



Landsat Project Status

Landsat Science Team Meeting

June 2010

Presented By:

Kristi Kline, PMP

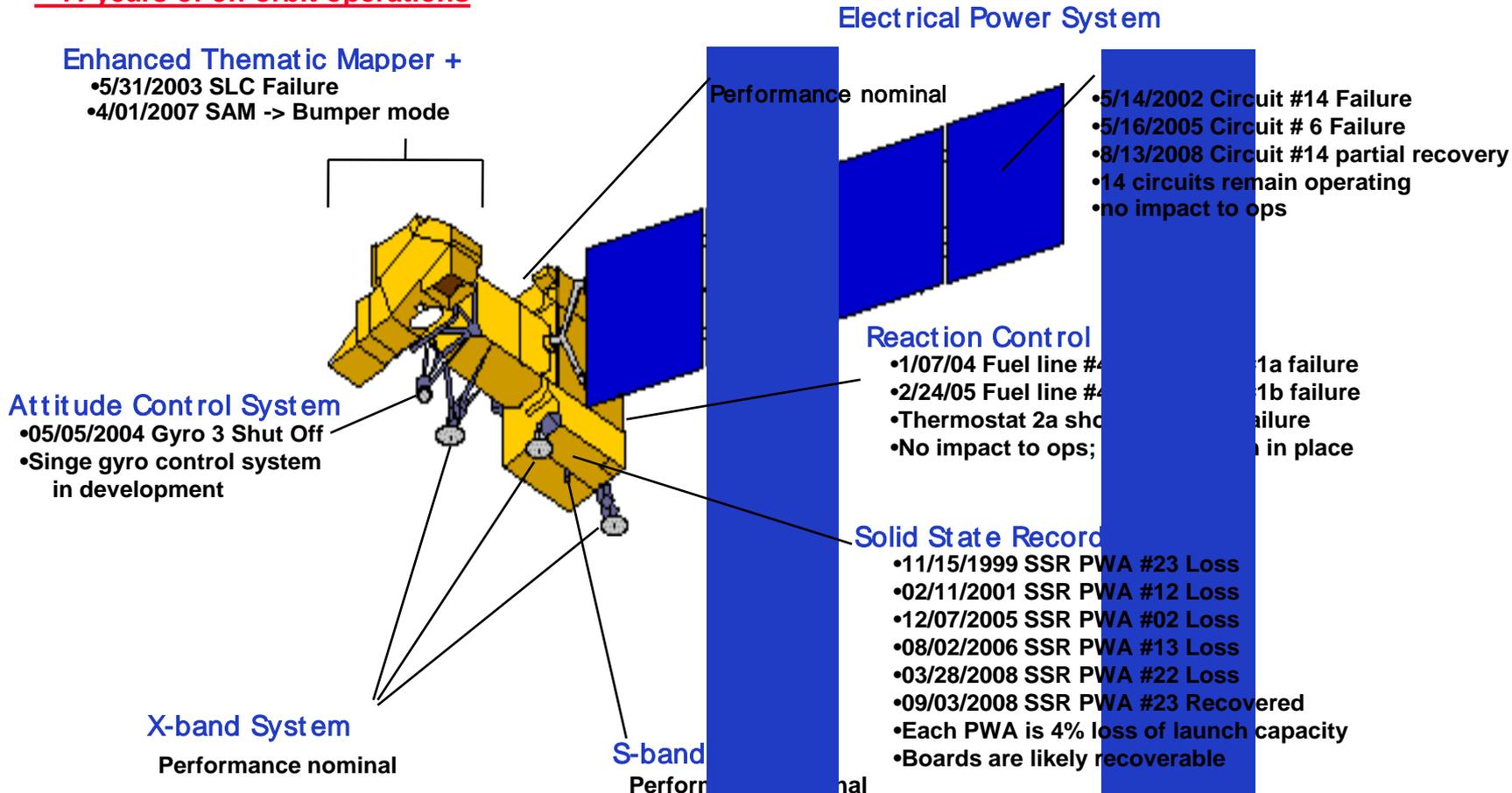
Landsat Project Manager, U.S. Geological Survey/EROS

kkline@usgs.gov, (605) 594-2585

Landsat 5 and 7 Status

Spacecraft Status

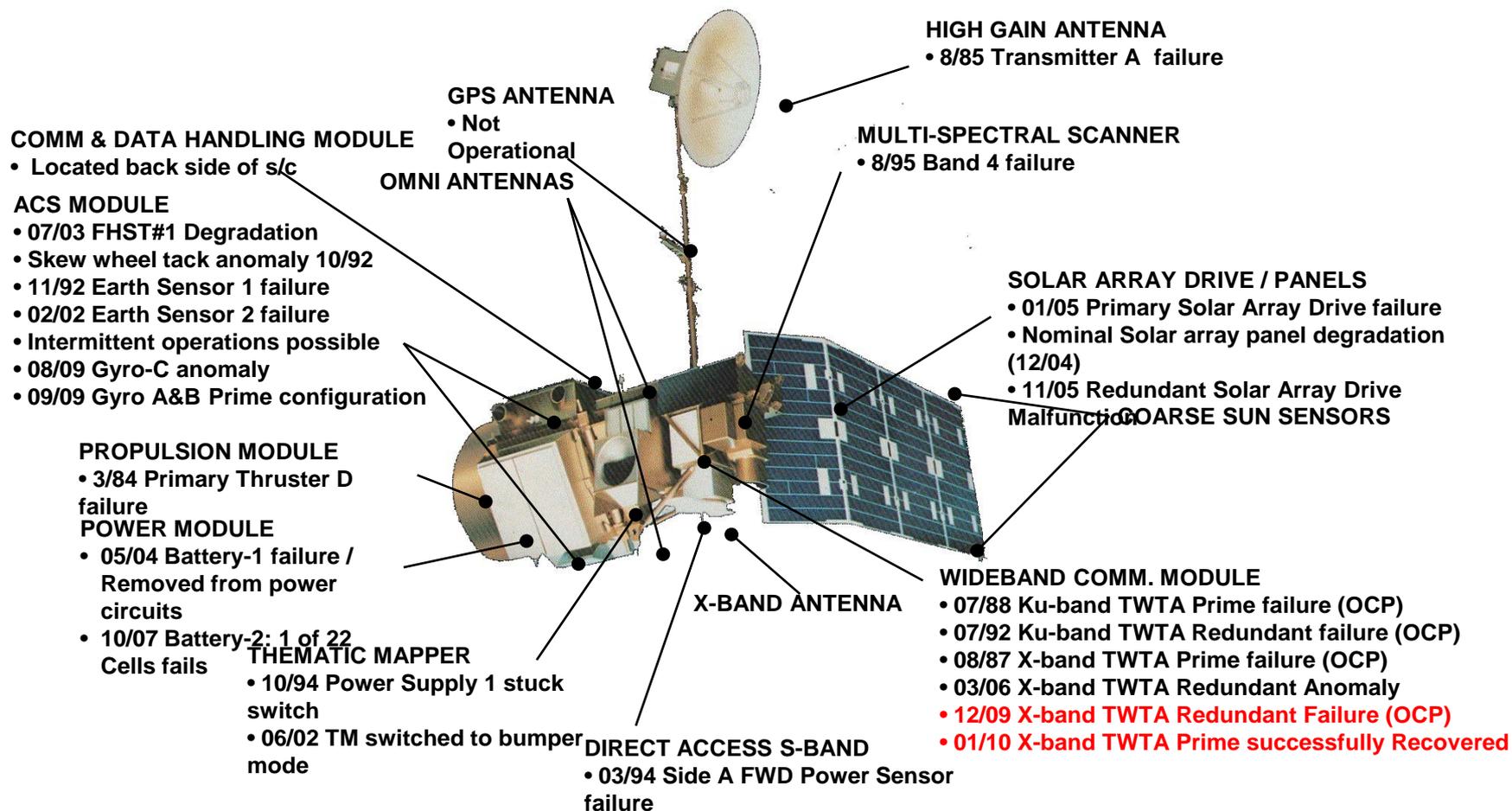
≈ 11 years of on-orbit operations



Activity Summary

- 10/01/2009; SSR data EDAC error. Less than 5 bits of data effected, no interruption to operations.
- 10/06/2009; Delta Inclination burn completed successfully
- 10/08/2009; Delta Velocity burn completed successfully
- 11/19/2009; SSR data EDAC error. Less than 5 bits of data effected, no interruption to operations.
- **12/11/2009; Collision Avoidance (Delta Velocity) burn completed successfully (2.5 sec burn)**
- 01/12/2010; SSR data EDAC error. Less than 5 bits of data effected, no interruption to operations.

Landsat 5 Flight Segment



Landsat 5 Activities Summary

Celebrated 26-Years: 3/1/1984 – 3/1/2010

138,284 orbits; 123,286 orbits past design life



- **Primary TWTA data**
- **Scan Line Error (Data from June 4)**
- **Conjunction Issue with NASA A-train**

Brief History of TWTA

- Landsat 5's primary Traveling Wave Tube Amplifier (TWTA) failed in 1987 (Current @2.75mA)
- L5's redundant TWTA operated 22 years until 12/2009
- Primary TWTA brought back on-line Jan 2010
- Concerns with rising helix current -- primary TWTA may not operate until Landsat 8 launches
- Testing various operations concepts -- strike balance between imaging and TWTA lifetime
- Invoked cloud avoidance to improve yield of usable images
- Current continues to rise more quickly than desired

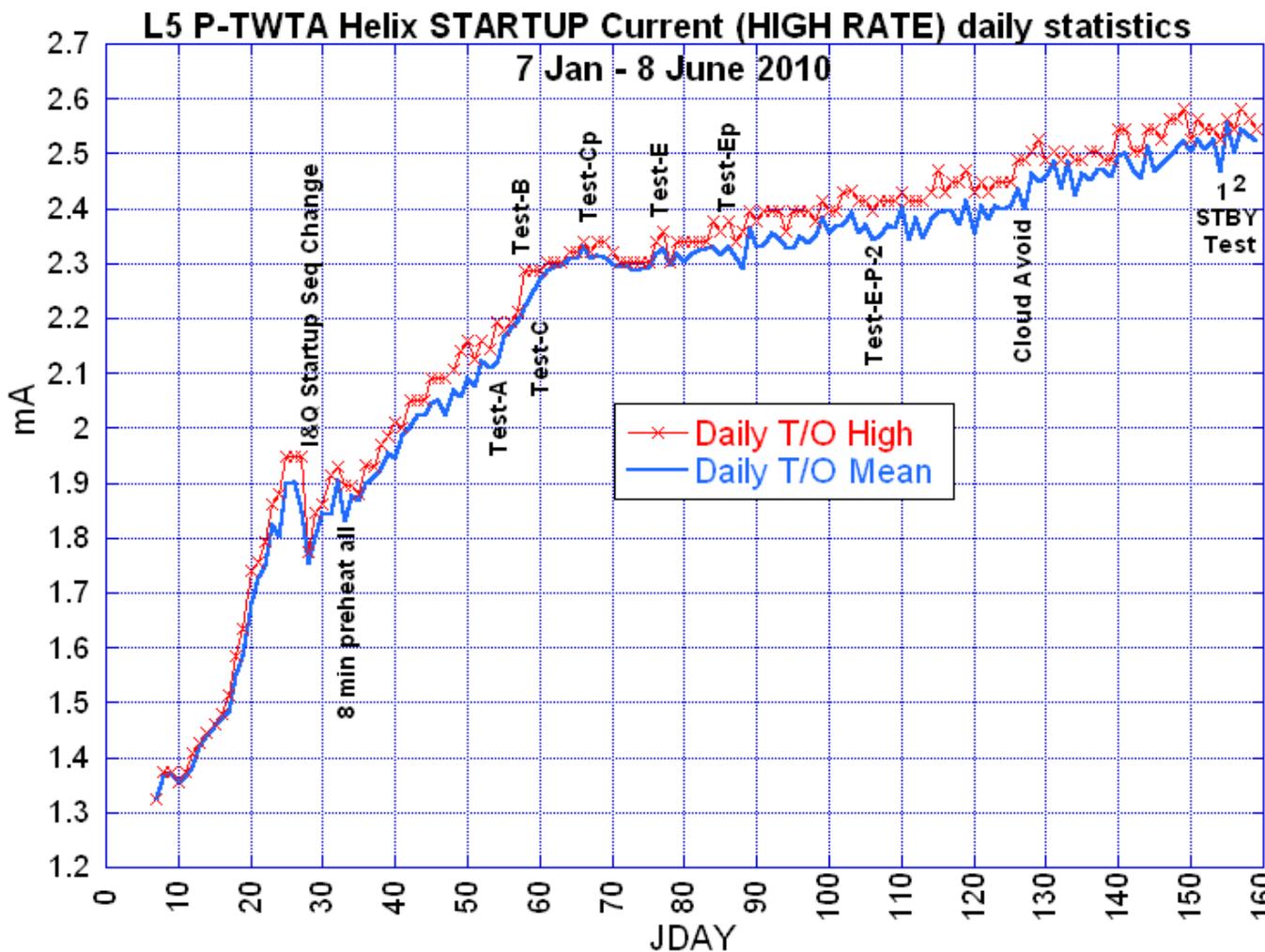
Review of L5 Tests Performed

Test	Dut/Pwr Cycle %	Duration	Comments/Results
A	100/100	23-27 Feb	Baseline run, removed other variables
B	100/200	4 orbits on 28 Feb	Rapid rise in currents – test cancelled
C	50/100	1-8 Mar	Uptrend at .075mA/day
C'	25/50	8-18 Mar	Helix current decreased
D	50/200	None	Not performed due to test B similarity
E	50/50	18-24 Mar	Moved towards ops. Changed North / South image start locations
E'	55/70	24 Mar – 15 Apr	Dual images, 0.0003 mA/day increase, better ops coverage
E'2	70/70	15 Apr – 6 May	0.00277mA/day increase

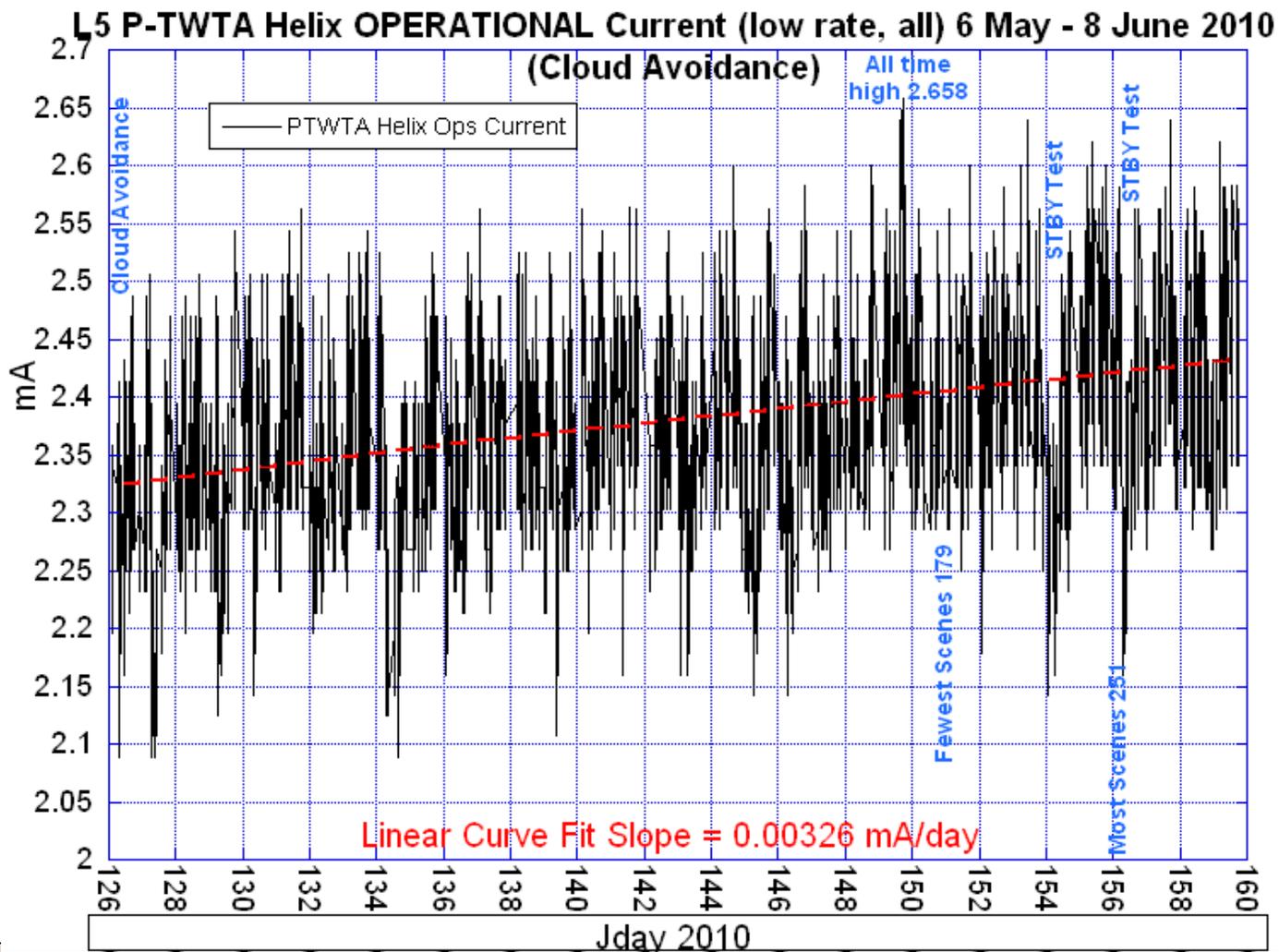
New Landsat 5 scheduler

- Executed controlled engineering tests beginning 17 March 2010
- Implemented new scheduler with cloud avoidance using a 50% duty cycle on 6 May 2010
- Hit high TWTA current of 2.658 on 9 June 2010

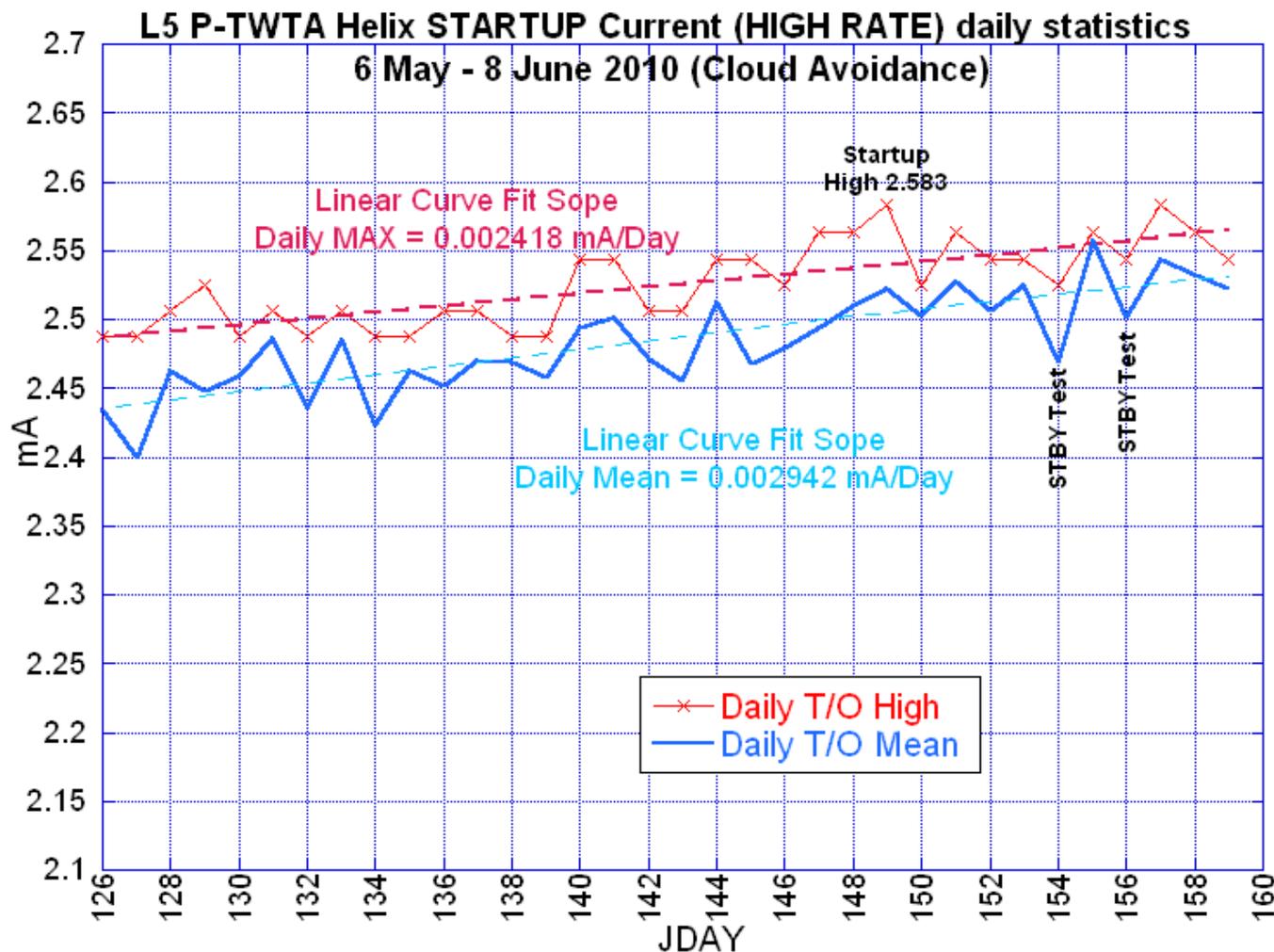
Recent Data 1 – Since Primary TWTA



Recent Data 2 – Cloud Avoidance



Recent Data 2A – Cloud Avoidance



Analysis of Current Trends

- **Unreliability of TWTA expected at 3.1mA**
- **Current high value: 2.658**
- **Current slope (Linear, all points): 0.00326**
- **Days until 3.1mA: 135**
- **Days until 2.75mA: 28**
- **Scenes left: (135x200) = 27000**
 - ◆ Mean value (2.52) leads to 168 days, 33600 scenes
- **Assumes constant rise**
- **Constant value required to make 2014:
~0.0005mA/day**

Scan Line Error

- **June 4, 2010 – anomalous data acquired on pass (path 43, row 23 – start of error)**



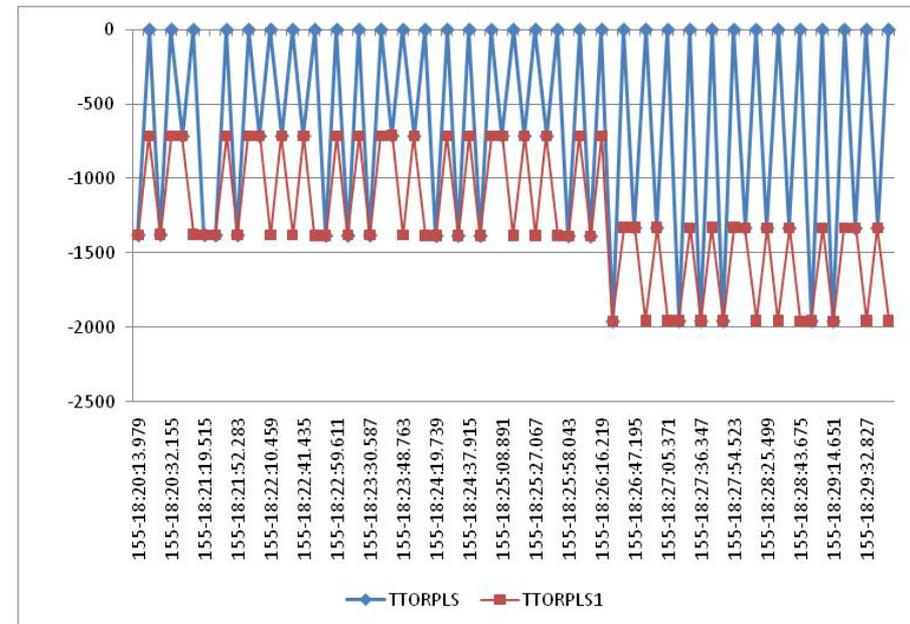
Scan Line Error

- **Details:**

- ◆ Began about 18:26:20.835 of day 155 in scan #305 (p43/r23), acquired June 4, 2010
- ◆ Began in a reverse scan
- ◆ Bumper mode scan timing disrupted for 10-15 scans -- total scan time varied from nominal by up to 0.7 msec
- ◆ Forward scans behaved nominally once scan timing settled back down, but reverse scans showed anomalous profile
 - Ends of scan close to being correct (due to return to controlled scan time), scan centers out of alignment by ~12 pixels
- ◆ Alignment error suggests midscan reached too soon (image detail is too far east) -- reverse scans experiencing additional drag
 - Scan velocity too high during 1st half and too low during 2nd half scan
- ◆ Scenes in remainder of interval appear to have same error
- ◆ Scenes from next interval (path 59) and subsequent imaging appear nominal

Scan Line Error

- **Error not a ground system issue**
 - ◆ Data from LGS, GLC (Gilmore Creek), and CCRS (Canada) all have same error
- **Flight Operations Team (FOT) discovered TM Torque Pulse Frequency telemetry non-nominal for period of the anomaly**
- **No further scan timing disruptions observed during session**
- **FOT reviewing additional data spans -- no other occurrences found as yet**



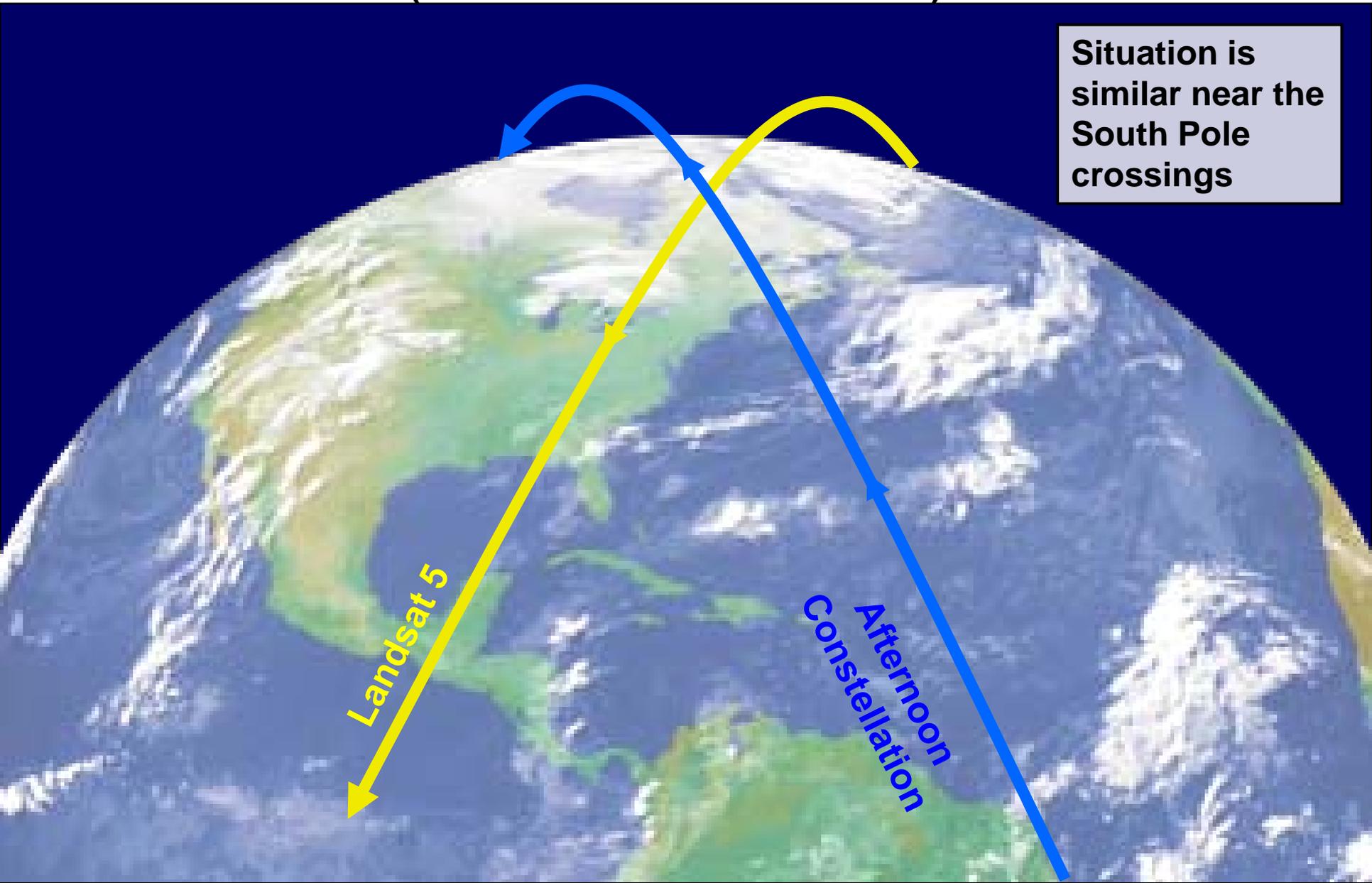
Landsat 5/A-train Conjunction

- **Several years ago (2002), effort made to align Landsat 5 MLT with that of Landsat 7**
 - ◆ Increased Landsat 5 MLT from ~9:45 to ~10:00
 - ◆ Moved Landsat 5 backwards relative to Terra, where it began to cross the Afternoon Constellation
- **Afternoon constellation performed large MLT change in spring 2009 to counteract large MLT drift rate**
 - ◆ Decreased Aqua's MLT from ~13:41 to ~13:37:30
 - ◆ Moved each afternoon constellation mission forward towards the Landsat 5 crossing
- **Landsat 5 has crossed an afternoon constellation missions 9 times since Aqua launch**

Landsat 5 Crosses Through A-Train

(Click to start the slide show mode)

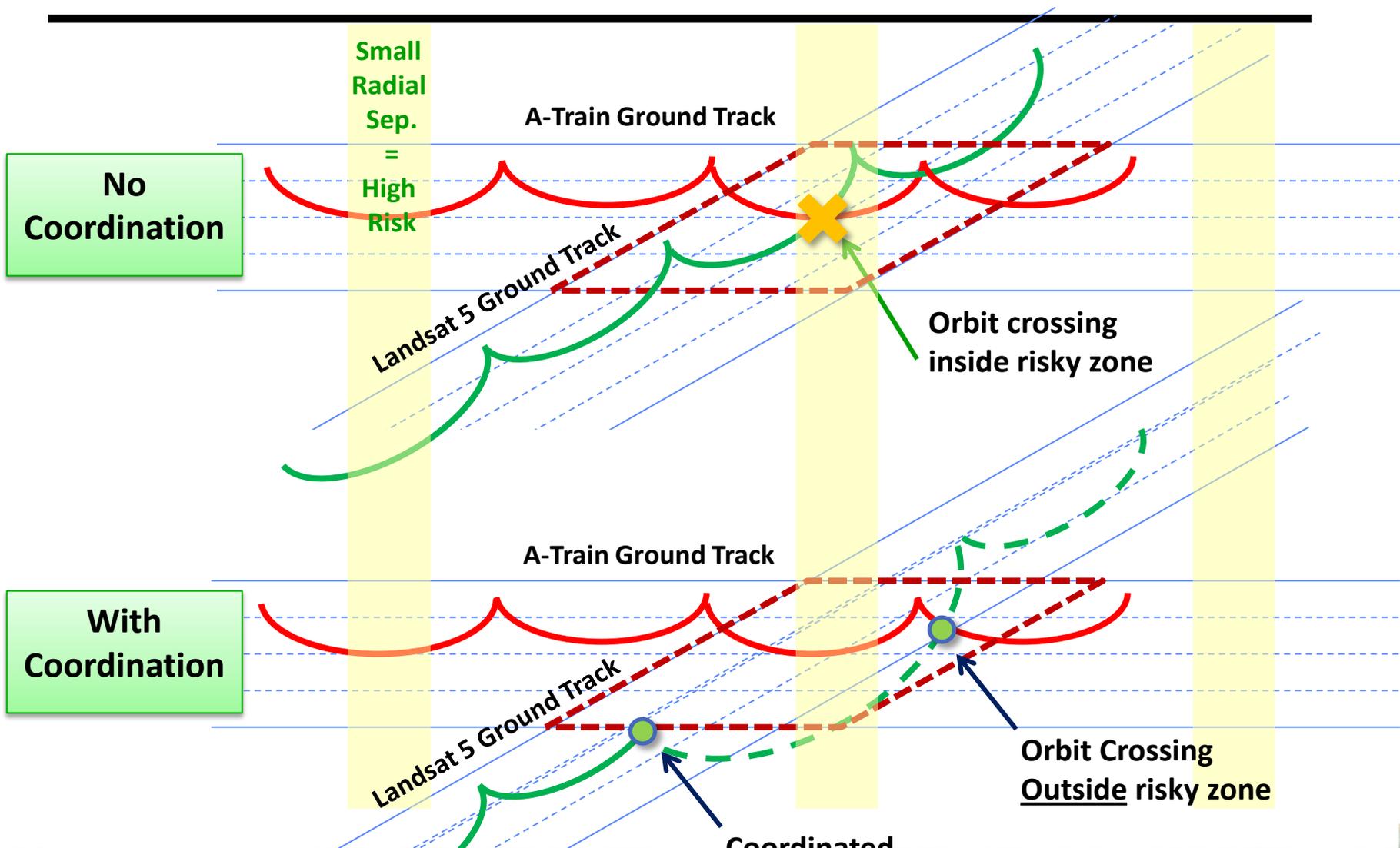
Situation is similar near the South Pole crossings



Landsat 5

Afternoon Constellation

Coordinated Maneuvers Avoid Risky Orbit Crossings

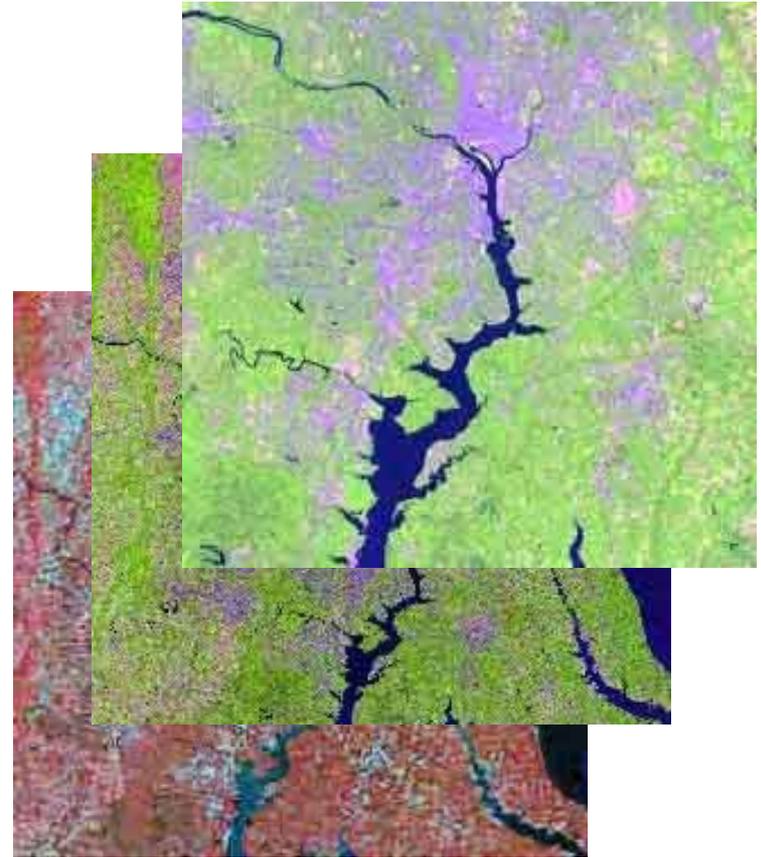


Landsat Archive and Processing Topics

U.S. Landsat Archive Overview

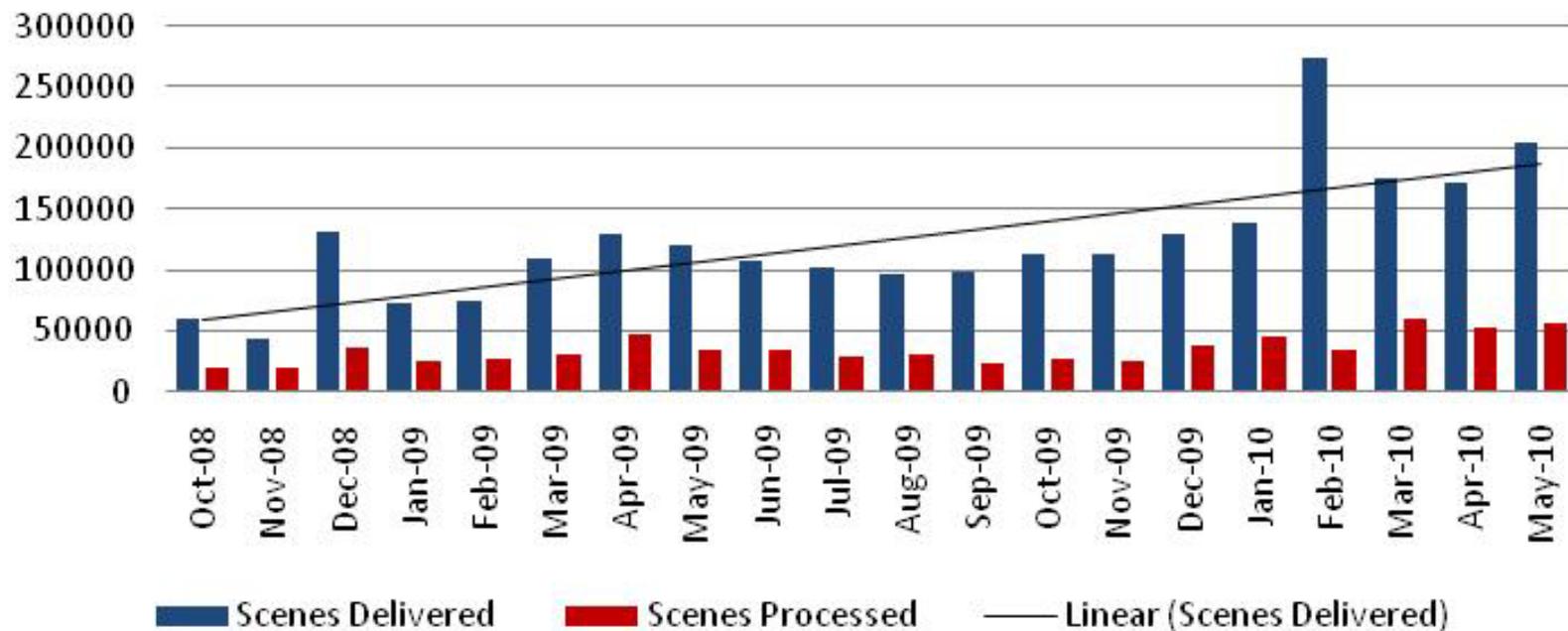
(Marketable Scenes through February 28, 2010)

- **ETM+: Landsat 7**
 - ◆ 1,016,250 scenes
 - ◆ 944TB RCC and L0Ra Data
 - ◆ Archive grows by 260 GB Daily
- **TM: Landsat 4 & Landsat 5**
 - ◆ 848,429 scenes
 - ◆ 212TB of L0Ra Data
 - ◆ Archive Grows by 40 GB Daily
- **MSS: Landsat 1 through 5**
 - ◆ 513,866 scenes
 - ◆ 15 TB of Data



Monthly Downloads / Processed

Landsat Web-Enabled Monthly Statistics



- **FY10 (October 2009 – May 2010)**

- ◆ Over 1.4M scenes delivered
- ◆ Almost 370,000 scenes processed

Project Activities and Status

- **Archive migration**

- ◆ Migrating all Landsat data to new tape archive unit and copy to on-line disk storage
- ◆ Old tape archive obsolete technology
- ◆ On-line storage will help increase processing throughput
- ◆ 1451 tapes migrated (of 9101)

- **Thermal data now processed to 30m pixels**

- **Began collecting SPOT 4/5 data**

- **LGAC, LGAC, LGAC! (Next presentation)**

Project Activities and Status

- **MSS processing algorithms on LPGS**

- ◆ On schedule to release in September
- ◆ Comparison of results from MSS-P to NLAPS
 - 95% of the images that autoprocessed to Level-1 Terrain Corrected (L1T) in NLAPS autoprocessed to L1T in LPGS
 - 85% of the images that processed with operator assistance to L1T in NLAPS autoprocessed to L1T in LPGS
 - ◆ Without operator intervention, these would have been created as L1Gs by NLAPS
 - 66% of the images that process with operator assistance to L1G in NLAPS auto processed to L1T in LPGS

Landsat MSS Orphans

- **What is an MSS Orphan?**

- ◆ Intervals of L1-3 data that are missing ephemeris information (scene center, lat/lon, spacecraft attitude, sun elevation/azimuth, sensor gain, etc.)
- ◆ Ephemeris data store on separate tape (9-track) during that era

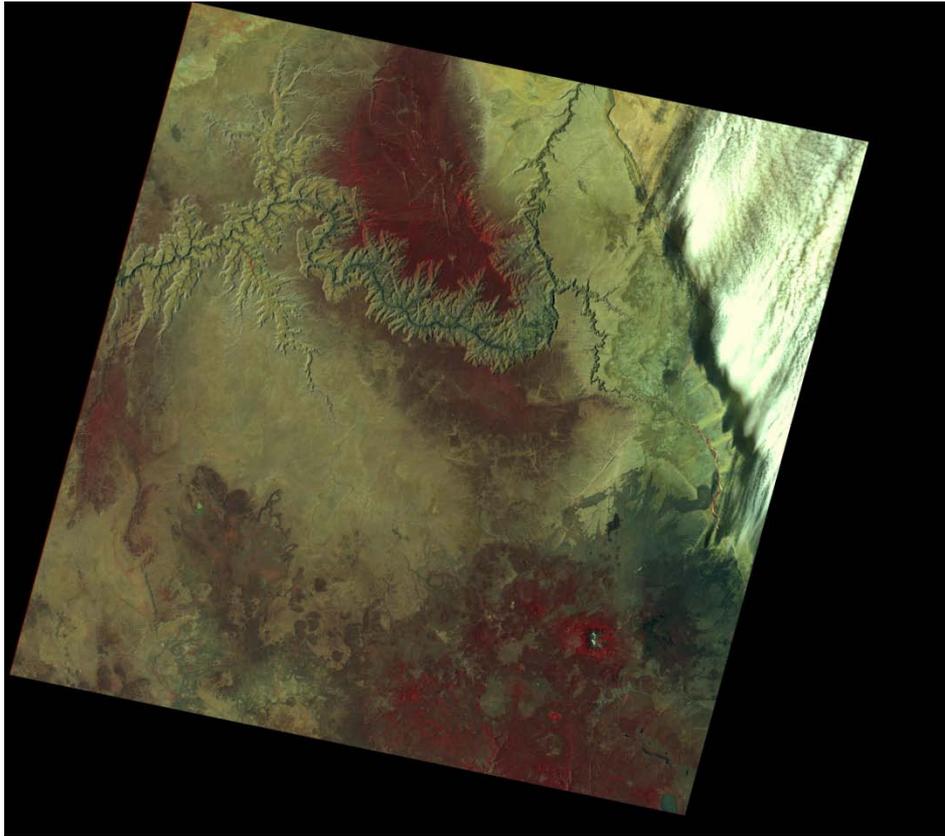
- **How much data are orphans?**

- ◆ Potentially 240,000 scenes

- **What are we doing to recover these scenes?**

- ◆ Software development in progress to recover images, generate necessary ephemeris, and be able to process with MSS algorithms (up to L1T product)
- ◆ Example of MSS orphan scene not available digitally

Prototype Orphan Scene



- **Landsat 2 Image**
 - ◆ Path 40, Row 35
 - ◆ 6-27-1978
- **Processed to L1T using prototype MSS algorithms on LPGS**
- **Will begin recovery of MSS orphans in FY11**

Full-Resolution Reflective Browse

- **Band combinations – “Green”**

- ◆ OLI: 6,5,4
- ◆ ETM+ & TM: 5,4,3
- ◆ MSS: 2,4,1

- **Data values**

- ◆ Top of Atmosphere Reflectance (P_p)
- ◆ $DN_B = 255 * P_p$ (1/gamma)

- **Image format**

- ◆ 3-band RGB JPEG
- ◆ Georeference information in World & GDAL XML files

- **File size is approximately 5 MB**

- **Pixel size is retained**

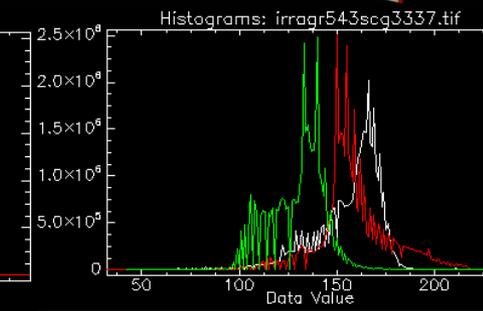
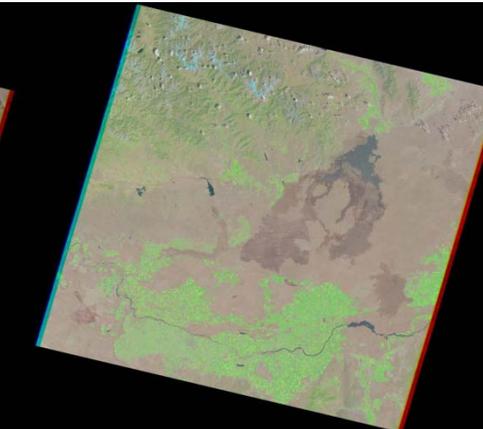
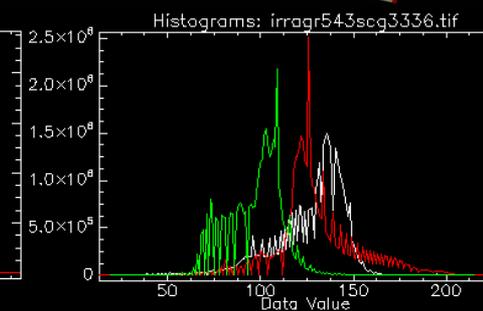
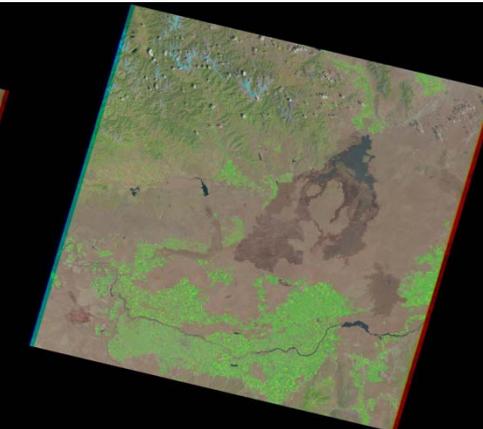
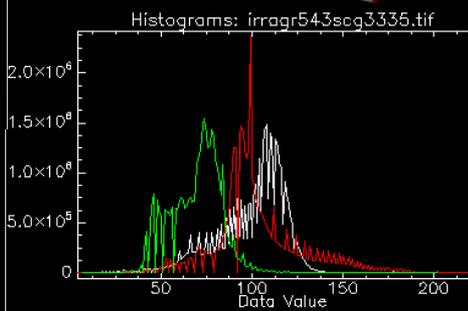
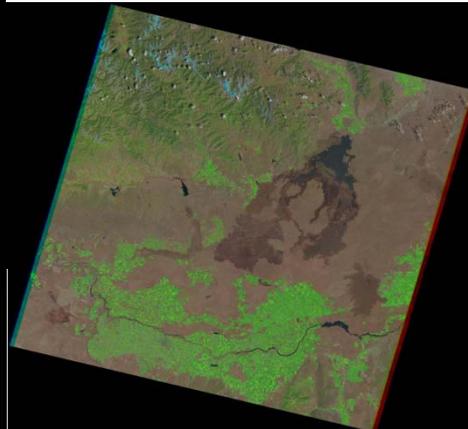
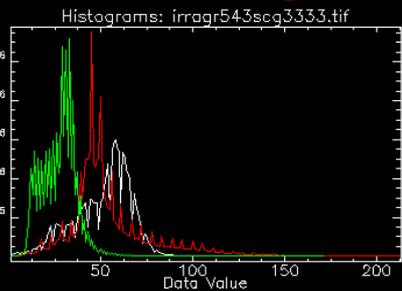
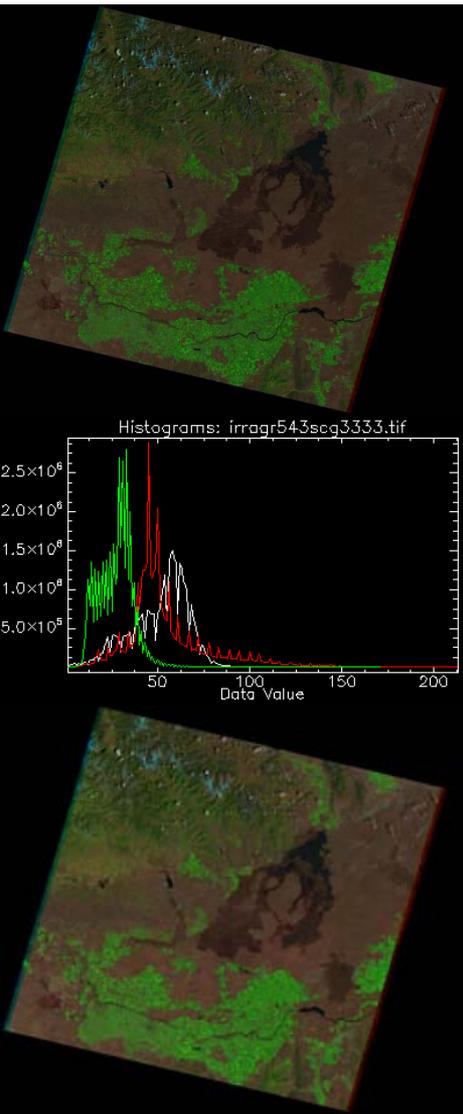
- ◆ http://picasaweb.google.com/109917760236279685357/Browse?authkey=Gv1sRgCKnk0KqL_KiXpQE&feat=email#

Landsat Browse

- **Browse color and brightness will be look different depending how display medium: Display versus projection versus print**
- **Changed to nonlinear gamma stretch from clipped linear stretch**
 - ◆ Shift 0.3 reflectance to 0.5, 0.6, 0.7 (gamma =1.739, 2.358, 3.378 respectively)
 - ◆ Each increase in shift brightens image, but compresses bright objects (clouds/snow/ice)
- **543 band combination reality**
 - ◆ Snow/ice is cyan due to absorption in band 5 (mid-IR)

Craters of the Moon, Idaho

10 July 1996 – Bands 5,4,3



Gamma = 1.739

Gamma = 2.358

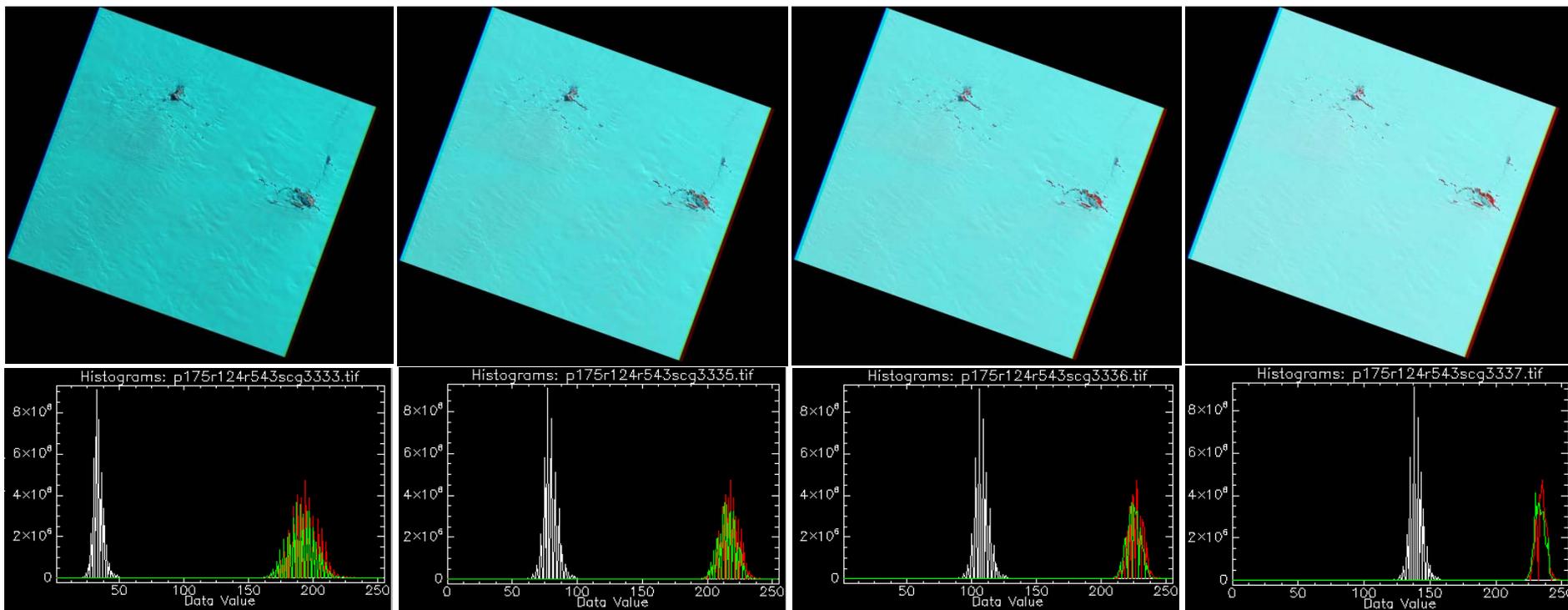
Gamma = 3.378

Graphs: white:band 5; red:band 4; green:band 3

Linear 0-1 & 0-0.8

Antarctica

DOY 322 - 1996 – Bands 5,4,3



Linear 0-1

Gamma = 1.739

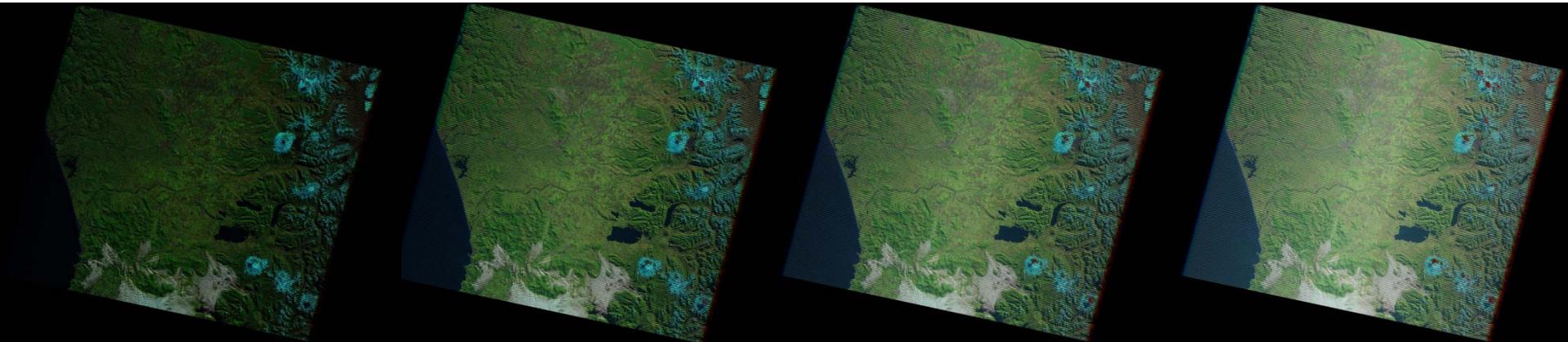
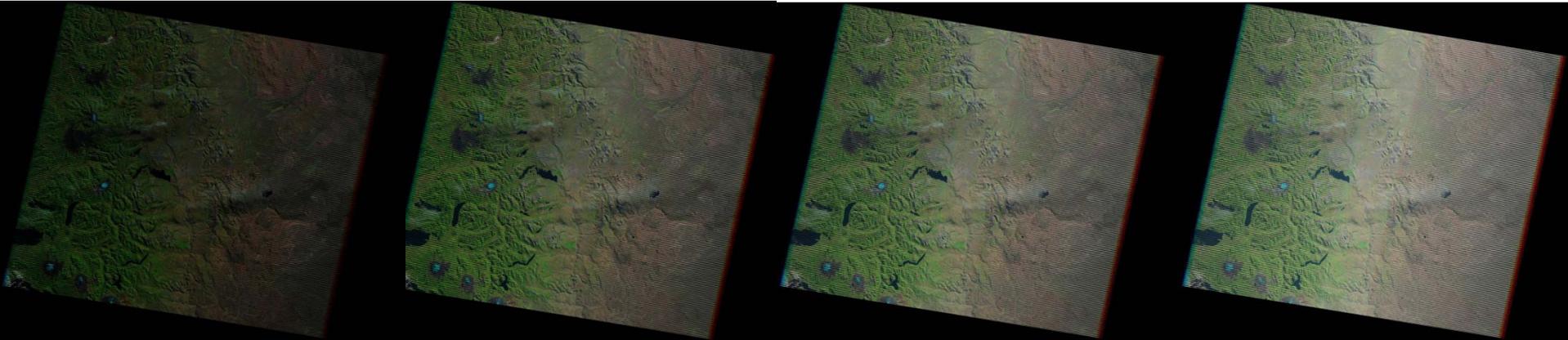
Gamma = 2.358

Gamma = 3.378

Graphs: white:band 5; red:band 4; green:band 3

Llaima Volcano – Chile

14 July 2009, 18 April 2009 – Bands 5,4,3



Linear 0-1

Gamma = 1.739

Gamma = 2.358

Gamma = 3.378

Las Vegas & Seattle

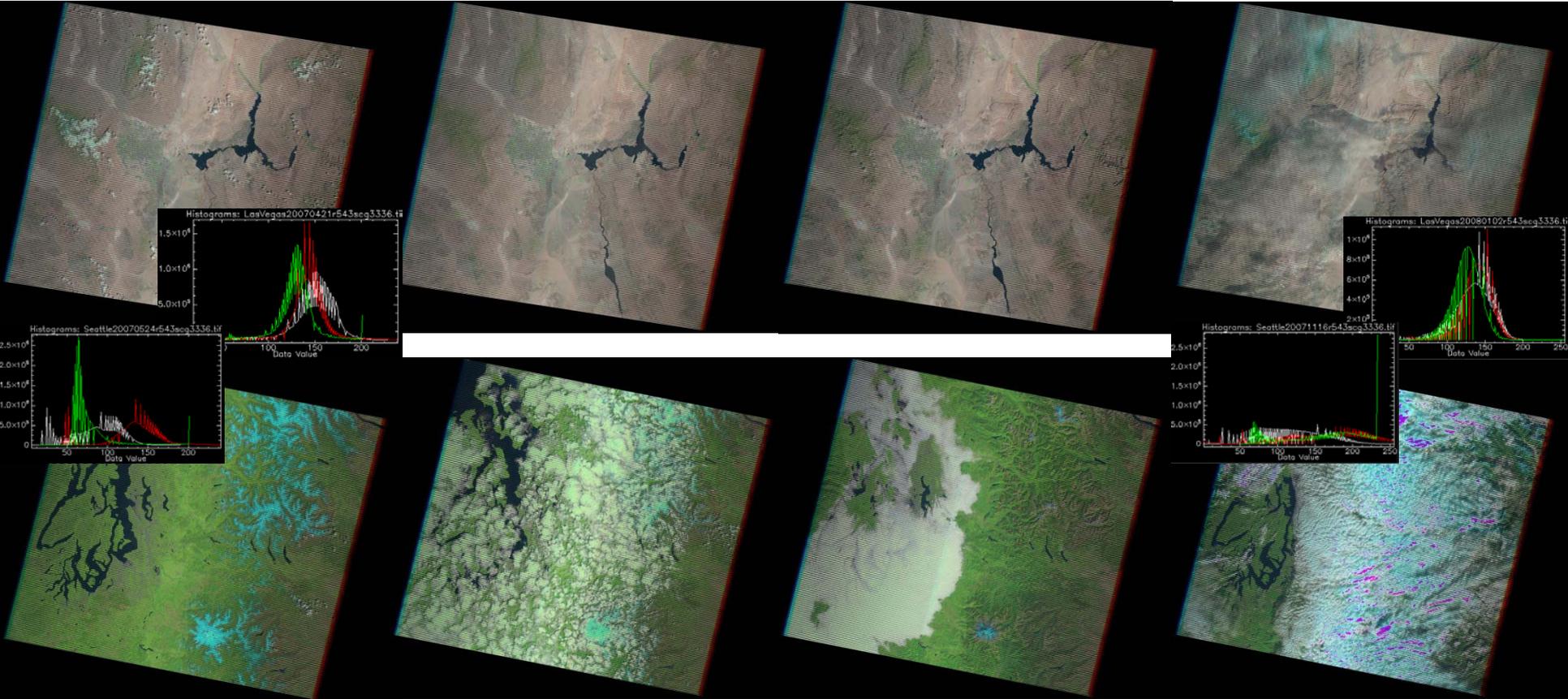
Gamma = 2.358 – Bands 5,4,3

2007-04-21

2007-05-07

2007-10-14

2008-01-02



2007-05-24

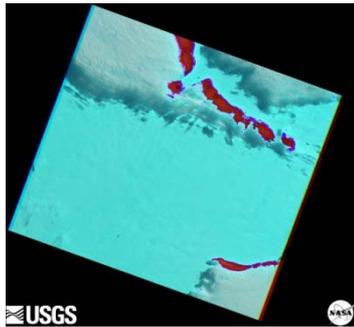
2007-06-26

2007-09-13

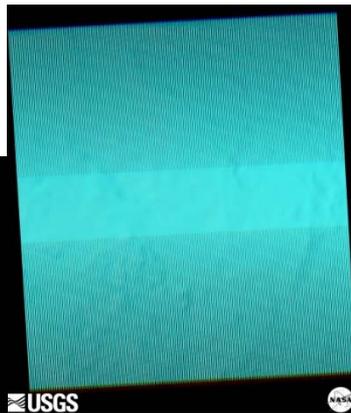
2007-11-16

Graphs: white:band 5; red:band 4; green:band 3

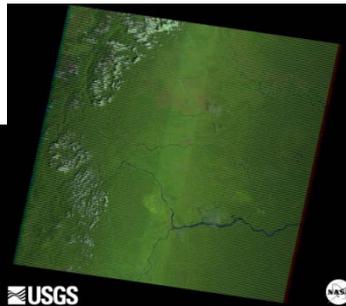
Browse Images with USGS and NASA Logos



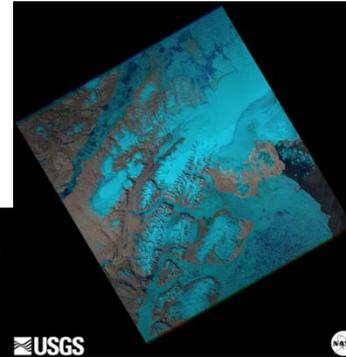
**Path 175
Row 123**



**Path 130
Row 122**



**Path
Row 60**



**Path 15
Row 1**



**Path 48
Row 246**