Session 27

Ground◀▶Grid - Simple, Right?

2025 WSLS Annual Institute
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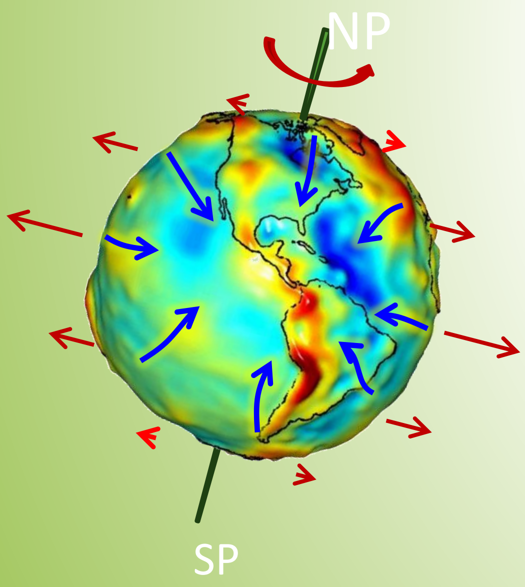
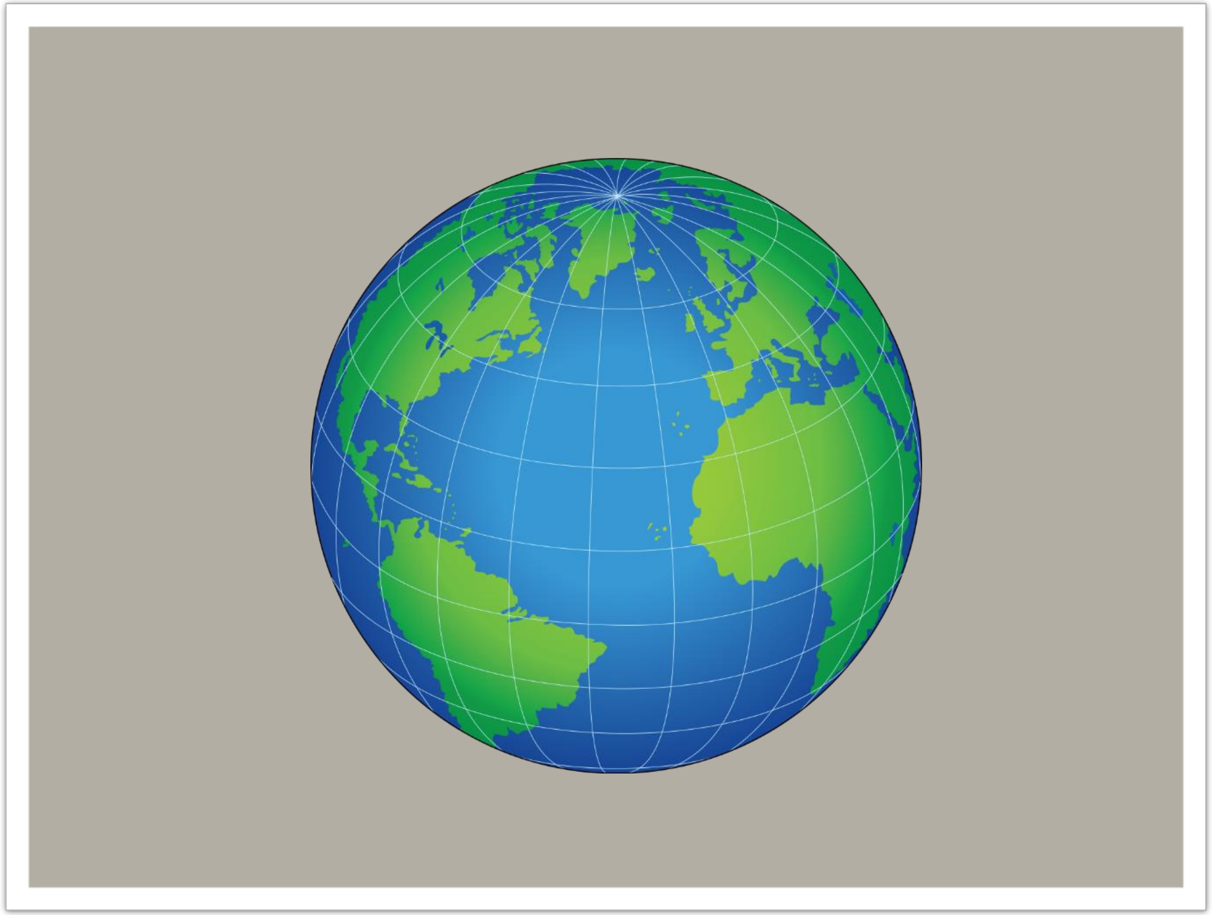


I. Spatial Systems
II. Distortions
III. Earth Models
IV. Creating a Grid
V. Wisconsin Coordinate Systems
VI. Ground and Grid
VII. Grids and PLSS Lost Corners

Grid⬌Ground - Simple, Right?



I. Spatial Systems

I. Spatial Systems

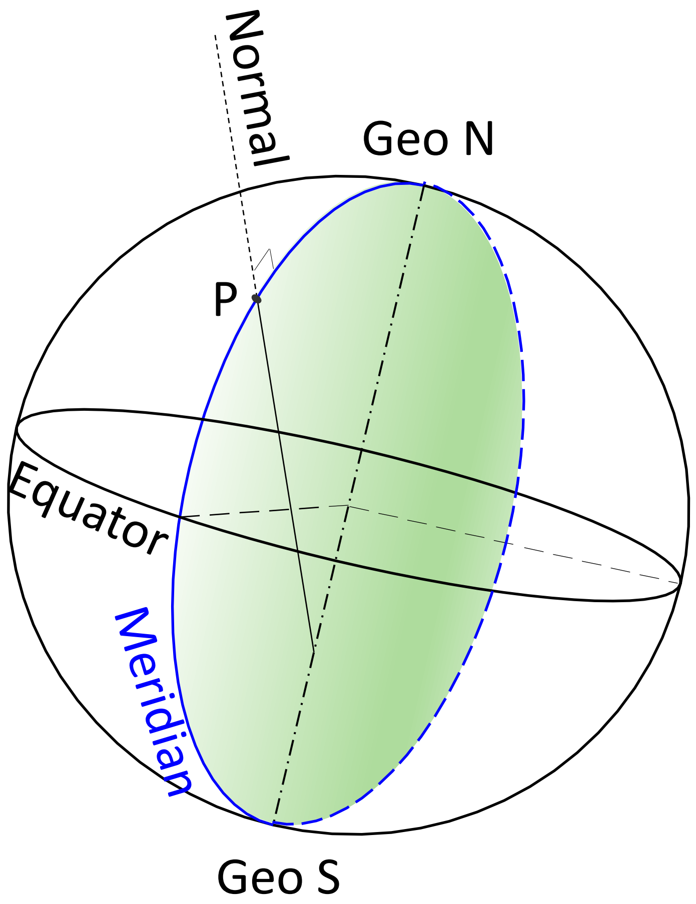
A. Three-Dimensional

1. Geodetic Coordinates

Reference defined by ellipsoid and fit.

NAD 83 - GRS 80 fit to Earth's mass center.

NAD 27 - Clarke 1866 fit to Meades Ranch, KS



Normal	A line from the observer's position, P, perpendicular to the ellipsoid
Meridian	An elliptical section containing the normal and semi-minor axes. Defines Geodetic N at a point.

Geodetic meridians converge.

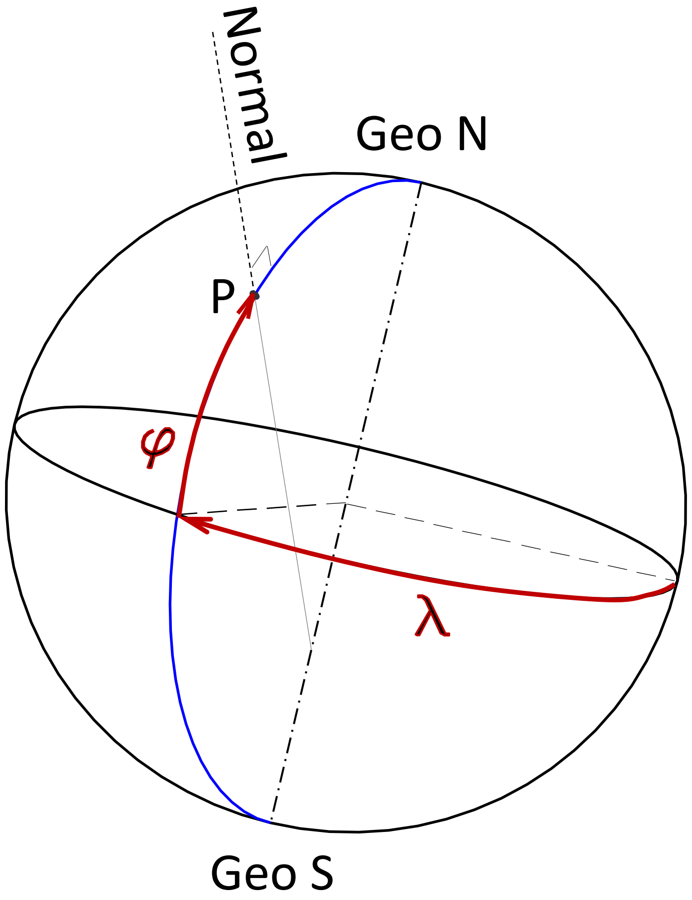
I. Spatial Systems

A. Three-Dimensional

1. Geodetic Coordinates

Longitude (λ) - Angle in Equatorial plane
E or W from Greenwich Meridian
0°-180°W; 0°-180°E

Latitude (Φ) - Angle in meridian N or
S of the Equator.
0°-90°N; 0°-90°S



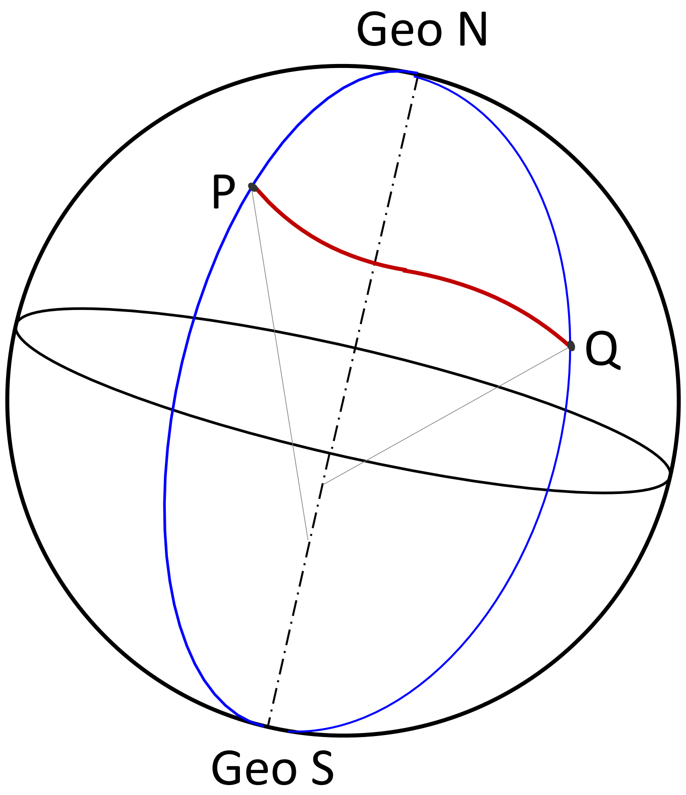
I. Spatial Systems

A. Three-Dimensional

1. Geodetic Coordinates

Disadvantages:

- Positions are expressed in angular values
- Distances are in angular values
- Elliptical geometry
  - Shortest distance between two points is a *geodesic* - shallow s-shape curve.



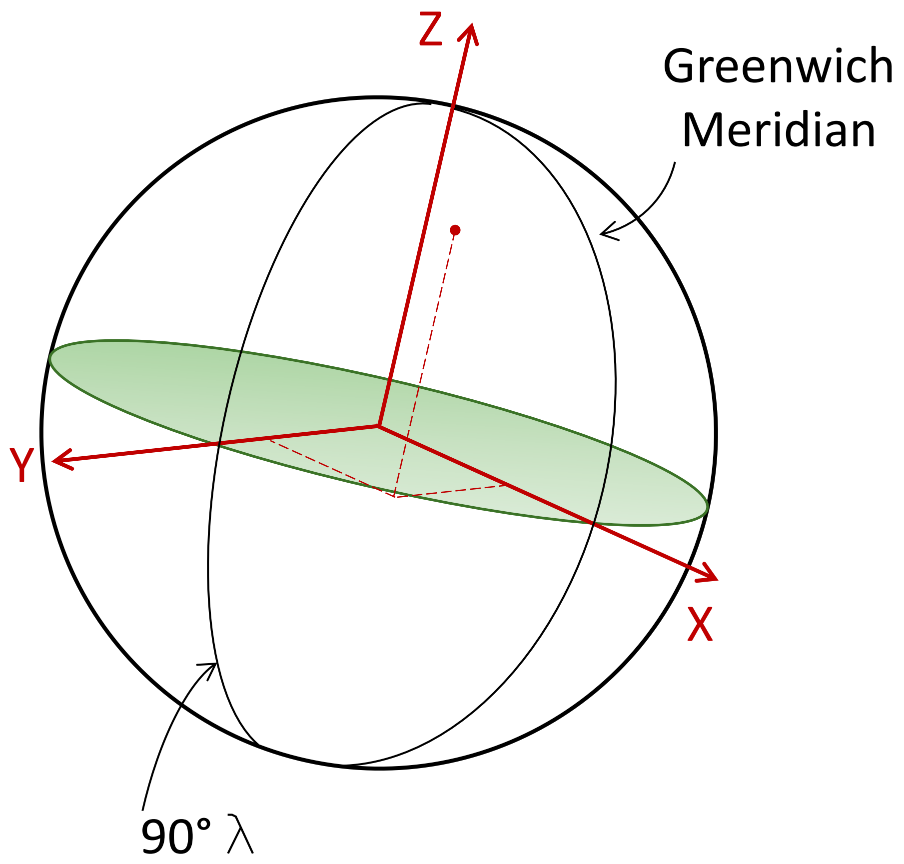
I. Spatial Systems

A. Three-Dimensional

2. Terrestrial Coordinate System - TCS

Three axis rectangular system

- Origin at Earth’s mass center
- Coordinates are linear values



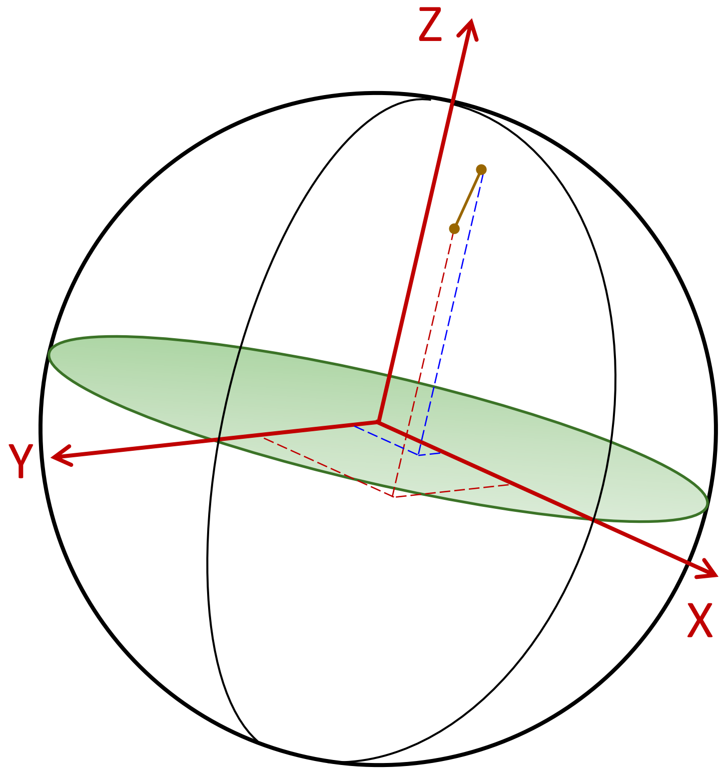
I. Spatial Systems

A. Three-Dimensional

2. Terrestrial Coordinate System - TCS

Disadvantages:

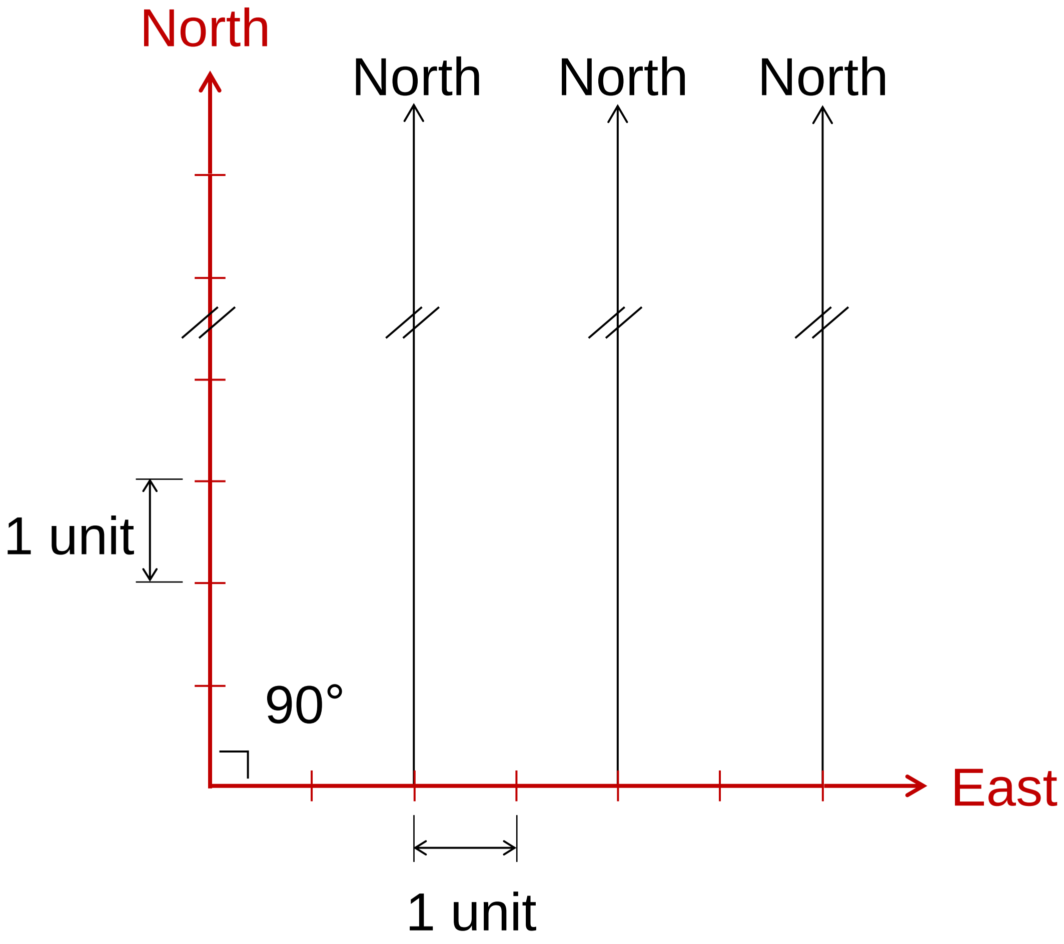
- Huge coordinate values.
- Negative coordinates
- No “up” (vertical direction)
  - Top and bottom of vertical structures have different 3D coordinates.



I. Spatial Systems

B. Two Dimensional

1. Planar



Characteristics

- a. Orthogonal
- b. Parallel north lines
- c. Uniform scale in both directions

Comps are simple.

Disadvantage(s)?

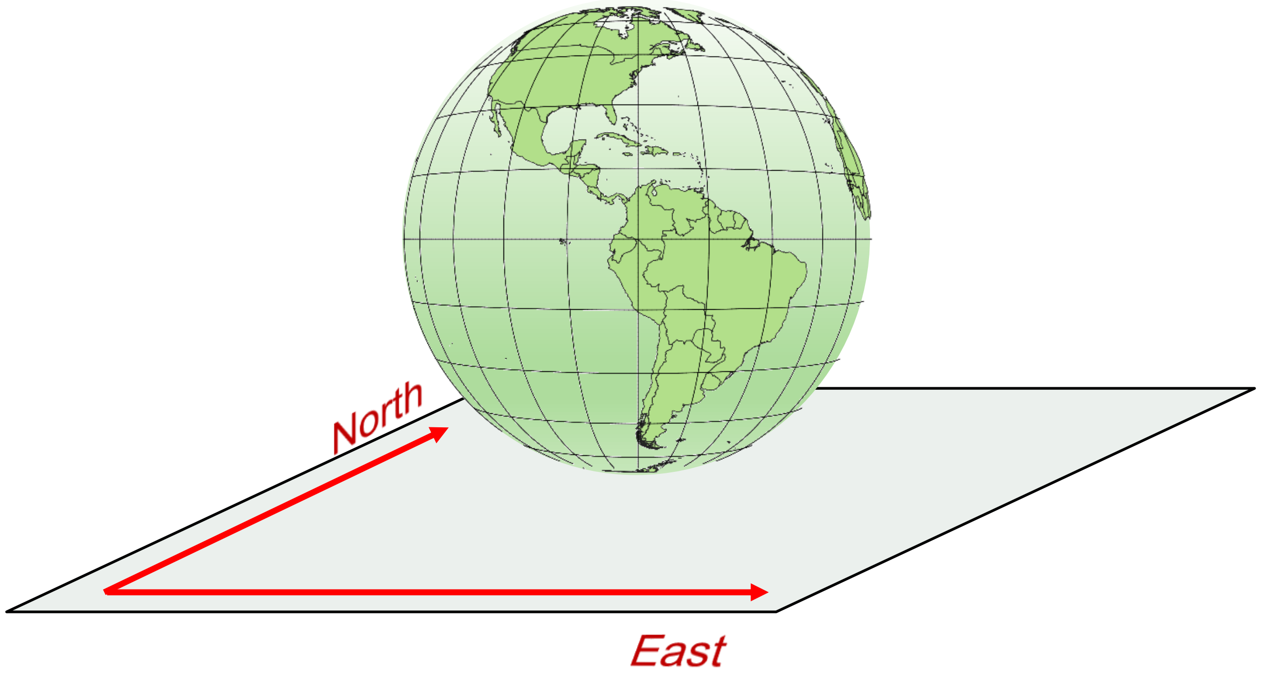
I. Spatial Systems

B. Two Dimensional

1. Planar

Disadvantages

- We're on a 3D earth
- We want to put it in a 2D system



I. Spatial Systems

B. Two Dimensional

1. Planar

Disadvantages

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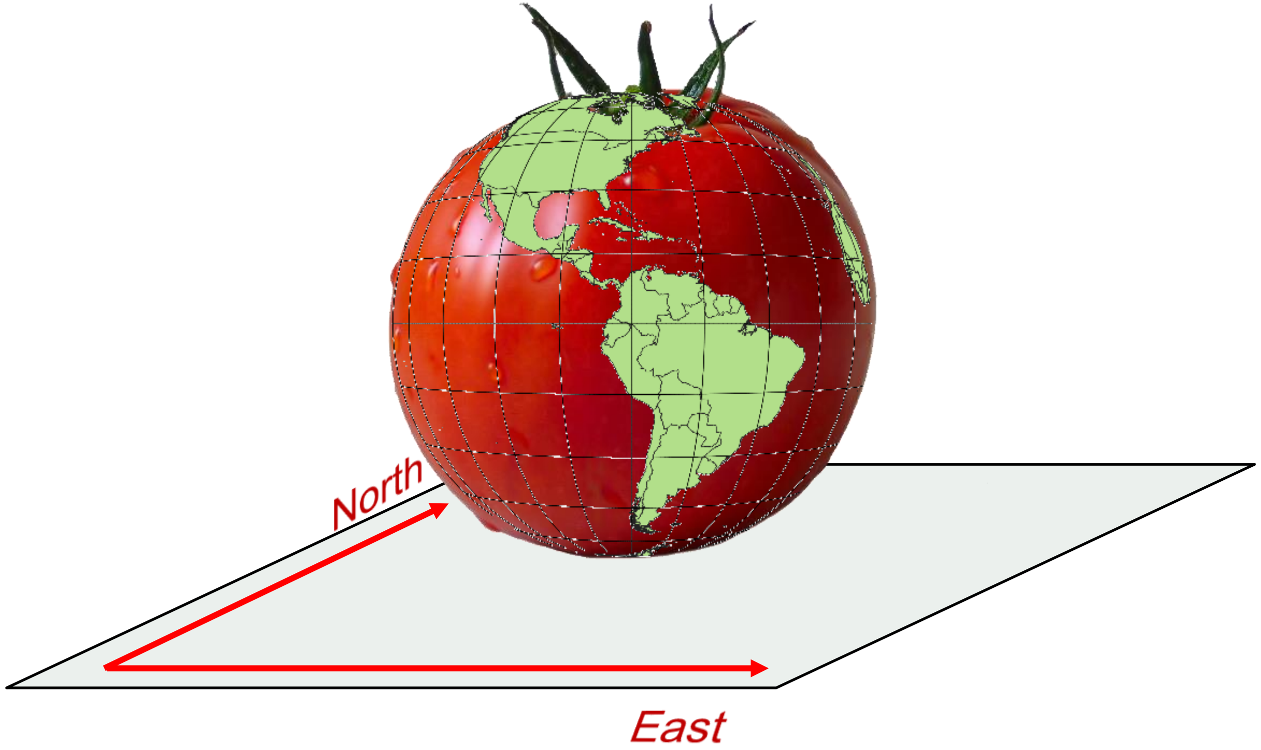


I. Spatial Systems

B. Two Dimensional

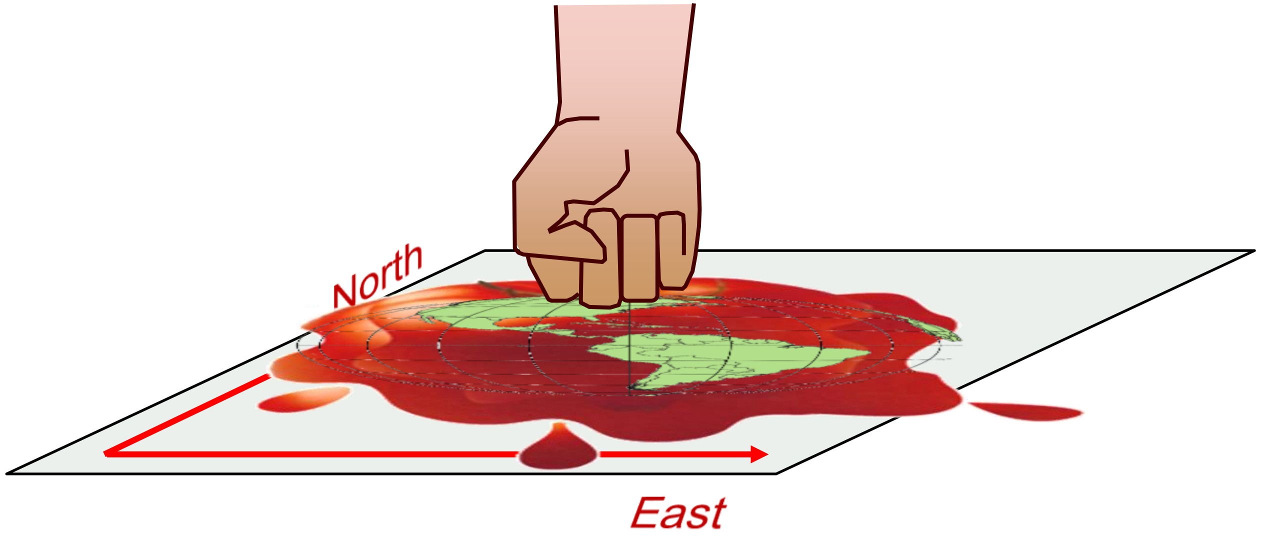
1. Planar

Disadvantages

We're on a 3D earth

We want to put it in a 2D system

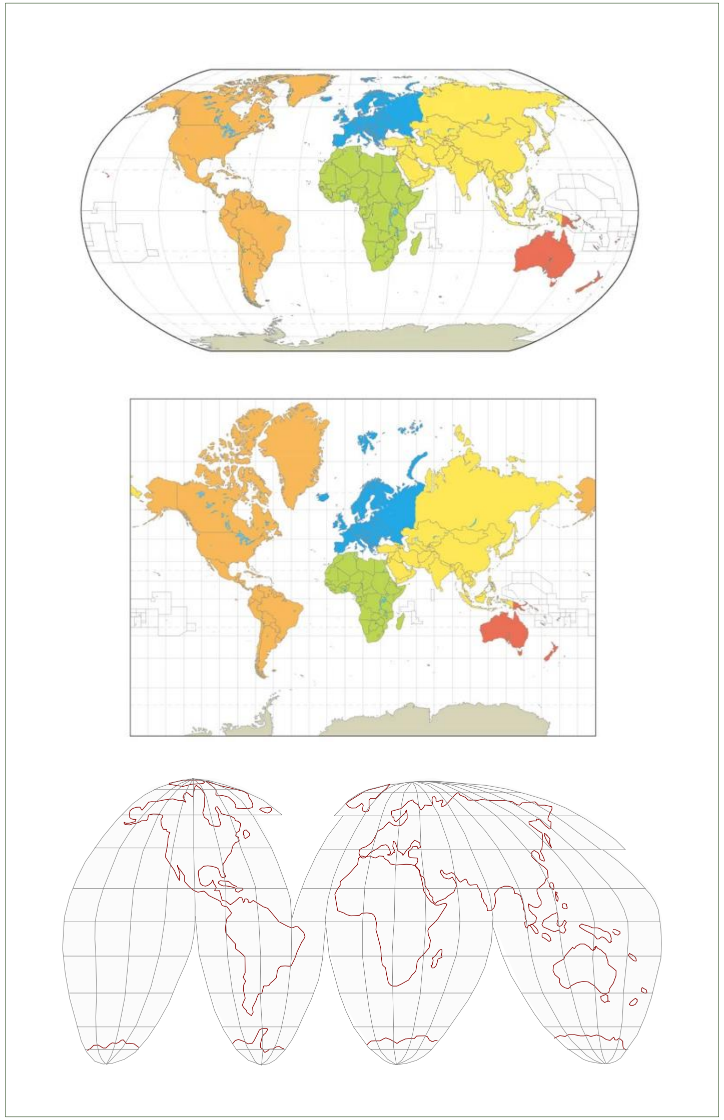
With a direct projection we get a distorted representation



I. Spatial Systems

B. Two Dimensional

1. Planar



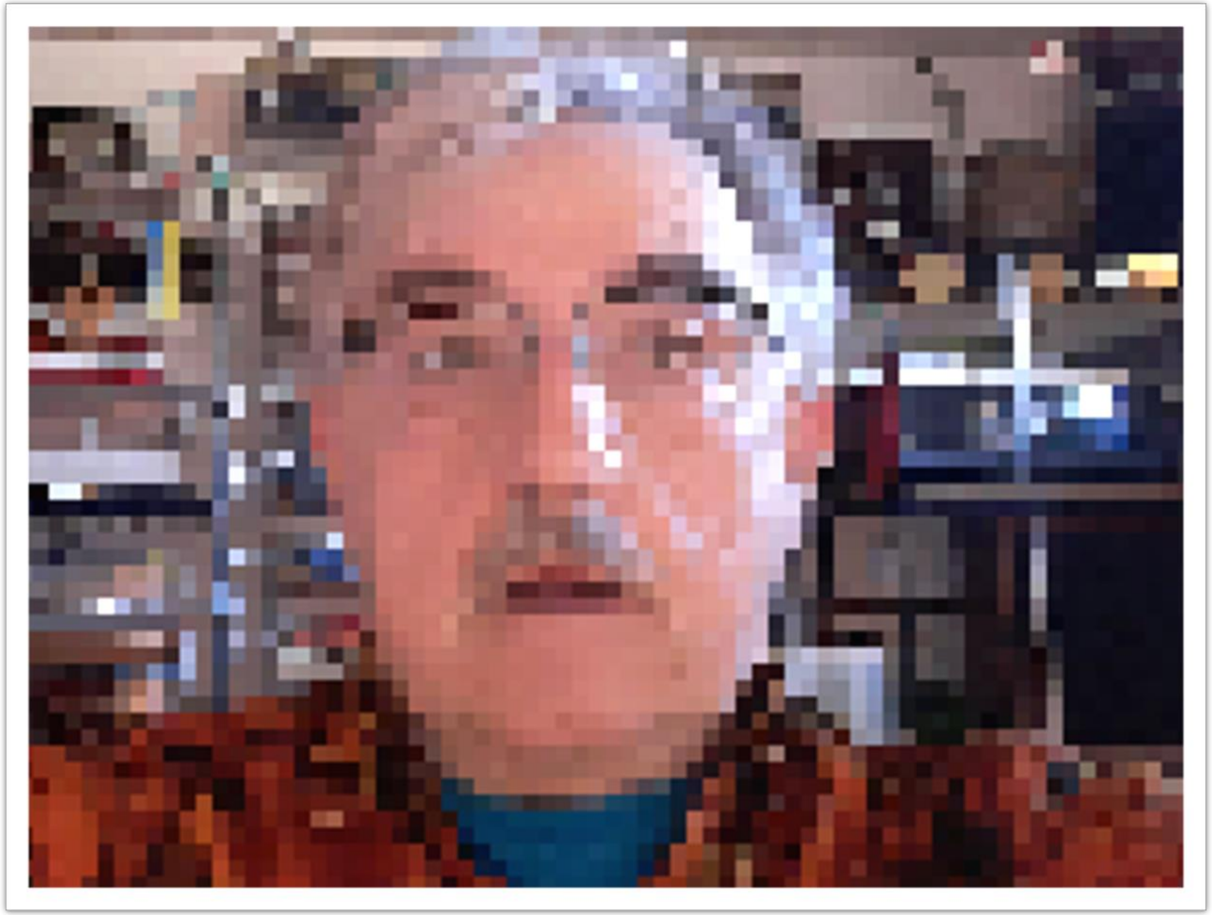
Disadvantages

We're on a 3D earth

We want to put it in a 2D system

With a direct projection we get a distorted representation

Different mathematical projections distort different ways.

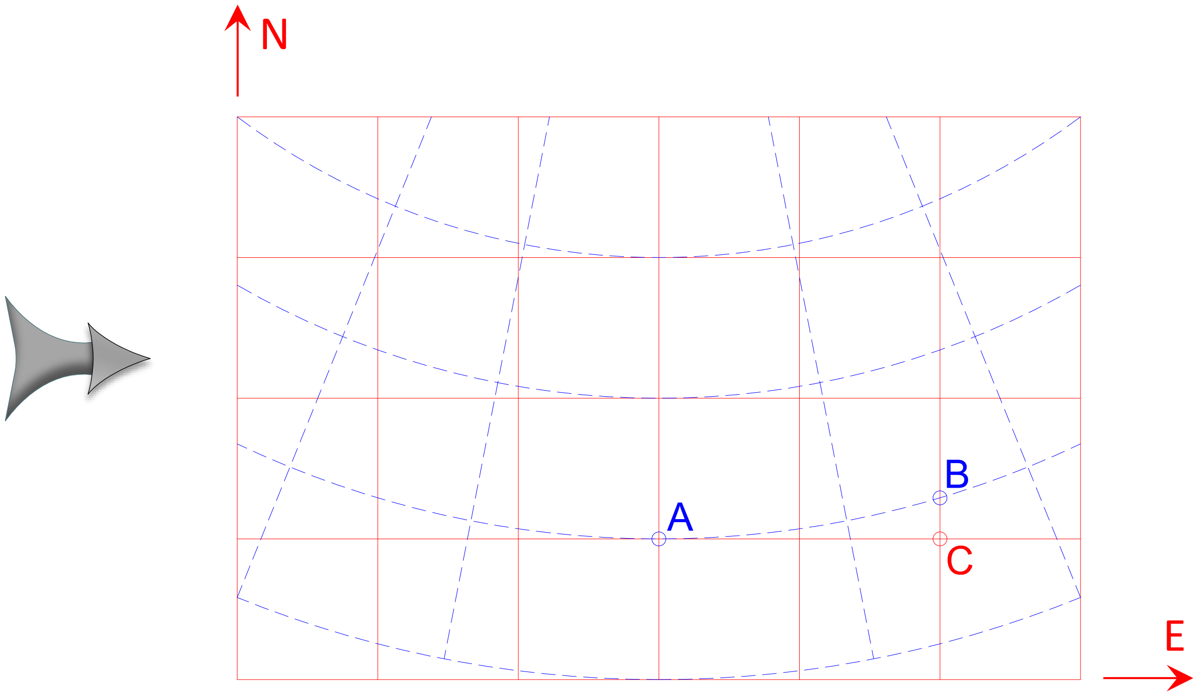


II. Distortions

II. Distortions

A. Projection Area

The smaller the area projected, the smaller the distortions.



Grid (2D) - Solid red
Geodetic (3D) - Dashed blue

II. Distortions

B. Types

The two primary distortions are

1. Direction

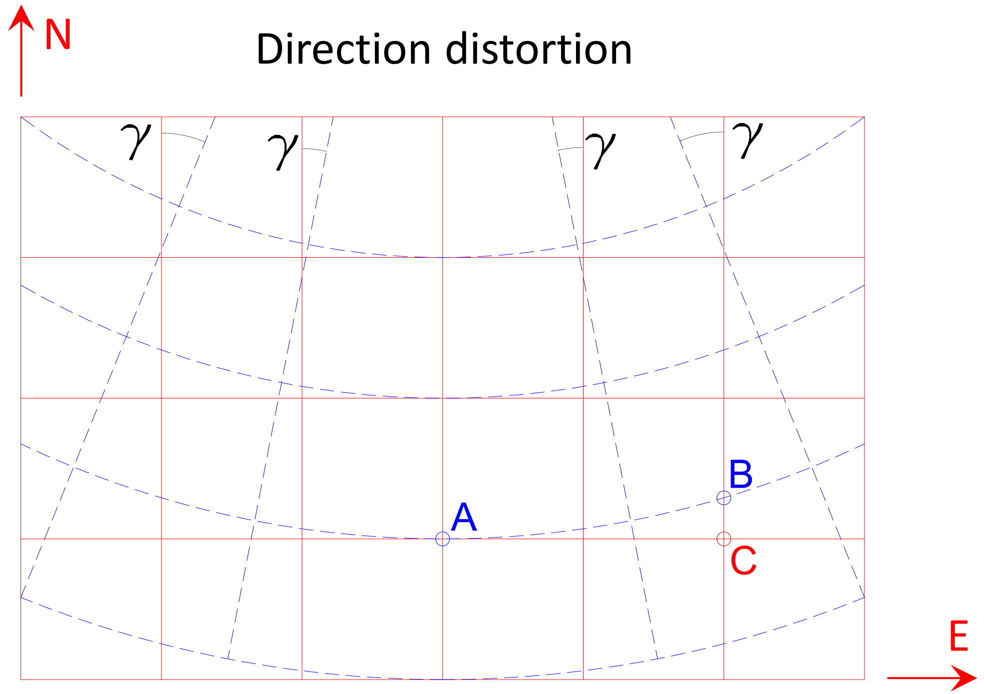
3D meridians converge, 2D do not.

3D E/W lines are curved, 2D are straight.

No distortion at center of projection

Increases moving E & W of center

γ: *convergence*; angle between grid and geodetic north



Grid (2D) - Solid red

Geodetic (3D) - Dashed blue

II. Distortions

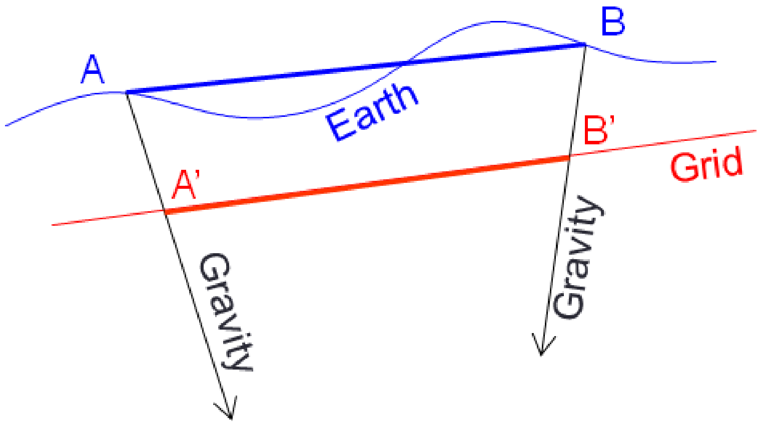
B. Types

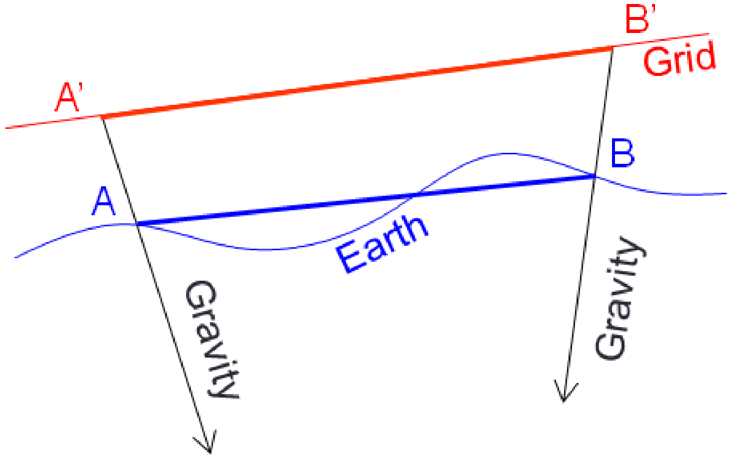
The two primary distortions are

2. Distance

Ground points must be projected vertically to the 2D grid plane.

This moves them closer together or further apart, altering distance.





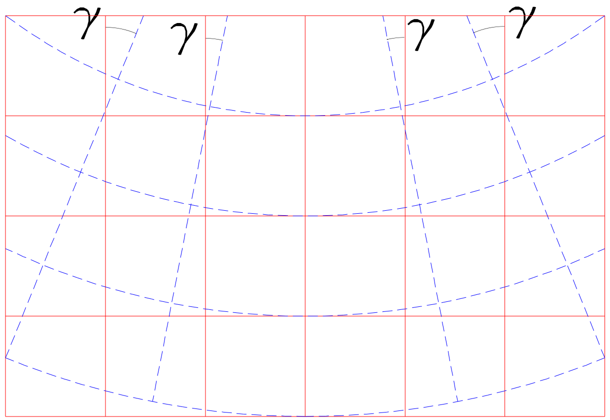
II. Distortions

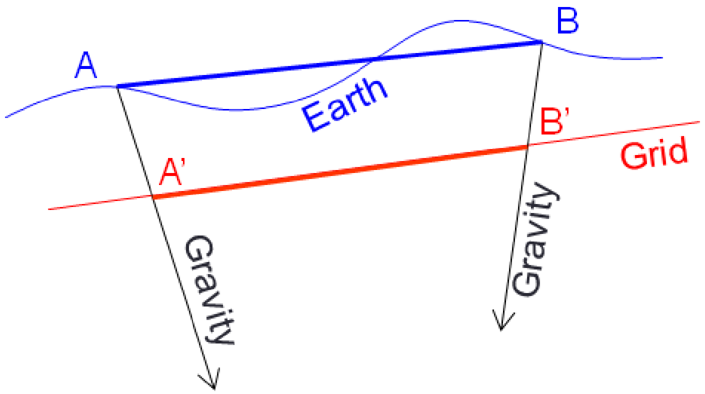
C. Compensation

Except for *extremely* small areas, projecting 3D to 2D will always create direction and distance distortions.

They are *systematic* errors - can be compensated mathematically *as long as* we know how the surfaces are mathematically connected.

For that, we need some earth models.



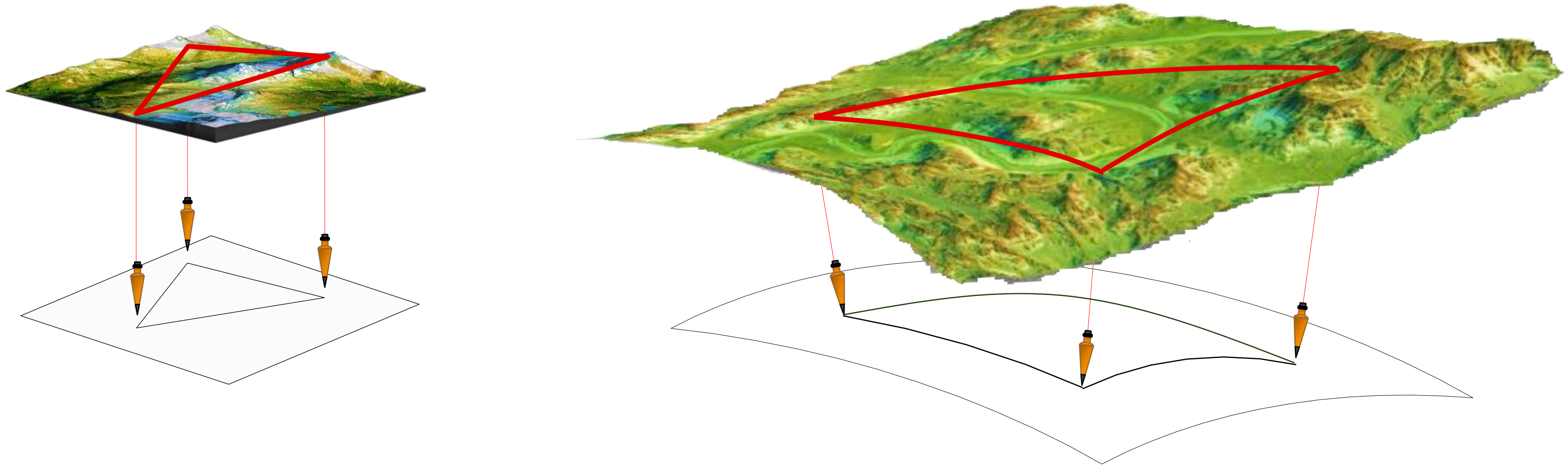


III. Earth Models

III. Earth Models

A. Physical Earth - Ground

- The surface on which we measure.
  - Not mathematical.
  - Over small areas, we can assume a flat reference system - plane; simple grid
  - Over larger areas, must account for earth's shape and dynamics - curved reference
    - Must then project from curved surface to a flat grid.
    - Need some to connect mathematically



III. Earth Models

B. Geoid

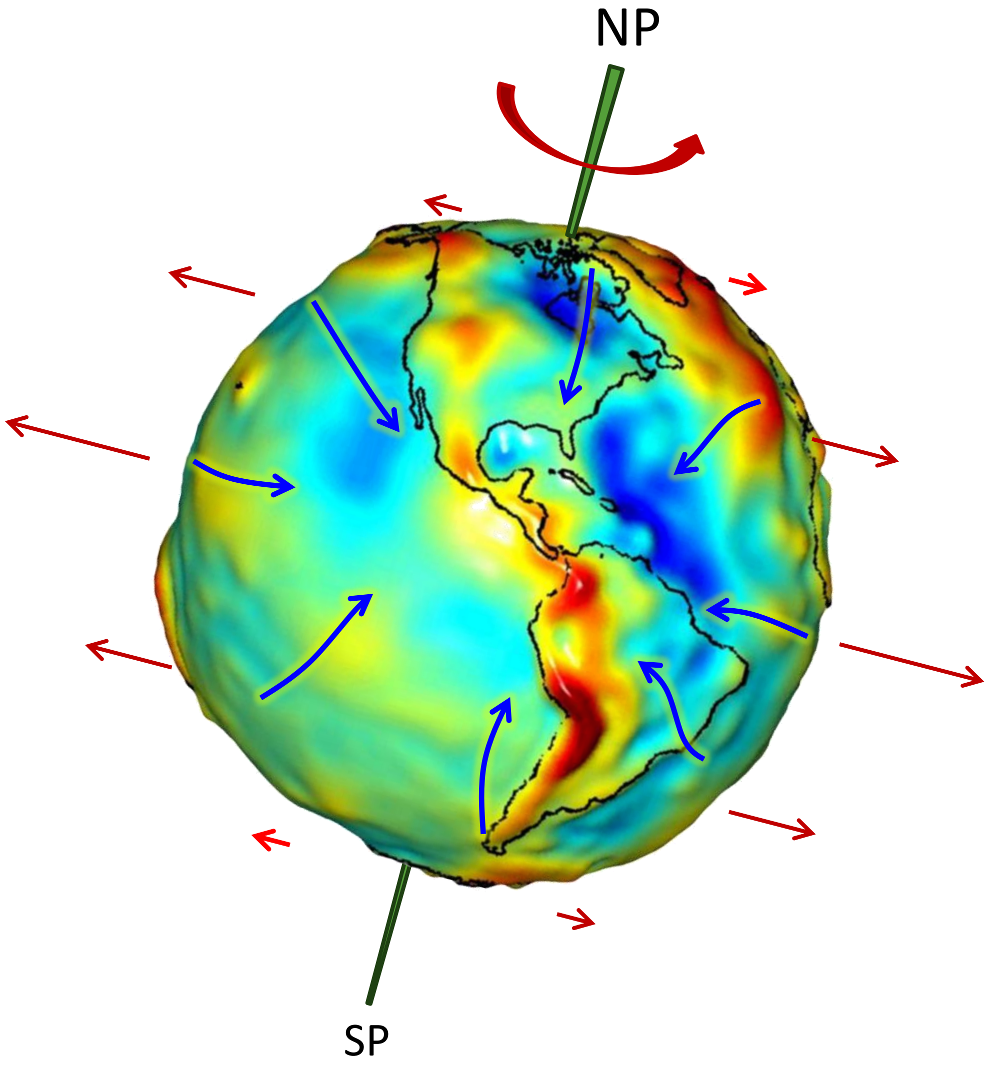
An equipotential surface defined by gravity (in) and centrifugal force (out).

Gravity = f(mass)

Earth: non-homogeneous; mass anomalies

⇨ Lines of gravity are neither parallel nor straight.

Geoid is a lumpy and changing nonmathematical surface.

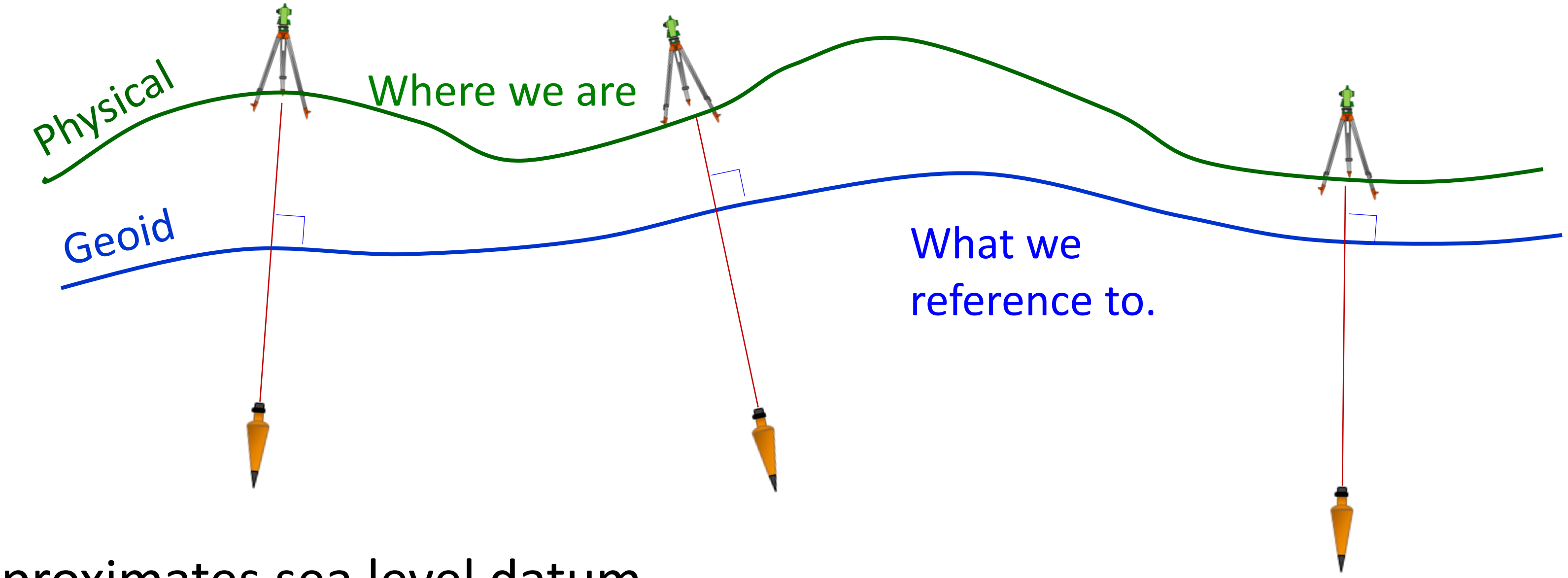


III. Earth Models

B. Geoid

Gravity is perpendicular to the geoid

Centering a bubble or using a plumb bob orients equipment to the geoid.



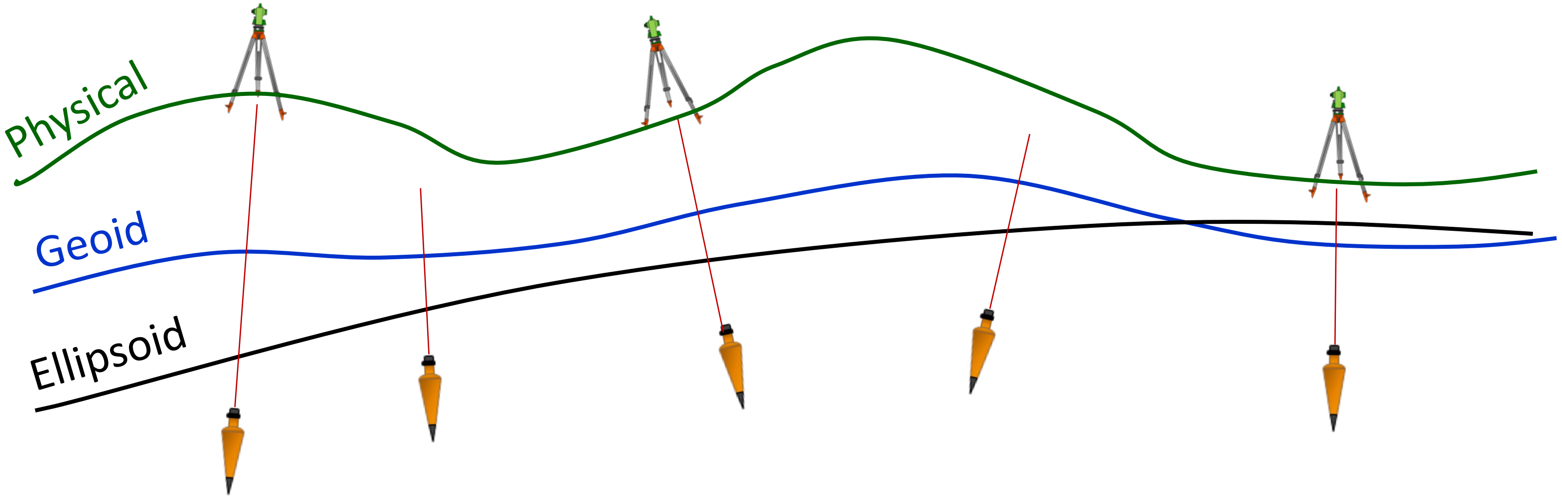
Geoid approximates sea level datum

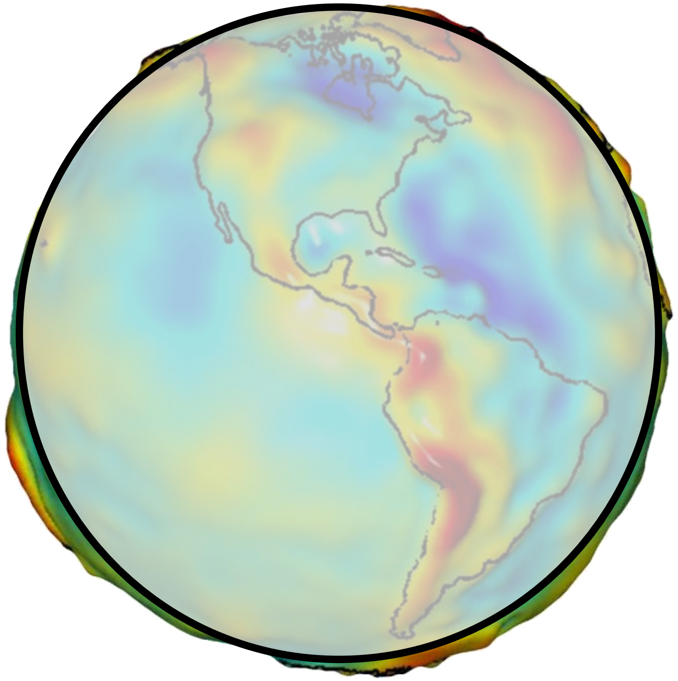
Connected to physical Earth by elevations - orthometric heights

III. Earth Models

C. Ellipsoid

- Mathematical 3D surface
- Fit to geoid
  - Doesn't fit exactly; compromises





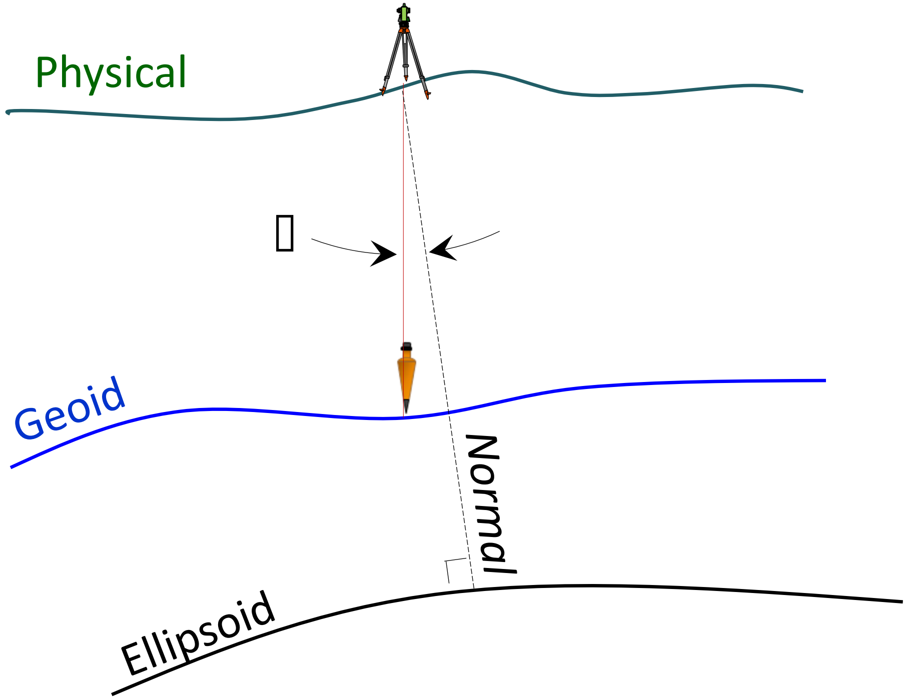
III. Earth Models

C. Ellipsoid

Geoid - Ellipsoid fit at a point is a function of Skewness and Vertical separation.

Skewness - Deflection of the vertical, δ

Angle between directions of gravity and ellipsoid normal.



III. Earth Models

C. Ellipsoid

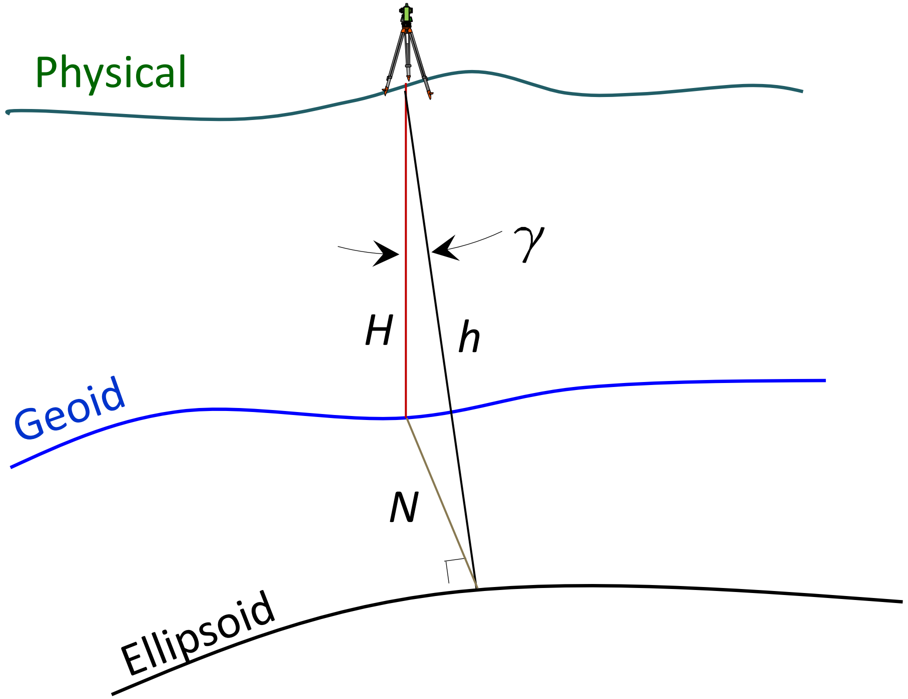
Geoid - Ellipsoid fit at a point is a function of Skewness and Vertical separation.

Vertical separation

Heights between the surfaces

- H - Orthometric: geoid to ground
- N - Geoid: ellipsoid to geoid
- h - Ellipsoidal: ellipsoid to ground

h = H+N

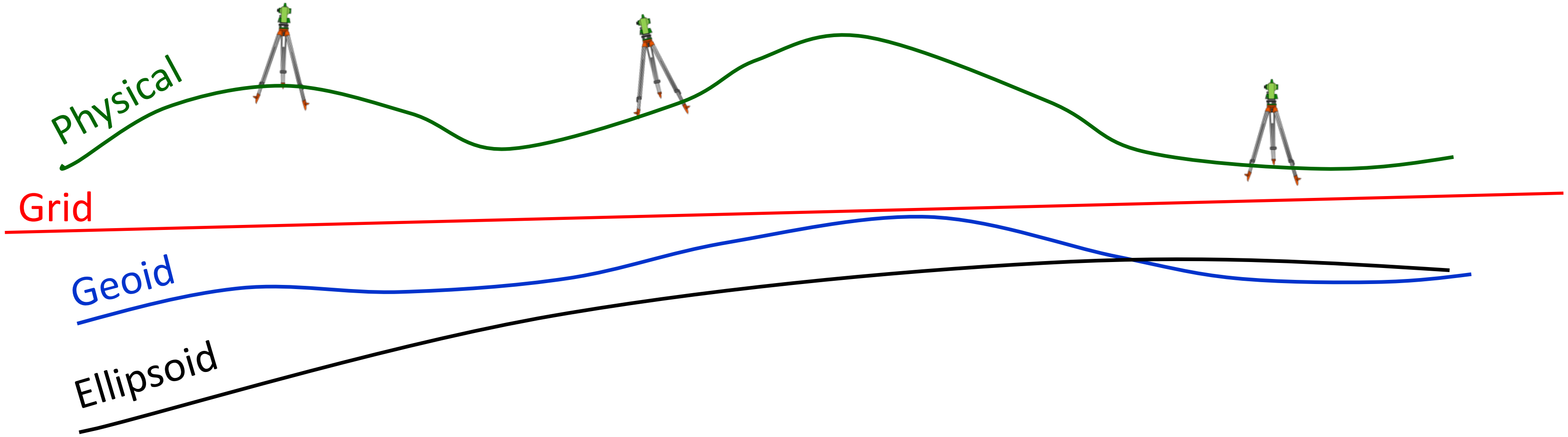


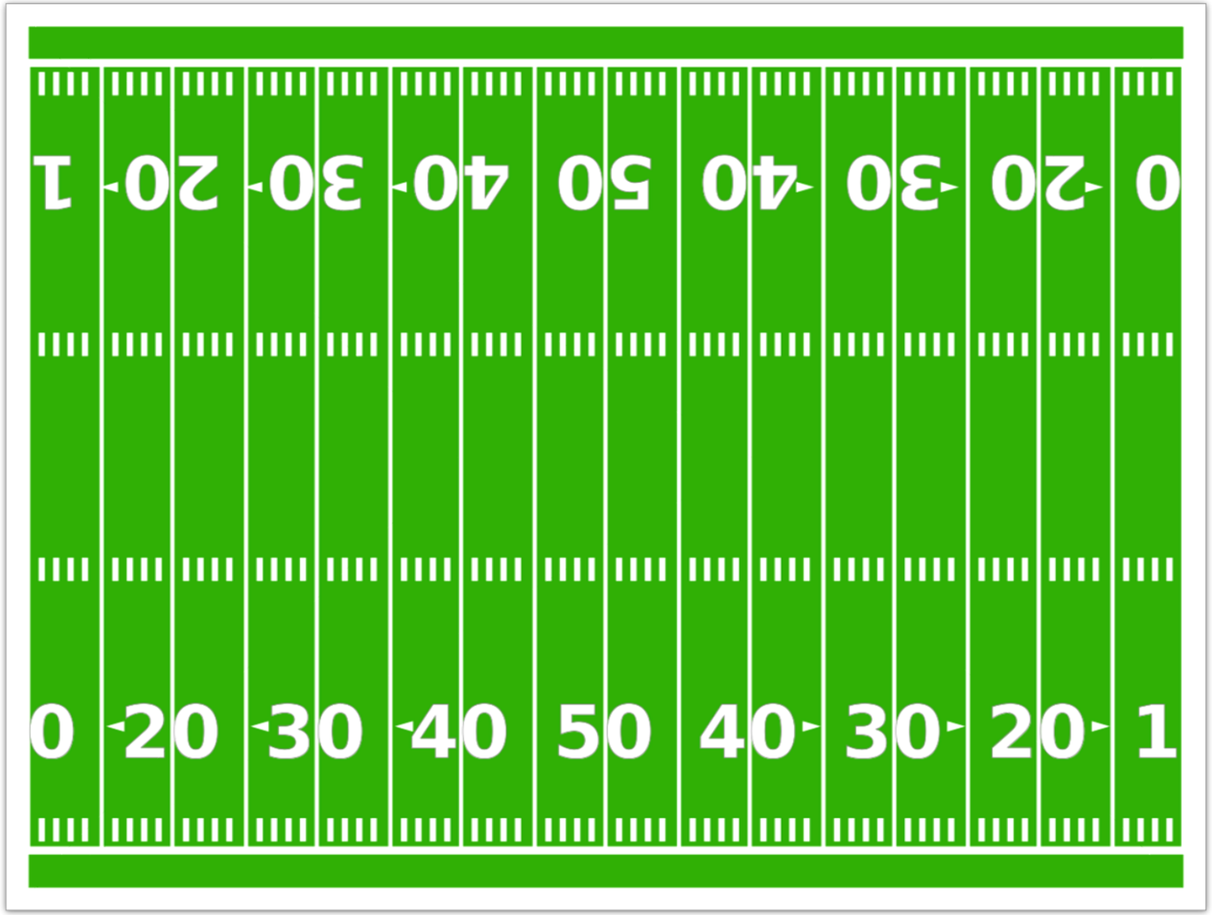
III. Earth Models

D. Grid

The final surface is a grid

- Can be more than one depending on coordinate systems needed.
- Move points from ground, through geoid and ellipsoid, to the grid



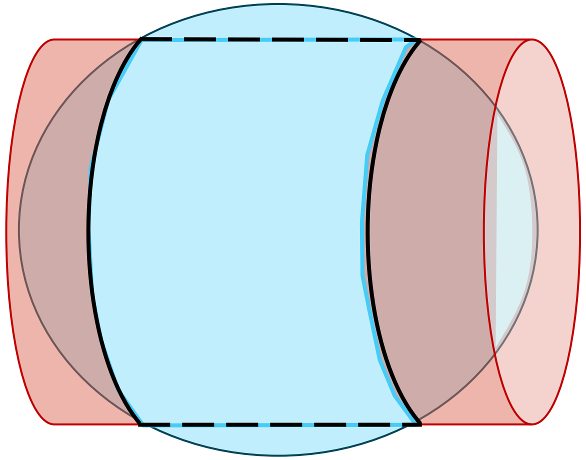


IV. Creating a Grid

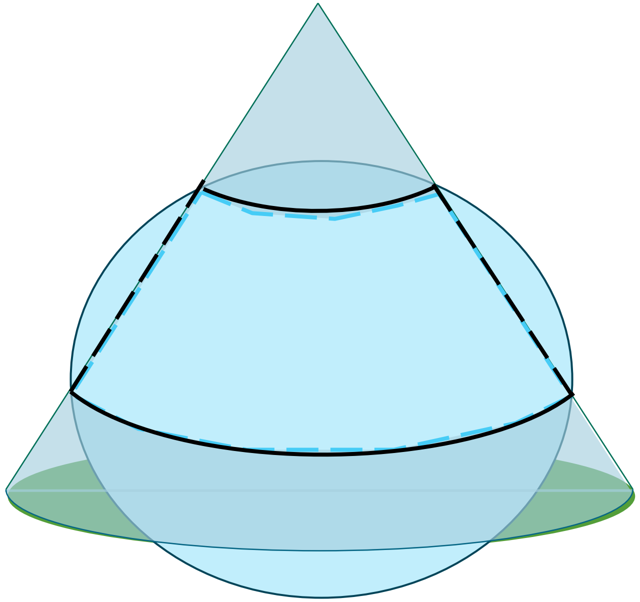
IV. Creating a Grid

A. Projection Surfaces

Grid is based on a Projection Surface which is fit to Ellipsoid



Cylinder

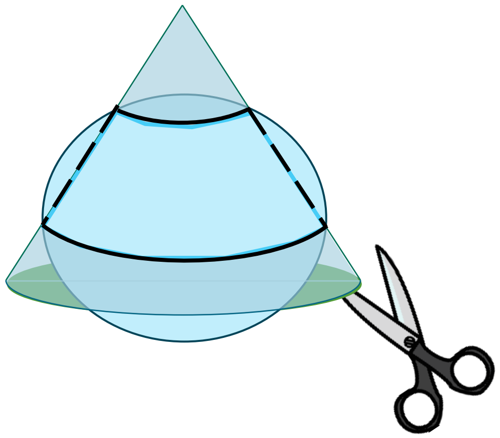


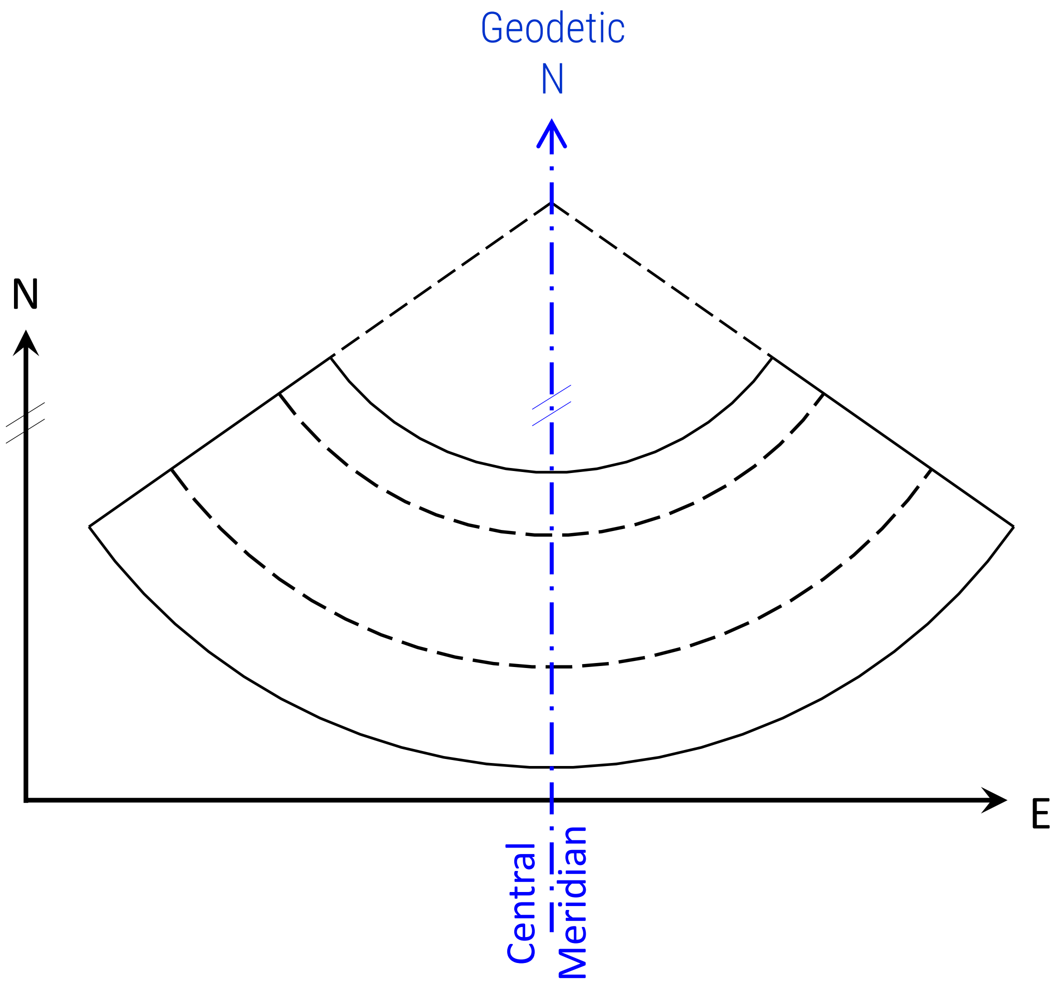
Cone

IV. Creating a Grid

B. Lambert Conic Conformal

- Cone placed over (and through) ellipsoid.
- Points projected.
- Projection is laid out flat and a coordinate system overlaid.



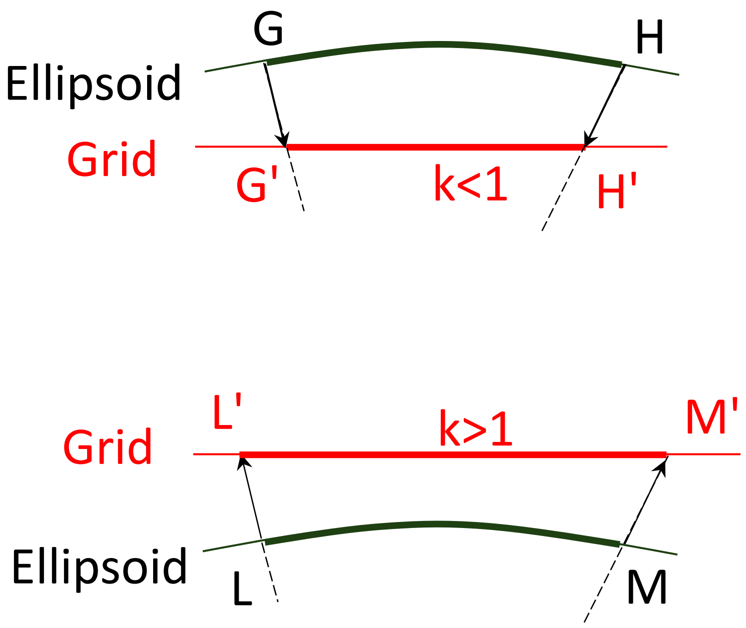


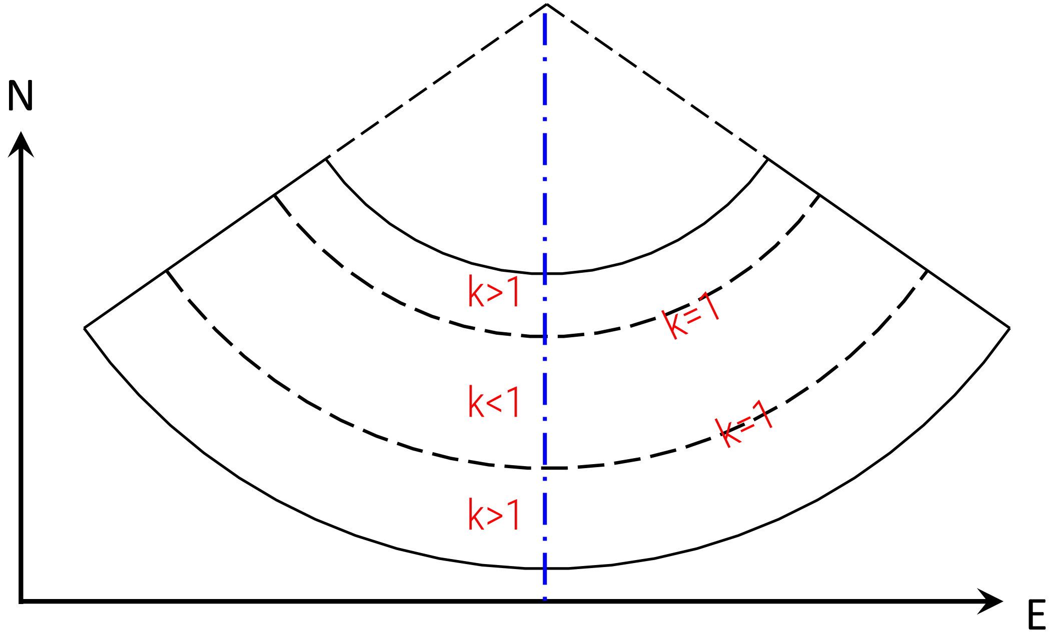
IV. Creating a Grid

B. Lambert Conic Conformal

Distance distortion

Scale, k, is constant E/W; varies N/S





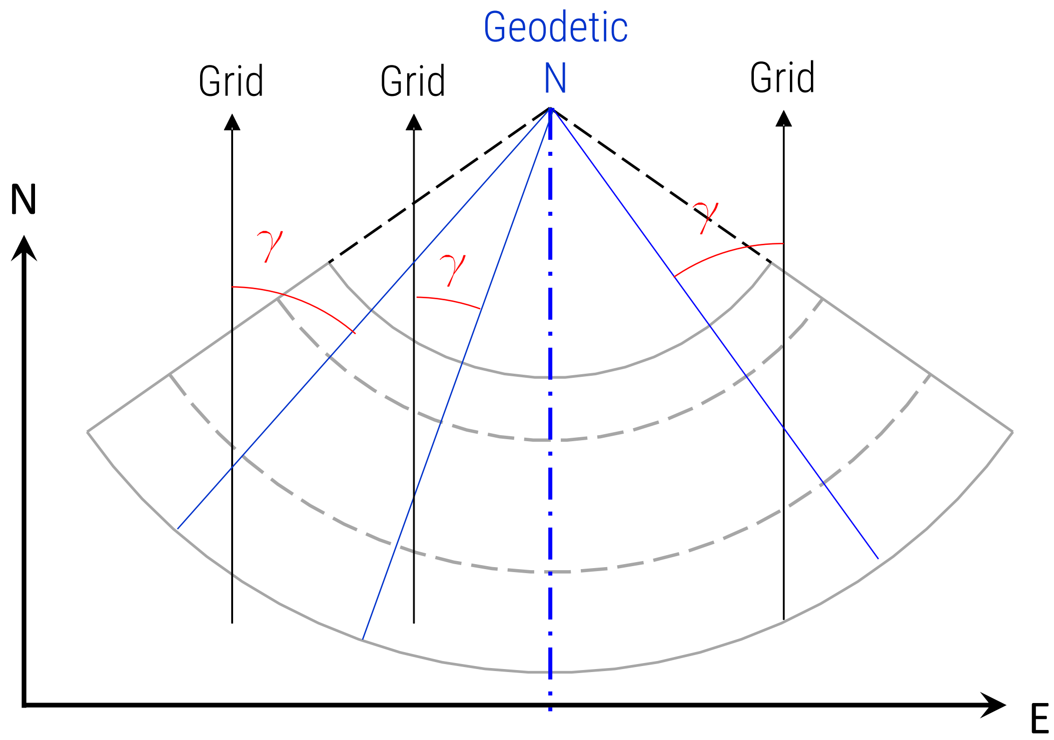
IV. Creating a Grid

B. Lambert Conic Conformal

Direction distortion

Convergence, γ, is angle between Grid and Geodetic North.

0° at CM, increases to E and to W

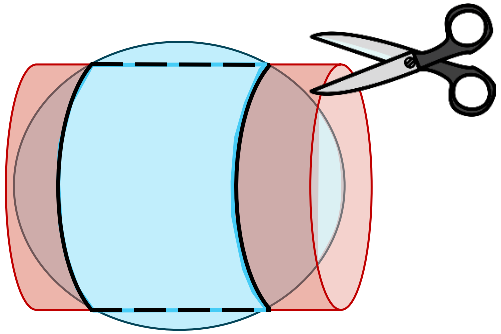


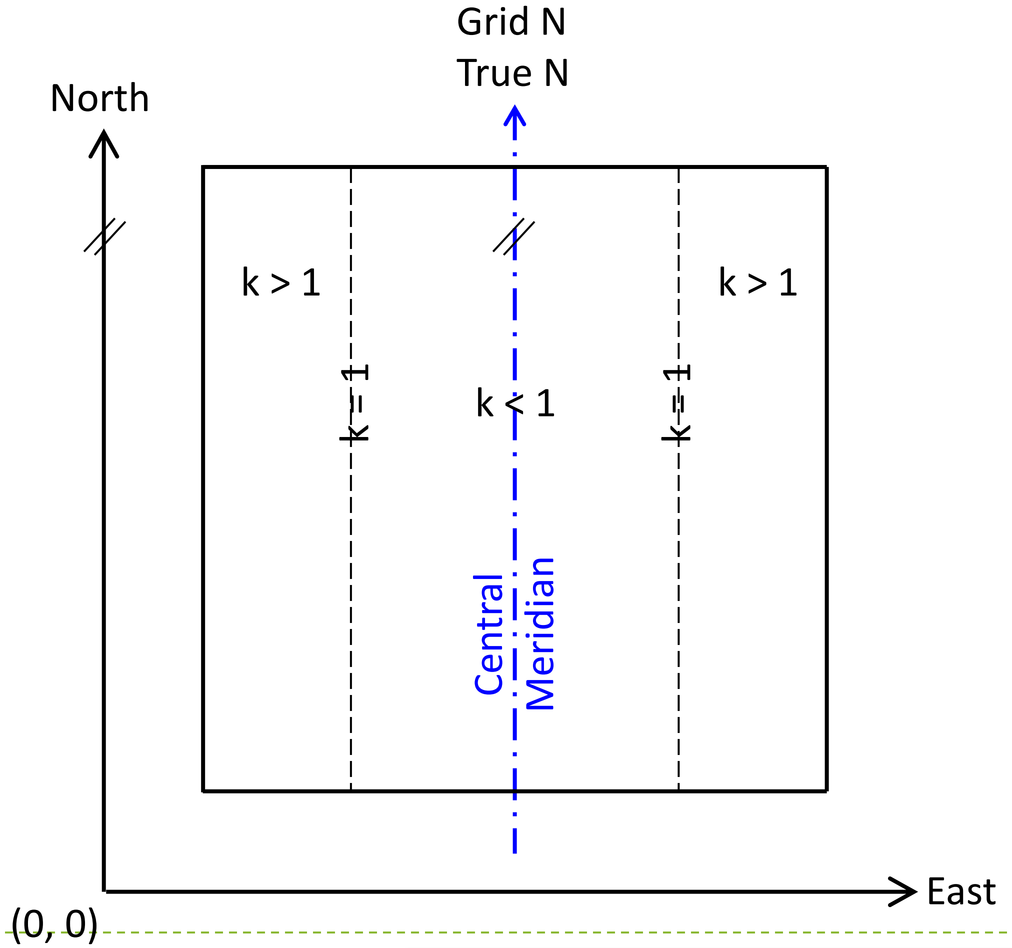
IV. Creating a Grid

C. Mercator Transverse Cylindric

The projection surface is “rolled” out.

Central Meridian defines Grid North





Distance distortion

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C. Mercator Transverse Cylindric

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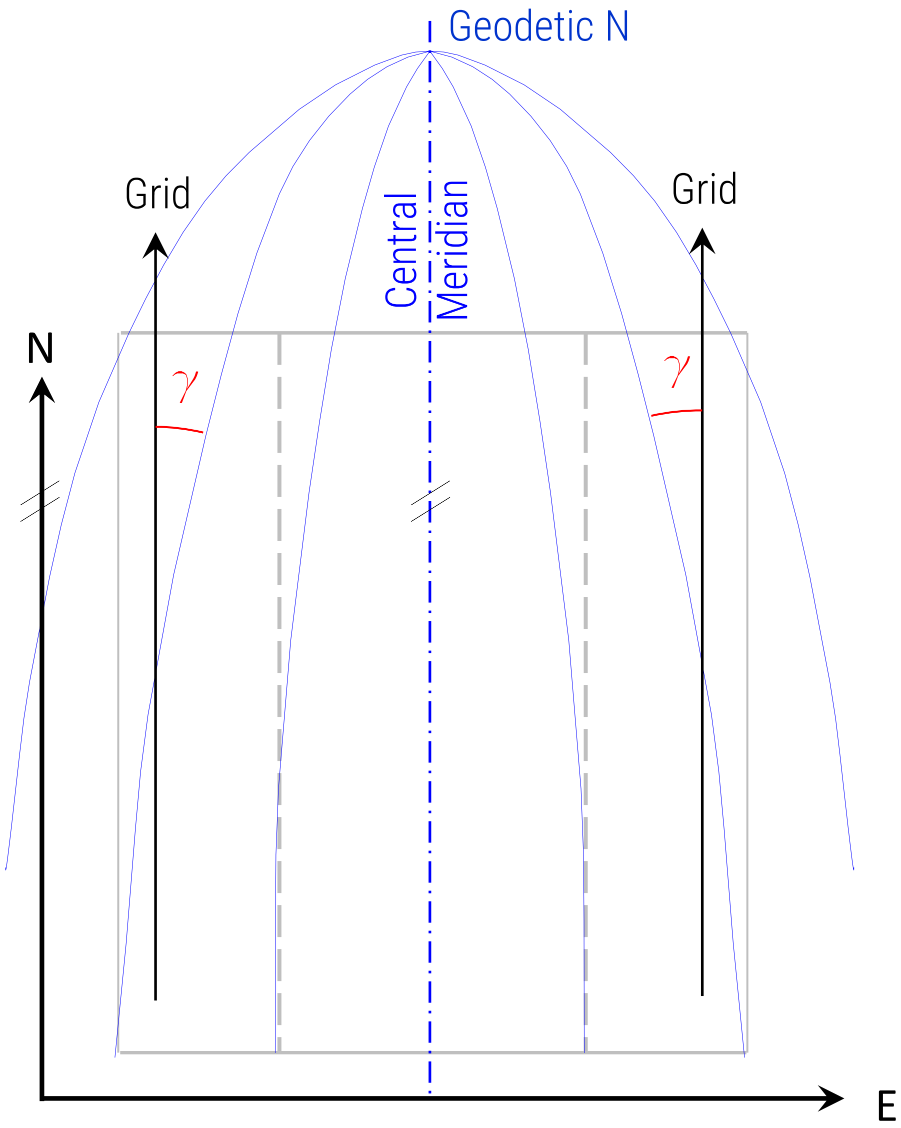
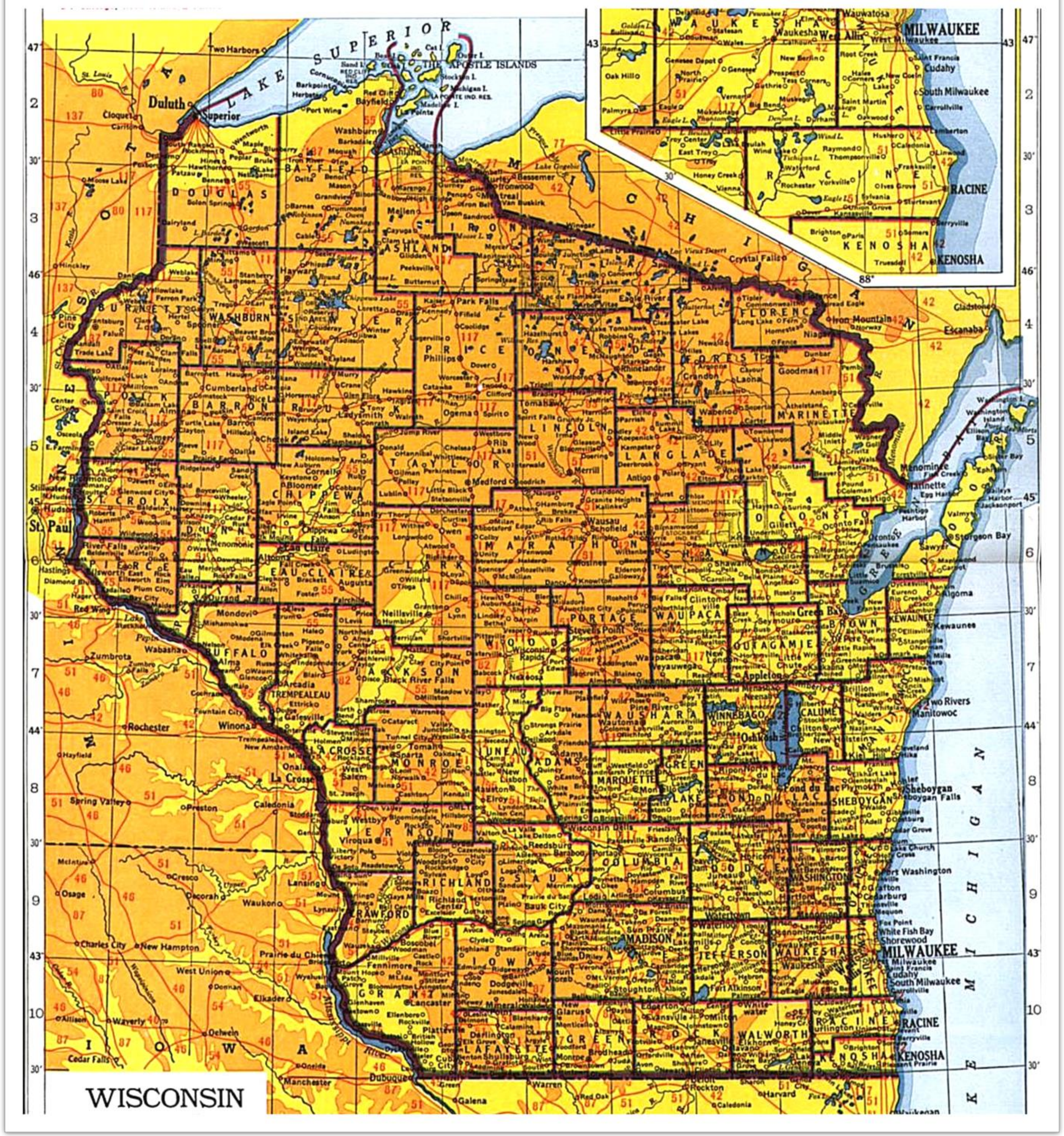


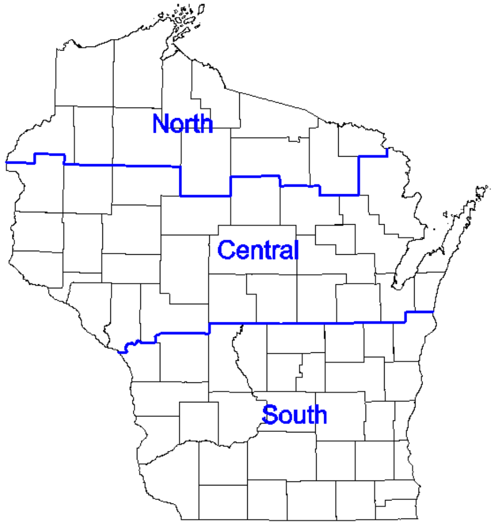


V. Wisconsin Coordinate Systems

V. Wisconsin Coordinate Systems

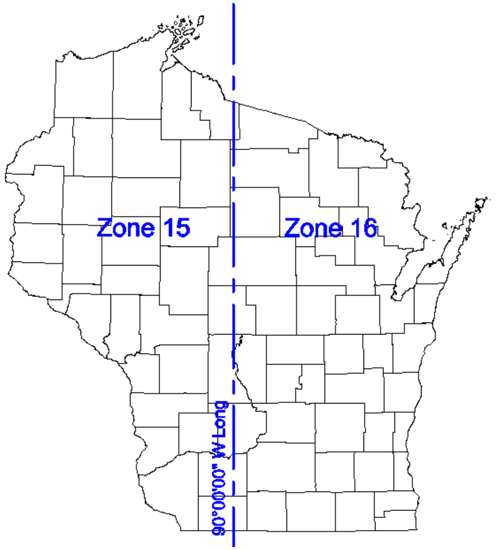
A. Nationally Defined & Supported

1. State Plane Coordinate (SPC) system



Projection	Conic
Zones	3
Max Distortion (ellipsoid to grid)	1/10,000

2. Universal Transverse Mercator (UTM)

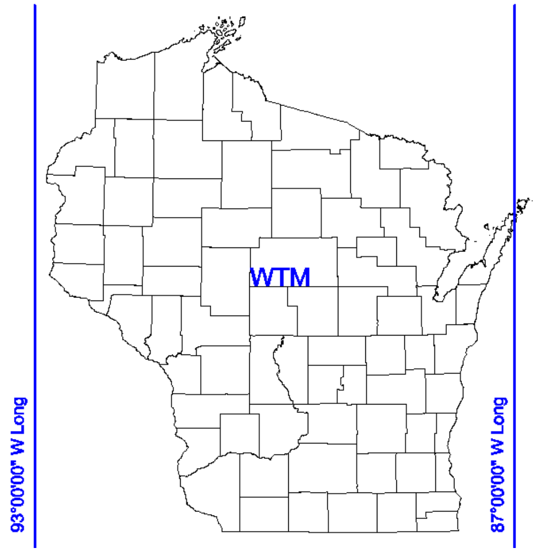


Projection	Cylindric
Zones	2
Max Distortion (ellipsoid to grid)	1/2500

V. Wisconsin Coordinate Systems

B. Locally Defined and Supported

1. Wisconsin Transverse Mercator (WTM) System



Projection	Cylindric
Zones	1
Max Distortion (ellipsoid to grid)	1/2500

Developed by WisDNR to facilitate statewide coverage on a single coord grid.

Modified UTM

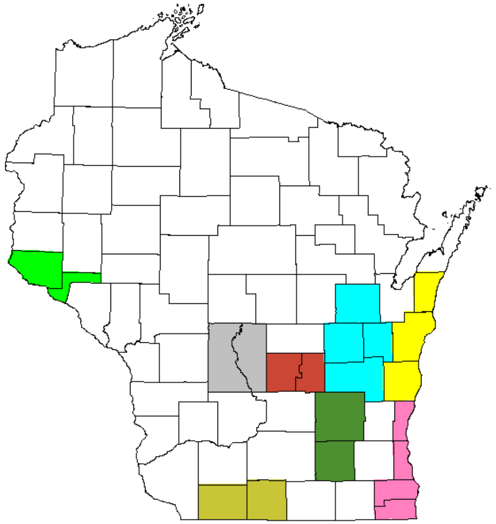
Cylindric projection rotated 3° placing it halfway between UTM Zones 15 & 16.

WisDNR data is generally provided in WTM system.

V. Wisconsin Coordinate Systems

B. Locally Defined and Supported

2. Low Distortion Projections



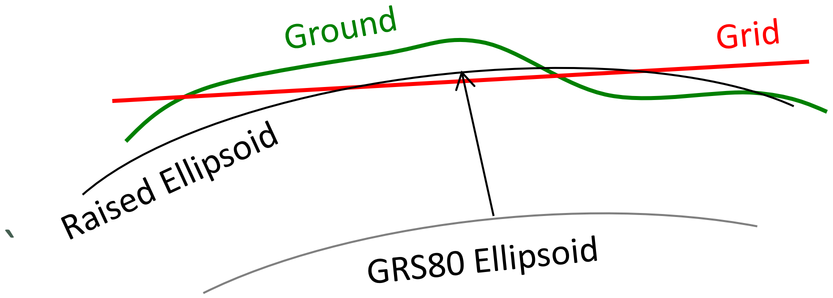
Projection	Cylindric & Conic
Zones	58
Max Distortion (ground to grid)	urban: 1/50,000 rural: 1/30,000

a. WCCS - Wis County Coord Systems

Original design.

All projections used raised ellipsoids

GRS80 + Ave Geoid ht + Median elev



Results in non-standard ellipsoid

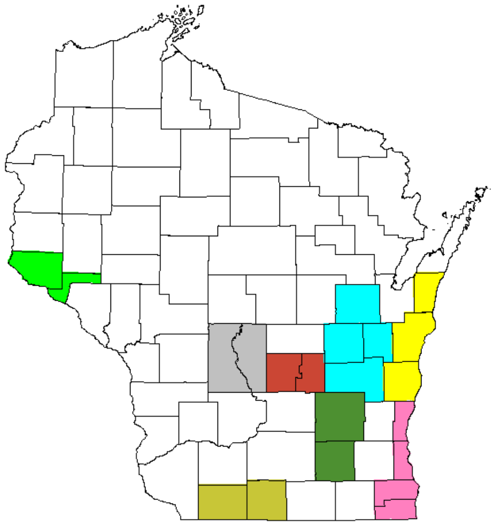
⇨ Different datum

Caused problems with some software.

V. Wisconsin Coordinate Systems

B. Locally Defined and Supported

2. Low Distortion Projections

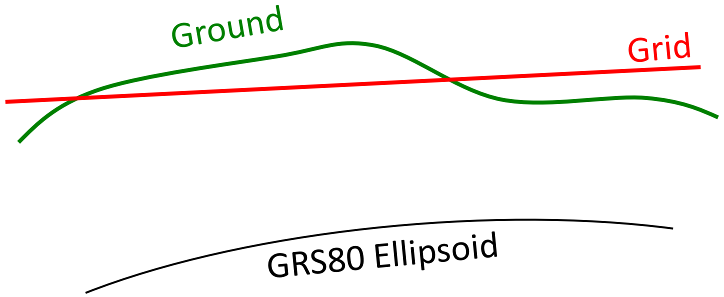


Projection	Cylindric & Conic
Zones	58
Max Distortion (ground to grid)	urban: 1/50,000 rural: 1/30,000

b. WisCRS - Wis Coord Reference Systems

WCCS redefinition

Same zones but each used GRS 80 ellipsoid directly.



Maintains accuracy with respect to WCCS.

Allowable design difference: ± 5 mm

VI. Ground and Grid

What's the beef?

VI. Ground and Grid

A. Distortion Compensation

1. Distance

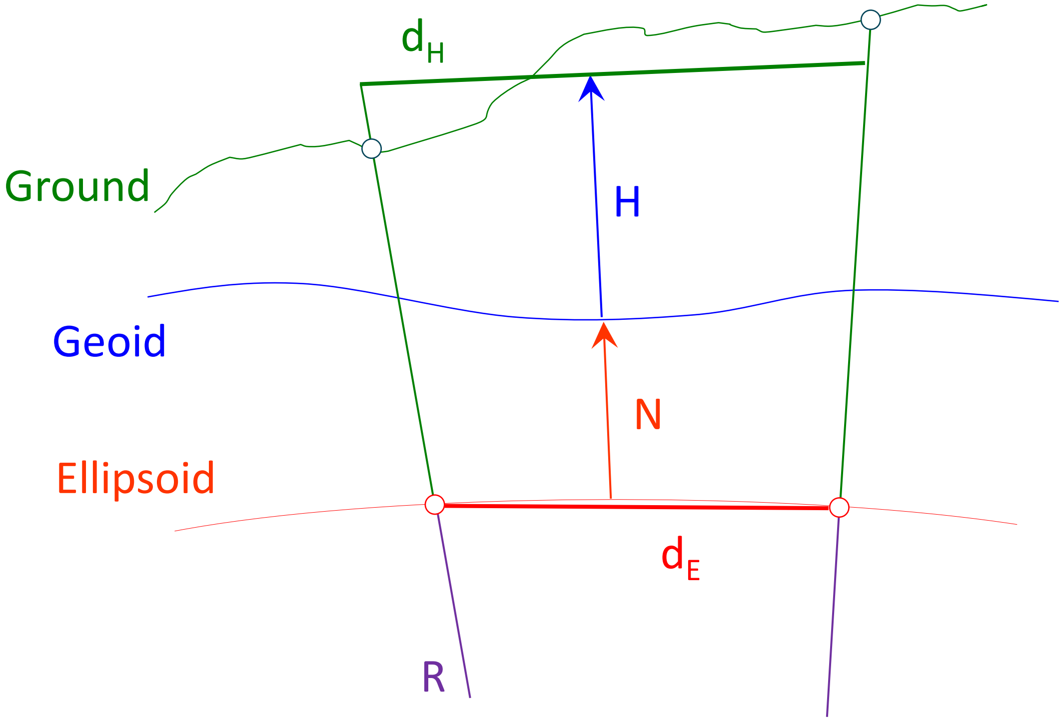
Two steps

a. Ground to ellipsoid

$$EF = \frac{R}{R + H + N}$$

$$d_E = d_H \times EF$$

d_H	Horizontal ground distance
d_E	Ellipsoidal (geodetic) distance
EF	Elevation Factor
R	Mean earth radius
H	Orthometric ht (elev)
N	Geoid height
k	Scale factor



R = 20,902,000 ft = 6,371,000 m (approx.)

VI. Ground and Grid

A. Distortion Compensation

1. Distance

Two steps

b. Ellipsoidal to grid

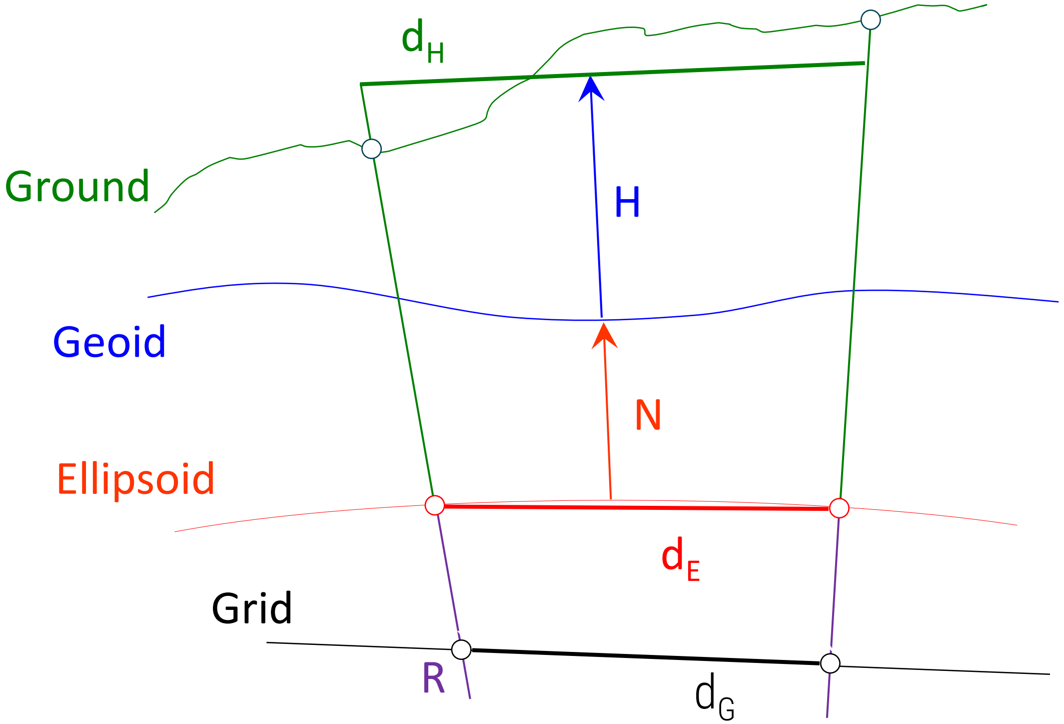
$$d_G = d_E \times k$$

d_G	Grid distance
d_E	Ellipsoidal (geodetic) distance
k	Grid scale factor

c. Combined factor

$$CF = EF \times k$$

$$d_G = d_H \times CF$$



VI. Ground and Grid

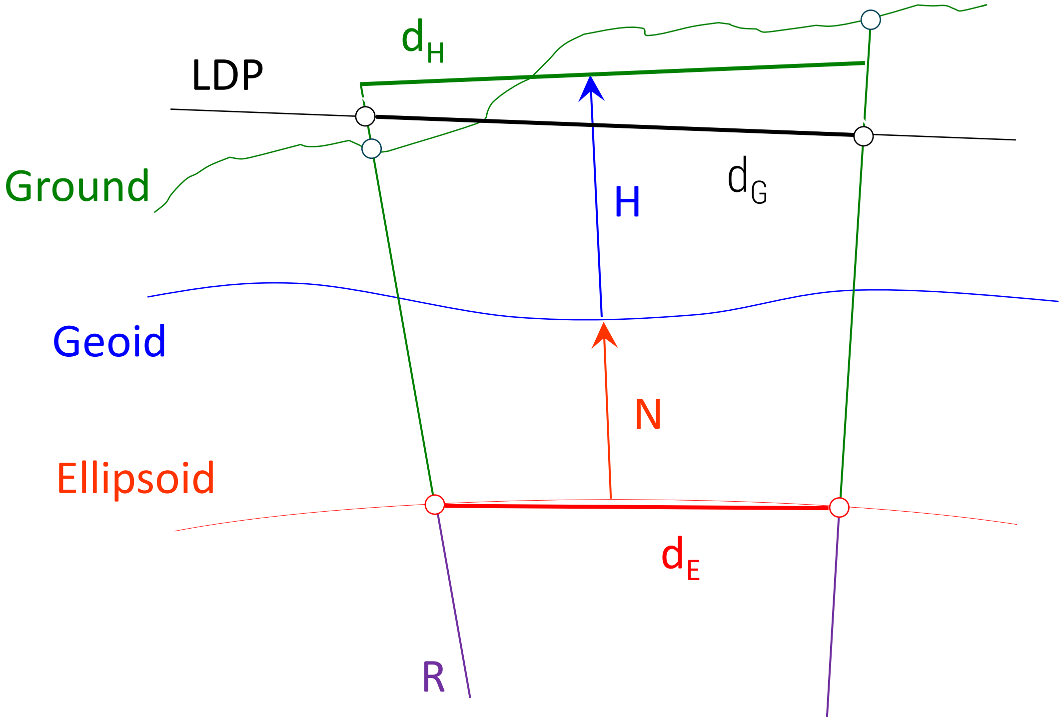
A. Distortion Compensation

1. Distance

c. LDP

Because a LDP grid is near-ground level, there may be no discernible difference between ground and grid distances.

Most of the time, this reduction can be ignored for both WCCS and WisCRS grids.



VI. Ground and Grid

A. Distortion Compensation

2. Direction

The convergence angle, γ, is **from** Geodetic N **to** Grid N

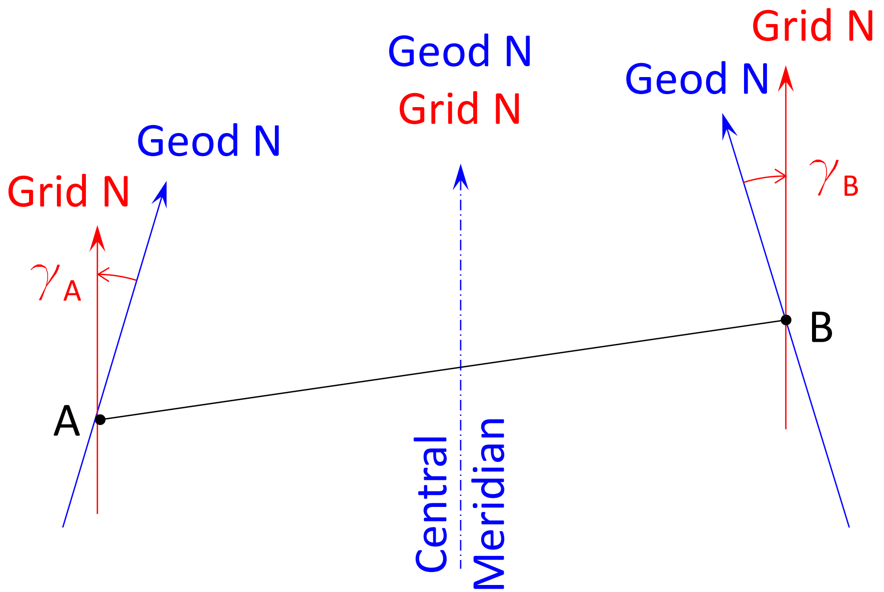
It is positive (cw) East of the CM, negative (ccw) West of the CM

To convert Geodetic (Ground) direction to Grid:

$$t = \alpha - \gamma$$

t	Grid azimuth
α	Geodetic azimuth
γ	Convergence

Might be significant for an LDP



VI. Ground and Grid

B. Reduction Elements

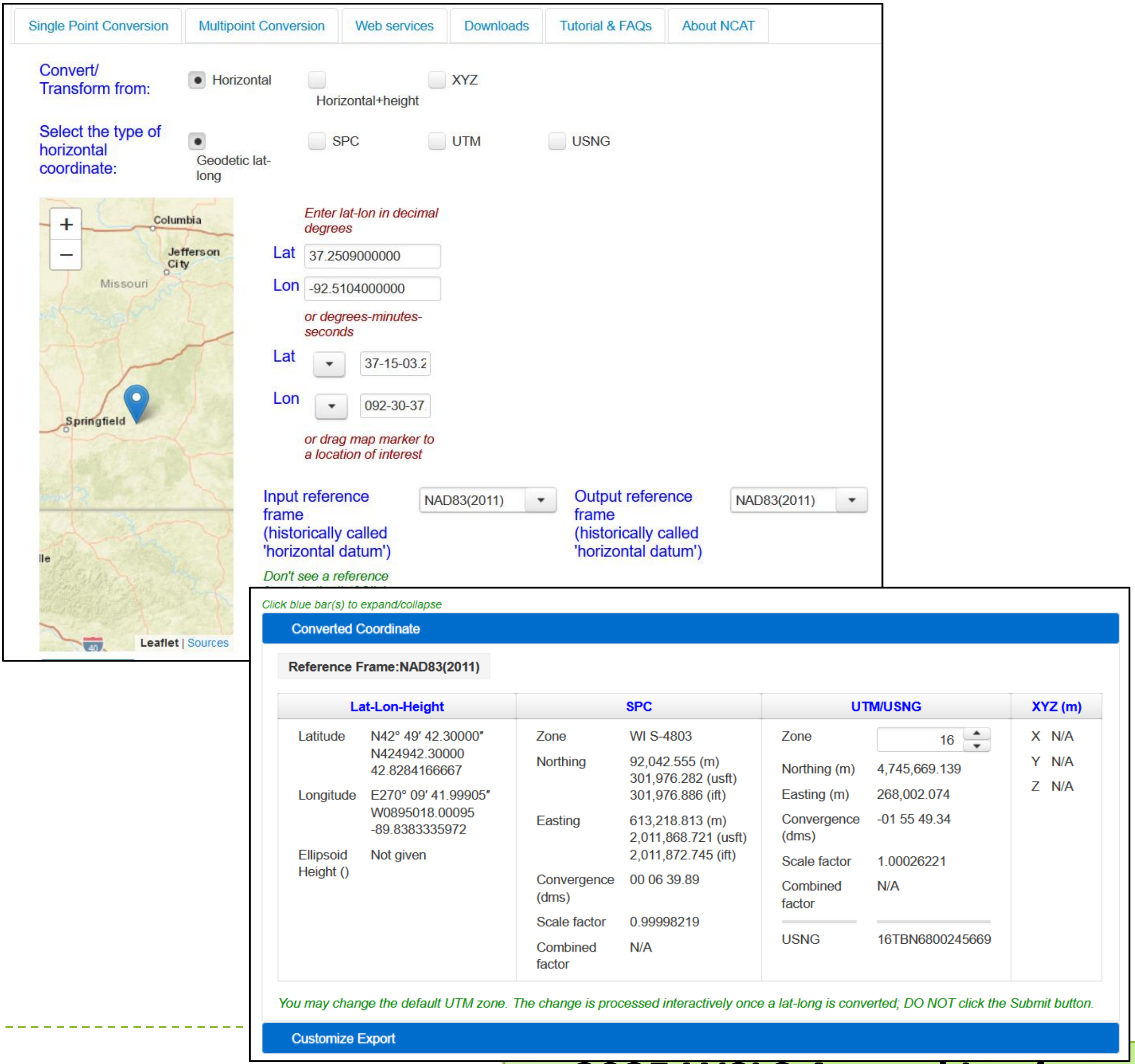
Where do we get the ortho and geoid heights, scale, and convergence angles?

NGS software (*Geodetic Tool Kit*):

NCAT[1]

GEOIDXX

Ortho heights from USGS topoquads



Convert/ Transform from: ● Horizontal ☐ Horizontal+height ☐ XYZ

Select the type of horizontal coordinate: ● Geodetic lat-long ☐ SPC ☐ UTM ☐ USNG

Enter lat-lon in decimal degrees

Lat 37.2509000000

Lon -92.5104000000

or degrees-minutes-seconds

Lat 37-15-03.2

Lon 092-30-37.

or drag map marker to a location of interest

Input reference frame (historically called 'horizontal datum') NAD83(2011)

Output reference frame (historically called 'horizontal datum') NAD83(2011)

Don't see a reference

Reference Frame:NAD83(2011)

Lat-Lon-Height		SPC		UTM/USNG		XYZ (m)	
Latitude	N42° 49′ 42.30000″ N424942.30000 42.8284166667	Zone	WI S-4803	Zone	16	X	N/A
Longitude	E270° 09′ 41.99905″ W0895018.00095 -89.8383335972	Northing	92,042.555 (m) 301,976.282 (usft) 301,976.886 (ift)	Northing (m)	4,745,669.139	Y	N/A
Ellipsoid Height ()	Not given	Easting	613,218.813 (m) 2,011,868.721 (usft) 2,011,872.745 (ift)	Easting (m)	268,002.074	Z	N/A
		Convergence (dms)	00 06 39.89	Convergence (dms)	-01 55 49.34		
		Scale factor	0.99998219	Scale factor	1.00026221		
		Combined factor	N/A	Combined factor	N/A		
				USNG	16TBN6800245669		

You may change the default UTM zone. The change is processed interactively once a lat-long is converted; DO NOT click the Submit button.

---

[1] *NCAT* does not currently support local LDPs. When NATRF2022 is adopted, *NCAT* will include NGS-accepted LDPs.

VI. Ground and Grid

B. Reduction Elements

NSRS

Datasheet

```
DESIGNATION -  JERRY
 PID         -  NH0936

______________________________________________________________________
* NAD 83(2011) POSITION- 42 54 24.02215(N) 089 43 53.76413(W)   ADJUSTED
* NAD 83(2011) ELLIP HT-   324.836 (meters)         (06/27/12)   ADJUSTED
* NAD 83(2011) EPOCH   -  2010.00
* NAVD 88 ORTHO HEIGHT -    358.6    (meters)      1177.     (feet) VERTCON

 ______________________________________________________________________
 GEOID HEIGHT      -         -33.902 (meters)                      GEOID18
 NAD 83(2011) X  -      21,919.631 (meters)                      COMP
 NAD 83(2011) Y  - -4,679,204.603 (meters)                      COMP
 NAD 83(2011) Z  -   4,320,134.562 (meters)                      COMP
 LAPLACE CORR      -           -0.36  (seconds)                    DEFLEC18

                   North          East      Units  Scale Factor Converg.
SPC WI S      -   100,758.292   621,917.891   MT  0.99996957   +0 11 03.9
SPC WI S      -   330,571.16  2,040,408.95   sFT  0.99996957   +0 11 03.9
UTM  16       - 4,754,071.382   277,008.712   MT  1.00021177   -1 51 37.6

              -  Elev Factor  x  Scale Factor =   Combined Factor
SPC WI S      -   0.99994906  x   0.99996957  =   0.99991863
UTM  16       -   0.99994906  x   1.00021177  =   1.00016082
```

At *Jerry*'s elevation

VI. Ground and Grid

C. Variations

1. Elevation factor, EF

$$EF = \frac{R}{R + H + N}$$

N doesn't change much so can generally use a single value over the project area.

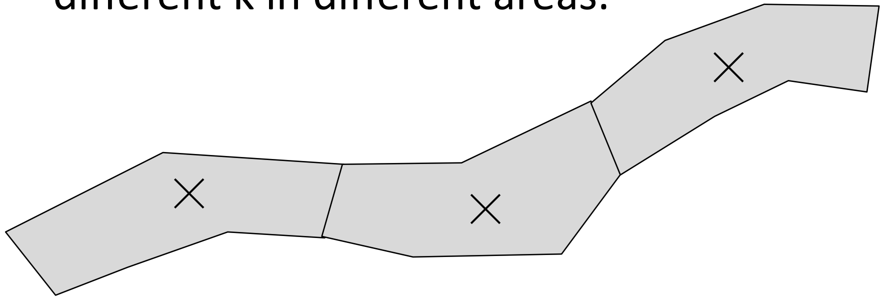
Depending on terrain, H can be:

- project area average – use for all lines
- computed average for each line

2. Grid scale, k

For relatively small projects, a single value at project center could be used.

Larger/longer projects would require applying different k in different areas.



SPC/UTM - use approx. lat & long with *NCAT* to determine k.

VI. Ground and Grid

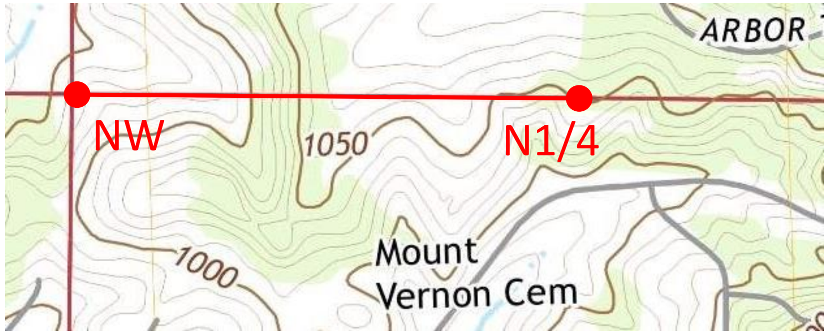
D. SPC Example

Quarter line NW-N1/4 of Sec 34 T5N R7E

Distance: 2638.25 ft

Bearing: S88°11’34”E

Determine WI SPC South zone grid distance and bearing from NW to N1/4



From topoquad

NW elev: 960 ft

N1/4 elev: 1050 ft

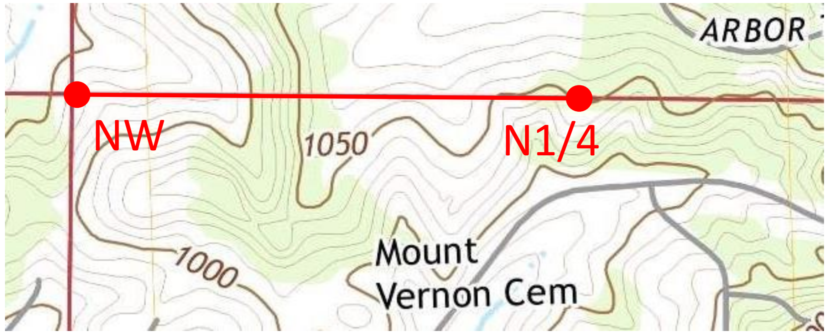
Approx position of NW corner is:

42°57.5' Lat

89°39.75' Long

VI. Ground and Grid

D. SPC Example



Quarter line NW-N1/4 of Sec 34 T5N R7E

Distance: 2638.25 ft

Bearing: S88°11’34”E

Determine WI SPC South zone grid distance and bearing from NW to N1/4

From topoquad

NW elev: 960 ft

N1/4 elev: 1050 ft

Approx position of NW corner is:

42°57.5' Lat

89°39.75' Long

From *NCAT*

k = 0.99996 224

γ = +0°13'53.46"

From *GEOID18*

N = -34.046 m

VI. Ground and Grid

D. SPC Example

1. Distance

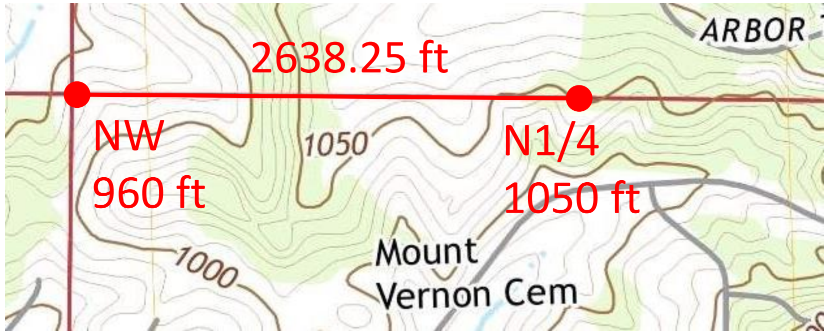
a. Ground to ellipsoid

$$H = \frac{960 + 1050}{2} = 1005$$

$$EF = \frac{20,902,000}{20,902,000 + 1005 + (-111.7)}$$

$$= 0.99995\ 7264$$

$$d_E = 2638.25 ft \times 0.99995\ 7264 = 2638.137 ft$$



R = **20,902,000 ft**

From *NCAT*

k = 0.99996 224

γ = +0°13'53.46"

From *GEOID18*

N = -34.046 m = **-111.7 ft**

VI. Ground and Grid

D. SPC Example

1. Distance

a. Ground to ellipsoid

$$H = \frac{960 + 1050}{2} = 1005$$

$$EF = \frac{20,902,000}{20,902,000 + 1005 + (-111.7)}$$

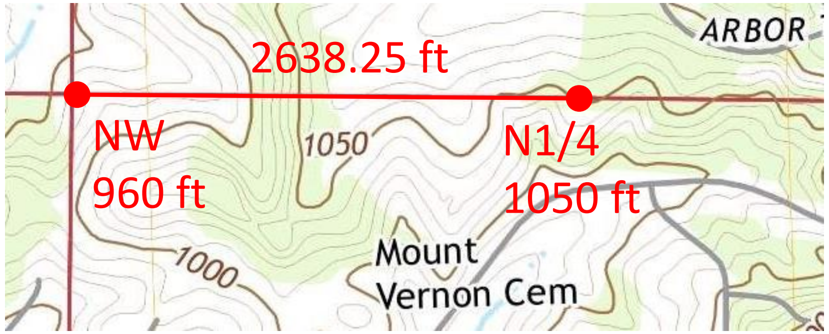
$$= 0.99995\ 7264$$

$$d_E = 2638.25ft \times 0.99995\ 7264 = 2638.137ft$$

b. Ellipsoid to grid

$$d_G = d_E \times k$$

$$d_G = 2638.137ft \times 0.99995\ 7264 = \underline{2638.024ft}$$



R = 20,902,000 ft

From *NCAT*

k = **0.99996 224**

γ = +0°13'53.46"

From *GEOID18*

N = -34.046 m = -111.7 ft

VI. Ground and Grid

D. SPC Example

2. Direction

Convert bearing to azimuth

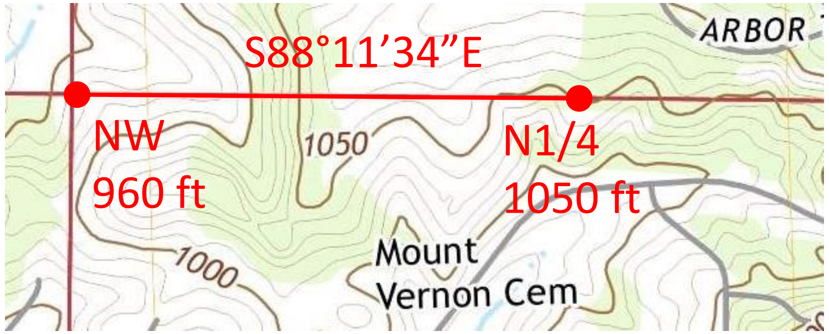
$$Az = 180°00'00'' - 88°11'34''$$
$$= 91°48'26''$$

Convert to Grid Az

$$Grid\ Az = 91°48'26'' - (+0°13'53'')$$
$$= 92°02'19''$$

Convert to bearing

$$Grid\ Brg = 180°00'00'' - 92°42'19''$$
$$= \underline{S87°17'41''E}$$



R = 20,902,000 ft

From *NCAT*

k = 0.99996 224

γ = **+0°13'53.46"**

From *GEOID18*

N = -34.046 m = -111.7 ft

VI. Ground and Grid

E. WCCS/WisCRS

1. Reduction Elements

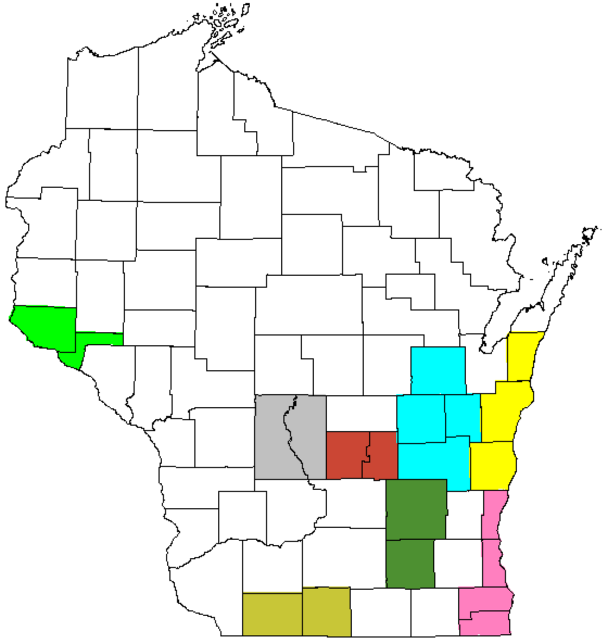
LDPs are not supported by *NCAT*, how to get N, convergence, and scale?

N: Use *GEOIDXX*, but need geodetic coordinates.

γ and k: ?

Need LDP-specific software.

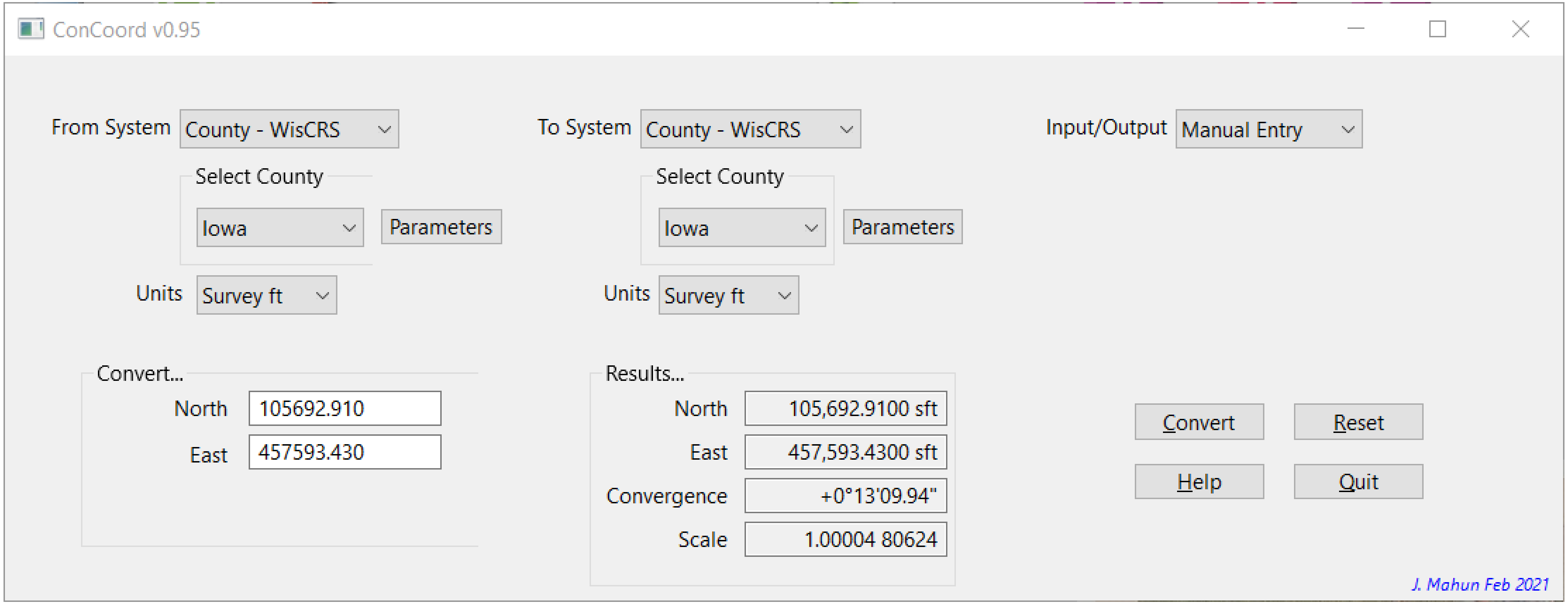
Some surveying and mapping software have support for LDPs, including Wisconsin's.



VI. Ground and Grid

E. WCCS/WisCRS

2. *ConCoord v0.95* At https://jerrymahun.com



ConCoord v0.95

From System: County - WisCRS

Select County: Iowa

Units: Survey ft

To System: County - WisCRS

Select County: Iowa

Units: Survey ft

Input/Output: Manual Entry

Convert...

North	105692.910
East	457593.430

Results...

North	105,692.9100 sft
East	457,593.4300 sft
Convergence	+0°13'09.94"
Scale	1.00004 80624

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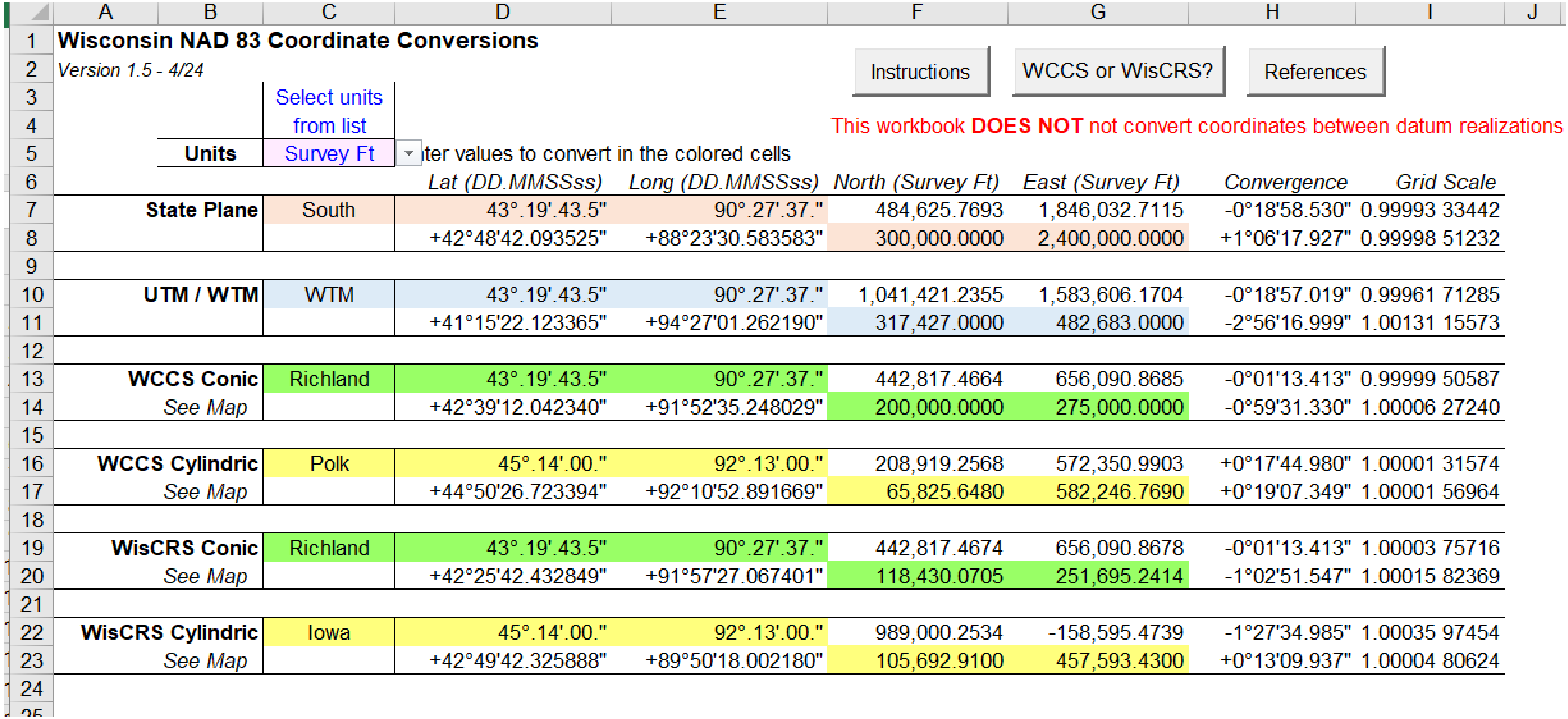
VI. Ground and Grid

E. WCCS/WisCRS

3. *Wis83CoordConv1-5.xlsm* At https://jerrymahun.com



Wisconsin NAD 83 Coordinate Conversions

Version 1.5 - 4/24

Select units from list

Units Survey Ft

This workbook **DOES NOT** not convert coordinates between datum realizations

ter values to convert in the colored cells

		Lat (DD.MMSSss)	Long (DD.MMSSss)	North (Survey Ft)	East (Survey Ft)	Convergence	Grid Scale
State Plane	South	43°.19'.43.5"	90°.27'.37."	484,625.7693	1,846,032.7115	-0°18'58.530"	0.99993 33442
		+42°48'42.093525"	+88°23'30.583583"	300,000.0000	2,400,000.0000	+1°06'17.927"	0.99998 51232
UTM / WTM	WTM	43°.19'.43.5"	90°.27'.37."	1,041,421.2355	1,583,606.1704	-0°18'57.019"	0.99961 71285
		+41°15'22.123365"	+94°27'01.262190"	317,427.0000	482,683.0000	-2°56'16.999"	1.00131 15573
WCCS Conic	Richland	43°.19'.43.5"	90°.27'.37."	442,817.4664	656,090.8685	-0°01'13.413"	0.99999 50587
See Map		+42°39'12.042340"	+91°52'35.248029"	200,000.0000	275,000.0000	-0°59'31.330"	1.00006 27240
WCCS Cylindric	Polk	45°.14'.00."	92°.13'.00."	208,919.2568	572,350.9903	+0°17'44.980"	1.00001 31574
See Map		+44°50'26.723394"	+92°10'52.891669"	65,825.6480	582,246.7690	+0°19'07.349"	1.00001 56964
WisCRS Conic	Richland	43°.19'.43.5"	90°.27'.37."	442,817.4674	656,090.8678	-0°01'13.413"	1.00003 75716
See Map		+42°25'42.432849"	+91°57'27.067401"	118,430.0705	251,695.2414	-1°02'51.547"	1.00015 82369
WisCRS Cylindric	Iowa	45°.14'.00."	92°.13'.00."	989,000.2534	-158,595.4739	-1°27'34.985"	1.00035 97454
See Map		+42°49'42.325888"	+89°50'18.002180"	105,692.9100	457,593.4300	+0°13'09.937"	1.00004 80624

VI. Ground and Grid

F. WisCRS Example

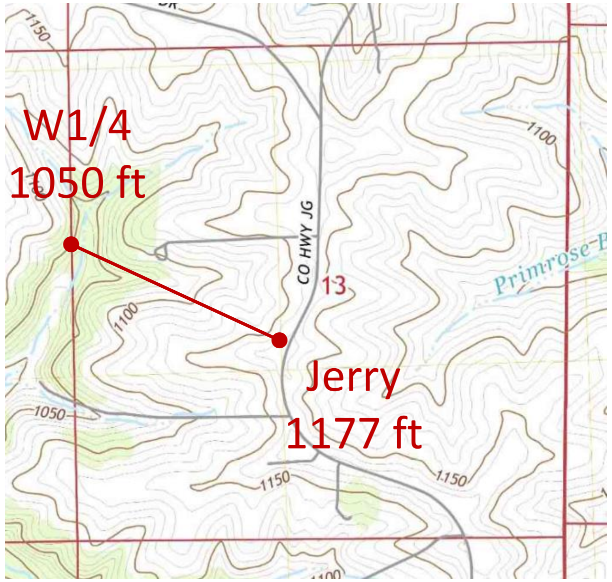
NSRS point *Jerry* to *W1/4* cor Sec 13 T5N R6E

Distance: 2313.88 ft

Azimuth: 283°39'44"

Elev: 1050 ft (topoquad)

What are the distance and direction in the WisCRS Dane County Coord System?



Jerry's data sheet has H and N, but not Dane Co coords data.

Must compute needed elements.

Use *Jerry*'s Lat and Long in *ConCoord.*

Pt *Jerry*

42°54'24.02215" Lat

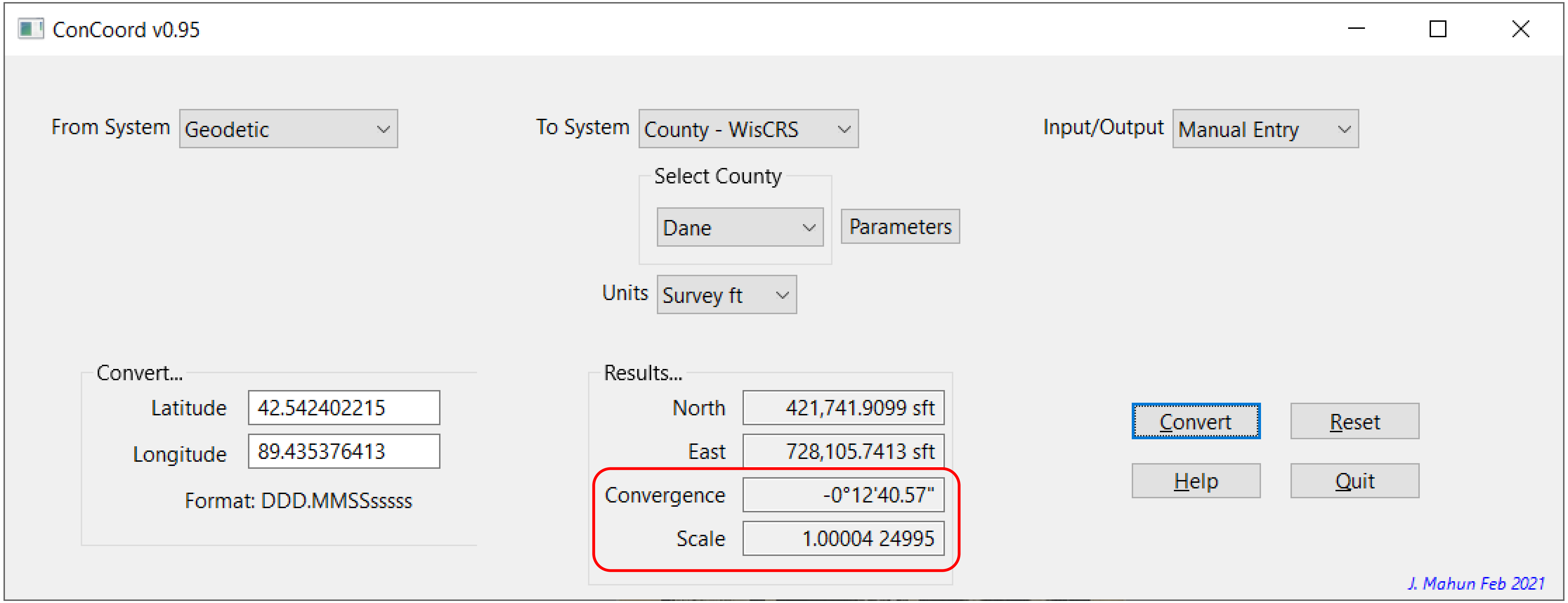
89°43'53.76413" Long

H = 1177 ft

N = -33.902 m = 111.2 ft

VI. Ground and Grid

F. WisCRS Example



From System: Geodetic

To System: County - WisCRS

Input/Output: Manual Entry

Select County: Dane

Units: Survey ft

Convert...

Latitude: 42.542402215

Longitude: 89.435376413

Format: DDD.MMSSsssss

Results...

North: 421,741.9099 sft

East: 728,105.7413 sft

Convergence: -0°12'40.57"

Scale: 1.00004 24995

J. Mahun Feb 2021

VI. Ground and Grid

F. WisCRS Example

1. Distance

$$H = \frac{1177 + 1050}{2} = 1113.5$$

$$EF = \frac{20902000}{20902000 + 1113.5 + (-111.2)}$$

$$= 0.999952050$$

$$CF = 0.99995\ 2050 \times 1.00004\ 24995$$

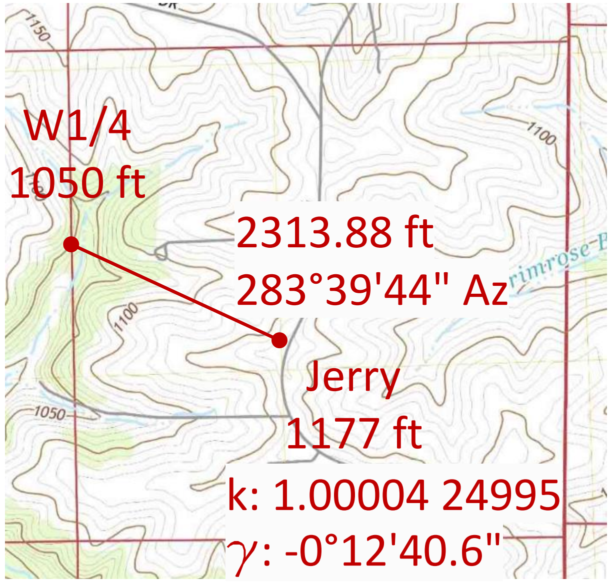
$$= 0.99999\ 4547$$

$$d_G = 2313.88ft \times 0.99999\ 4547 = \underline{2313.867ft}$$

2. Direction

$$Grid\ Az\ = 283°39'44'' - (-0°12'40.6'')$$

$$= \underline{283°52'24.6''}$$



F. WisCRS Example

1. Distance

$$H = \frac{1177 + 1050}{2} = 1113.5$$

$$EF = \frac{20902000}{20902000 + 1113.5 + (-111.2)}$$

$$= 0.999952050$$

$$CF = 0.99995\ 2050 \times 1.00004\ 24995$$

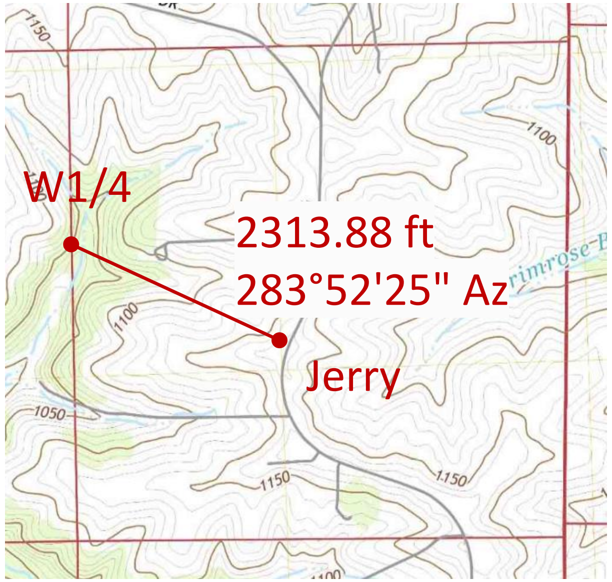
$$= 0.99999\ 4547$$

$$d_G = 2313.88ft \times 0.99999\ 4547 = \underline{2313.867ft}$$

2. Direction

$$Grid\ Az = 283°39'44'' - (-0°12'40.6'')$$

$$= \underline{283°52'24.6''}$$



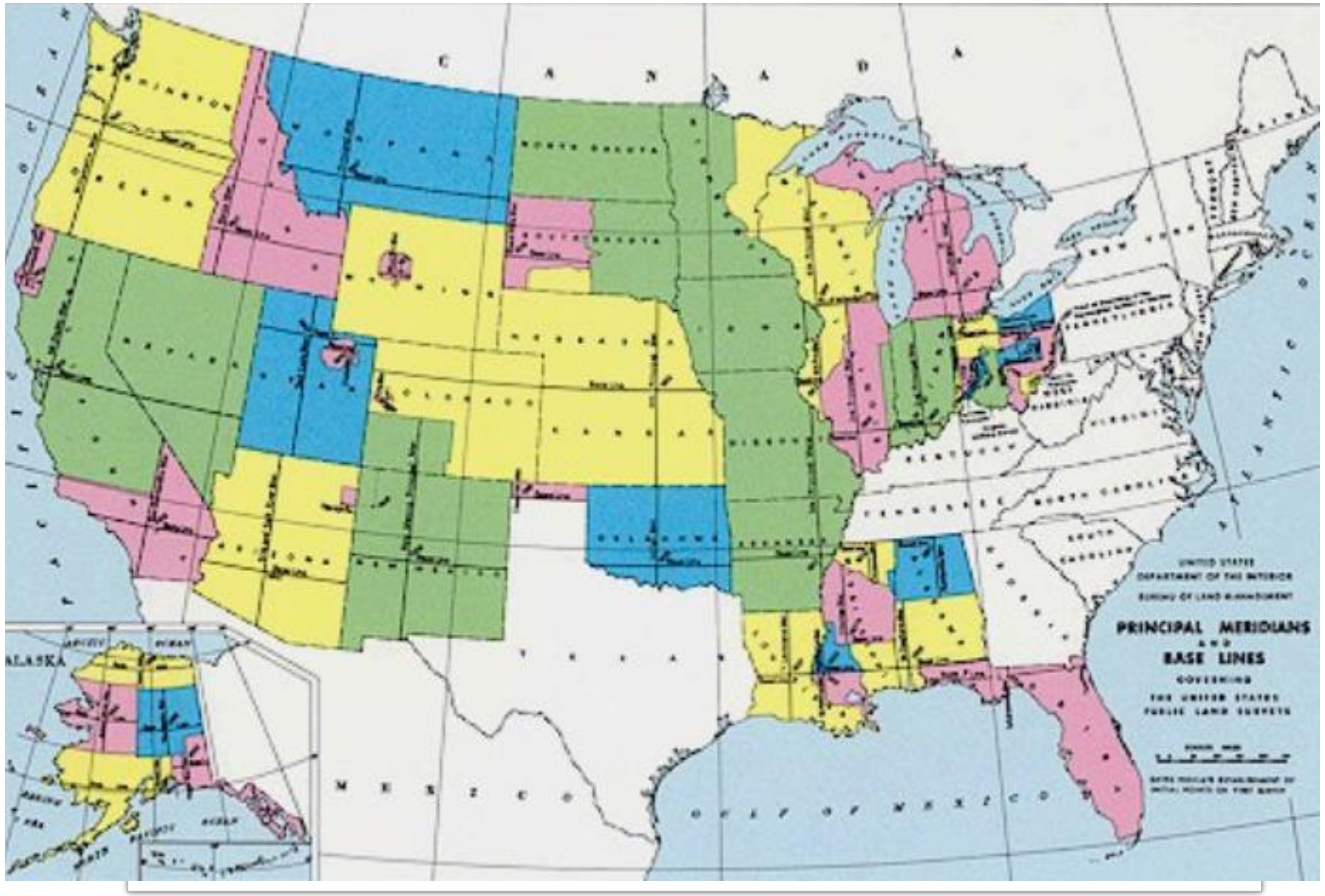
Distance distortion?

$$\frac{1}{1-CF} = \frac{1}{1-0.999994547} = 183385$$

$$\Rightarrow {}^{1}\!/_{183,400}$$

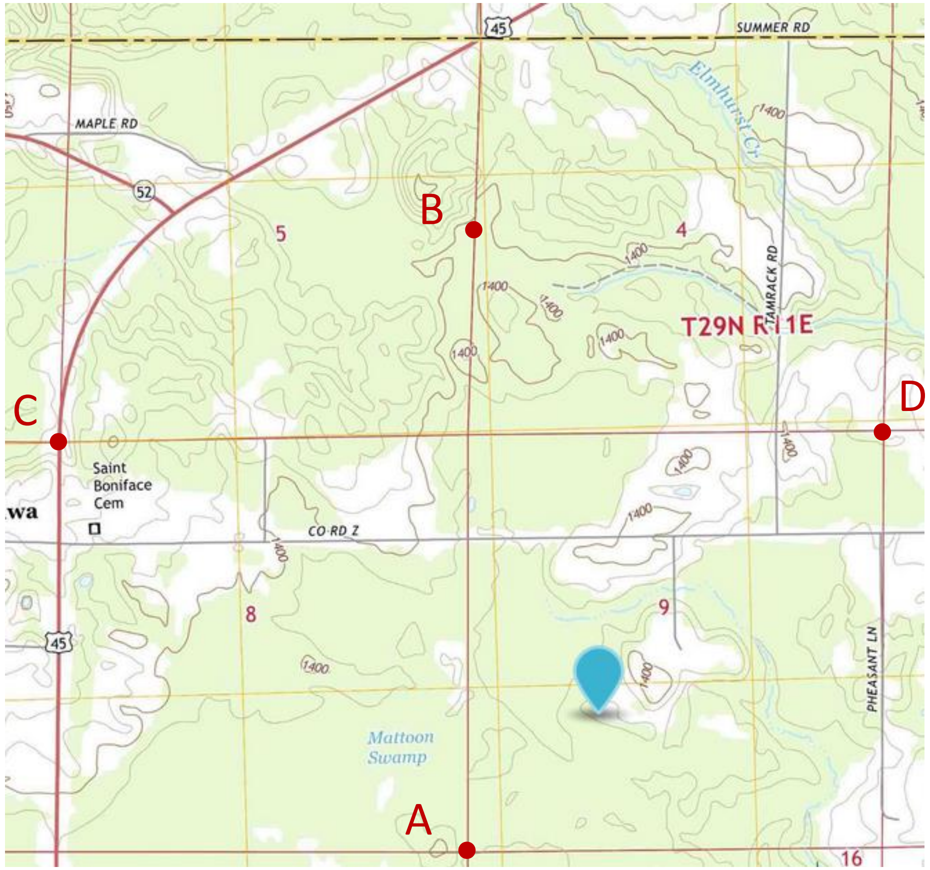
Can ignore reduction

VII. Grids and PLSS Lost Corners



VII. Grids and PLSS Lost Corners

A. Cardinal Equivalents



Proportionate Measurement

Recreating original locations based on record and contemporary measurements.

Proportioning.

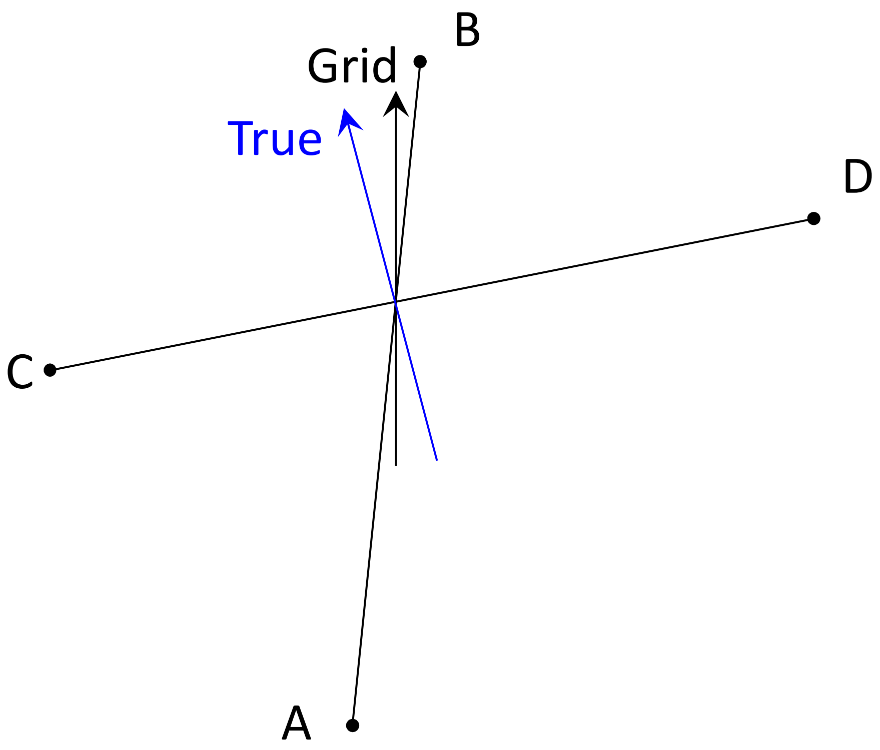
PLSS Manual states that proportioning must be done in *cardinal directions*

True N/S & True E/W

(*2009 Manual* treats Geodetic and True the same, which isn't *technically* correct, but close enough.)

VII. Grids and PLSS Lost Corners

A. Cardinal Equivalents

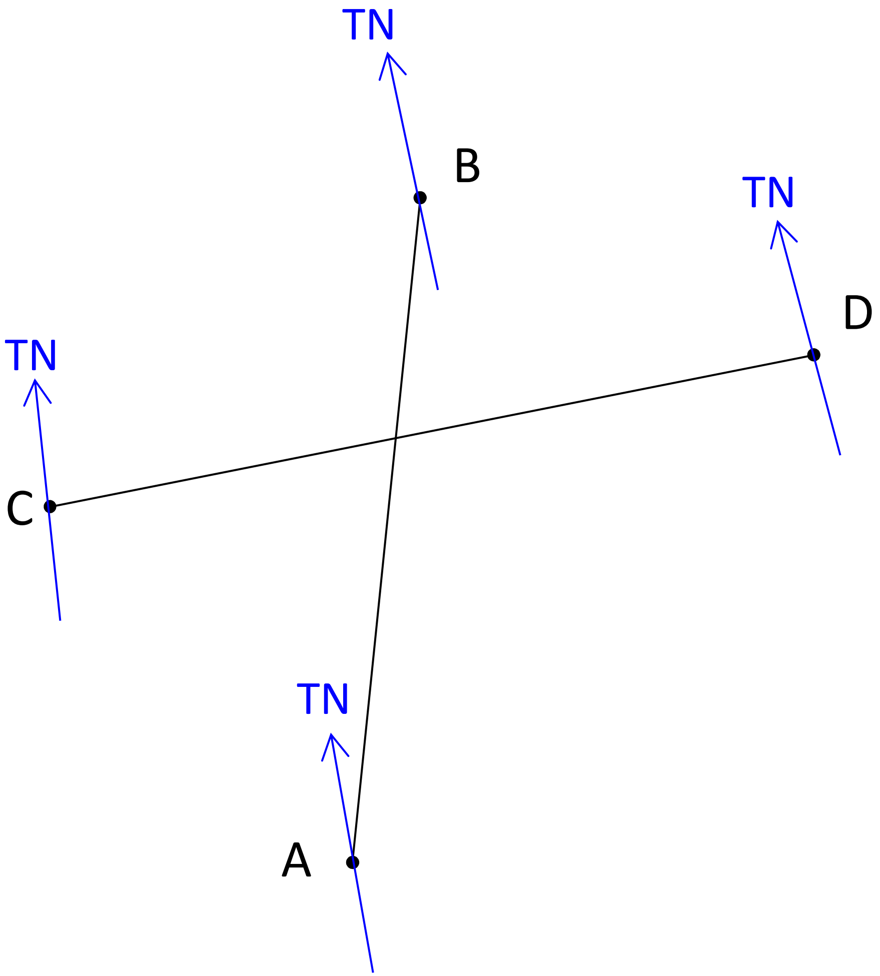


Proportionate Measurement

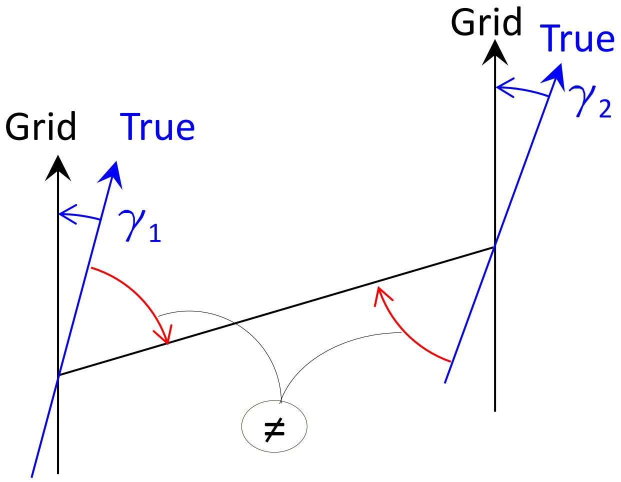
If working in a grid system must compensate for convergence.

- Before or after proportioning?
- How?
  - γ = f(Longitude) - it's not constant along E/W lines
- Is its effect significant?

B. Double Proportionate Procedure

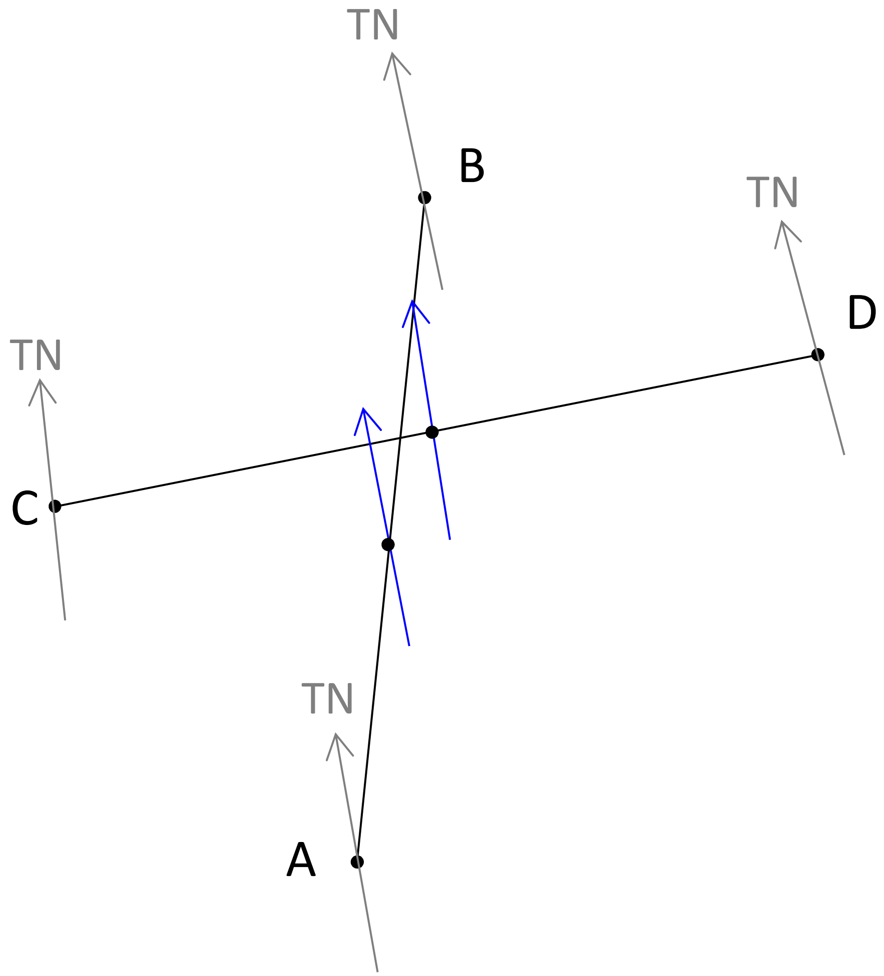


1. Compensate Before Proportioning
   - Compute grid bearings from coordinates
   - Determine convergence at each point
   - Convert grid to true directions
     - True directions are not exactly 180° apart



VII. Grids and PLSS Lost Corners

B. Double Proportionate Procedure



1. Compensate Before Proportioning

PLSS Manual: use mean bearing of a line for its cardinal computations.

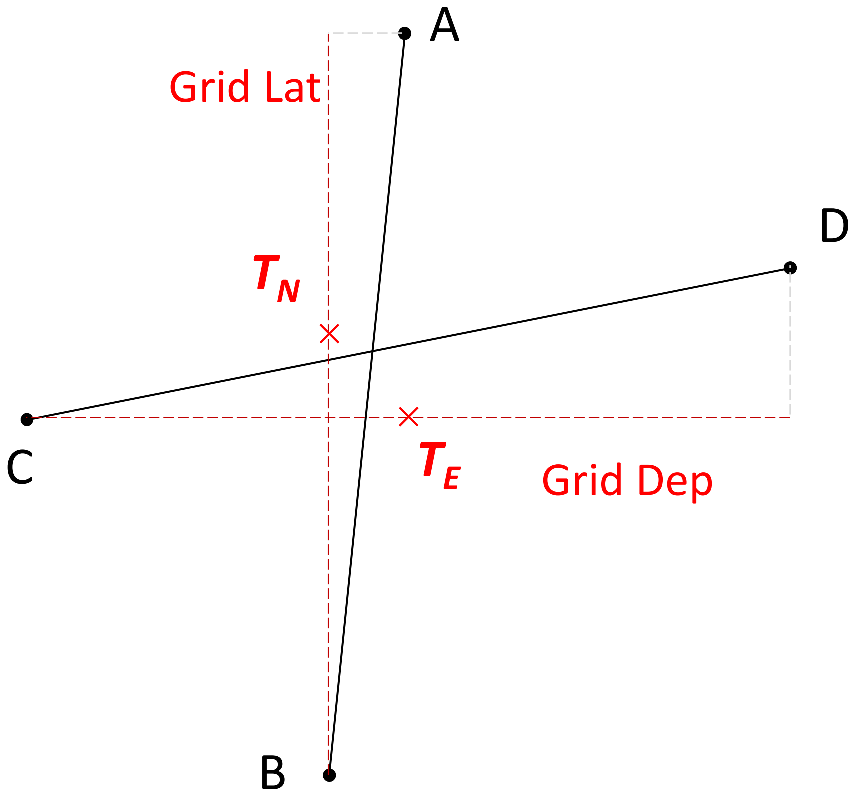
Compute the true bearings at line midpoints.

Then compute cardinal equivalents.

Continue regular DPM process.

VII. Grids and PLSS Lost Corners

B. Double Proportionate Procedure



2. Compensate After Proportioning

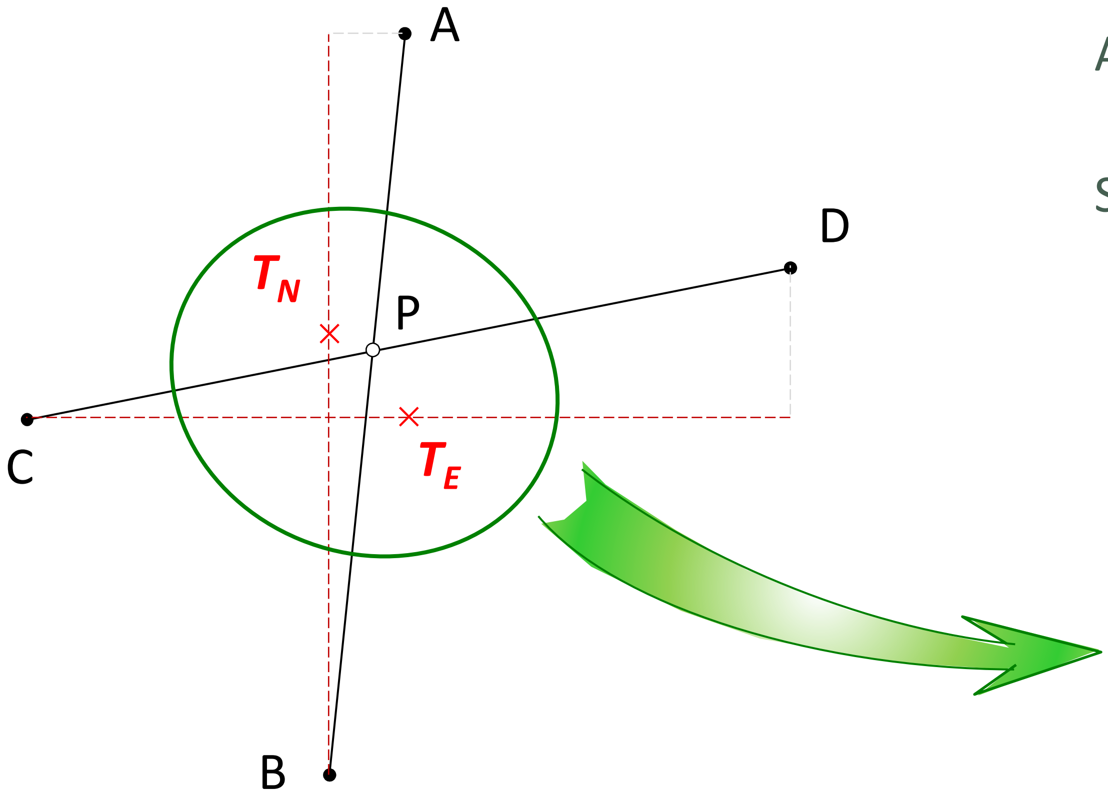
Set temporary points using grid equivalents

N-S	Grid Brng$_{AB}$	Grid Dist$_{AB}$
	Grid Lat$_{AB}$	Grid Dep$_{AB}$
Set T_N by SPM		
E-W	Grid Brng$_{CD}$	Grid Dist$_{CD}$
	Grid Lat$_{AB}$	Grid Dep$_{AB}$
Set T_E by SPM		

Compute γ_N and γ_E at the temp points.

VII. Grids and PLSS Lost Corners

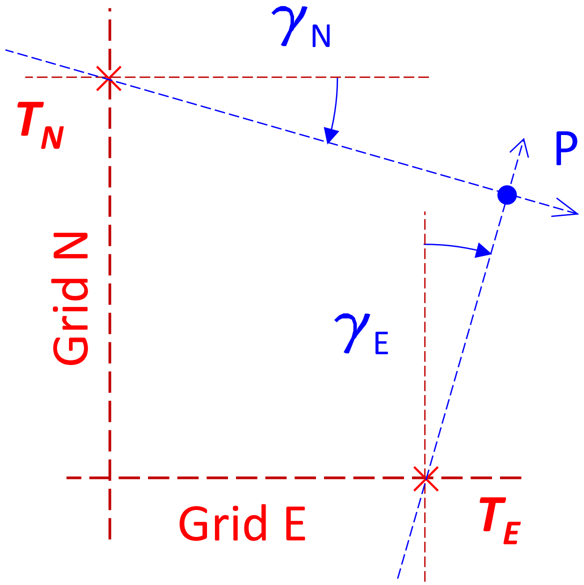
B. Double Proportionate Procedure



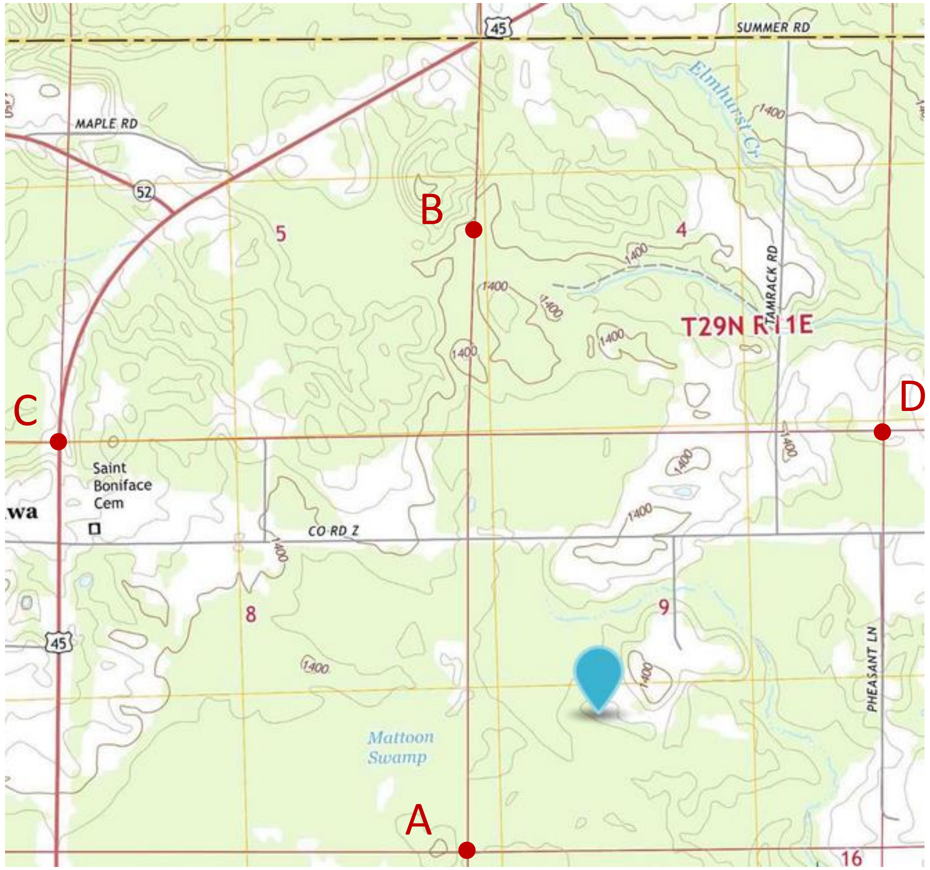
2. Compensate After Proportioning

At the two temporary points project lines rotated γ_N and γ_E from Grid N and Grid E.

Set lost corner at intersection of the lines.



C. Significant Effect?



Does ignoring convergence affect corner position?

Example: Shawano County

SW cor S4 T29N R11E is lost.

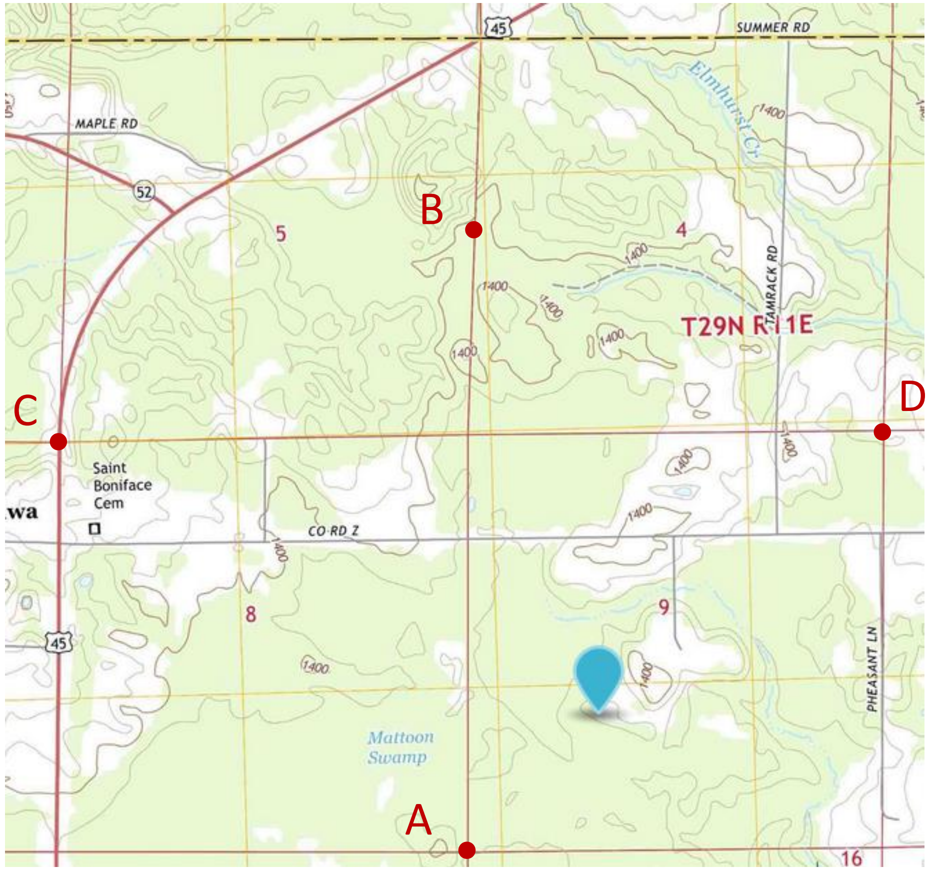
Existing corners and their Shawano Co WisCRS coordinates are:

ID	*Corner*	*North (ft)*	*East (ft)*	γ
A	SW S9	352,289.81	711,348.81	-0°24'32"
B	W1/4 S4	360,188.90	711,493.25	-0°24'33"
C	SW S5	357,550.43	706,134.07	-0°25'25"
D	SE S4	357,607.73	716,672.60	-0°23'46"

γ computed using *ConCoord*,

VII. Grids and PLSS Lost Corners

C. Significant Effect?



Does convergence have a significant effect?

Computed values

Pt	*North (ft)*	*East (ft)*	γ
T_N	357,556.08	711,348.74	-0°24'33"
T_E	357,550.43	711,403.34	-0°24'33"

Pt	*North (ft)*	*East (ft)*	*Convergence*
SW4	357,556.08	711,403.34	Not applied
SW4	357,555.69	711,403.37	Applied

Coordinates are close, but the two positions are 0.39 ft apart.

Enough for a pin cushion.

I. Spatial Systems

II. Distortions

III. Earth Models

IV. Creating a Grid

V. Wisconsin Coordinate Systems

VI. Ground and Grid

VII. Grids and PLSS Lost Corners

Grid⬖⬗Ground - Simple, Right?