

Coordinate systems and Georeferencing

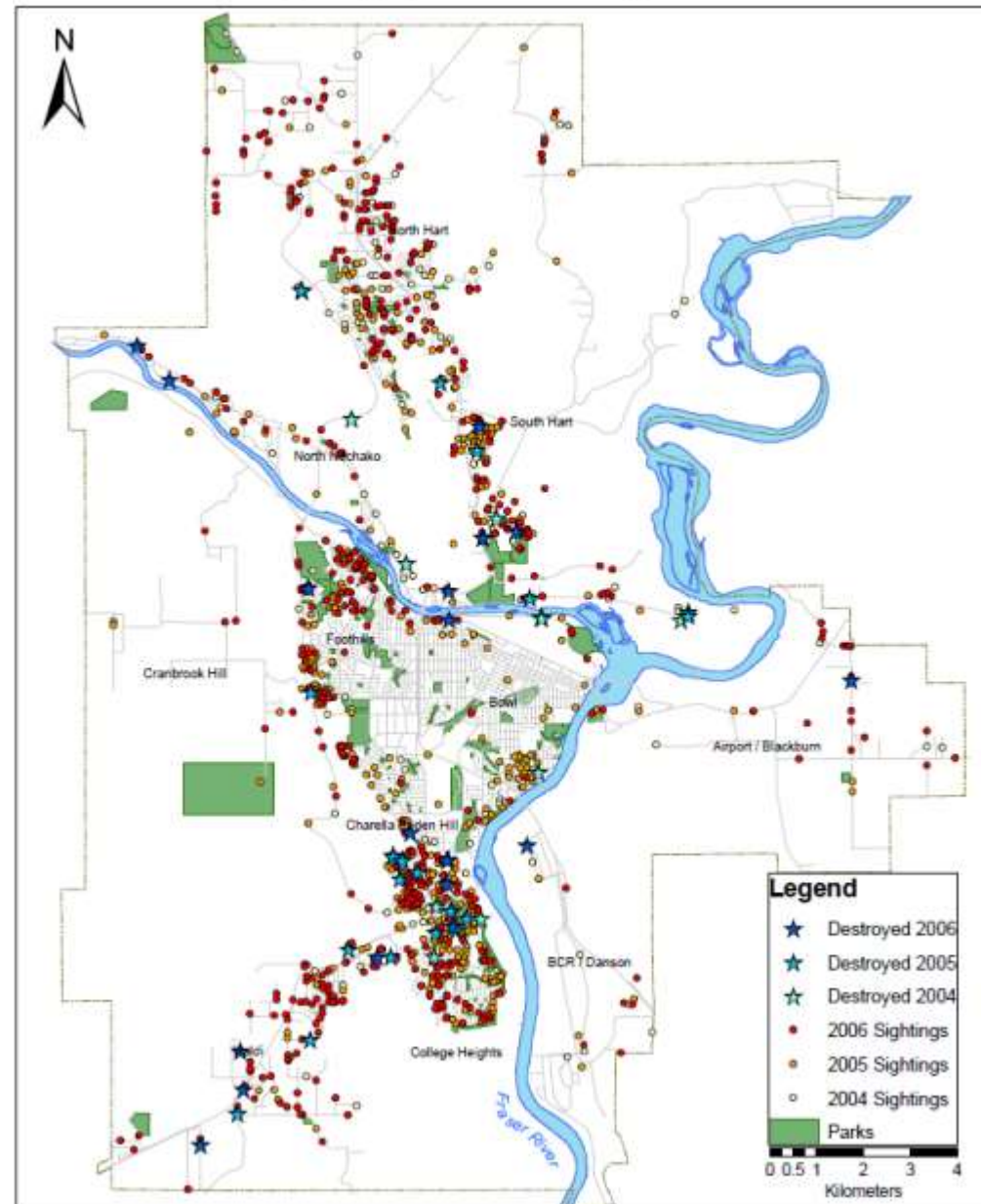
Bear Sightings, Prince George 2004-2006



Registered map layers

digital mapping needs coordinates

- Local for local mapping
- global for global datasets



Registration vs Referencing

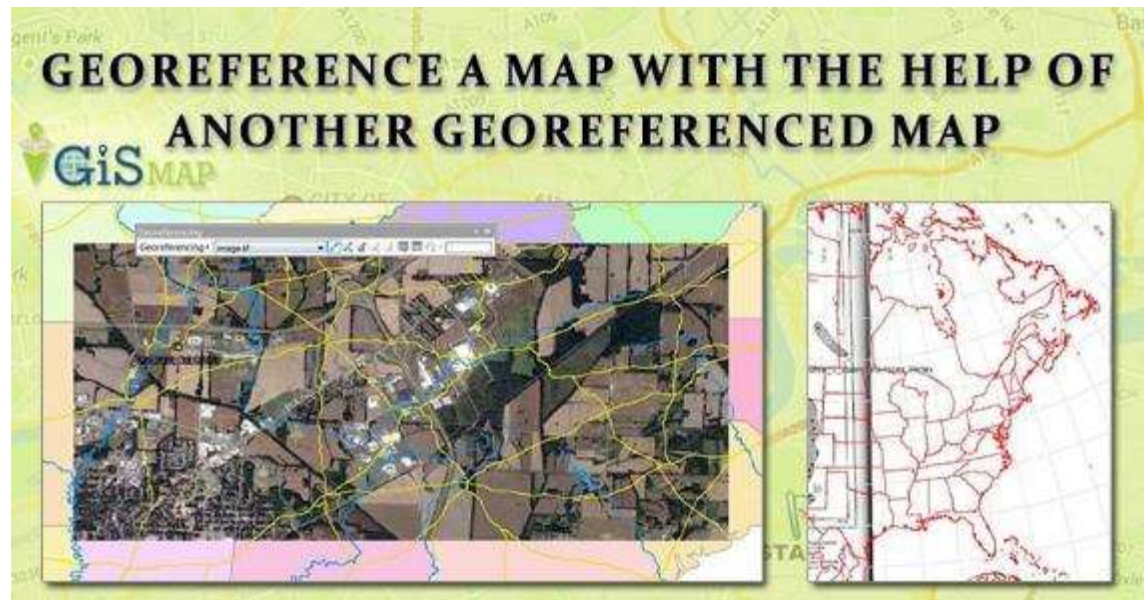
Registration:

-lining up the layers together

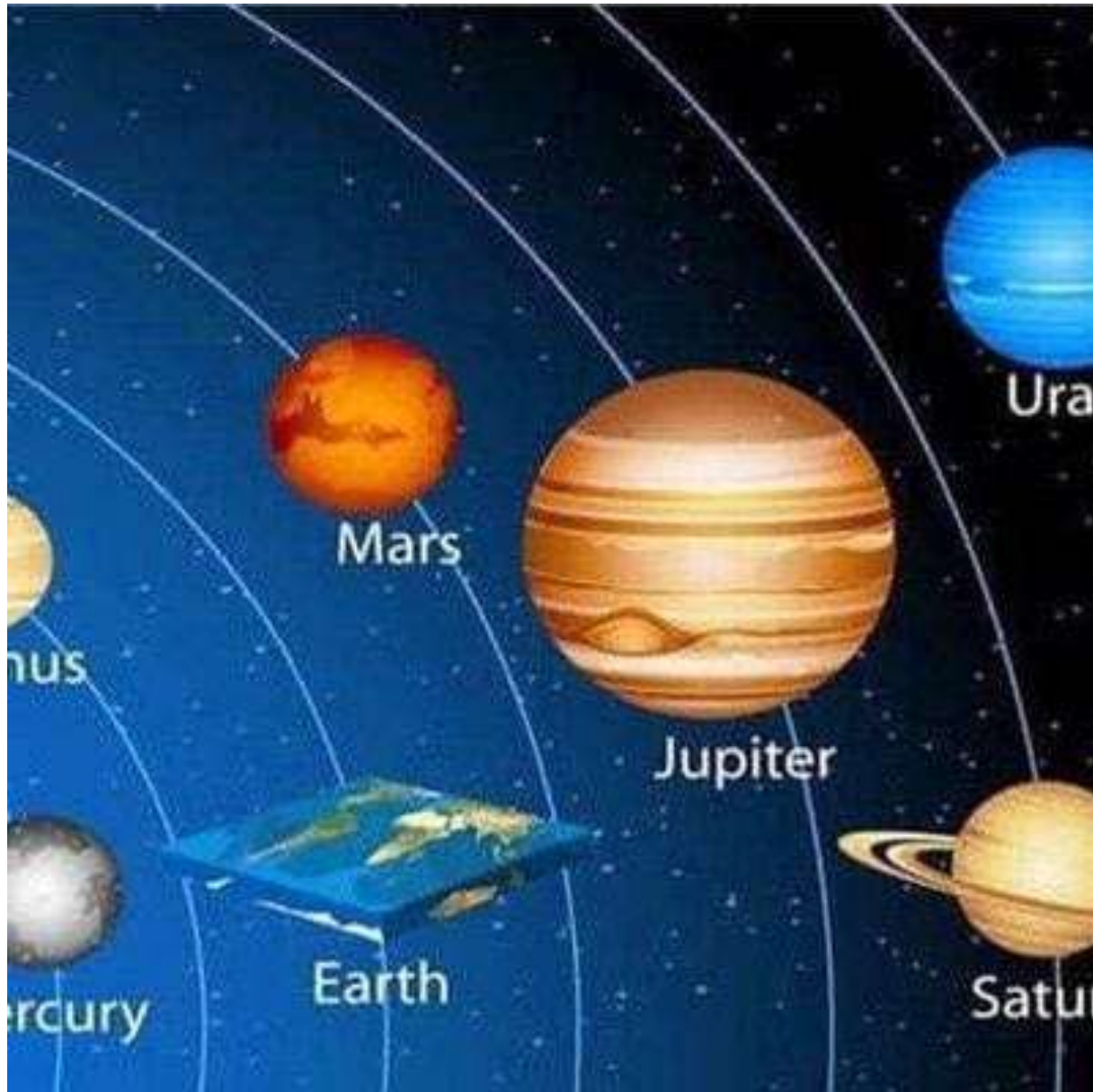


Georeferencing:

Linking layers to coordinates



Flat Earth options:– if only it was flat, this would be a short lecture



We're pretty sure the Earth is not 'flat': the Rockies from Space Station

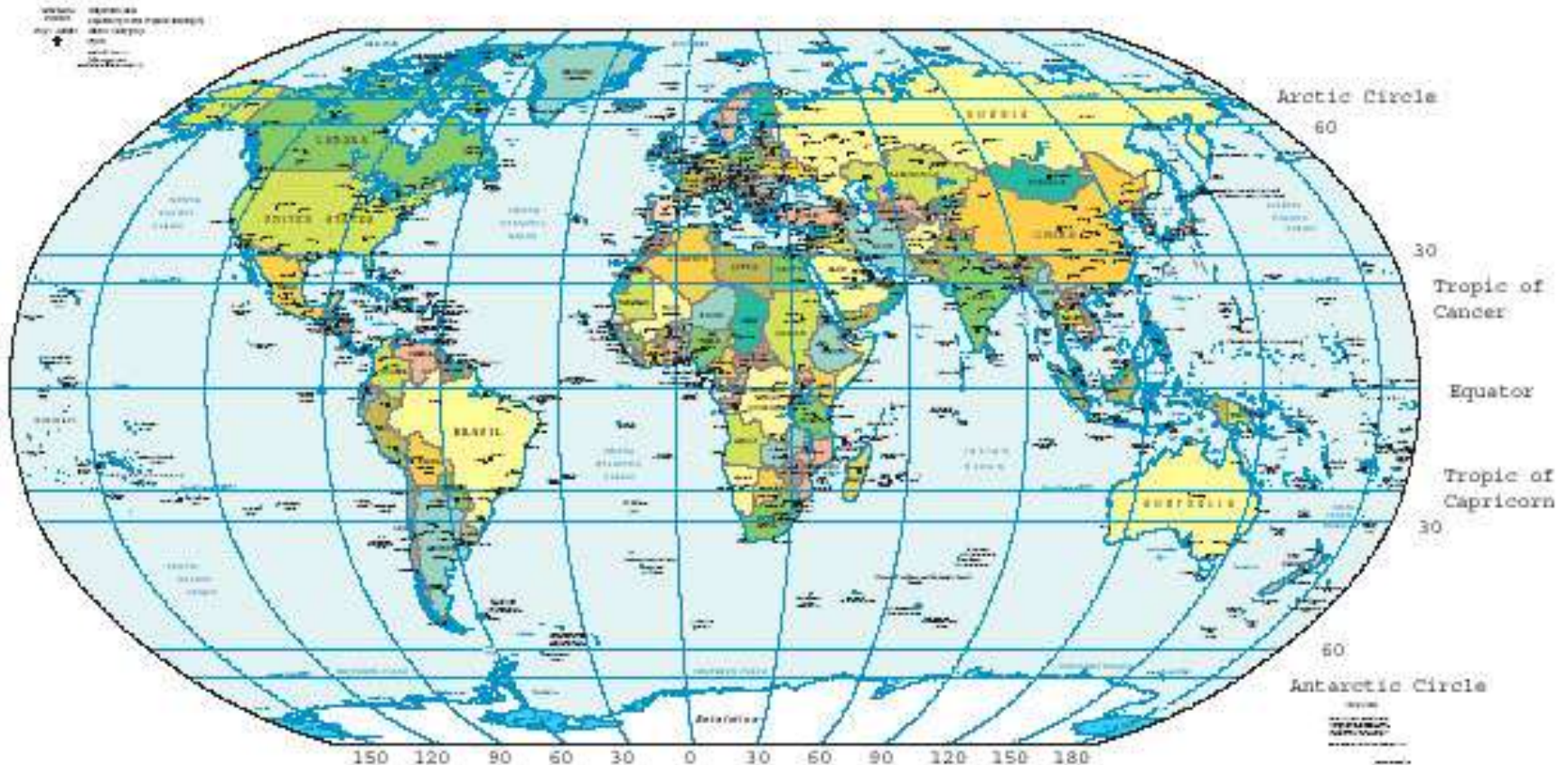


<https://www.facebook.com/businessinsider/videos/10154023449809071/>

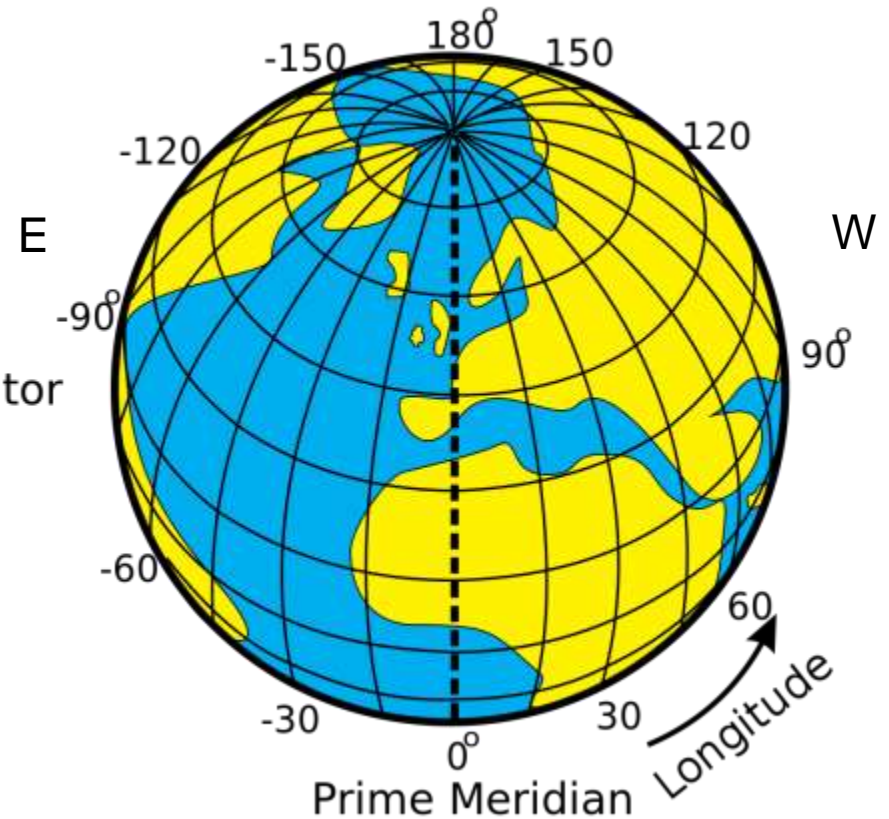
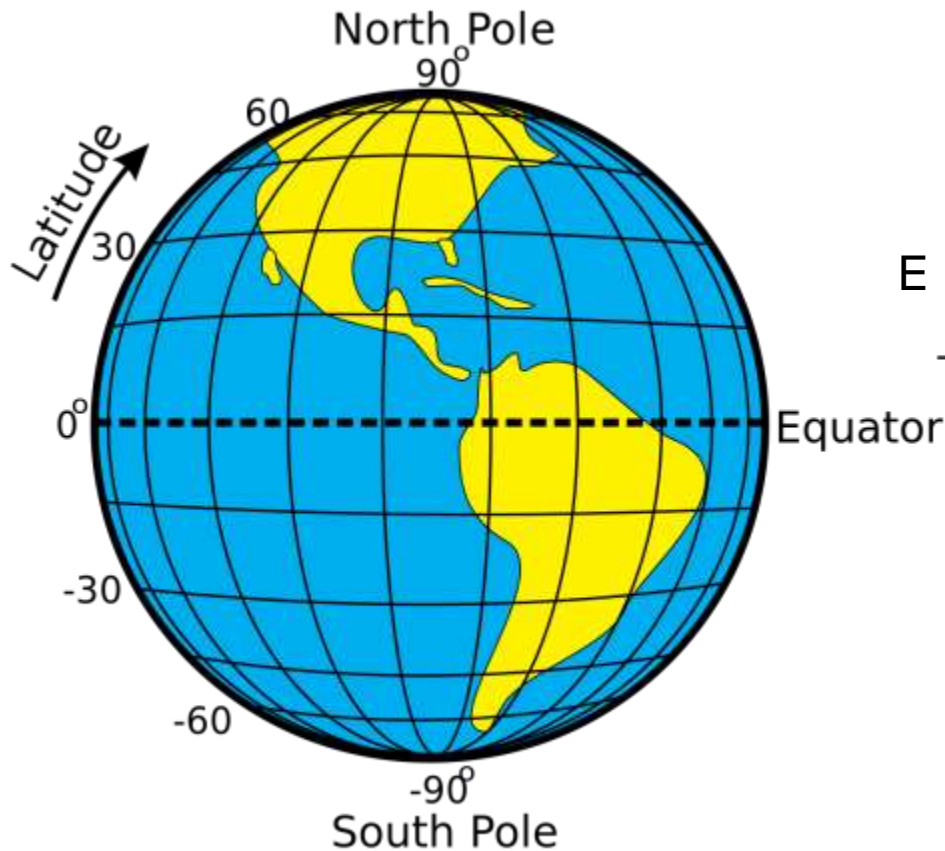
Coordinate map systems

1. The Earth's Graticule Latitude and Longitude

Political Map of the World, June 2003



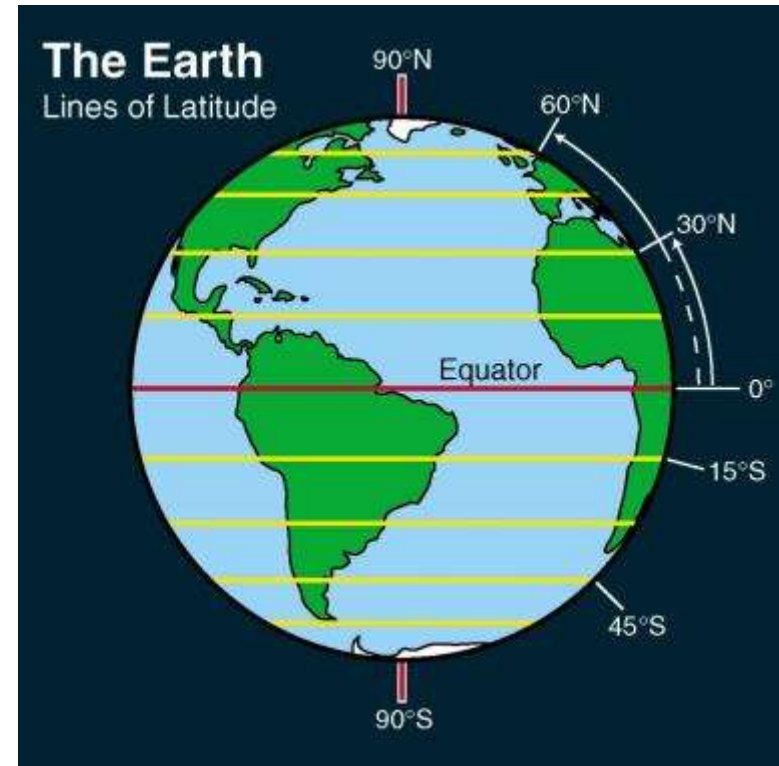
- The graticule is the imaginary grid of lines running east-west lines of latitude (parallels) and north-south lines of longitude (meridians)
- The system was first devised by Hipparchus (190-120 BC)



Latitude



- **Latitude** = the vertical angle from the centre of earth to the location
- Prince George is at 54°N
- Quesnel is at 53°N
- $[1^{\circ} = \sim 111\text{km}]$
- Latitude is 0 on the equator
- 1 degree = 60' (minutes)
- $[1' = \sim 2\text{km}]$
- $1' = 60''$ (seconds)
- $[1'' = \sim 30\text{m}]$

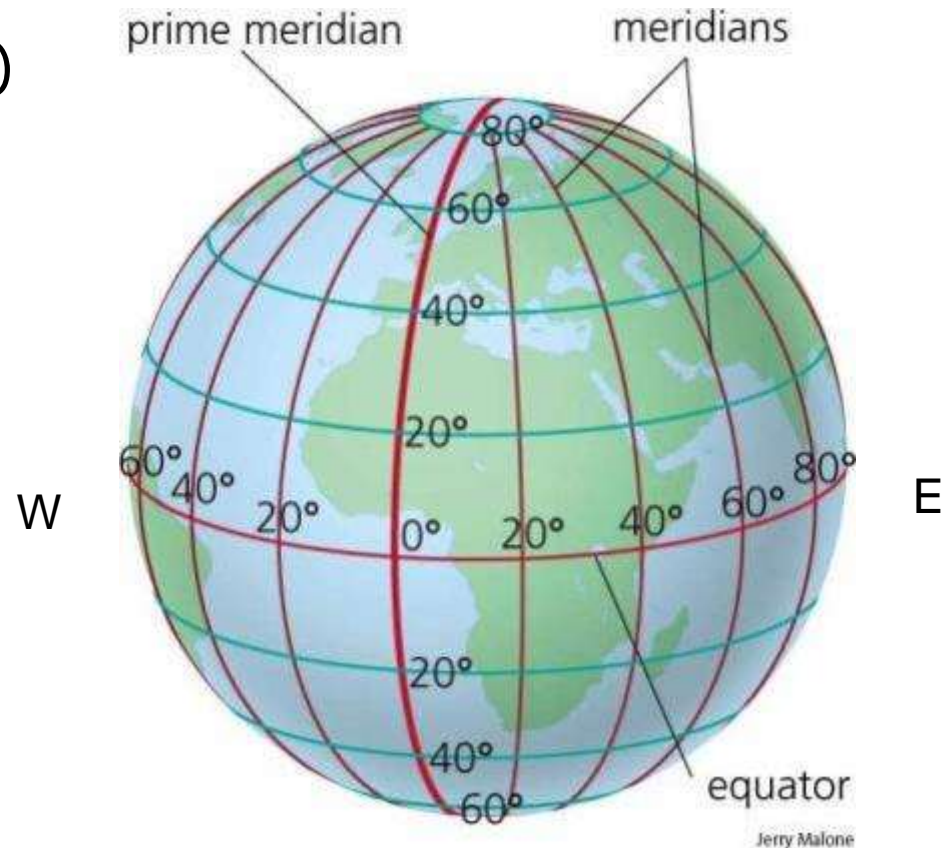
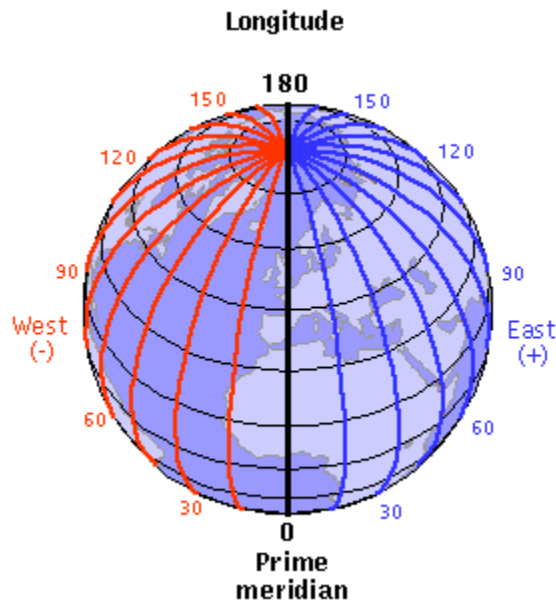


Longitude

Longitude = the angle formed between line from centre of earth to the (arbitrary) 'prime meridian' running through Greenwich, England and the local meridian. The 0 location is arbitrary (1884)

Longitude ranges from
0 to 180 W / 180 E (the same line)

Prince George = 123°W



The Greenwich Meridian

...where east meets west

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[Royal Observatory Greenwich](#)

[Latitude and Longitude](#)

[Airy Transit Circle \(ATC\)](#)

[WGS84 and the Greenwich Meridian](#)

[The Greenwich Meridian before the ATC](#)

[The Quest for Longitude](#)

[International Meridian Conference \(1884\)](#)

[Meridian Day \(1984\)](#)

[The Millennium](#)

[Millennium Tree Line \(MTL\)](#)

[Meridian Laser](#)

[Astronomers Royal](#)

[Telescopes used with Meridian Marks](#)

Location

England
West Sussex

East Grinstead

S side of: B2110 (Lewes Road)

Distance (S) from Greenwich
39.39 Km: 24.48 miles

OS map details
OS Explorer: 135
OS grid ref
TQ 39945.37948
(539945, 137948)

WGS84 lat/long
51.123729, -0.001647

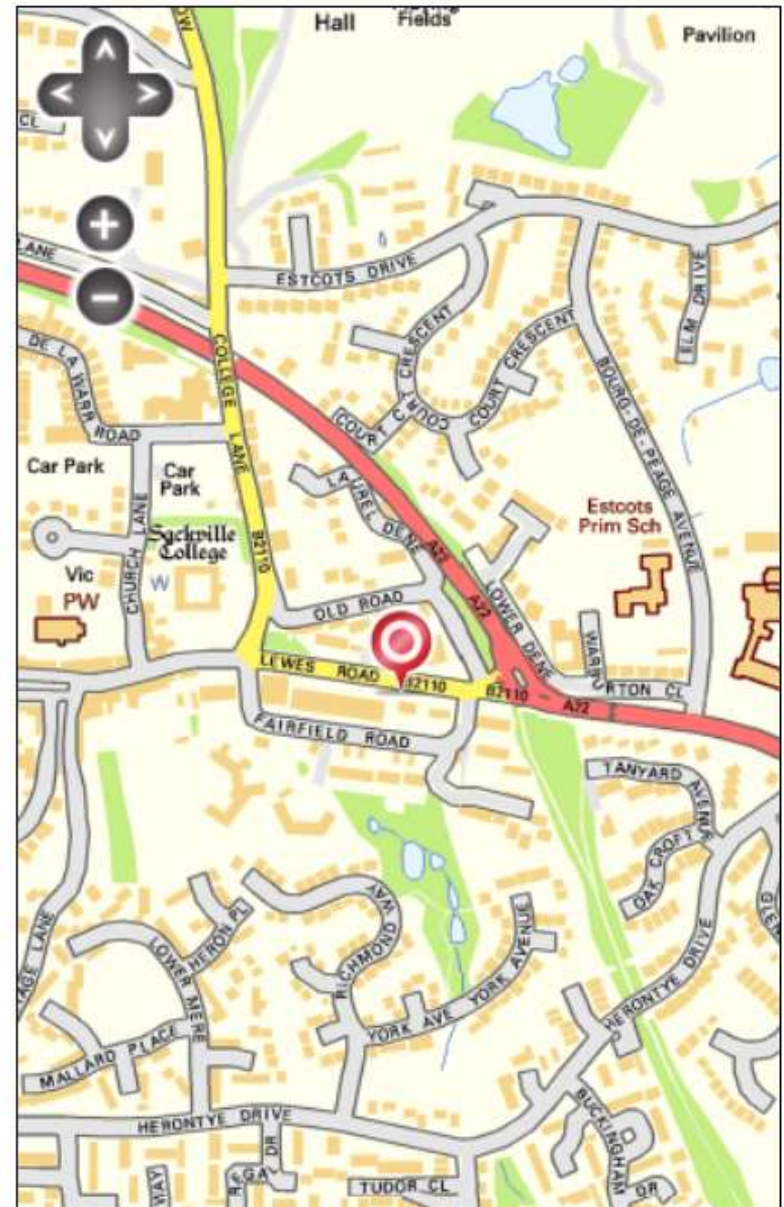
[Click here for images](#)

Type
Marker 'stone'

Marking date
2000

Access
Unrestricted

[Show satellite view](#)



1a. 'Geographic Referencing'

We identify locations by latitude, longitude

e.g. UNBC campus agora

In decimal degrees: 53.892381, -122.813699 (N, W)

See: <http://maps.google.ca> (right-click – What's here?)

In degrees, minutes, seconds:

53° 53' 33" (N) 122° 48' 50" (W)

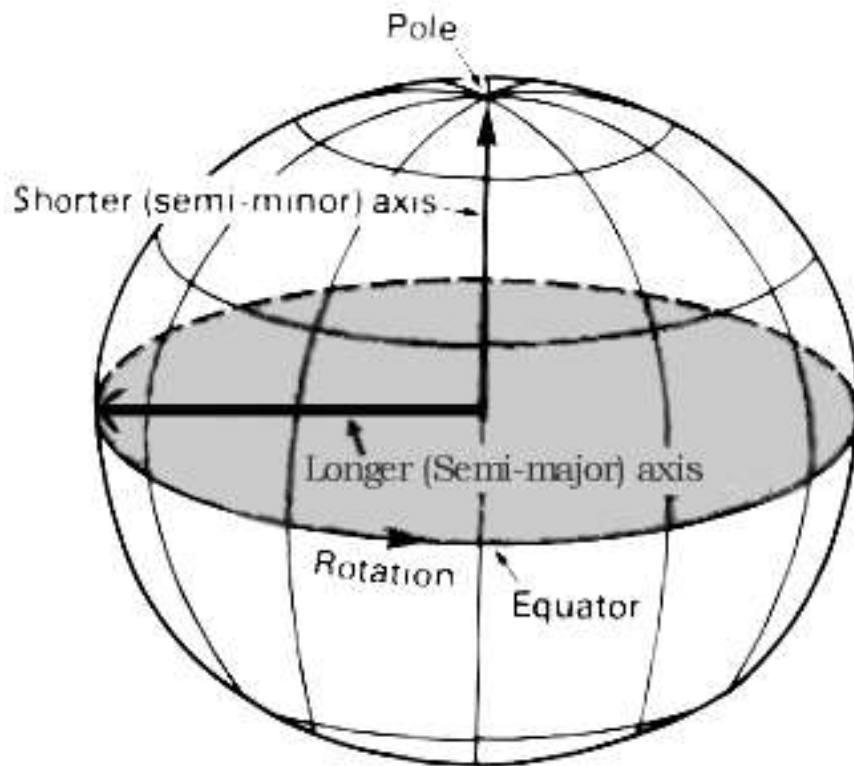
In degrees and decimal minutes (e.g. GPS)

53° 53.543' N 122° 48.822' W

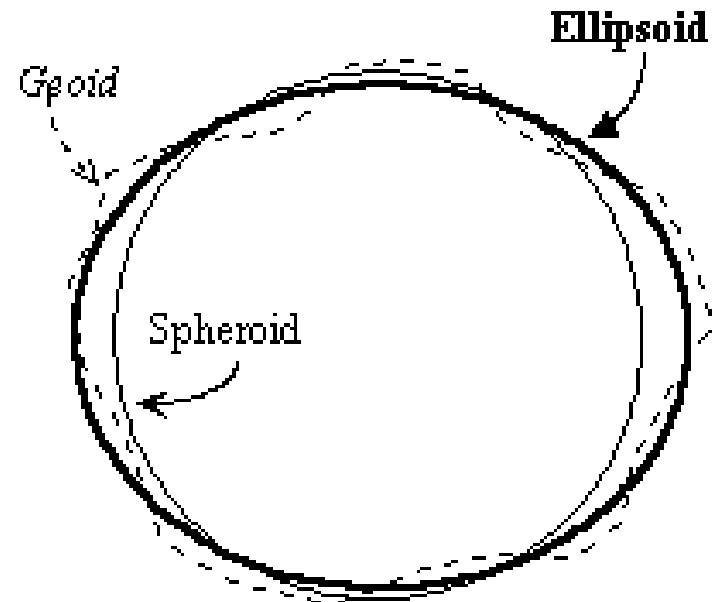
1b. The Geoid

Earth is not a perfect sphere, it is ellipsoidal ..

The difference between the length of the two axes = the amount of 'polar flattening' is about 1/300 (0.3%)



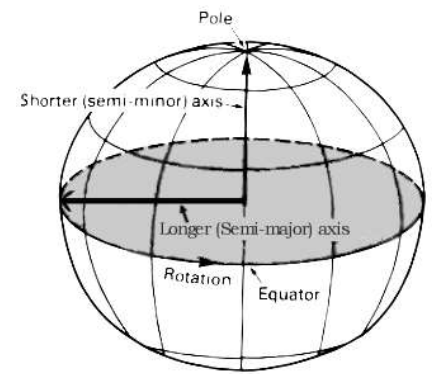
An ellipsoid is formed by rotating an ellipse on its shorter axis



99.7% soccer ball
0.3% 'football'

Official Ellipsoids

(from J. Snyder, Map Projections--A Working Manual)



An ellipsoid is formed by rotating an ellipse on its shorter axis

Name	Date	Equatorial	Polar	Polar Flattening
		Radius <i>a</i> (metres)	Radius <i>b</i> (metres)	
WGS 84	1984	6,378,137	6,356,752	1/298
GRS 80	1980	6,378,137	6,356,752	1/298
WGS 72	1972	6,378,135	6,356,750	1/298
<hr/>				
International	1924	6,378,388	6,356,912	1/297
Clarke	1866	6,378,206	6,356,584	1/295
Everest	1830	6,377,276	6,356,075	1/301



Datums (do we need to know this?)

'Datum' = "a set of values that serve as a base for mapping"

a. North American Datum, NAD27 (1927) based on Clarke 1866

b. North American Datum, NAD83 based on GRS80/WGS 1984

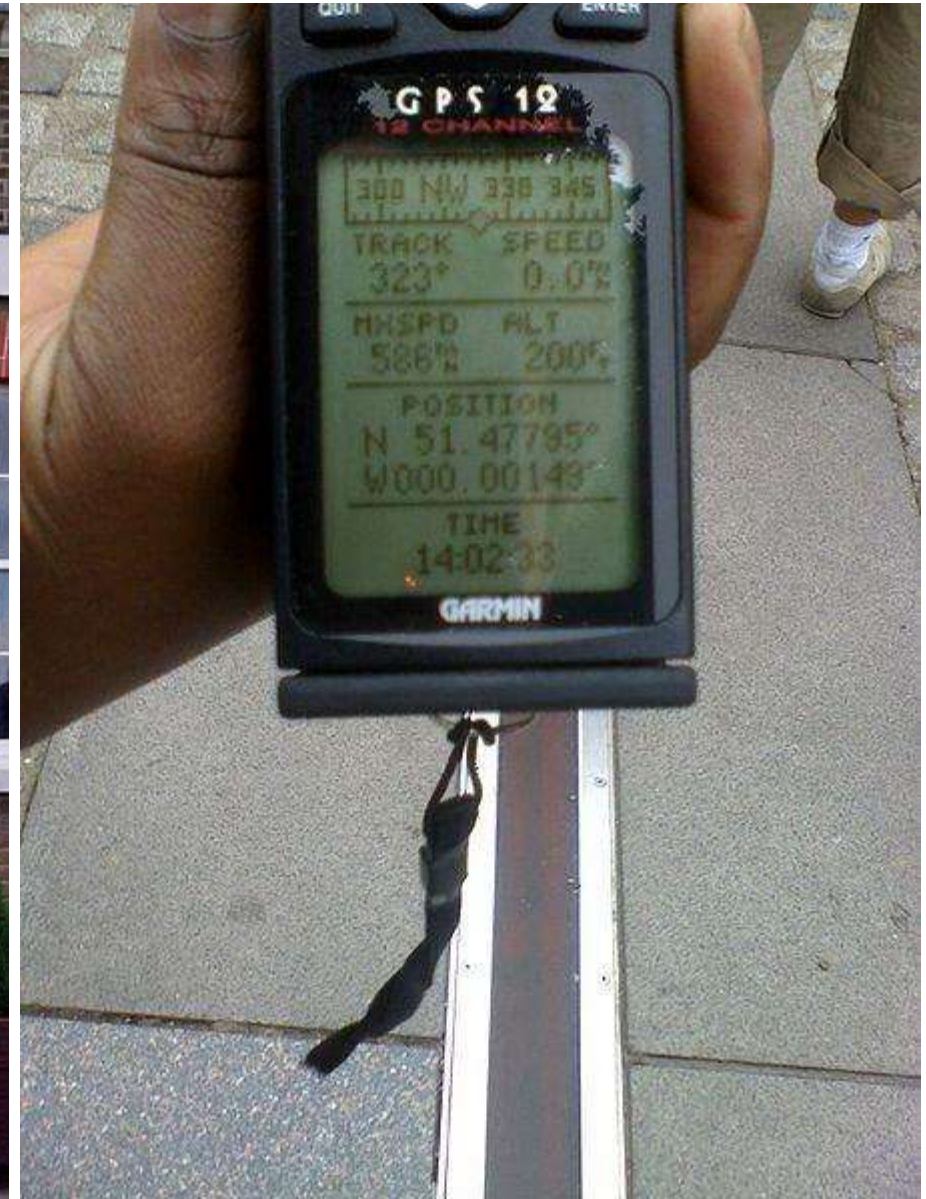
-> NAD27 was the datum for mapping in the 20th century

-> NAD83 is the current datum for digital mapping / GIS data

-> The two can differ by ~ **70 metres** (x) and **170 metres** (y)

New millennium mapping: you can 'almost' forget about NAD27

The datum shift: e.g. Greenwich prime meridian



W000.00149°

'Geographic' referencing issues

a. Geographic is not decimal, it is 'sexagesimal' (= base 60)

1 degree = 60 minutes

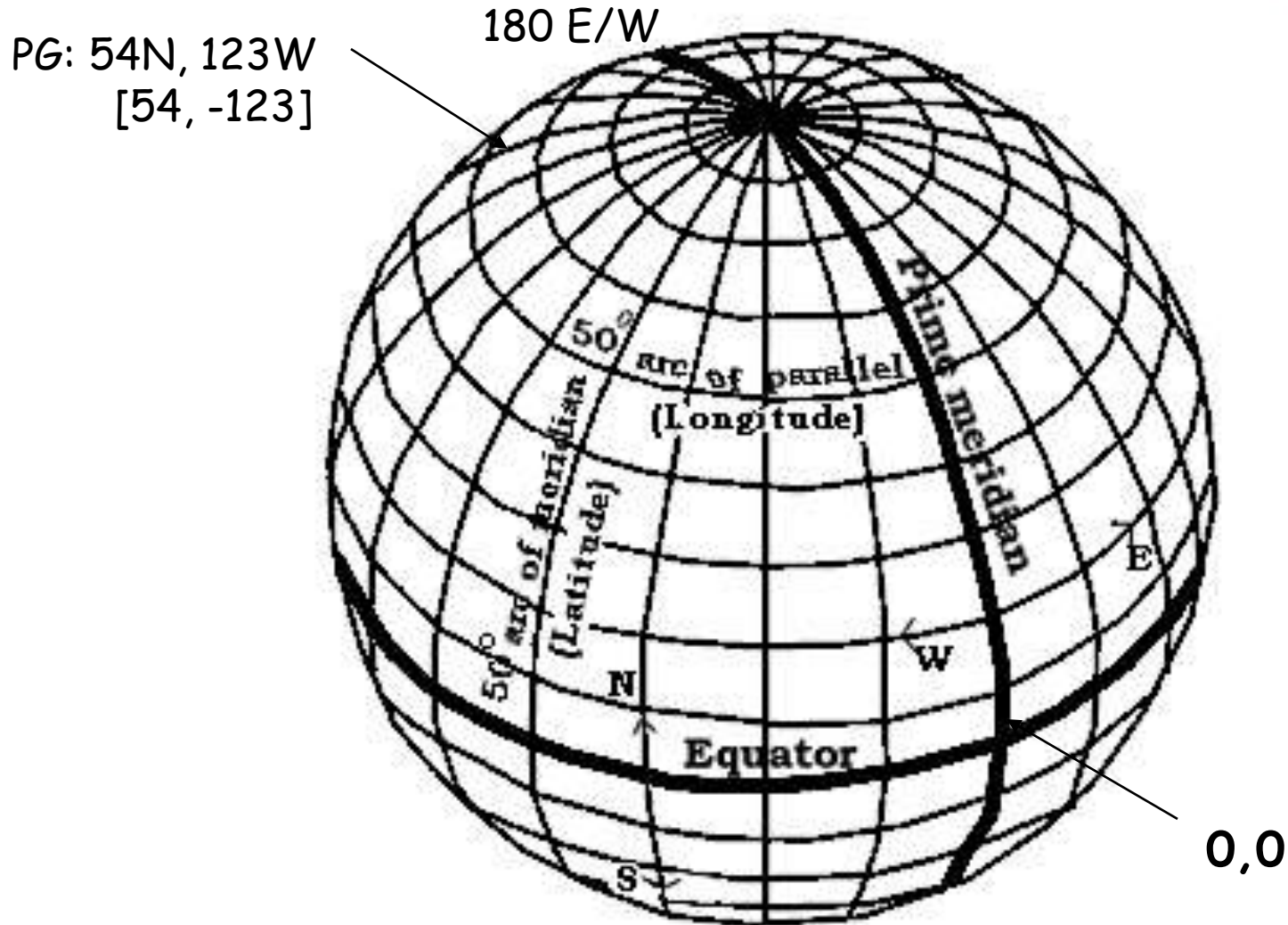
1 minute = 60 seconds

Decimal degrees: $58^{\circ} 30'$ = 58.5 $30/60 = 0.5$

Decimal degrees: $58^{\circ} 36'$ = 58.6 $36/60 = 0.6$

Decimal degrees: $58^{\circ} 36' 36''$ = 58.61 $36/(60*60) = 0.01$

b. Geographic referencing is suitable for storing global datasets, but **has negative values south and west of 0, 0**



Note that longitude is negative for Canada / western hemisphere

c. The main issue with Longitude

1 degree longitude varies widely from ~111 km at the equator to 0 km at poles

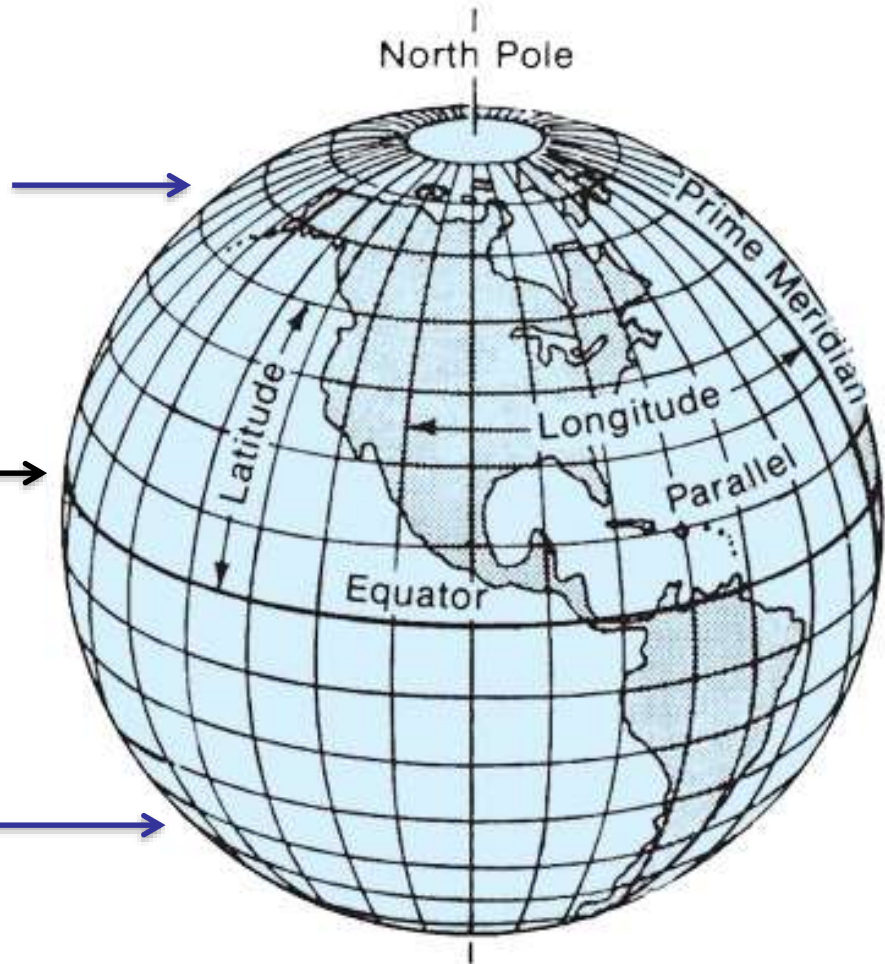
half the distance at 60 ° N/S

It is not rectangular

Equator

i.e. 1 degree has no fixed length

.. And the earth is pumpkin shaped !



Latitude and Longitude

Length of One Degree of Longitude			Length of a Degree of Latitude		
Latitude	Kilometres	Miles	Latitude	Kilometres	Miles
0°	111.32	69.17	0°	110.57	68.71
10°	109.64	68.13	10°	110.61	68.73
20°	104.65	65.03	20°	110.70	68.79
30°	96.49	59.95	30°	110.85	68.88
40°	85.39	53.06	40°	111.04	68.99
50°	71.70	44.55	50°	111.23	69.12
60°	55.80	34.67	60°	111.41	69.23
70°	38.19	23.73	70°	111.56	69.32
80°	19.39	12.05	80°	111.66	69.38
90°	0.00	0.00	90°	111.69	69.40

45th Parallel
Halfway Between
Equator-North Pole



GEOLOGICAL MARKER

THIS SPOT IN SECTION 14, IN THE TOWN OF RIETBROCK, MARATHON COUNTY IS THE EXACT CENTER OF THE NORTHERN HALF OF THE WESTERN HEMISPHERE. IT IS HERE THAT THE 90TH MERIDIAN OF LONGITUDE BISECTS THE 45TH PARALLEL OF LATITUDE, MEANING IT IS EXACTLY HALFWAY BETWEEN THE NORTH POLE AND THE EQUATOR, AND IS A QUARTER OF THE WAY AROUND THE EARTH FROM GREENWICH, ENGLAND.

MARATHON COUNTY PARK COMMISSION

THIS MONUMENT IS ONLY A REPRESENTATION OF THE INTERSECTION OF THE 90TH MERIDIAN & THE 45TH PARALLEL. THE TRUE LOCATION IS WITHIN ONE FOOT OF THIS MONUMENT.

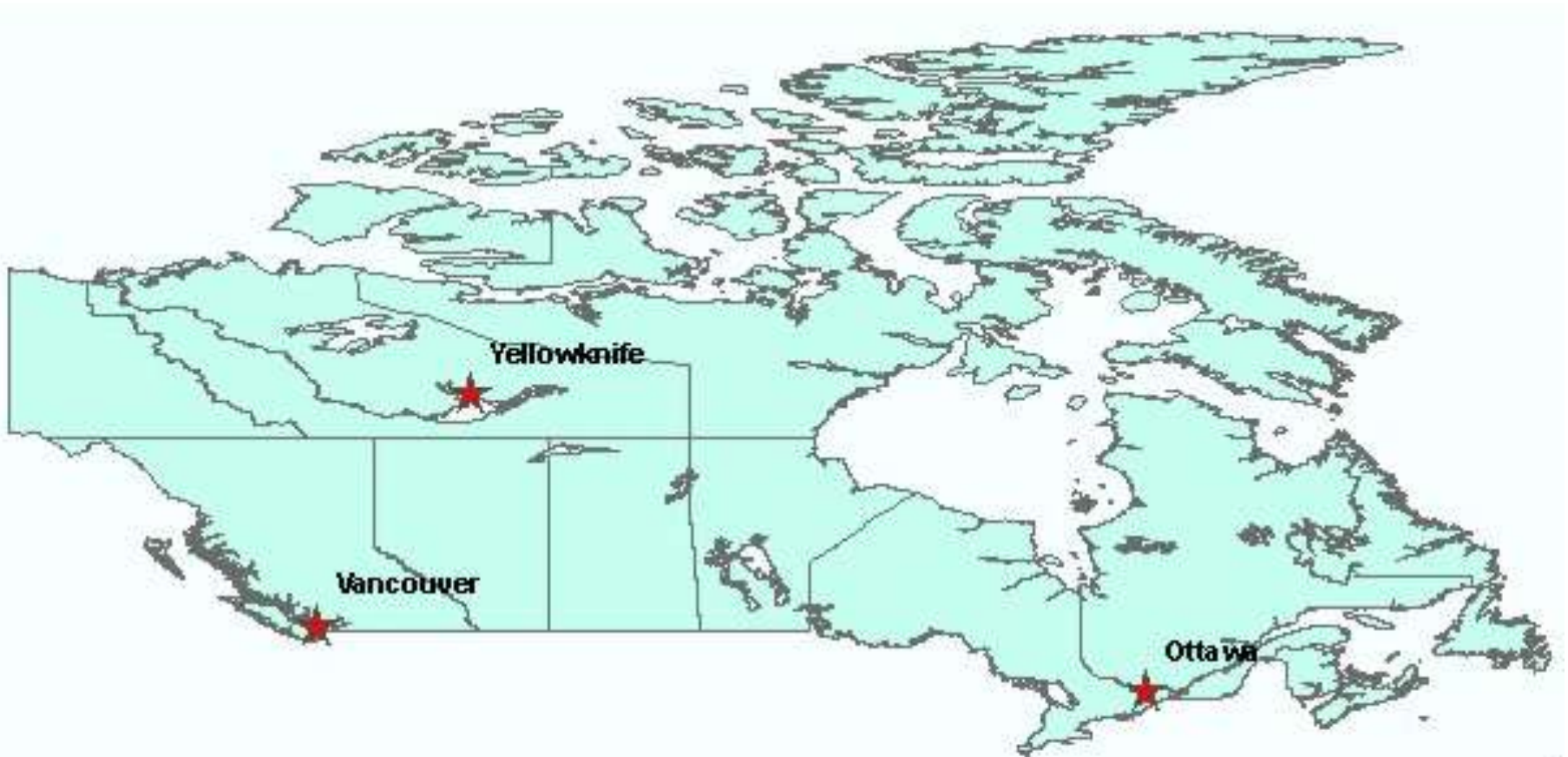
THIS MONUMENT IS ONLY A REPRESENTATION OF THE INTERSECTION OF THE 90TH MERIDIAN & THE 45TH PARALLEL. THE TRUE LOCATION IS WITHIN ONE FOOT OF THIS MONUMENT.



But is 45° North halfway ?

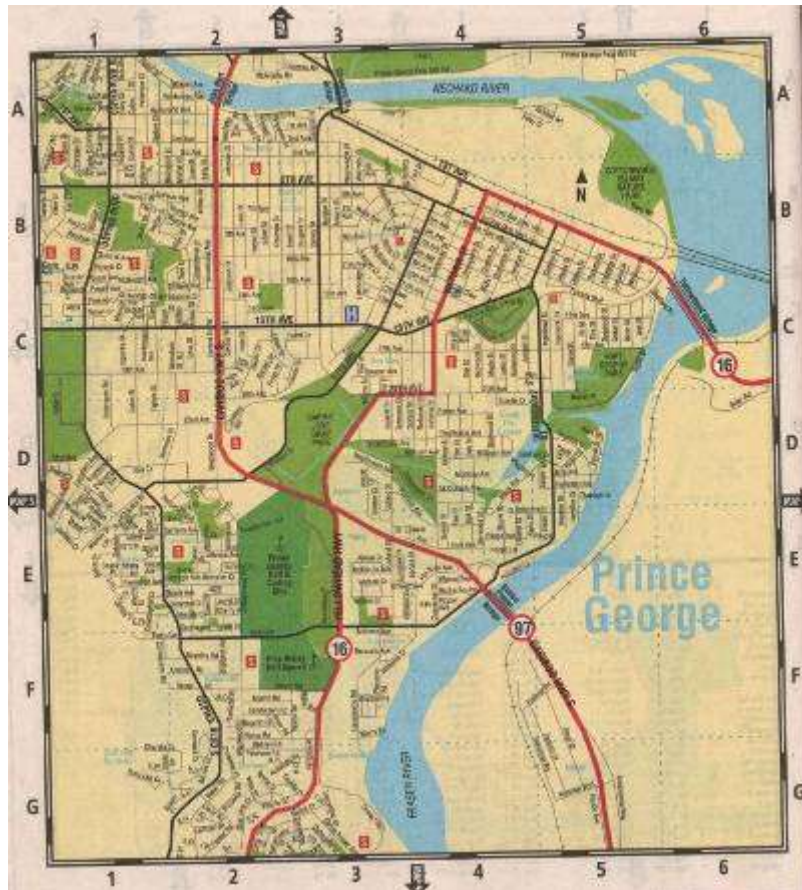
- 1 degree longitude varies from 0 - 111 km
- > East-west stretching away from equator
(as a degree is treated uniformly)

OK for data storage, not for display

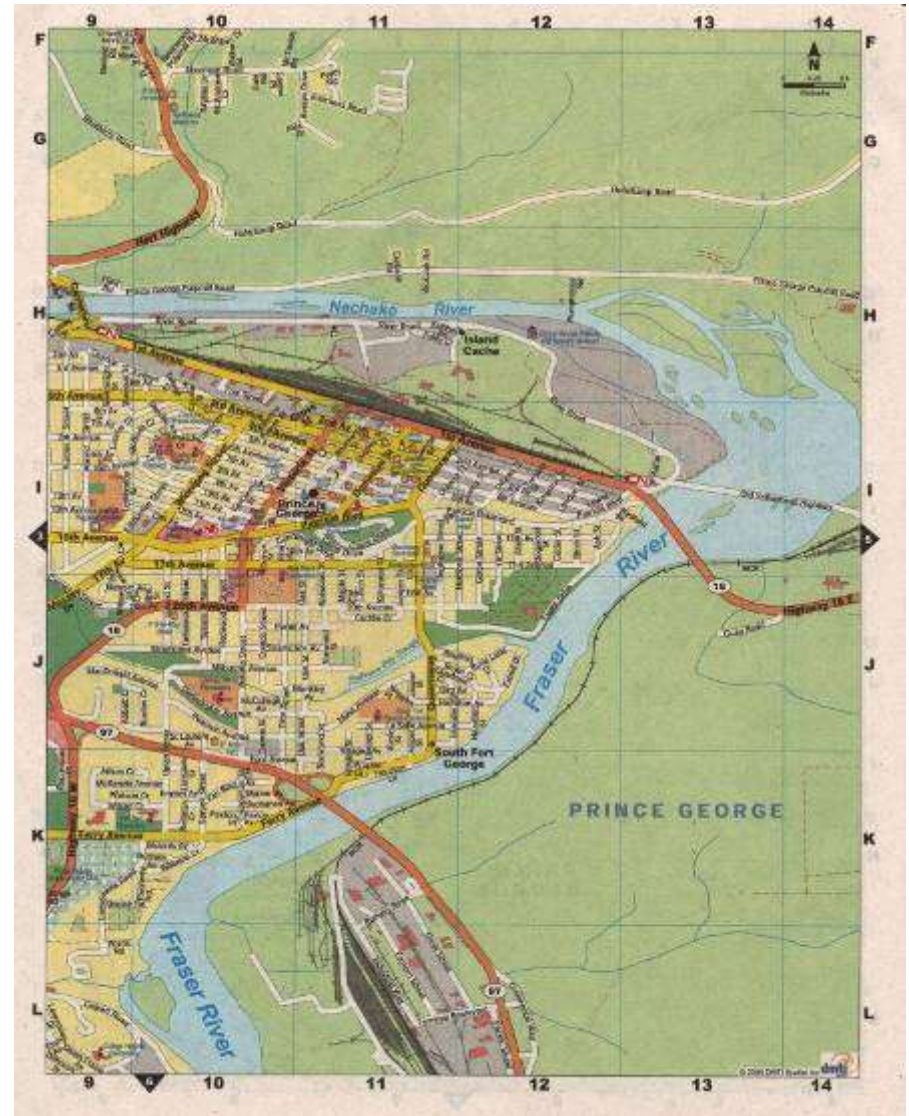


Local example from the phone book

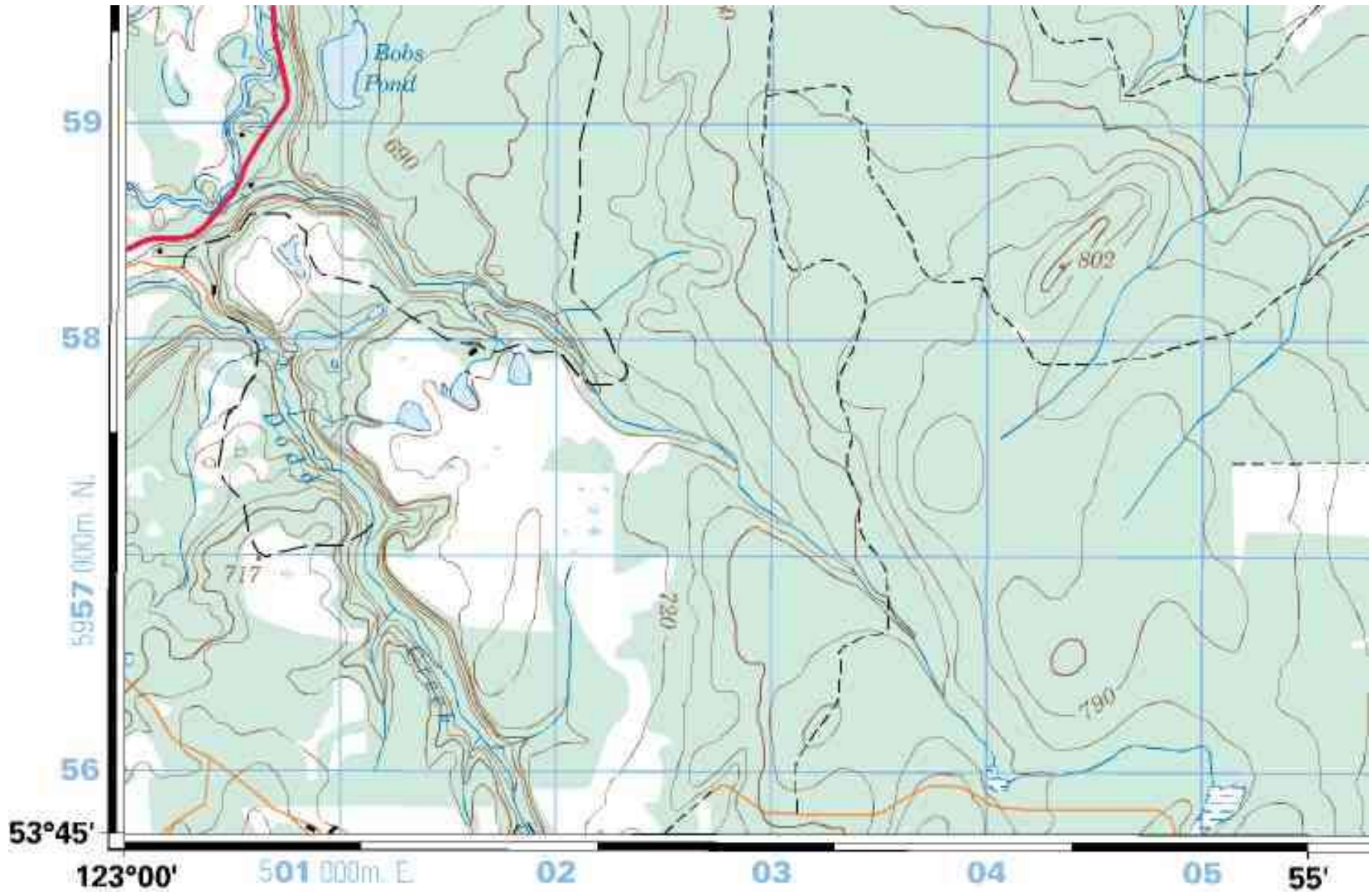
2007(OK) -scale is consistent



2008: horizontal scale is almost double



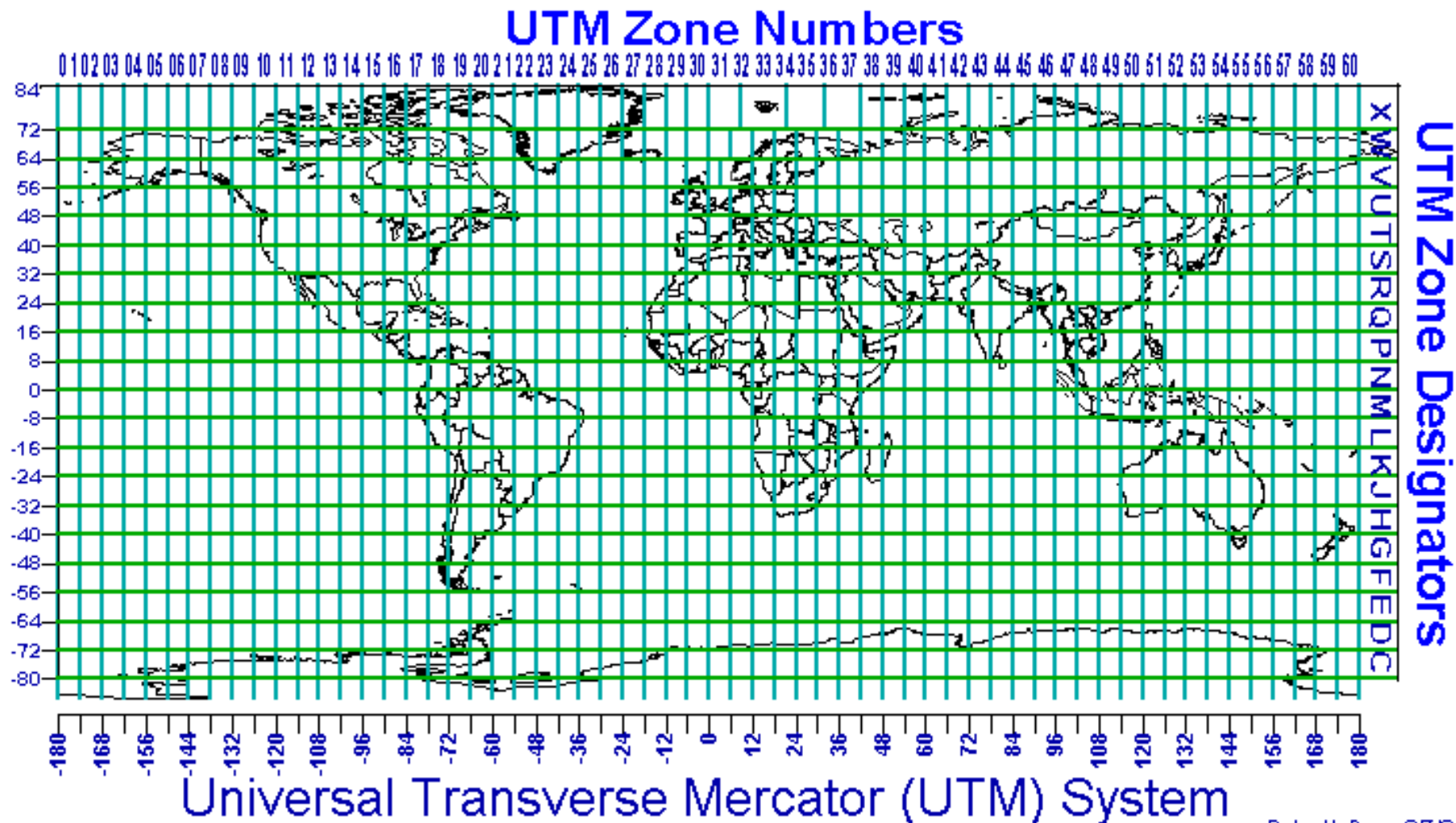
2. UTM map coordinates - a rectangular system



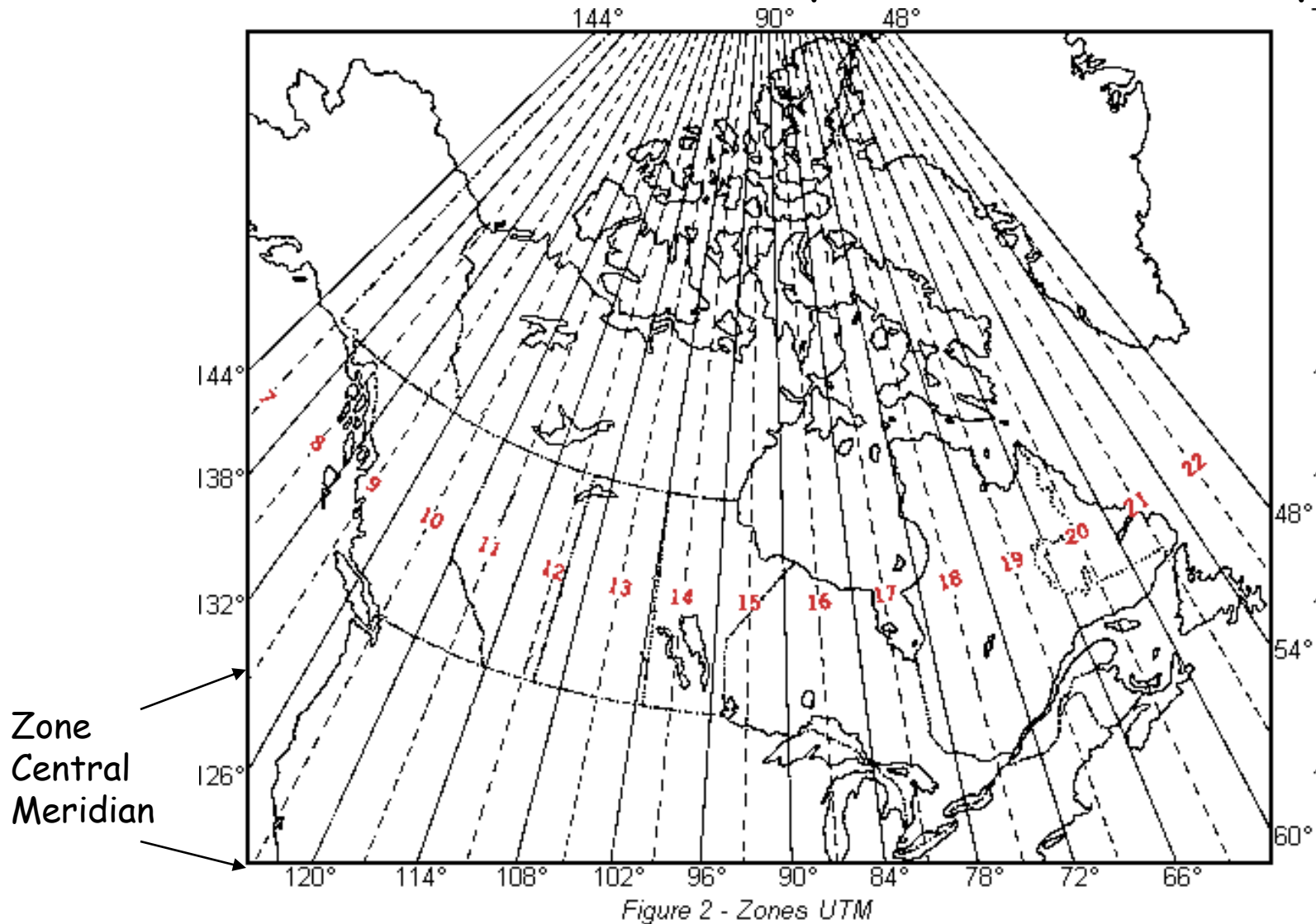
Universal Transverse Mercator (UTM) System

this bit is harder so pay attention ...

The world is divided into $60 \times 6^\circ$ longitude (vertical) strips numbered 1 - 60 from 180 degrees West to 180 degrees East



Canada: UTM zones - adopted in 1947 for mapping



- the width of each zone varies from 666 km ($6 \times 111\text{km}$) at the equator ...to ~ 333 km (6×55.5 km) at 60° N/S, with a 'central meridian' in the middle e.g. zone 10 from 126-120W has a CM at 123W

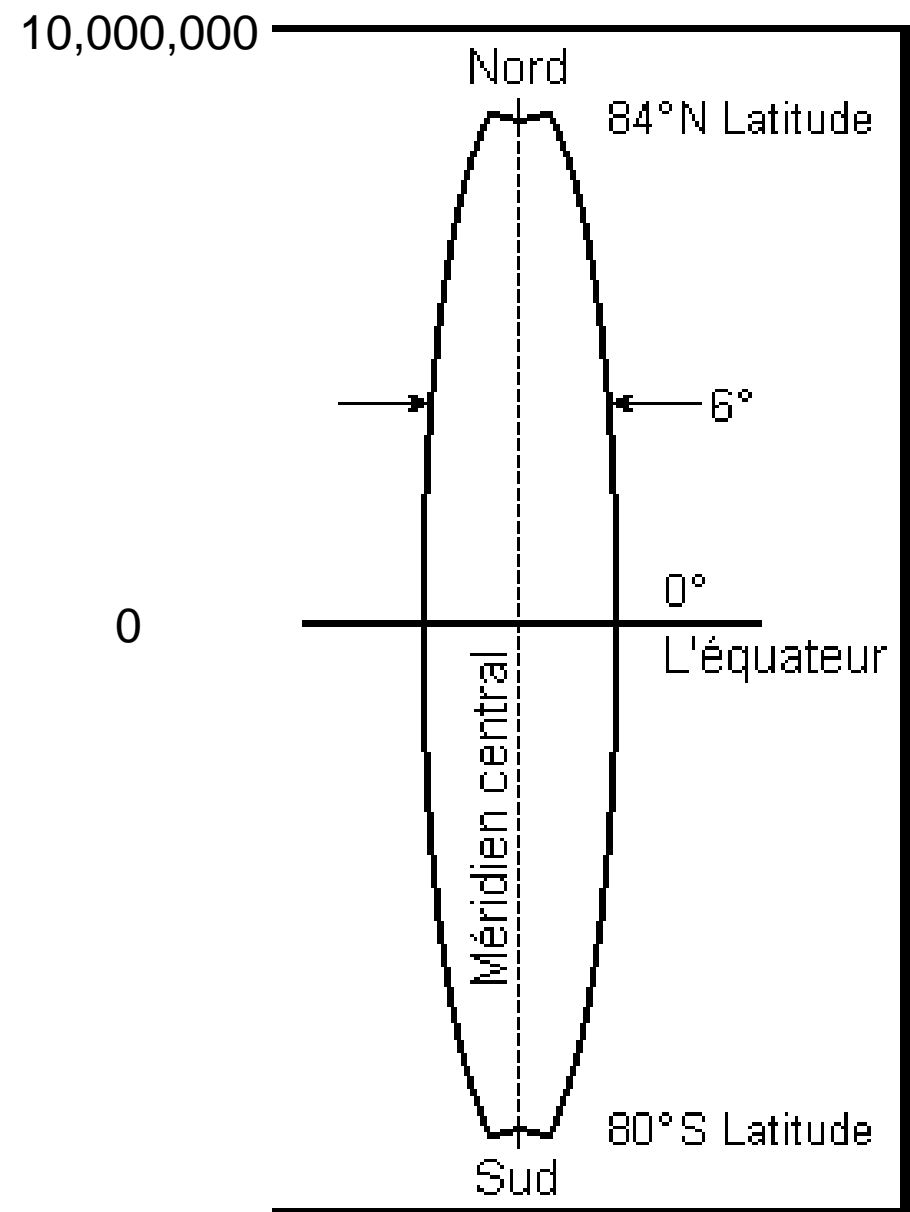
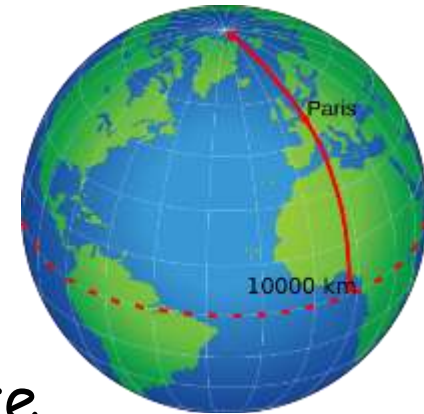


Figure 1 - Zone UTM

UTM coordinates

are in metres



The 'Y' coordinate
Northings (N):

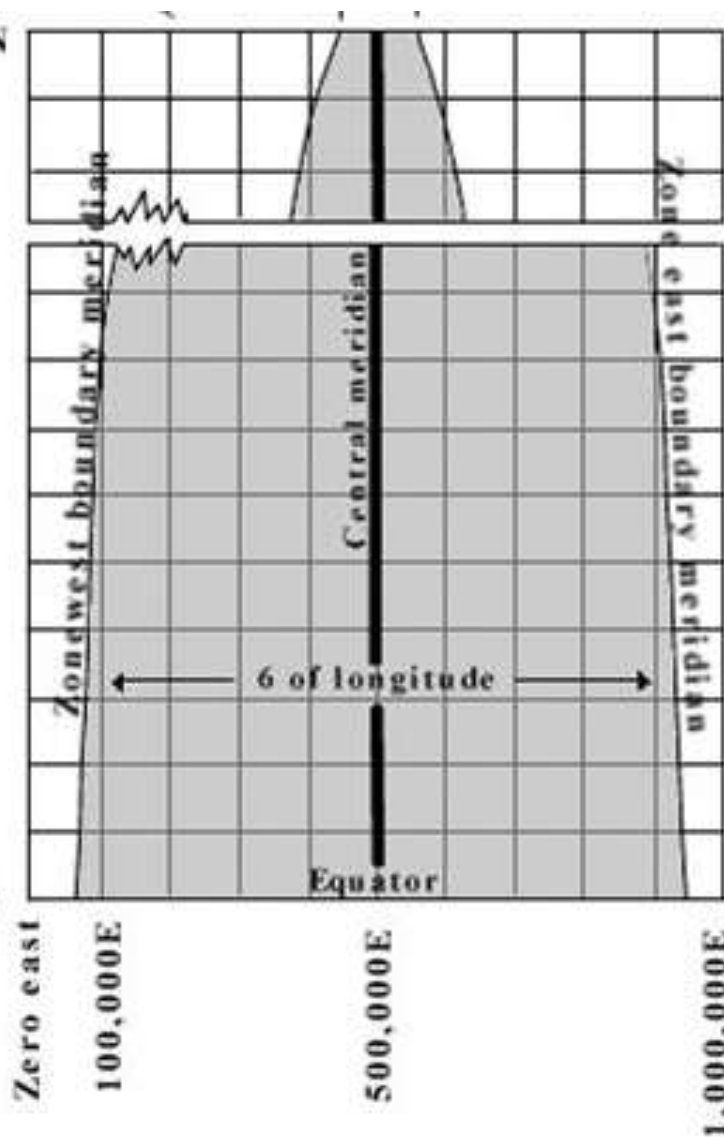
measured from the Equator
(0) - to the north pole
(10,000,000) ... in metres

e.g. UNBC 5,972,000
(= 5972km / 111 = 53.8N)

9,200,000 N

100,000 N

Zero north



BC range= 300,000-700,000

UTM coordinates

The 'x' coordinate

- this is the hardest part ...

Eastings (E) for each zone

- based on the zone

Central Meridian at 500,000

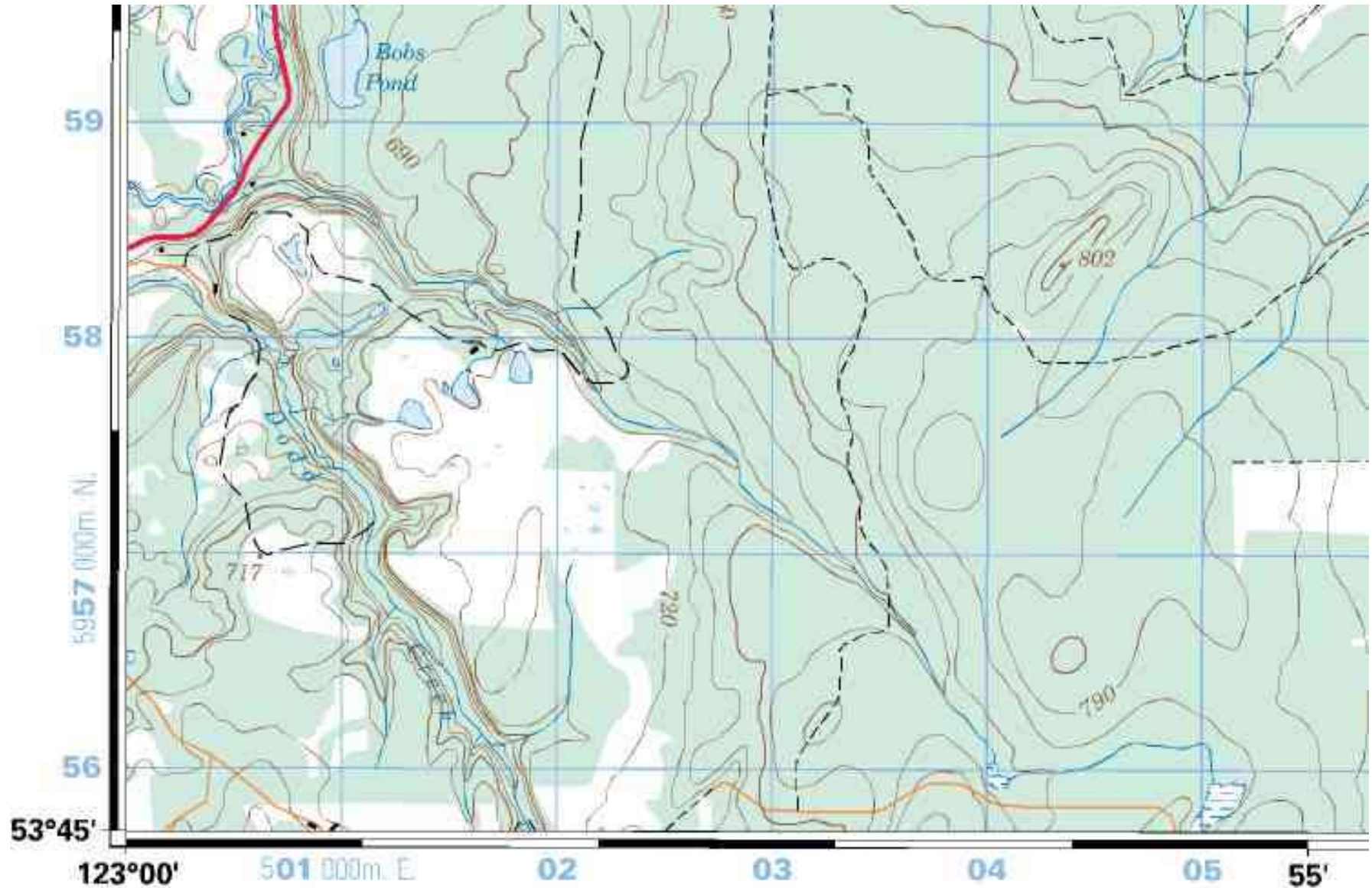
the easting value increases to the east, but not > 1,000,000

the easting value decreases to the west but not below zero

e.g. UNBC 512,000

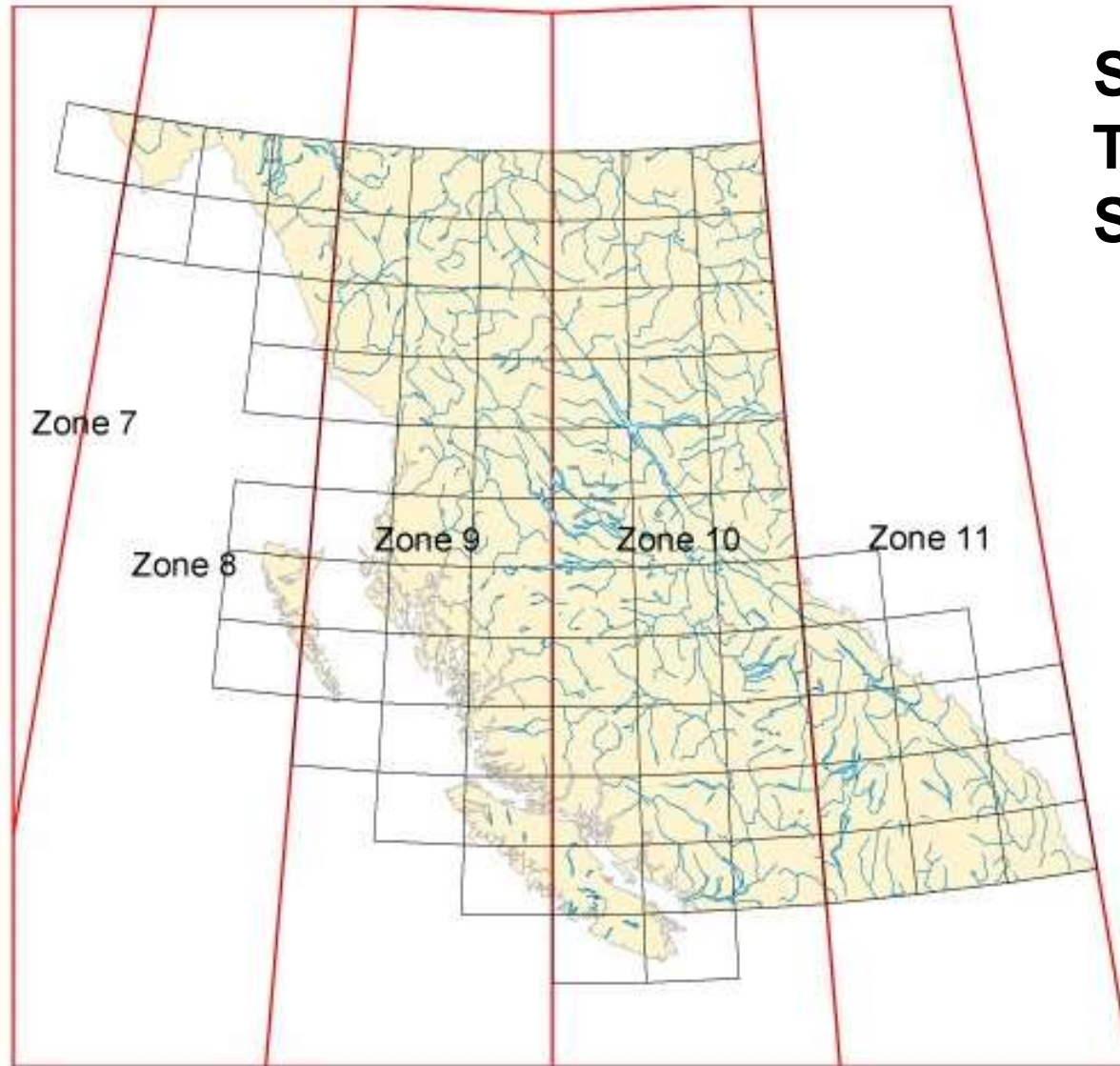
Zone must also be given as Coordinates repeat for each zone

UTM : Eastings are 6 digit, Northings are 7-digit (in Canada)



Blue grid squares in this map are 1000m = 1km

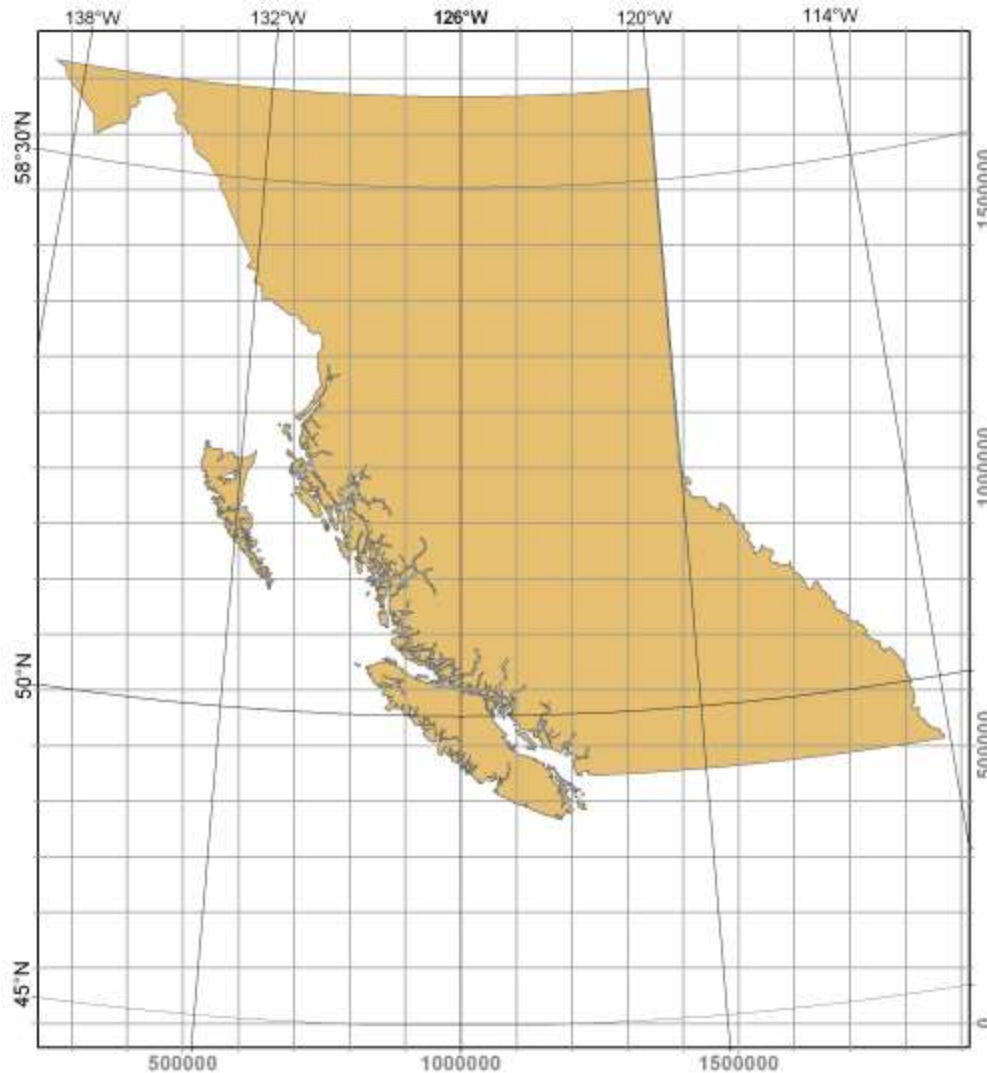
BC: UTM zones



**See google earth:
Tools-> options
Select UTM**

How to deal with multiple UTM zones: Eastings switch from ~700,000 at the east edge of one zone to ~300,000 at the west edge of the next ?

BC Albers coordinate system



BC Albers coordinates
are 6-7 digits x and y

British Columbia Albers Equal Area Conic
Central meridian: -126.0 Degrees West longitude
Latitude of projection origin: 45.0 Degrees North latitude

BC uses UTM for local areas
But Albers for the whole province

Summary: BC mapping coordinates

Could be one of:

1. Geographic - lat. / long. - for global reference
2. UTM - zones 7-11 - for local /regional mapping
3. BC Albers - for BC provincial data

Why is it important - because we 'import' data from different sources .. and they need to line up

Coordinate Converter:

<http://www.tsusiatsoftware.net/coordSys/CoordinateSystemCalculator.html>

It may make more sense here : - view these also in the lab

PGMAP: <http://pgmappub.princegeorge.ca/Html5Viewer/?viewer=PGMapMobile>

UTM coordinates - or lat/long (geographic)

BC IMAP: <http://maps.gov.bc.ca/ess/hm/imap4m/>

UTM, Lat/long and Albers

Google Earth: Geographic and UTM

UTM primer ... good summary for homework and first quiz:

https://testwww.for.gov.bc.ca/hra/Plants/IAPP_training/UTM_system_intro.pdf

The last 3 words on coordinates

<https://what3words.com>



What3words: The app that can save your life: 3 words for every 3 x 3 metre square on earth

<https://www.bbc.com/news/uk-england-49319760>