User guide for locating NEON camera Images

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1 Summary

NEON distributes digital images along with the hyperspectral spectrometer and lidar data. This tech memo describes how the user can easily locate the images of interest. It also describes the format of the images, the filename conventions and the organization

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2 Related documents and acronyms

2.1 Reference Documents

RD[01]	NEON.DOC.001211	NEON_Digital_Camera_Image_Orthorectification_ATBD
RD[02]	NEON.DOC.003652	NEON AOP Digital Camera Orthorectification Level 1 Processing Procedure
RD[03]	NEON.DOC.xxxxxx	AOP Digital Camera Mosaic ATBD (in preparation)

2.2 External Documents

ED[01]	NEON Project Locations (v15).kmz http://www.neonscience.org/sites/default/files/NEON-Project-Locations-v15.kmz
ED[02]	Google Earth https://www.google.com/earth/download/ge/agree.html
ED[03]	The national elevation map http://pubs.usgs.gov/fs/2009/3053/

3 Locating images

A single survey of a NEON site can produce over 11,000 orthorectified camera images. These images are mosaicked into a single tiled image (RD[03]). Each tile covers 1 km by 1 km at 0.1-meter resolution and there may be over 500 separate tiles covering a site.

As an aid to locating images of interest, there is a kmz file for the survey for each site that can be loaded into Google Earth. This kmz will display the outline of each tile in the mosaicked image allowing the user to associate a region of interest with a specific tile. It can optionally show the name and extent of each individual image used to make an individual tile.

The following figures demonstrate how to use the kmz files. Figure 1 shows Google Earth loaded with the kmz file for the survey of Talladega National Forest, Alabama in NEON Domain 8 in 2016. Figure 2 shows the menu options available for displaying the different items in the file:

1. The outlines of the mosaic tiles
2. Pushpins showing the locations of individual images
3. A copy of the complete mosaic image rescaled to a resolution of 5 meters
4. Outlines of the digital elevation model both without and with backfill.

When first loaded, items 1 and 4 are checked.

In Figure 1, the red outlines show the extent of each 1 km by 1km tile while the red pushpins are labeled with the tile index. Clicking on a pushpin displays the complete filename of that tile as shown in Figure 3, e.g., "`2016_TALL_2_463000_3645000_image.tif`" (see Section 5.2 for a discussion of filenames.) Selecting "Individual Images" from the menu displays a green pushpin at the center of each individual image, as shown in Figure 4. Hovering over the pushpin shows a green outline of the image extent while clicking on the pushpin reveals metadata on the image. The names of the individual images are of the form "`16050614_EH021656(20160506144437)-0001_ort.tif`" which are too long to include here but can be resolved from the date and time. (Note that the four digit image index may not be unique within the files for a single flight.)

Checking the menu item "5 meter Browse Image" displays the complete mosaic image rescaled to a resolution of 5 meters, as shown in Figure 5. This image is useful for getting a broad overview of the site and for quality control. By zooming in on this image, the user can see the boundaries between the individual images that make up the mosaic, as shown in Figure 6.

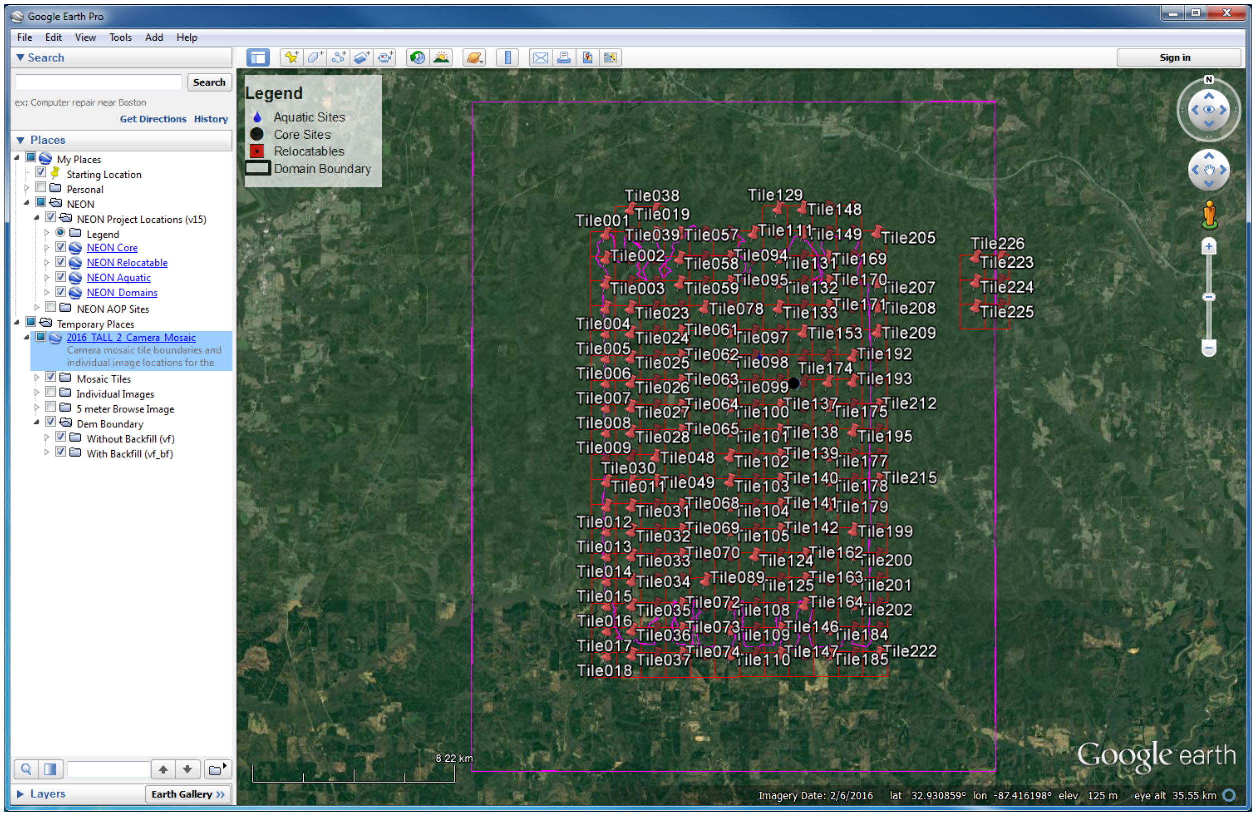

Figure 1. Google Earth with the file `2016_TALL_2.kmz` loaded showing the red tile outlines and pushpins for the site Talladega National Forest, Alabama in NEON Domain 8 surveyed in 2016. The file `NEON Project Locations (v15).kmz` is also loaded.

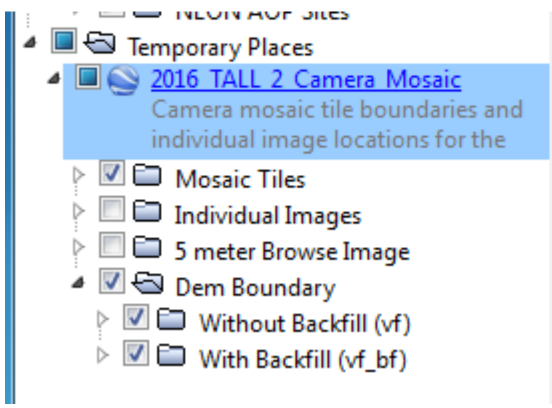

Figure 2. Menu in the left panel of Google Earth showing the different items that can be displayed.

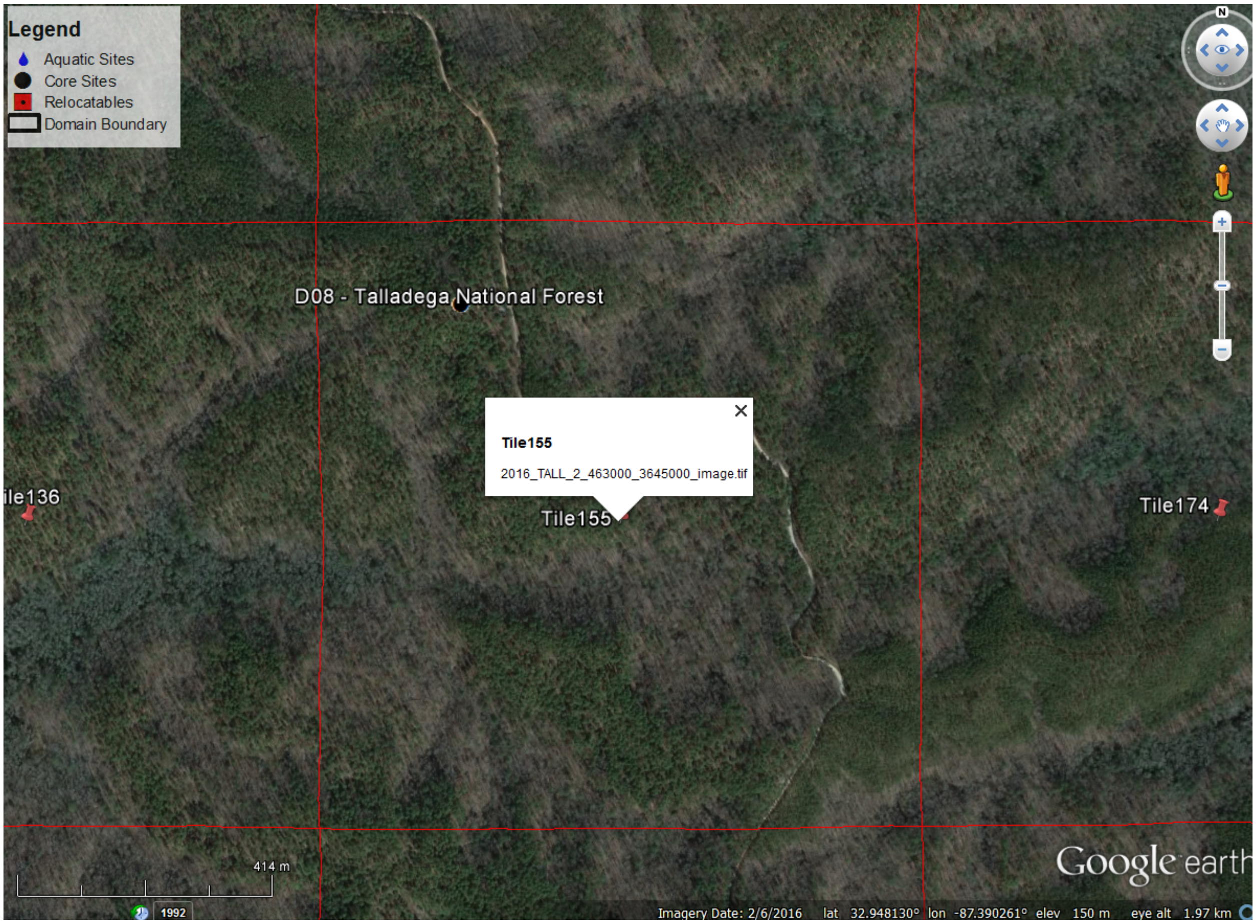

Figure 3. Figure 1 zoomed in to Tile 155. Clicking on the pushpin reveals a balloon with the complete name of the tile.

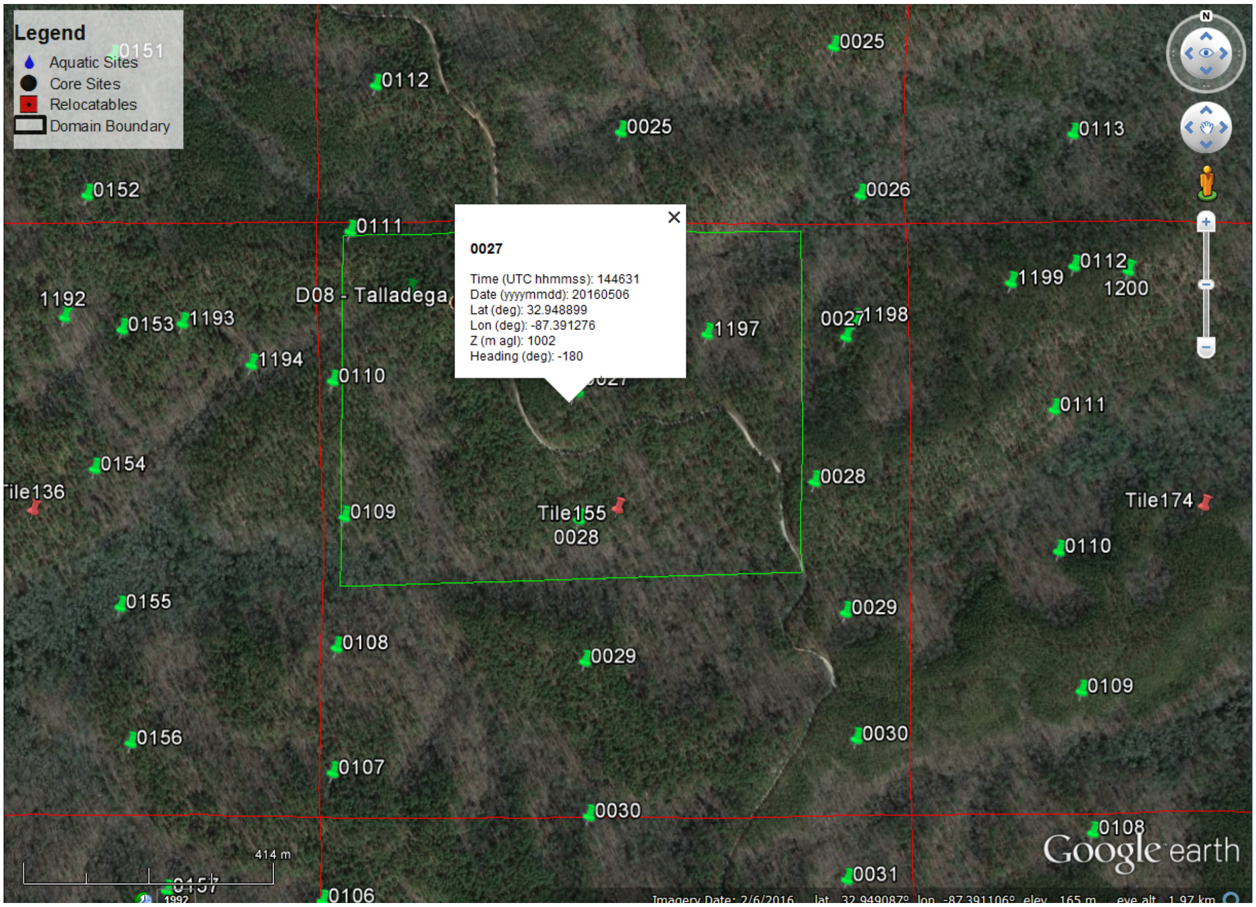

Figure 4. Figure 3 with the box "Individual Images" in the left menu checked. Each green pushpin represents an individual image. Hovering over a pushpin reveals the green outline of that image (0027 shown). Clicking on a pushpin reveals metadata on that image: UTC date and time, latitude and longitude, altitude above the ground and direction of flight.

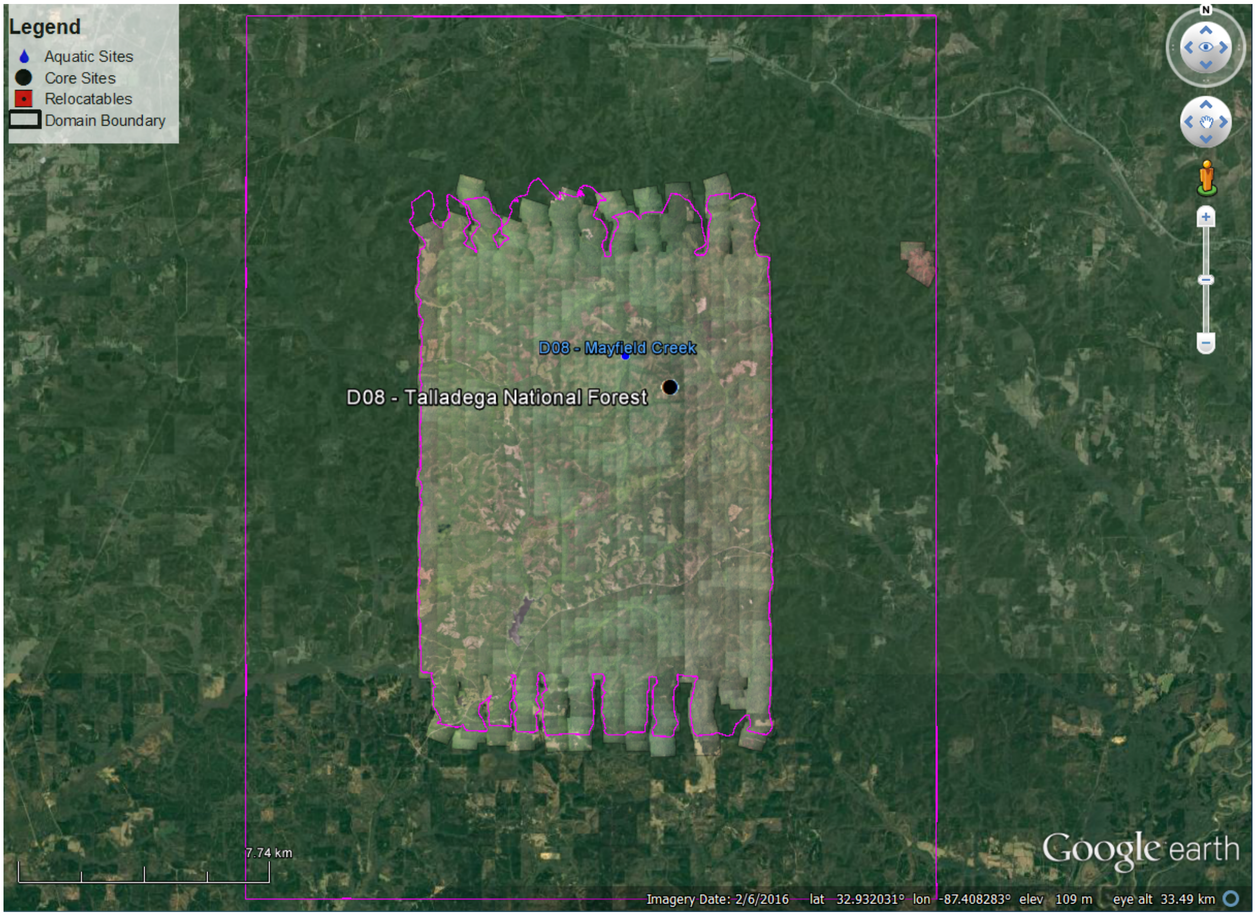

Figure 5. Figure 1 with the box "5 meter Browse Image" in the left menu checked. The background image is an image of the complete mosaic rescaled to a resolution of 5 meters.

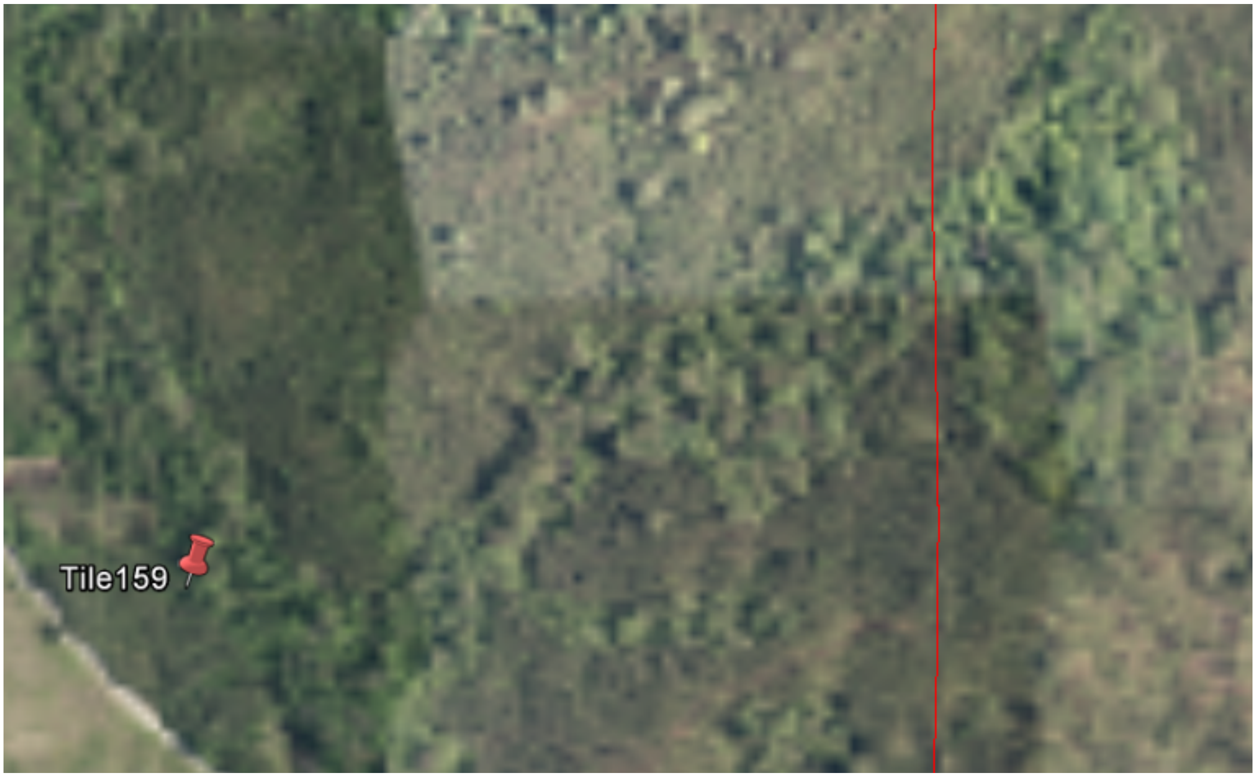

Figure 6. Figure 5 zoomed in to Tile 159 showing the boundaries where the individual images that make up the mosaic intersect.

4 Displaying Images

Both the individual images and the mosaic tiles are in geotiff format with jpeg encoding. Most image browsers (e.g., IrfranView ref) will display the images but without reference to the geographic metadata.

These images can also be viewed in Google Earth with limitations. The images are too large for Google Earth to display entirely. If you open an image in Google Earth, you are presented with two choices: display the whole image at reduced resolution or display a cropped version at full resolution (see Figure 7.) Once the image is displayed in Google Earth (Figure 8), you can compare the image with the Google image by:

1. Unchecking and checking the menu box on the left
2. Right click the image in the menu box and select properties. In the "Description" tab, move the slider labeled "Transparancy" from "Opaque" to "Clear" and back to reveal the underlying Google image.

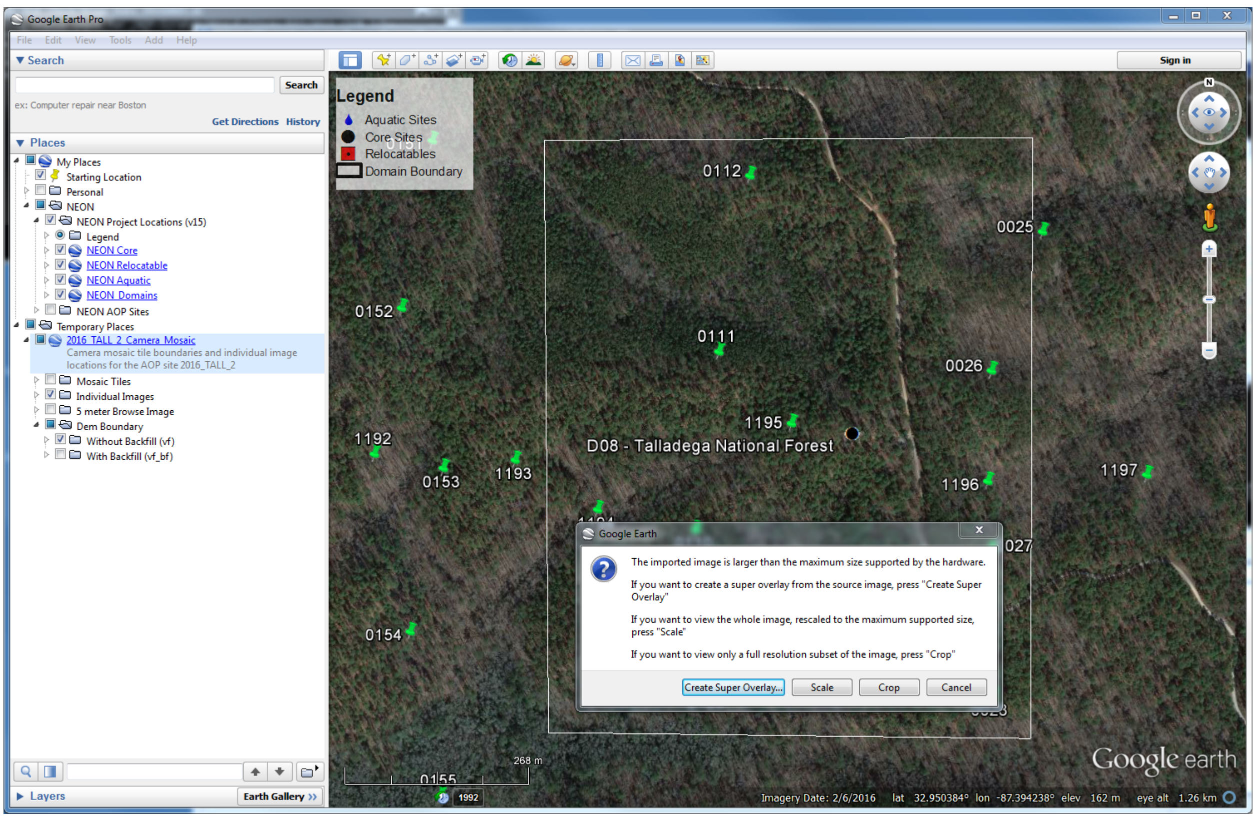

Figure 7. Image 1195 dropped into Google Earth, showing the import menu.

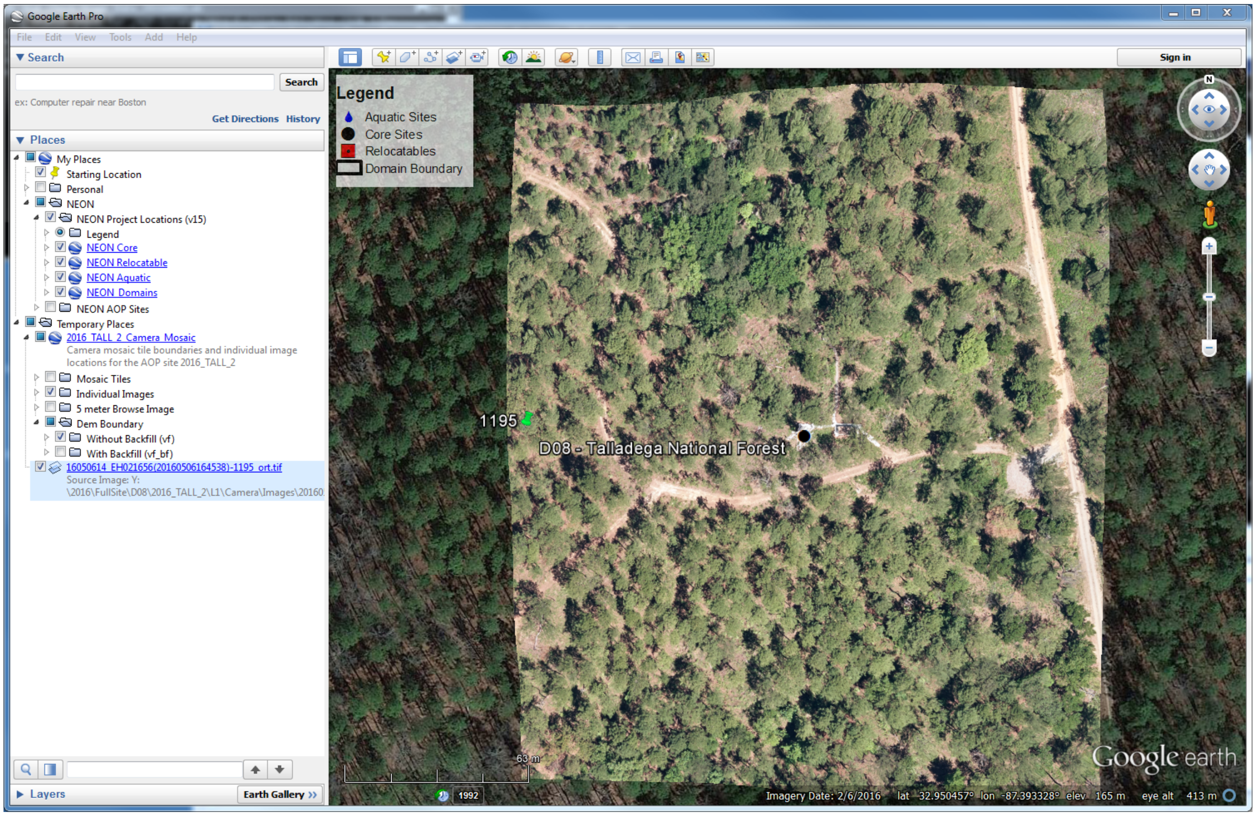

Figure 8. Cropped version of image 1195 centered over the D08 tower.

For a list of both open source and commercial software that can display the images in their geographic context, see https://en.wikipedia.org/wiki/List_of_geographic_information_systems_software.

5 Image characteristics

5.1 Format

The camera data is distributed both as Level 1 individual orthorectified images and as Level 3 tiles comprising the mosaic of all the individual images. The image format is jpeg-encoded geotiff, that is, tiff format files with embedded geolocation metadata with the images encoded as jpegs. The embedded geolocation data allows the images to be displayed in the proper location in GIS software (see Section 4.) The jpeg encoding reduces the file size by as much as 80 percent while preserving most of the detail. Currently the horizontal resolution of both the individual images and the mosaic tiles is 0.1 meters.

5.2 Filenames

5.3 Individual images

Individual orthorectified images have names such as:

16050614_EH021656(20160506144437)-0001_ort.tif

or:

*yymmddhh_EHssssss(yyyymmddhhmmss)-nnnn*_ort.tif

where:

yymmddhh are the 2-digit year, month, day and hour (UTC) of the flight

ssssss are the serial number of the camera (currently either 021656 or 021537)

yyyymmddhhmmss are the year, month, day, hour, minute and second (UTC) that the image was collected,

nnnn is sequential index of the image,

ort.tif indicates that the image is an orthorectified image in tiff format.

Note that the index *nnnn* may be restarted within a flight and not be unique. The time stamp *yyyymmddhhmmss* however is unique.

5.4 Mosaic tile images

Mosaic Image tiles have names such as:

2016_TALL_2_456000_3652000_image.tif

or:

*yyyy_site_n_xxxxxx_yyyyyyy*_image.tif

where:

yyyy is the of the survey,

site is the NEON abbreviation of the survey site

xxxxxx is the UTM easting coordinate in meters of the lower left corner of the image

yyyyyyy is the UTM northing coordinate in meters of the lower left corner of the image

5.5 Artifacts

Features near the edges of the orthorectified images may appear distorted, for example:

- straight lines (sidewalks, building edges) have wiggles: Figure 9
- vertical tall objects (trees, poles) appear to lean away from the image center: Figure 10
- tree crowns show a pronounced swirling effect

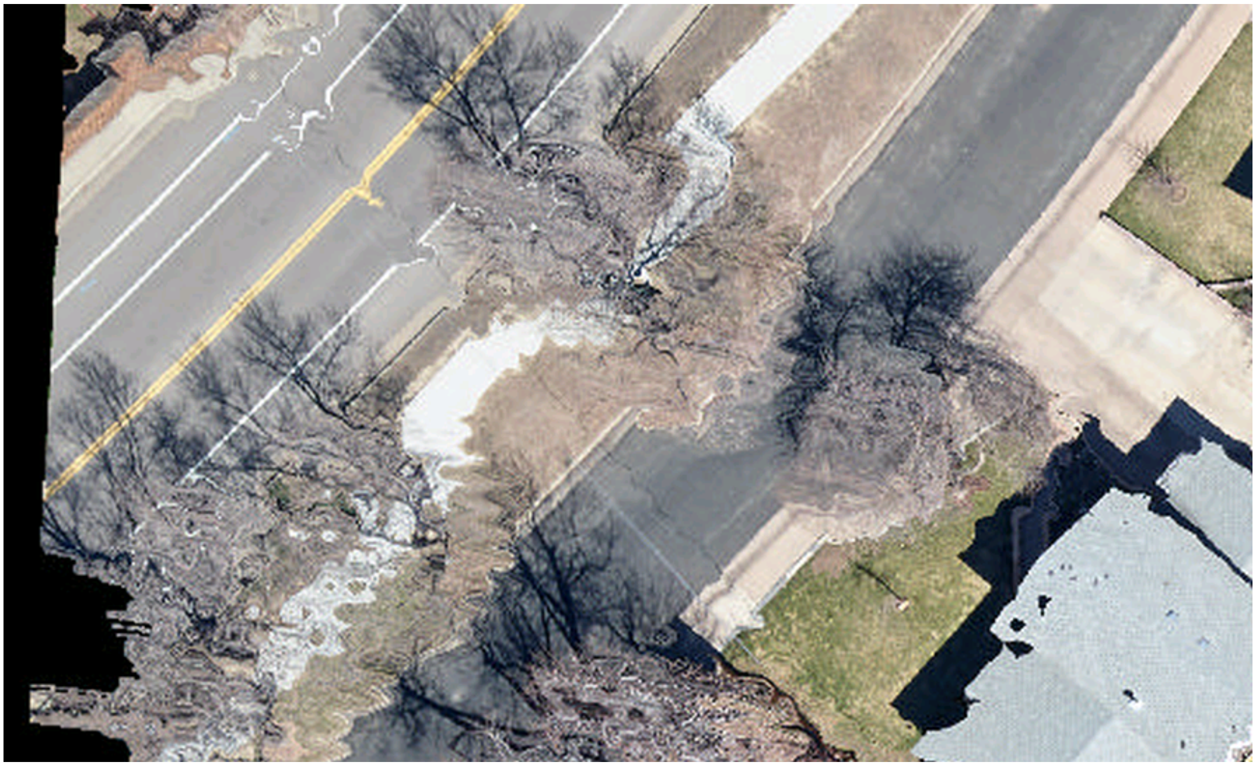

Figure 9. Distortions to straight lines at the edge of an image caused by a mismatch between the resolution of the image and the dem.

Figure 10. Distortions showing tall objects leaning away from the center at the end of an image caused by a mismatch between the resolution of the image and the dem.

These distortions are created in the orthorectification process (RD[01]) due to a mismatch between the image resolution (0.1 meter) and the dem resolution (1.0 meters). In a region with sharp changes in elevation, e.g., a tall tree next to a sidewalk, the orthorectification process may assign the elevation of the tree to the elevation of a nearby pixel at ground level. This elevation error introduces a horizontal parallax error in the location of the ground level pixel.

Errors of this sort are most pronounced at the edges of images where the zenith angle of the line-of-sight from the ground to the camera may be as much as 21 degrees. Near the center of the image, the parallax error is negligible.

The mosaic images show little of this effect: a mosaic pixel is populated with the pixel from the overlapping image that has the smallest zenith angle. Only at the outer boundary of the mosaic will this effect be evident.

However, a similar distortion can occur in areas where the dem is "backfilled". In Figure 5, the inner blue outlines the boundary between where the dem is "void filled" (inside) and "backfilled" (outside.) The backfilled area is populated with the elevation from the USGS 8 meter digital terrain model (get reference). In the image areas in the backfill region (which also correspond to relatively large zenith angles), there can be significant distortion. However, this area is small and outside the area covered by the lidar and the spectrometer.

6 Glossary

Table 1 Glossary

Term(s)	Meaning
dem/dsm/dtm	dem: digital elevation model = generic term for dtm/dsm dsm: digital surface model = elevation of the surface, including treetops, buildings, etc., above the geoid dtm: digital terrain model = elevation of the bare earth above the geoid
geolocate	To reference or locate data geospatially
Level 1/3	Level 1: Calibrated data from a single observation Level 3: Calibrated data from multiple sources, observations
orthorectify	To remap an image from device coordinates to map coordinates so that the pixels are on a regular geographic grid
tile	To break a large image into a number of smaller contiguous images
UTC	Coordinated Universal Time
UTM	Universal Transverse Mercator: a map projection
voidfill/ backfill	When creating a dem from lidar data, some pixels are not populated due to sampling or poor reflectance (e.g., over water). For small areas (less than 15 pixels across), the empty areas can be filled in by interpolation from the surrounding area. This is referred to as **voidfill**. For larger areas, particularly the outside boundary around the lidar data, the empty areas are filled in with elevation data interpolated from the USGS 8m dem (ED[03]])This is referred to as **backfill**.