

ENV101 EARTH SYSTEMS

Practical Exercise 2 – Introduction to ArcMap and Map Projections

1. OVERVIEW

This practical is designed to familiarise students with the use of ArcMap for visualising spatial data and undertaking basic analysis, including understanding the effects of changing data projections. The concepts covered in this practical are assessable (see assessment items in unit outline); however, students are not required to submit answers to questions contained herein.

1.1. Learning Outcomes

After completing this practical, students will be able to:

1. Open and view spatial data in ArcMap;
2. Use the basic navigation tools within ArcMap to become familiar with spatial data;
3. Identify the main distortions introduced to data when using a map projection;
4. Alter projection parameters in ArcMap and quantify the differences associated with these changes in terms of making measurements

1.2. Preparation

External students:

- Ensure that you have installed and licensed the ArcGIS 10 software from the CD that you received in the mail. Or for Mac users, that you can access ArcGIS 10 using the Virtual Desktop Interface (see the *Technical challenges* forum on the *learnline Discussion Board* for further info).
- Create a folder on your C drive on your home computer where you can store all the files and folders for this class. Regardless of the location, note that it is not good practice to use spaces in file or folder names. Instead, use an underscore to give the effect of a space between words.
- Copy all the data required for this tutorial from the CD you received in the mail, or download from week 2 of the ENV101 companion site <http://learnline.cdu.edu.au/units/ses101/materials.htm>, into the folder that you have just created. Hereafter this folder will be referred to as your *working directory*. **Note that if you download the compressed data.zip file from the companion site, you must then unzip it before ArcGIS can read/use the data.**

Internal students:

- Copy all the data required for this tutorial from the G drive (G:\Resources\ENV101\Prac2-intro_ArcMap) onto either your personal student folder (U: drive) or a personal memory stick/hard drive. Hereafter this folder will be referred to as your *working directory*.
- If you are working in the GIS/RS lab, you can either work from the student server (slow, but will be backed up), or your desktop (faster, but will NOT be backed up and all data will be removed on logout). If you are working from the desktop, you should copy your work onto a memory stick or the student server at the end of the session BEFORE logging out.

1.3. Required data

ENV101-Prac2-Intro_to_ArcMap.mxd - This ArcGIS project file has been created for the use of this practical and contains a number of global datasets as listed below:

World.img - Low spatial resolution, true colour satellite image mosaic.

World - Country boundaries, available from ESRI 1996.

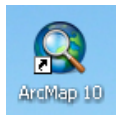
Continent - Continental boundaries, available from ESRI 1996.

World-populated places-110-million - Major population centres around the world

Plates - Tectonic plate boundaries

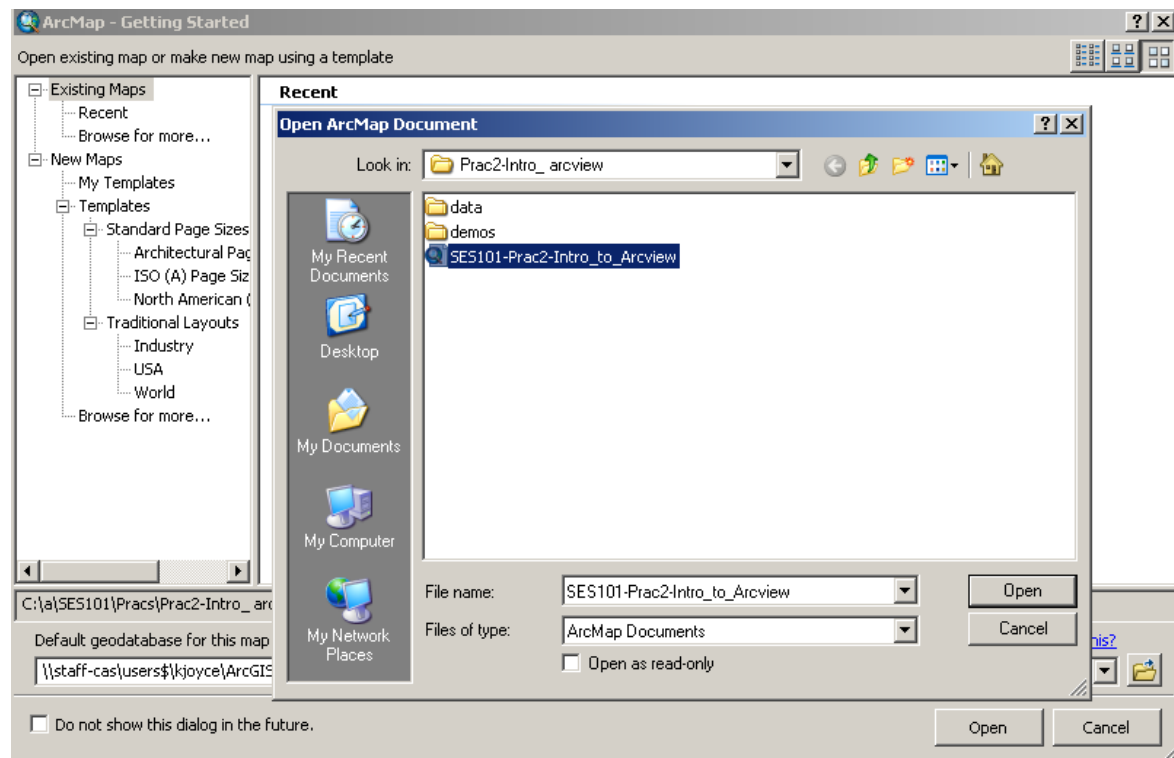
Note that if you download the compressed data.zip file from the companion site, you must then unzip it before ArcGIS can read/use the data.


2. OPENING AND VIEWING MAPS IN ARCMAP



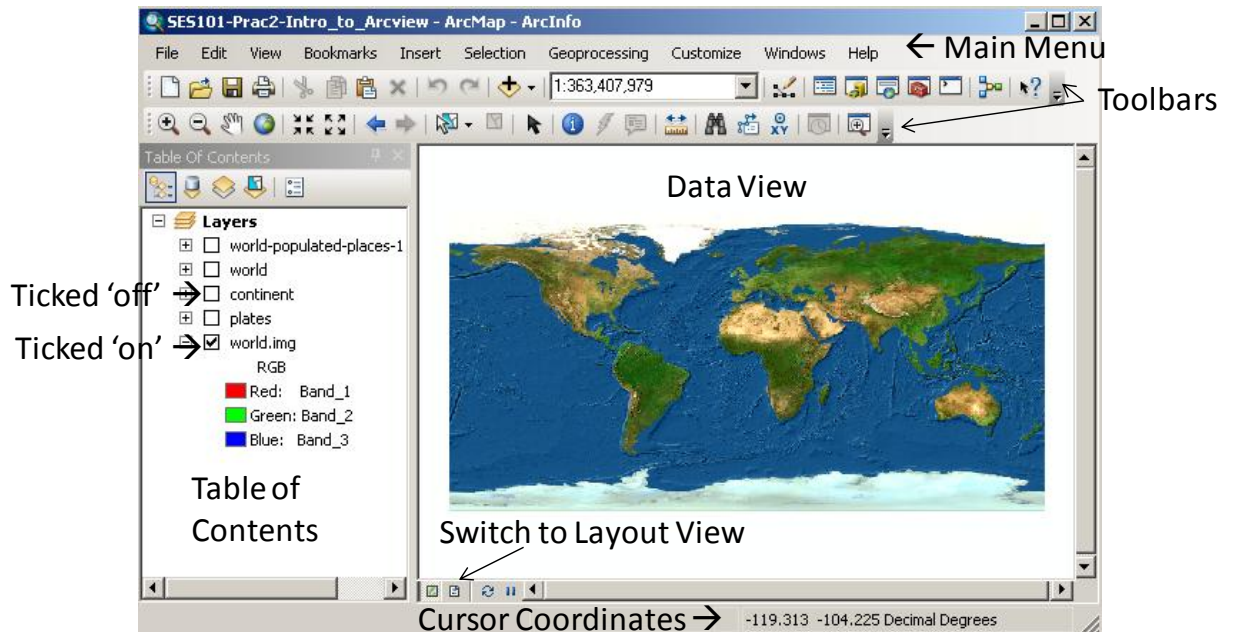
Open ArcMap by going to **Start → All Programs → ArcGIS → ArcMap10** (or by clicking the icon on your desktop).

In the 'Getting started' dialog, select **Browse for more...** and **navigate to and select the file ENV101-Prac2-Intro_to_ArcMap → Open**



 At any stage within ArcMap, you can open an existing document by going to File → Open, or clicking on the icon in the top left of the screen.

See over page for a diagram and description of some commonly used tools within the ArcMap interface. Keep this for reference in future practicals.



The Standard and the Tools toolbar should be visible at the top of your screen, as well as the main menu (File, Edit, View etc). There are a number of other toolbars and these can be added / removed at any time by right clicking your mouse anywhere in the toolbar area and selecting the toolbar you require. Below is a description of the tools available within the 'Tools' and 'Standard' toolbars.

The **Tools toolbar** is used for map navigation and query within the active data frame.



















ArcMap Tools toolbar buttons and their functions

| Button | Name | Function |
|--------|-------------------------|--|
| | Zoom In | Allows you to zoom in to a geographic window by clicking a point or dragging a box |
| | Zoom Out | Allows you to zoom out from a geographic window by clicking a point or dragging a box |
| | Fixed Zoom In | Allows you to zoom in on the center of your data frame |
| | Fixed Zoom Out | Allows you to zoom out on the center of your data frame |
| | Pan | Allows you to pan the data frame |
| | Full Extent | Allows you to zoom to the full extent of your map |
| | Back | Allows you to go back to the previous extent |
| | Forward | Allows you to go forward to the next extent |
| | Select Features | Allows you to select features by clicking or dragging a box |
| | Clear Selected Features | Deselects all of the currently selected features in the active data frame |
| | Select Elements | Allows you to select, resize, and move text, graphics, and other objects placed on the map |
| | Identify | Identifies the geographic feature or place on which you click |
| | Find | Finds features in the map |
| | Go To XY | Allows you to type an x,y location and navigate to it |
| | Measure | Measures distance on the map |
| | Hyperlink | Triggers hyperlinks from features |

The **Standard toolbar** most typically appears at the top of the ArcMap application window and is used for map printing, creating a new map, opening an existing map, saving your map, starting related ArcGIS applications, and more.



ArcMap Standard toolbar buttons and their functions

| Button | Name | Function |
|---|-------------------------------|---|
|  | New map file | Creates a new map |
|  | Open | Opens an existing map |
|  | Save | Saves the current map |
|  | Print | Prints the current map |
|  | Cut | Cuts the selected element(s) |
|  | Copy | Copies the selected element(s) |
|  | Paste | Pastes the clipboard contents into your map |
|  | Delete | Deletes the selected element(s) |
|  | Undo | Undoes the last action |
|  | Redo | Redoes the previously undone action |
|  | Add Data | Adds new data to the map's active data frame |
|  | Editor toolbar | Shows the Editor toolbar so you can edit the map's data |
|  | ArcCatalog | Launches ArcCatalog |
|  | Show/Hide ArcToolbox | Shows/Hides the ArcToolbox window |
|  | Show/Hide Command Line window | Shows/Hides the Command Line window |
|  | What's This? | Allows you to get help for a menu command or tool by clicking the What's This pointer and clicking the menu command or tool |

In the Table Of Contents, you will notice that there are a number of different 'layers' that have been added to this project. However, when you first open the project, in the viewer window you will only be able to see the mosaic satellite image of the world. This is because this is the only layer that has been 'ticked on'.

In turn, **'tick on' each of the other layers** to see what each data layer is showing.

As your map becomes more congested, 'tick off' layers that you don't immediately intend to view.

2.1. Data Exploration

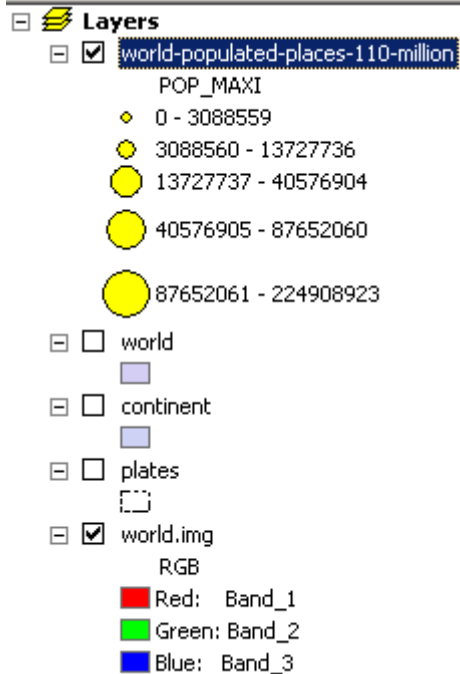


Get comfortable with the zooming and panning tools to navigate your way around the data. At any stage you can hold your cursor over a button to find out what it does.



If you zoom in or out too much and get 'lost', use the zoom to full extent button to return you to the global image.

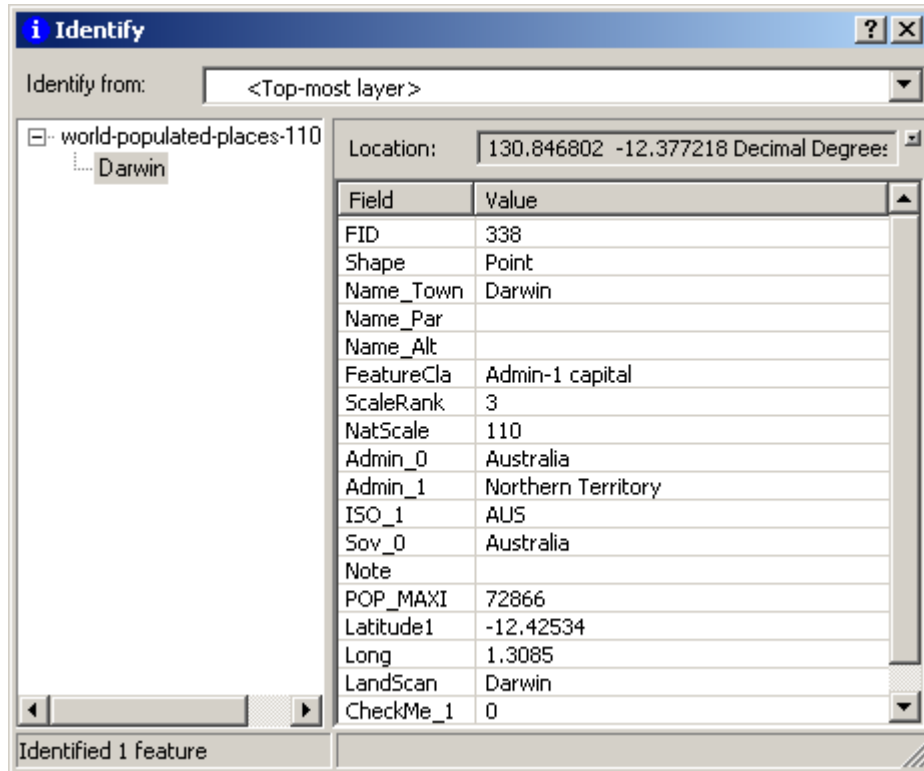
When you opened the project, you will have seen the names of individual layers listed in the table of contents with a small 'plus' sign to the left of each layer. **Click on the plus sign** to expand the table of contents legend.



This will give you a bit more information as to what is displayed in your viewing window.



With the world populated places layer ticked 'on', **use the identify tool** to find out the names of some of the population centres around Australia. How good is your geography? Do you know most of them?



Q1. Where is the biggest population 'dot' in Australia? How does the size of Australian dots compare to cities around the world?

As you can see with the identify tool, there is a large amount of information available that relates to each of the spatial layers that you can see in your data view. A GIS is essentially a large database that also presents data spatially, but the data base information is still retrievable.

In the TOC, right click on the world populated places layer → Open attribute table

| ScaleRank | NatScale | Admin_0 | Admin_1 | ISO_1 | Sov_0 | Note | POP_MAXI | Latitude1 | Long | LandScan | CheckMe_1 |
|-----------|----------|-------------|----------|-------|-------------|---------|----------|-----------|----------------|----------|-----------|
| 3 | 110 | Afghanistan | Kandahar | AFG | Afghanistan | 715542 | 31.61001 | 6.56949 | Kandahar | | 0 |
| 3 | 110 | Afghanistan | Kabul | AFG | Afghanistan | 4803365 | 34.5167 | 6.91832 | Kabul | | 0 |
| 4 | 50 | Afghanistan | Hirat | AFG | Afghanistan | 481009 | 34.33002 | 6.21699 | Herat | | 0 |
| 4 | 50 | Afghanistan | Balkh | AFG | Afghanistan | 458151 | 36.70001 | 6.71 | Mazar-e Sharif | | 0 |
| 8 | 10 | Afghanistan | Hirat | AFG | Afghanistan | 11293 | 34.48678 | 6.25917 | Karokh | | 0 |
| 7 | 20 | Afghanistan | Bamyan | AFG | Afghanistan | 515 | 34.82108 | 6.7521 | Bamian | | 0 |
| 7 | 20 | Afghanistan | Balkh | AFG | Afghanistan | 179969 | 36.74972 | 6.68997 | Balkh | | 0 |
| 7 | 20 | Afghanistan | Faryab | AFG | Afghanistan | 71730 | 36.93123 | 6.51014 | Andkhvoy | | 0 |
| 7 | 20 | Afghanistan | Faryab | AFG | Afghanistan | 199795 | 35.9298 | 6.477 | Meymaneh | | 0 |
| 8 | 10 | Afghanistan | Jawzjan | AFG | Afghanistan | 93241 | 36.65802 | 6.57382 | Sheberghan | | 0 |
| 7 | 20 | Afghanistan | Farah | AFG | Afghanistan | 73647 | 32.39174 | 6.20968 | Farah | | 0 |
| 7 | 20 | Afghanistan | Zabul | AFG | Afghanistan | 0 | 32.11184 | 6.68867 | | | 0 |

In the attribute table, you will be able to view all the data 'behind the scenes' of your spatial data view. Each record (row) represents one data point on in your data view

window. You can sort the information in any of the fields (columns) alphabetically or numerically by right clicking on the field heading.

Q2. How many records are there in the populated places shapefile?

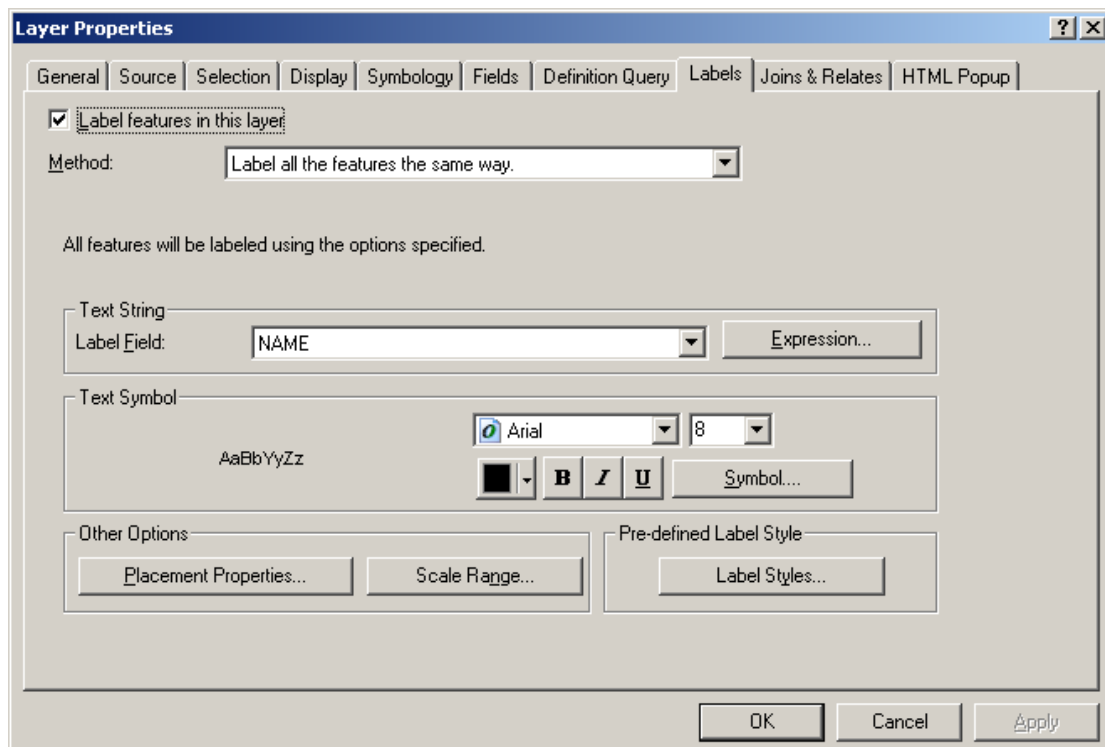
Q3. Which city is listed as the most populous?

Another way to display information from the attribute table on your map is to create data labels for different features.

Tick 'on' the plates layer. As above, **open the attribute table** for this layer to view the information presented.

In the TOC, **right click on plates** → **Properties** and **go to the Labels tab**.

Tick 'on' the option to **'Label features in this layer'**



Click OK

You should now see labels for each of the tectonic plates.

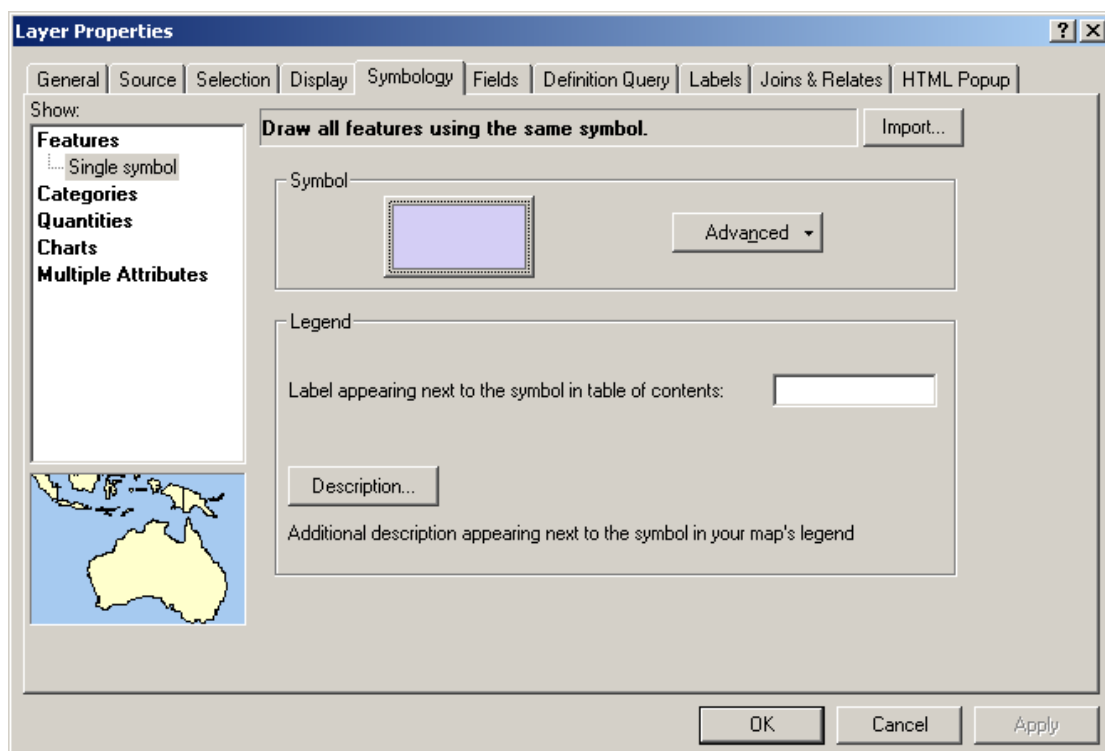
Q4. Which plate do you think is the largest?

2.2. Data Display

Tick 'on' the 'world' layer

Right click on the 'world' layer → **Properties**

Select the **Symbology** tab



Click on the purple colour patch, and select a different colour → OK → OK

Your new colour will be displayed for this particular layer. Experiment by changing the colours and outlines of any of the other layers as you see fit.

Note: if you cannot see your changes appearing in your data view window, check that you have the layer ticked 'on' in the table of contents.

The table of contents lists your layers in a set order, which is linked to the way in which they are displayed in your data view. This means that if a layer is listed before another layer in the TOC, then it will be displayed on top of that layer in the data view.

Tick 'on' the world populated places layer and the world.img layer. Tick 'off' the remaining layers

Click and drag the world populated places layer in the TOC to the bottom of the TOC list.

Q5. How does rearranging your TOC affect your data view window?

3. BASIC COORDINATE SYSTEMS AND DATUMS

Source: Peter H. Dana, The Geographer'sCraft Project, Department of Geography, The University of Texas at Austin. Copyright © 1999 Peter H. Dana.

There are many basic coordinate systems familiar to students of geometry and trigonometry. These systems can represent points in two-dimensional or three-dimensional space. René Descartes (1596-1650) introduced systems of coordinates based on orthogonal coordinates. These two and three-dimensional systems used in analytic geometry are often referred to as Cartesian systems.

3.1. Geodetic Datums

Geodetic datums define the reference systems that describe the size and shape of the earth. Hundreds of different datum have been used to frame position descriptions since the first estimates of the earth's size were made by Aristotle. Datums have evolved from those describing a spherical earth to ellipsoidal models derived from years of satellite measurements. Modern geodetic datum range from flat-earth models used for plane surveying to complex models used for international applications which completely describe the size, shape, orientation, gravity field, and angular velocity of the earth. While cartography, surveying, navigation, and astronomy all make use of geodetic datum, the science of geodesy is the central discipline for the topic.

Referencing geodetic coordinates to the wrong datum can result in position errors of hundreds of meters. Different nations and agencies use different datum as the basis for coordinate systems used to identify positions in geographic information systems, precise positioning systems, and navigation systems. The diversity of datum in use today and the technological advancements that have made possible global positioning measurements with sub-meter accuracies requires careful datum selection and careful conversion between coordinates in different datum.

3.2. **Global Coordinate Systems**

Latitude, Longitude, Height

The most commonly used coordinate system today is the latitude, longitude, and height system. The Prime Meridian and the Equator are the reference planes used to define latitude and longitude.

Equator and Prime Meridian

The geodetic latitude (there are many other defined latitudes) of a point is the angle from the equatorial plane to the vertical direction of a line normal to the reference ellipsoid. The geodetic longitude of a point is the angle between a reference plane and a plane passing through the point, both planes being perpendicular to the equatorial plane. The geodetic height at a point is the distance from the reference ellipsoid to the point in a direction normal to the ellipsoid.

ECEF X, Y, Z

Earth Centered, Earth Fixed Cartesian coordinates are also used to define three dimensional positions. Earth centered, earth-fixed, X, Y, and Z, Cartesian coordinates (XYZ) define three dimensional positions with respect to the center of mass of the reference ellipsoid. The Z-axis points toward the North Pole. The X-axis is defined by the intersection of the plane defined by the prime meridian and the equatorial plane. The Y-axis completes a right handed orthogonal system by a plane 90 degrees east of the X-axis and its intersection with the equator.

3.3. **Universal Transverse Mercator (UTM)**

Universal Transverse Mercator (UTM) coordinates define two dimensional, horizontal, positions. UTM zone numbers designate 6 degree longitudinal strips extending from 80 degrees South latitude to 84 degrees North latitude. UTM zone characters designate 8 degree zones extending north and south from the equator. There are special UTM zones between 0 degrees and 36 degrees longitude above 72 degrees latitude and a special zone 32 between 56 degrees and 64 degrees north latitude.

UTM Zones

Each zone has a central meridian. Zone 14, for example, has a central meridian of 99 degrees west longitude. The zone extends from 96 to 102 degrees west longitude. UTM Zone 14 Eastings are measured from the central meridian (with a 500km false easting to insure positive coordinates). Northings are measured from the equator (with a 10,000km false northing for positions south of the equator).

3.4. **Projection Systems**

Map projections are attempts to portray the surface of the earth or a portion of the earth on a flat surface. Some distortions of conformality, distance, direction, scale, and area always result from this process. Some projections minimize distortions in some of these properties at the expense of maximizing errors in others. Some projections are attempts to only moderately distort all of these properties.

Conformality

When the scale of a map at any point on the map is the same in any direction, the projection is conformal. Meridians (lines of longitude) and parallels (lines of latitude) intersect at right angles. Shape is preserved locally on conformal maps.

Distance

A map is equidistant when it portrays distances from the center of the projection to any other place on the map.

Direction

A map preserves direction when azimuths (angles from a point on a line to another point) are portrayed correctly in all directions.

Scale

Scale is the relationship between a distance portrayed on a map and the same distance on the Earth.

Area

When a map portrays areas over the entire map so that all mapped areas have the same proportional relationship to the areas on the Earth that they represent, the map is an equal-area map.

3.5. Geocentric Datum of Australia (GDA)

The Geocentric Datum of Australia (GDA) is the new Australian coordinate system, replacing the Australian Geodetic Datum (AGD). GDA is part of a global coordinate reference frame and is directly compatible with the Global Positioning System (GPS). It is the culmination of more than a decade of anticipation and work by the Intergovernmental Committee on Surveying and Mapping (ICSM) and its predecessor, the National Mapping Council (NMC). When the NMC adopted the AGD84 coordinate set in 1984, it "recognised the need for Australia to eventually adopt a geocentric datum." This was further recognised in 1988 when ICSM "recommended the adoption of an appropriate geocentric datum by 1 January 2000".

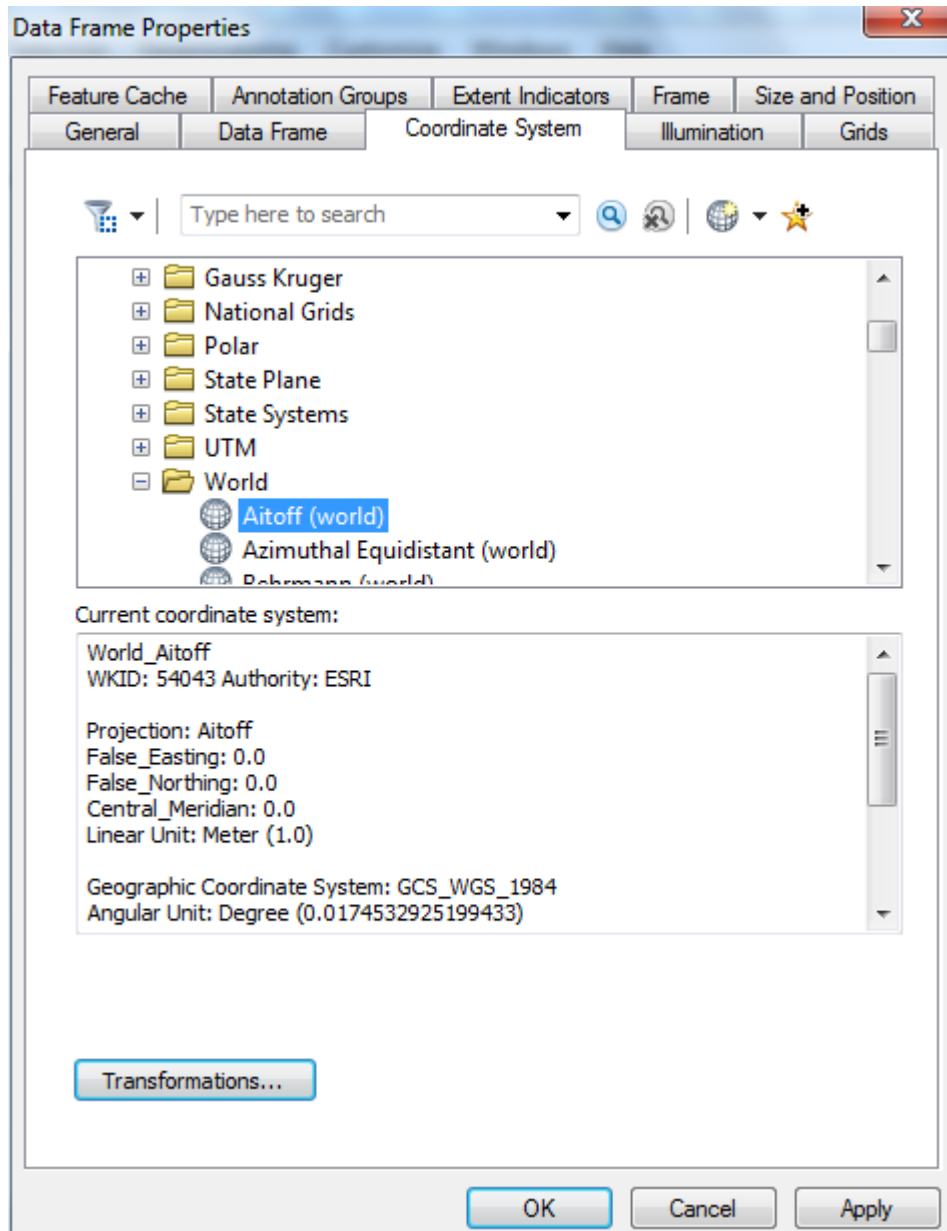
4. EXPERIMENTING WITH MAP PROJECTIONS

Zoom to the full extent of your data view

Right click on 'Layers' in the table of contents and go to **Properties**

Select the Coordinate System tab

In the select a coordinate system box, navigate to **Projected coordinate systems** → **World** and **select one of the options available**



Click **Apply**


Experiment with several different coordinate systems. Zoom and pan around the globe to observe the different distortions produced.

Sometimes it is useful to see what the lines of latitude and longitude (parallels and meridians) look like with the different projections. Under the data frames properties, click the **Grids** tab

Click the **New Grid** button. Accept all defaults by clicking through **Next** three times, and then **Finish**

Click **Apply**

To be able to view the grid, you must switch from the Data View to the **Layout View**.

This is the small button that looks like a new page at the bottom of your view  or you can select from the main menu bar **View > Layout View**

Q6. As you experiment with different co-ordinate systems, select three examples that look very different from each other. Complete the following table using the examples of your choice (hint, look for the measuring tape button on your toolbar – you can use this tool to draw lines for distances and polygons for areas).

| | Coordinate system 1 | Coordinate system 2 | Coordinate system 3 |
|---|----------------------------|----------------------------|----------------------------|
| Name | | | |
| Distance between Darwin and Brisbane | | | |
| Area of Antarctica | | | |
| Comment on relative shape of countries | | | |

Q7. Revisit your answer to Question 4. In light of what you have discovered with changing map projections, do you still think that the answer you provided is correct?

Q8. What is the central meridian? What happens if you modify this value in the coordinate system properties (hint, you can do this by right clicking on the projection → copy and modify)?

Q9. Suppose that you have been given two data sets, one of a bird species distribution, the other of an invasive plant that is known to endanger the birds. You would therefore like to see how the distributions correspond to each other. However they have been provided in different projections and co-ordinate systems. Explain how this might prove a challenge for you.