Landsat Ground Control Point (GCP) Improvement

June 5, 2014

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*Work performed under U.S. Geological Survey contract G10PC00044

U.S. Department of the Interior
U.S. Geological Survey
Overview

- **GCP Improvement Project Background and Goals**
  - Repair regions with poor accuracy
  - Refresh circa-2000 ETM+ GCP image chips with OLI data
  - Upgrade DEM (high latitude areas) if possible

- **GCP Improvement Plan**
  - Re-triangulate problem areas in three groups (phases)
    - High priority areas, low-latitude areas, Arctic areas
  - Extract new layer of OLI image chips globally
  - Evaluate potential sources for improved DEM data

- **GCP Improvement Status**
  - Phase 1 Results
  - Future Schedule

- **Summary and Conclusions**
The global control point library used for Landsat product generation was derived from the Global Land Survey (GLS) of 2000 data set

- This ensures that new products are consistent with the existing archive (and each other) and provides ~30m (CE90) accuracy

The GLS was originally established by triangulating blocks of ETM+ imagery containing sparse control provided by NGA (DoD)

- Scenes containing NGA control are referred to as “anchor” sites
- Some areas (e.g., NE Asia, islands) had little or no NGA control
- Landsat 7 scenes were used to “control” these areas

Landsat 8 has shown us that some areas that lack anchor sites are inaccurate

- It has also shown us areas where temporal change since GLS2000 has made the GCPs perform poorly
Anchor Site Distribution

- Note the gap north of 60N and east of 90E and the lack of sites away from continental land masses
Landsat GCP Improvement Goals

- The 18-20m (CE90) geolocation accuracy of Landsat 8 has allowed us to identify areas where the GLS-derived global control point library is deficient
  - Areas that exhibit repeatable large offsets will be re-triangulated
- The existing control library image chips are all Landsat 7 ETM+ (8-bit) circa 2000
  - We want to extract up-to-date 16-bit Landsat 8 Operational Land Imager (OLI) chips for the GCPs
- Some regions exhibit significant temporal and/or seasonal changes that degrade GCP performance
  - Will extract additional seasonal or multi-temporal chips
- The Landsat DEM relies upon GTOPO30 data in some high latitude areas (north of SRTM coverage)
  - Will evaluate potential alternative DEM sources
GCP Improvement Approach

- Landsat 8 images are used in satellite block triangulation adjustments to correct problem areas
  - GCP measurements collected as part of the L1T product generation process are used as input
  - In locations with temporal problems, create new OLI GCPs
  - GCPs in problem scenes are allowed to adjust
  - GCPs in nearby scenes are held fixed to remain consistent with the surrounding area

- The new GCP positions are verified using independent test scenes and data from WorldView and/or Landsat international cooperators
Landsat GCP Improvement Plan

• Triangulation updates are proceeding in three phases:
  ◆ Phase 1 – Fifteen high priority areas with largest offsets
  ◆ Phase 2 – Remaining low latitude areas
  ◆ Phase 3 – High latitude areas

• The updated GCP positions will be released upon the completion of each phase
  ◆ Phase 1 is now complete (results are summarized in this presentation) and updated GCPs will be released soon

• Once all triangulation updates are complete, new OLI image chips will be extracted for all GCPs
  ◆ The original ETM+ chips will also continue to be used

• Newer DEM sources (e.g., ASTER DEM, WorldDEM) will be evaluated as possible replacements for the GTOPO30-derived GLS DEM in high latitude areas
GCP Problem Area Locations

- GLS Control
- Phase 1 - High Priority
- Phase 2
- Phase 3 - Arctic
Phase 1 Triangulation Results

- The first 15 triangulation blocks are complete
  - Updated GCPs will be installed into production with the next release of the IAS/LPGS (this summer)
  - Some upgrades to the GCP database design (e.g., GCP version tracking) were required to implement the new points

- A triangulation report is created for each block
  - Shows the area affected and the pre- and post-adjustment geodetic accuracy as measured by Landsat 8
  - Shows the number of points adjusted, the number of points that could not be correlated and were deactivated, and the average adjustment for each scene
  - Shows independent (e.g., WorldView) accuracy testing results

- The triangulation reports will be available from the Landsat web site once the new GCPs are released
Phase 1 Block Locations
### Balearic Islands Block Example

#### Net Geodetic Offset in Meters

<table>
<thead>
<tr>
<th>WRS Row</th>
<th>Pre-Fit</th>
<th>Test Scenes</th>
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Red indicates scenes that were adjusted in the triangulation.
**Bold outline** indicates NGA anchor sites.
**Yellow background** indicates scenes included in the triangulation.
WorldView Verification Summary

- Used WorldView data to test at least one scene in each block where control points were readjusted
  - Chad and Mauritania had OLI GCPs extracted and were not tested
- Results are consistent with L8 validation scenes

<table>
<thead>
<tr>
<th>Triangulation Block</th>
<th>Path</th>
<th>Row</th>
<th># Points</th>
<th>X Mean (m)</th>
<th>Y Mean (m)</th>
<th>X StdDev (m)</th>
<th>Y StdDev (m)</th>
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Summary

- Landsat GCP improvement efforts are underway
  - Goal is to improve the absolute accuracy of Level 1T products by upgrading the underlying GLS control framework
  - Completed first phase with the 15 most problematic areas
  - Subsequent phases will address remaining areas
  - Scenes in areas with updated GCPs will be reprocessed

- New circa 2013-2014 OLI image chips will be extracted for the Landsat GCP library
  - Will also examine temporally and seasonally variable areas as candidates for the extraction of GCP chips with multiple dates

- Will also evaluate DEM data alternatives for high latitude areas lacking SRTM data