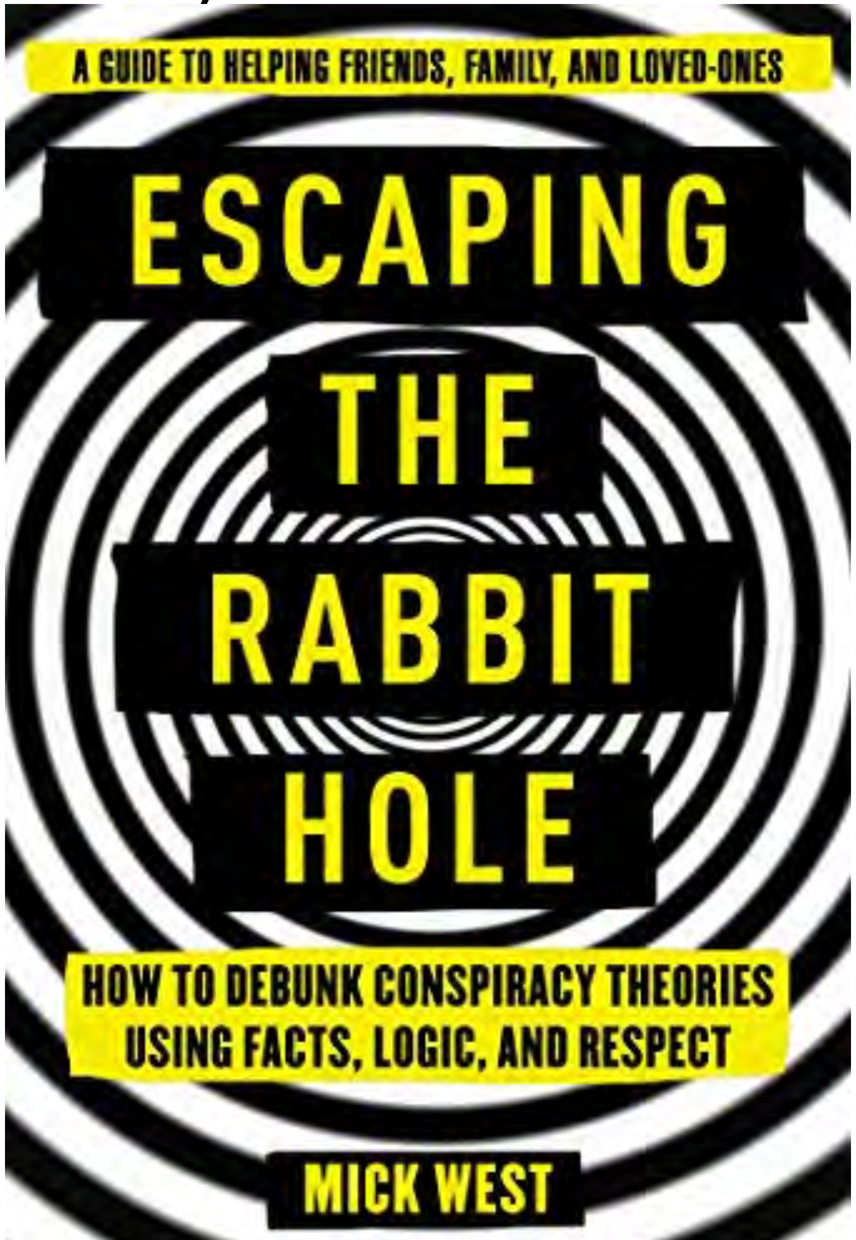
Why I Think the Earth is a Globe

Who am I (Mick West)

- Retired Videogame Programmer
- Started ContrailScience.com in 2007
- Metabunk.org in 2010
- Investigating Flat Earth since 2015
- *Escaping the Rabbit Hole* in 2018

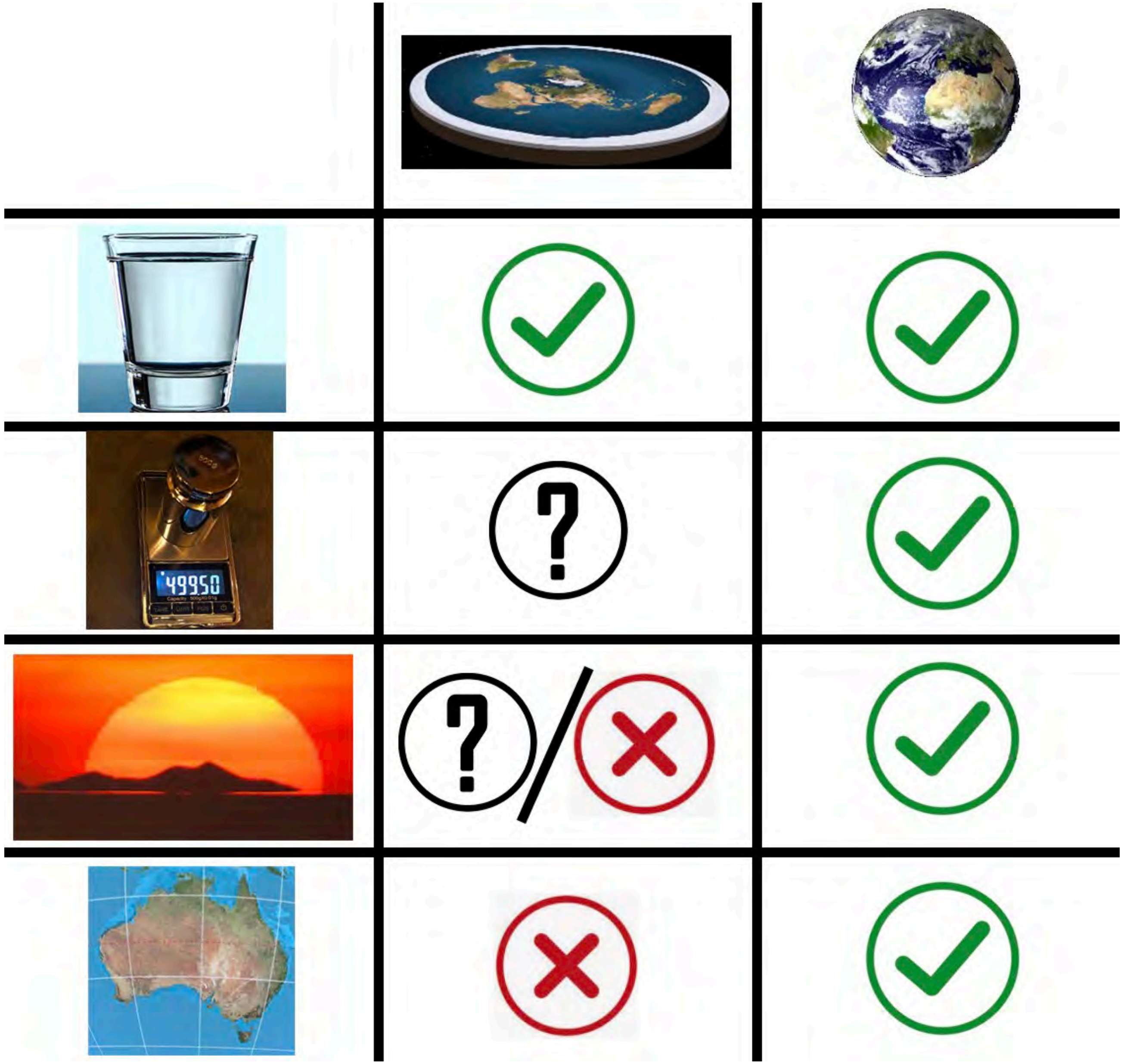


I think the Earth is a Globe because:

It’s the best model to explain what I see and measure

Comparing Models - Criteria

- Consistent with observations
- Lacking inconsistent observations
- Accuracy in predictions and explanations
- Simplicity, Occam's Razor,
- Utility, is it used to do useful work?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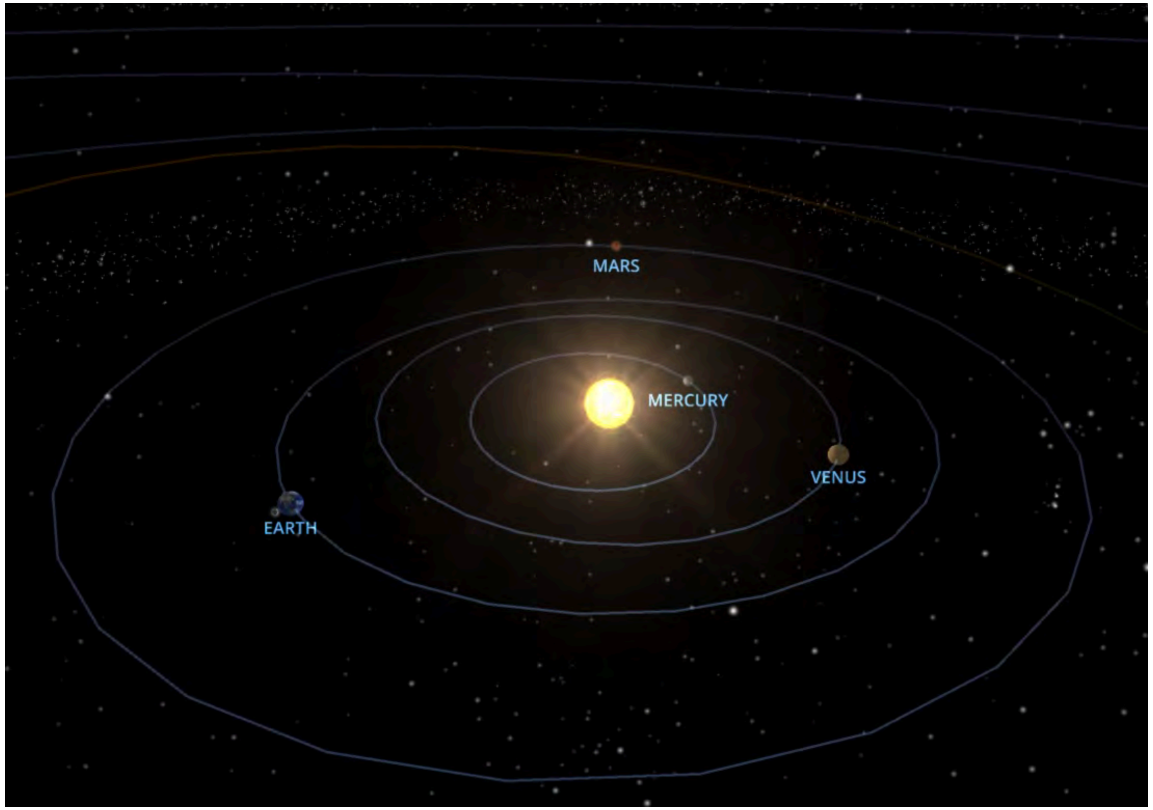
What are the models?

Flat Model

Varies

Standard Model



NOT TO SCALE

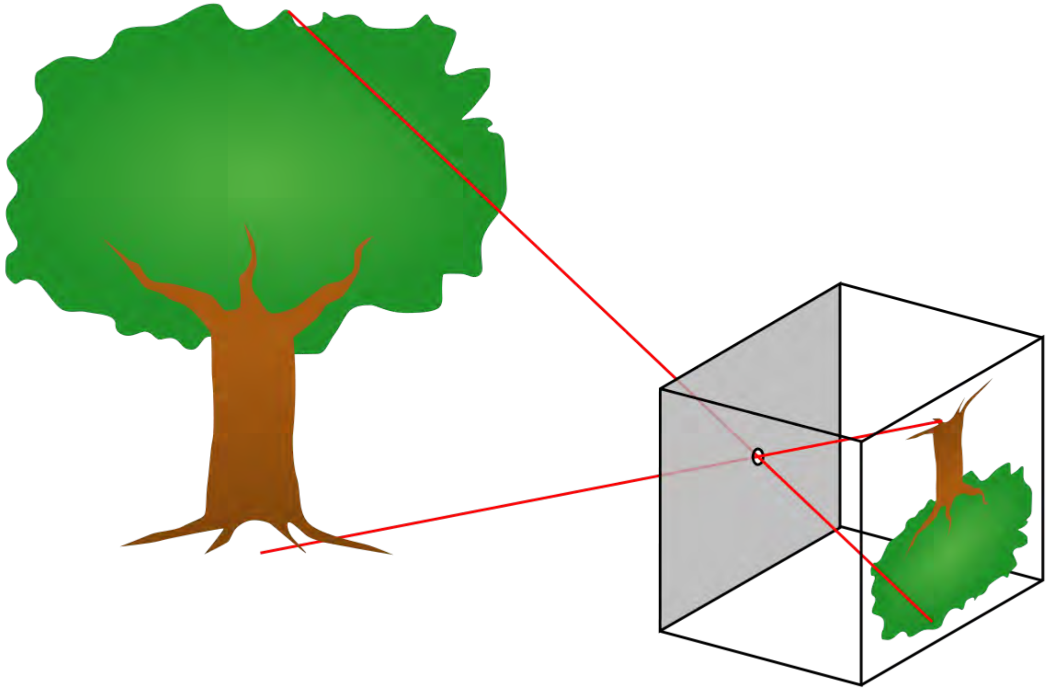
https://www.solarsystemscope.com/

Standard Model – Earth and Solar System

- Earth is an oblate spheroid about 4,000 miles in radius
- Earth has an atmosphere, smoothly decreasing in pressure
- The Moon is a spheroid, about 1,000 miles in radius, 250,000 miles away, no atmosphere, orbiting the Earth
- The Sun is very big, and millions of miles away
- The Earth and the other planets orbit the sun
- Stars are trillions of miles away

Standard Model – Light and Photos

- Cameras and eyes produce similar images
- Light enters the camera through a focal point, makes an image
- Light travels in straight lines over short distance
- Light is refracted (bent) towards the denser medium

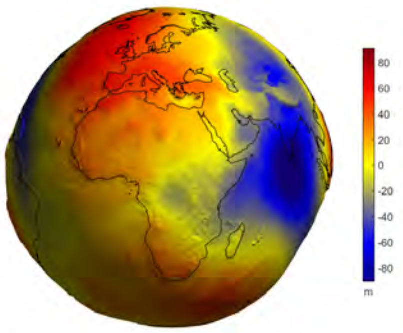


But *which* standard model?

- **Basic** – Just describes or gives rough numbers
- **Intermediate** – Accurate and gives useful numbers
- **Advanced** – Highly accurate, often complex and unnecessary

Example – The Shape of the Earth

- Basic – A Sphere
  - Works for things like rough distances
  - Works for calculating horizon curve and obscuration
- Intermediate – An Oblate Spheroid, WGS84
  - Needed for accurate navigation and surveying
  - Used by GPS
- Advanced – A geoid, with irregular land surfaces.
  - Very accurate navigation
  - Surveying and prospecting



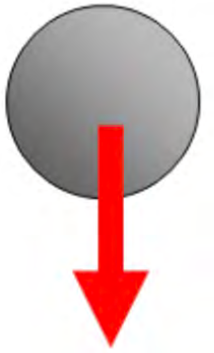
Geoid height (EGM2008, nmax=500)

Example: Force of Gravity (standard model)

Basic:

Force acts downwards

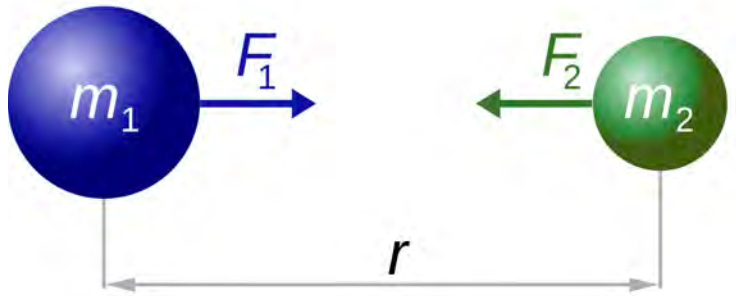
$$F = mg$$



Intermediate

Force is between two masses

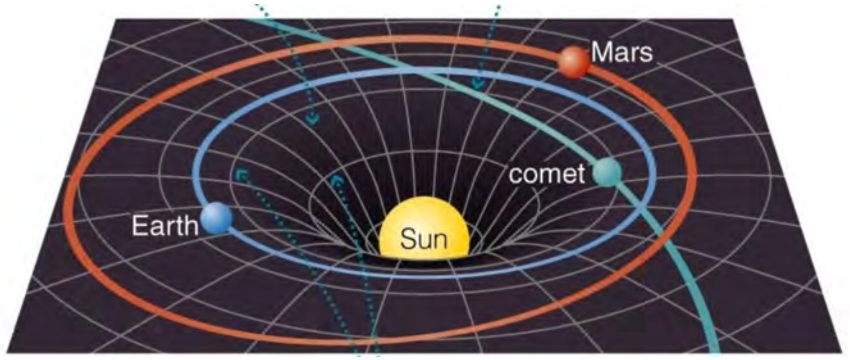
$$F = G\frac{m_1 m_2}{r^2}$$



Advanced

Force is a bending of spacetime

$$R_{\mu\nu} - \frac{1}{2}R\,g_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4}T_{\mu\nu}$$



Example: Lines of Sight in Air

- Basic:
  - Straight lines (no refraction)
- Intermediate
  - Average constant downwards refraction (“Standard” refraction)
- Advanced
  - Refraction varies based on temperature and humidity gradients
  - More so close to the ground, especially water

Basic and intermediate lines of sight

Earth's Curve Horizon, Bulge, Drop, and Hidden Calculator

Distance in Miles: 4

Viewer height in Feet: 6

Imperial Metric Advanced

Distance = 4 miles (21120 feet), View Height = 6 feet (72 inches) Actual Radius = 3959 miles

With "Standard" refraction adjustment of 7/6 radius (4618.83 miles)
Refracted Horizon = 3.24 miles (17107 feet)
Refracted Drop= 9.15 feet (109.74 inches)
Refracted Hidden= 0.33 feet (3.96 inches)
Refracted Horizon Dip = 0.040 Degrees, (0.0007 Radians)

Geometric results (no refraction)
Geometric Horizon = 3 miles (15838 feet)
Geometric Drop = 10.67 feet (128.03 inches)
Geometric Hidden= 0.67 feet (8.01 inches)
Geometric Horizon Dip = 0.043 Degrees, (0.0008 Radians)

Intermediate: Lines of sight

GEOGRAPHIC RANGE TABLE

The following table gives the approximate geographic range of visibility for an object which may be seen by an observer at sea level. It is necessary to add to the distance for the height of any object the distance corresponding to the height of the observer's eye above sea level.

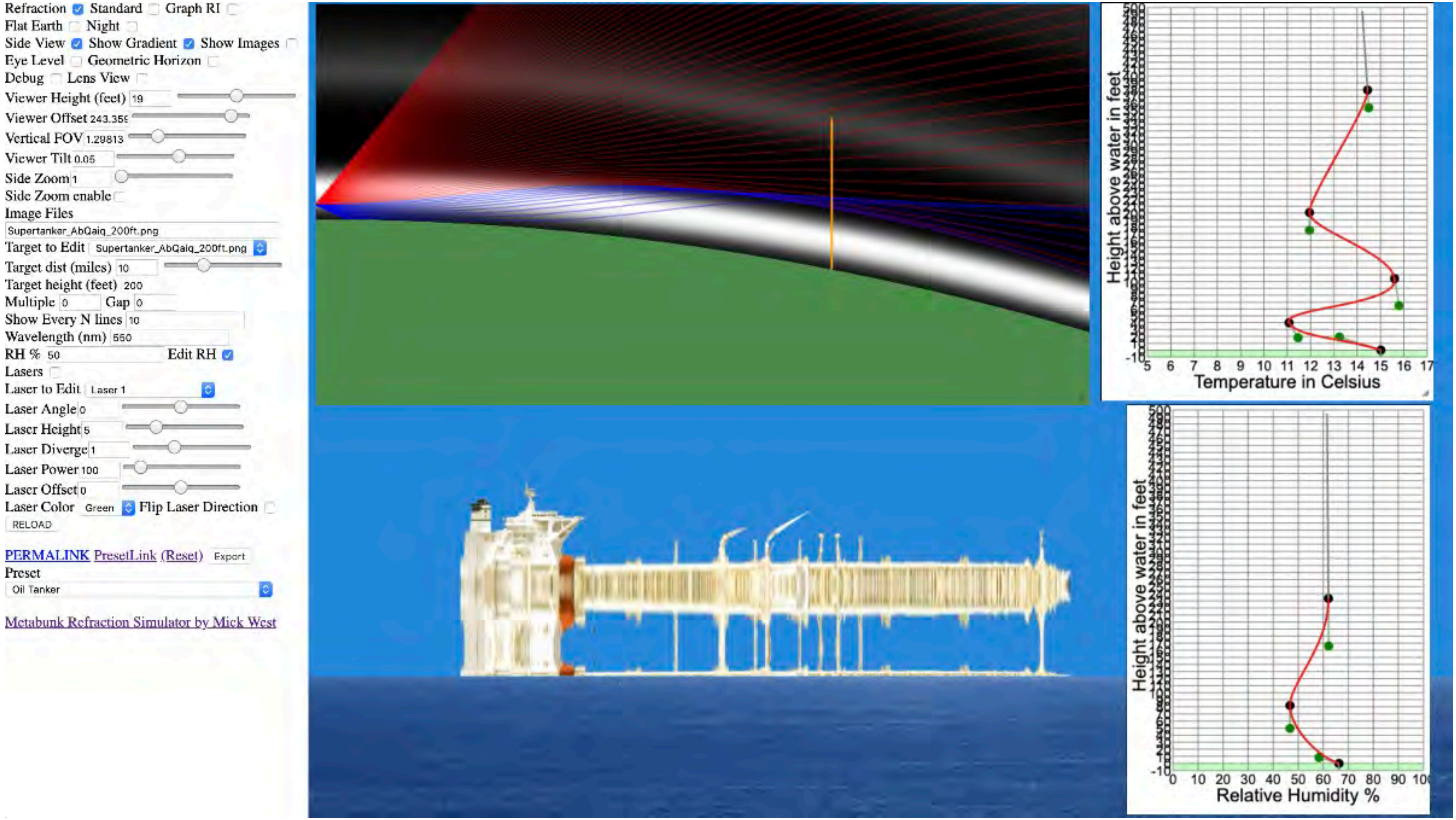
Height Feet / Meters	Distance Nautical Miles (NM)	Height Feet / Meters	Distance Nautical Miles (NM)	Height Feet / Meters	Distance Nautical Miles (NM)
5/1.5	2.6	70/21.3	9.8	250/76.2	18.5
10/3.1	3.7	75/22.9	10.1	300/91.4	20.3
15/4.6	4.5	80/24.4	10.5	350/106.7	21.9
20/6.1	5.2	85/25.9	10.8	400/121.9	23.4
25/7.6	5.9	90/27.4	11.1	450/137.2	24.8
30/9.1	6.4	95/29.0	11.4	500/152.4	26.2
35/10.7	6.9	100/30.5	11.7	550/167.6	27.4
40/12.2	7.4	110/33.5	12.3	600/182.9	28.7
45/13.7	7.8	120/36.6	12.8	650/198.1	29.8
50/15.2	8.3	130/39.6	13.3	700/213.4	31.0
55/16.8	8.7	140/42.7	13.8	800/243.8	33.1
60/18.3	9.1	150/45.7	14.3	900/274.3	35.1
65/19.8	9.4	200/61.0	16.5	1000/304.8	37.0

Example: Determine the geographic visibility of an object, with a height above water of 65 feet, for an observer with a height of eyeof 35 feet.

Enter above table;

Height of object 65 feet= 9.4 NM
Height of observer 35 feet= 6.9 NM
Computed geographic visibility= 16.3 NM

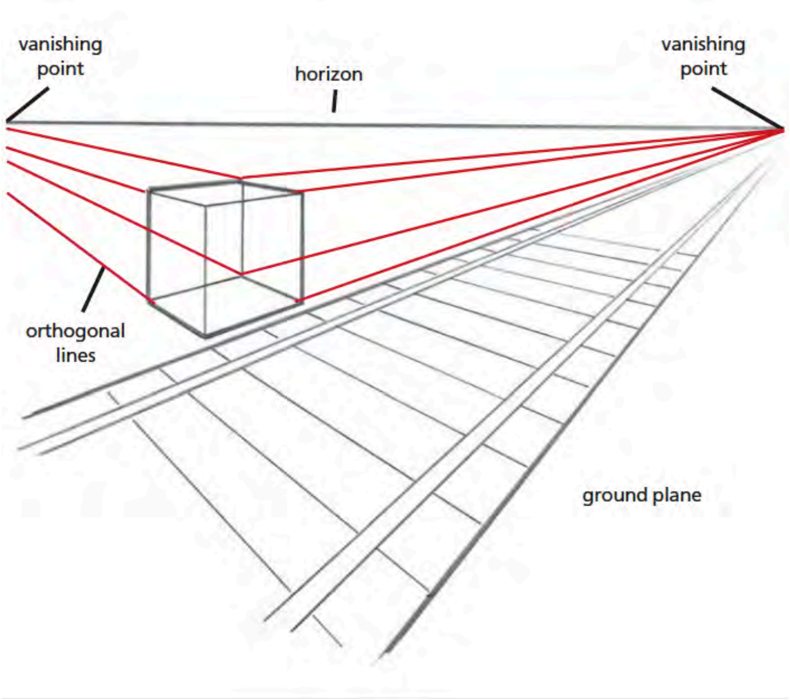
Advanced lines of sight

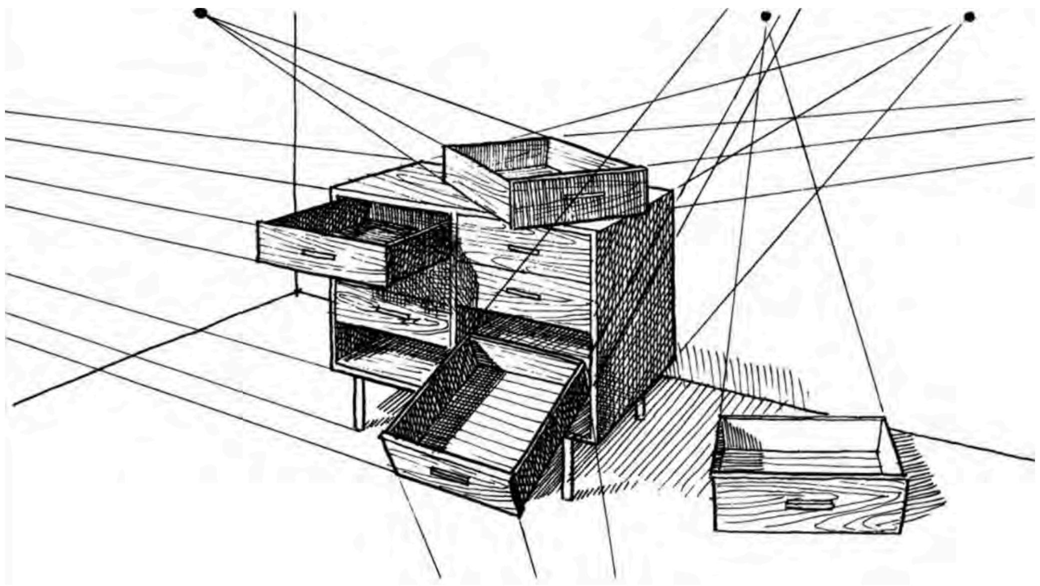


Perspective

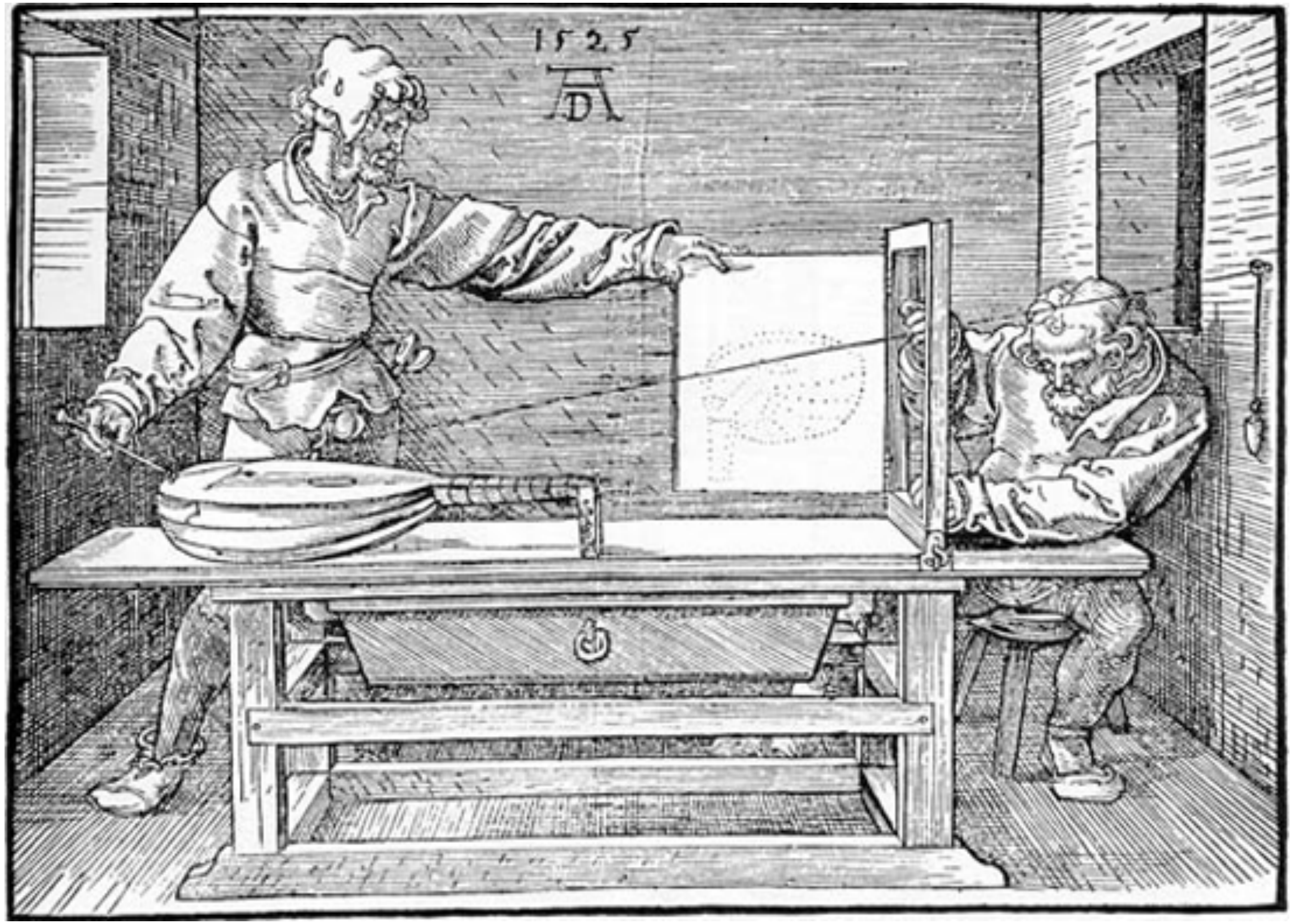
- **Basic**: Converging parallel lines, useful simplification for art
- **Intermediate**: Image size = Actual size / Distance
- **Intermediate+**: Light paths intersecting an image plane
- **Advanced**: The results of 3D ray tracing with air and lens refraction (photos.)

Basic Perspective

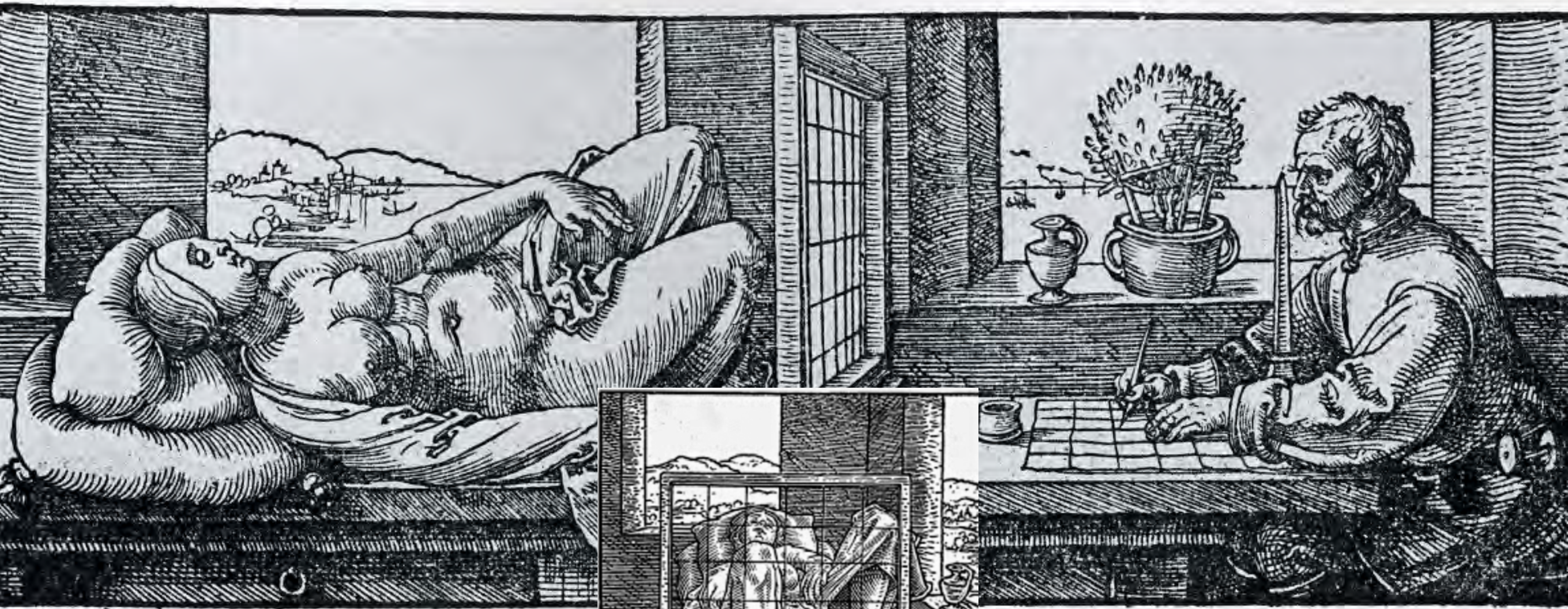


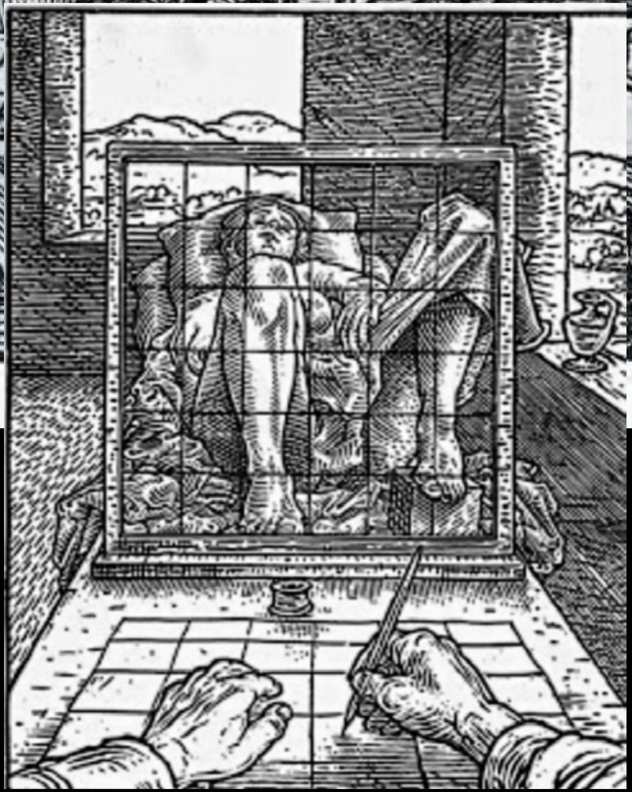


Intermediate Perspective

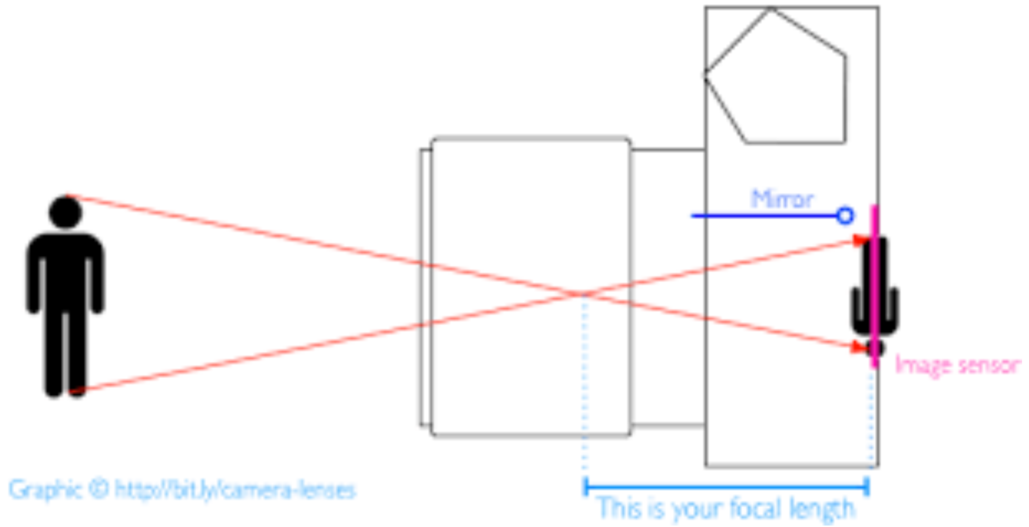


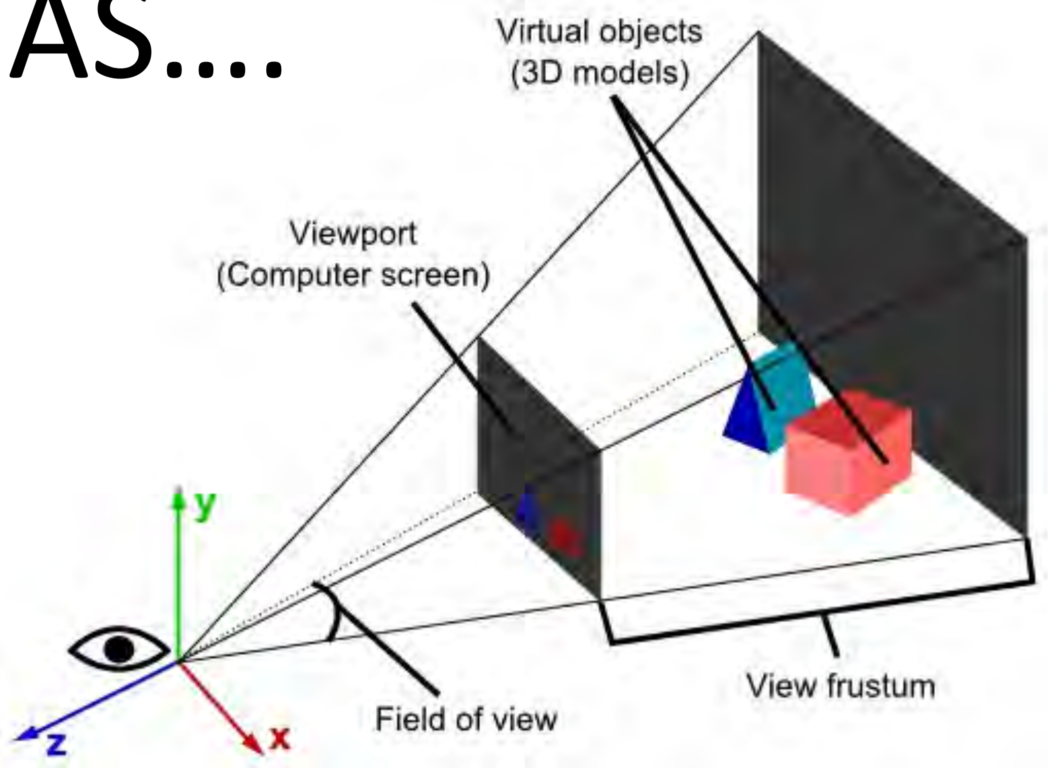
"The Painter's Manual" - Albrecht Dürer, 1538





SAME AS….


Mirror
Image sensor
Graphic © http://bit.ly/camera-lenses
This is your focal length


Virtual objects
(3D models)
Viewport
(Computer screen)
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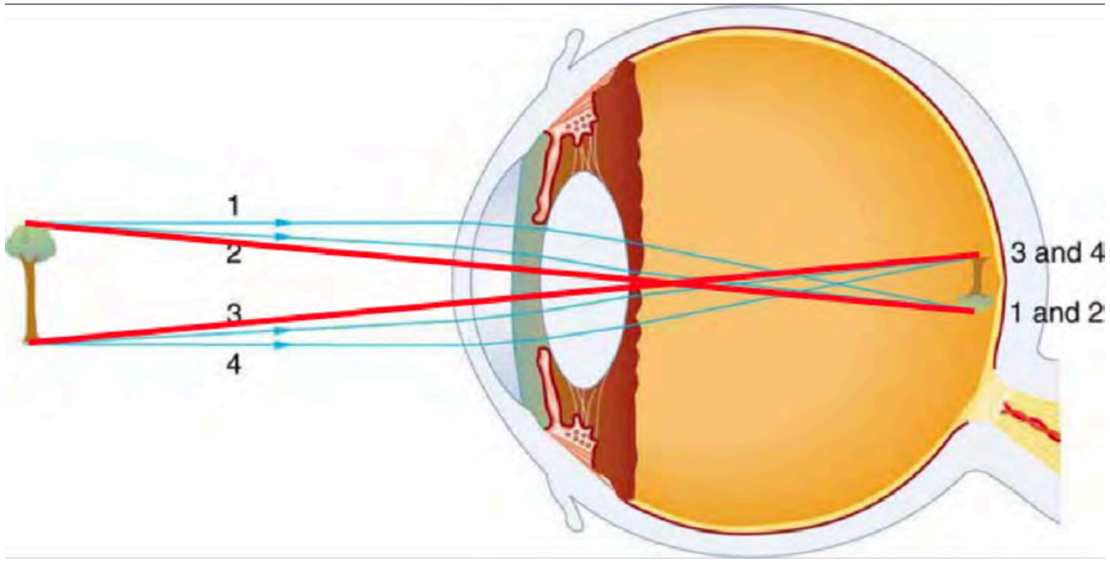
z
x
Field of view
View frustum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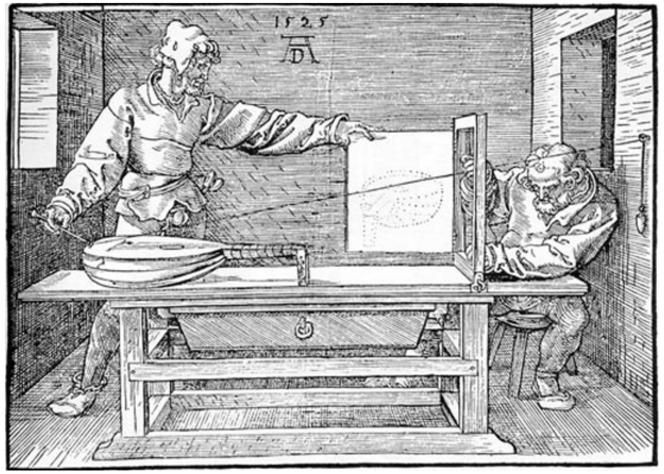
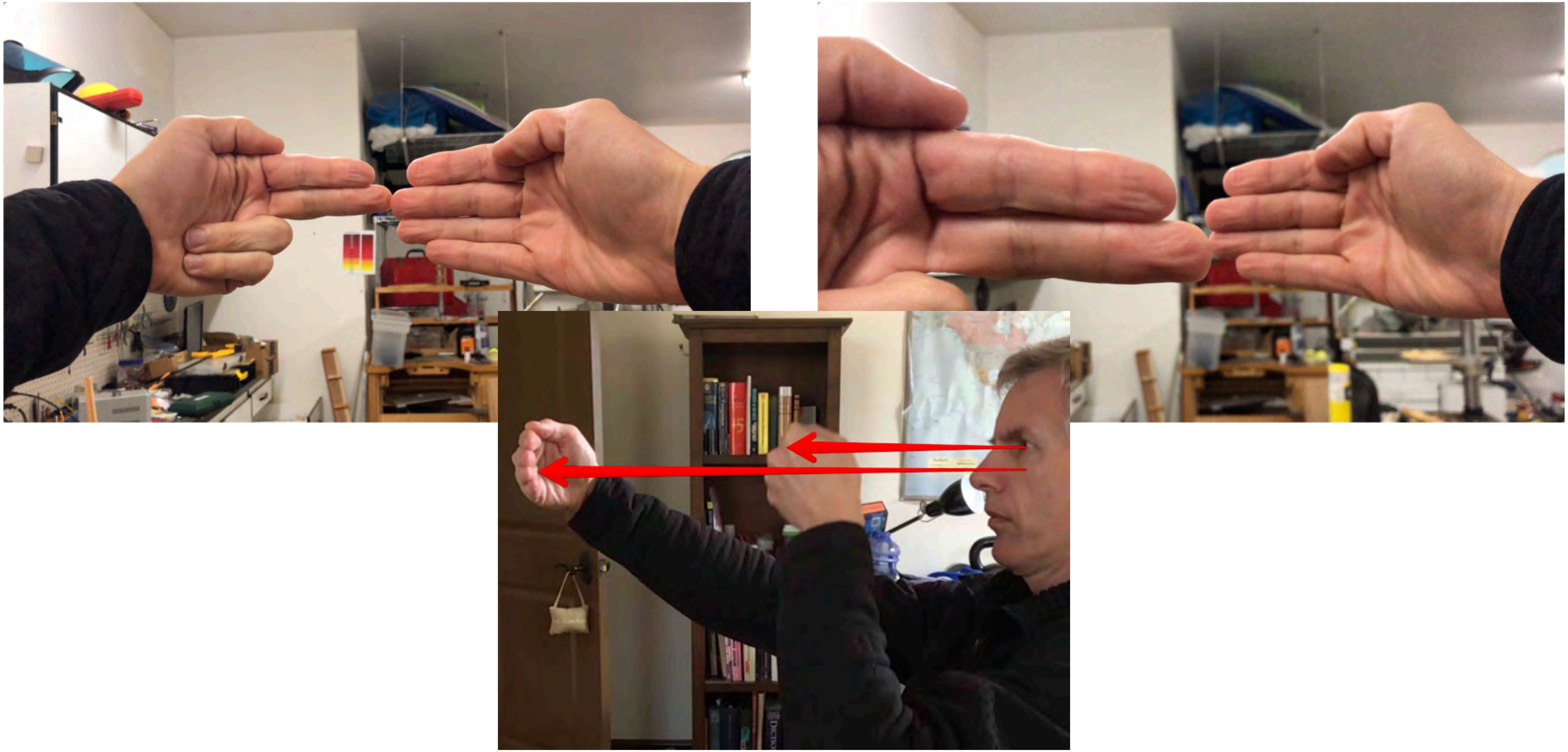
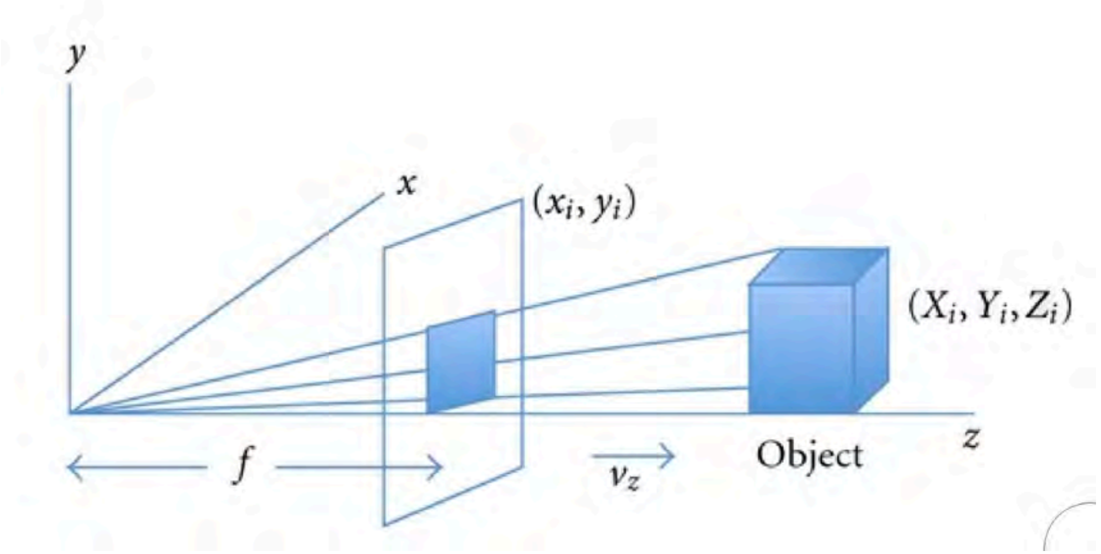


Image size = Actual size / Distance



Intermediate/Advanced Perspective

$$\frac{\text{Image distance from point to image center}}{\text{Focal Length}} = \frac{\text{Actual perpendicular distance from point to centerline}}{\text{Distance Along Centerline}}$$



YOU CAN TEST THIS!

Consequences of real perspective

- Basic perspective (converging parallel lines) comes from intermediate perspective. It's not a law, it's just one consequence
- If there is a line of sight to something, and it's big and/or bright enough, **then you can see it**
- Perspective does not hide things.

Beware of Rhetorical models!

- Rhetorical model = just a description
- Lower level than even basic models.
- Often used in memes:
- Example: “In the globe model water is curved, but water in a glass is flat, so the globe model is wrong”
- Rhetorical model’s don’t specify quantities or equations
- Ask “HOW MUCH?”
- Curve over 3” of water is about 0.000000018”, or 18 billionths of an inch. Not visible, so a glass of water does not invalidate the globe.

Beware of incomplete models

https://en.wikipedia.org/wiki/Fluid_mechanics#Fluid_statics

Fluid statics

Main article: Fluid statics

Fluid statics or **hydrostatics** is the branch of fluid mechanics that studies fluids at rest. It embraces the study of the conditions under which fluids are at rest in stable equilibrium; and is contrasted with fluid dynamics, the study of fluids in motion. Hydrostatics offers physical explanations for many phenomena of everyday life, such as why atmospheric pressure changes with altitude, why wood and oil float on water, and why the surface of water is always level and horizontal whatever the shape of its container. Hydrostatics is fundamental to hydraulics, the engineering of equipment for https://en.wikipedia.org/wiki/Hydrostatic_equilibrium

In fluid mechanics, a fluid is said to be in **hydrostatic equilibrium** or **hydrostatic balance** when it is at rest, or when the flow velocity at each point is constant over time. This occurs when external forces such as gravity are balanced by a pressure-gradient force.[1] For instance, the pressure-gradient force prevents gravity from collapsing Earth's atmosphere into a thin, dense shell, whereas gravity prevents the pressure gradient force from diffusing the atmosphere into space.

https://en.wikipedia.org/wiki/Hydrostatics

Hydrostatic pressure [edit]

See also: Vertical pressure variation

In a fluid at rest, all frictional and inertial stresses vanish and the state of stress of the system is called *hydrostatic*. When this condition of $V = 0$ is applied to the Navier-Stokes equation, the gradient of pressure becomes a function of body forces only. For a barotropic fluid in a conservative force field like a gravitational force field, pressure exerted by a fluid at equilibrium becomes a function of force exerted by gravity.

The hydrostatic pressure can be determined from a control volume analysis of an infinitesimally small cube of fluid. Since pressure is defined as the force exerted on a test area ($p = \frac{F}{A}$, with p: pressure, F: force normal to area A, A: area), and the only force acting on any such small cube of fluid is the weight of the fluid column above it, hydrostatic pressure can be calculated according to the following formula:

$$p(z) - p(z_0) = \frac{1}{A} \int_{z_0}^{z} dz' \iint_A dx' dy' \, \rho(z') g(z') = \int_{z_0}^{z} dz' \, \rho(z') g(z'),$$

Vertical pressure variation

From Wikipedia, the free encyclopedia

Vertical pressure variation is the variation in pressure as a function of elevation. Depending on the fluid in question and the context being referred to, it may also vary significantly in dimensions perpendicular to elevation as well, and these variations have relevance in the context of pressure gradient force and its effects. However, the vertical variation is especially significant, as it results from the pull of gravity on the fluid; namely, for the same given fluid, a decrease in elevation within it corresponds to a taller column of fluid weighing down on that point.

Contents [hide]

Basic formula [edit]

A relatively simple version [1] of the vertical fluid pressure variation is simply that the pressure difference between two elevations is the product of elevation change, gravity, and density. The equation is as follows:

$$\frac{dP}{dh} = -\rho g, \text{ and}$$

Pressure-gradient force

From Wikipedia, the free encyclopedia

The **pressure-gradient force** is the force that results when there is a difference in pressure across a surface. In general, a pressure is a force per unit area, across a surface. A difference in pressure across a surface then implies a difference in force, which can result in an acceleration according to Newton's second law of motion, if there is no additional force to balance it. The resulting force is always directed from the region of higher-pressure to the region of lower-pressure. When a fluid is in an equilibrium state (i.e. there are no net forces, and no acceleration), the system is referred to as being in hydrostatic equilibrium. In the case of atmospheres, the pressure gradient force is balanced by the gravitational force, maintaining hydrostatic equilibrium. In Earth's atmosphere, for example, air pressure decreases at altitudes above Earth's surface, thus providing a pressure gradient force which counteracts the force of gravity on the atmosphere.

Explains why the atmosphere has pressure and does not fly off into space.

“LEVEL”

LEVEL

- BASIC
  - It’s flat, horizontal.
- INTERMEDIATE
  - At right angles to a plumb line
  - Always parallel to a spirit level
  - Varies by location
- ADVANCED
  - Geopotential isosurface, or something.

OLD SURVEYING BOOKS AGREE

LEVEL = CURVED

(ON LARGE ENOUGH SCALES)

A Treatise on Surveying, Containing the Theory and Practice: , John Gummere, 1853, page 239

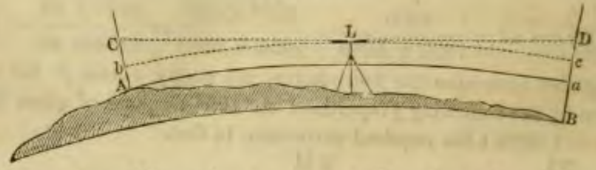
Levelling is the art of determining the difference or differences of level of two or more places.

In consequence of the globular figure of the earth, a level surface is not, as it appears to be, a plane surface. It is nearly, though not exactly, spherical. In the ope-

independently of the correction of apparent level.

Let CD, Fig. 121, be the line of apparent level indi-

Fig. 121.



cated by a levelling instrument L, placed midway between the places A and B; also let the arc *bc* be the

A Treatise of Practical Surveying, Robert Gibson, 1777

LEVELLING.

Plate XIII. fig. 2.

LEVELLING is the art of ascertaining the perpendicular ascent or descent of one place (or more) above or below the horizontal level of another, for various intentions; and of marking out courses for the conveyance of water, *&c.*

The *true level* is a curve conforming to the surface of the earth; as ABG.

The *apparent level* is a tangent to that curve; as ADE.

A treatise on surveying and navigation - Robinson, Horatio N, 1858

CHAPTER VIII.

LEVELING.

Two or more points are said to be on a level, when they are equally distant from the center of the earth, or when they are equally distant from a tranquil fluid, situated immediately below them. A level surface on the earth, is nearly spherical, *and is not a plane;* it is everywhere *perpendicular to a plumb line.*

Any small portion of a true level surface, cannot be distinguished from a plane; and, therefore, when observations are taken in respect to level, within short distances of each other, the spherical form of the earth is disregarded, and the level treated as a plane. But when any considerable portion of surface is taken into account, the curvature of the earth's surface must be considered.

A Treatise on Surveying - Part I, by Middleton and Chadwick, 1899

CHAPTER VII.

LEVELLING AND CONTOURING.

Levelling.

LEVELLING is the art of determining the relative altitudes of points on the Earth's surface.

Were the Earth a true sphere, the altitude of a point might be defined as its distance from the Earth's centre; but, as it is spheroidal in shape, the definition is not exact in a general sense, though it is nearly so as regards a limited area. If a long pipe A B (fig. 146) were laid, from one place to another, with vertical pipes at intervals, and filled with water, the altitude of the water-surfaces in the upright tubes would be equal when the water has come to rest. Further, if a network of

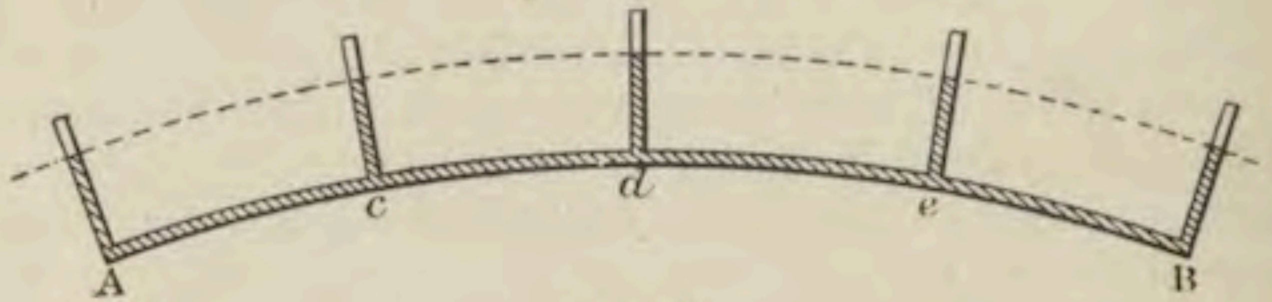


FIG. 146.

pipes were laid over a given area, connected together, and provided with upright pipes, the water-surface in each and every pipe would stand at the same altitude.

"A Text-book of Plane Surveying", Raymond, 1901

40. Curvature and refraction. The effect of curvature and refraction is shown as follows: In the exaggerated figure let *A* be a point in the line of sight of a level telescope. Let *FD* be a normal to the earth's surface, at some distance *K*, — approximately equal to *AB*, *GF*, or *AD*, — from the instrument. The level line through *A* cuts the normal at *B*, while the horizontal line of sight cuts it at *D*. *DB* is

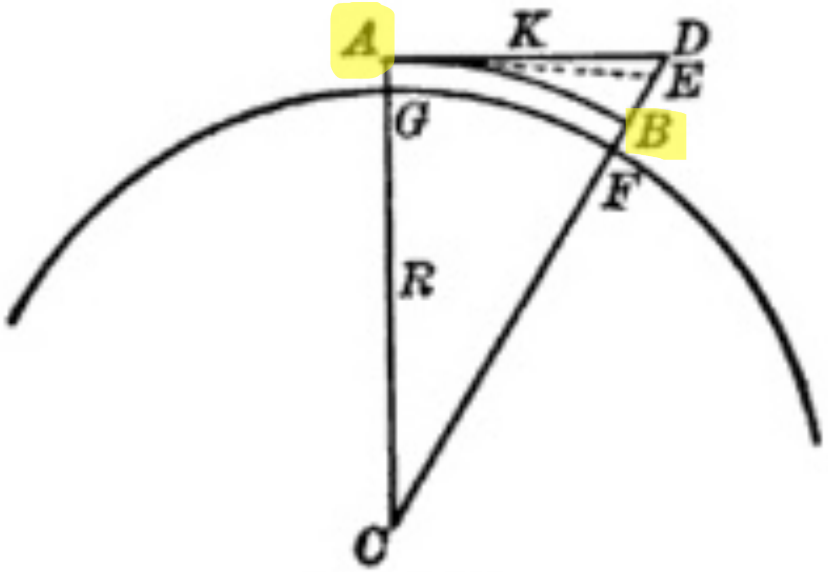


FIG. 34.

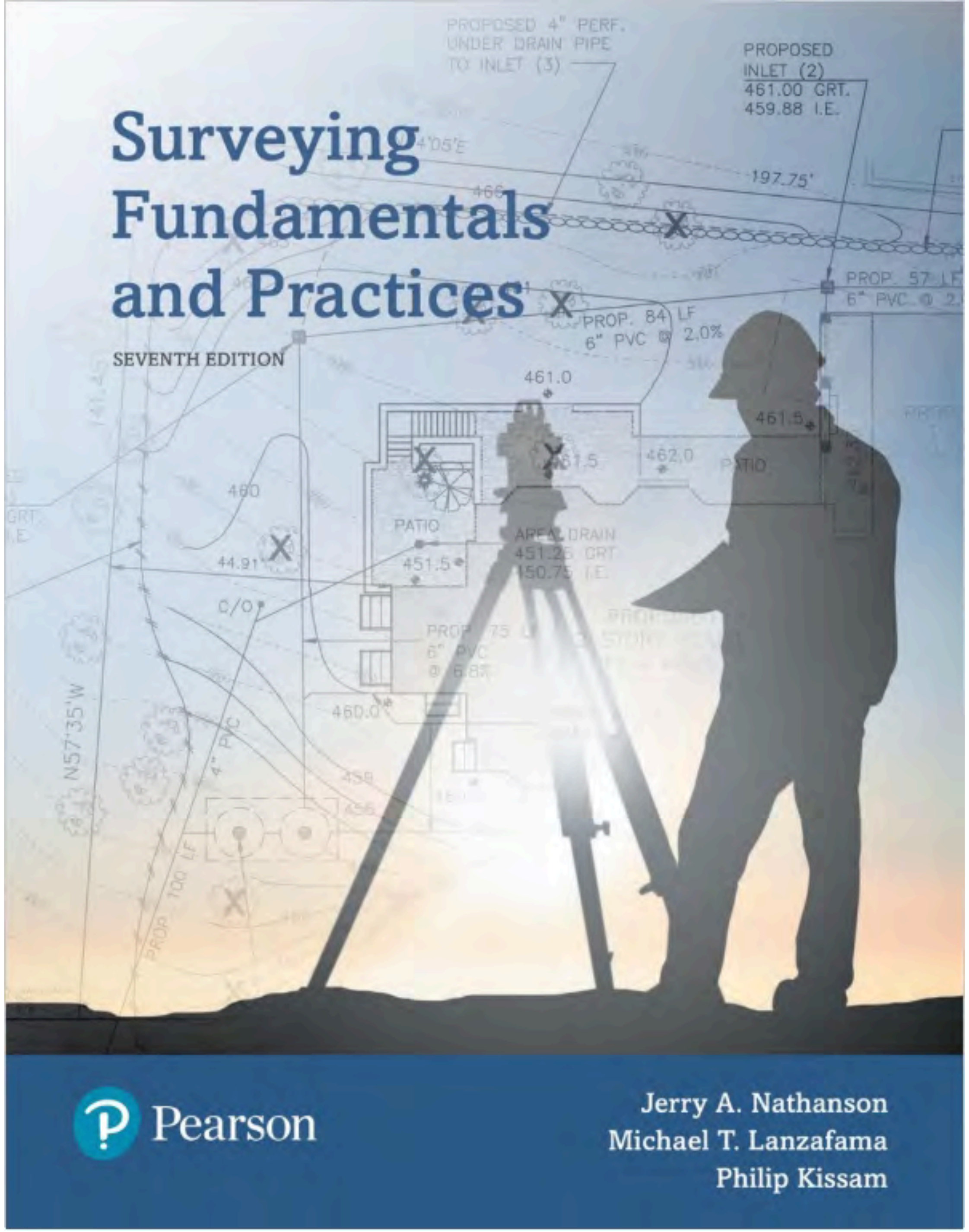
The Complete Dictionary of Arts and Sciences. Croker, et al., 1765

wherein are ſtaves; and on this foot is placed the box.

LEVELLING, the finding a line parallel to the horizon, at one or more ſtations, and ſo to determine the height of one place with regard to another. See LEVEL.

A truly level ſurface is a ſegment of any ſpherical ſurface which is concentric to the globe of the earth. A true line of level is an arch of a great circle which is imagined, to be deſcribed upon a truly level ſurface.

The apparent level is a ſtraight line drawn tangent to an arch or line of true level. Every point of the apparent level, except the point of contact, is higher than the true level: thus (plate LXXIX. *fig.* 13.) let EAG be an arch of a great circle drawn upon the earth; to a perſon



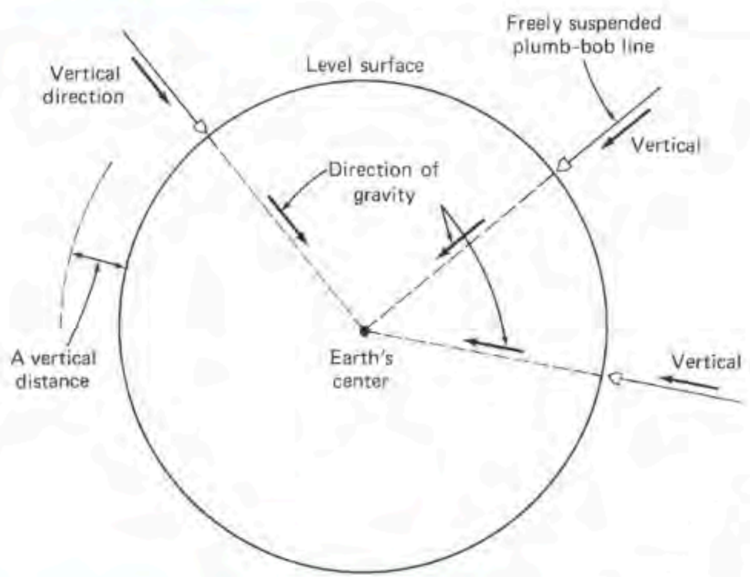


FIGURE 1-4. The vertical direction is defined as the direction of the force of gravity.

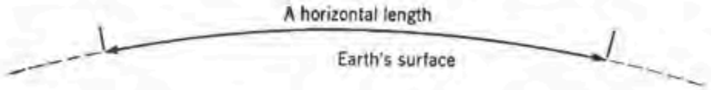
Defining Horizontal and Vertical Directions

The earth actually has the approximate shape of an *oblate spheroid*, that is, the solid generated by an ellipse rotated on its minor axis. Its polar axis of rotation is slightly shorter than an axis passing through the equator. But for our purposes, we can consider the earth to be a perfect *sphere* with a constant diameter. In fact, we can ignore, for the time being, surface irregularities like mountains and valleys. And we can consider that the surface of the sphere is represented by the average level of the ocean, or *mean sea level*.

By definition, the curved surface of the sphere is termed a *level surface*. The direction of gravity is perpendicular or normal to this level surface at all points, and *gravity* is used as a reference direction for all surveying measurements. The direction of gravity is easily established in the field by a freely suspended *plumb line*, which is simply a weight, or *plumb bob*, attached to the end of a string. The direction of gravity is different at every position on the earth's surface. As shown in Figure 1-4, the direction of all plumb lines converge at the center of the earth; at no points are the plumb lines actually parallel.

The *vertical direction* is taken to be the direction of gravity. Therefore, it is incorrect to define vertical as simply "straight up and down," as many beginning students tend to do. The vertical direction varies from point to point on the earth's surface. The only common factor is the direction of gravity.

By definition, the *horizontal direction* is the direction perpendicular (at an angle of 90°) to the vertical direction of gravity. Because the vertical direction varies from point to point, the horizontal direction also does. A horizontal length or distance, then, is not really a perfectly straight line. It is curved like the surface of the earth. This is illustrated in Figure 1-5.



Surveying Fundamentals and Practices. 7th Ed. 2017

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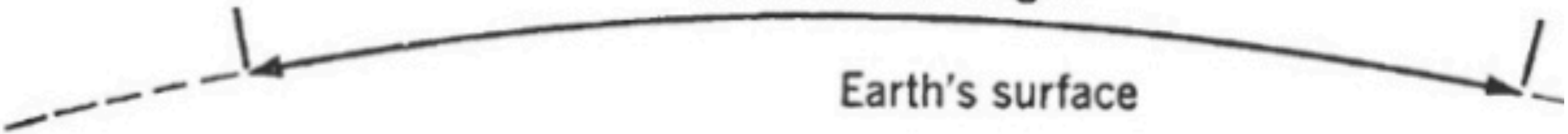
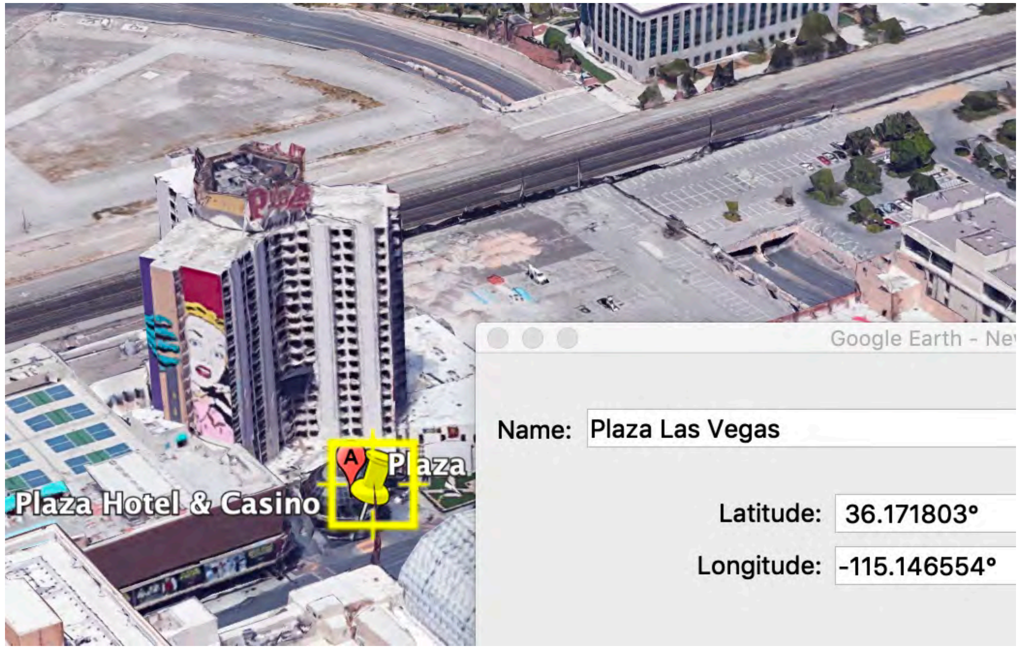


WHY I BELIEVE THE STANDARD MODEL

#1 – Latitude and Longitude

Latitude and Longitude Work

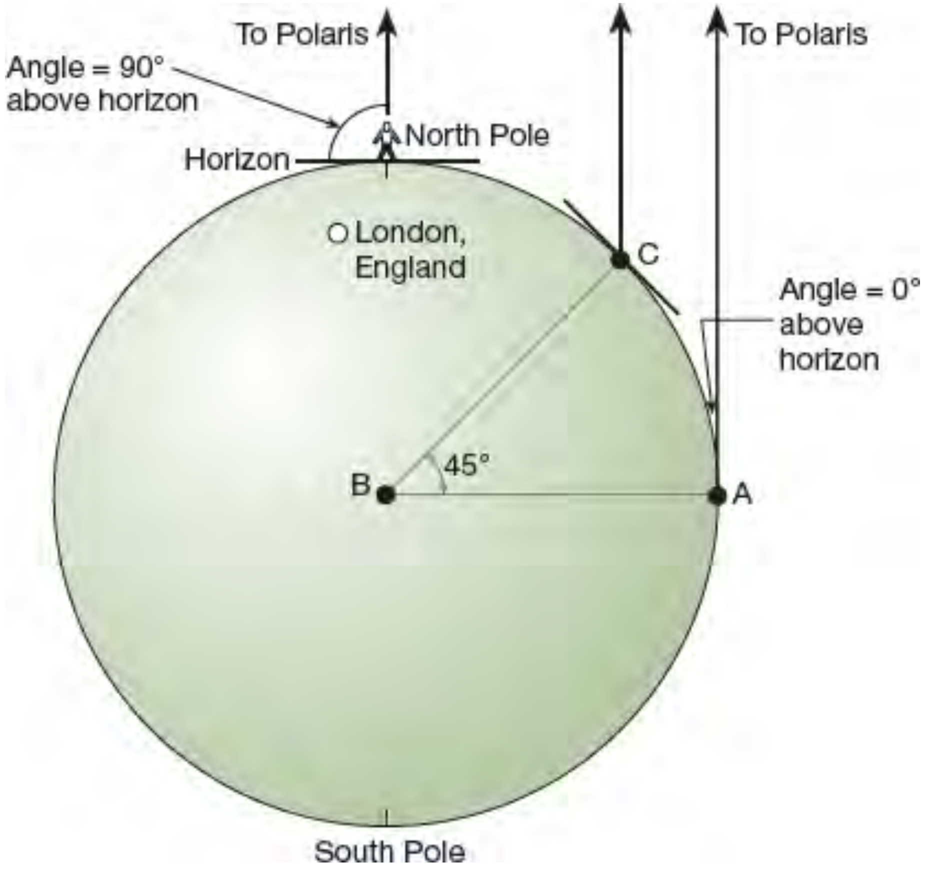
- Specifies <u>any</u> point on Earth's surface
- Fixed values, don't change
- Been used for navigation for centuries
- You use it for navigation, in GPS in phone or car

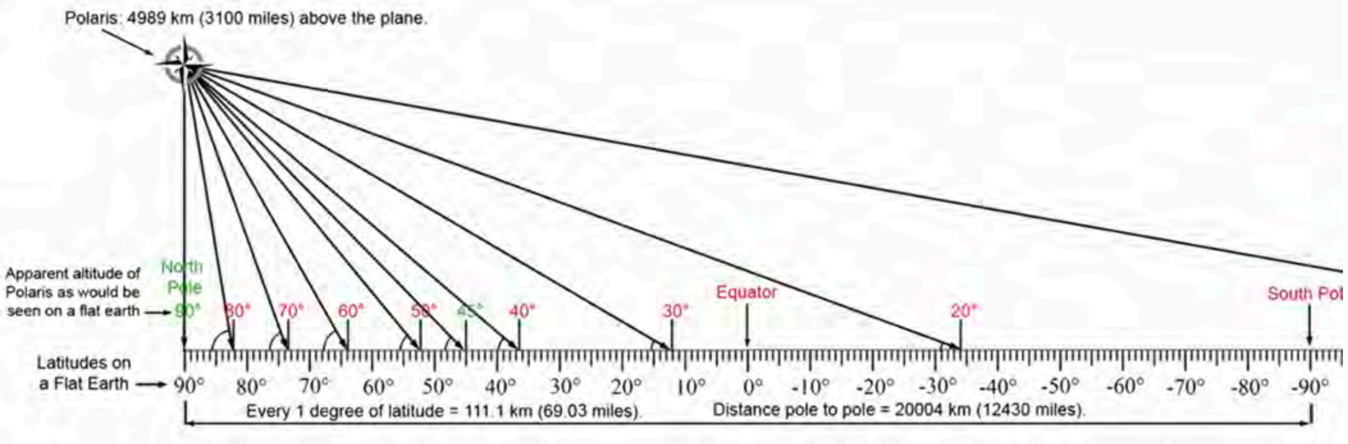


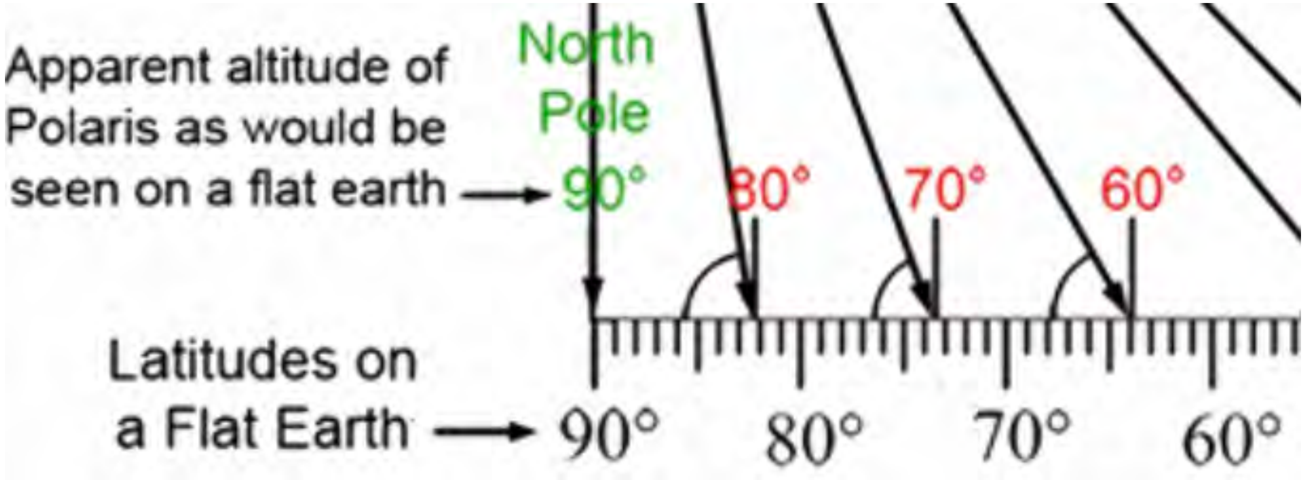
Latitude = Distance from the Equator

- Latitude of the Equator is 0°
- Latitude goes from -90° (south of equator)
- To 90° (the North pole)
- 1° of latitude is about 69 miles
  - (Polar circumference of Earth 24860 / 360 degrees = 69.055)
- Verifiable with your car. Find a straight N/S road.
- Basic = Sphere, Advanced = WGS84 Ellipsoid

Measuring Latitude with Polaris







Polaris, the wandering star, slightly

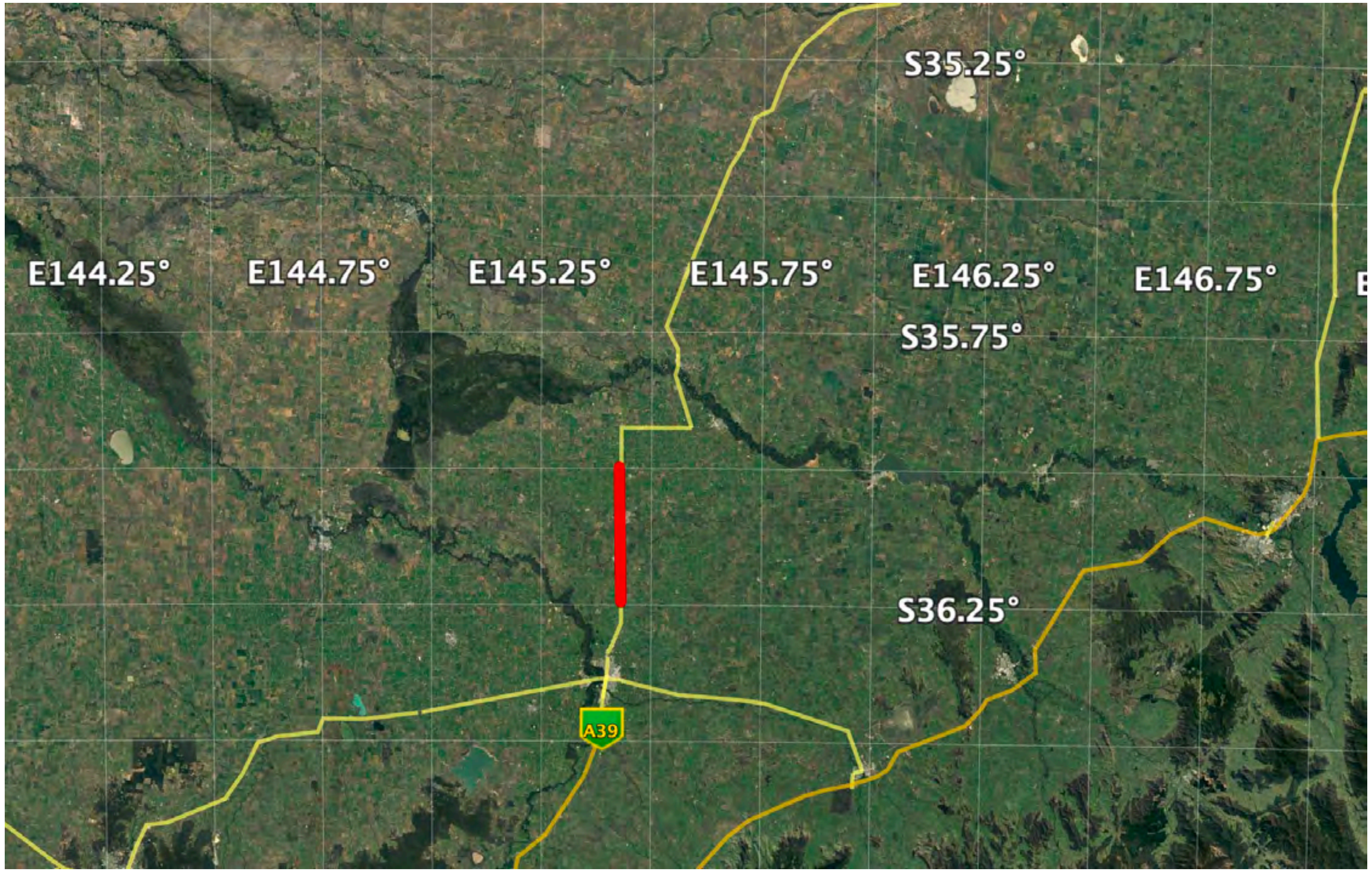
- Polaris is not fixed!
- And I don't mean precession
  - (although that's real too)
- Polaris is not at 90°, it's at 89.25°
- Take a star trail photo zoomed in, Polaris will make a little circle

Or just use your GPS

- We know it works from experience.
- Places have fixed latitude and longitude
- We see those latitude and longitude on the map
- Places don’t move
- Every measurement ever done with Polaris matches this.

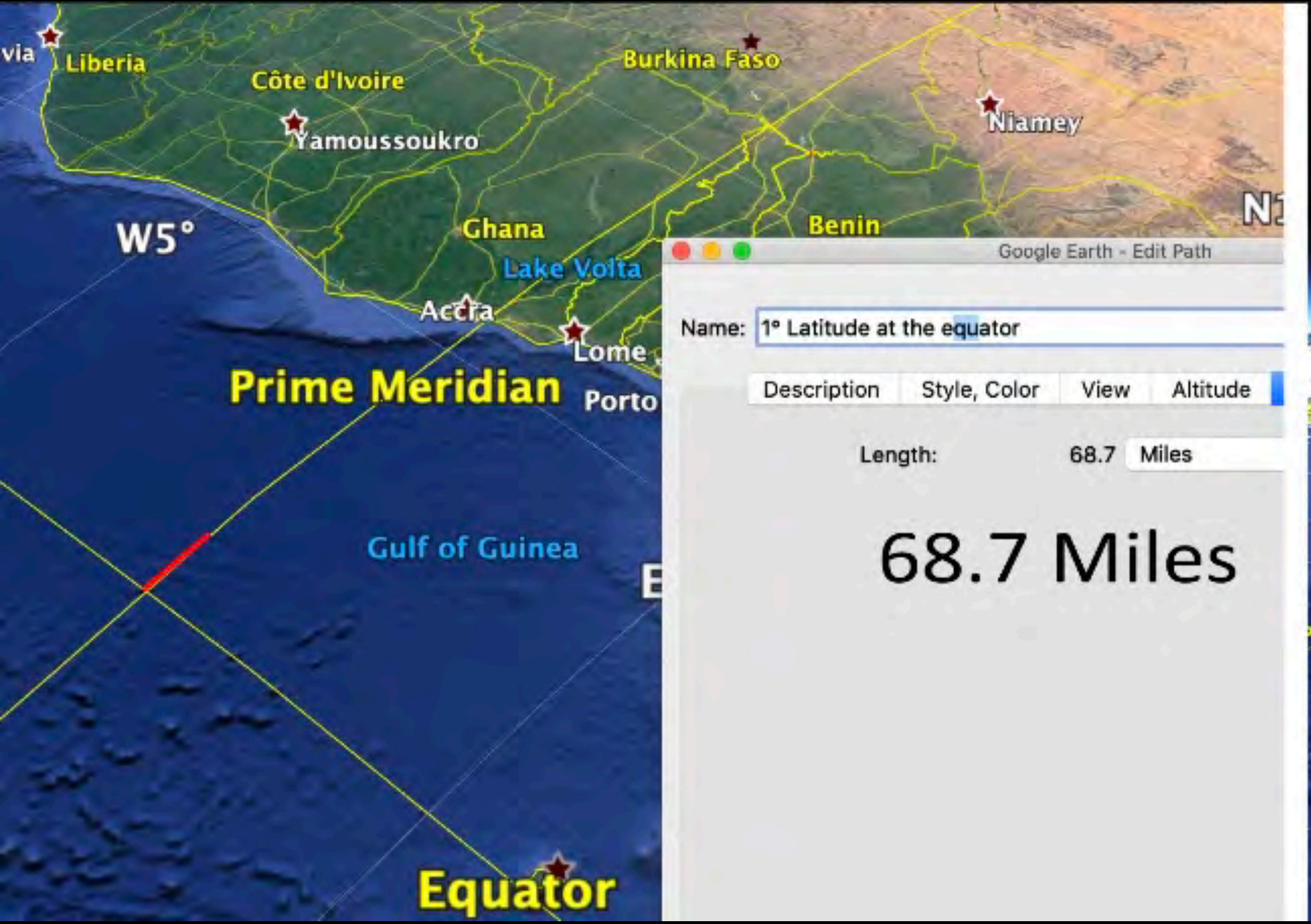
Testing Latitude - Kansas

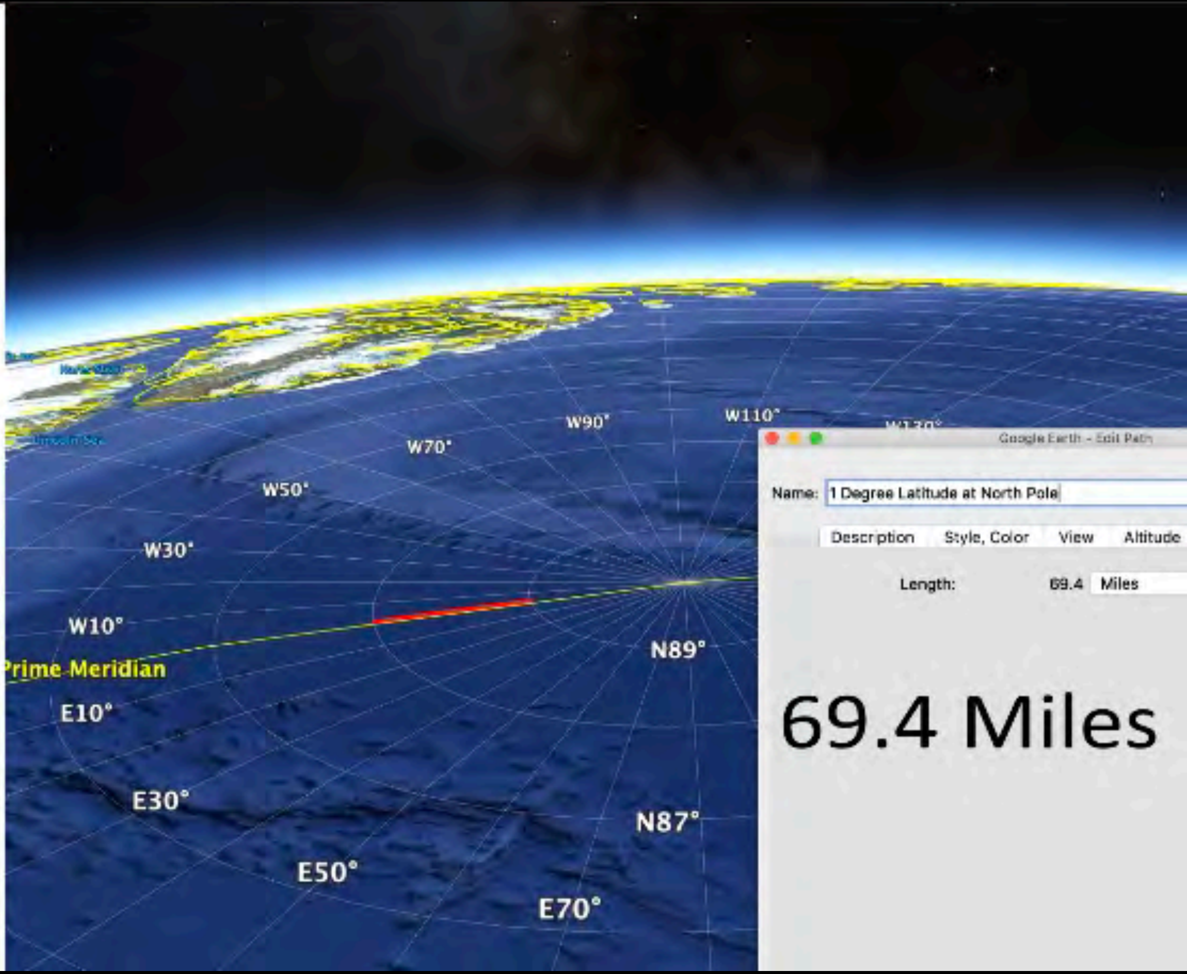
Testing Latitude - Australia



Advanced Latitude Observations – WGS84

- 1° of Latitude is not exactly 69.055.
- It’s varies from 68.7 miles at the equator, to 69.4 at the poles
- You can see this in Google Earth, and in any mapping software

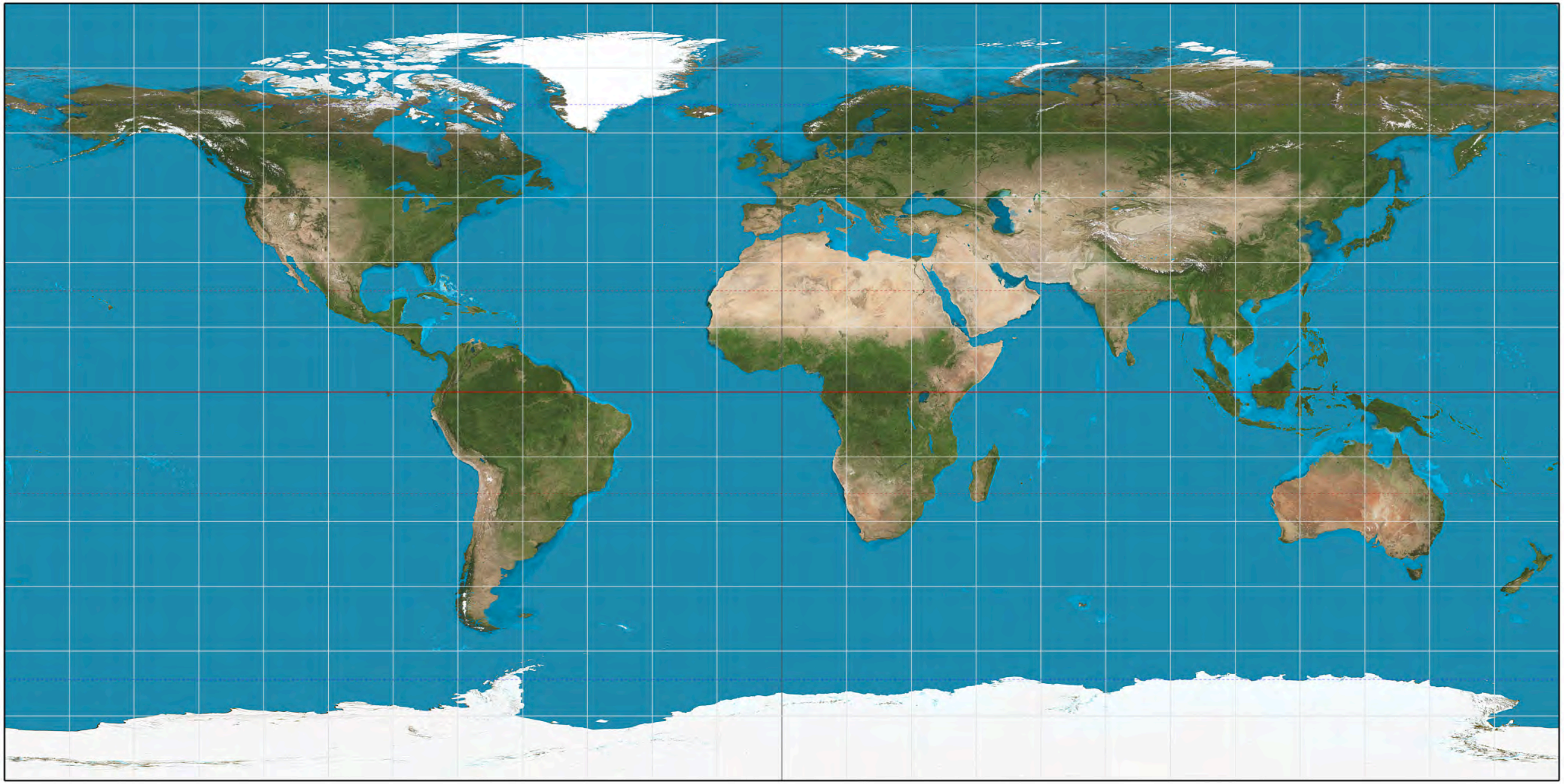

Liberia
Côte d'Ivoire
Yamoussoukro
Burkina Faso
Niamey
Ghana
Benin
Lake Volta
W5°
Accra
Lome
Prime Meridian
Porto
Gulf of Guinea
Equator
Google Earth - Edit Path
Name: 1° Latitude at the equator
Description
Style, Color
View
Altitude
Length: 68.7 Miles
68.7 Miles

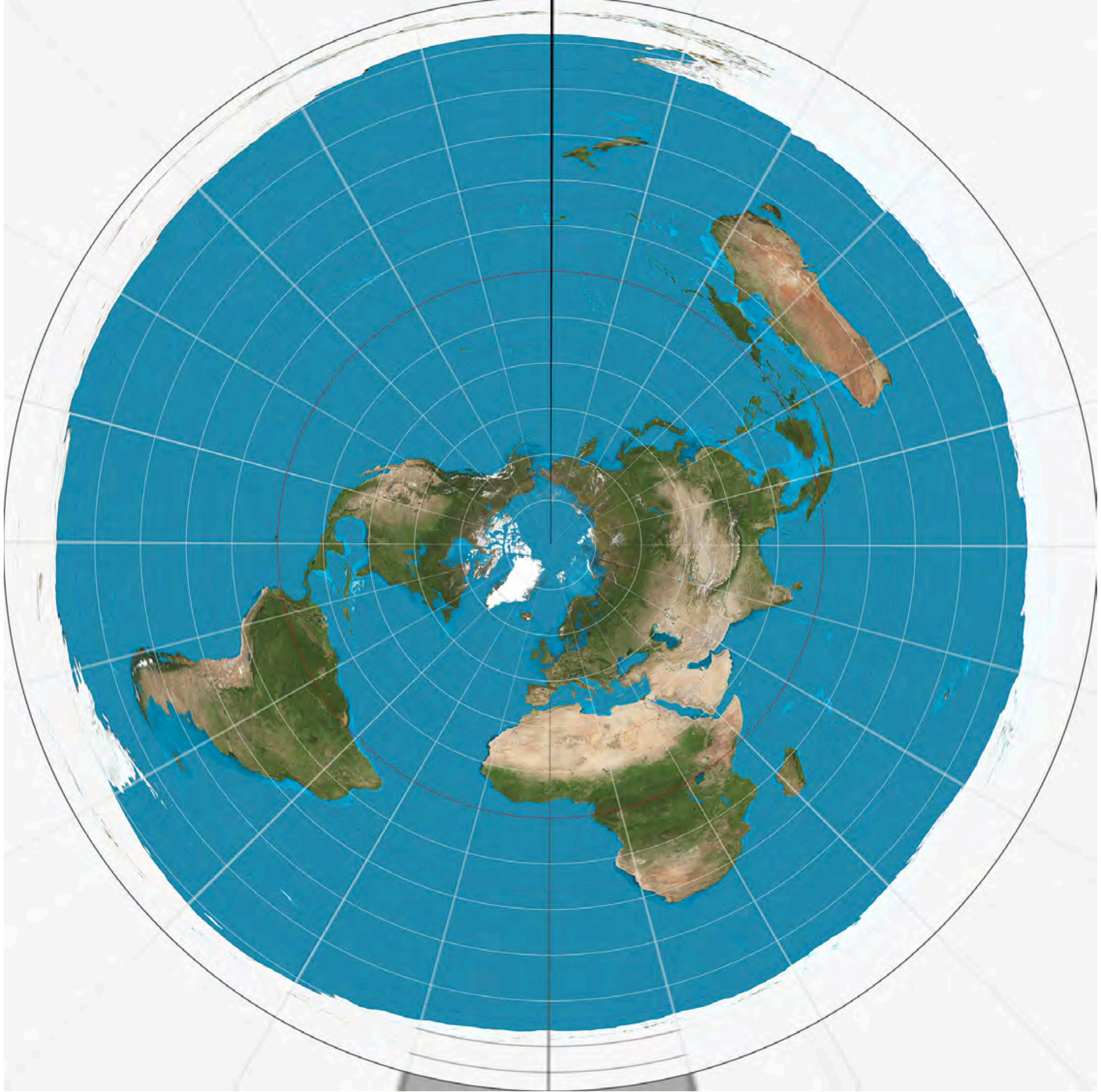

W90°
W110°
W70°
W50°
W30°
W10°
Prime Meridian
E10°
E30°
E50°
E70°
N89°
N87°
Google Earth - Edit Path
Name: 1 Degree Latitude at North Pole
Description
Style, Color
View
Altitude
Length: 69.4 Miles
69.4 Miles

Advanced Latitude Observations – WGS84

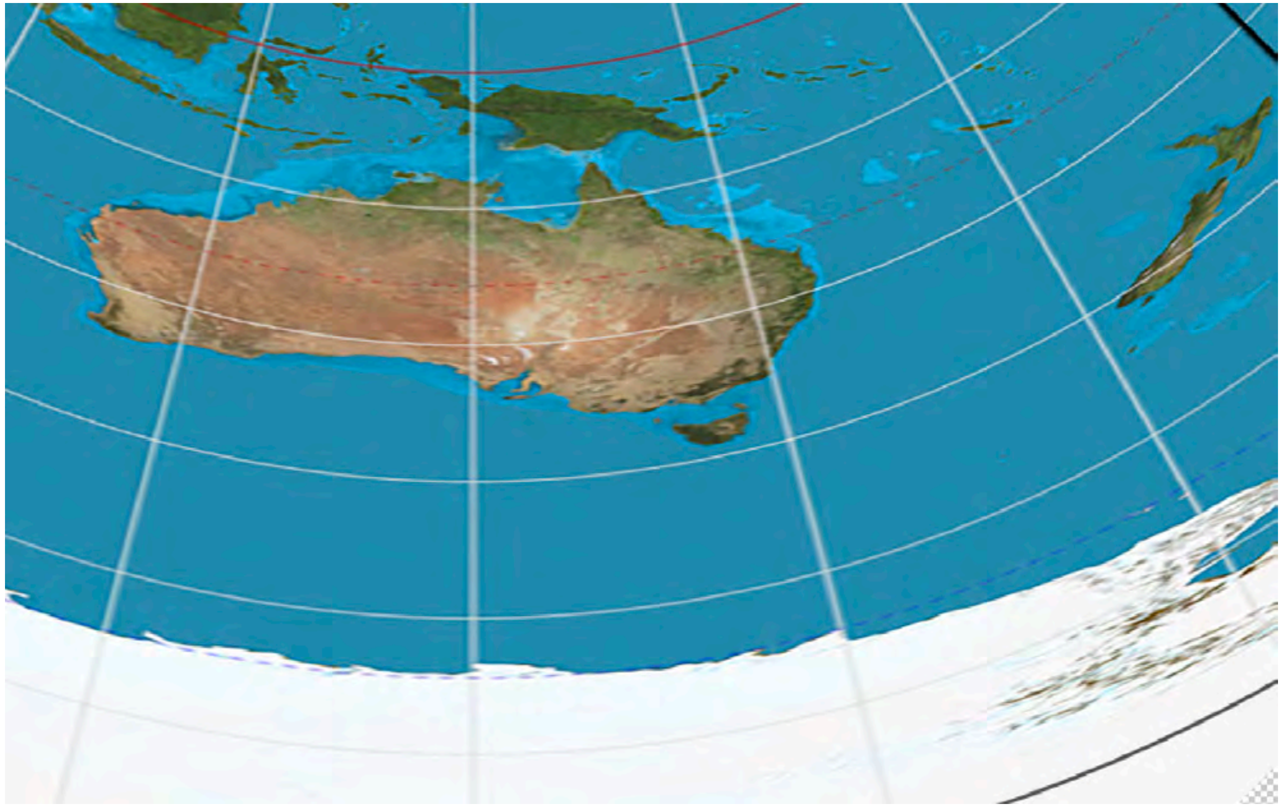
- 1° of Latitude is not exactly 69.055.
- It’s varies from 68.7 miles at the equator, to 69.4 at the poles
- You can see this in Google Earth, and in any mapping software
- You could in theory measure it yourself, but it’s a small change.
- The change in length matches the WGS84 Ellipsoid exactly
- So it’s consistent with the standard model, exactly
- But latitude is the LEAST of the problems for the flat model…

How Long is Longitude?

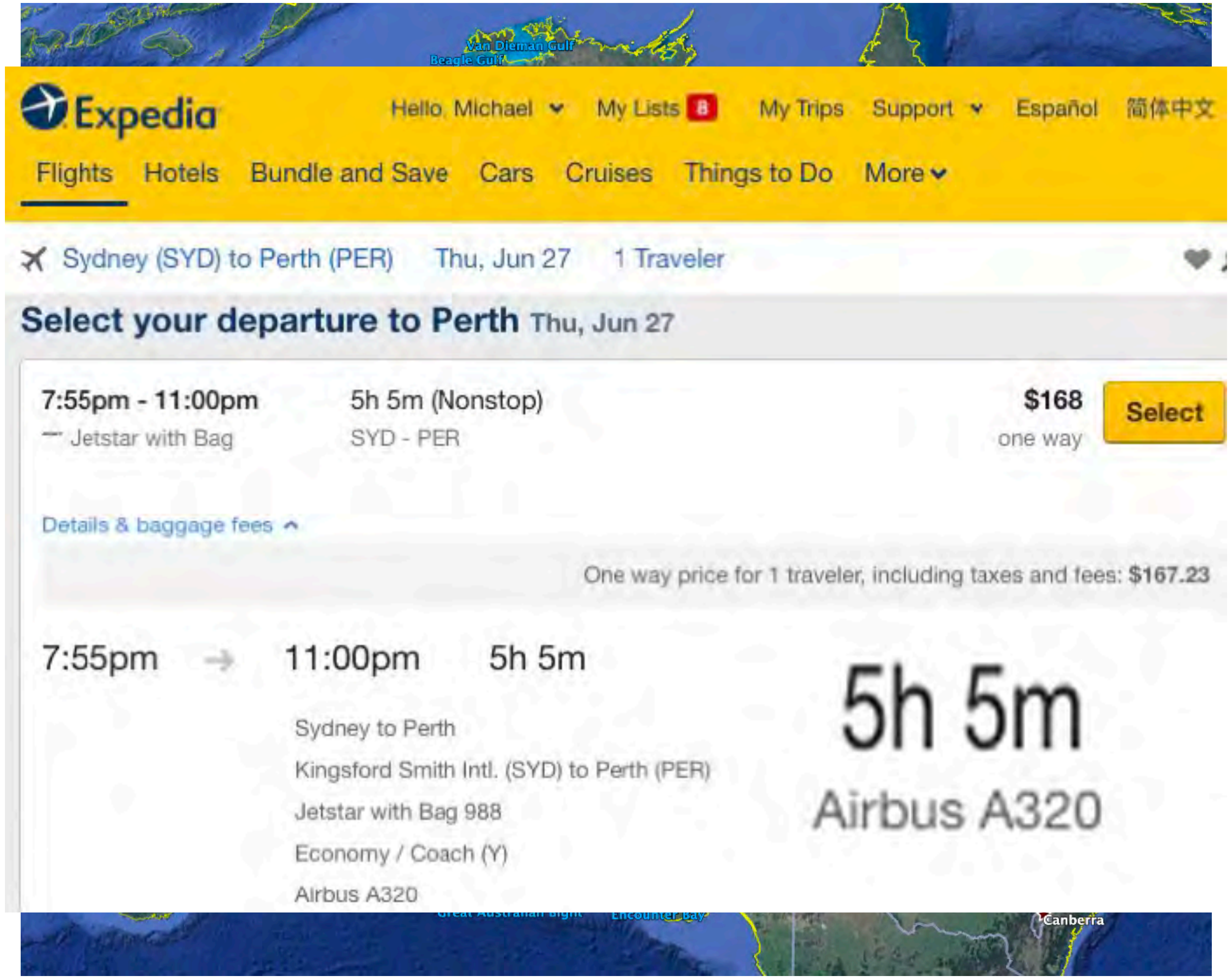




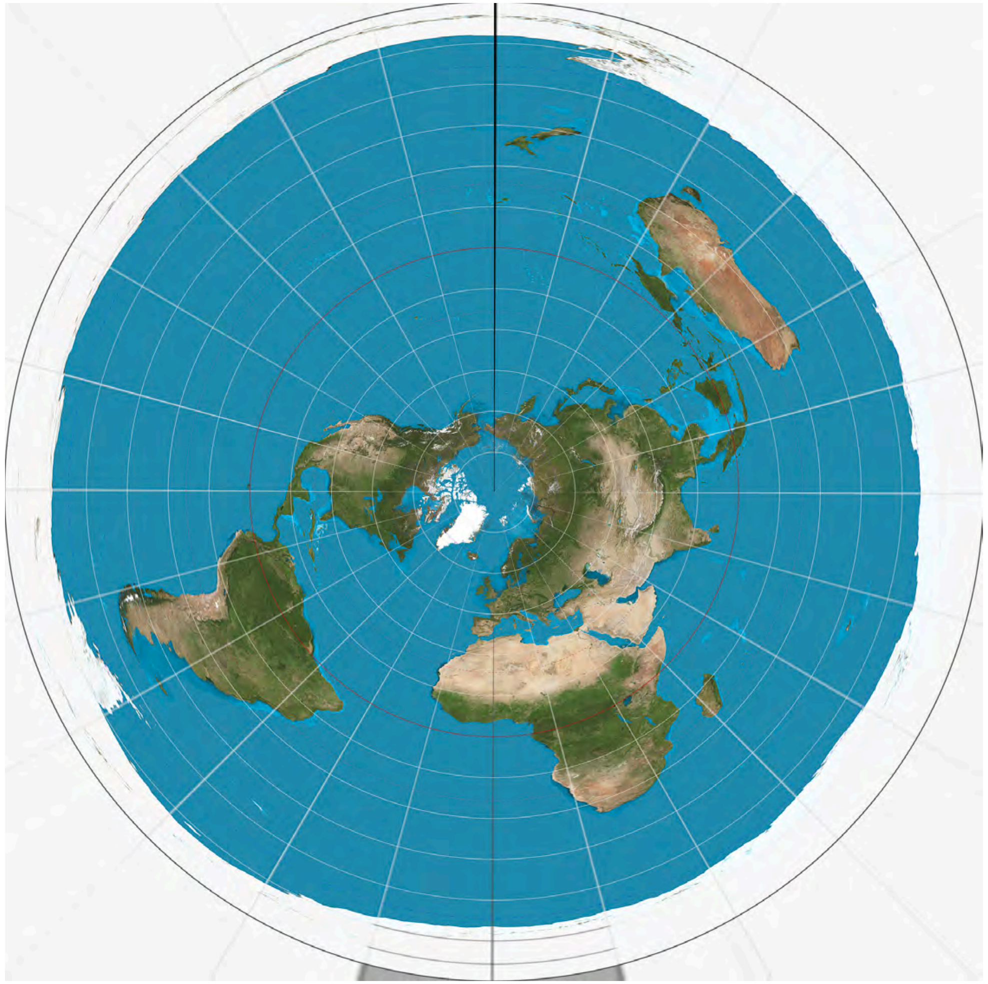
The Problem

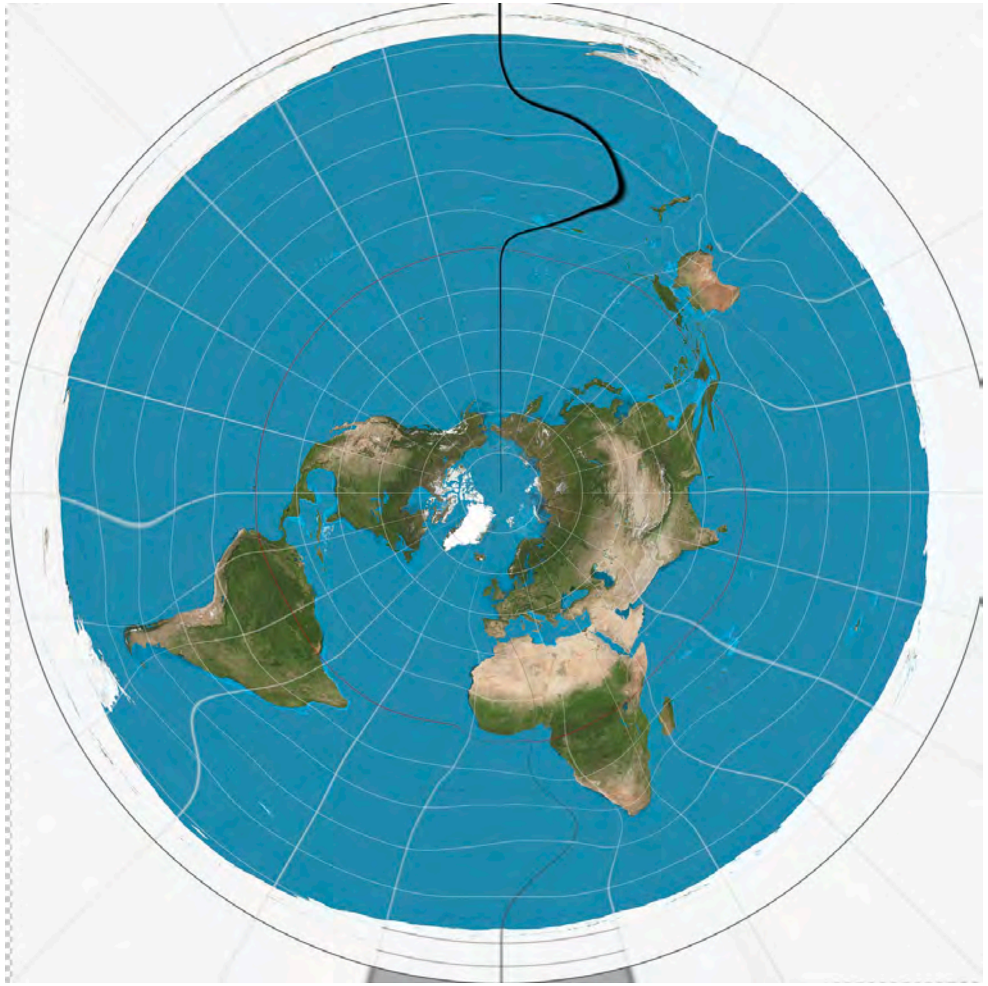


Have you measured Australia?



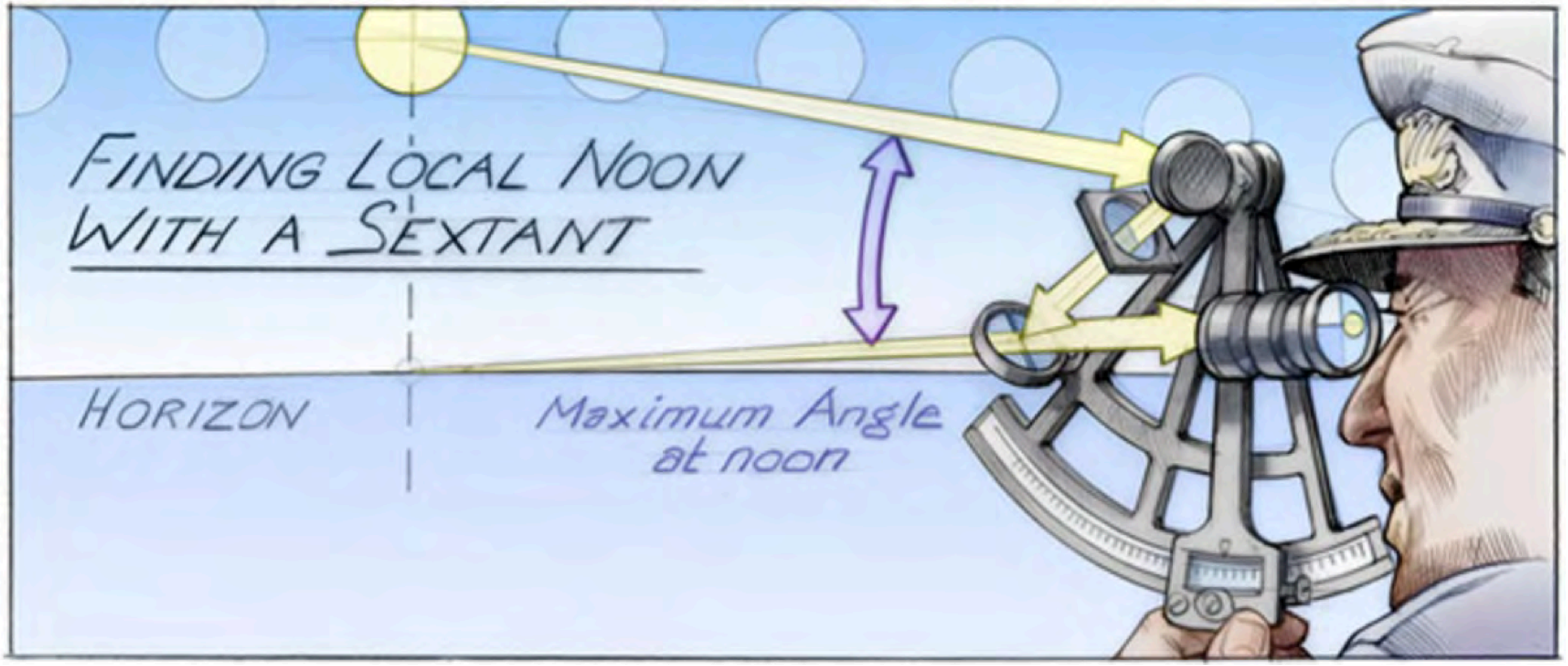
There Can Be Only One!





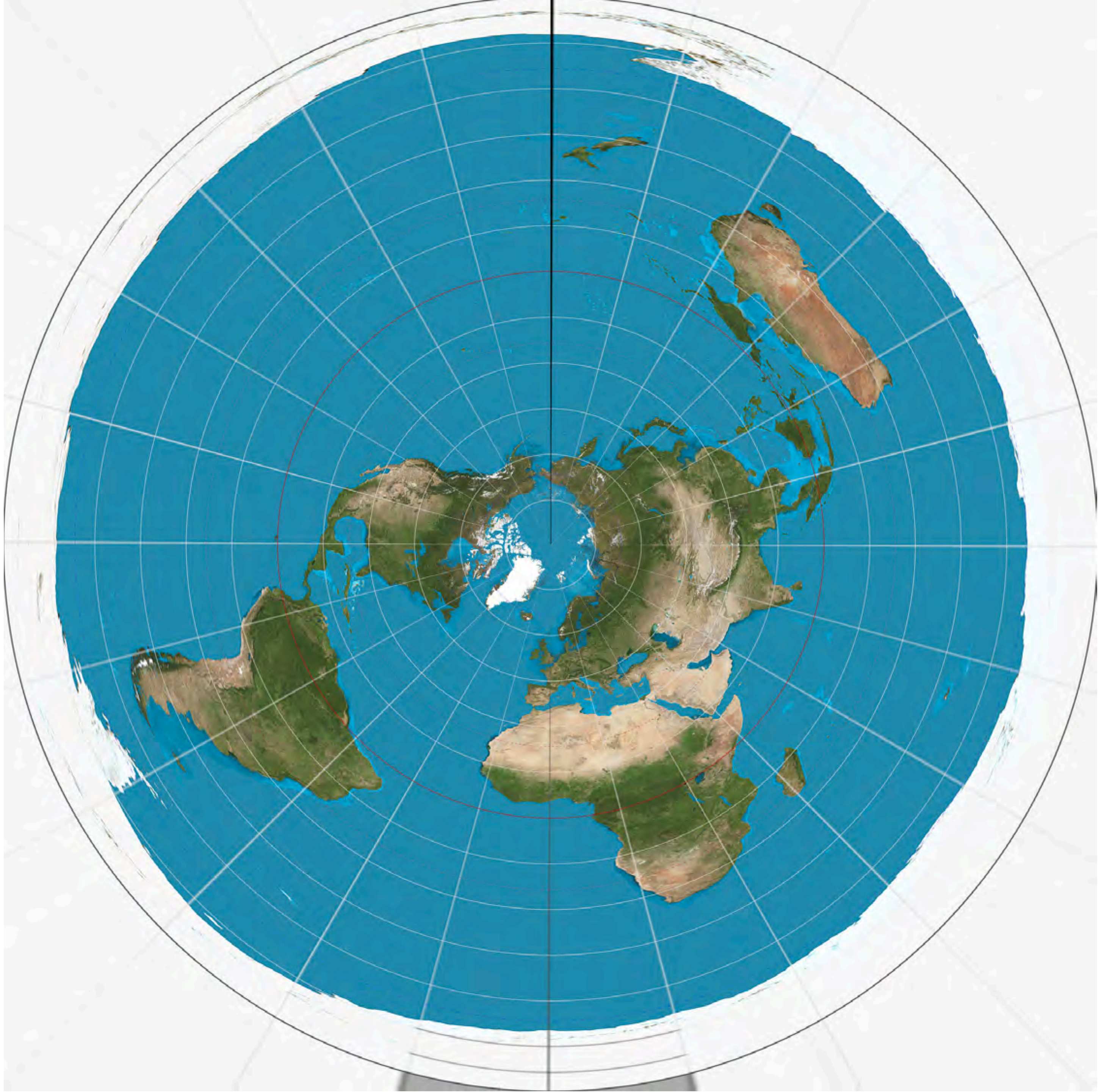
Longitude is Time!

Harrison #4 Type Chronometer K1 , Cpt. James Cook

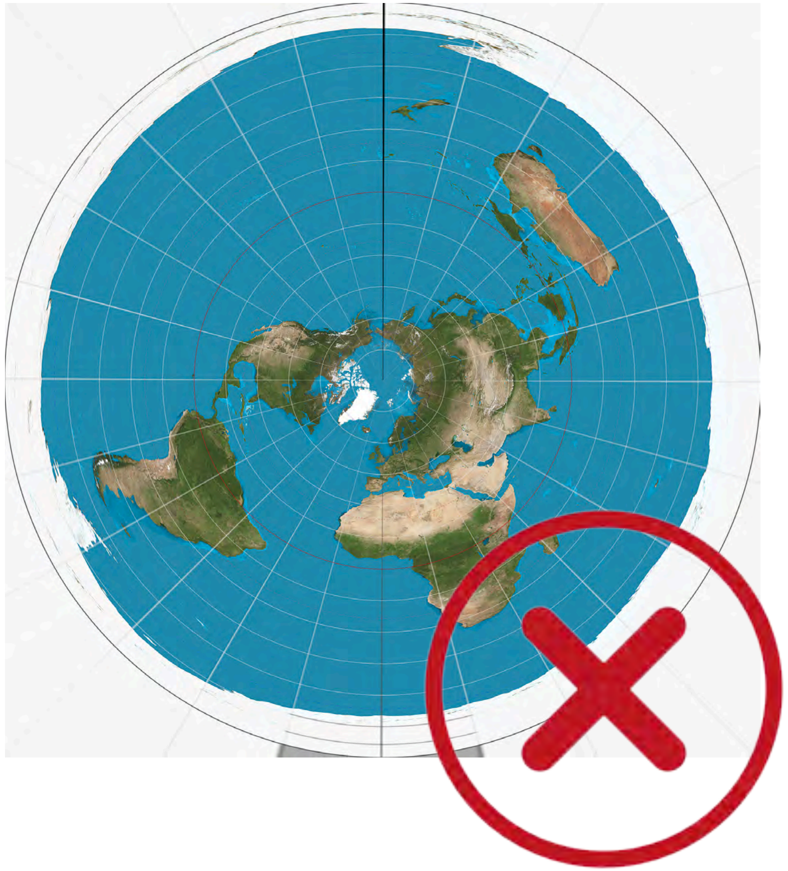


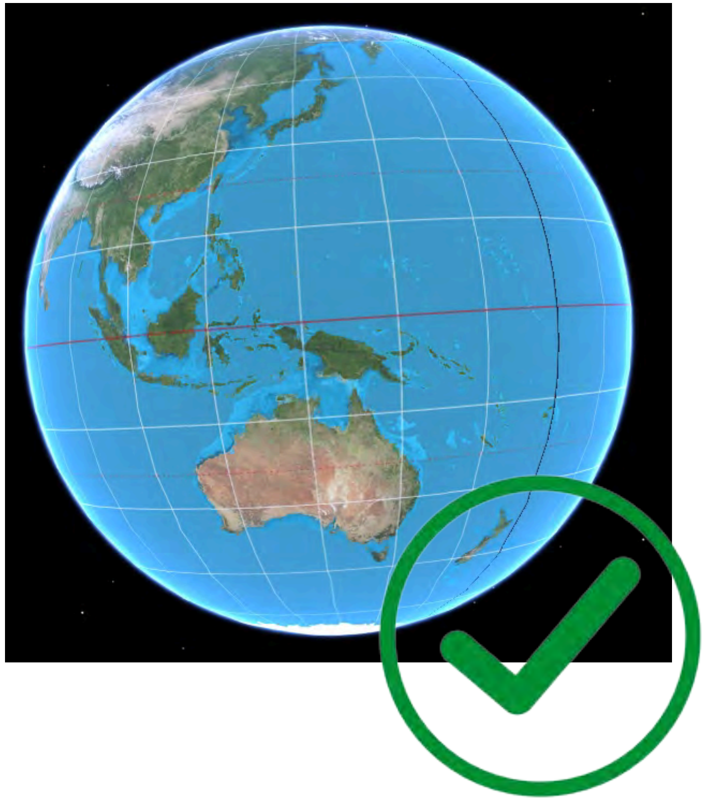
- Wait for local noon (time of highest sun)
- See what time it is in London
- Difference in minutes / 4 = Longitude
- Example:
  - Local noon is at 2:40PM London time
  - Time difference is 160 minutes / 4 = 40° Longitude

11:24:00
11:58:00
12:22
12:38
12:41:40



If The Model Fits …

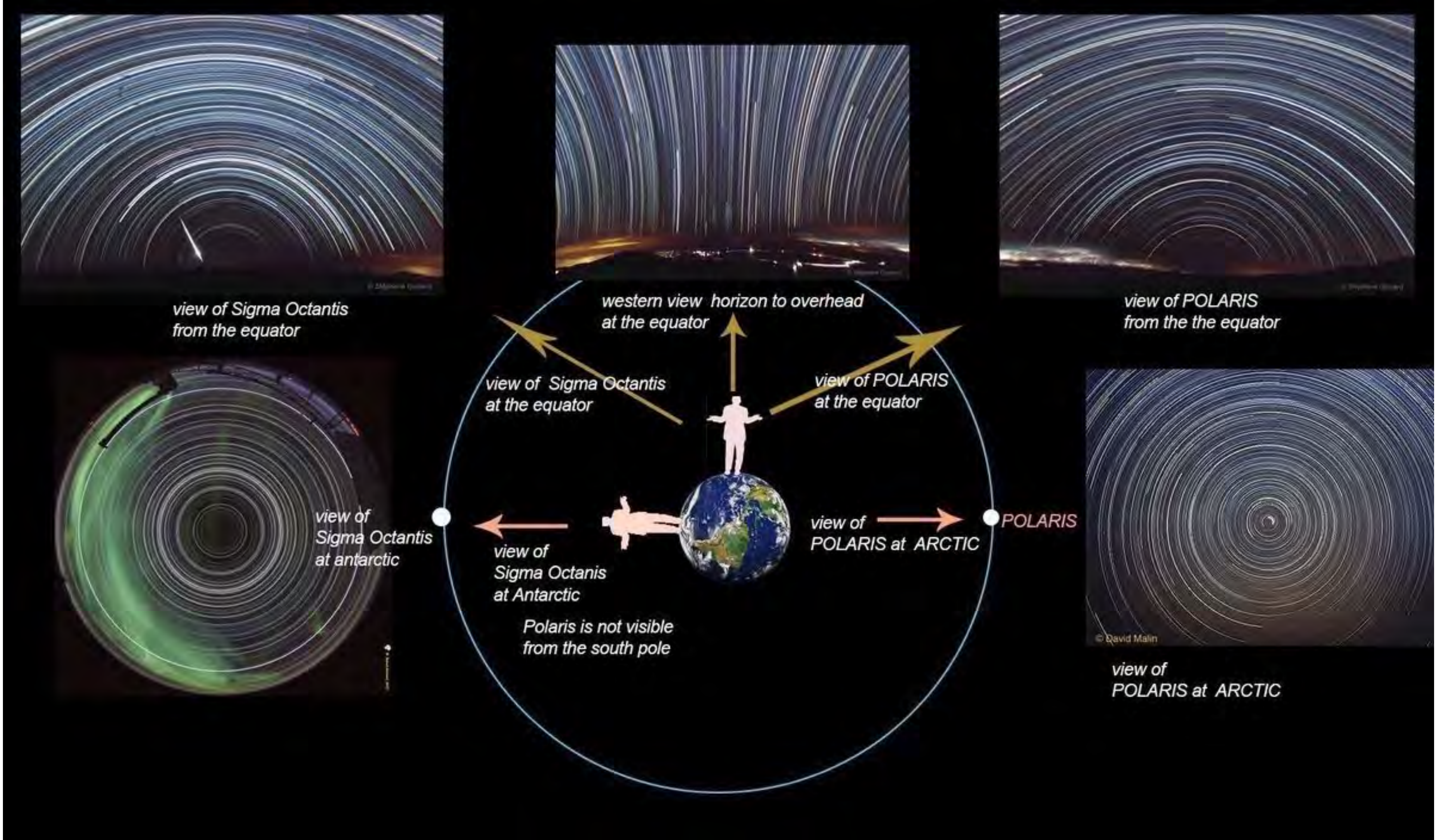




Do models “assume” things, like R

- For a model to work, there has to be a single value of a constant like the radius of the Earth, R.
- You can work out what it is to fit the model.
- You can measure it
- Use the Flat Earth value, distance from North Pole to Equator, just /(π/2)
- Or measure the dip of the horizon from a known altitude
- Or measure the hidden amount of distant mountain
- Or measure the length of sun shadows in three places
- Or survey the length of 1 degree of longitude
- All these values of R measured are the same, consistent with the standard model

The Stars


view of Sigma Octantis
from the equator
western view horizon to overhead
at the equator
view of POLARIS
from the the equator
view of Sigma Octantis
at the equator
view of POLARIS
at the equator
view of
Sigma Octantis
at antarctic
view of
Sigma Octanis
at Antarctic
Polaris is not visible
from the south pole
view of
POLARIS at ARCTIC
POLARIS
© David Malin
view of
POLARIS at ARCTIC

The ISS

- The standard model works perfectly for the ISS
- Height and speed are correct for Earth Orbit, in the standard model
- You can check this. SpotTheStation.nasa.gov will tell you
- It’s always right, anywhere in the world
- You can triangulate the height, and hence the speed. Verify the model
- You can photograph it. Verify it’s the right size.

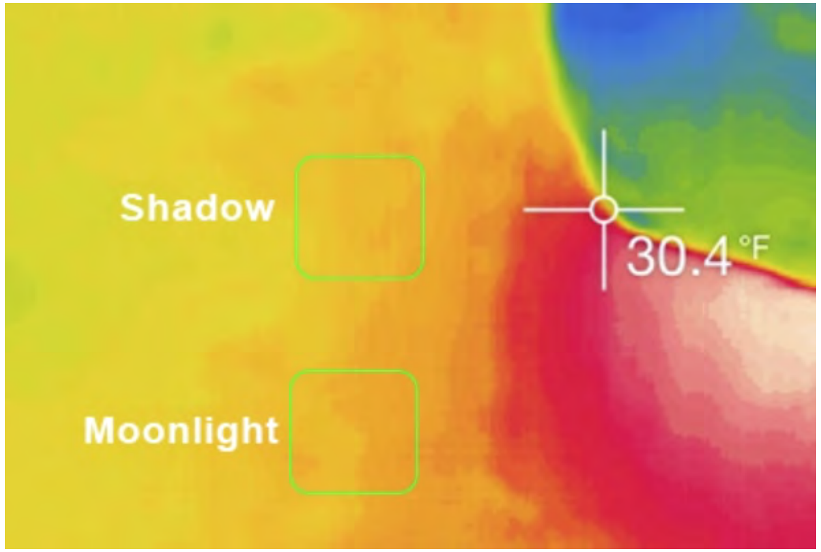
Angular Size of Sun and Moon

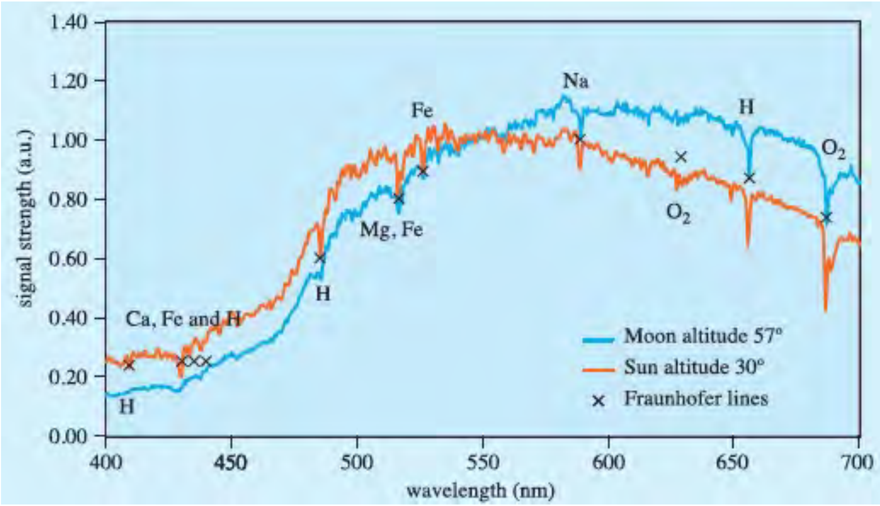
WARNING: Don't do this with a camera with an optical viewfinder, as it could burn your eyes, causing vision loss or blindness. The P900 has a digital viewfinder, so is safe. Even so, incorrect usage may damage your camera.

The Shadows on the Moon

Moonlight is Reflected Sunlight

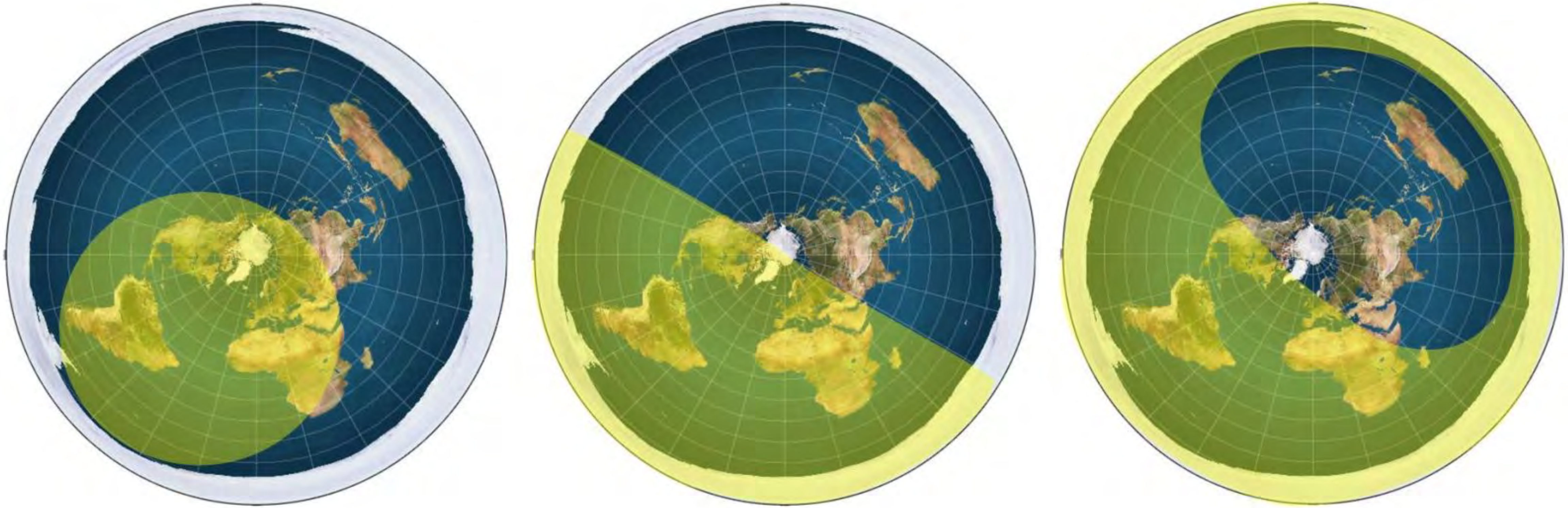
- Not cold, just dim
- Spectrum is same as sunlight, adjusted by rock reflectivity





Ciocca & Wang, Moonlight, 2013

Day and Night regions on Earth



June Mar/Sep December

September

Gravity's Gradual Variations

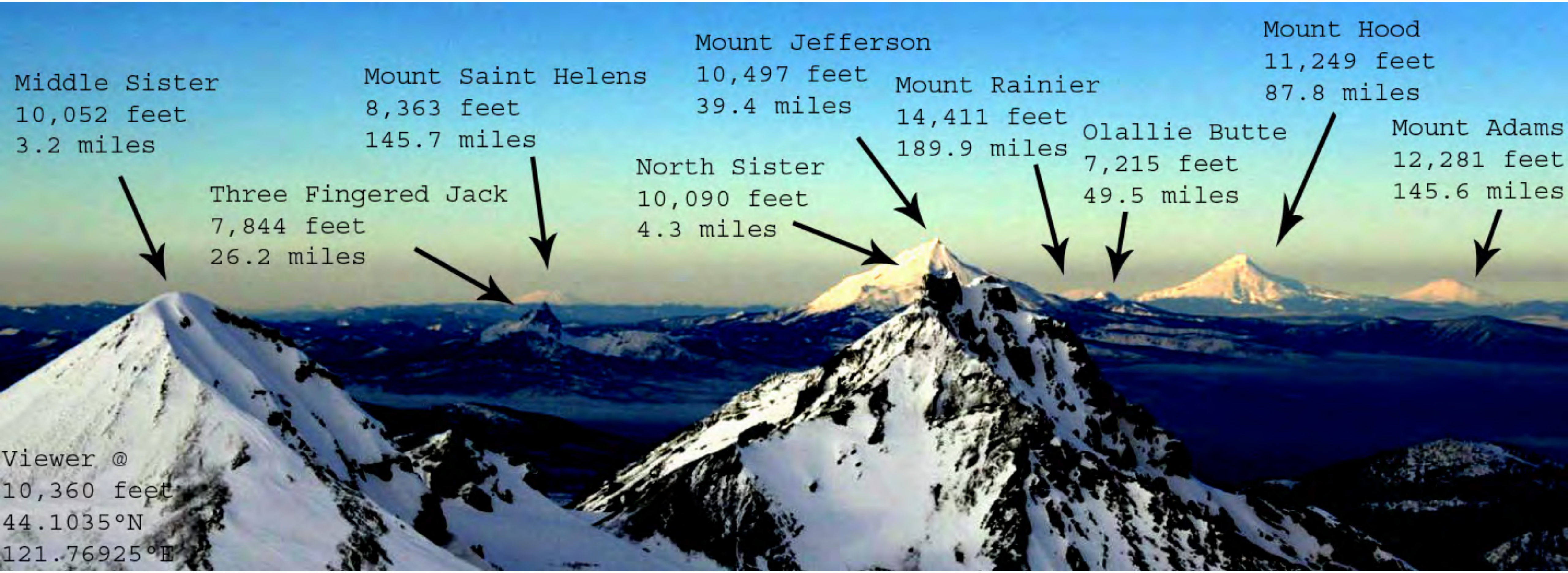
- Decreases when close to equator (Centrifugal force)
- Decrease as you get higher (Universal Gravitation)
- Exactly as the standard model predicts.

SACRAMENTO, CA

DENVER, CO

ALBUQUERQUE, NM

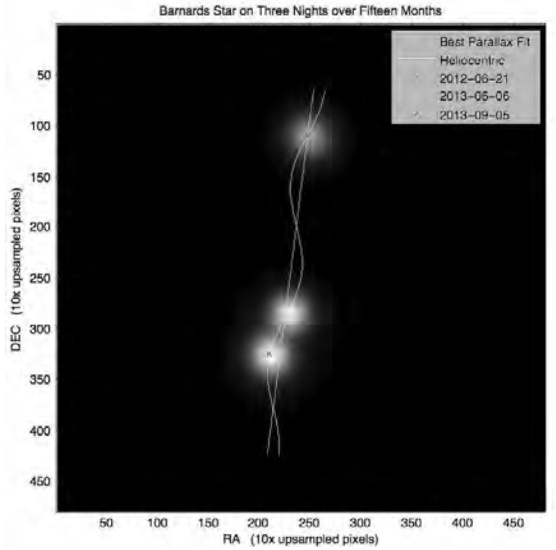
Levelling with Mountains



You can do the math, angular size, etc, but Rainier should appear well above Jefferson

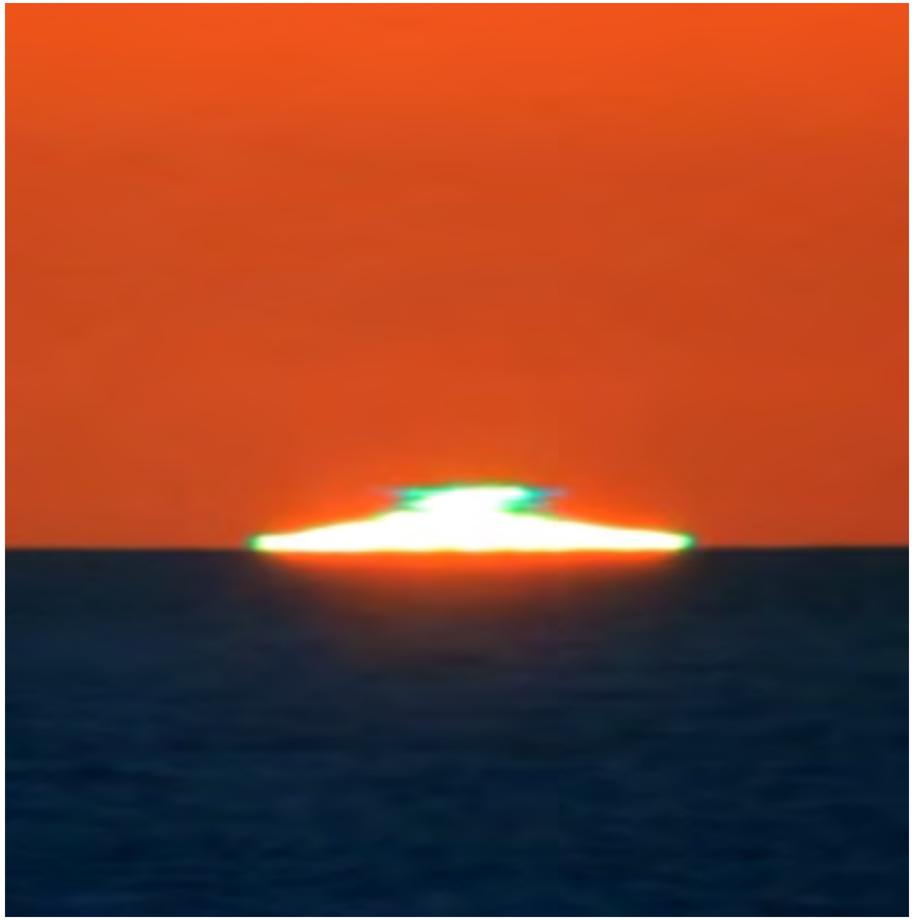
Stellar Parallax – Absence and Presence

- Expect to see Stars move relative to each other over a year?
- Stars are TRILLIONS OF MILES AWAY!!!!! (Standard model)
- So even though they are moving fast
  - They mostly move in the same direction
  - And their relative movement is not visible over a year, or longer
- BUT, it is visible in some stars, notably Barnard's star.
- By amateurs, using background stars
- (also lets you calculate the distance to sun!)



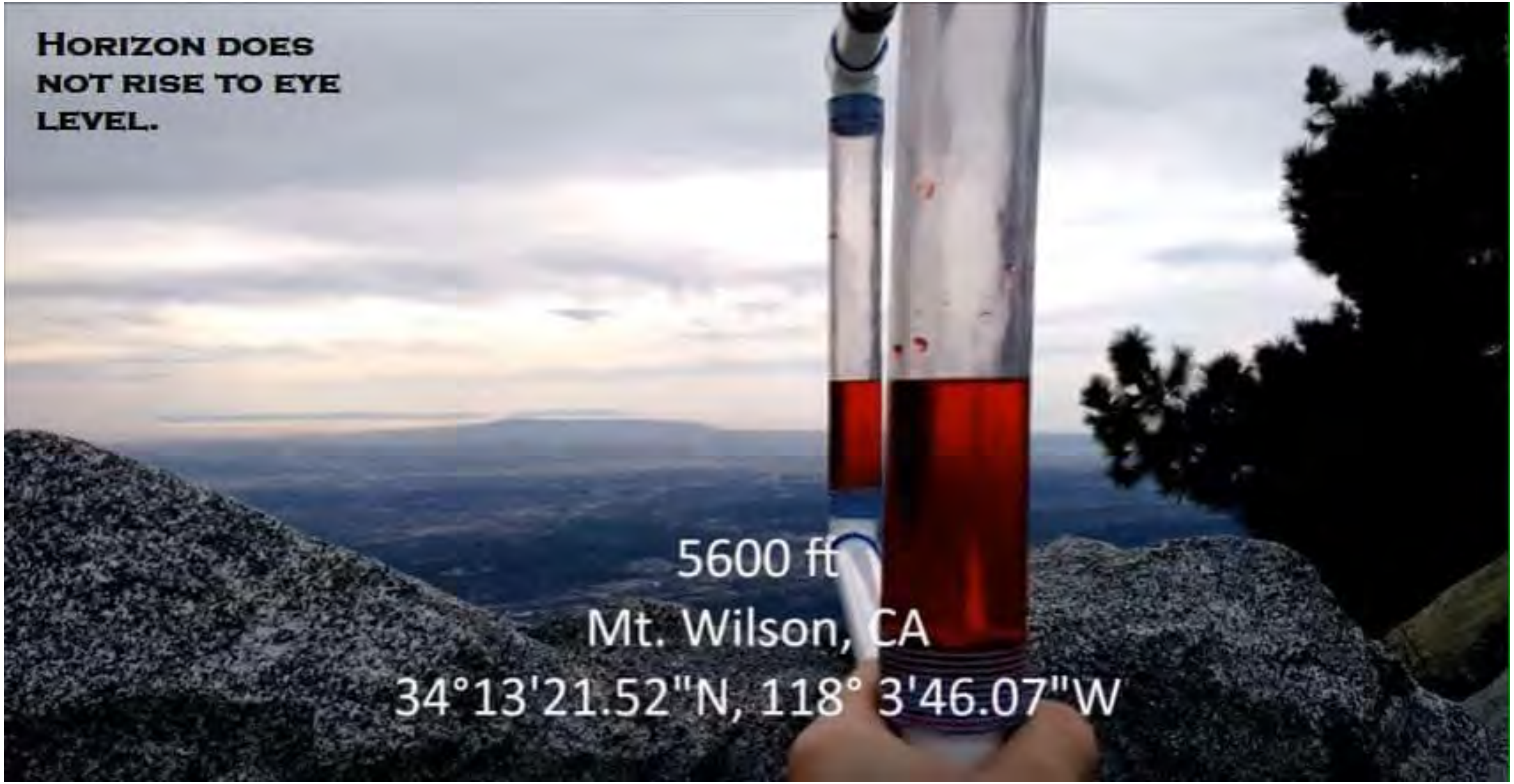
Green Flash – Sun is below the horizon

- Atmosphere refracts light downwards, toward more dense air
- Downward bend raises up image
- Shorter wavelength blue/green are bent most, so are raised up most
- This is not intuitive, but you can check it with a prism (ask me later)

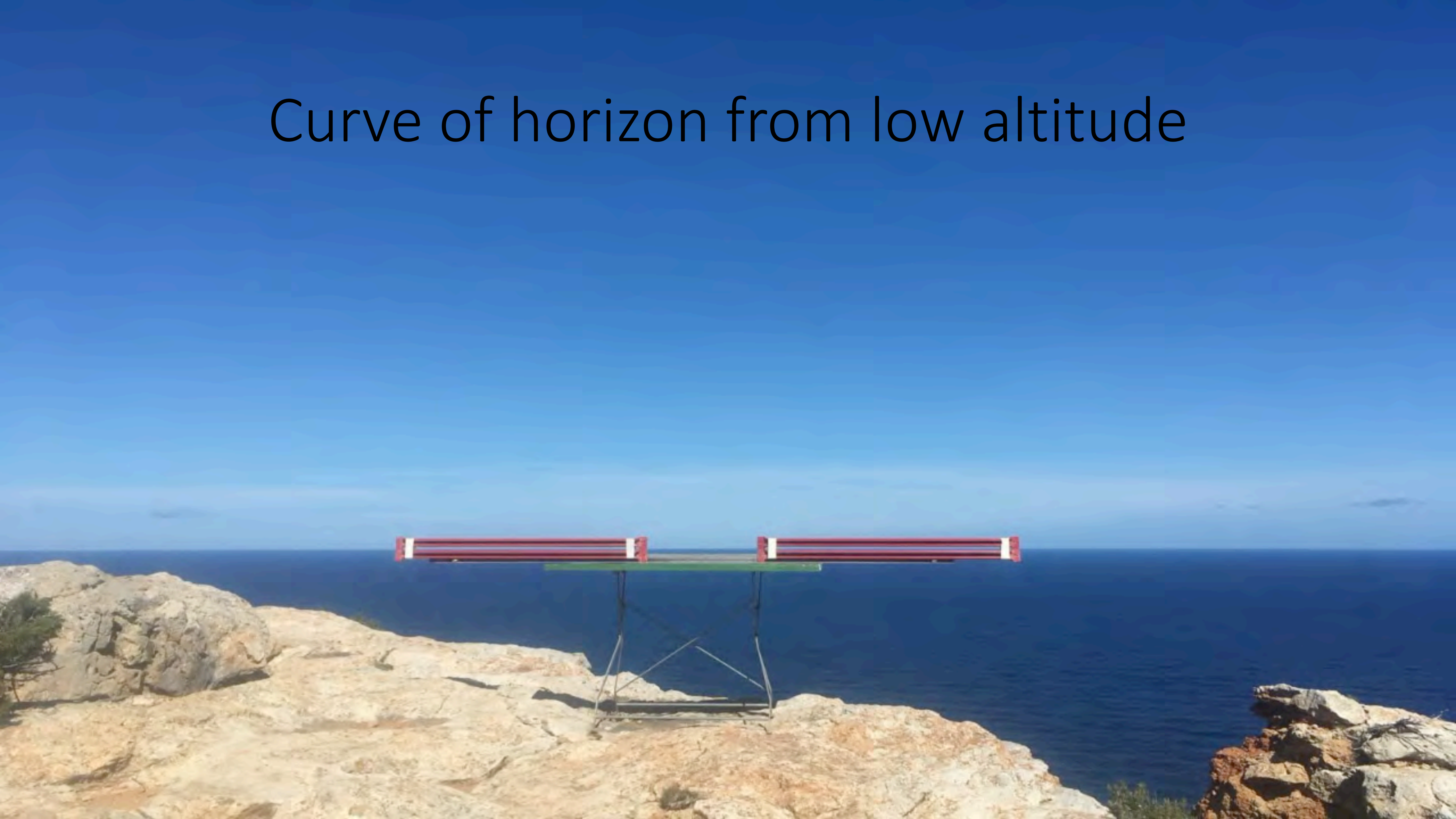



C++ Templates
MURDER-A-GO-GO'S
BUNK
Nutrition Facts

The dip of the horizon with altitude



Curve of horizon from low altitude



Canigou

Image © 2017 Institut Cartografic de Catalunya
Image © 2017 DigitalGlobe
metabunk.org


Barre des Ecrins
4,102m
Taken from Pic de Finestrelles (2,820 m) at 440 Km, before sunrise.
HIDDEN PORTION
3,680m
Curve calculator Refracted hidden = 3,720m

The horizon obscuring **Mountains**

- Reasons why you can’t see something on a Flat Earth
  - Maybe It’s behind waves
    - Not when looking over an ocean from 10 feet to a 1500 ft Mountain
  - Perspective???
    - No. If there’s a line of sight, then you can see it.
  - Maybe fog or haze obscures it
    - Clear view all the way to the horizon, and all the mountain above it
  - Maybe it’s too far away and too small to see
    - You can see the top. The top is smaller than the bottom.
  - Refraction curves light up
    - Requires higher air to be more dense, but it’s demonstrably not.
    - (see also: green flash)

Conclusion