

Geometric Assessment of DMC Data

March 21, 2007

Presented By: Gyanesh Chander*, SAIC

Mike Choate, SAIC

**Contract employee under U.S. Geological Survey
contract 03CRCN0001**

Outline and Introduction

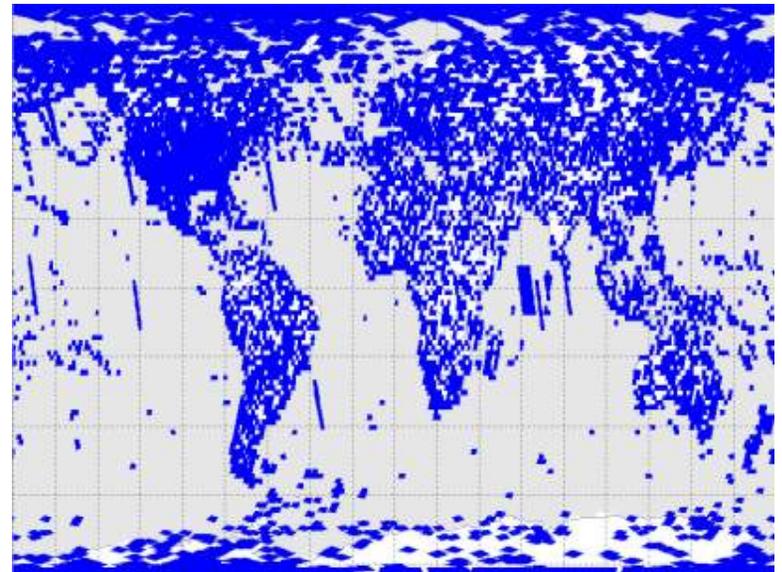
- **Landsat 7 Image Assessment System (IAS)**
 - ◆ Background
 - ◆ Expanding the use of IAS
- **IAS Geometric Assessment Tools**
 - ◆ Image to Image assessment
 - ◆ Band to Band assessment
 - ◆ Ground Control
- **SSTL DMC Background**
 - ◆ Data Sets
 - ◆ Statistics
 - ◆ Vector Plots
- **Conclusions**

Landsat 7 (L7) Image Assessment System (IAS)

- **The IAS is responsible for offline assessment of image quality to ensure compliance with the radiometric and geometric requirements of the L7 spacecraft and the ETM+ sensor throughout the mission**
 - ◆ IAS is part of the ground processing system and located at the USGS EROS
 - ◆ The NASA GSFC LPSO works with the IAS in analyzing the calibration information and updating the algorithms used within the IAS
 - ◆ One of the most important roles of the IAS is generation of the Calibration Parameter File (CPF) that contains all of the necessary parameters for generating a Level-1 products
- **IAS is staffed by 3+ FTE**
 - ◆ Geometric, Radiometric, Spatial expertise
 - ◆ Request satellite tasking
 - ◆ Coordinate data quality with International partners

L7 ETM+ IAS

- Since L7 Launch on April 15, 1999 the IAS has processed
 - Generate 1R-FASC 199
 - Generate 1R-Night Char 654
 - Generate 1R-PASC 2009
 - Generate 1R-Day Char 10850
 - MTF Characterization 79
 - Sensor Alignment 259
 - Band to Band 350
 - Geodetic Accuracy 1990
- Capable of determining & monitoring gain, bias, noises, & artifacts on a per-detector basis over life of mission
- Calibration trending database over 100 GB today
- Today, Landsat 7 is one of the best-calibrated sensors on orbit



Leveraging L7 IAS

- **Expanding the IAS – Working Backward**

- ◆ IAS is used as prototype for Thematic Mapper (TM) image assessment system (TMIAS)
 - Accomplished in partnership with SDSU
 - Adaptation straightforward: extremely similar instruments

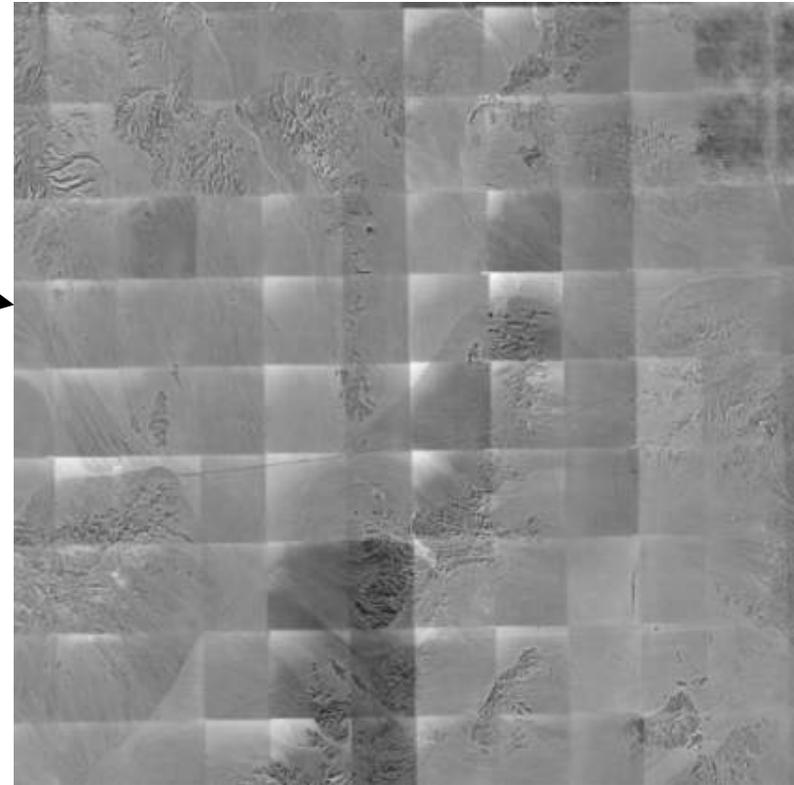
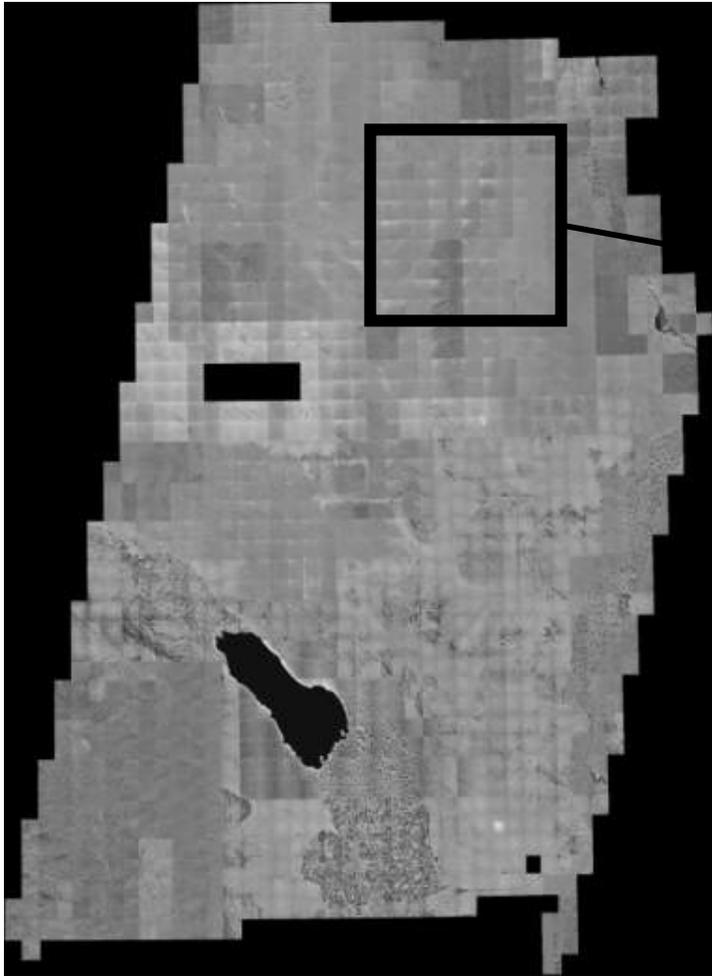
- **Expanding the IAS – Working Forward**

- ◆ IAS is used as prototype for Advanced Land Imager (ALI) assessment system (ALIAS)
- ◆ IAS tools used for assessment of other sensors and datasets
 - SSTL DMC, CBERS-2, IRS-P6, Orbview-3

Geometric Supersites

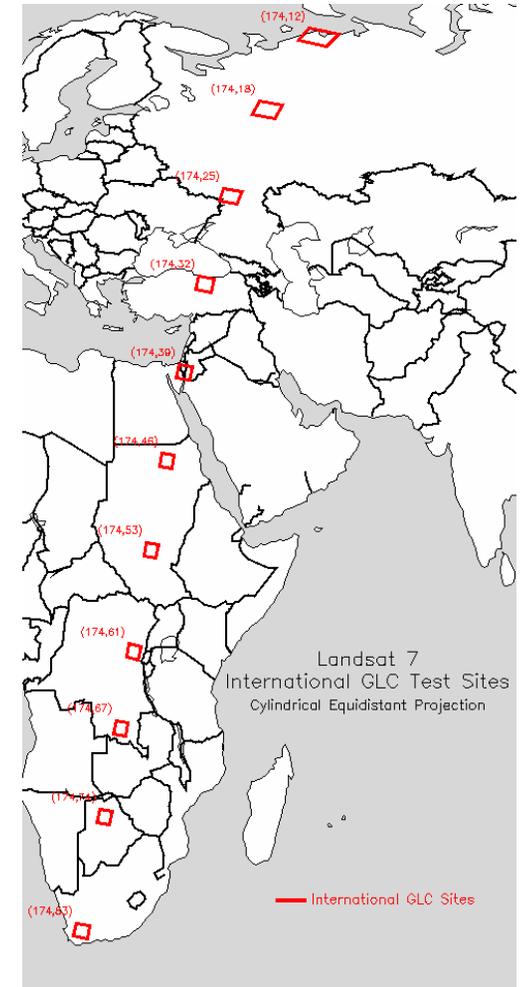
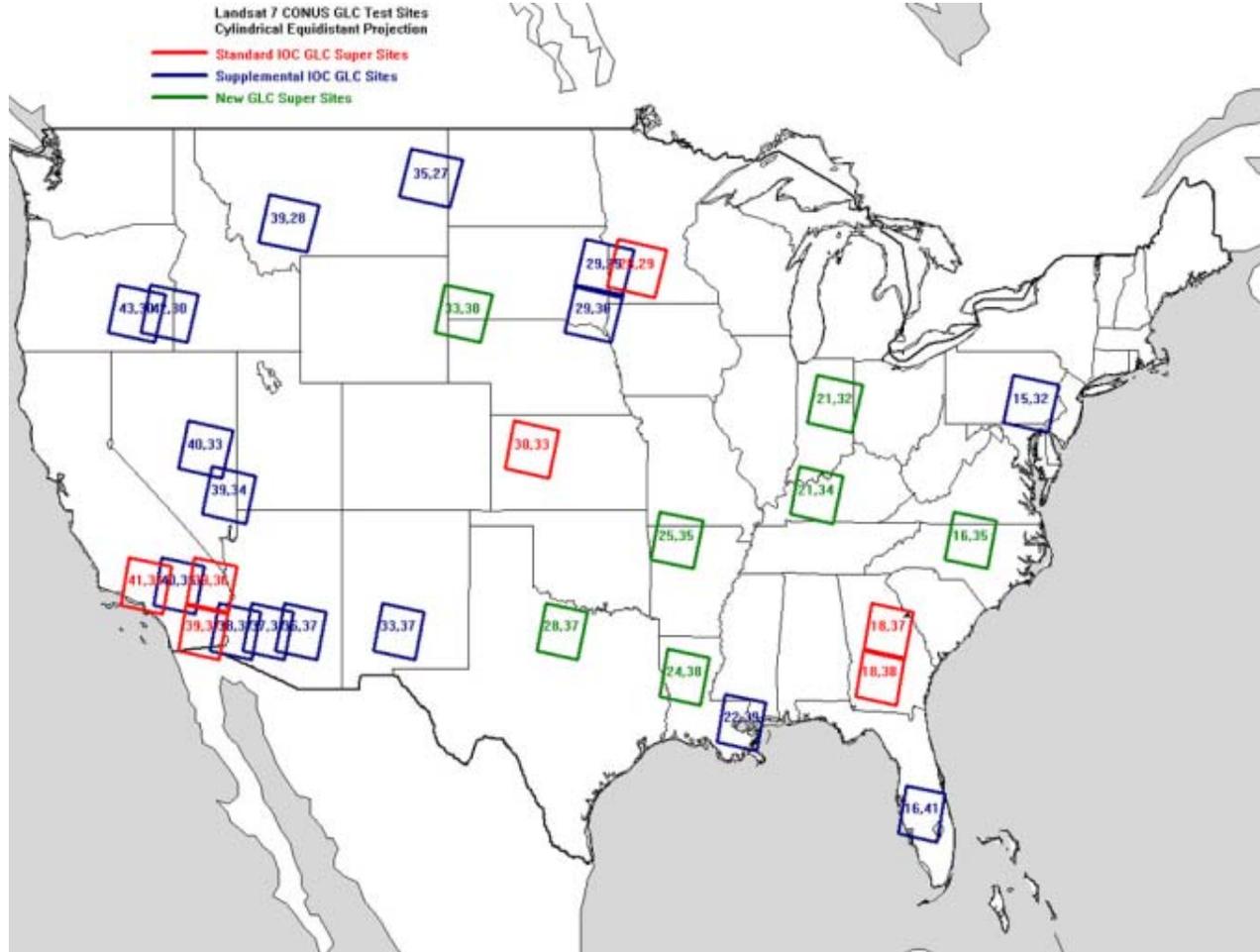
- **Supersites are geo-referenced images derived from high resolution source**
- **L7 IAS was used to built ground reference data sets (supersites)**
 - ◆ Built from Digital Orthophoto Quadrangulares (DOQs)
 - ◆ DOQs are designed to meet national mapping accuracy standards of 1:24k maps, or ~6 meters
 - ◆ Inspection with highly accurate GPS surveyed locations showed most DOQs exceeded 6 meters
- **DOQs are mosaiced to create a data set equal to one WRS-2 nominal swath**
 - ◆ Resampled to match Landsat resolution - 1 meter DOQs reduced in resolution to match PAN band (15m for ETM+ and 10m for ALI)
 - ◆ Image chips are pulled from DOQ mosaics
 - ◆ USGS 1 arc second DEMs used for ground control height
 - ◆ Currently 30 data sets available - these supersites are used for Landsat geometric calibration by using them as geodetic controls

DOQ Mosaic



Note that individual DOQ files are visible in the mosaic

Landsat WRS-2 Supersite Locations



Disaster Monitoring Constellation (DMC)

- The DMC design, consists of a three band imager with a green, red and NIR band that are set to similar band passes as Landsat bands 2, 3 and 4
- The imager has 32m spatial resolution with a 640 km swath. This is achieved by having two separate banks of cameras, each covering half the swath and overlapping at Nadir
- DMC data was provided under Technical Assistance Agreement (TAA) UK-08.0000, ACIS Reference ID # 8512 between the USGS and SSTL dated 29 September 2005
 - ◆ **The scope of the TAA effort allowed for the USGS RST Project to assist in the radiometric and geometric calibration of the DMC satellites**

SSTL DMC Imagery

- **Eight L1T DMC images were available**
 - ◆ L1T utilizes GeoCover imagery for ground control
 - ◆ 1km elevation used to account for terrain effects; Global One-km Base Elevation (GLOBE) Project
 - ◆ UTM Projection, North Up, WGS84, 32 meter pixel size
- **DOQ available over 6 data sets**
 - ◆ I2I performed against DOQ mosaics (6 images)
 - ◆ B2B alignment assessment against all 8 DMC images

DMC Images

Scene ID	Acquisition Date	I2I	B2B
DU00017dp_L1T	7-3-2004	Yes	Yes
DU000182T_L1T	7-6-2004	Yes	Yes
DU00018ap_L1T	7-11-2004	Yes	Yes
DU00018fs_L1T	7-14-2004	Yes	Yes
DU00005b2p_L1T	8-13-2005	No	Yes
DU0005cdT_L1T	8-21-2005	No	Yes
DU0005ddp_L1T	8-26-2005	Yes	Yes
DU00005eaT_L1T	8-29-2005	Yes	Yes

IAS Geometric Tools – I2I

- **IAS contains Image to Image (I2I) registration assessment tool**
 - ◆ I2I characterization is usually performed to compare the relative accuracy between two images
 - ◆ One image is selected as reference and another as the search image
 - ◆ Points / Image chips (small area of about 64x64 pixel) are selected from reference image and are correlated with the search image
 - ◆ The co-registration results provides an insight to the relative accuracy of the search image with respect to the reference image
 - ◆ When the correlated points were plotted in the image, it also helps to detect any systematic bias in the image
- Provides numerical evaluation of accuracy of common bands of temporally distinct ETM+ images
- No real restriction on image data sets that can be used, other sensor can be used in assessment

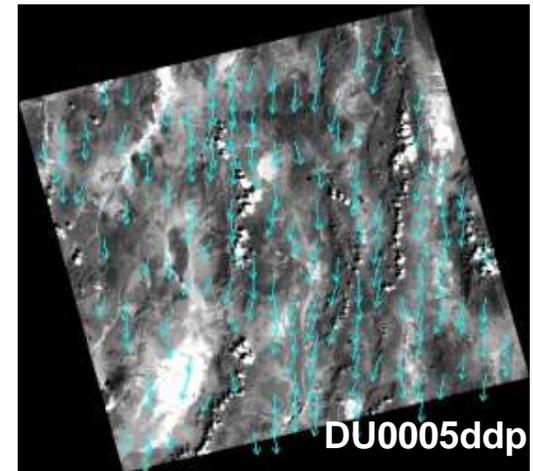
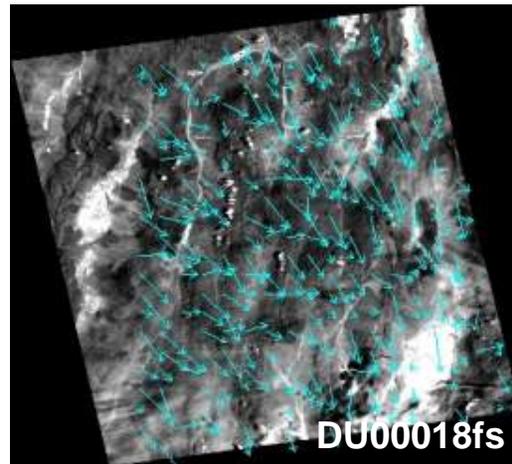
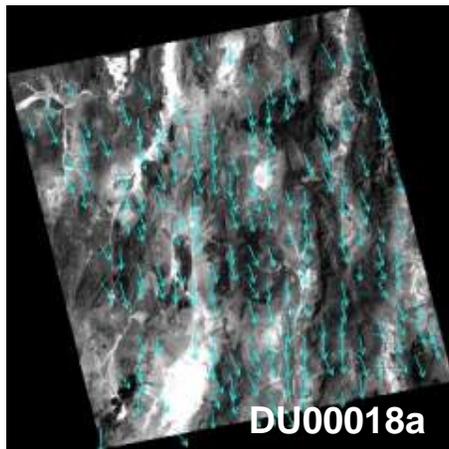
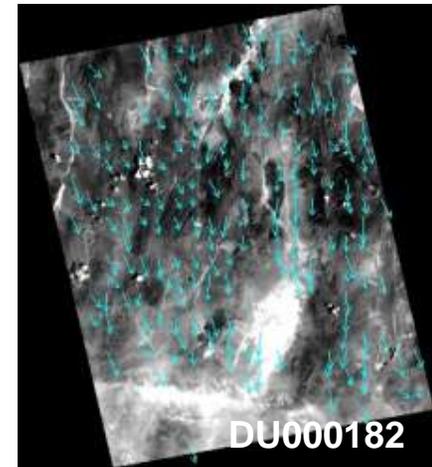
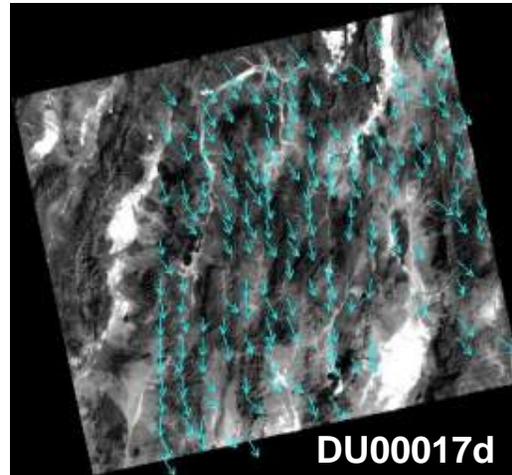
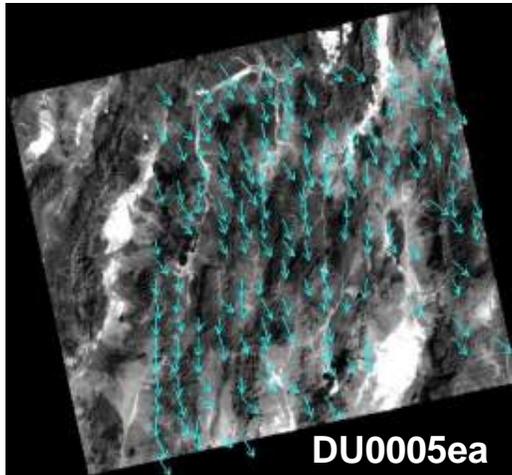
DMC I2I Comparison with DOQs (Values listed in pixels)

Scene Name	Points Kept	X Direction RMSE	Y Direction RMSE
DU00005eaT_L1T	171	0.495776	0.912960
DU00017dp_L1T	147	0.414438	1.077423
DU000182T_L1T	186	0.297355	0.818766
DU00018ap_L1T	188	0.363811	1.037334
DU00018fs_L1T	242	0.735469	0.927820
DU0005ddp_L1T	176	0.219586	1.145967

The RMSE measured between the DMC and reference data sets ranged from 7.03 to 23.53 meters in the X direction and 26.20 to 36.67 meters in the Y direction

Scene ID	X Direction (RMSE)	Y Direction (RMSE)
DU00005eaT_L1T	0.50	15.86
DU00017dp_L1T	0.41	13.26
DU000182T_L1T	0.30	9.52
DU00018ap_L1T	0.36	11.64
DU00018fs_L1T	0.74	23.54
DU0005ddp_L1T	0.22	7.03

Vector Residuals Between DMC and DOQ Mosaic Image Vectors are Scaled by a Factor of 4000



In all six comparisons there was a slight bias in the line, or more likely along track, direction

Scene ID	X Direction (RMSE)	Y Direction (RMSE)	Y Direction (RMSE)
DU00005eaT_L1T	0.50	15.86	0.91
DU00017dp_L1T	0.41	13.26	1.08
DU000182T_L1T	0.30	9.52	0.82
DU00018ap_L1T	0.36	11.64	1.04
DU00018fs_L1T	0.74	23.54	0.93
DU0005ddp_L1T	0.22	7.03	1.15

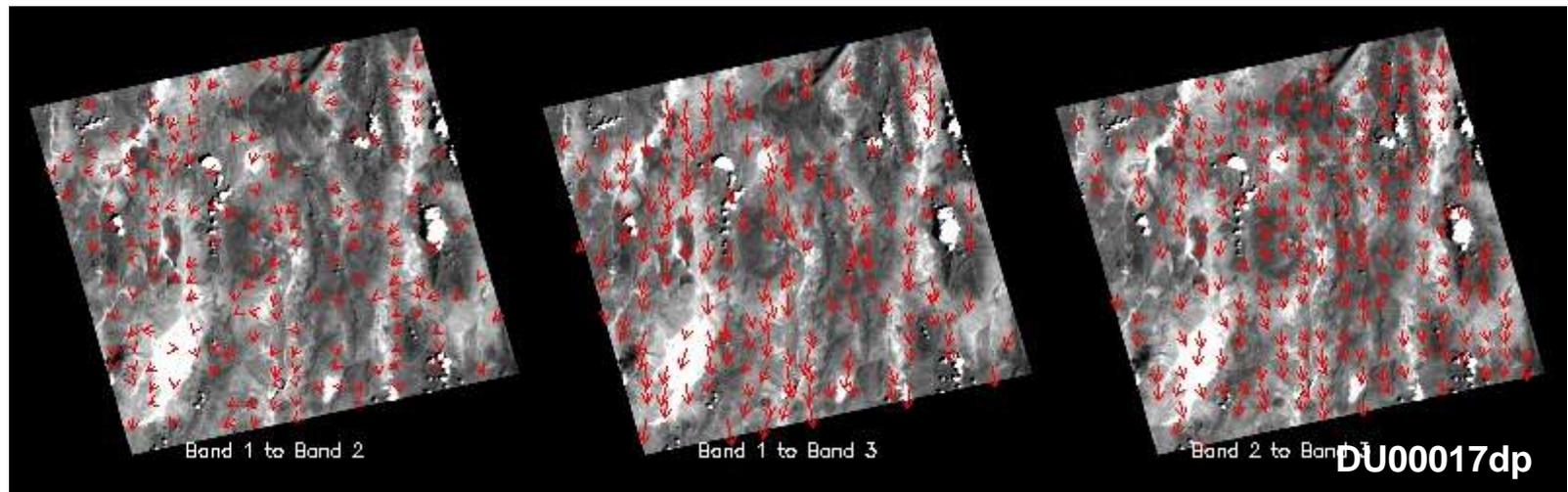
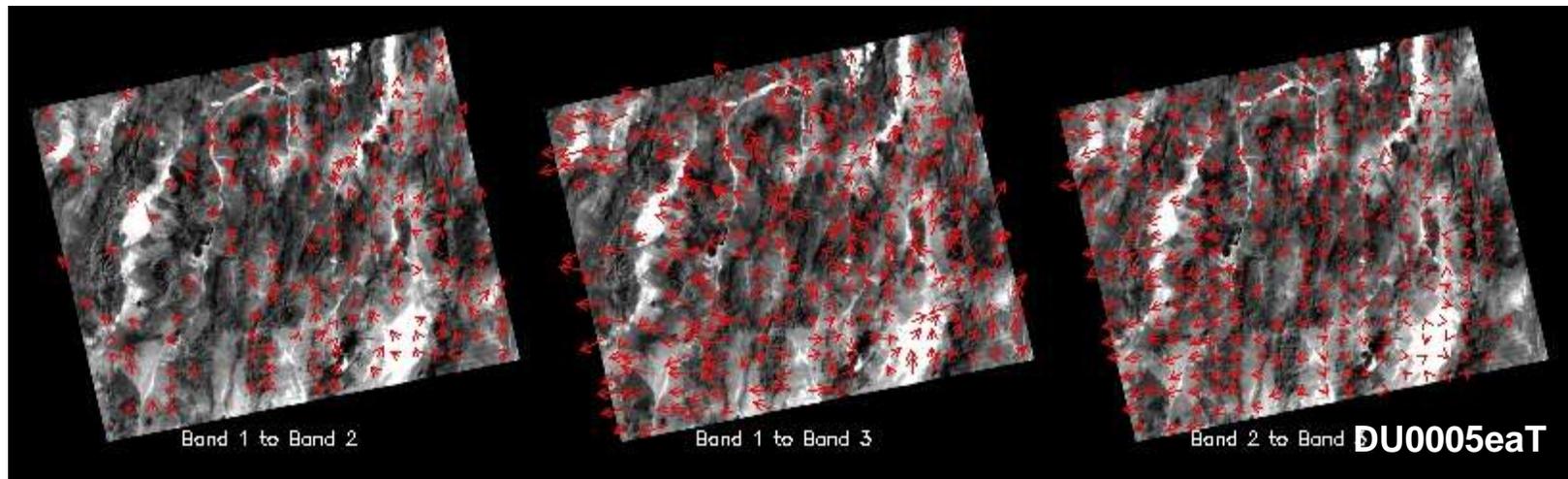
IAS Geometric Tools – B2B

- **IAS contains Band to Band (B2B) registration assessment tool**
 - ◆ B2B characterization is performed to ensure that the proper band alignment parameters are provided for the product generation
 - ◆ With Landsat, it is typically done by registering each band against every other band (resample bands of higher resolution to coarse resolution)
 - ◆ A reference band is selected (with L7 its band 8) and all other bands are adjusted (offset determined) by least square adjustment of the registration solution
 - ◆ These band offsets are provided in the CPF so that product generation system can align bands accordingly
- Provides numerical evaluation of accuracy of between band registration within an image
- No real restriction on image data sets that can be used, other sensor can be used in assessment

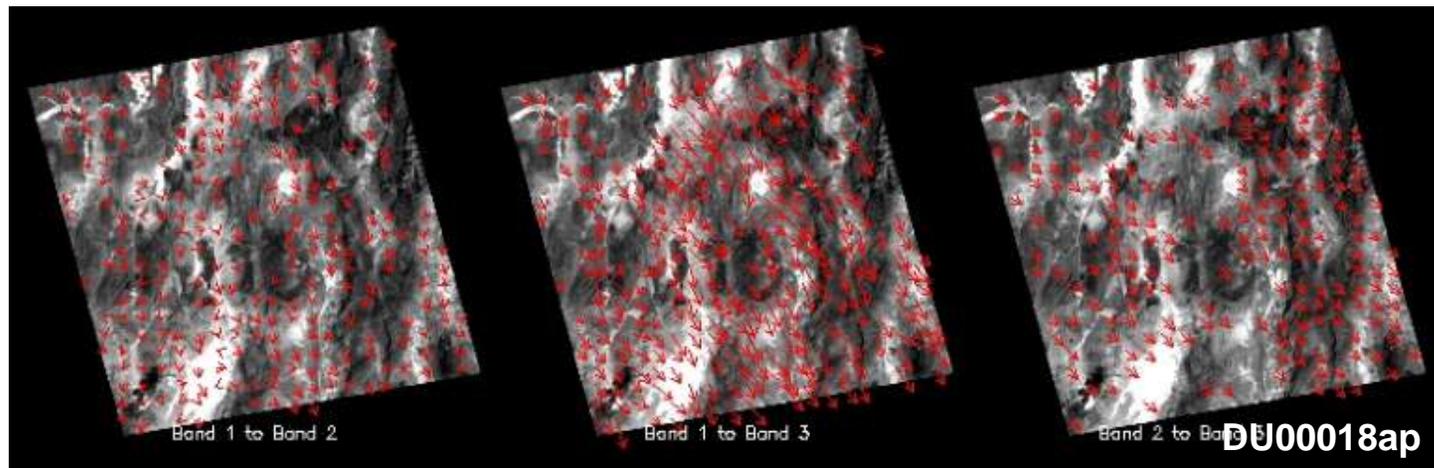
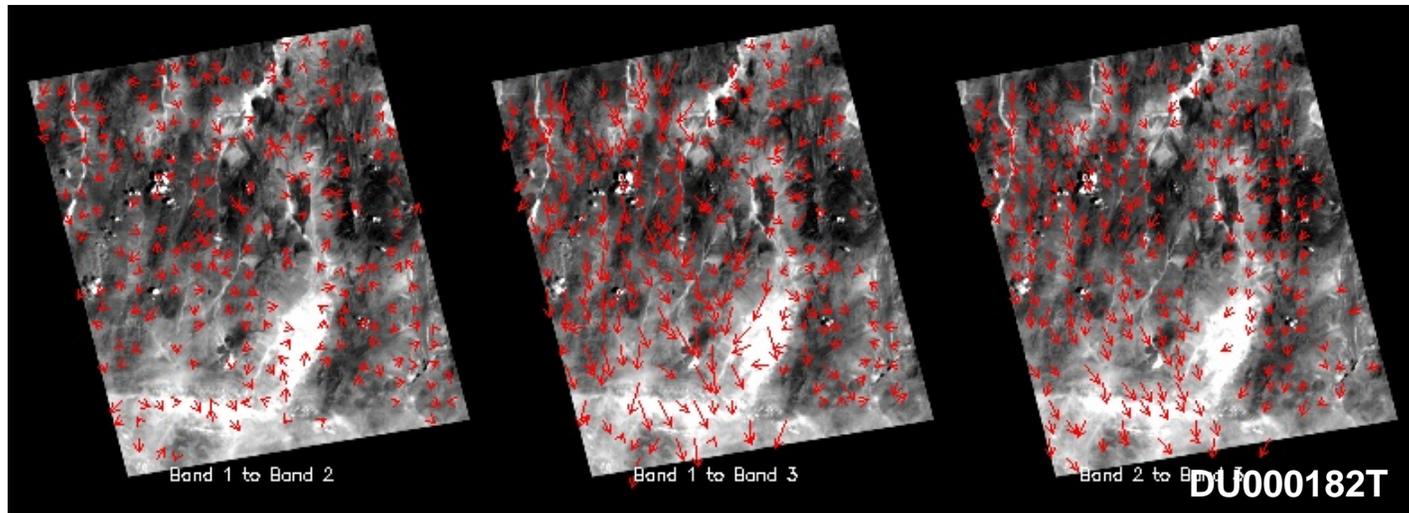
Band-to-Band Assessment Values listed in pixels

Scene	Rband	Sband	Points	Point Kept	Std Deviation		RMSE	
					Line	Sample	Line	Sample
DU0005eaT	1	2	396	182	0.0736	0.1154	0.1591	0.1181
DU0005eaT	1	3	398	291	0.1750	0.2497	0.1897	0.2761
DU0005eaT	2	3	403	309	0.0577	0.1598	0.0661	0.1856
DU00017dp	1	2	385	174	0.0672	0.0818	0.1180	0.0999
DU00017dp	1	3	385	176	0.1048	0.0794	0.3565	0.0814
DU00017dp	2	3	387	228	0.0561	0.0588	0.2457	0.0731
DU000182T	1	2	401	237	0.1194	0.1039	0.1191	0.1038
DU000182T	1	3	402	255	0.1825	0.1568	0.2841	0.1567
DU000182T	2	3	403	254	0.0779	0.1116	0.2106	0.1127
DU00018ap	1	2	397	240	0.0800	0.0738	0.1392	0.0781
DU00018ap	1	3	395	274	0.1203	0.1047	0.3606	0.2668
DU00018ap	2	3	400	198	0.0367	0.0331	0.2027	0.2158
DU00018fs	1	2	416	163	0.0538	0.0511	0.1427	0.0612
DU00018fs	1	3	414	191	0.0938	0.0927	0.2264	0.2230
DU00018fs	2	3	419	267	0.0752	0.0456	0.0833	0.1579
DU0005b2p	1	2	380	221	0.0733	0.0805	0.1765	0.1879
DU0005b2p	1	3	381	221	0.1148	0.1061	0.3759	0.5378
DU0005b2p	2	3	384	257	0.0772	0.0670	0.1553	0.3350
DU0005cdT	1	2	390	252	0.2101	0.0571	0.2115	0.0811
DU0005cdT	1	3	390	240	0.2179	0.1032	0.2546	0.2279
DU0005cdT	2	3	394	287	0.0660	0.0852	0.0891	0.1571
DU0005ddp	1	2	384	205	0.0767	0.0837	0.1333	0.1793
DU0005ddp	1	3	382	229	0.1451	0.0948	0.2682	0.6257
DU0005ddp	2	3	385	256	0.0716	0.0627	0.1227	0.3836

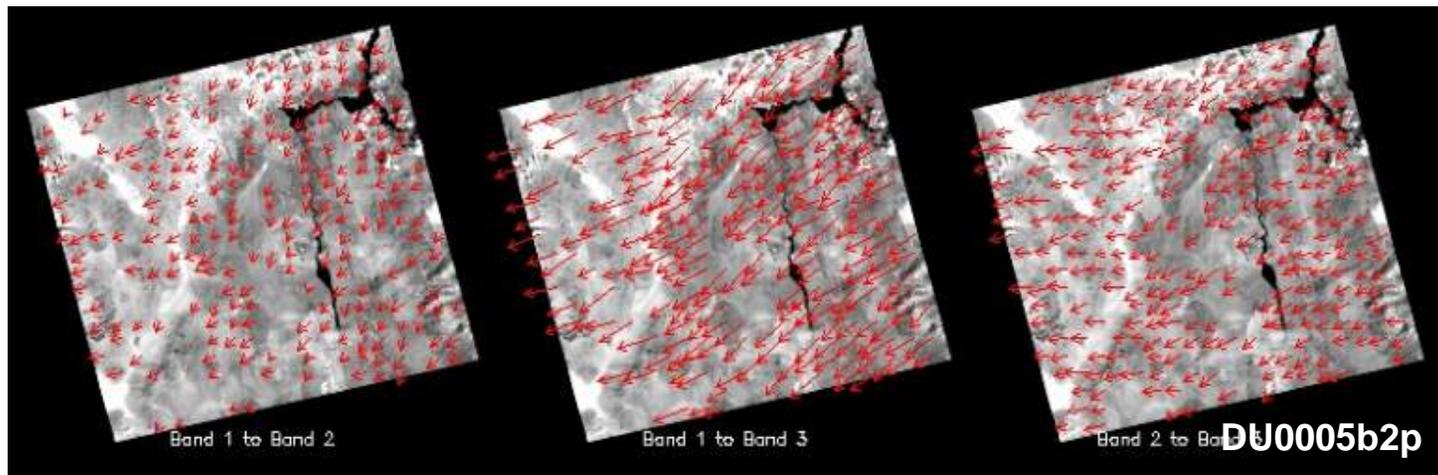
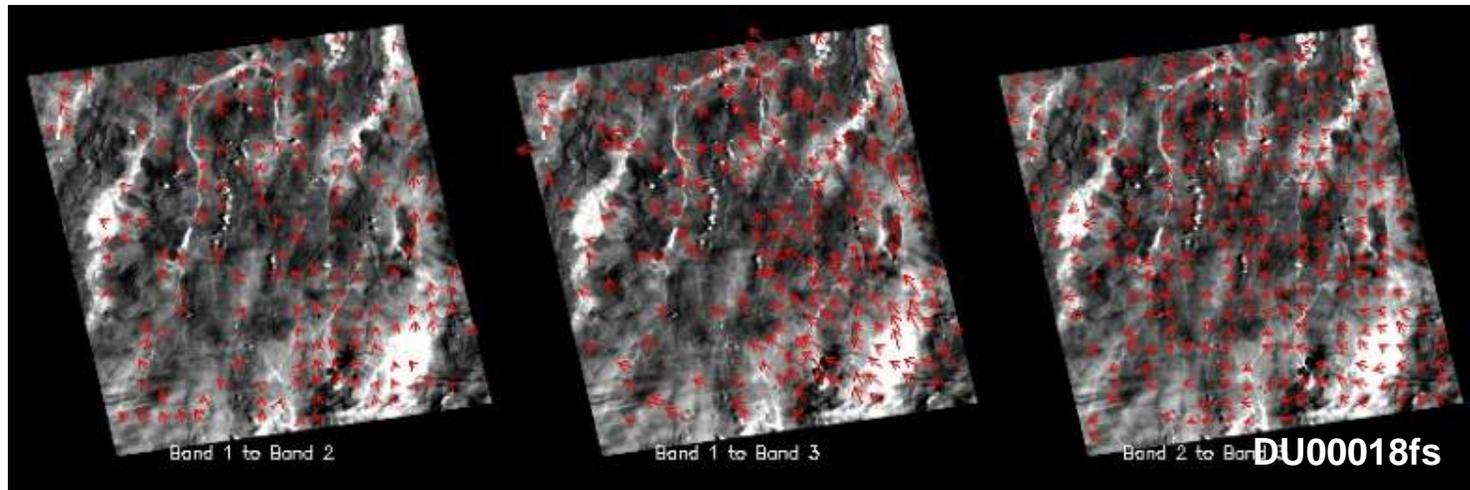
Band-to-Band Assessment Vector Plot (Vectors scaled by a factor of 3000)



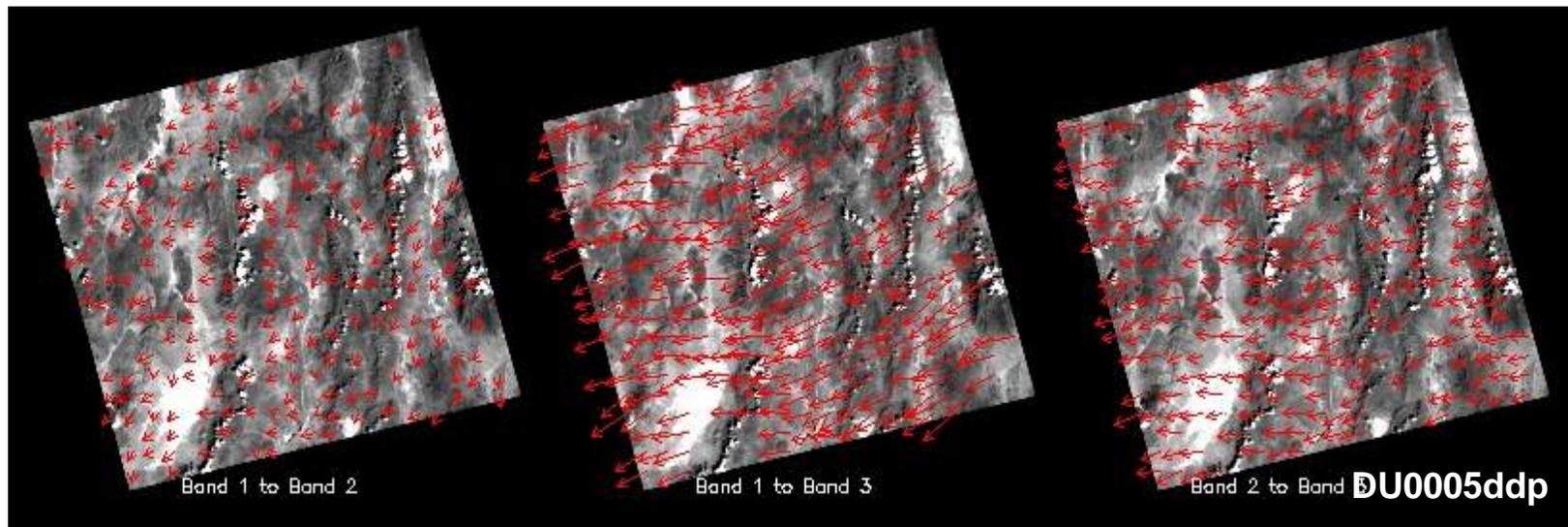
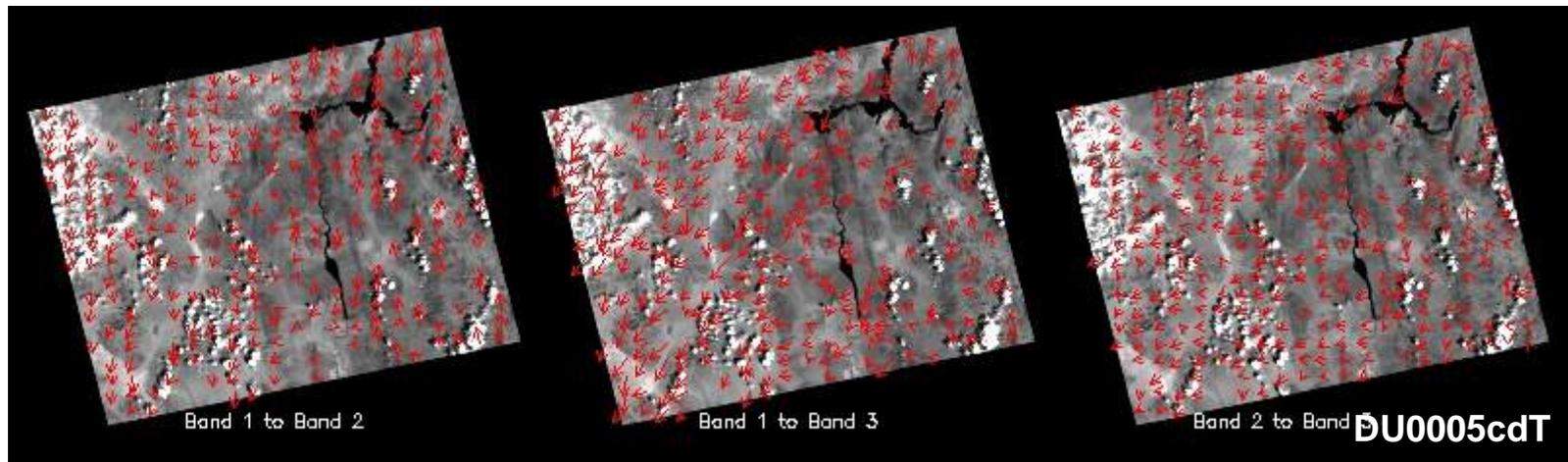
Band-to-Band Assessment Vector Plot (Vectors scaled by a factor of 3000)



Band-to-Band Assessment Vector Plot (Vectors scaled by a factor of 3000)



Band-to-Band Assessment Vector Plot (Vectors scaled by a factor of 3000)



Conclusion

- **Eight SSTL DMC L1T Images were assessed**
 - ◆ Six scenes compared against reference imagery
 - ◆ Eight scenes assessed for band registration
- **The RMSE measured between the DMC and reference data sets ranged from**
 - ◆ 7.03 to 23.53 meters (0.22-0.74 pixels) in the X direction
 - ◆ 26.20 to 36.67 meters (0.82-1.15 pixels) in the Y direction
- **The RMSE band alignment offsets measured within the DMC data sets had values of up to**
 - ◆ 12.03 meters (0.37 pixels) in the line direction and
 - ◆ 20.03 meters (0.62 pixels) in the sample direction