Datum, Projections, and Coordinate Systems

From Ground to Grid

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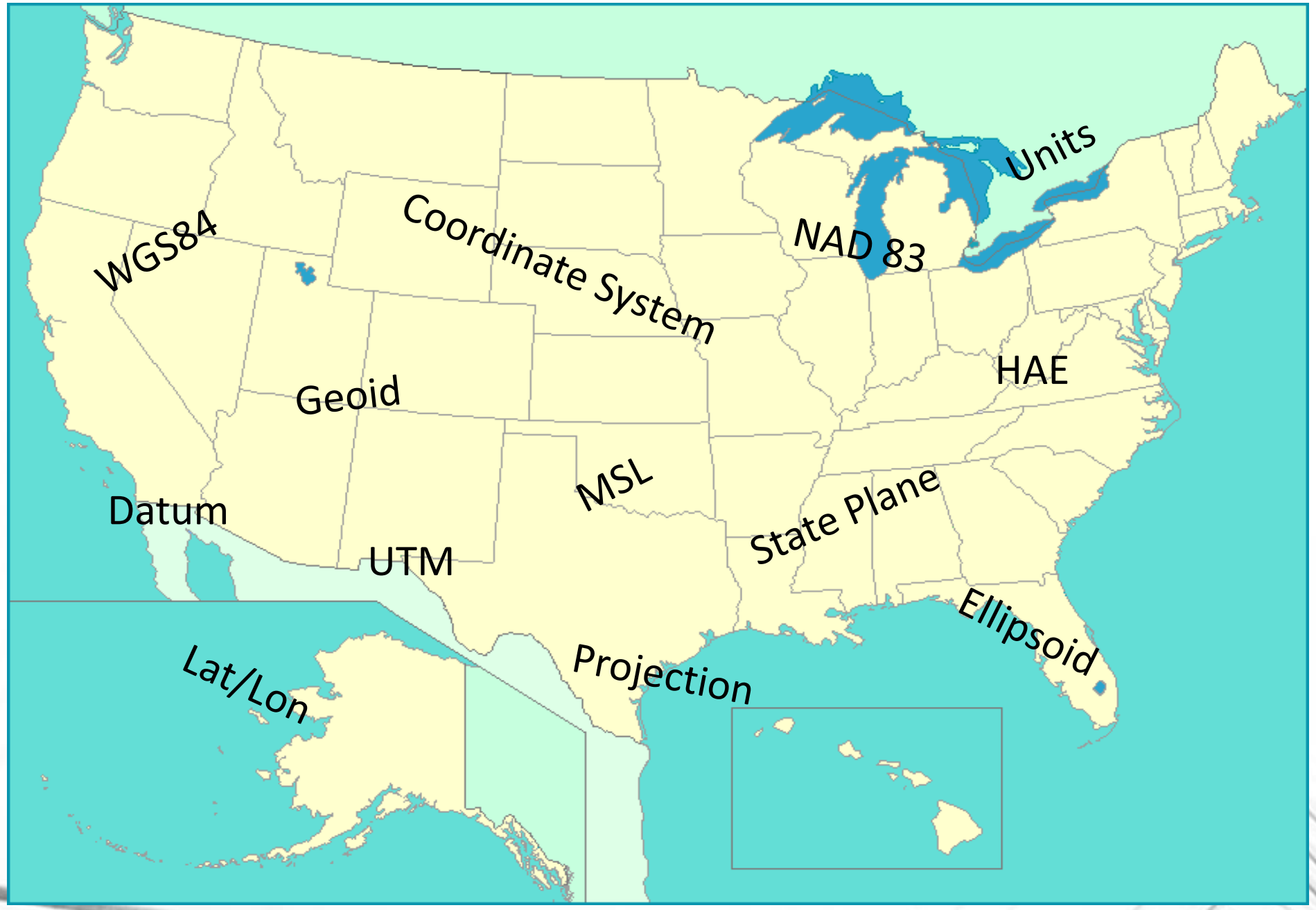
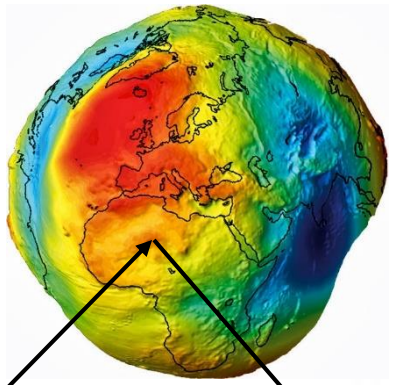
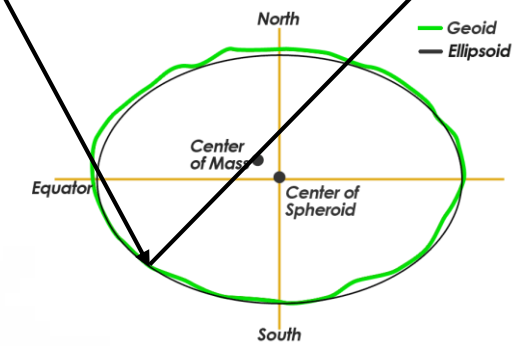

Units
WGS84
Coordinate System
NAD 83
HAE
Geoid
MSL
Datum
State Plane
UTM
Ellipsoid
Lat/Lon
Projection

From Ground to Grid

Ground





Grid

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Model Earth's Surface

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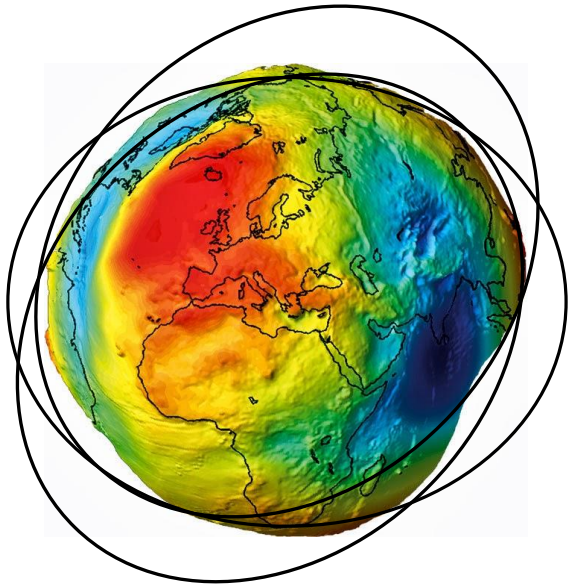
Ellipsoid Modeling

ITRF08

GRS80

Everest

ITRF00



South American 1969

Helmert

Clarke 1880

Australian National

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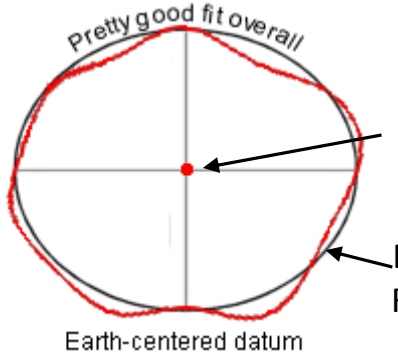
Datum

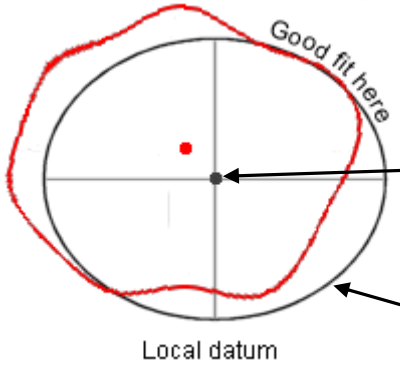
Global



Datum: World Geodetic Survey (WGS84)

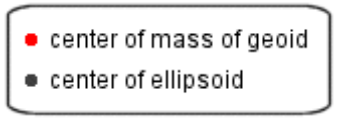
Ellipsoid: Inter-terrestrial Reference Frame (ITRF08)

Local (North America)



Datum: North American Datum (NAD83 2011)

Ellipsoid: Geodetic Reference System (GRS80)



WGS84 vs NAD83 (86)

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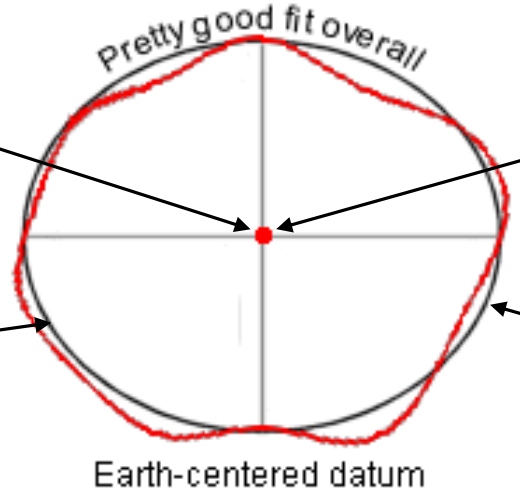
-NAD83 (86) is spatially equivalent to WGS84

Datum: North American Datum (NAD83 86) *Geocentric

Ellipsoid: Geodetic Reference System (GRS80)



Datum: World Geodetic Survey (WGS84) *Geocentric

Ellipsoid: Inter-terrestrial Reference Frame (ITRF08)

Following the shift

Issues with remaining in WGS84/NAD83 (86):

-The position recorded today is accurate for only a matter of time.

-Over time, positions will remain correct in comparison to the Datum (center of the ellipsoid), but not to the actual location on the surface.

-WGS84/NAD83 (86) do not take into account current local tectonic movement.

-The actual surface location will physically move away from the previously recorded WGS84/NAD83 (86) position over time.

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On The Move
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-Why are there different versions of NAD83?

-NAD83(Current) is getting farther from WGS84/NAD83 (86)

-Only the most recent version of NAD83 adjusts positions to the current on the ground location.

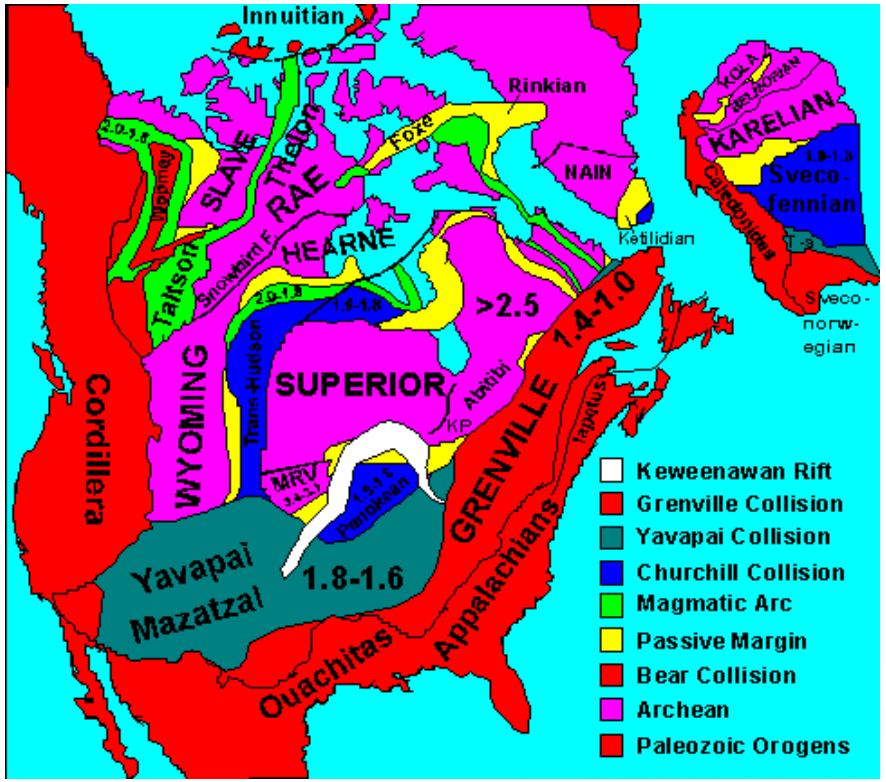

Plate Movement

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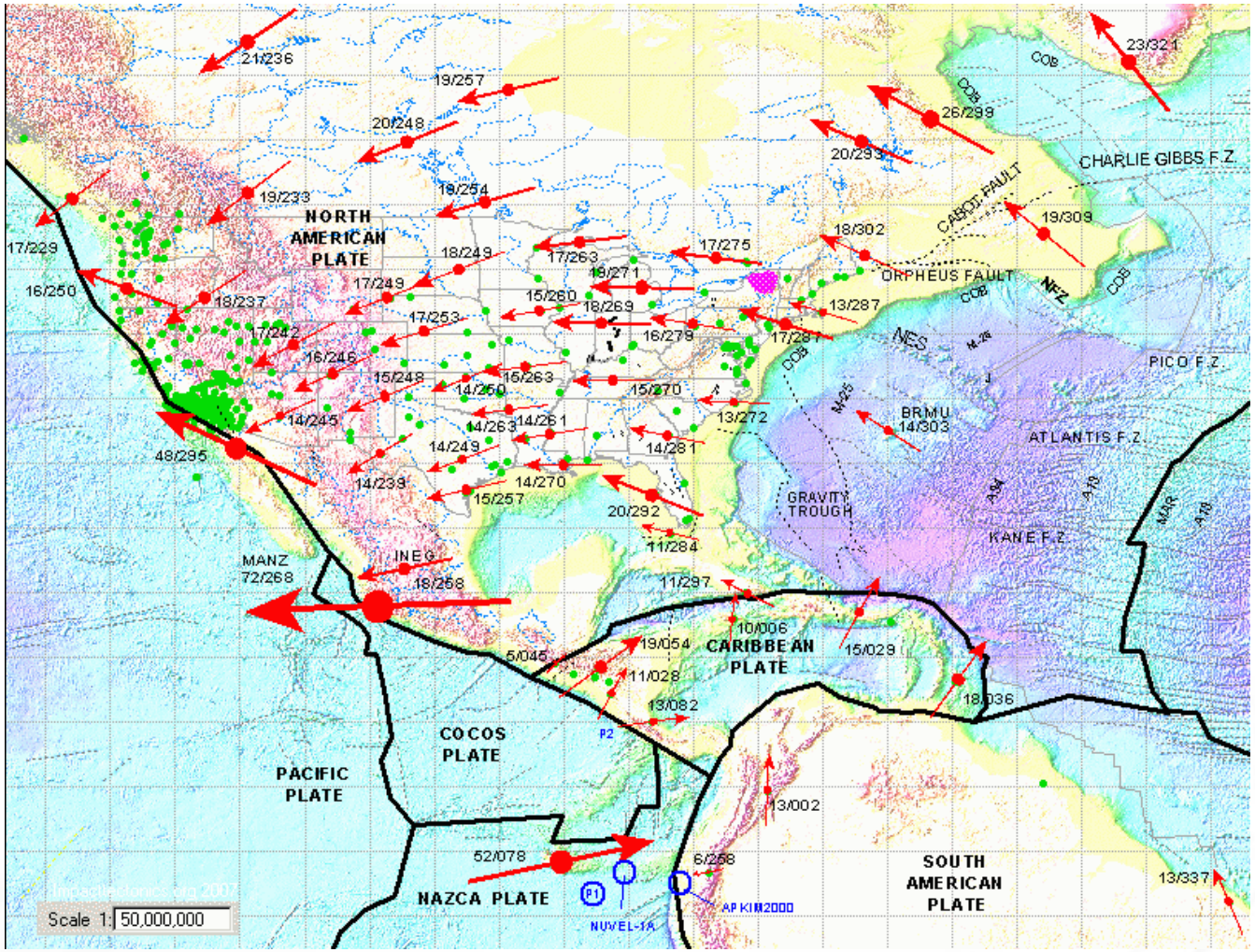

Evolution of NAD83 *Software

NAD83 (86) is spatially equivalent to WGS84
Small changes in WGS84 have occurred since created, but essentially still the same.

Epochs	Software Shift
NAD27	NAD27 to NAD83 (2011) = area dependent
NAD83 (86)/WGS84	*0.2 to 5 m of error when converted
NAD83 (HARN)	
NAD83 (NSRS)	NAD83 (86) to NAD83 (HARN) = approx. 1 m
NAD83 (CORS 96)	
NAD83 (2011)	NAD83 (HARN) to NAD83 (2011) = approx. 7-10 cm

Measurements are based on local shifts
(Eastern Mid-West and Western Northeast)

*

Evolution of NAD83 *On the Ground *

Epochs	On the Ground Shift
NAD27	NAD27 to NAD83 (2011) = area dependent
NAD83 (86)/WGS84	*0.2 to 5 m of error when converted
NAD83 (HARN)	
NAD83 (NSRS)	NAD83 (86) to NAD83 (HARN) = approx. 0.35 m
NAD83 (CORS 96)	
NAD83 (2011)	NAD83 (HARN) to NAD83 (2011) = approx. 3 cm

Measurements are based on local shifts
(Eastern Mid-West and Western Northeast)

WGS84 to NAD83 (2011)

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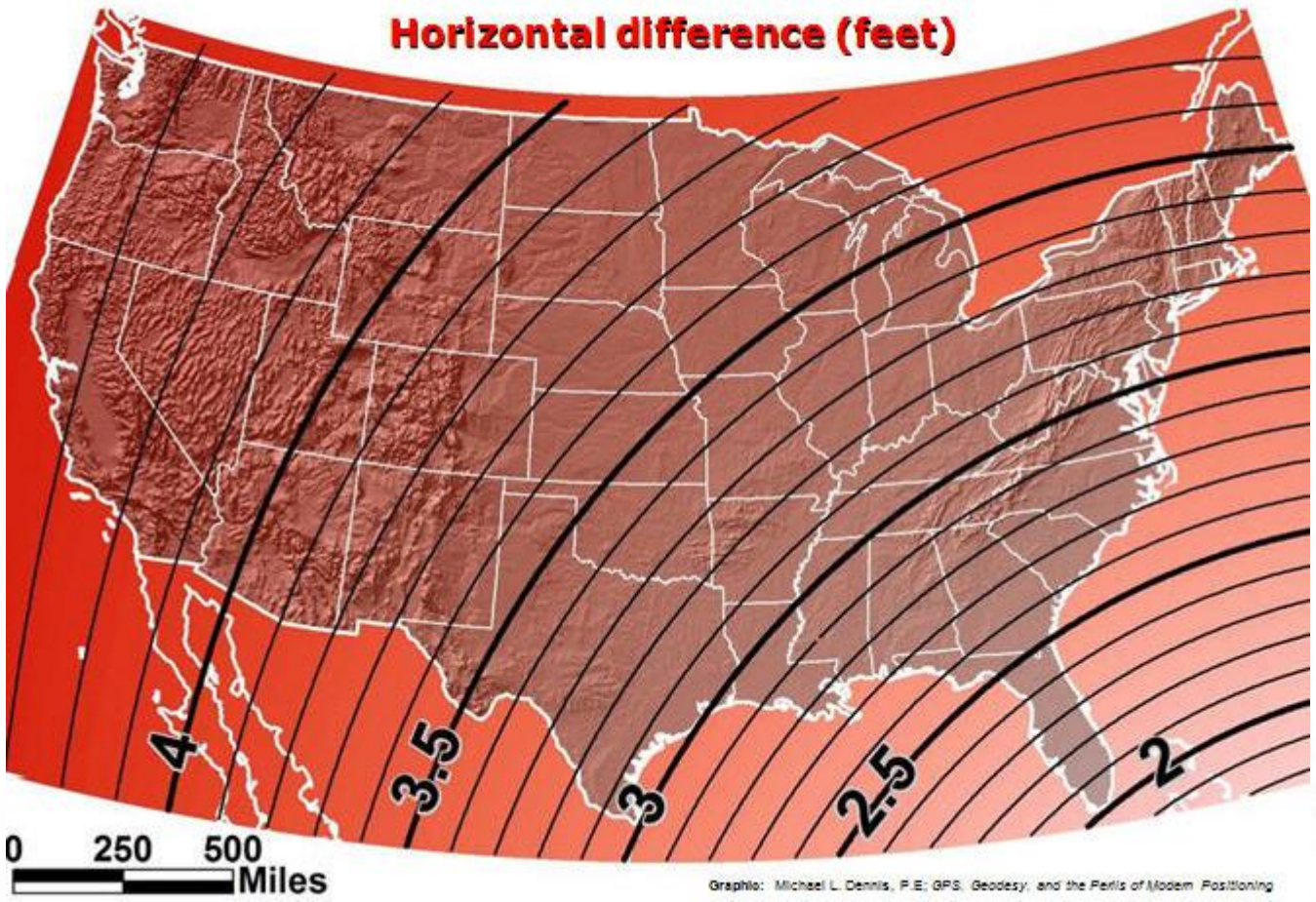

From Curved to Flat

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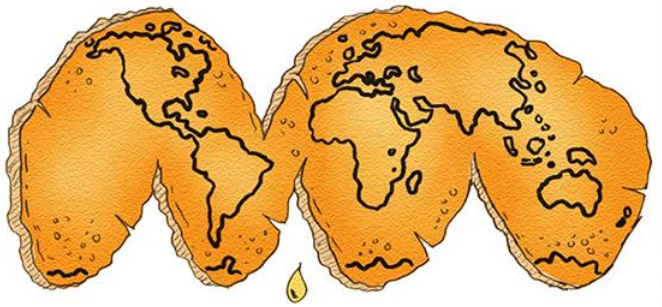
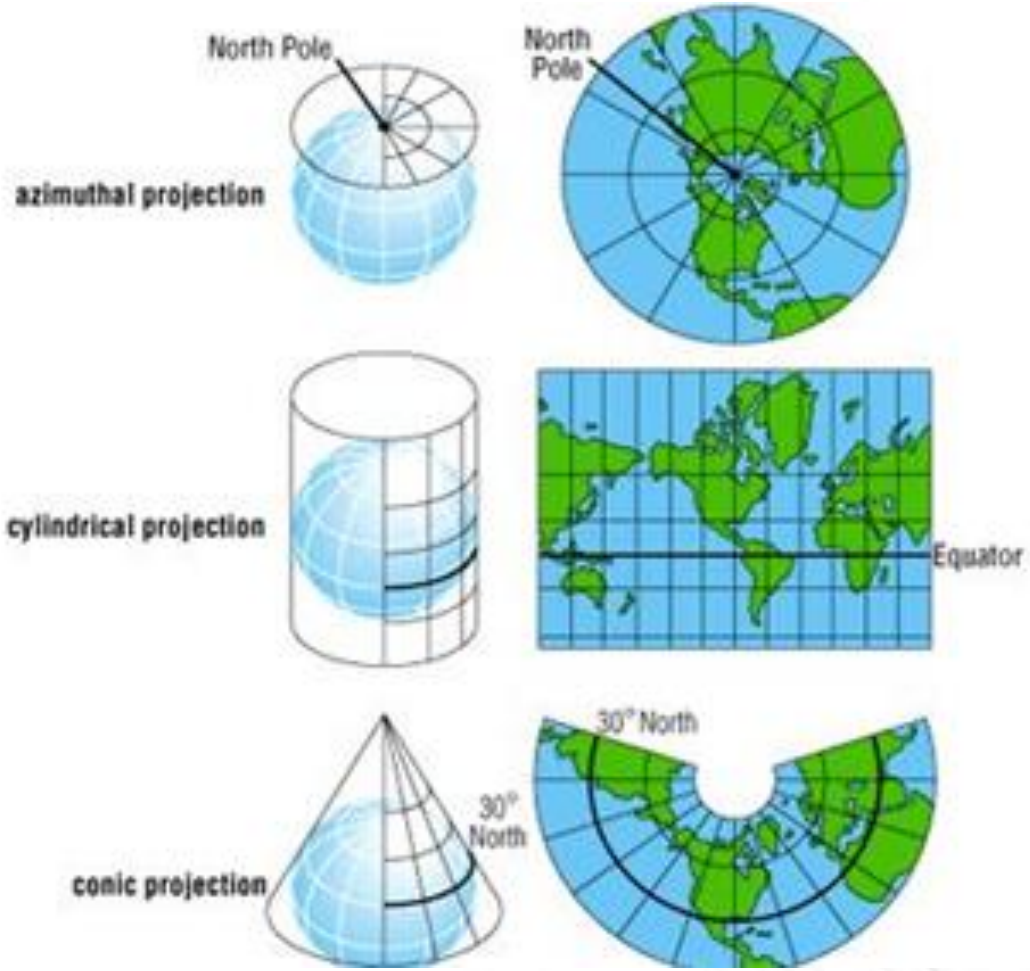


Projections

-Projection: a representation of one thing on the surface of another. In this case, the representation of a curved surface on a flat surface.

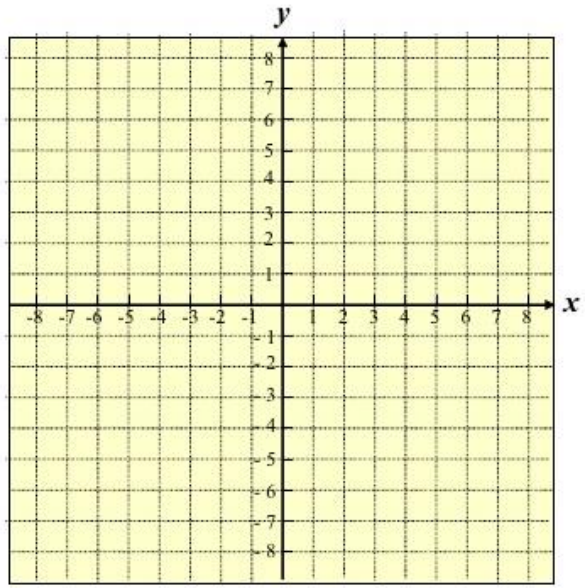
-Projection is chosen based on best fit for project area.

-Something has to be lost: Area, Distance, Size, Shape, Direction



Coordinate Systems

-Grid system placed over a projection to represent the locations of geographic features within a common geographic framework.



Common Systems:
State Plane- Local
UTM- Regional
Latitude/Longitude- Global

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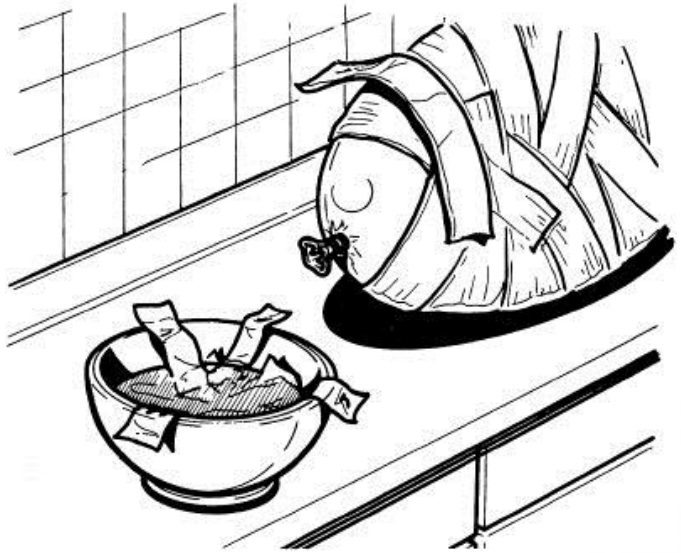
Coordinate Systems

Which Datum, projection, and coordinate system should I use?

Things to consider:
-Extent of the project
-Measurement accuracy
-Elevation accuracy
-System of any existing data (update or match)



Larger the Area = Less Measurement Accuracy

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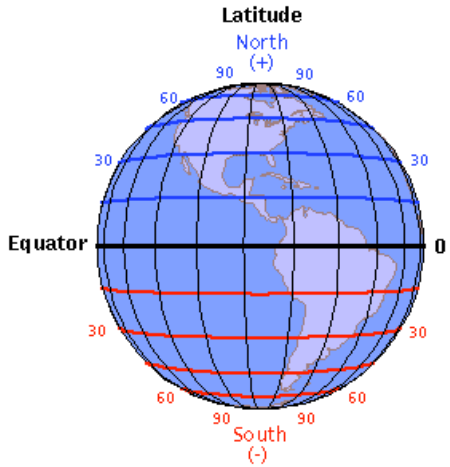
Latitude & Longitude

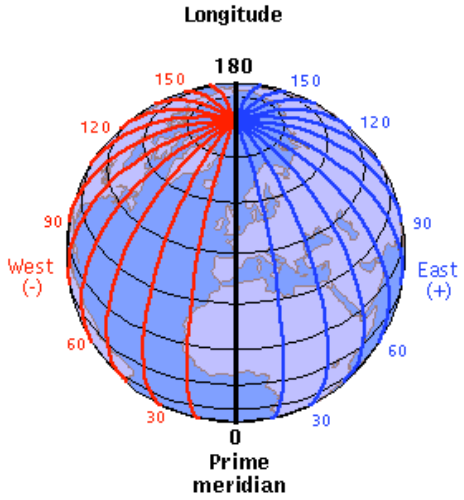
Basics:

- Geographic coordinate system (Global)
- Measured in Latitude (N or S) and Longitude (E or W)
- Locations measured E or W of Prime Meridian and N or S of the Equator.

Drawbacks:

- Map distortion increases as you move farther from the equator.
- Only direction measurements are accurate.
- Area, distance, shape, and size measurements are only accurate at the equator.
- Negative coordinates





State Plane

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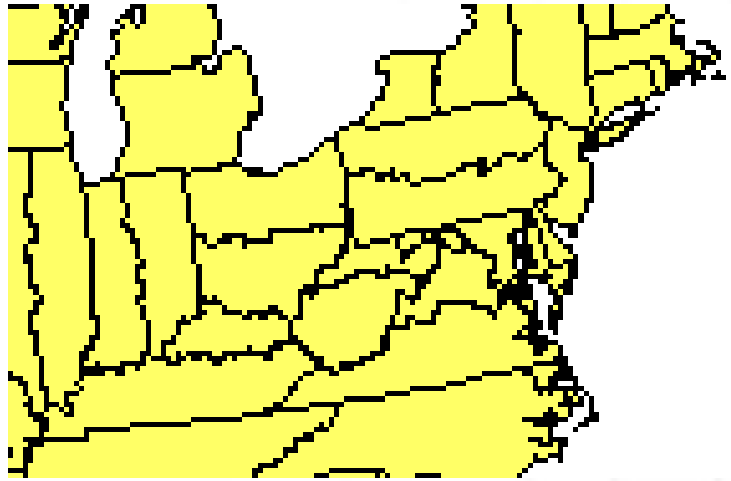
Basics

- Each state separated into zones
- 1/10,000 unit measurement error (most accurate for measurements)
- Simple Cartesian coordinates (+)

Drawbacks

- Projection and measurement units are zone dependent.
- Different zones cannot be accurately projected on the same map.
- Only good for local projects.



State Plane Origin

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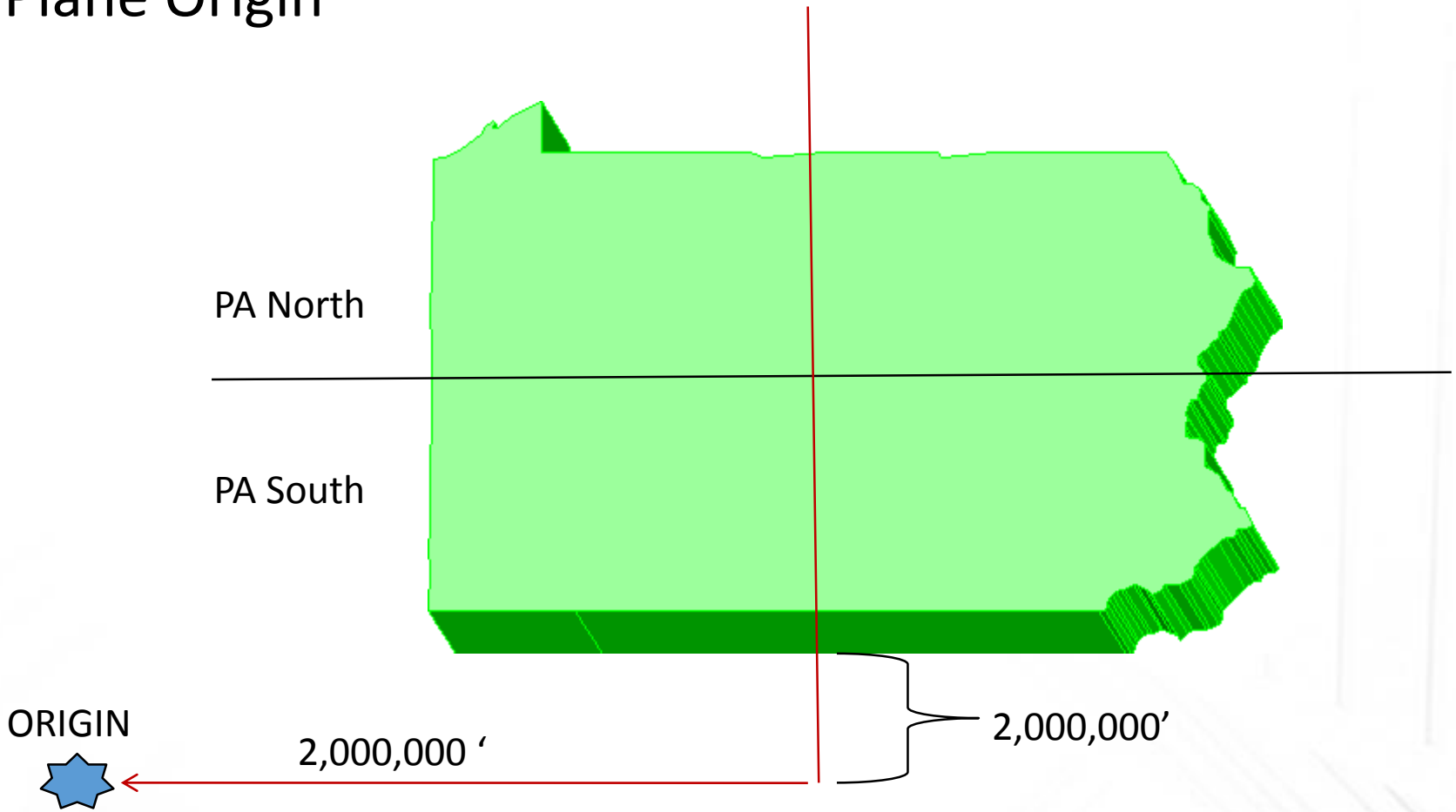
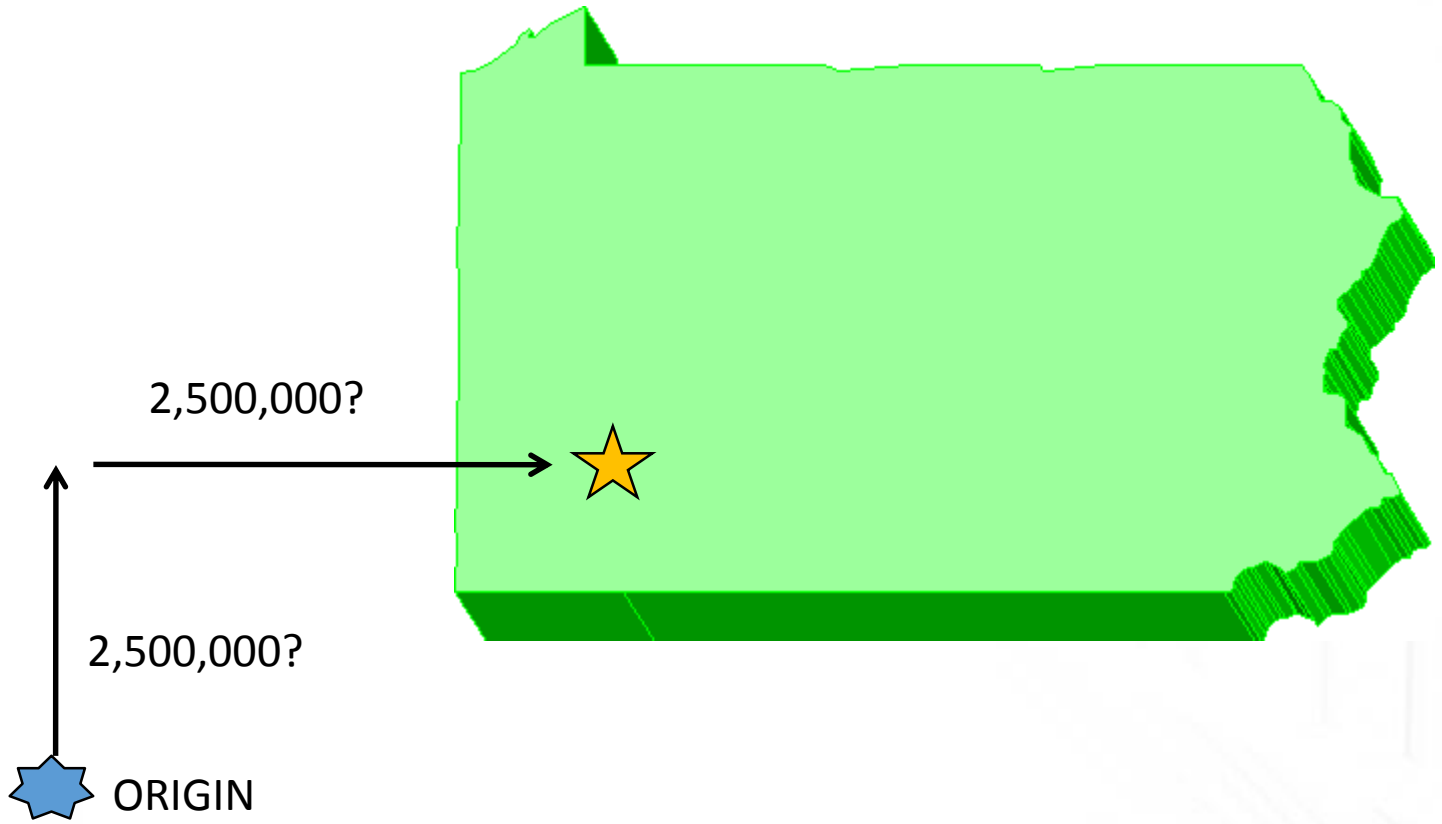


State Plane Units



Feet, US Survey Feet, Meters?

Universal Transverse Mercator (UTM)

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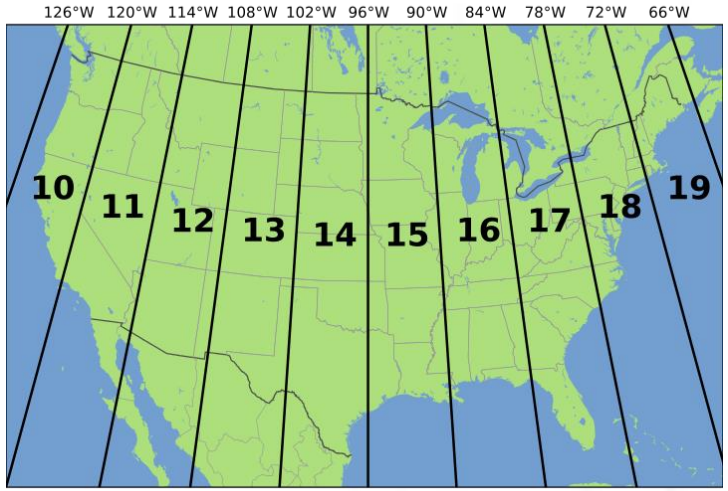
Basics:

- Cylindrical projection
- 60 zones each 6 degrees of longitude
- 84 degrees N to 80 degrees S
- Good for regional mapping

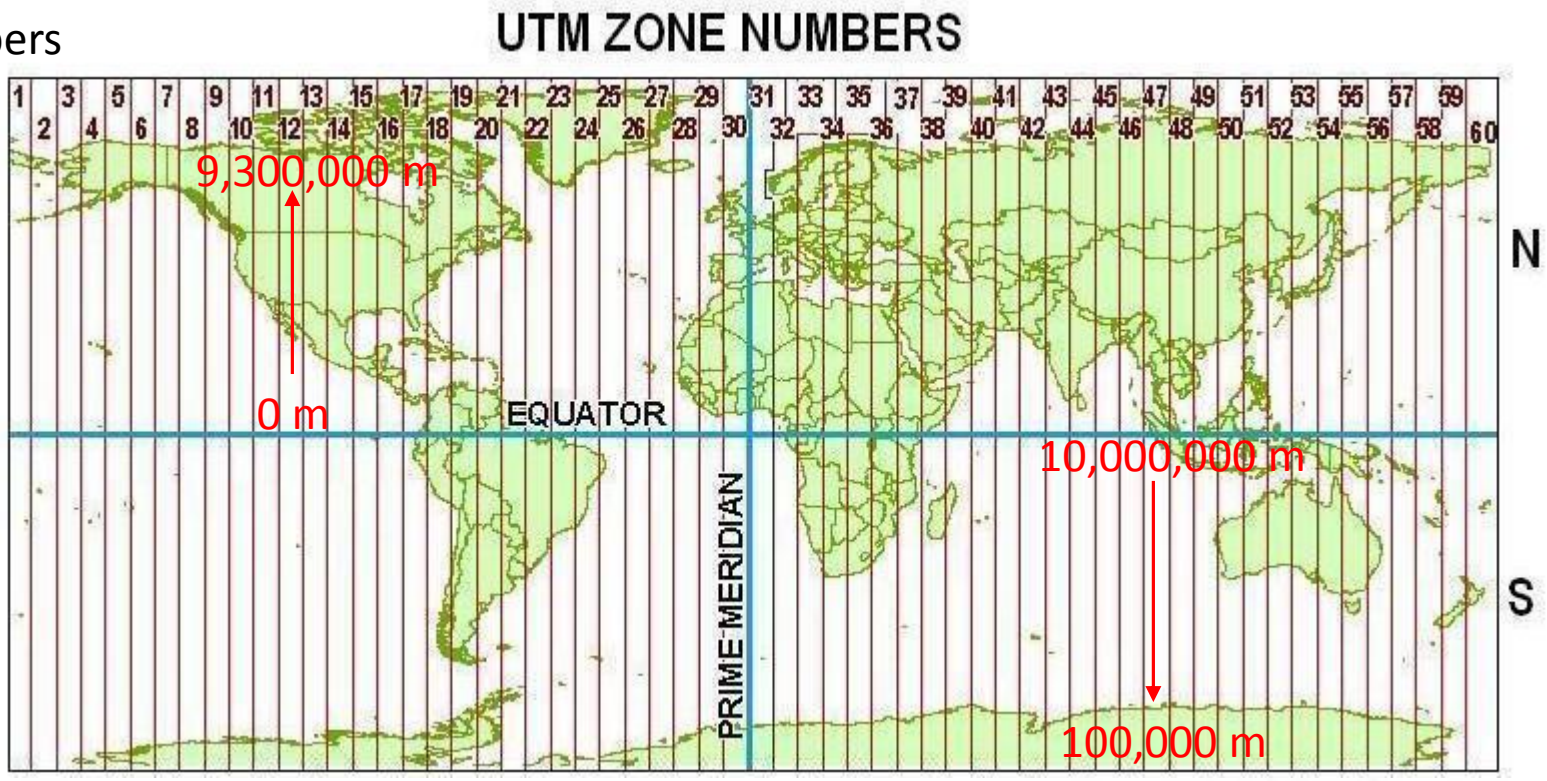


Drawbacks:

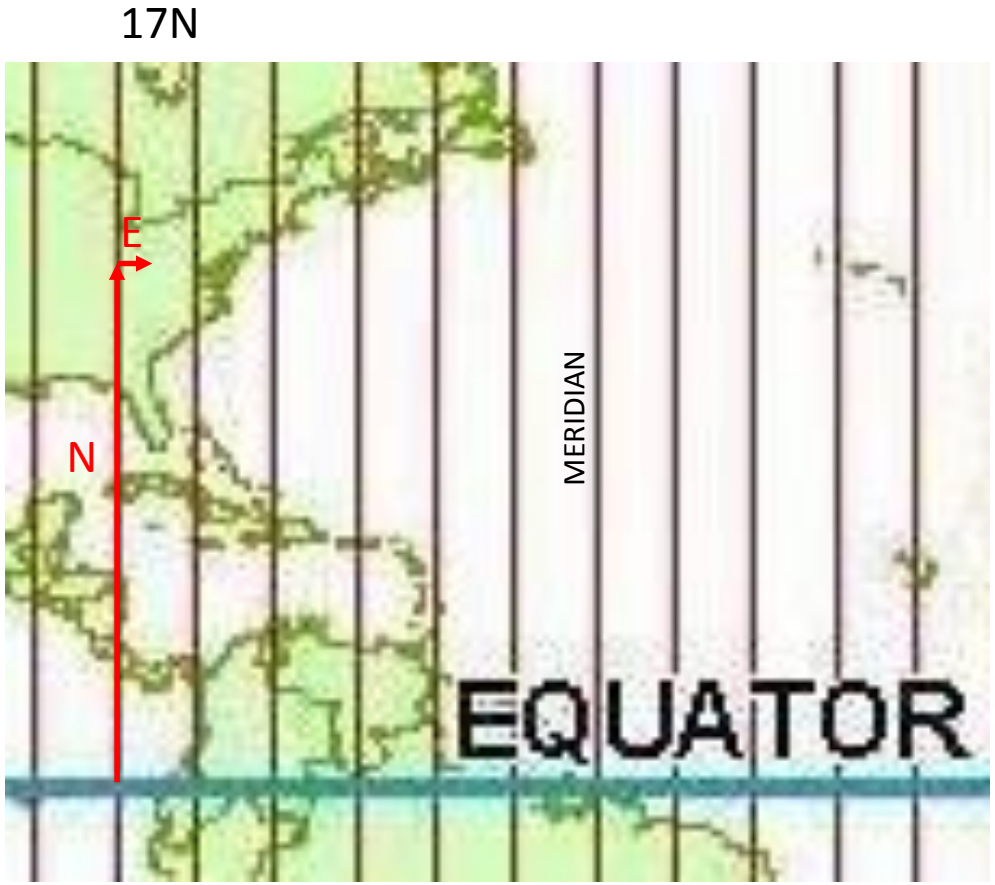
- 1/1,000 unit error
- Large coordinate numbers
- N and S poles are not covered

UTM Origin

Positive Numbers



UTM Measurements



Satellite Navigation Systems

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Global Positioning System (GPS)
-global system
-Owned and operated by the US DOD

GLObal NAvigation Satellite System (GLONASS)
-global system
-Owned and operated by the Russian Space Forces

BeiDou/COMPASS
-Estimated fully operational by 2020
-China (military and commercial)

Galileo
-Estimated fully operational by 2019
-Owned and operated by the European Space Agency

Global Navigation Satellite Systems (GNSS)

Raw GNSS Measurements

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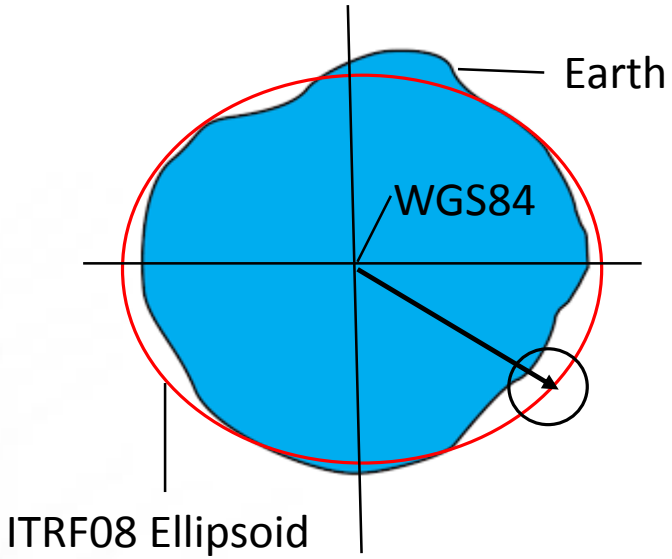

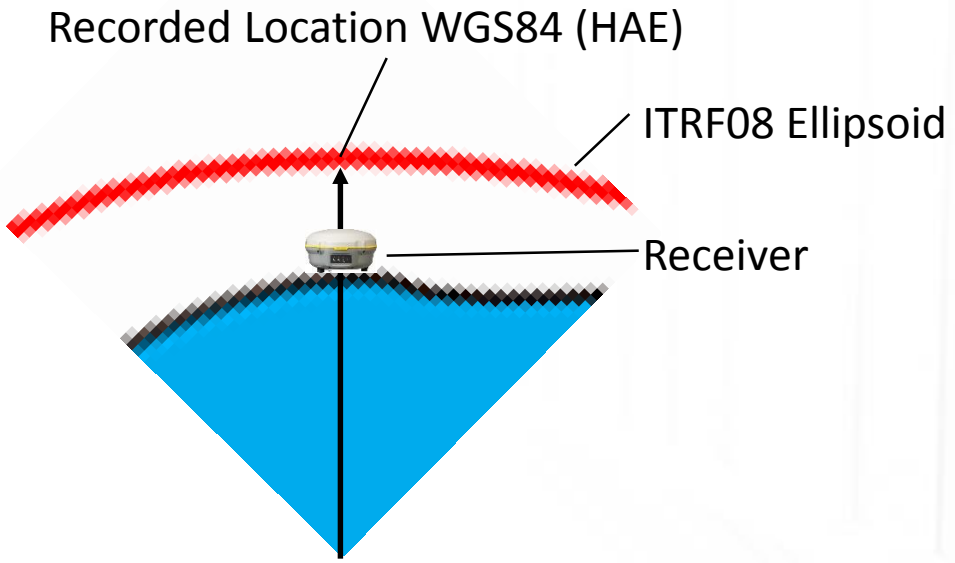

WGS84 to NAD83 (2011)

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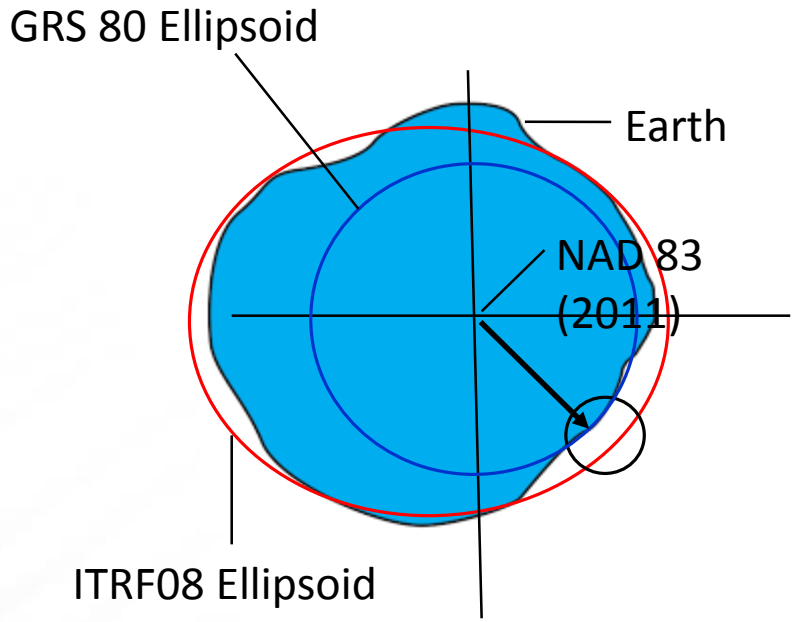

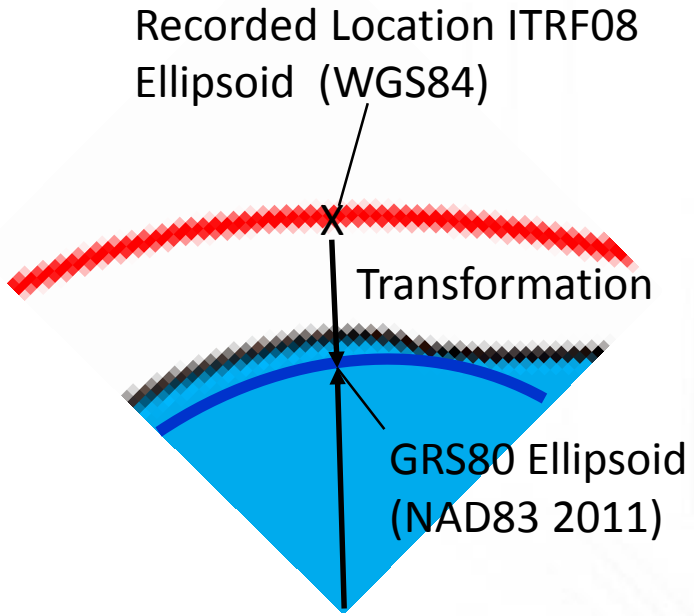

Height Above Ellipsoid (HAE) Elevation

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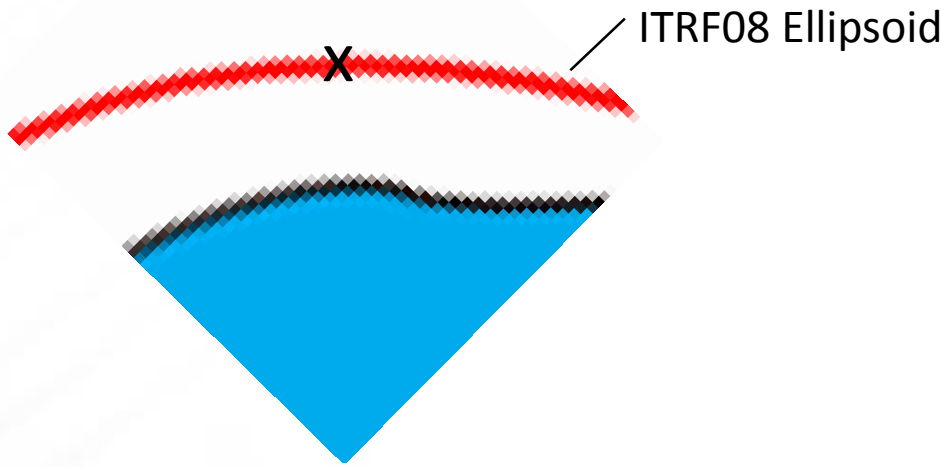
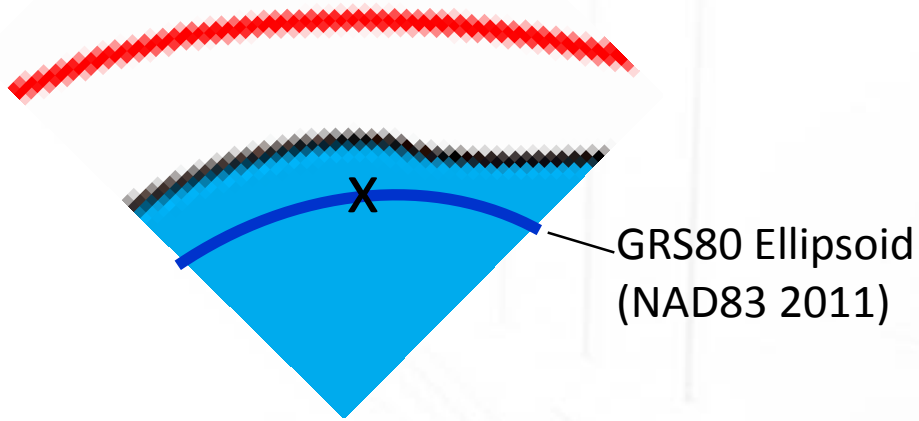
Recorded Elevation in HAE (ITRF08)



Recorded Elevation in HAE (GRS80)



Geoid Modeling

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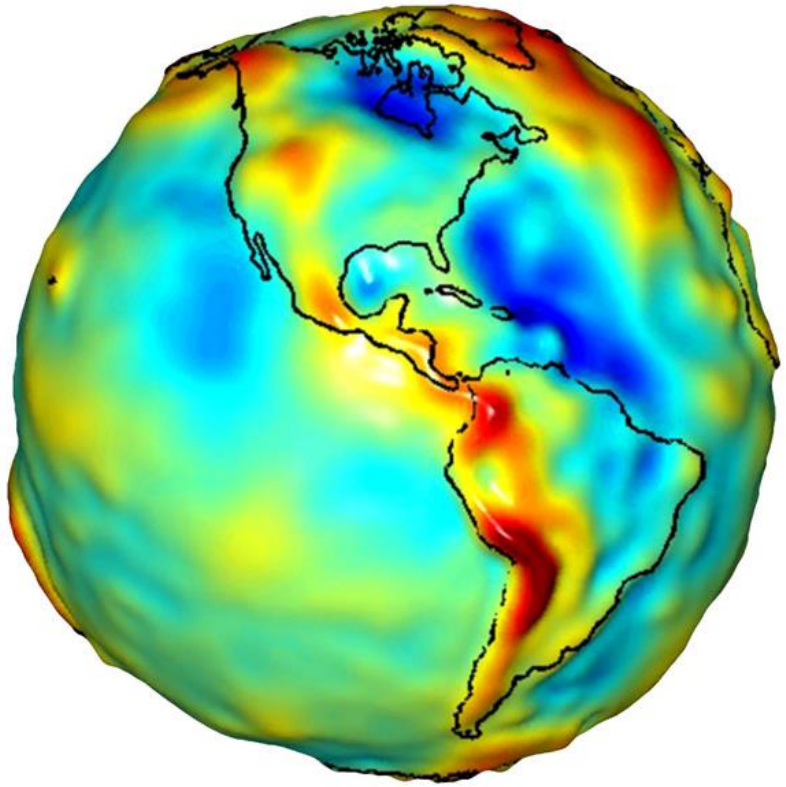
Geoid 12B



United States Gravimetric Model (USGG)

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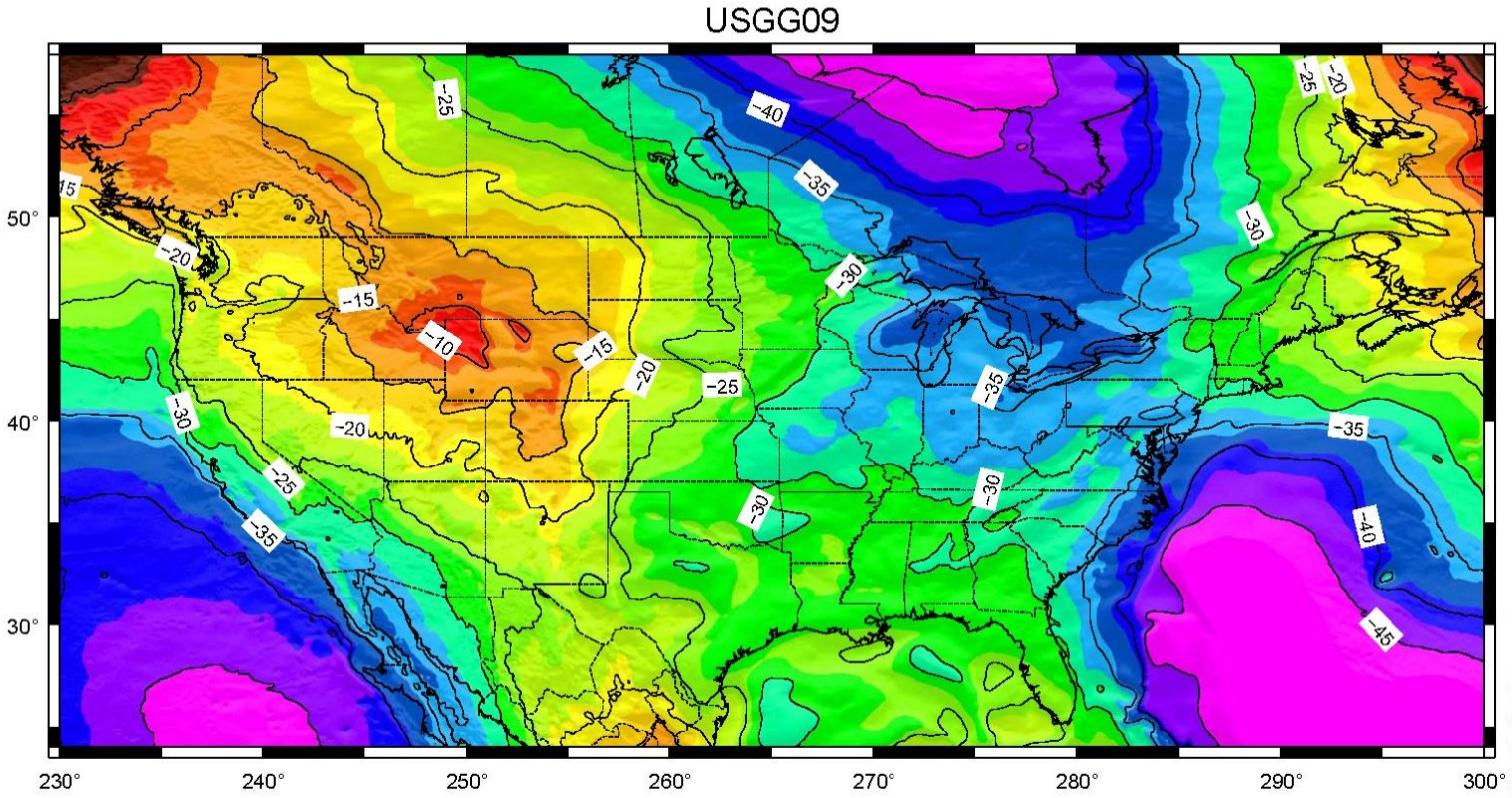

GPS derived Bench Marks (GPSBM)

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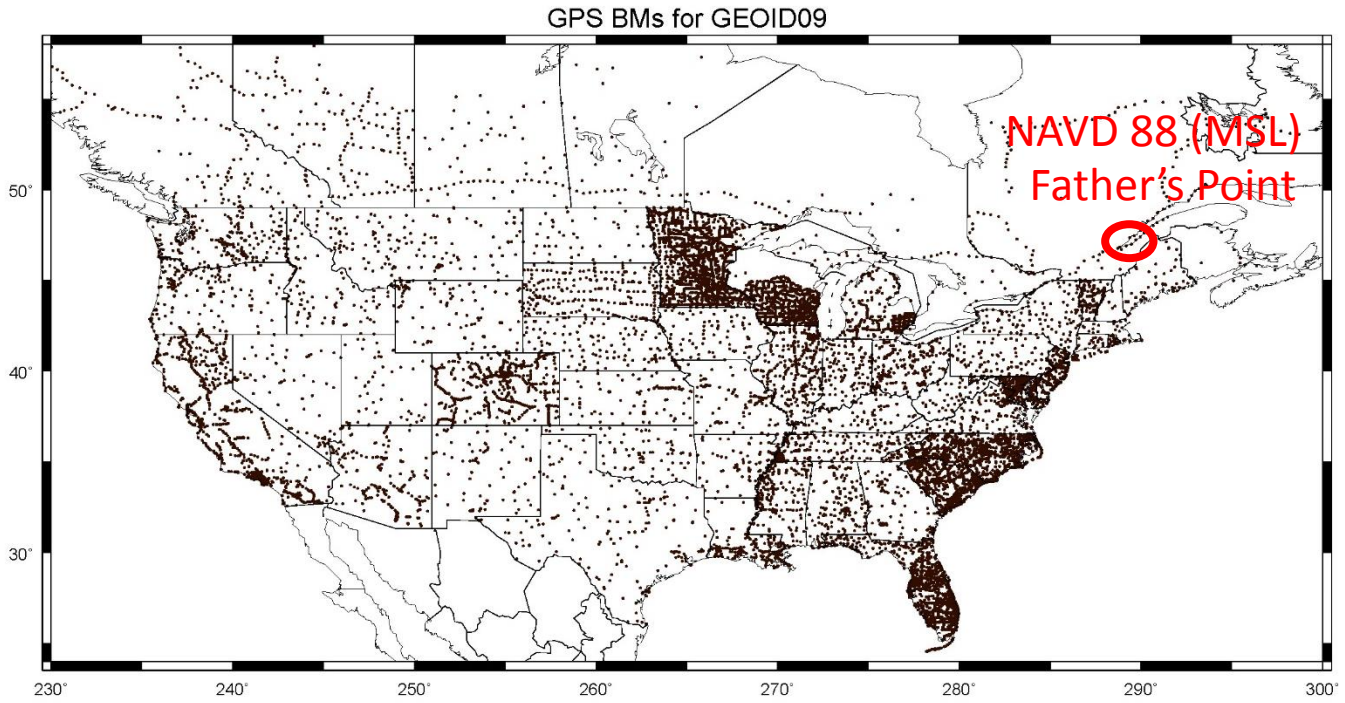

Geoid 12B

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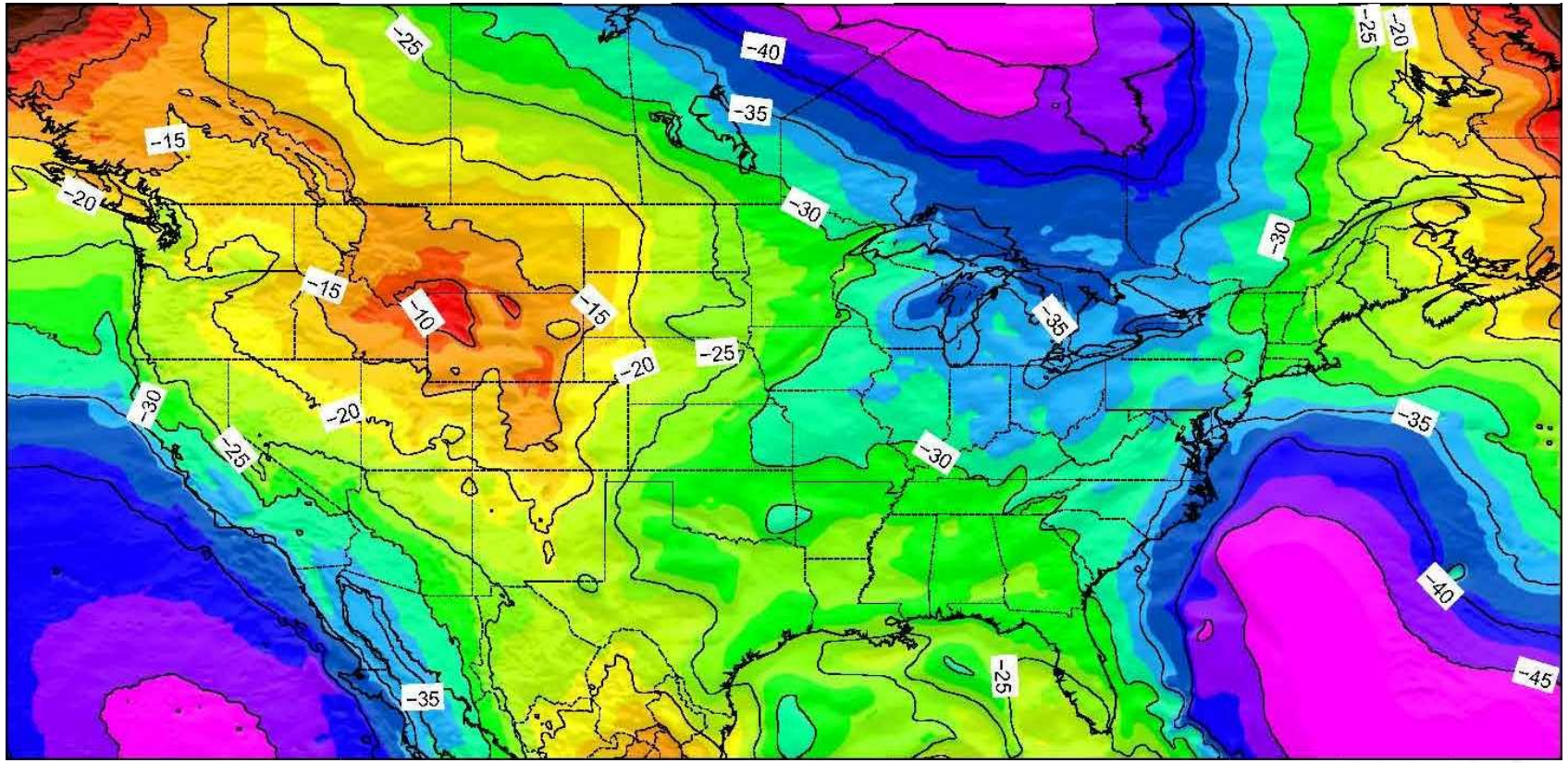

Calculating Mean Sea Level Elevation

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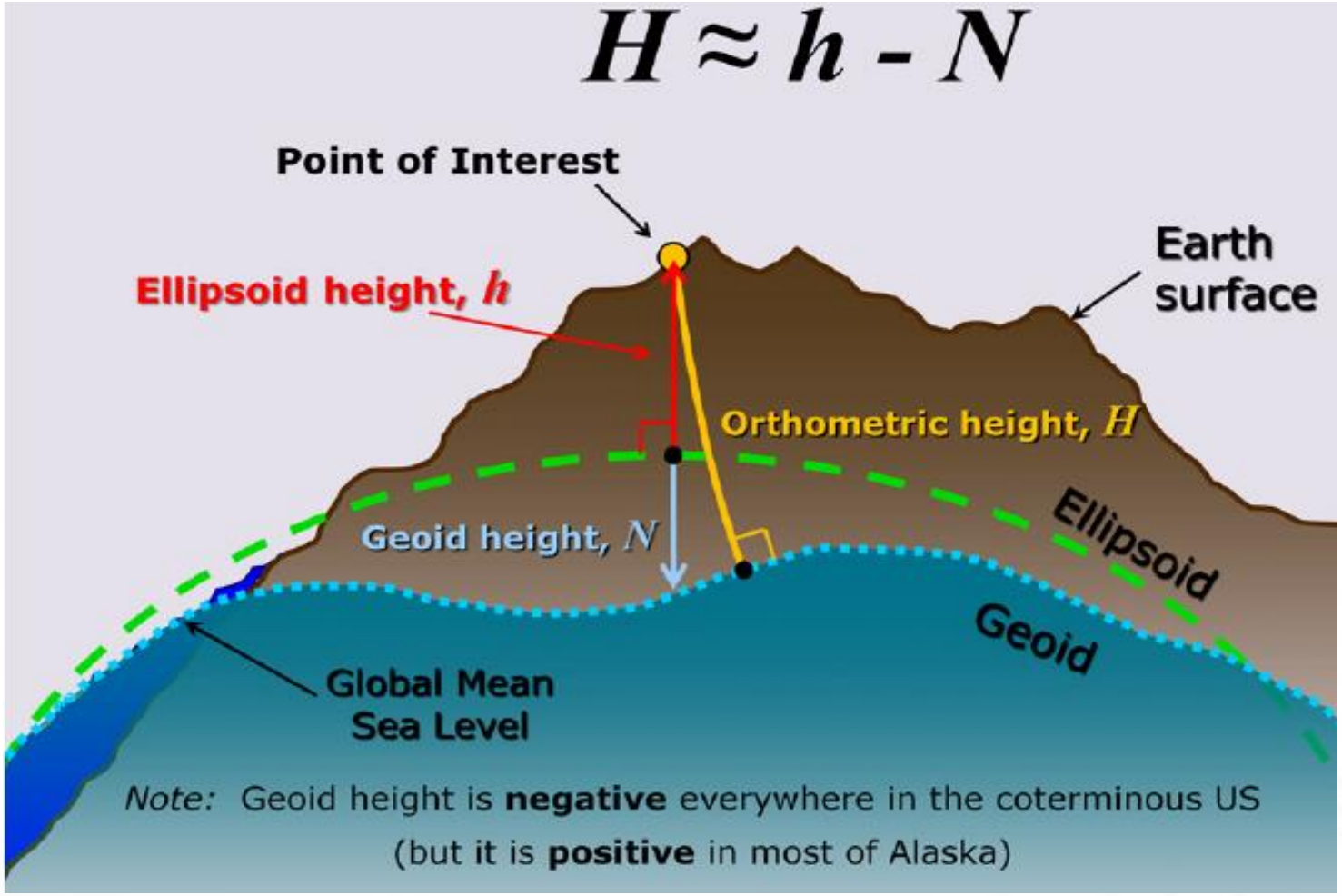


Elevation Accuracy

HAE

- Depends on the area: Upwards of 100’ +/-

Geoid 12B elevation with an NAD83 (2011) horizontal position

- +/- 1.5x horizontal accuracy

In order to achieve best vertical accuracy use the most recent version of NAD83 w/ the latest Geoid model.

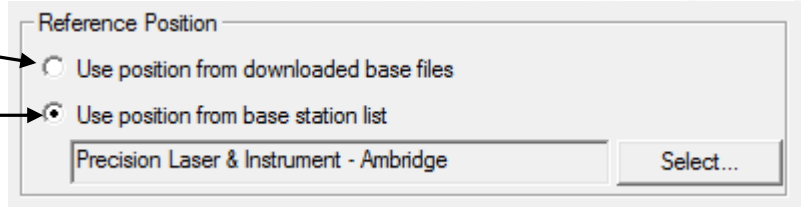
Differential Correction Shift

-Using public, private, or self-established base stations with known coordinates to correct data collected in the field.

-Base file records can be referenced to either WGS84 or NAD83 (2011).

Transforms corrected positions to NAD83 (2011)

Keeps corrected positions in WGS84



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Virtual Reference System (VRS) Shift

-Using public or private base station networks to provide real-time field corrections via internet.

-Base stations are referenced to NAD83 (2011).

-Depending on the software solution recorded positions may remain in WGS84, be transformed to NAD83 (2011), or be transformed to the datum set in your GIS.

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The Dreaded 3’ Software Shift

Symptoms
-Positions are consistently off by 3’ in the same direction.
-Positions in one dataset are off 3’ in the same direction from another dataset.

Cause
-The reference position and the position of comparison are referenced to a different Datum.

NAD83 (86) to NAD83 (2011) = 3’ shift
WGS84 to NAD83 (2011) = 3’ shift

Solution:
-Make sure all datasets are referenced to the same Datum.

*

Questions? Comments?