# Landsat 7 Gap Filling Using the Neighborhood Similar Pixel Interpolator (NSPI)

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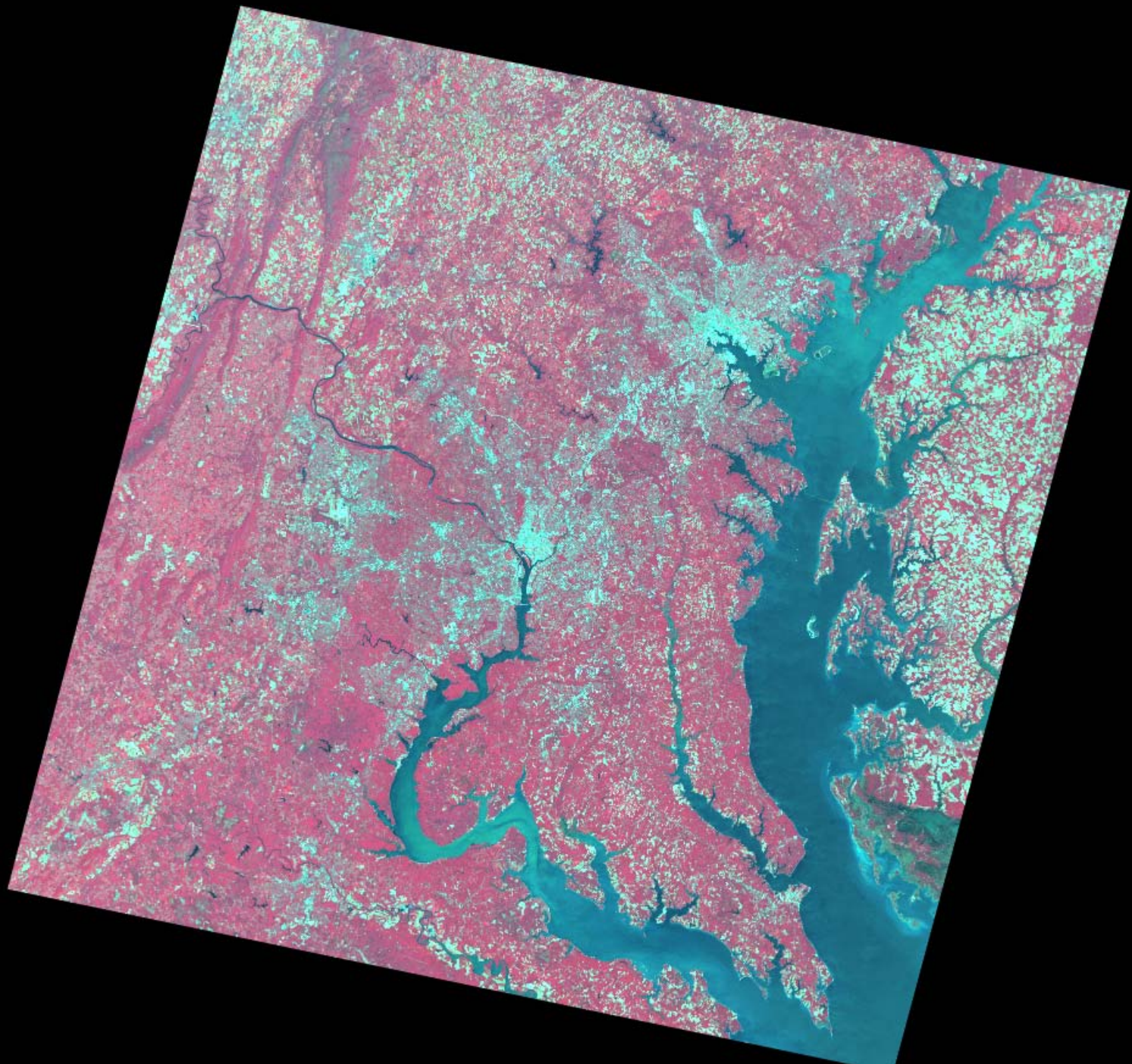
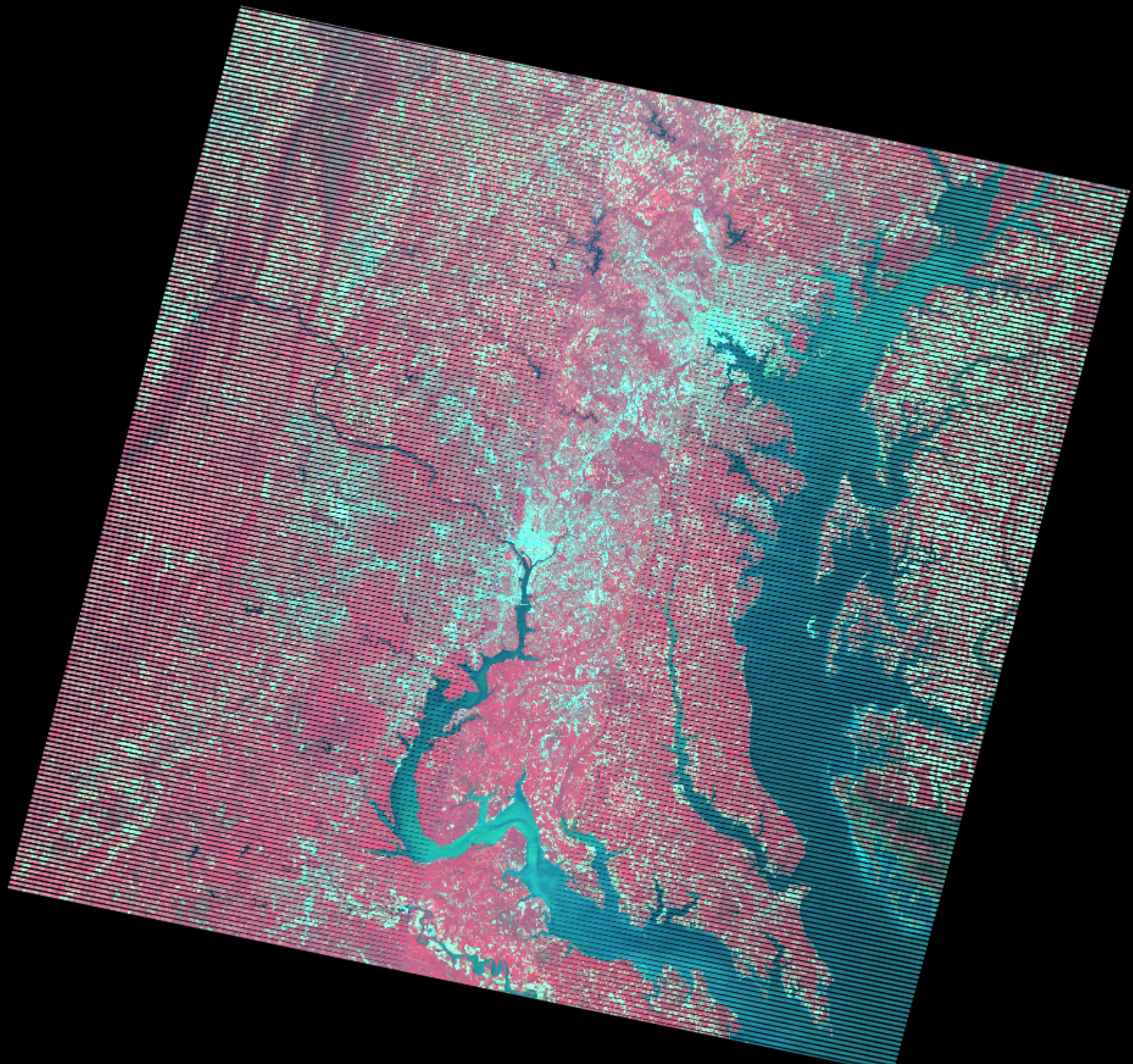
# General Approach

- Start with good Landsat 5 scenes (1) Washington DC/Baltimore area (2) ag area in northern Indiana/Illinois (3) Maine (seasonal issues) (4)fire area in Montana
- Create simulated SLC-OFF data set for those scenes
- Run Neighborhood Similar Pixel Interpolator (NSPI) over all simulated SLC-OFF scenes; NSPI described later
- Compare results with original Landsat 5 scenes

An “original” L 5 Scene (April 29, 2010) used for comparative gap filling analysis

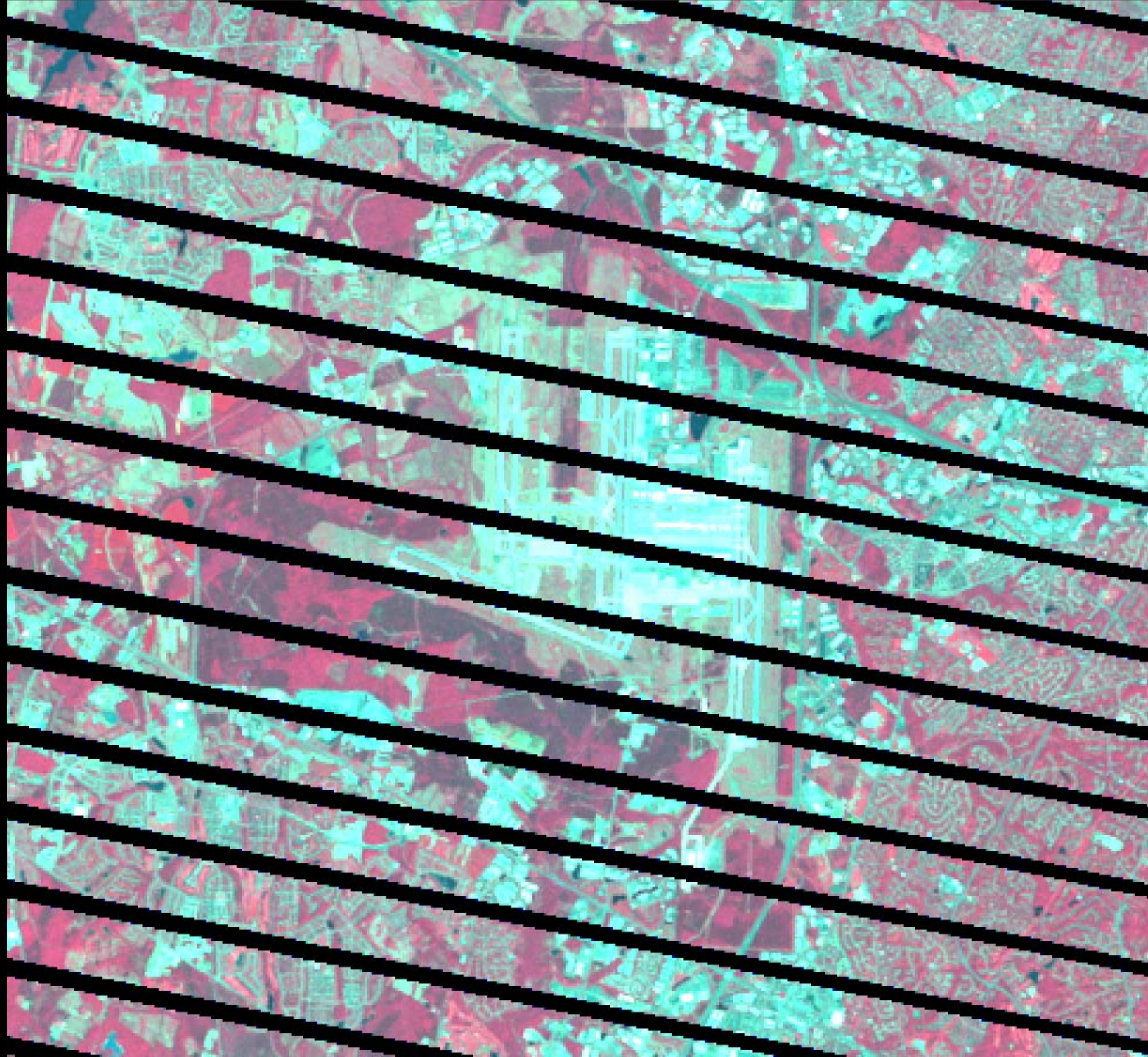


L 5 Scene (April 29, 2010) with SLC-OFF gaps added

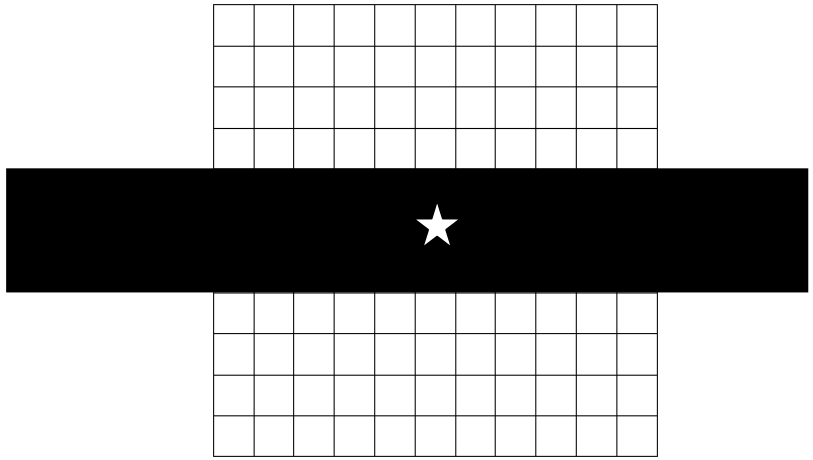


Original L 5 Scene (April 29, 2010): Dulles Airport

“Gapped” L5 Scene (April 29, 2010): Dulles Airport



Target Scene (in this case, an SLC-OFF Data Set)

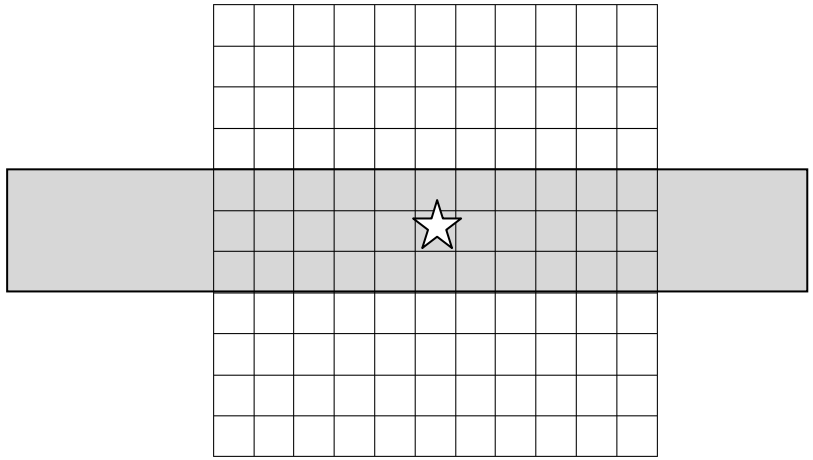


☆ Target pixel

□ Common pixel

Gap in target image

Input Scene (Used to Guide the Filling Process)

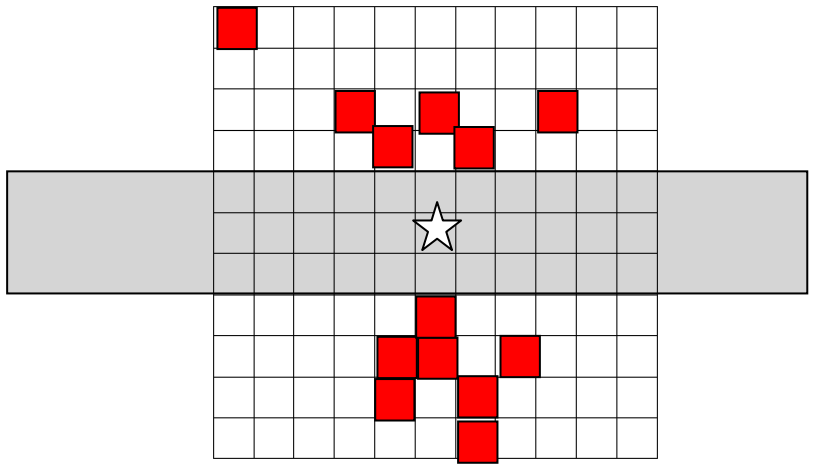


☆ Location of target pixel

□ Common pixel

Gap (from target image)

# Locate Similar Pixels in Input Scene

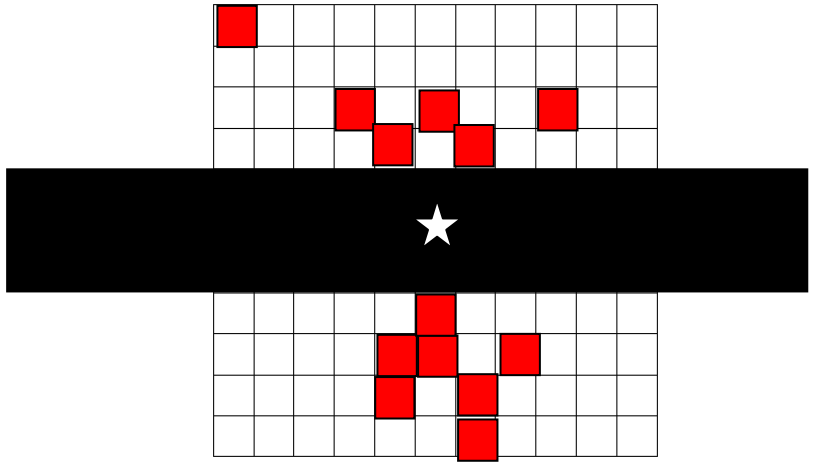


☆ Target pixel ■ Similar pixel

□ Common pixel

▭ Gap (from target image)

Then find those same “Similar Pixels” in Target Scene

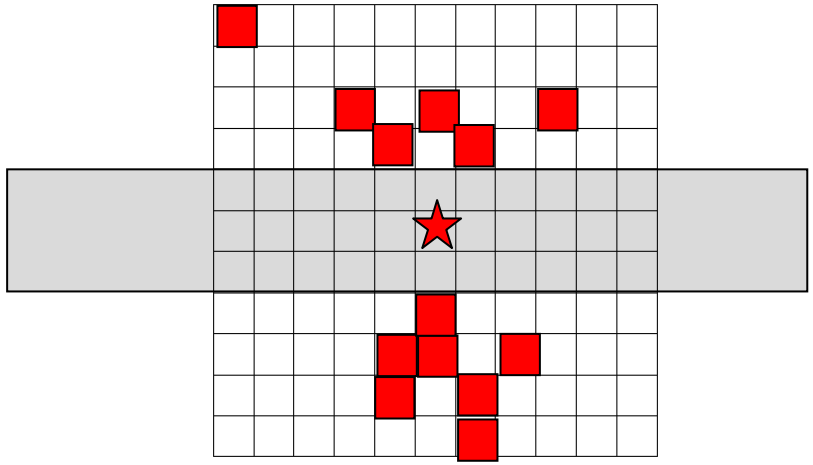


☆ Target pixel ■ Similar pixel

□ Common pixel

▬ Gap in target image

Then Fill in the Target pixel(s) in Target Scene



Target pixel filled using statistics
From Target Scene Similar Pixels ( )

Common pixel

Gap in target image

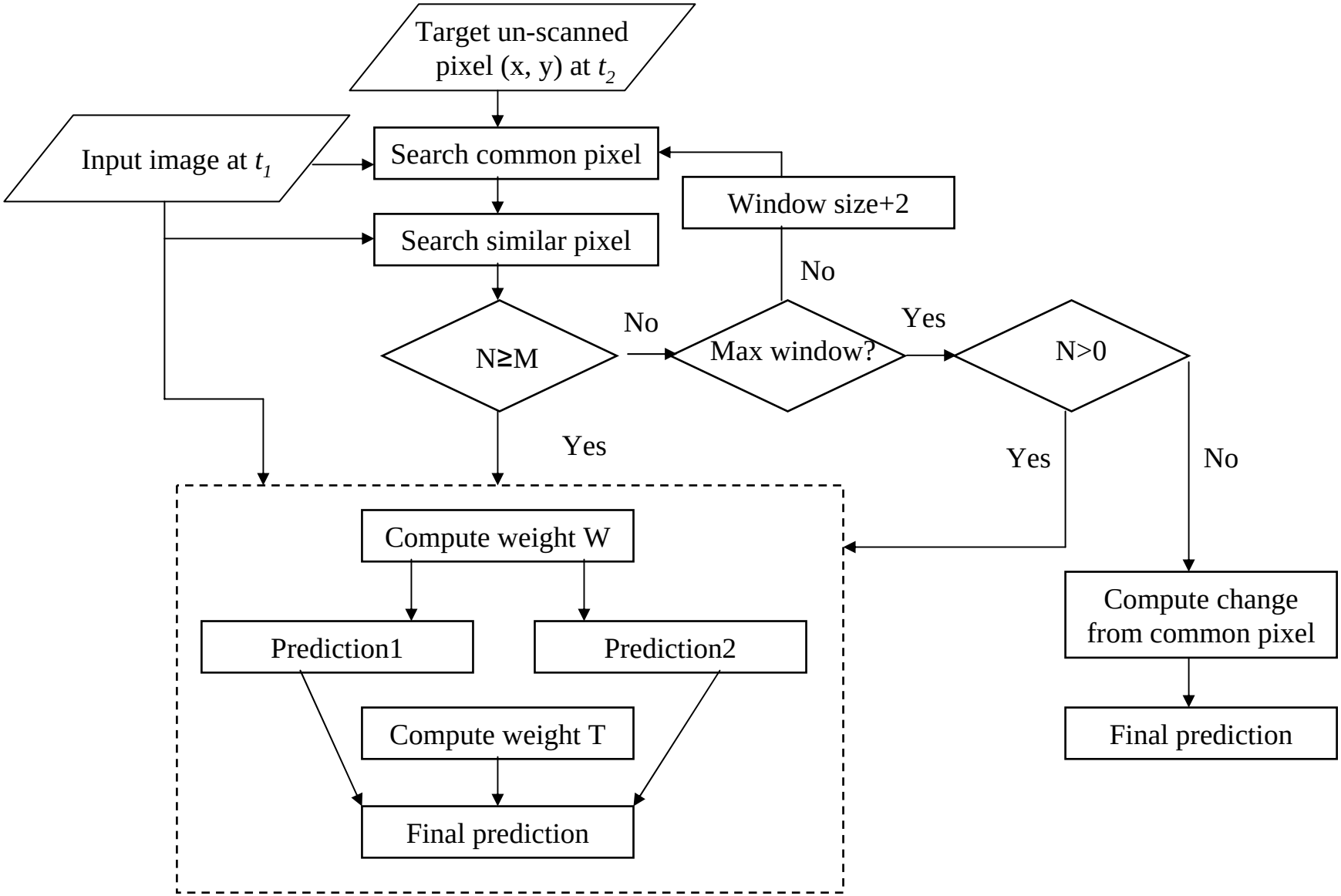
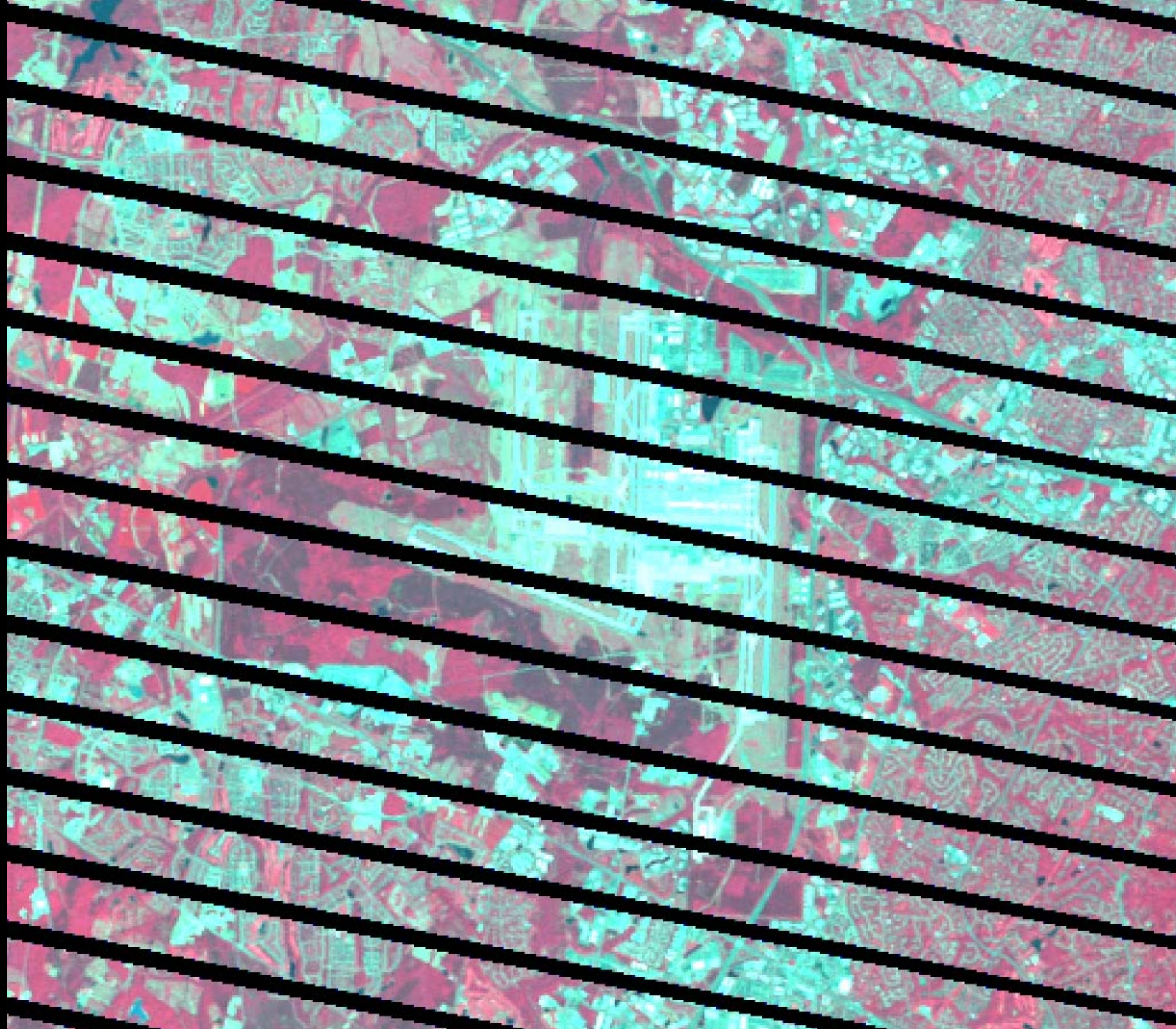

Target un-scanned pixel (x, y) at $t_2$
Input image at $t_1$
Search common pixel
Window size+2
Search similar pixel
No
N≥M
No
Max window?
Yes
N>0
Yes
Yes
No
Compute weight W
Prediction1
Prediction2
Compute weight T
Final prediction
Compute change from common pixel
Final prediction

Fig.1

# Test Area 1

# Baltimore and Washington DC area

Simulated SLC-OFF Scene; April 29, 2010 (Target Scene)



Filled using NSPI (using May 7 2007 as Input scene to fill the April 29 2010 target scene)

Test Area 2

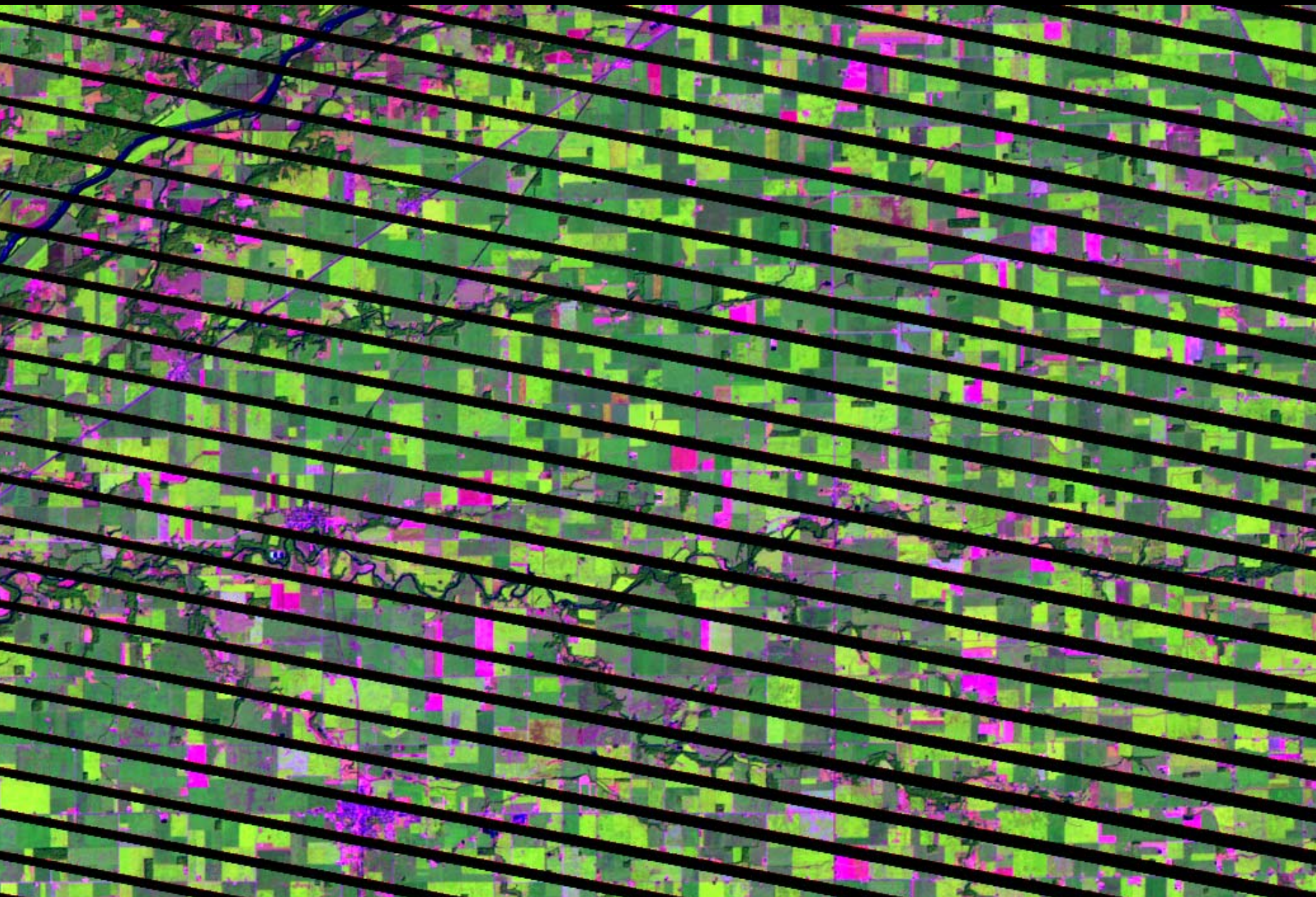
Northern Indiana and Illinois; corn and soybeans dominate

2a. Using input scene from different year (crop types change markedly between adjacent years)

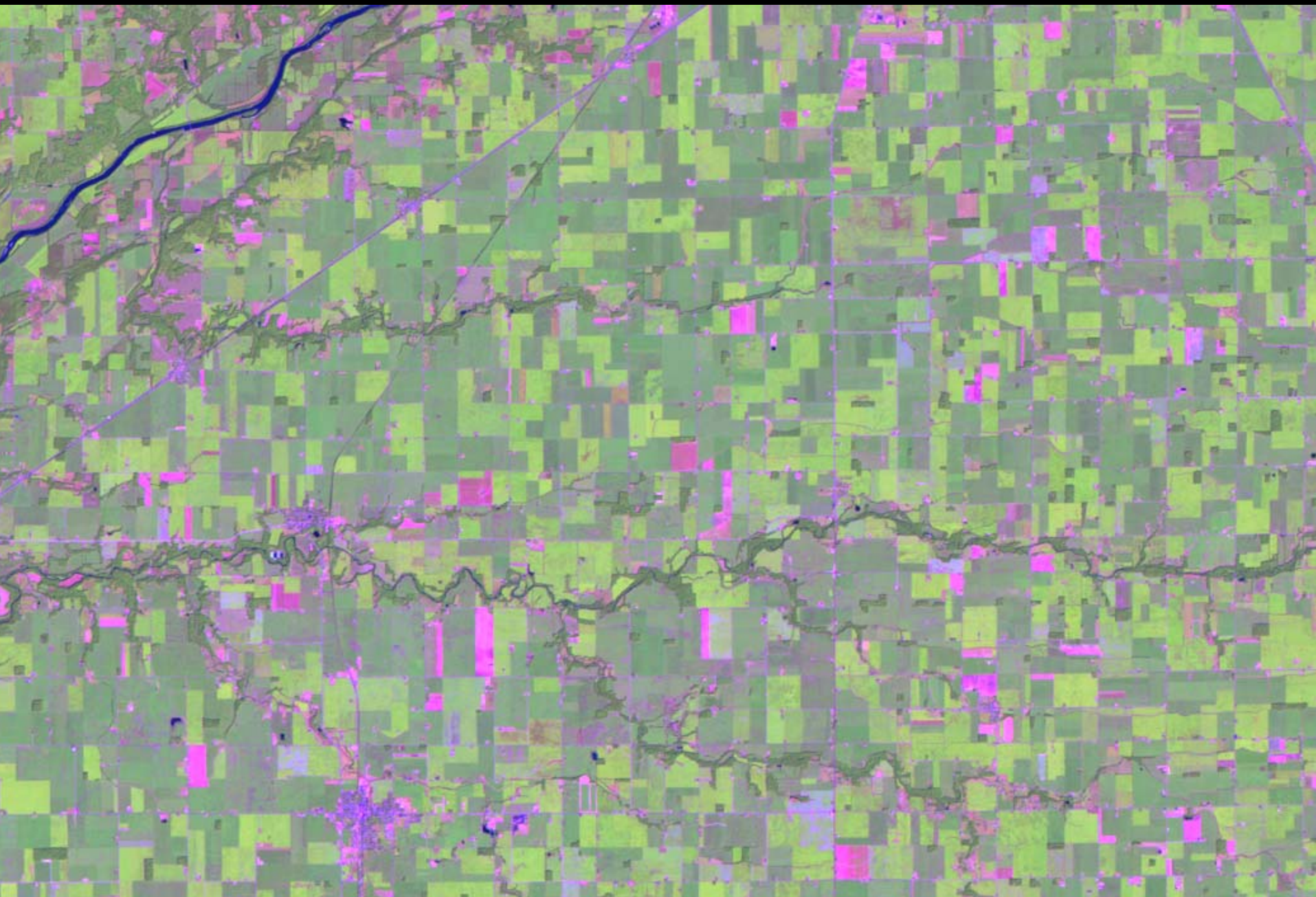
2b. Using input scene from same year, but having representing different phenological state

2a

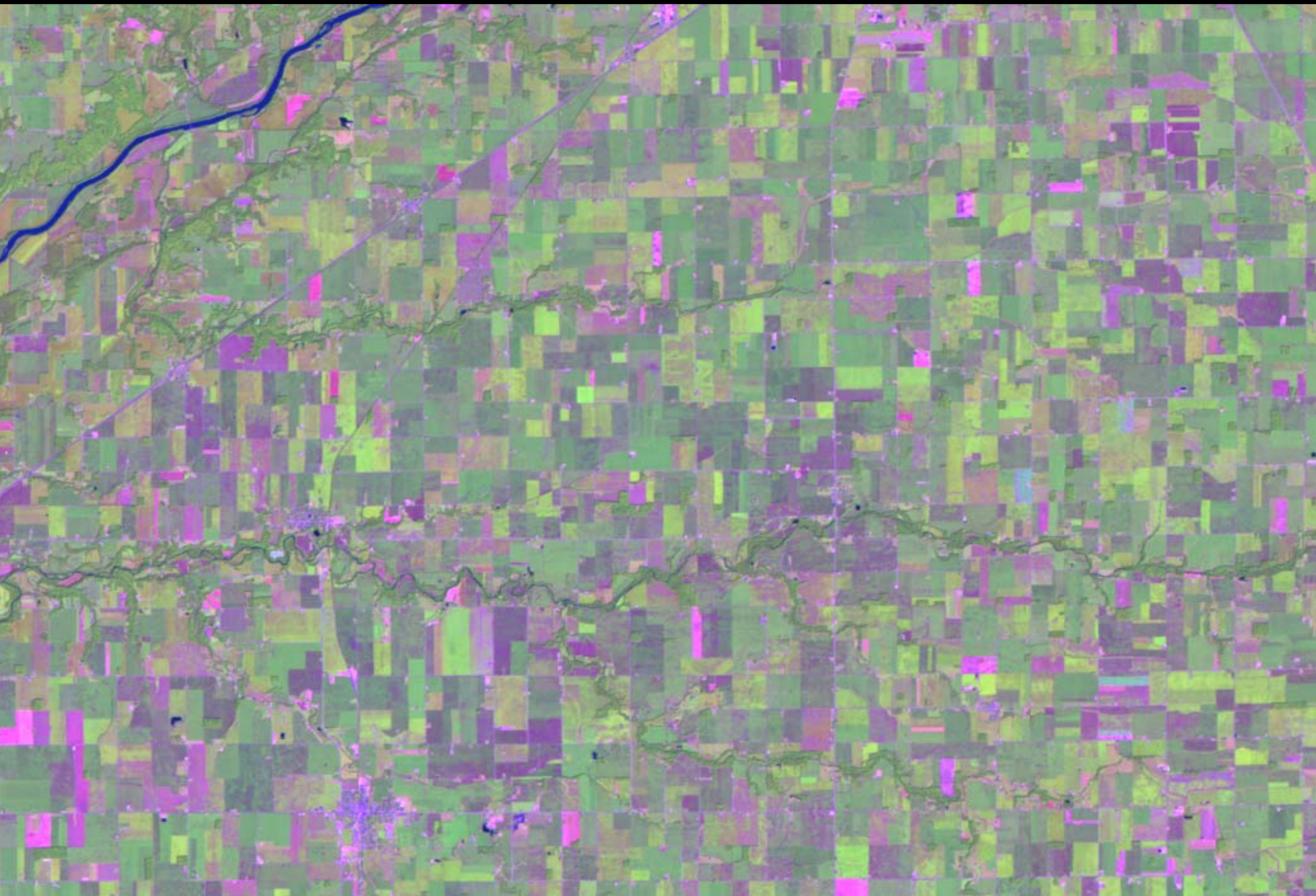
Simulated SLC-off Target Scene; N. Indiana and Illinois (August 30, 2008)



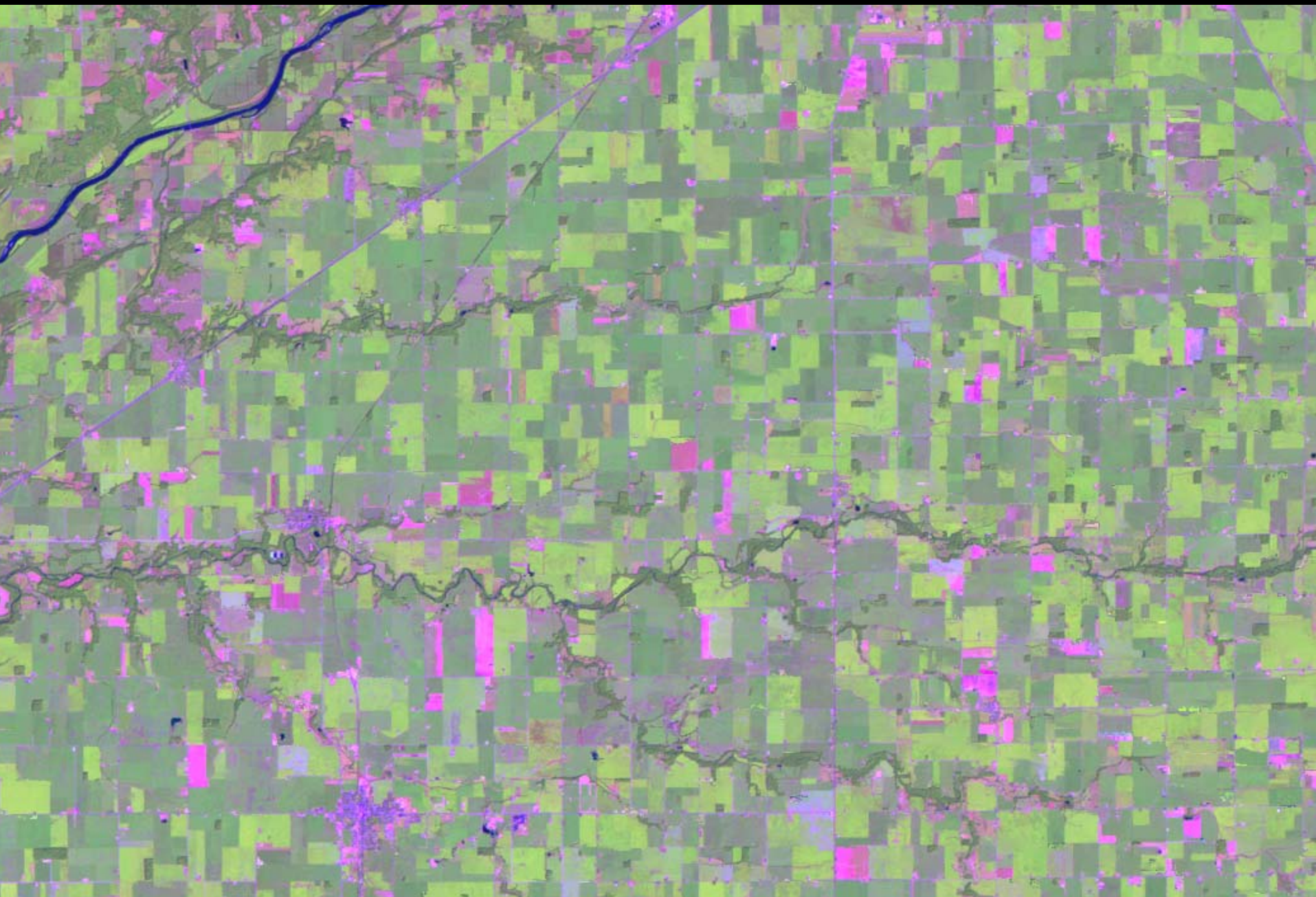
August 30, 2008 “Actual” data from which SLC-off data were simulated



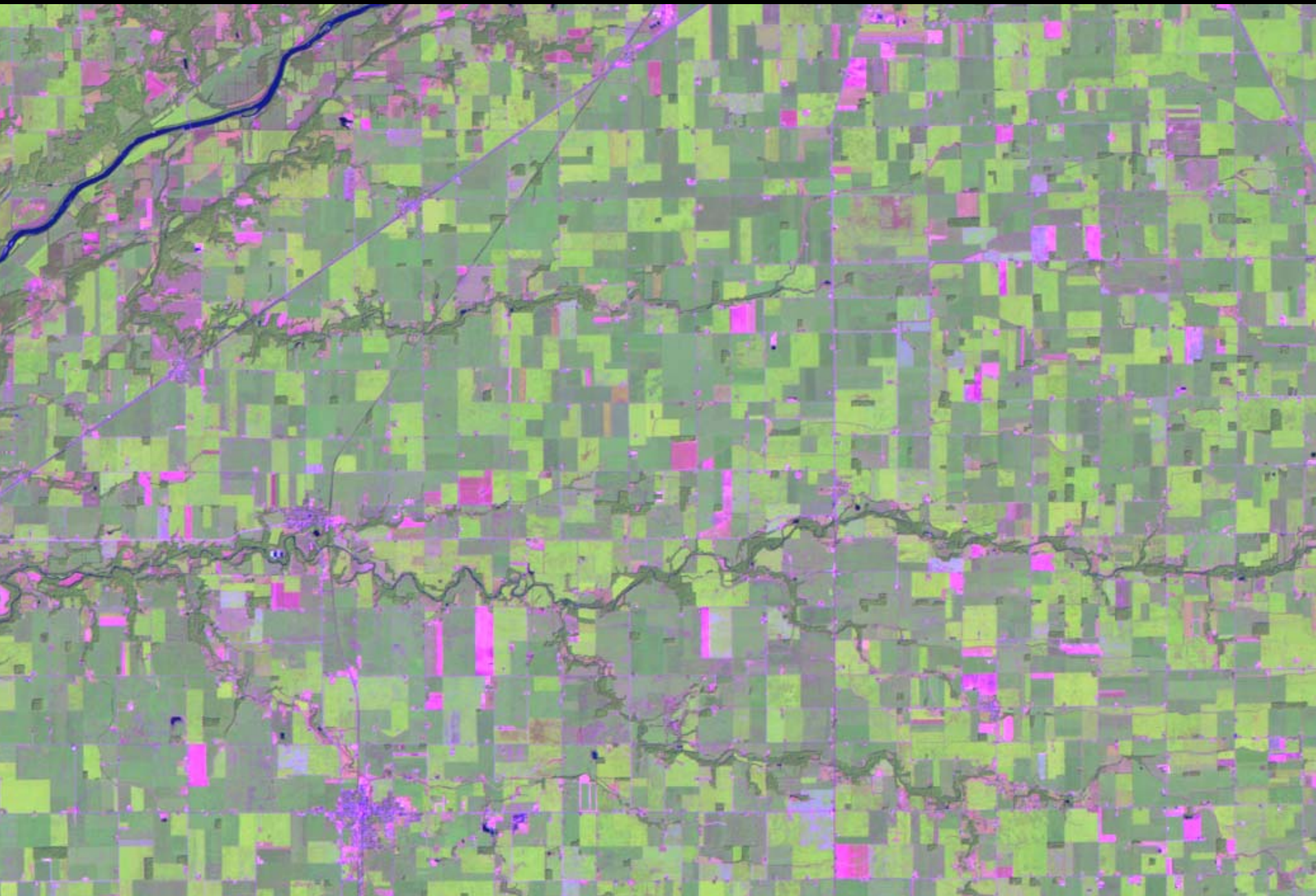
August 28 2007 Data (Input data for filling using NSPI)



Path 22 Row 32 August 30 2008 Filled with August 28, 2007 Data (NSPI)

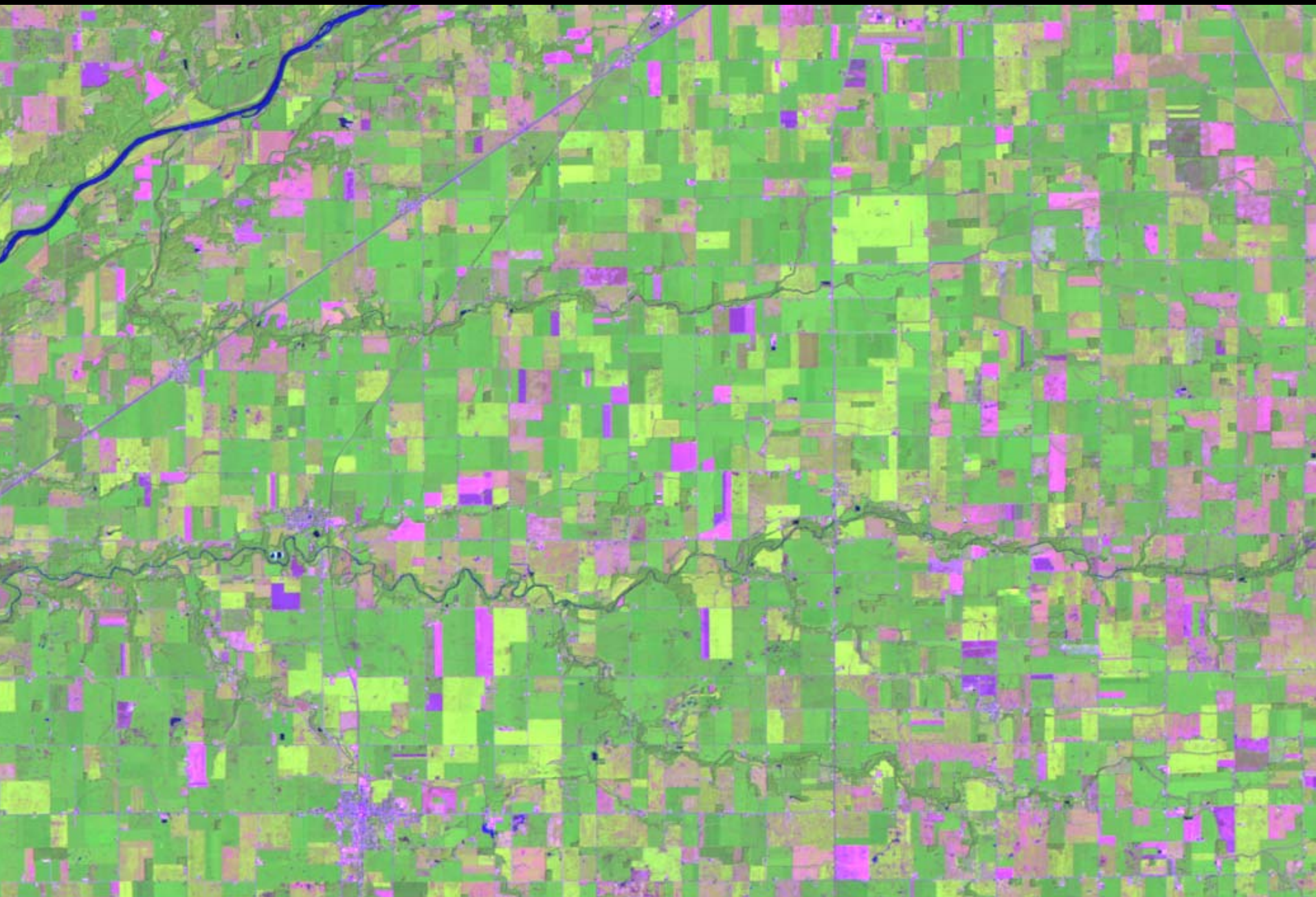


August 30, 2008 “Actual” data (from which SLC-off data were simulated)

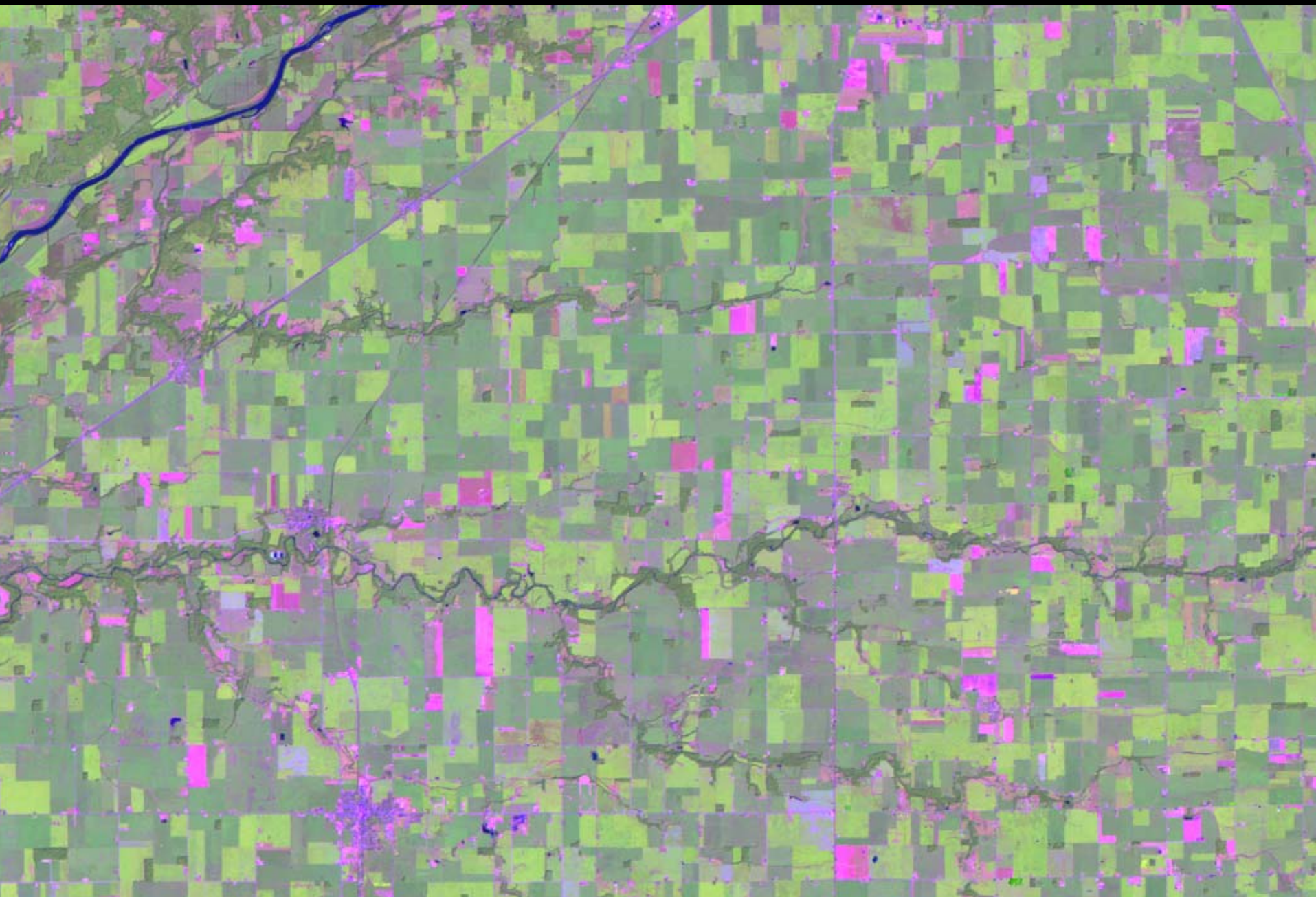


2b

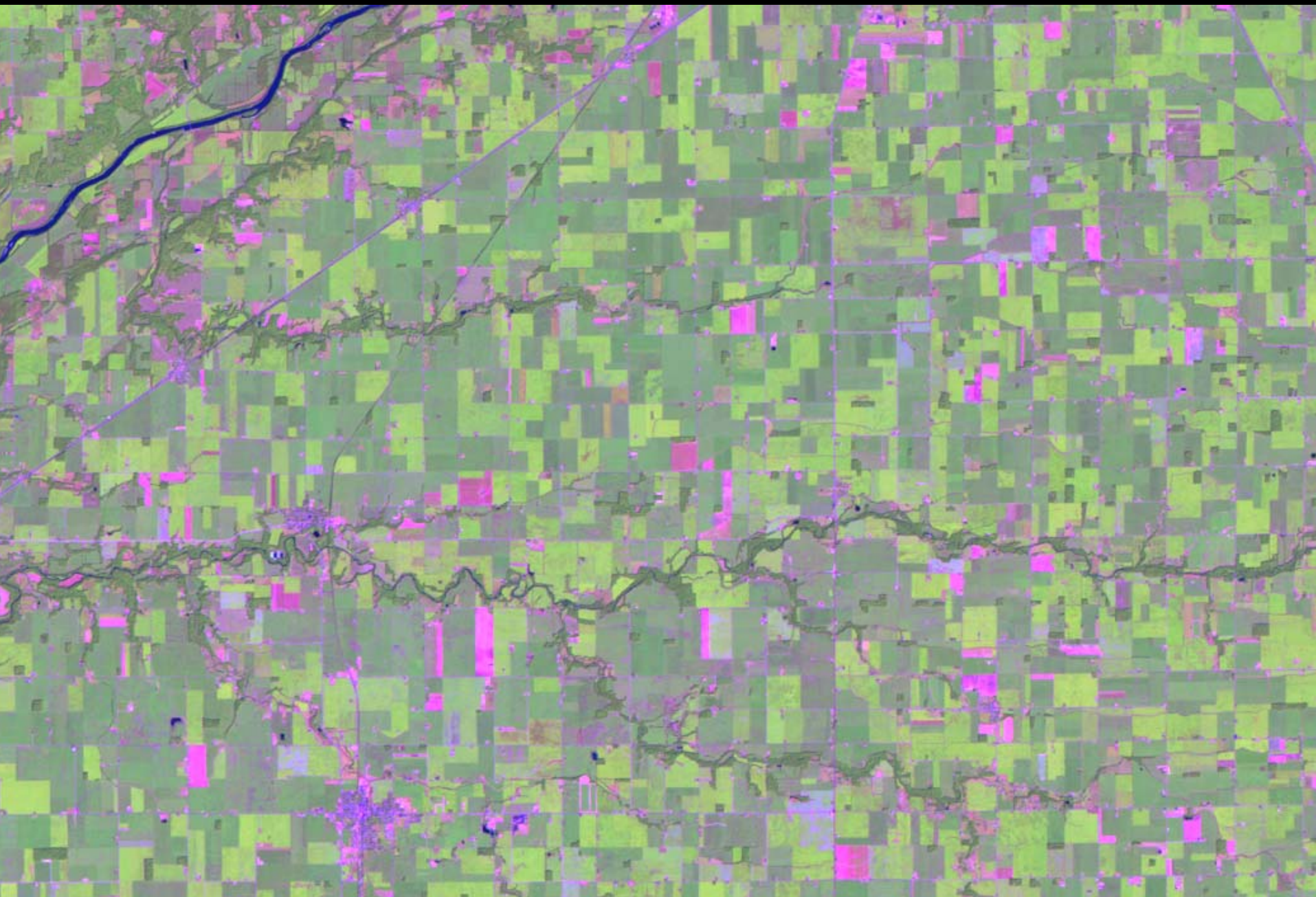
July 13 2008 Data (alternative input data for filling using NSPI)



Path 22 Row 32 August 30 2008 Filled with July 13, 2008 Data (NSPI)



August 30, 2008 “Actual” data from which SLC-off data were simulated

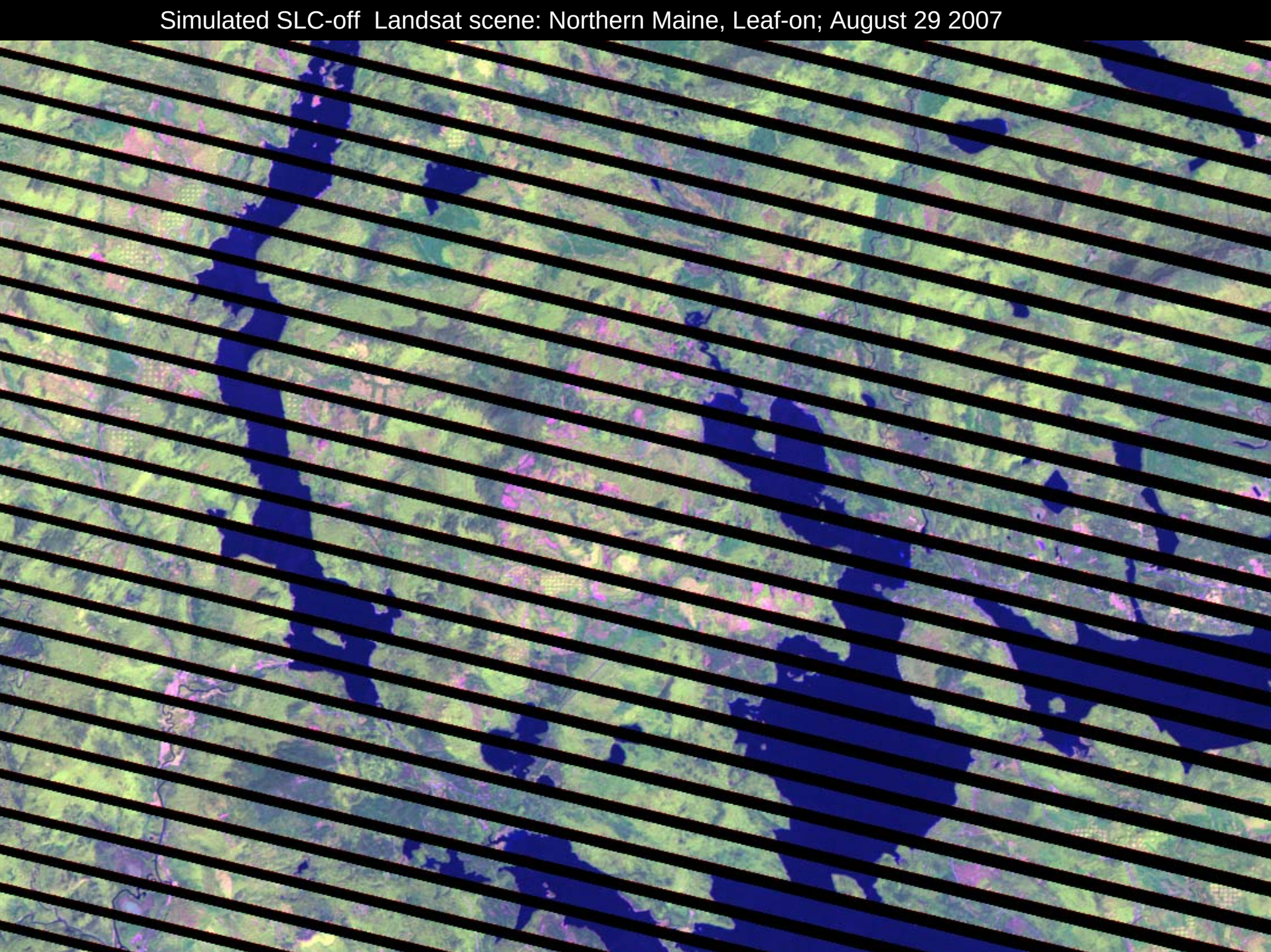


# Test Area 3

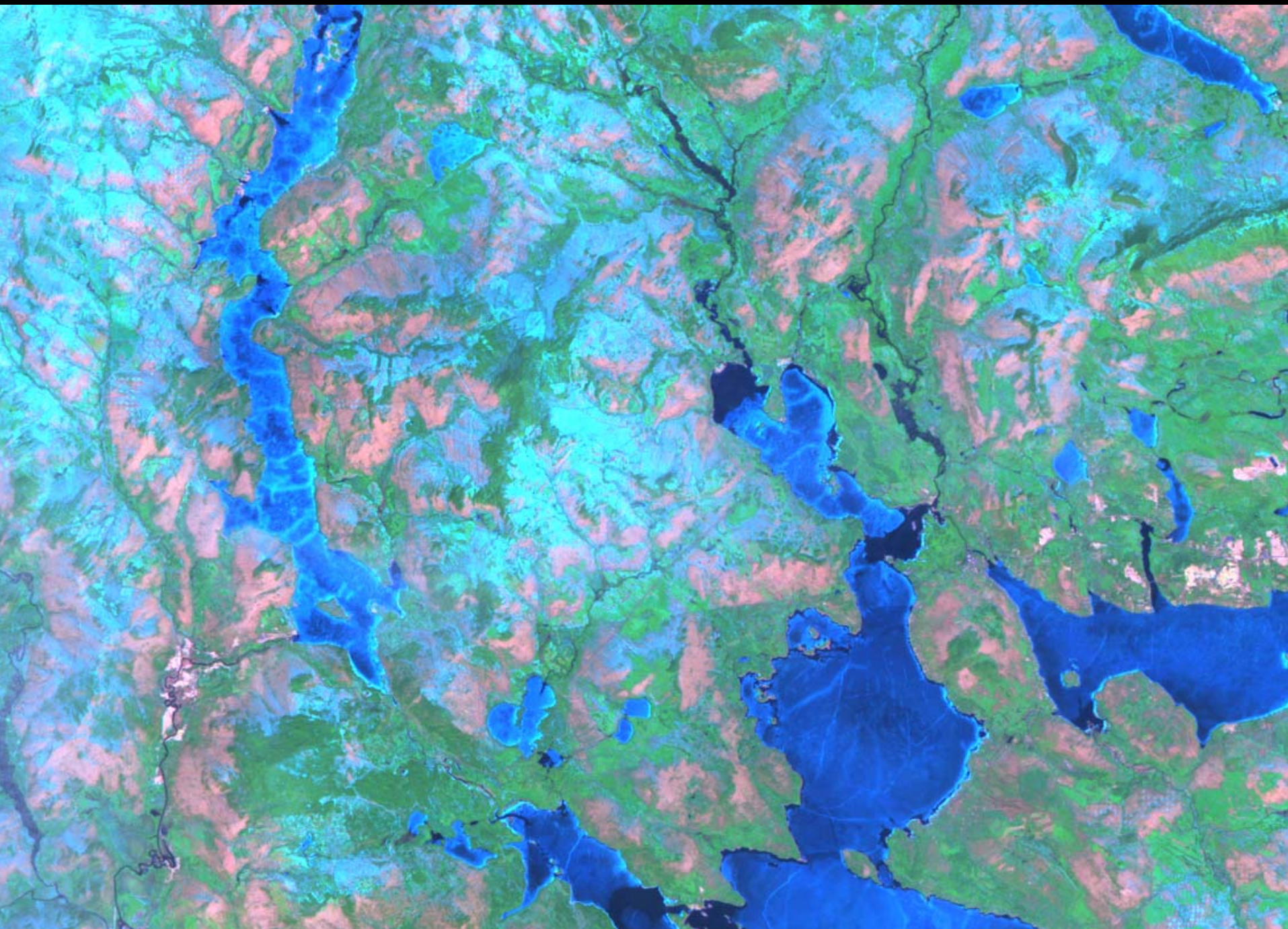
## Northern Maine

(Using late spring “snowy” scene as the input scene)

Original Landsat scene: Northern Maine, Leaf-on; August 29 2007


Simulated SLC-off Landsat scene: Northern Maine, Leaf-on; August 29 2007

Northern Maine: April 25, 2008 scene with snow and ice used as “input scene” for gap filling



Northern Maine:  August 29 2007 data set  gap filled using April 25, 2008 scene

Original Landsat Scene for “flickering” with previous slide to assess similarities/differences

Test 4

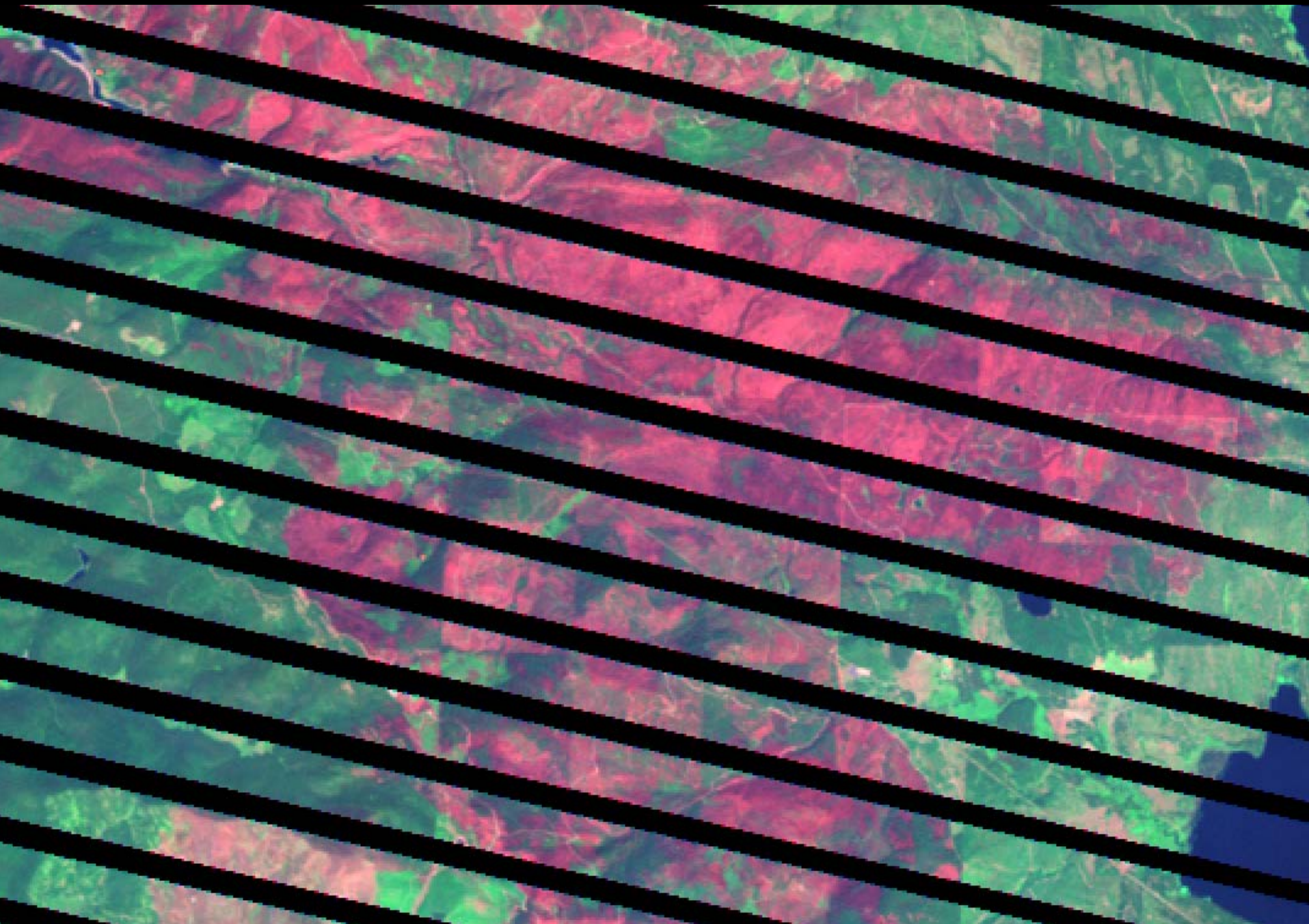
Burn area in Montana

Target scene was acquired after a major fire

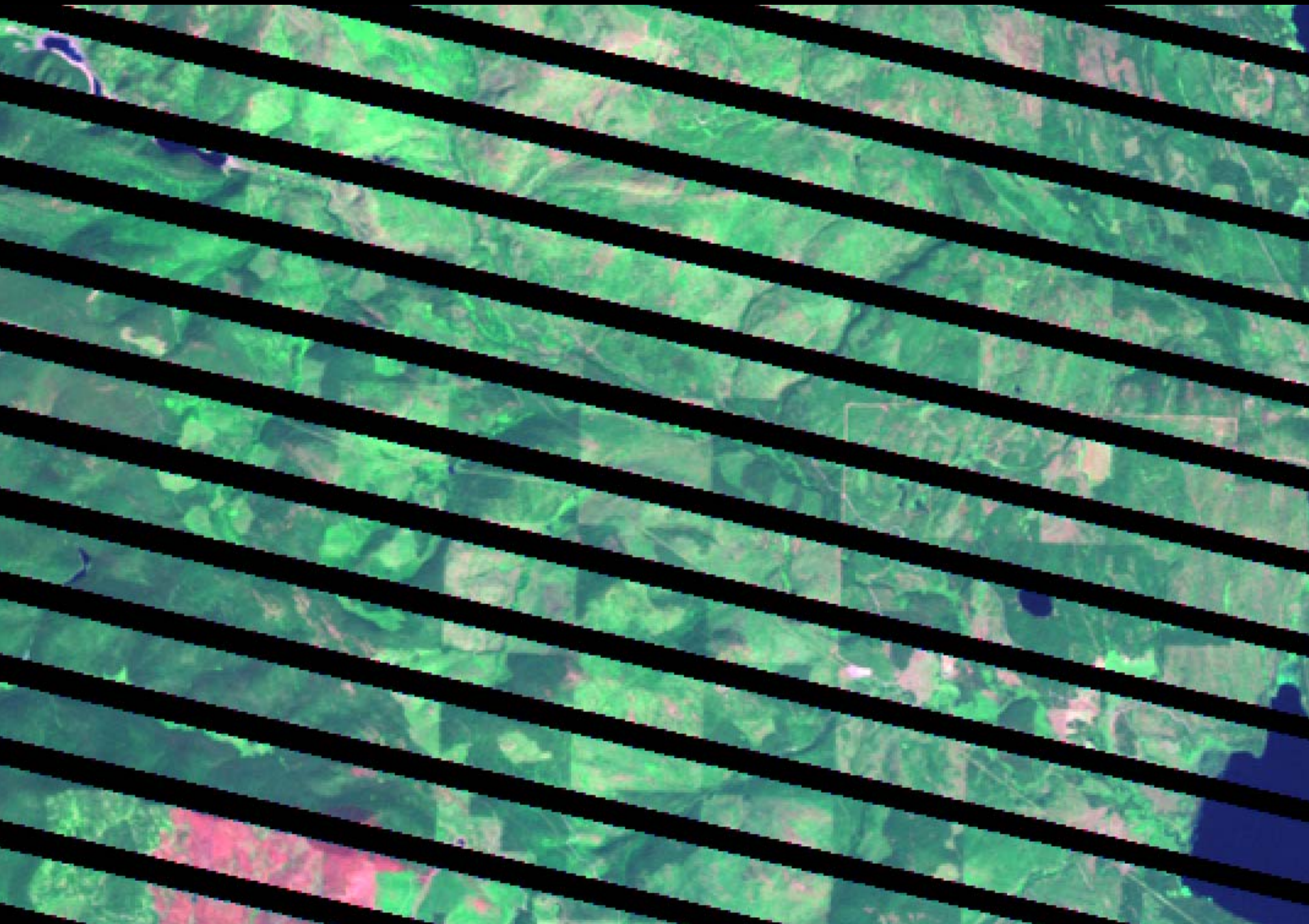
Scenes used as input scenes were acquired prior to fire

Only SLC-off scenes were used as input scenes; required 4 scenes to fill entire gaps

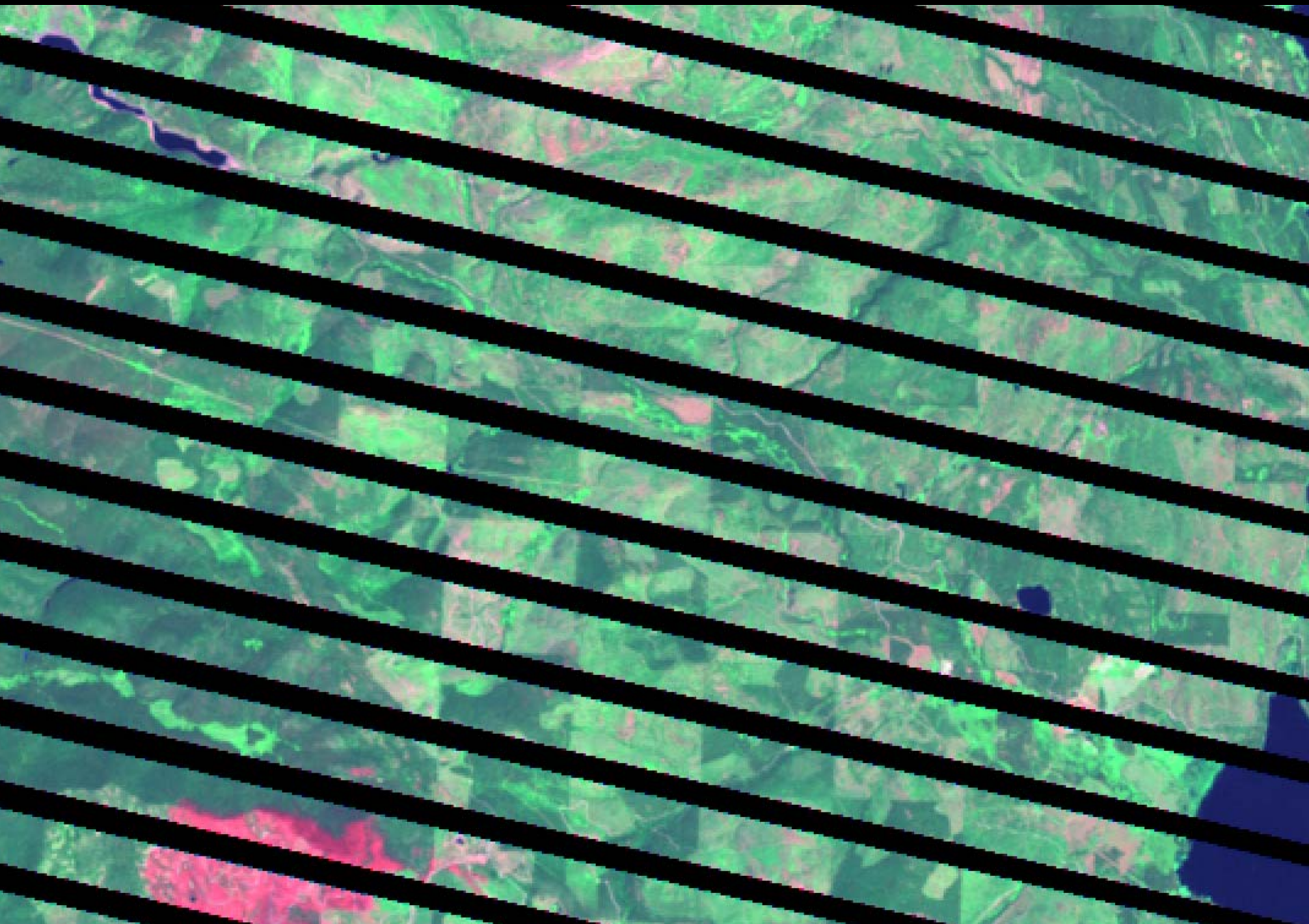
Original “Target” SLC-off data set: Sept 3, 2007



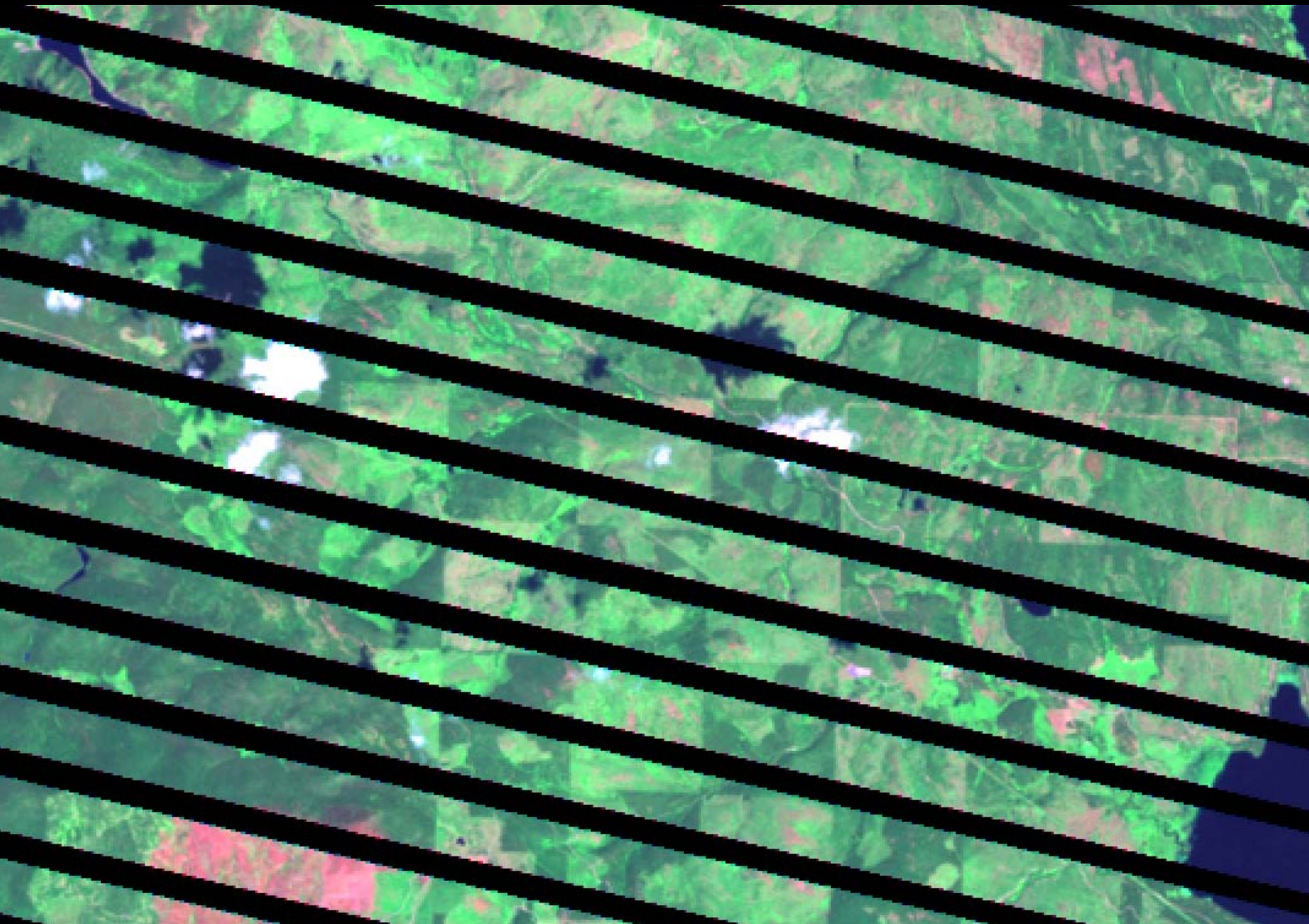
Input Data Set 1: August 28, 2005



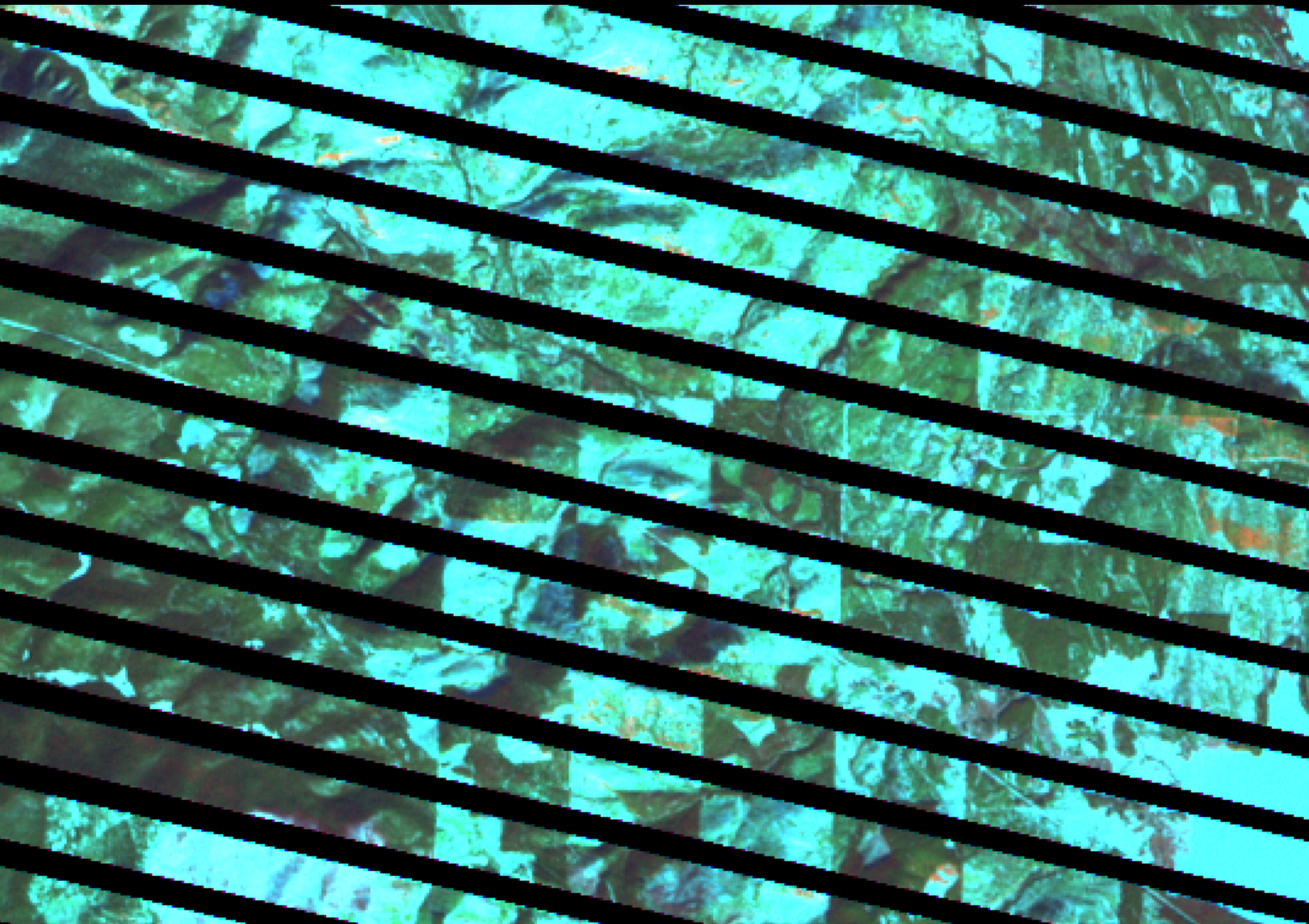
Input Data Set 2: July 24, 2004



Input Data Set 3: July 14, 2006



Input Data Set: 4: February 2, 2005

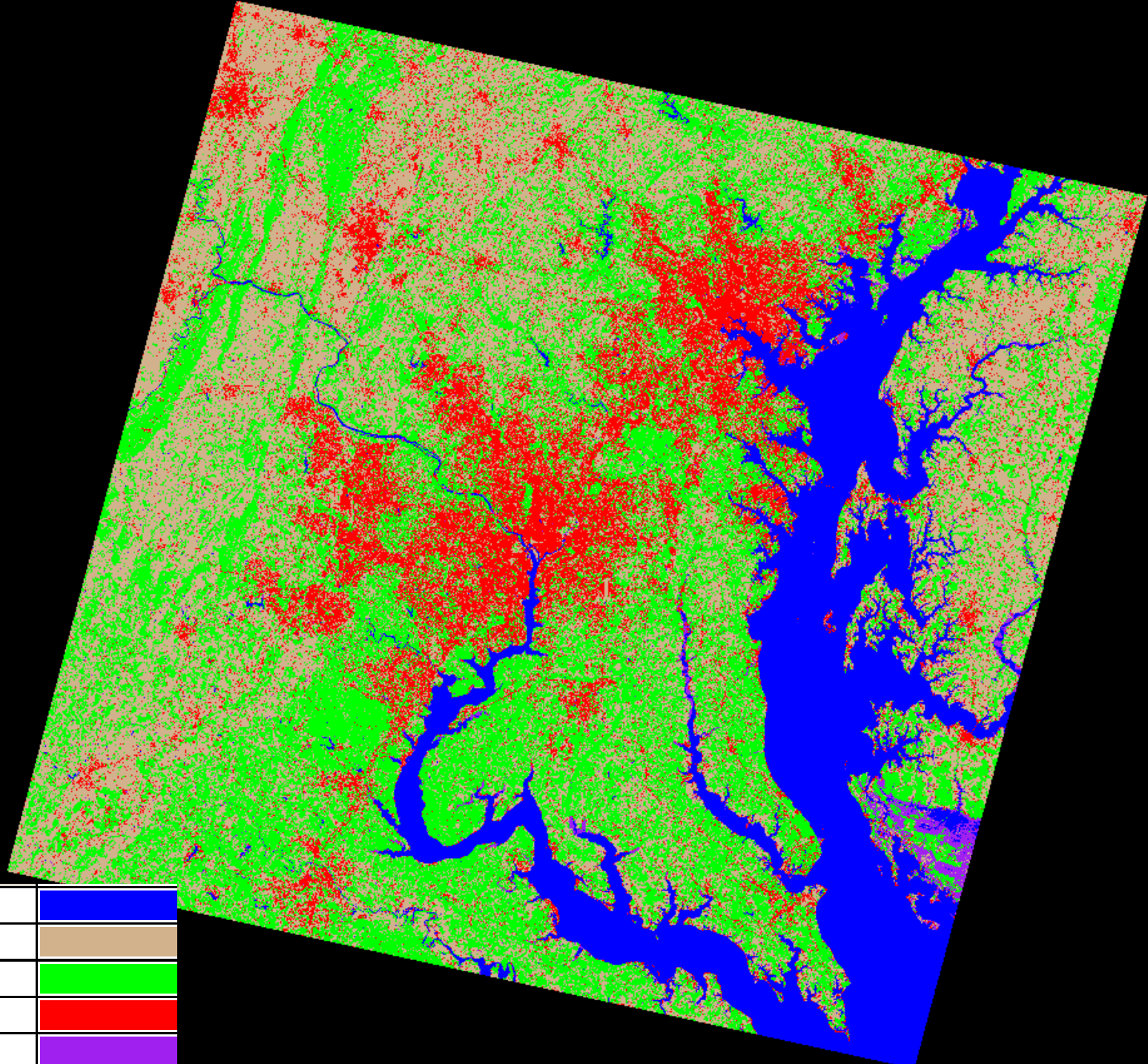


“Filled” Data Set (Original SLC-off Data Set Sept 3, 2007)

Sept 11 2007 Landsat 5 Data Set for Comparison

Results from five-class land cover classification generated using maximum likelihood supervised classification algorithm

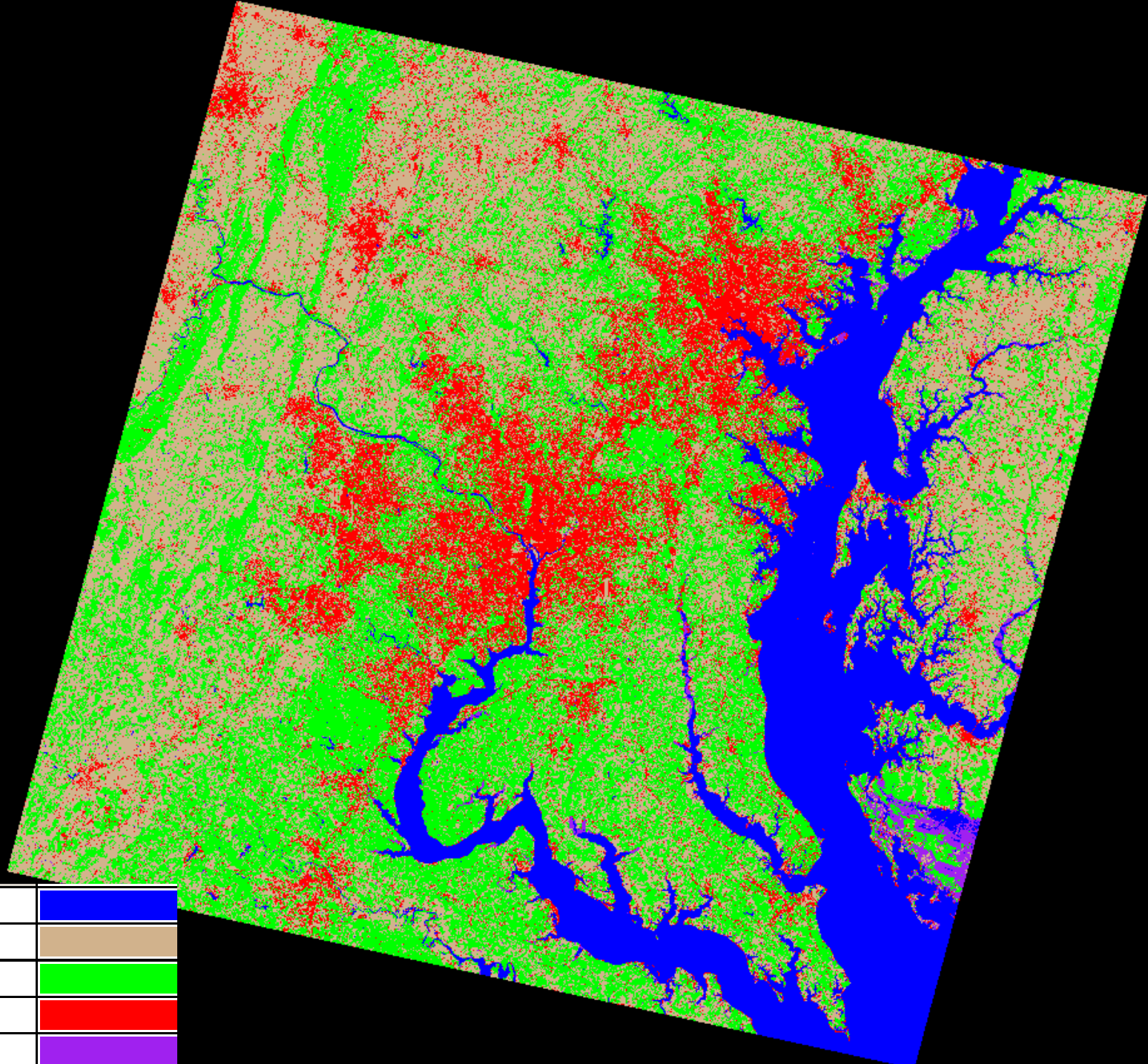
Original Data



| | |
|---|---|
| Water | |
| Ag | |
| Forest | |
| Urban | |
| Saltmarsh | |

Results from five-class land cover classification generated using maximum likelihood supervised classification Algorithm

Gaps filled with spectral sampling method



| | |
|---|---|
| Water | |
| Ag | |
| Forest | |
| Urban | |
| Saltmarsh | |

**Table 6**

Standard accuracy assessment of land cover classifications from just the gap areas. The first number relates to accuracies of land cover data generated from NSPI gap filled simulated SLC-off data, whereas the second (in bold) refers to accuracies developed using the actual imagery. Number of assessment points was 206. ***Overall classification accuracies*** within the gap areas were ***90.8% and 92.7% for gap-filled versus reference data sets, respectively***.

| Class | Reference Totals | Classified Totals | Number Correct | Producer's Accuracy | User's Accuracy |
|---|---|---|---|---|---|
| Water | 47 **47** | 45 **43** | 45 **43** | 95.7% **91.5%** | 100.0% **100.0%** |
| Agriculture and Grass | 67 **67** | 85 **75** | 67 **66** | 100.0% **98.5%** | 78.8% **88.0%** |
| Forest | 74 **74** | 61 **70** | 61 **68** | 82.4% **91.9%** | 100.0% **97.1%** |
| Urban | 15 **15** | 12 **14** | 12 **12** | 73.3% **80.0%** | 91.7% **85.7%** |
| Wetlands | 3 **3** | 3 **4** | 3 **2** | 100.0% **66.7%** | 100.0% **50.0%** |

# Comparison of Accuracies of Land Cover Data sets generated from gap-filled products using different approaches (Washington DC scene; 206 Reference Points used)

- Reference (Original) Data: 92.7%
- NSPI: 90.8%
  Neighborhood Similar Pixel Interpolator)
- Merging with different data set: 86.4%
  (linear regression to normalize data)
- Using E-Cognition approach: 82.0%
- Focal Window interpolation: 81.1%

# Some Comments regarding NSPI

- Process in empirical.
- Approach can yield very good composites even when “input” scenes are sub-par.  This may be important in areas where there are not many good scenes to use.
- Compensates for phenology (as well as other types of inter-scene differences)
- Classification results can be quite good using NSPI composites.
- Procedure works better if clouds/cloud shadows are masked out.