Creating Digitial Elevation Models and Orthoimages from ASTER Imagery

Richard Selby

PCI Geomatics, 33-35 Station Road, Henley On Thames, United Kingdom, RG9 1AT.
selby@pcigeomatics.com, tel +44 1491 412114, fax +44 1491 412115

Summary

The aim of this tutorial is to show how to easily create a Digital Elevation Model (DEM) and orthorectified image from free ASTER satellite imagery. PCI Geomatica OrthoEngine is the software package used to perform the processing. The imagery used in this tutorial is from Southern Scotland, around Loch Doon in the United Kingdom. These web sites provide contextual pictures of the area….

http://www.callycastles.plus.com/castles/strathclyde/lochdoon.htm
http://www.videoscotland.com/postcards/513%20loch%20doon%20south.htm
http://www.gla.ac.uk/medicalgenetics/LochDoon.jpg

Introduction

A DEM created from ASTER imagery can be expected to have a vertical accuracy of approximately 25 meters. Although in areas with less vegetation or man made features, this can rise to approximately 11 meters.

It is therefore useful for small to medium scale mapping applications, 1:50,000 to 1:100,000. Elevation models at this scale can be used in areas where DEM data is currently not available, or as an alternative to commercial DEM data products.

In addition to creating the DEM, ASTER imagery can be orthorectified using the DEM generated or any other DEM available for the area.

Orthorectification is the geometric correction process by which distortions in the imagery caused by the sensor and the terrain are removed. The output orthoimage can then be used for meaningful ground measurements and to fit with existing map data.

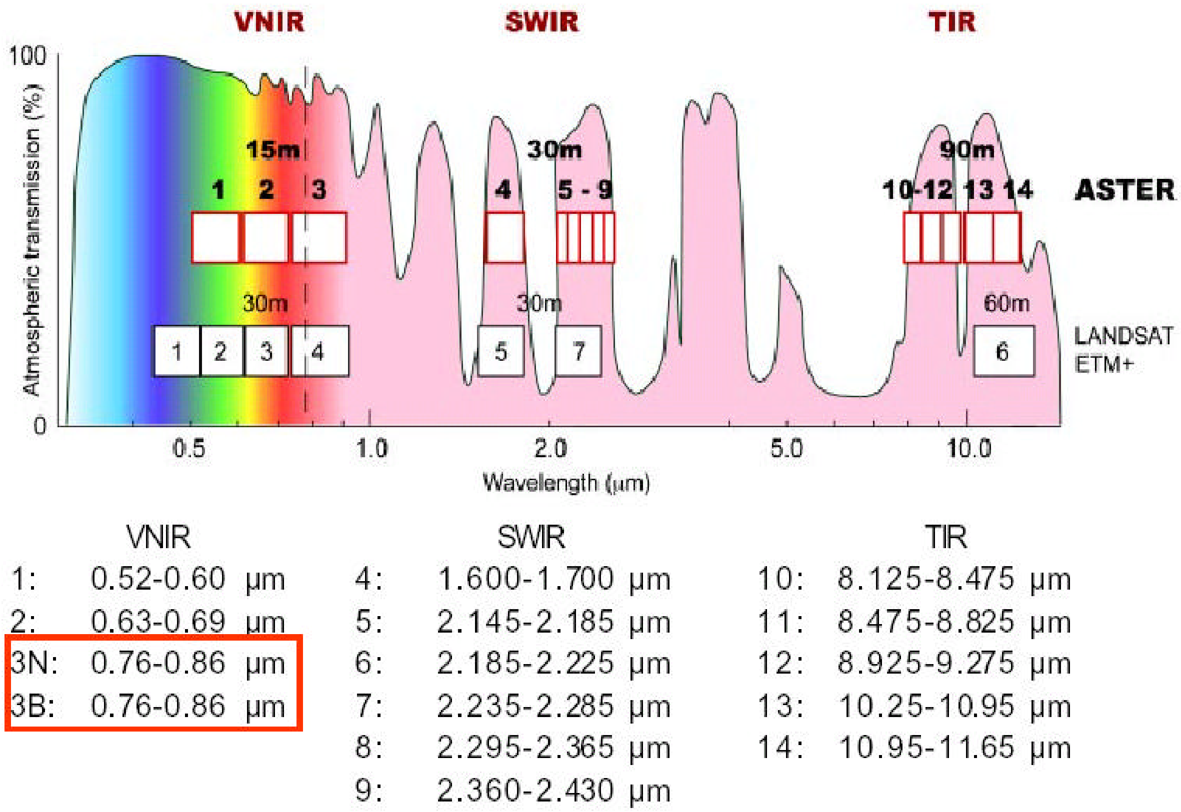
ASTER Imagery

Currently archived ASTER data is free to download by ftp, or at minimal cost on CD. To search and request ASTER data for your region of interest, use this web site…
http://edcimswww.cr.usgs.gov/pub/imswelcome/

The ASTER sensor is carried on board the Terra satellite that was launched in December 1999. The sensor has 14 spectral bands; three for Very Near Infra Red (VNIR) at 15 meters resolution, six for Short Wave Infra Red at 30 meters resolution, five for Thermal Infra Red at ninety meters resolution. Graphic 1 (below) shows the band coverage of the ASTER sensor.

An extra channel of image data is created by the sensor capturing a backwards looking image for the third VNIR band. So for image band three there exists one (nadir) image channel and also a backwards looking (off nadir) image channel. This creates an along-track stereo effect.

Graphic 1: The relationship between the wavelength coverage of ASTER and Landsat ETM+ imagery



Graphic created by Dr. Andreas Kaeaeb, Department of Geography, University of Zurich, Switzerland. kaeaeb@geo.unizh.ch

It is from this along-track stereo pair of images that the operator is able to automatically extract the DEM. The operator can also view the images in 3D and perform 3D vector digitizing.

Data types used most commonly for automatic DEM generation such as SPOT and IRS, use data that is across-track stereo. That is the images making up the stereo pair have been captured from two different orbits. The two images may therefore have not been captured in the same time period, which can affect the success of the DEM creation process.

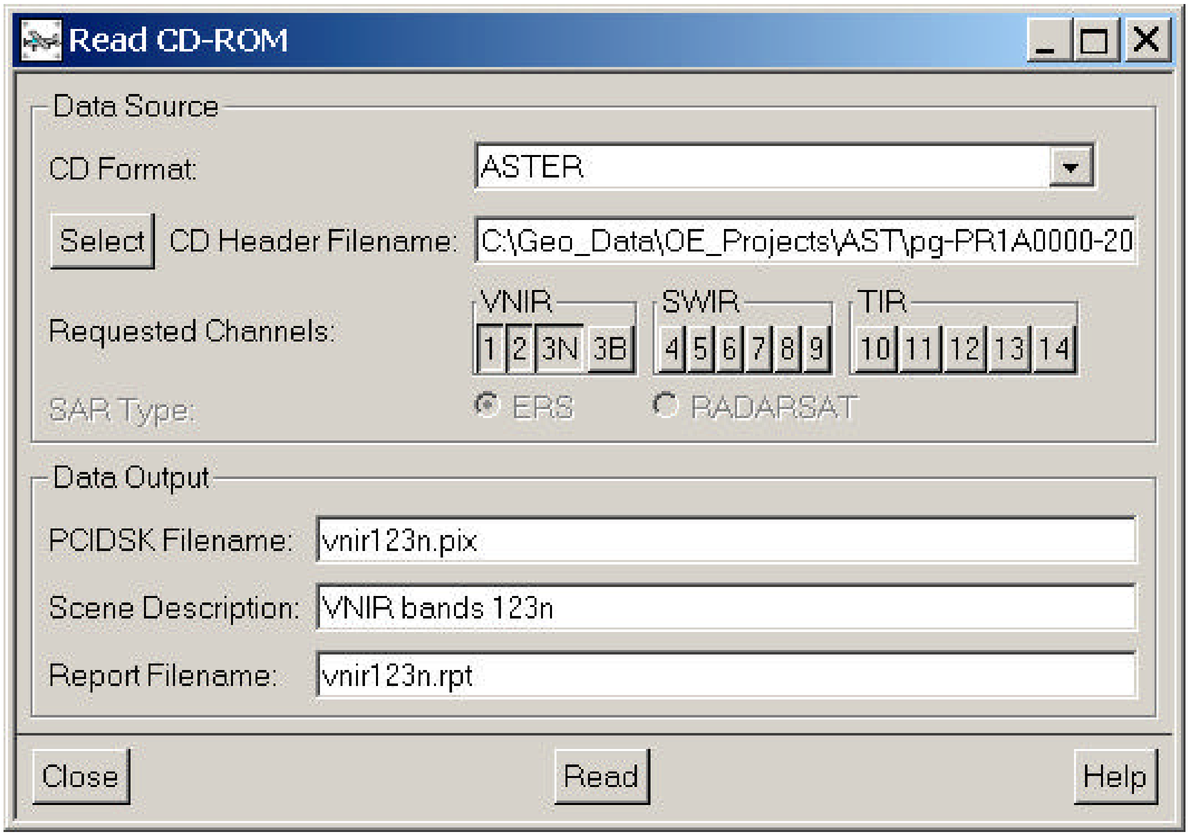
ASTER imagery is along-track stereo. So the two images that make up the stereo pair have been taken very closely together in time. Thus atmospheric, ground surface condition and illumination changes between the two images will be minimal. The downside of along-track stereo is that the stereo separation of the images may not be as optimal for DEM generation as across-track stereo can provide.

Along-track and across-track stereo have their own advantages and disadvantages.

Data Processing

Firstly the output projection required for the output DEM and orthoimages should be set. In this case the UK national projection was used. The ASTER data should then be read from the HDF format distribution file.

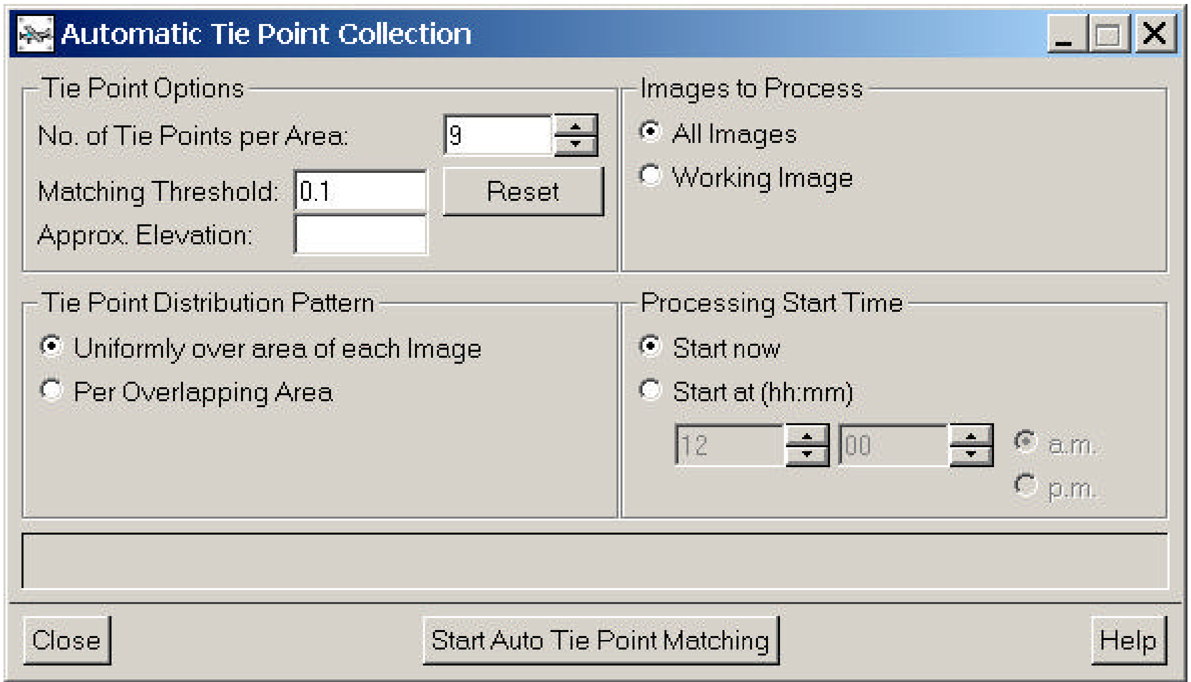
Graphic 2: The panel for reading ASTER data from a HDF file



The first three channels of data are read into one file and the fourth channel into another. The reason for not reading them into a single file is because the backwards looking channel (3B) has a different pixel/line size to the first three channels.

It is possible to automatically create a DEM from these two input files using Tie Points (TPs) only. The addition of Ground Control Points will permit precision geocoding and scaling of the DEM in the Z direction. TPs can be collected manually and/or automatically.

Graphic 3: The panel for automatically collecting Tie Points (TPs)

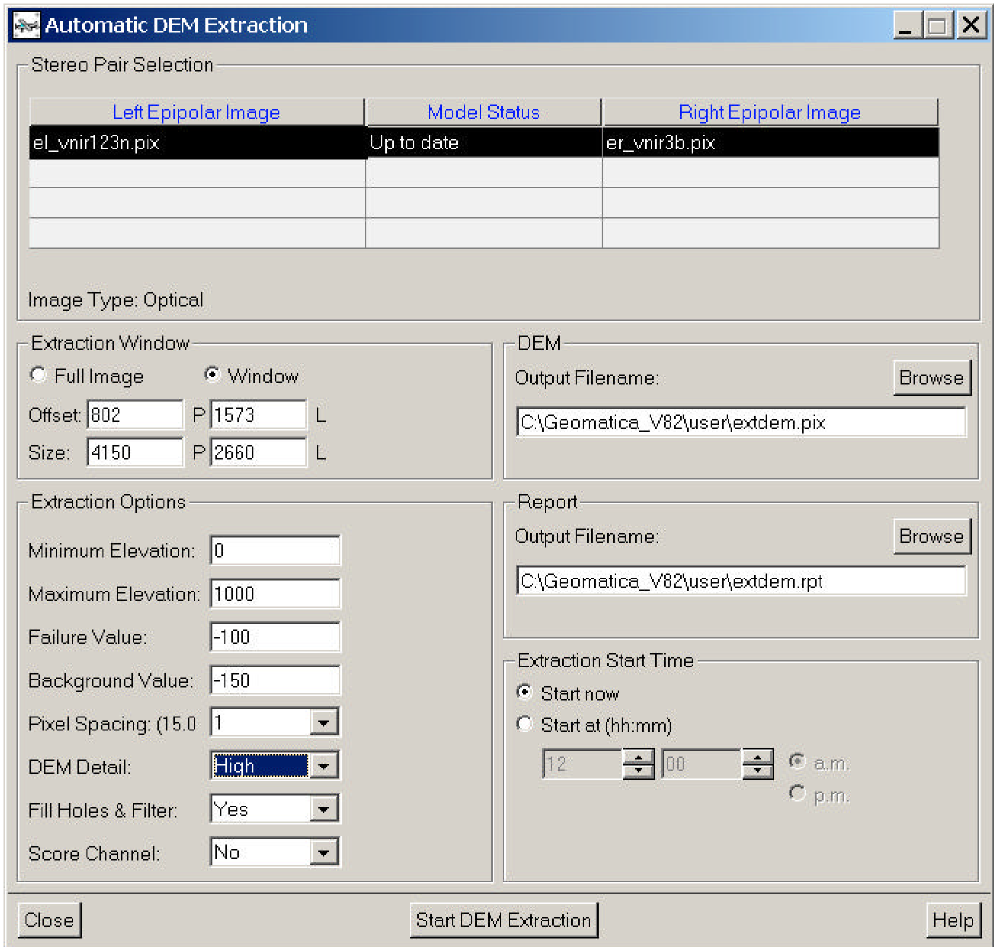


Once any TPs and GCPs have been collected then a Bundle Adjustment operation should be performed. The Bundle Adjustment computes the photogrammetric model using the orbital and sensor ephemeris information, plus the GCPs and TPs.

Epi-polar images are created for both input files. Creating epi-polar image versions of the original input files will remove any offsets between them in the Y direction. The autocorrelation pixel matching algorithm (that is run to automatically create the DEM) will run more quickly on the epi-polar images, because it shouldn't have to search so many pixels to find a match.

When extracting the DEM the whole stereo overlap area between the epi-polar files can be used, or just a sub window processed.

Graphic 4: Setting automatic DEM extraction options for the epi-polar files

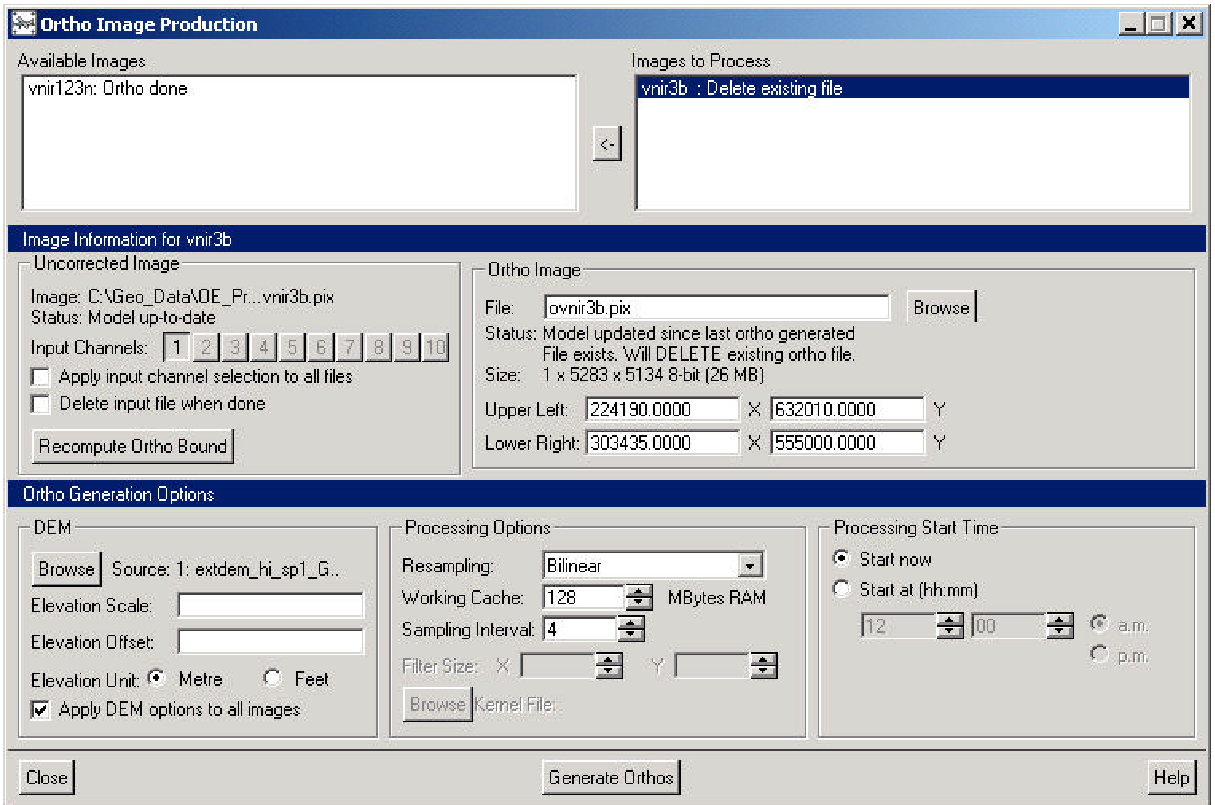


Before creating a DEM for the whole area, it is wise to extract just a sub window of the input files or at a lower resolution first. This way failures in the DEM extraction can be quickly identified and if possible remedied. Failures tend to occur in areas of the image with very low contrast, such as shadows, clouds, water bodies and snow.

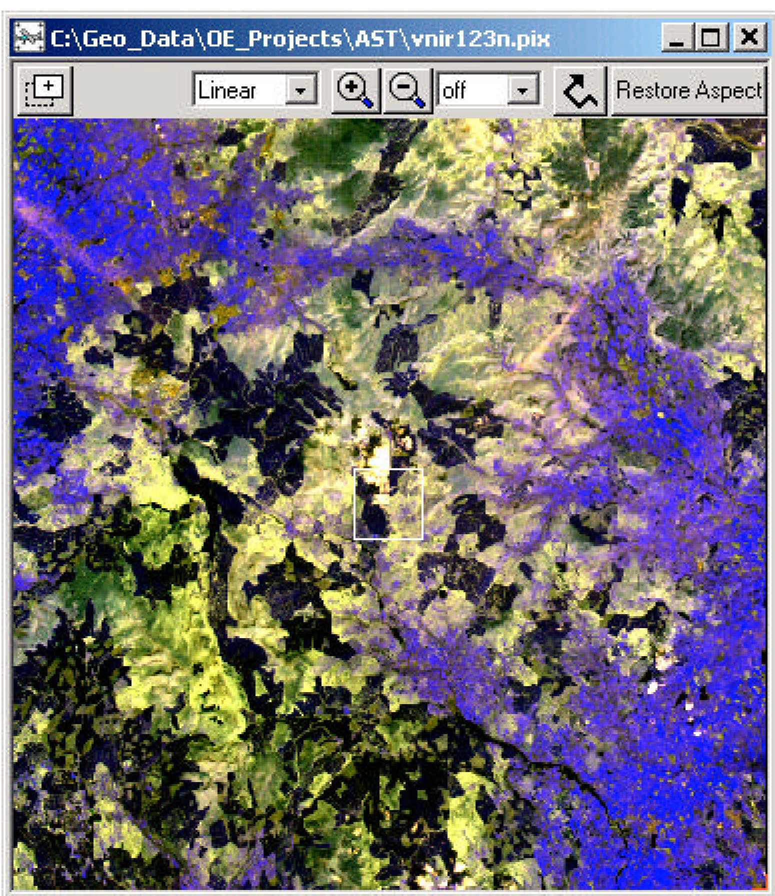
Small failure holes in the DEM can be filled automatically by interpolation. Large failed areas require manual editing to complete the DEM.

Following the automatic extraction of the DEM, stereo editing can be performed if required to edit out failures. The DEM is then automatically geocoded. Once geocoded it can be used with other data sets and to orthorectify any of the image channels within the ASTER file.

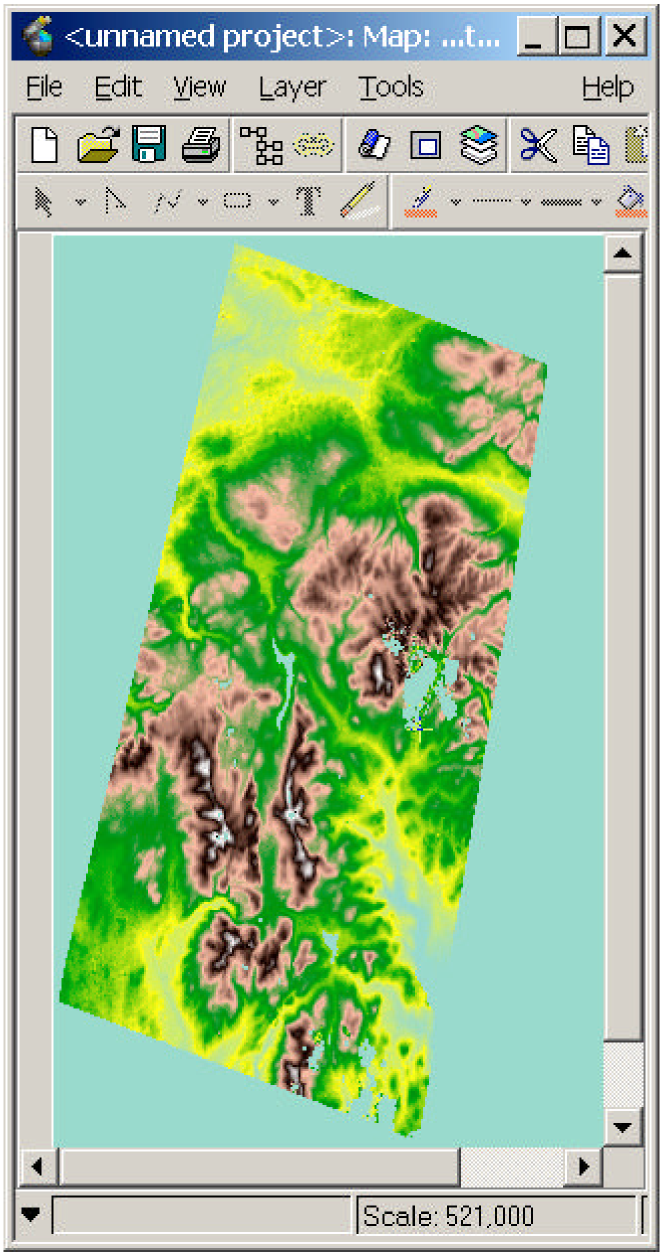
Graphic 5: Setting the orthorectification options for an ASTER image file



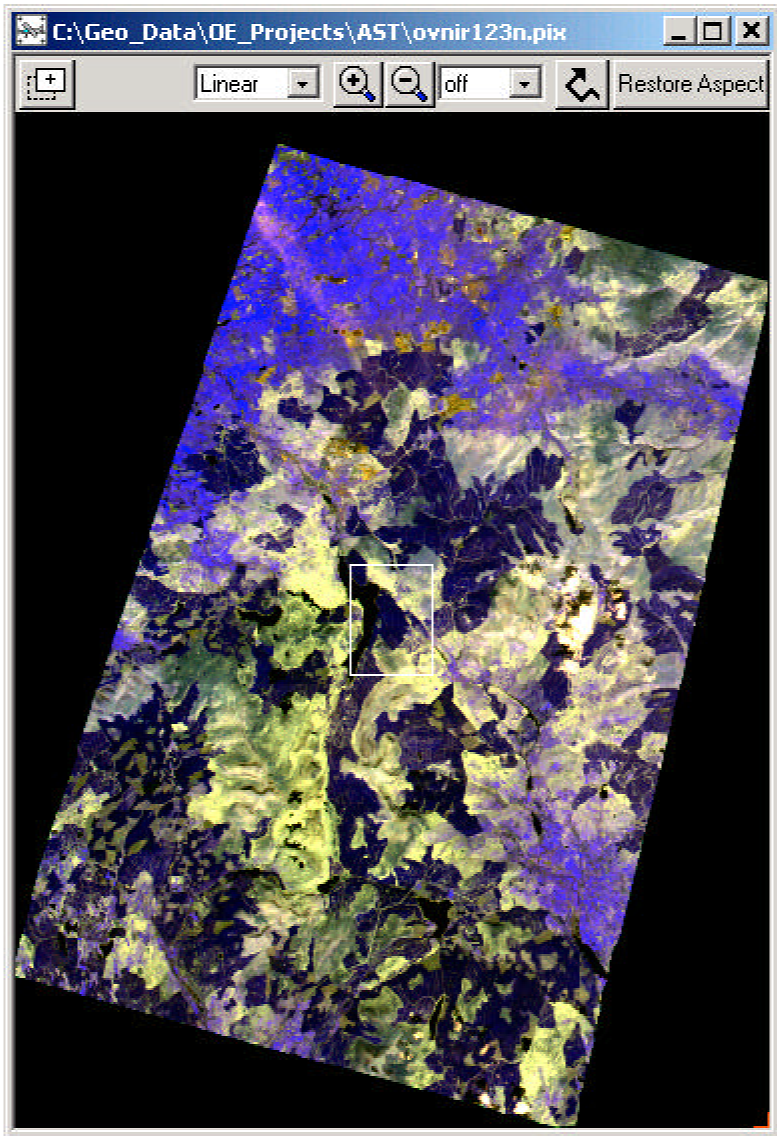
Graphic 6: The uncorrected VNIR bands 123 image from the area around Loch Doon



Graphic 7: The DEM created from the two input epi-polar ASTER image files



Graphic 8: The orthorectified VNIR bands 123 image from the area around Loch Doon



Conclusion

Extracting a DEM automatically from ASTER data is a relatively straightforward procedure. The addition of Ground Control Points will enable a fully scaled and preciscion located DEM and orthoimages to be created. The resulting DEM and orthoimagery can be used for interpretation of land form and geology. A more detailed step by step version of this tutorial with associated data and evaluation software is available free of charge from the PCI Geomatics UK office.