ImageScan

A target detection processing chain using ArcMap

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Be Where Aware!

Outline

- Background
- Overview
- Goals and Objectives
- ImageScan Methodology
- Examples and Results
  - Thermal IR Hotspots
  - Airborne Collection
  - VIIRS Collection
  - Other
- Summary
- List of Acronyms
- References

Background

- Increase in our ability to gather (intel) data
  - Especially geospatial data
  - Collecting more than 1500% more data than 5 years ago
  - ISR task force system can gather more than 53 TBytes data/day

Too Much Data?

Can you ever have too much data?

A simple search shows …

Too Much Data?

Google

too much isr data

Search

About 359,000 results (0.20 seconds)

Too Much Information, Not Enough Intelligence
www.nationaldefensemagazine.org › ... › Archive › 2012
... force not detected in time by **ISR** assets." Military drone operators amass untold amounts of **data** that never is fully analyzed because it is simply **too much**, ...

The Warner Robins Patriot - Air Force awash in **ISR data**
warnerrobinspatriot.com/.../18005407-Air-Force-awash-in-**ISR-data**
Air Force awash in **ISR data**. by Gene Rector The Warner Robins ... It's **too much** and the capacity to gainfully process all of it. U.S. forces receive mountains of ...

Sensory overload: Military is dealing with a **data** deluge -- Defense ...
defensesystems.com/.../02/.../home-page-defense-military-sensors.asp...
Feb 4, 2010 – **Too much data** inhibits analysts' ability to unearth meaningful ... and surveillances (**ISR**), as reported by National Defense magazine. No one is ...

All-seeing **ISR** | Aerospace | The Royal Aeronautical Society
media.aerosociety.com/aerospace-insight/2012/03/02/all...**isr**/6480/
Mar 2, 2012 – The operational **ISR** needs in Iraq and Afghanistan, and more recently ... with growing complexities in attempting to deliver so **much ISR data** from a ... if vital **data** is not to be missed or **data** flows become **too** massive to cope.

[RTOS Support] More efficient **ISR** queue handling
www.freertos.org/.../freertos_More_efficient_**ISR**_queue_handling_1...
There was **too much** overhead from the taskswitching, and thus I lost **data**. The problem was that the **serialISR** called taskYIELD if the queue contents changed ...

Too Much Data?

[***Too Much*** Information, Not Enough Intelligence]

... force not detected in time by ***ISR*** assets." Military drone operators amass untold amounts of ***data*** that never is fully analyzed because it is simply ***too much***, **...**

[Sensory overload: Military is dealing with a ***data*** deluge -- Defense **...**]

Too much data inhibits analysts' ability to unearth meaningful **...** and surveillances (***ISR***), as reported by National Defense magazine. No one is **...**

[All-seeing ***ISR*** | Aerospace | The Royal Aeronautical Society]

The operational ***ISR*** needs in Iraq and Afghanistan, and more recently **...** with g complexities in attempting to deliver so ***much*** ***ISR data*** from a **...** if vital ***data*** is not to be missed or ***data*** flows become ***too*** massive to cope.

[DARPA Doubling Down on Spy Technologies – AUVAC]

But analysts already complain that they are receiving ***too much data*** from ***ISR*** assets. DARPA used to focus more heavily on sensors and less **...**.

[Airborne *ISR* - Trajectory Magazine Online]

The history and future of airborne ISR. Where we've been, where we're ... The data content already is **too much for analysts to swallow**. "Presently, you've got a ...

Background (cont.)

- Increase in our ability to gather (intel) data
  - Especially geospatial data
  - Collecting more than 1500% more data than 5 years ago
  - ISR task force system can gather more than 53 TBytes data/day
- Real challenge is to improve our Processing, Exploitation/Analysis, and Dissemination (PED)
  - Continuous goal is to improve PED efficiency
  - Change/improve data dissemination
  - Data transfer - Identify data transmission bottle necks
  - Maximize our resource efficiencies
    - Identify high priority data for detailed analysis
    - Automate routine analysis

Background (cont.)

- Automation is a must
  - Computers are cost effective tools
  - Complete repetitive tasks
  - Analyst's time is expensive/valuable – manage it wisely
  - Need to build processes to …
    - maximize their efficiency by reducing their time spent on data searches and preprocessing
    - help prioritize their efforts
      - Identify key data sets
      - Identify points of interest
  - Catalog **geospatial results** are critical with GEOINT and ISR applications, distributed/federated analysis, and information sharing
    - Build historical databases
    - Useful in trend analysis
    - Useful in detecting anomalies
      - Focus analyst on unusual (potentially) key information

Overview

- The goal of ImageScan is to:
  - Create an automated or semi-automated image scanning and reporting processing chain (using ArcMap and other software if needed)
  - **Help data and production managers perform an initial review of data**
  - Alert customers, analysts, or end-users with a geospatial report of target locations and a subset list of priority images to analyze

Project Goals

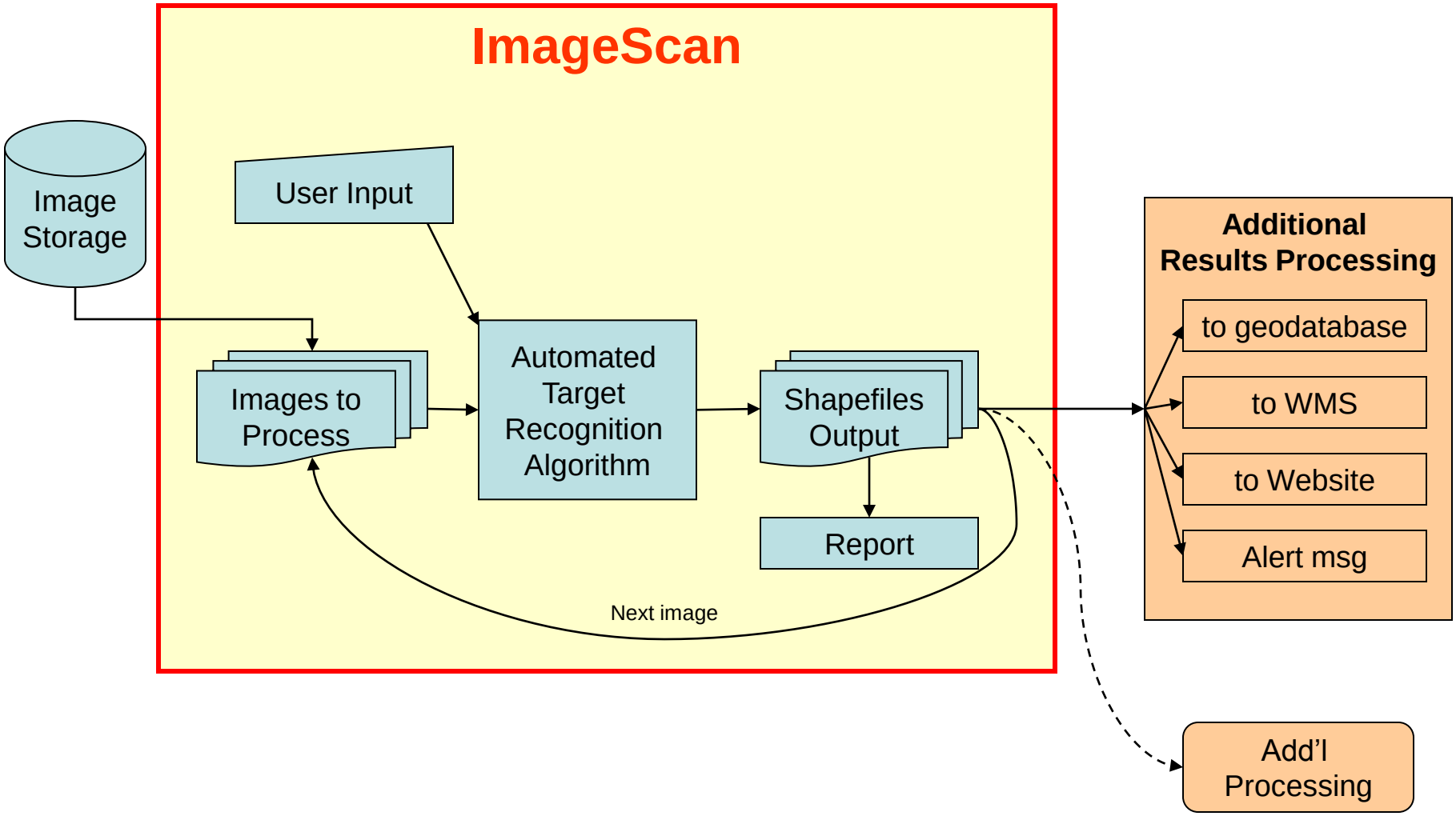
- ImageScan will be a system to
  - process data in an (ingest) directory,
  - read/enter a set of criteria
    - bounding box(es),
    - start stop dates,
    - detection threshold limits (size and intensity)
  - summarize the data (footprints, collection date/time),
  - identify/highlight data sets that meet the criteria for analyst review; and
  - create reports (tables, thumbnails, web pages), and
  - create shapefiles.
    - The shapefiles would be used to update a geodatabase for treading or other sensor integration/fusion analysis efforts.

- *Caveat: The "scanning" technique detects high contrast pixels in raster imagery with ArcGIS procedures. I have no doubt this can be improved upon.*

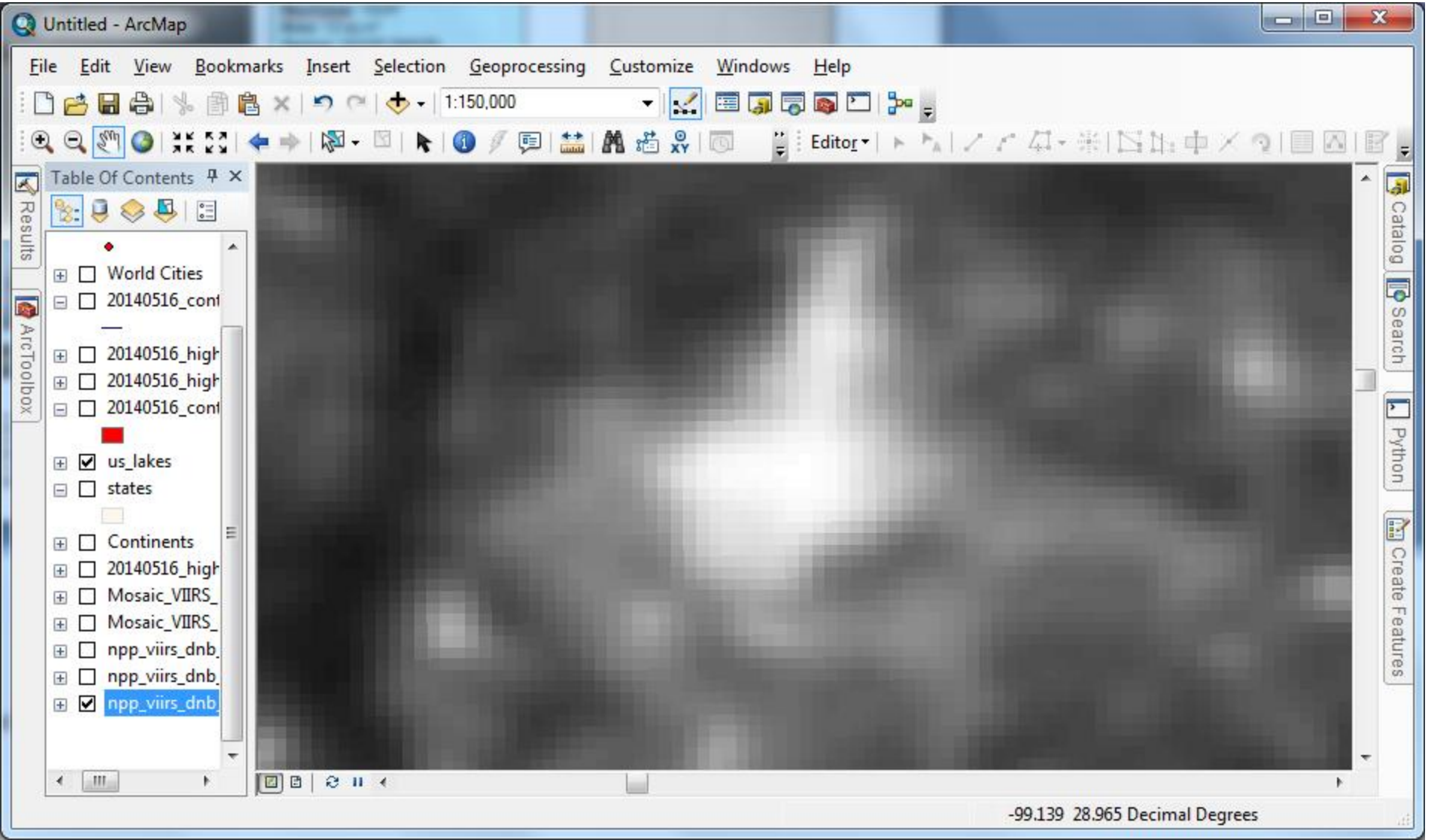
The Problem

- **The Problem**: With a library with over a thousand raster images, identify all data sets with high intensity values pixels (that exceed DN xxxx).
- For <u>each</u> raster image:
  - Determine the location of each detection
  - Do not report every pixel location; Cluster neighboring pixel (detections) together so that a multiple pixels target is reported as one target detection. For example, an oval 4x10 pixel target is reported as 1 target location and 1 polygon and not 40 individual target detections.
  - Locate the center of each target detection
  - Create a polygon for each target detection
  - Bonus: eliminate false alarms - in this case, small targets - single pixel detections
  - Create a library of detections that can be searched geographically, temporally
  - Repeat for the next image
- Repeat this every week (or every data delivery cycle)
- The results from ImageScan will be integrated with other data sources for a separate research project which is outside the scope of this capstone
- **This Capstone project will create a working prototype that will work on a few images.**

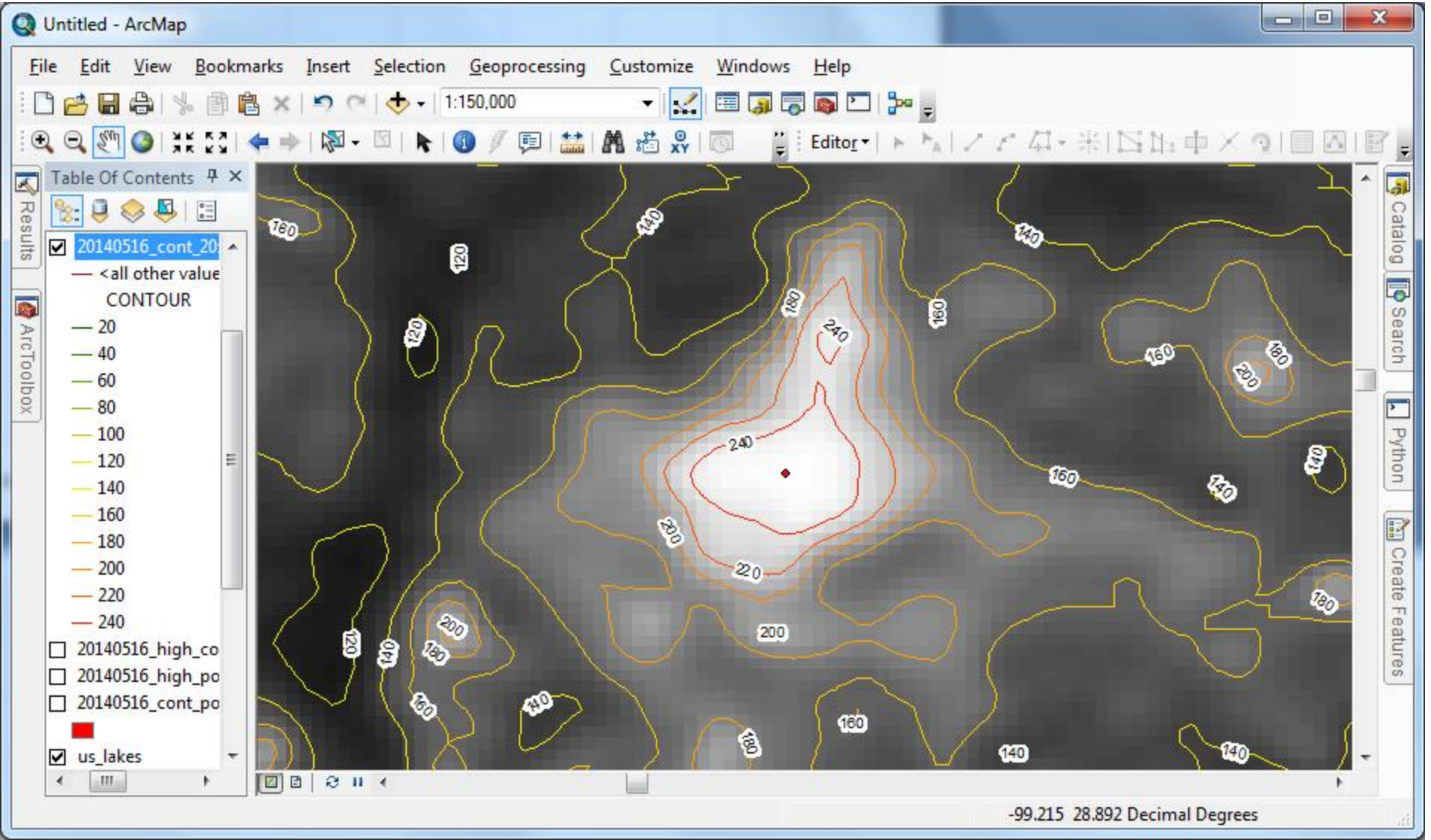
ImageScan - Process Overview



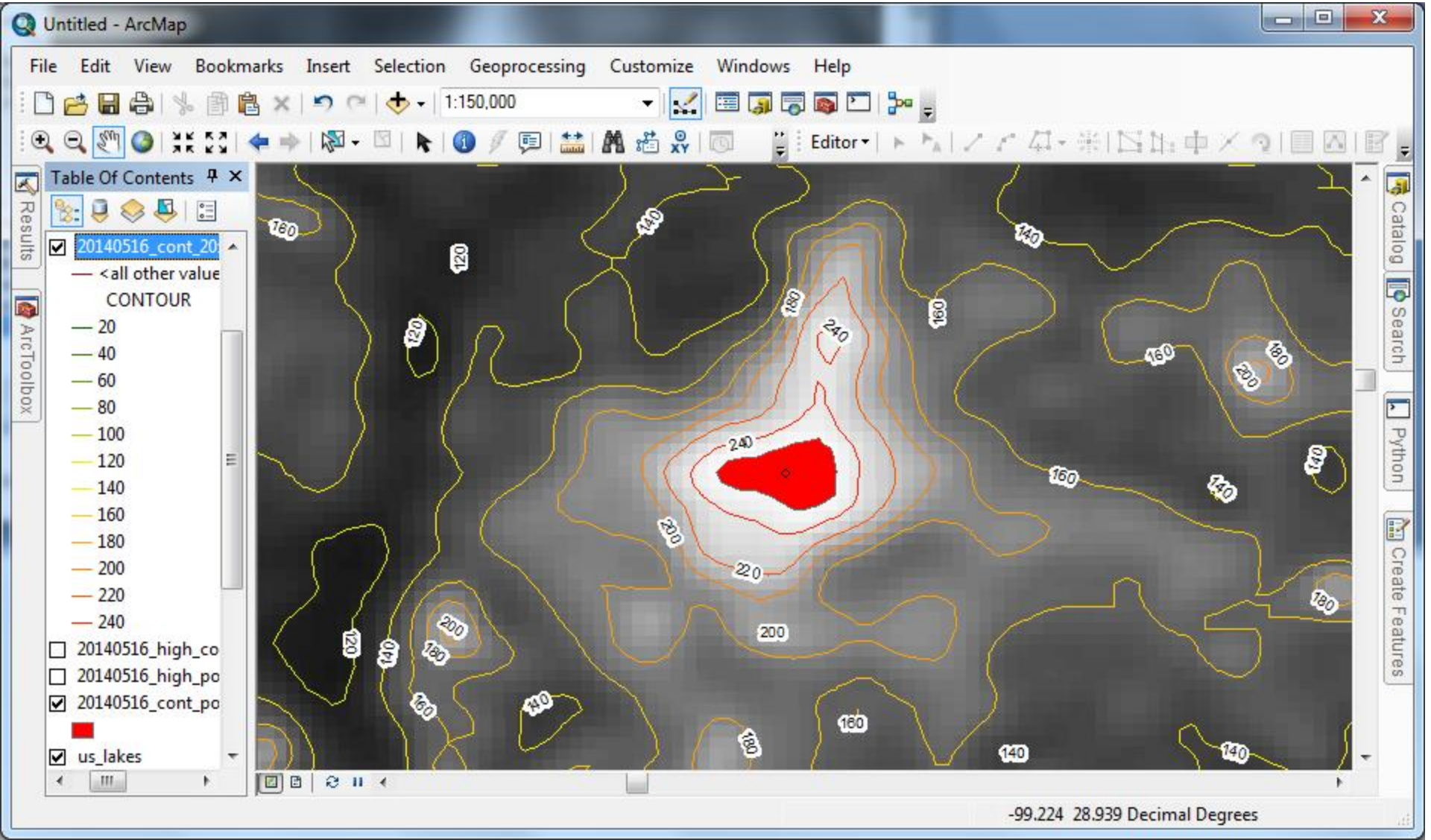
ArcGIS Scanning ATR Process



Contour Raster DN Values



Identify Saturation Areas



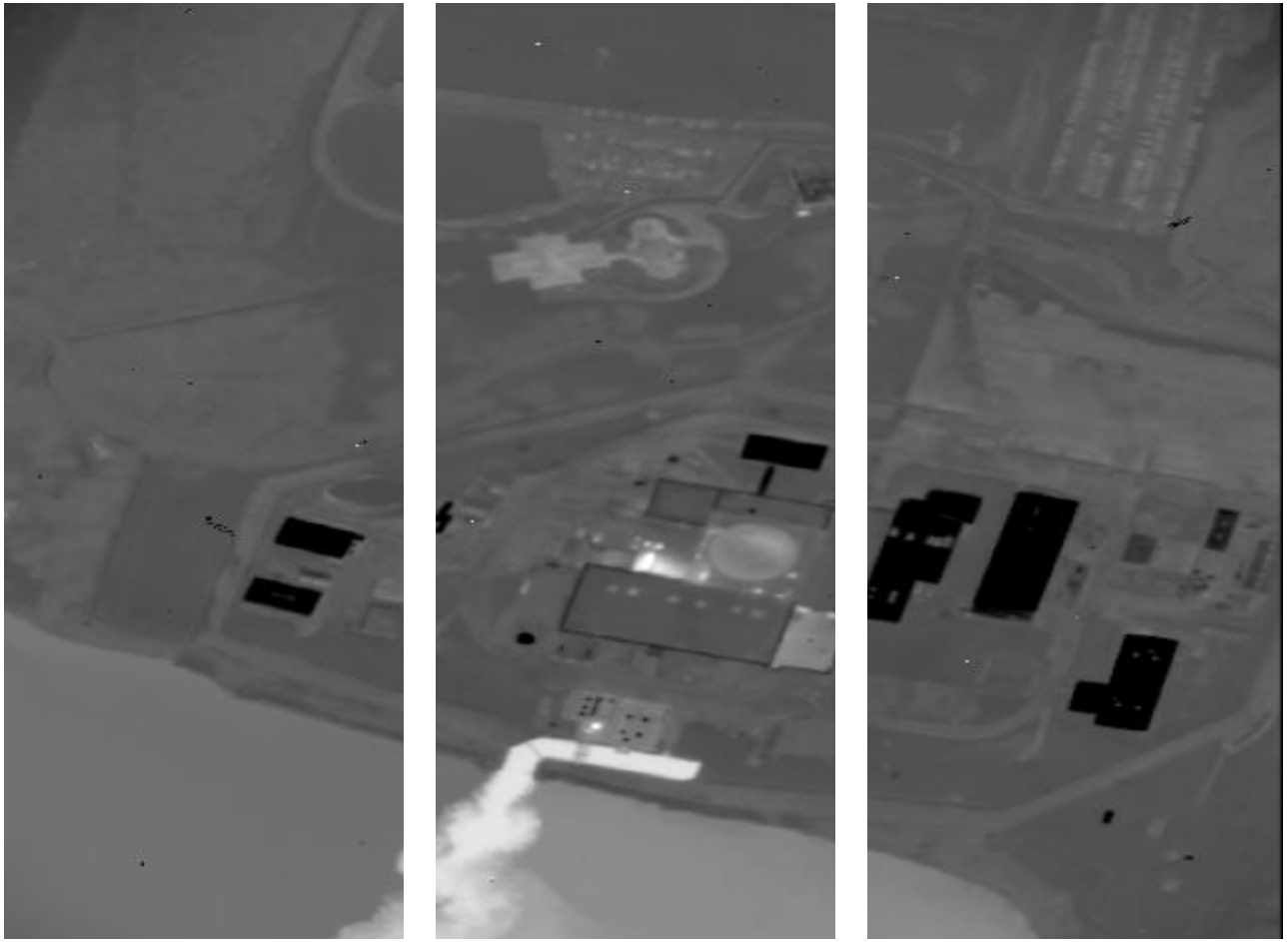
Example: TIR Hot Spots

- **Goal**: Detect and report locations of all probable hot spots with Thermal IR (MWIR) imagery

- Derived requirements:
  - Accomplish daily
  - Accomplish quickly with automated processing and minimal analyst input
  - Results will be in standard geospatial formats

Sample Images

. . .



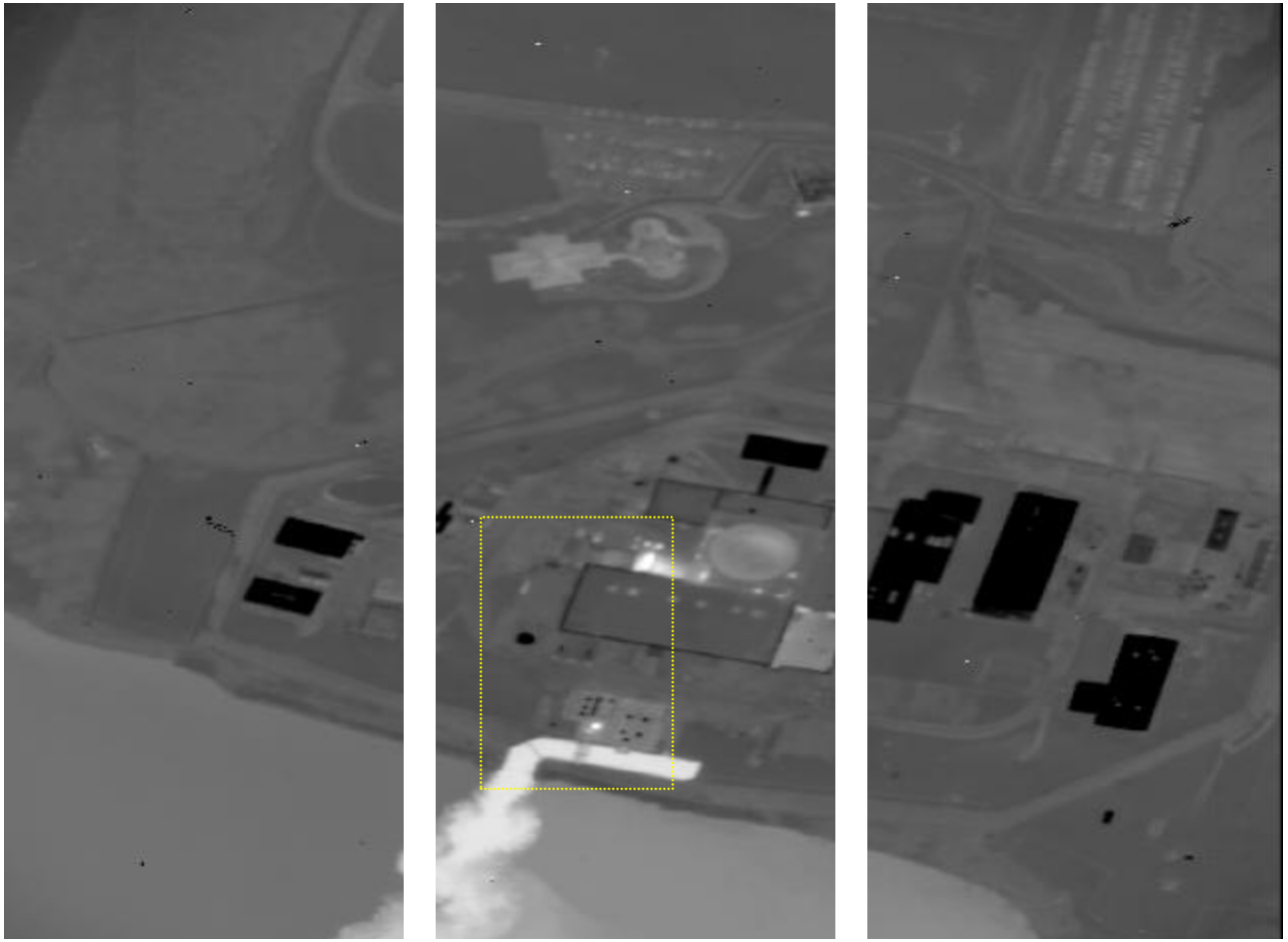
. . .

WASP Thermal MWIR Images of Ginna Power Plant

http://www.google.com/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=4&ved=0CDUQFjAD&url=http%3A%2F%2Flandsat.usgs.gov%2Fdocuments%2F6a_Schott_Overview_of_DIRS_Research%2520Activities.pdf&ei=N33JTqLfNa7y2gW6q4ngDw&usg=AFQjCNHKb35F1bXIjMoikF9xyUvBxEInCQ&sig2=vop2MSeAqS7z707GnHjOaw

Sample Images

. . .



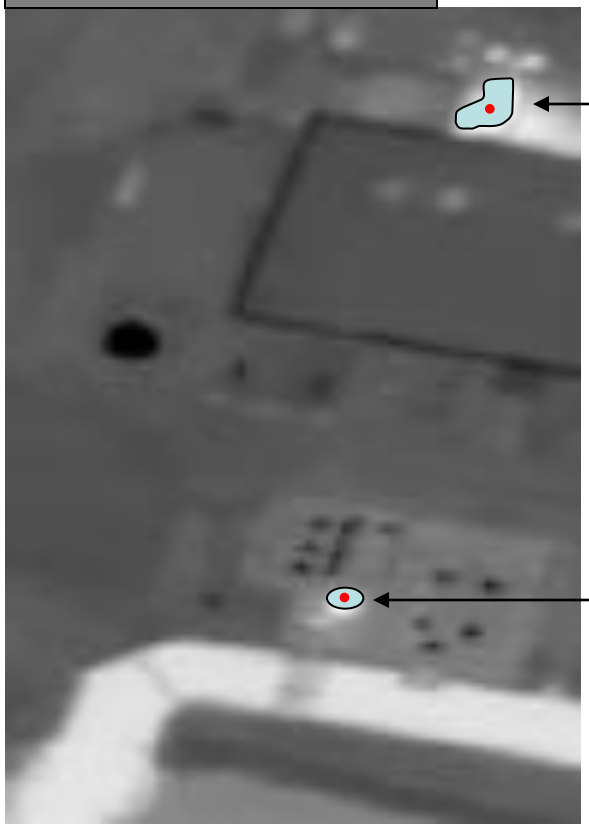
. . .

WASP Thermal MWIR Image of Ginna Power Plant

http://www.google.com/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=4&ved=0CDUQFjAD&url=http%3A%2F%2Flandsat.usgs.gov%2Fdocuments%2F6a_Schott_Overview_of_DIRS_Research%2520Activities.pdf&ei=N33JTqLfNa7y2gW6q4ngDw&usg=AFQjCNHKb35F1bXIjMoikF9xyUvBxEInCQ&sig2=vop2MSeAqS7z707GnHjOaw

Sample Results

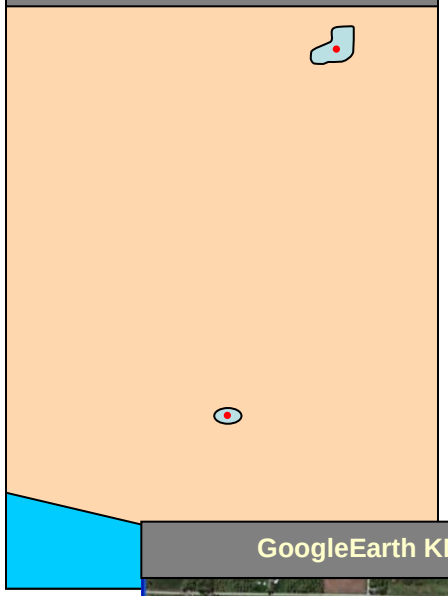
Image Close-up



Detection #: S001
ImageID: 20111116_041234.nitf*
Date: **2011-11-16***
Time: 04:12:34Z*
Lat: 43°16‘39.9"N
Lon: 77°18'30.5"W
MaxValue: 1024*
Area: 12 sq m*
Sensor: WASP (MWIR)
Notes: Sample Automated Detection - Not verified
** sample values*

Detection #: S002
ImageID: 20111116_041234.nitf*
Date: 2011-11-16*
Time: 04:12:34Z*
Lat: 43°16'43.25"N
Lon: 77°18'30.80"W
MaxValue: 1024*
Area: < 3 sq m*
…

Shapefile (point, polygon)



GoogleEarth KML

Table (CSV files)

ID	IMAGEID	DATE	TIME_Z	LAT	LON	MAXDN	AREA_SQKM	SENSOR		NOTES
S001	20111116_041234.nitf	2011-11-16*	04:12:34Z*	43.277750	-77.308483	1024*	12.34	WASP (MWIR)	N	Sample Automated Detection - Not verified
S002	20111116_041234.nitf	2011-11-16*	04:12:34Z*	43.278681	-77.308556	1024*	2.2	WASP (MWIR)	N	Sample Automated Detection - Not verified

Example: Airborne Collection

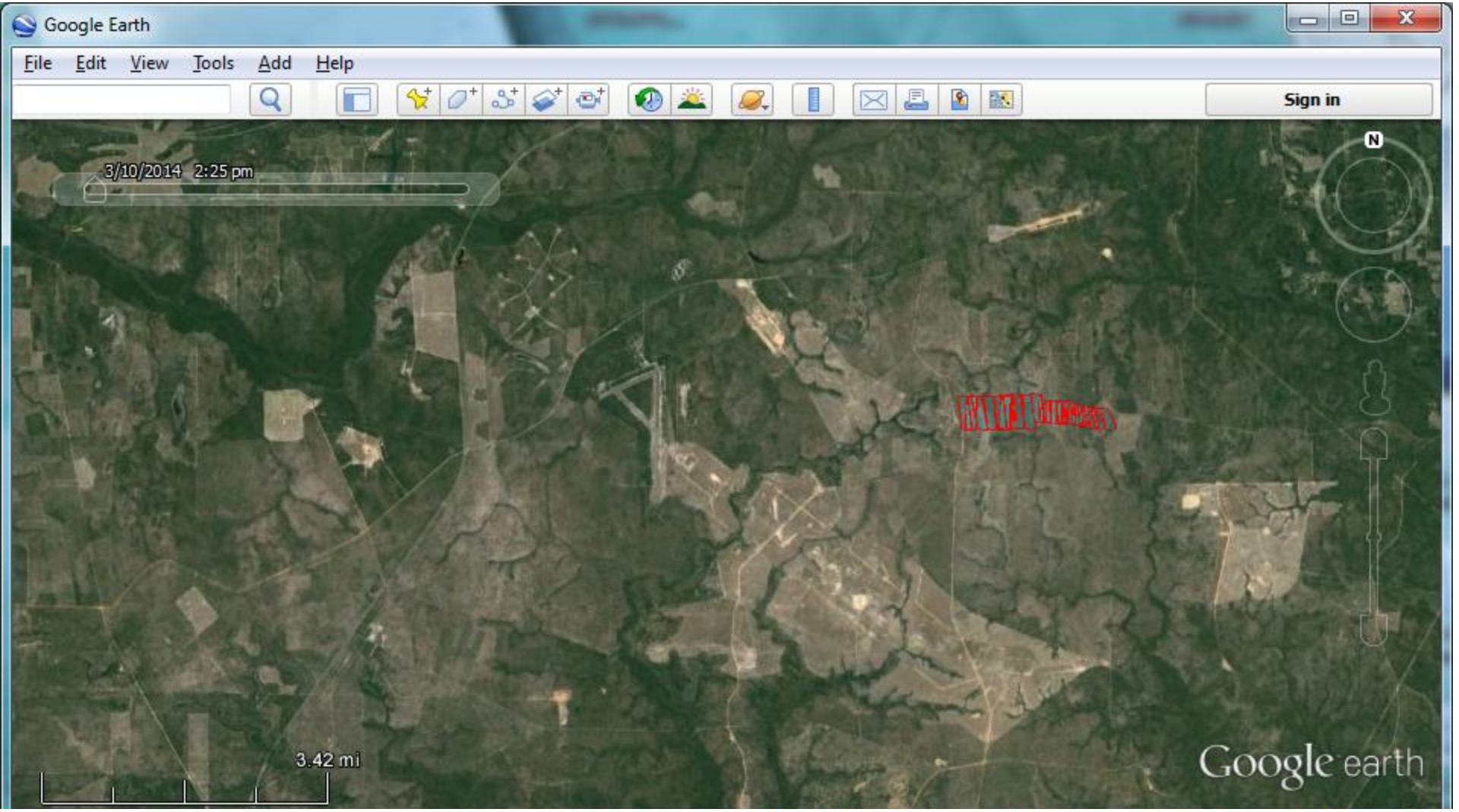
Highlights:

- Airborne data collection
- 5 sorties in 5 days
- 3 1-Tbyte hard drives
- Spectral whisk broom scanner
- Each scan in BIP fmt with associated ENVI hdr (metadata) file

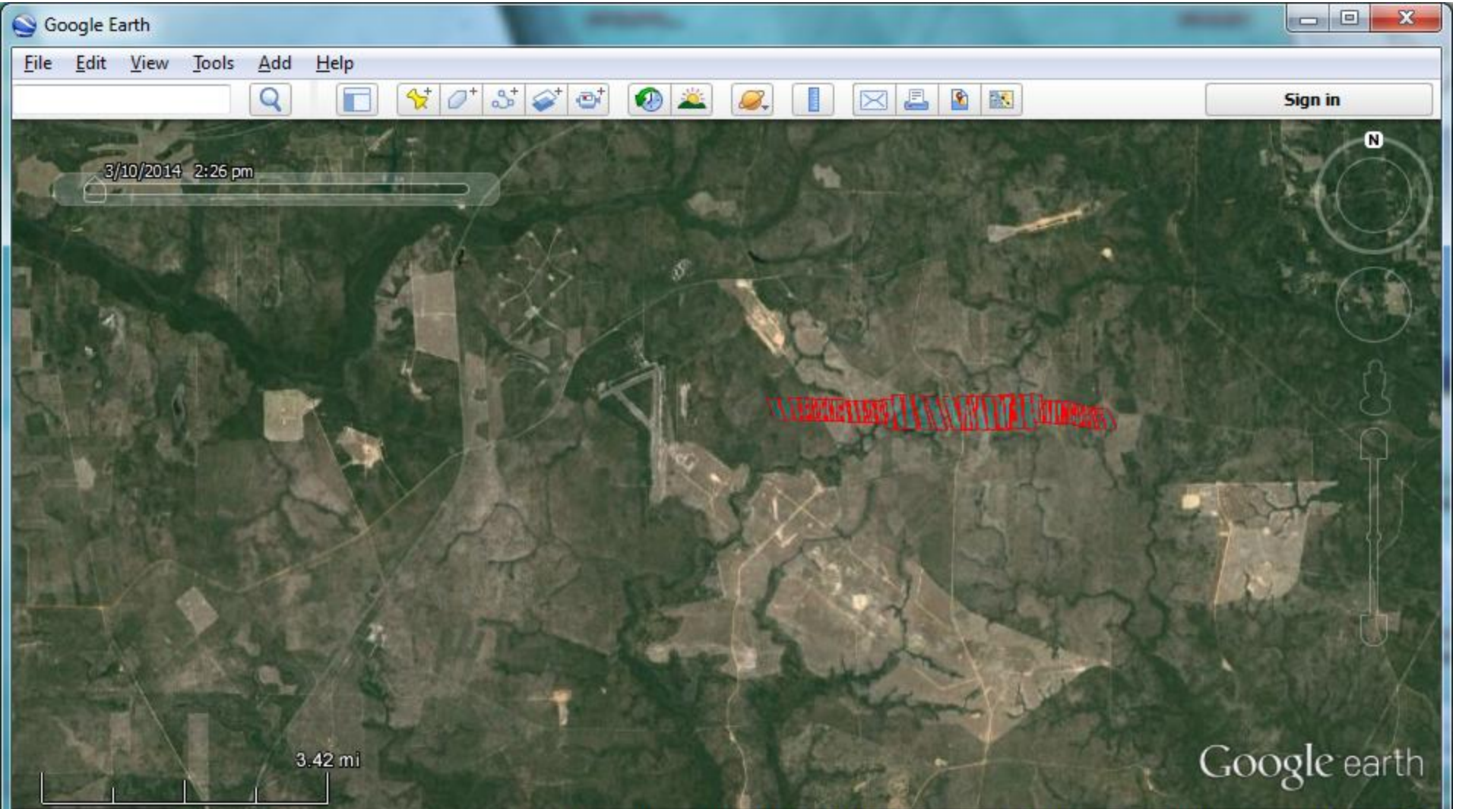
Requested outputs:

- Catalog data
- Create GoogleEarth KML file of scan footprints
- Thumbnails
- Create shapefile with attributes from metadata
- Identify data of interest
  - List of scans covering Target Area A1

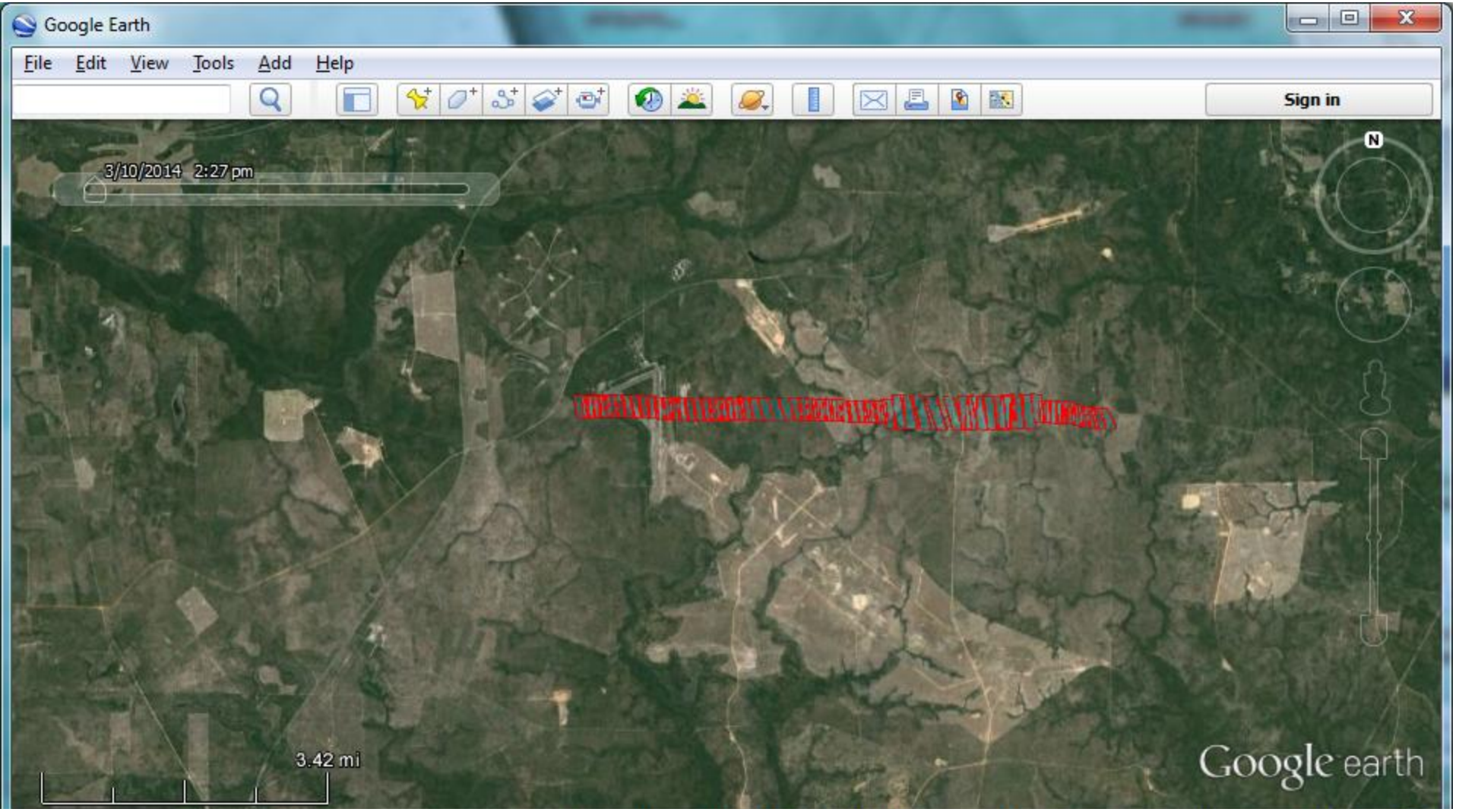
Airborne Whiskbroom Scanner



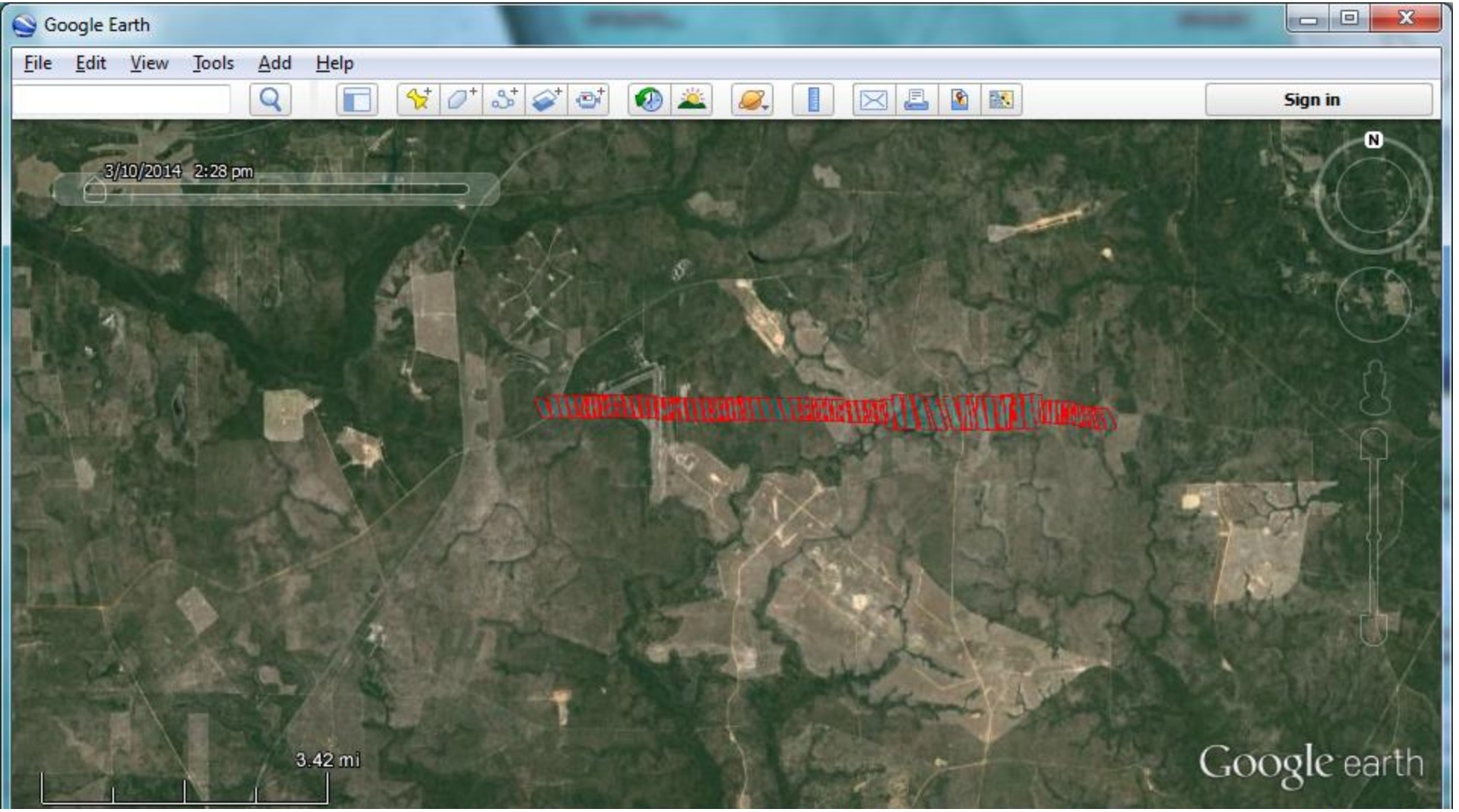
Airborne Whiskbroom Scanner



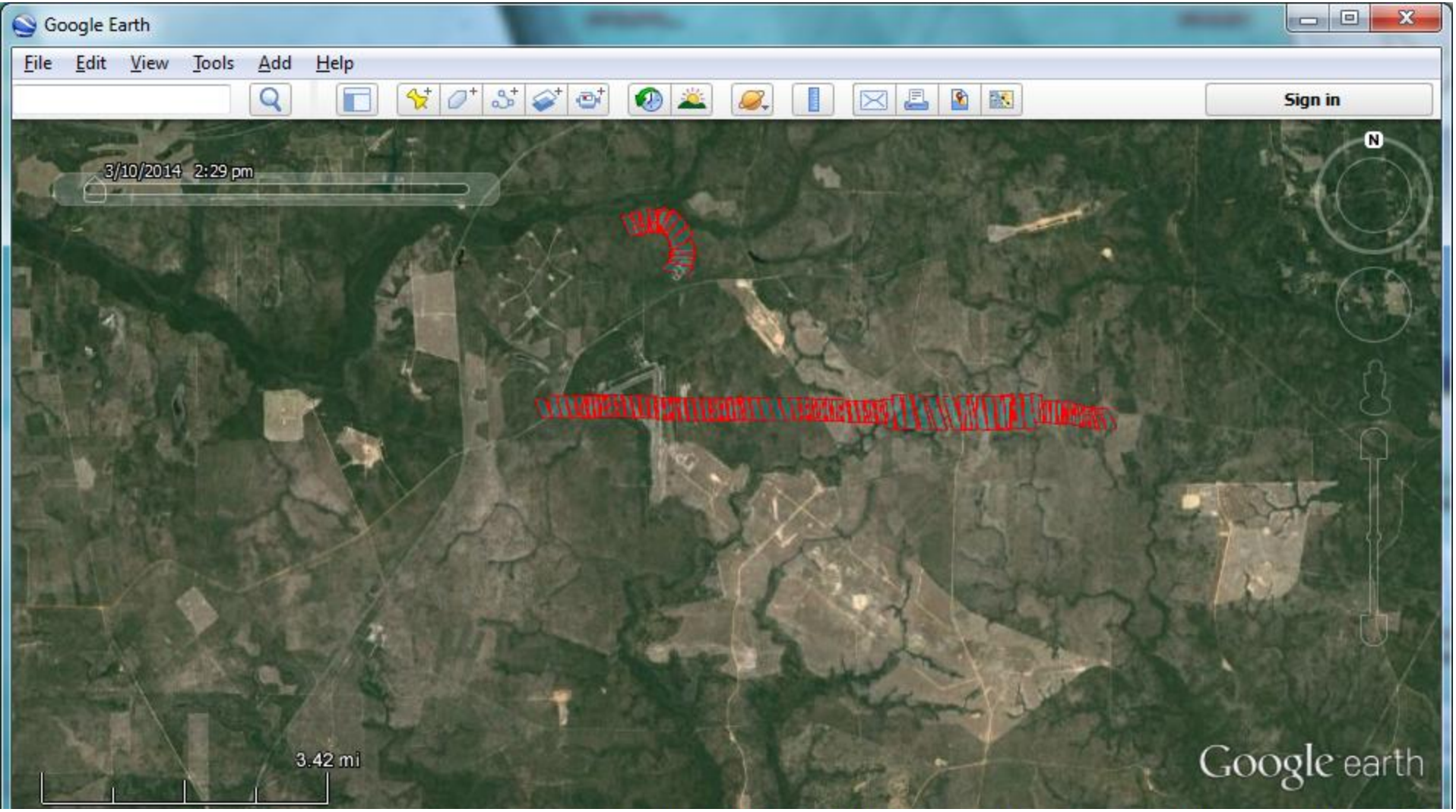
Airborne Whiskbroom Scanner



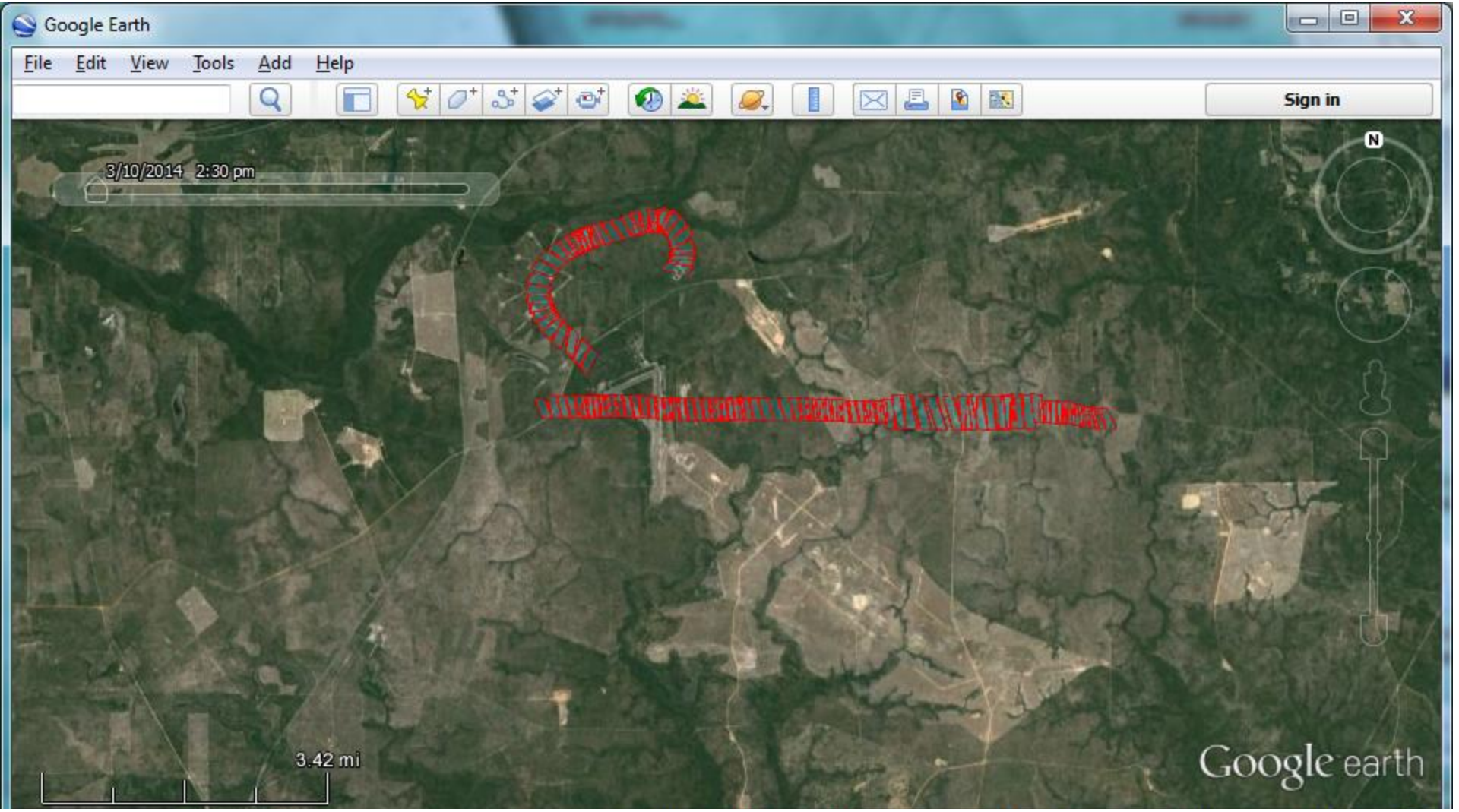
Airborne Whiskbroom Scanner



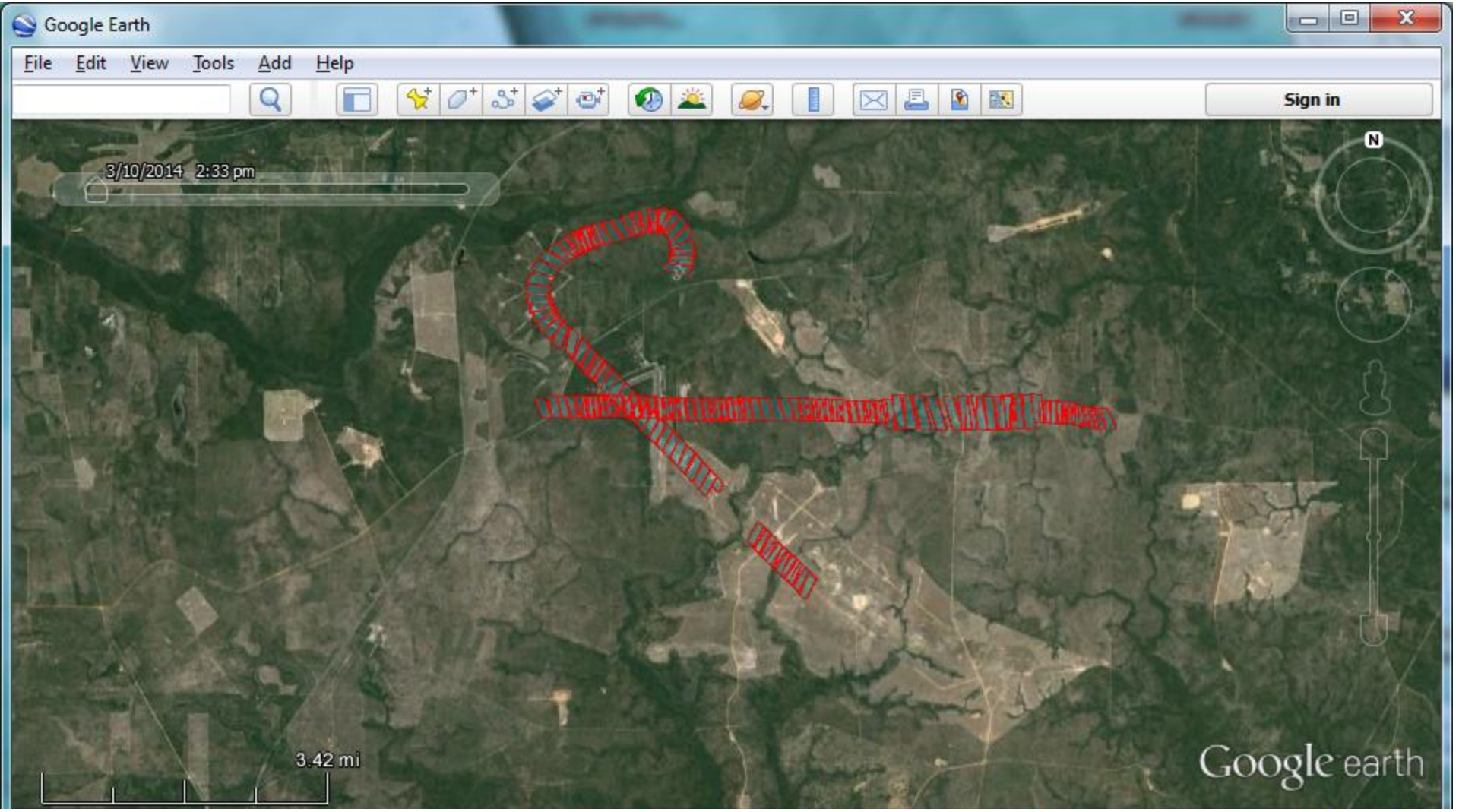
Airborne Whiskbroom Scanner



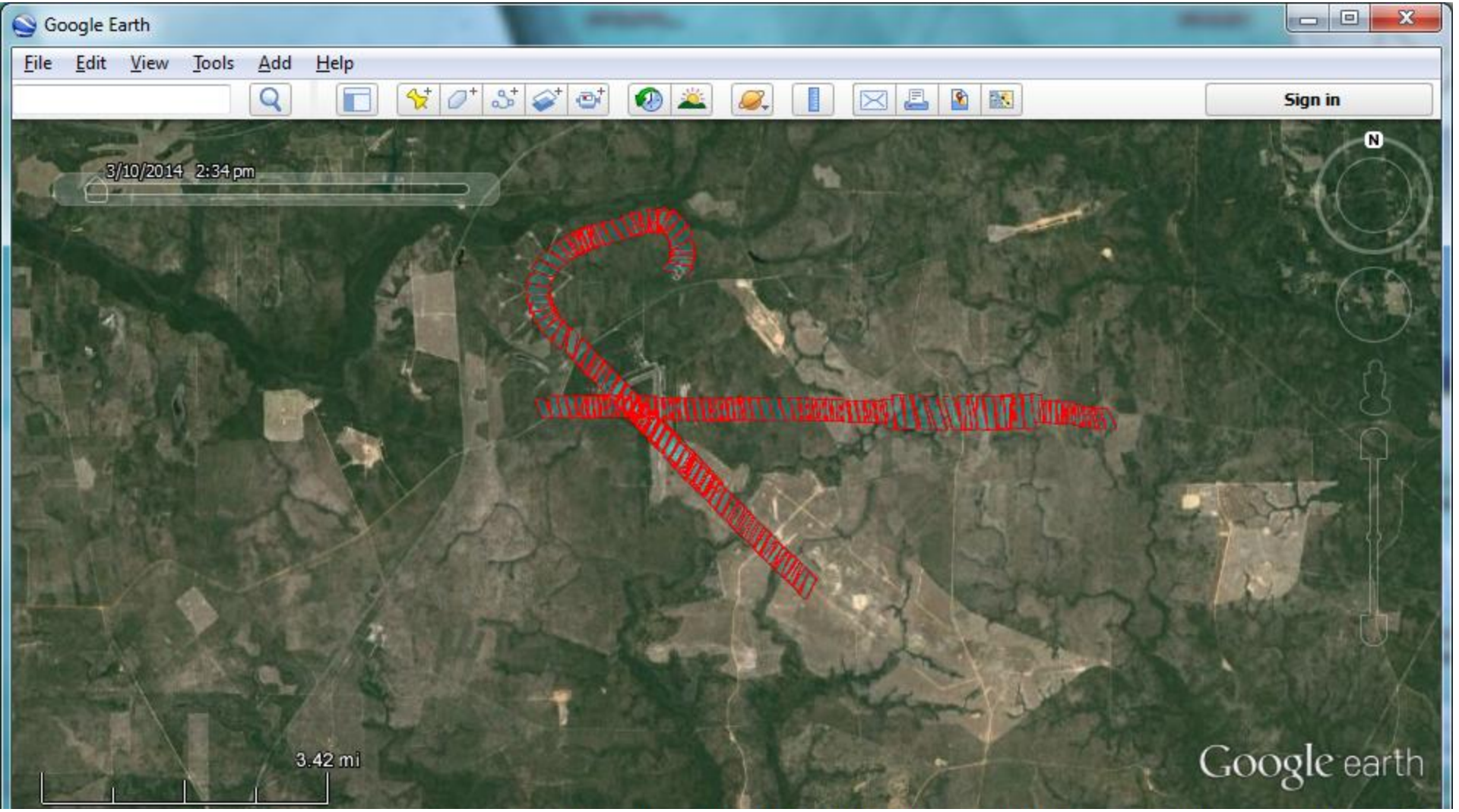
Airborne Whiskbroom Scanner



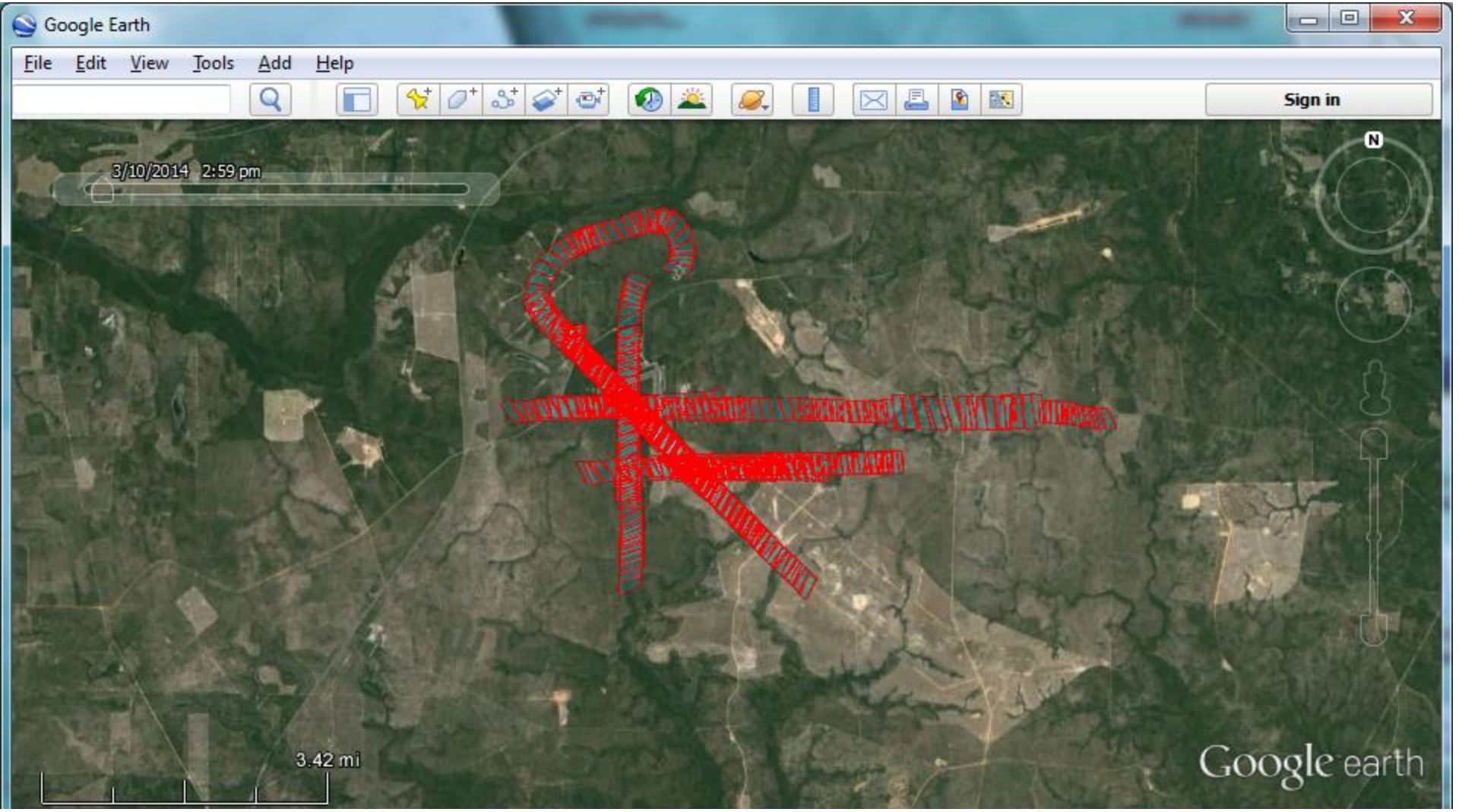
Airborne Whiskbroom Scanner



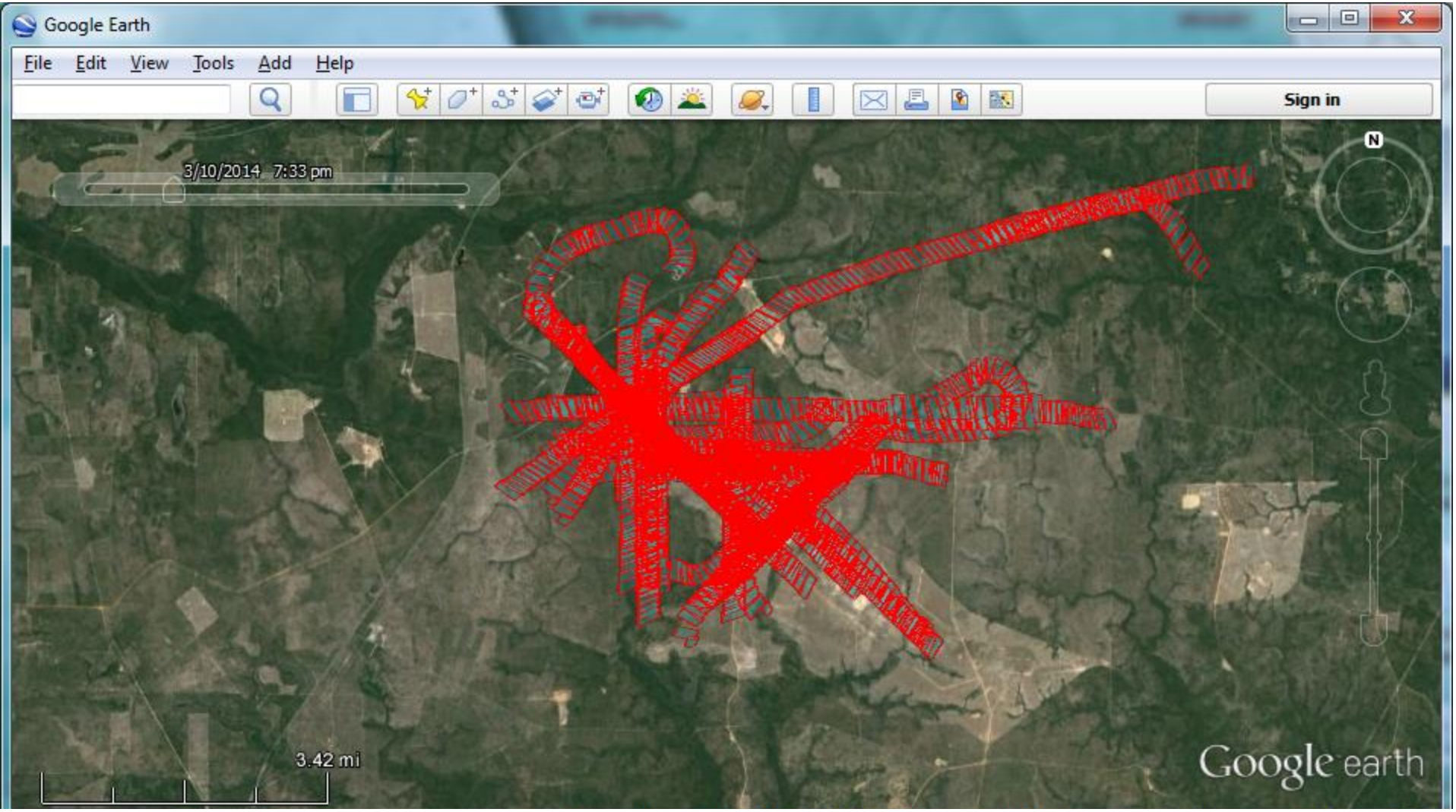
Airborne Whiskbroom Scanner



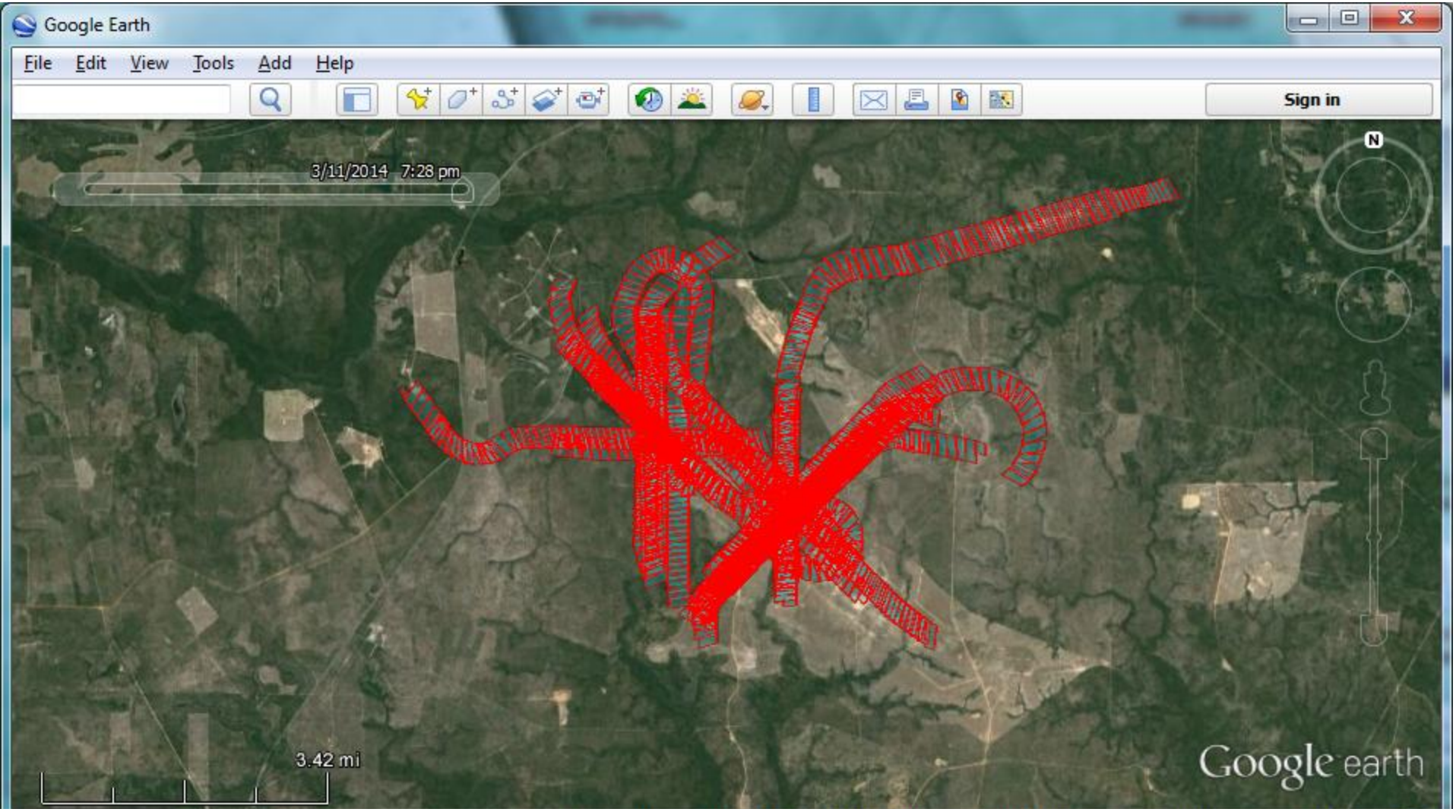
Airborne Whiskbroom Scanner



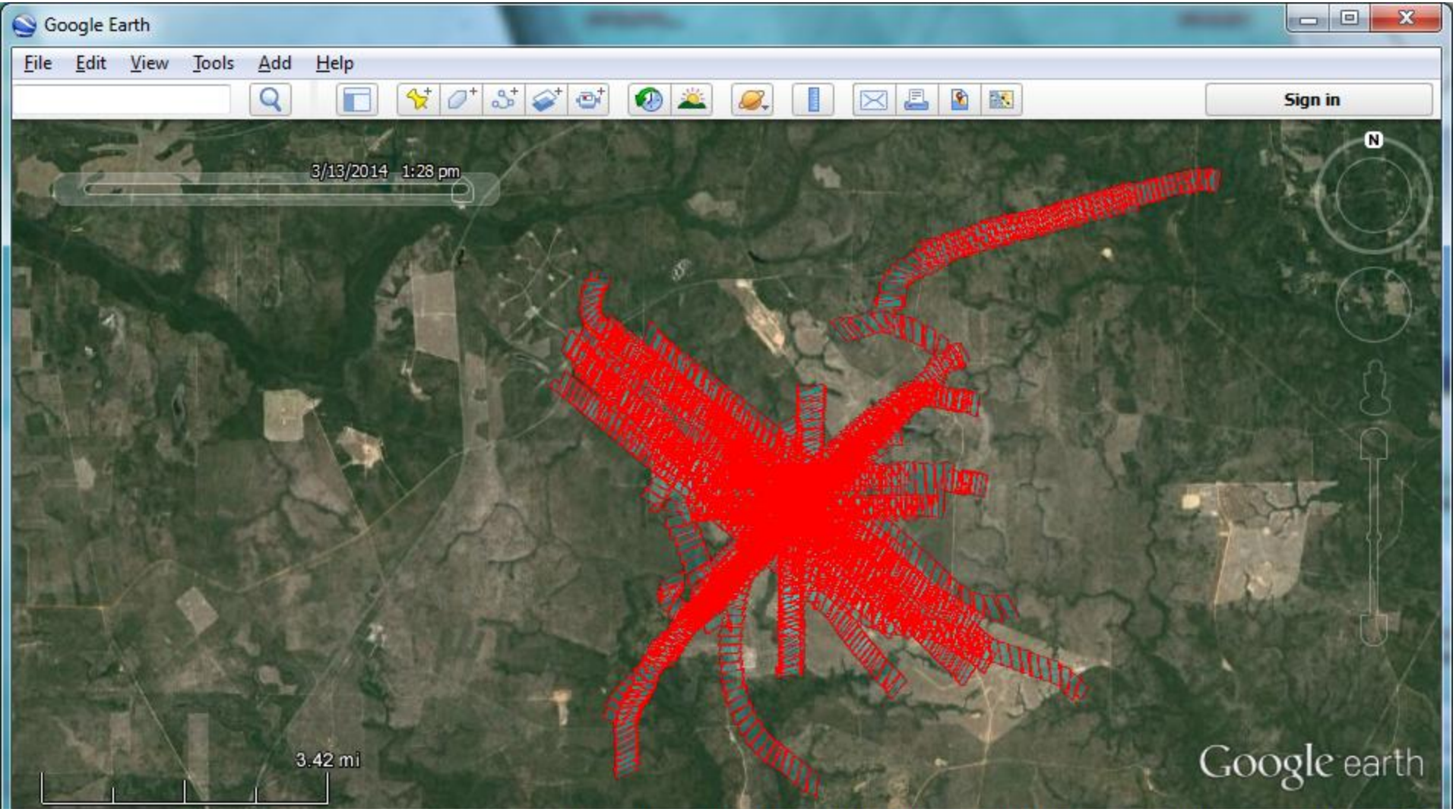
Sortie 1 – 1640 scans



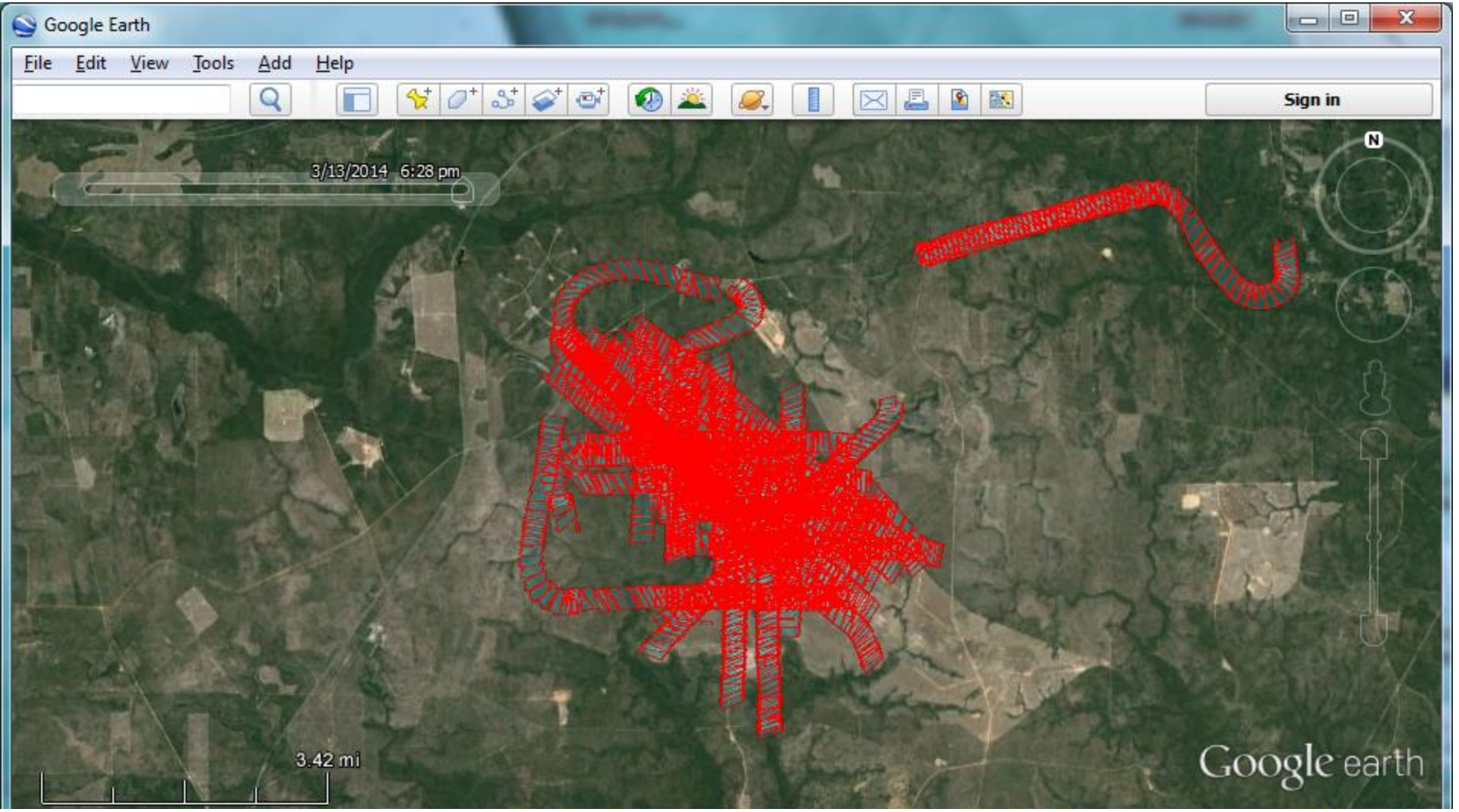
Sortie 2 – 1715 scans



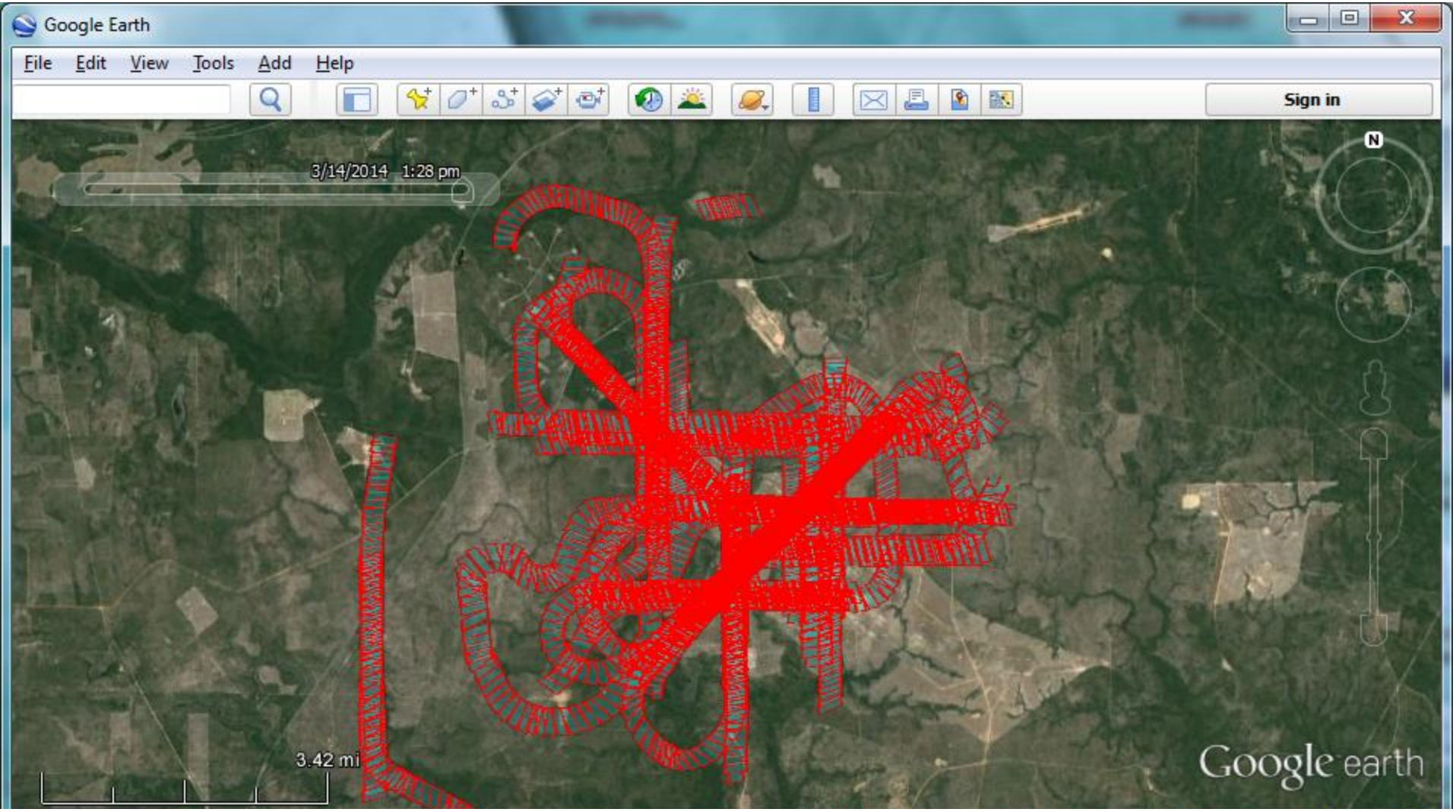
Sortie 3 – 1800 scans



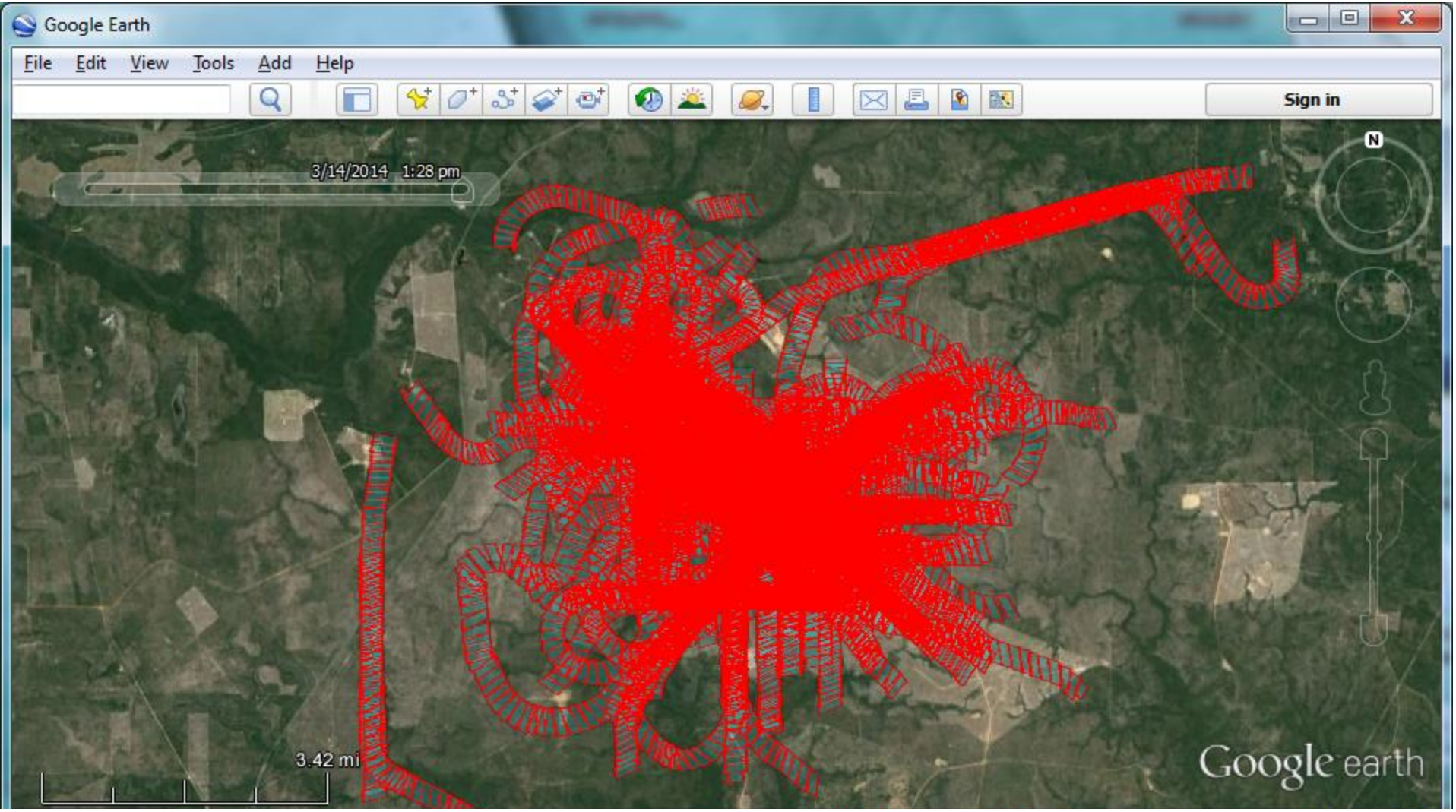
Sortie 4 – 1665 scans



Sortie 5 – 2100 scans

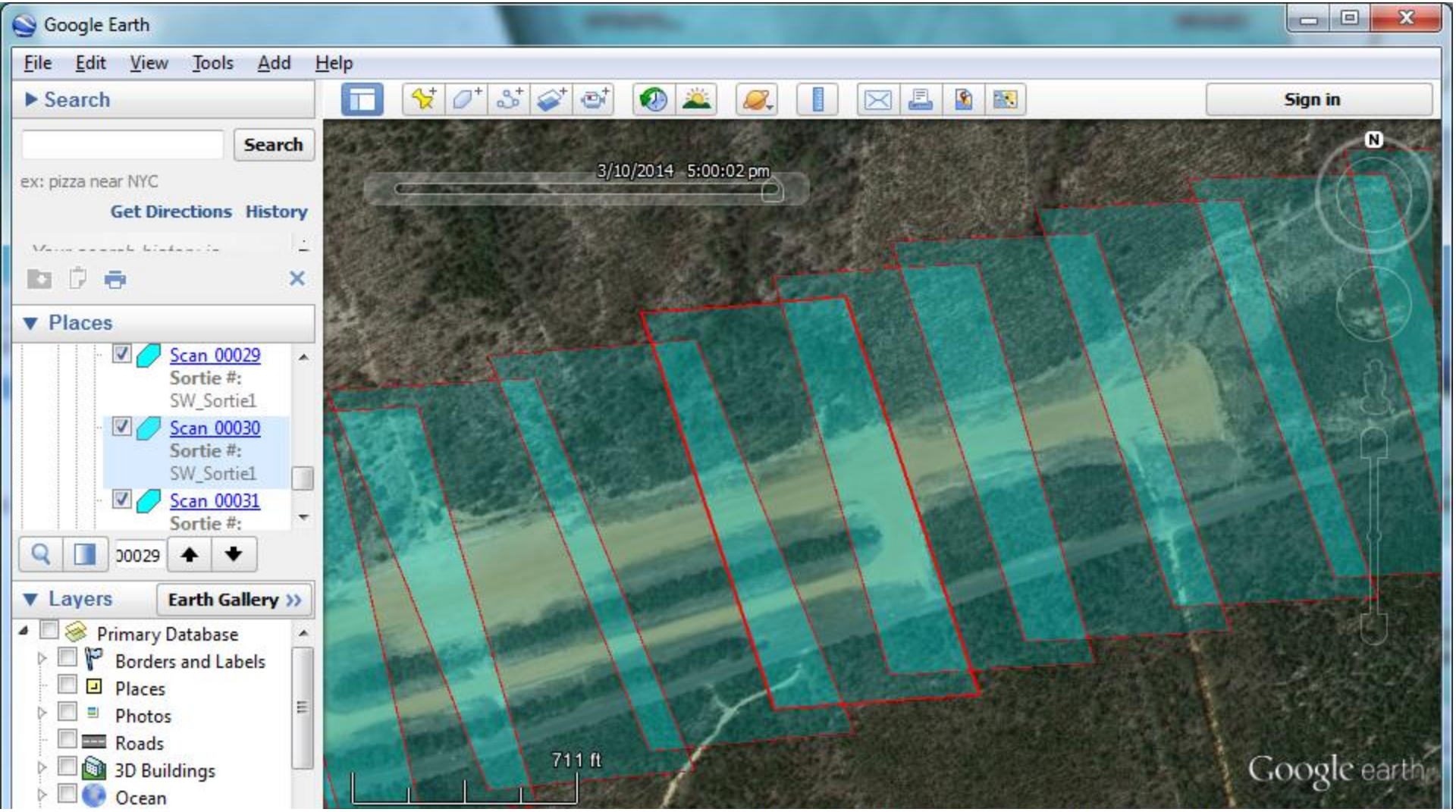


All Sorties – 8900+ scans



PENNSTATE

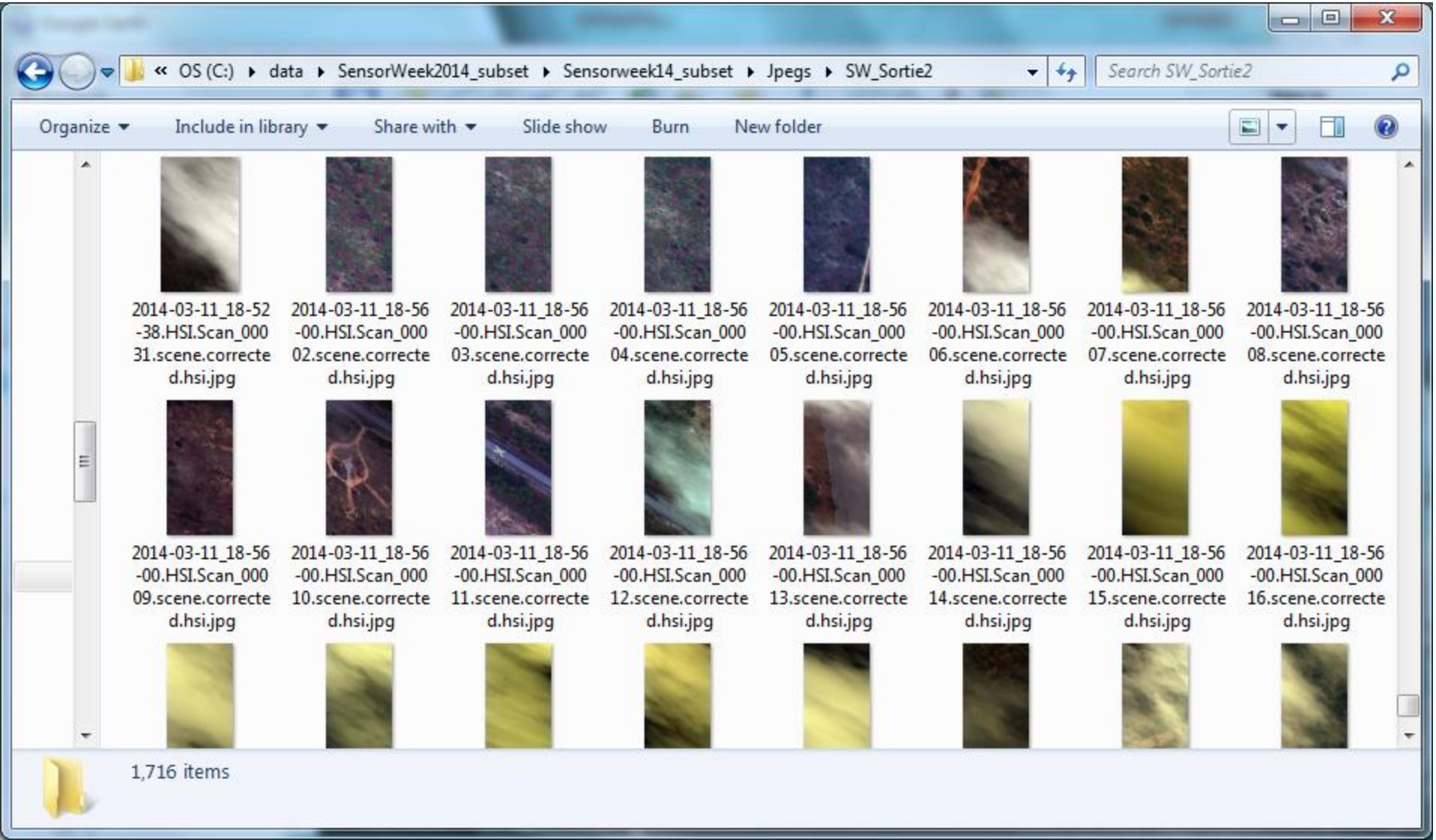
Set of scans over Target Area



PENNSTATE

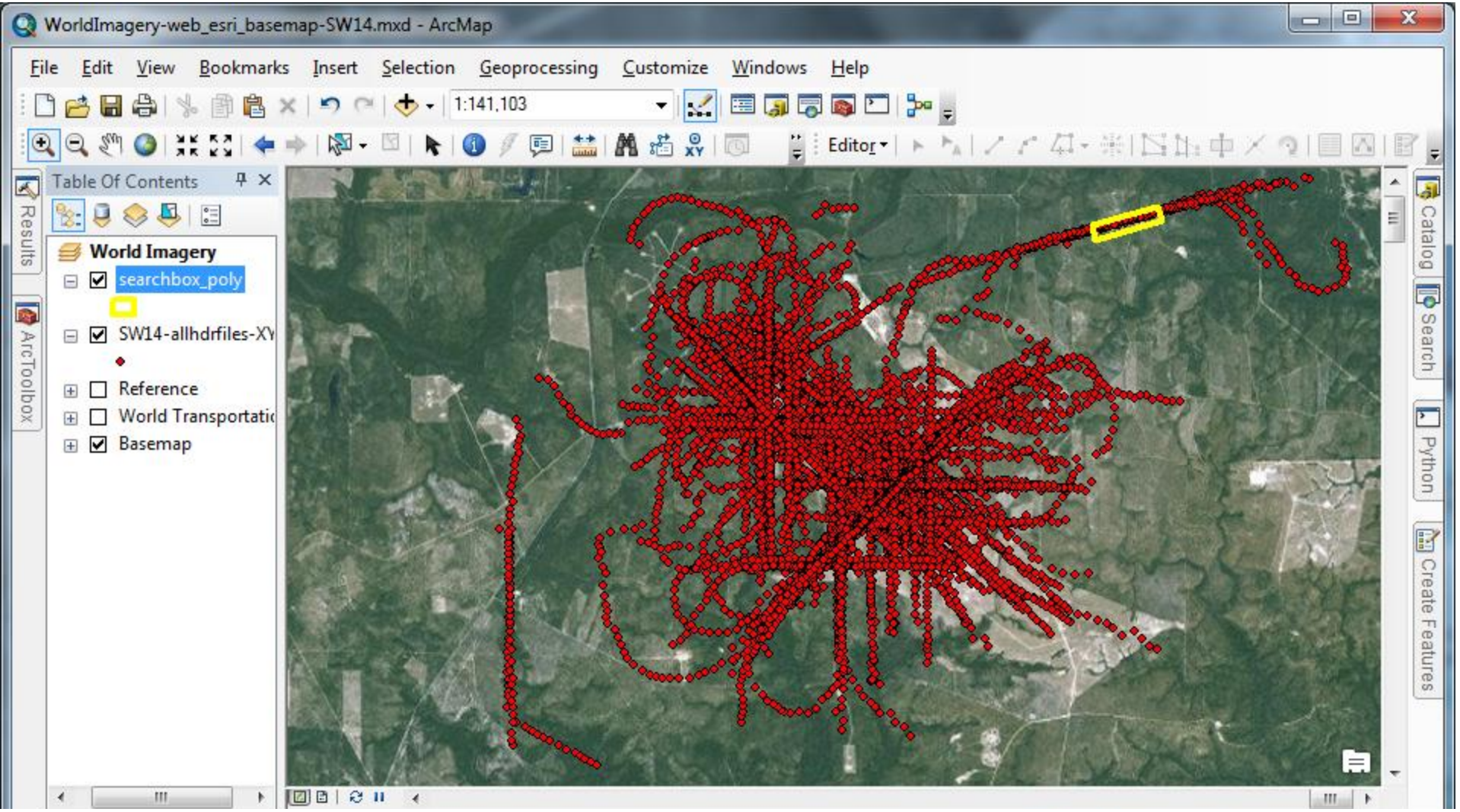
Key information for Scan 00030

Quick check with thumbnails

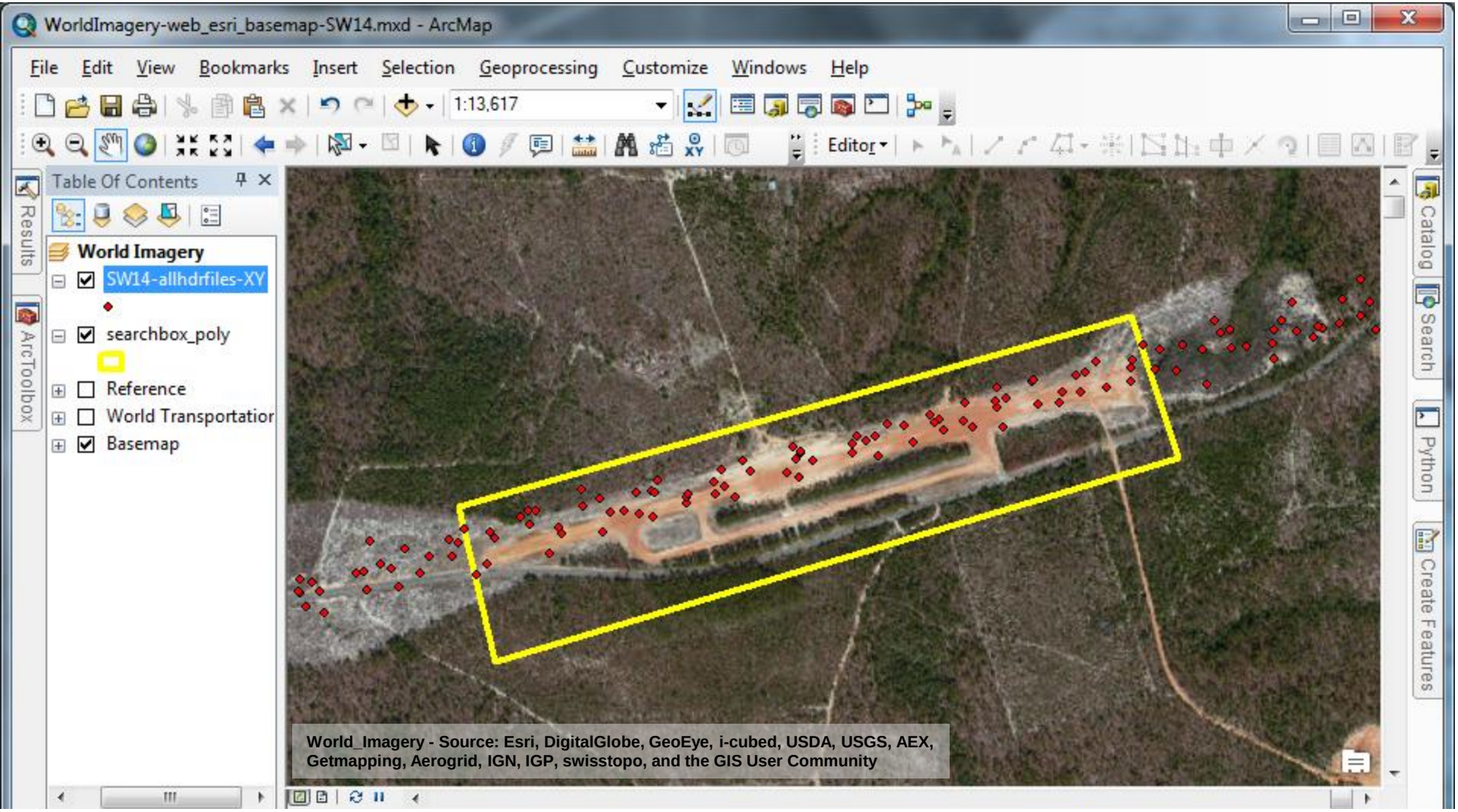


PENNSTATE

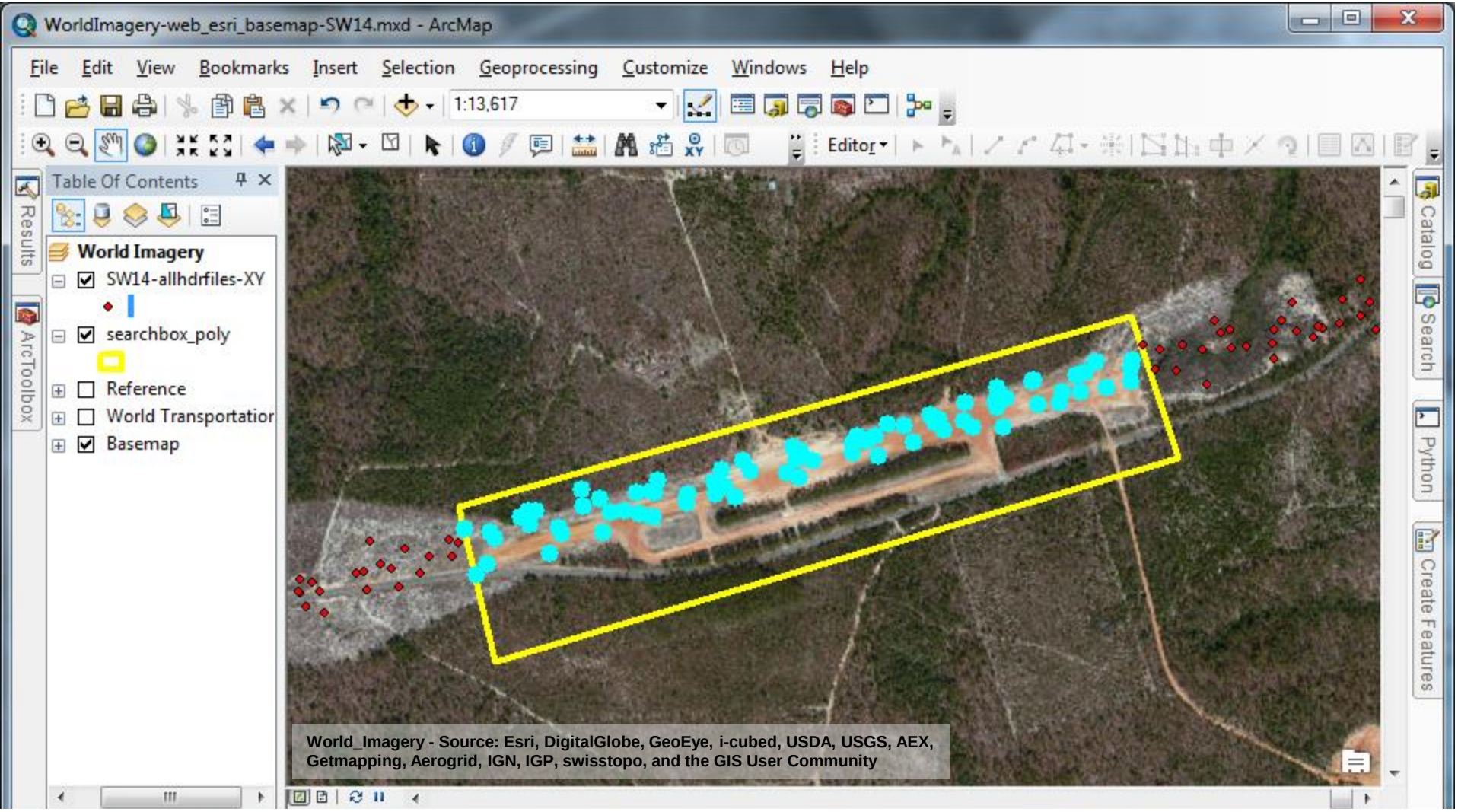
All Sorties – 8900+ scans



Set of scans over Target Area



Target Area *(75 scans of interest)*



Summary Exported For Production Manager

Table

SW14-allhdrfiles-XY

FID	Shape	DIR1	DIR3	DIR4	DIR5	FN
1418	Point	SW_Sortie1	2014-03-10_20-35-35	HSI	Scan_00067	2014-03-10_20-35-35.HSI.Scan_00067.scene.corrected.hsi.hdr
1419	Point	SW_Sortie1	2014-03-10_20-35-35	HSI	Scan_00068	2014-03-10_20-35-35.HSI.Scan_00068.scene.corrected.hsi.hdr
1420	Point	SW_Sortie1	2014-03-10_20-35-35	HSI	Scan_00069	2014-03-10_20-35-35.HSI.Scan_00069.scene.corrected.hsi.hdr
1421	Point	SW_Sortie1	2014-03-10_20-35-35	HSI	Scan_00070	2014-03-10_20-35-35.HSI.Scan_00070.scene.corrected.hsi.hdr
1422	Point	SW_Sortie1	2014-03-10_20-35-35	HSI	Scan_00071	2014-03-10_20-35-35.HSI.Scan_00071.scene.corrected.hsi.hdr
1423	Point	SW_Sortie1	2014-03-10_20-35-35	HSI	Scan_00072	2014-03-10_20-35-35.HSI.Scan_00072.scene.corrected.hsi.hdr
1424	Point	SW_Sortie1	2014-03-10_20-35-35	HSI	Scan_00073	2014-03-10_20-35-35.HSI.Scan_00073.scene.corrected.hsi.hdr
1425	Point	SW_Sortie1	2014-03-10_20-35-35	HSI	Scan_00074	2014-03-10_20-35-35.HSI.Scan_00074.scene.corrected.hsi.hdr
1426	Point	SW_Sortie1	2014-03-10_20-35-35	HSI	Scan_00075	2014-03-10_20-35-35.HSI.Scan_00075.scene.corrected.hsi.hdr
1470	Point	SW_Sortie1	2014-03-10_20-40-52	HSI	Scan_00027	2014-03-10_20-40-52.HSI.Scan_00027.scene.corrected.hsi.hdr
1471	Point	SW_Sortie1	2014-03-10_20-40-52	HSI	Scan_00028	2014-03-10_20-40-52.HSI.Scan_00028.scene.corrected.hsi.hdr
1472	Point	SW_Sortie1	2014-03-10_20-40-52	HSI	Scan_00029	2014-03-10_20-40-52.HSI.Scan_00029.scene.corrected.hsi.hdr
1473	Point	SW_Sortie1	2014-03-10_20-40-52	HSI	Scan_00030	2014-03-10_20-40-52.HSI.Scan_00030.scene.corrected.hsi.hdr
1474	Point	SW_Sortie1	2014-03-10_20-40-52	HSI	Scan_00031	2014-03-10_20-40-52.HSI.Scan_00031.scene.corrected.hsi.hdr
1475	Point	SW_Sortie1	2014-03-10_20-40-52	HSI	Scan_00032	2014-03-10_20
1476	Point	SW_Sortie1	2014-03-10_20-40-52	HSI	Scan_00033	2014-03-10_20
1477	Point	SW_Sortie1	2014-03-10_20-40-52	HSI	Scan_00034	2014-03-10_20
1478	Point	SW_Sortie1	2014-03-10_20-40-52	HSI	Scan_00035	2014-03-10_20
1479	Point	SW_Sortie1	2014-03-10_20-40-52	HSI	Scan_00036	2014-03-10_20
1480	Point	SW_Sortie1	2014-03-10_20-40-52	HSI	Scan_00037	2014-03-10_20
1481	Point	SW_Sortie1	2014-03-10_20-40-52	HSI	Scan_00038	2014-03-10_20
2800	Point	SW_Sortie2	2014-03-11_17-47-10	HSI	Scan_00017	2014-03-11_17

0 (75 out of 8934 Selected)

SW14-allhdrfiles-XY | Sum_Output

Table

Sum_Output

OID	DIR1	Count_DIR1	First_DIR3
0	SW_Sortie1	21	2014-03-10_20-35-35
1	SW_Sortie2	10	2014-03-11_17-47-10
2	SW_Sortie3	21	2014-03-13_17-09-14
3	SW_Sortie4	23	2014-03-13_21-25-35

1 (0 out of 4 Selected)

SW14-allhdrfiles-XY | Sum_Output

Example 2: VIIRS Collection

Highlights:

- Satellite Imagery
- Daily collections
- Day/Night Band (DNB)
- 8-bit Raster Images in GEOTIFF format
  - Max DN: 256 counts
  - 750 m spatial resolution

Request:

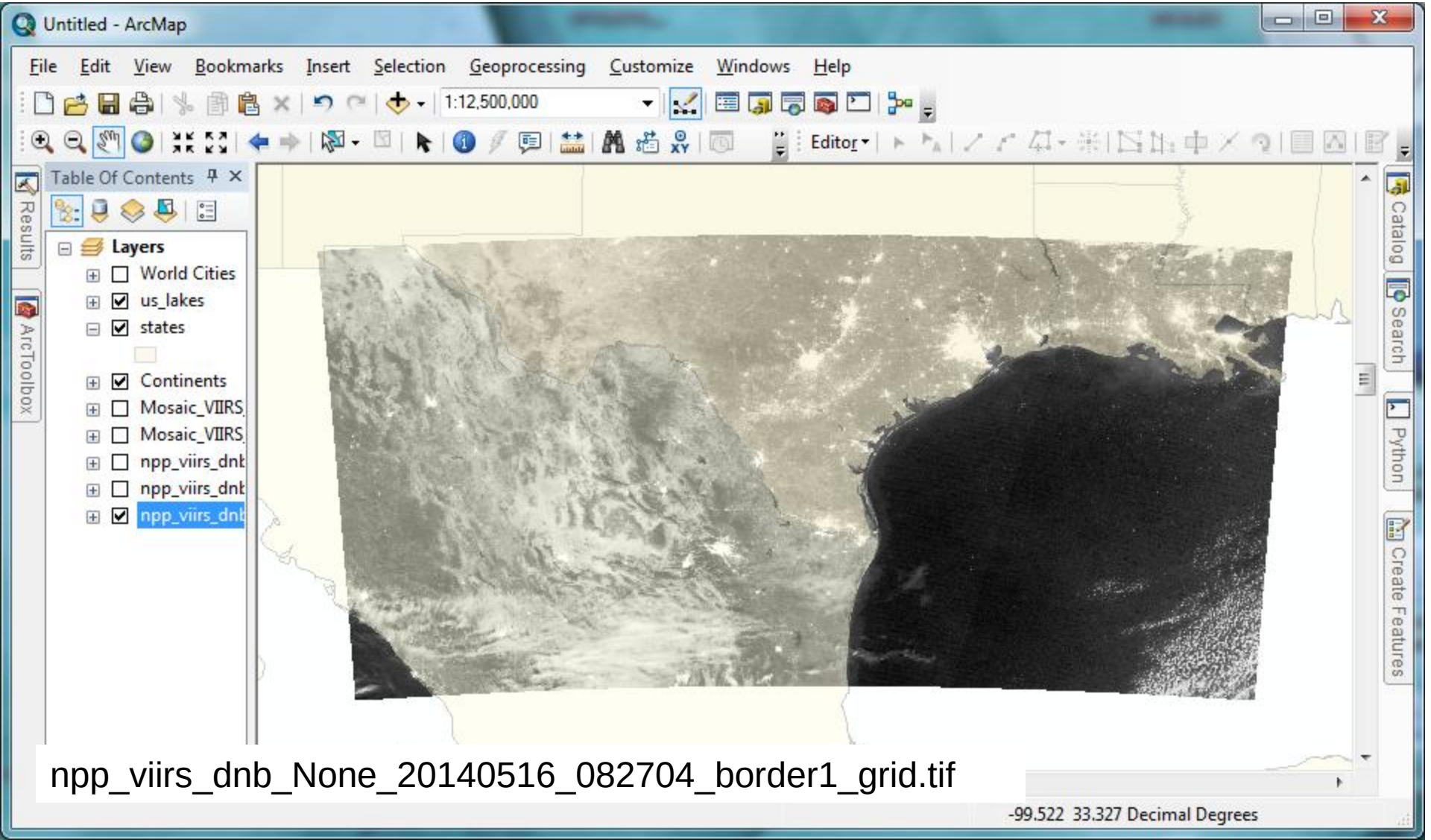
- Scan each file
- Shape file per image
  - Saturation area and centroid
  - Catalog data
- Create baseline of light activity in Target Areas
- Identify anomalous data for in-depth analysis

VIIRS Night Mosaic

This image of the continental United States at night is a composite assembled from data acquired by the Suomi National Polar-orbiting Partnership (NPP) satellite in April and October 2012. The image was made possible by the satellite's "day-night band" of the Visible Infrared Imaging Radiometer Suite (VIIRS), which detects light in a range of wavelengths from green to near-infrared and uses filtering techniques to observe dim signals such as city lights, gas flares, auroras, wildfires and reflected moonlight.

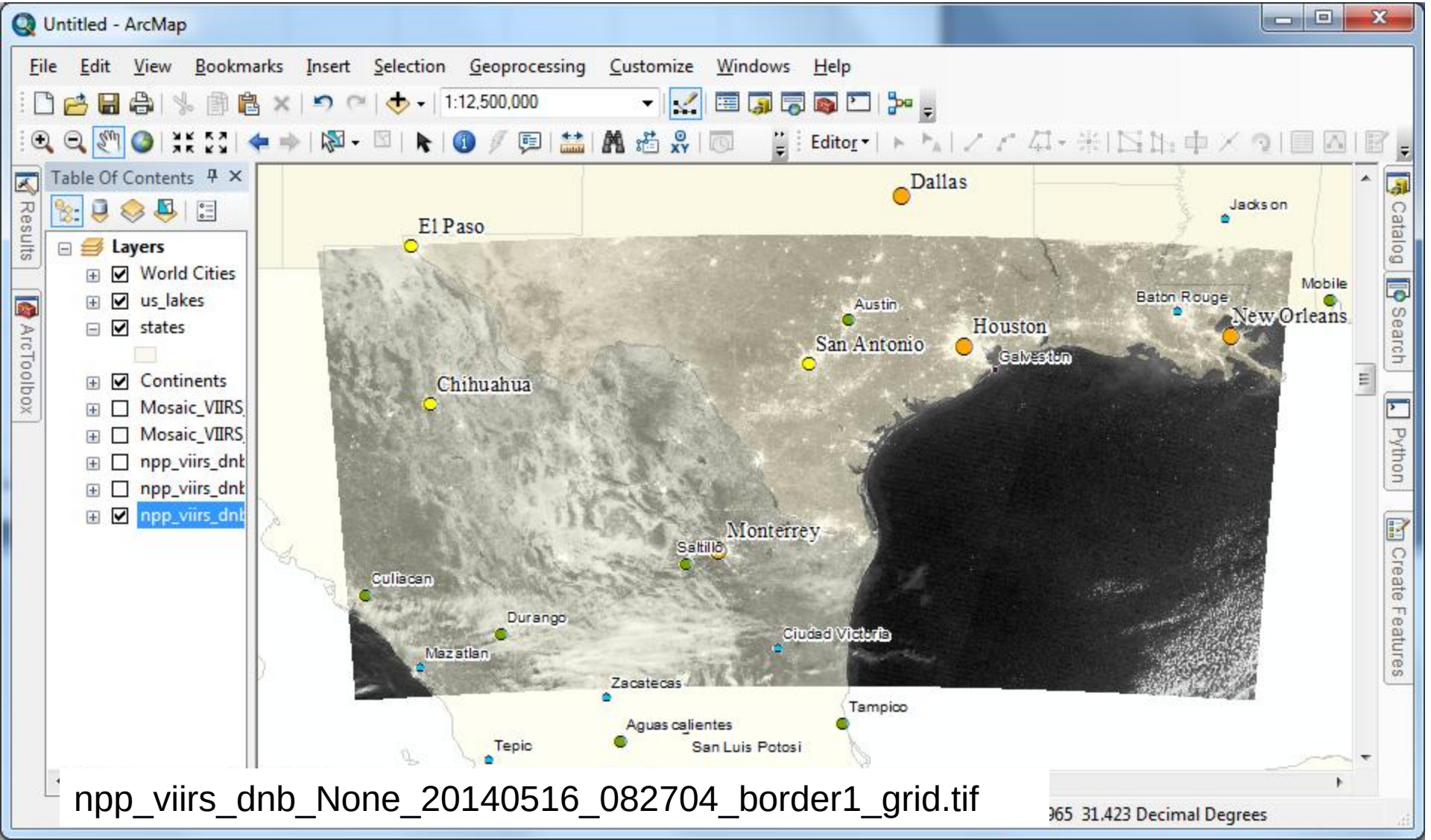
Credit: NASA Earth Observatory/NOAA NGDC

Example: VIIRS Day Night Band



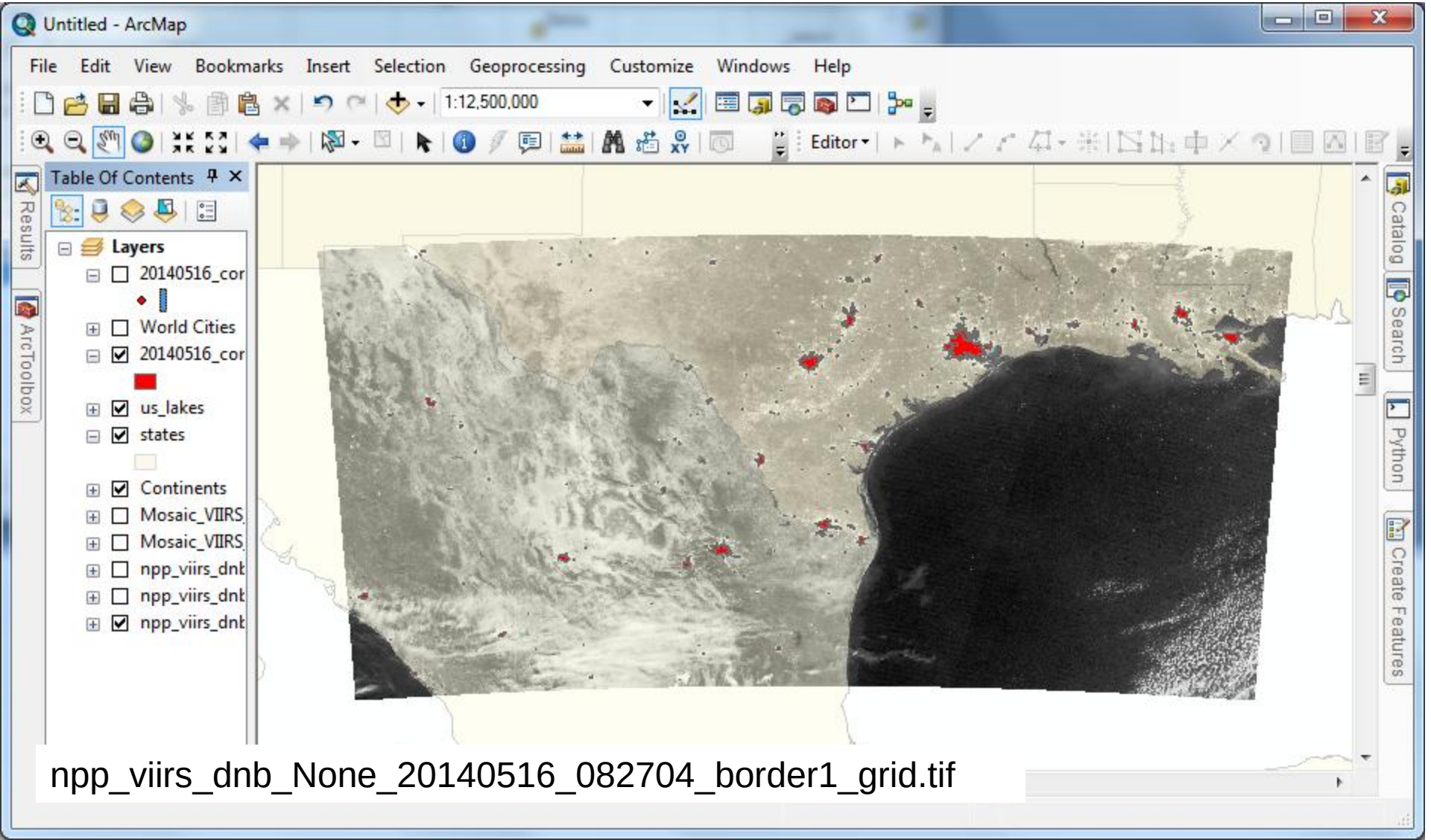
npp_viirs_dnb_None_20140516_082704_border1_grid.tif

Example: VIIRS Day Night Band



npp_viirs_dnb_None_20140516_082704_border1_grid.tif

Saturated Areas



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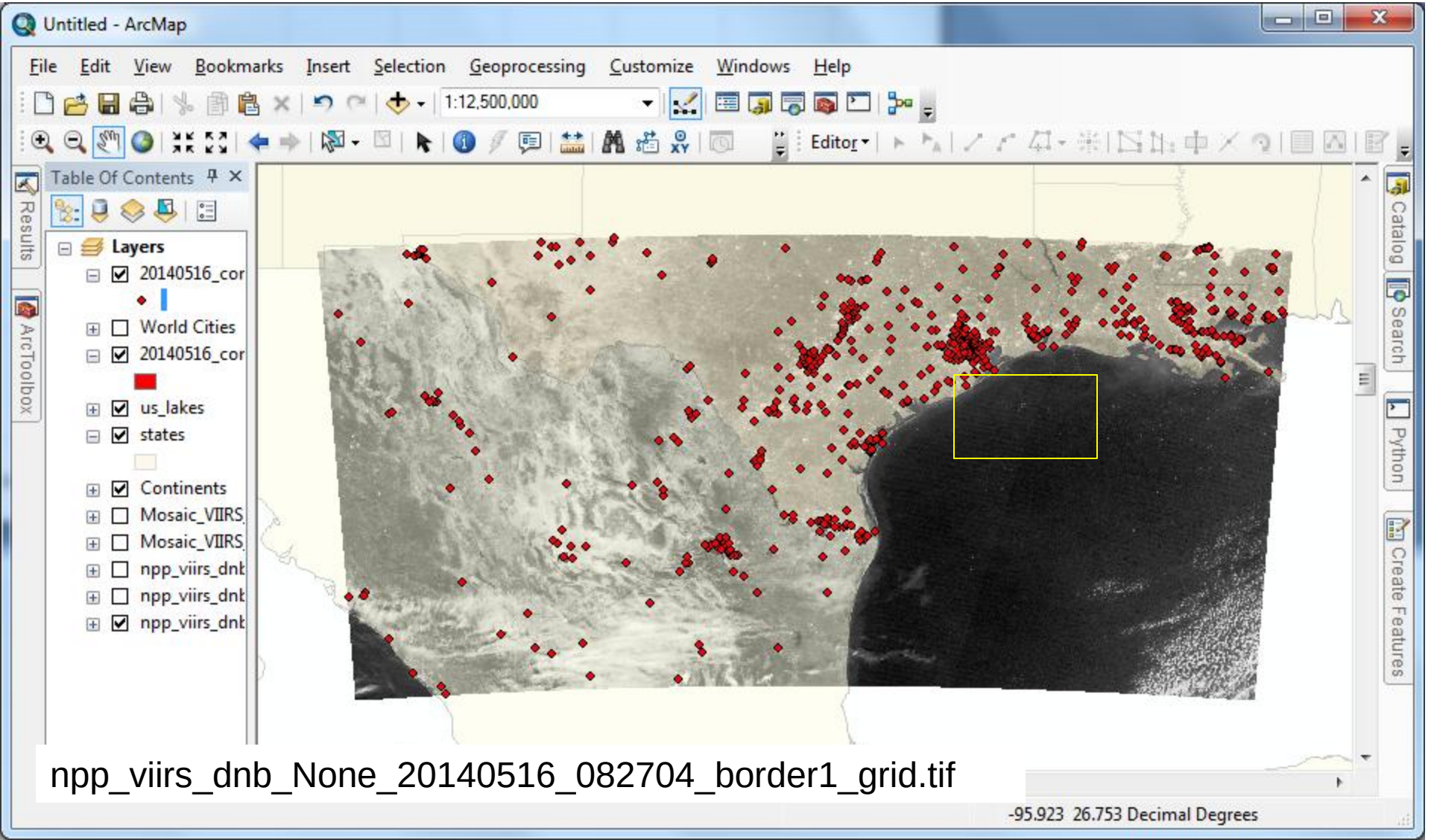
Saturated – Polygon Centroids



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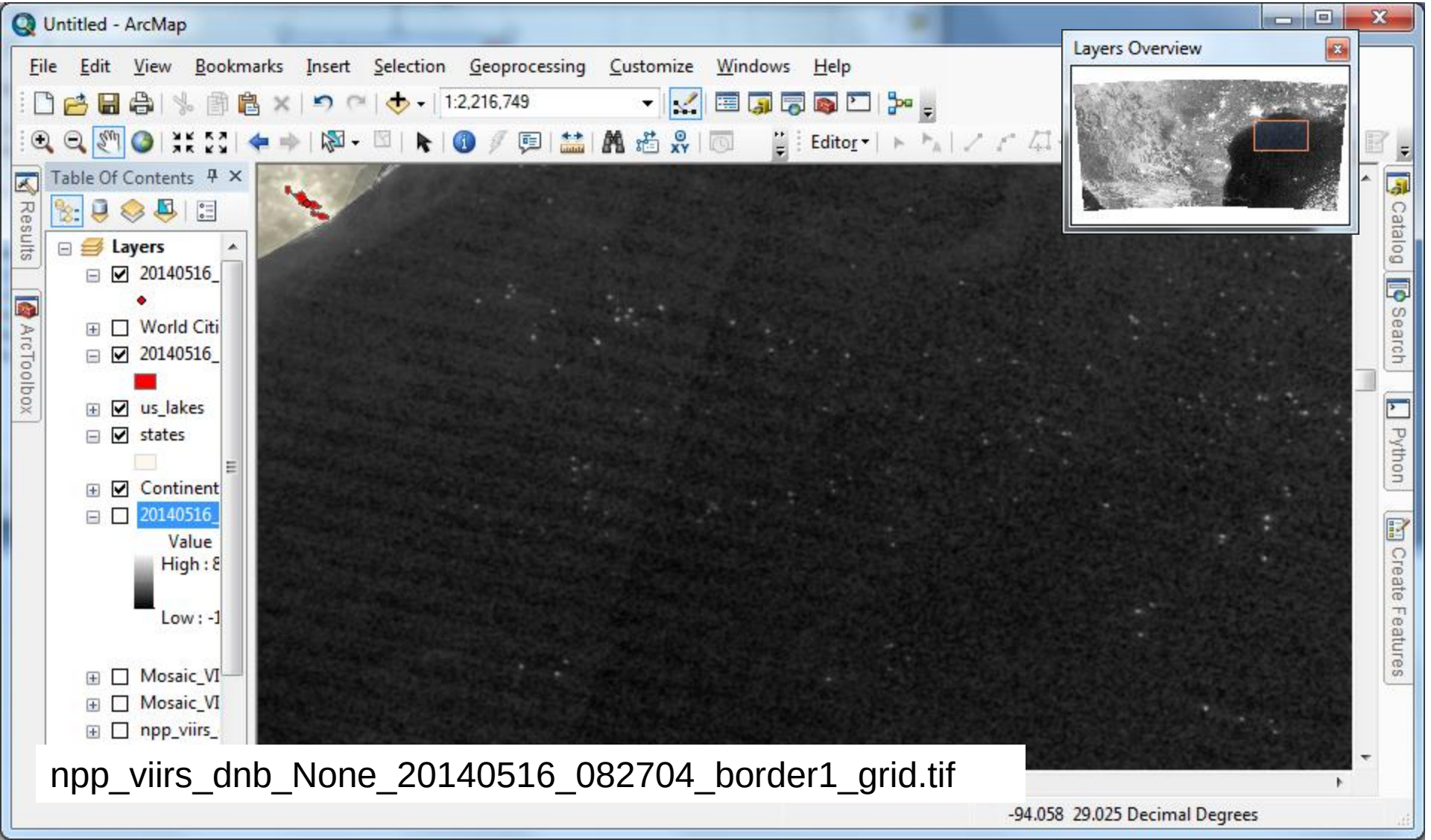
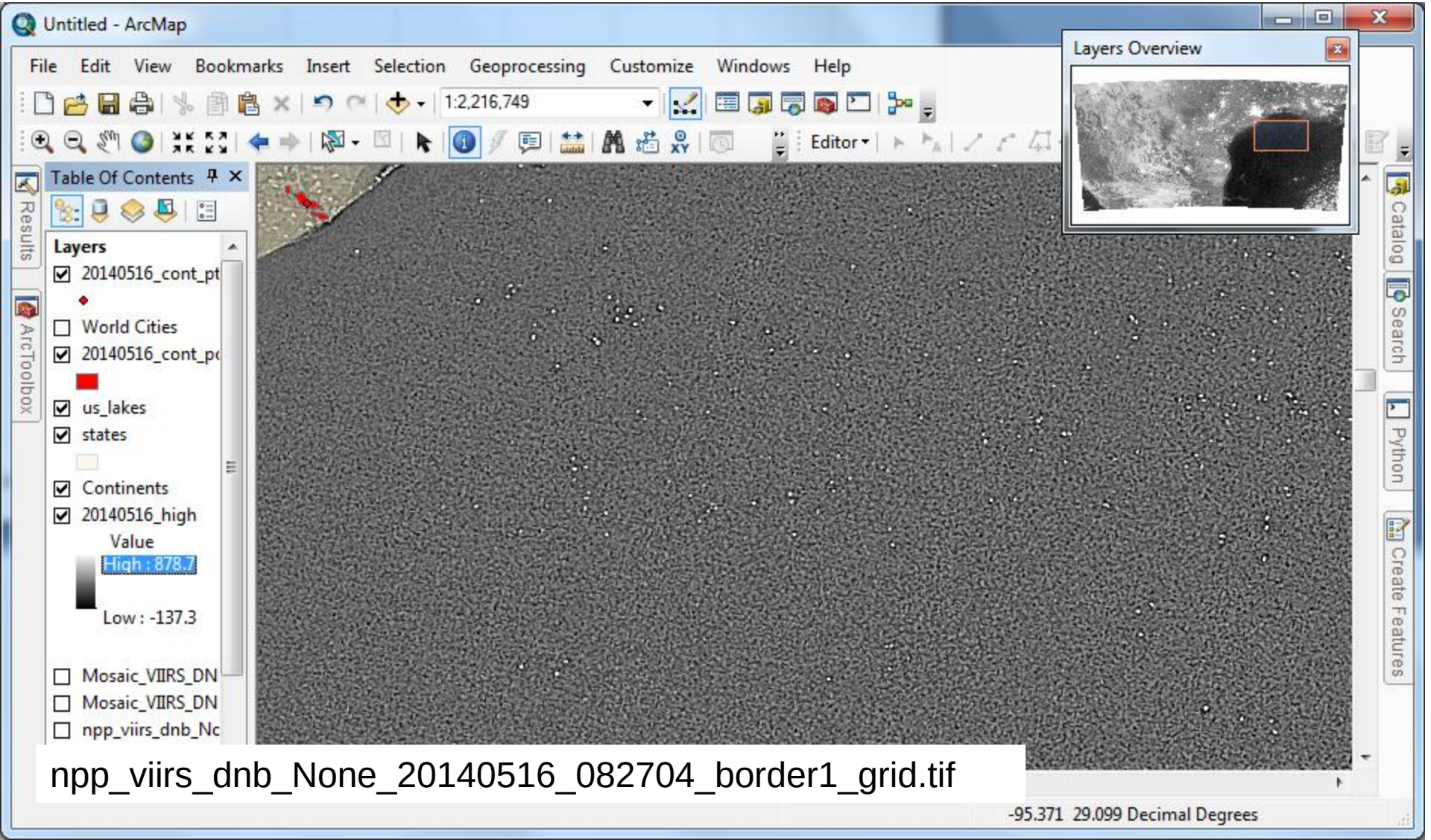
Dim Targets over water



npp_viirs_dnb_None_20140516_082704_border1_grid.tif

High pass filter



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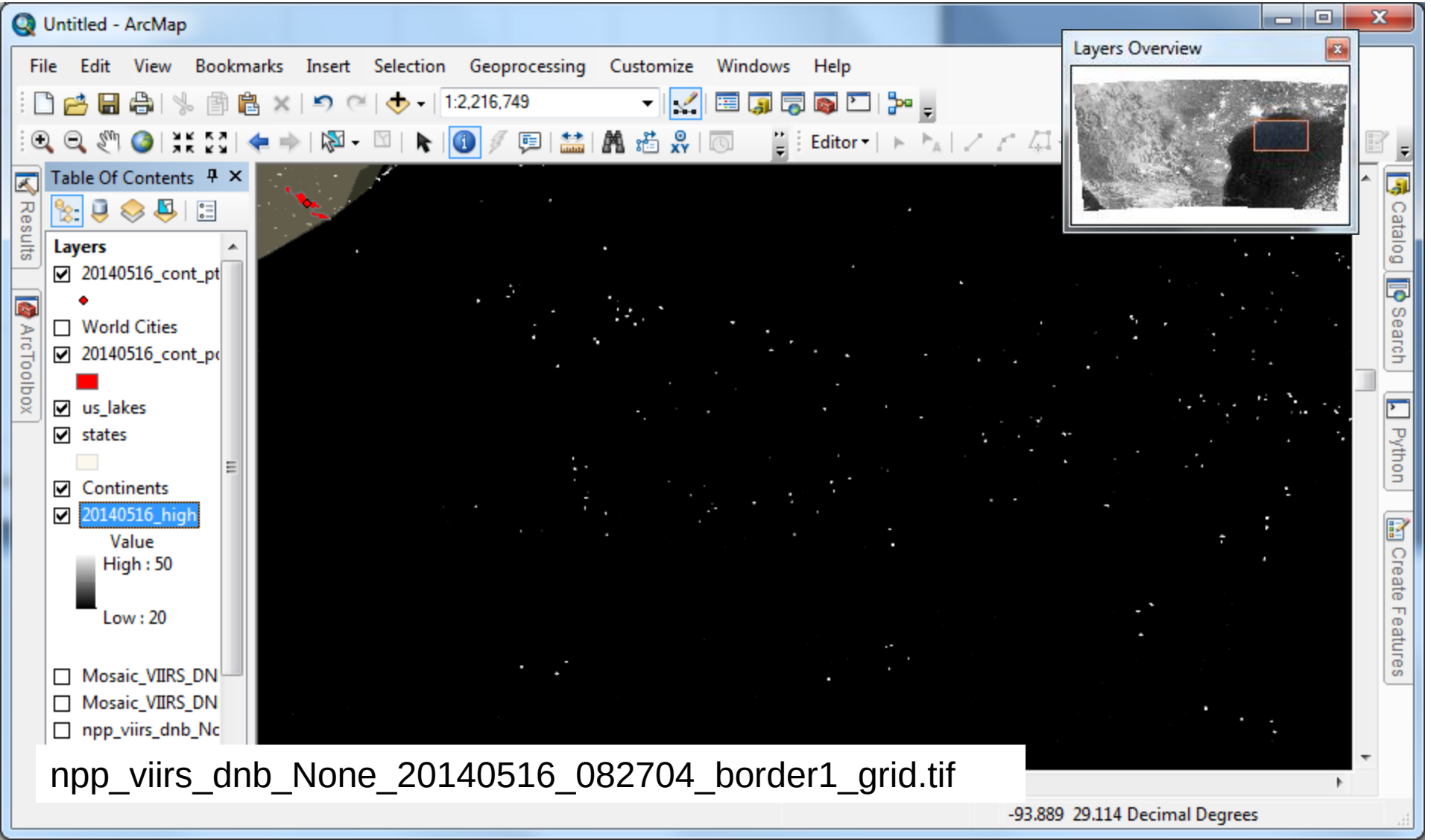
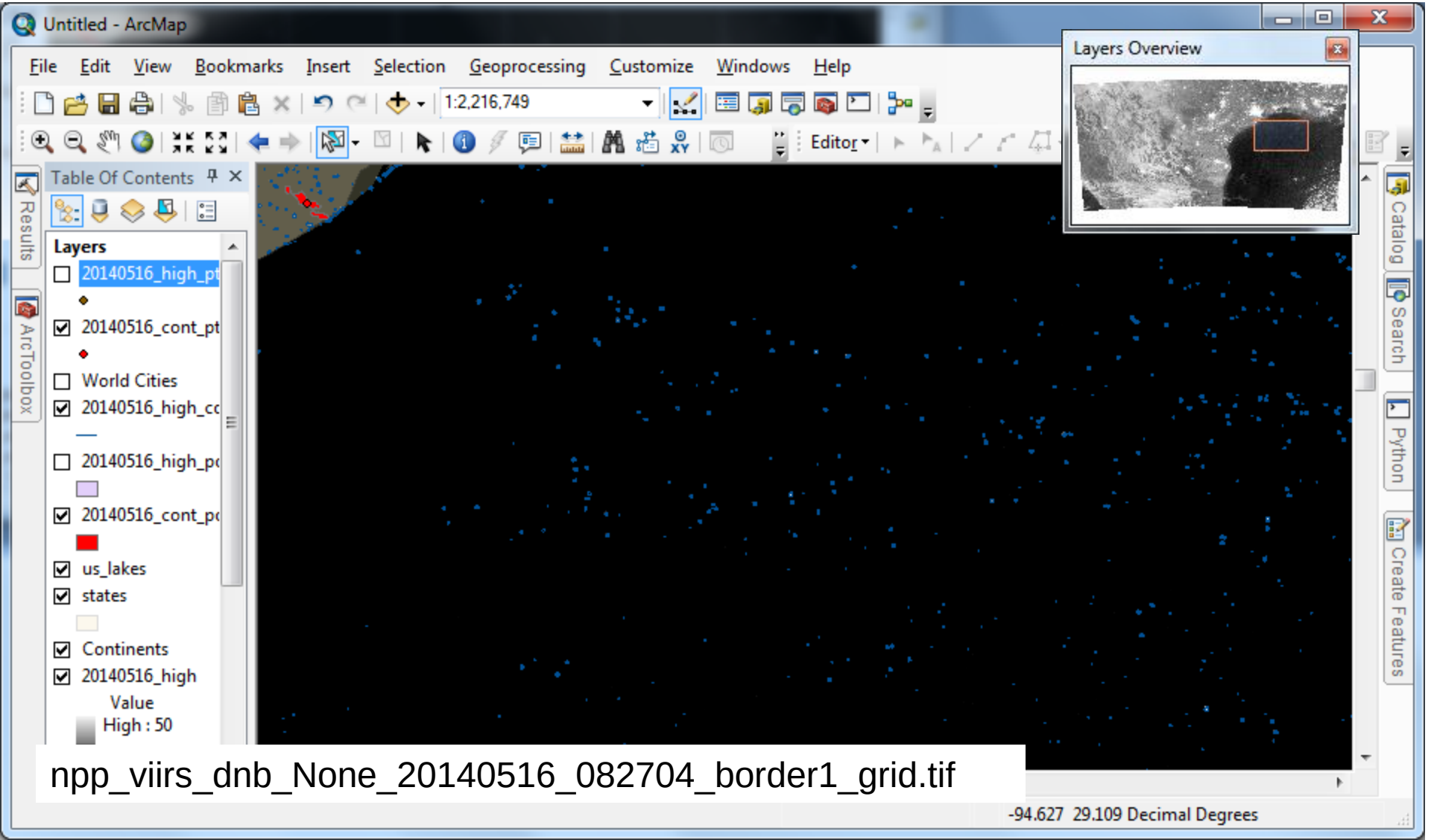
High Pass Filter stretched 20-50



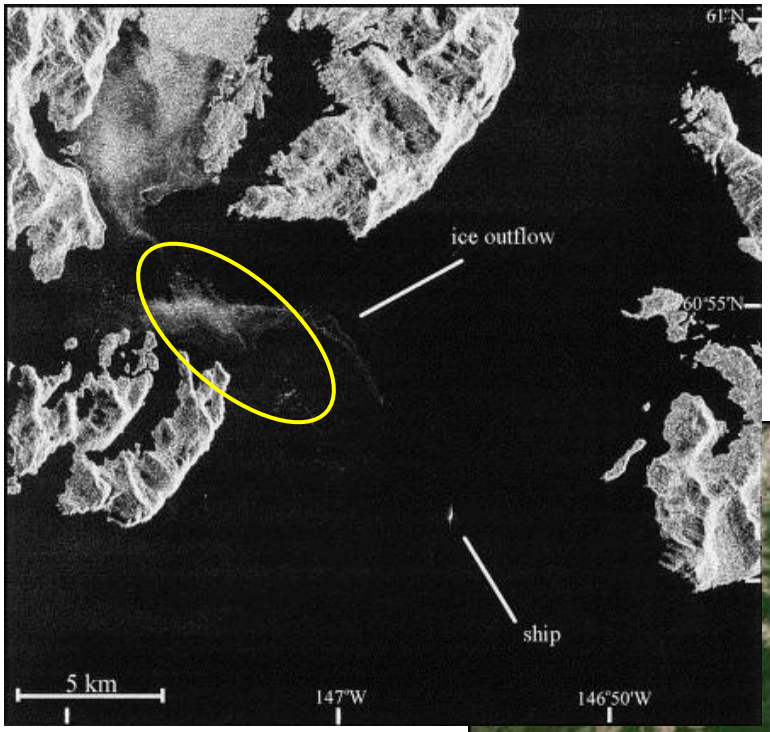
npp_viirs_dnb_None_20140516_082704_border1_grid.tif

ImageScan process (DN > 20)

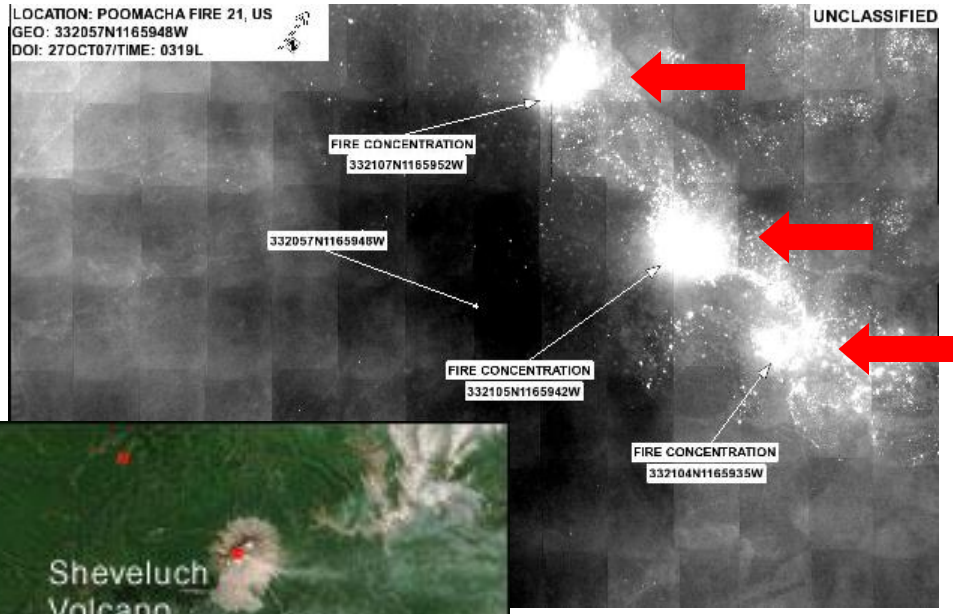


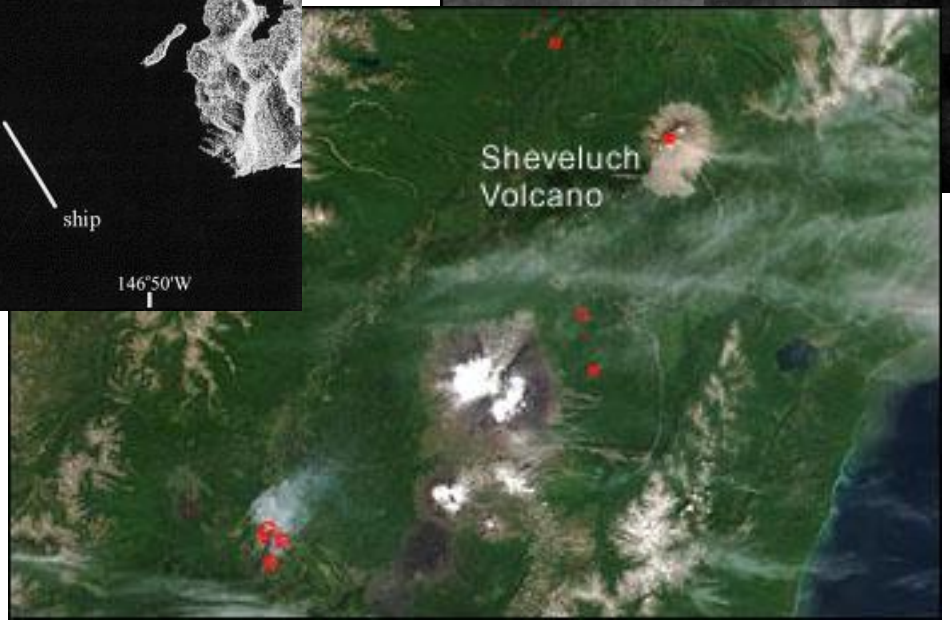
npp_viirs_dnb_None_20140516_082704_border1_grid.tif

Other Missions and Sample Imagery



Icebergs





Forest Fires

Advantages of ImageScan

- Automated scanning to minimize manual review of all data and identify “high interest” data
- Automated target detection
- Automated reporting
- Automatically builds a historical database for trend analysis

Summary

- Data volume is increasing
- Identifying smarter ways to process, store, transmit, and analyze large volumes of data is essential
- The ImageScan process is an ArcGIS based tool to complete an unsupervised processing and reporting chain to examine georectified raster imagery to automatically
  - Identify high interest data sets and
  - Report and database locations of potential targets of interest
- Shapefile and tabular results can be used for workload management, trend analysis, watch box reporting, and alert reporting

Acronyms & Definitions

- AGI - Advanced Geospatial Intelligence
- ArcMap - ESRI Geospatial Analysis software
- ATR - Automatic Target Recognition
- BATC - Ball Aerospace & Technologies Corp.
- CBP - Customs and Border Patrol
- CSV - Comma Space Variable text file – common text file format for tables
- DHS - Department of Homeland Security
- DN - Digital Number
- DNB - Day/Night Band (VIIRS)
- ENVI - Commercial Remote Sensing Analysis software
- GEOINT - GEOspatial INTelligence
- HTML - Hyper text markup language - common file format for web pages
- IC - Intelligence Community
- L0/L1/L2/L3 - Level # processing (L0 is raw ◊ L3 is substantially more processed)
- NGA - National Geospatial Agency
- NPP - Suomi National Polar-orbiting Partnership (NPP) satellite
- NITF - National Image Transfer Format
- NORTHCOM - Northern Command
- Opticks - Open Source Remote Sensing Analysis software
- shp - shape file (ESRI GIS standard) - – common GIS file format
- TIR - Thermal Infra Red
- USCG - United States Coast Guard
- USFS - United States Forest Service
- VIIRS - Visible/Infrared Imager/Radiometer Suite
- WFS - Web Feature Service
- WMS - Web Mapping Service

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Questions ?

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Penn State's MGIS and GEOINT programs:
http://www.worldcampus.psu.edu/degrees-and-certificates/geographic-information-systems-gis-master

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Credit: NASA Earth Observatory/NOAA NGDC