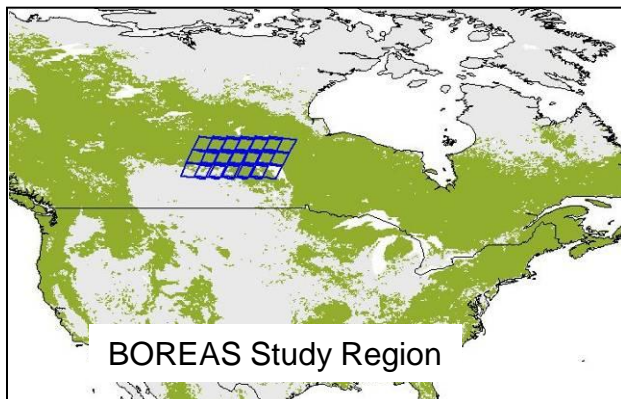
1990's Landsat-5 mosaic

← TOA reflectance

Surface reflectance ↓



100 km



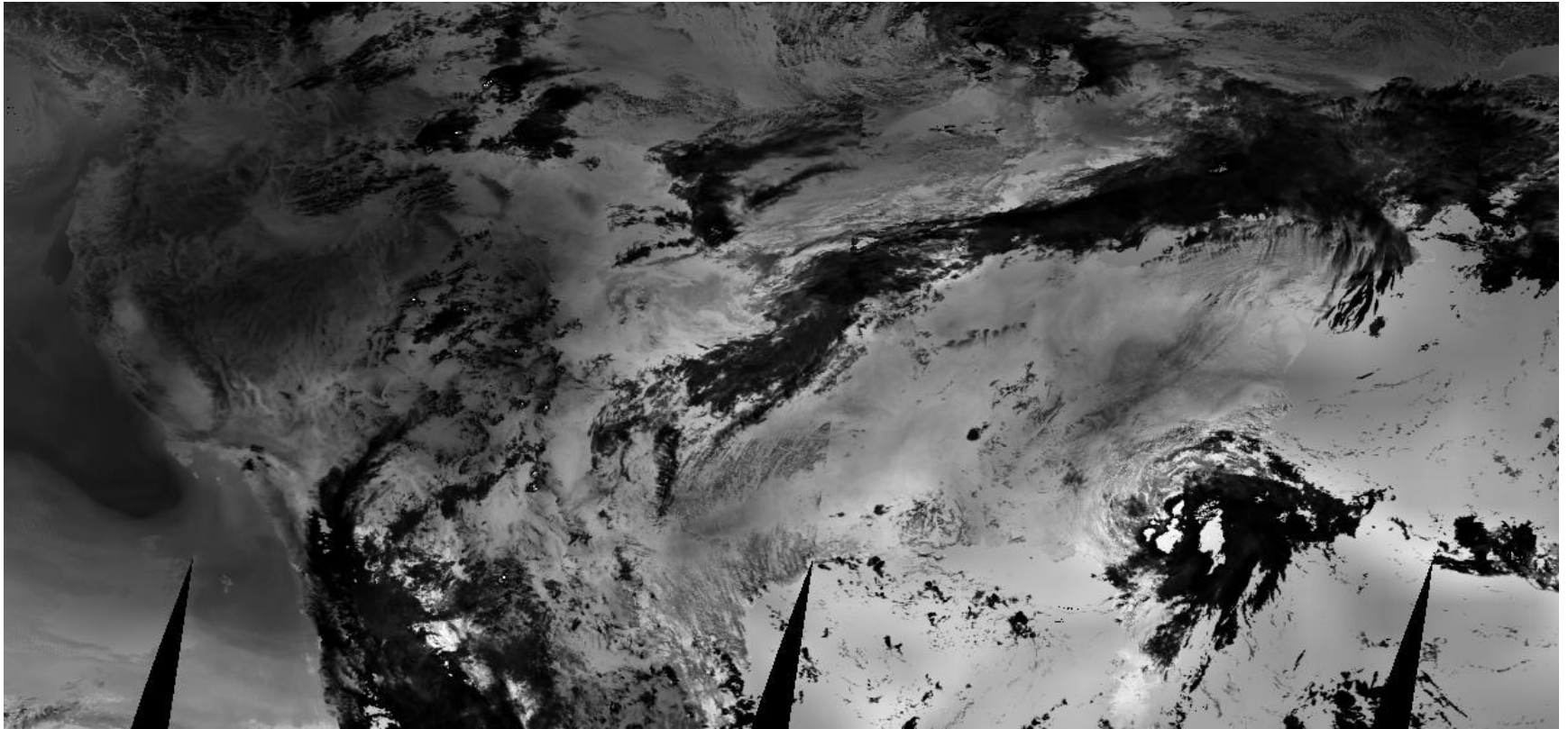


Landsat ETM+ and MODIS Terra in same morning  
overpass orbit - so we can use contemporaneous MODIS  
atmosphere parameterization data to correct Landsat data !





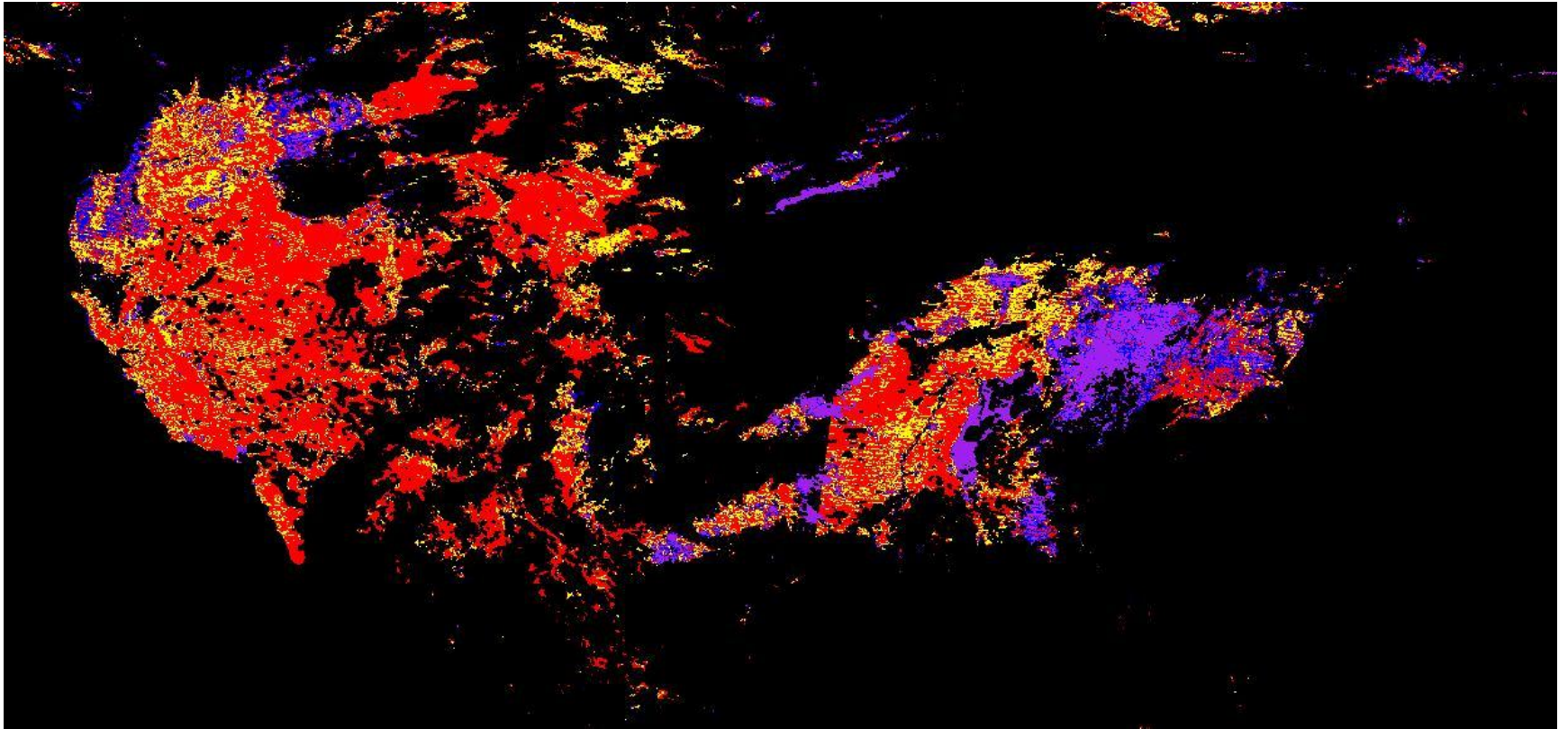
CONUS MODIS 0.05° CMG  
Water Vapor July 18<sup>th</sup> 2008



Black: Fill

retrieved from MODIS Terra orbits

# CONUS MODIS 0.05° CMG Aerosol Type July 18<sup>th</sup> 2008



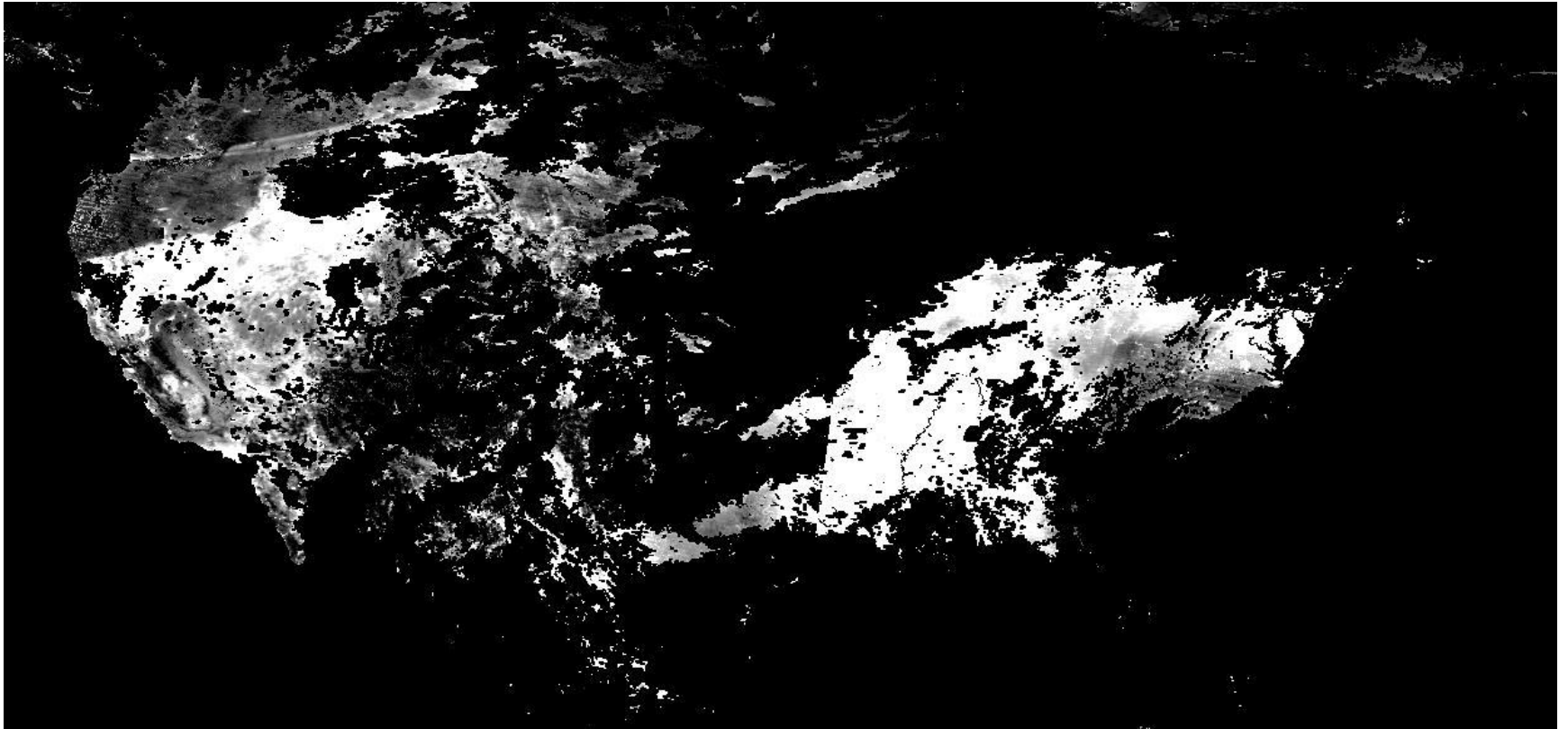
purple: low absorption smoke  
blue: high absorption smoke  
red: clean urban  
yellow: polluted urban

retrieved from MODIS Terra orbits



CONUS MODIS 0.05° CMG

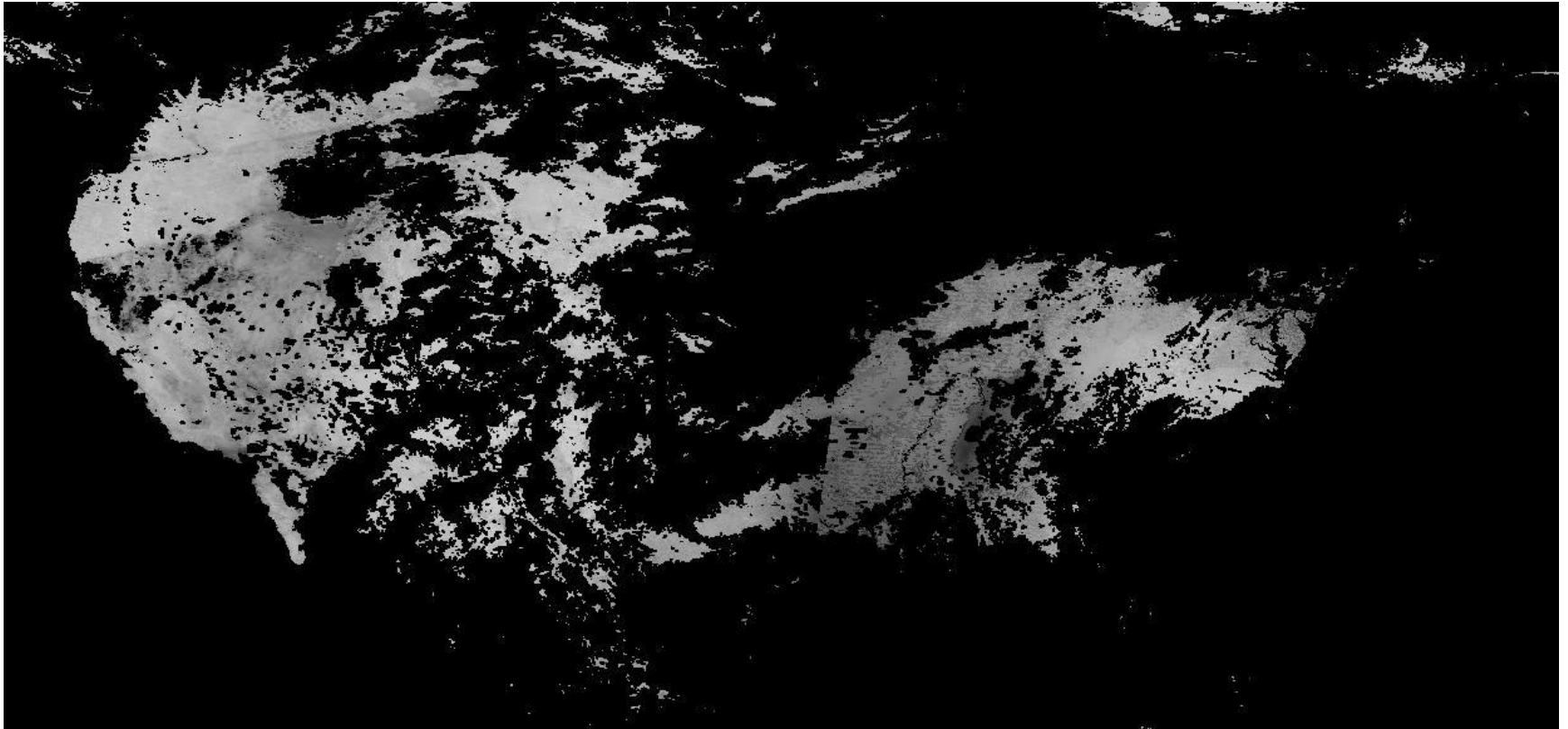
Aerosol Optical Thickness (550nm) July 18<sup>th</sup> 2008



Black: Fill

retrieved from MODIS Terra orbits

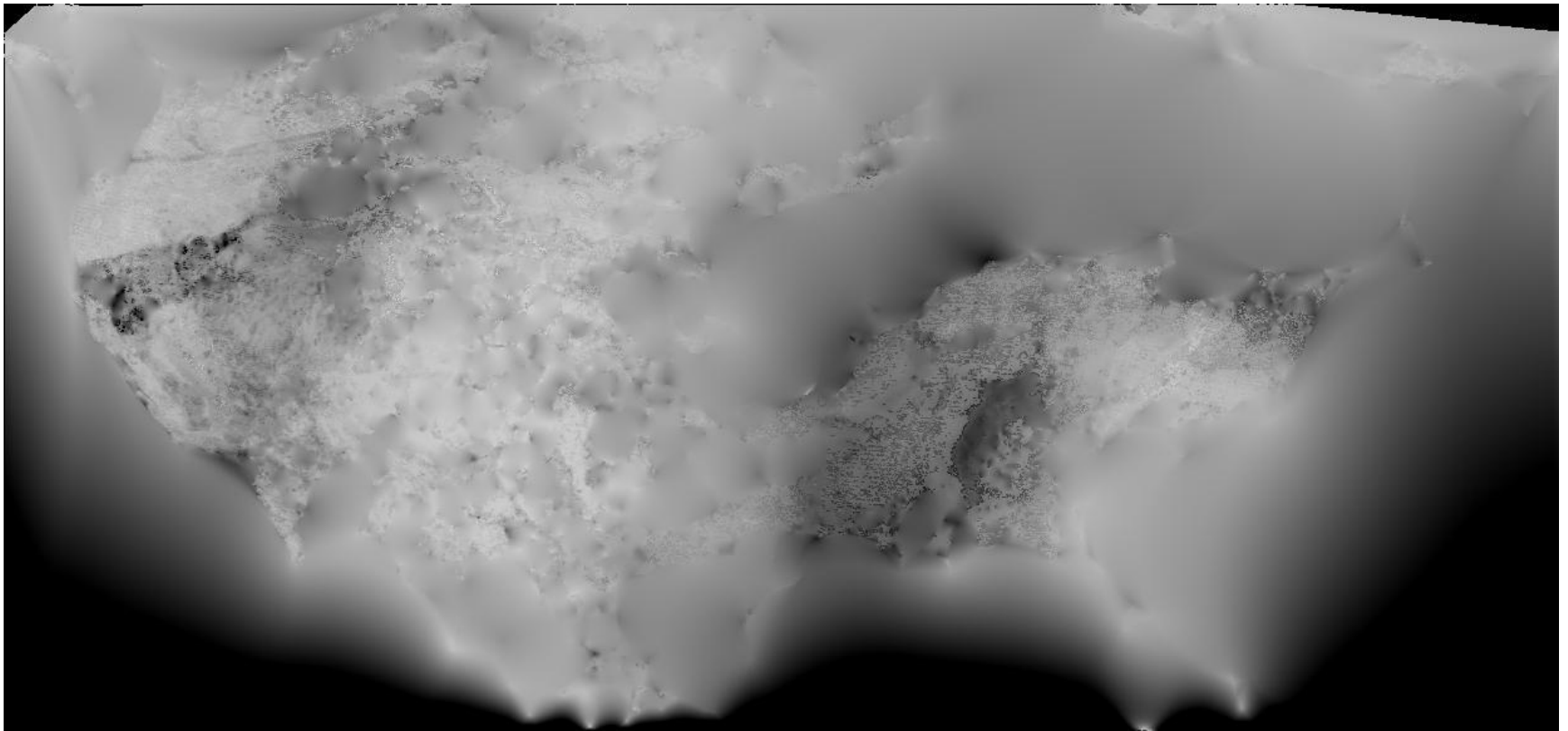
6SV Look Up Table generated  
0.05° atmospheric correction coefficients  
for Landsat ETM+ blue band



$C_{4, \text{blue } \lambda}$

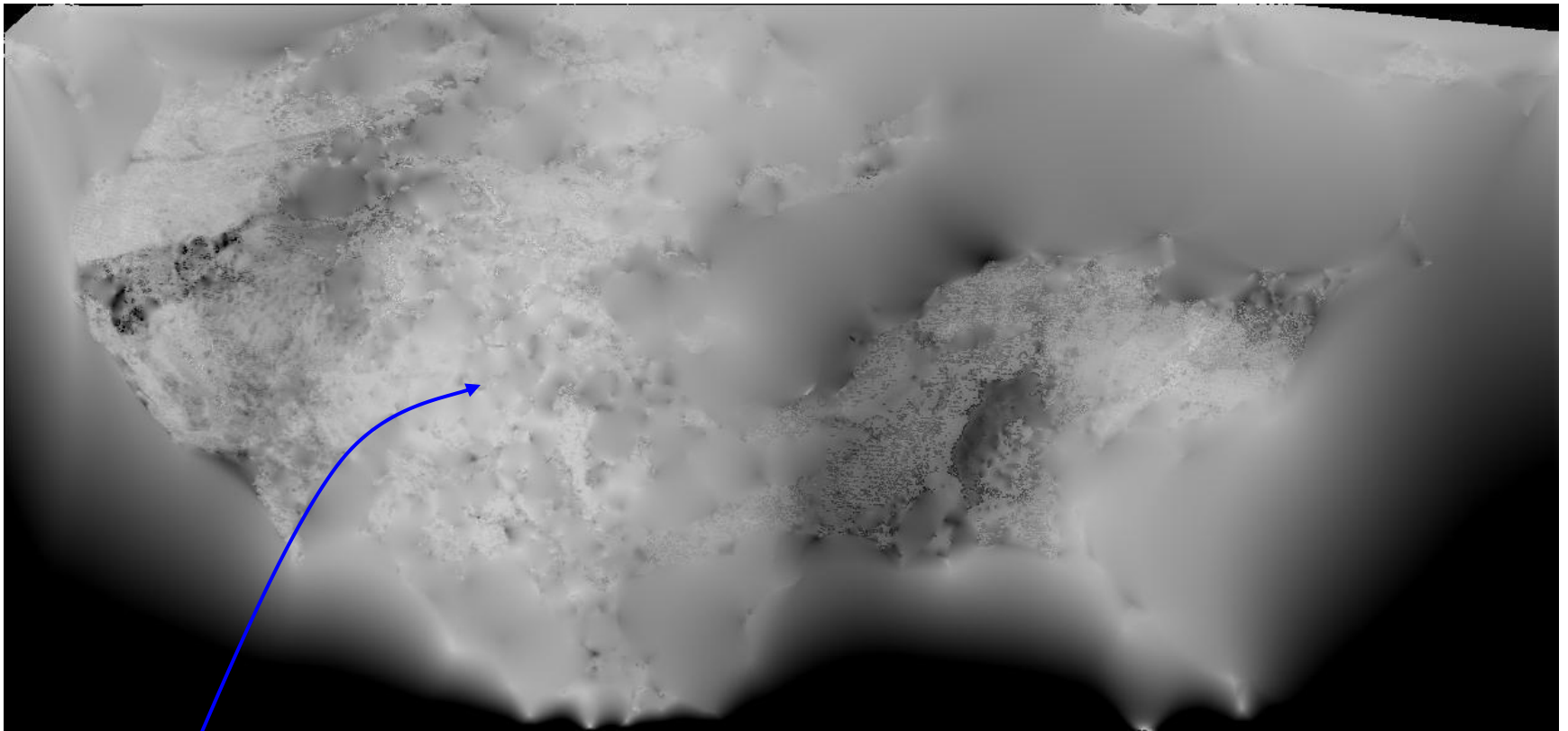


Natural neighbor interpolated 6SV LUT generated  
0.05° atmospheric correction coefficients  
for Landsat ETM+ blue band



$C_{4, \text{blue } \lambda}$

# Natural neighbor interpolated 6SV LUT generated 0.05° atmospheric correction coefficients for Landsat ETM+ blue band



For each ETM+ 30m pixel location interpolate  
the coefficient values  $c_{1,\lambda}$ ,  $c_{2,\lambda}$ ,  $c_{3,\lambda}$ ,  $c_{4,\lambda}$

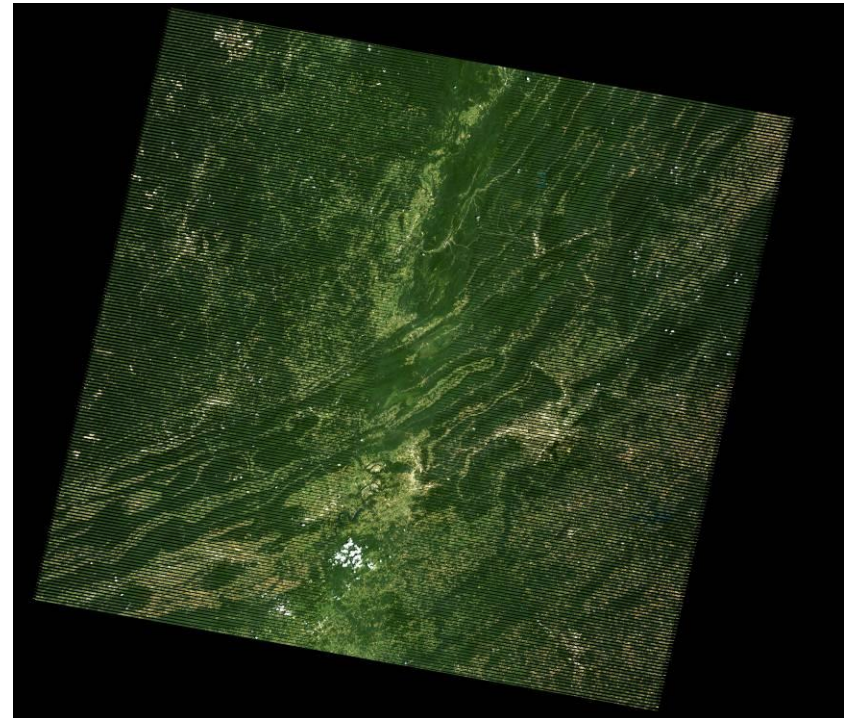
**Then compute Landsat 30m:**

$$\rho_{\text{surf},\lambda} = 1 / (c_{3,\lambda} / (\rho_{\text{toa},\lambda} / c_{1,\lambda} - c_{2,\lambda}) + c_{4,\lambda})$$



**North West:** Top of atmosphere Landsat ETM+ true color (red , green and blue bands); **South East:** Corresponding Surface reflectance computed using contemporaneous MODIS atmosphere parameterization data.

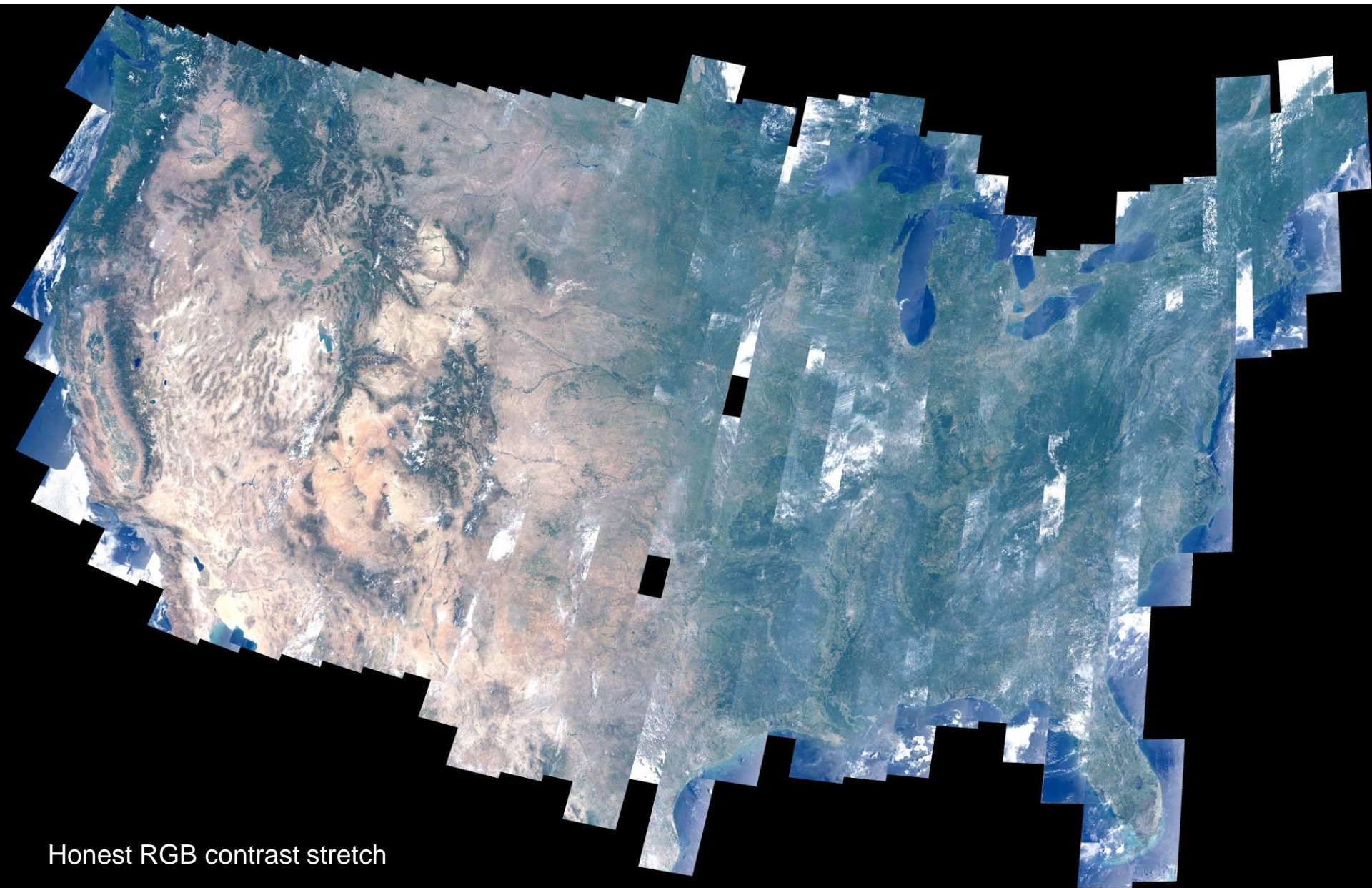
(Landsat Path 17 Row 34, Giles, Virginia, acquired July 18, 2008).



Honest RGB contrast stretches



July 2008 composite. Band 3, 2, 1 (red, green, blue)  
Top of Atmosphere Reflectance

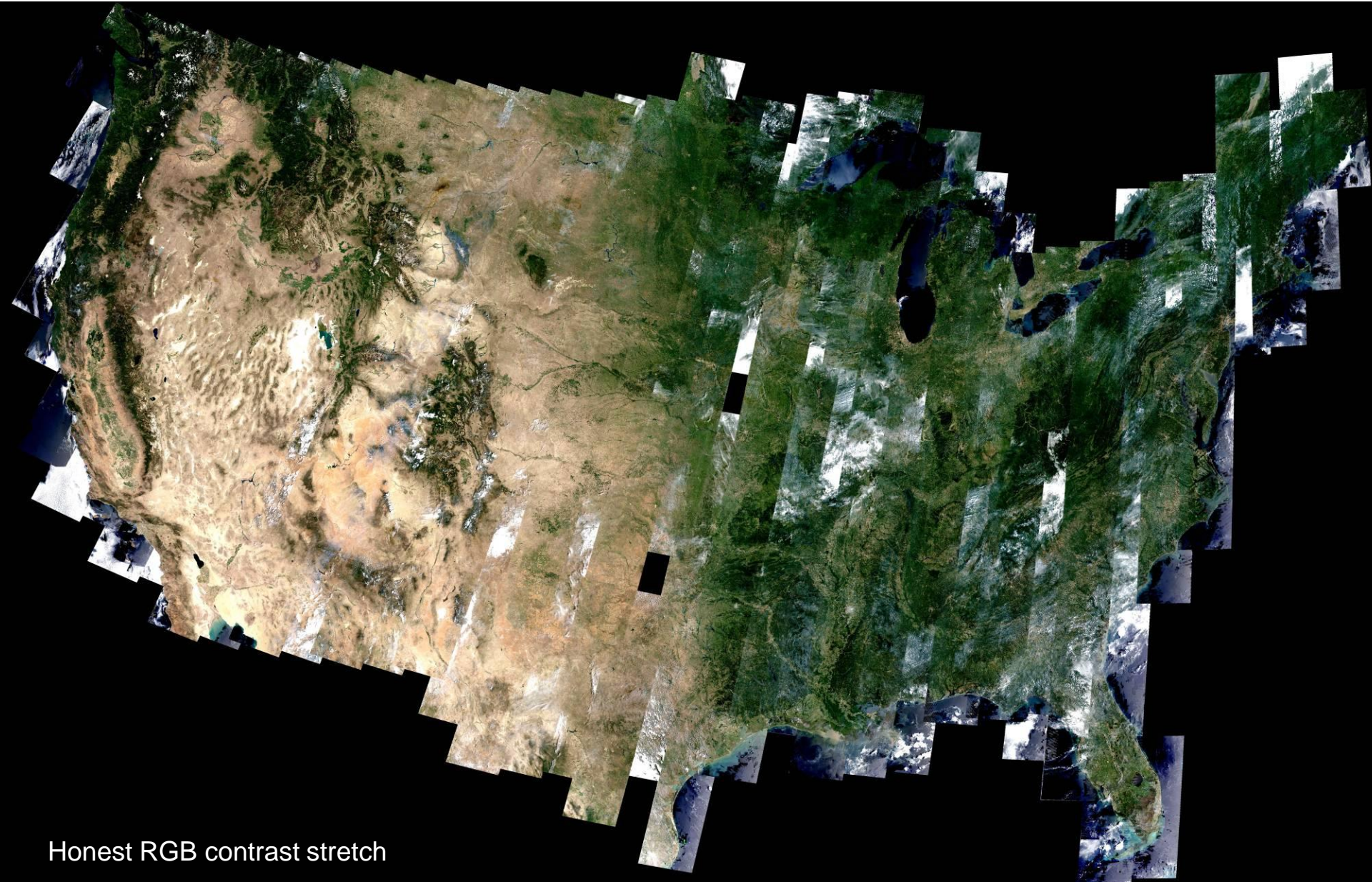


Honest RGB contrast stretch



July 2008 composite. Band 3, 2, 1 (red, green, blue)

Surface Reflectance - using advanced MODIS Landsat method



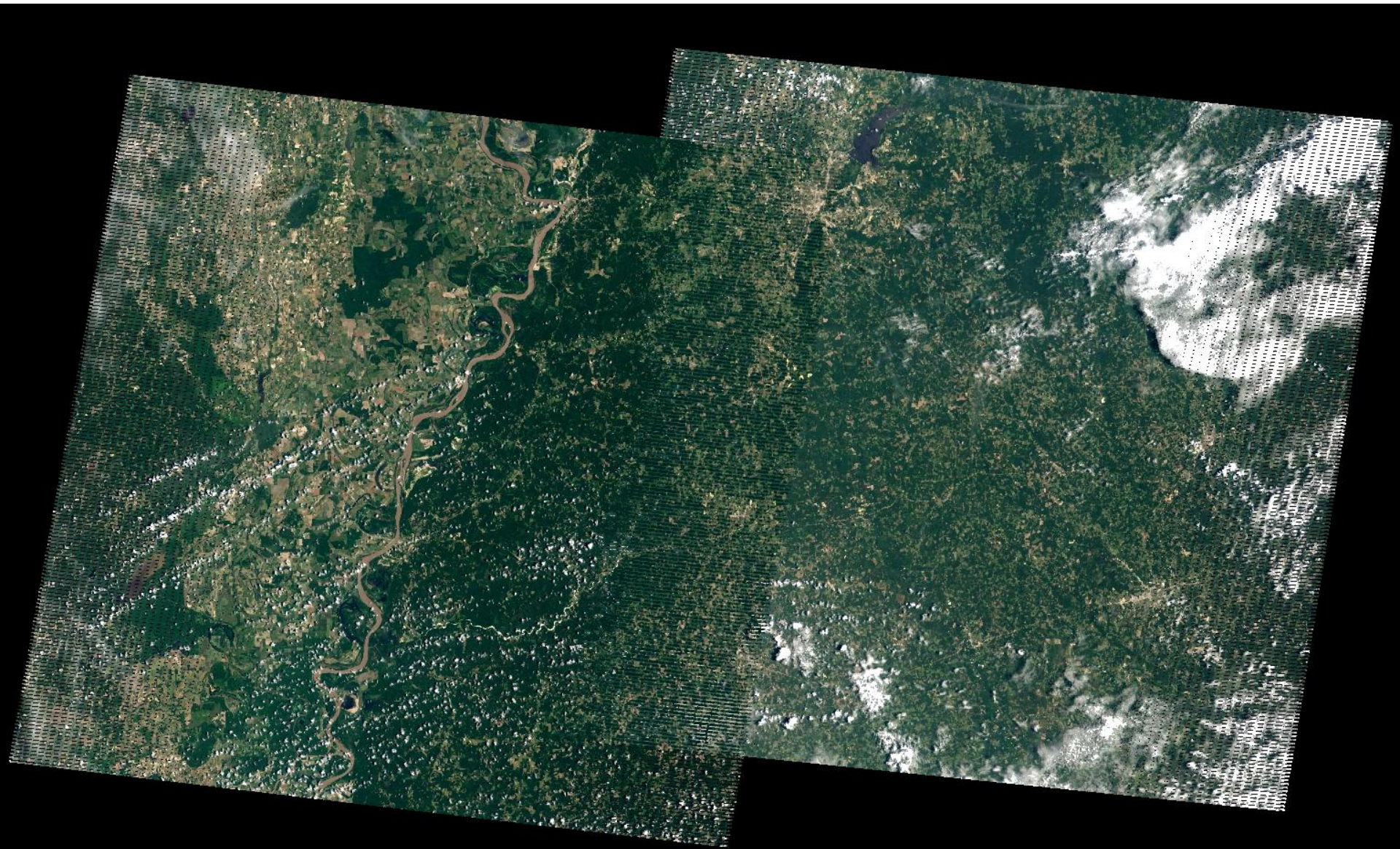
Honest RGB contrast stretch



Path 23 Row 38, July 12 & Path 22 Row 38, July 5, 2008

Band 3, 2, 1 (red, green, blue) TOA reflectance

Before radiometric normalization

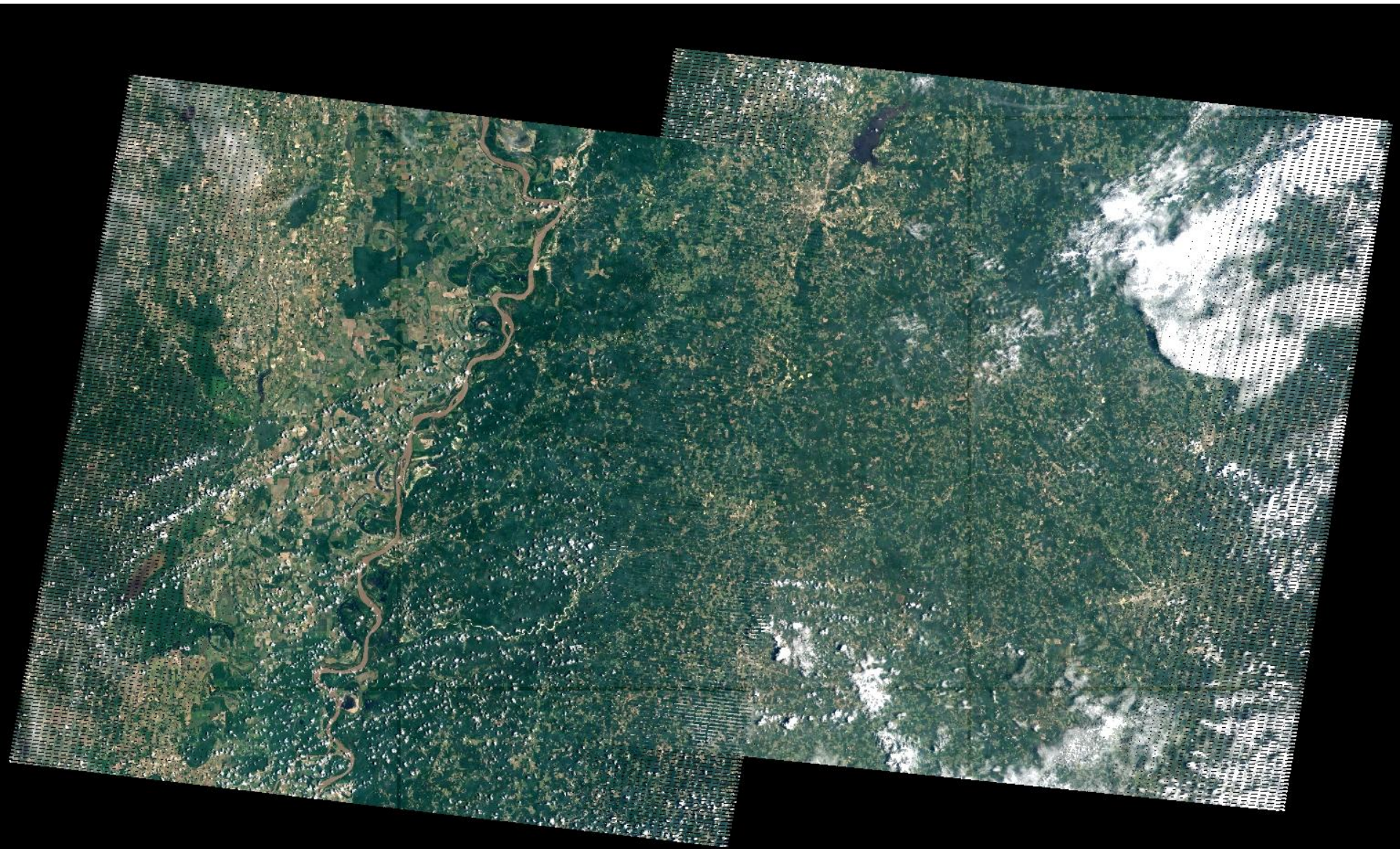




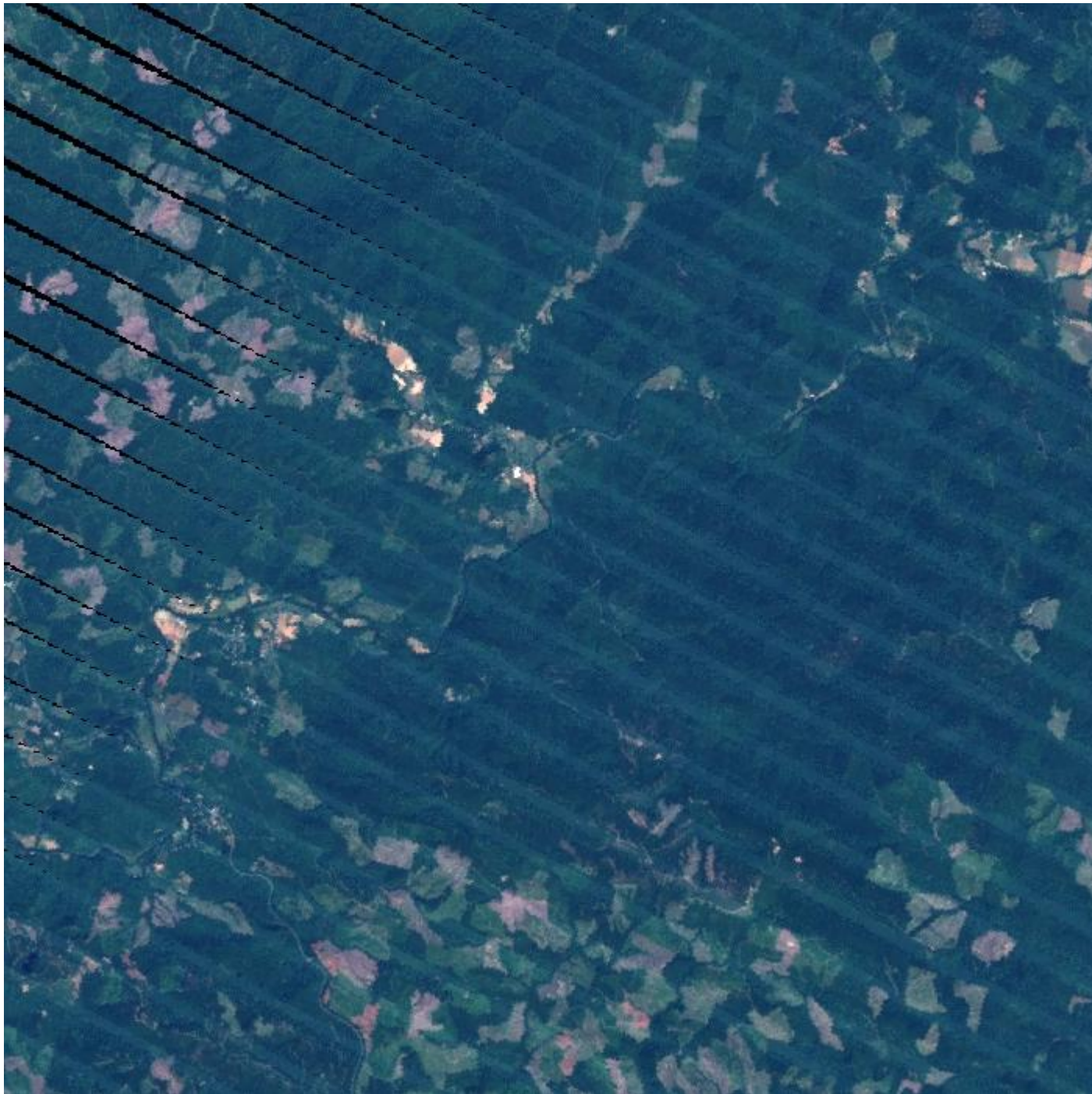
Path 23 Row 38, July 12 & Path 22 Row 38, July 5, 2008

Band 3, 2, 1 (red, green, blue) TOA reflectance

After radiometric normalization







July 2008

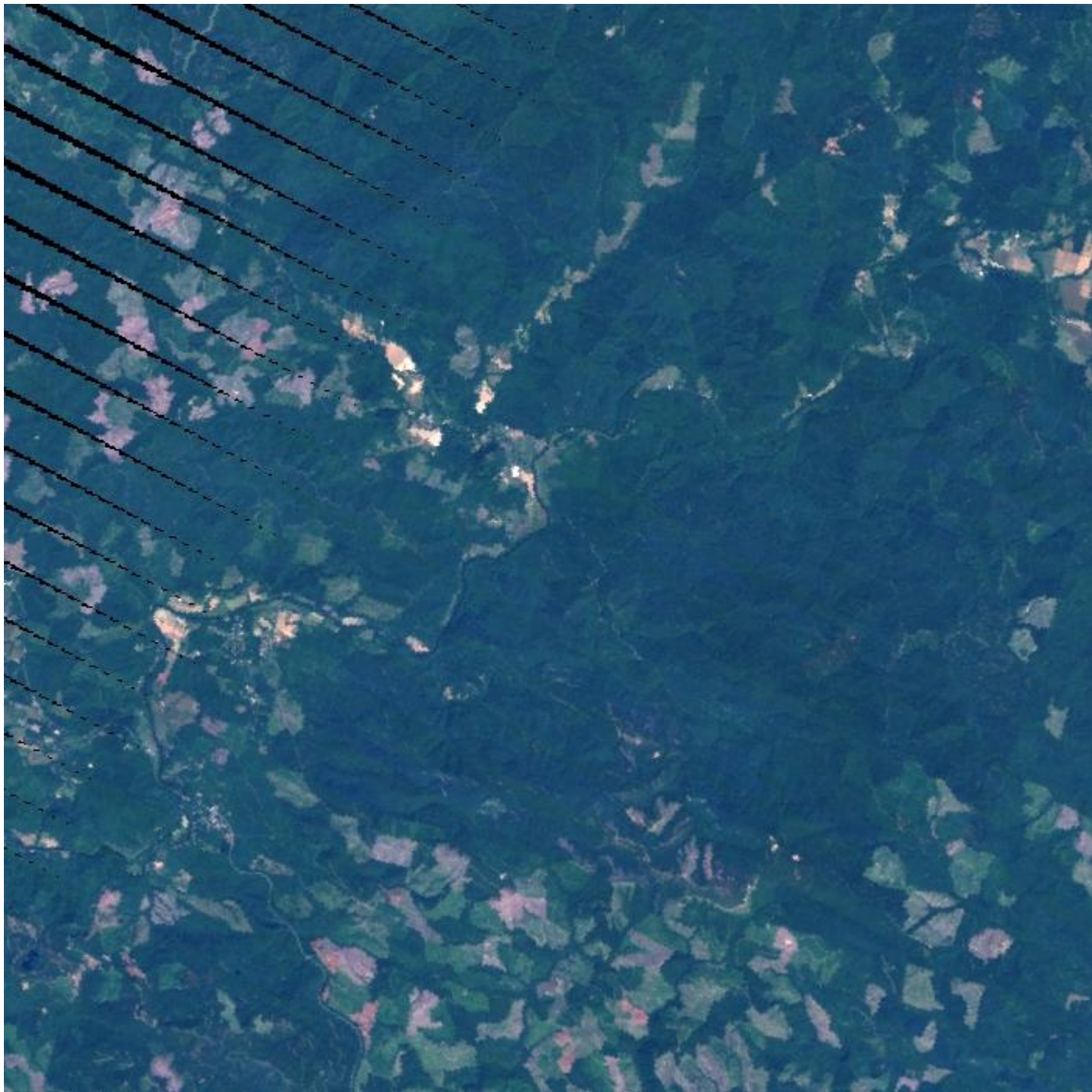
2 dates composited

Bands 3,2,1

700 x 700  
30m pixels

Before  
radiometric  
normalization





July 2008

2 dates composited

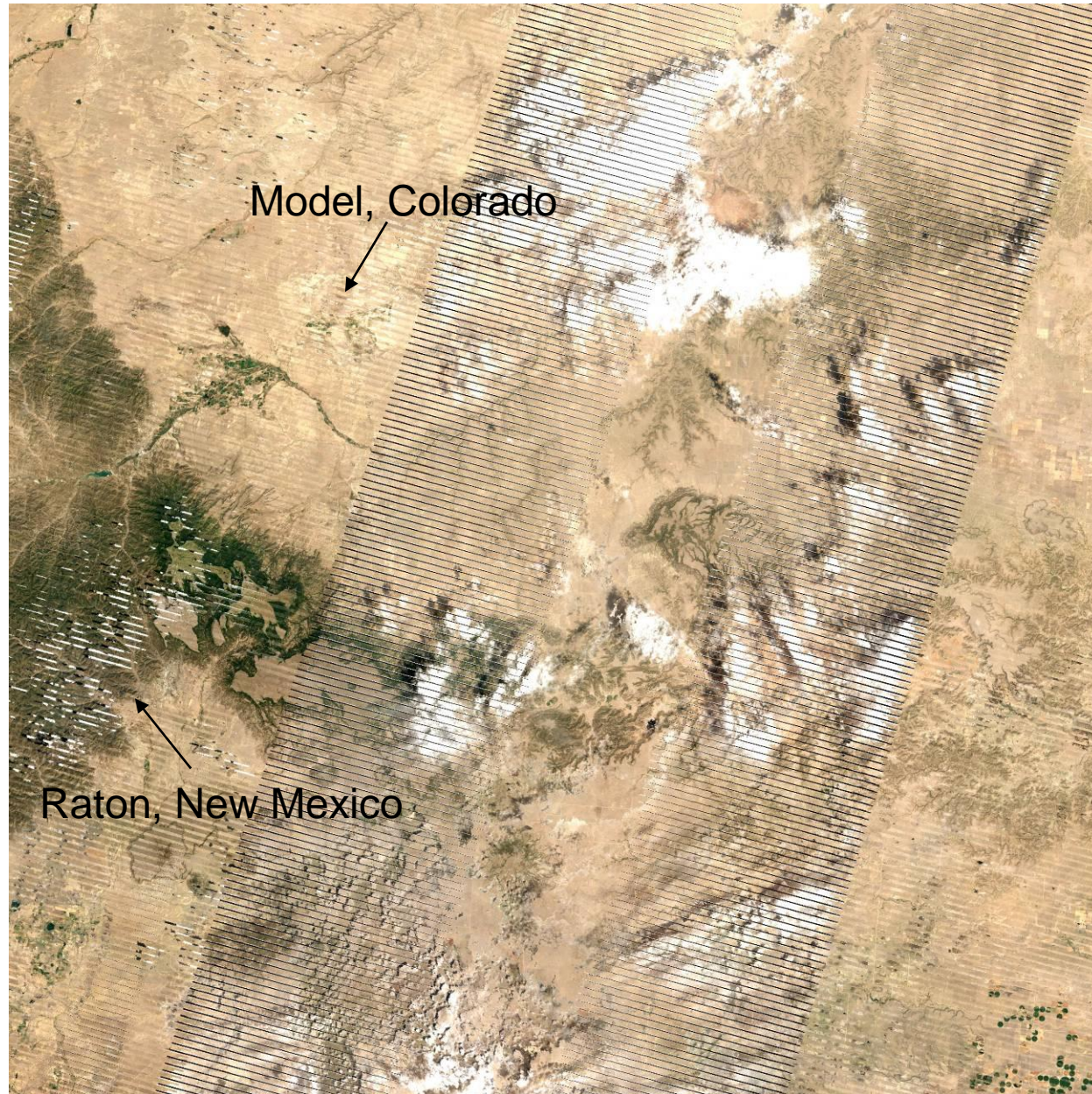
Bands 3,2,1

700 x 700  
30m pixels

After  
radiometric  
normalization



# WELD Tile h12v11



July 2008

dates composited

- July 2
- July 11
- July 18
- July 27

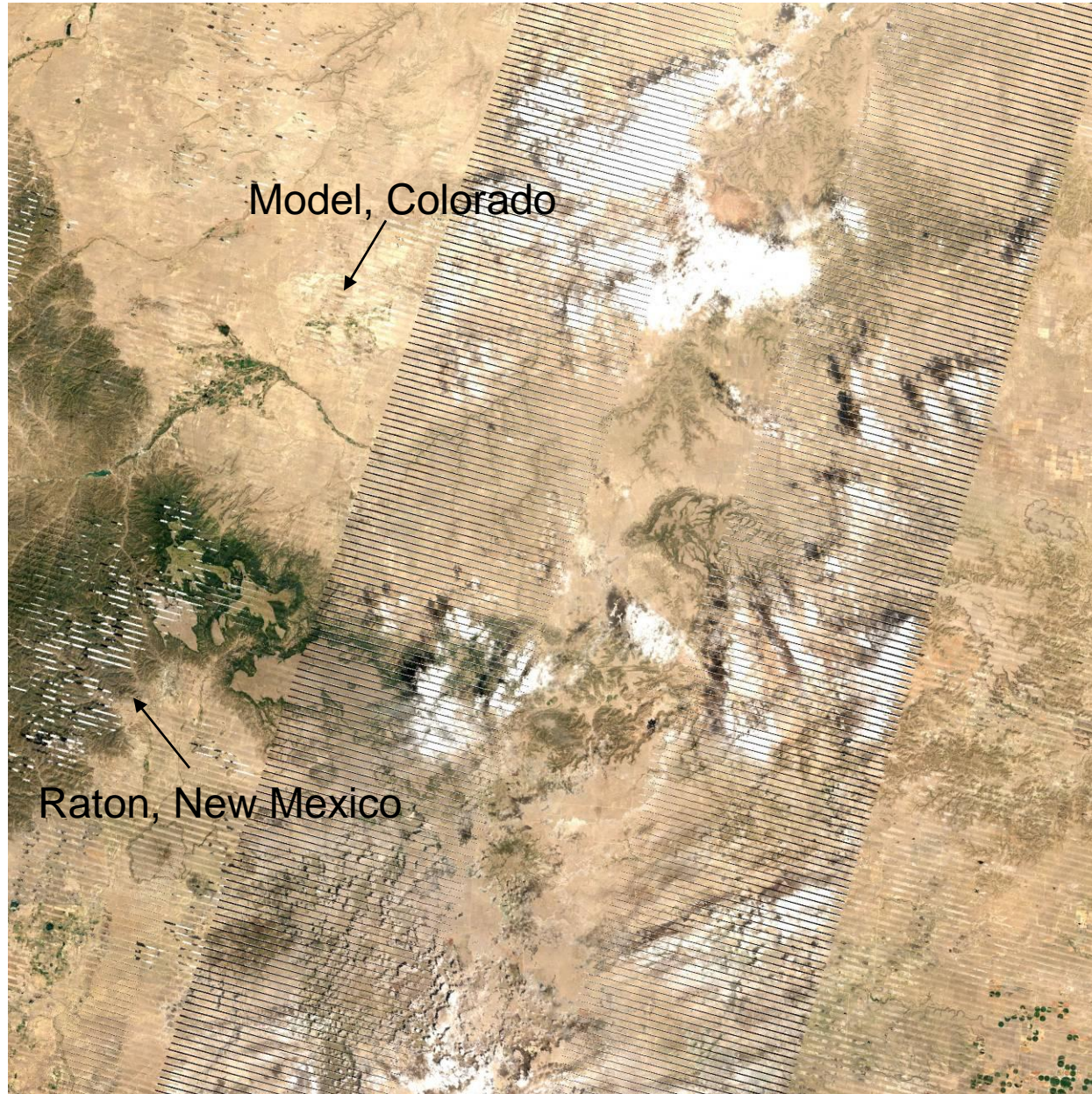
Bands 3,2,1

5000 x 5000  
30m pixels

Before  
radiometric  
normalization



# WELD Tile h12v11



July 2008

dates composited

- July 2
- July 11
- July 18
- July 27

Bands 3,2,1

5000 × 5000  
30m pixels

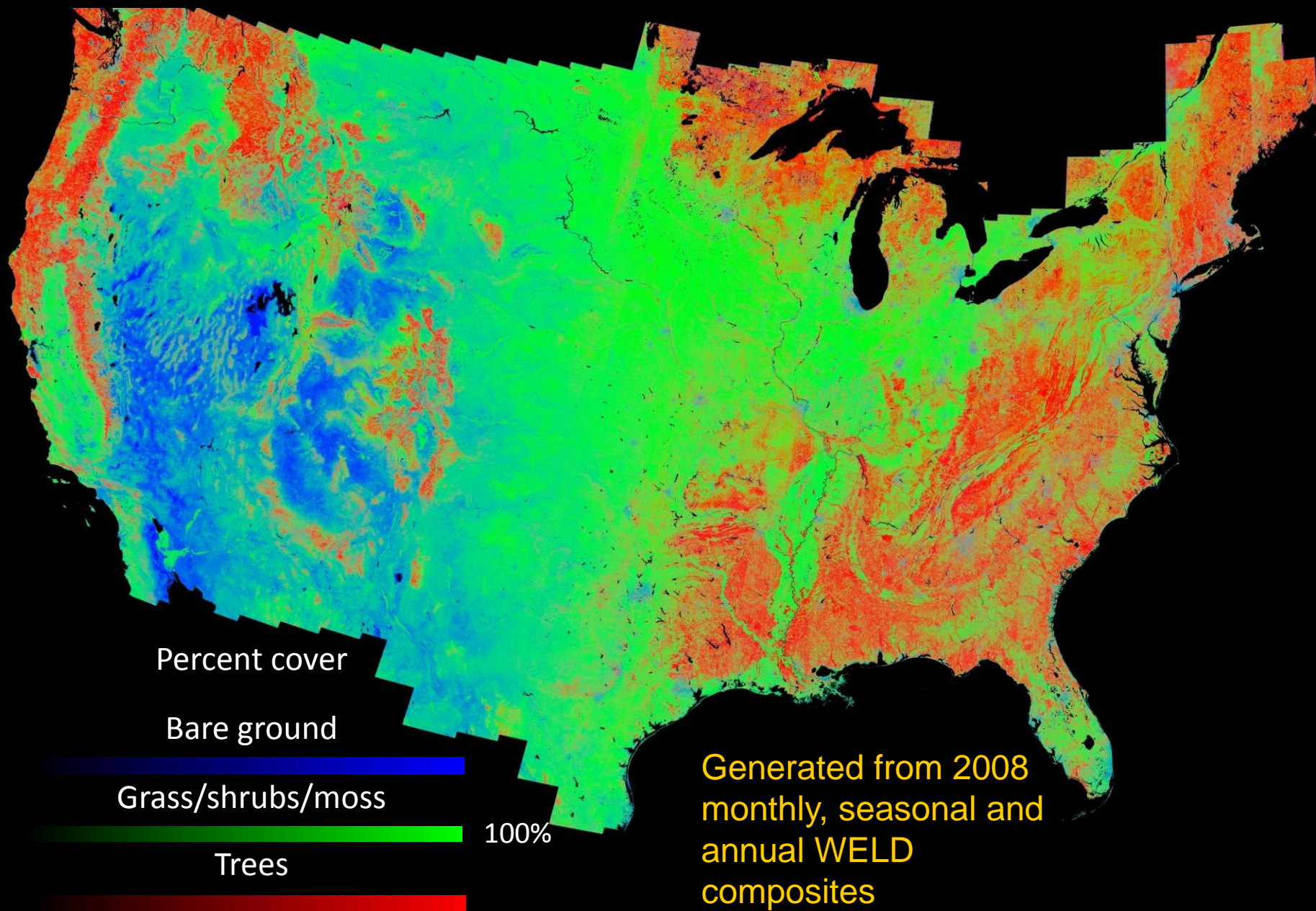
After  
radiometric  
normalization

# WELD Version 2.0 Land Cover Characterization

- Use MODIS Vegetation Continuous Field approach
- 30m sub-pixel fractional cover estimates
- **Annual**
  - Maximum percent tree cover
  - Maximum percent vegetation (excluding tree cover)
  - Minimum percent bare ground
  - Minimum surface water extent
  - Minimum snow/ice extent (nested within bare ground)
- **Weekly being considered**
  - weekly bare ground, water, snow/ice



# CONUS 30m Vegetation Continuous Fields (%)



# WELD Product Release Schedule



# Planned WELD Product Release

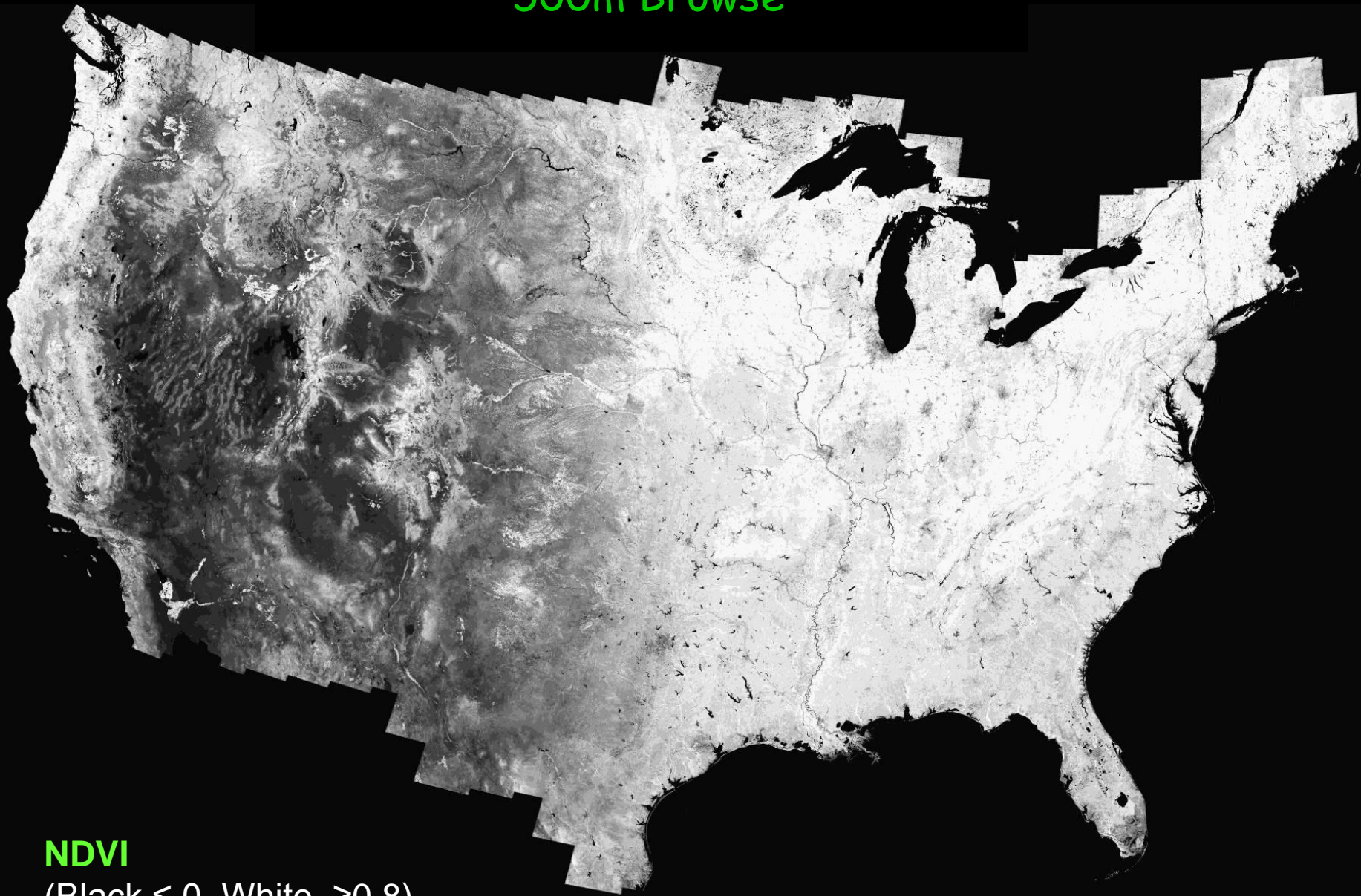
Release Date	Version	Region	Period
<b>2010</b>	1.5	CONUS & Alaska	2006, 2007, 2008, 2009, 2010 weekly, monthly, seasonal, annual
<b>December 2011</b>	2.0	CONUS & Alaska	<b>2010</b> weekly, monthly, seasonal, annual
<b>December 2011</b>	2.0	CONUS	Land cover

Cool WELD Stuff



# Annual 2008

## 500m Browse



**NDVI**

(Black  $\leq 0$ , White  $\geq 0.8$ )

December 2007

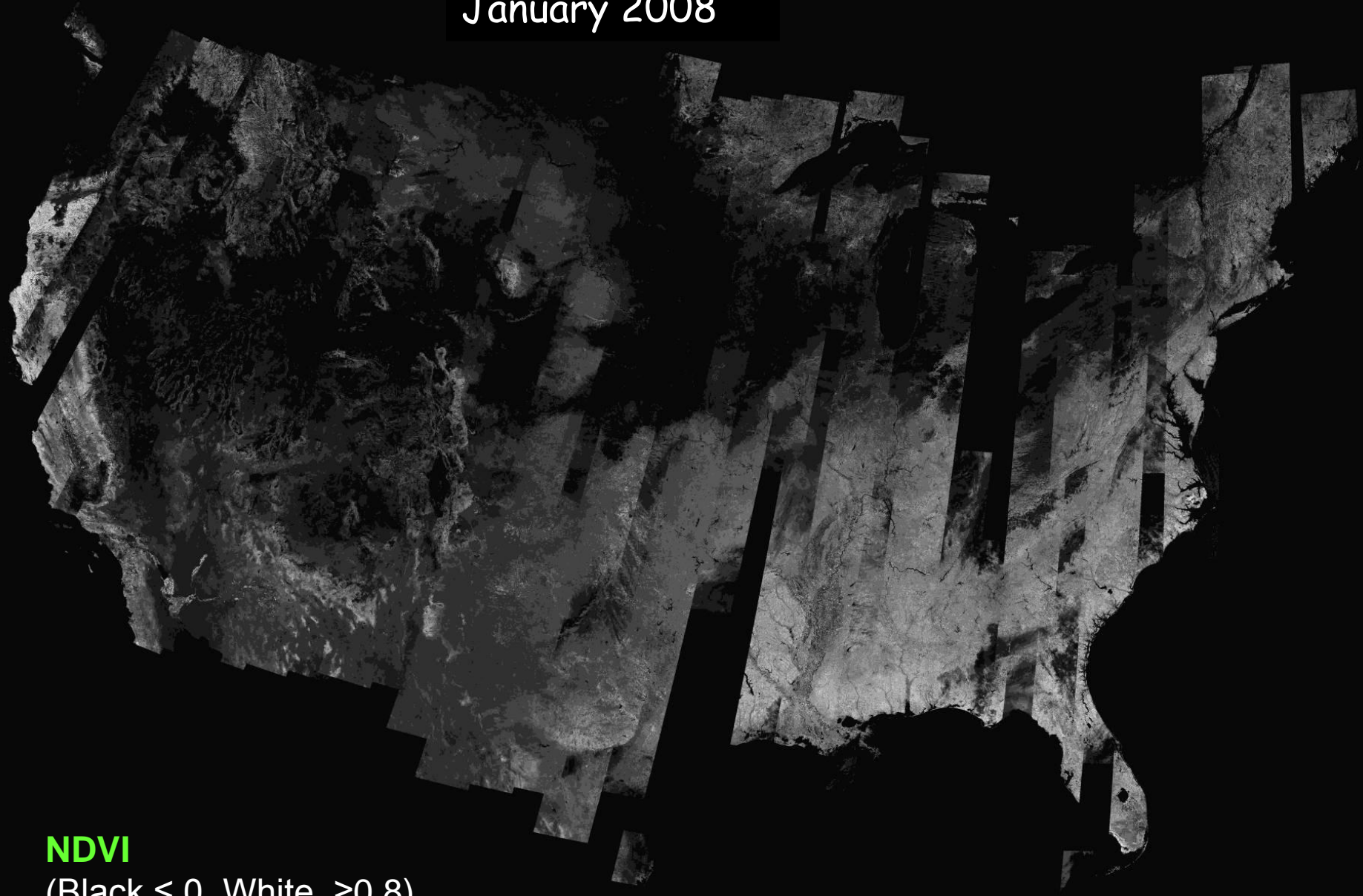


**NDVI**

(Black  $\leq 0$ , White  $\geq 0.8$ )



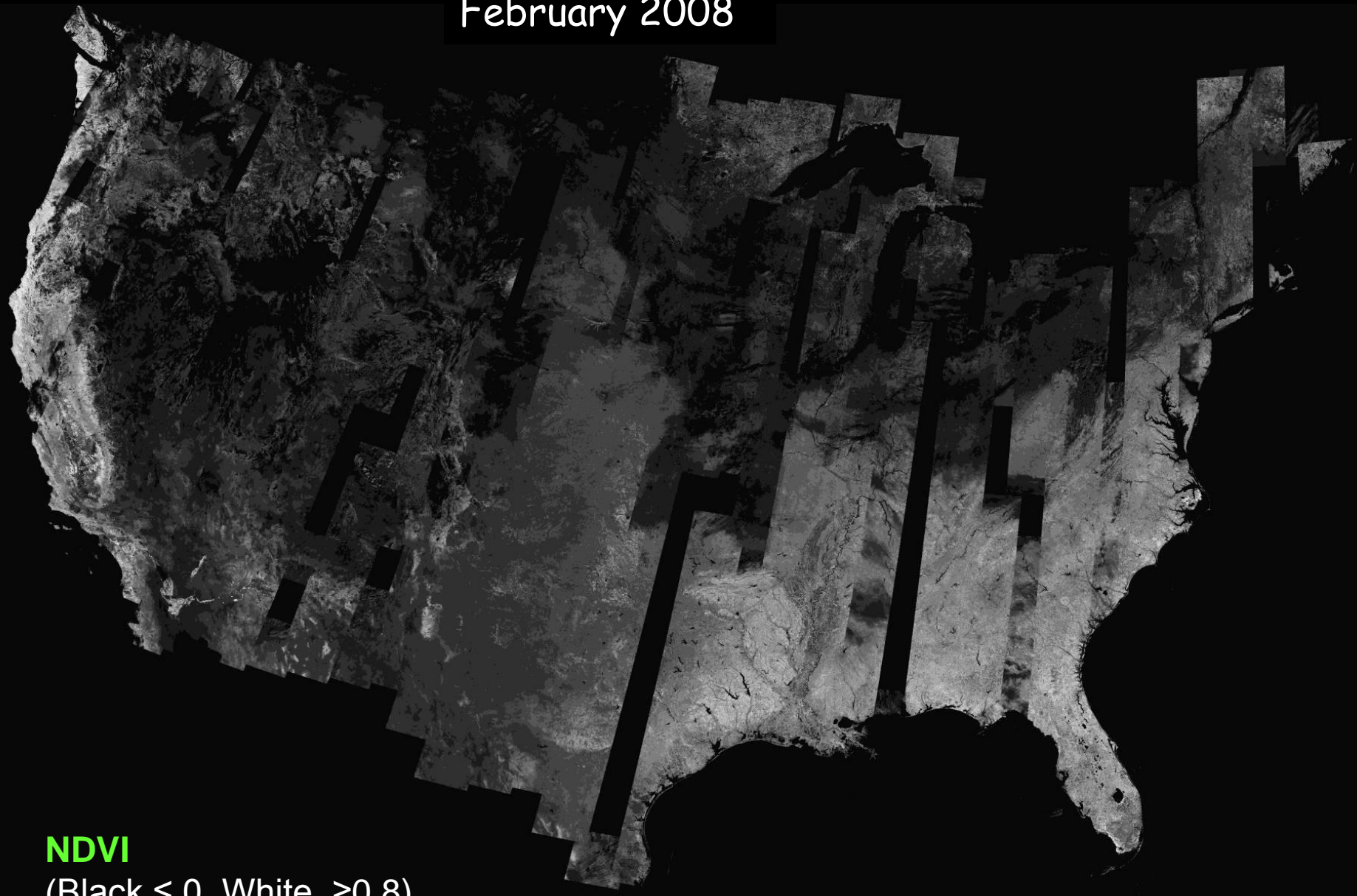
January 2008



**NDVI**

(Black  $\leq 0$ , White  $\geq 0.8$ )

February 2008

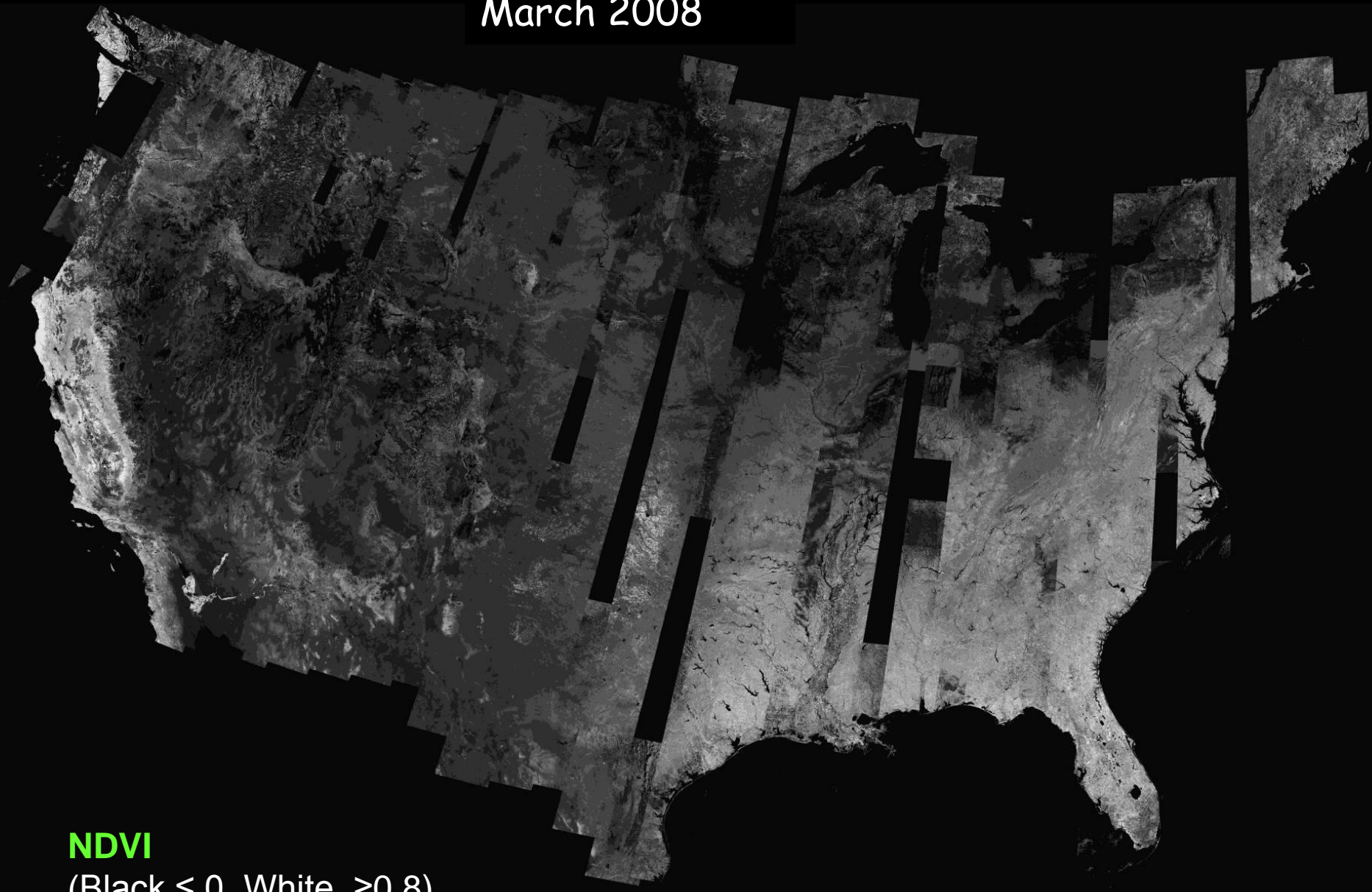


**NDVI**

(Black  $\leq 0$ , White  $\geq 0.8$ )



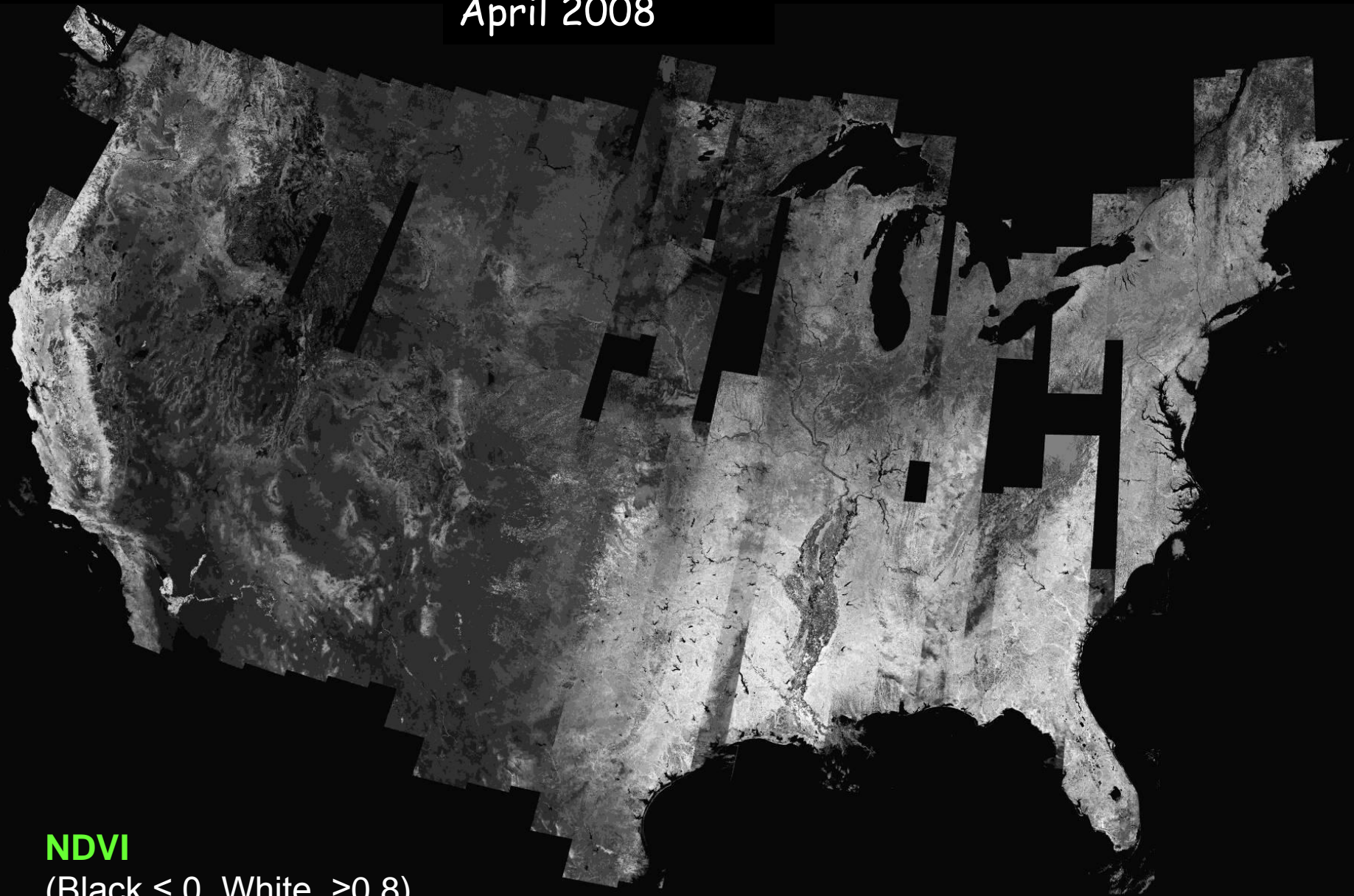
March 2008



**NDVI**

(Black  $\leq 0$ , White  $\geq 0.8$ )

April 2008

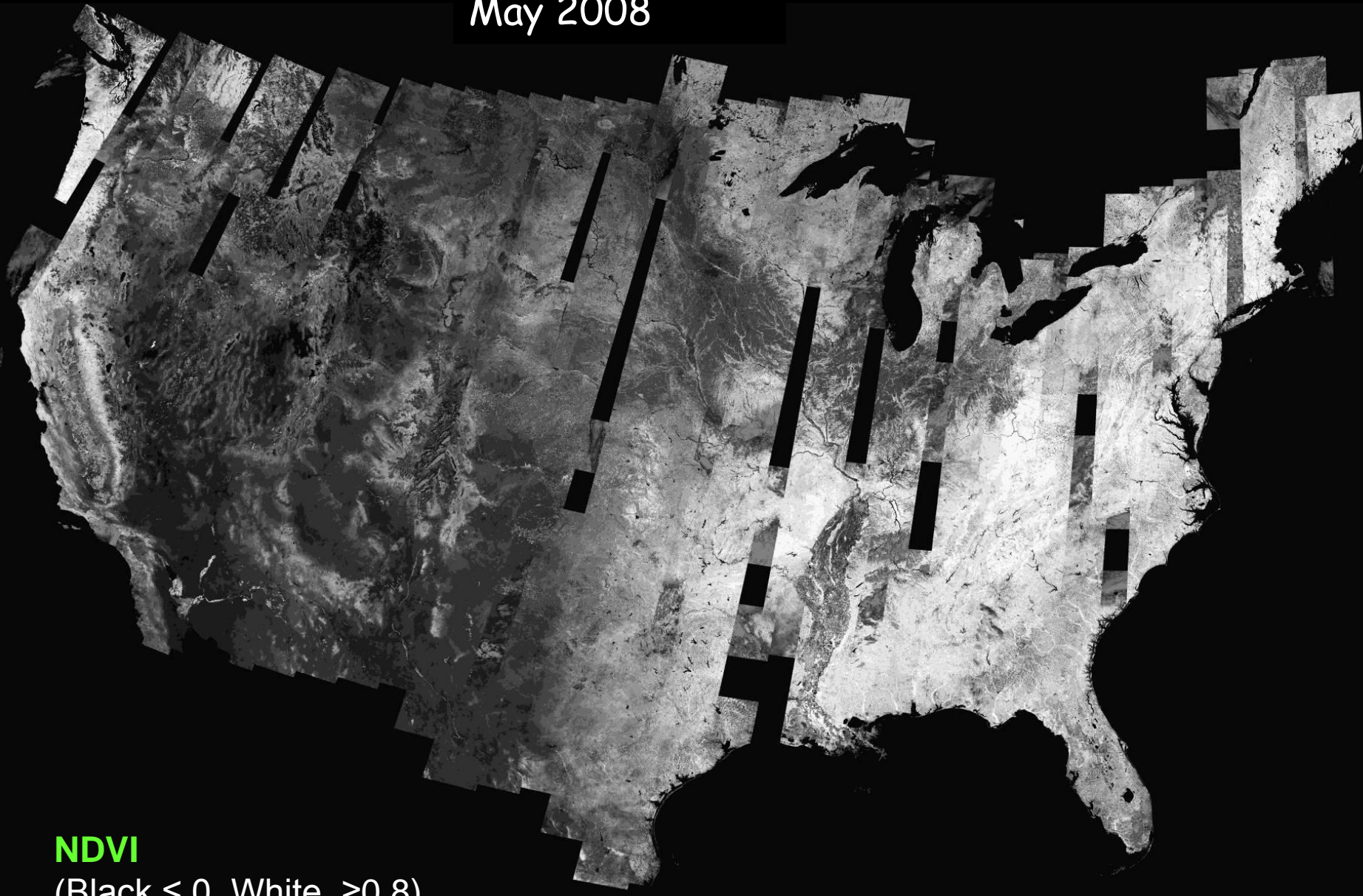


**NDVI**

(Black  $\leq 0$ , White  $\geq 0.8$ )



May 2008

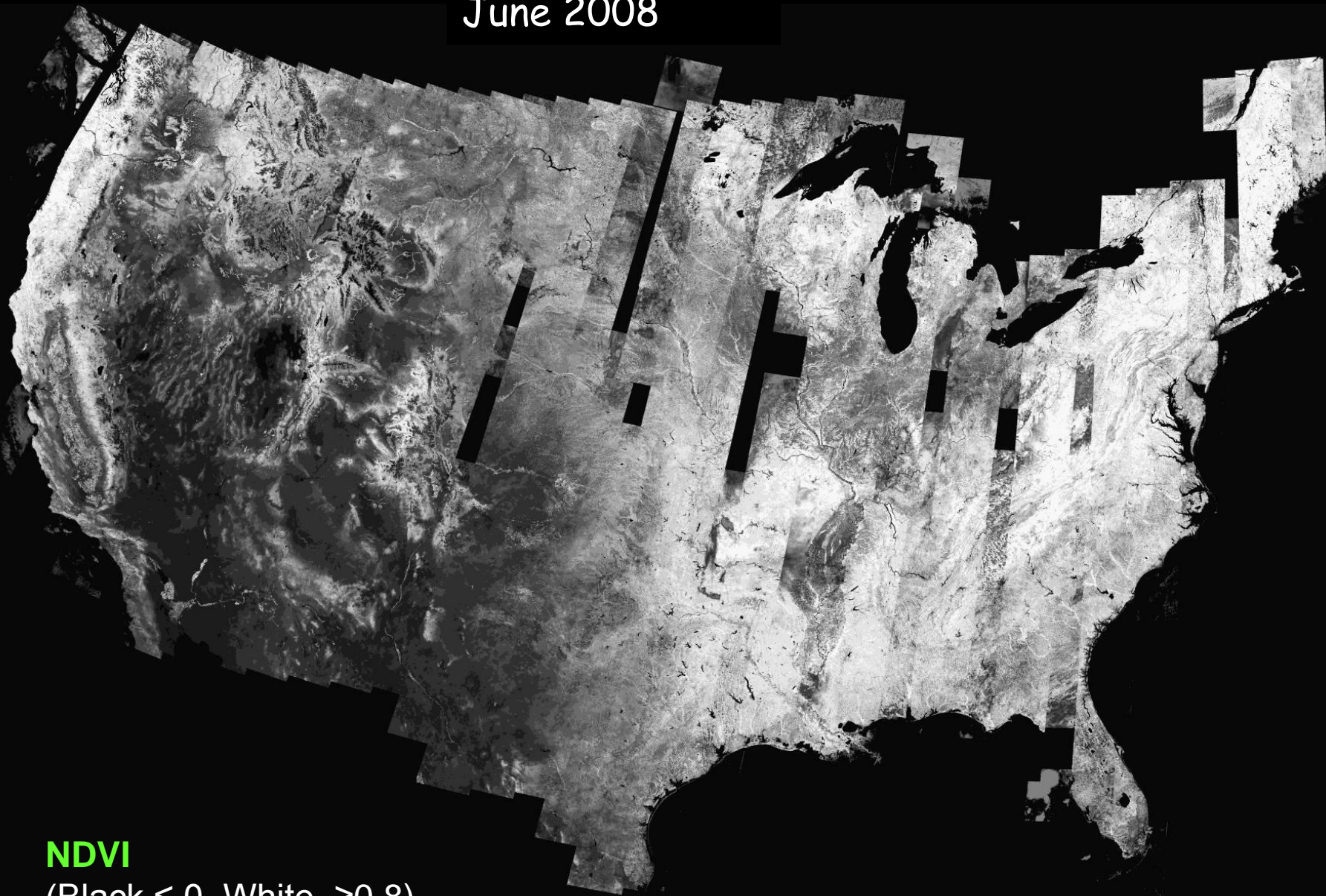


**NDVI**

(Black  $\leq 0$ , White  $\geq 0.8$ )



June 2008

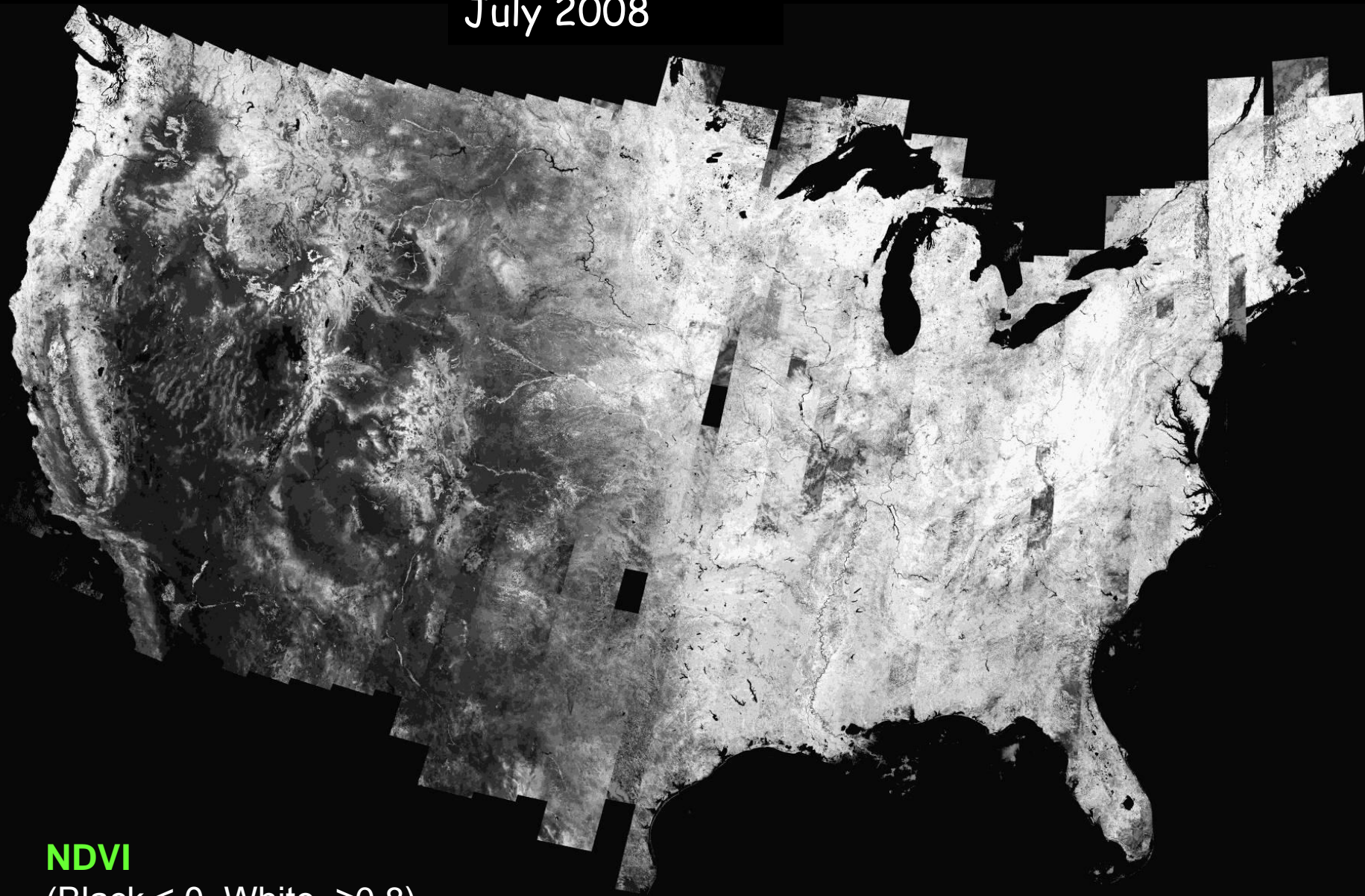


**NDVI**

(Black  $\leq 0$ , White  $\geq 0.8$ )



July 2008

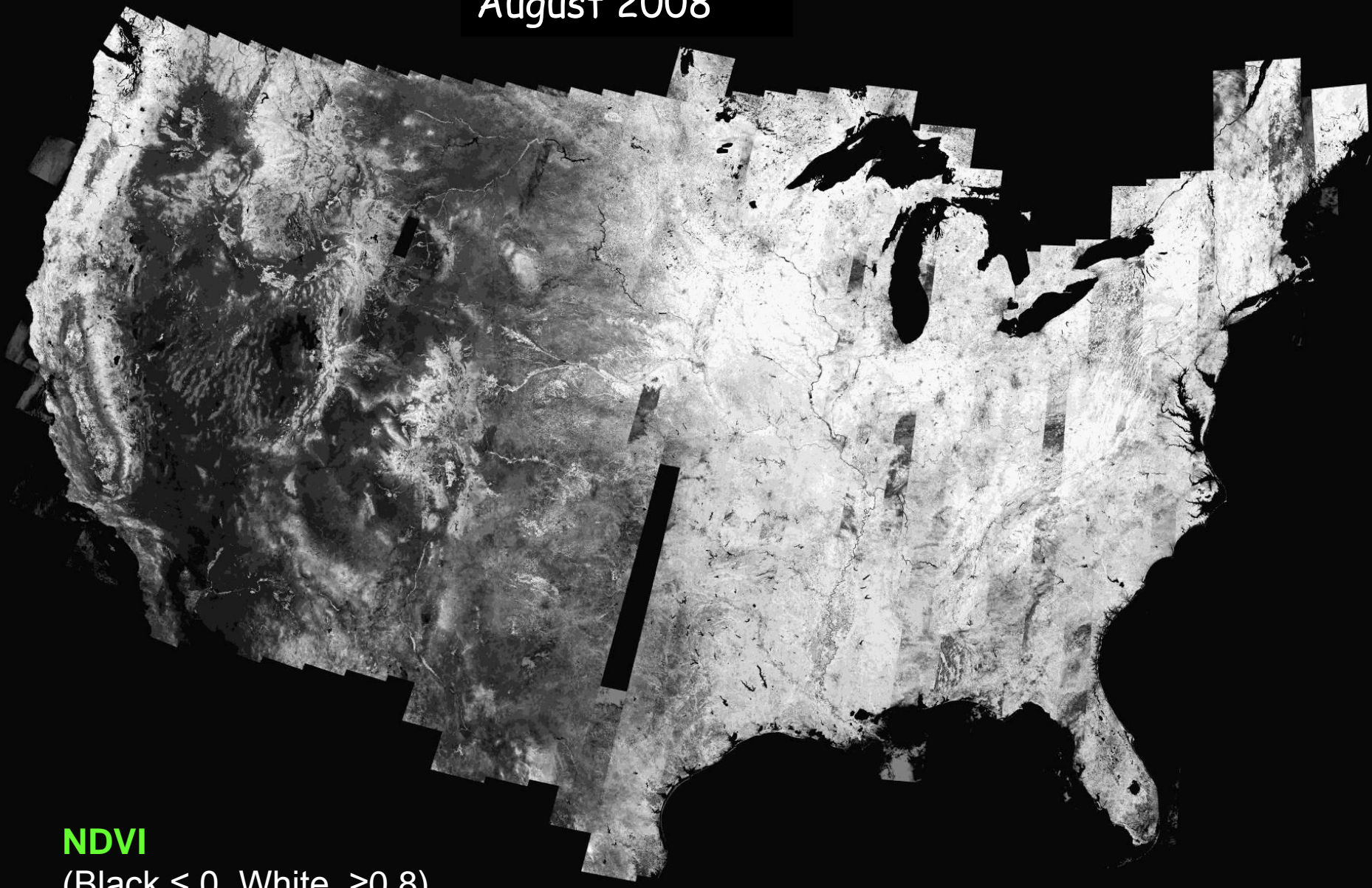


**NDVI**

(Black  $\leq 0$ , White  $\geq 0.8$ )



August 2008

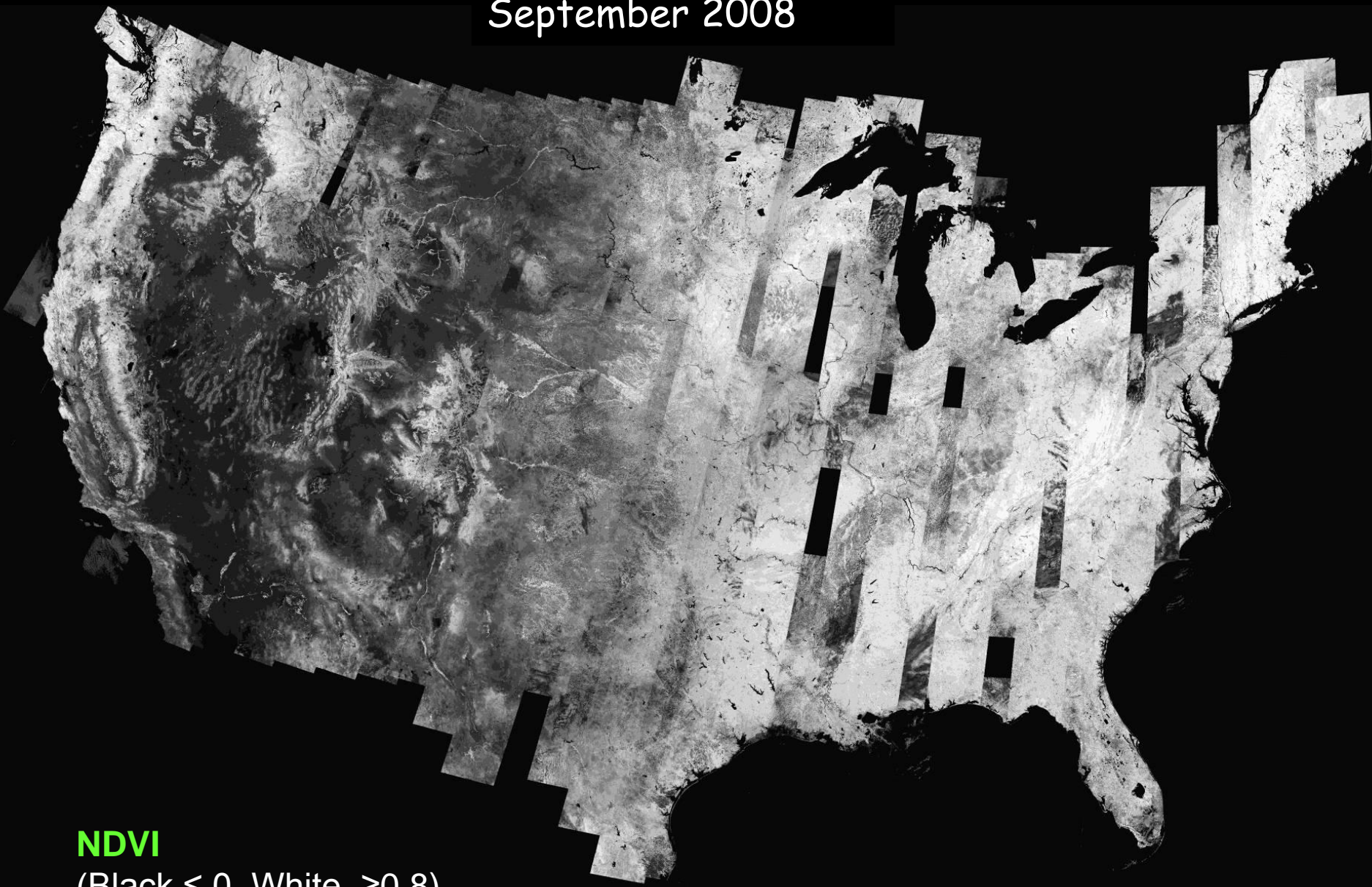


**NDVI**

(Black  $\leq 0$ , White  $\geq 0.8$ )



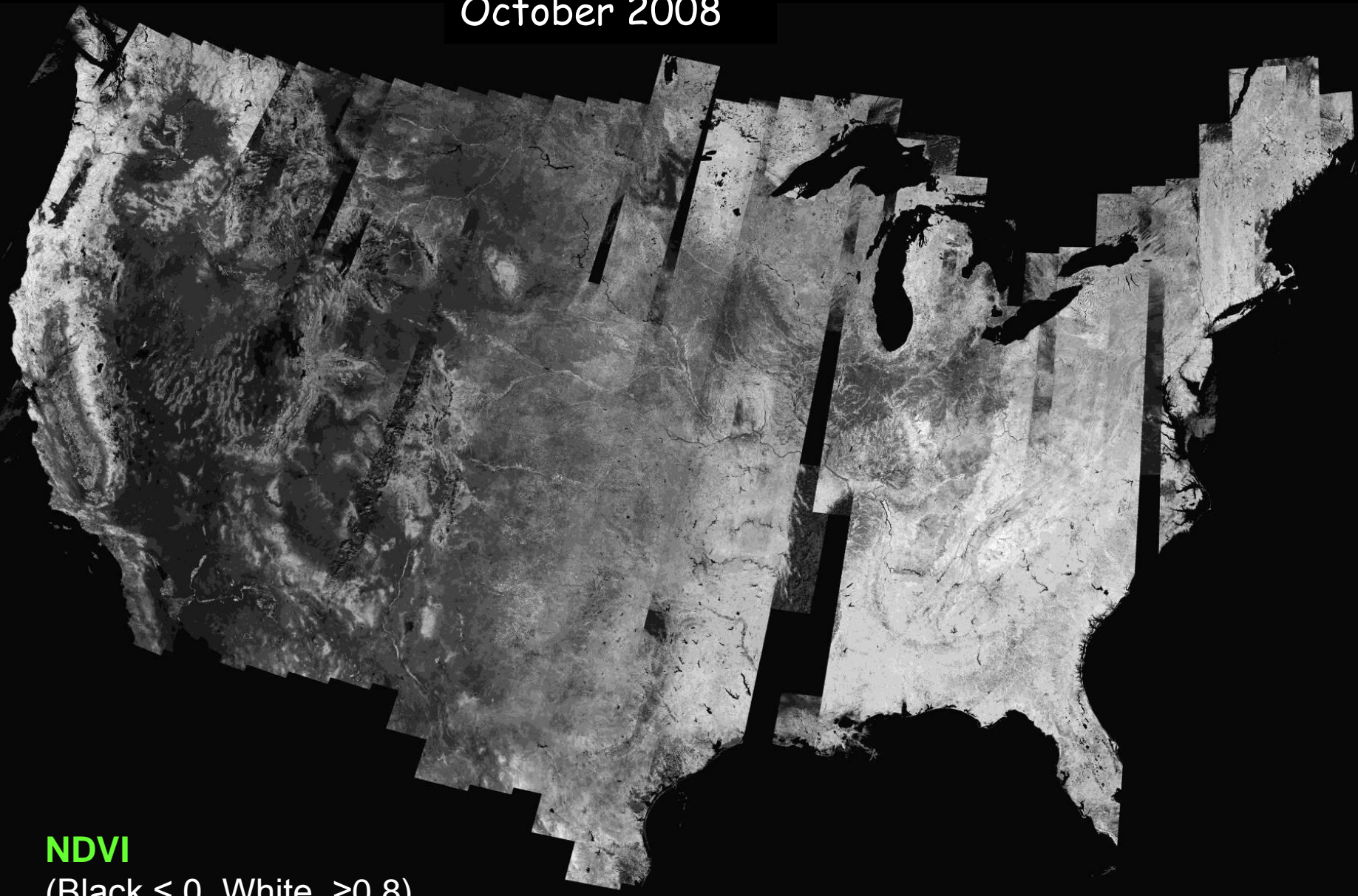
September 2008



**NDVI**

(Black  $\leq 0$ , White  $\geq 0.8$ )

October 2008



**NDVI**

(Black  $\leq 0$ , White  $\geq 0.8$ )



November 2008

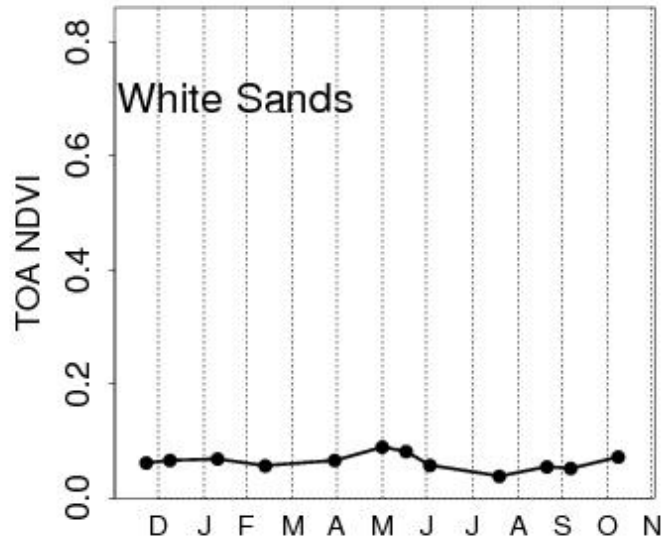
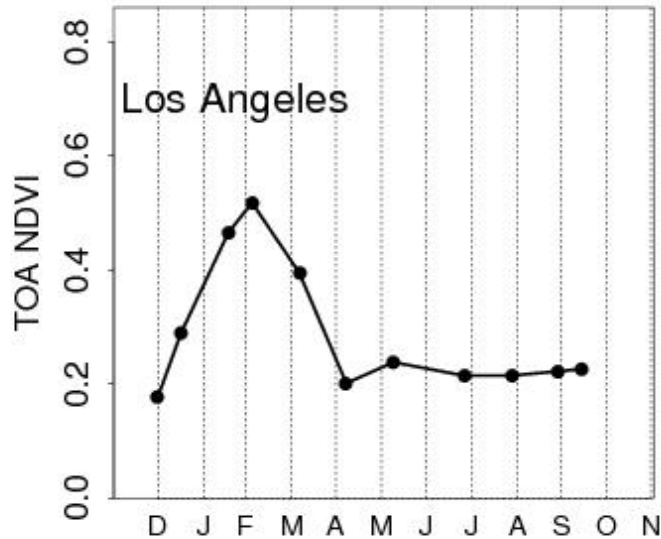
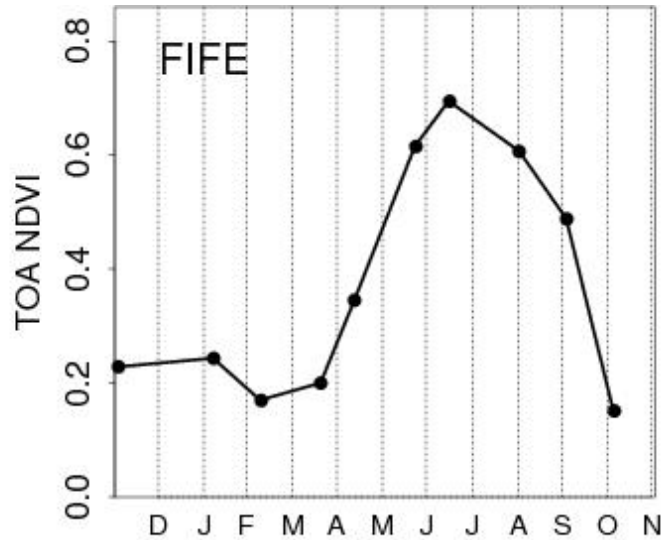
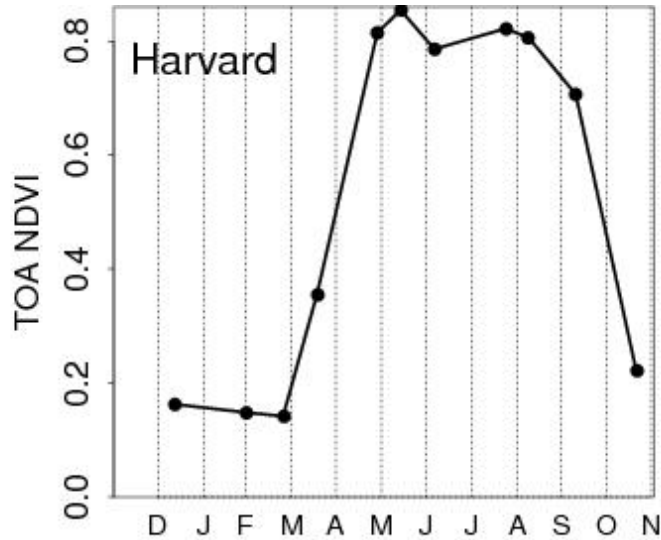


**NDVI**

(Black  $\leq 0$ , White  $\geq 0.8$ )

# Landsat Phenology

1 year NDVI for single 30m pixels  
extracted from 12 monthly WELD composites





# WELD NDVI Validation

## AmeriFlux tower instruments include

- pyranometer (0.3-2.8  $\mu\text{m}$ )
- photosynthetically active radiation (PAR) sensor (0.4-0.7  $\mu\text{m}$ )

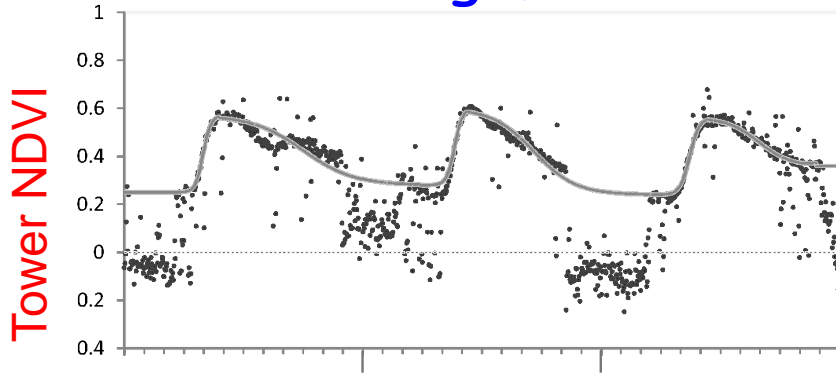


Compute 10AM flux tower **NDVI**  
(Wittich and Kraft, 2008)

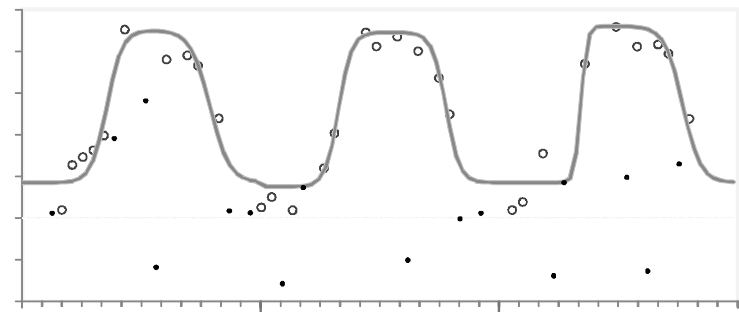
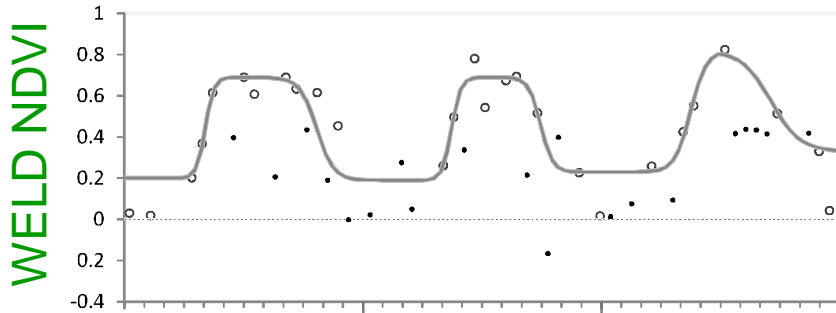
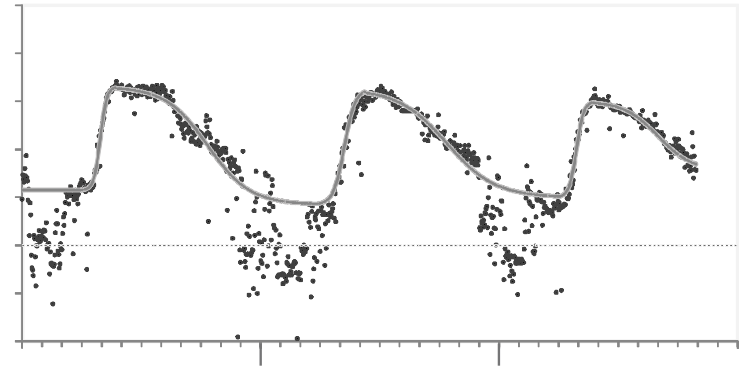
Flux tower **NDVI** sensed over an area  
comparable to a Landsat pixel, as sensors

- 2 - 2.5m above ground
- 80° conical field of view

# Brookings, SD



# Fermi, IL



2007

2008

2009

2007

2008

2009



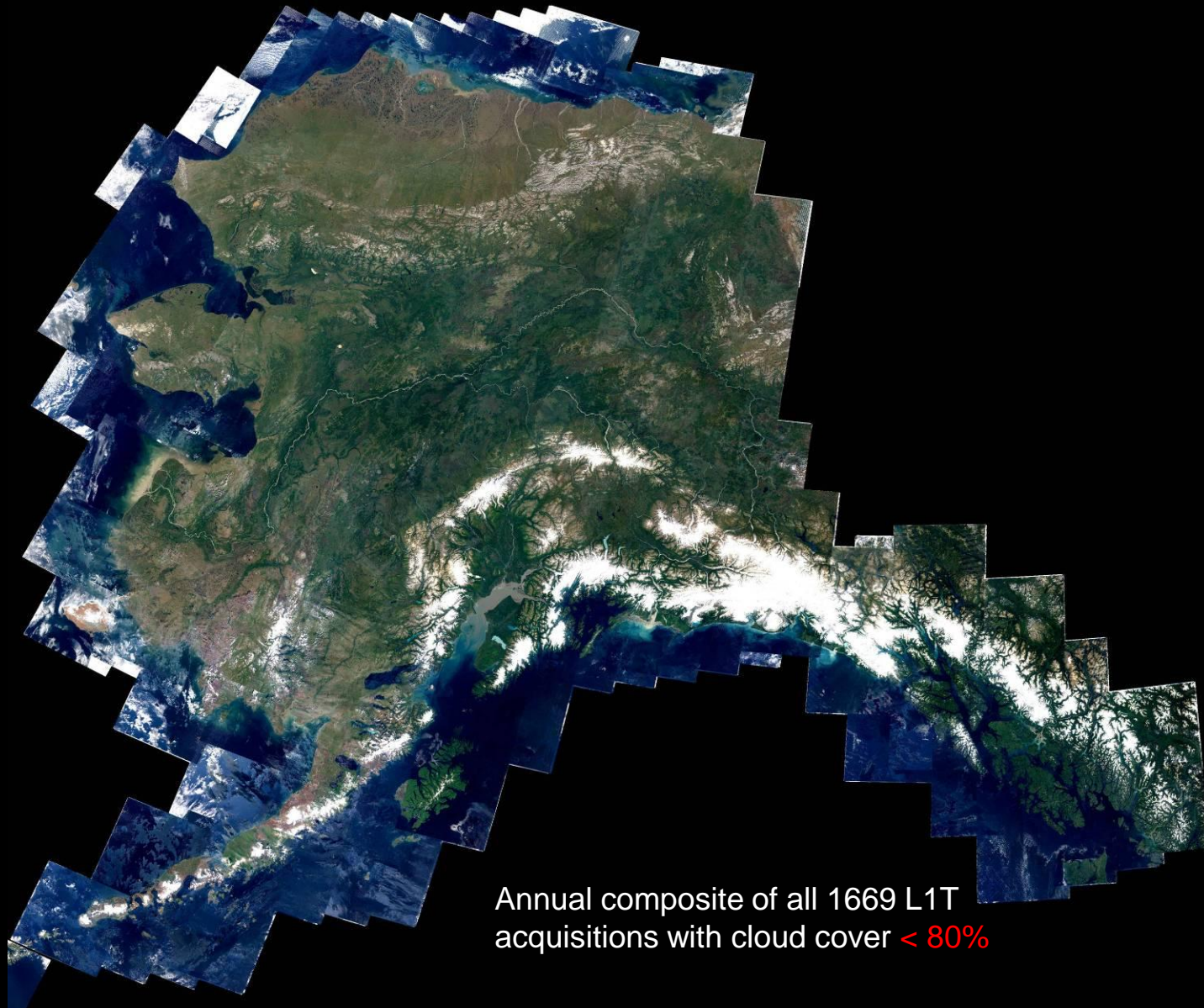
# Pearson correlation coefficients between 3 years of temporally corresponding good quality satellite NDVI

	Brookings (n=24)		Fermi (n=21)		Brookings and Fermi combined (n=45)	
	MODIS NDVI	WELD NDVI	MODIS NDVI	WELD NDVI	MODIS NDVI	WELD NDVI
Flux Tower NDVI	0.66	0.91	0.85	0.88	0.72	0.88

All correlations are significant at the 99% confidence level.

# Annual 2007 Composite

## 500m Browse

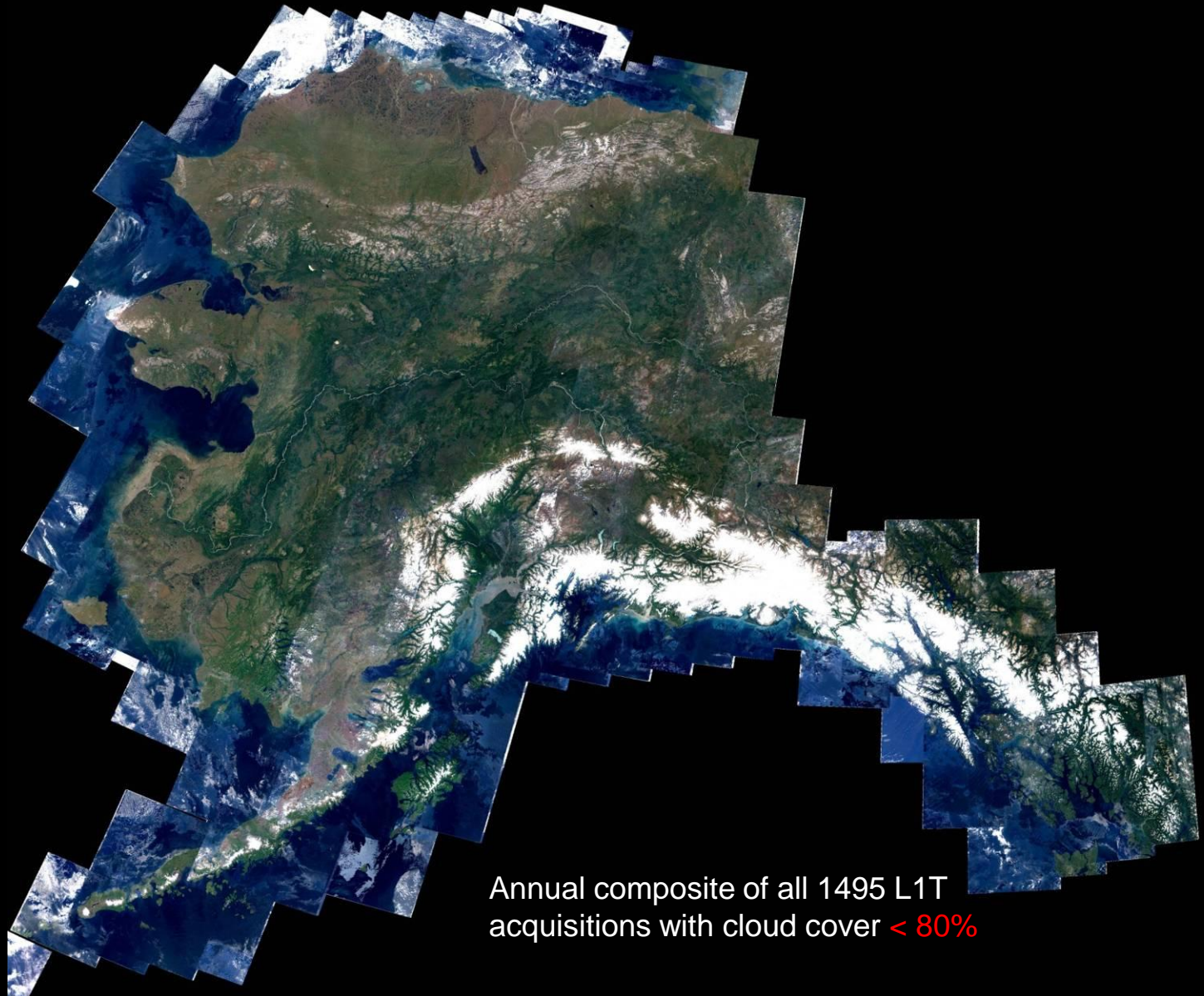


Annual composite of all 1669 L1T  
acquisitions with cloud cover < 80%



# Annual 2008 Composite

## 500m Browse

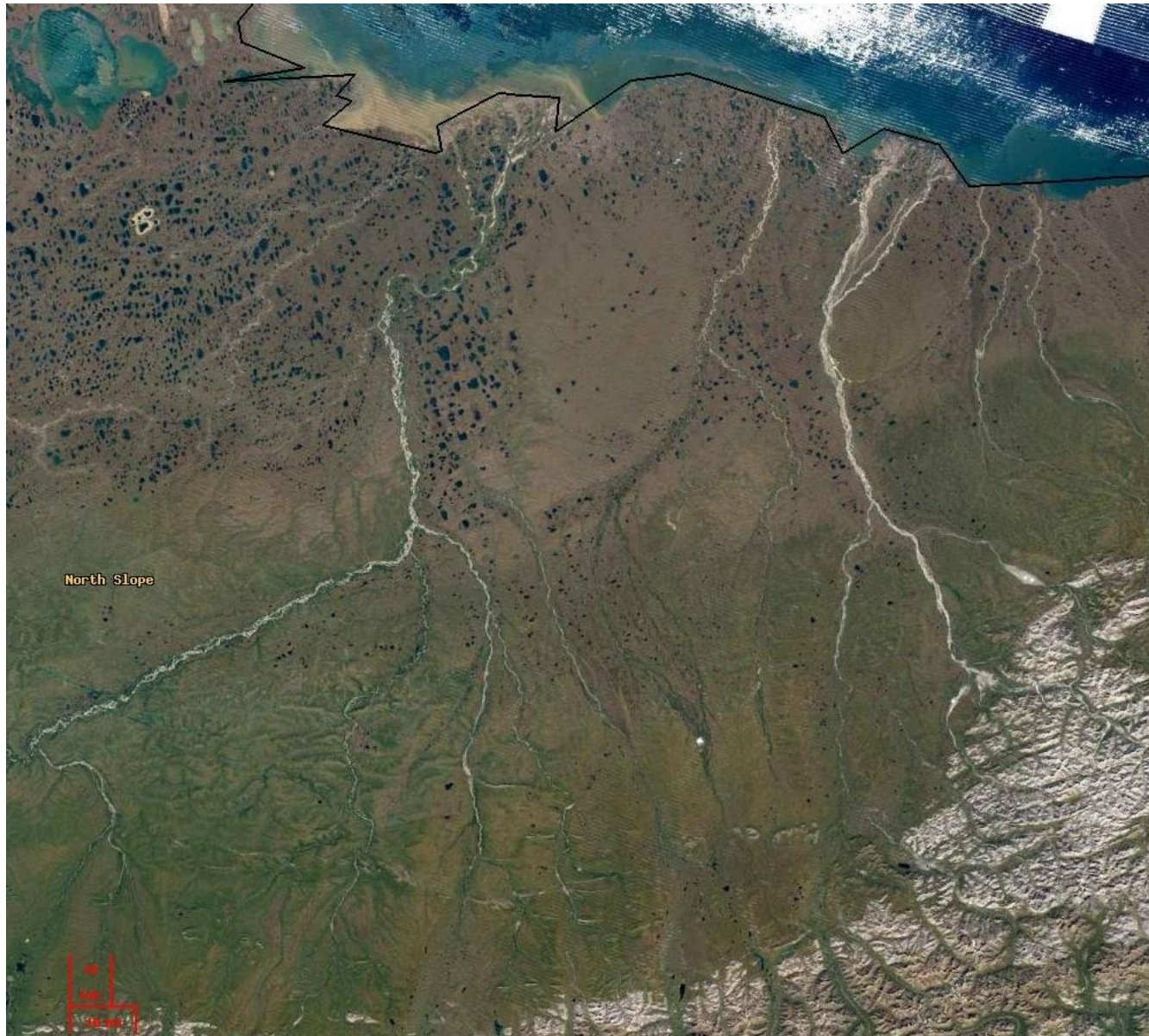


Annual composite of all 1495 L1T  
acquisitions with cloud cover < 80%



# Alaska, North Slope

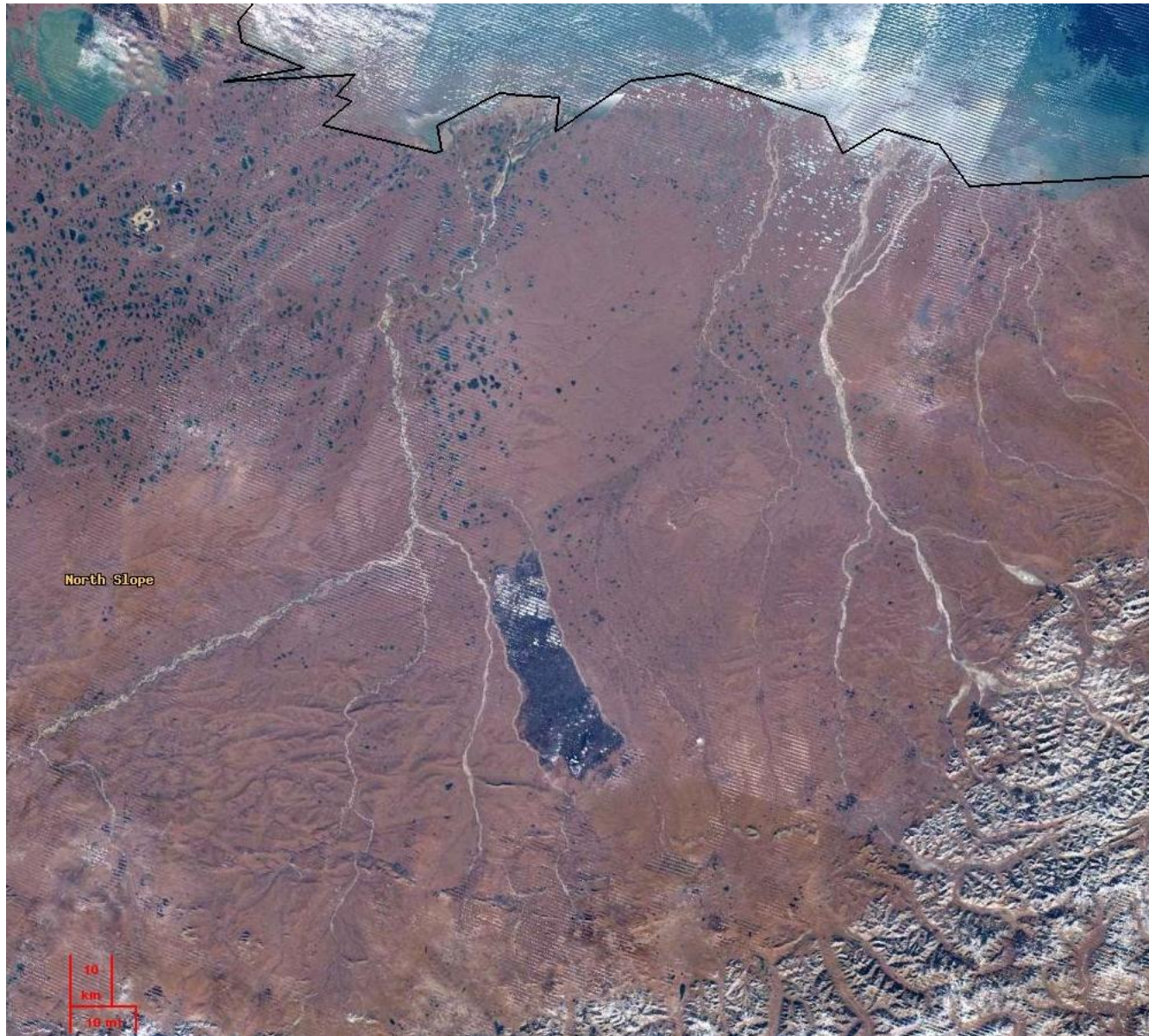
Summer WELD composite (June - August) 2007





# Alaska, North Slope

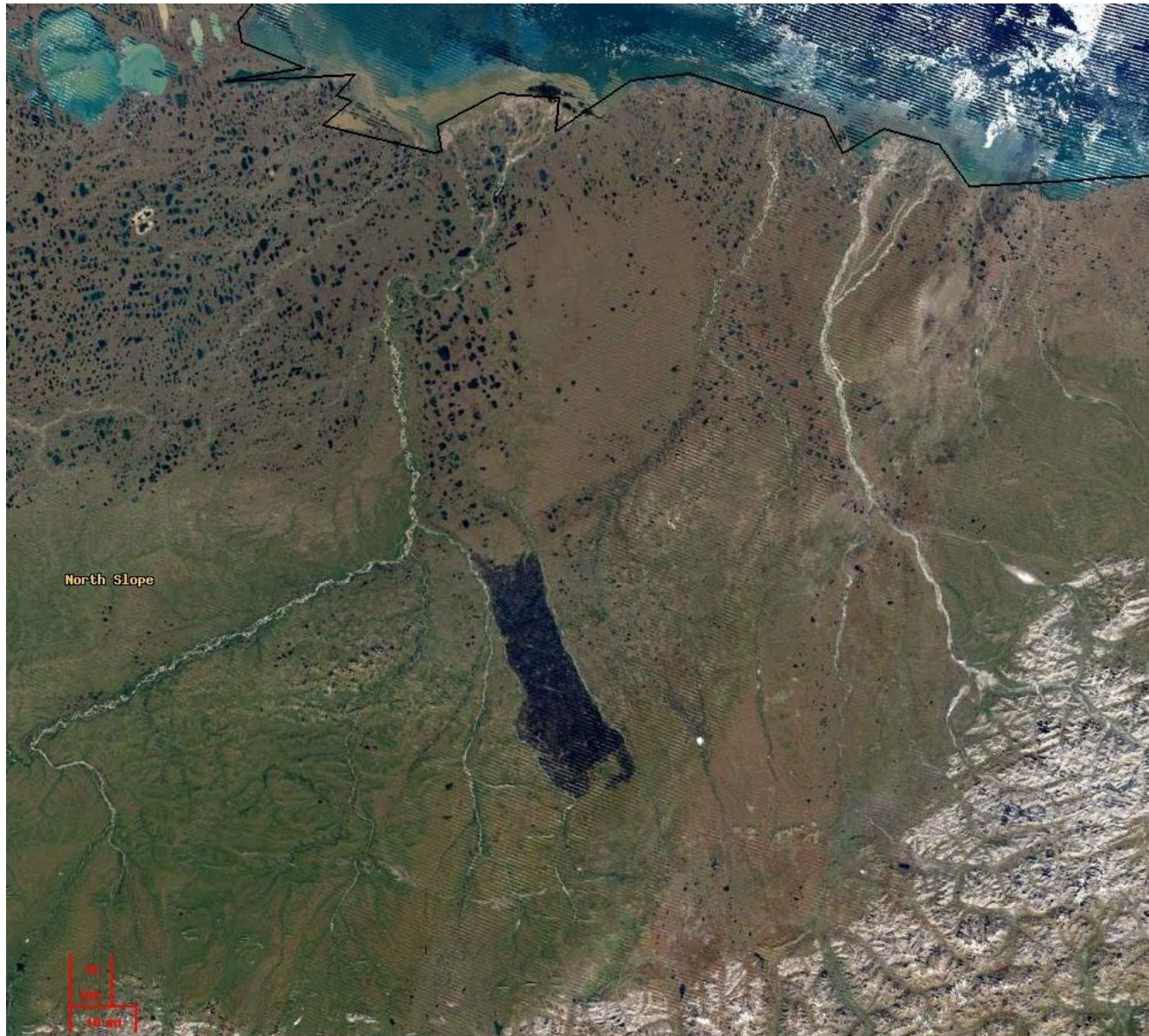
Autumn WELD composite (September - November) 2007





# Alaska, North Slope

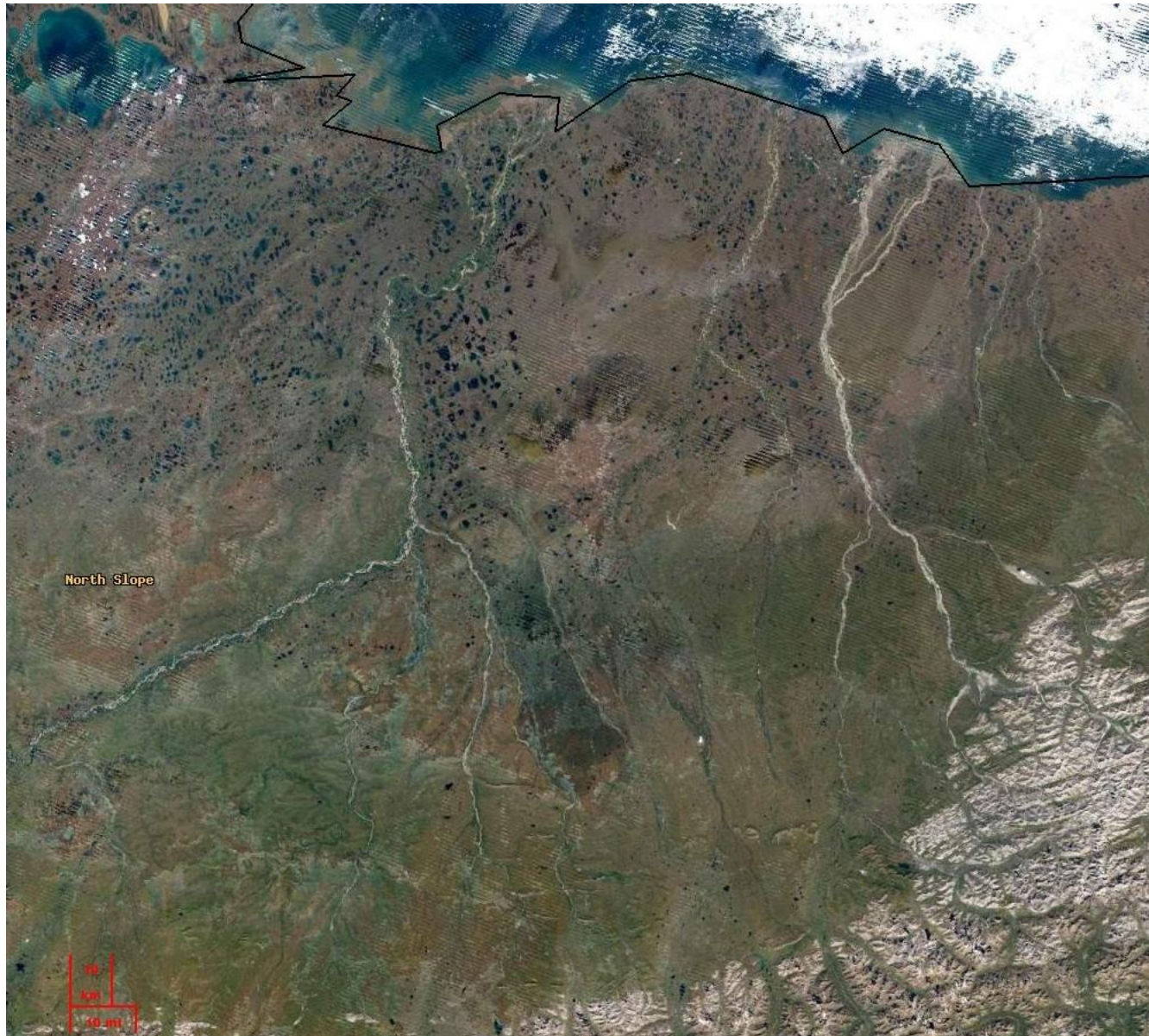
Summer WELD composite (June - August) 2008



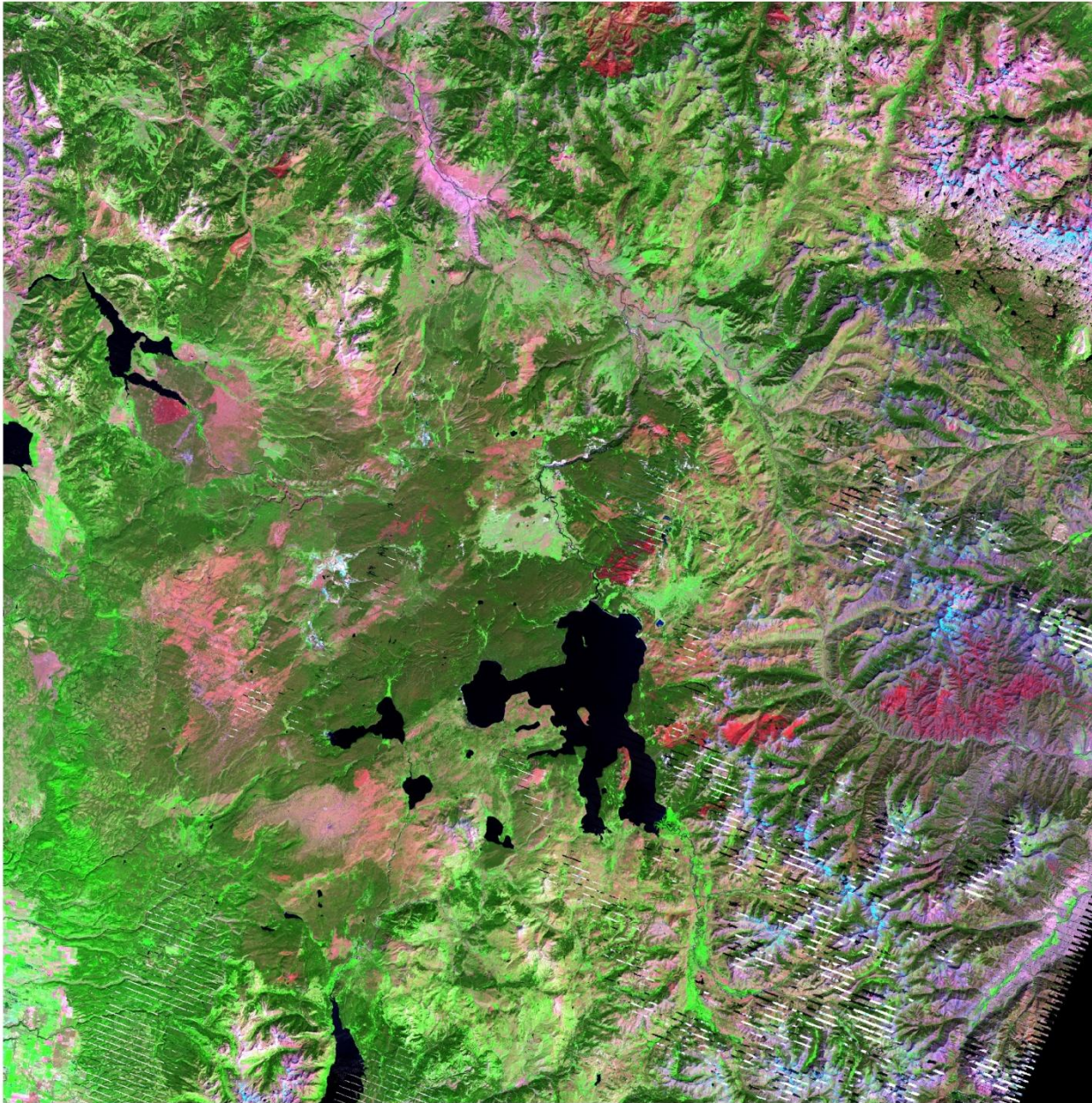


# Alaska, North Slope

Summer WELD composite (June - August) 2009







WELD tile h09v05

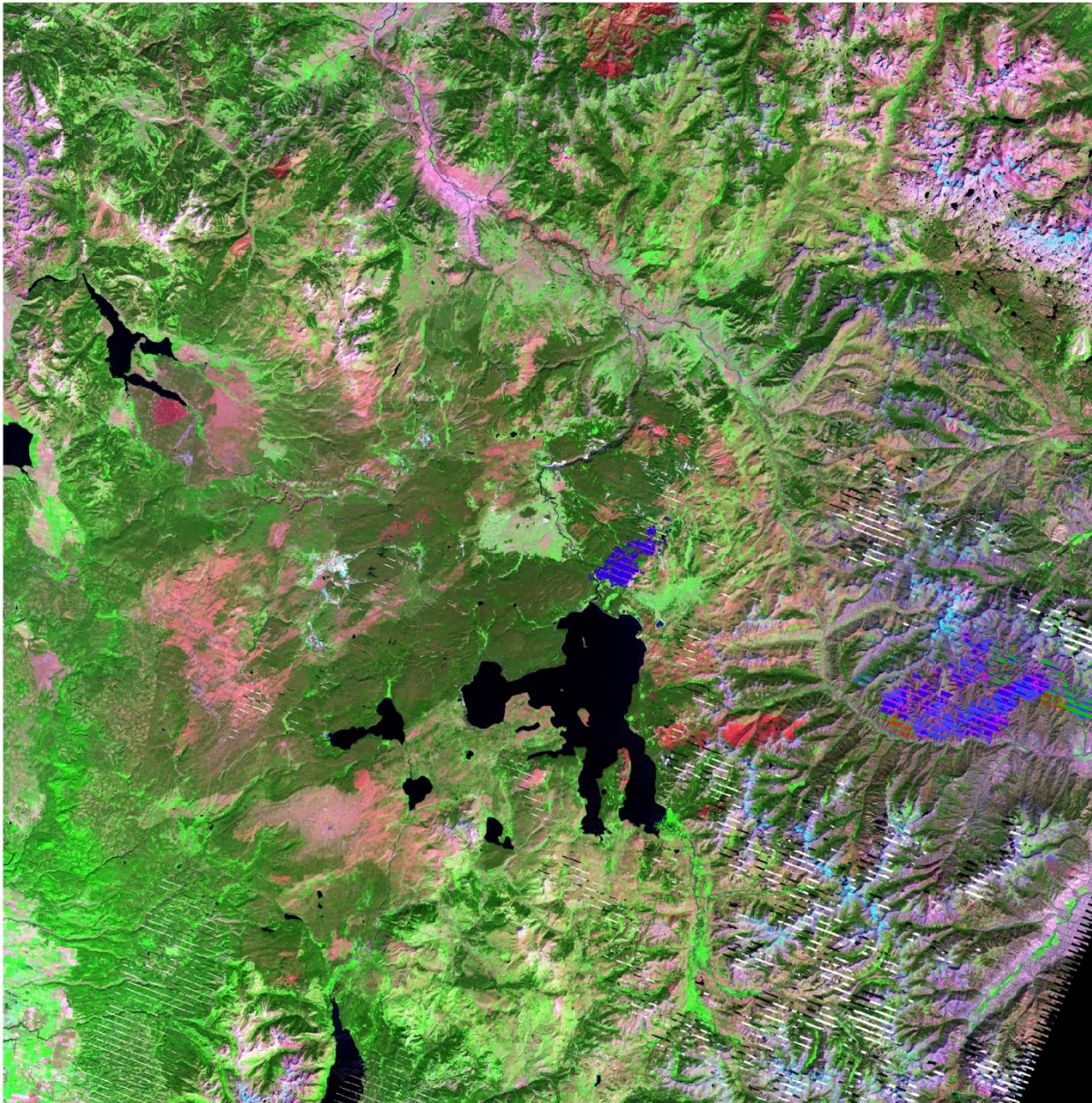
August 2008

Monthly composite

R=B7 G=B4 B=B3

Burned areas from  
2007 are still  
visible, some new  
extensive burns  
(red tones)





WELD tile h09v05

August 2008

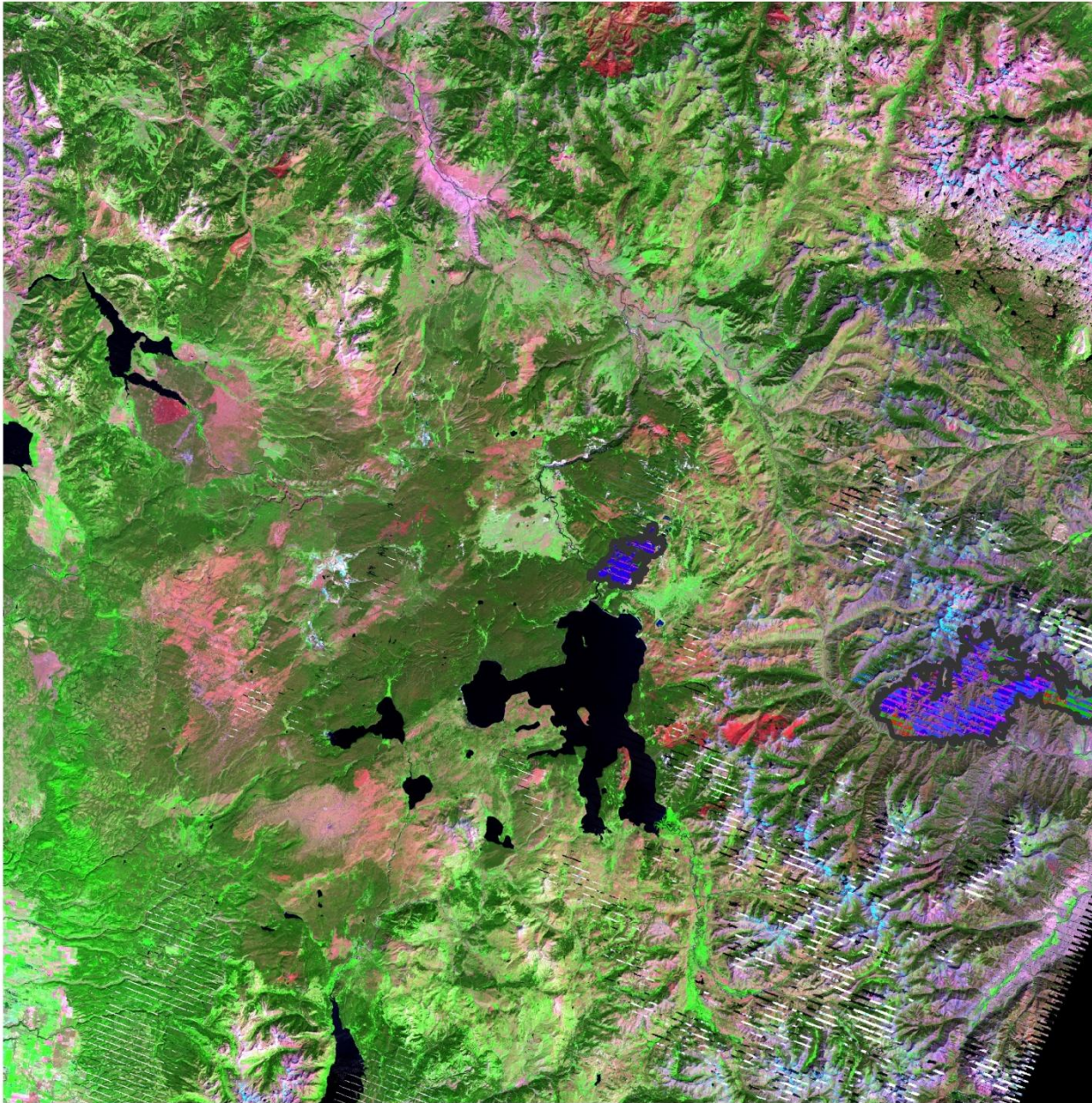
Monthly composite

R=B7 G=B4 B=B3

**Automatic  
detection of  
burned areas from  
a time series of  
weekly WELD  
composites.**

(Boschetti et al.)





WELD tile h09v05

August 2008

Monthly composite

R=B7 G=B4 B=B3

**Automatic  
detection of  
burned areas from  
a time series of  
weekly WELD  
composites.**

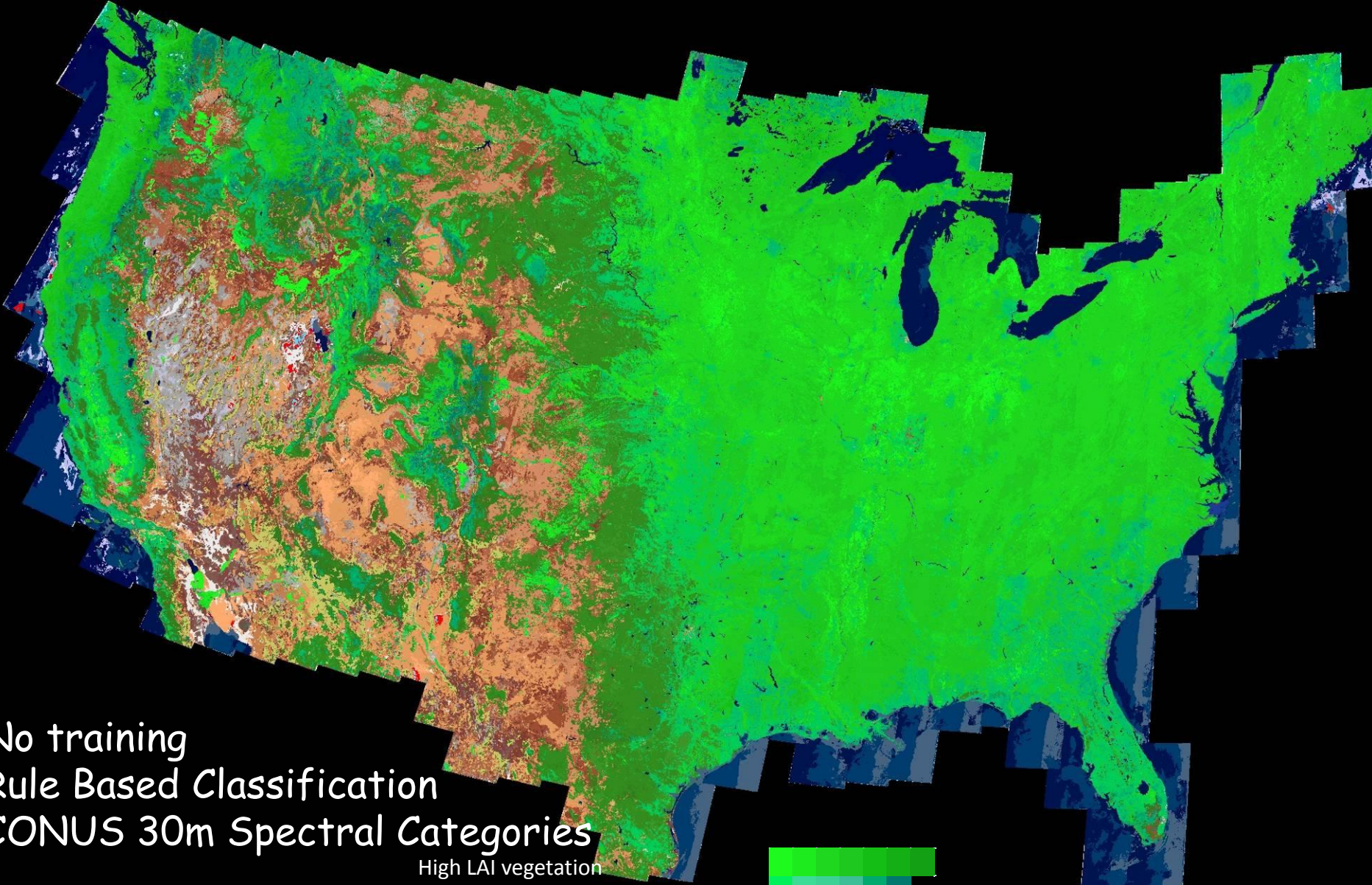
(Boschetti et al.)





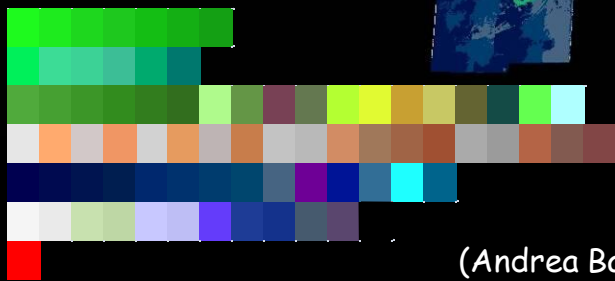
Annual 2008 composite  
7665 L1T acquisitions with cloud cover < 80%





No training  
 Rule Based Classification  
 CONUS 30m Spectral Categories

- High LAI vegetation
- Medium LAI vegetation
- Other vegetation types
- Bare soil or built-up
- Water, snow
- Clouds, smoke plumes, shadow
- Unclassified



(Andrea Baraldi et al.)



**WELD annual  
2007  
TOA reflectance**

h07v02  
(N.W. Montana)

5000 x 5000 30m  
pixels







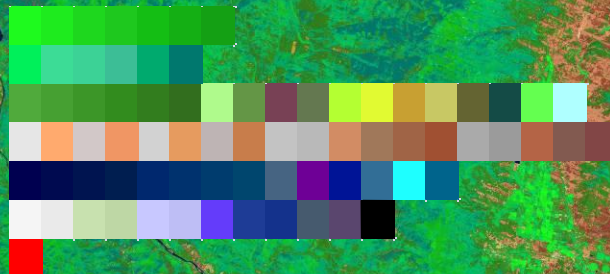
Satellite Image Automatic Mapper

## Spectral Categories

h07v02  
(N.W. Montana)

5000 x 5000 30m  
pixels

High LAI vegetation  
Medium LAI vegetation  
Other vegetation types  
Bare soil or built-up  
Water, snow  
Clouds, smoke plumes, shadow  
Unclassified







Satellite Image Automatic Mapper

## SIAM 2<sup>nd</sup> stage contextual land cover classification

Forest  
Croplands, Pasture, Grasslands  
Shrubland  
Unclassified vegetation  
Non-vegetation classes





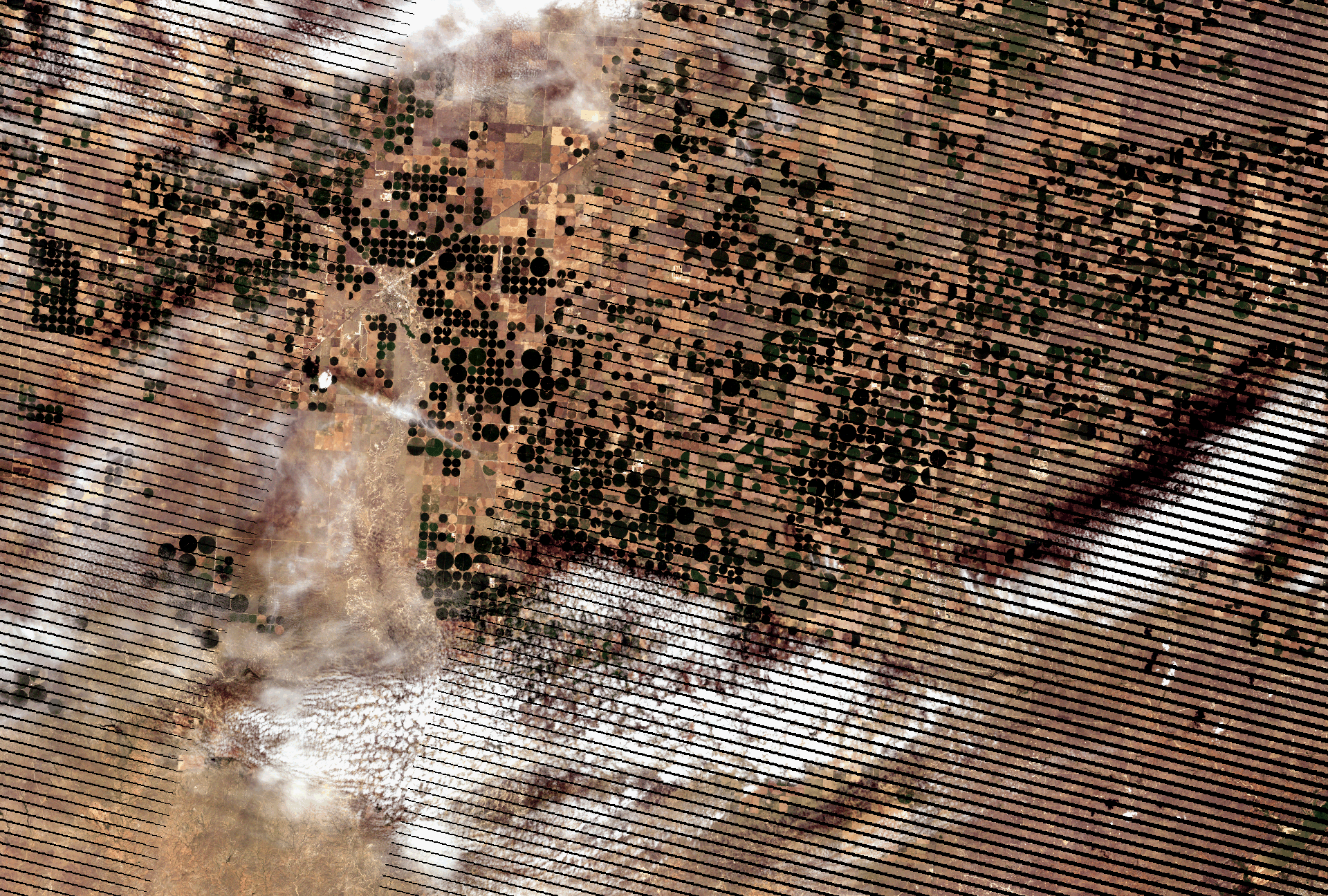


NLCD 2006  
(USGS EROS)

Evergreen Forest  
Shrub  
Grassland



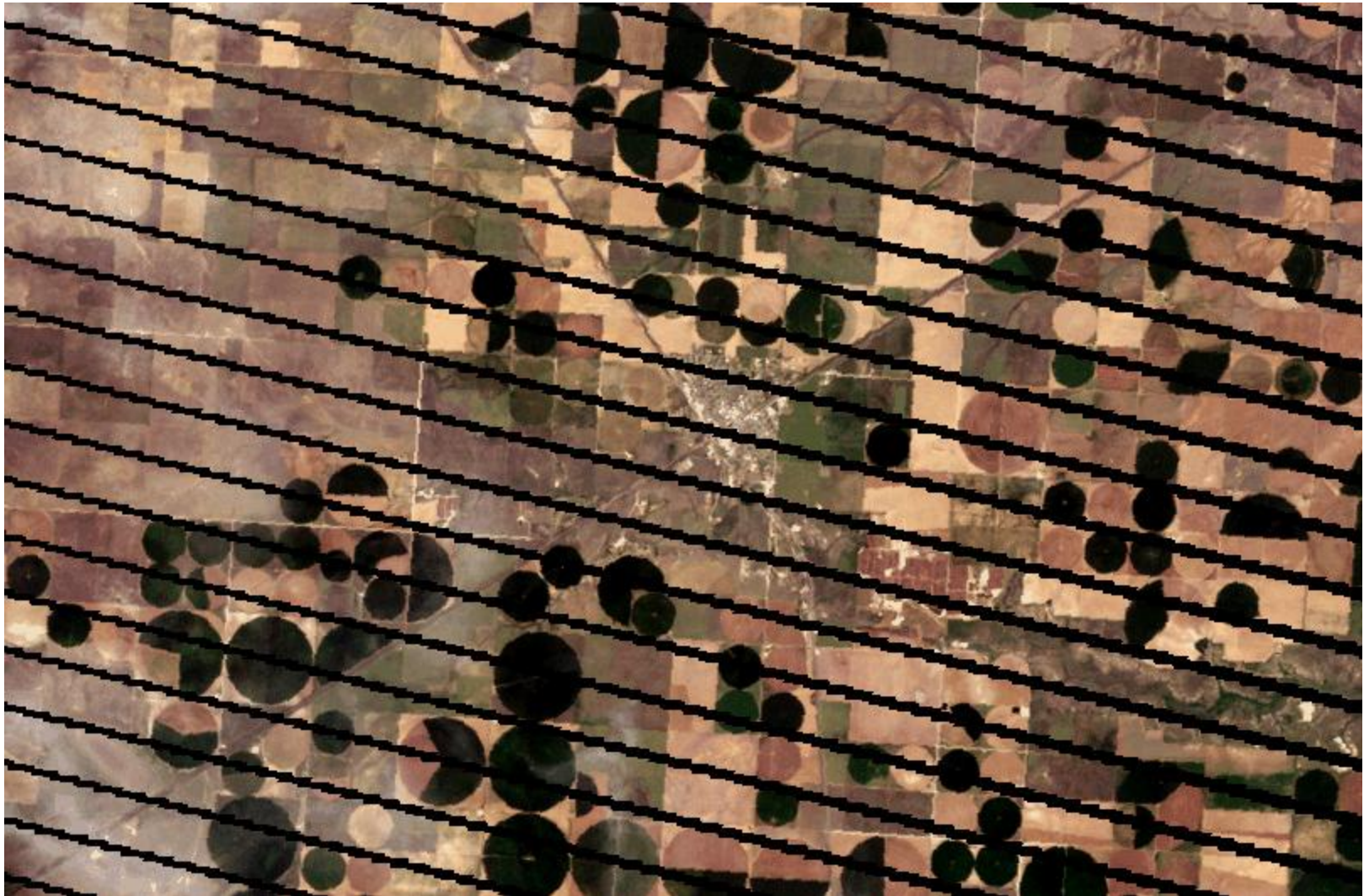




Northern Texas Panhandle  
Early August (WELD Week 32 2008)



# Early August (WELD Week 32 2008)

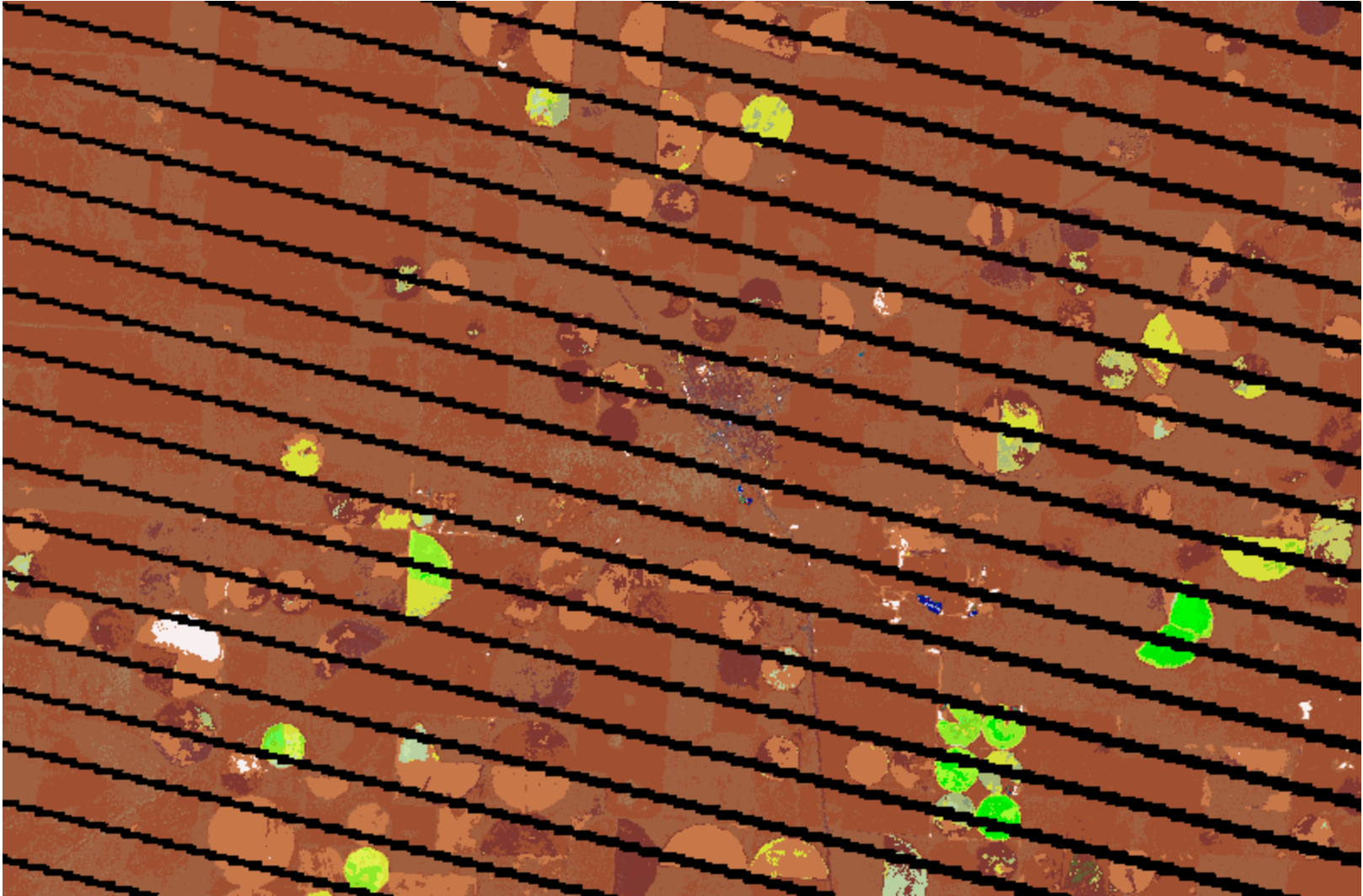


Stratford, Northern Texas Panhandle  
805 x 530 30m WELD pixels

WELD weekly TOA reflectance

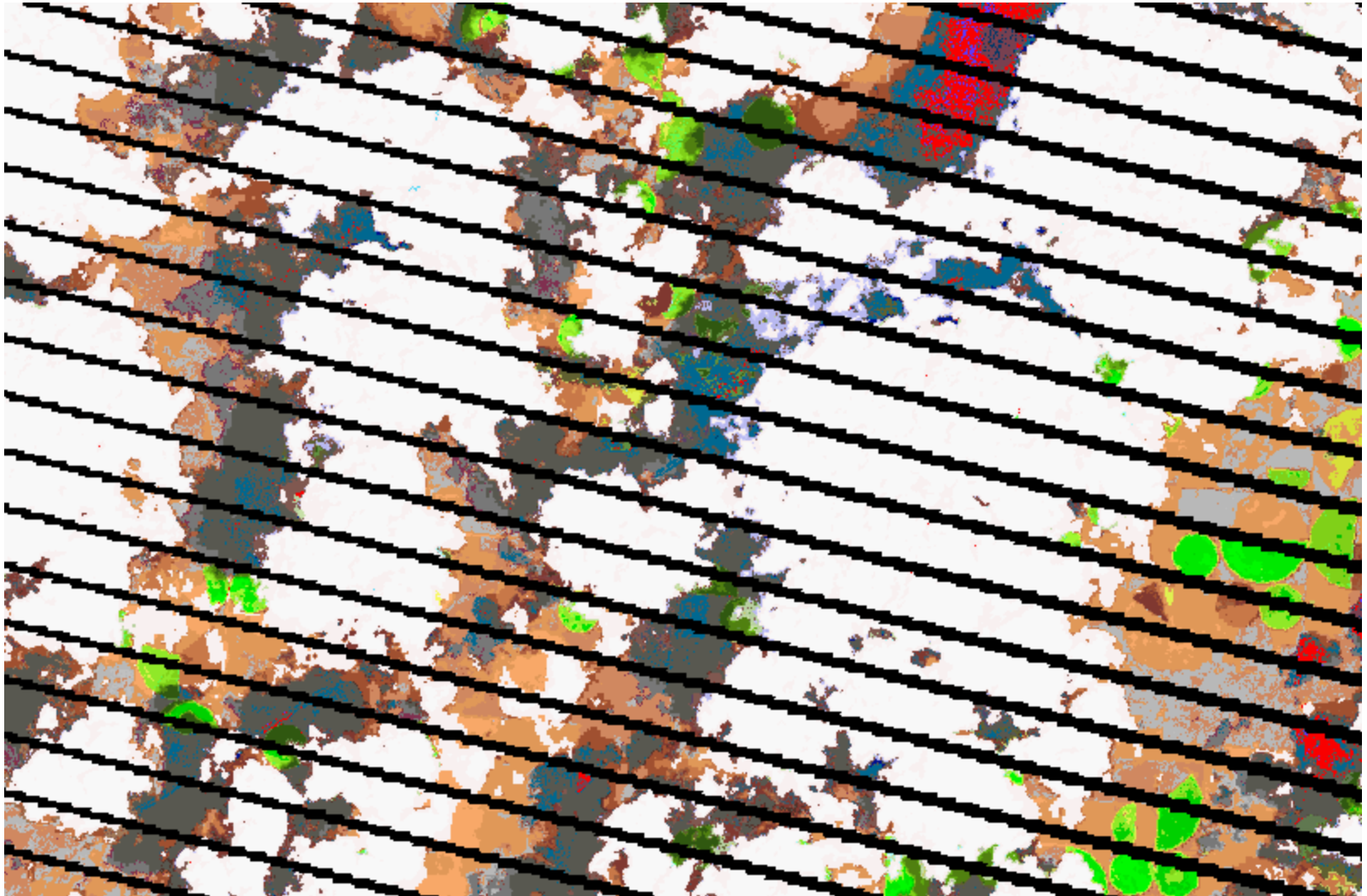


# Early March (WELD Week 9 2008)



95 spectral categories

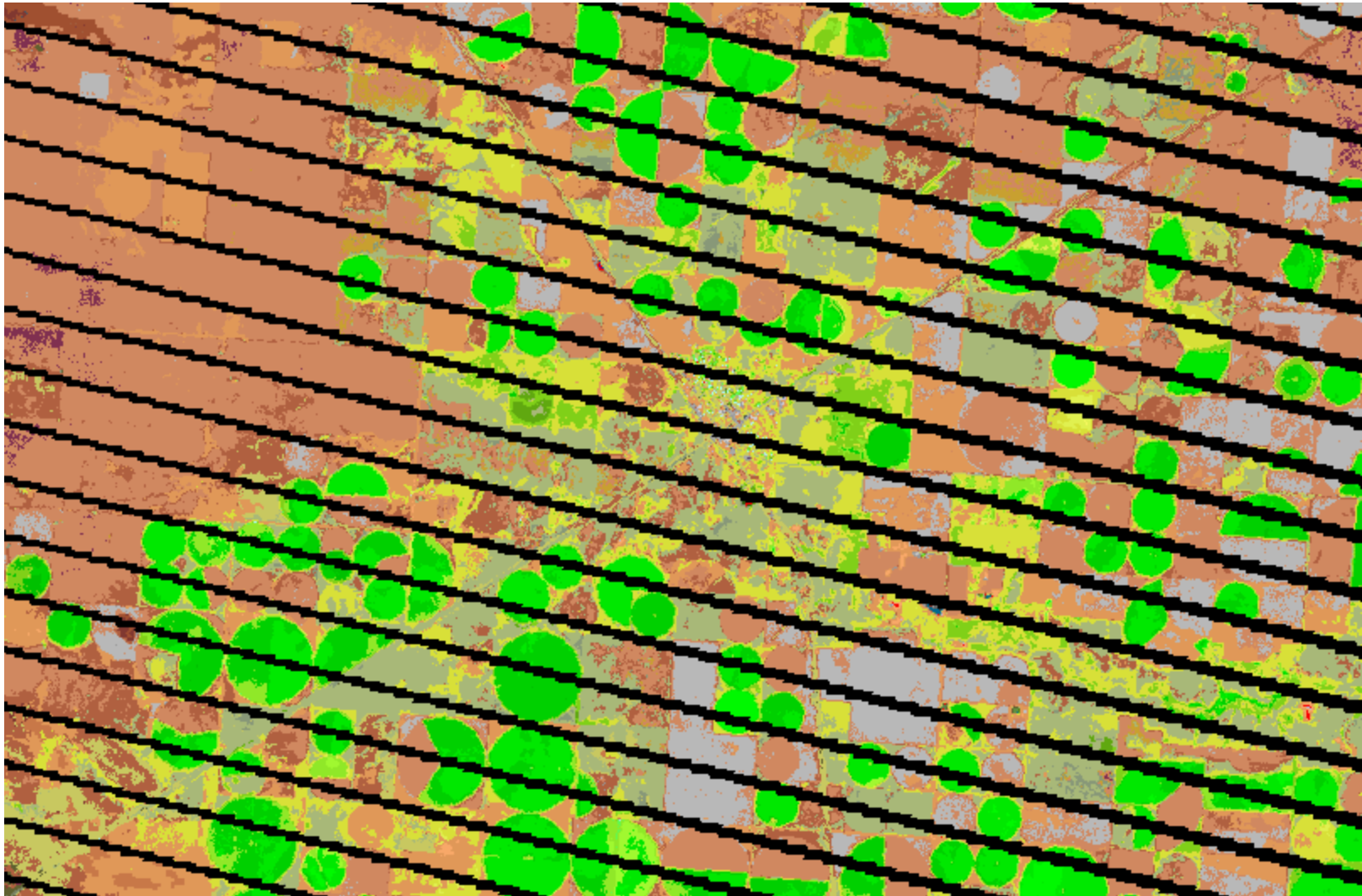
# Middle May (WELD Week 20 2008)



95 spectral categories

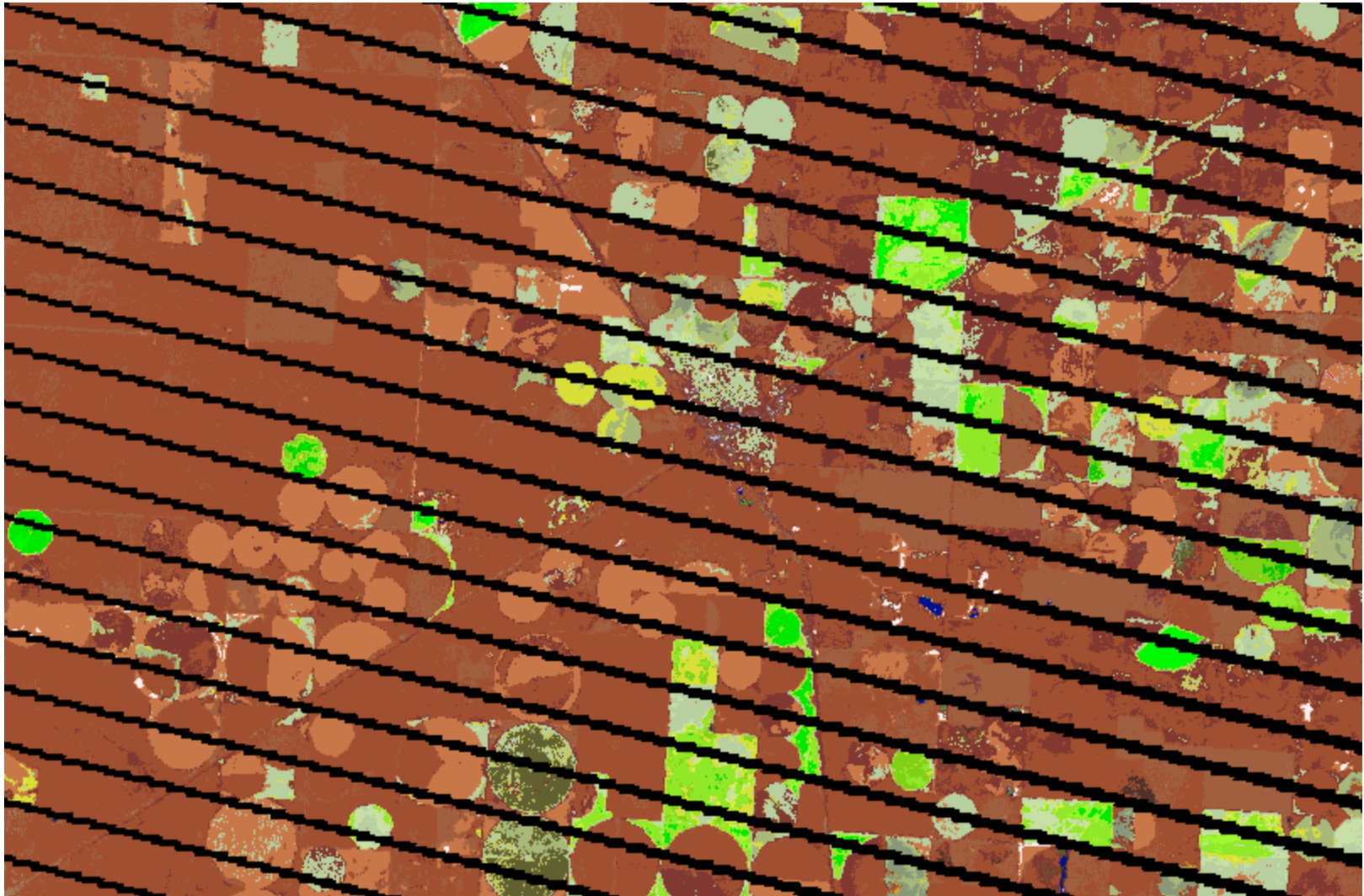


# Early August (WELD Week 32 2008)



95 spectral categories

# Early November (WELD Week 45 2008)



95 spectral categories

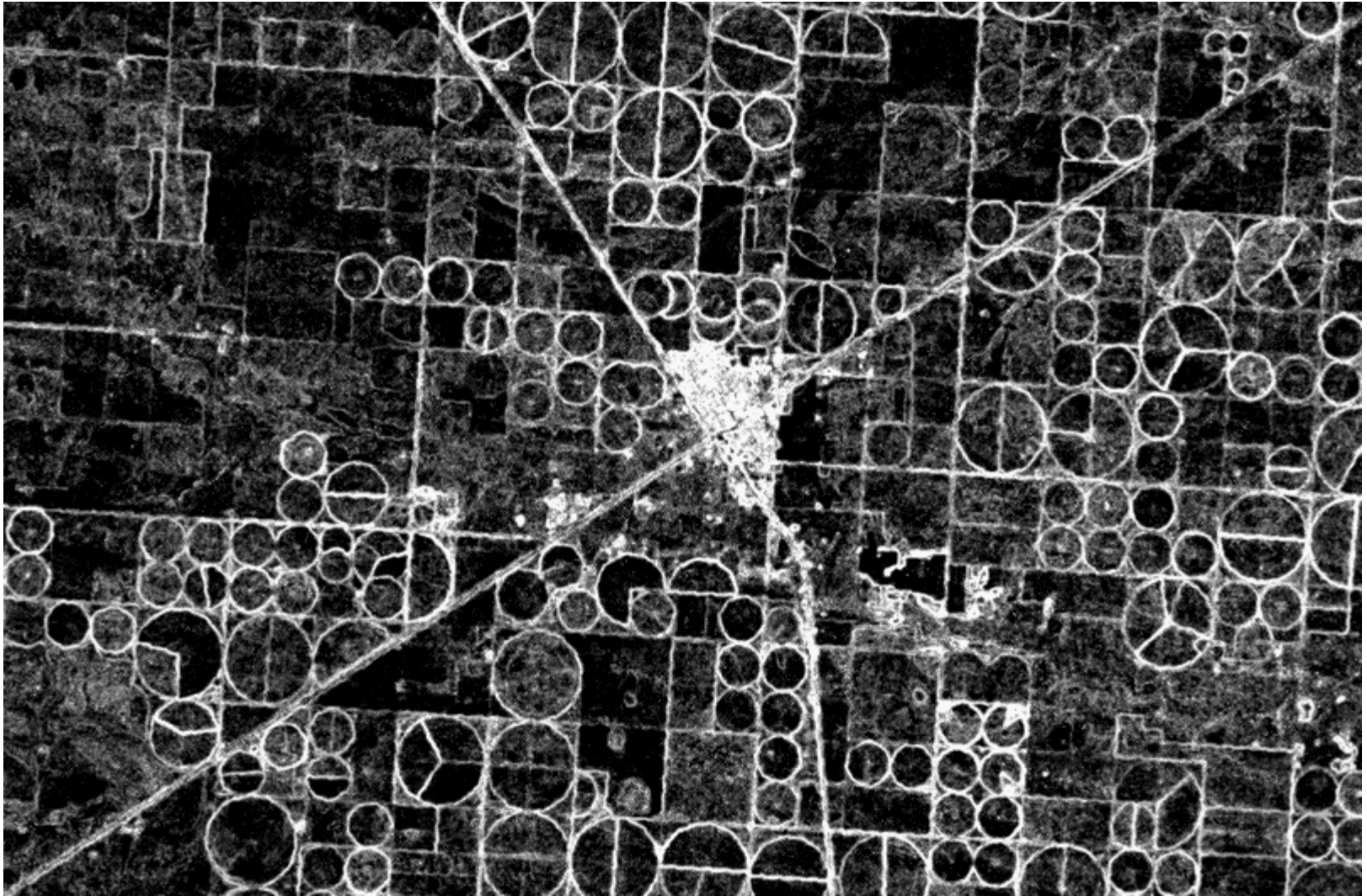


# Middle December (WELD Week 50 2008)



95 spectral categories

# Multiple-Temporal Semantic Based Edge Candidates !



Derived from SIAM spectral category classifications of 52 weekly WELD products

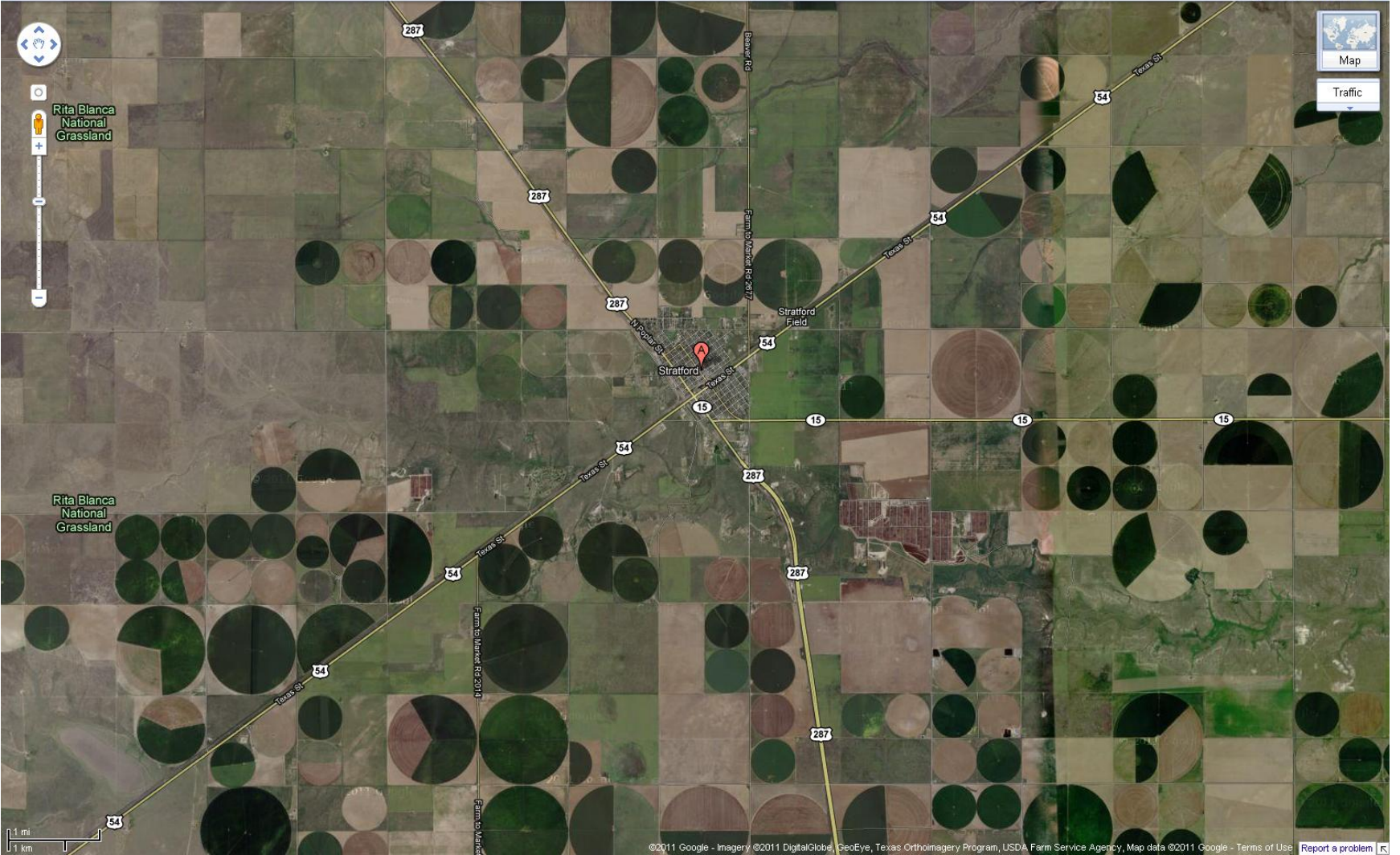




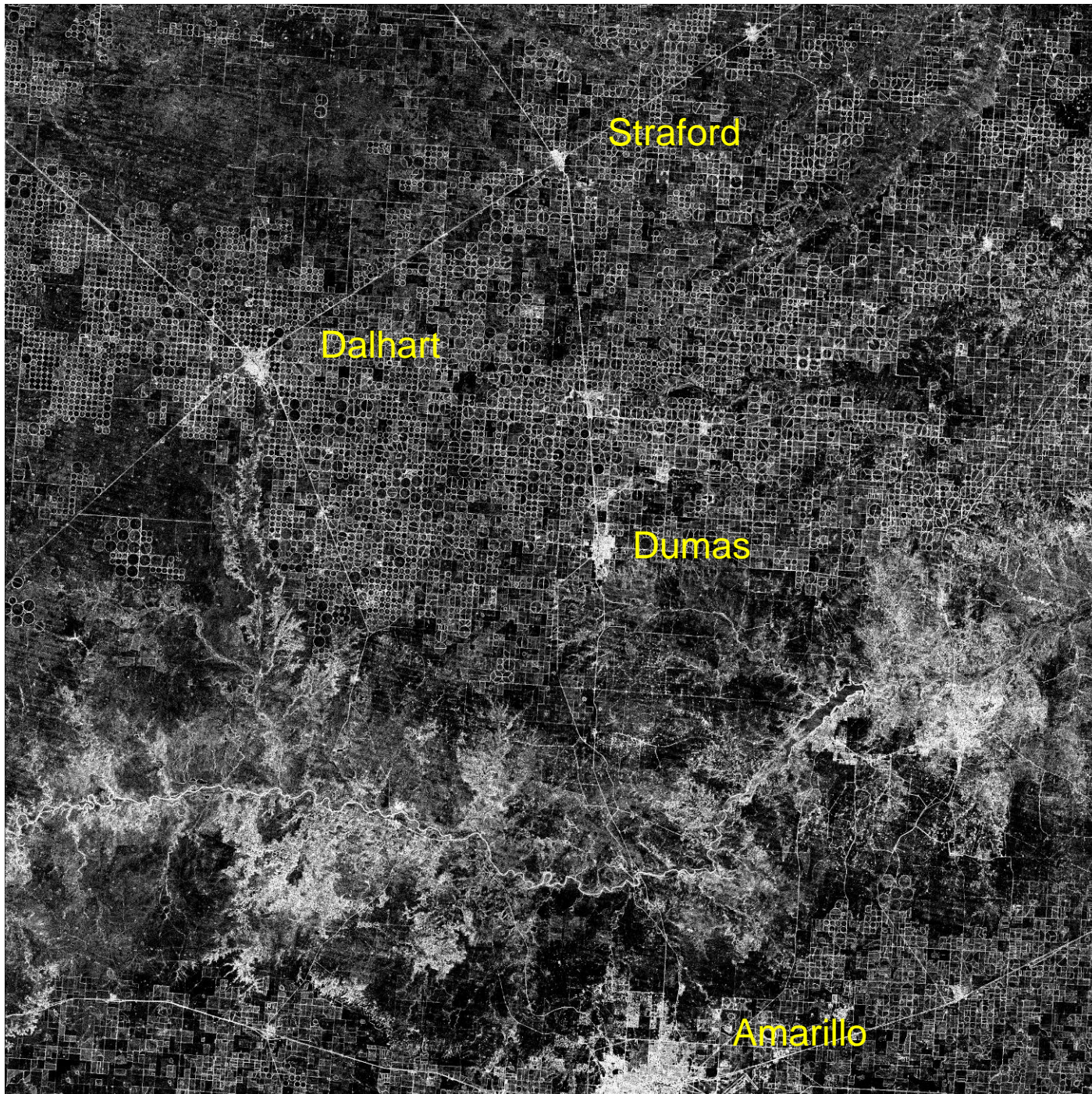
stratford texas

Search Maps

Print Send Link







Multiple-  
Temporal  
Semantic  
Based  
Edge  
Candidates  
from SIAM  
output

derived from  
one year of  
weekly WELD  
products

5000 x 5000  
30m pixels

Northern Texas  
Panhandle



# Landsat ETM+ 30m Leaf-on Single Month composite

(Southern hemisphere Jan. 2010, Tropics  $\pm 20^\circ$  October 2009, Northern hemisphere July 2009)

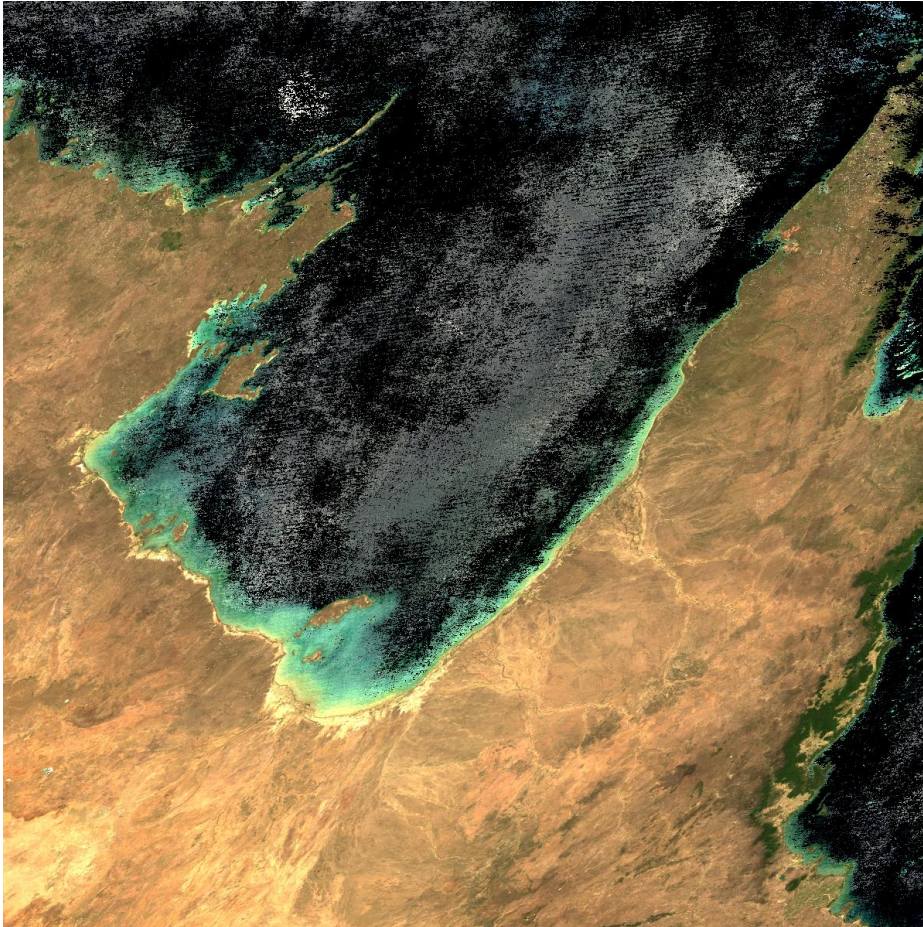
## Global WELD Pathfinding



MODIS Land Sinusoidal Projection

Generated from 6,796 L1T acquisitions in USGS EROS archive with cloud cover < 40%

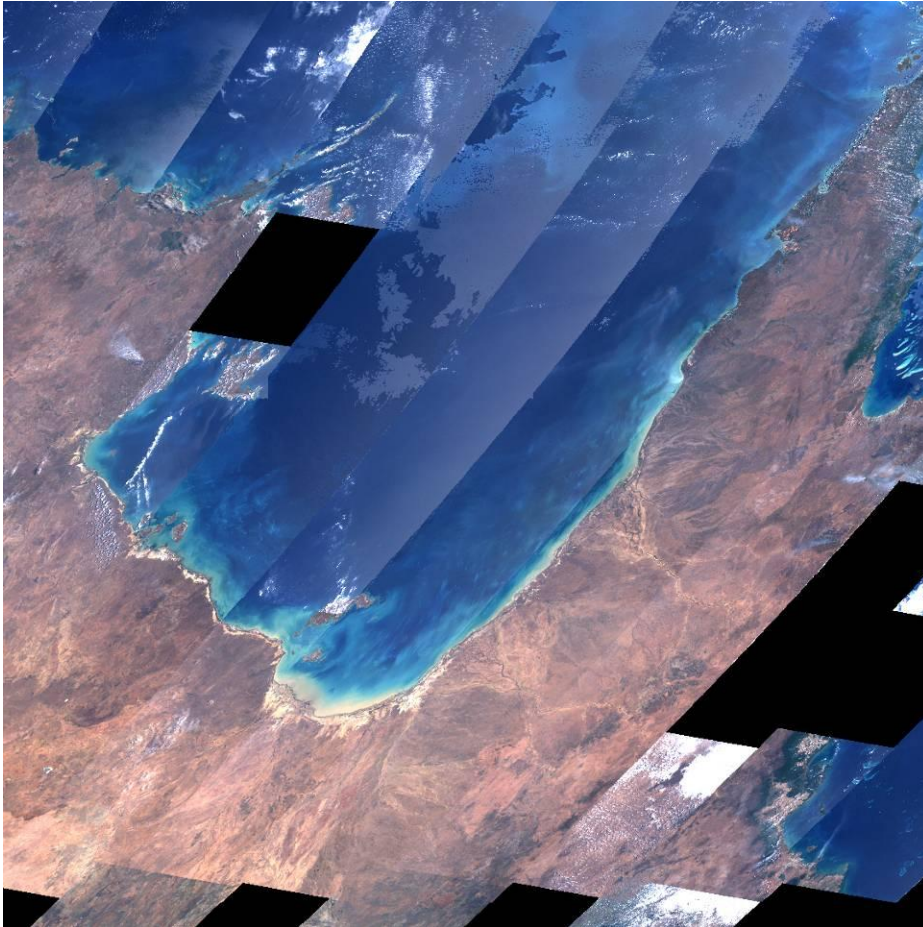
# MODIS Land Tile ~ 1200x1200km



- MODIS nadir view BRDF-adjusted 500m true color reflectance
- MODIS Land Tile h31v10
- All Terra and Aqua daily surface reflectance for October 2009
- Gulf of Carpentaria, Australia



# Global WELD single month composite



- ETM+ TOA true color 30m reflectance composite
- All October 2009 ETM+ acquisitions in USGS EROS archive cloud cover <40%
- Gulf of Carpentaria, Australia

# Global Coverage WELD Pathfinding



Over the conterminous US

~ 460 Landsat path/rows

~ 11,000,000,000 30m land pixels

Globally

~ 13,700 Landsat unique path/rows

≈ 170,000,000,000 30m land pixels



# NASA Earth Exchange (NEX)

NASA Ames Research Center, CA

The NEX is NASA's largest, most powerful supercomputer

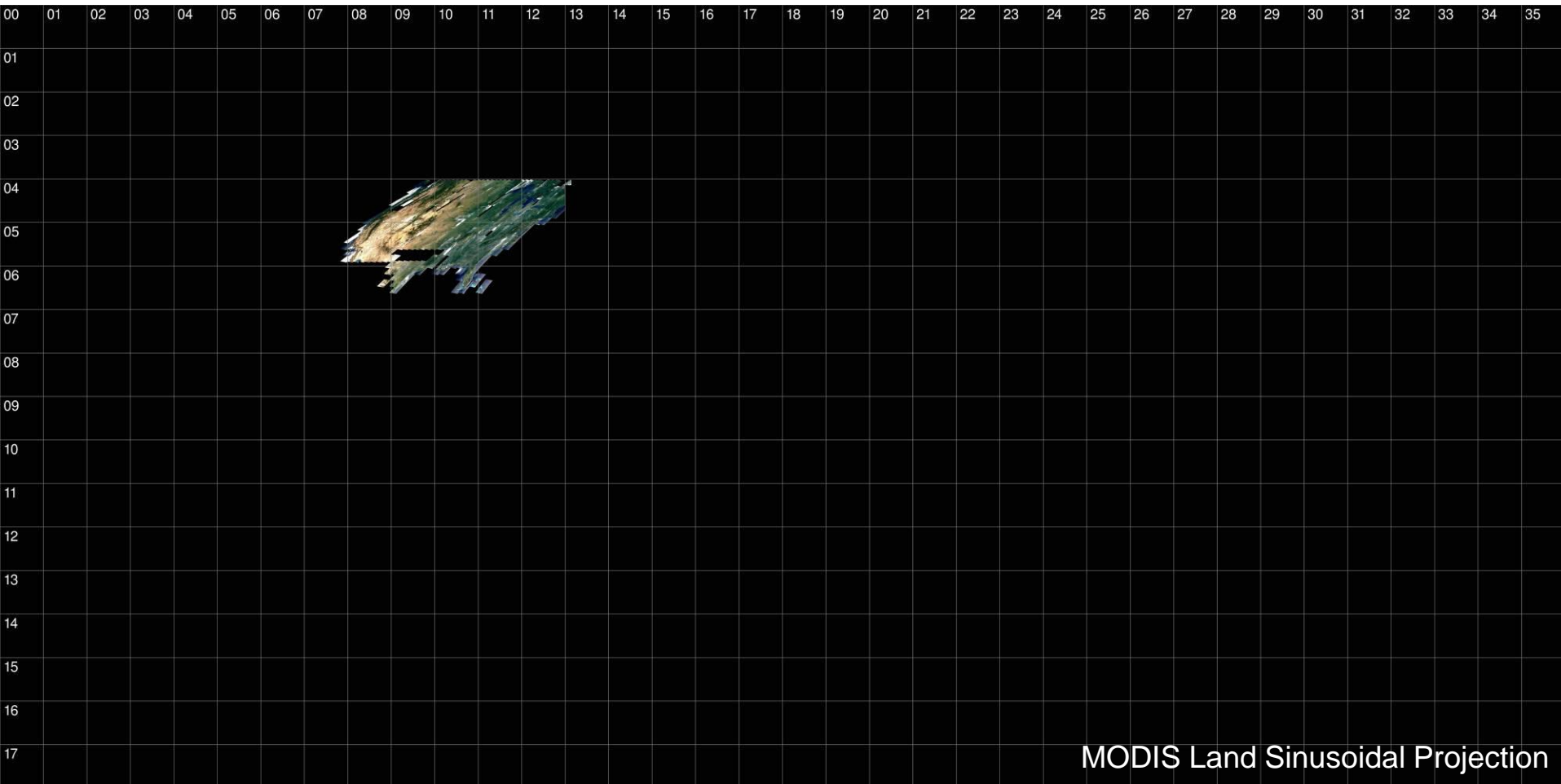
- cloud of 80,000 CPU cores
- more than 1 Petabyte of online disk storage
- access to over 10 Petabytes of tape backup storage.

Now working with Rama Nemani *et al.* at NASA AMES

- AMES Feb. meeting to discuss running GLOBAL WELD code on the NEX
- calculate that can run annual and 12 monthly Global WELD products in a single work day



# NEX - early result - CONUS July 2008





# NASA WELD Project Review Recommendations

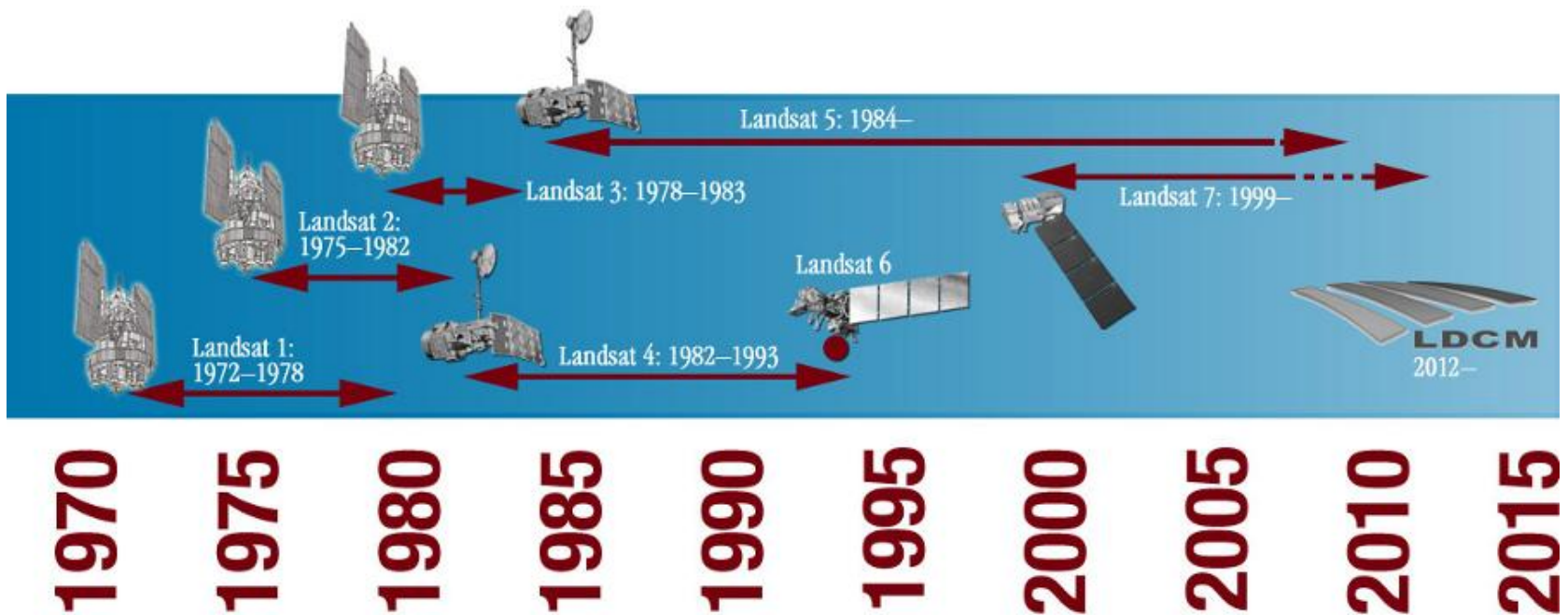
## Annapolis, March 8th 2011

Curtis Woodcock (Chair), Mark Carroll, Jeff Chambers,  
Jeff Masek, Diane Wickland, Martha Maiden, Rama Ramapriyan

- WELD product schedule & community review process encouraged
- In addition:
  - 1 year SLC-ON (2002) Landsat ETM+ WELD products
  - Sample Landsat 5 & Landsat 7 WELD product fusion
  - Clouds and Shadows
  - ATBD and Software

Will do these in the 2 years of remaining funding

# The community wants a long term Landsat data record of higher level products, globally



WELD process *all the global archive* (perhaps ..)





Expand All | Collapse All

About the WELD Project

Version 1.5 Product Documentation

Version 1.5 Product Quality

Planned Version 2.0 Product Improvements

**How To Obtain WELD Products**

WELD Product Distribution Metrics

Software Tools

Algorithm Theoretical Basis Document

Publications

<http://globalmonitoring.sdstate.edu/projects/weld/>

Recent Presentations

Example WELD Browse Images

Links

WELD Citation

Frequently Asked Questions (FAQ)

WELD Help Email

Backup Slides



## Version 1.5 WELD Product Format (all pixels are 30m)

Science Data Set Name	Data Type	Valid Range	Scale factor	Units	Fill Value
Band1_TOA_REF	int16	-32767 -- 32767	10000	Unitless	-32768
Band2_TOA_REF	int16	-32767 -- 32767	10000	Unitless	-32768
Band3_TOA_REF	int16	-32767 -- 32767	10000	Unitless	-32768
Band4_TOA_REF	int16	-32767 -- 32767	10000	Unitless	-32768
Band5_TOA_REF	int16	-32767 -- 32767	10000	Unitless	-32768
Band61_TOA_BT	int16	-32767 -- 32767	100	Degrees Celsius	-32768
Band62_TOA_BT	int16	-32767 -- 32767	100	Degrees Celsius	-32768
Band7_TOA_REF	int16	-32767 -- 32767	10000	Unitless	-32768
NDVI_TOA	int16	-10000 -- 10000	10000	Unitless	-32768
Day_Of_Year	int16	1 -- 366	1	Day	0
Saturation_Flag	uint8	0 -- 255	1	Unitless	None
DT_Cloud_State	uint8	0, 1, 2, 200	1	Unitless	255
ACCA_State	uint8	0, 1	1	Unitless	255
Num_Of_Obs	uint8	0 -- 255	1	Unitless	None

i.e., users do not need to apply the equations, spectral calibration coefficients & solar information to convert the ETM digital numbers to reflectance & brightness temperature.

Successive products are defined in the same coordinate system and align precisely, making them simple to use for multi-temporal applications.

# WELD L1T ETM+ ARCHIVE at SDSU

(on March 28<sup>th</sup> 2011)

	<b>Conterminous United States</b> (459 path/row) <80% cloud	<b>Alaska</b> (232 path/row) <80% cloud
2002	3514	85
2005	582	0
2006	8134	1759
2007	8267	2017
2008	8596	1687
2009	7934	1755
2010	8397	1741
2011	1464	294

**56,226** CONUS and Alaska acquisitions

> US \$33.7 million when each L1T acquisition cost US \$600





# a priceless archive

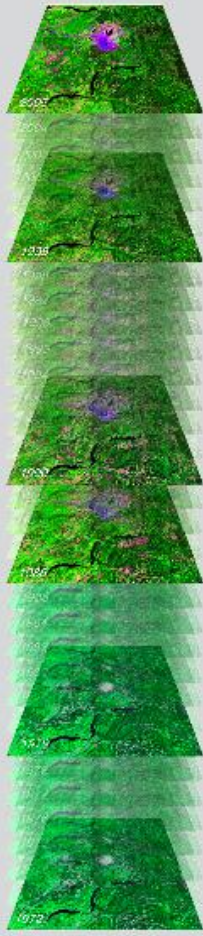
Landsat's quality, consistency, coverage, and value make it possible to conduct detailed analysis of change over time — to follow the life of a pixel.

As of 2009, all Landsat data in the USGS archive available at **no charge**, in standard format

- Orthorectified
- 30 m spatial resampling (60 m for the MSS)
- GeoTIFF
- Universal Transverse Mercator (UTM) projection



Exceptionally high standards of spectral, geometric, and radiometric calibration enable robust comparisons of change over time.

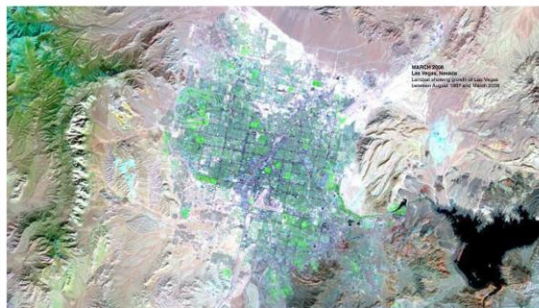


MS, SS, TM, ETM+, 1972-2012

www.nasa.gov



# an unparalleled record



## Celebrating Landsat

- The longest-running project for acquisition of moderate resolution imagery of the Earth from space
- Providing an unparalleled 35-year record of Earth's changing landscapes
- Continuously recording the entire global land surface, every season, every year
- Capturing essential images for people who work in agriculture, geology, forestry, regional planning and education

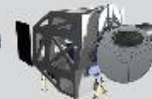
For more on the Landsat Project, visit us at <http://landsat.gsfc.nasa.gov>  
[www.nasa.gov](http://www.nasa.gov)



# Landsat next

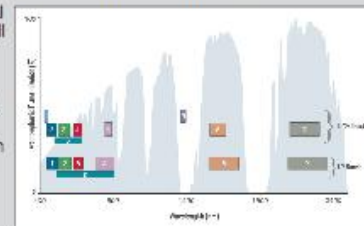
## Landsat Data Continuity Mission

LDCM's Operational Land Imager is based upon the successful EO-1 satellite's Advanced Land Imager, a pushbroom instrument.



## New and Improved Spectral Bands

**New:** The Operational Land Imager (OLI) will collect data for new coastal and cirrus bands and for the heritage multispectral bands.  
**Improved:** Bandwidth has been refined for six bands.



## Vastly Improved Radiometry

The OLI will provide improved signal-to-noise radiometric performance allowing 12-bit quantization of its data: **more fidelity, more signal, less noise.**



Landsat TM (TM1), 2001, 40 Images of Upstate New York, Collected June 28, 2001  
Landsat TM (TM1), 2001, 40 Images of Upstate New York, Collected June 28, 2001  
OLI TM, 12-bit Radiance, 2001  
OLI TM, 12-bit Radiance, 2001

## Expanded U.S. Archive

The USGS archive will preserve all 400 scenes collected daily by LDCM.

www.nasa.gov

# WELD Team

Principal Investigator: David Roy



Senior Scientist (algorithms and processing): Junchang Ju



Distribution System Software & Web Developer: Indrani Kommareddy

Distribution System Hardware Architect: Anil Kommareddy



Senior Scientist (land cover mapping): Matthew Hansen

Scientist (land cover mapping): Alexey Egorov



Senior Scientist (Atmospheric Correction): Eric Vermote

Programming support: Valeriy Kovalskyy



Landsat Data Ordering: Suba Velpuri



Landsat Cloud digitizers: Sanath Kumar, Sefa Adekpui, Devanshu Narang

EROS Distribution: Jason Werpy, David Hill, Adam Dosch, Tom Maiersperger, John Dwyer

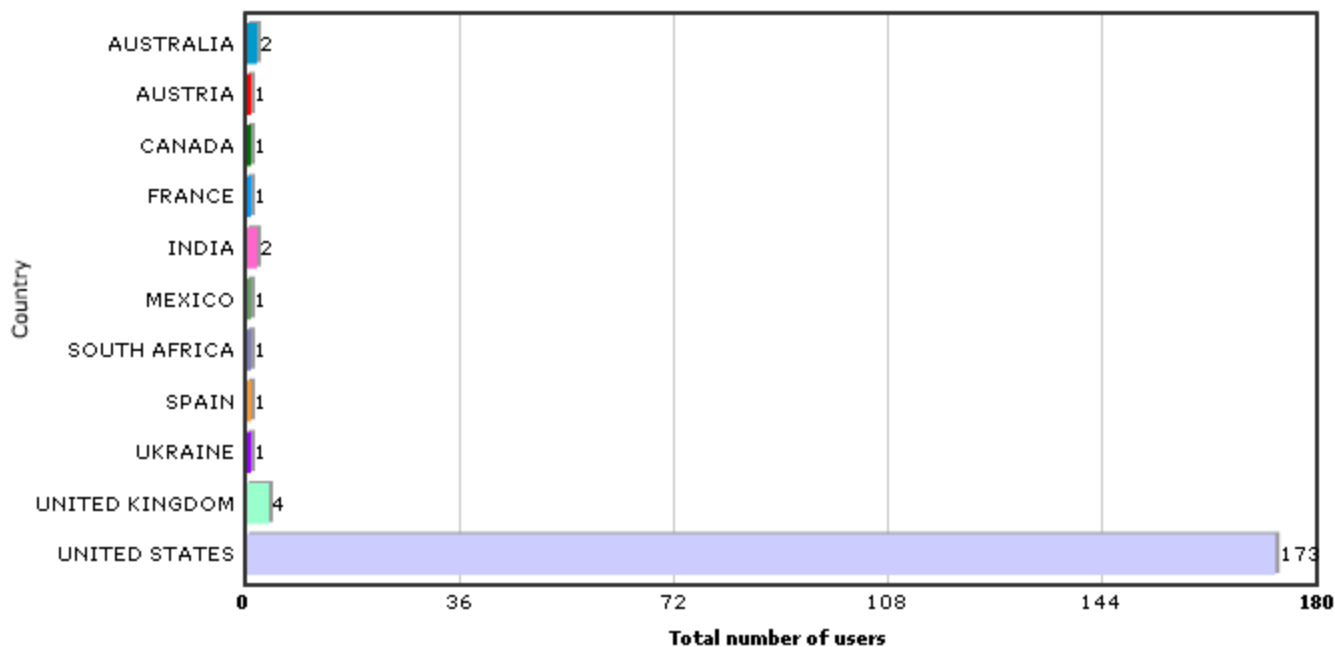
ORNL DAAC OCG Browse Distribution: Suresh SanthanaVannan, Yaxing Wei, Bob Cook



# What the Landsat user community wants ...

- Derived Landsat data products for free
- **Systematic, consistent, community endorsed data processing**
  - calibration, geolocation
  - radiometric normalization / BRDF correction, atmospheric correction
  - cloud-screening, SLC-off and cloud gap filling  
*(needed in order to derive higher level products)*
- **Composited large-area data product mosaics**
  - updated at the pixel level
  - using all the Landsat data, not just select acquisitions
  - processed shortly after acquisition i.e. “near real time”
- *i.e., similar to the NASA MODIS land products but at high spatial resolution*
- *Above is what the WELD project is developing,*
- *building on our 10 year MODIS product development, processing (and reprocessing) experience,*
- *taking advantage of the free calibrated, geolocated, Landsat (L1T) data.*

## Number of unique users ordered products by Country



## Other Metrics

Average number of 30m pixels placed by each user : 1285175139

Average number of orders placed by each user : 61

Number of unique users who registered : 190

Number of unique users who ordered data : 188

Total number of orders : 11380

Total volume of orders : 641GB

**CONUS and Alaska**





Enter email address

[<< Back](#) | [Home](#)

Email:

[? Interface Help](#)

[? WELD Product Information](#)

[? Distribution Metrics](#)



## Create Account

[<< Back](#)

Country:

Affiliation:

Primary Use:

### Secondary Use (Please select all that apply):

- |   |  |   |
|---|--|---|
| <input type="checkbox"/> Agriculture        | <input type="checkbox"/> Forestry                  | <input type="checkbox"/> Natural Resources      |
| <input type="checkbox"/> Climate Change     | <input type="checkbox"/> Geology                   | <input type="checkbox"/> Planning               |
| <input type="checkbox"/> Cryosphere         | <input type="checkbox"/> Human Ecology             | <input type="checkbox"/> Socioeconomics         |
| <input type="checkbox"/> Ecosystem Studies  | <input type="checkbox"/> Human Health              | <input type="checkbox"/> Telecommunications     |
| <input type="checkbox"/> Education          | <input type="checkbox"/> Insurance                 | <input type="checkbox"/> Terrestrial Monitoring |
| <input type="checkbox"/> Emergency Response | <input type="checkbox"/> International Land Issues | <input type="checkbox"/> Visualization          |
| <input type="checkbox"/> Energy             | <input type="checkbox"/> Land Change               | <input type="checkbox"/> Water                  |
| <input type="checkbox"/> Fire               | <input type="checkbox"/> National Security         | <input type="checkbox"/> Other                  |

Password:

Re-type Password:

**Note:** password should be at least 10 characters - including at least one lower case letter and one upper case letter and one number

Type the code shown:





The NASA funded Web-enabled Landsat Data (WELD) project is systematically generating 30m composited Landsat Enhanced Thematic Mapper Plus (ETM+) mosaics of the conterminous United States and Alaska from 2005 to 2012. The WELD products are developed specifically to provide consistent data that can be used to derive land cover as well as geophysical and biophysical products for regional assessment of surface dynamics and to study Earth system functioning.

[+] Visualize in Google Earth

[+] View Full Metadata

Use the links in the table below to view and download data using WCS.

This data set contains 17 data granules

Page 1	Navigation	Records per Page 10
Granule Name ▲	Metadata	Preview Image
<ul style="list-style-type: none"> <li>WELD CONUS 2008 December</li> </ul>	<b>Projection:</b> <a href="#">USA Contiguous Albers Equal Area Conic</a> <b>Spatial Extent:</b> N: 3314800, S: 14650, E: 2384520, W: -2565600 <b>Start DateTime:</b> 2008-12-01T00:00:00 <b>End DateTime:</b> 2009-01-01T00:00:00	
<ul style="list-style-type: none"> <li>WELD CONUS 2009 Annual</li> </ul>	<b>Projection:</b> <a href="#">USA Contiguous Albers Equal Area Conic</a> <b>Spatial Extent:</b> N: 3314800, S: 14650, E: 2384520, W: -2565600 <b>Start DateTime:</b> 2008-12 <b>End DateTime:</b> 2009-11	
<ul style="list-style-type: none"> <li>WELD CONUS 2009 April</li> </ul>	<b>Projection:</b> <a href="#">USA Contiguous Albers Equal Area Conic</a> <b>Spatial Extent:</b> N: 3314800, S: 14650, E: 2384520, W: -2565600 <b>Start DateTime:</b> 2009-04-01T00:00:00 <b>End DateTime:</b> 2009-05-01T00:00:00	
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<ul style="list-style-type: none"> <li>WELD CONUS 2009 February</li> </ul>	<b>Projection:</b> <a href="#">USA Contiguous Albers Equal Area Conic</a> <b>Spatial Extent:</b> N: 3314800, S: 14650, E: 2384520, W: -2565600	



# Google Earth rendering of Open Geospatial Consortium (OGC) compliant CONUS 2009 True Color Browse

