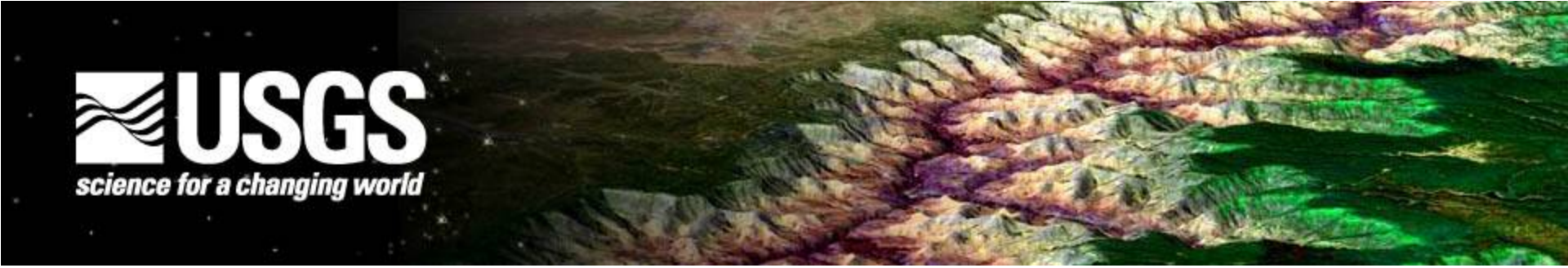

ResourceSat-2 AWiFS Preliminary Data Quality Assessment

JACIE Workshop, April 16 – 18, 2013

Gyanesh Chander[a], Amit Angal[b], Aparajithan Sampath[a], A. Senthil Kumar[c] Taeyoung (Jason) Choi[d], Xiaoxiong (Jack) Xiong[e], Greg Stensaas[f]

[a]SGT, Inc.,*contractor to the USGS EROS, Sioux Falls, SD, 57198 USA *Work performed under USGS contract G10PC00044; Telephone: 605-594-2554, E-mail: gchander@usgs.gov

[b]Science Systems and Applications, Inc., 10210 Greenbelt Road, Suite 600, Lanham, MD 20706 USA

[c]ISRO National Remote Sensing Center, Hyderabad, Andhra Pradesh, India

[d]Sigma Space Corporation, 4801 Forbes Boulevard, Lanham, Maryland 20706 USA

[e]NASA GSFC, Code 614.4, Greenbelt, MD, 20771 USA

[f]USGS EROS Center, Sioux Falls, SD, 57198 USA

U.S. Department of the Interior

U.S. Geological Survey

AWiFS Sensor Overview

- The ResourceSat-2 (RS-2) satellite was launched in a polar sun-synchronous orbit on April 20, 2011 (RS-1 was launched on Oct. 17, 03)

- AWiFS VITAL FACTS:
  - Instrument: Pushbroom
  - Bands (4): 0.52-0.59, 0.62-0.68, 0.77-0.86, 1.55-1.70 µm
  - Spatial Resolution: 56 m (near nadir), 70 m (near edge)
  - Radiometric Resolution: 12 bits (10 bits for RS-1 AWiFS)
  - Swath: 740 km
  - Repeat Time: 5 days
  - Design Life: 5 years

Cross-Comparison Methodology

- Compared near-simultaneous surface observations based on image statistics between RS-2 AWiFS and Terra and Aqua MODIS sensors

- Methodology and data processing
  - Focused on Libya-4 site (total of 14 RS-2 AWiFS images were rec'd from ISRO)
  - Used MODIS Collection 6 data
  - MODIS products processed at the native resolution (250 m and 500 m)
  - Reprojection of the MODIS L1B products performed using MRTSwath
  - Study restricted to the spectrally matching bands of MODIS and AWiFS
  - Processed corresponding Terra and Aqua MODIS near-simultaneous overpasses
  - Most of the near-simultaneous MODIS overpasses are off-nadir. Developed a MODIS-based semi-empirical BRDF model to account for the off-nadir acquisitions
  - RSR mismatch corrected using MODTRAN and real-time water-vapor information

Libya 4 Images Used for the Study

	Available (with Aqua)					
	Available (with Terra)					
	Not Available					
Libya-4	Terra overpasses					
DOP	**P/R-SubSc**	**Cloudy**	**Notes**	**AWiFS Status**	**DOY**	**MODIS Filename**
10-Jun-11	42/51-'B'			Transferred	2011/161	MOD021KM.A2011161.0845.006.2012284155623.hdf
5-Jun-11	42/51-'B'		partially covered (at the start of scan)	Transferred	2011/156	MOD021KM.A2011156.1005.006.2012284125346.hdf
19-Dec-12	42/51-'B'			Transferred	2012/354	MOD021KM.A2012354.0855.006.2012356225933.hdf
25-Nov-12	42/51-'B'		partially covered (at the edge)	Transferred	2012/330	MOD021KM.A2012330.0945.006.2012330224908.hdf
11-Feb-12	42/51-'B'	yes		Transferred	2012/042	MOD021KM.A2012042.0945.006.2012291035020.hdf
30-Nov-12	43/51-'B'		partially covered (at the start of scan)	Transferred	2012/335	MOD021KM.A2012335.1005.006.2012335192811.hdf
25-Dec-12	43/51-'B'	yes				
29-Dec-12	44/52-'C'			Transferred	2012/364	MOD021KM.A2012364.0935.006.2012364192137.hdf
18-Oct-12	44/52-'C'			Transferred	2012/292	MOD021KM.A2012292.0845.006.2012319220329.hdf
28-Jan-12	44/52-'C'	yes	partially covered (at the edge)			
10-Dec-12	45/50-'C'			Transferred	2012/345	MOD021KM.A2012345.0905.006.2012345194142.hdf
18-Aug-11	45/50-'C'		partially covered (at the start of scan)			
3-Jan-13	45/50-'C'		partially covered (at the edge)	Transferred	2013/003	MOD021KM.A2013003.0955.006.2013003192626.hdf
21-Dec-11	46/51-'C'		partially covered (at the start of scan)	Transferred	2011/355	MOD021KM.A2011355.0830.006.2012290095806.hdf
7-Feb-12	46/51-'C'	yes	partially covered (at the start of scan)			
6-Jun-11	46/53-'A'			Transferred	2011/157	MOD021KM.A2011157.0910.006.2012284135104.hdf
22-May-11	46/53-'A'	yes	partially covered (at the edge)			
11-Jun-11	47/53-'A'			Transferred	2011/162	MOD021KM.A2011162.0930.006.2012284161753.hdf
26-Nov-12	47/53-'A'			Transferred	2012/331	MOD021KM.A2012331.0850.006.2012331235639.hdf
Libya-4	Aqua Overpasses					
DOP	**P/R-SubSc**	**Cloudy**	**Notes**			
10-Jun-11	42/51-'B'			Transferred	2011/161	MYD021KM.A2011161.1155.006.2012074162208.hdf
5-Jun-11	42/51-'B'			Transferred	2011/156	MYD021KM.A2011156.1140.006.2012074131848.hdf
19-Dec-12	42/51-'B'		partially covered (at the edge)	Transferred	2012/354	MYD021KM.A2012354.1210.006.2012357002417.hdf
25-Nov-12	42/51-'B'			Transferred	2012/330	MYD021KM.A2012330.1120.006.2012331224250.hdf
11-Feb-12	42/51-'B'	yes		Transferred	2012/042	MYD021KM.A2012042.1120.006.2012096114945.hdf
30-Nov-12	43/51-'B'			Transferred	2012/335	MYD021KM.A2012335.1140.006.2012336173550.hdf
25-Dec-12	43/51-'B'	yes				
29-Dec-12	44/52-'C'		partially covered (at the start of scan)	Transferred	2012/364	MYD021KM.A2012364.1110.006.2012365155951.hdf
18-Oct-12	44/52-'C'			Transferred	2012/292	MYD021KM.A2012292.1155.006.2012293155411.hdf
28-Jan-12	44/52-'C'	yes	partially covered (at the start of scan)			
10-Dec-12	45/50-'C'		partially covered (at the edge)	Transferred	2012/345	MYD021KM.A2012345.1040.006.2012346181725.hdf
18-Aug-11	45/50-'C'		partially covered (at the edge)			
3-Jan-13	45/50-'C'			Transferred	2013/003	MYD021KM.A2013003.1125.006.2013004153426.hdf
21-Dec-11	46/51-'C'			Transferred	2011/355	MYD021KM.A2011355.1145.006.2012078233600.hdf
7-Feb-12	46/51-'C'	yes				
6-Jun-11	46/53-'A'		partially covered (at the edge)	Transferred	2011/157	MYD021KM.A2011157.1220.006.2012074130110.hdf
22-May-11	46/53-'A'	yes				
11-Jun-11	47/53-'A'		partially covered (at the start of scan)	Transferred	2011/162	MYD021KM.A2011162.1100.006.2012074165434.hdf
26-Nov-12	47/53-'A'		partially covered (at the edge)	Transferred	2012/331	MYD021KM.A2012331.1205.006.2012332195516.hdf

Conversion to at-sensor spectral radiance (Q_{cal}-to- L_λ) & reflectance

- **RS-2 AWiFS sensor**
  - Q_{calmax} is 1023 for 10-bit AWiFS

$$L_\lambda = \left(\frac{LMAX_\lambda - LMIN_\lambda}{Q_{cal\max} - Q_{cal\min}} \right) (Q_{cal} - Q_{cal\min}) + LMIN_\lambda$$

$$L_\lambda = \left(\frac{LMAX_\lambda}{Q_{cal\max}} \right) (Q_{cal})$$

- **AWiFS-B camera (B&D quadrant scenes):**
  - Minimum / maximum radiance for band 2 **[mw/cm2/str/um]** ... 0.00000 **52.0000**
  - Minimum / maximum radiance for band 3 **[mw/cm2/str/um]** ... 0.00000 **47.0000**
  - Minimum / maximum radiance for band 4 **[mw/cm2/str/um]** ... 0.00000 **31.5000**
  - Minimum / maximum radiance for band 5 **[mw/cm2/str/um]** ... 0.00000 **7.5000**
  - Same numbers for AWiFS-A camera (A&C quadrant scenes)

$$\rho_\lambda = \frac{\pi \cdot L_\lambda \cdot d^2}{ESUN_\lambda \cdot \cos\theta_s}$$

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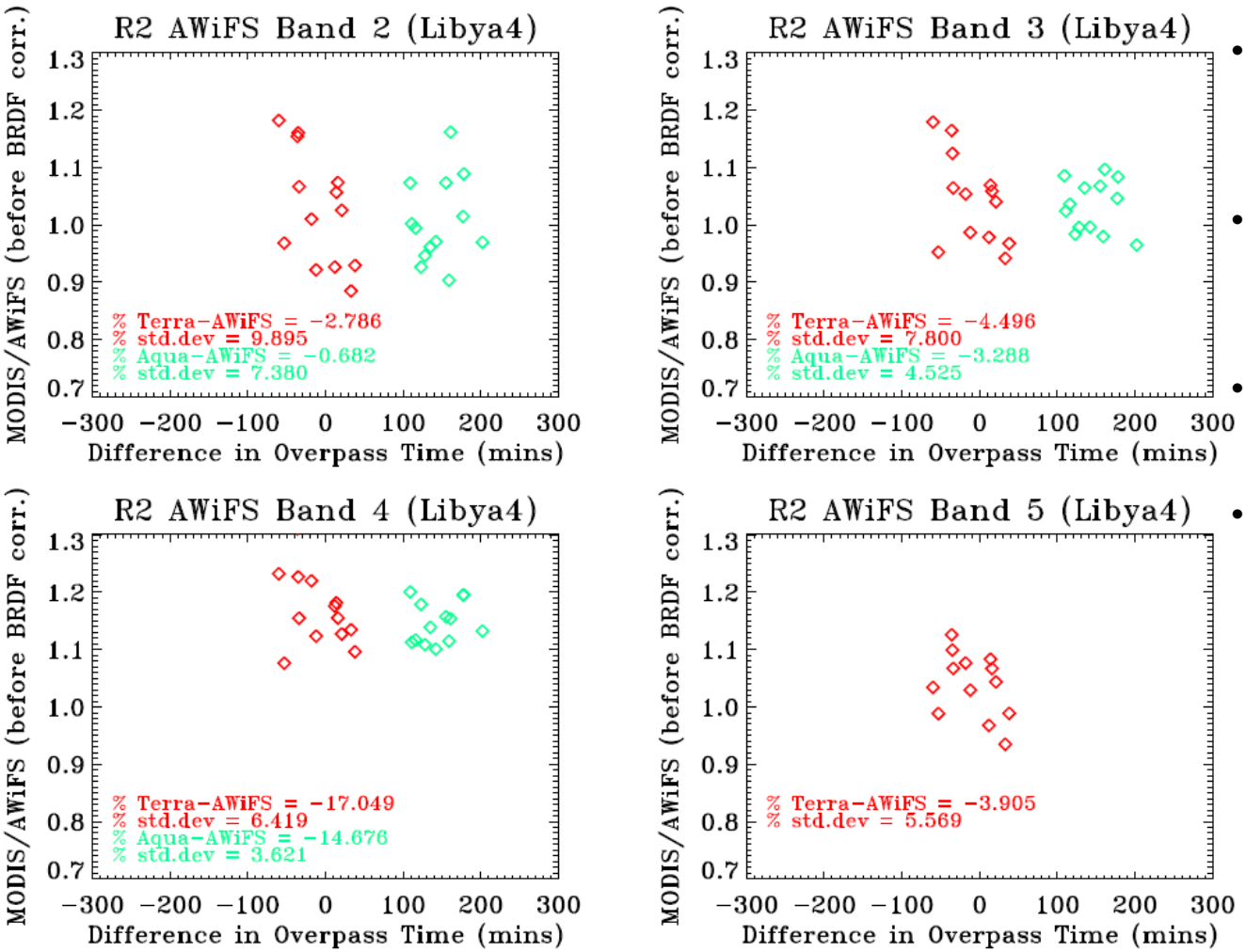
Table 4. Estimated bandpass solar exoatmospheric spectral irradiance E_0 (W m^{-2} μm^{-1}) for RS2 sensors along with E_0 values for earlier IRS sensors.

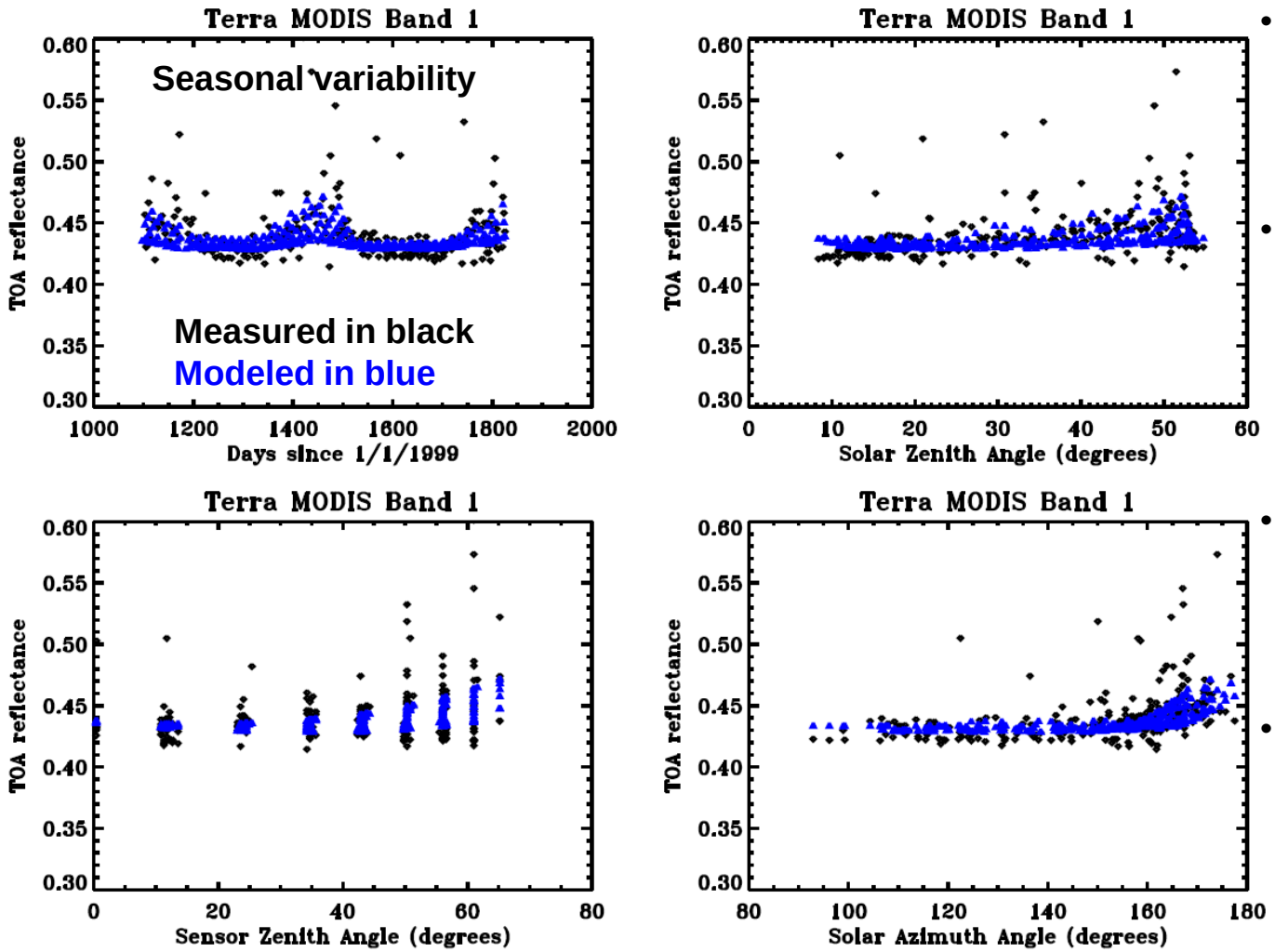
Satellite	Sensor	Blue	Green	Red	NIR	SWIR	Panchromatic
RS2	LISS-III	–	1850.05	1588.86	1106.72	241.80	–
	AWiFS	–	1853.76	1589.78	1094.79	237.03	–
	LISS-IV	–	1852.36	1596.43	1120.17	–	–

MODIS/AWiFS ratio versus Δ overpass time (before BRDF correction)



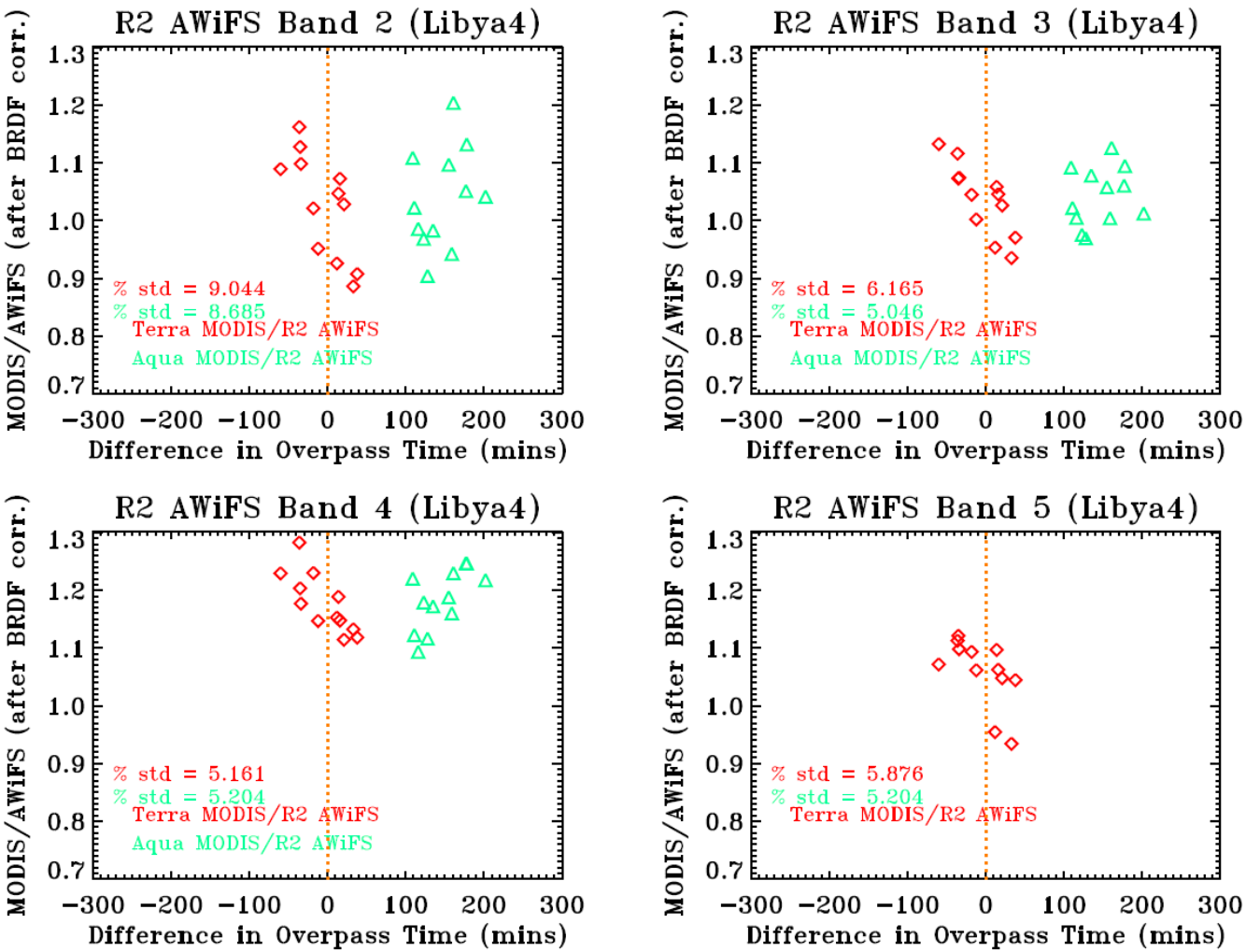
- AWiFS overpass time is closer to Terra MODIS (~30 min) than Aqua MOIDS (~ 2 hours)
- SWIR band results for Aqua MODIS are not shown due to various inoperable detectors
- Significant variability observed across all bands
- Necessary to account for contributions from BRDF, spectral mismatch, atmospheric water-vapor

BRDF Model Results (Band 1)



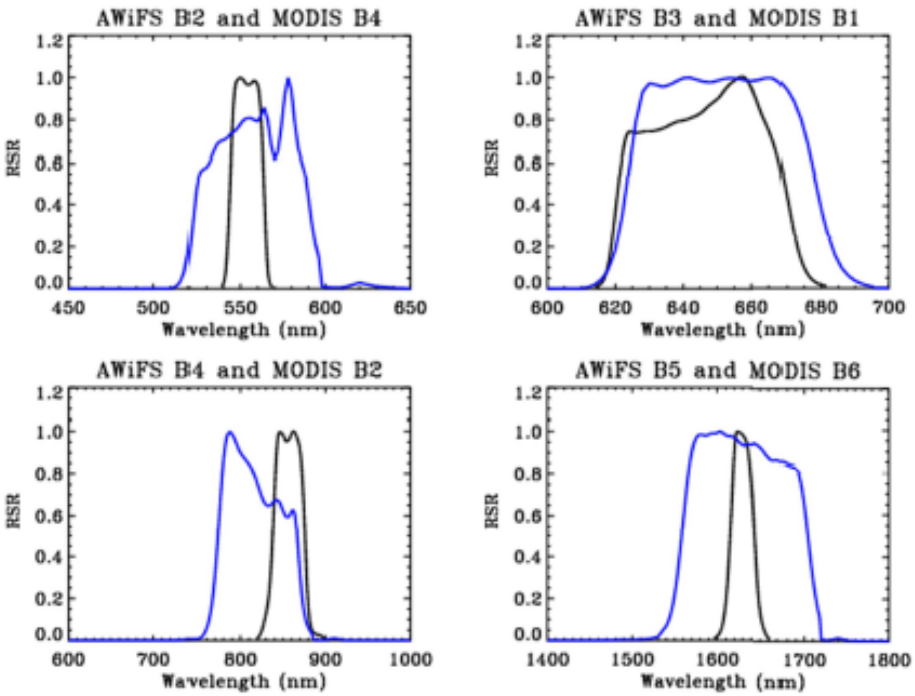
- A semi-empirical BRDF model (Roujean et. al.) was used to derive the BRDF correction coefficients
- Use “all” [584] Terra MODIS overpasses over Libya-4 from 2002-2003 time-period to construct the model (varying view-geometries covered)
- Residual variability still observed at larger sensor zenith angles (off-nadir images)
- The model coefficients derived from these observations applied to the TOA reflectance under consideration

MODIS/AWiFS ratio versus Δ overpass time (after BRDF correction)

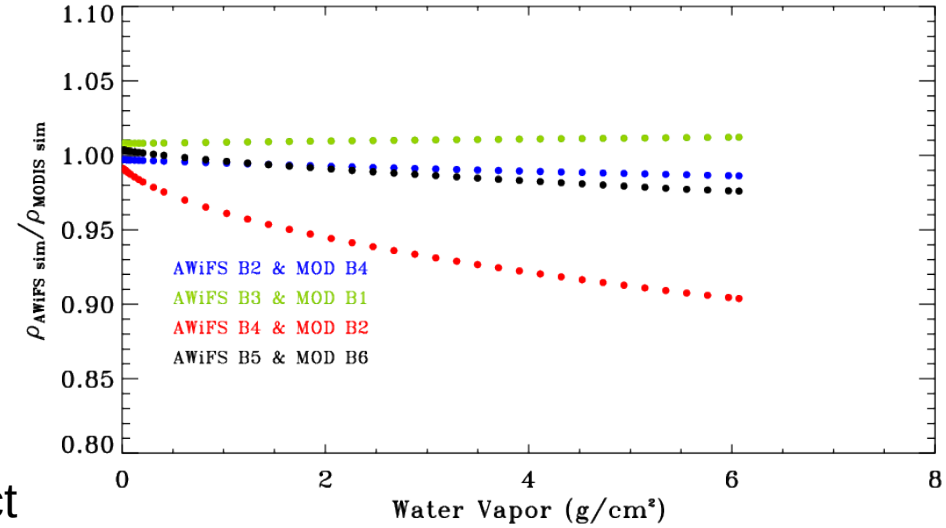


- BRDF correction essential since the MODIS scenes are acquired at off-nadir angles
- Most variability (~20%) still exists in B2 ratios indicating that the difference in overpass times may induce additional uncertainties
- AWiFS scenes from 2011/157 and 2011/162 report 7% larger reflectance in B5

Spectral-mismatch correction using MODTRAN RSR and ratio of simulated ρ

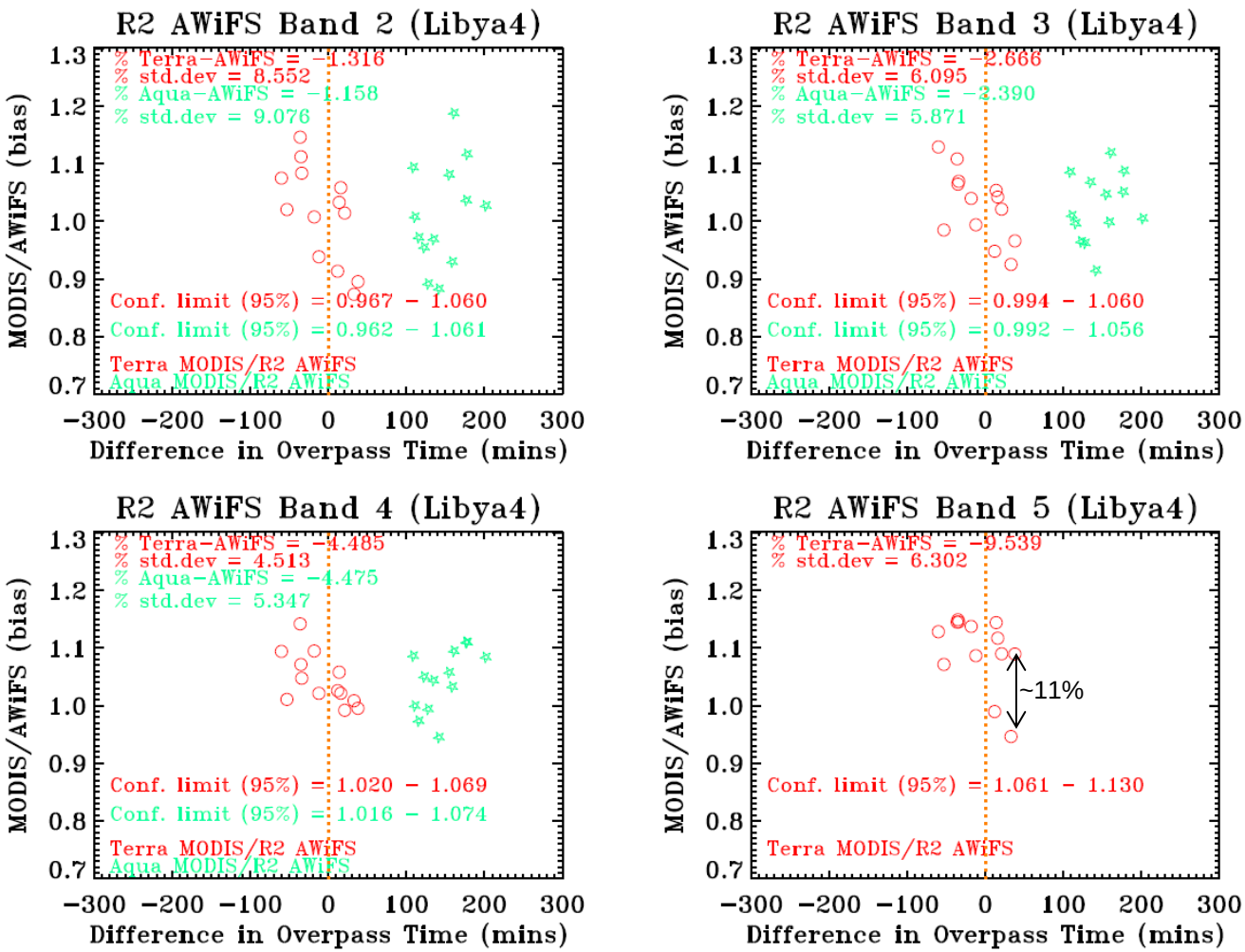


- RSR mismatch causes a bias in the TOA reflectance trending
- The magnitude of mismatch depends on wavelength, scene-type, and atmospheric conditions during the observation
- A typical mid-latitude desert profile was generated using MODTRAN and spectral mismatch was derived for four band-pairs



- Forced inputs for water-vapor to evaluate the spectral mismatch as a function of atmospheric water-vapor
- Real-time water-vapor information retrieved from MODIS water-vapor product

MODIS/AWiFS ratio versus Δ overpass time (after BRDF + SBAF correction)



- Deviation from 1.0 represents bias between two instruments
- MODIS-AWiFS ratio corrected for BRDF and spectral mismatch plotted in red and green for 'Terra' and 'Aqua' respectively
- Larger standard deviations likely due to off-nadir collects inadequately corrected for BRDF effects
- More Libya-4 AWiFS scenes might help reduce the observed deviations

Cross-comparison Summary

- The cross-comparison results from the RS-2 AWiFS sensors with Terra and Aqua MODIS sensor is summarized below

AWiFS Band	Terra vs. AWiFS	Standard Deviation	Aqua vs. AWiFS	Standard Deviation
2	1.36%	8.55%	1.15%	9.08%
3	2.66%	6.10%	2.39%	5.87%
4	4.49%	4.51%	4.48%	5.35%
5	9.53%	6.30%		

- Analysis of additional Libya-4 AWiFS images with corresponding Terra and Aqua MODIS is required, as well as extending the results to L7 ETM+ and LDCM OLI sensor

RS-2 AWiFS Geometry Assessment

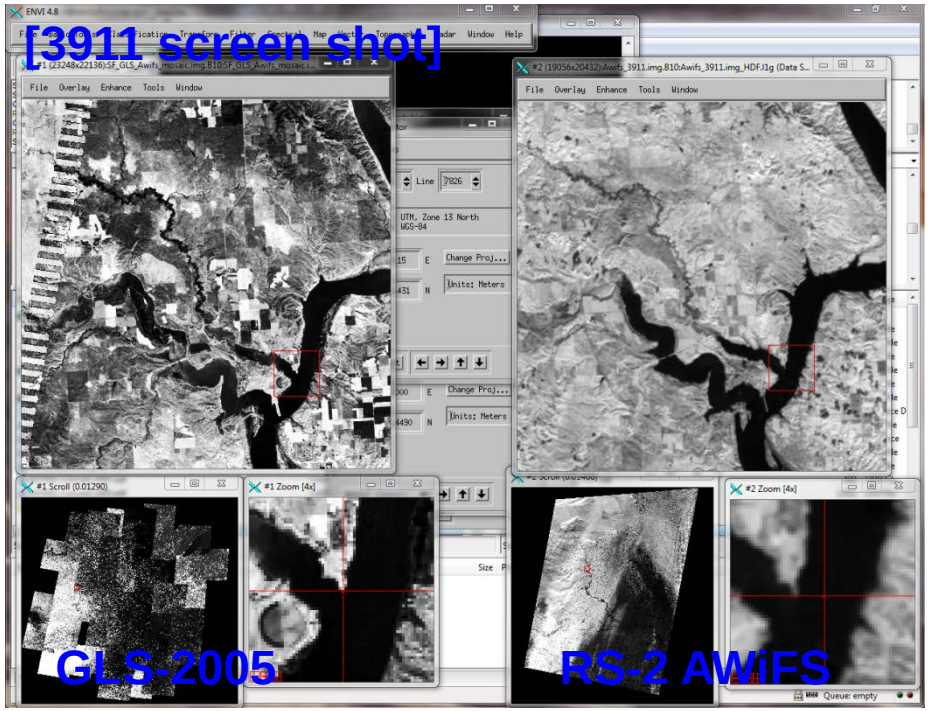
- Completed using the Image Assessment System (IAS) which was developed for Radiometric and Geometric Characterization and Calibration for the Landsat Program

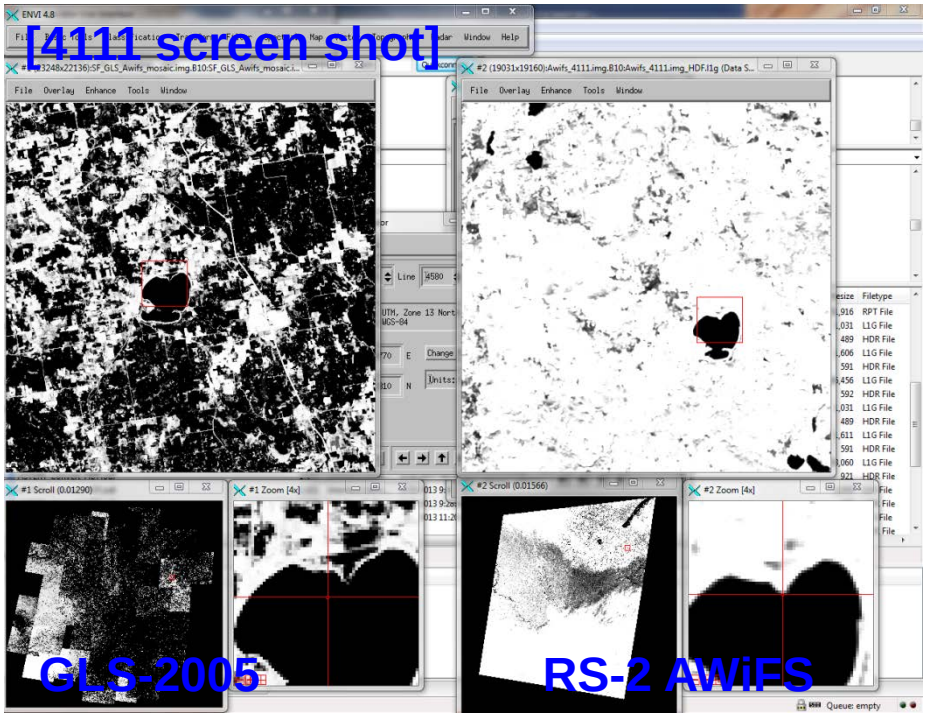
- The RS-2 AWiFS data acquired over Sioux Falls, SD and Pueblo, CO were used for this study
  - A total of 4 AWiFS images over Sioux Falls and 2 images over Pueblo were used in this study

- The positional accuracy was assessed by using the I2I registration assessment tool by comparing the RS-2 AWiFS imagery against the GLS-2005 dataset as a reference image
  - A total of 44 GLS images over Sioux Falls, SD Valley, and 17 images over Pueblo, CO were mosaicked and used as a reference

RS-2 AWiFS Images

- Sioux Falls, SD
  - 123173911 (Referred to as 3911)
    - I2I results reported, analysis screen shots shown
  - 123174011 (Referred to as 4011)
    - No quantitative results reported
  - 123174111 (Referred to as 4111)
    - I2I Results reported, analysis screen shots shown
  - 123174211 (Referred to as 4211)
    - No quantitative results
- Pueblo, CO
  - 123180911 (Referred to as 80911)
    - I2I results reported, analysis screen shots shown
  - 123181011 (Referred to as 81011)
    - No quantitative results (Substantial portion of image covered with clouds)





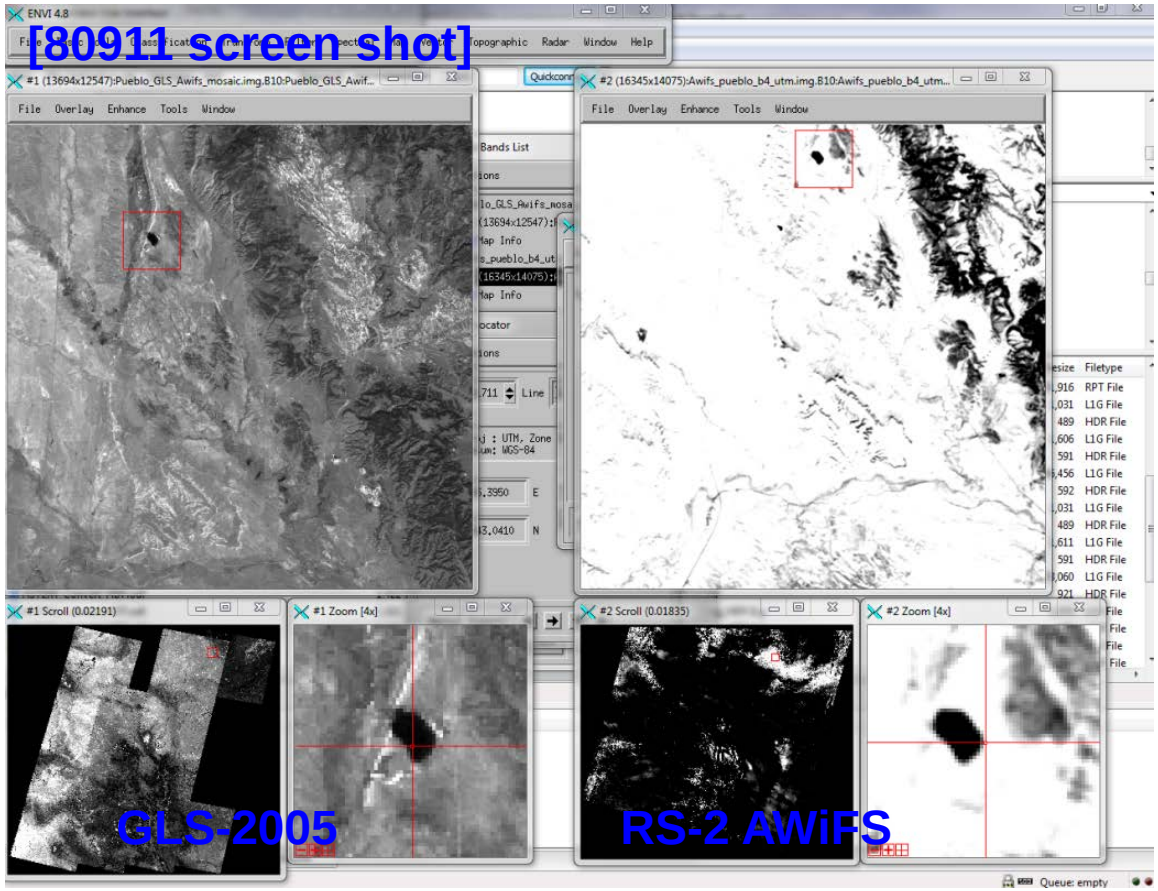
Results Over Sioux Falls (3911)		
In Pixels	Line	Sample
Minimum	0.51	-12.09
Mean	2.38	-5.76
Maximum	4.21	0.39
Median	2.40	-5.09
Std. Dev.	0.96	3.34
RMSE	2.56	6.65

Valid GCPs: 86
RMSE = 7.12 pixel

Results Over Sioux Falls (4111)		
In Pixels	Line	Sample
Minimum	0.00	-6.76
Mean	1.20	-4.18
Maximum	2.27	-1.72
Median	1.08	-3.76
Std. Dev.	0.63	1.35
RMSE	1.35	4.39

Valid GCPs: 110
RMSE = 5.09 pixel

RS-1/2 AWiFS Positional Accuracy



Results Over Pueblo (80911)		
In Pixels	Line	Sample
Minimum	-1.46	-10.90
Mean	1.20	1.09
Maximum	3.90	10.94
Median	1.11	0.75
Std. Dev.	1.38	6.13
RMSE	1.82	6.20

Valid GCPs: 157
RMSE = 6.47 pixel

- The results show that the positional errors in AWIFS products are about 6.3 pixels (on the average) or about 350 m location shift - **without the use of reference image** for geometric correction
- ISRO observed that without reference image bias correction, the positional accuracy should be better than 500 m, so this is acceptable.

Geometry Assessment Summary

- Our previous analysis with RS-1 showed that the data were typically registered to the reference GLS-2000 dataset to within one pixel

- RS-2 AWiFS preliminary analysis show discrepancies compared to the reference GLS dataset (this was confirmed by IAS and visual inspection)

- The RS-2 AWiFS data obtained from ISRO did not include GCP corrections to improve geometric quality, so we are working closely with ISRO to reevaluate the positional accuracy of RS-2 AWiFS data acquired outside India