



AWiFS Radiometric Assessment

Civil Commercial Imagery Evaluation Workshop

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David Aaron: Dept of Physics South Dakota State University

David.Aaron@sdstate.edu

605-688-6520

Physics Department (Satellite Calibration Group):

David Aaron

Larry Leigh

Sara Landau

-Basic results using standard analysis technique

-Experimental technique to extend model and analysis



2005 SDSU Calibration Collection Summary:

Data collections summary (perceived useful collections only)

2005:

- May 19: L5 good +: some cumulus later in day
- June 22: QB + AWiFS okay, some clouds
- July 6: L5 good – considerable cirrus
- July 14: L7 popcorn clouds but probably okay
- July 18: OV (pan)
- ** July 29: OV (MS) *OV failed decompression, data not retrievable*
- Aug 1: OV (MS) + IK shot thru considerable popcorn cumulus
- Aug 23: L5 okay but lots of cumulus
- Aug 29: Katrina
- Aug 31: L7 good - : cumulus just passed by
- Sept 16: L7 very good pm, okay late am
- Oct 7: OV (pan) excellent
- Oct 18: QB + L7 good



“3M” Site Characteristics

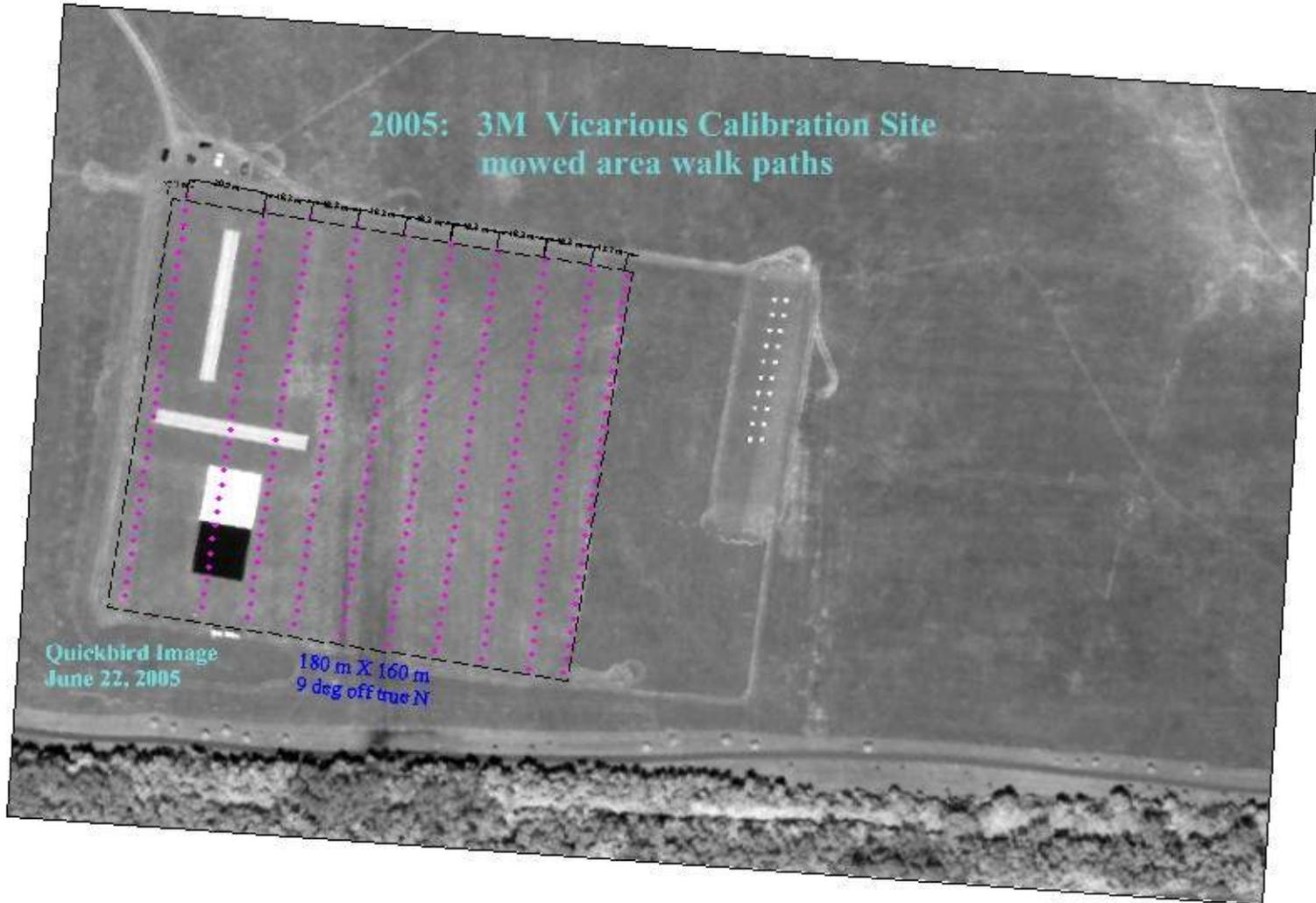
- 180 X 160m ‘grass’ site (approx)
 - rotated 9 degrees off N-S
 - NW corner:
 - Lat: $44^{\circ}17'31.12383''\text{N}$
 - Long: $96^{\circ}45'59.33636''\text{W}$
 - Elevation 503 m
 - Elevation change = 4.89 meters

Differential GPS values measured by the Stennis GRIT Staff
- Maintenance mowing
 - 6 ft rotary mower (rough, not finish cut) for easternmost 2/3 of site
 - western 1/3 of site, finish cut

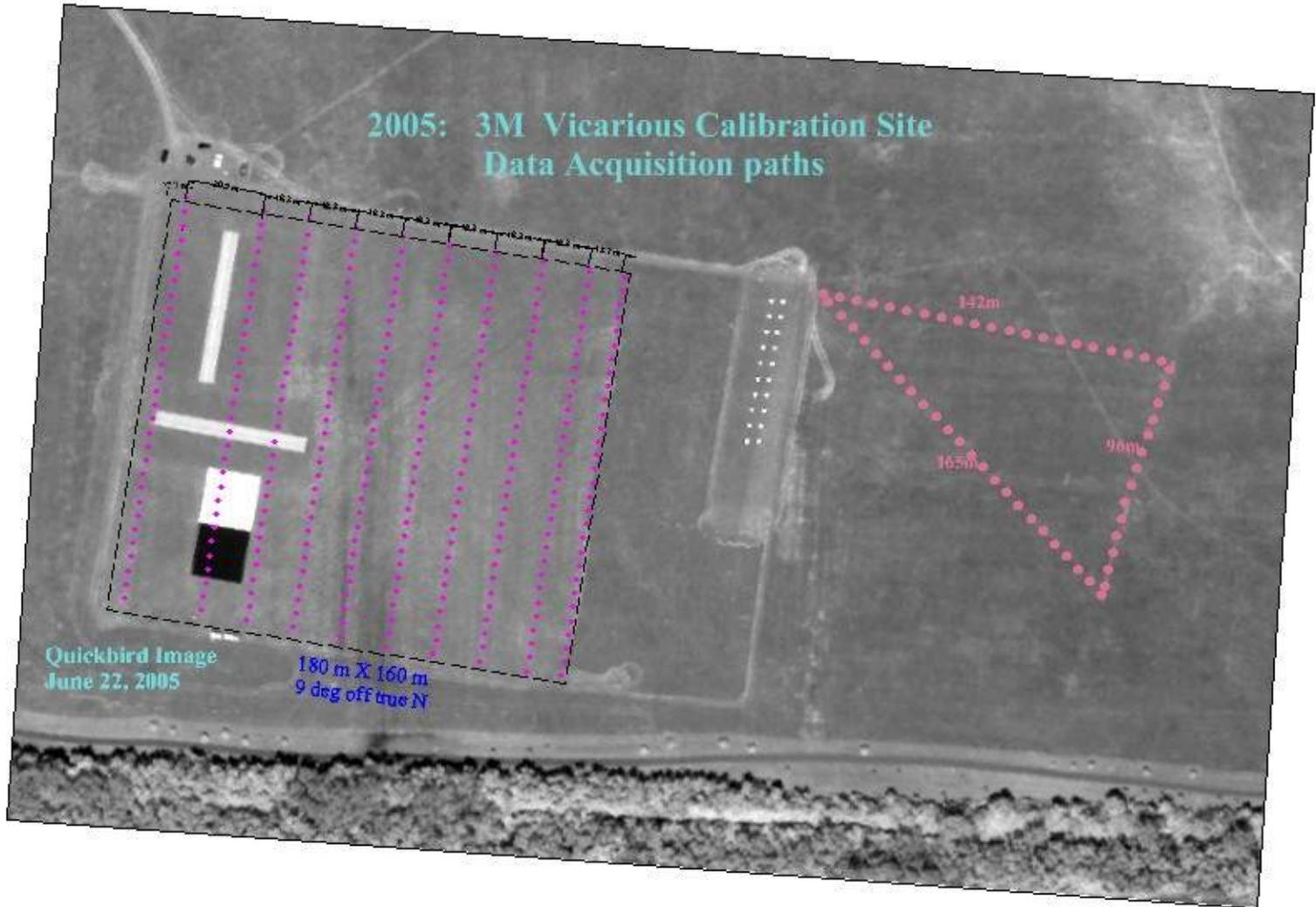
(target area for high resolution MTF collection)
- To accommodate AWiFS, new markers in unmowed area

Brookings '3M' Grass Site Shown with HR MTF targets deployed











AWiFS collection used two different grass surfaces



June 22, 2005 Quickbird





Useable pixel count was limited

Data analysis was performed using:

- 6 pixels: '3M mowed site'
- 6 pixels: 'AWiFS tall grass site'

To determine if statistics could be improved by using a larger 'tall grass' site, an exercise was completed in which the AWiFS area was extended (primarily N of mowed site) to 24 pixels. Both average values and standard deviations were not significantly changed.

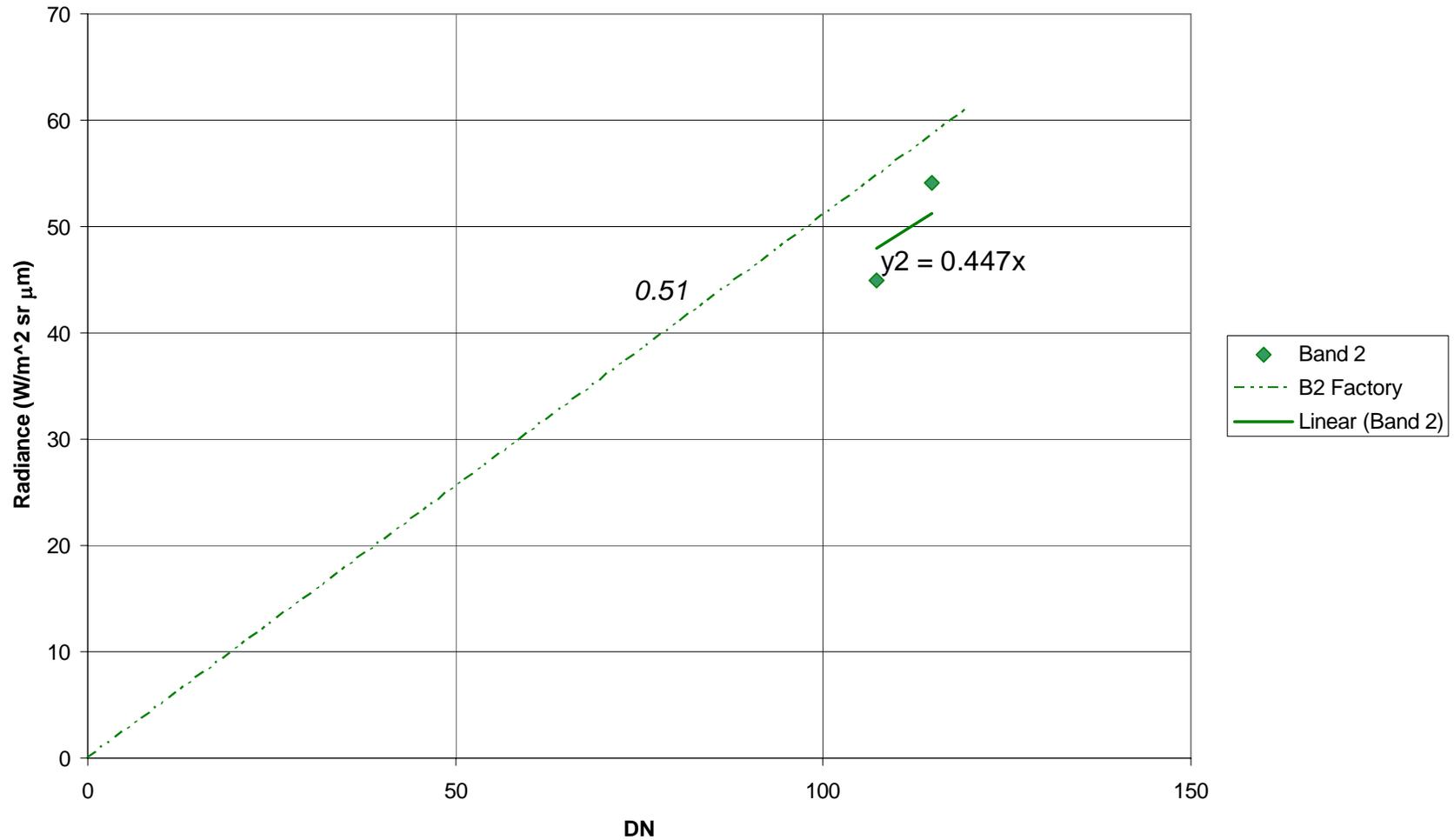
Results can be calculated in terms of radiance
per DN (simple arithmetic ratio)

Arithmetic gains		
	Mowed	Ext. Unmowed
Band 2	0.47	0.42
Band 3	0.45	0.38
Band 4	0.29	0.26
Band 5	0.047	0.041

A more visual result is to use a simple least squares fit with a forced zero intercept.

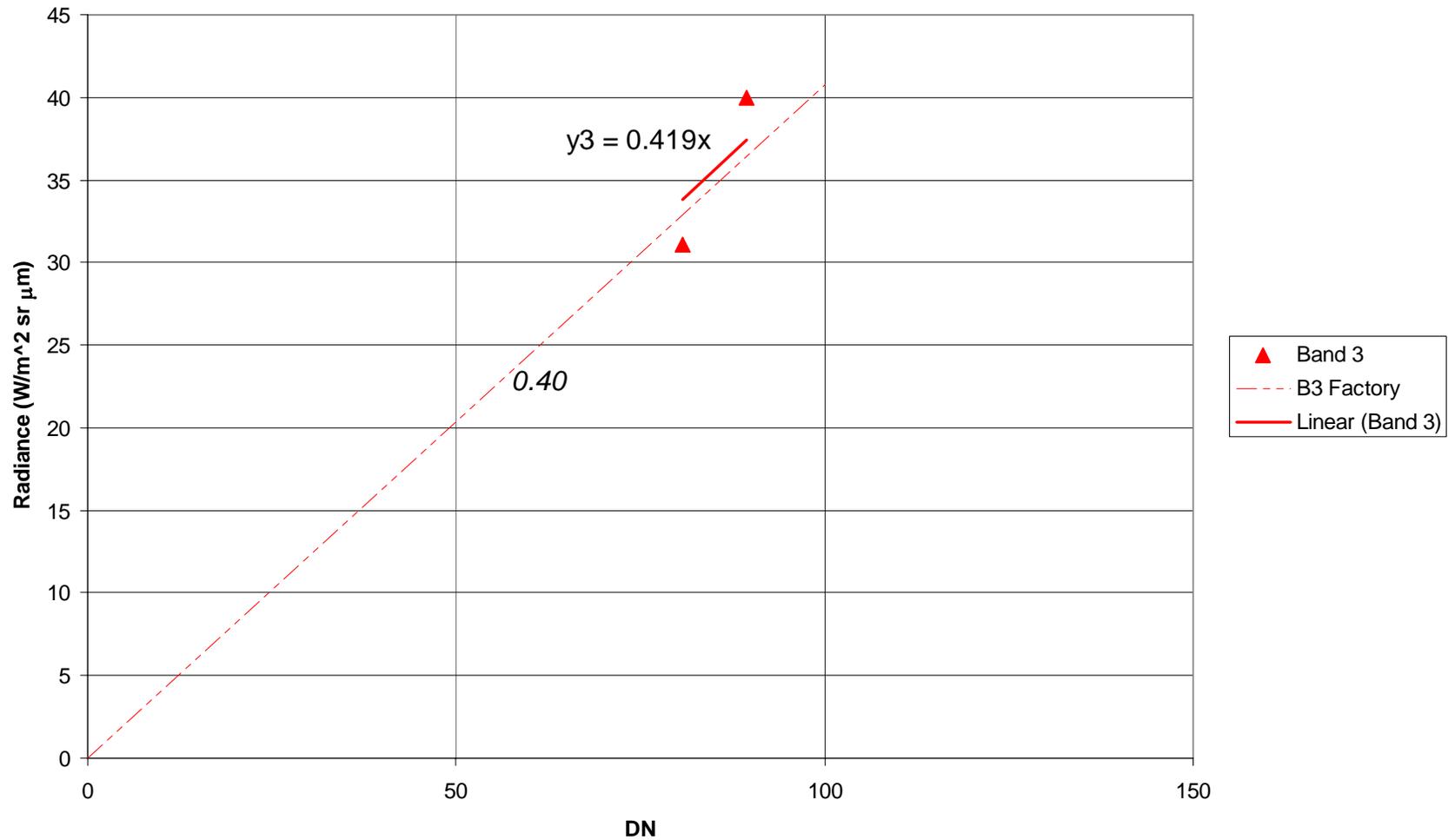


AWiFS Band 2 Gain: Forced Zero Intercept SDSU 2005 data



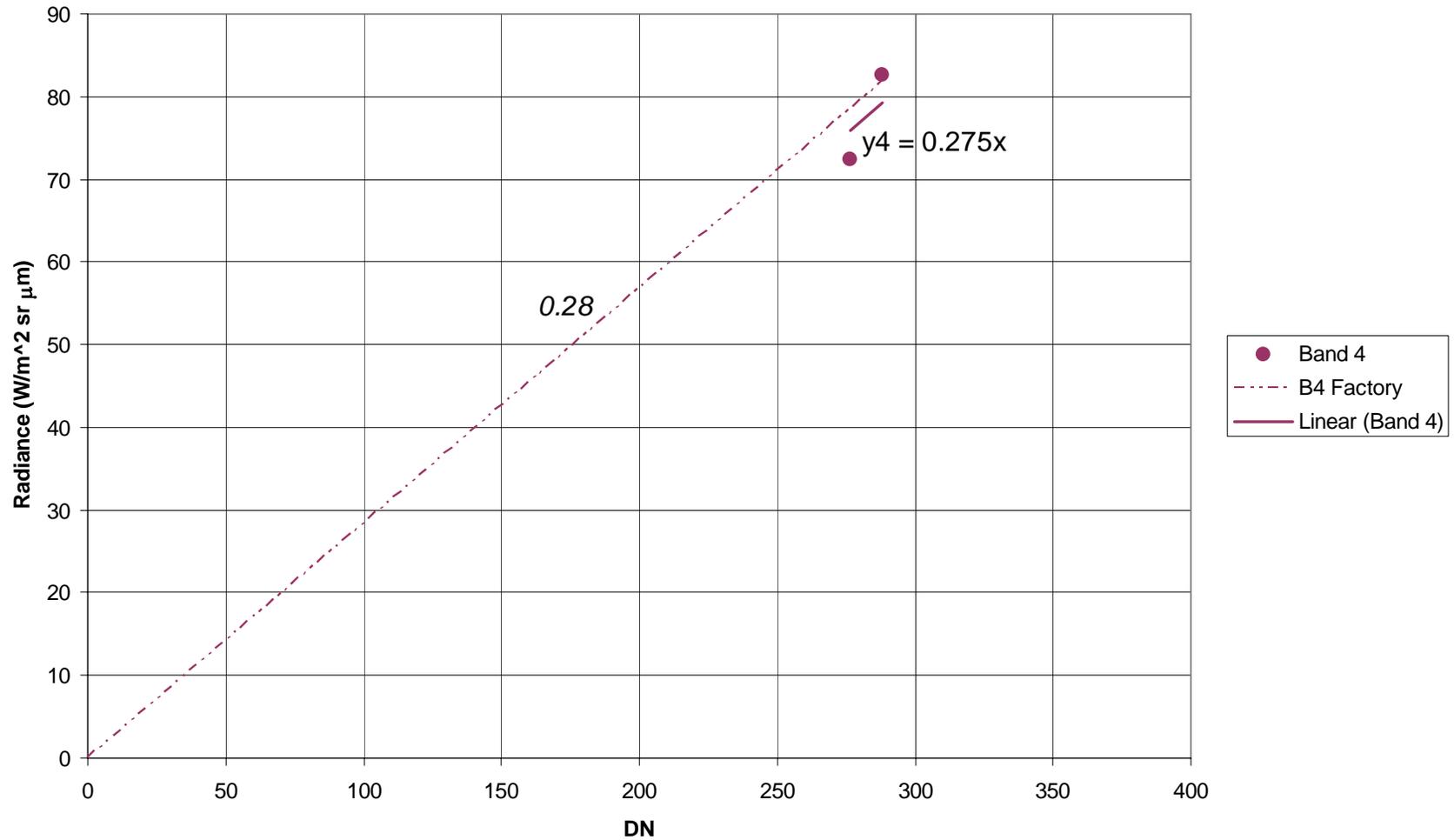


AWiFS Band3 Gain: Forced Zero Intercept SDSU 2005 data



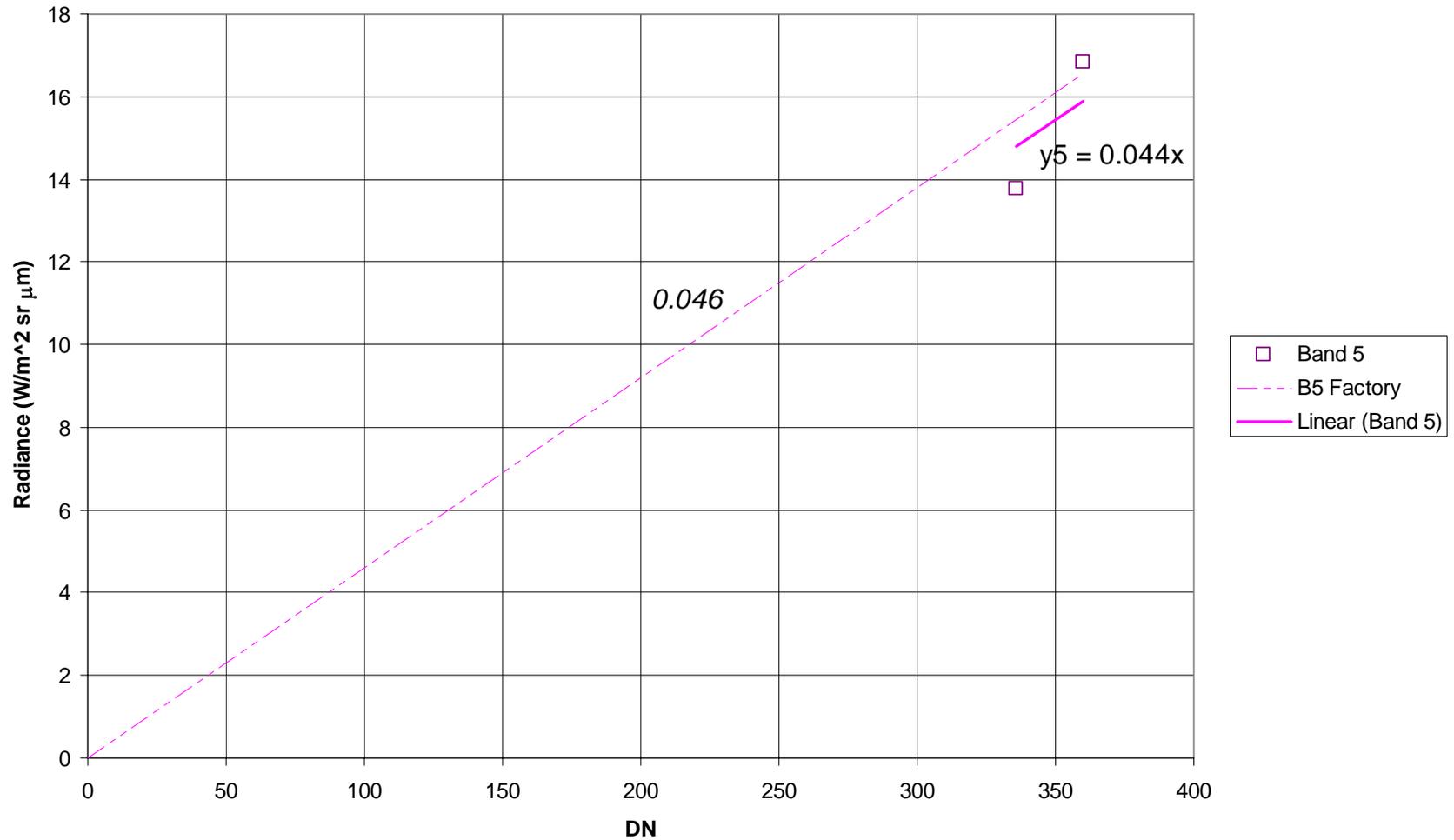


AWiFS Band 4 Gain: Forced Zero Intercept SDSU 2005 data



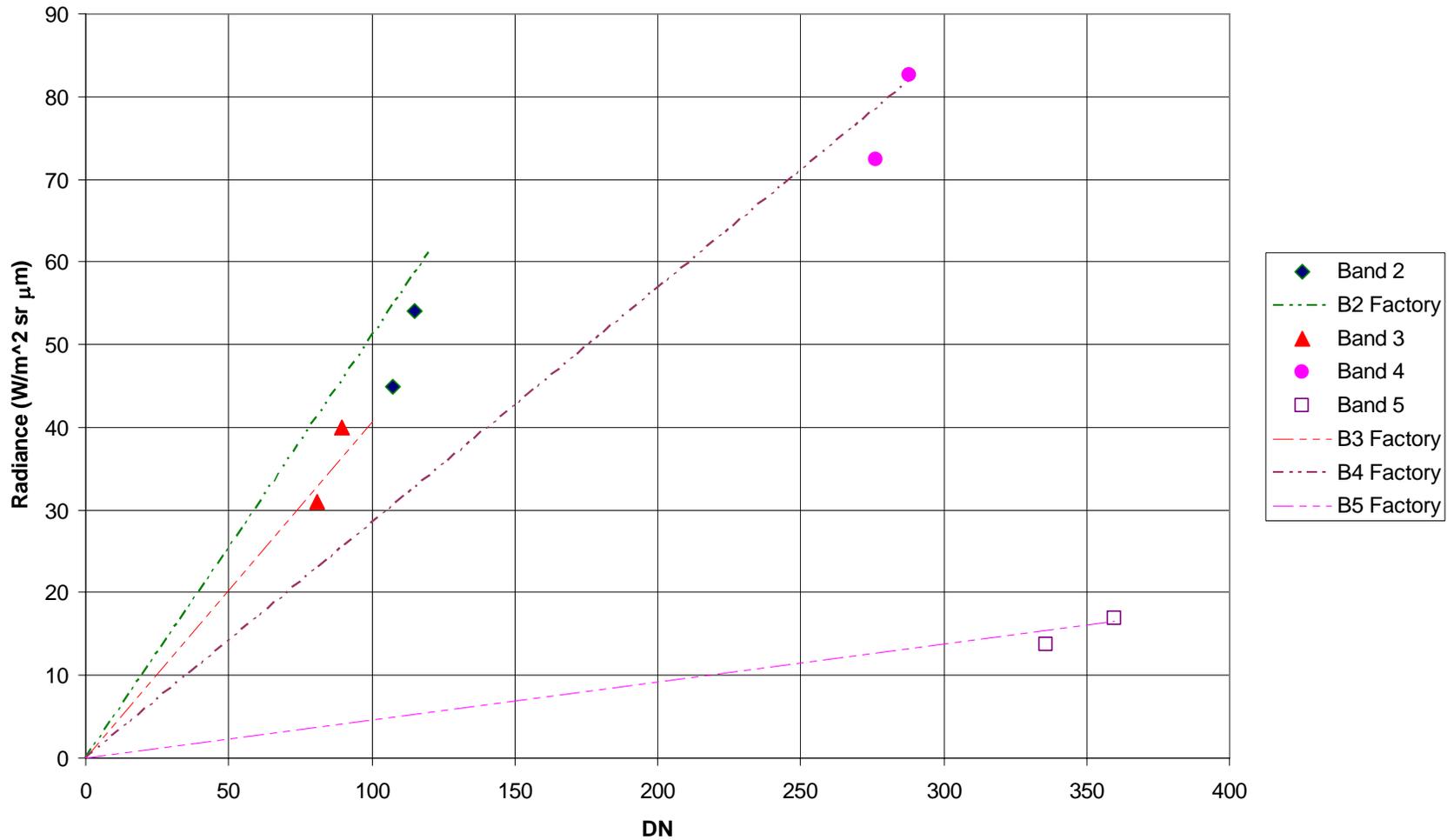


AWiFS Band 5 Gain: Forced Zero Intercept SDSU 2005 data





AWiFS Band Gains: Forced Zero Intercept SDSU 2005 data





Results:

Based on these two data points (with a forced zero intercept):

Band 2 (green):

SDSU gain: 0.45 which is 13% lower than 'factory gain'

Band 3 (red)

SDSU gain: 0.42 which is 5% lower than 'factory gain'

Band 4 (NIR)

SDSU gain: 0.28 (to within 1.5% of 'factory gain')

Band 5 (SWIR)

SDSU gain: 0.044 which is 5% lower than 'factory gain'

Due to the single data collection, no estimate of uncertainty was made, the net uncertainty is best put into context of NASA group collection.



Vicarious Calibration of AWiFS using Cross Calibration Reflectance Synthesis Technique.



Question:

Can more information be extracted on multiple satellite overpass days?

- Never comfortable with a single data point
 - especially for a ‘new’ sensor
- Would like to have a range of radiance values
 - characterize slope (gain) versus offset (zero DN value)
- Concept from Phil Teillet talk at SDSU in 2002



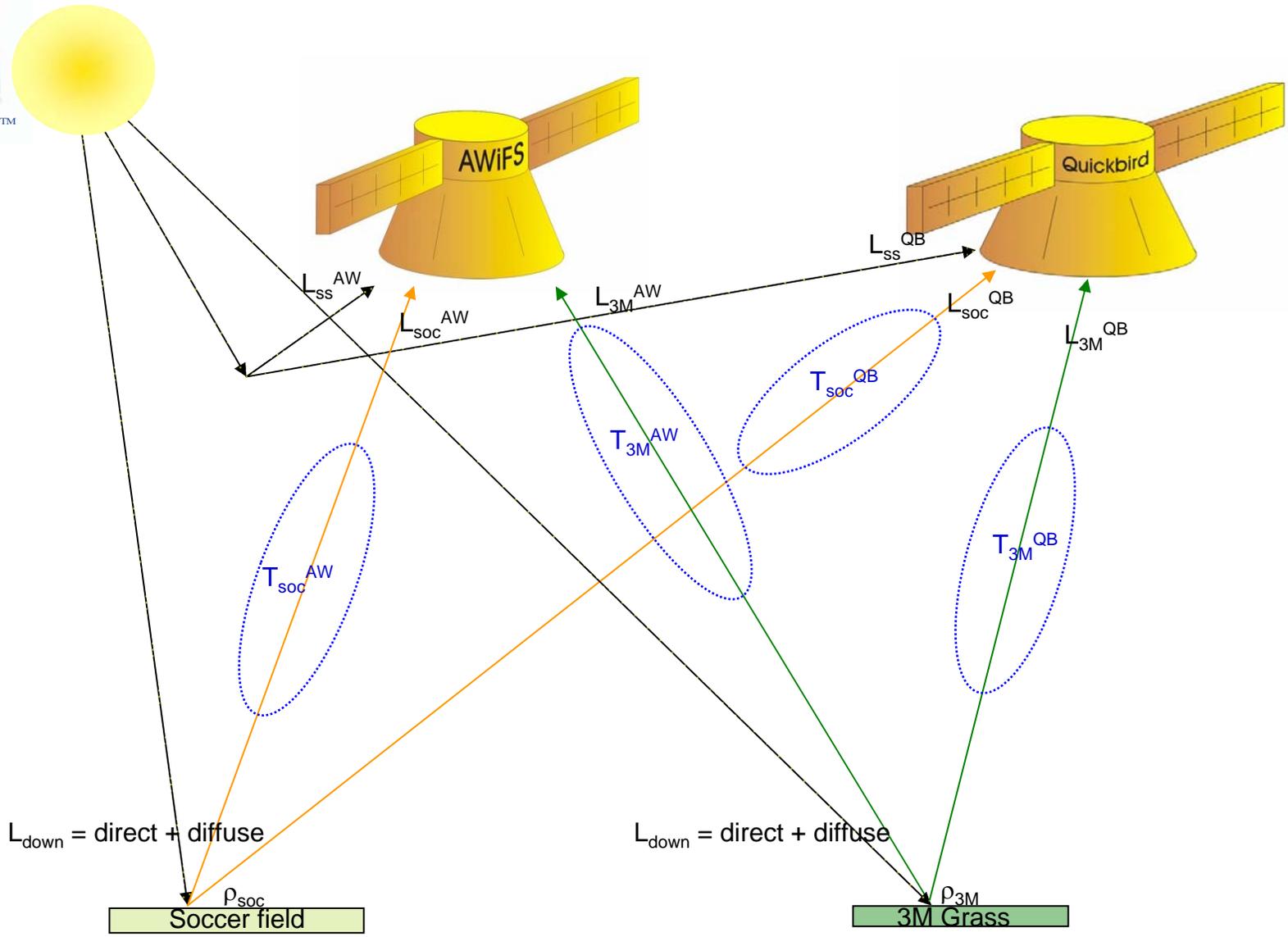
Image to Image Cross Calibration

Basic Tenet: Use a satellite image with known gain coefficients to estimate TOA radiance as seen by satellite with 'unknown' gain coefficients.

- Tried by many groups
 - Gives a reasonable zeroeth order calibration
 - Can improve by correcting for different look angles
 - Can improve by correcting for different filter band response

Common approaches rely solely on spectrally banded satellite data

- very difficult to correctly compensate for atmospheric effects (through different look angles), BRDF, spectral band filter functions, solar scatter, etc.





Cross Calibration Synthesis Technique.

Trial Run:

June 22, 2005 Coincident AWiFS/QuickBird Overpasses

- Based on 10 select sites within 8km radius of ground based radiance data (3M site)
 - sites represent various ground covers
grass, corn, soybeans, and water
- Assumes extinction values measured at 3M site apply over this entire area
 - (note that scattered small clouds were present that day, one very near 3M)
- TOA radiances are predicted based on ‘known’ in-band radiances as measured by the ‘known calibration’ satellite
 - Assume that QB ‘factory’ cal numbers are exact
- NOTE: For this study, band calibration is only reported where there is significant spectral overlap between the satellite sensors.*



Key Concepts for Methodology

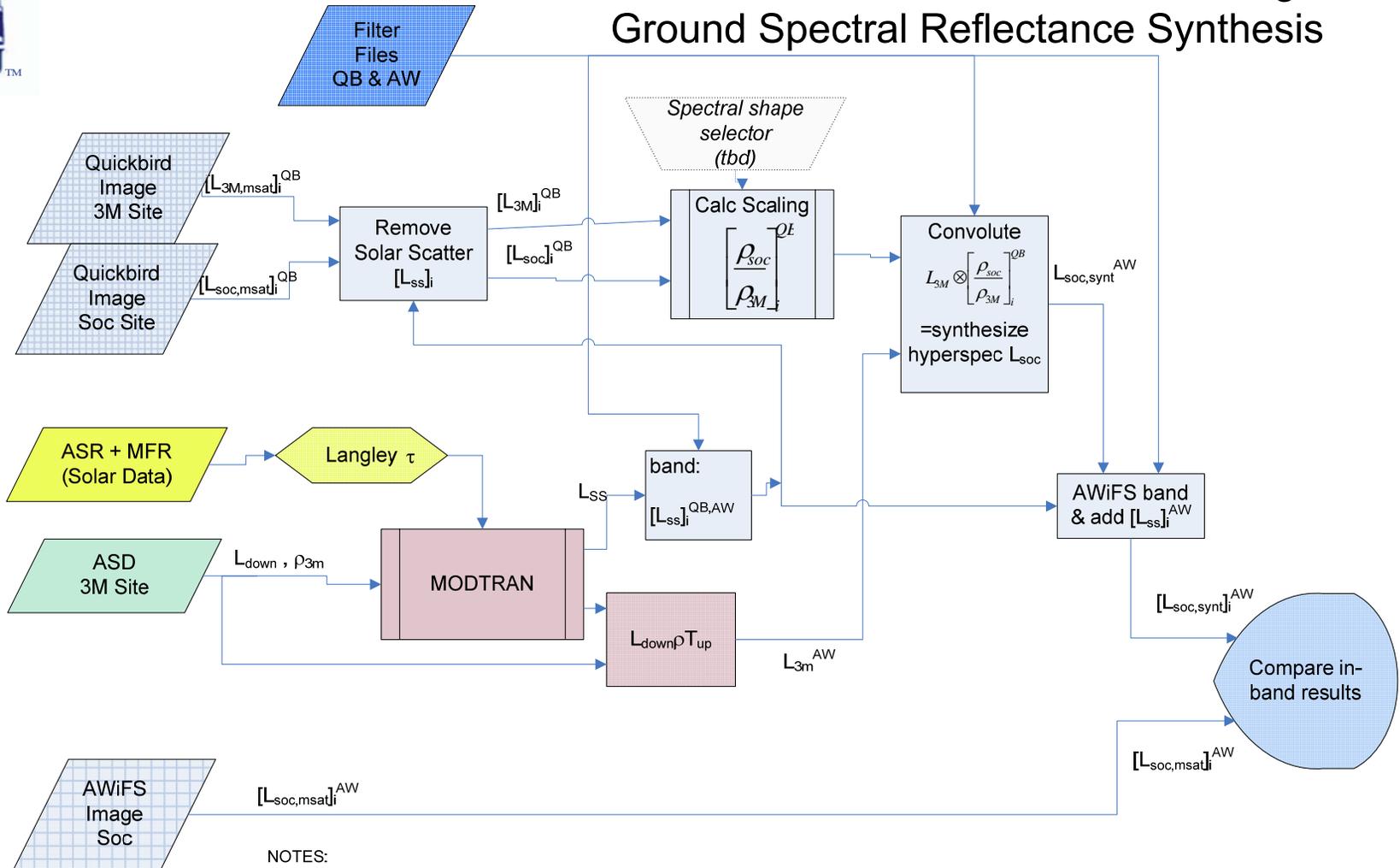
- Process radiance and atmospheric data hyperspectrally (MODTRAN)
- Different satellite 'look angles' are incorporated into the hyperspectral atmosphere model (via MODTRAN)
- All hyperspectral radiances banding is accomplished using the appropriate hyperspectral filter set for each satellite
- Solar scatter (which is unrelated to ground reflectance) is processed separately so will not be affected by ground scaling.



Methodology (cont)

- The unknown ground level reflectance is synthesized using a combination of in-band radiance ratios
 - brought down to Top of Canopy (TOC) by the atmospheric model
 - within each band's range, scaling factors are calculated
 - these scaling factors then synthesize a set of hyperspectral reflectances for the 'unknown' canopy which are each valid over a specific wavelength range
- New hyperspectral TOC radiances are calculated and propagated to satellite (instrument being calibrated) using MODTRAN
- upwelling radiances are recombined with solar scatter and banded
- These TOA values are compared with satellite DN values to determine gain equation.

Satellite to Satellite Calibration through Ground Spectral Reflectance Synthesis



NOTES:

- Unbracketed parameters are generally hyperspectral. Brackets refer to banding with the i subscript being band numbers 2 thru 4 (for this Quickbird to AWiFS example).
- The '3M' subscript refers to the site where ground measurements have been made
- The 'soc' subscript refers to the site where ground level reflectance is not known
- The 'QB' superscript is the reference sensor (assume gain values are known precisely)
- The 'AW' superscript is the sensor which is being characterized via the synthesized site radiance values



Results: June 22, 2005 data only AWiFS and Quickbird Overpasses

- AWiFS

- acquisition at: 17:19:46 UTC
- sat elevation: 82° sat azimuth: 188°
- sun elevation: 65° sun azimuth: 138°

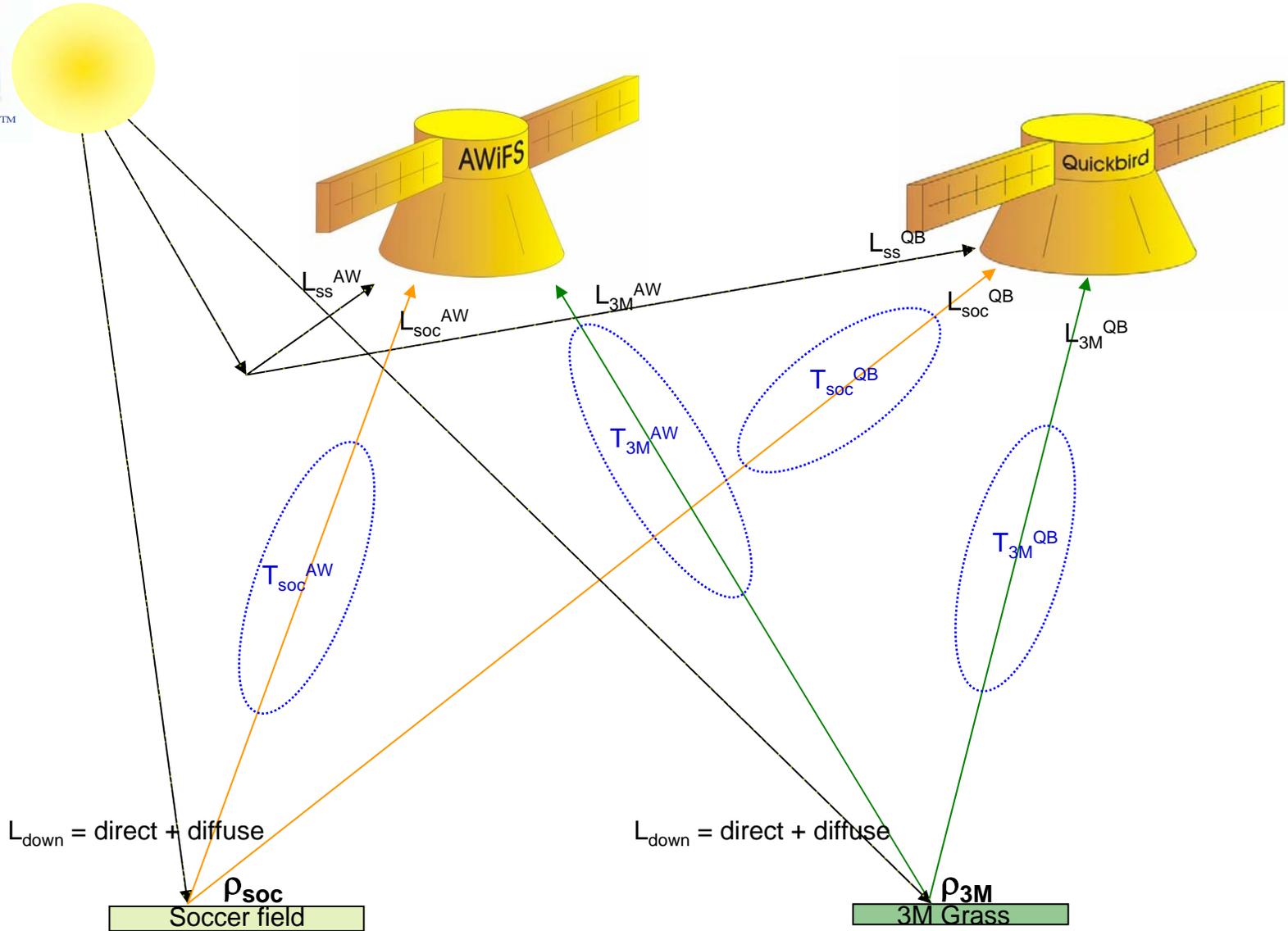
- Quickbird

- acquisition at: 17:28:22 UTC
- sat elevation: 72° sat azimuth: 88°
- sun elevation: 66° sun azimuth: 144°

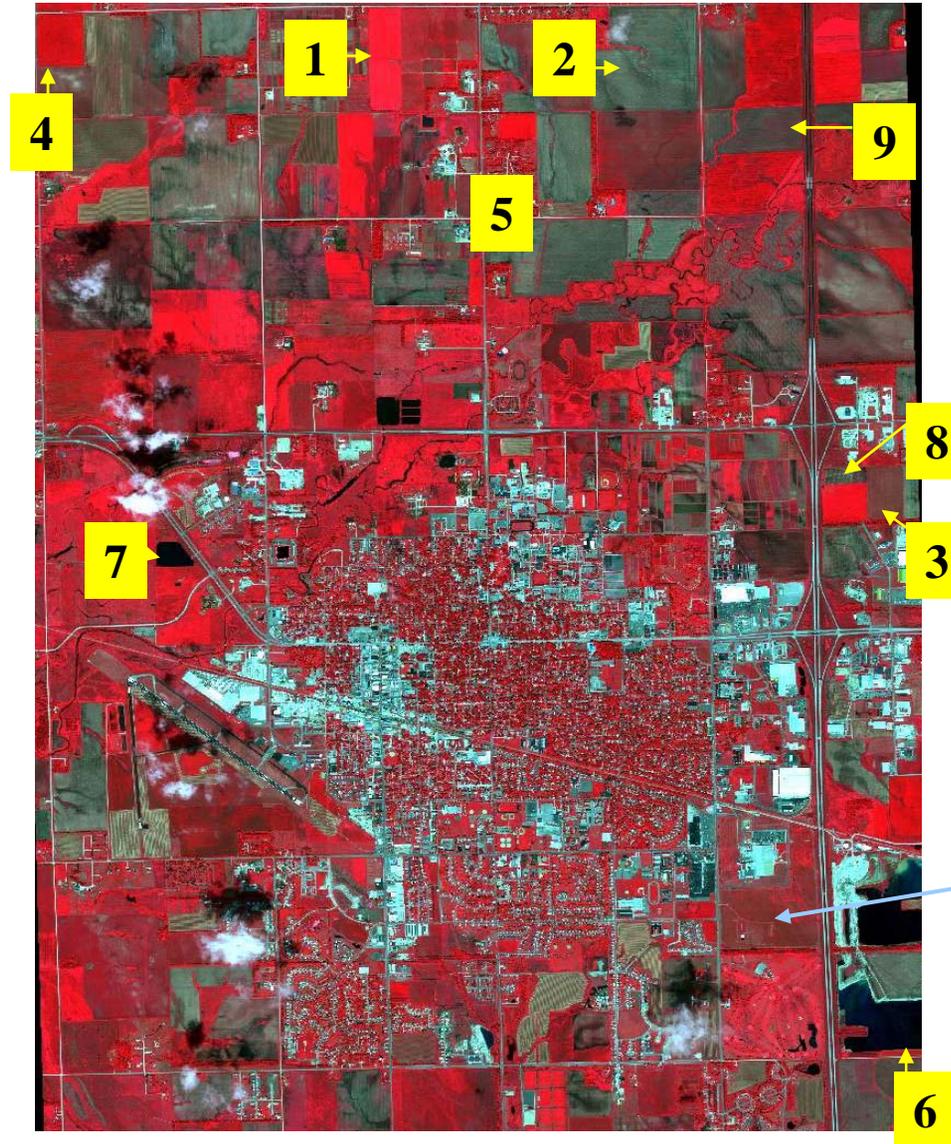
(wind out of the S at 12 mph; 82°F)

Caution: Methodology has been applied to one day only.

- Nearby small clouds may cause some light trapping and excess solar scatter
 - Neither effect was compensated for in this analysis
 - Gains (slopes) will only be affected slightly, however intercepts may be influenced more strongly.



June 22, 2005 Quickbird Image – Test regions



- 1 – Prairie Grass
- 2, 3, 5 – Soybeans
- 4 – Wheat
- 6, 7 – Water
- omit 8 due to cloud in AWiFS image
- 9 – Corn

3M site

6



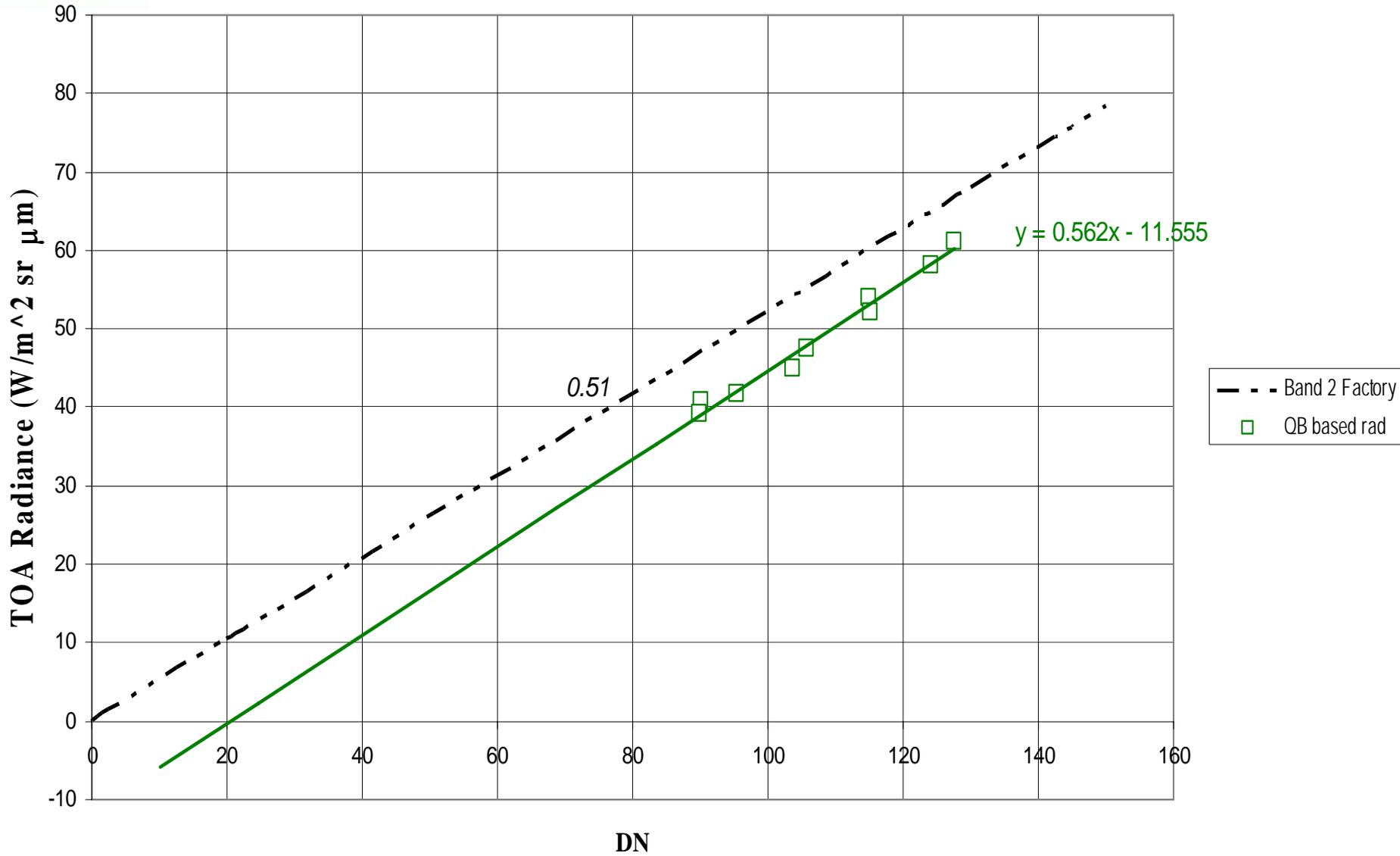
Number of Pixels Used to Analyze Each Site

		# of Pixels	
		QB	AWiFS
3M site		2692	6
AWiFS site		1987	6
prairie grass	1	24420	30
soybeans	2	72886	91
soybeans	3	12476	12
wheat	4	17979	20
soybeans	5	39103	49
water	6	20642	20
water	7	3874	8
corn	9	20531	18



AWiFS Calibration via Reflectance Synthesis Technique

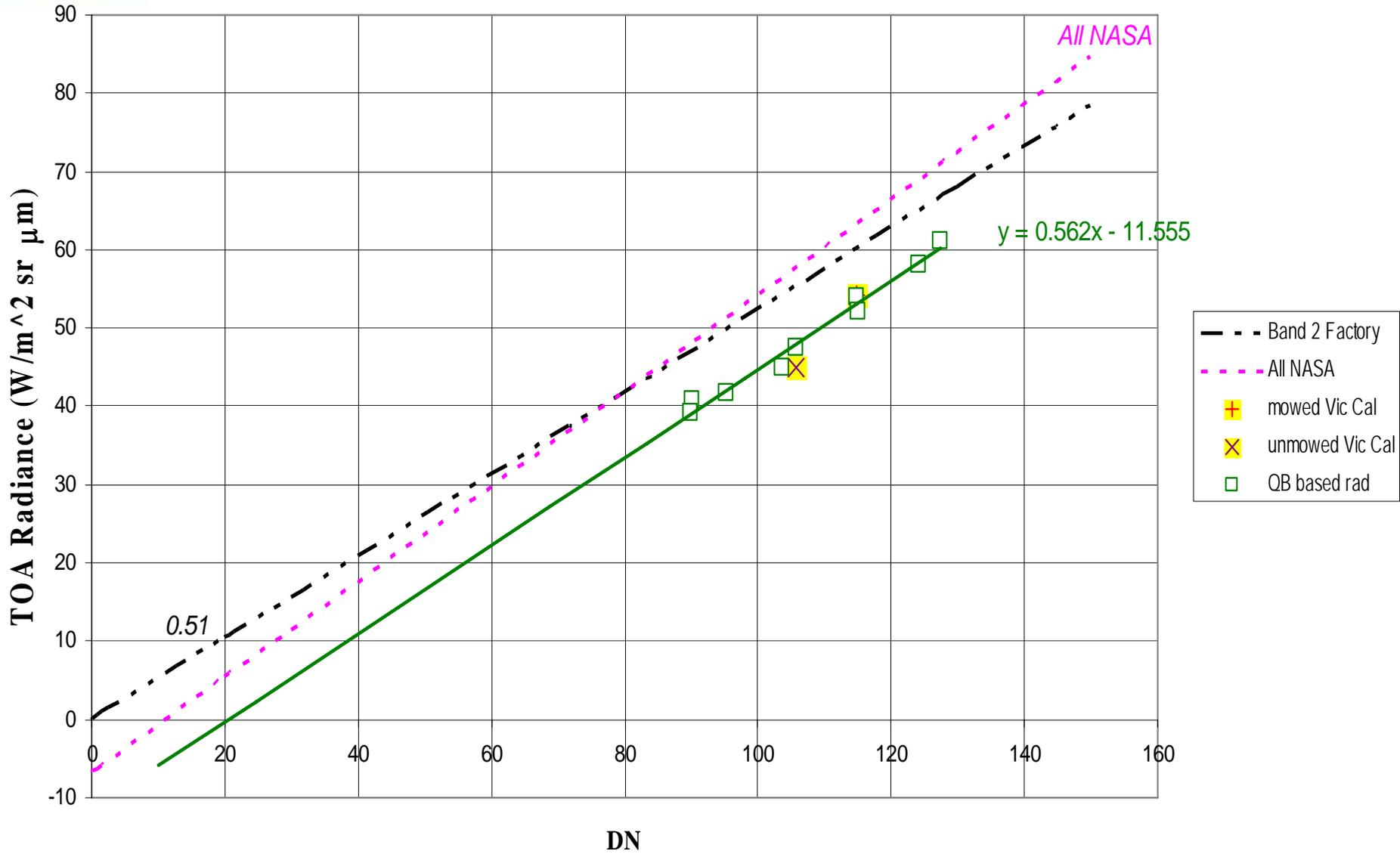
Band 2 (green)





AWiFS Calibration via Reflectance Synthesis Technique

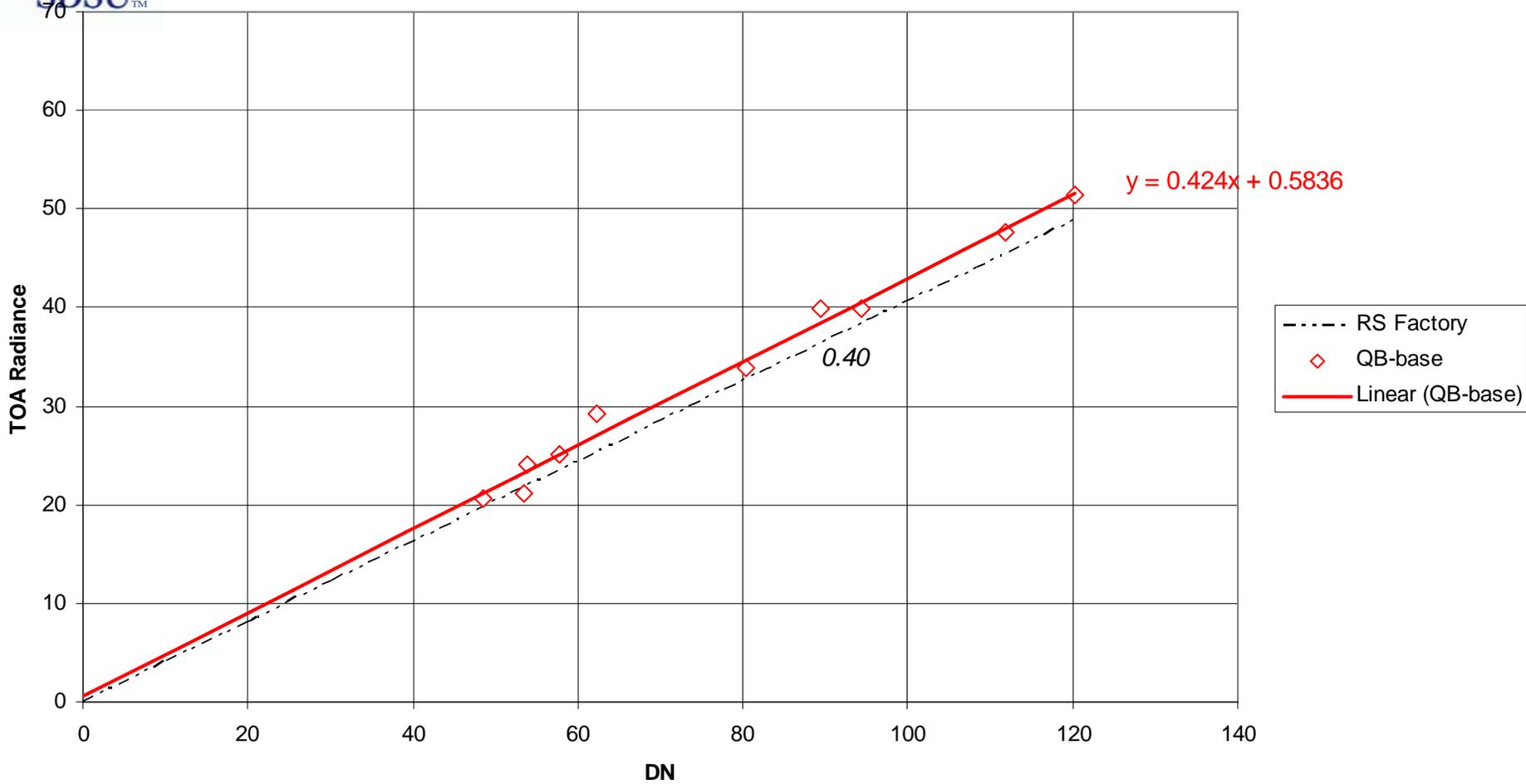
Band 2 (green)





AWiFS Calibration via Reflectance Synthesis Technique Satellite Calibration Research Group

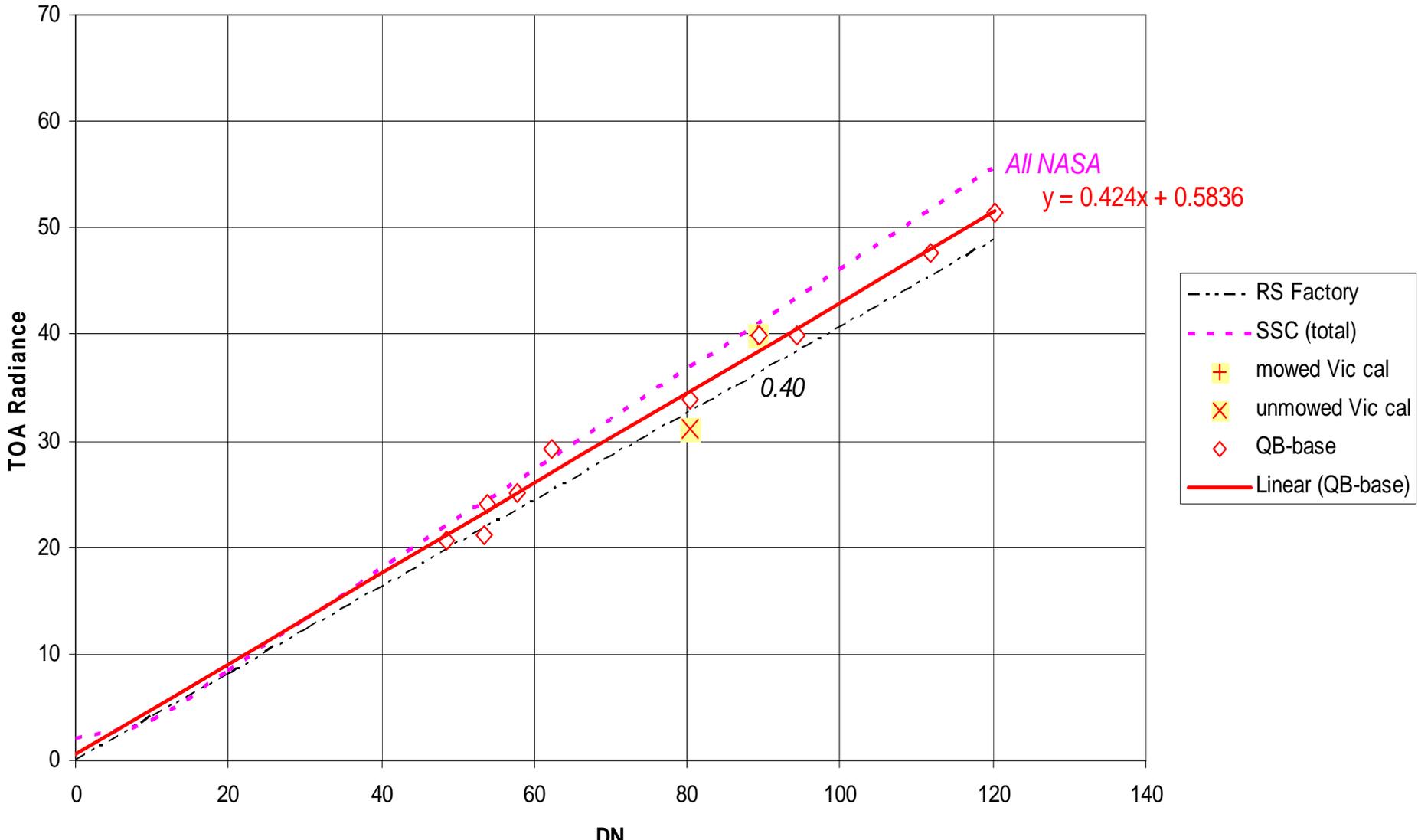
Band 3 (red)





AWiFS Calibration via Reflectance Synthesis Technique

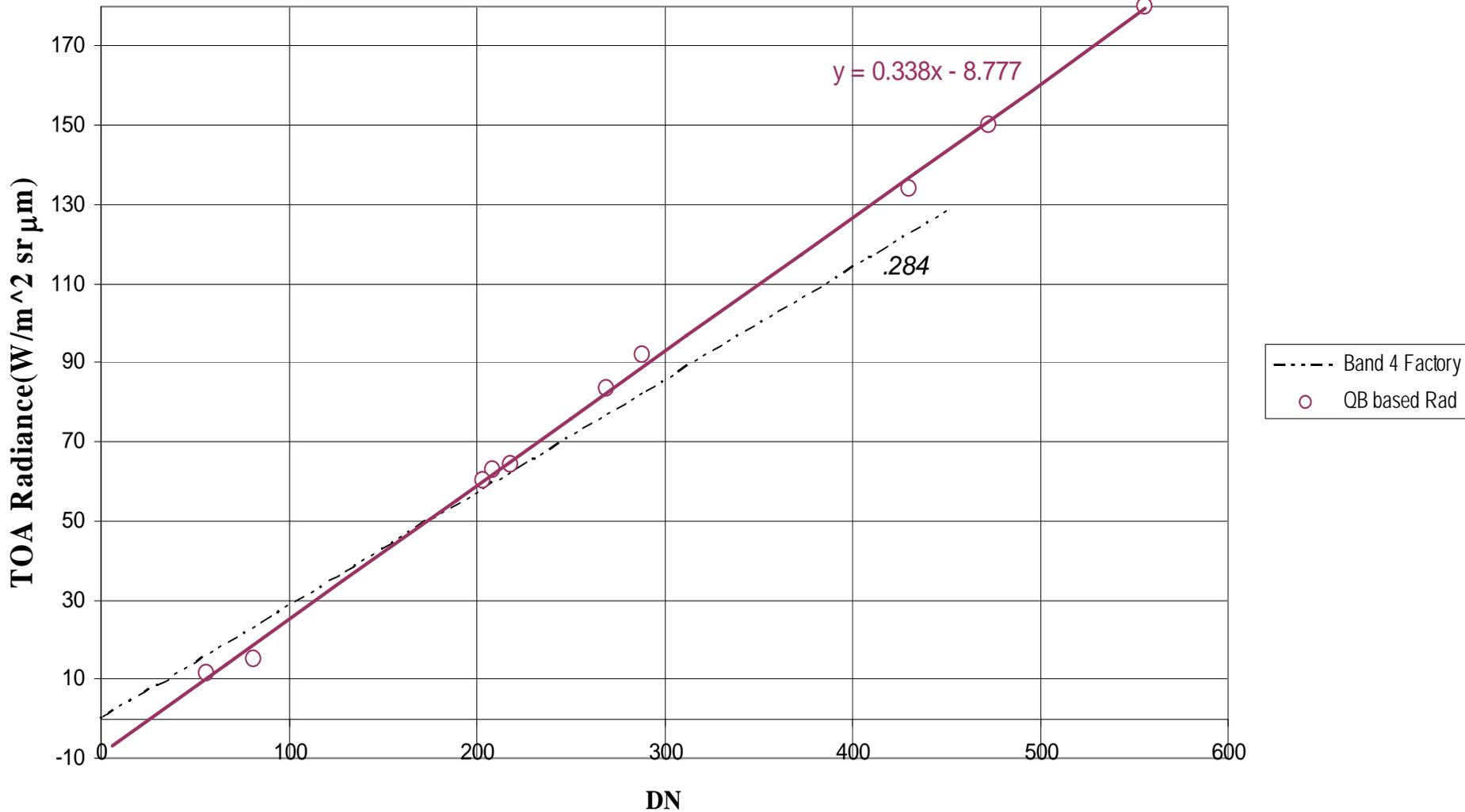
Band 3 (red)





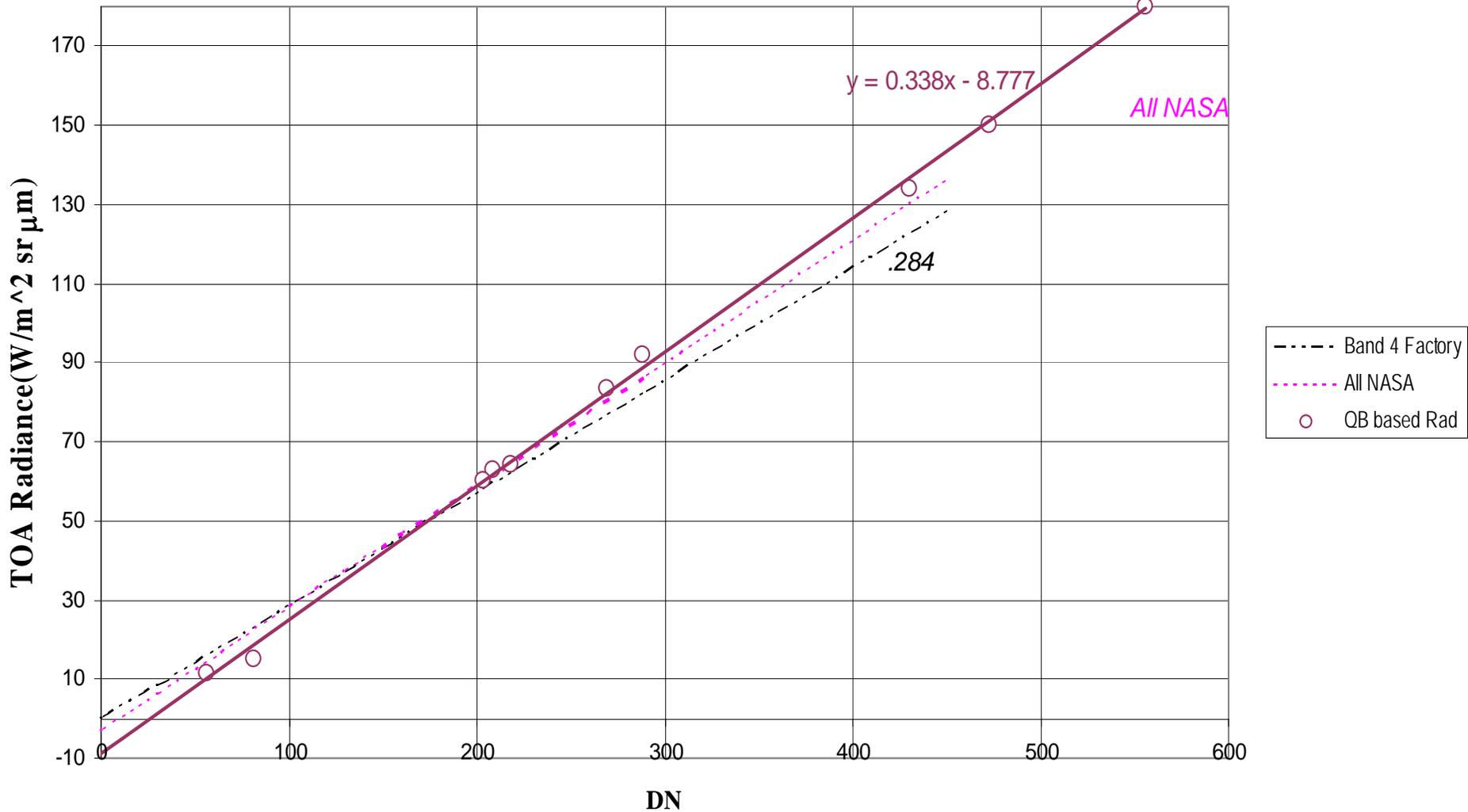
AWiFS Calibration via Reflectance Synthesis Technique

Band 4 (NIR)





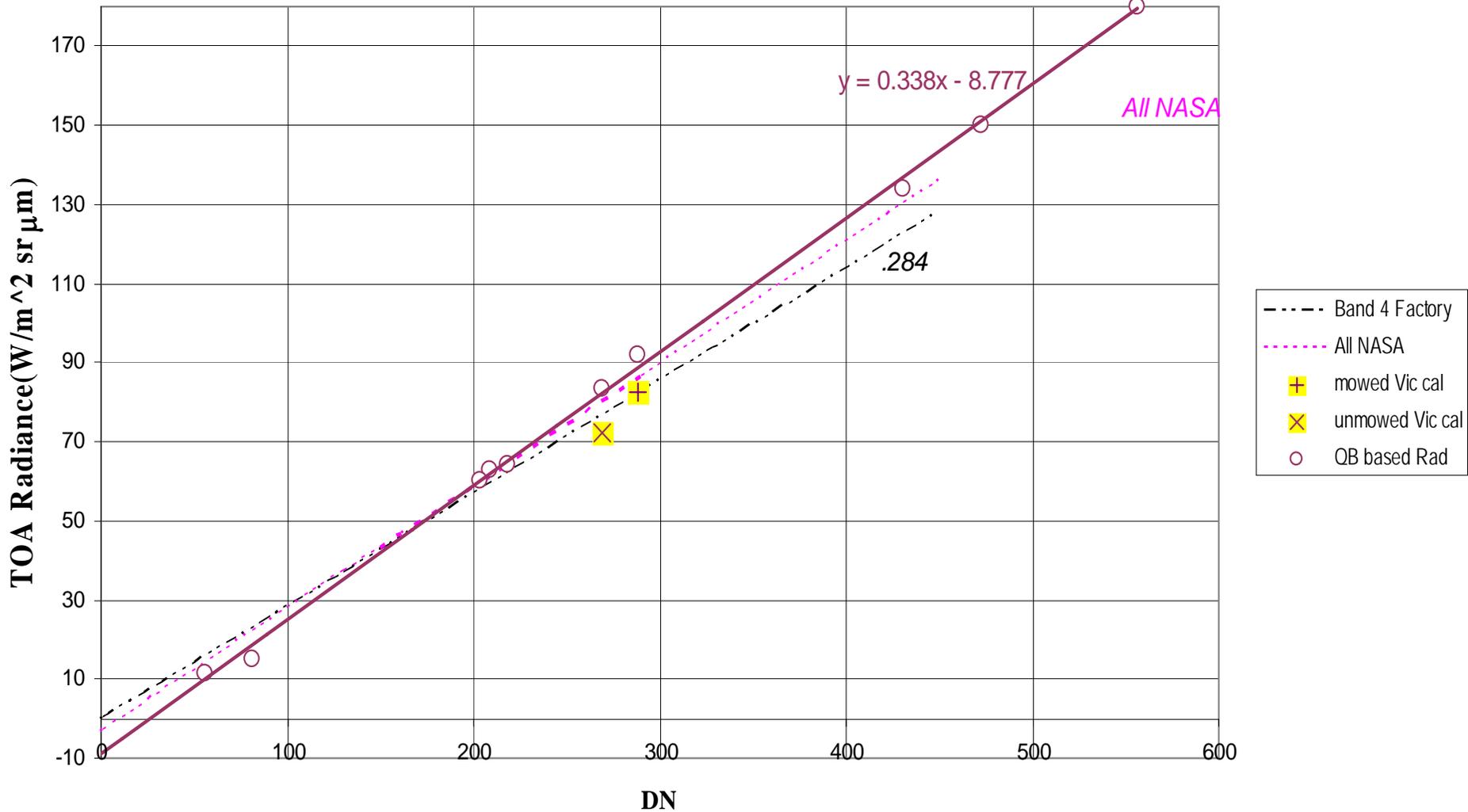
AWiFS Calibration via Reflectance Synthesis Technique Band 4 (NIR)





AWiFS Calibration via Reflectance Synthesis Technique

Band 4 (NIR)





Results:

- Band 2 (green):

$$L_{AW,2} = 0.56 * DN2 - 11.70 \quad 1 \text{ sigma: gain} = +/- 0.027 \text{ intercept } +/- 2.99$$

$$\text{Factory} = 0.51 * DN2$$

(thus SDSU slope is 9% higher than factory)

- Band 3 (red):

$$L_{AW,3} = 0.42 * DN3 + 0.58 \quad 1 \text{ sigma gain: } = +/- 0.017 \text{ intercept } +/- 1.37$$

$$\text{Factory} = 0.40 * DN3$$

(thus SDSU slope is 3% higher than factory)

- Band 4 (NIR):

$$L_{AW,4} = 0.34 * DN - 8.78 \quad 1 \text{ sigma: gain} = +/- 0.004 \text{ intercept } +/- 1.39$$

$$\text{Factory} = 0.28 * DN4$$

(thus SDSU slope is 15% higher than factory)



Acknowledgements:

The SDSU team would like to thank:

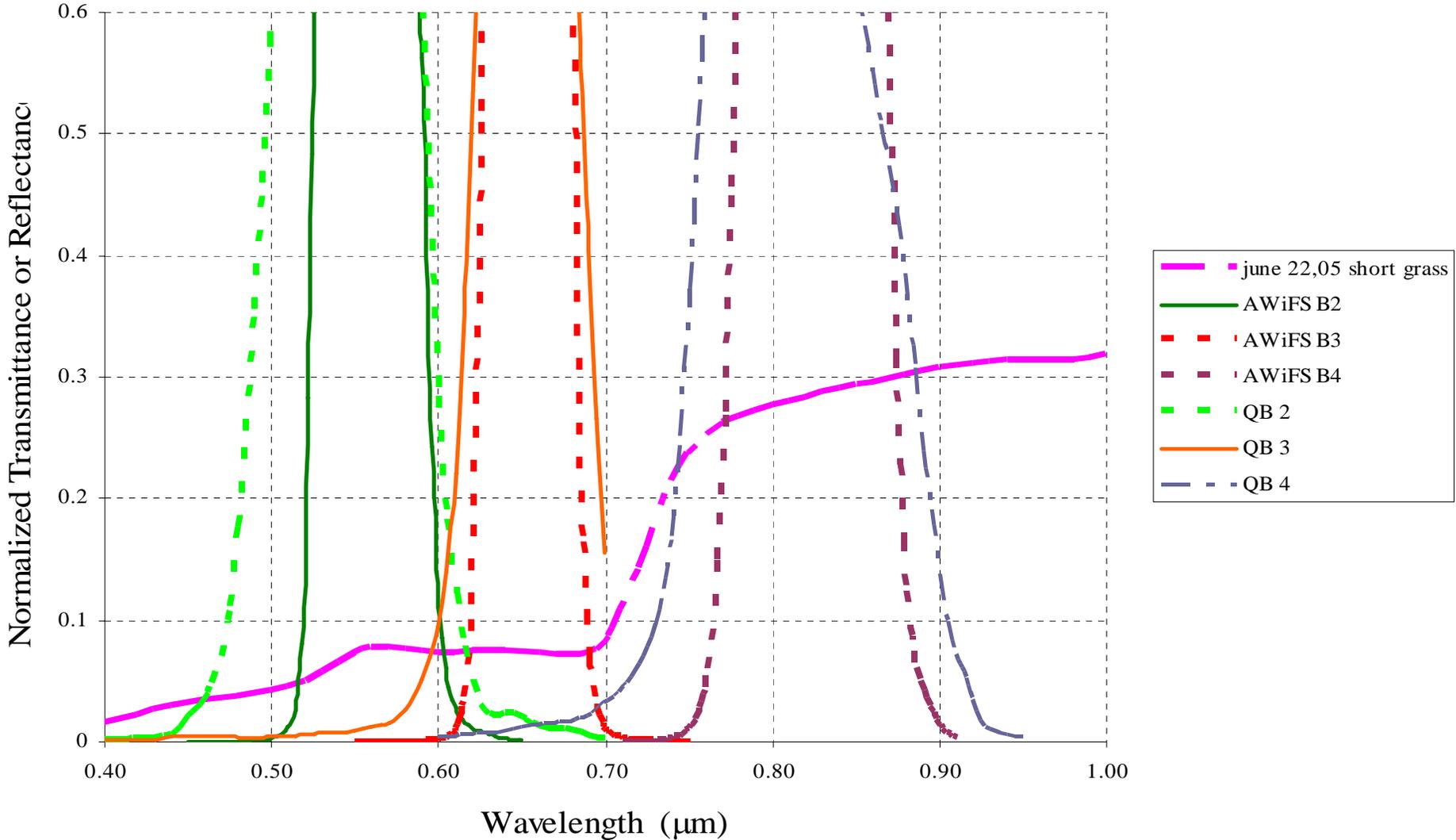
- NASA NNS04AB66C
- NASA EPSCoR NCC5-588



Additional Information

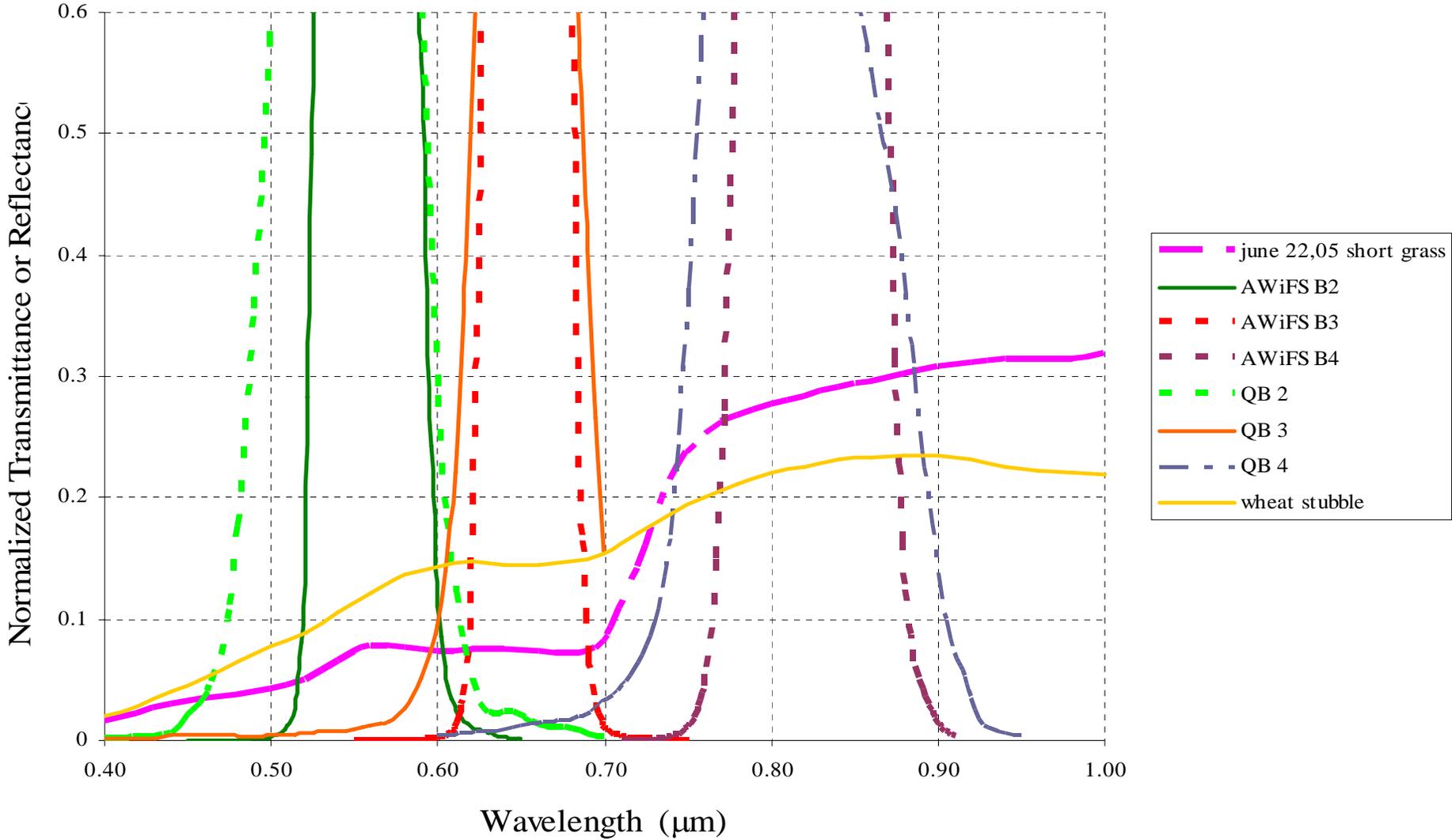


AWiFS and QB Spectral Response and typical mowed grass reflectance



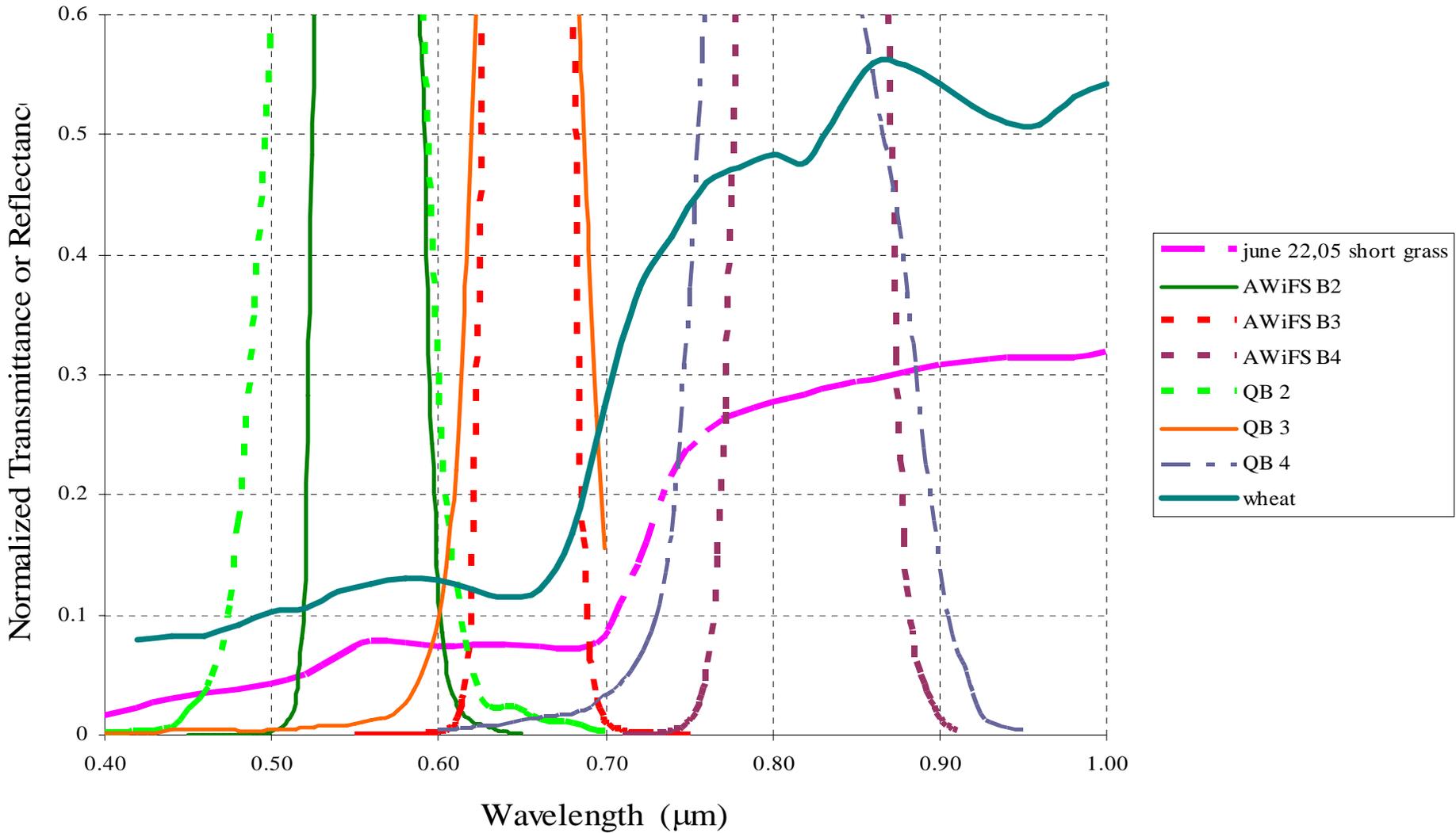


AWiFS and QB Spectral Response Grass and Wheat Stubble



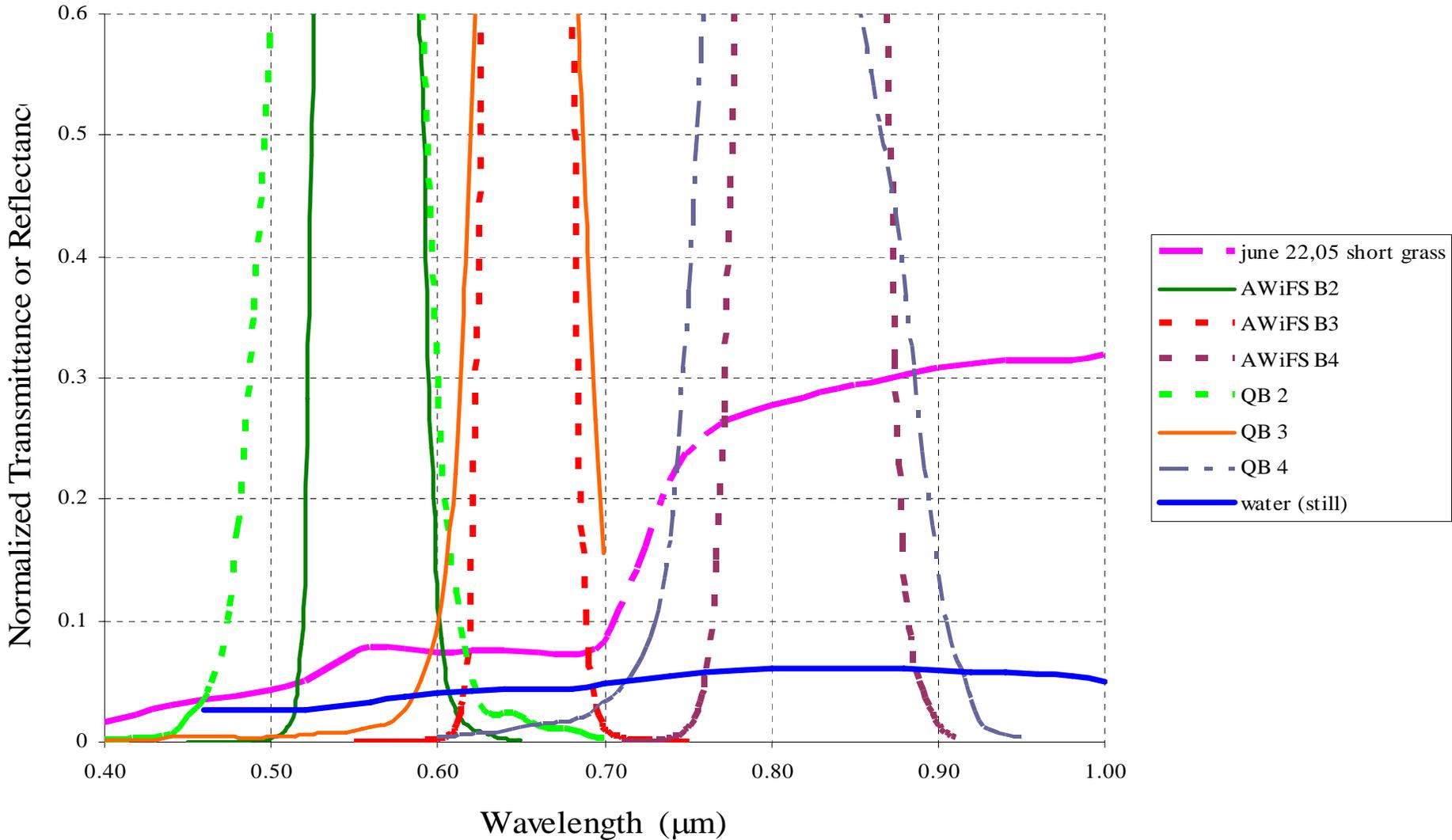


AWiFS and QB Spectral Response Grass and Wheat





AWiFS and QB Spectral Response Grass and Still Water





Results:

• Band 2 (green):

$$L_{AW,2} = 0.56 * DN2 - 11.70$$

$$NL_{AW,2} = 0.61 * DN2 - 6.81$$

$$\text{Factory} = 0.51 * DN2$$

1 sigma: gain = +/- 0.027 intercept +/- 2.99

1 sigma: gain = +/- 0.03 intercept +/- 5.42

• Band 3 (red):

$$L_{AW,3} = 0.42 * DN3 + 0.58$$

$$NL_{AW,3} = 0.47 * DN3 + 2.14$$

$$\text{Factory} = 0.40 * DN3$$

1 sigma gain: = +/- 0.017 intercept +/- 1.37

1 sigma gain: = +/- 0.01 intercept +/- 3.67

• Band 4 (NIR):

$$L_{AW,4} = 0.34 * DN - 8.78$$

$$NL_{AW,4} = 0.31 * DN - 3.12$$

$$\text{Factory} = 0.28 * DN4$$

1 sigma: gain = +/- 0.004 intercept +/- 1.39

1 sigma: gain = +/- 0.02 intercept +/- 7.01