

CHAPTER 4

Spatial data management

In the previous chapter you have seen how spatial data is entered in ILWIS via digitizing. Another method for obtaining spatial data is to convert digital data into other file formats. Sometimes, you obtain data that might not be directly usable in an analysis. The data may still need to be edited. The data may be in the wrong data type for a specific type of analysis. You may have to convert data from one vector type to another (e.g. from segments to polygons), or from vector to raster (rasterization). The data may also contain the wrong coordinates, georeference, domain or representation.

In this chapter the various spatial data management operations are shown, which precede the actual data analysis. The first part of this chapter (section 4.1) deals with the import of raster and vector maps from different file formats. In section 4.2, the topic of map projections is treated, and how you can change maps from one projection to another. In section 4.3, tools for vector data management are shown, and in section 4.4, the vector to raster conversion is demonstrated. Then in section 4.5, the tools for the management of raster maps are explained.

The final section 4.6 focuses on the conversion of domains.

Before you can start with the exercises, you should start ILWIS and change to the subdirectory C:\ILWIS 3.0 Data\Users Guide\Chapter04, where the data files for this chapter are stored.



- Double-click the ILWIS icon on the desktop.
- Use the Navigator to go to directory the C:\ILWIS 3.0 Data\Users Guide\Chapter04.

4.1 Importing digital data

In the previous chapter you have seen how to digitize maps. However, sometimes maps may already be available in digital format from another source. They may have been generated using different software, they may have resulted from scanning maps, or they may be available as digital satellite images or scanned images. In order to use these digital data in ILWIS, the files need to be imported to the ILWIS file formats that are required. Importing can be done with the Import module, in which you can select the import method and format.

While importing files into ILWIS, you must know what type of data you are importing: whether it is a point, segment, polygon or raster map, and what type of information is stored inside the map. The content of a map determines the domain type (class, ID, value, image, picture, color, etc.) that will be assigned to the imported map.

Within ILWIS, you can use the normal ILWIS import, but you can also import external files via GeoGateway.

GeoGateway is a product of PCI Geomatics (<http://www.pcigeomatics.com>) which allows programs to access data in many geomatics file formats, in a uniform manner, without having to translate them before use in applications. *GeoGateway* includes access to imagery, vectors, attributes, projections and other auxiliary information of interest to users of geomatics applications.

When using *GeoGateway*, you can choose to:

- perform a *genuine import* and translate the external file to an ILWIS format:
 - the external data will be translated into ILWIS file formats: ILWIS object definition files (e.g. .MPR, .TBT) as well as ILWIS data files will be created.
 - you can view the imported data, calculate with it, use it in ILWIS operations, etc.
 - the imported data can be edited in ILWIS.
- keep the external file in its original format (*Use As*):
 - the external data will *not* be translated into ILWIS file formats: only ILWIS object definition files (e.g. .MPR, .TBT) will be created; as the same data file will not appear twice on your hard disk in different formats, you will save some hard disk space in this way.
 - you can view the imported data, calculate with it, use it in ILWIS operations, etc.
 - the imported data *cannot* be edited in ILWIS however.

After you used Import via *GeoGateway*, you will obtain an ILWIS *object collection* . The object collection contains the ILWIS objects that are the result of the import. You can open an object collection by double-clicking it in a Catalog; you can subsequently open the imported objects also by double-clicking.

4.1.1 Importing raster data through ILWIS import

Raster maps can be imported from a number of file formats. Some of these formats do not allow the storage of coordinates. This is the case for the frequently used file interchange formats: Tag Image File (TIF) format, and the Windows Bitmap (BMP) format. When you import a raster map from these formats, the resulting ILWIS map will have a georeference *None*. This means that the map is not georeferenced.

The TIF file format is frequently used as the storage type for scanned images. Here an example is shown of importing a scanned aerial photograph of the city of Cochabamba.



- From the File menu of the Main window, select Import, Map. The Import dialog box is opened. Click the Help button if you like.
- Select the Import Format: Tagged Image File Format .TIF.
- Select the file: `Airphoto.tif`, leave the Output Filename as it is and click OK. The map `Airphoto` is now imported.
- Open the raster map `Airphoto` and check that it doesn't have coordinates.
- From the File menu of the map window, select Properties, and 1 map `Airphoto`. The Properties sheet is opened.
- Check the size of the map and the domain and close the Properties sheet and the map window afterwards.

As you can see the import of black and white TIFF images, results in an image domain for the output map.

When you import a TIFF image, the domain of the imported image depends on the storage type of the TIFF file. ILWIS can import raster data with 1 bit/pixel (into domain bit), 4 or 8 bits/pixel (into domain image), 4 or 8 bits/pixel with a color lookup table (into domain picture), up to 24 bits per pixel (RGB, into domain color). The same is true for files that are in Windows bitmap format (.BMP).

The user has no control over the selection of output domains of these maps. Methods to convert domains of maps are explained in section 4.6.

Now some examples of importing Windows bitmap files will be shown: one of a map showing the country of Bolivia (`Bolivia_mask`). The other map is a hillshading image of Bolivia and its surroundings (`Hillshad`) with 8 bits/pixel, with a color lookup table, resulting in an ILWIS map with a picture domain.



- From the File menu of the Main window, select Import, Map. The Import dialog box is opened.
- Select the Import Format: Windows bitmap .BMP.
- Select the file: `Bolivia_mask.bmp`. Leave the Output Filename as it is and click OK. The map `Bolivia_mask` is now imported.





- Import also the Windows bitmap `Hillshad`.
- Open the raster maps `Bolivia_mask` and `Hillshad` and check the domain types and other properties of both maps.
- Close the map windows. The maps will be used later on.

Other file formats, such as the ERDAS `.GIS`, ERDAS `.LAN` and IDRISI `.DOC/.IMG`, also allow for the conversion of coordinate information. The conversion of these file formats will result in maps with a georeference corners.

4.1.2 Importing raster data through GeoGateway

To import external raster file formats in ILWIS, you can use the normal ILWIS Import, but you can also Import via GeoGateway, which supports many current raster file formats. The result of a GeoGateway import is an ILWIS object collection.

In this exercise, you will import an ERDAS `.IMG` file using GeoGateway and convert this data to ILWIS data format. This file contains a Landsat TM image of Cochabamba. The result will be an object collection, containing a map list and 3 different bands (raster maps).



- Expand the Import/Export item in the Operation-tree, and double-click Import Via GeoGateway. The Import dialog box is opened.
- Select the file: `Tm_b123.img`.
- Make sure the option Use PCI-GeoGateway is selected in the Import Format list box.
- Accept the Output Filename `Tm_b123`.
- Select the check box Convert to ILWIS data format and click OK. The map `Tm_b123.img` is now imported.
- Double-click the object collection `Tm_b123`. The object collection is opened.
- Open the maps to see the contents. Check the domain types and other properties of the maps.
- Close the object collection and the map windows after you have finished the exercise.

In the next exercise you will import an IKONOS image with a 1 meter resolution. As this file is almost 90 MB, we will use the Use AS option (see section 4.1). The file is furthermore in GeoTiff format so that coordinates will be preserved. You will obtain an object collection which contains a map list and the definitions of three bands.



- From the File menu of the Main window, select Import, Via GeoGateway. The Import dialog box is opened.
- Select the file: `Ikonos_Cochabamba.tif`.
- Make sure the option Use PCI-GeoGateway is selected in the Import Format list box, leave the Output Filename as it is, clear the check box Combine compatible vector layers, and make sure that the check box Convert to ILWIS data format is cleared.
- Click OK. The `Ikonos_Cochabamba.tif` file is now imported.
- Double-click the object collection `Ikonos_Cochabamba`. The object collection is opened.
- Double-click the map list in the object collection and click the Open As ColorComposite button. The Display Options – Map List as ColorComp dialog box appears.
- Select image `Ikonos_Cochabamba__3` for the Red Band, `Ikonos_Cochabamba__2` for the Green Band and `Ikonos_Cochabamba__1` for the Blue Band.
- Adapt the default stretch values to 1% intervals. For the minimum and the maximum stretch values, use for the Red Band 36 and 328, for the Green Band 37 and 332, and for the Blue Band 39 and 338. Click OK. The interactive color composite is shown in a map window.
- Zoom in on the image; close the map window, the map list and the object collection after you finished the exercise.

4.1.3 Importing through General Raster Import

Import General Raster is designed to import raster map formats which are not directly supported by ILWIS nor by GeoGateway. Files to be imported may have a band sequential structure, a band interleaved structure or a pixel interleaved structure.

This option does not automatically read the header line of the file that normally contains information about the map's dimensions, coordinates, data type, etc. The user is asked to enter required information manually, therefore you should have some knowledge about the header size and the structure of the file.

In this exercise, a global 30 Arc Second Elevation Data file will be imported which is part of a global Digital Elevation Model. The file covers part of South America.

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- ! This file has been downloaded from the USGS EROS Data Center at
 - <http://edcdaac.usgs.gov/gtopo30/gtopo30.html>. As exercise material it is also available on the ILWIS CD-ROM and the ILWIS web site.
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- Expand the Import/Export item in the Operation-tree, and double-click Import General Raster. The Import dialog box is opened.
- Select the file: `w100s10.DEM`.
- Make sure the option Use General Raster Import is selected in the Import Format list box.
- Accept the Output Filename `w100s10` and click OK. The Import General Raster dialog box is opened.
- Type 0 for Header Size.
- Select 1 for Number of Bands.
- Type 4800 for Number of Columns.
- Select Integer numbers for Pixel Structure.
- Select 2 for Number of bytes per pixel.
- Select the check box High Endian Byte Order.

If you would like to edit the contents of the map, you need to convert the data file to ILWIS data format. In this case, you will not edit the map nor use it in another exercise. Therefore it is sufficient to use the data file in the original file format.



- Make sure that the check box Use data file in original format is selected.
- Accept the Output Name `w100s10` and click OK. The map `w100s10.DEM` is now imported.
- Open the map to see its contents.

The map window shows part of the continent of South America. The imported map has system domain value. When moving the mouse pointer in the map window, you will see that the map has no coordinates. Before you can use this imported map together with other data in ILWIS, you need to create a georeference for the map.



- Close the map window.
- In the Main window, open the File menu and select Create, GeoReference. The Create GeoReference dialog box is opened.
- Type for the GeoReference Name `w100s10`.
- Accept the GeoRef Corners option.
- Select the Coordinate System `LatLonWGS84`.
- Type for Pixel size `0° 0' 30"`.
- Type for Min Latitude `60° 0' 0" S`.
- Type for Min Longitude `100° 0' 0" W`.
- Type for Max Latitude `10° 0' 0" S`.





- Type for Max Longitude 60° 0' 0" W.
- Make sure the option Center of Corner pixels is *not* selected and click OK. The georeference is created.
- In the Catalog, click with the right mouse button on raster map W100S10 and select Properties from the context-sensitive menu. The Properties sheet is opened.
- In the Properties sheet, select GeoReference W100S10 and click OK.
- Open the map W100S10 and check the coordinates.

Raster map W100S10 is now displayed with the proper coordinates and can be used in combination with other data in ILWIS.

Note that pixels in the ocean area have a value -9999, which indicates that there is no data available, while in ILWIS this should be undefined. You can correct the map with a Map Calculation in which you replace value -9999 by "?".



- Type the following formula on the Command line of the Main window:
CorrectDEM = IFF(W100S10=-9999,?,W100S10) ↵
- The map is calculated and the Raster Map Definition dialog box is opened.
- Accept the defaults in the Raster Map Definition dialog box and click OK. The output map is now displayed with undefined values where no data is available, and with a proper stretch for elevation data.
- Close all map windows after you have finished the exercise.

4.1.4 Importing vector data through ILWIS import

The most frequently used file formats for importing vector data in ILWIS, are the ArcInfo .E00 (non-compressed) format, the ArcView .SHP format and the AutoCad .DXF format.

The conversion from ArcInfo .E00 format depends on the contents of the file, and will either result in a segment map, possibly with a point map containing polygon labels, or a polygon map. The domain will always be identifier.

In this exercise, you will import an ArcInfo .E00 file which contains the entire drainage network of Bolivia. The file, Dnnet .E00, is part of the Digital Chart of the World and has been downloaded from the Digital Chart of the World Server at Penn State University Libraries at <http://www.maproom.psu.edu/dcw>. The import will result in an ILWIS segment map and an attribute table.



- From the File menu of the Main window, select Import, Map. The Import dialog box is opened.
- Select the Import Format: Arc/Info .E00 interchange format.
- Select the file: Dnnet .E00. Accept the Output Filename and click OK. The map Dnnet .E00 is now imported.
- Open the Properties sheet of segment map Dnnet, and change the coordinate system to LatLon. The coordinates in this drainage map are geographical coordinates.
- Display the segment map Dnnet, check the names of the segments, and check the coordinates.
- If you like, add segment maps Contour and Drainage to the map window, and zoom in.
- Close the map window when you are finished.

The conversion from AutoCad .DXF may be a segment map, a polygon map and/or a point map, depending on the contents of the file. If the codes in the .DXF file only contain numerical values (as is the case for contour lines), the output domain will be value. Otherwise it will be a class domain (if there is more than 1 code).

In this example a map of South America, in AutoCad .DXF format (Samerica), will be imported as a polygon map with a class domain. Note that in this case each polygon has a separate boundary line, without topology.



- From the File menu of the Main window, select Import, Map. The Import dialog box is opened.
- Select the Import Format: AutoCad .DXF.
- Select the file: Samerica .dxf. Leave the Filename as it is and click OK. The map Samerica is now imported.
- Open the Properties sheet of the polygon map Samerica, and change the coordinate system to LatLon. The coordinates in this map are geographical coordinates.
- Display the polygon map Samerica, check the coordinates and the names of the polygons and close the map window after you have finished the exercise.

4.1.5 Importing vector data through GeoGateway

External vector file formats can be imported using the normal ILWIS Import, but you can also import vector files through GeoGateway, which supports many current vector file formats. The result of a GeoGateway import is an ILWIS object collection.



- From the File menu of the Main window, select Import, Via GeoGateway. The Import dialog box appears.
- Select the file: Cochabamba.pix.
- Make sure the option Use PCI-GeoGateway is selected in the Import Format list box and leave the Output Filename as it is.
- Clear the check box Combine compatible vector layers and click OK. The Cochabamba.pix file is now imported.
- Double-click the object collection Cochabamba. The object collection is opened.
- Open the map list and click the Open As ColorComposite button. The Display Options – Map List as ColorComp dialog box appears.
- Select image Cochabamba__4 for the Red Band, Cochabamba__3 for the Green Band and Cochabamba__2 for the Blue Band.
- Adapt the default stretch values to 1% intervals. For the minimum and the maximum stretch values, use for the Red Band 7 and 74, for the Green Band 9 and 71, and for the Blue Band 10 and 49. Click OK. The interactive color composite is shown in a map window.
- Drag and drop the segment layers on top of the color composite and close the map window, the map list and the object collection after you finished the exercise.

For more information on the import of vector and raster data, see the ILWIS Help.

Summary: Importing data

- Raster maps can be imported from a number of file formats. Some of these formats do not allow for the storage of coordinates, for instance the Windows Bitmap (.BMP) format. The Tagged Image File format (.TIF) only stores coordinates when it has been exported as GeoTIFF. Other file formats, such as the ERDAS .GIS, ERDAS .LAN, and the IDRISI .DOC/.IMG generally contain coordinate information.
- Frequently used file formats for importing vector data into ILWIS are the Arc/Info .E00 format, the Arc/View .SHP format and the AutoCad .DXF format.
- To import external raster and vector file formats into ILWIS, you can use the normal ILWIS Map Import, but you can also Import via GeoGateway, which supports many current raster and vector file formats.
- Import General Raster is designed to import raster maps which formats are not directly supported by ILWIS nor by GeoGateway. Files to be imported may have a band sequential, a band interleaved, or a pixel interleaved structure.

4.2 Map projections

The maps that you obtain after importing, often need to be changed before you can use them in combination with the rest of your data. The different tools that you can use to change vector and raster maps will be explained in the rest of this chapter. One of the most important changes that may have to be done is related to the coordinates of the map. The map may not have coordinates (in the case of raster maps imported from TIFF or BMP for example). In that case you will have to georeference and resample so that they have equal dimensions, pixel size and projection as the other maps. Also, for vector maps, which have coordinates by definition, these coordinates may not be the ones that you use for other maps. In that case you will need to transform the coordinate system. The most important reason that coordinates may be different (apart from the fact that a local coordinate system may have been used), is that the original maps had different projections.

A map *projection* defines the relationship between the map coordinates and the geographic coordinates, latitude and longitude.

The *geographic coordinate* system is a spherical coordinate system composed of parallels of latitude (ϕ) and meridians of longitude (λ) (see Figure 4.1.A).

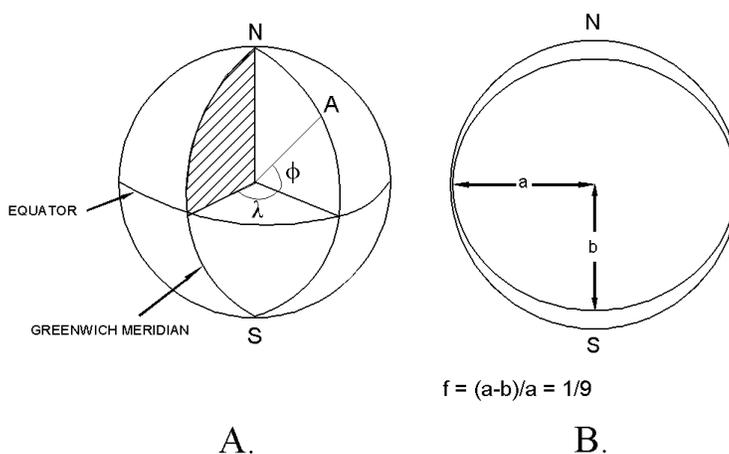


Figure 4.1: A: Geographic coordinate system: The location of A is determined by the longitude (λ) and the latitude (ϕ). B: The relationship between a sphere with radius a and an ellipse with major and semi-axis a and b

Because of the earth's rotation, the shape of the earth is not a perfect sphere. The earth is flattened towards the poles: The equatorial axis (line from the center to the equator) is longer than the polar axis. The earth's shape can be represented by an *ellipsoid*, or as it is sometimes called, a *spheroid* (shapes that are generated by revolving an ellipse around its minor axis).

A *spheroid* has 2 different semi-axes a and b , where a is the radius of the equator circle and b is the half axis of rotation ($b < a$). See Figure 4.1B.

The flattening of the ellipsoid is defined by:

$$f = (a-b)/a$$

and the eccentricity:

$$e^2 = (a^2 - b^2) / a^2$$

It follows that the ellipsoid shape is also completely defined by a and f or by a and e . Nearly 93% of the earth's land surface is mapped using only four of these ellipsoids: International, Krassovsky, Bessel and Clarke (1880). Table 4.1 lists the ellipsoids available in ILWIS. They are stored in text file `ELLIPSO.def`. In this file, for each ellipse the value of a (equatorial radius) and $1/f$ (the inverse of the flattening) are listed.

If no ellipsoid is known, the choice by default is a sphere with $a = b = 6371007$ m.

The choice of the ellipsoid, which fits best a given region of the earth's surface to be mapped, depends on the surface curvature and *geoid* undulations in that region. Hence every country has its own "best" ellipsoid. See also the ILWIS Help topic `Select Ellipsoid`.

Table 4.1: Reference ellipsoids, which can be chosen in ILWIS.

| | |
|---------------------------------------|------------------------|
| Airy 1830 | Fischer 1960 |
| ATS 77 | Fischer 1968 |
| Australian National | GRS 80 |
| Bessel 1841 | Helmert 1960 |
| Bessel 1841 (Japan by Law) | Hough 1960 |
| Bessel 1841 (Namibia) | Indonesian 1974 |
| Clarke 1866 | International 1924 |
| Clarke 1880 | Krassovsky 1940 |
| Clarke 1880 (IGN) | Modified Airy |
| D-PAF (Orbits) | Modified Fischer 1960 |
| Everest (India 1830) | New International 1967 |
| Everest (India 1956) | SGS 85 |
| Everest (Malaysia 1969) | South American 1969 |
| Everest (E. Malaysia and Brunei) | WGS 60 |
| Everest (Malaysia and Singapore 1948) | WGS 66 |
| Everest (Pakistan) | WGS 72 |
| Everest (Sabah Sarawak) | WGS 84 |

The surface of the earth is curved but this should be presented in maps as a plain surface. This will always result in some deformation or distortion, unless you use a spheroidal map (a globe). To correctly represent the curved earth's surface on a flat map, you need a special *map projection*. With the help of a map projection, geographic coordinates are converted into a two dimensional metric coordinate system, measuring the X and Y directions in meters. Each map projection has unique equations for the transformation from geographic to metric coordinates.

Map projections can be subdivided according to three aspects: class, aspect and properties.

There are three classes of map projections:

- *Cylindrical projections*

Cylindrical projections may be imagined, as the transformation to a plane that is wrapped around the globe in the form of a cylinder (see Figure 4.2). Note that it is possible that the cylinder intersects the sphere (a secant cylinder). The outline of the world map would be rectangular in shape.

- *Azimuthal projections*

These projections may be imagined as the transformation on a plane tangent to the globe (Figure 4.2). As with the cylindrical projections, here the plane may intersect the sphere (a secant plane). The characteristic outline of the world map would be circular.

- *Conical projections*

These projections may be imagined as the transformation to a plane that is wrapped like a cone around the globe (Figure 4.2). The possibility of a secant cone is also present in this class. The outline of the world would be fan shaped.

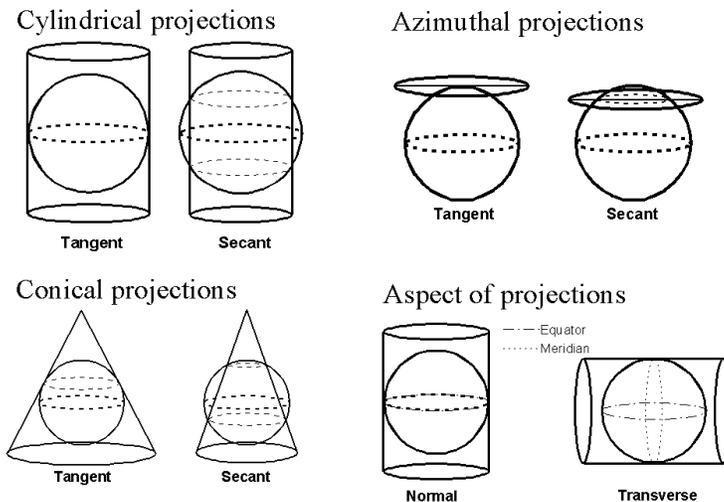


Figure 4.2: Cylindrical, azimuthal and conical projections. For each projection a tangent (touching the globe), and a secant (intersecting the globe) version is shown. The lower right part of the figure illustrates two aspects: Normal (oriented parallel to the earth's axis) and transversal (oriented perpendicular to the earth's axis)

Projections can also be subdivided according to their *aspect*: The direction in which a cylinder, plane or cone is oriented with respect to the globe. In Figure 4.2 two possibilities are given: Normal and transverse aspects. For cylindrical projections a *normal aspect* is a cylinder that touches the equator. A *transverse aspect* is a cylinder that touches the poles. Similarly the normal and transverse aspects of azimuthal projections can be visualized. The aspect may also be *oblique*; in that case the cylinder, plane or cone is not horizontally or vertically oriented, but something in between.

Another important way to subdivide map projections is according to their *properties*. As mentioned before, a map projection always results in some deformation or distortion. Depending on the type of projection, these distortions will be different. This is indicated by the so-called special properties. The most important properties are:

- *Conformality*: A conformal map is one in which all angles are indicated correctly. All angles measured on the earth's surface are measured with the same values in the map. As all angles are maintained, the shape of the objects is also preserved.
- *Equivalence*: A map with an equivalence property is called an *equal-area map*. Although the shape of objects is distorted, the area as measured on the globe is correctly indicated on the map.
- *Equidistance*: An equidistant map has the characteristic that along a special set of lines, distances are equal.

Map projections are named according to the class, the aspect, the property, the name of the originator and the nature of any modification. In Table 4.2 an overview is given of the projections available in ILWIS.

Now we will take a look at some map projections and see how the map of the world is displayed.



- Open the segment map `World`.
- Click the Add Graticule option in the Layers menu. The Display Options - Graticule dialog box is opened.
- Type `20°` for Graticule Distance, accept all other defaults and click OK. The graticule is now added to the map window, showing parallels and meridians every `20°`.
- In the map window, open the File menu, choose Properties and select the segment map `World`. Check the coordinate system on the Segment Map tab of the Properties sheet.
- Close the Properties sheet.

Now the effect of several map projections on the display of the world map will be demonstrated. For each projection a new coordinate system should be created.



- Drag the map window to the side of the screen.
- In the Main window, open the File menu and select Create, Coordinate System. The Create Coordinate System dialog box is opened.
- Type for the Coordinate System Name: `Centcyl`.
- Type for the Description: `Using the central cylinder projection`.
- Select CoordSystem Projection and click OK. The Coordinate System Projection dialog box is opened.





- Click the Projection button.
- Select the projection: `Central Cylindrical` and click OK.

The Coordinate System dialog box now displays more information, relevant for this projection. The central cylindrical uses the equatorial radius of the earth, since the cylinder touches the earth at the equator. See Figure 4.2.

The *false easting*, *false northing* and *central meridian* are used to define the X, Y coordinates of the map. *False easting*: Overall increase of map x-coordinates ('eastings'), indicating the eastward shift of the origin of the projection relative to the redefined origin (negative if projection origin is west of false origin). *False northing*: Overall increase of map y-coordinates ('northings'), indicating the northward shift of the origin of the projection relative to the redefined origin (negative if projection origin is south of false origin). We won't change them now.



- Type some positive values for Max X,Y. These coordinates will be adapted automatically, based on the map displayed in the map window.
- Click OK in the Coordinate System dialog box.
- Drag and drop coordinate system `Centcyl` to the map window in which the map `World` is displayed.
- Note how the `World` map and the 20° graticules change.
- Zoom in on the central part of the world, around the equator.

The map you see is neither conformal nor equal area. It is projected perspectively from the center of the earth onto a cylinder tangent to the equator (see Figure 4.2). The equator and other parallels are straight lines (spacing increases towards the poles) and meet meridians (equally spaced straight lines) at right angles. Parallel spacing increases towards the poles. The poles cannot be shown. Scale is true along the equator. Shape, area and scale distortion increases rapidly away from the equator. This map projection only shows the areas surrounding the equator correctly. All other areas are too much distorted.



- Create another coordinate system projection: `Lambert_AEA`. Select the projection: Lambert Azimuthal Equal Area.
- Type some positive numbers for Max X Y. These coordinates will be adapted automatically, based on the map displayed in the map window.
- Enter for the Sphere Radius: 6356007 and click OK.
- Drag and drop coordinate system `Lambert_AEA` to the map window displaying the map `World`.

Table 4.2: Some of the projections available in ILWIS. See for other projections and descriptions also the ILWIS Help topics Select projection and Suggested projections.

| Projection | Remarks |
|------------------------------|---|
| Cylindrical | |
| Cassini | Map is equidistant. Used in ellipsoidal form for topographic mapping of Great Britain before the 1920's (supposedly Airy ellipsoid) and detailed mapping of German states in the same period; also used for topographic mapping of France in the 18th century. |
| Central Cylindrical | Map is perspective but neither conformal nor equal area. Projected perspectively from the center of the earth onto a cylinder tangent to the equator. Only used for teaching purposes. |
| Eckert I | Pseudo-cylindrical projection. Map has equally spaced parallels and is neither conformal nor equal area. Used for showing straight line equal-area graticule. |
| Eckert II | Pseudo-cylindrical projection. Map is equal area. Meridians are equally spaced straight lines broken at the Equator. Used for showing straight line equal-area graticule. |
| Eckert III | Pseudo-cylindrical projection. Map has equally spaced parallels and is neither conformal nor equal area. Used for showing straight line equal-area graticule. |
| Lambert Cylind Equal Area | Also called Cylindrical Equal Area. Mainly used for educational purposes. |
| Mercator | Conformal. Designed for navigational use; standard for marine charts. Recommended use for conformal mapping of regions predominantly bordering the equator. Often inappropriately used as a world map. |
| Miller | Compromise between Mercator and other cylindrical projections. Used in numerous world maps. |
| Mollweide | Pseudo-cylindrical projection. Map is equal area. Occasionally used in thematic world maps. |
| Oblique Mercator | Map is conformal. Oblique aspect of Mercator. Used for larger scale mapping in Switzerland, Madagascar and Borneo, and for atlas maps of regions having a greater extent in an oblique direction, such as Hawaii. |
| Plate Carree | Also called Simple Cylindrical or Equidistant cylindrical. Used for raster maps which store information of the whole world: Each pixel represents a square block of LatLon coordinates, i.e. information is stored per degree, per minute, etc. Used for mapping the earth taken as a sphere. |
| Plate Rectangle | Also called EquiRectangular. Variant of Plate Carree. Used for raster maps which store information of the whole world: Each pixel represents a rectangular block of LatLon coordinates. |
| Robinson | Pseudo-cylindrical projection for world maps compromising distortion. Map is neither conformal nor equal area. Used for world maps, for example, by Rand McNally in Goode's Atlas for thematic world maps. Only used in spherical form. |
| Transverse Mercator | Also called Gauss Conformal, or Gauss Krüger. Transverse form of the Mercator Projection (conformal). Used for many topographic maps at scales from 1: 20000 to 1: 250000. Recommended for mapping regions that are predominantly north-south in extent. |
| UTM | Universal Transverse Mercator. Map is conformal. Widely used for topographic maps and military maps. |
| Azimuthal | |
| Azimuthal Equidistant | Commonly used in the polar aspect for maps of polar regions and the Northern and Southern hemispheres. The oblique aspect is frequently used for world maps centered on important cities and occasionally for maps of continents. |
| Gnomonic | Map is perspective and neither conformal nor equal area. It is used to show great circle paths as straight lines and thus to assist navigators and aviators. |
| Hammer Aitoff | Hammer Aitoff Equal Area, variant of Lambert Azimuthal Equal Area. |
| Lambert Azimuthal Equal Area | Used for maps of continents and hemispheres. Also suited for regions extending equally in all directions from a center point, such as Asia and the Pacific Ocean. |
| Orthographic | Known by Egyptians and Greeks 2000 years ago. Map is perspective and neither conformal nor equal area. Only one hemisphere can be shown. The earth appears as it would on a photograph from space. |

Table 4.2 continued:

| Projection | Remarks |
|----------------------------------|--|
| Stereographic | Apparently invented by Hipparchus (2nd century bc). Used in combination with UTM projection as Universal Polar Stereographic (UPS) for mapping poles and in navigation charts for latitudes above 80°. Recommended for conformal mapping of regions that are approximately circular in shape. For example, used for topographic maps of the Netherlands. |
| UPS | Universal Polar Stereographic. Azimuthal and perspective projection. Map is conformal. Used in combination with UTM projection as Universal Polar Stereographic (UPS) in Arctic and Antarctic maps and in navigation charts for latitudes above 80°. |
| Conical | |
| Albers Equal Area Conic | If the pole is one of the standard parallels, it is equal to Lambert's Equal Area Conic. Frequently used for maps of the United States, for thematic maps and for world atlases. Recommended for equal area maps of regions that are mainly east-west in extent. |
| Bonne | Pseudo-conic projection. Map is equal area. Frequently used until mid-20th century for atlas maps of continents and for topographic mapping of some countries. |
| Equidistant Conic | Also called Simple Conic. The most common projection in atlases for small countries. |
| Lambert Conformal Conic | Lambert Conformal Conic/Conical Orthomorphic (Lambert, 1972) (conformal). Extensively used for large-scale mapping of regions predominantly east-west in extent. Further widely used for topographic maps. |
| Polyconic | or American Polyconic (Hassler, ± 1820). Map is neither conformal nor equal area. The sole projection used for large scale mapping of the United States by the USGS until the 1950's. |
| Other projections | |
| Dutch RD | Dutch topographic map projection. Map is conformal. The stereographic projection of the Netherlands is a so-called double projection. The datum Rijksdriehoeksmeting, which implies the Bessel 1841 ellipsoid, will be used automatically. |
| Gauss-Boaga (Italy) | Country projection. Transverse Mercator used in topographic maps of Italy. |
| Gauss (Colombia) | Country projection. Transverse Mercator used in topographic maps of Colombia. |
| Gauss-Krüger (Germany) | Country projection. Transverse Mercator used in topographic maps of Germany. |
| General Perspective | Shows the earth as seen from space. Projection is perspective. |
| Lambert Conformal Conic (France) | Country projection. Lambert conformal conic projection used in topographic maps of France. |
| Sinusoidal | used since 16th century. Also called Mercator Equal Area. Pseudo-cylindrical projection. Map is equal area. Used in atlas maps of South America and Africa. Occasionally used for world maps. Modifications are called Sinusoidal Interrupted, Sinusoidal 2x Interrupted and Sinusoidal 3x Interrupted. |
| Van der Grinten | Shows the entire earth within one circle. All areas, shapes and angles are greatly distorted. |

You will see that the world is projected in a circular way on a plane which touches the earth at 0 degrees latitude and longitude. Therefore, the equator and the 0 degrees meridian are straight lines.



- Open coordinate system: Lambert_AEA.
- Enter for the Central Meridian: 60° 00' 00" W and for the Central Parallel: 20° 00' 00" N and click OK.
- Press the Redraw button in the map window.

Now the projection is such that the plane touches South America. The equator is no longer a straight line. Only the 60° W meridian is now a straight line.

Now the effect of a conical projection will be demonstrated.



- Create another coordinate system: `Lambert_CC`. Select the projection: `Lambert Conformal Conic`.
- Type some positive numbers for Max X, Y, enter for the Sphere Radius: `6356007` and click OK.
- Drag and drop coordinate system `Lambert_CC` to the map window displaying the map `World` and zoom in on the centre of the map.

Now only the area surrounding the North Pole is displayed, in a very distorted way.



- Open coordinate system: `Lambert_CC`.
- Enter for the Central Meridian: `20° 00' 00" W`.
- Enter for the Central Parallel: `50° 00' 00" S`.
- Enter for the Standard Parallel 1: `40° 00' 00" S`.
- Enter for the Standard Parallel 2: `60° 00' 00" S`.
- Click OK and press the Redraw button in the map window.

The Southern Hemisphere is now shown in a conical projection.

Some projections will also be shown that are useful for displaying world maps.



- Create another coordinate system: `Orthographic`. Select the projection: `Orthographic`.
- Type some positive numbers for Max X, Y, enter for the Sphere Radius: `6356007` and click OK.
- Drag and drop coordinate system `Orthographic` to the map window displaying the map `World`.

The world map is now displayed as if you look at the earth from space.



- Open coordinate system: `Orthographic`.
- Enter for the Central Meridian: `90° 00' 00" E`.
- Enter for the Central Parallel: `30° 00' 00" N`.
- Click OK and press the Redraw button in the map window.

You will now see the continent of Asia.



- See the effect of the Plate Carree, the Mercator, the Mollweide and the Sinusoidal projection.
- Try also other projections, if you like.
- When finished, close the map window.

Up to now you have only seen the different projections displayed on the screen. To actually transform the map, you need to use the Transform Segment operation in this case, since the map world is a segment map. For points you use the Transform Points, and for polygons the Transform Polygons operation. They work basically the same.



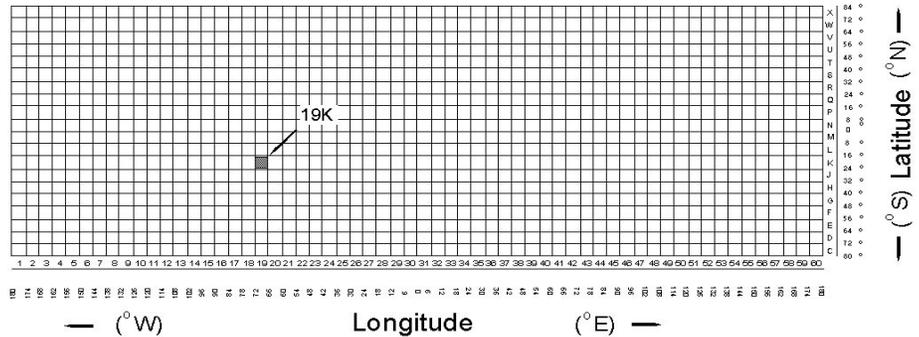
- In the Catalog, click segment map world with the right mouse button and select Vector Operations, Transform Segments. The Transform Segment Map dialog box is opened.
- Select the (target) Coordinate System: Lambert_AEA.
- Type for Output Segment Map: world_Lambert_AEA and click the Show button. The segment map world_Lambert_AEA is created and the Display Options – Segment Map dialog box is opened.
- Click OK. The map is displayed.
- Add a graticule to the map window and look at the effect.
- Close the map window when you are finished.

The UTM projection

There is one map projection that will be treated in more detail, which is the projection used most in GIS and image processing for relatively small study areas. The *Universal Transverse Mercator (UTM)* projection system was developed in the late 1940s by the US Army. Since then, it has become a standard in topographic mapping. The UTM comprises the following features:

- The projection is the “Gauss- Krüger” version of the Transverse Mercator.
- The projection is only intended for mapping between 84° N and 80° S. Beyond that there is too much distortion.
- The unit of measure is the meter.
- The world is divided into 60 zones of 6° of *longitude* in width. Zone 1 has its western edge at the 180° meridian. Zone 60 has its eastern edge on the same meridian. Consequently the zones are numbered from west to east. The zones are shown in Figure 4.3. Cochabamba is located 66° 08' 52" W in longitude, and 17° 23' 30" S in latitude. So it is located on the boundary between UTM zones 19 and 20.
- A second zoning is made along the *latitudes* following 8° intervals (except for the most northern zone that has an interval of 12°). These zones have a better designation from south to north (see Figure 4.3). So Cochabamba is located in zone 19K.

- The origin of each zone is located on a point at the equator, where it is intersected by the central meridian of that zone.
- The Easting of the origin of each zone is assigned a value 500,000 m.
- Each zone has its own coordinate system.



Example: Cochabamba, Bolivia 66° West , 17°South → zone number 19K

Figure 4.3: UTM grid zone designations for the world, shown on an equidistant cylindrical projection index map.

- The UTM has a special convention for recording the Northings. For the Southern Hemisphere the equator is assigned the value 10,000,000. For the Northern Hemisphere the value at the equator is assigned as 0.
- The UTM might use one of the following definitions of the shape of the earth: International Spheroid, Clarke 1866 (Africa), Clarke 1880 (North America), Everest or Bessel (both for smaller parts of Southern and South East Asia).

One of the objections to the introduction of the UTM map projection, was the method of dividing the world into 60 zones. A country was likely to be divided into several UTM zones, each having its own coordinate definition and origin. Still the UTM system was accepted worldwide. Many maps show the coordinates of the national system as well as those of the UTM.

For large scale mapping, if an area lies within more than one UTM zone, the entire area has to be mapped as if it lies in that zone. One should select the zone that occupies the major part of the area, extending the borders of the zone over the +3° and -3° boundaries.

Likewise, if the country covers both sides of the equator, the coordinates from the Southern Hemisphere are extended for the part on the Northern Hemisphere (so larger than 10,000,000).

The data on the projection used should be found on the topographic map, from which you have digitized the information. On the topomap of Cochabamba, the following information is given:

- Ellipsoid: International.
- Projection: Transverse Mercator.
- Vertical Datum: Sea level.
- Horizontal datum: Provisional South America 1956.
- UTM zone: 19 K.



- Open the coordinate system: Cochabamba.
- Click the Ellipsoid button and select the Ellipsoid: International 1924 and click OK.
- Click the Datum button and select the Datum: Provisional South America 1956, select the Area: Bolivia and click OK.
- Clear the check box Northern Hemisphere.
- Enter for the (UTM) Zone: 19 and click OK in the Coordinate System Projection dialog box.

Suppose you want to convert data from the Cochabamba area from UTM zone 20 to UTM zone 19. To illustrate the transformations you first create a coordinate system for the adjacent UTM zone 20.



- Open the File menu in the Main window and select Create, Coordinate System. The Create Coordinate System dialog box is opened.
- In the Create Coordinate System dialog box type Cocha20 for the Coordinate System Name, select the option CoordSystem Projection and click OK. The Coordinate System Projection dialog box appears.
- Enter some positive values for Max X, Y and click the Projection button.
- In the Select Projection dialog box, select the Projection: UTM and click OK.
- Click the Ellipsoid button, select the Ellipsoid: International 1924 and click OK in the Select Ellipsoid dialog box.
- Click the Datum button and select the Datum: Provisional South America 1956, the Area: Bolivia and click OK.
- Clear the check box Northern Hemisphere.
- Enter for the UTM Zone: 20 and click OK in the Coordinate System Projection dialog box.

Now that a new coordinate system is made for UTM zone 20, you can link this coordinate system to the maps digitized in that projection.

Checking coordinate transformation

Before making a coordinate transformation, it is wise to check the transformation for a few coordinate pairs. This can be done with the Transform Coordinates dialog box.

The following steps have to be done:

- Select a certain point on one of the paper maps and note its X and Y coordinates.
- Determine this point on the other paper map and note its X and Y coordinates.
- Enter one of the coordinate pairs in the ILWIS Transform Coordinates dialog box as the following:



- Double-click the Transform Coordinates operation in the Operation-list. The Transform Coordinate dialog box is opened.

The options in this box can be used to check whether the transformation is correct. It allows you to select an input and output coordinate system, to type the X and Y coordinates of a point to be transformed and to interactively view the output coordinates for the selected point.

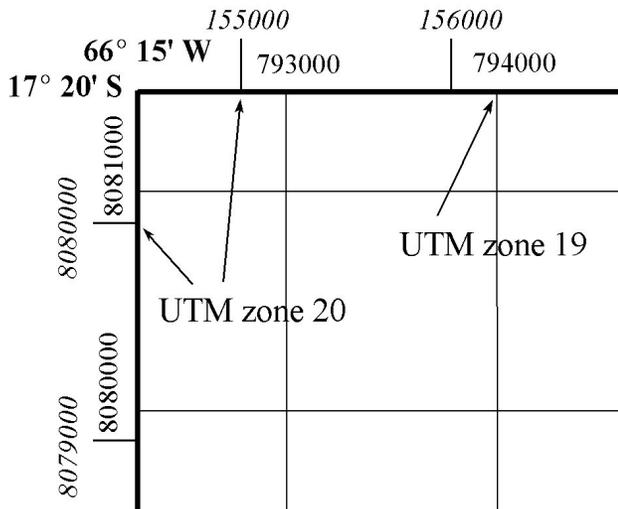


Figure 4.4: The corner of the topomap of sheet "Cochabamba" indicated the grid in UTM 19 coordinates, the tickmarks in UTM 20 coordinates and the upper left corner in geographic coordinates.

First you will check whether the conversion from latitude/longitude to metric coordinates of a certain UTM zone is correct.



- Select the Input Coordinate System *LatLon*.
- Type the latitude and longitude as indicated in the corner of the map in Figure 4.4.
- Select the Output Coordinate System *Cochabamba* in the list box Output Coordinate System.
- Check the metric coordinates of UTM zone 19 with those in the map in Figure 4.4. Write them down.





- Select the coordinate system `Cocha20` list box Output Coordinate System.
- Check the metric coordinates of UTM zone 20 with those in the map in Figure 4.4 and write them down.

Now you will check if the conversion of coordinates from UTM zone 20 to 19 is done correctly.



- In the Transform Coordinates dialog box select the Input Coordinate System `Cocha20`.
- Type the X and Y values that have been noted down for the conversion from `LatLon` to UTM 20.
- Select the coordinate system `Cochabamba` in the list box Output Coordinate System.
- Check the metric coordinates of UTM zone 19 with those that you have written down for UTM 19.
- Close the Transform Coordinates dialog box.

The calculated coordinates for this point in other projections will be displayed in the box. You should check the X and Y value with the ones you have noted from the paper map with the UTM projection. Small differences may occur, due to rounding errors. If the calculated coordinates are very different, you better check whether the projection parameters in the input coordinate system are correct. If the calculated coordinates are the same, follow the next steps to transform the actual map.

Transforming vectors

After checking that the transformation of some known points in two maps with different projections is done correctly, you can do the actual transformation. In this example, we have a map `City20`, in which the outline of the city of Cochabamba is digitized in UTM 20 coordinates. This polygon file will be temporarily transformed to UTM zone 19, for display purposes. There is also a segment map `City19`, with which you can check the result.



- Display polygon map `City20`. This map has coordinates in UTM 20.
- Display segment map `City19`. This map has coordinates in UTM 19.
- Drag-and-drop polygon map `City20` into the map window displaying `City19`.
- Compare the boundaries of the city polygon and segments.

Now the actual transformation can be done.



- Close both map windows.
- Double-click Transform Polygons in the Operation-list. The Transform Polygon Map dialog box is opened.
- Select the map City20 in the list box Polygon Map.
- Select Cochabamba in the list box Coordinate System.
- Type City19 in the text box Output Polygon Map and click Show. The Display Options - Polygon Map dialog box is opened.
- Accept the defaults by clicking the OK button. Polygon map City19 is displayed.
- Compare the input polygon map City20 with the transformed output polygon map City19.
- Check the result by adding segment map City19 to the map window and zoom in where the lines are doubled.
- Add gridlines every 1000 meters (in Blue), and a graticule (in Green) every 5 minutes.
- Close the map window when you have finished the exercise.

Summary: Map projections

- After importing vector maps, their coordinates may not be the ones that you use for your other maps. In that case you will need to transform the coordinate system. The most important reason that coordinates may be different (apart from the fact that a local coordinate system may have been used) is that the original maps had different projections.
- A map *projection* defines the relationship between the map coordinates and the geographic coordinates latitude and longitude.
- Projections are classified according to their class (cylindrical, azimuthal, conical), their aspect (normal, transverse) and their properties (conformality, equivalence, equidistance).
- The Universal Transverse Mercator (UTM) projection system, is the projection used most in GIS and image processing, for relative small study areas. In this projection the world is divided into 60 zones of 6° of longitude in width.
- Before making a coordinate transformation, it is wise to check the transformation for a few coordinate pairs. This can be done with the Transform Coordinates dialog box.
- After checking that the transformation of some known points in two maps with different projections is done correctly, you can do the actual transformation.

4.3 Vector data management

A vector map can be obtained either via digitizing a paper map, as was explained in chapter 3, or from importing digital vector data, as was shown in section 4.1. A number of tools are available to adapt vector maps for the analysis. In order to be able to use vector maps of the same area together, all maps should have the same coordinate system. In the previous section, the transformation from one coordinate system to another was explained. In this section, a number of tools for further manipulating vector maps will be shown such as the creation of a sub map, combining two or more vector maps into one map, copying selected information from a vector map using a mask, densifying coordinates, or thinning them using tunneling, editing vector maps, and the conversion from one type to another. The change of the domain type of the map will be explained in section 4.6.

Creating a sub map

The *sub map* operation makes it possible to select a rectangular part in a vector map and save it as a new map. The user has to specify minimum and maximum XY-coordinates for the new segment map. The output segment map can be smaller than the input map, but it can also be larger.

In this exercise, a rectangular part of the segment map *Drainage* will be saved as a new segment map.



- Expand respectively the Vector Operations item and the Segments item in the Operation-tree.
- Double-click SubMap of Segment Map operation. The Sub Map of Segment Map dialog box is opened.
- Select segment map *Drainage* in the list box Segment Map.
- Type 797200 for minimum X and 8078200 for minimum Y in the text box Min X, Y.
- Type 805300 for maximum X and 8083300 for maximum Y in the text box Max X, Y.
- Type *Drainsub* in the Output Segment Map text box and click Show. The Display Options - Segment Map dialog box is opened.
- Click OK. The map is displayed.
- Compare the *Drainsub* map with the map *Drainage* and close both map windows when you have finished the exercise.

Glueing segment maps

This operation merges two or more segment maps of the same coordinate system and domain together. By default, it copies all segments of the input maps into the output map, unless a mask to select specific segment codes is specified. The operation also

creates coordinate boundaries for the output map, based on the minimum and maximum X and Y coordinates of the input maps. Note: If a user defines coordinate boundaries that are smaller than the default, all segments of the input maps that fall within these user-defined coordinates are copied, and the segments outside this boundary are deleted.

-
- ! The output map of this operation may have double segments, which can be removed by editing the map (see chapter 3 on editing segments).
 - The segments that are supposed to continue in two or more sheets are *not* automatically connected to each other in the output map. They can be connected in the Segment editor using the Move Points option.
-

Suppose you have digitized contour lines for the Cochabamba area from two map sheets. Now you want to combine them into one single map. Suppose also that you only want the hundred meter contour lines. This means you have to use a mask.



- Display segment map Connorth. This segment map contains the contour lines for the northern part of the study area.
- Also display Consouth. This map contains the segments for the southern part of the area.
- Close both map windows and double-click the item Glue Segment Maps in the Operation-list. The Glue Segment Maps dialog box is opened.
- Select the option 2 for Number of Input Maps.
- Select the map Connorth and Consouth in the list boxes Map.
- Type 100 in both text boxes Mask. This has the effect that only the contour lines with 100 meter contour interval are copied.
- Select the check box Clip Boundary.

This check box is used when a user wants to specify different coordinate boundaries for the output map than those of the combination of the input maps. Otherwise, by default, the output map comprises the whole area of all input maps.



- Leave the Min X and Max X unchanged and type for Min Y: 8071798. Type for Max Y: 8090600.
- Type Concomb in the New Domain and the Output Segment Map text boxes.
- Type the Description: 100 meter contour lines in the entire study area and click the Show button. The Display Options - Segment Map dialog box is opened.
- Accept the defaults by clicking the OK button in this dialog box. The new segment Concomb is displayed.
- Close the map window when you have finished the exercise.

Masking vector data

This operation allows to selectively copy points, segments, or polygons into a vector map, by specifying a *mask*, which lists the names and/or codes that are to be copied. A mask contains one or more search strings, separated by a comma (spaces before or after a comma make no difference). Asterisks can be used as a wild card for zero or more characters (e.g. *grass**, *forest** or *1**, *2**). Also question marks may be used to replace only one character (e.g. the mask *??00* or **00* in a contour map). For more information, open the ILWIS Help, search for Mask, and open the help topic How to use masks. See also chapter 7, in which more examples of data retrieval with a mask will be given.

Any vector map (with domain type class, ID, value) can be used as input map in this operation. In fact there are three separate operations for points (Mask Points), segments (Mask Segments) and polygons (Mask Polygons), but they work the same. The output map uses the same domain, coordinate system and coordinate boundaries as the input map. In this example, segment map *City19* will be used to extract only the grid lines.



- Display the segment map *City19*, and open the domain to look at the domain items.
- Close the Domain Class editor and the map window.
- Double-click the Mask Segments item in the Operation-list. The Mask Segments dialog box is opened.
- Select segment map *City19* in the list box Segment Map.
- Type *Grid19* in the text box Mask and in the text box Output Segment Map.
- Click Show. The Display Options - Segment Map dialog box is opened.
- Accept the defaults by clicking the OK button in this dialog box. Now only the grid lines are shown.
- Close the map window when you have finished the exercise.

Densify segment coordinates

The operation Densify Segment Coordinates adds extra intermediate coordinates within segments of an input map, at a user-specified distance, and copies them to an output segment map. It is advised to use this operation during the Transform Segments. The segment map *Grid19*, which was created in the previous exercise, will be used as an example. This map contains gridlines, digitized for the Cochabamba area. Each gridline in the input map is defined by a starting and ending coordinate.



- Double-click `Densify Segment Coordinates` in the Operation-list. The `Densify Segment Coordinates` dialog box is opened.
- Select the map `Grid19` in the list box `Segment Map`.
- Type `200` in the text box `Distance`. An intermediate coordinate will be added every 200 meters.
- Type `Grid19new` in the text box `Output Segment Map` and click `Show`. The `Display Options - Segment Map` dialog box is opened.
- Accept the defaults by clicking the `OK` button in this dialog box. The map is now displayed. Apparently there is no difference.
- Close the map window.

In order to be able to compare the output segment map `Grid19new` with the input map `Grid19`, you need to look at both maps in the `Segment` editor, which allows you to see the intermediate coordinates as crosses. The editor can only be used on maps that are not dependent, so the dependency link should be broken first, for both maps.



- Break the dependencies of the maps `Grid19` and `Grid19new` by clicking the `Break Dependency Link` button on the `Dependency` tab of the `Properties` sheet.
- In the `Catalog` click the map `Grid19` with the right mouse button and select `Edit` from the `Context-sensitive` menu. The `Segment` editor is opened.
- Zoom in on a part of the map and select the `Move Point Mode`. As you can see each gridline only has a starting and ending point. Close the `Segment` editor.
- Click the map `Grid19new` with the right mouse button and select `Edit` from the `Context-sensitive` menu. The `Segment` editor is opened.
- Zoom in on a part of the map and select the `Move point mode`. As you can see there are now intermediate coordinates at regularly spaced intervals of 200 meter.
- Close the `Segment` editor and the map windows when you have finished the exercise.

Tunnel segments

This is more or less the opposite of the densify coordinate operations. The aim of this operation, is to reduce the number of intermediate points and remove superfluous nodes within segments of the input map. This operation can also be used when you want to generalize your maps. The principle of tunneling was explained in chapter 3.



- Double-click Tunnel Segments in the Operation-list. The Tunnel Segments dialog box is opened.
- Select the map Drainage in the list box Segment Map.
- Type 20 (meter) in the text box Tunnel Width.
- Type Draintun20 in the text box Output Segment Map and click Show. The Display Options - Segment Map dialog box is opened.
- Accept the defaults by clicking the OK button in this dialog box.
- Repeat the exercise twice: once with a Tunnel Width of 50 meters (Output Segment map Draintun50), and the other with a Tunnel Width of 100 meters (Output Segment map Draintun100).
- Compare the results by displaying the maps Draintun20, Draintun50 and Draintun100 in the same map window, and zooming in on a part of the map.
- Close the map windows when you have finished the exercise.

In ILWIS several other vector operations are possible. An overview is given in table 4.3. For more information see also the ILWIS Help topic Vector operations.

Table 4.3: Overview of vector operations in ILWIS.

| Operation | Point | Segment | Polygon |
|---------------------|----------------------------|------------------------------|------------------------------|
| Attribute map | Attribute Map of Point Map | Attribute Map of Segment Map | Attribute Map of Polygon Map |
| Mask | Mask Points | Mask Segments | Mask Polygons |
| Assign labels | - | Labels to Segments | Labels to Polygons |
| Sub map | SubMap of Point Map | SubMap of Segment Map | - |
| Glue map | Glue Point Maps | Glue Segment Maps | - |
| Densify coordinates | - | Densify Segment Coordinates | - |
| Transform | Transform Points | Transform Segments | Transform Polygons |
| Tunnel | - | Tunnel Segments | - |

Creating a polygon map from a segment map

In some cases you may have a segment map from which you want to generate a polygon map. This may be the case if you have imported a polygon map from Arc/Info E00 format. The import results in a segment map and a point map, containing polygon labels.

When you want to generate a polygon map from a segment map, there are two possibilities:

- Using the Segment editor. This method should be followed when you are not sure whether the segment map is error free. In the Segment editor you can edit the

segments, make a check of them, and then polygonize them. This method was explained in section 3.4.

- Using the Segment to Polygon (Polygonize Segment Map) operation. This method can be followed when you are sure that the segment map is correct. The advantage of this method is that it can be used in an automated way to periodically update files.

The last method will be shown.

In this example a segment map `Landunit` will be used, similar to the map used in section 3.4. To create a polygon map out of a segment map, all segments in the input map should be correctly digitized, that means no dead ends, no intersections, no double segments, etc. The output of this operation is a polygon map using system domain Unique ID, which contains IDs such as `pol 1`, `pol 2`, `pol 3`,..., etc.



- Double-click Segment to Polygon in the Operation-list. The Polygonize Segment Map dialog box is opened.
- Select segment map `Landunit` in the list box Segment Map.
- Clear the Mask, Topology and Auto Correction check boxes.
- Select the option Unique Identifiers and type `Landunit` in the text box Output Polygon Map.
- Click the Show button. After creating the polygon map, the Display Options - Polygon Map dialog box is opened.
- Click OK to display the map.
- Check the meaning of the polygons by clicking them.
- Close the map window when you have finished the exercise.

The resulting polygon map uses system domain unique ID, indicating the different polygons as `Pol 1`, `Pol 2`, etc. If you want to change these ID's, create an attribute table for the map, create in the table an attribute column with correct (class) names and create an attribute map.

A better option would be to polygonize the map using label points. The label points can be generated from another polygon map using the Polygon to Point operation, or digitized as a point map. In this case a label point map was already made (point map `Landunit`).



- Double-click the Segment to Polygon operation in the Operation-list. The Polygonize Segment Map dialog box is opened.
- Select segment map `Landunit` in the list box Segment Map.
- Make sure the Label Point check box is selected and use the point map `Landunit` as Label Points.
- Type for Output Polygon Map: `Landunit2` and click the Show button. 



The polygon map `Landunit2` is created and the Display Options – Polygon Map dialog box is opened.

- Click OK in the Display Options – Polygon Map dialog box. The polygon map `Landunit2` now contains the correct names.
- Close the map window when you have finished the exercise.

Creating a segment map from a polygon map

The *extract boundaries* operation creates a new segment map out of a polygon map, containing all polygon boundaries. The input map for this operation is a polygon map with any domain type. The output map resulting from the conversion is a segment map with an internal class domain. The class name of a segment in the output map, is the combination of the name of the neighbouring polygons. For example, the boundary between two polygons with the class name `Lake` and `Mountain` is codified in the output segment map as `Lake|Mountain`.

In this exercise the polygon map `Landuse` is converted to a segment map.



- Display polygon map `Landuse`, and click several polygons to find out their names. Close the map window.
- Double-click Polygon to Segment in the Operation-list. The Boundaries of Polygons dialog box is opened.
- Select the polygon map `Landuse` in the list box Polygon Map.
- Make sure the check box Single Name is cleared. If this check box is selected all segments get the name: `Segments`.
- Type `Landuse_bound` in the text box Output Segment Map and click Show. After creating the segment map the Display Options – Segment Map dialog box is opened.
- Select the Info check box and press OK.
- Click several segments to find out the meaning of the codes.
- Close the map window when you have finished the exercise.

Several other conversion options between tables, point, segment and polygon maps are possible. An overview is given in Table 4.4. The operations are described in the ILWIS Help topic Vectorize.

Table 4.4: Overview of data conversions in ILWIS.

| Data type | to Point | to Segment | to Polygon | to Table |
|--------------|------------------|--------------------|--------------------|---------------|
| from Point | - | - | - | Open as Table |
| from Segment | Segment to Point | - | Segment to Polygon | - |
| from Polygon | Polygon to Point | Polygon to Segment | - | - |
| from Table | Table to Point | - | - | - |

Point maps can be opened as a table, for instance by clicking the right mouse button on the object and selecting Open as Table in the context-sensitive menu. When you make the Command line visible in the table window, you can calculate with the values in the columns.

Summary: Vector data management

The following tools can be used to manage vector data:

- Creating a sub map of a vector map and merging two or more vector maps.
- Selectively copying vector data using a mask.
- Obtain more intermediate coordinates within segments in a segment map using the Densify Segment Coordinates operation.
- Tunneling reduces the amount of coordinate data stored in a segment map.
- Creating a segment map from a polygon map.
- Assigning labels to segments or polygons.
- Creating an attribute map.
- Glueing of maps.
- Transforming the coordinates of a map into another coordinate system.
- Conversion of one vector data type into another.

4.4 Vector to Raster conversion

As has been mentioned already in chapter 1, most of the analyses in ILWIS are based on raster data. Therefore, conversion from vector to raster format (rasterization) is often a necessary step preceding the analysis. Points, segments and polygons are represented by grid cells (pixels) in the raster data structure. In order to convert a map from vector into raster format, a mesh with pre-defined cell size, is laid over the map. The size of the grid cells is a crucial aspect of the raster data structure.

Before starting the rasterization, a georeference should be created. A georeference contains the minimum and maximum X and Y coordinates of the raster map, the number of rows and columns and the pixel size. When rasterizing various maps of the same area, it is preferred to select the *same georeference* for them.

The resulting raster maps have the same domain as the corresponding source vector map. Since the vector to raster operation is basically the same for point, segment or polygon maps, only the Polygon to Raster operation is shown here.

Creating georeferences

In this exercise the same polygon map will be rasterized three times, using three different georeferences with different pixel sizes, to show you the effect of the pixel size on the final result. The three georeferences will have pixel sizes of 10, 25 and 100 meters.



- Expand the Create option in the Operation tree and double-click the New GeoReference item. The Create GeoReference dialog box is opened.
- Type for GeoReference Name: Cocha10.
- Select the Coordinate System: Cochabamba.
- Type for Pixel size: 10 and for the Description: Georeference with 10 meter pixel size.
- Accept all other defaults and click OK in the Create GeoReference dialog box.
- Create also the georeference Cocha25 with Pixel size 25 meters and Cocha100 with 100 meters Pixel size.

Rasterization of a polygon map

The Polygon to Raster operation, creates a raster map from a polygon map. In this exercise the polygon map Landuse will be rasterized.



- Double-click the Polygon to Raster item in the Operation-list. The Rasterize Polygon Map dialog box is opened.
- Select polygon map Landuse in the list box Polygon Map and type 



for the Output Raster Map: Land10.

- Select GeoReference: Cocha10, type Raster map showing land use in the text box Description and click the Show button in the Rasterize Polygon Map dialog box. The Display Options - Raster Map dialog box is opened.
- Accept the defaults by clicking the OK button of this dialog box. The raster map Land10 is displayed.
- Repeat the procedure, and create raster map Land25 with georeference Cocha25, and raster map Land100 with georeference Cocha100.
- Zoom in on the same part of the map in the three map windows. Drag-and-drop polygon map Landuse to each of the three map windows. Display only the boundary lines.
- Compare the three maps and evaluate the effect of different pixel sizes and close all map windows when finished.

In ILWIS, two other rasterization operations are available, i.e. Point Density and Segment Density. For each output pixel the total number of points respectively the total length of segments is calculated. For more information, see the ILWIS Help topic Rasterize.

Summary: Vector to Raster conversion

- Conversion from vector to raster format (rasterization) is often a necessary step preceding data analysis.
- Points, segments and polygons are represented by grid cells (pixels) in the raster data structure.
- In order to convert a map from vector into raster format, a mesh with pre-defined cell size is positioned over the map. The size of the grid cells is a crucial aspect of the raster data structure.
- Before starting the rasterization, a georeference should be created. A georeference contains the minimum and maximum X and Y coordinates of the raster map, the number of rows and columns and the pixel size.

4.5 Raster data management

A raster map can be obtained either via rasterizing a vector map, as was explained in the previous exercise, or from importing raster data, as was shown in section 4.1. A number of tools are available to adapt raster maps for the analysis. In order to be able to use raster maps of the same area together, all maps should have the same pixel size, and the same number of rows and columns. In this section a number of tools for manipulating raster maps will be shown, such as the creation of a sub map, combining two raster maps into one map, mirroring and rotating maps, resampling maps, editing raster maps, and the conversion from raster to vector.

Creating a sub map of a raster map

The *sub map* operation allows you to specify a rectangular part of a raster map and copy it into a new raster map. You can specify corners either in row and column numbers or in XY-coordinates. A raster map with any type of domain can be used as input. The output map uses the same domain as the input map. The operation automatically creates a new georeference for the output map. This operation is very useful for creating subscenes from an entire frame of a satellite image, only covering the area of interest.

In this exercise, a selected window of a hillshading map of a part of South America (*Hillshad*) will be saved as a new raster map (*Hillshad_sub*). We also have a map *Bolivia_mask*, containing only the country of Bolivia. From this image the area that has to be extracted can be found.



- Open the map *Bolivia_mask*, and find out the area that should be extracted (expressed in first line, first column, nr. of lines, nr. of columns).
- Close the map window and double-click the SubMap of Raster Map operation in the Operation-list. The Sub Map of Raster Map dialog box is opened.
- Select raster map *Hillshad* in the list box Input Raster Map.
- Make sure the Lines and Columns option is selected.
- Type 300 in the text box First Line and 375 in the text box First Column.
- Type 670 in the text box Number of Lines and 650 in the text box Number of Columns.
- Type for Output Raster Map: *Hillshad_sub* and click the Show button. The map is created and the Display Options – Raster Map dialog box is opened.
- Click OK in the Display Options - Raster Map dialog box and close the map window after you have seen the result.

You can use the same method to extract the same area from the map *Bolivia_mask*, and then create a final map only showing the hillshading for the country of Bolivia.

Glueing raster maps

The Glue Raster Maps operation merges two or more georeferenced raster maps. The input maps should have a georeference and a domain which can be merged. The input maps can have different georeferences, coordinate systems and pixel size. In the case of different georeferences, the output map will use the georeference of the first input map. If needed, the second, third etc. input map will then first be resampled to the georeference of the first input map. If the georeferences of the input maps have different coordinate systems, the coordinate system of the second, third etc. input map will be transformed into the coordinate system of the first input map. In the resampling process, the size of the pixels in the second, third etc. input map will be adjusted to the size of the pixels in the first input map, if they are different.

If the maps have different domains, the possible combinations for merging input domains, are given in the Table 4.5. See the ILWIS Help topic Glue raster maps for more information.

The output map is sized to allow all maps to fit in. In this way, you can glue adjacent or partly overlapping georeferenced raster maps, derived from different sources. The output map uses a new georeference in which all input georeferences fit. The map uses the coordinate system and pixel size of the first input map. It is, therefore, important to make a careful choice of the input map.

In case input maps overlap, users can define from which map the pixel values should be used for the overlapping parts. By default, the pixel values of the first input map are used.

Table 4.5: Possible combinations of domains of input raster maps and the resulting domain of the output raster map.

| | unique ID | ID | class | value | bool | image | color | picture | bit |
|-----------|-----------|----|-------|-------|-------|-------|-------|---------|-------|
| unique ID | unique ID | ID | ID | - | - | - | - | - | - |
| ID | ID | ID | ID | - | - | - | - | - | - |
| class | ID | ID | class | color | class | color | color | color | color |
| value | - | - | color | value | value | value | color | color | value |
| bool | - | - | class | value | bool | value | color | color | bool |
| image | - | - | color | value | value | image | color | color | value |
| color | - | - | color | color | color | color | color | color | color |
| picture | - | - | color | color | color | color | color | color | color |
| bit | - | - | color | value | bool | value | color | color | bit |

In this exercise two parts of a TM image, one covering the northern (Tmb1_north) and the other covering the southern part (Tmb1_south) of the study area, are glued together. Both maps have the image domain.



- Double-click the Glue Raster Maps operation in the Operation-list. The Glue Raster Maps dialog box is opened.
- Select raster map Tmb1_north in the list box 1st Map.





- Select raster map `Tmb1_south` in the list box 2nd Map.
- Type `Tmb1_combined` in the text box Output Raster Map.
- Click the Show button. The map is created and the Display Options - Raster Map dialog box is opened.
- Click OK in the Display Options - Raster Map dialog box. The map is shown.
- Display also the raster maps `Tmb1_north` en `Tmb1_south` and close the map windows when you have finished the exercise.

If you select the Last Map on Top check box, the values of the pixels defining the overlap are taken from the second input map. Clear this check box if these values should be taken from the first input map.

Mirror rotate

The Mirror Rotate operation allows you to mirror a raster map in a horizontal, vertical, or diagonal line, to transpose (switch) the map's rows and columns, or to rotate a raster map 90°, 180°, 270° (clock-wise). There are no special requirements for the input map. The output raster map uses the same domain as the input raster map. The operation creates a new georeference for the output map which obtains the same name as the output map. The new georeference depends on the georeference of the input map. This operation may be needed if you get an input raster map from another source, which is rotated or mirrored. For example, when you use a scanned image and the image was not properly oriented on the scanner. As an example there is a 3D view, which is upside down.



- Display the map `View3D` and close the map window again.
- Double-click Mirror Rotate in the Operation-list. The Mirror Rotate dialog box is opened.
- Select raster map `View3D` in the list box Raster Map and select the option Mirror Horizontal.
- Type `View3D_ok` in the text box Output Raster Map.
- Click Show. The map `View3D_ok` is created
- Click OK in the Display Options - Raster Map dialog box. The map is displayed now in the correct form.
- Close the map window when you have finished the exercise.

Resampling

In many cases, the raster operations shown above will not be sufficient to get your imported raster data in the correct form, to combine them with other maps. The pixel size may be different from the other maps, or the map may lack coordinates. To overcome these problems, the map should be resampled to another existing raster map in your data base. Resampling will be explained in more detail in chapter 6, dealing with image processing. Here it is important to note that many of the tools, originally designed for image processing, are equally valuable when working with other types of raster maps.

Suppose that you have received a geological map from someone else. Suppose that apart from the digital file you also received a table with a series of control points. If these were missing you would have to find out control points yourself by comparing the raster map with a topographic map, or with another digital map. This is shown in chapter 6. Here it is assumed that 10 control points are known. The next thing to do is to make a georeference for this map, using the control points listed in Table 4.6.



- Open raster map *Geology*.
- From the File menu of the map window select Create, GeoReference. The Create GeoReference dialog box is opened.
- Type for the GeoReference Name: *Geology*.
- Accept the default option GeoRef Tiepoints.
- Select the Coordinate System: *Cochabamba* and click OK. The GeoReference Tiepoints editor is opened.
- From the Edit menu in the GeoReference Tiepoints editor select Add Tie Point or press the Add Tie Point button  in the Toolbar of the editor. The Add Tiepoint dialog box is opened.
- Type the Row, Column, X and Y coordinates for the first point as shown in Table 4.6.
- Repeat this for the other 9 tiepoints. The transformation should display Affine, and the Sigma (the error) should be lower than 1.
- Close the GeoReference Tiepoints editor by clicking the Exit Editor button . Raster map *Geology* is now georeferenced.
- Close the map window.

! If a digital table with tiepoint data is available, you can also use Copy and Paste to insert your data in the Georeference Tiepoints editor.

Table 4.6: Tiepoint locations for the raster map *Geology*.

| X | Y | Row | Column |
|--------|---------|------|--------|
| 797955 | 8088615 | 127 | 165 |
| 804195 | 8087085 | 229 | 581 |
| 804915 | 8080185 | 689 | 629 |
| 797415 | 8080335 | 679 | 129 |
| 800078 | 8083830 | 446 | 306 |
| 802343 | 8081985 | 569 | 457 |
| 800835 | 8073450 | 1138 | 357 |
| 796455 | 8072865 | 1177 | 65 |
| 796050 | 8083628 | 460 | 38 |
| 802973 | 8089080 | 96 | 499 |

Now that the raster map *Geology* is georeferenced, you can resample it to another raster map, for example *Landuse*, which uses the georeference *Cochabamba*.



- Double-click *Resample* in the *Operation*-list. The *Resample Raster Map* dialog box is opened.
- Select raster map *Geology* in the list box *Input Raster Map*.
- Type for *Output Raster Map*: *Geolout*.
- Select the *GeoReference: Cochabamba* make sure the resampling method *Nearest Neighbour* is selected and click the *Show* button. The map *Geolout* is calculated.
- Click *OK* in the *Display Options - Raster Map* dialog box. The map which is now displayed has the same pixel size and the same number of rows and columns as the raster map *Landuse*.
- Close the map window when you have finished the exercise.

-
- ! If you want to practice some more with resampling, you can generate control points from the polygon map *Cityblock* (city blocks of *Cochabamba*), and use these to georeference the raster map *Airphoto* (scanned aerial photograph of the center of *Cochabamba*). Then rasterize the polygon map *Cityblock* (with a pixel size of 5 meters) and resample the map *Airphoto*.
-

Editing raster maps

Maps may contain errors, which are introduced during digitizing, or which are in the original imported data coming from other packages. Maps also need to be updated when changes have occurred in an area, for example when the land use has changed. In those situations you will need to edit the maps. When you use the *Pixel editor* you can change the value, IDs or class name of pixels in a raster map. In the *Pixel editor*, only the mouse pointer can be used, not the digitizer cursor.

Editors can only be used to edit *source maps*. *Dependent maps* (e.g. the raster map created by rasterizing a polygon map) and maps which are defined in their properties form as *read only*, cannot be edited. Conceptually, it would not be a good idea to edit a dependent map, since such a map is derived from source maps, which are not changed in that case. To edit a dependent map, you should either edit the source map(s) and use the Make Up to Date button in the dependent map's Properties sheet or you should break the dependency. To edit a read only map, clear the Read-Only check box in the Properties sheet of the read-only map.

Editing raster maps using the Pixel editor is only useful if you want to make relatively small changes to a raster map. Since you can only edit pixel by pixel (including the possibility to select multiple pixels, and rectangular groups of pixels), changing irregular shapes in a raster map is rather time consuming. In that case it would be better to convert the raster map to vector (as will be explained in the next exercise) and do the editing in the Segment editor. Another option would be to digitize the areas that should be changed as lines or polygons, rasterize these vector maps and use them in a map calculation statement to mask away the wrong areas in the raster map. In this exercise you will edit a raster map (called `wrong`) with a class domain.



- Display the raster map `wrong`. As you can see there is a part that needs to be edited: the word `EDIT`.
- From the Edit menu in the map window, select Edit Layer, and 1 map `wrong`. The Pixel editor is opened.
- Zoom in on the word `EDIT` and click the Normal button.
- Select with the left mouse button a part of the letter `E` which is surrounded by green pixels by dragging a box.
- Press the right mouse button and select Edit from the Context-sensitive menu. The Edit dialog box is opened.
- Select for Class Name: `class 2`.
- To see the result press the Redraw button in the Toolbar of the Pixel editor.

In the Pixel editor, you can select one or more pixels by clicking them or dragging a box around them, in order to change their class name, ID, or value. You can add pixels to a selection, clear a part of a selection or toggle between select and deselect pixels.

- To add pixels to a selection:
Press and hold the CTRL key and click the other pixels you want to select.
- To clear a part of a selection:
Press and hold the CTRL+SHIFT keys, then click previously selected pixels or drag a box around them.

- To toggle between selecting and deselecting pixels:
Press and hold the SHIFT key, then click pixels or drag a box around pixels (selected pixels are deselected and non-selected pixels are selected).



- Practice with these various options. Edit the map so that the word `EDIT` is replaced by the pixel values of the areas surrounding it.
- Exit the Pixel editor by pressing the Exit Editor button.
- Close the map window when you have finished the exercise.

Raster to Vector conversion

Sometimes it can be necessary to convert raster maps back to vector maps. This can be the case if you obtain a thematic raster map by importing a digital file from other sources. If you want to edit the map extensively, it is better not to do that with the Pixel editor. It is best to convert the raster map to polygons first, then extract segments and create labels, and do the editing in the Segment editor, after which you polygonize and rasterize the map again. It may also be useful to convert raster maps back to vector maps if you want to use them for high quality map production.

To convert raster data to vector data format, a 3x3 matrix moves over the input map and assigns a code (class name, ID or value) to the center pixel of the matrix in the output map, which depends on the class name, ID or value of the center pixel and its 4 or 8 neighbours. See chapter 9 for more information about 4 or 8-connectivity. Undefined pixels will not be vectorized. The result of the conversion depends on the homogeneity of the raster map and the pixel size compared to the size of the mapping units. The program is provided with a smoothing facility, to remove the sharp corners formed by the boundaries between mapping units of the raster map. Automatic tunneling (see chapter 3) is performed on the coordinates of the vector data to delete the redundant ones. In this exercise the raster map `Slopeclass` is converted to a polygon map.



- Double-click the Raster to Polygon operation in the Operation-list. The Polygons of Raster Map dialog box is opened.
- Select raster map `Slopeclass` in the list box Raster Map.
- Accept the defaults for connectivity and smoothing.
- Type `Slopeclass` in the text box Output Polygon Map, type `Polygon map slope classes` in the text box Description and click Show. The calculation will take some time. After that the Display Options - Polygon Map is opened.
- Accept the defaults by clicking the OK button. The polygon map is shown.
- Close the map window when you have finished the exercise.

Now you will see the effect of converting a raster map to segments. When you convert from raster to segments, only the boundary lines between mapping units are stored, but in such a way that it is still possible to find out what the mapping units on both sides of the line are.

The output map resulting from the raster to segment conversion uses a unique ID domain and an attribute table with 3 columns: *Area1*, *Area2* and *Length*. *Area1* and *Area2* have the domain of the input raster map and indicate the right and left area. The column *Length* gives the length of the segment. For example, *Boundary1* is the segment between an area with class a and an area with class b (Figure 4.5).

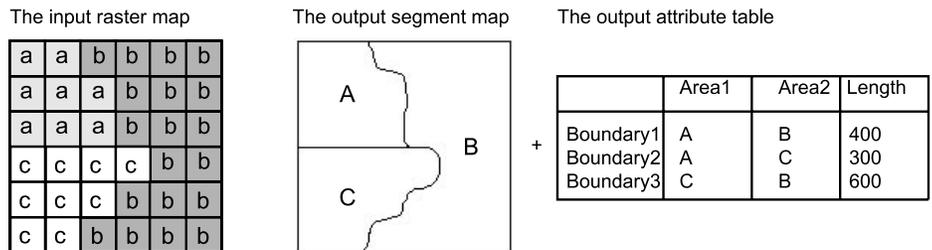


Figure 4.5: Conversion of a raster map to a segment map (see the text for explanation).



- In the Catalog, click with the right mouse button on raster map *Slopeclass* and select *Vectorize, Raster to Segment*. The *Segments of Raster Map* dialog box is opened.
- Make sure the check box *Single Name* is cleared.
- Type *Slopeseg* in the text box *Output Segment Map* and type *Segment map slope class* in the text box *Description*.
- Click the *Show* button. The segment map *Slopeseg* is calculated and the *Display Options - Segment Map* is opened.
- In the *Display Options - Segment Map* dialog box, select the *Info* check box and click *OK*.
- Find out the class names of the segments via the attribute table *Slopeseg* and close the map window when you have finished the exercise.

Summary: Raster data management

The following tools can be used for raster data management:

- Copying a rectangular part of a raster map into a new raster map, using the SubMap of Raster Map operation.
- Merge raster maps (Glue Raster Maps operation).
- Mirror, transpose or rotate a raster map (Mirror Rotate operation).
- Resampling a raster map to another georeference (Resample operation).
- Editing a raster map using the Pixel editor.
- Converting a raster map to a point, segment or polygon map (Raster to Point, Raster to Segment, Raster to Polygon operations).

4.6 Domain conversion

In the previous exercise, especially during the exercise dealing with import, you have seen that in ILWIS your map may have another domain than you would like. Sometimes the domain of a map should be changed, e.g., converting a domain value to a domain class. In this exercise the various methods for domain conversion are treated.

A warning about changing domains

Apparently the easiest solution for changing the domain type would be to simply change the domain in the Properties sheet of the map. This should be done with care! This method is only recommended for converting between domains of the same type (e.g. for converting a class domain `Landuse` to a class domain `Landuse1`). You should make sure, however, that the two domains have the same ordering of the raw values. If the ordering is different, than the names in the map will be mixed after changing the domain.

Changing domains of maps via the Properties sheet, is not recommended for changing from one domain type to another (e.g. from domain class to domain value). If you do that your file may become corrupt. For changing domain types, follow the guidelines described below.

Conversion between an ID domain and a class domain

Class domains and identifier domains are not so different. It is, therefore, easy to convert from one type to the other. The conversion from a class domain to an identifier domain can be done by clicking the button `Convert to classes` in the Properties sheet of an ID domain. The conversion from a class domain to an identifier domain can be done by clicking the button `Convert to identifiers` in the Properties sheet of the class domain.

Take for example the polygon map `Landuse`, containing the land use types in the study area. This is a class map.



- In the Catalog, click the domain `Landuse` with the right mouse button and select `Properties`. The Properties sheet is opened. As you can see the domain contains 12 domain items.
- Press the `Convert to identifiers` button. The class domain is converted to an identifier domain.
- Open the Properties sheet of the domain `Landuse` again. Now you can see that it reads: Domain Identifier "Landuse".
- Press the `Convert to classes` button. The ID domain is converted back to a class domain.

The conversion from classes to identifiers is not very logical for the map `Landuse`, since each land use class contains various polygons. An identifier domain is generally useful if each domain item is linked to one map feature (point, segment, polygon, or group of connected pixels in a raster map).

There is, however, a way to convert a class map to a unique ID map, using the Unique ID operation. This operation can be used to give a unique ID to all features in a segment, polygon or point map. The results of the operation are a map and an attribute table with the same name. The output map uses the system domain Unique ID. The output table has the same domain as the output map and consists of two columns, containing the original class names and the areas of each polygon. The information in the column consists of the classes, IDs or values of the original map per ID in the output map.



- Double-click Unique ID in the Operation-list. The Unique ID dialog box is opened.
- Select polygon map `Landuse` in the list box Input Map.
- Type `Landid` in the text box Output Map.
- Click the Show button. The map `Landid` is made and the Display Options – Polygon Map dialog box is opened.
- Click OK to display the map and click the polygons in the map window to view the IDs.
- Open the table `Landid` to view the original class name of the polygons and the assigned ID.
- Close the map window and the table when you have finished the exercise.

The Unique ID operation can only be performed on vector maps. The equivalent operation for raster maps is called Area Numbering, which will be treated in Chapter 9.

Converting a class or an ID domain to a value domain

The conversion from a class or an identifier domain to a value domain, can best be done by creating an attribute map from a value column of the map's attribute table.

Take for example the map `Cityblock`, which is a map using an identifier domain, in which each building block of the city of Cochabamba has a separate code. Linked to that map is an attribute table `Cityblock` which contains, amongst others, information on the number of persons living in each cityblock (column `Population`).



- Open the polygon map `Cityblock` and double-click some units to find out the information from the attribute table `Cityblock`.

In this case the conversion from identifier to value only makes sense when you want to create for example a population map.



- Close polygon map `Cityblock`.
- In the Catalog click polygon map `Cityblock` with the right mouse button and select `Vector Operations, Attribute Map` in the context-sensitive menu. The `Attribute Map of Polygon Map` dialog box is opened.
- Select the `Attribute: Population` and type for `Output Polygon map: Population`.
- Click `Show`. The map `Population` is created and the `Display Options - dialog box` opened.
- Click `OK` to display the map.
- The map `Population` is a value map. Check this by looking at the `Properties` sheet of the map `Population` or by clicking some units in the map.
- Close the map window and the `Properties` sheet.

The simple conversion of the map `Cityblock` from identifier to value domain would make no sense. If you do that the values have no logical meaning, and besides that, the map can no longer be linked to an attribute table.

Converting a value domain to a class or an ID domain

The conversion from a value or an image domain to a class domain may sometimes be necessary. For example, when you have imported a scanned thematic map as a gray scale TIF file. When you want to convert from a value map to a class map, you should know the names of the legend units that should be assigned to the different values.

For the conversion from a value map to a class or ID map, there are two possibilities:

- When you have a value map that has values with a precision other than 1, you should create a group domain (in which the boundary values and the class names are indicated) and use the `Slicing` operation as described in chapter 7. An example of this is the classification of a `Digital Elevation Model` into a classified altitude map.
- When you have a value map that has values with a precision of 1, which actually display thematic information instead of measured data, the procedure is as follows:
 1. Create an ID domain with a sufficient number of items.
 2. Change the domain from value to the ID domain in the `Properties` sheet of the map.
 3. Edit the domain while keeping the map open.
 4. Convert the IDs to classes if necessary.

This is illustrated with a map that was imported as if it had an image domain. It is, however, not an image but a class map with information on land use types.

Table 4.7: Relation ID and Class names.

| ID | Class name |
|-------|-------------------------|
| nr 1 | Agriculture |
| nr 2 | Agriculture (irrigated) |
| nr 3 | Airport |
| nr 4 | Bare rock |
| nr 5 | Bare soils |
| nr 6 | Forest |
| nr 7 | Grassland |
| nr 8 | Lake |
| nr 9 | Riverbed |
| nr 10 | Shrubs |
| nr 11 | Urban centre |
| nr 12 | Urban periphery |



- Open the raster map `Landimage` and click some pixels in the map. As you can see the map displays numbers instead of class names.
- Close the map window and select `Create, Domain` from the `File` menu in the `Main` window. The `Create Domain` dialog box is opened.
- Type for the `Domain Name`: `Luse`. Select the option `Identifier`, and type for the `Nr of items`: `12`.
- Accept the default `Prefix` and click `OK`. The `Domain Identifier` editor is opened. No changes will be made now.
- Close the `Domain Identifier` editor and open the `Properties` sheet of map `Landimage`.
- Select `Domain Luse` and click `OK` in the `Properties` sheet.
- Open the map `Landimage` and the domain `Luse`. Click a unit to find out its `ID`. Change the name of this `ID` to the class name, according to Table 4.7.
- Change all the domain items and replace them by the land use type, according to Table 4.7.
- Close the `Domain Identifier` editor and the map `Landimage`.
- Open the `Properties` sheet of the domain `Luse` and press the `Convert to classes` button. Now a representation is also created with the same name as the domain.
- You can edit the representation and the conversion from value to classes is ready.
- Open the map `Landimage` look at the result and close it afterwards.

Converting a picture domain to a class domain

The conversion from a picture domain to a class domain, can be done by clicking the button Convert to Classes in the Properties sheet of the domain. If you want to convert a picture domain to an identifier domain, you first convert the picture domain to classes and then press the button Convert to Identifiers in the Properties sheet of the class domain.

This type of conversion is also quite common, after importing a Windows bitmap .BMP or .TIF file. Similarly for the conversion from value to class, you should know which pixel values represent which classes.

This is illustrated with map `Landpicture` that was imported with a picture domain. It should be a class map, with information on land use types.



- Double-click raster map `Landpicture`. In the Display Options – Raster Map dialog box select the check box Info and click OK.
- Click some pixels in the map. As you can see the map displays a combination of Red, Green and Blue instead of class names.
- Close the map window and open the Properties sheet of the domain `Landpicture`.
- On the Properties sheet, press the button Convert to Classes.
- Open the map `Landpicture` and the domain `Landpicture`. Click a unit to find out its class name.
- Change all the domain items and replace them by the land use type according to Table 4.7. Deleting the domain items that are not used is not necessary. Close the Domain Class editor.
- Now you can edit the representation and the conversion from picture to classes is ready.
- Close the map window.

Converting a picture domain to an image domain

The conversion from a map with a picture domain to an image (or value) domain may sometimes be necessary. For example, the import of TIF color files or BMP files results in a picture domain for the output map, while in fact it should be value (in the case of a slope map for example), or image (in the case of a satellite image). So the conversion from picture to value, or to image, may happen quite often.

A recommended way to convert a map with a picture domain to another map with an image domain is to use Map Calculation. On the Command line of the Main window, type a statement like:

```
MapImage = MapPicture
```

Where `MapPicture` is the name of the map with the picture domain and `MapImage`

is the name of the output map. In the Raster Map Definition dialog box that follows directly after you typed the statement, select the system domain `Image`.

The conversion can also be done by changing the domain type in the Properties sheet. This can be demonstrated with the hillshading map of Bolivia (`Hillshad`), which was imported in section 4.1 from Windows bitmap `.BMP` format. This map has a picture domain. It will be converted to an image domain.



- Open raster map `Hillshad`, check that it has a picture domain and close the map window.
- In the Catalog, click raster map `Hillshad` with the right mouse button and select Properties from the context-sensitive menu. The Properties sheet is opened.
- Select Domain `Image` and click OK in the Properties sheet.
- Open raster map `Hillshad` again. From the Display Options – Raster Map dialog box you can see that the map has domain `Image`.
- Close the map window when you have finished the exercise.

Converting a color domain to a value domain

Finally, there is a possibility that you have imported a 24 bits/pixel Windows bitmap. This is converted in ILWIS to the color domain. The colors of a map with a color domain, can only be seen correctly when your screen uses a 24 bits/pixel display (millions of colors). You can convert maps with a color domain easily to an image domain, with the Color Separation operation.

An overview of domain conversions in ILWIS is given in Table 4.8. For more information see also the ILWIS Help topic How to change the domain of a map.

Table 4.8: Domain conversions in ILWIS.

| From | To | Recommended procedure |
|---------------|-------------|--|
| Class | ID | Properties, button Convert to identifiers |
| Class or ID | Value | Attribute table/column → Attribute Map |
| Color | Image | Color Separation |
| ID | Class | Properties, button Convert to classes |
| Picture | Value | Map Calculation |
| Picture | Class | Properties, create class domain, button Convert to classes |
| String column | Class or ID | Column Properties, button Create new Domain from Strings in column |
| Value | Class | Slicing or Properties, select or create new domain |
| Value* | Value | Map calculation |

* Domain type value includes all value domains (e.g. system domains `Image`, `Radar`, `Bool`, `Bit`, etc. and your own value domains).

Summary: Domain conversion

You should be careful when changing the domain of a map. If you do not follow the guidelines described in this section, the file may get corrupt.

The following domain conversions are possible in ILWIS:

- Conversions between class and ID maps, is easily done by pressing the Convert to Identifiers button or the Convert to Classes button, in the Properties sheet of the domain.
- Conversion from class or ID to value, is done by creating an attribute map with a value column from an attribute table.
- Conversion from a value domain to a class/ID domain, can be done either by using the Slicing operation (when the value map has a precision other than 1), or by creating an ID domain, and replacing this in the Properties sheet of the map (when the value map has a precision of 1).
- Conversion from a picture domain to a class domain can be done, by pressing the Convert to Classes button in the Properties sheet of the domain. Conversion to ID domain can then also be done (see above).
- Conversion from a picture domain to an image or value domain can be done, by using a Map Calculation or by changing the domain in the Properties sheet of the map.
- Conversion from a color domain to an image domain can be done with the Color Separation operation.