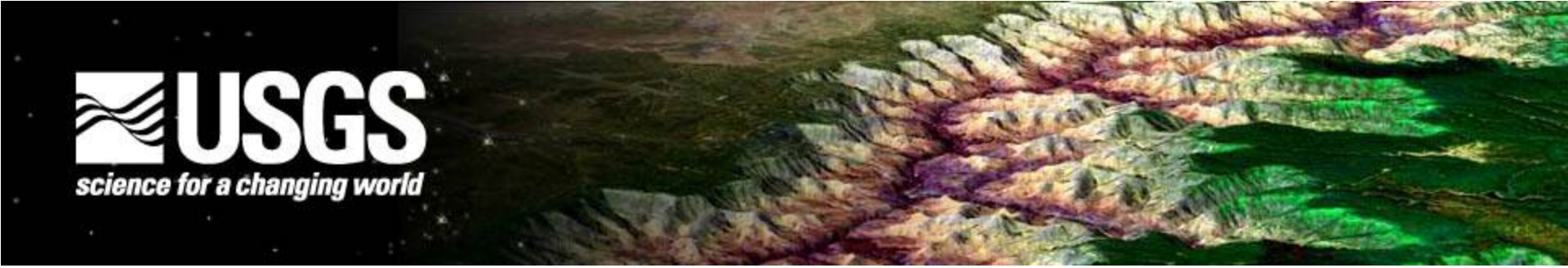

Geometric Accuracy Assessment of Data from Deimos-1 and Pleiades 1-A

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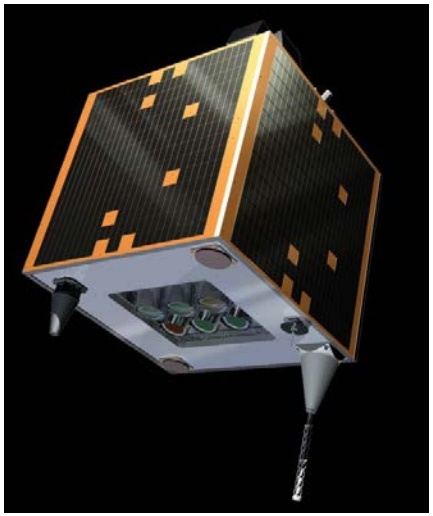
Earth Resources Observation and Science (EROS)
Work performed under USGS contract 08HQCN0005

Outline

- **Data Overview**
  - Deimos-1
  - Pleiades 1-A
- **Geometric Assessment**
- **Results**
  - Deimos -1
  - Pleiades 1-A
- **Summary**

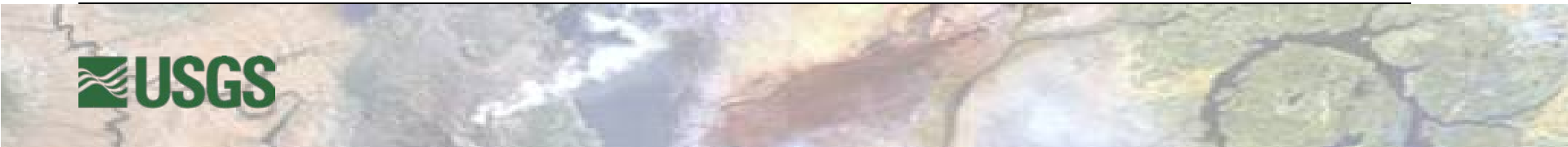
Deimos-1



- 6 datasets provided by Fabrizio Pirondini of Deimos
- Three bands
  - Green, Red and NIR
- GSD of 22m
- ~600 km swath width
- Data for analysis in WGS UTM Zone 13N (Pueblo), and 14N (Sioux Falls)
- Reference Data: GLS2005

Pleiades 1-A overview

- Data from Pleiades 1-A
  - Sioux Falls – Ortho (Produced using SRTM DEM)
  - Pueblo – Ortho (Produced using SRTM DEM)
- Four spectral bands
  - Blue, Green, Red, Near Infrared
- Ground sampling distance: 0.5 m (PAN), 2 m (MSS)
- Data for analysis in WGS UTM Zone 13N (Pueblo) and 14N (Sioux Falls)
- Reference data: Orthoimagery, Ground Control Points

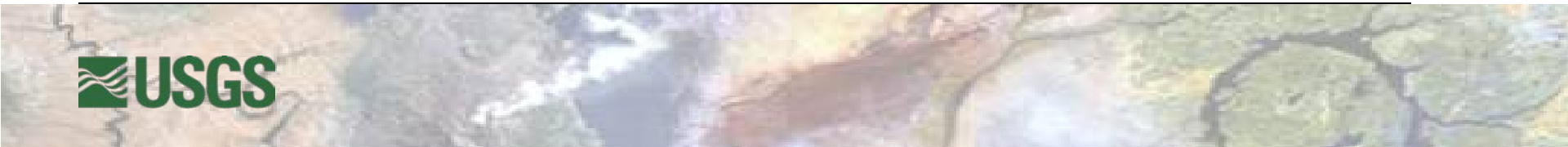


Geometric Accuracy Assessment

- **Using Ground Control Points**
  - For high resolution satellites
  - USGS Geometric Test Ranges
    - Sioux Falls (SD), Pueblo (CO), Rolla (MO), Surrey (NC)

- **Performed using the Landsat Image Assessment System (IAS)**
  - Developed for Radiometric and Geometric Characterization and Calibration for Landsat data.
- **Band to Band (B2B) assessment**
  - B2B is performed to test band alignment of the image data
  - It is typically done by registering each band against every other band

- **Image to Image (I2I) registration assessment tool**
  - Search image assessed against an image of higher accuracy (reference data)
  - When the correlated points are plotted in the image, it also helps to detect any systematic bias in the image



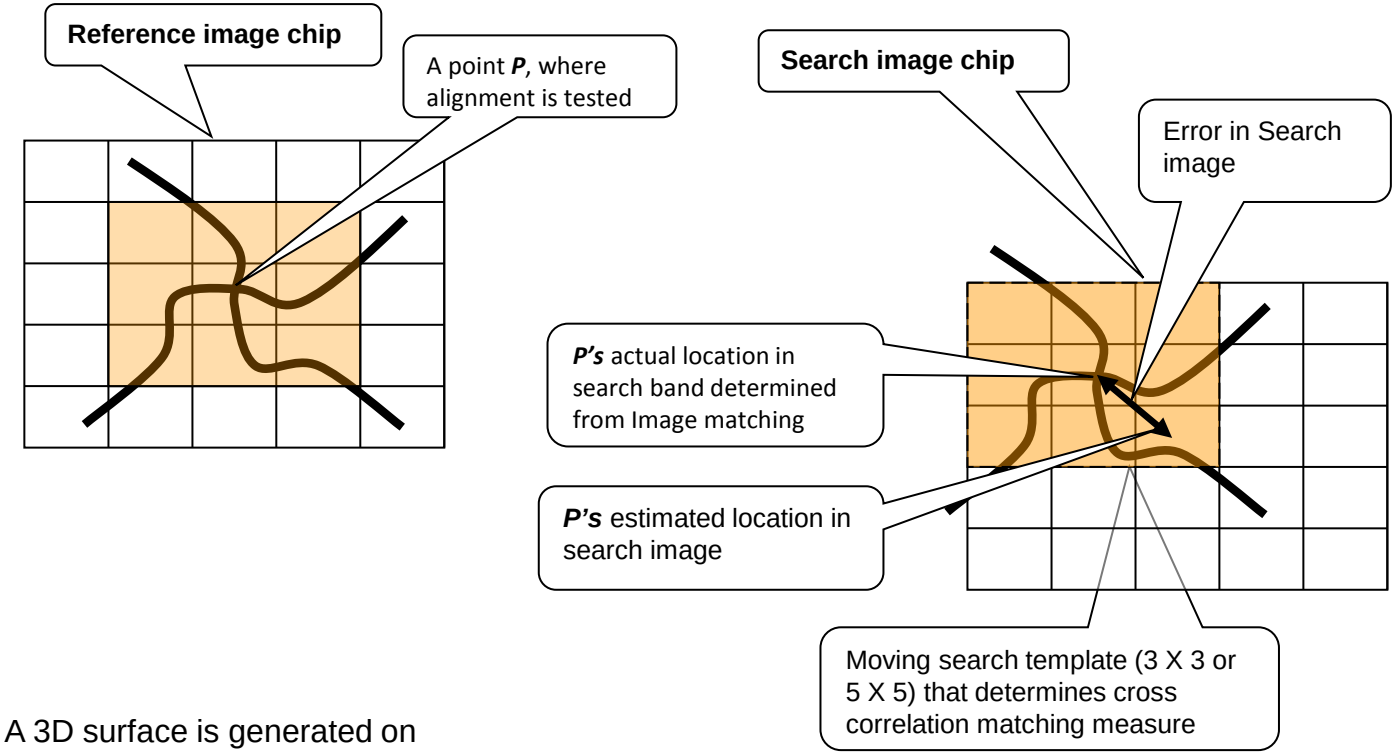
Geometric Accuracy Assessment: IAS

- **Compares relative positions of two images**
  - The input consists of a reference image and a search image
- **The reference image and the corresponding pixels in the search image inputs are uniformly sampled (using the image geolocation/header information).**
  - Image chips (64 x 64 or 32 x 32 pixels) for reference and study images are selected around these samples.
- **Normalized cross-correlation values between the center of the reference image chip and study image chip are generated**

$$CC(I,S) = \left(\sum_{i,j} \left(I_R(i,j) - \bar{I}_R\right)\left(I_S(i,j) - \bar{I}_s\right) \right) \Big/ \left(\sqrt{\Sigma\left(I_R - \bar{I}_R\right)^2} \sqrt{\Sigma\left(I_S - \bar{I}_s\right)^2} \right)$$

- **A correlation surface (third order) is generated and its peak is taken to be the measure of image displacement**

Geometric Accuracy Assessment : Image Registration



- A 3D surface is generated on the correlation values.
- The maxima of the surface is taken as the location of offset

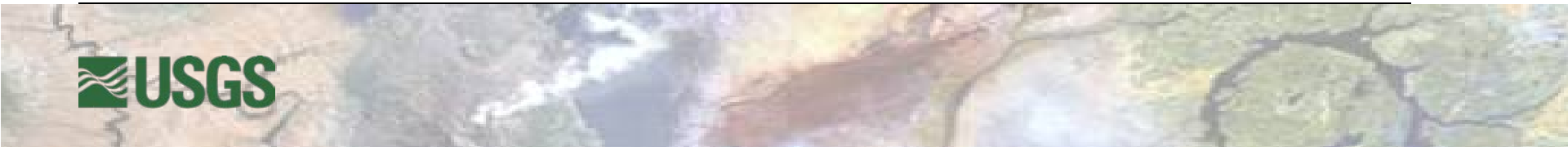
Deimos -1 Data Analysis

Deimos Data Analysis

- **Data acquired over Sioux Falls, SD and Pueblo, CO**

DMC2 Study Target Region	Acquisition Date	Assessment	
		I2I	B2B
Pueblo, CO	2012-04-17	Yes	Yes
Pueblo, CO	2012-06-17	Yes	No
Pueblo, CO	2012-07-03	Yes	No
Sioux Falls, SD	2011-04-12	Yes	Yes
Sioux Falls, SD	2011-01-10	Yes	No
Sioux Falls, SD	2012-03-28	Yes	No

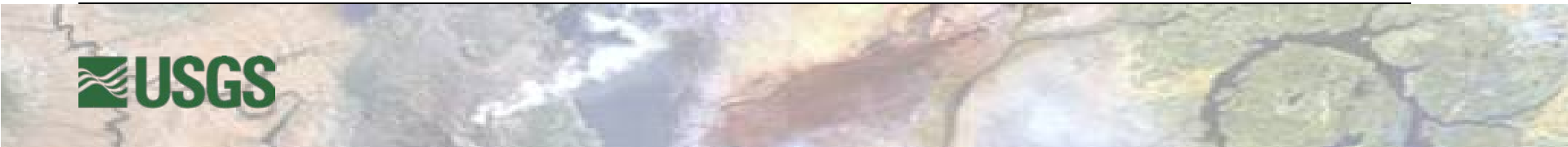
- **Datasets were Geometrically corrected to L1T products**
- **Coordinate System: WGS84 UTM Zones 13 (Pueblo) and 14N (SF)**
- **Reference data used: GLS2005 30 m GSD Red band data were resampled to 22 m to match Deimos data**



Deimos I2I Results: Sioux Falls

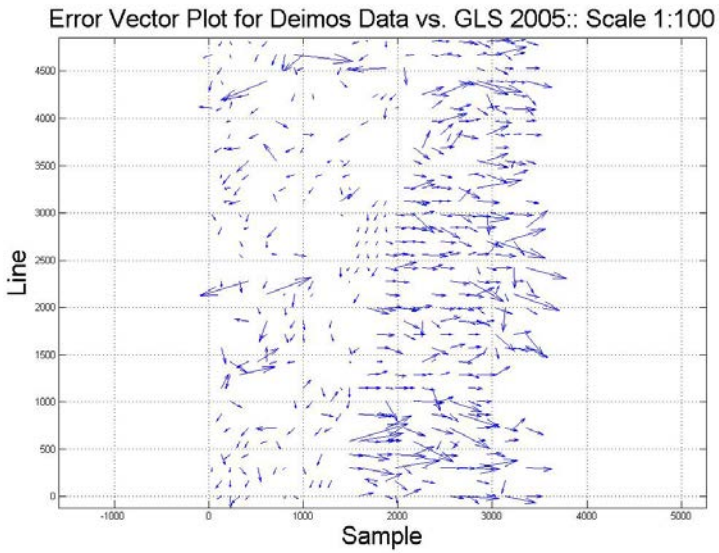
Summary statistics for Deimos I2I analysis for imagery over Sioux Falls

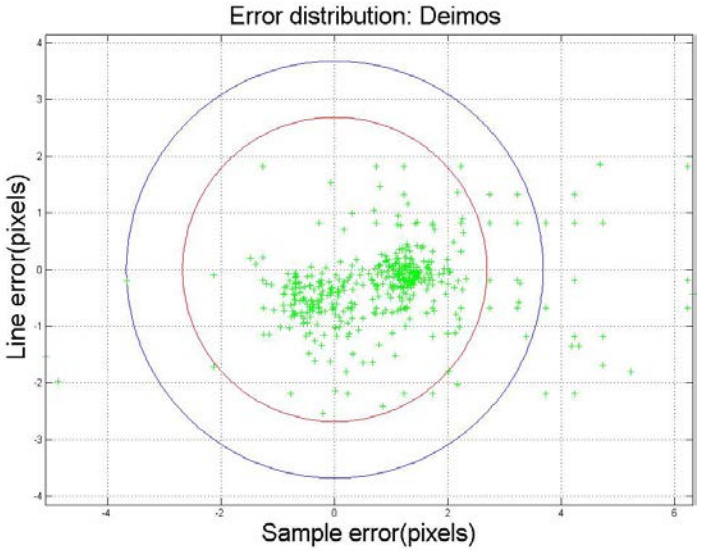
		Line	Sample	Line	Sample
		Pixels		Meters	
Sioux Falls Dataset 1 483 points	Mean	-0.30	0.87	-6.71	19.12
	Std Dev	0.66	1.39	14.60	30.51
	RMSE	0.73	1.64	16.07	36.02
	Total RMSE	1.79		39.44	
Sioux Falls Dataset 2 720 points	Mean	-0.36	0.57	-7.91	12.53
	Std Dev	0.52	1.03	11.49	22.81
	RMSE	0.63	1.18	13.96	26.03
	Total RMSE	1.34		29.54	
Sioux Falls Dataset 3 659 Points	Mean	-0.45	-0.56	-10.03	12.49
	Std Dev	0.64	1.18	14.22	26.09
	RMSE	0.79	1.31	17.40	28.93
	Total RMSE	1.53		33.76	



Deimos I2I Results: Sioux Falls

- **Dataset 1**

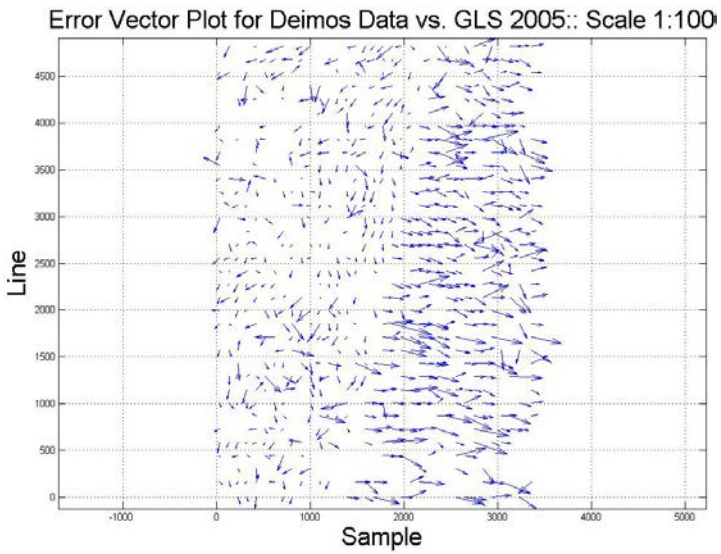


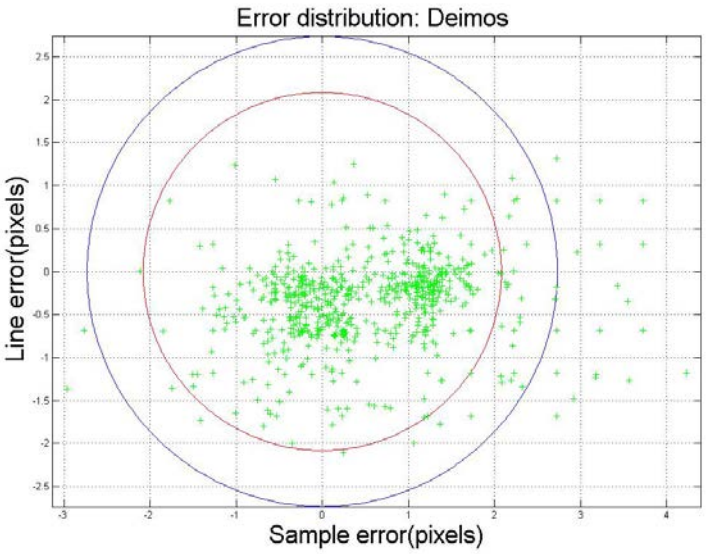


Deimos data over Sioux Falls
RMSE of 1.79 pixels or 39.44 m
The Red and Blue circles indicate the 90th and 95th percentile values of error

Deimos I2I Results: Sioux Falls

- **Dataset 2**

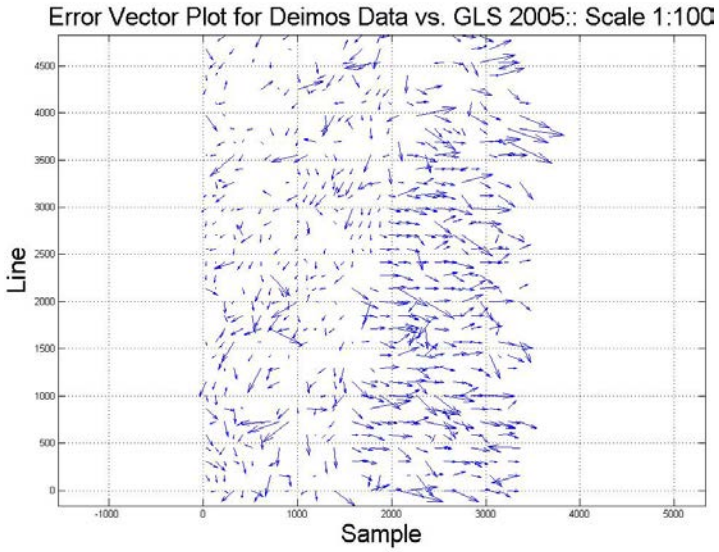


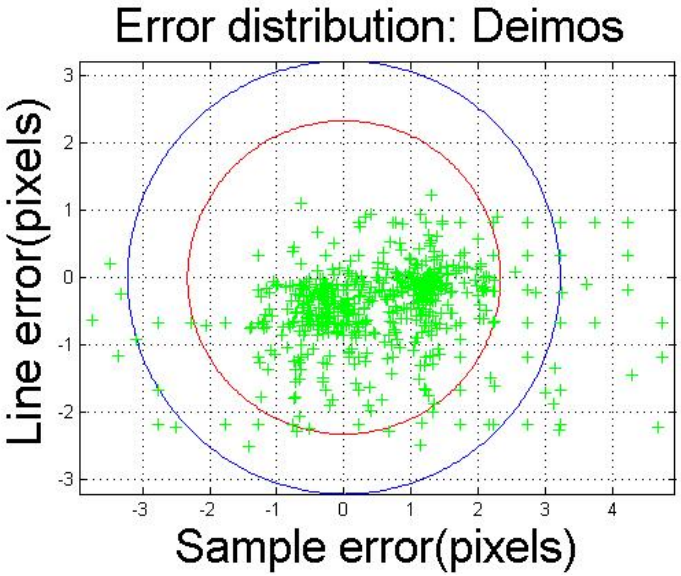


Deimos data over Sioux Falls
RMSE of 1.34 pixels or 29.54 m
The Red and Blue circles indicate the 90th and 95th percentile values of error

Deimos I2I Results: Sioux Falls

- **Dataset 3**



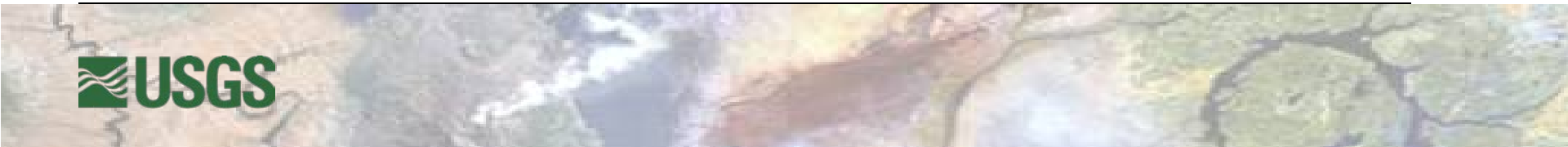


Deimos data over Sioux Falls
RMSE of 1.53 pixels or 33.56 m
The Red and Blue circles indicate the 90th and 95th percentile values of error

Deimos I2I Results: Pueblo

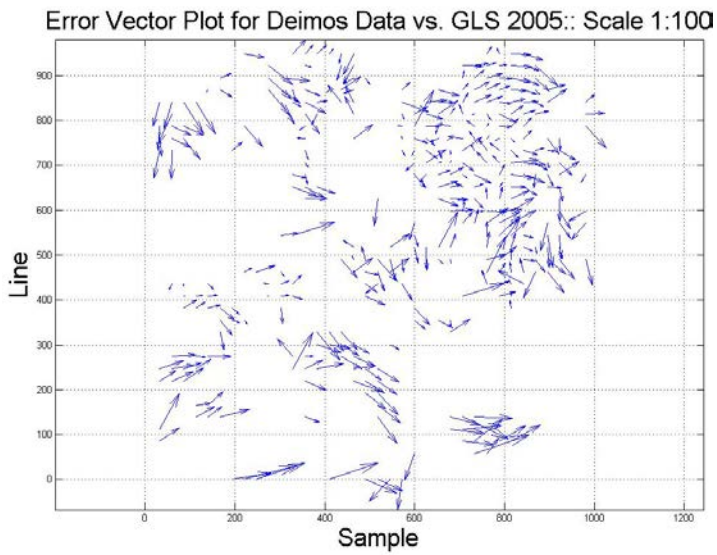
Summary statistics for Deimos I2I analysis for imagery over Pueblo

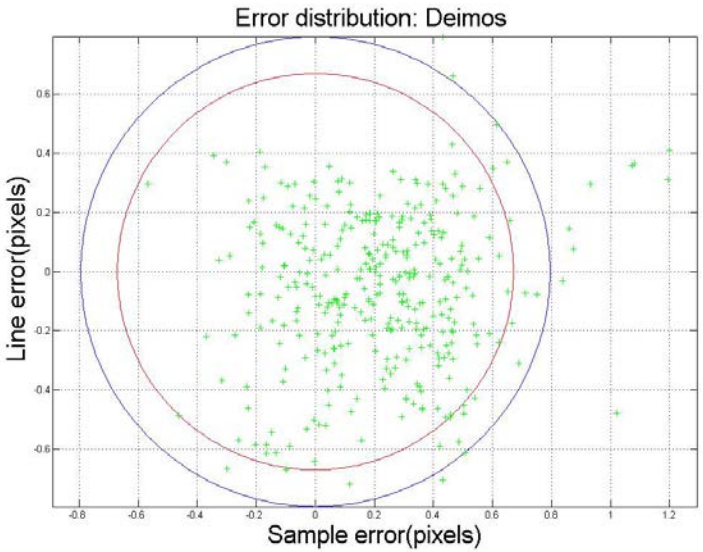
		Line	Sample	Line	Sample
		Pixels		Meters	
Pueblo Dataset 1 367 points	Mean	-0.04	0.23	-0.95	5.09
	Std Dev	0.28	0.27	6.10	5.93
	RMSE	0.28	0.35	6.17	7.82
	Total RMSE	0.45		9.96	
Pueblo Dataset 2 261 points	Mean	0.09	0.11	1.97	2.62
	Std Dev	0.22	0.30	4.88	6.64
	RMSE	0.24	0.32	5.27	7.13
	Total RMSE	0.40		8.87	
Pueblo Dataset 3 370 Points	Mean	0.07	0.25	1.63	5.49
	Std Dev	0.21	0.26	4.71	5.81
	RMSE	0.23	0.36	4.99	8.00
	Total RMSE	0.43		9.43	



Deimos I2I Results: Pueblo

- **Dataset 1**

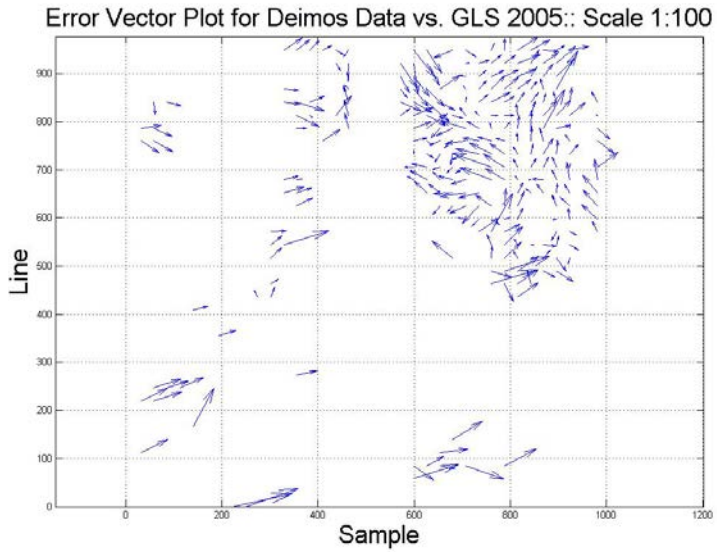


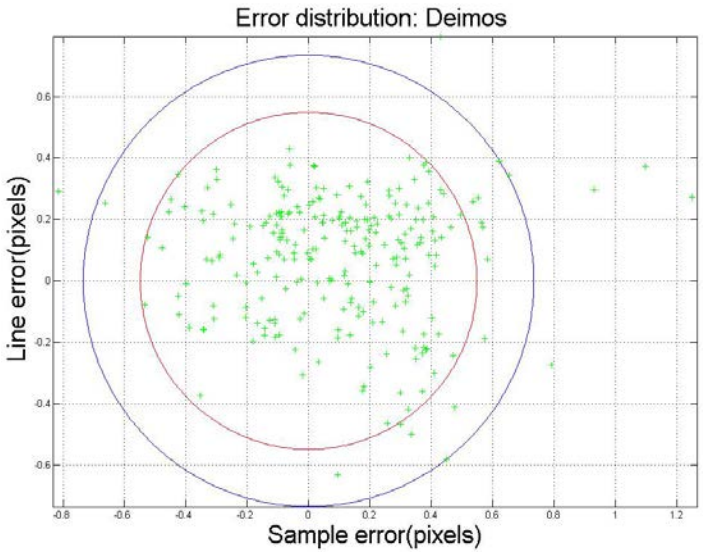


Deimos data over Pueblo
RMSE of 0.45 pixels or 9.96 m
The Red and Blue circles indicate the 90th and 95th percentile values of error

Deimos I2I Results: Pueblo

- **Dataset 2**

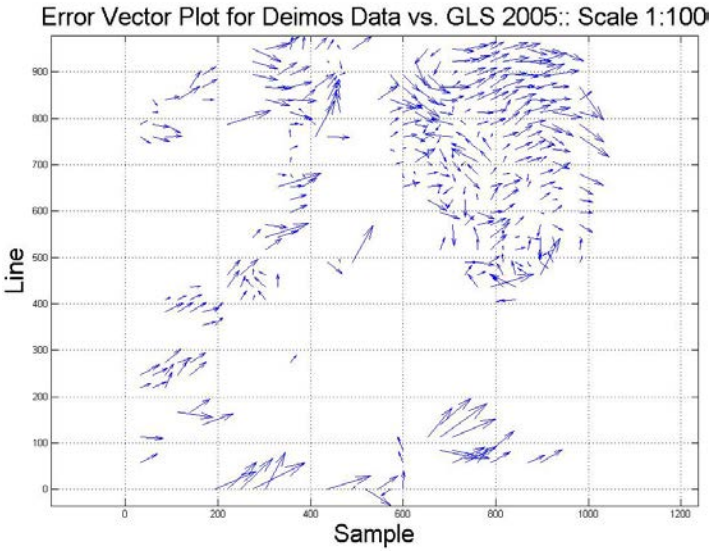


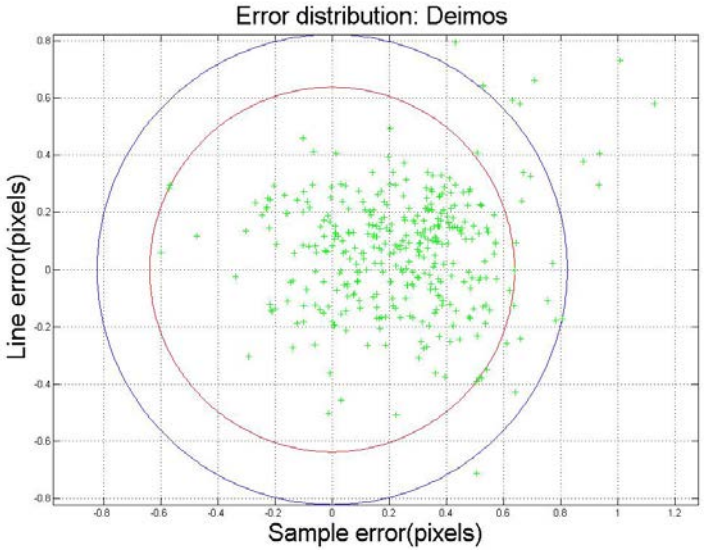


Deimos data over Pueblo
RMSE of 0.4 pixels or 8.87 m
The Red and Blue circles indicate the 90th and 95th percentile values of error

Deimos I2I Results: Pueblo

- **Dataset 3**

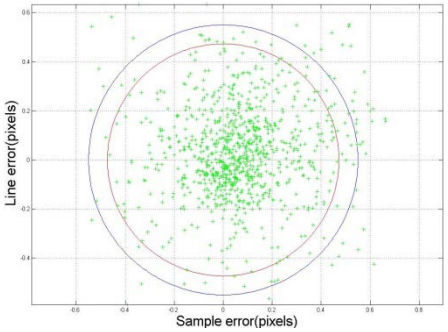


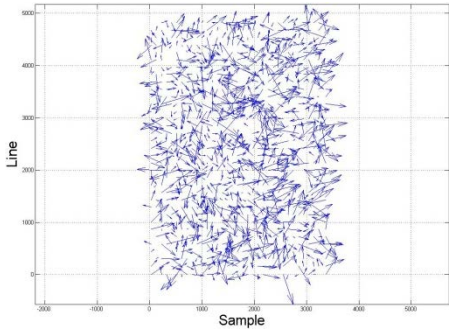


Deimos data over Pueblo
RMSE of 0.43 pixels or 9.43 m
The Red and Blue circles indicate the 90th and 95th percentile values of error

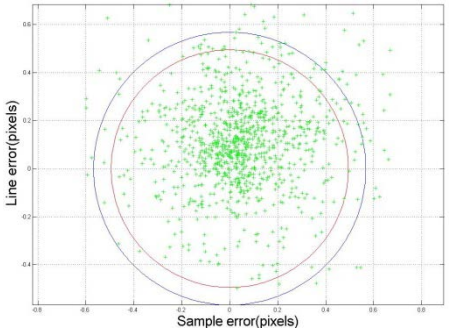
Deimos B2B Results

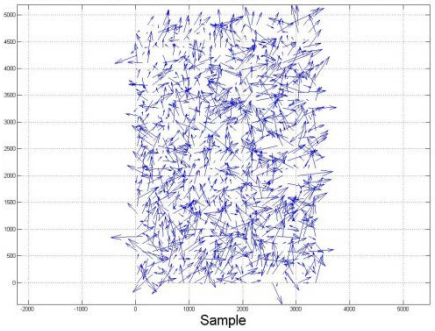
Band 1- Band 2
RMSE: 0 .12 pixels



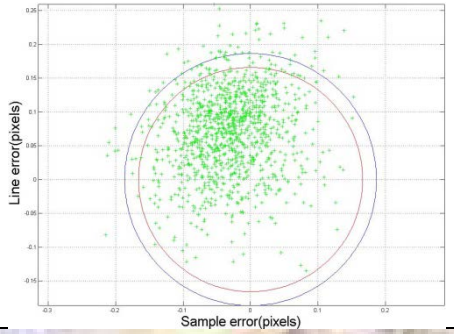


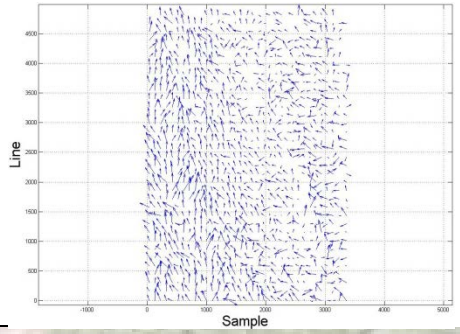
Band 1- Band 3
RMSE: 0.14 pixels





Band 2- Band 3
RMSE: 0.09 pixels





Pleiades 1-A Data Analysis

Pleiades 1-A Data Analysis

- Ground Control Points based analysis for 0.5 m PAN data
- I2I matching using Orthoimagery as control data for MSS data
- Coordinate System: WGS 84 UTM Zone 13N for Pueblo and Zone 14 N for Sioux Falls data

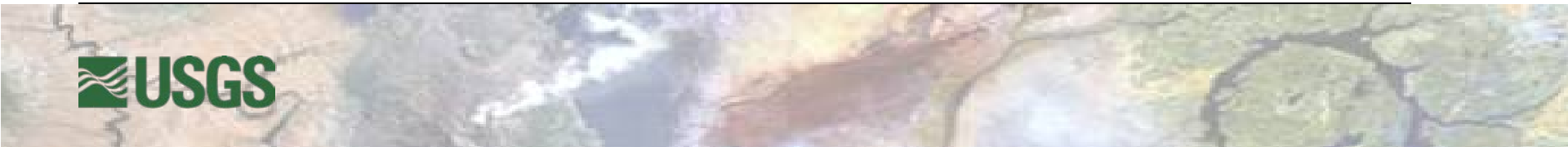
Pleiades 1-A Geometric results

Summary statistics for Pleiades 1-A GCP analysis for imagery: Sioux Falls

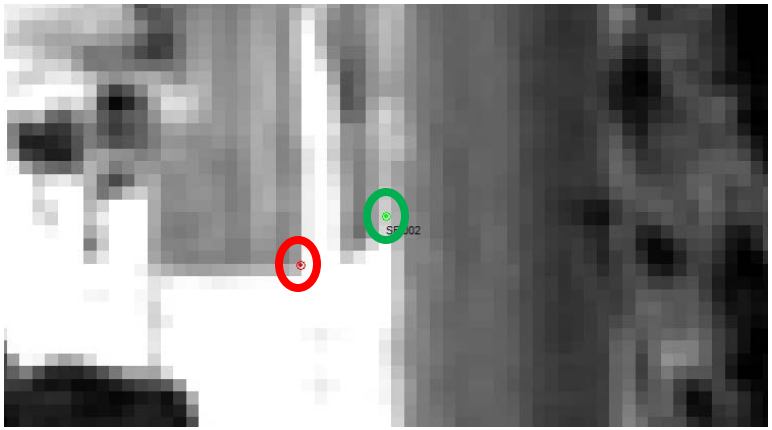
Sioux Falls GCP analysis PAN Band	X	Y
	Meters	
Mean	-3.62	2.20
StDev	0.28	0.33
RMSE	3.63	2.22
Total RMSE	4.26	

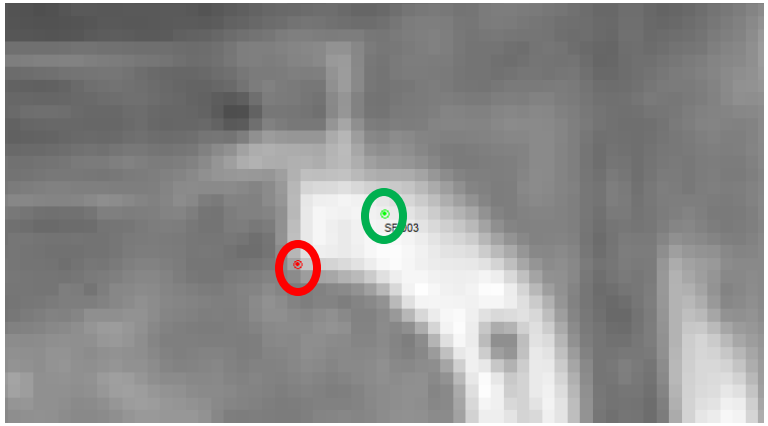
Summary statistics for Pleiades 1-A GCP analysis for imagery: Pueblo

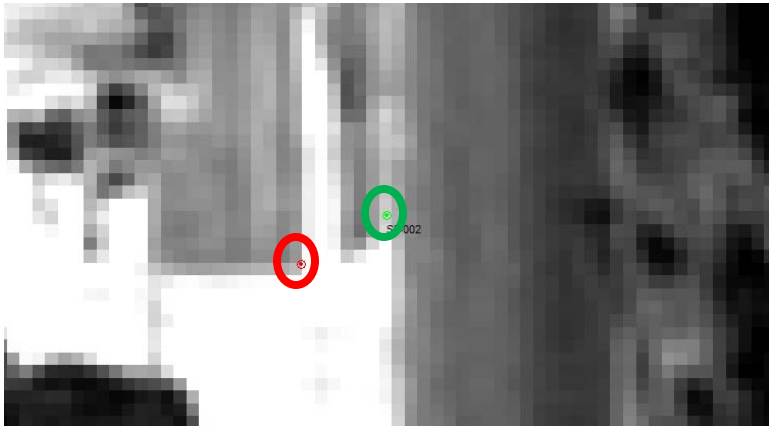
Pueblo GCP analysis PAN Band	X	Y
	Meters	
Mean	2.13	-5.26
StDev	1.36	1.68
RMSE	2.58	5.52
Total RMSE	6.06	

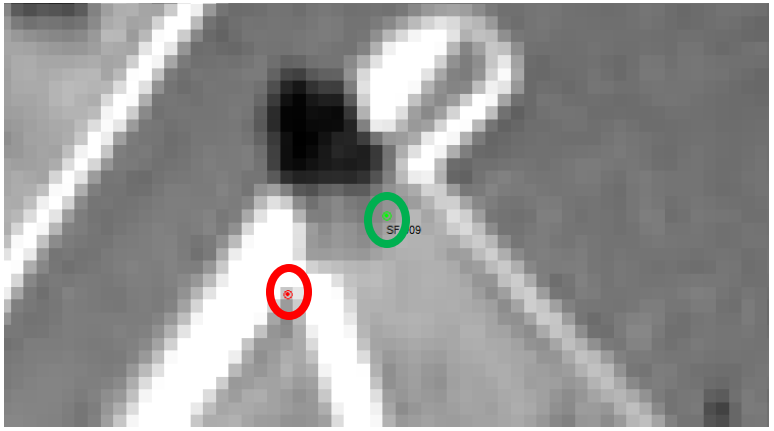


SF Visuals

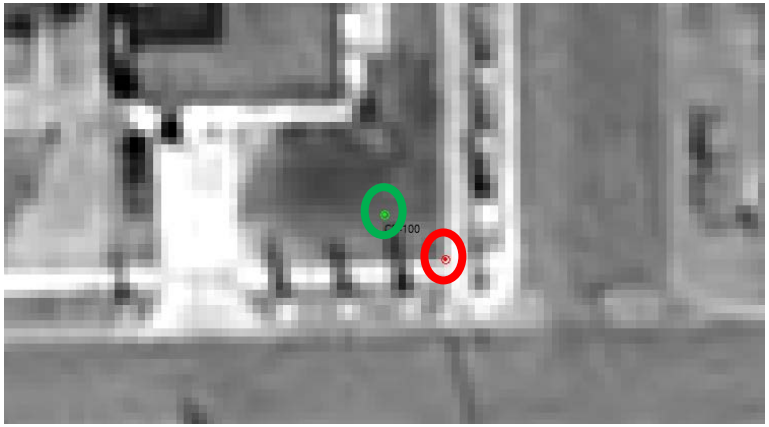


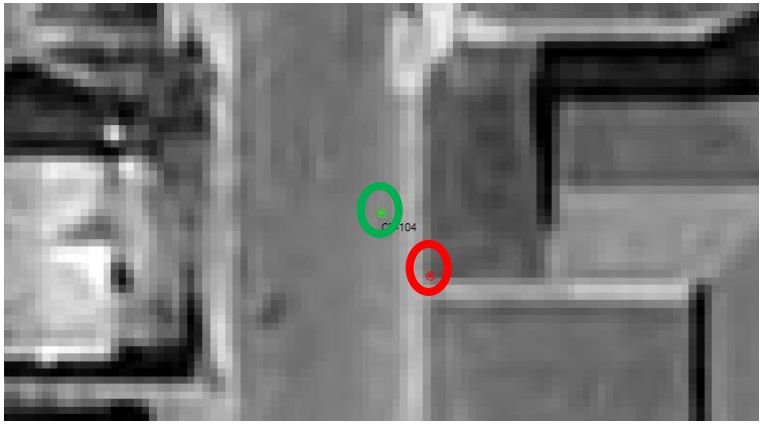


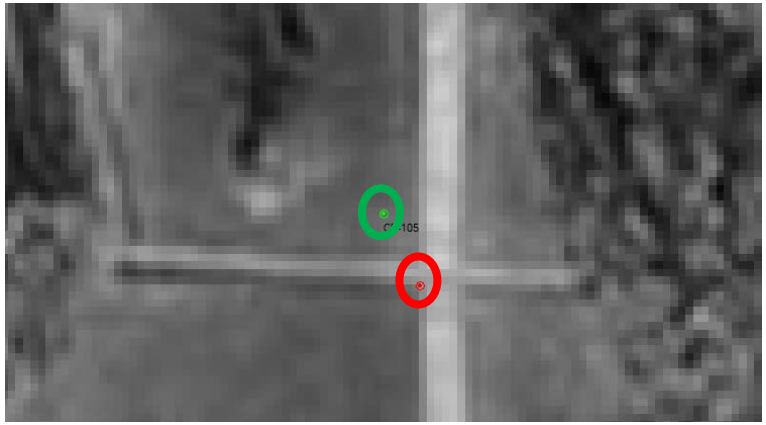


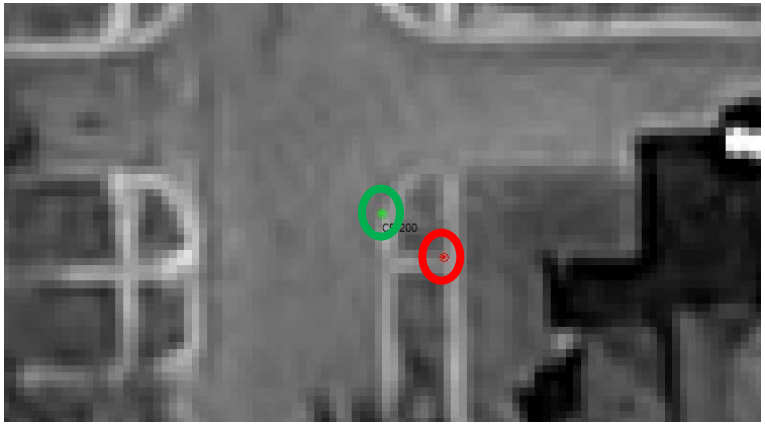


Pueblo Visuals



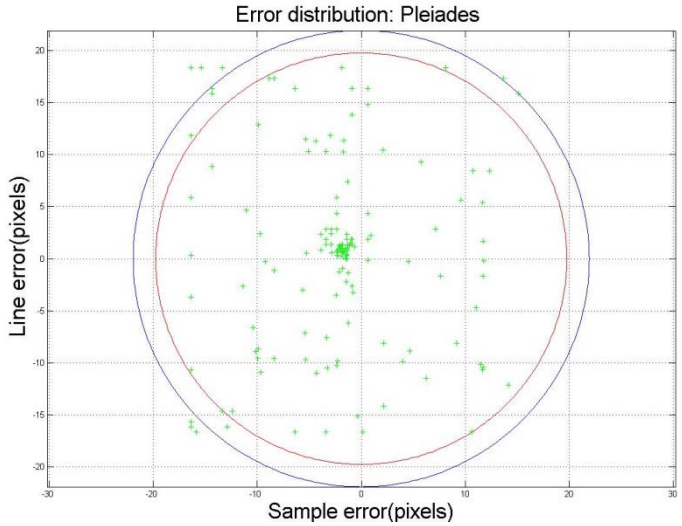


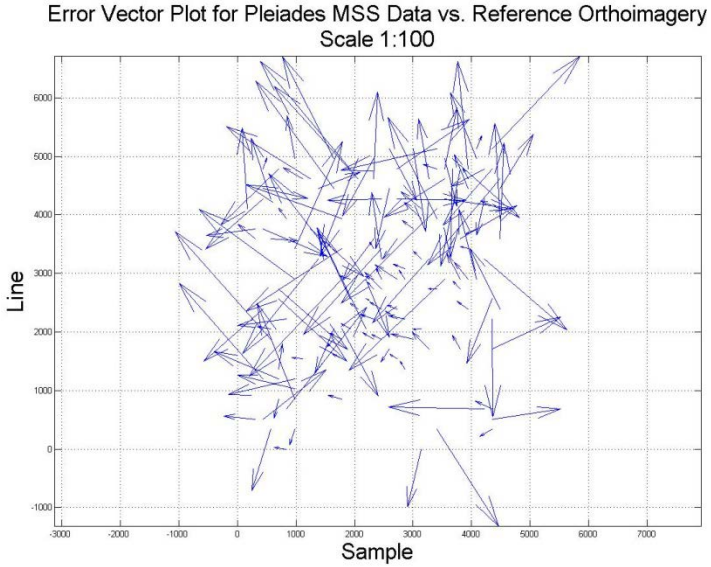




Pleiades 1-A MSS results

		Line	Sample	Line	Sample
		Pixels		Meters	
Sioux Falls Dataset 1 147 points	Mean	1.24	-1.92	2.48	3.84
	Std Dev	0.80	0.72	1.60	1.44
	RMSE	1.47	2.04	2.94	4.08
	Total RMSE	2.51		5.02	



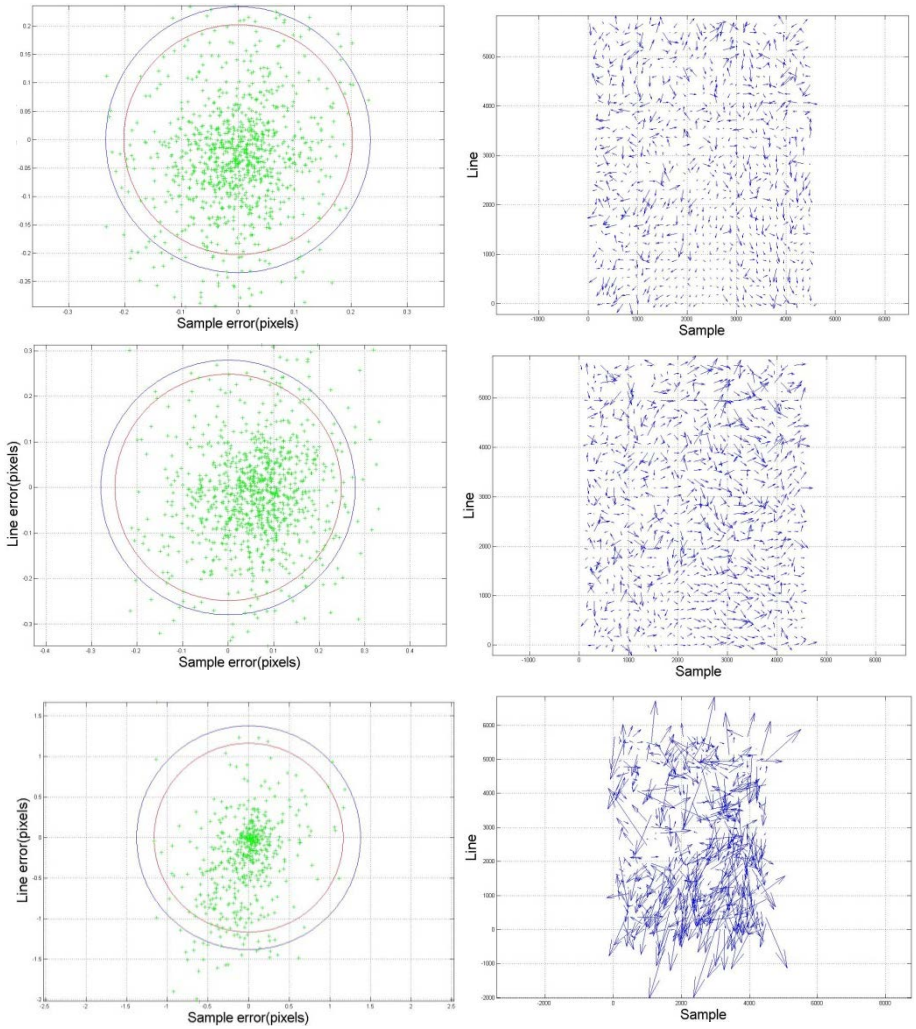


Pleiades 1-A B2B Results

Band 1 vs. Band 2:
RMSE 0.05 pixels

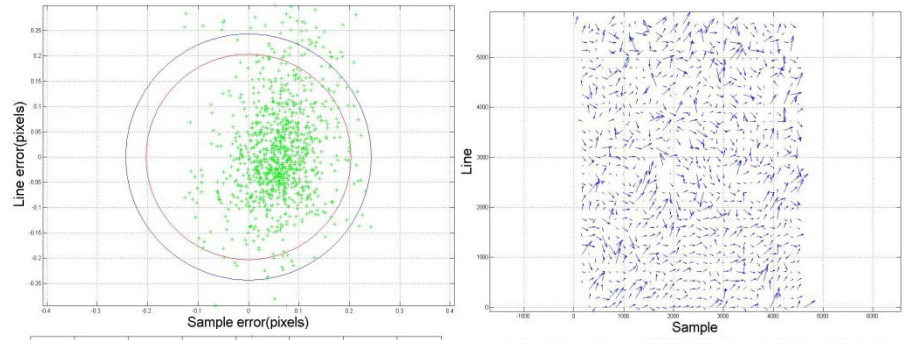
Band 1 vs. Band 3:
RMSE 0.09 pixels

Band 1 vs. Band 4:
RMSE 0.08 pixels

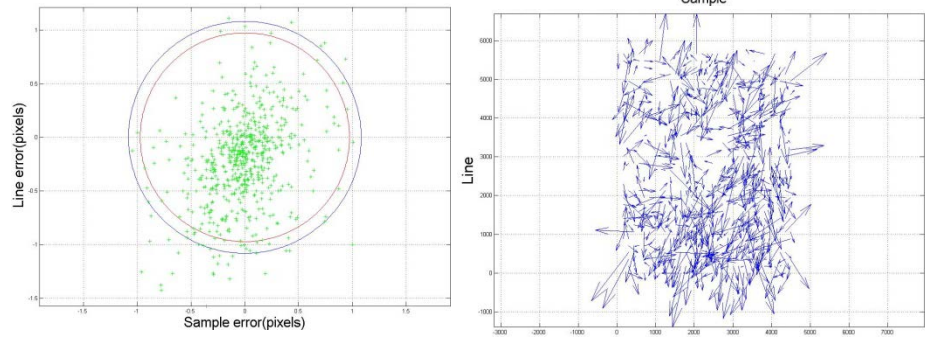


Pleiades 1-A B2B Results

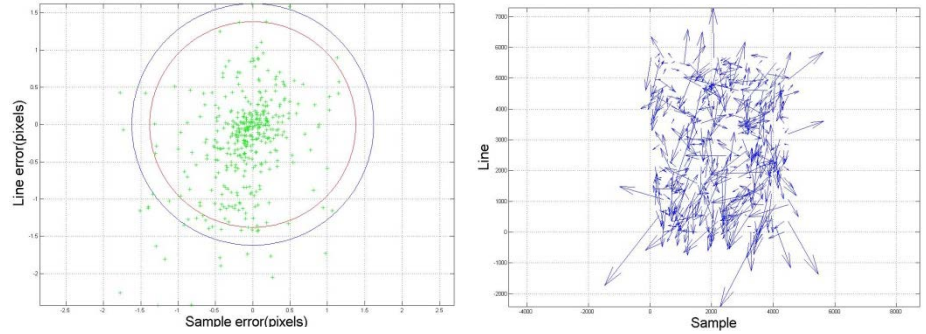
Band 2 vs. Band 3:
RMSE 0.08 pixels



Band 2 vs. Band 4:
RMSE 0.23 pixels



Band 3 vs. Band 4:
RMSE 0.19 pixels



Summary

- **Remote Sensing Technologies (RST) team has completed the data characterizations for Deimos, Pleiades 1-A**
  - Deimos-1 data were less than 1.8 pixel RMSE in SF and less than 0.5 pixel RMSE in Pueblo
    - Band registration was good
  - Pleiades 1-A data were found to have 4-6 m RMSE
    - B2B registration was good
- **Look forward to more assessments in the future**
  - Continued data assessments for Medium and high resolution datasets ..
  - Elevation data characterizations
    - As resolution of DEM increases, assessing planimetric accuracy (in addition to vertical accuracy) also becomes important
  - More data and more collaborations welcome