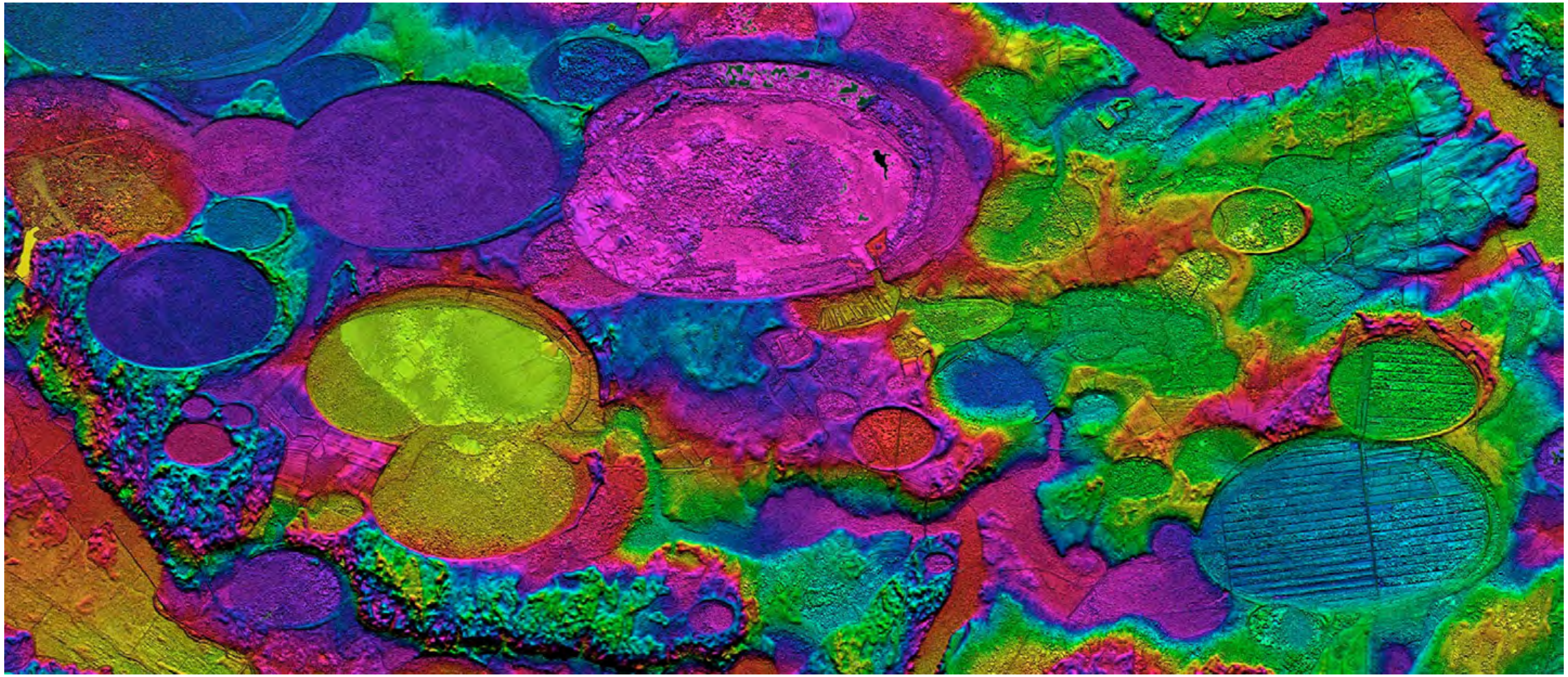
Cookie Cutter

Assessing the Planform of 500 Carolina Bays in Lidar Digital Elevation Maps



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Cookie Cutter: Assessing the Planform of 500 Carolina Bays in Lidar Digital Elevation Maps

Over the past ten years, our Carolina Bay Survey (Survey) has performed the precise measurement of over 50,000 Carolina bay landforms. Six common planform archetypes have been identified, each associated with different geographies of the USA. The most common archetype - named by us as bayCarolina - has been assigned to over 26,000 gentle depressions in Virginia, North Carolina, and South Carolina. While the match of the archetype to the actual depression's encompassing rim is occasionally subjective when inspecting bays whose major axis are under a 800 meters, the overwhelming majority of larger bays are robustly correlated to the archetype. We present digital elevation maps of 500 bays from the Survey’s 2,100 bayCarolina-shaped landforms larger than 800m. Google Earth is used for interactive visualization and static map creation, allowing the viewing of our seamless bare-earth terrain imagery in situ. The Survey’s elevation maps are generated in the Global Mapper GIS platform using publicly available LiDAR datasets. When considering a relief of only 1 to 5 meters across kilometer-scale landforms, identifying the true shape of those basins is enhanced by our use of a 20x elevation exaggeration and high gain hsv-shading during map creation. Google Earth's *groundOverlay* supports the manipulation of a templated PNG image representing the archetype, and enables the operator to obtain an optimal fit to the bay’s actual rim. The template can be stretched or shortened to accommodate the variations in eccentricity and scale seen in the Survey, but cannot be “distorted” in any other fashion. Once created, the overlay’s XML structure allows for the efficient extraction and documentation of a bay’s spatial metrics, which are stored in a geospatially referenceable Google Fusion database (https://goo.gl/EHR4Lf). To accentuate any variations from the archetype across the 500 bays, each is presented in an individual LiDAR-derived elevation map in which the applied scale and orientation have been normalized. The bayCarolina shape is basically a geometric oval, but with an observable flattening on one side. Many Carolina bays exhibit raised rims along segments of their periphery, but we emphasize that these landforms are often merely depressions in a pediment, where an enclosing escarpment fully encircles a shallow basin.

Goals of Talk

- A Morphometric Survey of the Carolina bays
- Update: Carolina bay Geospatial Survey
- LiDAR DEMs and presentation in Google Earth
- The bayCarolina planform shape
- Focused today on 500 bays in 2 USGS 1º Quads
- Examining details of the bay rims with web-based viewer
- Summary

- Bay planform viewer freely available @ **planform.cintos.org**

A Morphometric Survey of the Carolina bays

"Their very randomness of grouping and scatter demands an explanation. As a statistical phenomenon, they deserve to be studied statistically."

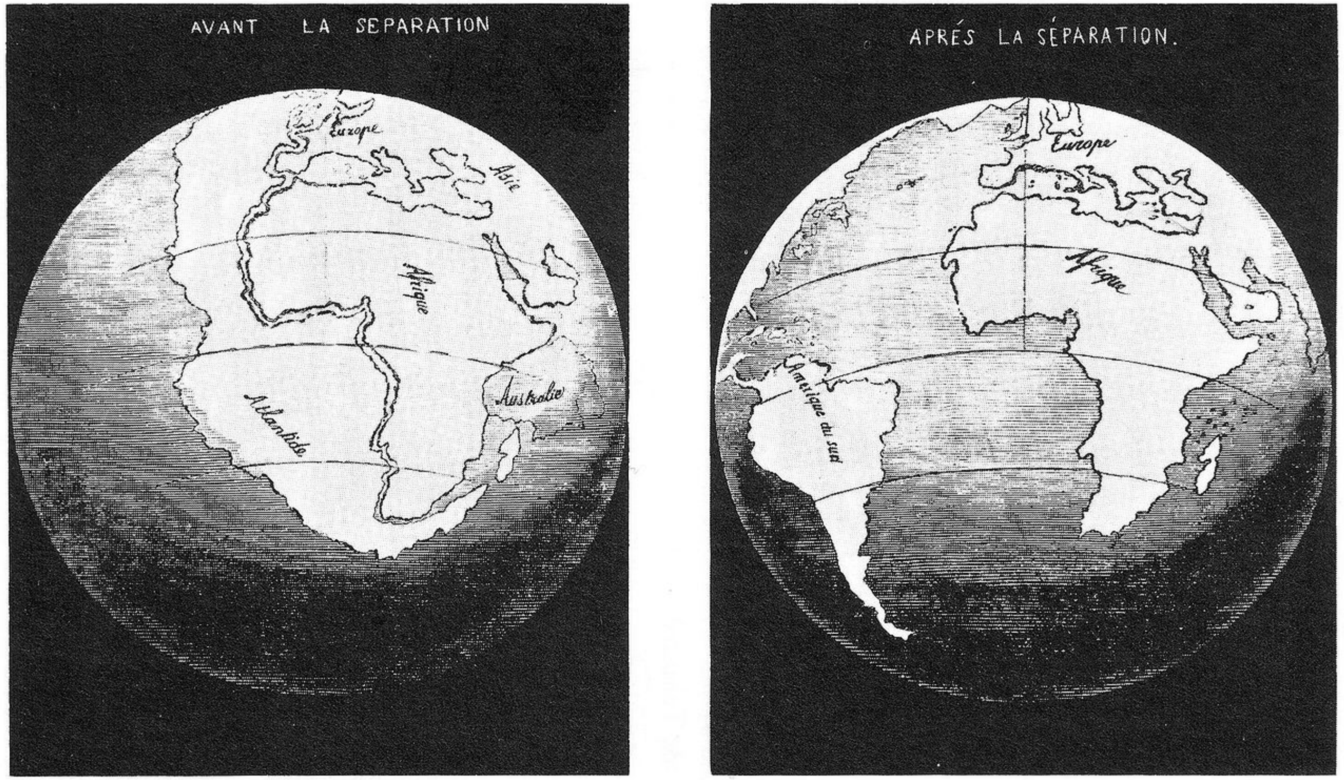
W.C. Rasmussen, 1953

William C. Rasmussen, 1953, Periglacial Frost-Thaw Basins in New Jersey, The Journal of Geology, Vol. 61, No. 5

Fanciful Geological Maps

Inspires curiosity and informs speculation

Antonio Snider-Pellegrini's Illustration
of the closed and opened Atlantic Ocean
(Paris, FR, **1858**)

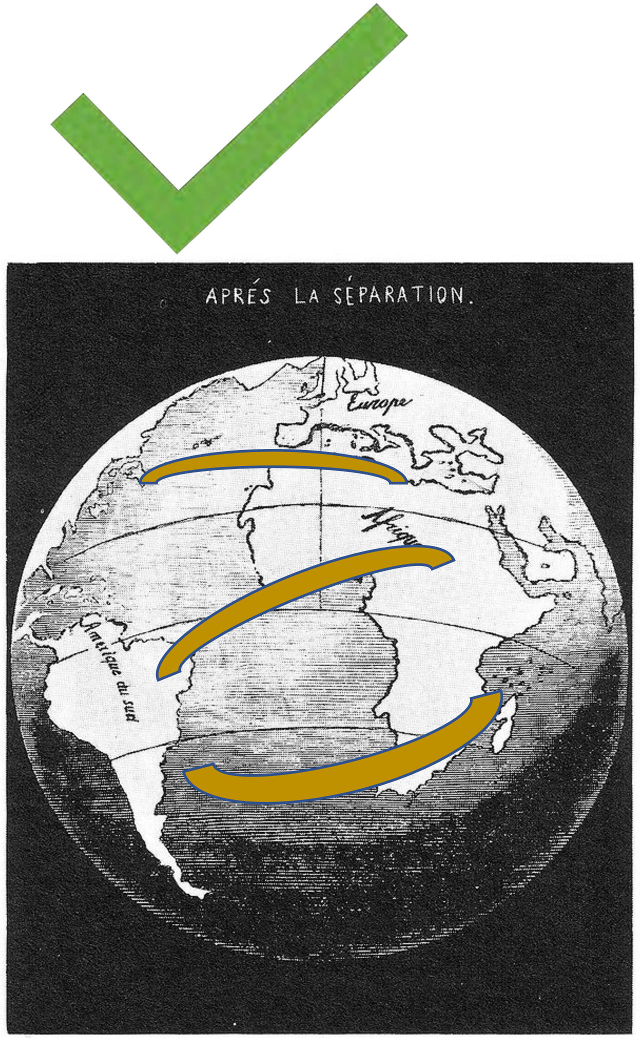


Fanciful Geological Maps

Inspires curiosity and informs speculation

We must remember that Antonio Snider-Pellegrini's attempt at promoting the advancement of science was held at bay for a over a hundred years by the great minds of geology. The uniformitarian dogma maintained that nothing that we can't see at work today could be responsible for the Earth's geomorphology. "Land Bridges" were proposed to have allowed flora and fauna to pass between the two hemisphere's land masses. *Although no remnants of land bridges had ever been identified!*

I propose that the consensus opinion that Carolina bays are *wispy ephemeral* landforms is a *land bridge* solution. If you buy that, I've got a bridge in Brooklyn I'd like to sell you.



Fanciful Geological Maps

Inspires curiosity and informs speculation

Pacific Northwest Ocean Floor

Surveys of magnetic field off of west coast in mid-1950's by **Raff and Mason** discovered linear magnetic anomalies: "zebra stripes."

Their origin was a mystery.

Unfortunately for Raff and Mason, this was before it was known that the magnetic field reverses periodically.

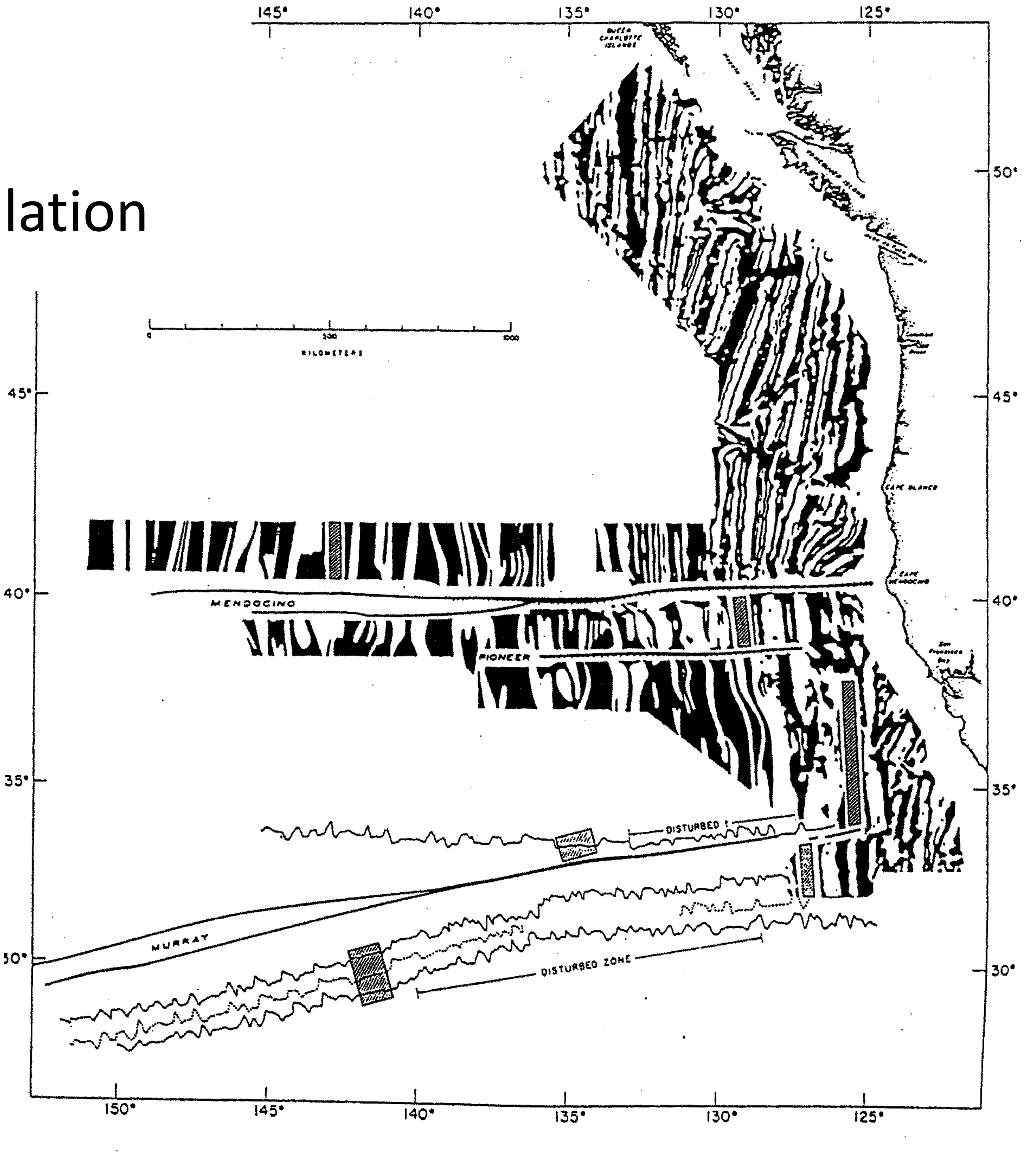
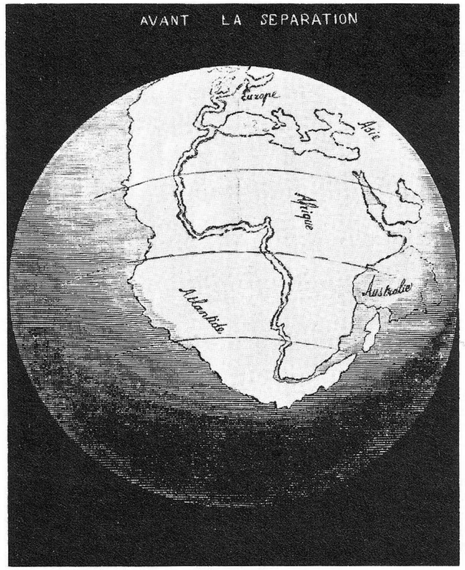


Figure 3.4 Magnetic anomalies and offsets on fracture zones.

Fanciful Geological Maps

Inspires curiosity and informs speculation



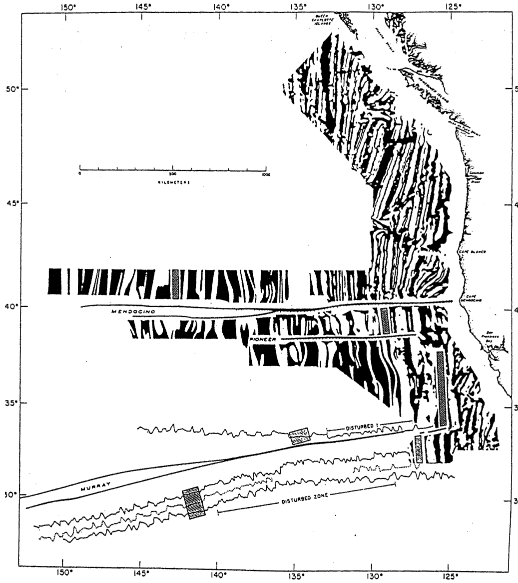
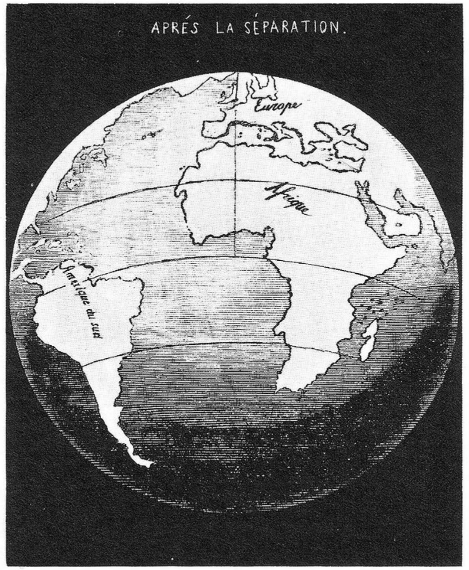


Figure 3.4 Magnetic anomalies and offsets on fracture zones.



Lets be honest with ourselves: Are we as scientists curious enough to tickle out a very "complicated" solution to this, or are we to sit back and buy the Brooklyn Bridge as a simple, unassailable solution.

My goal is to tickle out the geomorphology of the Carolina bays by inspection of the start condition and the end condition using visual cartoons to stimulate the mind. I invite you to speculate along with me as I evoke the only geophysical force I believe is powerful enough to render my LiDAR imaged Carolina bays – an inconceivable scale cosmic impact.

Fanciful Geological Maps

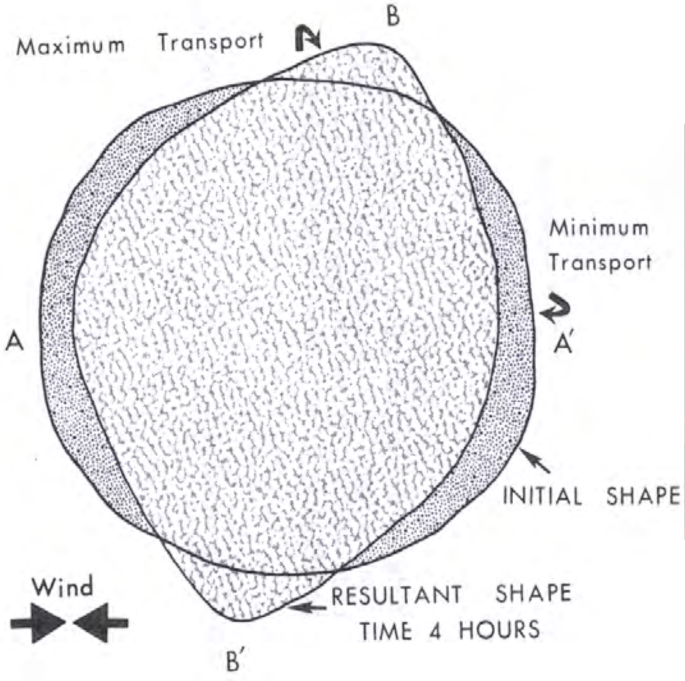
Inspires curiosity and informs speculation

Kaczorowski's gradualistic demonstration mandates the presence of an antecedent water-filled circular depression (where did they come from ???), then he demonstrates surficial modification using an unrealistic alternating prevailing wind regimen.

When his protocol is invoked without actual demonstrations, it is unequivocally done without invoking the 50-50 duty cycle of alternating wind fields. Another shortcoming of Kaczorowski's protocol is that the wind is provided by an oscillating fan sweeping across the water, generating a decidedly unconventional wind field.

This eventually yields a planform which doesn't accurately represent any known Carolina bay. None of the archetype planforms identified in my Survey posses opposing pointed lobes at the furthest reaches of the major axis.

I maintain this process is nothing more elaborate that two otherwise migrating "clamshell" lakes stabilized in one location by the rigorous and unrealistic 50-50 cycle. Let me sell you that bridge….



R. T. Kaczorowski, 1977, *The Carolina Bays: A Comparison With Modern Oriented Lakes,* Coastal Research Div. USC, Technical Report #13-CRD

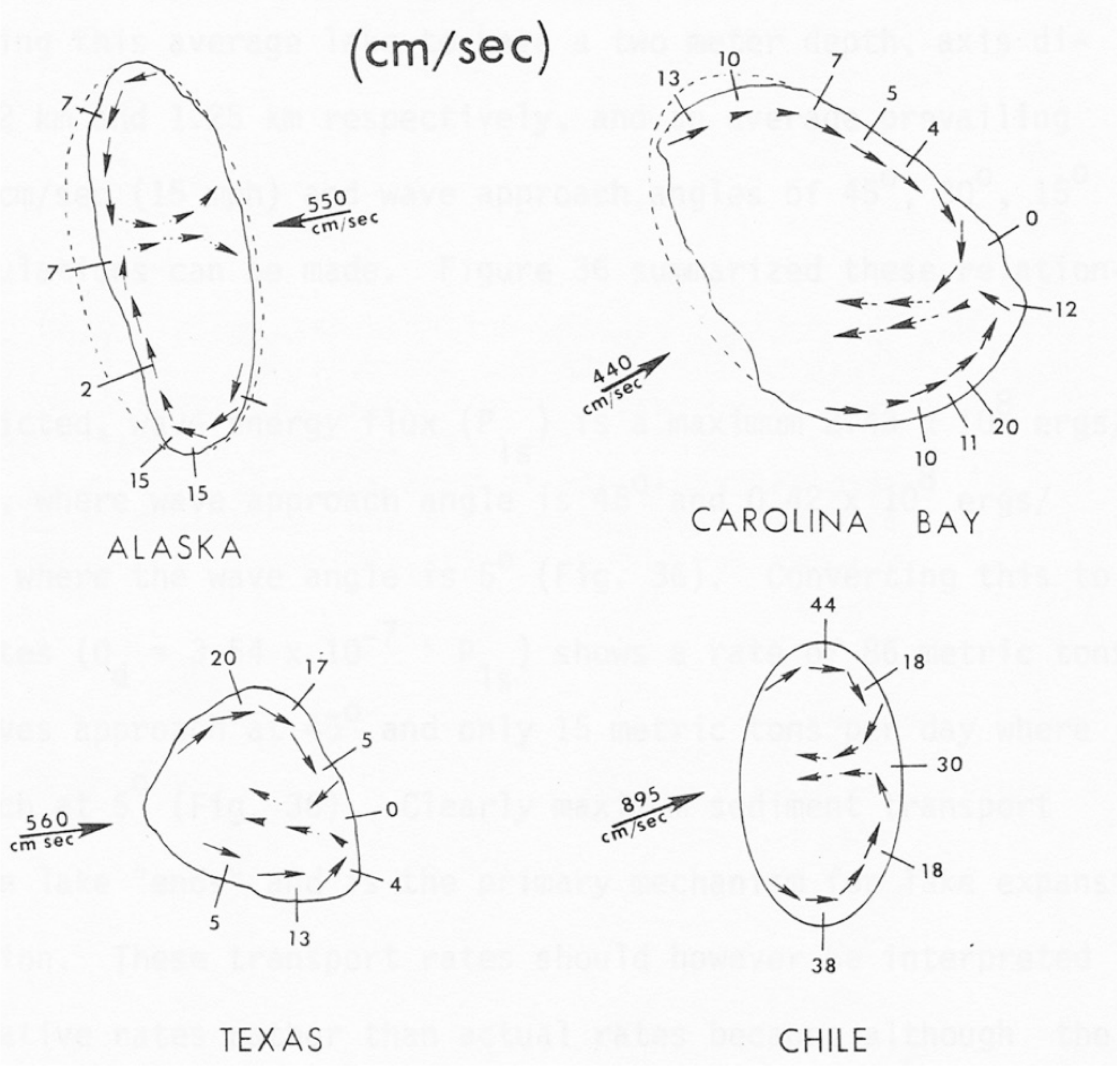
Wind & Wave (Bidirectional ???)

Kaczorowski's figure 35 compares well-researched aligned and oriented lakes with Lake Waccamaw. While I find it quaint that Waccamaw is commonly called a Carolina bay, I find it quite depressing that professional geologists consider that lake's shape as a proxy for all Carolina bays! Its aerial expanse is at least four times that of the next largest water-filled Carolina bays. Out of 25,000 bayCarolina examples in the Survey, it is one of only a few that do not easily conform to the archetype shape. Any chance at all that is simply a naturally-formed lake?

When he does model an oval lake, he does it with a 1-in-100 pure oval lake found amongst the prevailing wind-driven migrating clamshell lakes in Chile.

And where is the 50-50 duty cycle alternating wind field used in his demonstration?

R. T. Kaczorowski, 1977, *The Carolina Bays: A Comparison With Modern Oriented Lakes,* Coastal Research Div. USC, Technical Report #13-CRD

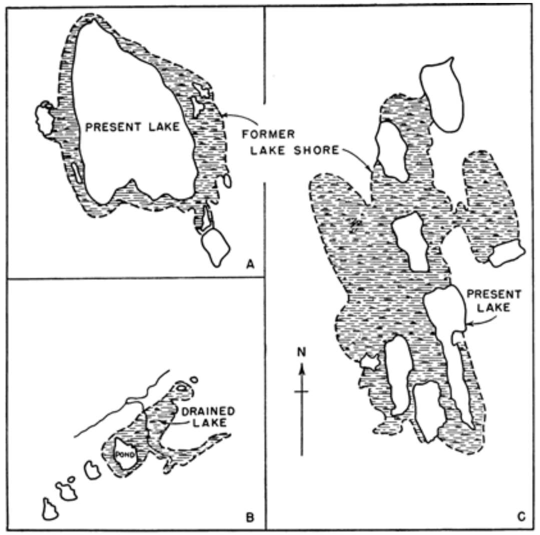


Alaskan Tundra Freeze-Thaw Lakes

Quaternary geologists point to the aligned periglacial lakes of Alaska as being perfect proxies for the gradualist processes which formed the Carolina bays.

I refute that by simply sharing their true planforms. They show as a collection of rag-tag bodies of water that possess neither the smooth circumferential rim nor the robust adherence to any specific ovoid shape.

Indeed, these lakes has been extensively evaluated, and "wind & wave" seem to have had no role in their genesis.



REPRESENTATIVE OUTLINES OF EXISTING LAKES AND THE BASINS THEY OCCUPY

SCALE 1 0 1 2 MILES

FIG. 5

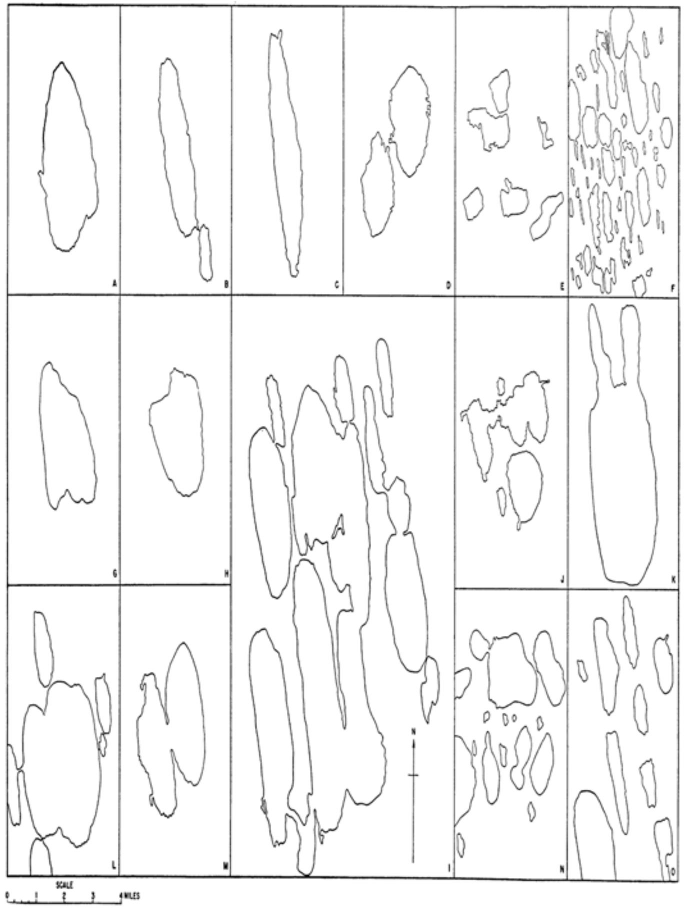
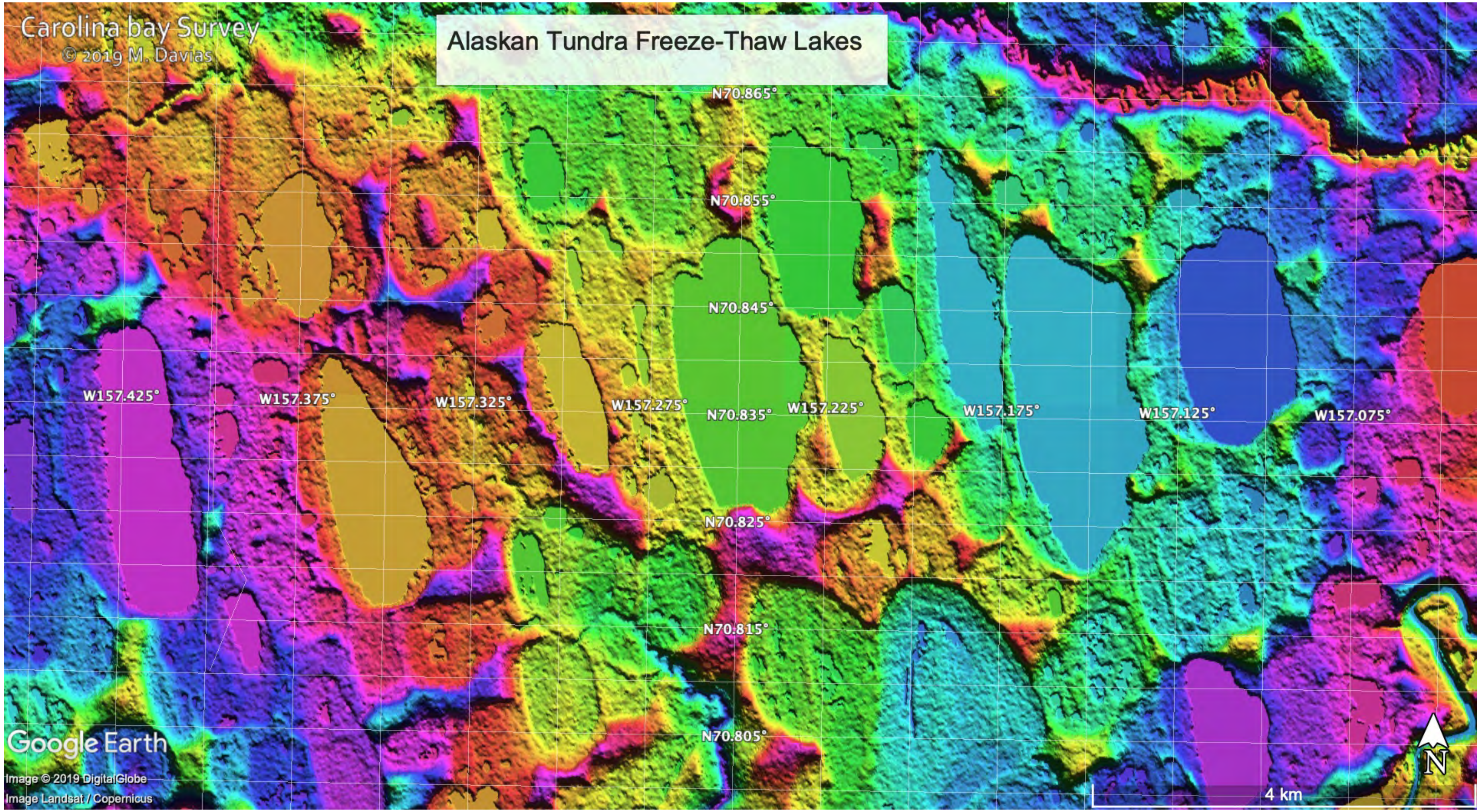


FIG. 4.—Representative outlines of oriented lakes, showing size, shape, and orientation

Alaskan Tundra Freeze-Thaw Lakes

Even when viewed in LiDAR-derived elevation maps, the aligned paleolakes of Alaska fail as proxies for Carolina bays.



Bay Planforms as seen by Johnson

When Douglas Johnson documented the planform of bays of North and South Carolina, he listed two. In the northern areas bays are more oval, and to the south, more tear-drop shape. Neither have two pointed ends.

Today's discussion will focus on the more oval shaped bays seen in the area straddling the border between the two states.

His findings validated the often-noted characteristics that the bay orientation varies systematically by latitude.

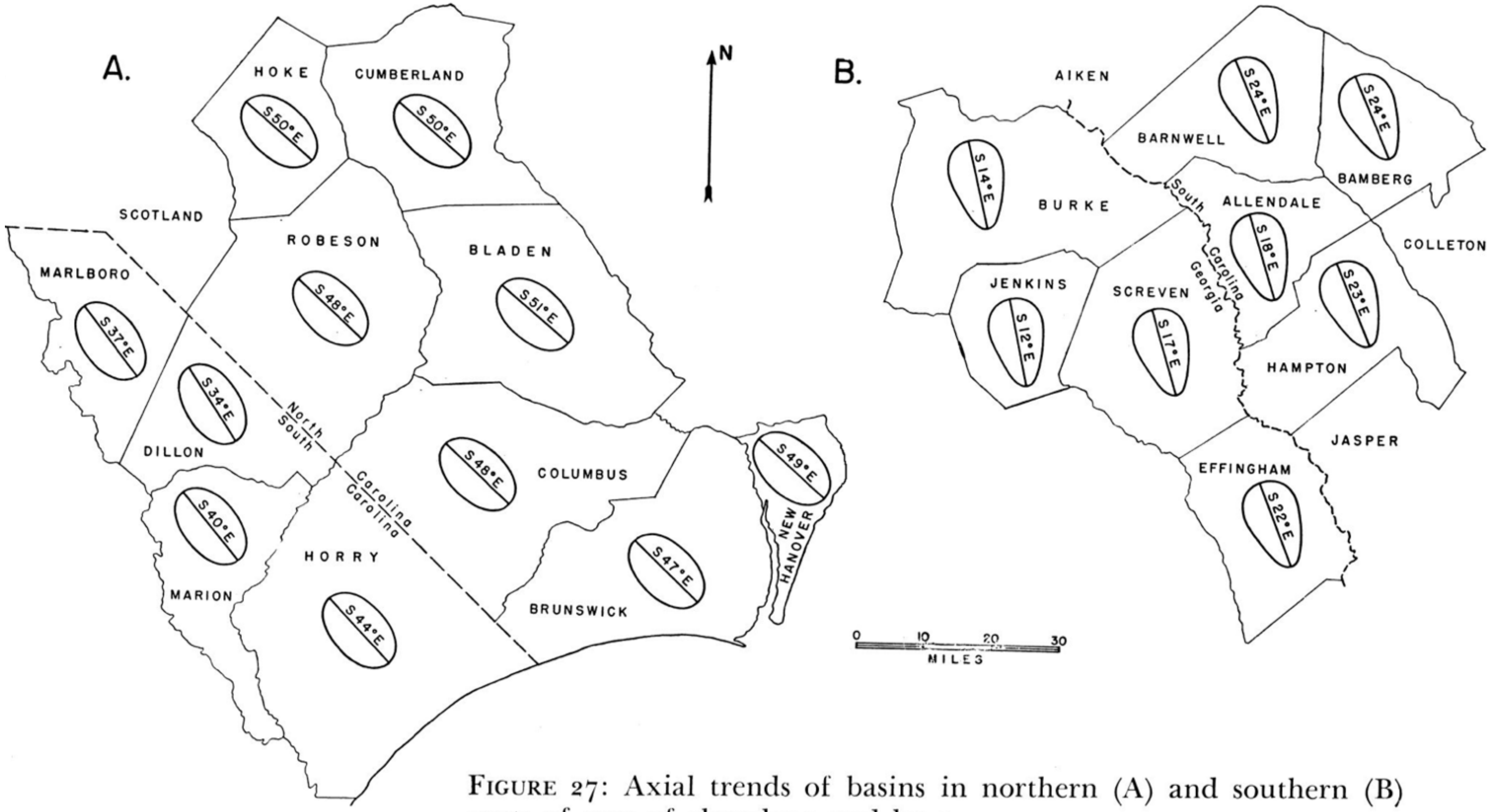


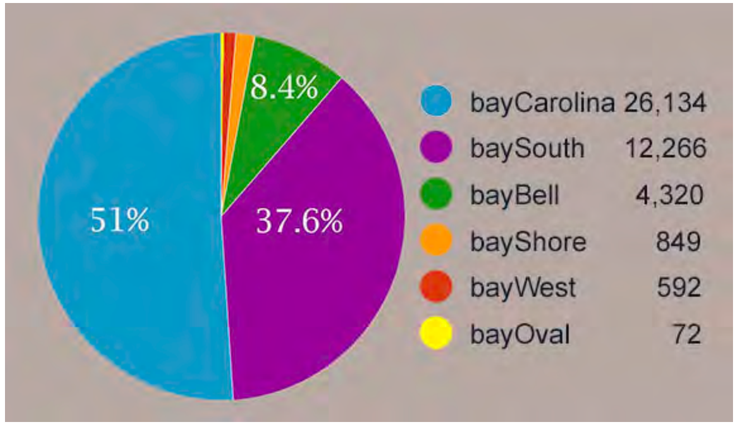
FIGURE 27: Axial trends of basins in northern (A) and southern (B) parts of area of abundant oval bays.

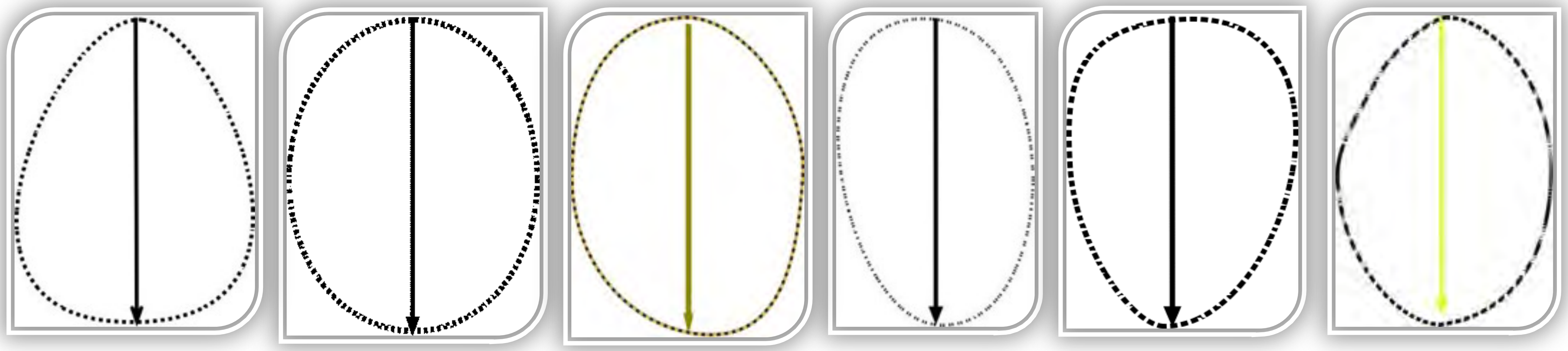
Douglas Johnson, 1942, *The Origin of the Carolina Bays,* Columbia University Press

Taxonomy of landform Genus "Carolina Bay"

The Survey has identified six stylized planforms which conform to bay shapes found in various regions of the continent. Each is a slightly modified ovoid, but with pronounced and persistent differences. These outlines are used in the survey as *groundOverlays* in the Google Earth virtual globe to capture bay metrics.

By far the most common bay shape is the *bayCarolina* archetype, comprising over half of the bays in the survey.





bayBell bayOval bayShore bayCarolina baySouth bayWest

Update: Carolina bay Geospatial Survey

- Undertaken in 2009, current total of over 50,000 bays catalogued
- Currently being re-imagined
  - Google is deprecating the Fusion Table facility
  - Presenting all LiDAR, bay placemarks & planform overlays using region support
  - On-line database using MySQL for processing
- USGS 1º Quads, divided into 16 ¼º "Hextants" as unit of presentation
- First up: Florence_W and Florence_E

Fusion Table Example

Map of all *bayCarolina* archetypes measured

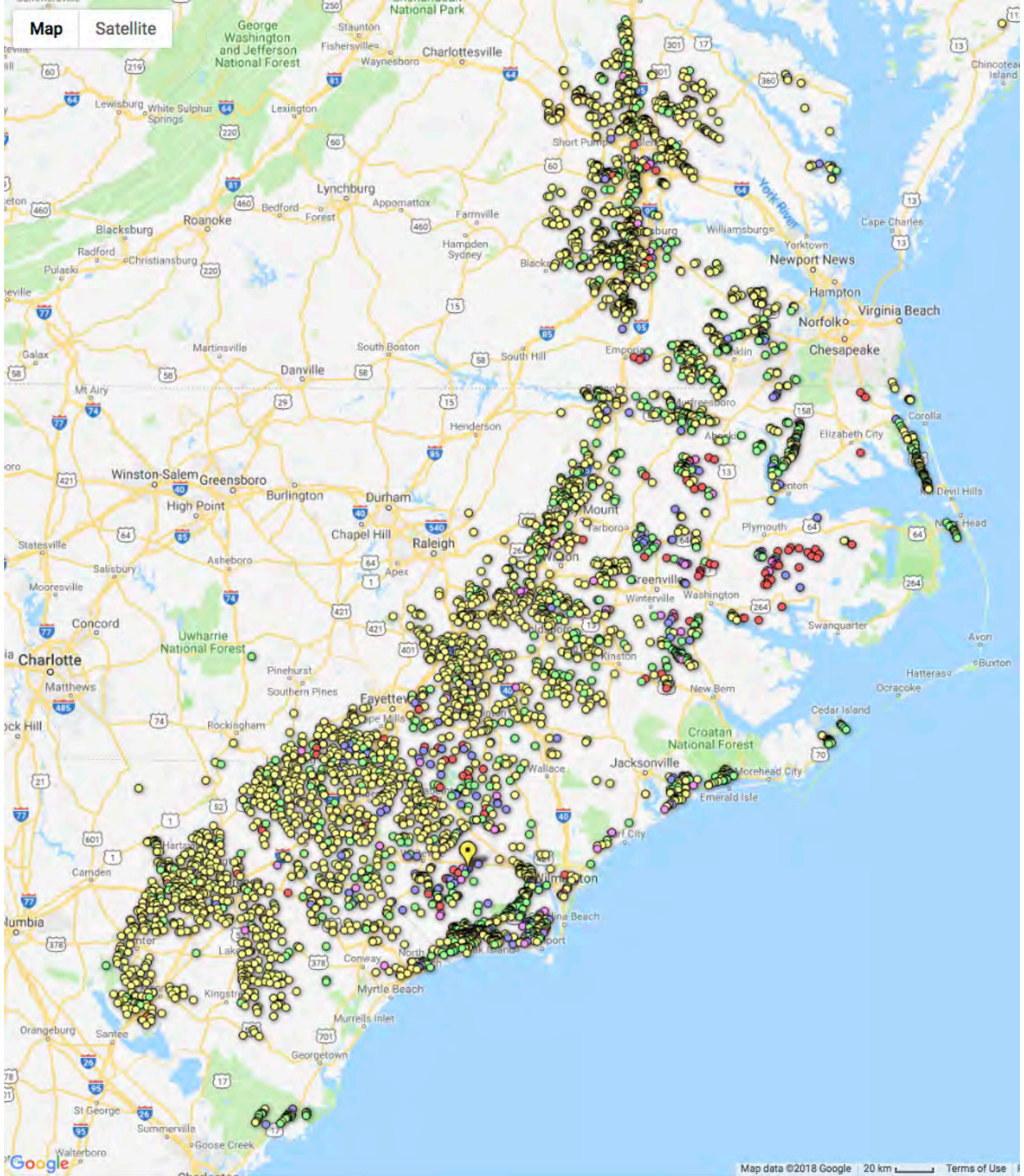
Google will be turning down the Fusion table facility at the end of 2019. That on-line database has been utilized by me to hold the 50,000 + row database and present bays for users to interrogate. Each placemark presents a popup with measured bay data.

The map shows only 500 bays for any viewpoint, so as a user zooms into a smaller region, Google automatically populates it with as may bays as available, up to 500 total. This functionality keeps the user's machine from becoming overloaded with 50,000 placemarks.

This map can be accessed in a web browser until December, 2019 using the url

https://goo.gl/EHR4Lf

My challenge is to replicate the functionality of this map in a web browser to provide a geospatial index for the Survey’s database.



Getting Normalized For New Survey

- Bays presented horizontally to enhance expression of sheet flow artifacts
- View size has been constrained computationally based on major axis
- I'd like to have normalized "colors" but too work intensive
- "before-after" interactive experience using web browser
- Full screen visualization on desktops and tablets where supported

The primary motivation of a "new Survey" was driven by the imminent demise of the Google Fusion Tables spatial visualization database facility. A single Fusion Table holds the identification and metrics of over 50,000 bays, and provides the intelligent feed to the Survey's Google Earth visualization of each bay as a placemark with a popup describing the bay and linking to the archetype planform overlays used to measure each bay.

A secondary goal is to eliminate the exclusive use of Google Earth to visualize the bays and their planform overlays using the Survey's hsv-shaded elevation maps. We maintain that the crisp and robust adherence of thousands of landforms to archetype planforms is the signature of catastrophic event, as opposed to a gradualistic mechanism. It is hoped that a web browser facility would allow more individuals to interrogate the Survey's data.

Bays seen as Depressions

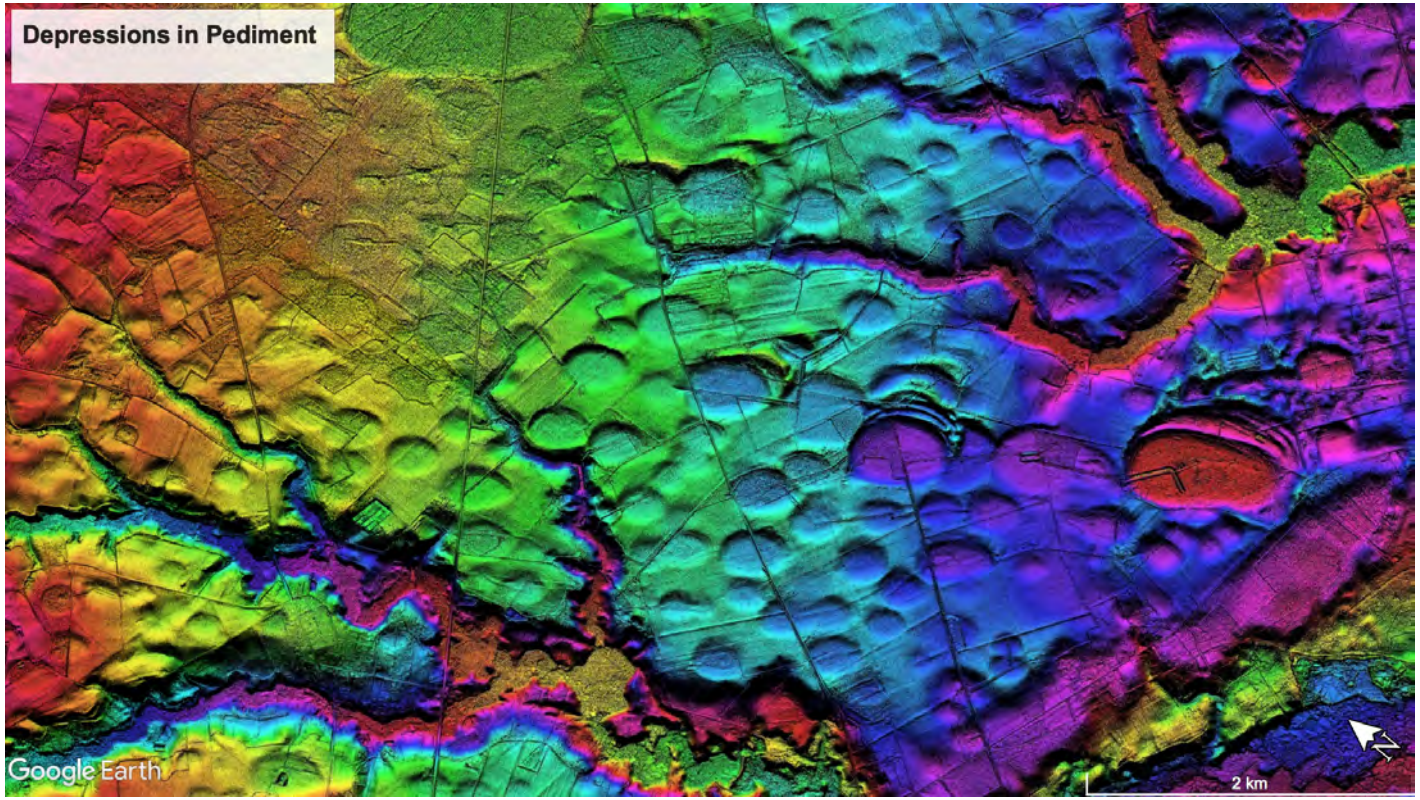
When seen in the true light of LiDAR-resolution digital elevation maps (DEMs), many Carolina bays appear as simple depressions in a pediment.

This conflicts with the commonly ascribed characteristic of a bay as having a “prominent rim on the southeast side”.

Indeed, a small percentage of bays do have prominent raised dunes mantling areas of their rims as a result of aeolian dust and sand transported across larger bay reaches by prevailing winds, and up onto the leeward side of the bay.

In my opinion, Quaternary geologists are far too enamored with poking around in those dunes, rather than sampling and dating the actual foundational structure of the bay’s circumferential rim.

Johnson provides an example of a common bay rim’s profile in his book’s figure 18:



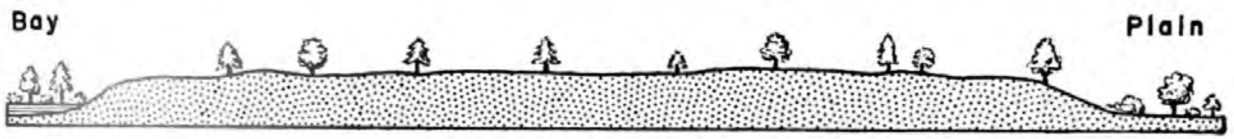
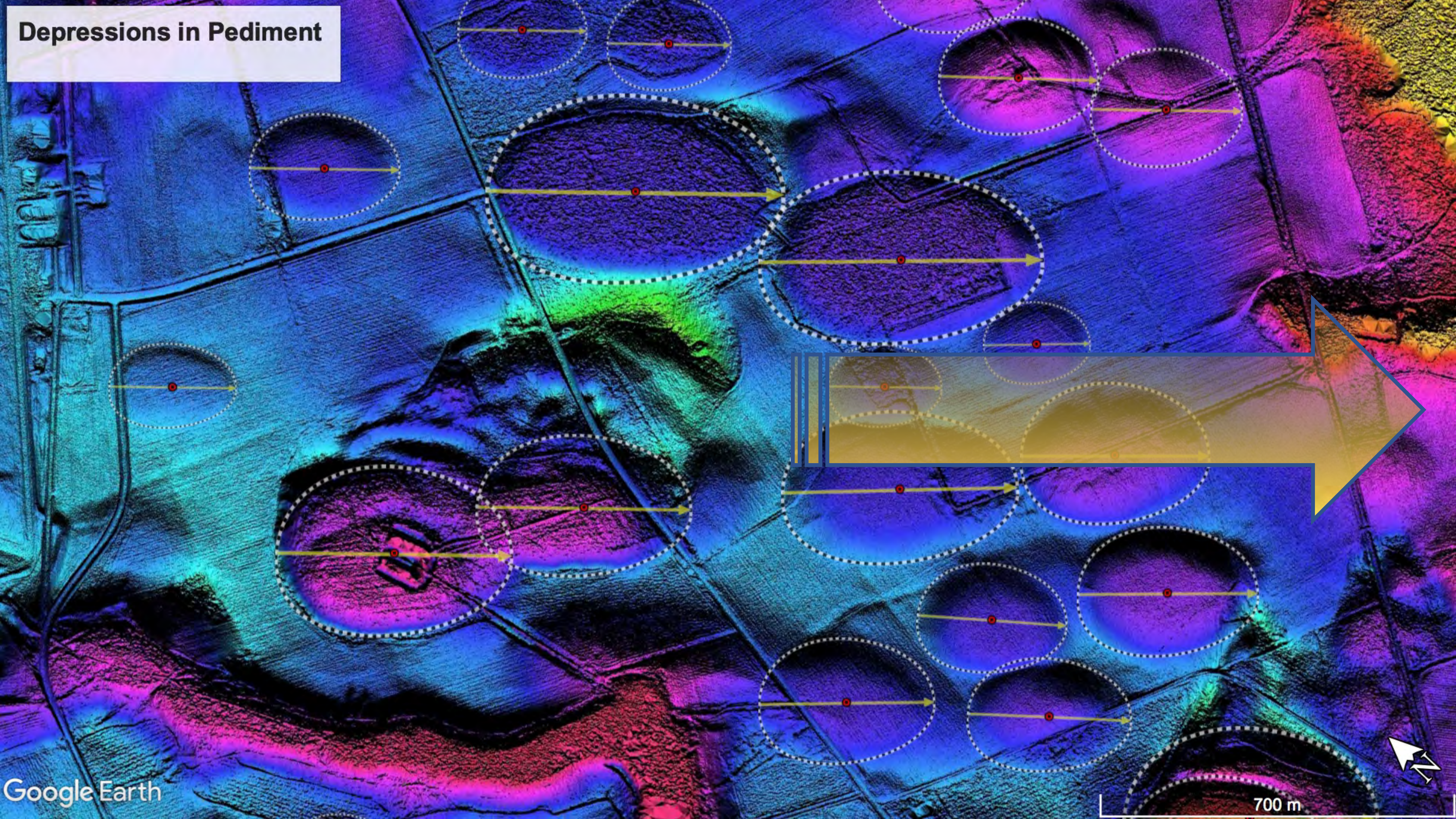


FIGURE 18: Typical cross profile of sandy rim from inner side next bay to outer side bordering plain. Vertical scale greatly exaggerated. Altitude of broad flat-topped rim usually varying from 2 or 3 up to 5 or 6 feet; breadth from 150 to 800 feet or more.

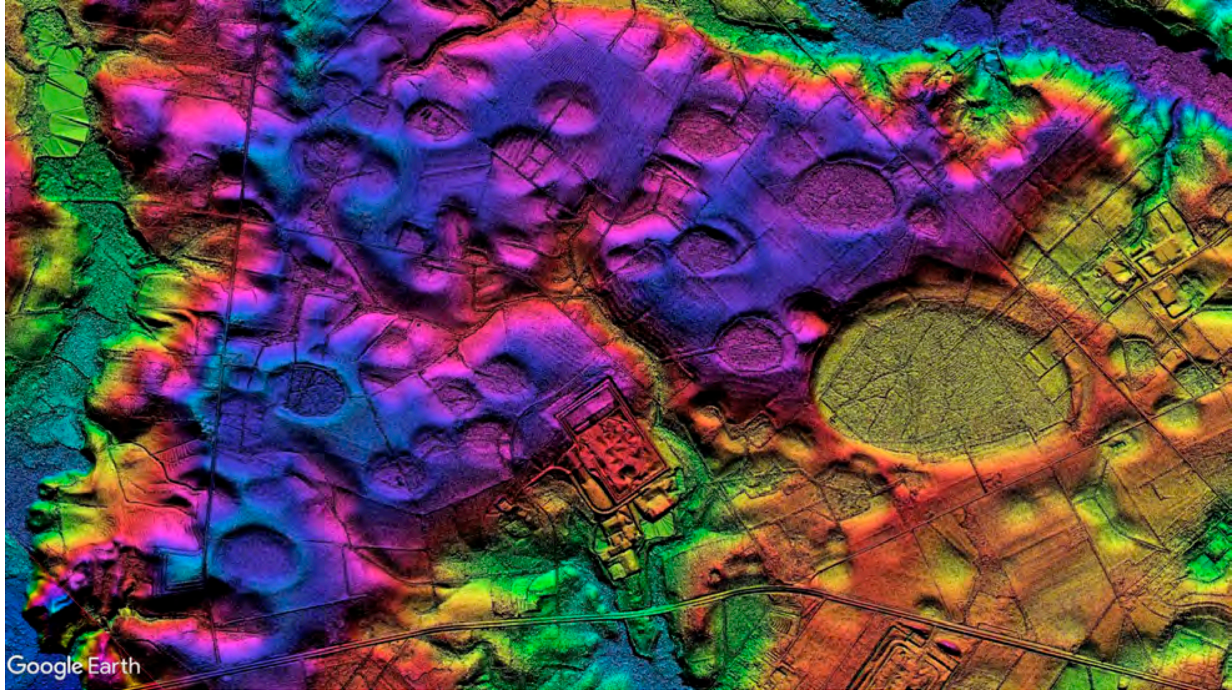
Depressions in Pediment

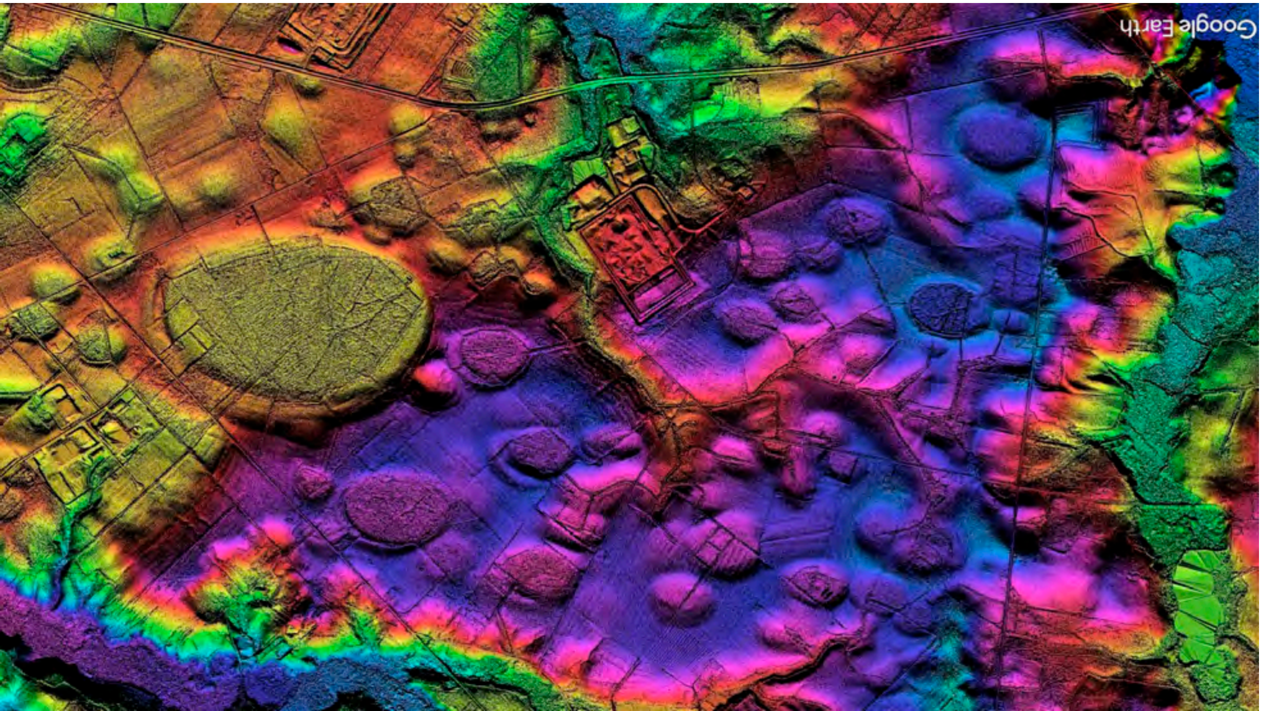


Optical Illusions

My LiDAR hsv-shaded maps apply hill shading, producing shadows which attempt to simulate a 3-D visualization.

The image to the right has the sun angle coming from the top of the page. Do you see the bays as depressions?





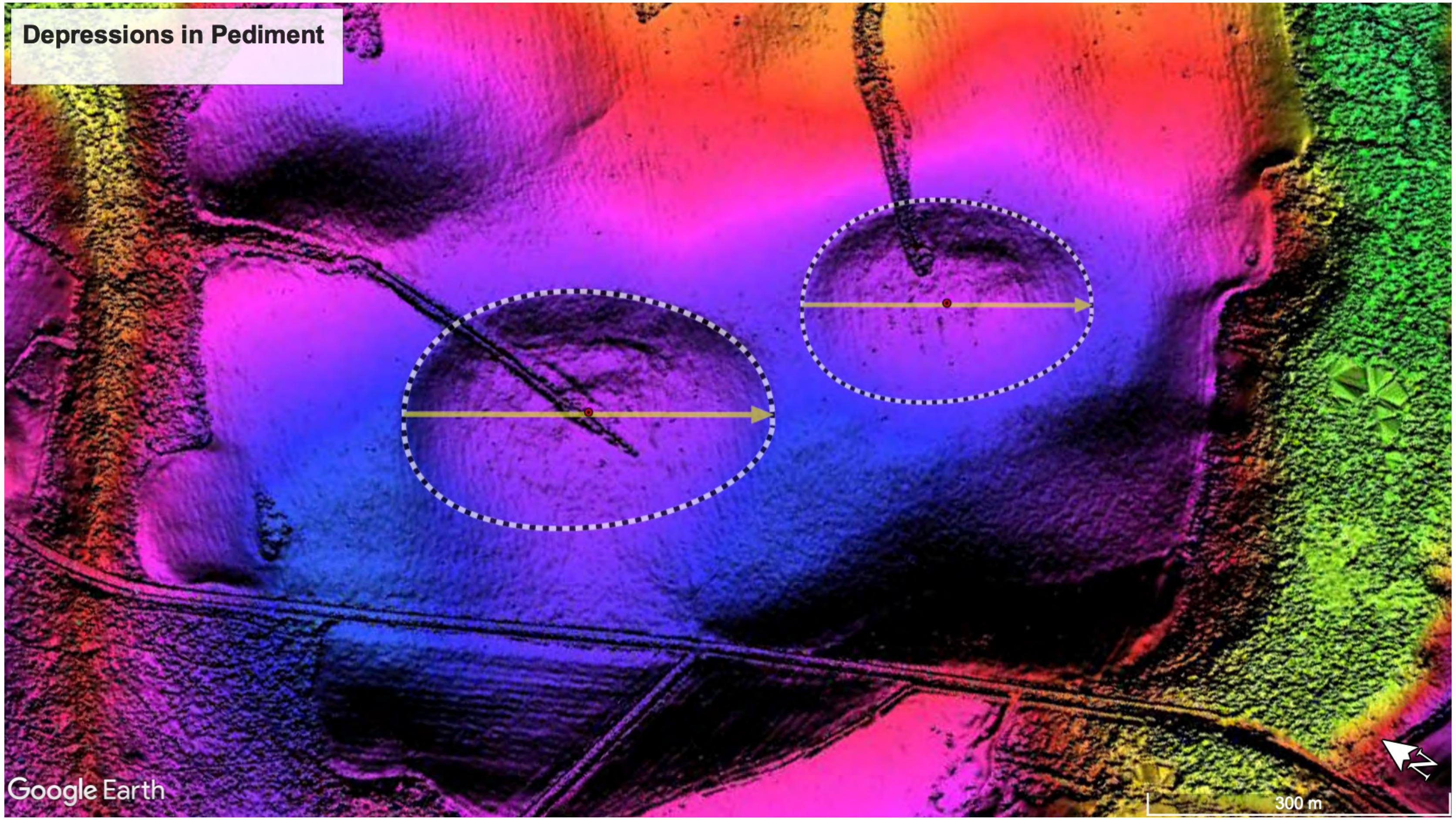
The image to the left has been inverted to mimic the sun coming from the bottom of the page.

Depending on the individual, only one of these will allow the bay to be rendered in the viewer's mind as a depression. The alternative is seeing it as a raised plateau.

This presents an impediment to the successful communication of the actual morphology of a Carolina bay. Geologists would be more likely to see the image above correctly, while astronomers - who are conditioned to look at inverted images in telescopes - are likely to correctly visualize the image to the left.

Measuring the bays

Here is an example of using Google Earth to present my hsv-shaded DEMs and instantiate and fit a *groundOverlay* upon bays to capture their shape and measurements.



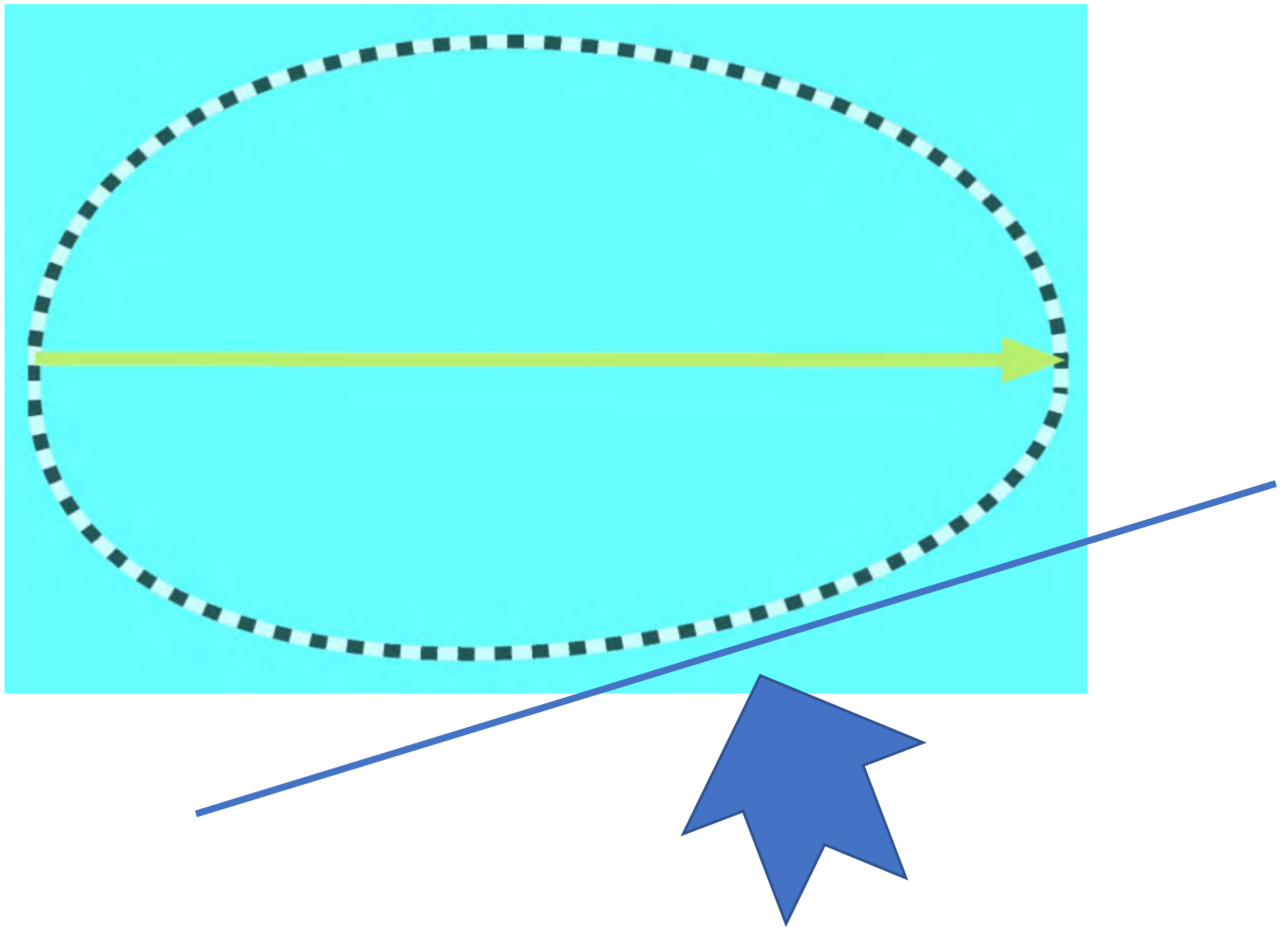
bayCarolina Archetype groundOverlay png file

The *bayCarolina* archetype being discussed today is primarily a pure oval, excepting that one side is slightly flattened.

This graphic file was produced in Adobe Illustrator as a png file with a transparent layer. Only the perimeter and the arrow are presented to the user, everything else is transparent, allowing the underlying imagery to show through.

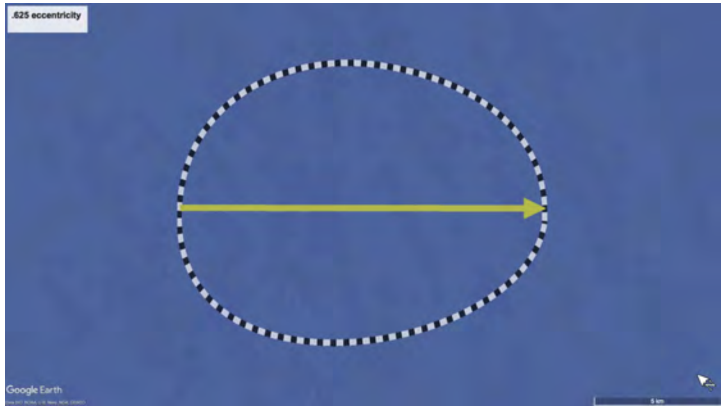
This distortion is seen across thousands of bays, and is required for the archetype to properly follow the circumferential rim of the bays.

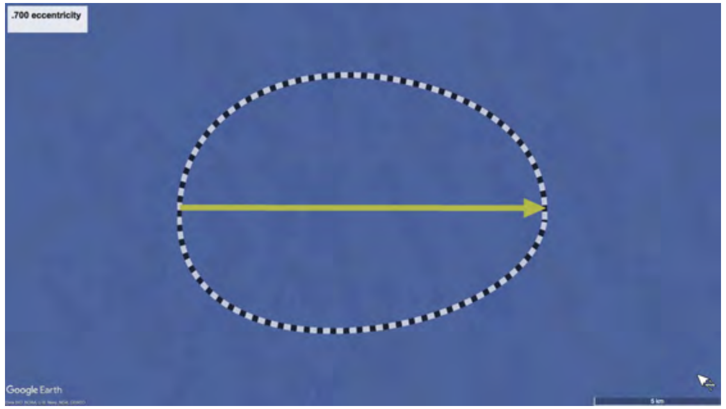
The orientation arrow is placed in a somewhat arbitrary position, but it is important to recognize that each and every bay fitted with this overlay will carry the exact same implicit "error".

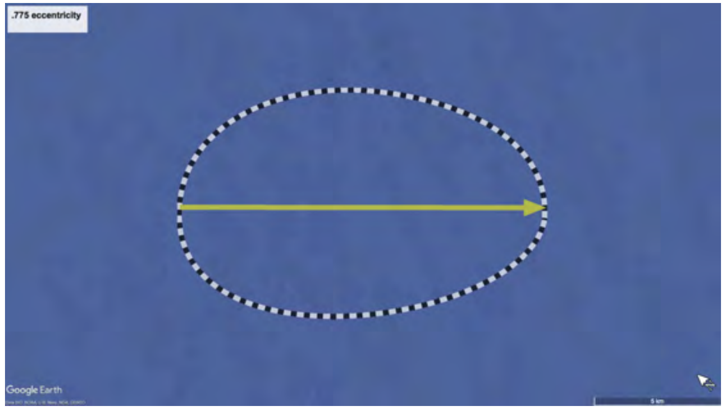


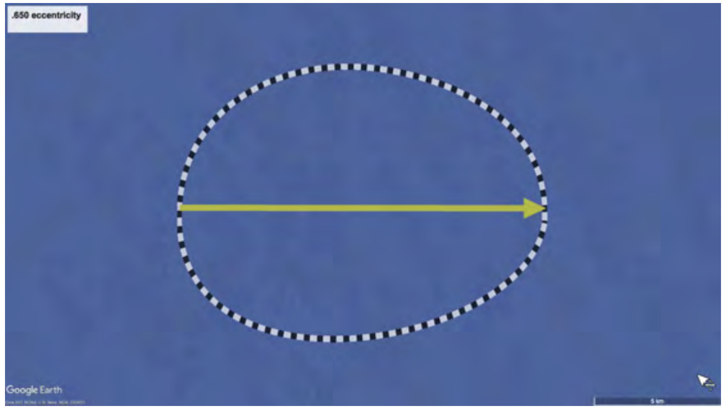
http://cintos.org/ge/survey/planform/bayCarolina.png

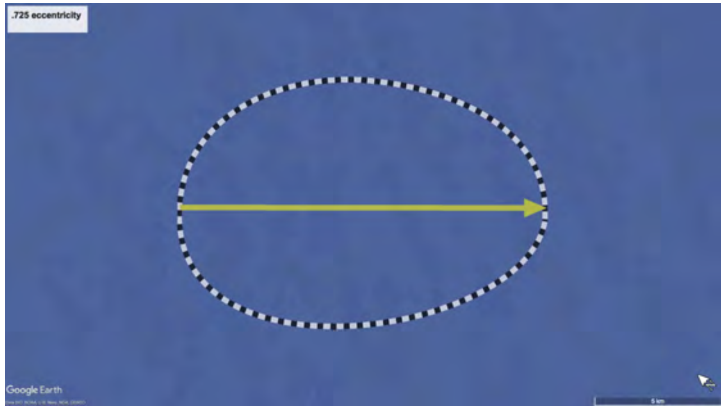
A Given Archetype shape varies in application only by eccentricity

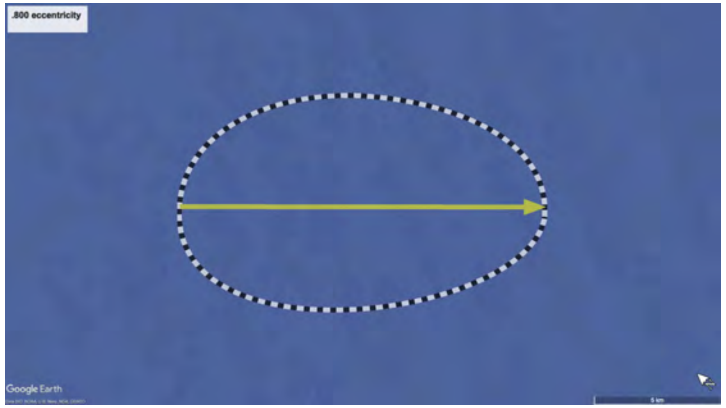


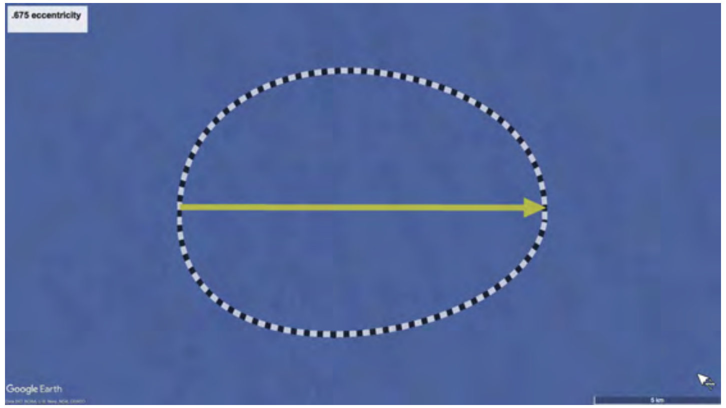


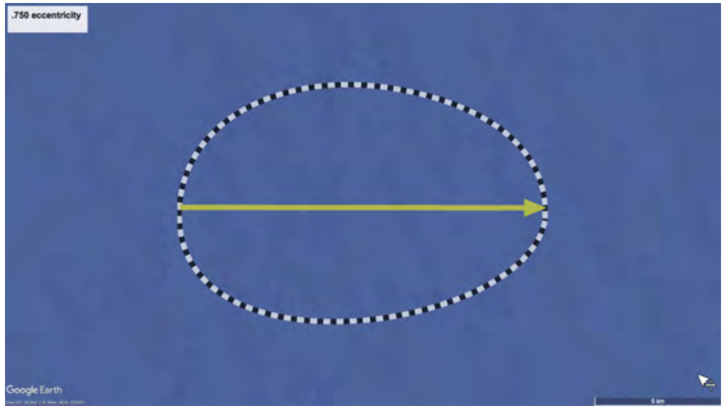


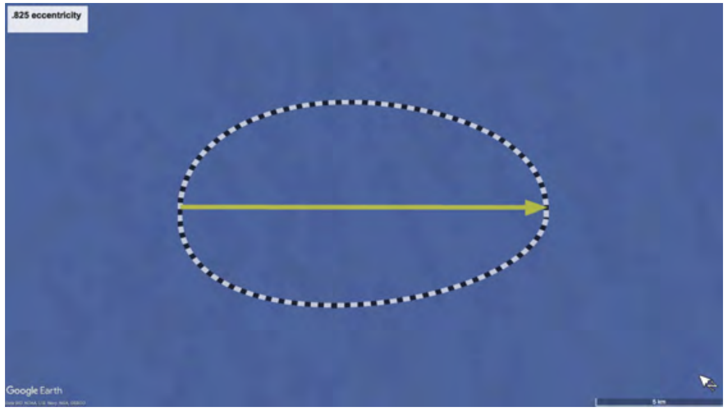


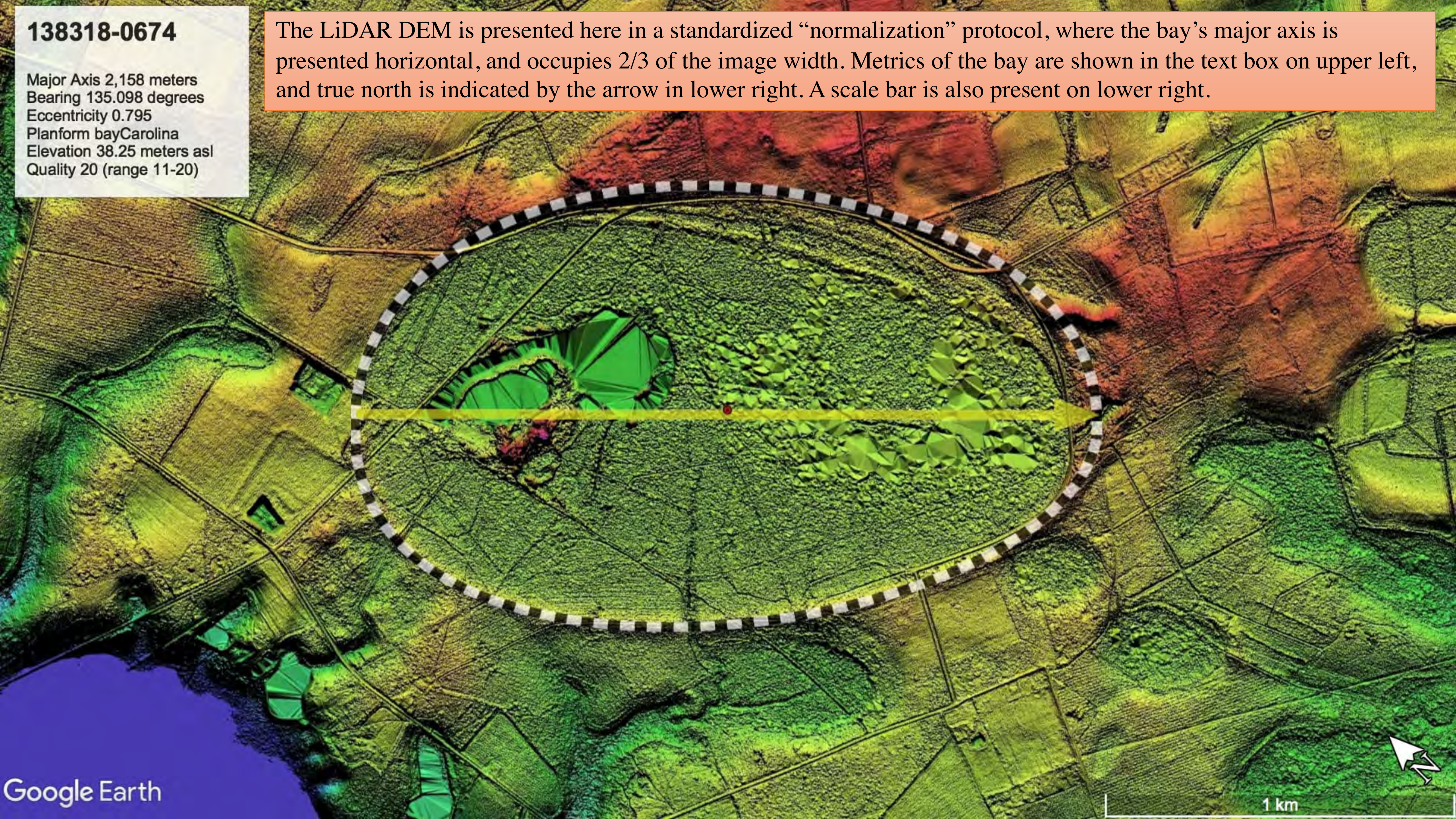








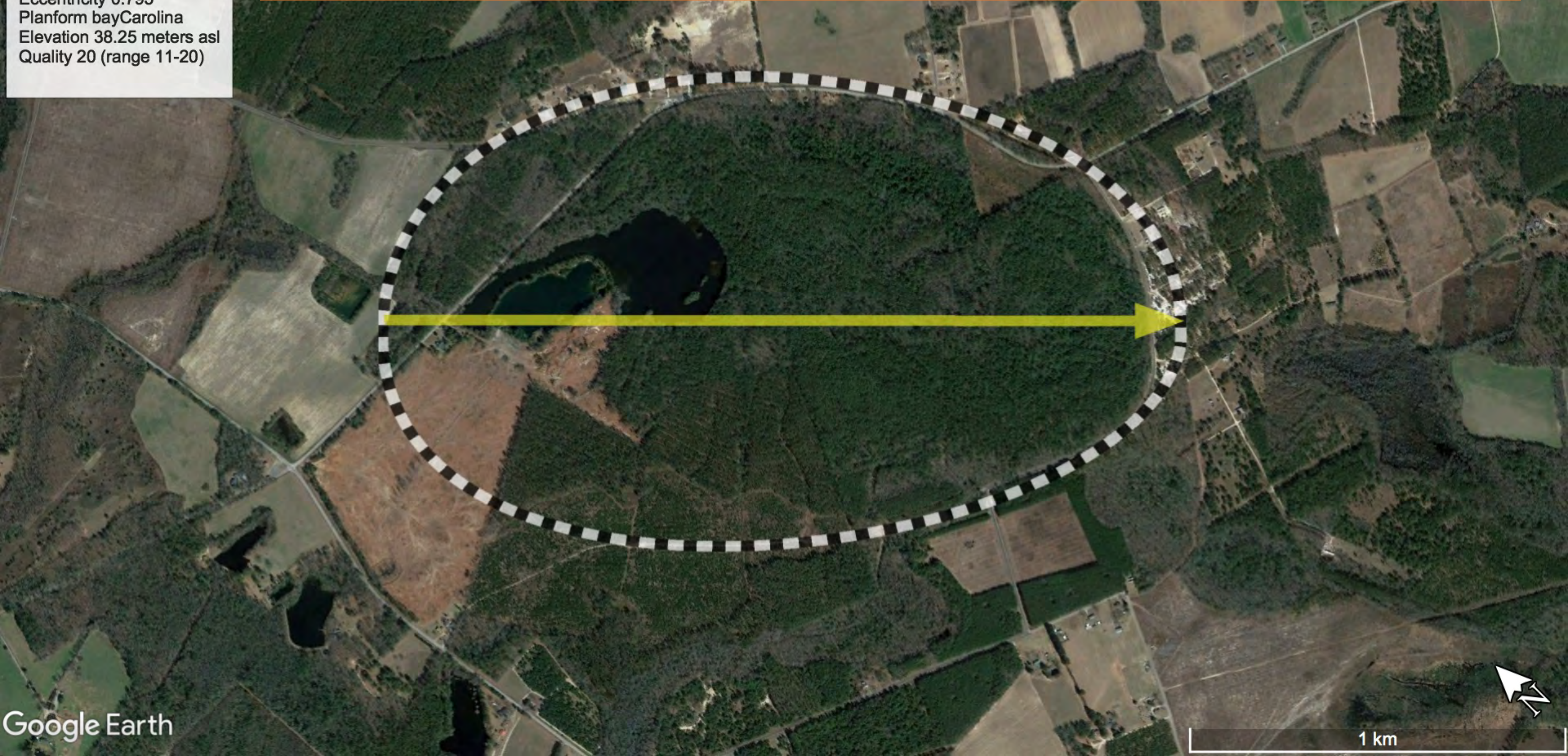


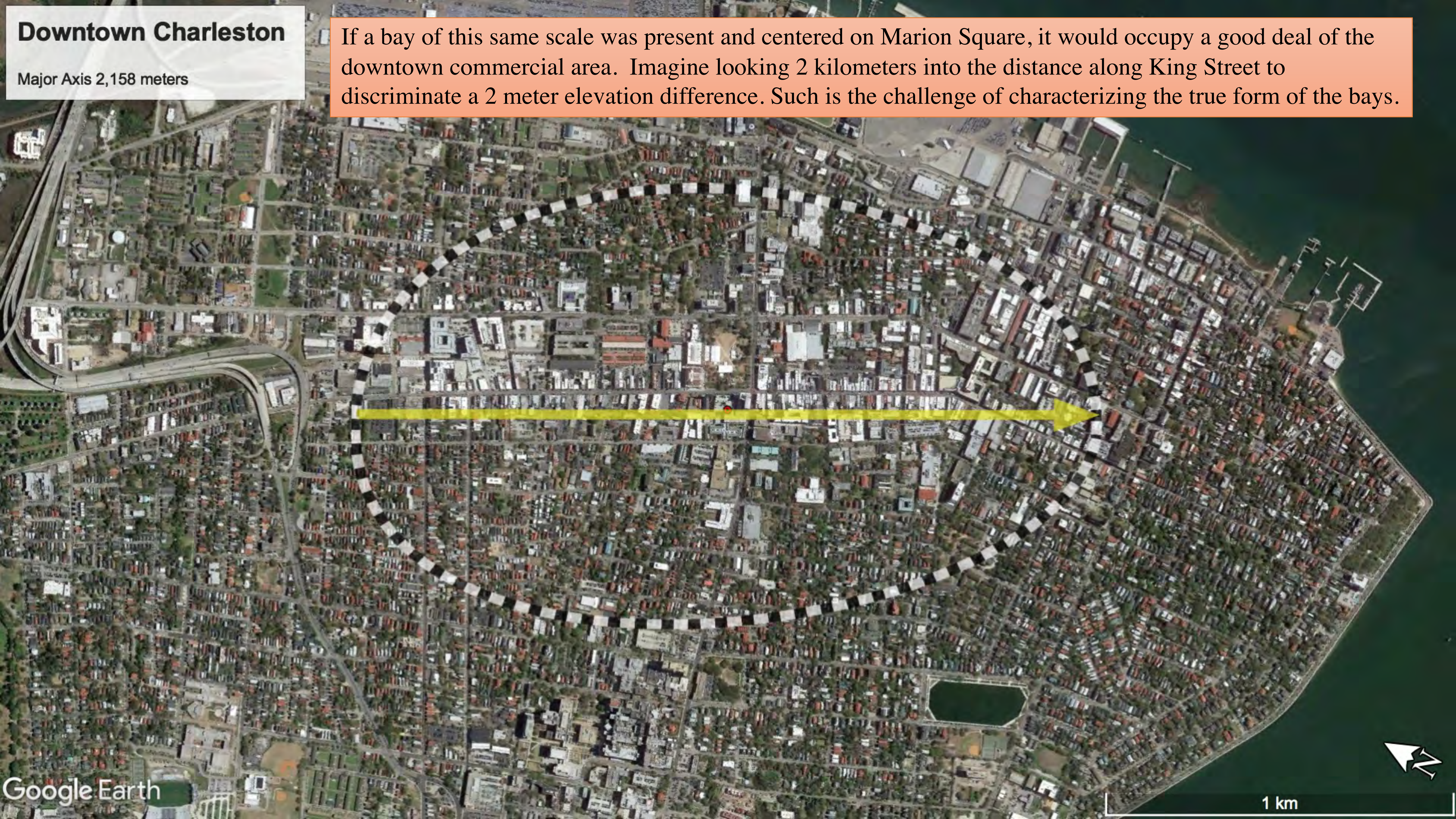

138318-0674
Major Axis 2,158 meters
Bearing 135.098 degrees
Eccentricity 0.795
Planform bayCarolina
Elevation 38.25 meters asl
Quality 20 (range 11-20)
The LiDAR DEM is presented here in a standardized “normalization” protocol, where the bay’s major axis is presented horizontal, and occupies 2/3 of the image width. Metrics of the bay are shown in the text box on upper left, and true north is indicated by the arrow in lower right. A scale bar is also present on lower right.
Google Earth
1 km

138318-0674

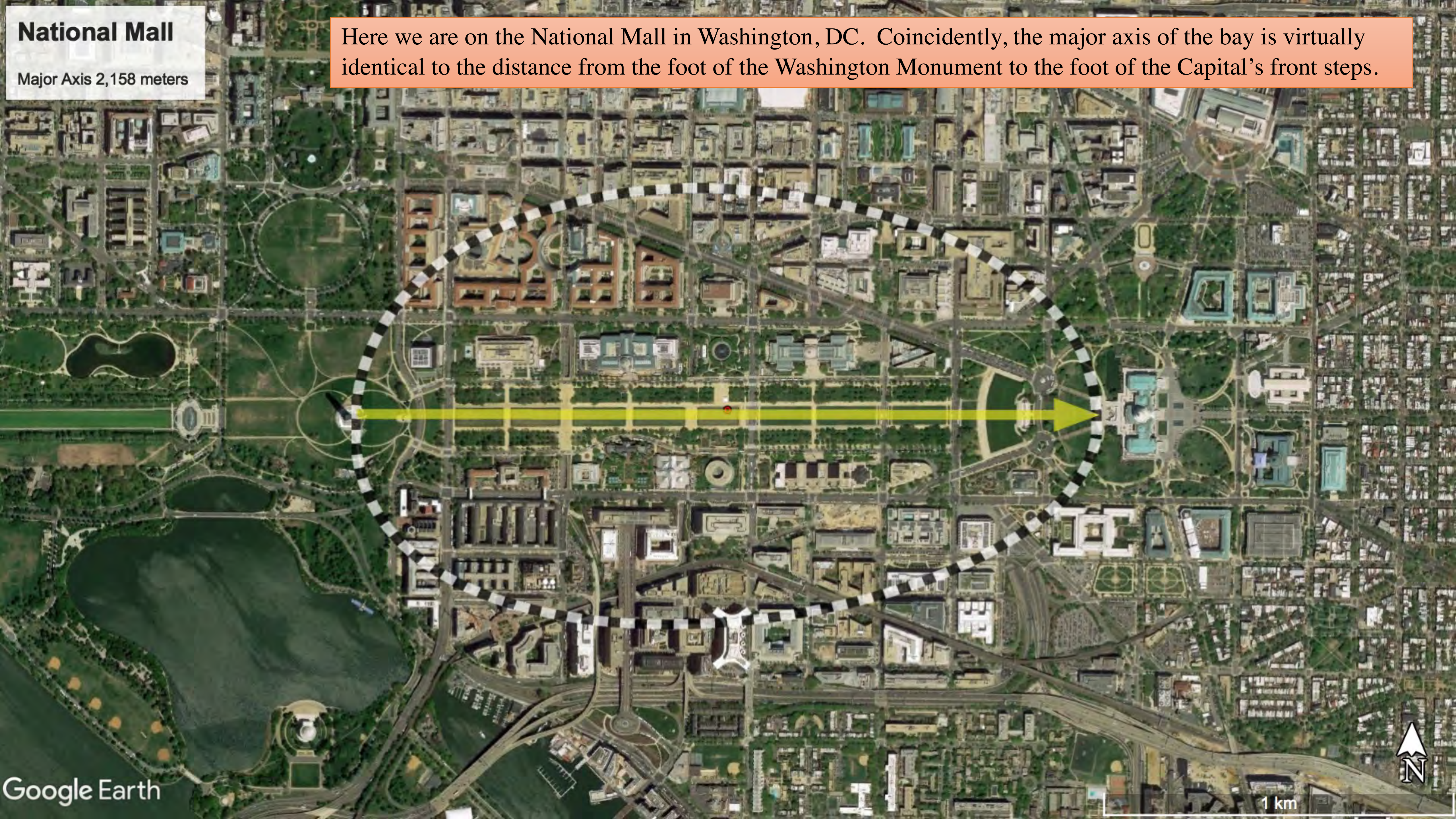
Major Axis 2,158 meters
Bearing 135.098 degrees
Eccentricity 0.795
Planform bayCarolina
Elevation 38.25 meters asl
Quality 20 (range 11-20)

Here is the same bay as visualized in Google Earth satellite imagery. At 2,158 meters on its major axis, its scale is truly incredible, and virtually impossible to visualize from this viewpoint as a Carolina bay. A quick glance tells us that measuring this bay using the orthophotography would fail to accurately capture its true size and shape.



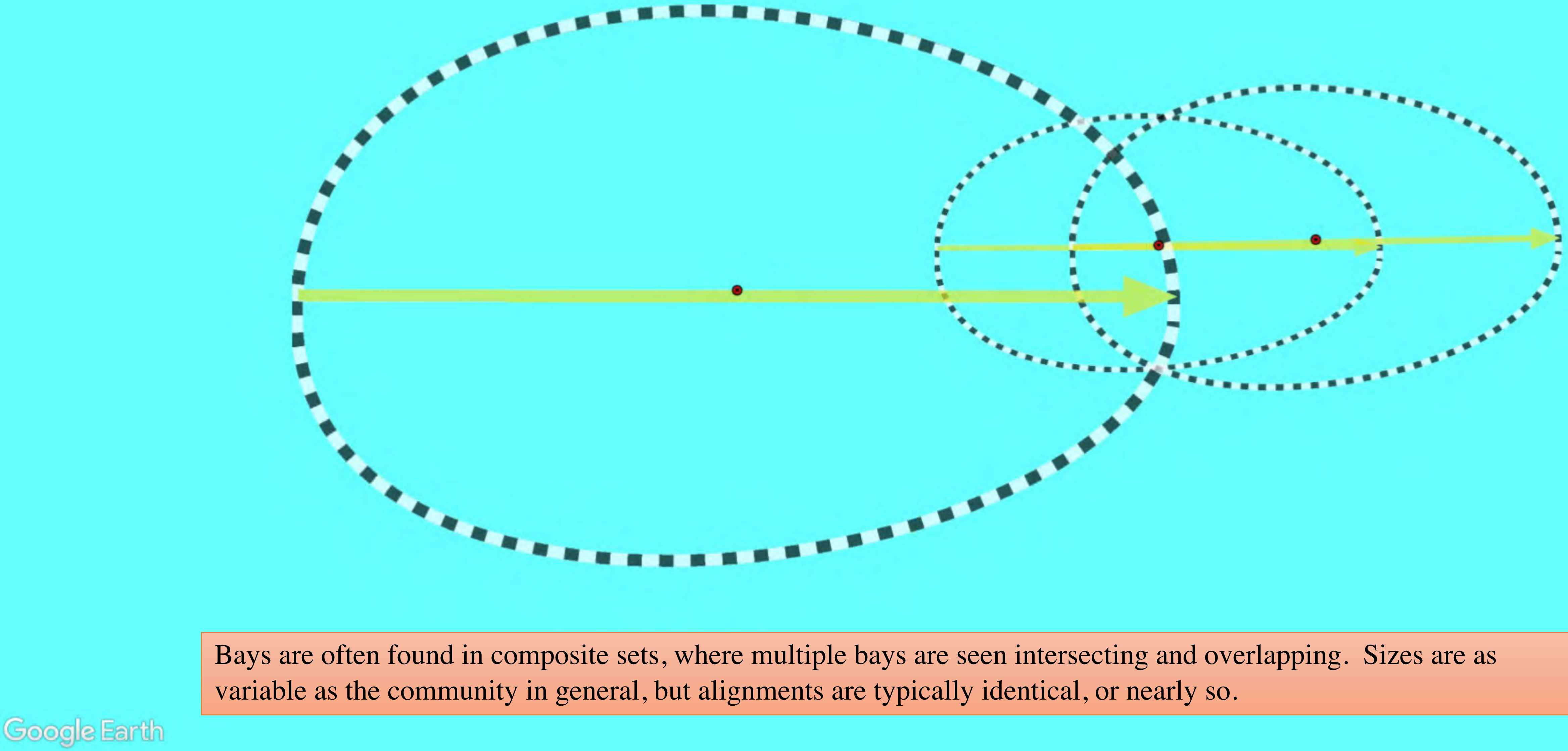

Downtown Charleston
Major Axis 2,158 meters
If a bay of this same scale was present and centered on Marion Square, it would occupy a good deal of the downtown commercial area. Imagine looking 2 kilometers into the distance along King Street to discriminate a 2 meter elevation difference. Such is the challenge of characterizing the true form of the bays.
Google Earth
1 km

Here we are on the National Mall in Washington, DC. Coincidently, the major axis of the bay is virtually identical to the distance from the foot of the Washington Monument to the foot of the Capital’s front steps.



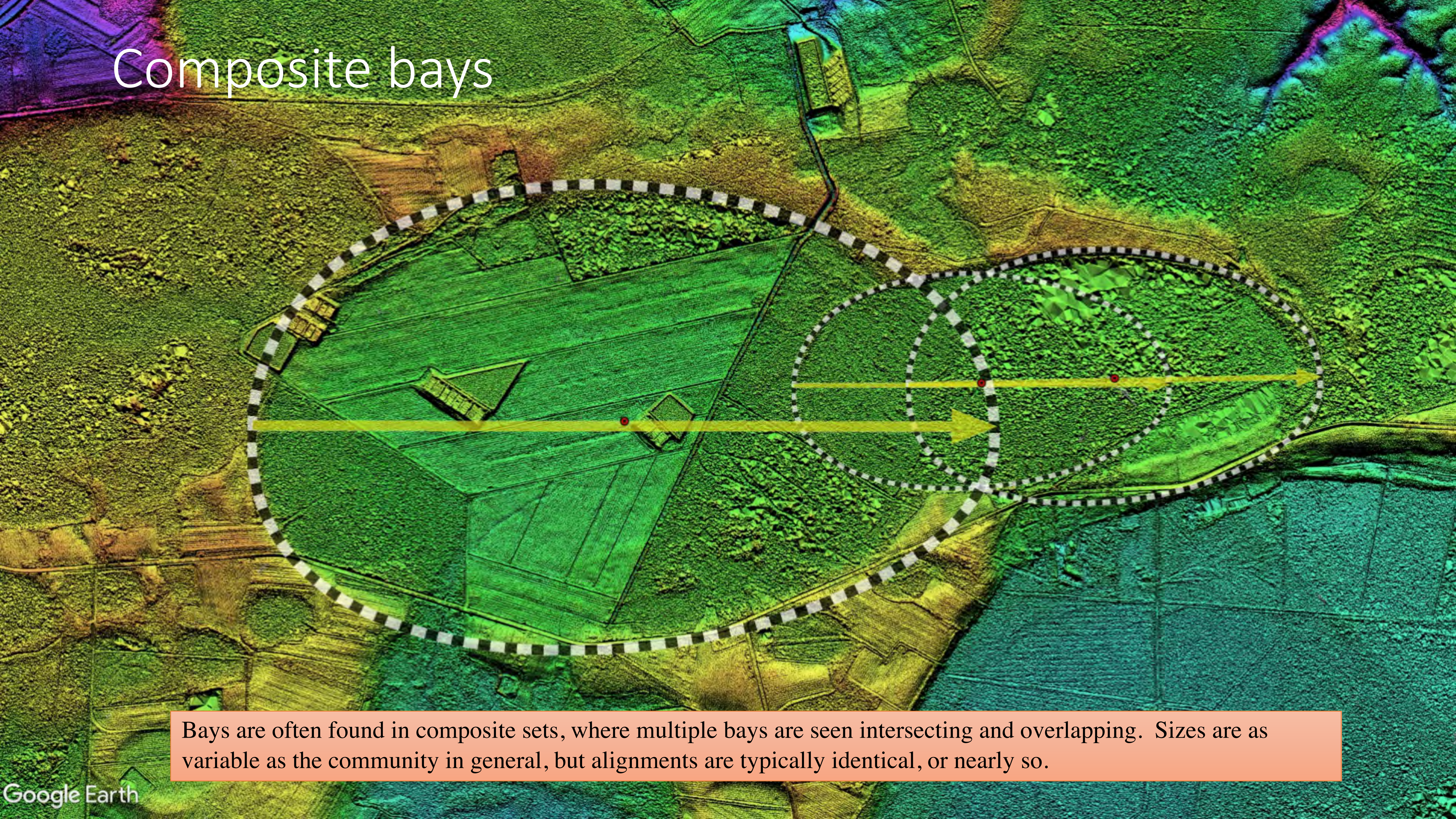

138318-0674
Major Axis 2,158 meters
Bearing 135.098 degrees
Eccentricity 0.795
Planform bayCarolina
Elevation 38.25 meters asl
Quality 20 (range 11-20)
Here is the bay without the overlay. The “walking” distance along this rim is well over 5 kilometers. My protocol for generating the DEM pumps up the elevation by 20x, otherwise the fine detail of its profile would be lost. It has been suggested that that exaggeration is responsible for the presence of a smooth-looking rim, but elevation exaggeration is a common facet of any geophysical representation, be it a DEM, a diagram of a transect or a GPR plot.
The rim structure is there, all the way around. Deal with it.
Google Earth
1 km

Composite bays



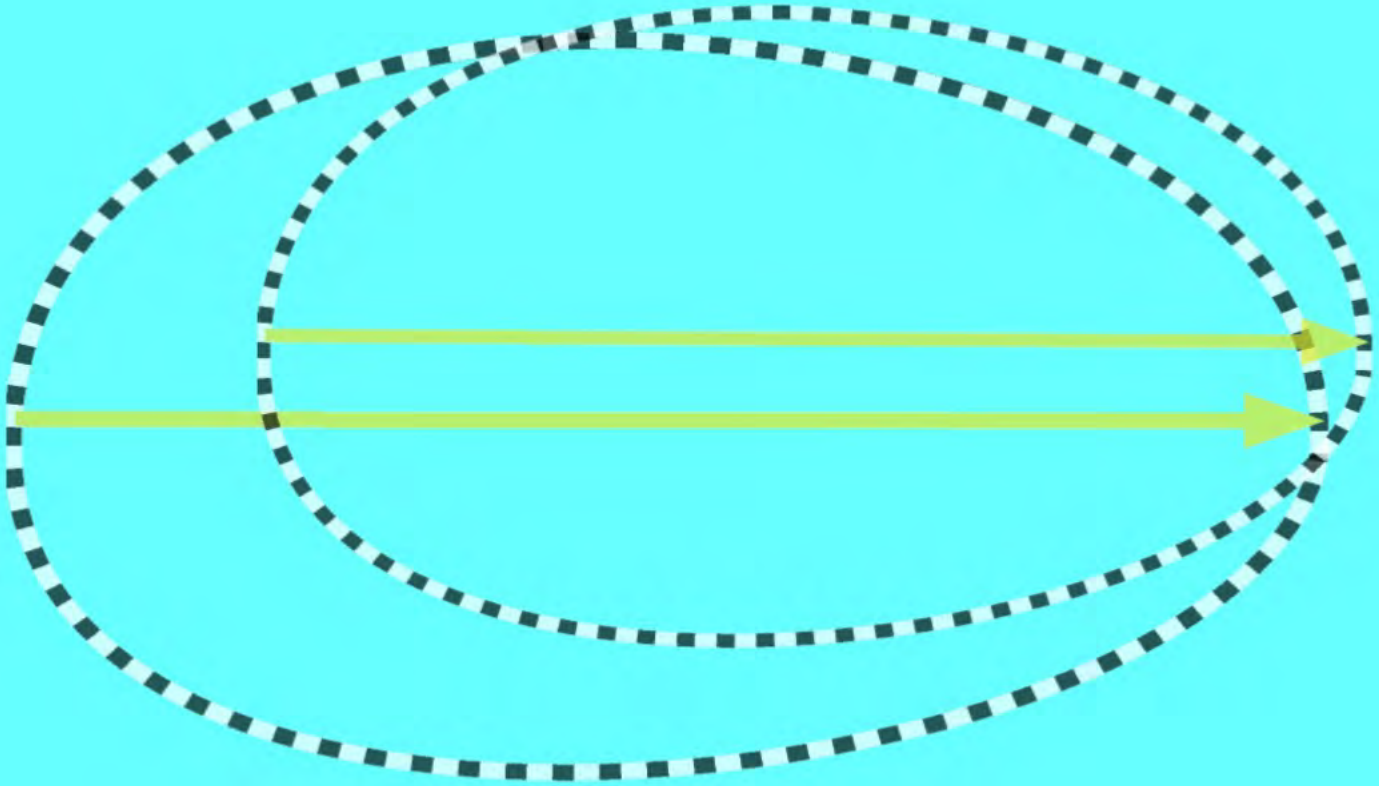
Bays are often found in composite sets, where multiple bays are seen intersecting and overlapping. Sizes are as variable as the community in general, but alignments are typically identical, or nearly so.

Composite bays



Bays are often found in composite sets, where multiple bays are seen intersecting and overlapping. Sizes are as variable as the community in general, but alignments are typically identical, or nearly so.

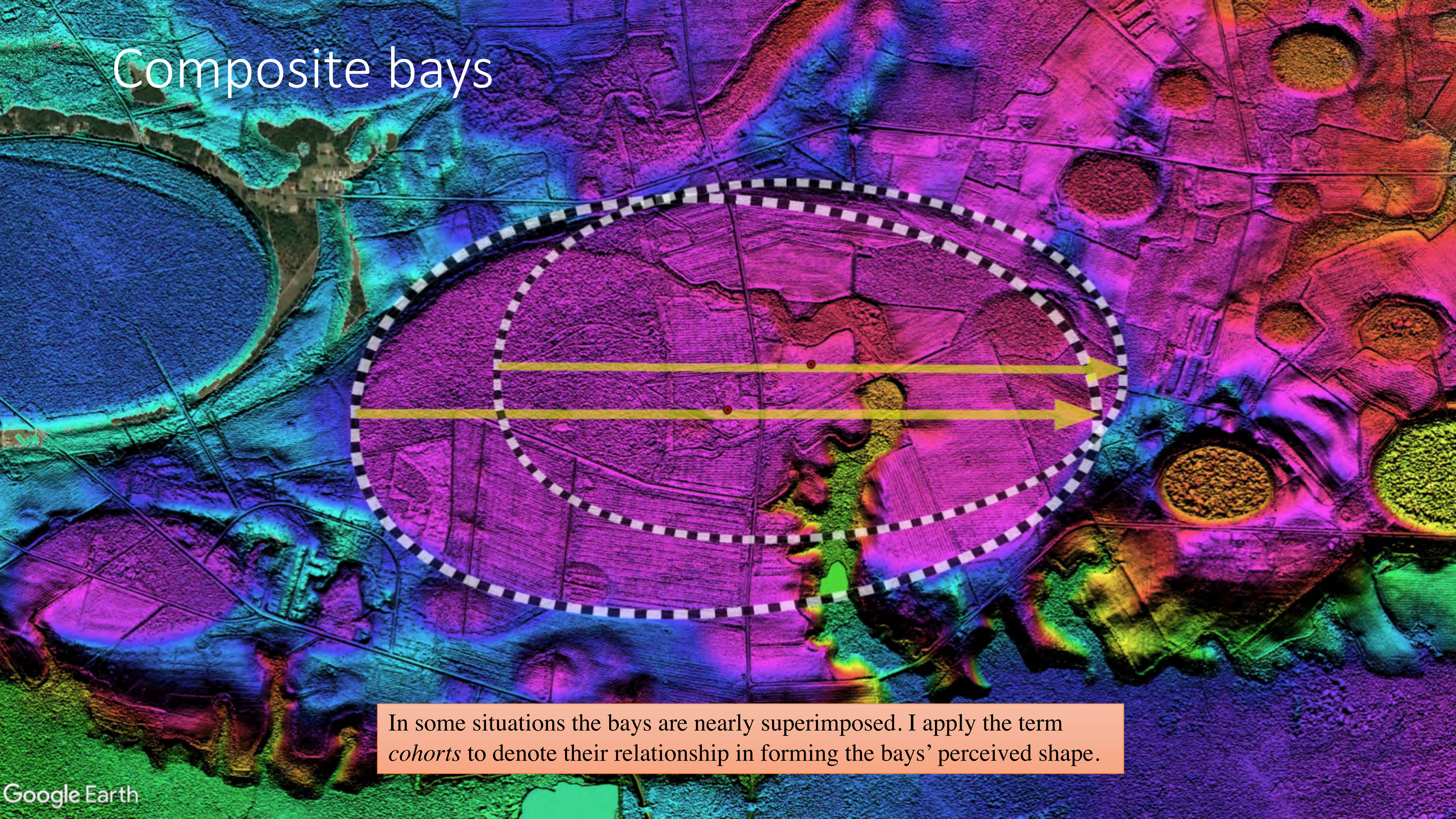
Composite bays



In some situations the bays are nearly superimposed. I apply the term *cohorts* to denote their relationship in forming the bays' perceived shape.

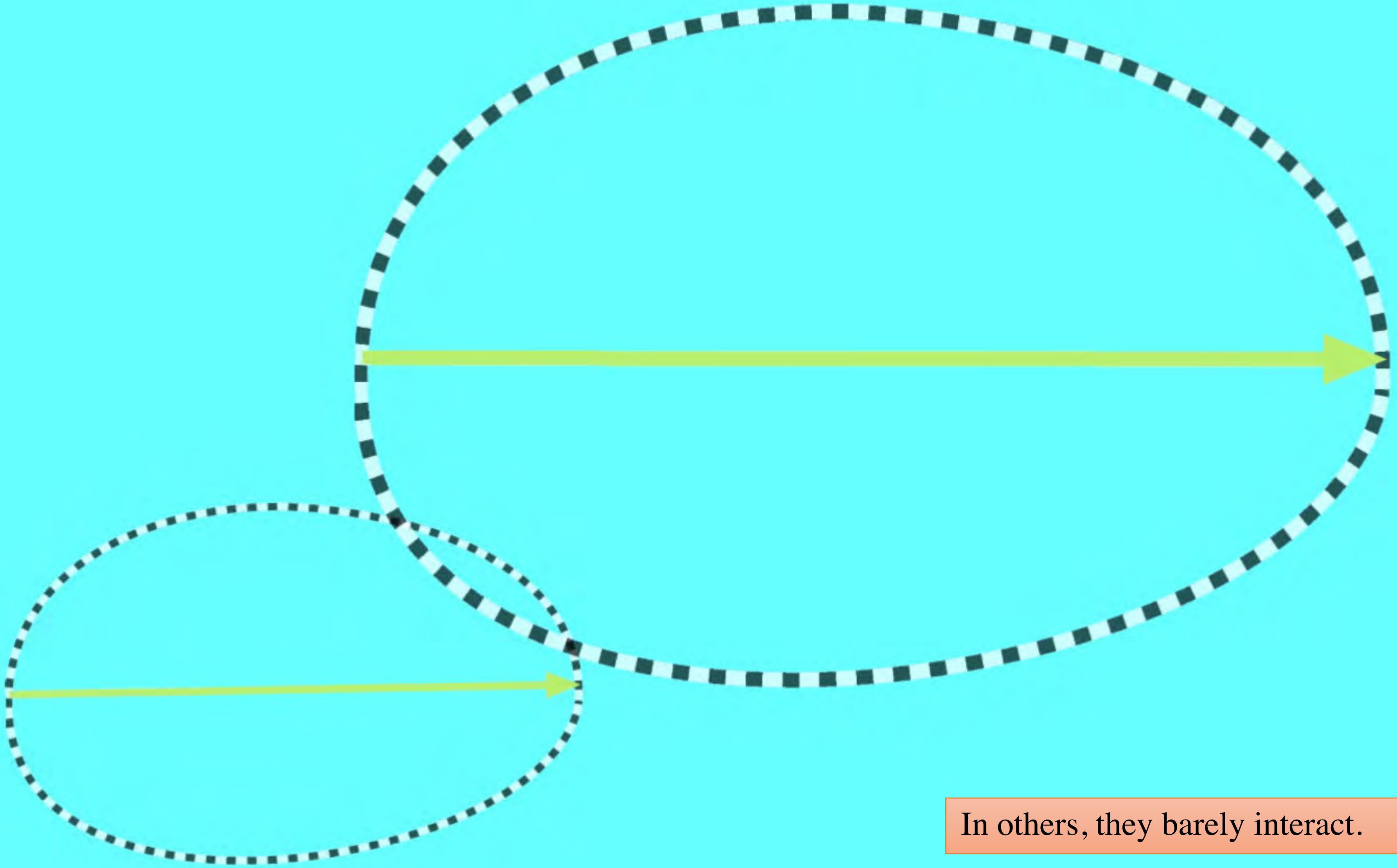
Google Earth

Composite bays



In some situations the bays are nearly superimposed. I apply the term *cohorts* to denote their relationship in forming the bays' perceived shape.

Composite bays

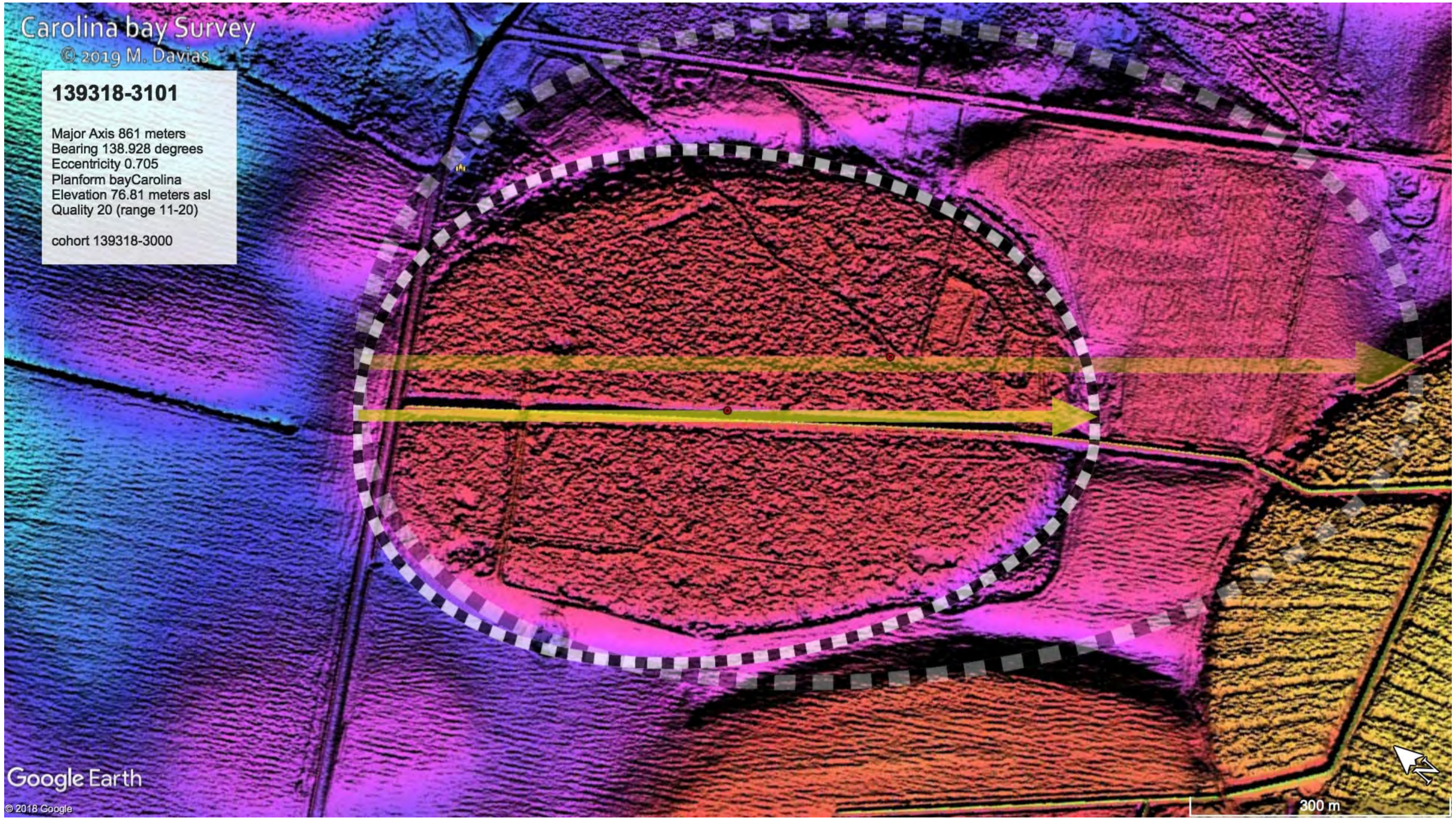


In others, they barely interact.

Google Earth


Composite bays
In others, they barely interact.
Google Earth

Example: Use of the Overlay to fit bays



A movie demonstrating the cloning of one bay's overlay to create a cohort's planform can be seen in this movie:
`http://cintos.org/GSA-SE_2019/139318-3101_cloning.mp4`

Keyhole Markup Language Data in GroundOverlay

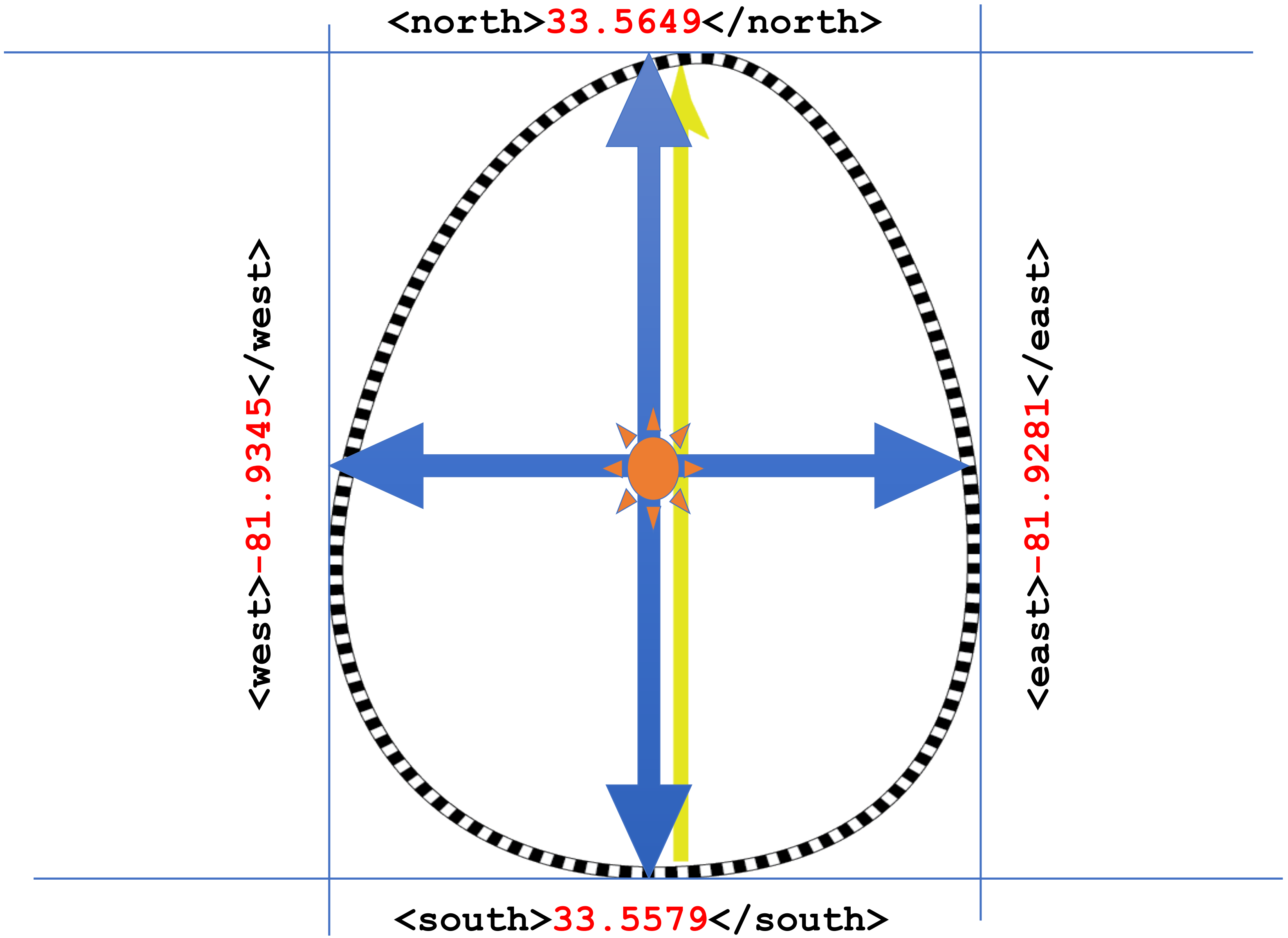
A png image file is referenced from our servers to provide the overlay outline on Google Earth.

The *groundOverlay* meta data's bounding box defines (with a bit of trig) the major and minor axis of the bay, a bay center, and an approximate surface area. Coordinates define the box with zero rotation applied.

The orientation is derived from the *rotation* meta data.

```
<GroundOverlay>
          <name>134327_2472</name>
                    <Icon>
          <href>http://cintos.org/ge/survey/planform/bayCarolina.png</href>
                    </Icon>
                    <LatLonBox>
                              <north>33.56496759262686</north>
                              <south>33.55789073070017</south>
                              <east>-81.92816781208678</east>
                              <west>-81.93459628710748</west>
                    <rotation>-157.3564252687467</rotation>
                    </LatLonBox>
</GroundOverlay>
```

GroundOverlay LatLonBox Computations



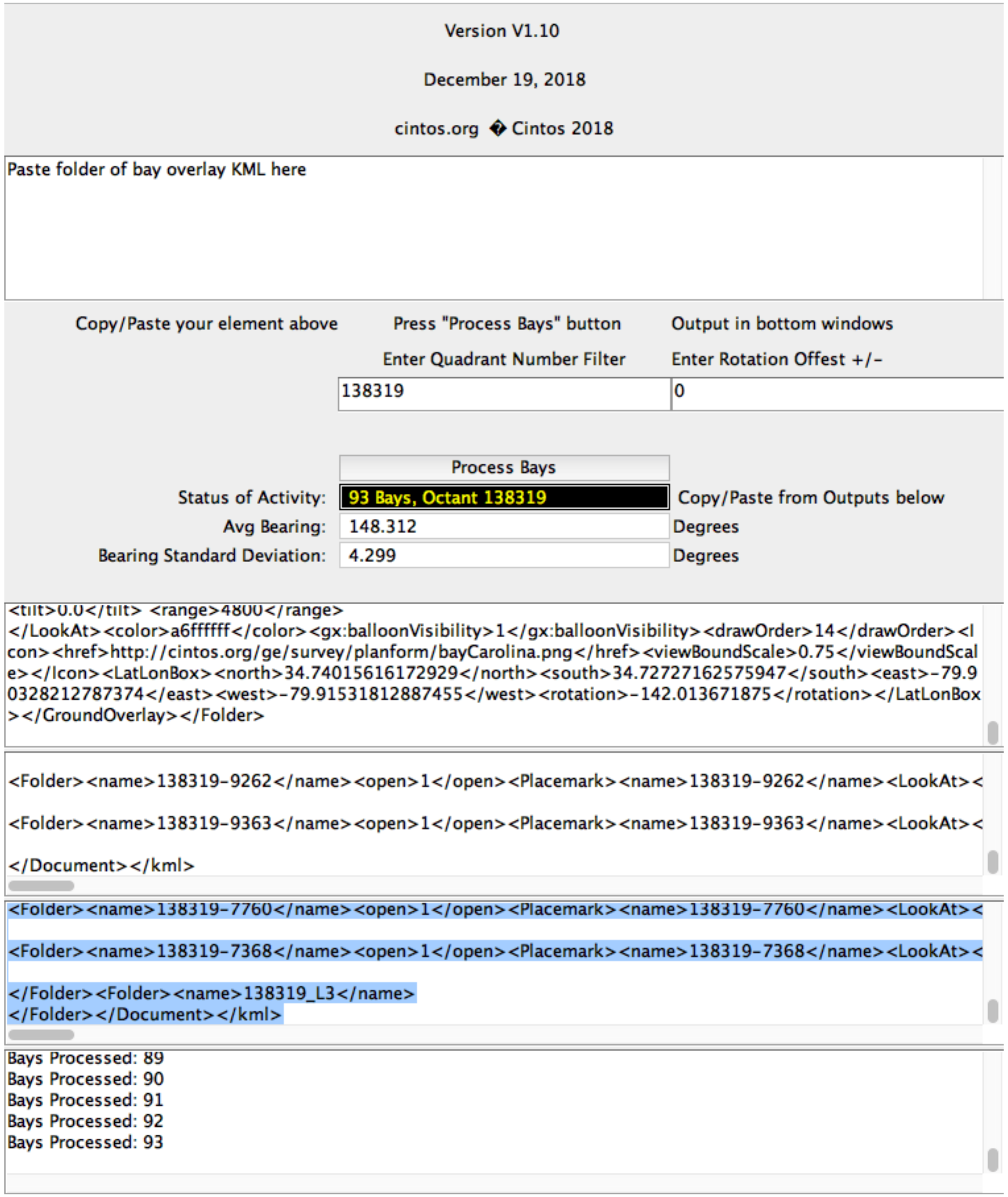
Java Program

A Java program ingests a folder of bays coped from Google Earth and generates output by interrogating the metadata from the kml *groundOverlay*.

Outputs are

1. csv format for database
2. folder of kml sorted by bay name
3. folder triaged into largest 10%, next 40% and smallest 50% for presentation using Google Regions

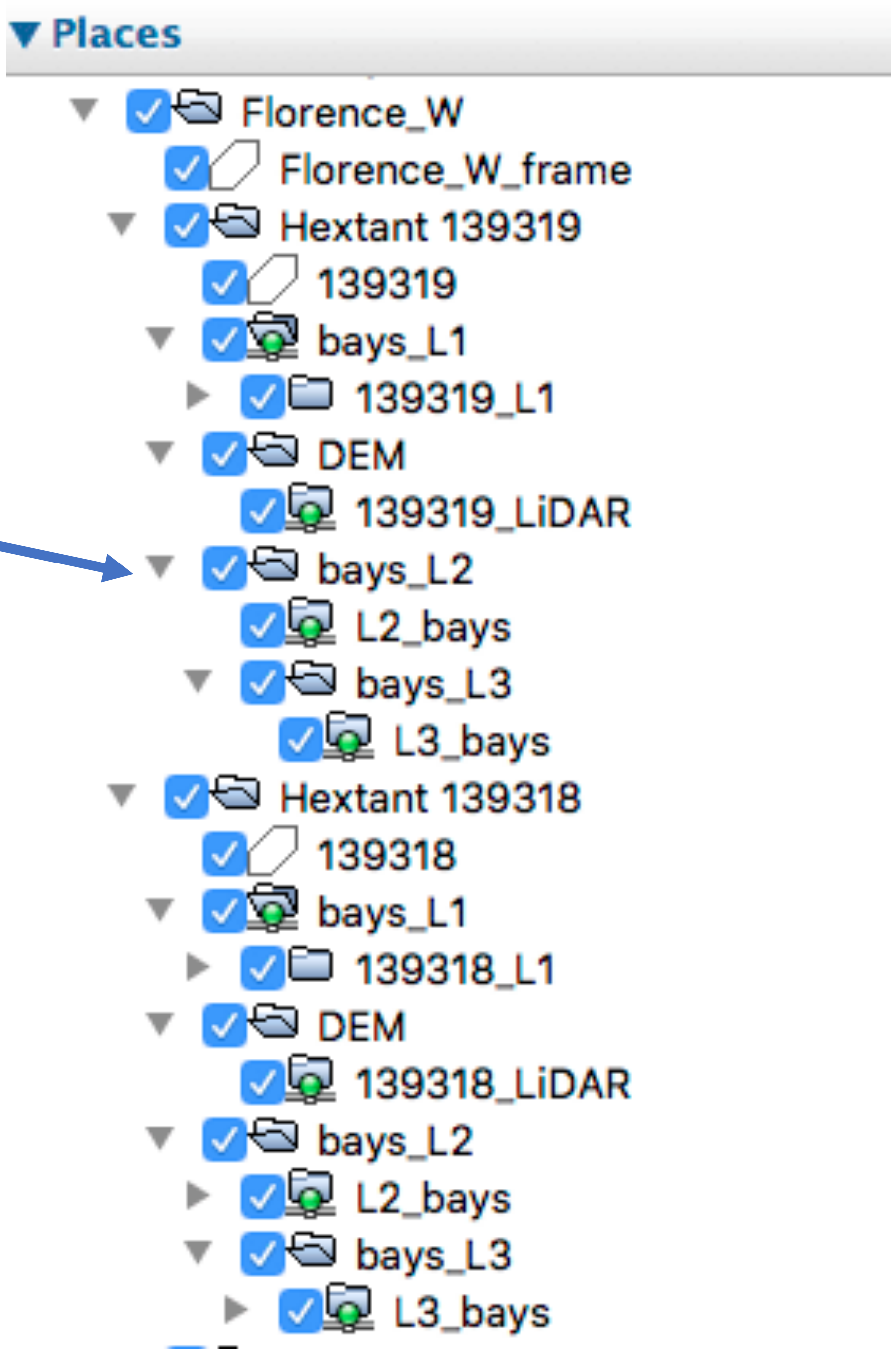
Google *Regions* are also used to present the LiDAR tile set at increasingly higher resolutions as viewer zooms in. The regionalization keeps the application, server and network links from being overloaded.



Hierarchy of KML structure

- example of Region coding

```
<Folder>
    <name>bays_L2</name>
    <Region>
        <LatLonAltBox>
            <north>35</north>
            <south>34.75</south>
            <east>-79.75</east>
            <west>-80</west>
        </LatLonAltBox>
        <Lod>
            <minLodPixels>2048</minLodPixels>
            <maxLodPixels>-1</maxLodPixels>
        </Lod>
    </Region>
```

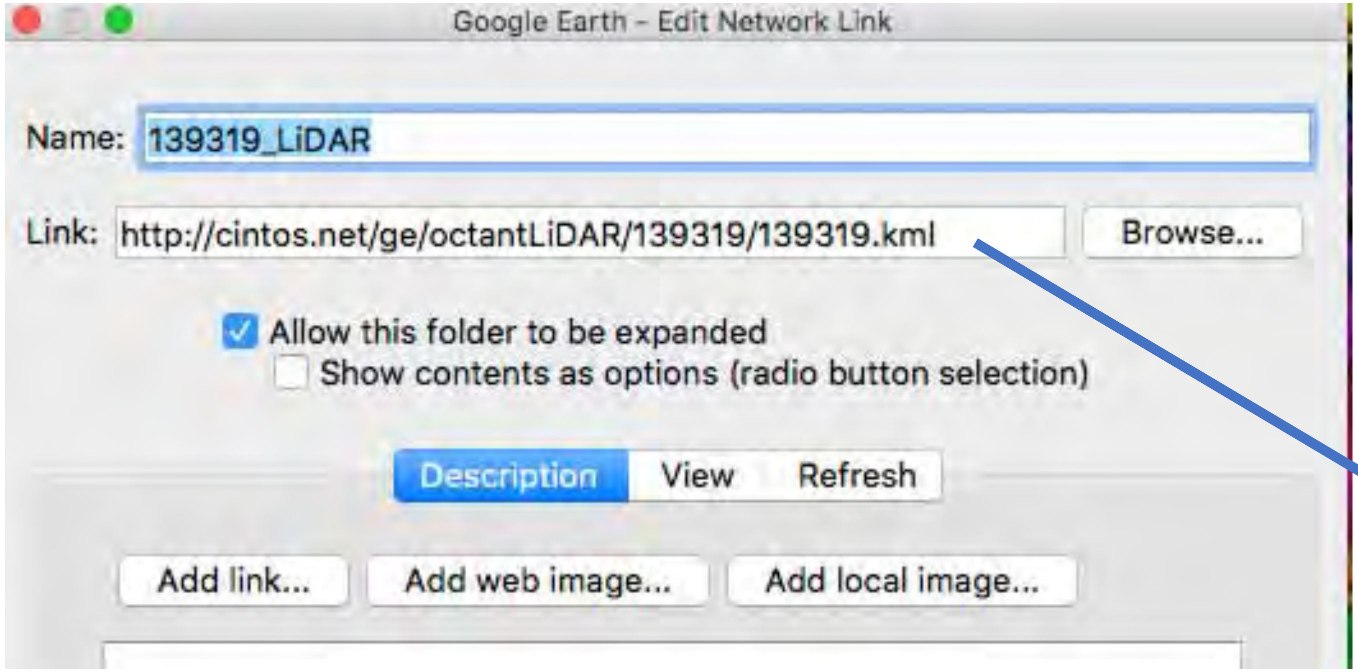


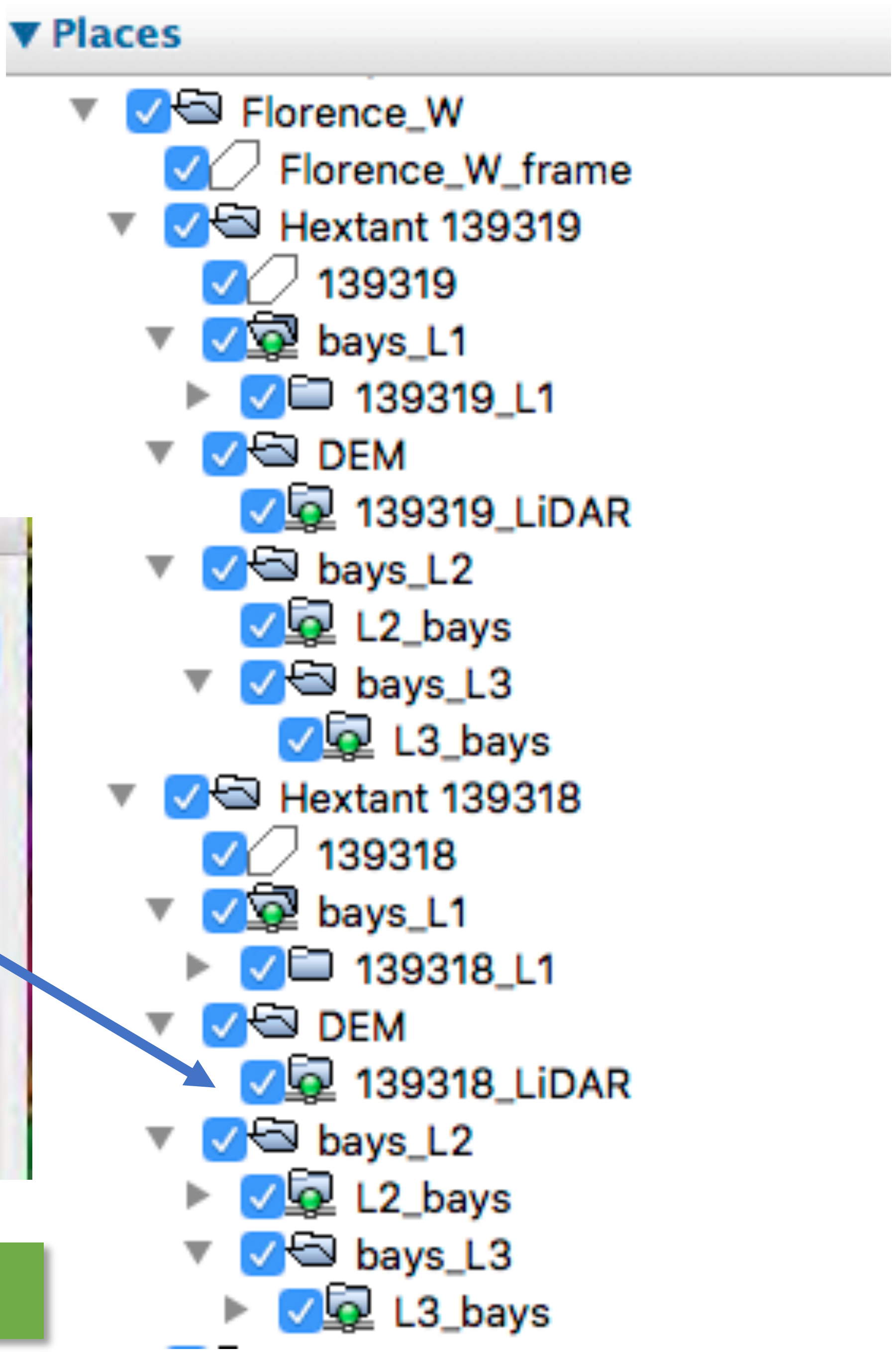
The folder ”bays_L2” will load the network link “L2_bays” when the geographical area described by the LatLonAltBox’s coordinates occupies a minimum of 2048 pixels on the display, and never turns off (-1).

Hierarchy of KML structure

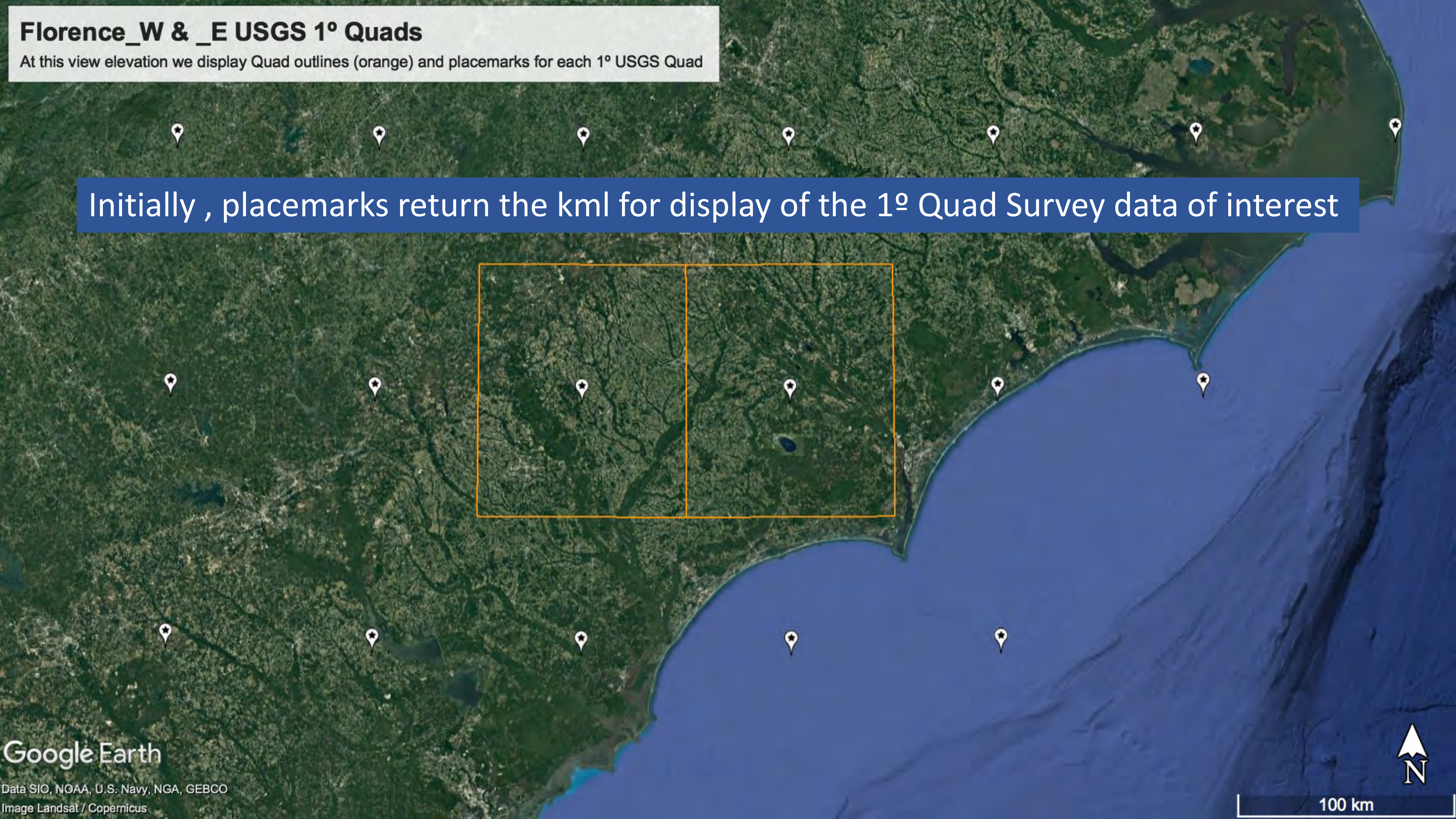
- Network Links

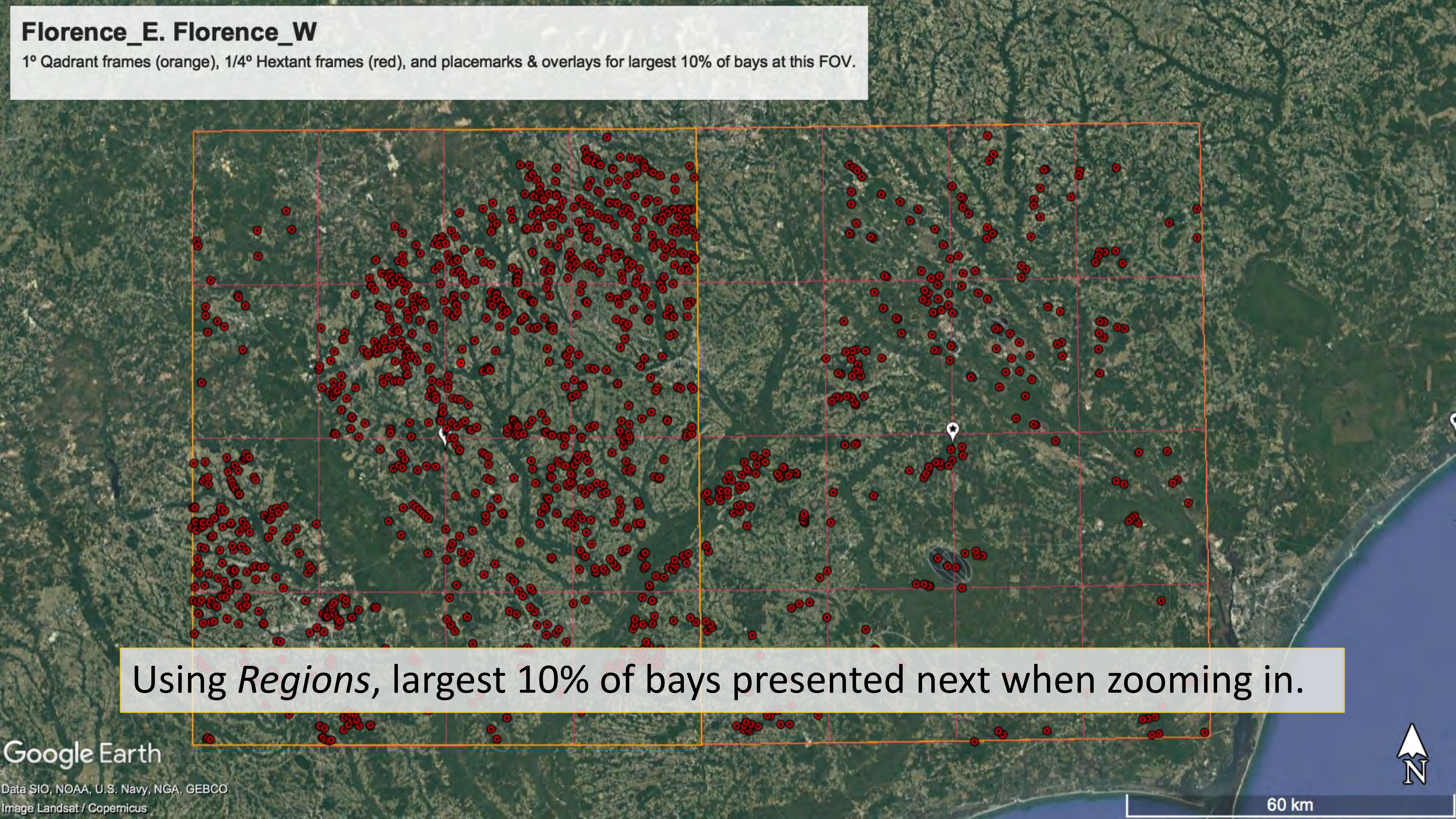
The Network Link facility provides a vehicle to access a large amount of data to be loaded from a networked location, without burdening the KMZ file with the responsibility to carry that data in the file.

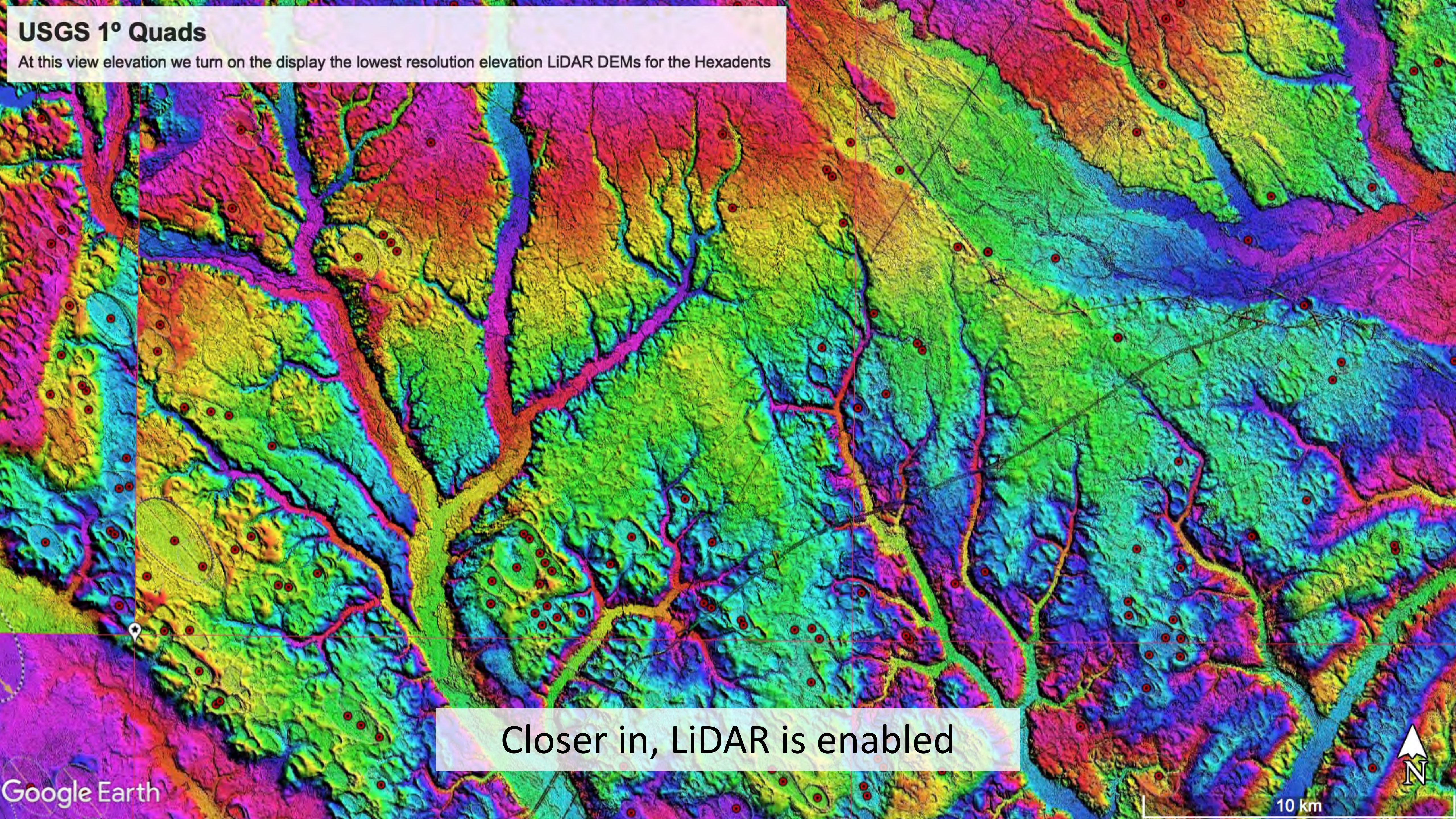




The Florence Quads KML file is only 110 kbytes

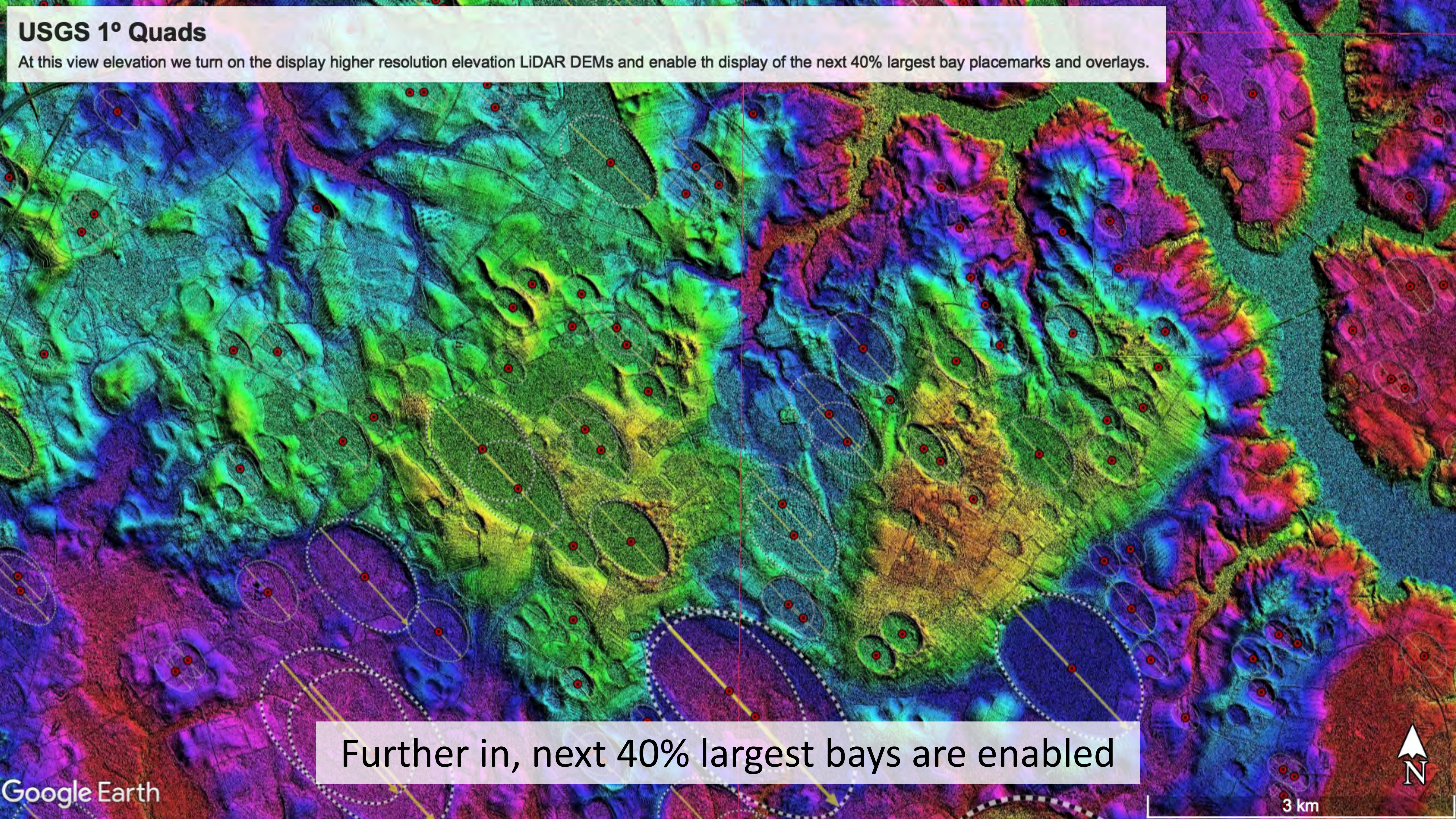

Florence_W & _E USGS 1º Quads
At this view elevation we display Quad outlines (orange) and placemarks for each 1º USGS Quad
Initially , placemarks return the kml for display of the 1º Quad Survey data of interest
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
N
100 km


Florence_E. Florence_W
1º Qadrant frames (orange), 1/4º Hextant frames (red), and placemarks & overlays for largest 10% of bays at this FOV.
Using *Regions*, largest 10% of bays presented next when zooming in.
Google Earth
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
60 km
N


USGS 1º Quads
At this view elevation we turn on the display the lowest resolution elevation LiDAR DEMs for the Hexadents
Closer in, LiDAR is enabled
Google Earth
N
10 km

USGS 1º Quads

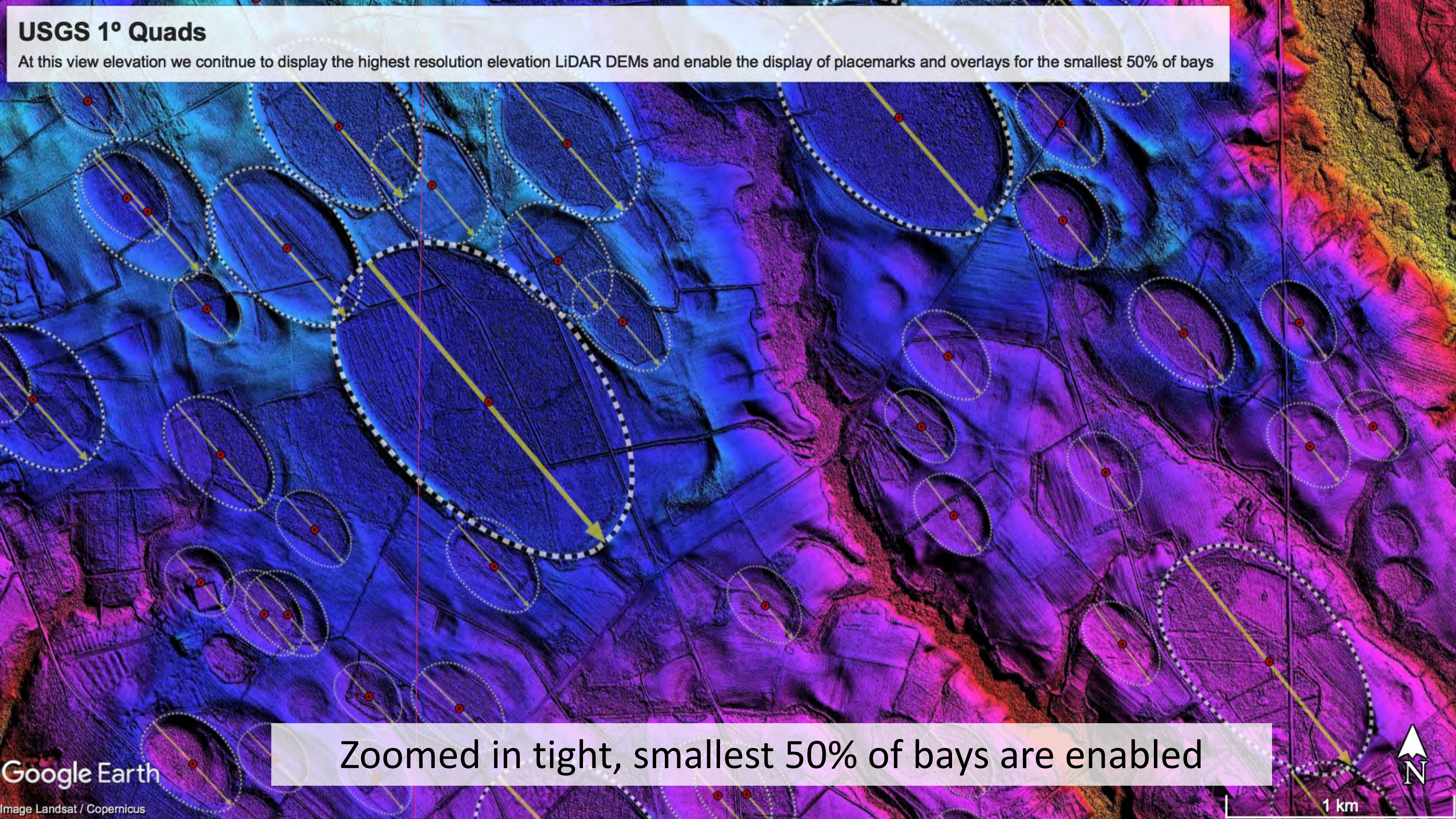
At this view elevation we turn on the display higher resolution elevation LiDAR DEMs and enable th display of the next 40% largest bay placemarks and overlays.



Further in, next 40% largest bays are enabled

USGS 1º Quads

At this view elevation we conitnue to display the highest resolution elevation LiDAR DEMs and enable the display of placemarks and overlays for the smallest 50% of bays



Zoomed in tight, smallest 50% of bays are enabled

… about the LiDAR

- Point cloud data sourced from public repositories
- Now getting some areas from USGS in 1 meter DEMs (whew!)
- Global Mapper commercial GIS used to assemble disparate footprints
- Output “seamless” .25 deg “hextant”, as 1/16 of a USGS 1 deg Quad
- Our Cloud-based LiDAR DEMs generated on 150 cm horizontal grid
- Some bay-specific DEMs generated on 50 & 100 cm horizontal grid
- All LiDAR images are web-accessible and *View Region* sensitive
- Very lightweight KMZ files, uses network links to load from cloud
    - LiDAR
    - Placemarks
    - Planform overlays
- Visualization implemented on the Google Earth Virtual Globe

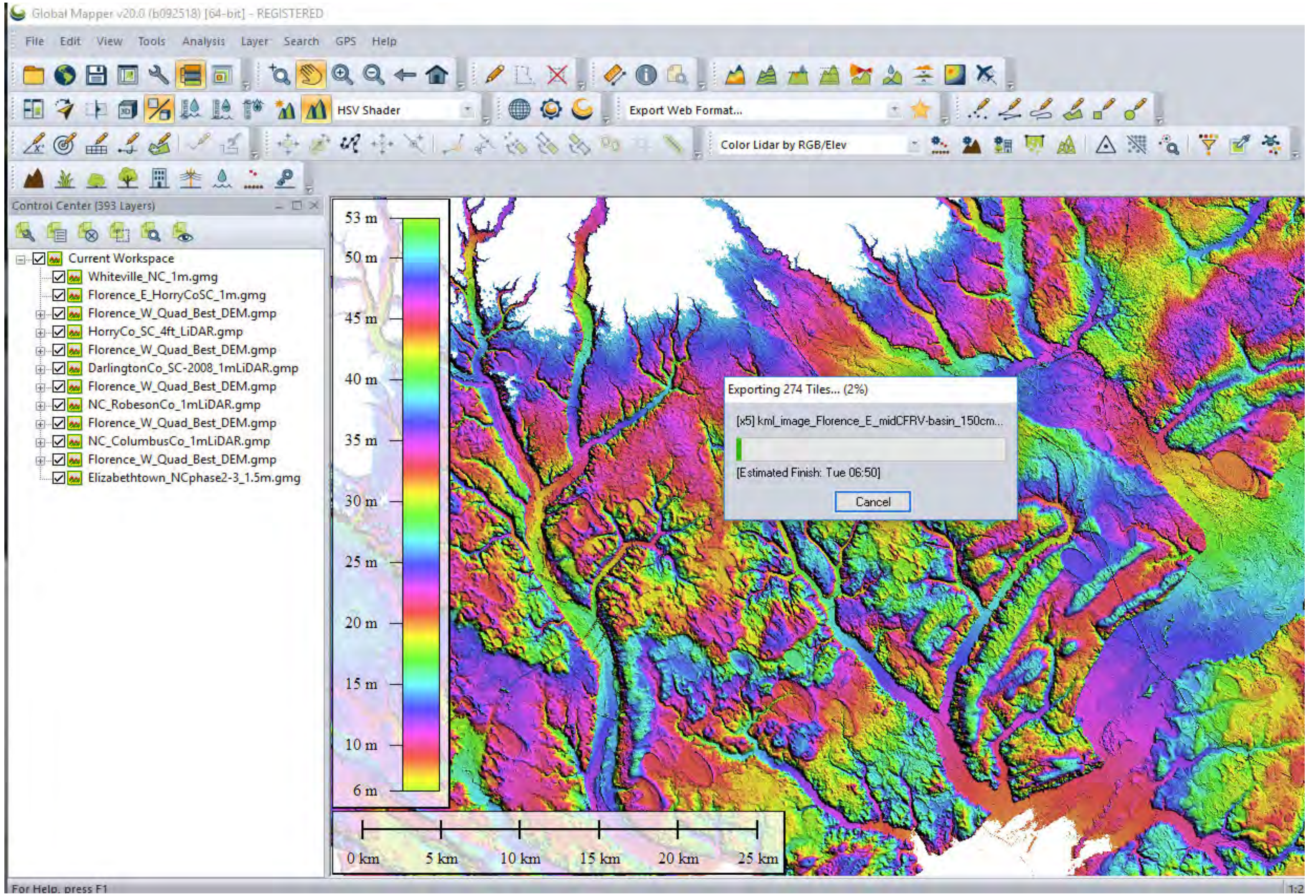
… about the LiDAR

Global Mapper commercial GIS system is used to compile various county-scale LiDAR point clouds into seamless datasets for areas as large as a 1° USGS Quadrant.

The hsv-shaded elevation imagery is exported from Global Mapper as KMZ-indexed tile sets. These are fed into Google Earth for visualization of the true bay shapes.

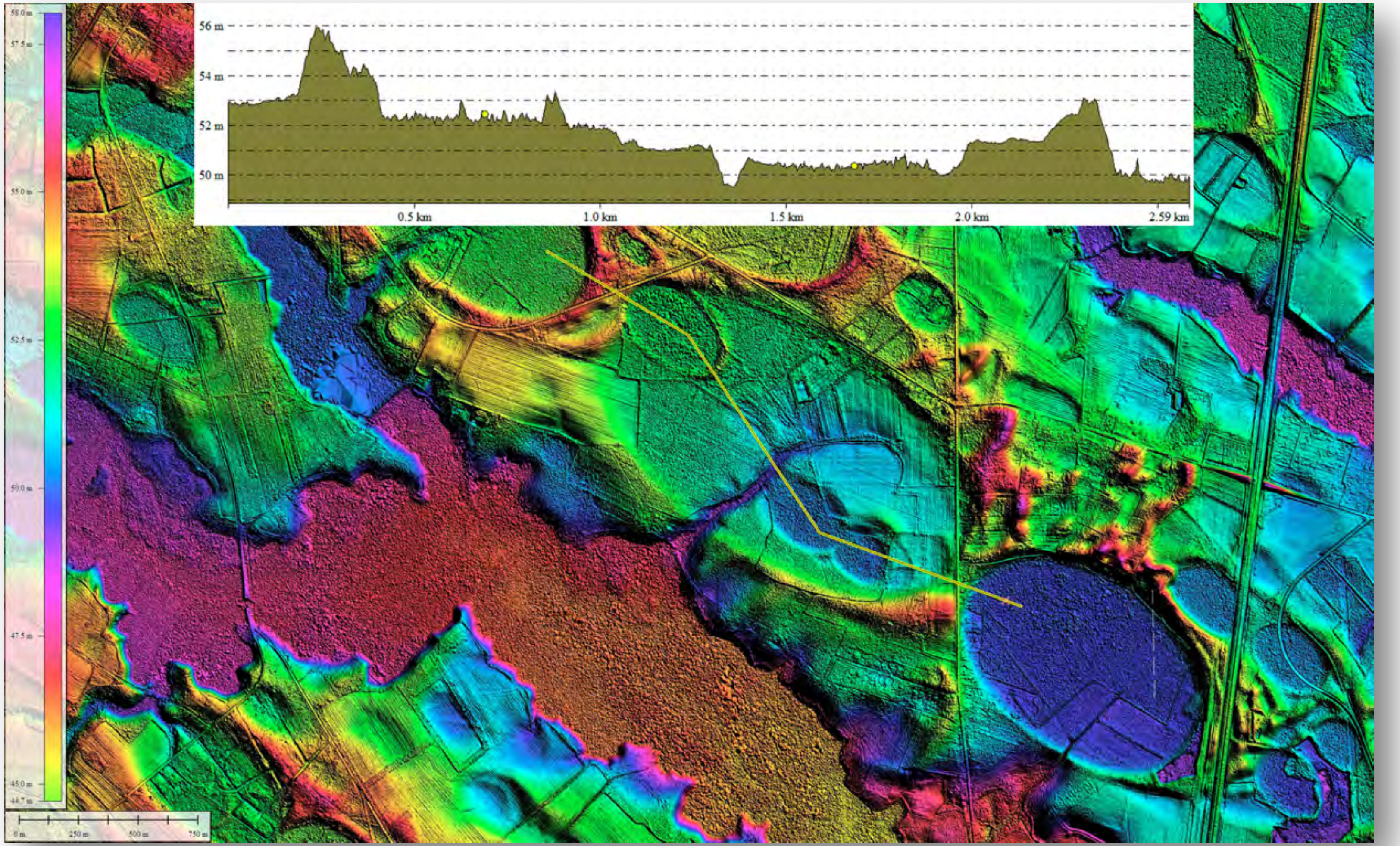
Tile sets have for over 1,000 ¼° quadrant been generated, covering all areas of the continent that offer LiDAR coverage and are known to host Carolina bays.

I am looking forward to acquiring more LiDAR from Georgia, which is lagging behind other states on the Eastern Coast.



Elevation Profiles

Global Mapper commercial GIS system is also used to generate maps for various uses. This example demonstrates the use of Elevation Profile across a selected transect.

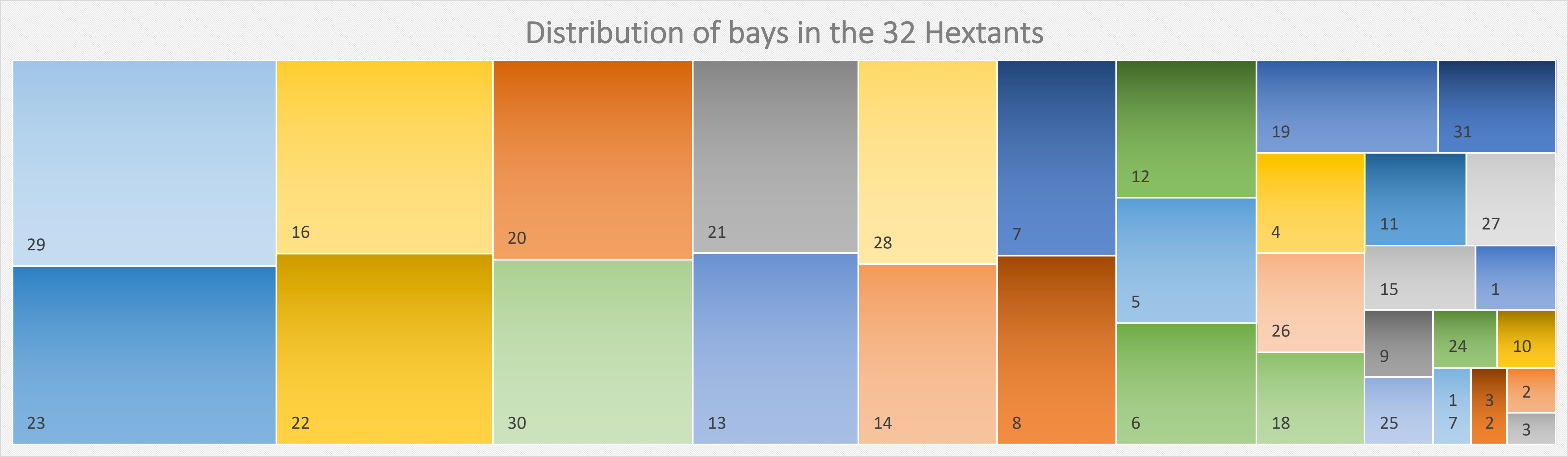


DEM Imagery enhanced

- hsv-shaded using high gain (multiple passes through spectrum)
  - ✓ No attempt made to communicate actual elevations
  - ✓ Looking for 1 m relief of planforms on scale of 100’s of meters to 10 kilometer
  - ✓ Still challenging to get color visualization of 1 meter changes when a USGS Quad can represent 200 m of elevation change
- 20x elevation exaggeration (@ “0” you see very little)
- Hill shading applied

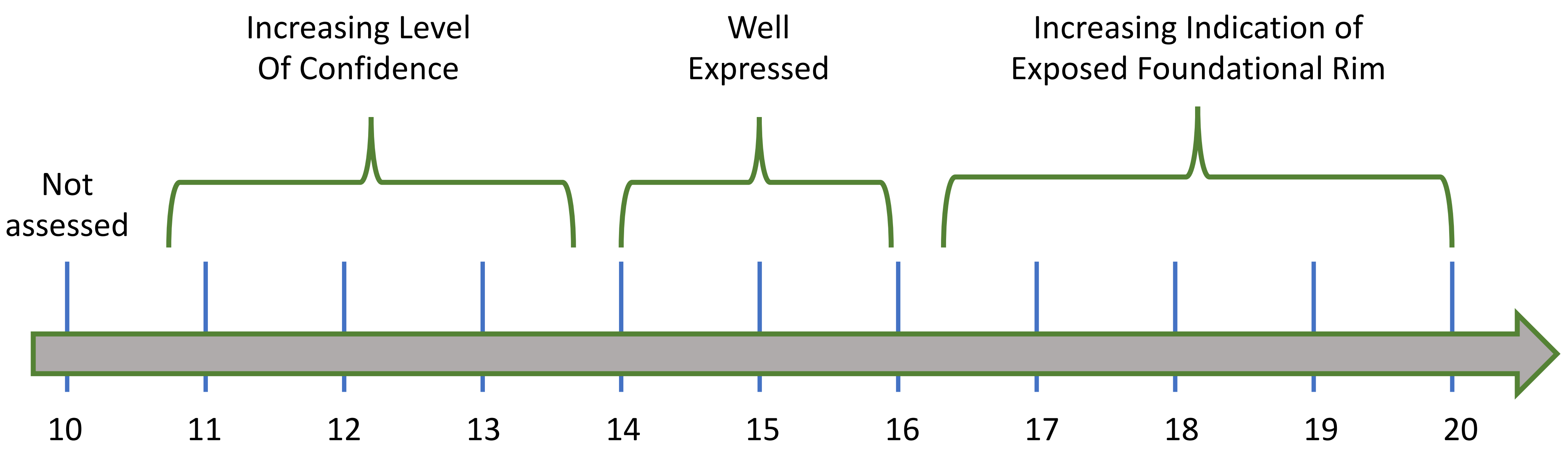
bayCarolina counts in 1º Florence W & E Quads

- Carolina bays Measured in Survey: 51,362
- Total *bayCarolina* planforms Measured in full Survey: 26,047 (~50% of all bays)
- Measured in USGS 1º Florence W & E Quads: 14,944 (~60% of all *bayCarolina* forms)

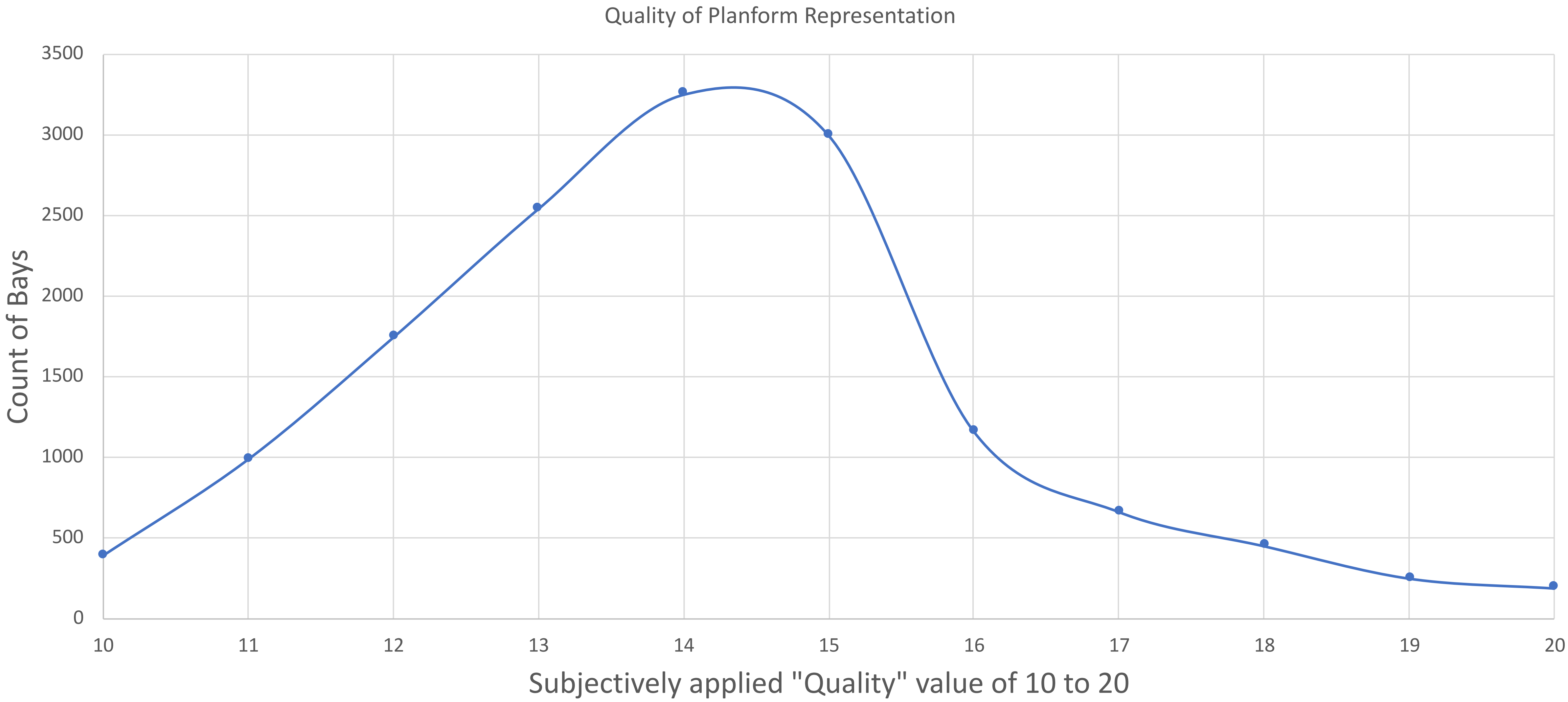


Applying a Subjective Bay "Quality" Metric

- All landforms in the survey are considered by us to match the applied archetype overlay
- User-supplied value in range of 10 to 20 connotates the voracity of the match
- Input as "Draw Order" when placing the overlay during the measurement process in Google Earth



bay “Quality” metric in 1º Florence W & E Quads



Web based visualization facility

The use of an overlay to trace the rim obfuscates the very details it is attempting to call attention to.

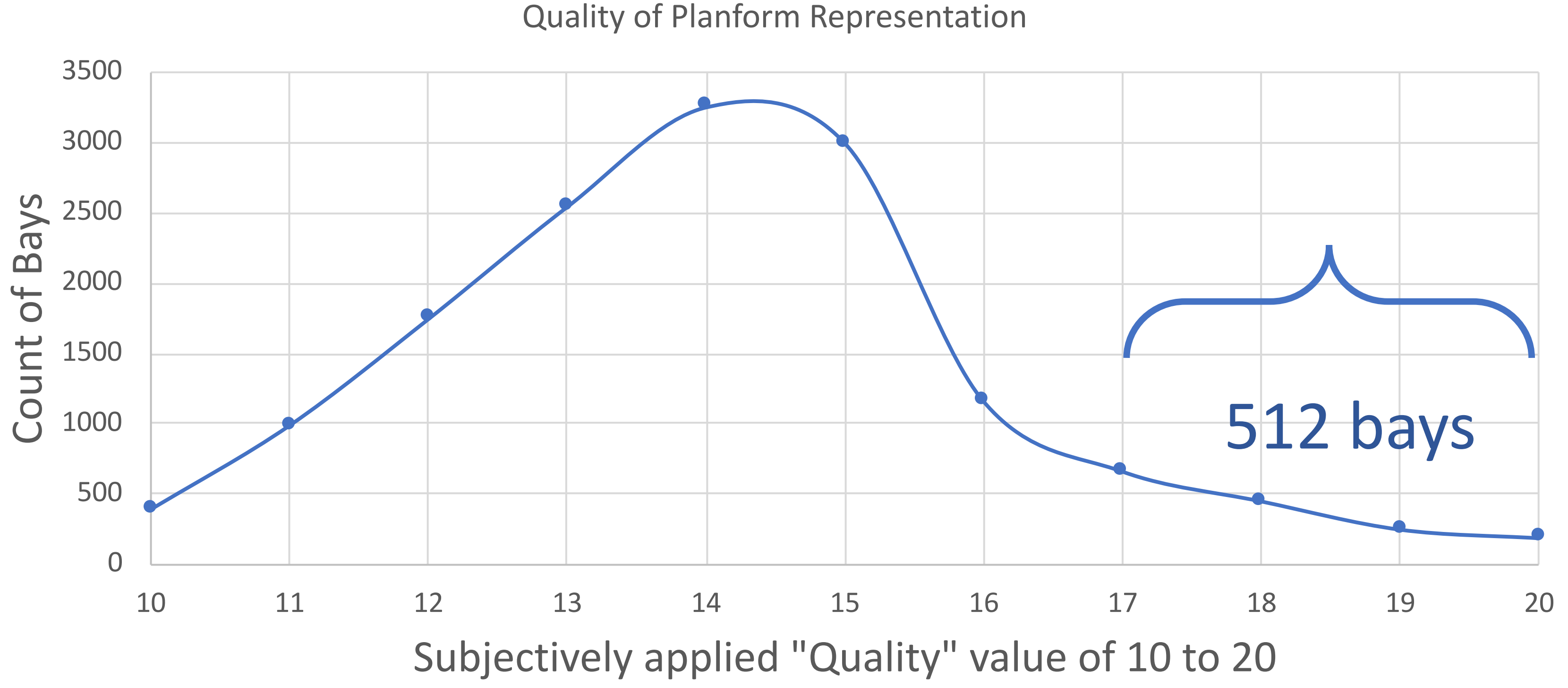
How does one "reveal" the true relief? To address this need, I am offering the use of a "slider" tool to allow rolling the overly on and off the bay elevation imagery. Delivery is via a simple html-encoded web page, using Rapid Weaver commercial web development environment, a blog posting tool, a "before-after" tool and a "full-screen" tool.

- 500 bays chosen for socializing the robust repetitiveness of planforms
- KMZ that presents placemarks for each: 500 Bays
- KMZ to integrate our LiDAR into Google Earth: Florence Quads DEM
- Popup box has link to open visualization tool in browser
- … or Directly access library of imagery from planform.cintos.org

Selecting 500 bays for review

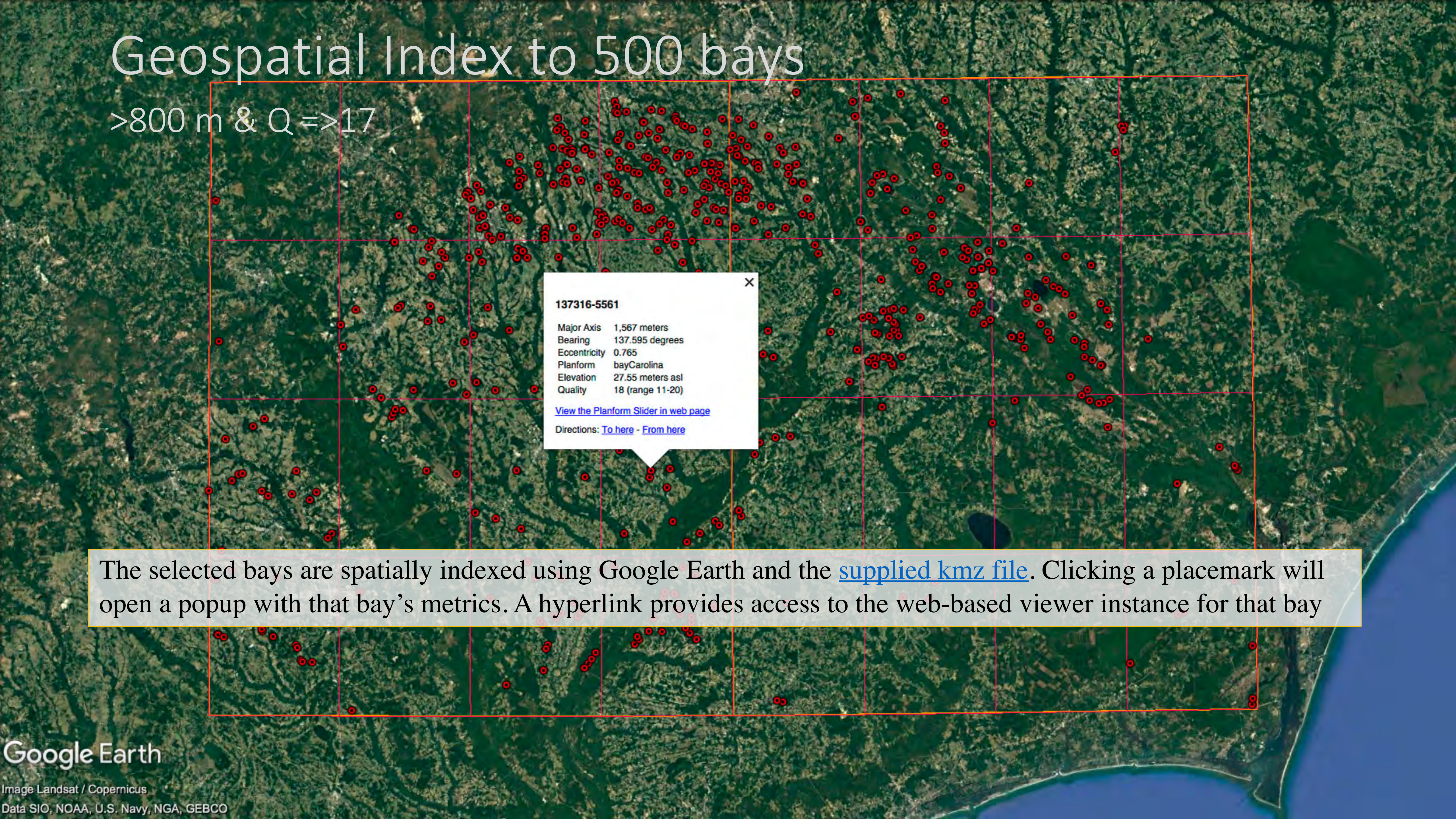
All bays which have received a quality metric of 17 or better, and are also over 800 meters on major axis are identified by running a Sequel statement against the MySQL database of the bays in the two Quadrants. This resulted in 512 “hits”. In addition to these bays, ~50 smaller or lower quality bays which are considered their *cohorts* due to overlapping bays are also identified and included in the tool’s data set.

```
select KML from bayMetrics where Quality >= 17 and Major > 800order by Major DESC
```



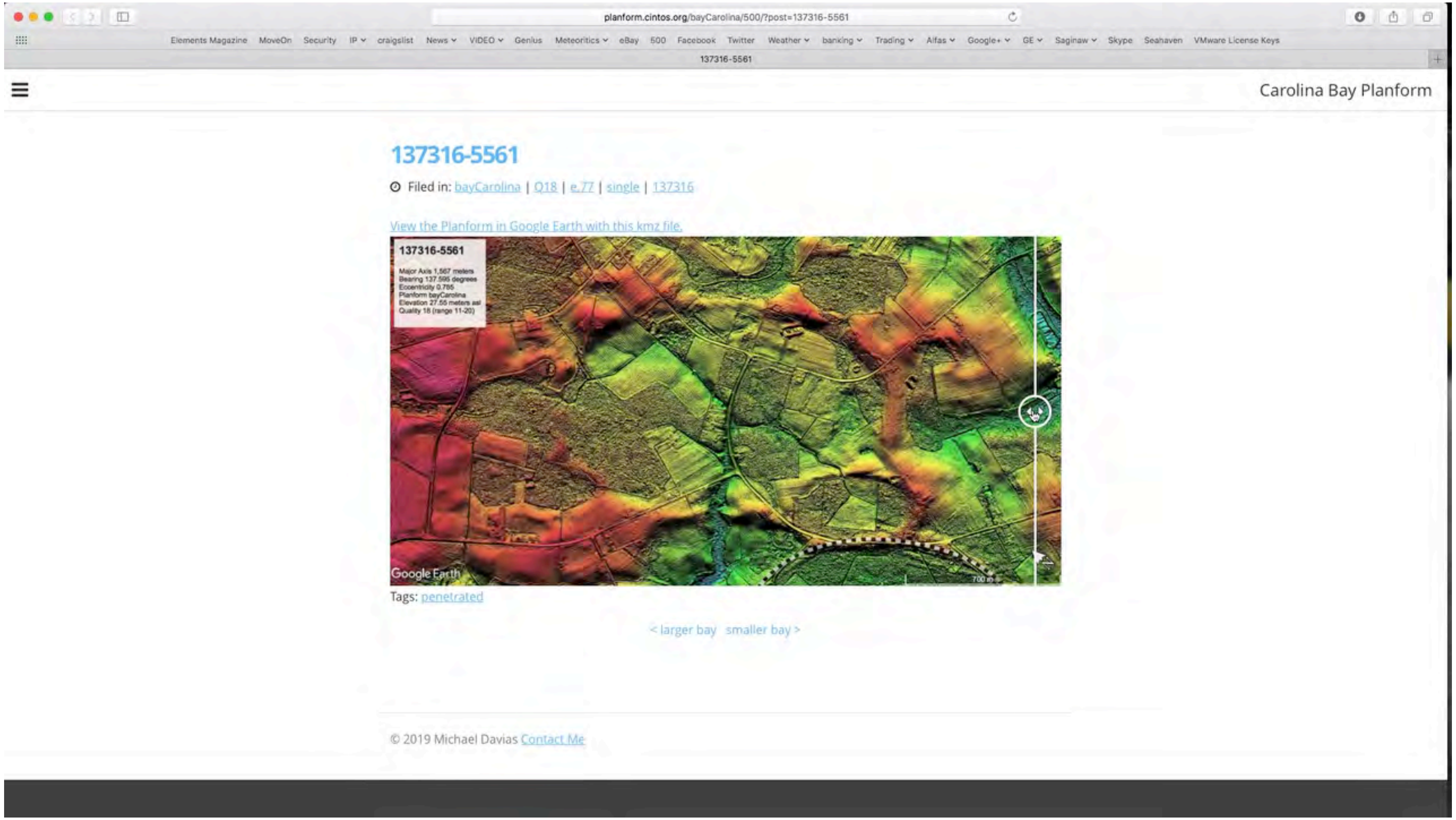
Geospatial Index to 500 bays

>800 m & Q =>17

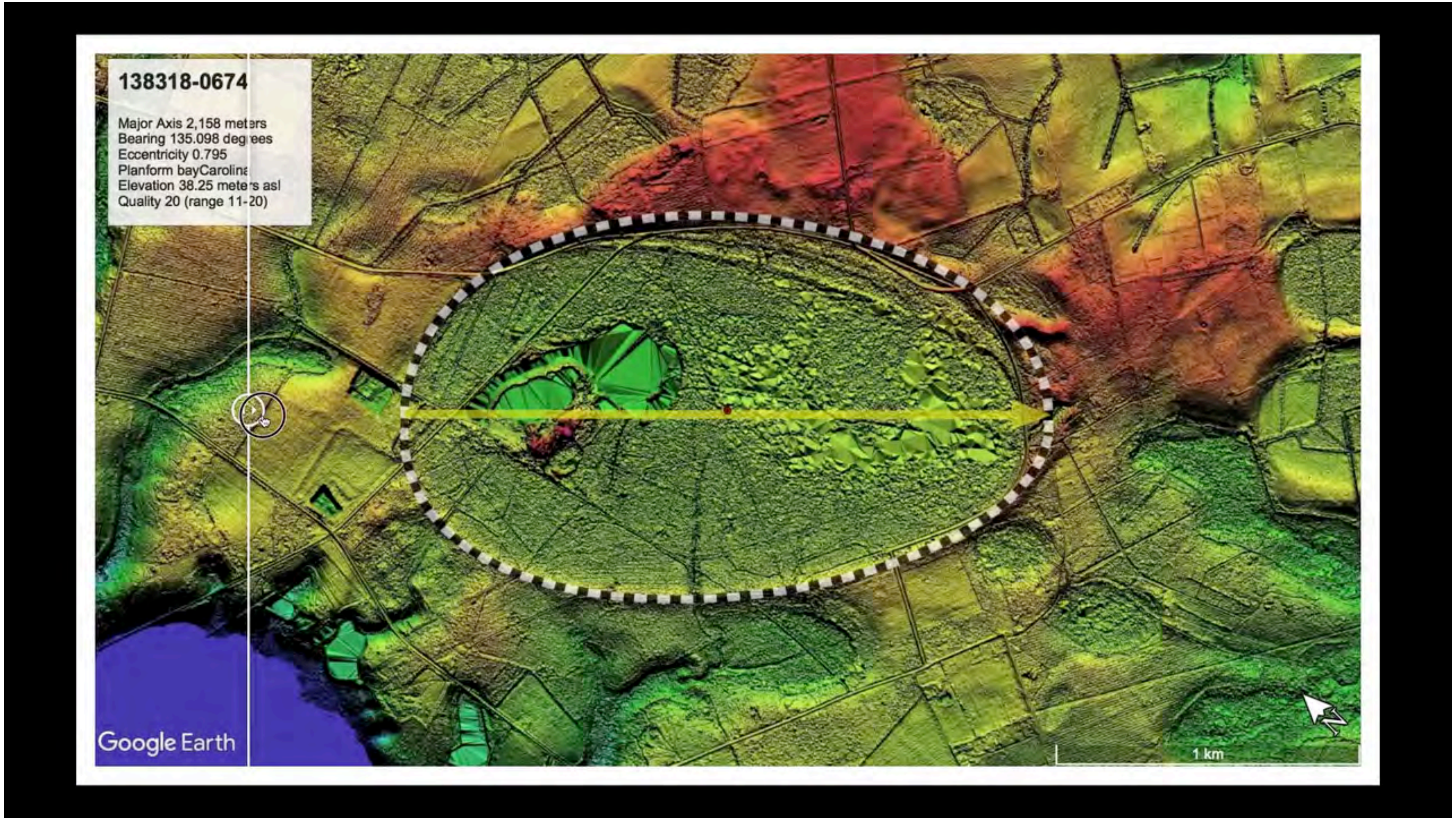


The selected bays are spatially indexed using Google Earth and the [supplied kmz file](). Clicking a placemark will open a popup with that bay's metrics. A hyperlink provides access to the web-based viewer instance for that bay

Example Slider Movie



Movie example of Full Screen in browser



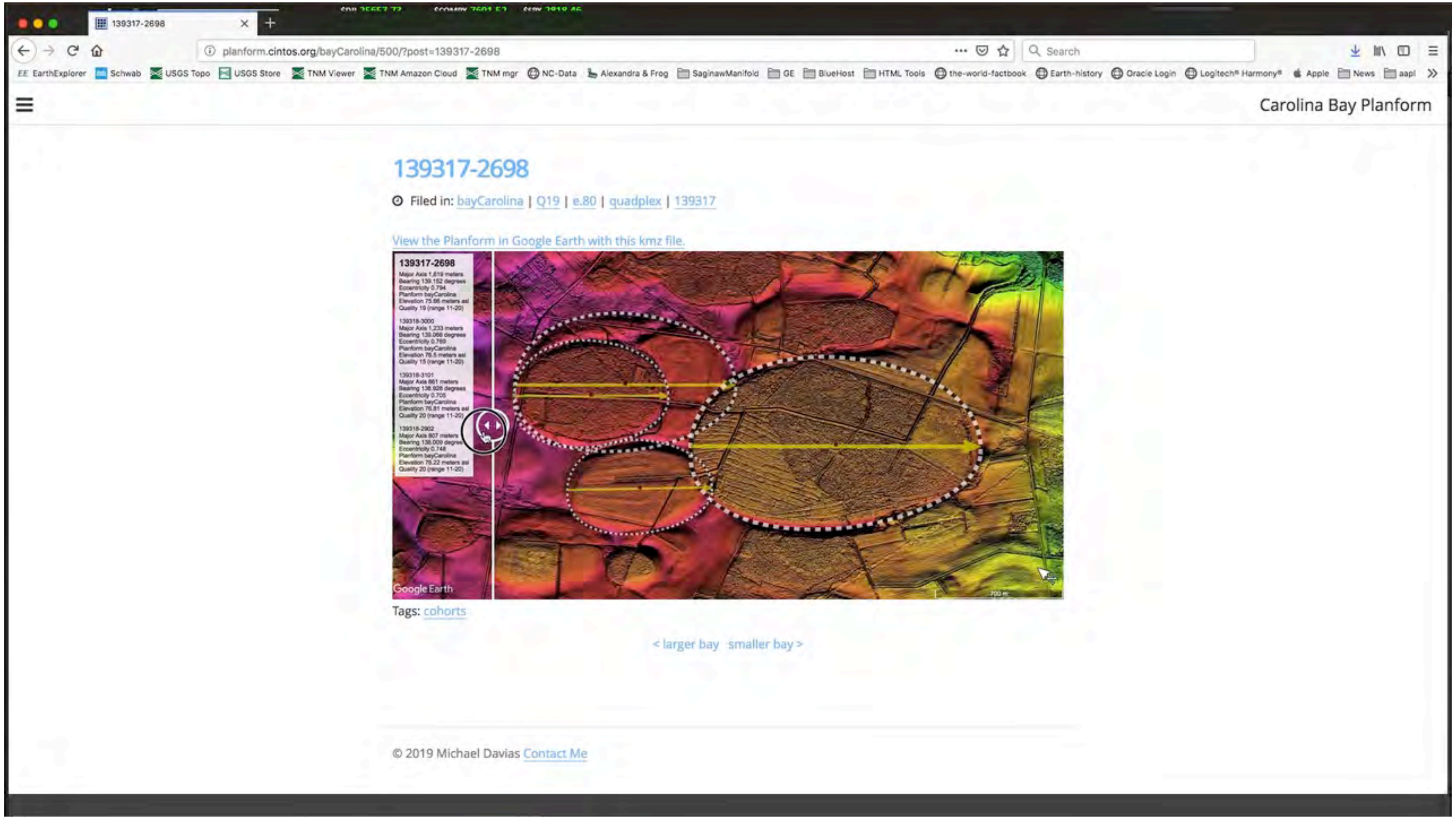
Sample Links to web-based planform viewing facility

- Home page
- 138313-3784
- Tupelo Bay, NC
- Heart of the bays
- Singletary Lake, NC
- Antioch Bay, NC
- Green Pond Bay, NC
- Juniper Bay, NC

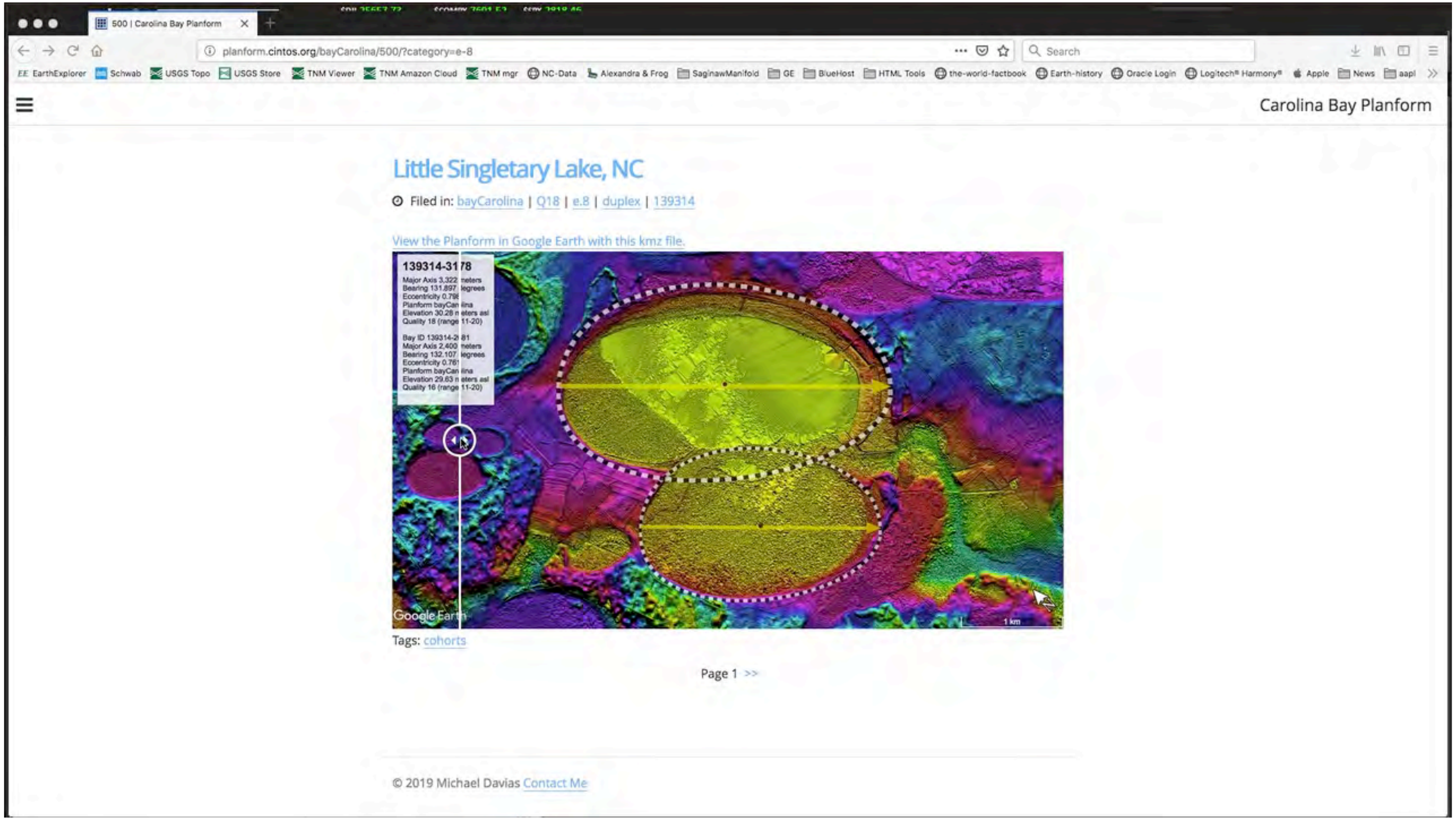
- Eccentricity ~ 0.74
- Eccentricity ~ 0.76
- Eccentricity ~ 0.78
- Eccentricity ~ 0.80
- Quality == 20
- Quality == 19
- Quality == 18
- Quality == 17

- cohorts
- duplex
- Triplex
- Quadplex
- Internal erosion
- Urban
- Twins
- Plugs Channel

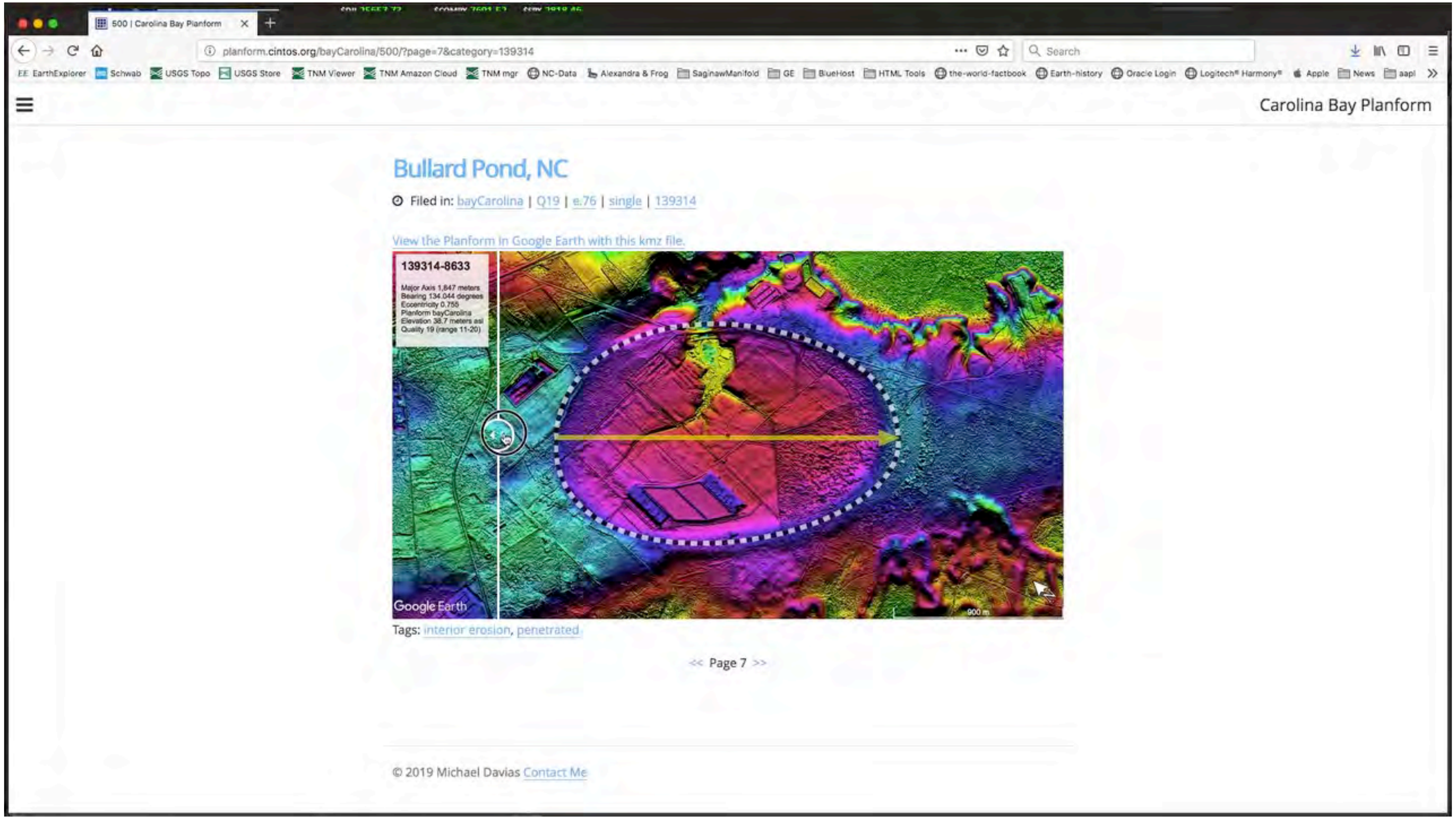
Example Slider Movie



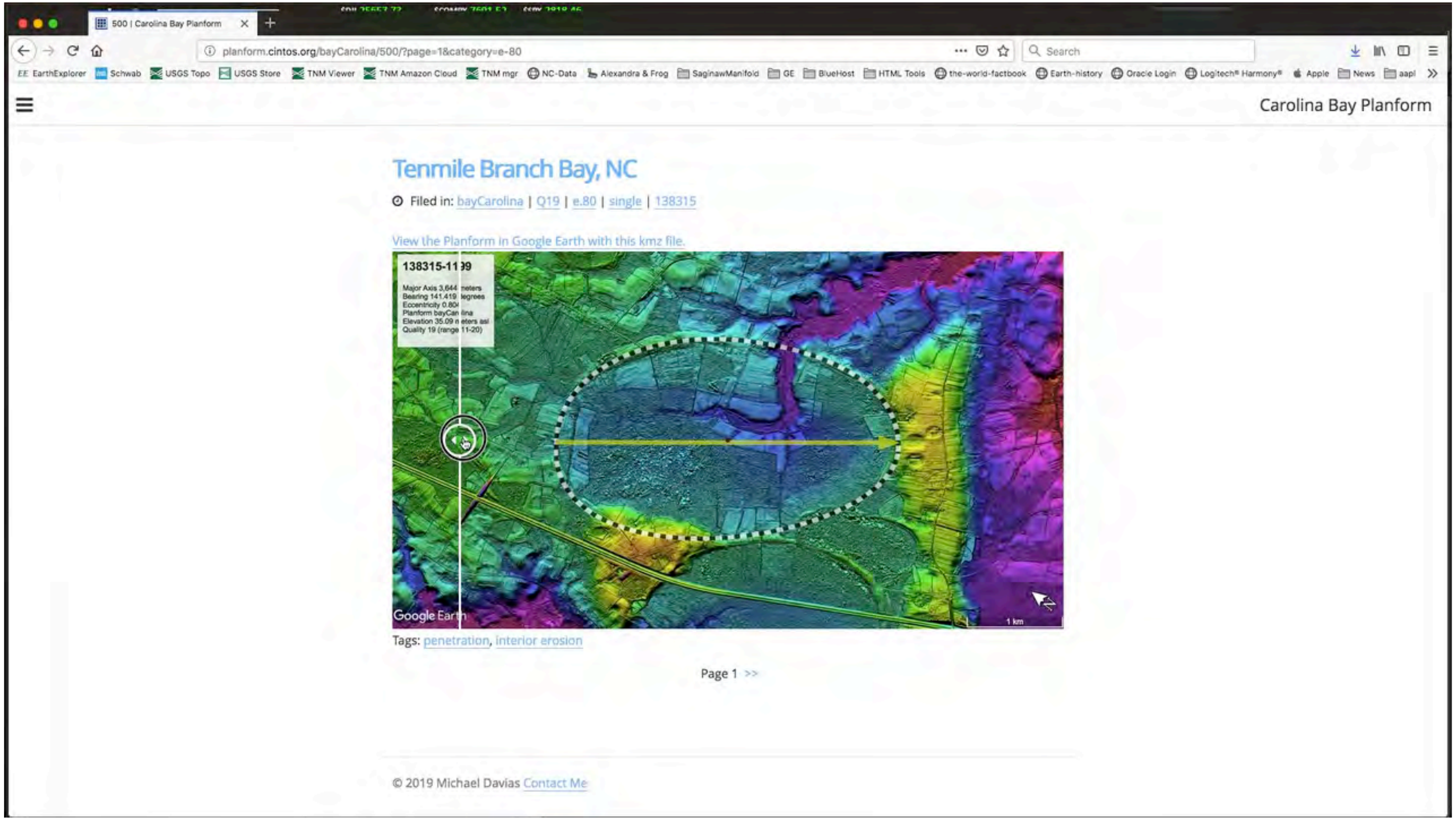
Example Slider Movie Duplex Cohorts



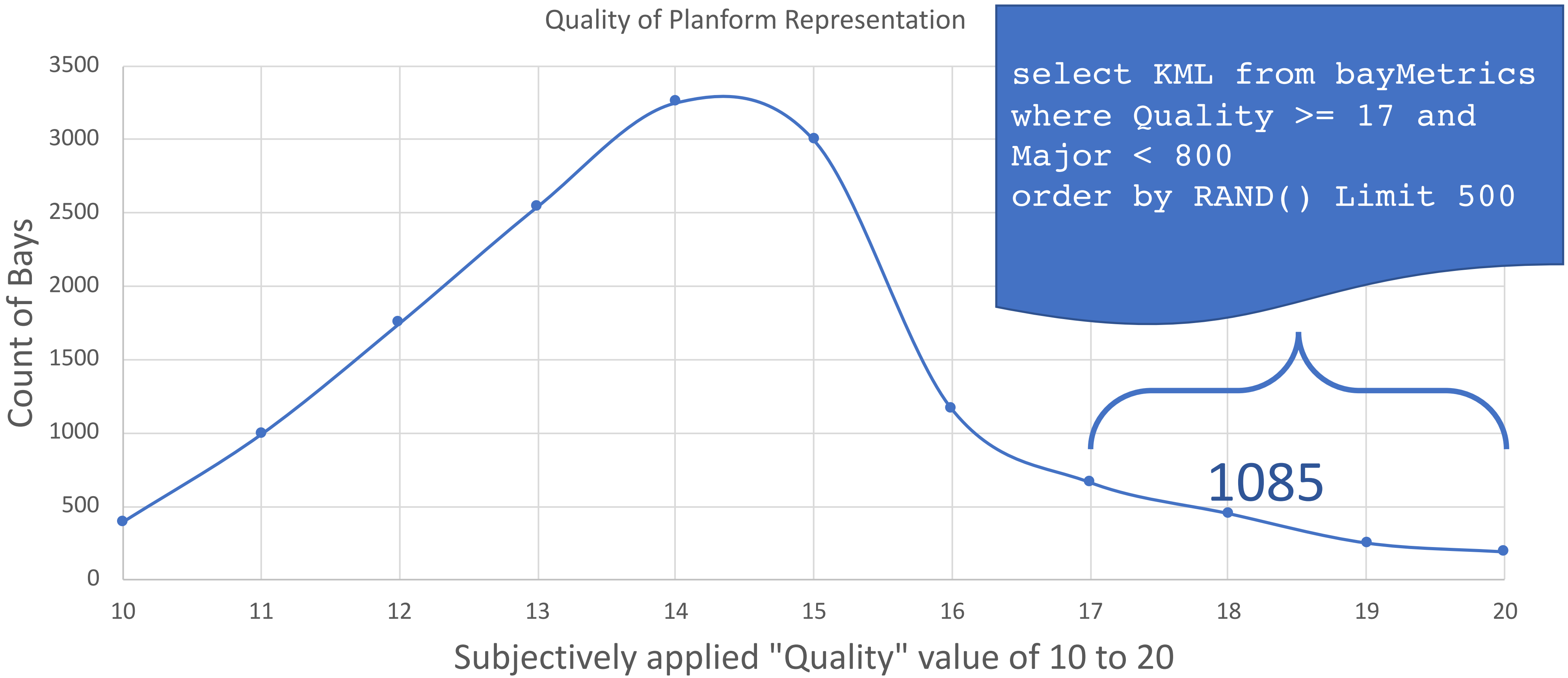
Example Slider Movie - eccentricity ~ 0.76



Example Slider Movie - Interior Erosion



Next step: 500 randomly selected bays from ~1000 < 800m long



Lots more to do…

- Extend “slider” tool to *baySouth* and *bayWest* archetype planforms
- Core the foundational rims
- Motivate resources to perform Al^{26}/Be^{10} cosmic isotopic burial dating
  - Across Carolina bay rim transects to depths of 30 m
  - Across the costal pain to finally elucidate the age of last 5 my depositions

What You Can Do

- ✓ Review the Bays Survey "slider" library:
  - ➢ http://planform.cintos.org
- ✓ Download the KMZ for Florence Quads into Google Earth:
  - ➢ planform.cintos.org/survey/FlorenceQuads.kmz
- ✓ Download the KMZ for the 500 selected examples:
  - ➢ http://planform.cintos.org/survey/500-Bays-Quality-17-over-800m.kmz/
- ✓ Review the "Carolina bay of the Day" library:
  - ➢ http://CBotD.cintos.net
- ✓ Have a good chuckle – look at the MPT Impact hypothesis:
  - ➢ http://mptimpact.org/

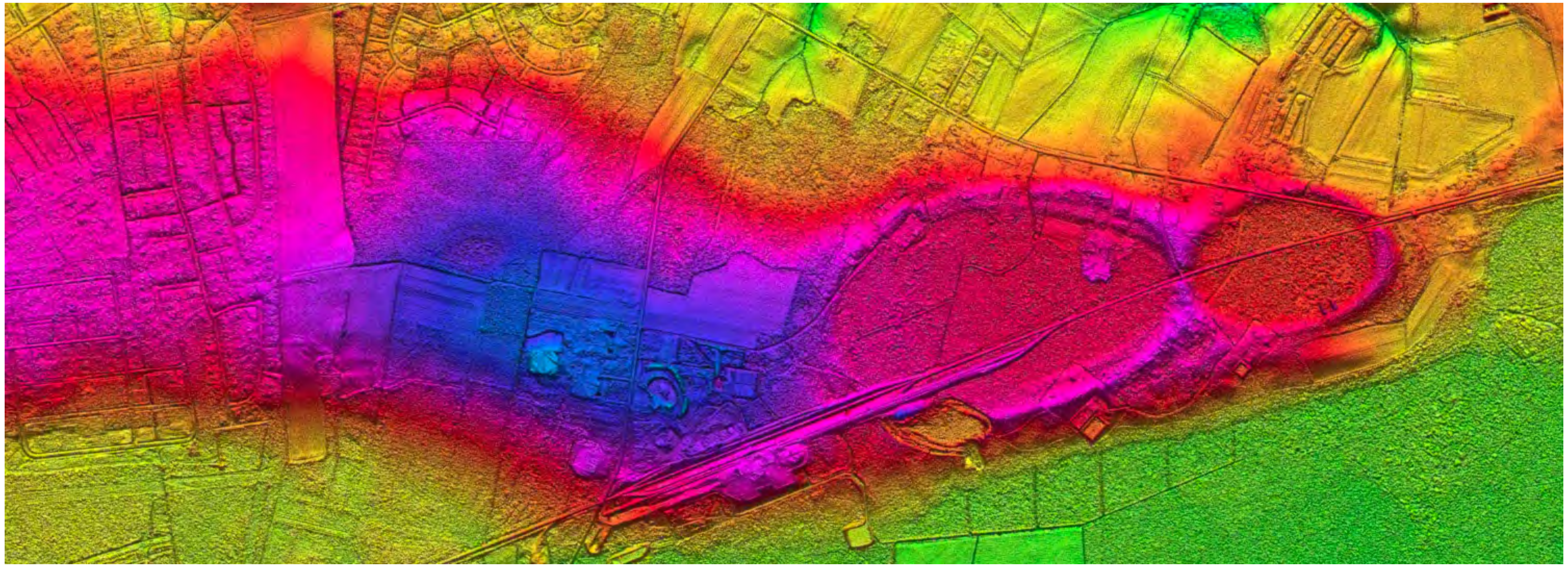
- ✓ **Consider research into the Origins of the Carolina Bays**
- ✓ **Promote the advancement of cosmogenic isotope burial dating**
- ✓ **Apply these techniques to your own particular geospatial data**

A Morphometric Survey of the Carolina bays

No one has yet invented an explanation which will fully account for all the facts observed
Douglas Johnson, 1942[1]

Daniels, Gamble and Wheeler did offer an excellent explanation, in 1971[2].

The sand in the bay rim is not different from the Goldsboro sand. Therefore, these Carolina Bays are merely surface features associated with the formation of the ridge.



1. Douglas Johnson, 1942, The Origin of The Carolina Bays, Columbia University Press
2. R. B. Daniels, E. E. Gamble and Wheeler, 1971, *The Goldsboro Ridge, an Enigma,* Southeastern Geology, Vol. 12 No. 3

Inventing An Explanation

We speculate on a high-energy, catastrophic deposition mechanism, where successive sheets of pulverized clastics were spread as mass geological flows from a cosmic impact into the Laurentide Ice Sheet at the Mid-Pleistocene Transition, ~786 ka.

The bay depressions are posited to be surficial dimples or voids in the blanket, artifacts of cavitation-produced bubbles frozen in time as the depositional energies relaxed and the sand transited from liquefaction to lock-up. The "foundational rim" of each bay demonstrates an increased resistance to fluvial sheet erosion.

Successive sheets terminated ever closer to the impact site, evidenced as meter-scale "stair-steps" at the toe of each sheet.

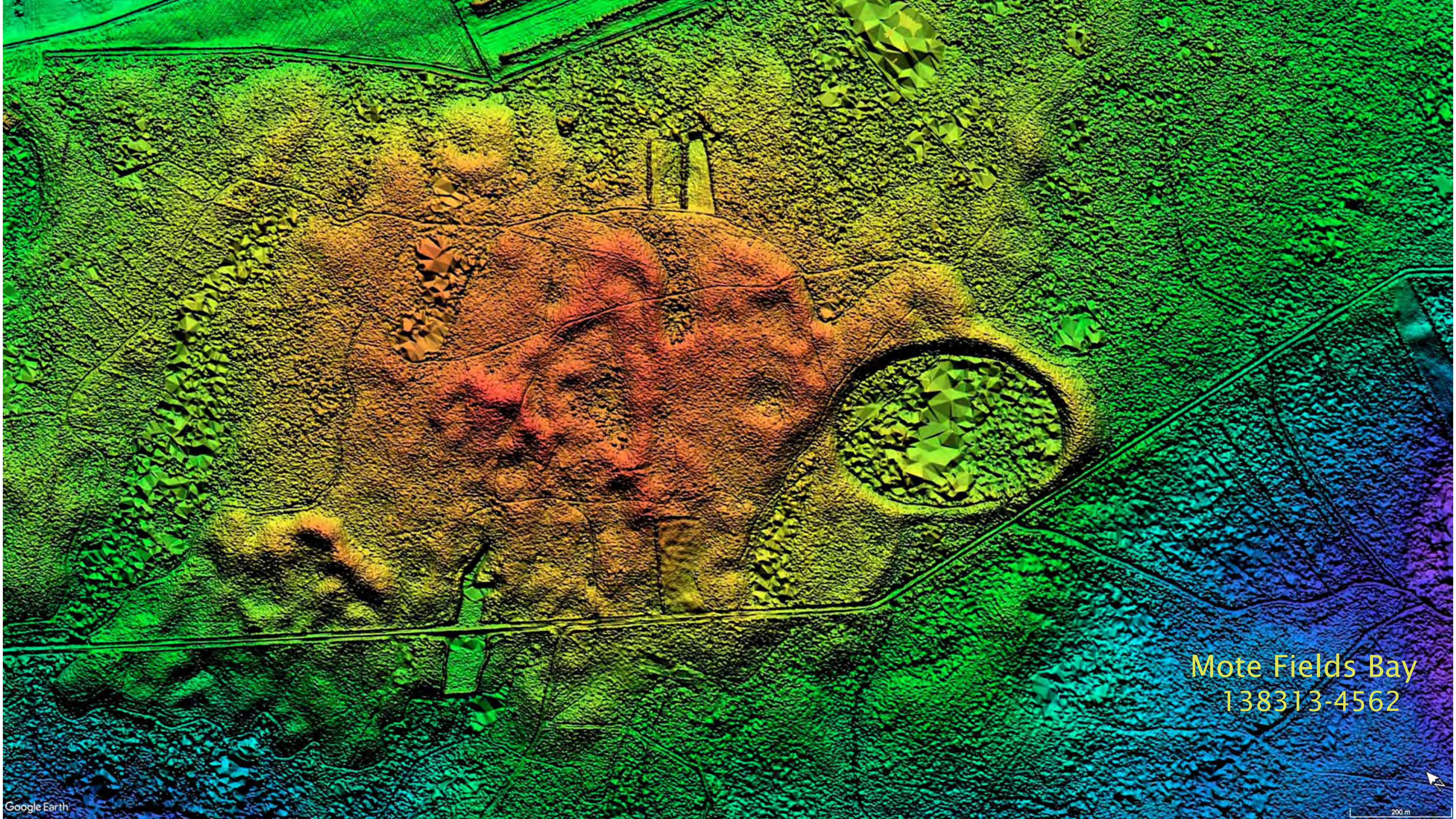
The ejecta's arrival vector are evidenced in the orientation and distortion of the bubble.

Addendum – raw JPG maps used in viewer

The addendum PDF file contains 1100 maps at one per page. Two maps are provided for each of the 550 bays examined in the first iteration of the Planform Viewer. One map/page has the hsv-shaded elevation map of the bay without the measurement overlay, and the second includes the overlay.

The interactive web viewer references these 1100 images in pairs, one pair per bay, and generates a “before/after” visualization.

455 Mb file available @ http://cintos.org/GSA-SE_2019/rawJPGmaps.pdf


Mote Fields Bay
138313-4562
Google Earth
200 m