Meta-Art: Using Metadata Preview Images to Support Analysis

Eric Robeck, NGA/SFNEE

10 August 2021

NATIONAL GEOSPATIAL NGA INTELLIGENCE AGENCY

Introduction

- Preview images allow analysts to check reliability of quality metrics, and to identify probable error locations.
- Uses are not limited to shaded relief – effective for assessing quality, source data, water bodies, slope, urban development, etc.
- SFNE (Source Foundation Elevation) Division has optimized preview image styling, already in use for DGED data.
- Multiple images can be viewed in a web browser using the NSG Elevation Metadata Implementation Specification (NEMIS) XML template.
- Transparency highlights void areas and supports overlay with other datasets.
- Point cloud images can include more than default relief and intensity.

Why are Preview Images Important?

- Metadata is critical for cataloguing and displaying exploding 3D content.
- Files are complex, often overlooked but can be valuable for analysis.
- Quality metrics like LE90 cannot map dataset variability and are often wrong.
- SFNE is working with Precise Imagery and Elevation Services (PIES) and ATSCL to create preview images to view in GRiD prior to download.
- The benefits of preview images include:
  - expanded quality control
  - improved search results
  - reduced download quantity
  - increased metadata utility

BLUF: Preview images support NGA's mission – to provide the highest quality 3D data to its clients.

NGA

TanDEM-X* Raw (TDR): Shaded Relief Shows Quality Metrics Are Wrong

Reported LE90 from ICESat is low, but image reveals…

- cell values >1 km below sea level
- distribution of >50% void cells
- water surface noise
- shoreline edge defects

* TanDEM-X is terrain data produced by TanDEM-X High Resolution Elevation Data Exchange (TREx) and is available for government purposes only, within the countries that are members of the TREx Alliance.

Name: TDR_N22E120_01.xml
Creation Date: 2015-10-16
Hierarchy Level: Geotile
Status: OnGoing
Maintenance: AsNeeded

- Description
- Constraints
- Raster Geometry
- Reference Systems
- Data Quality

Coverage Completeness

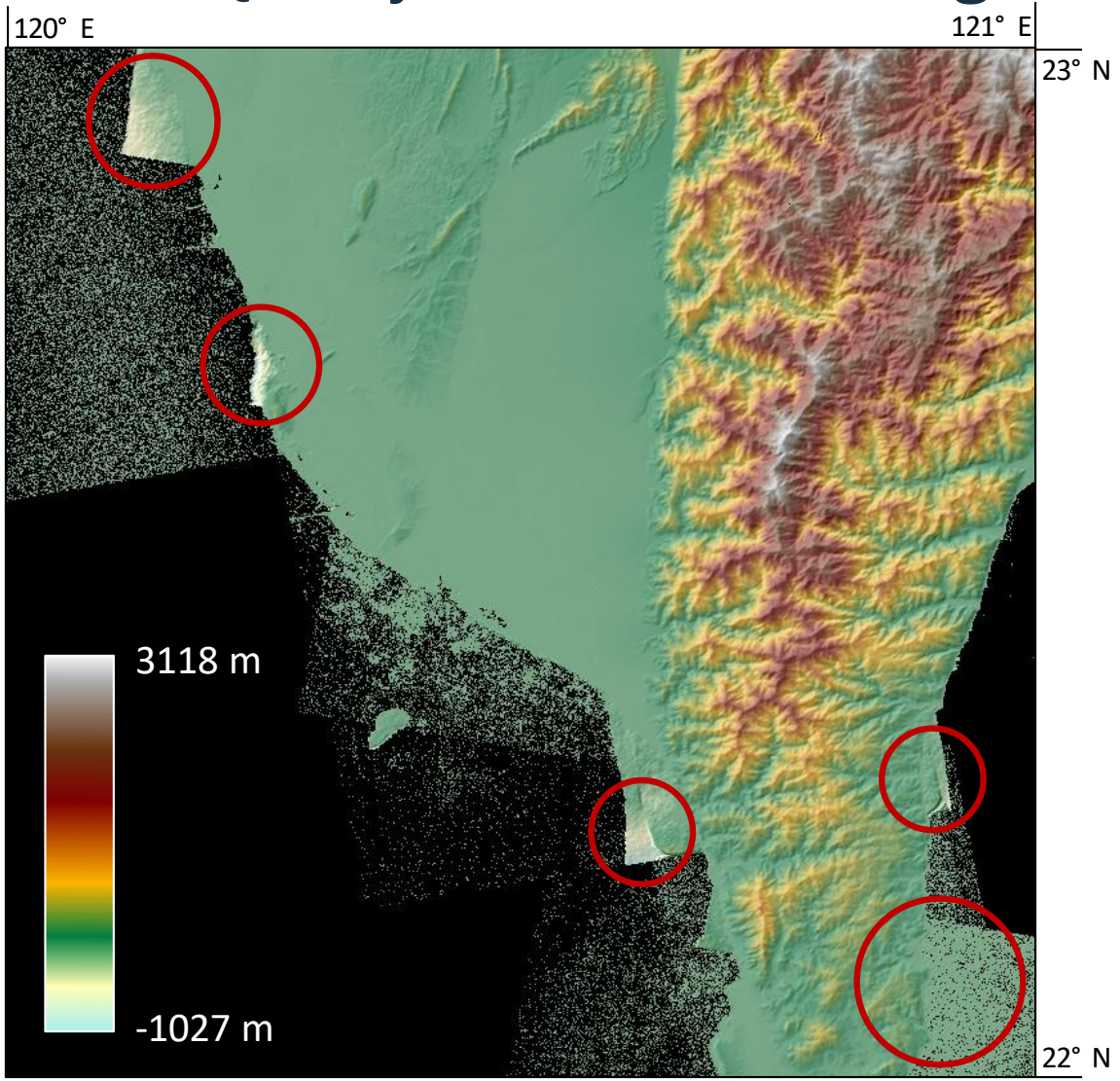
54.07%

Vertical Accuracy (Difference to ICESat)

Points #:	**999**
LE90:	**2.19m**
Mean:	**0.59m**
StdDev:	**1.61m**

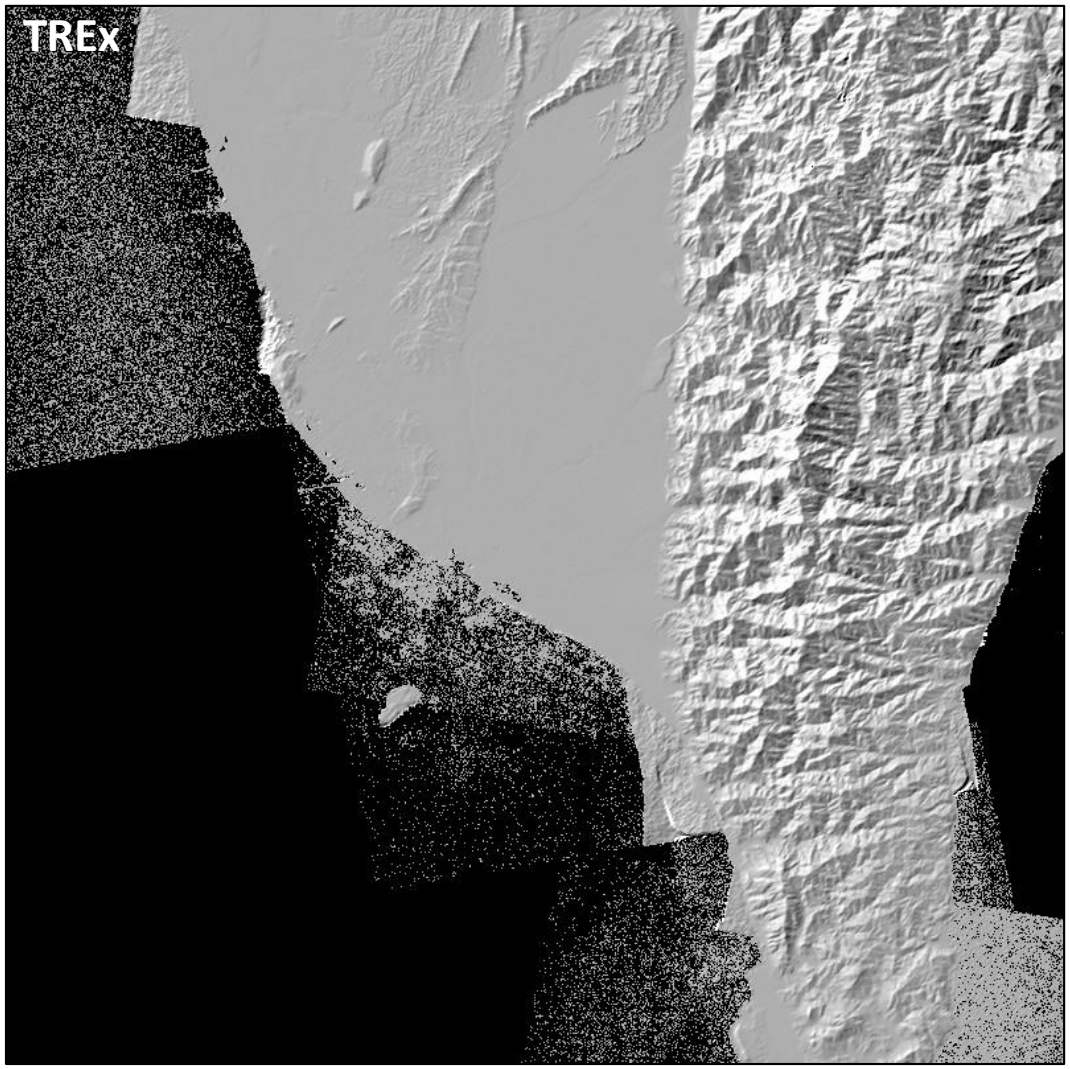
- Edge Matching
- Distribution

TREx Quality Metadata Report

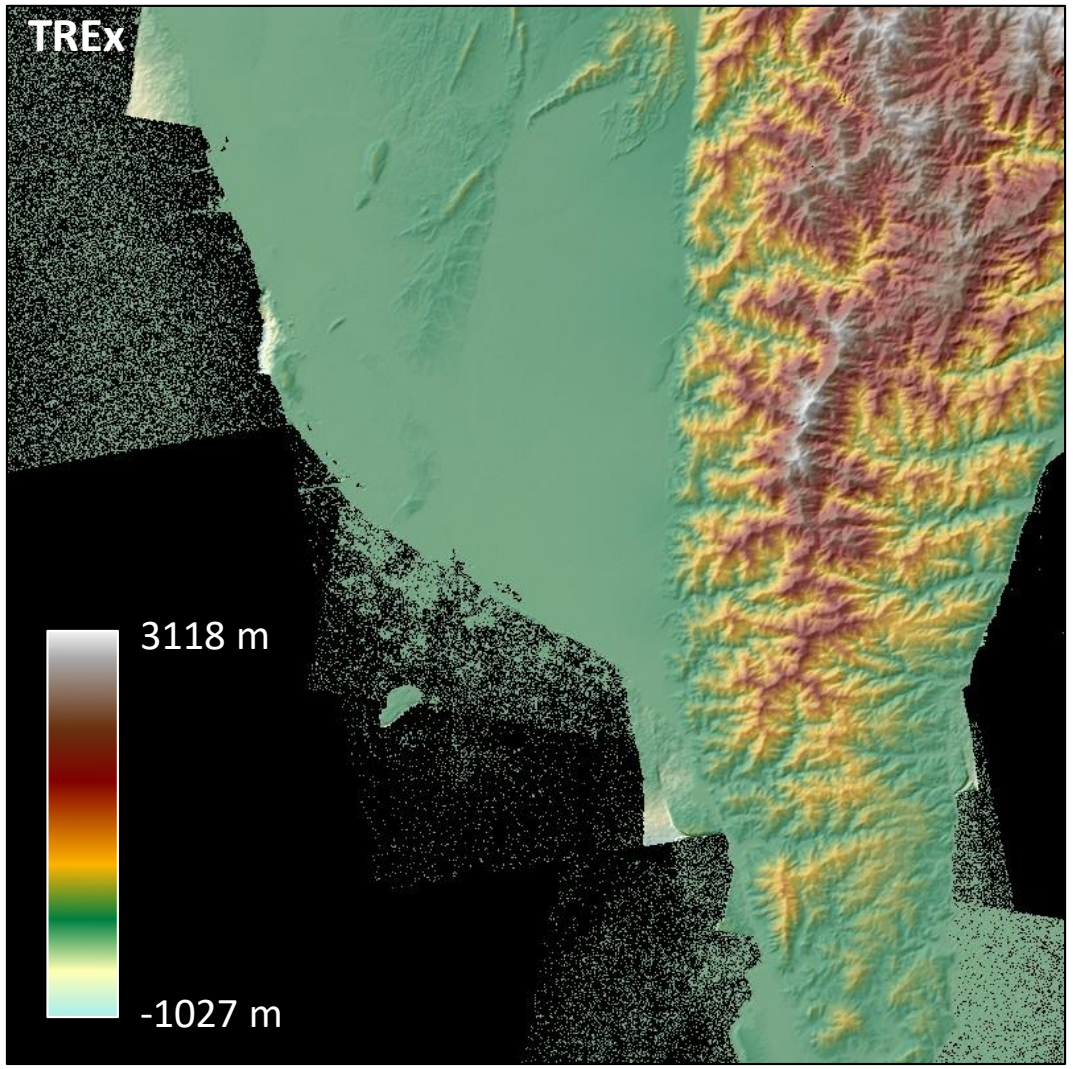


TREx Shaded Relief

TDR Preview Images – South Taiwan (TDR_N22E120)

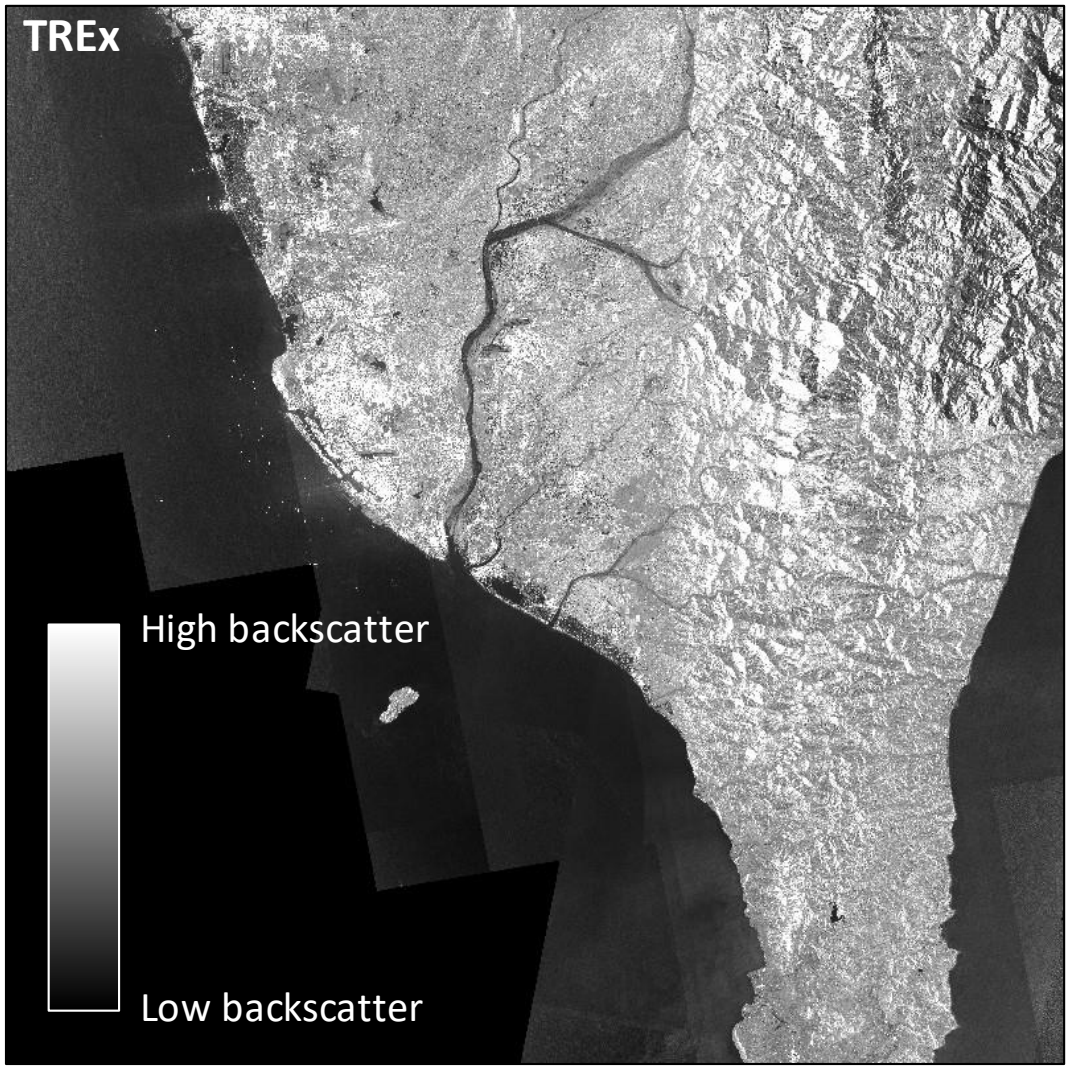


Hillshade

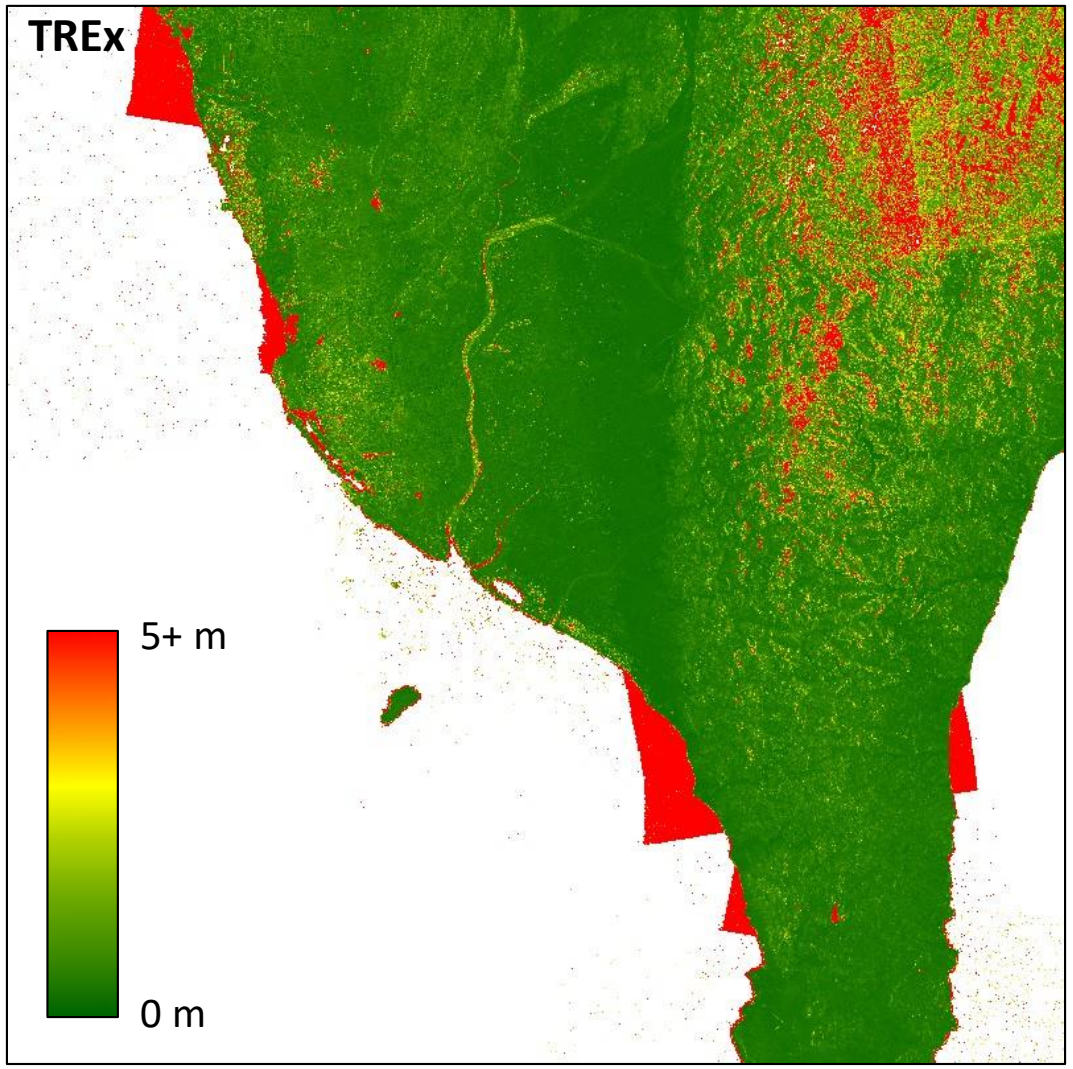


Shaded Relief

Shaded Relief Not the Whole Story… TDR Source/Error Metrics

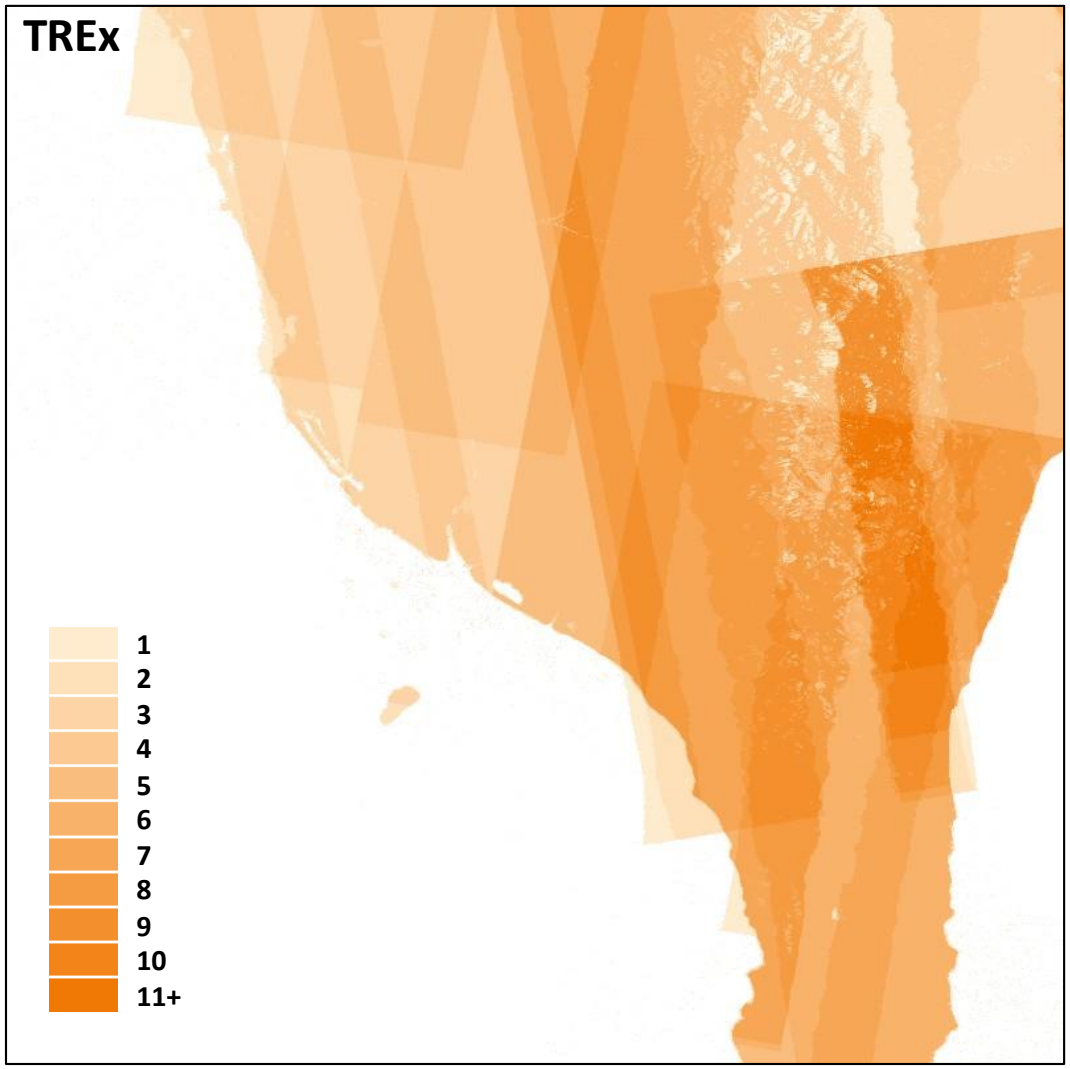


SAR Amplitude Mosaic (AMP)

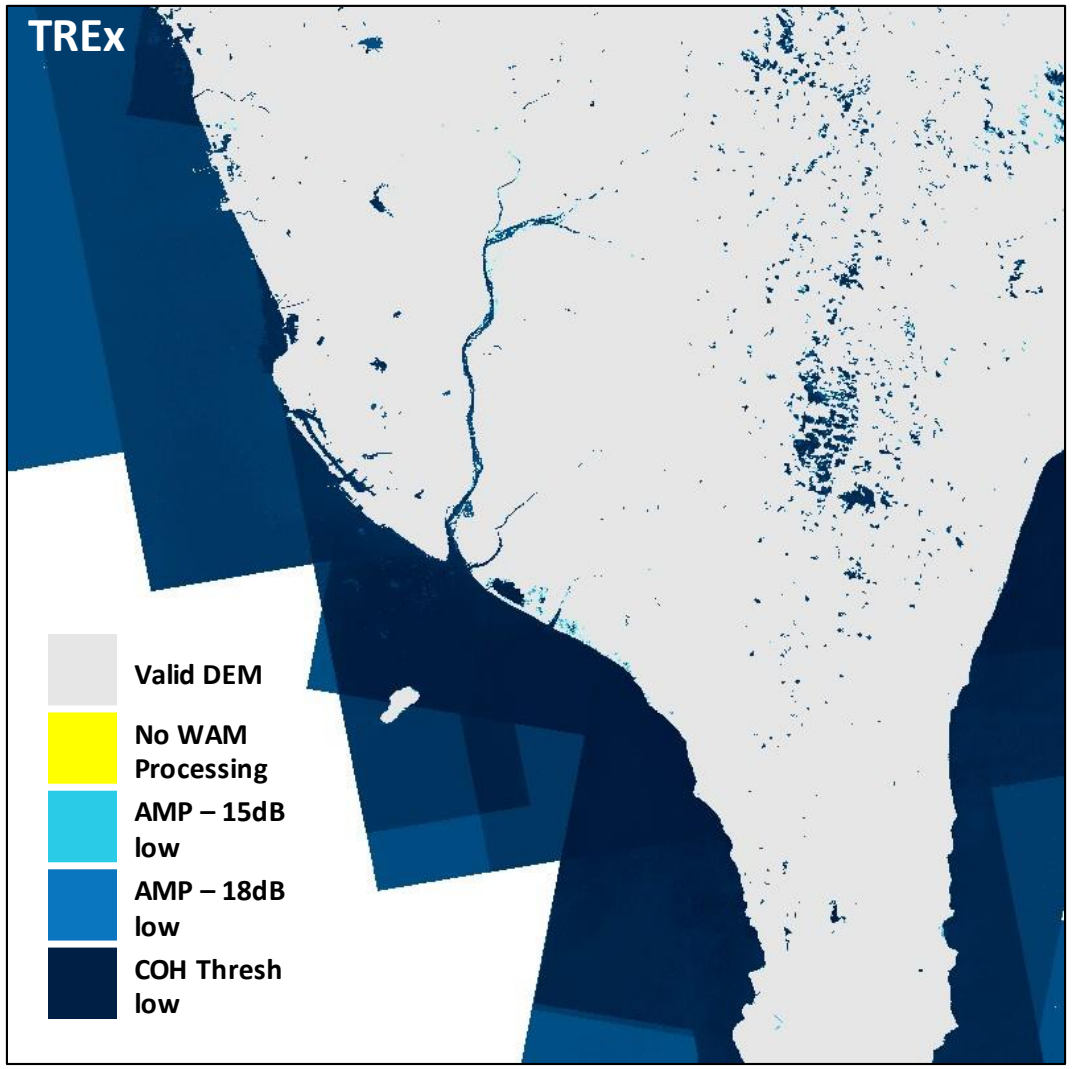


Height Error Map (HEM)

Shaded Relief Not the Whole Story… TDR Source/Error Metrics

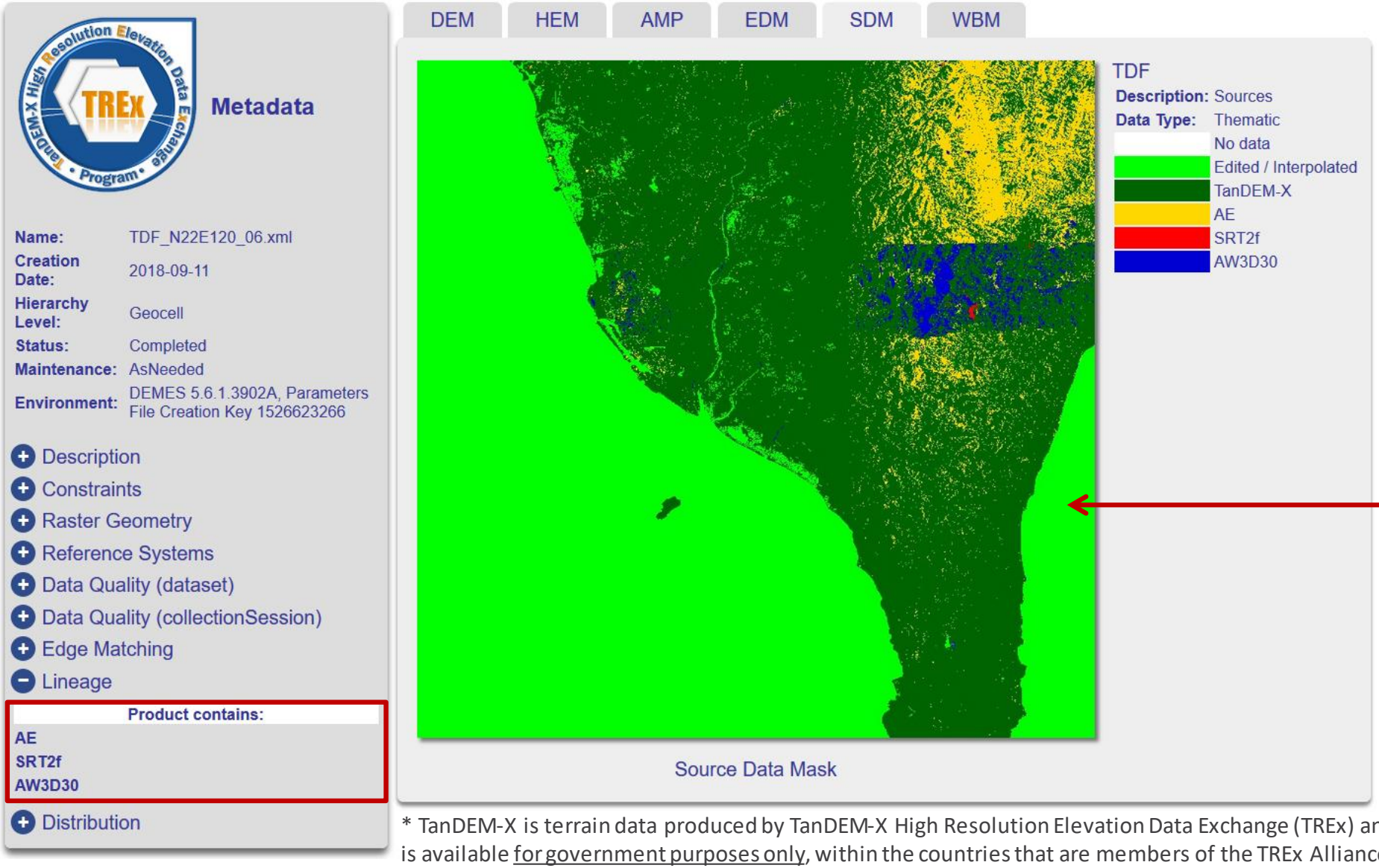


Coverage Map (COV)



Water Indication Mask (WAM)

Multiple Preview Images : TanDEM-X* Finished (TDF) Template



DEM: shaded relief

HEM: height error map

AMP: SAR amplitude

EDM: edit model

SDM: source data mask

WBM: water body mask

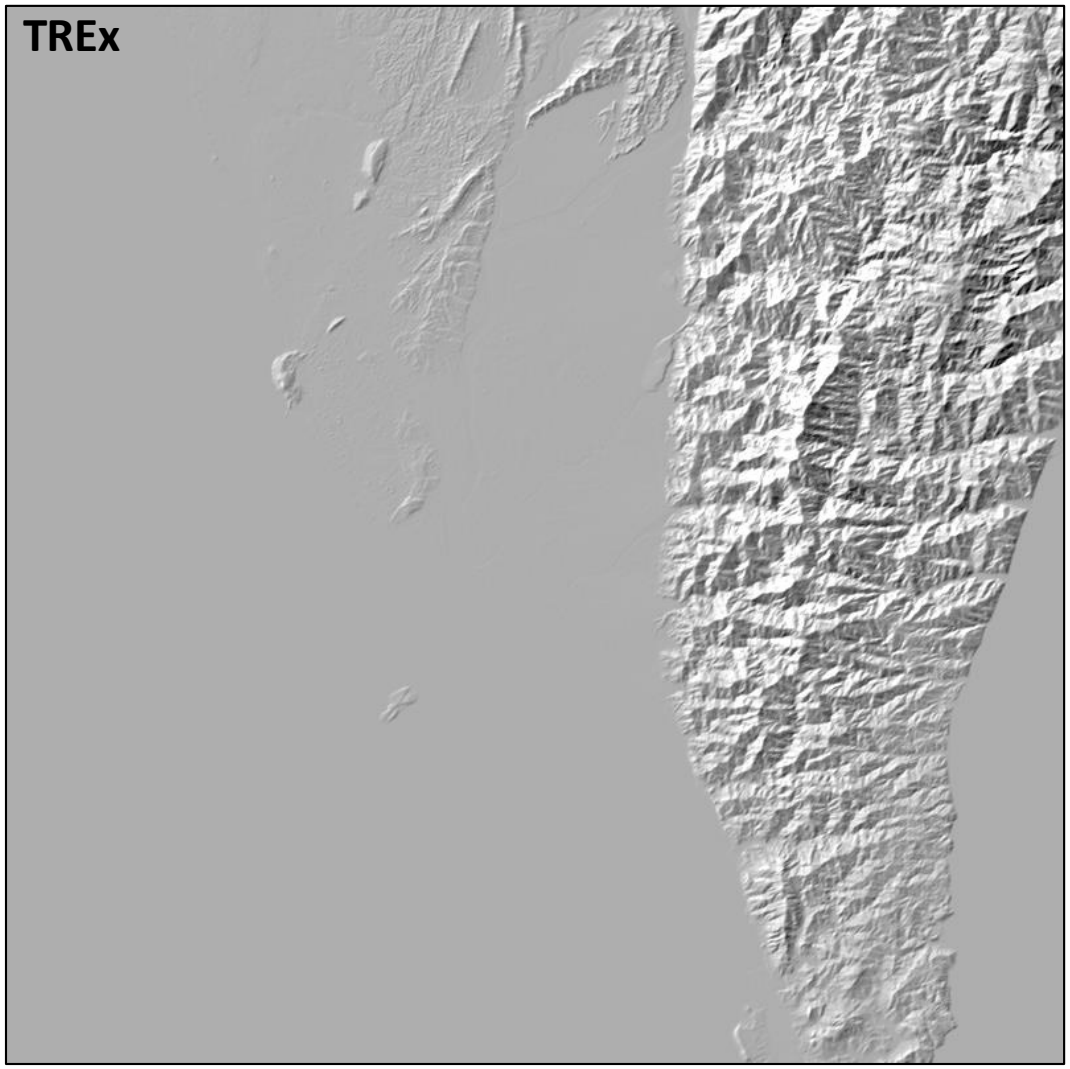
* TanDEM-X is terrain data produced by TanDEM-X High Resolution Elevation Data Exchange (TREx) and is available for government purposes only, within the countries that are members of the TREx Alliance.

Example XML Metadata Entry

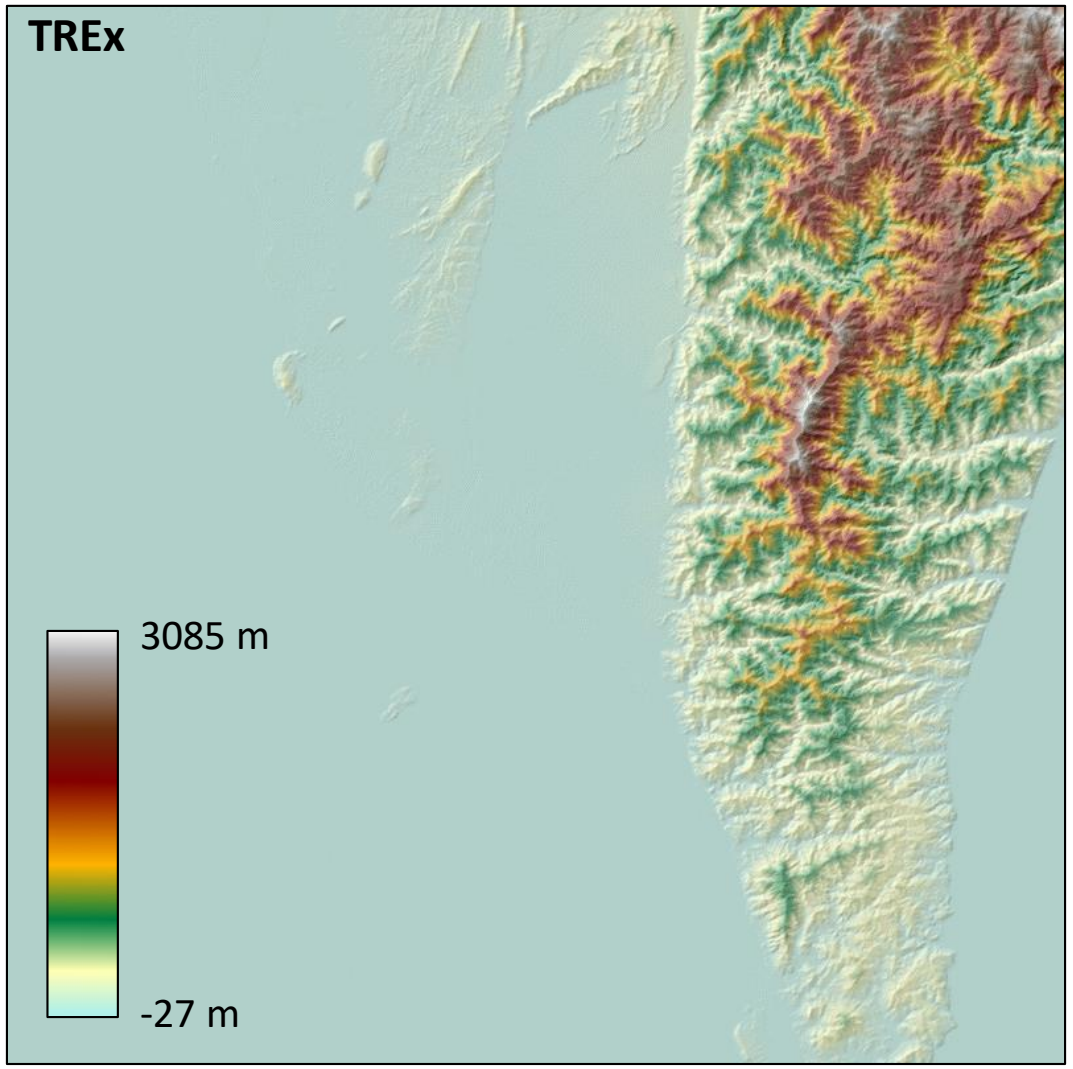
- A preview image is referenced in the XML metadata file with this template:

```
<mri:graphicOverview>
    <mcc:MD_BrowseGraphic>
        <mcc:fileName>
           <gco:CharacterString>U_59N650000e5850000n_30km_2012_ArcticPS_NGA_DSM_3m_01.png</gco:CharacterString>
        </mcc:fileName>
        <mcc:fileDescription>
            <gco:CharacterString>DSM Shaded Relief</gco:CharacterString>
        </mcc:fileDescription>
        <mcc:fileType>
            <gco:CharacterString>PNG</gco:CharacterString>
        </mcc:fileType>
        <mcc:linkage>
            <cit:CI_OnlineResource>
                <cit:linkage>
                    <gco:CharacterString>./PREVIEW/U_59N650000e5850000n_30km_2012_ArcticPS_NGA_DSM_3m_01.png</gco:CharacterString>
                </cit:linkage>
            </cit:CI_OnlineResource>
        </mcc:linkage>
    </mcc:MD_BrowseGraphic>
</mri:graphicOverview>
```

TanDEM-X Finished (TDF) – TREx Default Templates

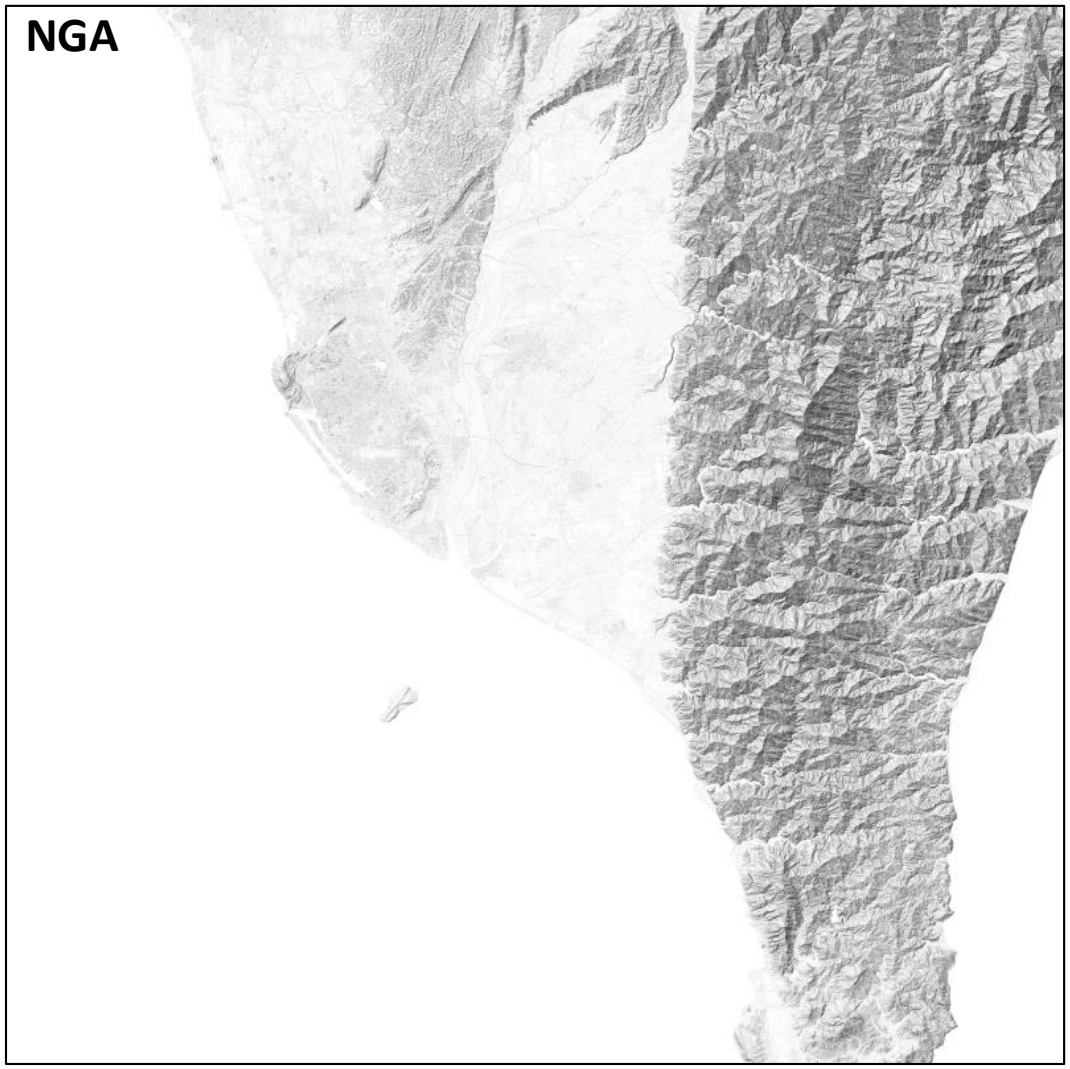


Hillshade

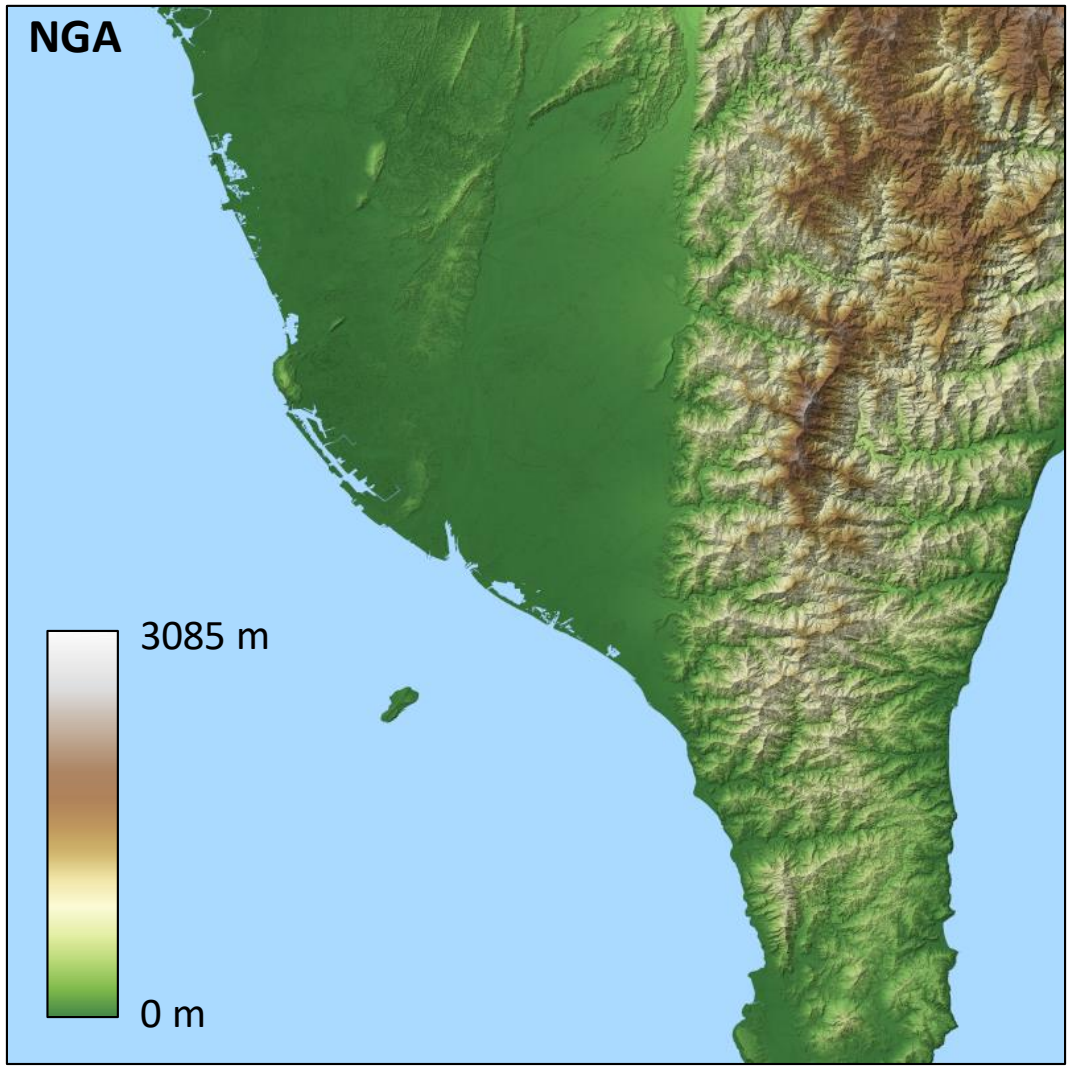


Shaded Relief

TanDEM-X Finished (TDF) – NGA Updates Hillshade, Terrain and Ocean



Hillshade



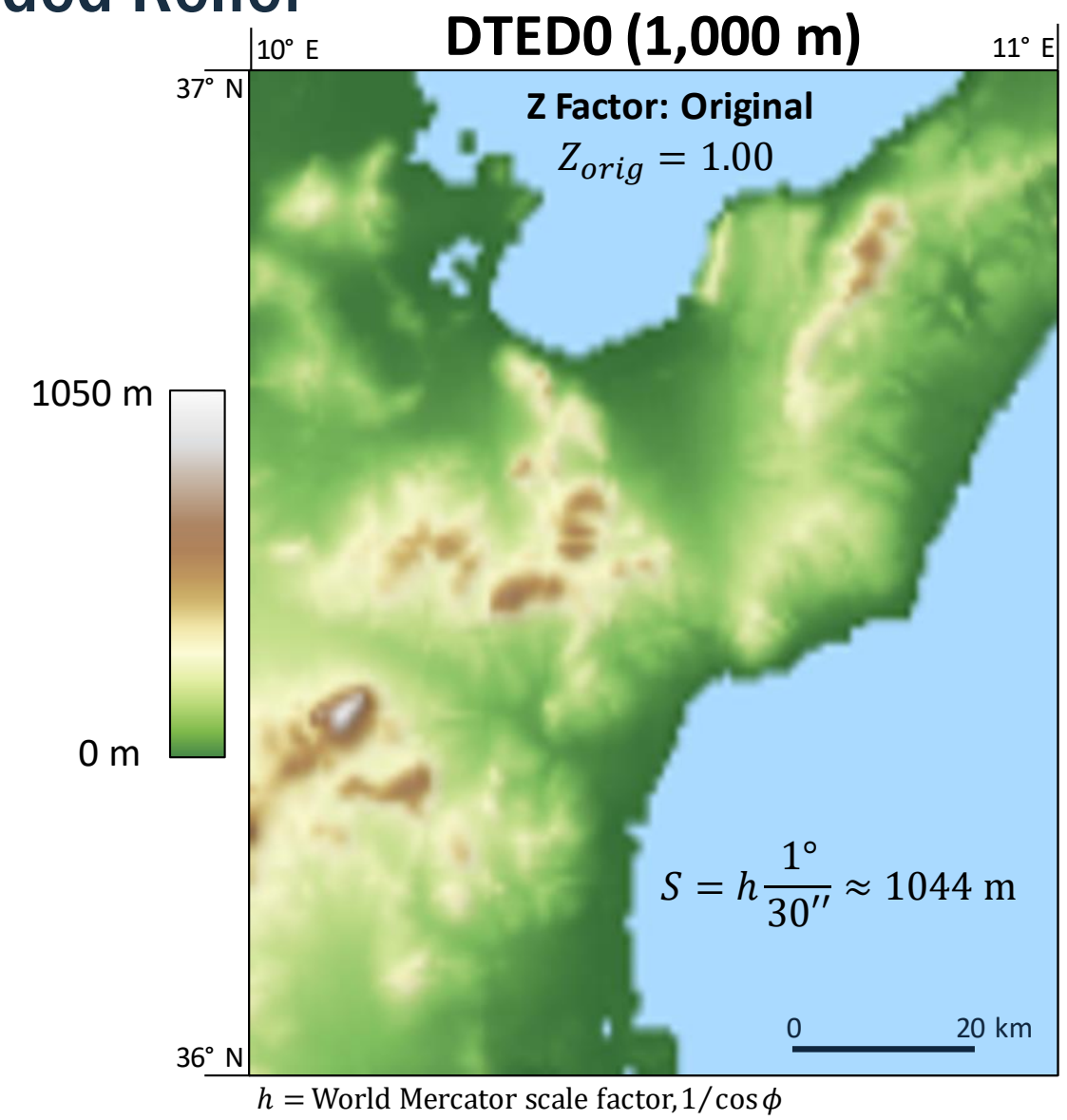
Shaded Relief

Adjusted Z Factor for Hillshade and Shaded Relief

- Shaded result is scaled dynamically by adjusting the Z Factor.
- Slope is a factor of pixel size, representing the *average* slope.
- Over larger distances, the average slope decreases.
- Hillshade needs to account for the sampling distance (scale).

$$Z_{adj} = Z_{orig} + F \times S^P$$

Z_{adj}	**Adjusted Z Factor**
Z_{orig}	**Original Z Factor**: scaling factor used to convert elevation unit (Z) to horizontal coordinate units; default = 1.0 when X, Y, Z are in meters
S	**Pixel Size**: maximum of cell size or pixel size; in meters
F	**Pixel Size Factor**: controls the rate at which the Z Factor changes; default = 0.024
P	**Pixel Size Power**: exponent applied to Pixel Size; default = 0.664

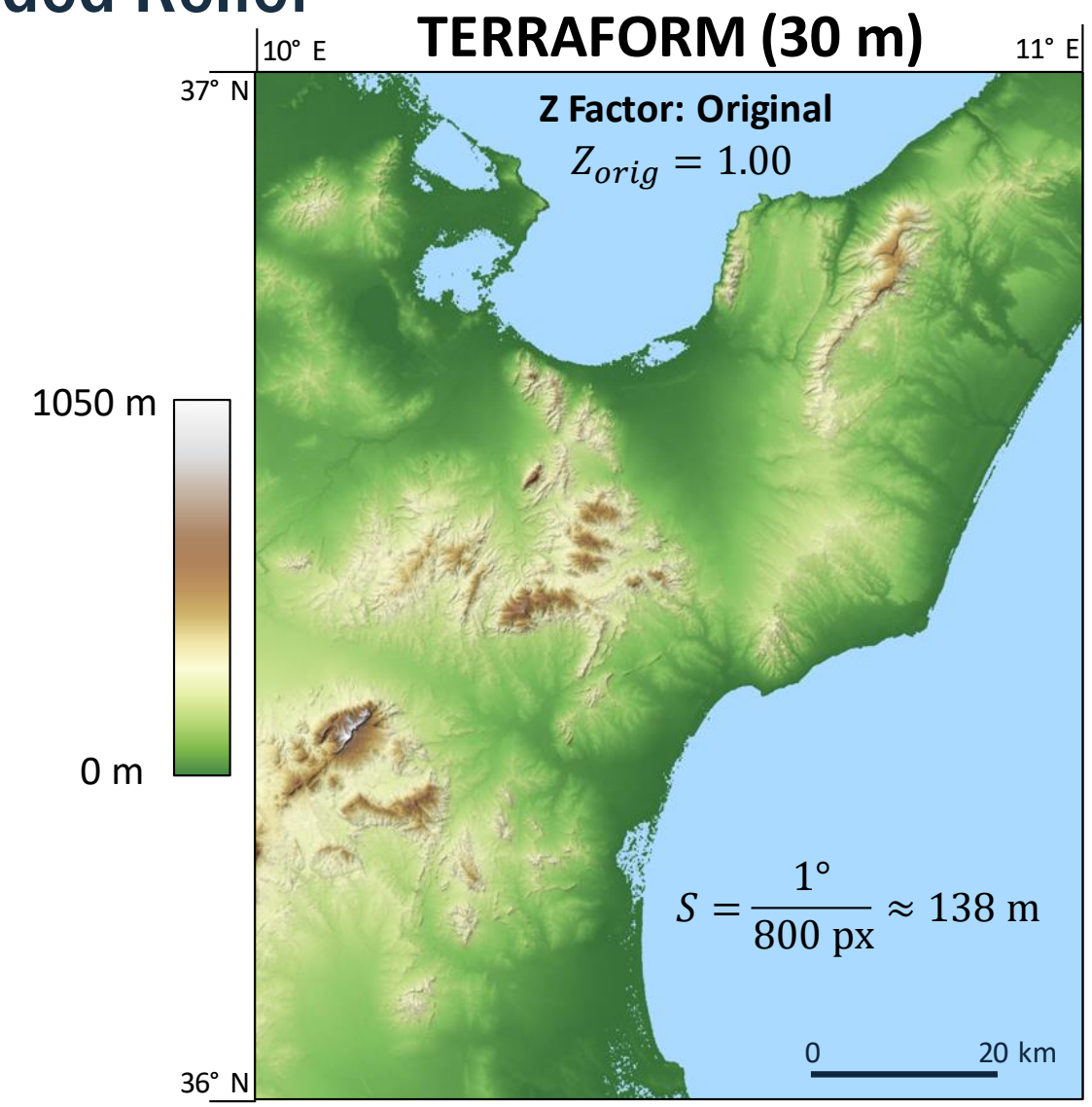


Adjusted Z Factor for Hillshade and Shaded Relief

- Shaded result is scaled dynamically by adjusting the Z Factor.
- Slope is a factor of pixel size, representing the *average* slope.
- Over larger distances, the average slope decreases.
- Hillshade needs to account for the sampling distance (scale).

$$Z_{adj} = Z_{orig} + F \times S^P$$

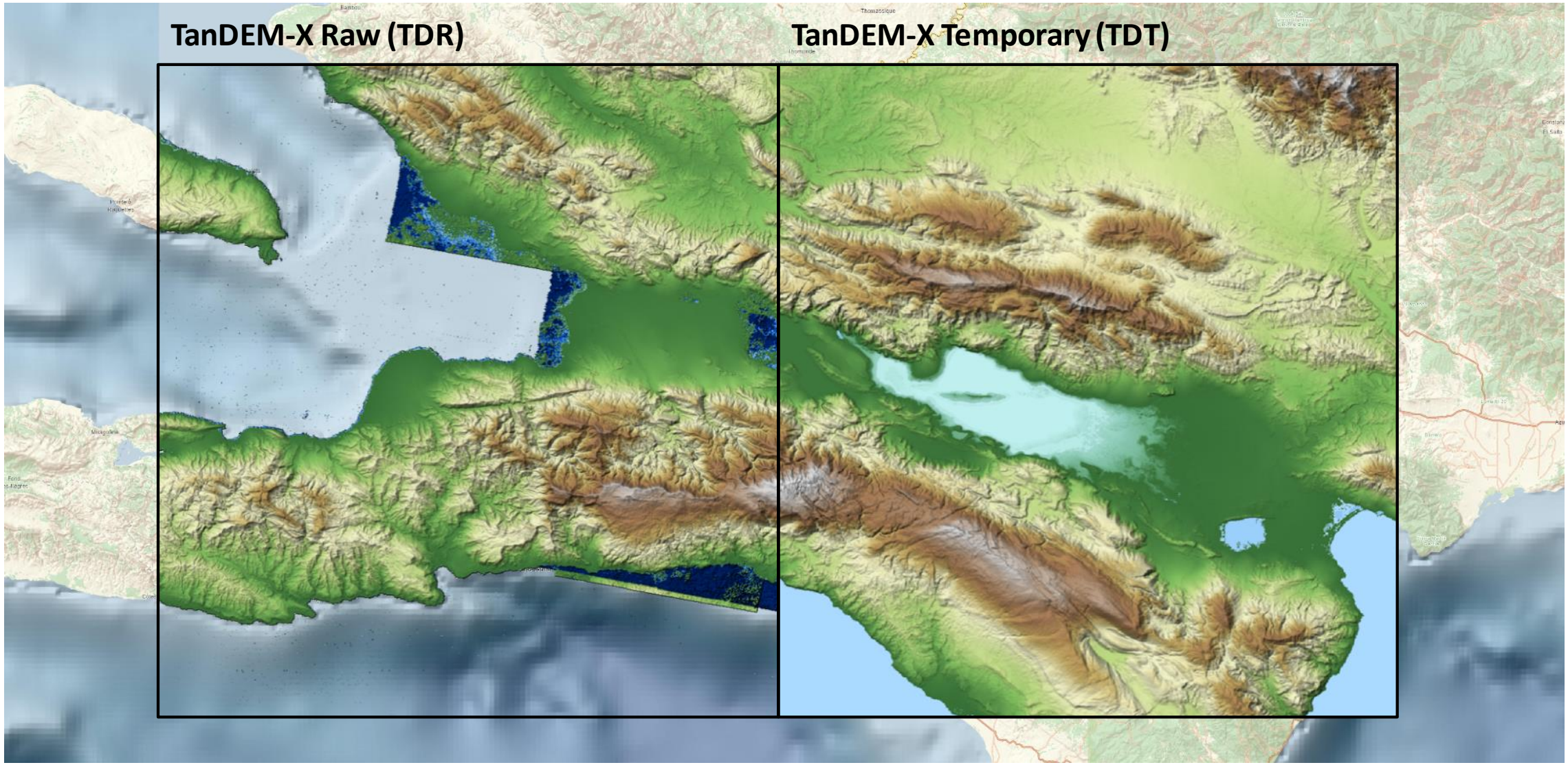
Z_{adj}	**Adjusted Z Factor**
Z_{orig}	**Original Z Factor**: scaling factor used to convert elevation unit (Z) to horizontal coordinate units; default = 1.0 when X, Y, Z are in meters
S	**Pixel Size**: maximum of cell size or pixel size; in meters
F	**Pixel Size Factor**: controls the rate at which the Z Factor changes; default = 0.024
P	**Pixel Size Power**: exponent applied to Pixel Size; default = 0.664



GRiD Derived Raster Products – Potential Image Sources

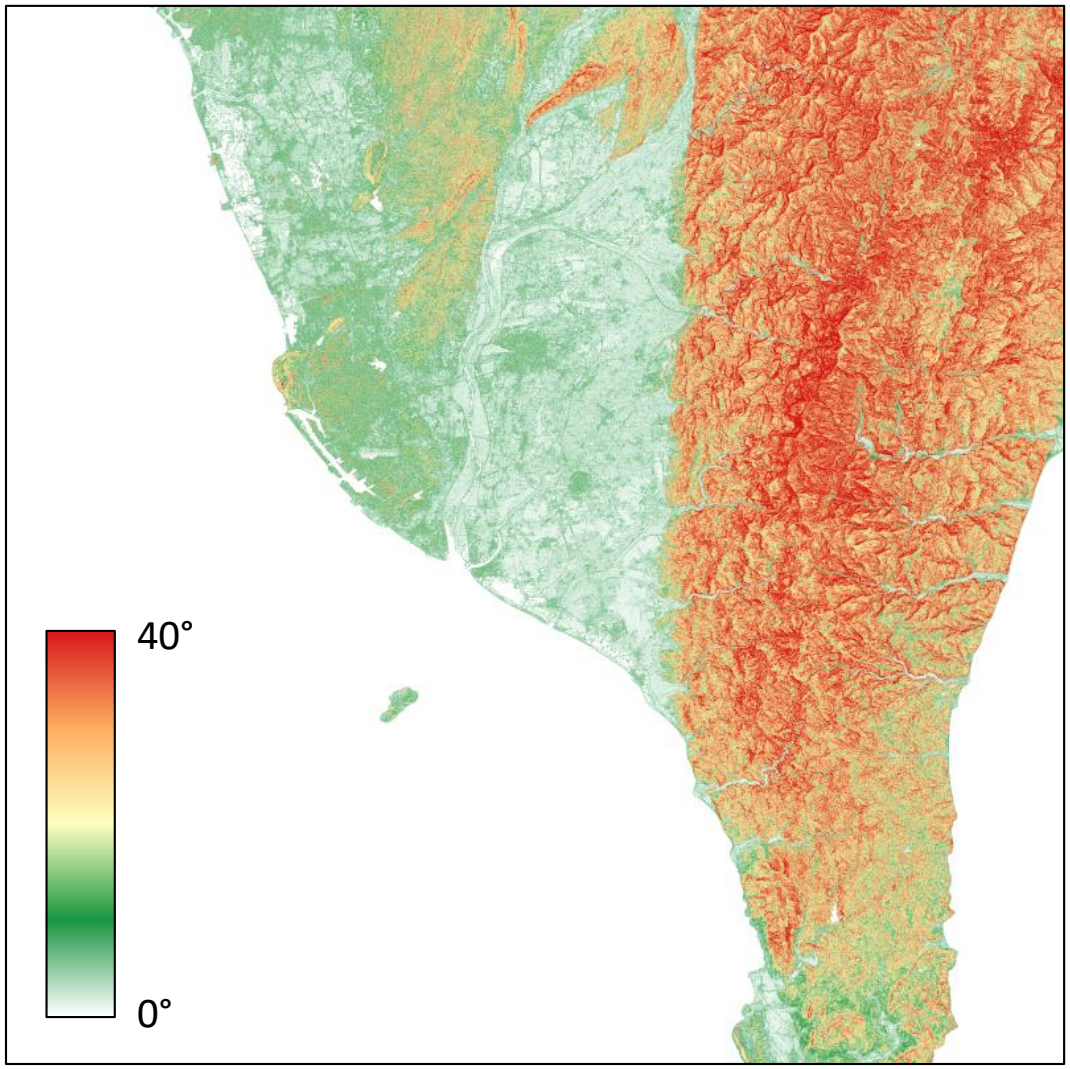
- SFNE collaborated with Precise Imagery and Elevation Services (PIES) to create “derived raster products” for DEM analysis in GRiD.
- The full-resolution products can also be downsampled as preview images.
- Shaded relief images are viewable as in-place GRiD Map overlays.
- Other image types may be viewed in a metadata summary in a browser window, such as the TREx examples on the previous slides.
- Initially, five preview image types are available:
  - Hillshade
  - Shaded relief
  - Slope
  - Shaded slope
  - Aspect

Which Product Should I Download from GRiD?

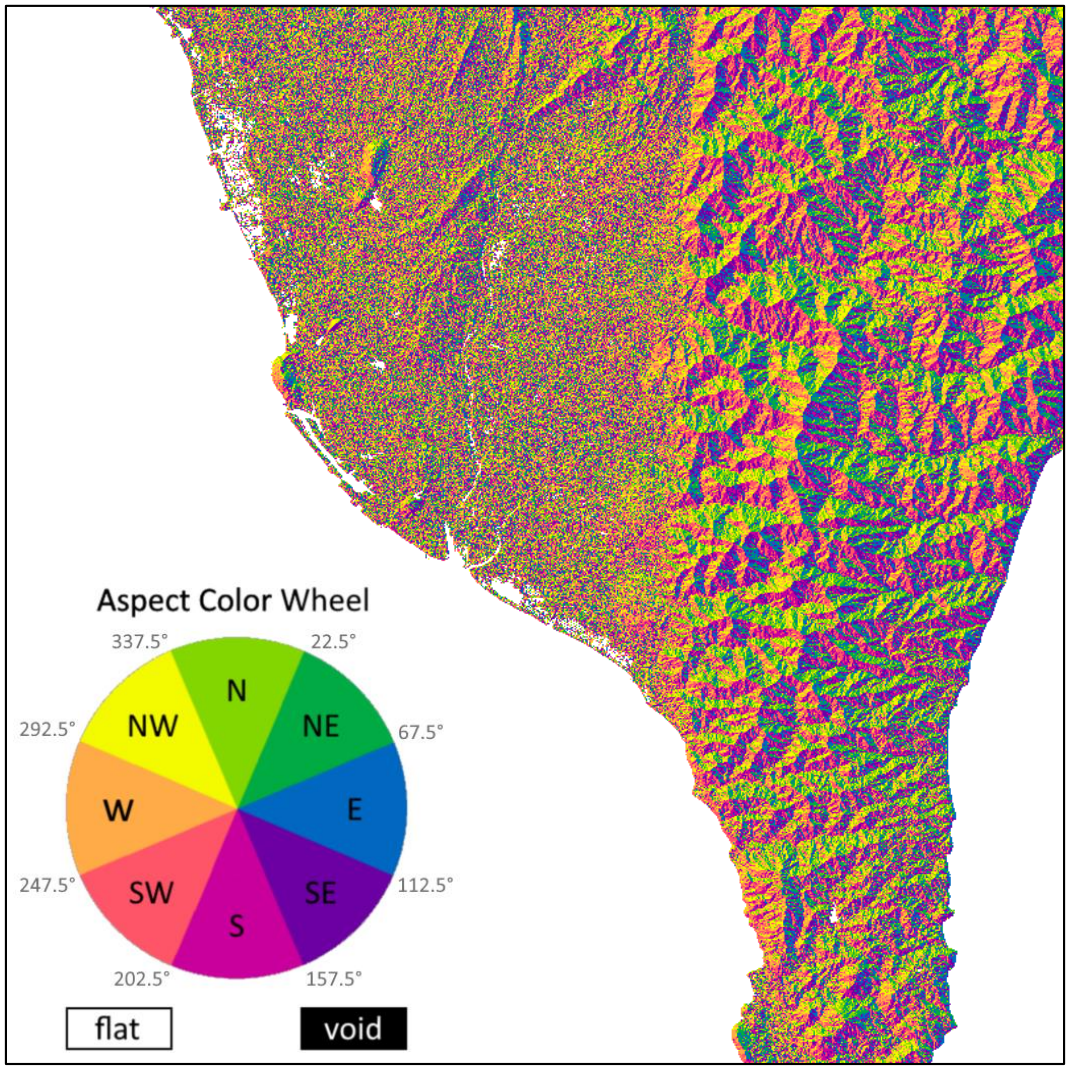


GRiD Map

GRiD Export Product Options

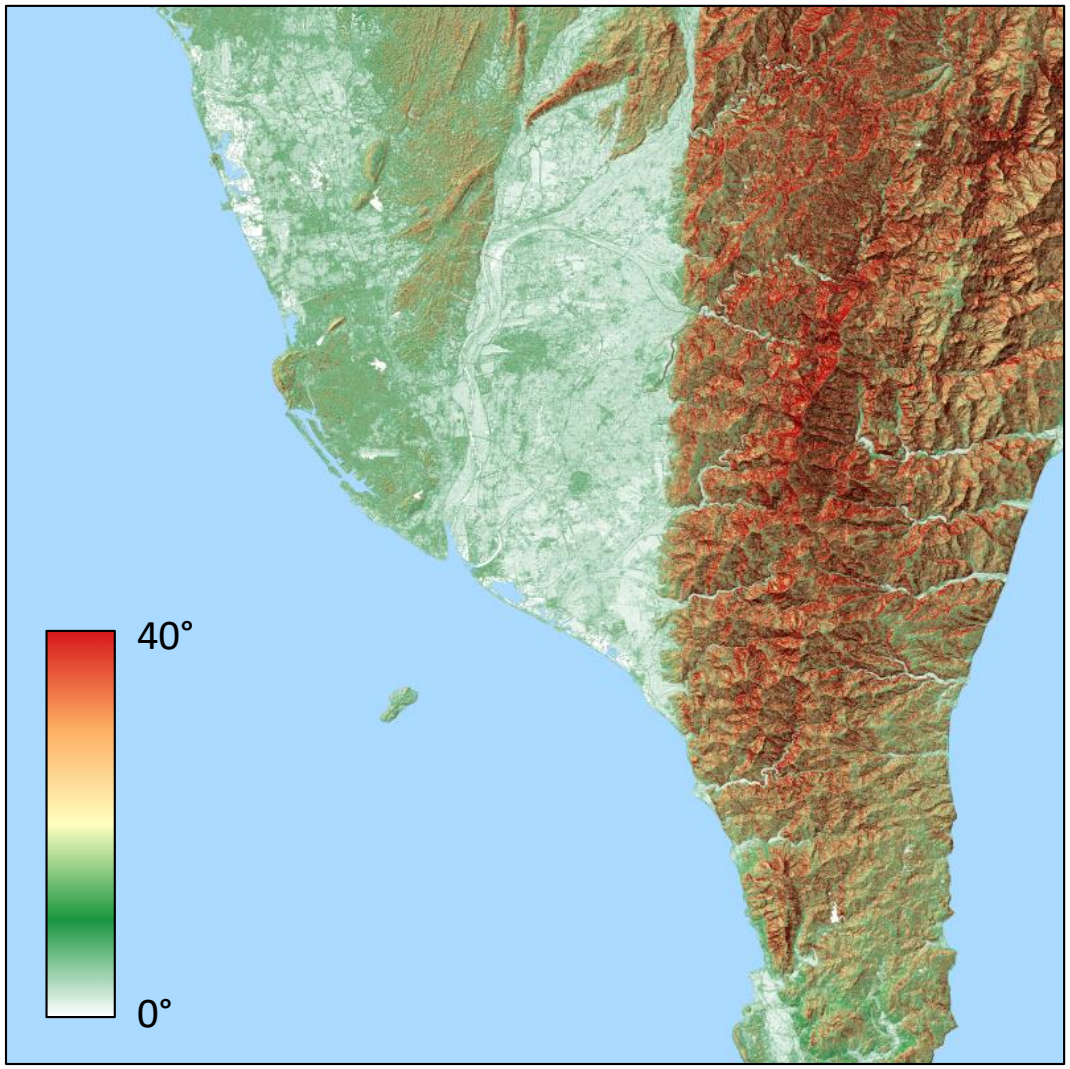


Slope

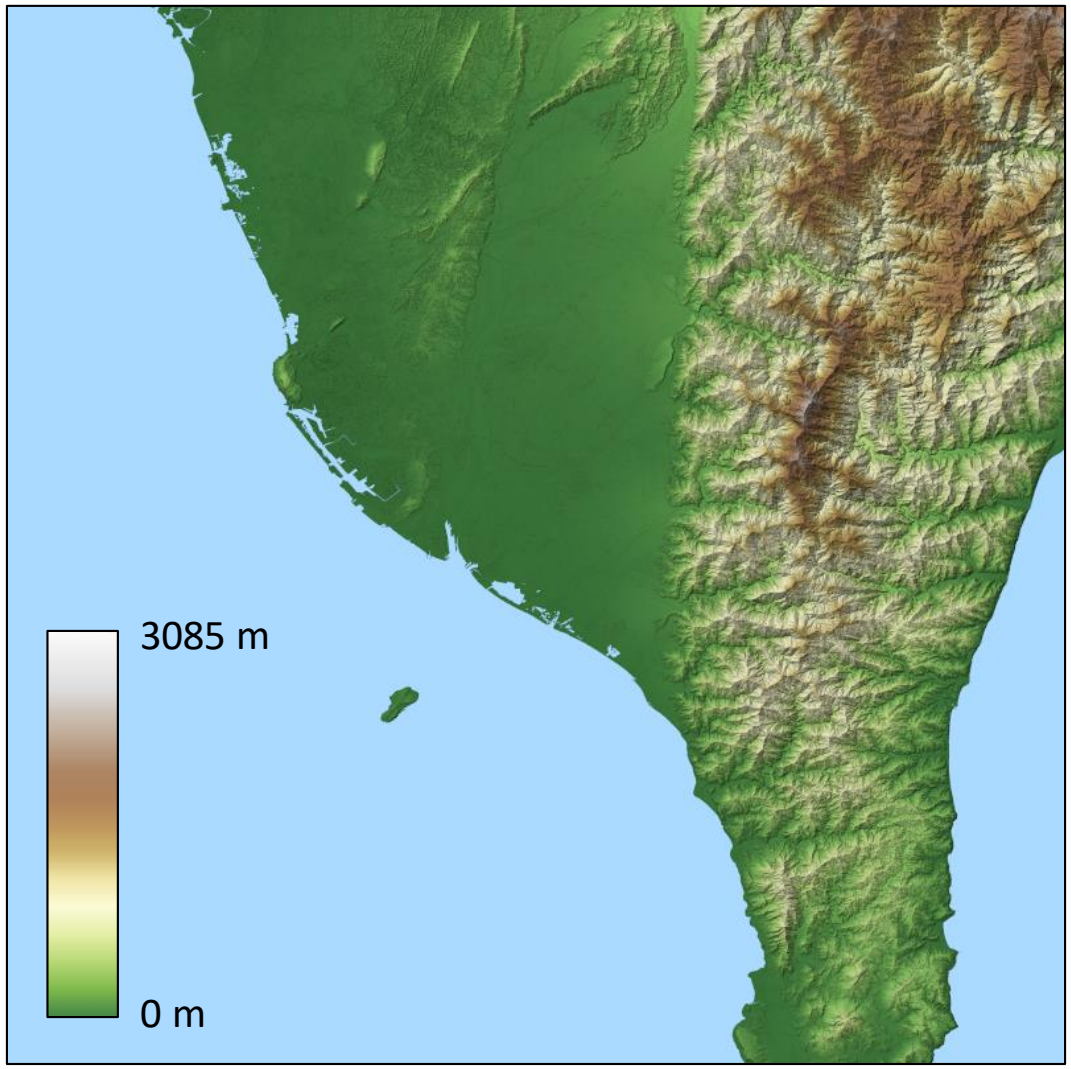


Aspect

GRiD Export Product Options



Shaded Slope



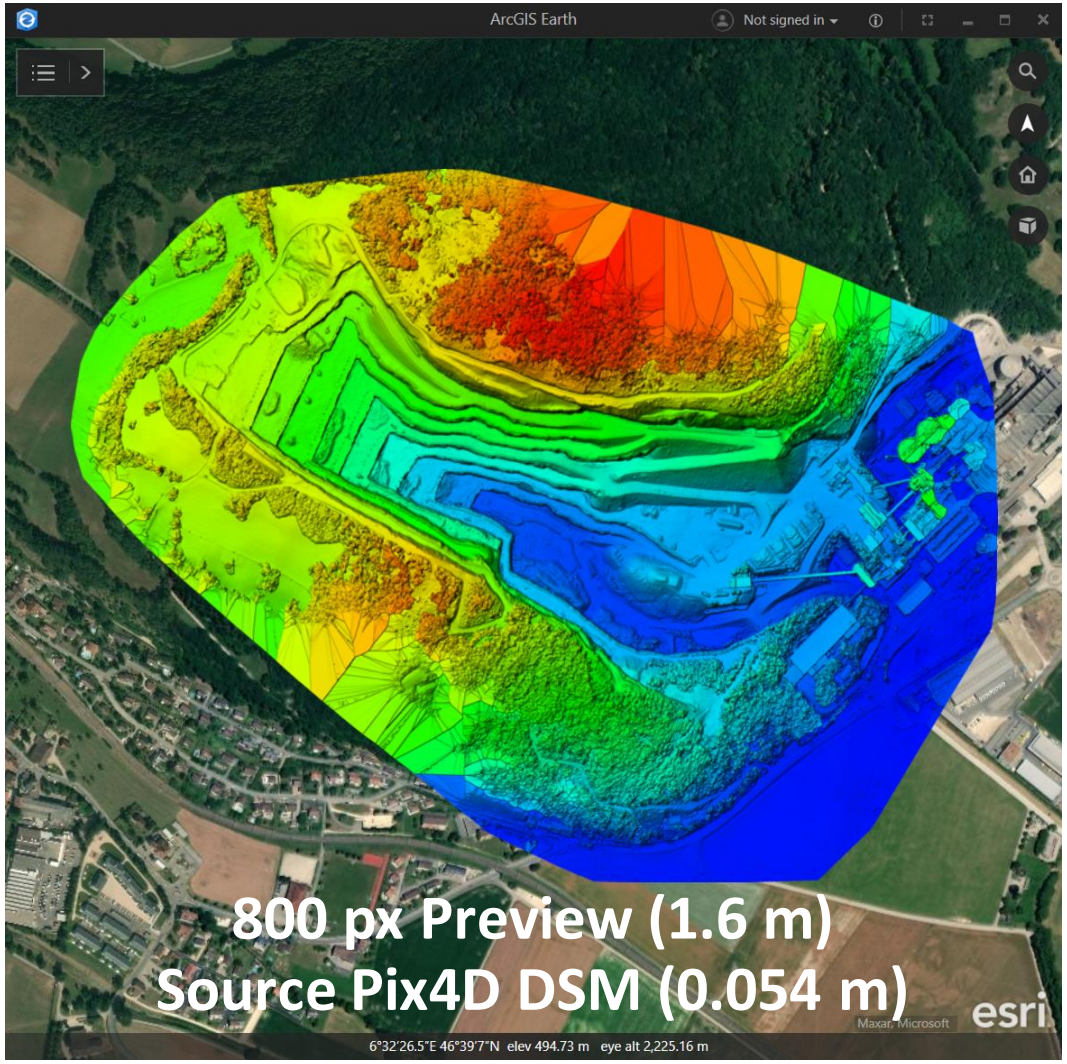
Shaded Relief

Why Use Transparency?

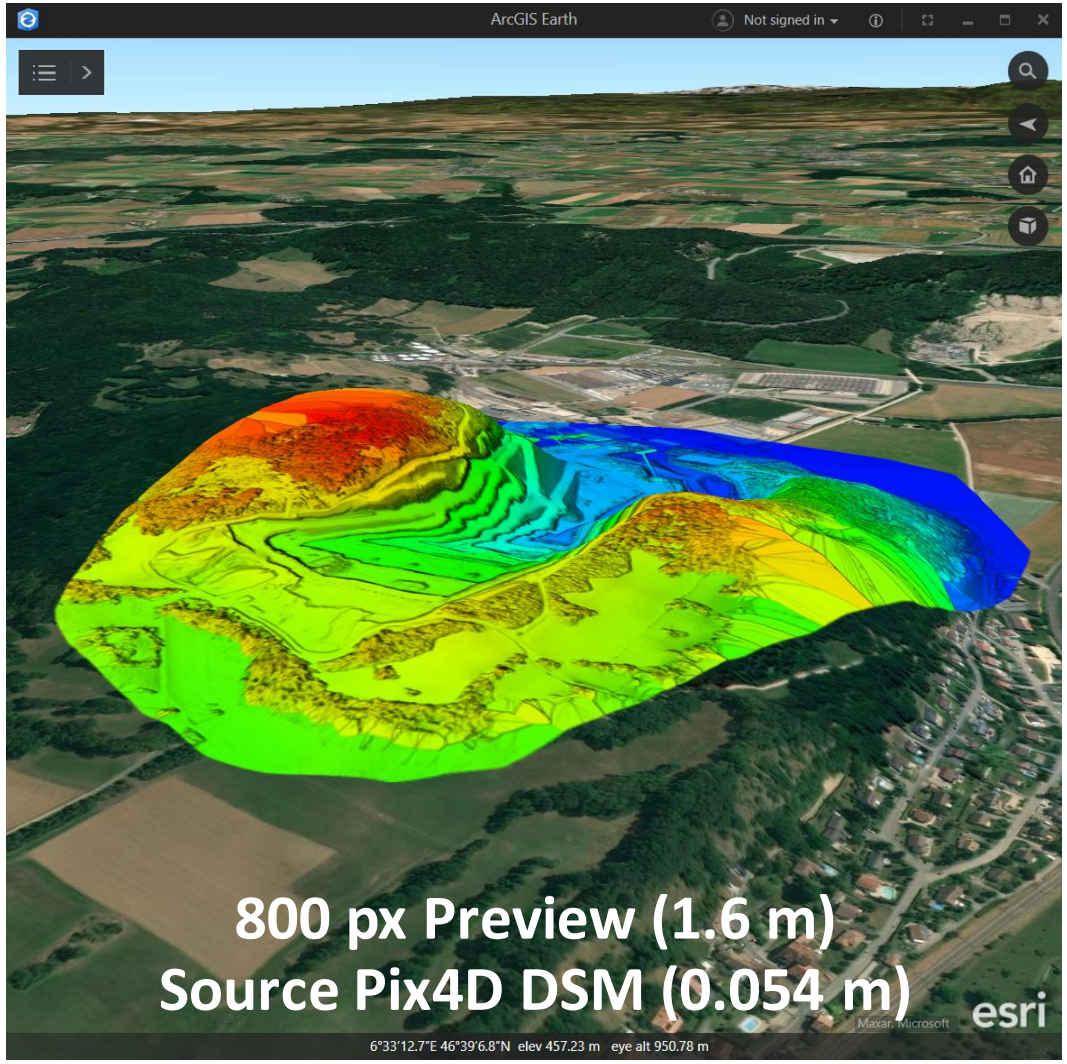
- Important for datasets with irregular borders
- Allows comparison of search results in the GRiD Map because opaque void values could mask other potential fill sources
- Supports alternate background colors when viewing in HTML or PDF, to highlight voids
- Images must be saved in PNG format, as JPEG format does not support transparency

TDR Shaded Relief

Georeferenced Preview Images in 2D and 3D for Rapid Analysis



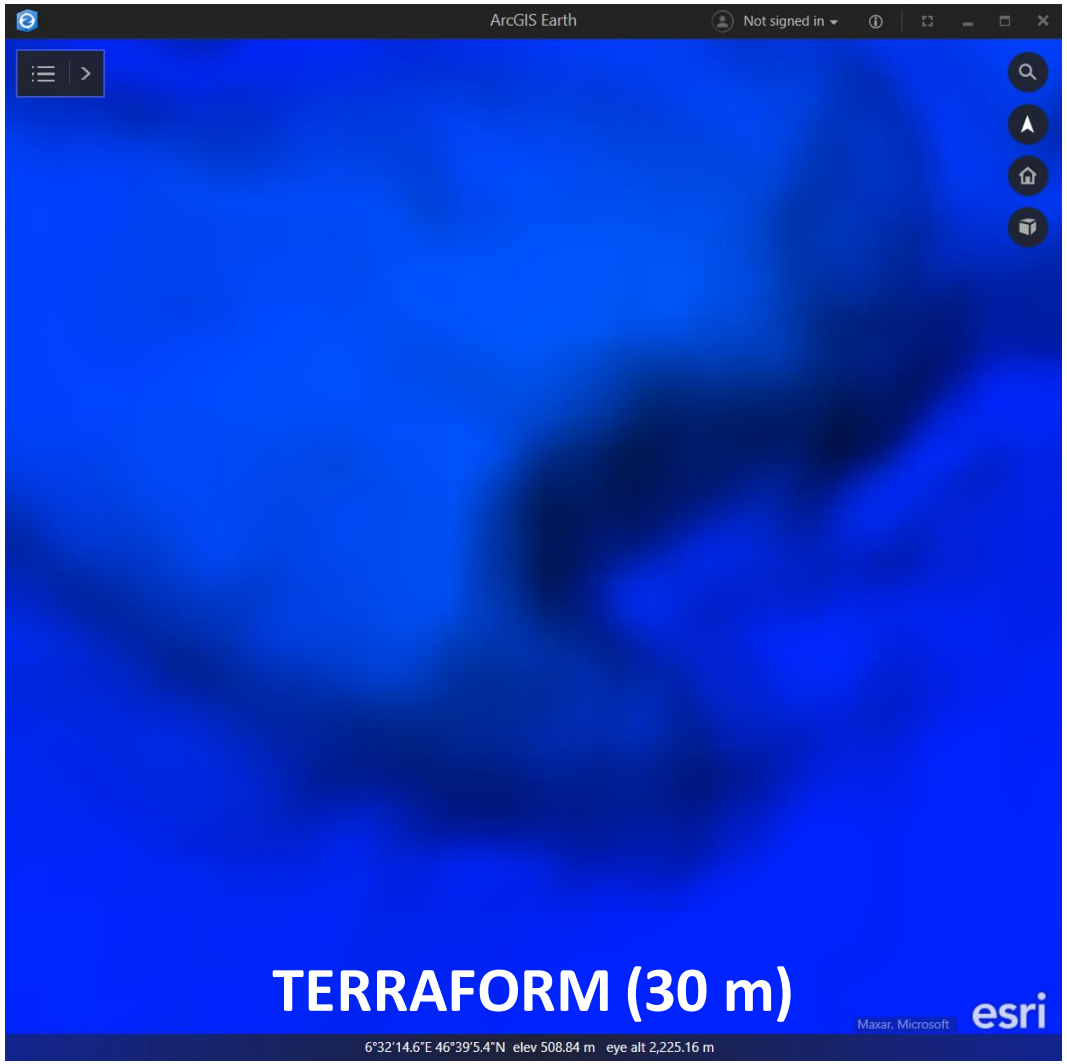
Imagery © Microsoft, Maxar



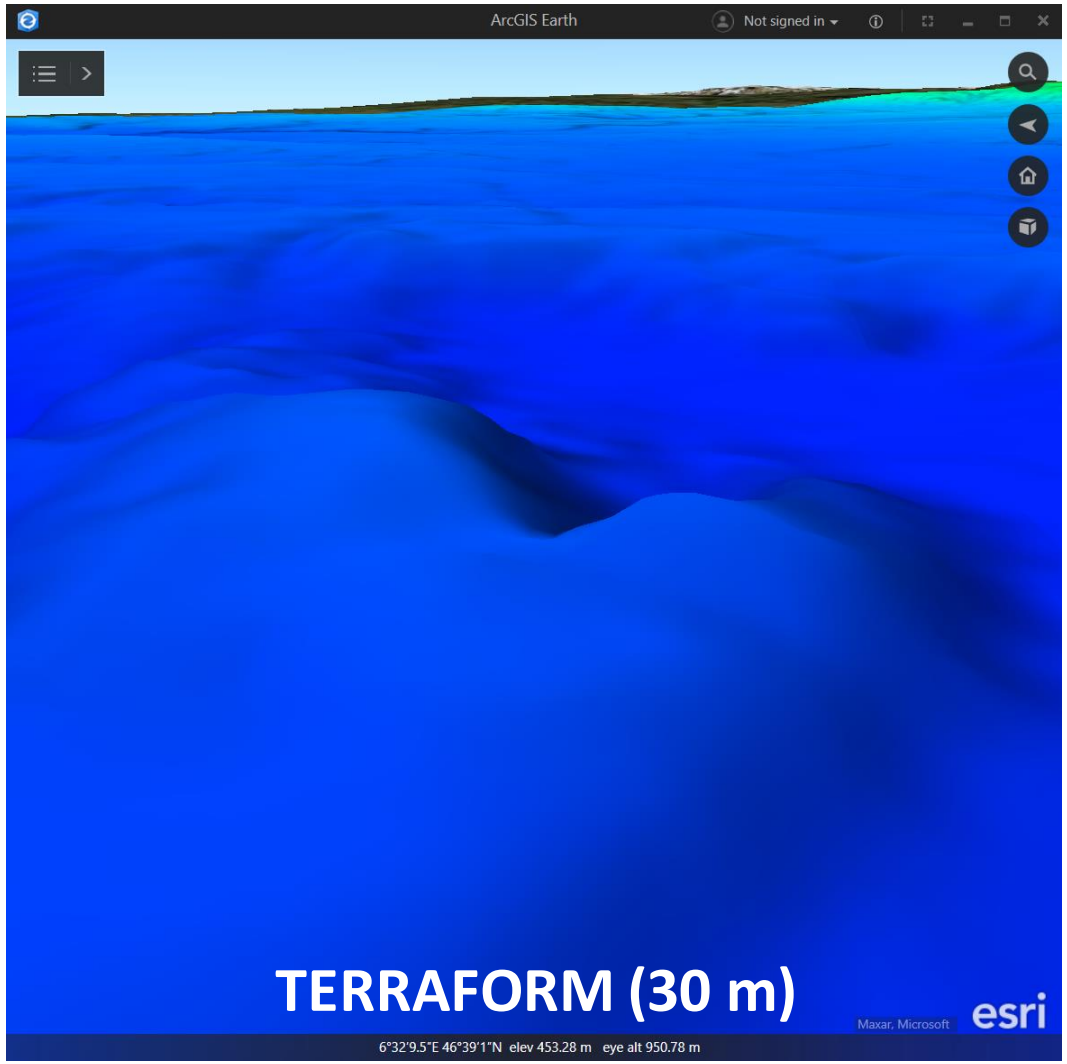
Imagery © Microsoft, Maxar

Source UAS data: Pix4Dmapper example project

Georeferenced Preview Images in 2D and 3D for Rapid Analysis



Imagery © Microsoft, Maxar



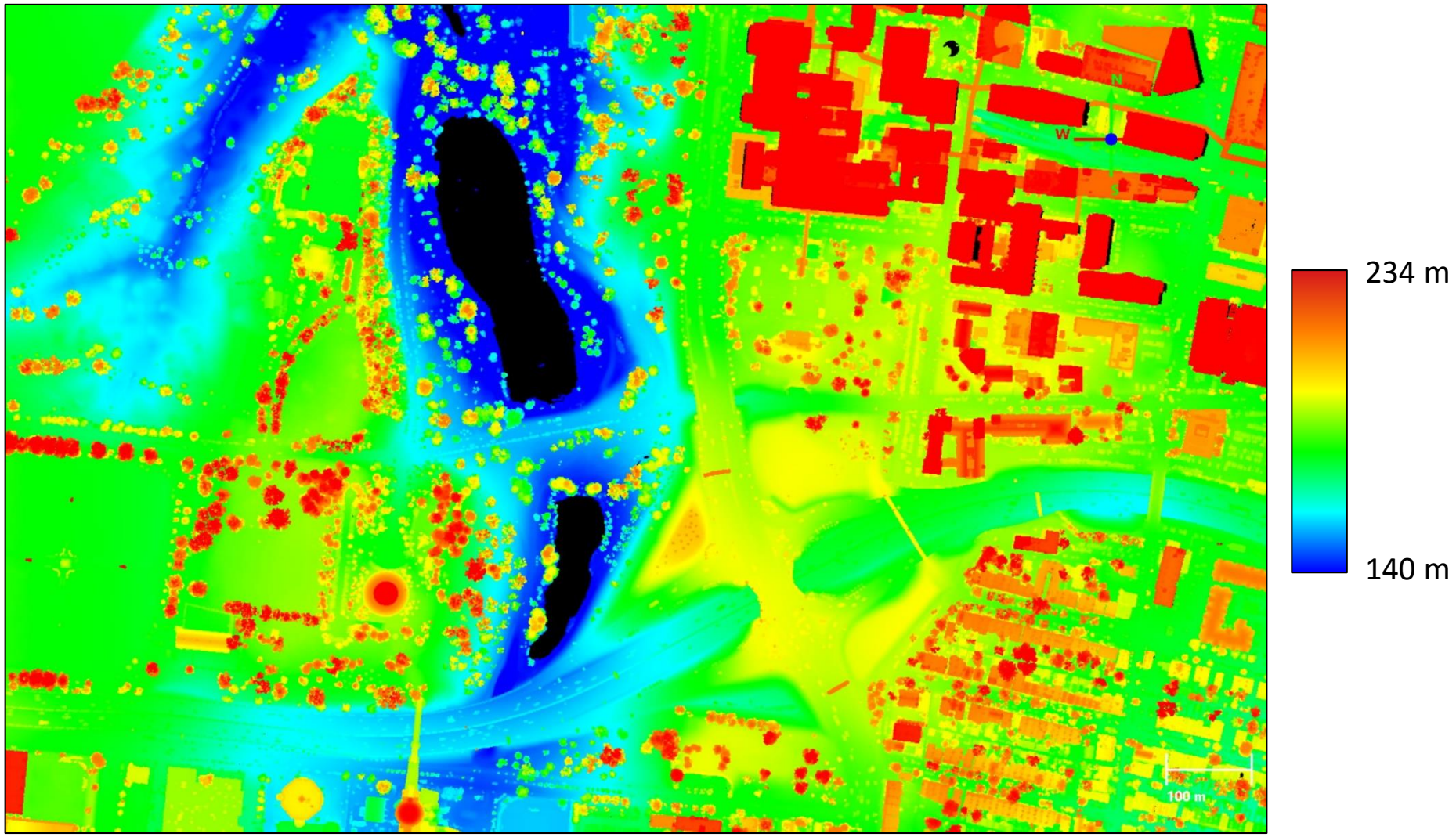
Imagery © Microsoft, Maxar

Point Cloud Preview Images

- Point cloud preview images typically only contain height colors, intensity, or a combination of the two.
- Point clouds with R, G, and B attributes may also create orthophotos.
- Because points are not joined in a mesh, they can't create shadows or slopes, which are helpful for visual interpretation.
- 2D preview images are more intuitive and may better represent the data if points are classified and gridded to DSM/DTM first.
- The following slides show 5 standard (point only) and 5 extended (surface-augmented) preview images for a LiDAR point cloud in St. Louis.

NGA

Standard PC: Point Height Colors



Source Data: USGS LiDAR Survey of St. Louis, MO; February 2017

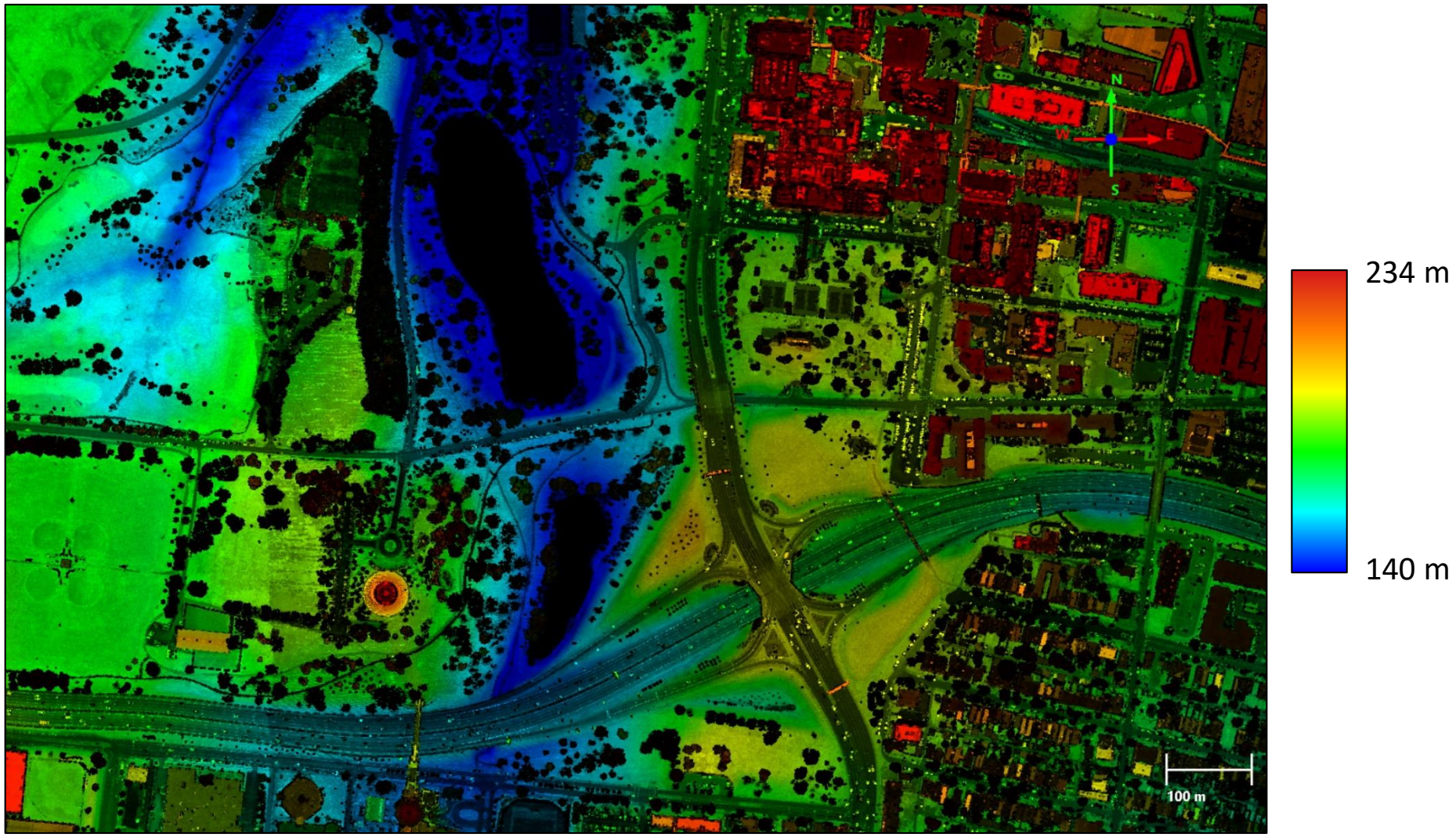
Standard PC: Point RGB Attributes (Orthophoto)

Source Data: USGS LiDAR Survey of St. Louis, MO; February 2017

Standard PC: Point Intensity

Source Data: USGS LiDAR Survey of St. Louis, MO; February 2017

Standard PC: Height Color & Intensity



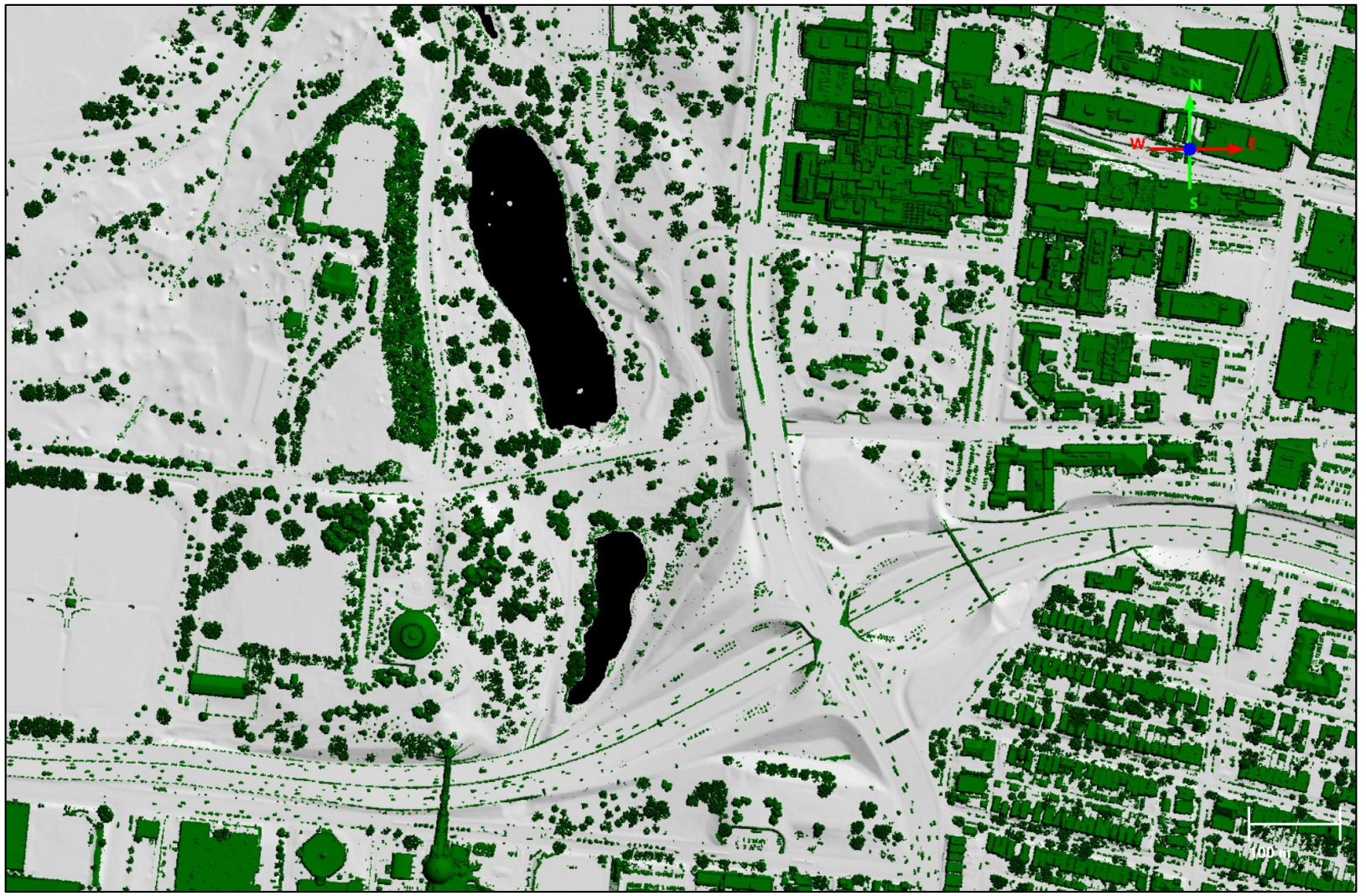
Source Data: USGS LiDAR Survey of St. Louis, MO; February 2017

Standard PC: Classification

ground
non-ground
void

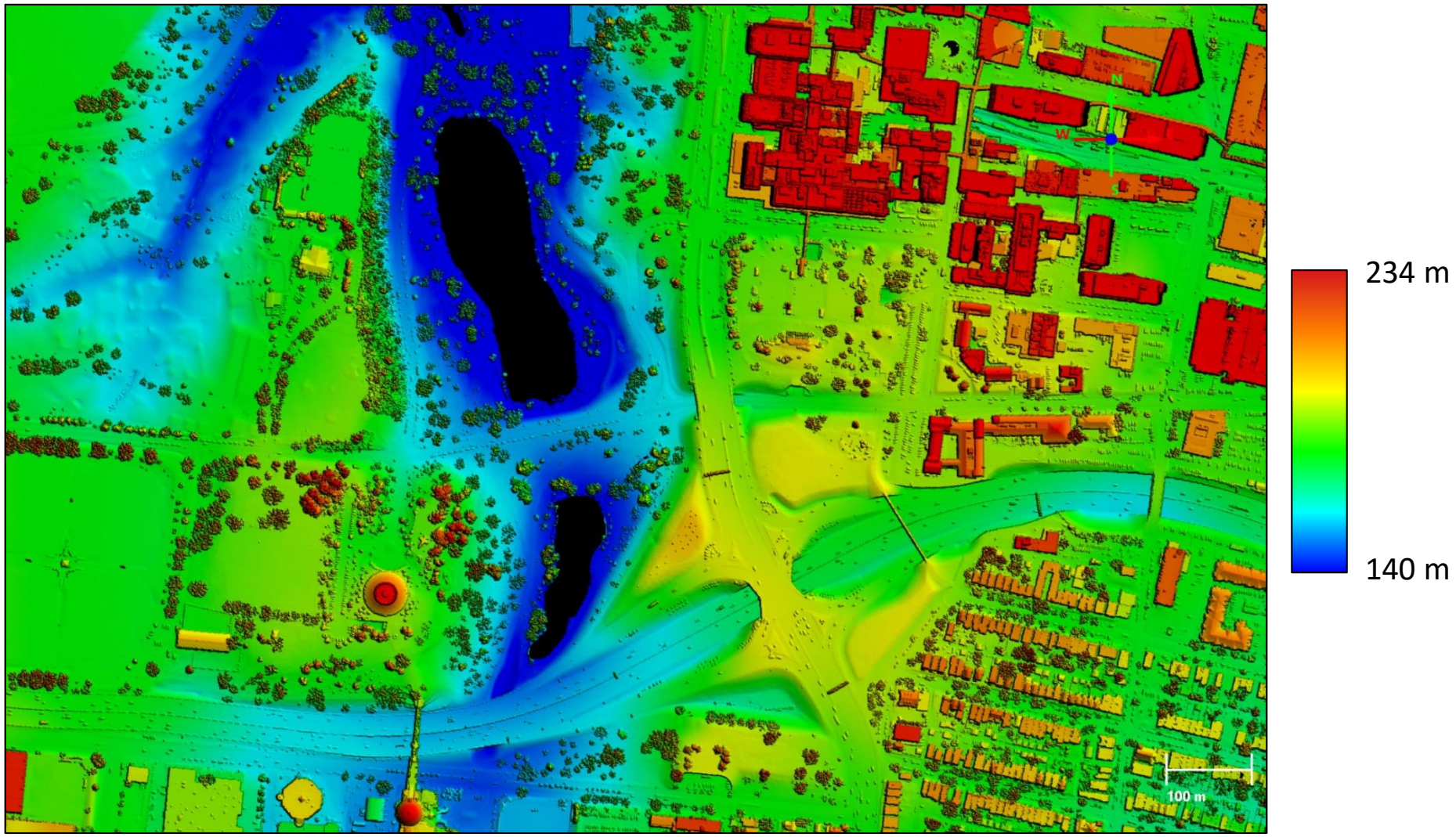
Source Data: USGS LiDAR Survey of St. Louis, MO; February 2017

Extended PC: Shaded Classification



Source Data: USGS LiDAR Survey of St. Louis, MO; February 2017

Extended PC: Shaded Relief

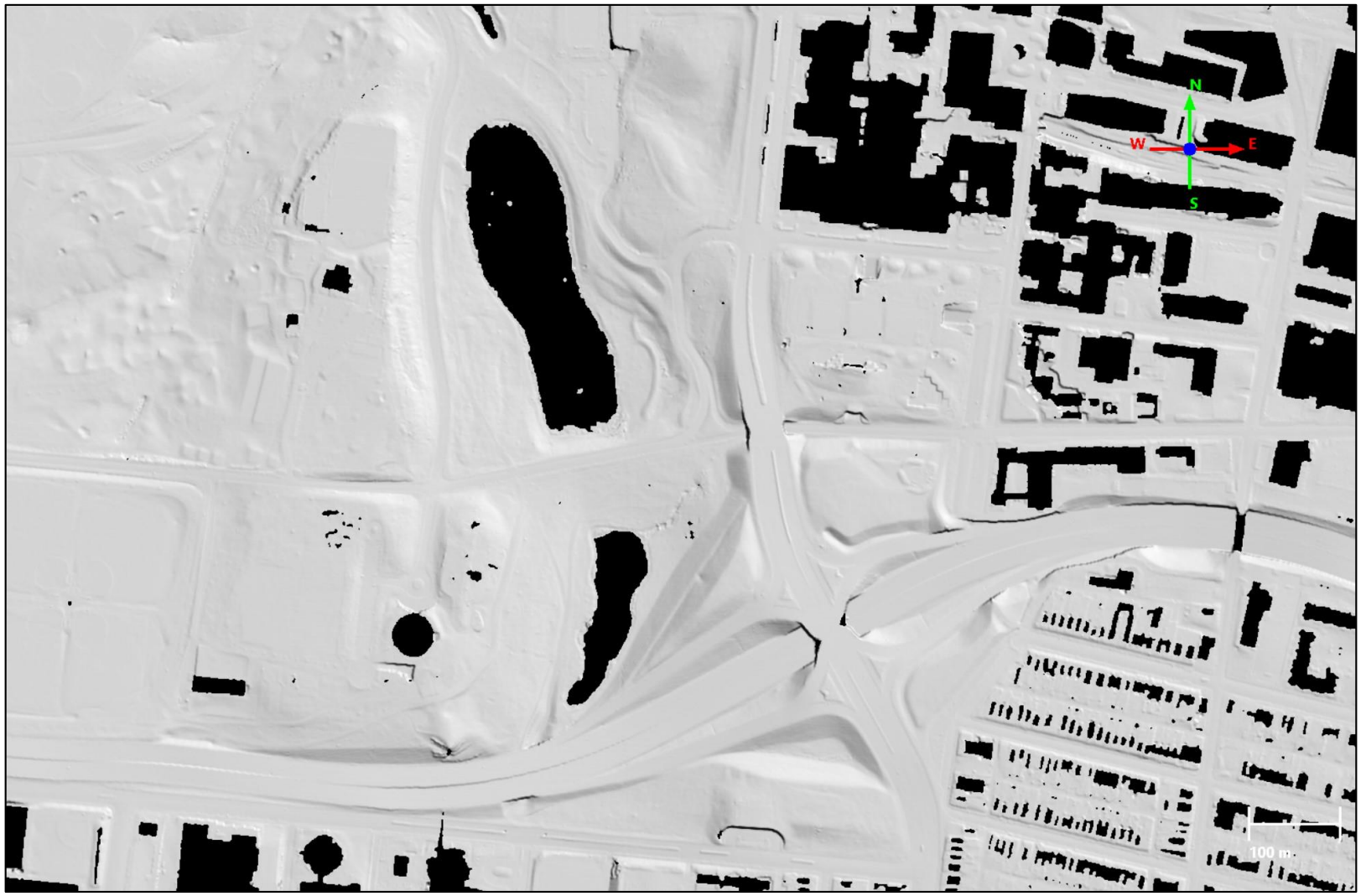


Source Data: USGS LiDAR Survey of St. Louis, MO; February 2017

Extended PC: DSM Hillshade

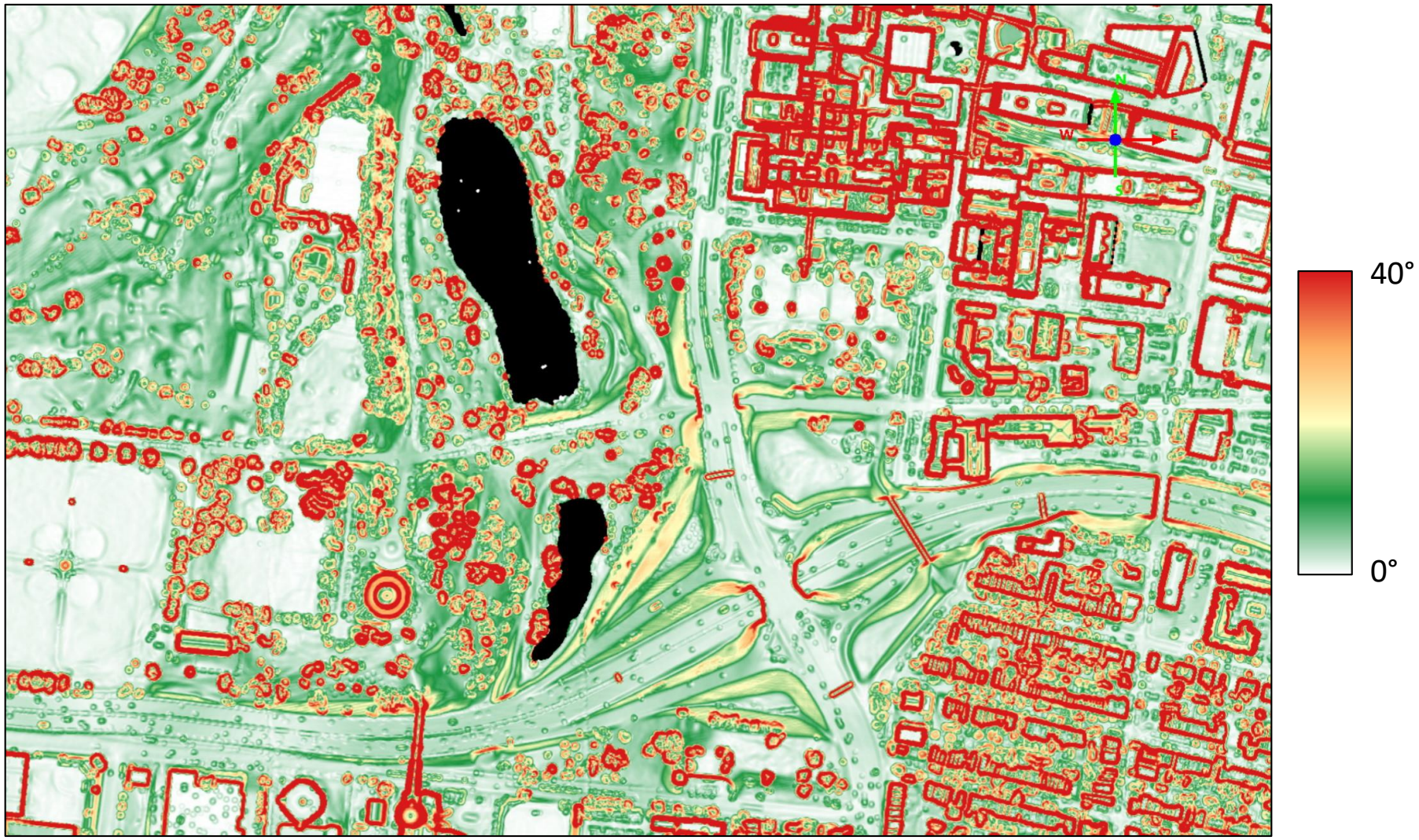
Source Data: USGS LiDAR Survey of St. Louis, MO; February 2017

Extended PC: DTM Hillshade



Source Data: USGS LiDAR Survey of St. Louis, MO; February 2017

Extended PC: Slope



Source Data: USGS LiDAR Survey of St. Louis, MO; February 2017

Coming Soon: LE90 and CE90 from LAS and BPF Files

- The Generic Point Cloud Model (GPM) stores error ellipsoids for EO-derived point clouds.
- GPM error data cannot be viewed in commercial software.
- A draft QT Modeler plugin utilizes GPM and Per Point Error (PPE) to interpolate LE90/CE90 as a point level attribute.
- The error attributes can then be interpolated into GeoTIFFs.
- RGB preview images of the error grids will alert analysts of data reliability and highlight areas where new data is needed.

Conclusion

- Metadata text can be long but not spatial; a picture truly is worth 1,000 words.
- Preview images allow analysts to check quality metrics and identify errors.
- SFNE has optimized preview styling, already in use for DGED data.
- Multiple images can be viewed in a web browser using the NSG Elevation Metadata Implementation Specification (NEMIS) XML template.
- SFNE offers the following recommendations for preview images:
  - Don’t limit them to shaded relief
  - Use moderate resolution; 800 pixels on longest edge is optimal
  - Format as PNG files to support transparency, as needed
  - Apply ‘Adjusted Z Factor’ to darken shadows, highlight relief
  - Create extended point cloud images by first gridding as DSM or DTM

NGA

NGA