SPOT 1 to 4 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 SPOT 1 to 4 panchromatic or monochromatic and multispectral digital satellite imagery can be used in achieving forest and range management objectives.

2. Satellite Programming and Data Archive

Unlike the earlier archiving conditions with SPOT satellite data, SPOT 2 and 4 now need to be specifically programmed to acquire new images. Users must submit satellite-tasking information that includes area of interest bounds, imaging time window and acceptable viewing geometry. A non-refundable Programming Fee is payable at the time of order. Once acquired, images are archived and can be browsed using the SPOT browse system SIRIUS. If new SPOT imagery is required, an acquisition order should be placed 1 to 3 months before the imagery is needed.

3. Data Requirements

1. SPOT 1, 2 and 3 sensors acquire panchromatic image data at a 10 metre nominal pixel size and multispectral image data at a 20 metre nominal pixel size. SPOT 4 sensors acquire monospectral image data at a 10 metre nominal pixel size and multispectral image data at a 20 metre nominal pixel size. Imaging geometry is normally off-nadir and viewing angles may vary from zero to >20 degrees from vertical.

2. The SPOT 1, 2 and 3 panchromatic and SPOT 4 monochromatic imagers acquire imagery over a 60 kilometres wide swath. Standard

scene size is 60 kilometres in the swath direction and 60 kilometres in the along-track direction.

3. Multispectral image data from SPOT 1 to 4 are acquired in 3 bands with a 20 metre nominal pixel size. Bands 1, 2 and 3 are visible green, visible red and near-infrared respectively. SPOT 4 has an additional 4th multispectral band, a short-wave infrared, also with a 20 metre nominal pixel size.

4. For orthogonal geometric correction (orthorectification) of SPOT data, it should be supplied in Level-1A (or equivalent) correction to UTM map projection in DIMAP, or CAP format, on CD-ROM. These formats include the satellite orbit data (ephemeral and attitude) and imaging geometry.

5. Imaging geometry should be as close to nadir as possible to ensure a consistent pixel ground sampling distance. As the off-nadir viewing angle increases, the accuracy of orthorectification will decrease. Off-nadir viewing may be specified to improve opportunities for capture of images in areas subject to cloud. There is an important trade-off between ideal viewing geometry and the likelihood of cloud-free image acquisition. Decisions should consider the risk associated with not obtaining an image during a specified imaging time window and the need for precise positioning of the orthorectified image.

6. 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 SPOT panchromatic or monochromatic imagery 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)).

7. 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.

4. Orthorectification

Orthorectification of full scene SPOT 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 SPOT 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 whenever panchromatic and multispectral data are to be orthorectified, that GCPs be collected for both (i.e. 10 metre panchromatic or monochromatic bands and 20 metre band 3, 2 and 1 colour composite). Sufficient GCPs per full SPOT scene must be collected for use as control in the orthorectification transformation (a minimum of 12 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 checkpoints should also be collected to assess the accuracy of the orthorectification model. The consistency of fit of the orthorectified data to the TRIM map vectors is a good test of the accuracy of the orthorectification process.

3. If more than one adjoining SPOT 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, stereo GCPs, tie points and independent check points is within $\pm$10 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 is used 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 of all orthorectified SPOT image data must be evenly divisible by 100 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.

5. 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 or monochromatic bands 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 100 metres and file origins should be defined in even 100 metres.

6. Deliverables

Orthorectification, it is recommended that deliverables for SPOT 1 to 4 full scenes should include:

1. Uncorrected working files in PCIDSK *.pix format. These files must contain the GCP segments used in the orthorectification.

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 SPOT 1 to 4 satellite data may include un-enhanced resampled 10 metre pixel panchromatic or monochromatic bands (depending on satellite) and un-enhanced 20 metre pixels for multispectral bands 1, 2 and 3. An intensity hue saturation (IHS) fusion of the SPOT 1 to 4 panchromatic or monochromatic bands together with bands 5, 4 and 3 from a Landsat 5 or 7 image may be requested. LUTs used for enhancement of the panchromatic or monochromatic band, bands 5, 4 and 3 of the Landsat image 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 SPOT 1 to 4 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 track 517 frame 245, acquired by SPOT 2 on September 13, 2002, un-enhanced 10 metre panchromatic band, delivered in PCIDSK format:

   s2_517245_20020913_utm10_10m_pan.pix

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

   s2_517245_20020913_ bcalb _10m_pan.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 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 SPOT image. The typical enhanced deliverables include the enhanced panchromatic or monochromatic image. If the SPOT panchromatic or monochromatic data has been IHS fused with Landsat 5 or 7, the typical enhanced deliverables will also include the Landsat 5 or 7 image bands 5, 4 and 3 as Red, Green and Blue (RGB) and an enhanced IHS fuse of the SPOT panchromatic or monochromatic with bands 5, 4 and 3 of the Landsat 5 or 7 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 SPOT 5 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-identifier-(metres)_band-identifier_enhanced.file-format-extension

   e.g. for track 517, frame 245, acquired by SPOT 2 on September 13, 2002, enhanced 10 metre panchromatic band, delivered in GeoTIFF format:

   s2_517245_20020913_utm10_10m_pan_enh.tif

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

s2_517245_20020913_bcalb_10m_pan_enh.tif

e.g. for orthorectified and enhanced IHS fuse of the SPOT 2 panchromatic with Landsat 7 multispectral bands 5, 4 and 3 as Red, Green, Blue (RGB):

s2_l7_517245_20020913_utm10_10m_ihs_enh.tif

7. The generic file naming scheme for SPOT 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 94f:

s2_94f_20020913_utm10_10m_pan_enh.tif

e.g. for 1:50 000 NTS map 94f16:

s2_94f16_20020913_utm10_10m_pan_enh.tif

e.g. for 1:20 000 BCGS map 94f035:

s2_94f035_20020913_utm10_10m_pan_enh.tif

7. 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://srmwww.gov.bc.ca/risc/pubs/other/index.htm

British Columbia Ministry of Sustainable Resource Management. October 1996. Base Mapping and Geomatic Services Branch. Gridded DEM Specification. Release 1.1. *URL site:* http://srmwww.gov.bc.ca/bmgs/products/griddem.htm

British Columbia Ministry of Sustainable Resource Management. January 1992. Base Mapping and Geomatic Services Branch. British Columbia Specifications and Guidelines for Geomatics, Content Series Volume 3, Digital Baseline mapping at 1:20 000. Release 2.0. Terrain Resource Information Management (TRIM) program. *URL site:* http://srmwww.gov.bc.ca/bmgs/trim/trim/index.html

British Columbia Albers Standard Projection. *URL site:* http://srmwww.gov.bc.ca/gis/bceprojection.html

SPOT Image. *URL site:* http://www.spot.com

SIRIUS on line catalogue of archived SPOT data. *URL site:* http://sirius.spotimage.fr/anglais/welcome.htm

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

USGS Earth Explorer. *URL site:* http://edcsns17.cr.usgs.gov/cgi-bin/EarthExplorer/phtml/verify_login.phtml

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

USGS Global Visualization Viewer. *URL site:* http://glovis.usgs.gov/

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