

Landsat Ground Control Point (GCP) Improvement

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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

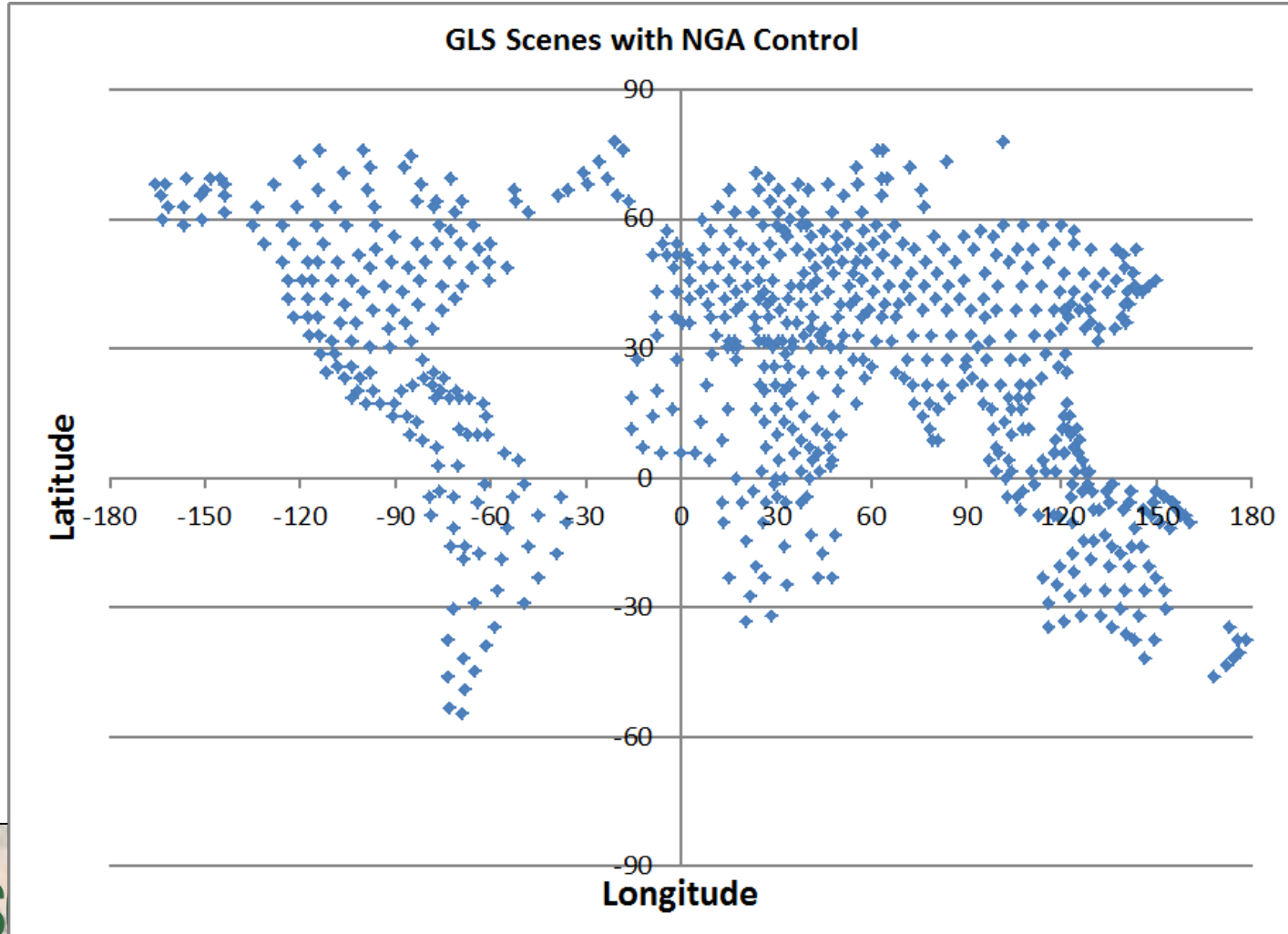
- **Summary and Conclusions**

GLS Ground Control Background

- **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

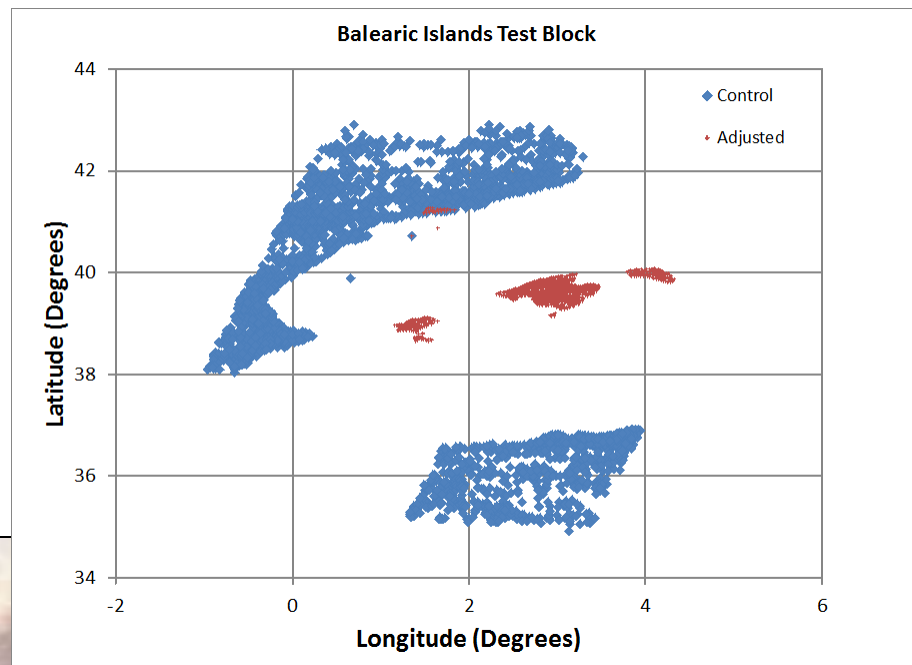


Landsat GCP Improvement Goals

- **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

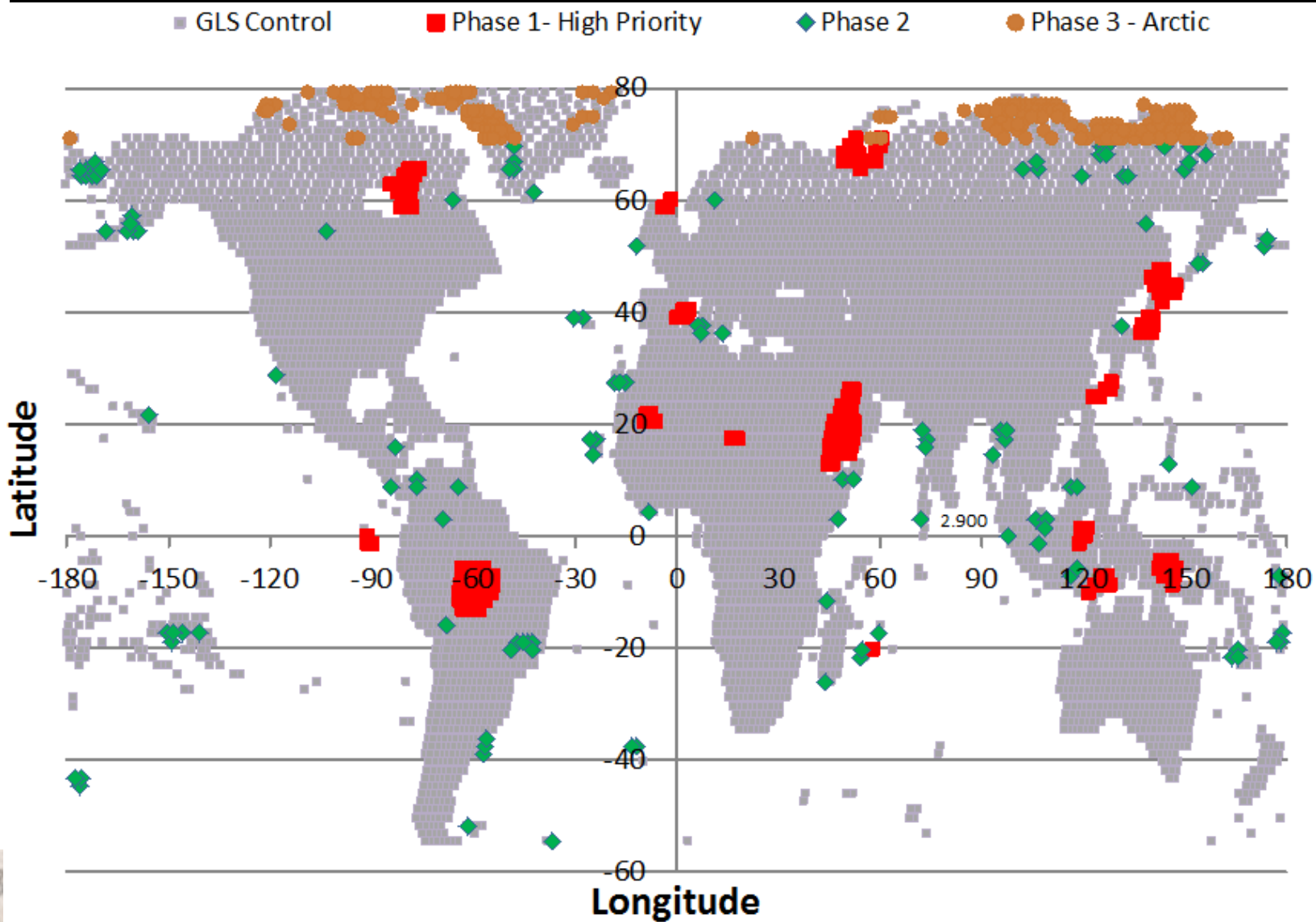
- **Landsat 8 images are used in satellite block triangulation adjustments to correct problem areas**
 - ◆ GCP measurements collected as part of the L1T product generation process are used as input
 - ◆ In locations with temporal problems, create new OLI GCPs
 - ◆ GCPs in problem scenes are allowed to 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**

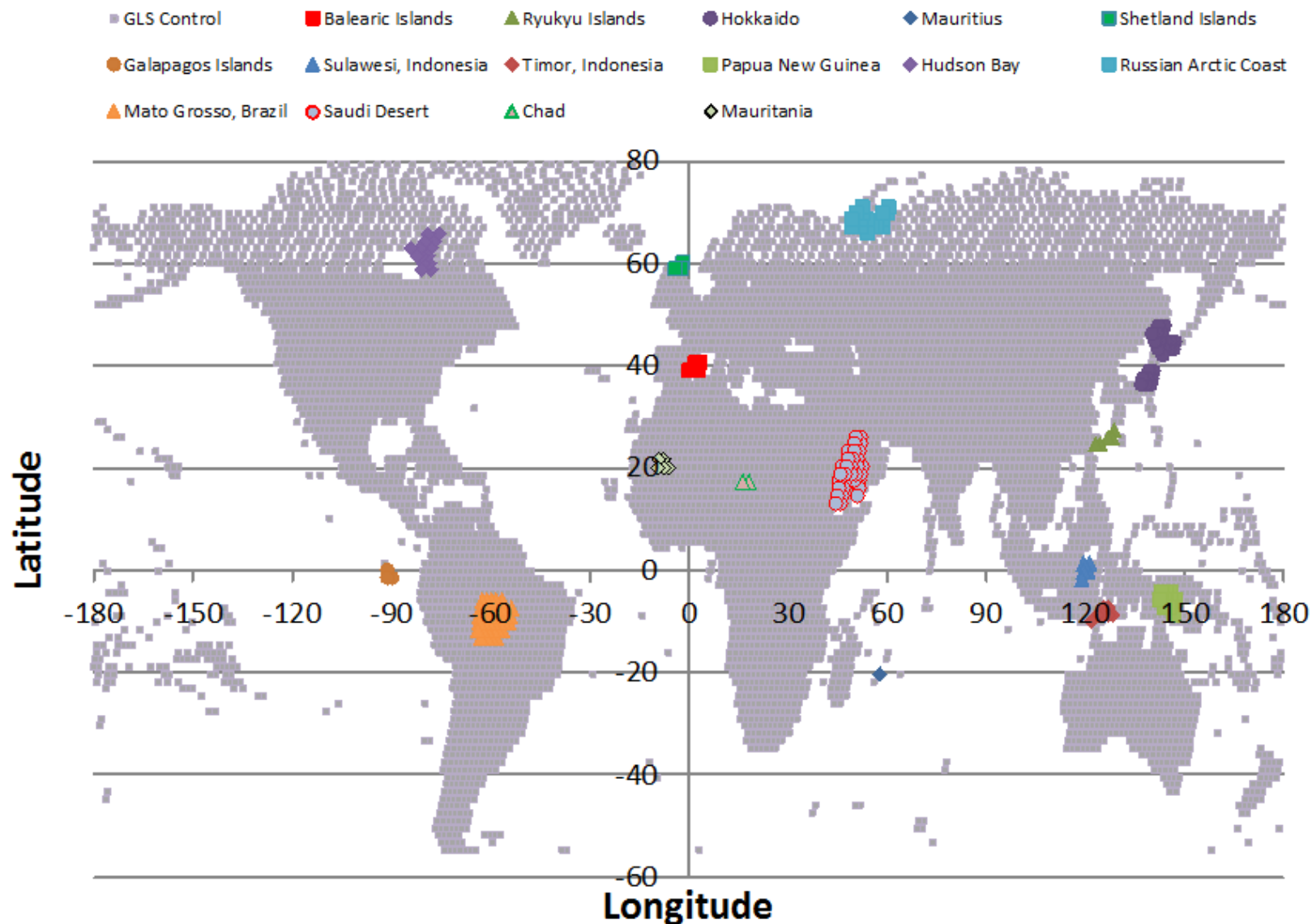
GCP Problem Area Locations



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

Triangulation Scenes
Pre-Adjustment

Pre-Fit		WRS Path		
		198	197	196
WRS Row	31	10	8	
	32	13	166	174
	33	57	156	167
	34	29	18	25
	35	17	10	18

Validation Scenes
Post-Adjustment

Test Scenes		WRS Path		
		198	197	196
WRS Row	31	10	8	
	32	13	12	21
	33	29	20	20
	34	29	18	25
	35	17	10	18

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**

Triangulation Block	Path	Row	# Points	X Mean (m)	Y Mean (m)	X StdDev (m)	Y StdDev (m)
Balearic Islands	196	32	10	-4.50	1.13	7.03	4.35
Balearic Islands	196	33	10	-6.75	-0.38	4.94	4.13
Ryukyu Islands	113	42	26	7.93	0.29	5.84	4.49
Hokkaido	105	30	10	9.75	21.00	6.66	4.74
Hokkaido	107	29	10	-4.50	7.88	5.53	7.17
Hokkaido	108	28	15	-7.25	1.00	7.43	6.41
Mauritius	152	74	20	2.92	-6.18	6.51	3.28
Shetland Islands	205	18	20	-6.38	4.50	7.31	6.51
Galapagos Islands	18	60	20	7.50	2.25	4.39	3.31
Sulawesi, Indonesia	114	59	20	2.81	-9.56	5.82	6.61
Timor, Indonesia	109	66	20	-7.13	-7.13	4.70	9.73
Papua New Guinea	98	63	20	23.44	-12.00	7.49	5.25
Hudson Bay	23	18	20	1.50	-8.06	5.89	6.35
Russian Arctic Coast	174	12	20	7.50	-4.50	4.71	7.26
Mato Grosso, Brazil	228	67	20	-0.94	1.13	3.41	4.57
Mato Grosso, Brazil	229	67	20	6.75	6.75	5.52	9.15
Saudi Desert	163	46	10	3.75	-10.13	9.52	15.52
Totals	17	scenes	291	2.14	-0.71	6.21	7.03

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**