Geolocation Accuracy Evaluation of Global Land Survey 2005 Imagery Layer

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Global Land Survey 2005 (GLS2005)

GLS2005 is a global ground-controlled and orthorectified image base consisting of imagery from the Landsat 5 Thematic Mapper (TM), Landsat 7 Enhanced Thematic Mapper Plus (ETM+), Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), and Earth Observing 1 (EO-1) Advanced Land Imager (ALI) sensors. GLS2005 images were obtained for this evaluation from the Global Land Cover Facility (GLCF) web site (www.landcover.org) and are distributed as band-separated GeoTIFF files in the Universal Transverse Mercator (UTM) map projection and grid coordinate system. GLS2005 is an improved and more current version of its predecessor Landsat GeoCover imagery base layer.

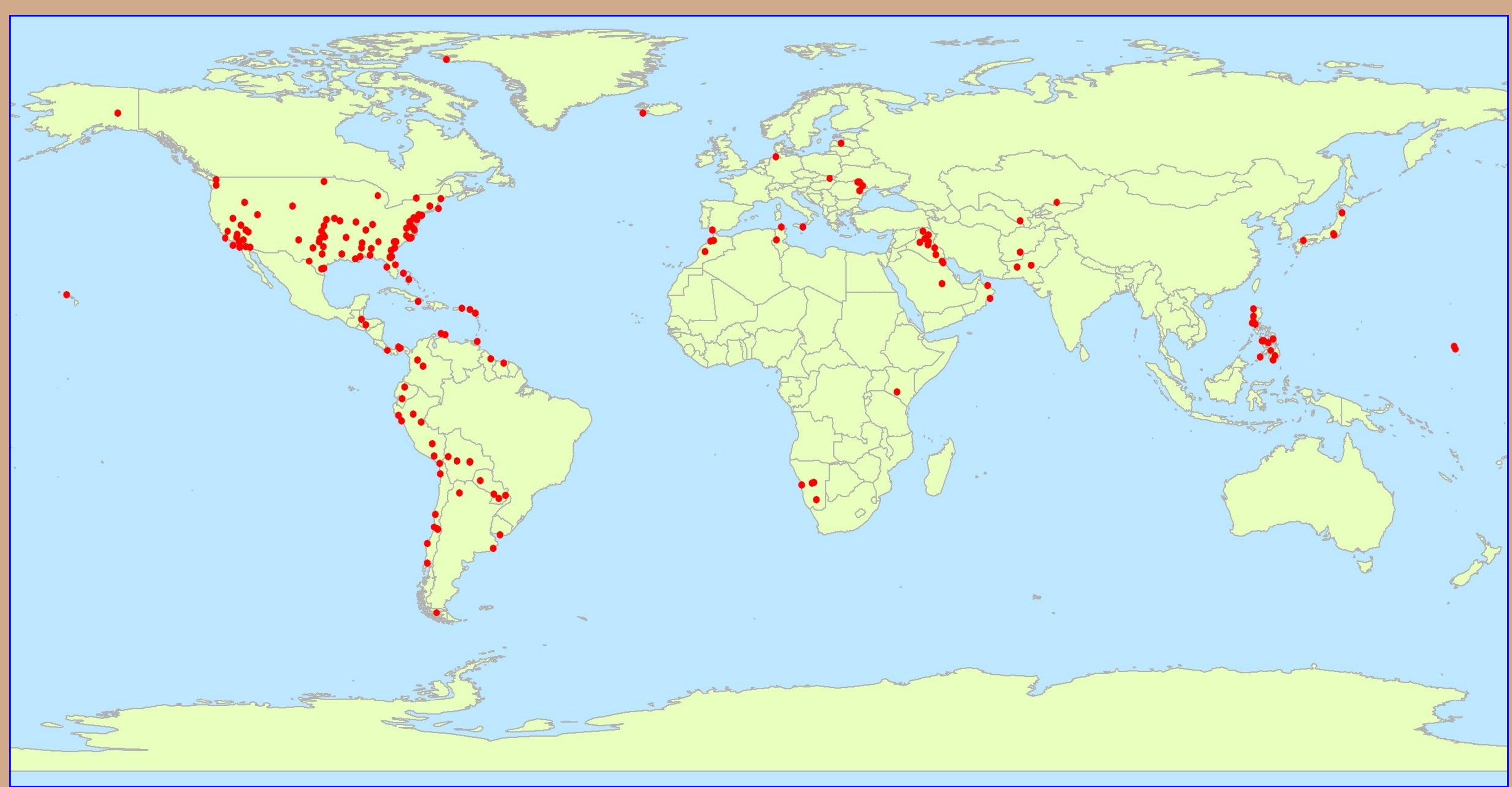
NIQU/CCAP downloaded 202 GLS2005 images from the GLCF over the available test sites. 159 of the images are from Landsat 7 ETM+ and 43 are from Landsat 5 TM. The "2005" in GLS2005 indicates the general collection epoch for the imagery base layer, with the actual collection dates between 2004 and 2007. Due to limited coverage over NIQU/CCAP test sites, this evaluation did not include imagery from the ASTER and EO-1 ALI sensors.

Test Sites

NIQU/CCAP estimated the absolute geolocation accuracy by comparing ground coordinates derived from the images to photo-identifiable Ground Control Points (GCPs) used as Check Points (CPs). These ground truth CPs are extracted from the Terminal Aeronautical Global Navigation Satellite System (GNSS) Geodetic Survey (TAGGS) program data. The CPs are accurate to a sub-meter level.

Figure 1 portrays the global distribution of the 185 test sites that NIQU/CCAP used for the GLS2005 evaluation.

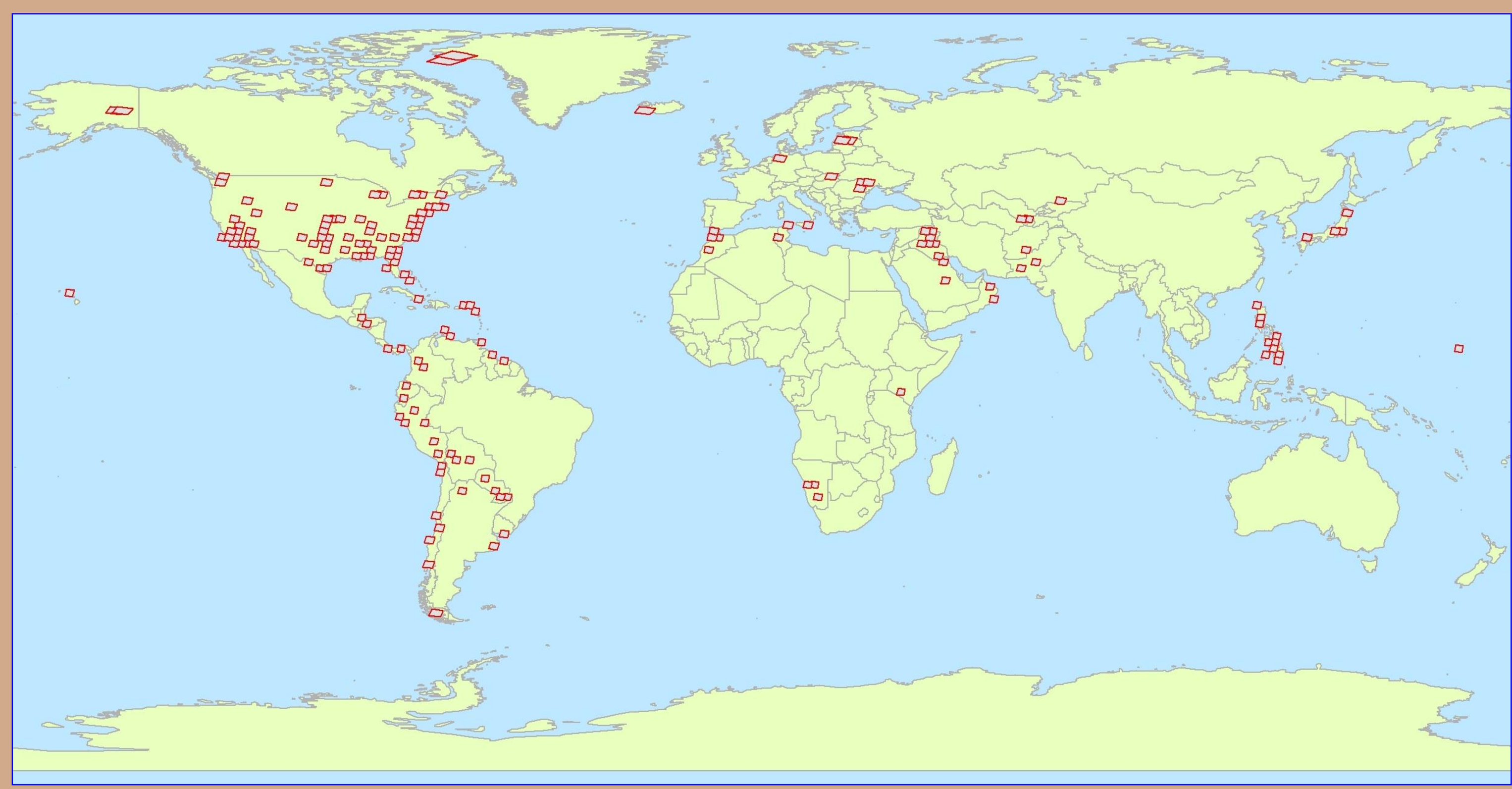
Figure 1. Test Sites Used for the GLS2005 Evaluation



The Evaluation

The National Geospatial-Intelligence Agency (NGA) Image Quality and Utility (NIQU) / Civil and Commercial Applications Project (CCAP) performed an absolute geolocation accuracy evaluation of GLS2005 imagery. Imagery bases such as GLS2005 and its Landsat GeoCover predecessor are used by some imagery providers as an imagery control base. The objectives of this evaluation were to quantify the geolocation accuracy of GLS2005, and thus the expected accuracy of imagery registered to it, and to compare it to its predecessor Landsat GeoCover layer. Because some GLS2005 images simultaneously cover multiple test sites and because some test sites are covered by adjacent, overlapping Landsat orbital paths, a total of 238 individual test cases were formed for the evaluation. **Figure 2** depicts the Landsat path/rows used for the GLS2005 evaluation.

Figure 2. Path/Row Used for the GLS2005 Evaluation



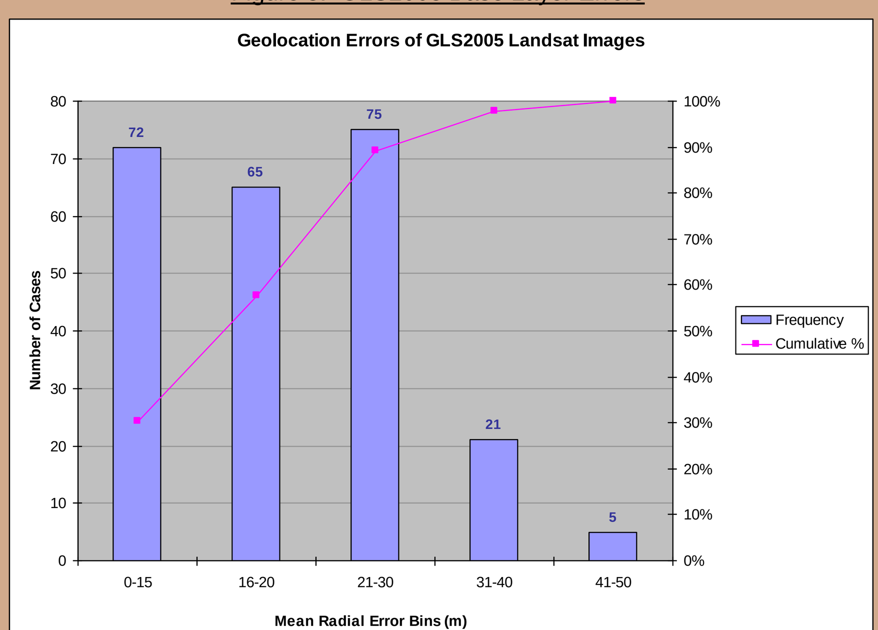
Test and Evaluation Methodology

- **Imagery Import**
  NIQU/CCAP obtained the GeoTIFF images from the GLCF and evaluated the images "as is" without any triangulation or registration. The imagery was imported using SOCET Set® v5.5 photogrammetric software.
- **Point Measurement and Ground Coordinate Comparison**
  The SOCET Set® Control Point Editor (CPE) and Coordinate Measurement Tool (CMT) were used to record radial distances between the truth and observed points on the imagery, which typically included only 2-4 CPs per site due to the coarse ground sampled distance of the Landsat imagery.
- **Absolute Geolocation Accuracy Estimation**
  NIQU/CCAP used the mean radial error between the imagery-derived and ground-surveyed coordinates on each test case as a single data point representing the horizontal radial error for the estimation of Circular Error 90% (CE90). NIQU/CCAP sorted the mean radial errors from smallest to largest and then determined the value at the 90th percentile position. In this way, each test case's mean radial error value serves as a single, equally-weighted data point in the CE90 estimation.

Results

NIQU/CCAP estimated statistics using the differences between the imagery-derived ground coordinates and the photo-identifiable ground surveyed coordinates for each test case. The primary data points obtained were the mean radial error and azimuth of each test case. **Figure 3** shows a histogram of the mean radial errors from the 238 test cases of GLS2005 images. The data presented shows that almost 90% of analyzed scenes were within 30 meters of surveyed check points. The assessed CE90 for GLS2005 was 31.7 meters. No image evaluated exceeded the mean radial error bin of 41-50 meters, and the largest observed error was 49 meters.

Figure 3. GLS2005 Base Layer Errors



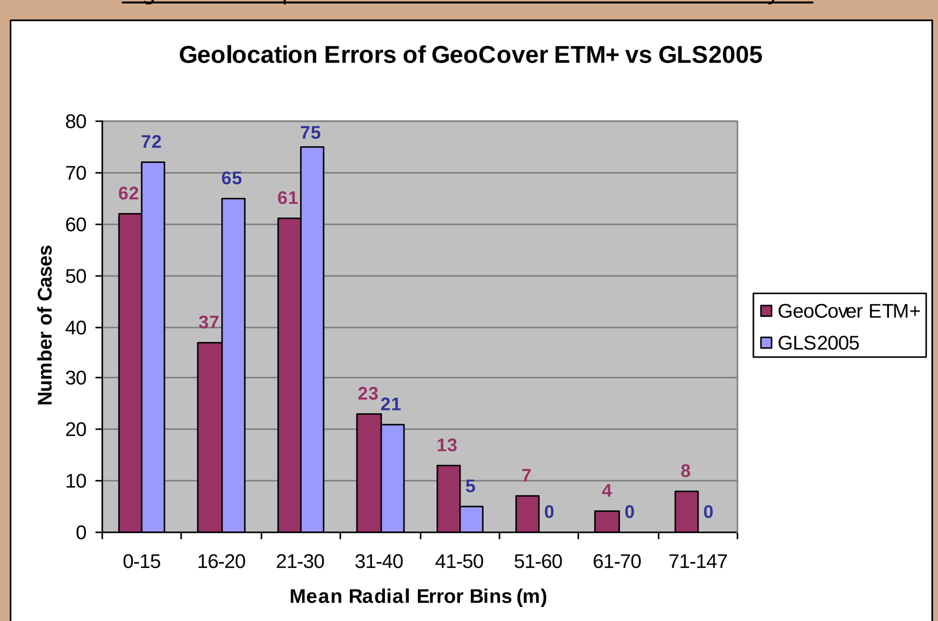
Key GLS2005 Statistics

Number of Images Evaluated:	**202**
Number of Test Cases Formed:	**238**
Monoscopic CE90 (m):	**31.7**
Maximum Observed Error (m):	**49**

Analysis and Conclusions

Figure 4 compares the Landsat GLS2005 layer to its predecessor Landsat GeoCover layer sorted into the same mean radial error bins for ease of analysis. In this case, all of the GeoCover imagery was from the Landsat 7 ETM+ sensor collected in the 2000-era and was assessed in a previous NIQU/CCAP evaluation. As can be seen from the histogram, both datasets exhibit somewhat similar accuracy where the majority of the errors reside in the first three low-error bins (0-15, 16-20, 21-30). These bins when combined for each layer represent 74% of the GeoCover ETM+ errors and 89% of the GLS2005 errors. Upon further analysis it is evident that the most notable improvement of the GLS2005 layer over the GeoCover ETM+ layer is the lack of outliers, or images that greatly exceed expected accuracy. Of the GLS2005 images, no radial error exceeded 49 meters. Conversely, the GeoCover ETM+ layer had a significant number of errors in the top three bins (51-60, 61-70, 71-147). Almost 9% of the GeoCover ETM+ errors resided within these bins, with the maximum observed radial error being 147 meters. The presence of outliers increased the monoscopic CE90 of the GeoCover ETM+ layer significantly, to 48.0 meters.

Figure 4. Comparison of GLS2005 and GeoCover ETM+ Layers



The primary conclusion of this evaluation is that there is a marked decrease in the number of outlier images in the GLS2005 layer compared to the GeoCover ETM+ layer. **Table 1** shows a comparison of 7 selected path/row images with higher-than-expected errors from the GeoCover ETM+ layer alongside the errors of the same path/row images from the GLS2005 layer. The table clearly shows the accuracy improvement for these selected sites for the re-processed GLS2005 layer.

Table 1. Outlier Analysis of Selected Images

Path/Row	GeoCover ETM+ Mean Radial Error (m)	Location	GLS2005 Mean Radial Error (m)
12-54	147	Tocumen, Panama	15
12-54	119	Howard, Panama	17
12-54	113	Enrique Adolfo Jimenez, Panama	13
228-75	106	Mariscal Estigarribia, Paraguay	22
231-77	95	Salta, Argentina	39
41-37	76	San Clemente, California	22
19-49	74	Puerto Barrios, Guatemala	17

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