



# Space Imaging IKONOS Radiometric Characterization

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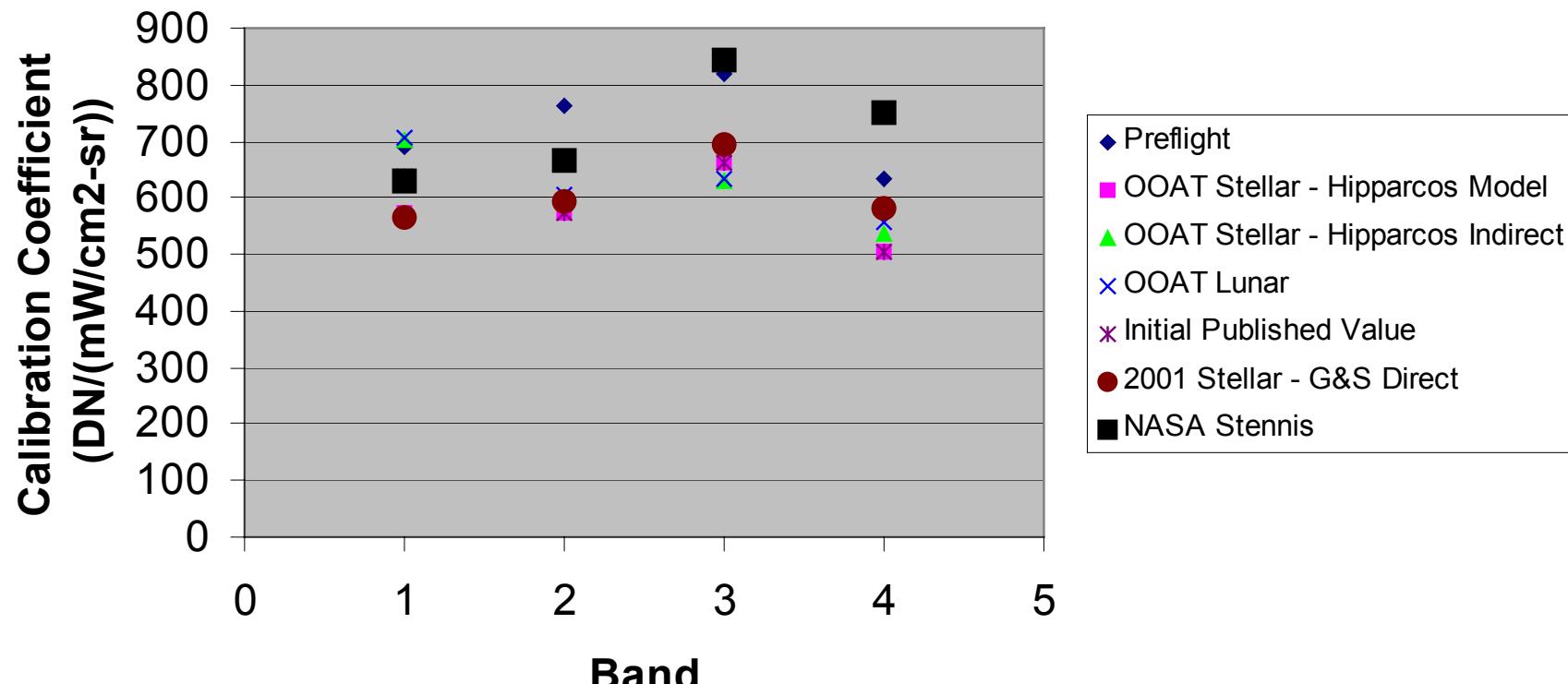


## IKONOS Radiometric Calibration

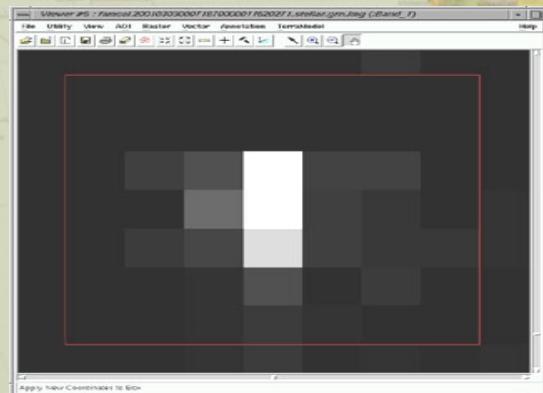
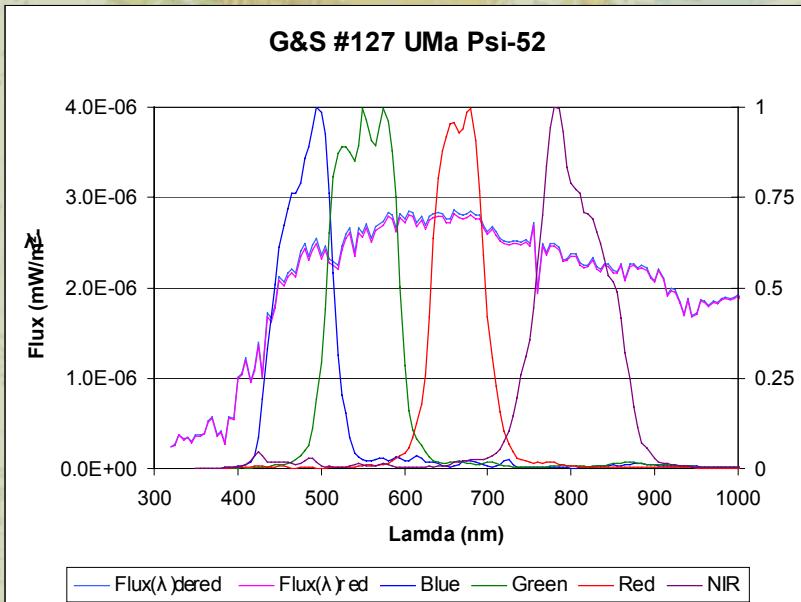
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- Initial IKONOS Radiometric Calibration performed during On-Orbit Acceptance Testing
  - Exoatmospheric methodologies used to determine system calibration
    - Stellar calibration using stars from Hipparcos catalog
    - Lunar calibration for corroboration of results
- Initial results released May 10, 2000
- System calibration revisited early 2001
  - Repeat of radiometric calibration using well-known stellar sources (Gunn & Stryker)
  - Update of radiometric processing LUTs to improve relative calibration and image quality

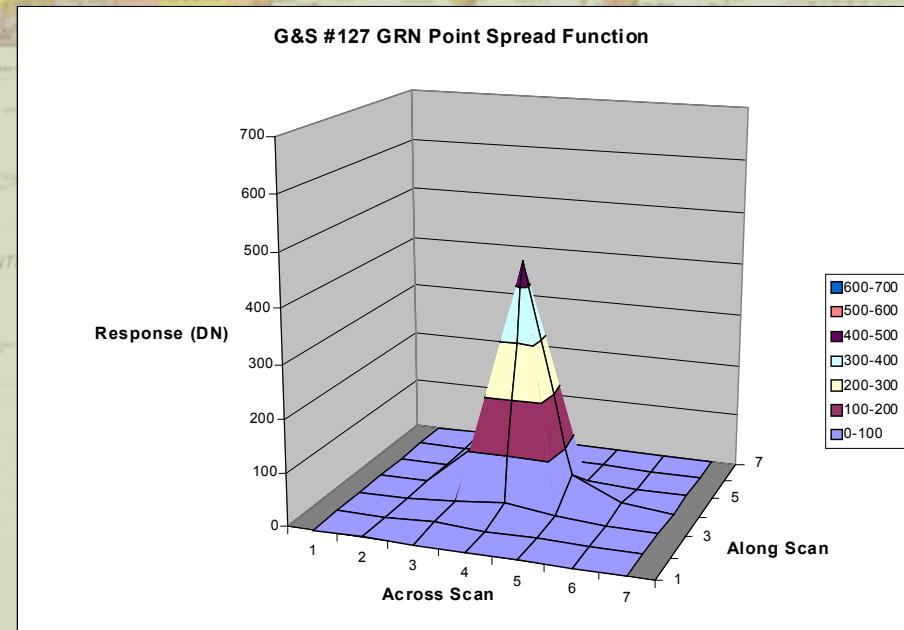
## IKONOS Radiometric Calibration



# SI IKONOS Calibration Approach



- Collect stars of known radiometric characteristics
  - Gunn & Stryker Catalog
- Determine in-band flux at aperture
- Integrate system DN response in image
- Calculate Calibration Coefficient





# Aperture In-Band Radiance

- In-band radiance determined by conversion of G&S catalog data to at-aperture spectral radiance and integrating over IKONOS passbands

Gunn-Stryker Catalog Reference

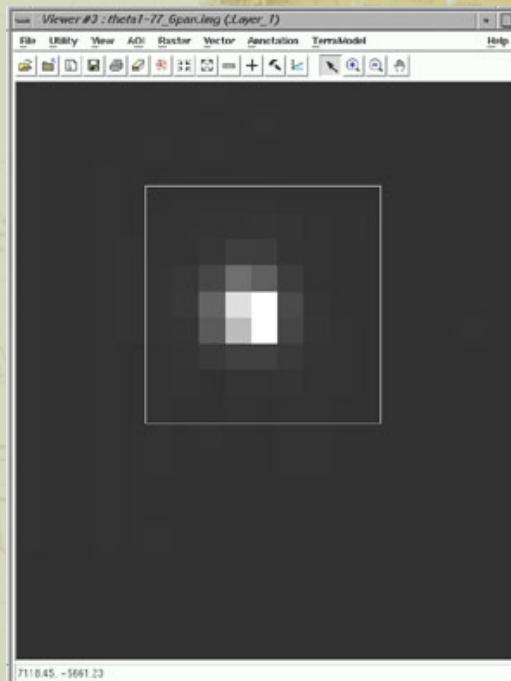
Calculated In-Band Radiance

2001 Image Date	G&S#	Star Name	V mag	Av mag	HIP#	MS-1 BLU mW/cm <sup>2</sup> -sr	MS-2 GRN mW/cm <sup>2</sup> -sr	MS-3 RED mW/cm <sup>2</sup> -sr	MS-4 NIR mW/cm <sup>2</sup> -sr
13-Feb-01	7	Hya Eta-7	4.134	0.030	42799	0.386	0.309	0.131	0.106
7-Feb-01	109	Tau Theta1-77	3.694	0.027	20885	0.352	0.465	0.352	0.386
15-Feb-01	118	LMi 46	3.672	0.025	53229	0.359	0.475	0.359	0.394
16-Feb-01	123	Crt Alpha-7	3.964	0.030	53740	0.258	0.362	0.295	0.339
3-Mar-01	127	UMa Psi-52	2.861	0.018	54539	0.712	1.010	0.852	0.959
2-Mar-01	134	Unukalhay	2.508	0.015	77070	0.983	1.407	1.162	1.335
8-Feb-01	135	Leo Mu-24	3.733	0.026	48455	0.303	0.450	0.392	0.446
14-Feb-01	142	Hya Lota-35	3.741	0.037	47431	0.283	0.442	0.411	0.501
9-Feb-01	149	CMa Theta-14	3.888	0.044	33160	0.228	0.382	0.344	0.479
9-Feb-01	150	Gem 81	4.650	0.067	37908	0.110	0.187	0.189	0.264



# IKONOS Response Determination

- Stellar collection processed to radiometrically corrected image
- Star identified in image product
- Image DN summed over PSF to determine system response to point-source input



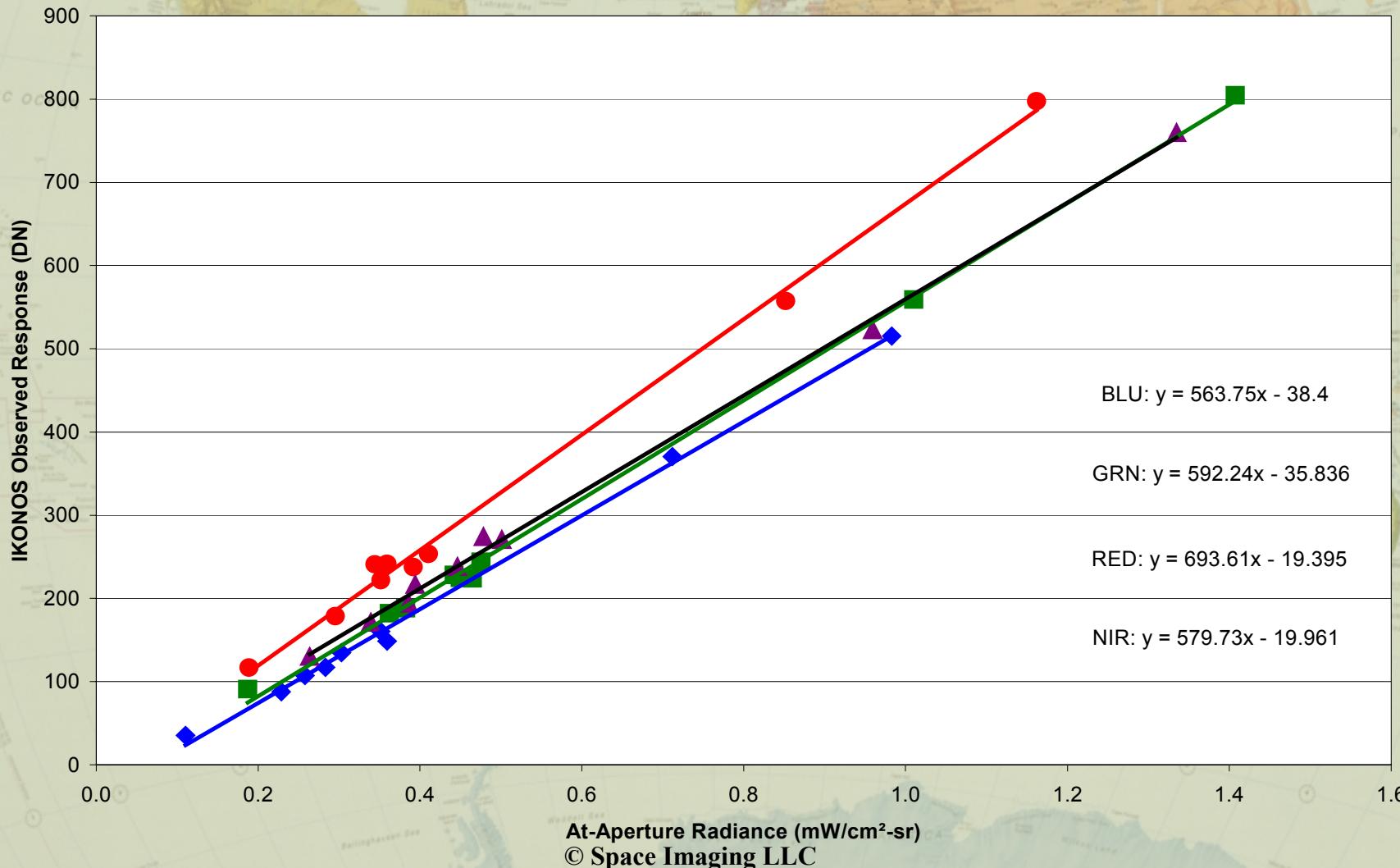
G&S#	Star Name	BLUE (DN)	GRN (DN)	RED (DN)	NIR (DN)
7	Hya Eta-7	169.2	144.8	61.5	38.3
109	Tau Theta1-77	160.3	224.2	221.8	194.2
118	LMi 46	148.7	244.0	241.7	217.0
123	Crt Alpha-7	107.5	182.2	178.8	171.5
127	UMa Psi-52	370.5	559.1	557.5	522.9
134	Unukkalhay	515.2	804.6	797.4	759.6
135	Leo Mu-24	134.8	224.8	237.7	238.2
142	Hya Lota-35	117.2	228.3	253.7	270.8
149	CMa Theta-14	88.0	188.3	241.2	274.2
150	Gem 81	35.3	91.0	116.8	130.3



# IKONOS Radiometric Calibration

IKONOS Radiometric Stellar Calibration 2001

IKONOS radiometric response to Gunn & Stryker stellar sources

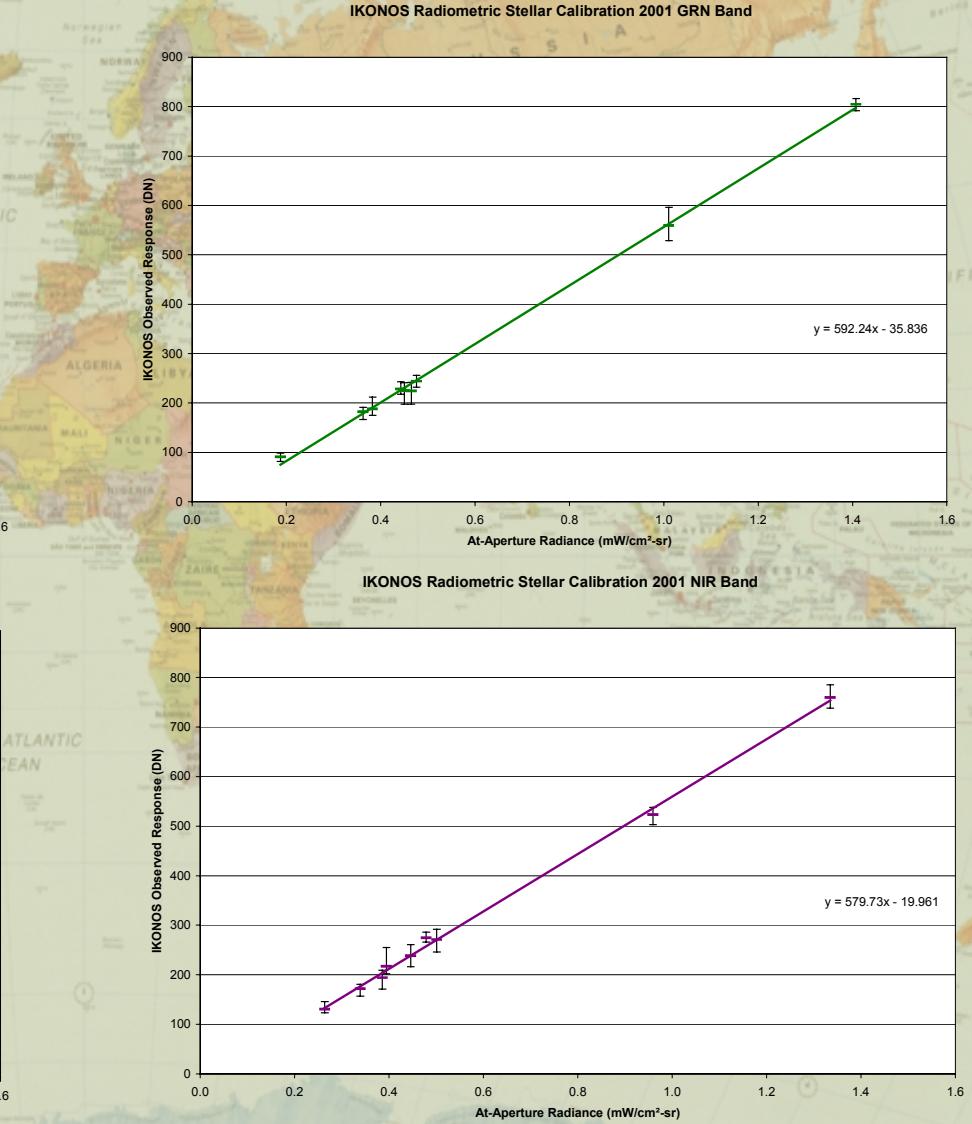
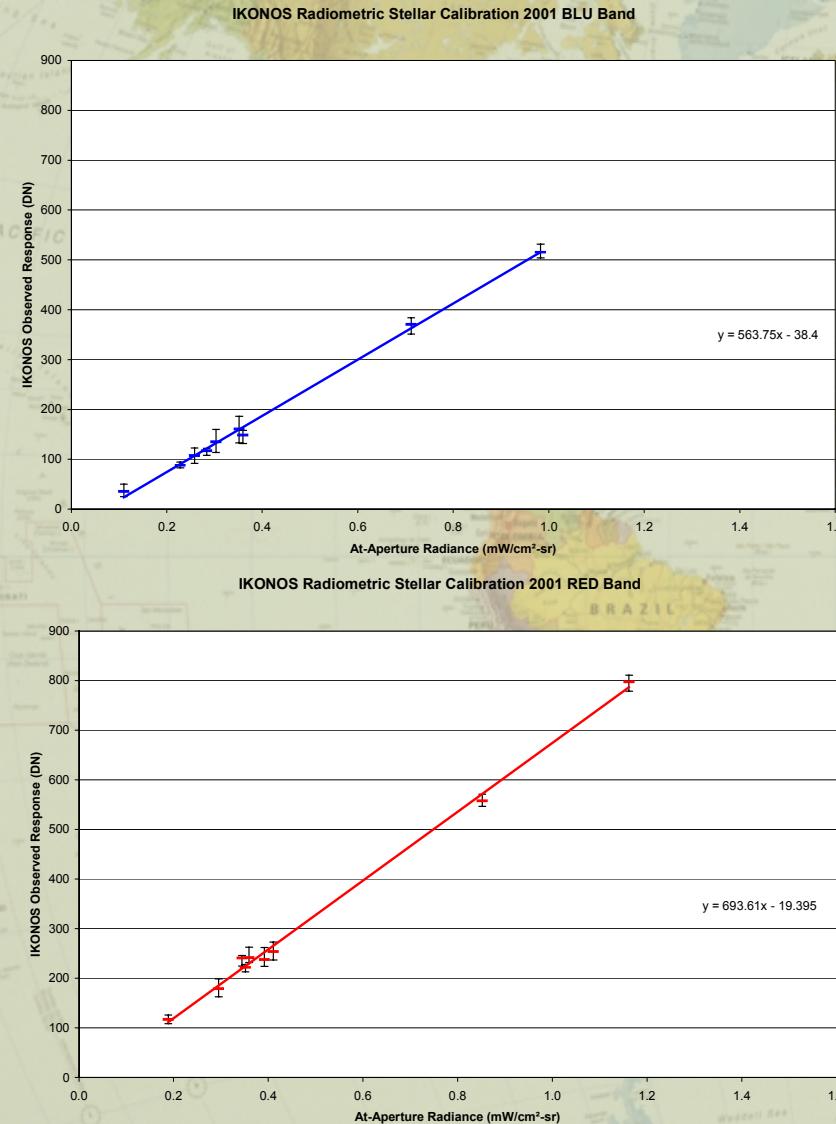


At-Aperture Radiance (mW/cm<sup>2</sup>-sr)

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# Stellar Collection Data Variability





# Updated SI Radiometric Calibration

- Update based upon 2001 GS Stellar Calibration Results
- Calibration of product is dependent upon production date
  - System Gain change 2/22/01 with LUT update
  - Improved Relative Calibration and uniformity

Updated IKONOS Radiometric Calibration (Pre-Release)  
Stellar Methodology  
(DN/(mW/cm<sup>2</sup>-sr))

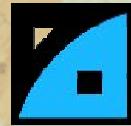
	Pre <u>2/22/01</u>	Gain Change	Post <u>2/22/01</u>
Blue	564	1.15	649
Green	592	1.12	663
Red	694	1.13	784
NIR	580	1.13	655



# On-Going Radiometric Calibration

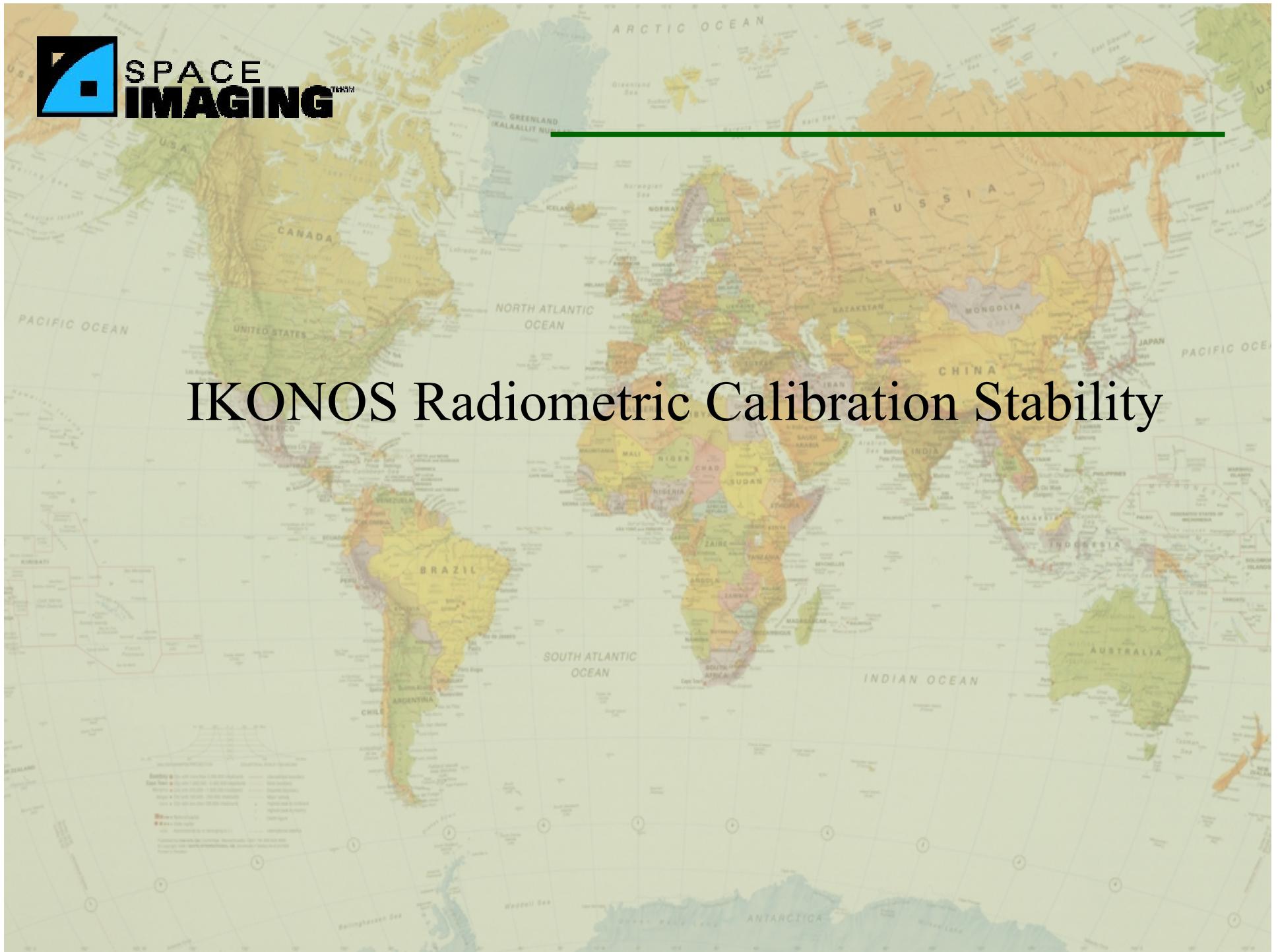
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- Calibration Discrepancy Investigation
  - SI/NASA discrepancy of system calibration exceeds expected measurement uncertainty in some bands
    - Results from SI stellar methodology consistently lower than ground-based vicarious method
    - Discrepancy appears to increase with wavelength
  - Consulting with system contractors and external agencies to understand potential sources of calibration errors
    - EK contacted for any payload nuances with stellar collection
      - PSF, Compression, evaluation/analysis, ...
    - Space Telescope Science Institute
      - IKONOS stellar methodology is fundamentally same as that used by HST
- Calibration Maintenance is nominal IKONOS operations
  - Periodic revisit of Radiometric Calibration to ensure stability
  - Maintenance of Radiometric LUT



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# IKONOS Radiometric Calibration Stability





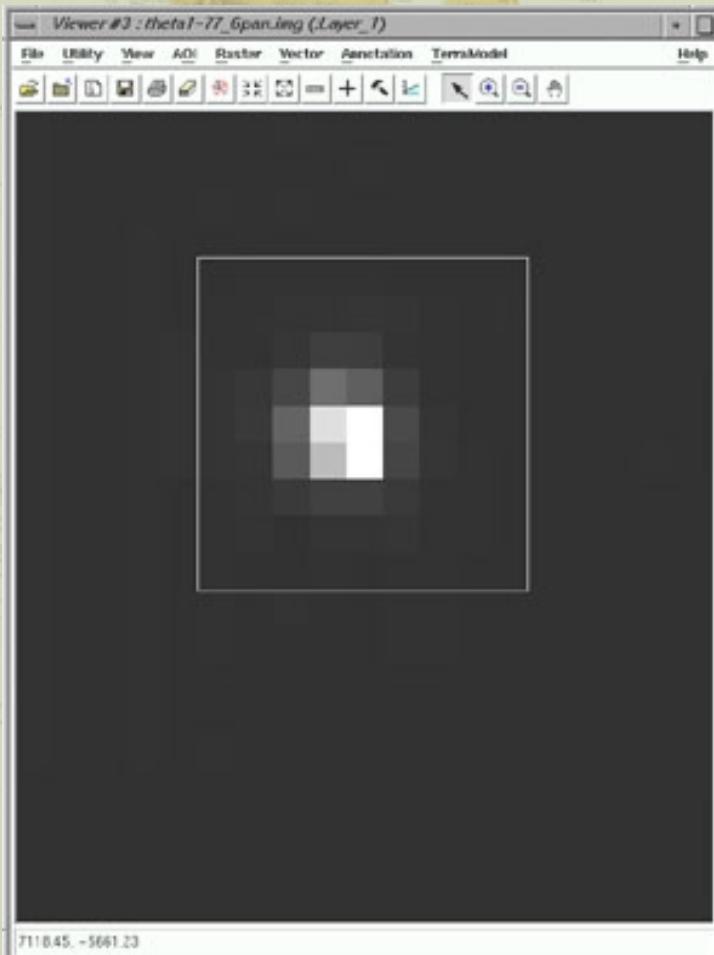
# Radiometric Calibration Stability

- Stability of IKONOS radiometric response demonstrated by separate corroborating methodologies
  - Stellar calibration
  - Solar imaging (calibrator)
  - Lunar imaging

	<u>Stellar</u>	<u>Solar</u>	<u>Lunar</u>
<b>Blue</b>	1.1%	---	stable
<b>Green</b>	0.3%	---	---
<b>Red</b>	2.0%	1.0%	---
<b>NIR</b>	1.0%	1.5%	---



# Stellar Imaging Stability Verification



- Stellar imagery used to verify system stability
- Same stars imaged during 2000 On-Orbit Testing and 2001 Collection
- Difference of system response to same star collected 1 year apart <2% on average



# Stellar Imaging Stability

- Difference of system response to same stellar collections separated by a year indicate good system stability

## IKONOS Radiometric Stability

Data from images collected During OOAT

Data from images collected in February 2001

Star Name	HIP#	BLU (DN)	GRN (DN)	RED (DN)	NIR (DN)	BLU (DN)	GRN (DN)	RED (DN)	NIR (DN)
Leo Epsilo-17	47908	407	553	493	420	385	529	466	402
Zozca	54872	798	763	472	333	792	763	461	333
Denebola	57632	1208	1119	684	463	1220	1158	688	477
Gem Gamma-24	31681	1491	1345	792	558	1507	1377	790	546

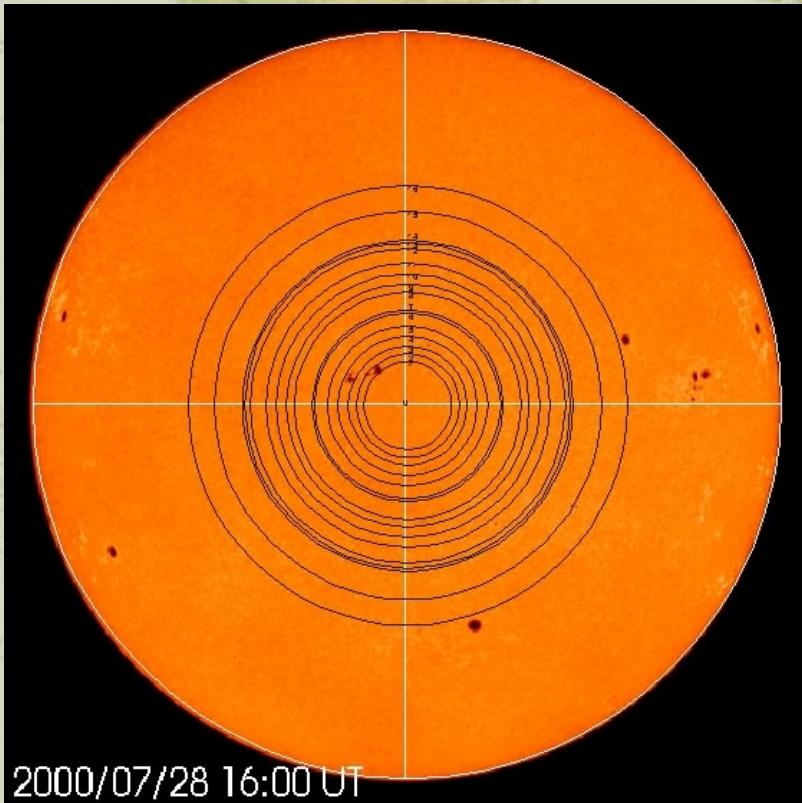
## Stellar Collection Difference

	HIP#	BLU	GRN	RED	NIR
		(%)	(%)	(%)	(%)
Leo Epsilo-17	47908	5.7	4.6	5.8	4.6
Zozca	54872	0.8	0.0	2.3	0.1
Denebola	57632	-1.0	-3.4	-0.5	-3.0
Gem Gamma-24	31681	-1.0	-2.4	0.3	2.1

Avg      1.1      -0.3      2.0      1.0



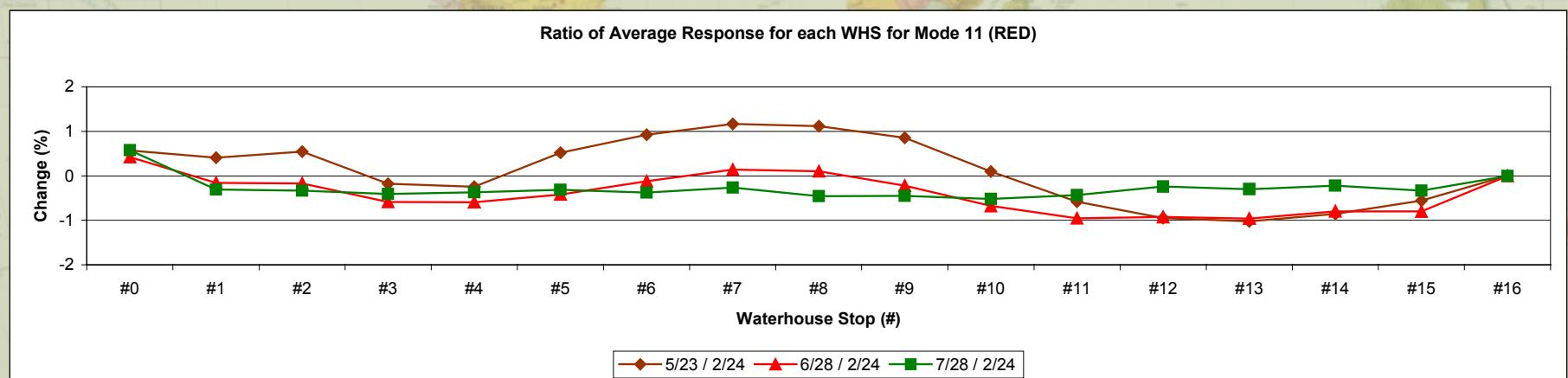
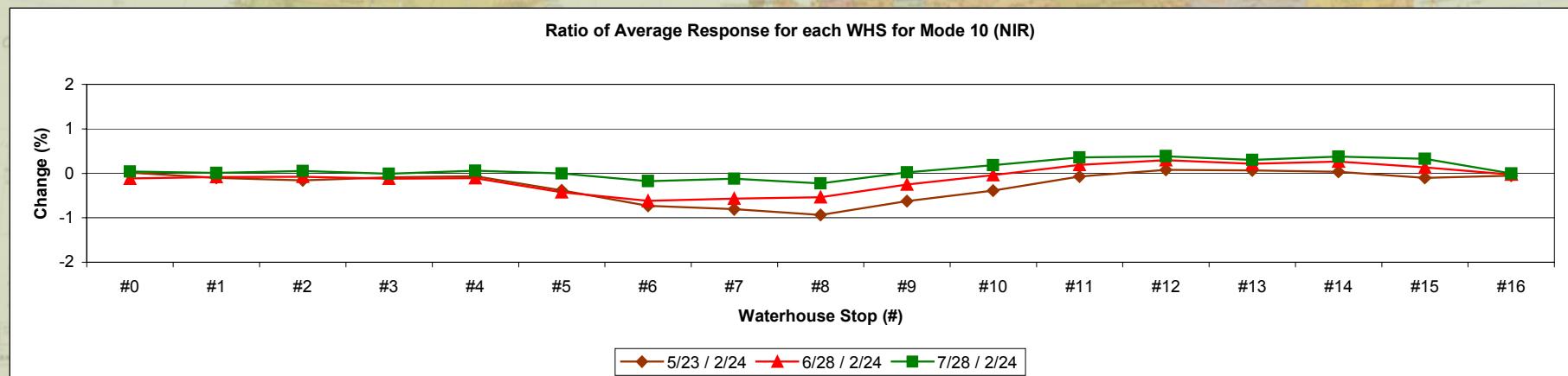
## Stability - Calibration Assembly



- 4 collections of solar images through payload calibration assembly in 155 day observation period
- Stable performance demonstrated
  - RED < 1% change
  - NIR < 1.5% change

# Solar NIR & Red MS Bands Results

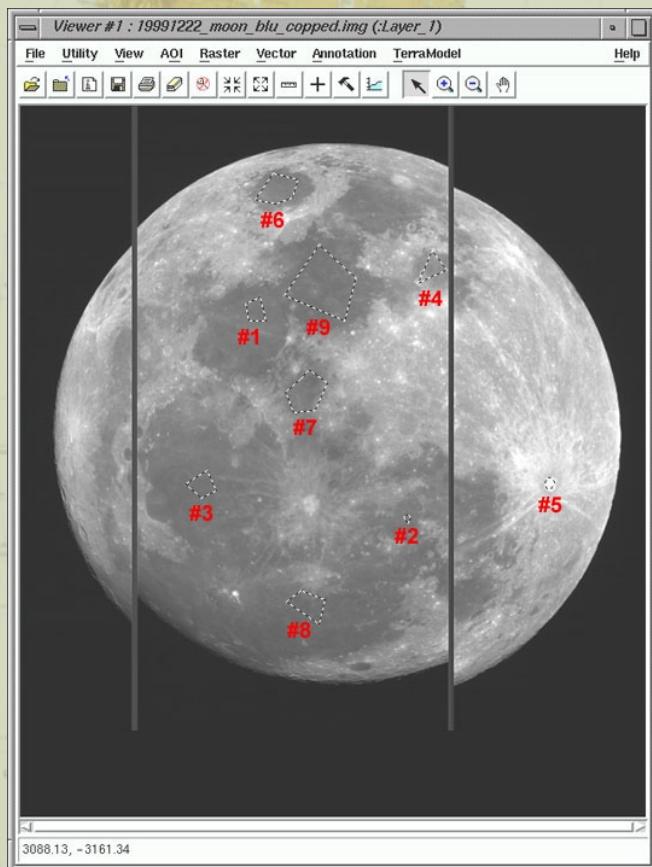
- % Change in NIR and RED Band from initial 2/24/2000 observation





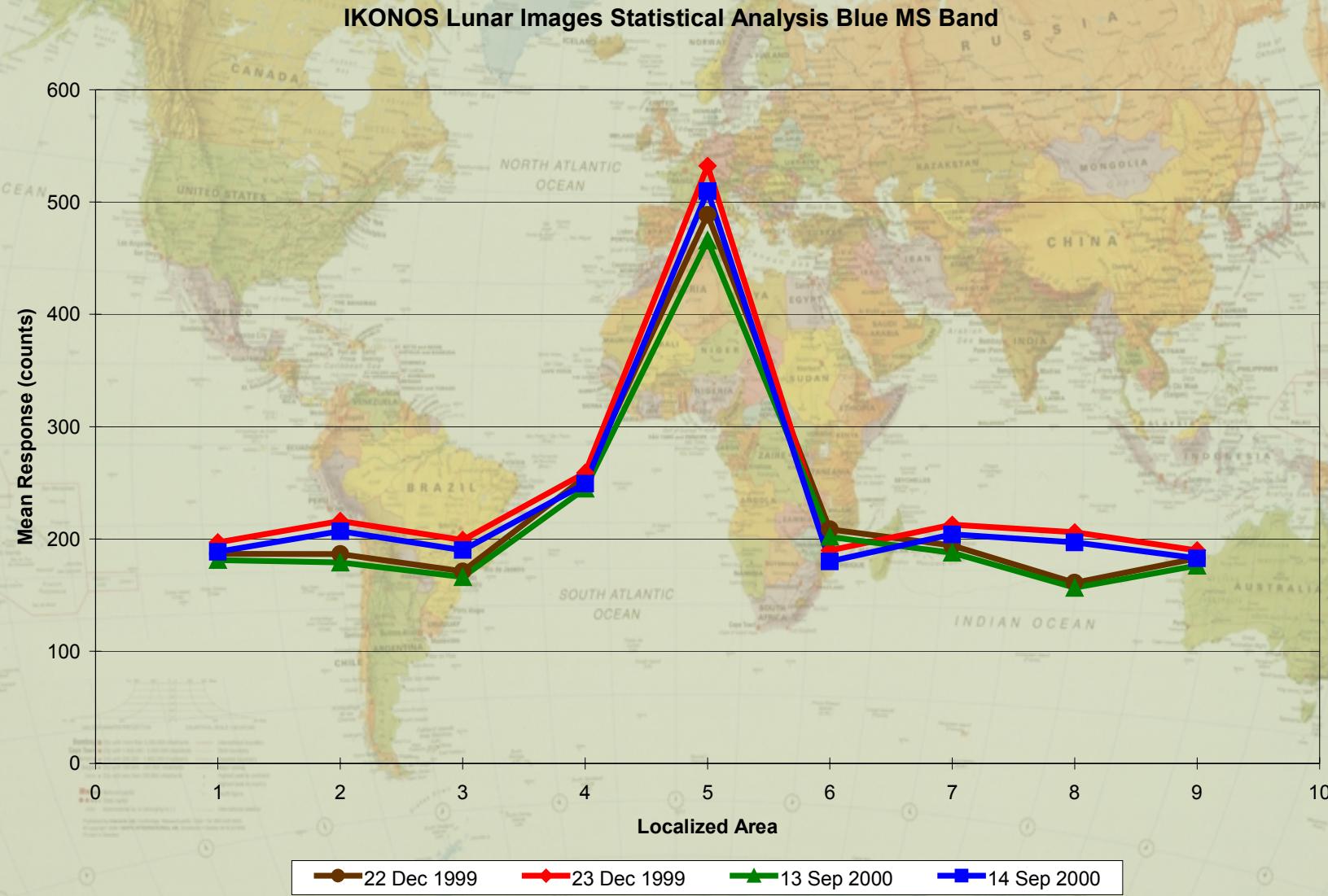
# Stability - Lunar Observations

Lunar Image 19991222



- Nine evaluation areas
- Each area defined by identifiable features
- Mean response within evaluation AOI evaluated for Blue response
- Coarse corroboration of through-aperture Blue stability
- Stable performance confirmed

# Lunar MS-BLU Band Results



- Exoatmospheric stellar methodology for radiometric calibration
  - Gunn & Stryker catalog as radiometric sources
- Discrepancy with ground-based vicarious calibration identified recently
  - Working it
- Re-release of system calibration pending
  - 2/22/01 system gain change and updated coeffs
- System response is stable