The view from on-orbit –
New challenges and opportunities in Earth observation and satellite remote sensing

June 14, 2009

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Acknowledgments

Mark Friedl, Allan Strahler (Boston U.)

Chris Small (Columbia U.)

Will Turner (Conservation International)

Ben Tuttle (NOAA)

Budhu Bhaduri, Eddie Bright, Neal Feierabend (Oak Ridge National Lab)

Solly Angel, Tom Espenshade, Kosuke Imai, Doug Massey, Burt Singer, David Wilcove (Princeton U.)

Wayne Appleton, Chang Chung, Jennifer Curatola, Bill Guthe, Dawn Koffman, Wangyal Shawa, Henry Umansky (Princeton U. and OPR IT/Programming Support)

Mark Montgomery (Stony Brook U.)

Dan Civco, Jason Parent (U. of Connecticut)

Erle Ellis (U. of Maryland-Baltimore County)

Mutlu Ozdogan, Annemarie Schneider (U. of Wisconsin-Madison)

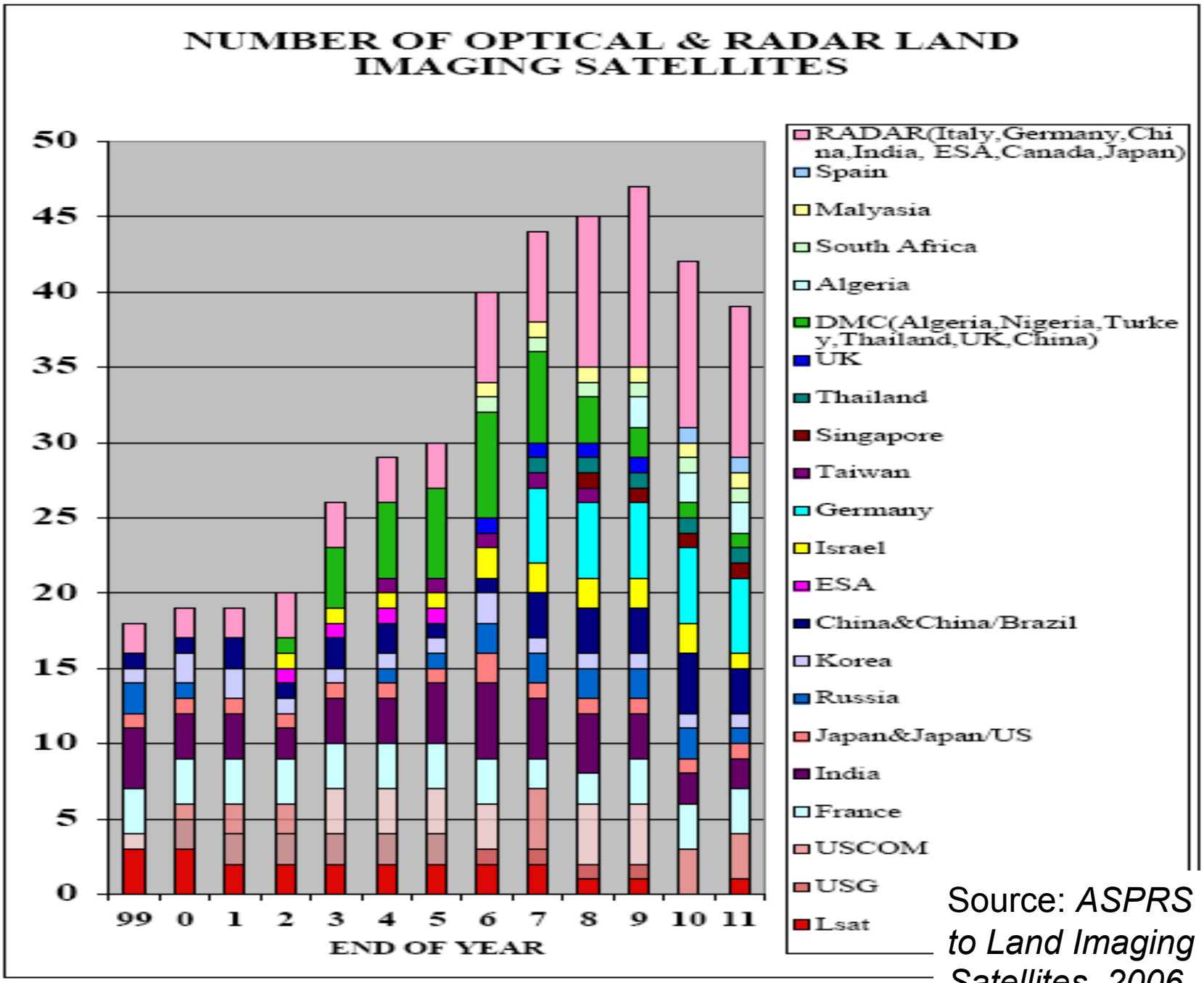
Alessandro Baccini (Woods Hole Oceanographic Inst.)

Group on Earth Observations - Member Countries

55 Members of GEO + EC

05.03.05

Sources:
Map - ESRI
Members - http://earthobservations.org
Design - Ministry of Environment, Israel



Source: *ASPRS Guide to Land Imaging Satellites, 2006.*

Four Frontiers of Earth Observation

Spatial Resolution

Spectral Resolution

Temporal Resolution

New Sensors


N
Image © 2009 TerraMetrics
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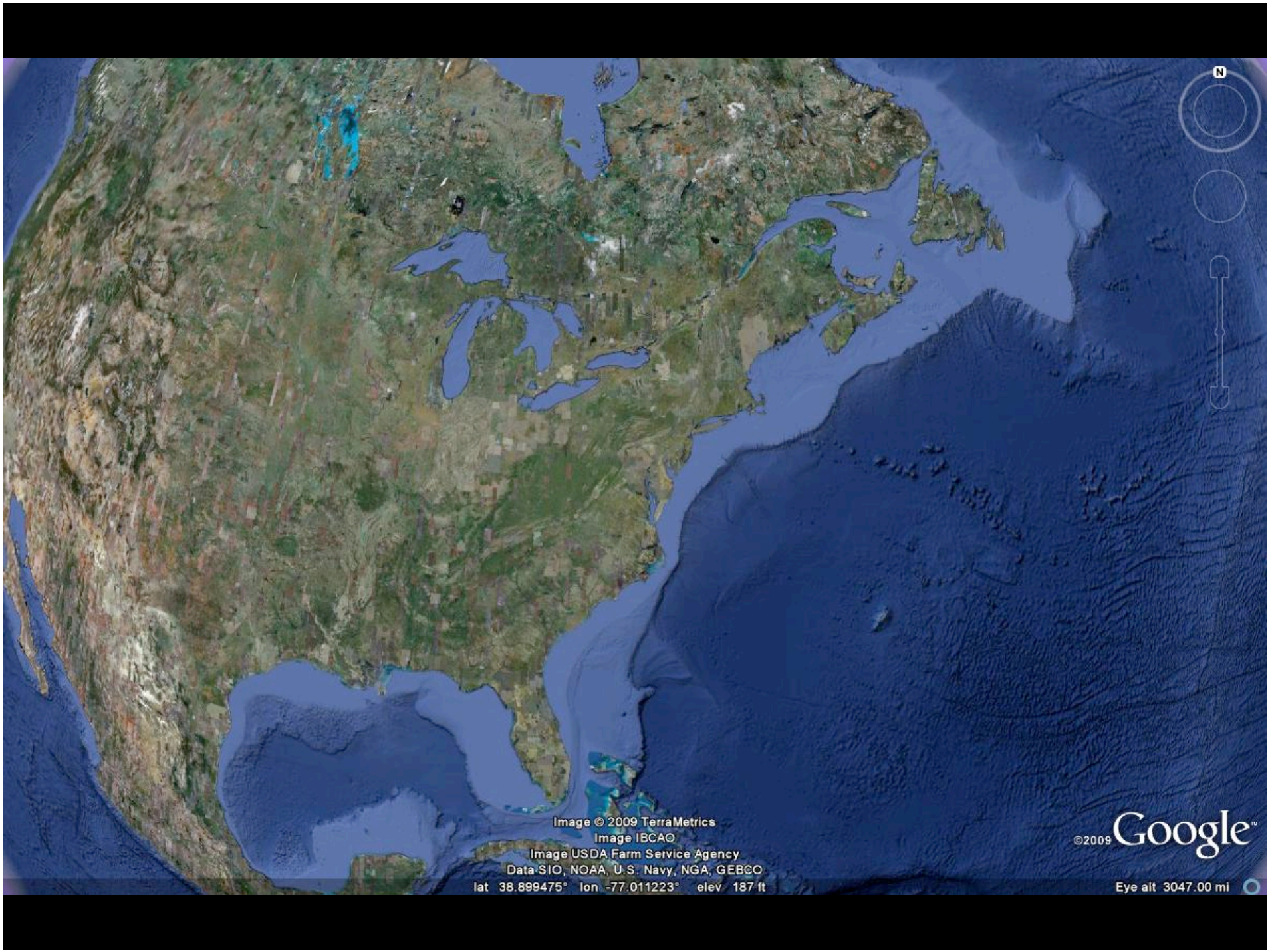
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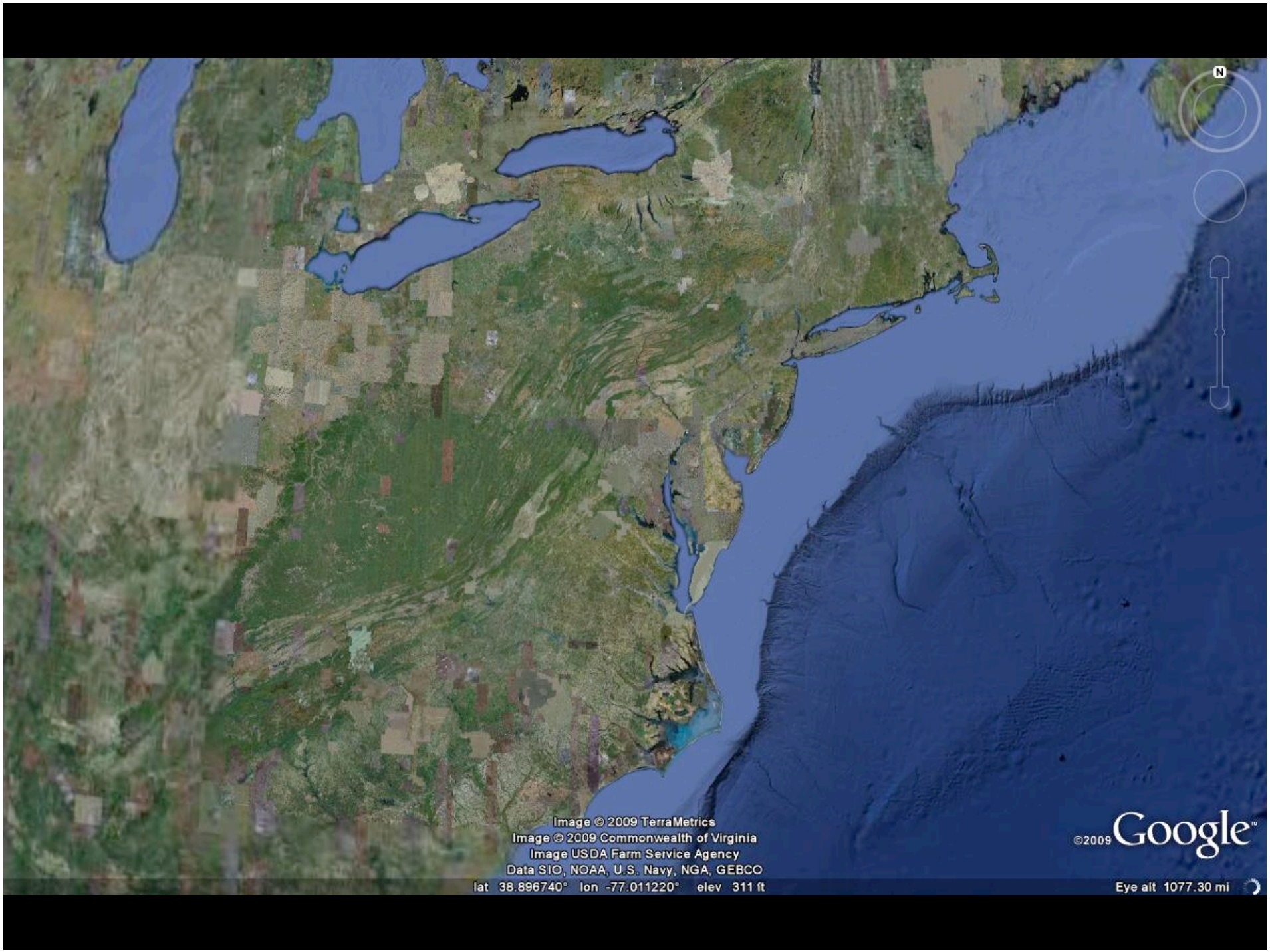
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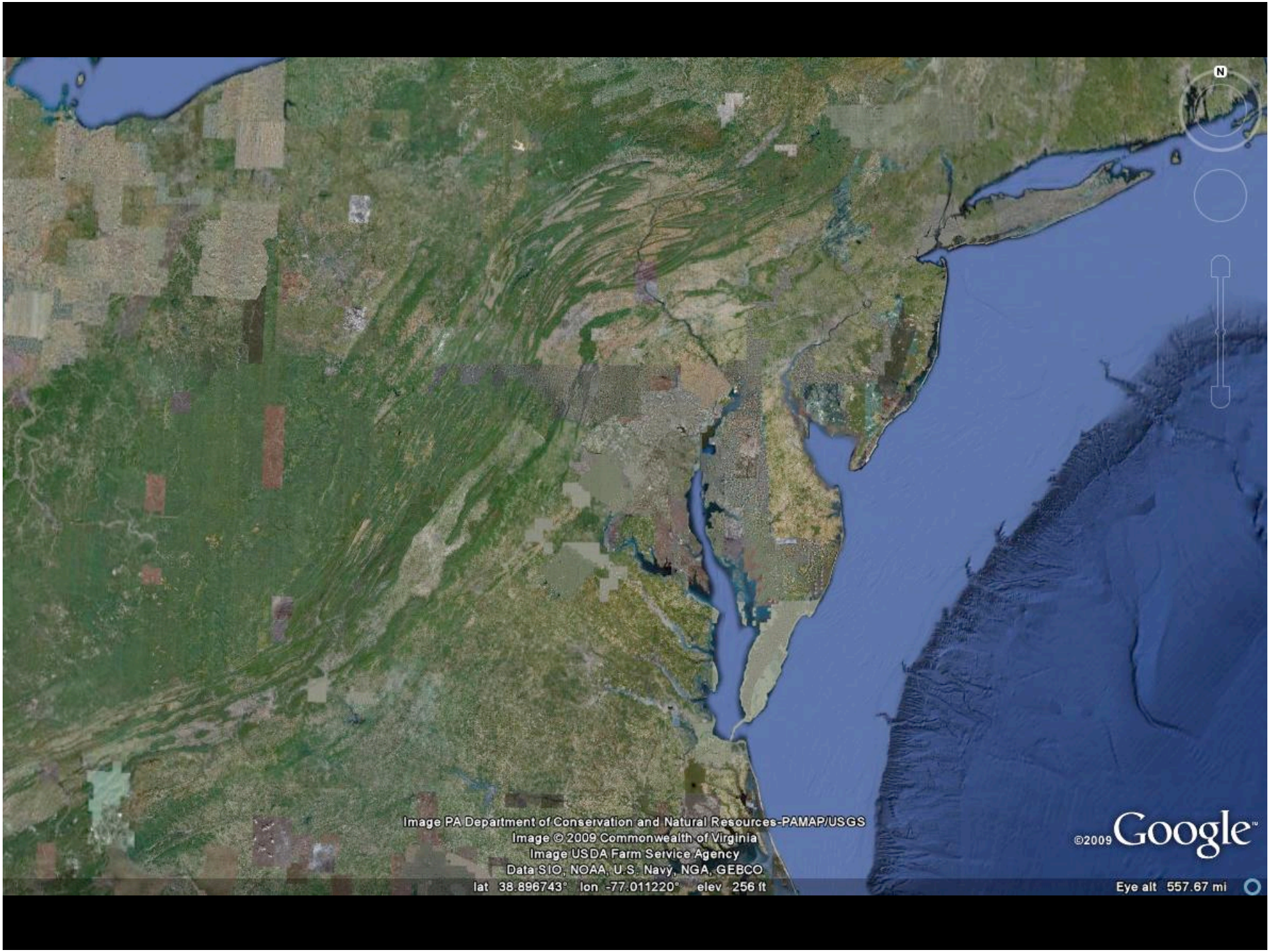
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Eye alt 557.67 mi


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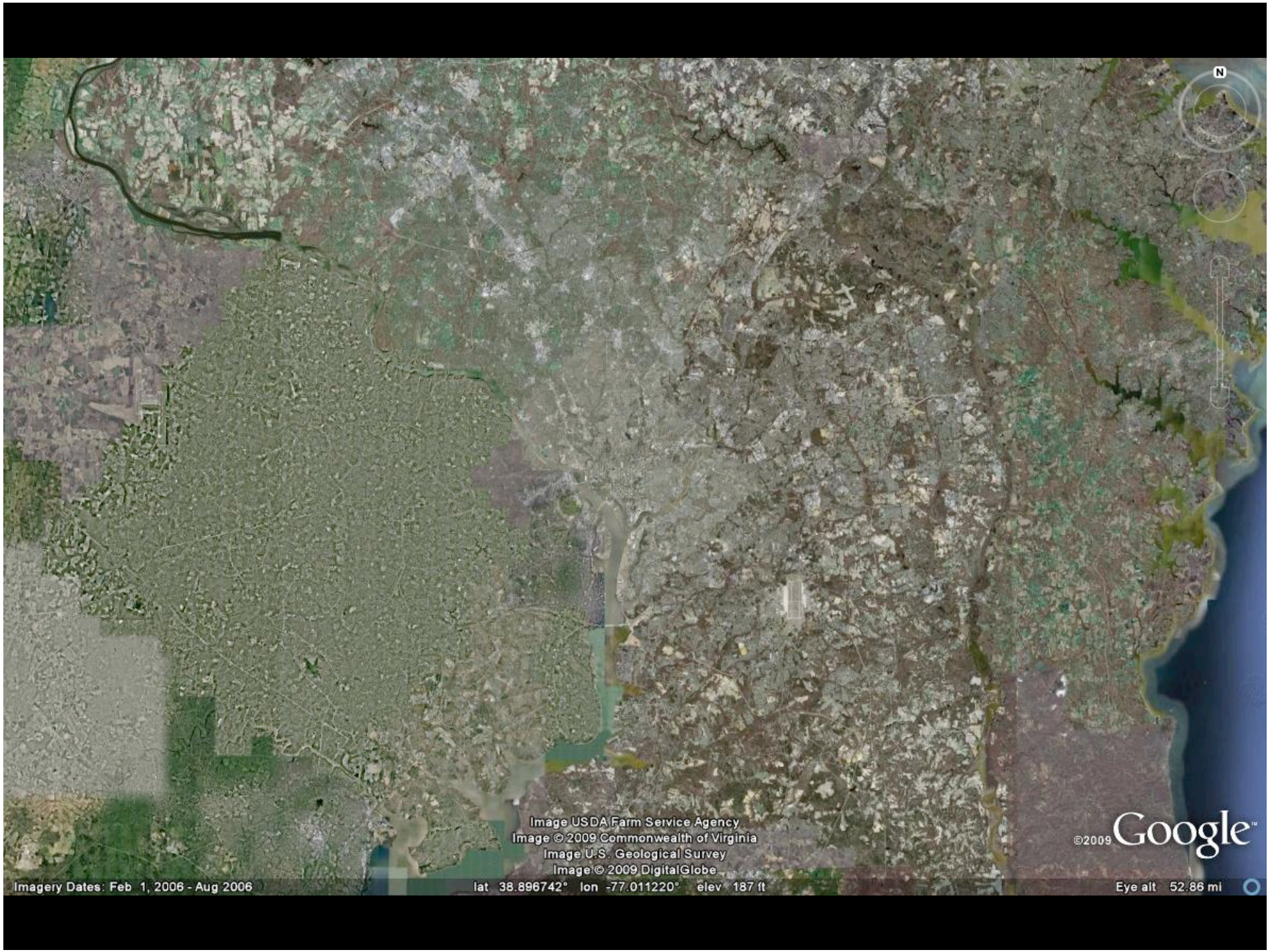
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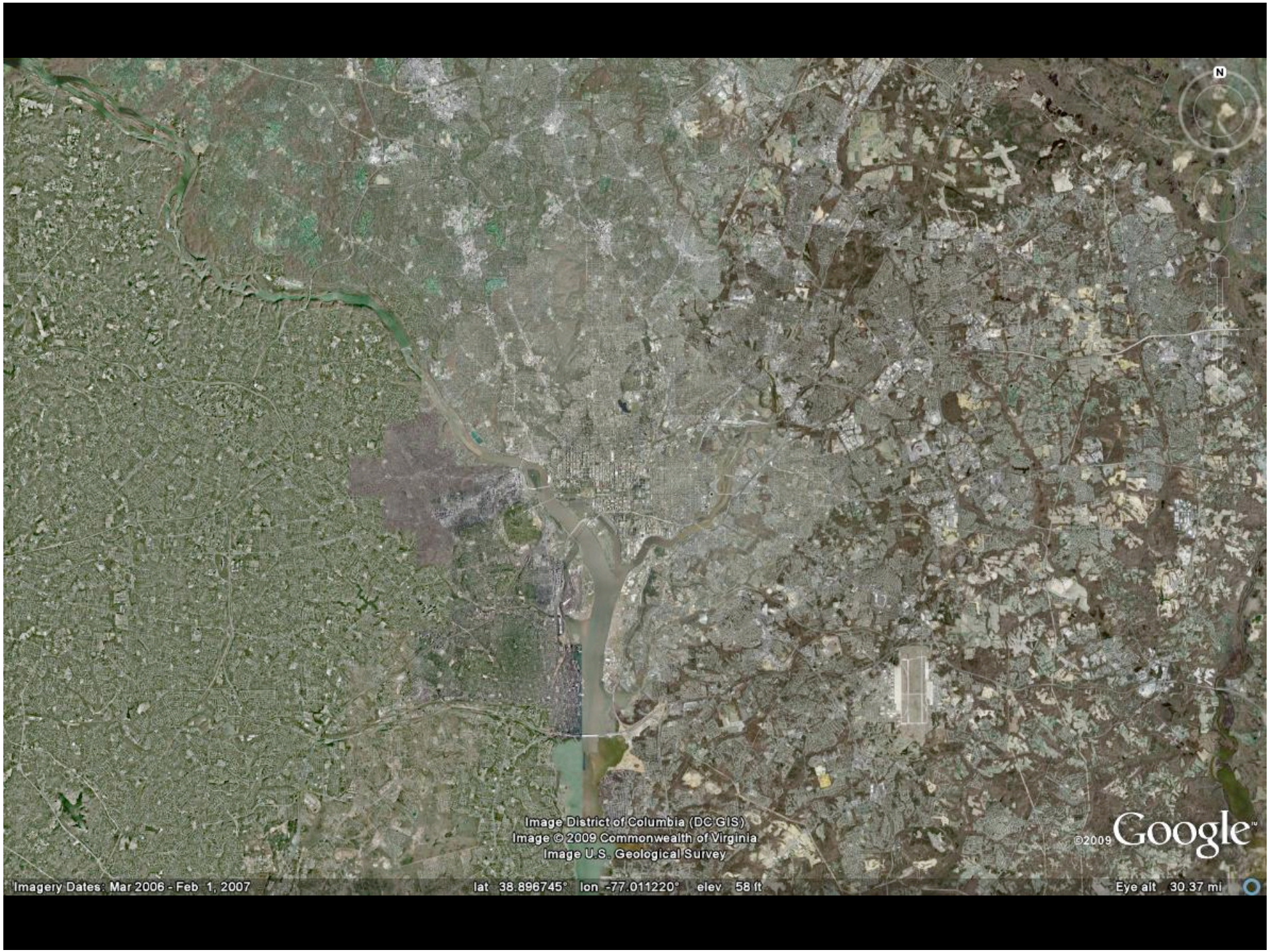
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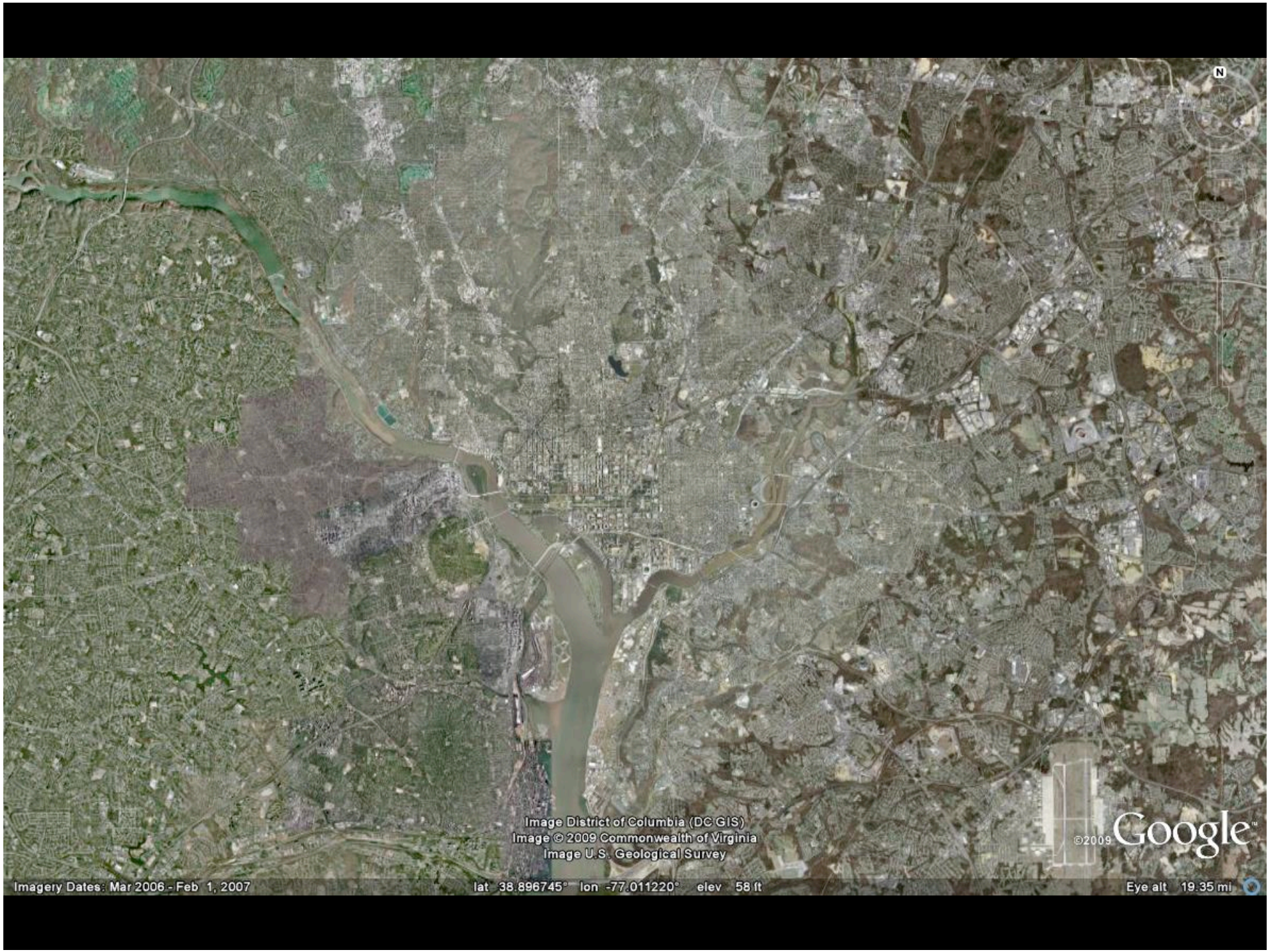
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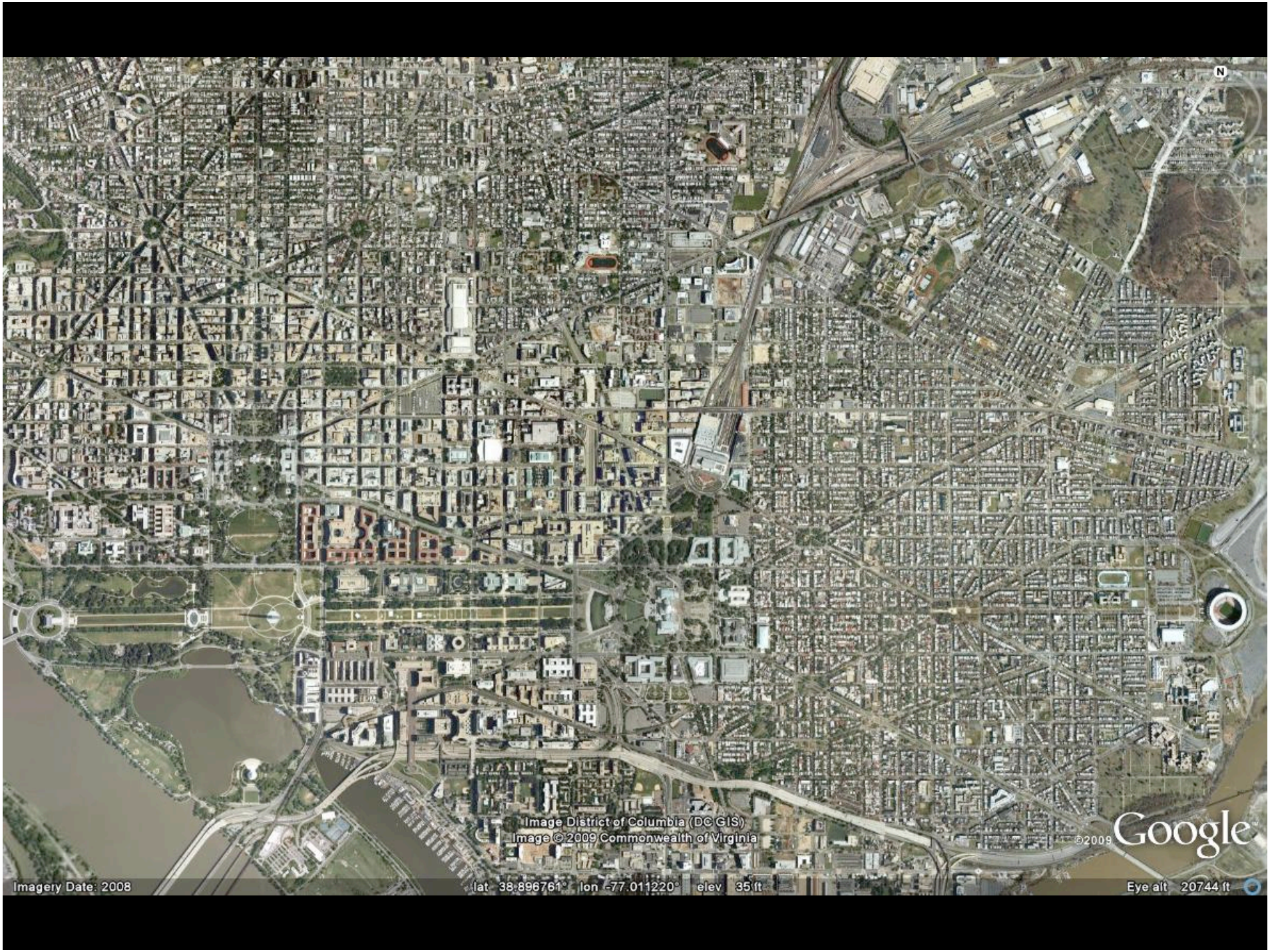
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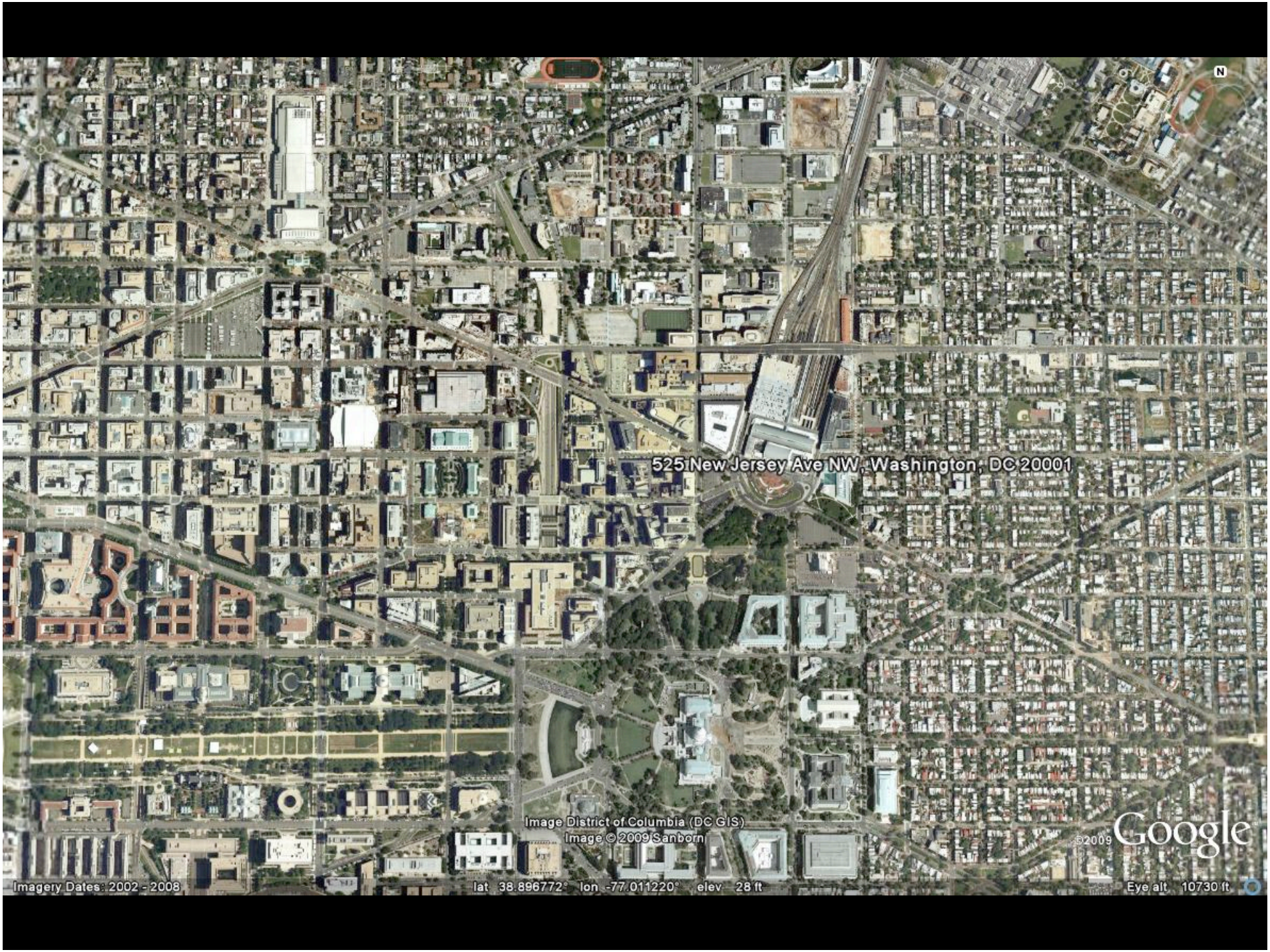
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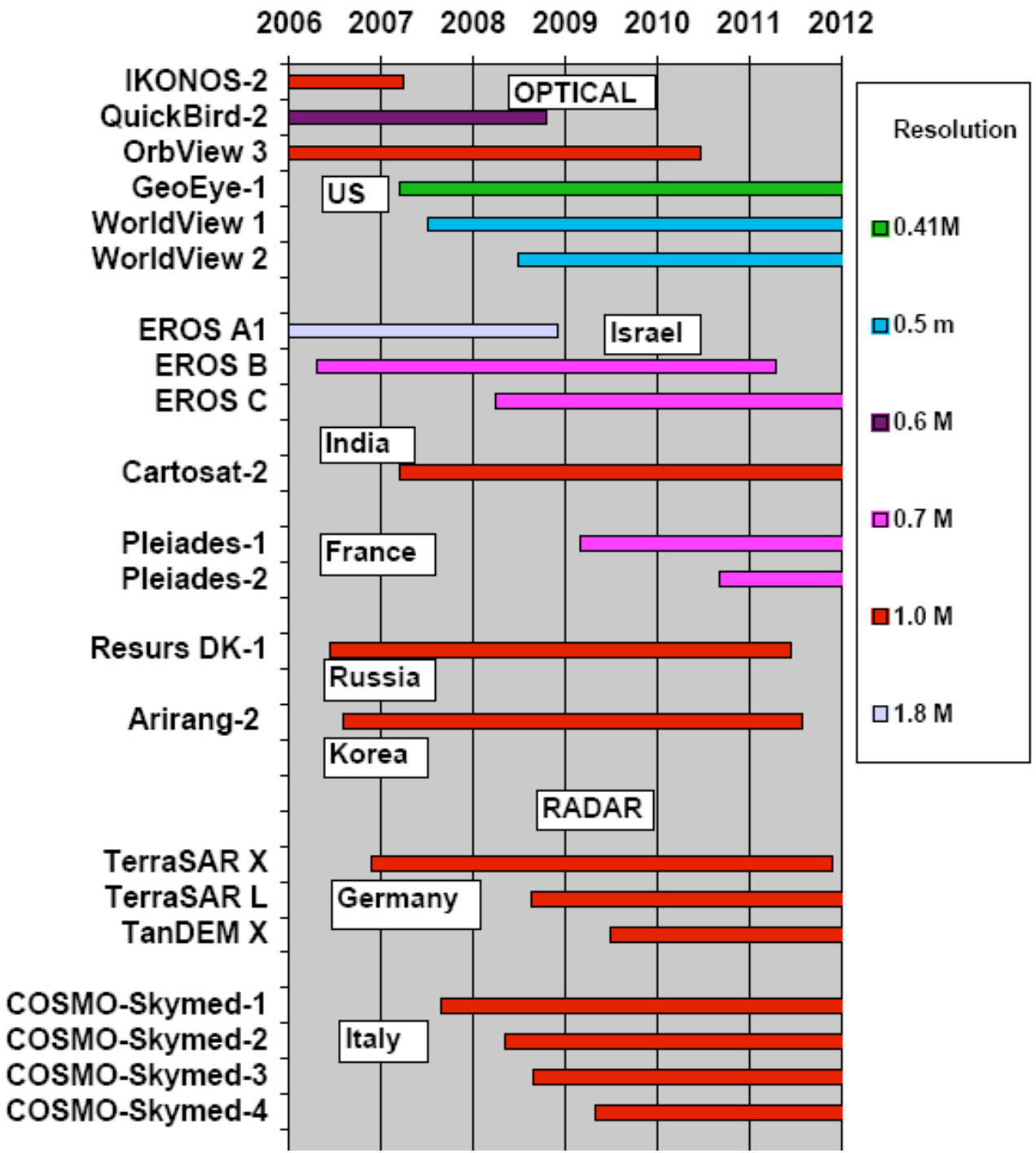
High Spatial Resolution Satellites



Source: *ASPRS Guide to Land Imaging Satellites, 2006.*

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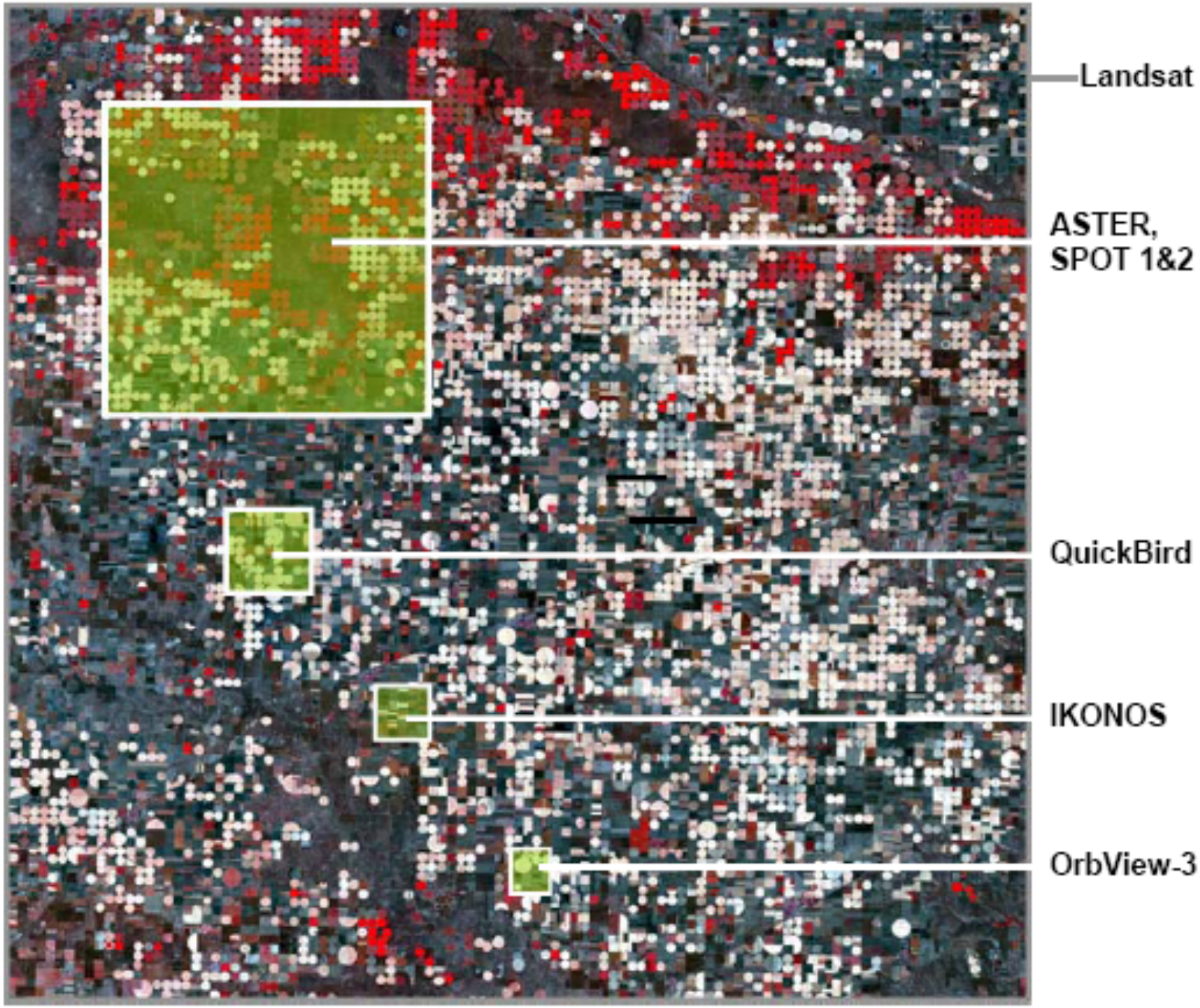
Temporal Resolution

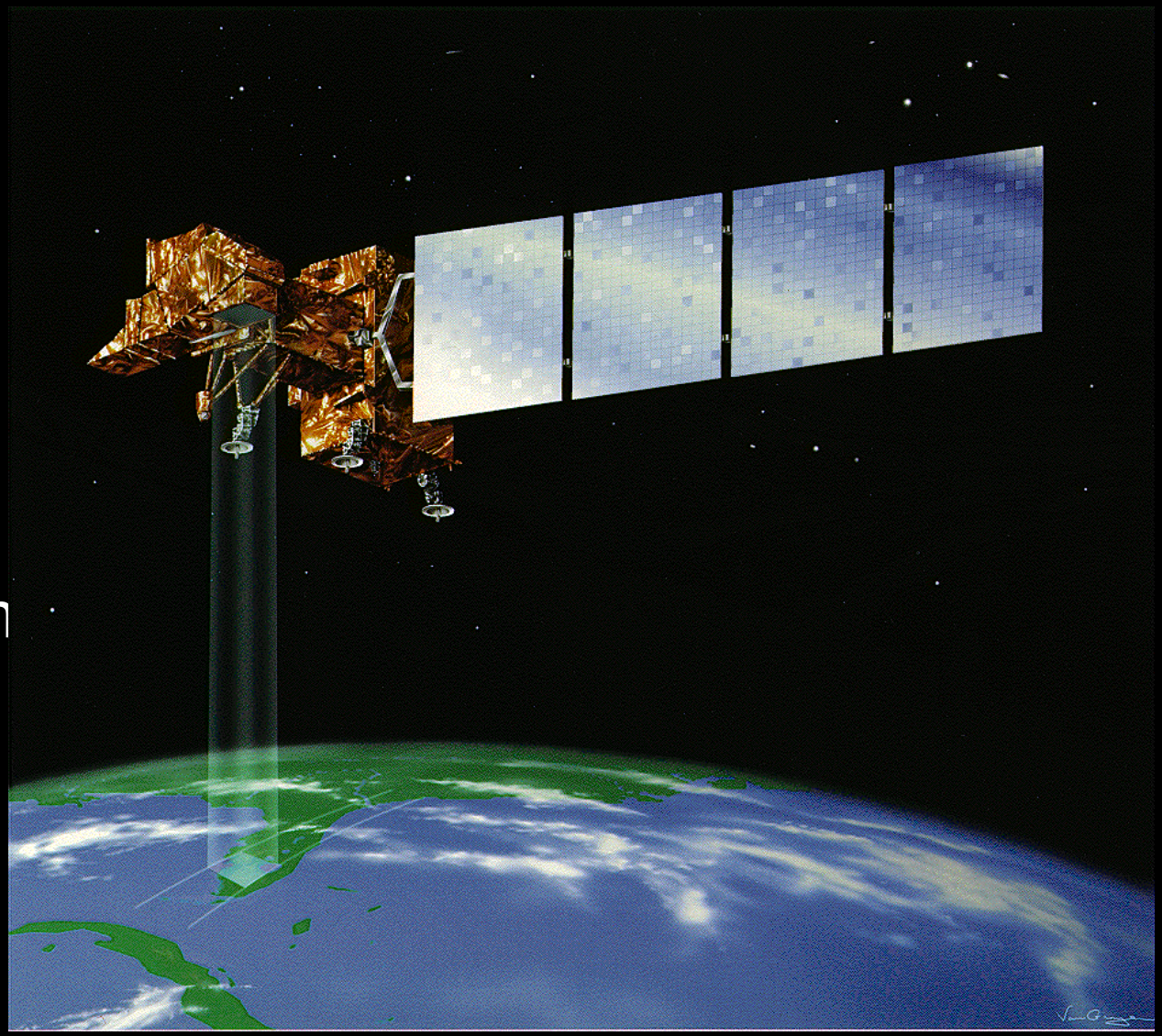
New Sensors


Landsat
ASTER,
SPOT 1&2
QuickBird
IKONOS
OrbView-3

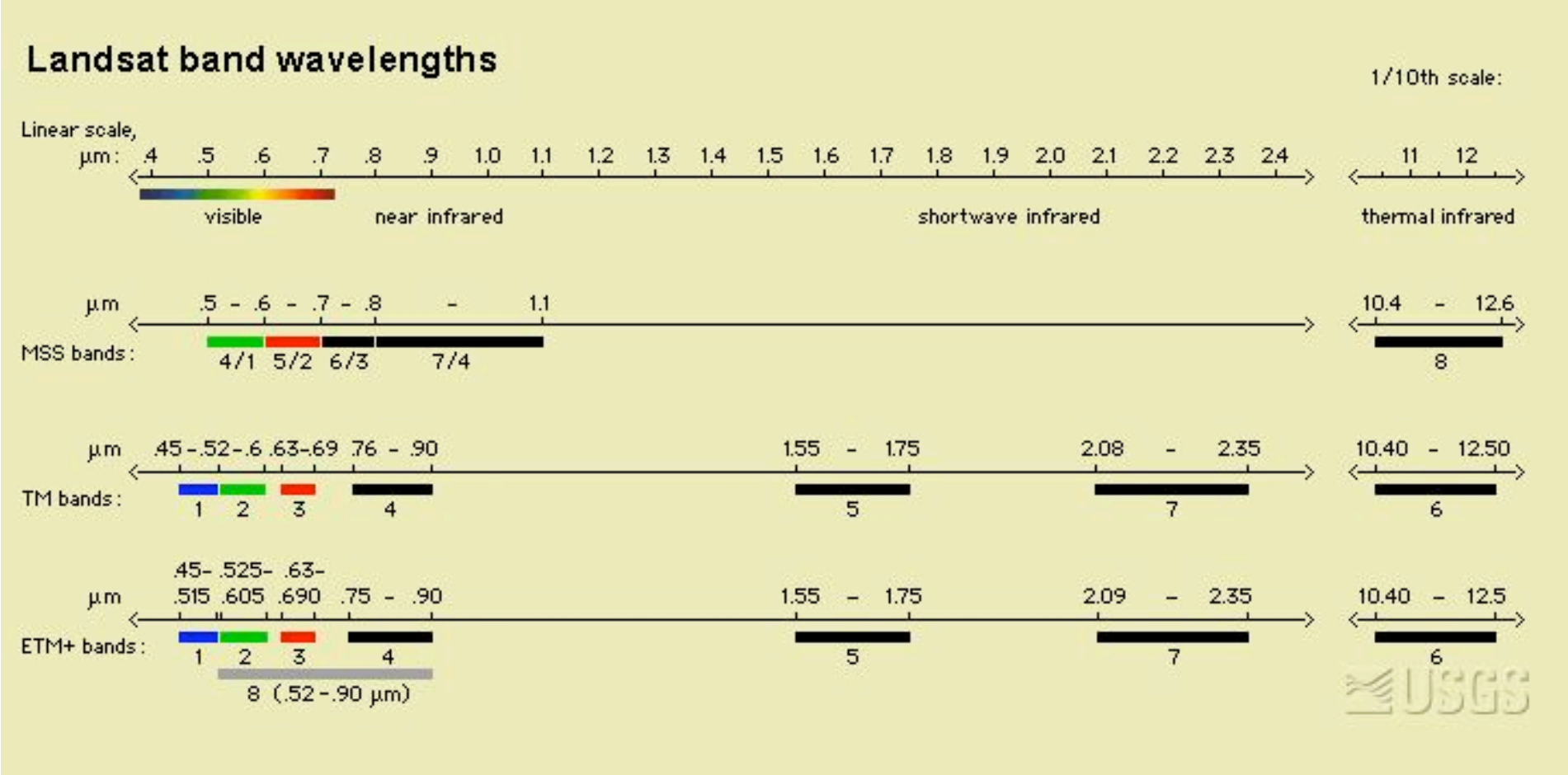
Landsat Series Primer

Polar Orbit
5000 lbs
700 km
6.8 km/sec
(15,212 mph)

Spatial Res. ~
60m, 30m, 15m
Spectral ~
8 bands
Temporal ~
16 day repeat

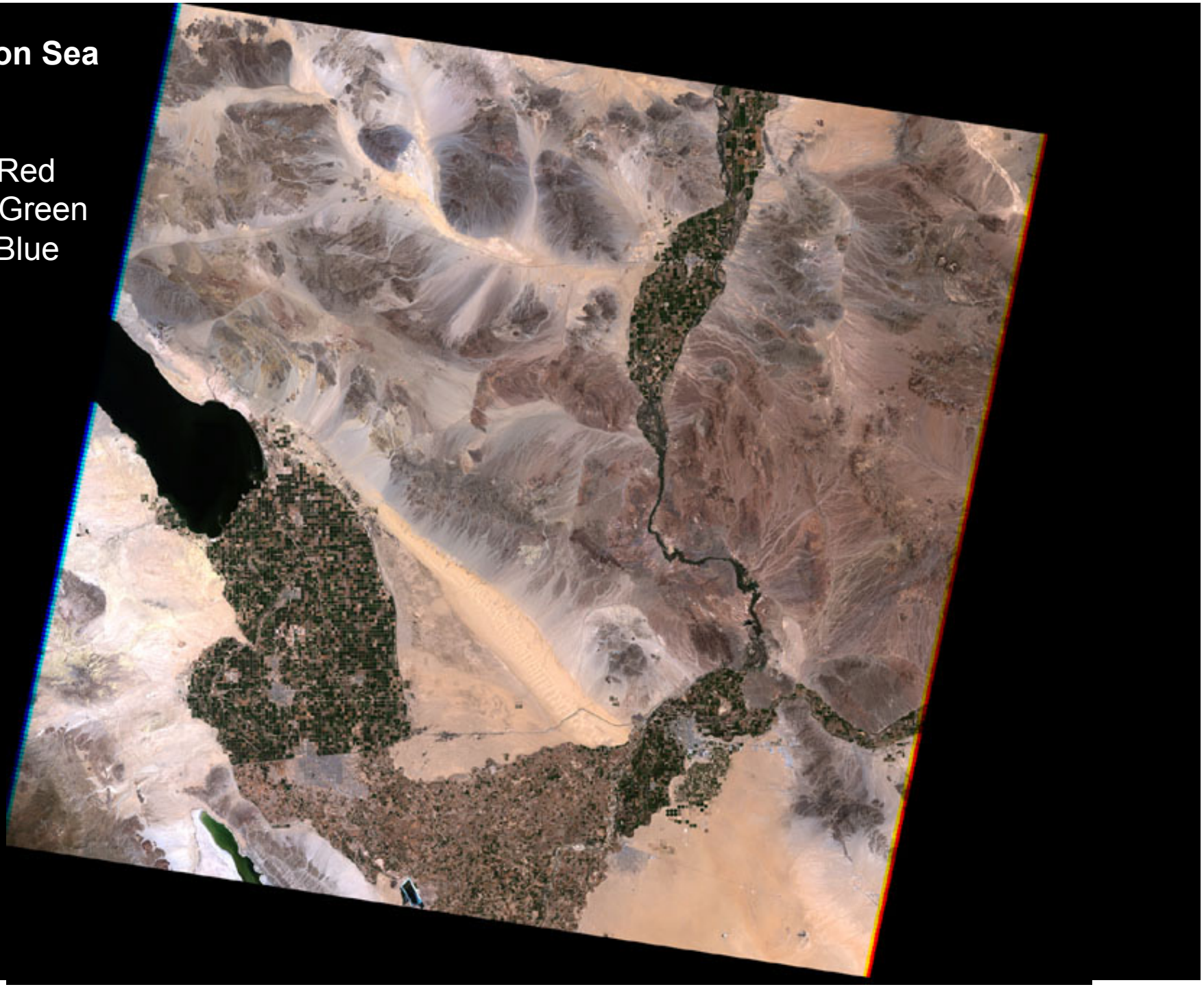


Where are the 7 bands?



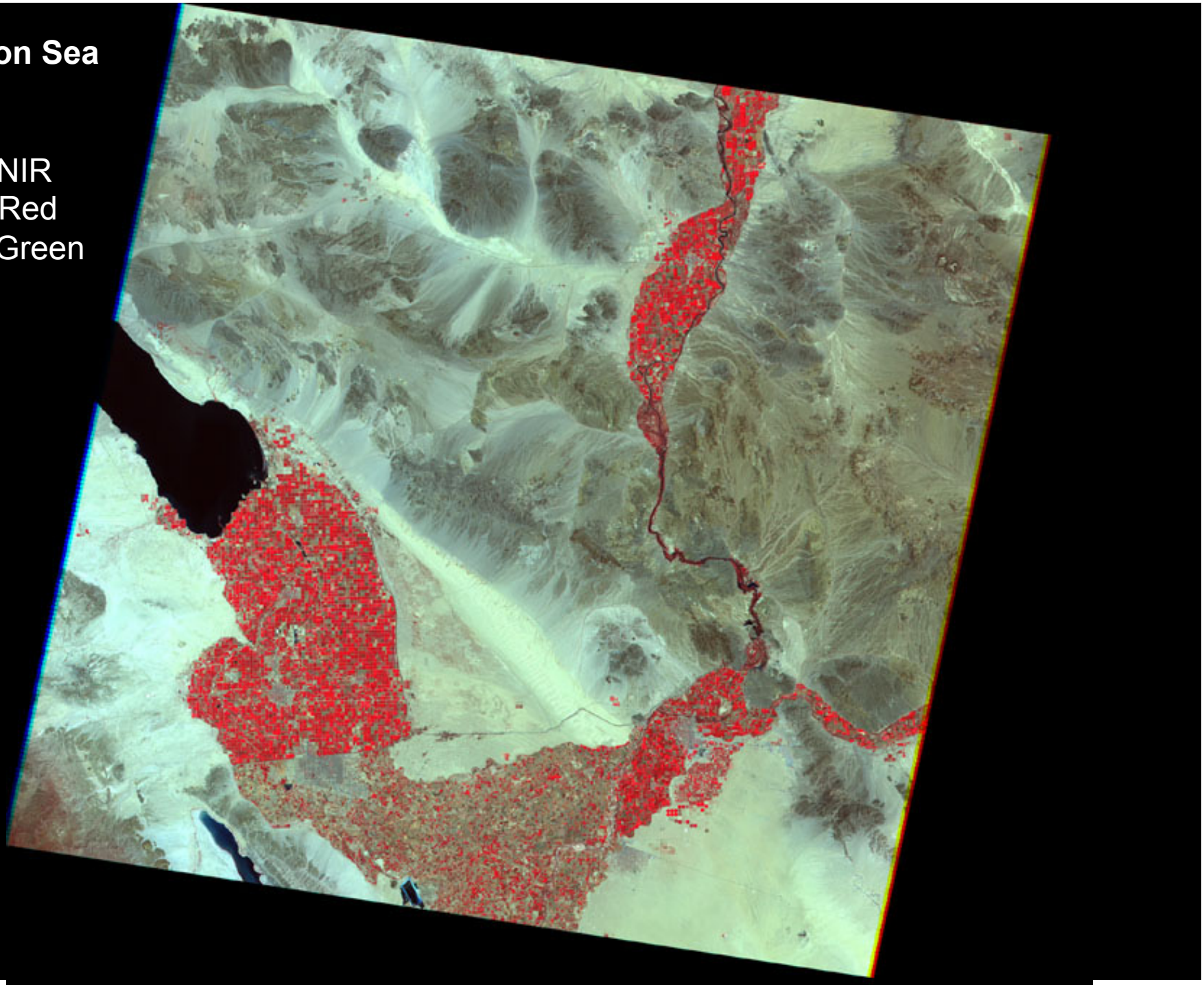
Salton Sea
321

(R) Red
(G) Green
(B) Blue



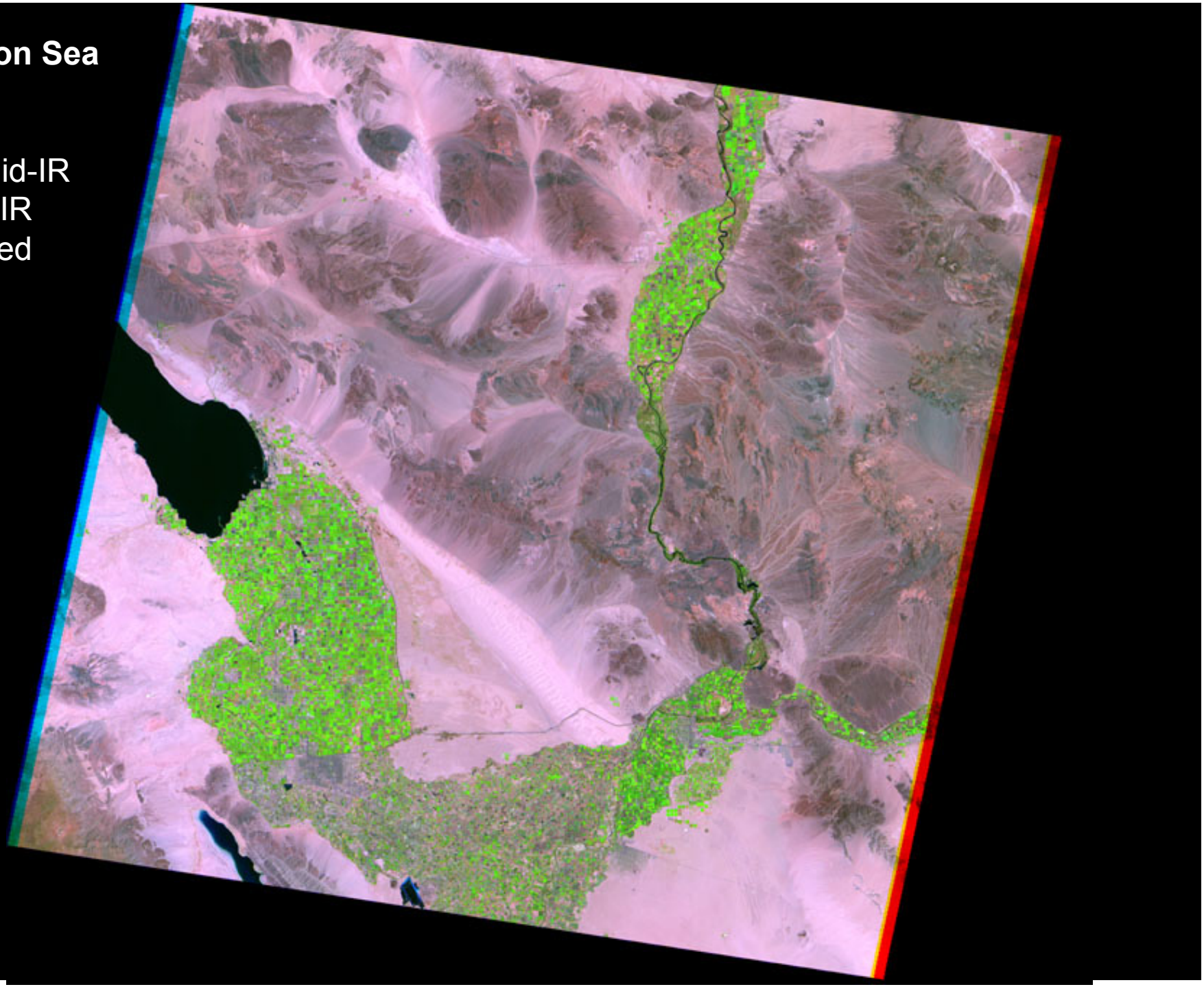
Salton Sea
432

(R) NIR
(G) Red
(B) Green



Salton Sea
543

R: Mid-IR
G: NIR
B: Red



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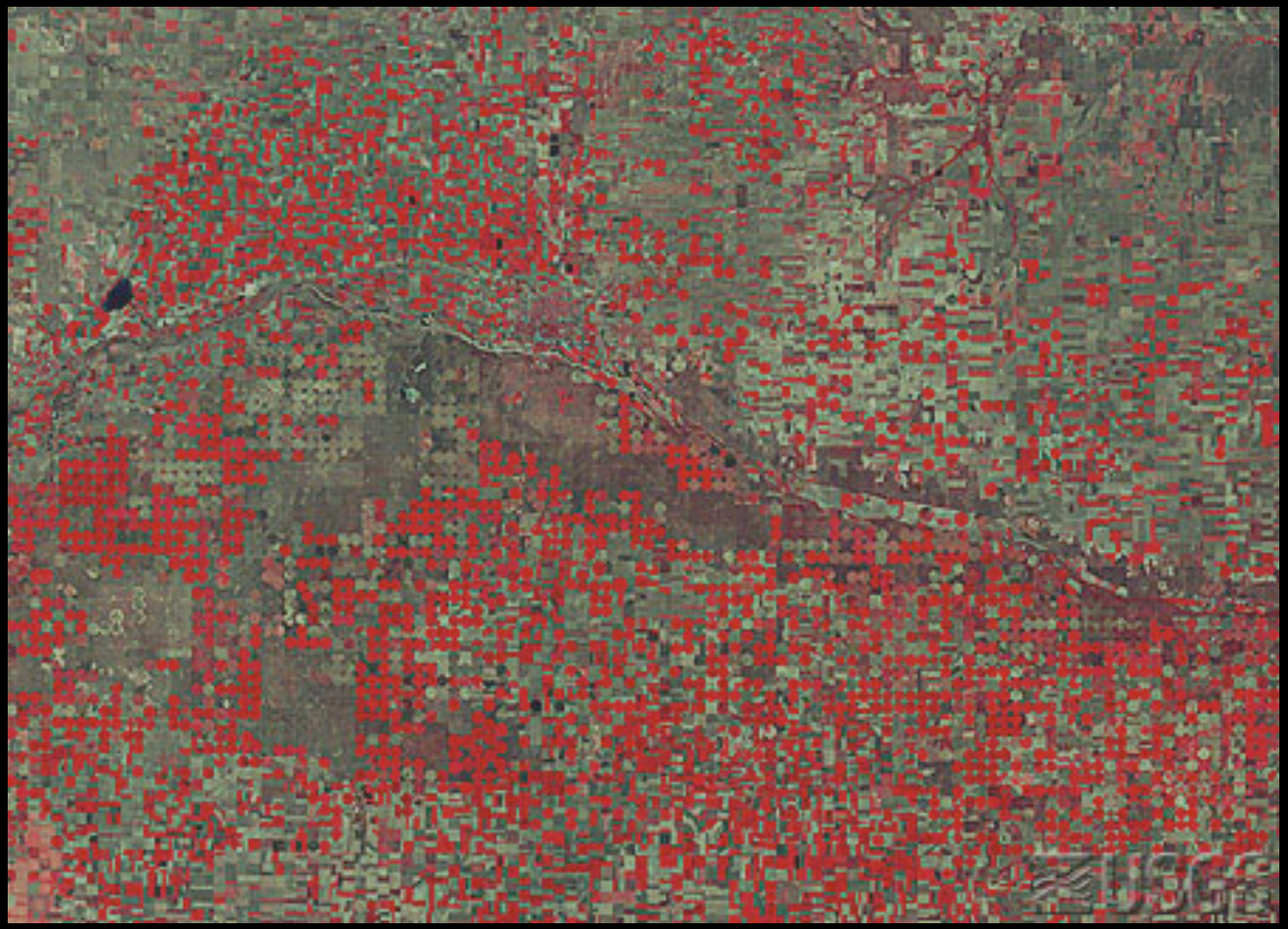

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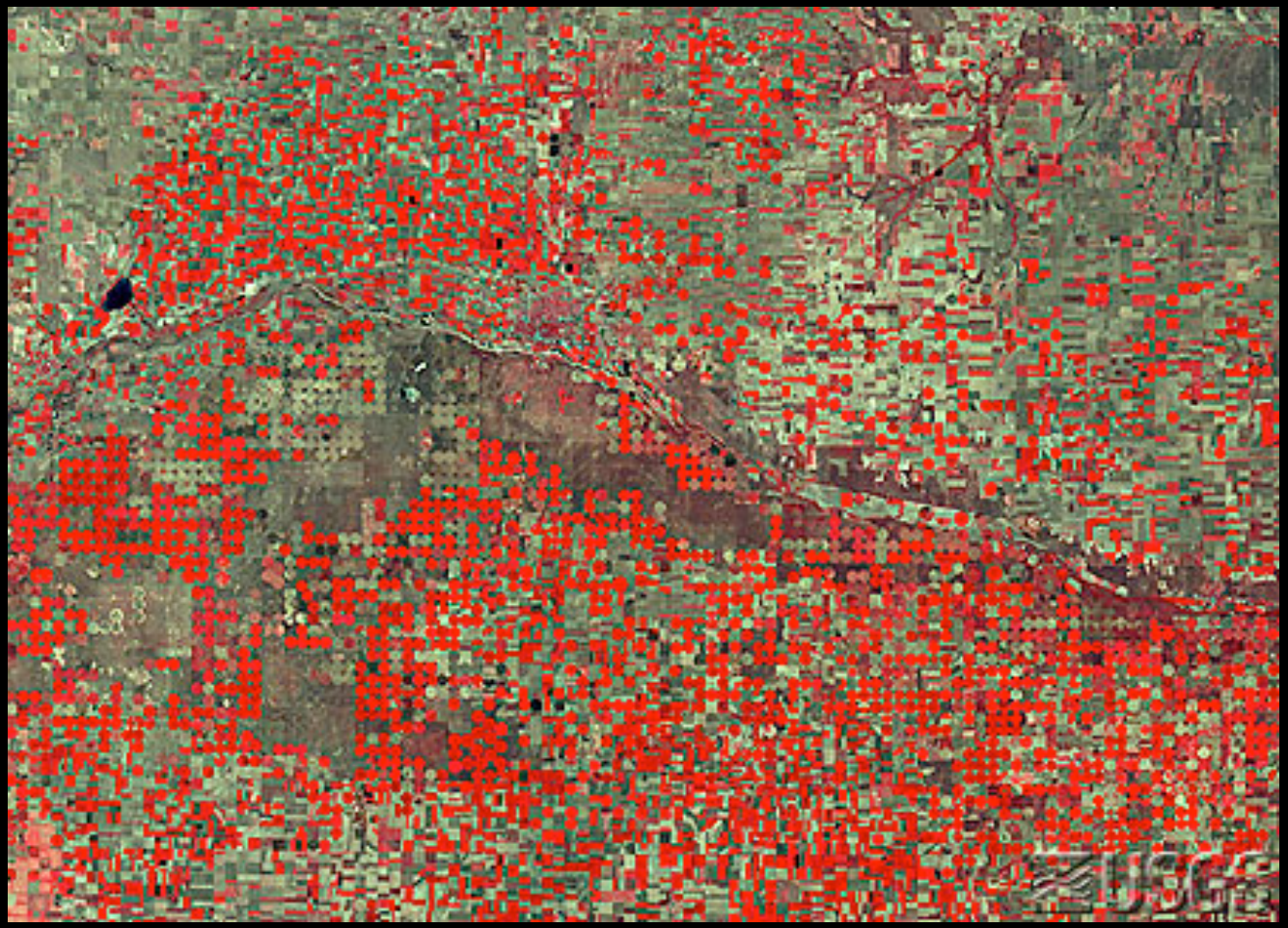
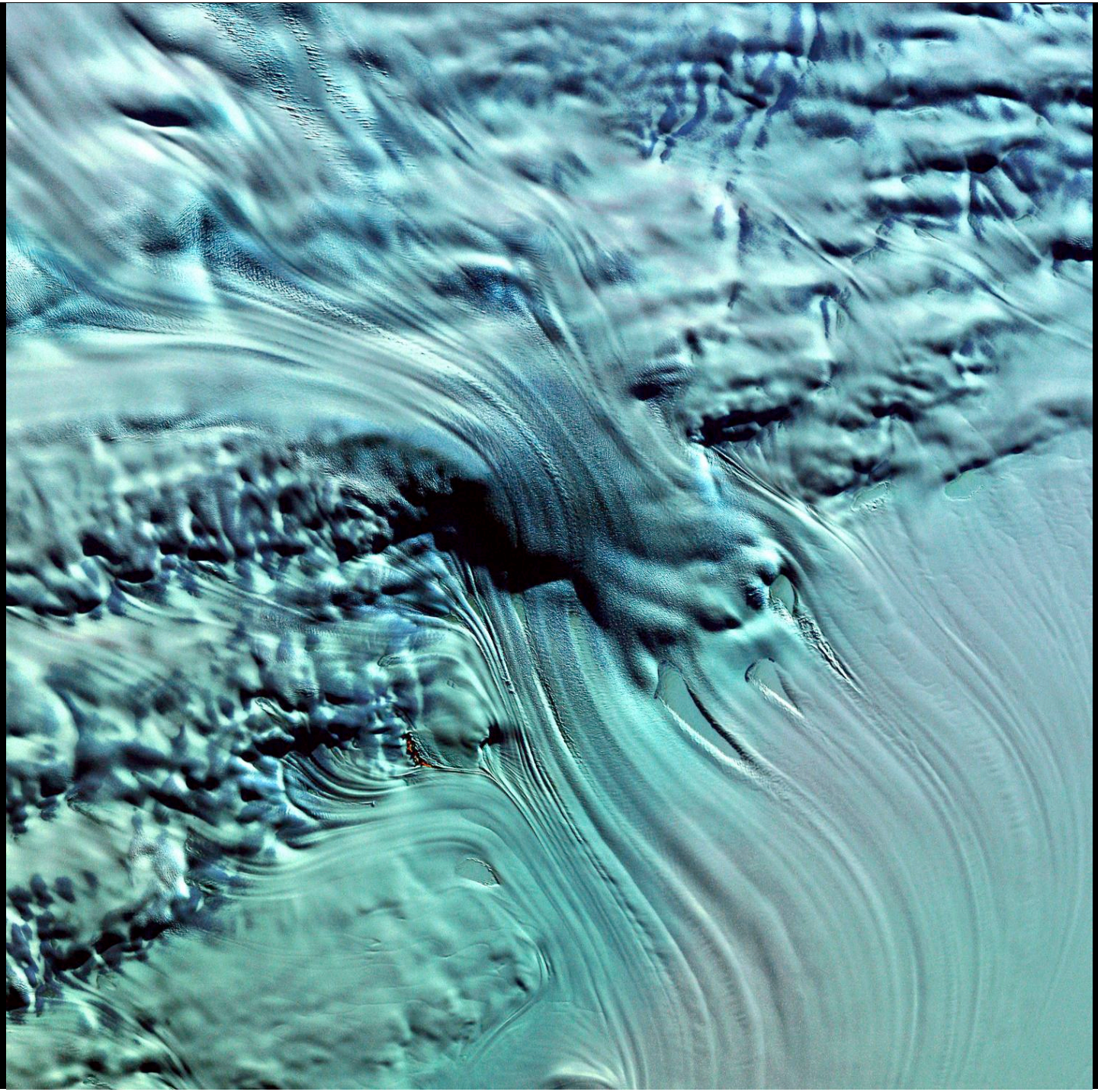
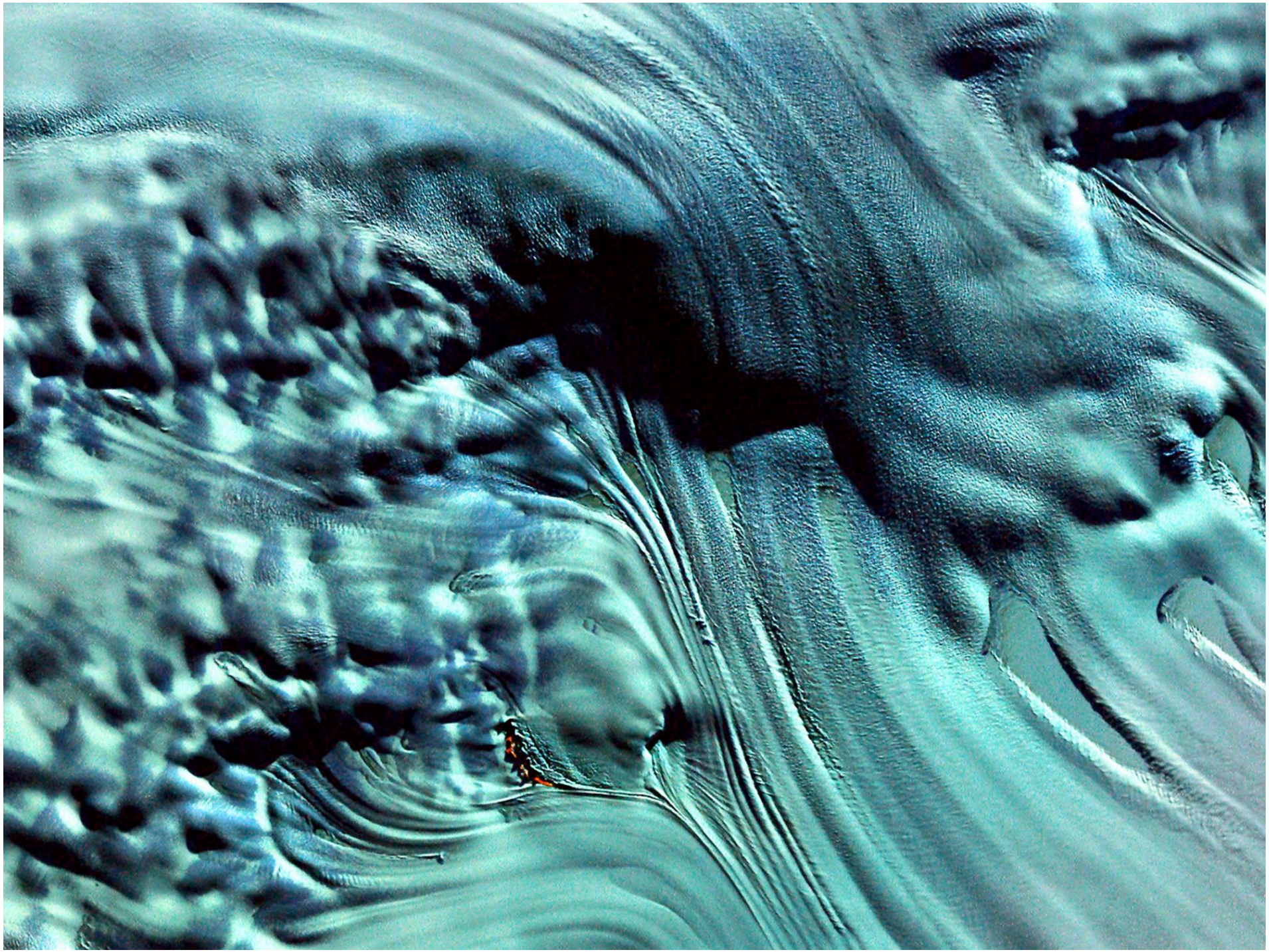
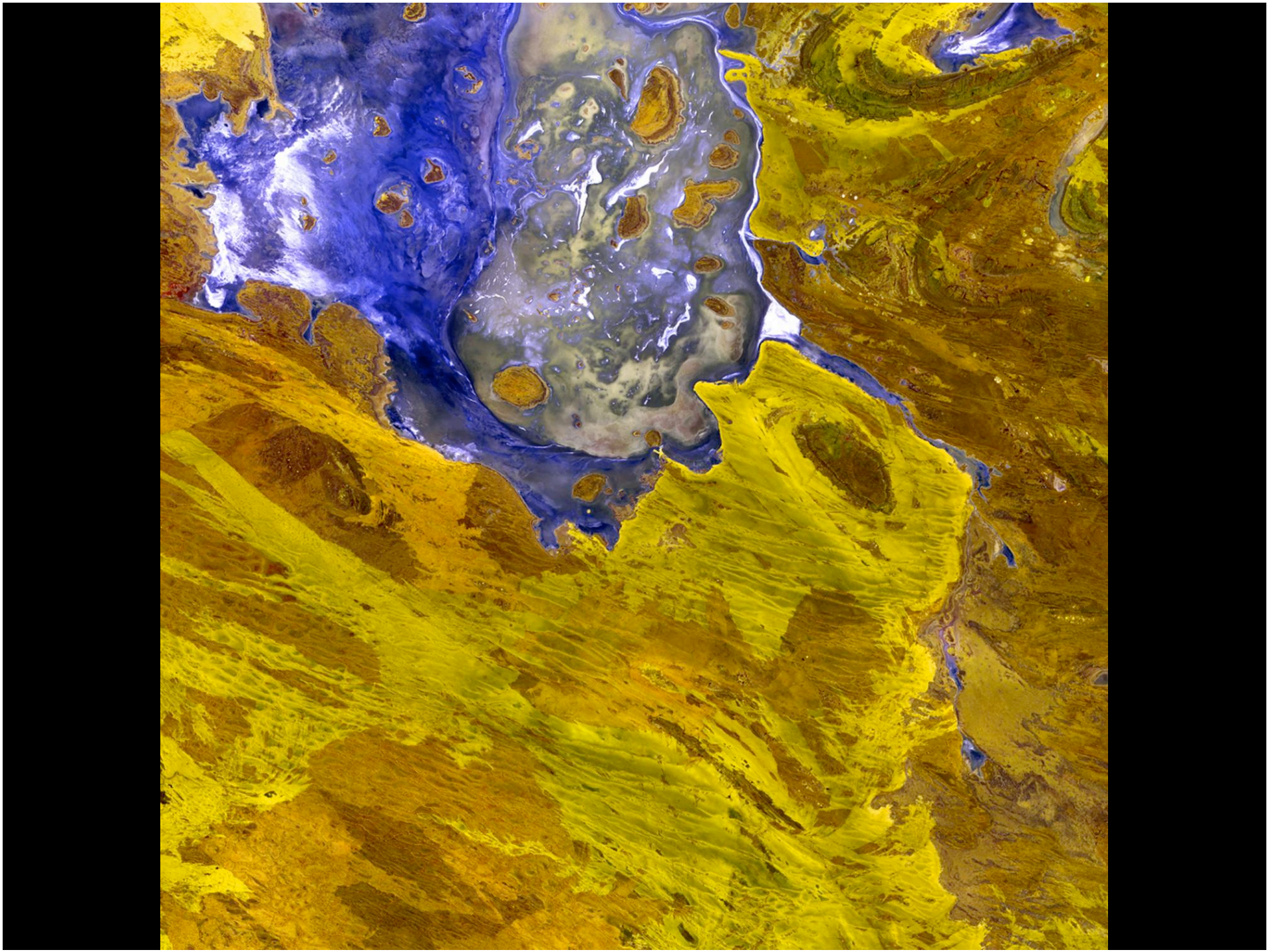


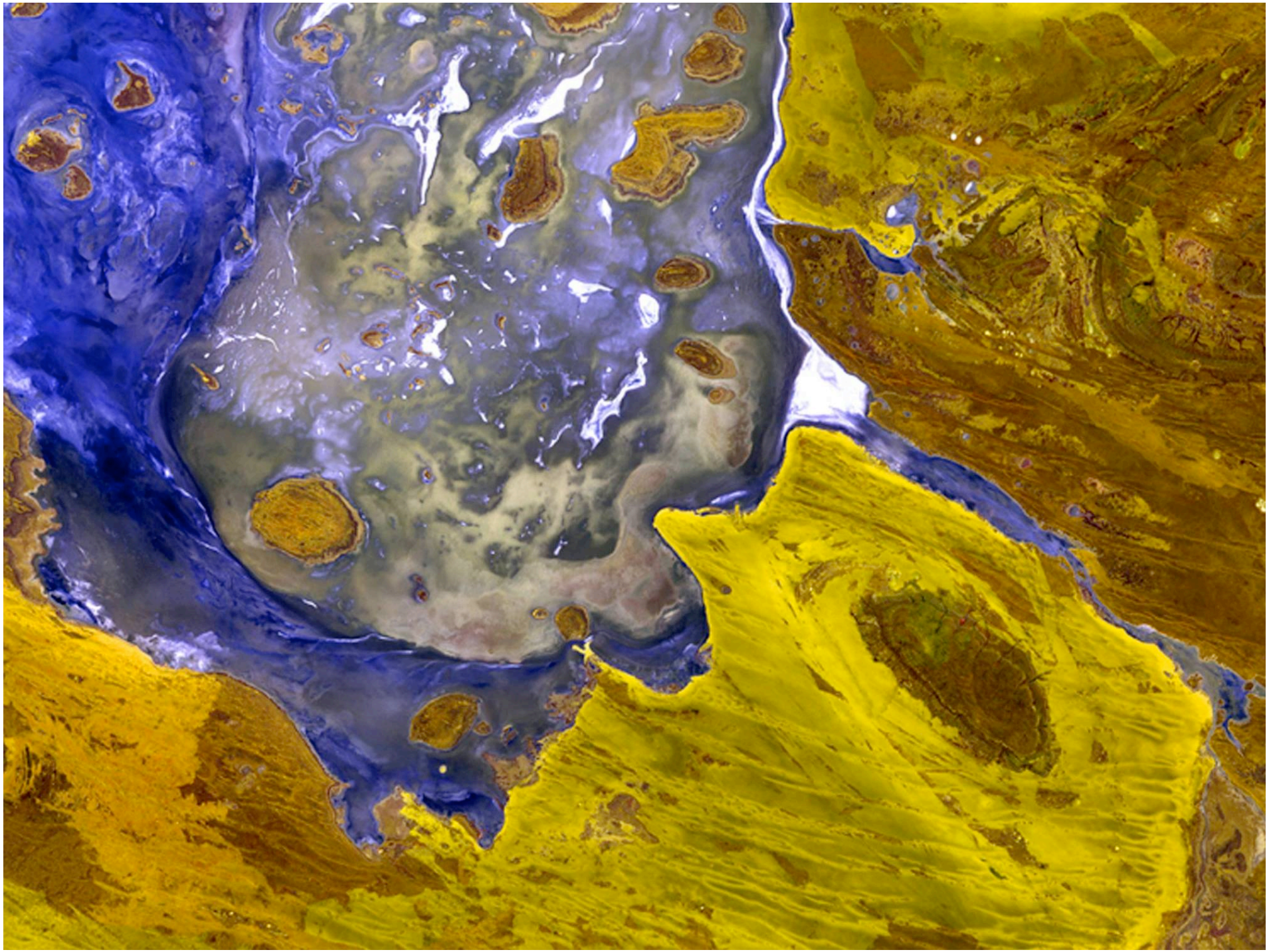
NASA’s Earth As Art Gallery

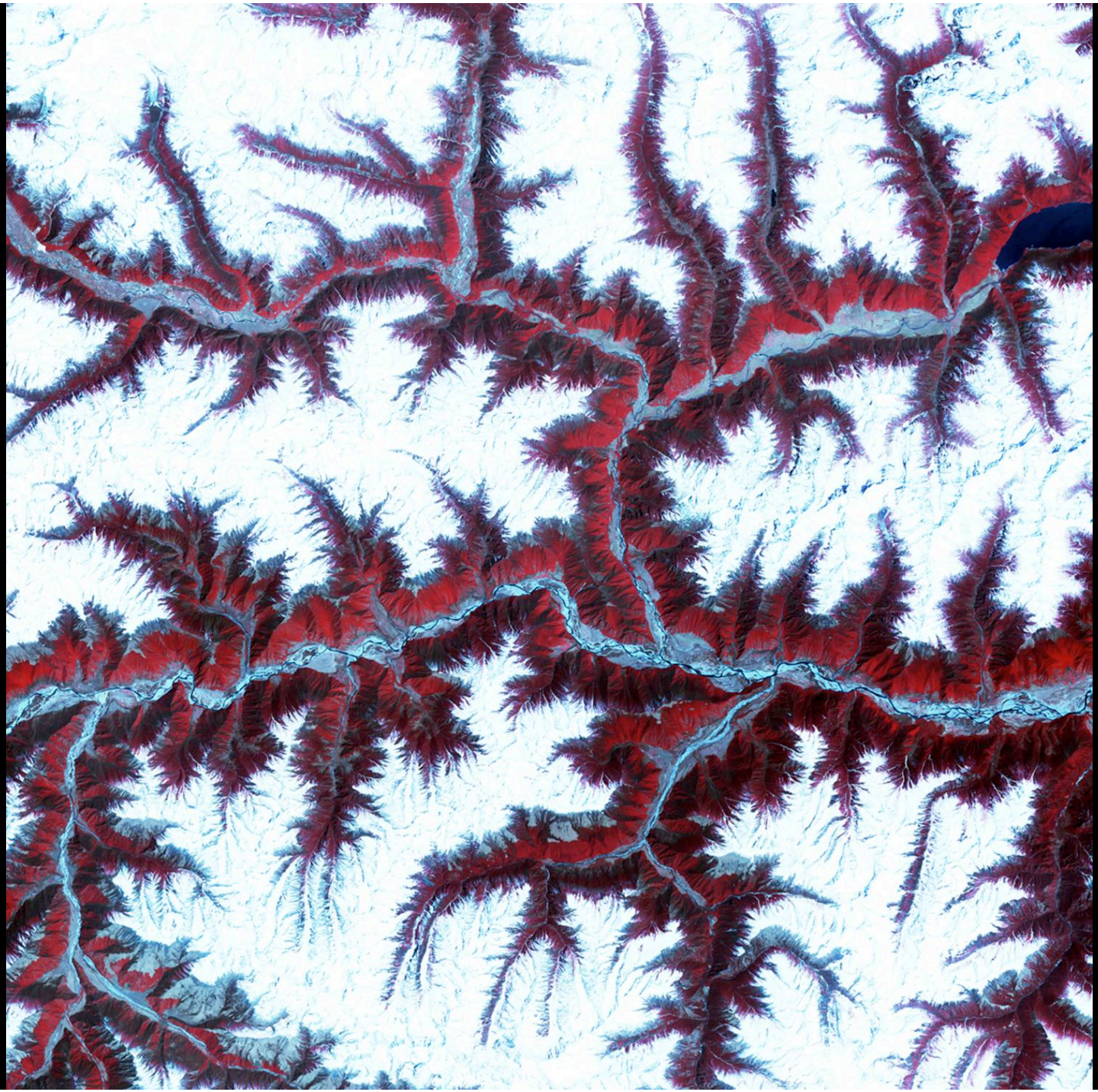
Goddard Spaceflight Center
Greenbelt, Maryland

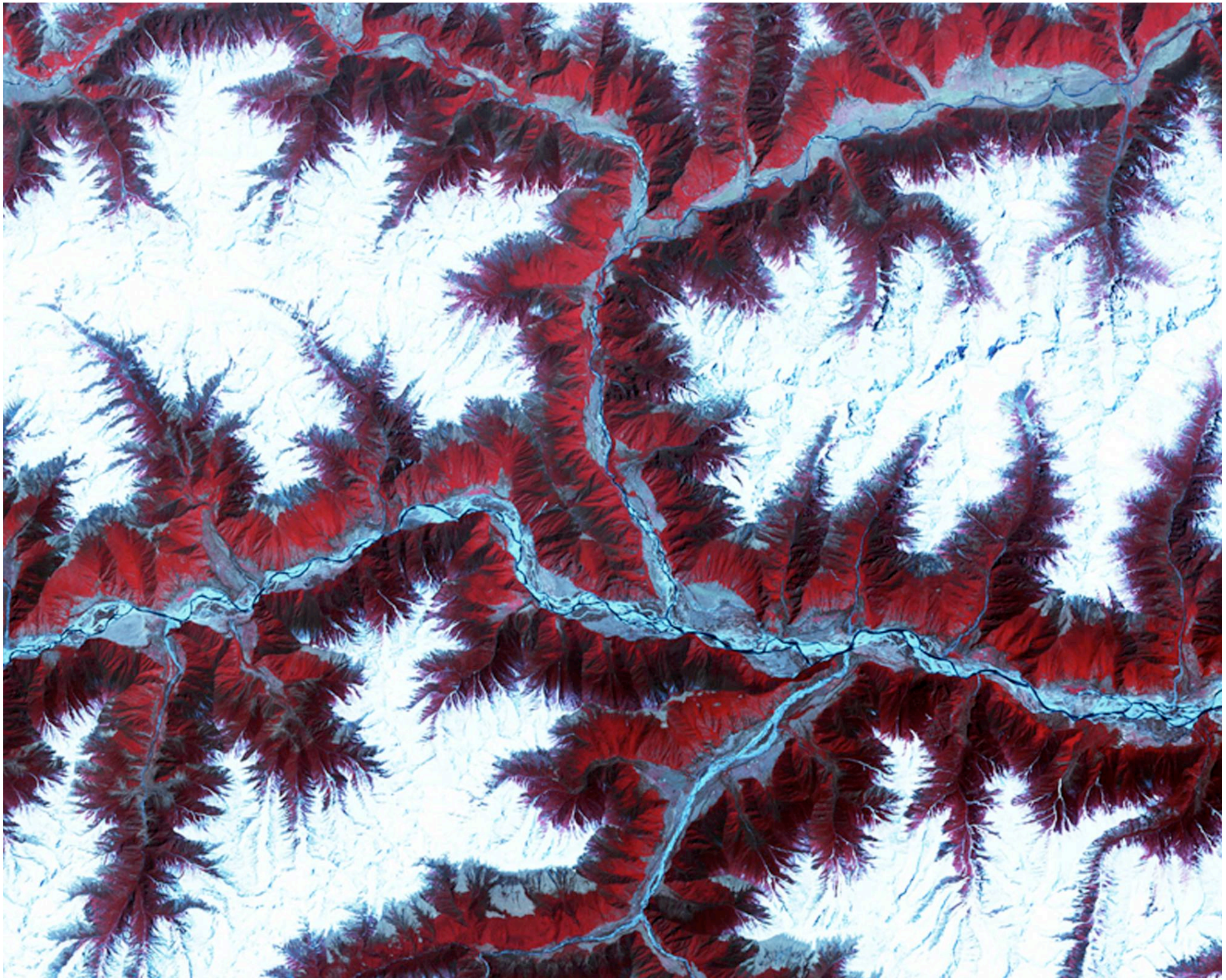


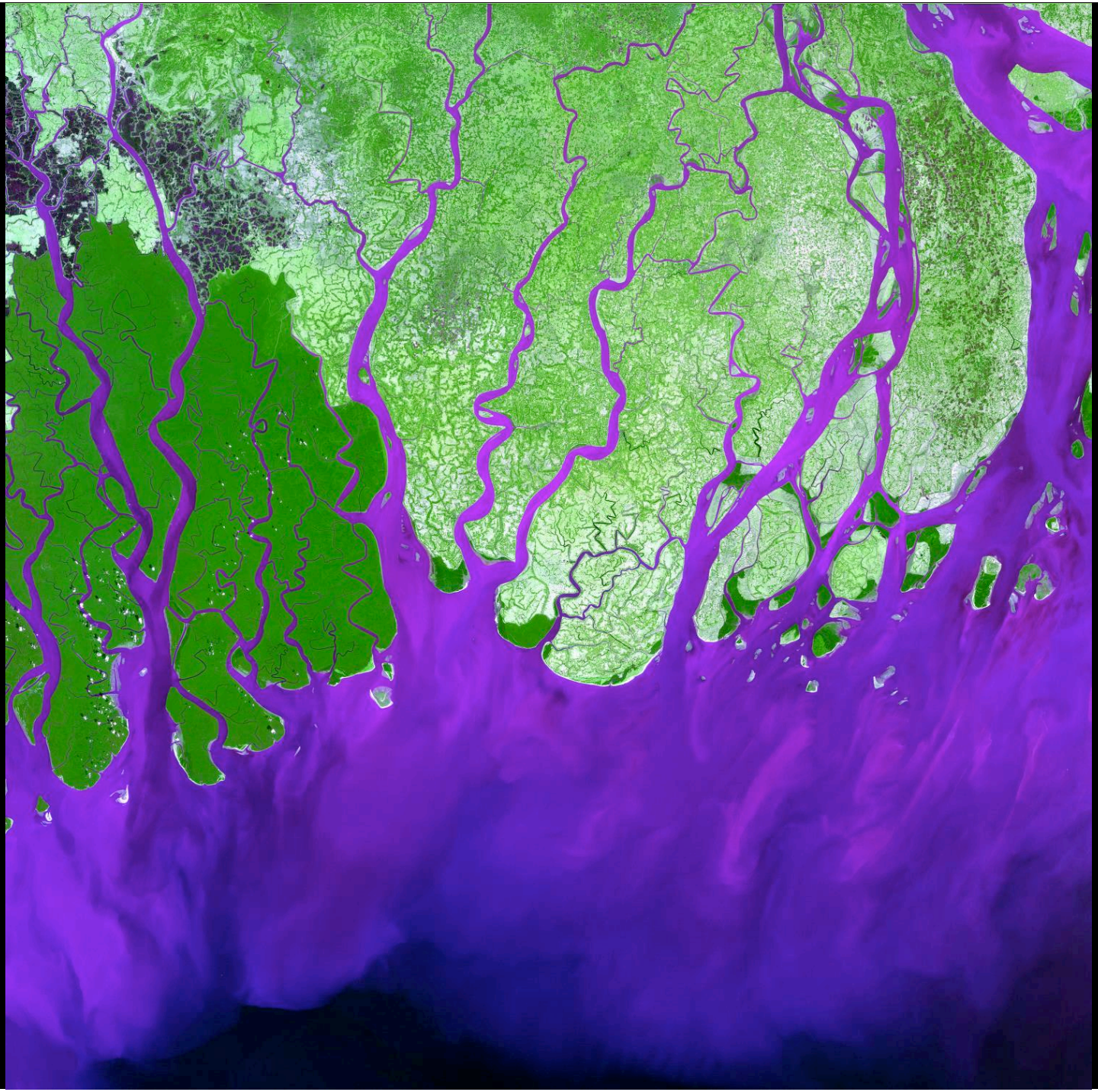


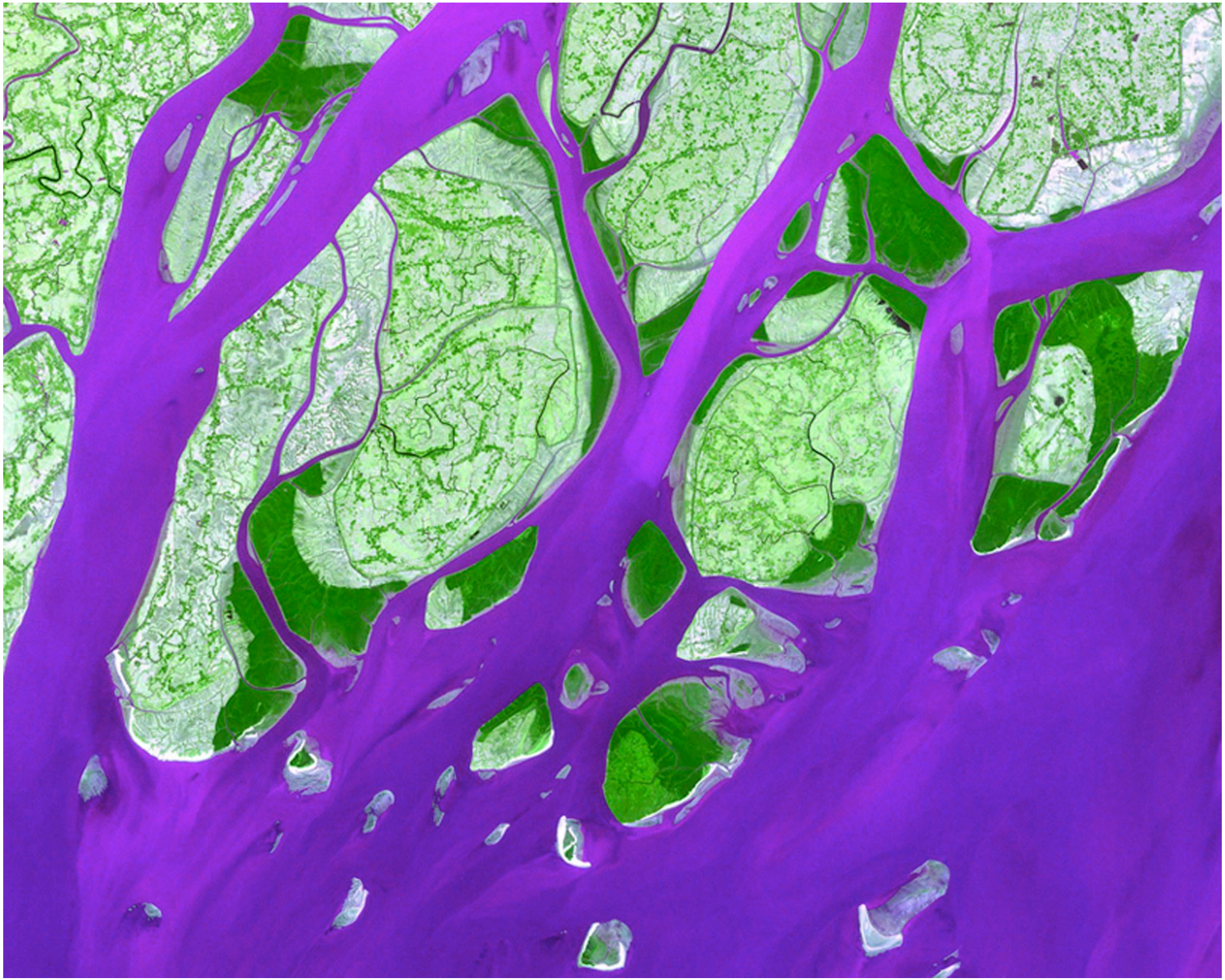


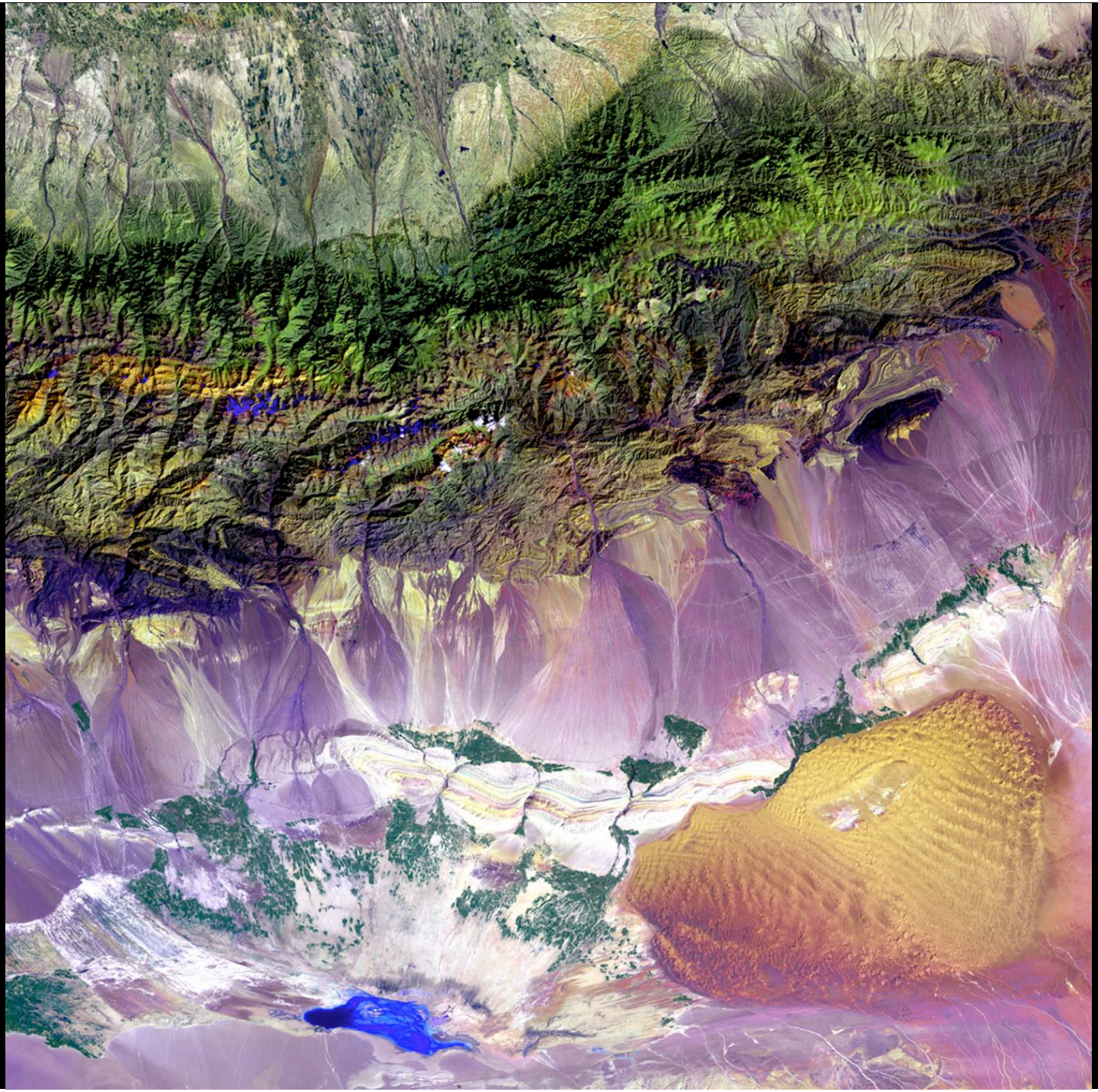


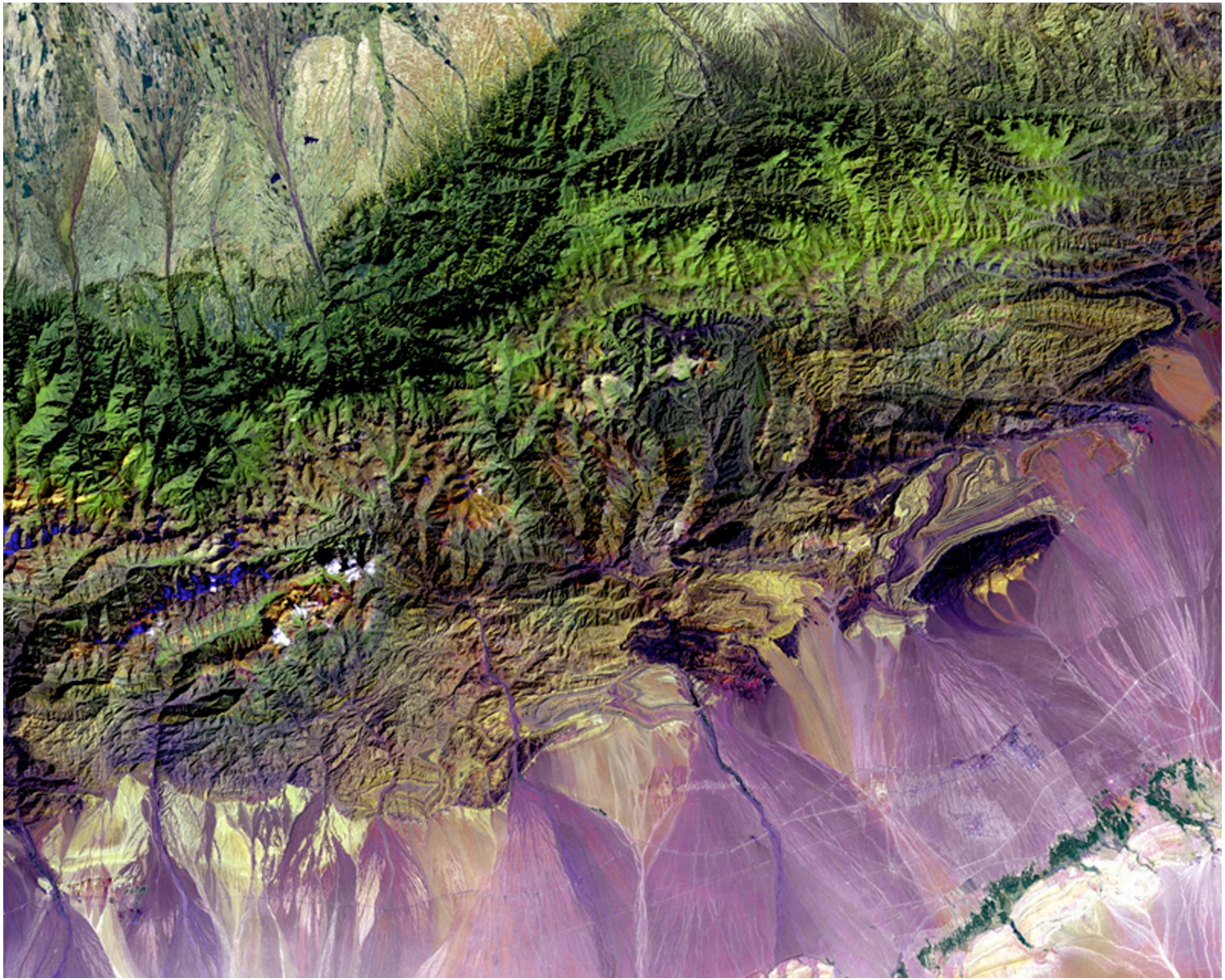


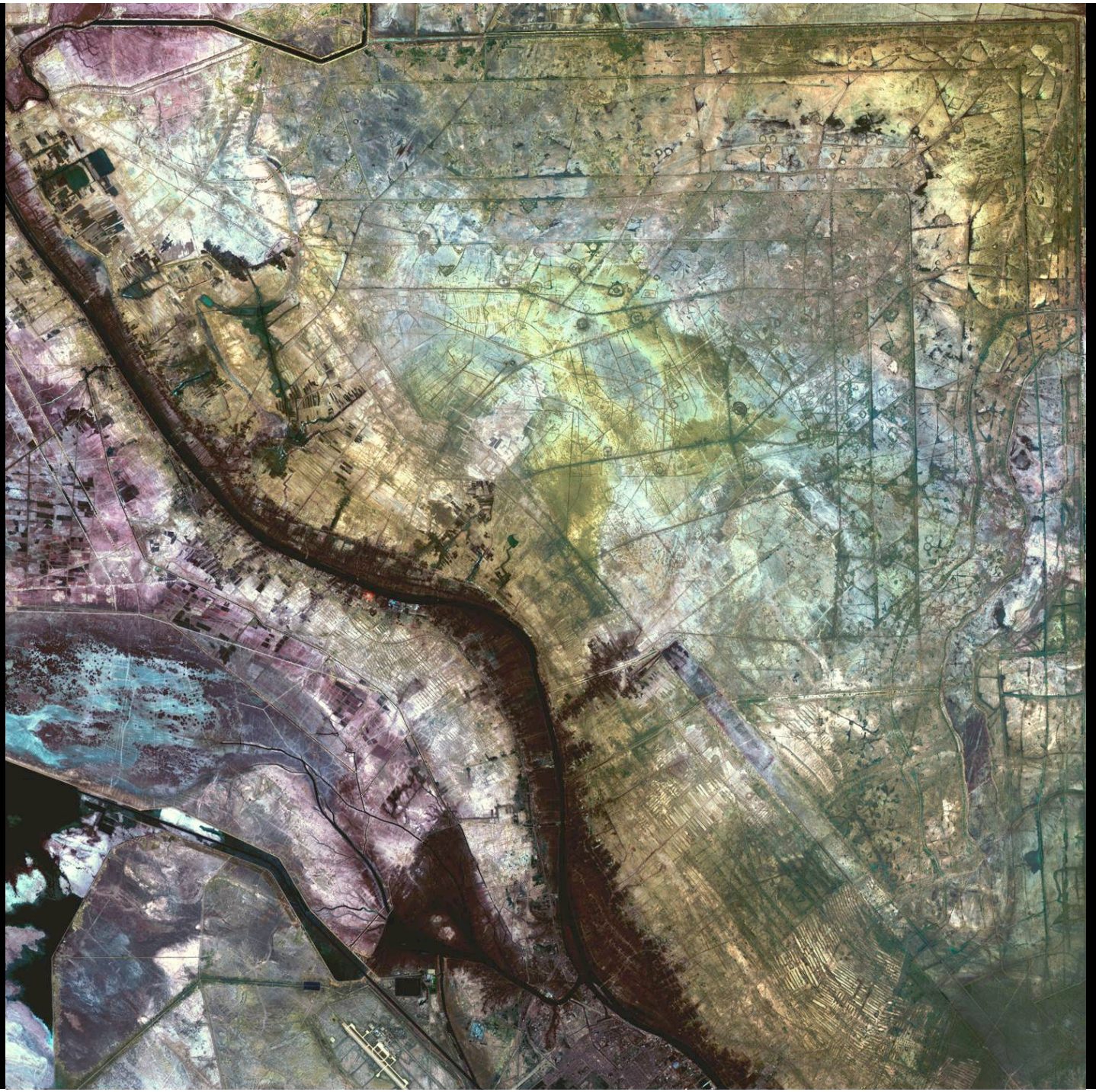


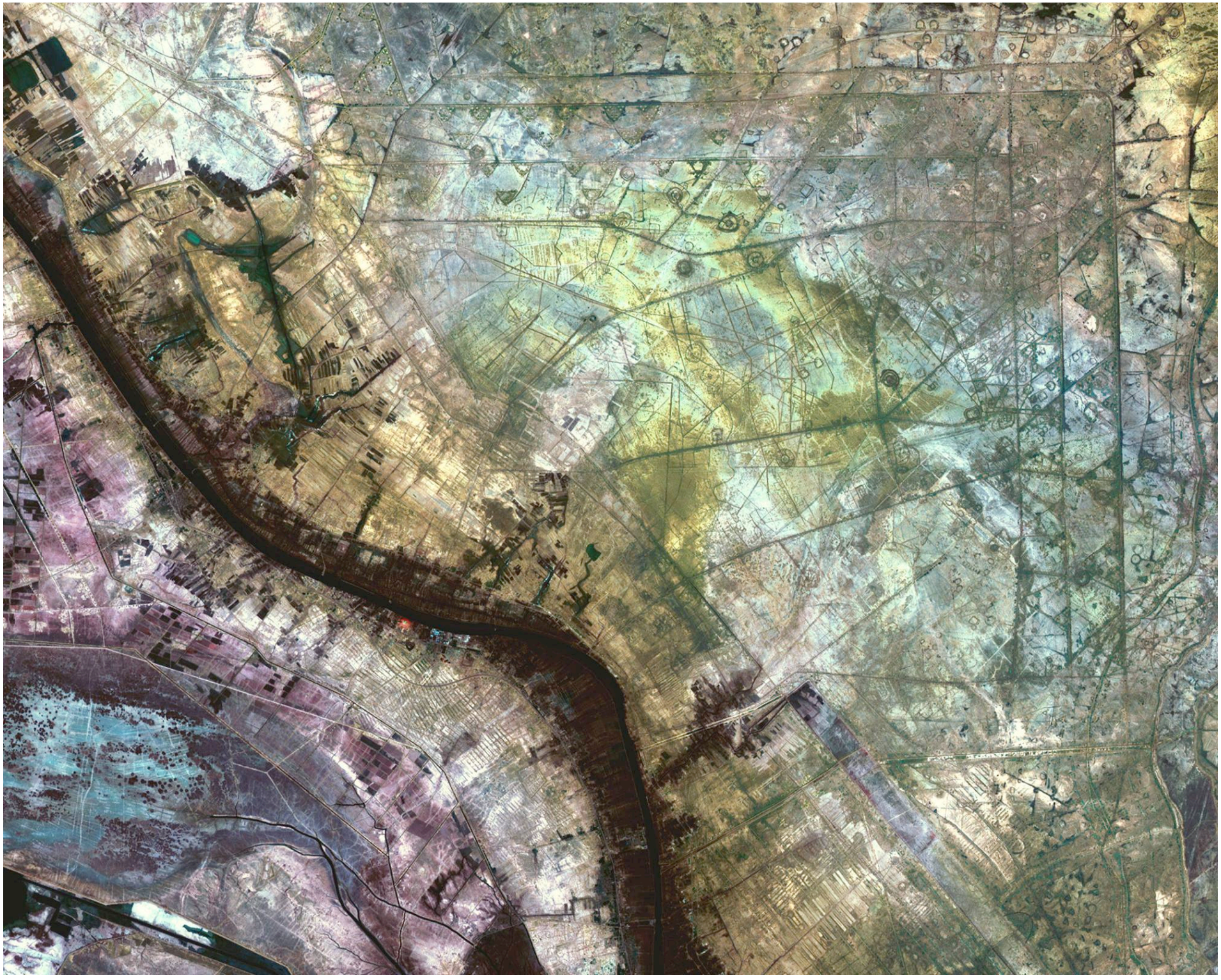


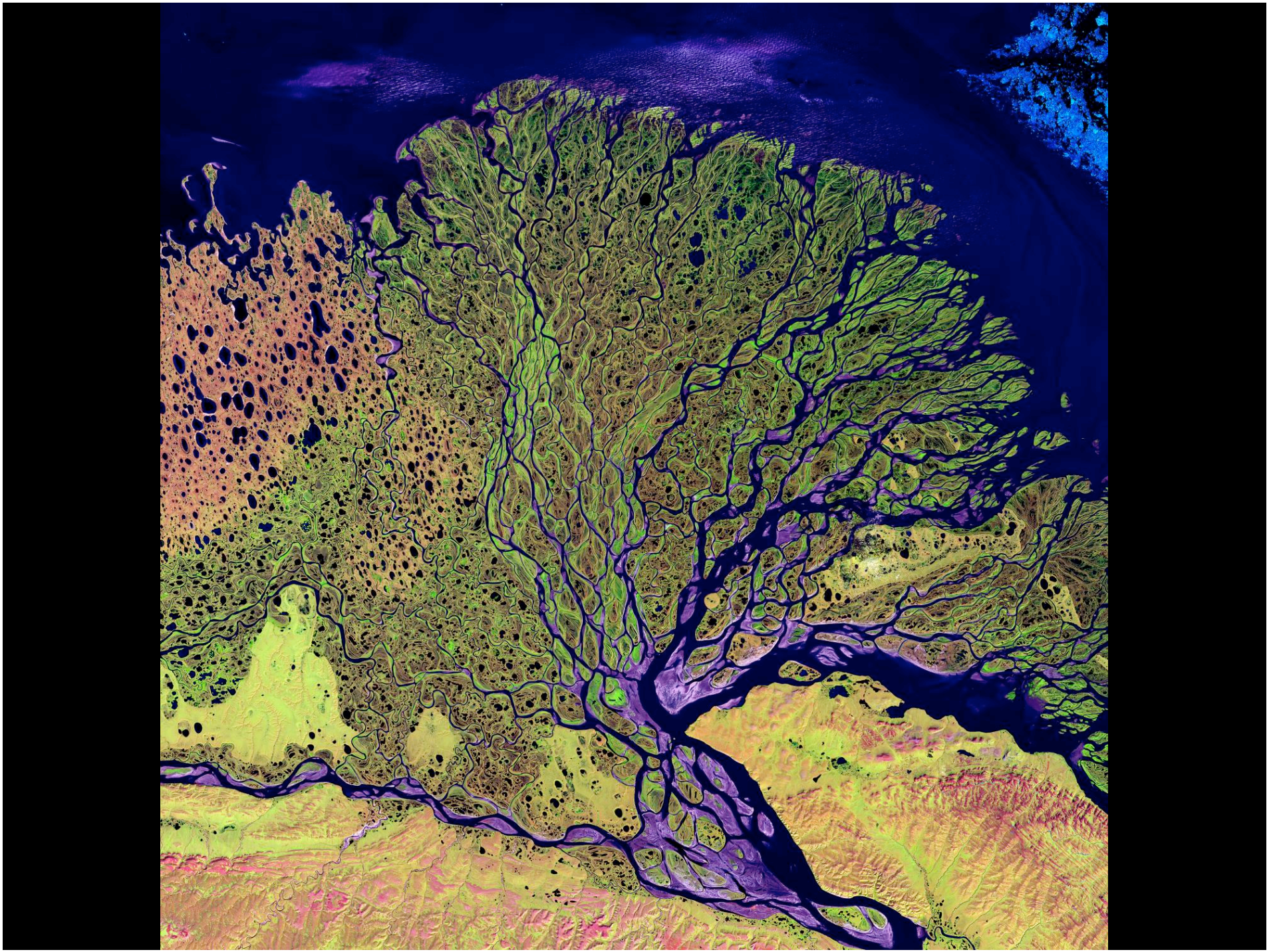


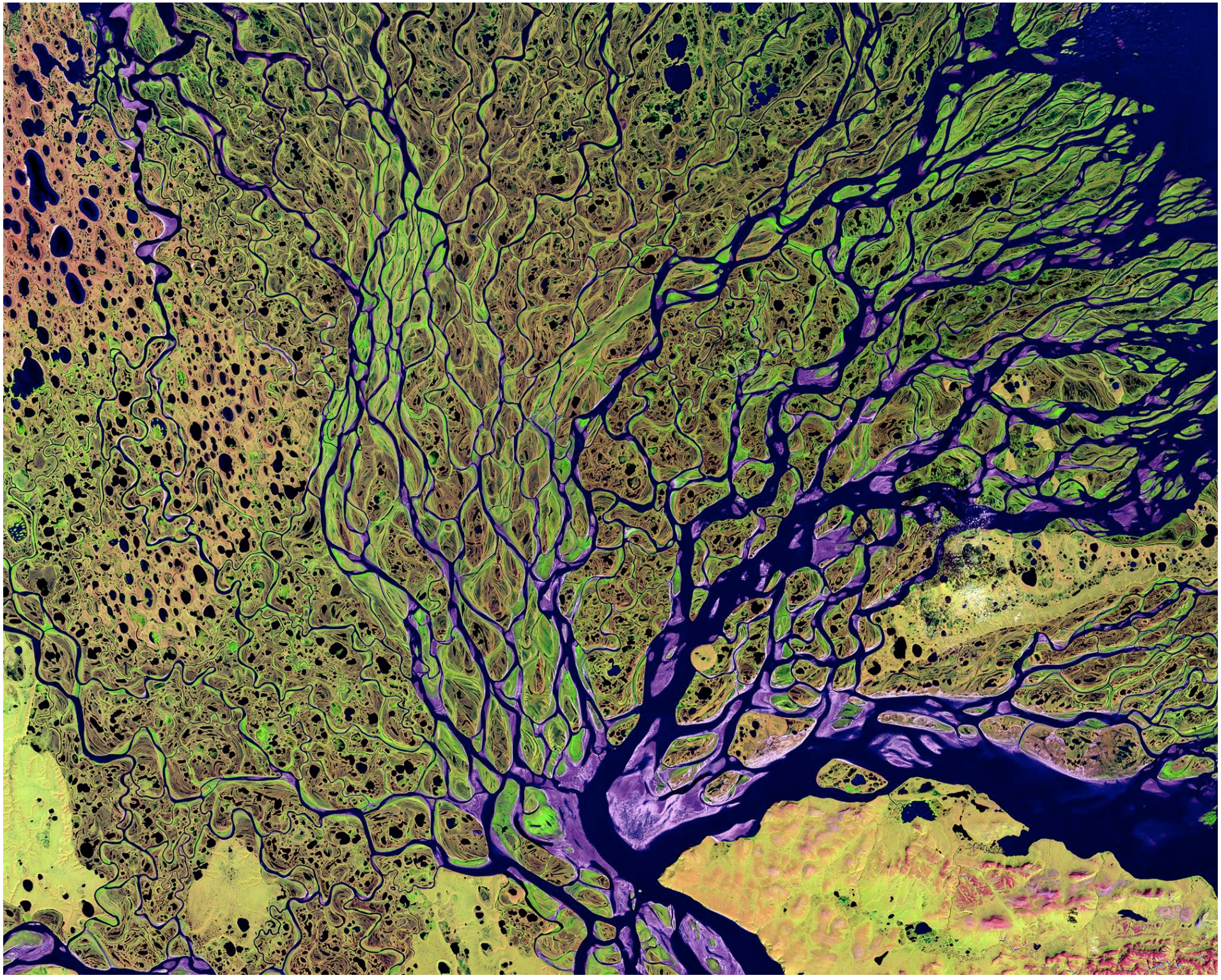


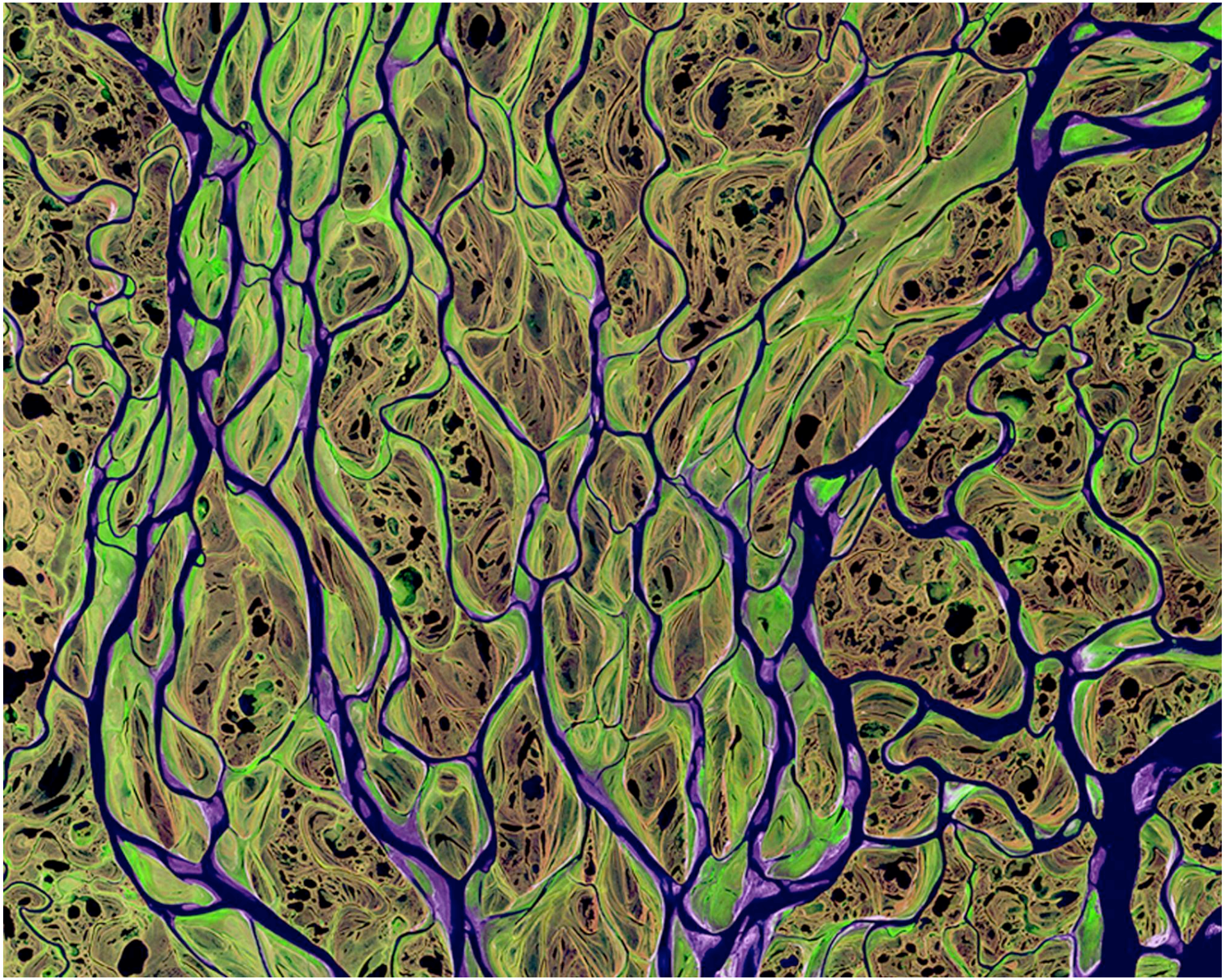


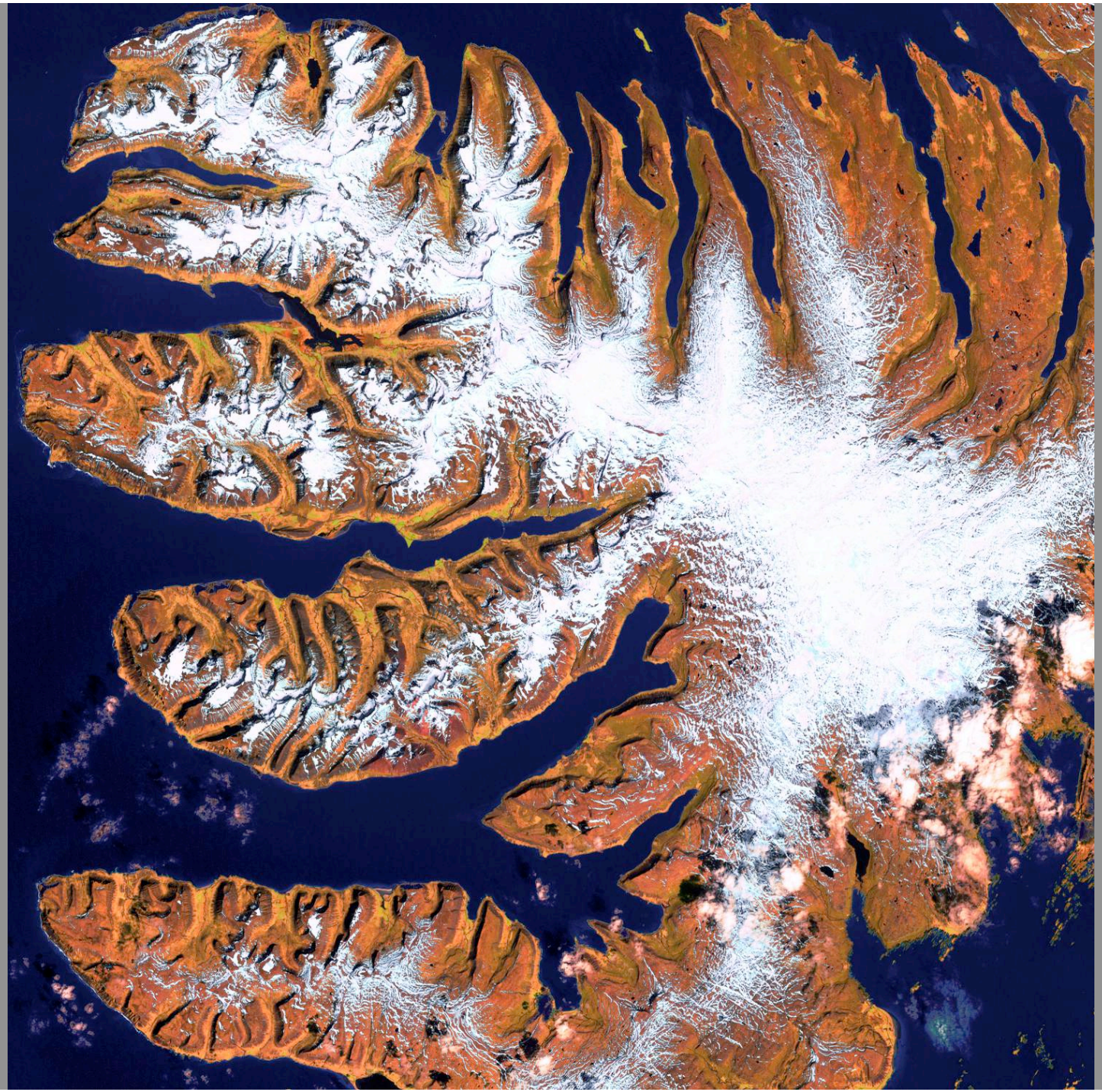


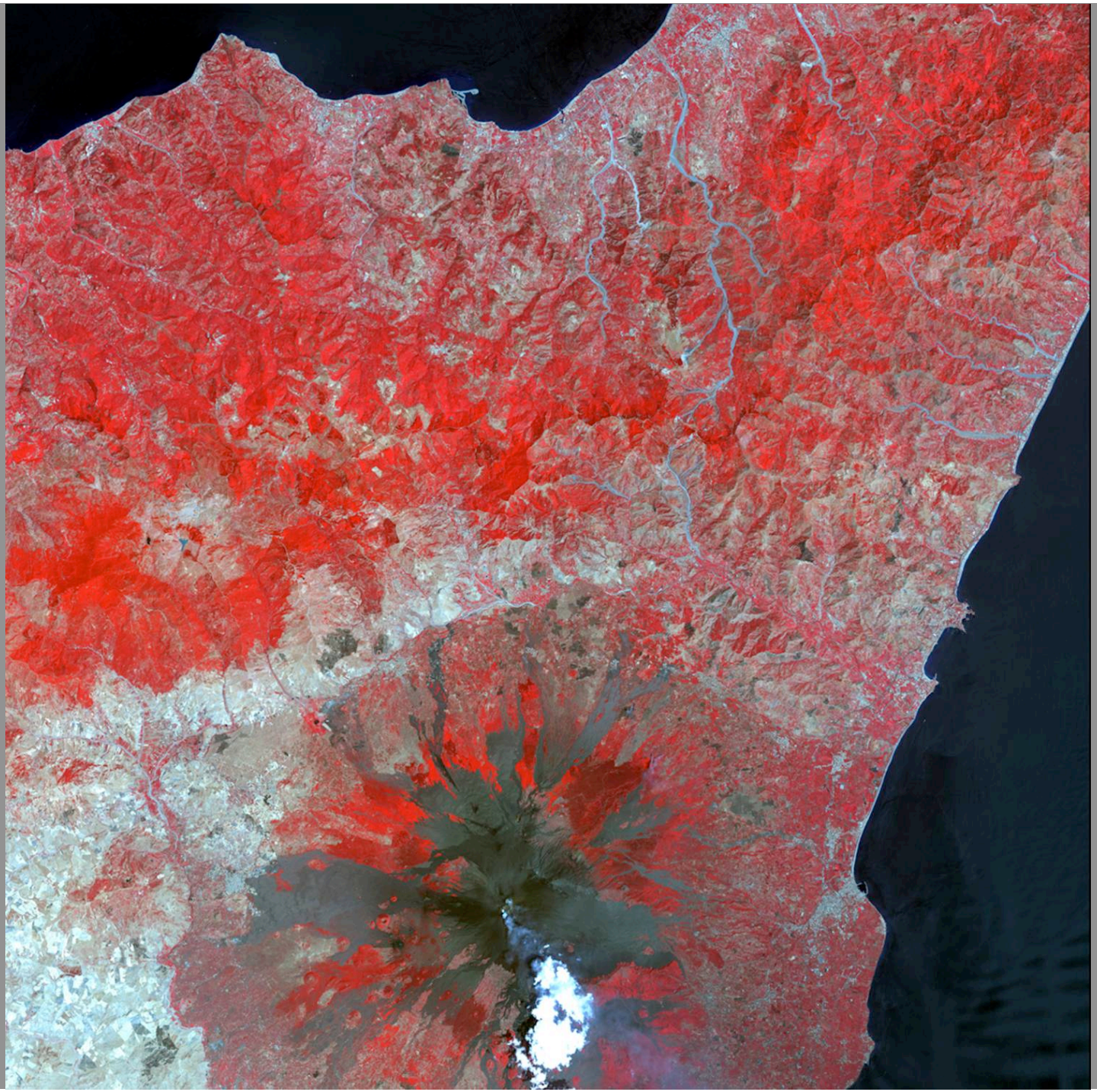


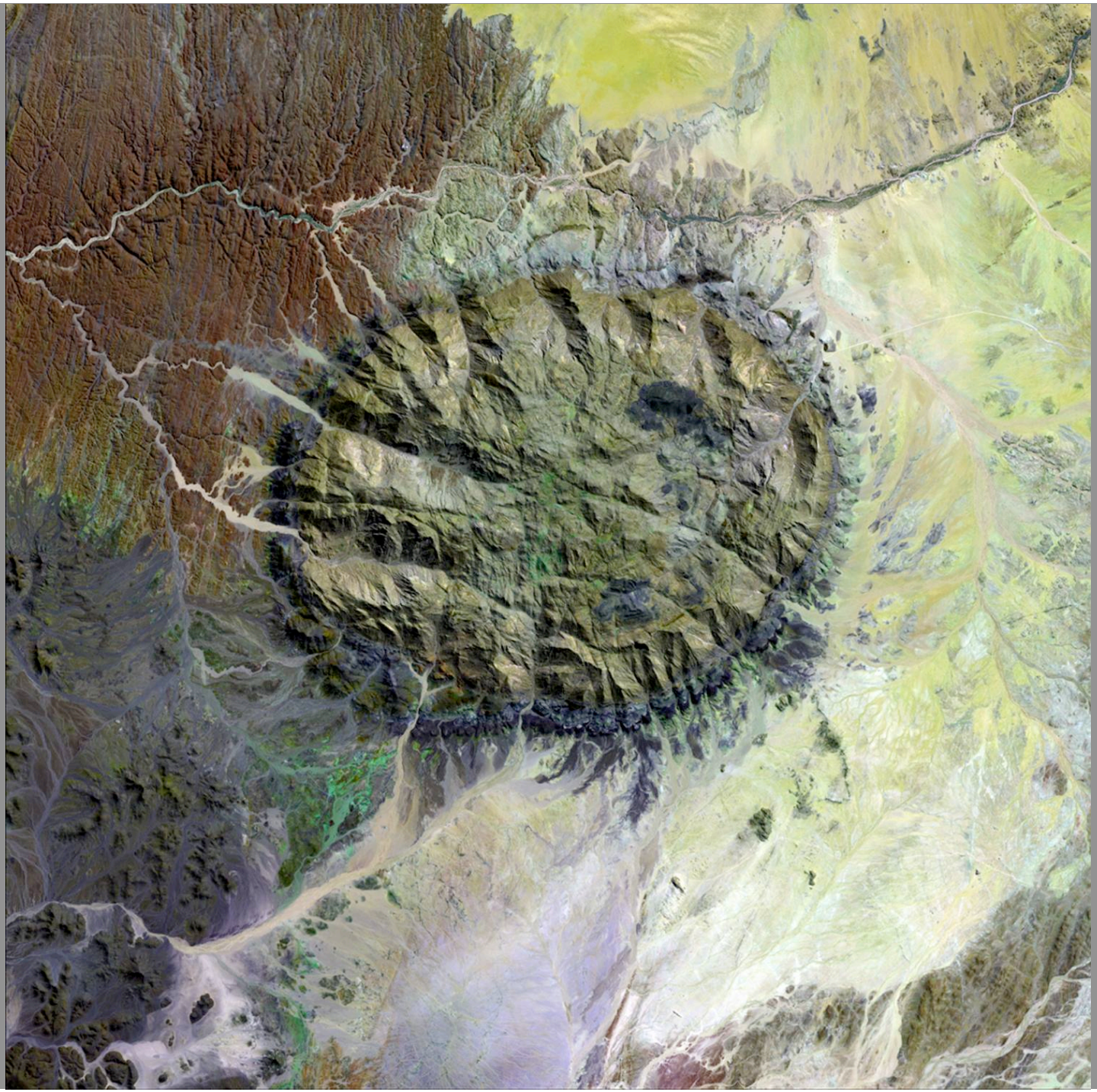


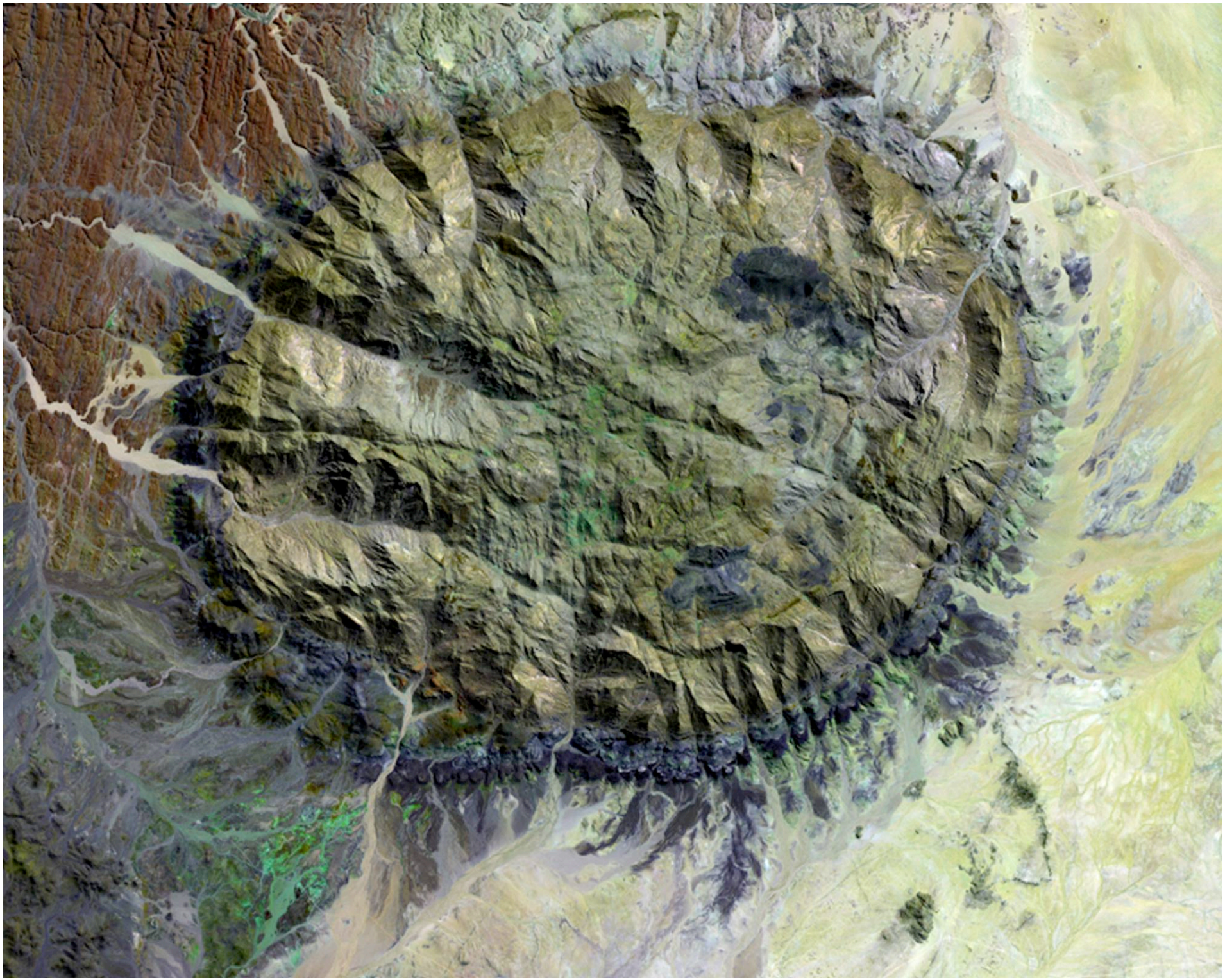


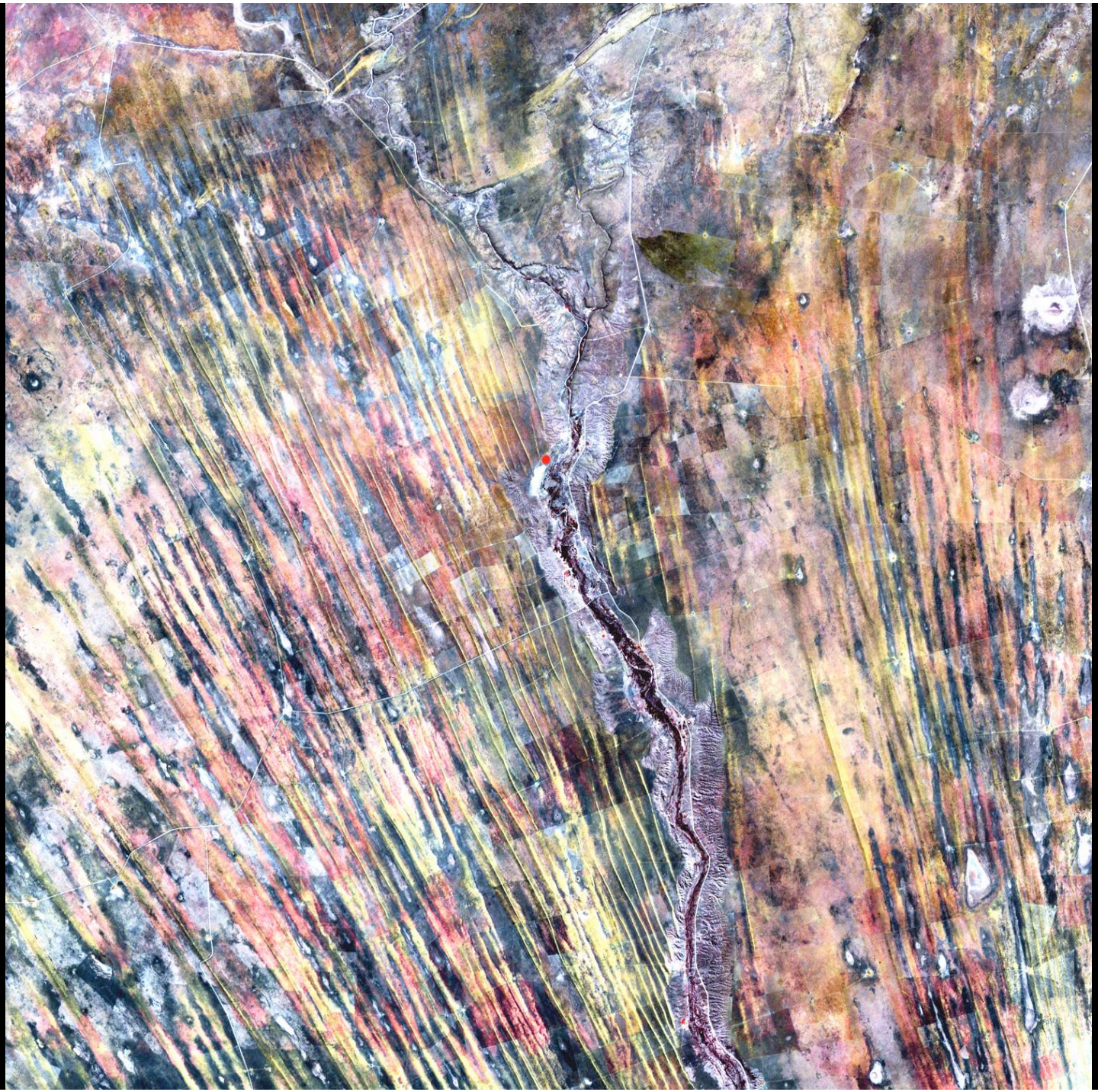


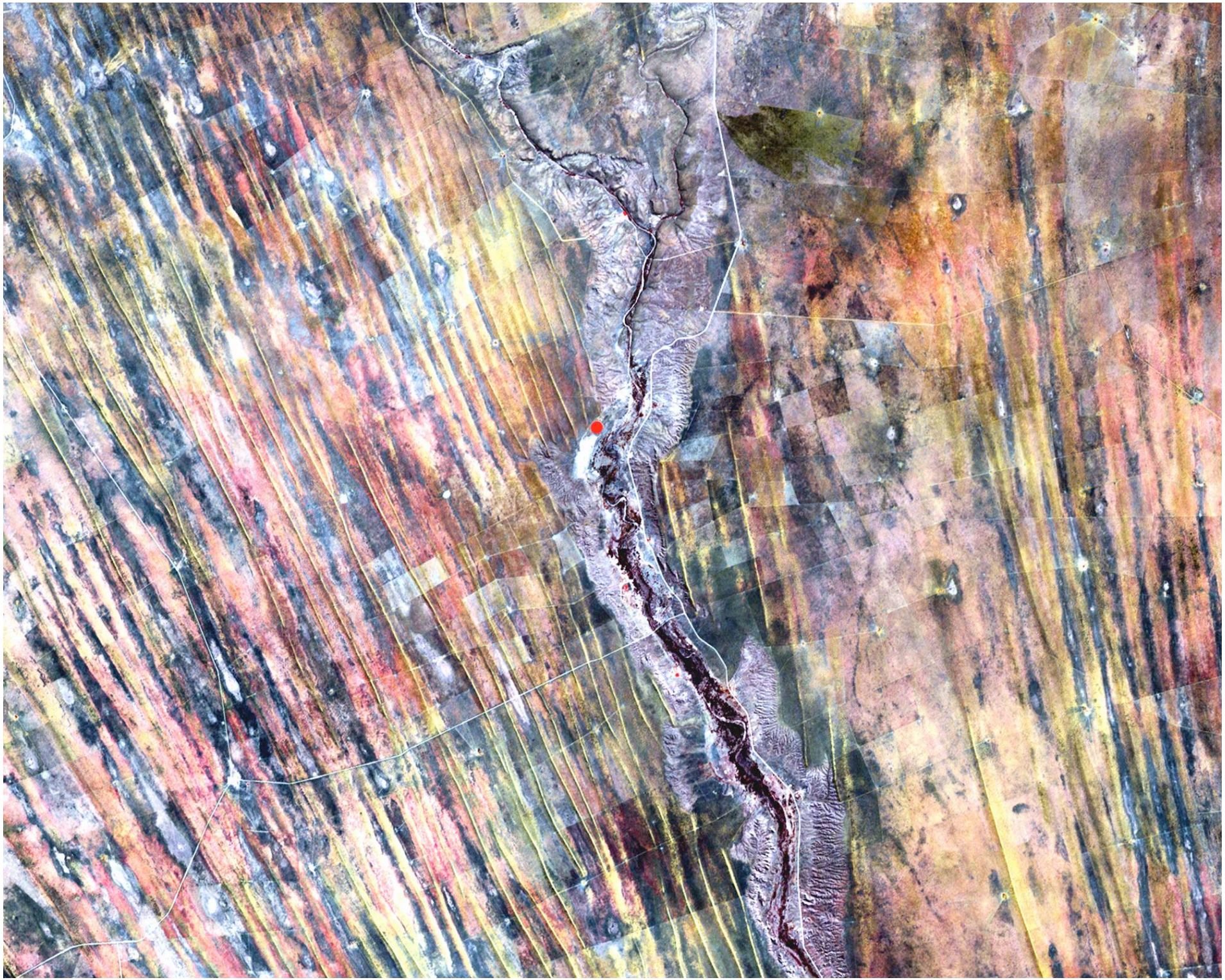


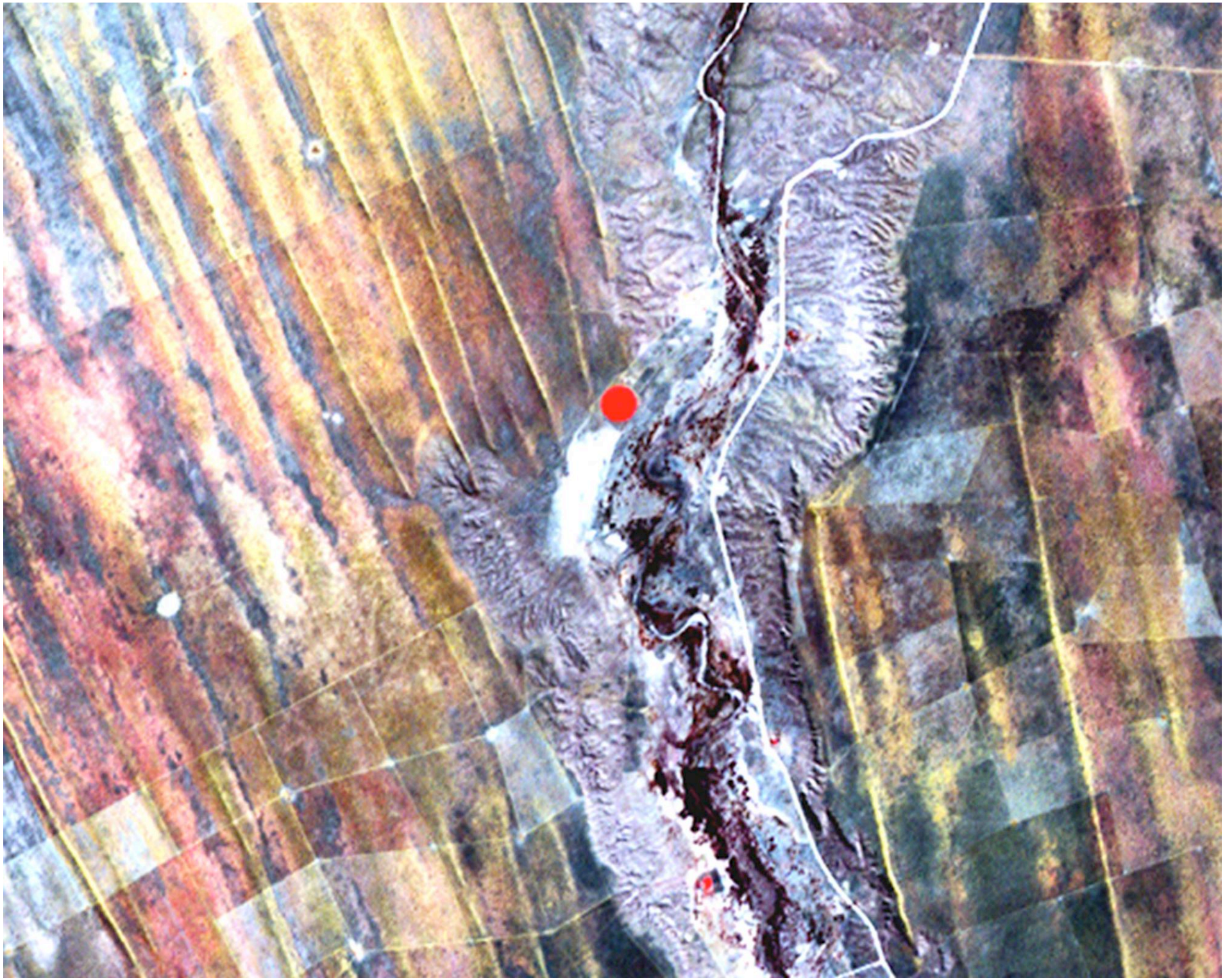


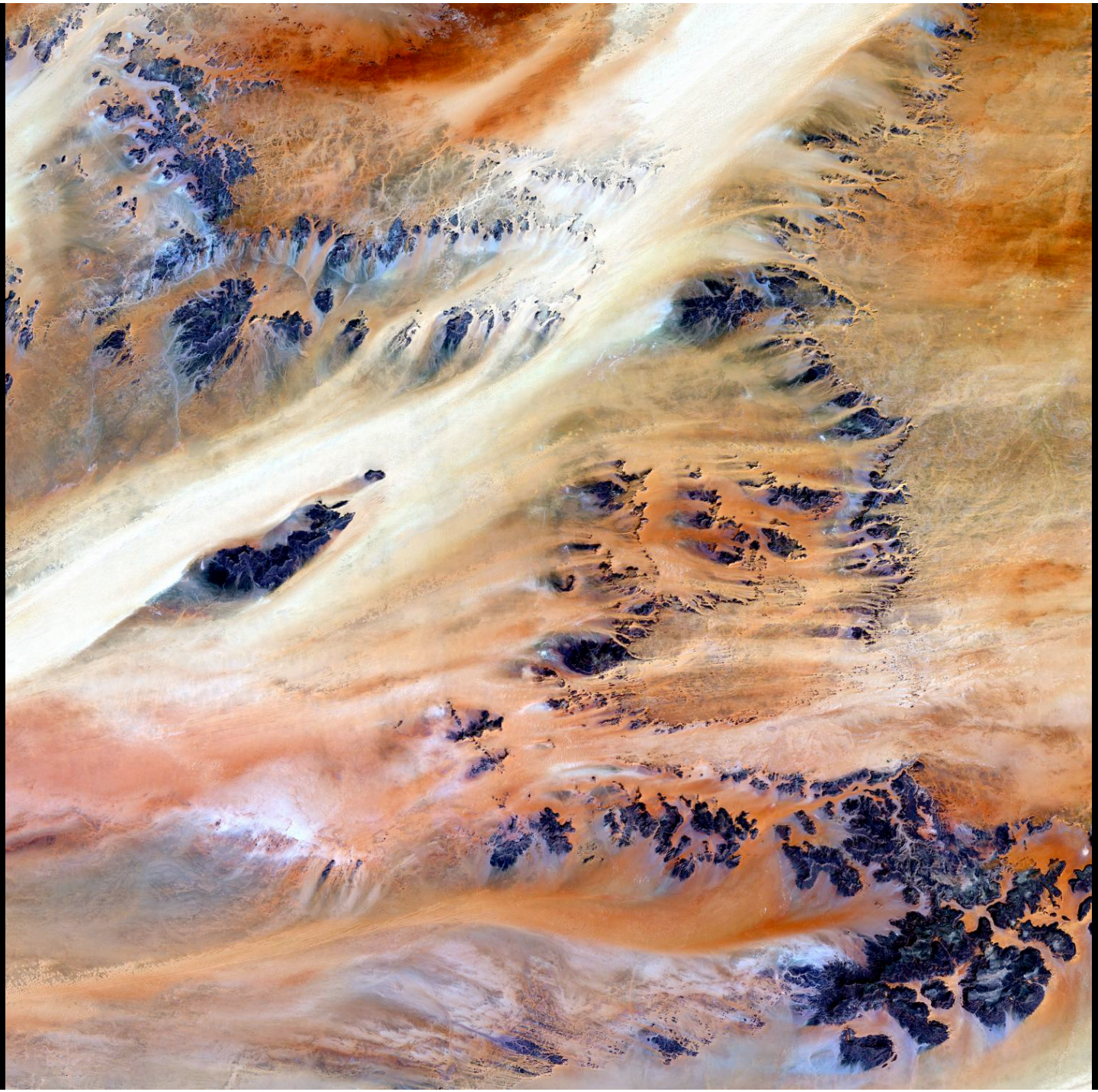


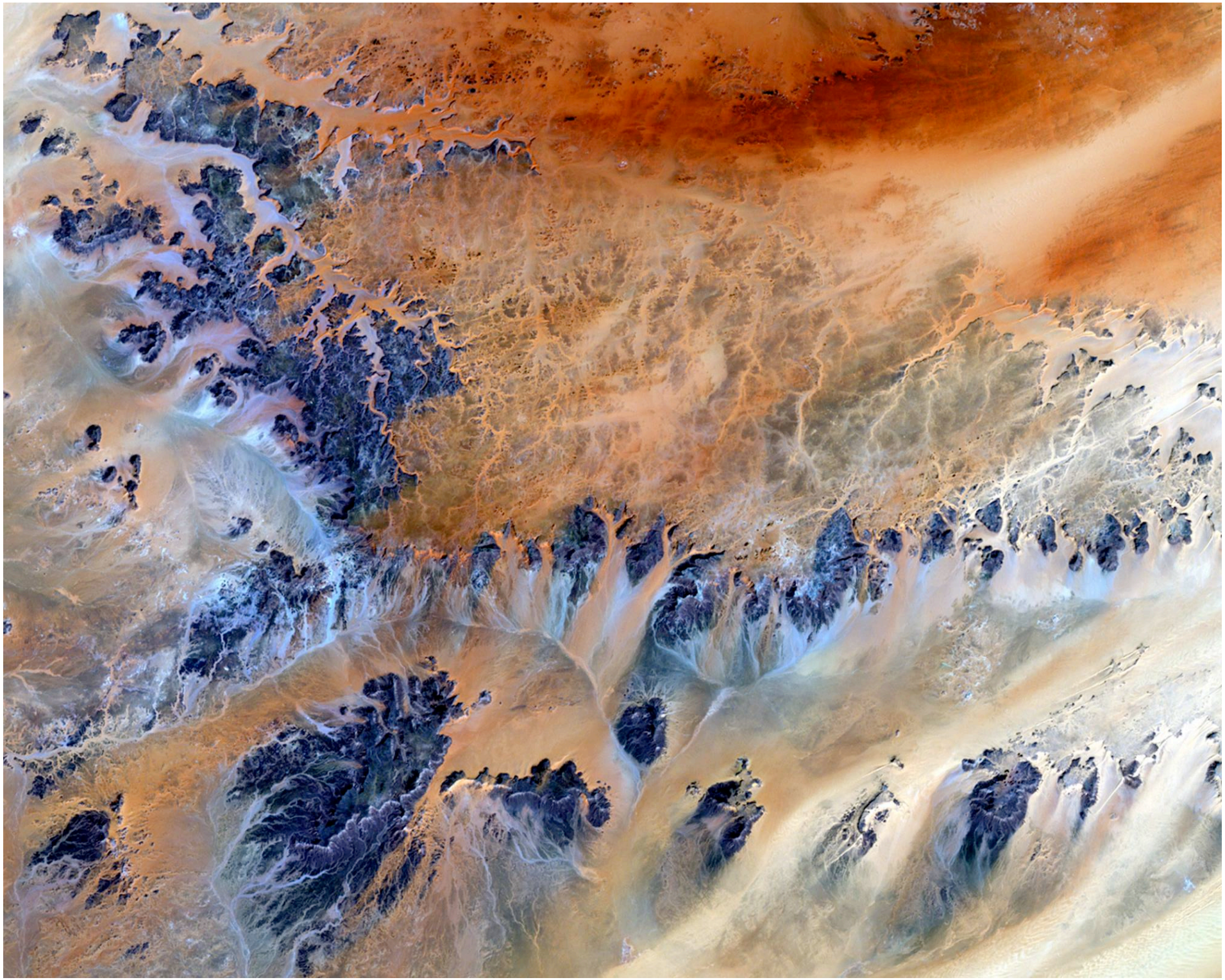


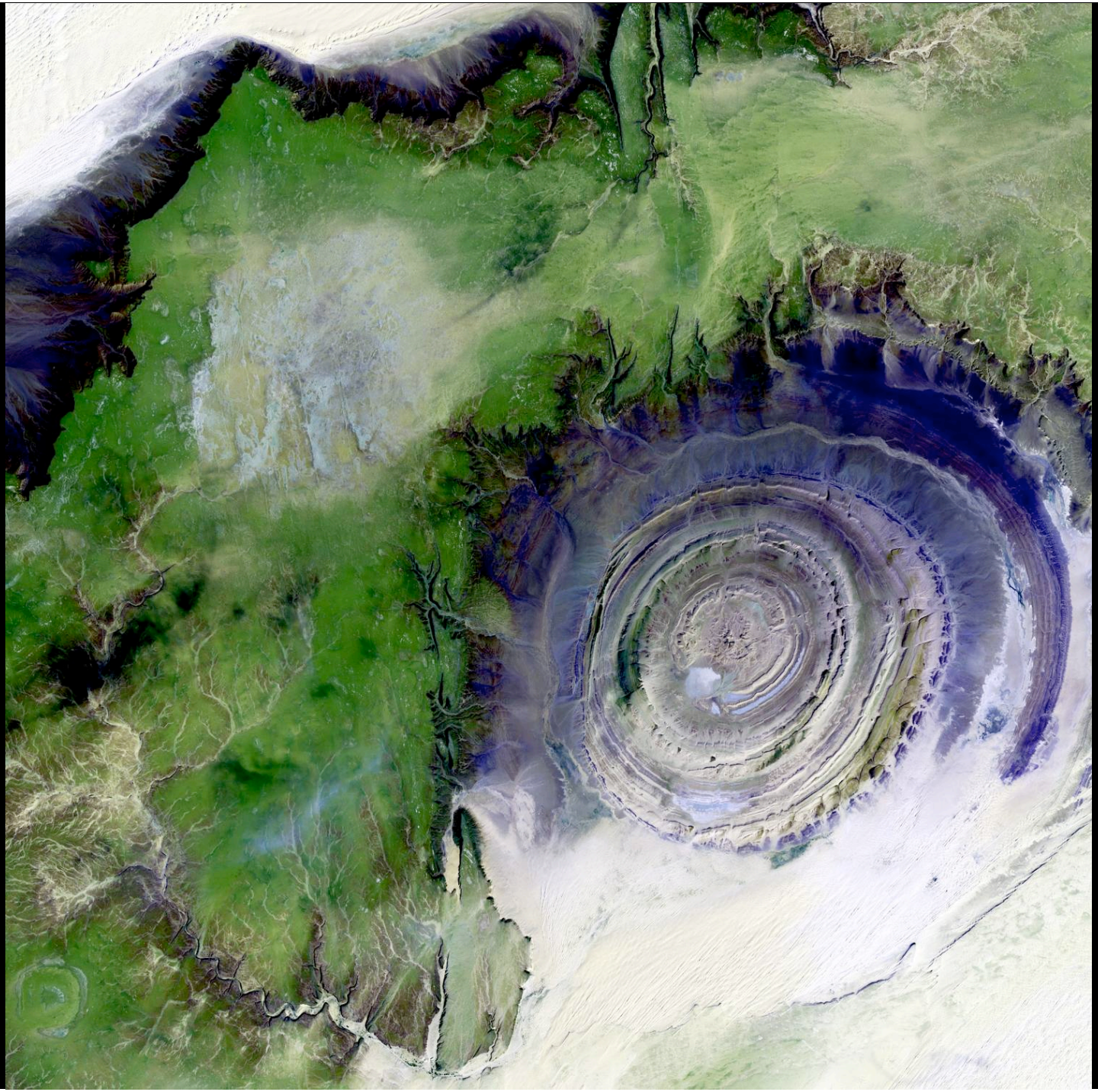


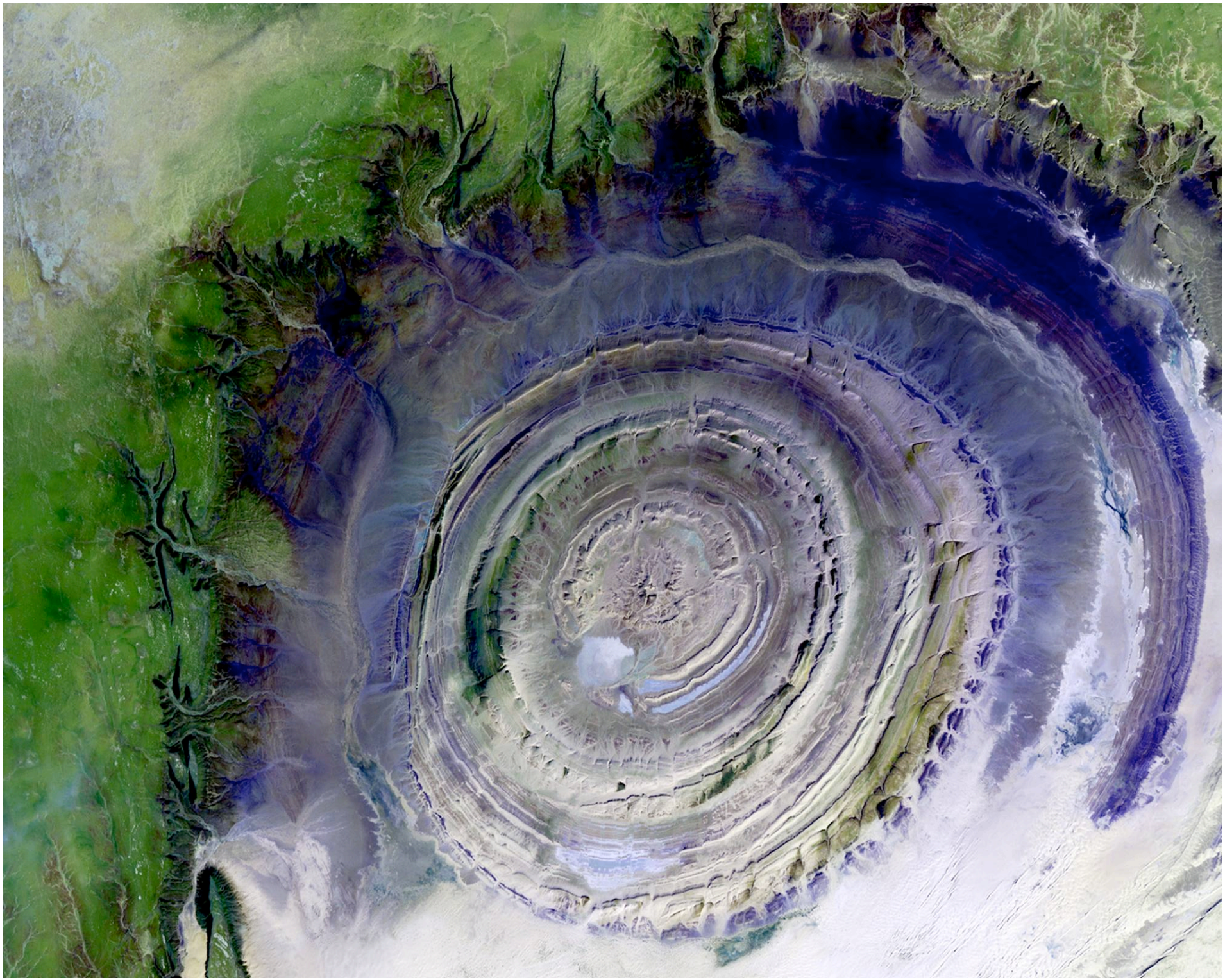


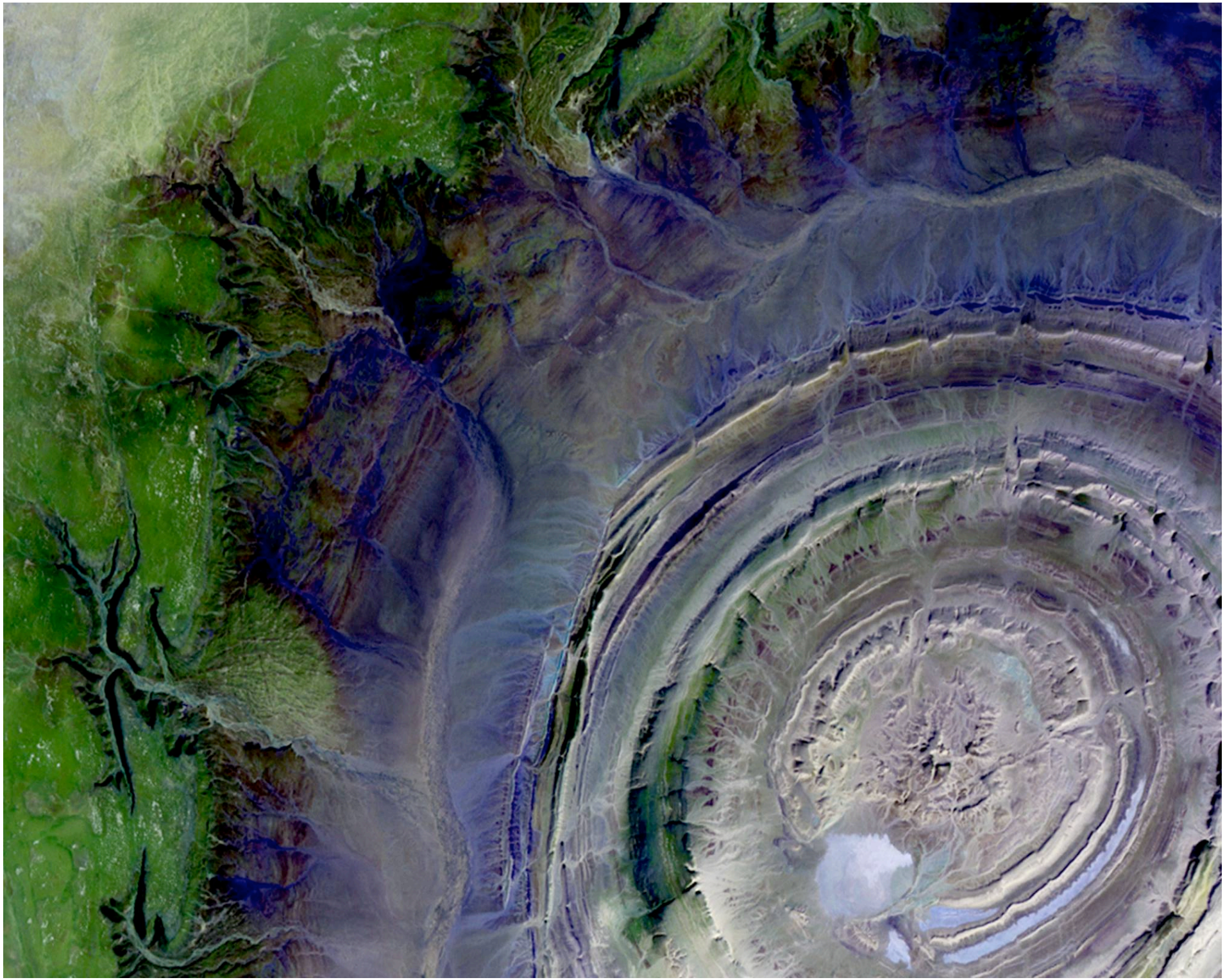


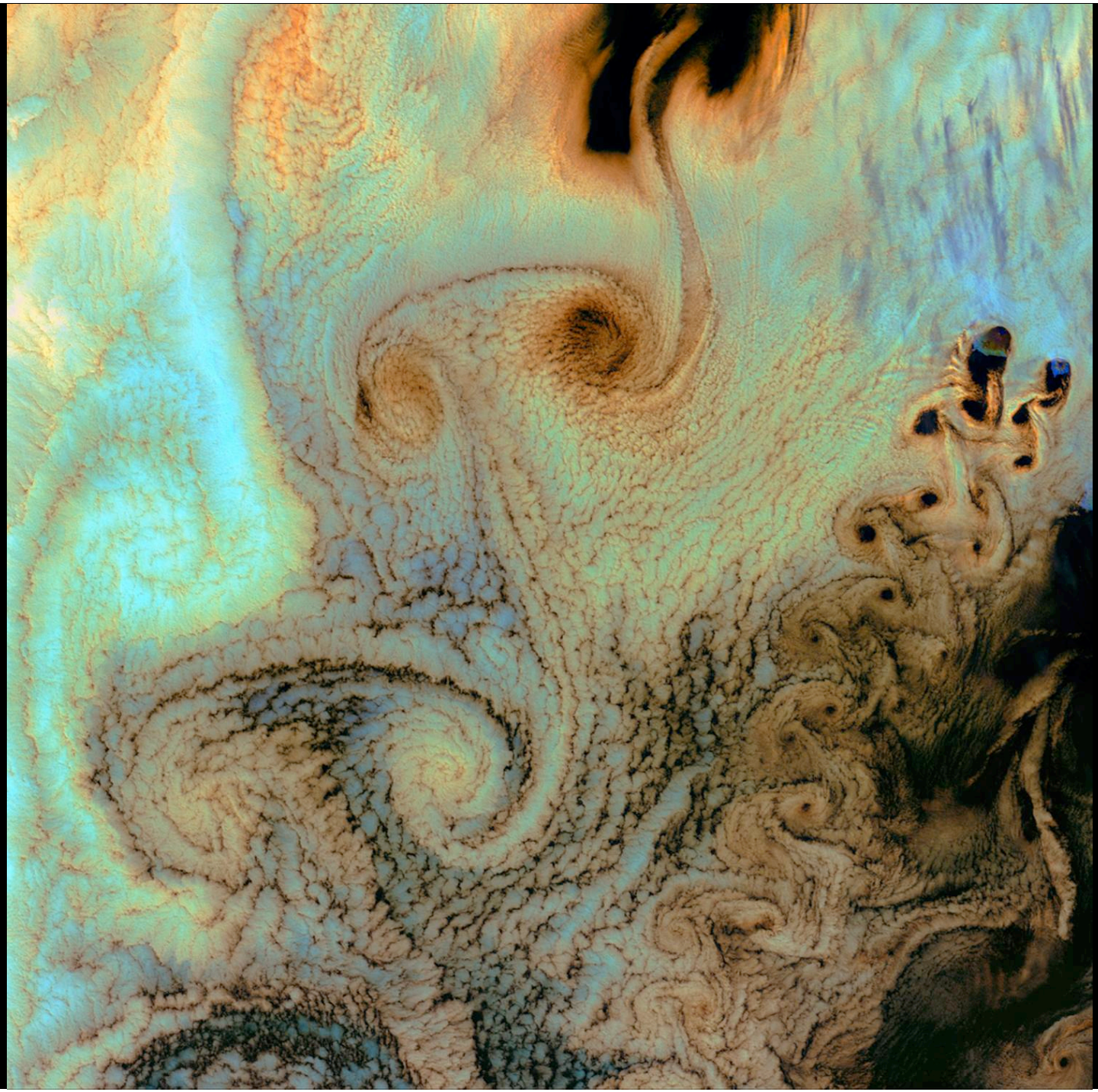


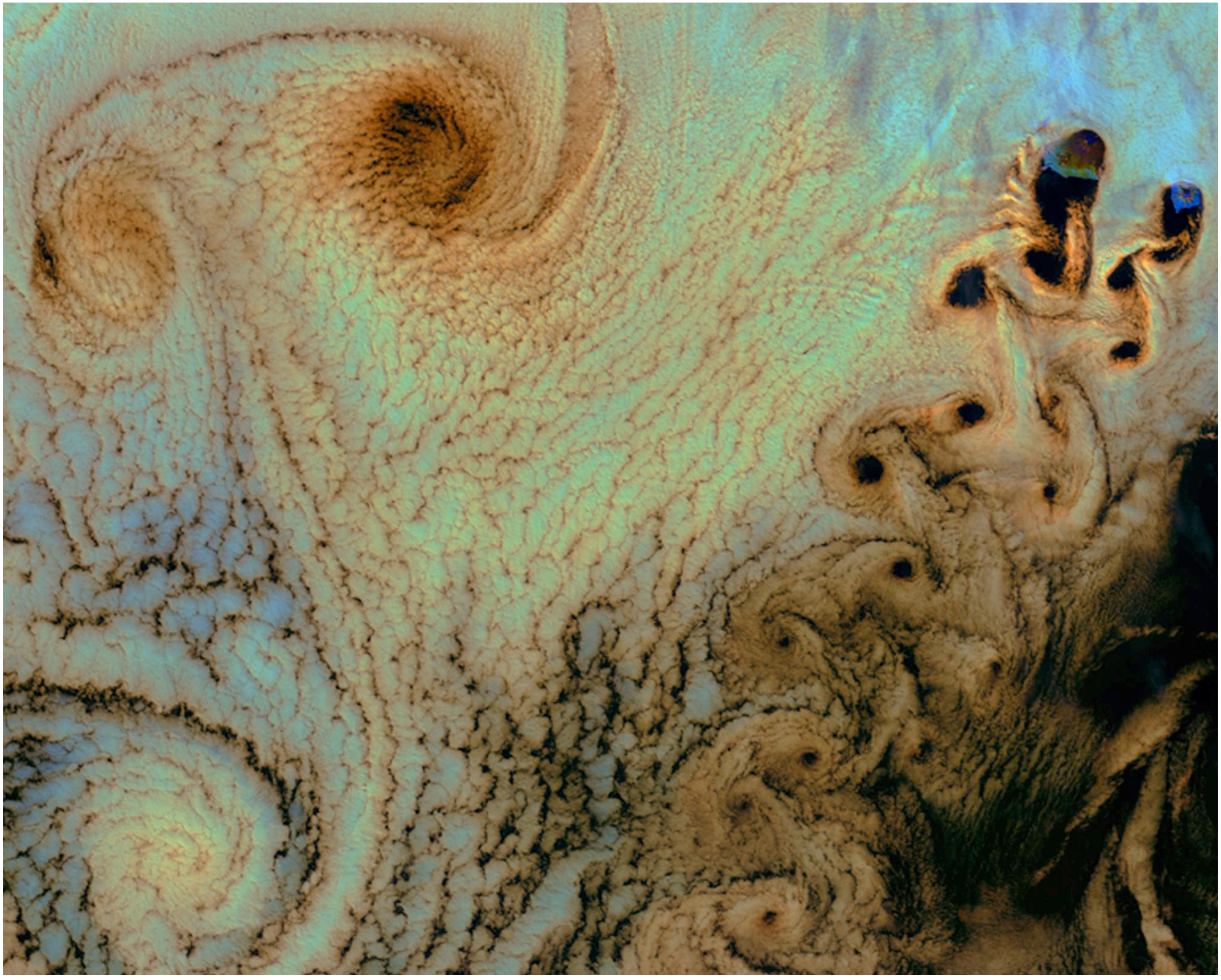


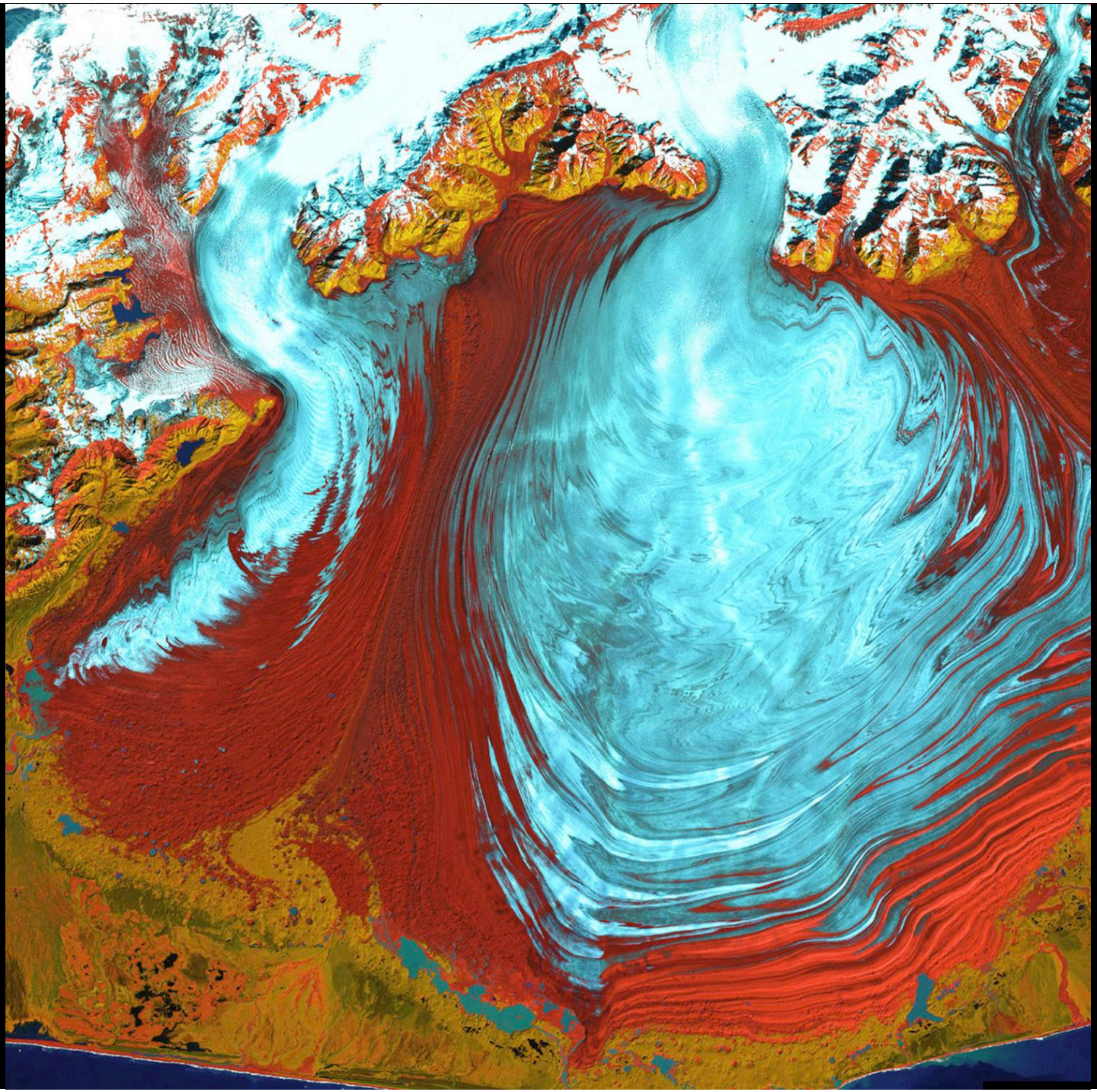


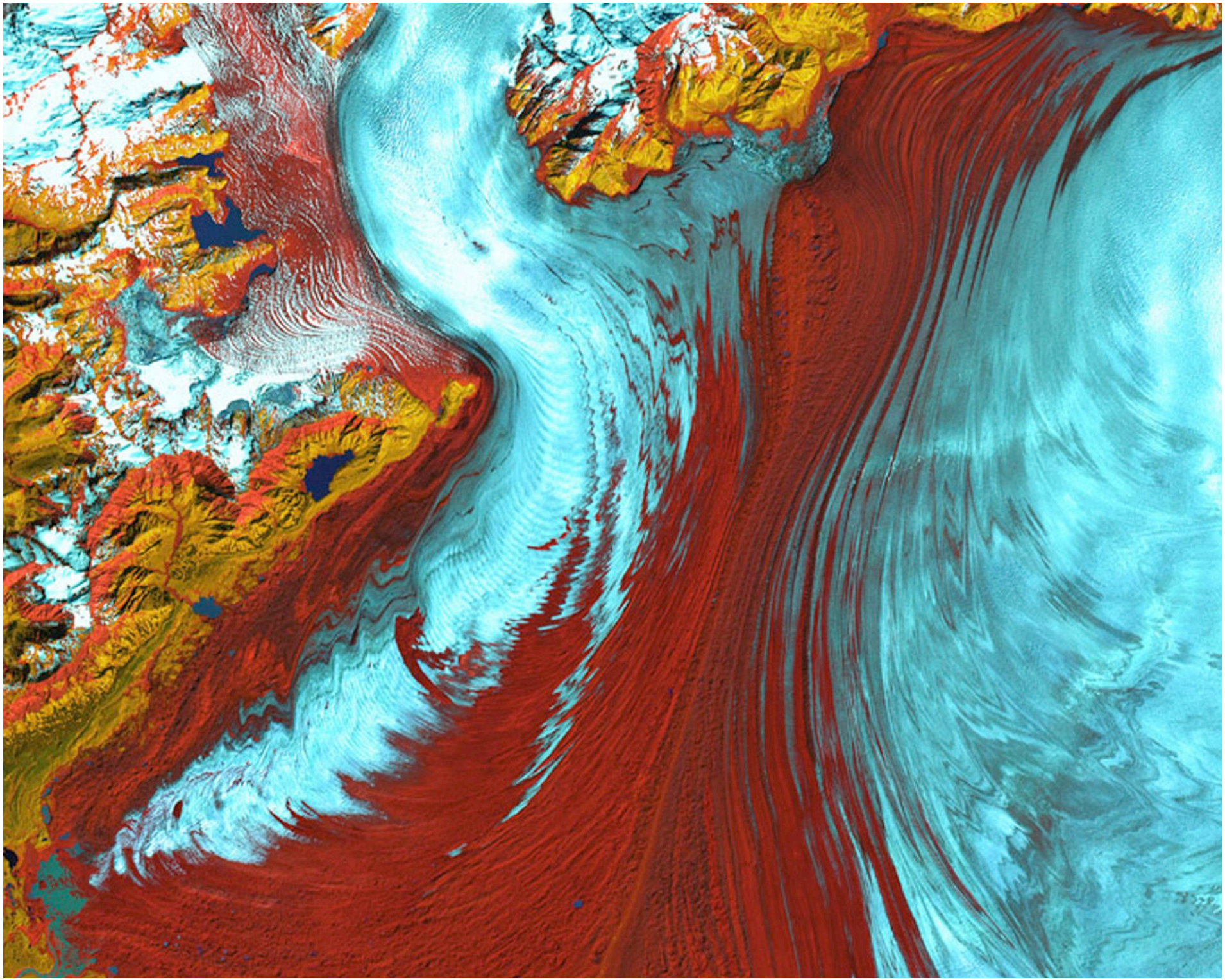


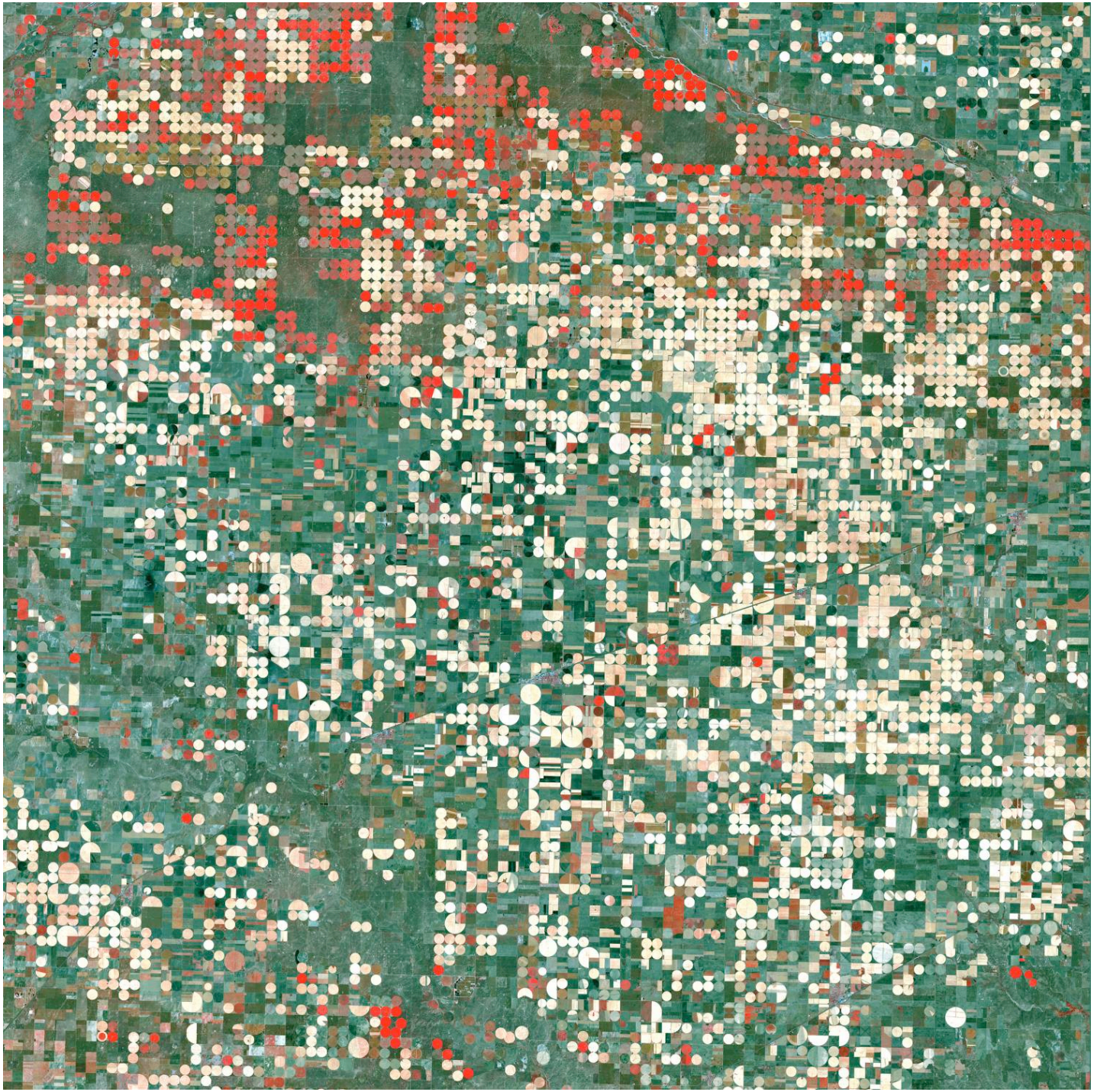


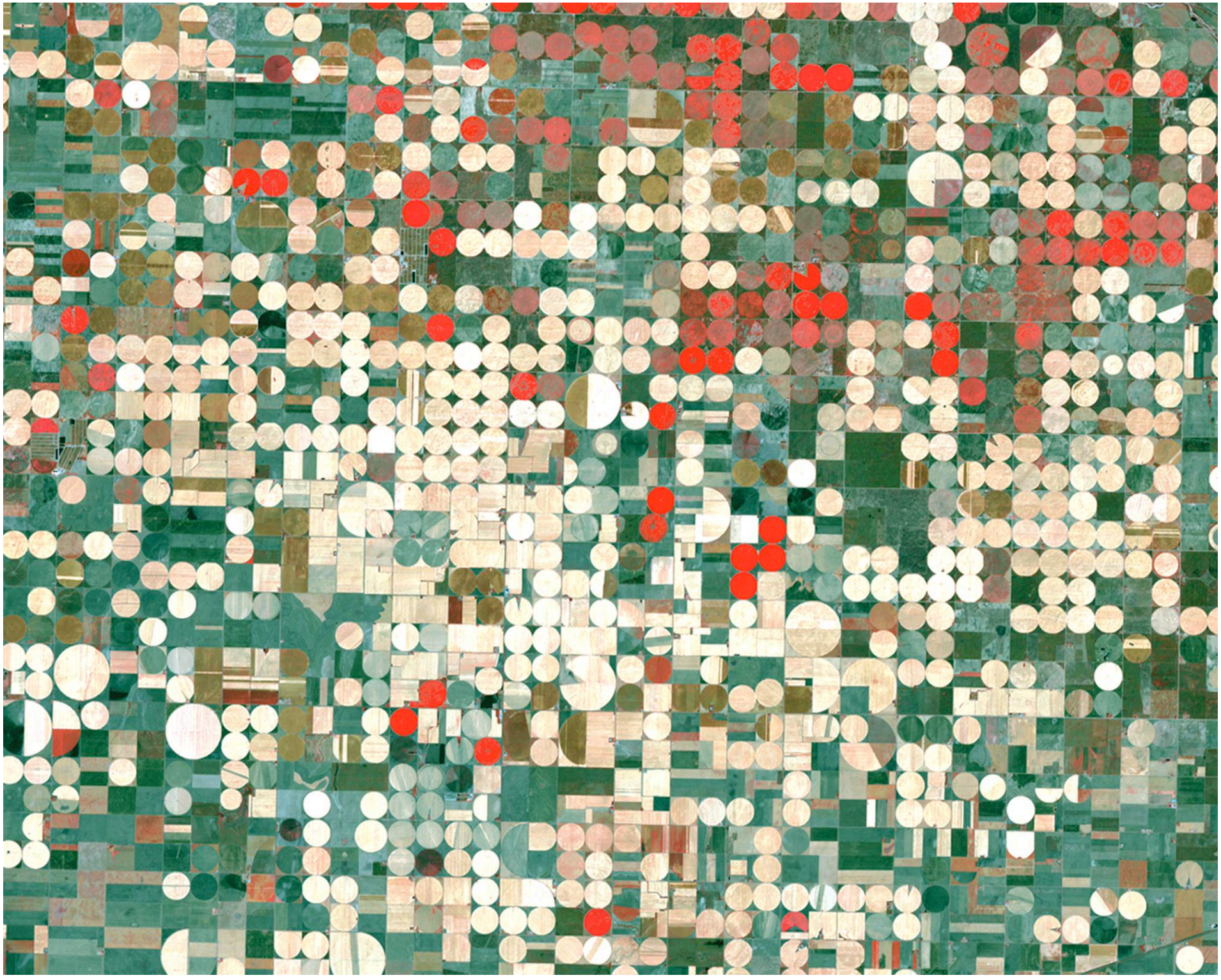


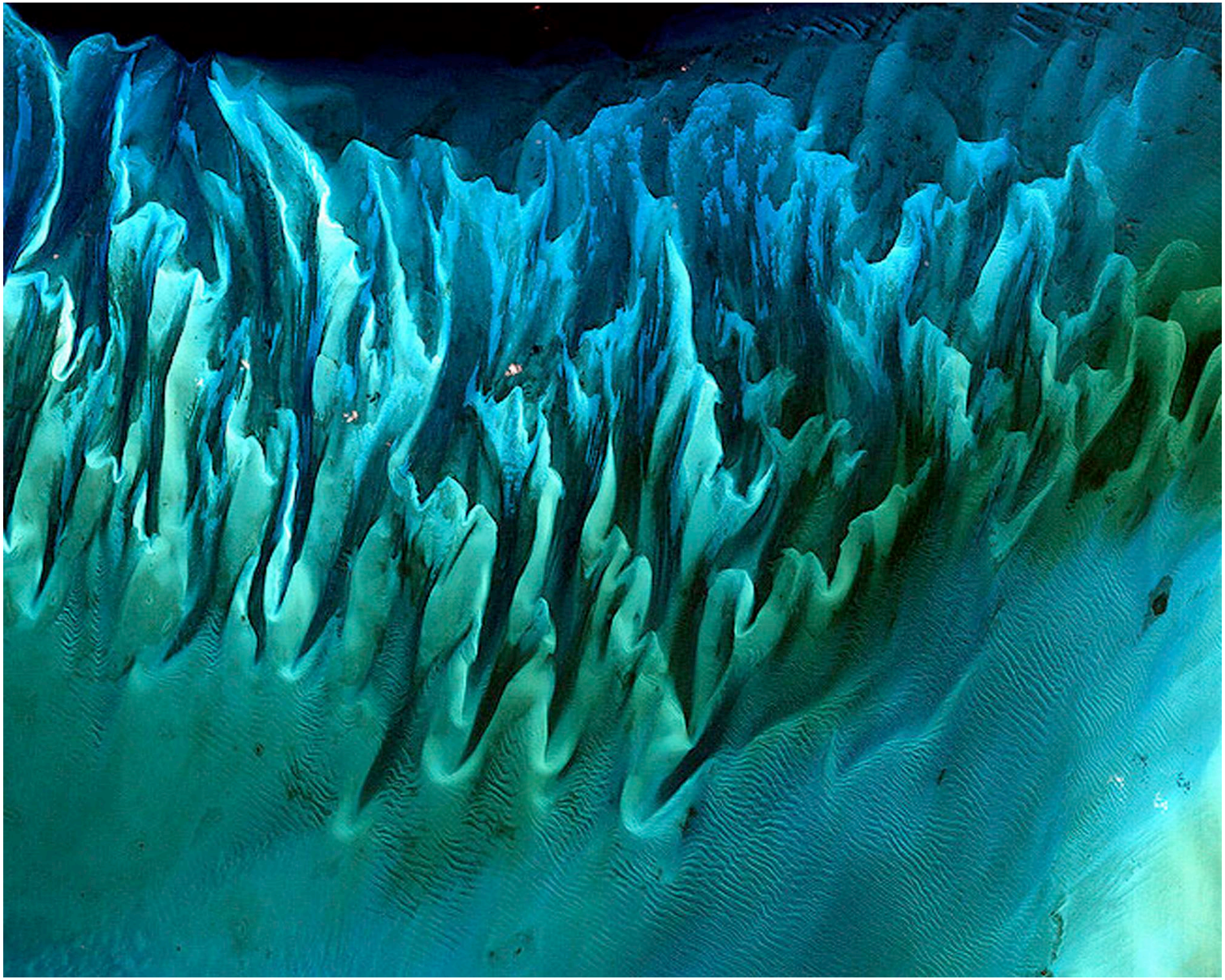


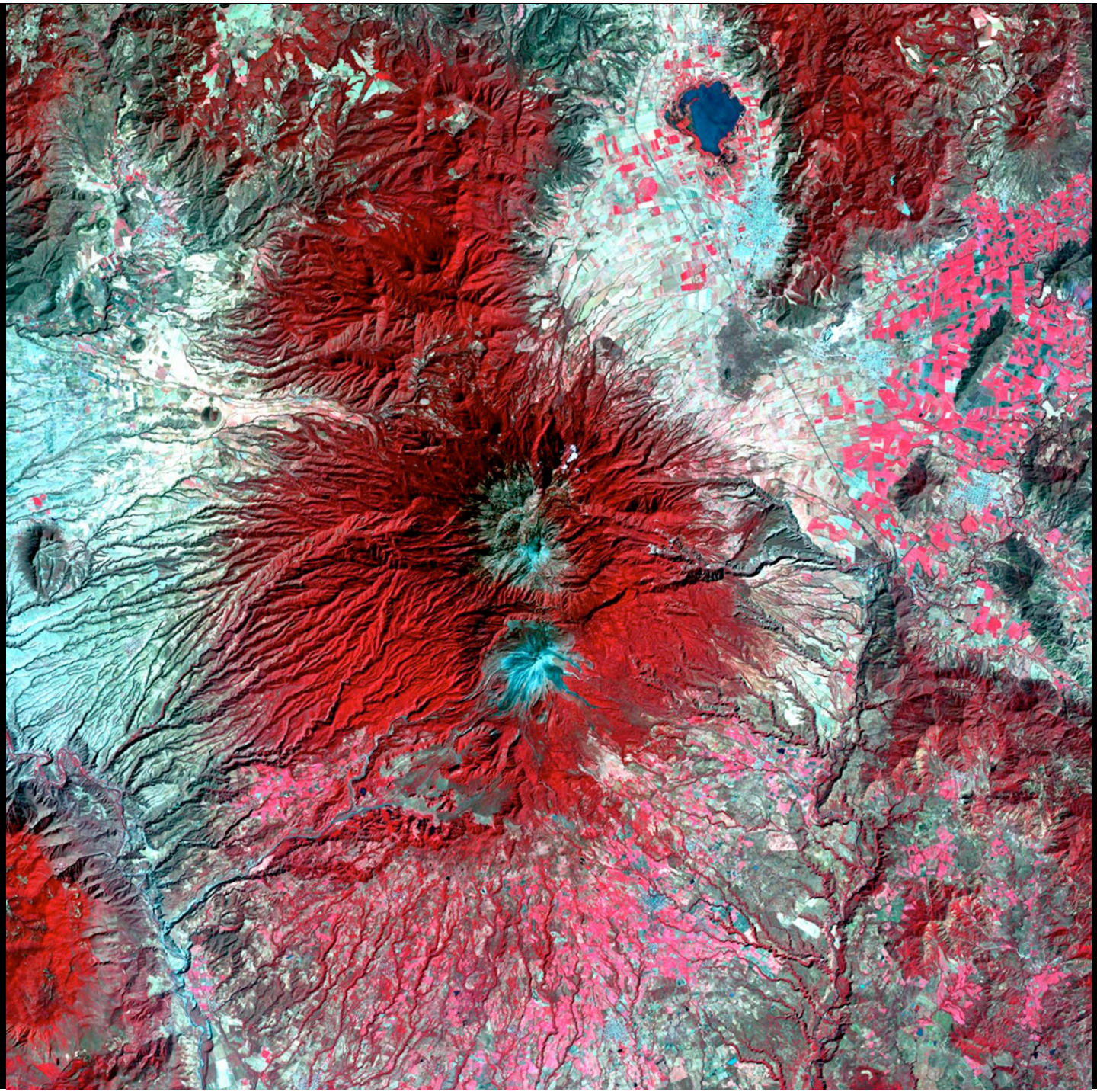


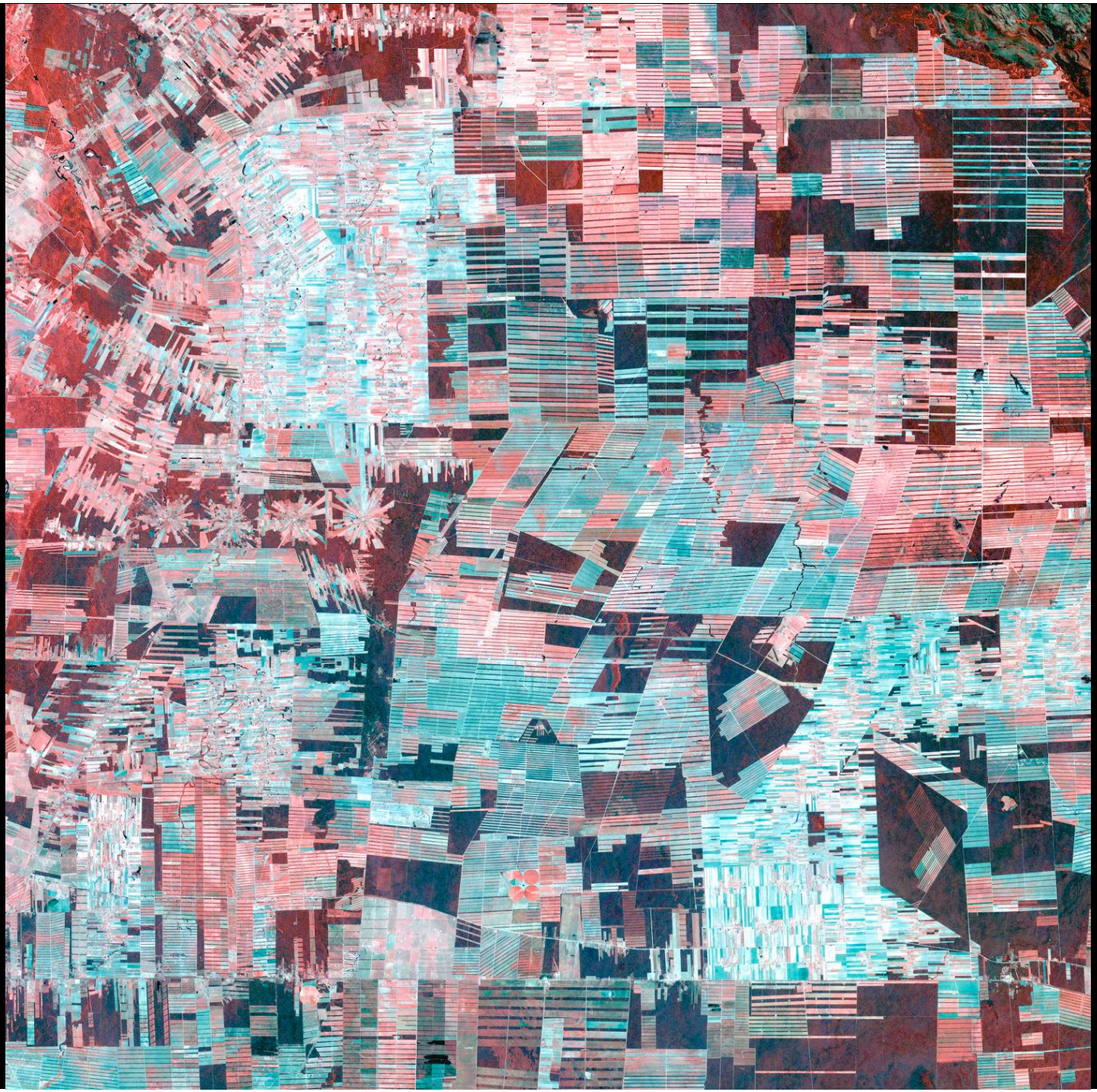


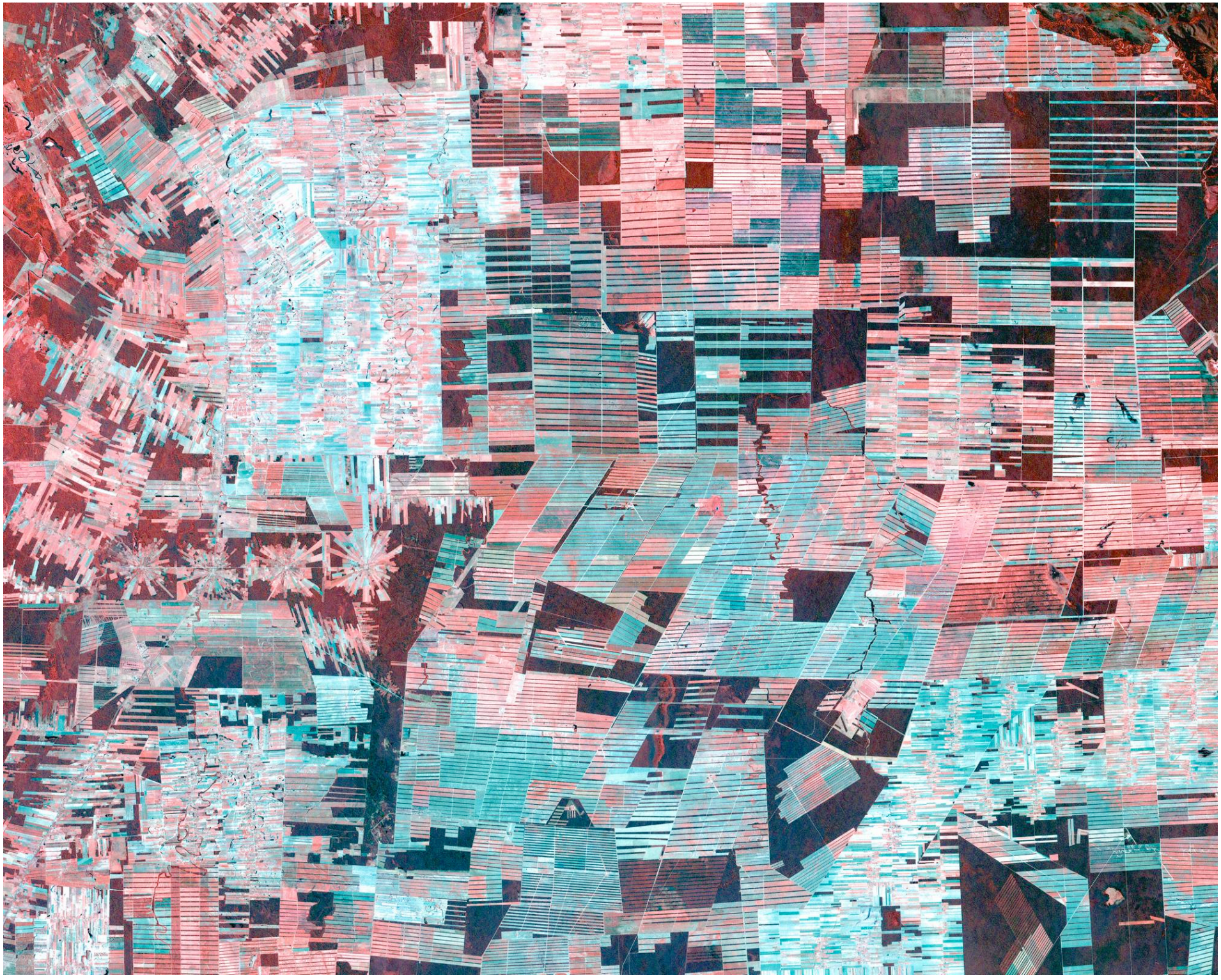


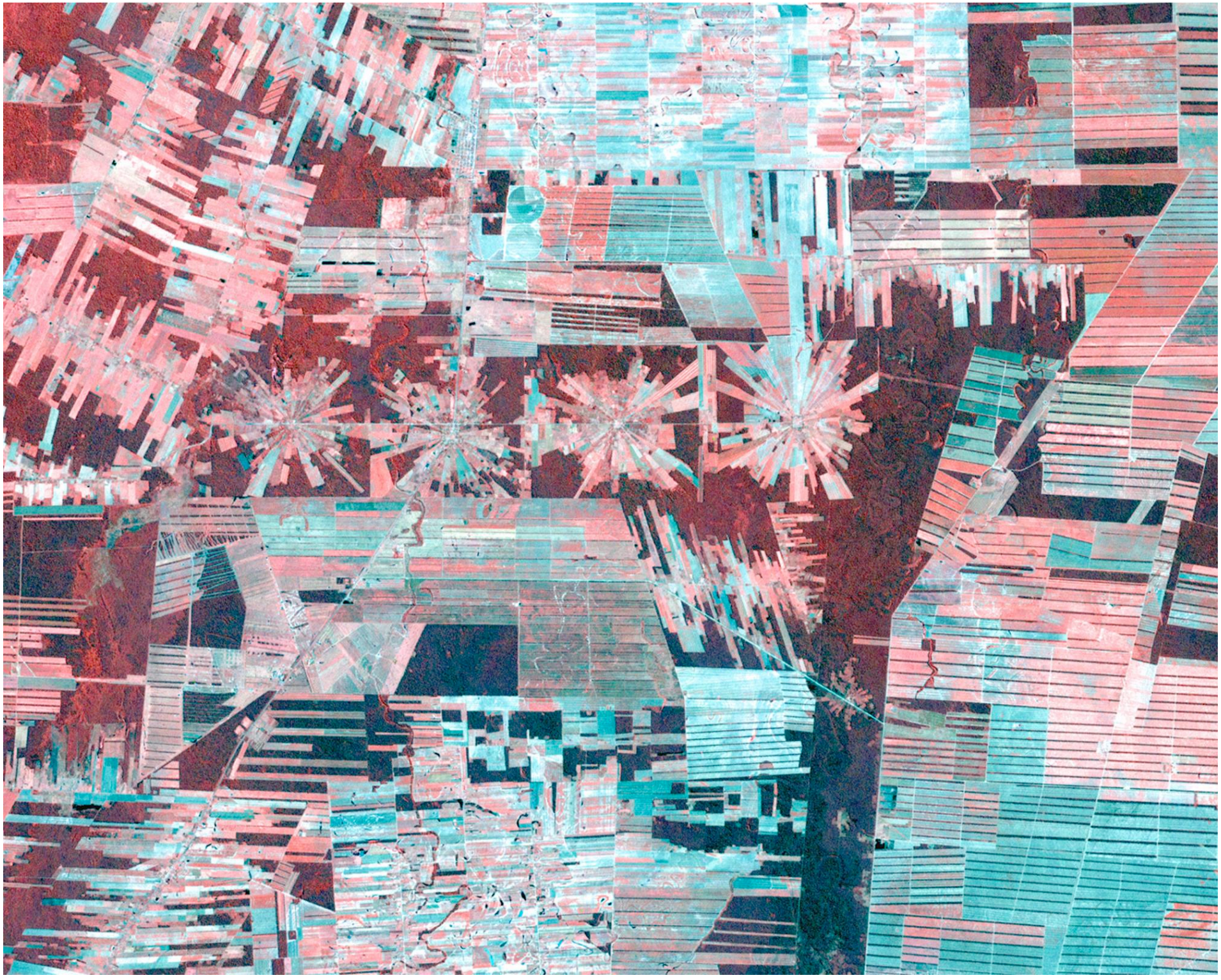












Four Frontiers of Earth Observation

Spatial Resolution

Spectral Resolution

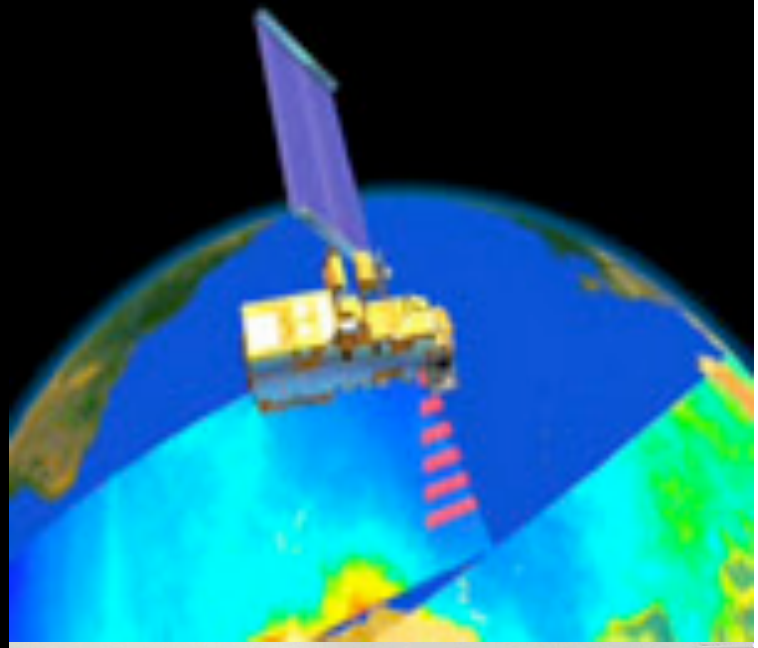
Temporal Resolution

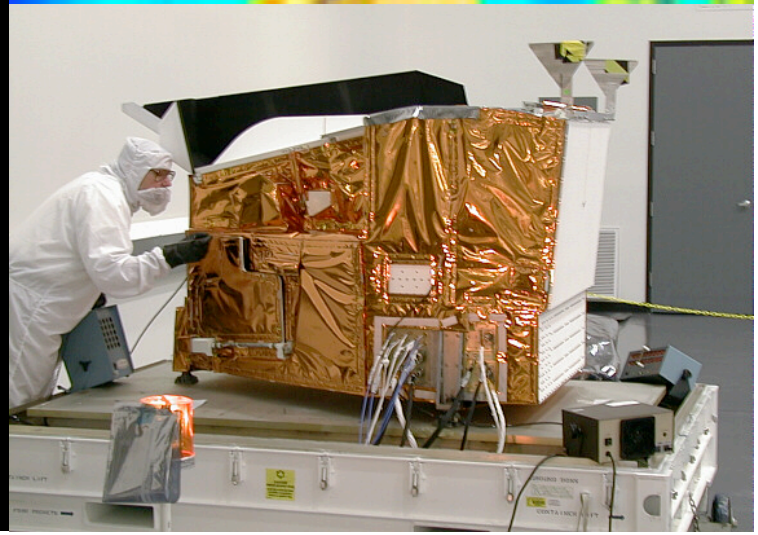
New Sensors

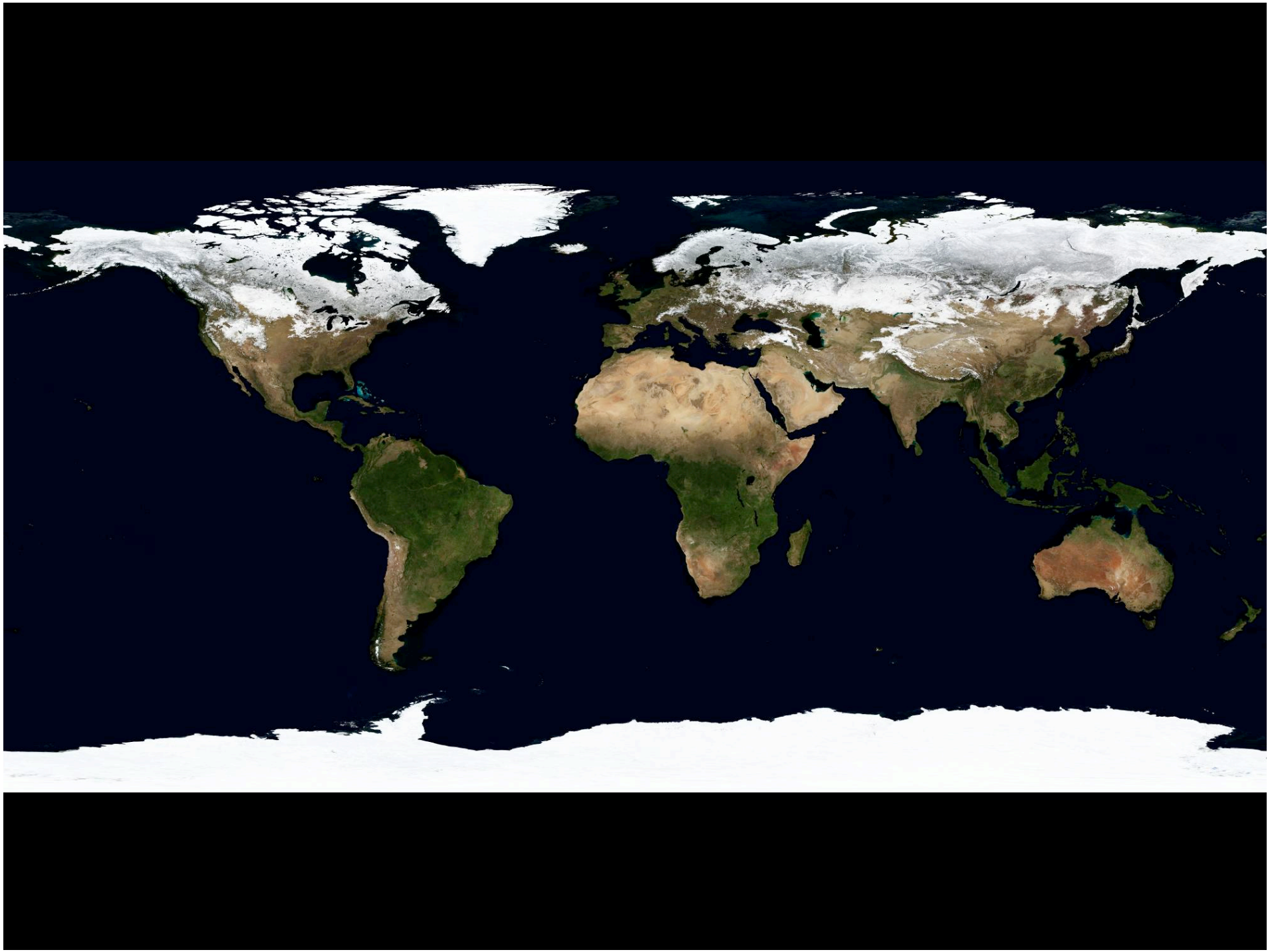
MODIS
(Moderate Resolution Imaging Spectro-radiometer)

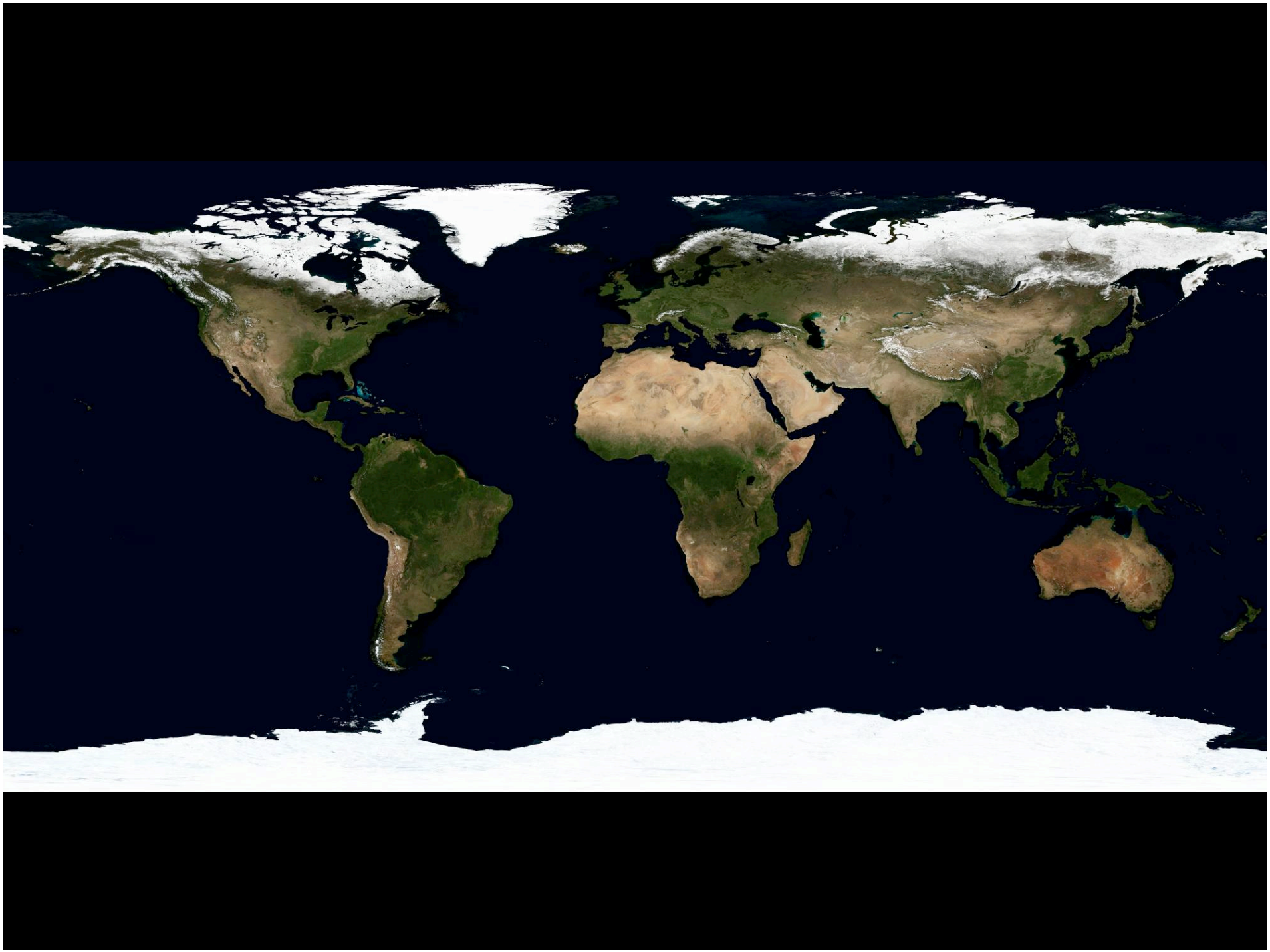
Landsat-like orbit

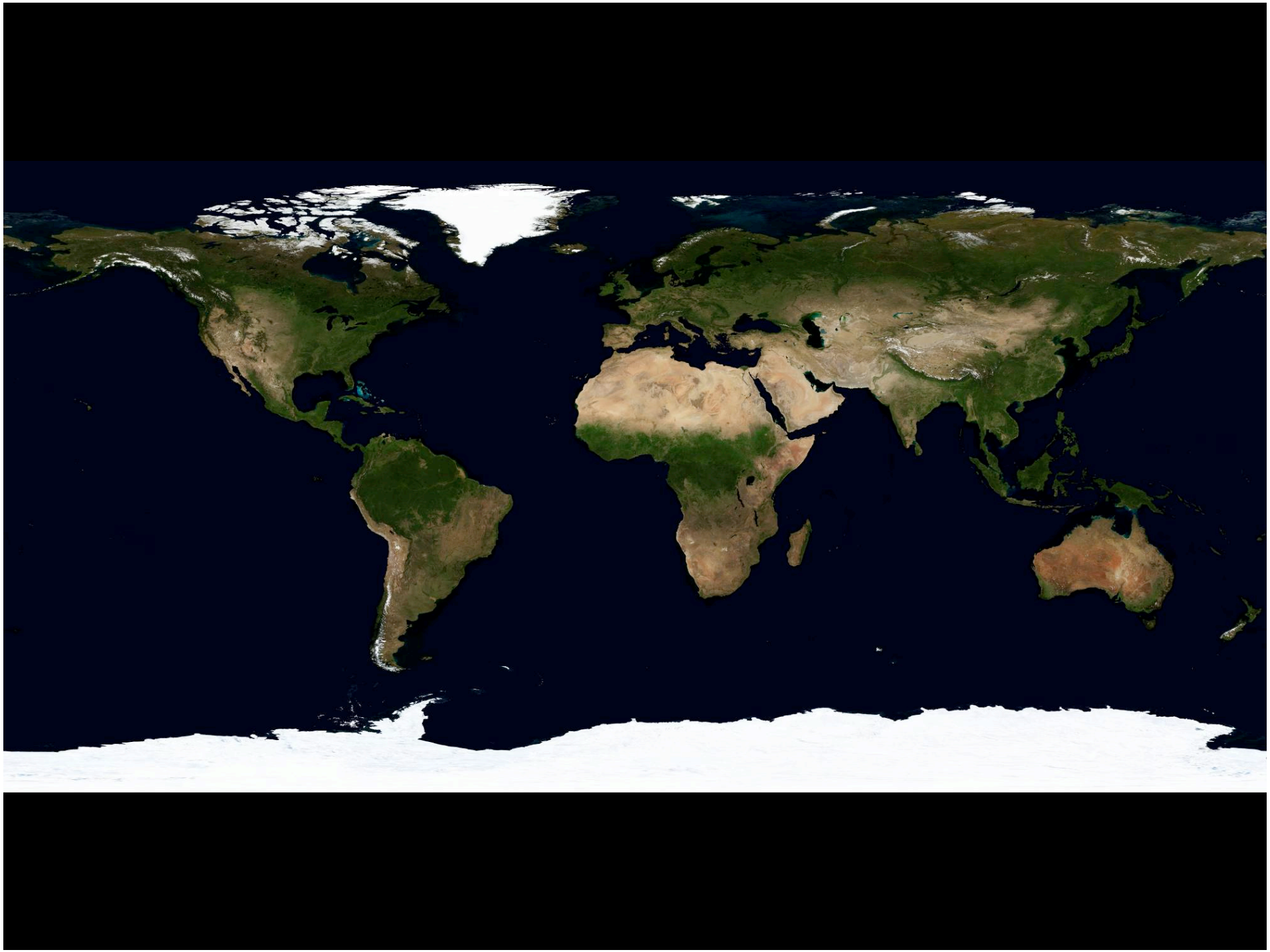
Spatial Res. ~
1km - 250m
Spectral ~
32 bands
Temporal ~
Twice-daily repeat

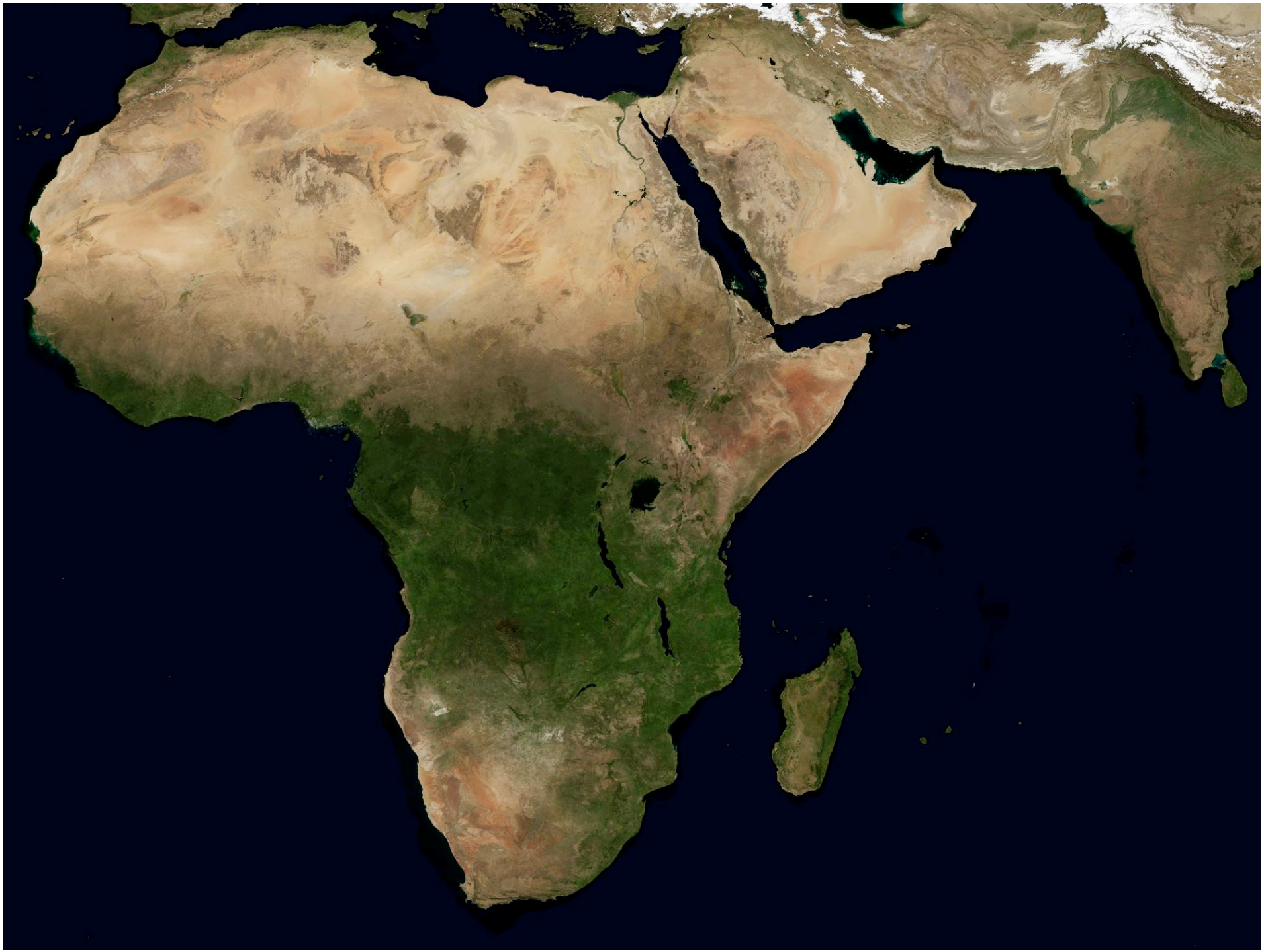


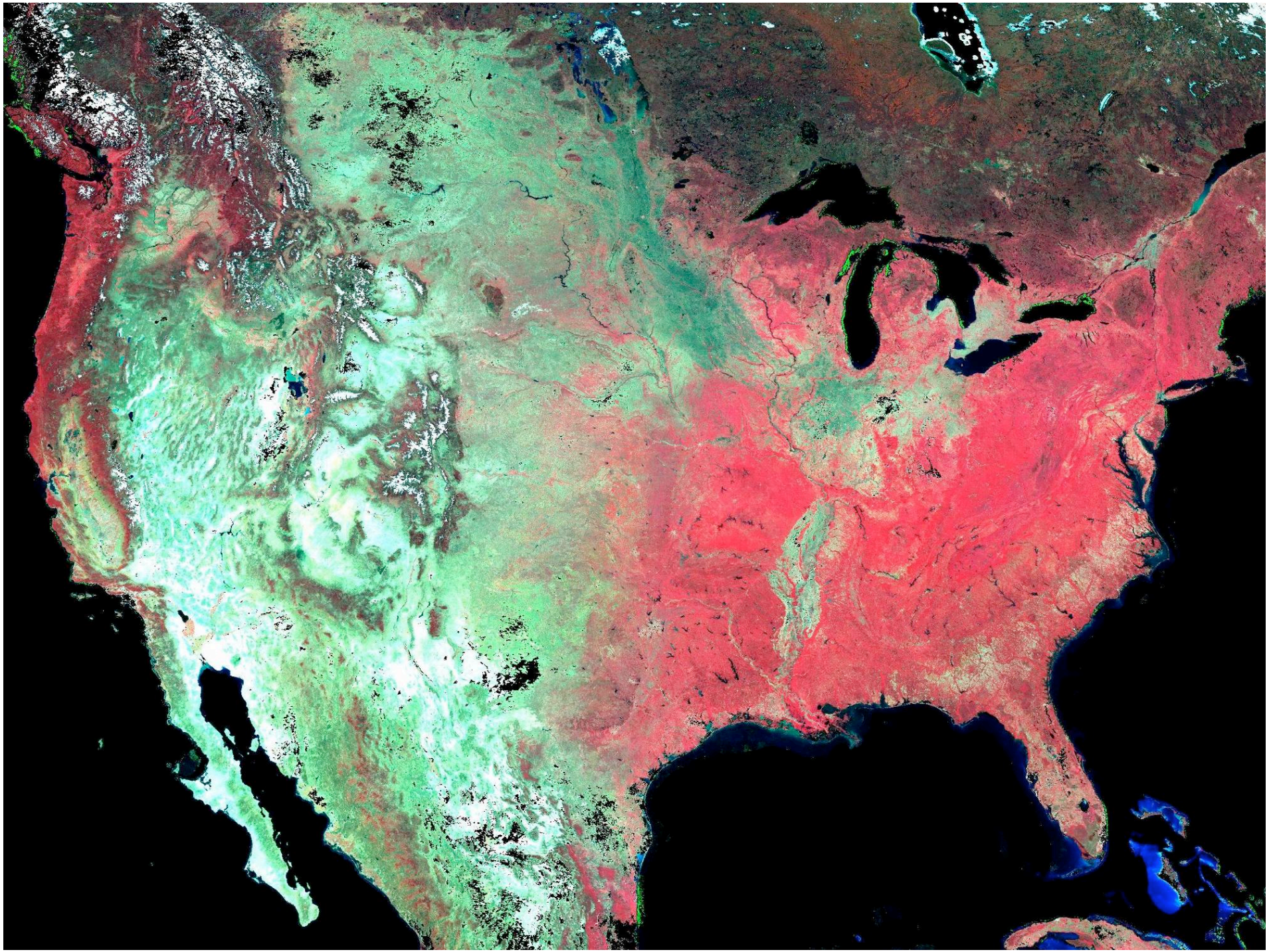




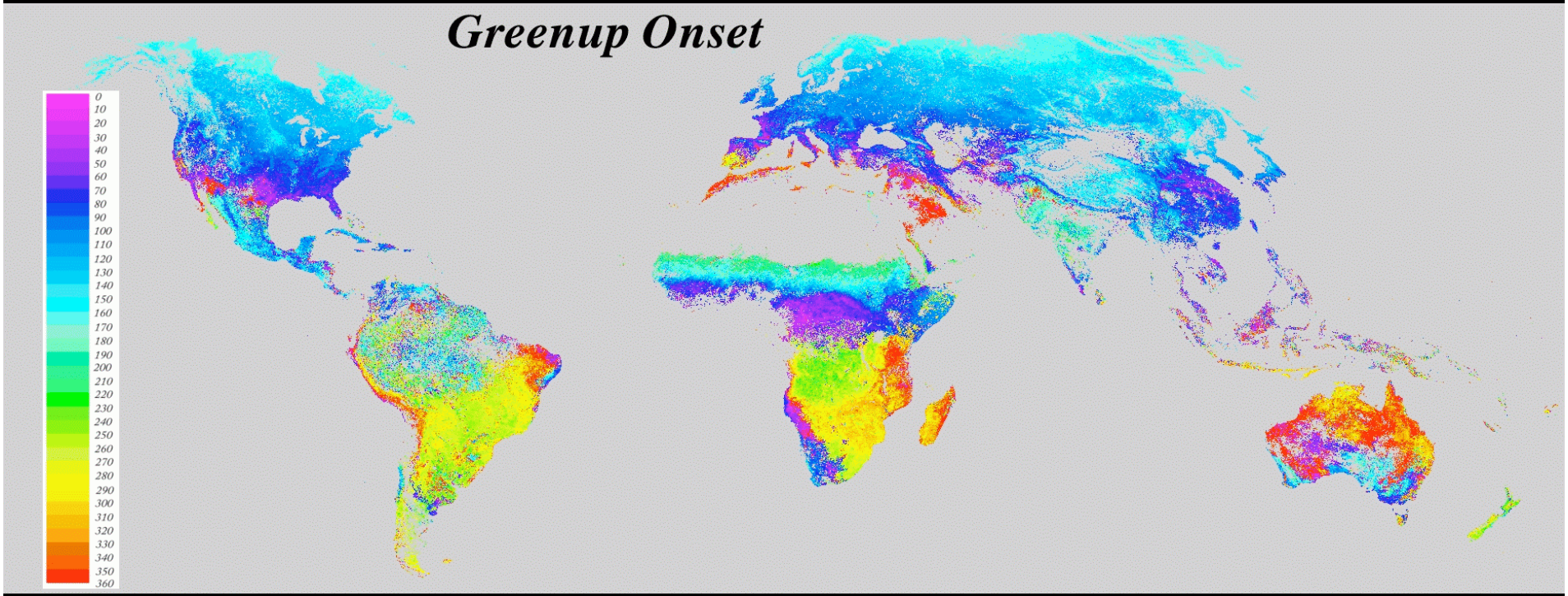




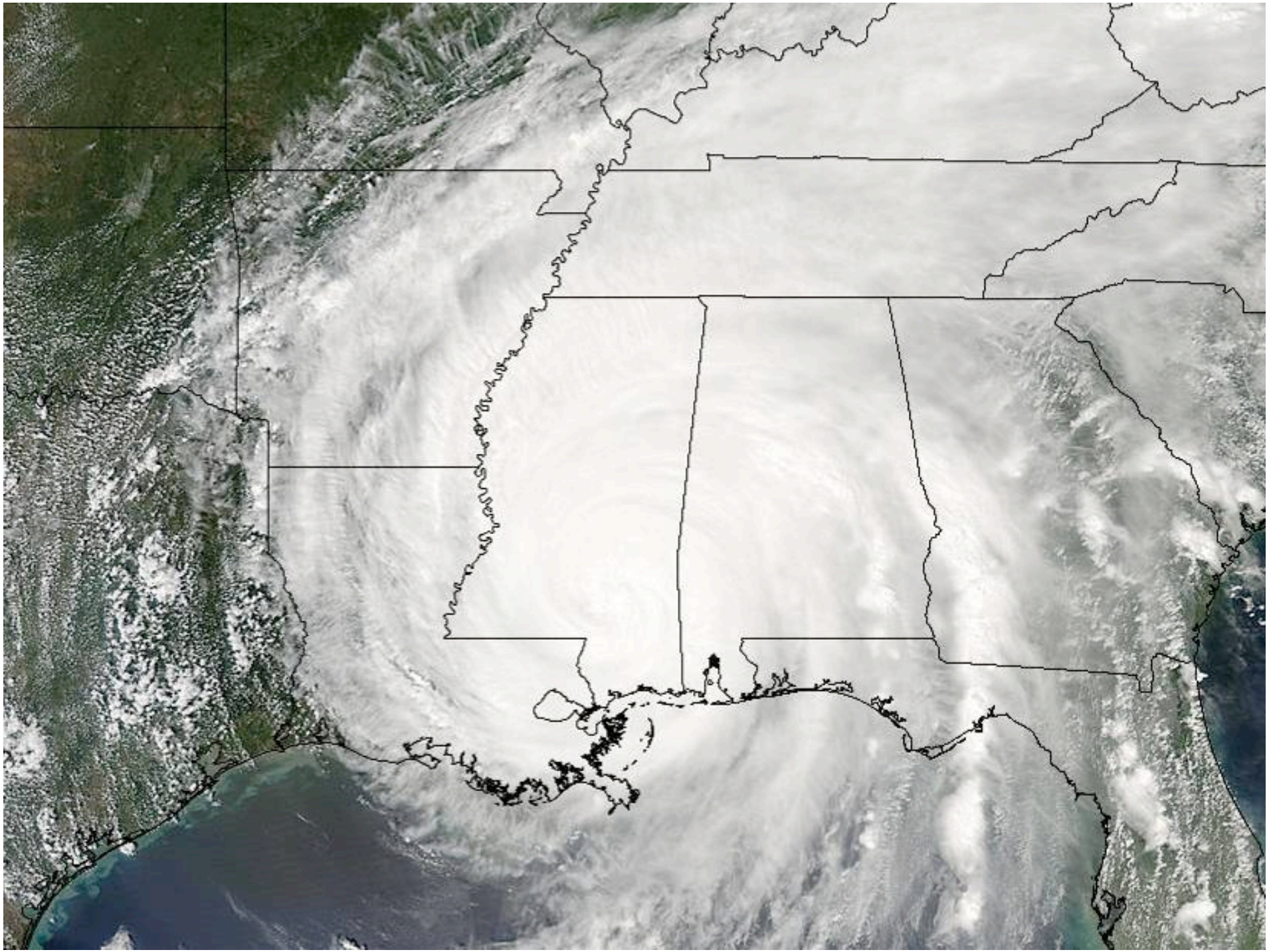




MODIS Phenology -2001



Credit: Xiaoyang Zhang



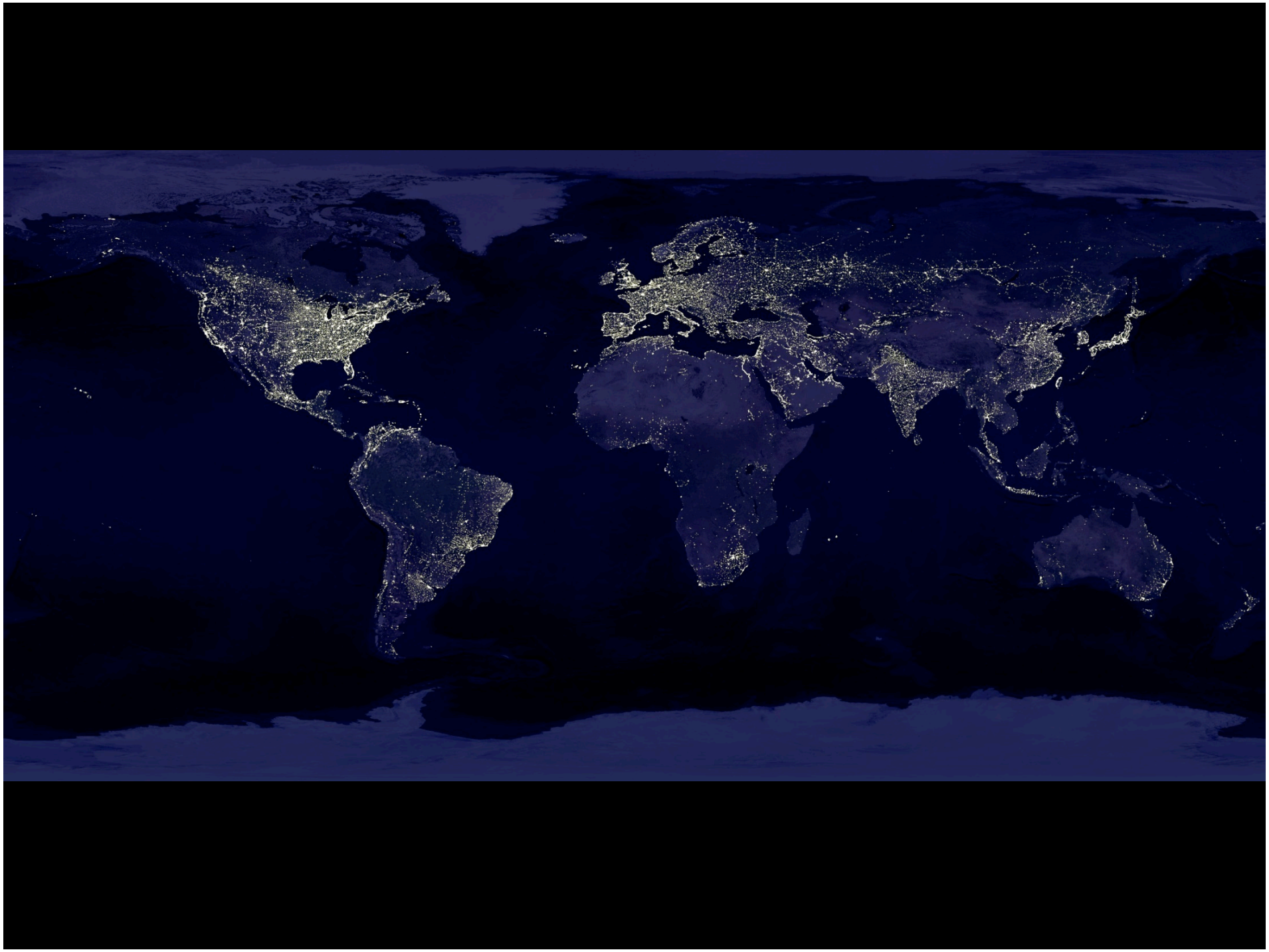
Four Frontiers of Earth Observation

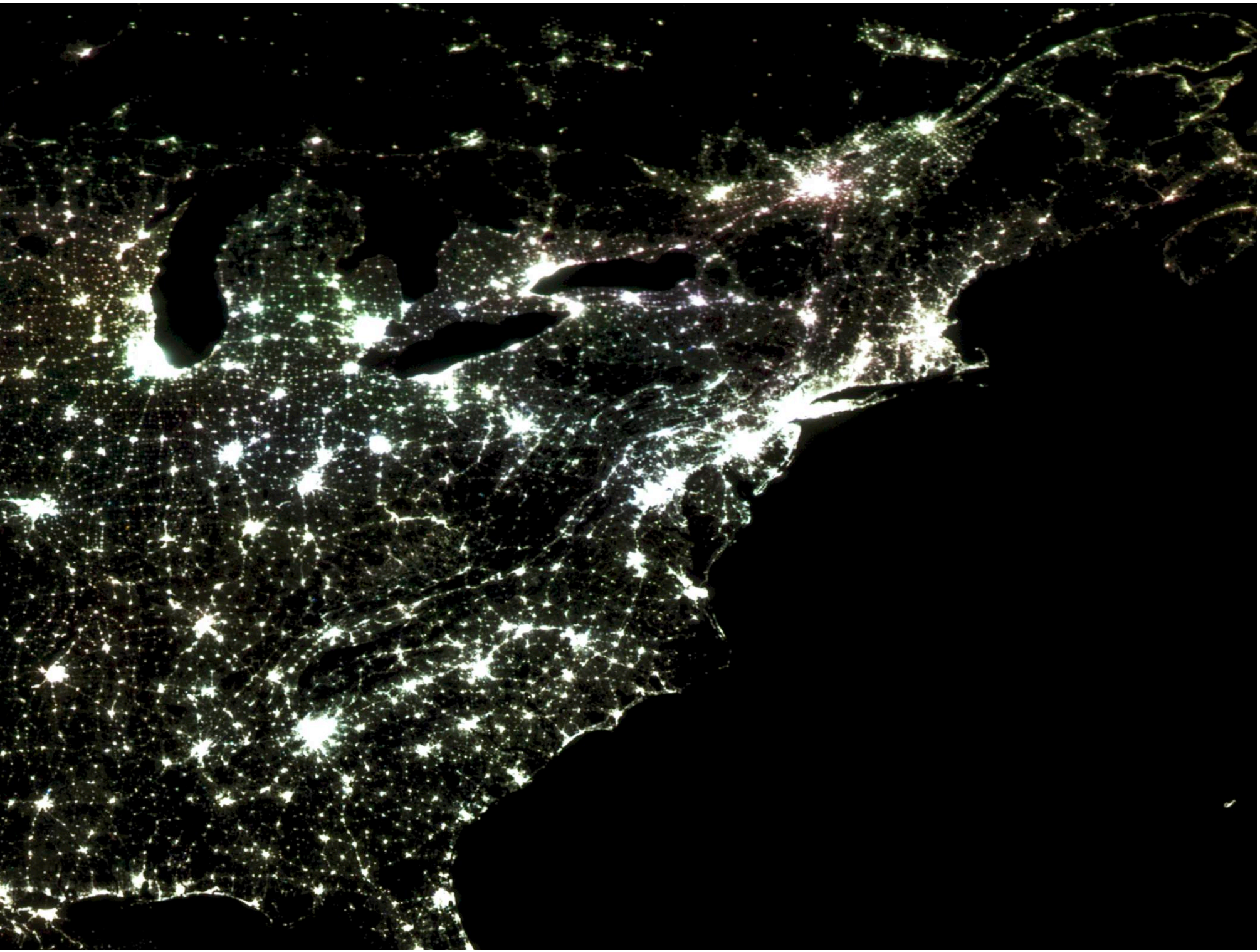
Spatial Resolution

Spectral Resolution

Temporal Resolution

New Sensors





Patterns of Forest Clearing along the Appalachian Trail Corridor

Potere, D., C.E. Woodcock, A. Schneider, M. Ozdogan, A. Baccini. Patterns in Forest Clearing along the Appalachian Trail Corridor, *Photogrammetric Engineering and Remote Sensing* (forthcoming, June 2007).

Photo © Frank Logue

The Appalachian Trail from Maine to Georgia

Forest Dynamics

Growth
- replanting
- natural succession

Mortality
- fire
- disease, pests, invasives
- drought, flooding, storms

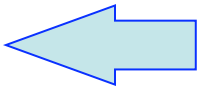
Clearing
- harvest (land cover change)
- development (land use change)

Photos courtesy of www.forestryimages.org and USFS.

Mapping Forest Clearing using Remote Sensing

Acquire Images

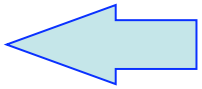
Correct Images



GeoCover Landsat Dataset

Interpret Images

Change Detection



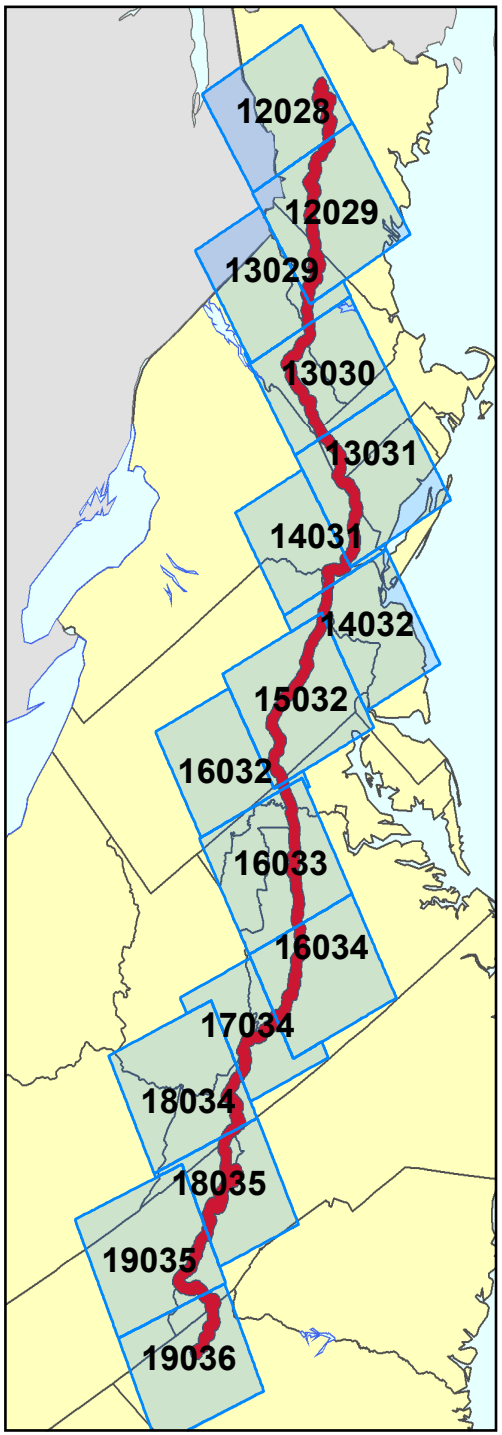
Multitemporal Kauth-Thomas Transforms

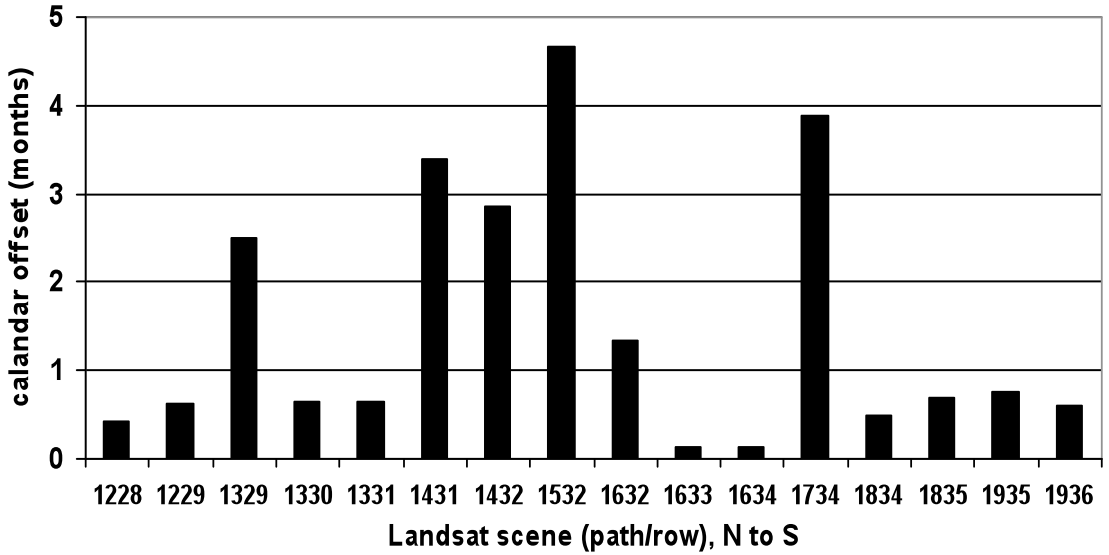
Decision Tree Classifiers

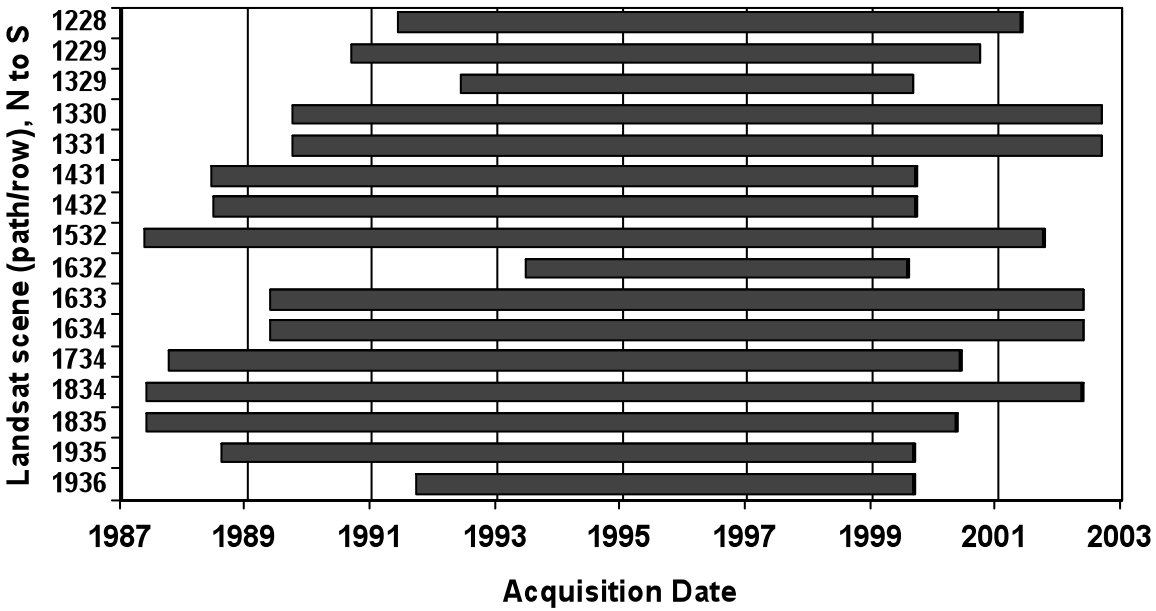
Editing

Accuracy Assessment

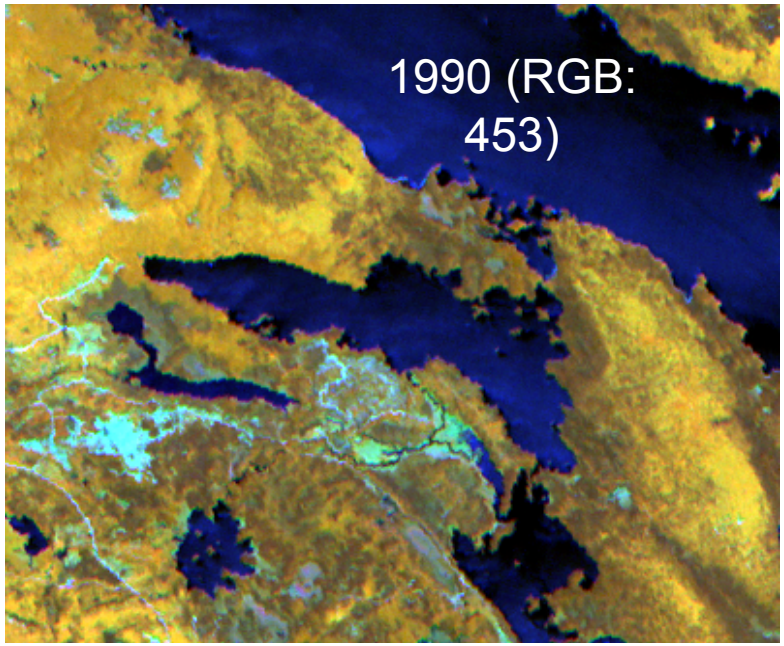
Image Acquisition and *GeoCover*

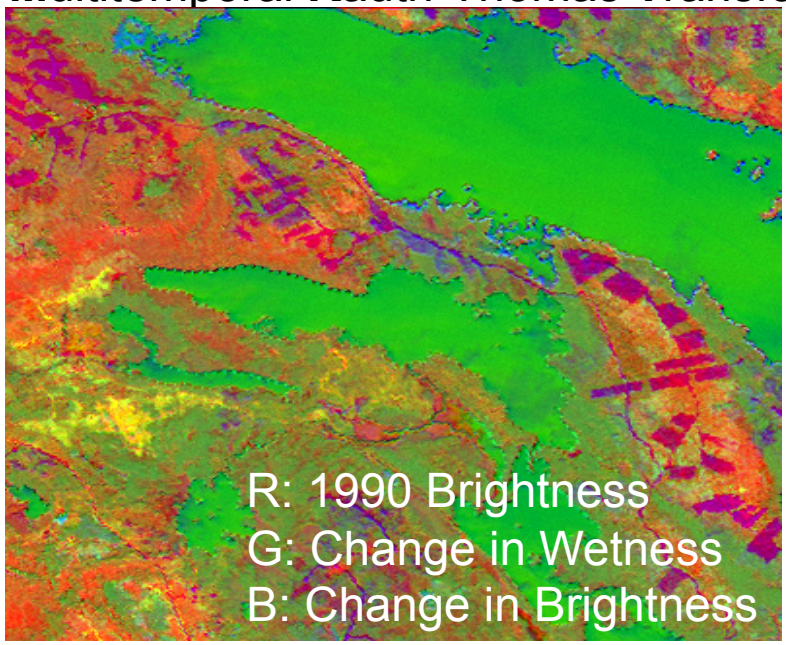


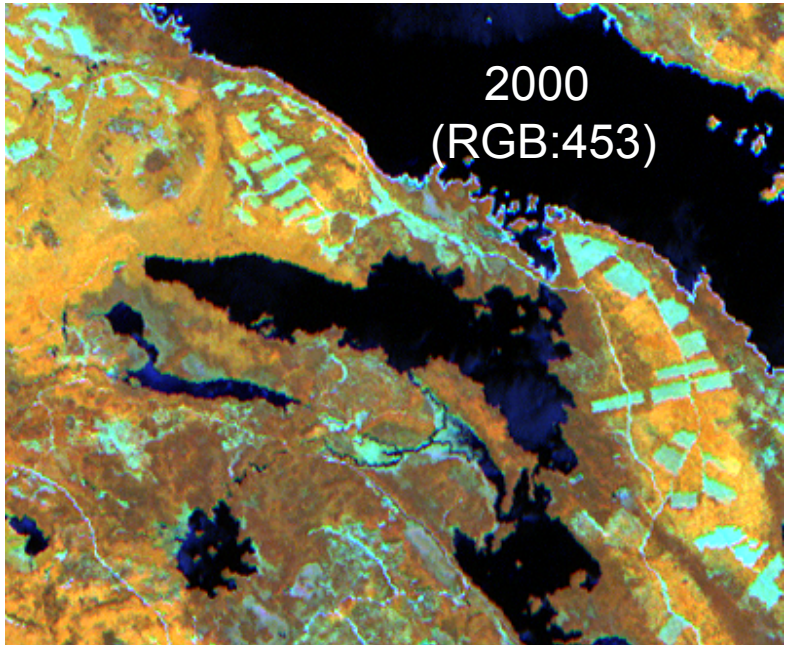


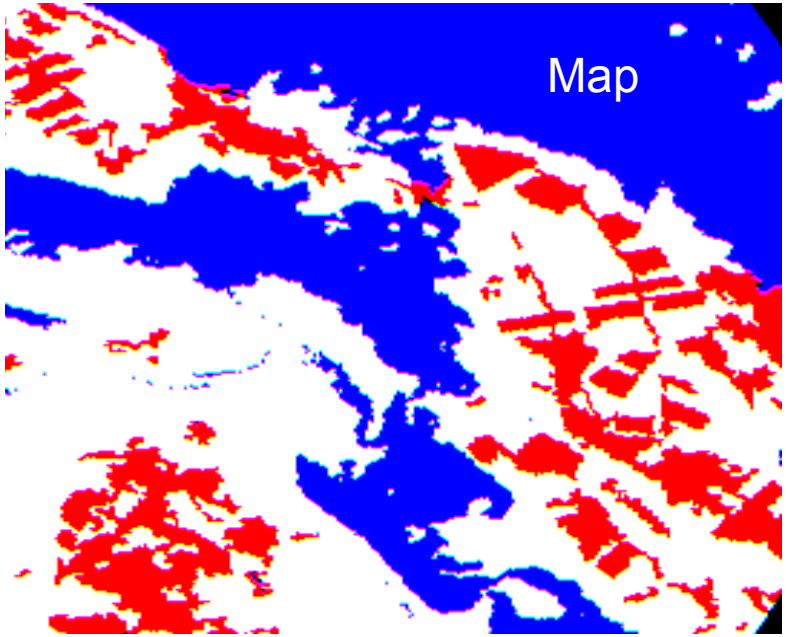


Multitemporal **K**auth-Thomas **T**ransforms





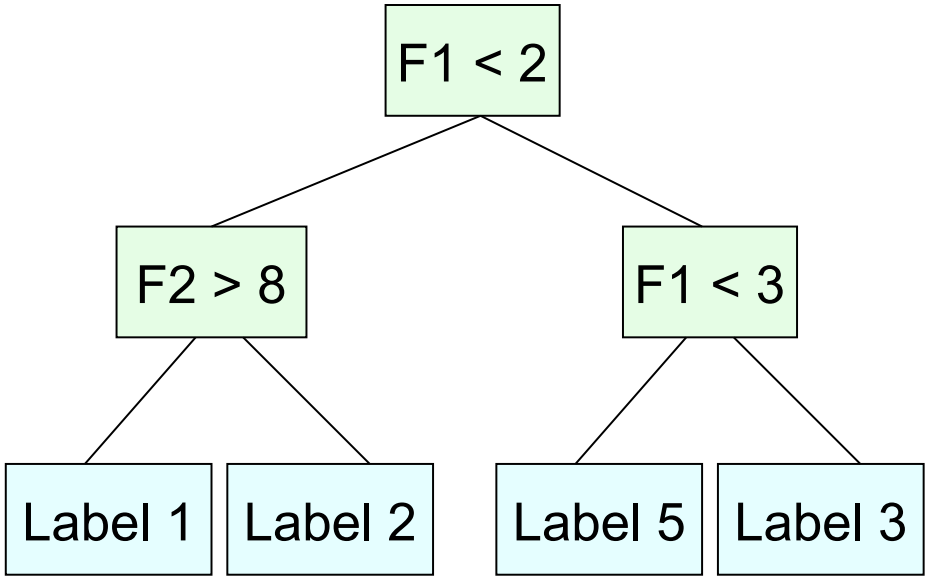




Decision Tree Classification

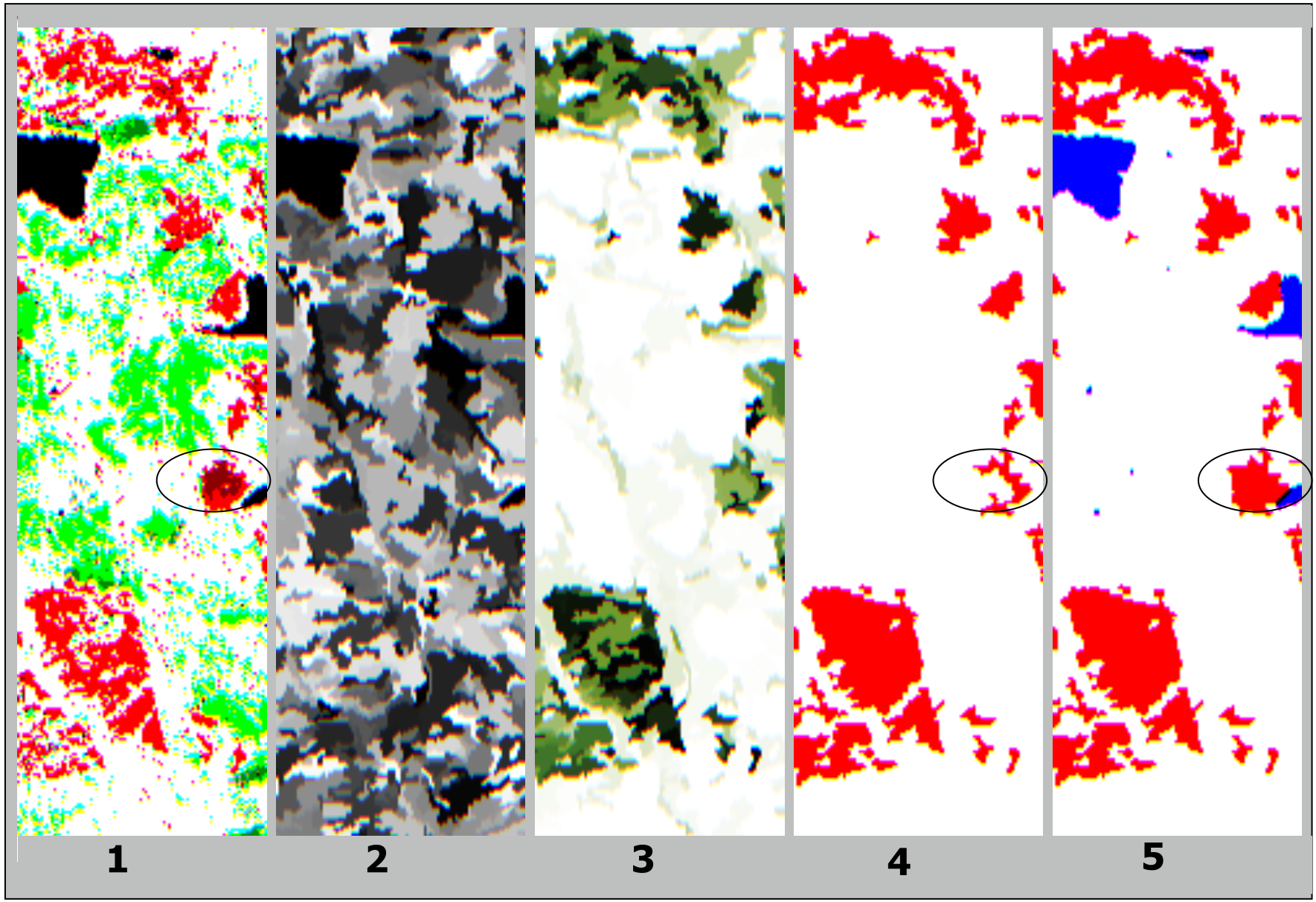
Labels	Features
Forest Clearing Forest Growth Agriculture Loss Agriculture Gain Other	1990 & 2000 BGW Δ BGW (MKT) Stable BGW (MKT)

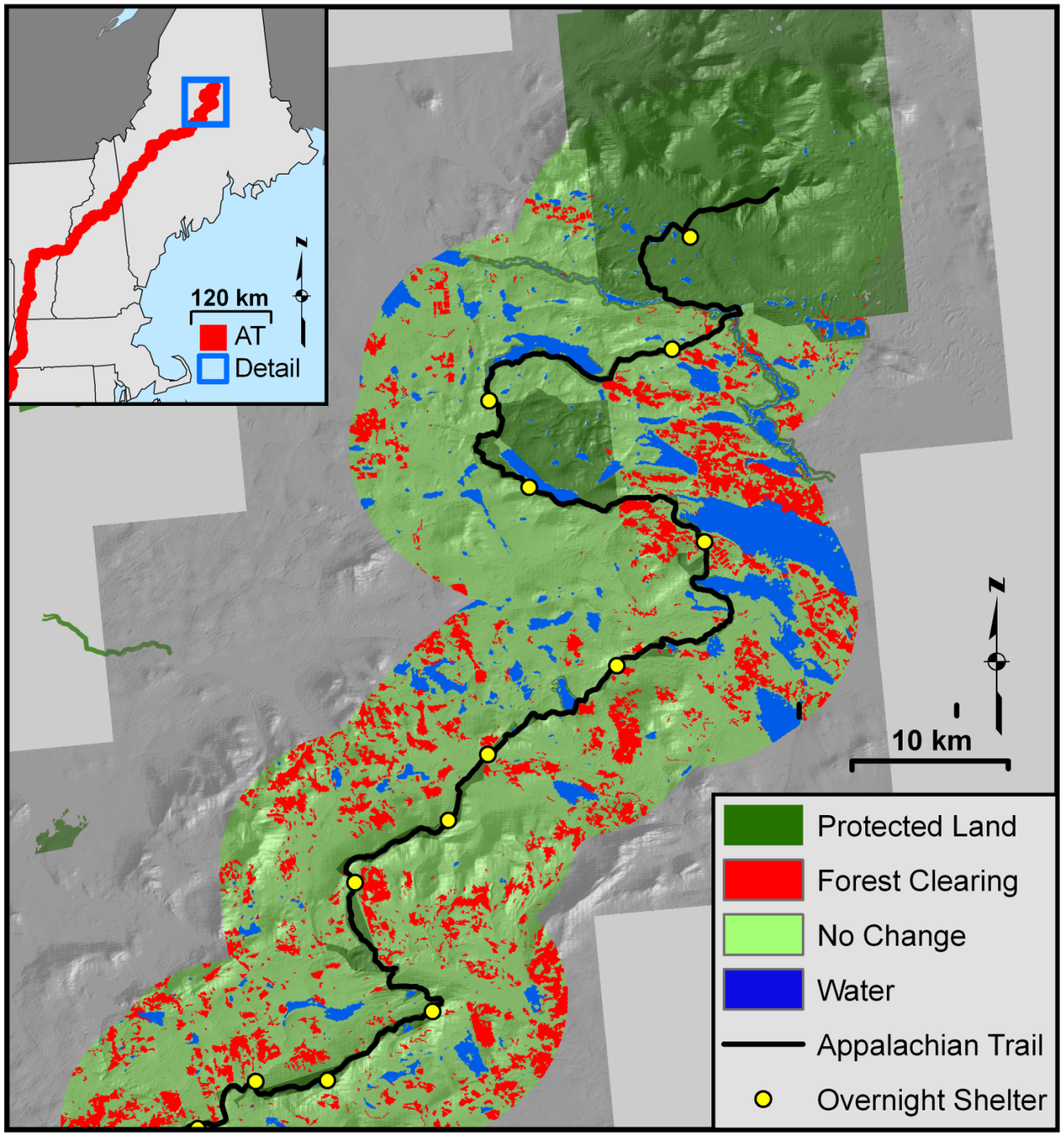
- Ross Quinlan's C4.5, U New South Wales
- BU Boosted Version




```
C4.5 [release 8] decision tree generator
Mon Apr 25 09:21:46 2005
----------------------------------------


    Options:
        File stem <1228>
        Display Trees

Read 34388 cases (9 attributes) from 1228.data
Decision Tree:

ch_we <= 1410 :
|   st_br <= 1391 :
|   |   90_we <= 2902 :
|   |   |   90_we <= 2860 : 5 (146.0/1.4)
|   |   |   90_we > 2860 :
|   |   |   |   00_we <= 1290 : 1 (9.0/2.4)
|   |   |   |   00_we > 1290 :
|   |   |   |   |   st_br <= 1320 : 5 (11.0/1.3)
|   |   |   |   |   st_br > 1320 : 3 (2.0/1.0)
|   |   90_we > 2902 :
|   |   |   ch_br <= 1684 :
|   |   |   |   ch_we <= 1348 :
|   |   |   |   |   st_we <= 2164 :
|   |   |   |   |   |   st_br > 1101 : 1 (184.0/1.4)
|   |   |   |   |   |   st_br <= 1101 :
|   |   |   |   |   |   |   00_gr <= 2841 : 1 (18.0/1.3)
|   |   |   |   |   |   |   00_gr > 2841 : 5 (3.0/1.1)
```

Classification at the level of Regions

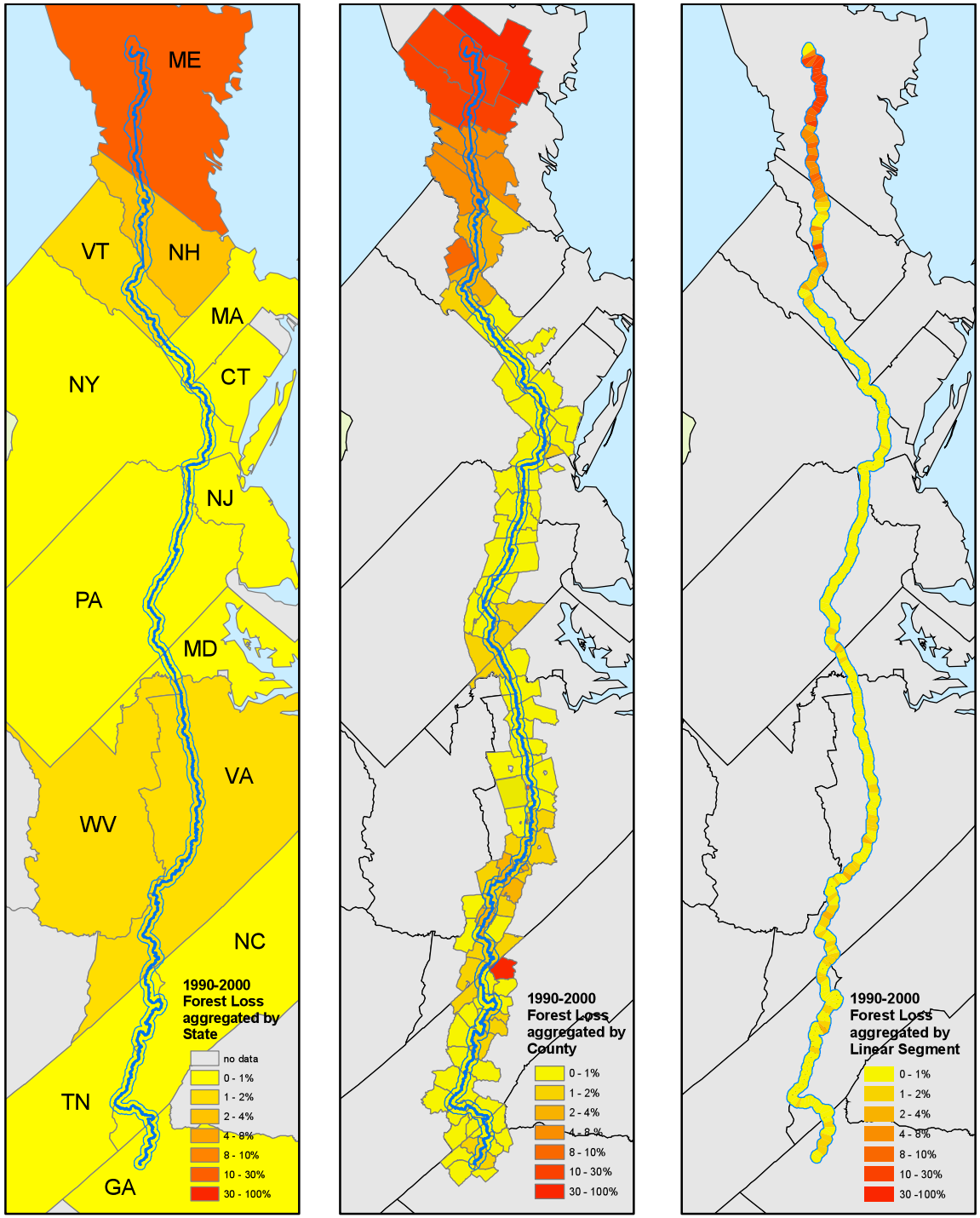




Final Map

Northern
Terminus
of the
Appalachian Trail

Mt. Katahdin,
Maine



Three Aggregation Methods:

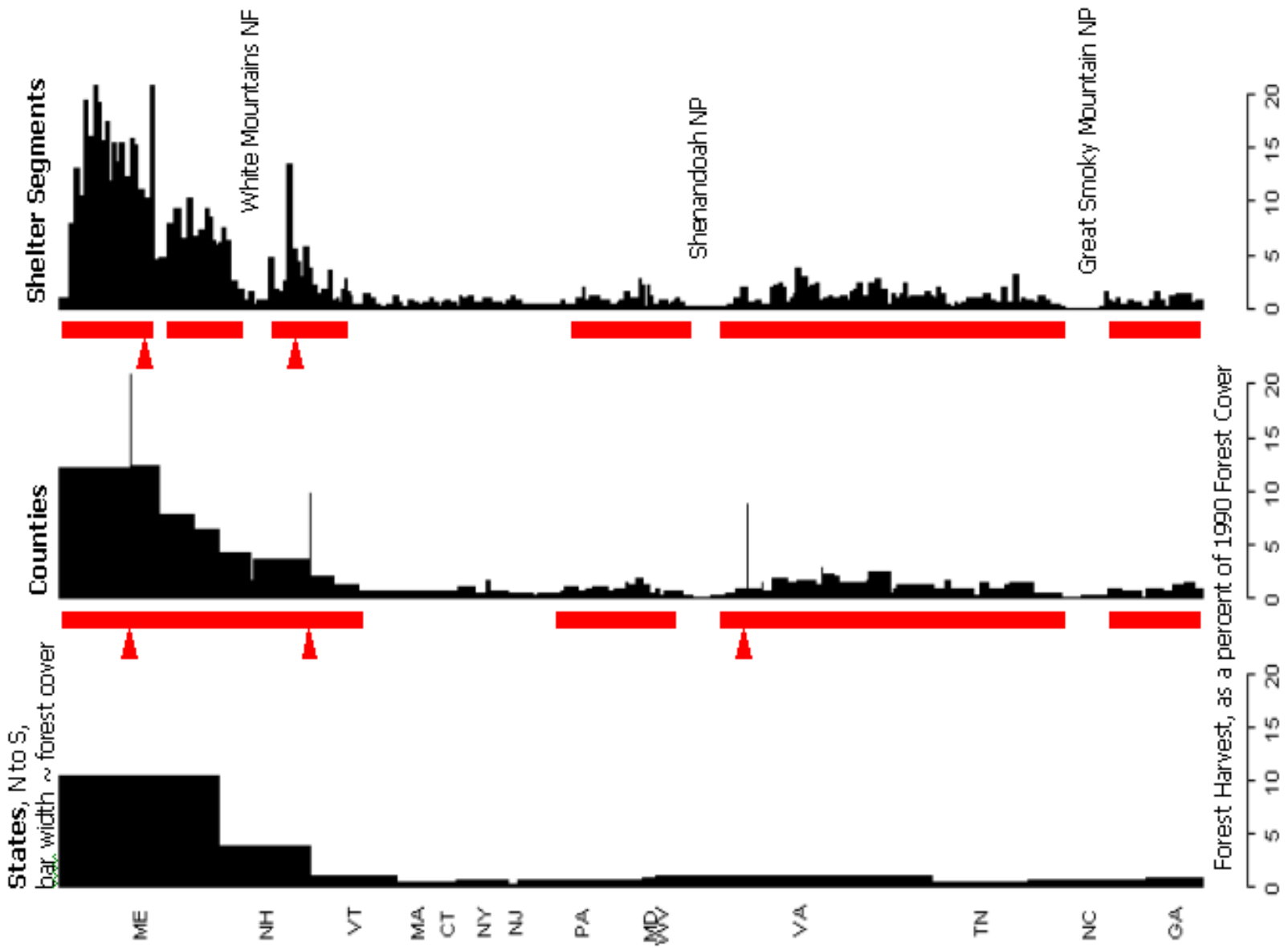
(1) State

(2) County

(3) Segment

Left to Right

Regularized Corridor Plots



Wal-Mart from Space

Potere, D., N. Feierabend, A. Strahler, E. Bright. Wal-Mart from Space: A New Land Cover Change Validation Product, *Photogrammetric Engineering & Remote Sensing*, 2008.

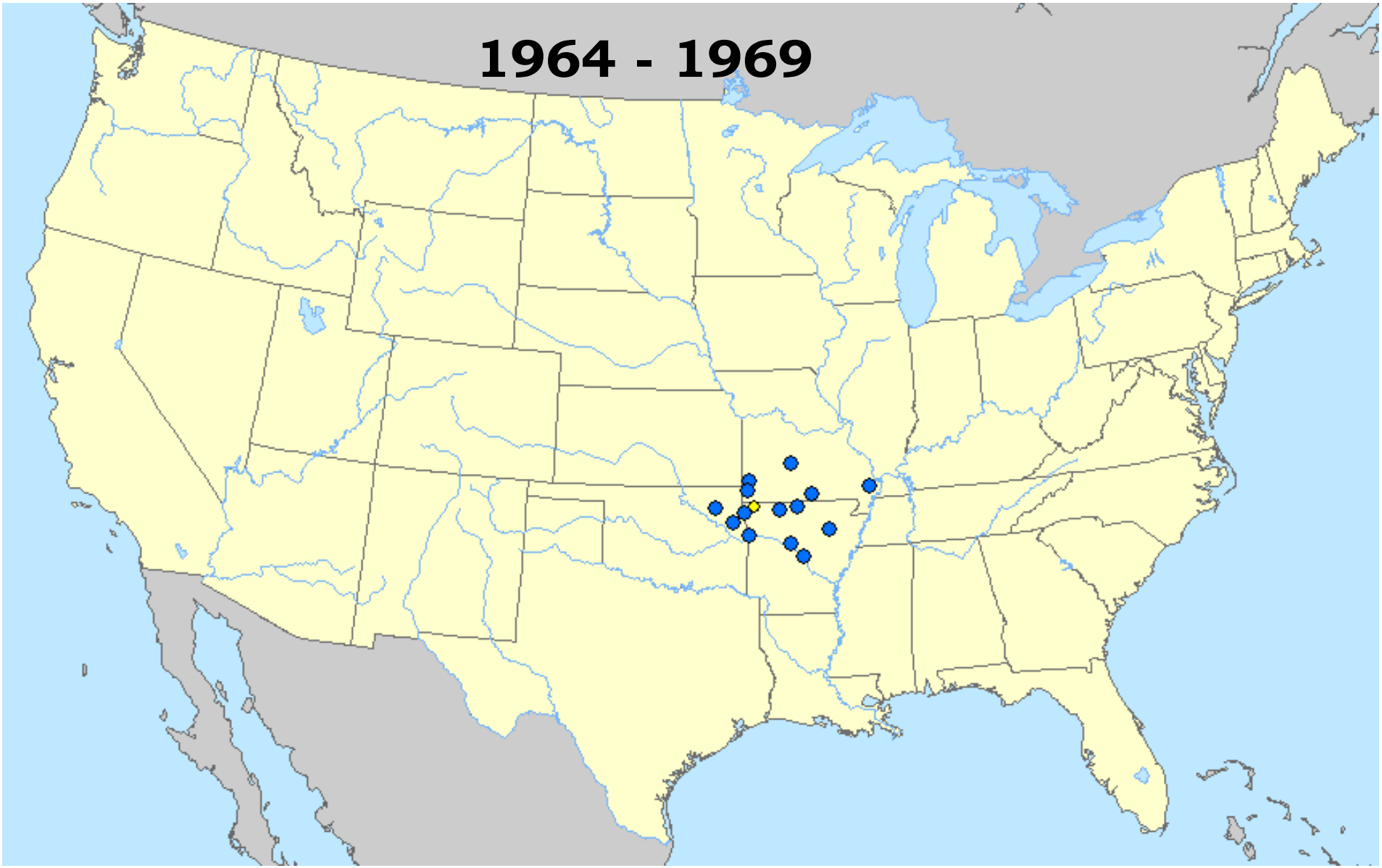
Wal-Mart Opportunity

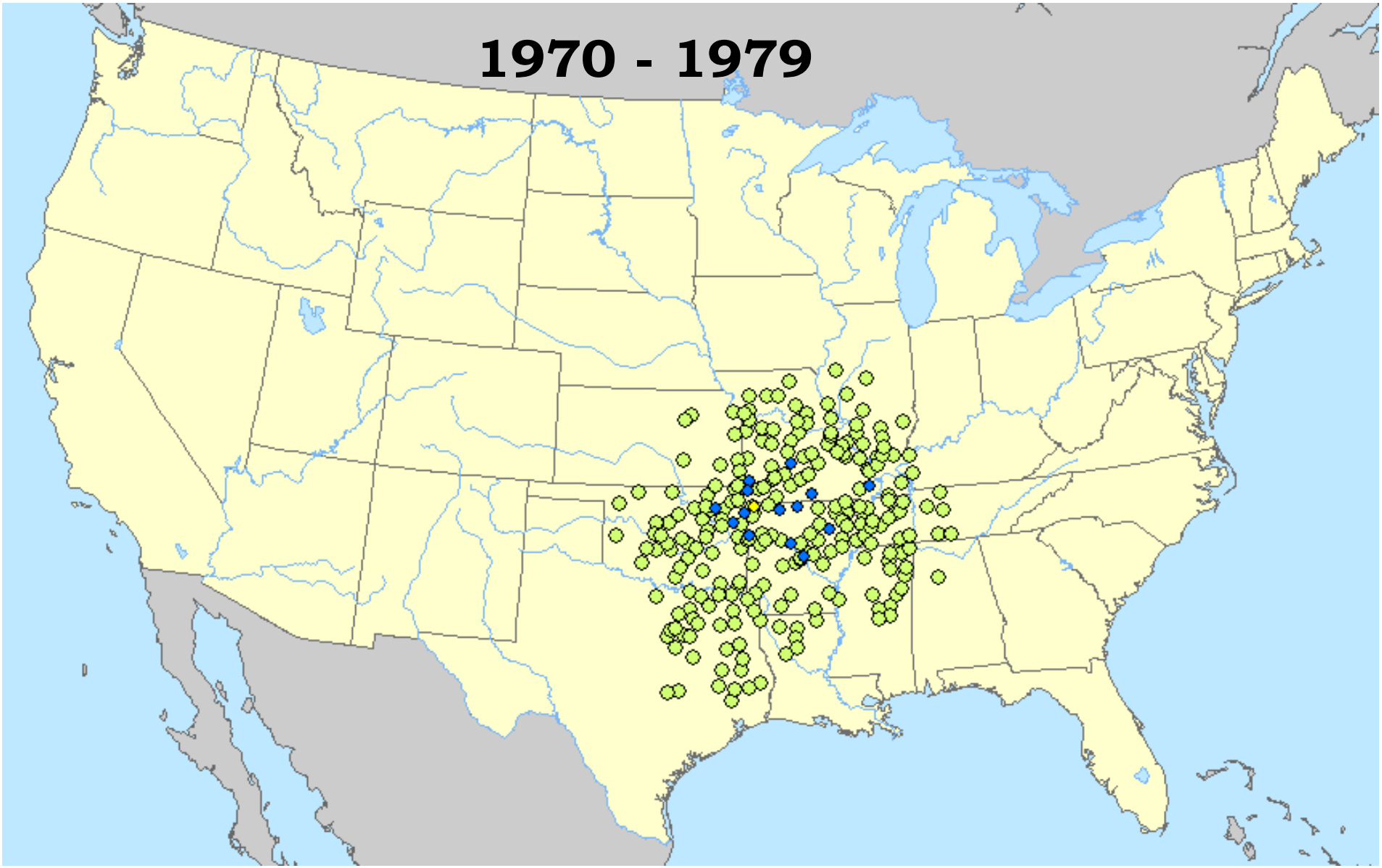
Wal-Mart stores represent an excellent set of training data for land cover change.

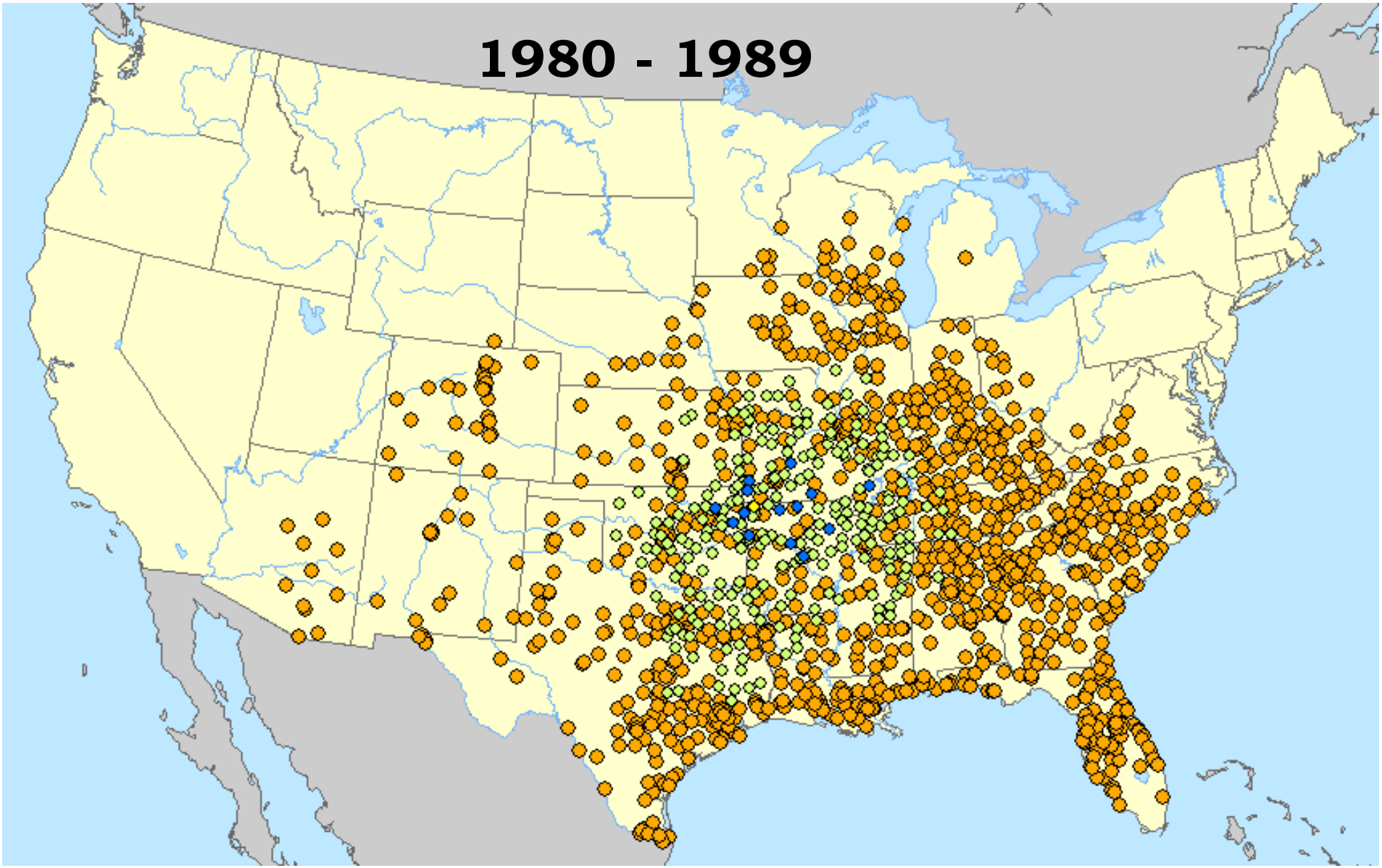
1. Plenty of sites – 5,000 facilities globally.
2. Stores are big – 300 meters on a side.
3. Company lifespan is long – 1964-2005.
4. Wal-Mart builds on undeveloped land.

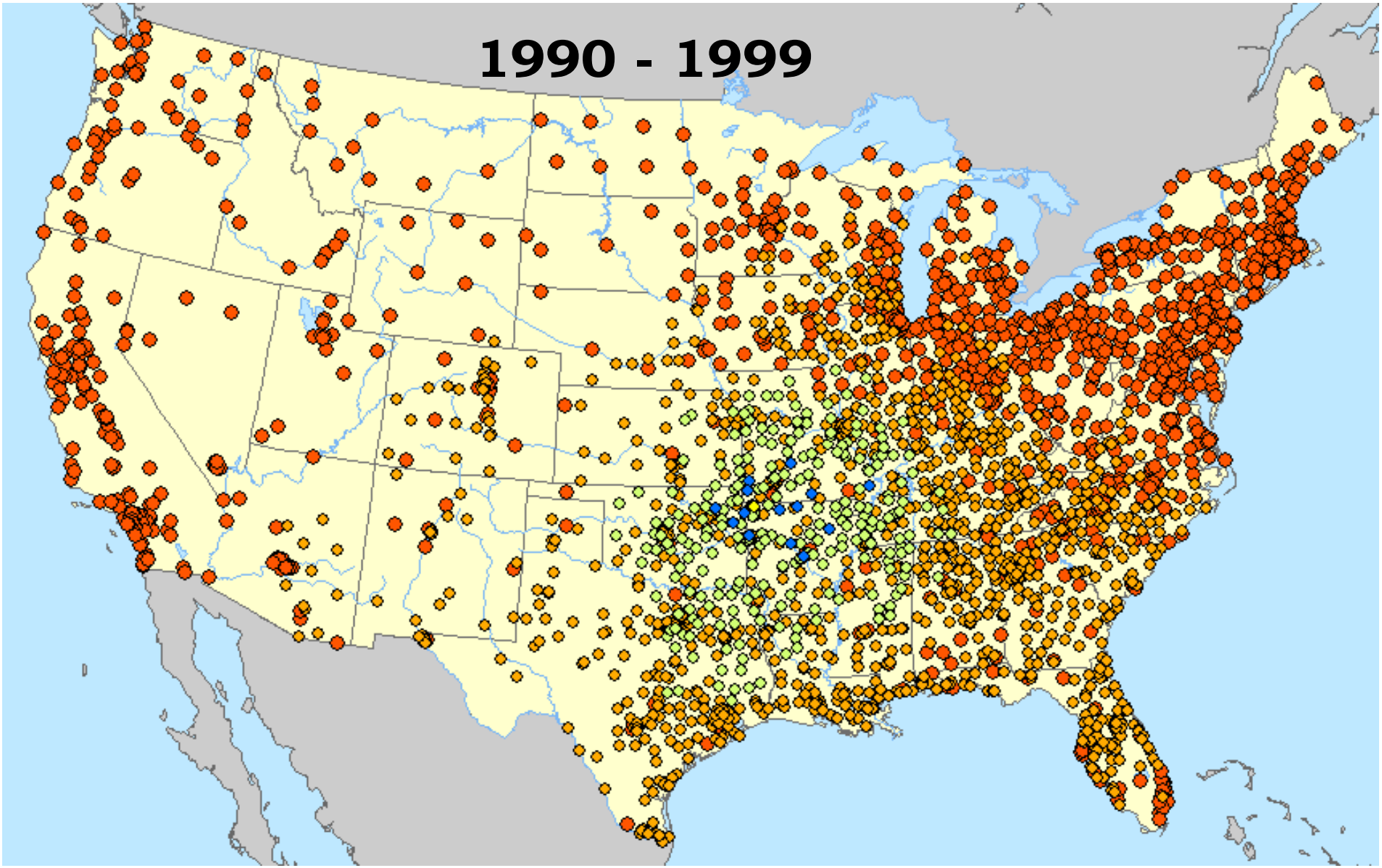
Useful for validating both endpoint and time series land cover change mapping methods.

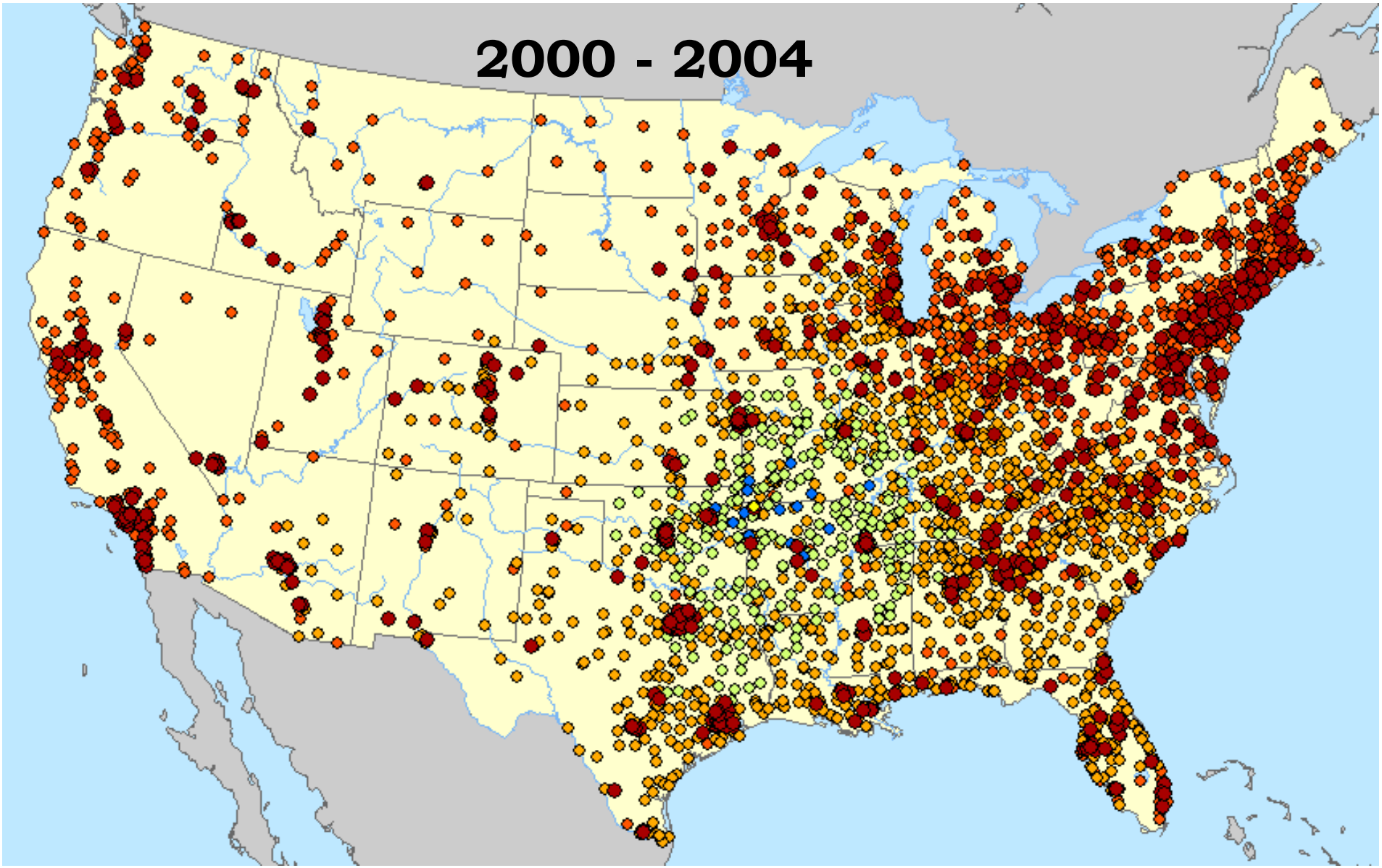

First Wal-Mart -1962

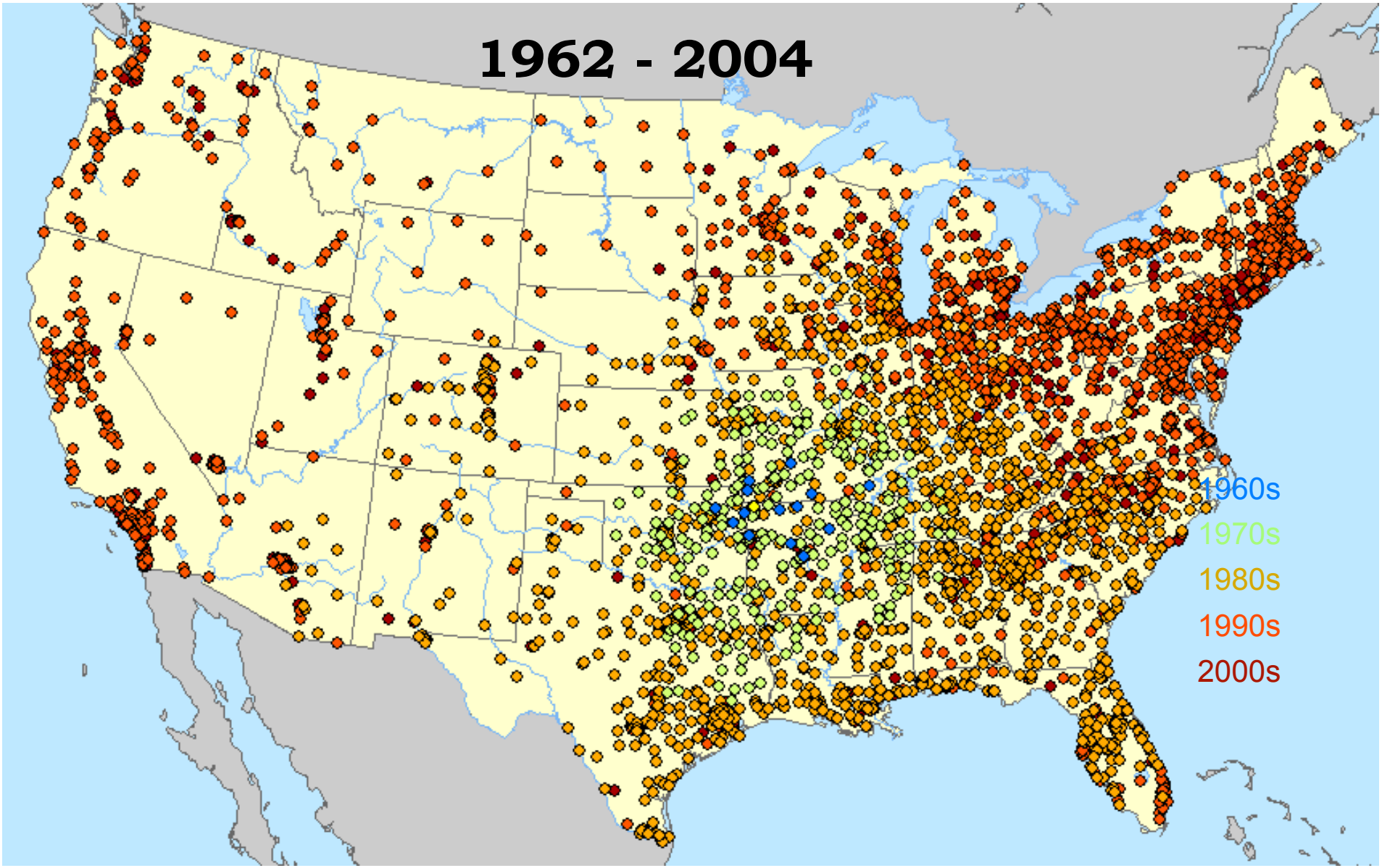

1964 - 1969


1970 - 1979


1980 - 1989


1990 - 1999


2000 - 2004

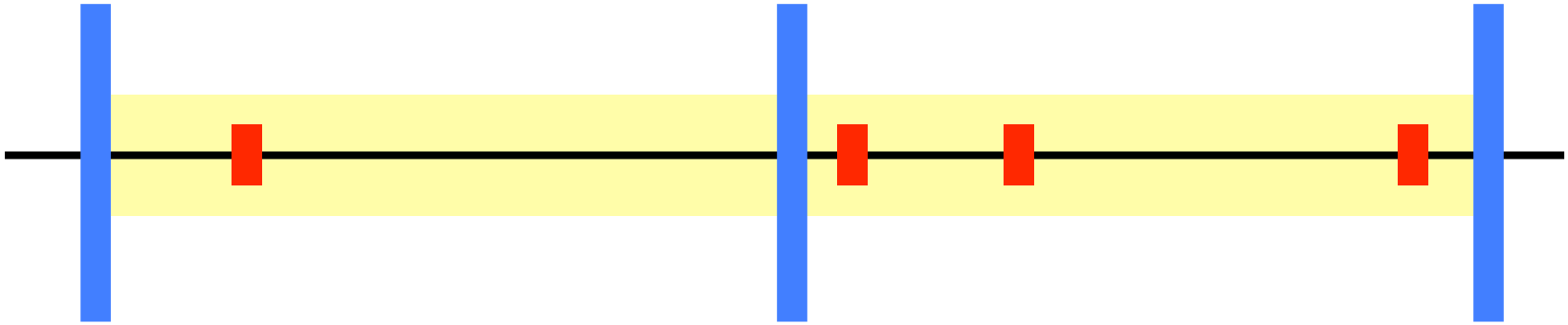

1962 - 2004
1960s
1970s
1980s
1990s
2000s

Land Cover Change Mapping—Two Strategies

1. *Endpoint Based*: Collect two images (or image clusters) of the same area, separated by a time interval.

2. *Time Series Analysis*: Collect imagery at frequent intervals throughout the year, and identify change events from shifts in the phenology.

Endpoint based methods



Inputs

few images
medium-fine resolution,
multispectral

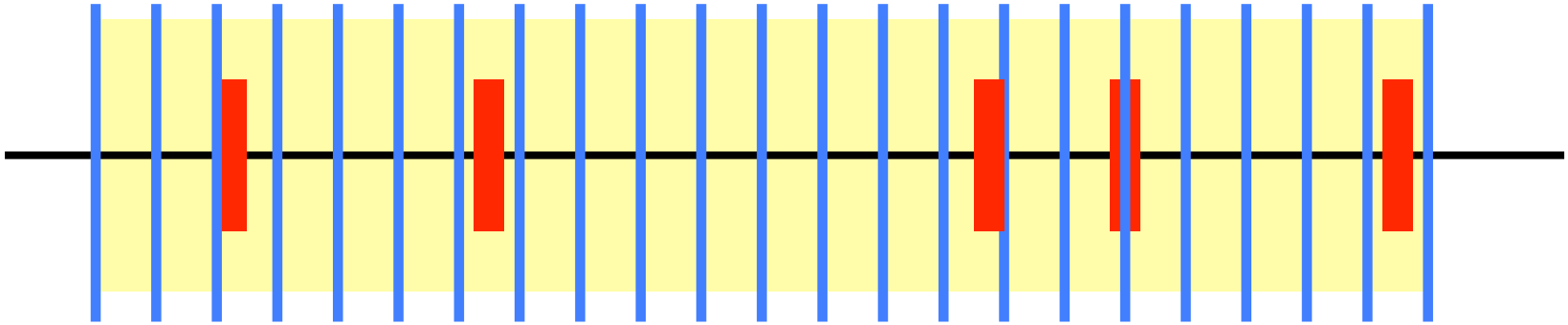
Landsat, SPOT

Outputs

high spatial resolution
coarse temporal resolution

LEDAPS

Time Series Analysis



Inputs

many images
atmospherically corrected
coarse resolution

MODIS, SPOT-Veg, AVHRR

Outputs

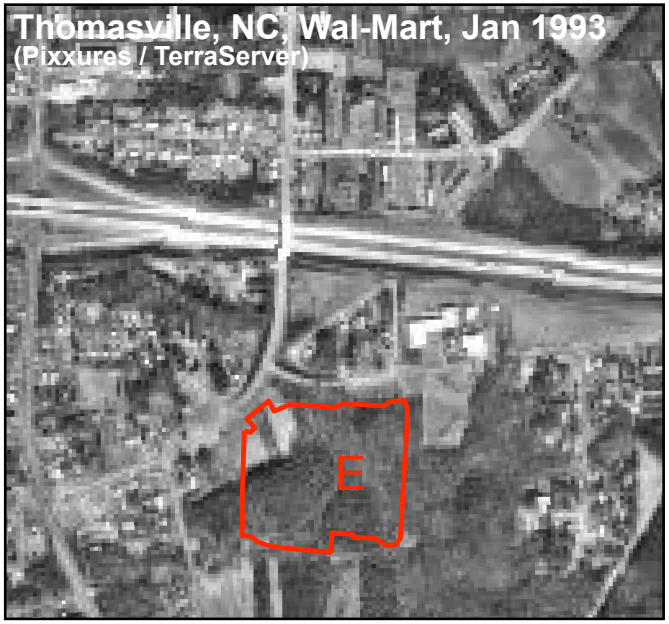
high temporal resolution
coarse spatial resolution

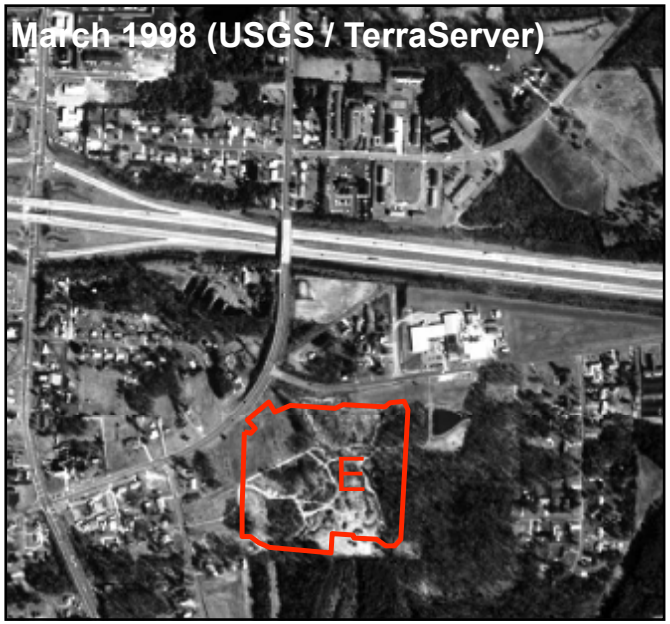
MODIS 250m NDVI

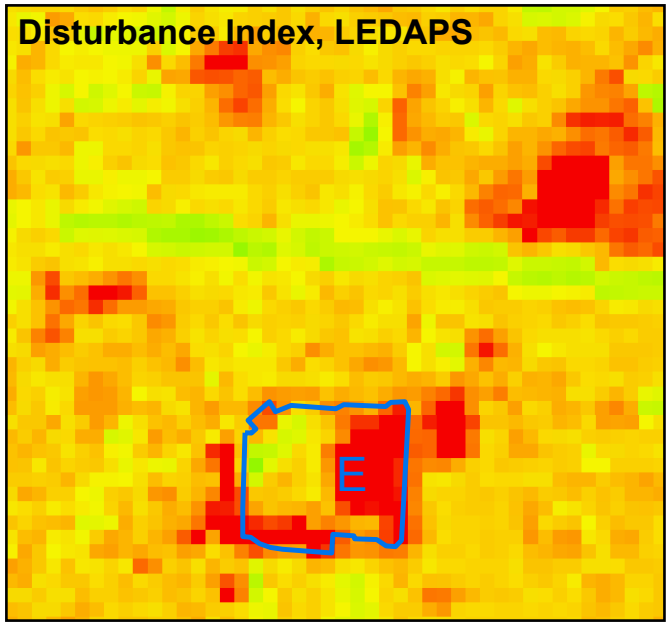
Wal-Mart & LEDAPS

Landsat Ecosystem Disturbance Adaptive Processing System

Dr. Jeff Masek (Goddard Spaceflight)







Disturbance Index Change (1987-2002)

High Disturbance

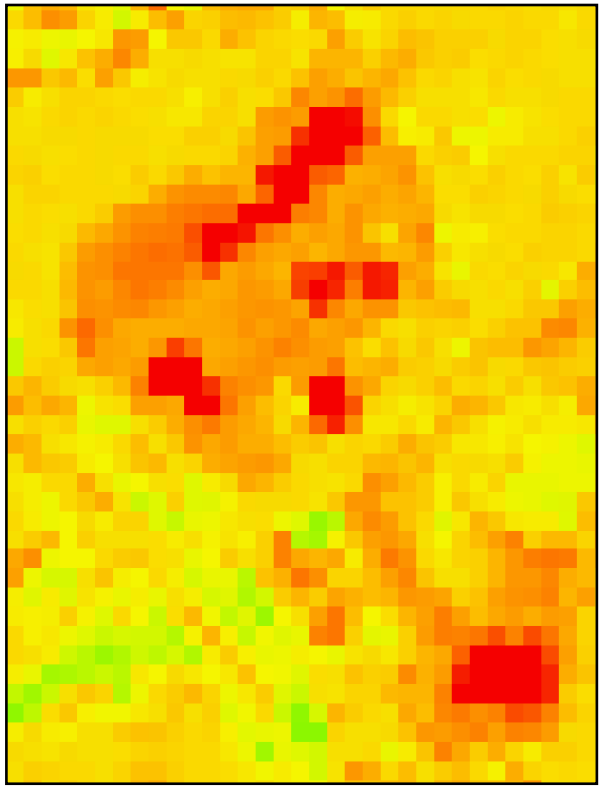
Low Disturbance

LEDAPS Disturbance Index Product

Wal-Mart Store in Durham, NC
Opened October 17, 1995

Durham, NC, March 1993
(Pixxures, TerraServer)

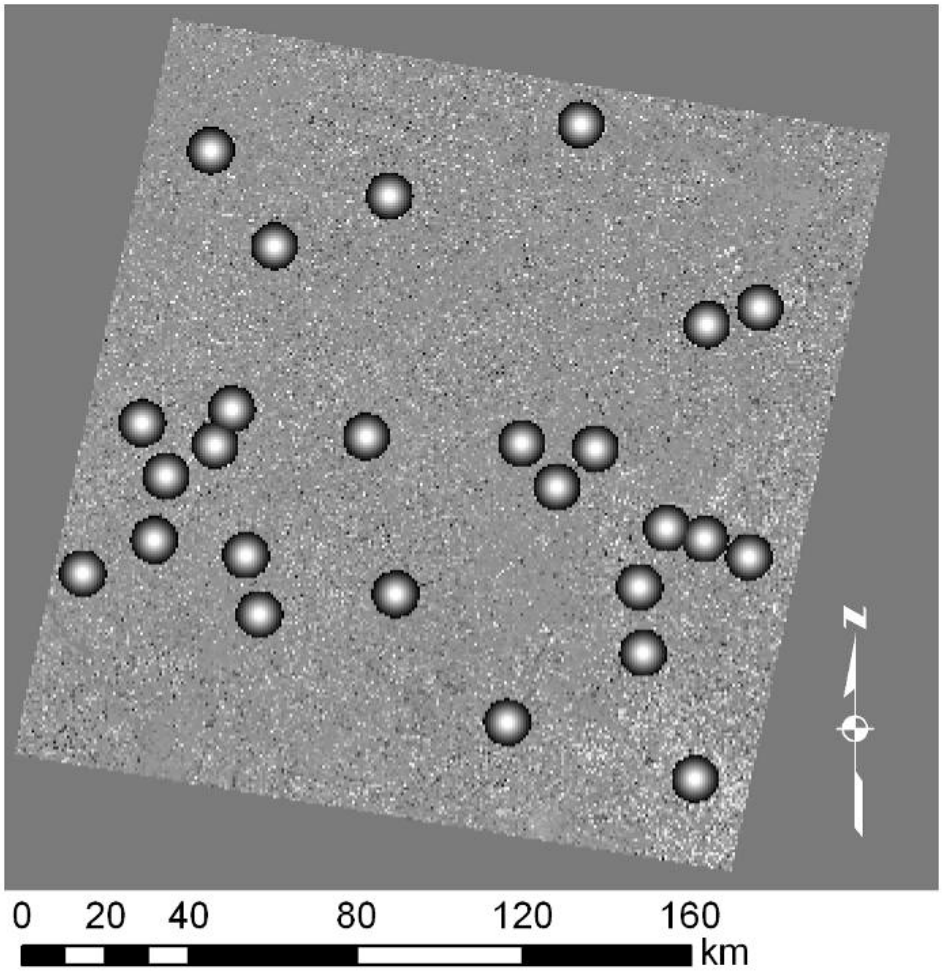
Durham, NC, Wal-Mart, 2005
(DigiGlobe, GoogleEarth)



Disturbance Index Change (1987-2002)

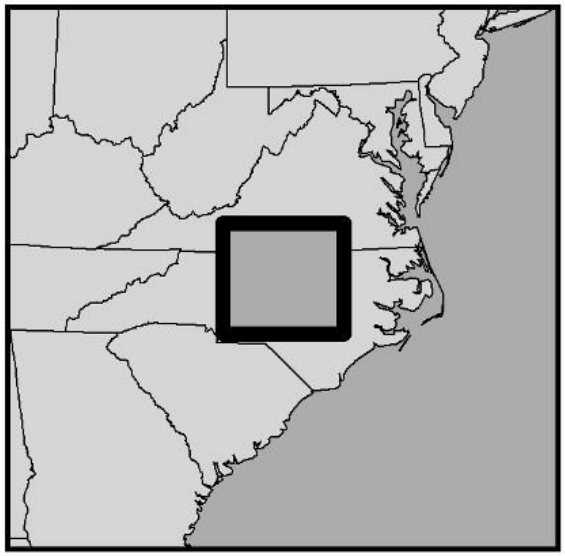
High Disturbance

Low Disturbance



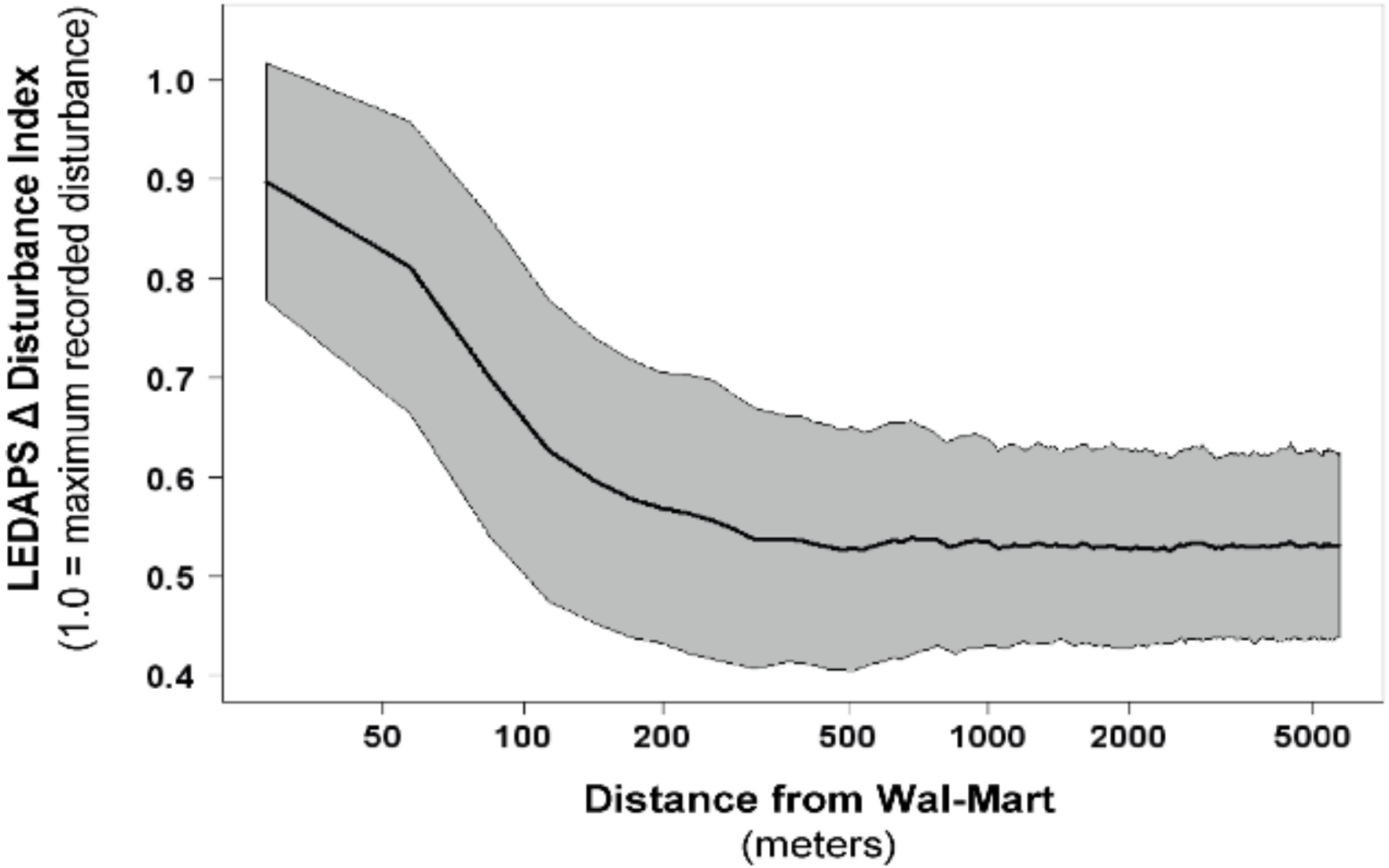
2e. Wal-Mart Validation Sites for LEDAPS scene 016/035

Wal-Mart Store (5.7 km radius)

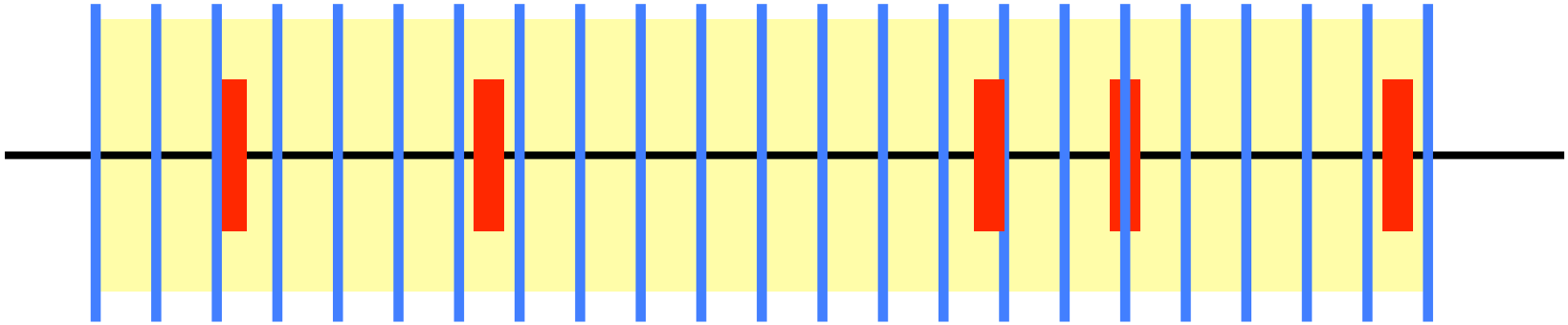


26 Wal-Mart stores in North Carolina and Virginia.

2f. Shift in LEDAPS Disturbance Index for Wal-Mart proximate pixels in scene 016/035, mean ± one standard deviation.



Time Series Analysis



Inputs

many images
atmospherically corrected
coarse resolution

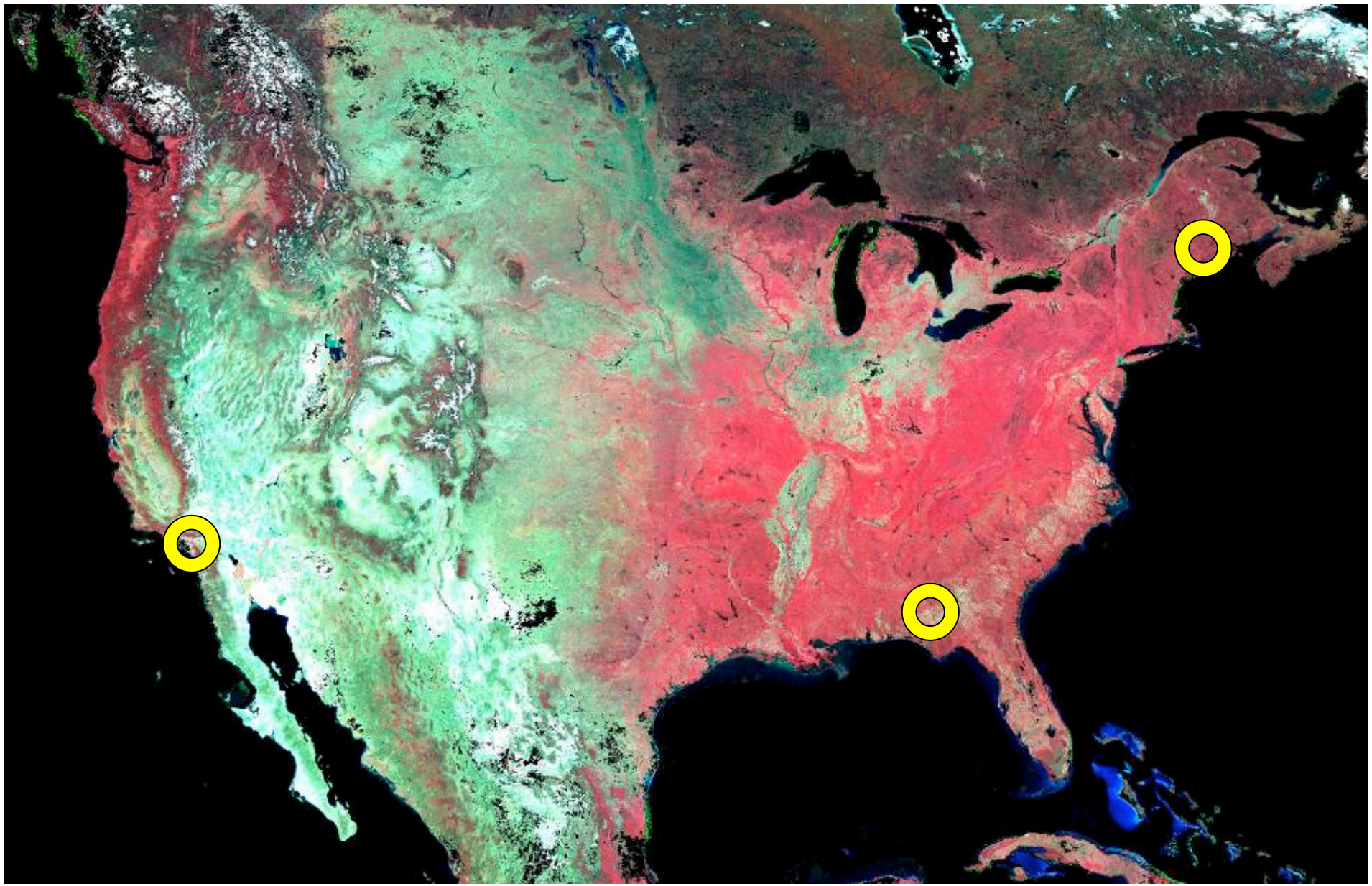
MODIS, SPOT-Veg, AVHRR

Outputs

high temporal resolution
coarse spatial resolution

MODIS 250m NDVI

Boston University, Normalized Bi-Directional Reflectance Product
May 2001, False-Color Infrared




Wal-Mart Distribution Center
Apple Valley, Feb. 03, 2003

Detail view of Apple Valley, CA, site. – UMD 250m NDVI MODIS

Figure 3a. Apple Valley, CA, May 1994 (TerraServer).

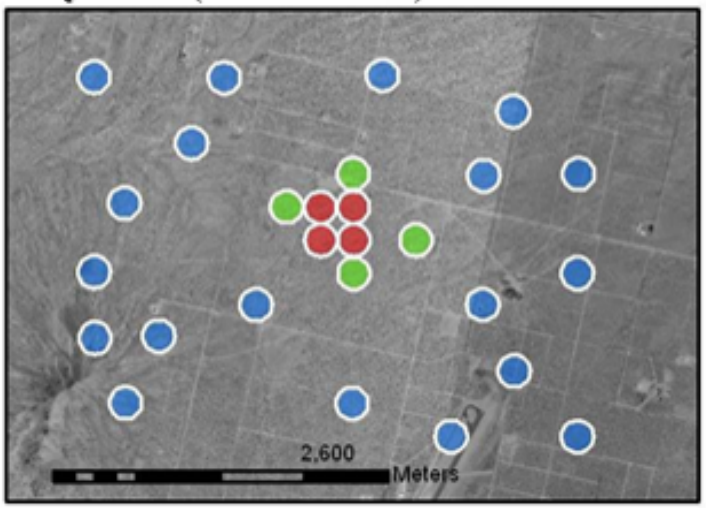
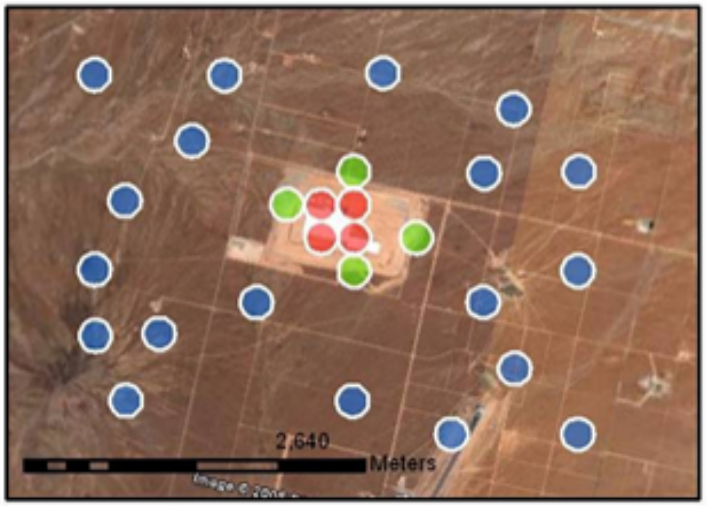
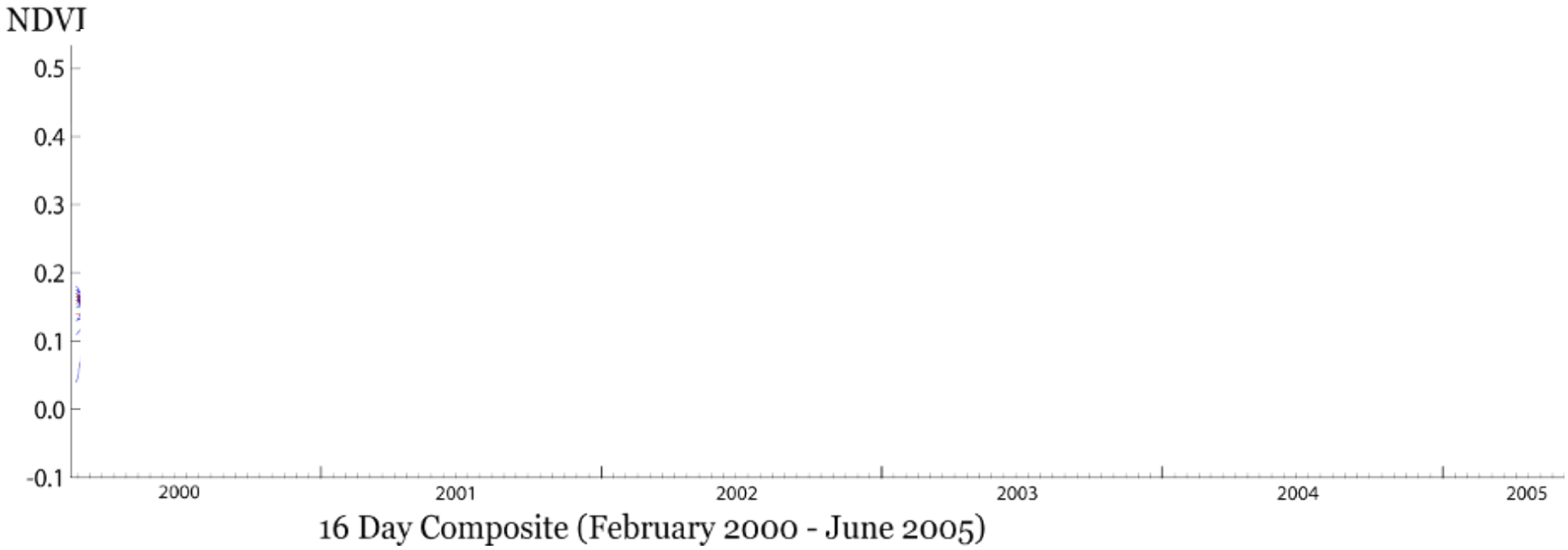


Figure 3b. Apple Valley, May 2005 (DigiGlobe / GoogleEarth).





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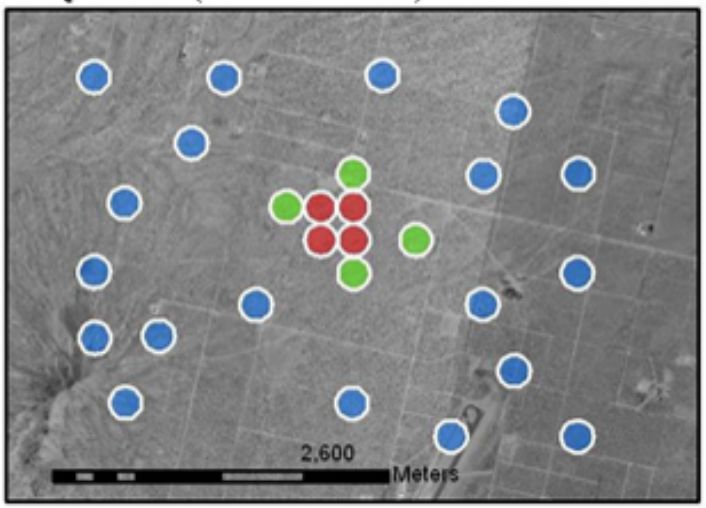
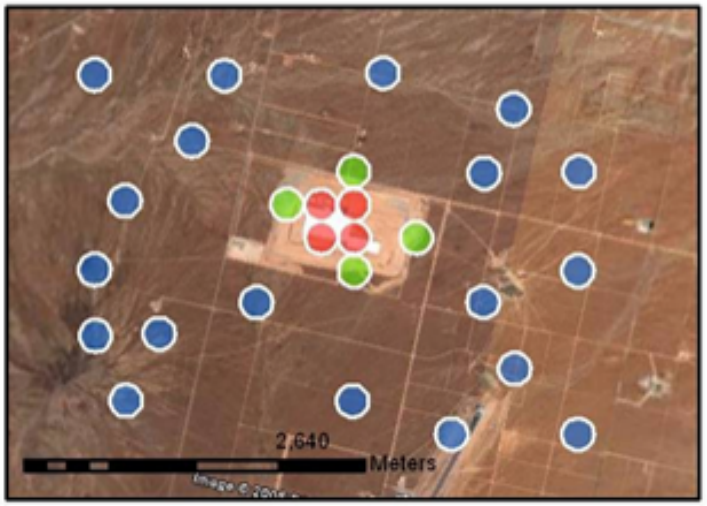
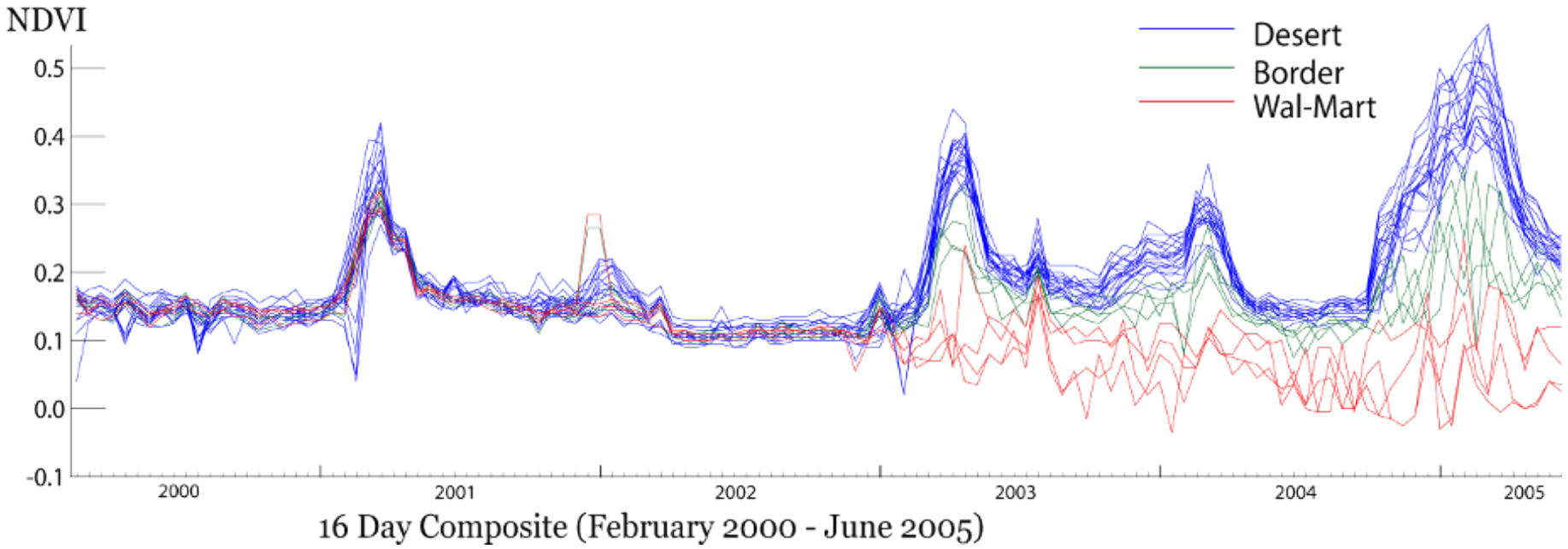


Figure 3b. Apple Valley, May 2005 (DigiGlobe / GoogleEarth).





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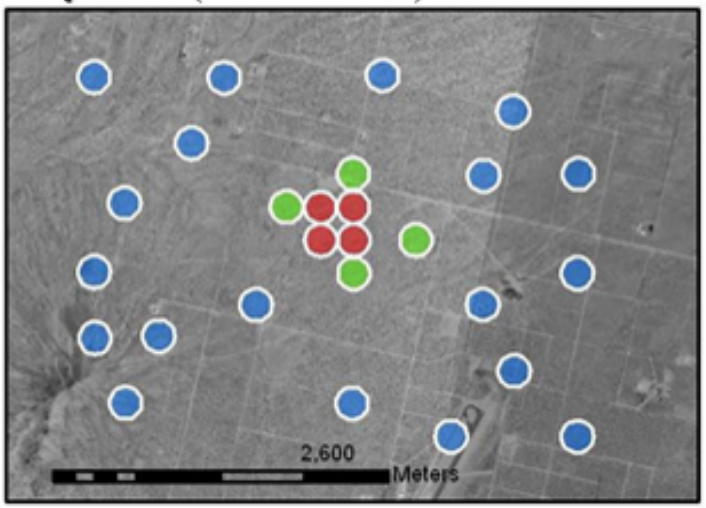

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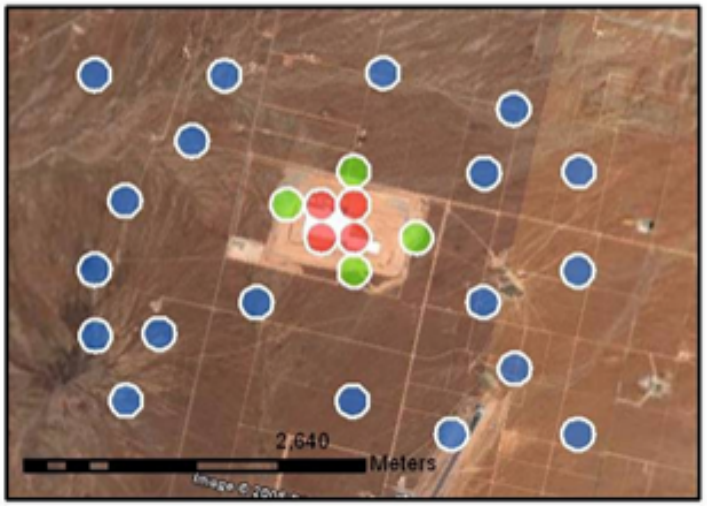
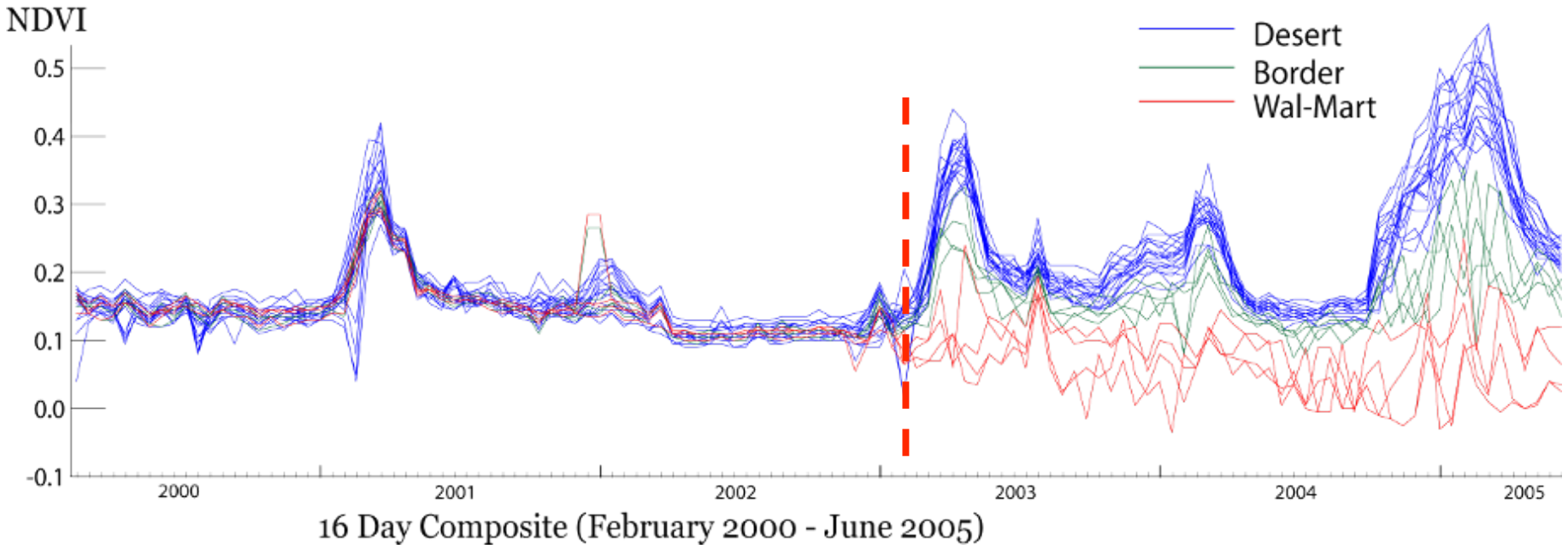
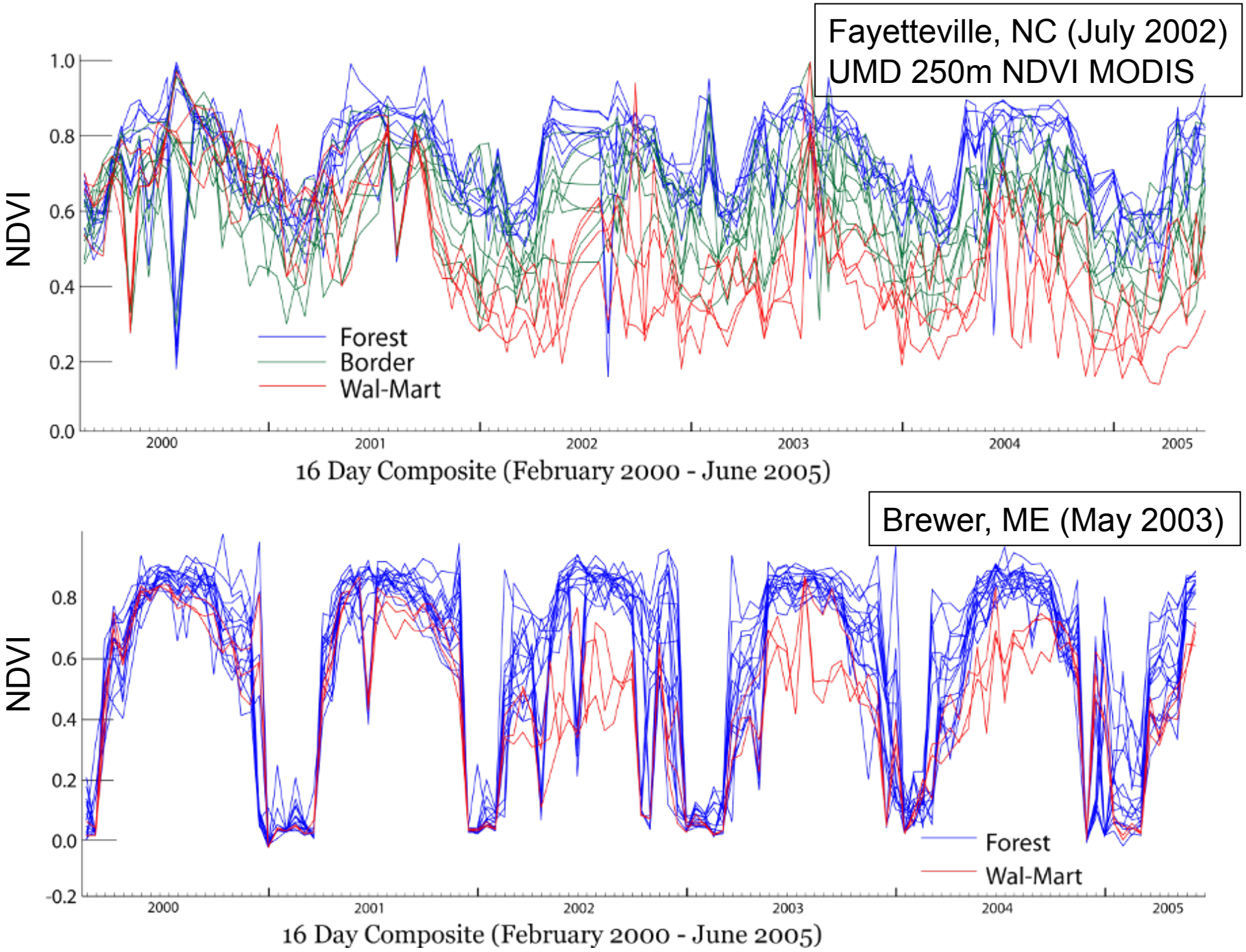
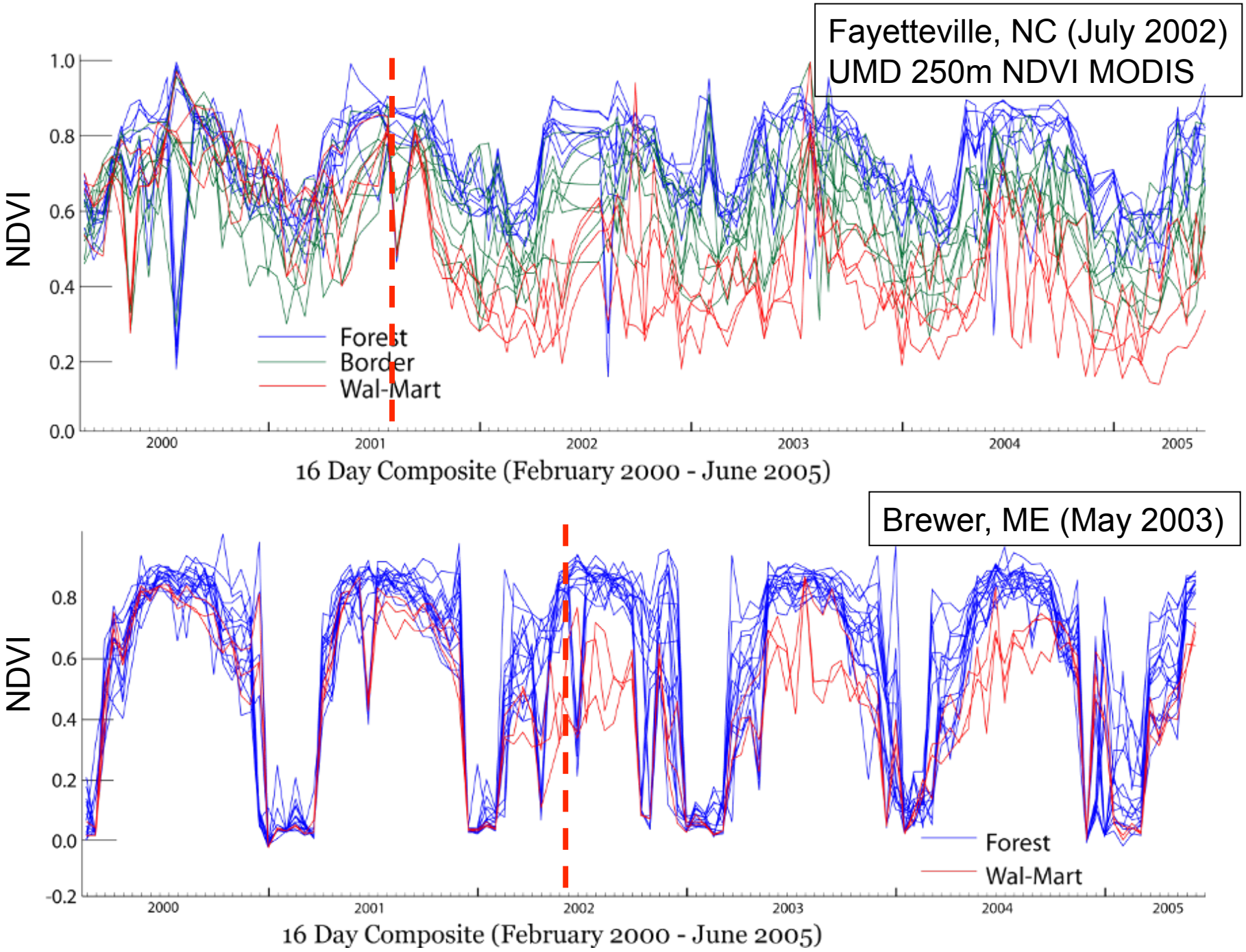





Fayetteville, NC (July 2002)
UMD 250m NDVI MODIS
NDVI
1.0
0.8
0.6
0.4
0.2
0.0
Forest
Border
Wal-Mart
2000
2001
2002
2003
2004
2005
16 Day Composite (February 2000 - June 2005)
Brewer, ME (May 2003)
NDVI
0.8
0.6
0.4
0.2
0.0
-0.2
Forest
Wal-Mart
2000
2001
2002
2003
2004
2005
16 Day Composite (February 2000 - June 2005)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