Remote Sensing with IDRISI® Taiga
A Beginner's Guide

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Includes CD ROM

Contents

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Chapter 1 Introduction

1.1 Guide to Using the Manual

1.1.1 Objectives

The objectives of this manual are twofold. The first objective is to introduce the reader to the display and basic processing procedures for enhancement, analysis and classification of satellite imagery. The second objective is to train the user in how to accomplish these tasks within the IDRISI environment. IDRISI is an excellent software suite for illustrating image processing in that the program has a wide array of basic programs, which the user combines in order to undertake an analysis. This ensures that each operation within the overall analysis is transparent and ultimately understandable.

You will be exposed to a wide variety of image analysis approaches and techniques through this manual. However, no single manual could ever be a comprehensive guide to either remote sensing or IDRISI. Nevertheless, at the end of this manual you should have the confidence and experience to continue exploring the wide range of functionality in IDRISI, and learning new approaches to image analysis. Indeed, probably the most important skill you will learn from this manual is not how to use IDRISI, but rather how to approach remote sensing problems.

1.1.2 Organization

This training manual is primarily designed to be a stand-alone self-study guide. The skills you need before starting this training manual are only those of basic familiarity with the personal computer environment. Specifically, you need understanding of files and directory structures, and the ability to maneuver around in the Windows environment. Basic knowledge of image processing concepts is useful, but not essential. However, access to a general remote sensing text (Table 1.1.2.a) is strongly recommended as a supplement to the coverage of topics introduced in this manual. More advanced texts may also be a useful supplement (Table 1.1.2.b).

The format of this manual was chosen to help the reader perform the included topical exercises. A section covering a specific image analysis topic begins with a brief general introduction to the subject matter, and then is followed by detailed instructions associated with example exercises.

- The **exercise instructions** are generally contained within a textbox with blue-colored text (Figure 1.1.2.a). These textboxes give step-by-step instructions in performing tasks in IDRISI. The first line of the text box, printed with a blue background, provides a summary of the activity. The second line, also with a blue background, gives the **menu location** of the IDRISI module described.
- **Icons** that provide shortcuts to Modules, or commands within modules, are printed in the left banner, next to the appropriate text (Figure 1.1.2a).
- **Program names**, such as DISPLAY LAUNCHER, are given in capitals.

Table 1.1.2.a Example introductory remote sensing texts.

Campbell, J. 2007. *Introduction to Remote Sensing.* Guilford Press, New York, NY, 626p.

Jensen J R 2005. *Introductory Digital Image Processing: A Remote sensing perspective.* Prentice Hall Inc., Upper Saddle River, NJ, 526p.

Jensen, J. R. 2007, *Remote Sensing of the Environment: An Earth Resources Perspective.* Prentice Hall Inc., Upper Saddle River, NJ, 592p.

Lillesand, T. M., R. W. Kiefer, and J. W. Chipman, 2008. Remote Sensing and Image Interpretation. Wiley, New York, 756p.

Richards, J. A., and X. Jia, 2006. *Remote Sensing Digital Image Analysis: An Introduction.* Springer, Berlin, 439p.

Vincent, R. K., 1997. *Fundamentals of Geological and Environmental Remote Sensing.* Prentice Hall Inc., Upper Saddle River, NJ, 366p.

Table 1.1.2.a Example advanced remote sensing texts.

ASPRS Manual of Remote Sensing, 3rd Edition

Henderson, F. M., and Anthony J. Lewis (eds), 1998. *Principles & Applications of Imaging Radar.* Volume 2. John Wiley & Sons, NY, 866p.

Rencz, A. (ed), 1999. *Remote Sensing for the Earth Sciences.* Volume 3. John Wiley & Sons, NY, 707p.

Ustin, S. (ed), 2004. *Remote Sensing for Natural Resource Management and Environmental Monitoring.* Volume 4. John Wiley & Sons, NY, 736p.

Ridd, M. K., and J. D. Hipple (eds), 2006. *Remote Sensing of Human Settlements.* Volume 5. ASPRS, Bethesda, MD, 752p.

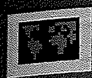
Grower, J. F. R. (ed), 2006. *Remote Sensing of the Marine Environment.* Volume 6. ASPRS, Bethesda, MD, 338 p.

Other advanced texts

Maune, D. F. (ed), 2007. *Digital Elevetion Model Technologies & Applications*, 2nd Edition. ASPRS, Bethesda, MD., 620pp.

Liang, S., 2004. *Quantitative Remote Sensing of Land Surfaces.* John Wiley & Sons, NY, 534p.

Warner, T. A., M. D. Nellis and G. Foody (eds), 2009. *The SAGE Handbook of Remote Sensing.* SAGE, London UK, 490pp.



Displaying an image

Menu Location: **Display – DISPLAY LAUNCHER**

1. Start the DISPLAY LAUNCHER.
2. Within the *DISPLAY LAUNCHER* window, select a file by clicking on the browse button (...) and then click on the ***etm_pan*** raster file in the pick list window.
3. Select *GreyScale* in the *Palette File* section in the lower left corner of the DISPLAY LAUNCHER window.
4. Click on *OK* to display the image

Figure 1.1.2.a Example of instructions for the DISPLAY LAUNCHER program. Note that the first line is a general explanation of the task. The second line gives the menu location, as well as the IDRISI menu icon, if available.

- The **names of dialog boxes and windows** are printed in italics, e.g. *DISPLAY LAUNCHER* window.
- **Text within the IDRISI program windows and dialog boxes** is also printed in italics. For example, the name of an input text box might be *Input file name*.
- **Names of files** that already exist are printed in bold italics (e.g. ***etm_pan***).
- Text that you, the reader, should enter in a program (e.g. through a text box) is given in bold, including the names for new files you will generate. For example the text may specify: Enter the file name **pca_123** in the text box.
- Terms that we wish to highlight are also shown in bold, for example **ground control point**.
- Finally, the sequence of menu options you should select to start programs is also highlighted in bold: e.g. **Display - DISPLAY LAUNCHER**.

1.1.3 Sample Data

This manual comes with sample data covering a number of different locations around the globe (Table 1.1.3.a). The locations were chosen to cover a variety of natural and human-modified environments.

The first data set, used in Chapters 1 through 4, comprises Landsat Thematic Mapper (TM) imagery of the coastal region of Hong Kong, China and part of the Pearl River estuary. We will be using these data to illustrate the importing, displaying, merging and creating maps. In addition, combination of imagery and elevation data will be used to create 3D displays and fly-throughs. The elevation data were acquired through the Shuttle Radar Topography Mission (SRTM), in which the Spaceborne Imaging Radar-C (SIR-C) was flown aboard the NASA Space Shuttle Endeavour during 11-22 February, 2000. The SRTM mission generated a near-global digital elevation model (DEM) of the Earth using overlapping radar images, through a process called radar interferometry (Maune, 2001).

Table 1.1.3.a Image data and directory location on the CD.

Directory Name	Geographic Area	Data
Chap1-4	Hong Kong, China	Landsat TM ETM+ (Multispectral & Pan), SIR-C SRTM Digital Elevation
Chap1-4/Raw images	Hong Kong, China	Landsat TM ETM+ (Tiff format)
Chap5/Chap5_3	African continent	Advanced Very High Resolution Radiometer (AVHRR)
Chap5/Chap5_4	Washington State, USA	Landsat TM
Chap5/Chap5_5	Atacama, Bolivia/Chile	Landsat TM
Chap6/Chap6_3	Hawaii	Thermal Infrared Multispectral Scanner (TIMS)
Chap6/Chap6_4	Hong Kong, China	Landsat TM (resampled to 90 meter pixels)
Chap6/Chap6_4alt	Hong Kong, China	Landsat TM (full resolution – 30 meter pixels)
Chap7	West Virginia, USA	Landsat TM (Summer)
Chap8/Chap8_3	West Virginia, USA	Mosaicked Digital Orthophotos (& results from Chapter 7 classification
Chap8/Chap8_4	West Virginia, USA	Landsat TM (Autumn)
Chap9	Las Vegas, Nevada, USA	Landsat MSS (1972 & 1992)

Chapter 4 is followed by two chapters on image enhancement. Chapter 5 explores image ratios. In this chapter we first use coarse-resolution Advanced Very High Resolution (AVHRR) imagery of Africa to generate a continental scale vegetation map. We will then use Landsat data of Washington State to develop an index to discriminate snow from clouds. Finally, we will use TM imagery from the Andes of the Atacama region along the Chile-Bolivia border, where we will examine how image ratios can be used for geologic mapping.

Chapter 6 is the second chapter on image enhancement. In the first half of this chapter, we will use Thermal Infrared Multispectral Scanner (TIMS) imagery of lava flows from Hawaii to investigate a range of enhancement methods for highly correlated data. The second half of the chapter draws on the Hong Kong TM data set, already used in Chapters 1-4, to investigate segmentation and non-standard false color composites.

For the classification in Chapter 7 we will use TM imagery of Morgantown, West Virginia, and the neighboring areas in the Appalachian Plateau of West Virginia, USA. The area is marked by deciduous forest and some farming activity.

Chapter 8 also has two major sections. First, the procedures for an accuracy assessment will be discussed using a classification from the previous chapter and a digital orthophotography mosaic. The latter half of the chapter is a linear pixel unmixing, and uses an autumn Landsat TM image.

The final data set comprises two multi-temporal Multispectral Scanner (MSS) images of Las Vegas, Nevada, USA, which is used in Chapter 9. The arid city of Las Vegas and its surrounding valley will be used to demonstrate the mapping of change, in this case urban growth around the city of Las Vegas over two decades.

1.1.4 Working with the Manual

This manual is written assuming that you will work progressively through the material. Thus, instructions are more detailed in the beginning chapters, especially Chapters 1-4. The instructions are generally slightly briefer the second and subsequent times any program is described. If you should find that the instructions for any program are too brief, you may wish to return to the earlier sections, to review the particular program or procedures described, and also draw on the extensive Help in IDRISI, as described below.

Some readers may prefer to sample the manual selectively. This should be fine, but do note that many chapters draw on images prepared earlier in the chapter, or skills developed in prior sections. If this is a barrier to your completing the exercise, you will need to do the earlier work first.

1.2 *IDRISI Software*

1.2.1 What's in a Name?

The IDRISI software is named after the cartographer and botanist, Abu Abd Allah Mohammed al-Idrisi (1100-1165 or 1166 A.D.) (Wikipedia 2005, Eastman 2009). Al-Idrisi was one of the most important medieval scholars, producing maps for the Norman King, Roger II of Sicily that would serve as a primary reference for the next 500 years. In addition, he made a major contribution in cataloging medicinal and other plants, which had not previously been recorded.

1.2.2 History and Overview of IDRISI

First released in 1987, IDRISI provides raster-based GIS and image processing modules in a single integrated package (Warner and Campagna 2004). The latest version of IDRISI, IDRISI Taiga, is a 32-bit version designed for Windows, and is the sixteenth release.

IDRISI specializes in analytical functionality covering the full spectrum of GIS and remote sensing analysis from database query, to spatial modeling, to image enhancement and classification. Although IDRISI is primarily oriented towards the use of raster data, vector data can also be displayed and used in some of the programs.

IDRISI includes routines for environmental modeling and natural resource management, including change and time series analysis, land change prediction, multi-criteria and multi-objective decision support, uncertainty analysis and simulation modeling. Spatial operations include interpolation, Kriging and conditional simulation. For image processing, a suite of tools for image restoration, enhancement and spectral transformation are available. IDRISI has a particularly sophisticated range of classification algorithms, including traditional "hard" classifiers, in which each pixel is assigned to a single class, as well as "soft" classifiers, in which multiple classes are potentially associated with each pixel. In addition, IDRISI offers hyperspectral image classification procedures, designed for use with images with hundreds of spectral bands (a *band* is an image layer associated with a specific wavelength region of the electromagnetic spectrum). IDRISI Taiga is specifically designed to allow programmers and modelers to incorporate IDRISI routines into their own applications. Despite the highly sophisticated nature of these capabilities, the system is still easy to use.

The nearly 300 modules which make up IDRISI are organized in menus in seven major groups, with most of the analytical functionality concentrated in the *GIS Analysis* and *Image Processing* Menus. Because IDRISI tends to generate many individual files, a program for file management is an important component of the File menu.

A particularly effective IDRISI program module is the graphical MACRO MODELER, which allows users to develop and link a sequence of IDRISI modules. This program is useful for designing an image analysis in a conceptual manner, for speeding up implementation of a complex sequence of tasks, for building a macro for repeating an analysis sequence on different data sets, and for documenting analysis procedures.

IDRISI tends to be highly modular in design. This modular design tends to make an analysis in IDRISI more complex because of the many steps involved. However, this approach makes IDRISI a superb teaching tool, because the user is forced to understand every step in each procedure.

1.3 Starting IDRISI and the IDRISI Workspace

1.3.1 Copying the Data from the CD

Before starting the IDRISI program, we will need to create and organize file folders for our project data.

We will begin by creating a folder called ***ID Man*** (short for IDRISI Manual), in which we will store our data. Depending on your preferences, you may wish to create this new folder on your desktop, the root directory (C:\) or elsewhere. We find that there is some advantage in keeping the paths (directory names) short, and so for this manual the examples we give will be based on creating this directory in the root directory. The choice of where to place the data, however, is up to you.

There are a number of ways to create a folder on your desktop, and one way is described below.

IDRISI folder creation
1. Click on the Windows *Start* button and select *My Computer*.
2. Double click on the *C:* drive. (Note if you want to create your new folder in a location other than *C:*, then you should now navigate to that location.)
3. Right-click in the folders panel.
4. Select *New*, then select *Folder* and name the folder **ID Man**.

We are now ready to copy some of the data provided with this project to your computer.

Data transfer
1. Put in the data CD to your CD drive.
2. If the file explorer window does not open automatically, double click on *My Computer.*
3. Double click on the CD drive.

4. Right-click on the CD folder labeled *Chap1-4*, and select *Copy* from the pop-up menu.
5. Move up the directory tree to *My Computer* and select the *C:* drive. (Note if you created the *ID Man* folder in a location other than *C:*, then you should now navigate to that location.)
6. Double click on *ID Man* folder.
7. Move cursor to the main folders pane, right click, and select *Paste* from the pop-up menu.

At the start of each section you will be prompted for the appropriate data for that section, so you do not need to transfer the remaining data from the CD now.

A very important final step in preparing your data each time you copy data from the CD is to set the appropriate folder properties. The data on the CD is marked as *Read-only*, which means the files cannot be changed. Therefore we must modify the *Read-only* attribute, as described below.

Remove *Read-Only* attribute from the data folder

1. Use the *Windows Explorer* or *My Computer* (as described in the previous instruction box) to display the contents of the *ID Man* folder (Figure 1.3.1.a).
2. Right click on the *Chap1-4* folder. (Note: Instead of selecting the *Chap1-4 folder*, you can alternatively select the parent *ID Man* folder if you need to apply the *Read-only* attribute change to more than one folder in the *ID Man* directory.
3. Select the *Properties* option from the pop-up menu (Figure 1.3.1.a).
4. The Properties window will now open for that folder. Uncheck the *Read-only* attribute check box (Figure 1.3.1.b).
5. A *Confirm Attribute Changes* Window will open. Ensure that the radio button for the default option of *Apply changes to this folder, subfolder and files* has been selected automatically. (Figure 1.3.1.c).
6. Click on *OK*.
7. The check box in the *Properties* window will now be blank.

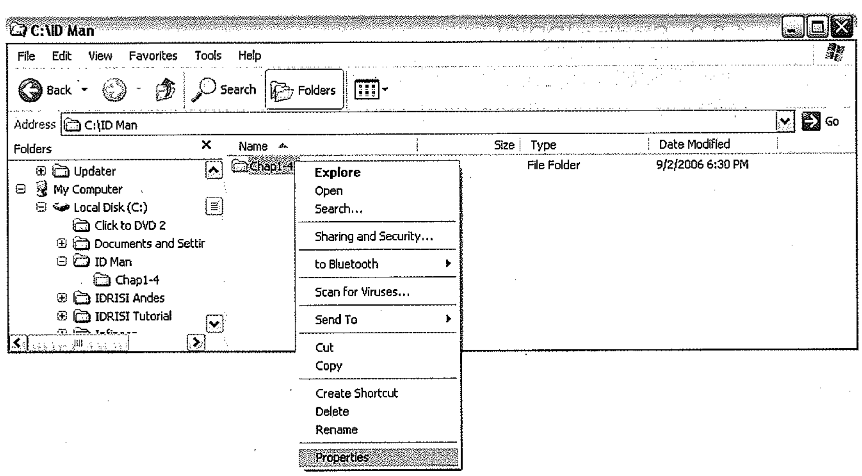


Figure 1.3.1.a Right click on the folder name to access a pop-up menu that includes the option to set the folder properties.

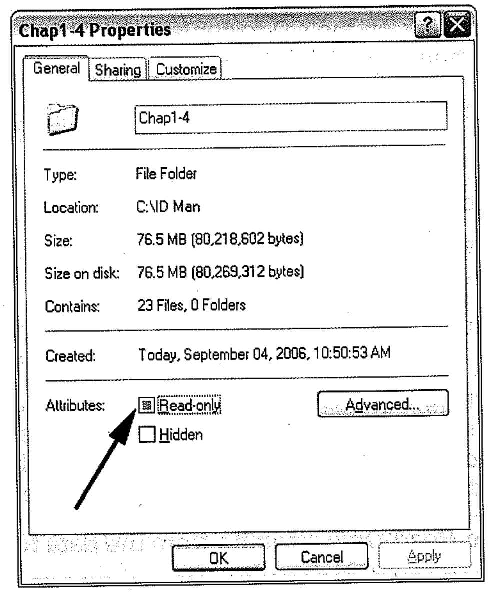


Figure 1.3.1.b Uncheck the *Read-only* attribute for the folder.

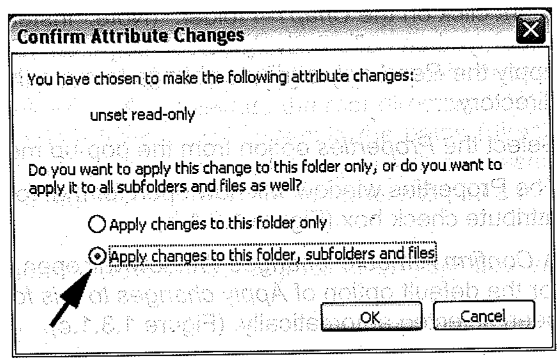


Figure 1.3.1.c Ensure the default option to apply changes to the folder, subfolders and files, has been selected.

1.3.2 Starting IDRISI

The IDRISI program is started by double clicking on the IDRISI icon on your desktop. Alternatively, you can use the Windows® Start menu, by selecting *IDRISI Taiga* within the *IDRISI Taiga* menu.

The IDRISI workspace window will now open. If this is the first time you have opened IDRISI, the *Quick Start Navigation Guide* will be displayed (Figure 1.3.2.a). Review the information in the guide.

If you do not want the guide to display every time you open IDRISI, check the box in the lower left corner labeled *Don't show this again.* (If you change your mind, and want to redisplay the *Quick Start Navigation Guide,* simply use the main IDRISI menu to access **File – User Preferences**, and then, on the System settings pane, checking the check box for *Show tip screen on start up.*) Close the navigation guide by clicking on the red *x* in the lower right corner.

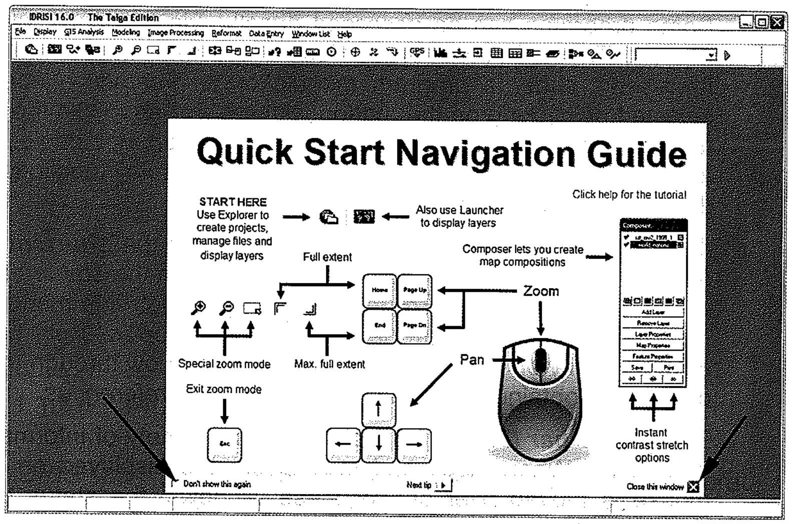


Figure 1.3.2.a The IDRISI workspace with the *Quick Start Navigtaion Guide*, which may be displayed when IDRISI first starts.

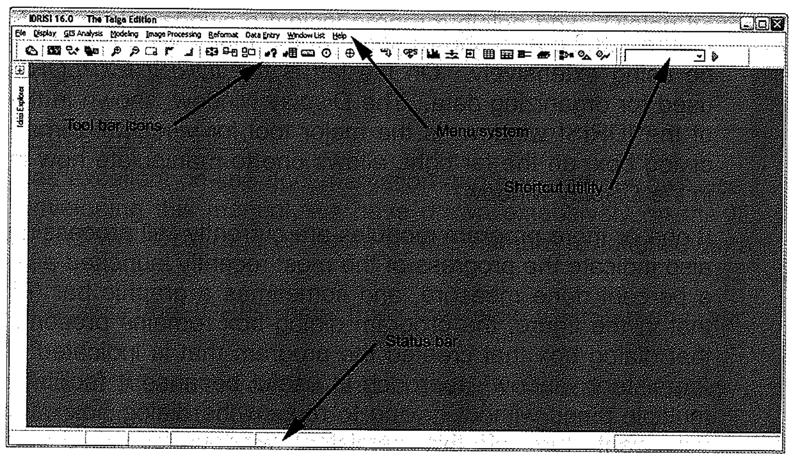


Figure 1.3.2.b The IDRISI workspace.

The IDRISI workspace includes the **toolbar**, the **menu system**, the **shortcut utility**, and the **status bar** (Figure 1.3.2.b). There are many ways to start an individual program. One of the simplest ways is through the **menu system**, which is at the top of the application window (Figure 1.3.2.b).

You can activate the menus by clicking on the menu with the mouse. If you select a menu option that includes a right-pointing arrow, a submenu will appear. You can navigate through the submenus using the arrows on the keyboard (on the number pad) or using the *Enter* key. Clicking on a menu option without a right-pointing arrow will cause a dialog box for that module to appear.

Alternatively, you can navigate through the menus with the keyboard, by depressing the ALT key and a particular letter. When you first press ALT, an initial letter of each menu is underlined, to help you identify the appropriate key. This will open the menu, which can then be navigated by pressing the key associated with first letter of the submenu or program. If you wish to access a submenu that starts with the same letter as an earlier submenu, press the key for the letter twice. You will then need to press the ENTER key to start the program.

Some programs can be accessed directly, via the icons, or buttons, below the menu. These buttons are collectively known as the ***tool bar.*** Each icon represents either a program module or an interactive operation that can be selected by clicking on that button with the mouse. Hold the cursor over an icon to display momentarily the name of the function or module represented by that icon. The set of icons represents interactive display functions as well as some of the most commonly used modules.

A third method for selecting a program is from the ***shortcut utility***, a pull-down menu with a scroll bar, which is accessible from the *status bar*, along the bottom of the IDRISI window. You can navigate through this menu with the mouse, or you can type the program name in the box directly. Note that you can turn the *Shortcut* utility on or off on the main IDRISI window through the User Preferences dialog box, obtained from the menu *File-User Preferences*.

The ***status bar*** (Figure 1.3.2.c) provides a variety of information about program operation. When maps and map layers are displayed on the screen and the mouse is moved over one of these windows, the status bar will indicate the position of the cursor within that map in both column and row image coordinates and X and Y map reference system coordinate. In addition, the *Status Bar* indicates the scale of the screen representation as a Representative Fraction (RF).

Figure 1.3.2.c also shows some of the major windows within IDRISI that we will be using extensively. On the left is the *IDRISI EXPLORER* window, which is used for organizing data. The *Display* window, shown in the figure in the center of the IDRISI window, is the major tool for visualizing images. The *Composer* dialog box, on the far right, allows one to manipulate how images are displayed in the *Display* window.

If one or more program modules are currently still processing, the ***status bar*** will also indicate the progress of the most recently launched analytical operation with a percent done measure, and sometimes a graphic bar (Figure 1.3.2.d). Note that in the figure, the program dialog box remains present, even though it was that dialog box that created the program that is indicated as still running. This "persistent window" approach is useful because it facilitates running programs multiple times without having to reopen the dialog box each time. (You can, if you want, turn off this persistent window feature through the *File - User Preferences* menu, and unchecking the option for *Enable persistent dialogs.*) Despite the benefit of persistent windows, users should exercise caution in exploiting this capability because you should not try to open a file that is still being processed by another program.

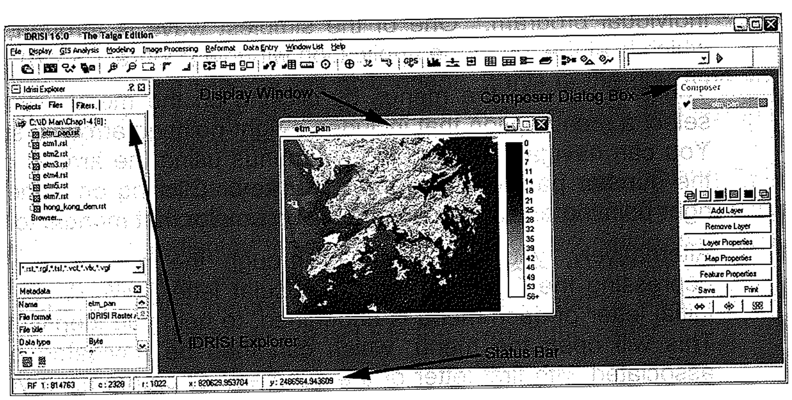


Figure 1.3.2.c The IDRISI status bar, and related main windows.

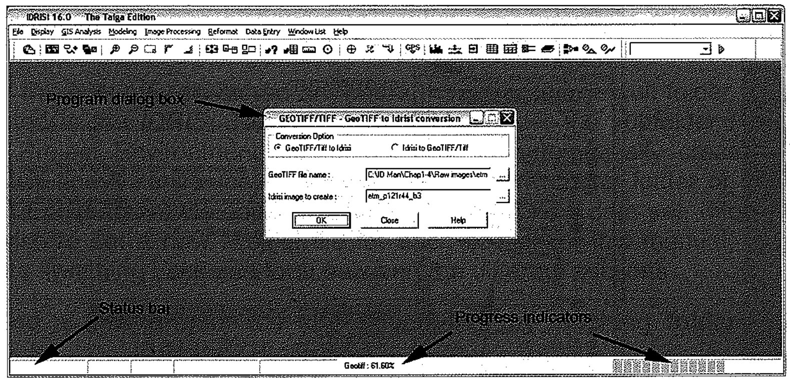


Figure 1.3.2.d Progress indicator within the status bar.

Since IDRISI has been designed to permit multi-tasking of operations, it is possible that more than one operation may be working simultaneously. To check active processes and their status, simply double click on the bottom right hand part of the *status bar* panel. A *Progress of modules* window will open, listing the current programs running. Modules may also be terminated from this window.

Figure 1.3.2.d also shows a typical program dialog box. Dialog boxes are used to provide information to the IDRISI programs regarding input and output data, as well as important processing parameters.

1.3.3 IDRISI On-Line Help

IDRISI has excellent on-line documentation and help. In our own use of IDRISI, and in developing this manual, we have drawn extensively on the IDRISI help material, and we encourage all users of this manual to take advantage of this outstanding resource.

You can access the IDRISI help from the main IDRISI menu bar: **Help – Contents.**

Another way to access the on-line help is through the button labeled *Help*, found in the dialog box that controls each program (Figure 1.3.3.a). This button automatically opens the help material for the particular program from which the help was called. The help material is very useful for understanding the general nature of each program, as well as the limitations, such as the type of data that can be used. The on-line help also provides a comprehensive **glossary** and an **index**, which can be found through the *Glossary* and *Index* tabs on the left hand

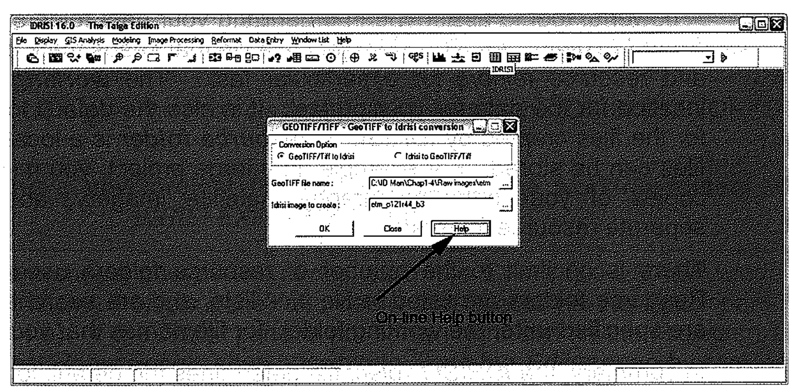


Figure 1.3.3.a Typical dialog box showing button for on-line help.

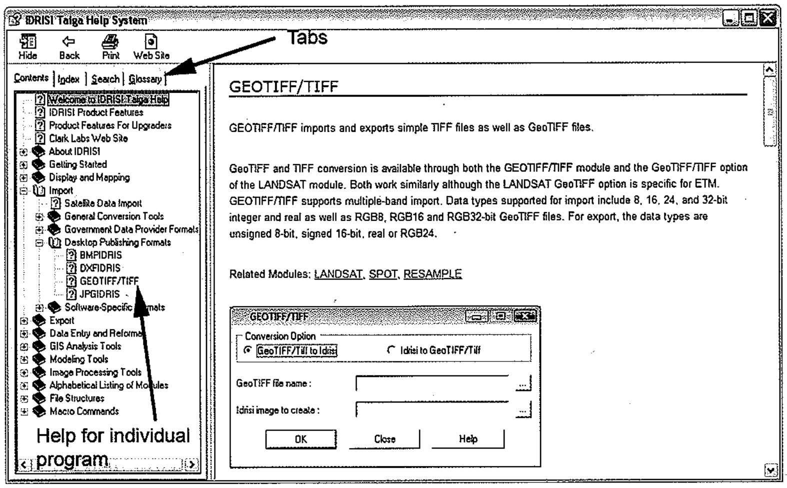


Figure 1.3.3.b The IDRISI on-line Help.

side of the Help window (Figure 1.3.3.b). The glossary is helpful for clarifying the meaning of remote sensing terminology in general, and IDRISI terms in particular. The index provides a tool for rapid searches through the main sections of the Help system. You can also identify the specific subsections within the Help, by clicking on the *Contents* Tab, and navigating through the hierarchical structure, as shown in Figure 1.3.3.b.

In addition, a very good PDF-format tutorial document can be accessed from the main IDRISI menu: **Help – IDRISI Tutorial.**

1.3.4 Managing IDRISI Project Files with the IDRISI EXPLORER

In a typical image analysis activity you will produce many files. It is therefore essential to have an effective method to organize your files. Firstly, you should specify meaningful file names for files you generate with IDRISI. Do not simply use the IDRISI default names. Instead use names that have meaning within your analysis, perhaps referring to the program used, or crucial parameters used in the processing. In addition, you should keep good notes on the names of the input and output files, as well as all parameters selected.

In addition to using appropriate file names and keeping good notes, it makes good sense to organize your data in a series of folders, much as the data for the exercises in this manual are organized.

A powerful tool to assist you in organizing your data folders is the concept of an ***IDRISI Project.*** An *IDRISI Project* is a file that keeps track of the *working folders* and *resource folders* for a particular task. The ***working folder*** is the main location for the data for your project. It is also the default location for the output for the files created by IDRISI. A ***resource folder*** is a location where additional files can be stored. For example, in a large project, you might store the original copies of your orthophotography, satellite imagery, and elevation data in separate resource folders.

There is no limit to the number of resource folders used in a single project. Resource folders are listed in file pick lists, and are searched in the orders they are specified (after the working folder) for file names that you type in manually.

In summary, the *IDRISI Project* file determines the default locations where IDRISI will look for data, and the locations to which it will write the output files. Although you can over-ride the *Project* file in determining file locations, it can be tedious to do so, and the chance of becoming confused and making mistakes becomes quite high.

IDRISI Projects may be stored anywhere, however the default folder for projects is located in the *IDRISI Taiga* program folder under the subfolder *Projects*. A single Project Environment file, *default.env*, is automatically created. Some users will find it convenient simply to change the working folder of this default Project Environment file each time they work on a new data set. However, you may wish to set a new *Project* file for each section of this manual, in order to facilitate switching back and forth between the different sections.

Creating a new project file and specifying the working folders with the *IDRISI EXPLORER*

Menu Location: **File – IDRISI EXPLORER**

1. Start the IDRISI EXPLORER from the main menu or toolbar.
2. The *IDRISI EXPLORER* window will open on the left side of the IDRISI workspace. It is anchored to this location, and although you can change the width of the window, you cannot move it to other locations.
3. Practice minimizing the window by clicking on the "-" icon on the top left of the *IDRISI EXPLORER* window. The window will collapse into the left hand side of the IDRISI workspace.
4. Reopen the *IDRISI EXPLORER* by clicking on the "+" icon in the minimized window.
5. Select the *Projects* tab (Figure 1.3.4.a).

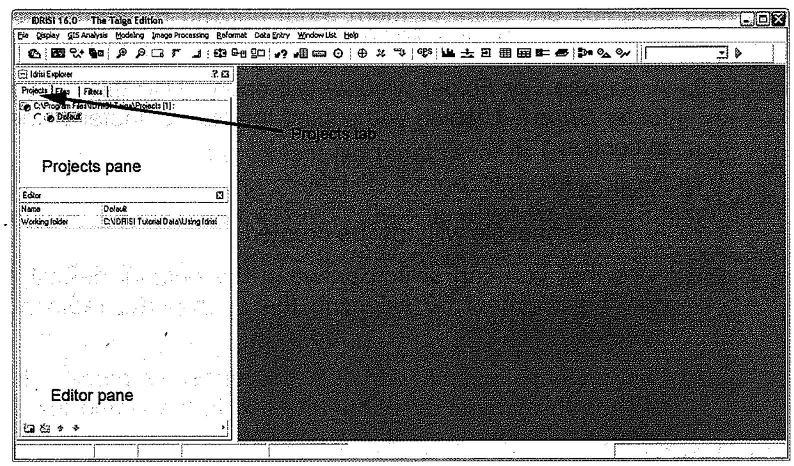


Figure 1.3.4.a The *Projects* and *Editor* panes in the IDRISI EXPLORER.

Creating a new project file and specifying the working folders with the *IDRISI EXPLORER* (cont.)

6. There should now be two panes within the *IDRISI EXPLORER* window. The first is the *Projects* pane, and below that should be the *Editor* pane (Figure 1.3.4.a). If the *Editor* pane is not shown right click in the *Projects* pane, and select *Show Editor*. (It is possible to close the *Editor* pane by clicking on the red "x" in that pane, hence the need to have a way to open the pane again.)

7. Note also that the boundary between the *Projects* and *Editor* panes can be dragged with the mouse, in order to change the relative size of the two panes. This is convenient if the *Editor* pane is obscuring information in the *Projects* pane.
8. Right click within the *Projects* pane, and select the *New Project Ins* option (Figure 1.3.4.b).

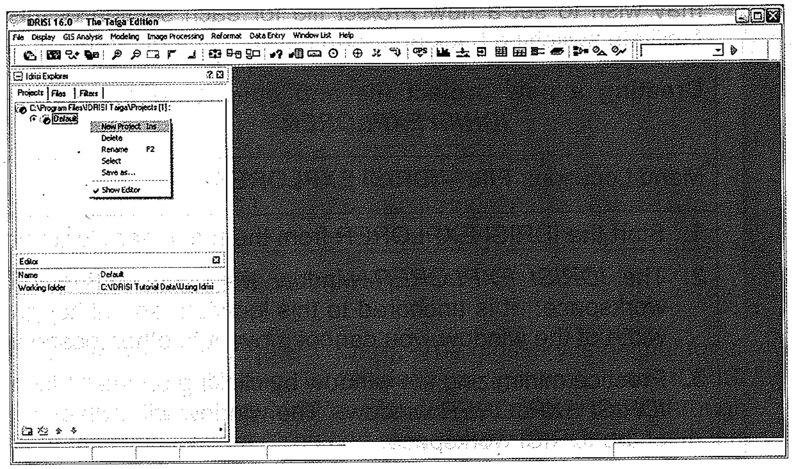


Figure 1.3.4.b Right click within the *Projects* pane to select the *New Project Ins* option.

Creating a new project file and specifying the working folders with the *IDRISI EXPLORER* (cont.)

9. A *Browse For Folder* window will open. Use this window to navigate to the folder *Chap1-4*, which you copied to your computer to the new *ID_Man* folder, in section 1.3.1.
10. Click *OK*.
11. A new project file will now be created.
12. Note that you can switch between the original default environment and the new environment by selecting the appropriate radio buttons in the *Project* pane.
13. The project's default name is the directory name. If you wish, you can rename the project by editing the text in the *Name* text box, within the *Editor* pane.
14. You can also modify the *working folder* by clicking on the name of the current file listed in the text box next to *Working folder*. This will generate a browse icon (a button with three dots). Clicking on the browse icon will open a *Browse For Folder* window. If we wanted to specify a new file, we would now navigate to that file, and then click *OK*. However, for now, we will leave the existing file, and therefore press *Cancel*.
15. Add a resource folder by right clicking in the *Editor* pane, and selecting *Add folder*.
16. A new line in the Editor pane will open, with the text *Resource folder (1)* in the left cell. Click in the right cell, and a browse icon will appear (a button with three dots). (Figure 1.3.4.c).

17. Click on this browse button, and the *Browse for Folder* window will open. Navigate to the *Raw Images* subfolder, within the *ID Man\Chap1-4* folder on your computer. Click on *OK*. (Figure 1.3.4.c).

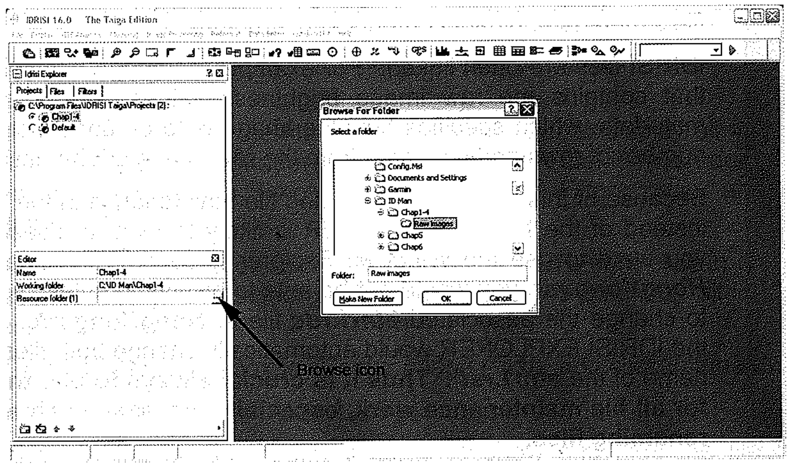


Figure 1.3.4.c Adding a *Resource Folder*.

Creating a new project file and specifying the working folders with the *IDRISI EXPLORER* (cont.)

18. Once the *Browse for Folder* closes, your project should now be specified. If necessary, you can drag the *IDRISI EXPLORER* window boundary to the right, in order to provide more room to show the compete path file for the folder locations (Figure 1.3.4.d)

The new *project* file now points to the location of the working folder and resource folder for Chapters 1-4 in this manual, as shown in Figure 1.3.4.d. When you exit and re-launch IDRISI, the project file most recently used is retained. Therefore you only need to change the *project* file information when you start a new project. For example, we will create a new *project* file when we start Chapter 5.

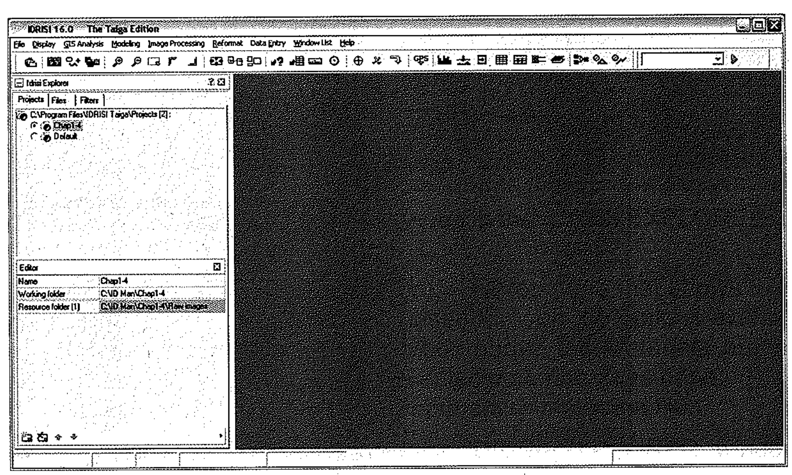


Figure 1.3.4.d The new project file successfully created.

1.3.5 Basic File Management with the IDRISI EXPLORER

The IDRISI EXPLORER is a powerful tool that has functionality well beyond that of simply managing project files. For example, you can manage all aspects of IDRISI-specific files, including regular file maintenance as well as examining a file's metadata, binary contents and structure.

IDRISI files are often linked. For example, an image has two separate files, one that contains the raw image brightness values, and a second file with the metadata, which specifies how the image is to be constructed (for example, the number of rows and columns) from the raw image brightness values.

Because of this linking of files, doing file maintenance in the ***Windows Explorer***, instead of the **IDRISI EXPLORER** is likely to lead to disaster. For example, if you were to use the Windows Explorer to rename the image file ***etm1.rst*** to ***HongKong.rst***, you would not be able to display it, unless you also remembered to change the associated ***etm1.rdc*** file to ***HongKong.rdc***. On the other hand, the IDRISI EXPLORER would automatically change both files, if you changed the name of the ***etm1.rst*** . **Thus it is crucial always to use the IDRISI EXLORER for all file maintenance work, especially for tasks such as copy, deleting or renaming files.**

We will now examine how we can use the IDRISI EXPLORER to manage files.

Basic file management with the IDRISI EXPLORER
Menu Location: **File – IDRISI EXPLORER**
1. If the *IDRISI EXPLORER* window is not already open, open it again. 2. Click on the tab for *Filters* (Figure 1.3.5.a). 3. Observe the list of file types listed. These are only the primary IDRISI extensions. The many different types of file extensions that IDRISI recognizes give some indication of the wide range of functionality that IDRISI offers. 4. Note that it is possible to check which types of files one wants to list in the *Files* pane, an option that we will look at in a moment. The default is to list raster Image files, as well as five other file types.

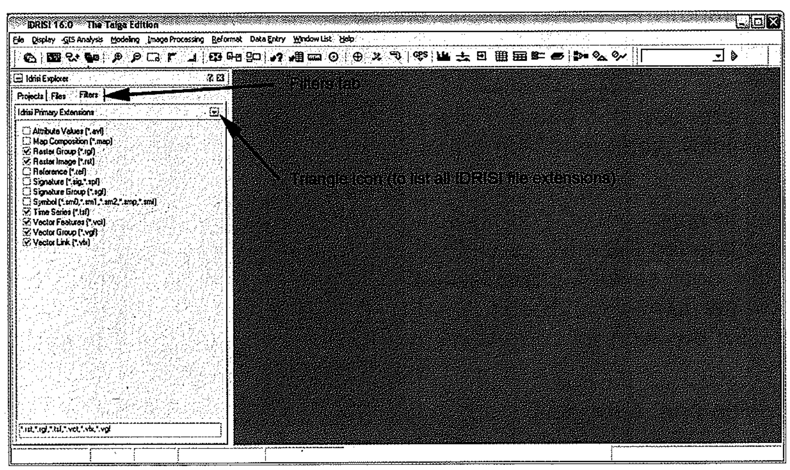


Figure 1.3.5.a IDRISI EXPLORER showing the *Filters* pane.

Basic file management with the IDRISI EXPLORER (cont.)

5. Click on the small downward pointing triangle on the top right hand side of the pane (Figure 1.3.5.a), representing the icon to switch between the primary and entire list of IDRISI file extensions.
6. After clicking on the downward pointing triangle, observe the much greater list of file types listed.
7. If you want to check all the file types listed, in order to display all the files in the *IDRISI EXPLORER* window, there is a short cut that is much quicker than clicking on each box. Simply right click in the *Filters* pane, and in the resulting pop-up menu click on *Select All*.
8. Before leaving this section of the IDRISI EXPLORER, right click in the *Filters* pane once again, and select *Clear Filter*. This will uncheck all the check boxes.
9. Now scroll to the check box for *Raster Image (*.rst)*, and click in the box.
10. Click on the tab for *Files* (Figure 1.3.5.b).
11. Practice clicking on the directory name to show and hide the file names (Figure 1.3.5.b). In many cases when you open the IDRISI Explorer the files may be hidden, and you need to click on the directory to show the files.
12. If necessary, drag the *Metadata* pane boundary up, so that you can see more of the metadata information.
13. Click on the file ***etm1.rst*** in the Files pane.

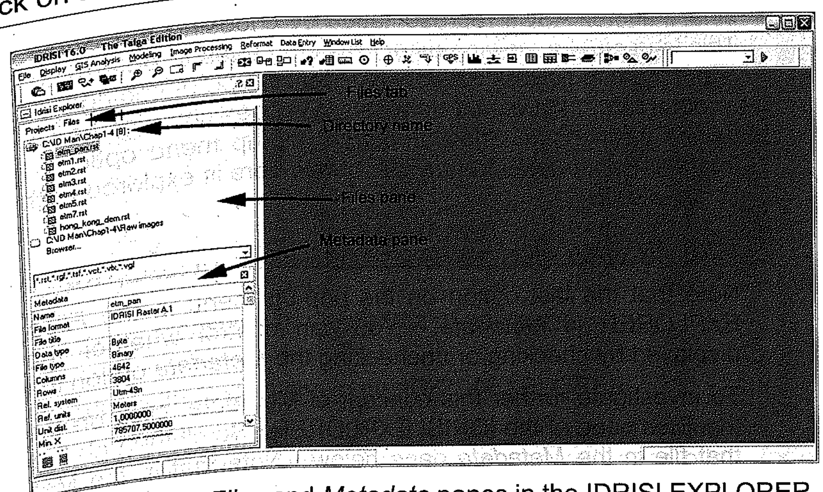


Figure 1.3.5.b The *Files* and *Metadata* panes in the IDRISI EXPLORER.

The *Files* tab has two panes (Figure 1.3.5.b). The top pane that shows the list of files based on the list of filter selections chosen through the options available via the *Filters* tab, and also listed in the text box above the *Metadata* pane. The lower pane shows the metadata for the file selected in the *Files* pane. The slider bar on the right allows one to scroll through the entire metadata file.

The basic file maintenance routines in the IDRISI EXPLORER window are accessed by selecting one or more files, and then right clicking in the *Files* pane. A pop-up menu will appear (Figure 1.3.5.c). The menu has options for *Copy, Move, Rename* and *Delete*. These functions work in the way you would expect.

Basic file management with the IDRISI EXPLORER (cont.)

5. Click on the small downward pointing triangle on the top right hand side of the pane (Figure 1.3.5.a), representing the icon to switch between the primary and entire list of IDRISI file extensions.
6. After clicking on the downward pointing triangle, observe the much greater list of file types listed.
7. If you want to check all the file types listed, in order to display all the files in the *IDRISI EXPLORER* window, there is a short cut that is much quicker than clicking on each box. Simply right click in the *Filters* pane, and in the resulting pop-up menu click on *Select All*.
8. Before leaving this section of the IDRISI EXPLORER, right click in the *Filters* pane once again, and select *Clear Filter*. This will uncheck all the check boxes.
9. Now scroll to the check box for *Raster Image (*.rst)*, and click in the box.
10. Click on the tab for *Files* (Figure 1.3.5.b).
11. Practice clicking on the directory name to show and hide the file names (Figure 1.3.5.b). In many cases when you open the IDRISI Explorer the files may be hidden, and you need to click on the directory to show the files.
12. If necessary, drag the *Metadata* pane boundary up, so that you can see more of the metadata information.
13. Click on the file ***etm1.rst*** in the Files pane.

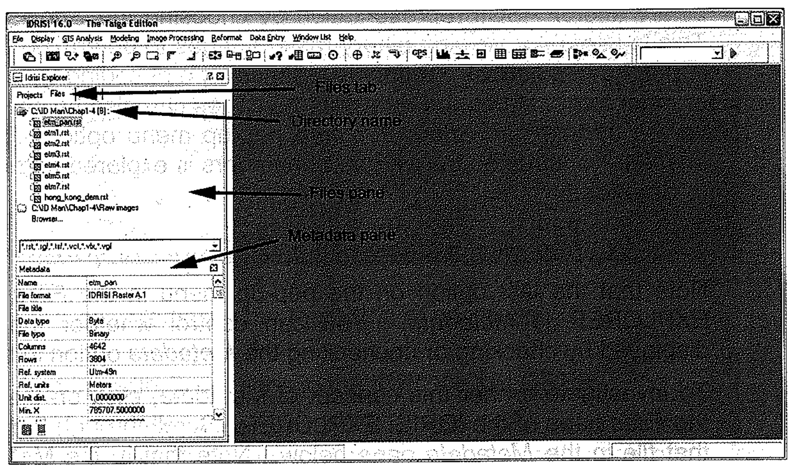


Figure 1.3.5.b The *Files* and *Metadata* panes in the IDRISI EXPLORER.

The *Files* tab has two panes (Figure 1.3.5.b). The top pane that shows the list of files based on the list of filter selections chosen through the options available via the *Filters* tab, and also listed in the text box above the *Metadata* pane. The lower pane shows the metadata for the file selected in the *Files* pane. The slider bar on the right allows one to scroll through the entire metadata file.

The basic file maintenance routines in the IDRISI EXPLORER window are accessed by selecting one or more files, and then right clicking in the *Files* pane. A pop-up menu will appear (Figure 1.3.5.c). The menu has options for *Copy, Move, Rename* and *Delete*. These functions work in the way you would expect.

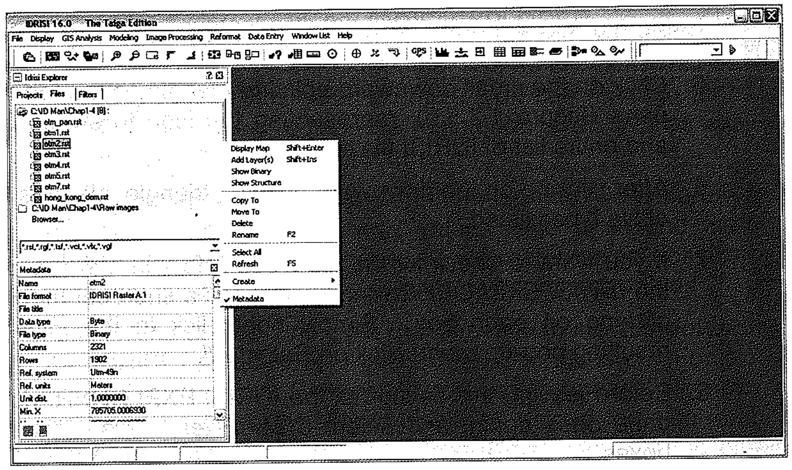


Figure 1.3.5.c The pop-up menu for basic file maintenance commands.

The IDRISI EXPLORER also provides shortcuts for displaying images and also the raw data that underlie an image. When a raster or vector file is selected in the IDRISI EXPLORER, right clicking and selecting the option for *Display Map* will display the image using default options. We will learn about the program DISPLAY LAUNCHER, which allows greater control over how an image is displayed in Chapter 2.

The IDRISI EXPLORER pop-up menu for the *Files* pane also offers options to view the underlying data from in a file. A file may be viewed in its byte-by-byte binary and/or ASCII representation by choosing the *Show Binary* menu option. This is useful for viewing binary raster images to determine their file structure for importing into IDRISI. (Binary is a dense type of coding typically used for images or other large, structured data sets.) Images can also be shown as a grid of pixel values through the *Show Structure* pop-up menu option. The topic of how an image is constructed from a grid of numbers is explored further in the introduction to Chapter 2.

1.3.6 Working with Metadata Using the IDRISI EXPLORER

Note that the last option on the pop-up menu in the *Files* pane of the IDRISI EXPLORER is *Metadata*. You can control whether the *Metadata* pane is displayed by checking or unchecking the *Metadata* option in the pop-up menu.

To investigate further this concept of Metadata, click on the ***etm_pan.rst*** file in the *Files* pane of the IDRISI EXPLORER. Scroll through the metadata values for that file in the *Metadata* pane below. Note that in the Metadata window, each row has two cells. The left cell is a category, for example *Name*. The right cell is the attribute. In order to change the attribute, you simply click in the cell, and type the new value. Be warned, though: if the new values you enter are inappropriate, you can make it impossible to display the file.

Observe the type of data about the image that is recorded in the metadata file: the data type (which determines the potential range of the values stored), number of columns and rows, pixel size, map information, file lineage as well as user-supplied titles, legends and notes. Notice that no title has been specified for the ***etm_pan*** file. In the next exercise, we will add the image title information to the metadata, so that when the image is displayed we will have the option of automatically also displaying a title.

Modifying image metadata with IDRISI EXPLORER
Menu Location: **File - IDRISI EXPLORER**

1. If the *IDRISI EXPLORER* window is not already open, open it again.
2. In the IDRISI EXPLORER, click on the tab for *Files*.
3. If the files are not listed in the *Files* pane, double click on the directory name to display the files.
4. In the *Files* pane, select ***etm_pan.rst***.
5. If the *Metadata* pane is not displayed, right click in the *Files* pane, and select the option for *Metadata*.
6. In the *Metadata* pane, click in the text cell to the right of *File title*, and enter **Hong Kong Landsat Panchromatic Band** (Figure 1.3.6.a).
7. Click on the *Save* icon at the bottom left side of the *Metadata* pane (Figure 1.3.6.a). (Note: the *Save* icon is grayed out most of the time, and is only shown in color when the metadata has been changed, and therefore can be saved.)

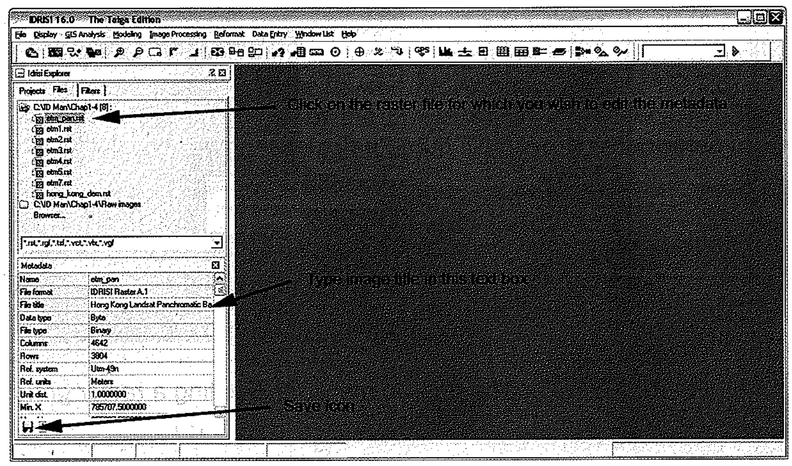


Figure 1.3.6.a Modifying the metadata of an image.

1.3.7 <u>Working with Collections in the IDRISI EXPLORER</u>

A useful management tool in IDRISI is the concept of collections. A layer collection is a group of layers that are associated with each other, for example the different image bands that together make up a single satellite image. Collections are used to facilitate the input of filenames to dialog boxes. They may also be required as input for particular analytical modules. Finally, raster files that are grouped into a collection and linked when displayed can be viewed in a systematic way, such as through linked zooming and panning.

In this part of the exercise, we will use the IDRISI EXPLORER to create a raster group file with the Hong Kong Landsat data, as a preparatory step for displaying two bands as linked displays in Chapter 2. IDRISI also offers a dedicated program for dealing with collections, available through the menu: *File – Collection Editor*. However, generally, the IDRISI EXPLORER provides a more powerful interface for working with collections.

Creating a file collection with the IDRISI EXPLORER
Menu Location: **File – IDRISI EXPLORER**

1. If the *IDRISI EXPLORER* window is not already open, open it again.
2. Click on the tab for *Files*.
3. Highlight the files ***etm1.rst*** through ***etm7.rst*** (note that there is no ***etm6.rst*** in this data set. The Landsat band 6 is a thermal band, and we will work with that band later, in Chapter 5). You can select multiple bands either by clicking on each file sequentially, while simultaneously pressing the *Ctrl* key. Alternatively, you can click on ***etm1.rst*** , then, while simultaneously pressing the Shift key, click on the ***etm7.rst*** file. This will highlight the beginning and end files, as well as all those in between. (Figure 1.3.7.a).
4. Right click in the *Files* pane. Select the menu option for *Create – Raster Group* (Figure 1.3.7.a).

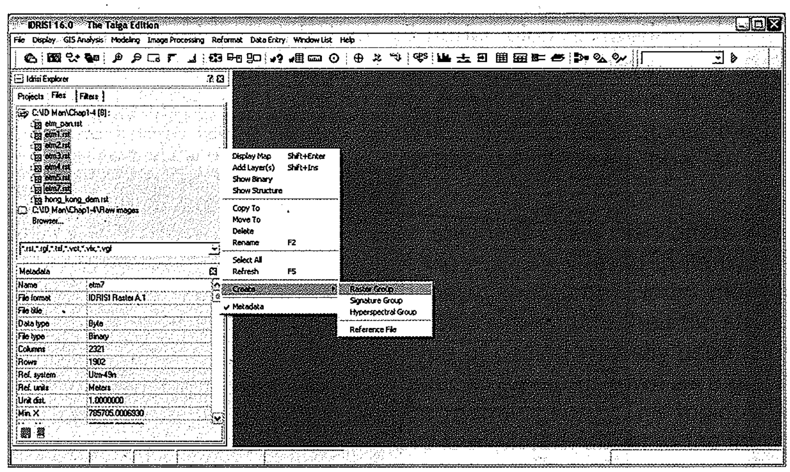


Figure 1.3.7.a The pop-up menu for creating a *raster group file*.

Creating a file dollection with the IDRISI EXPLORER (cont.)

5. A new file, ***Raster Group.rgf***, will be listed in the *Files* pane. Click on this file.
6. In the *Metadata* pane, enter a new name in the right hand cell of the first row, typing over the default name of *Raster Group.* Since this is an entire collection of satellite image bands, we will enter **hk_etm_all** (Figure 1.3.7.b).
7. Press Enter on your computer keyboard.
8. Click on the *Save* icon, at the bottom left hand corner of the *Metadata* pane. The name will immediately be updated in the Files window.

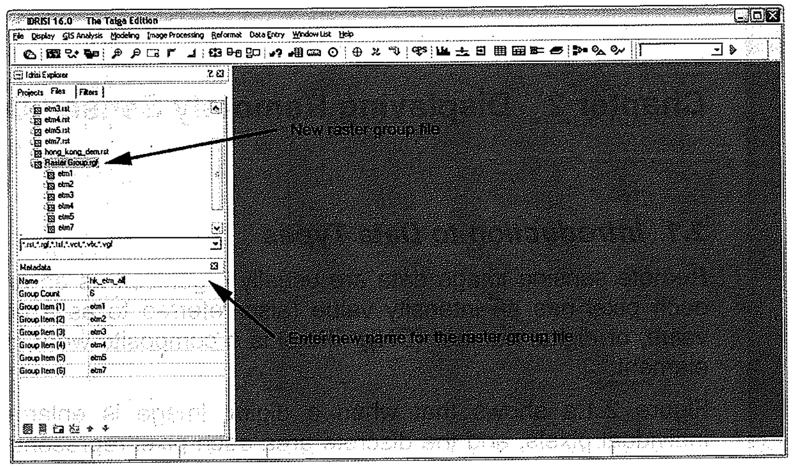


Figure 1.3.7.b Entering a new name for the *raster group file*.

The *Metadata* pane has additional powerful built-in functionality to add, delete, and reorder the individual layers in the collection. This can be observed by highlighting the ***hk_etm_all.rgf*** raster group file in the *Files* pane, and noting how the *Metadata* pane lists the file names associated with this collection. Now click on the Metadata cell for *etm2*, and then right click. A pop-up menu will list options such as *Remove, Move up* and *Move down* (Figure 1.3.7.c). The latter two options change the order of the layers within the collection. This can be important if the order of the layers in a group file have an associated meaning.

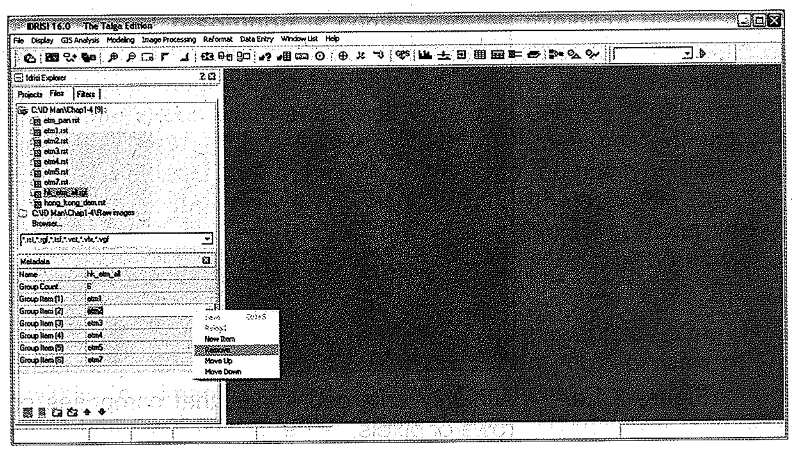


Figure 1.3.7.c Manipulating individual files in a raster group file.

Chapter 2 Displaying Remotely Sensed Data

2.1 Introduction to Data Types

Remote sensing image data are usually organized as an array of pixels, where each pixel has an intensity value (also referred to as a gray level, brightness value, or digital number (DN)). Pixel is a composite word, derived from "picture element."

Figure 2.1.a shows that when a digital image is enlarged significantly, the individual pixels, and the discrete area each pixel represents, become apparent. The legend shows the scheme by which the DN values have been mapped to image gray tones. Table 2.1.a shows the same information as Figure 2.1, except as numbers instead of gray tones. Note that pixels with dark gray tones in Figure 2.1.a correspond to low DN values in Table 2.1.

The fundamental characteristics of remotely sensed data depend upon the **resolution** of the sensor used to acquire the data (Jensen 2005). There are four types of resolution: radiometric, spatial, spectral and temporal (Warner et al. 2009a).

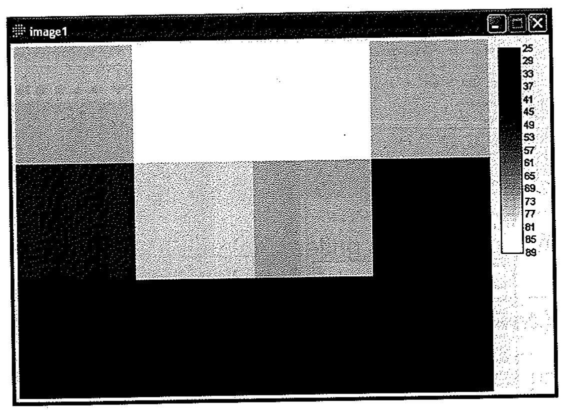


Figure 2.1.a A highly enlarged image that comprises only 4 columns and 3 rows of pixels.

Table 2.1.a The pixel values for the image shown in Figure 2.1.a.

73	86	89	73
50	77	72	43
25	34	34	25

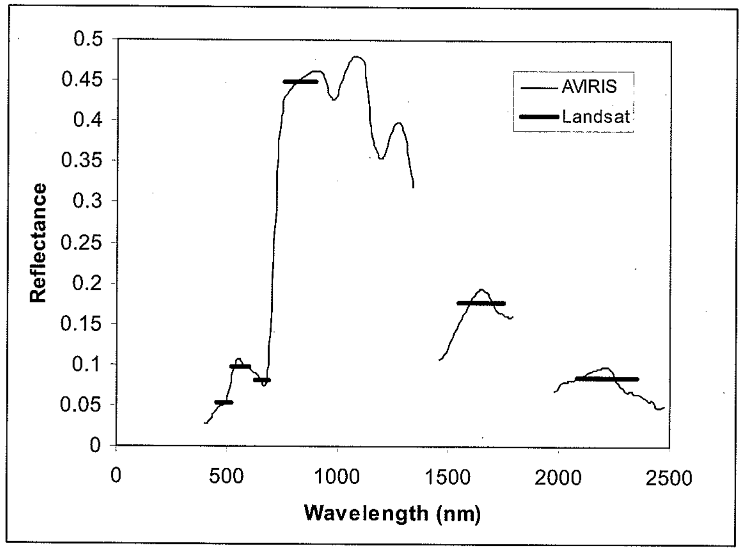


Figure 2.1.b Simulated spectral curves for a forested pixel as seen by AVIRIS and Landsat sensors.

Radiometric resolution refers to the sensitivity of the sensor to incoming radiance (i.e., how much change in radiance is required to result in a change in recorded brightness value?). This sensitivity to different signal levels will determine the total range of values that can be generated by the sensor.

Traditionally, **spatial resolution** is considered the minimum distance between two objects that can be differentiated from one another (Sabins 1997, Jensen 2005). For aerial photography the spatial resolution is usually measured from a test pattern of numerous white and black lines of a defined brightness contrast, but varying thickness. Resolution can then be measured directly from a photograph of the test pattern as the maximum number of line pairs per millimeter that can be resolved. In practice, photographic resolution is determined not only by the camera properties, including focal length and configuration determine, but also the aircraft height and stability, as well as the resolution of the film used.

For satellite-borne sensors, resolution is often loosely specified as the dimension of the ground area that falls within the instantaneous field of view of a single detector within the imaging array. In this terminology, spatial resolution is equivalent to unit pixel size in ground-based units. However, it is important to realize that this equivalency is not the same as the formal definition of resolution. In fact, using the word resolution to imply the pixel area is somewhat misleading. Most objects that are similar in size to the pixel area will not be large enough to be resolved on the image, since the object is unlikely to be imaged by just a single pixel. Nevertheless, using the pixel size to refer to resolution is a convenient short hand.

Sensors also are characterized by the wavelength regions of the electromagnetic spectrum for which they record data. A single sensor may record one or more separate measurements per pixel, with each measurement associated with a particular part of the spectrum, usually referred to as a *band,* or sometimes as a *channel.* An instrument's **spectral resolution** is determined by the number of bands, and the width of the electromagnetic spectrum each band covers. A sensor may detect energy from a wide region of the electromagnetic spectrum, but have poor spectral resolution, if it has a small number of wide bands.

Another sensor that is sensitive to the same portion of the electromagnetic spectrum but has many small bands would have greater spectral resolution. Like spatial resolution, the goal of finer spectral sampling is to enable the analyst, human or computer, to distinguish between scene elements. More detailed information about the how individual elements in a scene reflect or emit different wavelengths of electromagnetic energy increases the probability of finding relatively distinct characteristics for a given element, allowing it to be distinguished from other elements in the scene.

Figure 2.1.b illustrates this principle by showing simulated spectral reflectance curves, or spectral signatures, generated when two sensors, Landsat Thematic Mapper and AVIRIS, are used to image the same pinyon pine forest (an evergreen species, common in the US Southwest and in Mexico). AVIRIS (Airborne Visible/Infrared Imaging Spectrometer) is a research sensor, developed by NASA's Jet Propulsion Laboratory (for more information on AVIRIS see http://aviris.jpl.nasa.gov/). Landsat Thematic Mapper is a satellite borne sensor flown by NASA on a series of spacecraft since 1982. In the following section (2.1.1), the Landsat program is discussed in more detail.

It is a subtle but important point that the data recorded by these sensors is actually radiance (energy) measured at the sensor, not reflectance, which is what is shown in Figure 2.1.b. The radiance measured at the sensor is a function of the reflectance of the ground materials, as well as the solar illumination and atmospheric transmission, which both vary with time of day, season, and atmospheric properties. Therefore, to make the simulated data from the two sensor measurements comparable, it is necessary to convert them to reflectance.

Both Landsat and AVIRIS cover the same broad range of the electromagnetic spectrum, from 400 to 2,500 nm. However, AVIRIS has approximately 210 unique, contiguous bands, each 10 nm wide. (In Figure 2.1.b, AVIRIS bands over the atmospheric moisture absorption regions have been deleted, hence the gaps in the spectrum.) Landsat, on the other hand, has just six bands in the 400 to 2,500 nm region, with a seventh band, not shown, in the thermal region. The Landsat bands are indicated in the figure by horizontal black lines. Each line represents a single band, for which a single radiance value is recorded.

As can be seen from Figure 2.1.b, although both AVIRIS and Landsat capture the overall shape of the spectrum, the AVIRIS curve has much greater detail. For example, in the 2,000 to 2,500 nm region, Landsat has just one band (from 2,080 to 2,350 nm), whereas AVIRIS has approximately 50 bands across this region. In addition, the AVIRIS sensor has another 50 bands in the 900-1,400 nm region, whereas Landsat misses this region entirely. Note that the AVIRIS spectrum has some interesting absorption features (lows) in this region.

The spectral limitations of Landsat may be significant if one were trying to differentiate very similar land cover types. On the other hand, if your main interest is differentiating forest from soil, then the Landsat sampling of the spectrum is more than likely sufficient.

2.1.1 Example: Landsat Data

One of the most important series of satellites for civilian remote sensing is Landsat (Lauer *et al.* 1997). The Landsat Project, which began in the early 1970s, has incorporated a sequence of satellites that have been placed in earth orbit. The most recent of the Landsat series of satellites is Landsat 7 (Figure 2.1.1.a), which was launched on April 15, 1999 and orbits the Earth at an altitude of approximately 438 miles (705 kilometers) with a sun-synchronous 98-degree inclination and a descending equatorial crossing time of 10 a.m.

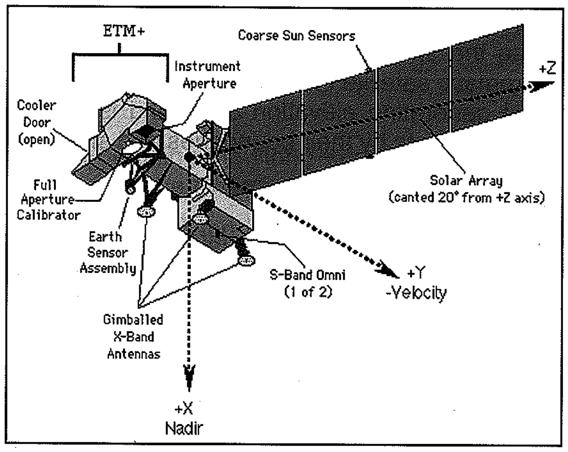


Figure 2.1.1.a Landsat satellite (from: http://science.hq.nasa.gov/missions/satellite_48.htm).

Landsat images are spatially referenced by the Landsat World-Wide-Reference system (WRS), which comprises 57,784 scenes, each 115 miles (183 kilometers) wide by 106 miles (170 kilometers) long. Each scene consists of approximately 3.8 gigabits of data. The WRS system is based on the orbital tracks of the satellite (paths, in WRS terminology) and arbitrary rows, in which the tracks are divided into discrete scenes. Thus, Landsat images are usually referenced by WRS path and row.

The Landsat 7 satellite carries the Enhanced Thematic Mapper Plus (ETM+) sensor (Mika 1997). This name was chosen to indicate it was an enhanced version of the earlier Thematic Mapper (TM) instrument, flown on Landsats 4 and 5. (Landsat 6 was destroyed during launch.) The ETM+ instrument acquires two basic types of data: a single band panchromatic image and multispectral images comprising seven bands, each sensitive to a different wavelength, from the visible, through the near and short wave infrared, to the thermal infrared.

Unfortunately the Landsat 7 ETM+ sensor experienced a malfunction in May 2003, and the imagery collected since then is of reduced value because of periodic gaps in each image (USGS 2006). Nevertheless, the large global archive of high quality historical Landsat data are still useful today. In addition, Landsat 5 data, which is not quite as high quality as Landsat 7, is also available.

2.1.1.1 Panchromatic Data

The Landsat ETM+ differs from previous Landsat sensors in that it includes an additional, eighth, band (Mika 1997). This band 8 is a panchromatic band that covers the 0.5-0.9 µm spectrum and has a 15 meter pixel size. The term "panchromatic" traditionally referred to black and white photographic film that is sensitive to the entire wavelength region of visible light. When used, this film was generally filtered to remove blue wavelengths. Likewise, panchromatic digital satellite imagery usually excludes blue wavelengths, in order to minimize the effect of atmospheric scattering, and instead may include a portion of the near-infrared spectrum. By gathering more energy over a wide spectrum, panchromatic sensors can be designed to acquire data with a higher spatial resolution than if those sensors acquired data with multiple bands (i.e. higher spectral resolution) because the signal to noise ratio of the sensor is limited by the amount of energy reaching the detector.

Panchromatic imagery is sometimes used in image processing to sharpen or increase the spatial resolution of the coarser resolution multispectral imagery. Panchromatic satellite images are also used on their own for mapping endeavors such as generating elevation data, and is also quite suitable for detecting the shapes of objects by their boundaries and shadows.

2.1.1.2 Multispectral Data

The Landsat-7 system collects data in six multispectral bands of reflected energy and one band of emitted energy. The spatial resolution is 30 meters for the visible and near infrared (bands 1-5 and 7) and the thermal infrared (band 6) is 60 meters.

The seven multispectral bands of ETM+ data are used to discriminate between Earth surface materials through the development of spectral signatures. The term *spectral signature* was coined based on the idea that for each material, the proportion of incident radiation that is reflected varies by wavelength, and is a characteristic of that material. The basic premise of using spectral signatures is that the signatures, or reflectance patterns, may be sufficiently different to make it possible to distinguish between different classes of materials. The term spectral signature is, however, a somewhat misleading term, as in practice spectral signatures have inherent variability that makes it challenging to separate between them. Thus, automated identification of surface materials based on spectral signatures is almost never 100% accurate.

In displaying multispectral image bands, we can select combinations of individual bands that highlight particular types of signatures. Such multispectral images normally exploit color to provide a visual representation of the earth's surface.

2.1.2 Surface (Elevation and Bathymetry)

A Digital Elevation Model (DEM) is a data set that contains information on the heights or depths of a surface. The format of DEMs can be either a regular grid of points in binary or ASCII format, or an irregular set of points which are typically in an ASCII XYZ file. The United States Geological Survey distributes DEMs for much of the United States that are a regular grid of elevation points in a standard ASCII format. Other government agencies and commercial providers also provide data in binary format. One of the more common formats, however, is the standard XYZ format where the data are ordered in a three-column ASCII file.

Elevations were in the past almost exclusively produced directly or indirectly by photogrammetric analyses in which images from different vantage points are compared to determine the ground elevations. In the last two decades, two competing technologies have become very common: inteferometric radar (the DEM used in Section 2.3 was originally developed from inteferometric radar) and lidar. Inteferometric radar uses a comparison of two radar images acquired from very slightly different perspectives, whereas lidar uses the measured time it takes for a pulse of light to travel from the sensor, to a reflecting object, and back to the sensor (Maune 2001).

2.2 Satellite Image Display

As discussed in Section 2.1 above, the brightness of a particular pixel in an image is proportional to the pixel DN value. The DN value in turn is related to the intensity of incident solar radiation, and the reflectance properties of the surface material. Thus, a panchromatic image may be interpreted in a manner similar to that of a black-and-white aerial photograph of the same area. A multispectral image consists of several bands of image data. For visual display, each band may be displayed individually as a gray scale image, or in a combination of three bands as a multispectral color composite image.

2.2.1 Preparation

For this section we will be using the Hong Kong Thematic Mapper multispectral and panchromatic data from the *Chap1-4* folder on the CD.

If you have not already copied the data from the CD as described in Section 1.3.1, copy the *Chap1-4* folder from the CD to a new folder in your workspace (e.g. *C:\ID Man\Chap1-4*).

Start IDRISI. In the previous Chapter we set the project file and working folder, however to ensure that nothing has changed since we did that work, we will first check that the data are organized as we expect.

Check project file and working folder with IDRISI EXPLORER

Menu Location: **File - IDRISI EXPLORER**

1. The *IDRISI EXPLORER* window is automatically opened if it was open when you last shut down IDRISI. Therefore it may not be necessary to re-open the *IDRISI EXPLORER.* However, if it is not open, do so.
2. Click on the *Projects* tab to ensure the *Chap1-4* project is listed, and the radio button next to that project has been selected as the current project. If the *Editor* pane is obscuring part or all of the *Projects* information, drag the boundary for the *Editor* pane down to create more room for the *Projects* pane.
3. Confirm in the *Editor* pane that the *working folder* correctly points to the folder you created with the data from the CD (*C:\ID Man\Chap1-4*). (If necessary, return to Section 1.3.4 to review the procedures to create or edit the project file.)
4. Click on the *Files* tab.
5. Check if all the satellite image files (raster) are listed in the *Files* pane.
6. If the files are not listed in the *Files* pane, double click on the directory name to display the files.
7. In order to see the full list of data in the *Metadata* pane it may be necessary to drag the boundary of the *Metadata* pane to make the latter pane smaller. Also, if the space to show the full list of files is not sufficient, you may have to use the slider bar in order to see the entire list of files.
8. There should be 8 ***.rst*** files present: a DEM (***hong_kong_dem.rst***), one panchromatic image (***etm_pan.rst***), and 6 multispectral images numbered 1-5 and 7 (***etm1.rst*** , ***etm2.rst*** …***etm5.rst***, and ***etm7.rst***) (note that band 6, a thermal band is not included). In addition, if you have completed the exercise in Section 1.3.7, there will also be the ***hk_etm_all.rgf***, a *raster group file*.

If the files you expect are not listed in the *Files* pane, then the working folder has not been set correctly. You will need to return to the *Projects* pane, and set the correct folder.

2.2.2 Image Display

In this exercise you will display a single band of a satellite data as a gray scale image, and investigate the nature of a contrast stretch. Panchromatic image data are most commonly displayed as a gray tone image, just like a black and white photograph.

Displaying a panchromatic image with the DISPLAY LAUNCHER
Menu Location: **Display – DISPLAY LAUNCHER**
1. Start the DISPLAY LAUNCHER program from the main menu, or the tool bar. 2. In the *DISPLAY LAUNCHER* dialog box (Figure 2.2.2.a), start the process to select a file by clicking on the browse button (…) in the center left column. 3. A file *Pick List* window will open. In the new window, if only the directory is listed, click on the plus sign (+) to list the files. 4. Select the ***etm_pan.rst*** raster file (Figure 2.2.2.b) by either double clicking on the file name, or clicking once, and then clicking on *OK*. 5. Select *GreyScale* in the *Palette File* section of the Display Launcher window. (Figure 2.2.2.a). 6. Click on *OK* to display the image.

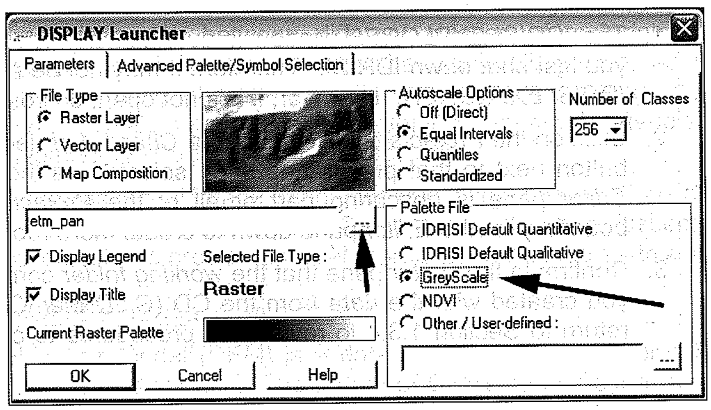


Figure 2.2.2.a Display Launcher window, with parameters chosen for displaying the ***etm_pan.rst*** image.

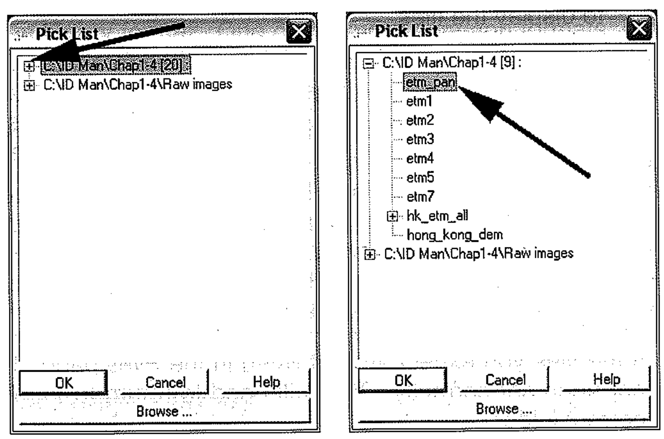


Figure 2.2.2.b Pick list window. Left: directories can be expanded by clicking on the plus sign. Right, directory with an image file highlighted.

The ***etm_pan*** image is a subset of a panchromatic image from the Landsat Enhanced Thematic Mapper Plus (ETM+) sensor. The image represents green to infra-red radiance (0.5 - 0. 9 µm). This image should therefore at least somewhat correspond to how we view the world, because humans tend to see best in the green to red regions of the spectrum. However, you should be cautious about interpreting this image, because it also includes information from the near infrared (0.7 - 0. 9 μm), for which our eyes are not sensitive.

As a single band image, this image is best displayed in shades of gray. This is true of any single band image. This may be confusing, because you might feel, for example, that an image that represents red radiance should perhaps be displayed in shades of red. Although colors are indeed used when multiple bands are displayed in a single composite image, for the display of single band images, gray shades should be used. This is at least in part due to the fact that the eye is much more sensitive to brightness variation for gray, than the brightness variations within a particular color hue.

Adding further confusion to this issue of how to represent a single band of satellite data, the IDRISI default is to display all single band images with the *IDRISI Default Quantitative* palette. A **palette** in IDRISI terminology is a file that specifies the relationship between the pixel DN values and the colors or gray shades used to represent those pixels on the monitor. The *IDRISI Default Quantitative* palette is a rainbow of colors from blue to red, and although it useful for showing patterns, it is not ideal for most raw images which are best thought of as analogs to black and white photographs. It is for this reason that we specifically selected the *GreyScale* palette file in displaying the image, and you should always make a point of using *GreyScale* for single band images, unless you have a specific reason not to.

Examine the ***etm_pan*** image that you have displayed (Figure 2.2.2.c) and note that the image is dark and has poor contrast. The image is not optimal for visual interpretation. This problem arises because the DISPLAY LAUNCHER automatically applies a stretch to an image based on the minimum and maximum values of the image. However, most images have a rather limited range of values, with a few outliers that are either very dark or very bright. Thus, the stretch applied in this case is not optimal. In the next section, we will investigate this idea of the contrast stretch, including why it is generally necessary and what it means in practice.

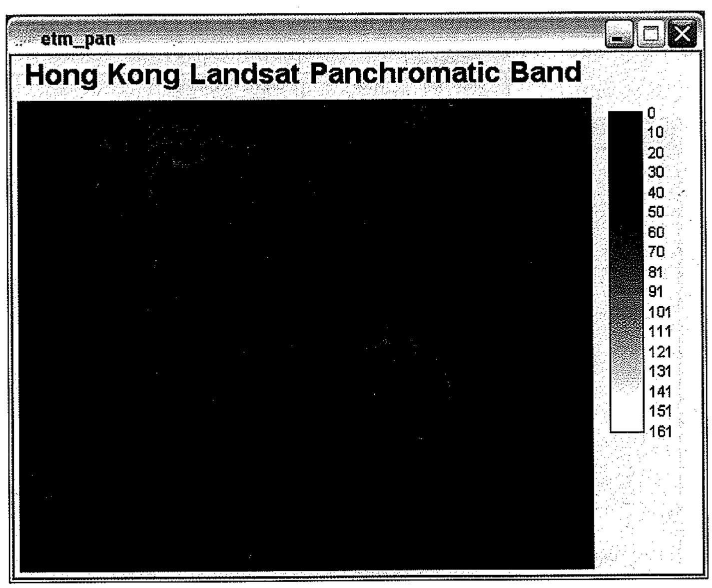
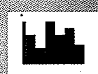


Figure 2.2.2.c Landsat panchromatic image based on the default stretch.

2.2.3. Image Statistics and a Simple Contrast Stretch

A common format for optical satellite data is for the DN values to be scaled over a potential range from 0 to 255. This range was chosen because it is an efficient way to store numbers in a binary computer file. Computers use a counting system based on the powers of 2, unlike our conventional counting, which is based on powers of 10. The smallest number representation on a computer is a bit, which is location that has a value of 0 or 1. Bits are grouped arbitrarily every 8. This made an 8 bit number (2^8, or 2x2x2x2x2x2x2x2 = 256) a convenient unit of computer storage.

Within this 0-255 range, the optical settings of the sensor are designed to cover the broadest range of possible landscapes, from highly reflective snow and beach sand, to very dark material such as basalt rock, water and shadow. However, any individual scene is unlikely to include the full range of landscape cover types. Thus the range of DN values in a single image is likely to be rather limited. In this section you will adjust the contrast in the image so that the small range of DN values found within a scene is mapped to a wider range of display values, utilizing the full range of 256 brightness levels available for viewing on the computer monitor.



Analyzing the image data distribution with HISTO

Menu Location: **Display - HISTO**

1. Start the HISTO program from the main menu or the toolbar.
2. In the *HISTO* dialog box, click on the browse button (...) next to the text box for the *Input file name*.
3. The *Pick list* window will open. Use it to select the ***etm_pan*** data set.
4. Set the class width to **1**.
5. Leave the remaining parameters set at their default values.
6. Click on *OK*.

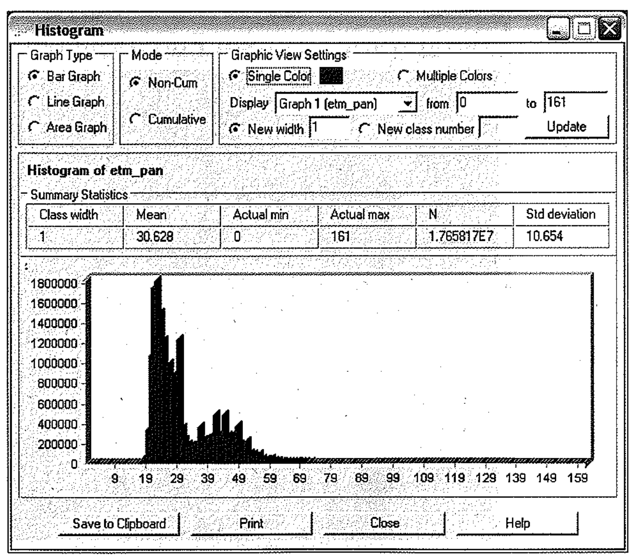


Figure 2.2.3.a Histogram graphical display of ***etm_pan.rst*** image.

The frequency histogram is shown as a bar graph (Figure 2.2.3.a). The vertical axis shows the number of pixels in the image that have each particular DN value, as indicated on the horizontal axis.

Note that Figure 2.2.3.a shows that the full 2^8 (0-255) range is not represented in this image, and that the population is not a normal Gaussian distribution (i.e. does not follow a bell-shaped curve). In fact, many satellite images reveal a bimodal frequency distribution, particularly if the scene contains both land and water areas. Also the minimum value and maximum values, 0 and 161, are well outside the range of the majority of pixel values.

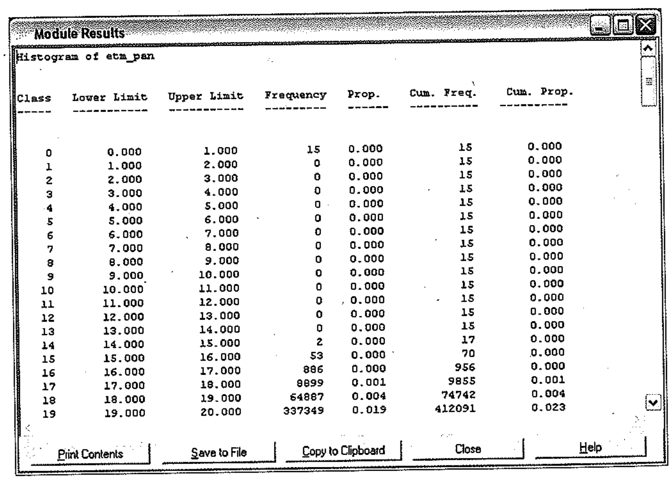
Notice how you the graph can be updated dynamically. You can convert the graph to cumulative plot or a line graph by clicking on the appropriate options in the *Histogram* window. You can also set new maximum and minimum numbers for the graph by editing the values in the text boxes for *Display … from… to….*, and then pressing the *Update* button. For example, you might enter **18** and **80** in these boxes, respectively, and by doing so, obtain a new graph that displays just that part of the histogram.

IDRISI has persistent windows, which means that the dialog boxes that control programs do not close once the program has run. Therefore, the HISTO dialog box should still be open in your IDRISI workspace and available to be run again, though you may need to move the *Histogram* window to one side to see the dialog box.

Analyzing the image data distribution with HISTO (cont.)

7. In the *HISTO* dialog box (i.e. not in the *Histogram* display window, but the original *HISTO* dialog box that produced the *Histogram* window), select the radio button for *Numeric* output, instead of the default *Graphic*.
8. Click *OK*.

This time, because we selected *Numeric* as the output format, the program will generate a text file with the number of pixels for each DN value (Figure 2.2.3.b). From this file, we can learn that there are only 15 pixels with a value of zero, out of a total of 17.7 million pixels. Furthermore, the cumulative frequency of all pixels only reaches 0.001 at a DN value of 17. This means that if you sum all the pixels with a value of 17 or less, they would comprise less than 0.1% of the image.


Module Results

Histogram of etm_pan

Class	Lower Limit	Upper Limit	Frequency	Prop.	Cum. Freq.	Cum. Prop.
0	0.000	1.000	15	0.000	15	0.000
1	1.000	2.000	0	0.000	15	0.000
2	2.000	3.000	0	0.000	15	0.000
3	3.000	4.000	0	0.000	15	0.000
4	4.000	5.000	0	0.000	15	0.000
5	5.000	6.000	0	0.000	15	0.000
6	6.000	7.000	0	0.000	15	0.000
7	7.000	8.000	0	0.000	15	0.000
8	8.000	9.000	0	0.000	15	0.000
9	9.000	10.000	0	0.000	15	0.000
10	10.000	11.000	0	0.000	15	0.000
11	11.000	12.000	0	0.000	15	0.000
12	12.000	13.000	0	0.000	15	0.000
13	13.000	14.000	0	0.000	15	0.000
14	14.000	15.000	2	0.000	17	0.000
15	15.000	16.000	53	0.000	70	0.000
16	16.000	17.000	886	0.000	956	0.000
17	17.000	18.000	8899	0.001	9855	0.001
18	18.000	19.000	64887	0.004	74742	0.004
19	19.000	20.000	337349	0.019	412091	0.023

Print Contents | Save to File | Copy to Clipboard | Close | Help

Figure 2.2.3.b Histogram numeric output for the ***etm_pan.rst*** image.

Use the slider bar on the right of the *Module Results* window showing the numeric histogram data to observe the DN value associated with a cumulative proportion of 0.999. This should be a DN value of 73. We can therefore summarize our findings to say that only 0.2% of the image DN values lie outside the range 18-73.

Now, using the graphic and numeric histogram data as a guide, let's develop an enhancement of the image contrast that makes the patterns in the majority of the image much clearer. This procedure is called a **contrast stretch**. In carrying out our contrast stretch, we have to accept that we will lose discrimination of changes in DN values at the extremes of the distribution, such as between DN values 0 and 18, and between 73 and 160. However, because there are so few pixels with such values, and overall the image will look much clearer.

At this stage you can close the HISTO dialog box, and the graphic and numeric data windows that program generated.

Contrast Enhancement through modifying the *Display* settings in the *Composer Window*

1. If you have closed the image displayed in Section 2.2.2, redisplay the ***etm_pan.rst*** image using the DISPLAY LAUNCHER and a *GreyScale* palette file (see Section 2.2.2 for further instructions, if necessary.)
2. In the *Composer* dialog box (this window is automatically also opened in the Workspace when an image is displayed), click on the button for *Layer Properties.*
3. The *Layer Properties* dialog box will open (Figure 2.2.3.c). Note that the window has three tabs, with the *Display Parameters* tab as the default.
4. Use the sliders *Display Min* and *Display Max* to set the minimum to **18** and the maximum to **73**, or alternatively, simply type in the appropriate numbers in the text boxes to the right of the sliders.
5. Click on the button for *Apply*, *Save* and then *Close*.

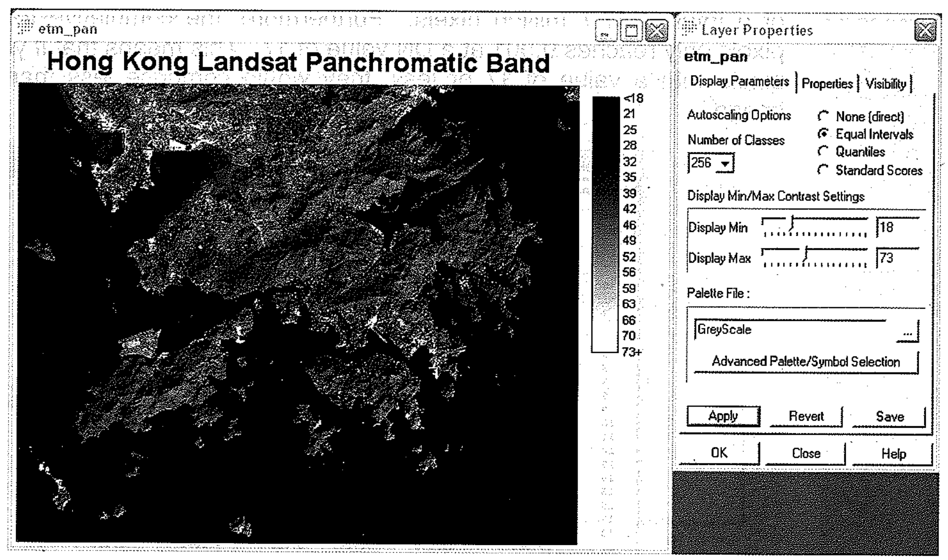


Figure 2.2.3.c The contrast-stretched ***etm_pan.rst*** image and the *Layer Properties* dialog box.

Note how the image contrast has improved greatly (Figure 2.2.3.c). This is because we have assigned a black color on the screen to 18, instead of 0, and white to 73, instead of 161. Shades of gray between black and white are assigned linearly from 18 to 73, respectively. Thus middle gray is a DN value of 45 (half way between 18 and 73), instead of the 80, as was the case when we were using a 0-161 stretch. If we refer back to the histogram of the data distribution, we can see that 45 is within the main data distribution, whereas 80 is greater than nearly all the values in the image.

The contrast adjustment we have made so far is not applied to the original data, but only to mapping function for display of the data on the screen. This is a key concept, because it means that the original data are unchanged, which may be important if we are to apply further processing.

By clicking on the button for *Save*, we are storing the minimum and maximum values in the metadata. This means that every time the image is displayed, the enhancement is applied automatically, through the DISPLAY LAUNCHER's *Autoscale* option. In the future, when this image is displayed, the program will automatically use these values to determine the contrast stretch. In the next exercise, we will check the metadata to see where the values are recorded, and the redisplay the image to observe the automatic image stretch.

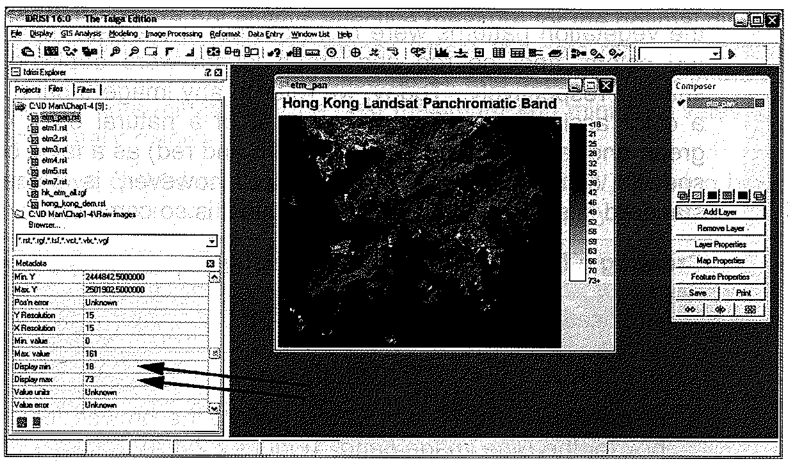


Figure 2.2.3.d Using the IDRISI EXPLORER to view *Display min* and *Display max*.

Contrast Enhancement (cont.)

6. If the *IDRISI EXPLORER* window is not open, click on the IDRISI EXPLORER icon.
7. Select the *Files* tab.
8. If the files are not listed in the *Files* pane, double click on the directory name to display the files.
9. In the *Files* pane, click on the ***etm_pan.rst*** image.
10. In the *Metadata* pane, drag the slider down until the lines labeled *Display min* and *Display max* are visible.
11. Confirm that the *Display min* text box shows a value of *18* (upper arrow in Figure 2.2.3.d), and the *Display max* text box a value of *73*.

12. Note that it is possible to change these values by simply typing new values in the text boxes.
13. Close the image in the display window, if it is not already closed.
14. Redisplay the ***etm_pan.rst*** image again. Be sure to select the *GreyScale* palette file, as with any single band satellite image.

The redisplayed image should show a good contrast, as it did when we applied the contrast stretch manually. In this case, however, the contrast is applied automatically.

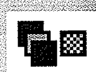
End this section by closing any windows that are still open in the IDRISI workspace.

2.2.4 Creating False Color Composite Images

In this section, we will create a standard false color infrared composite of three TM image bands (i.e. the ETM+ green band displayed in blue on the screen, the red band displayed as green, and the near infrared band displayed as red).

The concept of a false-color image stems from false color infrared aerial photography. When infrared photography was first developed, an infrared layer was substituted for a blue sensitive layer in the film. However, it was noticed that the vegetation patterns were more obvious if the near infrared was displayed in red colors, and the red and green layers were depicted in green and blue shades, respectively. Today, we refer to any image 3-band composite that uses a color assignment different from that of a natural color composite (i.e. blue, green and red displayed as blue, green and red) as a false color composite. The specific combination we will produce, however, is sometimes known as a standard false color composite, because it is so common.

Creating a false color composite image



Menu Location: **Display - COMPOSITE**

1. Start the COMPOSITE program.
2. In the *COMPOSITE* dialog box, select the browse icon (…) next to the text box for the *Blue image band*. (Figure 2.2.4.a)
3. A *Pick List* window will open. Select the ***etm2*** raster file. Click twice on the file, or once and click on *OK*.
4. Repeat for the *Green* and *Red image bands*, selecting the files ***etm3*** and ***etm4*** files, respectively. (Note: you can also type the names of the files directly in the text boxes.)
5. Enter the *Output image* filename in the text box provided: **etm234_composite**
6. Select the radio button for *Contrast stretch type* as *Linear with saturation points.*
7. In the *Output type* section, select the radio button for *Create 24 bit composite, with original values and stretched saturation points*. (This is the default.)
8. In the Title dialog text box, enter: **Hong Kong False Color Composite**
9. Click *OK* to create and display the false color composite.

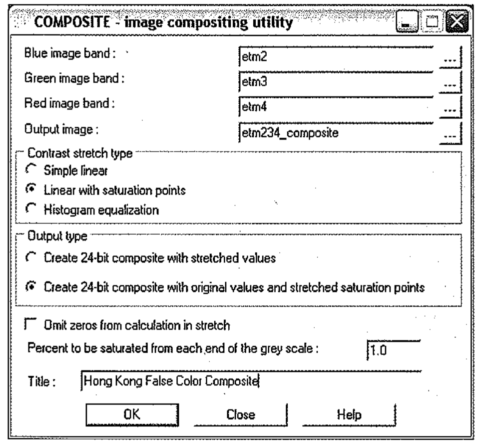


Figure 2.2.4.a *COMPOSITE* dialog box.

Linear with saturation stretch is much better than a simple linear stretch that uses the minimum and maximum vales as the end points of the stretch. As we discovered in the previous section, the minimum and maximum values found in the raster data set are not always effective measure for the optimal display. The linear stretch with saturation determines where the data range encompasses a certain percent of the data (in this case 98%), and use this range in the stretch – much like our determination of the best maximum and minimum vales to use for the panchromatic display in Section 2.2.3

After you have clicked on the OK button in the *COMPOSITE* dialog box, IDRISI will generate the composite image, an automatically display the result.

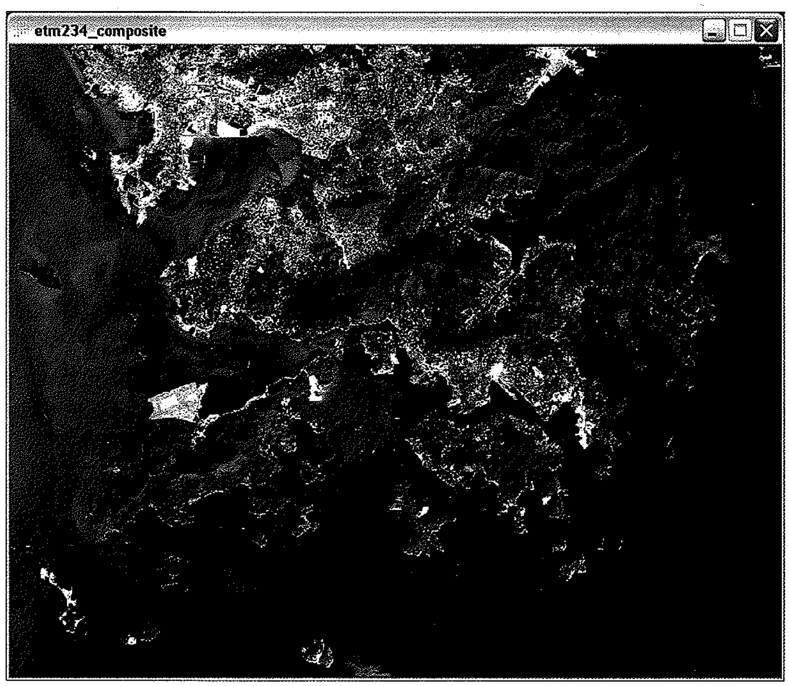


Figure 2.2.4.b Landsat false color composite image of Hong Kong, with bands 2,3,4 as blue, green, red (B,G,R).

Try bringing up the metadata for the false color composite. The simplest way to do this is through the *Composer* window, which is always present in the IDRISI workspace when an image is displayed. Click on the *Layer Properties* button in the *Composer* window, and the *Layer Properties* window will open. The tab for the *Display Parameters* will show the stretches applied to each image band. Alternatively, you can use the IDRISI EXPLORER, as we have learned to do in Section 2.2.3. Note, however, if you use the IDRISI EXPLORER you may need to refresh the *Files* window pane. This can be done by right clicking in the *Files* pane, and selecting *Refresh* from the pop-up menu. You will need to scroll down in the *Metadata* pane to see the triplicate of values (one for each band) for both the Display min and Display max.

Note that the COMPOSITE module automatically enters the Display Minimum and Display Maximum values in the metadata file of the color composite. This way, when you display the composite raster image, it will always be enhanced optimally.

2.2.5 Map Annotation

We can also design and create maps within the *Display* window. Maps not only show a representation of the Earth's surface, such as a satellite image, but also include useful and important information such as the reference grid, the north direction, and scale. In addition, maps usually have a title, and provide information about the map projection and data source.

We will now use the Hong Kong false color image as the basis for creating a map composition (Figure 2.2.5.a). The first step in creating a map is to resize your *Display* window so that enough background around the image is available to accommodate our planned map elements.

Map composition construction

Menu Location: **Display - DISPLAY LAUNCHER**

1. Open the DISPLAY LAUNCHER from the main menu or icon bar.
2. Select the raster file ***etm234_composite***.
3. Click on the *OK* button to display the image.
4. Your image should have a title automatically displayed. If not, it means you did not enter a title when you created the image, and you should return to Section 2.2.4, or enter the title through the *Metadata* pane in the *IDRISI EXPLORER*, and then redisplay the image.
5. Resize the *Display* Window by clicking on one of the corners, and dragging the window to an appropriate size to encompass the annotation planned (Figure 2.2.5.a).
6. Double click on the image within the *Display* window.
7. Click and drag the image to center it horizontally beneath the title.
8. Double click on the title in the *Display* window, to select the title. The title will be boxed by a series of black squares, indicating the title box has been selected.
9. Click and drag the title box to a position centered above the image.
10. When you are done, click elsewhere in the *Display* window, to de-select the title box.

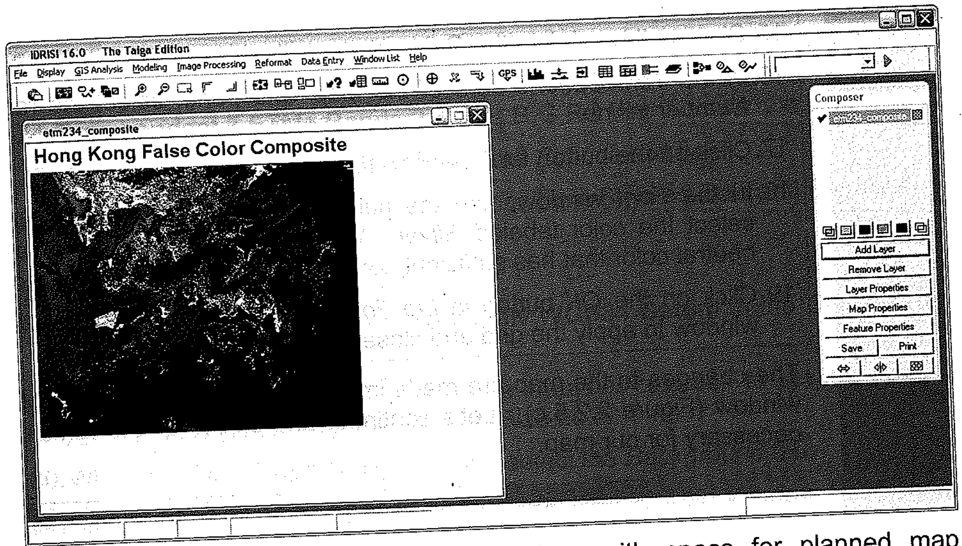


Figure 2.2.5.a The re-sized display window, with space for planned map elements.

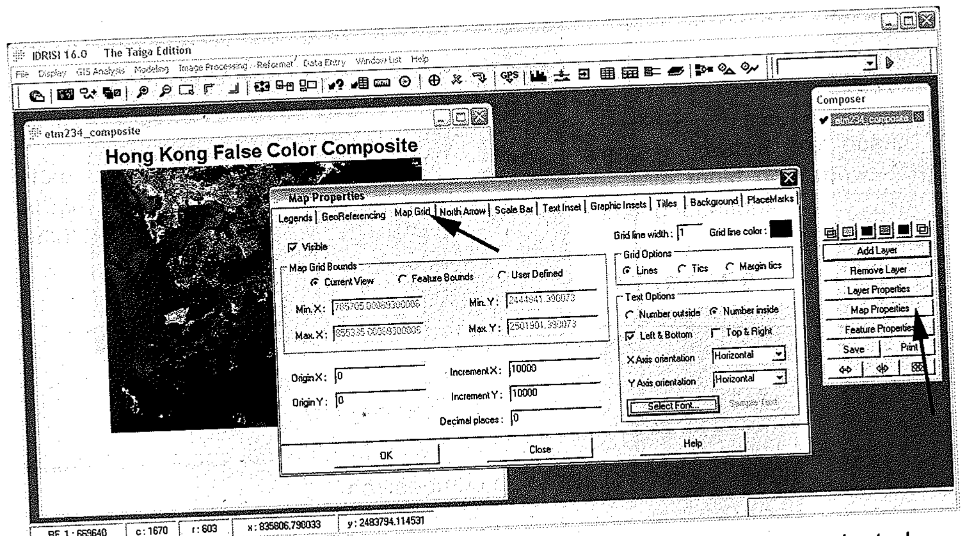


Figure 2.2.5.b The *Map Properties* dialog box with *Map Grid* pane selected.

We will now create the other components of our map including the map grid, a north arrow, and a scale bar. The tools to create these features are found in the *Map Properties* window.

Map composition construction (cont.): Applying a map grid
11. Open the *Map Properties* window, by either right-clicking on the image in the *Display* window, or by clicking on the *Map Properties* button located in the *Composer* window (Figure 2.2.5.b). 12. Select the *Map Grid* tab to open the *Map Grid* pane (Figure 2.2.5.b). 13. Click to place a check mark in the box labeled *Visible*. 14. In each of the two text boxes labeled *Increment X* and *Increment Y*, enter **10000**.

15. Change the value in the *Decimal places* text box to **0.**
16. In the *Text Options* area of the *Map Grid* pane, select the radio button for *Number inside*.
17. Click on the button for *Select Font*.
18. In the *Font* window, use the pull-down menu under the heading *Color* to select the color labeled *Silver*. We are selecting this color as a relatively neutral color that has sufficient contrast with the image to be discernable.
19. Click on the *OK* button in *the Font* window, and *OK* in the *Map Properties* window to apply the grid and close the *Map Properties* window.

The changes to the map are made immediately after closing the *Map Properties* window (Figure 2.2.5.c). Let's continue, and create all the remaining elements necessary for our map.

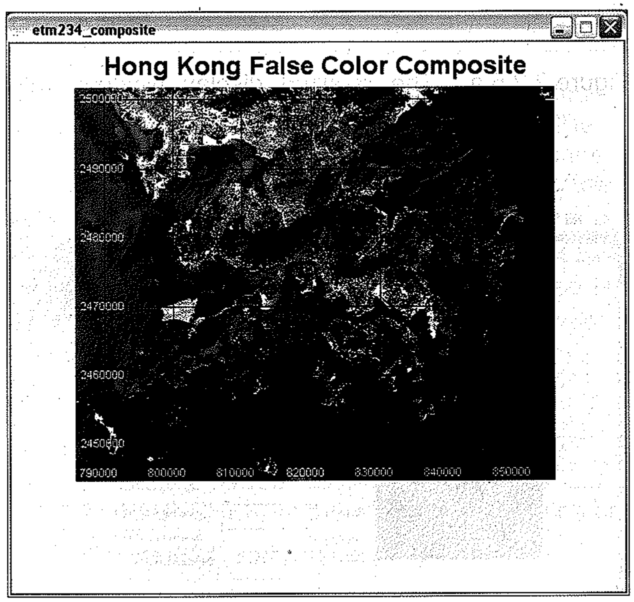


Figure 2.2.5.c Initial map composition.

Map composition construction (cont.): Applying north arrow, scale bar, additional text, and background color

14. Click on the *Map Properties* button in the *Composer* window.
15. Select the *North Arrow* tab.
16. Within the *North Arrow* pane, click in the *Visible* check box.
17. Select the north arrow type you wish to use from the four options. The option you select will be indicated by a black box.
18. Click on the *Scale Bar* tab.
19. Within the *Scale Bar* pane, click on the *Visible* check box.
20. The Units box should indicate *Meters*.
21. Type **20000** in the *Length (in Ground Units)* text box.
22. Click on the *Titles* tab.

23. In the *Titles* pane, click on the *Visible* check box for both subtitle and caption text.
24. Type **Landsat 7 ETM+ Bands 2,3,4 as B,G,R** in the *Subtitle* text box.
25. Click on the *Select Font* button below the *Subtitle* text box.
26. In the *Font* window, set the Font as *Arial*, Font Style as *Bold* and Font Size as *14.*
27. Click *OK* to close the *Font* window.
28. In the *Titles* pane, type **UTM Zone 49N WGS84 Datum** in the *Captions* text box.
29. Use the *Select Font* button below the *Captions* text box to set the Font as *Arial*, Font Style as *Regular* and Font Size as *8.*
30. Within the *Map Properties* dialog box, select the *Background* tab.
31. Within the *Background* pane, click on box labeled *Map Window Background Color.*
32. A *Color* dialog box will open. Select the white color chip in the *Basic colors* section of the window. Click *OK* to close the *Color* dialog box.
33. Click in the check box for *Assign map window background color to all map components.*
34. Click on *OK.*

Note that many of the map components that we just created are located in arbitrary positions that obscure parts of the map. We must now move these elements to a more organized and aesthetically pleasing locations.

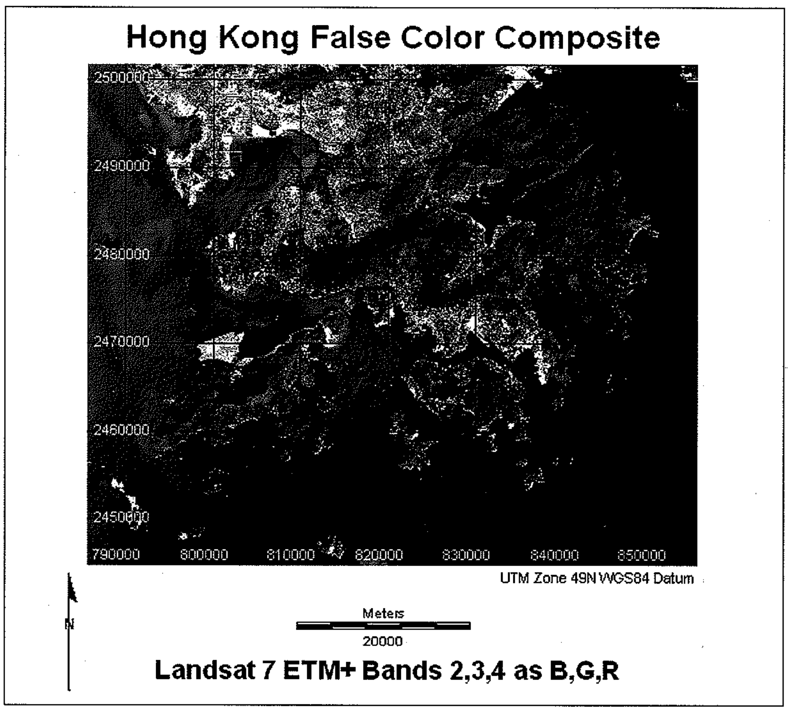


Figure 2.2.5.d The completed Hong Kong Landsat Satellite Image Map.

Map composition construction (cont.): Arranging map elements

35. Double click on the North arrow.
36. Click and hold the cursor over the highlighted North arrow, and move the arrow to the lower left corner. You can resize the arrow, if necessary, by dragging one of the corners of the highlighted box.
37. Double click on the scale bar, so that the scale bar is selected.
38. Click and drag the highlighted scale bar to a location near the bottom-center of the map.
39. Double click on the caption text, *UTM Zone...*
40. Drag the text to a location at the bottom right corner of the image.
41. Double click on the subtitle text, *Landsat 7...*
42. Drag the text to a location at the bottom-center of the map, below the scale bar.

Congratulations! You have now made your first IDRISI map. The map composition should look something like the map in Figure 2.2.5.d.

Now there are several options to save your composition. The simplest is to save it in an IDRISI *map* file format and the other is to save it as a graphic file such as the Windows *Bitmap* (bmp). We will save our composition in both formats.

Map composition construction (cont.): Save to MAP format

43. Select the *Save* button in the *Composer* window.
44. The *Save Composition* dialog box will open.
45. Click on the *Save composition to MAP file* radio button, if it is not already selected.
46. In the text box for *Output file name,* enter **Hong Kong ETM map**.
47. Click on *OK.* The *Save Composition* dialog box will close.

Once saved, a map composition can be redisplayed at any time with the *DISPLAY LAUNCHER*, as we will see in Section 2.2.6 below.

Map composition construction (cont.): Save to BMP format

48. Re-open the *Save Composition* dialog box by clicking on the *Save* button in the *Composer* window.
49. Click on the *Save to Windows bitmap (BMP)* radio button.
50. In the text box for *Output file name,* enter **Hong Kong ETM map**.
51. Click on *OK.* The *Save Composition* dialog box will close.

The BMP file creates a useful graphic for importing into in reports and presentations. Note that you can also use the *Copy to clipboard* option in the *Save Composition* dialog box, to paste a figure directly into another Windows application. However, in our experience this is not always so reliable, and sometimes the resulting image has artifacts. If you find this problem, then you should rather choose the BMP option.

To end this section, close all the files in the IDIRISI workspace.

2.2.6 Printing a Map

The dialog box for printing maps or images from the *Display* window are accessed through the *Composer* window. Importantly, the print function is the only one where you can precisely control the scale of your map. We will now print our Hong Kong image map as a scaled print at 1:500,000.

Printing a map
Menu Location: **Display – DISPLAY LAUNCHER**
1. Start the DISPLAY LAUNCHER. 2. In the *File Type* section of the *DISPLAY LAUNCHER* dialog box, select the *Map composition* radio button. 3. Click on file pick button (…) 4. Select the ***Hong Kong ETM map*** file we created in the previous section (2.2.5). 5. In the *DISPLAY LAUNCHER* window, click on *OK* 6. Select the *Print* button in the *Composer* window. 7. The *Print Composition* dialog box will open. 8. Click on the *Printer Setup* button. A *Printer Setup* dialog box will open. Make sure that your printer is set for *landscape* orientation. Close the *Printer Setup* dialog box. 9. In the Print Composition dialog box, in the section labeled *Rendering*, click on the radio button for *Highest Quality*. 10. In the *Scaling* section, select the radio button for *Print to scale*. 11. In the *Scale: 1/* text box, type in **500000** 12. Click on the *Print* button.

IDRISI will render and send to your printer a map at the precise scale of 1:500,000. Measure the scale bar to check (it should be exactly 4.0 cm).

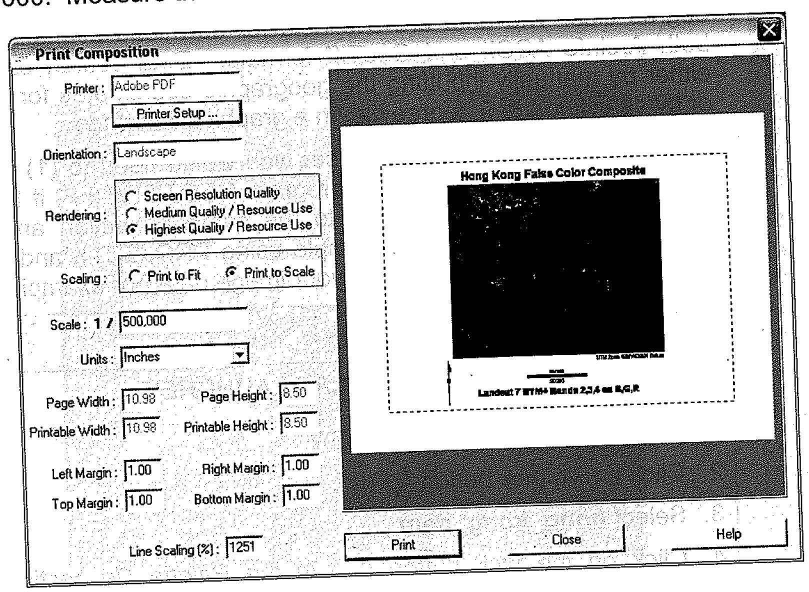


Figure 2.2.6.a *Print Composition* dialog box.

2.3 3-D Visualizations

IDRISI has a number of modules that allows the user to create three dimensional displays and visualizations. Typically these modules require the use of digital elevation data (DEM) as the basis for the orthographic view. The surface represented can be used to control a palette, or a second file may be draped over the surface. A common choice for the drape files is a satellite image, which results in a perspective view of the Earth's surface. These perspective views can be animated to create fly-through visualizations. We will create such a visualization over Hong Kong.

2.3.1 Preparation

Let us first examine the DEM of Hong Kong supplied with this manual. The DEM is a subset of the nearly global DEM derived from NASA's Spaceborne Imaging Radar-C (SIR-C) Topographic Mission. The Shuttle Radar Topography Mission (SRTM) was an international project that obtained high-resolution digital elevation data on a near-global scale. SRTM consisted of a specially modified radar system that flew onboard the Space Shuttle Endeavour during an 11-day mission in February of 2000. The SRTM DEM was derived from a process known as radar interferometry. In radar interferometry, two images are made of the same scene by two separate radar antennas, separated in the "range" direction, perpendicular to the line of flight. The two radar images have very slight differences between them. These differences allow the calculation of the elevation of the ground surface that was imaged by the radar system. The SRTM experiment aboard the shuttle consisted of one radar antenna in the shuttle payload bay, and a second radar antenna attached to the end of a mast extended 60 meters (195 feet) out from the shuttle.

There are many sources for the SRTM DEM data, including the USGS seamless data distribution system (http://seamless.usgs.gov/) and the Earth Science Data Interface (ESDI) at the Global Land Cover Facility of the University of Maryland (http://glcfapp.umiacs.umd.edu:8080/esdi/index.jsp).

One of the most straightforward sources of SRTM is provided by The Consortium for Spatial Information (CGIAR-CSI) (http://csi.cgiar.org/index.asp). CGIAR maintains a 90m SRTM database of the entire world in mosaicked 5 degree by 5 degree tiles. The data are available for download at http://srtm.csi.cgiar.org in both ArcInfo ASCII and GeoTiff formats. Data search can be accomplished either by manually inputting the geographic coordinates for the area of interest, or by selecting the 5 degree tile on a graphical interface.

If you download your own data set, you would need to (1) import the DEM into IDRISI (for example, using the program GEOTIFF/TIFF, if the image is in TIFF format), (2) reproject the data to the same projection and pixel size as the imagery you are using (for example using PROJECT), and then (3) subset the data to the same dimensions as your image data (for example, using WINDOW).

Display DEM data
Menu Location: **Display – DISPLAY LAUNCHER**
1. Open the *DISPLAY LAUNCHER.* 2. Click on file pick button (…). 3. Select ***hong_kong_dem*** 4. Click on the pick button (…) in the *Palette file* section of the *DISPLAY LAUNCHER*.

5. Select the *\IDRISI Taiga\Symbols* folder. (Note that the entire path will be displayed, not just the final folder names as indicated here. The specifics of the entire path will depend on your installation of IDRISI.) (Figure 2.3.1.a.)
6. Scroll down and select the ***terrain*** palette.
7. Click on *OK* to close the *Palette* window.
8. In the *DISPLAY LAUNCHER*, click on *OK* to display the image.

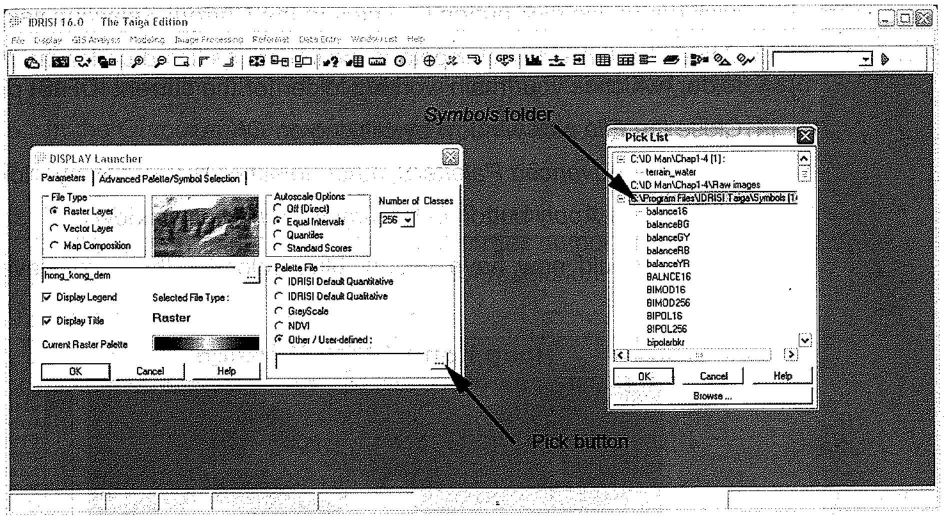


Figure 2.3.1.a Selecting a palette file from within the */IDRISI/Taiga/Symbols* folder.

Note that the data are a bit noisy with some data drop-outs (Figure 2.3.1.b). The data has yet to be quality checked by NASA and is delivered "as is." The *terrain* palette also shows the zero elevation value as a dark green color. We have included a custom palette along with the DEM data that depicts the zero value (sea level) as a dark blue color. Let's learn how to change the image palette file of a displayed image.

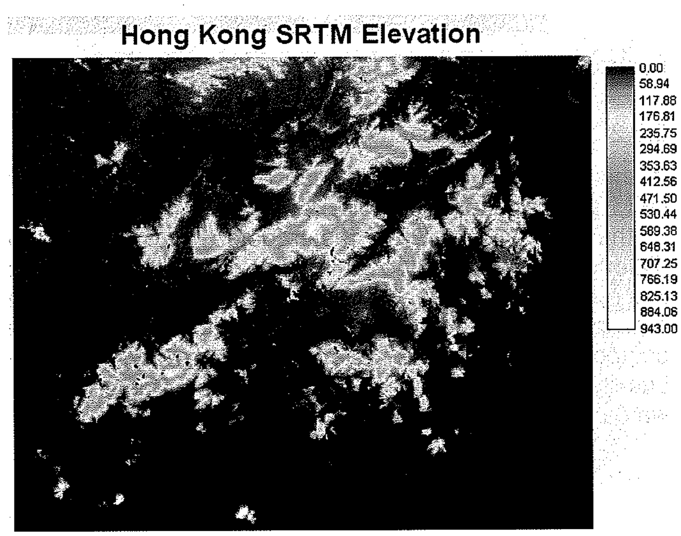


Figure 2.3.1.b The Hong Kong digital elevation model.

Display DEM data (cont.): Change the palette file
9. In the *Composer* window, select the *Layer Properties* button.
10. The *Layer Properties* window will open, with the *Display Parameters* tab selected.
11. In this new window, click on the *Advanced Palette/Symbol Selection* button.
12. The *Advanced Palette/Symbol Selection* dialog box will open. In this window, click on the file pick button (...) next to the *Current Selection* field.
13. Select the ***terrain_water*** palette, which will be listed under the *ID Man/Ch1-4/* folder, which is your main working folder for the current IDRISI project.
14. Close the *File* pick window by clicking on *OK*.
15. Close the *Advanced Palette/Symbol Selection* dialog box by clicking on OK.
16. Click on the *Apply* button in the *Layer Properties* window.

The DEM should now have a dark blue color for the zero elevations (Figure 2.3.1.c).

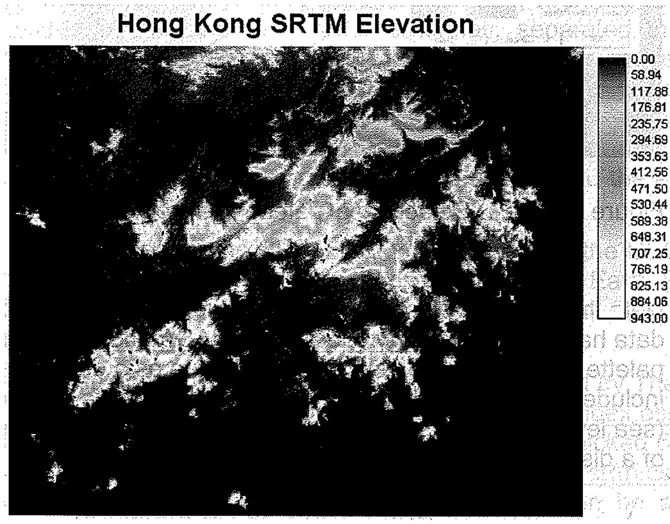


Figure 2.3.1.c The Hong Kong digital elevation model with an alternate palette.

2.3.2 <u>ORTHO Perspective Display</u>

In this section we will create an orthographic display of Hong Kong using the DEM and Landsat false color raster files. If you were to check the metadata file of the Hong Kong DEM raster data set you would observe that the image dimensions are exactly equal to that of the Hong Kong Landsat raster files. This is a requirement for the orthographic displays and visualizations if we wish to use a drape image. Another requirement for the drape image is that it is either a composite image or a raster file with binary or integer data between 0-255. Luckily for you, we have met all these requirements in our included data sets so we can continue and make our displays.

Orthographic display

Menu Location: **Display - ORTHO**

1. Start the ORTHO program from the main menu.
2. In the *ORTHO* dialog box, double click in the *Surface image* text box. (Figure 2.3.2.a)
3. In the resulting pick list, double click on the file ***hong_kong_dem***.
4. In the *ORTHO* dialog box, double click in the *Use drape image* text box.
5. In the resulting pick list, double click on the file ***etm234_composite***.
6. In the *Output image* text box, type in the name of a new file: **HK_ortho_1**
7. Click in the *Title* check box.
8. The default resolution is *604 x 480* pixels. If you have a large computer monitor, you can select one of the larger output file sizes by clicking on the appropriate radio button under *Output resolution*.
9. Click on *OK*.

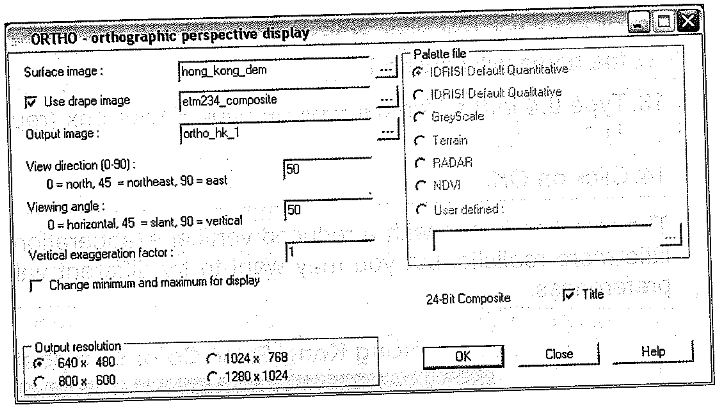


Figure 2.3.2.a The *ORTHO* dialog box.

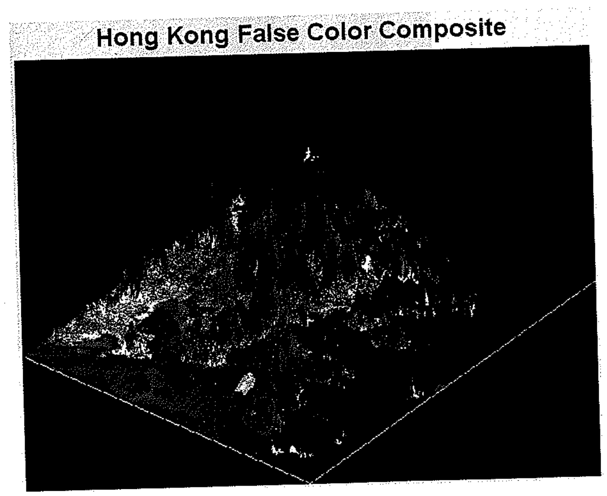


Figure 2.3.2.b Orthographic image of Hong Kong with a vertical exaggeration factor of 1.

The display window appears with your new orthographic display of Hong Kong from a perspective of a compass direction of 50 degrees (northeast) (Figure 2.3.2.b). One aspect of the display is immediately apparent. The vertical relief looks very unnatural due to an exaggerated display of the terrain. The ORTHO module does not employ a metric scaling, which means that the program does not take into account the units of the DEM values. Therefore the degree of exaggeration is entirely qualitative. The most expedient way to control the degree of exaggeration is to set the viewing angle, and then alter the exaggeration factor to create an appropriate perspective. Specifying an exaggeration factor value of "0.5" will halve the amount of exaggeration, while a value of "2" will double it.

Let's alter our display to create a better orthographic display by modifying the exaggeration factor. We'll try a value of 0.4.

Orthographic display (cont.)
10. Close the *Display* window with the orthographic view.
11. Assuming you have the persistent windows option specified in IDRISI, the *ORTHO* dialog box will still be open. If not, restart the *ORTHO* dialog box, and enter the same parameters as above.
12. Change the last digit of the file name of the Output image from *1*, to a *2*, so the name will now be **HK_ortho_2**.
13. Type **0.4** in the Vertical Exaggeration Factor box (replace the default value of 1)
14. Click on *OK*.

The resulting image with a reduced vertical exaggeration (Figure 2.3.2.c) looks a little more realistic, but you may want to try different values, depending on your preferences.

Hong Kong False Color Composite

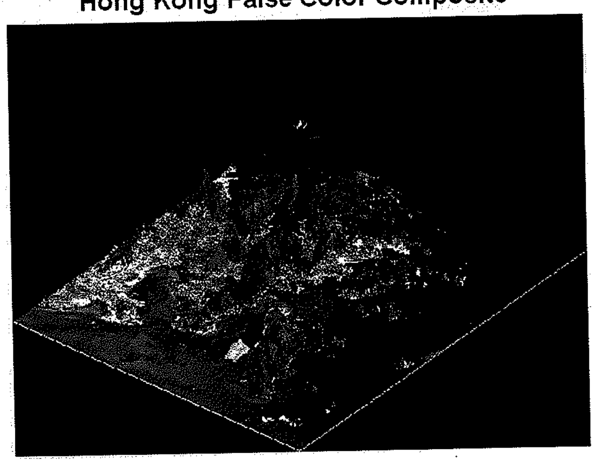


Figure 2.3.2.c. Orthographic image of Hong Kong with a vertical exaggeration factor of 0.4.

2.3.3 Fly-Through Visualization

The FLY-THROUGH program provides the ability for the user to control interactively the viewing perspective of an orthographic display in real time. This creates a perception of "flying" above and around the surface depicted. Such displays are commonly used as an interesting animation that helps the viewer gain an appreciation for the area depicted.

We will use the same data sets as those in creating our orthographic perspective of Hong Kong. When we open the Fly-Through module, please pay special consideration to the key pad commands, as these are the only means for you to control the display once activated.

Fly-through interactive display
Menu Location: **Display – FLY-THROUGH**
1. Start the FLY-THROUGH program from the menu or the icon bar. 2. In the *FLY-THROUGH* dialog box, click on the pick button (...) to the right of the text box for the *Surface image*. (Figure 2.3.3.a.) 3. Select the ***hong_kong_dem*** file. 4. Click on pick button (...) to the right of the *Use drape Image* text box, and select the ***etm234_composite*** file. 5. Select the *Slow* button in the *Initial velocity* section. 6. Use the slider bar to reduce the *Exaggeration factor* to 25%.

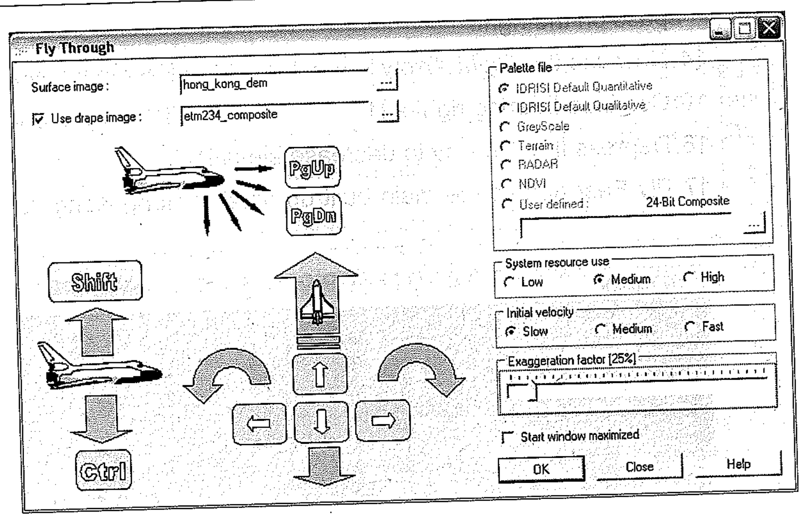


Figure 2.3.3.a FLY-THROUGH dialog box.

The lower left-hand section of the Fly-Through dialog box shows graphically the keypads that control the view angle, elevation, and direction of movement as you move through the image display (Figure 2.3.3.a).

When we start the FLY-THROUGH display, the initial position is located to the southwest of the surface area. We will try to fly above Hong Kong, making several turns as we go. See if you can use the description in the instruction to fly over the Hong Kong airport, and then over the main part of the city.

Note: If the FLY-THROUGH program gives you an error message when you press *OK* in the instructions below (see for example Figure 2.3.3.b), try following the suggestions in the IDRISI on-line Help. There is a direct link to the Help for this program in the FLY-THROUGH dialog box.

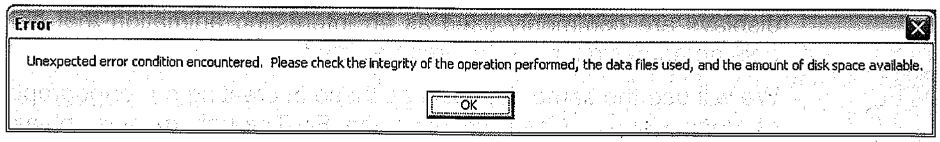


Figure 2.3.3.b FLY-THROUGH error message.

Fly-through interactive display (cont.)
7. In the FLY-THROUGH window, click on *OK*.
8. A new window, a FLY-THROUGH viewer should open.
9. Hold down the *Up Arrow* Key and watch the display move in the FLY-THROUGH viewer.
10. Tap the *Up Arrow* Key a few times and note how you can move incrementally as well as smoothly.
11. Continue holding the *Up Arrow* Key and as you advance, until some of the first islands you reach have disappeared from view.
12. Press the *Page Down* key to change your view angle downwards.
13. Depress the *Left Arrow* Key to fly to the North West, so that the airport should pass on the right.
14. Now use the *Right Arrow* key to turn North East to fly over the airport.
15. Continue bearing right a little further (this will take you due East).
16. Depress the *Ctrl Key* to decrease elevation.
17. Fly East across the main built up area of Hong Kong, until you reach the far side of image.

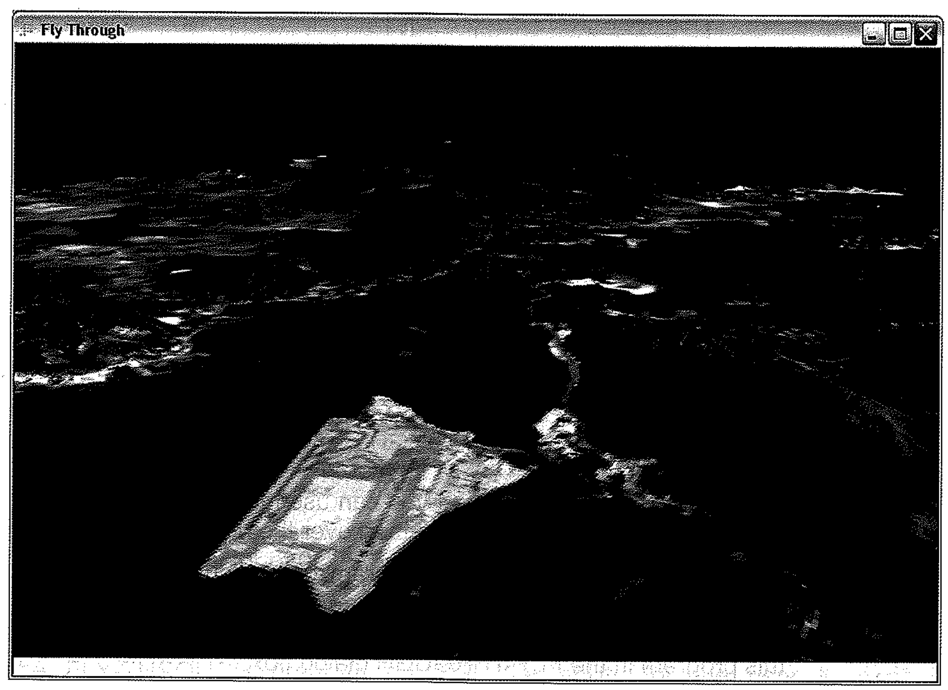


Figure 2.3.3.c A FLY-THROUGH perspective of the Hong Kong airport.

2.3.4 Recording and playing back fly-through movies

Now that you are familiar with the IDRISI FLY-THROUGH module, you are ready to become your own fly-through movie director! There are two broad ways of creating fly-through movies in IDRISI:

1. Save a path, which the IDRISI FLY-THROUGH program can use to replay a fly-through.
2. Record a fly-through as an .AVI file.

The path approach is attractive because it is very simple, and is a small, text file that takes only minimal disk resources. You can also create the text-file manually, thus giving you tremendous control over creating new movies.

On the other hand, the AVI file recording is also very simple. Once you have created the file, you can play it in any AVI player, such as the Windows Media Player. IDRISI also offers an AVI player, called MEDIA VIEWER. Like many uncompressed video files, AVI files are large, which makes them hard to email. Nevertheless, the advantage of creating and AVI file is that once you have created it, you can play it without access to IDRISI.

In this exercise we will record both a FLY-THROUGH path, and an AVI movie. Before we start, we will create a non-standard false color composite as a base image for our movie. Since we have already used the COMPOSITE program for creating false color composites, the instructions below will be slightly briefer than in Section 2.2.4, where the program was introduced. We will also take advantage of a short cut for selecting files. Instead of clicking on the file browse button (a button with "..." on it, we will simply double click in the text box. In addition, by double clicking on a file, we can insert that file name in the text box. This is demonstrated in the next sub-section.

2.3.4.1 Create a non-standard false color composite

Create a non-standard false color composite image

Menu Location: **Display - COMPOSITE**

1. Start the COMPOSITE program from the main menu, or the main icon bar.
2. In the *COMPOSITE* dialog box, double click in the text box for the *Blue image band.* In the resulting pick list window, double click on the file ***etm3***.
3. Double click in the text box for the *Green image band.* In the resulting pick list, double click on ***etm4***.
4. Double click in the text box for the *Red image band.* In the resulting pick list, double click on ***etm5*** .
5. Enter the *Output image* filename in the text box provided: **etm345_fcc**
6. In the section labeled *Output type*, select the radio button for *Create 24 bit composite, with stretched values.*
7. In the Title dialog text box, enter: **Hong Kong ETM+ 345 as BGR**
8. Figure 2.3.4.1.a shows the *COMPOSITE* window with parameters specified.
9. Click *OK* to create and display the false color composite (Figure 2.3.4.1.b).
10. Close the *COMPOSTE* window, once the new image has been created.

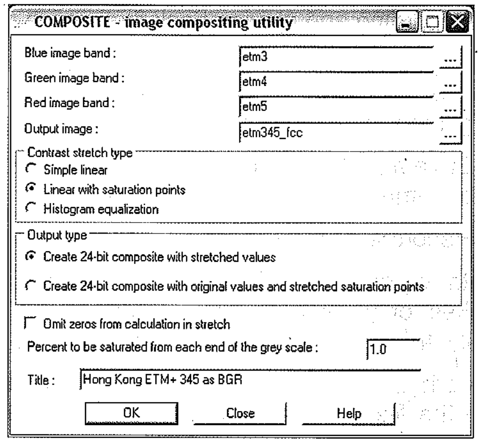


Figure 2.3.4.1.a The *COMPOSITE* window.

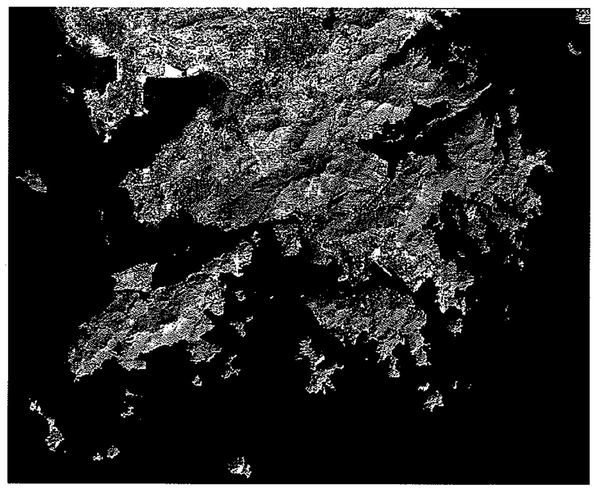


Figure 2.3.4.1.b Non-standard false color composite of Hong Kong.

2.3.4.2 Save a fly-through path

We will now create a new fly-through, following similar procedures to Section 2.3.3. This time, however, we will use the new non-standard false color composite. You might also try different combinations of settings for starting the FLY-THROUGH program, to see what combination works best for your computer. The settings suggested below are not necessarily the optimal settings for you.

Saving a fly-through path

Menu Location: **Display – FLY-THROUGH**

1. Start the FLY-THROUGH program from the menu or the icon bar.
2. In the *FLY-THROUGH* dialog box, double click in the *Surface image* text box. In the resulting pick list, double click on ***hong_kong_dem***
3. Double click in the *Use drape Image* text box, and in the resulting text box, double click on ***etm345_fcc***
4. In the System resource use section, select the radio button for *Low.*

5. In the *Initial velocity* section, select the radio button for *Slow*.
6. Use the slider bar to reduce the *Exaggeration factor* to 50%.
7. Click on *OK*.
8. The FLY-THROUGH viewer will open.
9. Move the cursor over the FLY-THROUGH viewer, and right click with the mouse.
10. A pop-up menu will appear. Note the range of options available, and the associated F-key short cuts (Figure 2.3.4.2.a). Some options are grayed out at this stage, but will become available later on.
11. Select *Smooth pixel.*
12. Right click again in the FLY-THROUGH viewer. This time, in the pop-up menu, select *Record*. (Note that the shortcut key **F8** is an alternative for starting to record the movie.)
13. Immediately fly across the Hong Kong image, following the path across the airport as in Section 2.3.3. Change height, perspective and direction, as you wish.
14. When you are done, right click in the viewer, and select *Stop* from the pop-up menu. (Note that the shortcut key **F11** is an alternative.)
15. Right-click in the image, and from the pop-up menu, select *Save path.*
16. A Save as dialog box will open. In the file name text box, enter **flight1**
17. Click on *Save*.

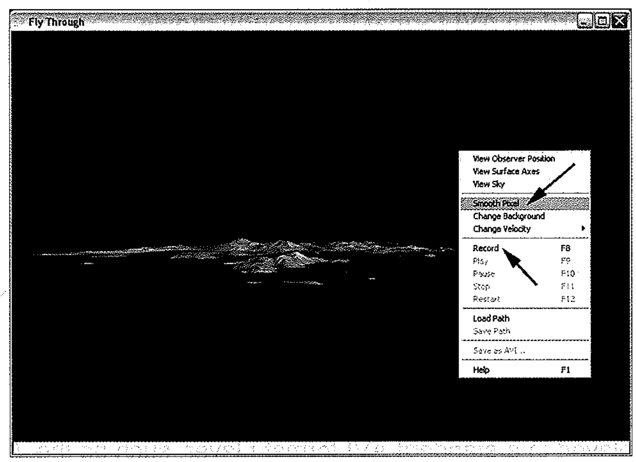


Figure 2.3.4.2.a The FLY-THROUGH pop-up menu.

2.3.4.3 Play a fly-through based on a saved path

The process of saving a path also automatically loads it, and makes it available for subsequent use.

Play a fly-through from a previously recorded path
1. The *FLY-THROUGH* viewer should still be open from the *Save as* step in the previous section (2.3.4.2).

2. Right-click in the *FLY-THROUGH* viewer, and from the pop-up menu, select *Play*. (Note that **F9** is an equivalent command.)
3. This should generate a fly-through based on your previously recorded flight path.

Once the fly-through is completed, you can experiment with playing the pre-recorded flight path. Note that the flight path merely specifies the path, and not the images. Thus, if you were to be starting from scratch, you would need to specify the image, and the drape file. In this case, because we are continuing from the previous step, with the fly-through viewer still displayed, there is no need to specify the images once again.

Play a fly-through from a previously recorded path (cont.)

4. Right-click in the image, and select *Load path* from the pop-up menu.
5. In the subsequent pick list, double click on flight_ex1.csv.
6. Right-click in the image, and select *Play* from the pop-up menu.
7. The pre-recorded fly-through path should now play.

2.3.4.4 Record a fly-through as an AVI file

As a final step in this exercise, we will record an AVI file from the flight path recorded in Section 2.3.4.2, above. It is worth noting that it is not necessary to first save the path; you could instead save your recorded path directly to an AVI. However, there is some advantage in first saving the path, as that allows you to preview the movie, prior to generating the movie.

Record an AVI-format fly-through movie

1. The *FLY-THROUGH* viewer should still be open from the *Save as* step in the previous sections (2.3.4.2 and 2.3.4.3).
2. Right-click in the *FLY-THROUGH* viewer, and from the pop-up menu, select *Save as AVI.*
3. A Save as dialog box will open. In the File name text box, type **flight1.avi**.
4. Click on *Save*.
5. The fly-through will play as it is generated and saved in AVI format.

The file, flight1.avi, can be played in IDRISI, through the main menu: **Display – MEDIA VIEWER**. You would then simply open the file, and the movie starts automatically. It is perhaps more useful, however, to see how this movie can be played in a standard AVI format player, such as the Windows Media Player. We provide an example AVI file, **flight_ex1.avi** on the CD, which you can also play.

Play a previously recorded AVI-format fly-through movie

1. Use the *Windows Explorer* to navigate to your data directory (e.g. *C:\ID Man\chap9*)
2. Find the file ***flight1.avi***
3. Double click on the file. This should automatically start the Windows Media Player, and start playing the movie.
4. Alternatively, you can first open the Windows Media Player from the main Windows Start menu, and then open the ***flight1.avi*** file in that program.

Chapter 3 Importing, Georeferencing, Mosaicking and Exporting Images

In this section we will learn how to use IDRISI to import data, georeference the data to our preferred projection, combine data to cover our area of interest, and export it to a general software-independent format. We will use subsets of the four Landsat images required to cover all of Hong Kong, and will end up with a mosaic similar to the Hong Kong images we explored earlier.

3.1 Importing Data into IDRISI

Data formats are numerous and vary widely from those of government and data providers such as the USGS and SPOT Image to software specific such as ERDAS Imagine and ArcInfo. IDRISI comes with a number of import routines for data that cover many of the most common formats. One important format for raster data is the GeoTIFF format. This is probably the closest we have to an international standard for raster data formats.

3.1.1 GeoTIFF Format

Our original Landsat data from Hong Kong was provided by the vendor in the GeoTIFF format, an image format that is growing in popularity. We will use some of this original data to demonstrate the importing of data into IDRISI. A GeoTIFF format is a special case of the Tagged Image File format (TIFF). TIFF is an image format in the public domain, capable of supporting compression, tiling, and extension to include other metadata. GeoTIFF incorporates geographic metadata, such as coordinates and projection type, using compliant TIFF tags and structures.

Let's import a single band (band 3, corresponding to the red spectrum) from subsets of four different Landsat ETM+ scenes of Hong Kong.

Import data
Menu Location: **File – Import – Desktop Publishing Formats – GEOTIFF/TIFF**
1. This program has no associated icon on the main toolbar, so use the menu as described in the title to this instruction box to start the GEOTIFF/TIFF program. 2. The *GEOTIFF/TIFF* dialog box will open. (Figure 3.1.1.a shows the dialog box with the options selected described below.) 3. Note that dialog box has radio buttons for selecting the options for importing and exporting IDRISI files. For this exercise, the default, which is importing files, is what we want. 4. To select an input file, click on the pick button (…) for the *GeoTIFF file name* text box. 5. A *Pick list* window will open. Double click on the *ID Man\Chap1-4\Raw images* subfolder title.

6. The plus sign next to the title will change to a minus sign, and a list of four file names will be displayed.
7. Click on ***etm_p121r44_b3***.
8. Click on *OK*, to close the *Pick list* window.
9. IDRISI will automatically put the same name as the potential output filename in the *IDRISI image to create* text box. The IDRISI file has a different extension (**.rst**) from that of the GeoTIFF raw data (.tif), so using the same name will not cause any problems.
10. Click on *OK* to start the import.

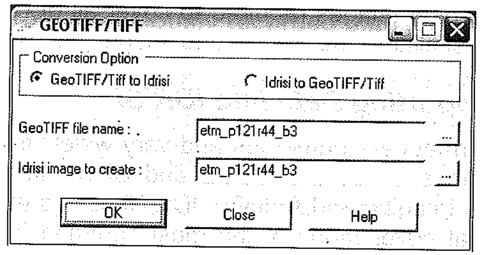


Figure 3.1.1.a The *GEOTIFF/TIFF* dialog box.

The import process is monitored in the status bar. Once the import process finishes, the DISPLAY LAUNCHER is automatically started, and the image is displayed (Figure 3.1.1.b).

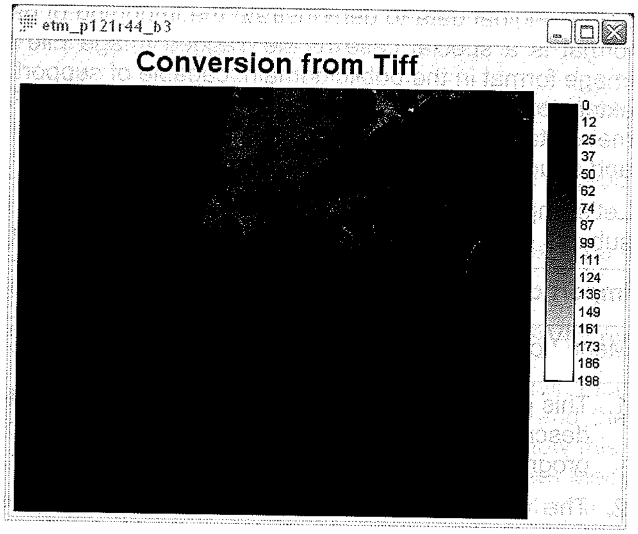


Figure 3.1.1.b. Successful import of a GeoTIFF Landsat band 3 into IDRISI.

The image is displayed as a gray-scaled image as in Figure 3.1.1.b. As you can see, the actual image only covers part of the display. The TIFF file was generated with bounds that correspond with our area of interest over Hong Kong. More often than not, one's area of interest may span beyond a single frame of imagery. In order to cover the area of interest completely, multiple images are required. In IDRISI it will be necessary to create a spatial composite of the overlapping images in one data file to view the complete area of interest.

Let's see what information was embedded in the GeoTIFF file, by viewing the metadata of the new file. Can you remember how? If so, go ahead and open the metadata. If not, just follow the instructions below, which describe how to open the *Layer Properties* window. (You can also access the same information through the IDRISI Explorer.)

Import data (cont.): Viewing image metadata
11. With the newly created image still open in a display viewer, select the *Layer Properties* button in the *Composer* window
12. Click on the *Properties* tab to open the *Properties* pane (Figure 3.1.1.c).

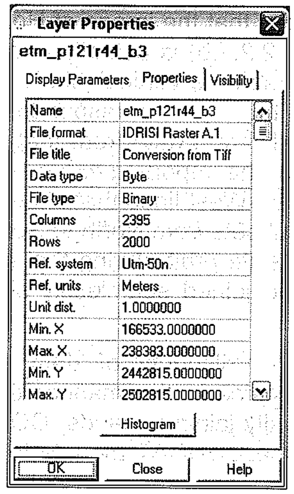


Figure 3.1.1.c Imported data layer properties.

Note that the image comes with projection reference information including the UTM zone (UTM-50n), and the bounding coordinates (minimum and maximum X and Y).

Close the *Layer Properties* window before continuing.

Now import the remaining three GeoTIFF images.

Import data (cont.): Import remaining three images
13. Because of IDRISI's persistent windows, the GEOTIFF/TIFF dialog box should still be open, though you may need to move or minimize the other windows in the IDRISI workspace. If you do not have the option for persistent windows set, or you have closed the dialog box, use the menu to restart this module.
14. As before, click on the pick button (...) for the *GeoTIFF file name* text box, and select the *ID Man\Chap1-4\Raw images* subfolder title in the *Pick list* window.
15. Select the ***etm_p121r45_b3*** file.
16. Note how once again the output file name automatically changes to the same name as this new input file.
17. Click on *OK* to import the file.

18. Once the status bar indicates the file has been imported, find the GEOTIFF/TIFF dialog box again, and this time select ***etm_p122r44_b3*** for the *GeoTIFF file name* (input data).
19. Click on *OK* to import this file.
20. Finally, select ***etm_p122r45_b3*** for the input file, and click on *OK* in the GEOTIFF/TIFF dialog box to import the last data set.

Check the layer properties of each file, as we did for the first image we imported. Note that the path 121 images (i.e. those with *p121* as part of the name) are georeferenced with the UTM50n and the path 122 images (i.e. those with *p122* as part of the file name) are georeferenced with the UTM49n.

Now you can see that the image of Hong Kong that we displayed in the previous section (Figure 2.2.4.b) is actually a mosaic of subsets from four image frames. One can easily see the vertical join line in the original mosaic. The difference in the colors, and thus spectral response, is because the two Western images were acquired on a different date from that of the two Eastern images. However, as we have seen in the importing exercise, the mosaic comprises four images. Can you see any East-West lines that show the remaining joins? The joining of each pair of image subsets from North to South involved data acquired along the same track of the satellite orbit, during the same North to South overpass. Therefore the data can be joined seamlessly since they were acquired under the same conditions.

The similarity or disparity of data spectral qualities during acquisition will influence our choice in the manner that we join data sets. IDRISI offers two modes of spatially joining images, CONCAT and MOSAIC. In the next section, we will utilize the CONCAT module to join the Landsat data with common path acquisition.

3.1.2 Concatenation

Note: The original release of IDRISI Taiga (v. 16.00) has a bug in the CONCAT program. This bug should be fixed in a Service Update release from Clark Labs, available from http://www.clarklabs.org/support/downloads.cfm. Therefore, prior to completing this section (3.1.2) you should first check what version of IDRISI you are running. Use the main IDRISI menu for **Help – About IDRISI 16: The Taiga Edition** to display the program version number (Figure 3.1.2.a). If you are still running 16.00, and an update is available from Clark Labs, you should install the updated program files. Alternatively, you can simply skip this section, and instead complete section 3.1.3, which uses an alternative program, MOSAIC.

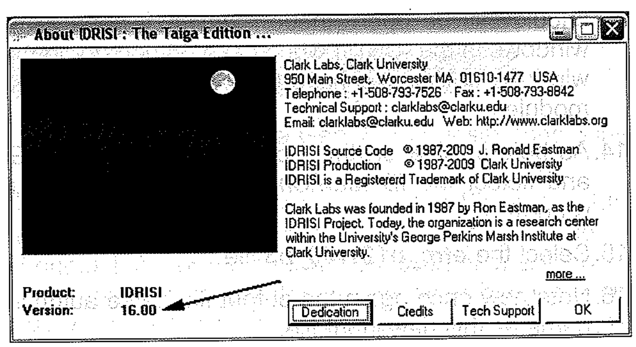


Figure 3.1.2.a The *About IDRISI* window. The version number is indicated by the arrow.

CONCAT is a program module to concatenate, or join, multiple images or vector files to form a larger file. This program may also be used to paste a portion of an image over another image. Some preprocessing may be necessary because all data to be joined must be of the same data type, and have the same spatial resolution (pixel size) and reference system. Since CONCAT does not modify the DN values of the component images, the program works best if the images have comparable spectral characteristics – like along path satellite images – or if the data has been normalized to a standard, for example, elevation data.

Landsat data frames along the same path generally meet the requirement of spectral similarity. Such images are essentially subsets of a single continuous data acquisition along the path of the satellite, and are sub-divided into arbitrary individual images based on the predefined row grid. Thus CONCAT is well-suited to perform the operation of rejoining Landsat images along the same path.

We will use the CONCAT module in IDRISI to join the path images that form each half of the Hong Kong mosaic.

Concatenation of Images with CONCAT

Menu Location: **Reformat – CONCAT**

1. Start the CONCAT program from the main menu.
2. The *CONCAT* dialog box will open.
3. Under *Placement type*, select the radio button for *Automatic placements using reference coordinates.*

The data sets that we will join were originally georeferenced to UTM projection. It is often best to have all data properly georeferenced before joining. This avoids the need for manual placement and also maintains better control of the geographic coordinates of each pixel. When the "Automatic placement" is selected, a new section is created where one can select the images to be joined.

Concatenation of images with CONCAT (cont.)

4. In the *Images to be concatenated* section of the *CONCAT* dialog box, click on the *up* arrow button next to *Number of files*, to set the number of input images to 2 (Figure 3.1.2.b).
5. Click in the first text box under *Filename* (Figure 3.1.2.b). Select the browse files button (…), and the *Pick list* window will open.
6. If necessary, click on the folder name *\ID Man\Chap1-4:* to list the files in the subdirectory. Select the file ***etm_p121r44_b3***, and click *OK*.
7. Click in the second text box, open the Pick list window, select ***etm_p121r45_b3***, and click *OK*.

Now with the appropriate files selected, one last choice is the manner in which we will deal with the overlap regions of the two files. In the *Concatenation Type* section of the *CONCAT* window, one has a choice of either *Opaque*, or *Transparent*. For *Opaque* concatenation, the first image overwrites the second image, regardless of the values in either image. The second option, *Transparent*, operates in the same way, with the exception of pixels in the first image that have a 0 DN value. These 0 DN pixels are assumed to be null values, and are therefore treated as if they were transparent, allowing the DNs of the second image to be retained, and not overwritten.

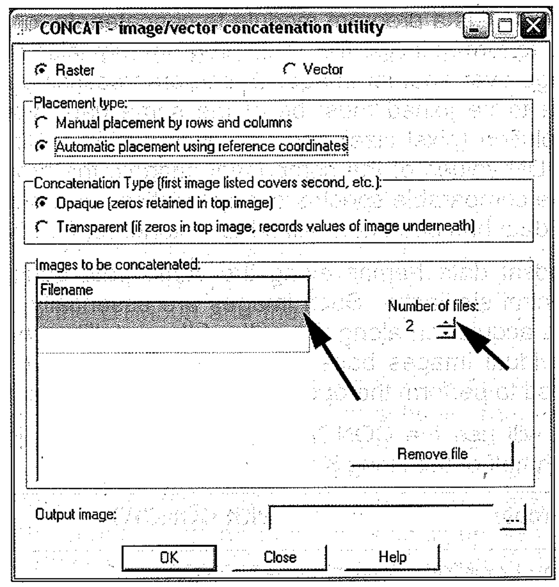


Figure 3.1.2.b *CONCAT* dialog box, with Automatic Placement option selected.

Generally, image data are almost always transparently joined, whereas for other data that may have negative values or have actual zero values (such as elevation data), we typically use the opaque option. However, we do need to be careful, as many images also have 0 DN values that represent real image data values.

We will now choose the transparent option, and then give an appropriate output name for the concatenated image.

Concatenation of images with CONCAT (cont.)
8. In the *Concatenation Type* of the *CONCAT* dialog box, select the radio button for *Transparent*. 9. In the *Output image* textbox, type the name **etm_p121r44-45_b3**. 10. Click on *OK* to run the CONCAT module.

When the program module has completed the process of concatenating these two images, the image will be displayed automatically (Figure 3.1.2.c). The default for IDRISI for a single band display is a color palette. As we discussed in Section 2.2.2, a gray scale palette is more appropriate for single band images. Therefore, we really should use the *Composer* window to change the palette file for this image to *GreyScale*. However, since we are only interested in checking to see that the file has been joined correctly, we will not worry to change the palette file this time. Also, since the eye is more sensitive to color variations than gray tone variations, you could argue this non-standard representation is useful in this instance.

The joined image shows no seam between the two individual subsets (Figure 3.1.2.c). However, while much of Hong Kong is covered by the image, there still remains a significant portion in the West of the image that is blank. We will need the Path 122 images to cover this region. Therefore, we will need to concatenate the path 122 images just as we did for the path 121 images.

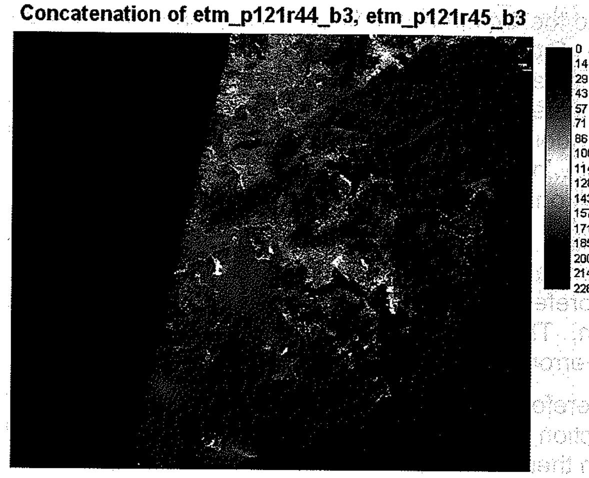


Figure 3.1.2.c Landsat Path 121 images joined by concatenation.

Concatenation of images with CONCAT (cont.)
11. The *CONCAT* dialog box should still be open from the concatenation operation. We will use the same parameters, but simply change the input and output files.
12. Click in the first text box under *Filename*. Select the browse files button (...), and the *Pick list* window will open.
13. Select the file ***etm_p122r44_b3***, and click *OK*.
14. Click in the second text box, open the Pick list window, select ***etm_p122r45_b3***, and click *OK*.
15. In the *Output image* textbox, type the name **etm_p122r44-45_b3**. (Note you can simply edit the file name we used the previous time, which only differed in that the path was specified as *p121*, instead of *p122* this time.)
16. Click on *OK* to run the CONCAT module.

Once again the concatenated image will be displayed automatically, with a color palette applied (Figure 3.1.2.d).

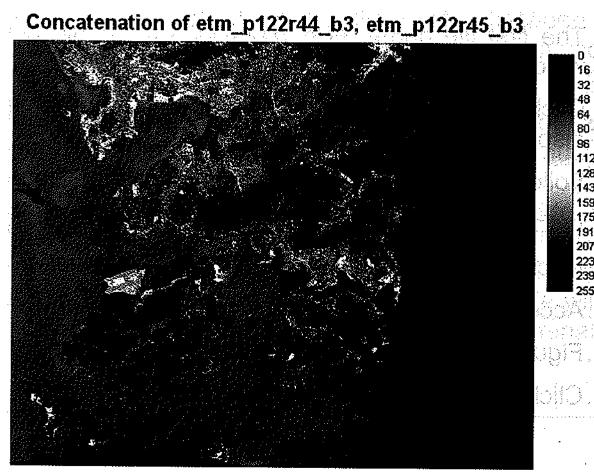


Figure 3.1.2.d Landsat Path 122 images joined by concatenation.

Find the *Composer* window, click on the *Layer Properties* button, and then select the *Properties* tab, to examine the metadata for each of the two newly concatenated images. Notice how when you switch the focus between the two concatenated images (i.e. when you click in each image, bringing it to the front), you don't have to reopen the *Layer Properties* window to see the attributes of that window; the attributes are changed automatically. However, you do have to click on the *Property* tab again, as it is not the default pane.

Notice that the concatenated Landsat path images retain the projection information from the original TIFF files. Thus, the path 122 image is georeferenced to UTM-49n, and the path 121 image is georeferenced to UTM-50n. The different projections are a problem in IDRISI in that you will encounter an error if you try to join these images now, to form one single image.

Therefore, let us learn a bit more about map projections and georeferencing in section 3.2 so that we can transform these images to the same projection, and join them to make a mosaic over Hong Kong.

3.1.3 Concatenation using the MOSAIC program

Note: This section is an alternative to section 3.1.2 above. See the note at the start of section 3.1.2 about the choices between sections 3.1.2 and 3.13. You do not need to complete section 3.1.3 if you have successfully completed section 3.1.2.

The MOSAIC program allows us to join two images that are on the same projection.

Concatenation of Images with MOSAIC
Menu Location: **Image Processing – Restoration - MOSAIC**
1. Start the MOSAIC program from the main menu. 2. The *MOSAIC* dialog box will open. 3. In the Images to be processed pane, click in the white area under Filenames. A *Pick list* button will be displayed (...). 4. Click on the *Pick list* button. 5. A *Pick list* window will open. 6. Select the file ***etm_p121r44_b3***. Click on *OK* to close the *Pick list*. 7. The first file name, ***etm_p121r44_b3***, should now be listed in the *MOSAIC* window. 8. Click in the white space below the first file name. A Pick list button will be displayed. 9. Follow steps 4-7, except this time, chose the file ***etm_p121r45_b3***. 10. In the text box labeled *Output mosaicked image*, type **etm_p121r44-45_b3**. 11. Uncheck the option for *Match image grey level*. 12. Accept all other defaults. 13. Figure 3.1.3.a shows the complete dialog box. 14. Click on *OK* to run the concatenation.

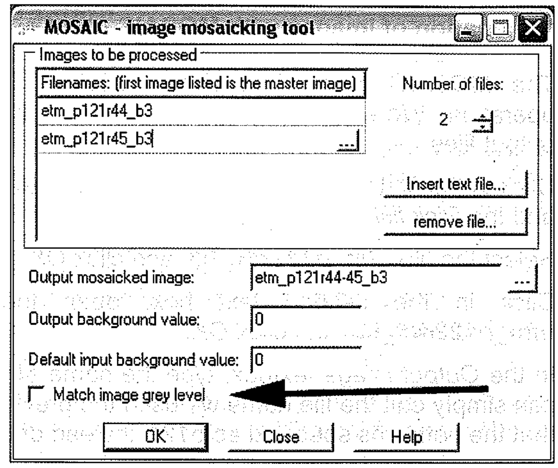


Figure 3.1.3.a. The *MOSAIC* dialog box with parameters chosen for concatenating the two Landsat images. The *Match image grey level check box* should be unchecked.

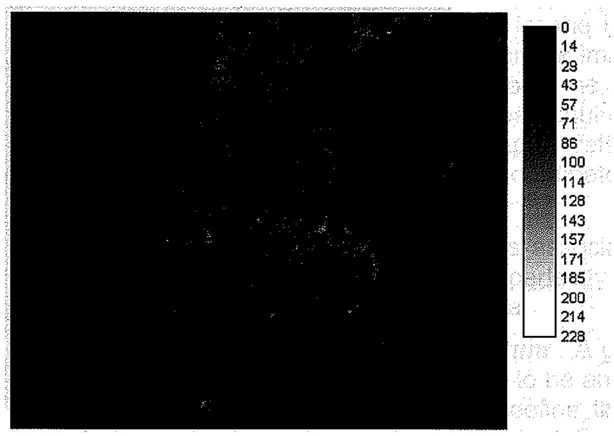


Figure 3.1.3.b Landsat Path 121 images joined by the MOSAIC program.

The MOSAIC program offers a powerful tool for matching the histograms of images to try to compensate for brightness differences between images. In this case, however, we do not need the image matching tool because the DN values are equivalent between the images we are joining.

When the program module has completed the process of concatenating or mosaicking these two images, the image will be displayed automatically with a grey scale palette (Figure 3.1.3.b). The joined image shows no seam between the two individual subsets, confirming that there was no need to match the image brightness values with the *Match image grey level* tool in MOSAIC. Although much of the Hong Kong region is covered by the image, there still remains a significant portion in the West of the image that is blank. We will need the Path 122 images to cover this region. Therefore, we will concatenate the path 122 images just as we did for the path 121 images.

Concatenation of images with MOSAIC (cont.)

15. The *MOSAIC* dialog box should still be open from the concatenation operation. We will use the same parameters, but simply change the input and output files.
16. Click in the first text box under *Filenames*. Select the browse files button (…), and the *Pick list* window will open.
17. Select the file ***etm_p122r44_b3***, and click *OK*.
18. Click in the second text box, open the Pick list window, select ***etm_p122r45_b3***, and click *OK*.
19. In the *Output image* textbox, type the name **etm_p122r44-45_b3**. (Note you can simply edit the file name we used the previous time, which only differed in that the path was specified as *p121*, instead of *p122* this time.)
20. Click on *OK* to run the CONCAT module.

Once again the concatenated image will be displayed automatically (Figure 3.1.3.c).

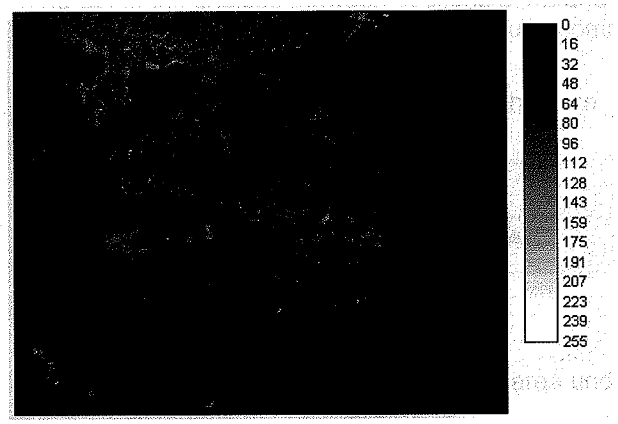


Figure 3.1.3.c Landsat Path 122 images joined using the MOSAIC program.

Find the *Composer* window, click on the *Layer Properties* button, and then select the *Properties* tab, to examine the metadata for each of the two newly concatenated images. Notice how when you switch the focus between the two concatenated images (i.e. when you click in each image, bringing it to the front), you don't have to reopen the *Layer Properties* window to see the attributes of that window; the attributes are changed automatically. However, you do have to click on the *Property* tab again, as it is not the default pane.

Notice from the *Layer Properties* window that the mosaicked Landsat path images retain the projection information from the original TIFF files. Thus, the path 122 image is georeferenced to UTM-49n, and the path 121 image is georeferenced to UTM-50n. The different projections are a problem in IDRISI in that you will encounter an error if you try to join these images now, to form one single image.

Therefore, let us learn a bit more about map projections and georeferencing in section 3.2 so that we can transform these images to the same projection, and join them to make a mosaic over Hong Kong.

3.2 Georeferencing

3.2.1 Introduction to Map Projections

Georeferencing is an important, but rather technical topic. Fortunately, much of the complexity of the subject is hidden from us, because IDRISI will take care of the mathematical specifics for us. However, it is necessary for the user to have a qualitative understanding of the principles involved. In the following section we provide a short and highly abbreviated overview of the topic. The reader is encouraged to read further on the topic. For example, the IDRISI manual has an excellent section on georeferencing (Eastman 2009). In addition, most of the texts listed in Table 1.1.2.a have extensive discussions on georeferencing and the issues involved in resampling onto a projection.

A ***map projection*** is a mathematical procedure which converts between a spherical or ellipsoidal representation of the earth, and a flat planar map surface. Although many projections have been designed over the centuries, just a few are widely used today. The process of geographic referencing of images is known by many names, such as, georeferencing, geocoding, georectification, but they all refer to a process of transforming the image data from a simple matrix reference system (row and column) to a geographic map reference system.

The geographic referencing of individual images allows for the identification of the relative distance and arrangement between features on the image, as well as both the absolute location of features in the imagery, and the comparison of features over time through the overlay of multiple images acquired on different dates. The importance of having an accurate geographic reference system linked to the imagery cannot be overstated. A common coordinate system is the essential element of any GIS database.

No matter how sophisticated the mathematical equations associated with each projection, the Earth's surface can never be converted perfectly to a flat map. There is always some distortion, great or small, in each map.

An important attribute of a projection is the ***geodetic datum***. A geodetic datum is the representation of the earth's shape, usually chosen to be an ellipsoid. The geodetic datum therefore includes the parameters that define the ellipsoid, as well as the associated coordinate system origin and orientation. A geodetic datum can be a global datum if it is defined by the center of the Earth, as is the case for WGS84. Otherwise, a local datum defines a specific origin position and azimuth relative to a specific location on the ellipsoid. By locating a datum near one's area of interest, the error associated with projecting onto a flat surface is minimized.

Another aspect of transforming your data to a projection is the decision of how to ***resample*** or ***interpolate*** your data to fit the projection grid. Resampling is necessary, because the new grid will have center points for each pixel that differ from the old grid. There are a number of different strategies for estimating the pixel DN values at the new pixel location, including nearest neighbor and bilinear interpolation.

- ***Nearest neighbor*** is the simplest resampling method. This approach assumes the best estimate of the new pixel value is simply the original DN value of the closest pixel from the input image.
- ***Bilinear interpolation*** uses the distance-weighted average of the values of the four nearest cells in the input image for the new pixel value.

Choose nearest neighbor whenever it is critical that original pixel values remain unchanged. However, because original pixel values are unchanged, nearest neighbor resampling tends to be very blocky in appearance. Choose bilinear interpolation where averaging seems appropriate for better visual quality. Bear in mind, however, that smoothing will tend to blur the data somewhat.

IDRISI has two modules that may be used for geographic referencing. The first is the module PROJECT, which automatically transforms data from one known geographic projection to another. The second module is RESAMPLE, which allows for the generation of a polynomial equation based on control points picked by the user. Thus, if the data are already georeferenced, but you need to convert the image to another projection, you would use PROJECT. On the other hand, if your data are not georeferenced, you would use RESAMPLE to convert the image to a projection. It is important to note that RESAMPLE requires a georeferenced map or image of the same area to serve as a base map for developing the transformation equation.

3.2.2 Converting Between Projections Using IDRISI-Defined Projections

As discussed above, PROJECT transforms raster images from one known geographic reference system to another known system. IDRISI uses *Reference System Parameter Files* to identify the complete characteristics of a projection, including the datum, origin, units, etc. Thus, to apply the PROJECT module, we will need a *Reference System Parameter File* for both the input and output reference systems.

The IDRISI on-line help gives the source of the algorithms used in the PROJECT module. The projection transformations are based on the formulas of Snyder (1987). Datum transformations are accomplished using the Molodensky transform process, which assumes that the axes of the source and target coordinates are parallel. In the case of conversions between NAD27 and NAD83 within the continental US, IDRISI uses the US National Geodetic Survey's NADCON procedure.

IDRISI incorporates over 500 *Reference System Parameter Files* for a wide variety of projections and datums. These include files for a geodetic system using latitude and longitude and the WGS84 datum, the UTM system (one each for the 60 UTM zones, for both the northern and southern hemispheres) using the WGS84 datum, and, for the United States, the UTM system using NAD27 and NAD83. IDRISI also includes all US State Plane Coordinate (SPC) systems based on the Lambert Conformal Conic and Transverse Mercator projections.

Furthermore, IDRISI allows for the creation of geographic systems by the user, by developing new *Reference System Parameter Files*, which are given the extension ***.ref***. Often the best way to create a new *.ref* file is to copy an existing one, and then edit it. The user will need to change the parameters necessary for the new system, and save the file with a new name.

Let us try using the PROJECT module to create maps of our Hong Kong image in different projections. The original Hong Kong images were provided in one of the most common map projections in use today, the Universal Transverse Mercator (UTM) projection. We will transform these images from this projection to a *Geographic* projection that will use latitude and longitude degrees as its coordinates.

Converting between projections using PROJECT
Menu Location: **Reformat - PROJECT**
1. Use the main menu to start the PROJECT module. 2. The *PROJECT* dialog box will open (Figure 3.2.2.a).

3. Use the radio button to specify that the *Type of file to be transformed* is *raster*.
4. Click on the browse button (…) next to the text box for specifying the *Input file name*, and select the ***etm1*** file from the *Pick list* window.
5. Click on *OK* to close the input file *Pick list*.
6. Note that PROJECT will examine the input raster file's documentation file to determine the reference system in use, and will automatically enter the name of the reference system as it appears in the documentation file in the *Input reference system* text box (*utm-49n*, in this case).
7. Enter a new name for the transformed file in the *Output file name* text box: **etm1_latlong**
8. We will now choose the reference file that defines the grid referencing system for the new output file. To find the list of available reference files, start by clicking on the browse button (…) next to the text box for *Reference file for output result*.
9. The *Pick list* window will open. Double click on *IDRISI Taiga/Georef* to see the files in that folder.
10. Scroll down list and select ***latlong***
11. Click the *OK* button to return to the *PROJECT* dialog box.
12. For the *Resample type*, we will use the default option of *Nearest Neighbor*.
13. Likewise, for the *Background value*, we will use the default of *0*.

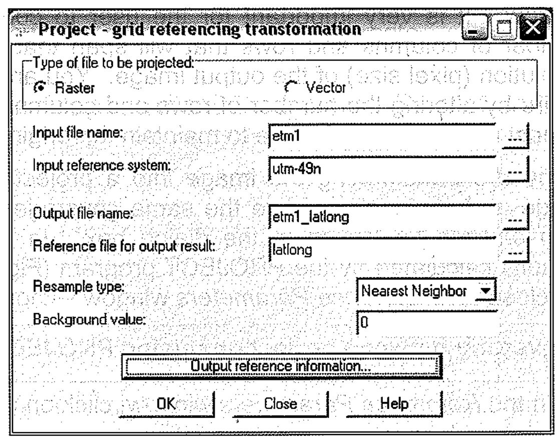


Figure 3.2.2.a The *PROJECT* dialog box with parameters selected.

The background value is the value that will be used for all new pixel locations that lie outside the bounds of the old image. Because a slight rotation of the image is common in most projection changes, there will likely be regions in the new image for which we don't have data from the old image. Thus, specifying a value for such locations is very important.

Converting between projections using PROJECT (cont.)

14. Click on the *Output reference information…* button.
15. The *Reference Parameters* window will open (Figure 3.2.2.b).

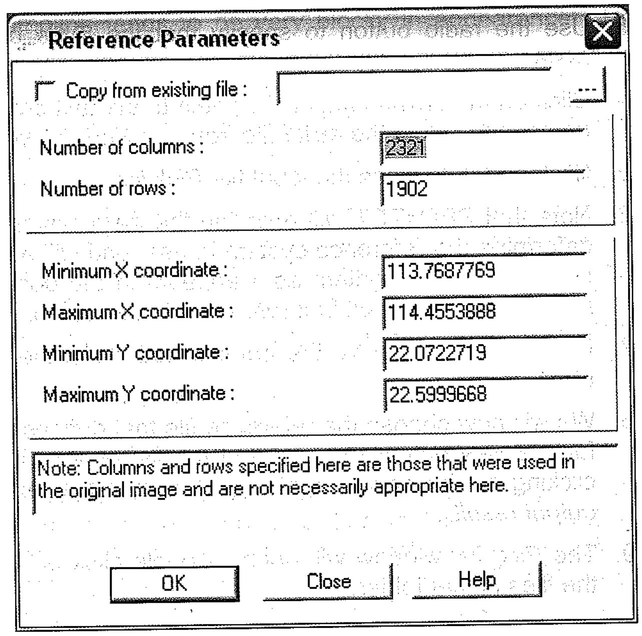


Figure 3.2.2.b The *Reference Parameters* window.

The PROJECT operation automatically calculates the output boundaries, given the user-selected reference system or the unit distance of the output image. The calculated values are inserted automatically in the *Reference Parameters* window. It is very important for the user to consider carefully the calculated number of columns and rows that will span that region, as this will define the resolution (pixel size) of the output image. You are free to set any resolution you desire by altering the number of rows and columns for the output data; however, in most cases, it is preferable to maintain the original resolution of the data.

If you are transforming the image into a projection already in use by another image and you wish to have the same coverage and resolution, use the *Copy from existing file* option in the dialog box. In our case, we will choose the defaults calculated by the PROJECT program (Figure 3.2.2.a), and therefore we will close the *Reference Parameters* window without changing any parameters.

Converting between projections using PROJECT (cont.)

16. In the *Reference Parameters* window, click on OK to close the window.
17. In the *PROJECT* window, click the *OK* button to start the resampling operation.

The resampling to create the new image will take some time, and therefore it may take a few minutes to generate the new output image. IDRISI will automatically display the new image with a color palette applied (Figure 3.2.2.c). In this case, the color palette shows the rotation very clearly, because the background pixels, which lie outside the boundaries of the original image, are shown in black.

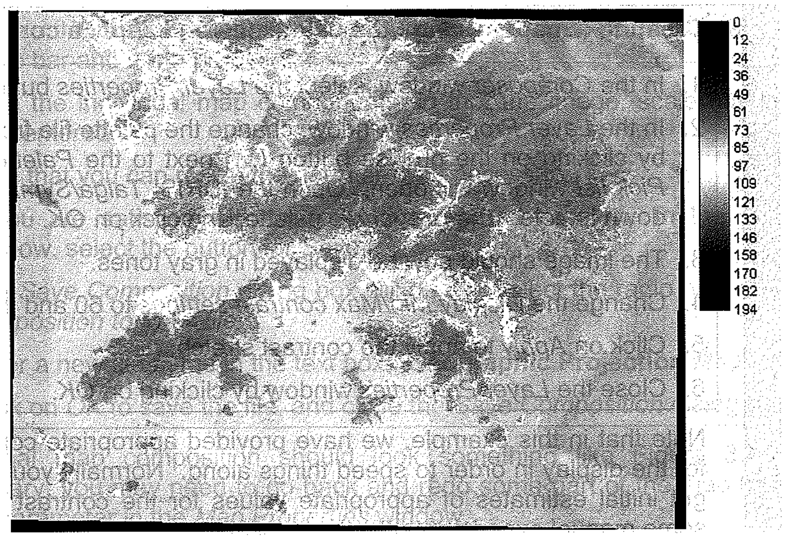


Figure 3.2.2.c The Landsat image with a geographic projection, and the color palette automatically applied.

This might be a good time to review our skills in modifying a display and creating a map. In the description below, only brief instructions will be provided, since this material has already been covered in Section *2.2.5,* on *Map Annotation*. If you find the instructions below too brief, you will need to review the detailed instructions in *Section 2.2.5*.

Figure 3.2.2.d shows the map we are trying to create.

Hong Kong Landsat Geographic Projection Map

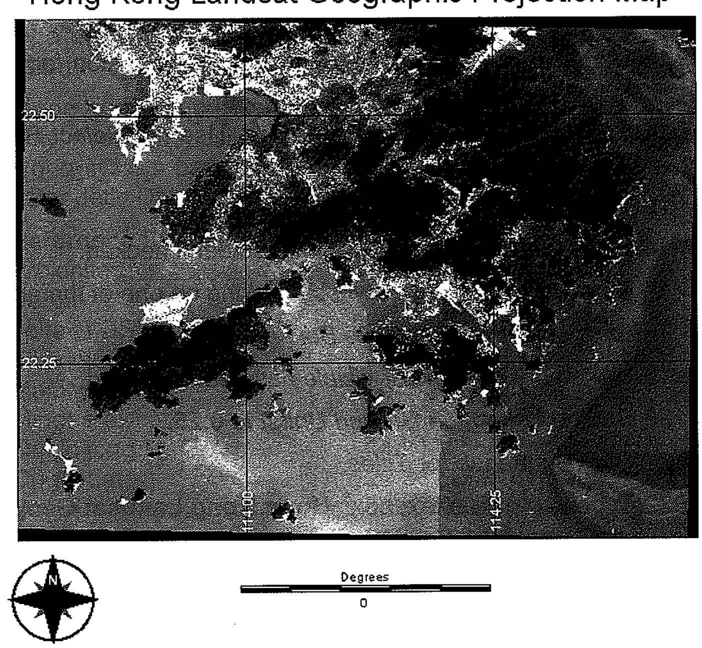


Figure 3.2.2.d Hong Kong Landsat image map using the *Geographic* projection.

Creating a map: Change the palette file and apply a contrast stretch

1. In the *Composer* window, select the *Layer Properties* button.
2. In the *Layer Properties* window, change the palette file from the default *quant*, by clicking on the browse button (…) next to the *Palette file* text box. The *Pick list* window will open. Open the IDRISI *Taiga/Symbols* folder, and scroll down to select the ***greyscale*** palette, and click on *OK*.
3. The image should now be displayed in gray tones.
4. Change the *Display Min/Max contrast settings* to 60 and 100.
5. Click on *Apply* to apply the contrast stretch.
6. Close the *Layer Properties* window by clicking on *OK*.

Note that in this example, we have provided appropriate contrast stretch values for the display in order to speed things along. Normally you would run HISTO to get initial estimates of appropriate values for the contrast stretch, followed by some manual experimentation if necessary.

The image should now have a more useful contrast stretch applied, and we can work on the map presentation itself.

Creating a map (cont.): Specify and apply the map annotation

7. In the *Composer* window, click on *Map Properties.*
8. In the *Map Properties* window, select the tab for *Legends*.
9. Uncheck the box for *Visible* (to remove the legend from the display).
10. Select the tab for *Map Grid*.
11. Click on the *Map Grid Bounds* radio button for *Current View*.
12. Set both *Increment X* and *Increment Y* to **0.25**.
13. Under *Text Options*, make sure the radio button for *Number inside* has been selected.
14. Set *X axis orientation* to *Vertical*. Use the *Select Font* button to change the font color to white.
15. Select the tab for *North Arrow*.
16. Make sure the box for *visible* has been checked.
17. Select a *North Arrow* style by clicking on one of the arrow icons.
18. Click on the tab for *Scale Bar.*
19. Make sure the box for *visible* has been checked.
20. Set the *Length (in Ground Units)* to **0.25**.
21. Click on the tab for *Titles.*
22. Type in the *Title* text box: **Hong Kong Landsat Geographic Projection Map**
23. Select the *Background* tab.
24. Change the *Map Window Background Color* box to white, by double clicking in the box, and selecting the appropriate color chip.
25. Check the box for *Assign map window background color to all map components*.
26. Click OK to close the *Map Properties* window.

27. Resize the Display window, so that you have room below the image for the scale bar and north arrow.
28. Drag the individual map components so that the image, scale bar, and title are centered.
29. Note that you can resize the north arrow if necessary.
30. If you are satisfied with the map, you should save it: In the *Composer* window, select the button for *Save.*
31. The *Save Composition* dialog box will open. Select the radio button for *Save composition to MAP file.*
32. Enter a new file name in the text box: **Geographic Projection Map**
33. Click on *OK* to save the file, and close the *Save Composition* dialog box.

The final map composition should look something like Figure 3.2.2.d. If necessary, you may need to go back and redo some part of the map by altering some parameter in the *Map Properties* window.

Since you have saved the map composition, you can close the *DISPLAY* window.

3.2.3 Converting Between Projections Using User-Defined Projections

Although IDRISI supplies more than 500 specific map projections with specific datum and coordinate origins, occasionally you might need to use a projection that is not included with the software. Fortunately, IDRISI does allow one to specify a new projection, provided that the new projection is a derivative of an existing IDRISI projection, and one knows the datum shift with regards to the datum, spheroid and geographic origins of the IDRISI-supplied projection.

In this exercise, we will create a new projection *reference system parameter file* for the **Hong Kong 1980 grid**. The file will contain all the necessary data for calculating the transformation from a projection based on the WGS84 datum to the HK80 datum.

The Hong Kong grid was created and used by the government of Hong Kong to provide highly accurate positions within that region. HK1980 Grid is a local rectangular grid system based on the Transverse Mercator projection and Hong Kong 1980 Geodetic Datum. The details of the Hong Kong 1980 grid are:

Reference System:	**Hong Kong 1980 Grid System**
Projection:	Transverse Mercator
Datum:	Hong Kong 1980
delta WGS84:	162.619 -276.959 -161.764
Ellipsoid:	International 1924
Major s-ax:	6378388 meters
Minor s-ax	6356911.946 meters
Origin long:	114.17855 degrees
Origin Lat:	22.3121333 degrees
Origin X (False easting):	836694.05 meters
Origin Y (False northing):	819069.8 meters
Scale factor:	1.00
Units:	meters
Parameters:	0

We will use the IDRISI text editor to modify an existing *reference system parameter file* to create the Hong Kong 1980 grid file.

Modifying a *Reference System Parameter File*

Menu Location: **Data Entry – Edit**

1. Use the main menu or icon bar to open the *IDRISI TEXT EDITOR* window.
2. In the *IDRISI TEXT EDITOR* window, use the menu to select *File - Open…*
3. The *OPEN FILE* window will open.
4. Browse to the main IDRISI program directory (for example, *C:\Program Files\IDRISI Taiga,* or possibly *C:\IDRISI Taiga*). Within the *IDRISI Taiga* folder, double click on the *Georef* subfolder, to list the files within that directory.
5. Select the *LATLONG.REF* file.
6. Click on *OPEN.*
7. In the *IDRISI TEXT EDITOR* window, use the menu to select *File – Save as…*
8. Once again navigate to the *IDRISI Taiga\georef* folder, and then in the *File name* text box enter **HK80**.
9. Use the information provided about the Hong Kong Grid to change the details of the file to the new projection. Use the original file to guide you as to the appropriate format. For example, observe that the *major s-ax and minor s-ax* fields do not include the designation of the units (meters), only the number. The units are specified later in the file.
10. When you are done, use the *IDRISI TEXT EDITOR* menu to select *File – Save.*

Now that the new projection file has been developed, the procedure to apply the Hong Kong 1980 projection in a REPROJECT operation will be very similar to what we did before in the previous section (Section 3.2.2) using the IDRISI-supplied projection. Therefore, the instructions will be slightly briefer in this section, as it is assumed that you are familiar with the module steps.

Applying a user-specified projection

Menu Location: **Reformat - PROJECT**

1. Use the main menu to start the PROJECT module.
2. In the *PROJECT* dialog box, use the radio button to specify that the *Type of file to be transformed* is *raster*.
3. Click on the browse button (…) next to the text box for specifying the *Input file name*, and select the ***etm1*** file from the *Pick list* window.
4. Click on *OK* to close the *Pick list*.
5. Enter a new name for the transformed file in the *Output file name* text box: **etm1_hk80**.
6. Specify the *Reference file for output result* by clicking on the browse button (…) next to the text box. In the resulting *Pick list* window, double click on *IDRISI Taiga/Georef* to see the files in that folder.
7. Scroll down list and select ***HK80***.
8. Click the *OK* button to return to the *PROJECT* dialog box.

9. Note that the *PROJECT* dialog box *OK* button is grayed out. IDRISI forces us to check the output parameters. Therefore, click on the button for *Output reference information*.
10. The *Reference Parameters* dialog box will open. Click on *OK* in this dialog box to close it.
11. The *PROJECT* dialog box *OK* button will now be enabled. Click on the button to start the resampling operation.

The final image is now projected with the coordinates consistent with topographic maps published by the government of Hong Kong. When done processing, IDRISI will automatically display the image with a color palette applied. The image should look very similar to the image created with the geographic projection (Figure 3.2.2.c).

See if you can, on your own, create a map display, as we did for the geographic coordinate projection (Figure 3.2.2.d). You can follow the instructions at the end of Section 3.2.2 for creating the map, if you need to be reminded of the steps. However, because this map has a different projection, in the *Map Grid* pane, you will need to choose values of **20000** for the *Increment X* and *Increment Y*, with **0** decimal places. Also, in the Scale Bar pane, you will need to choose **20000** for the *Length (in Ground Units)* parameter. Don't forget to save your map composition when you are done, through the *Save* button on the *Composer* window. The end results should look something like Figure 3.2.3.a.

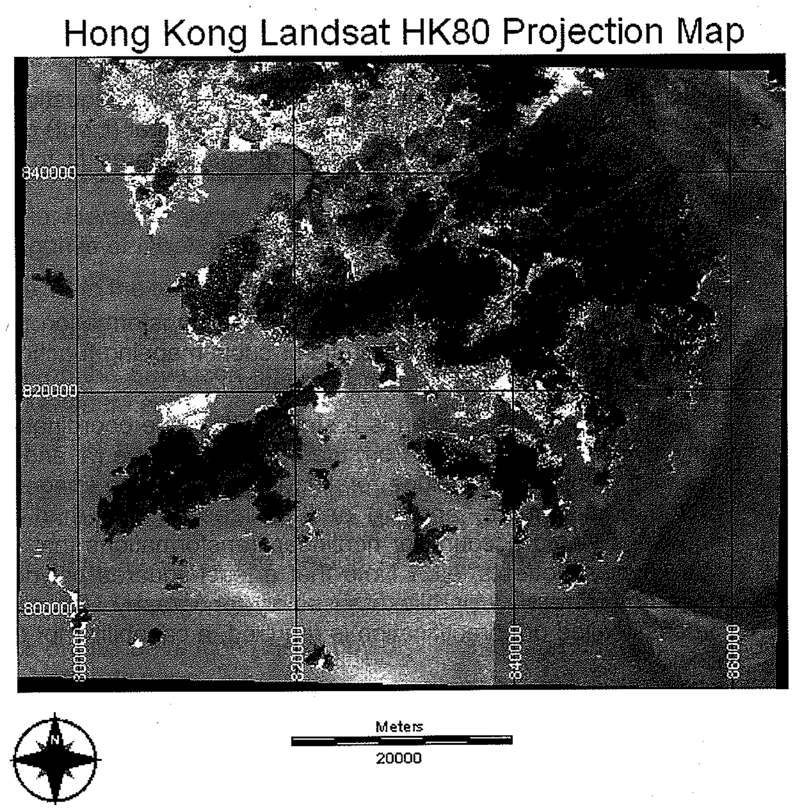


Figure 3.2.3.a Hong Kong Landsat image map using Hong Kong 1980 national grid projection.

3.2.4 Resample - Transformations with control points

So far we have studied the reprojecting of an image based on the mathematical formulae of the projections themselves, using the PROJECT module. Reprojecting implies the image is already on a map projection, and that we would like to change that projection. However, in many cases the original image is not projected on a formal map projection, but is simply organized based on the view of the sensor at the time of acquisition.

Sometimes, even if the image is already on a projection, we may find that the georeferencing was only approximate, and we need to do a more precise registration of the image. For example, when we do change detection analysis in Chapter 7, in which we will identify and map changes on the landscape, it is essential that we have a very precise co-registration between two images. Likewise, when we mosaic two images, it is very important that the images match well, so there is no obvious misregistration at the join between the two images.

In the circumstances described above, we need to develop an empirical georeferencing, where we calculate our own formula for the relationship for the transformation from the original image orientation to the map projection. In IDRISI, this is done with the RESAMPLE module.

RESAMPLE performs a matrix transformation on a raster file using an equation determined by a series of user-defined **ground control points**. These ground control points are points on both images that correspond to identical ground features. The feature could be a road intersection, or a bridge, or a natural feature like a stream confluence. The amount of error of the transformation can then be regulated by the accurate placement of control points, as well as the order of the polynomial equations.

Using these control points, a set of polynomial equations is developed to describe the transformation of data from its original (input) grid to a new (output) one. Often this is accomplished using least-squares fit to a polynomial of the form:

$$X = a_0 + a_1x' + a_2y' + a_3x'y' + a_4x'^2 + a_5y'^2 \ldots + \varepsilon_x$$

$$Y = b_0 + b_1x' + b_2y' + b_3x'y' + b_4x'^2 + b_5y'^2 \ldots + \varepsilon_y$$

where ε_x and ε_y are residual errors after the transformation. IDRISI includes the option of using the linear, quadratic or cubic mapping functions (the first, second and third orders of the polynomial equation).

The simplest transformation is a static shift of the coordinate system and would only involve the first terms from the equations above (a_0 and b_0). A simple linear transformation would include rotating and shifting the image (the next two terms of the equations, a_2 and b_2) and the second and third order terms of the equations would account for nonlinear transformations that would correct skew, roll, keystone effects, etc. Note that a least-squares polynomial fit cannot and does not correct for parallax caused by topography. To correct for parallax, a process called orthorectification is required, a capability not currently available in IDRISI.

One characteristic of the RESAMPLE operation is that the program does not automatically calculate the output boundaries, reference system or the unit distance of the output image. It is very important for the user to know the minimum and maximum X and Y coordinates of the final output image as well as the number of columns and rows that will span that region. Note that the span of the X and Y coordinates and the number of columns and rows define the resolution of the output image. You are free to set any resolution you desire, however, in most cases it is preferable to maintain the original resolution of the data. Fortunately, one can also copy the reference parameters from an existing file, just as we did in the PROJECT module.

Now that we have some background in the georeferencing of images of an unknown projection, we will apply the IDRISI RESAMPLE procedure to the Hong Kong Landsat ETM+ images. As we have seen already, these images were provided by the vendor in two different projections; the images of path 121 are referenced to UTM 50 and the path 122 images are referenced to UTM 49. We will use the RESAMPLE module to provide an accurate transformation of the ***etm_p121r44-45_b3*** image to the UTM-49n projection. Although we could also use the PROJECT module in this case, because the images are already on a projection, the RESAMPLE approach is perhaps the best choice because the georeferencing was not a precision correction, but only an approximate correction. Thus, PROJECT will not be able to align the images from two different satellite orbit paths with the accuracy we would like.

Before we begin, we need to set the display minimum and maximum DN values in the metadata of the images we will use, so that the images are optimally stretched in the display process. If this preparatory step is confusing, you may need to review Section 2.2.3.

Specify metada values for an optimal display stretch

Menu location: **File – IDRISI EXPLORER**

1. Open the *IDRISI EXPLORER* window using the main menu or icon bar.
2. In the *IDRISI EXPLORER* window, select the *Files* tab.
3. If the files are not listed in the *Files* pane, double click on the directory name to display the files.
4. In the *Files* pane, click on the ***etm_p121r44-45_b3.rst*** image.
5. In the *Metadata* pane below the file listing, drag the slider down until the categories of *Display min* and *Display max* are visible.
6. Type **18** in the text box to the right of *Display min* field.
7. Type **100** in the text box to the right of *Display max* field.
8. Click on the *Save* icon (the floppy disk icon) in the bottom left hand corner of the *Metadata* pane.
9. In the *Files* pane, click on the ***etm_p122r44-45_b3.rst*** image.
10. In the *Metadata* pane, once again drag the slider down until the categories of *Display min* and *Display max* are visible.
11. Type **10** in the text box to the right of *Display min* field.
12. Type **120** in the text box to the right of *Display max* field.
13. Click on the *Save* icon (the floppy disk icon) in the bottom left hand corner of the *Metadata* pane.
14. Close the *IDRISI EXPLORER* by clicking on the red *X* at the top right of the window.

In the instructions above, we have specified optimal display minimum and maximum values to save time. Be aware, however, that normally you would identify the appropriate values by first running the HISTO program to get approximate values, and then selecting values by interactively modifying the values in the *Layer Properties* window, which in turn is accessed through the *Composer* Window.

Georeferencing using RESAMPLE

Menu Location: Image Processing – Restoration – RESAMPLE

1. Use the menu to start the RESAMPLE program.
2. The *RESAMPLE* window will open (Figure 3.2.4.a).

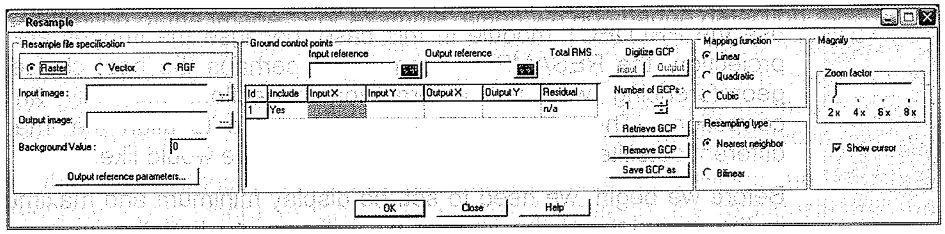


Figure 3.2.4.a The *RESAMPLE* window.

Let's take a moment and examine the *RESAMPLE* window. The window comprises five major sections:

- The *Resample file specification* section defines the input and output file names, as well as the output bounds and resolution.
- The *Ground control points* section allows an interactive designation of the control points by providing displays of the reference image and the image to be transformed.
- *Mapping function* determines the type of equations used in the transformation.
- *Resampling type* gives the option of a bilinear resampling, which involves a smoothing of the data during the transformation, or nearest neighbor resampling, which retains the spectral integrity of the original pixels.
- The *Magnify* section specifies the amount of zoom for the displayed images.

Let's now fill in the *Resample file specification* section.

Georeferencing using RESAMPLE (cont.): *Resample file specification*

3. In the *Resample file specification* section of the RESAMPLE window, click on the browse button (...) to right of *Input Image* text box.
4. From the *Pick list*, select ***etm_p121r44-45_b3***, which you created in Section 3.1 from the two original ETM+ path 121 images.
5. Click *OK* to close the *Pick list.*
6. In the *Output Image* text box enter **etm_p121r44-45_b3_UTM49**.
7. Accept the default value of *0* to use as the *Background Value.*
8. Click on the button for *Output reference parameters...*
9. In the *Reference Parameters* dialog box, click in the check box for *Copy from existing file.*

10. Click on the browse button (...) to the right of the text box for *Copy from existing file.*
11. Select file ***etm_p122r44-45_b3*** from the *Pick list* window, and then click on the *OK* button to close the *Pick list.*
12. Note that the fields in the *Reference Parameters* window were populated with information obtained from the ***etm_p122r44-45_b3*** metadata file (Figure 3.2.4.b).

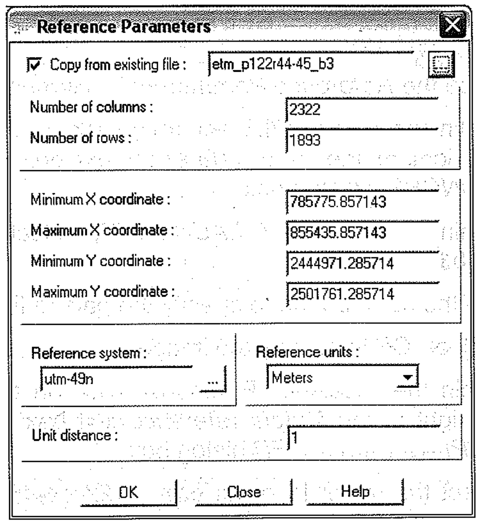


Figure 3.2.4.b The Reference parameters window with parameters specified from an existing file.

The transformed path 121 image generated by the RESAMPLE program will have the same projection, bounds and resolution as the path 122 image. This will facilitate mosaicking the path 121 and 122 images.

We will now begin to choose our ground control points (GCPs). The GCPs are important because they are used to determine the polynomial equation developed by RESAMPLE and subsequently used in the transformation. The geographic coordinates of the GCPs may be determined by using a GPS system at the locations themselves (hence the name "ground control points"), or by locating the exact same feature in second raster file that has a known and accurate geographic reference system.

For our Hong Kong example, we will use the latter option, that of obtaining the location from another image, in this case the satellite image from the adjacent path. This may seem a bit surprising, since we earlier said that we would use RESAMPLE precisely because the georeferencing for these images is only approximate. Therefore, this would seem to contradict the idea that we can use the adjacent path's image for GCPs. However, in this case, our concern is not absolute georeferencing, but rather obtaining a high quality relative georeferencing of the one image to the other, so that they can be mosaicked without an obvious misalignment at the join.

There are two methods for entering the locations of control points in the *RESAMPLE* dialog box: by image matching or by manually keying in the data. With both methods, a correspondence file is created that records the input and output coordinates for each GCP. Ground control points are entered into the grid on the form. Each line of the grid has text boxes for four numbers. The first two text boxes are used to specify the input X and Y coordinates of a point in the input reference system. The last two text boxes are used to specify the coordinates of that same point in the output reference system.

If points are being digitized for both the input and output reference images, after three control points are entered, subsequent output points will be interpolated linearly, and automatically placed on the output reference grid.

To enter GCPs automatically from image map to image we need to display both the input and output reference files.

Georeferencing using RESAMPLE (cont.): Specifying the reference files

13. Close the *Reference Parameters* by clicking on *OK.*
14. Within the RESAMPLE window, click on the DISPLAY LAUNCHER icon to the right of the *Input reference* text box. This will bring up the *DISPLAY LAUNCHER* dialog box.
15. Within the *DISPLAY LAUNCHER*, select the raster layer ***etm_p121r44-45_b3***.
16. Use the radio button to specify the palette file as *GreyScale*.
17. Click on *OK* to display the image.
18. Within the RESAMPLE window, click on the DISPLAY LAUNCHER icon to the right of the *Output reference* text box. This will once again bring up the *DISPLAY LAUNCHER* dialog box.
19. Select the raster layer as ***etm_p122r44-45_b3***, the palette file as *GreySale*, and click on *OK*.

The displayed images are now linked to the RESAMPLE module for automatic input of locations into the record of GCP locations. However, the displays themselves are not linked to one another, so take care in zooming to create similar zoomed displays.

A potentially useful feature in the RESAMPLE window is the ability to display a zoom window that magnifies the location of your cursor within the main image display. The *Magnify* window gives a detailed view of a portion of the main display, to help locate your control point more precisely. It is very important that each control point be located within one pixel of the correct location, and so the *Magnify* window is very important for obtaining a satisfactory transformation.

We will now modify the zoom window to aid us in placing our ground control points.

Georeferencing using RESAMPLE (cont.): Using the *Magnifier* window

20. In the *Magnify* section of the *RESAMPLE* window, move the *Zoom factor* slider to *4x*.
21. Uncheck the *Show cursor* check box, as we will want a clear view in the zoom window, without the cursor present.
22. Move your cursor over one of the two main displayed images and observe how the *Magnify* display works in creating a zoomed view in the *RESAMPLE* window (Figure 3.2.4.c).

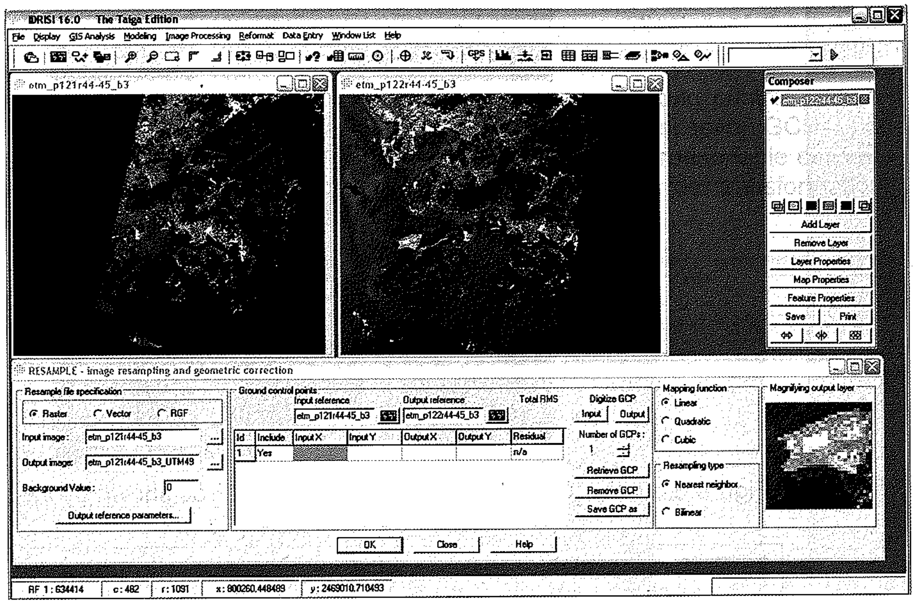


Figure 3.2.4.c The *RESAMPLE* window, including the *Magnifier* display.

The *Magnifier* magnifies what is displayed in the *DISPLAY VIEWER*, and does not return to the original image to show the full resolution of the data set. Thus, if the image in the *DISPLAY VIEWER* is not at full resolution, then the image in the Magnifier will also not be at full resolution. This is because your screen monitor has a limited resolution, and cannot display the entire image at full resolution. Instead, the DISPLAY VIEWER automatically shows a reduced resolution image, in order to fit the image on the screen. Only by showing a subset of the image, can we see the image at full resolution, as we will see in the next few steps.

Once we have all the displays as we want, let's begin placing GCPs using the *Digitize GCP* option in the top right corner of the *Ground Control Points* section of the *RESAMPLE* window.

Georeferencing using RESAMPLE (cont.): Identifying the first GCP

23. Make the *Input reference* display window (i.e. the left display window showing ***etm_p121r44-45_b3***) the focus window by clicking in or on the borders of the window. This will make the window frame a different color, and bring it to the front of any other windows with which it may overlap.
24. We will now need to select an area for the first GCP. Specifically, we'd like a feature that is found on both images, and has a very distinctive shape so we can identify a location down to the specific pixel.

25. Click on the *Zoom Window* icon in the main tool bar.
26. Move cursor into the *Input reference* display.
27. Click the left mouse button, and keeping the button depressed, draw a box around the general vicinity of the first GCP. (Figure 3.2.4.d highlights the region we will select, which is an island in the bay. Make sure you can find the island on both displays, *input* and *output*, before you start zooming in.)

28. If necessary, you can refine the area that you have zoomed in on by repeatedly using the *Zoom Window* icon, or using the Zoom window icon in conjunction with the *Zoom in / Center* and *Zoom out / Center* tools.

Figure 3.2.4.d General vicinity of the first GCP as shown by the white box.

29. Perform the same set of operations to zoom in to the same location in the right *Output reference* display.

30. In the *RESAMPLE* window, in the *Ground Control Points* section, and near the words *Digitize GCP*, find the *Input* button, and click on it. A GCP will be appear, located in the center of the *input reference* image, with a numeric identifier (*1*, for this first GCP).

31. Move the GCP to an identifiable location you can find in both displays by selecting the GCP with the cursor and dragging it to the feature. The edge of the breakwater makes a good choice for such a feature.

32. In the *RESAMPLE* window, click on the (Digitize GCP) *Output* button. A GCP with the same numeric identifier as before (1, for this first GCP) will appear in the center of the *output reference* image.

33. Move the GCP to the location of the same feature identified in the *input* display window (Figure 3.2.4.e).

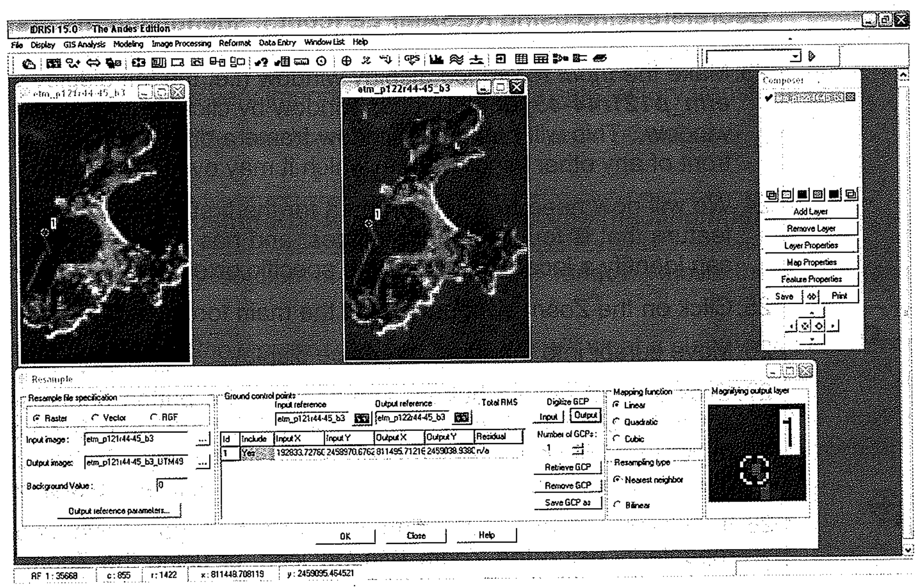


Figure 3.2.4.e First GCP location.

Note that the RESAMPLE window now has the coordinates of the first GCP recorded on the first line of the *Ground Control Points* form (Figure 3.2.4.e).

Now that we have mastered the capability to locate ground control points, we should pick at least six additional points. By picking at least seven GCPs, we will have a number of redundant points, so that we can get a reasonable estimate of the error in the transformation. If we were using a higher order transformation we would need even more points.

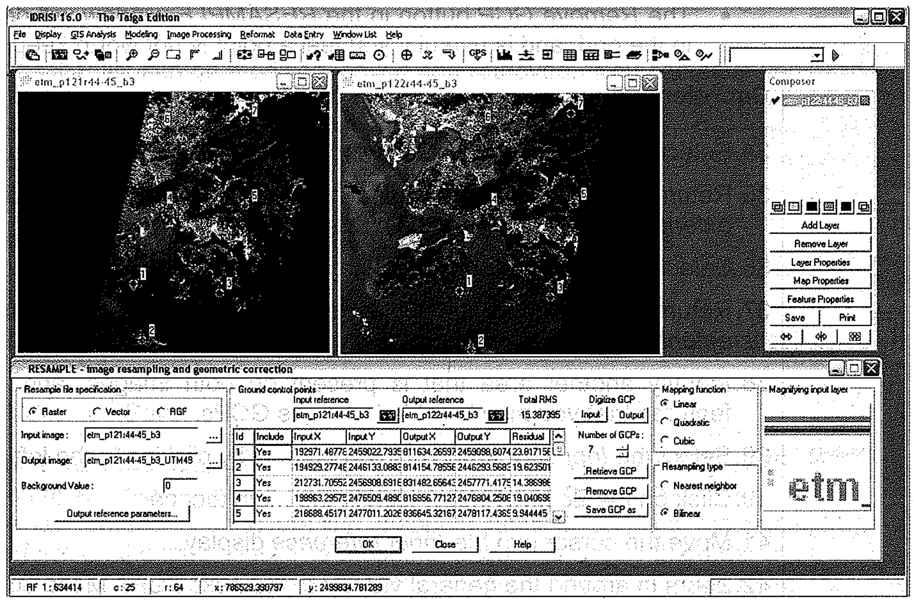


Figure 3.2.4.f GCPs and RMS error in the *RESAMPLE* window and displays.

Here are some suggestions you should consider as you choose your GCPs:

- You should aim to have the seven GCPs as well-distributed around the images as possible (Figure 3.2.4.f). Thus, in general, try to select each new GCP some distance from the previous GCPs.
- In picking GCPs make sure that you are not confusing boat wakes or other temporary features with permanent features that are likely to be present in both images.
- It can be quite difficult to find suitable objects, so you may want to zoom in slowly, first looking at a general region, and then zooming in a second, and even possibly a third time.
- The best objects to use are road intersections, or other linear objects. Do not use indeterminate objects, for example, the center of an island, unless that island is only 1-2 pixels in size.
- Once three GCPs have been selected, a linear solution is calculated and the total root mean squared error (RMS), and residual error for each point within the GCP table, are all displayed as zero. The next time you pick a GCP in the *input* display, the position of the GCP in the *reference* image is estimated automatically for you. **It is very, very important that you do not simply accept this estimated location.** You must check the location very carefully, and in general you probably will find you need to move the GCP slightly. If you do not conscientiously move the automatically

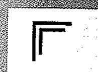
selected points, you will end up with a completely false estimate of the error in your transformation.

- The RMS is an estimate of the average error of the points you have selected. It is important to realize it is only an estimate based on the points you have selected, and not for every pixel in the image. This again emphasizes the importance of a well-distributed set of GCPs so that your estimate of error is representative of most of the image.
- The *Remove GCP* button in the *RESAMPLE* window will delete entire row in the grid, and is useful if you feel a point is not worth keeping.

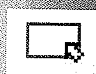
Georeferencing using RESAMPLE (cont.): Identifying additional GCPs

34. Select *Input reference* display window by clicking in the left image.

35. Return the image to its original zoom and extents by clicking on the *Full extent normal* icon on the main menu bar.
36. Select the *Output reference* display window by clicking in the right image.



37. Return the image to its original zoom and extents by clicking on the *Full extent normal* icon on the main menu bar.
38. Identify another area that is present on both images, and potentially has features that you may be able to use as GCPs.
39. Select the *Input reference* display window by clicking in the left window.
40. Click on the *Zoom Window* icon in the main tool bar.
41. Move the cursor into the *Input reference* display.



42. Zoom in around the general vicinity of the next GCP. Make sure you can find the same area on both displays, *input* and *output*, before you start zooming in.
43. Click on the *Input* button in the Ground Control Points section and a GCP will be located in the center of the input reference image with a numeric identifier.
44. Move the GCP to an identifiable location observed in both displays by selecting it with the cursor and dragging it to a feature that you can identify in both images.
45. Click on the digitize *Output* button. A GCP with the same numeric identifier as that of the *Input reference* image will appear in the center of the *Output reference* image.
46. Move the GCP to the location of the same feature identified in the *Input Reference* display window.
47. Pick at least seven GCPs in total (Figure 3.2.4.f).

Your aim should be for an RMS of less than one half the resolution of the input image. For the Hong Kong image, we have 30 meter pixels, and therefore our aim is for an RMS of 15 or less. If you have an error of 30 or more it means that on average your image registration is one pixel off. We suggest that in this exercise if you error is more than 30 meters, you should review all the GCPs.

One solution to a high RMS is to discard the GCPs that have the highest residuals. These points lie furthest away from the average transformation calculated for the images. You can omit any GCP by changing the *Include* option in the *RESAMPLE* window from *Yes* to *No*. This is done by simply clicking in the appropriate cell from the *Include* column, and using the drop down menu to select *No*. Note that once you change the *Include* attribute of a GCP, the RMS and residuals are automatically recalculated.

It is important, however, that the ground control points cover the image area evenly to control the error. If one were not to pick any control points in an area of the image, the transformation of the image in that area could result in large error even though the overall RMS is within an acceptable range. Therefore, if you have to exclude more than one GCP, or if after excluding even one GCP you find that your points are not longer well-distributed across the image, you should probably add one or more points.

The GCP list can be modified, saved and retrieved. You can save your GCPs at any time using the *Save GCP* button. This will save the GCPs to an IDRISI correspondence file (.cor), which can be retrieved at a later time. Use the *Retrieve GCP* button to retrieve saved GCPs. Let's save our GCPs now in case we wish to use them again.

Georeferencing using RESAMPLE (cont.): Saving GCPs

48. In the *RESAMPLE* window, click on *Save GCP as.*
49. Type in file name as **Hong_Kong_GCP**. (IDRISI will automatically add the .cor extension.)
50. Click on *Save*.

Once you are satisfied with the GCP list and the resulting RMS error, the resample process can be performed. Before performing the resample, however, the last criteria needed are the mapping function and the resampling type to perform on the input files. The mapping function is simply the order of polynomial fit desired: linear (first order), quadratic (second order), or cubic (third order). A lower order of polynomial often provides a reasonable solution since the error associated with poor control point designation increases as the order of equation increases. Since we are simply transforming from adjacent UTM zones in this case, the first order (linear) mapping function is adequate.

The new pixel locations in the geographically referenced grid as determined by the polynomial equations may not align exactly with any existing pixel centers in the original data grid. IDRISI offers two procedures to determine the new pixel location's digital number value, nearest neighbor and bilinear resampling. In a nearest neighbor interpolation, the value of the closest input cell to the position of the output cell is conveyed. In the case of a bilinear interpolation, a linear distance-weighted average of the four closest cells is used. Since we have no need to smooth the data, the nearest neighbor can be chosen.

The reference unit is simply the unit of measure used in the reference coordinate system (e.g., meters). The unit distance refers to the actual ground distance spanned by one reference unit. The unit distance will be 1.0 in most cases. One exception would be the case of a latitude-longitude reference system where the unit distance could be in fractions of a degree.

RESAMPLE (cont.): Running the program

51. Accept the default *Mapping function* of *Linear*.
52. Use the default *Resampling function* of *Nearest Neighbor*.
53. Click on *OK* in the bottom of the RESAMPLE window. This will begin the resample process and the resulting image will be displayed in a new window.

The new path 121 image is displayed automatically with the same bounds, resolution, and projection of the path 122 image. Note that the automatic display uses the default color palette, and therefore will not look quite the same as the Input reference image. This is easily corrected, using the method of changing palette files that we have already experimented with earlier. You are probably quite familiar with the method now, but for completeness sake, we repeat it here.

Change display properties of an image

1. In the *Composer* window, select the button for *Layer Properties*.
2. In the *Layer Properties* window, click on the button for *Advanced Palette/Symbol Selection*.
3. This will open the *Advanced Palette/Symbol Selection* window. In this new window, click on the browse button (…) next to the *Current selection* text box.
4. In the file *Pick list*, click on the *IDRISI Taiga/Symbols* folder, and scroll down to ***greyscale***. Click on *OK* in the Pick list, and in the *Palette/Symbol Selection* window.
5. Note that you also need to adjust the display minimum and maximum values in the *Layer Properties* window. Use the values we chose at the start of this section: **18** and **100**.

Now that the two images for paths 121 and 122 are on the same projection, we will join them to create a single mosaic image of Hong Kong in the next section.

3.3 Mosaicking Images

3.3.1 Background

So far we have focused on the geometric challenges of joining images. However, there is an added problem when it comes to joining images. Images acquired at different times typically have different radiometric properties. This means that the DN values for a particular area in one image are not identical to those in another image of the same area. Among the many reasons for this variation in radiometric properties between images are illumination variation due to changes in sun angle as a consequence of the time of day or season, changing atmospheric properties, especially water vapor and pollutants, and sensor differences.

Joining images of dissimilar radiometric properties is a major challenge in image processing. Generally, the goal in mosaicking is to blend adjacent images in an effort to make the join appear seamless. The balancing of the radiometric properties between imagery can be a highly subjective process based on human perception of what a person believes looks "good."

The mosaicking process is relatively effective in areas of sparse development and low terrain relief. However, we should be aware that sometimes there are real differences between images that are not an artifact of the image acquisition. Thus, for example there may be vegetation differences due to seasonal or climate variations, variation in the presence of snow on the ground, changes in the landscape due to fires, agriculture or urbanization, and even differences due to the presence of clouds. Generally, there is very little hope for removing such image differences.

Numerous methods have been developed to make the image join less discernable, for example by blending the overlapping regions, matching the histogram of the images, or using a nonlinear cut line. One approach is to blend the DN values across a join region, rather a sharp line. If a blend region is used, one could average the DN values of the two input images. Alternatively, a feathering could be used, which is a special case of the averaging method. With feathering, the new DN value is a weighted average, where the weights are a function of the distance across the join. Thus the overlap region becomes a progressive blending of the one image into the other.

3.3.2 Mosaicking the Hong Kong data

We did not run into this problem of radiometric matching between images in our concatenation exercise (Section 3.1.2) because when we joined the images that were along the same satellite paths, there was essentially no difference in time, atmospheric conditions or sensor properties between them. However, we have not yet joined the images from the different paths, specifically paths 121 and 122. Since the paths were imaged on different days, we should expect there to be radiometric differences between the images.

In IDRISI, the MOSAIC module creates a new image by spatially orienting overlapping images and balancing the overlap regions by numerically averaging the individual pixels in the overlap region. We will use MOSAIC to join the two path images for Hong Kong. If you have not already done the exercises in Sections 3.1, you will need to do them now, in order to generate the files needed for this section.

MOSAIC
Menu Location: **Image Processing – Restoration – Mosaic**
1. Use the main menu bar to start the MOSAIC program. 2. The *MOSAIC* dialog box will open. In the *Images to be processed* section of the dialog box, click in the first text box below *Filenames*, to bring up the browse button (…). 3. Click on the browse button. 4. Select the path image generated using the RESAMPLE program, ***etm_p121r44-45_b3_utm49***. 5. Click *OK*. 6. Click in the second text box below *Filenames,* to bring up the browse button (…). 7. Click on the browse button. 8. Select the path image, ***etm_p122r44-45_b3***. 9. Click *OK*.

Note that the module allows for different background values to be selected. The *Output background value* is the DN value the program will assign to pixels that lie outside the bounds of the two images we are joining. A DN of 0 is the default, and the most common background value used. The *Default input background value* is the DN value which will be regarded as not part of the input images. This is a very important option, because our images have large blank areas, which we expressly do not want the MOSAIC program to regard as part of the data to be used in the mosaicking process.

The *MOSAIC* dialog box has as a default procedure for the radiometric matching between the images. If this option is deselected, then the MOSAIC module operates much like the CONCAT module in that no radiometric adjustment is applied.

There are two options for determining the output pixel DN values in the overlap region: *Cover* and *Average*. We will test both options to see which works best for us in this case.

MOSAIC (cont.): *Cover* option for *Overlap Method*
11. Type **HK_b3_mosaic_cover** in the *Output mosaicked image* text box.
12. Leave remaining options at their default settings (Figure 3.3.2.a).
13. Click *OK* to run MOSAIC.

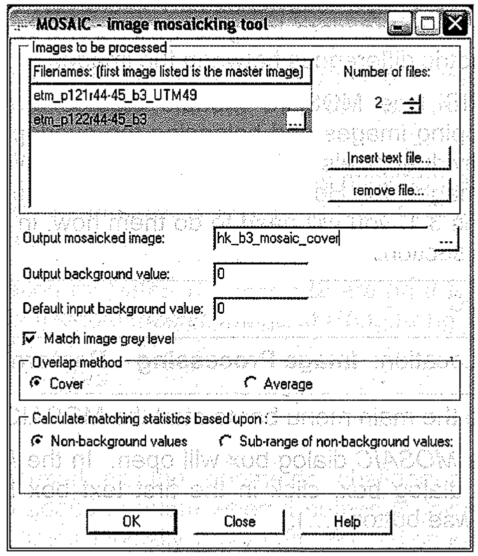


Figure 3.3.2.a *MOSAIC* dialog box with initial parameter selection.

The image is automatically displayed after the processing is complete. In this case, the mosaic has a GreyScale palette applied, which is appropriate for the data. However, remember to adjust the contrast stretch values. In the *Composer* window, click on the *Layer Properties* button, and in the *Layer Properties* window, set the *Display min* and *Display max* to **18** and **100**, respectively. Figure 3.3.2.b shows the image after the contrast stretch has been applied.

The first thing that is obvious upon examining the output image is that there is a sharp line at the boundary between the two images. However, this line is only evident in the water part of the image. For the land part of the image, the two images appear to be well balanced and almost seamlessly joined. This suggests that the image differences in the sea portion of the mosaic represent a real difference in water quality between the two images. For example, the amount of sediment in the ocean might be different between the two dates.

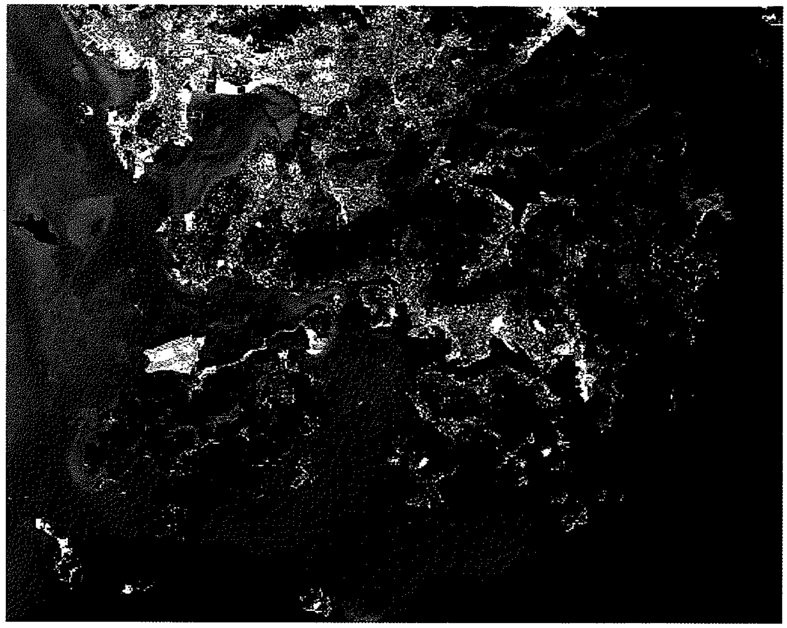


Figure 3.3.2.b Hong Kong Landsat mosaic.

This difference between the two images in the sea portion of the mosaic could possibly be minimized by further processing or more involved mosaicking procedures not available in IDRISI. However, it is doubtful that these differences could totally be overcome.

Overall, one could be satisfied with this mosaic. However, let's try the *Average* cover option for the overlap region to see if it yields any improvement.

MOSAIC (cont.): *Average* option for *Overlap Method*

14. Because of IDRISI's persistent windows, the MOSAIC window should still be open in your IDRISI workspace.
15. Type **HK_b3_mosaic_average** in the *Output mosaicked image* text box.
16. Change the *Overlap method* to *Average*, by clicking on the radio button.
17. Leave remaining parameters as before.
18. Click on *OK* to run MOSAIC.

Once the program has finished processing the image, don't forget to change the display min and display max to **18** and **100** in the *Layer Properties* dialog box.

The resulting image (Figure 3.3.2.c) has perhaps a less noticeable join in the water part of the image. However, there is a striking diagonal pattern across the left side of the image. This artifact is due to the characteristics of the preprocessing of the original data. The edge effects on the left side of the path 121 image are due to the jagged scene edges and shutter intrusion at the end of each scan. The jagged edges have non-zero data and thus are not ignored in the average option, unlike the background areas.

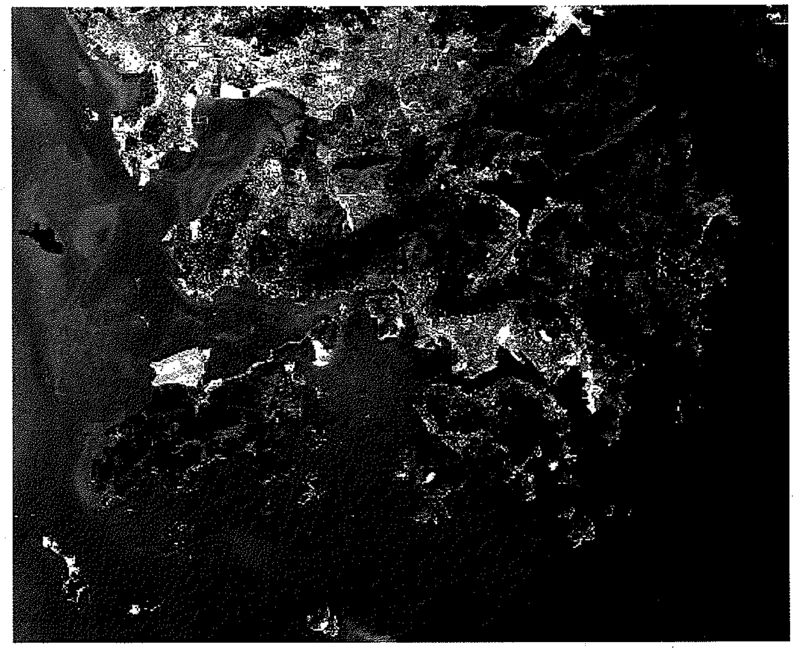


Figure 3.3.2.c Hong Kong Landsat mosaic using "average" option.

Thus, while the *Average* option did indeed help create a smoother join in the water areas, averaging changes the actual radiometric values of the images and may cause difficulties in classifying the imagery later.

3.4 Exporting Images

At the start of this chapter (Section 3.1) we saw that IDRISI could be used to import images into IDRISI. IDRISI also supports the exporting of data and composite imagery into many formats. The main bar menu divides these formats into three group, each with their own submenu.

- **General Conversion Tools** are utilities for converting image DN values into text files of various formats.
- **Desktop Publishing Formats** are modules for exporting raster data, and include GeoTIFF as well as JPEG and BMP formats. The Desktop Publishing Formats work well with the composite images created in IDRISI.
- **The Software-Specific Formats** are modules that export the IDRISI format to those of other remote sensing and GIS programs. This group of programs generally works best for single band data, rather than the composite images.

We will now try an export of our newly created Hong Kong mosaic file to a GeoTIFF format, using one of the modules in the Desktop Publishing Formats category.

EXPORT
Menu Location: **File – Export – Desktop Publishing Formats – GEOTIFF/TIFF**
1. Use the main menu to start the GEOTIFF/TIFF module. 2. The *GEOTIFF/TIFF* dialog box will open.

3. Select the radio button for the *Idrisi to GeoTIFF/Tiff* option.
4. Click the browse button (...) next to the *Idrisi file name* text box.
5. Select ***hk_b3_mosaic*** and click *OK.*
6. Note that IDRISI automatically inserts the same name in the output GeoTIFF file to create text book. Because the output file will have a **.tif** extension, there will be no confusion between the IDRISI format file and the TIFF format file. However, if you wish to change the name of the output file, you can do so at this time.
7. Click the browse button (...) next to the *Palette to export with image* text box.
8. Select the *\Idrisi Taiga\Symbols* folder (the folder name will include the full path, the specifics of which will depend on your IDRISI installation) .
9. Scroll down till you see, and can select, the file ***greyscale***.
10. Click *OK.*
11. Review in the parameters for the dialog box to see they are all correctly specified (Figure 3.4.a).
12. Click on *OK* in *GeoTIFF/TIFF* window to start the export routine.

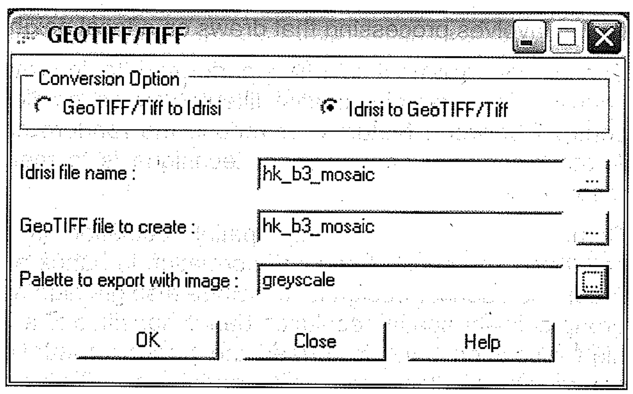


Figure 3.4.a The *GEOTIFF/TIFF* dialog box.

The file is exported when the lower left pane in the main window is clear. The file has now been exported successfully and you can easily read it into any image display software or word processing software.

To end this chapter, close all DISPLAY windows and dialog boxes.