Computational Spatial Humanities

M.Sc. DH, Summer 2024

Dr. Thomas Efer
thomas.efer@uni-leipzig.de

Lecture 02
Coordinates & Geodesics

M.Sc. DH, Summer 2024

UNIVERSITÄT LEIPZIG

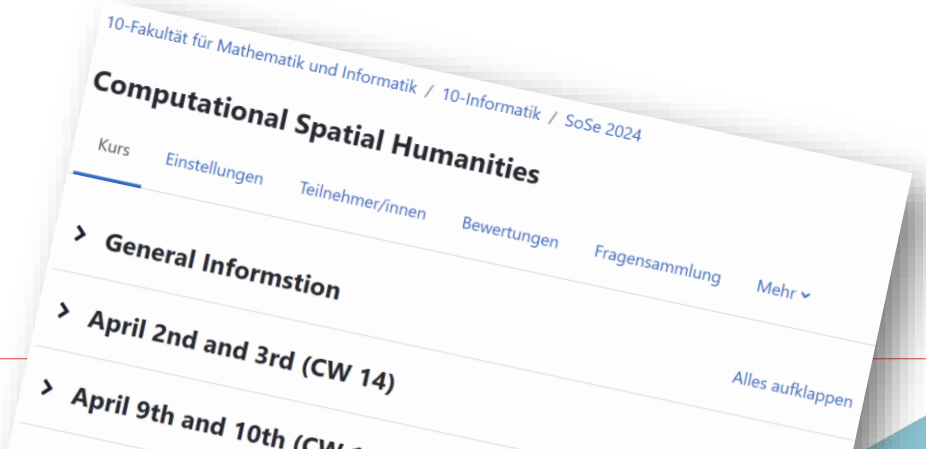
Dr. Thomas Efer
thomas.efer@uni-leipzig.de

Today:

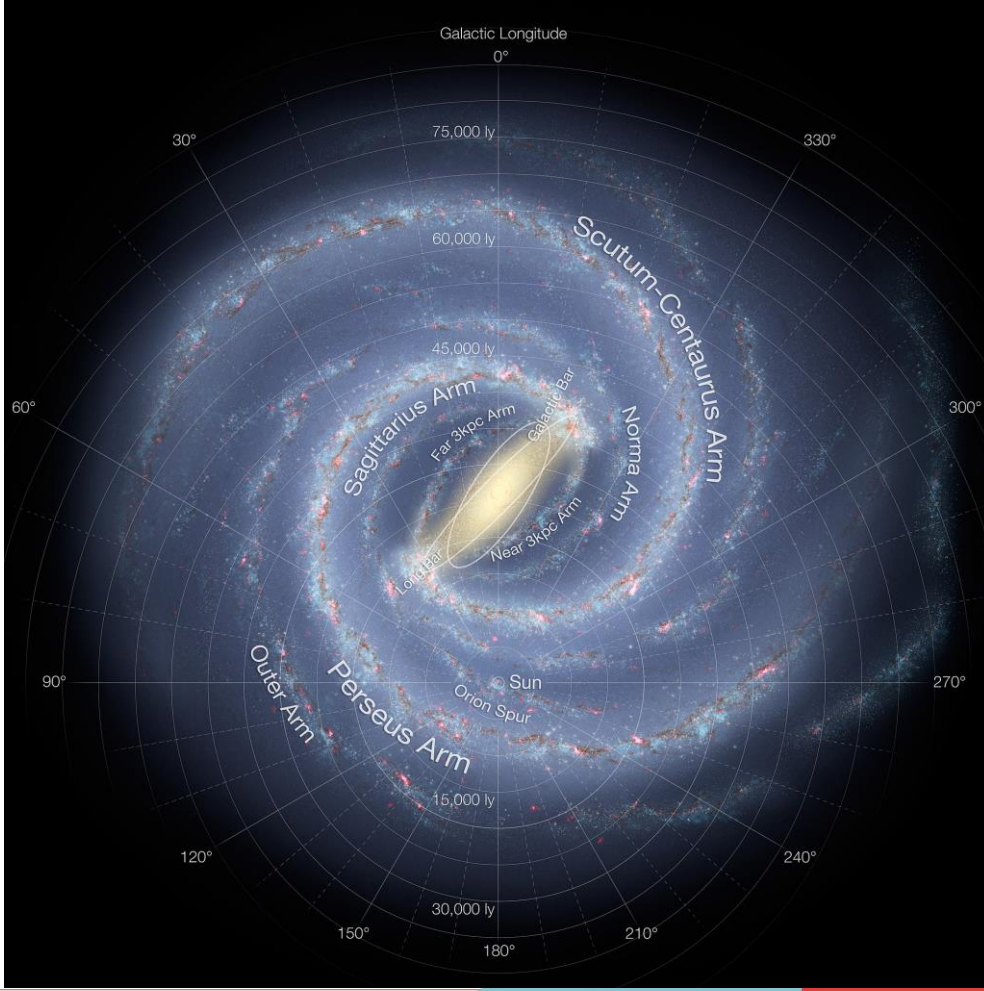
- Shape of the Earth
- Navigation and History of Coordinate Systems
- WGS84
- Hierarchical Coordinate notations

Dates, Rooms, Online Ressources

- **Tuesday**, 9:15–10:45, **Lecture** at Paulinum, room **P-701**
- **Wednesday**, 9:15–10:45, **Praktikum** at seminar building, room **SG 3-11**
- **Moodle course!**
  https://moodle2.uni-leipzig.de/course/view.php?id=48972
  Kurse > 10-Fakultät für Mathematik und Informatik > 10-Informatik > Sommersemester 2024 > 10-DIH-1003.VL01
- **Materials** are provided as PDF files or web links

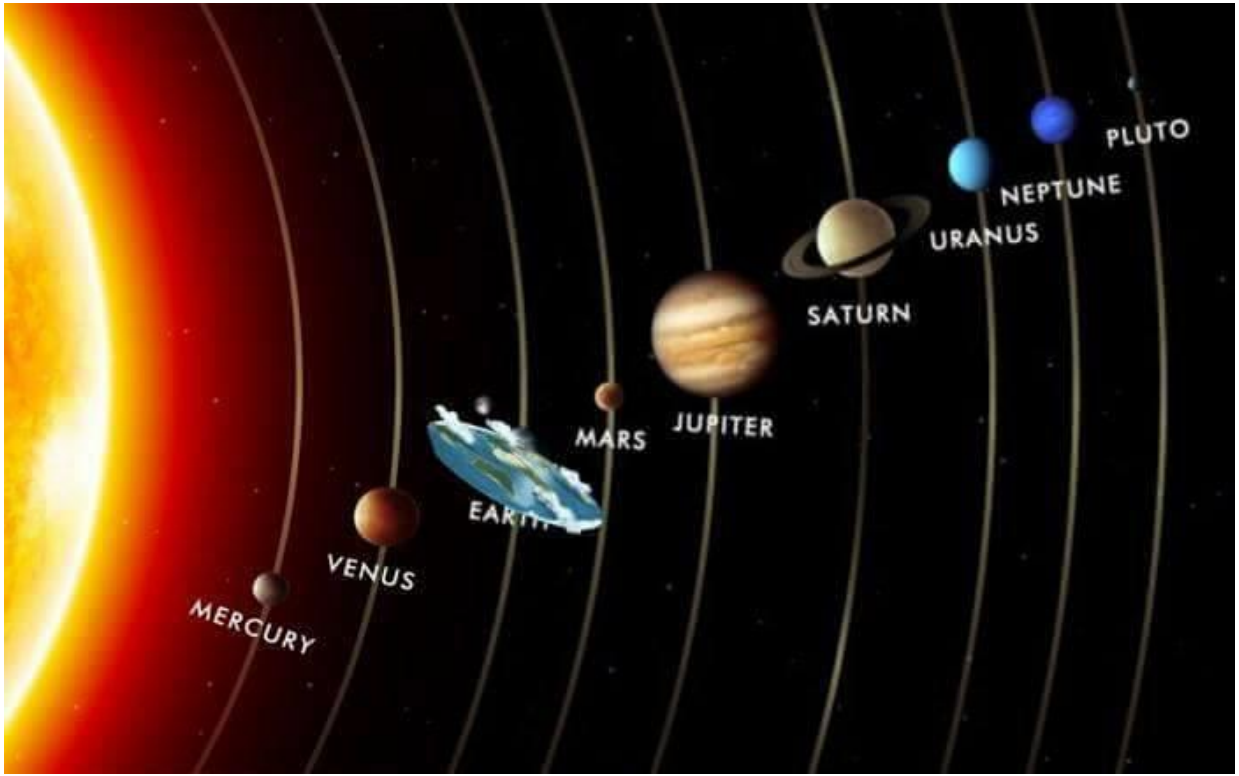


Knowing where we are...



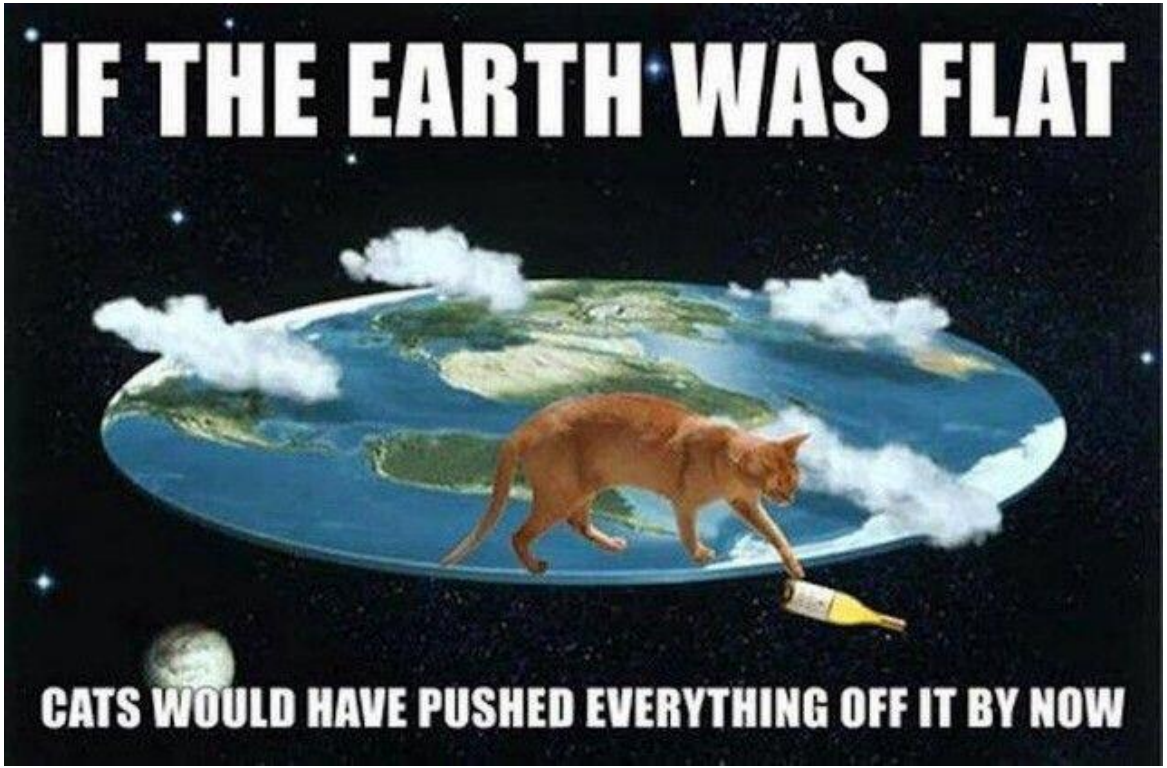
https://en.wikipedia.org/wiki/Galactic_coordinate_system#/media/File:Artist's_impression_of_the_Milky_Way_(updated_-_annotated).jpg

Shape of the Earth



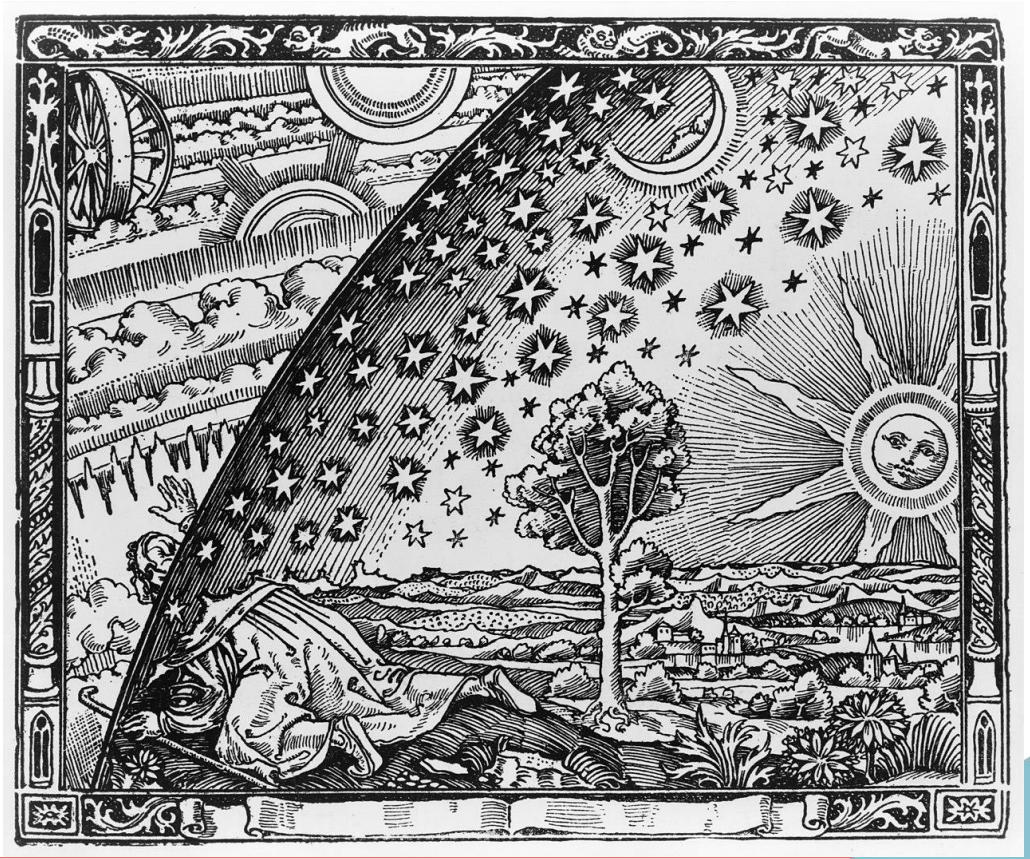
https://knowyourmeme.com/photos/1205102-flat-earth-theory

Shape of the Earth



https://knowyourmeme.com/photos/1323410-flat-earth-theory

Shape of the Earth



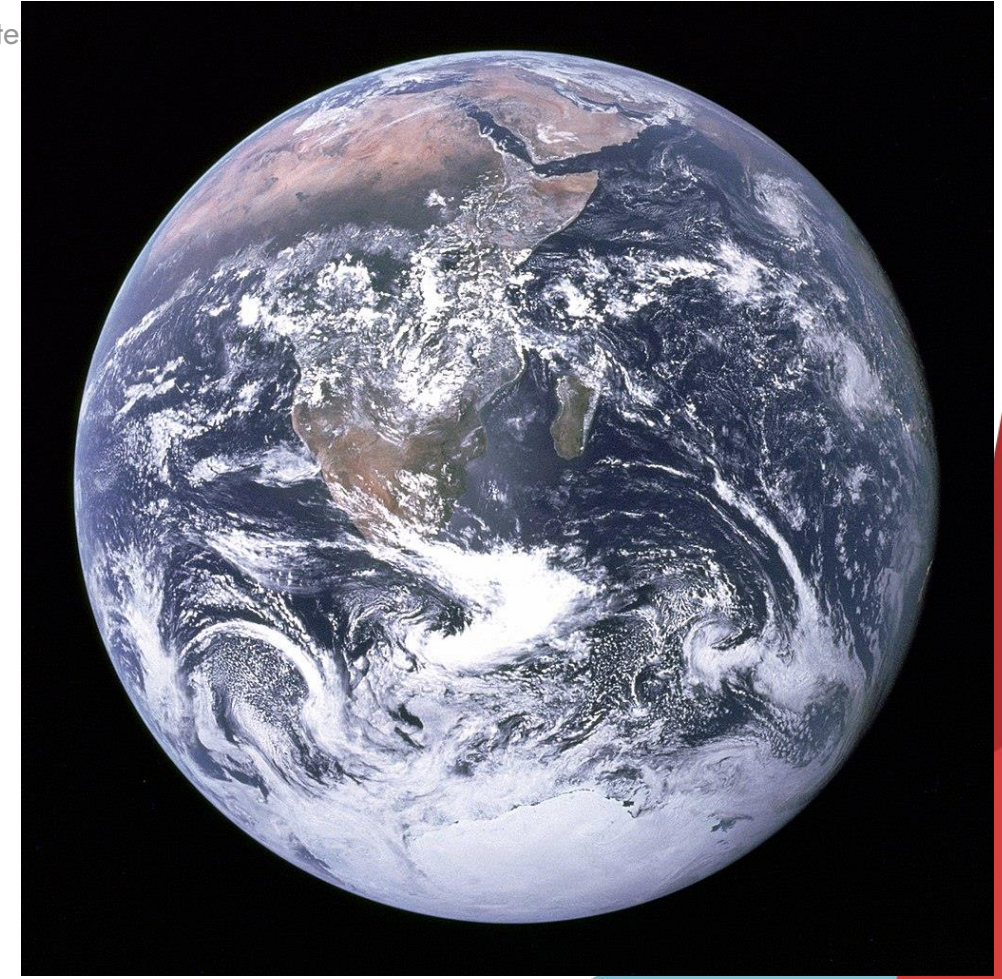
https://de.wikipedia.org/wiki/Flammarions_Holzstich

Shape of the Earth

https://de.wikipedia.org/wiki/Flammarions_Holzstich

Blue Marble...

View of the Earth as seen by the Apollo 17 crew traveling toward the moon. This translunar coast photograph extends from the Mediterranean Sea area to the Antarctica south polar ice cap. This is the first time the Apollo trajectory made it possible to photograph the south polar ice cap. Note the heavy cloud cover in the Southern Hemisphere. Almost the entire coastline of Africa is clearly visible. The Arabian Peninsula can be seen at the northeastern edge of Africa. The large island off the east coast of Africa is the Republic of Madagascar. The Asian mainland is on the horizon toward the northeast.



AS17-148-22727 by Harrison Schmitt
https://www.lpi.usra.edu/resources/apollo/images/print/AS17/148/22727.jpg

A Sphere? Surface Features:

- "[If] the Earth were shrunk down to the size of a billiard ball, [would it] actually be smoother than one?
- According to the World Pool-Billiard Association, a pool ball is 2.25 inches in diameter, and has a tolerance of +/- 0.005 inches. [It] must have no pits or bumps more than 0.005 inches in height. [...] The ratio of the size of an allowable bump to the size of the ball is 0.005/2.25 = about 0.002.
- The Earth has a diameter of about 12,735 kilometers [..] Using the smoothness ratio from above, the Earth would be an acceptable pool ball if it had no bumps (mountains) or pits (trenches) more than 12,735 km x 0.00222 = about 28 km in size.
- The highest point on Earth is the top of Mt. Everest, at 8.85 km. The deepest point on Earth is the Marianas Trench, at about 11 km deep."

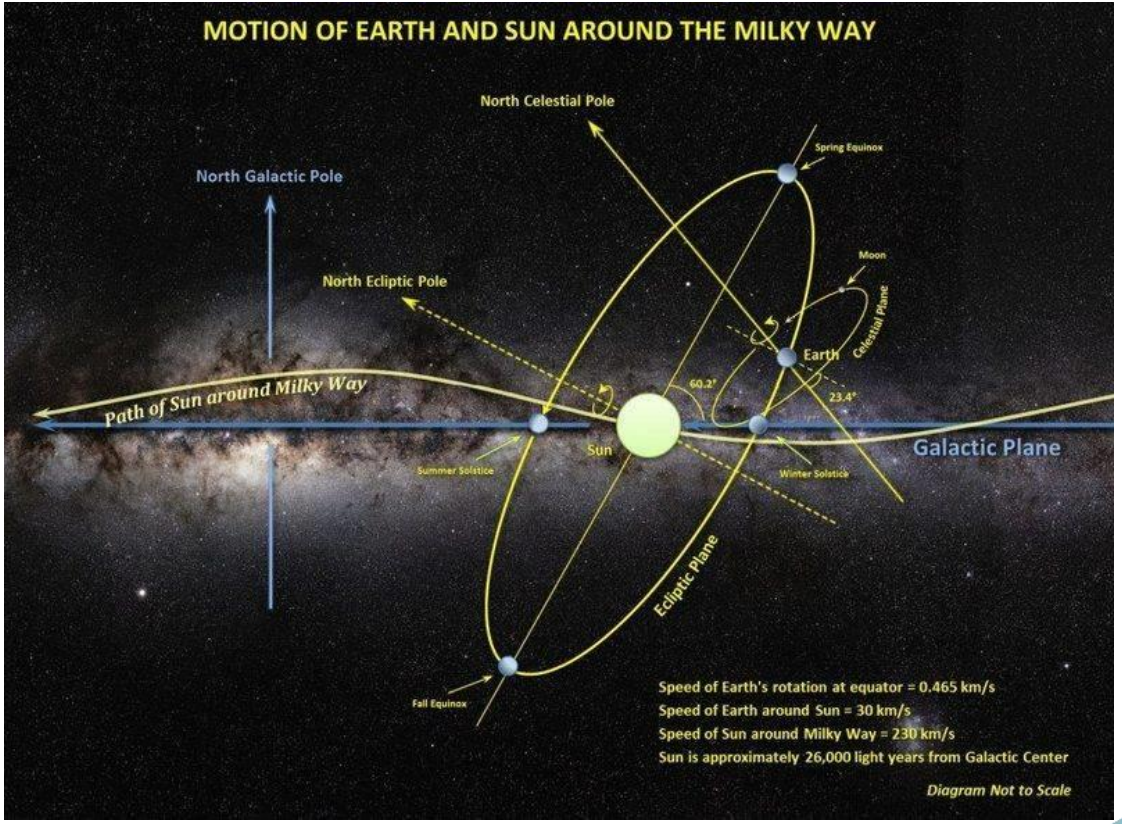
https://www.discovermagazine.com/the-sciences/ten-things-you-dont-know-about-the-earth

Coordinates

- Co – Latin “together”
- Ordinate – Latin “arrange”

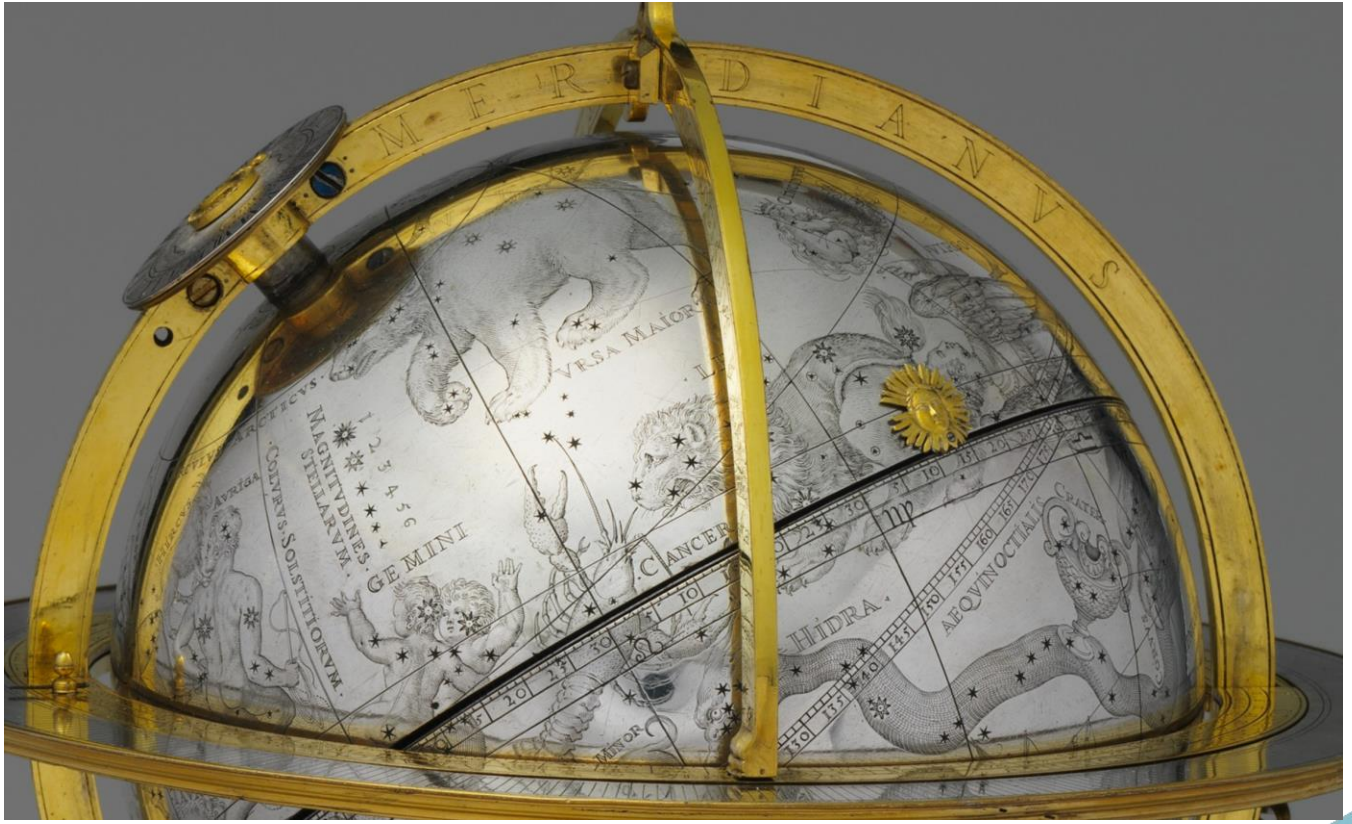
- Numbers used for recording and communicating the **exact position** of something on earth’s surface

Navigation using the night sky...



https://www.physicsforums.com/attachments/motion-of-earth-and-sun-around-milky-way-eso_-10oct2016-jpg.107278/

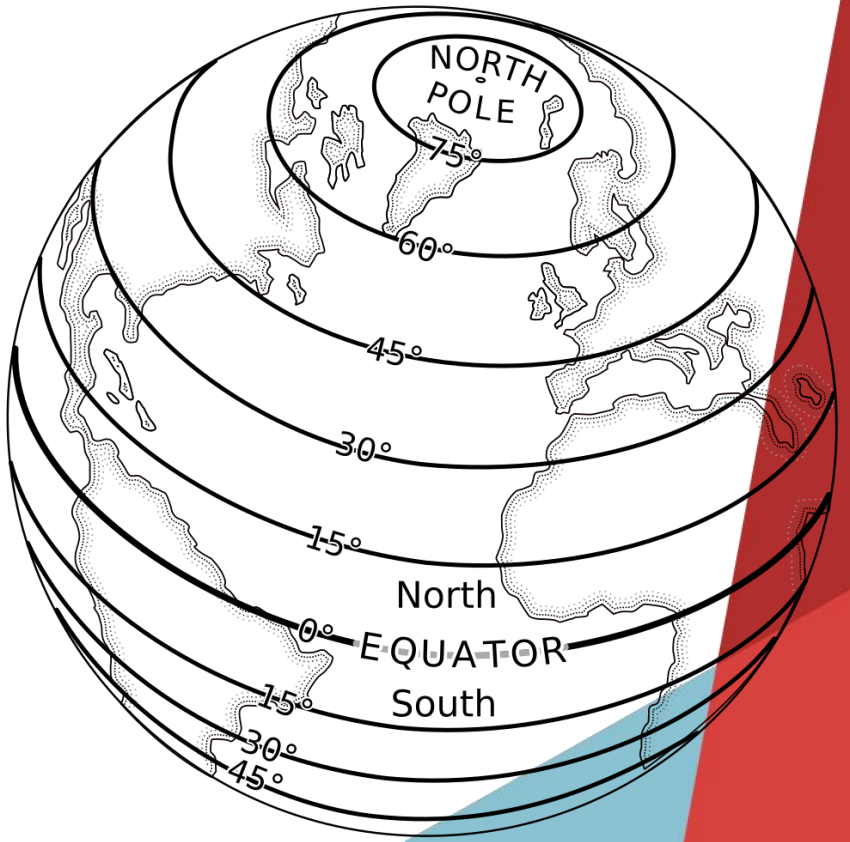
Knowing the night sky…



https://upload.wikimedia.org/wikipedia/commons/b/b4/Celestial_globe_with_clockwork_MET_DP237685.jpg

Latitude – *Geographische Breite*

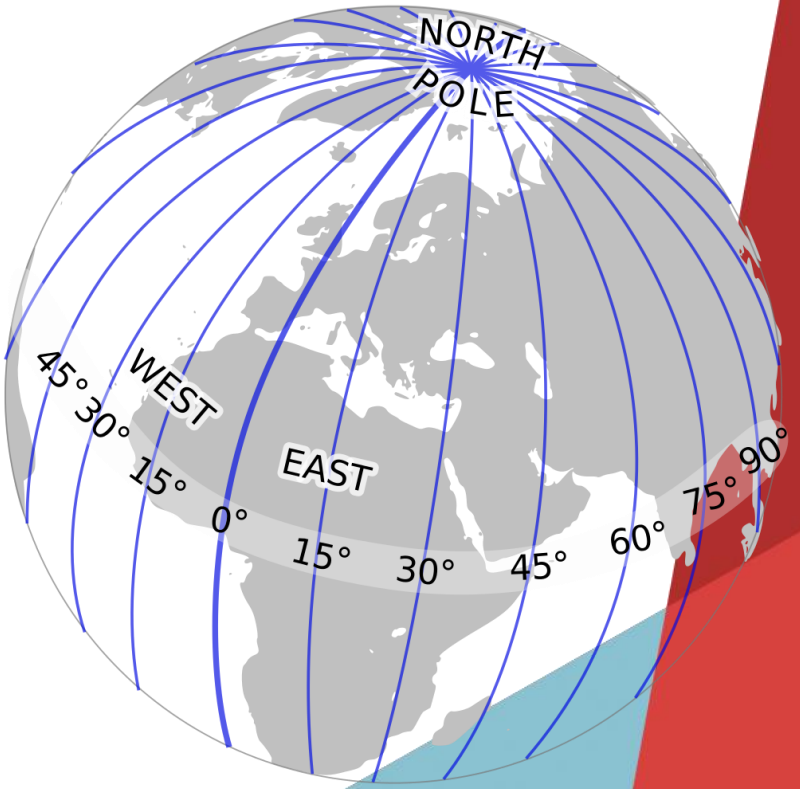
- Sextant
  →
  Angle of Polaris vs. Horizon
  →
  Correction tables
  →
  Done ?



https://commons.wikimedia.org/wiki/File:Latitude_lines.svg

Longitude – *Geographische Länge*

- Sextant
  →
  Angle of … wait!
  →
  It's all moving!
  →
  Could anyone invent a robust clock, please?



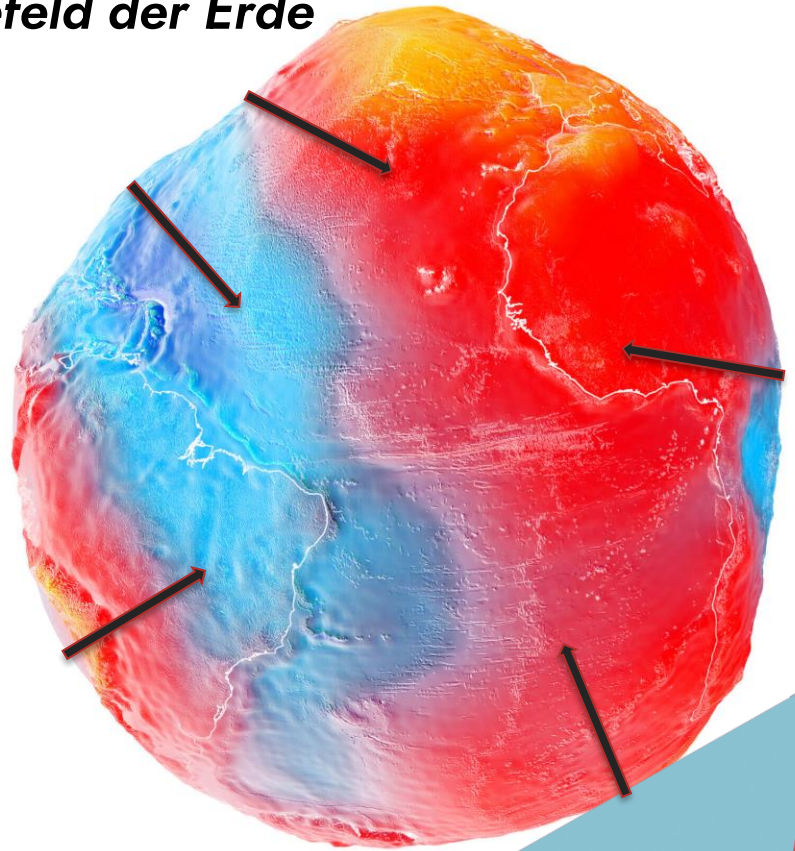
https://commons.wikimedia.org/wiki/File:Longitude_blue.svg

Longitude – *Geographische Länge*

- Prime Meridian *(Nullmeridian)* through Greenwich Observatory (London)
- „standardized“ in 1884
- 102,5 Meters away from this line on the ground →

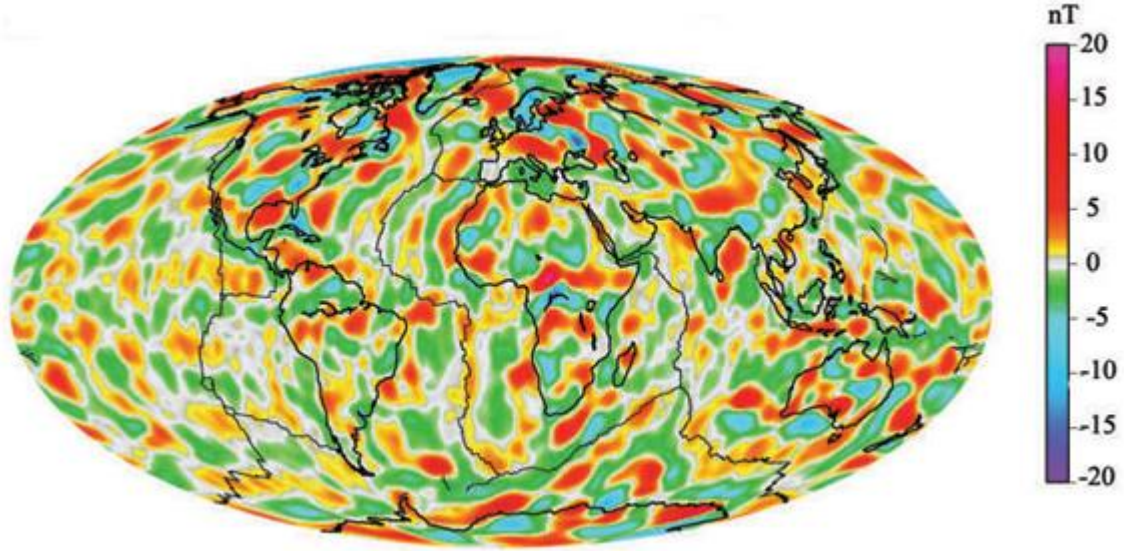
Gravitational anomalies – *Schwerefeld der Erde*

Plumb bob *(Lot)*
https://commons.wikimedia.org/wiki/File:Plumb_bob.jpg



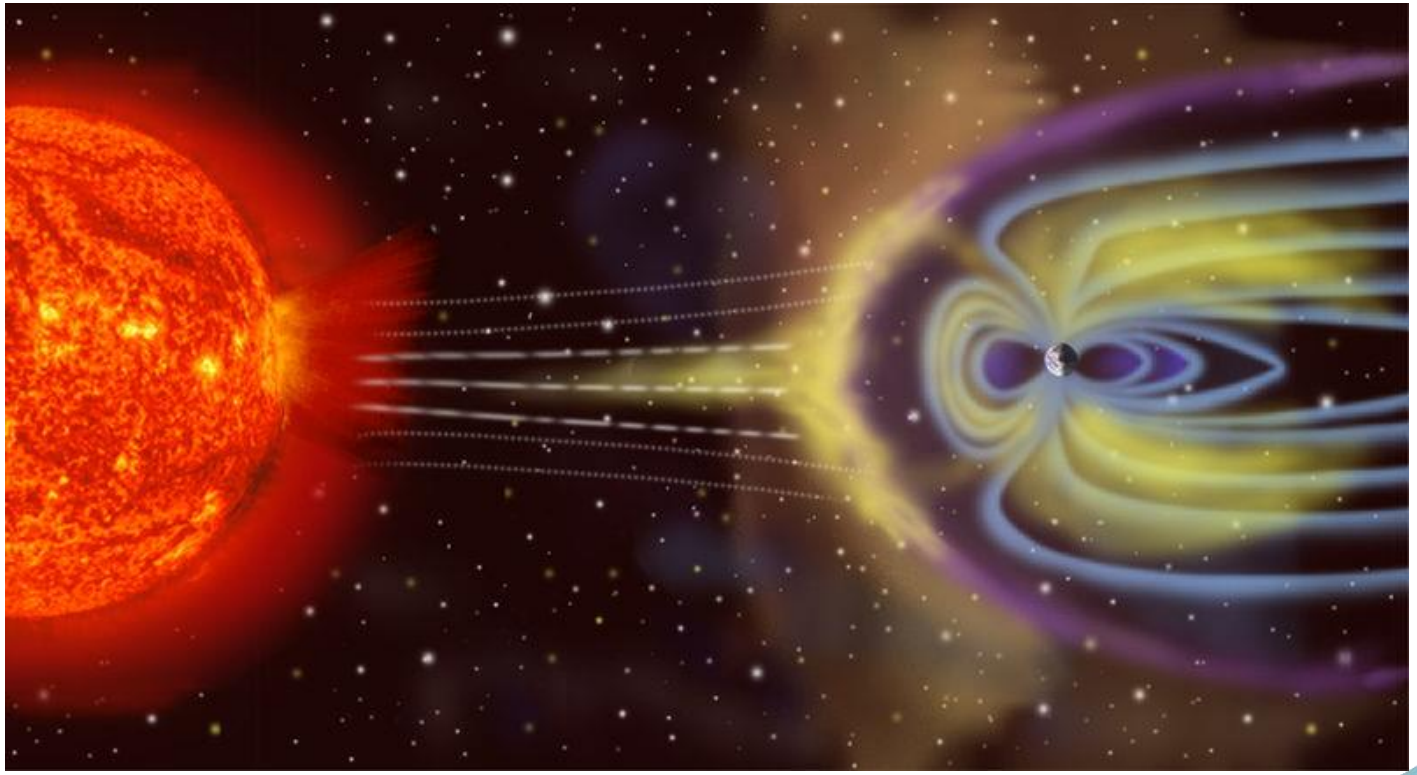
https://www.esa.int/Applications/Observing_the_Earth/FutureEO/GOCE/Introducing_GOCE

Magnetosphere



https://en.wikipedia.org/wiki/File:Magnetic_Field_Earth.png

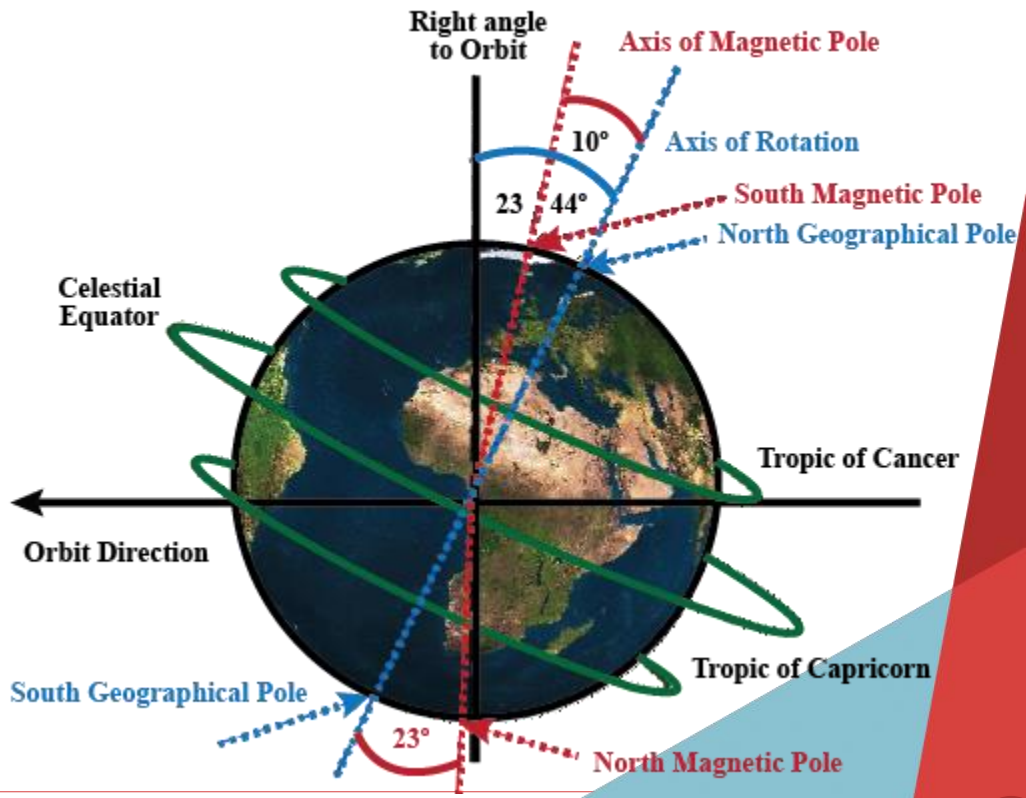
Magnetosphere



https://en.wikipedia.org/wiki/File:Magnetosphere_rendition.jpg

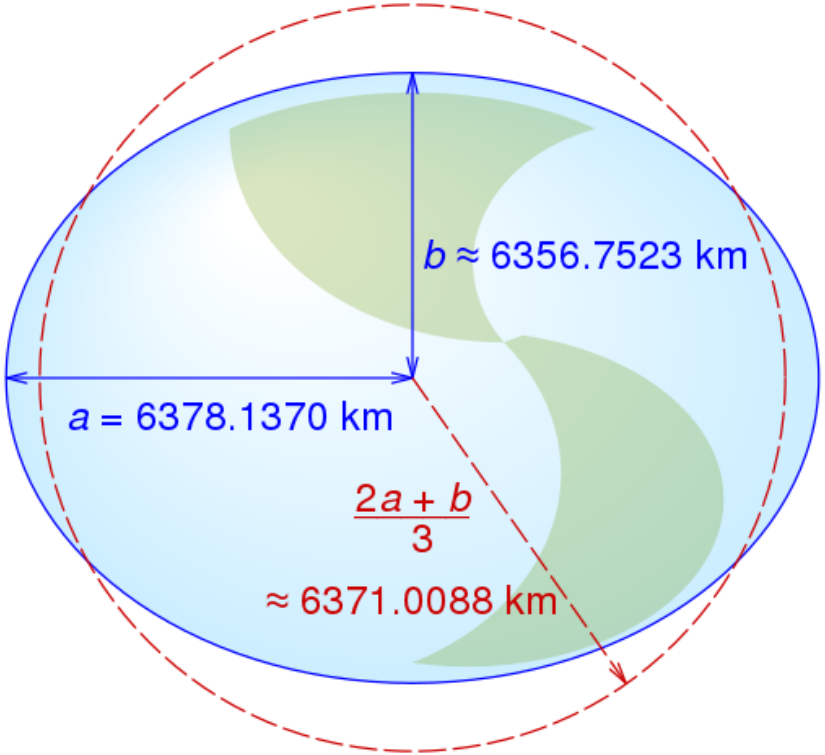
Defining the “middle” and “axes”

- Do the different axes intersect?
- Do they remain static?



https://www.toppr.com/ask/question/the-change-in-seasons-on-the-earth-occurs-because/

Geodesic Reference Systems



https://de.m.wikipedia.org/wiki/Datei:WGS84_mean_Earth_radius.svg

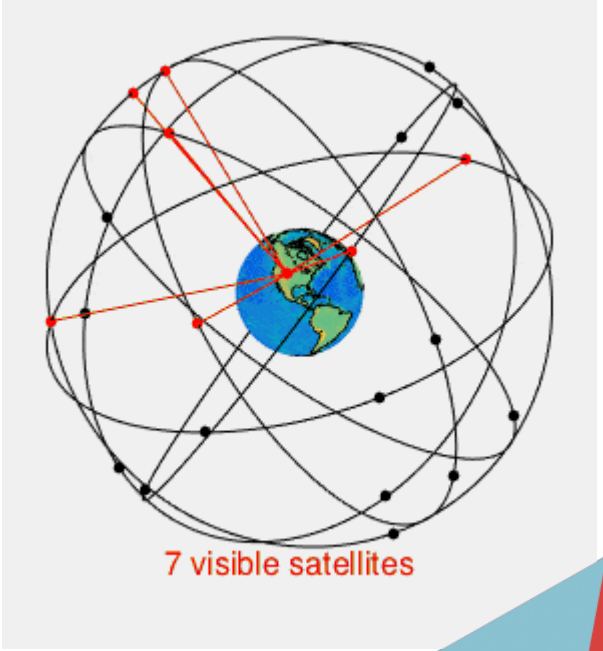
WGS84

Ellipsoid		
Semi-major axis of the ellipse	a	$6\,378\,137.0\ m$
Flattening factor	f	$1/298.257223563$
Earth angular velocity	ω_E	$7\,292\,115.0 \cdot 10^{-11}\ rad/s$
Gravitational constant	μ	$3\,986\,004.418 \cdot 10^{8}\ m^3/s^2$
Speed of light in vacuum	c	$2.99792458 \cdot 10^{8}\ m/s$

https://gssc.esa.int/navipedia/index.php/Reference_Frames_in_GNSS

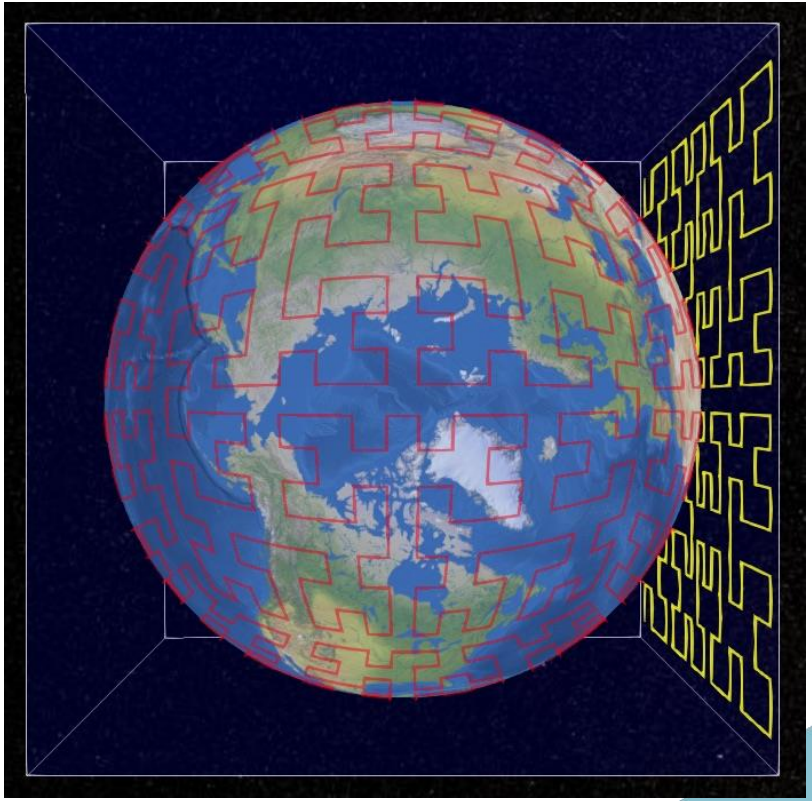
WGS84 & GPS

- ~30 GPS-Satellites, NOT geostationary on 6 different tracks
- Data sent: ID, WGS84-Position, current time aus (atomic clocks with 15 sub-second fractional digits!)
- Doppler Effect of 1575,42 MHz carrier frequency
- At least "Contact" to 4 Satellites needed: 2 → Disc | 3 → Line | 4 → Point
- GALILEO and GLONASS: use a different reference model



Condensing Lon/Lat into a Single String – S2 (Google)

- Space filling curve (Hilbert Curve)
- Growing accuracy with each curve subdivision

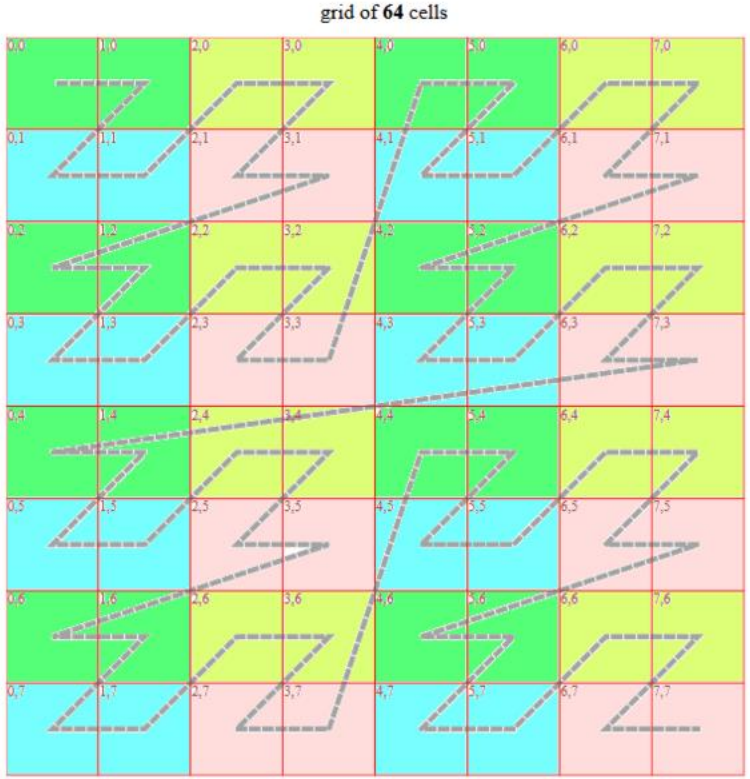


https://yarnpkg.com/package/s2-geometry

Condensing Lon/Lat into a Single String

- GeoHash (PublicDomain)
  https://www.movable-type.co.uk/scripts/geohash.html

- Shortlink (Open Streetmap)
  https://wiki.openstreetmap.org/wiki/DE:Shortlink



https://commons.wikimedia.org/wiki/File:MortonCurve64grid-mergingCells.png

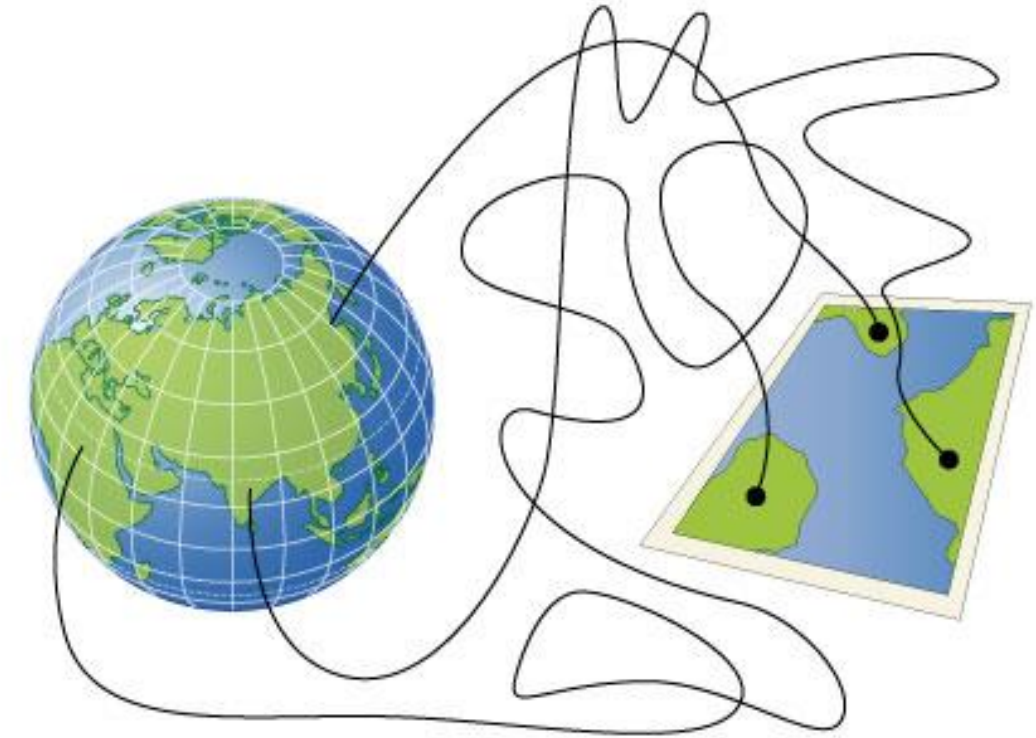
Links & Further Resources

- https://gisgeography.com/ellipsoid-oblate-spheroid-earth/
- https://www.youtube.com/watch?v=3MJoKhO9G1g
- https://www.scinexx.de/news/geowissen/warum-der-greenwich-meridian-wanderte/
- https://gssc.esa.int/navipedia/index.php/Reference_Frames_in_GNSS

- https://www.britannica.com/technology/navigation-technology/Longitude-measurements (And more relevant articles via infinite scroll!)

- https://blog.christianperone.com/2015/08/googles-s2-geometry-on-the-sphere-cells-and-hilbert-curve/

Next: Map Projections



http://geographx.co.nz/map-projections/

"Homework"

- https://www.giperspective.co.uk/the-mercator-projection-how-interactive-maps-can-wrongly-influence-our-perception-of-the-world/
- https://www.visualcapitalist.com/mercator-map-true-size-of-countries/
- Read, investigate, write down questions for a short discussion next week