Geodesy 1 (GED203)

Lecture No: 1

INTRODUCTION

Ali ELSAGHEER, Reda FEKRY

reda.abdelkawy@feng.bu.edu.eg

YOUR SUBJECT

- **Name:** Geodesy 1, **Code:** *GED203*
- A bridging subject for surveying students
- Forms a basis for remaining study.
- Promote an awareness of where some geospatial (2D and 3D) data used comes from and the factors that govern its creation and accuracy
- Class is scheduled every **Tuesday at 1:15 pm**.
- Lecture **Venue**: ***B8***

References

1. Hooijberg, M., 2007. Geometrical Geodesy: Using Information and Computer Technology. Springerverlag, Berlin, Germany.
2. Hooijberg, M., 2011. Practical Geodesy: Using Computers. Springer Ltd, London, UK. d- Periodical
3. Fes4surveying@wordpress.com

Assessment

Subject	Contact Hours				Marks				Final Exam
	Lectures	Tut.	Lab.	Total	Sem. Work	Oral exam	Written Exam	Total	
Geodesy 1	2	1	2	5	45	30	75	150	3 hrs.

Tool	Week	Weight
Midterm Examination	8	25 %
Final Examination	(As Scheduled)	50 %
Attendance & Quizzes	3,5,9	15 %
Home assignments, and Reports	2,4,6,8,10,12	10 %
Total		**100** %

Scope

- Recognize the concept of geodesy.
- Explain the geometry of the figure of the earth.
- Apply the geodetic mathematical models.
- Evaluate measurement of geodetic networks.
- Use the knowledge of mathematics, engineering sciences, information technology and planning projects in geodesy.
- Construct different geodetic networks.
- Select rules needed for different geodetic networks.
- Solve different geodetic problems.

Course Content

1. Definition of Geodesy
2. Difference between plane and geodetic survey
3. Figure of the Earth (Topographic – Geoid – Ellipsoid - Sphere)
4. Geometrical properties of the ellipsoid
5. Solution of spherical and ellipsoidal triangles
6. Ellipsoidal and spherical excess
7. Calculating lengths along the meridian and parallel of latitude
8. Direct and inverse geodetic problem
9. Establishing of horizontal and vertical datums
10. Observation and adjustment of geodetic horizontal control
11. Trigonometric and precise leveling.

Your Teacher

- **Name**
  - Reda Fekry
- **Research Interests**
  - Multi-modality 3D remote sensing.
  - Pattern recognition, and related environmental and industrial applications.
  - Sensor fusion for environmental informatics.
  - Deep learning-based point processing and modeling.
  - Object segmentation and classification
- **Teaching Areas**
  - Surveying and Geodesy.
  - Photogrammetry and Remote Sensing.
  - Geospatial computer vision and machine learning.
- **Room**
  - RBO-20
- **E-mail**
  - reda.abdelkawy@feng.bu.edu.eg
  - fekry.khaliel@connect.polyu.hk

Your Tutor

Name

Doha Saeed

E-mails

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Overview of today's lecture

- Definition of geodesy
- Objective of Geodesy
- Branches of Geodesy
- History of Geodesy
- Shape and Size of The Earth
- Latitude and Longitude
- Geoid
- Ellipsoid
- Summary

Expected Learning Outcomes

- **Understanding the Definition and Purpose of Geodesy:** Students will understand the purpose of geodesy in providing accurate measurements and reference systems for positioning, mapping, and various applications.
- **Familiarity with Branches of Geodesy**: Students will gain a basic understanding of how these branches focus on different aspects and techniques within the field of geodesy
- **Knowledge of the History of Geodesy**: Students will understand how geodesy has evolved over time and the role of key figures and milestones in shaping the field.
- **Understanding Earth's Shape and Size**: Students will explore the concepts of the Earth's shape and size, including the recognition that the Earth is not a perfect sphere but an oblate spheroid.
- **Comprehension of Latitude and Longitude:** Students will gain a thorough understanding of latitude and longitude as coordinates used to specify locations on the Earth's surface. They will learn how latitude measures the angular distance from the equator and how longitude measures the angular distance from a reference meridian (often the Prime Meridian).
- **Knowledge of Geoid and Ellipsoid**: Students will understand the geoid as a hypothetical surface representing mean sea level and the reference for measuring heights. They will learn about the ellipsoid as an approximation of the Earth's shape, which allows for the creation of coordinate systems and datums.

Definition of Geodesy

What does “Geodesy” Mean?

- The term "geodesy" has origins in ancient Greek.
- It is derived from the Greek words: "***geo***" meaning Earth, and "***daisia***" meaning to divide or distribute.
- The combination of these words reflects the *essence of geodesy* as the science of measuring and dividing the Earth's surface.

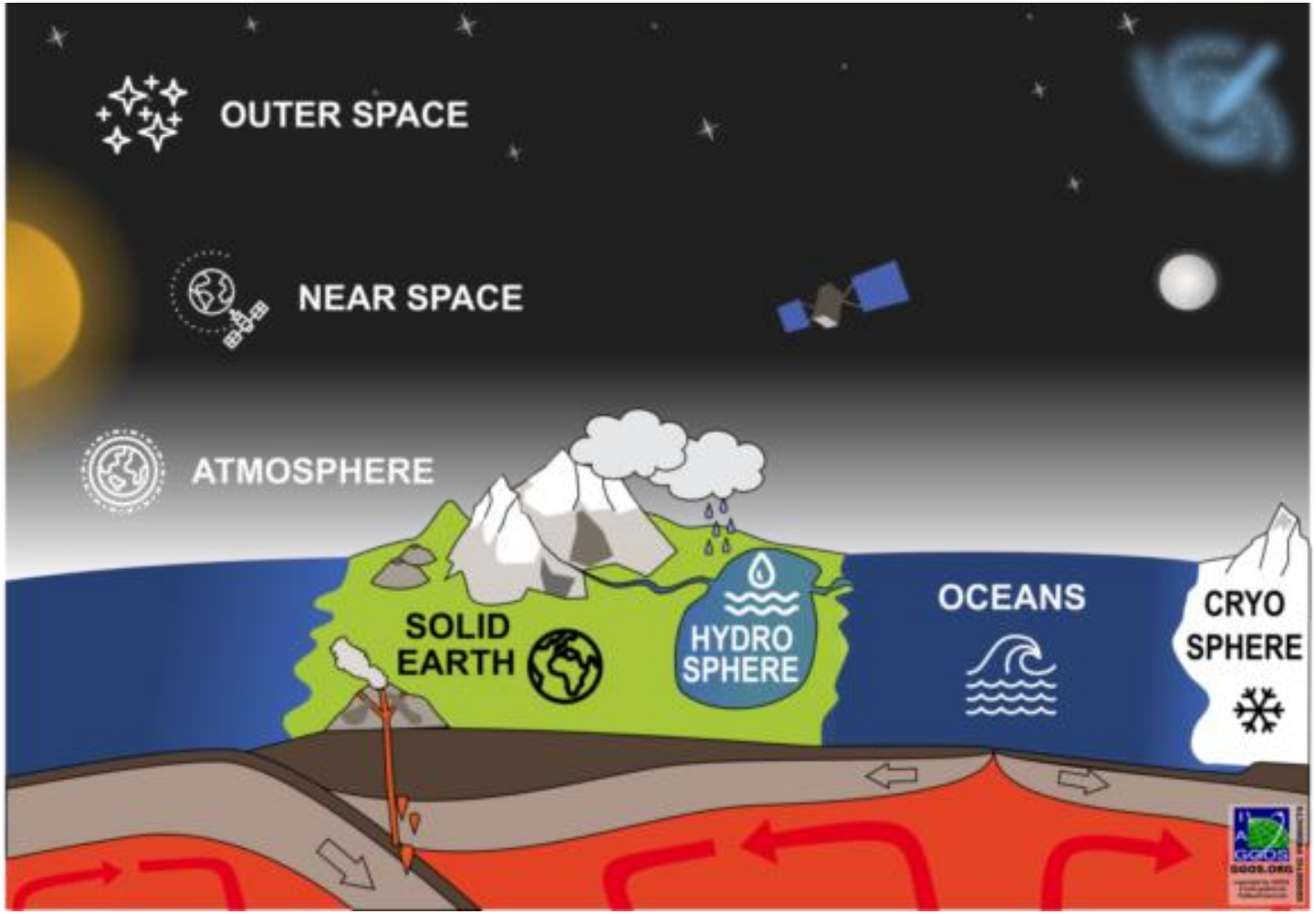
WHAT IS GEODESY?

- The International Association of Geodesy (IAG) defined it as "**the science of determining the size and. figure of the earth, and its external gravity field**" (*1).
- National Oceanic and Atmospheric Administration (NOAA) stated that "**Geodesy is the science of accurately measuring and understanding three fundamental properties of the Earth: its geometric shape, its orientation in space, and its gravity field— as well as the changes of these properties with time**" (*2).

1) https://www.iag-aig.org/geodesy
2) https://oceanservice.noaa.gov/welcome.html

GEODESY PRODUCTS

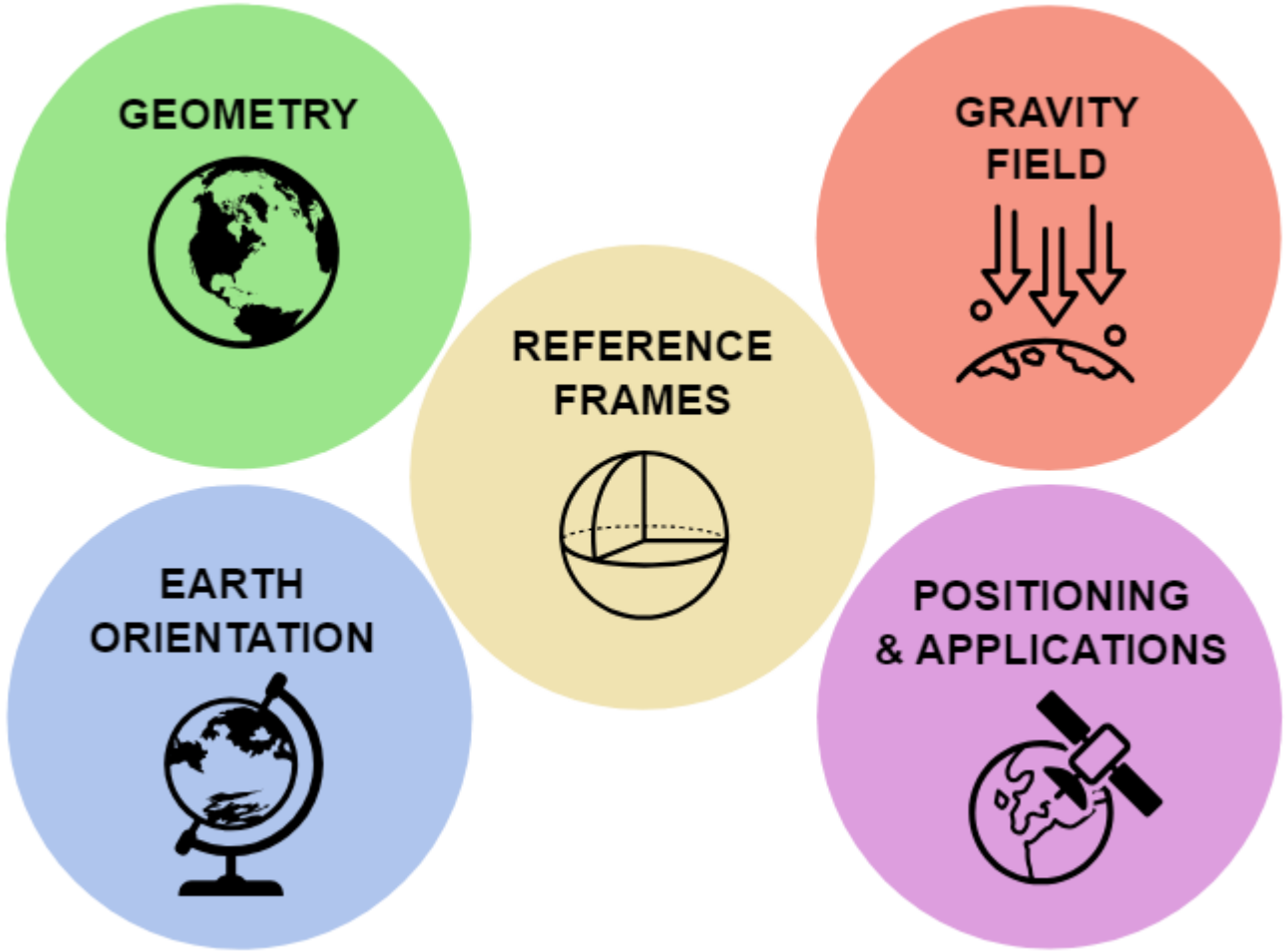
This forms the basis for studying the Earth System and the interactions between its sub-components and the outer space.



Geodetic Products

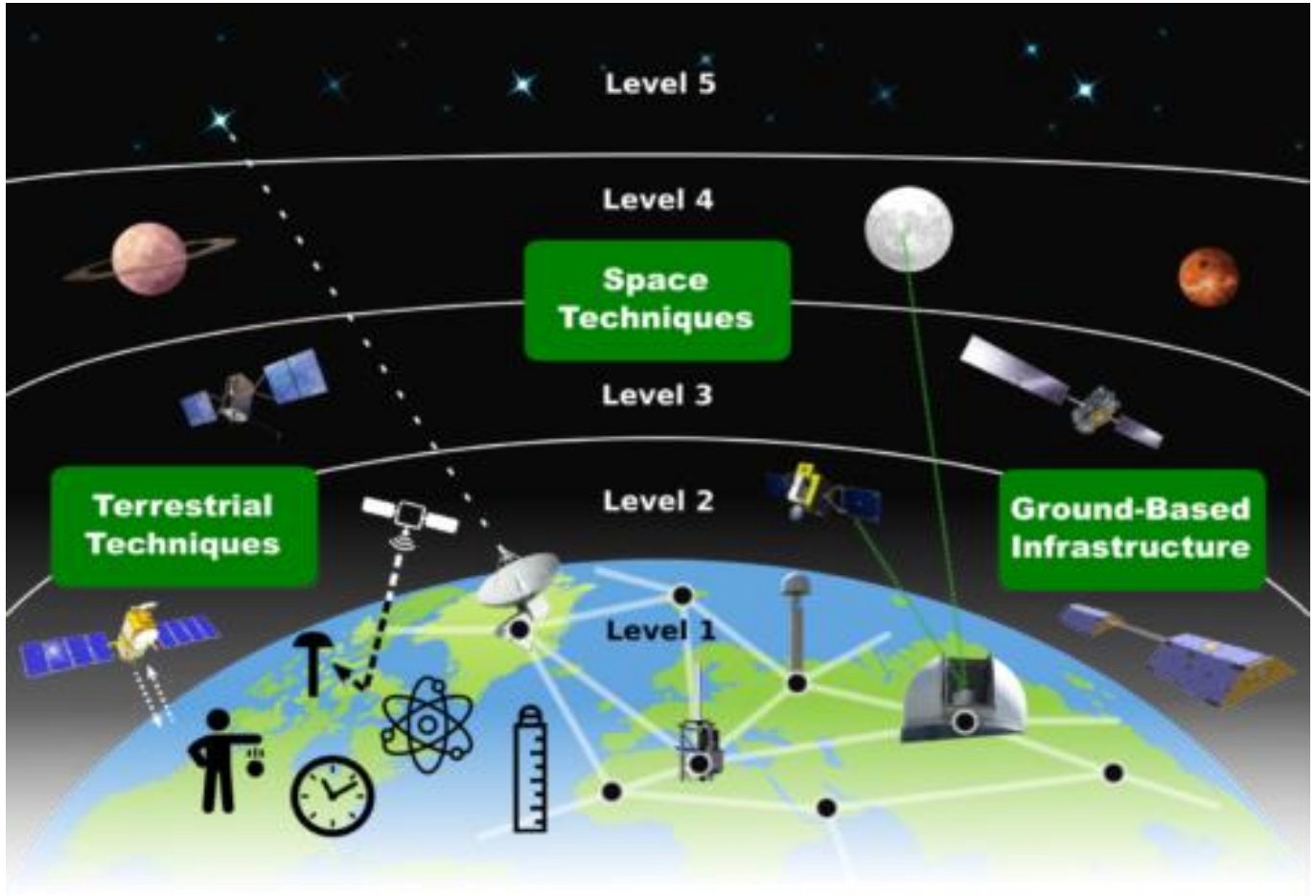
GEODESY PRODUCTS

This forms the basis for studying the Earth System and the interactions between its sub-components and the outer space.



TOOLBOX OF GEODESY - OBSERVABLES

The toolbox of geodesy comprises different sensors and instruments on the Earth, in the air, and in space, which together form one large, comprehensive "geodetic instrument" for monitoring the System Earth in a wide range of spatial and temporal scales.



Geodetic Earth Observations

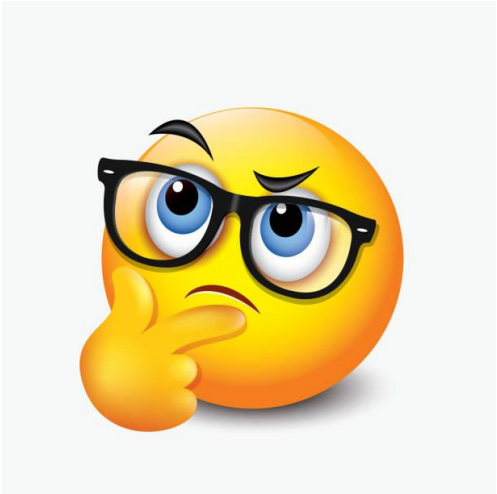
Video about Geodetic Products

BASED ON DEFINITION, WHAT SHOULD BE THE *OBJECTIVES*?

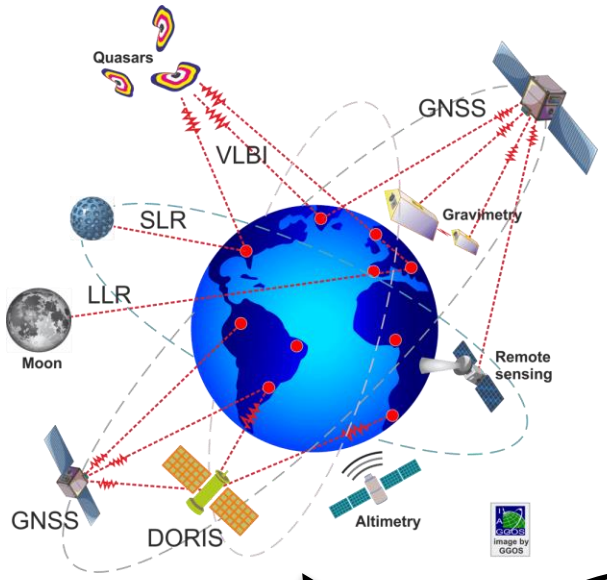
Objectives of Geodesy

Determining the Earth's Shape and Size
Establishing Geodetic Reference Systems
Defining Geoid and Gravity Field
Understanding Earth's Rotation and Orientation
Monitoring Earth's Deformation and Tectonic Movements
Supporting Surveying, Mapping, and Infrastructure Development
Facilitating Global Navigation and Satellite Positioning
Contributing to Earth Sciences and Climate Research

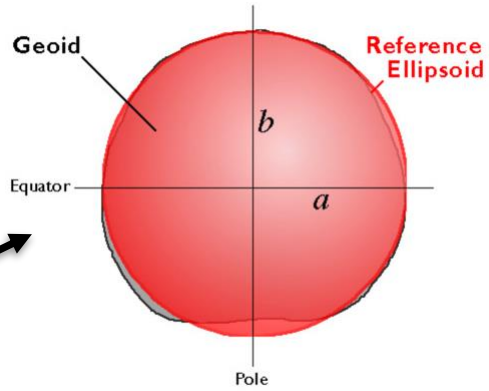
TO ACHIEVE THESE OBJECTIVES, THERE SHOULD BE *DIFFERENT BRANCHES*!

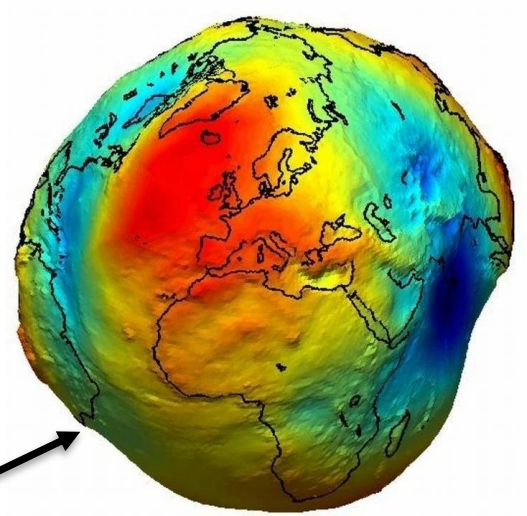


Branches of Geodesy



Geometric Geodesy





Physical Geodesy

Satellite Geodesy

Branches of Geodesy - Geometric Geodesy

- Geometric Geodesy focuses on the measurement and analysis of geometric properties of the Earth's surface, such as distances, angles, and elevations. It includes techniques like triangulation, trilateration, and leveling. **Its main objective is to determine the shape and size of the earth.**
- It also involves:

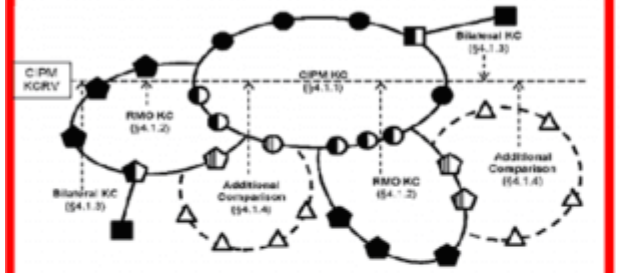
1. **Geodetic Surveying** which is practical aspects of surveying and mapping, using geodetic principles and techniques. It involves the measurement of angles, distances, and elevations to establish precise control networks, determine property boundaries, and create accurate maps. Geodetic surveying plays a crucial role in infrastructure development, construction projects, and land management.
2. **Geospatial Geodesy** that involves the integration of geodetic data with other spatial data sources, such as remote sensing imagery, Geographic Information Systems (GIS), and geospatial databases. It focuses on the management, analysis, and visualization of geodetic information within a broader spatial context. Geospatial geodesy plays a crucial role in applications such as geospatial data infrastructure, land administration, disaster management, and environmental monitoring.

Branches of Geodesy - Physical Geodesy

- Physical geodesy deals with understanding the physical properties of the Earth and its gravitational field.
- It involves studying the Earth's gravity field, gravity anomalies, and the effects of mass distribution on the Earth's shape.
- It utilizes techniques such as satellite gravimetry and gravimetric measurements to investigate the Earth's interior structure and dynamics.
- It combines geodetic measurements with geophysical techniques to study Earth's dynamic processes.
- It also involves monitoring crustal deformations, plate tectonics, and seismic activities using geodetic instruments and satellite observations. Geodetic geophysics contributes to the understanding of earthquakes, volcanic activities, and the behavior of Earth's lithosphere.
- It focuses on the study of Earth's dynamic processes, particularly related to plate tectonics, crustal movements, and deformations.

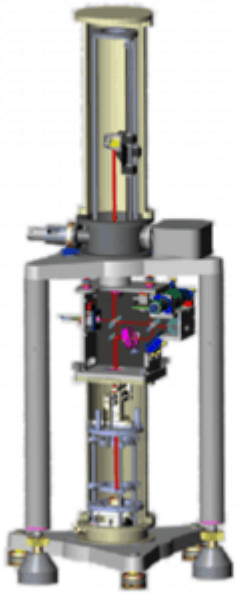
Branches of Geodesy - Physical Geodesy

Intercomparison
of Absolute Gravimeters



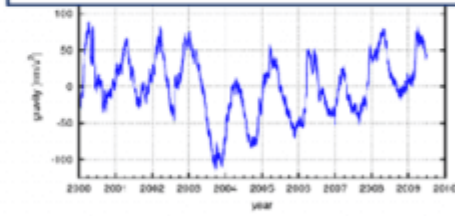
Central Inventory (Database)

Absolute Gravimeters



Gravity reference stations
with continuous comparison reference function

Continuous monitoring by
- Superconducting
- Repeated Absolute
- Continuous Quantum Gravimeters



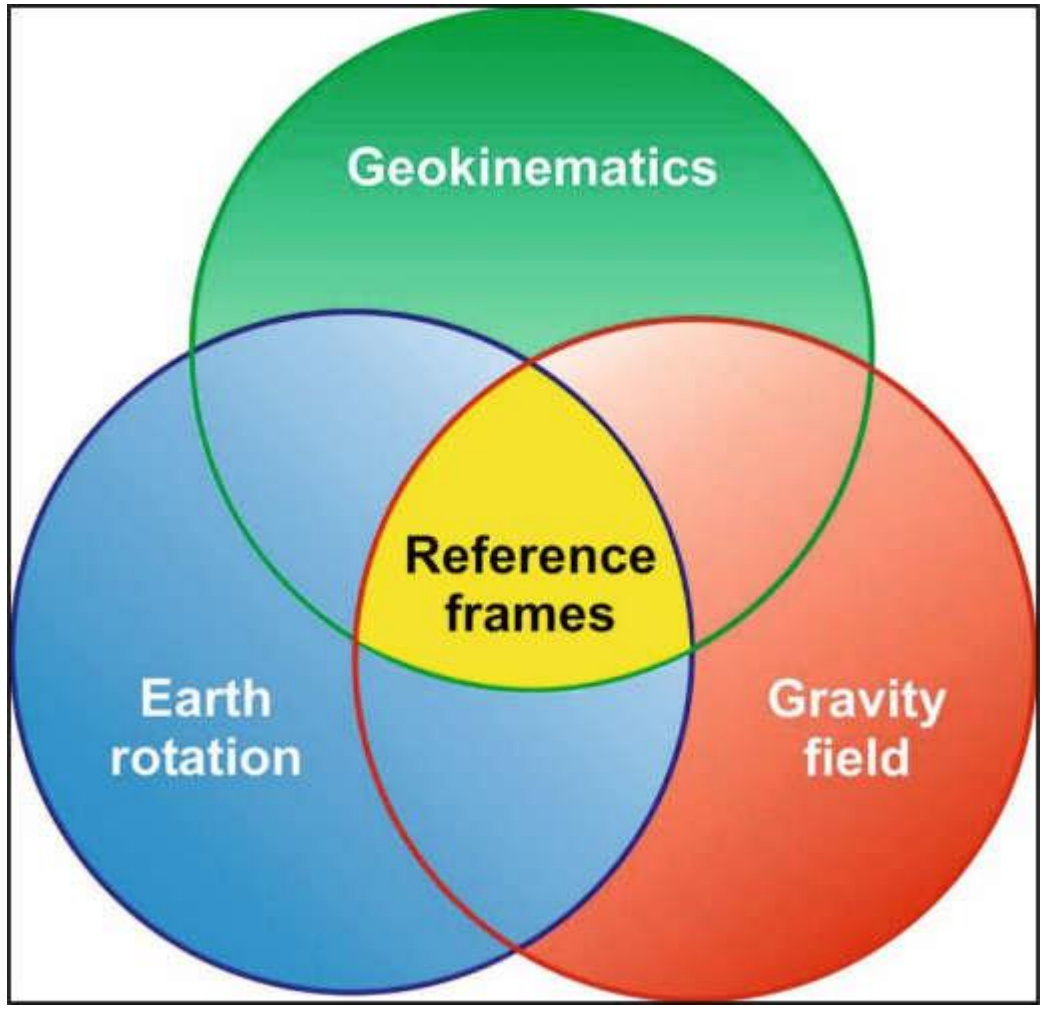
Conventional models for temporal gravity changes:
Tides, Atmosphere, Polar Motion

https://ggos.org/item/gravity-reference-frame/

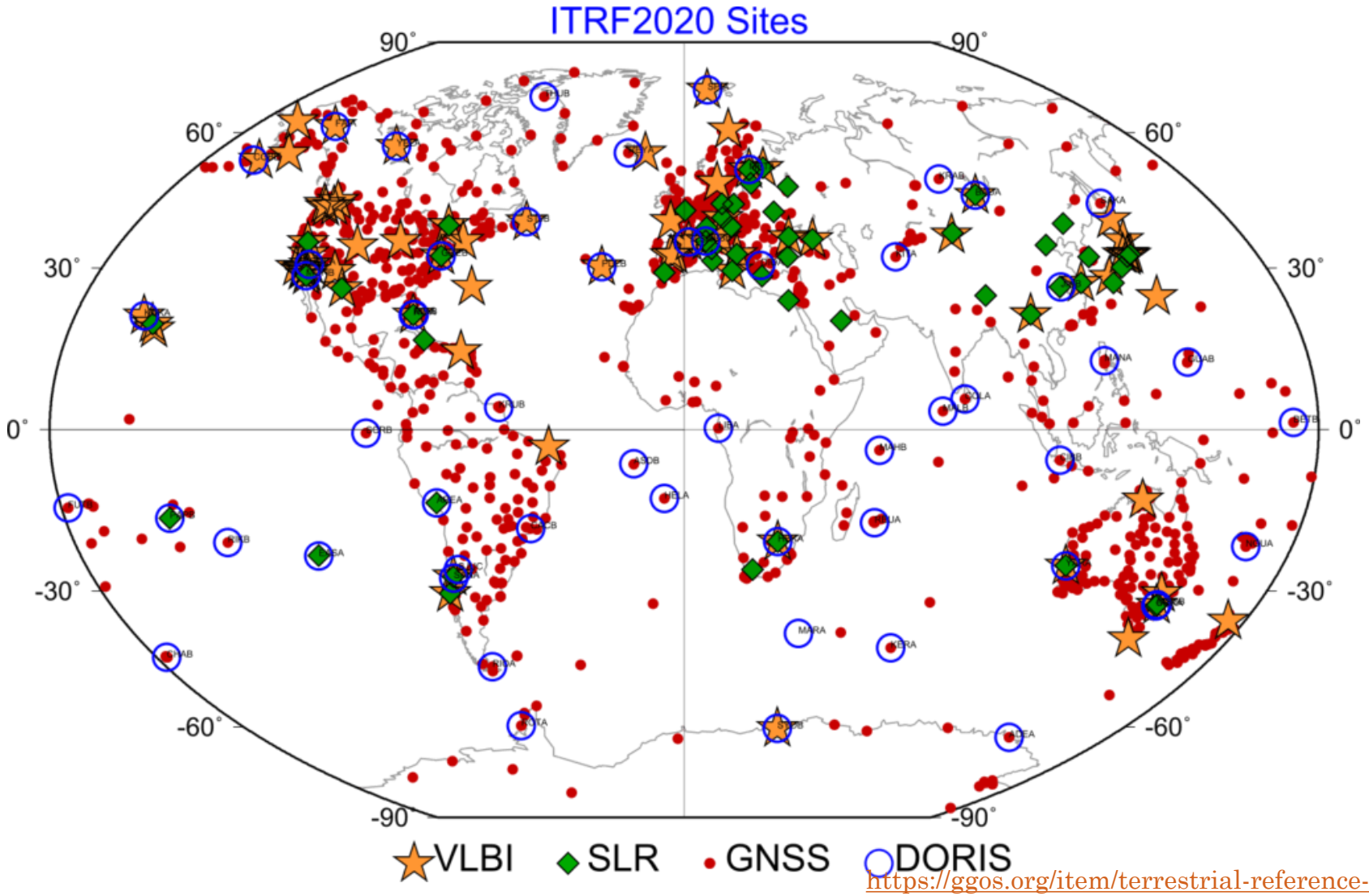
Branches of Geodesy - Satellite Geodesy

- Satellite geodesy utilizes satellite-based observations and measurements to determine precise positions, velocities, and deformations of points on the Earth's surface.
- Techniques employed in satellite geodesy include satellite positioning systems like GPS, GLONASS, and Galileo, as well as satellite altimetry, satellite laser ranging (SLR), and satellite gravimetry.
- Satellite geodesy enables global positioning, monitoring of Earth's deformation, and determination of geodetic reference systems.

Branches of Geodesy - Satellite Geodesy



Branches of Geodesy - Satellite Geodesy



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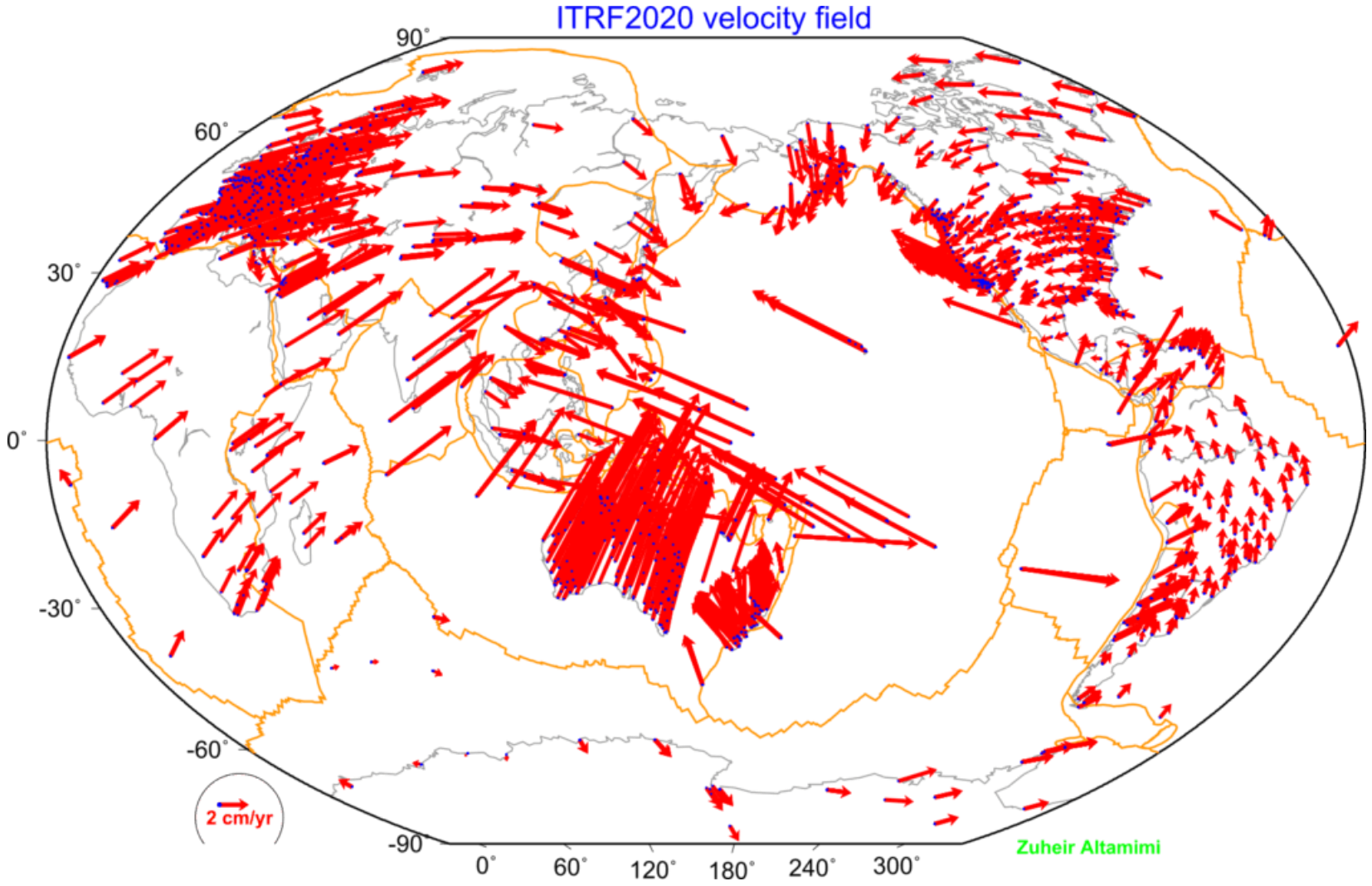
Branches of Geodesy - Satellite Geodesy



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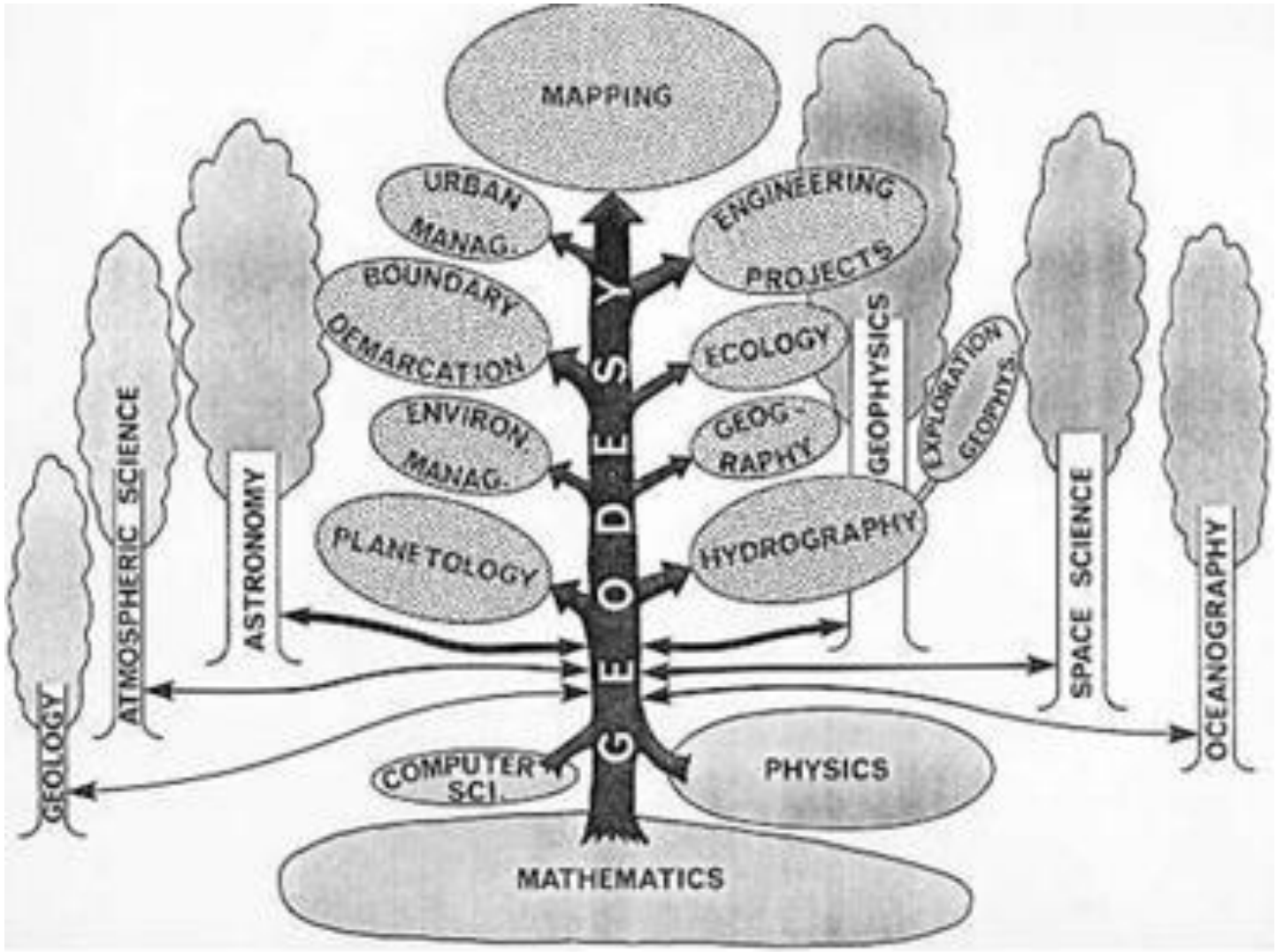
These Branches are closely related to other fields of science!

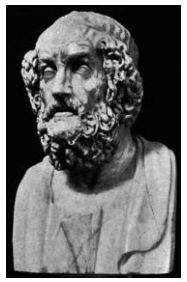
Geodesy and Other Sciences



ACCORDINGLY, GEODESY IS OF UTMOST IMPORTANCE IN HISTORY.

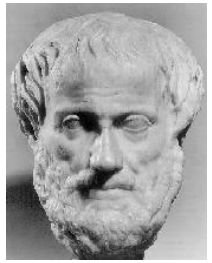
Watch History of geodesy

History of Geodesy - Shape of the Earth



- 9th century BCE (Homer)
  - "**Flat** Earth with hemispherical sky"

- 6th century BCE (Pythagoras)
  - "**Spherical** Earth"
    - As a "perfect form"
    - No scientific deduction



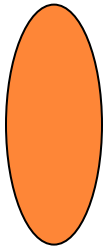
- 4th century BCE (Aristotle)
  - "**Spherical** Earth"
    - Deduction from horizon issues

History of Geodesy - Shape of the Earth

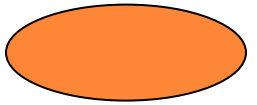
- 230 BCE (Eratosthenes)
  - First computation of Earth Radius!!
    - Off by only a few percent

- (1492? Has nothing to do with flat vs. round)

- 17th century CE (L'Academe Royale de Sciences)
  - "the Cassinis"
  - **Ellipsoidal** Earth (prolate)



- 17th century CE (Sir Isaac Newton)
  - **Ellipsoidal** Earth (oblate)



History of Geodesy - Shape of the Earth

Eratosthenes' experiment

Measured the angle of the Sun's rays at two different locations and using the distance between those locations.

He used the fact that at noon on the summer solstice, the Sun was directly overhead in the Egyptian city of Syene (modern-day Aswan), while in Alexandria, the angle of the Sun's rays was slightly less than 90 degrees.

By measuring the angle and knowing the distance between the two cities, Eratosthenes was able to estimate the Earth's circumference with remarkable accuracy.

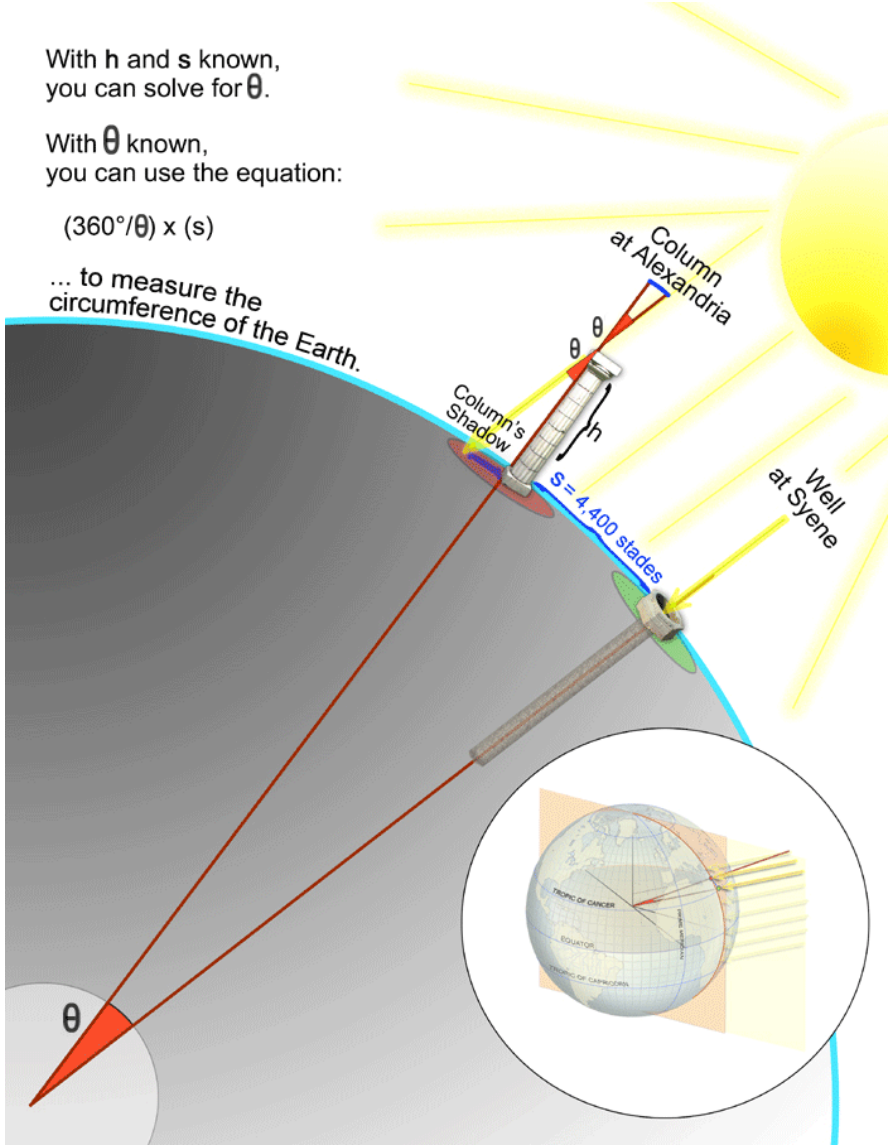
His estimation was close to the modern value, considering the limited technology available at that time (a = 6267km).

Assumed (all ok for 250 BCE):

(1) Syene on Tropic of Cancer

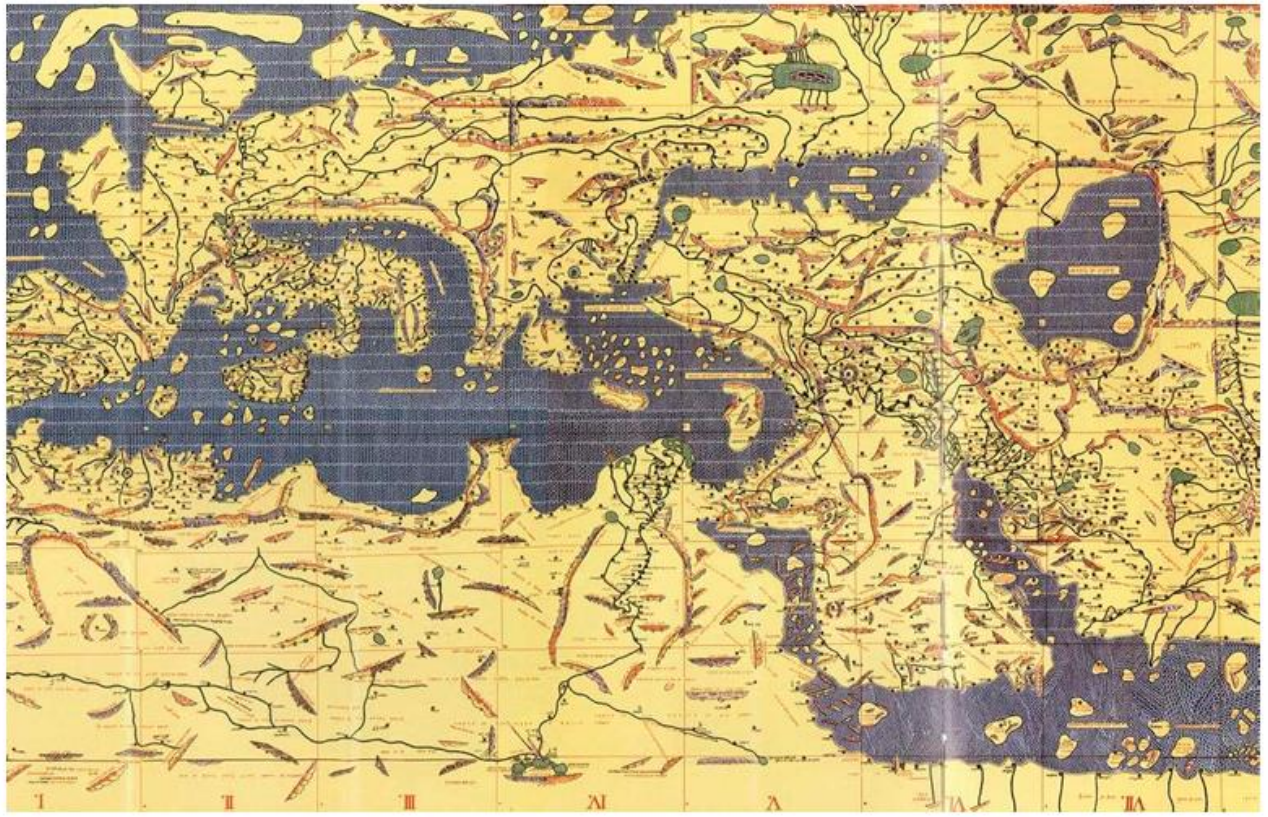
(2) Alexandria due north of Syene

(3) The sun's rays are parallel to each other

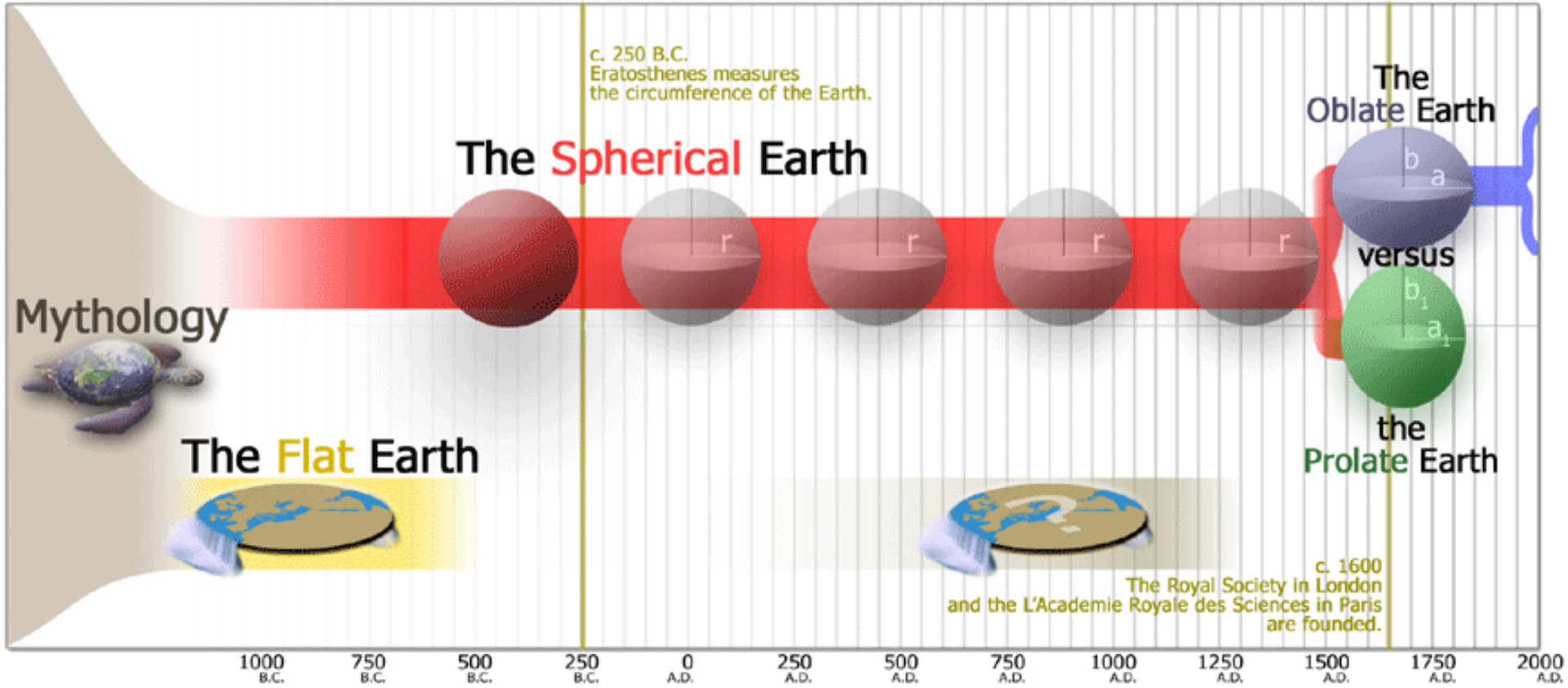


History of Geodesy - Shape of the Earth

- Muhammed Al-Idrisi, 1175 AD

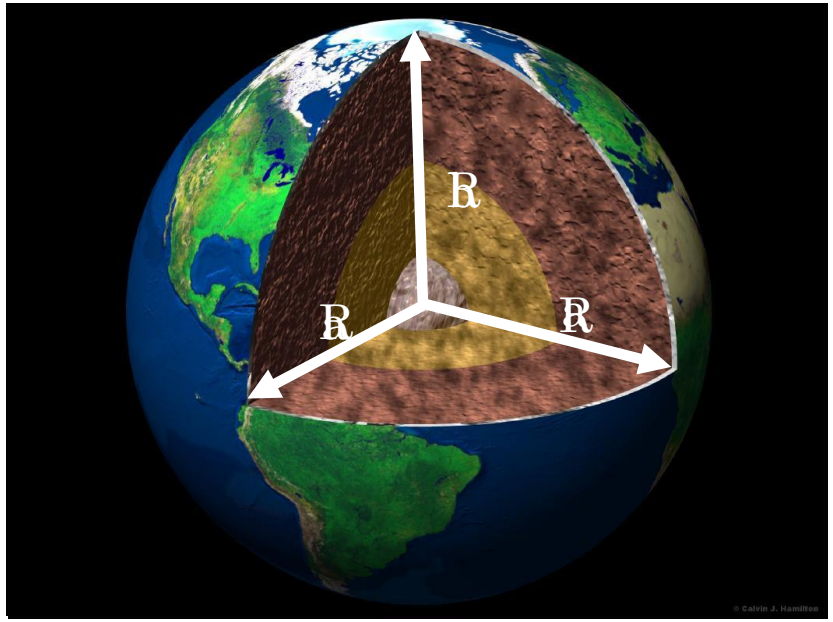


History of Geodesy - Shape of the Earth



History of Geodesy - Shape of the Earth

- **So, just how big is it?**



Sphere?
Average Radius = 6371 km (3959 miles)

Ellipsoid?
a = 6378.137 km (3963 miles)
b = 6356.752 km (3950 miles)

The North and South Poles are about 13 miles closer to the Earth's center than points on the equator!

- Even an ellipsoid isn't the true Earth shape

- 1888 G.G. Stokes proposed a new, better "figure (shape) of the Earth",
  - "The **geoid**"
  - Basically, the ocean surface, if you take away tides, and circulation and let it be still

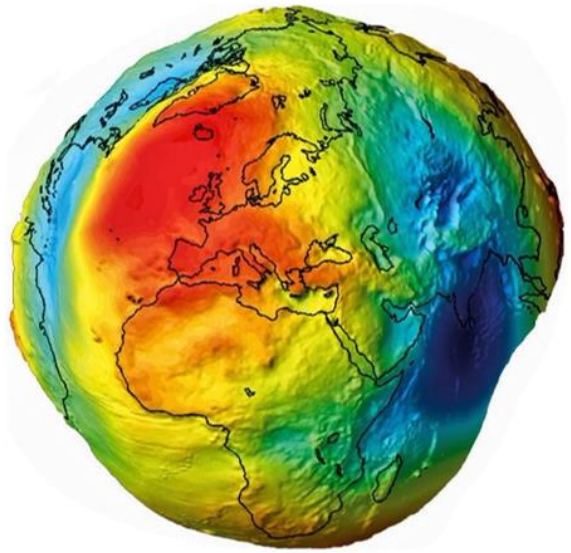
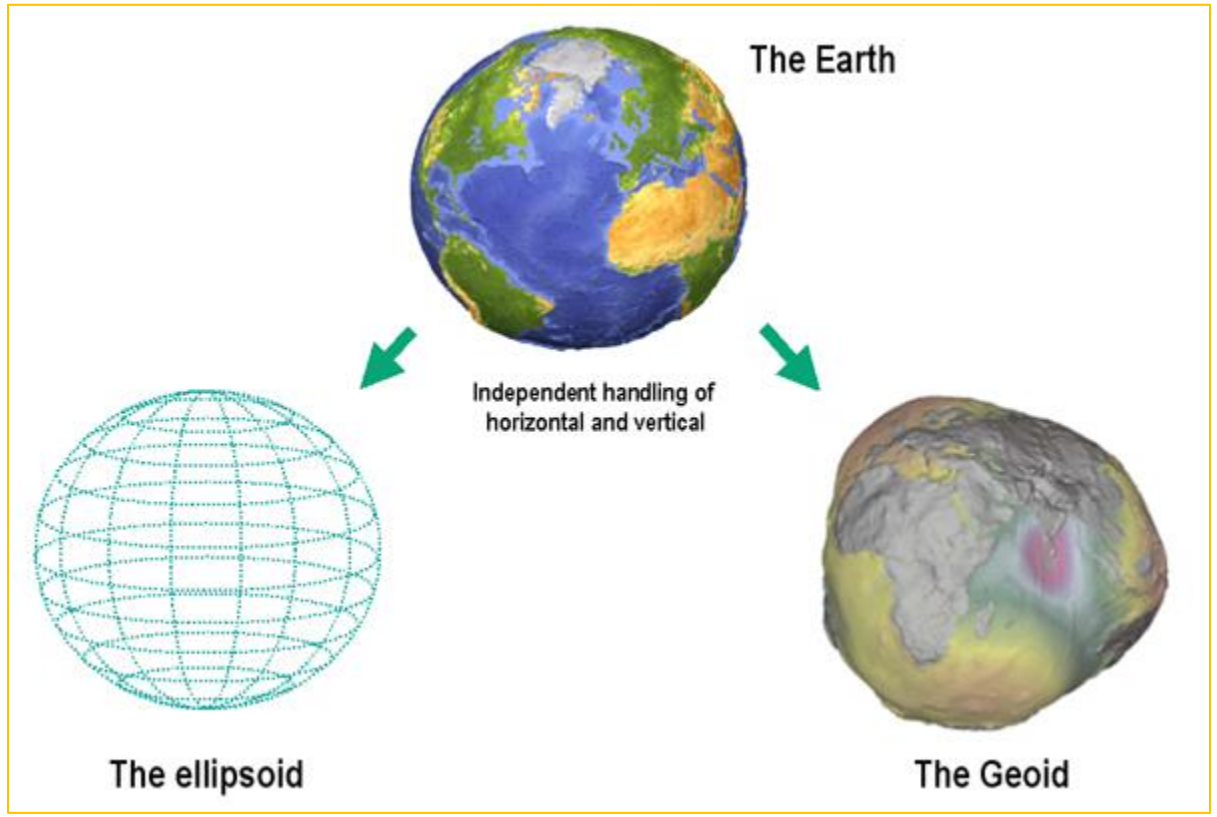


FIGURE OF THE EARTH – THE GEOID

- **The geoid** is a hypothetical surface that represents the shape the Earth's oceans would take under the influence of gravity alone, assuming the absence of other forces such as tides and currents.
- The geoid is not a perfect sphere or ellipsoid but is irregular due to variations in the Earth's gravity field caused by the uneven distribution of mass. It accounts for the gravitational effects of mountains, ocean trenches, and density variations in the Earth's interior.
- The geoid approximates mean sea level (MSL), meaning that if the Earth's surface were entirely covered by a calm, idealized ocean, the geoid would coincide with the surface of this ocean.
- The geoid serves as a *reference surface* for measuring *elevations* on the Earth.
- It is an *equipotential surface*, meaning that at any given point on the geoid, the gravitational potential is the same.
- Geodesists construct mathematical models and representations of the geoid (geoid models) based on precise measurements of the Earth's gravity field. These models are continually refined and updated with new data to improve the accuracy of geoid representations.

Figure of The Earth – The Ellipsoid



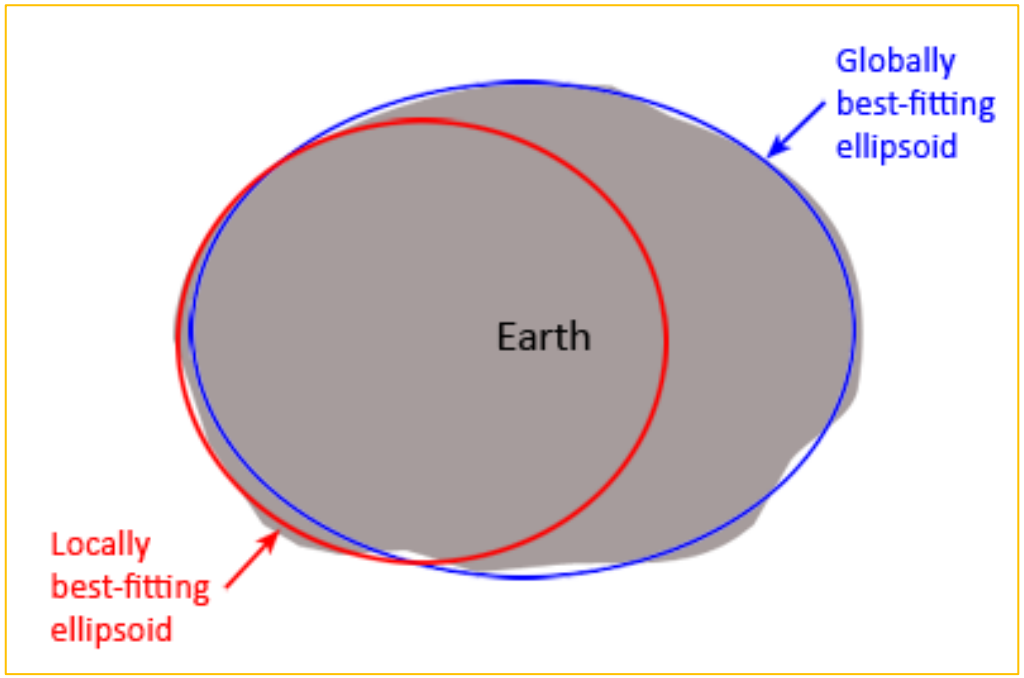
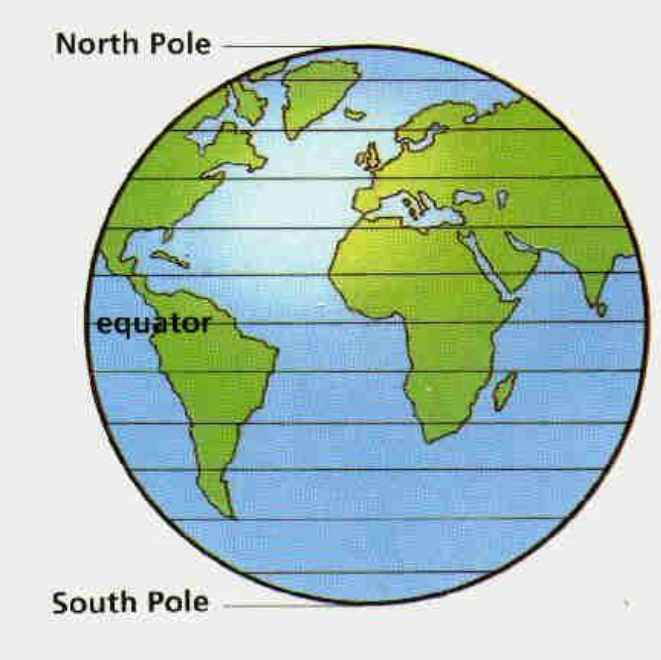
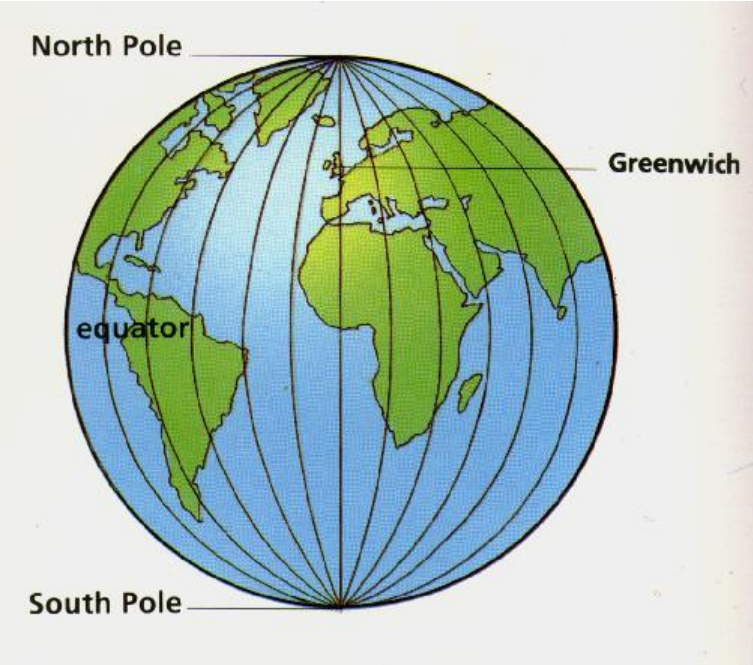


Figure of The Earth – So What?

- The geoid
  - To know "height above sea level" (helps if you live in a city near sea level, like New Orleans)
- Last 20 years: *Changes* to Earth shape are studied
  - Tectonic movements, Earth Tides, length of day
- Nowadays, most of geodesy concentrates on the ***positioning*** side and less on size/shape issues
  - **Positioning requires a coordinate system…**

Latitude and Longitude





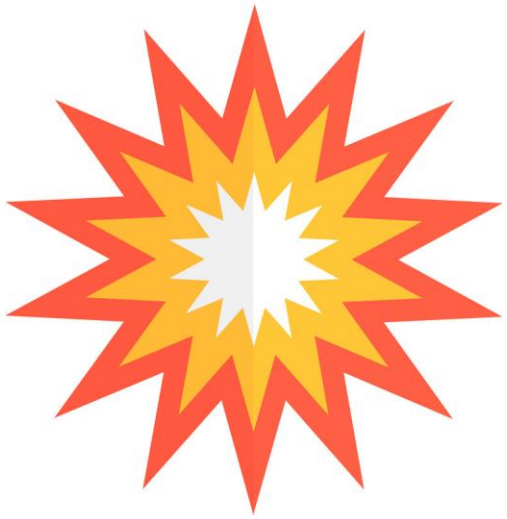
Parallels:
Lines of the same Latitude
Drawn around the Earth, parallel to the equator

Meridians:
Lines of the same Longitude
Drawn from North Pole to South Pole

Latitude and Longitude

Greenwich or Prime

Impact of Geodesy



Watch impact of geodesy

Online Resources

- https://www.iers.org/IERS/EN/Home/home_node.html
- https://www.iag-aig.org/
- https://geodesy.noaa.gov/
- https://oceanservice.noaa.gov/welcome.html
- https://www.ga.gov.au/scientific-topics/positioning navigation/geodesy
- https://itrf.ign.fr/en/homepage
- https://network.igs.org/

LET'S SUMMARIZE

Next Tuesday

Lecture 2 - Geometry of Ellipsoid

Be Prepared

End of Presentation

GEODESY