GIST 7128
ArcGIS 1: Introduction

Lecture 2
Mapping Fundamentals

Module 2 Topics

- **Lecture**
  - Map Scale
  - Map Projections & Coordinate Systems
  - Map Projections in ArcGIS
- **Lab**
  - Chapter **5**. Exploring Online Resources
  - Chapter **6**. Working with Coordinate Systems and Projections
- **Project**
  - EastCity – Part **1**: Create New Map and Add Data (4%)
- **Quiz:** *Compressed Course: end of day // Evening Course: next week*
  - Lectures 1 & 2, Text chapters/labs 1-4 & 6
  - Short Answer, T/F, and Multiple Choice (5%)
  - Some practical questions using ArcMap and ArcCatalog

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Map Scale

Scale represents the relationship (or ratio) between measurements on a map compared to the same measurements on the earth's surface.

$$\text{Scale} = \frac{\text{Map Distance}}{\text{Ground Distance}}$$

Scale can be expressed in three ways:

1. Statement Scale

- Map Distance = Ground Distance
- Any values and units on each side
  - ½ in = 1 mile
  - 1 in = 5 miles
  - 2 cm = 10 km

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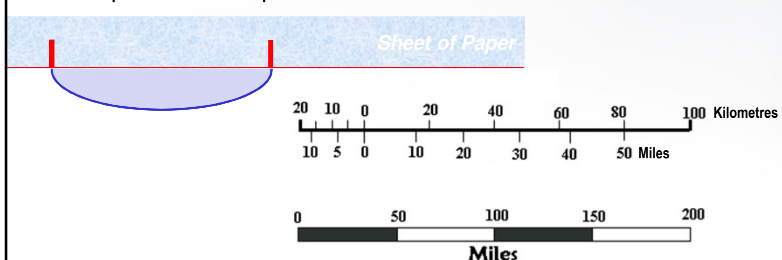
2. Scale Bar

- Graphical – easy to use (with sheet of paper)
- Most useful when final map size is subject to change (e.g. hardcopy reproduction, computer screen, projection)
- Units can be metric and/or imperial
- The left end is often subdivided into sub-units in order to provide more precise measurement



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3. Representative Fraction (RF)

- RF states the amount of reduction as a fraction or ratio
  – e.g. 1/100,000 → **1:100,000**

1. **Left side is always "1"**
2. **Unitless** – any unit can be applied to left and right sides

   – e.g. 1:5,000 → 1 cm = 5,000 cm → 1 inch = 5,000 inch

- Often used as map series designation (e.g. 1:50,000 NTS maps)
- 1:2,000 is a <u>larger</u> scale than 1:10,000
  – because 1/2,000 is larger than 1/10,000
- Remember with "map features appear <u>larger</u> at large scales"

- 1 cm = 1 km is the same as an RF of 1: ____________

- RF of 1:25,000 is the same as 1 cm = ___________ km

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Large vs Small Map Scales

Category *(nominal)*	Scale	Example Map	20 cm wide
Very Large Scale	1:1,000	City Block	
Large Scale	1:10,000	Neighbourhood	
Medium Scale	1:100,000	City	
Small Scale	1:1,000,000	County/Region	
Very Small Scale	1:10,000,000	Prov/State/Country	

<u>Large</u> Scale
→ <u>large</u> fraction (*small* denominator)
→ map features appear <u>large</u>
→ map area is *small*

<u>Small</u> Scale
→ <u>small</u> fraction (*large* denominator)
→ map features appear <u>small</u>
→ map area is *large*

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Map Scale Samples

Scale = 1: ______________ **(Small Scale)**

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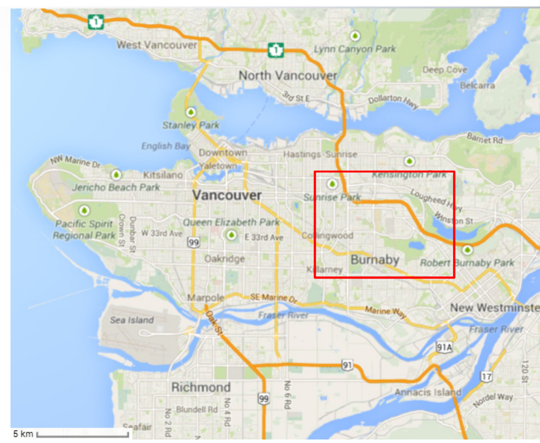

Scale = 1: ______________ **(Medium Scale)**

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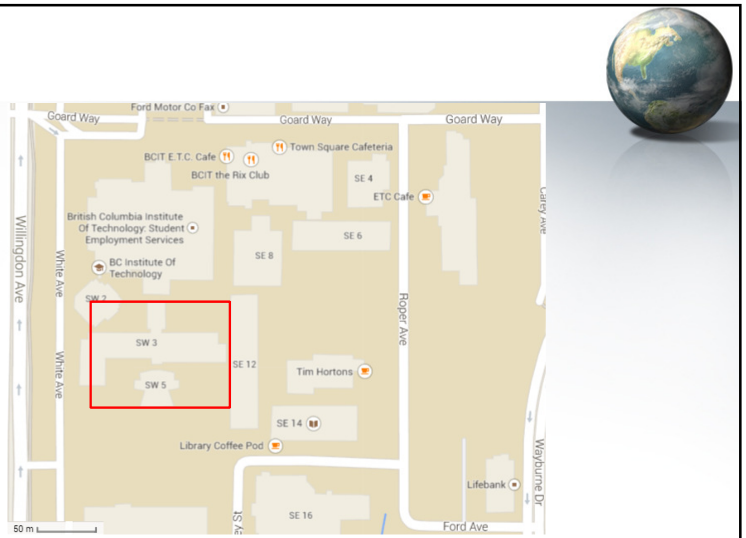

Scale = 1: ________________ **(Large Scale)**

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Map Projection Example

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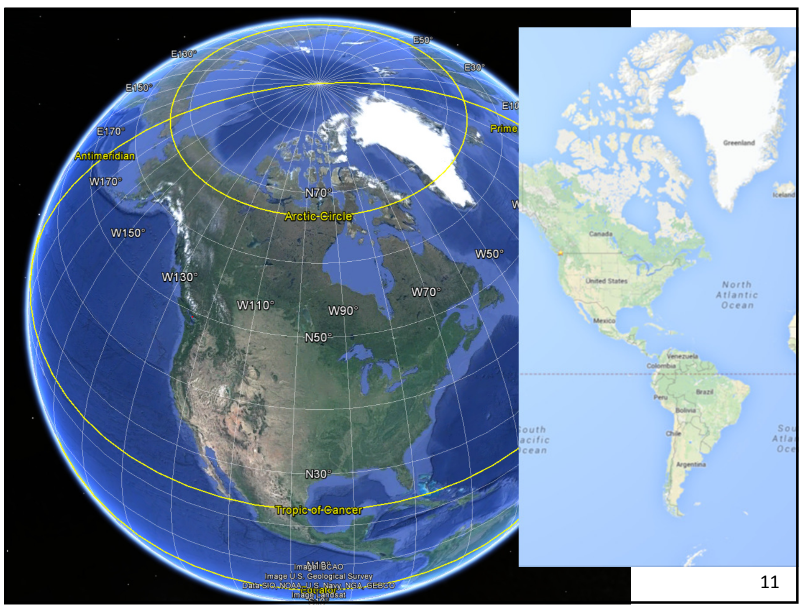

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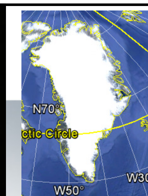

Greenland

- 2,166,086 km^2
- 12th largest country

Argentina

- 2,780,400 km^2
- 8th largest country

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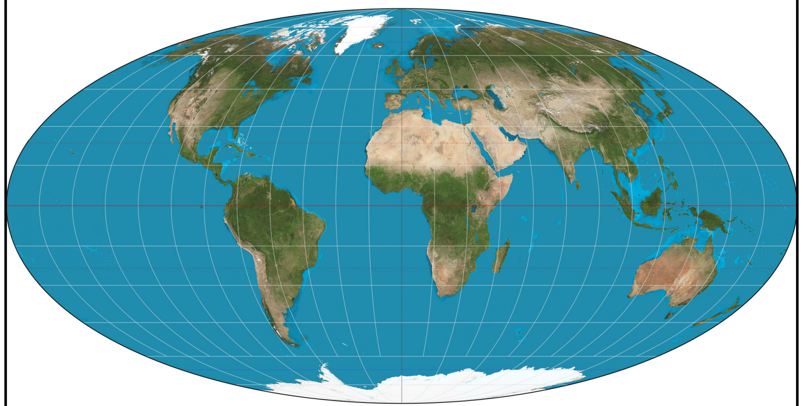
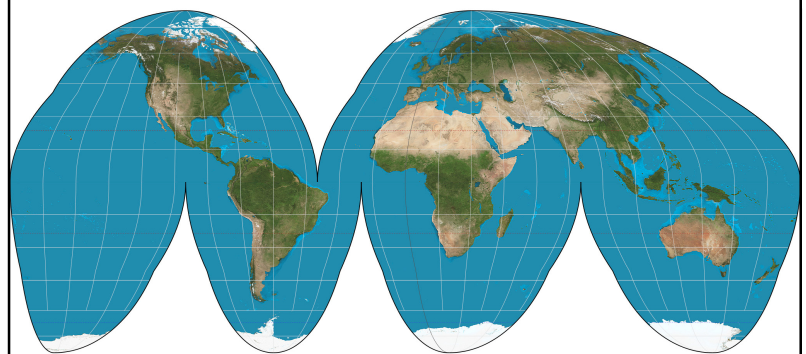
Mollweide: equal area



Goode Homolosine: equal area



Example Projection Formulas

Eckert IV pseudocylindrical map projection

Forward formulas [edit]

Given a radius of sphere R, central meridian λ_0 and a point with polar coordinates (φ, λ), x and y can be computed using the following formulas:

$$\boxed{x} = \frac{2}{\sqrt{4\pi + \pi^2}} R\,(\lambda - \lambda_0)(1 + \cos\theta) \approx 0.4222382\,R\,(\boxed{\lambda} - \lambda_0)(1 + \cos\theta),$$

$$\boxed{y} = 2\sqrt{\frac{\pi}{4 + \pi}} R \sin\theta \approx 1.3265004\,R\sin\theta,$$

where $\theta + \sin\theta\cos\theta + 2\sin\theta = \left(2 + \frac{\pi}{2}\right)\sin\boxed{\varphi}$. This equation can be solved numerically using Newton's method.[2]

(phi, lambda) = (latitude, longitude)

(x,y) = (easting, northing)

Inverse formulas [edit]

$$\theta = \arcsin\left[y\frac{\sqrt{4+\pi}}{2\sqrt{\pi}R}\right] \approx \arcsin\left[\frac{y}{1.3265004\,R}\right]$$

$$\varphi = \arcsin\left[\frac{\theta + \sin\theta\cos\theta + 2\sin\theta}{2 + \frac{\pi}{2}}\right]$$

$$\lambda = \lambda_0 + x\frac{\sqrt{4\pi + \pi^2}}{2R(1 + \cos\theta)} \approx \lambda_0 + \frac{x}{0.4222382\,R\,(1 + \cos\theta)}$$

Projections and Coordinate Systems

- **Map Projections**
  - required to transform the earth's surface to a flat map
  - mathematical formula, but represented graphically
  - cause some distortion in area, shape, distance, &/or direction
  - preserve: Equal Area, Conformal, Equidistant, Azimuthal
- **Coordinate System**
  - reference framework to determine positions in 2D/3D space
  - Geographic CS – non-projected, based on the spherical earth
  - Projected CS – based on a plane (derived using a projection)
  - Variety of Coordinate Systems in both categories
    - Geographic depends on ellipsoid (estimated model of earth)
    - Projected depends on type of projection and parameters

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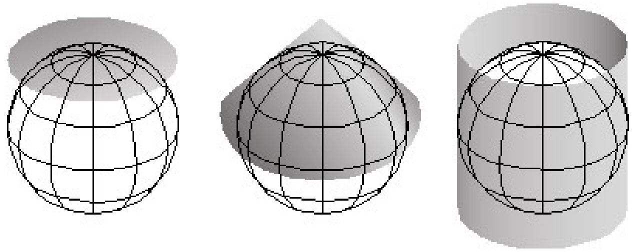
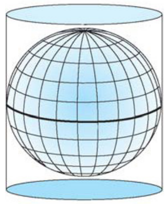
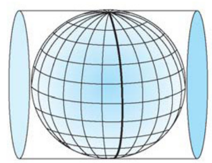
Projection Surfaces



MERCATOR USES THE CYLINDRICAL PROJECTION





UTM = **U**NIVERSAL **T**RANSVERSE **M**ERCATOR USES A ROTATED CYLINDER

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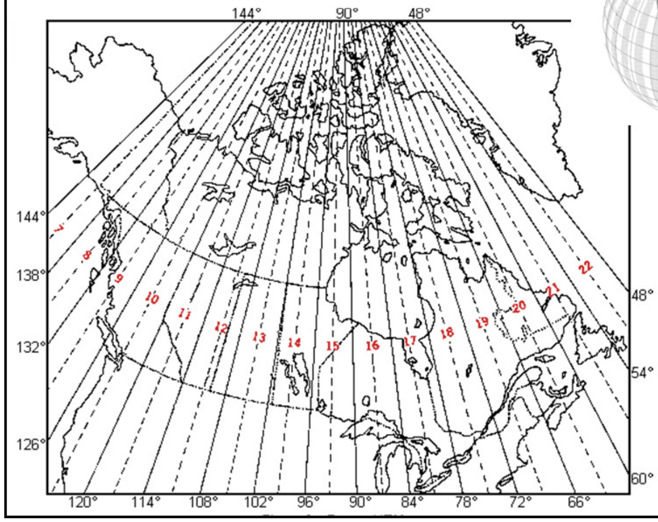
UTM Zones



Earth's surface is divided into 60 UTM Zones

Canada is mapped in 16 UTM Zones (Zone 7 in west to Zone 22 in east)

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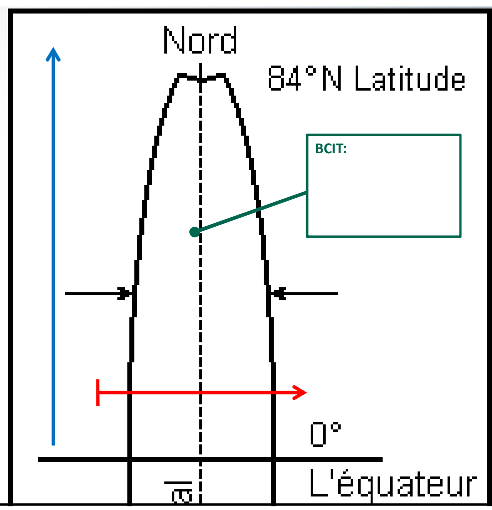
UTM Zone



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Coordinate Systems

	Geographic	Projected: UTM
Underlying Geometry:		
Measures:		
X,Y Axis:		
Units:		
Foundation:		

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Map Projections in ArcGIS

- Introduction to projections & coordinate systems
  - Text chapter 6, pages 154-163
- Every spatial dataset has a coordinate system
  - Geographic Coordinates stored as lat/long values
    - Also includes spheroid datum, dimensions, other specifications
  - Projected Coordinates stored as X/Y values
    - Also includes projection specifications
    - And Geographic CS on which it is based

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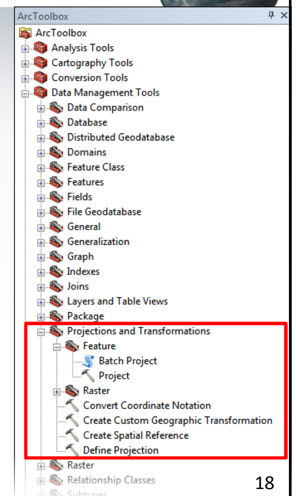
Map Projections in ArcGIS

- On-the-fly Projections
  - Data Frame is set to the CS of first layer added to it
  - additional layers are dynamically re-projected if their CS is different
- Projection Tools
  - ArcToolbox > Data Management > Projections and Transformations
  - For both Vector (Feature) & Raster



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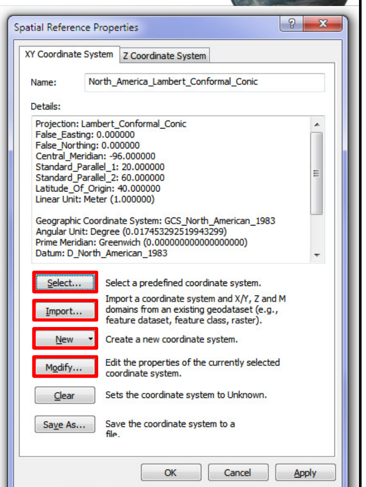
Defining a Projection

- Necessary if CS for dataset is missing or corrupted
- **Select** from hundreds of predefined CS
- **Import** CS from an existing dataset
- **New** to create a specialized or unique CS
- **Modify** to adjust para-meters of an existing CS



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Thank You

End of Lecture 2