

# An Overview of GeoEye's AWiFS Ortho Production Process

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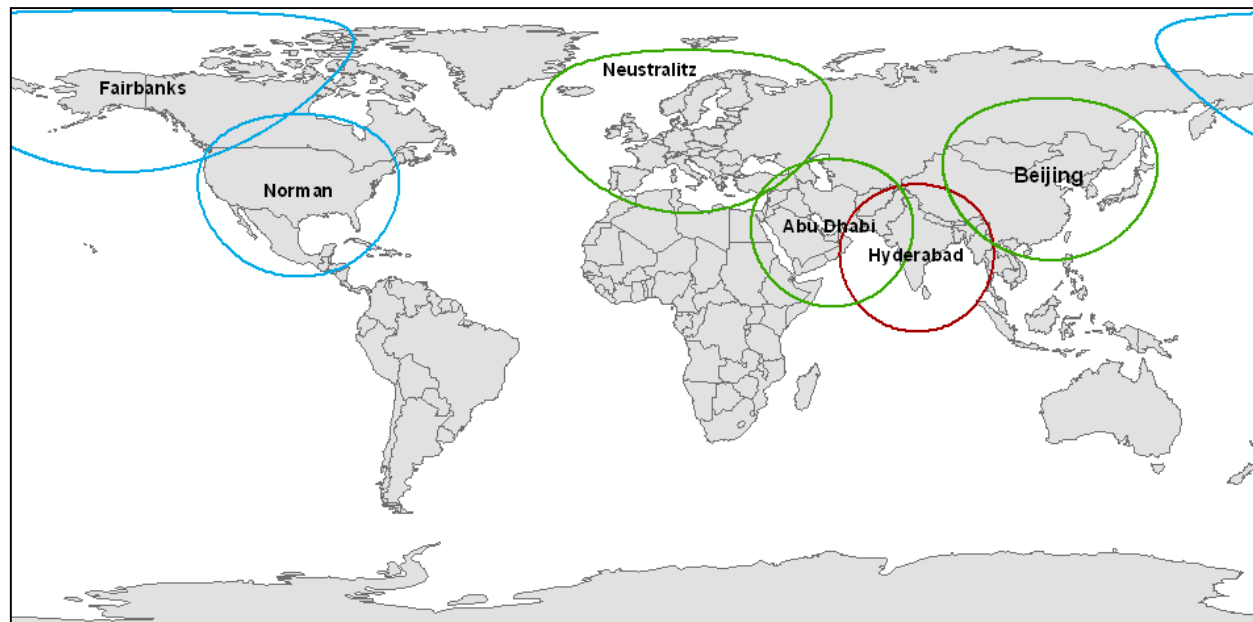


# Introduction

- Most Resourcesat-1 imagery sold to USDA is in the form of orthorectified AWiFS scenes
- AWiFS orthos require map control to meet accuracy specifications (uncontrolled scenes: ~500 m CE90 positional accuracy)
- GeoEye has developed a production workflow with custom software to streamline the process of data management, control point measurement, block adjustment and orthorectification
- Production workflow is interactive but not labor intensive
- Major workflow steps:
  - Source data acquisition and QC
  - Ancillary data compilation
  - Control point measurement and assessment
  - Block adjust and orthorectification
  - 10-to-8 bit rescaling

# Source Data Acquisition

- Customer specifies path/row/quad/date for collection
- Inside CONUS:
  - Scenes collected and downlinked in realtime to Norman, OK ground terminal
- Outside CONUS:
  - Realtime collection / downlink to IRS-P6 regional affiliate station;
  - or
  - Stored on OBSSR and downlinked at India

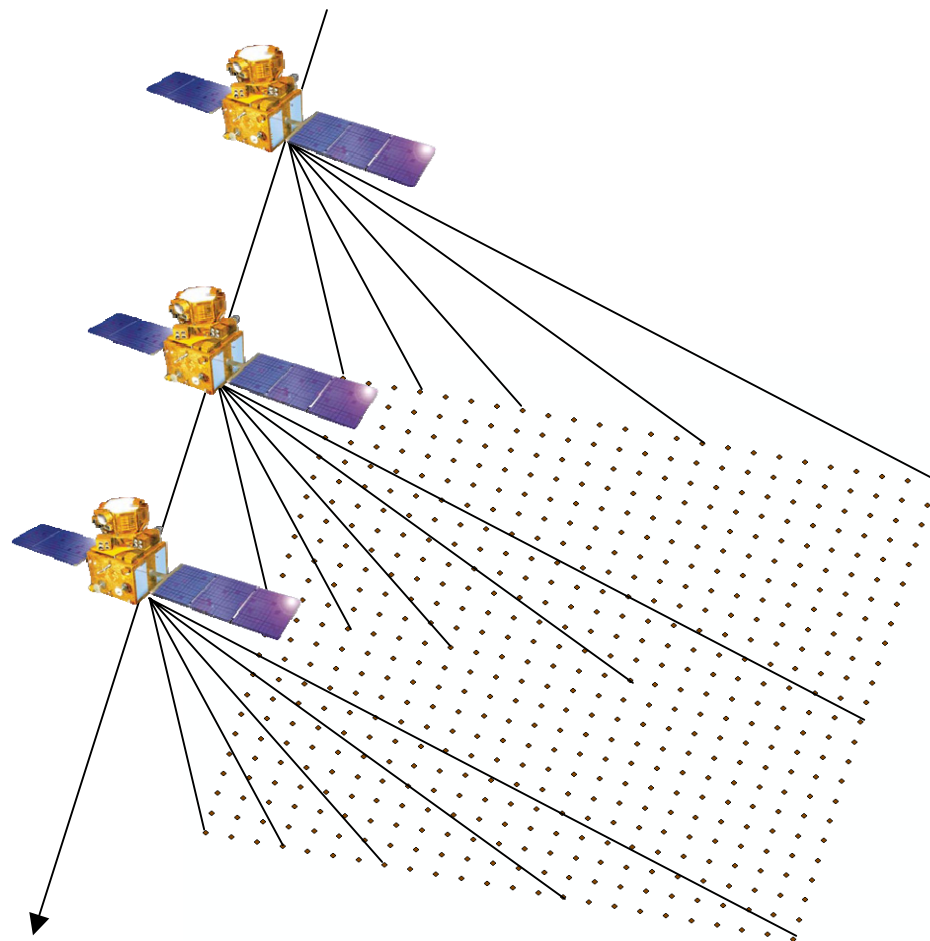


## IRS-P6 Receiving Stations

Norman, Fairbanks: **GeoEye**  
Hyderabad: **NRSA**  
Neustalitz: **Euromap**  
Abu Dhabi: **Space Imaging Middle East**  
Beijing: **RSGS**  
(Not all sites listed)

# Source Data Acquisition cont'd

- Ortho processing performed outside IRS-P6 ground station
- Process starts with standard IRS-P6 product:
  - Geo product (path-oriented)
  - LGSOWG format
  - LCC projection
  - CC resampling
- LGSOWG format contains metadata allowing reconstruction of view geometry (*Lutes, 2005*)
- LGSOWG scenes sent from receiving station to Norman for ortho processing
  - Direct downlink: < 2 hours
  - FTP: 1-2 days
  - Courier: 4-5 days



*LGSOWG 'map projection' records indicate direction from ground to satellite from various points in the image*

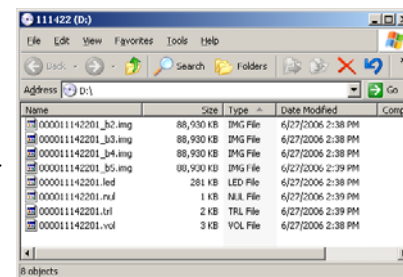
# Initial Reformatting / QC

- GeoEye proprietary software reformats LGSOWG to more convenient format
- 4-band TIFF created
- RPCs generated from LGSOWG view geometry metadata
- Visual examination of scene:
  - Cloud cover
  - Processing/downlink anomalies
  - Correct path/row/quad/date
- Customer contacted (email with screen captures) for questionable scenes

```

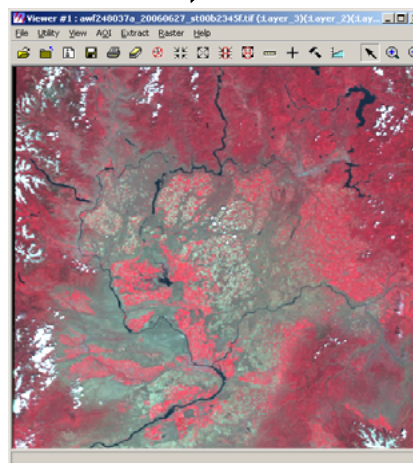
Command Prompt - awf_data_prep_disk

Output base directory : ..
Reference file directory: G:\sdg_ref_32n
MED DEM directory     : G:\med
Genid directory       : G:\genid_data
Reproject ref files   : False
Work folder: ..\AWF248037A_20060627
Inverting normals for sample
Finished inverting normals for sample
Forming misclosure vector
Forming misclosure vector
Computing residuals
Computed RMS (W.08941)
Inverting normals for line
Finished inverting normals for line
Forming misclosure vector
Forming misclosure vector
Computing residuals
Computed RMS (0.08653)
Initializing output TIFF file
Processing line 1 of 6684
Processing line 581 of 6684
Processing line 1061 of 6684
Processing line 1541 of 6684
Processing line 2021 of 6684
Processing line 2501 of 6684
Processing line 3081 of 6684
  
```

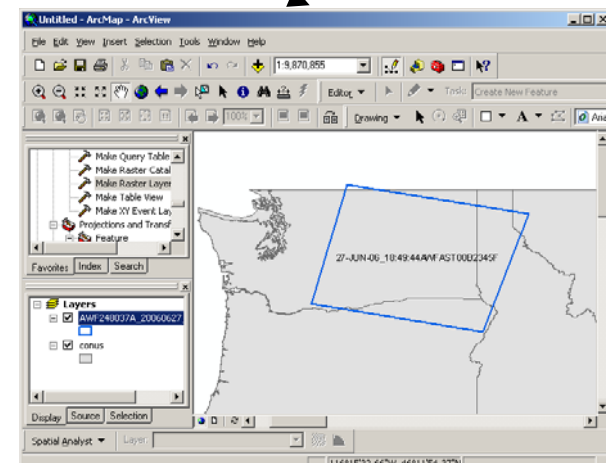


Source LGSOWG files

Data staging / reformatting utility



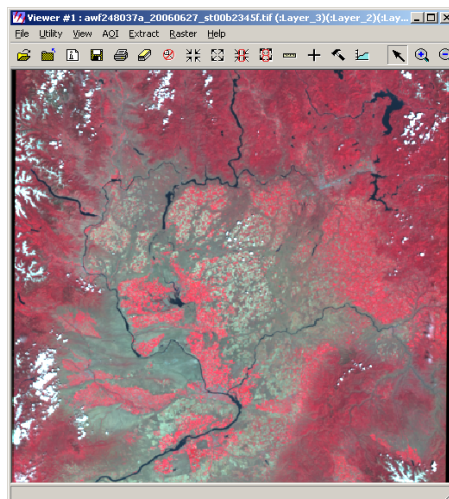
4-band TIFF + RPC



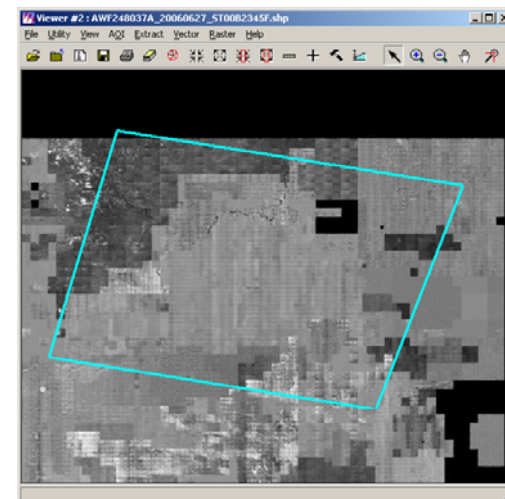
Scene footprint

# Ancillary Data Compilation (CONUS)

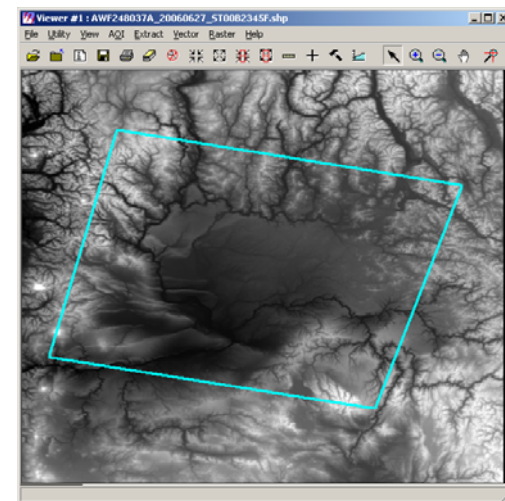
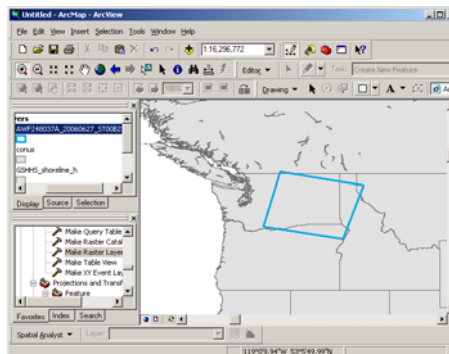
- Data staging utility also compiles reference orthoimagery and DEM
- DEM: **1-arcsecond NED**
  - SRTM-3 used for scenes straddling US borders
- Imagery: **USGS DOQs**
  - Reduced resolution DOQs used for AWiFS control (32 m GSD)
  - ~12 m CE90 positional accuracy (1:24K)



Source Image

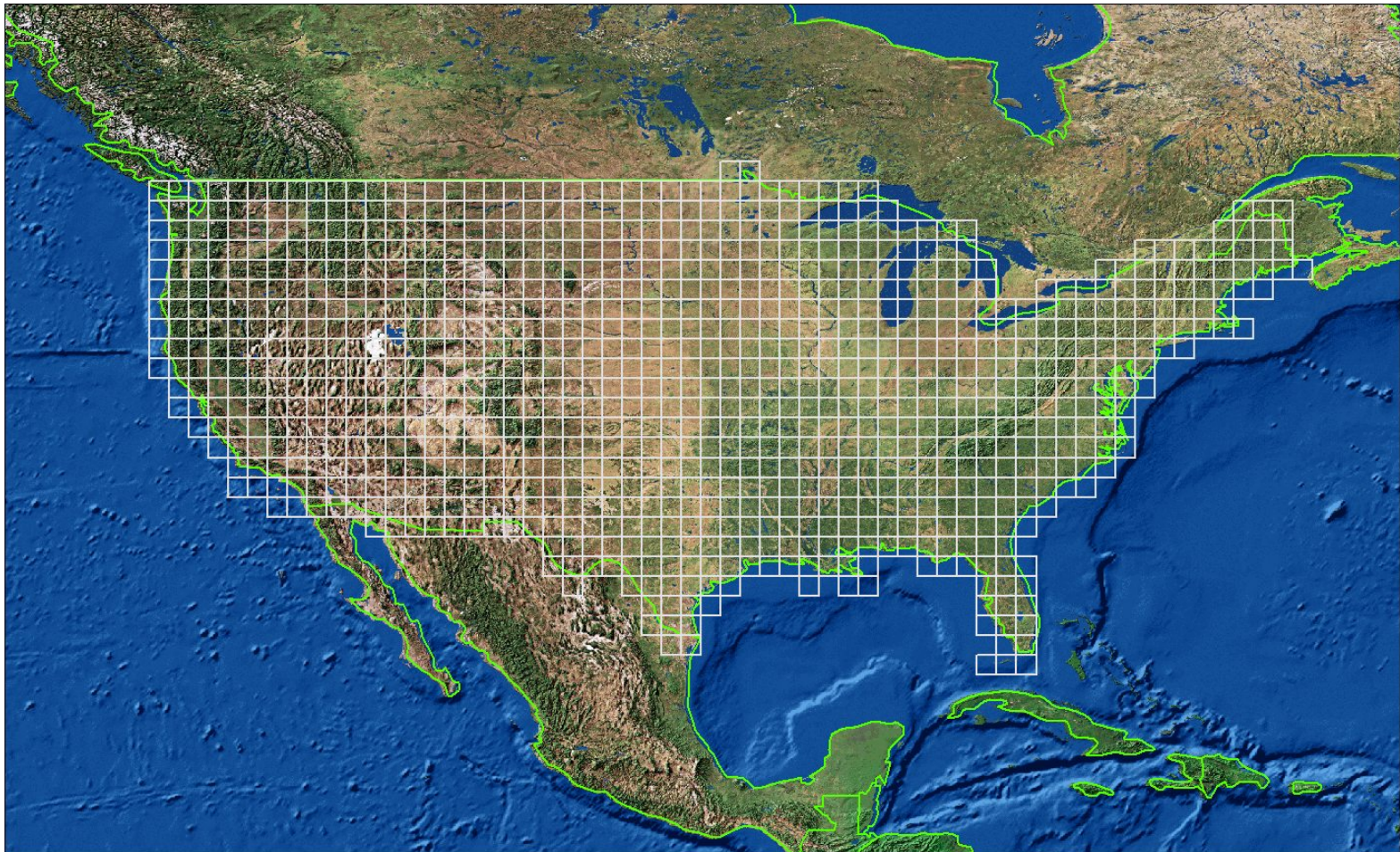


Reference DOQ Image

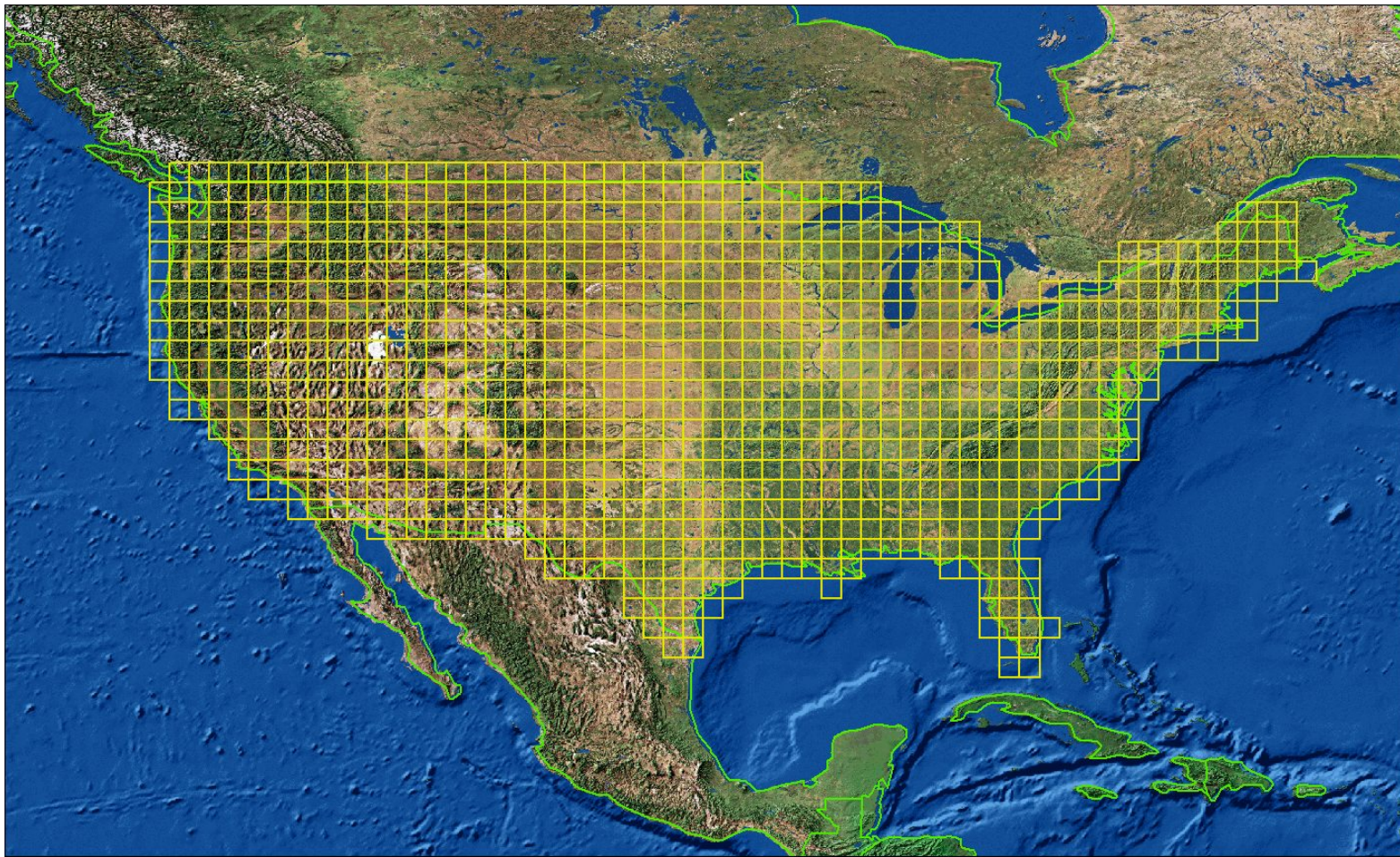


Digital Elevation Model

# CONUS NED DEM Coverage



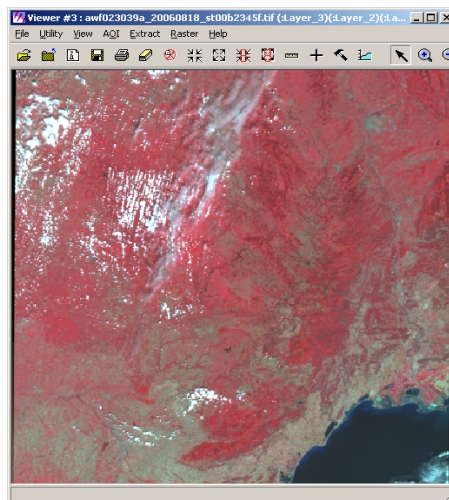
# CONUS DOQ Coverage



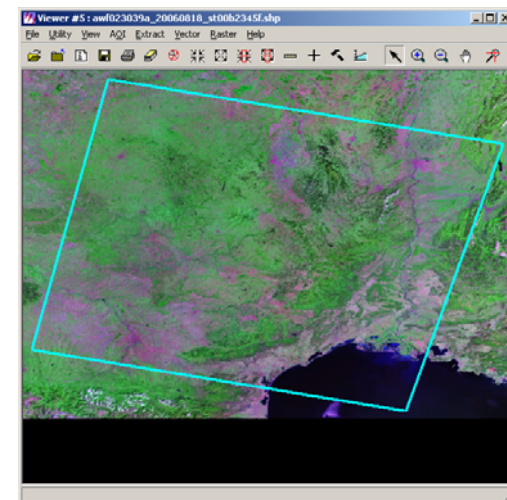


# Ancillary Data Compilation (International)

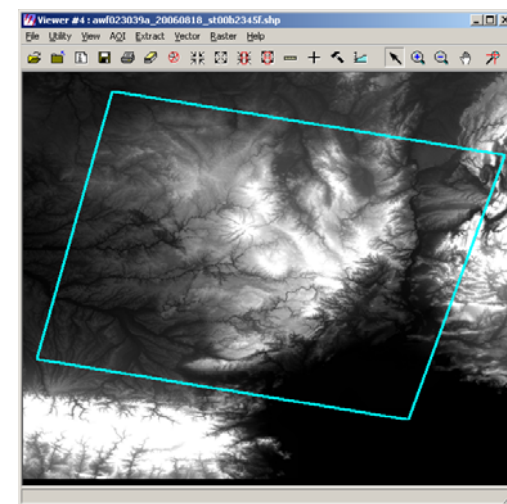
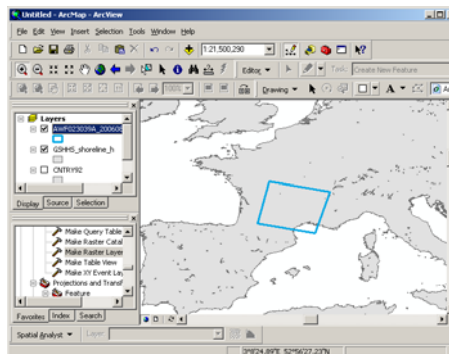
- Same process as CONUS collections, but different DEM / reference image datasets
- DEM: **SRTM-3**
  - Alaska NED and Canada CDED used in high latitudes
- Imagery: **GeoCover 2000**  
Landsat orthos
  - ~110 m CE90 positional accuracy
  - Reference image accuracy is limiting factor for international ortho products



Source Image

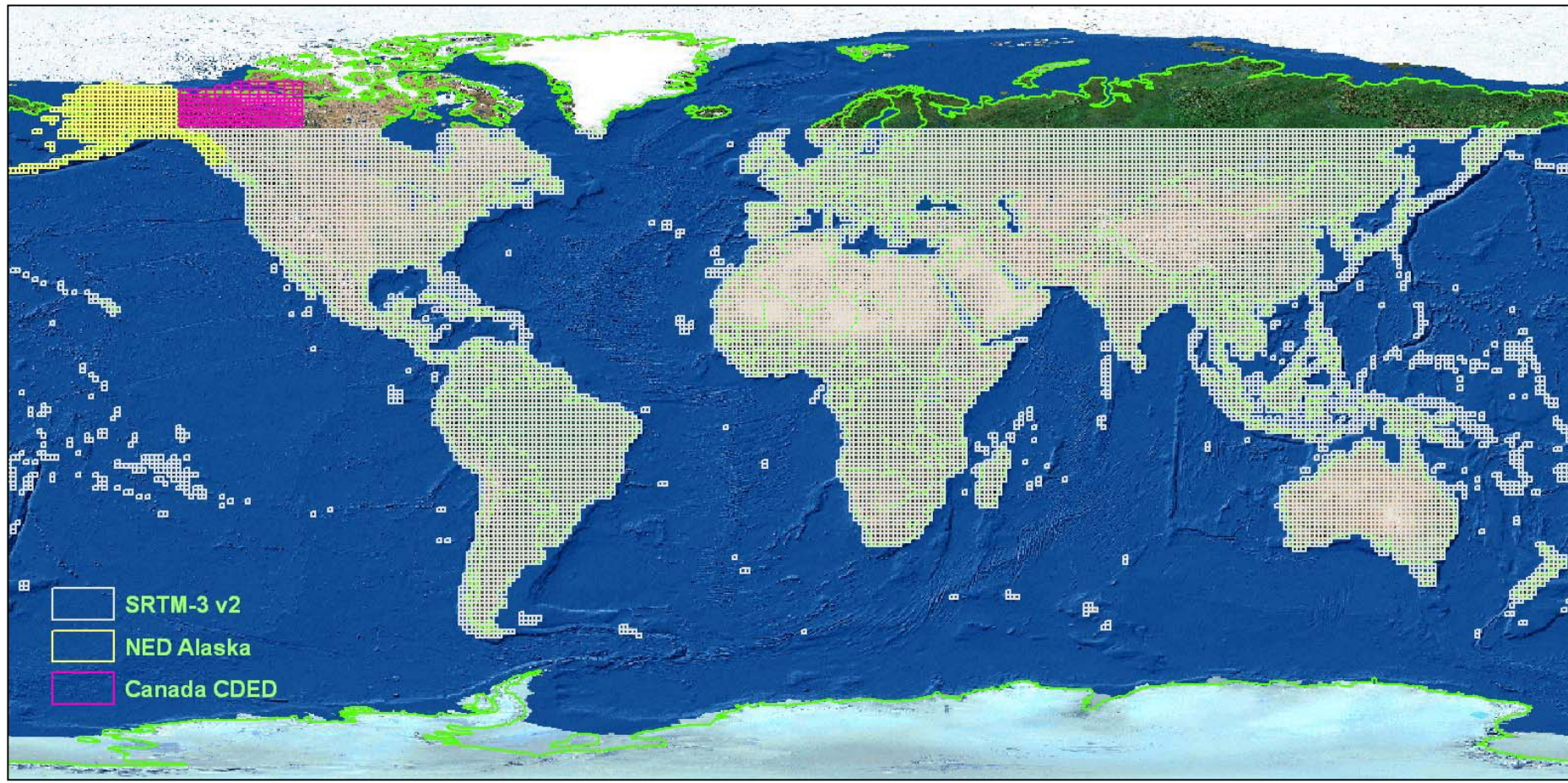


Reference GeoCover Image



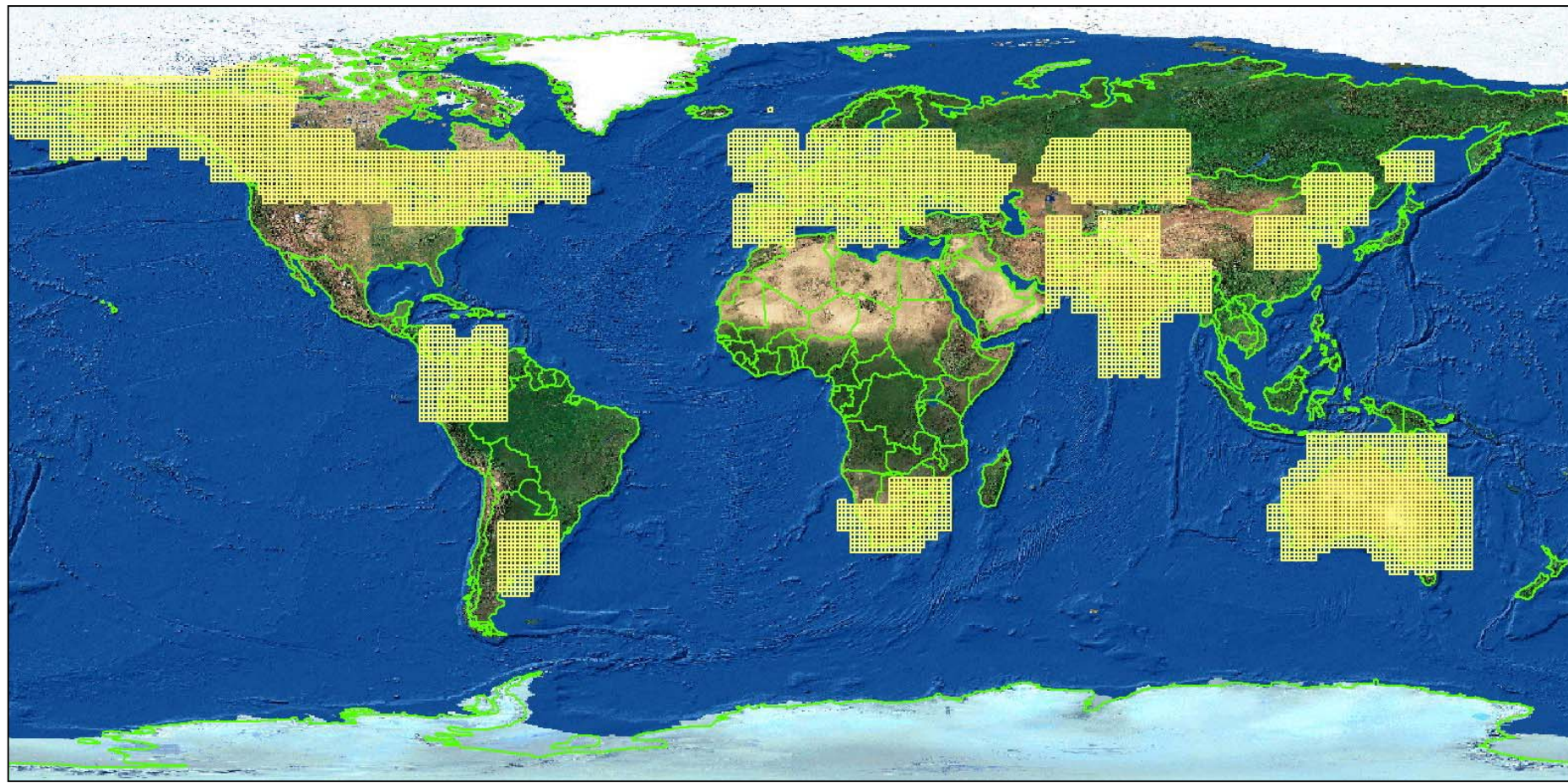
Digital Elevation Model

# International DEM Coverage



*Current holdings – CDED added as needed*

# International Reference Imagery Coverage



*Current holdings – GeoCover scenes added as needed*

# Control Point Measurement

- Automated image matching software used to collect tiepoints
  - Configured for AWiFS file naming conventions
  - Matches TIFF + RPC/DEM and reference orthoimage
  - User can override spacing of tiepoint measurement attempts, min/max number of points to extract
- Software generates a project file for interactive review / edit / block adjustment utility

```

c:\ Command Prompt
F:\Projects\PECAD2006\int1\AWF023039A_20060818>awfTpt
** awfTpt ver. 0.8 beta Tue Jul 11 14:16:18 2006 **
Source image : AWF023039A_20060818_ST00B2345F.tif
Reference image: AWF023039A_20060818_ST00B2345F_ref.tif
DEM file : AWF023039A_20060818_ST00B2345F_dem_e11.tif

Generating RPCs for reference ortho
Wrote F:\Projects\PECAD2006\int1\AWF023039A_20060818\ref\AWF023039A_20060818_ST00B2345F_ref_rpc.txt
Computing min/max height from DEM...
Min height = 34
Max height = 3368
Creating tiepoints for image AWF023039A_20060818_ST00B2345F_ref.tif
13806 candidate locations to check...
Measuring tiepoints...
Image 1: AWF023039A_20060818_ST00B2345F_ref.tif
Image 2: AWF023039A_20060818_ST00B2345F.tif
Number of common tiepoints: 8905
Building AWF023039A_20060818_ST00B2345F_ref_RRD01.tif
Processing...100.0%
Building AWF023039A_20060818_ST00B2345F_RRD01.tif
Processing...100.0%
Processing...100.0%
Processing tiepoints at coarse GSD...
8905 total points -- 3344 good matches of 8905 attempts < 37.55%>
Processing tiepoints at fine GSD...
8905 total points -- 1975 good matches of 8905 attempts < 22.18%>
F:\Projects\PECAD2006\int1\AWF023039A_20060818>
  
```

*Tiepoint measurement utility*

TextPad - [F:\Projects\PECAD2006\ref\AWF023039A\_20060818\AWF023039A\_20060818\_ST00B2345F\_proj1.tif]

```

1 PFile F:\Projects\PECAD2006\int1\AWF023039A_20060818\AWF023039A_20060818_ST00B2345F.tif
2 RefImg F:\Projects\PECAD2006\int1\AWF023039A_20060818\ref\AWF023039A_20060818_ST00B2345F_ref.tif
3 DemFile F:\Projects\PECAD2006\int1\AWF023039A_20060818\dem\AWF023039A_20060818_ST00B2345F_dem_e11.tif
4 DemMinMax 34 00 3368 00
5 SampleTerrain OFF S SS L
6 LineTerrain OFF S
7 # Point PName UserFlag RefNameFlag RefImg RefS RefL Lon Lat H SceneNameFlag SceneS SceneL
8 Point gcp0001 1 1 AWF023039A_20060818_ST00B2345F_ref 8146 75 2839 68 0 0 0 0 0 1 4676 38 1638 35
9 Point gcp0002 1 1 AWF023039A_20060818_ST00B2345F_ref 6729 92 4775 04 0 0 0 0 0 1 4152 31 3743 38
10 Point gcp0003 1 1 AWF023039A_20060818_ST00B2345F_ref 8753 96 1688 89 0 0 0 0 0 0 1 4813 32 425 60
11 Point gcp0004 1 1 AWF023039A_20060818_ST00B2345F_ref 4021 51 5795 40 0 0 0 0 0 0 1 4036 48 5733 95
12 Point gcp0005 1 1 AWF023039A_20060818_ST00B2345F_ref 9259 97 5558 55 0 0 0 0 0 0 1 6093 69 4078 72
13 Point gcp0006 1 1 AWF023039A_20060818_ST00B2345F_ref 4199 88 3198 00 0 0 0 0 0 0 1 4746 12 1904 98
14 Point gcp0007 1 1 AWF023039A_20060818_ST00B2345F_ref 7134 73 4503 80 0 0 0 0 0 0 1 4830 69 5341 69
15 Point gcp0008 1 1 AWF023039A_20060818_ST00B2345F_ref 1669 83 5565 55 0 0 0 0 0 0 1 803 41 5281 04
16 Point gcp0009 1 1 AWF023039A_20060818_ST00B2345F_ref 8247 95 4635 31 0 0 0 0 0 0 1 5169 53 2052 77
17 Point gcp0010 1 1 AWF023039A_20060818_ST00B2345F_ref 8349 15 3485 46 0 0 0 0 0 0 1 4966 30 3228 07
18 Point gcp0011 1 1 AWF023039A_20060818_ST00B2345F_ref 9857 18 4491 59 0 0 0 0 0 0 1 6250 19 2935 43
19 Point gcp0012 1 1 AWF023039A_20060818_ST00B2345F_ref 10170 78 4419 71 0 0 0 0 0 0 1 4441 25 2812 85
20 Point gcp0013 1 1 AWF023039A_20060818_ST00B2345F_ref 4199 88 4934 99 0 0 0 0 0 0 1 2957 48 6230 28
21 Point gcp0014 1 1 AWF023039A_20060818_ST00B2345F_ref 5717 90 4419 71 0 0 0 0 0 0 1 3370 40 3558 28
22 Point gcp0015 1 1 AWF023039A_20060818_ST00B2345F_ref 8428 28 2413 60 0 0 0 0 0 0 1 3774 69 2440 71
23 Point gcp0016 1 1 AWF023039A_20060818_ST00B2345F_ref 8428 28 5791 25 0 0 0 0 0 0 1 4398 81 5736 48
24 Point gcp0017 1 1 AWF023039A_20060818_ST00B2345F_ref 7741 94 5641 42 0 0 0 0 0 0 1 5055 26 4407 62
25 Point gcp0018 1 1 AWF023039A_20060818_ST00B2345F_ref 7444 34 4275 98 0 0 0 0 0 0 1 4872 56 2057 64
26 Point gcp0019 1 1 AWF023039A_20060818_ST00B2345F_ref 6527 52 3485 46 0 0 0 0 0 0 1 3720 55 2526 41
27 Point gcp0020 1 1 AWF023039A_20060818_ST00B2345F_ref 5110 69 4775 04 0 0 0 0 0 0 1 3033 13 4001 46
28 Point gcp0021 1 1 AWF023039A_20060818_ST00B2345F_ref 7134 73 6288 21 0 0 0 0 0 0 1 4780 53 5133 56
29 Point gcp0022 1 1 AWF023039A_20060818_ST00B2345F_ref 2277 04 4635 31 0 0 0 0 0 0 1 1040 05 4286 13
30 Point gcp0023 1 1 AWF023039A_20060818_ST00B2345F_ref 6932 33 4791 26 0 0 0 0 0 0 1 4784 16 5452 87
31 Point gcp0024 1 1 AWF023039A_20060818_ST00B2345F_ref 7843 14 3701 06 0 0 0 0 0 0 1 4671 05 2520 37
32 Point gcp0025 1 1 AWF023039A_20060818_ST00B2345F_ref 7033 53 2341 73 0 0 0 0 0 0 1 4034 74 2308 04
33 Point gcp0026 1 1 AWF023039A_20060818_ST00B2345F_ref 8628 72 5785 15 0 0 0 0 0 0 1 4310 87 4731 37
34 Point gcp0027 1 1 AWF023039A_20060818_ST00B2345F_ref 8349 15 4607 41 0 0 0 0 0 0 1 5579 82 4720 62
35 Point gcp0028 1 1 AWF023039A_20060818_ST00B2345F_ref 3693 87 5719 29 0 0 0 0 0 0 1 2246 48 5123 53
36 Point gcp0029 1 1 AWF023039A_20060818_ST00B2345F_ref 7235 93 5085 02 0 0 0 0 0 0 1 4752 15 4709 89
37 Point gcp0030 1 1 AWF023039A_20060818_ST00B2345F_ref 9968 38 4635 31 0 0 0 0 0 0 1 6355 27 3055 68
38 Point gcp0031 1 1 AWF023039A_20060818_ST00B2345F_ref 7843 14 4322 77 0 0 0 0 0 0 1 4958 85 3657 94
39 Point gcp0032 1 1 AWF023039A_20060818_ST00B2345F_ref 8753 96 1545 10 0 0 0 0 0 0 1 4778 61 731 20
40 Point gcp0033 1 1 AWF023039A_20060818_ST00B2345F_ref 8247 95 2048 16 0 0 0 0 0 0 1 4958 84 859 96
41 Point gcp0034 1 1 AWF023039A_20060818_ST00B2345F_ref 7462 37 6215 34 0 0 0 0 0 0 1 6371 88 4665 25
42 Point gcp0035 1 1 AWF023039A_20060818_ST00B2345F_ref 6223 91 6575 67 0 0 0 0 0 0 1 4206 77 5560 89
  
```

*Auto-generated project file w / tiepoints*

# Control Point Measurement / Block Adjustment

- Custom GUI developed with ERDAS Imagine Developer's Toolkit
- Interface similar to Raster->Geometric Correction tool; specialized for IRS-P6 processing workflow

The screenshot displays the IRS-P6 Ortho Utility software interface. It features two satellite imagery viewers at the top, showing different views of the same area. The left viewer shows a green and purple image, while the right viewer shows a red and white image. Below the viewers is a table with columns for Row, Name, Enabled, Ref Sample, Ref Line, Longitude, Latitude, Height, Color, Scene Sample, Scene Line, Color, Sample Resid, Line Resid, and RSS error. The table contains 9 rows of data for control points gcp0001 through gcp0009.

Row	Name	Enabled	Ref Sample	Ref Line	Longitude	Latitude	Height	Color	Scene Sample	Scene Line	Color	Sample Resid	Line Resid	RSS error
1	gcp0001	X	8146.75	2838.68	4.1398750	45.4601600	650.66	Green	4676.38	1638.35	Yellow			
2	gcp0002	X	6729.92	4779.04	3.4314600	44.4899800	984.69	Green	4152.31	3743.38	Yellow			
3	gcp0003	X	8753.96	1688.83	4.4434800	46.0350850	657.80	Green	4813.32	429.60	Yellow			
4	gcp0004	X	6021.51	6719.40	3.0772550	43.5198000	318.71	Green	4096.98	5733.09	Yellow			
5	gcp0005	X	9259.97	5569.95	4.6964850	44.0947250	90.19	Green	6093.69	4078.72	Yellow			
6	gcp0006	X	8146.75	3198.00	4.1398750	45.2805000	526.96	Green	4761.12	1984.98	Yellow			
7	gcp0007	X	7134.73	6503.80	3.6338650	43.6276000	235.43	Green	4830.69	5341.69	Yellow			
8	gcp0008	X	1669.83	5569.95	0.9014150	44.0947250	108.73	Green	803.41	5281.04	Yellow			
9	gcp0009	X	8247.95	4635.31	4.1904750	44.5618450	439.70	Green	5169.53	3352.77	Yellow			

# Control Point Measurement / Block Adjustment



IRS-P6 Ortho Utility - [awf023039a\_20060818\_st00b2345f\_proj.txt]

Project Tools Help

Model State: STALE

Row	Name	Enabled	Ref Sample	Ref Line	Longitude	Latitude	Height	Color	Scene Sample	Scene Line	Color	Sample Resid	Line Resid	RSS error
149	gcp0149	X	7337.13	2191.89	3.7350650	45.7835550	1137.95	Green	3975.52	1147.03	Yellow			
150	gcp0150	X	10575.59	4132.25	5.3542950	44.8133750	758.67	Green	6647.22	2465.33	Yellow			
151	gcp0151	X	5616.70	3413.60	2.8748500	45.1727000	1273.84	Green	3079.71	2600.68	Yellow			
152	gcp0152	X	6223.91	7366.19	3.1784550	43.1964050	104.98	Green	4385.10	6325.30	Yellow			
153	gcp0153	X	6223.91	4707.17	3.1784550	44.5259150	1050.71	Green	3785.42	3755.89	Yellow			
154	gcp0154	X	8450.35	4707.17	4.2916750	44.5259150	324.59	Green	5326.81	3387.86	Yellow			
155	gcp0155	X	7033.53	5066.50	3.5832650	44.3462500	748.25	Green	4429.69	3971.23	Yellow			
156	gcp0156	X	6729.92	6360.07	3.4314600	43.6994650	210.19	Green	4514.26	5269.98	Yellow			
157	gcp0157	X	9462.37	3844.79	4.7976850	44.9571050	637.62	Green	5814.17	2384.64	Yellow			

# Control Point Measurement / Block Adjustment

- If auto-generated tiepoints are not well distributed, new points can be added manually
- At least 20 well-distributed points are used for block adjustment

Row	Name	Enabled	Ref Sample	Ref Line	Longitude	Latitude	Height	Color	Scene Sample	Scene Line	Color	Sample Resid	Line Resid	RMS error
187	gcp0187	X	7843.14	47.75	3.9880700	45.7476250	544.23	4336.43	1134.08			-0.27	0.15	0.31
188	gcp0188	X	3592.67	5541.60	1.8628350	44.0587900	381.94	2161.03	5069.70			-0.16	-0.46	0.48
189	gcp0189	X	9158.77	5713.29	4.6458850	44.0228550	293.83	6058.39	4234.50			-0.26	-0.01	0.26
190	gcp0190	X	8045.55	4994.63	4.8892750	44.3821850	522.00	5114.04	3733.48			0.34	-0.14	0.36
191	gcp0191	X	3592.67	5713.29	1.8628350	44.0228550	320.13	2176.01	5138.58			0.19	0.37	0.42
192	gcp0192	X	2175.84	5138.36	1.1544200			89.41				0.17	-0.08	0.19
193	gcp0193	X	7337.13	5210.23	3.7350650			80.18				-0.62	-0.46	0.77
194	gcp0194	X	6021.51	3844.79	3.0772550			54.06				-0.21	0.31	0.38
195	gcp0195	X	8349.15	6216.34	4.2410750			59.07				0.26	-0.16	0.31
196	gcp0196	X	6436.32	7006.86	3.2795600	43.3780700	91.91	4447.34	5944.86			-0.19	-0.03	0.20
197	gcp0197	X	7235.33	4522.77	3.6344650	44.4181150	1546.44	4534.24	3793.30			-0.03	-0.23	0.23
198	gcp0198	X	8450.35	2198.00	4.2916750	45.2805000	892.43	4967.20	1934.20			0.04	-0.11	0.12
199	gcp0199	X	8349.15	4707.17	4.2410750	44.5259150	404.83	5256.16	3405.22			0.49	-0.19	0.52
200	gcp0200	X	6932.33	3701.06	3.5326650	45.0289700	932.12	4047.06	2669.43			-0.21	0.13	0.25
201	gcp0201	X	2675.88	492.13				473.27	204.24					

# Control Point Measurement / Block Adjustment

- Block adjustment performed by using 'Calculate' toolbar button
- Line/sample/RSS errors shown for each point, as well as overall statistics
- Individual points can be enabled / disabled or added / deleted
- All auto-generated tiepoints with RSS error > 1.5 pixel are disabled
- Aim for total RMS < 0.5 pixel
- Correction model as appropriate for AWiFS-A or AWiFS-B camera (Lutes, 2005)

Summary Statistics:

Sample RMS: 0.31 Line RMS: 0.21 Total RMS: 0.37

Color	Scene Sample	Scene Line	Color	Sample Resid	Line Resid	RSS error
83	5256.16	3405.22		0.49	-0.19	0.53
12	4047.05	2669.43		-0.21	0.16	0.27
74	479.27	204.24		-0.03	-0.20	0.20
13	899.27	289.48		0.16	0.28	0.32
35	1440.70	261.67		0.57	-0.38	0.68
66	1418.07	224.27		-0.43	-0.16	0.46
70	635.81	1786.27		0.24	-0.81	0.85
59	282.77	3155.57		0.24	-0.28	0.37
99	1375.93	2540.92		-0.38	-0.09	0.39

Table with 7 columns: Row, Name, Enabled, Ref Sample, Ref Line, Color, Scene Sample, Scene Line, Color, Sample Resid, Line Resid, RSS error.



# Control Point Measurement / Block Adjustment

- Adjustment model can be modified
  - add or remove line drift terms
- Detailed report generation for later reference or troubleshooting

**Block Adjustment Report**

IRS-P6 Ortho Utility version 1.05 -- Adjustment Report

Report generation time: 09/08/06 09:40:51

IRS-P6 Image Settings  
Image file: F:\Projects\PECAD2006\int1\AWF023039A\_20060818\AWF023039A\_20060818\_ST00B2345F.tif

Reference Image Settings  
Number of reference images: 1  
Reference image 000 : F:\Projects\PECAD2006\int1\AWF023039A\_20060818\ref\AWF023039A\_20060818\_ST00B2345F.tif

Model Settings  
DEM file : F:\Projects\PECAD2006\int1\AWF023039A\_20060818\dem\AWF023039A\_20060818\_ST00B2345F.tif  
Sample terms : OFF S L SS  
Line terms : OFF S L

Ground Control Point Summary  
Number of points included in adjustment: 207  
Sample RMS: 0.31  
Line RMS: 0.21  
Total RMS: 0.37

Point	Reference Image	RefS	RefL	Lon	Lat	Ht
gcp0001	AWF023039A_20060818_ST00B2345F.ref	8146.75	2838.68	4.139875	45.460160	650.66
gcp0002	AWF023039A_20060818_ST00B2345F.ref	6729.92	4779.04	3.431460	44.489980	984.69
gcp0003	AWF023039A_20060818_ST00B2345F.ref	8753.96	1688.83	4.443480	46.035085	657.80
gcp0004	AWF023039A_20060818_ST00B2345F.ref	6021.51	6719.40	3.077255	43.519800	318.71
gcp0005	AWF023039A_20060818_ST00B2345F.ref	9259.97	5569.55	4.696485	44.094725	90.19
gcp0006	AWF023039A_20060818_ST00B2345F.ref	8146.75	3198.00	4.139875	45.280500	526.96
gcp0007	AWF023039A_20060818_ST00B2345F.ref	7134.73	6603.80	3.633865	43.627600	235.43
gcp0008	AWF023039A_20060818_ST00B2345F.ref	1669.83	5569.55	0.901415	44.094725	108.73
gcp0009	AWF023039A_20060818_ST00B2345F.ref	8247.95	4635.31	4.190475	44.561845	439.70
gcp0010	AWF023039A_20060818_ST00B2345F.ref	8349.15	3485.46	4.241075	45.136770	944.41
gcp0011	AWF023039A_20060818_ST00B2345F.ref	9867.18	4491.58	5.000090	44.633710	370.61
gcp0012	AWF023039A_20060818_ST00B2345F.ref	10170.78	4419.71	5.151890	44.669645	647.68
gcp0013	AWF023039A_20060818_ST00B2345F.ref	4199.88	6934.99	2.166440	43.412005	746.98
gcp0014	AWF023039A_20060818_ST00B2345F.ref	5717.90	4419.71	2.925450	44.669645	1387.52
gcp0015	AWF023039A_20060818_ST00B2345F.ref	6628.72	3413.60	3.380860	45.172700	642.23
gcp0016	AWF023039A_20060818_ST00B2345F.ref	6426.32	6791.26	3.279660	43.483870	131.00
gcp0017	AWF023039A_20060818_ST00B2345F.ref	7741.94	5641.42	3.937470	44.058790	273.24
gcp0018	AWF023039A_20060818_ST00B2345F.ref	7944.34	4275.98	4.038670	44.741510	1359.62

**Model Properties**

Sample Terms	Line Terms
<input checked="" type="checkbox"/> OFF	<input checked="" type="checkbox"/> OFF
<input checked="" type="checkbox"/> S	<input checked="" type="checkbox"/> S
<input checked="" type="checkbox"/> L	<input checked="" type="checkbox"/> L
<input checked="" type="checkbox"/> S^2	<input type="checkbox"/> S^2
<input type="checkbox"/> SL	<input type="checkbox"/> SL
<input type="checkbox"/> L^2	<input type="checkbox"/> L^2

Row	Name	Enabled	Ref Sample	Ref Line	Longitude	Latitude	Height	Color	Scene Sample	Scene Line	Color	Sample Resid	Line Resid	RMS	error
199	gcp0199	X	8349.15	4707.17	4.2410750	44.5259150	404.83		5256.16	3405.22		0.49	-0.19	0.53	
200	gcp0200	X	6932.33	3701.06	3.5326850	45.0289700	932.12		4047.05	2663.43		-0.21	0.16	0.27	
201	gcp0201	X	2675.88	492.13	1.4044400	46.6334350	140.74		479.27	204.24		-0.03	-0.20	0.20	
202	gcp0202	X	3253.13	664.38	1.6930650	46.5473100	259.13		899.27	289.48		0.16	0.28	0.32	
203	gcp0203	X	4036.88	751.63	2.0849400	46.5036850	361.35		1440.70	261.67		0.57	-0.38	0.68	
204	gcp0204	X	4014.13	709.88	2.0735650	46.5245600	307.66		1418.07	224.27		-0.43	-0.16	0.46	
205	gcp0205	X	2433.38	2084.38	1.2831900	45.8373100	270.70		635.81	1786.27		0.24	-0.81	0.85	
206	gcp0206	X	1542.13	3365.13	0.8375650	45.1969350	144.59		282.77	3155.57		0.24	-0.28	0.37	
207	gcp0207	X	3253.88	2983.38	1.6934400	45.3878100	521.99		1375.93	2540.92		-0.38	-0.09	0.39	

# Ortho Generation

- Map projection parameters / output resolution preconfigured for AWiFS scenes
- Imagery optionally scaled from 10 bits per pixel to 8 bits per pixel
- Cubic convolution resampling employed

Row	Name	Enabled	Ref Sample	Ref Line	Longitude	Latitude	Height	Color	Scene Sample	Scene Line	Color	Sample Resid	Line Resid	RSS error
199	gcp0199	X	8349.15	4707.17	4.2410750	44.5259150	404.83	Green	5256.16	3405.22	Green	0.49	-0.19	0.53
200	gcp0200	X	6932.33	3701.06	3.5326850	45.0289700	932.12	Green	4047.05	2663.43	Green	-0.21	0.16	0.27
201	gcp0201	X	2675.88	492.13	1.4044400	46.6334350	140.74	Green	479.27	204.24	Green	-0.03	-0.20	0.20
202	gcp0202	X	3253.13	664.38	1.6930650	46.5473100	259.13	Green	899.27	289.48	Green	0.16	0.28	0.32
203	gcp0203	X	4036.88	751.63	2.0849400	46.5036850	361.35	Green	1440.70	261.67	Green	0.57	-0.38	0.68
204	gcp0204	X	4014.13	709.88	2.0735650	46.5245600	307.65	Green	1418.07	224.27	Green	-0.43	-0.16	0.46
205	gcp0205	X	2433.38	2084.38	1.2831900	45.8373100	270.70	Green	635.81	1786.27	Green	0.24	-0.81	0.85
206	gcp0206	X	1542.13	3365.13	0.8375650	45.1963350	144.59	Green	282.77	3155.57	Green	0.24	-0.28	0.37
207	gcp0207	X	3253.88	2983.38	1.6934400	45.3878100	521.99	Green	1375.93	2540.92	Green	-0.38	-0.09	0.39

# Ortho Generation: 10-to-8 bit rescaling

- Ortho metadata provides DN-to-radiance scaling coefficients

$$L_{rad} = \frac{DN_{10}}{1023} \cdot (L_{max} - L_{min}) + L_{min}$$

$DN_{10}$  = 10-bit pixel value

$L_{min}$  = Min radiance value provided in scene metadata

$L_{max}$  = Max radiance value provided in scene metadata

- 10- to 8-bit rescaling maintains integrity of DN-to-radiance coefficients

$$DN_8 = DN_{10} \cdot \frac{255}{1023}$$

$$L_{rad} = \frac{DN_8}{255} \cdot (L_{max} - L_{min}) + L_{min}$$

# AWiFS Nearest Neighbor Resampling Issues

- Nearest Neighbor commonly requested for Remote Sensing applications because it is thought to most closely resemble what was collected by the satellite – i.e., NN pixels are thought to be more radiometrically 'pure' than those from other resampling techniques
- Nearest Neighbor resampling NOT recommended for ResourceSat-1 products!

## *Why not?*

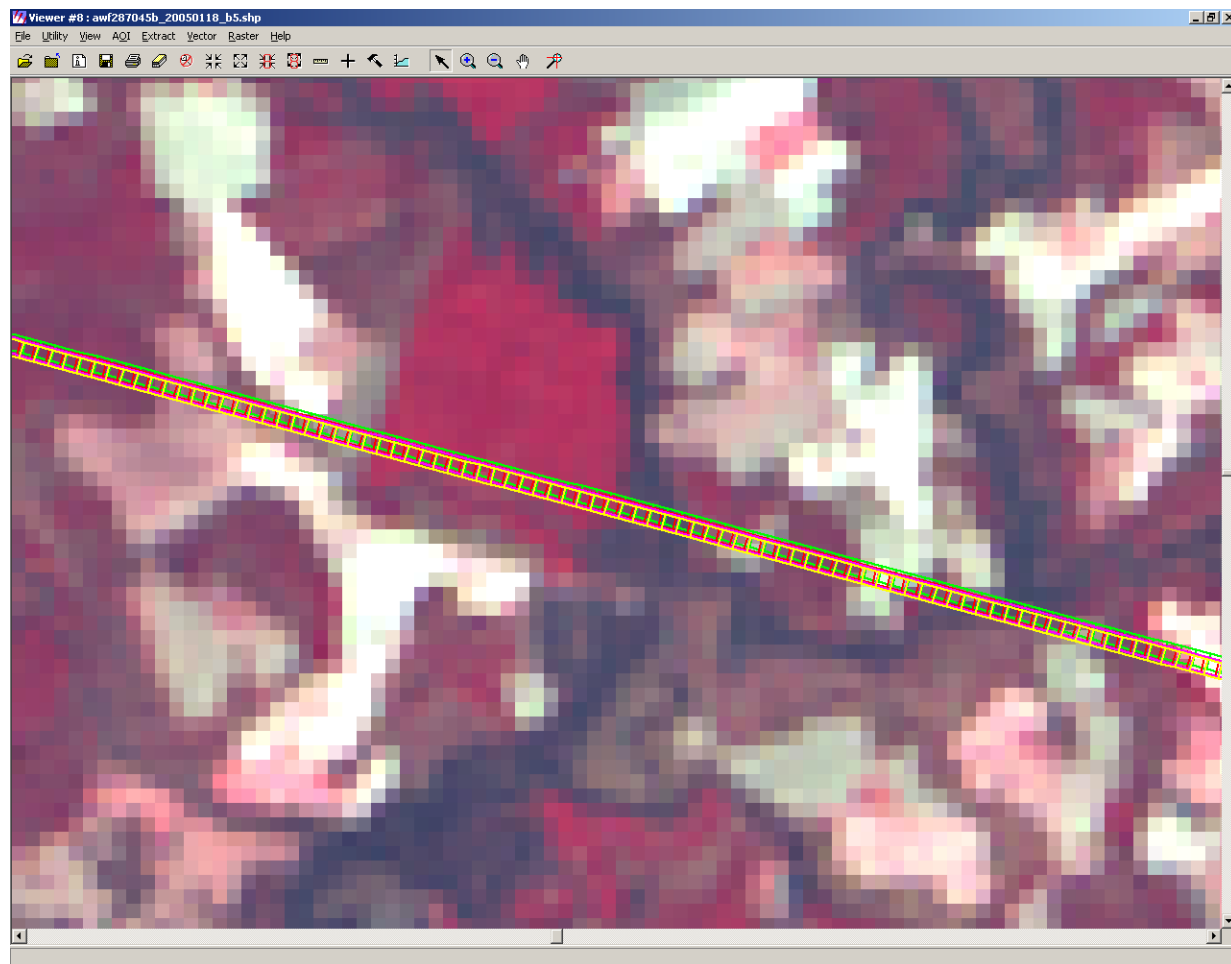
- AWiFS collects 4 bands of imagery using 4 different telescope assemblies.
- Detectors from different bands do *not* collect energy from the same area on the ground!
- This is true for **most** satellite sensors. Only systems with beam splitter arrangements can direct energy from exactly the same ground area to the different bands.

*AWiFS Camera Assembly*



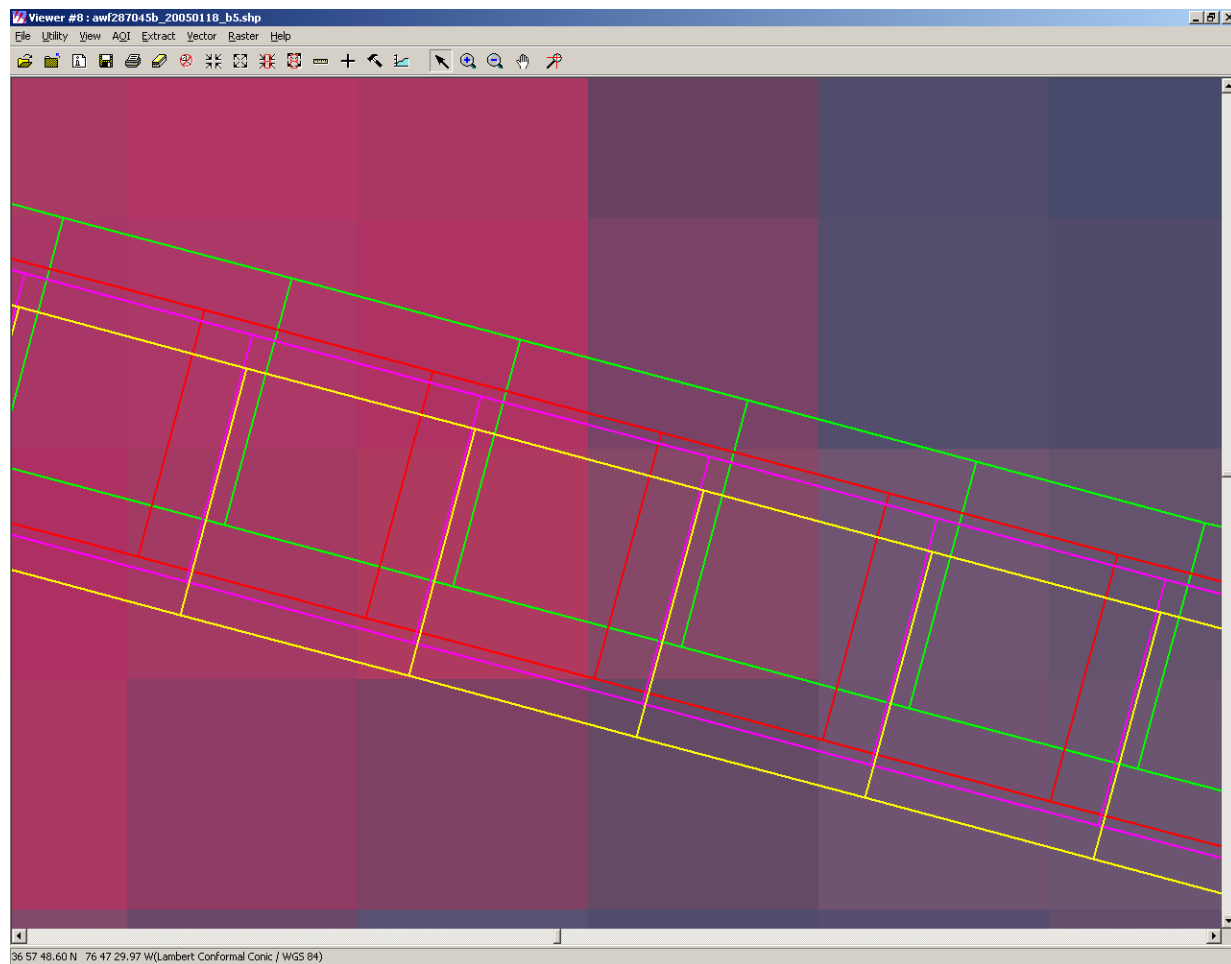
# NN Resampling Example

- This is an *actual scene* illustrating the effect of NN resampling on image reconstruction
- Ground track of the detector arrays shown for a single as-collected line:
  - Green = green band
  - Red = red band
  - Magenta = NIR band
  - Yellow = SWIR band



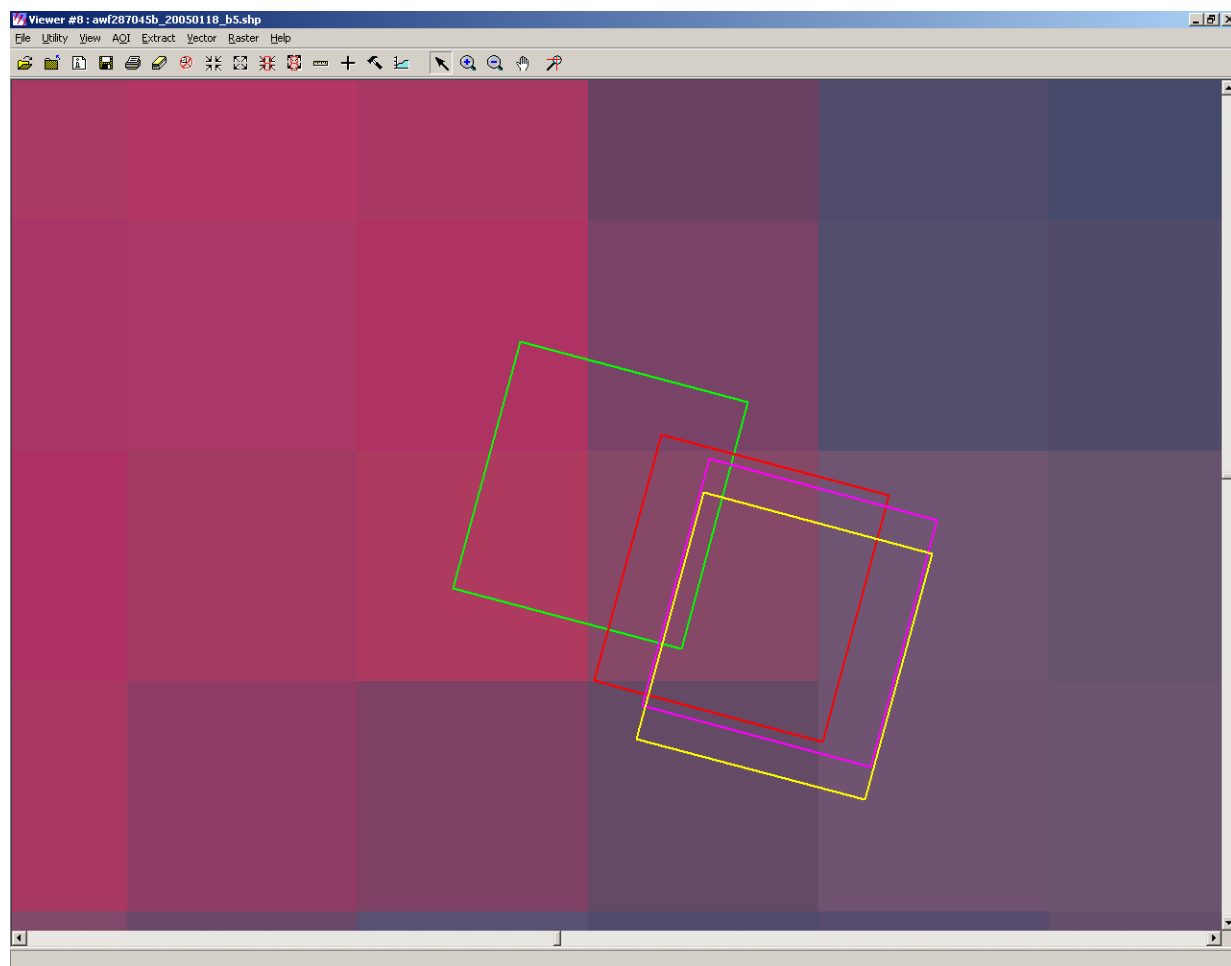
# NN Resampling Example cont'd

- Close-up shows that pixel offsets can be large
- NN resampling could result in a pixel with data coming from source pixels having very little overlap



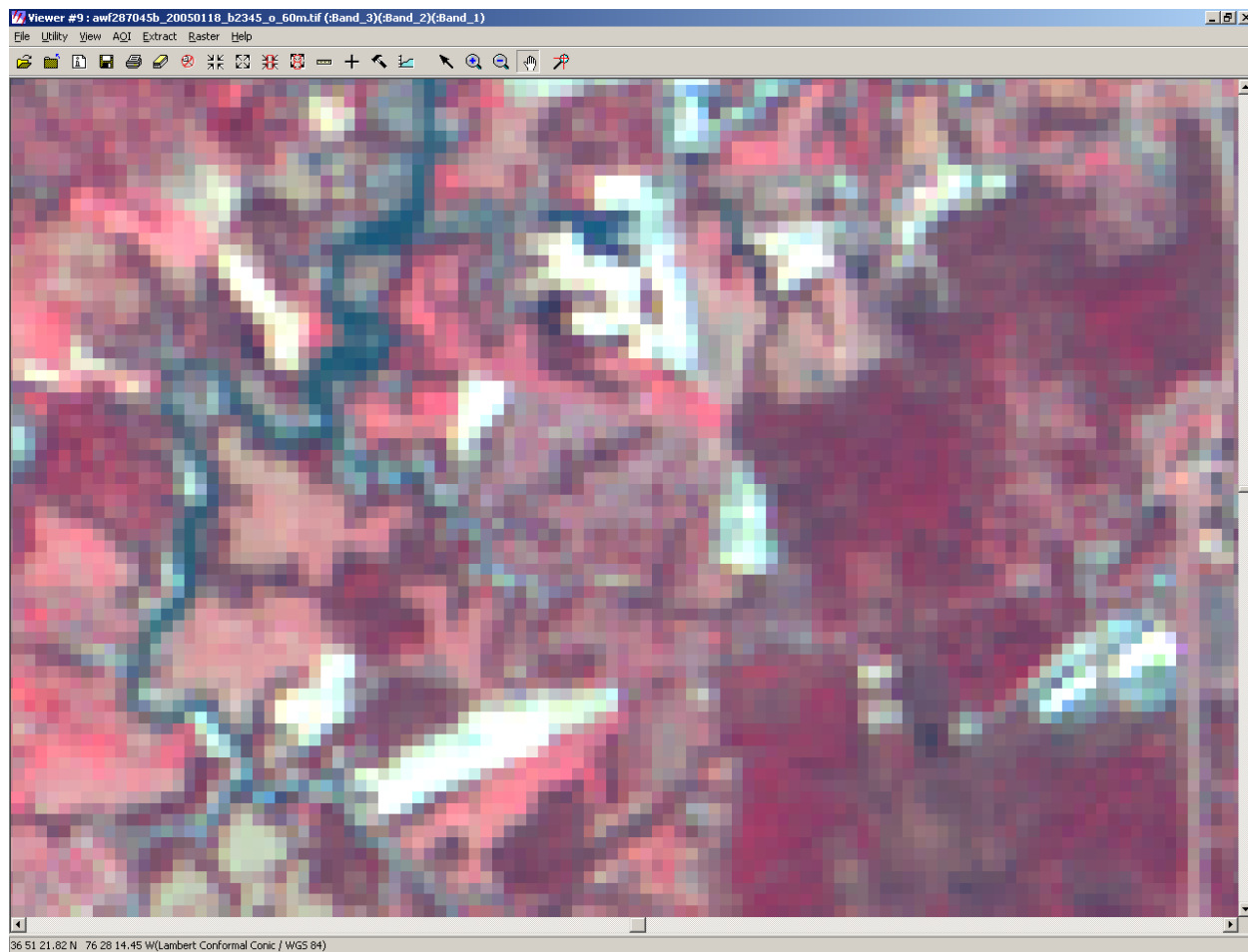
# NN Resampling Example cont'd

- Plot illustrates source pixel footprints that were used to compile output pixel
- Almost no overlap between green and SWIR!



# NN Resampling Example cont'd

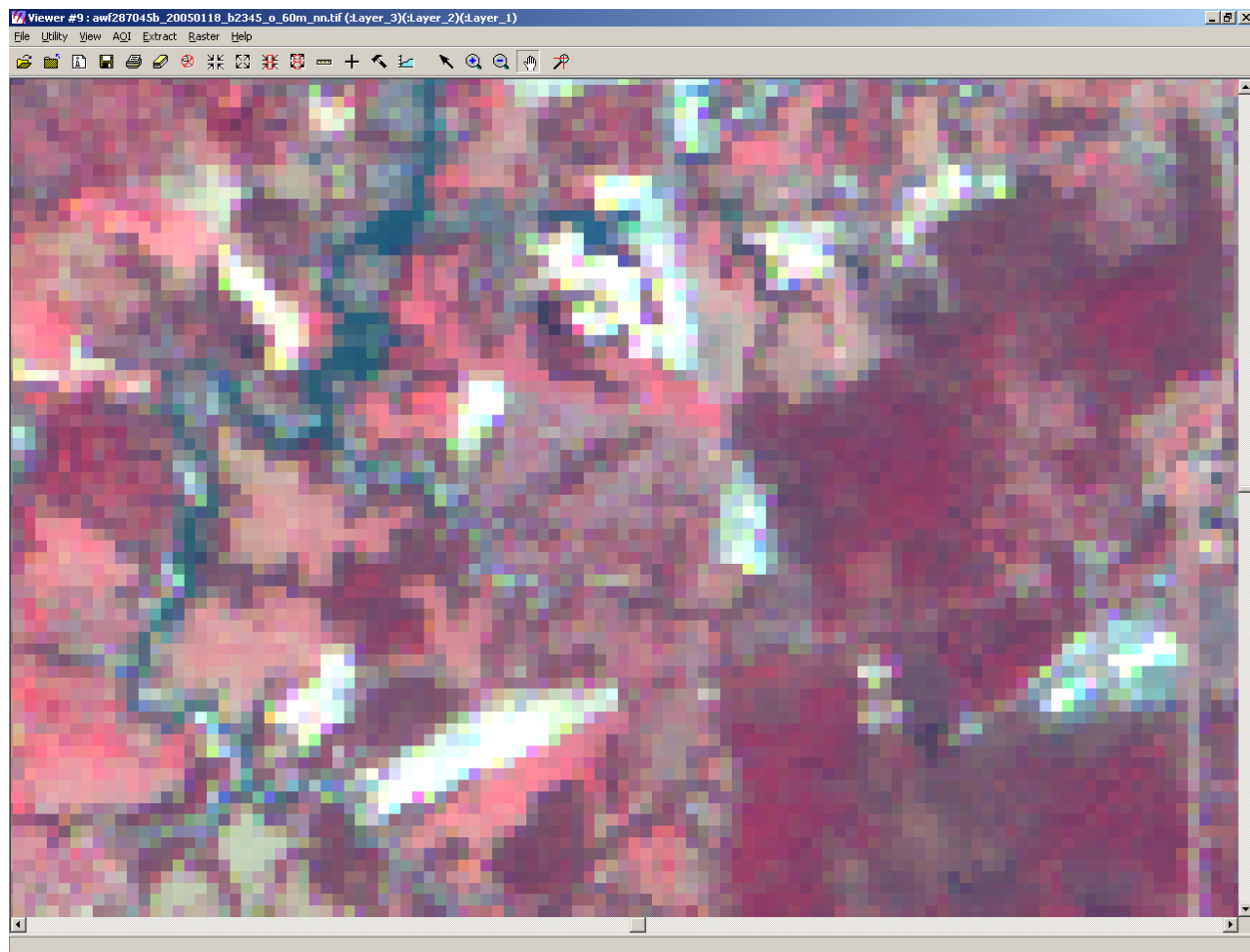
- Closeup of scene with CC resampling



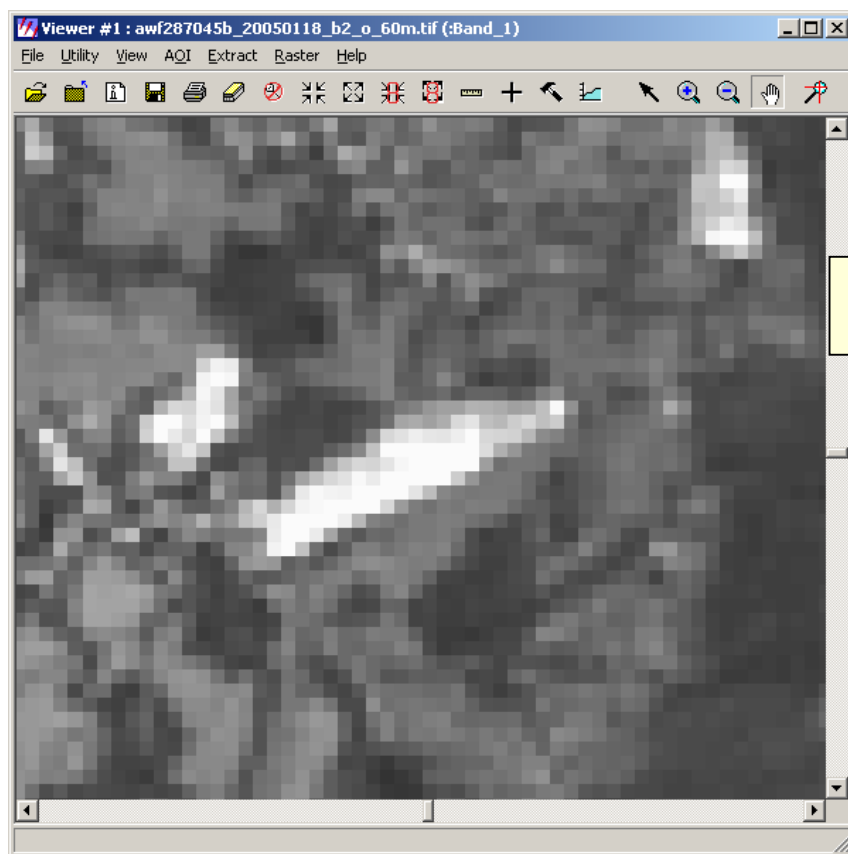


# NN Resampling Example cont'd

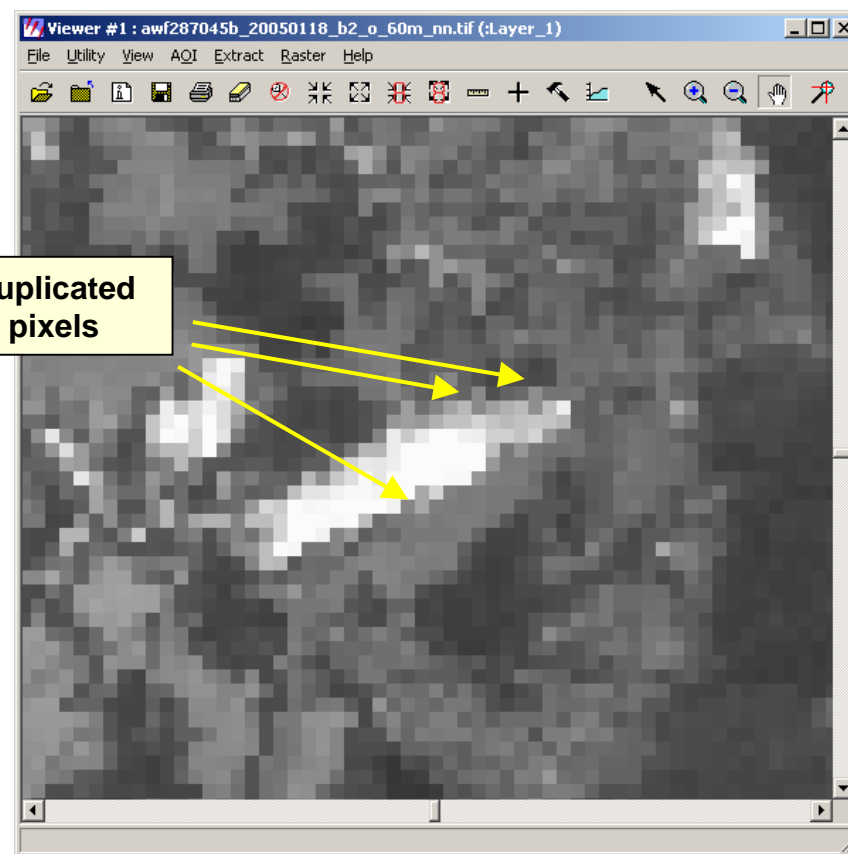
- Same scene with NN resampling
- Note color artifacts around bright features
- In addition to band-to-band registration issues, there is also pixel duplication – the same source pixel generates more than one destination pixel.
- Happens because of scale variability throughout AWiFS scenes



# Pixel Duplication in NN Resampling



*CC Resampling*

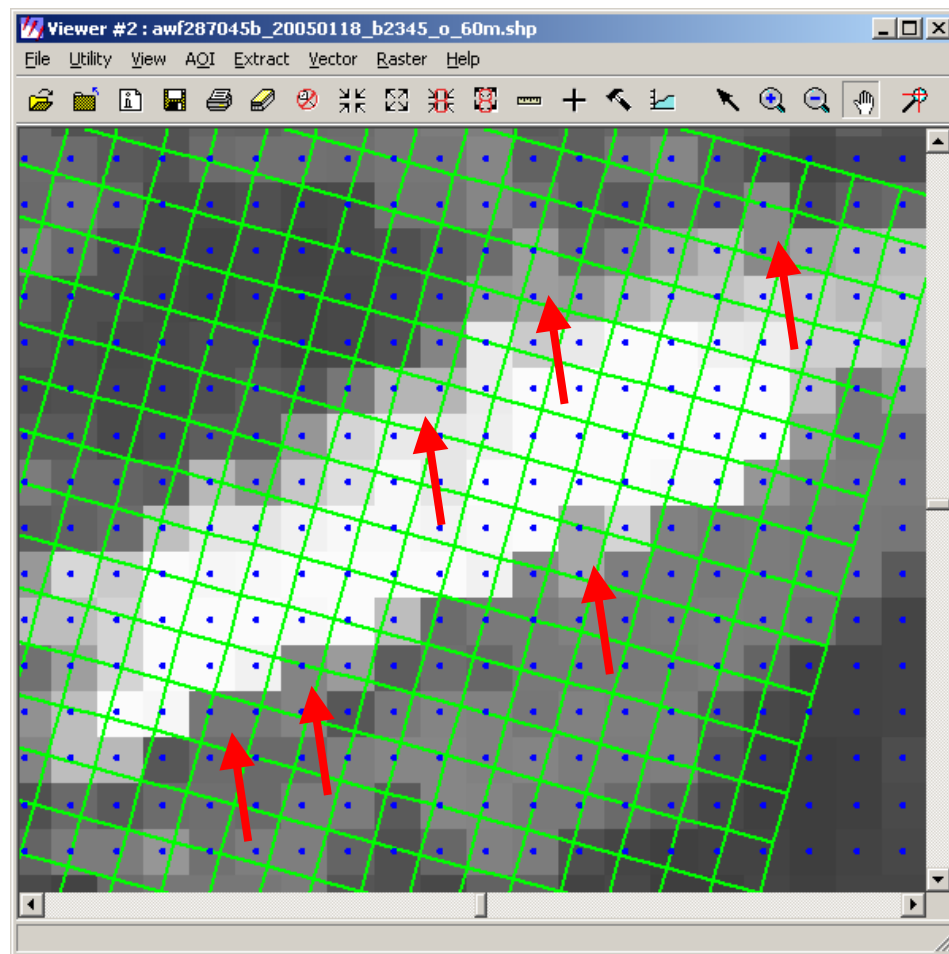


*NN Resampling*

Blue band of scene from previous slide.

# Pixel Duplication in NN Resampling cont'd

- Plot of pixel centers illustrates several areas where two destination pixels fall within the same source pixel
- This effect worsens in areas where as-collected GSD diverges from GSD of output product
  - AWiFS as-collected GSD is 56 m at nadir but ~70 m at far edge of scene
- To avoid this, use a lower GSD for output product (e.g., 70 m instead of 56 or 60) or don't use NN resampling for image reconstruction

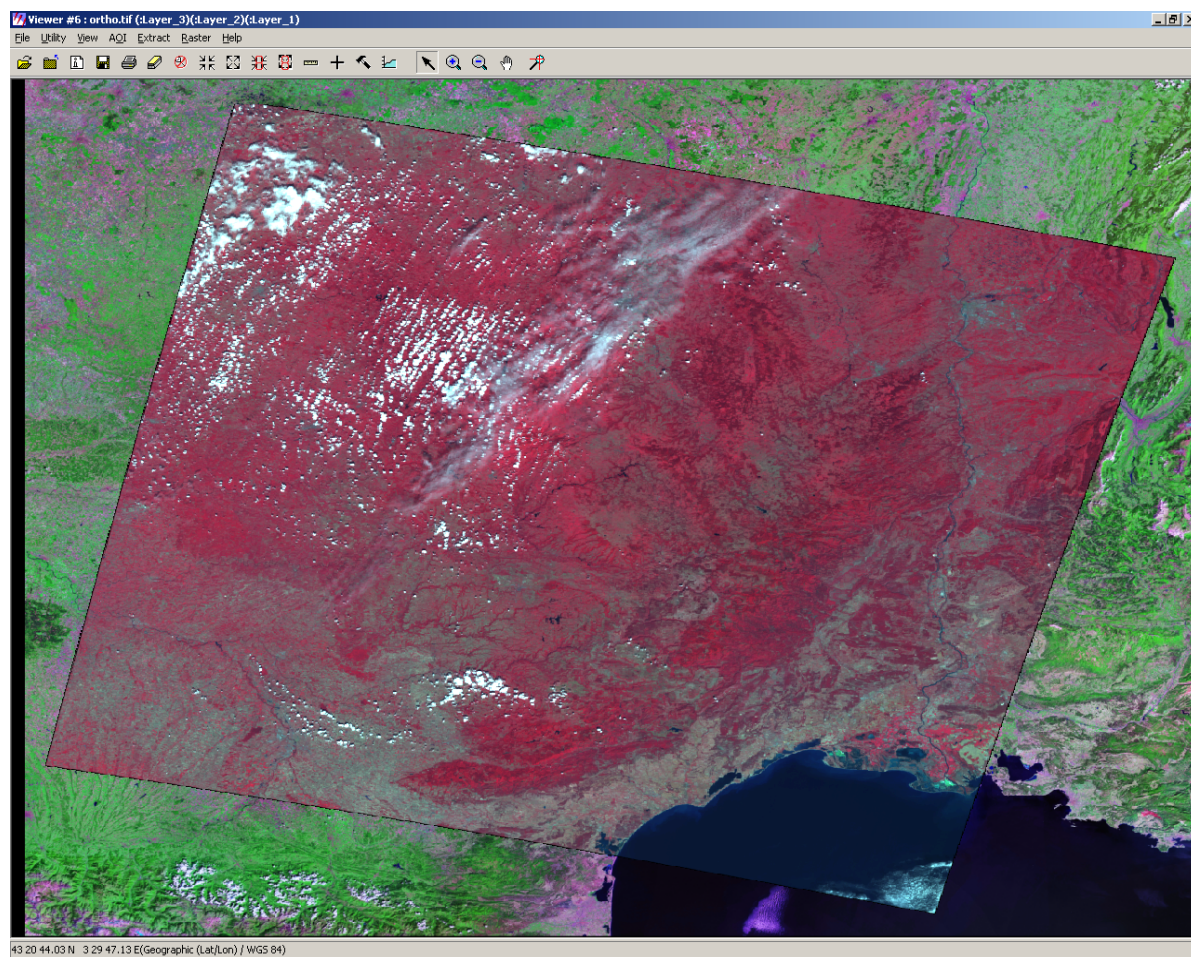


# NN Resampling Summary

- AWiFS has two characteristics that make it difficult to use Nearest Neighbor resampling for image reconstruction:
  1. Detectors from different bands do NOT collect energy from the same ground area (different optical distortion, timing, detector placement, etc.)
  2. Scale variation across the scene forces a compromise in choice of product GSD, resulting in pixel duplication in parts of the processed image
- GeoEye recommends CC or other resampling techniques for AWiFS ortho products

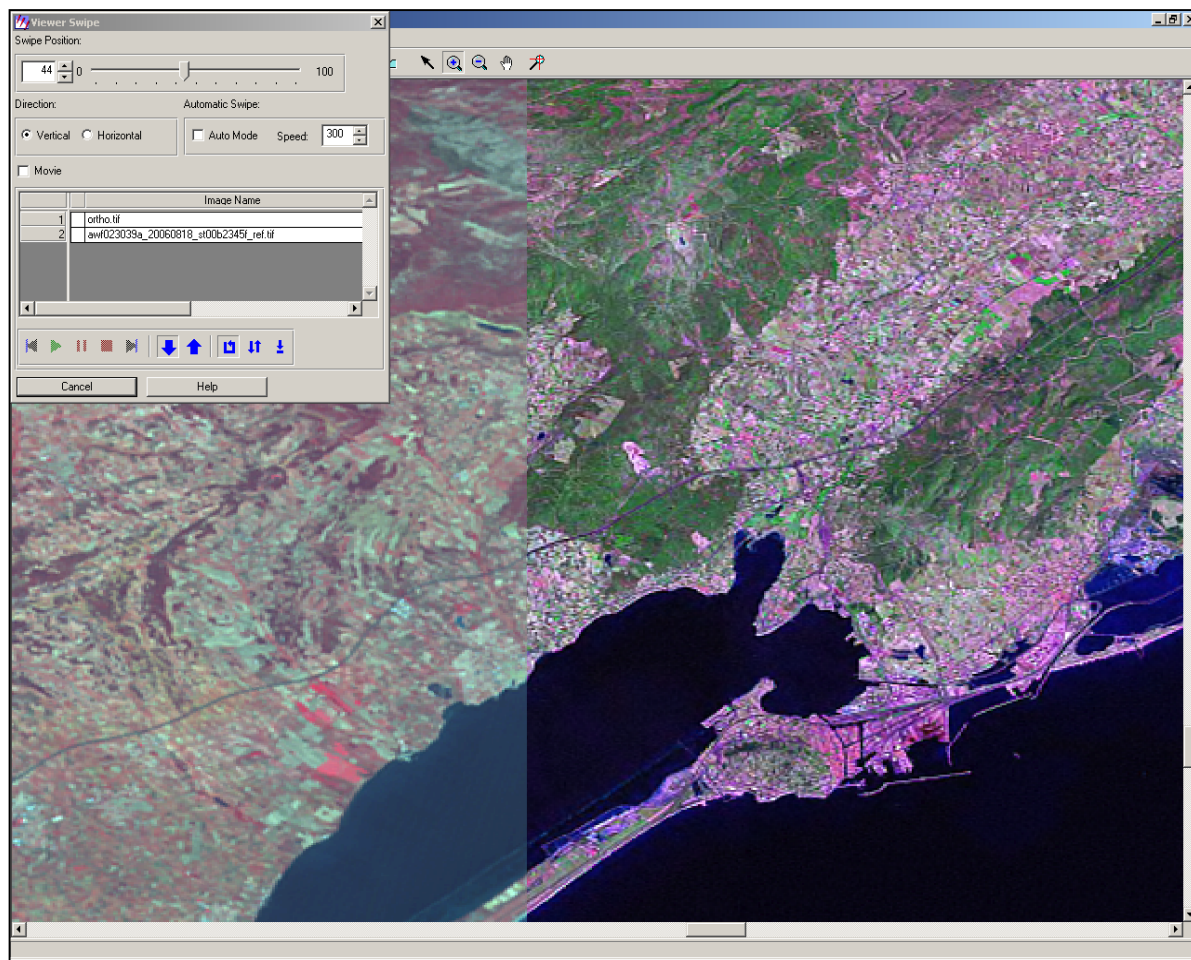
# Ortho QC

- ERDAS IMAGINE 'flicker' and 'swipe' tools used to compare ortho with reference orthoimage



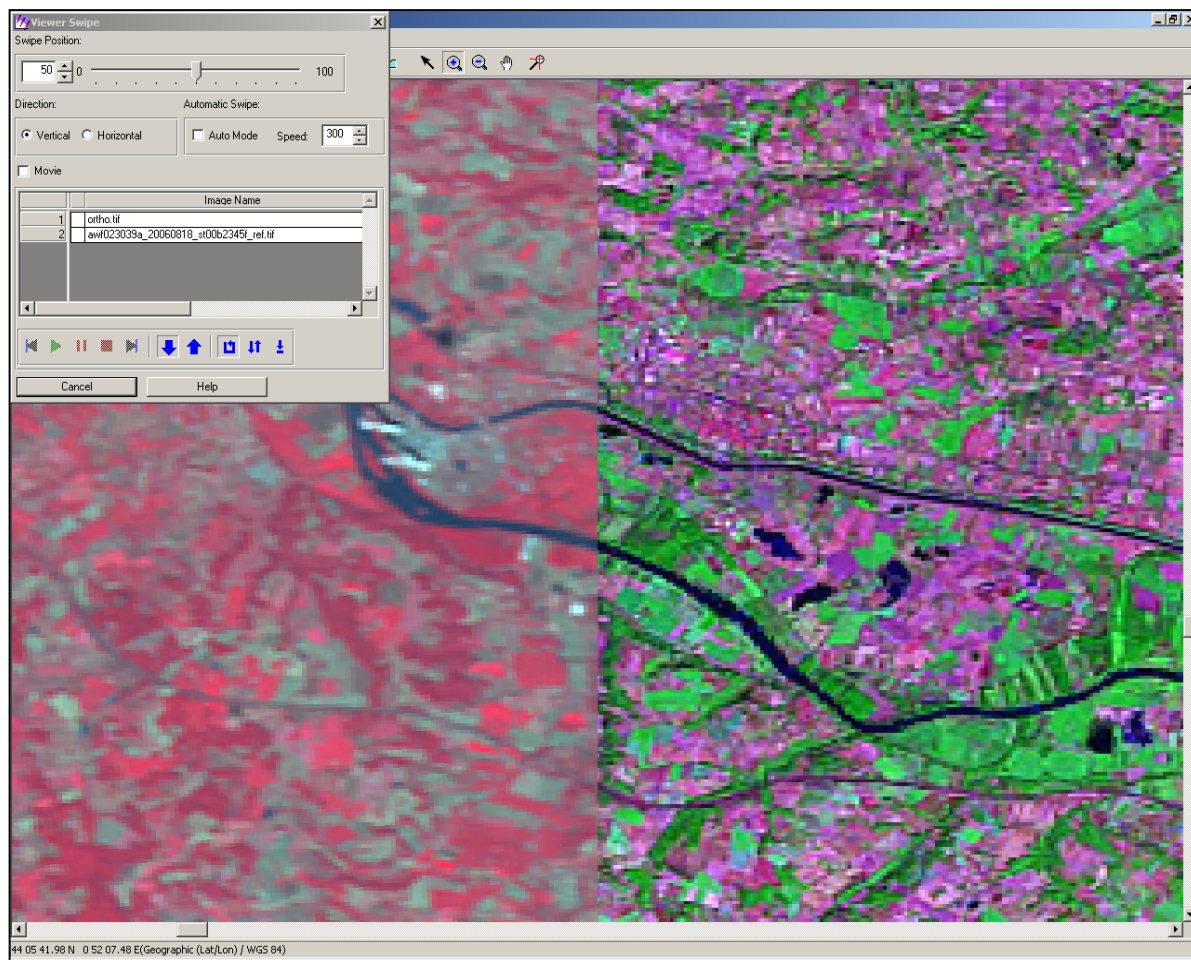
# Ortho QC

- QC operator checks several areas within image for alignment
- All areas should be within 1 pixel of reference image
  - Reference imagery sometimes has local problem areas (both GeoCover and DOQs)
  - Can be detected by local shear within reference image
- More tiepoints added and ortho regenerated if tolerance is not met



# Ortho QC

- 1 pixel alignment with reference is typically achieved with no rework necessary
- Ortho is also checked at this stage to ensure complete coverage (e.g., no corners cut off due to incomplete DEM coverage)
- Ortho viewed with different band combinations to ensure that all 4 bands are OK







# Summary

- GeoEye's AWiFS ortho production workflow has been described
- Current implementation is interactive but not laborious, providing numerous operator QC points to ensure product quality
- Custom software used for most data processing steps
- International product accuracy is limited by control dataset accuracy
- Nearest neighbor resampling not recommended due to nature of AWiFS sensor
- 8-bit ortho product is generated from the 10 bit source image - 10 bit products also available