ASTER Validation Summaries

Outline

- Data Products and Validation Status
- Instrument Characteristics
- Validated accuracies on a per product basis:
  - Radiance at sensor
  - Radiance at surface
  - Surface reflectance
  - Surface temperature
  - Surface emissivity
  - Digital elevation models
  - Polar cloud mask.

ASTER Data Products

Product Name	Date of Latest Upgrade	Current Release State	Upgrade Schedule
Level 1a	28 Apr '01	**Validated**	
Level 1b (AST03)	28 Apr '01	**Validated**	
Decorrelation Stretch (AST06)	19 Jun '01	**Validated**	
Brightness Temperature (AST04)	12 Jun '01	**Validated**	
Surface Reflectance (AST07)	24 Jan '01	Provisional	Nov '01 (V)
Surface Radiance VNIR, SWIR (AST09)	24 Jan '01	Provisional	Nov '01 (V)
Surface Radiance TIR (AST09)	28 Mar '01	Provisional	Nov '01 (V)
Surface Kinetic Temperature (AST08)	09 Apr '01	Beta	Nov '01 (P) Feb '02 (V)
Surface Emissivity (AST05)	09 Apr '01	Beta	Nov '01 (P) Feb '02 (V)
Digital Elevation Model (DEM) (AST04) absolute	10 July '01	**Validated**	
Digital Elevation Model (DEM) (AST04) relative	10 July '01	Beta	Sep '01 (V)
Polar Classification (AST13)	Dec '01	TBD	tbd

Platform/Instrument Characteristics

- The Terra platform is in a 10:30 am sun-synchronous polar orbit at 705km.

- ASTER consists of 3 bore-sighted subsystems: VNIR (3 channels), SWIR (5 channels and TIR (6 channels) covering the 0.56-11.3 um region. ASTER has swath width of 60 km

Preflight VNIR Specification

- 15m spatial resolution
- Pointing capability +/- 24 degrees
- 3 spectral bands between 0.52 and 0.86 um
- 1 spectral bandfor backward viewing with a B/H ratio of 0.6
- NEΔR of 0.5%
- Absolute accuracy of 4%
- MTF of 0.25 cross track and 0.2 along track
- 8-bit digitization
- Onboard calibration:
  - Tungsten lamps monitored by photodiodes

Preflight SWIR Specification

- 30m spatial resolution
- Pointing capability +/- 8.55 degrees
- 6 spectral bands between 1.60 and 2.43 um
- NEdR of 0.5-1.3% depending on channel
- Absolute accuracy of 4%
- MTF of 0.25 for cross track and 0.2 for along track
- 8 bit digitization
- On-board calibration
  - Tungsten lamps monitored by photodiode

Preflight TIR Specification

- 90m spatial resolution
- Pointing capability 0f +/- 8.55 degrees
- 5 spectral bands between 8.13 um and 11.65 um
- NEdT of 0.3
- Absolute accuracy of 1-3 K depending on band
- MTF of 0.25 for cross tracka nd 0.2 for along track
- 12 bit digitization
- On-board calibration
  - Blackbody source used between 270 and 340K. Temperatures outside range by extrapolation

Registered Radiance at Sensor (AST03)

Product Description:

Registered radiance at sensor for the ASTER channels.

Validation Approach:

Comparison to calibrated reflectance sites.

Comparison to calibrated radiance sites, including the moon

Comparison to calibrated temperature/emissivity sites

Comparison to calibrated geometric targets

Comparison to simultaneous in-situ and aircraft measurements made by:
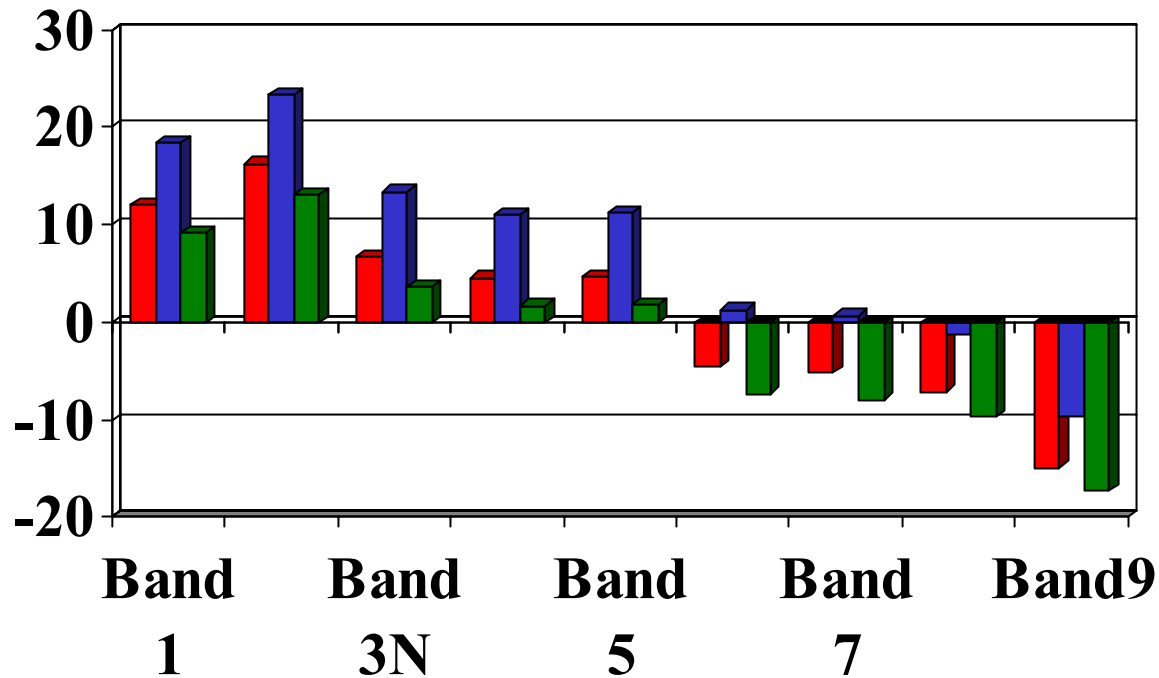
       a) Algorithm developers

       b) EOS validation scientists

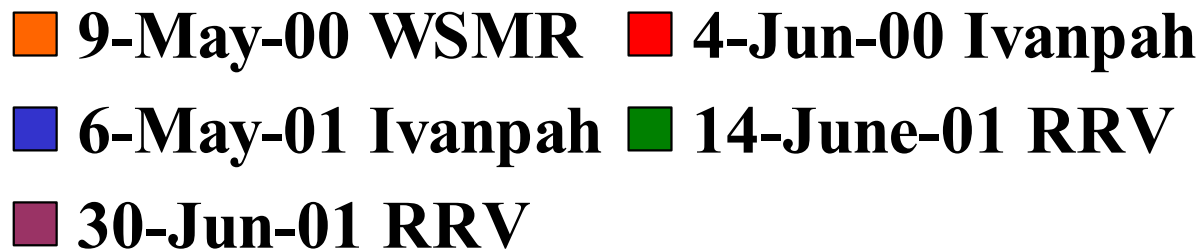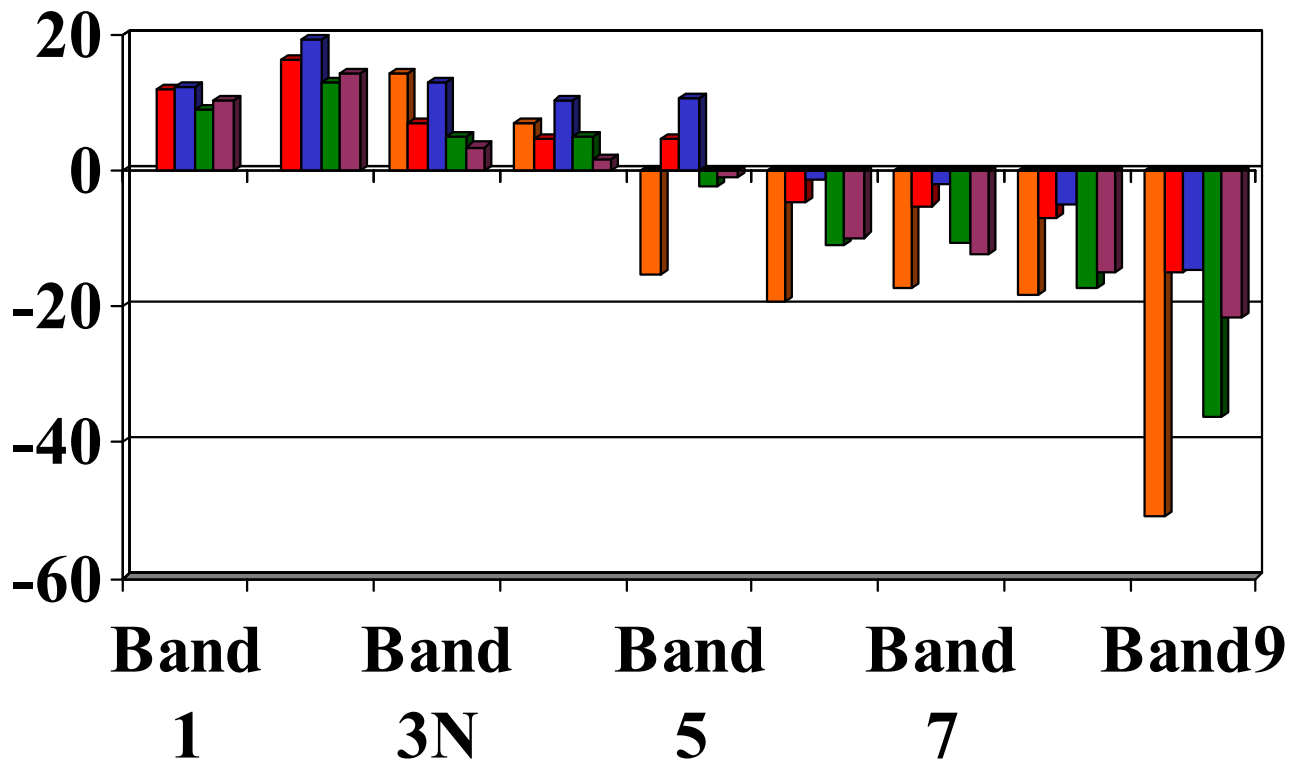Comparison to equivalent values measured by other instruments.

Percent difference between reported ASTER Level 1B radiance and vicarious approaches (positive value indicates vicarious value exceeds ASTER value)
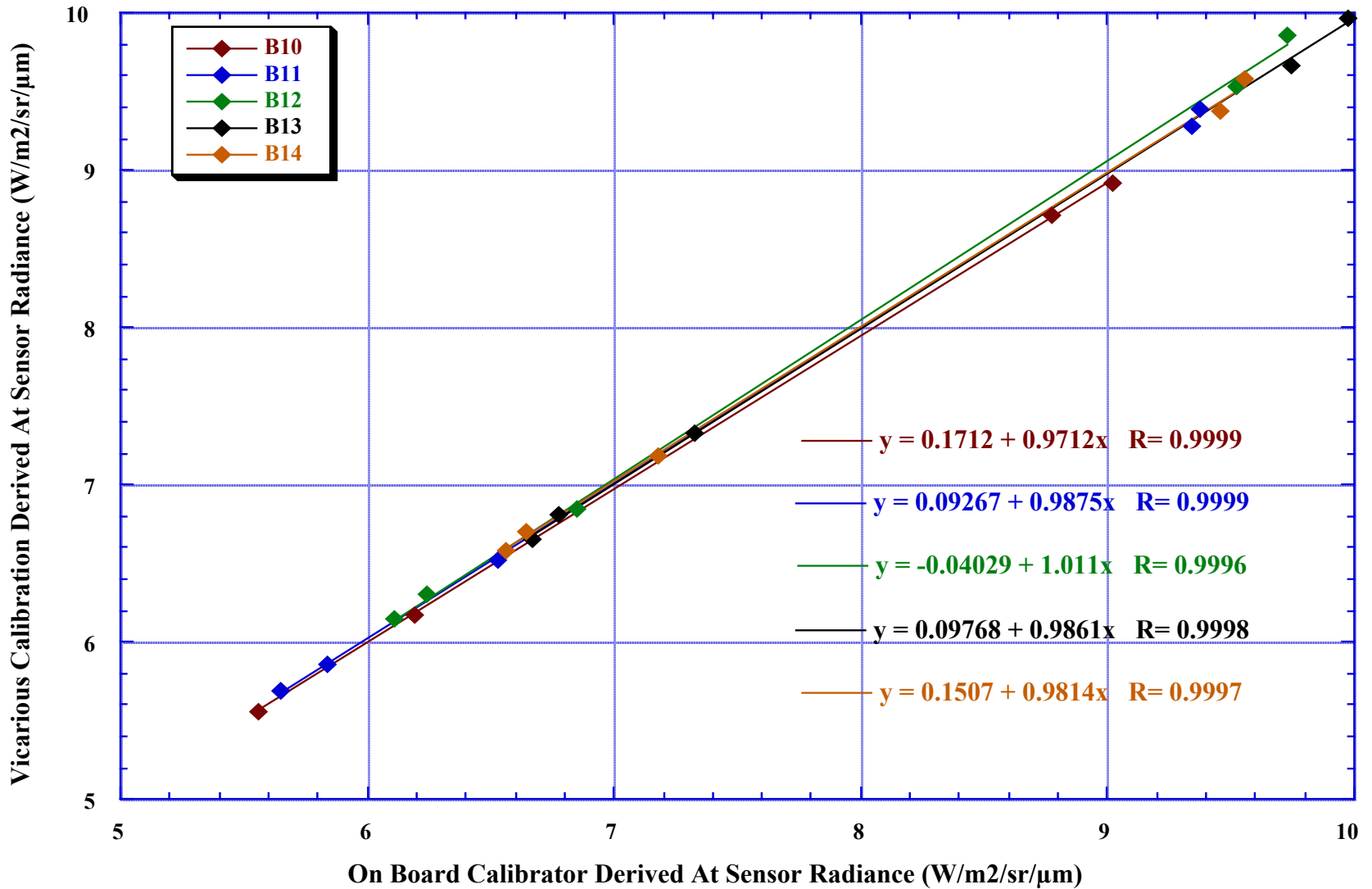
Ivanpah Playa from June 4, 2000

Vicarious Calibration Results

Validated Accuracy and Precision of Radiance at Sensor, VNIR/SWIR

Band	Accuracy	Precision	NEDL
1	10%	5%	
2	14%	8%	
3N	8%	5%	
4	6%	3%	
5			
6	Site dependent due to cross-talk effects		
7			
8			
9			

ASTER TIR Band OBC/VC At Sensor Radiance Comparison (Version 1.01 Software)
Data From Lake Tahoe 12 March/07 November 2000, 27 February 2001
Salton Sea 04 June/07 August 2000

Legend:
- B10
- B11
- B12
- B13
- B14

y = 0.1712 + 0.9712x   R= 0.9999

y = 0.09267 + 0.9875x   R= 0.9999

y = -0.04029 + 1.011x   R= 0.9996

y = 0.09768 + 0.9861x   R= 0.9998

y = 0.1507 + 0.9814x   R= 0.9997

X-axis: On Board Calibrator Derived At Sensor Radiance (W/m2/sr/µm)

Y-axis: Vicarious Calibration Derived At Sensor Radiance (W/m2/sr/µm)

Comparison of Predicted minus Satellite TIR Band Temps. for 3/12-D, 8/19-D, 6/24-N, 9/28-N and 11/07-D for 3 Similar MODIS and ASTER Bands

Legend:
- AB11 - 8.63 um, MB29 - 8.53 um
- AB13 - 10.66 um, MB32 11.01 um
- AB14 - 11.29 um, MB33 - 12.03 um

X-axis categories: a 3/12/00, m 3/12/00, a 6/24/00, m 6/24/00, a 8/04/00, m 8/04/00, a 8/19/00, m 8/19/00, a 9/28/00, m 9/28/00, a 11/07/00, m 11/07/00

Y-axis: Predicted - Measured (from -1 to 1)

X-axis label: Instrument and Overpass
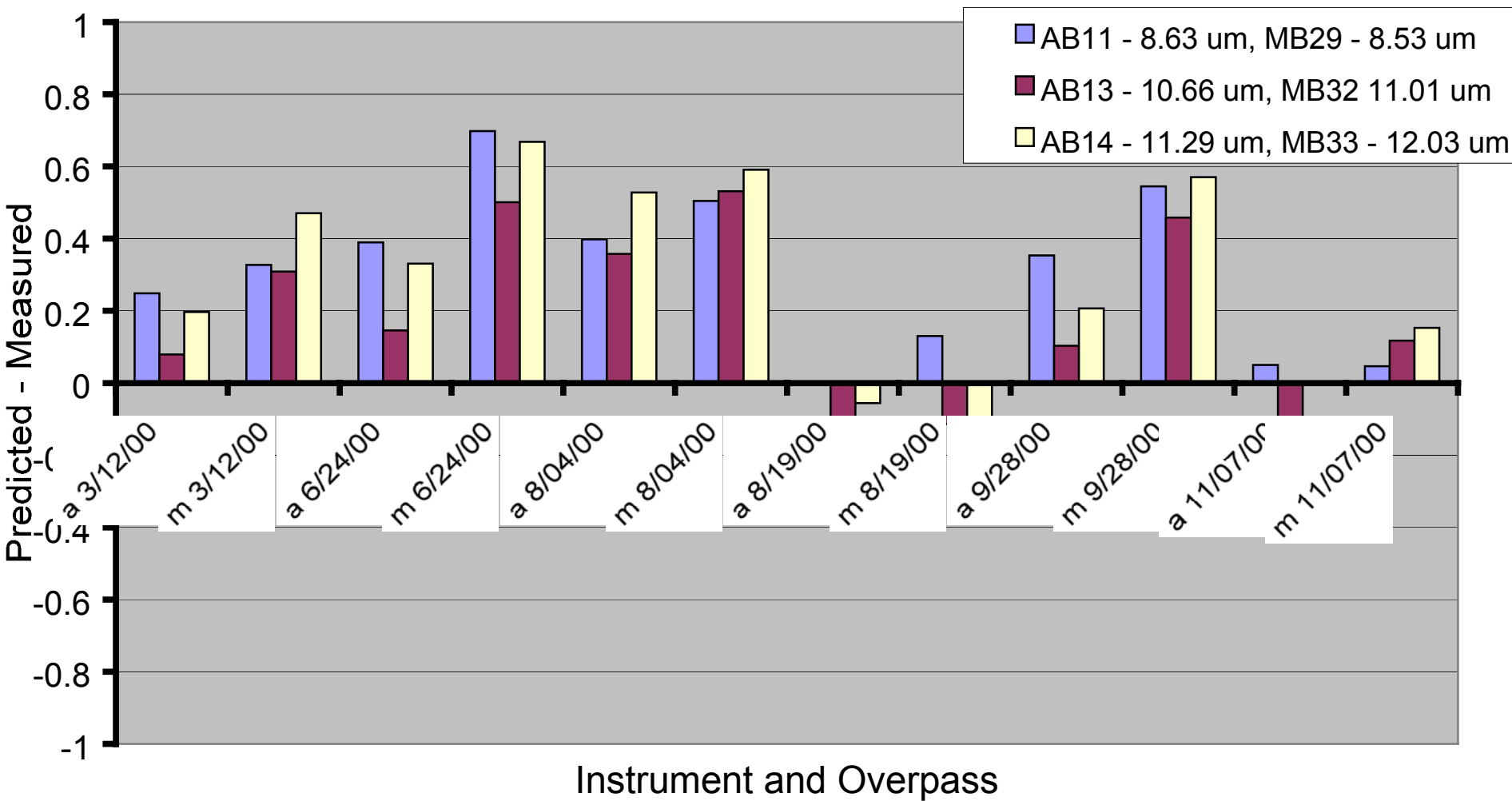
Preflight and In-Flight Validated Accuracies for MODIS and ASTER Window Channels

Sensor	Band And Center (um)	Preflight Calibration Accuracy Req. [1]	Validated Accuracy Mean of % Difference (%) [2,3,4,5]	Validated Accuracy Mean of BT Difference (K) [3,4,5]	Validated Accuracy Std. Dev. of % Difference (%) [2,3,4,5]	Validated Accuracy Std. Dev of BT Difference (K) [2,3,4,5]
MODIS	29 (8.53)	<1%	0.57	0.27	0.58	0.28
MODIS	31 (11.02)	<1%	0.27	0.17	0.51	0.31
MODIS	32 (12.03)	<1%	0.38	0.25	0.48	0.32
ASTER	10 (8.29)	$\leq$1 K	0.69	0.32	0.52	0.24
ASTER	11 (8.63)	$\leq$1 K	0.49	0.24	0.36	0.18
ASTER	12 (9.08)	$\leq$1 K	0.44	0.22	0.36	0.19
ASTER	13 (10.66)	$\leq$1 K	0.09	0.06	0.34	0.20
ASTER	14 (11.29)	$\leq$1 K	0.32	0.20	0.33	0.21

Notes for Radiance at Sensor Validation Table

[1.] The ASTER preflight calibration accuracy requirement is for the 270-340 K range.

[2.] The % difference is calculated as the (Predicted-Measured)/Predicted)*100 where the predicted is derived from the field measurements and the measured is the satellite values.

[3.] The results are for scenes in the radiance range 6.8-8.3 W/m2/sr/μm, brightness temperature range 278-290K using MODIS channel 31 as a reference.

[4.] All scenes used were nadir views and the Table 3 does not include differences due to view angle (e.g. response versus scan angle for MODIS).

[5.] Different sized areas were used for the retrievals due to the different spatial resolutions of the 2 instruments.

Surface Radiance – VNIR, SWIR (AST09)

Product Description:
Surface radiance in VNIR and SWIR bands at 15-m and 30-m resolutions, respectively, obtained by applying an atmospheric correction to the at-sensor radiances. The atmospheric correction algorithm is applied to clear-sky pixels .

Validation Approach:
Comparison to calibrated reflectance sites.
Comparison to calibrated radiance sites, including the moon
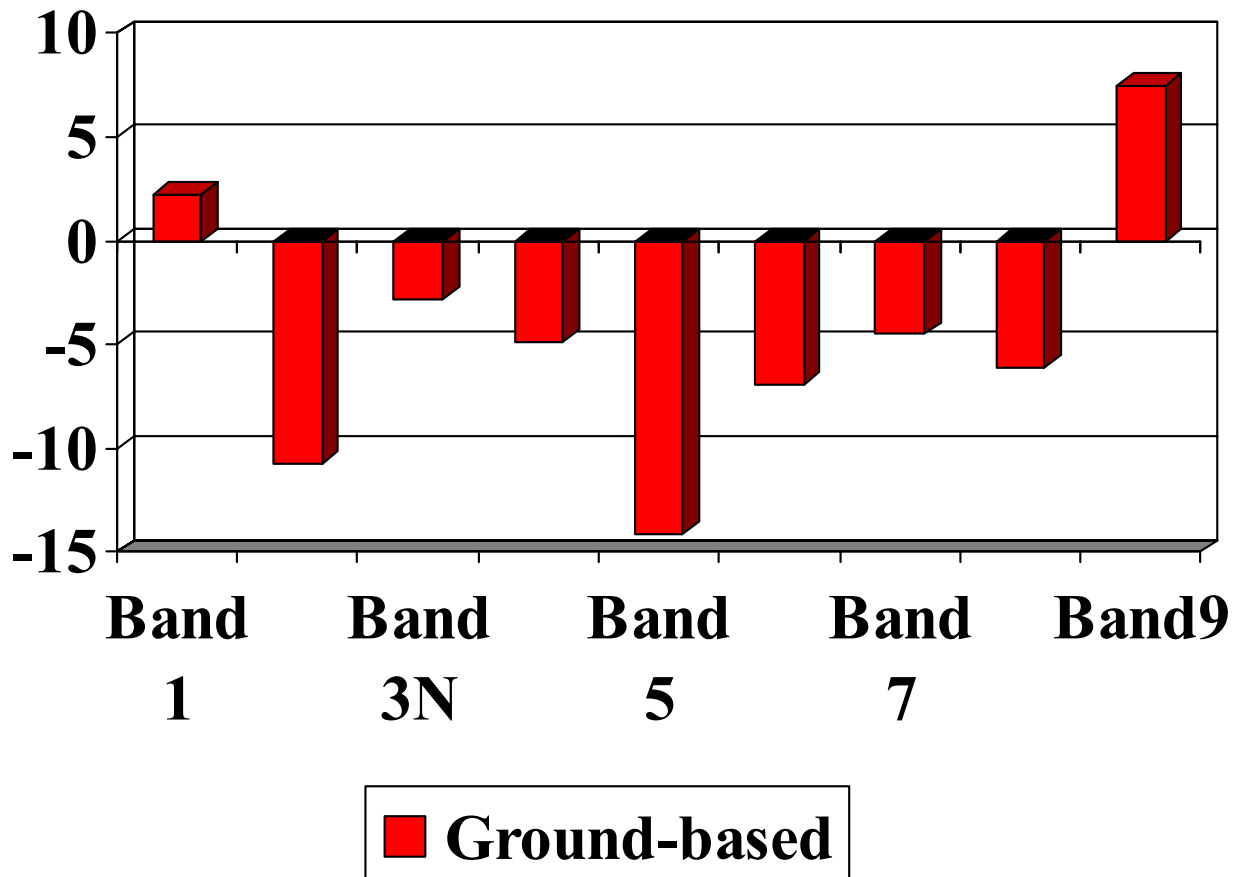Comparison to simultaneous in-situ and aircraft measurements made by:
      a) Algorithm developers
      b) EOS validation scientists
Comparison to equivalent values measured by other instruments.

Percent difference between retrieved Level 2 radiance/reflectance and ground-based measurements

Ivanpah Playa from June 4, 2000

Band	Prelaunch Estimated Accuracy	Postlaunch Validation
1	8% at reflectance larger than 0.2 0.012 in reflectance for values less than 0.2	TBD awaiting calibration evaluation
2		
3N		
4		
5	Site dependent due to cross-talk effects	
6		
7		
8		
9		

Surface Radiance – TIR (AST09)

Product Description:
Surface leaving radiance and downwelling sky irradiance for the five TIR channels at 90 m spatial resolution. This radiance includes both surface emitted and surface reflected components, it is calculated for clear-sky pixels only.

Validation Approach:
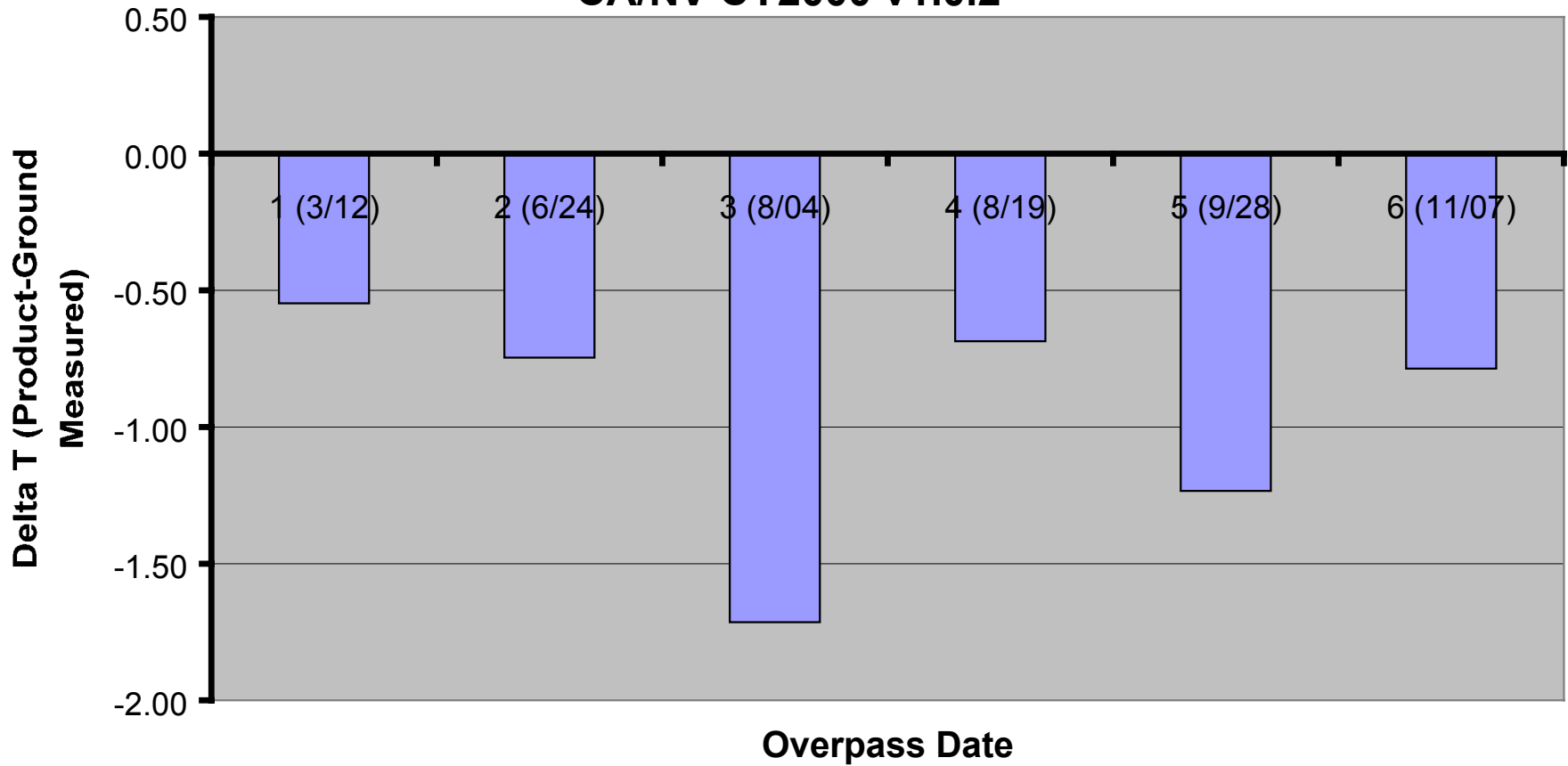Comparison to calibrated temperature/emissivity sites
Comparison to simultaneous in-situ and aircraft measurements made by:
       a) Algorithm developers
       b) EOS validation scientists
Comparison to equivalent values measured by other instruments.

ASTER TIR Band Surface Leaving Radiance Level 2 Product Data Validation

Status:

1. Current Status is "Beta". Upgrade to "Provisional" expected in August 2001.
2. Several important errors related to interpolation and extrapolation of the auxiliary data sets (DEMs, NCEP atmospheric profiles were found and corrected.
3. Direct validation at higher altitudes (i.e. less than 1 cm column water amount) indicates agreement to within 2%using NCEP assimilation model profiles.
4. Statistical analysis by Japanese ASTER colleagues indicates larger errors are directly correlated to larger water amounts.
5. MODIS derived atmospheric profiles have been tried but these beta version profiles do not yet provide better results than the NCEP assimilation model data.

Surface Reflectance (AST08)

Product Description:

Surface reflectance for each of the VNIR and SWIR bands at 15-m and 30-m resolutions, respectively. The atmospheric correction algorithm is applied to clear-sky pixels only and the results are reported as a number between 0 and 1.

Validation Approach:
Comparison to calibrated reflectance sites
Comparison to simultaneous in-situ and aircraft measurements made by:
      a) Algorithm developers
      b) EOS validation scientists
Comparison to equivalent values measured by other instruments.
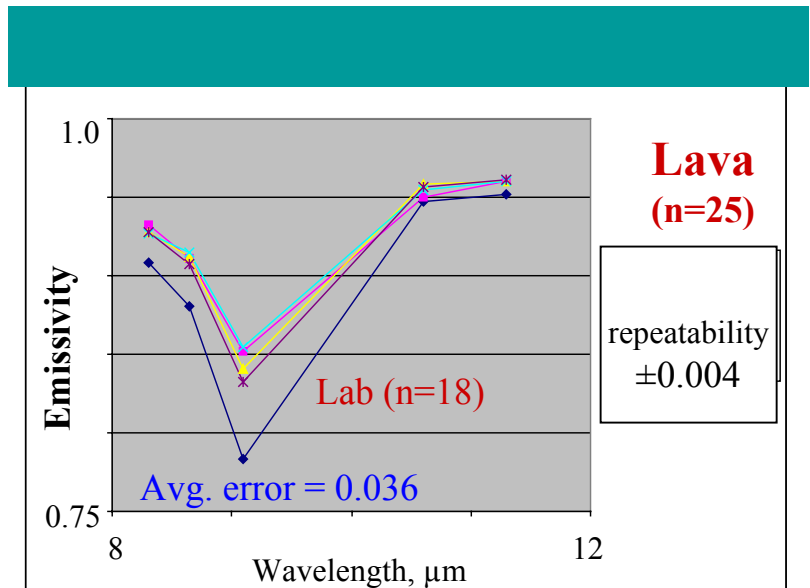
Surface Kinetic Temperature (AST08)

Product Description:

This product contains surface temperatures at 90-m resolution generated the five thermal infrared channels.

Validation Approach:
Laboratory modeling
Comparison to calibrated temperature sites
Comparison to simultaneous in-situ and aircraft measurements made by:

       a) Algorithm developers
       b) EOS validation scientists

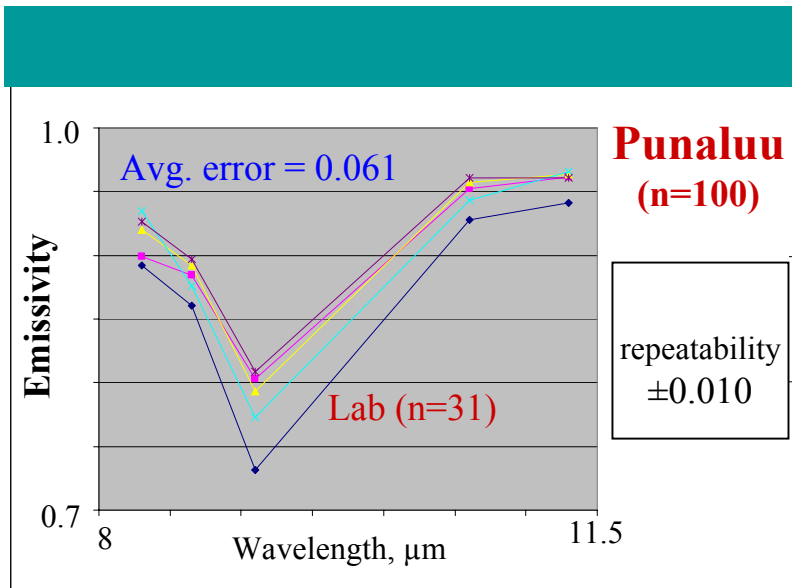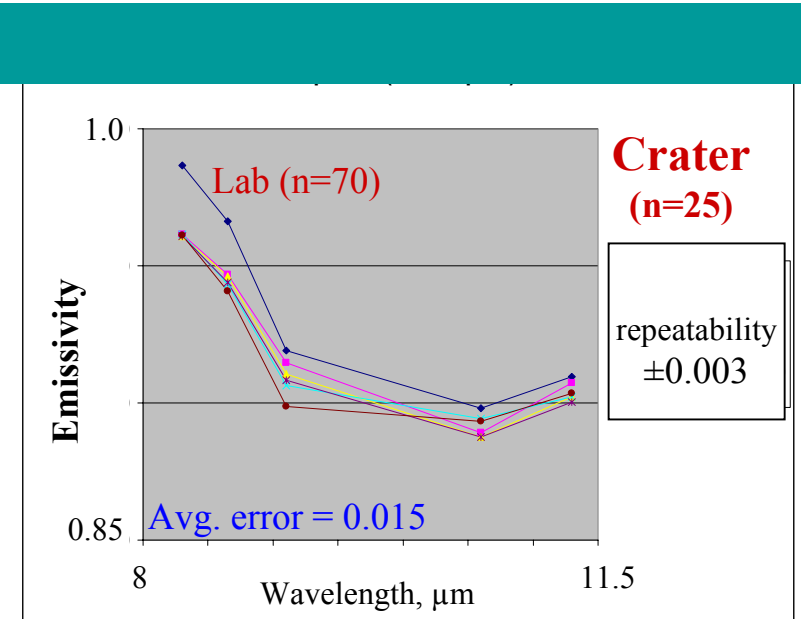Comparison to equivalent values measured by other instruments.

Temperature Difference between Predicted (ASTER) and Measured (Field Radiometer) Values over Time at L. Tahoe CA/NV CY2000 v1.0.2

Surface Emissivity (AST05)

Product Description:
Surface emissivity at 90-m resolution generated from the five thermal infrared channels. Surface emissivity is required to derive land surface temperature (AST08) data, also at a resolution of 90 meters.

Validation Approach:
Comparison to calibrated emissivity sites
Comparison to simultaneous in-situ and aircraft measurements made by:

      a) Algorithm developers
      b) EOS validation scientists

Comparison to equivalent values measured by other instruments.

Emissivity Difference between Product and Lab. Measured Water Values at L. Tahoe CA/NV over Time CY2000 v1.0.2
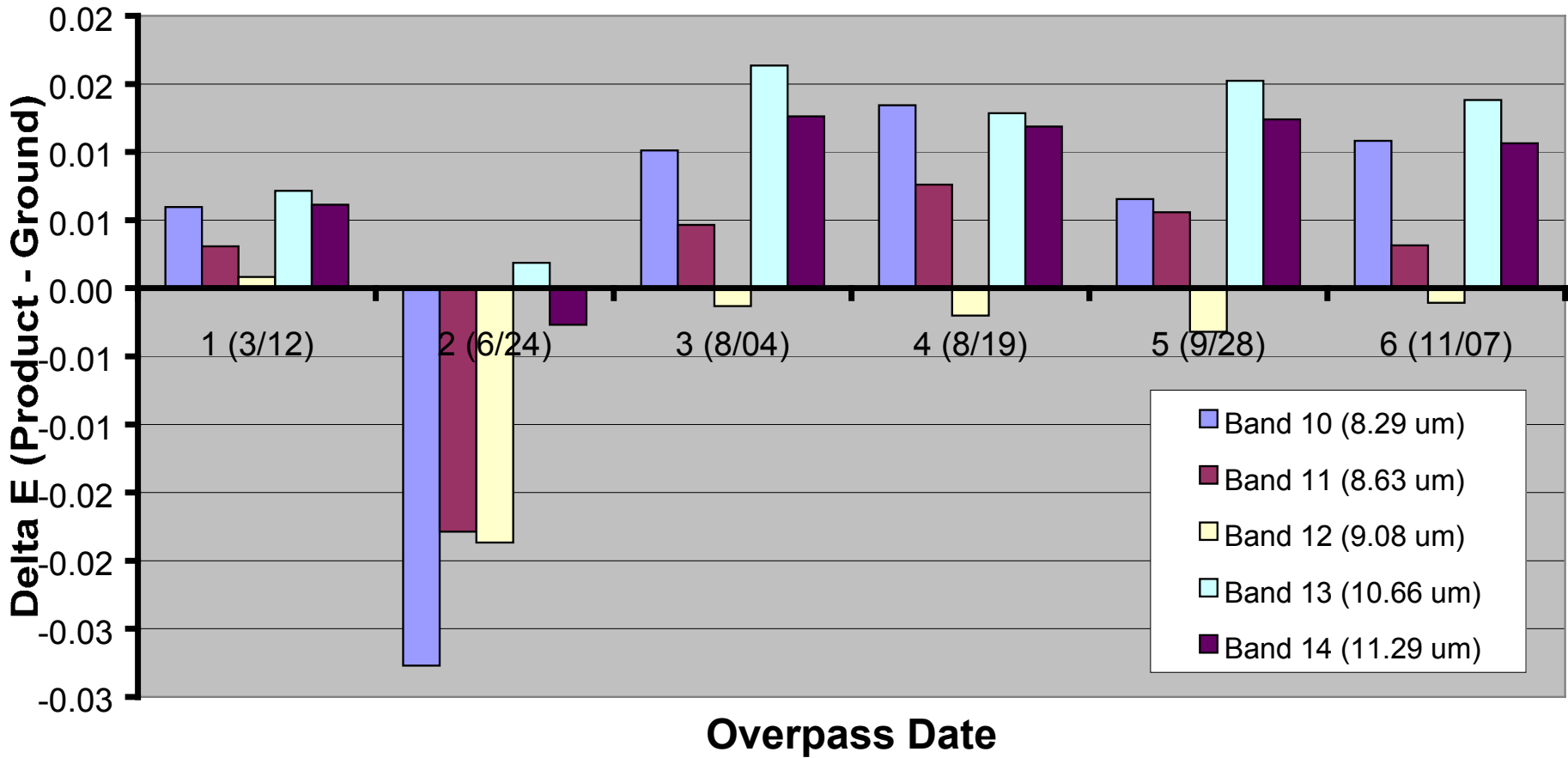
EMISSIVITY RECOVERY OVER ROCKS

• Recovery is within specifications for "best" site

• Performance is degraded at sea level

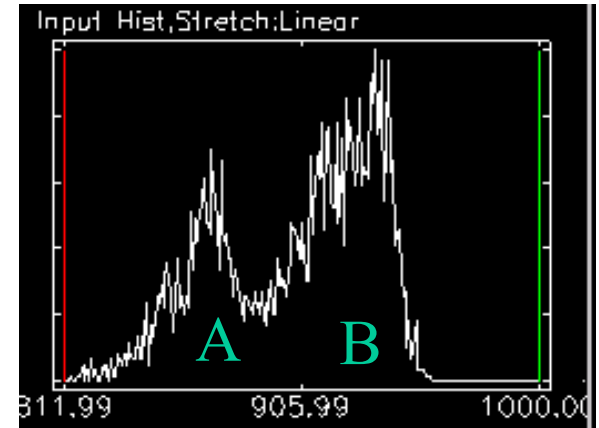• Natural variability vs. characterization

Crater (n=25)

Lab (n=70)

repeatability ±0.003

Avg. error = 0.015

Punaluu (n=100)

Avg. error = 0.061

Lab (n=31)

repeatability ±0.010

Lava (n=25)

Lab (n=18)

repeatability ±0.004

Avg. error = 0.036

Effect of MMD-thresholding on <u>lava</u> emissivities
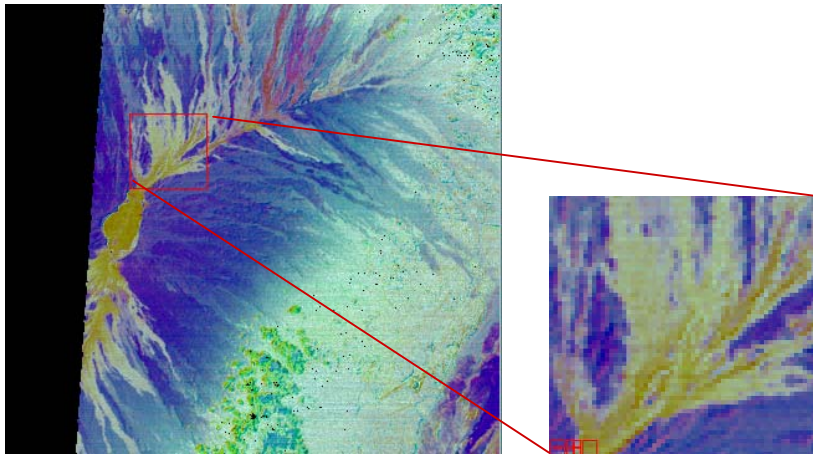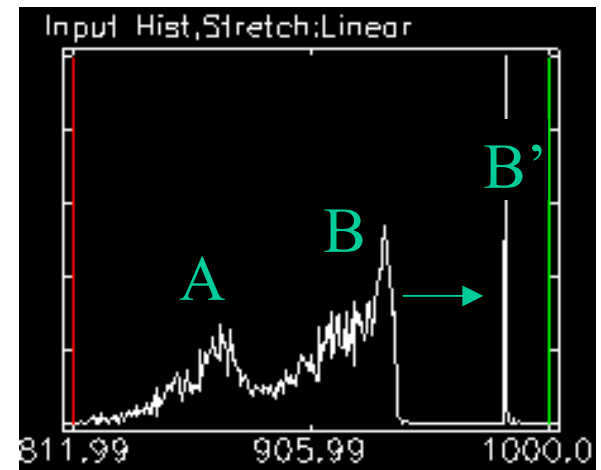

Emissivity (MMD = 0.0)
(R=10, G = 12, B = 14)

Subset

Histogram of Band 12
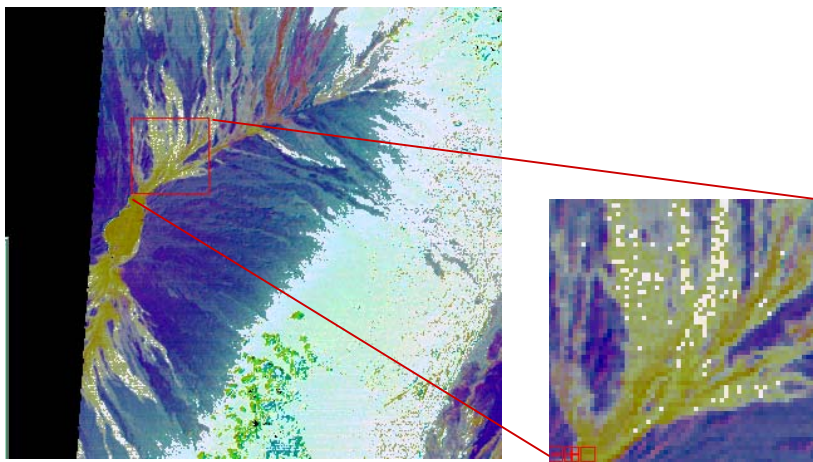
Emissivity (MMD = 0.032)
(R=10, G = 12, B = 14)

Subset

Histogram of Band 12

Performance

- TES can under some conditions meet the predicted performance criteria: ±1.5K and ±0.015 emissivity

- Performance depends critically on atmospheric correction

- Natural variability provides a limit on TES performance (MMD regression) even of all engineering problems are considered

Preflight and Validated Accuracy of the ASTER surface emissivity product (AST08) over water.

ASTER Surface Temperature Product (AST08)			
Cover Type	Preflight Product Accuracy Requirement (K)	Validated accuracy Mean of Temperature Difference (K) [1,2]	Validated accuracy Std. Dev of Temperature Difference (K) [1,2]
Water	± 1.5	-0.95	0.44

ASTER Surface Emissivity Product (AST08)			
Cover Type Water	Preflight Product Accuracy Requirement (K)	Validated accuracy Mean of Emissivity Difference (K) [1,2]	Validated accuracy Std. Dev of Emissivity Difference (K) [1,2]
Band 10	± 0.015	0.003	0.015
Band 11	± 0.015	0.001	0.009
Band 12	± 0.015	-0.004	0.007
Band 13	± 0.015	0.011	0.006
Band 14	± 0.015	0.008	0.006

Digital Elevation Models (AST14)

Product Description:
High spatial resolution DEMs (up to 7 m absolute horizontal and vertical accuracy with appropriate ground control, and up to 10 m relative accuracy without ground control) ASTER DEMs should meet 1:50,000 to 1:250,000 map accuracy standards. A DEM data set will be acquired for all of the Earth's land surface below 82 degrees latitude by the end of the 6 year mission. ASTER stereo pairs also can be processed to DEMs by users operating their own software.
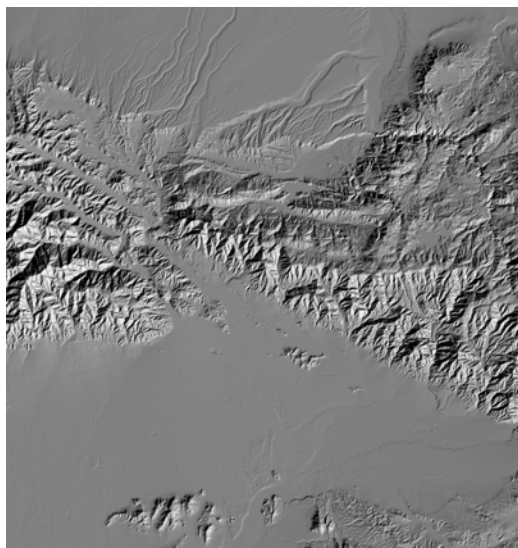
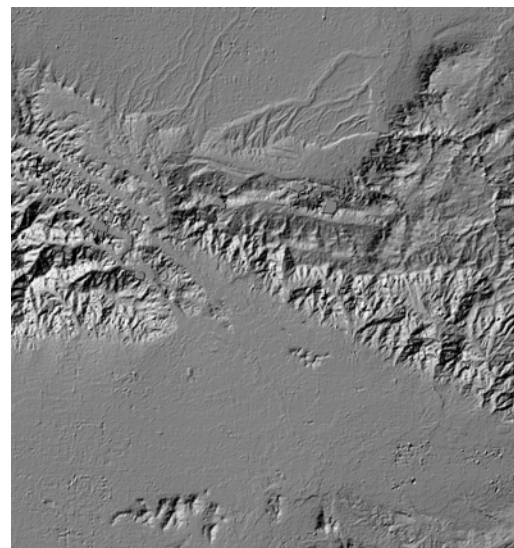**Validation Approach:**
Comparison to calibrated DEM sites
Comparison to DEM's created by other instruments
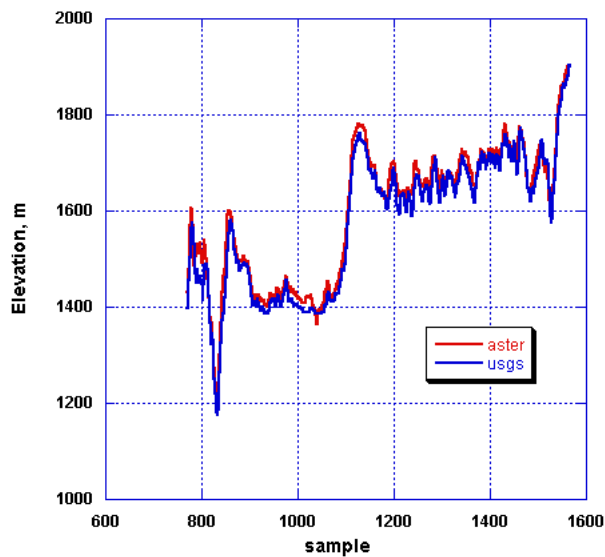
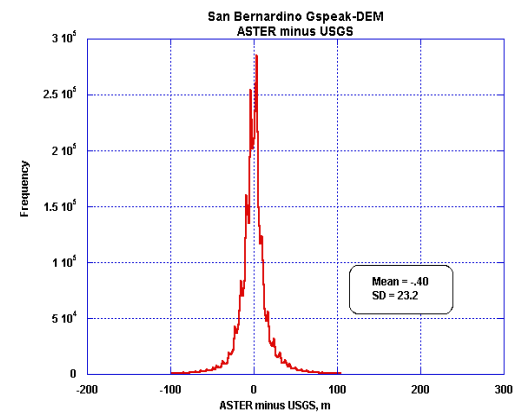# Absolute DEM Validation, San Bernardino CA site

USGS NED DEM

ASTER DEM

ASTER minus NED elevations
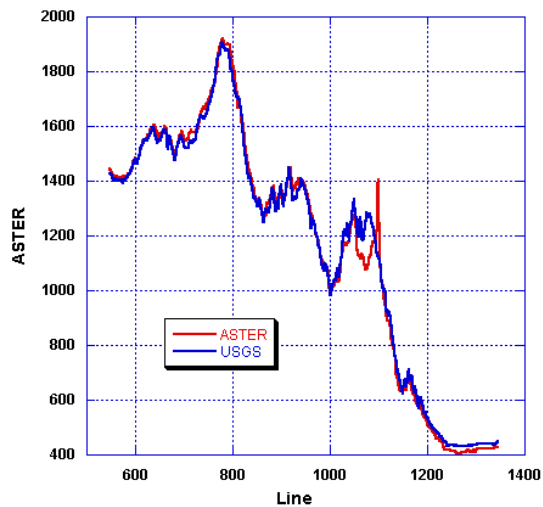
	Mean, m	Std. Dev.,m
San Bernardino	-0.4	23.2
Okoboji	2.5	11.5
Drum Mtns.	4.5	9.3

Huntsville DEMs, independently derived

	RMSEz,m	RMSExy,m
ASTER DEM	+-12	
U. GA DEM	+-7	+-10

Toulouse DEMs, independently derived

	Mean, m	Std. Dev., m
ASTER minus ISTAR	3.8	7.3

Polar Surface and Cloud Classification (AST13)

Product Description:

Each pixel of a scene is classified, using a neural network technique, into one of 8 classes: water cloud, ice cloud, aerosol/dust, water, land, snow/ice, slush ice, and shadow. This product uses a combination of visible, near-infrared and infrared channels and is produced at 30-m spatial resolution.

Validation Approach:

Testing of classification algorithm on sets of labeled samples.

Subjective analysis of color-code classification masks.

Testing of classification algorithm on randomly selected samples.

Comparison of classification results with surface based observation.

Outstanding Issues

- Absolute calibration of visible-shortwave infrared channels (lamp degradation)

- Registration of shortwave infrared channels

- Absolute calibration of thermal infrared channels (long-term blackbody drift)

- Leakage in shortwave infrared channels

- Product biases