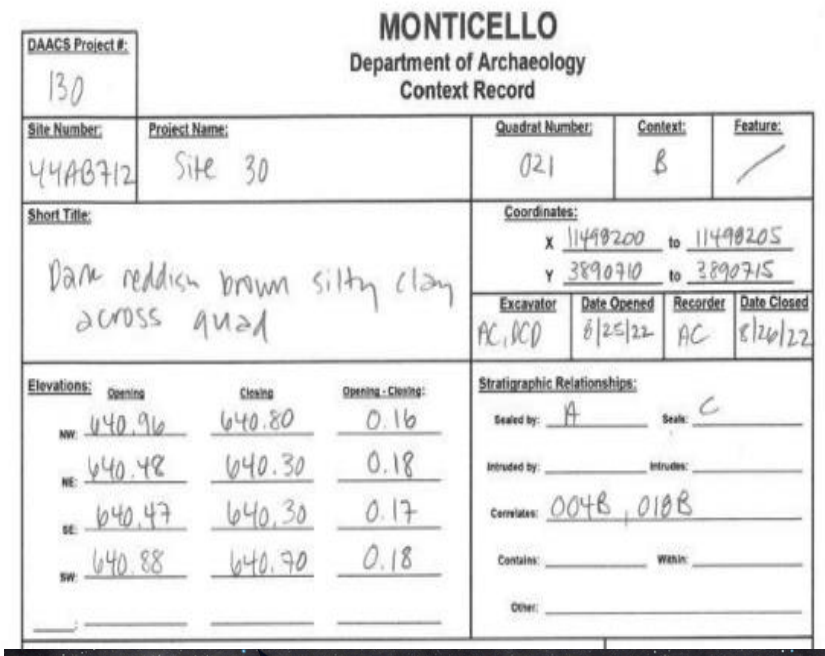
Archaeological Research Design Decision!

What kind of coordinate system ?

- -Local
  - -It's easy and always has been
- -Global
  - -It's harder, but getting easier, thanks to

Global Positioning Systems ….

- Personal
- Mapping grade
- Survey grade



MONTICELLO
Department of Archaeology
Context Record

DAACS Project #:	Site Number:	Project Name:	Quadrat Number:	Context:	Feature:
130	44AB712	Site 30	021	B	/

Short Title: Dark reddish brown silty clay across quad

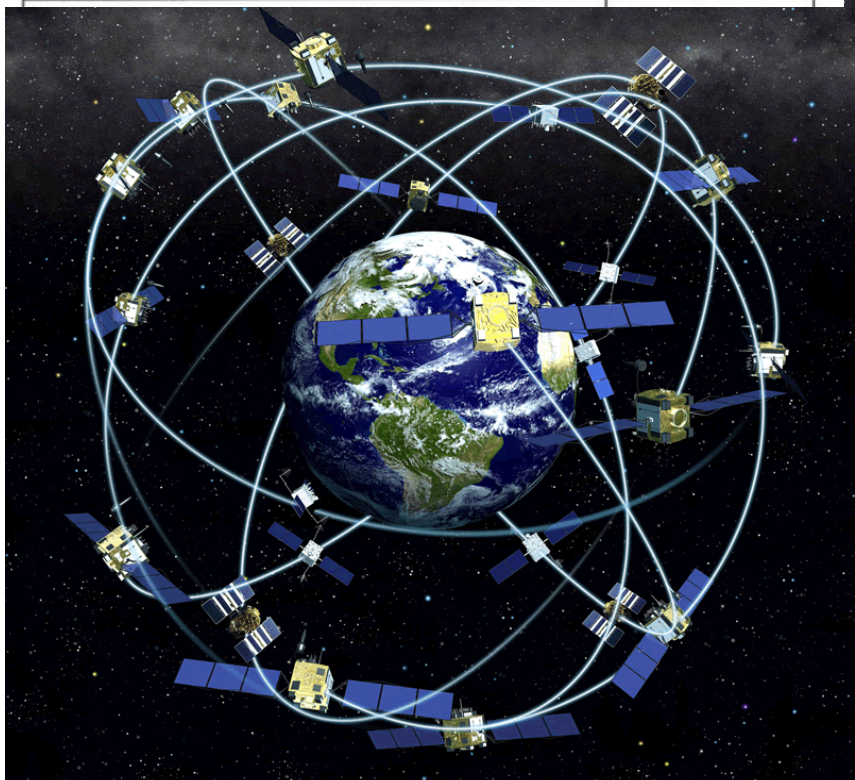
Coordinates: X 11498200 to 11498205; Y 3890710 to 3890715

Excavator	Date Opened	Recorder	Date Closed
AC, BCD	8/25/22	AC	8/26/22

Elevations:

	Opening	Closing	Opening - Closing
NW:	640.96	640.80	0.16
NE:	640.48	640.30	0.18
SE:	640.47	640.30	0.17
SW:	640.88	640.70	0.18

Stratigraphic Relationships:
Sealed by: A Seals: C
Intruded by: Intrudes:
Correlates: 004B, 010B
Contains: Within:
Other:



Datums, Projection, and Grids
Key Concepts

1. **Geodesy** –Science of measuring the shape of the Earth.

Geodesy

- Newton showed the earth is roughly an **ellipsoid.**

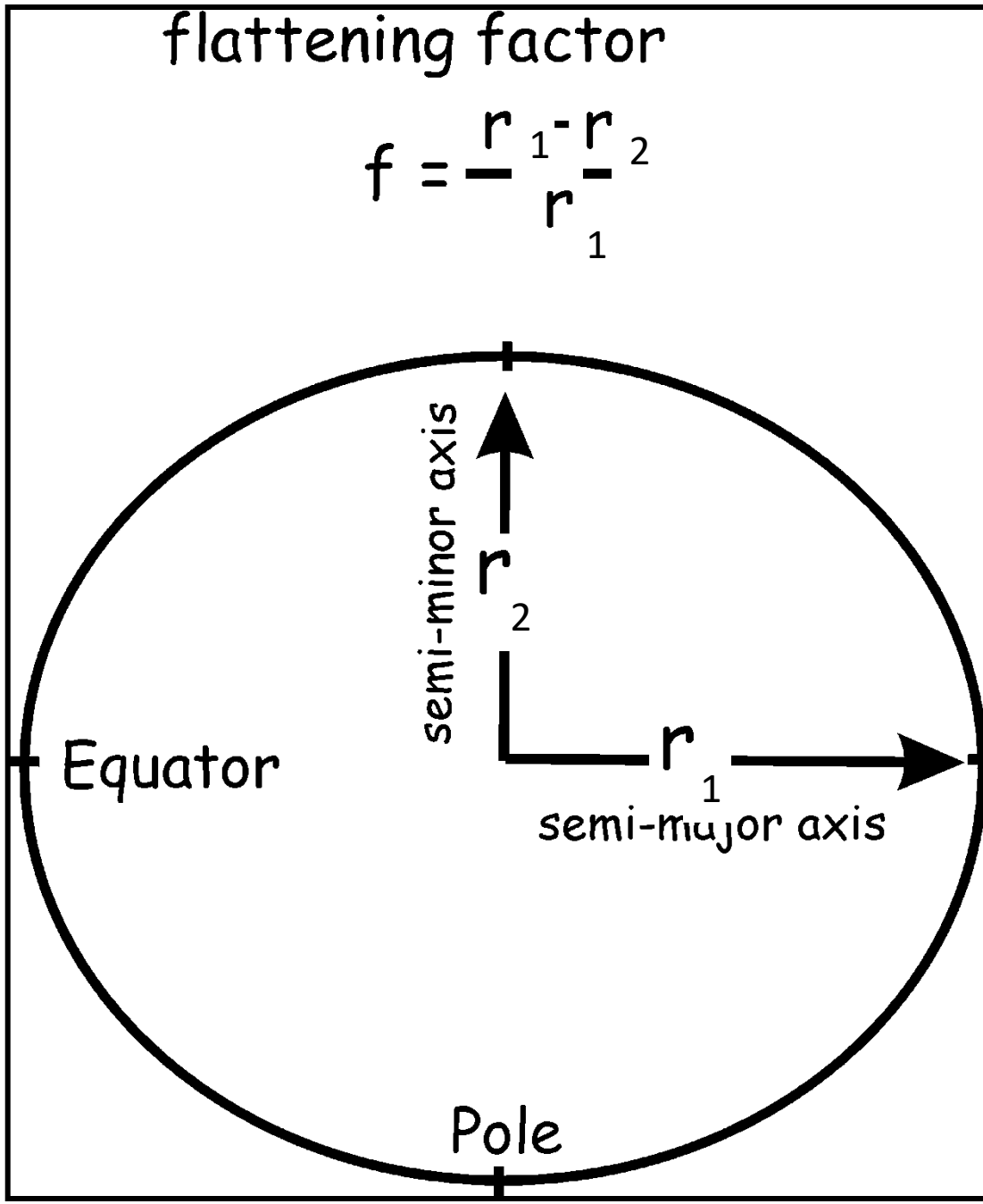
- Ellipsoid size has been estimated from many places on earth

- But estimates differ across regions and continents.

- In 19th and early-20th centuries, different ellipsoids were developed for different parts of the world.

- Measurements were made using astronomical observations to establish latitudes and longitudes.

- ***No ellipsoid model, no latitude or longitude***

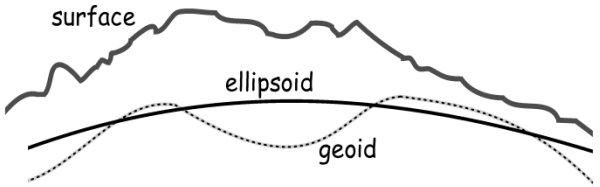


Why so many different ellipsoid models?

- The Earth's general shape is not uniform (duh!). But the ellipsoid is. How then to fit the ellipsoid to locally variable topography?

- A step on the way to a solution: try to fit the ellipsoid to the **Geoid** (hat tip: Karl Friedrich Gauss).

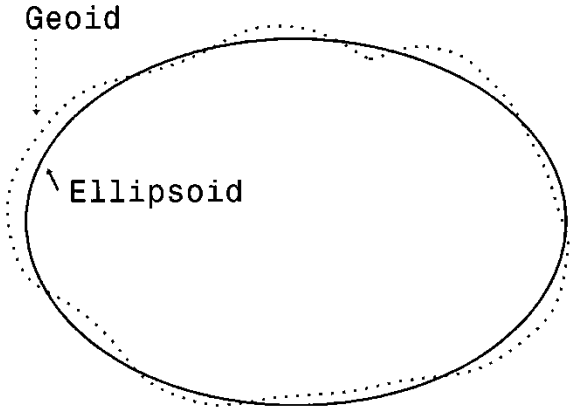
- The **Geoid** surface can be thought of as the surface of a sea if it were to cover the entire earth. This imaginary sea is not affected by the moon, wind, or waves – only gravity.



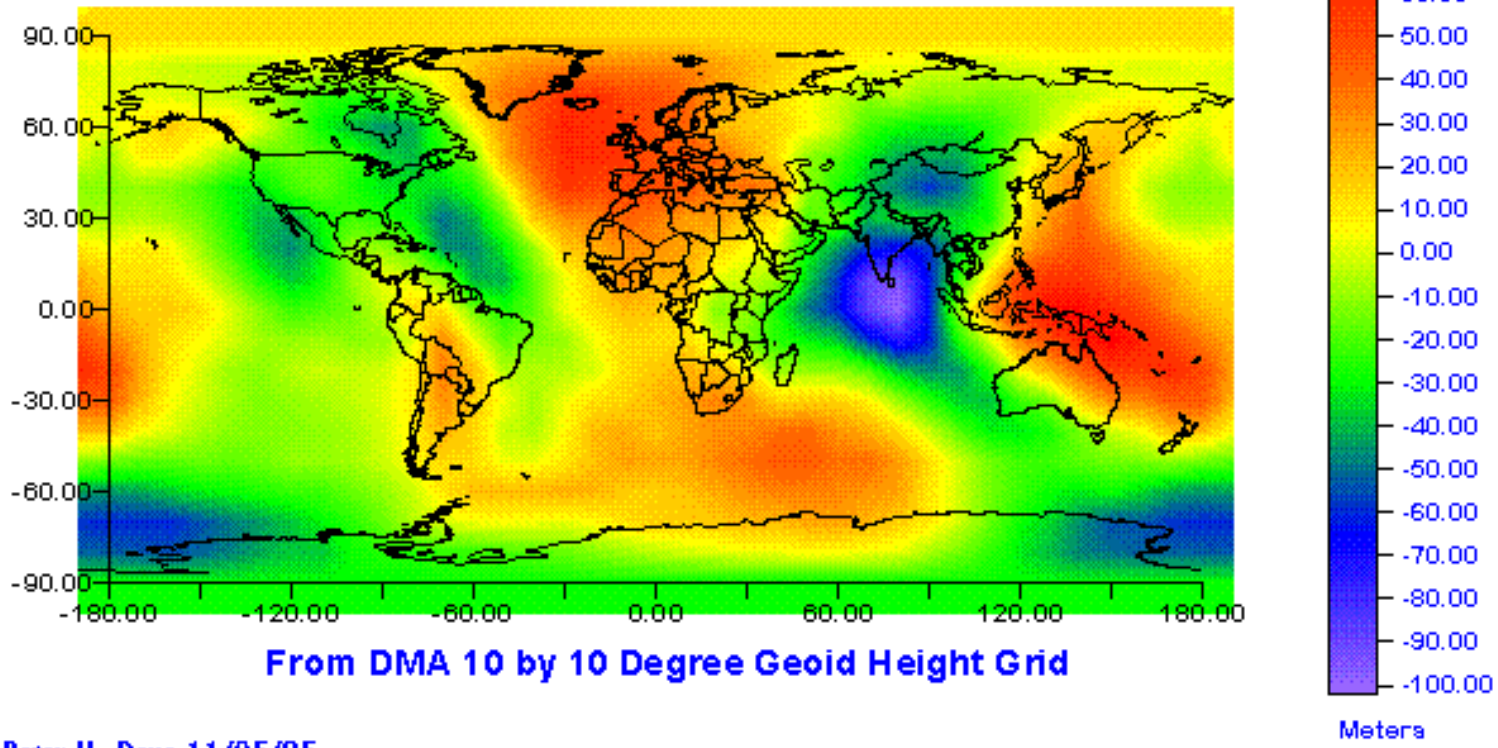
- Estimating the undulations in the earth's surface due to differential forces of gravity yields a **Geoid model.**

- Early ellipsoids defined to fit the LOCAL bumps of a geoid model.

-With satellite measurements, modern ellipsoids fit the GLOBAL bumps: applicable for the entire world.



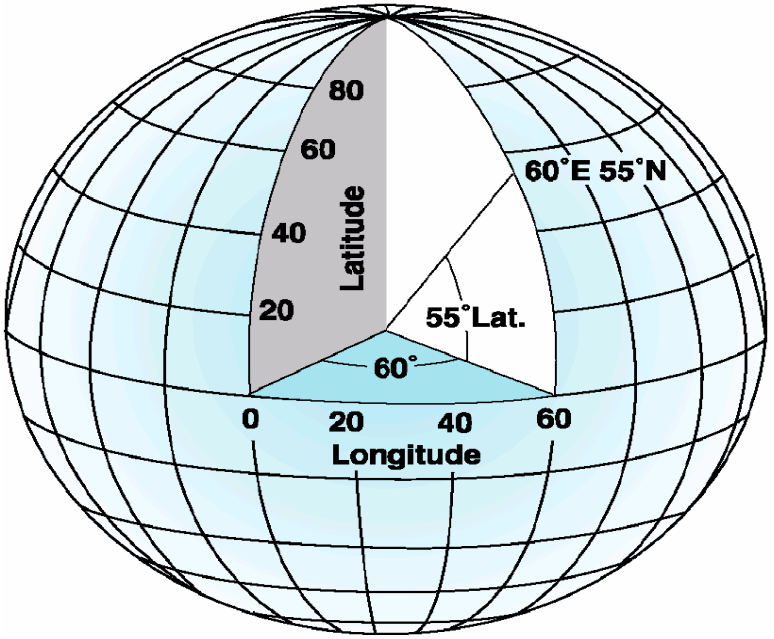
World Geodetic Survey (WGS)1984



From DMA 10 by 10 Degree Geoid Height Grid

Peter H. Dana 11/05/95

Latitude and Longitude



- An ellipsoid is defined by its major and minor axes.

-In turn, the poles and equator can be defined:

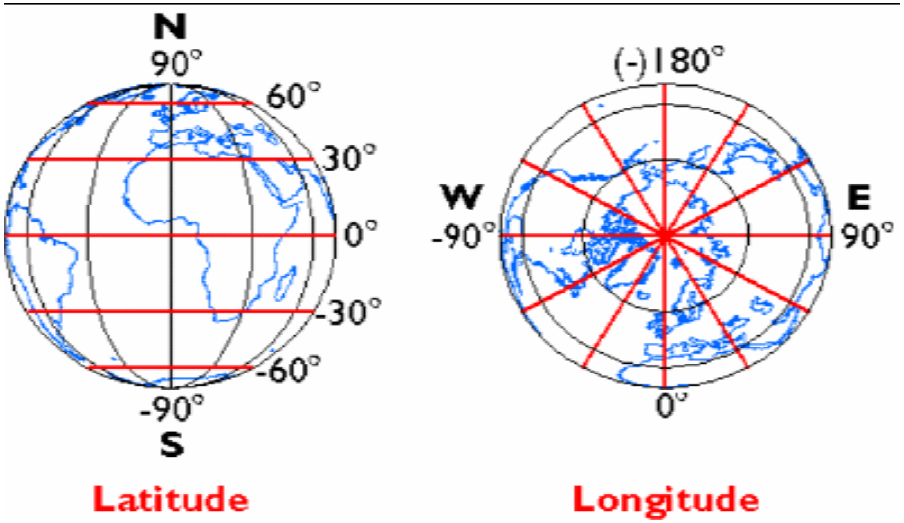
-poles: axis of revolution of the ellipsoid, around the minor axis

-equator: circle mid-way between the poles spanning the widest part of the ellipsoid

-together these define **latitude**

-**Longitude** is define arbitrarily:

-0 degrees= Greenwich Meridian



So how do we know where the longitudes and latitudes actually are on the ground?

We need a….

Geodetic Datum

Key Concepts

1. Geodesy –Science of measuring the shape of the Earth.

2. Geodetic Datum – Basis for defining accurate locations on the surface in the context of a **reference ellipsoid.**

2. Geodetic Datum

-a network of carefully controlled points on the ground, whose locations are given in terms of estimated ***latitude and longitude.***

-To create a **geodetic datum:**

- specify an **ellipsoid model** of the earth
- create a network of carefully surveyed locations, estimating lat/long

-datums are updated as:

-instruments get more accurate

-ellipsoids get more accurate

--Older datums are based on **local ellipsoids**. In these cases, the initial reference point is located on the surface of the earth.

-Newer datums, are based on **geocentric ellipsoids** – the initial reference is the center of the earth.

-lat/long coordinates measured in one datum may not match coordinates measured in a newer, updated datum

The main datum used for Jamaica is ...

JAD69: Jamaican Datum of 1969.

- The reference ellipsoid is Clarke's 1866 ellipsoid
  -OK for mapping Jamaica, but poor fit to ellipsoid elsewhere.

- 1:50,000 Jamaica Metric Topographic Maps

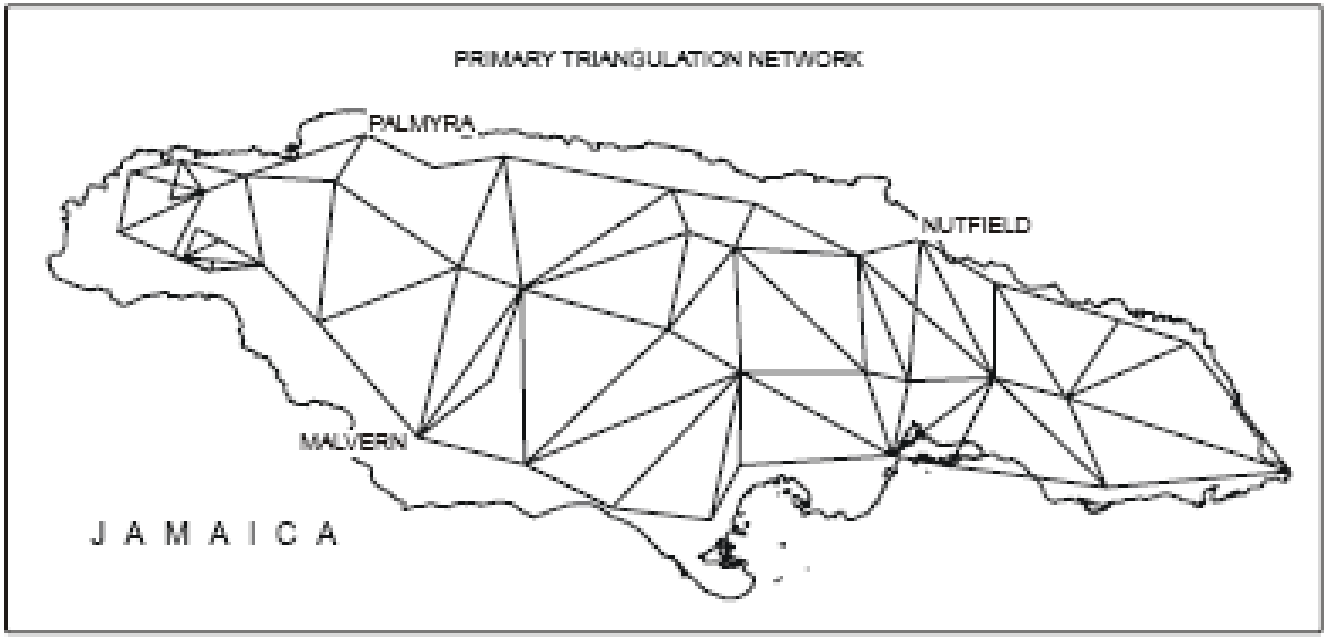


Figure 2. The Jamaica Primary Control Stations

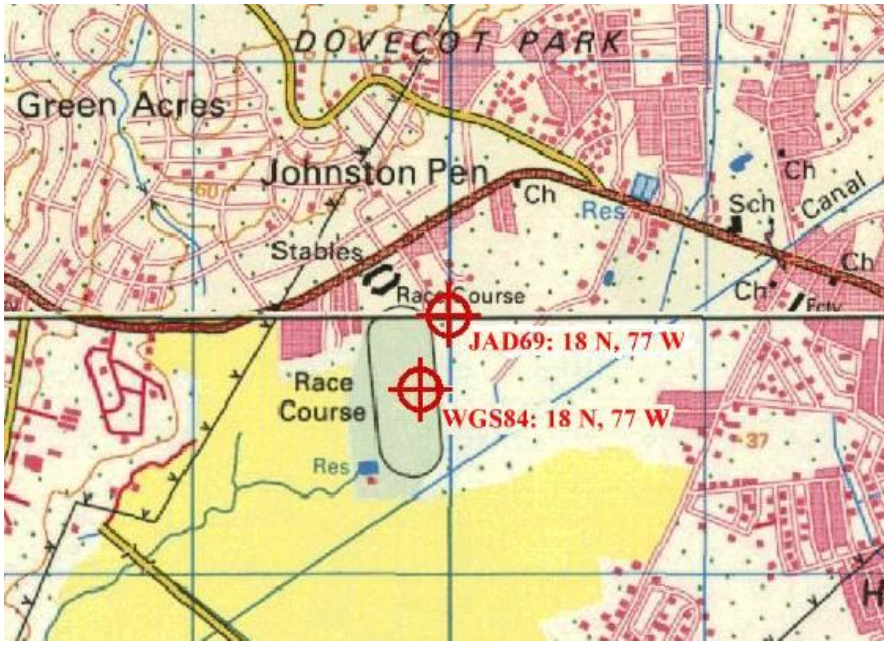
-**WGS84: World Geodetic Survey of 1984**.

-This datum was developed based on Doppler satellite measurements of the earth.

-The reference ellipsoid (with the same name (WGS84) is **geocentric. So it is useful anywhere!**

-Warning!!

-The Lat/Long in JAD69 and WGS84 can be up to 300 meters off!!



Three main datums used for North America are: NAD27, NAD83, and WGS84

- **NAD27: North American Datum of 1927**.
  - The reference ellipsoid is Clarke's 1866 ellipsoid
  -A local datum with its center in Kansas.

- **NAD83: North American Datum of 1983**.
  -It included adjustments based on all survey points taken between the 20's and 80's.
  -The reference ellipsoid used is GRS80, which is a **geocentric ellipsoid.**

- **WGS84: World Geodetic Survey of 1984**.
  -This datum was developed based on Doppler satellite measurements of the earth.
  -The reference ellipsoid (with ther same name (WGS84) is **geocentric,**

- Coordinates measured in reference to the NAD27 Datum will be different than those measured in the more recent datums. The difference in positions can be off by up to 100 meters or more!

- GPS positions are determined to the WGS84 Datum as a default, although others can be specified.

Key Concepts

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3. Map Projection -the process of transferring points from the surface of the ellipsoid to a plane.

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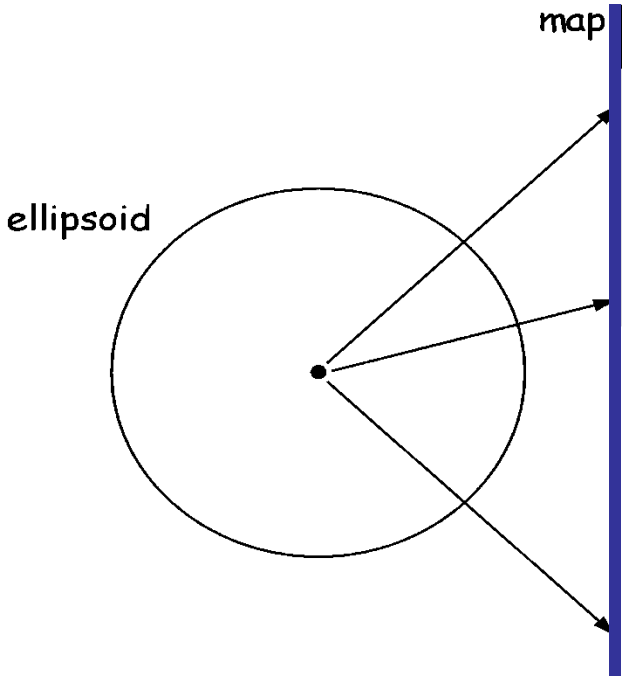
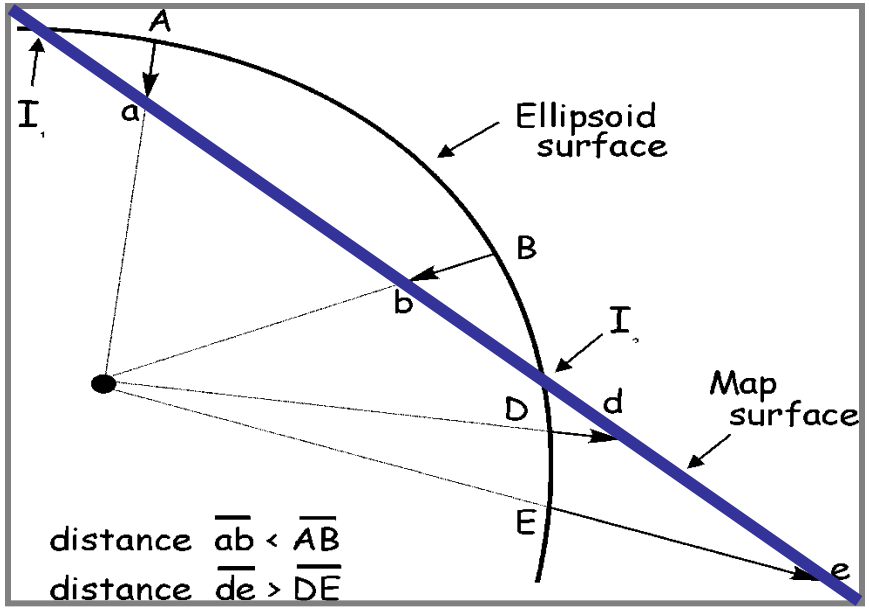
-the process of transferring points from the surface of the ellipsoid to a plane.



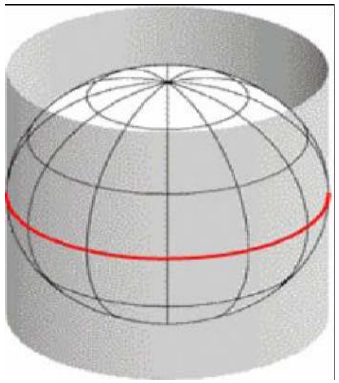
-all projections create distortion

-but some are better than others.

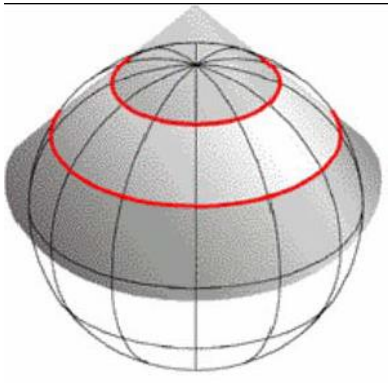
-which is best depends on shape of the area you are trying to map.



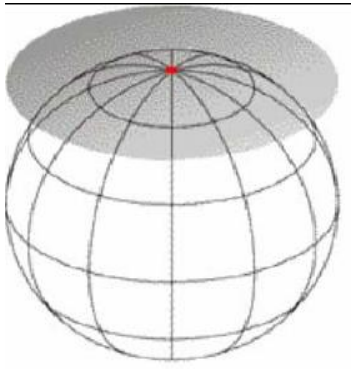
Three projection surfaces:



Cylindrical

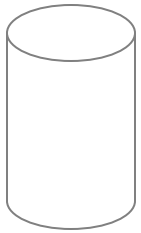


Conic



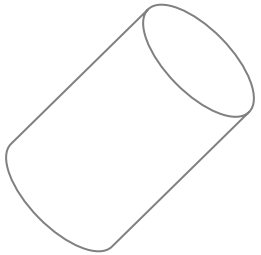
Planar (Azimuthal)

Three projection orientations:



Equatorial

Transverse



Oblique

Two kinds of contact:

-tangent: being in contact at a single point or along a line

-secant: cutting, intersecting the surface:

Coolest Projections

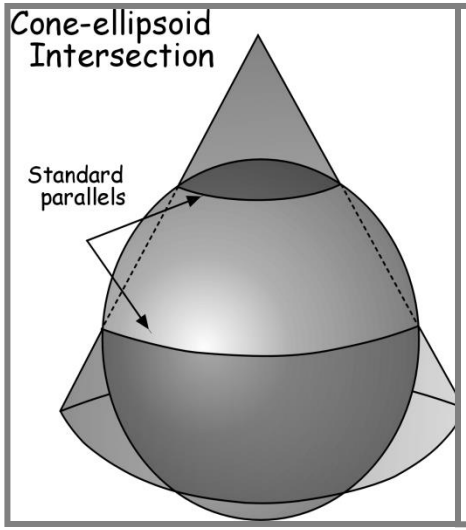
1. Lambert Conformal Conic:

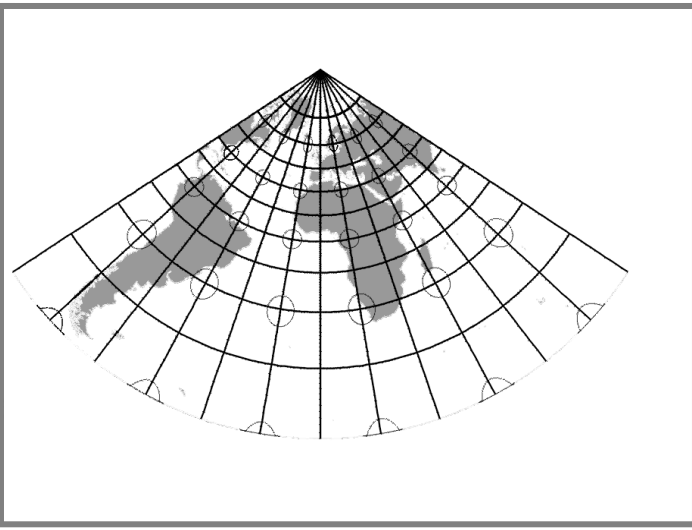
A cone wrapped around

the earth, such that the projection surface touches the ellipsoid

surface along two standard parallels:

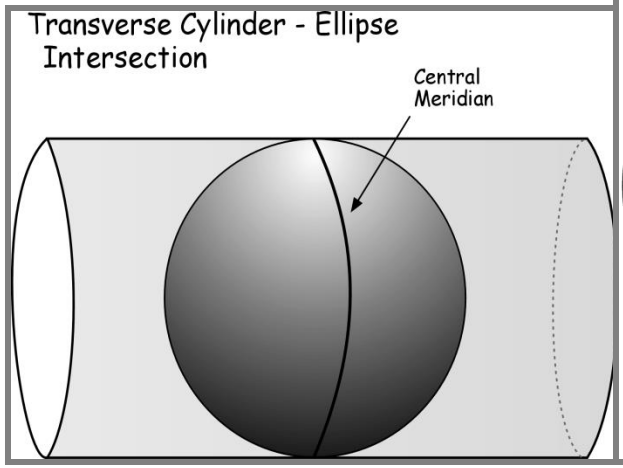
Distortion is least along these E-W parallels

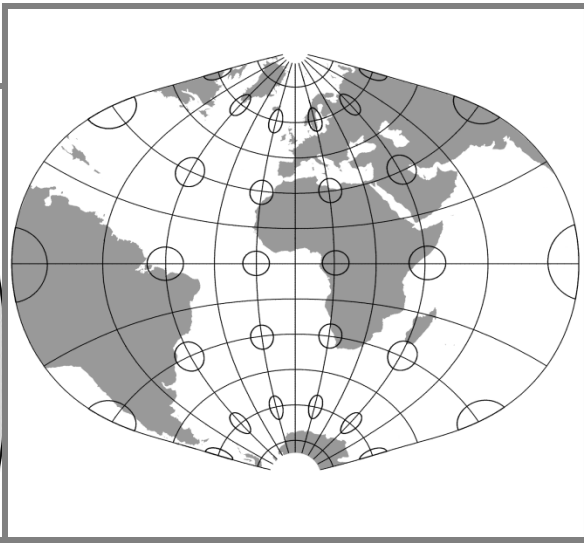




2. Transverse Mercator Projection:

Transverse, cylindrical projection. The projection surface touches the ellipsoid surface along one central N-S meridian, and distortion is the least along this line.





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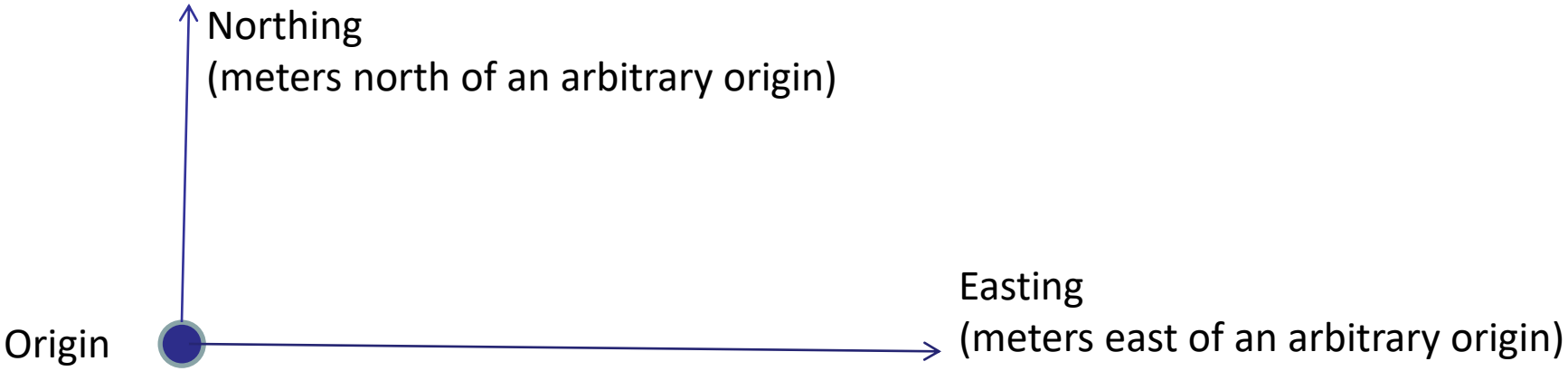
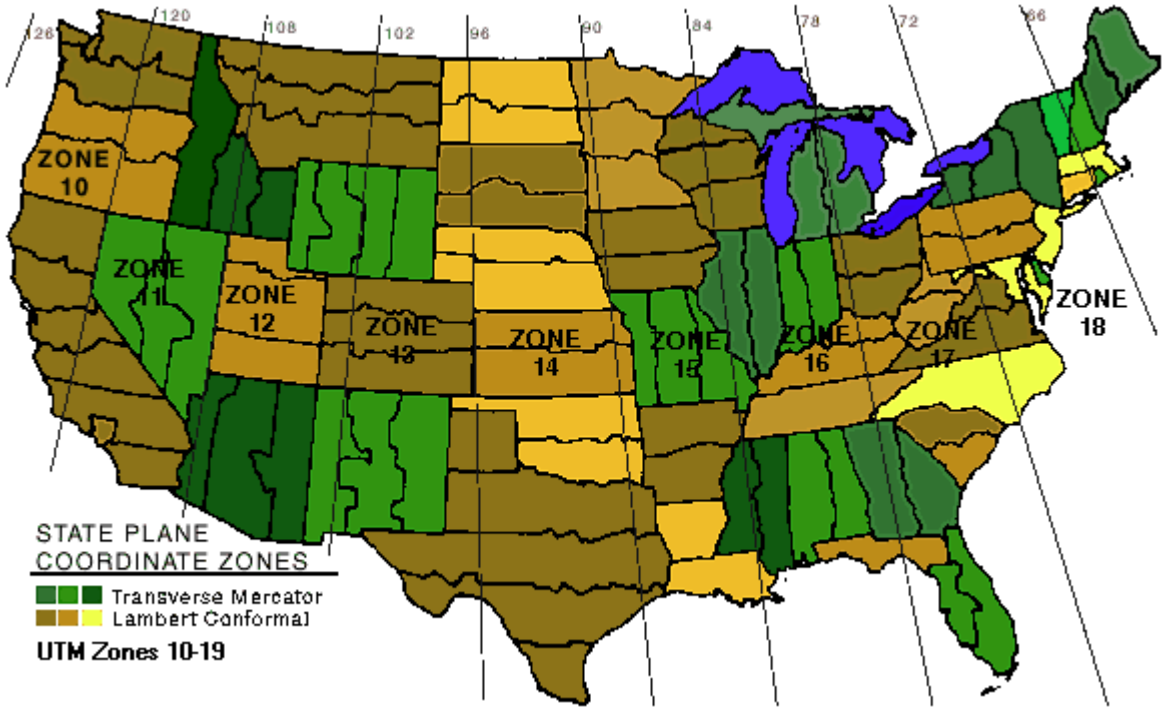
4. Coordinate Systems – Allow us to use meters instead of degrees



4. Coordinate Systems

U.S. State Plane Coordinate System

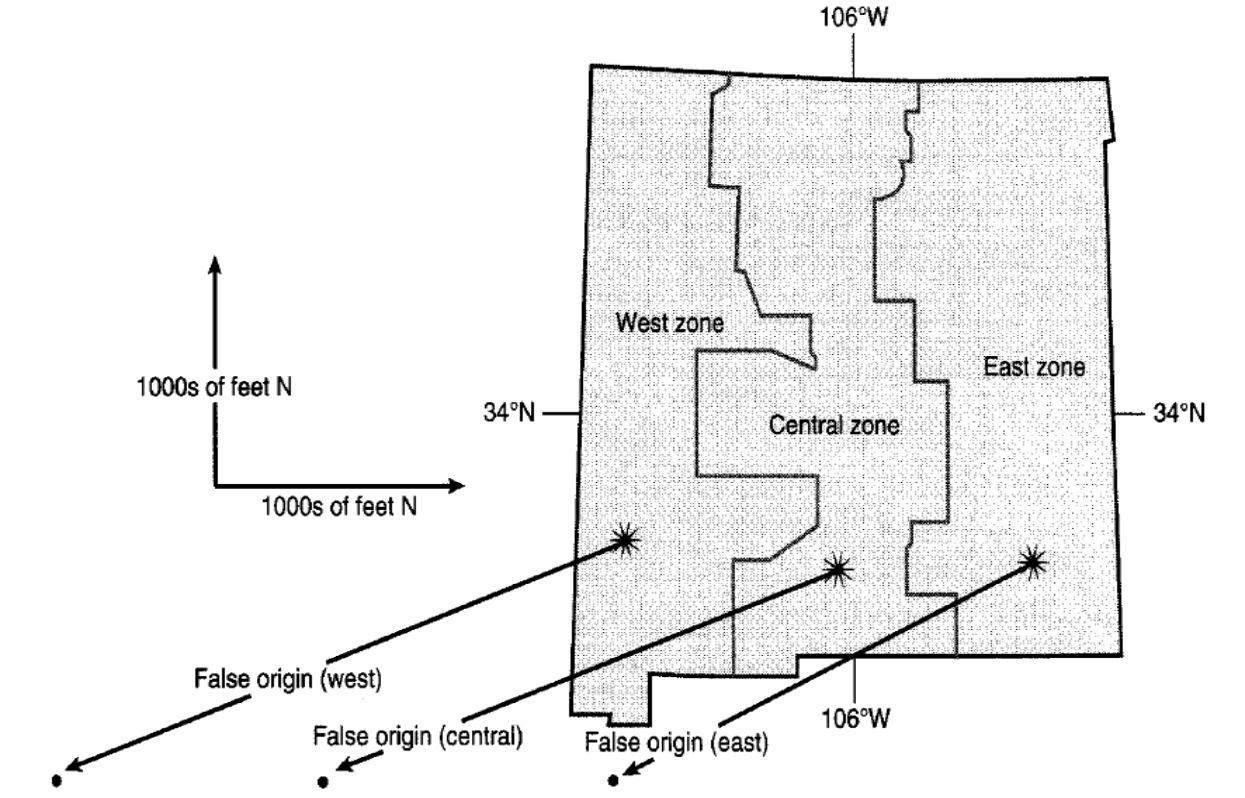
- Not a projection
- Underlying projections:
  - –Lambert Conformal Conic for “east-west” areas
  - –Transverse Mercator for “north-south” areas



U.S. State Plane Coordinate System

- A “false” origin for each SP zone.

-“false” northings and eastings for each SP zone.



Universal Transverse Mercator (UTM) Coordinate System

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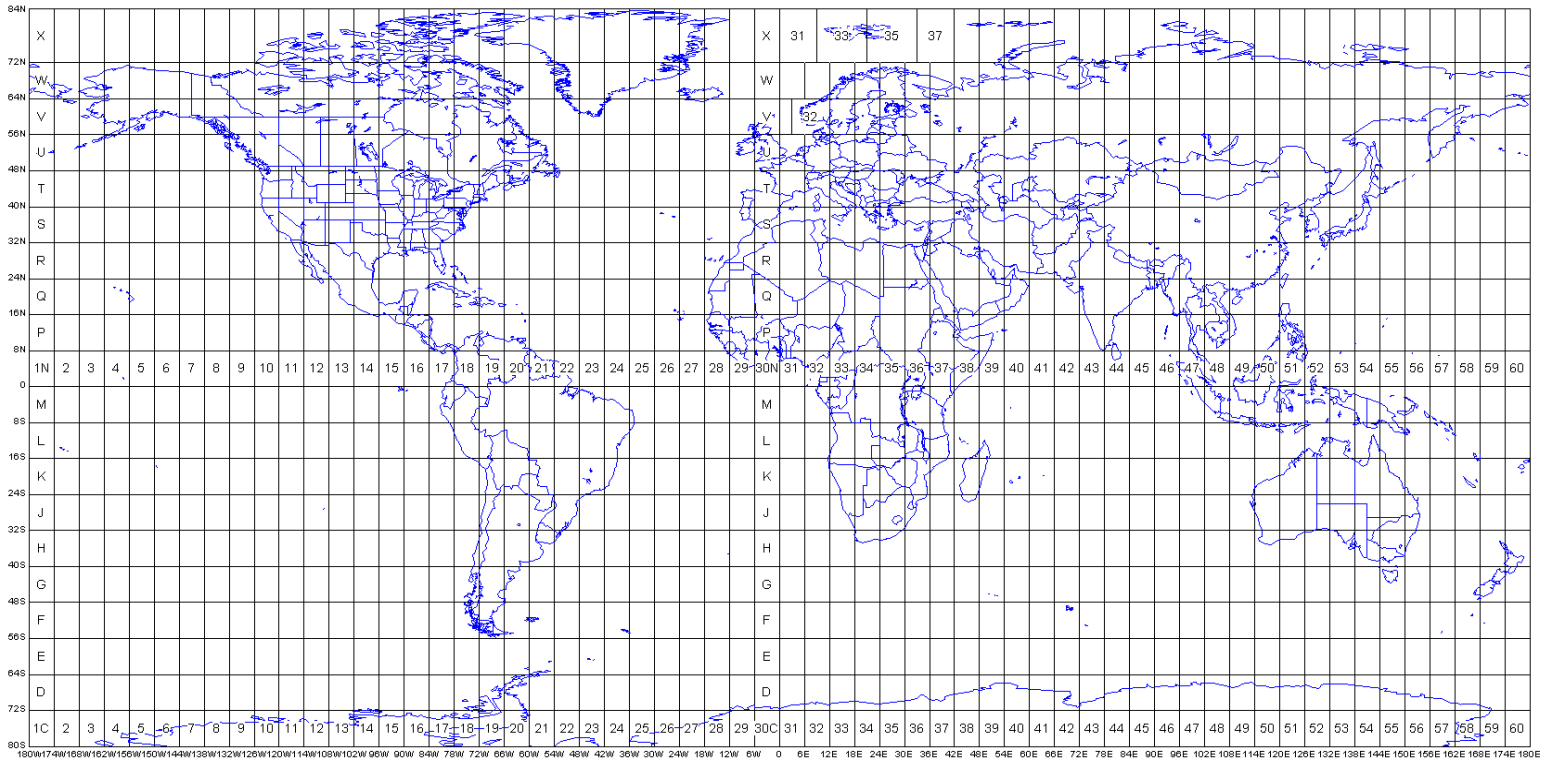
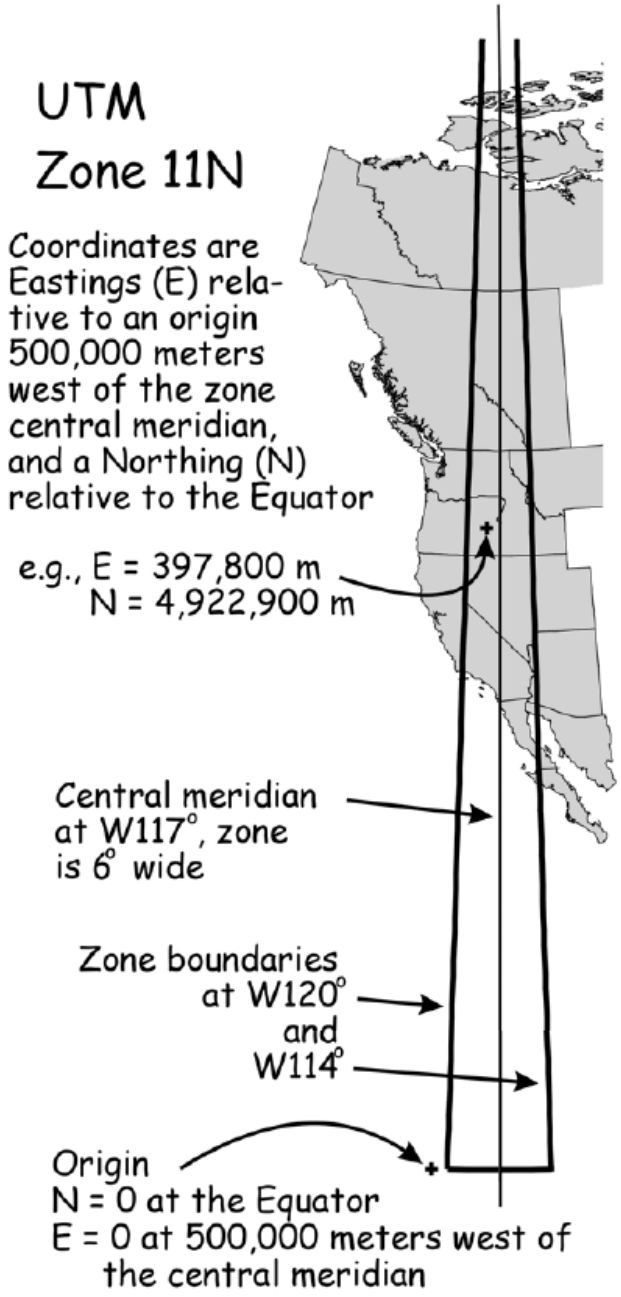
- Not a projection
- Underlying projection: Transverse Mercator
- **World** divided into 60 six-degree-wide zones
- Wide zones good for large study areas
- Coordinates discontinuous across zone boundaries





"False" origin for each zone:

-To eliminate negative coordinate values to the west of the central meridian in each UTM zone, the origin of each is given a false easting value of 500,000 meters. This places the origin 500,000 meters west of the central meridian..

- The Equator is the origin for latitude, and it is zero for all Northern zones Southern UTM zones have a false northing at the equator equal to 10,000,0000 meters so that there are no negative latitudes for southern zones

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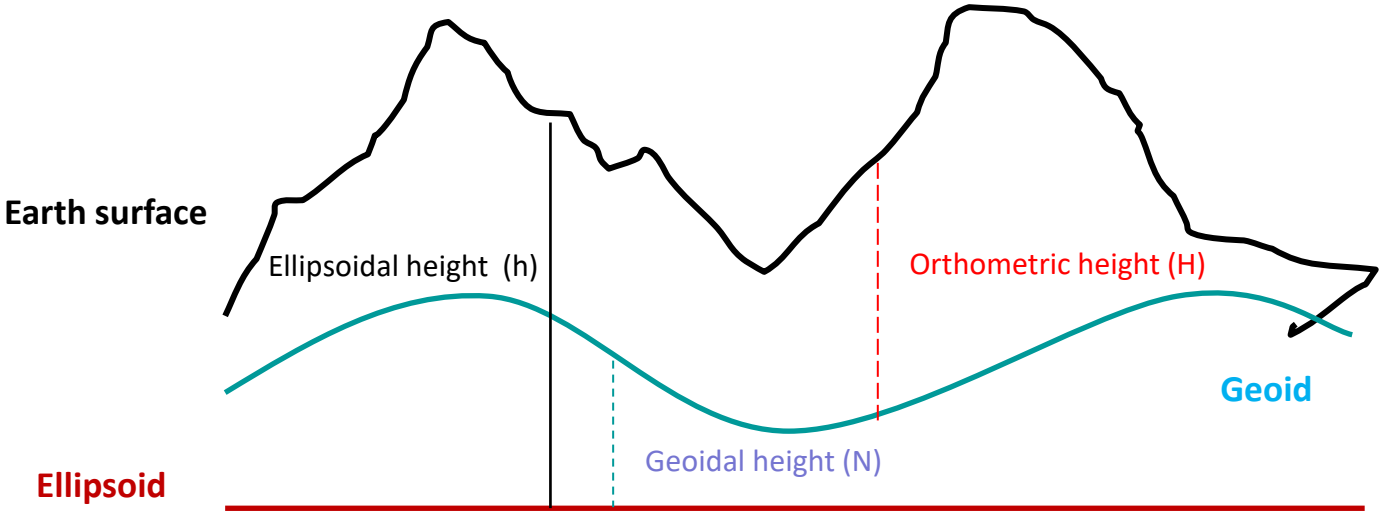
5. Elevations– different kinds

5. Elevation

-Typically we think of measuring elevation with regard to the **mean sea level.** However, mean sea level is actually influenced my many factors such as tides and the moon's gravity, wind, and waves. So many "local" mean sea levels.

- For Globally comparable elevations, we need a better standard: ellipsoid or geoid model:
  - Ellipsoidal height: elevation of surface above ellipsoid
  - Orthometric height: elevation of surface above geoid.
  - Geoidal height: height of geoid above elllpsoid



$$H = h - N$$

Key Concepts

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2. Geodetic Datum – Basis for defining accurate locations on the surface in the context of a reference ellipsoid.

3. Map Projection – Portrayal of the curved surface of Earth on a flat map

4. Coordinate System – Numeric representation of positions on a map projection: UTM, State Plane.

5. Elevation – three kinds!