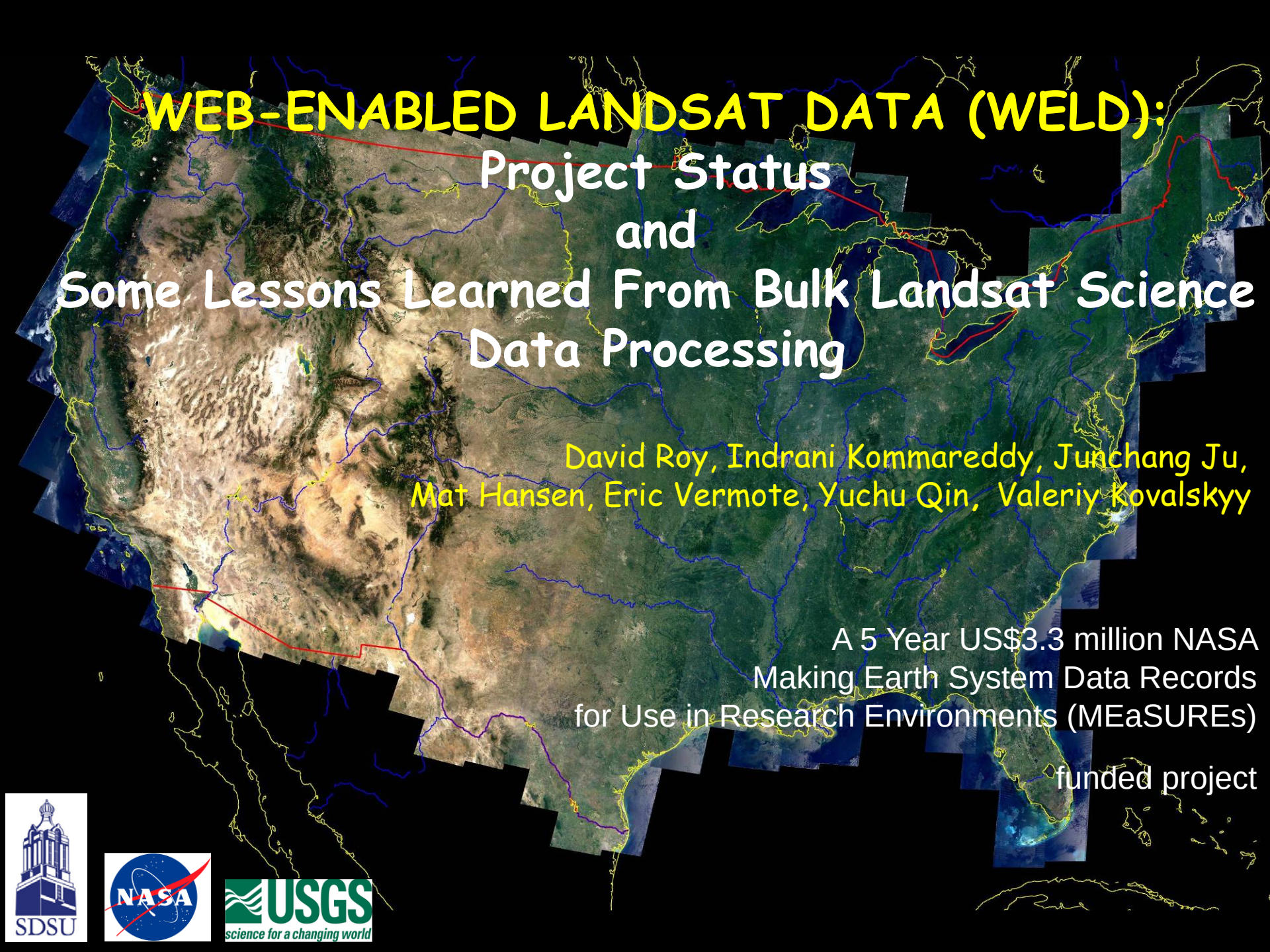


WEB-ENABLED LANDSAT DATA (WELD): Project Status and Some Lessons Learned From Bulk Landsat Science Data Processing

David Roy, Indrani Kommareddy, Junchang Ju,
Mat Hansen, Eric Vermote, Yuchu Qin, Valeriy Kovalskyy

A 5 Year US$3.3 million NASA
Making Earth System Data Records
for Use in Research Environments (MEaSUREs)

funded project

SDSU

NASA

USGS
science for a changing world

Talk Outline

- WELD project
  - overview
  - version 1.5 products
  - distribution

- Some lessons learned from bulk WELD Landsat science data processing
  - food for thought for LDCM higher level product processing

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
- Distributed from USGS EROS for free via the internet

Currently Available

(Version 1.5)

WELD Products

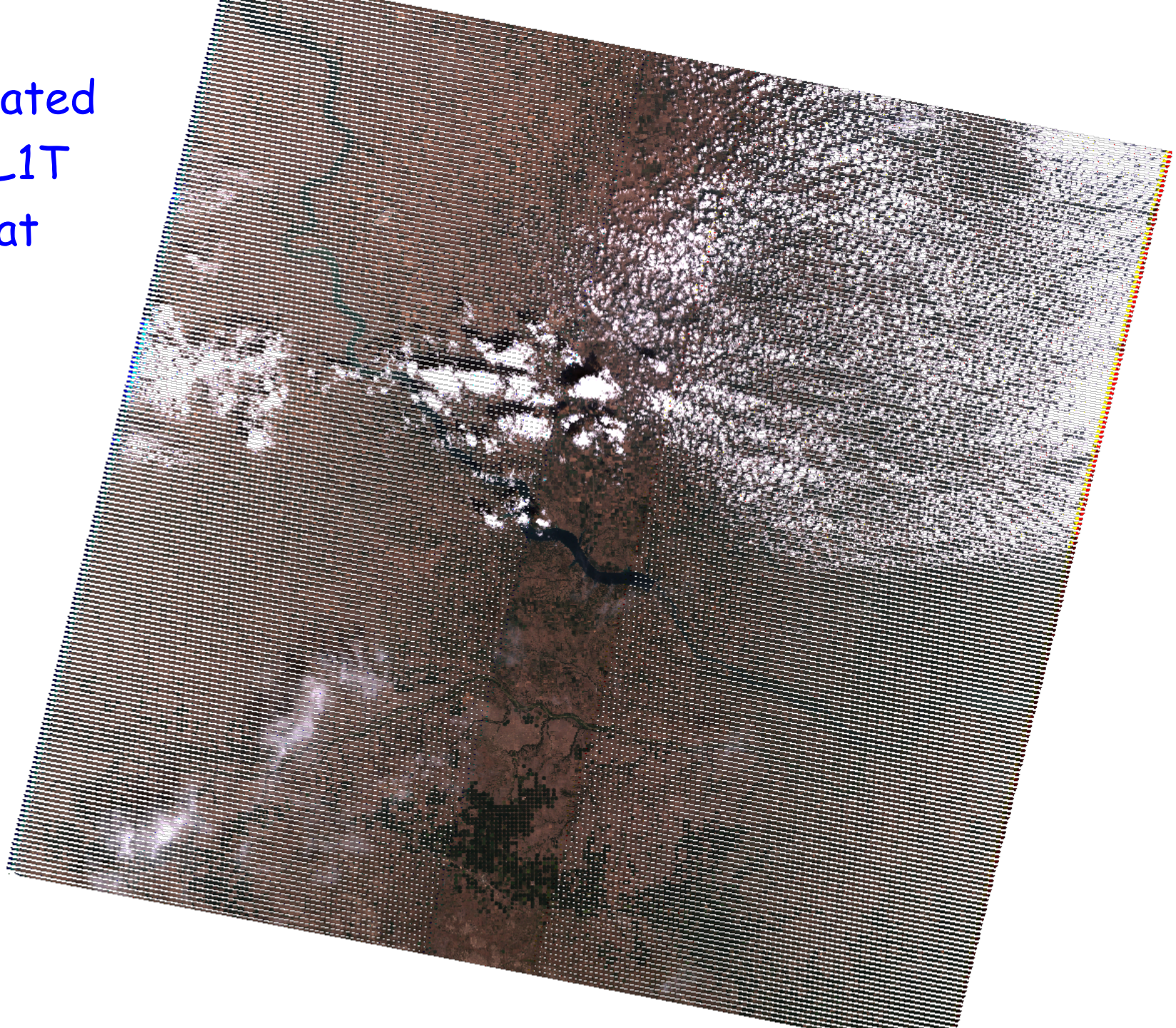
Version 1.5 WELD Product Format (all pixels are 30m)

Science Data Set Name	Data Type	Valid Range	Scale factor	Units	Fill Value

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.

Generated from L1T Landsat ETM+



WELD Landsat 7 ETM+ L1T ARCHIVE at SDSU

(August 15th 2011)

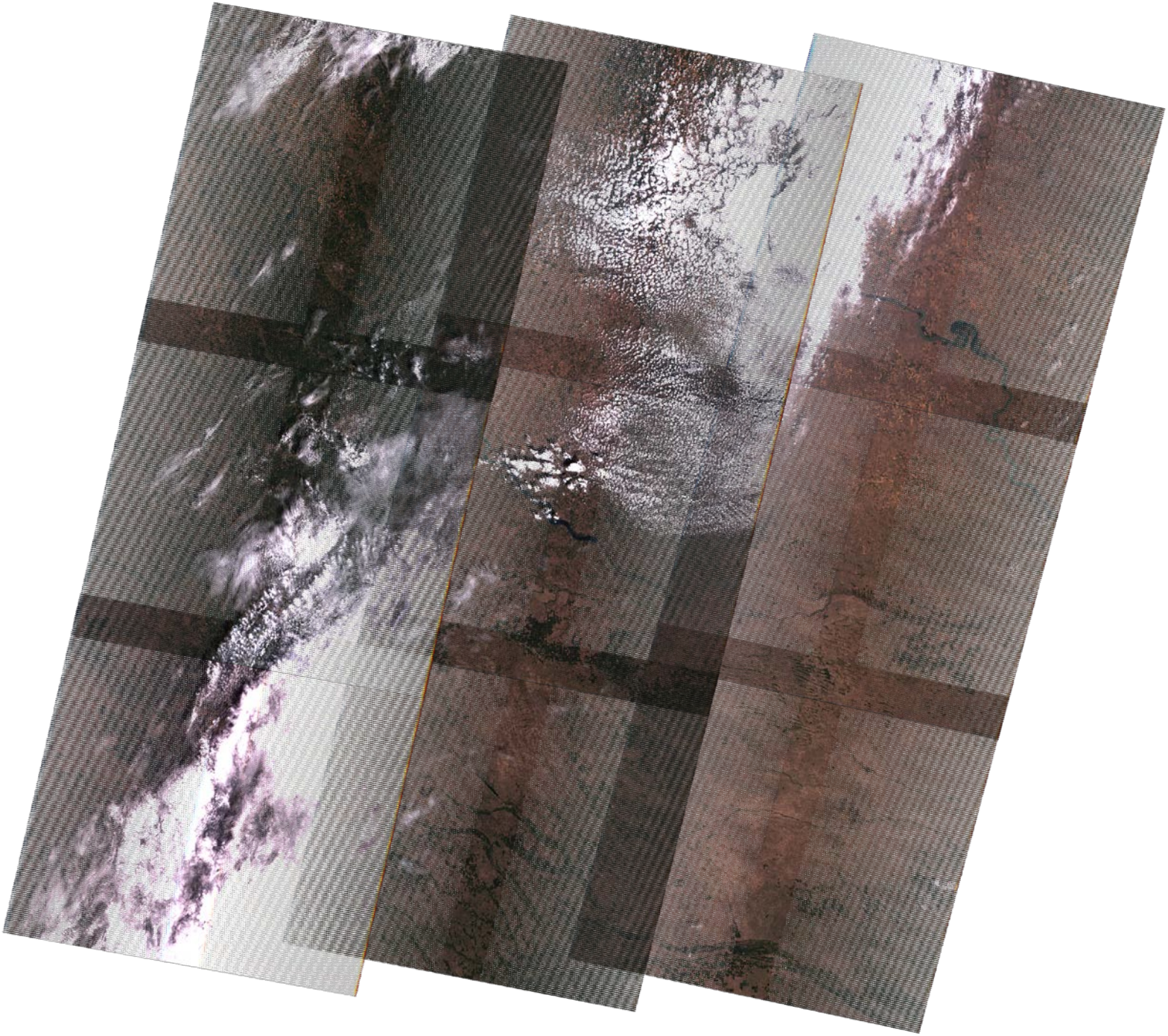
	Conterminous United States (459 path/row) <80% cloud	**Alaska** (232 path/row) <80% cloud
2001	644	94
2002	7878	2380
2005	584	1
2006	**8158**	**1762**
2007	**8285**	**2018**
2008	**8624**	**1687**
2009	**7987**	**1756**
2010	**8421**	**1742**
2011	5286	1531

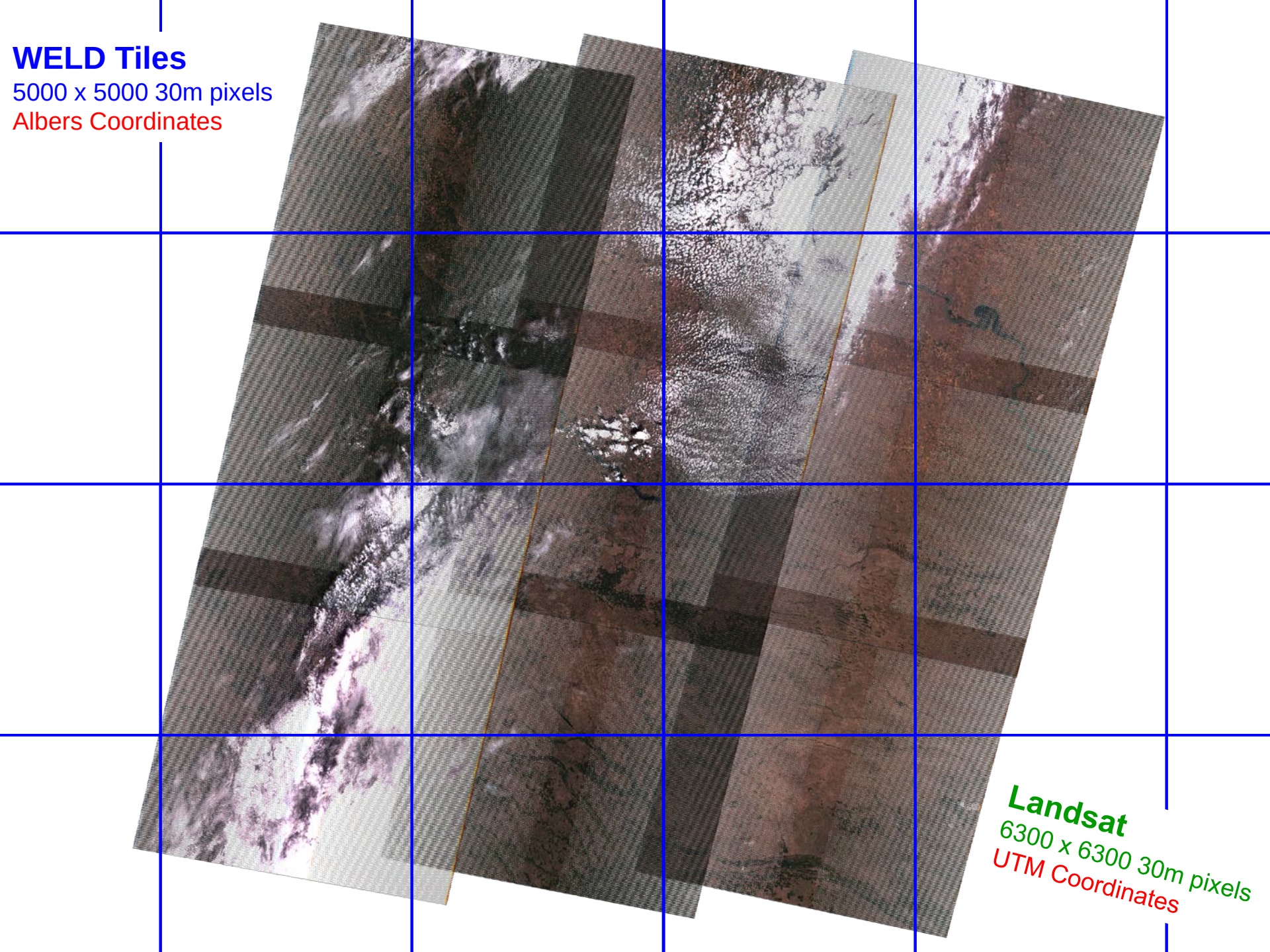
Each L1T acquisition is **~221MB**

Annual ETM+ data volume: **1.7TB** CONUS **0.4TB** Alaska

68,838 CONUS and Alaska acquisitions

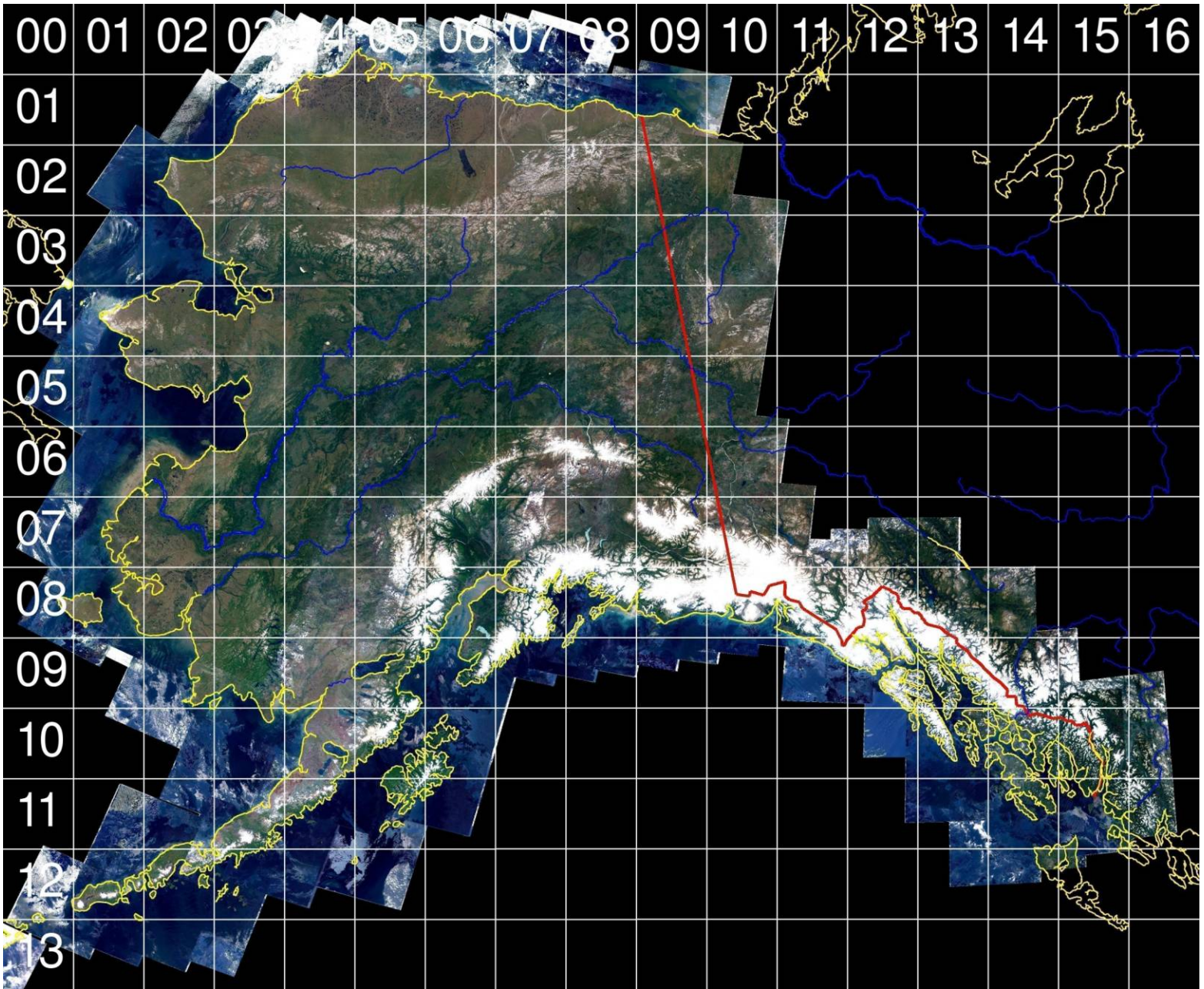
> US $41.3million when each L1T acquisition cost US$600.



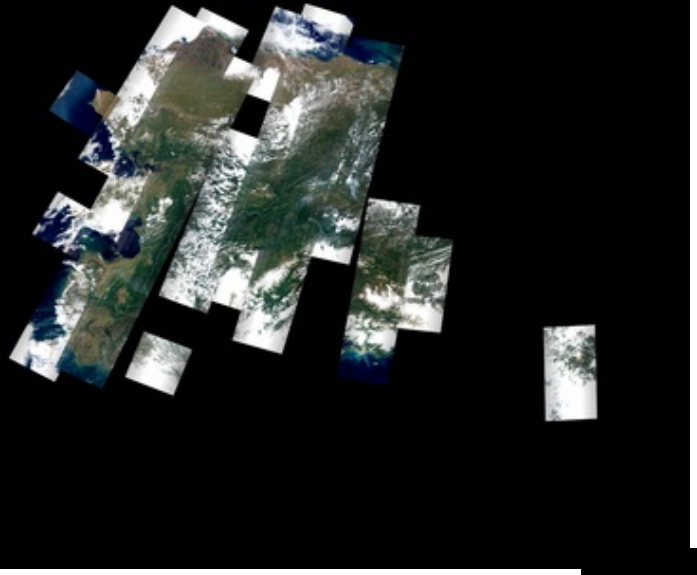

WELD Tiles
5000 x 5000 30m pixels
Albers Coordinates
Landsat
6300 x 6300 30m pixels
UTM Coordinates

WELD Tile Map (Alaska has 162 5000x5000 30m pixel tiles in Albers)

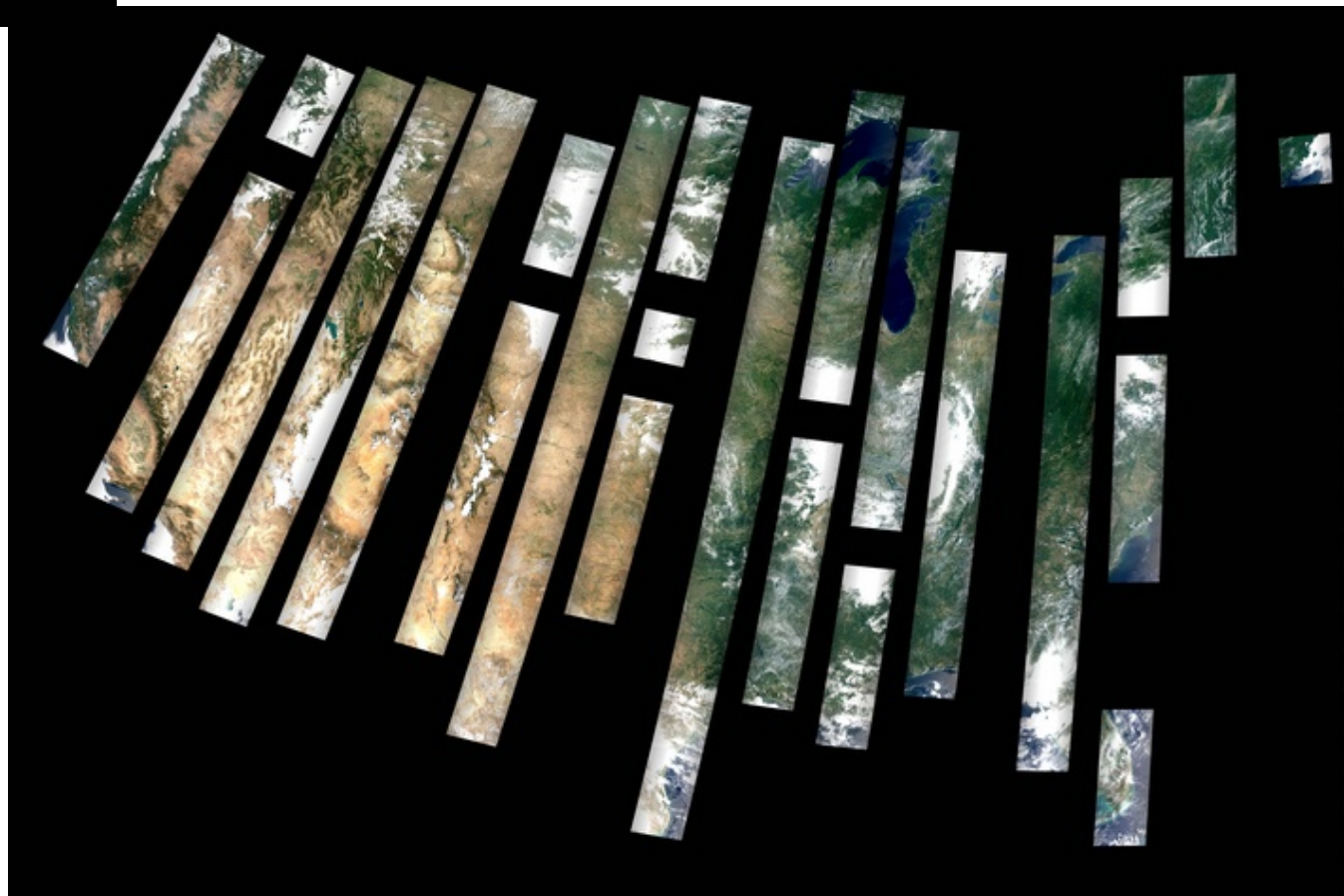
~3,100 million 30m land pixels

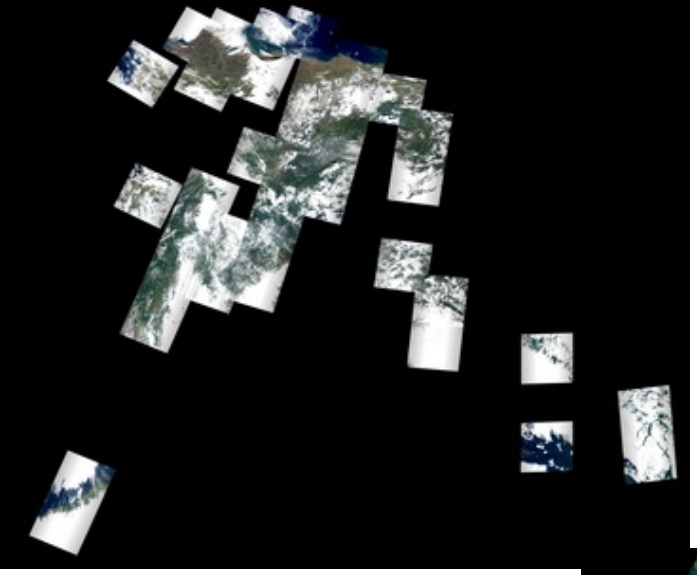


Landsat ETM+ L1T processed data acquired over 213 Alaska and 455 CONUS path/rows

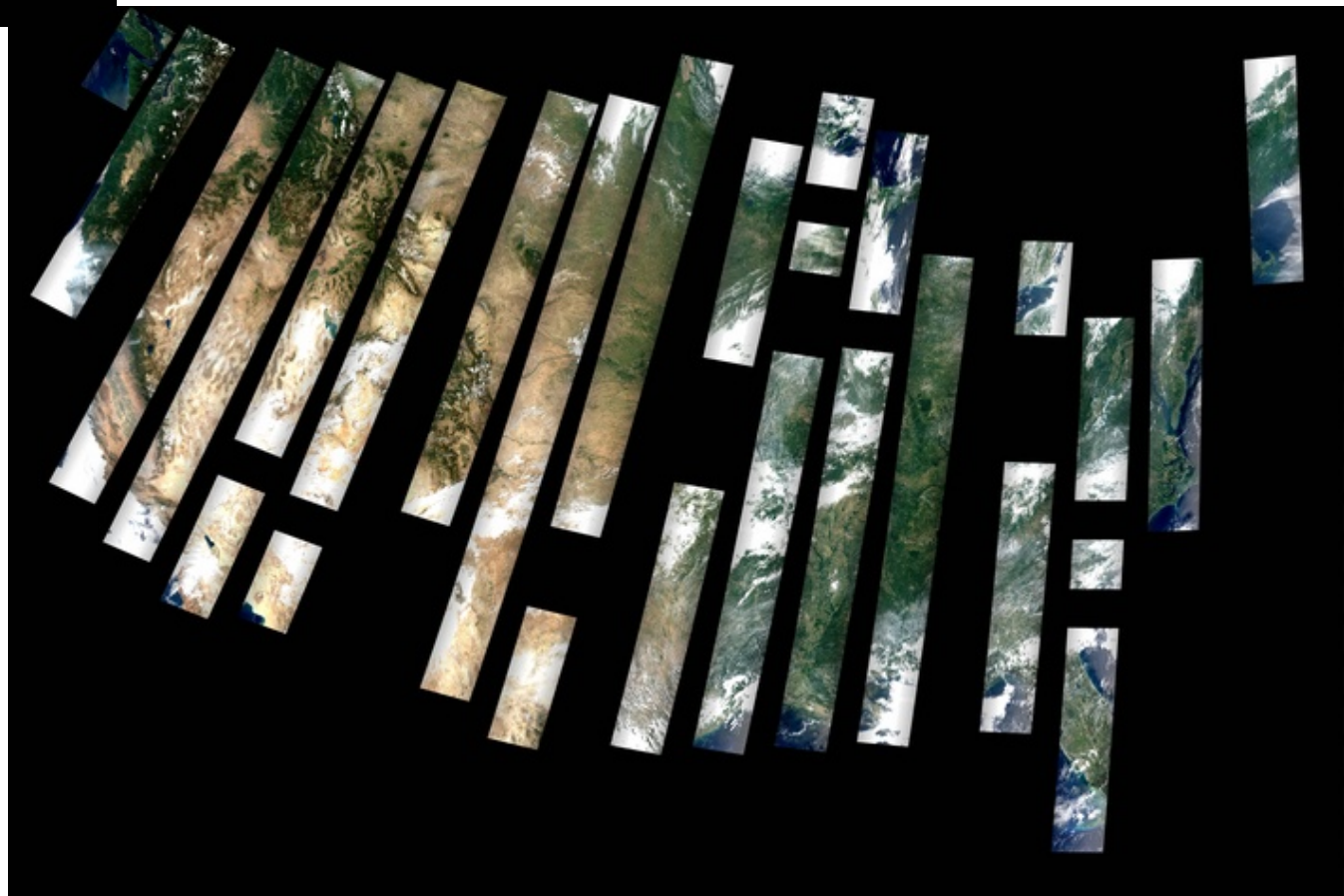


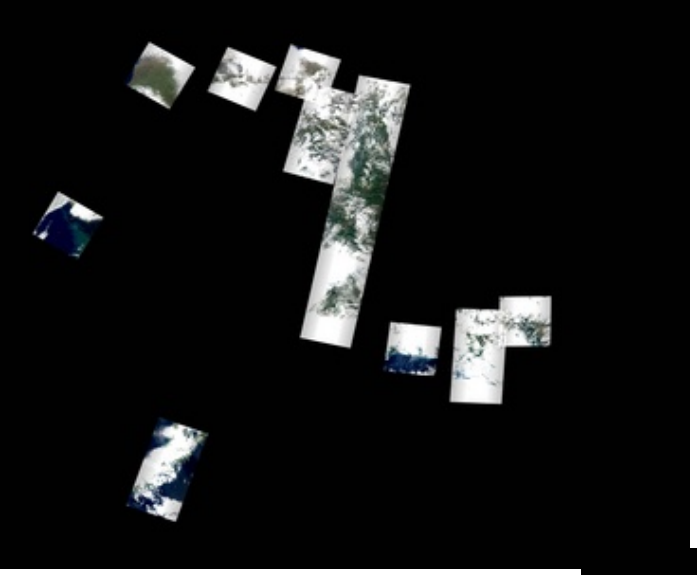
Week 27: July 8 - 14 2008



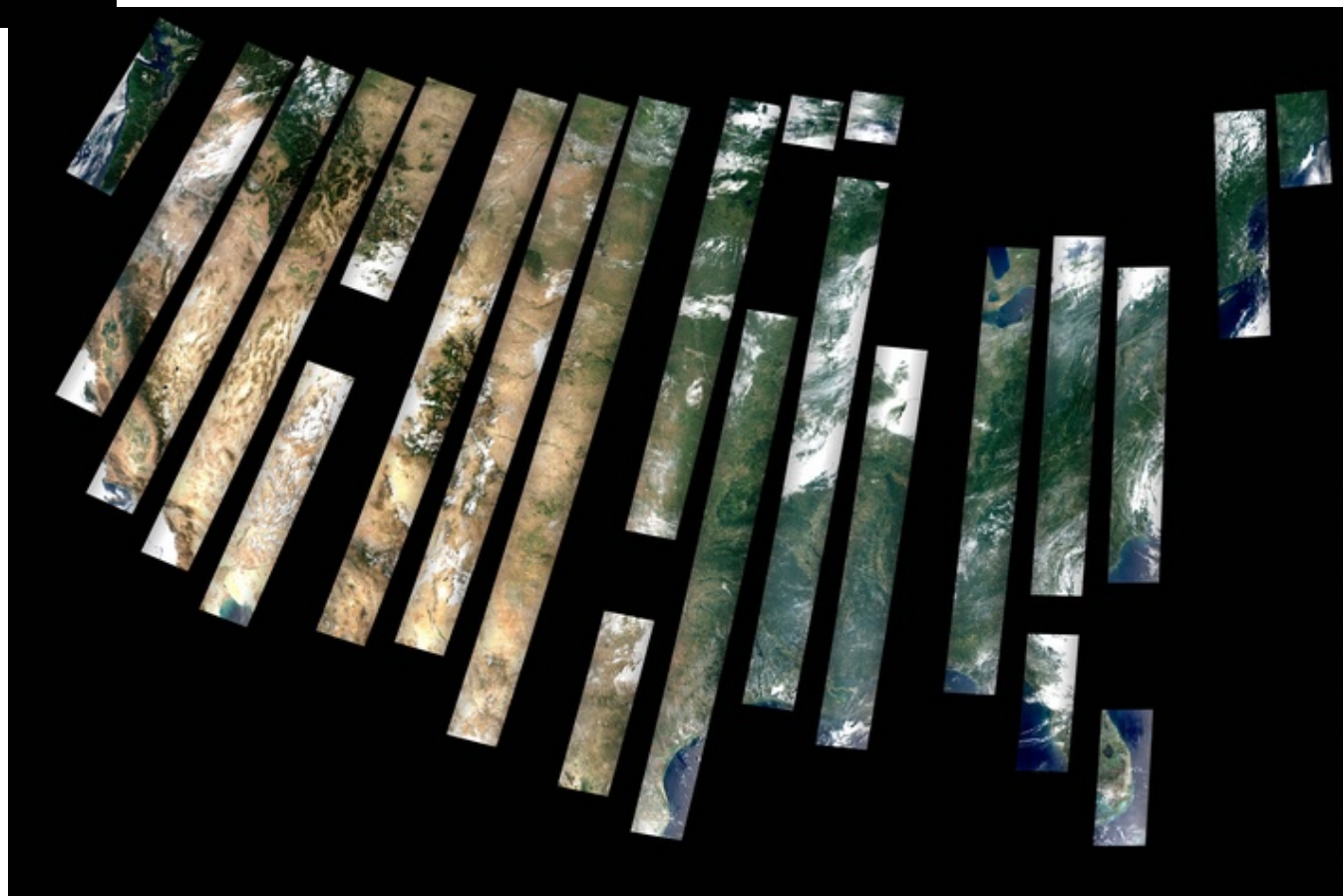


Week 28: July 8 - 14 2008

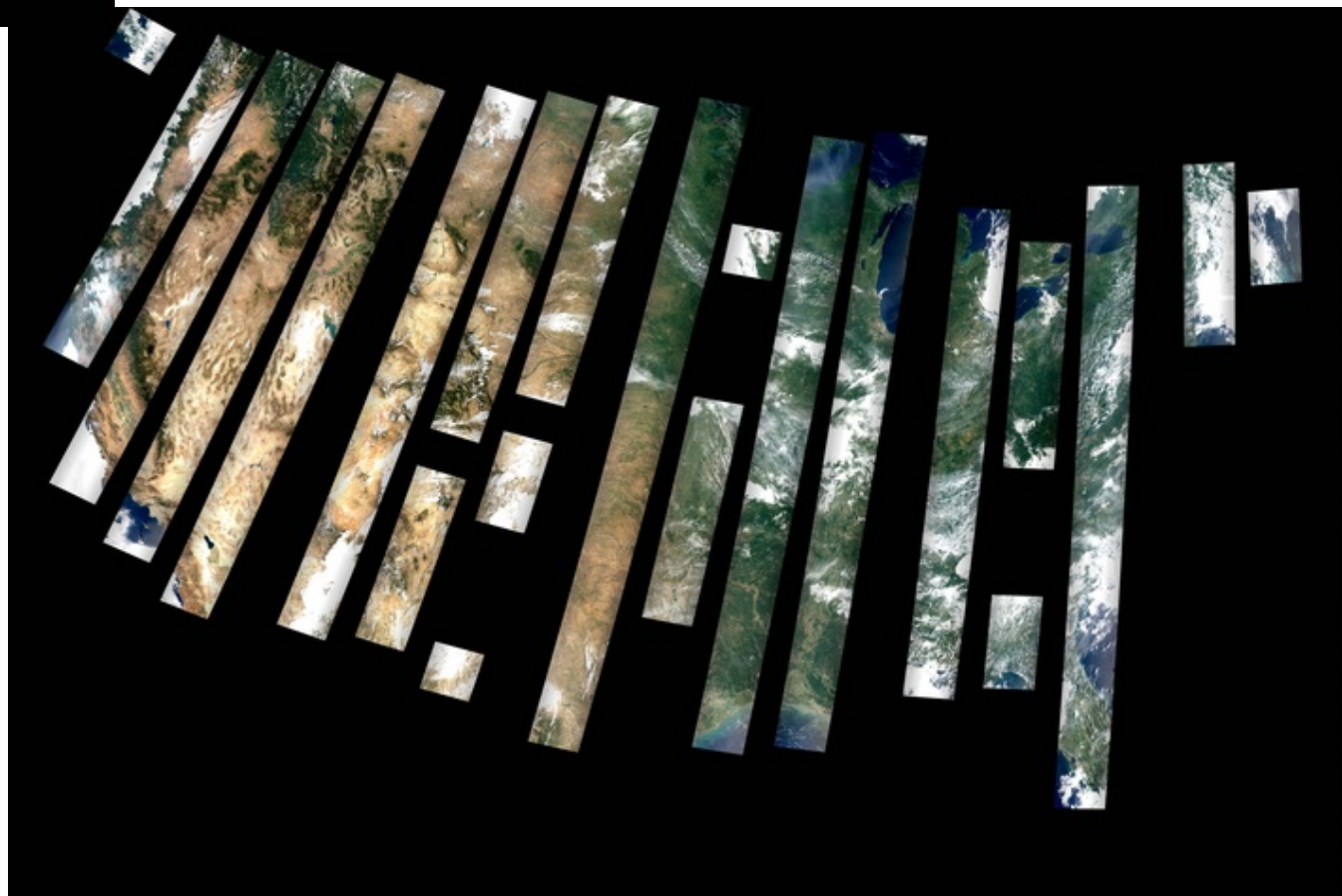


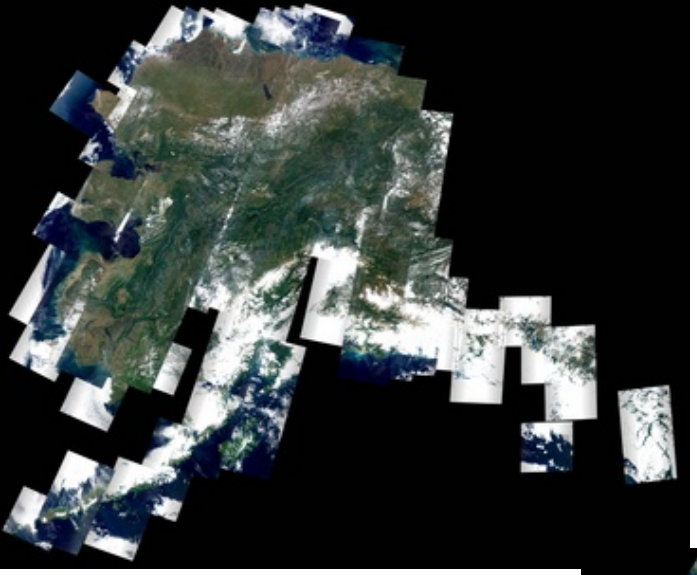


Week 29: July 15 - 21 2008

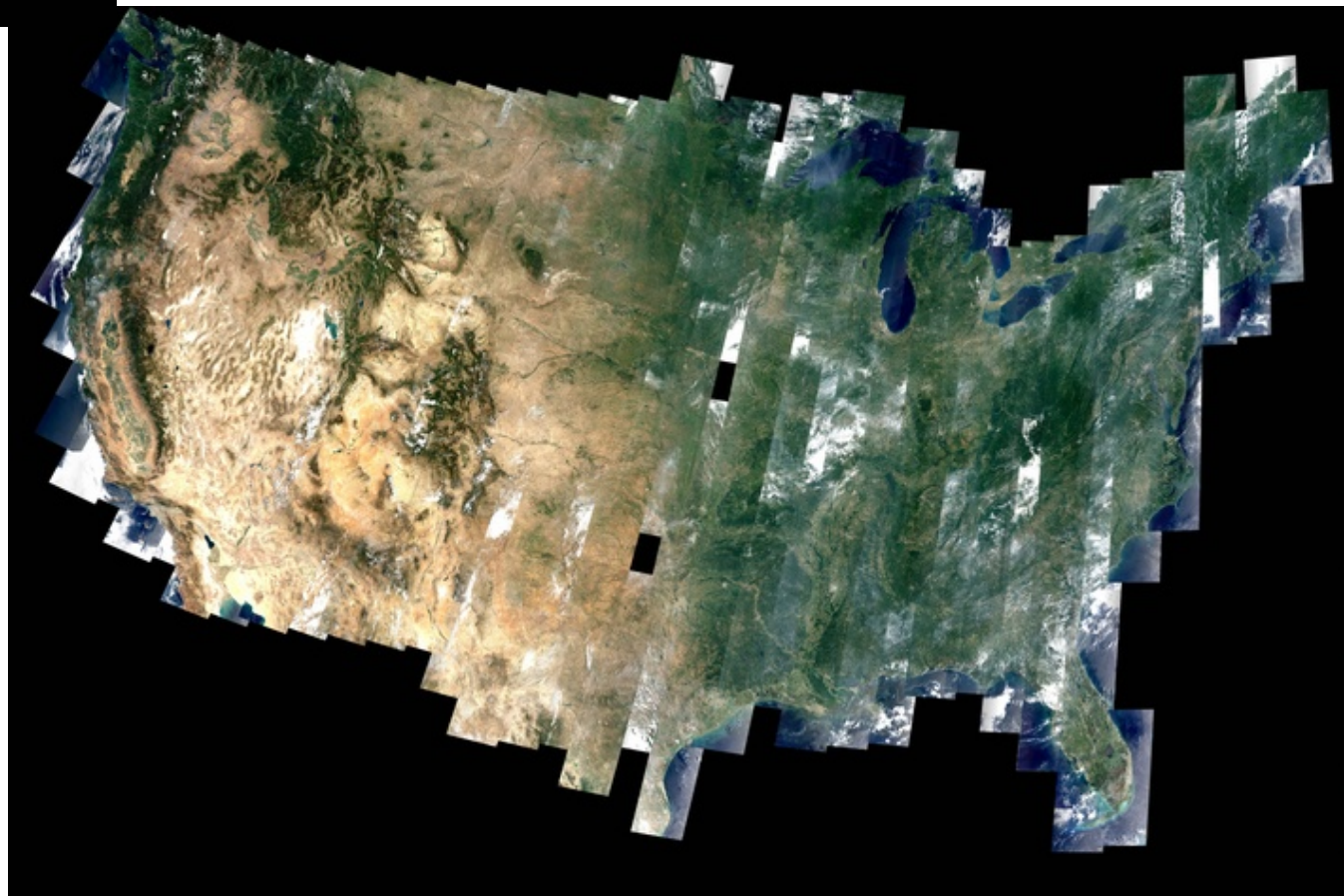


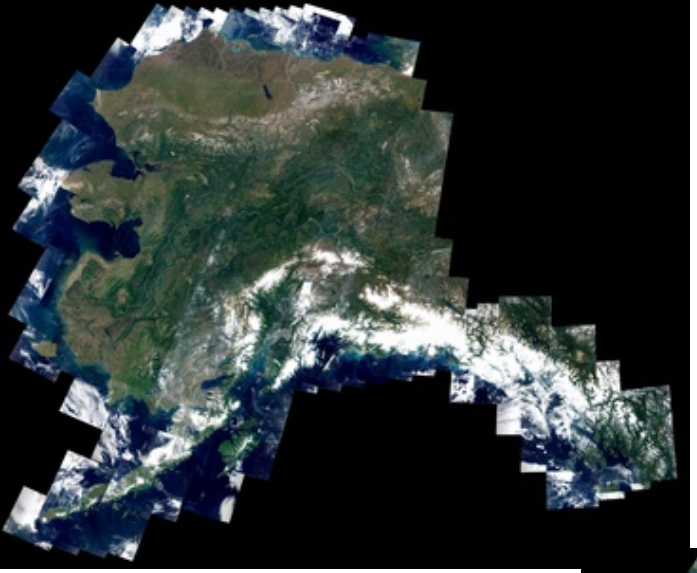
Week 30: July 22 – 28 2008





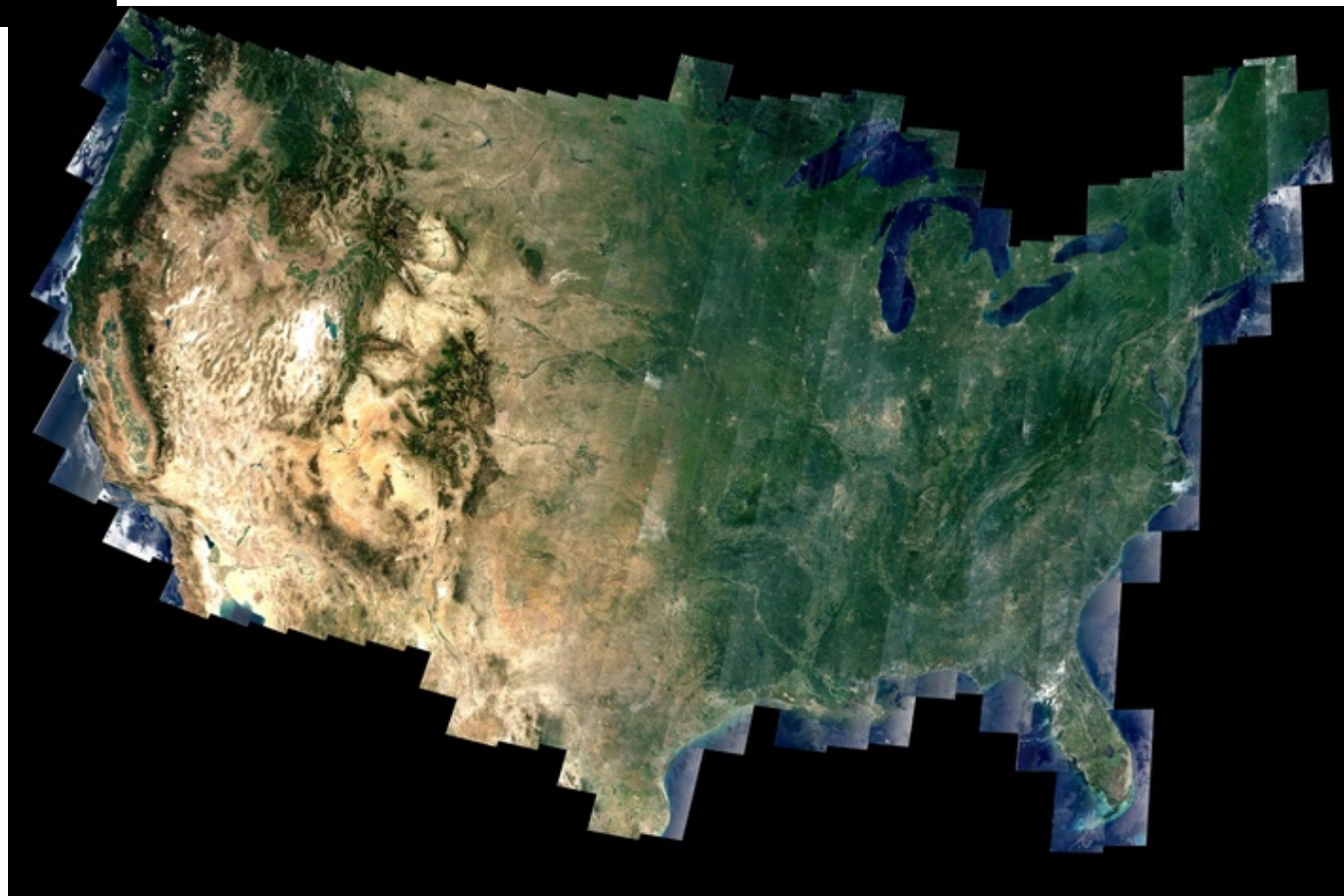
July 2008

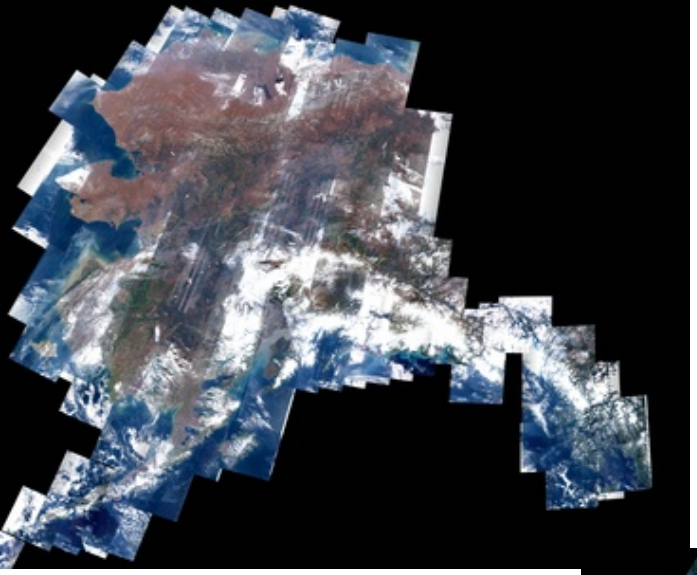




Summer

(June, July, August) 2008



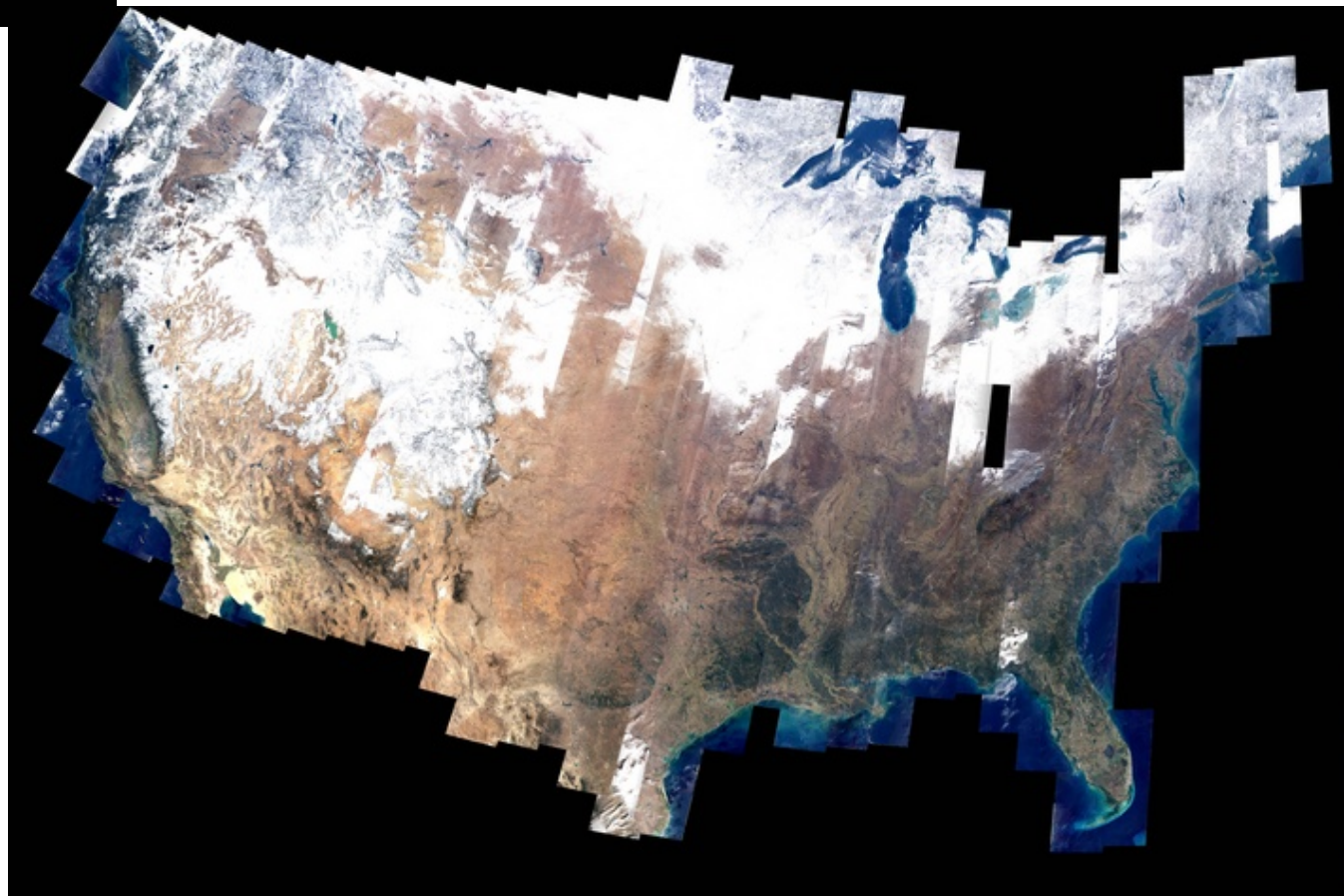


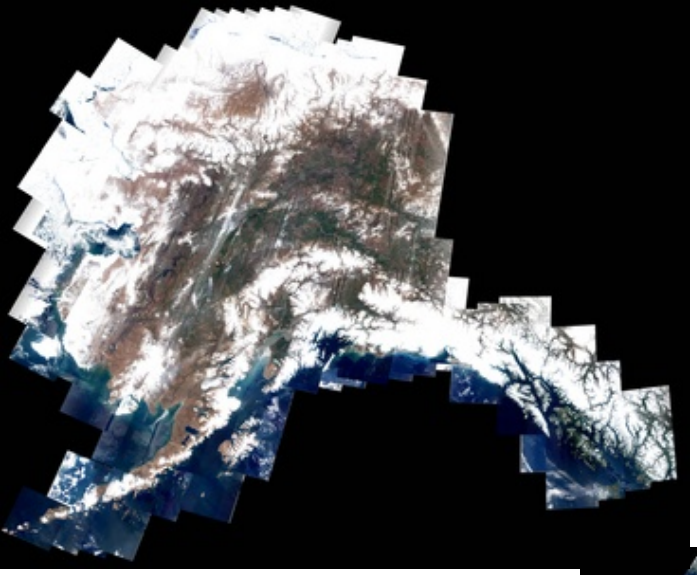
Fall

(September, October, November) 2008

Winter

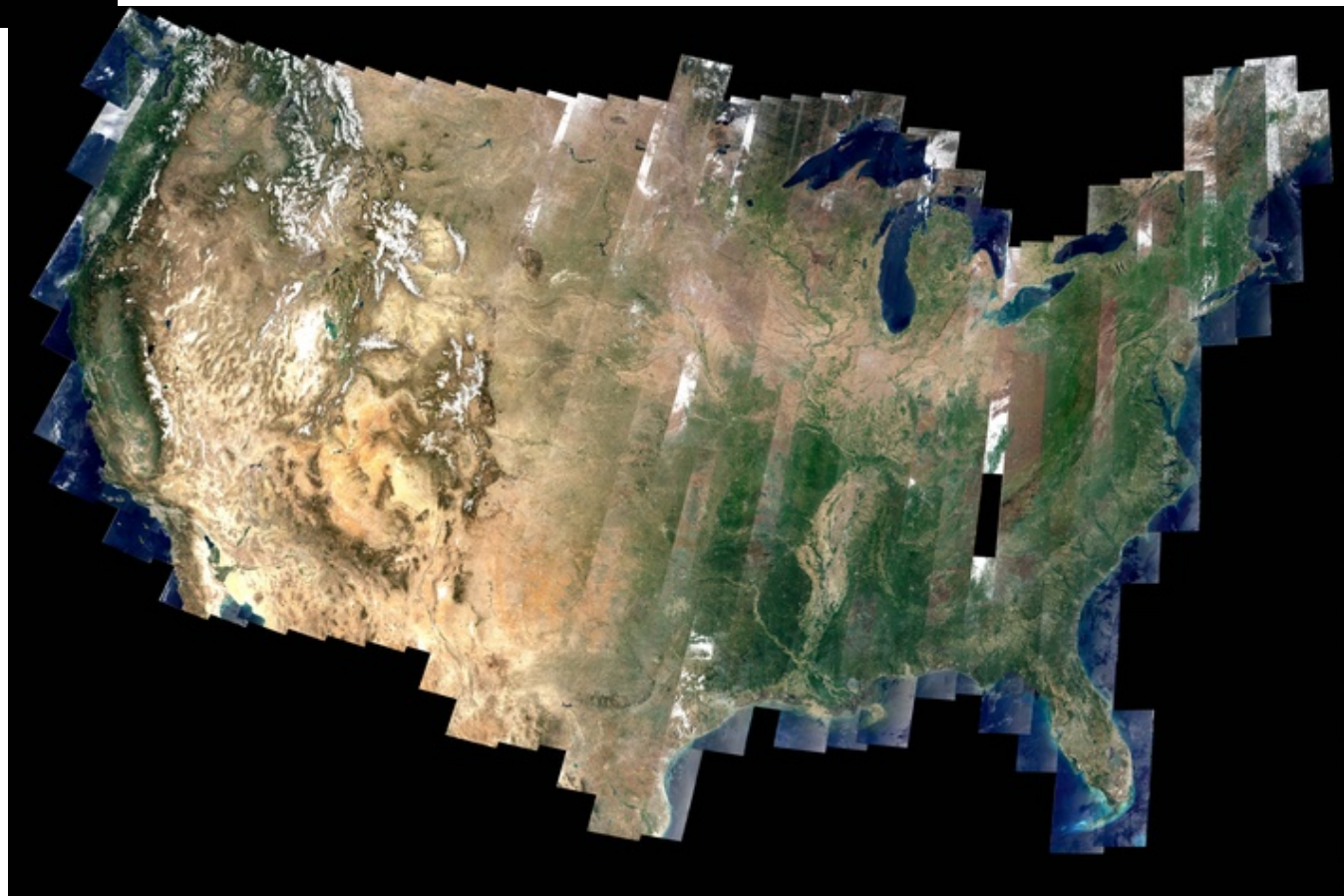
(December, January, February) 2008/09

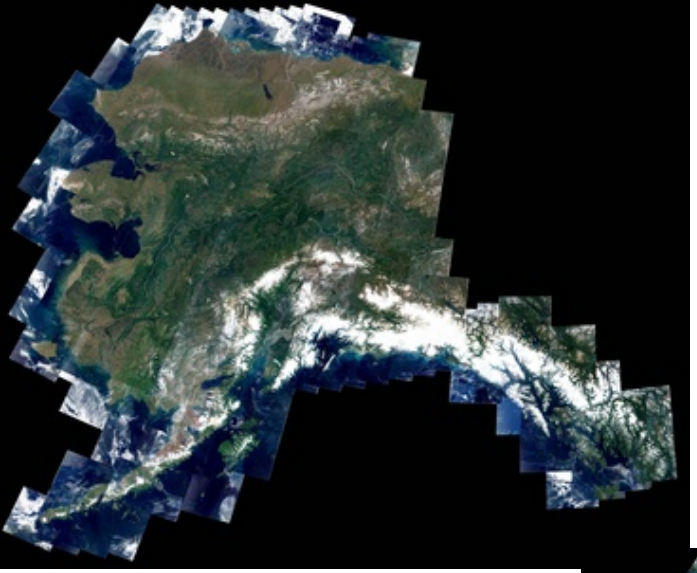




Spring

(March, April, May) 2009





Annual

(December 2009 – November 2008)

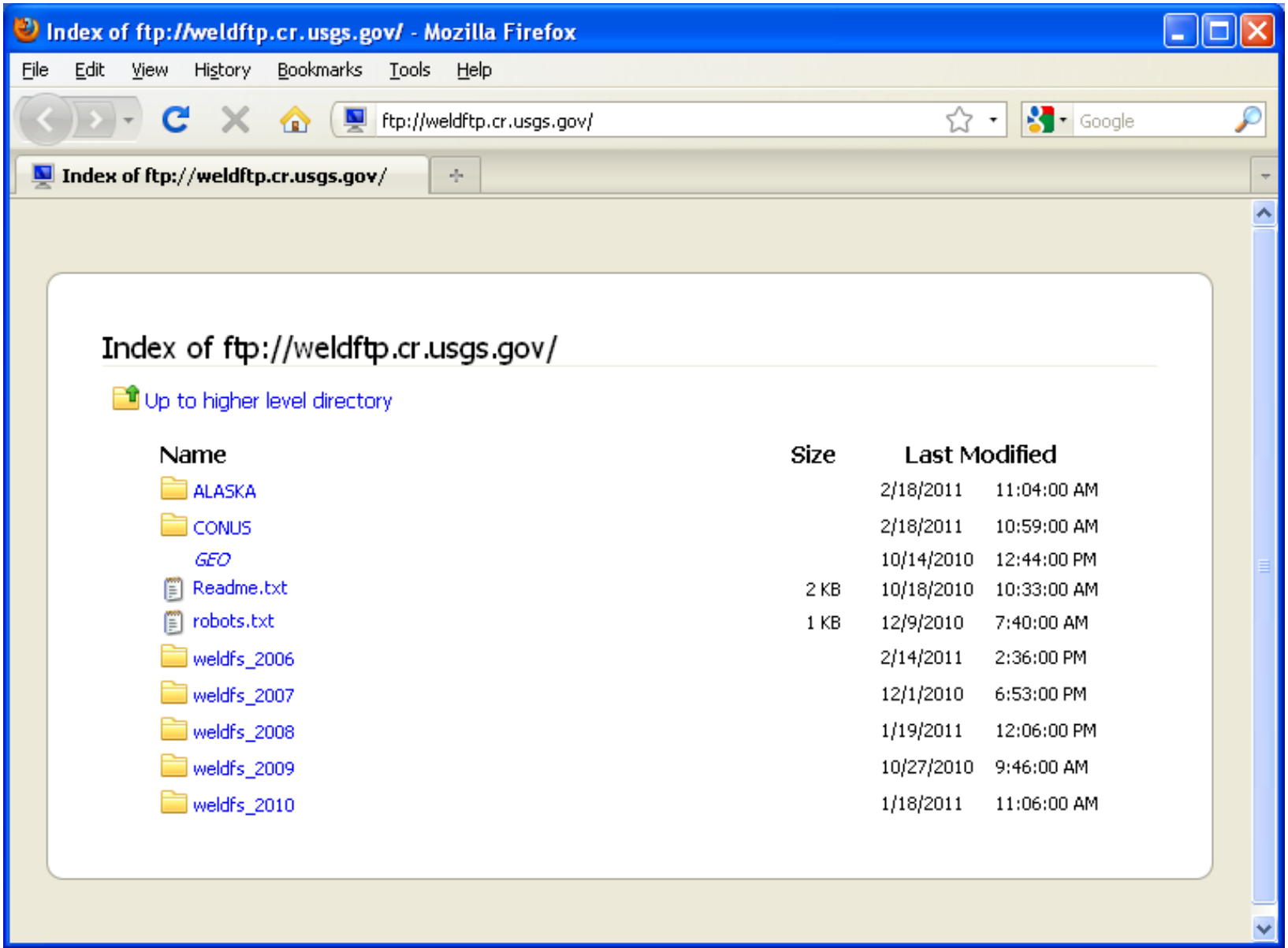
Alaska ~ 1,700 L1T acquisitions / year

CONUS ~ 8,000 L1T acquisitions / year

Different WELD Product distribution portals to Support Different Users

- FTP HDF tile products
  - Suited for bulk orders
    - e.g., all of WELD for a tile
    - e.g., all of the data for the CONUS for a year
    - e.g., all of the data
  - Support the needs of
    - “Science Team” user
    - “Agency” user
- Interactive GeoTIFF internet distribution - WYSIWYG
  - Suited for small volume orders
    - limited geographic and temporal ranges
  - Suited for users for who dislike HDF
  - Support the needs of
    - Individual researchers
    - Students
- OGC Browse JPG Distribution
  - geographic context

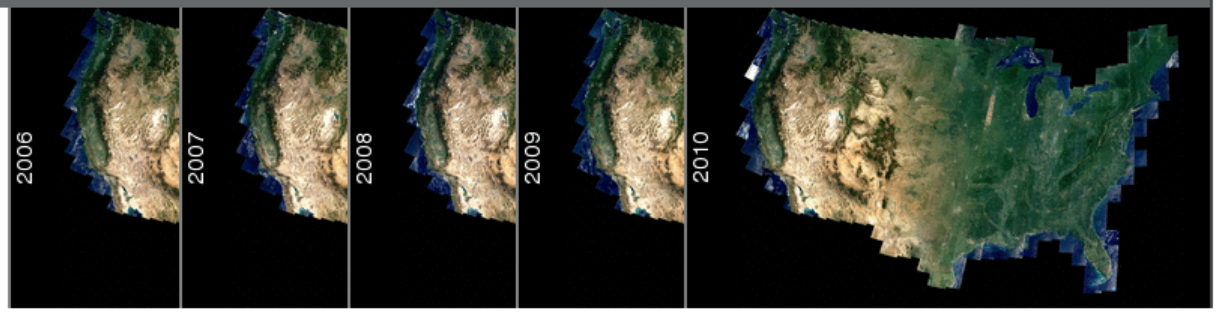
5 Years 2006-2010 Version 1.5
WELD HDF Tiles Available via FTP (4TB/year)



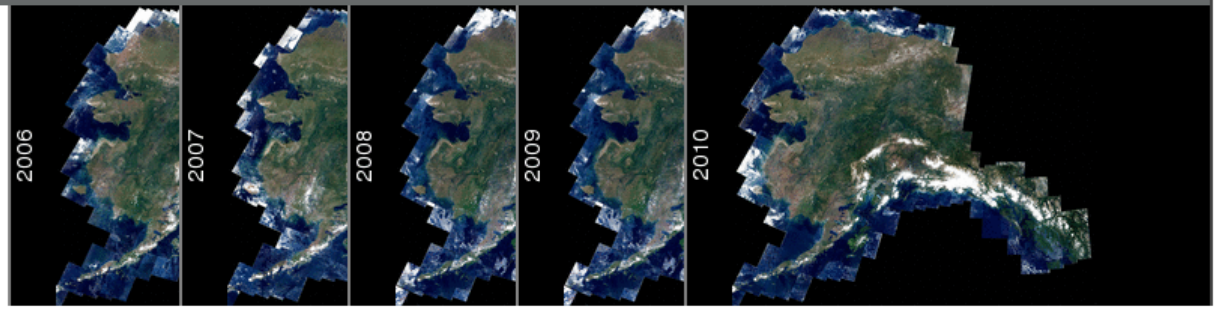
WELD: Web - Enabled Landsat Data

Available Years:

CONUS



Alaska



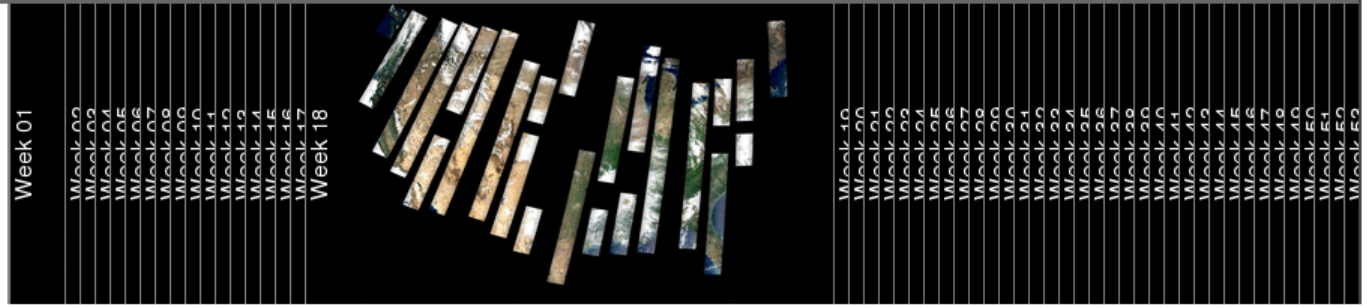
CONUS 2006

<< Home

Annual & Seasonal

Monthly

Weekly



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

WELD Distribution System

CONUS: Annual 2006 [Dec 2005 - Nov 2006]

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

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:	41.6
South:	40.8
West:	-113.3
East:	-110.6

Order Data

You have selected a CONUS region of 7882 x 1692 30m pixels

<< Home

You can order this region for the following WELD products:

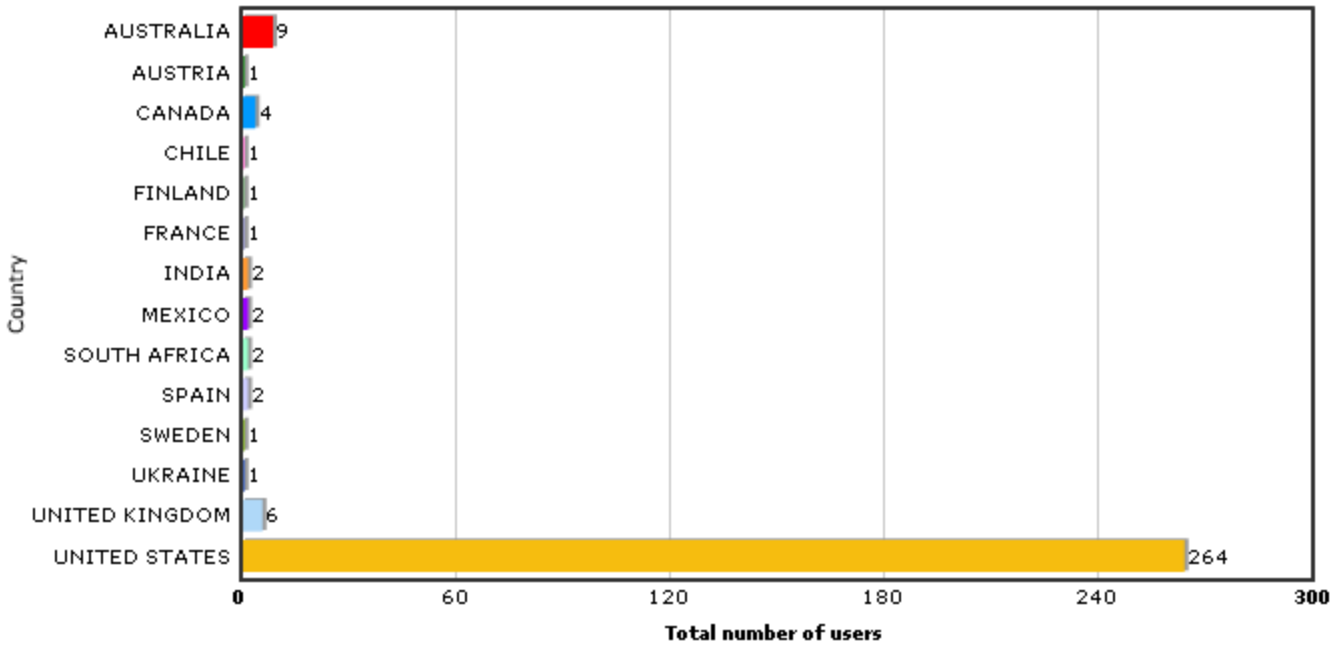
- Annual [December 2008 - November 2009] ☑
- Seasonal [December 2008 - November 2009] ☐
- Monthly [December 2008 - November 2009] ☐
- Monthly [January 2009 - December 2009] ☐
- Weekly [January 2009 - December 2009] ☐

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 >>

Number of unique users ordered products by Country



Other Metrics

Average number of 30m pixels placed by each user : 895723151
Average number of orders placed by each user : 42
Number of unique users who registered : 302
Number of unique users who ordered data : 297
Total number of orders : 12531
Total volume of orders : 1.157TB

Encouraging distribution statistics

- 95% of the available 20TB WELD version 1.5 data product volume distributed in first 4 months of availability

- more than 300 users, from 14 countries

WELD Internet WYSIWYG Planned Enhancement

John Schott (previous Landst ST meeting):

"I want the government to be able to give me all the Landsat data at a single pixel"

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:	41.6
South:	40.8
West:	-113.3
East:	-110.6

Order Data

- [x] 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:	41.6
South:	40.8
West:	-113.3
East:	-110.6

Order Data

Click the left button to define a single pixel time series dump, or enter the pixel coordinates below

North:	40.08235317
West:	-113.48454620

Order Pixel Time series

Single pixel time series dump for CONUS longitude(-113.484546), latitude(40.082353)

<< Home

You can order a time series dump from one the following:

- Weekly (selected)
- Monthly
- Seasonal
- Annual

Place order >>

Order Notification [Order Id: l1i1Dwqw] - Message (Plain Text)

Reply | Reply to All | Forward

File Edit View Insert Format Tools Actions Help

From: weld@usgs.gov
Sent: Mon 8/15/2011 2:40 PM
To: Roy, David
Cc:
Subject: Order Notification [Order Id: l1i1Dwqw]

Dear Landsat WELD user,

Your order for the following file has been processed:
weld.conus.weekly.h07v08.long-113.484546.lat40.082353.v1.5.txt

Your order is available at the following HTTP address:

http://snowdon.sdstate.edu/downloads/l1i1Dwqw/

Please note the time series is provided in a a simple ASCII comma separated format, each column corresponds to a WELD product band and each row corresponds to a WELD product time period. The pixel values are written out with the relevant WELD band scale factor and offset already applied or as a WELD band fill value. For more information on the WELD products please see http://globalmonitoring.sdstate.edu/projects/weld/

For help, please contact us at sdsu.weld@sdstate.edu

You have 14 days to retrieve this order before it is removed from our server.

Thank you,

WELD Team

Year Day_Of_Year Band1_TOA_REF Band2_TOA_REF Band3_TOA_REF Band4_TOA_REF Band5_TOA_REF Band61_TOA_BT Band62_TOA_BT Band7_TOA_REF NDVI_TOA Saturation_Flag DT_Cloud_State ACCA_State Num_Of_Obs
2009 4.0000 0.3957 0.3703 0.3971 0.4510 0.1630 -8.0600 -8.2300 0.0947 0.0636 0 2.0000 1.0000 1.0000
2009 0 -32768 -32768 -32768 -32768 -32768 -32768 -32768 -32768 -32768 0 255 255 0.0000
2009 20.0000 0.2330 0.2535 0.2768 0.3222 0.3057 1.0900 1.5400 0.1682 0.0758 0 0.0000 1.0000 1.0000
2009 0 -32768 -32768 -32768 -32768 -32768 -32768 -32768 -32768 -32768 0 255 255 0.0000
2009 0 -32768 -32768 -32768 -32768 -32768 -32768 -32768 -32768 -32768 0 255 255 0.0000
2009 0 -32768 -32768 -32768 -32768 -32768 -32768 -32768 -32768 -32768 0 255 255 0.0000
2009 52.0000 0.2608 0.2907 0.3248 0.3600 0.3498 8.3100 8.5300 0.2515 0.0514 0 0.0000 1.0000 1.0000
2009 0 -32768 -32768 -32768 -32768 -32768 -32768 -32768 -32768 -32768 0 255 255 0.0000
2009 68.0000 0.4598 0.4581 0.4780 0.5281 0.4492 -4.6900 -5.2200 0.3455 0.0498 0 1.0000 1.0000 1.0000
2009 0 -32768 -32768 -32768 -32768 -32768 -32768 -32768 -32768 -32768 0 255 255 0.0000
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2009 132.0000 0.3640 0.3842 0.4009 0.4314 0.3953 10.6100 10.4400 0.3108 0.0366 0 1.0000 1.0000 1.0000
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2009 0 -32768 -32768 -32768 -32768 -32768 -32768 -32768 -32768 -32768 0 255 255 0.0000
2009 148.0000 0.2416 0.2703 0.2996 0.3275 0.3237 38.3600 38.4300 0.2159 0.0445 0 0.0000 0.0000 1.0000
2009 0 -32768 -32768 -32768 -32768 -32768 -32768 -32768 -32768 -32768 0 255 255 0.0000
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2009 180.0000 0.2874 0.3148 0.3453 0.3760 0.3609 37.9100 38.1800 0.2507 0.0426 0 0.0000 0.0000 1.0000
2009 0 -32768 -32768 -32768 -32768 -32768 -32768 -32768 -32768 -32768 0 255 255 0.0000
2009 196.0000 0.3241 0.3512 0.3751 0.4055 0.3996 36.0700 36.1500 0.2945 0.0389 0 0.0000 0.0000 1.0000
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2009 212.0000 0.2872 0.3192 0.3560 0.3832 0.3932 36.5300 36.6600 0.2865 0.0368 0 0.0000 0.0000 1.0000
2009 0 -32768 -32768 -32768 -32768 -32768 -32768 -32768 -32768 -32768 0 255 255 0.0000
2009 228.0000 0.2851 0.3219 0.3605 0.4030 0.4220 31.3800 31.2100 0.3202 0.0557 0 0.0000 0.0000 1.0000
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2009 244.0000 0.3032 0.3396 0.3748 0.4142 0.4350 35.6100 35.9000 0.3382 0.0499 0 0.0000 0.0000 1.0000
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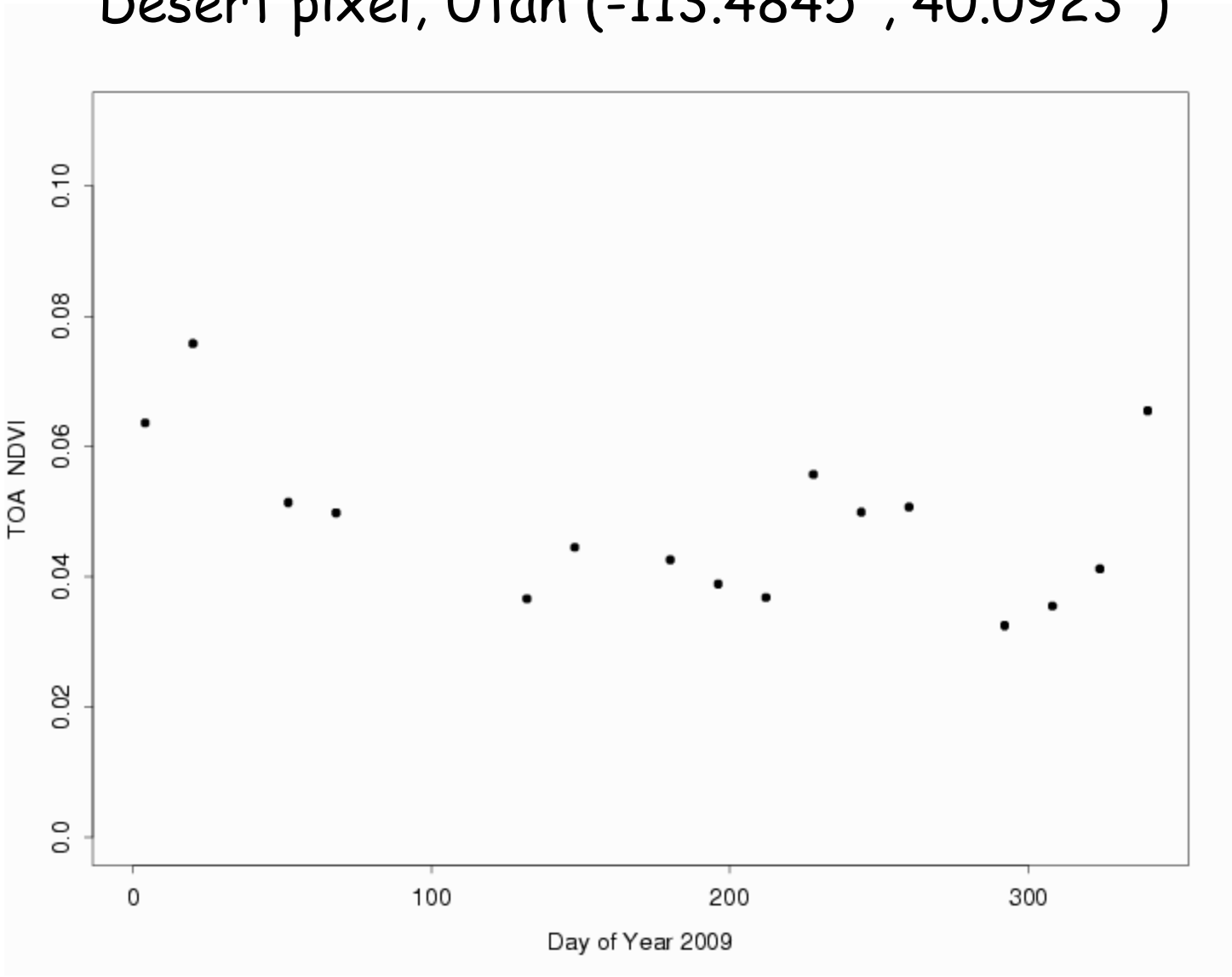
2009 0 -32768 -32768 -32768 -32768 -32768 -32768 -32768 -32768 -32768 0 255 255 0.0000
2009 260.0000 0.2337 0.2639 0.2933 0.3246 0.3419 33.2800 33.3100 0.2320 0.0507 0 0.0000 0.0000 1.0000

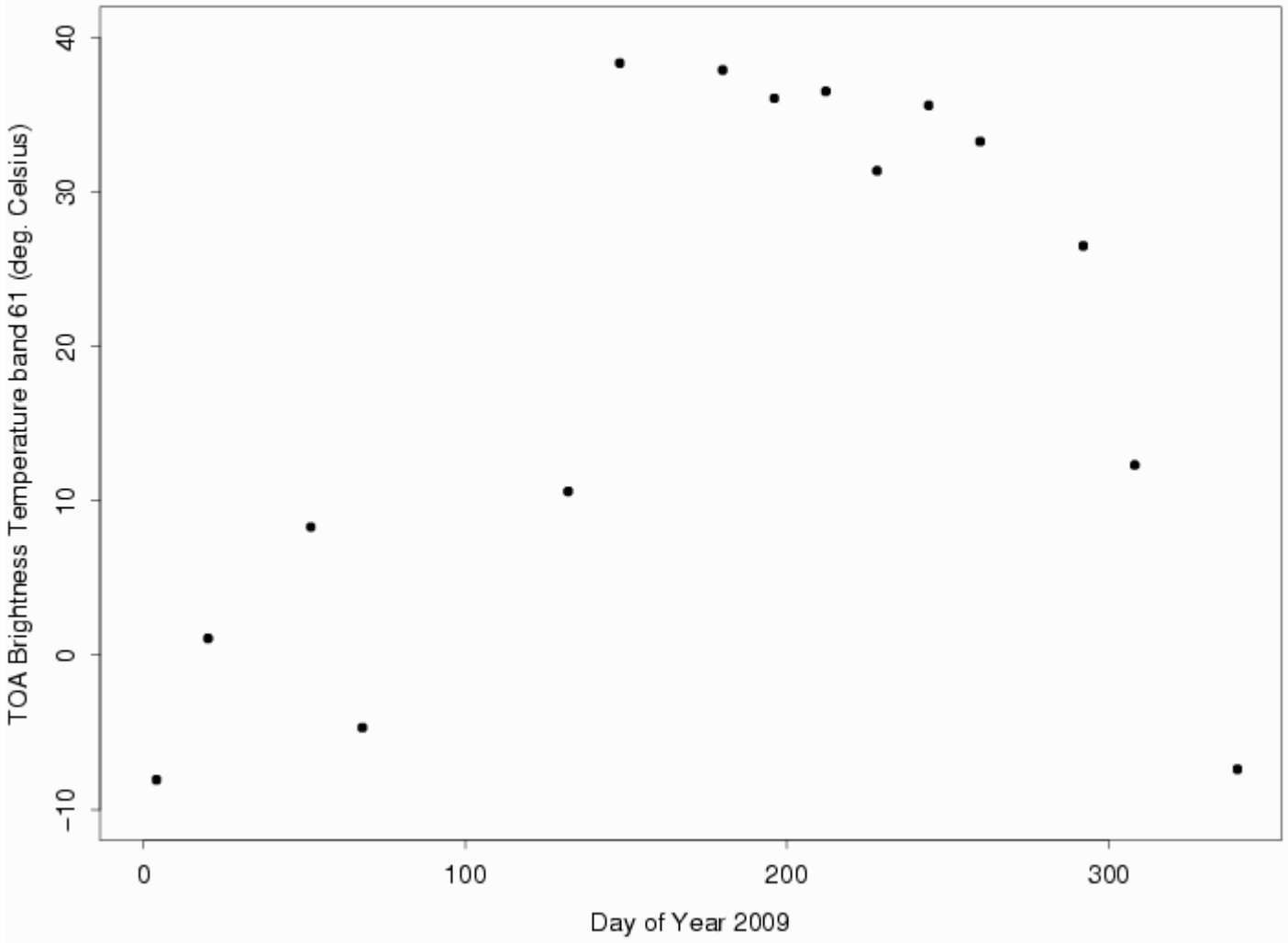
TOA NDVI

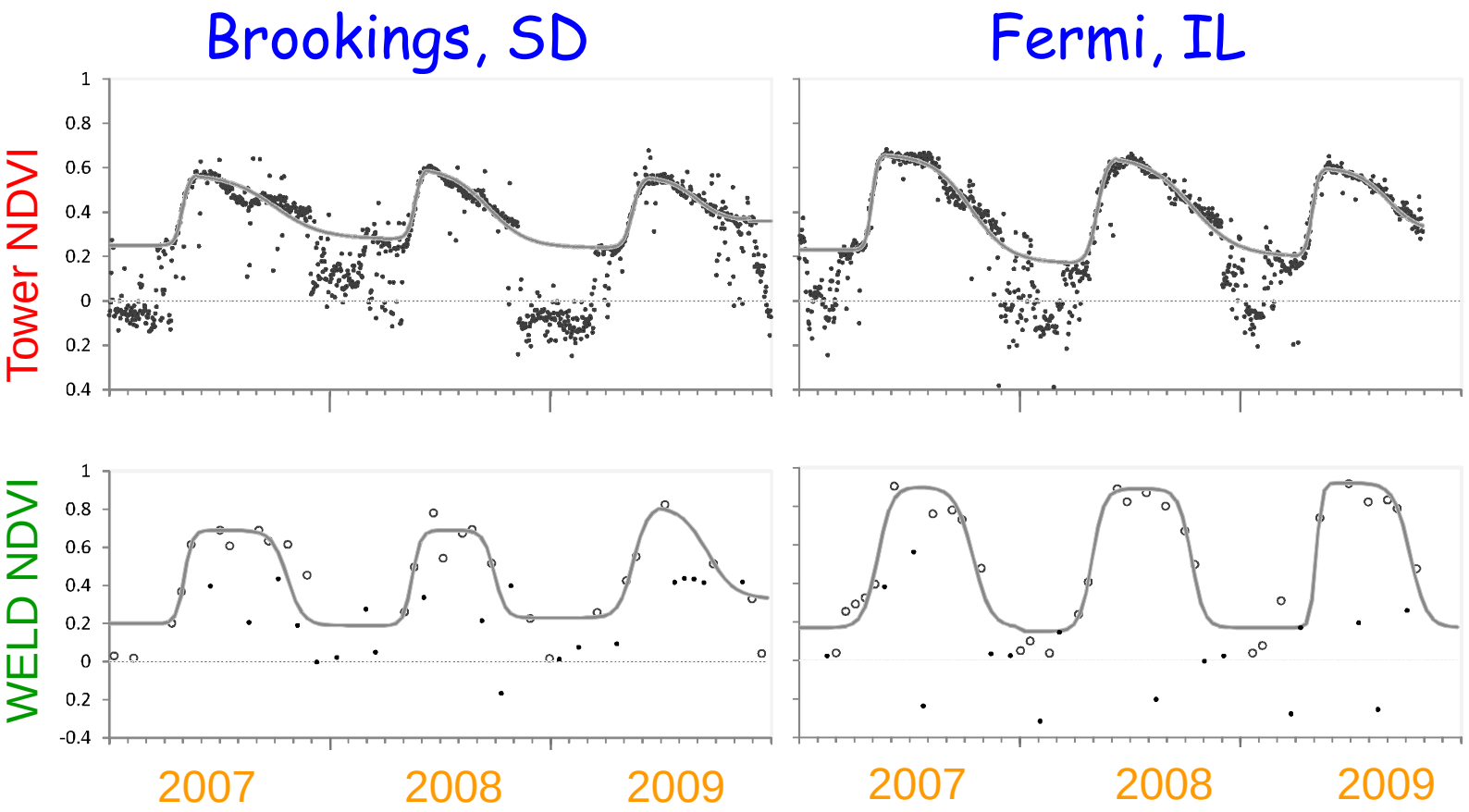
2009 WELD single pixel time series, Desert pixel, Utah (-113.4845°, 40.0923°)



TOA Brightness Temperature

2009 WELD single pixel time series, Desert pixel, Utah (-113.4845°, 40.0923°)




Brookings, SD
Fermi, IL
Tower NDVI
WELD NDVI
1
0.8
0.6
0.4
0.2
0
0.2
0.4
-0.4
2007
2008
2009

WELD Version 2.0 Algorithms

Available Spring 2012

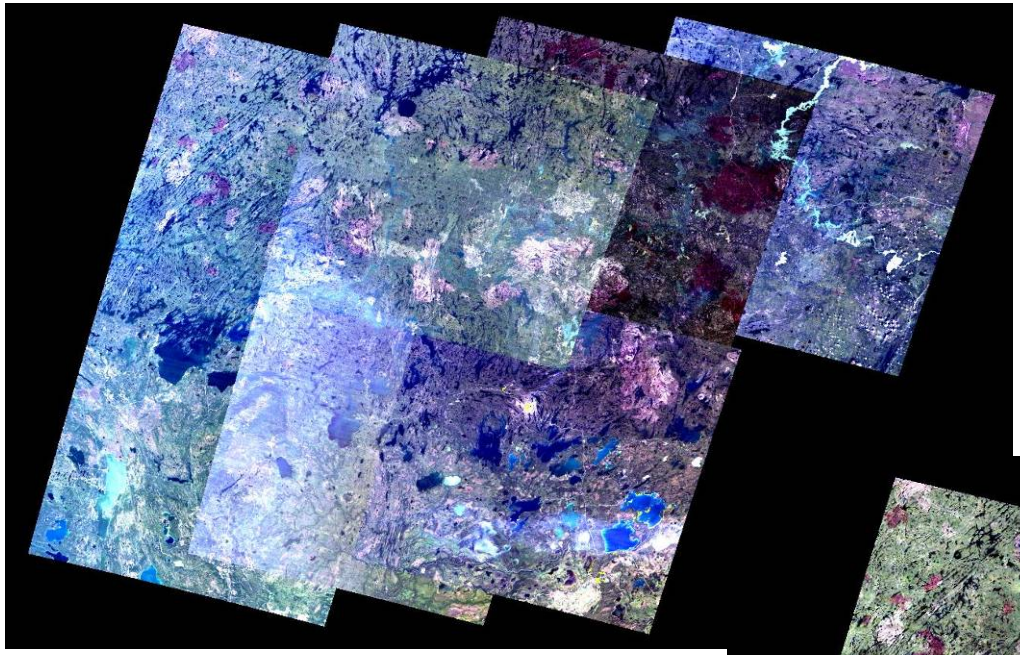
Version 2.0 WELD Products

- Atmospheric Correction of the Top of Atmosphere Reflectance Bands
- Reflective Wavelength Radiometric Normalization
- 30m Percent Tree, Bare Ground, Vegetation and Water Classification (Hansen et al.)

Version 2.0 Algorithm

Atmospheric Correction

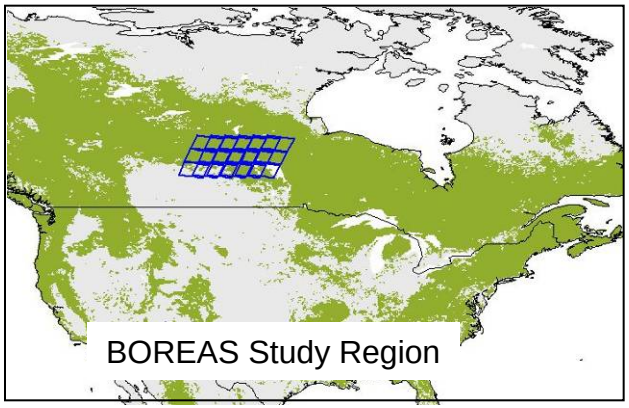
Heritage: LEDAPS Atmospheric Correction - 6SV

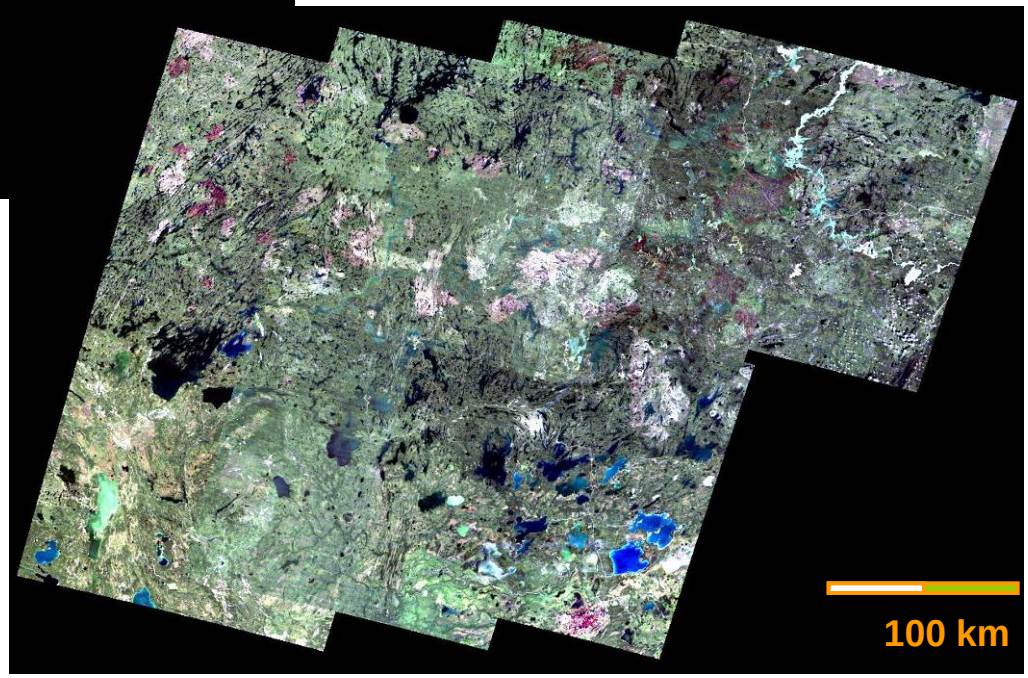


1990's Landsat-5 mosaic

← TOA reflectance

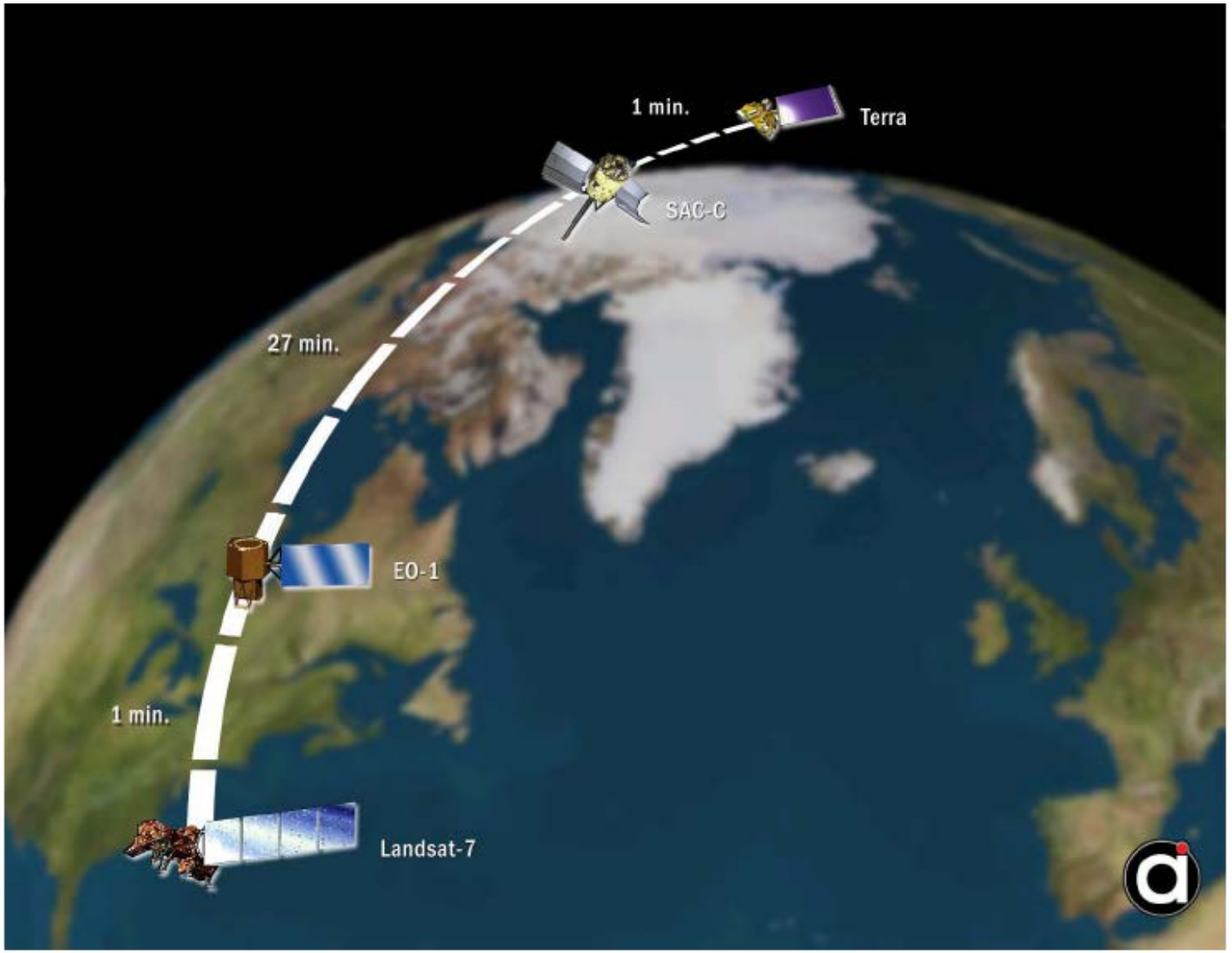
Surface reflectance ↓





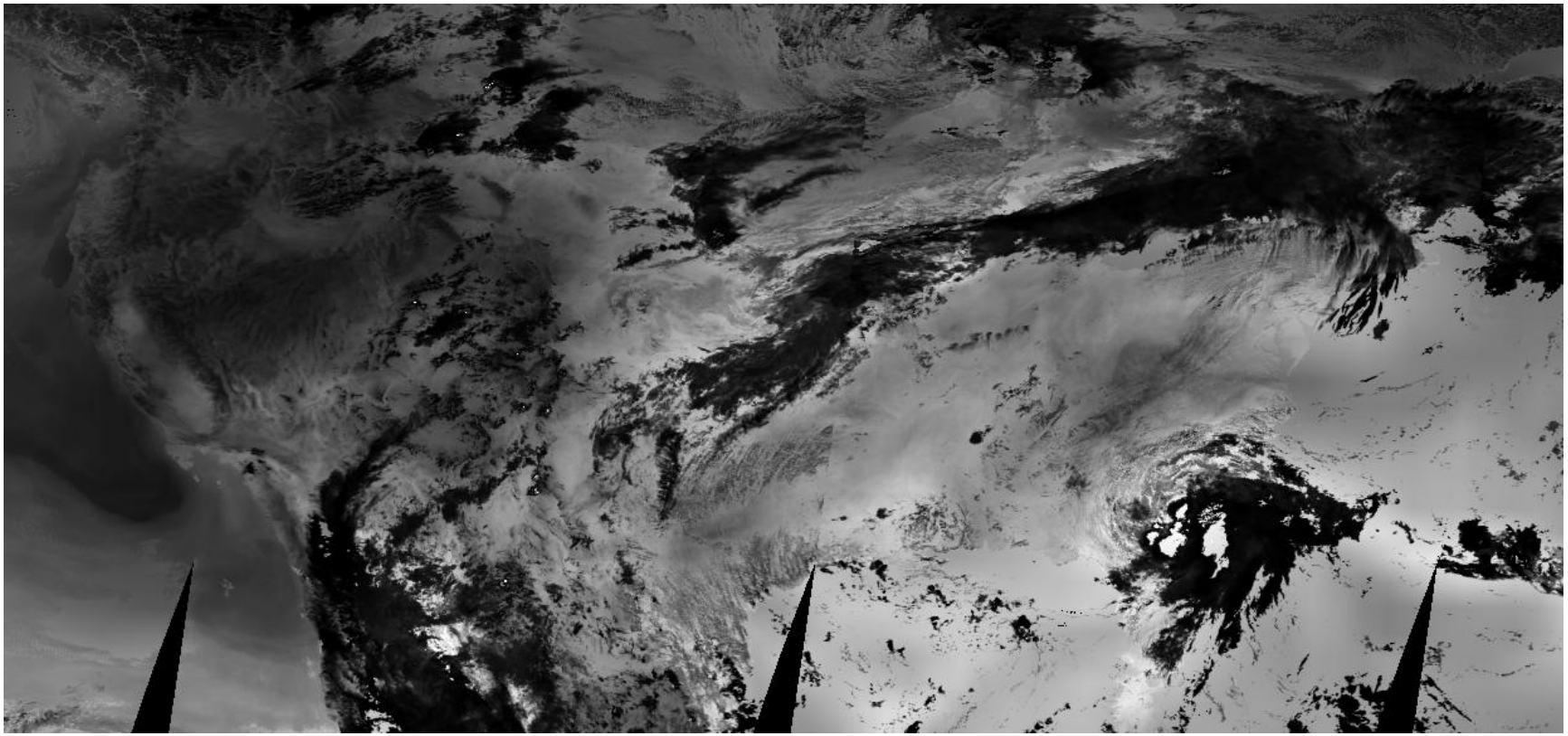
Jeff Masek

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



GSFC

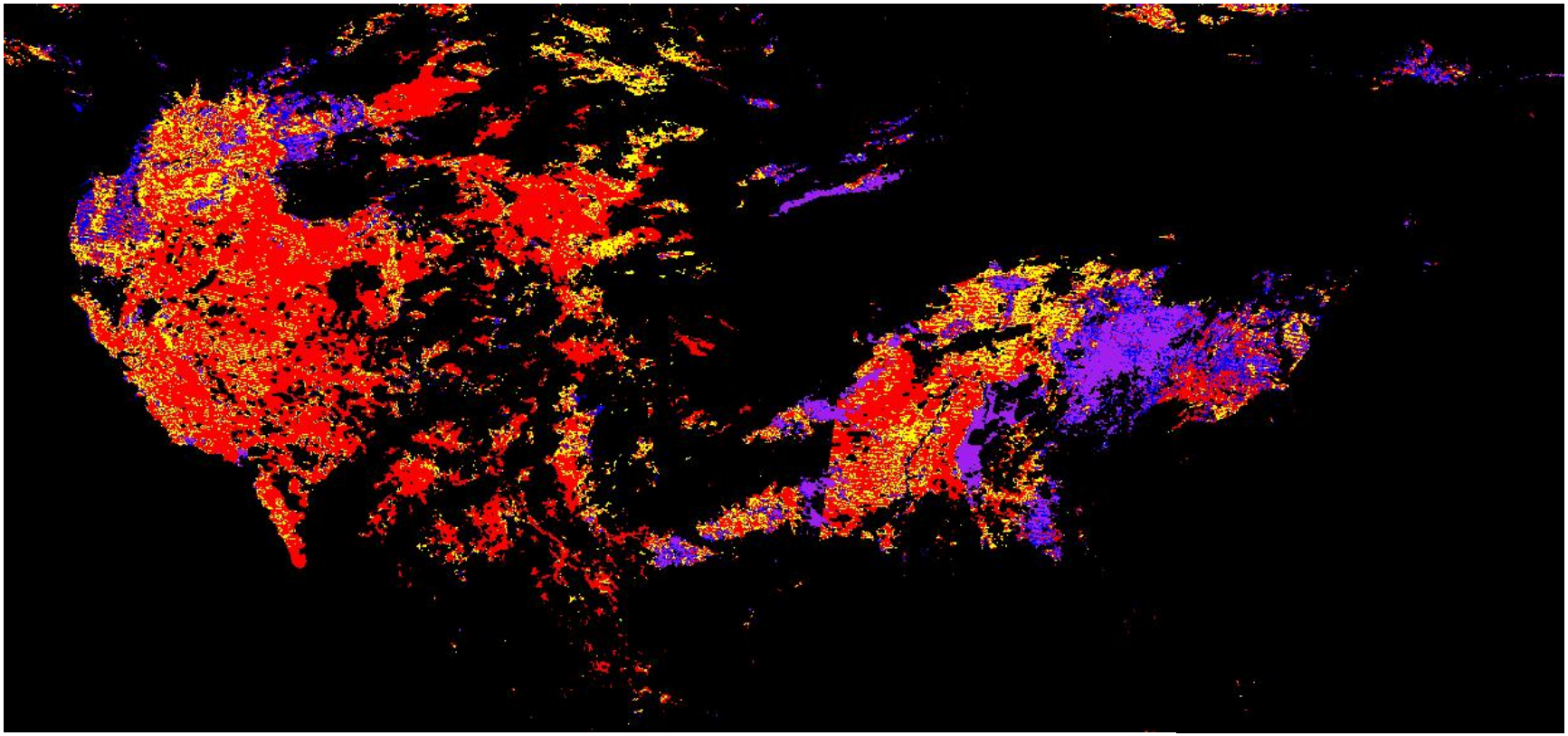
MODIS 0.05° Water Vapor over US, July 18th 2008



Black: Fill

retrieved from MODIS Terra orbits

MODIS 0.05° Aerosol Type over US, July 18th 2008

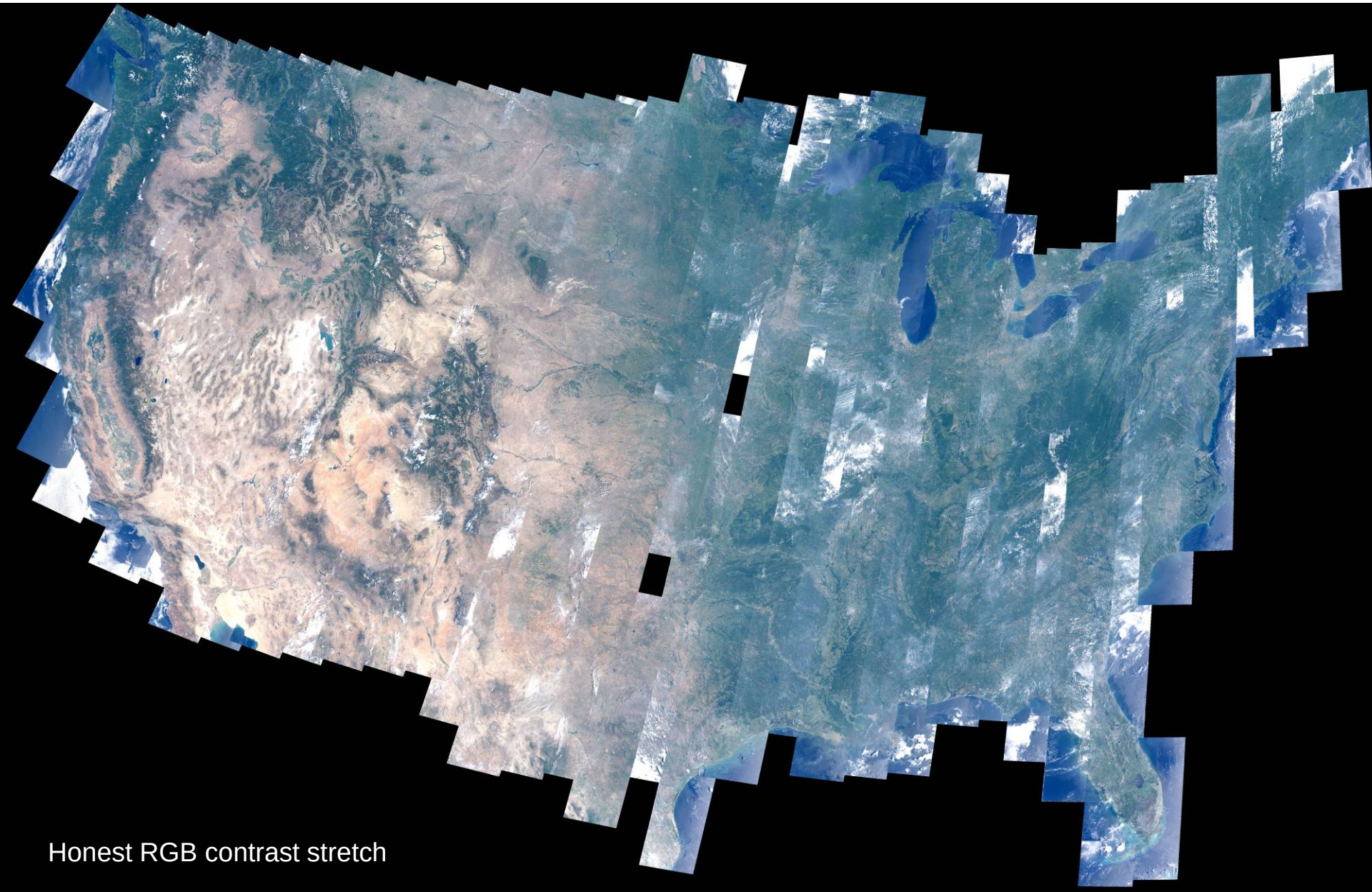


purple: low absorption smoke
blue: high absorption smoke
red: clean urban
yellow: polluted urban
black: fill

retrieved from MODIS Terra orbits

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

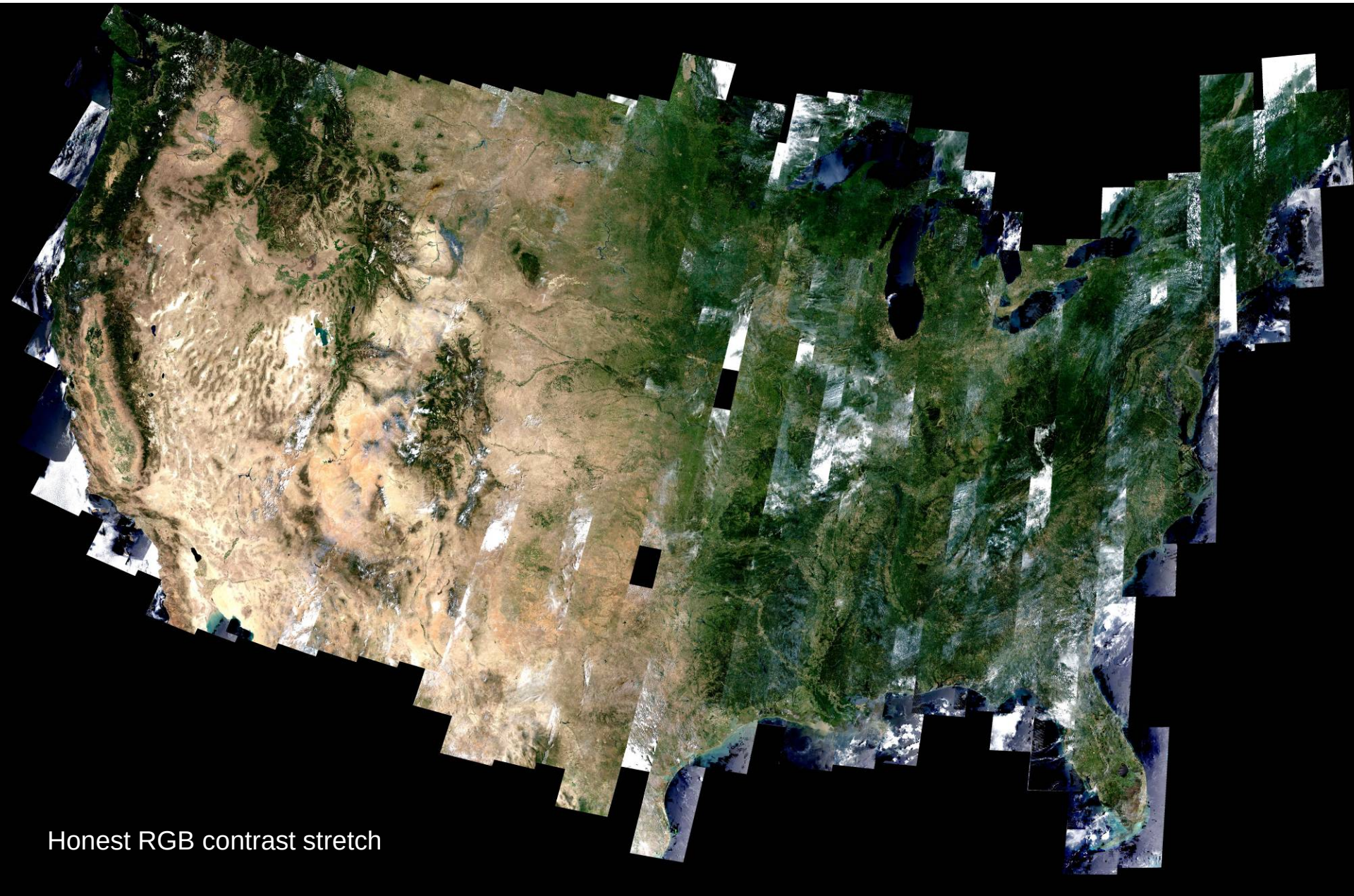
Top of Atmosphere Reflectance



Honest RGB contrast stretch

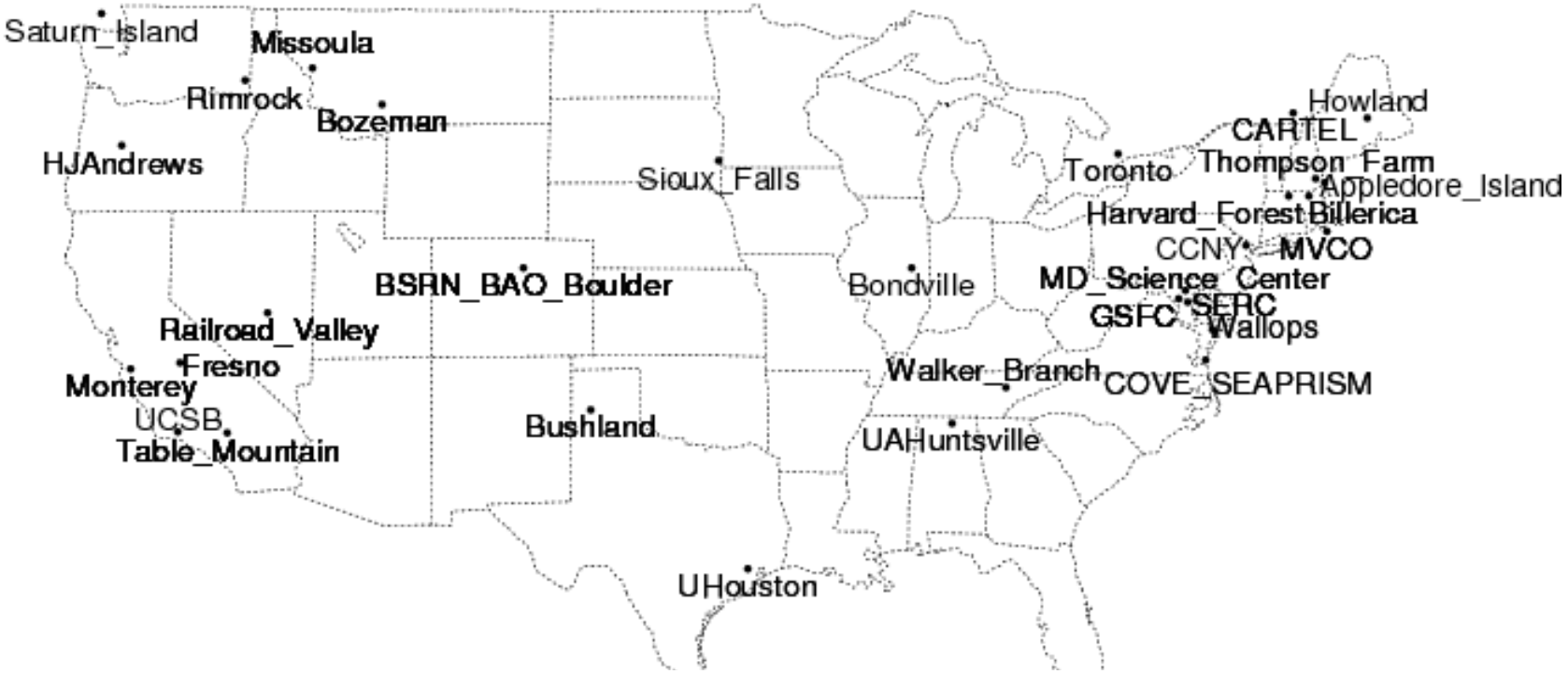
July 2008 composite. Band 3, 2, 1 (red, green, blue)

Surface Reflectance – using advanced MODIS Landsat method



Honest RGB contrast stretch

Spatial Distribution of WELD Atmospheric Correction Validation AERONET Sites



AERONET based atmospheric correction coefficients were derived for

- ***122*** *10x10km subsets*
- ***109*** acquisitions
- ***31*** AERONET sites

Mean absolute residuals of LEDAPS and MODIS-based methods relative to mean AERONET reflectance

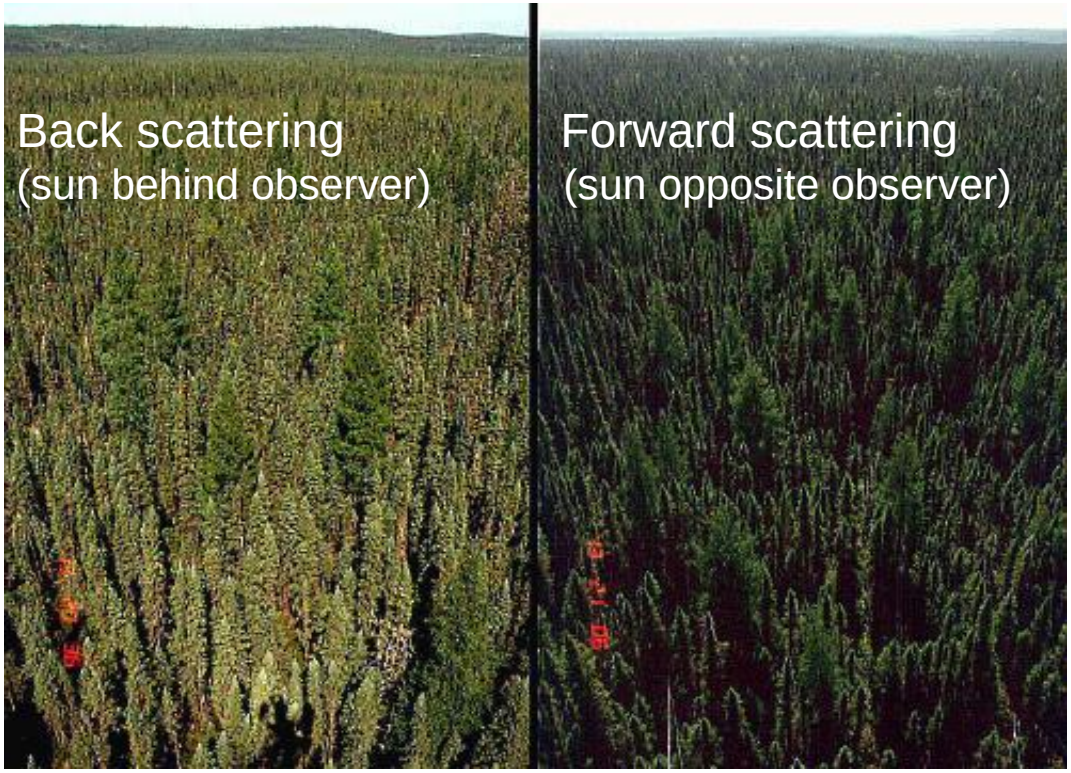
10 million pixels from 109 ETM+ acquisitions over 31 AERONET sites

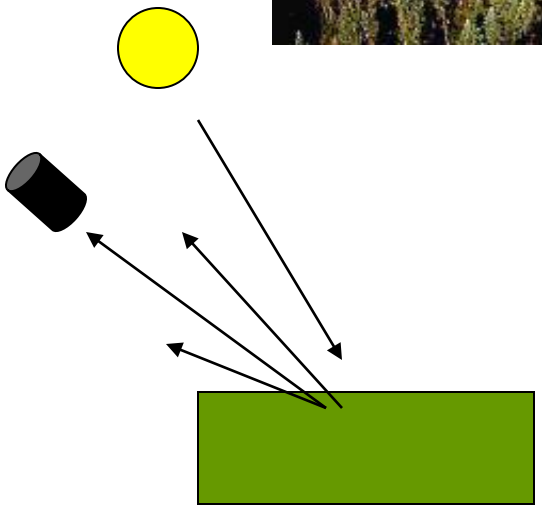
ETM+ Band	LEDAPS	MODIS-based
1	12.6%	11.7%
2	6.1%	5.0%
3	6.0%	3.5%
4	5.5%	1.9%
5	4.4%	1.0%
7	6.7%	1.6%

So, Version 2.0 WELD products will be processed with MODIS based atmospheric correction approach

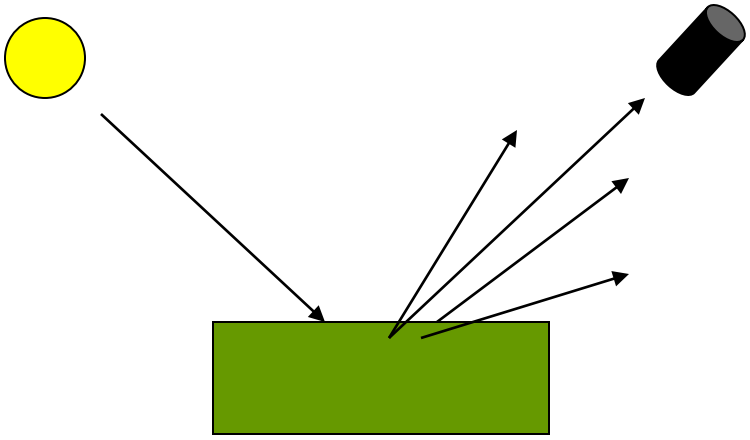
Version 2.0 Algorithm

Radiometric/BRDF normalization and gapfilling



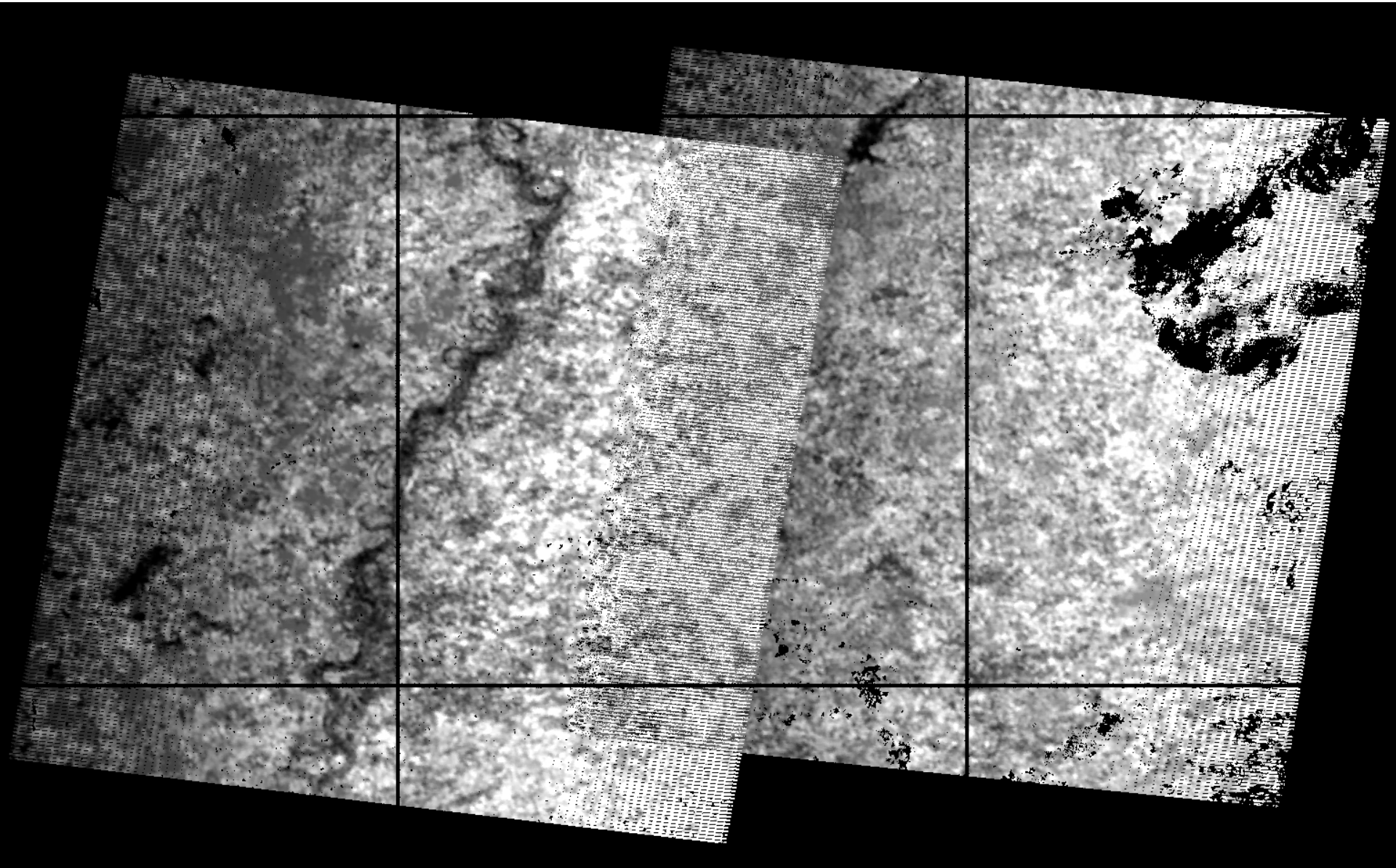


Back scatter direction

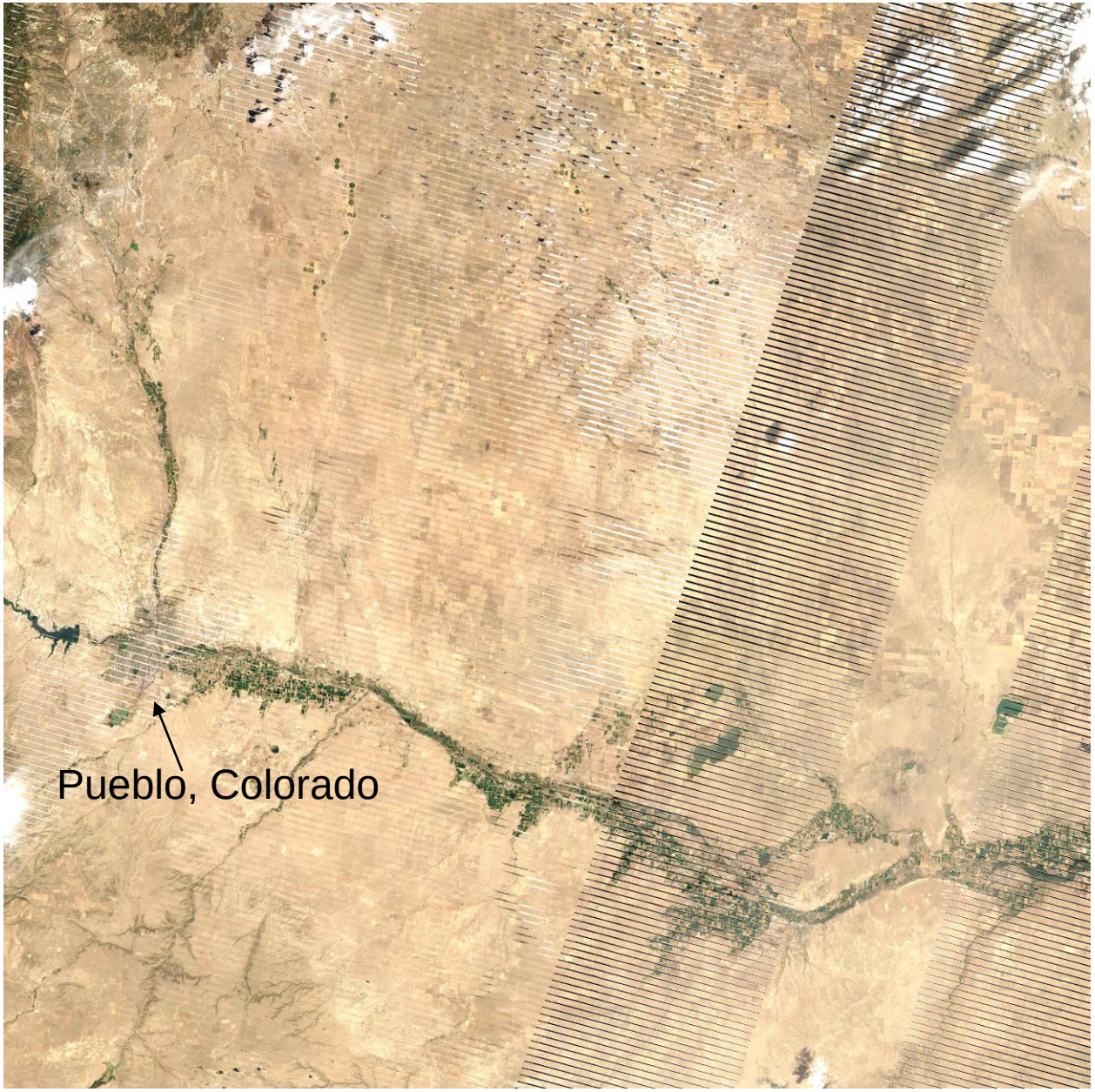


Forward scatter direction

Band 3 (red, 0.63-0.69 μm)
MODIS derived scaling factors (range: 0.97-1.43)



WELD Tile h12v10



July 2008

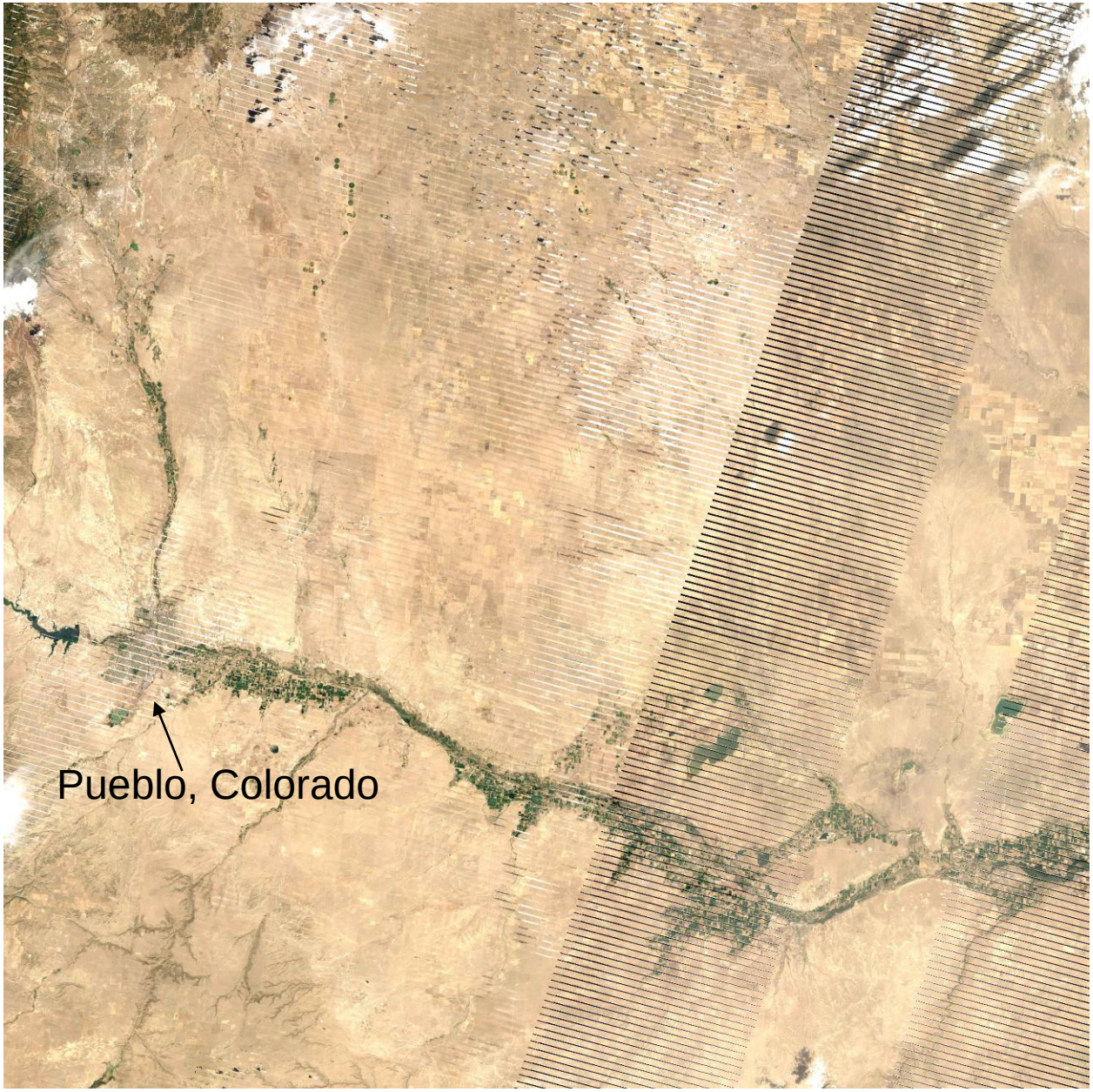
dates composited
- July 2
- July 11
- July 18
- July 27

Bands 3,2,1

5000 x 5000
30m pixels

Before radiometric normalization

WELD Tile h12v10



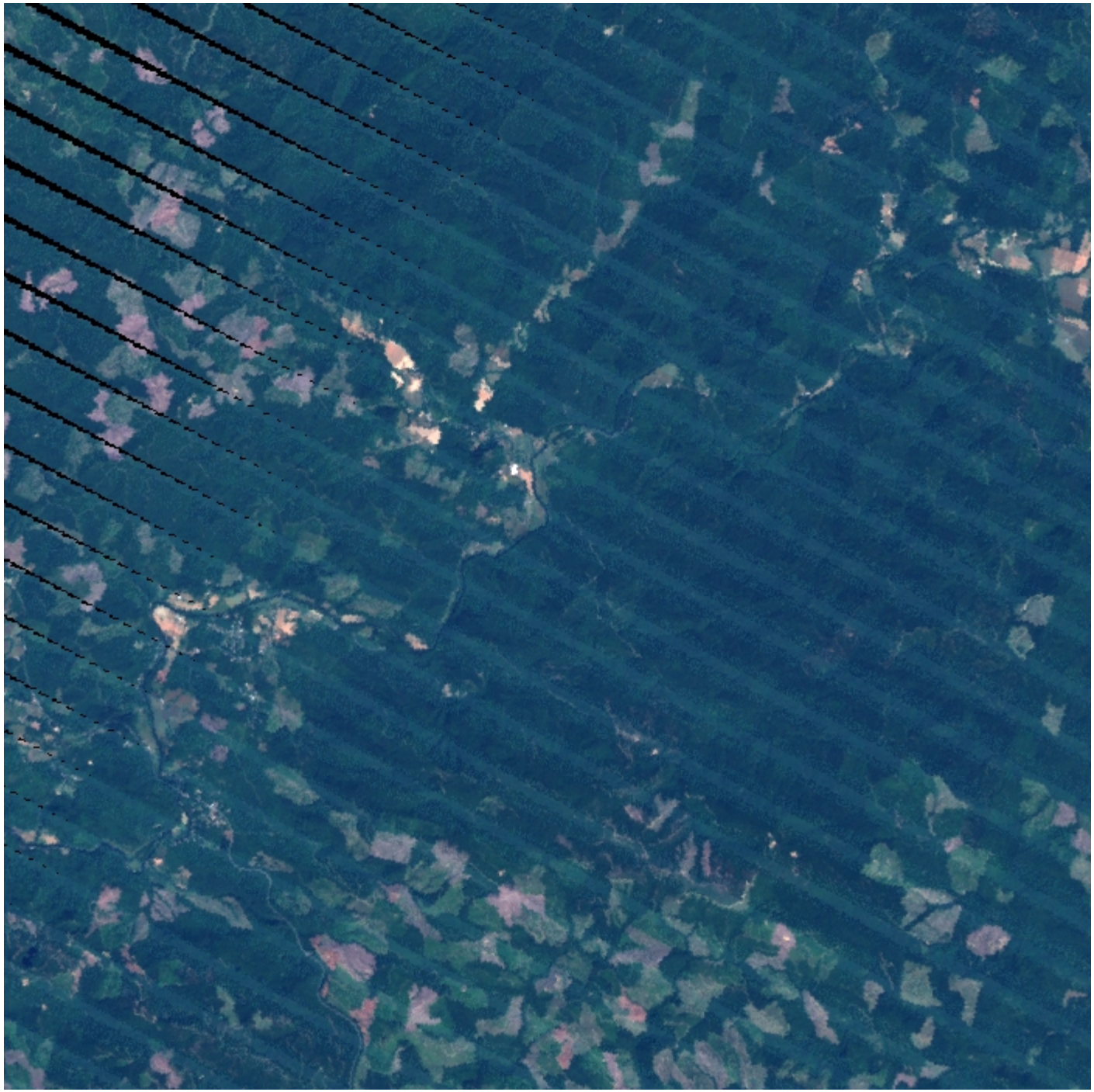
July 2008

dates composited
- July 2
- July 11
- July 18
- July 27

Bands 3,2,1

5000 x 5000
30m pixels

After radiometric normalization



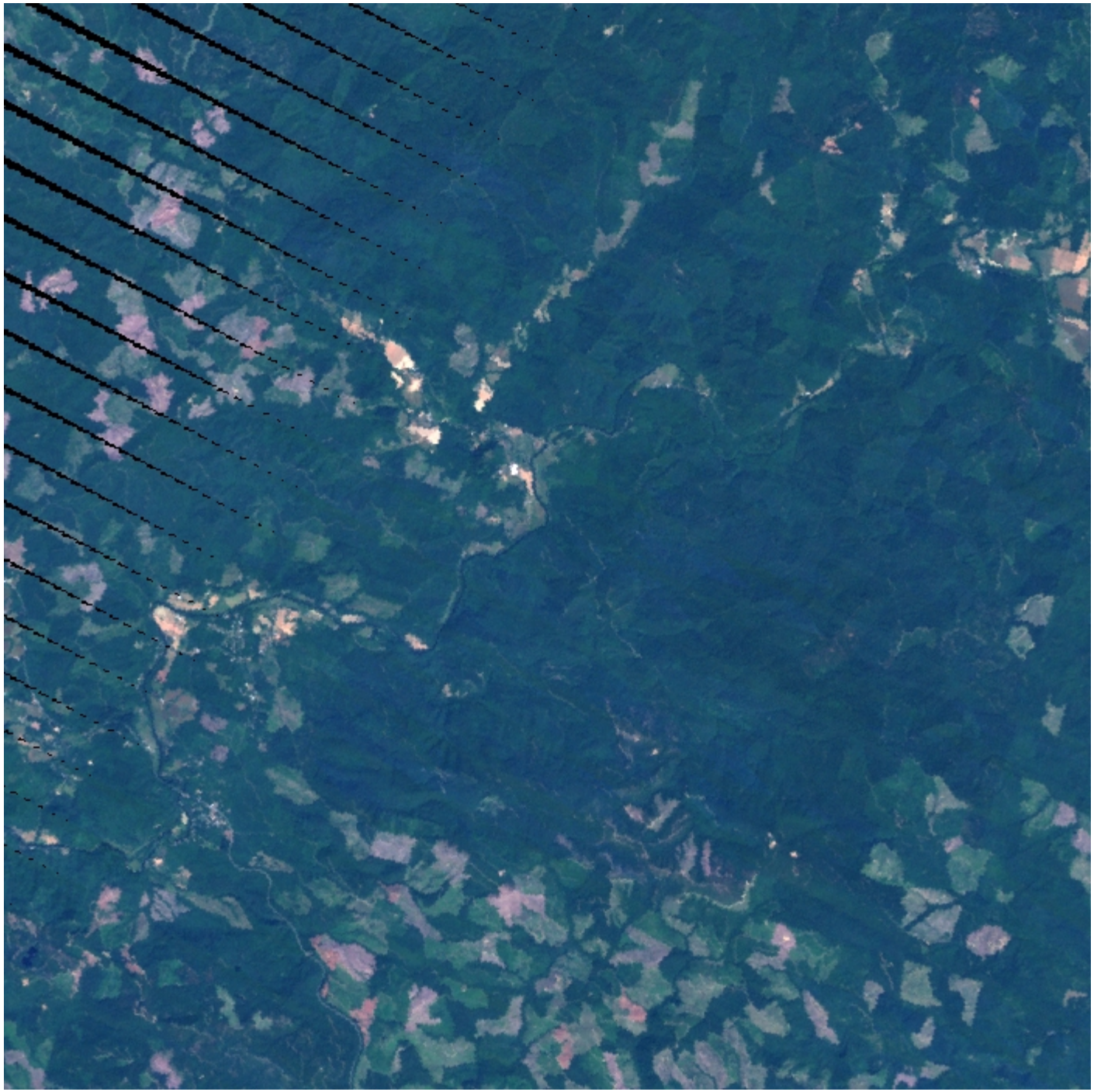
July 2008

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

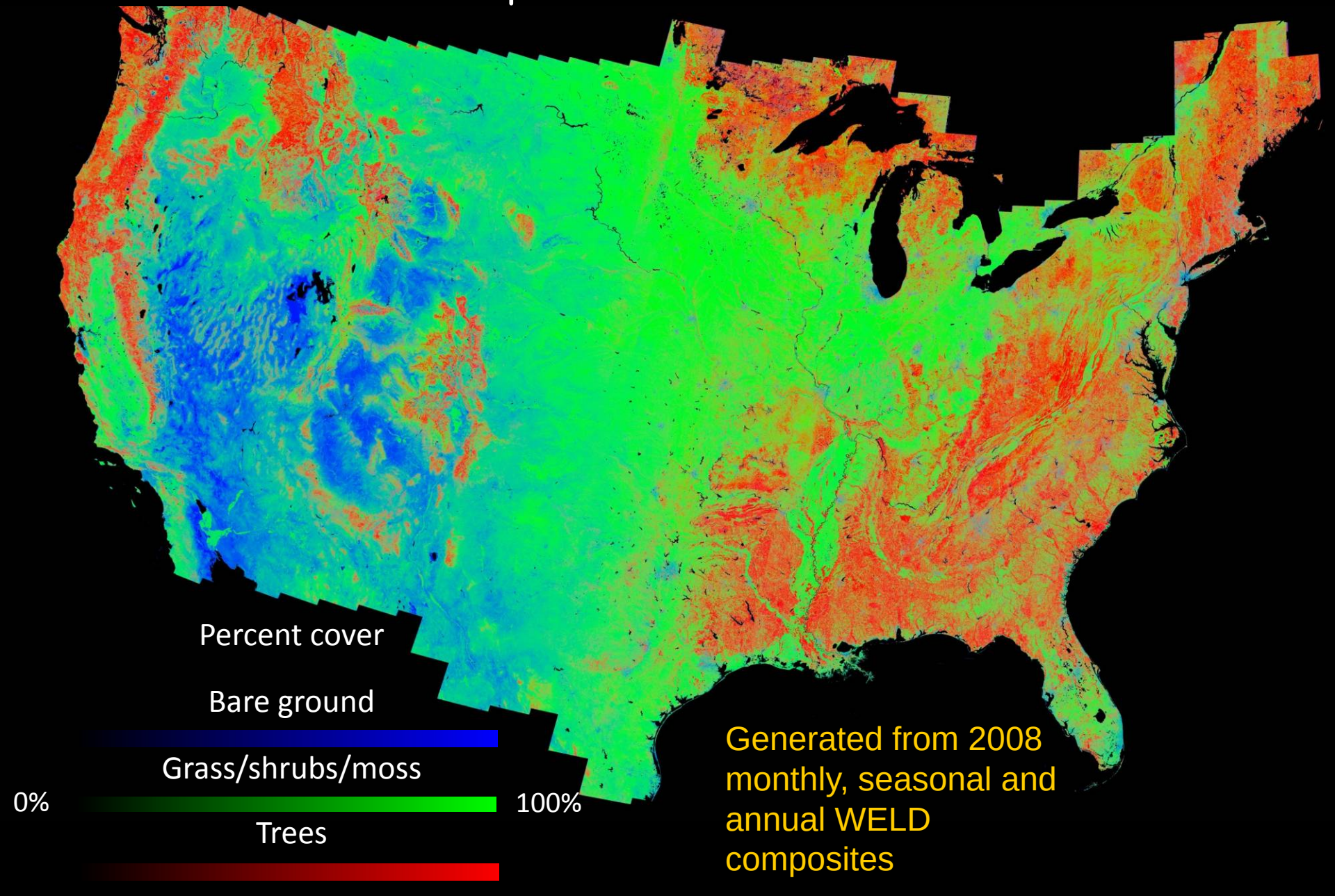
After radiometric normalization

Version 2.0 Algorithm

Land Cover Characterization

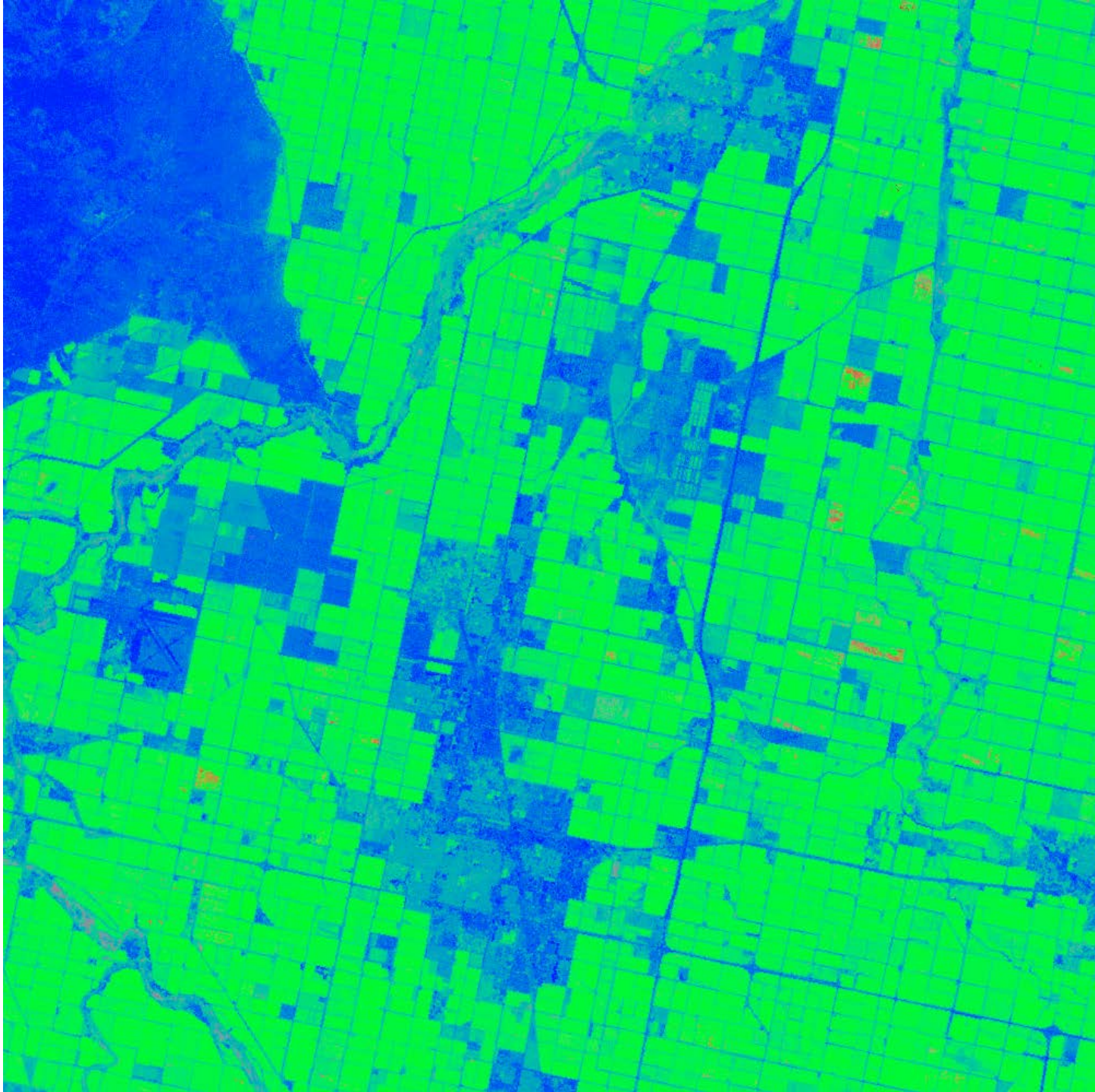
CONUS 30m Vegetation Continuous Fields (%)

30 meter sub-pixel fractional cover estimates



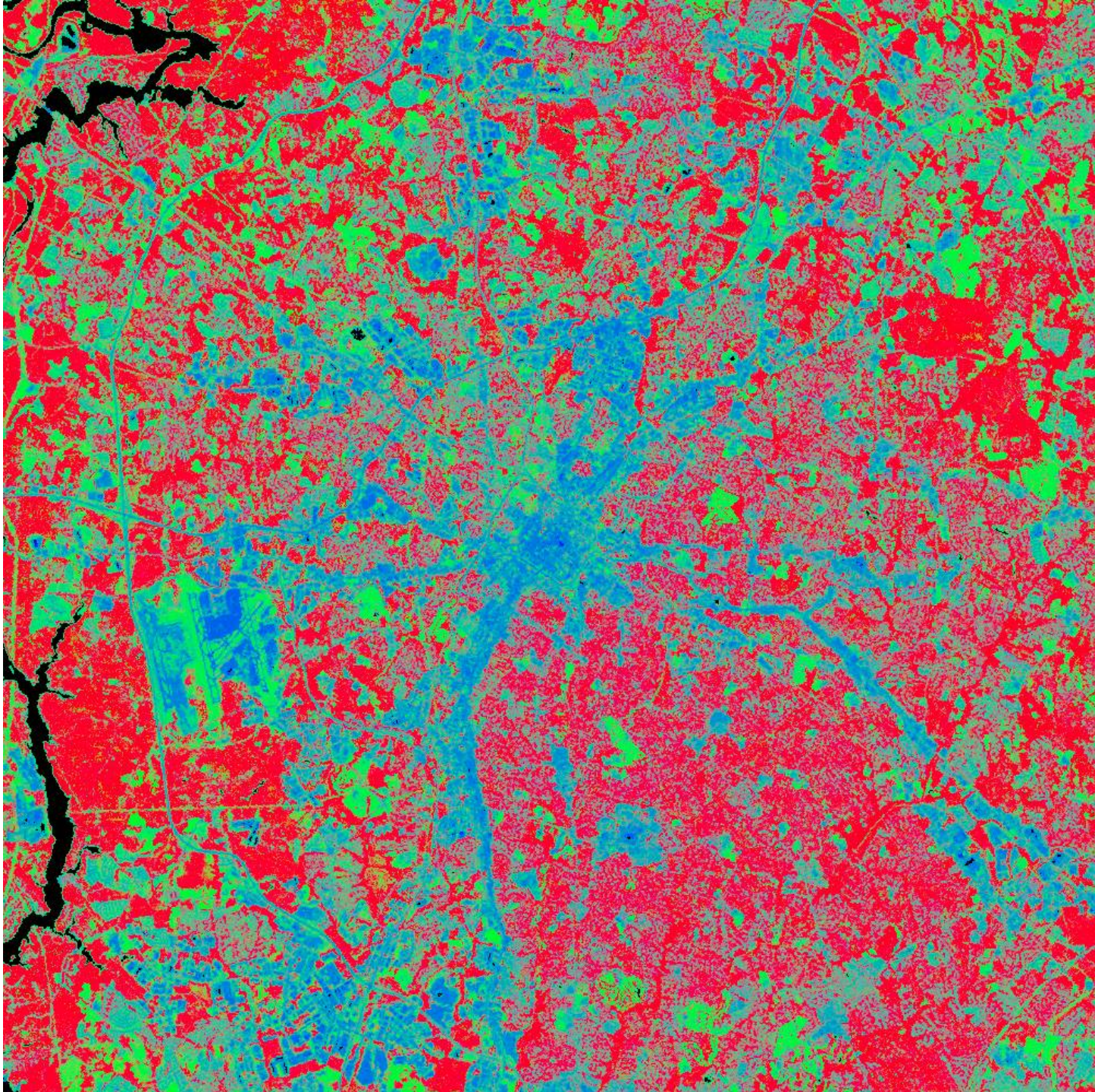
Generated from 2008 monthly, seasonal and annual WELD composites

Imperial Valley agriculture, CA



Generated from 2008 monthly, seasonal and annual WELD composites

Charlotte, NC



Percent cover

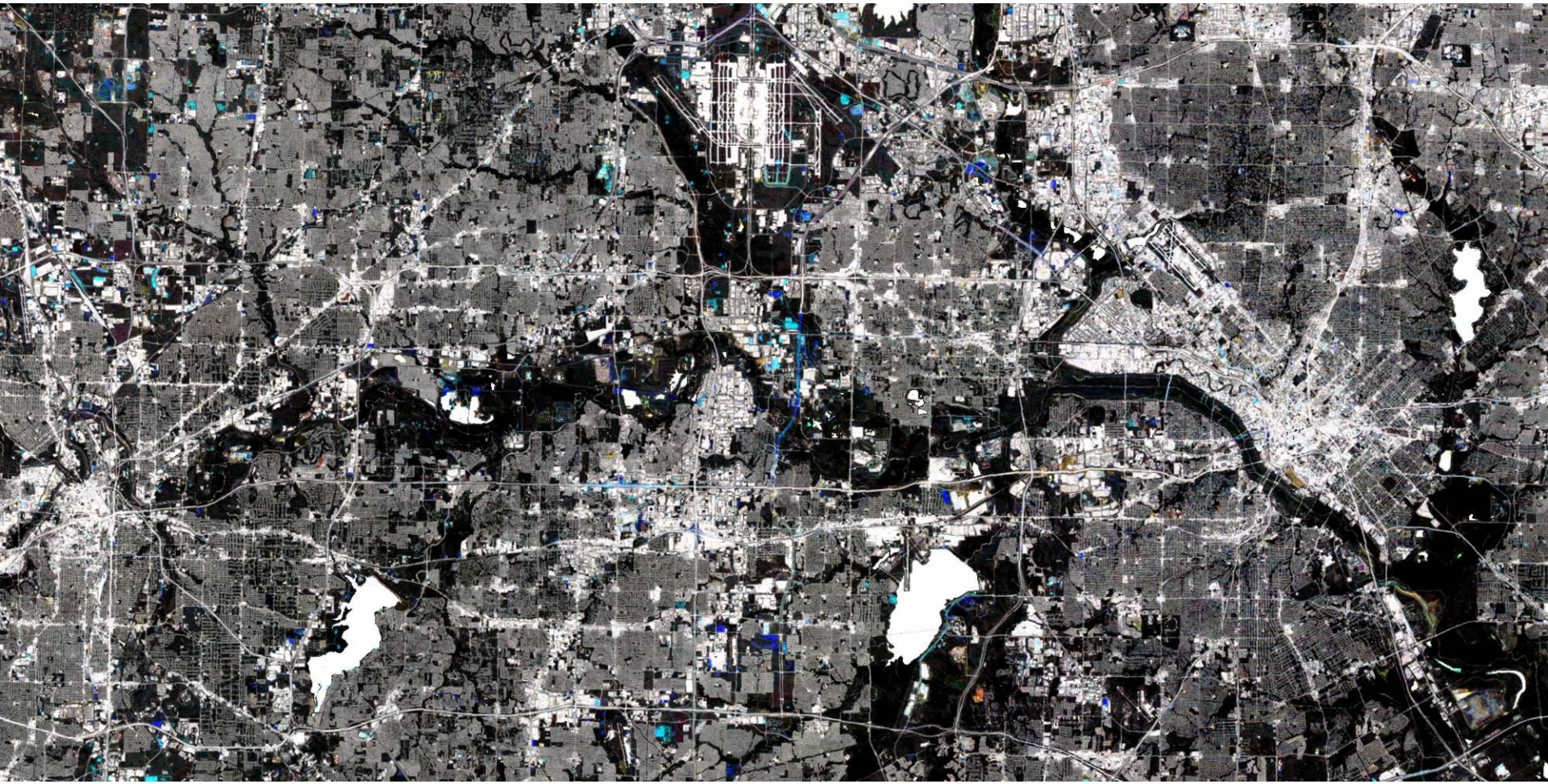
Bare ground

Grass/shrubs/moss

0%

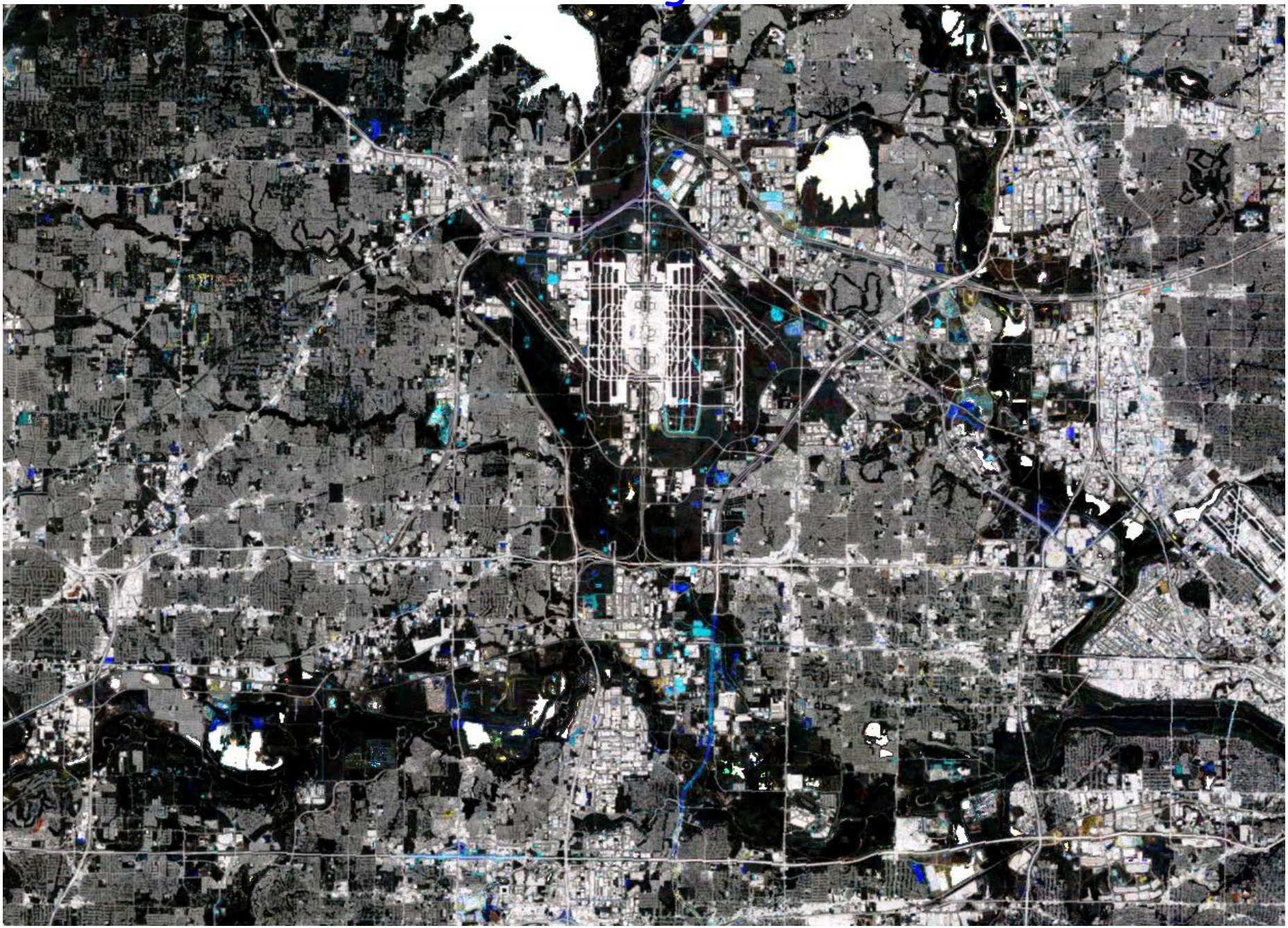
Trees

5 Years of WELD driven Bare Ground Change: Dallas – Fort Worth



Grey-scale = no change
Blue/Cyan = increase in bare ground,
Red/Yellow = decrease in bare ground

5 Year Bare Ground Change: Dallas – Fort Worth



5 Year Tree Cover Change: North Carolina coastal

Grey-scale = no change, Blue/Cyan = increase in tree cover, Red/Yellow = decrease in tree cover

Some Lessons Learned From WELD Science Data Processing

7 lessons, with implications for LDCM higher level Landsat product generation

Lesson #1

- Get the product out early
- Ensure mechanisms to involve the user community in product QA
- Reprocess products as needed

WELD: Web - Enabled Landsat Data

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

Recent Presentations

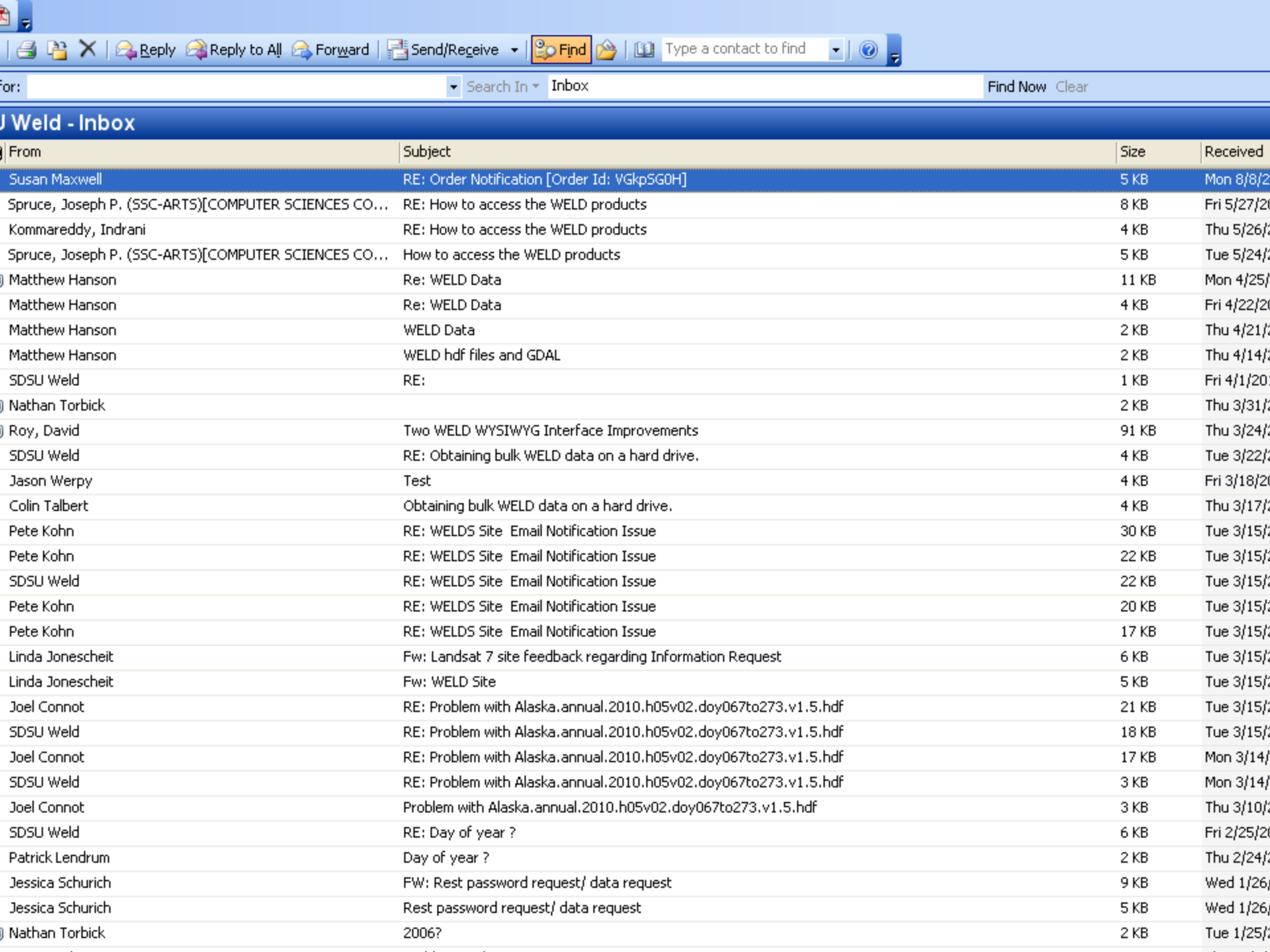
Example WELD Browse Images

WELD Citation

Frequently Asked Questions (FAQ)

WELD Help Email

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


Reply
Reply to All
Forward
Send/Receive
Find
Type a contact to find
for:
Search In
Inbox
Find Now
Clear
U Weld - Inbox
From
Subject
Size
Received
Susan Maxwell
RE: Order Notification [Order Id: VGkpSG0H]
5 KB
Mon 8/8/2
Spruce, Joseph P. (SSC-ARTS)[COMPUTER SCIENCES CO...
RE: How to access the WELD products
8 KB
Fri 5/27/20
Kommareddy, Indrani
RE: How to access the WELD products
4 KB
Thu 5/26/
Spruce, Joseph P. (SSC-ARTS)[COMPUTER SCIENCES CO...
How to access the WELD products
5 KB
Tue 5/24/
Matthew Hanson
Re: WELD Data
11 KB
Mon 4/25/
Matthew Hanson
Re: WELD Data
4 KB
Fri 4/22/20
Matthew Hanson
WELD Data
2 KB
Thu 4/21/
Matthew Hanson
WELD hdf files and GDAL
2 KB
Thu 4/14/
SDSU Weld
RE:
1 KB
Fri 4/1/20
Nathan Torbick
2 KB
Thu 3/31/
Roy, David
Two WELD WYSIWYG Interface Improvements
91 KB
Thu 3/24/
SDSU Weld
RE: Obtaining bulk WELD data on a hard drive.
4 KB
Tue 3/22/
Jason Werpy
Test
4 KB
Fri 3/18/20
Colin Talbert
Obtaining bulk WELD data on a hard drive.
4 KB
Thu 3/17/
Pete Kohn
RE: WELDS Site Email Notification Issue
30 KB
Tue 3/15/
Pete Kohn
RE: WELDS Site Email Notification Issue
22 KB
Tue 3/15/
SDSU Weld
RE: WELDS Site Email Notification Issue
22 KB
Tue 3/15/
Pete Kohn
RE: WELDS Site Email Notification Issue
20 KB
Tue 3/15/
Pete Kohn
RE: WELDS Site Email Notification Issue
17 KB
Tue 3/15/
Linda Jonescheit
Fw: Landsat 7 site feedback regarding Information Request
6 KB
Tue 3/15/
Linda Jonescheit
Fw: WELD Site
5 KB
Tue 3/15/
Joel Connot
RE: Problem with Alaska.annual.2010.h05v02.doy067to273.v1.5.hdf
21 KB
Tue 3/15/
SDSU Weld
RE: Problem with Alaska.annual.2010.h05v02.doy067to273.v1.5.hdf
18 KB
Tue 3/15/
Joel Connot
RE: Problem with Alaska.annual.2010.h05v02.doy067to273.v1.5.hdf
17 KB
Mon 3/14/
SDSU Weld
RE: Problem with Alaska.annual.2010.h05v02.doy067to273.v1.5.hdf
3 KB
Mon 3/14/
Joel Connot
Problem with Alaska.annual.2010.h05v02.doy067to273.v1.5.hdf
3 KB
Thu 3/10/
SDSU Weld
RE: Day of year ?
6 KB
Fri 2/25/20
Patrick Lendrum
Day of year ?
2 KB
Thu 2/24/
Jessica Schurich
FW: Rest password request/ data request
9 KB
Wed 1/26/
Jessica Schurich
Rest password request/ data request
5 KB
Wed 1/26/
Nathan Torbick
2006?
2 KB
Tue 1/25/

About the WELD Project

Version 1.5 Product Documentation

Version 1.5 Product Quality

Known Version 1.5 Product Issues

Pixel alignment

- The Albers coordinates of the WELD pixels have a sub-pixel misalignment with the Albers coordinates defining the U.S. National Land Cover Data dataset. The WELD Albers projection origin does not fall perfectly at a WELD product pixel center. For example, the CONUS projection origin is in horizontal tile 17, vertical tile 22 at column 520.000, row 493.333, and the Alaska projection origin is in horizontal tile 5, vertical tile 16 at column 3390.000, row 2478.333 (where column 0.5, row 0.5 refers to the center of the NW pixel of a tile). This issue will be rectified in the next WELD product version.

2007 and 2010 product mixed 30m thermal band resolution issue

- Since February 26th 2010 the Landsat L1T data have been produced at USGS EROS with the 60m thermal bands resampled to 30m (resampling applied in the L0 to L1T processing at USGS). Prior to February 26th 2010 the WELD product thermal bands were generated at 30m as part of the WELD processing using a different nearest neighbor resampling methodology. As a consequence the 2007 and 2010 WELD product 30m thermal bands were generated from L1T data processed with both methodologies. The impact of this mixed thermal band resolution issue is thought to be minimal.

2010 Summer and Annual Composite (central Iowa, SE Minnesota, Wisconsin)

- There were unusually cloudy conditions at the time of Landsat ETM+ overpass for a single Landsat path over central Iowa, SE Minnesota, and west central Wisconsin in the summer months of 2010; consequently, the 2010 Summer WELD product is cloudy and the Annual WELD product does not include summer observations in this locality.

Extent of Alaska

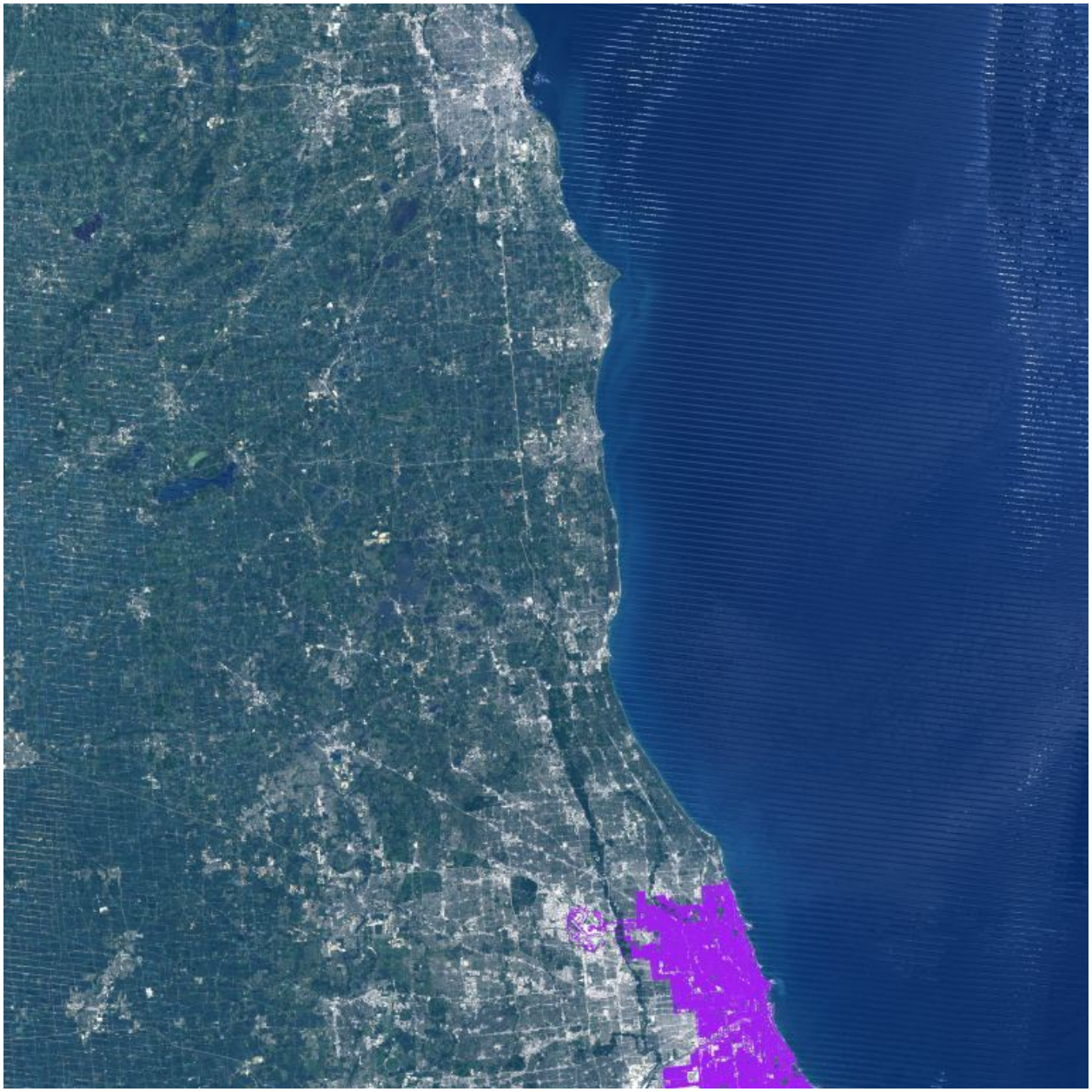
- Because of the scarcity of Landsat acquisitions over the islands off the Alaskan west coast, many western islands are not included in the Version 1.5 Alaska WELD products. More of these Aleutian islands are being considered for inclusion in the next WELD product version.

Product Improvements on Previous Versions

Product Accuracy/Consistency

Planned Version 2.0 Product Improvements

How To Obtain WELD Products



WELD Tile
h21v07
Chicago

TOA Reflectance
True Color

June, 2008

Purple Vector
Street Map

5000 X 5000 pixels

GIS data: http://www.cityofchicago.org/city/en/depts/doit/provdrs/gis.html

WELD, July 2008, Version 1.5

100 X 80 30m pixels

WELD, July 2008, Version 1.6

100 X 80 30m pixels

Lesson #2

Routinely QA the input data
in order to

- prevent code failure
- provide consistent science products through time

i.e., don't rely on EROS to provide consistent L1T data, for example, In the last 3 project years, we have seen

- Thermal band 60m to 30m resolution change
- Metadata changes
- Filename convention changes
- also, most recent calibration always used

Lesson #3

Track the production date/time as well as the acquisition date/time of the input data and implement and manage a product versioning scheme

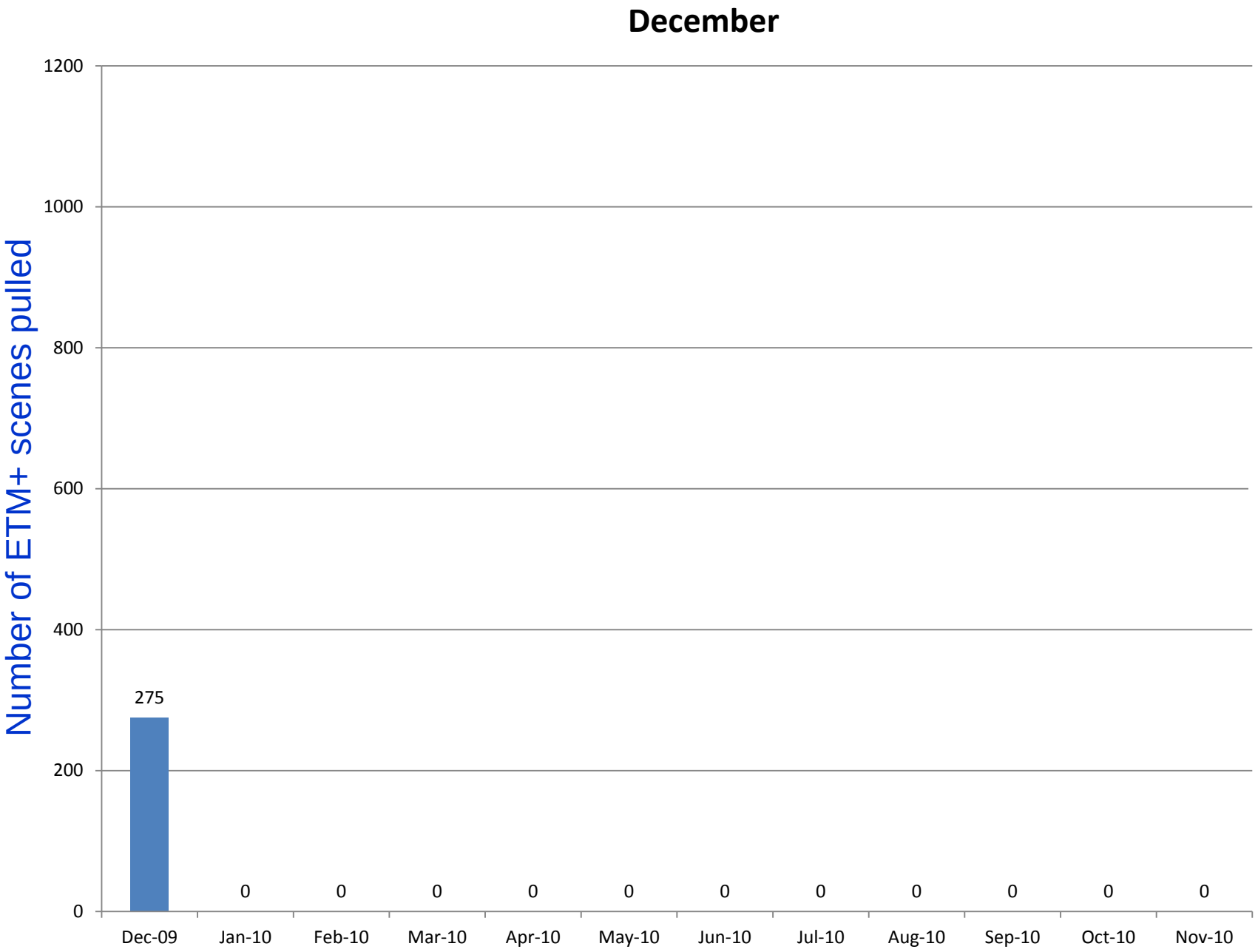
USGS
science for a changing world

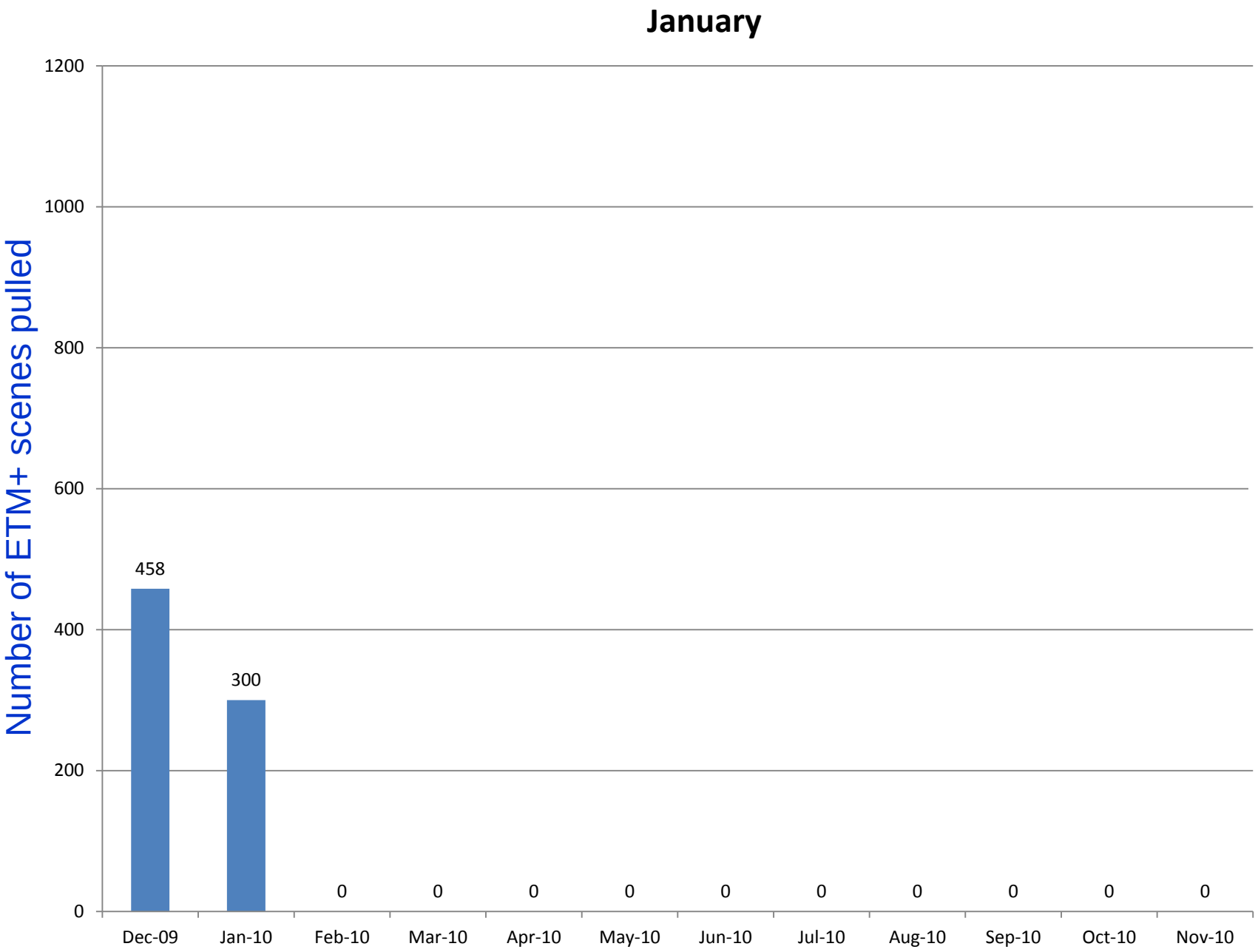
- L1T from USGS to SDSU by an FTP-Cron job

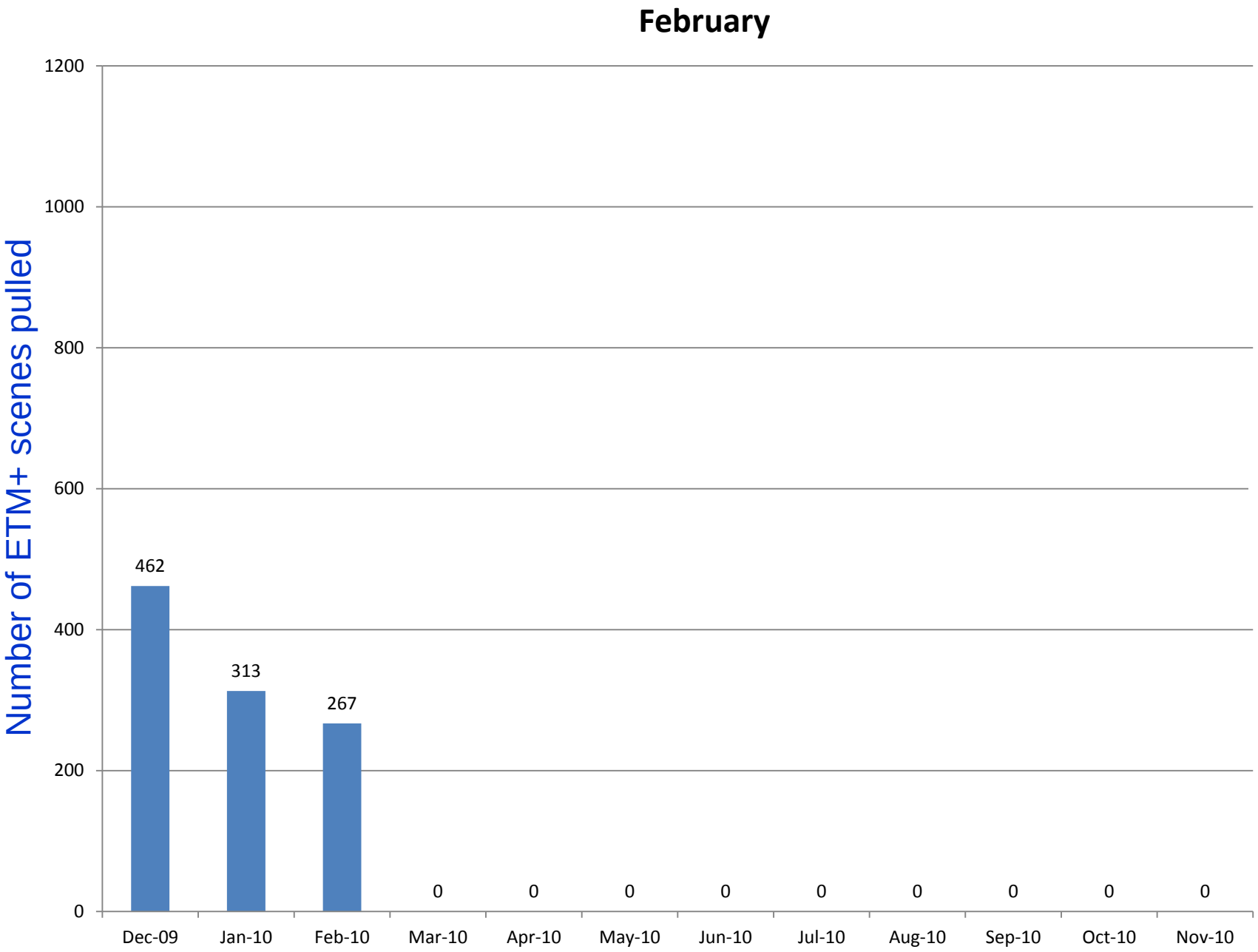
may get scenes cloud cover > 80% ordered by other users

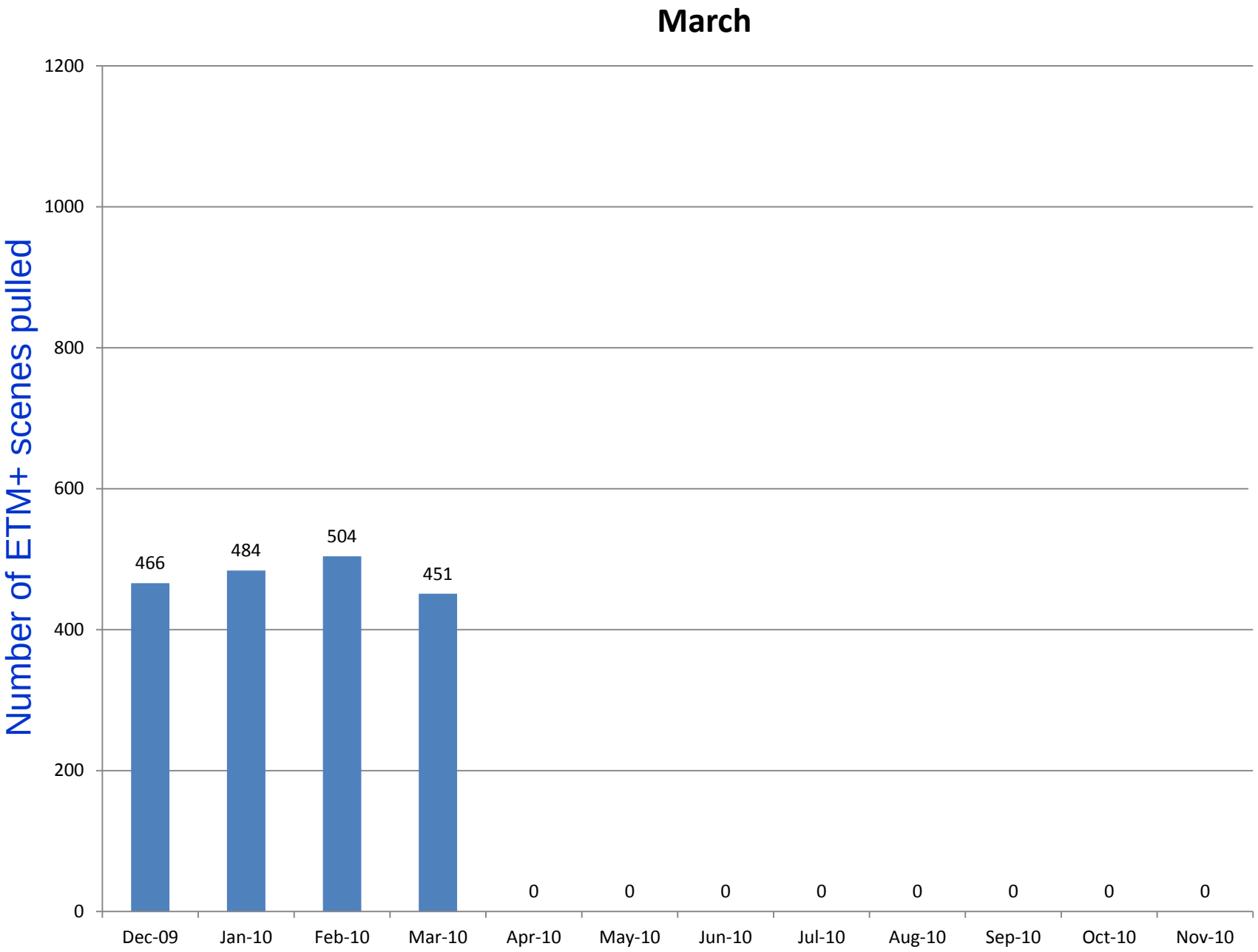
- SDSU student manually orders scenes with cloud cover < 80% via EROS GLOVIS interface every 2 days

SDSU
South Dakota State University
Geographic Information Science Center of Excellence

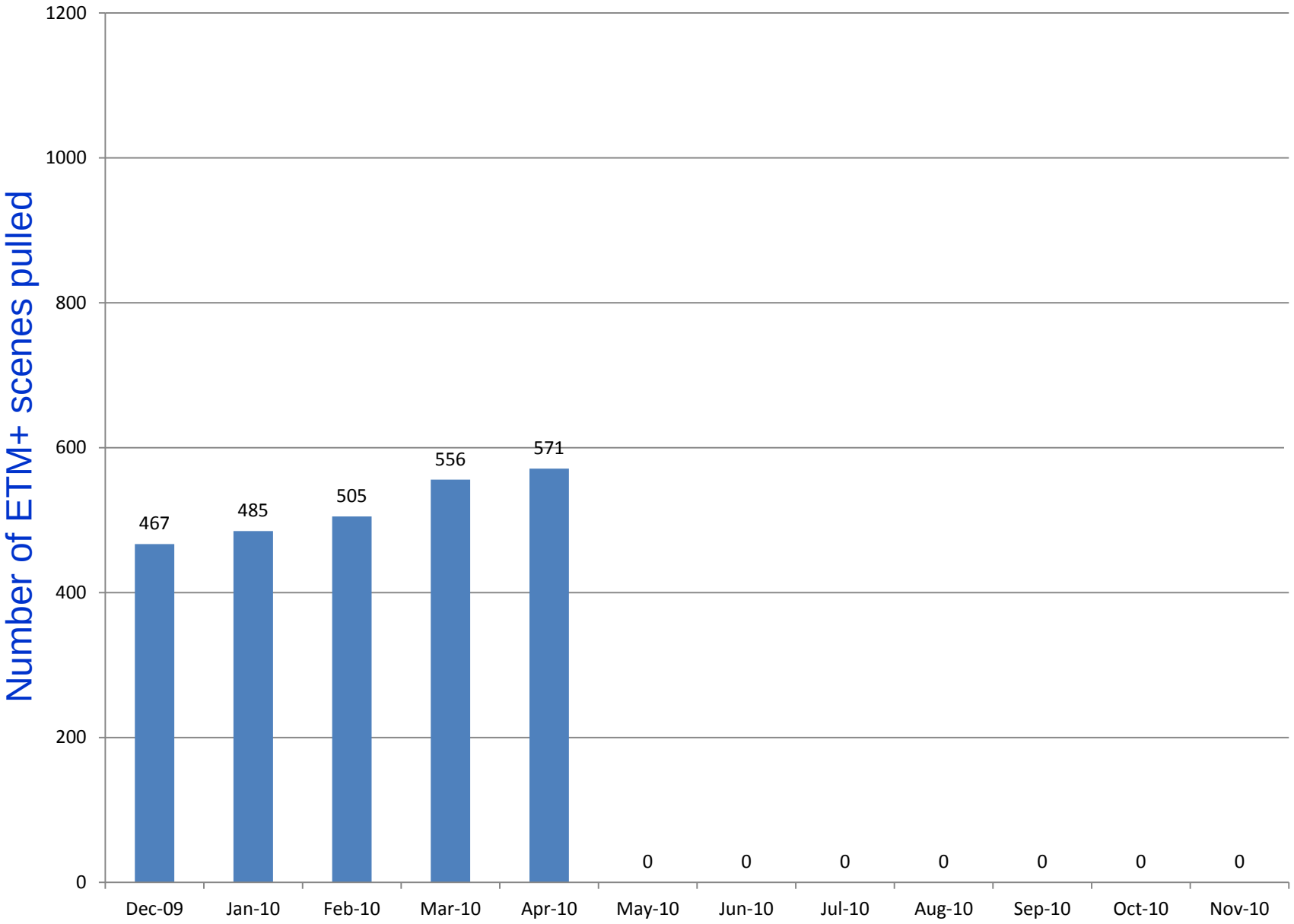

December
Number of ETM+ scenes pulled
1200
1000
800
600
400
200
0
275
0
0
0
0
0
0
0
0
0
0
0
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10
Nov-10

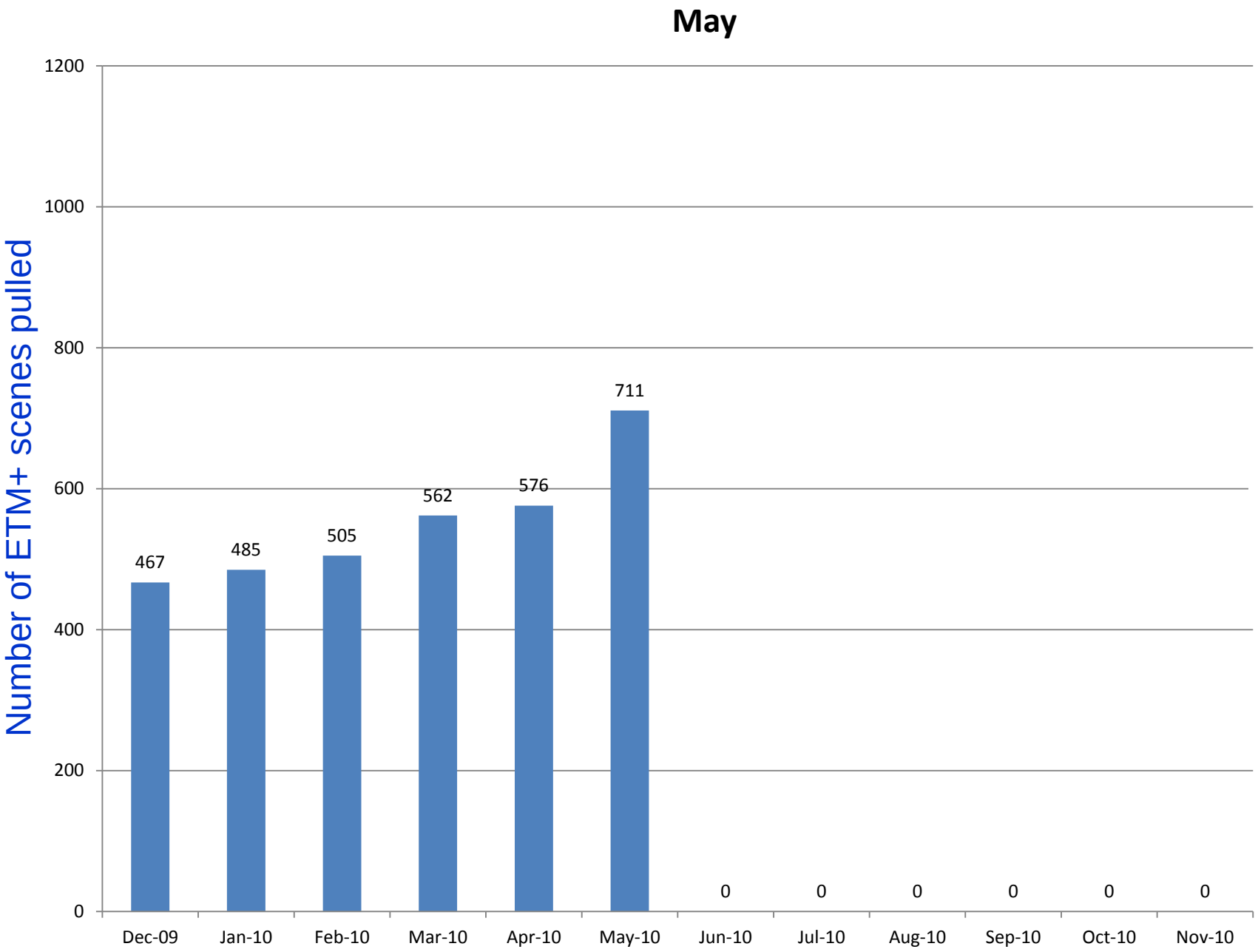

January
Number of ETM+ scenes pulled
1200
1000
800
600
400
200
0
458
300
0
0
0
0
0
0
0
0
0
0
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10
Nov-10

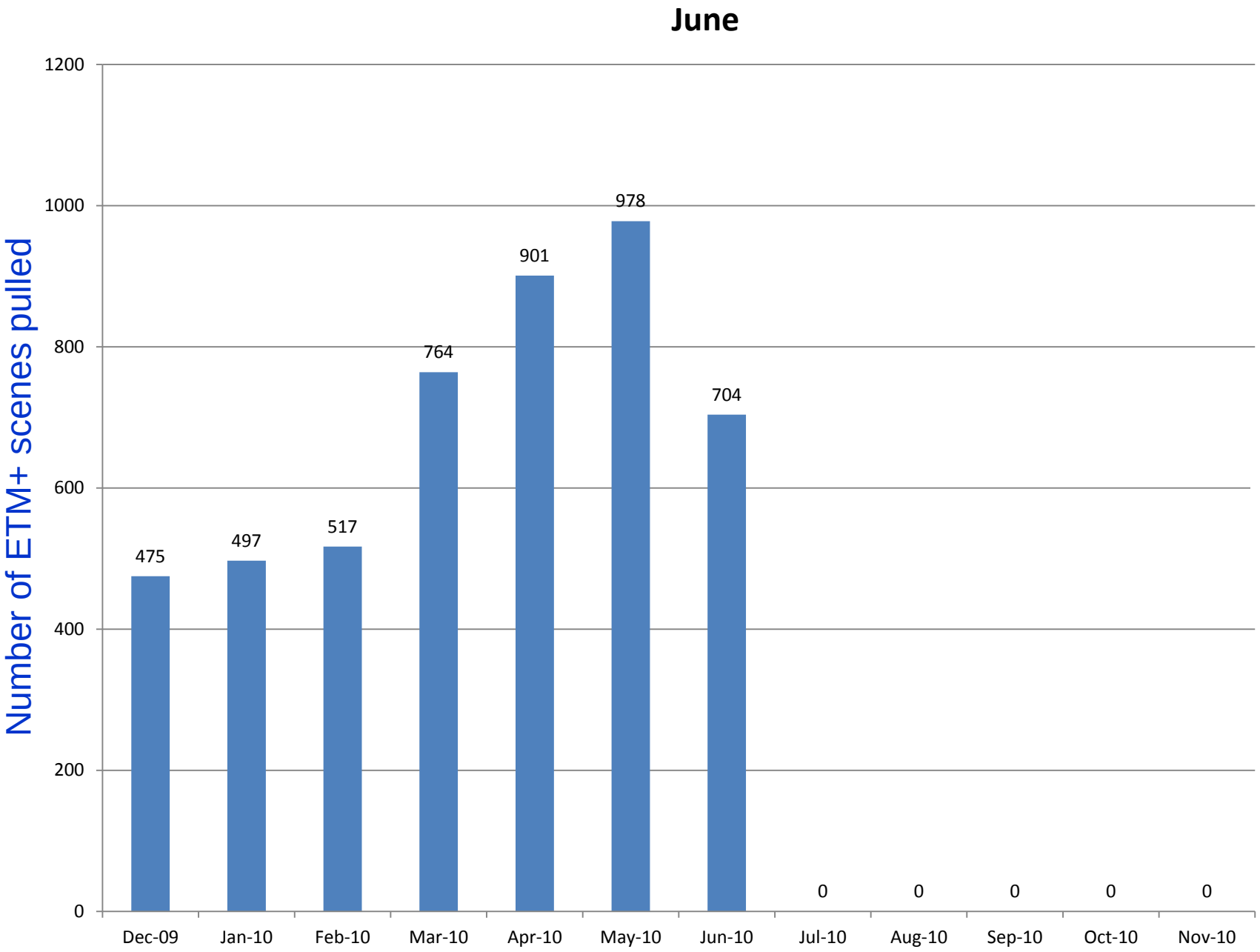

February
Number of ETM+ scenes pulled
1200
1000
800
600
400
200
0
462
313
267
0
0
0
0
0
0
0
0
0
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10
Nov-10

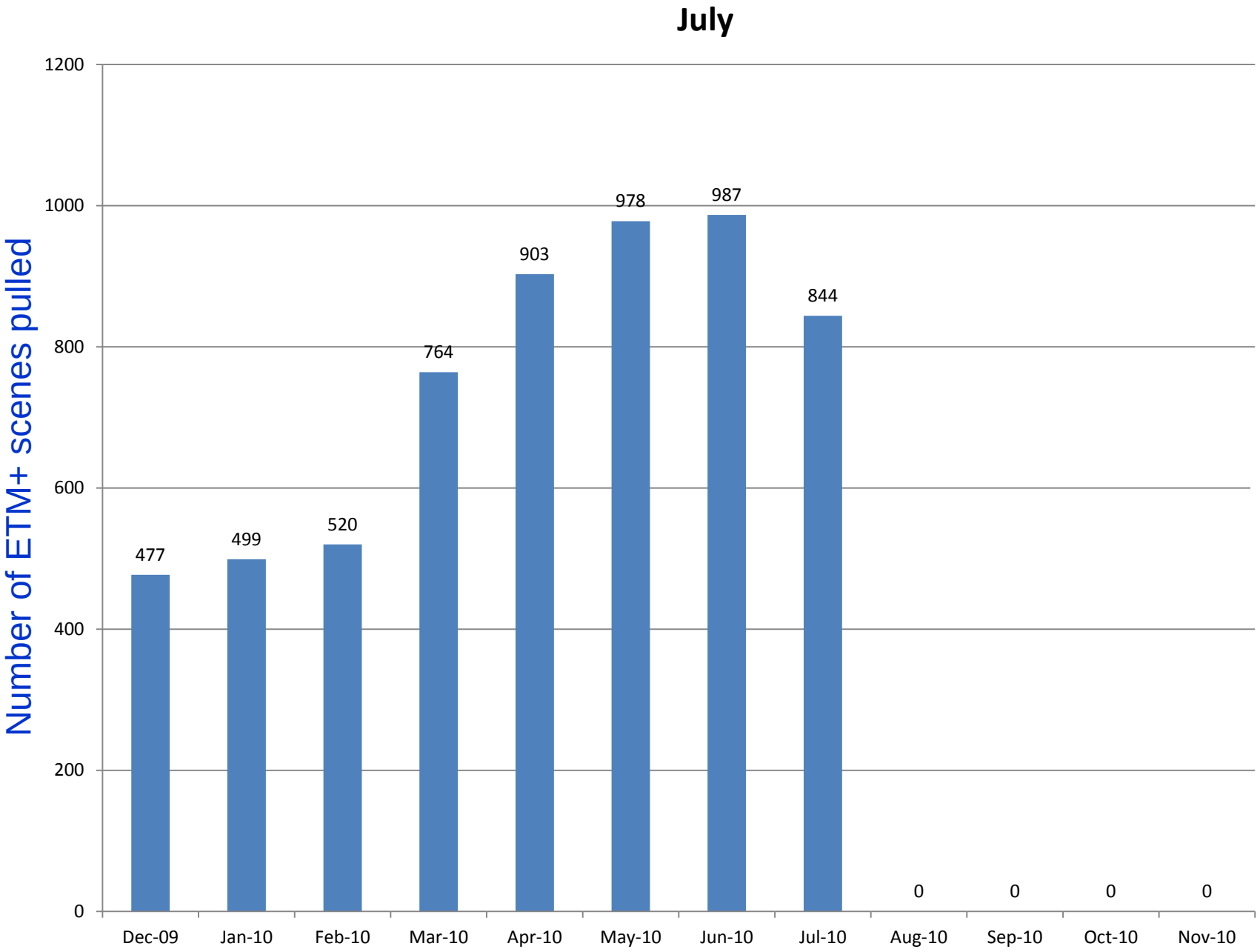

March
Number of ETM+ scenes pulled
1200
1000
800
600
400
200
0
466
484
504
451
0
0
0
0
0
0
0
0
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10
Nov-10

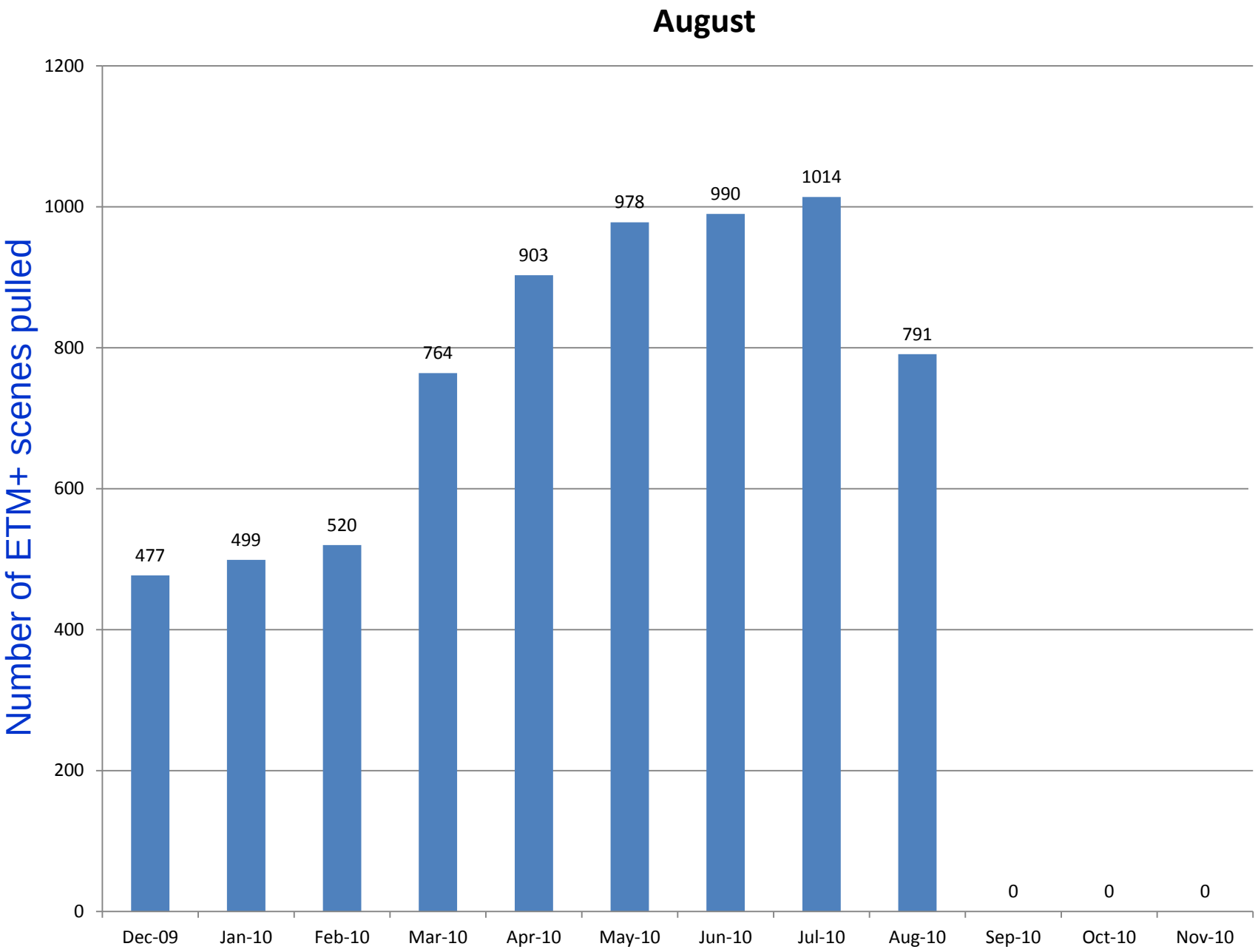
April

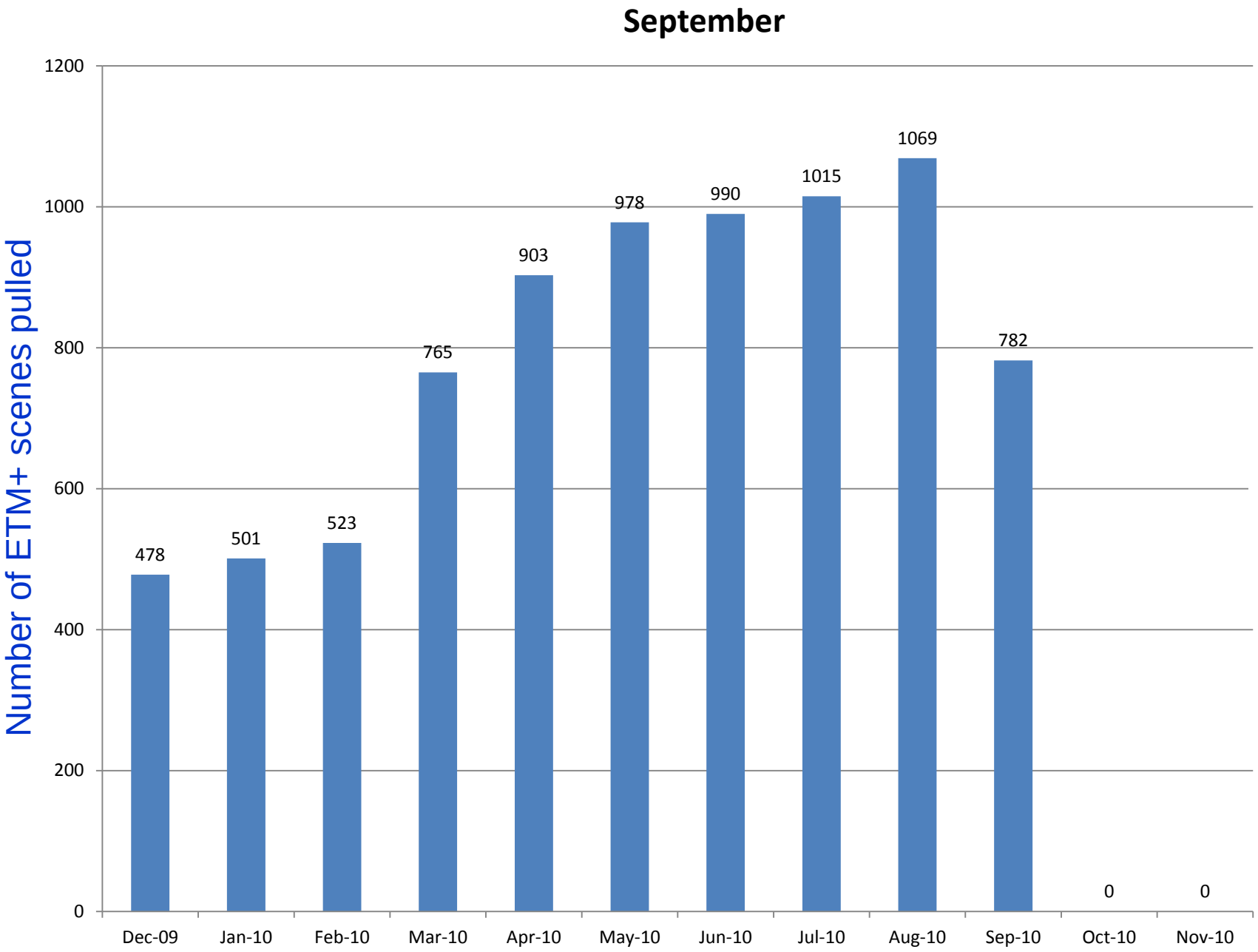

Number of ETM+ scenes pulled
1200
1000
800
600
400
200
0
467
485
505
556
571
0
0
0
0
0
0
0
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10
Nov-10

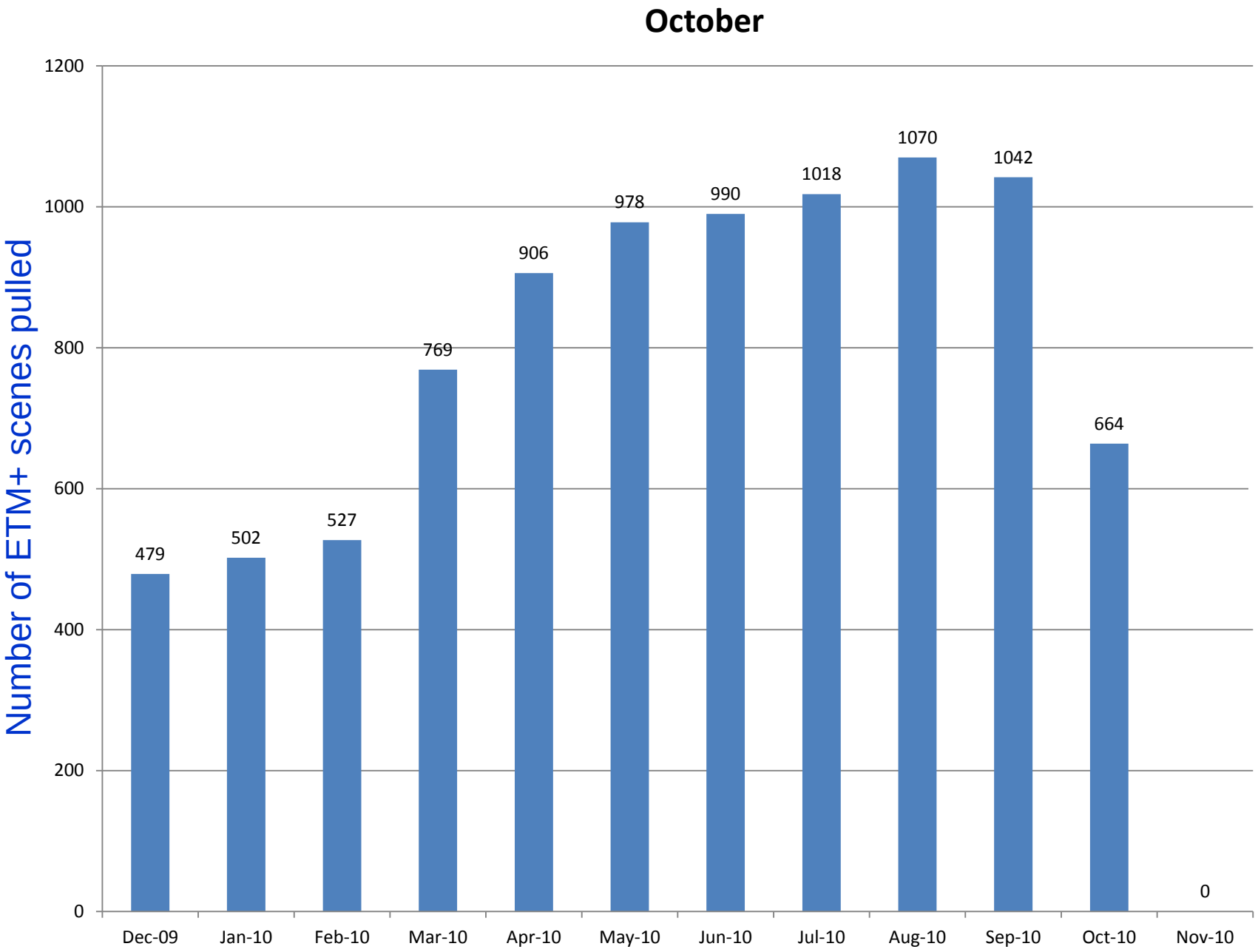

May
Number of ETM+ scenes pulled
1200
1000
800
600
400
200
0
467
485
505
562
576
711
0
0
0
0
0
0
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10
Nov-10

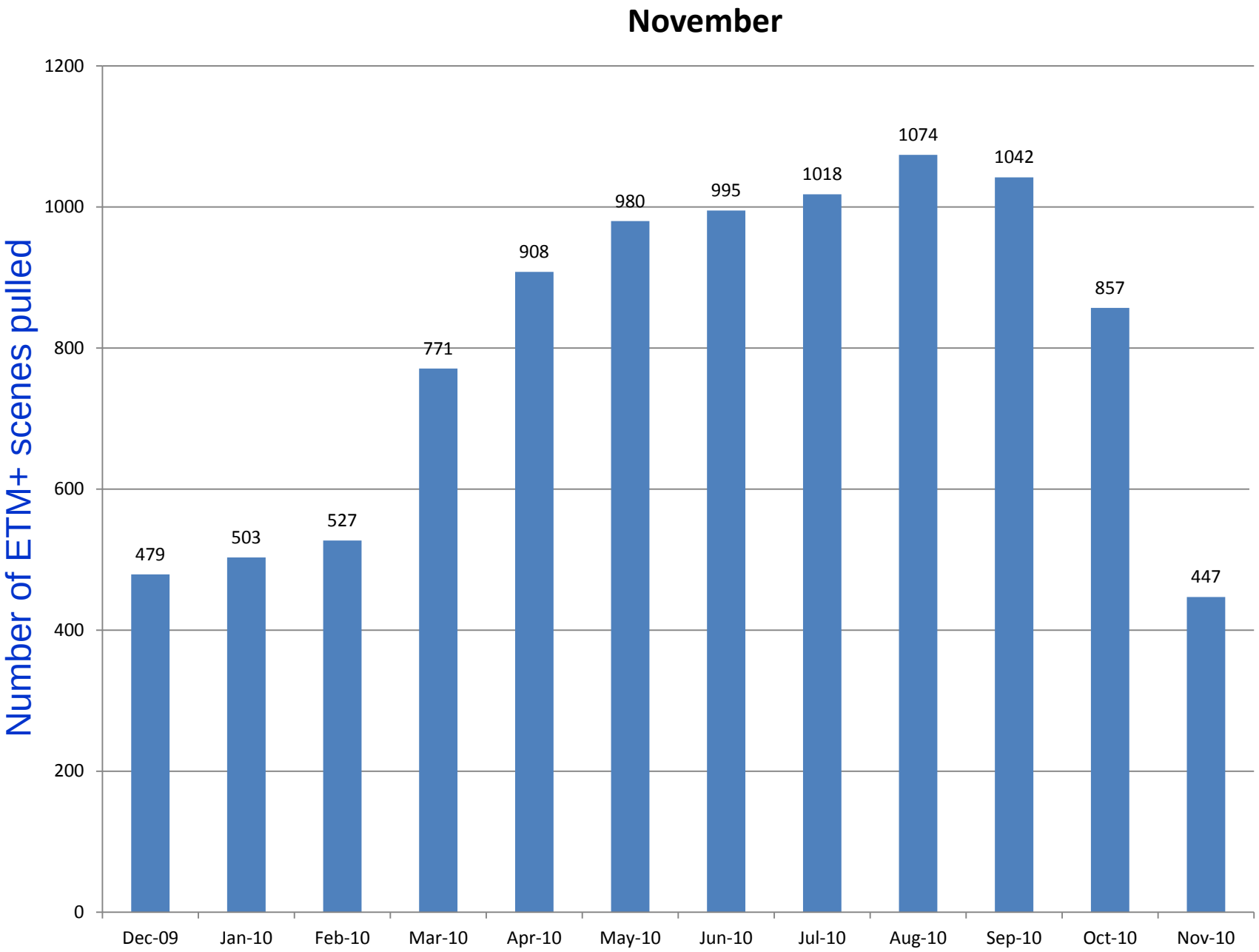

June
Number of ETM+ scenes pulled
1200
1000
800
600
400
200
0
475
497
517
764
901
978
704
0
0
0
0
0
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10
Nov-10


July
Number of ETM+ scenes pulled
1200
1000
800
600
400
200
0
477
499
520
764
903
978
987
844
0
0
0
0
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10
Nov-10


August
Number of ETM+ scenes pulled
1200
1000
800
600
400
200
0
477
499
520
764
903
978
990
1014
791
0
0
0
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10
Nov-10


September
Number of ETM+ scenes pulled
1200
1000
800
600
400
200
0
478
501
523
765
903
978
990
1015
1069
782
0
0
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10
Nov-10


October
Number of ETM+ scenes pulled
1200
1000
800
600
400
200
0
479
502
527
769
906
978
990
1018
1070
1042
664
0
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10
Nov-10


November
Number of ETM+ scenes pulled
1200
1000
800
600
400
200
0
479
503
527
771
908
980
995
1018
1074
1042
857
447
Dec-09
Jan-10
Feb-10
Mar-10
Apr-10
May-10
Jun-10
Jul-10
Aug-10
Sep-10
Oct-10
Nov-10

Lesson #4

Science algorithms developed
on individual scenes

don’t necessarily provide consistency
between scenes

V1.5 WELD Cloud Tree Algorithm

500m browse: cloud fraction (0-100%) in each 500m pixel

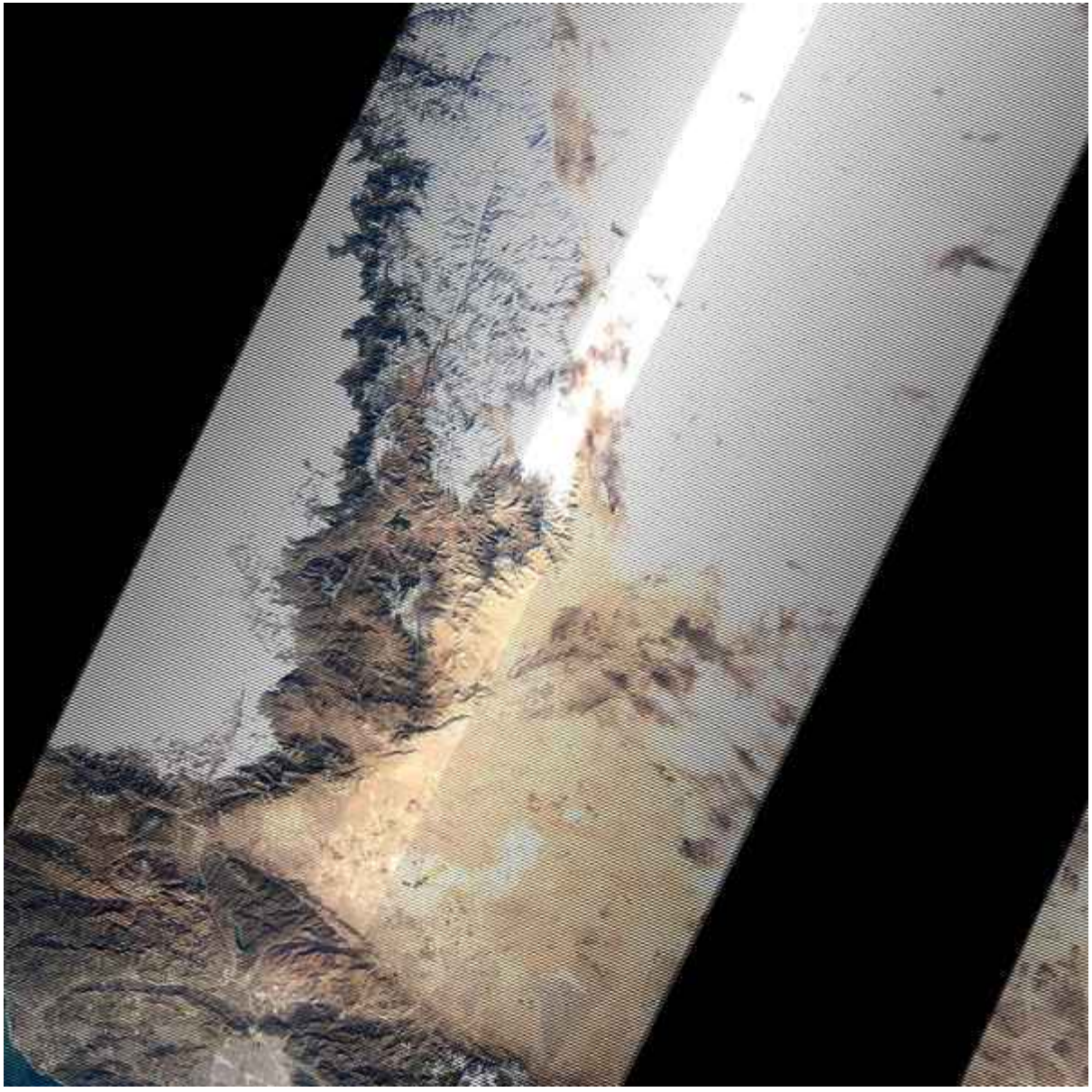
Jan 15-21, 2008 CONUS WELD tiles

ACCA

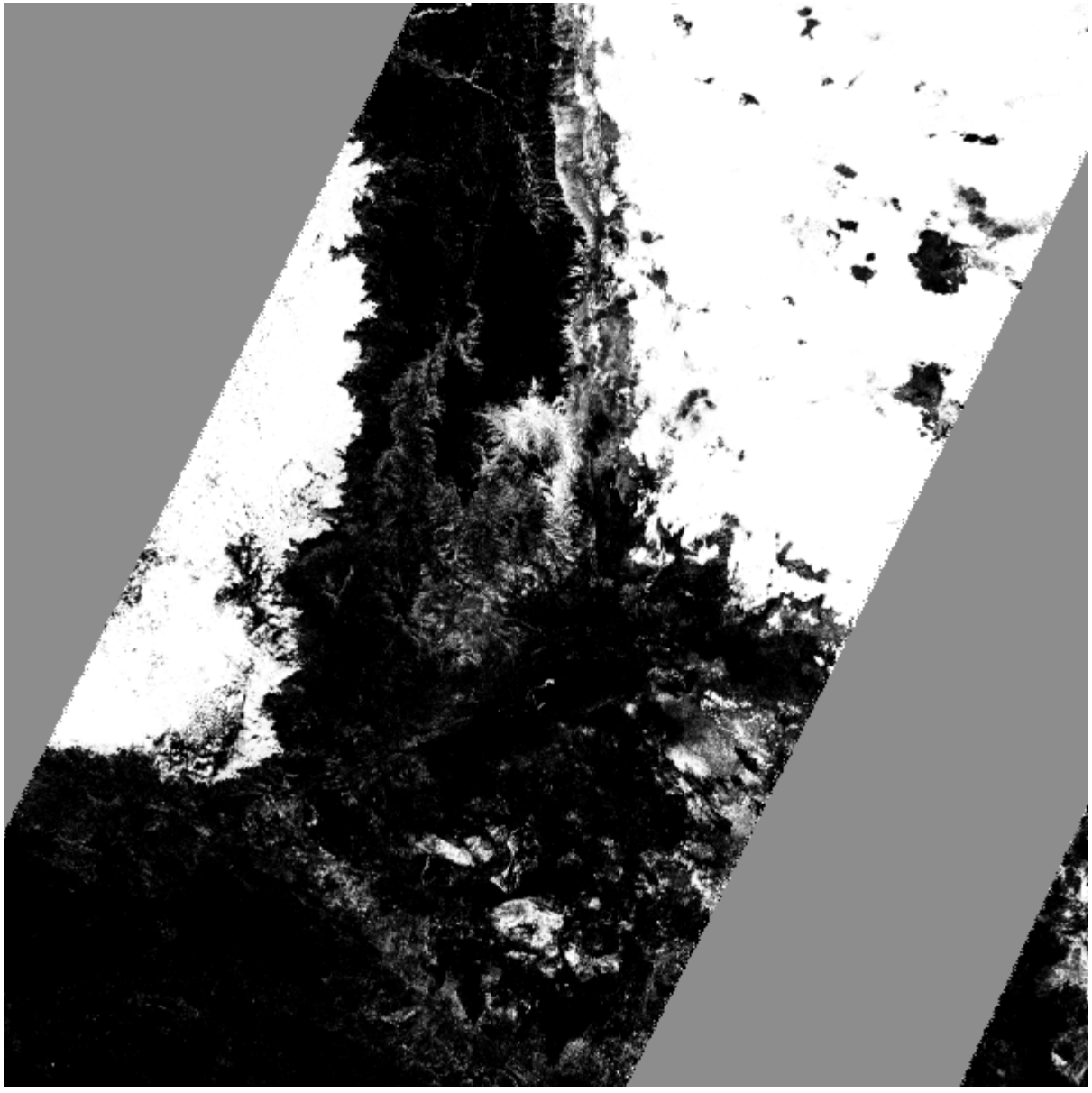
500m browse: cloud fraction (0-100%) in each 500m pixel

Jan 15-21, 2008 CONUS WELD tiles

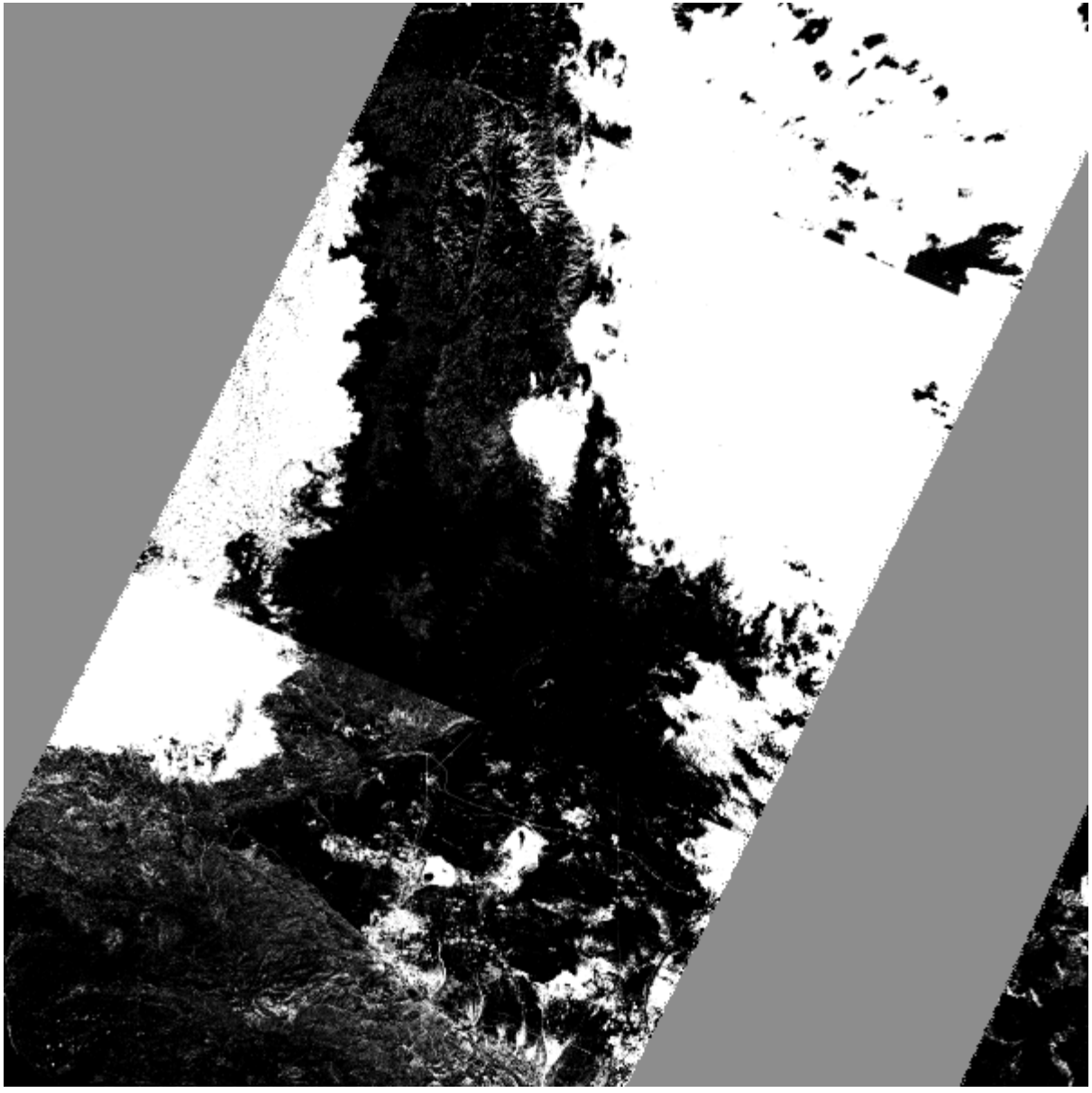
Spatial Subset V1.5 WELD TOA True Color 30m Reflectance
Jan 15-21, 2008 CONUS (10217x10217 30m pixels)



V1.5 WELD Cloud Tree Algorithm



ACCA

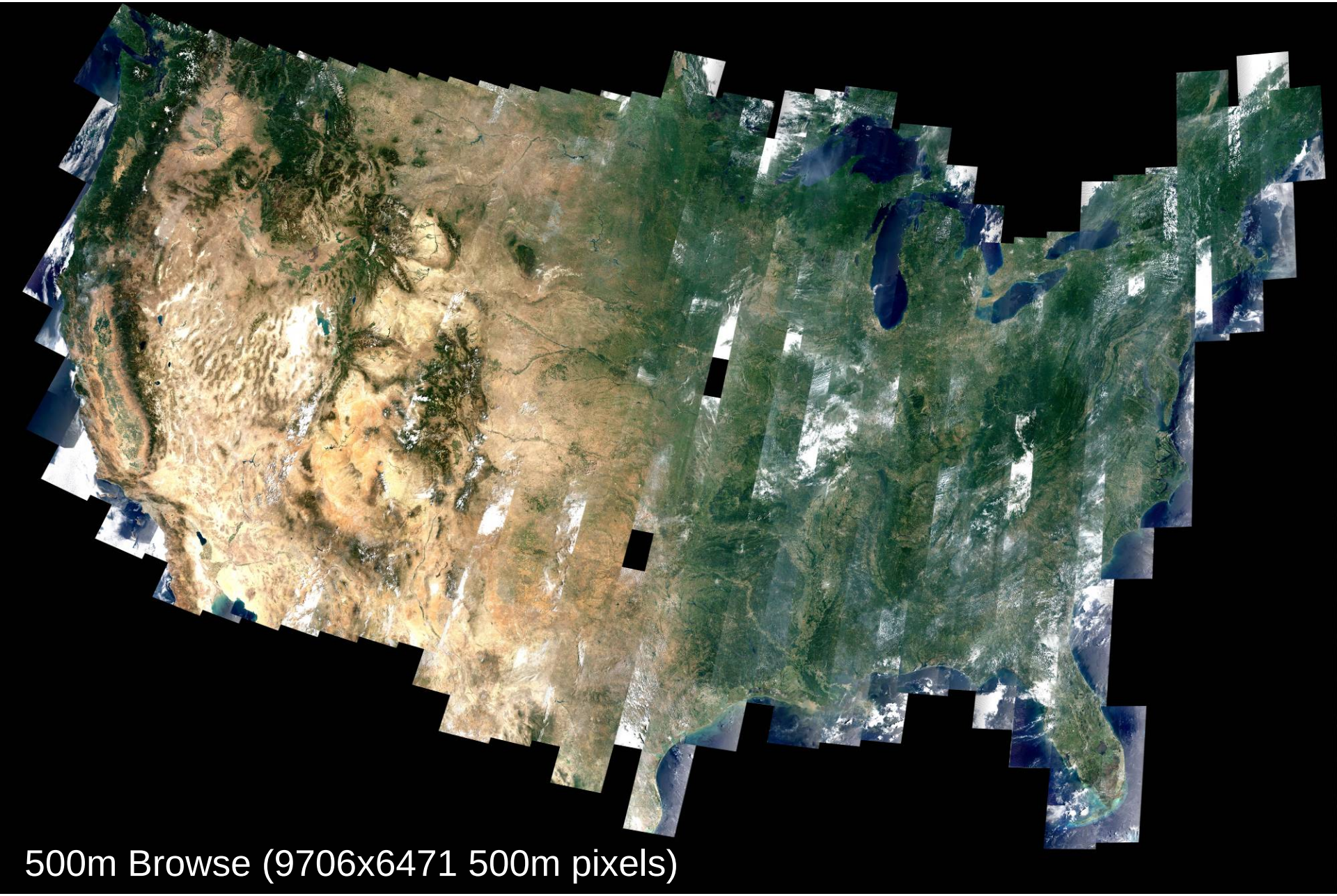


Lesson #5

Product Quality Assessment challenge increases with

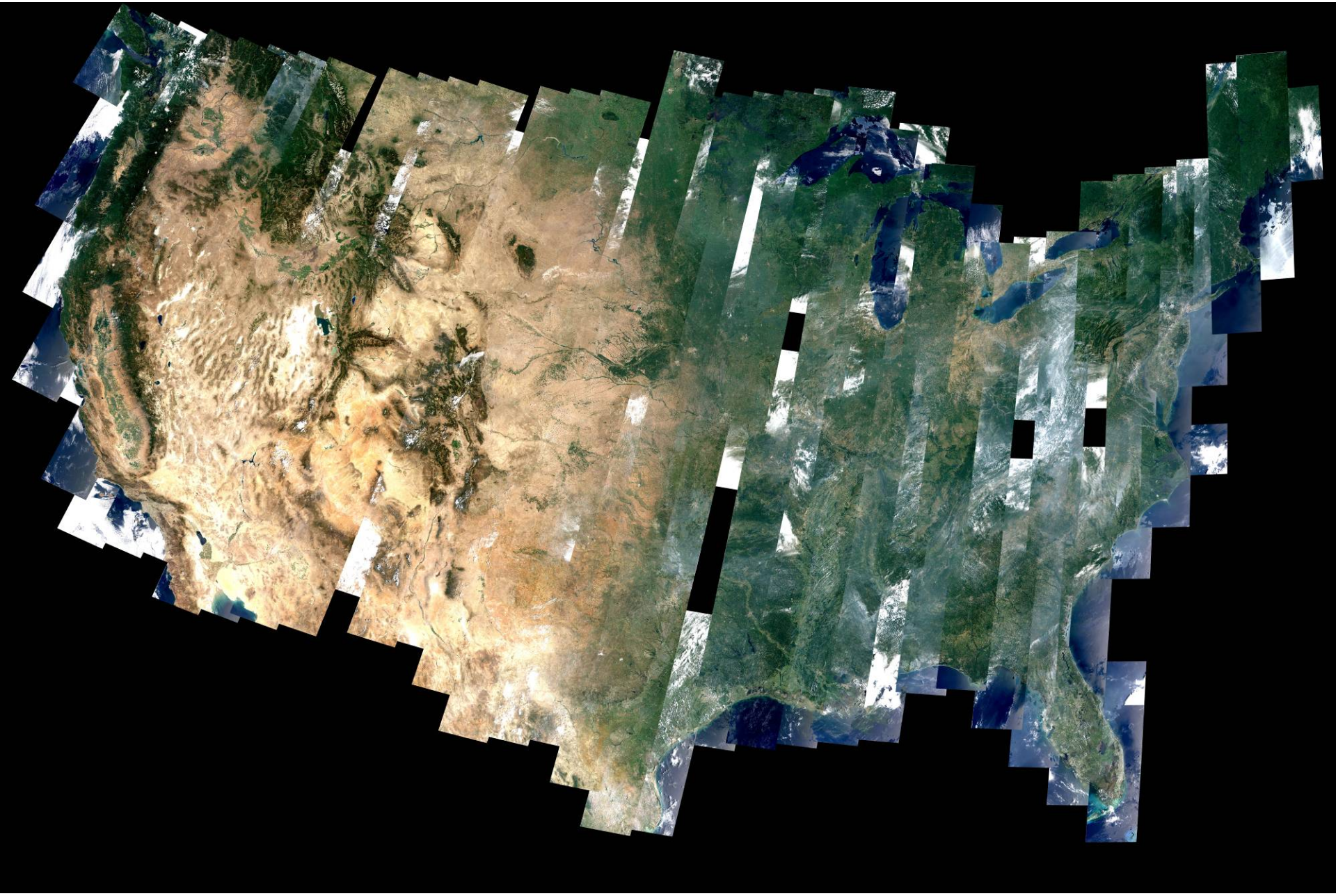
- Data Volume

Landsat 7 ETM+ July 2008 11,000,000,000 30m land pixels

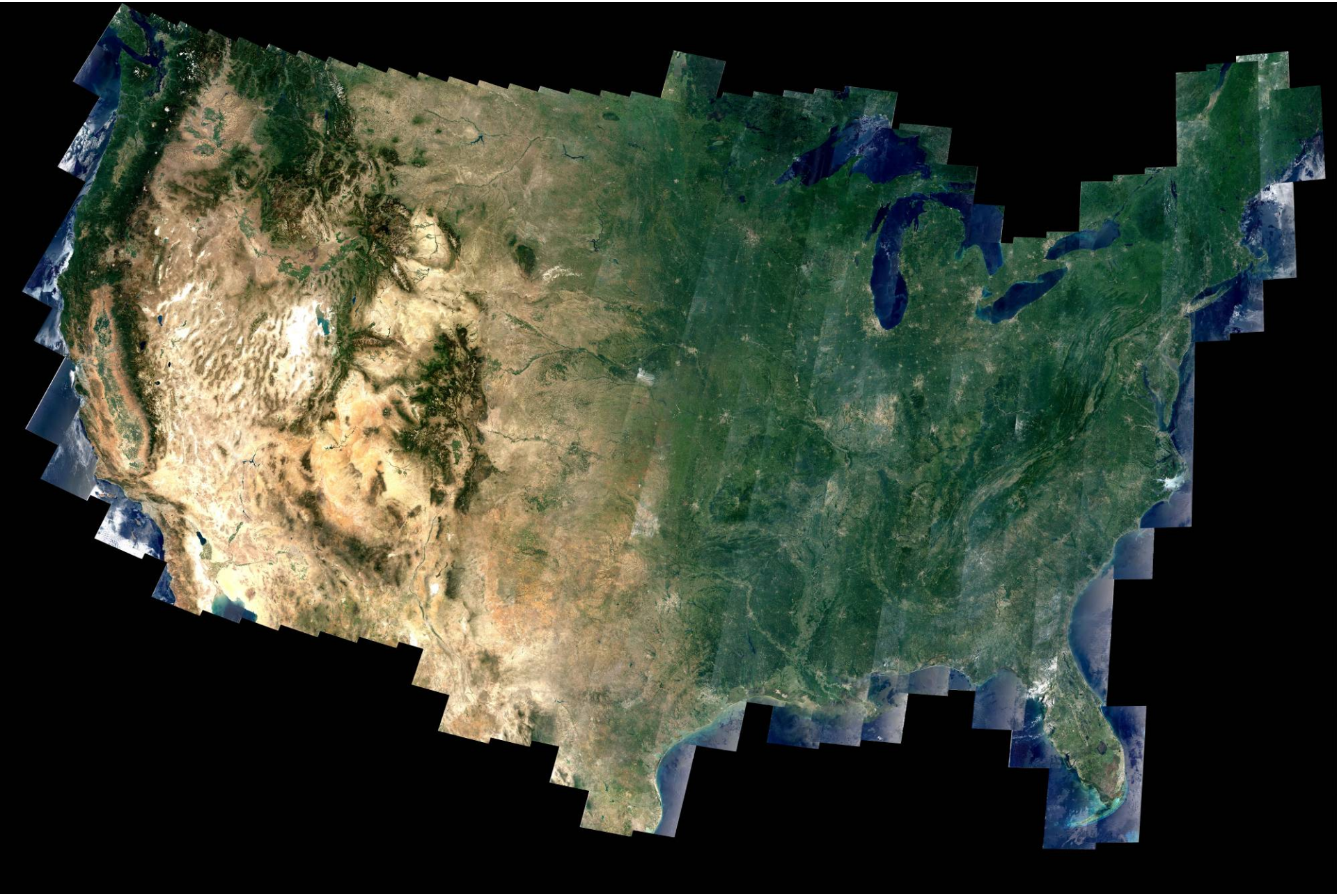


500m Browse (9706x6471 500m pixels)

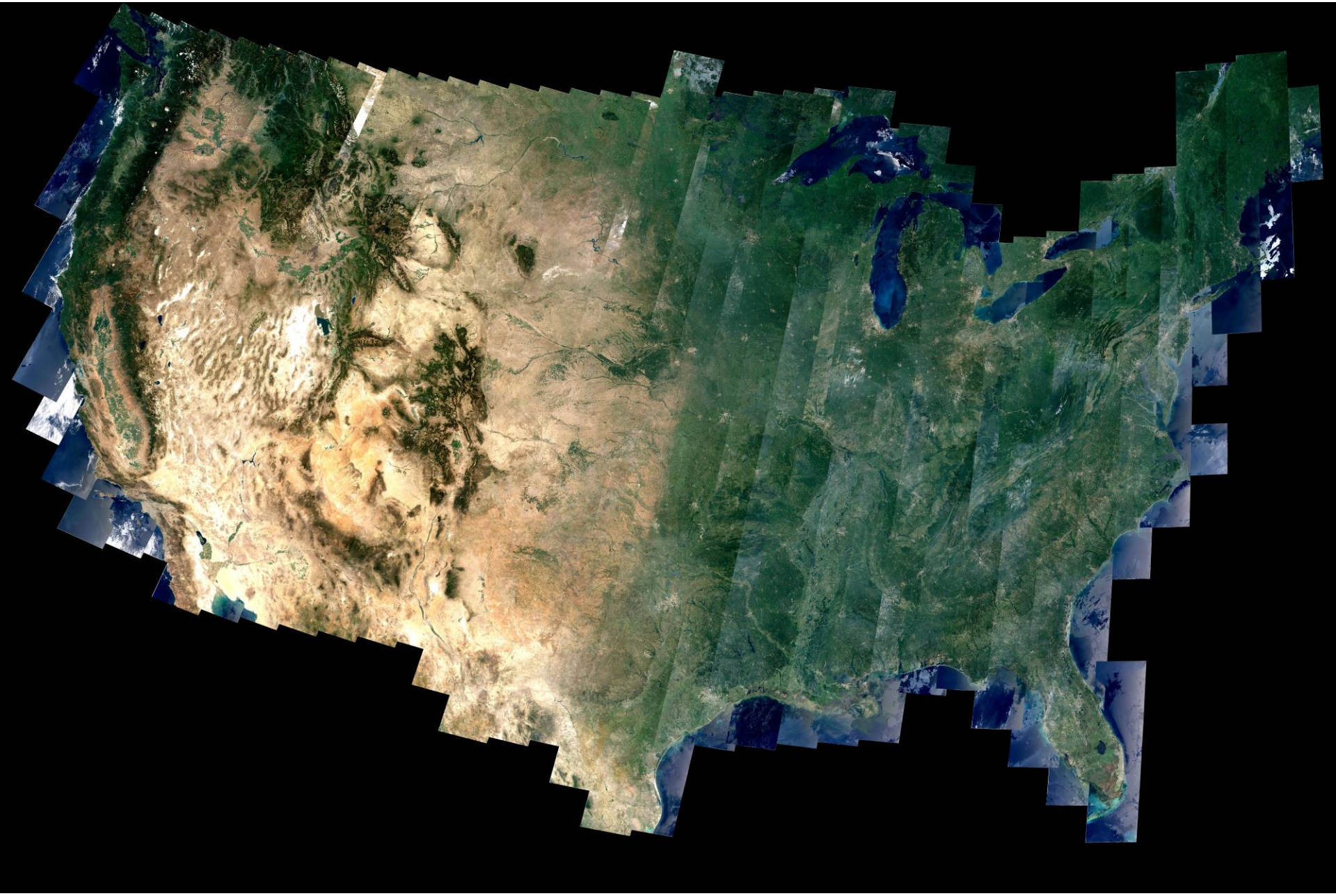
Landsat 7 ETM+ July 2002



Landsat 7 ETM+ Summer 2008



Landsat 7 ETM+ Summer 2002

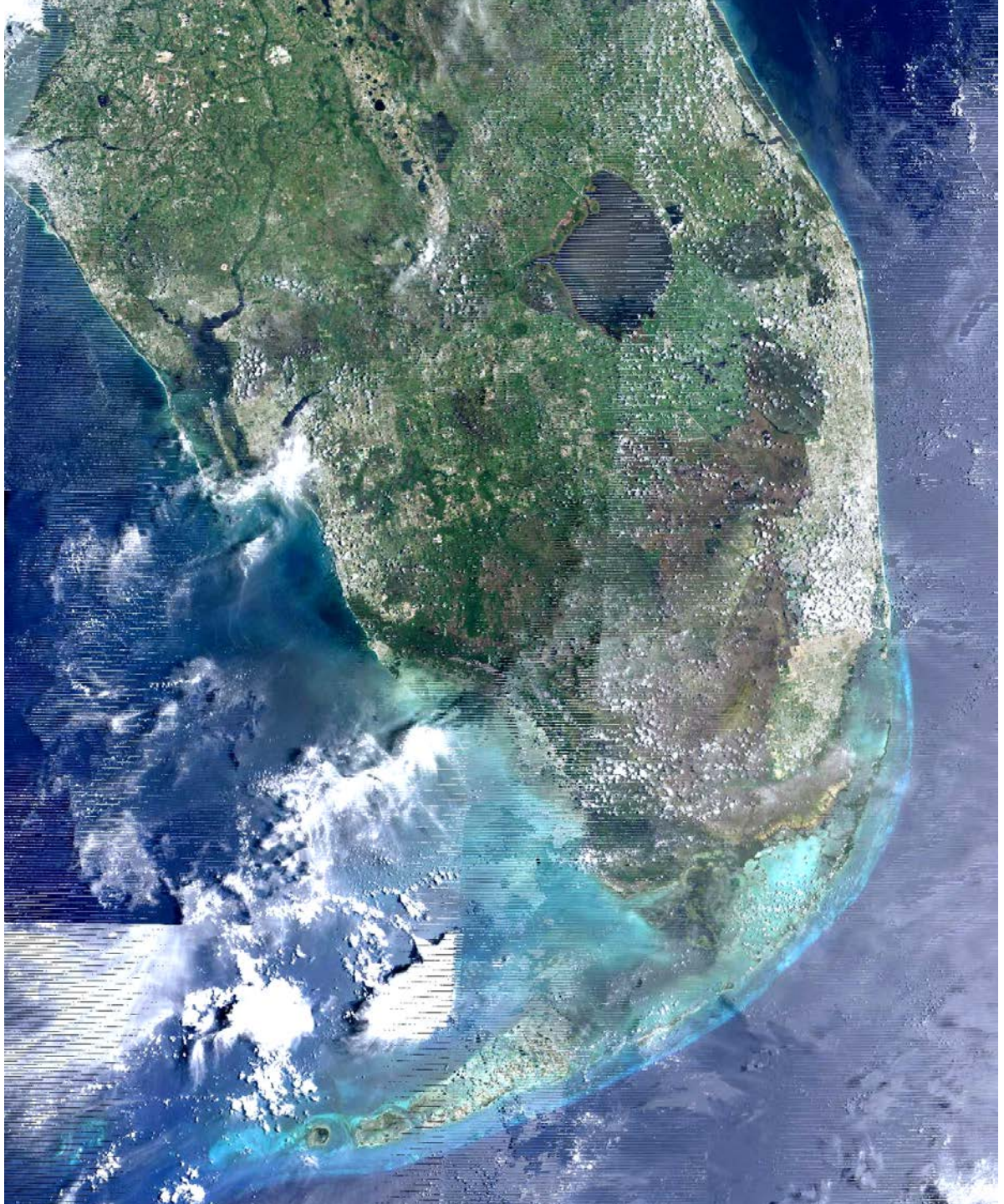


Landsat 7
ETM+

July 2008

Florida

1500 x 1900 30m pixels



July 2008
Landsat 7 ETM+

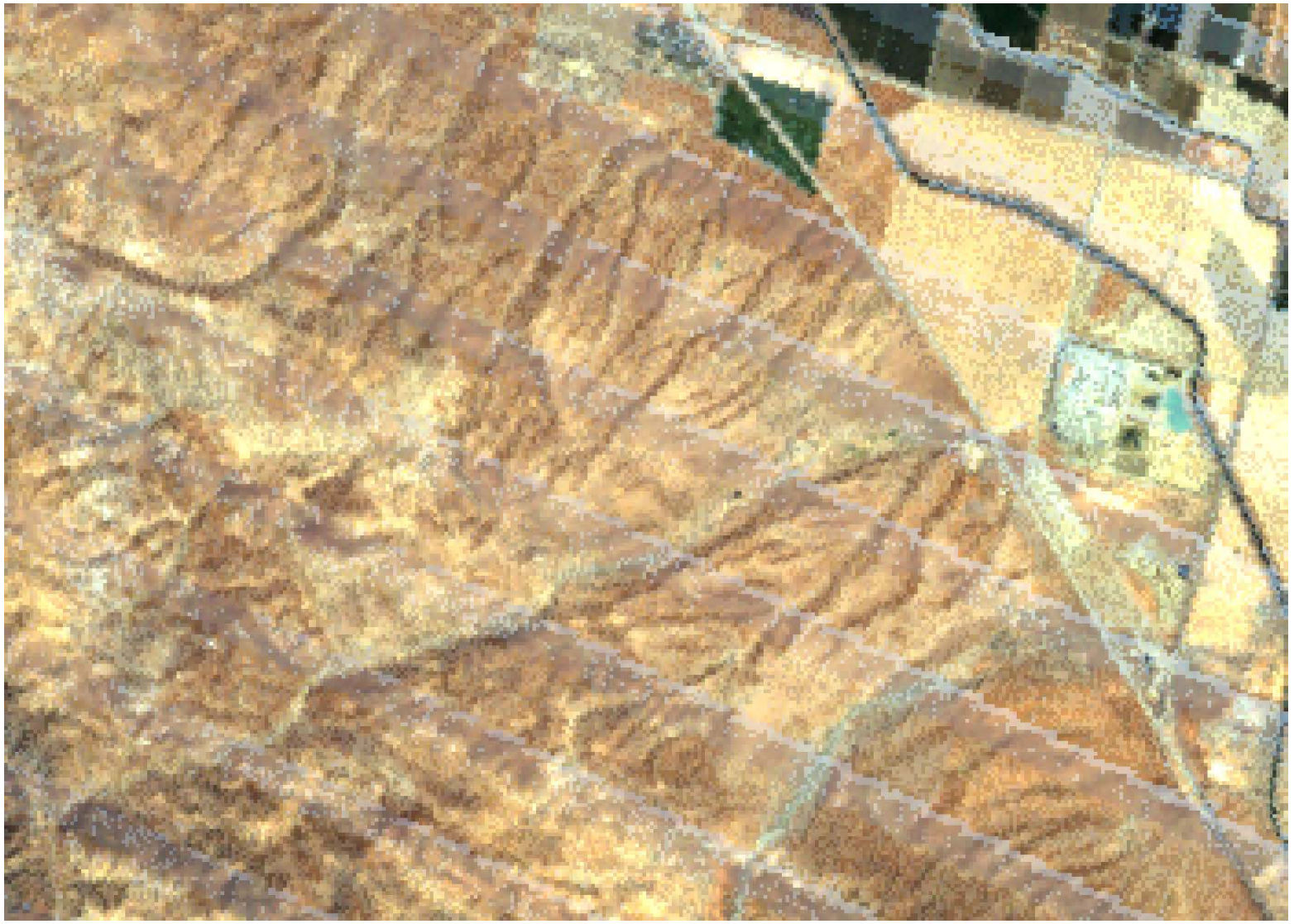
July 2002
Landsat 7 ETM+

WELD, July 2008, Version 1.5

350X250 pixels

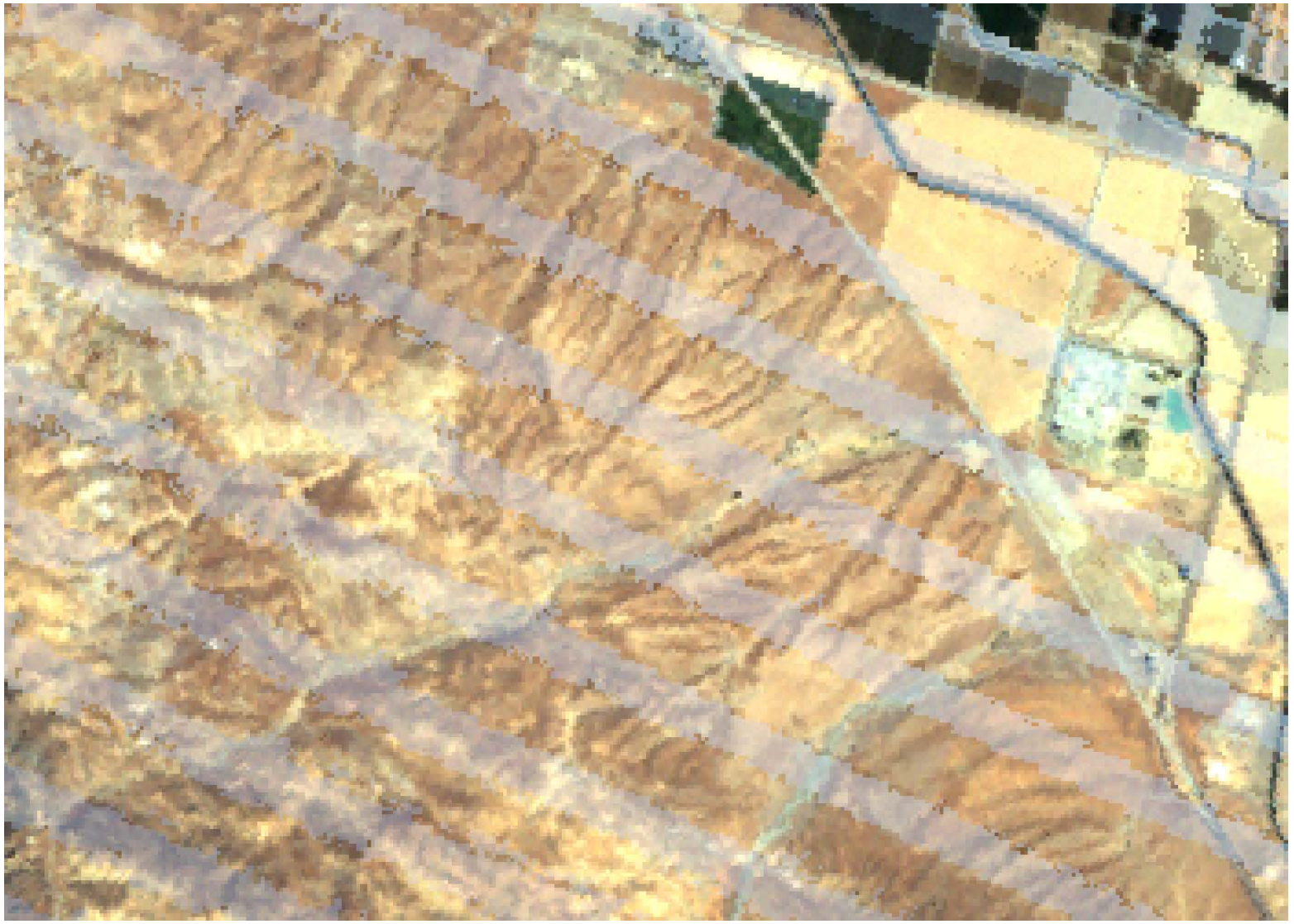
WELD, July 2008, Version 1.6

350X250 pixels



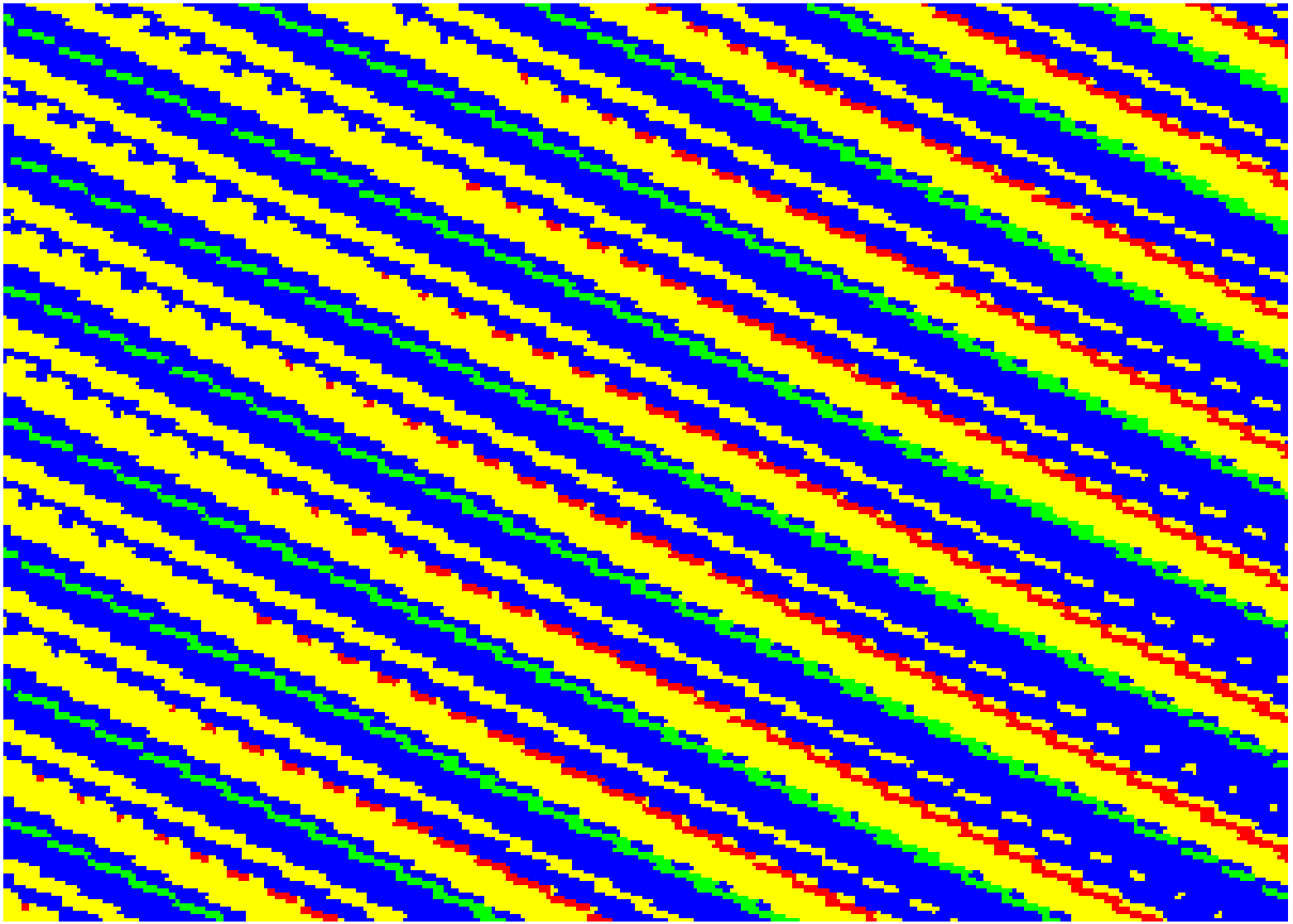
WELD, July 2008, Version 1.5

350X250 pixels



WELD, July 2008, Version 1.6

350X250 pixels



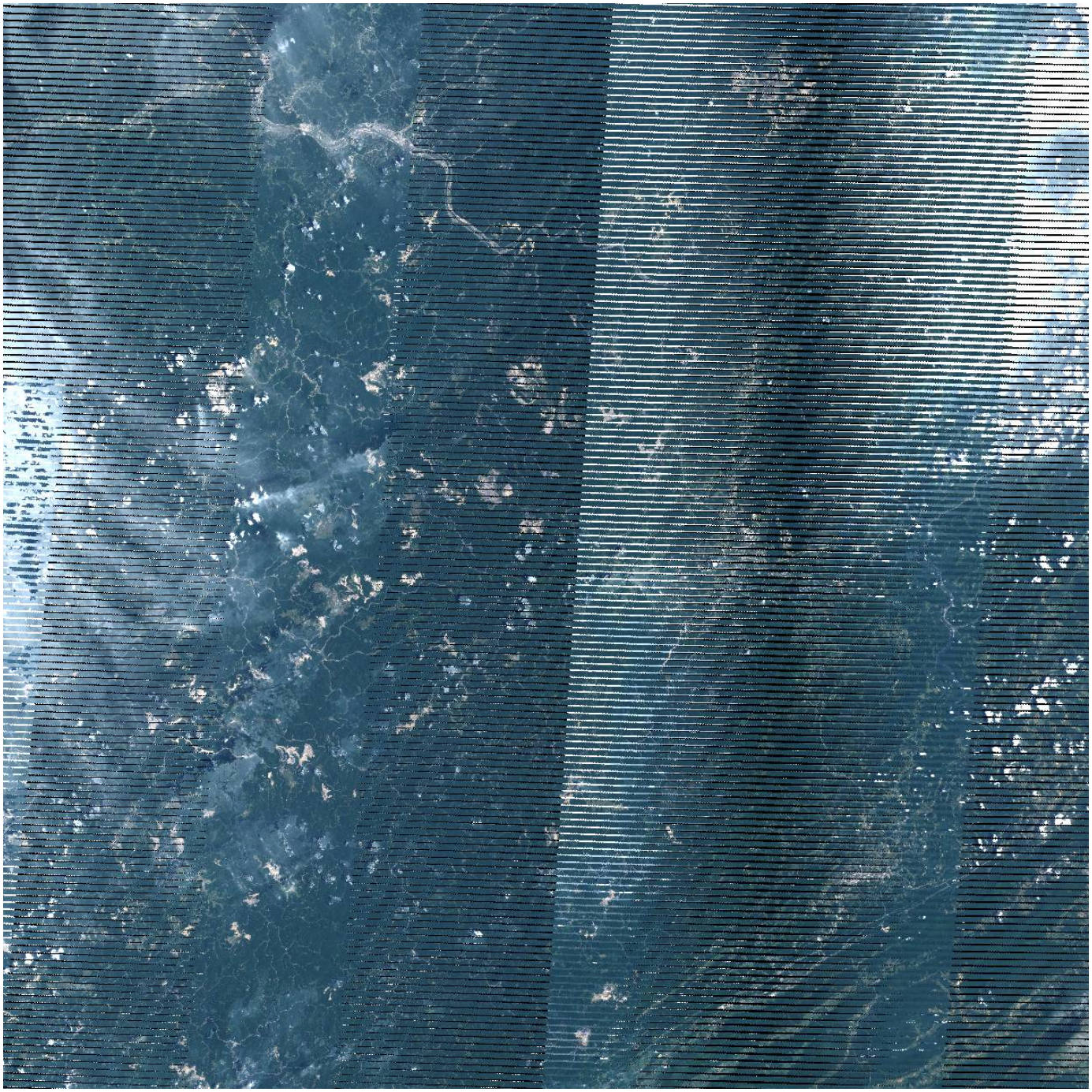
Number of Observations in monthly compositing period

Red = 1 Yellow = 2 Blue = 3 Green = 4

Lesson #6

Product Quality Assessment challenge increases with

- Algorithm complexity
- Product dependencies

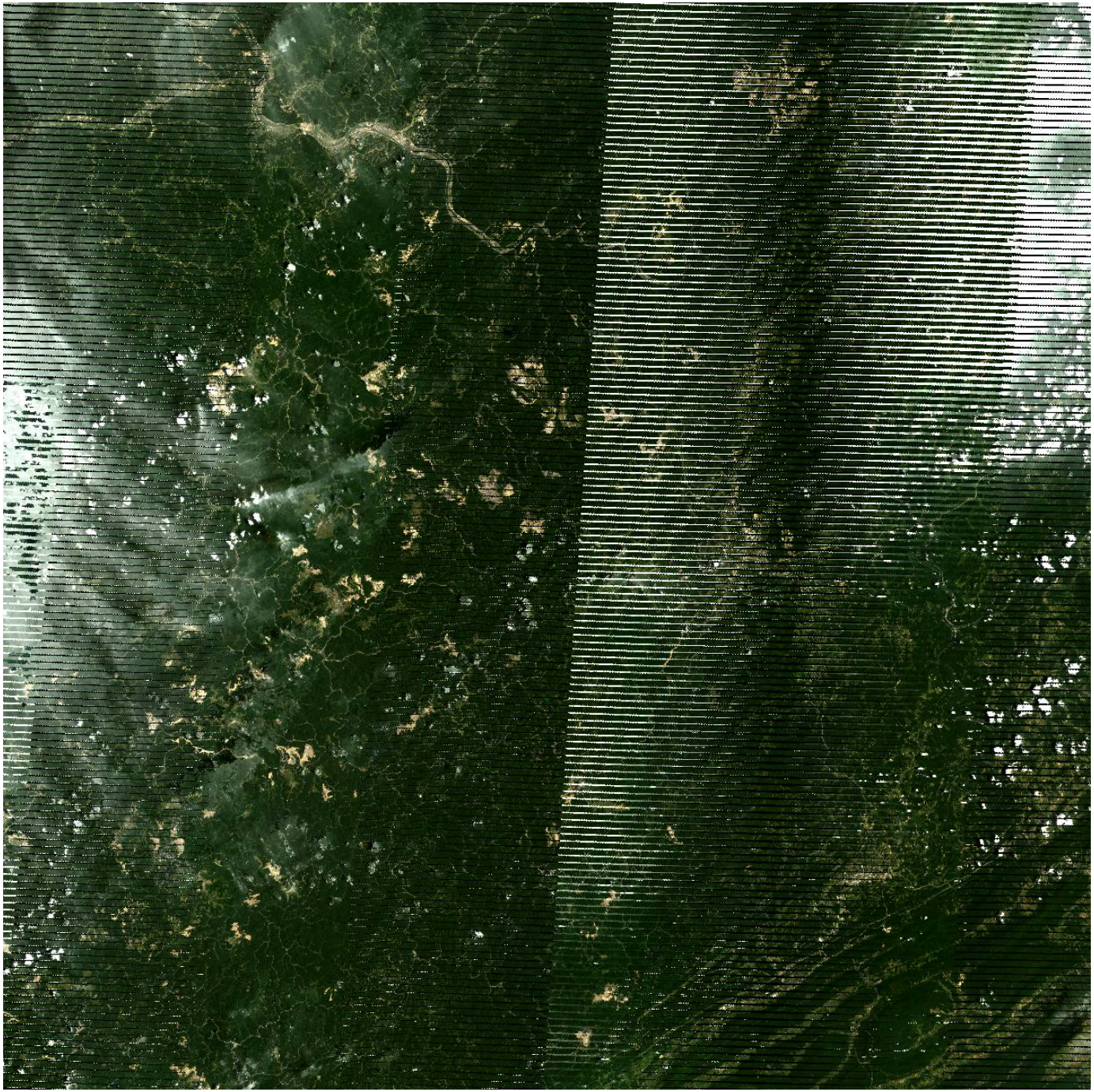


WELD
Tile h25v10,
West Virginia

TOA
Reflectance
True Color

June, 2008

5000 X 5000 pixels



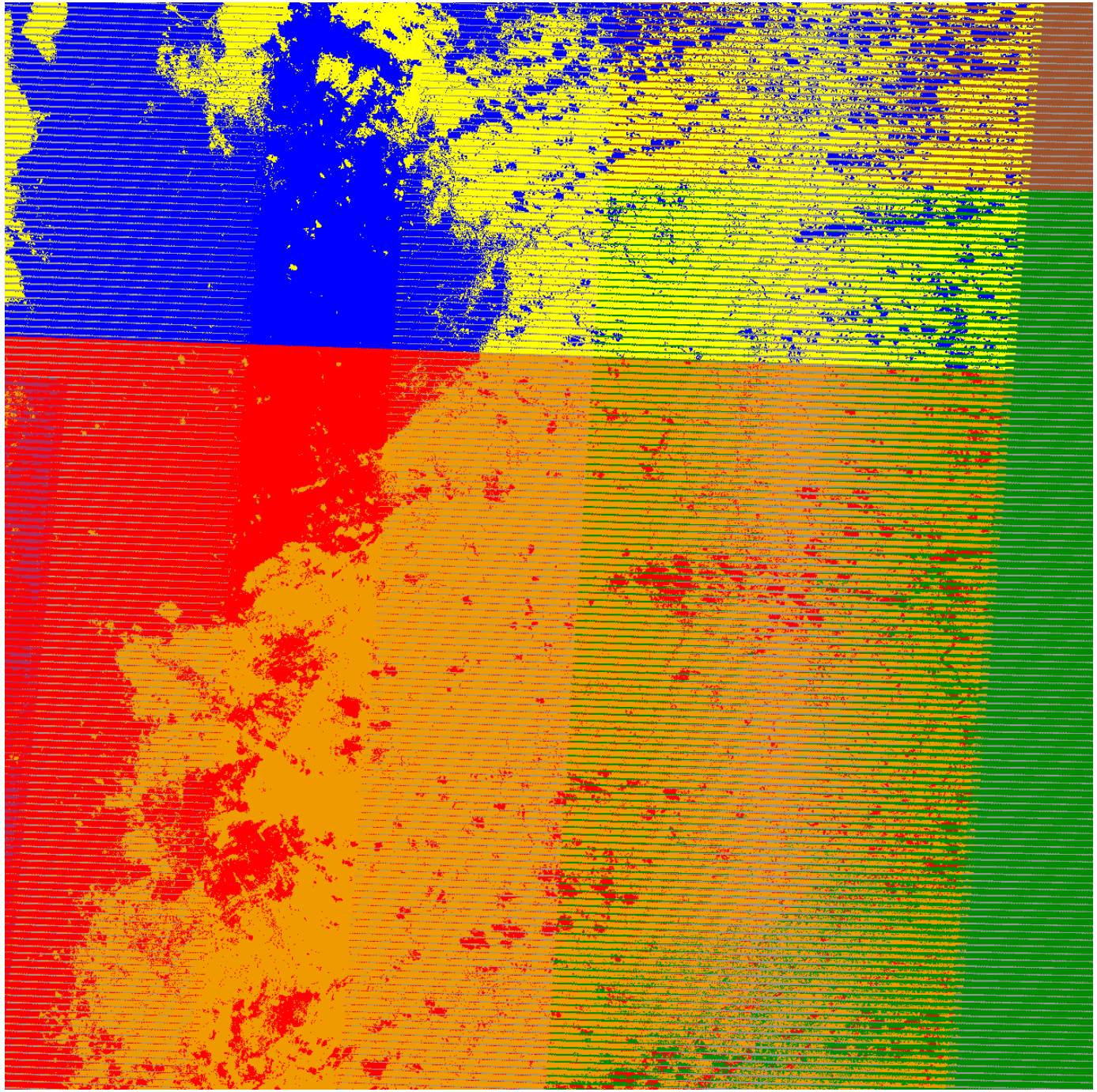
WELD
Tile h25v10,
West Virginia

Surface
Reflectance

True Color

June, 2008

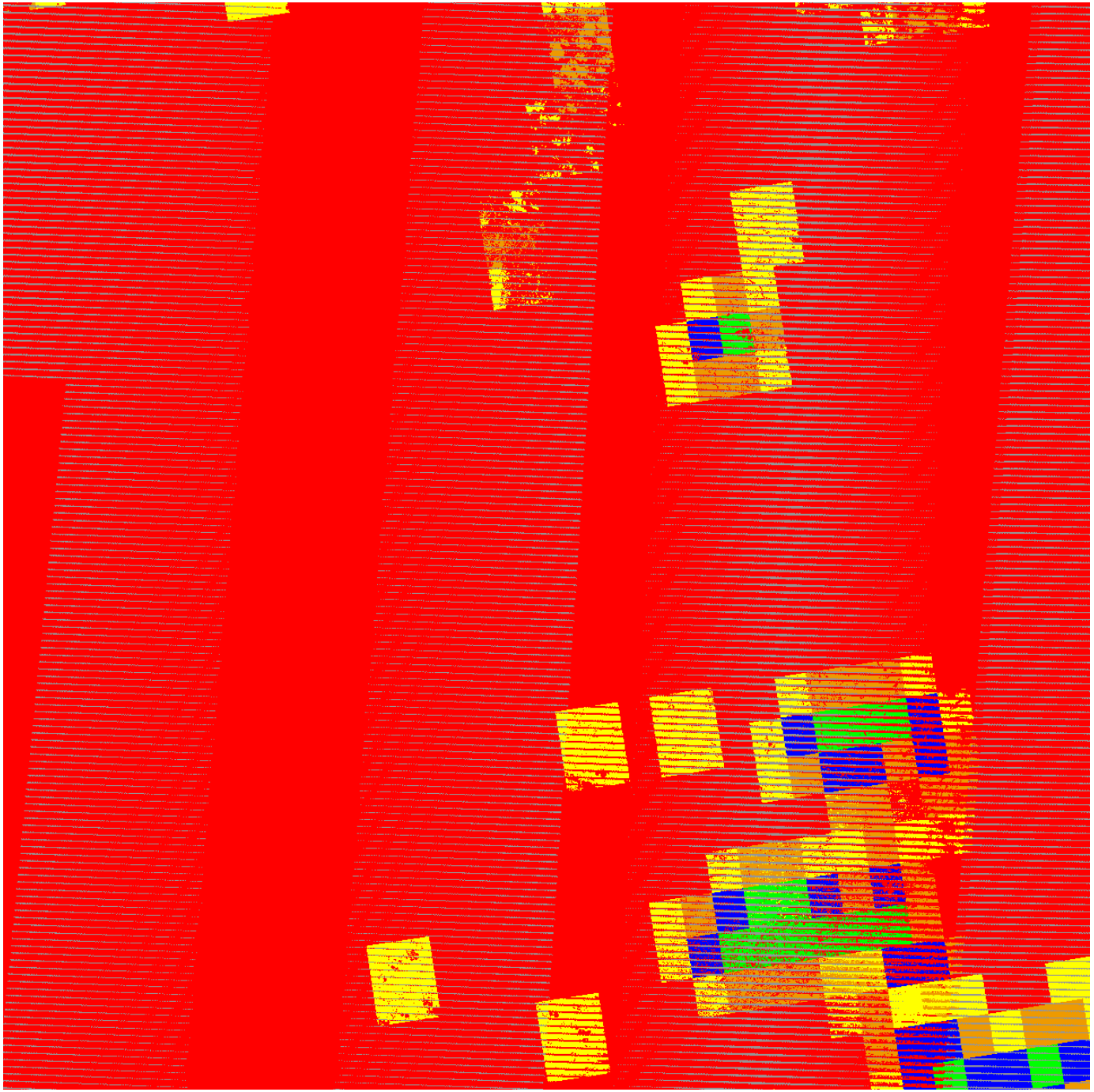
5000 X 5000 pixels



WELD
Tile h25v10,
West Virginia

New
L1T Index band (unique code per pixel defining L1T file – relative to filename list in product metadata)

9 L1T files used to make this monthly WELD tile

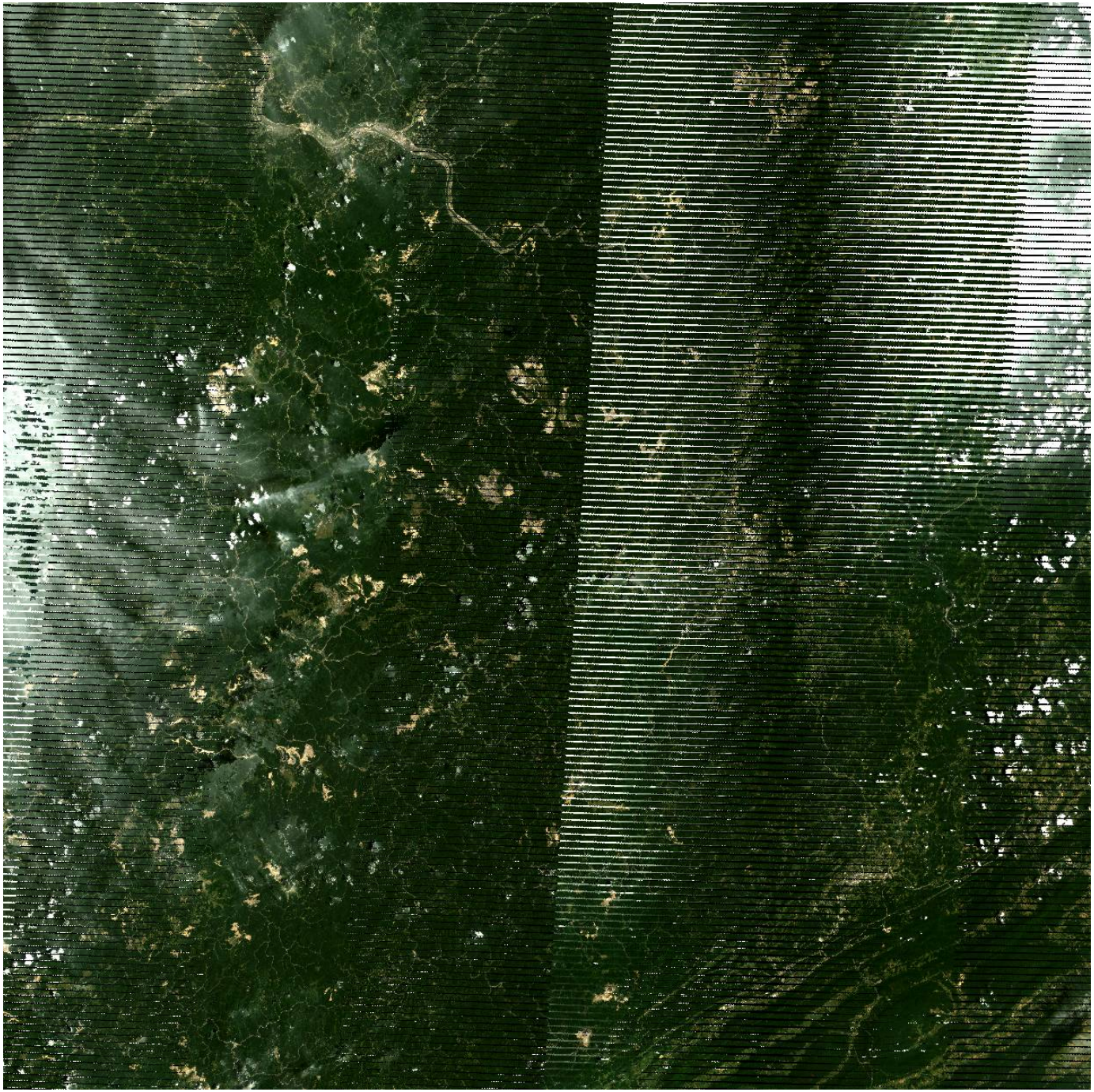


WELD
Tile h25v10,
West Virginia

Atmospheric
Correction
Aerosol QA
bits

June, 2008

5000 X 5000 pixels



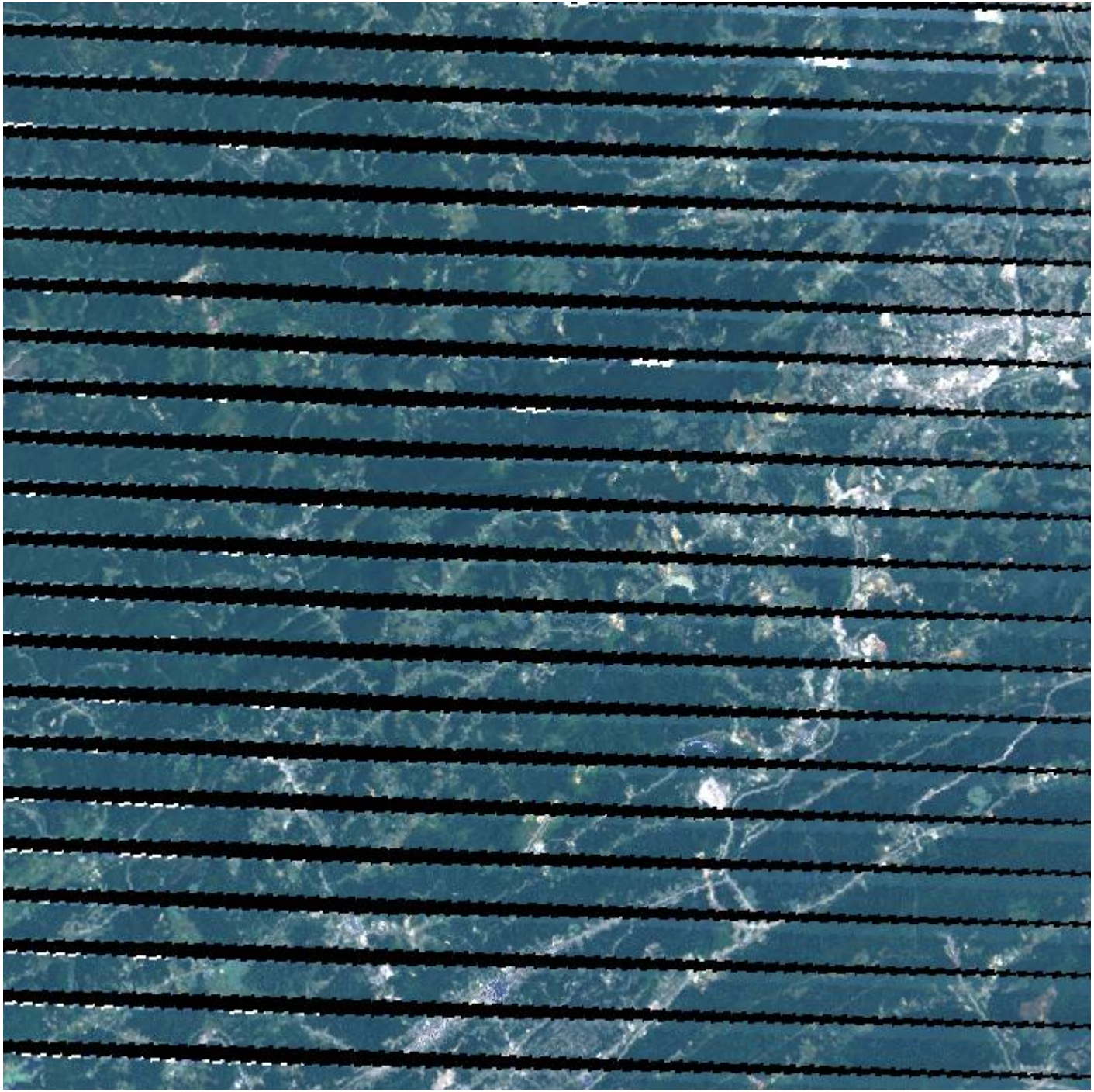
WELD
Tile h25v10,
West Virginia

Surface
Reflectance

True Color

June, 2008

5000 X 5000 pixels

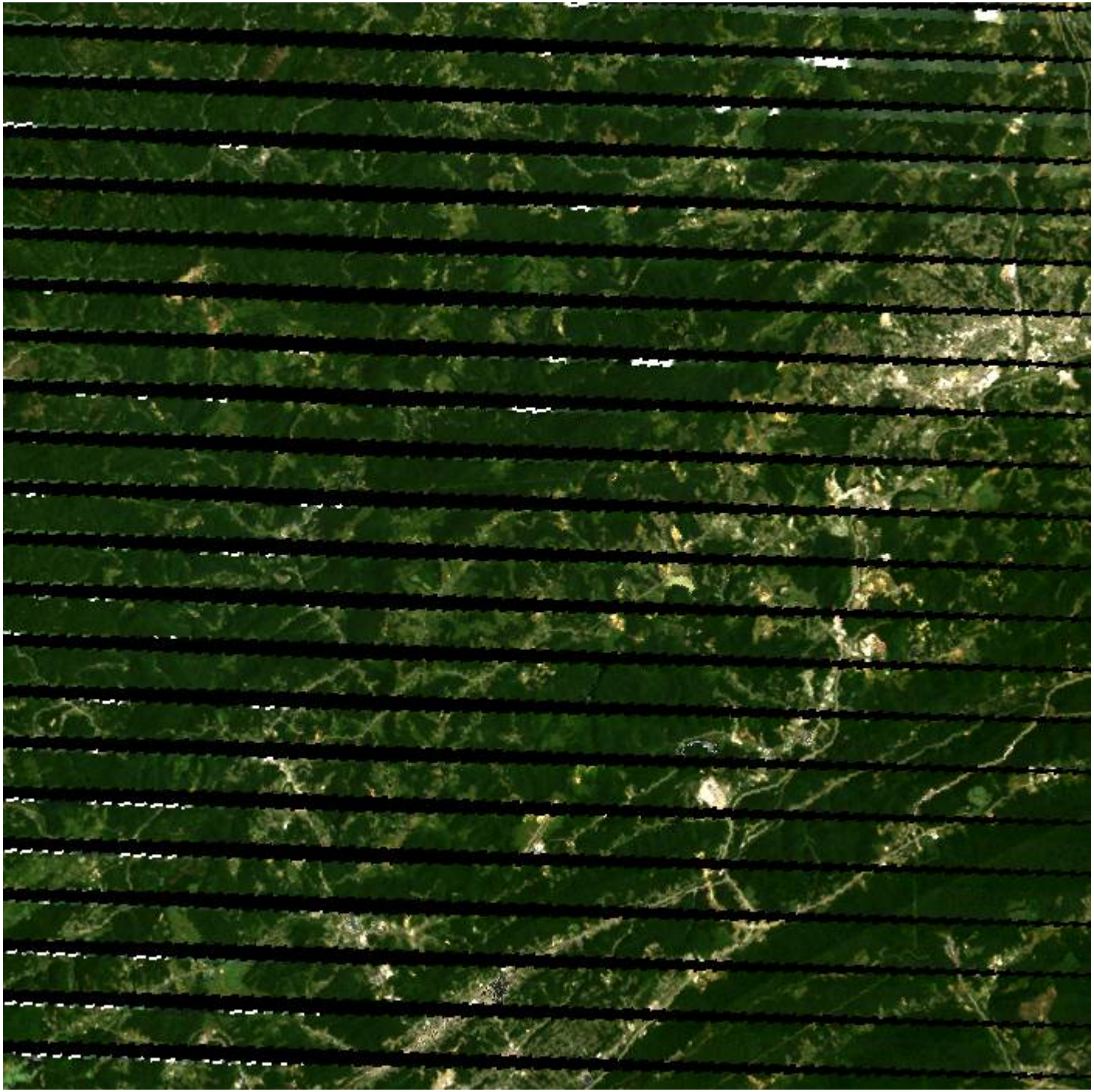


WELD
Tile h25v10,
West Virginia

TOA
Reflectance
True Color

June, 2008

700 X 700 pixels

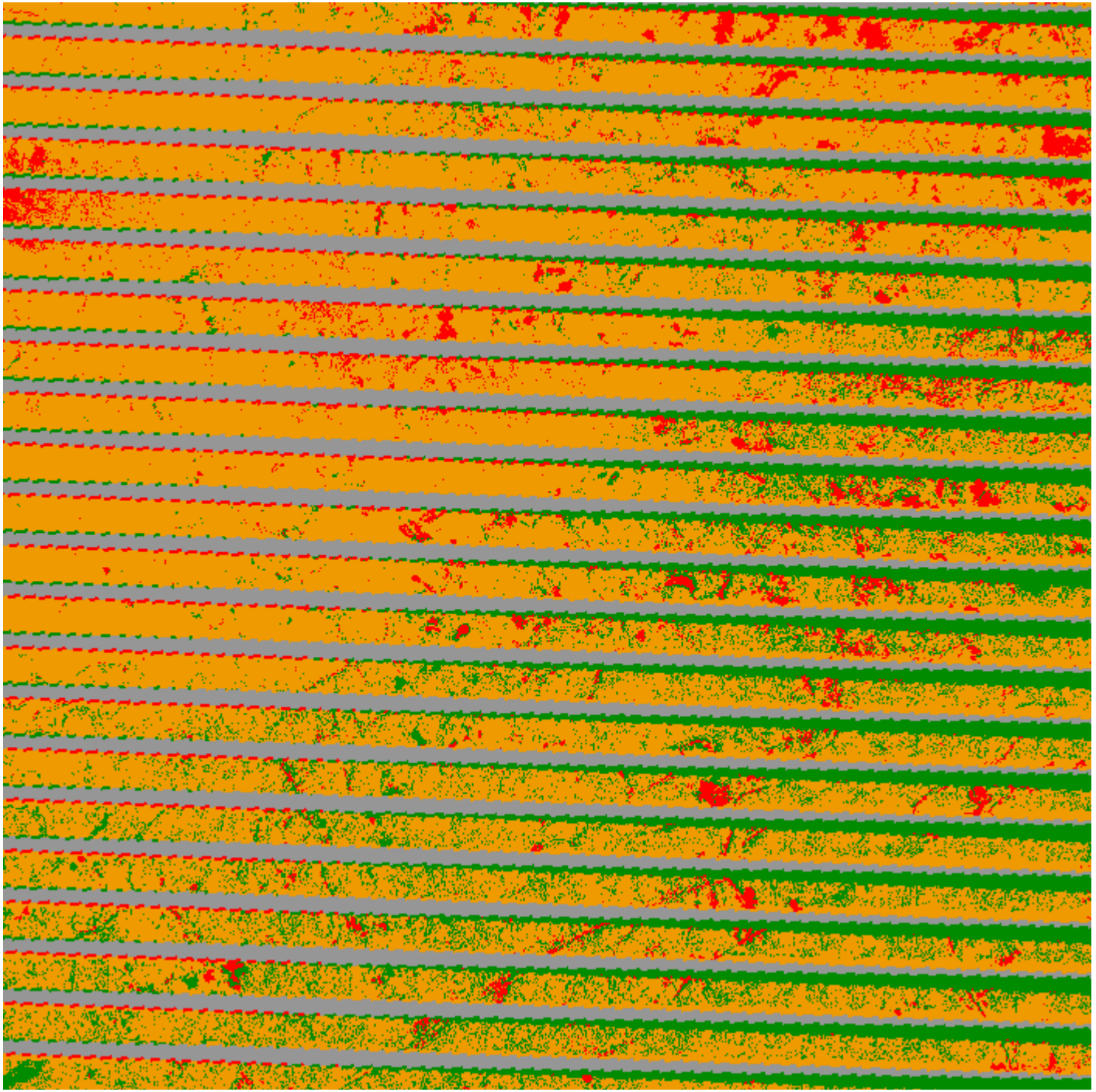


WELD
Tile h25v10,
West Virginia

Surface
Reflectance
True Color

June, 2008

700 X 700 pixels



WELD
Tile h25v10,
West Virginia

New
L1T Index
band (unique
code per pixel
defining L1T
file – relative
to filename
list in product
metadata)

June, 2008

Lesson #7

Expect schedule creep

in Science Product Development

Planned WELD Product Release

Presented at half day NASA WELD review at the ORNL-LP DAAC Joint User Working Group Meeting, Annapolis, MD, March 8th 2011

Release Date	Version	Region	Period
Keep Online	1.5	CONUS & Alaska	2006, 2007, 2008, 2009, 2010 weekly, monthly, seasonal, annual
December 2011	2.0	CONUS & Alaska	2010 weekly, monthly, seasonal, annual
December 2011	2.0	CONUS	5 year based land cover

Revised WELD Product Release
As of today, August 2011

Release Date	Version	Region	Period
January 2012	1.6	CONUS & Alaska	2005 / 06 / 07 / 08 / 09 / 10 / 11, weekly, monthly, seasonal, annual
Late Spring 2012	2.0	CONUS & Alaska	2010 weekly, monthly, seasonal, annual
Late Spring 2012	2.0	CONUS	5 year based land cover

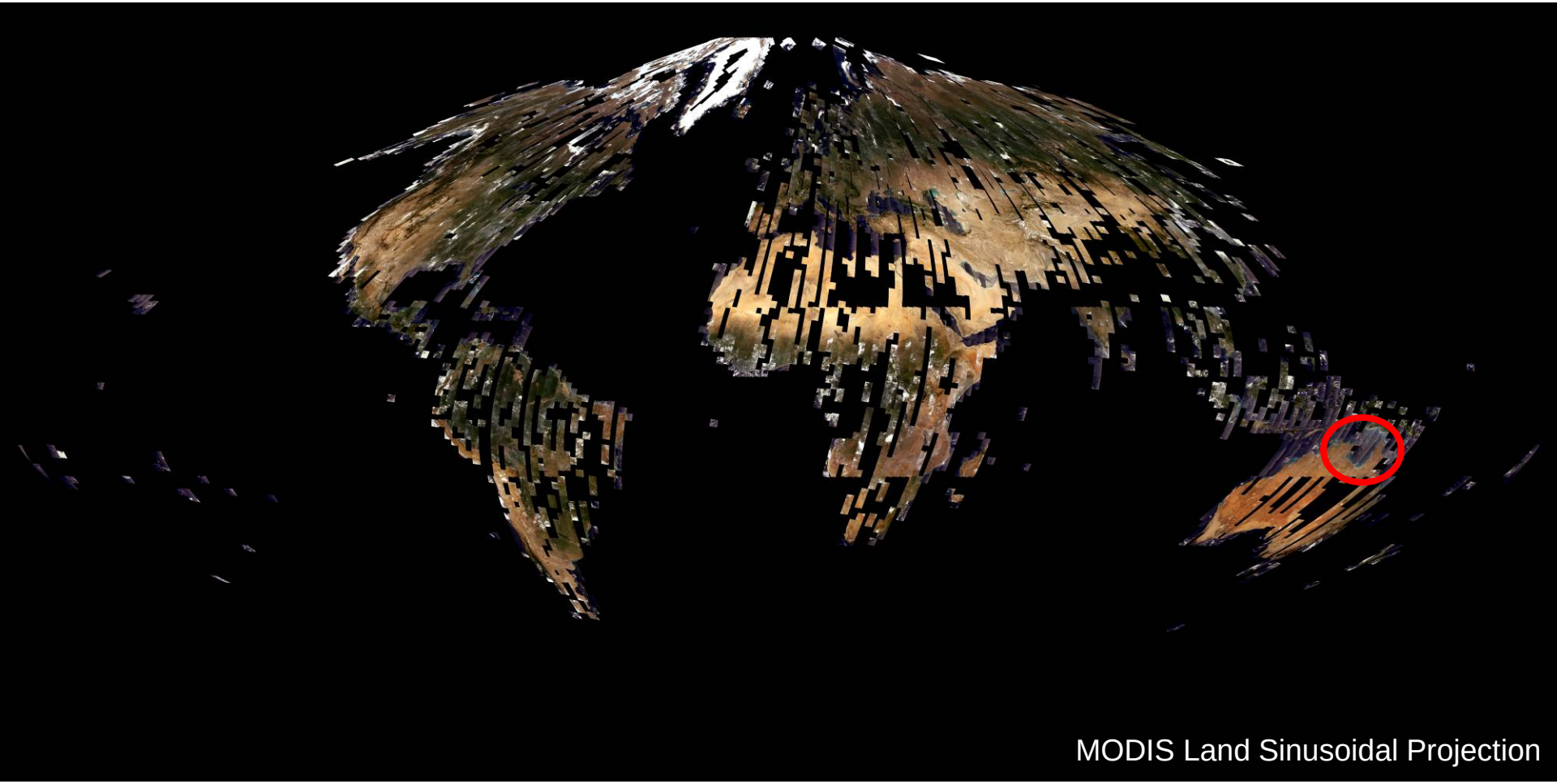
Lessons Summary

- **You cannot hit a *big red button* to make reliable large area and/or long term Landsat higher level data products**
- Get the product out early, Ensure mechanisms to involve the user community in product QA, Reprocess products as needed
- Routinely QA the input data
- Track the production date/time as well as the acquisition date/time of the input data and implement and manage a product versioning scheme
- Science algorithms developed on individual scenes don't necessarily provide consistency between scenes
- Product Quality Assessment challenge increases with data volume, algorithm complexity and product dependencies
- Expect schedule creep in Science Product Development

Landsat ETM+ 30m Leaf-on Single Month composite

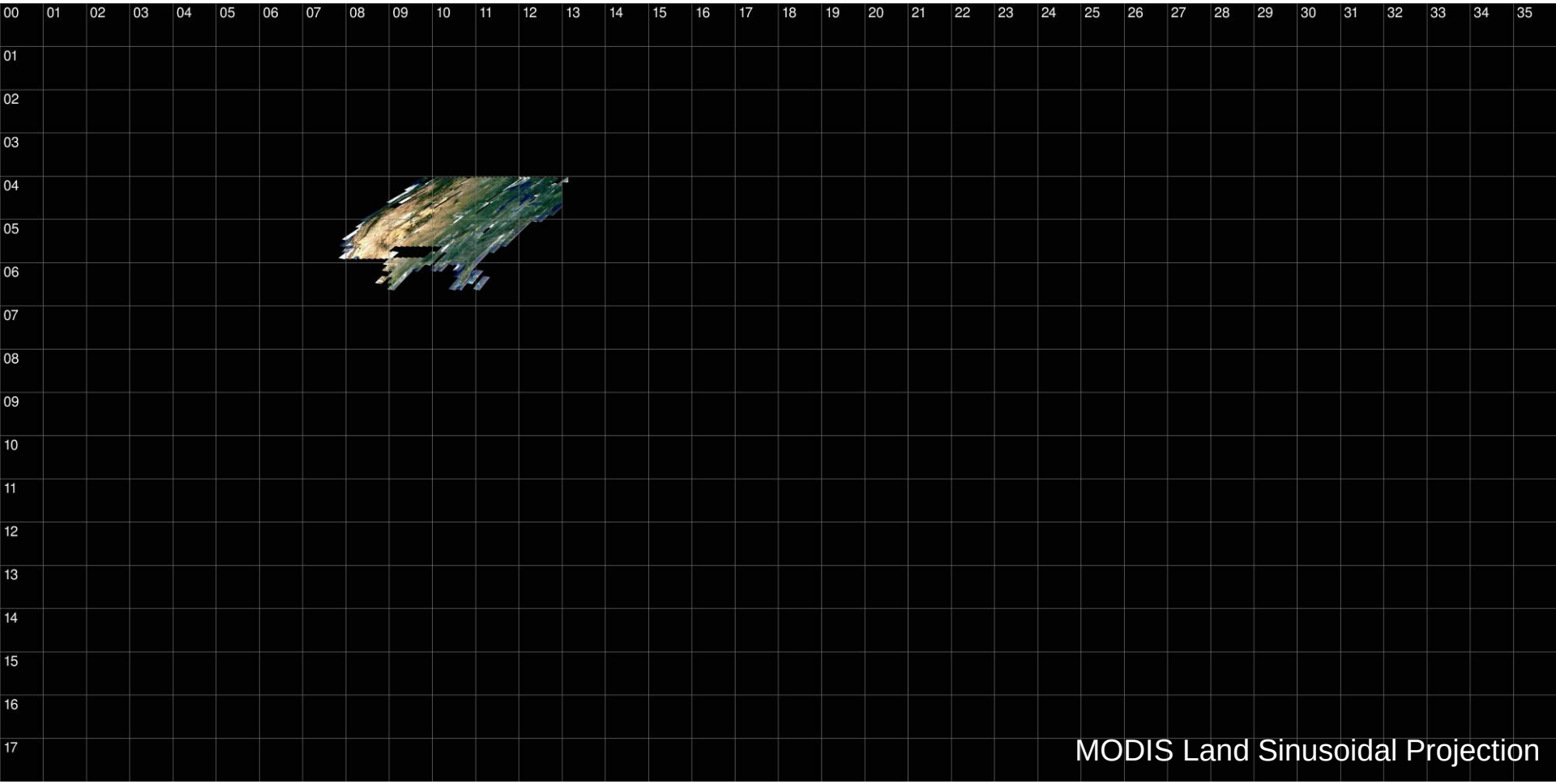
(Southern hemisphere Jan. 2010, Tropics ±20° October 2009, Northern hemisphere July 2009)

Global WELD Pathfinding

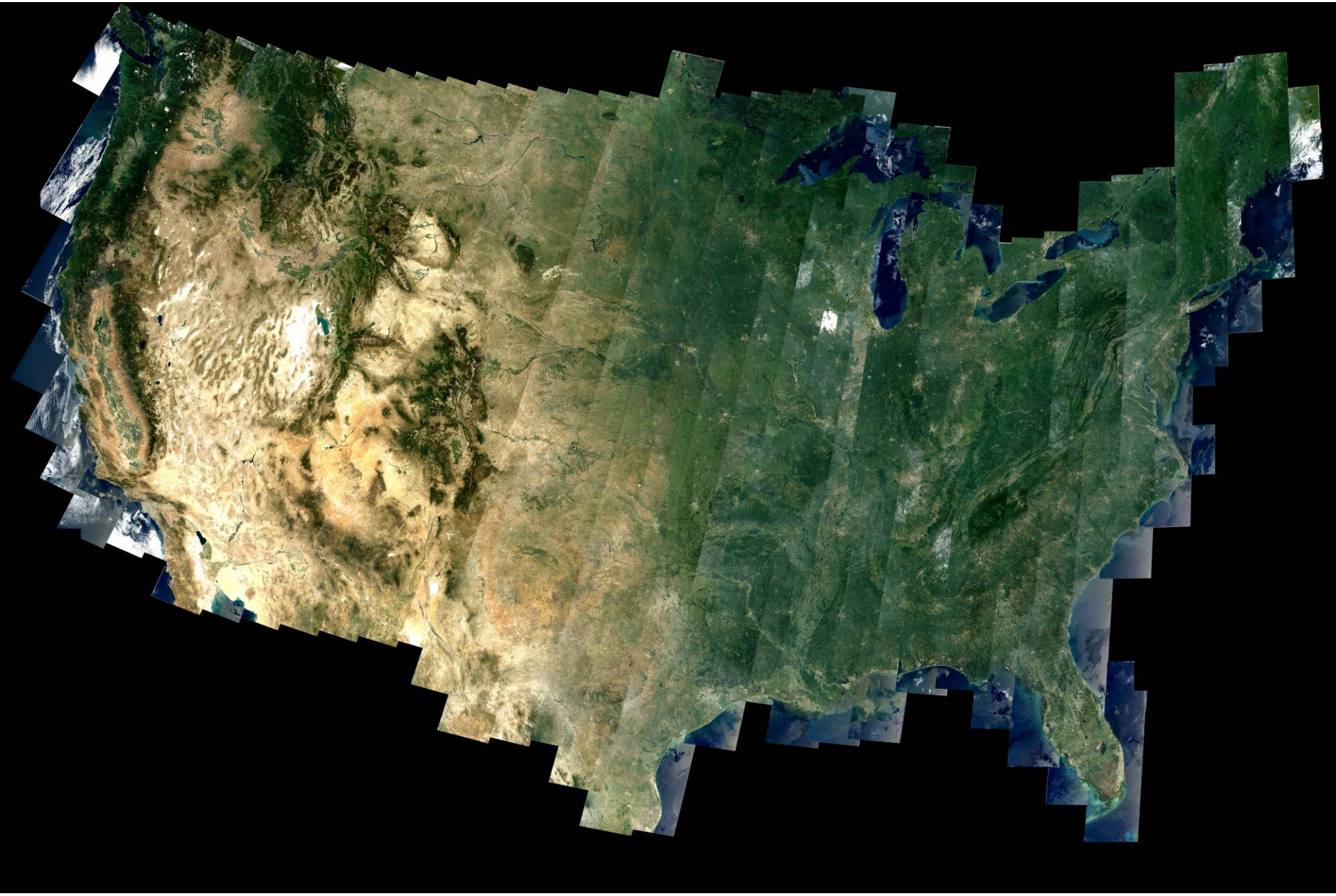
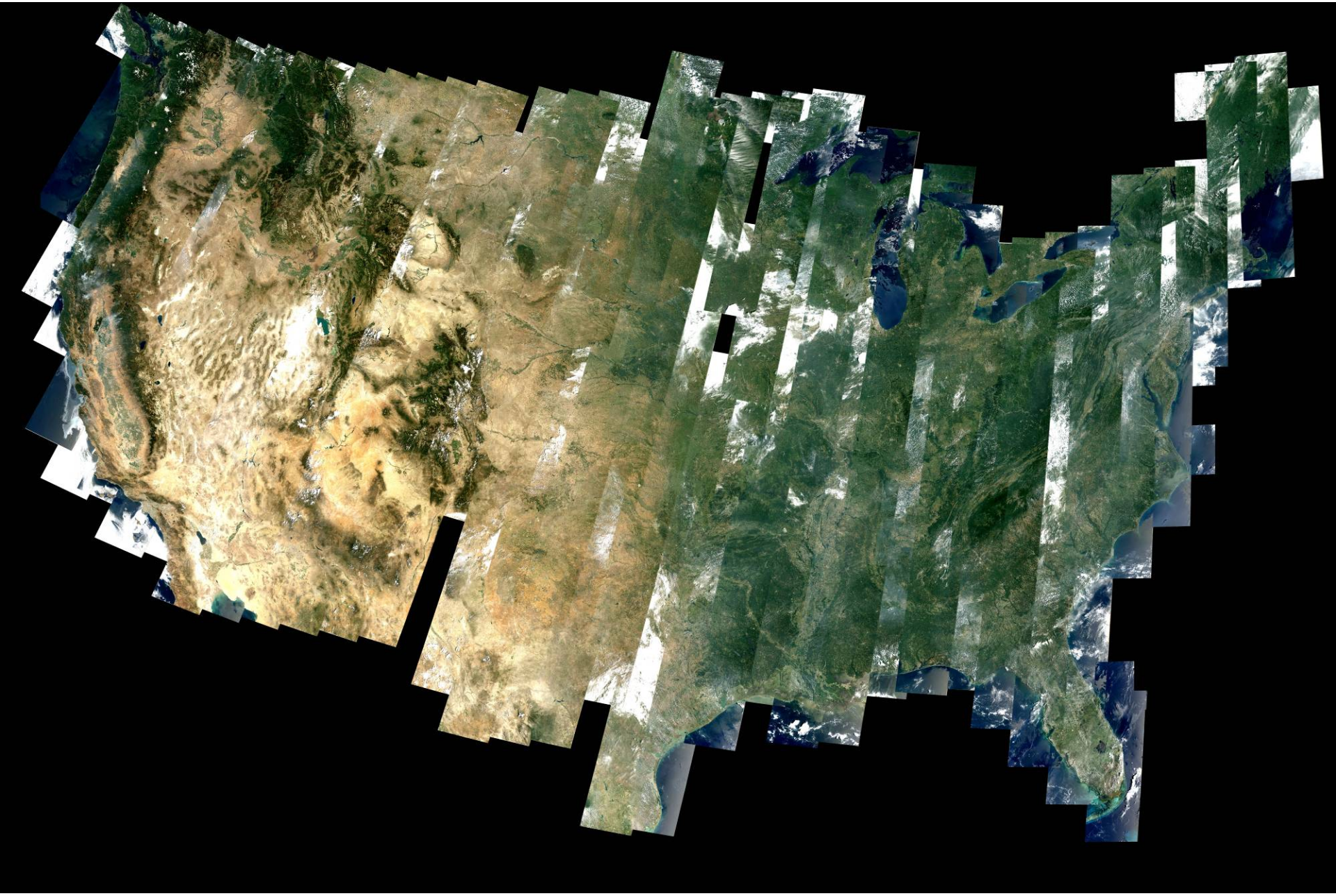


Generated from 6,796 L1T acquisitions in USGS EROS archive with cloud cover < 40%

NEX – early result – CONUS July 2008



Landsat 5 TM+ Summer 2008



Landsat 5 TM+ July 2008