



# ***Viability of NLCD Products From IRS-P6, And From Landsat 7 Scan-gap Data***

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

**Center for Earth Resources**  
**Observation and Science (EROS)**

<http://edcwww.cr.usgs.gov/>

# Why?

## *National Land Cover Dataset (NLCD) –*

Nationwide products of 30m pixel data layers, generated from at least 3 dates (leaf-off, leaf-on, spring) of Landsat 5/7 imagery. All landsat imagery is preprocessed with precision terrain-corrections, and normalized with at-satellite reflectance.

Current national products are Land Cover, Percent Tree Canopy, and Percent Impervious Surface.

Second generation (NLCD '01) is being finished. Next generation is being discussed (NLCD '06/'07).

With the aging of Landsat 5, and current scan-gap problems with Landsat 7, alternative data platforms and providers must be considered.

# What are AWiFS and LISS-III?

Indian Government satellite, RESOURCSAT-1 (also called IRS-P6)

IRS-P6 carries three sensors

- High Resolution Linear Imaging Self-Scanner (LISS-IV)
- Medium Resolution Linear Imaging Self-Scanner (LISS-III)
- Advanced Wide Field Sensor (AWiFS)

LISS-III is a medium resolution sensor offering a GSD of 23.5m

- Quantization: 7 bits (SWIR band 10 bits – selected 7 transmitted)
- Ground swath is 141 km with 24 days repeat cycle
- Operates in four spectral bands - similar to Landsat bands 2,3,4,5

AWiFS with twin cameras is a moderate-resolution sensor offering a GSD of 56m

- Quantization: 10 bits
- Combined ground swath is 740km with five days repeat cycle
- Operates in four spectral bands – similar to Landsat bands 2,3,4,5

*Assumption: AWiFS and LISS-III spectral bands are similar to Landsat 5 & 7 bands 2, 3, 4, 5.*

*Note: AWiFS and LISS-III lack any spectral bands similar to Landsat bands 1 and 7.*



## ***What Datasets Were Evaluated?***

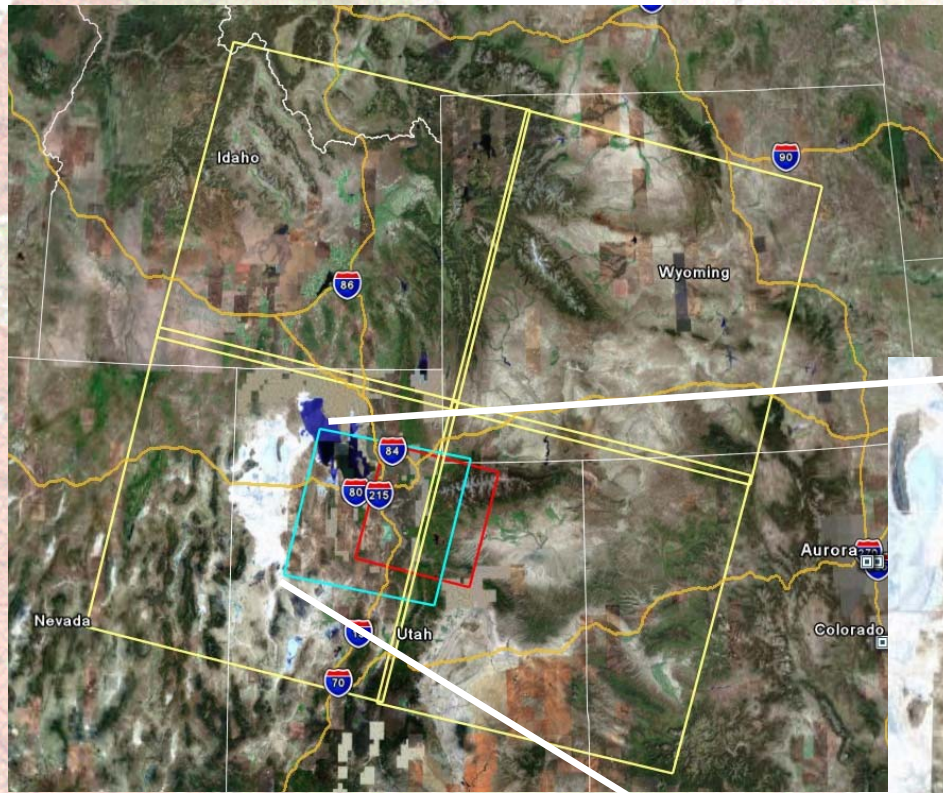
Two test sites were found to contain same-day acquisitions – Salt Lake, UT and Mesa, AZ.

In Salt Lake, a cloudfree IRS-P6 AWiFS and LISS-III scene was acquired on June 19, 2005. ~35 minutes later, a Landsat 5 scene covering part of the AWiFS footprint was acquired.

In Mesa, a cloudfree IRS-P6 AWiFS and LISS-III scene was acquired on June 29, 2005. ~35 minutes later, a Landsat 7 scene covering part of the same footprint was acquired. Because of the scan-gap issue, the prior and post scenes (June 13, July 15) were also obtained, making a completed L7-based dataset.

In both test sites, the area in common to all images was evaluated for each available image source, in terms of its ability to duplicate existing NLCD products.

# Salt Lake Tests – AWiFS, LISS-III, L-5



Yellow – AWiFS (56m) Quadrants  
Red – LISS-III (23.5m)  
Cyan – Landsat 5 (30m)



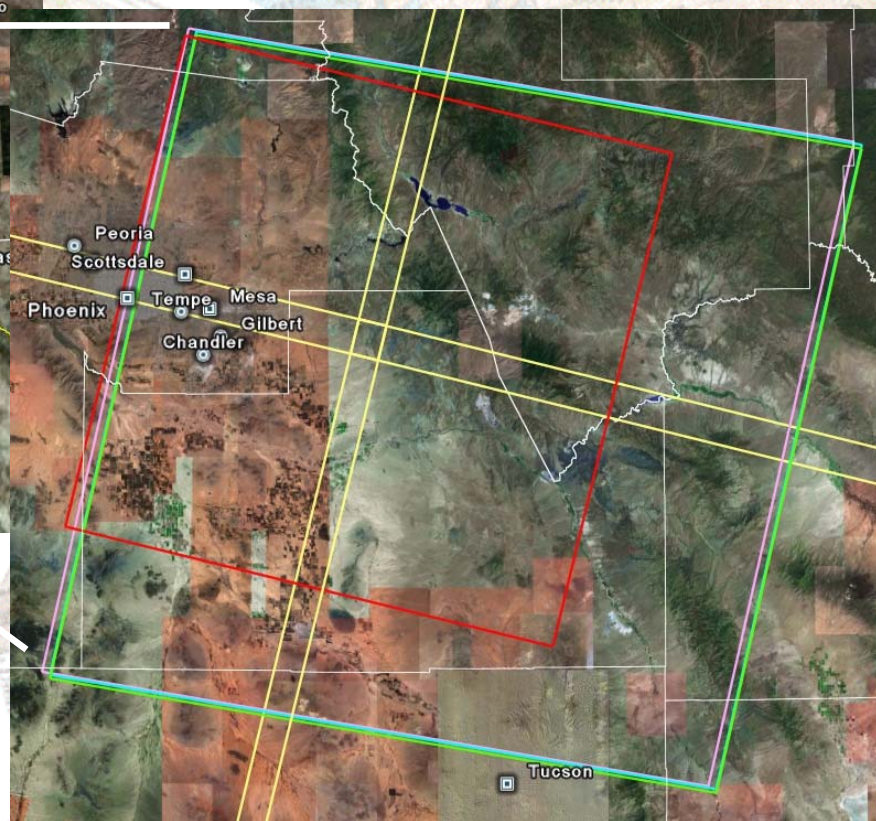
Extents of common areas for L5/AWiFS are L5, straddling two AWiFS quadrants.

Extents of common areas for L5/LISS-III are ~80% complete footprint of LISS-III.

# Mesa Tests – AWiFS, LISS-III, L-7 (3 dates)



Yellow – AWiFS (56m) Quadrants  
Red – LISS-III (23.5m)  
Cyan, Green, Magenta – Landsat 7 scan gap data (30m, 3 dates)



Extents of common areas for L7/AWiFS are L7, straddling four AWiFS quadrants.

Extents of common areas for L7/LISS-III are ~97% complete footprint of LISS-III.

## ***Experimental Design-***

Constructed artificial products by massively sampling existing products, and assessed each image's ability to generate a duplicate by comparing its version to the source.

Purposely did NOT use ancillary information - results are generated based solely on spectral information unique to each dataset.

All AWiFS and LISS-III products were reprojected to standard USGS Albers projection, and resampled with cubic convolution to 30m, to match NLCD needs and conventions as closely as possible.

Due to differing common extents on each test site, 2 results are reported per product, per site.

All classifications used standard NLCD tools (See5, Cubist) for classification logic.

## ***Experimental Procedures-***

*Land Cover* (available for Salt Lake site only) -

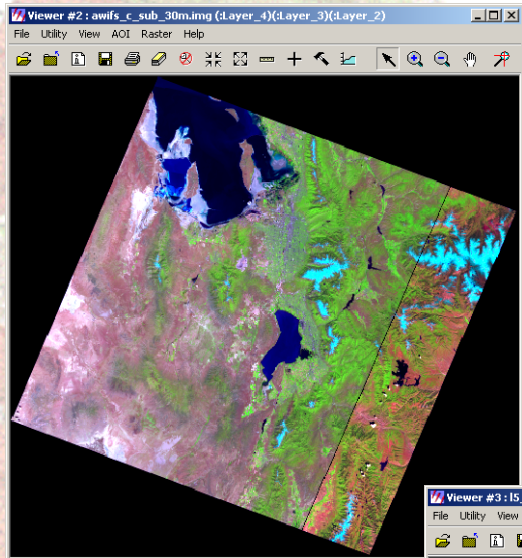
10,000 random points extracted per land cover class from existing land cover product, yielding 110,000 points total for 11 NLCD classes. Urban classes were excluded, as they are derived from a separate product, the impervious estimation. Points common to all image pairs were used for classification via decision tree, with cross-validation and boosting options.

*Percent Canopy Density, Percent Impervious Surface* (Salt Lake and Mesa sites) -

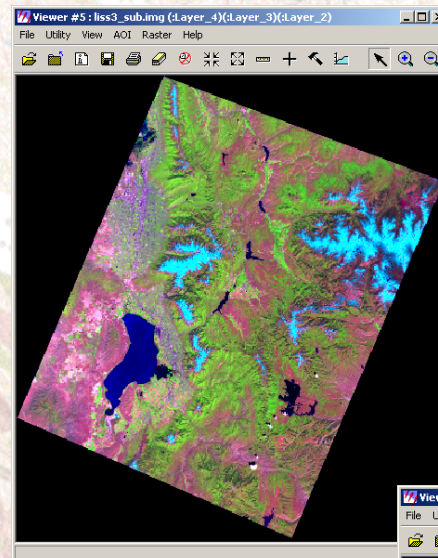
~1,000 random points extracted per value, from 1 to 100, for ~100,000 points total. Points common to all image pairs were used for continuous estimations via multiple regression, with cross-validation and committee model options.



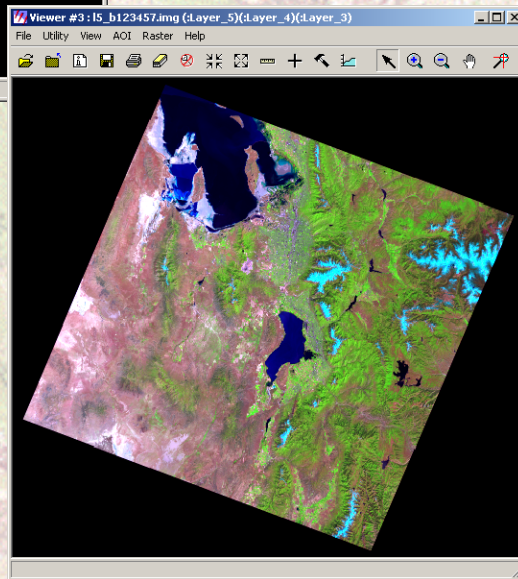
# Salt Lake – AWiFS, LISS-III, L5 Imagery



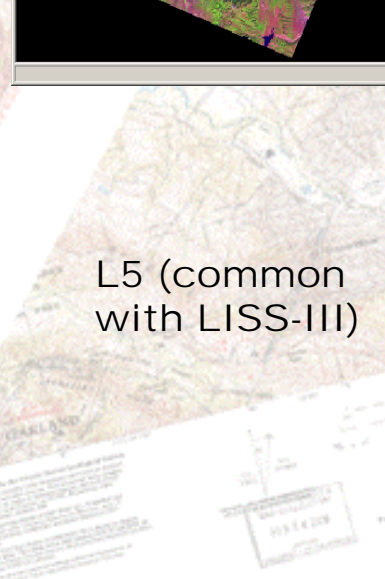
AWiFS  
(common with L5)



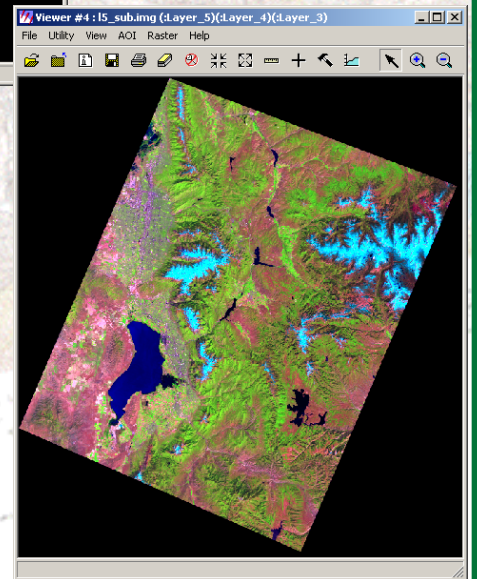
LISS-III  
(common with L5)



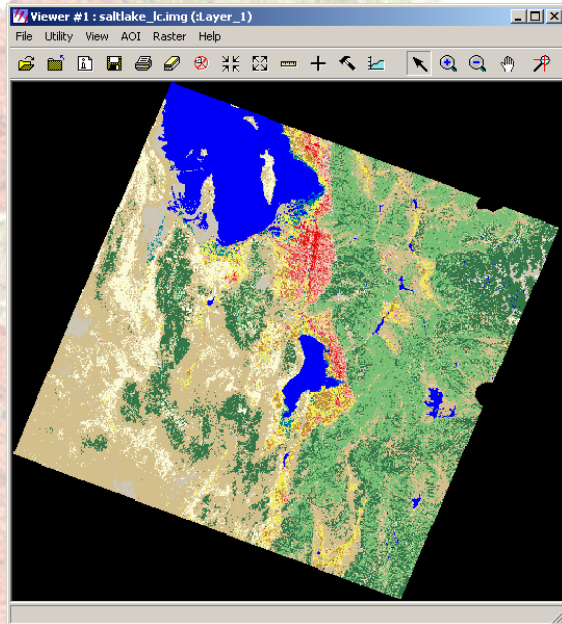
L5  
(full scene)



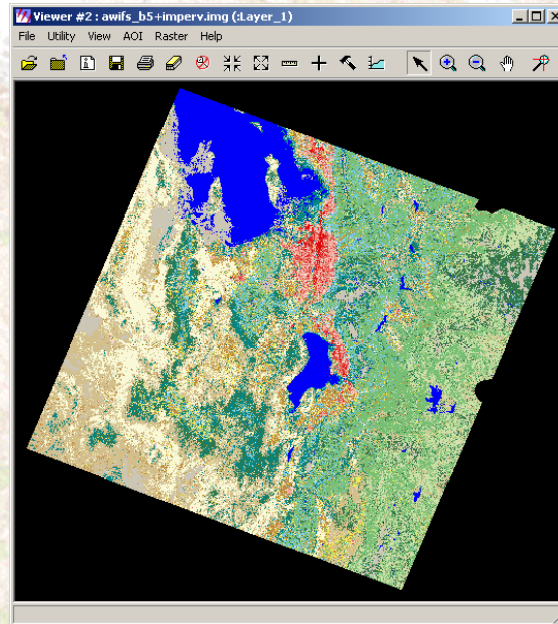
L5 (common  
with LISS-III)



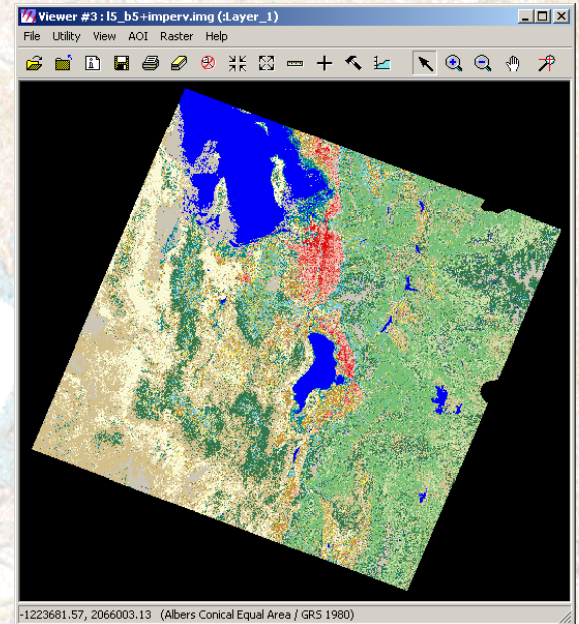
# Salt Lake – Land Cover, AWiFS & L5



Original Land Cover



AWiFS

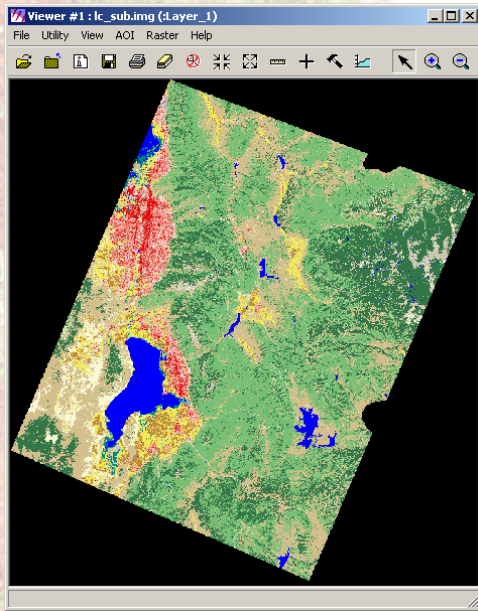


Landsat 5

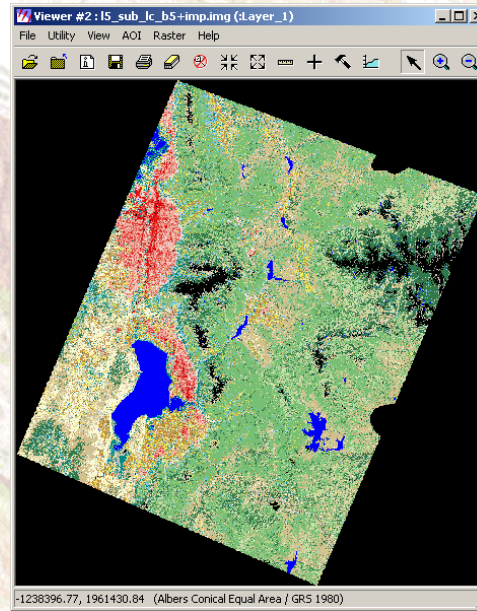
Cross validation shows a consistently more complex tree (about 20% more nodes) with L5 data, likely due to the presence of bands 1 and 7.

Mean error estimate: 44.9% AWiFS, 42.8% L5.

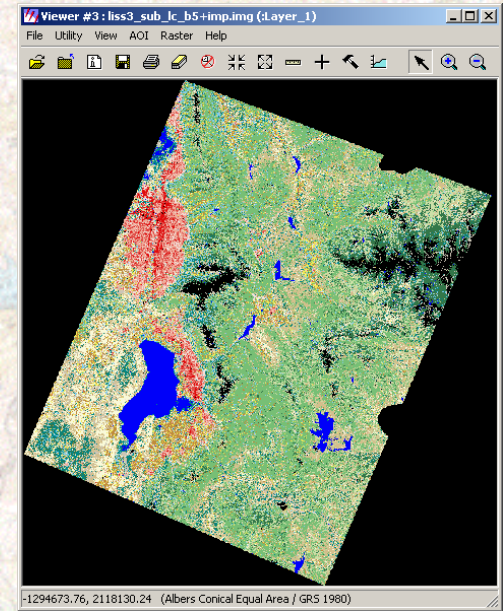
# Salt Lake - Land Cover, LISS-III & L-5



Original Land Cover



LISS-III



Landsat 5

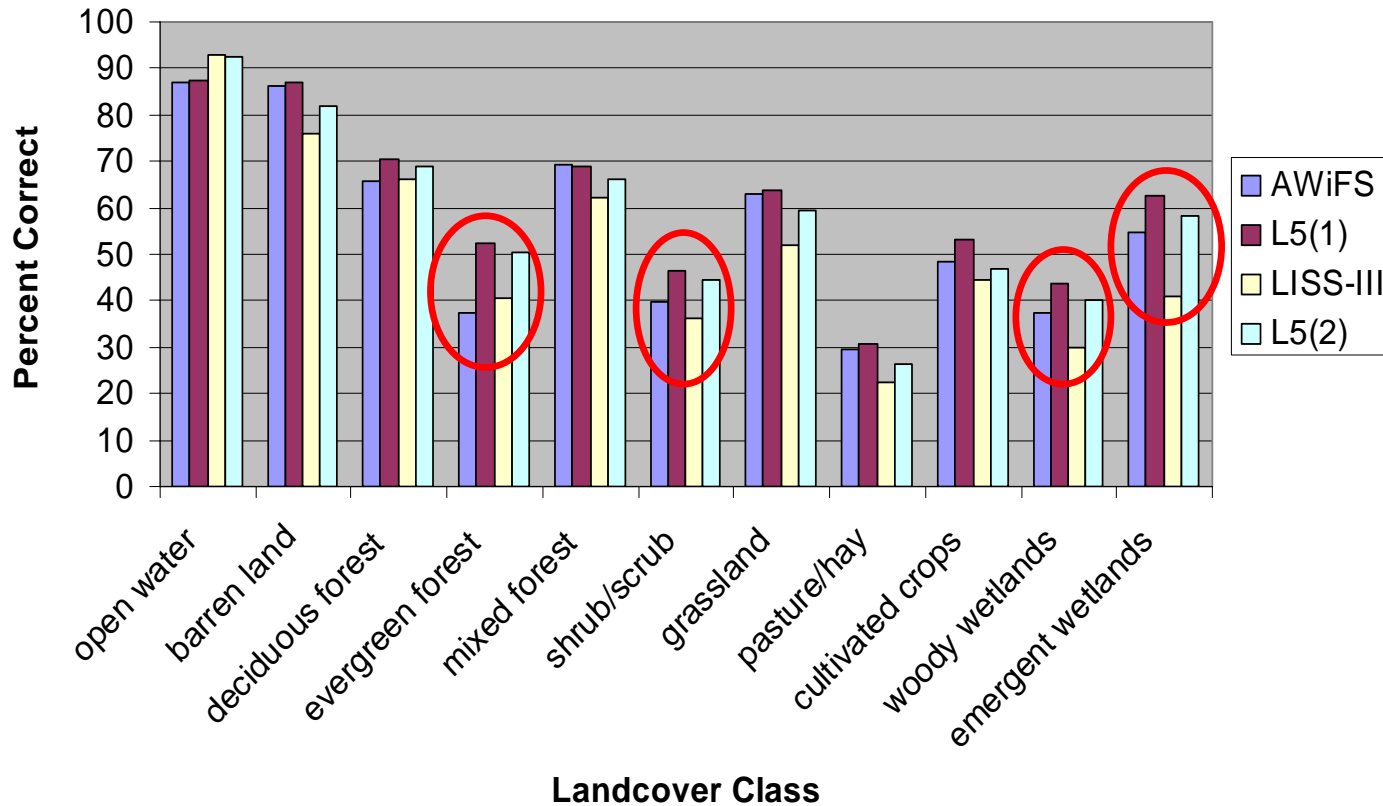
Cross validation shows ~10% more nodes with L5 vs LISS-III

Mean error estimate: 50.7% LISS-III, 44.8% L5.

NOTE: Areas of snow cover present in imagery on the higher elevations has been masked out. No training data for "perennial ice and snow" existed in this small region.

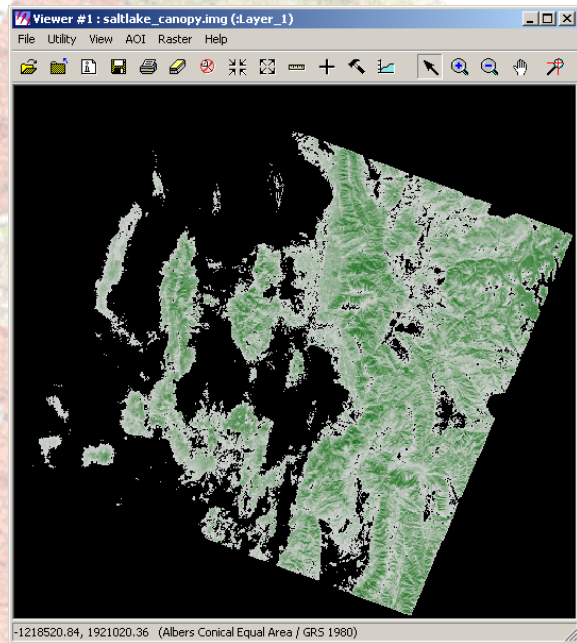
# Salt Lake – Land Cover, AWiFS, LISS-III & L5 Combined

Landcover Classification Tests -  
Percent Correctly Classified, Per Class

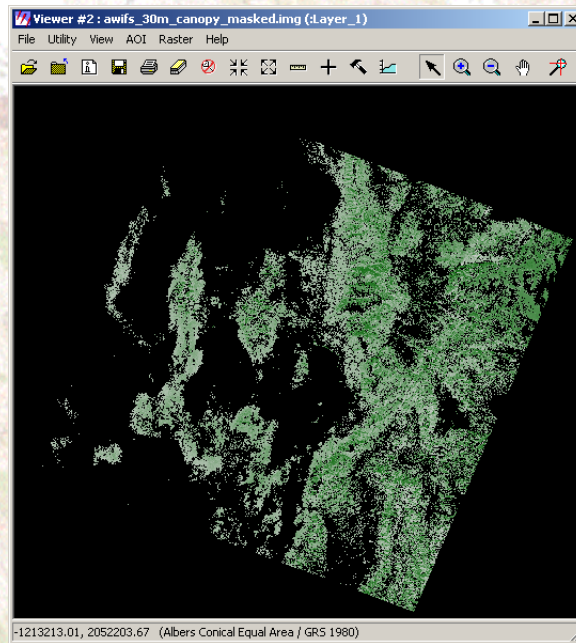


Landsat 5 was markedly better than AWiFS/LISS-III with these classes:  
*evergreen, shrub/scrub, woody wetlands, emergent wetlands.*

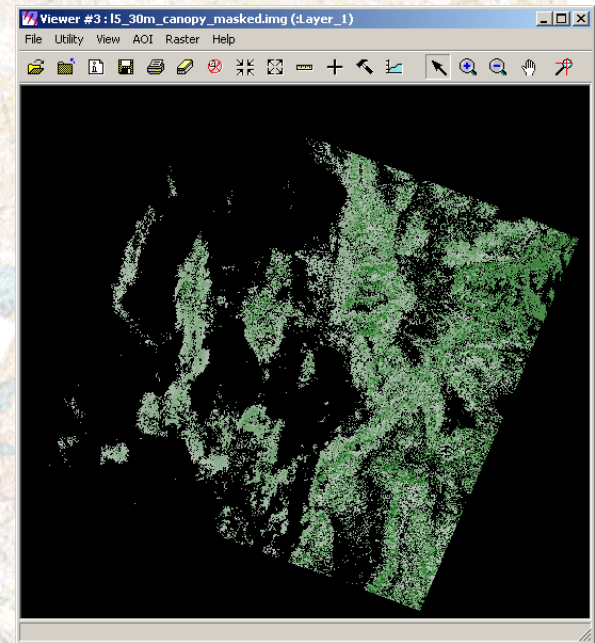
# Salt Lake – Canopy Density, AWiFS & L5



Original Canopy Density



AWiFS

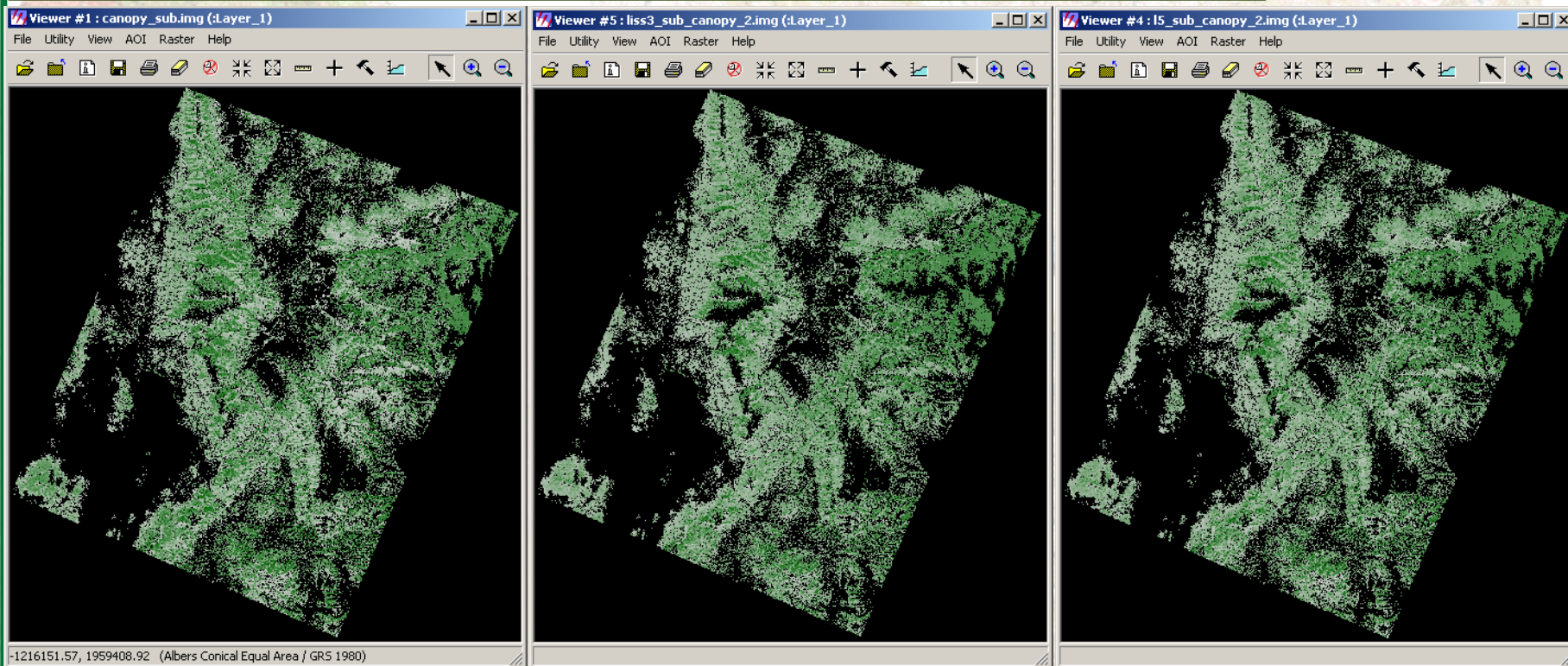


Landsat 5

## Cross-validation Statistics

	AWiFS	Landsat 5
Average  error	14.6	13.9
Relative  error	0.58	0.55
Correlation coefficient	0.75	0.77

# Salt Lake – Canopy Density, LISS-III & L5



Original Canopy Density

LISS-III

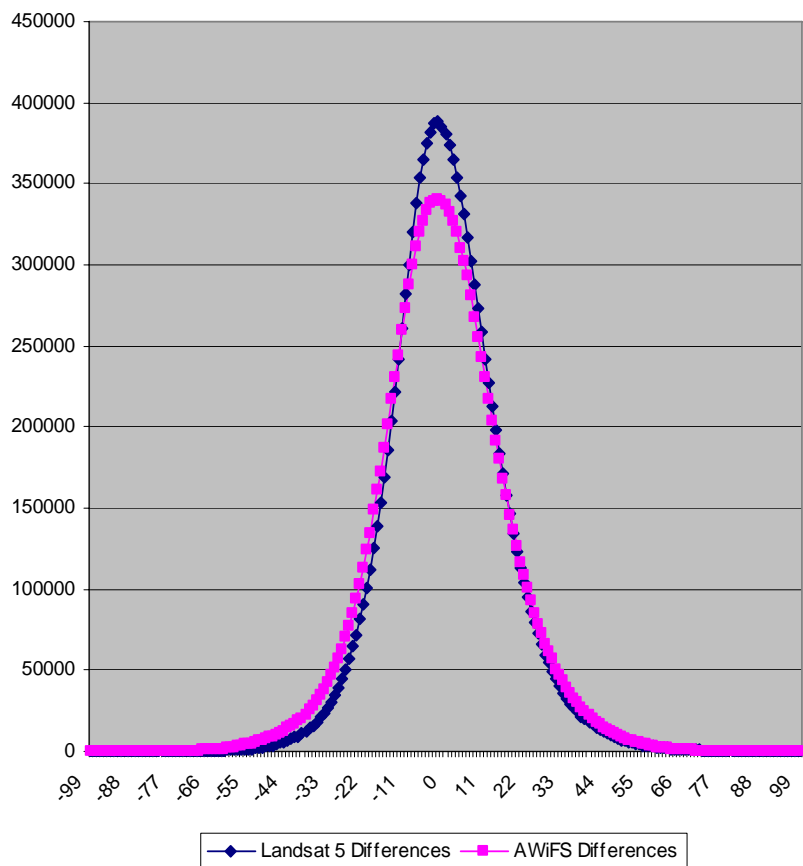
Landsat 5

## Cross-validation Statistics

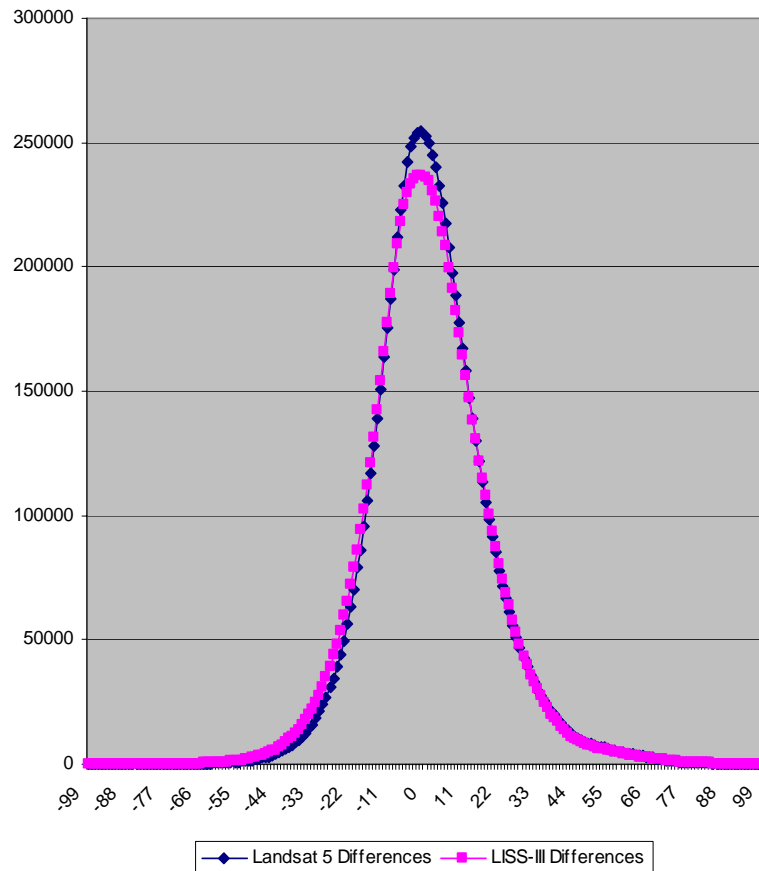
	LISS-III	Landsat 5
Average  error	14.7	14.1
Relative  error	0.58	0.56
Correlation coefficient	0.75	0.77

# Salt Lake – Canopy Differences From Source

Canopy Estimation: Differences From Source -  
Landsat 5 and AWiFS (Salt Lake)

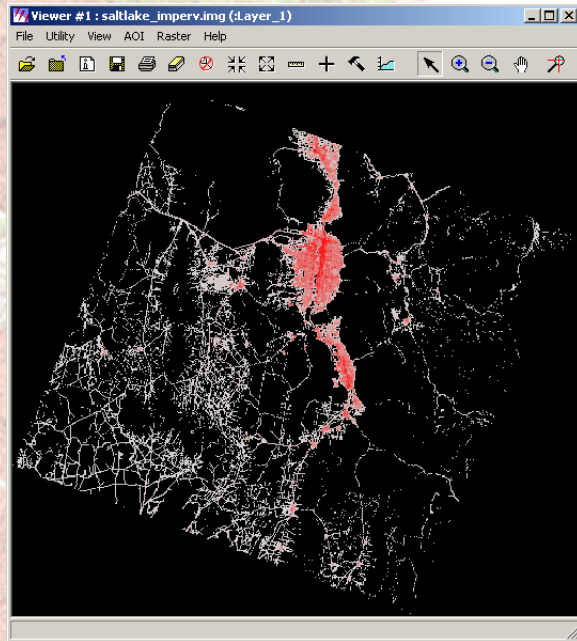


Canopy Estimation: Differences From Source -  
Landsat 5 and LISS-III (Salt Lake)

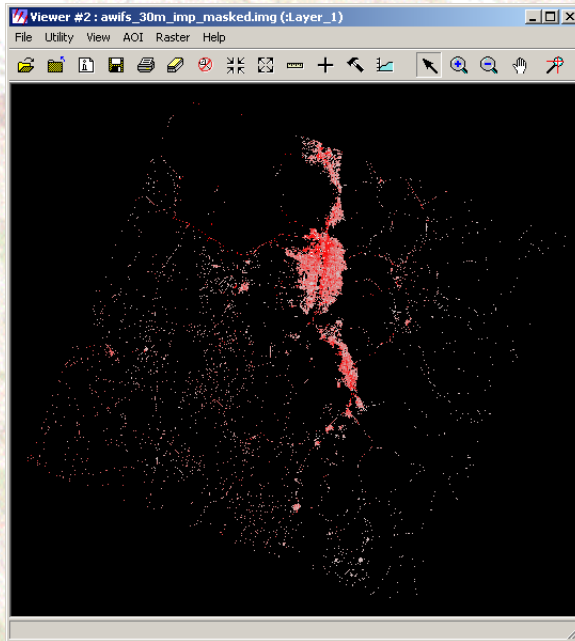


Comparisons of estimated value to original value, per pixel

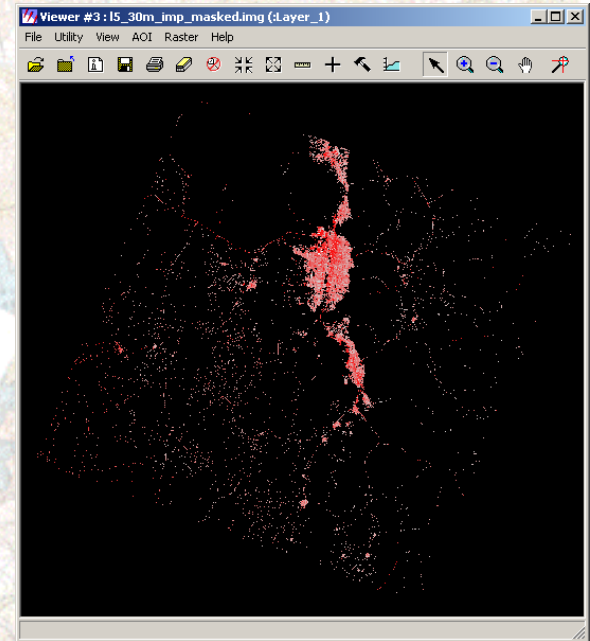
# Salt Lake – Impervious Surface, AWiFS & L5



Original Impervious Surface



AWiFS



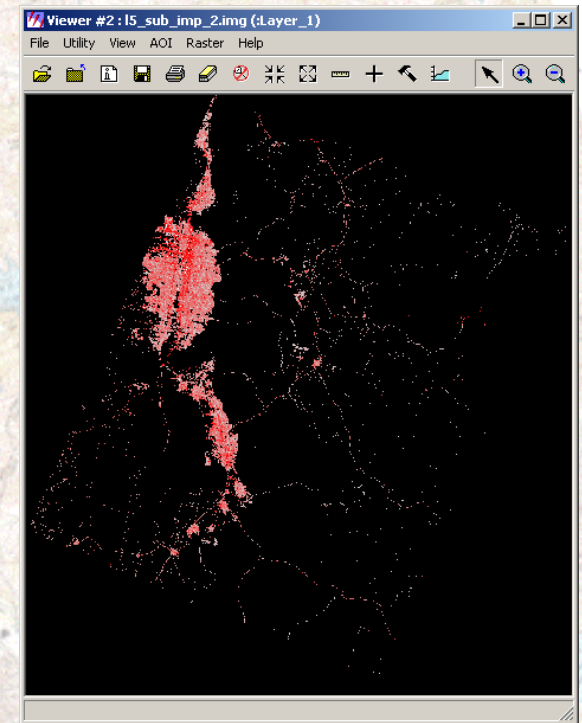
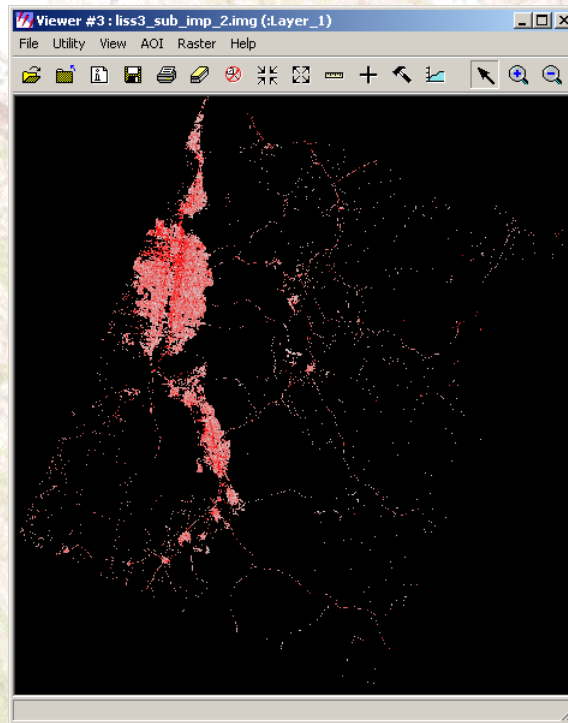
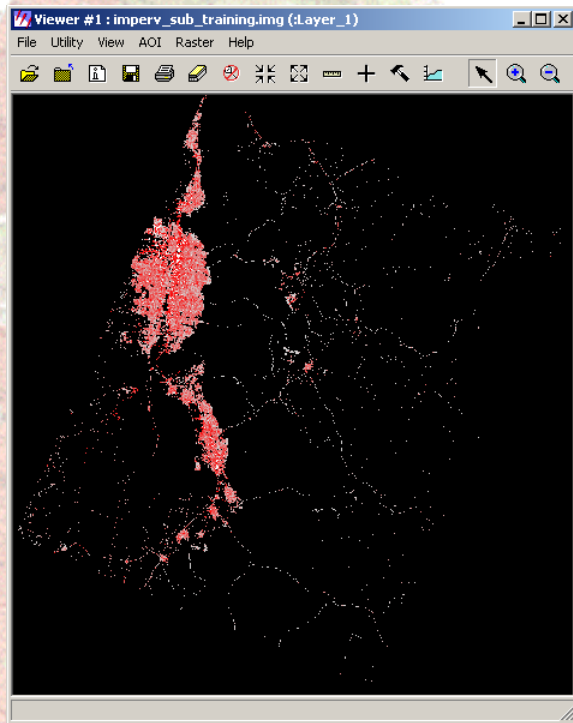
Landsat 5

## Cross-validation Statistics

	AWiFS	Landsat 5
Average  error	14.8	14.5
Relative  error	0.59	0.58
Correlation coefficient	0.75	0.75



# Salt Lake – Impervious Surface, LISS-III & L5



Original Impervious Surface

LISS-III

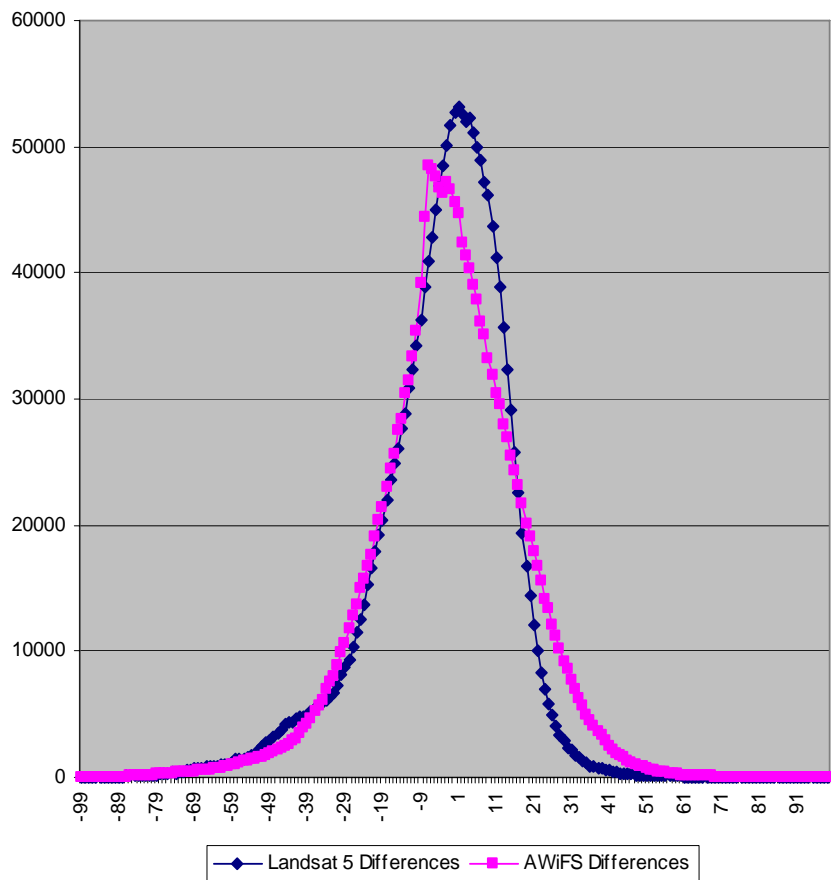
Landsat 5

## Cross-validation Statistics

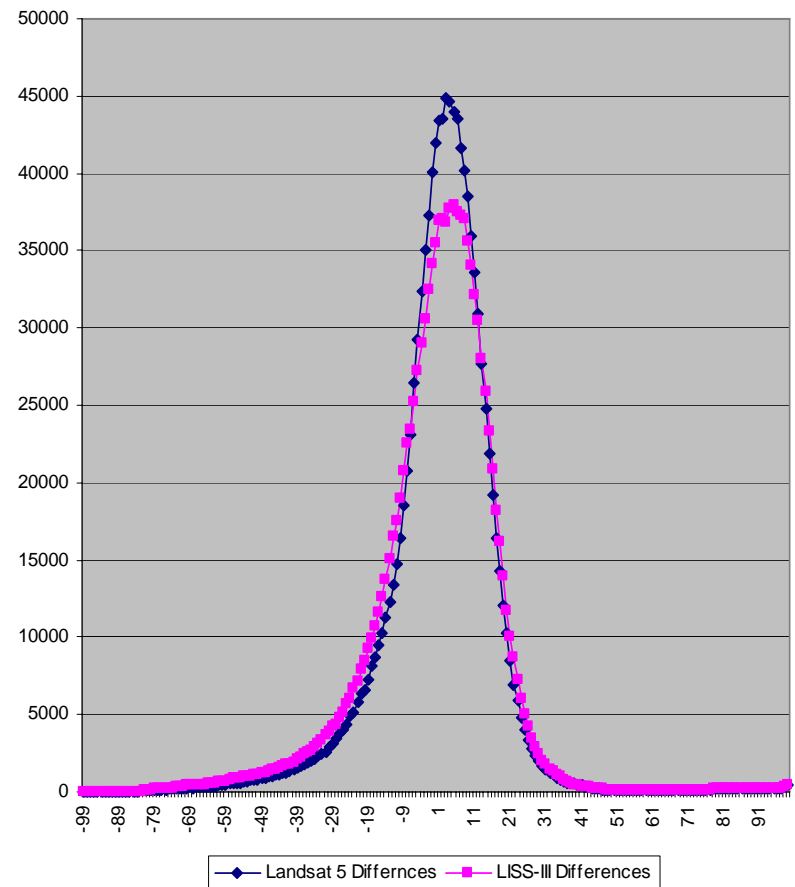
	LISS-III	Landsat 5
Average  error	15.5	14.1
Relative  error	0.61	0.56
Correlation coefficient	0.72	0.77

# Salt Lake – Impervious Differences From Source

Impervious Estimation: Differences From Source -  
Landsat 5 and AWiFS (Salt Lake)



Impervious Estimation: Differences From Source -  
Landsat 5 and LISS-III (Salt Lake)

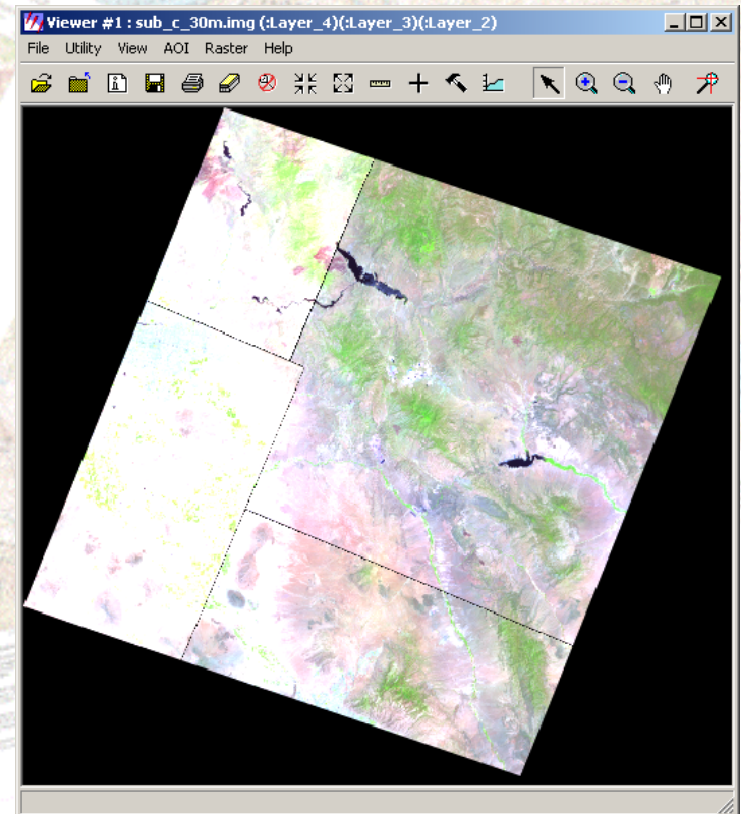
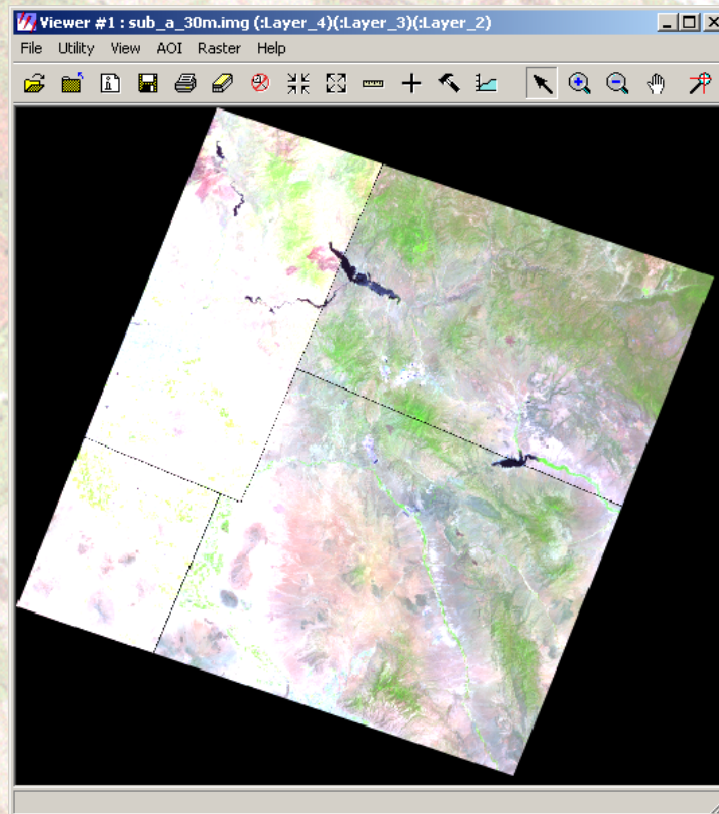


Comparisons of estimated value to original value, per pixel

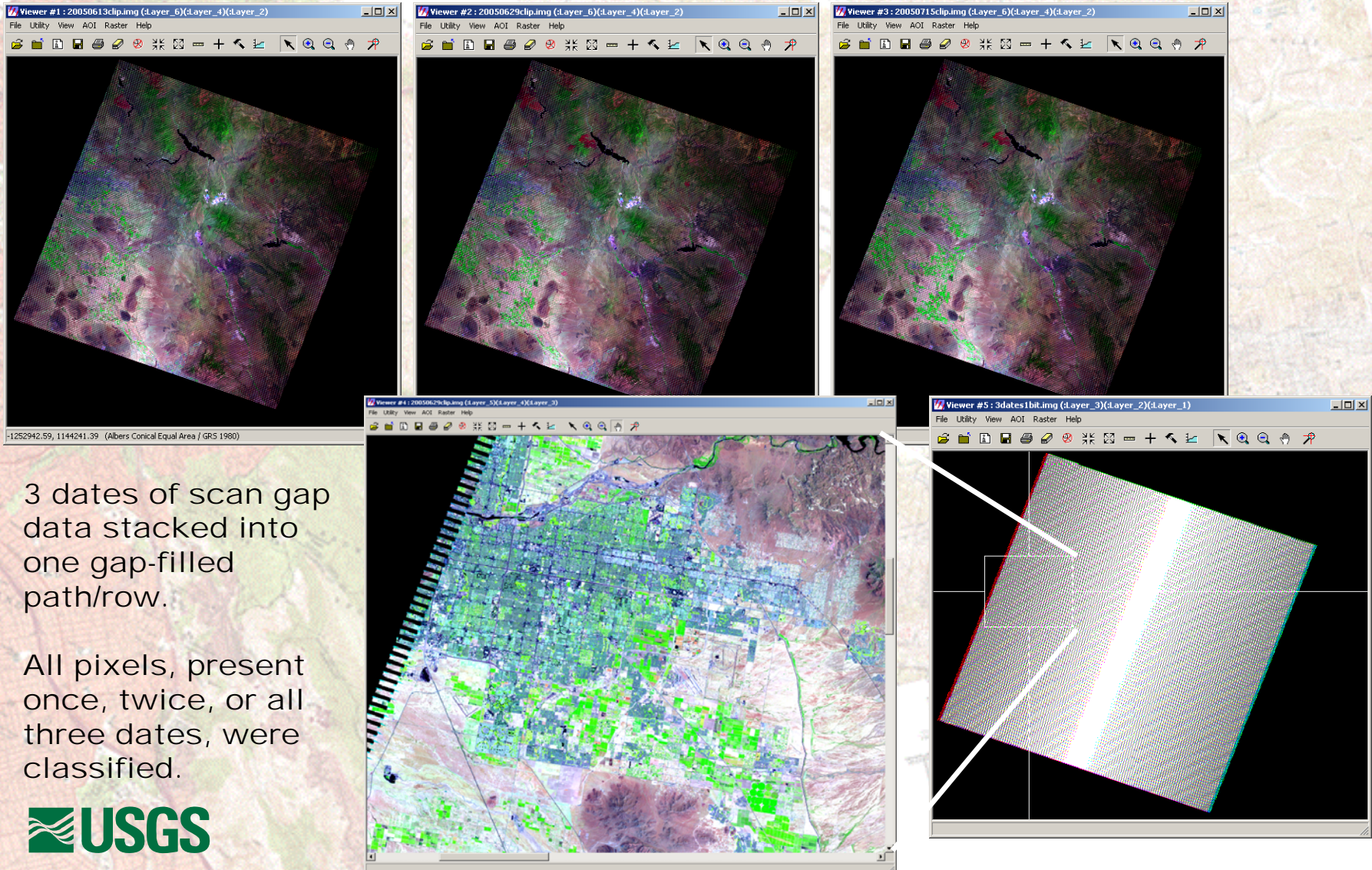
# Mesa – Four Quadrants of AWiFS

Generous overlap exists in the area near the center of the AWiFS scene acquisition. Here the quadrants are clipped to the same extent as the L7 path/row temporal mosaic. Two views of the overlap are shown to illustrate.

All pixels, present in any quadrant, were classified.



# Mesa –L7 Scan Gap: Temporal Mosaic (06/13, 06/29, 07/15)

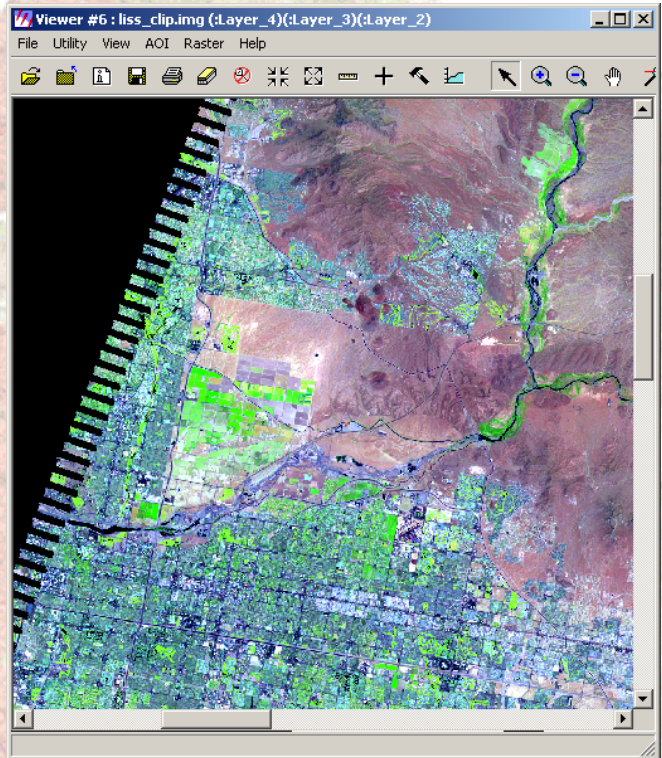


3 dates of scan gap data stacked into one gap-filled path/row.

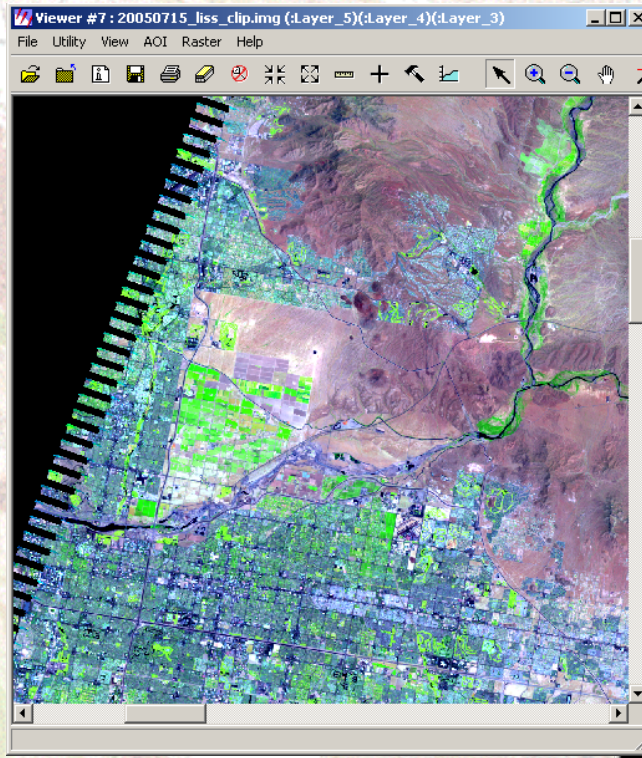
All pixels, present once, twice, or all three dates, were classified.



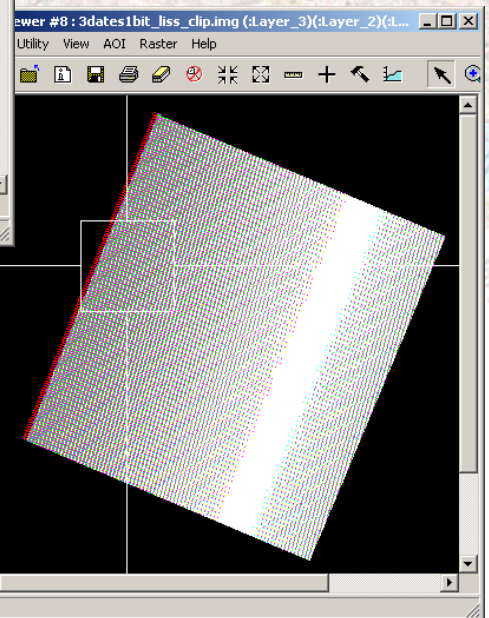
# Mesa – LISS-III and L7 Scan Gap



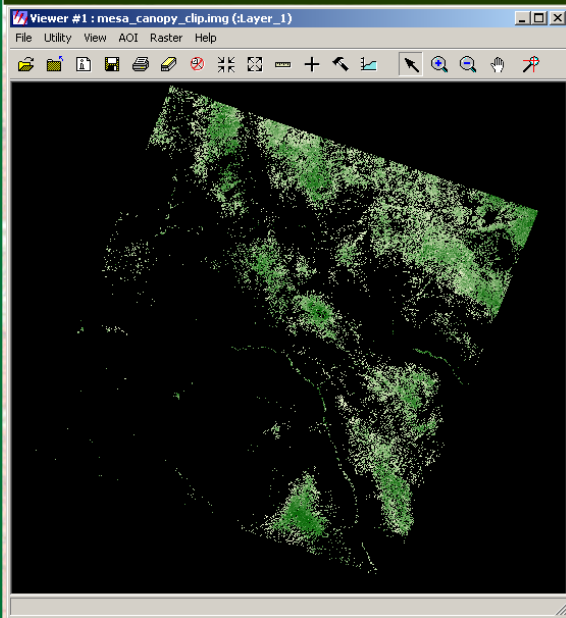
LISS-III  
Clipped to same  
common extent as  
L7 Scan Gap



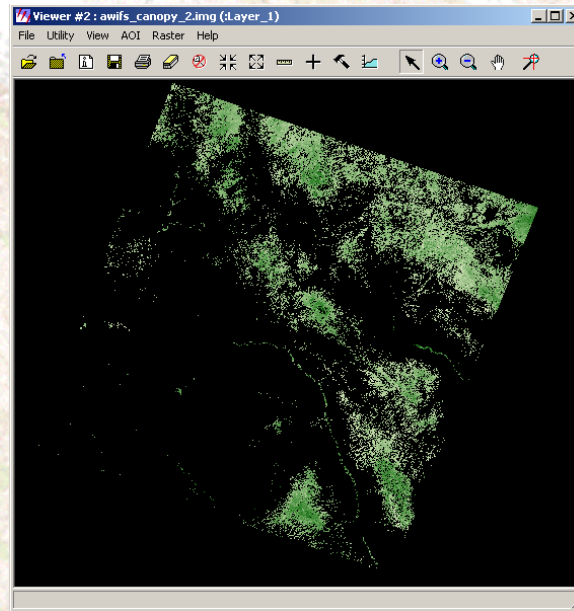
L7 Scan Gap



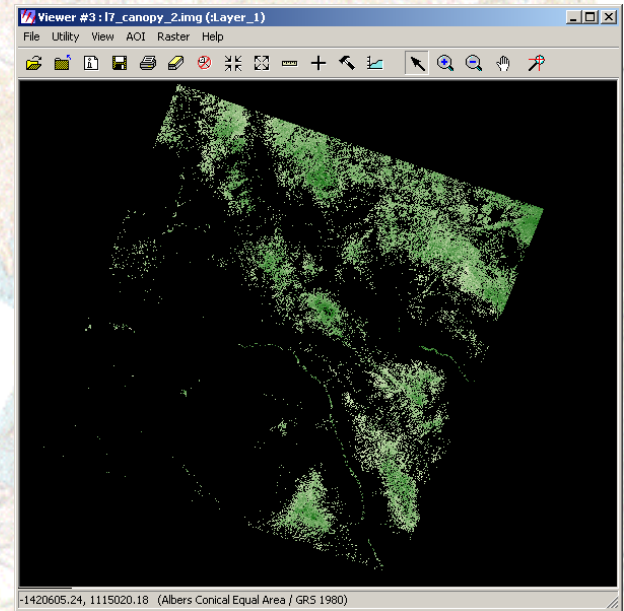
# Mesa - Canopy Density, AWiFS & L7 Scan Gap



Original Canopy Density



AWiFS

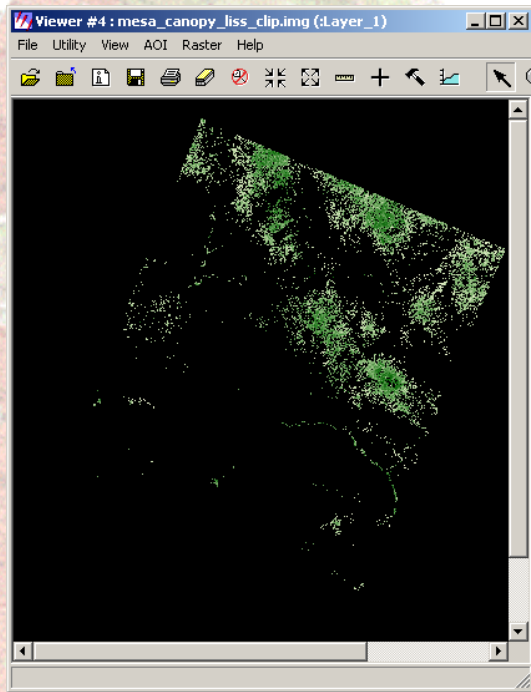


Landsat 7

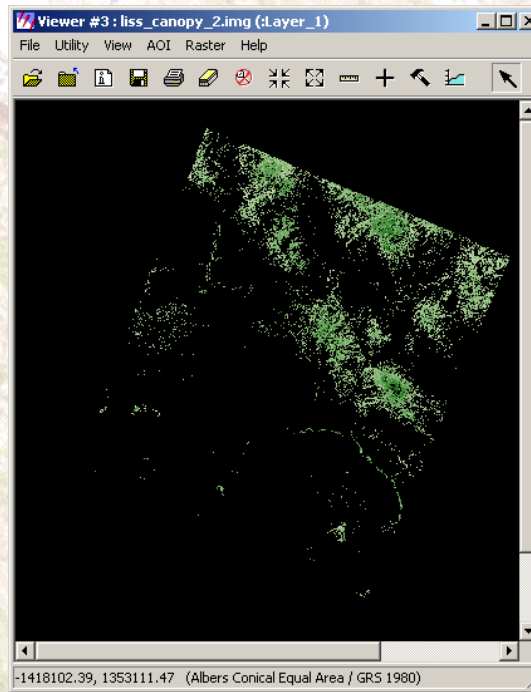
## Cross-validation Statistics

	AWiFS	Landsat 7
Average  error	12.0	11.8
Relative  error	0.70	0.69
Correlation coefficient	0.67	0.68

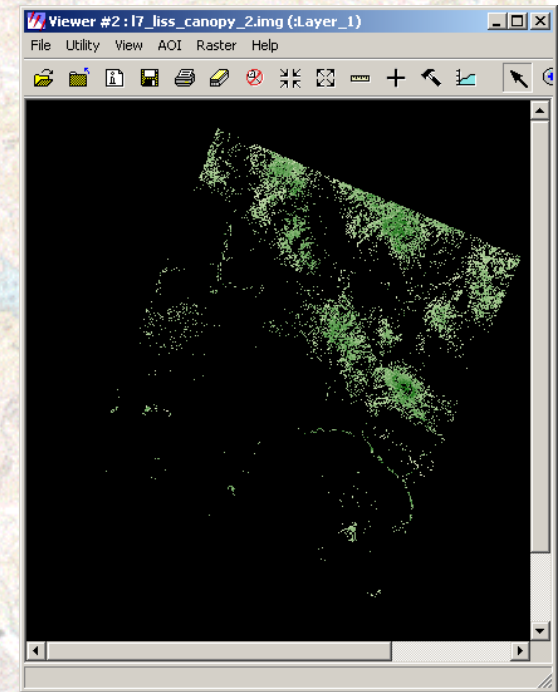
# Mesa - Canopy Density, LISS-III & L7 Scan Gap



Original Canopy Density



LISS-III



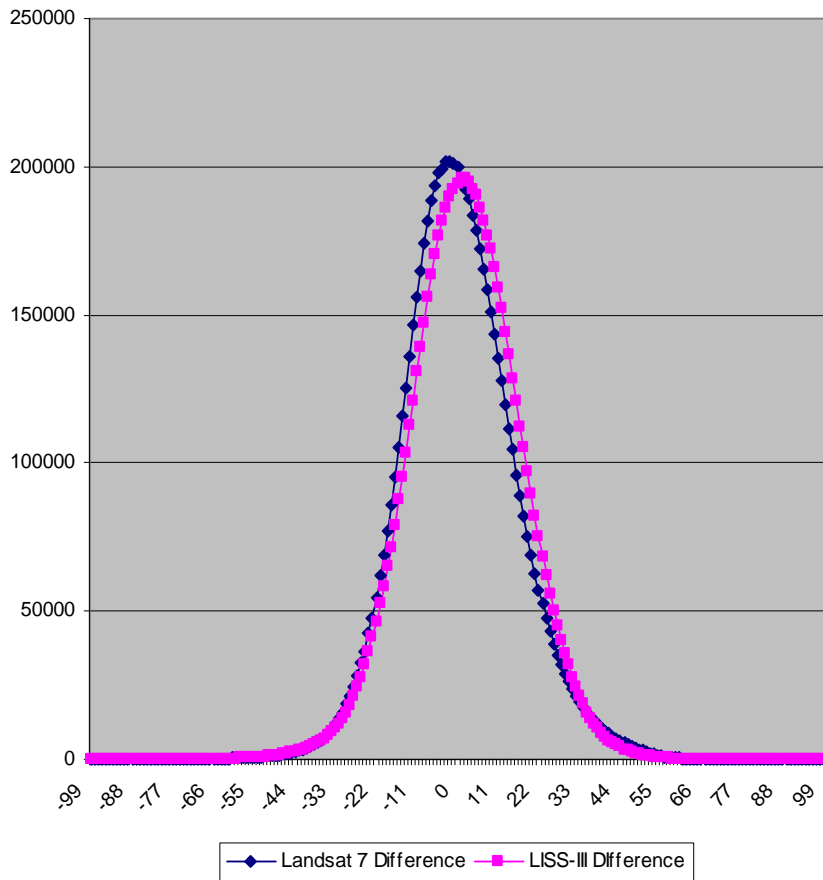
Landsat 7

## Cross-validation Statistics

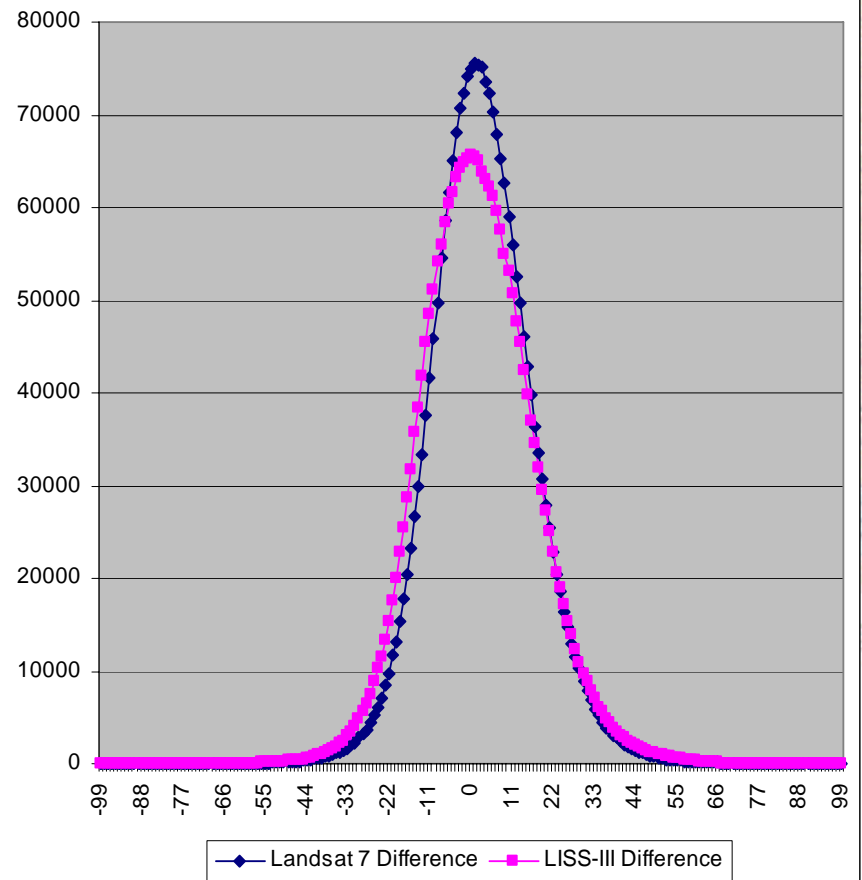
	LISS-III	Landsat 7
Average  error	12.1	11.5
Relative  error	0.67	0.64
Correlation coefficient	0.68	0.71

# Mesa – Canopy Differences From Source

Canopy Estimation: Differences From Source -  
Landsat 7 and AWiFS (Mesa)



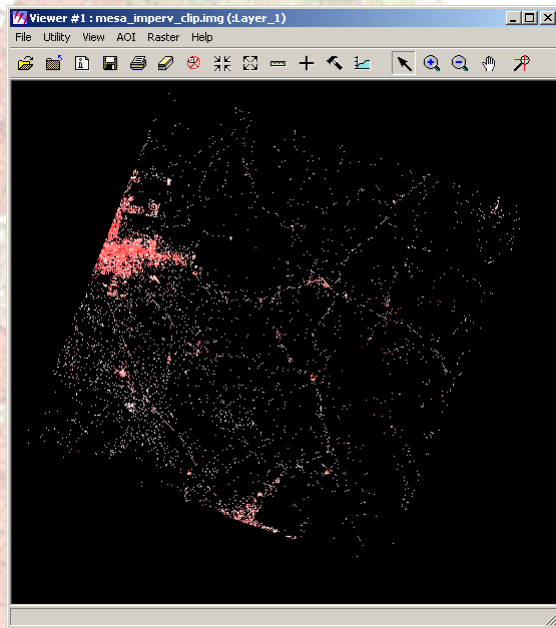
Canopy Estimation: Differences From Source -  
Landsat 7 and LISS-III (Mesa)



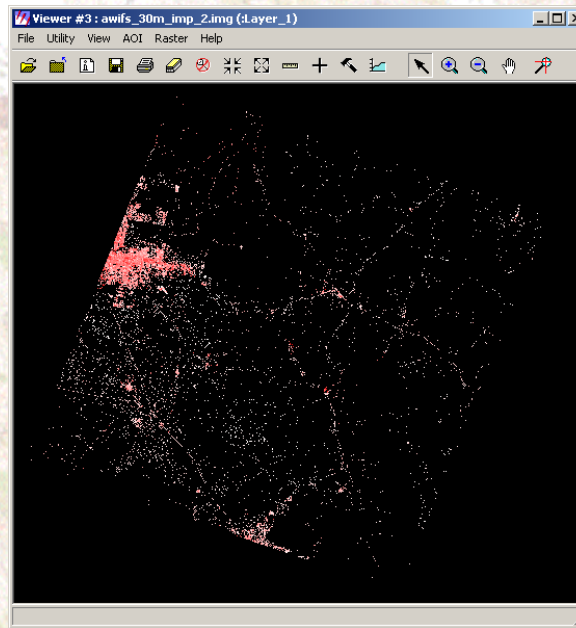
Comparisons of estimated value to original value, per pixel



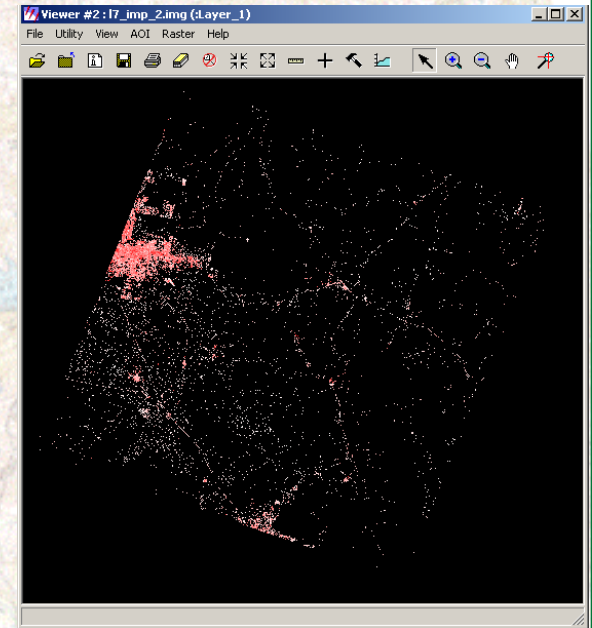
# Mesa – Impervious Surface, AWiFS & L7 Scan Gap



Original Impervious Surface



AWiFS

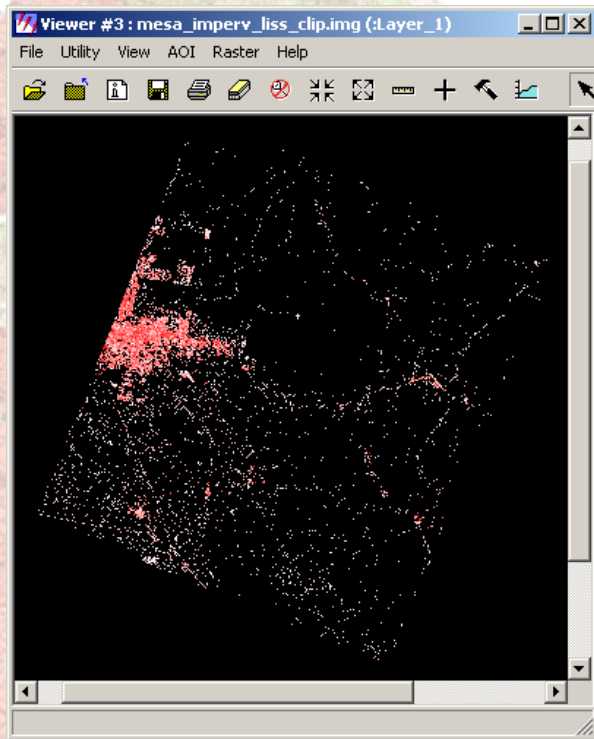


Landsat 7

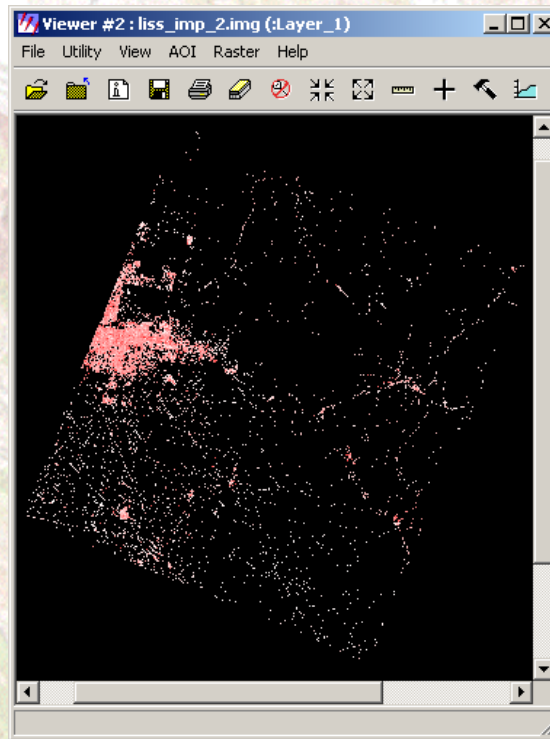
## Cross-validation Statistics

	AWiFS	Landsat 7
Average  error	15.6	15.4
Relative  error	0.65	0.64
Correlation coefficient	0.70	0.70

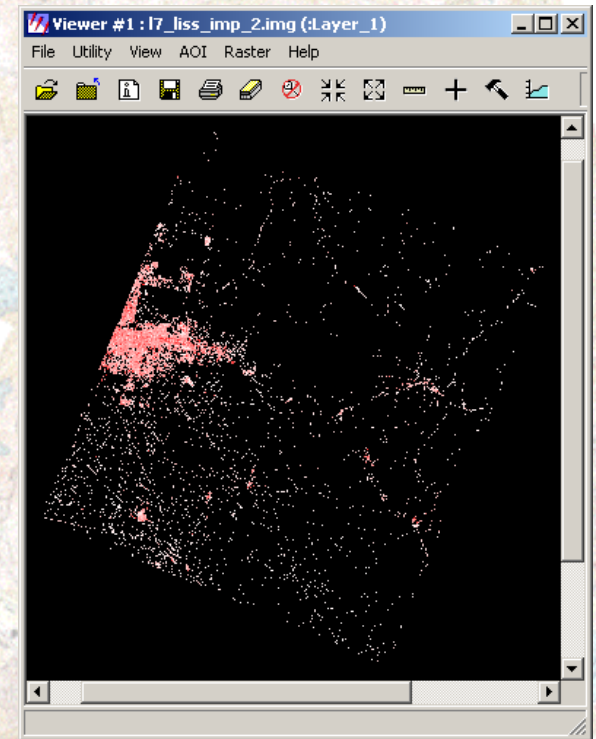
# Mesa – Impervious Surface, LISS-III & L7 Scan Gap



Original Impervious Surface



LISS-III



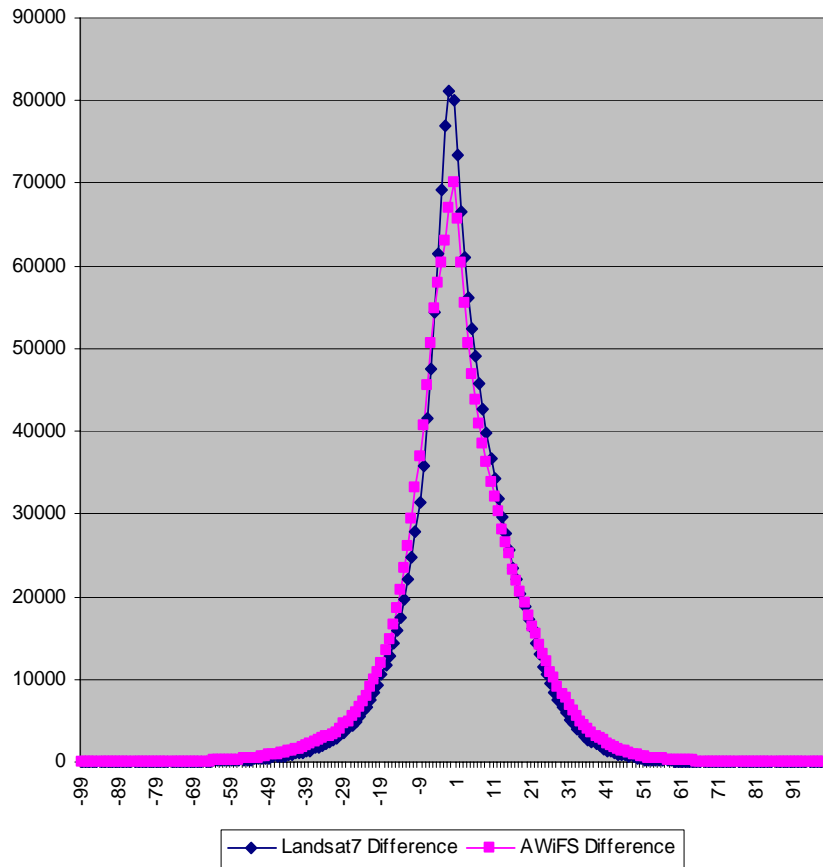
Landsat 7

## Cross-validation Statistics

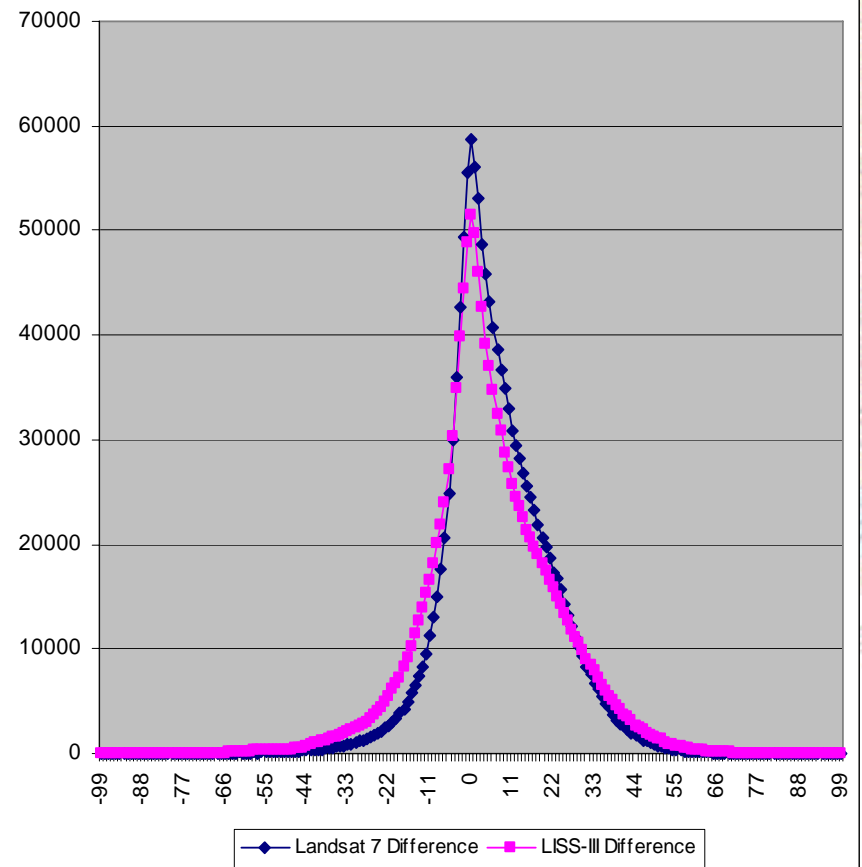
	LISS-III	Landsat 7
Average  error	16.9	15.0
Relative  error	0.78	0.70
Correlation coefficient	0.57	0.68

# Mesa – Impervious Differences From Source

Impervious Estimation: Differences From Source -  
Landsat 7 and AWiFS (Mesa)

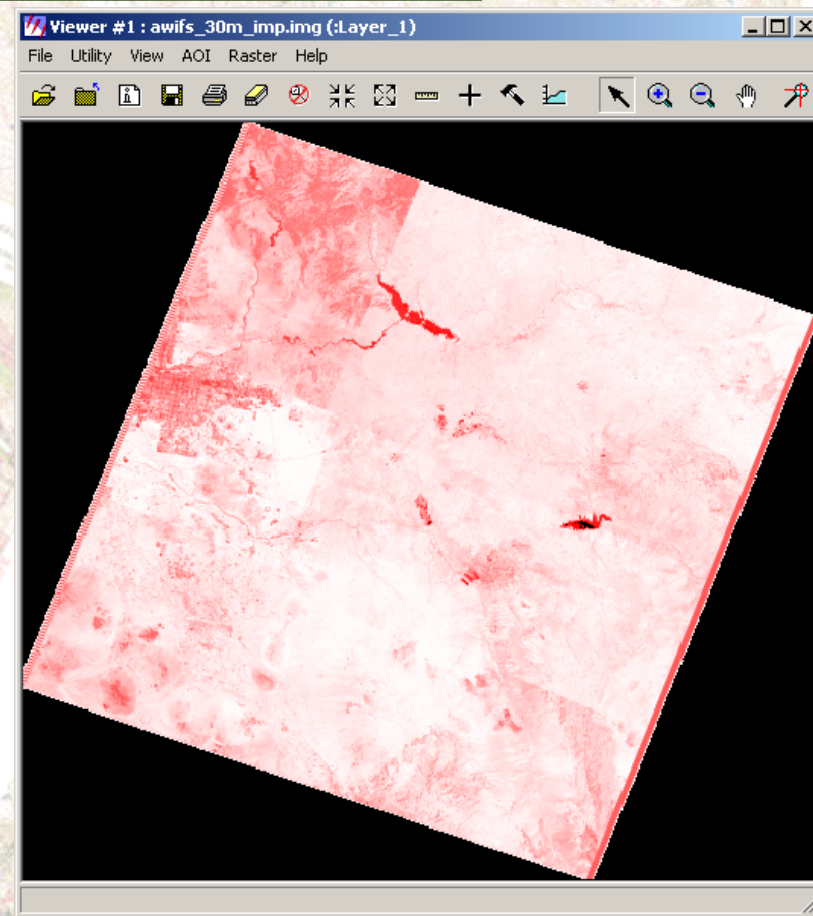
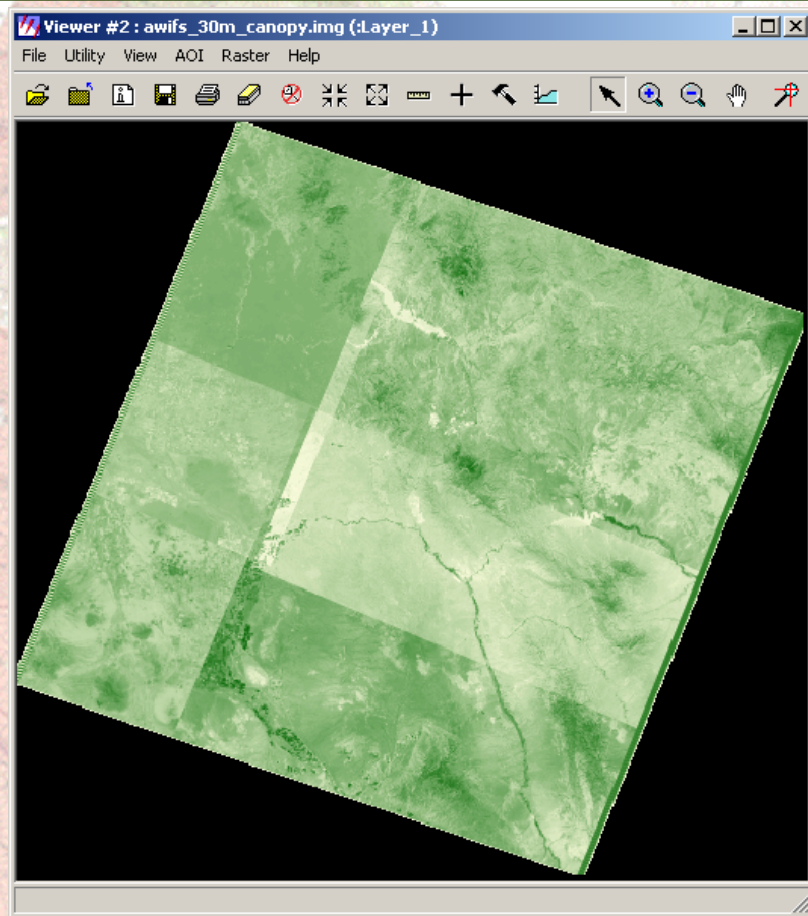


Impervious Estimation: Differences From Source -  
Landsat 7 and LISS-III (Mesa)



Comparisons of estimated value to original value, per pixel

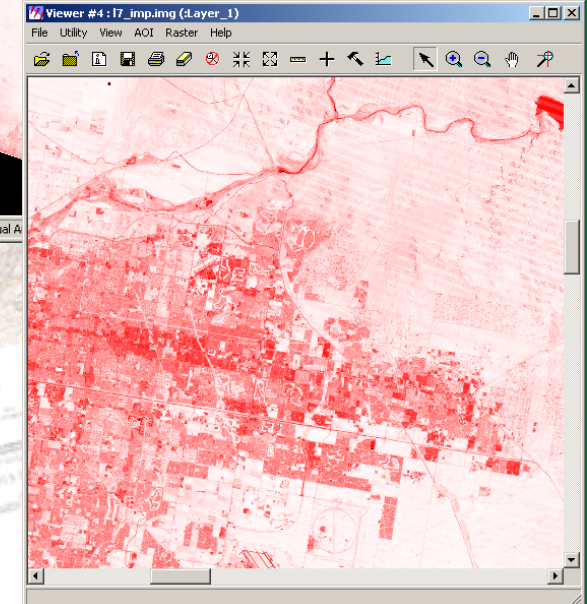
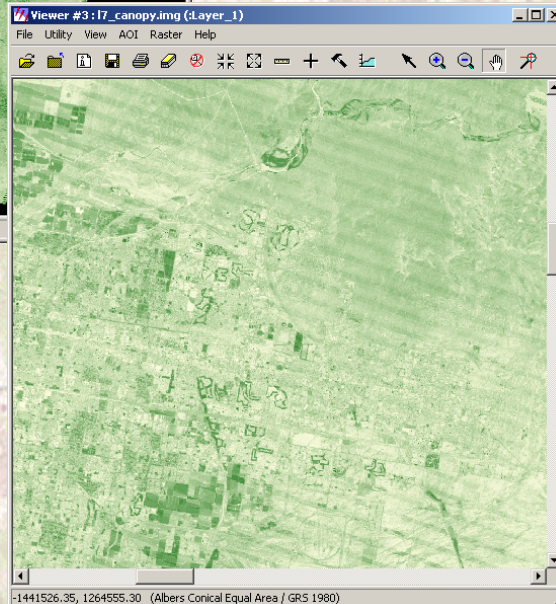
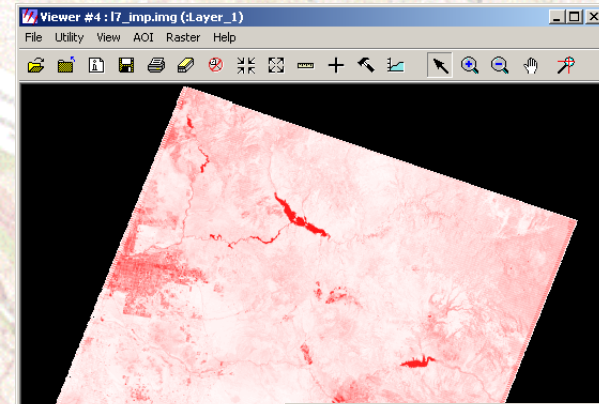
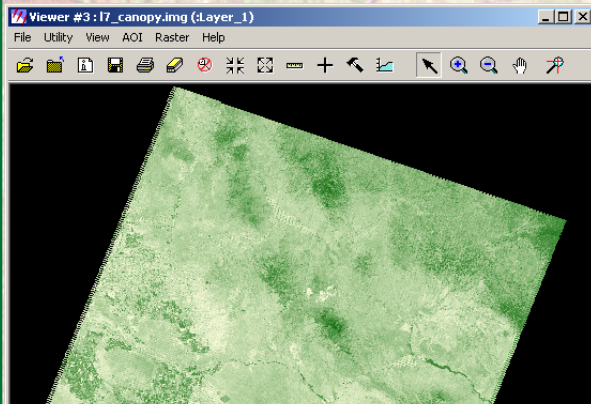
# AWiFS Anomalies



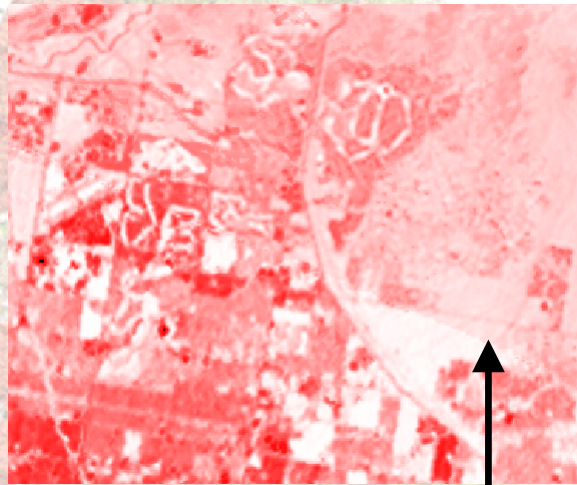
Unmasked versions of Canopy and Impervious products show intensity artifacts due to various quadrant overlaps.

# Landsat 7 Scan Gap Anomalies

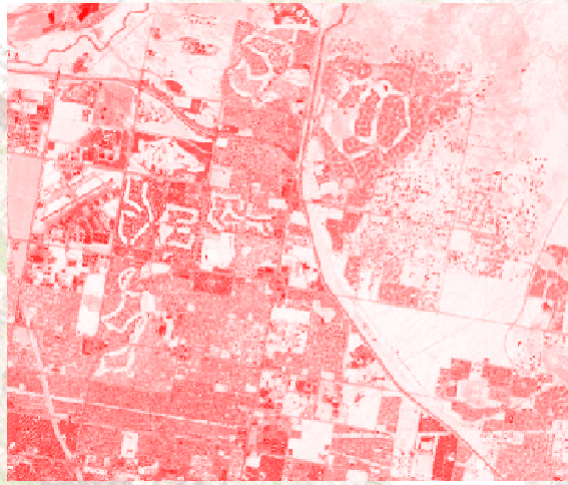
Low intensity “stripes” in unmasked versions of canopy and impervious products. Values appear to vary by 2 to 10 percent across stripe edges.



# Qualitative Look at Impervious Products



AWiFS originally 56m  
resampled to 30m  
NOTE: Quadrant  
seamline effects



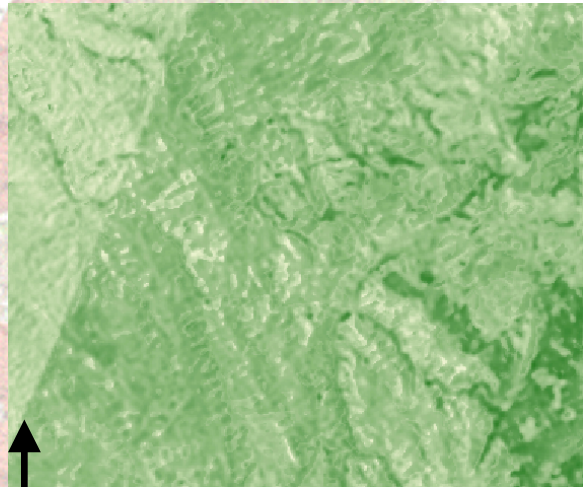
LISS-III originally 23.5m  
resampled to 30m



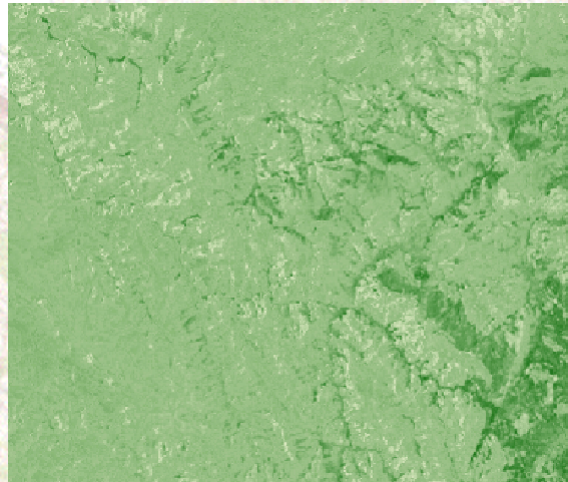
Landsat 7 scan gap  
data, w/all valid pixels  
of 1, 2, or 3 dates



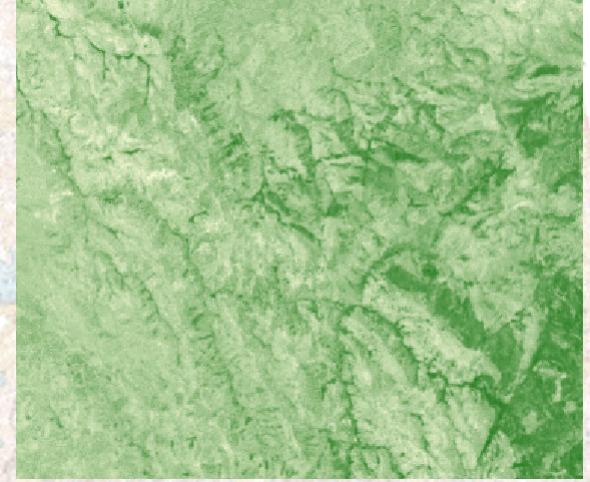
# Qualitative Look at Canopy Products



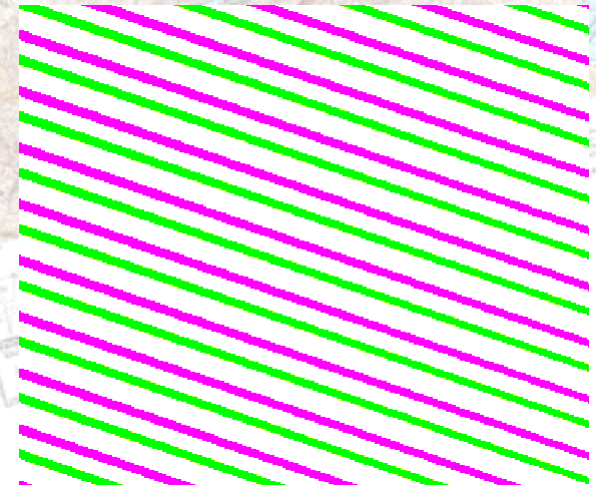
AWiFS originally 56m  
resampled to 30m  
NOTE: Quadrant  
seamline effects



LISS-III originally 23.5m  
resampled to 30m



Landsat 7 scan gap  
data, w/all valid pixels  
of 1, 2, or 3 dates



# Summary-

Land cover test on Salt Lake test site illustrates potential issues with AWiFS/LISS-III for classification of certain land cover classes (*evergreen, shrub/scrub, woody wetlands, emergent wetlands*).

Canopy and impervious graphs of product differences from source indicate slightly lower overall accuracies (shorter peaks, wider bases) for AWiFS/LISS-III, compared to L5/L7.

Inspection of individual products from canopy and impervious estimate tests revealed issues with combining AWiFS quadrants, and similar but less severe effects with combining multiple dates of L7 scan gap data.

Cross-validation Statistics for Canopy and Impervious Tests

Salt Lake		AWiFS	LISS-III	L5(A)	L5(L)
<b>Canopy</b>	avg abs err	14.60	14.70	13.90	14.10
	rel abs err	0.58	0.58	0.55	0.56
	corr coef	0.75	0.75	0.77	0.77
<b>Imperv</b>	avg abs err	14.80	15.50	14.50	14.10
	rel abs err	0.59	0.61	0.58	0.56
	corr coef	0.75	0.72	0.75	0.77
Mesa		AWiFS	LISS-III	L7(A)	L7(L)
<b>Canopy</b>	avg abs err	12.00	12.10	11.80	11.50
	rel abs err	0.70	0.67	0.69	0.64
	corr coef	0.67	0.68	0.68	0.71
<b>Imperv</b>	avg abs err	15.60	16.90	15.40	15.00
	rel abs err	0.65	0.78	0.64	0.70
	corr coef	0.70	0.57	0.70	0.68