Landsat 7 Orthorectification and Processing Specifications and Guidelines

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1. Introduction

The Ministry of Forests and Range is responsible for setting data specifications and maintaining information pertaining to the forest resources of British Columbia. Orthorectified Landsat 7 panchromatic and multispectral digital satellite imagery can be used in achieving forest and range management objectives.

2. Data Requirements

1. Landsat 7 ETM+ sensors acquire image data consisting of 9 spectral bands. Bands 1, 2 and 3 are visible blue, green and red light respectively with a 30 metre nominal pixel size. Band 4 and 5 are near-infrared and mid-infrared, also with a 30 metre nominal pixel size. There are two Band 6 components, resulting from high and low gain settings, these are thermal-infrared bands at a 60 metre nominal pixel size. Band 7 is an additional mid-infrared band with a 30 metre nominal pixel size. Band 8 is the panchromatic band with a 15 metre nominal pixel size. The Landsat 7 full scene (approximately 185 km x 170 km) has a near nadir look angle (i.e. $\pm 0.05^{\circ}$ off nadir). For orthogonal geometric correction (orthorectification), Landsat 7 data should be supplied with a level 1G correction to UTM map projection using cubic convolution (CC) resampling, on CD-ROM in HDF format. The HDF format includes the satellite orbit and imaging geometry data (ephemeral and attitude), which should be used in the orthorectification process.

2. Ground Control Points (GCPs) should be collected from either 1:20 000 digital Terrain Resource Information Management (TRIM) planimetry vector maps or from differentially corrected Global

Positioning System (DGPS) points. GCPs should be well identified features, such as near right angle road intersections, where the position can be interpreted on the ground, on 1:20 000 TRIM maps and on the Landsat 7 panchromatic band, at sub-pixel precision. Intermittent or indefinite features or temporary features should not be used as GCPs. GCP source data should be in a North American Datum (NAD83 (Canada, National Transform version 1 (NTv1)).

3. TRIM derived gridded Digital Elevation Model (DEM) files must be used in the orthorectification process. These files are 16 bit signed and cover 1:250 000 National Topographic System (NTS) maps with a pixel size of 25 metres. These data are available as ESRI ASCII grid and USGS DEM formatted files. Files are available in both BC Albers standard and UTM projections with appropriate georeferencing information, NAD83 (Canada, NTv1) datum.

3. Orthorectification

Orthorectification of full scene Landsat 7 data is achieved using either 1:20 000 TRIM planimetric features or DGPS points and gridded Digital Elevation Models (DEM).

1. The image analyses software used for orthorectification purposes must be capable of incorporating and utilizing the data listed above. This includes the digital Landsat 7 full scenes with associated satellite orbit and imaging geometry data (ephemeral and attitude), either the TRIM planimetric files or the DGPS points and the gridded DEM data.

2. It is recommended that GCPs be collected from the smallest pixel size data (i.e. 15 metre panchromatic band 8). It is highly recommended that the GCPs for the 30 metre multispectral data and the 60 metre thermal-infrared data be derived mathematically from the GCP pixel locations interpreted from the15 metre panchromatic data. This procedure will maintain the co-registration of the three resolutions of Landsat 7 data (15, 30 and 60 metres). To derive GCP pixel locations for the 30 metre data from the 15 metre GCPs, divide the 15 metre pixel locations by 2. To derive GCP pixel locations for the 60 metre data from the 15 metre GCPs, divide the 15 metre pixel locations by 4. Sufficient GCPs per full Landsat 7 scene should be collected for use as control in the orthorectification transformation (a minimum of 20 GCPs is recommended for a full scene). The GCPs should be well distributed (both horizontally and vertically) and encompass the extents of the image as much as is possible. A minimum of 5 independent check points should also be collected to verify the orthorectification model. The consistency of fit of the orthorectified data to TRIM map vectors is a good test of the accuracy of the

orthorectification process.

3. If more than one adjoining Landsat 7 image is to be orthorectified, stereo GCPs and/or tie points should be collected and used in the overlapping image areas for simultaneous orthorectification.

4. The recommended overall RMS error for GCPs, tie points and independent check points is within ±15 metres with a 90% confidence level. It is recommended that the orthorectification process use a cubic convolution resampling routine and that a linear interpolation routine on the DEM elevation values in calculating the horizontal corrections.

5. It is recommended that the orthorectification process use the co-linearity condition method (Toutin 1995) of geometric modeling to adjust pixel locations to UTM and/or BC Albers standard map projection coordinates in NAD83 (Canada, NTv1).

6. The outside geographic extents for all resolutions of data for a specific Landsat 7 scene must be identical. The outside geographic extents of all orthorectified Landsat 7 image data must be evenly divisible by 300 metres.

7. The upper left pixel origins for UTM projection files must be calculated using pixel size in Eastings from the Zone meridian and in Northings from the equator.

8. The upper left pixel origins for BC Albers standard projection files must be calculated using pixel size in Eastings from the central meridian of 126° West longitude and in Northings from the latitude of projection origin of 45° North latitude. The first standard parallel must be specified as 50° and the second parallel 58°30'. The false EASTING should be specified as 1000000.

9. An IHS fusion of the panchromatic band with bands 5, 4 and 3 of the multispectral bands may be requested. This process should use a cubic convolution resampling method and a cylinder IHS colour model to derive output reflectance values.

4. Image Processing

Image processing involves image enhancement, mosaicing and clipping (sub-setting) of orthorectified images into areas of interest. These may include Ministry Regions, Districts, 1:250 000 NTS maps, 1:50 000 NTS maps and/or 1:20 000 BCGS maps.

1. Image enhancement is a process of improving feature interpretability through various techniques, such as adjusting brightness and contrast. The values used to adjust brightness and contrast are stored in a look up table (LUT). LUTs should be created to optimize interpretability of features of interest such as natural and man made disturbances from the surrounding forest canopy. Disturbances include such features as harvesting, roads, fires and pest damage. Enhancements should also optimize gray level balancing of the panchromatic band and colour balancing of multispectral bands between adjacent scenes while maintaining the variability in the source data (saturation should be avoided). **Enhancements must not result in valid spectral reflectance values being changed to null or zero values in the enhanced image.** The enhanced images should be used in the mosaic and clipping (sub-setting) processes.

2. Mosaicing is the process of joining adjacent and/or overlapping scenes to achieve complete coverage of an area of interest and/or to replace poor image areas (e.g. cloud, haze, or shadow). The mosaicing process should not result in any repositioning of the input pixel coordinates. In order to maintain a clear relationship between images acquired on different dates, blending or feathering of the images along mosaic seam lines is not recommended.

3. Clipping is the process of sub-setting the enhanced orthorectified and mosaiced image into areas of interest that may include Ministry Regions, Districts, 1:50 000 NTS maps and/or 1:20 000 BCGS maps. The geographic extent of each of these image areas should extend beyond their geographic limits by at least 100 metres and be evenly divisible by 300 metres and file origins should be defined in even 100 metres.

5. Deliverables

Orthorectification, it is recommended that deliverables for Landsat 7 full scenes should include:

1. Uncorrected working files in GeoTIFF format. If used, the GCP segments used for each orthorectification process must also be provided as separate text files. (e.g. for 15 metre, 30 metre and 60 metre data sets).

2. A brief report describing the orthorectification procedures used. This report must include an RMS error report for the orthorectification transformation with a listing of all GCPs, independent check points

and tie points or altimetric points, a description of the resampling algorithm used, a description of the adjustment process used and a description of all image file geographic extents in NAD83 (Canada, NTv1). Orthorectified data may be requested in both UTM and/or BC Albers standard projection with a NAD83 (Canada, NTv1) datum.

3. Digital image deliverables for orthorectified Landsat 7 satellite data may include un-enhanced resampled 15 metre pixel panchromatic band, un-enhanced resampled 30 metre pixel multispectral bands and un-enhanced resampled 60 metre pixels for the thermal-infrared bands. An intensity hue saturation (IHS) fusion of the panchromatic band and bands 5, 4 and 3 of the multispectral data may be requested. LUTs used for enhancement of the panchromatic band, bands 5, 4 and 3 and the IHS fuse in the image processing tasks should be delivered with these data. Data should be delivered in PCIDSK *.pix and/or GeoTIFF *.tif format.
4. The generic file naming scheme for orthorectified Landsat 7 full scenes uses lower case letters and is parsed using underscores to separate key pieces of metadata information:

   satellite-identifier_image-location-identifier_acquisition-date_projection-identifier-(zone)_pixel-size-(metres)_band-identifier.file-format-extension

   e.g. for path 050, row 025, acquired September 21, 2000, un-enhanced panchromatic band, in PCIDSK format:

   l7_5025_20000821_utm09_15m_pan.pix

   e.g. for data delivered in BC Albers standard projection, replace the projection-identifier with bcalb:

   l7_5025_20000821_bcalb_15m_pan.pix

   e.g. for un-enhanced 30 metre multispectral bands 1 to 5 and 7 delivered in GeoTIFF format:

   l7_5025_20000821_utm09_30m_b123457.pix

   e.g. for un-enhanced 60 metre thermal-infrared bands 61 and 62 delivered in GeoTIFF format:

   l7_5025_20000821_utm09_60m_b6162.pix

   e.g. for un-enhanced 15 metre intensity hue saturation (IHS) fuse of the panchromatic band with bands 5, 4, 3 delivered in PCIDSK format:

l7_5025_20000821_utm09_15m_ihs.pix

Image processing deliverables for enhanced, mosaiced and clipped (sub-set) images should include:

1. A brief technical report describing enhancements, mosaicing and clipping (sub-setting) of the orthorectified images into areas of interest that may include Ministry Regions, Districts, 1:250 000 NTS maps, 1:50 000 NTS maps and/or 1:20 000 BCGS map areas.

2. This report should include a description of geographic extents of the area of interest image files.

3. It is recommended that LUTs used for image enhancement be delivered with the orthorectification deliverables in a suitable digital format for each orthorectified Landsat 7 image. The typical enhanced deliverables include enhanced panchromatic, enhanced bands 5, 4 and 3 as Red, Green, Blue (RGB) and an enhanced IHS fuse of the panchromatic with bands 5, 4 and 3 of the multispectral as RGB.

4. It is recommended that the mosaic seams used in the mosaicing process be supplied as a deliverable in a suitable digital polygon vector format.

5. Each orthorectified, enhanced, mosaiced and/or clipped (sub-set) image should be delivered in GeoTIFF *.tif format.

6. The generic file naming scheme for enhanced orthorectified Landsat 7 full scenes uses lower case letters and is parsed using underscores to separate key pieces of metadata information:

   satellite-identifier_image-location-identifier_acquisition-date_projection-identifier-(zone)_pixel-size-(metres)_band-identifier_enhanced.file-format-extension

   e.g. for path 050, row 025, acquired September 21, 2000, enhanced panchromatic band, in GeoTIFF format:

   l7_5025_20000821_utm09_15m_pan_enh.tif

   e.g. for data delivered in BC Albers standard projection, replace the projection-identifier with bcalb:

   l7_5025_20000821_bcalb_15m_pan_enh.tif

e.g. for enhanced 30 metre multispectral bands 5, 4 and 3 delivered in GeoTIFF format:

l7_5025_20000821_utm09_30m_b543_enh.tif

e.g. for enhanced 15 metre intensity hue saturation (IHS) fuse of the panchromatic band with bands 5, 4, 3 delivered in GeoTIFF format:

l7_5025_20000821_utm09_15m_ihs_enh.tif

7. The generic file naming scheme for Landsat 7 image files covering 1:250 000 NTS maps, 1:50 000 NTS maps or 1:20 000 BCGS maps must include the map name identifier as the image-location-identifier in the file name:

e.g. for 1:250 000 NTS map 104g:

l7_104g_20000821_utm09_30m_b543_enh.tif

e.g. for 1:50 000 NTS map 104g16:

l7_104g16_20000821_utm09_30m_b543_enh.tif

e.g. for 1:20 000 BCGS map 104g089:

l7_104g089_20000821_utm09_30m_b543_enh.tif

6. References

British Columbia Resource Information Standards Committee (RISC). March 2001. Geographic Data BC. British Columbia Standards, Specifications and Guidelines for Resource Surveys Using Global Positioning System (GPS) Technology. Release 3.0. *URL site:* http://ilmbwww.gov.bc.ca/risc/pubs/other/index.htm

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British Columbia Albers Standard Projection. *URL site:* http://ilmbwww.gov.bc.ca/risc/pubs/other/mappro/index.htm

Canadian Earth Observation Network (CEONet). GeoConnections Discovery Portal. *URL site:* http://geodiscover.cgdi.ca/gdp/index.jsp?language=en

USGS Land Processes Distributed Active Archive Center (LP DAAC). *URL site:* http://edcdaac.usgs.gov/main.asp

USGS Land Processes Distributed Active Archive Center (LP DAAC). Landsat 7 ETM+. *URL site:* http://edcdaac.usgs.gov/landsat_notice.asp

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Toutin, T. October 1995. Multisource data fusion with an integrated and unified geometric modelling. EARSeL Advances in Remote Sensing. Vol. 4 (2). 118-129.