On Earth's Alleged Curvature

"You can just go on airplane and see the from the air the earth is curved / rounded or see the a ship go below the horizon after a certain distance"

Let's break that down into its respective two components:

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[1] You can just go on airplane and see from the air the Earth is curved.
[2] You can see a ship go below the horizon after a certain distance.
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Starting with [1], I'll cite the highest level of academia that I could fine to support the notion that the Earth's curvature can be visually discerned from a plane.

Lynch, D. K. (2008). "Visually Discerning the Curvature of the Earth." Applied Optics 47: H39.

"Visual daytime observations show that the minimum altitude at which curvature of the horizon can be detected is at or slightly below 35,000 ft, providing that the field of view is wide (60°) and nearly cloud free."

"Photographs purporting to show the curvature of the Earth are always suspect because virtually all camera lenses project an image that suffers from barrel distortion. To accurately assess curvature from a photograph, the horizon must be placed precisely in the center of the image, i.e., on the optical axis."

To be clear here, this paper isn't saying "it looks a certain way, therefore; xyz", this an attempt to discern the curvature via analysis of photographs based on known optical conditions that effect how a camera see's reality. An important aspect to keep in mind moving forward, something can "appear" to look one way, but we're interested in measurements here. Some way to tangibly discern curvature.

Lynch continues to state (paraphrase): You need clear blue skies with no clouds with an unobstructed 90° field of view or more. If your field of view is sub 60°, Earth's curvature is not discernible.

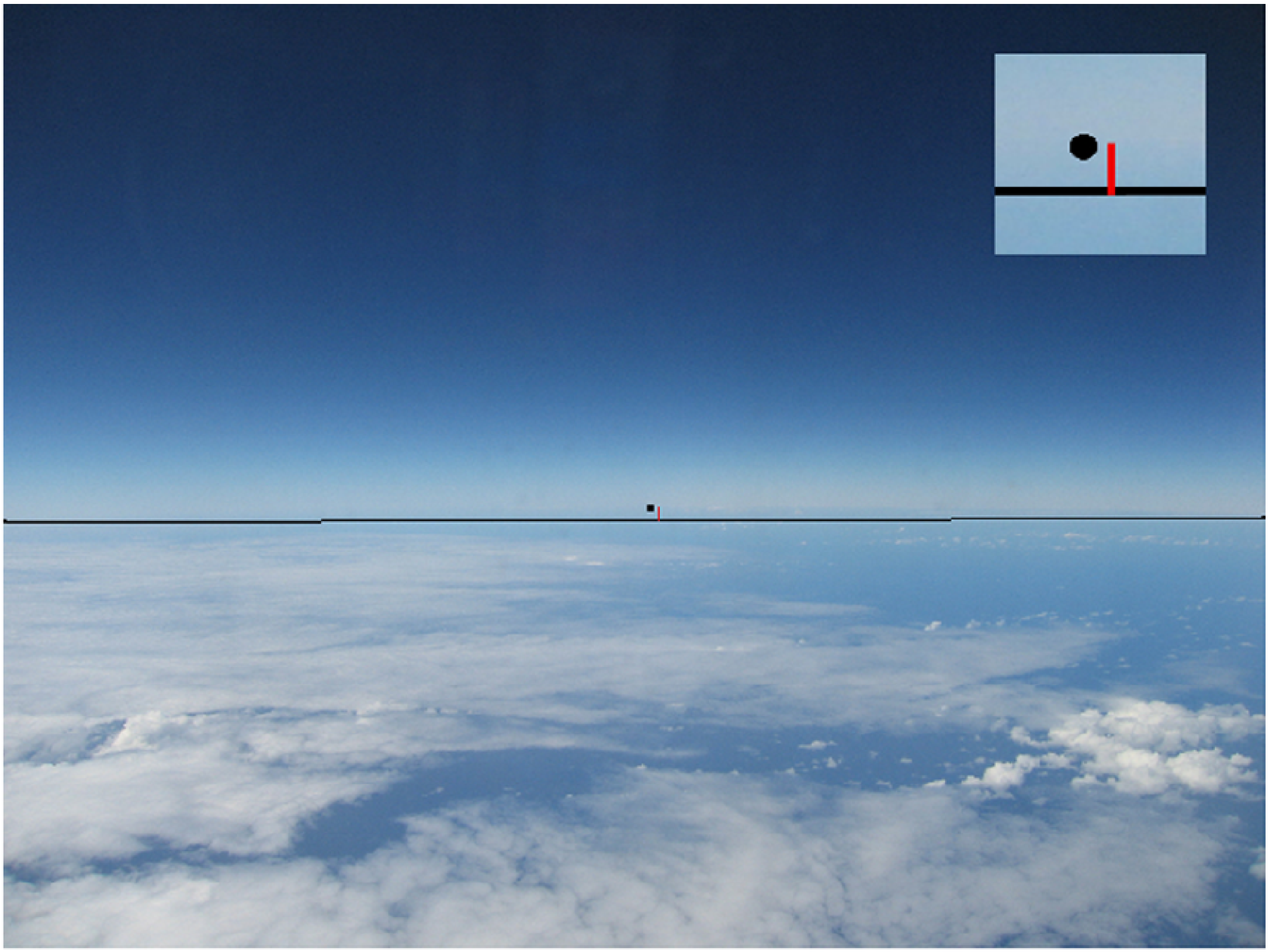


Fig. 5. (Color online) This picture shows a photograph of the horizon from an elevation of 35, 000 ft and with a horizontal FOV of 62.7°. Also shown are the three reference points defining the horizon, a horizontal line connect the left- and right-hand points, and the measured amount of sagitta (see inset for a closeup of the sagitta measurement).

"The image was imported into a drawing program, and three small dots were placed on the horizon: one each at the left and right edge of the image, and one near the center. A line was drawn between the left and right dots and was found to fall slightly below the center dot, a clear indication of curvature (inset in Fig. 5). The measured distance (sagitta) was 0:51°, or about 17 pixels (note that the horizontal angle from the limb center is half of the FOV, or about 31:3°)."

To summarize so far what Lynch is putting forward: using a horizontal line and counting pixels with no actual scale or reference, he has determined that the "bulge" seen the middle is the sagitta.

The sagitta is how much of the Earth is obscured behind physical Earth curvature (land or water).

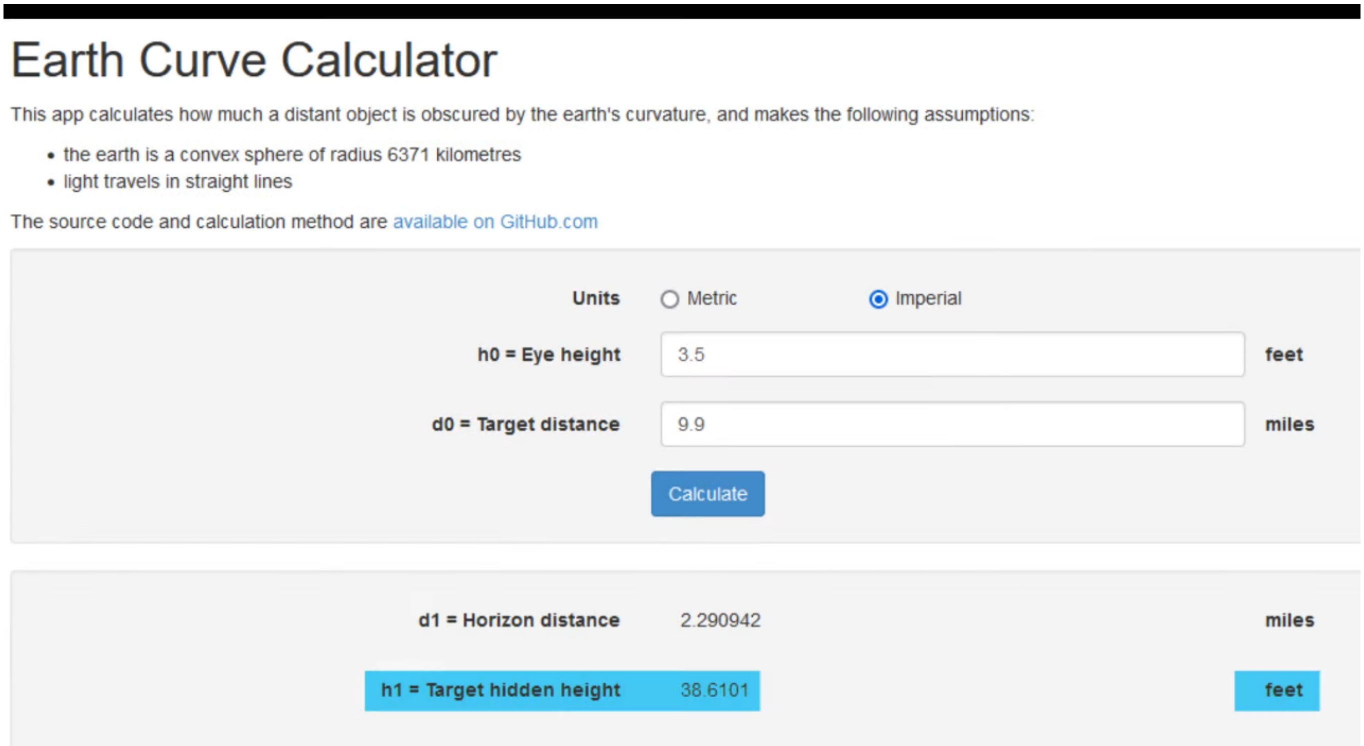
Let's address what's being said before we move on: From ~35,000ft it is claimed that the sagitta is visually discernible (under optimal conditions). So the physical obstruction is there. That 100% absolute has to be physical earth curvature. Not apparent. Keep that in mind when you loo at terrestrial observations where this sagitta (the PHYSICAL EARTH CURVATURE) should be.

Taboo Conspiracy III https://www.youtube.com/watch?v=bP3firT4HBM

Telescope observation height: 3.5ft

9.90mi

Elevation: 17ft



38.61ft should be hidden by the Earth's curvature. The same sagitta that was photographed at 35,000ft should also be blocking terrestrial observation. However see in this next screen shot that none of the target building is obscured. You can even see cars and trucks driving by in front of the building (timestamp: 218).

It gets even worse from here when Taboo starts breaking down the height of the trucks vs the sagitta.

I don't expect you to be convinced with one video. Here is an entire archive of videos over a wide range of subjects and observations. You can search for curvature until your heart is content, but there's an even easier way to discern the shape of where we live that I'll get to at the end.

Before we move on the [2], let me finish Mr. Lynch's paper to the graveyard.

This paper was published in Optical Society of American and is archived on Harvard and NASA. Checking the citations, we find that there really isn't any of note.

of the Earth is evident, but commercial aircraft seldom exceed altitudes of 40,000 ft (1 ft = 0.3048 m).

Interviews with pilots and high-elevation travelers revealed that few if any could detect curvature below about 50,000 ft. High-altitude physicist and experienced sky observer David Gutierrez [6] reported that as his B-57 ascends, the curvature of the horizon does not become readily sensible until about 50,000 ft and that at 60,000 ft the curvature is obvious. Having talked to many other high fliers (SR-71, U2, etc.), Gutierrez confirms that his sense of the curvature is the same as theirs. Passengers on the Concorde (60,000 ft) routinely marveled at the curvature of the Earth. Gutierrez believes that if the field of view (FOV) is wide enough, it might be possible to detect curvature from lower altitudes. The author has also talked to many commercial pilots, and they report that from elevations around 35,000 ft, they cannot see the curvature.

When trying to understand the perception of a

References and Notes

1. R. W. Emerson, *Nature: Addresses, and Lectures*, new and revised ed. (Houghton, Mifflin, 1884), p. 22..

2. Piccard is widely believed to be the first. There are many references to his achievement on the Internet, most of them certainly derivative. I contacted the Piccard family and they were aware of the claim but had no hard evidence or literature citation backing it up.
3. S. W. Bilsing and O. W. Caldwell "Scientific events," Science **82** 586–587 (1935).
4. A brass plaque placed at the Lamont Odett vista point in Palmdale, Calif., by E. Vitus Clampus claims that X-1A pilot Arthur "Kitt" Murray was the first person to see the curvature of the Earth. The plaque does not cite the year or altitude, but, according to the NASA archives, it was probably on 26 August 1954 when Murray took the X-1A to a record-breaking altitude of 90, 440 ft (27, 566 m).
5. Entering "curvature of the earth" into the image search using any search engine will find thousands of images. Most photographers place the horizon near the top of the frame in order to capture the scene of interest below the horizon. The resulting barrel distortion produces a pronounced upward (anticlinal) curvature of the horizon that most people incorrectly interpret as the curvature of the Earth.
6. D. Gutierrez, djgutierrez1@verizon.net (personal communication, 2007).
7. C. F. Bohren and A. B. Fraser, "At what altitude does the horizon cease to be visible?" Am. J. Phys. **54**, 222–227 (1986).
8. A. P. French, "How far away is the horizon?" Am. J. Phys. Vol. **50**, 795–799 (1982).
9. E. J. McCartney, *Optics of the Atmosphere* (Wiley, 1976), Fig, 4.8, p 205.

Citation #2: Is an urban legend as confirmed by Mr. Lynch when he tried to follow up on the claim that he still included in his paper to give the appearance that Piccard supplemented his argument.

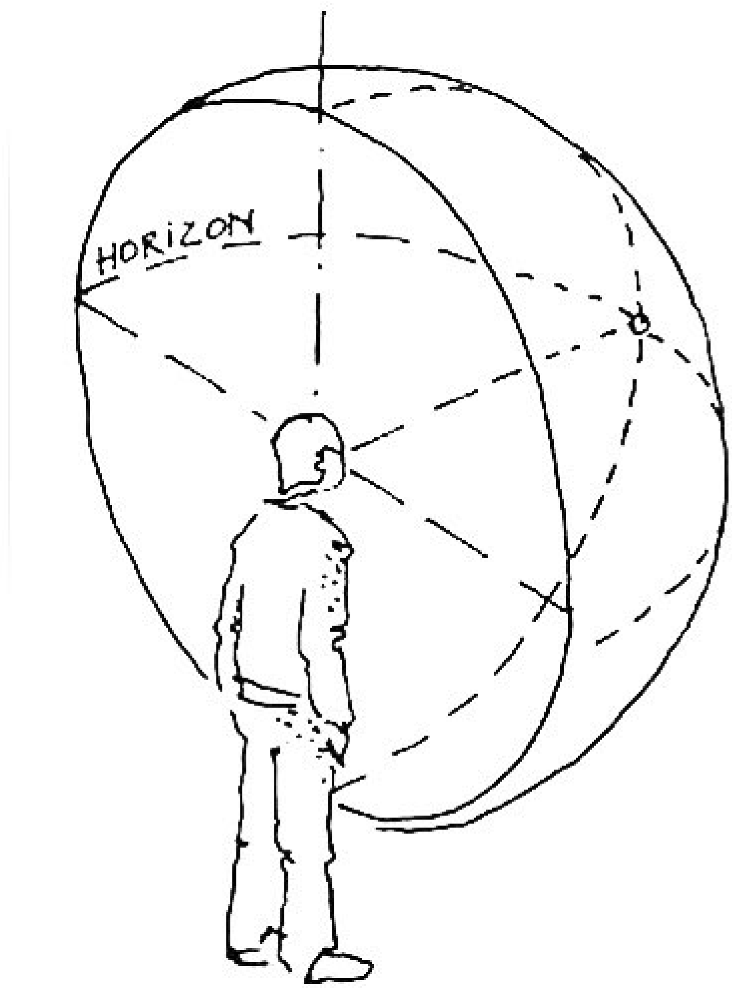
Citation #4: A plaque place at somewhere that doesn't even include a year or altitude isn't a citation or evidence of anything. Although, I suppose it's evidence that there's a plaque at that location. However, that's unrelated to providing actual substances to the argument.

Citation #5: Isn't a citation at all. That's antidotal and should have been included in the actual paper. Not a reference.

Citation #6: Perhaps the most egregious of them all; to supplement an anecdotal story provided by one D. Gutierrez, an email address is provided so you can ask him if the story provided is true. Typing "LOL" isn't sufficient to express how hard I laughed when I seen the citation for an anecdote was contact information to ask the person about the story.

Now let's move on to #[2]. You can see a ship go below the horizon after a certain distance.

In that pastebin link, you'll find many videos on optics and boats not actually vanishing behind a physical horizon. (Pastebin reference again: https://pastebin.com/MwaRqfMM)



A diagram on optics. 180° converges to the center (left to right and top to bottom)

To break this down mechanistically. That convergence two the center produces optical compression. Example: Say you're 5.5ft tall and there's a 6ft man standing next to you.

Optically, you can tell right away that he's bigger than you. As he gets farther from you, you'll notice that becomes the same height as you, and then eventually he becomes smaller. He'll start vanishing bottom up (which we'll get to in shortly).

4b. The Vieth-Müller Torus-Perceived Radial Distance

It will be recalled that a Vieth-Müller Circle (VMC) is one of the circles γ = constant in the horizontal plane and is a circle passing through the eyes. The Vieth-Müller Torus is the three-dimensional surface obtained by rotating this circle about the axis through the eyes. It looks a bit like an apple with the eyes at the bottom of the indentations at either end (Figure 5). Luneburg observed that a set of points arranged in the horizontal plane so as to give the perception of a circle of points at the same fixed distance from the observer, approximates fairly well an arc of a Vieth-Müller circle. Subsequent experiments have shown that this observation is substantially true. Consistent deviations seem to exist, but there is insufficient statistical evidence to warrant replacing γ by a more complicated coordinate.

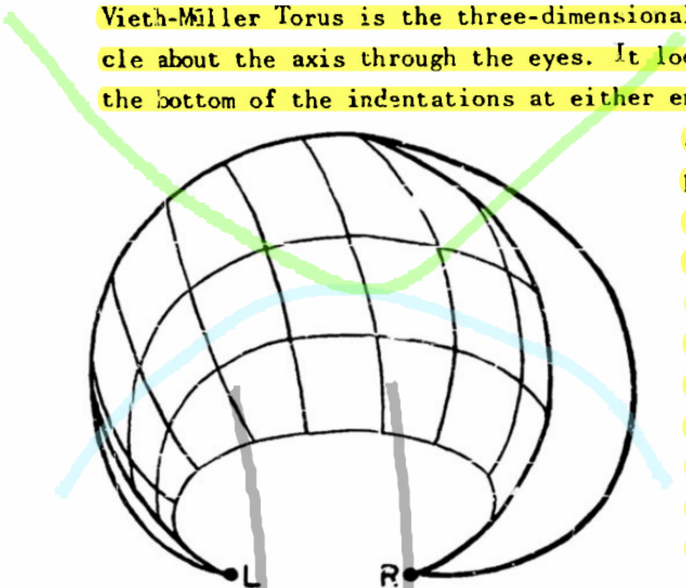


FIG. 5. SEGMENT OF A VIETH-MÜLLER TORUS

On the basis of this evidence Luneburg expressed the hypothesis,

H_1 A Vieth-Müller Torus is perceived as a sphere with the observer at its center.

In mathematical language, the hypothesis asserts that the toruses γ = constant in physical space are mapped as spheres in the visual space. It is possible that this hypothesis may have to be modified. For example, the well-known observation that the zenith of the night sky appears to be closer than the horizon (although such an observation may not be absolutely free from intellectual clues) indicates that the hypothesis is worth re-examining.*

*cf. LUNEBURG[3] p. 633.

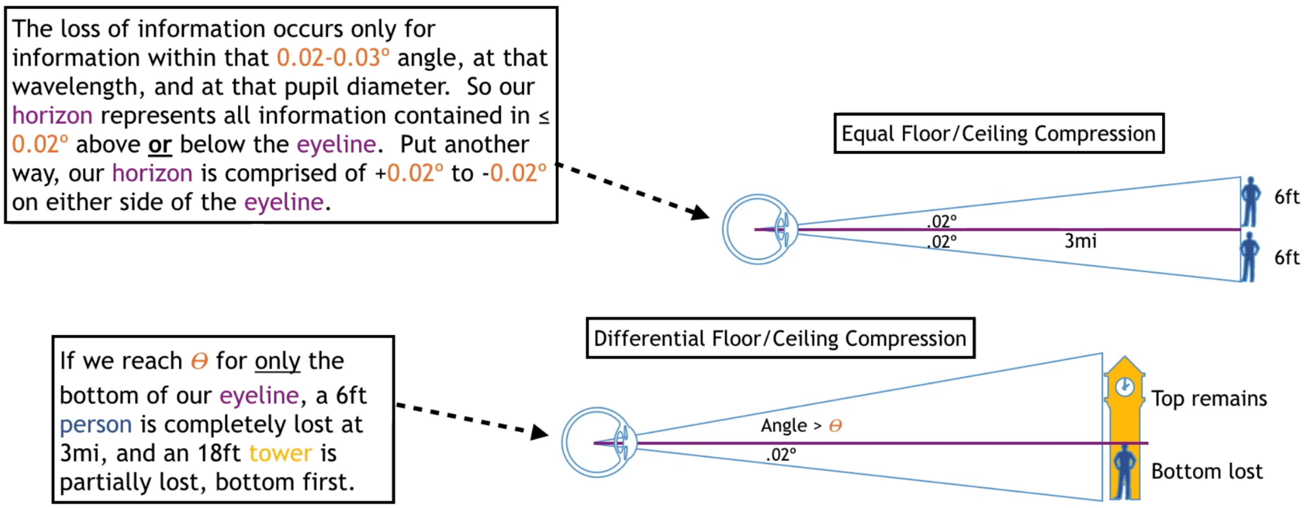
Traditionally optics is taught to us in Euclidean geometry. These representation of perspective, being bond to Euclid must follow that no parallel line can converge at the horizon. They must remain parallel. If you recall a picture of train tracks, what happens? They laterally converge at the horizon. This a violation of Euclid's postulates. So why do we still use Euclidean geometry to describe optics? Its approximations are "close enough", as they say. However, in the 1940s it was discovered by Karl Rudolph Luneburg that we actually see in what's called curved visual space or "hyperbolic geometry". The above citation regarding a Vieth-Muller Torus has be experimentally and mathematically verified as equivalent to the Euclidean predictions and hyperbolic geometry outperforms at the horizon (where Euclidean errors the most).

In short; the near-field and far-field have different types of optical compression applied to them. How you see something will be relative to its size, distance from you and elevation. This provides dynamic optical scaling so that everything in your 180° field of view fits proportional to its location from you.

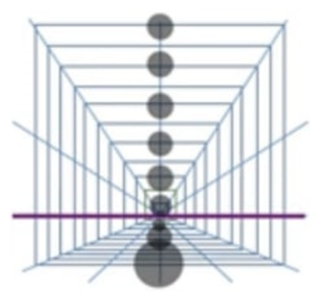
This means the horizon will not be perfectly flat regardless of what we live on (sphere or plane) and further; the horizon will NOT always rise to eye level due to this hyperbolic relationship.

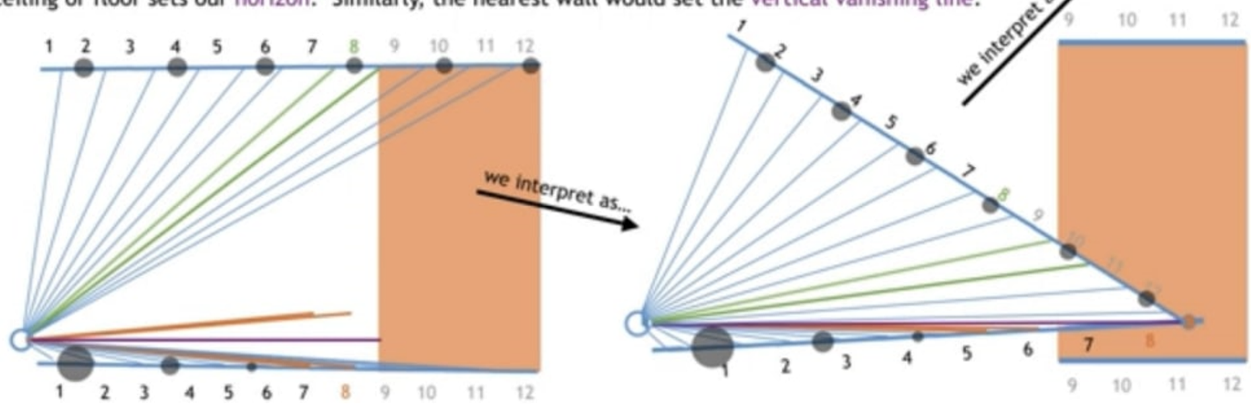
Before we leave this subject, let me explain why a boat vanishes from the bottom up:

> So if θ is only met below the horizon and not above, the object disappears below our horizon, and not above. Recall that the angular compression rate is determined by observer height.



When observing this scenario, θ is met for my lowered observer height and 'sets' my lower horizon distance, which is now closer in, at angle 8. For the information above my eyeline, the descent rate is now steeper, but I have less of an angular compression rate. These angle pairs (the 8's, or the 1's, or the 11's, etc) must always remain in proportion but diminish together according the ceiling/floor distance. If one angle decreases, the other increases, but they are both diminishing with distance. θ is never met along the top because the horizon distance is set by the bottom. It occupies 50% of my vision, so wherever the information above my eyeline is at that point when these two halves collapse, is what I see above my eyeline. The top continues on independently, but you will never see the objects diminish in size and reach θ because they will have already set into your lower horizon. Note also the steeper descent rate at the top. The higher the ceiling, the steeper the descent rate within our perspective. That's how our brain interprets it. The nearest ceiling or floor sets our horizon. Similarly, the nearest wall would set the vertical vanishing line.





Simply put, the angle from the ground to the horizon is smaller than the angle from the sky to horizon. The optical compression happens quicker below the horizon to stay in proportion to the sky which converges at the horizon as the same location as the ground.

Citations:
(1) Hardy, L. H., et al. (1954). The Geometry of Binocular Space Perception.
(2) Koenderink, J. J., et al. (2000). "Direct Measurement of the Curvature of Visual Space." Perception 29(1): 69-79.
(3) Blank, A. A. (1953). "The Luneburg Theory of Binocular Visual Space." Journal of the Optical Society of America 43(9): 717-727.
(4) Luneburg, R. K. (1950). "The Metric of Binocular Visual Space*." Journal of the Optical Society of America 40(10): 627-642.