

# Continuity of the Web Enabled Landsat Data (WELD) Product Record in the LDCM Era

David Roy

Val Kovalsky and Indu Kommareddy

Geographic Information Science Center of Excellence,  
South Dakota State University  
Brookings, SD 57007



Landsat Science Team Meeting  
Stuart Udall DOI Building,  
Room 1352  
Washington, DC  
December 12-13, 2012

# MODIS



**Terra Launch: Dec. 18, 1999**  
**First Image: Feb. 24, 2000**



**Aqua Launch: May 04, 2002**  
**First Image: June 26, 2002**

# MODIS Land Products

## Energy Balance Product Suite

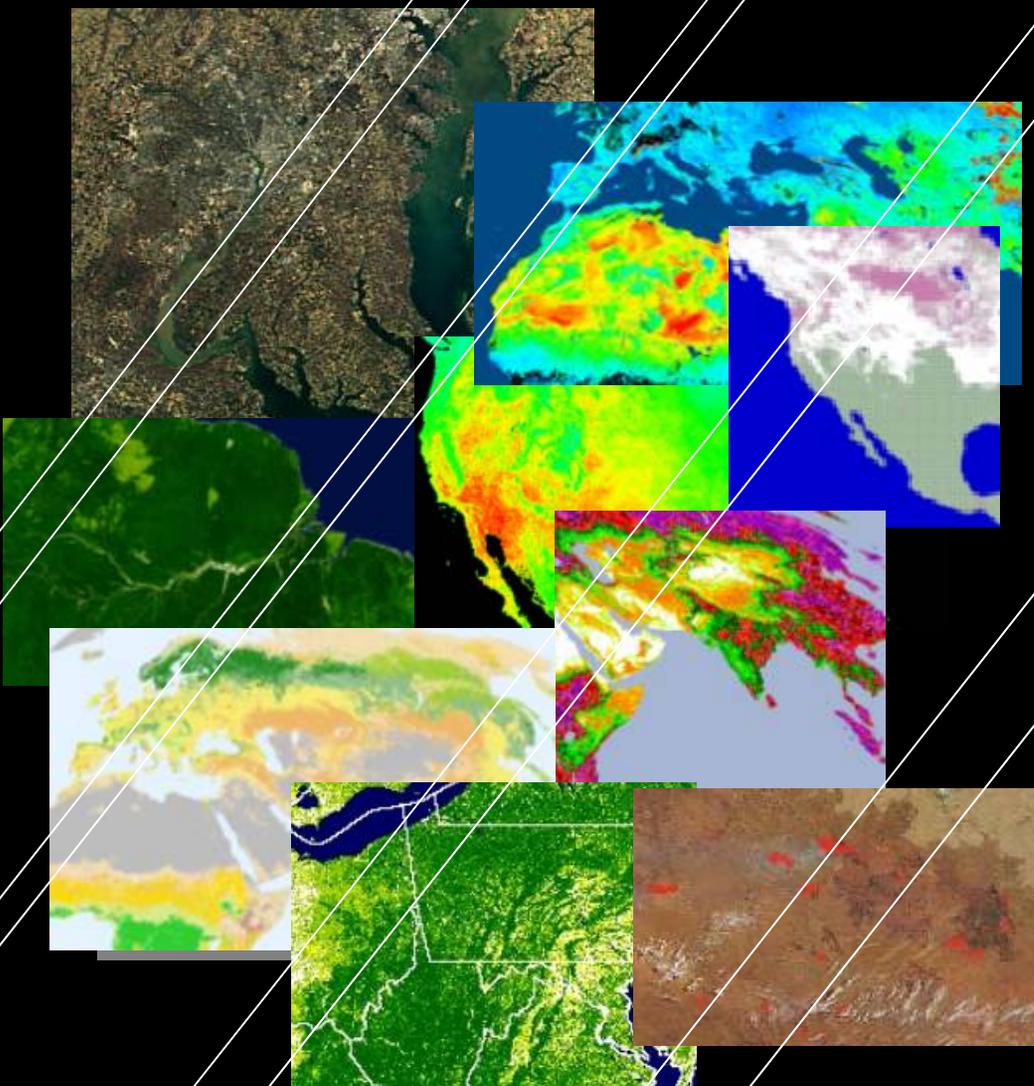
- Surface Reflectance
- Land Surface Temperature, Emmissivity
- BRDF/Albedo
- Snow/Sea-ice Cover

## Vegetation Parameters Suite

- Vegetation Indices
- LAI/FPAR
- GPP/NPP

## Land Cover Suite

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



# The Science and Applications Communities want and need higher-level Landsat Products like the MODIS Land Products

## Energy Balance Product Suite

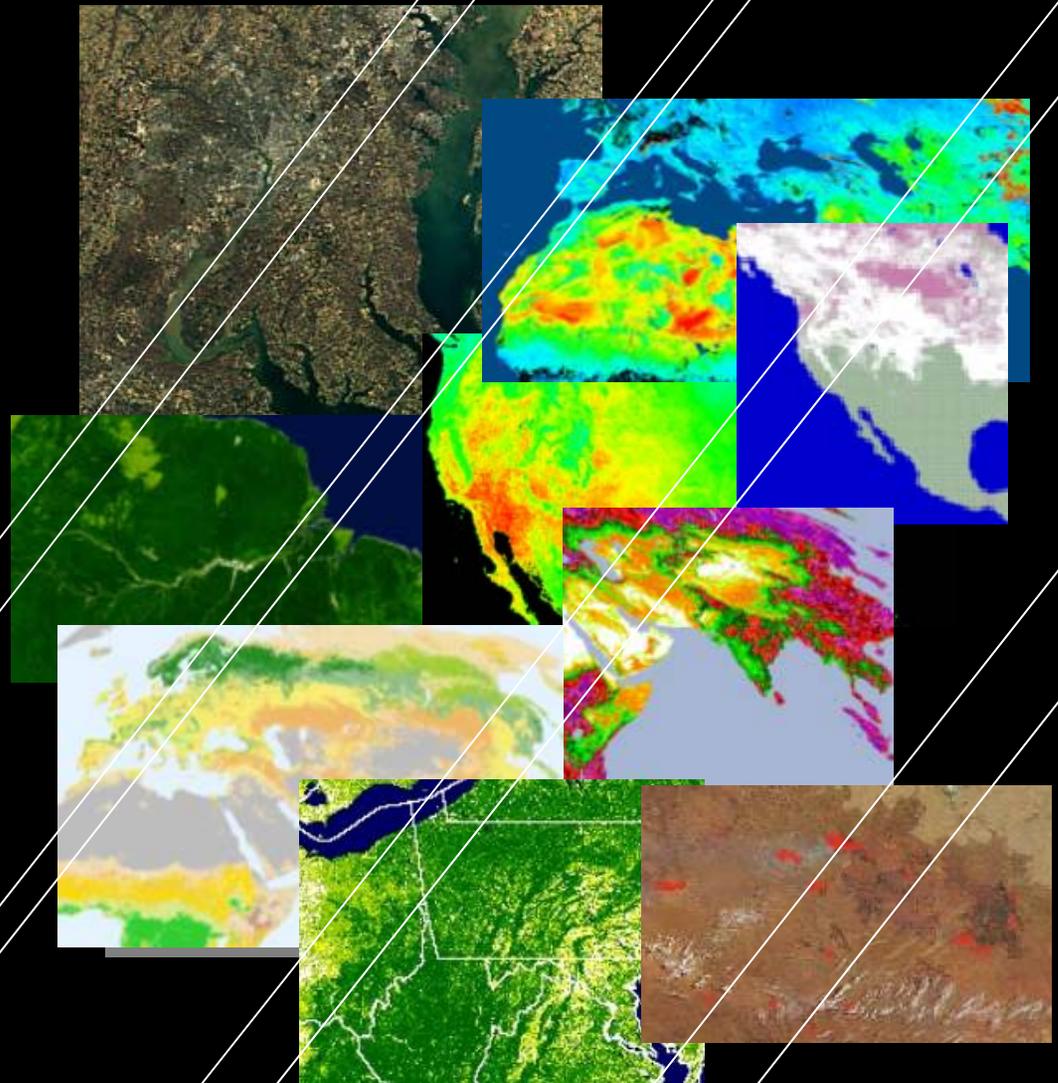
- Surface Reflectance
- Land Surface Temperature, Emmissivity
- BRDF/Albedo
- Snow/Sea-ice Cover

## Vegetation Parameters Suite

- Vegetation Indices
- LAI/FPAR
- GPP/NPP

## Land Cover Suite

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



**Web-enabled Landsat data (WELD) - a consistent seamless near  
real time MODIS-Landsat data fusion  
for the terrestrial user community**

Funded by NASA  
**NNH06ZDA001N Making Earth System data records for Use in  
Research Environments (MEASURES)**

**Principal Investigator:**

David Roy  
Geographic Information Science Center of Excellence,  
South Dakota State University  
Brookings, SD 57007

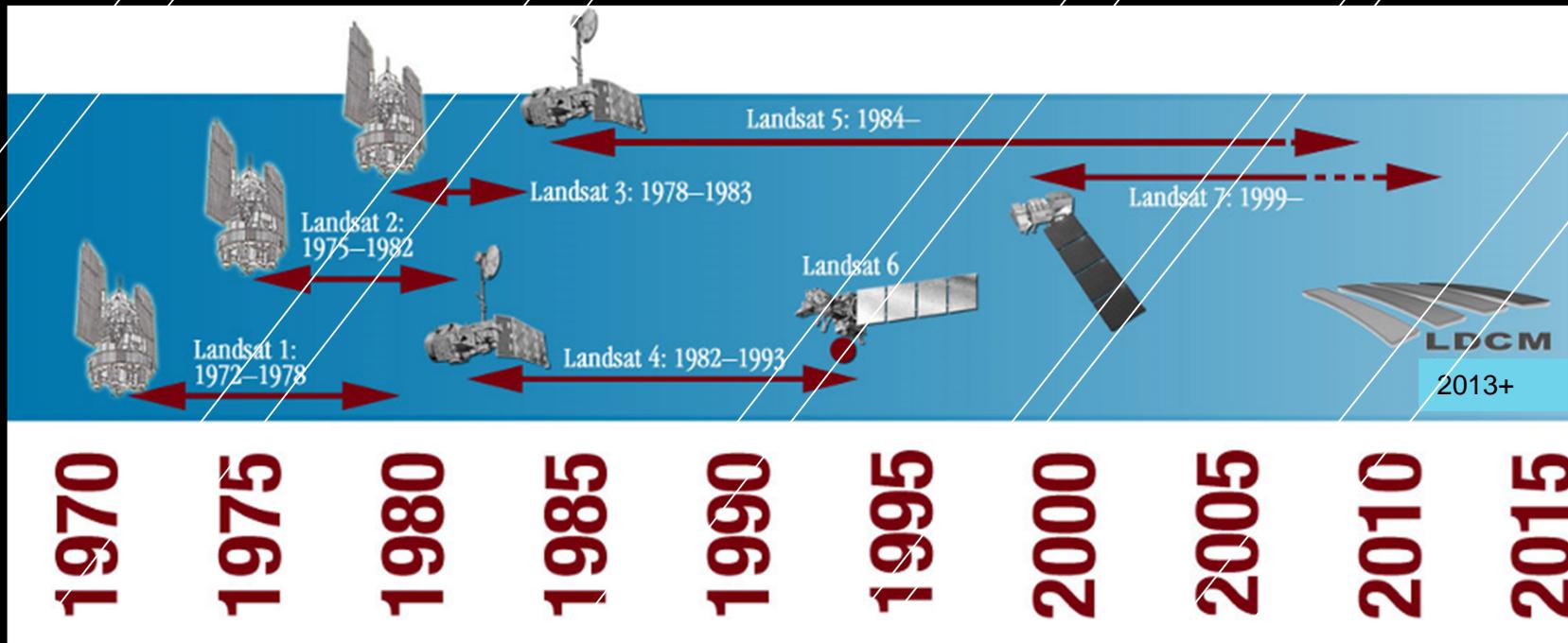
**CO-Investigators**

Hansen, M., Loveland, T., Vermote, E., Kline, K., Zhang, C.

**\$3.3 million + USGS Distribution Cost Share  
5 years, Spring 2008-2013**

# Landsat Satellite Series

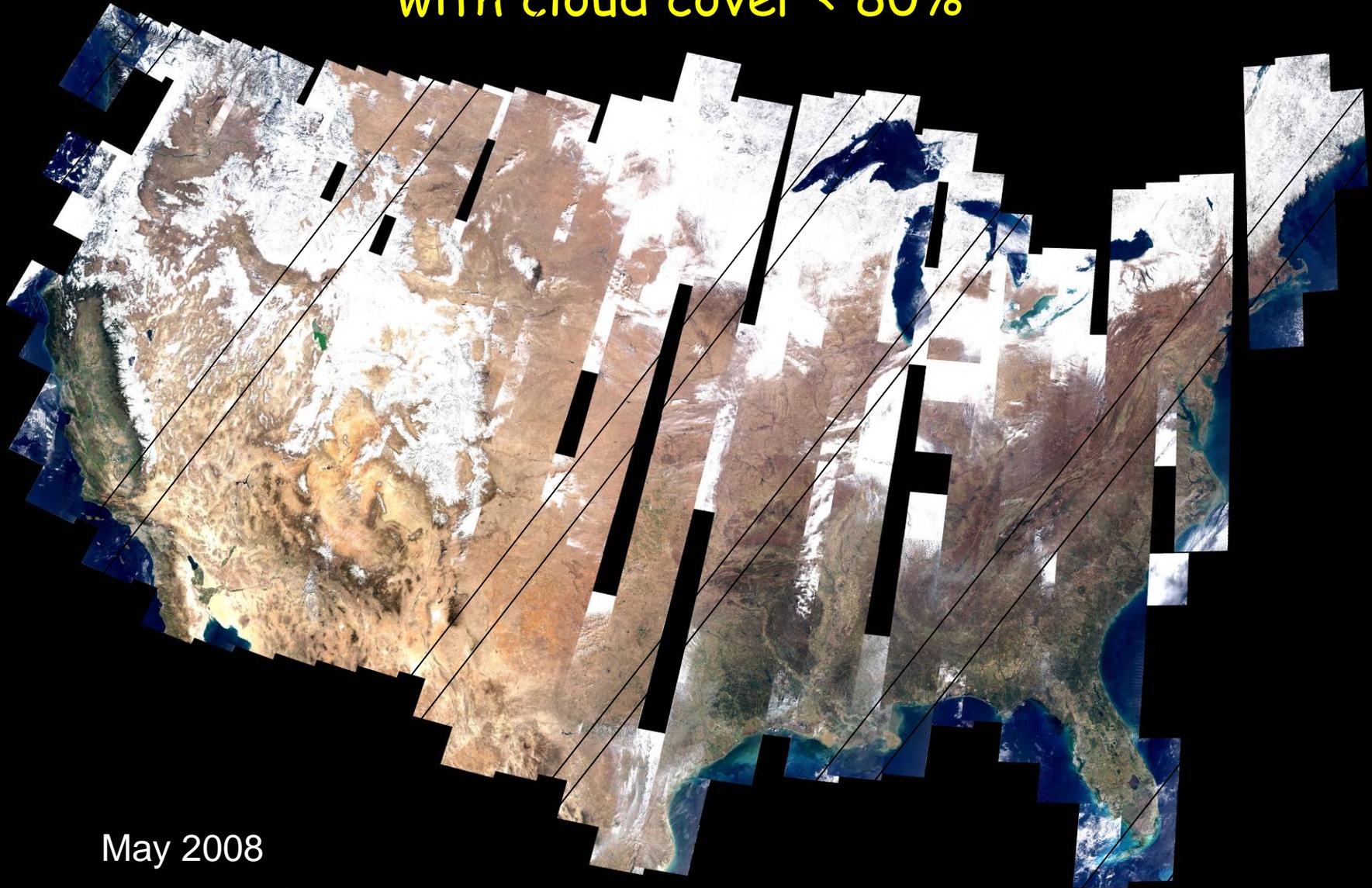
The longest Land surface observation record



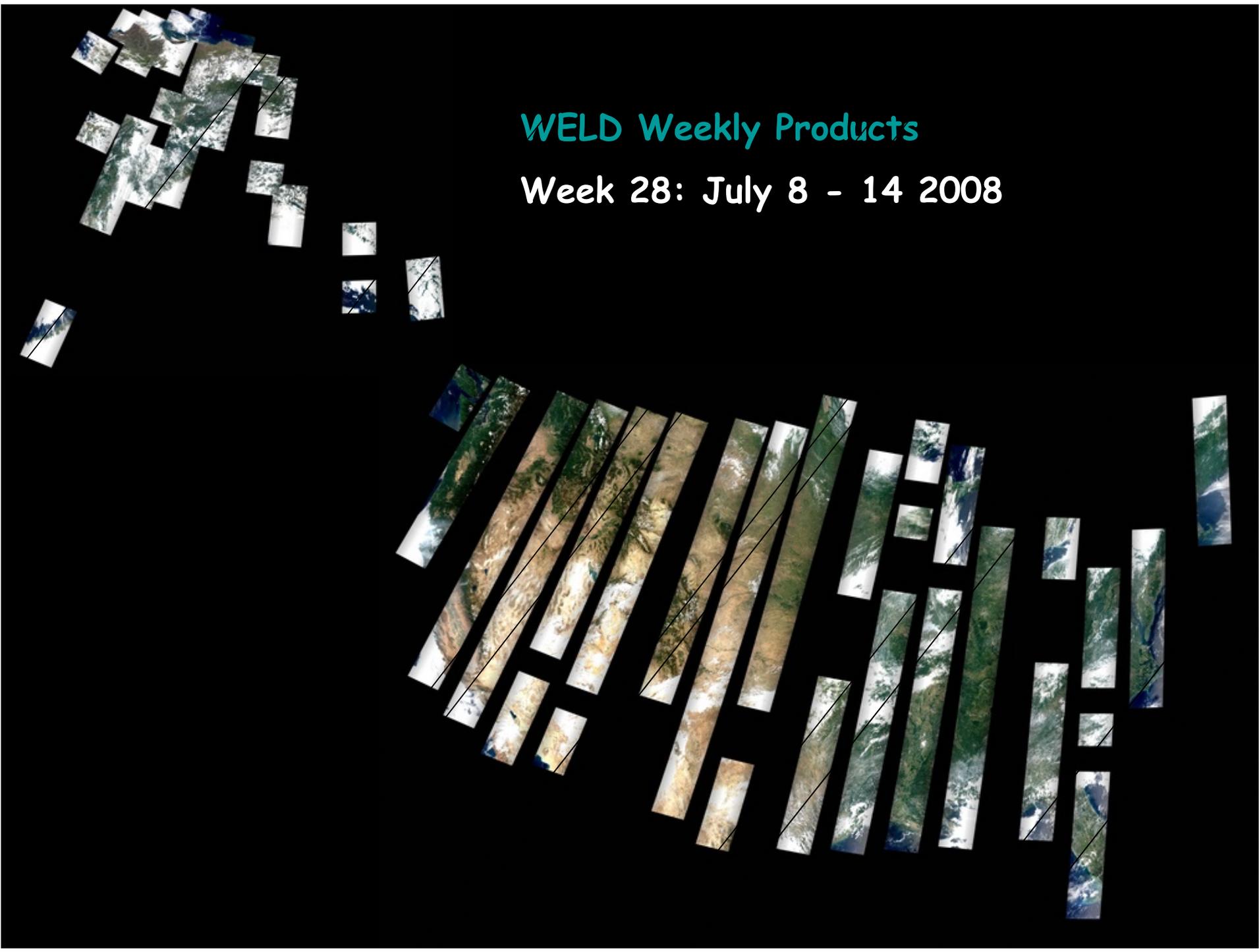
WELD process 10 years of CONUS and Alaska 30m Landsat ETM+ data (in MODIS era)



Currently, WELD 30m products generated  
using all Landsat 7 ETM+ acquisitions in US archive  
with cloud cover < 80%



May 2008

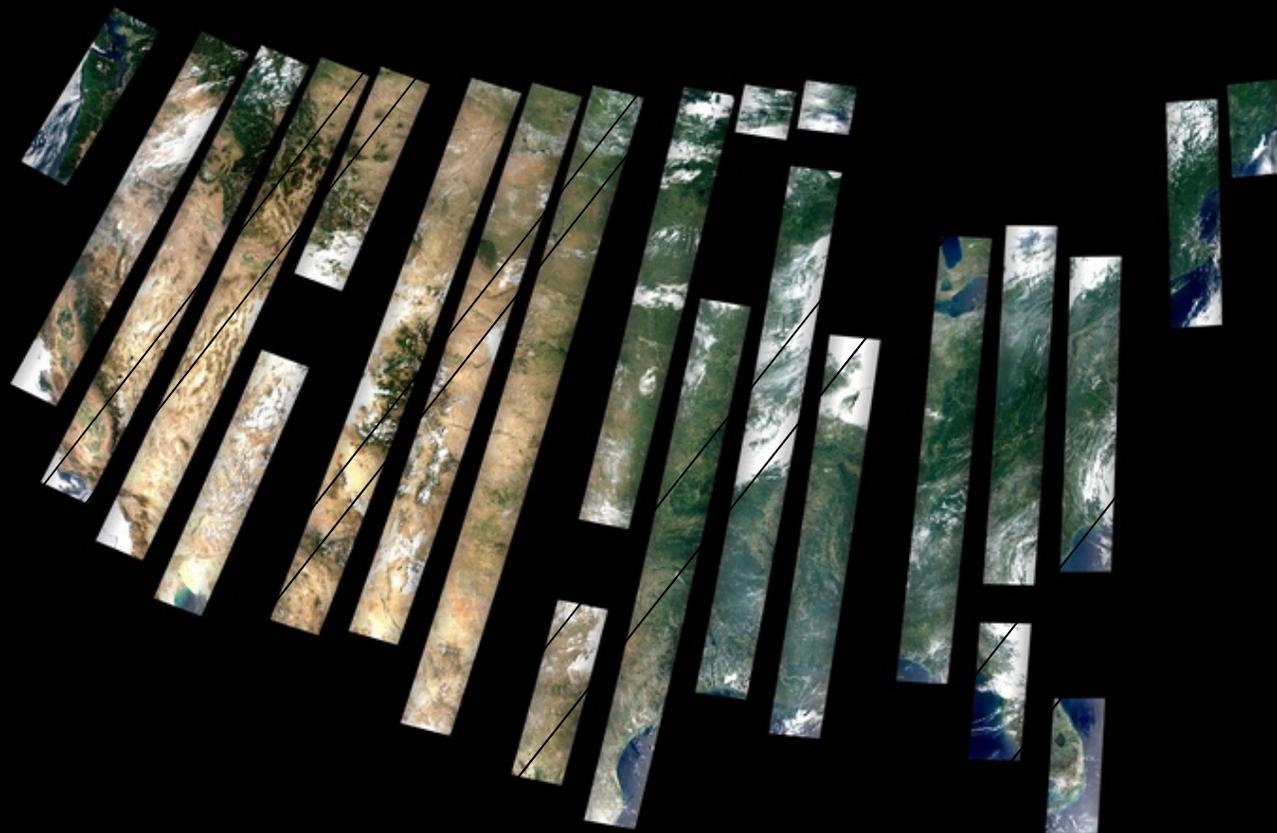
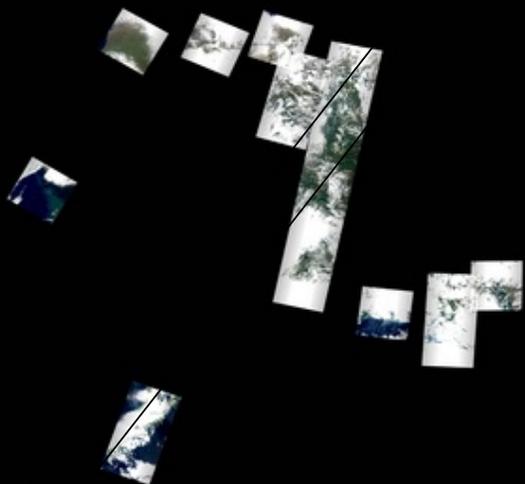


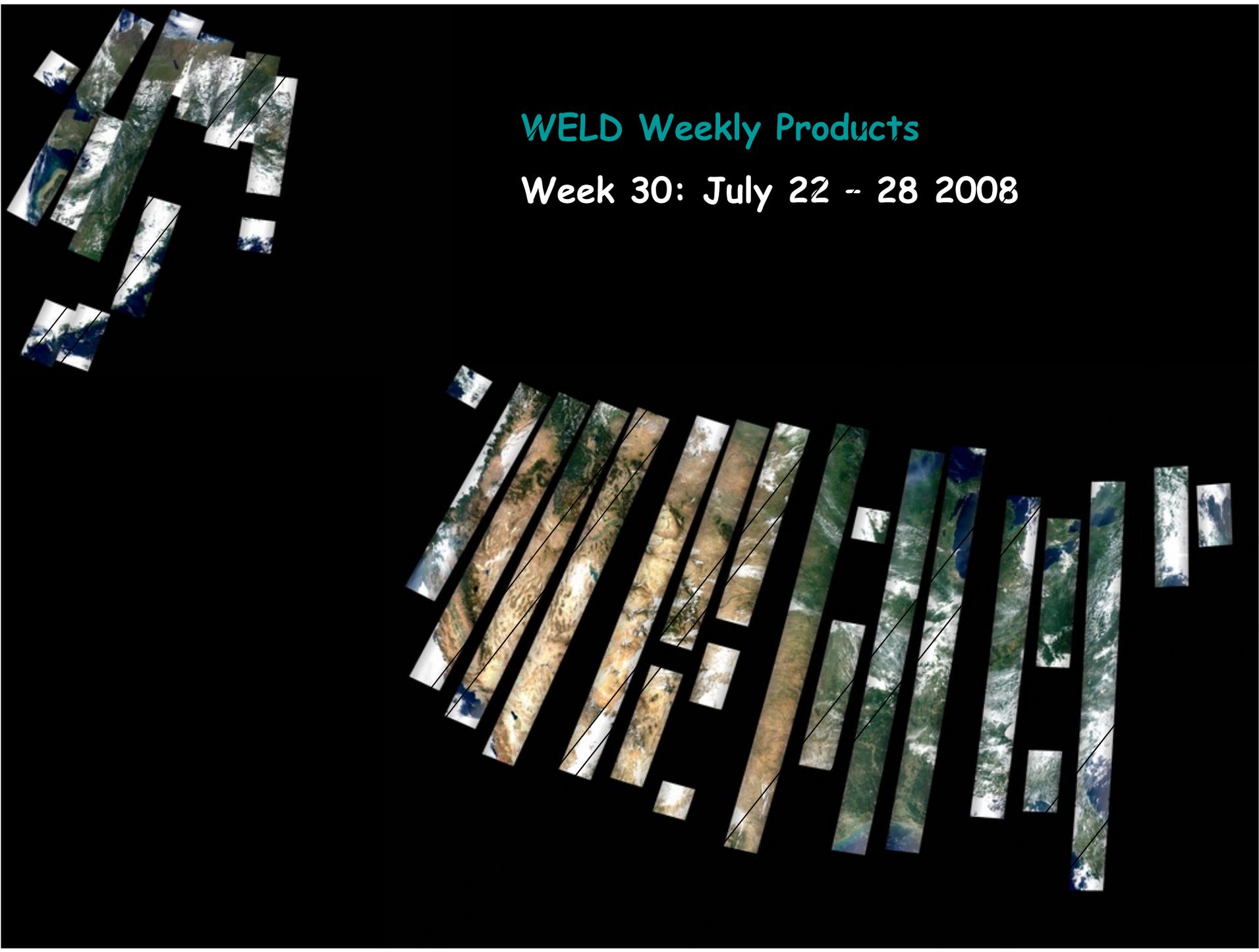
## WELD Weekly Products

Week 28: July 8 - 14 2008

# WELD Weekly Products

Week 29: July 15 - 21 2008



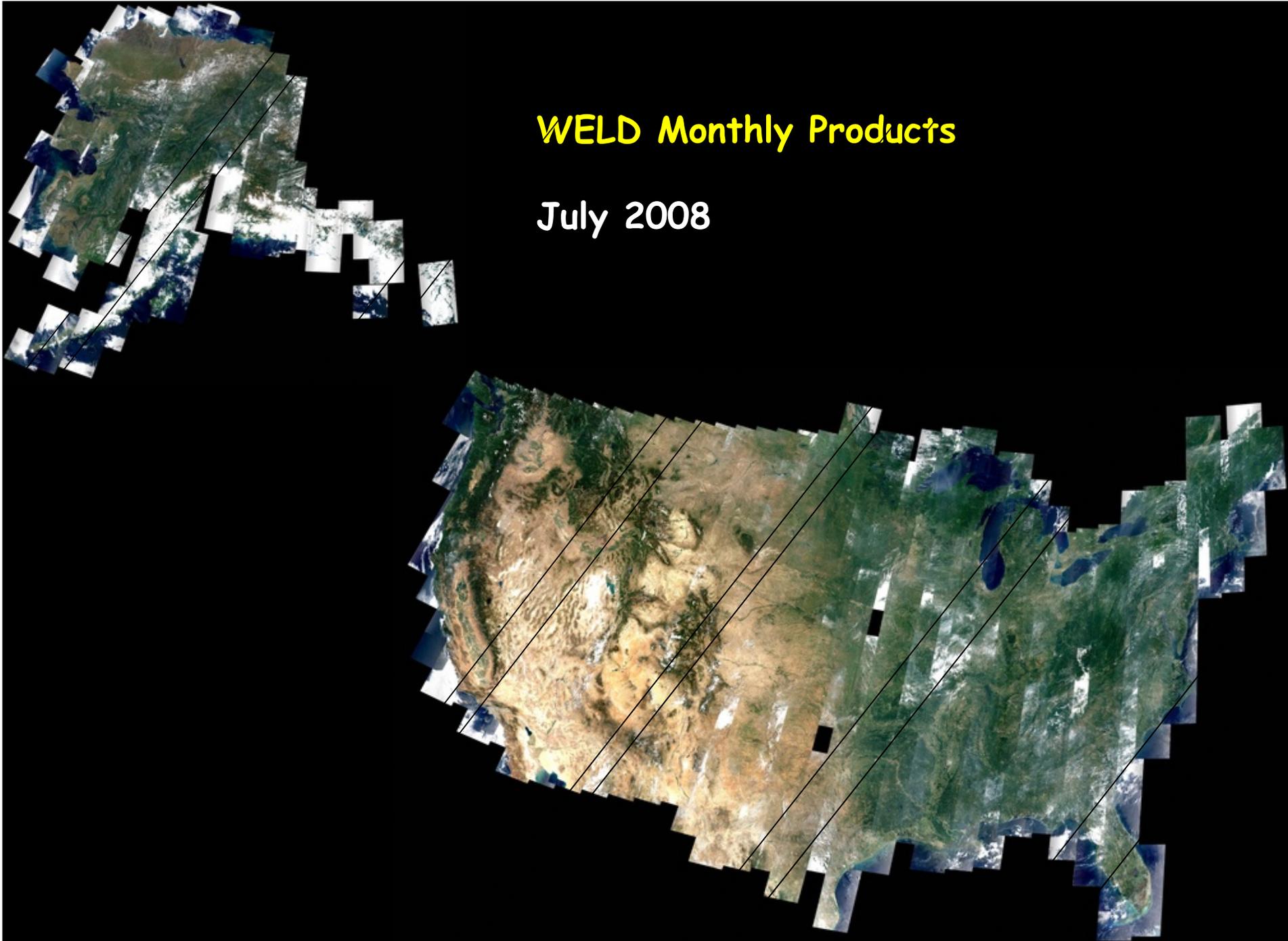


## WELD Weekly Products

Week 30: July 22 - 28 2008

# WELD Monthly Products

July 2008

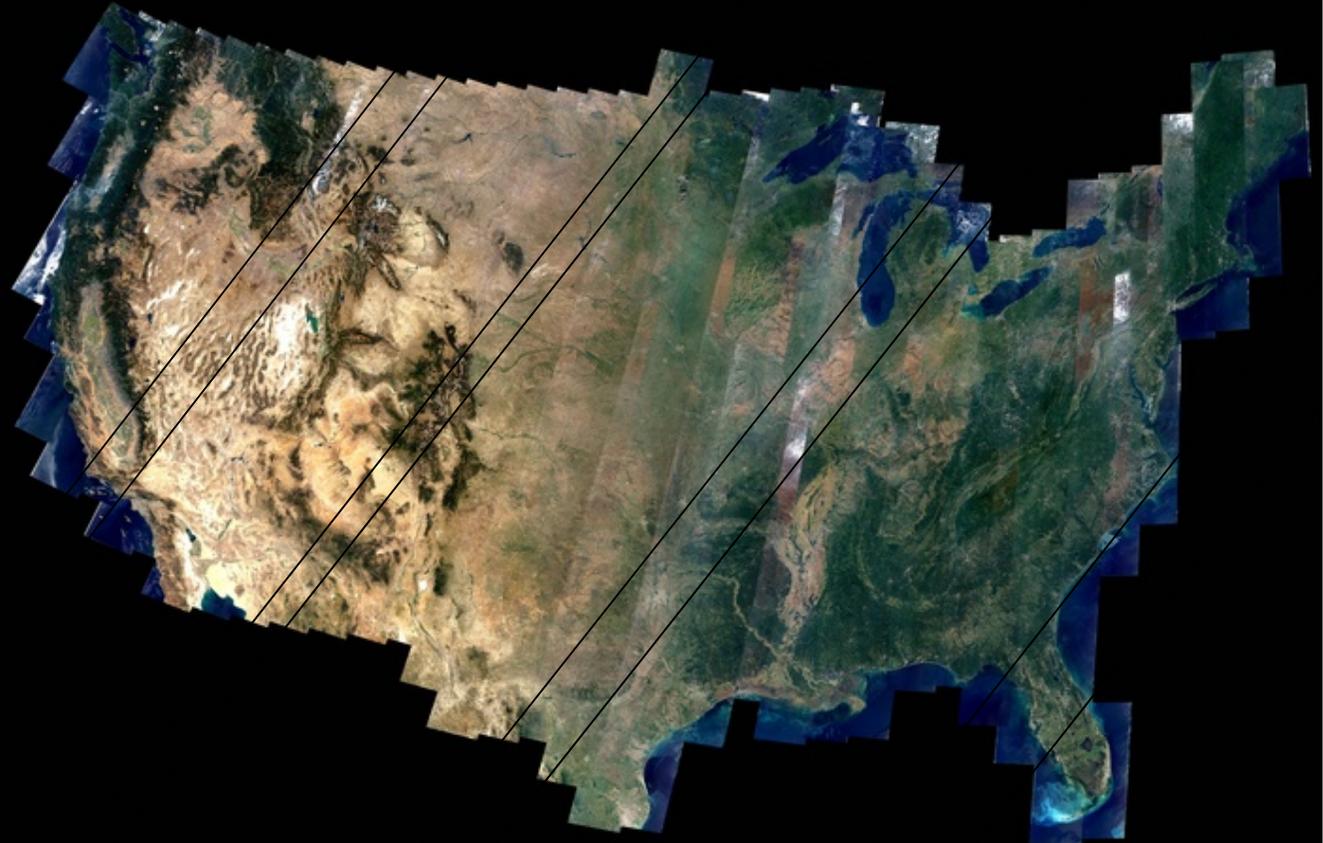
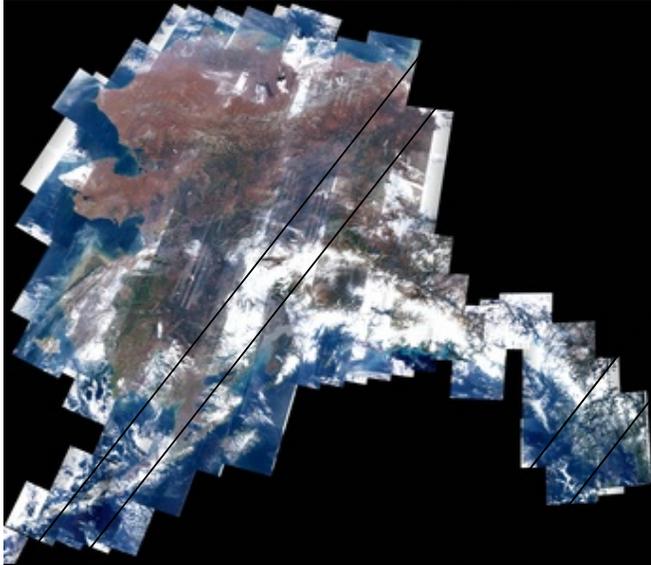


**WELD Seasonal Products**  
**Summer (June, July, August) 2008**



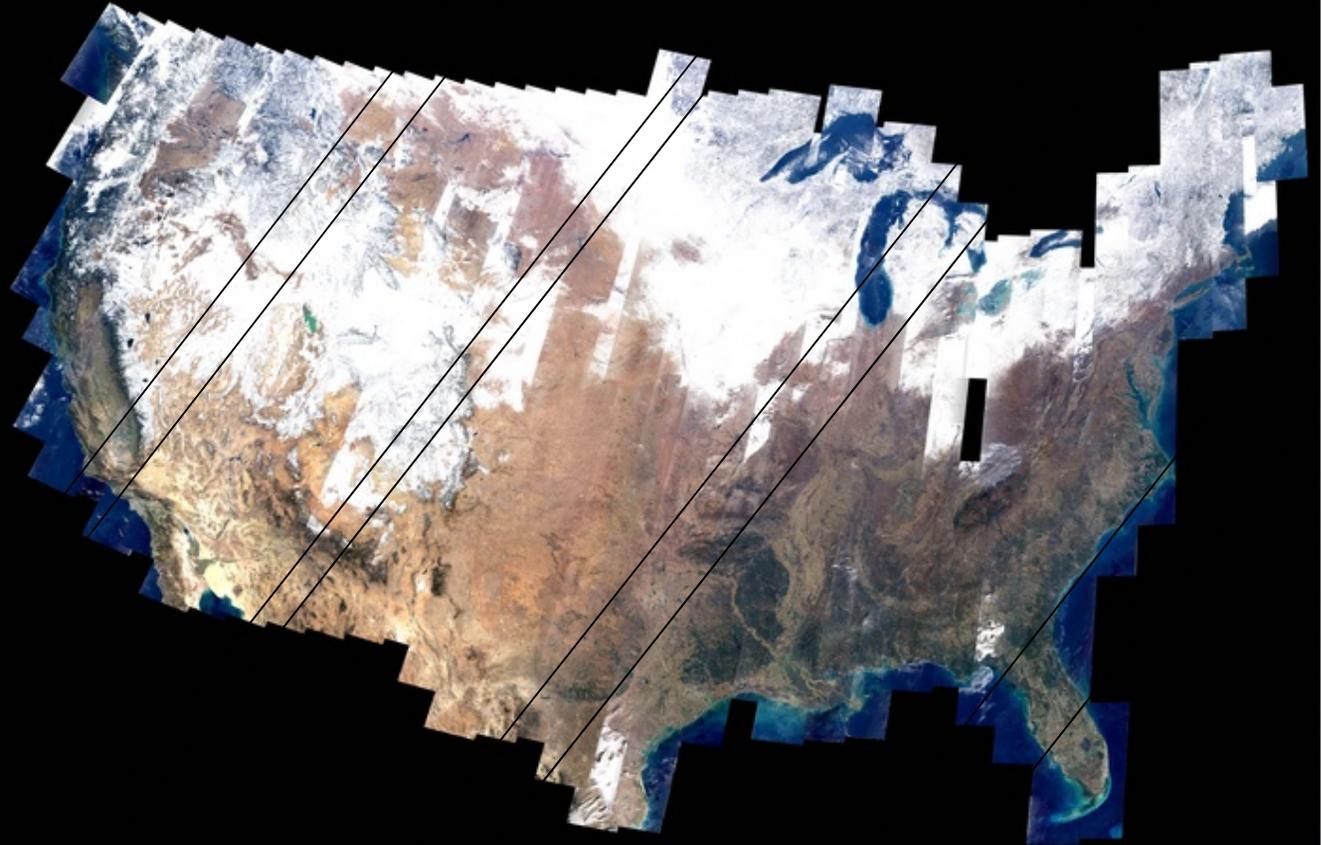
## WELD Seasonal Products

Fall (September, October, November)



## WELD Seasonal Products

Winter (December, January, February)



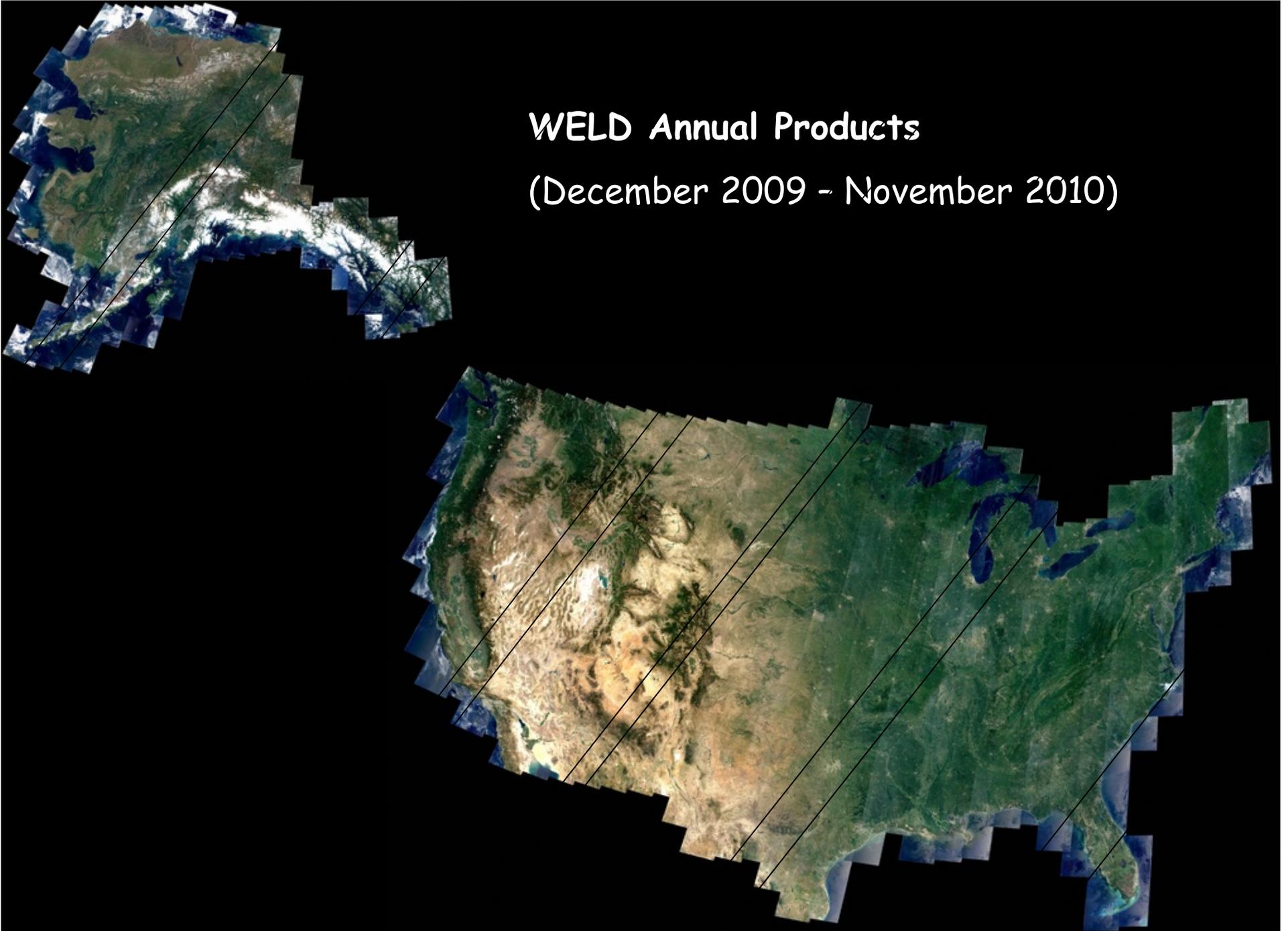
**WELD Seasonal Products**

**Spring (March, April, May) 2009**



# WELD Annual Products

(December 2009 - November 2010)



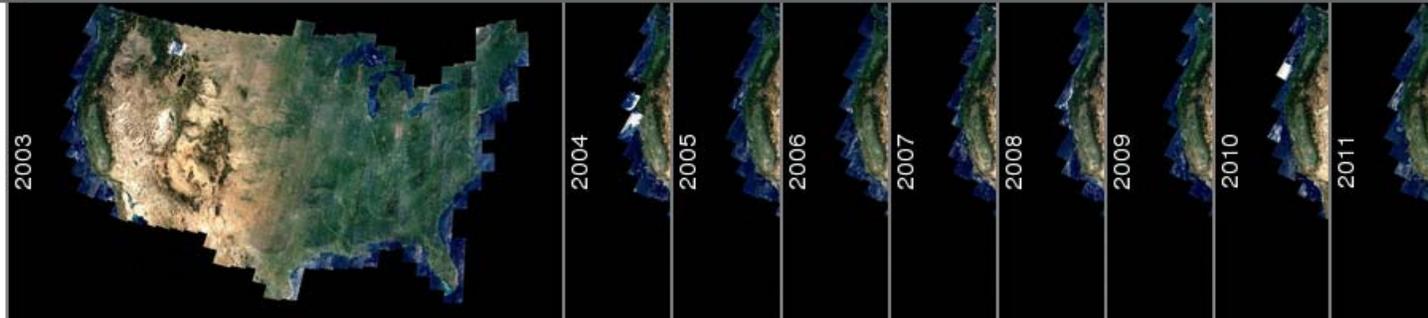
## Version 1.5 WELD Product Format (all pixels are 30m)

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_Observations	uint8	0 -- 255	1	Unitless	None

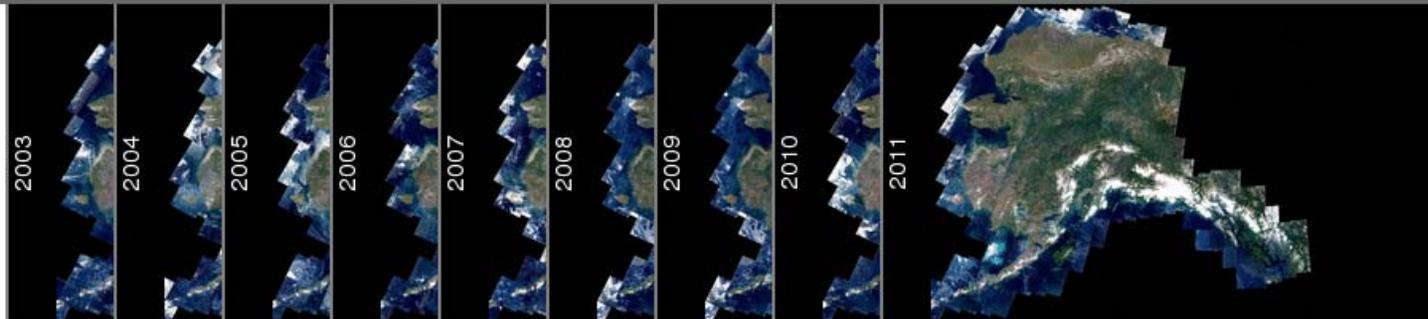
Designed to be easy to use for science and applications, including development of other higher-level products

## Available Years:

### CONUS



### Alaska



WELD product distribution

What You See Is What You Get from USGS EROS

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

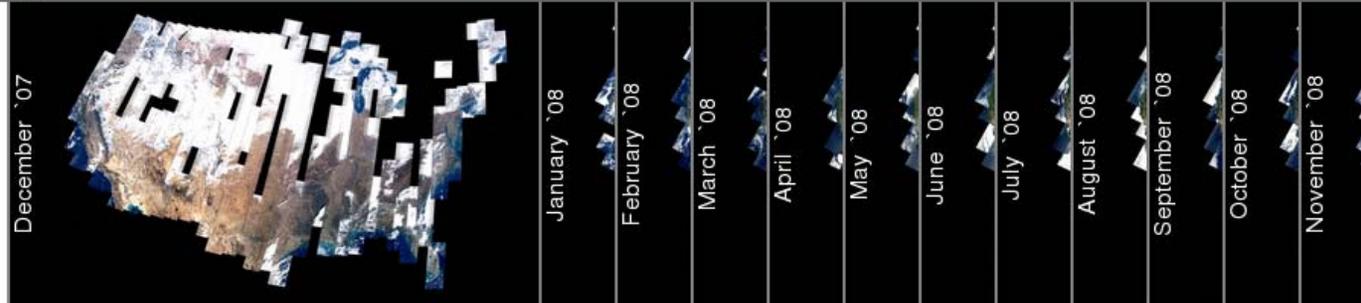
## CONUS 2008

[<< 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:

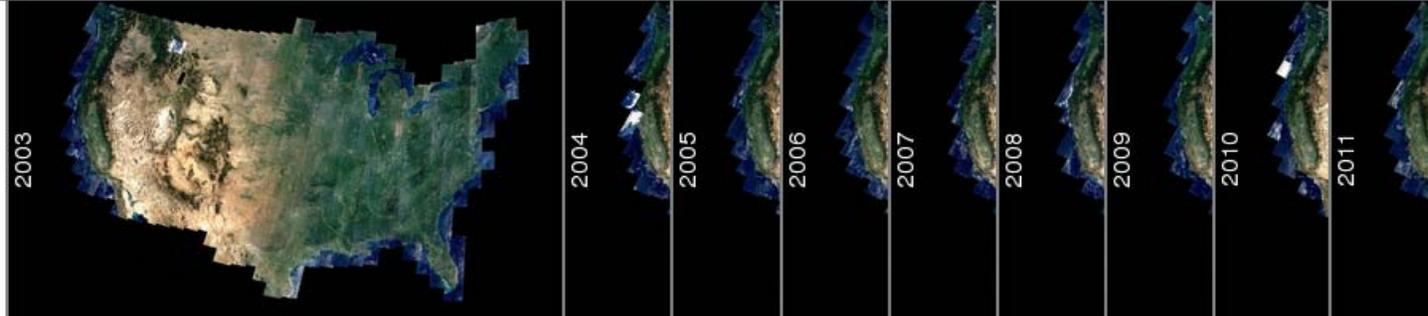
**Click the left button to define a single pixel time series dump, or enter the pixel coordinates below**

North:

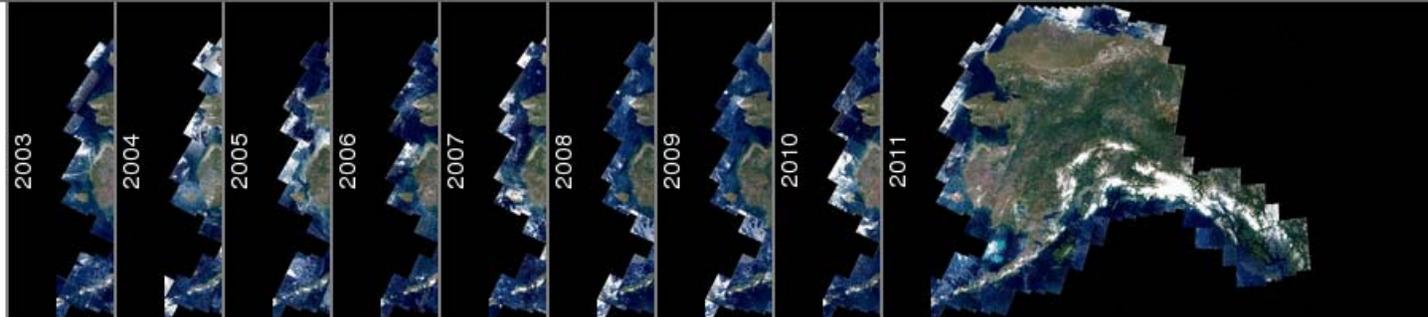
West:

## Available Years:

### CONUS



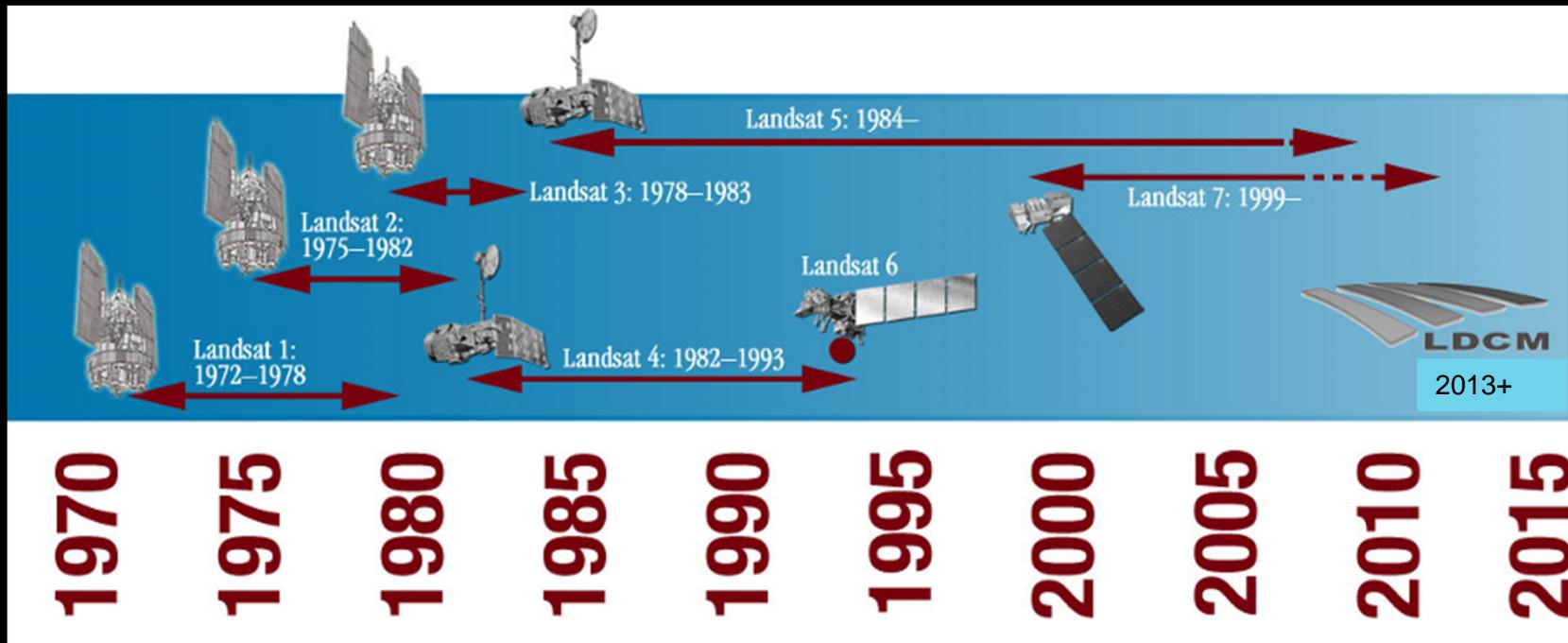
### Alaska



9 years for CONUS and Alaska (36TB) currently online  
~0.5 million files, >60TB, have been distributed to >890 users

# Landsat Satellite Series

The longest Land surface observation record



WELD process 30m Landsat TM & ETM+

Global Archive



# **Global Long-Term Multi-Sensor Web-Enabled Landsat Data Record**

Funded by NASA  
**NNH12ZDA001N-MEASURES**

**Principal Investigator:**

David Roy

Geographic Information Science Center of Excellence,  
South Dakota State University  
Brookings, SD 57007

**Co-Investigators:**

Rama Nemani

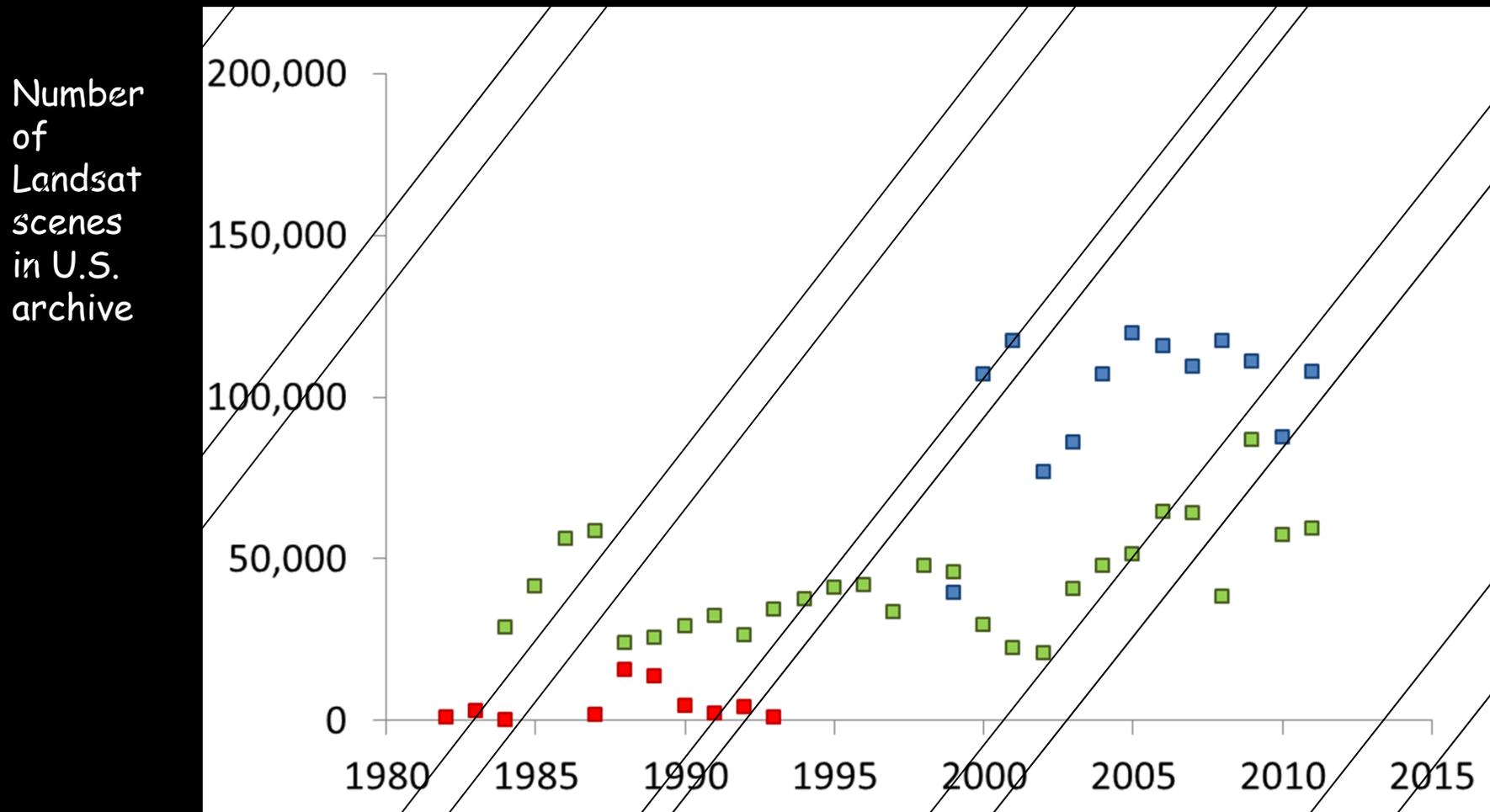
NASA Ames Research Center  
Moffett Field, CA 94035

Matthew Hansen

Department of Geography,  
University of Maryland, College Park, MD 20742

**\$4.8 million + Massive USGS Distribution Cost Share**  
**5 years, Spring 2013+**

~ 2.5 million global Landsat 4, 5 and 7 acquisitions in the U.S. archive (each ~220MB)



Landsat repatriation from other space agencies may double number of scenes in the archive in the next 5 years

L4 TM (red) > 50,000  
L5 TM (green) > 1.2 million  
L7 ETM+ (blue) > 1.3 million

# Global WELD Proof of Concept

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

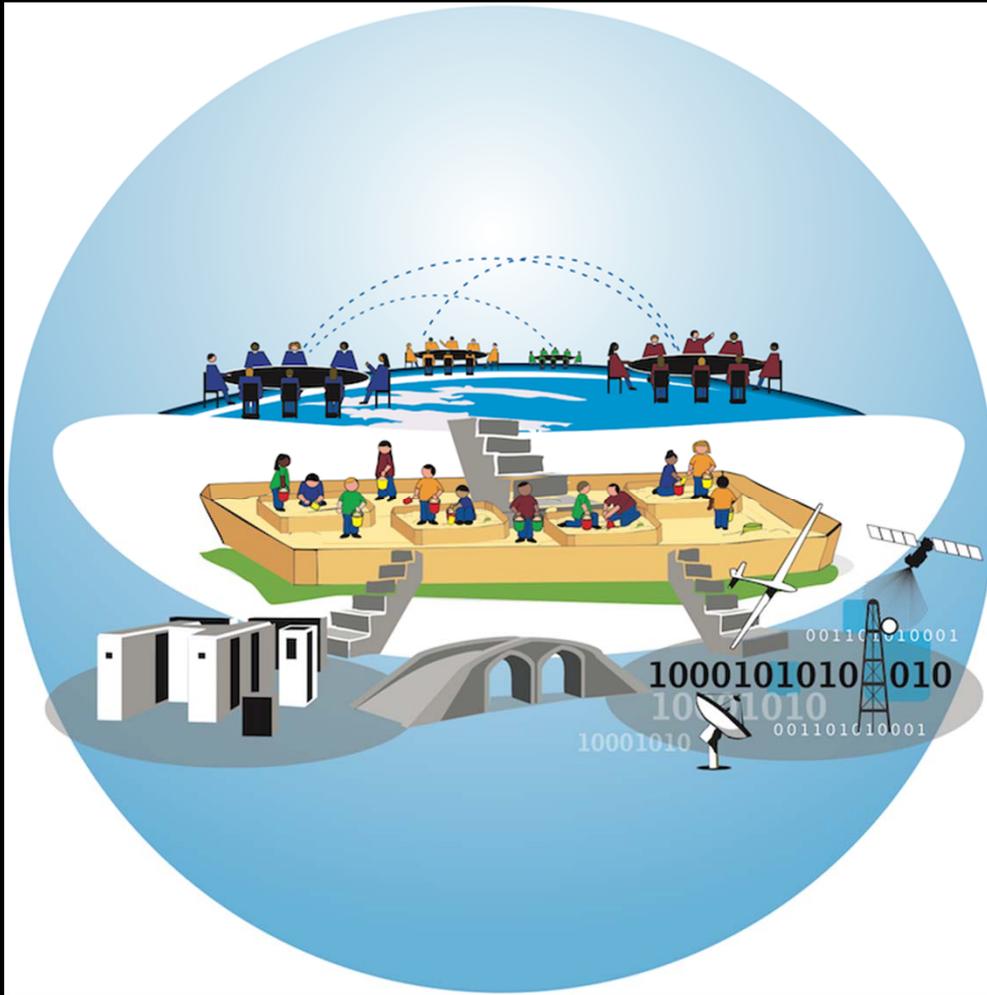
~2.5 weeks to generate @ WELD Lab SDSU



MODIS Land Sinusoidal Projection

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

# NASA Earth Exchange (NEX) WELD Processing



- 9PB on-line storage, 50PB tape storage
- 512 cores readily accessible
- 180,000 total available cores



## Pleiades

NASA's fastest supercomputer



**COLLABORATION**

(over 250 members)

**COMPUTING**

(9PB, 180,000 cores)

**Data Repository**

(over 400 TB of data)

Global WELD prototype, Landsat 7 ETM+, 7300 May 2010 acquisitions,  
processed on NASA Earth Exchange (NEX) Supercomputer



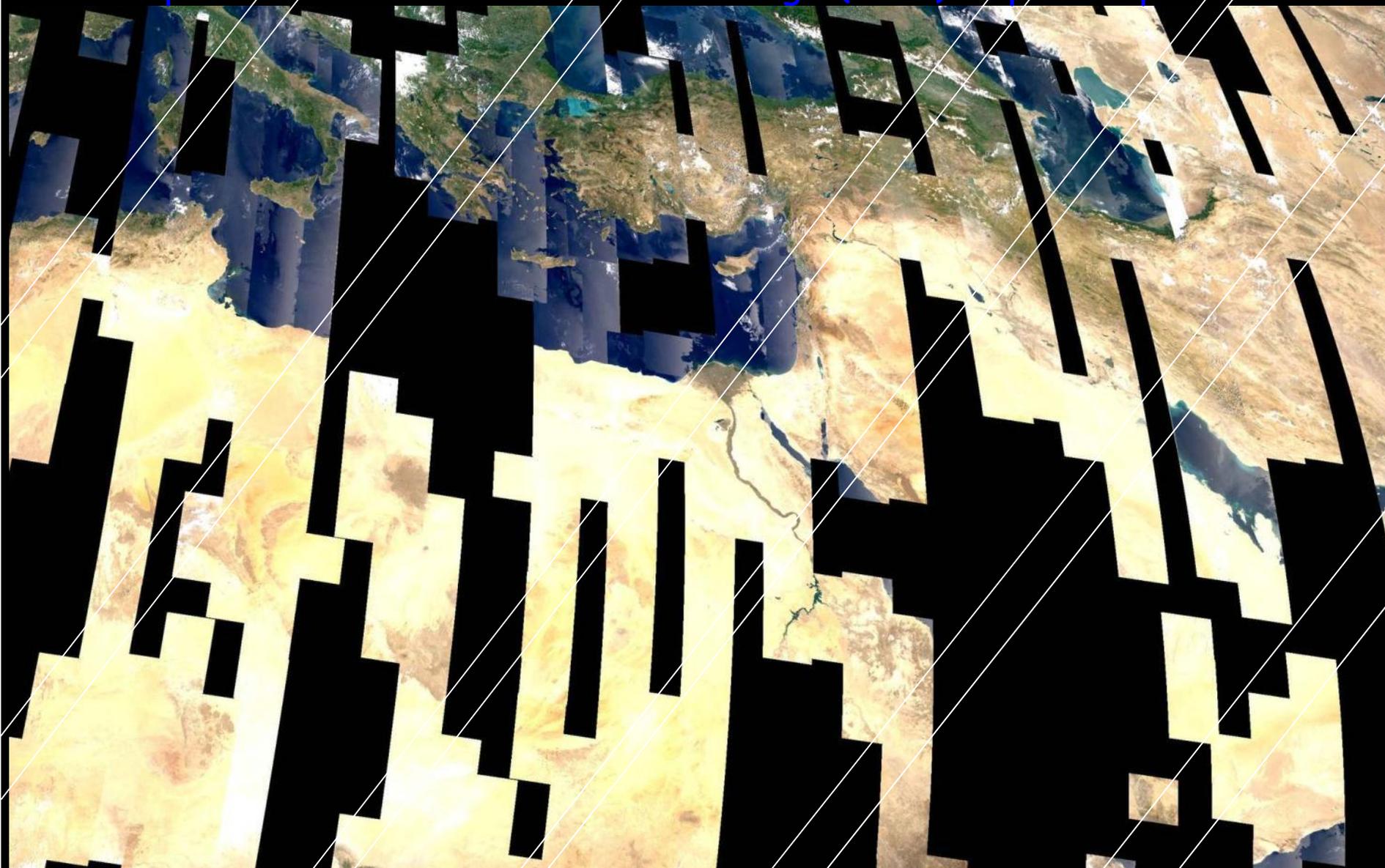
Global WELD prototype, Landsat 7 ETM+, 7300 May 2010 acquisitions,  
processed on NASA Earth Exchange (NEX) Supercomputer



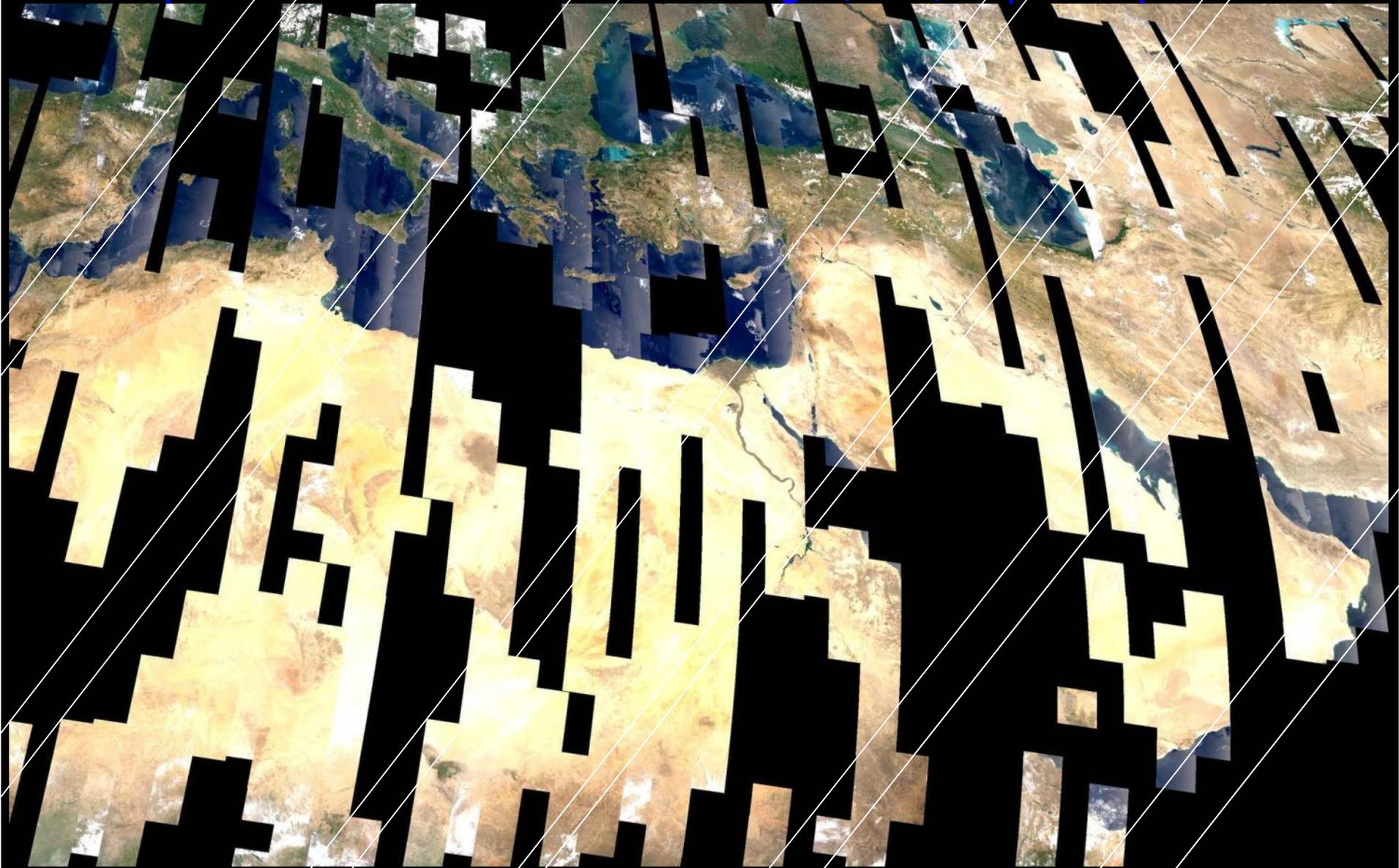
Global WELD prototype, Landsat 7 ETM+, 7300 May 2010 acquisitions,  
processed on NASA Earth Exchange (NEX) Supercomputer



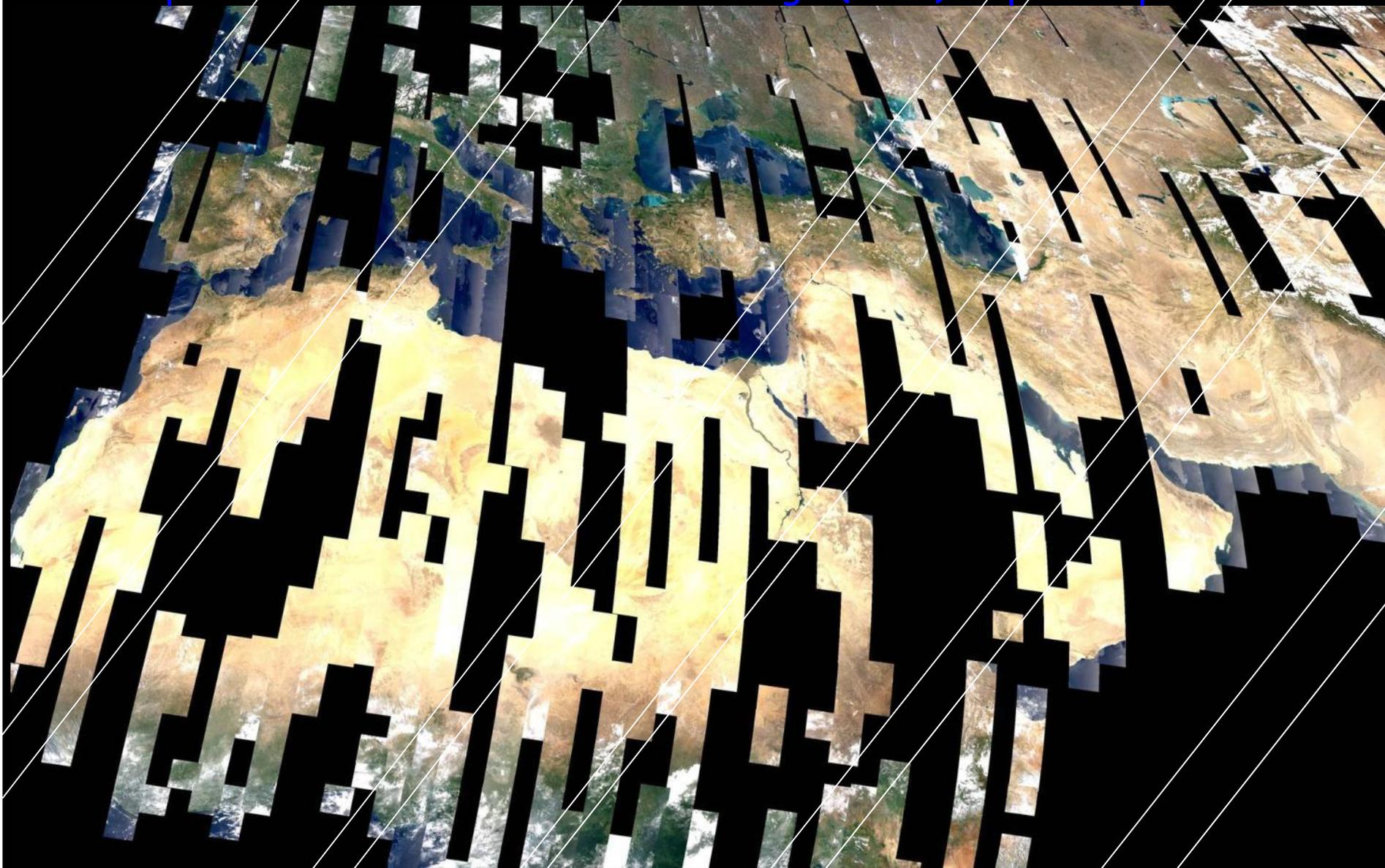
Global WELD prototype, Landsat 7 ETM+, 7300 May 2010 acquisitions,  
processed on NASA Earth Exchange (NEX) Supercomputer



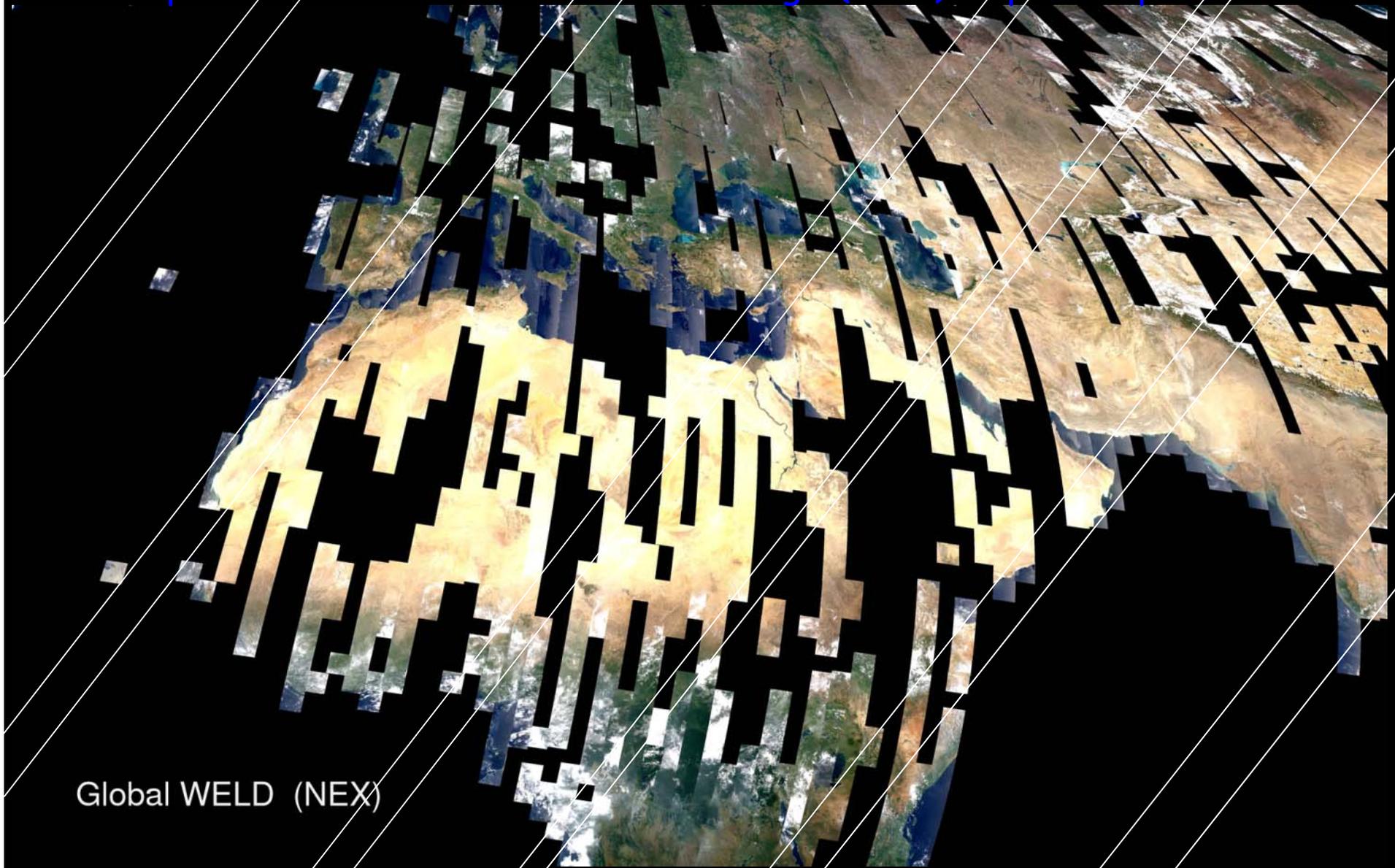
Global WELD prototype, Landsat 7 ETM+, 7300 May 2010 acquisitions,  
processed on NASA Earth Exchange (NEX) Supercomputer



Global WELD prototype, Landsat 7 ETM+, 7300 May 2010 acquisitions,  
processed on NASA Earth Exchange (NEX) Supercomputer

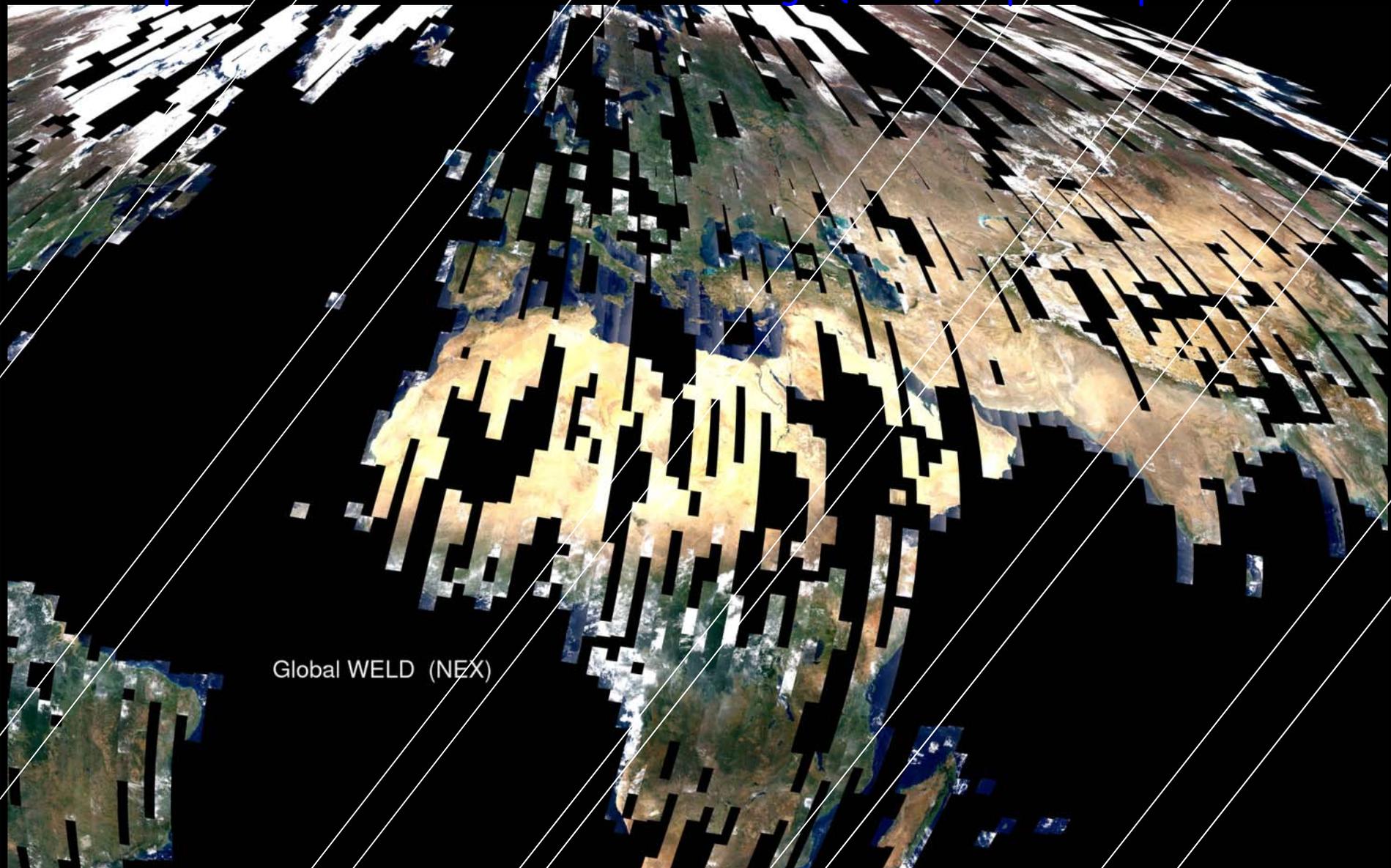


Global WELD prototype, Landsat 7 ETM+, 7300 May 2010 acquisitions,  
processed on NASA Earth Exchange (NEX) Supercomputer



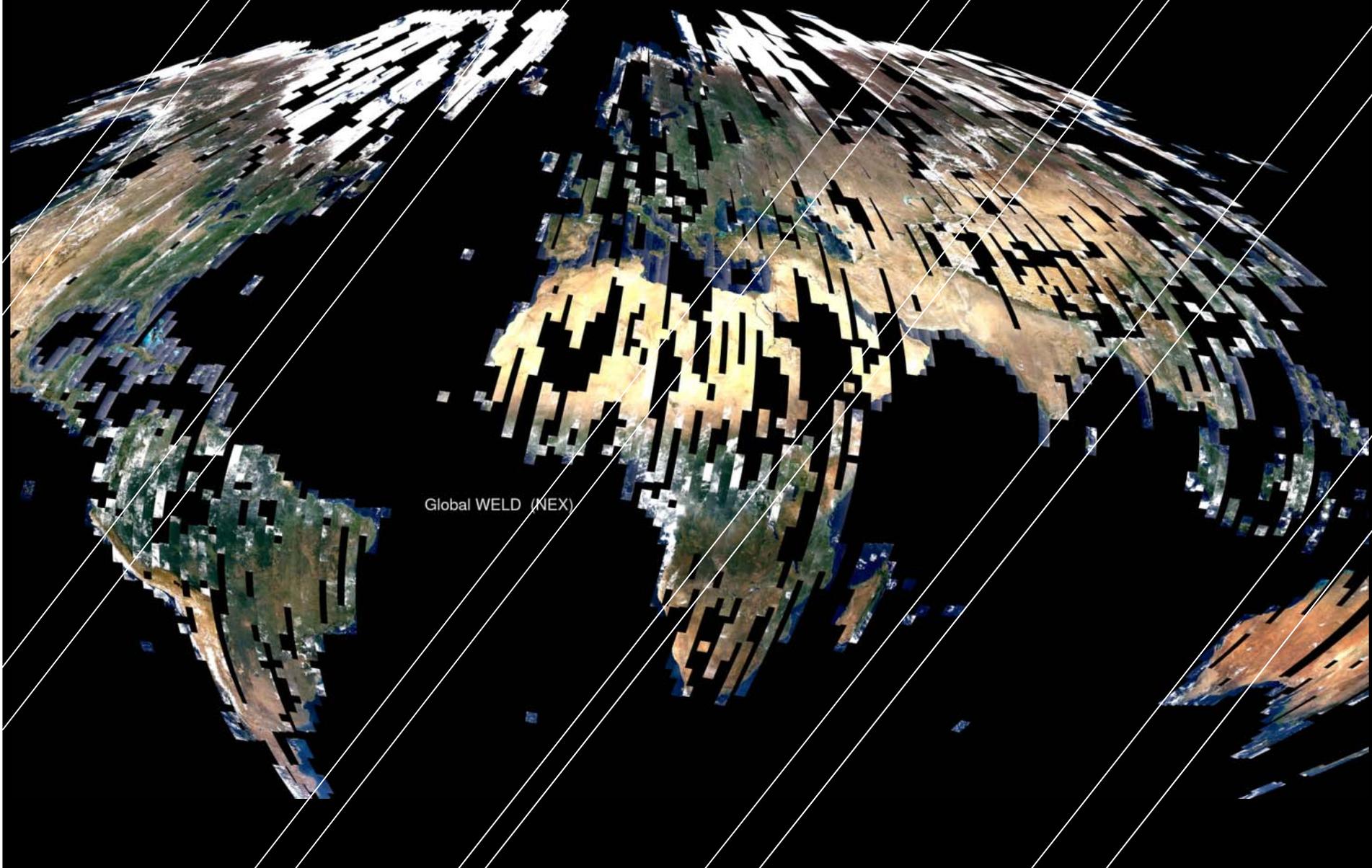
Global WELD (NEX)

Global WELD prototype, Landsat 7 ETM+, 7300 May 2010 acquisitions,  
processed on NASA Earth Exchange (NEX) Supercomputer

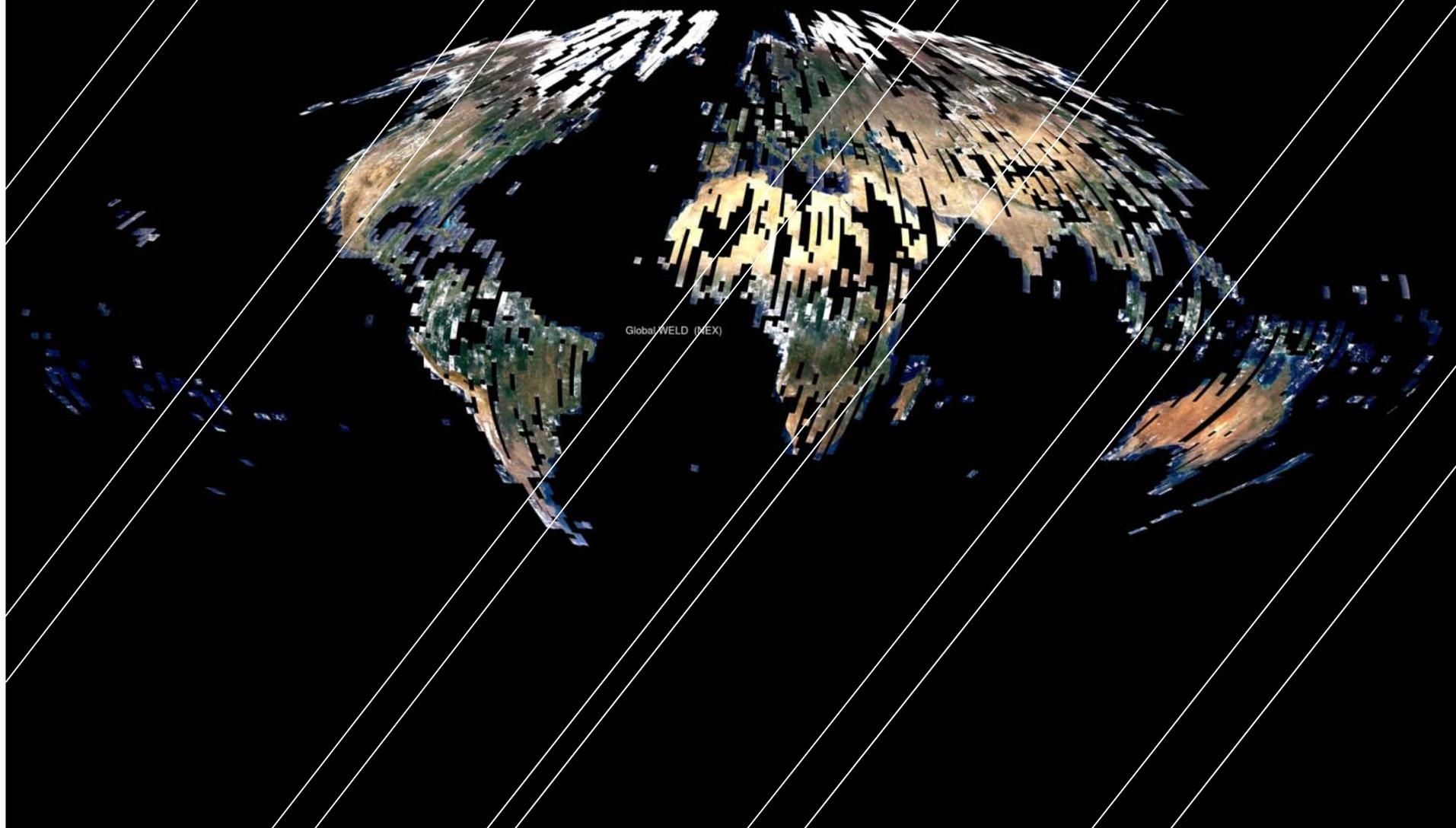


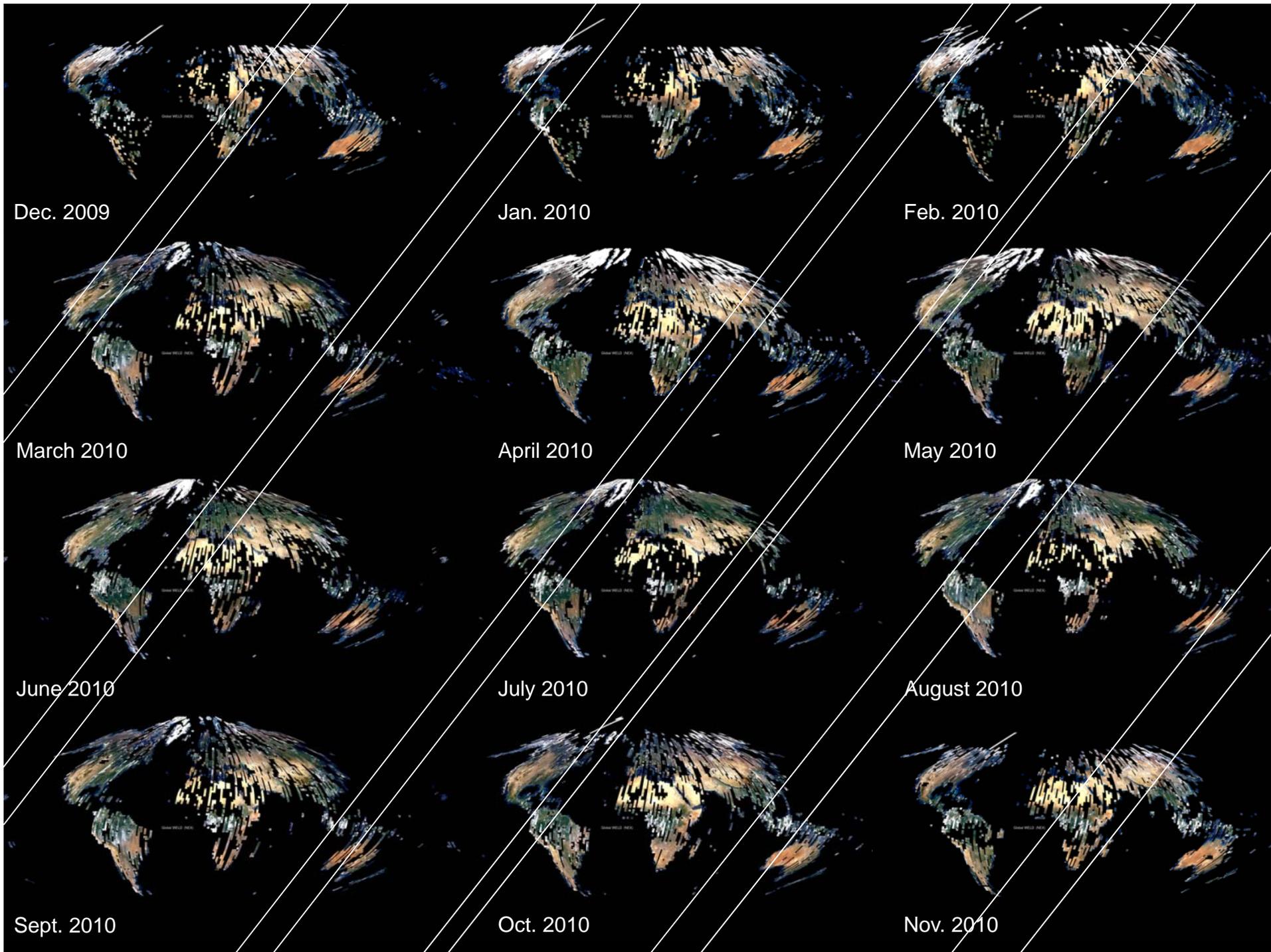
Global WELD (NEX)

Global WELD prototype, Landsat 7 ETM+, 7300 May 2010 acquisitions,  
processed on NASA Earth Exchange (NEX) Supercomputer



Global WELD prototype, Landsat 7 ETM+, 7300 May 2010 acquisitions,  
processed on NASA Earth Exchange (NEX) Supercomputer

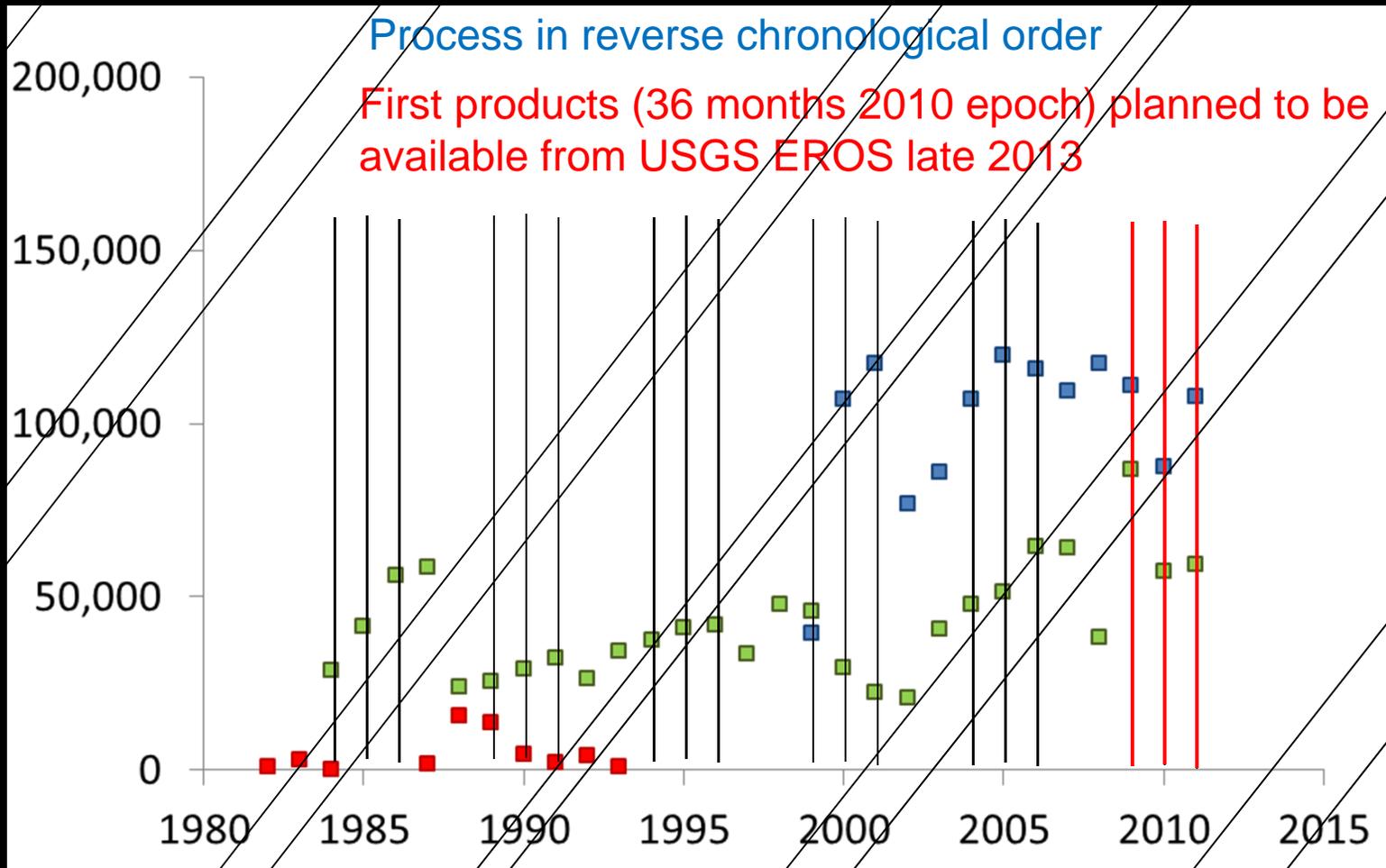




# Planned Global WELD Production on NEX

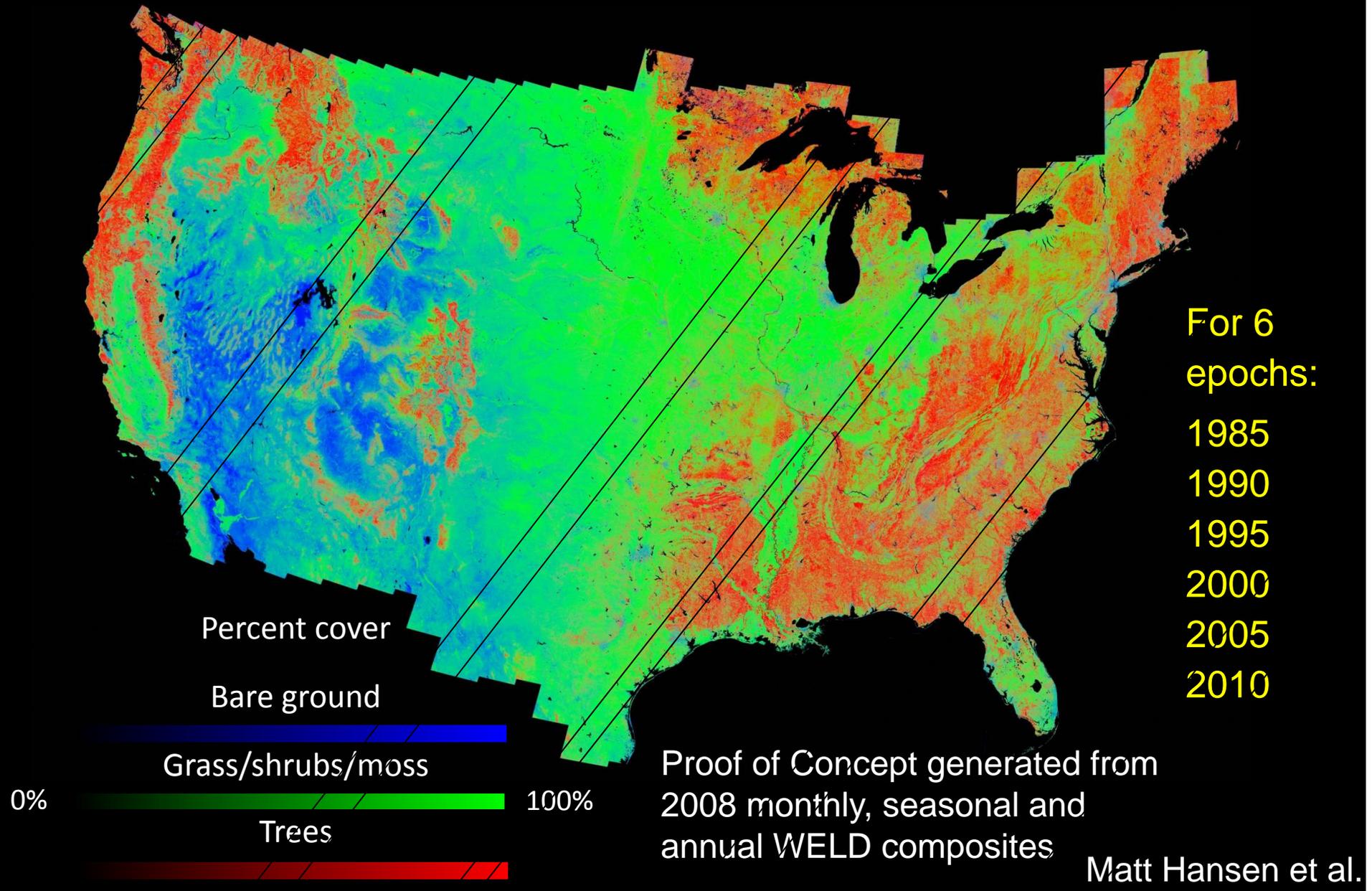
monthly 30m products, fusion of contemporaneous Landsat 4,5,7  
6 epochs of 36 months

Number of Landsat scenes in U.S. archive

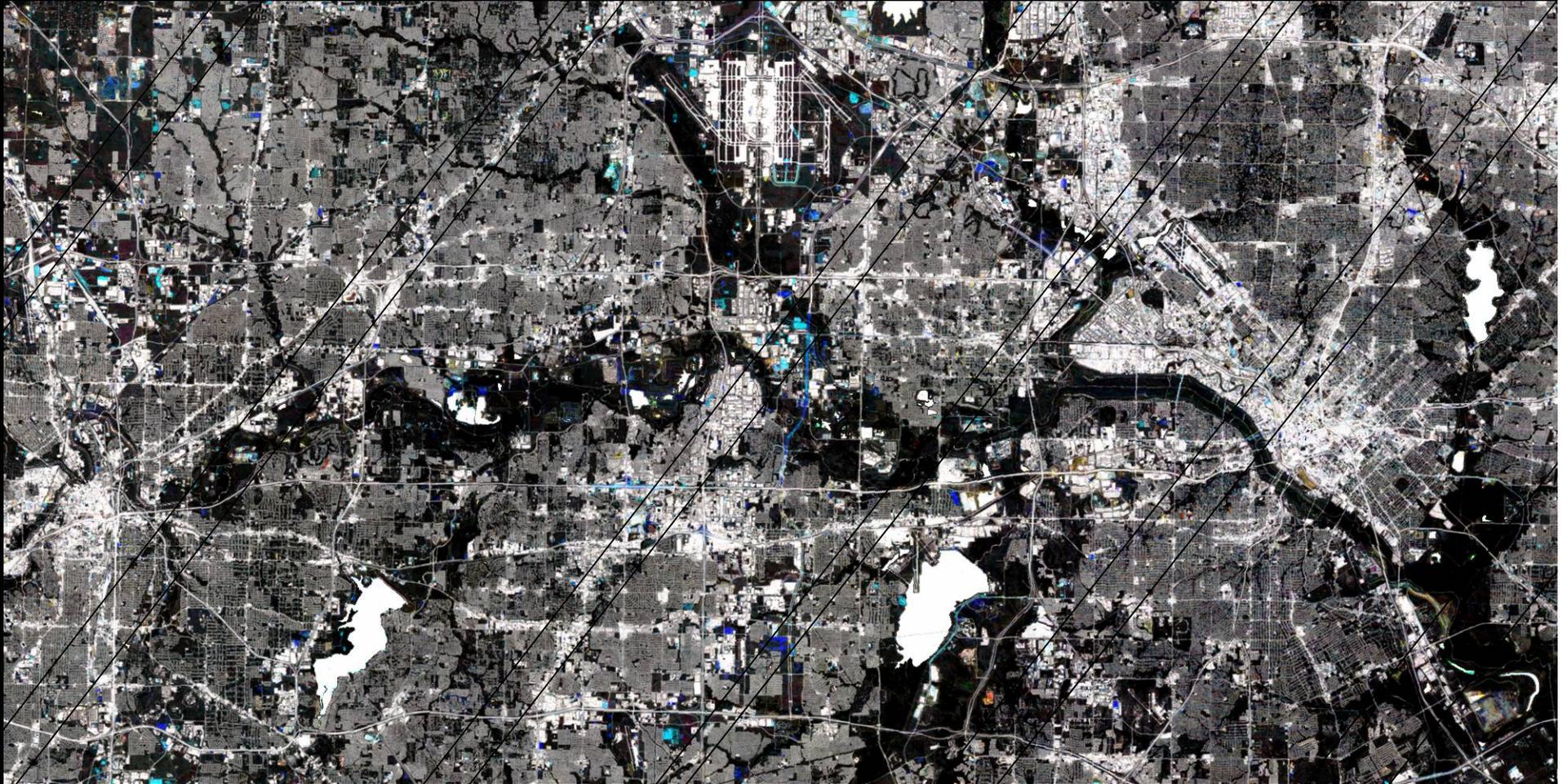


Landsat repatriation from other space agencies will provide more Landsat data in earlier epochs

# Planned Global 30m Vegetation Continuous Field Products to be generated at EROS from global 36 monthly WELD inputs



# Planned Global 30m land cover change between consecutive epochs to be generated at EROS



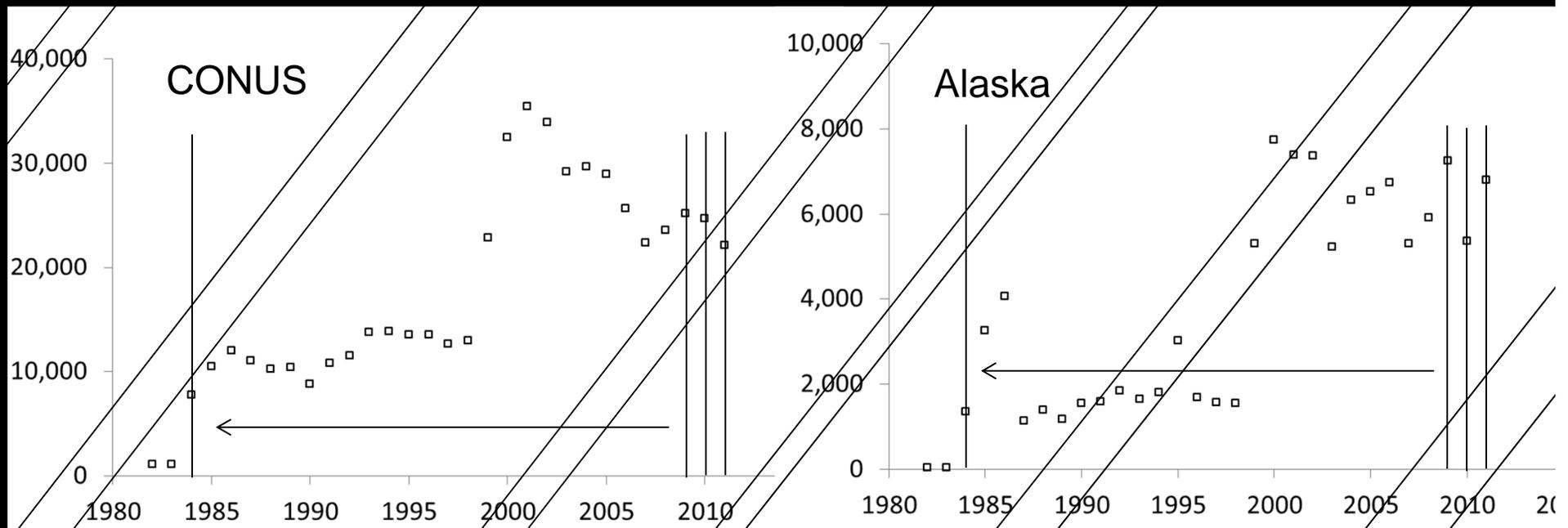
Grey-scale = no change

Blue/Cyan = increase in bare ground,

Red/Yellow = decrease in bare ground

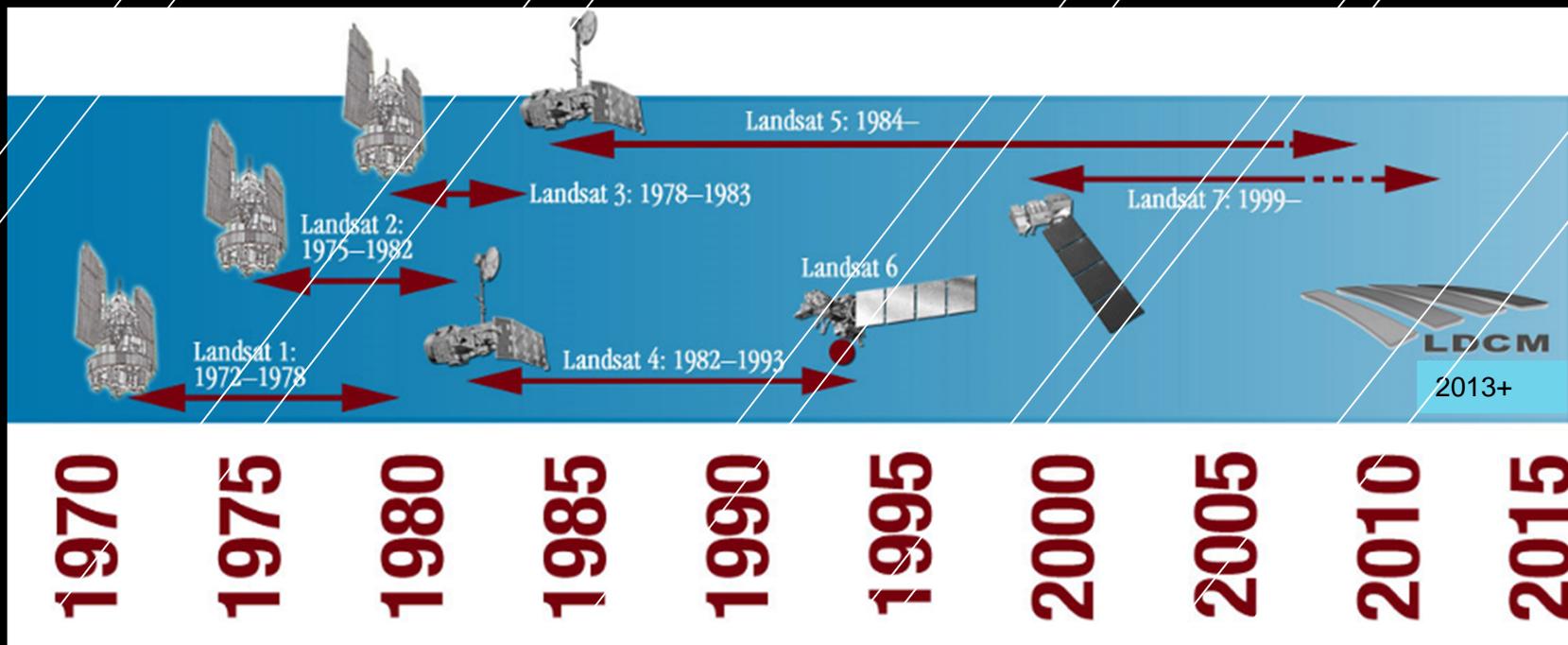
Proof of Concept 5 Years of WELD driven  
Bare Ground Change: Dallas – Fort Worth

Also, continued WELD Production at SDSU  
weekly, monthly, seasonal and annual 30m products,  
fusion of contemporaneous Landsat 4,5,7  
for every year back to 1984



# Landsat Satellite Series

The longest Land surface observation record



WELD process LDCM data  
(CONUS)



**Continuity of the Web Enabled Landsat Data (WELD)  
Product Record in the LDCM Era:  
Product Data Processing, Evaluation and Distribution Strategies**

Funded by *U.S. Department of Interior, U.S. Geological Survey,  
Solicitation G11PS00422*

**Principal Investigator:**

David Roy

Geographic Information Science Center of Excellence,  
South Dakota State University  
Brookings, SD 57007

**CO-Investigators**

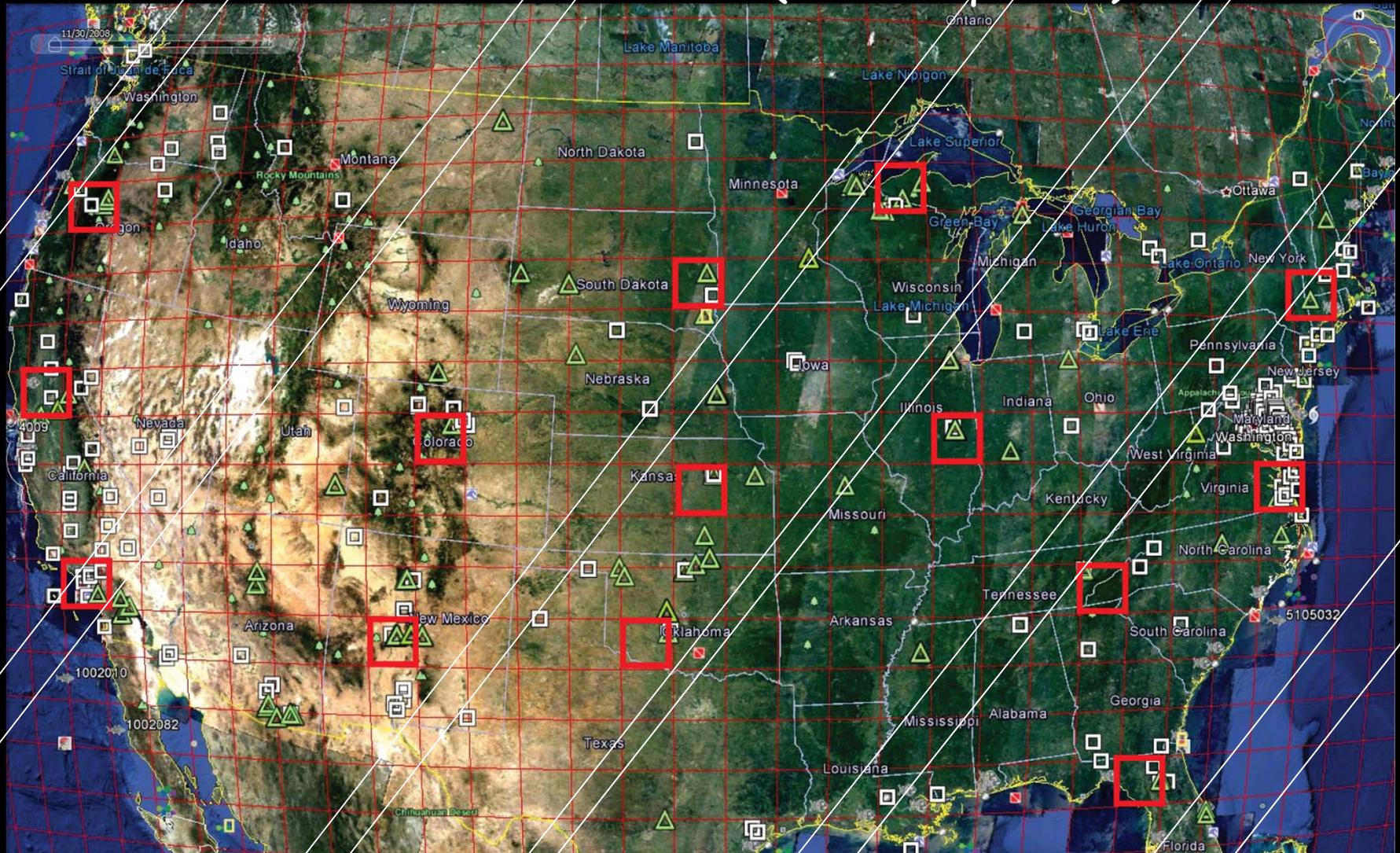
Val Kovalskyy and Indu Kommareddy  
Geographic Information Science Center of Excellence,  
South Dakota State University  
Brookings, SD 57007

**\$1.1 million  
5 years, Fall 2012+**

# 4 WELD LDCM Tasks - Investigate

1. WELD product continuity into the LDCM era
    - generation of WELD LDCM products
  2. WELD LDCM product performance
    - quality assessment
    - validation
    - characterization of the consistency of the WELD TM, ETM+, LDCM product time series
  3. The utility of the WELD product record to develop “higher-level” derived products
    - collaboration with Sci. Team, NASA & USGS staff, academia
1. Expansion of the WELD internet product distribution interface to support WELD LDCM products

**WELD LDCM Prototyping** 14 WELD 5000 x 5000 30m pixel tiles (red), that encompass Ameriflux towers (green triangles) and AERONET sites (white squares)



Screen shot of a Google Earth rendering of OGC WMS compliant 2009 CONUS annual WELD true color browse

# WELD LDCM Schedule

- Year 1

- understand the LDCM L1T format
- QA of the first light LDCM L1T data
- secure the L1T data flow to SDSU
- WELD LDCM algorithms: reflectance and brightness temperature, band saturation, NDVI

- Year 2

- WELD LDCM algorithms: cloud masks, angular geometry computation, re-projection, resampling and tiling, compositing, radiometric/BRDF normalization
- WELD product QA
- make products available to the science team and affiliates for evaluation
- refine algorithms and products as needed

# WELD LDCM Schedule

- Year 3

- generate one year of CONUS WELD LDCM products
- make products and browse imagery available
- undertake QA and any needed refinements

- Year 4

- validate products
- characterize the Landsat TM, ETM+ LDCM WELD product time series
- generate 4+ years of 14 tiles of WELD products available for assessment of their utility for development of “higher-level” products
- develop WELD LDCM internet distribution interface

- Year 5

- assess the capability for expansion globally/institutionalization

# WELD Projects Metrics of Success

- Science relevant long-term consistent 30m global WELD products 1984-2017
  - demonstrably used for climate – people - environment research
- Provision of simple, intuitive and elegant internet product distribution interface
  - high user statistics
  - copied by other agencies and other DAACs
- Operationalization
  - Integration of WELD-like capability into an operational Landsat higher-level product generation system at a Federal agency
    - near-real time Landsat monitoring/change detection capability
    - OGC or similar web compliant imagery and product distribution for burgeoning commercial sector