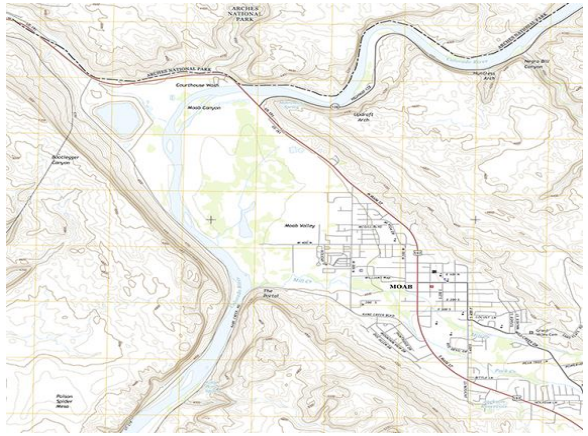
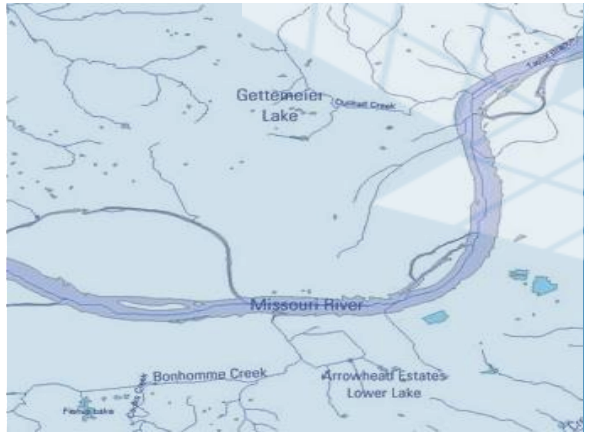
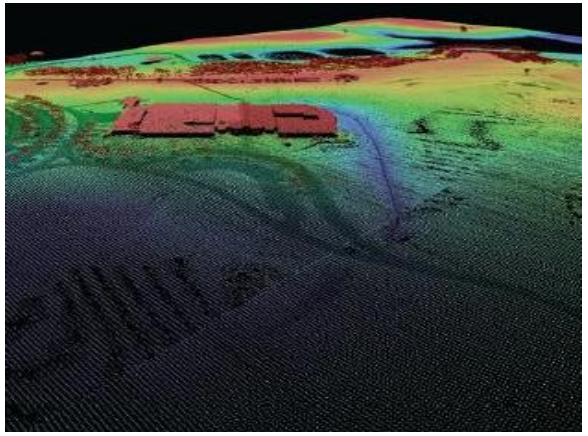
GPSC Technical Exchange







Barry Miller and Josh Nimetz
National Geospatial Program | National Geospatial Technical Operations Center
Virtual Web Conference
July 12, 2022

Topics for discussion

- 3DEP Lidar Base Specification News
  - https://www.usgs.gov/3dep/lidarspec
- Swath Separation Imagery and Maximum Surface Height Raster Resolution – 4 x NPS
- SSI Clarification
- Intensity Values
- Tile Index Must Match Tiled Deliverables
- Horizontal Accuracy Reporting
- Access to TEM materials – slides, recordings, etc.
  - https://rockyweb.usgs.gov/outgoing/3DEP_TEM/

+ Lidar Base Specification – Future Revisions

- Remember to review the LBS revisions page
  - https://www.usgs.gov/ngp-standards-and-specifications/lidar-base-specification-revision-status

Revisions being considered for the Lidar Base Specification:

Short name of revision	Status	Last updated
Clarify Intensity Requirement	Under review by ESRB	April 11, 2022
Number of Decimal Places	Under review by ESRB	April 11, 2022
Withheld flag Proof of Performance Version Control	Under review by ESRB	April 11, 2022
Report on Withheld flag Proof of Performance	Under review by ESRB	April 11, 2022
Point Cloud Delivery in LAZ Format	Under review by ESRB	April 11, 2022

- USGS has moved to a new listserv for email notifications
  - No action required – current emails on file should be ported over to new system
  - If you're not on the list, you can sign-up here: https://public.govdelivery.com/accounts/USDOIGS/subscriber/new?topic_id=USDOIGS_17

+ MSHR and SSI – Spatial Resolution

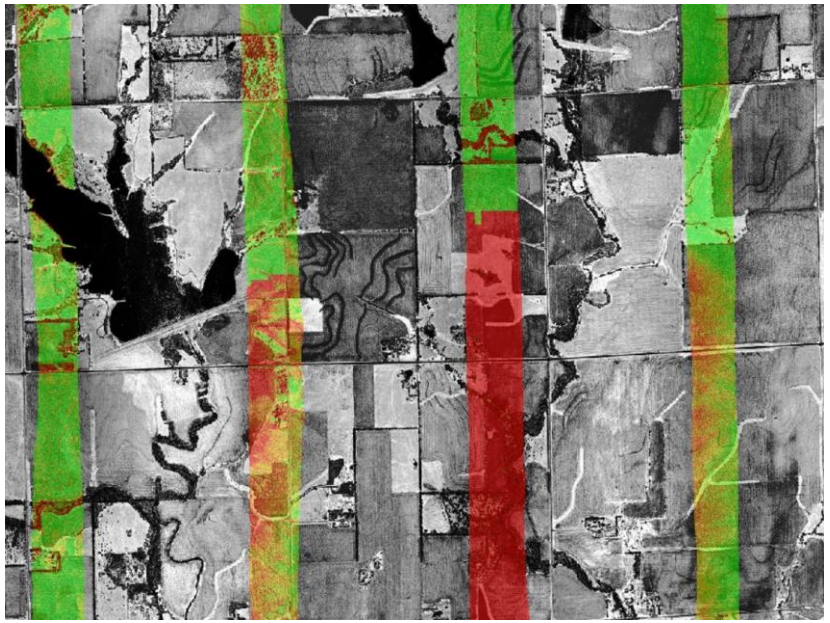
- USGS would like the MSHR and SSI spatial resolution (pixel size) to be equal to 4 * NPS
- Our intent is to make sure pixels contain valid signal and are not data voids
  - Exceptions are for areas where voids are expected such as over open water
- In order to keep things simpler and consistent, we will require the same pixel size for both ancillary products
  - This should decrease raster creation time and decrease file sizes vs using the same resolution as the bare-earth DEM
  - For QL1, the pixel size would be 4 x 0.35 = 1.4 meters
  - For QL2, the pixel size would be 4 x 0.71 = 2.84 meters
- What are your thoughts on this?

+ Swath Separation Imagery Clarification

- SSI need to be modulated by intensity

  - Image Creation:
    - All returns, single returns, or last returns shall be used to create the images.
    - All point classes and flags shall be enabled when creating the images and points flagged as withheld or classified as noise shall be excluded.
    - Elevation values and differences shall not be subjected to a threshold or otherwise clipped so all differences are represented.
    - The images will be derived from TINs to reduce the number of false difference values on slopes; however, other algorithms are acceptable.
    - The images shall consist of a 50 percent transparent RGB layer overlaying the lidar intensity image.
    - The images shall use at least three color levels wherever two or more swaths overlap within a pixel.

- We have seen many examples of SSIs where no intensity is used or where the transparency on the RGB layer is so low that you cannot see the intensity under the colors
  - This makes it much harder to understand if you are in vegetated areas



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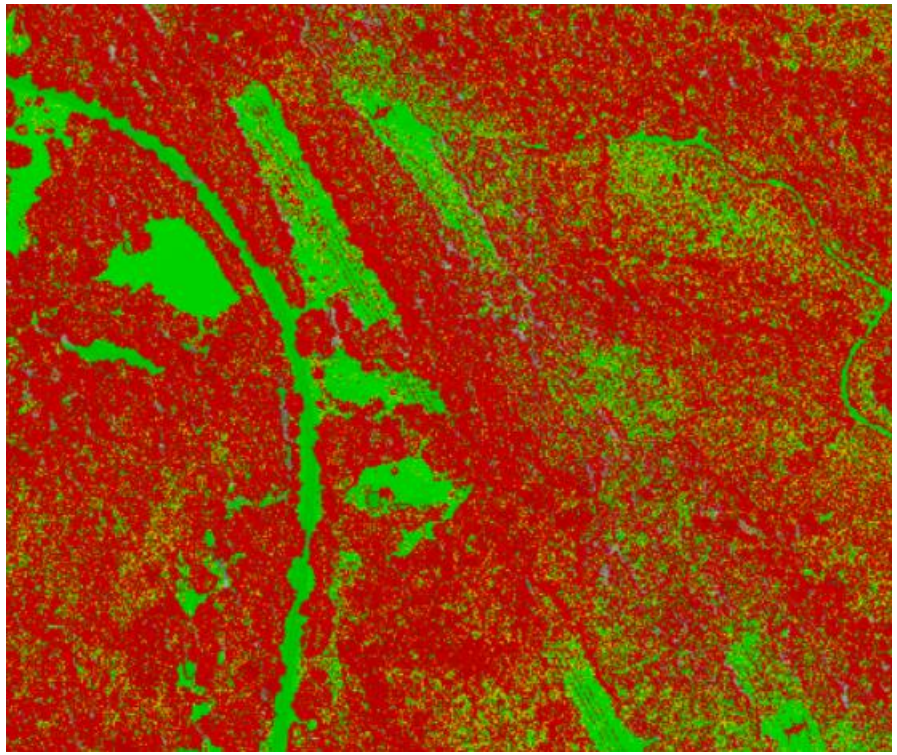
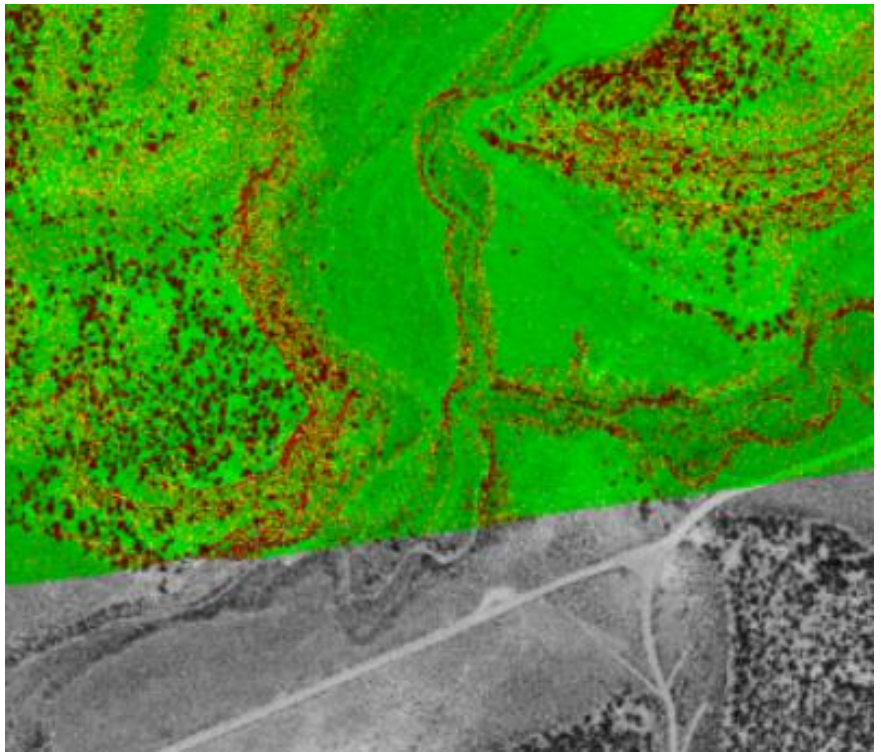
+ Swath Separation Imagery Clarification

- SSI need to be modulated by intensity



- Intensity very difficult to see



- Intensity easier to see with 50% transparency

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+ Swath Separation Imagery Clarification

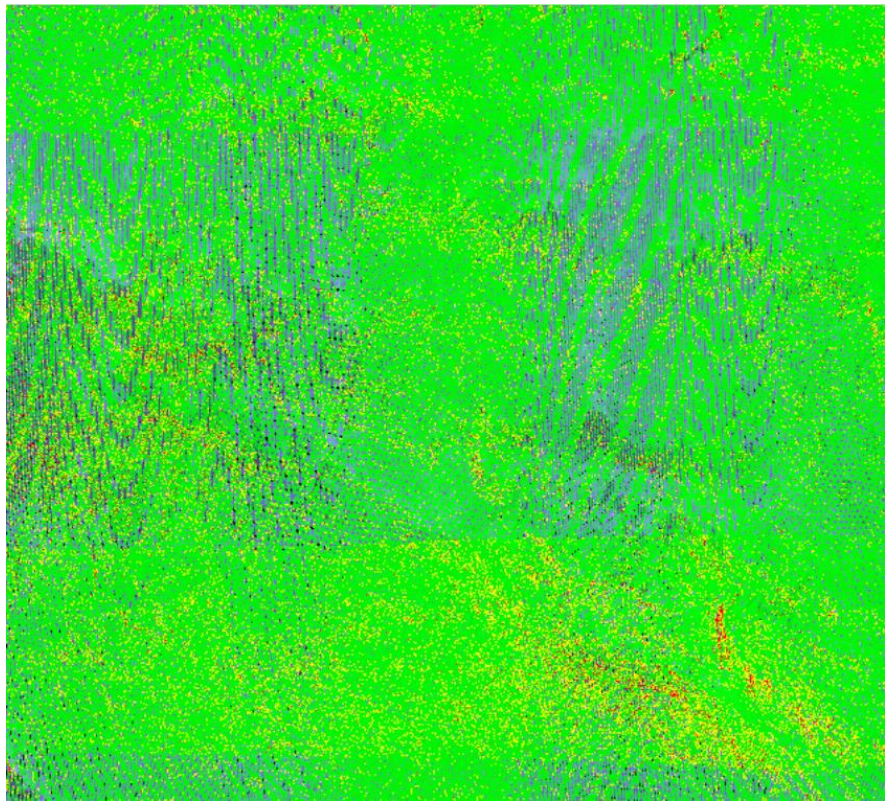
- Overlap areas should have no uncolored pixels

  - Where two or more swaths overlap within a pixel (based on point source ID),
    - pixel color shall be based on vertical difference of swaths using the following breaks (based on multiples of the Swath Overlap Difference for the QL, table 2).
      - For QL1 or QL2 data the breaks are:
        - 0-8 cm: GREEN;
        - 8-16 cm: YELLOW;
        - > 16 cm or > last additional color ramp bin value: RED (for example, addition of ORANGE pixels for the range of 16-24 cm would require red pixels to represent > 24 cm).
    - color choice of green, yellow, and red is suggested but not required.
    - no pixel shall remain uncolored (transparent) in the overlap areas.
  - Where swaths do not overlap, pixel values shall be intensity alone.

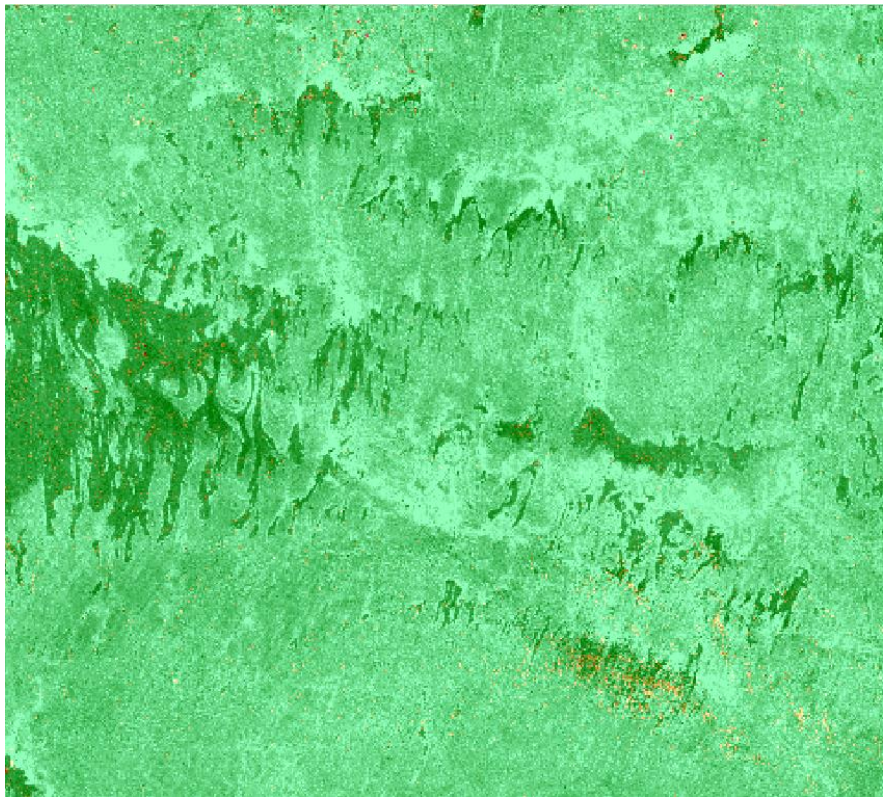
- Depending on the interpolation algorithm used, we have seen SSIs that are delivered with a speckling of uncolored pixels in overlap areas where we would not expect to see data voids (such as water)
  - This is a result of having a pixel that doesn't contain lidar points from both swaths and can be avoided by using a TIN interpolation

+ Swath Separation Imagery Clarification

- Overlap areas should have no uncolored pixels



- Uncolored pixels where the intensity shows through



- All overlap pixels are colored green, yellow, or red

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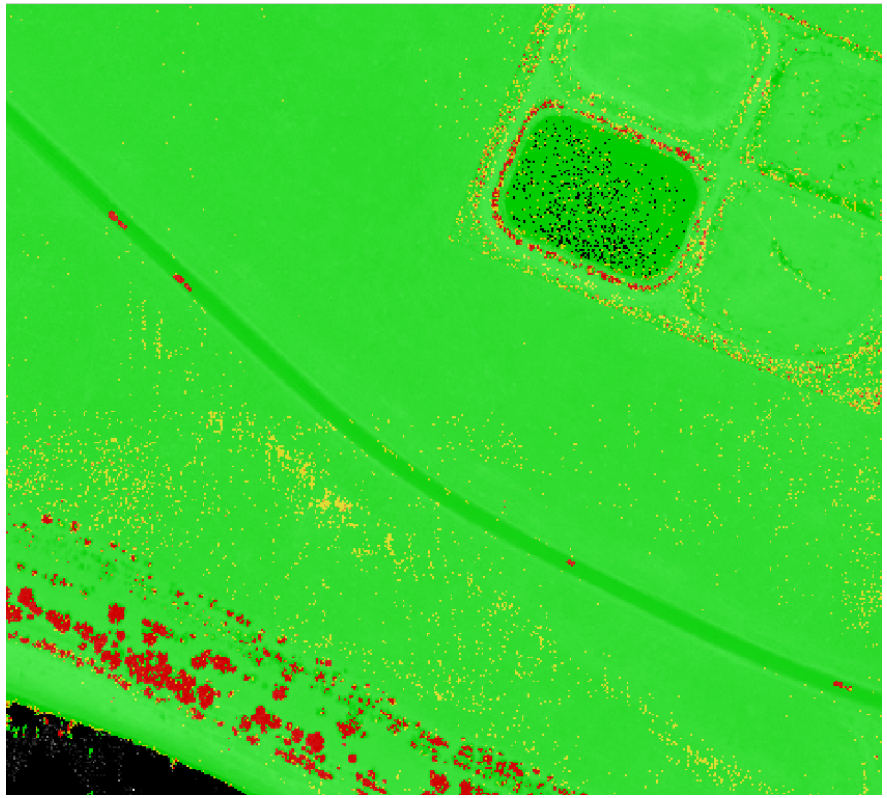
+ Swath Separation Imagery Clarification

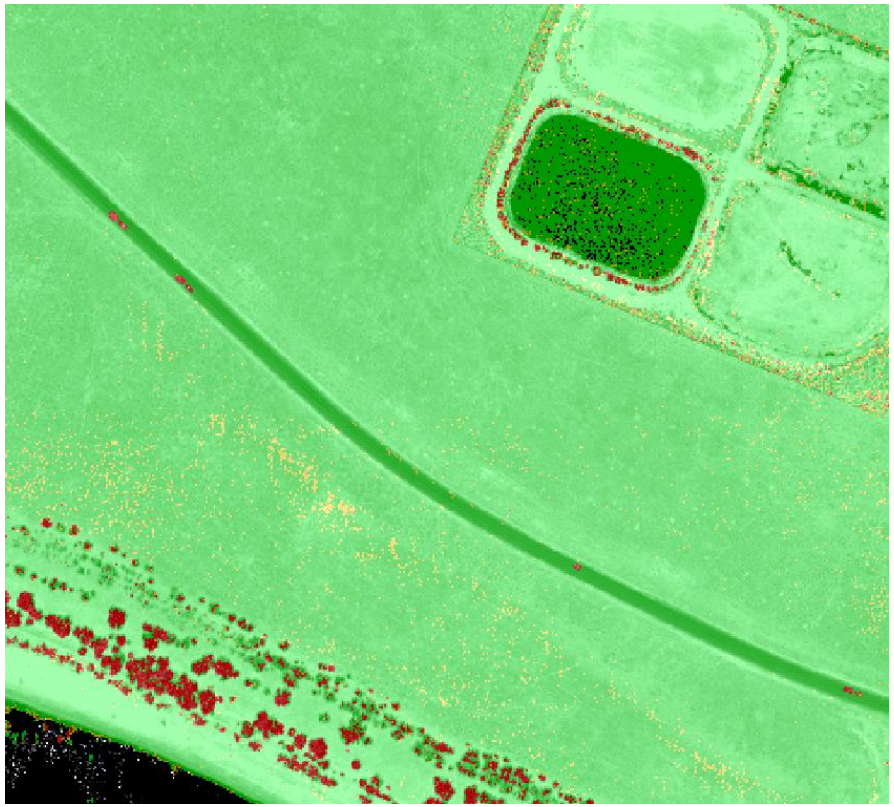
- Interpretable intensity images
- The SSI is more useful for you, our customers, and us if we can interpret what we are seeing in the intensity values
- Although imagery stretches are currently forbidden on the native lidar point cloud intensity values (more to follow on this), this prohibition does not apply to the SSI
- Feel free to use your best judgement and apply an imagery stretch to the SSI raster if it improves useability

+ Swath Separation Imagery Clarification

- Interpretable intensity images



- No stretch applied



- Imagery stretch applied

+ Intensity Values

- Currently the LBS forbids the use of common imagery stretches on intensity values in the **point cloud values**

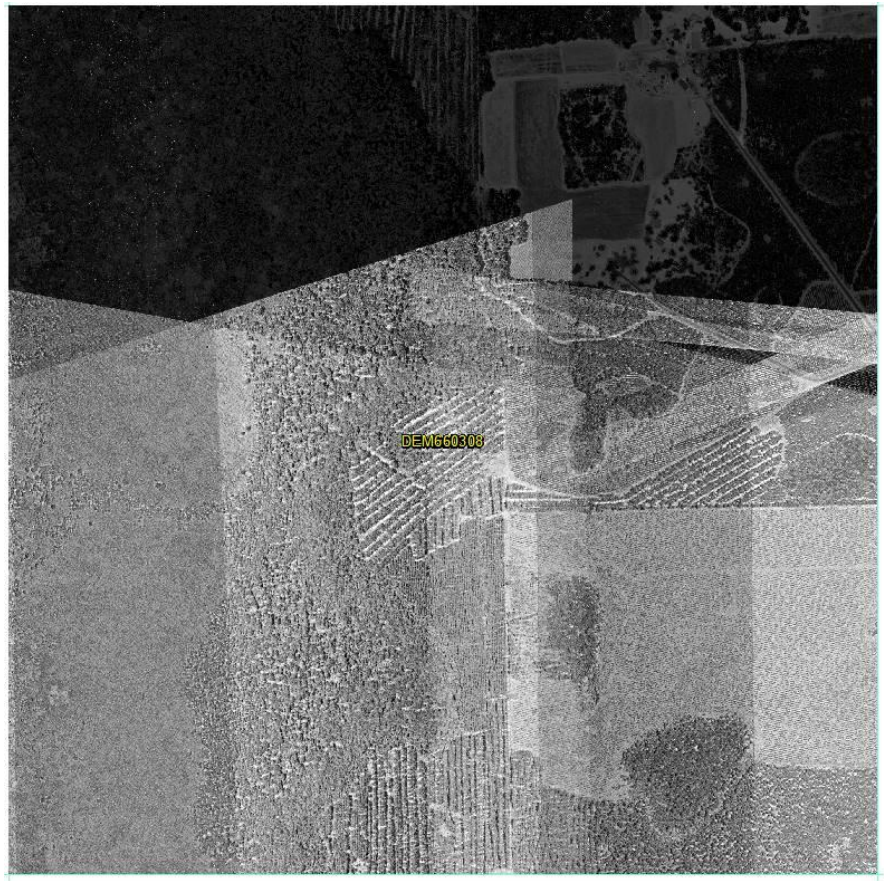
Intensity Values

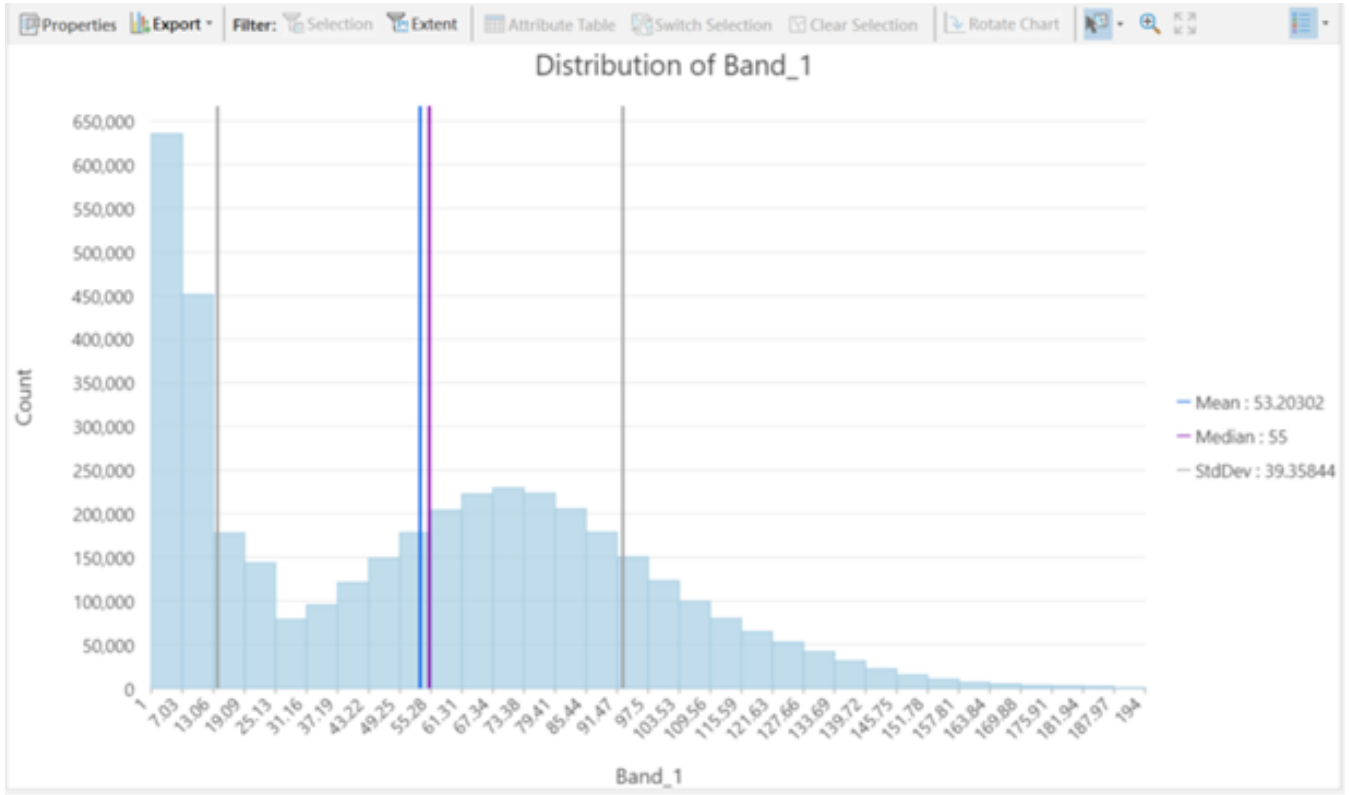
- Intensity values are required for each multiple discrete return.
- The intensity values recorded in the LAS files shall be normalized to 16 bit, as required by the LAS specification version 1.4–R15 (ASPRS, 2011).
- Intensity normalization shall be strictly linear.
- Common image stretches (minimum-maximum, standard deviations, percent clip, histogram, and so forth) are expressly forbidden.

- However, our customers would probably prefer to see intensity values that are visually pleasing and interpretable as opposed to too dark or too bright
  - Since lidar sensors are not calibrated for intensity collection, does keeping the native values matter?
  - Is this something we should change, perhaps by using extrabytes to store the original intensity value?
- What are your thoughts?

+ Intensity Values

- Here is an example of an intensity image where the intensity values are not consistent throughout the entire project





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+ Tile Index Must Match Tiled Deliverables

- We have seen examples of where the tiled raster deliverable doesn't match the tiling scheme exactly
  - This could be a result of the loss of precision in the delivered shapefile (compared to a geopackage or geodatabase feature being used to tile the rasters)
- We are running a new tool that is better at discovering data voids and discrepancies between the tile index and the delivered product

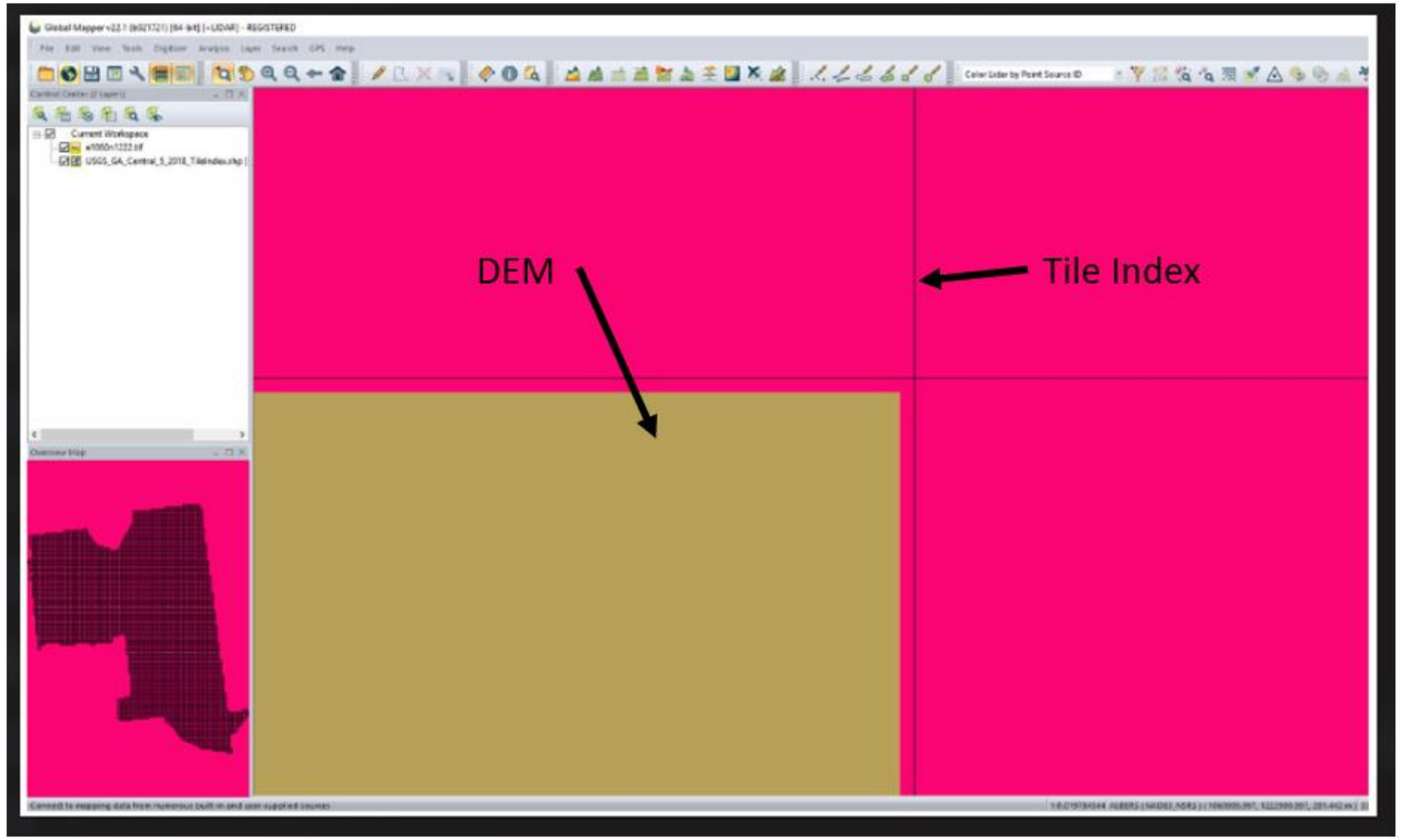
Tiles

- A single nonoverlapping project tiling scheme will be established and agreed upon by the data producer and the USGS–NGP before collection.
- The tiling scheme will be used for all tiled deliverables:
  - The tiling scheme shall use the same coordinate reference system and units as the data.
  - The tile size shall be an integer multiple of the cell size for raster deliverables.
  - The tiles shall be indexed in *x* and *y* to an integer multiple of the *x* and *y* dimensions of the tile.
  - The tiled deliverables shall edge-match seamlessly and without gaps.
  - The tiled deliverables shall conform to the project tiling scheme without added overlap.

+ Tile Index Must Match Tiled Deliverables

- Please ensure you are verifying that your tile index feature exactly matches the tiled deliverables such as the LPC and bare-earth DEMs

Offset by ~10,000th of a meter



+ Horizontal Accuracy Reporting

- We have a requirement for absolute horizontal accuracy reporting in the project report and LPC XML metadata
- We have noticed the horizontal accuracy is not consistently reported

Positional Accuracy Validation

- Prior to classification and development of derivative products from the point data, the absolute and relative vertical accuracy of the point data shall be verified and a detailed report of the validation processes used shall be delivered.

Absolute Horizontal Accuracy

- The horizontal accuracy of each lidar project shall be reported using the form specified by the ASPRS (2014): "This data set was produced to meet ASPRS Positional Accuracy Standards for Digital Geospatial Data (2014) for a ___ (cm) RMSEx / RMSEy Horizontal Accuracy Class which equates to Positional Horizontal Accuracy = +/- ___ cm at a 95% confidence level."

- We will update the filled in lidar XML metadata template in a future revision with an actual number to clarify that we do want this reported and not left blank

+ Horizontal Accuracy Reporting

- Refer to ASPRS Positional Accuracy Standards for Digital Geospatial Data (2014)
  - https://www.asprs.org/wp-content/uploads/2015/01/ASPRS_Positional_Accuracy_Standards_Edition1_Version100_November2014.pdf
- You can use the formula or table to calculate your produced to meet accuracy

$$Lidar\ Horizontal\ Error\left(RMSE_r\right) = \sqrt{\left(GNSS\ positional\ error\right)^2 + \left(\frac{\tan(IMU\ error)}{0.55894170}\ x\ flying\ altitude\right)^2}$$

$$RMSE_x \text{ or } RMSE_y = \frac{RMSE_r}{1.4142}$$

TABLE B.10 EXPECTED HORIZONTAL ERRORS ($RMSE_r$) FOR LIDAR DATA IN TERMS OF FLYING ALTITUDE

Altitude (m)	Positional $RMSE_r$ (cm)	Altitude (m)	Positional $RMSE_r$ (cm)
500	13.1	3,000	41.6
1,000	17.5	3,500	48.0
1,500	23.0	4,000	54.5
2,000	29.0	4,500	61.1
2,500	35.2	5,000	67.6

Thank You!
Let's Talk…

GPSCTechnicalInquiries@usgs.gov