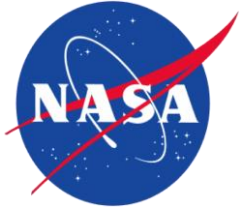
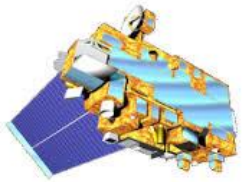


National Aeronautics and Space Administration
Goddard Space Flight Center



Coincident Cross-calibration of IKONOS, QuickBird, and MODIS of Railroad Valley Playa from 2005 & 2009

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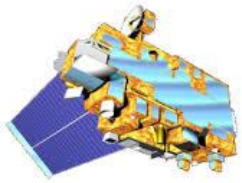
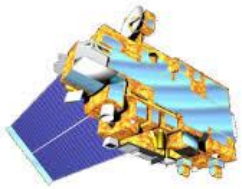
Overview



- Importance of Calibration
- Characteristics of Calibration Test Site
- Background on IKONOS, QuickBird, MODIS
- Data / Methods
- Results
- Future Work
- Conclusions

Calibration



- Use of high-resolution commercial images is on the rise
  - Accessible via USGS and NASA
  - Fulfill scientific needs
- Number of commercial datasets on the rise

<u>Quality and Quantity</u>

  - Decadal studies / trends
  - Earth system variables
- Ensure data are consistent and that the use of multiple satellite datasets are without biases
- Continue to assess radiometric and spatial quality
  - New commercial imagers, calibration lapse
- Consistent data leads to confident results

Calibration Test Site

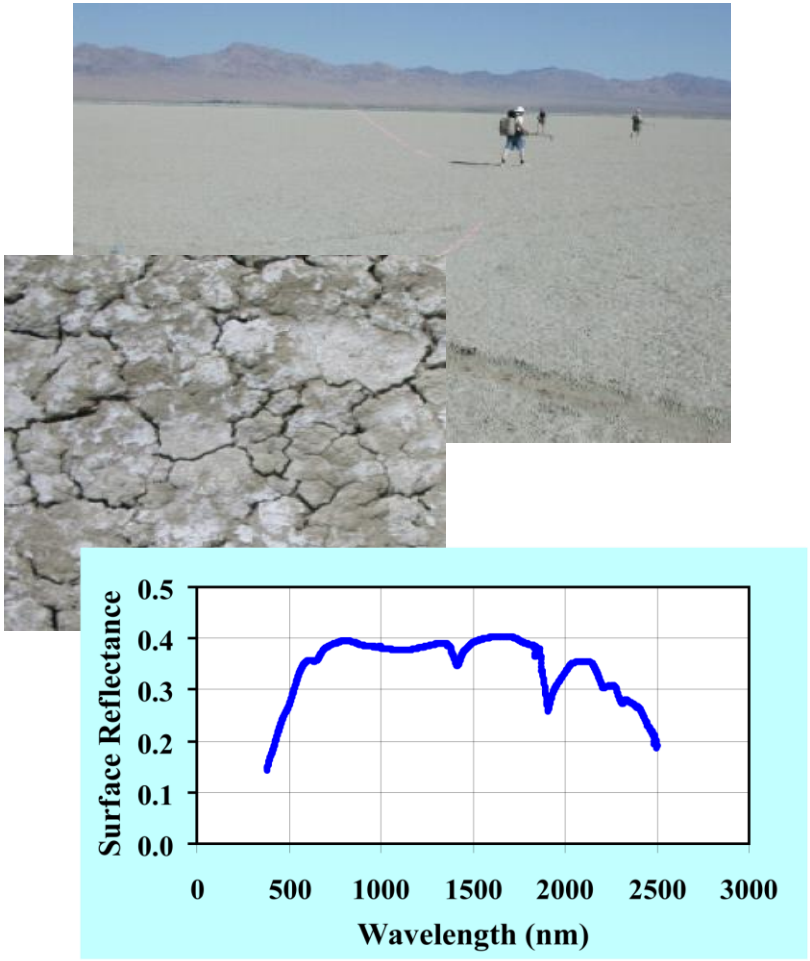
Railroad Valley Playa, NV USA

- Vicarious calibration site and post launch calibration reference site
- 200 miles north of Las Vegas
- 15 km x 15 km
  - ➢ Suitable for large footprint sensors such as MODIS and small footprint sensors such as IKONOS and QuickBird
  - ➢ Spatially uniform, minimizes effects of misregistration

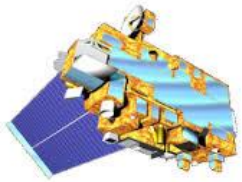
Calibration Test Site cont'd

- High spectral reflectance 0.4 at a wavelength longer than 500 nm
- Flat spectral reflectance in the visible and near infrared visible spectrum
  - ➢ Reduces the need for band correction
- Nearly Lambertian for view angles < 30° from nadir
  - ➢ It minimizes BRDF effects
- Elevation ~1.5km
  - ➢ Low aerosol loading

Kurt knows the area well!



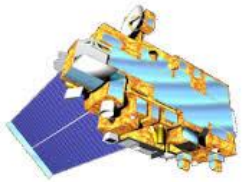
MODIS Background



- Launched in Dec. 1999
- One of five sensors on board the EOS flagship, Terra

	MODIS
Swath width	2333 km
Crossing time	10:30 AM (solar time)
Orbit altitude	705 km
Scanner	Paddlewheel scanner
Spectral range	250m: band 1 (0.62 -0.67), band 2 (0.84 – 0.88) 500m: band 3 (0.46 - 0.48), band 4 (0.55 - 0.57) 1000m: bands 8 - 36
On-board calibrators	Solar diffuser and solar diffuser stability monitor

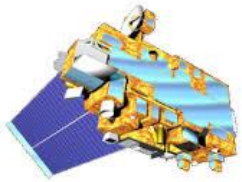
IKONOS & QuickBird

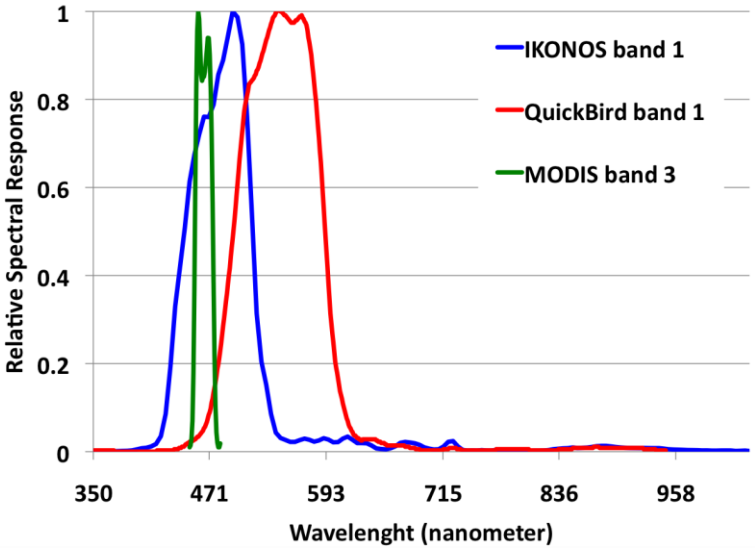


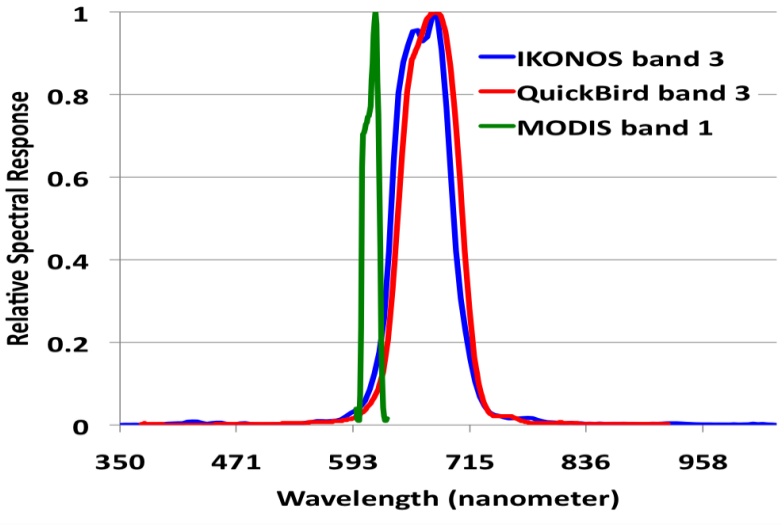
Operated by Digital Globe

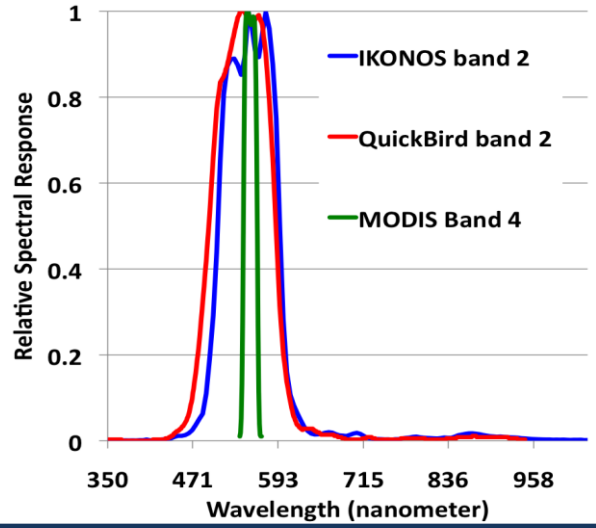
	IKONOS	**QuickBird**
Swath width	11.3 km	14.9 km
Crossing time	10:30 AM (solar time)	10:30 AM (descending time)
Orbit altitude	681 km	450 km
Scanner	pushbroom	pushbroom
Spectral range	Band 1: 0.445 - 0.516	0.450 - 0.520
	Band 2: 0.506 - 0.595	0.520 - 0.600
	Band 3: 0.632 - 0.698	0.630 - 0.690
	Band 4: 0.757 - 0.853	0.760 - 0.900

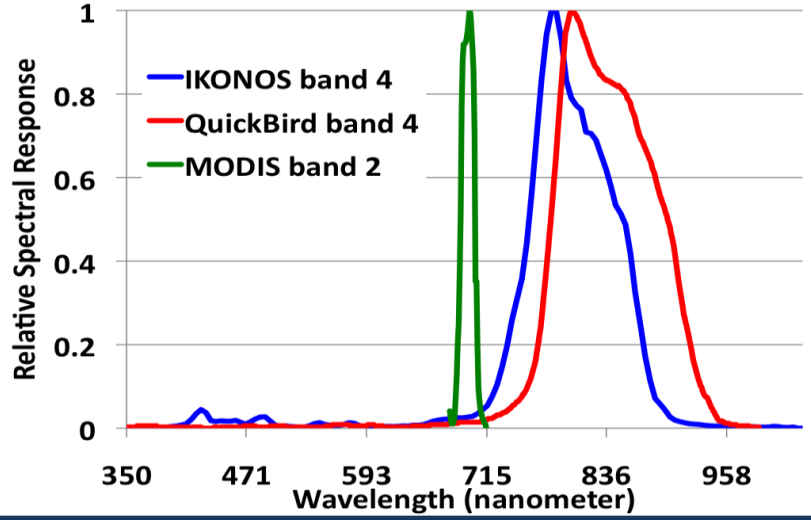
Additional Instrument Background



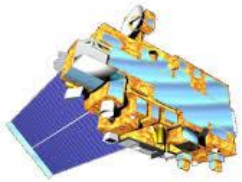








Data



	IKONOS	QuickBird	MODIS
	USGS & NASA distribution portals		NASA
Registration	Privileged user		free
# of Images	38	90	~250 TB
Time period	5/2000 – 9/2014	5/2002 - 2/2013	4/2000 - present

Image Selection Criteria:

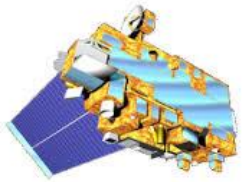
- Easy format
- Summer, cloud free
- Post 2005

Data

Coincident IKONOS and MODIS image pairs

	July 6, 2009		July 9, 2009		August 8, 2009	
	IKONOS	MODIS	IKONOS	MODIS	IKONOS	MODIS
Overpass time	18:34	18:35	18:42	19:05	18:35	19:20
Solar Zenith Angle	22.4	20.9	21.5	21.0	27.6	25.8
Solar Azimuth Angle	129.29	126.6	133.7	131.05	139.22	127.76
Sensor Zenith Angle	15.6	45.6	12.1	13.6	10.5	25
Sensor Azimuth Angle	138	104	349.89	284	66.7	104

Data

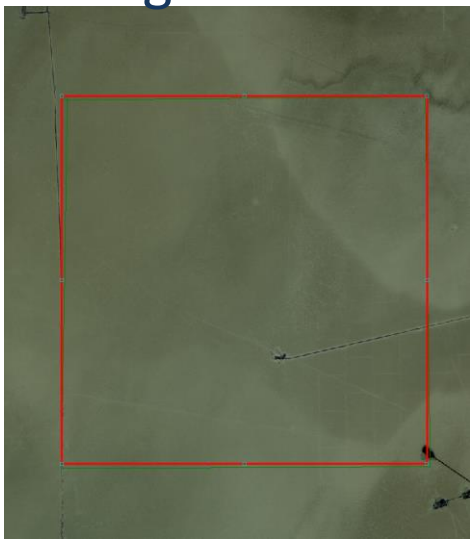


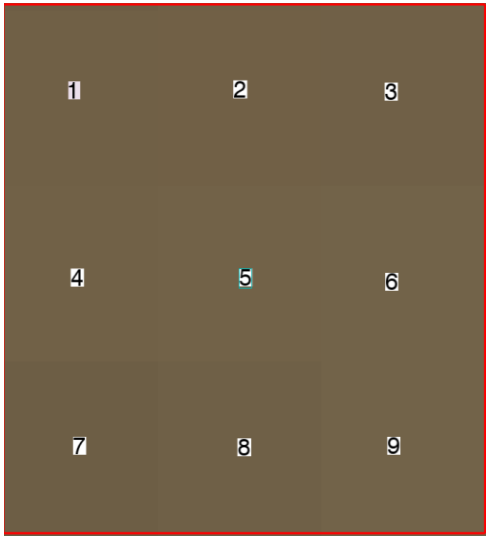
Coincident QuickBird and MODIS image pairs

	Same date different geometry (7/13/2005)		Different date same geometry (7/11/2005)
	QuickBird	MODIS	MODIS
Overpass time	18:48	18:25	18:35
Solar Zenith Angle	21.0	21.7	20.9
Solar Azimuth Angle	138.0	90.82	113.04
Sensor Zenith Angle	23.9	26.4	15.8
Sensor Azimuth Angle	335.3	98.3	99.1

Methods

Registration based on geolocation information





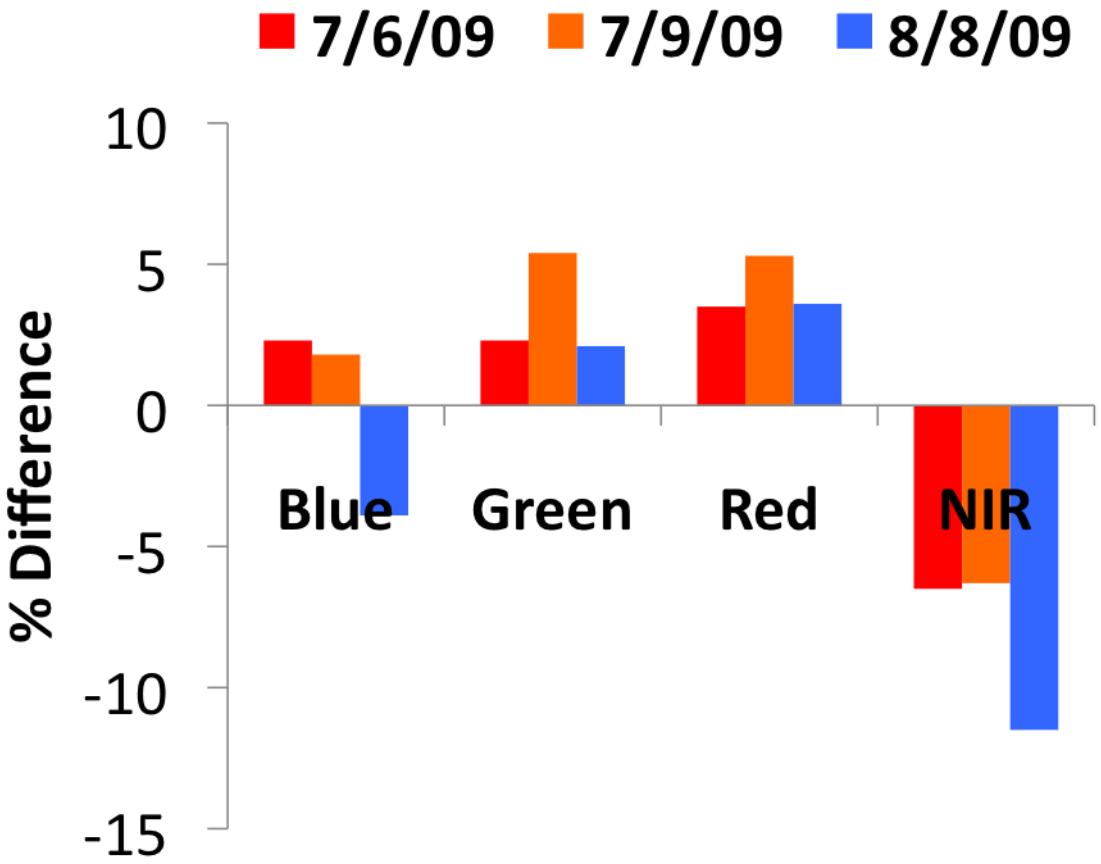
DN -> L_λ -> TOA Reflectance

MOD02/MOD3
TOA Radiances -> TOA Reflectance

Solar Spectrum: Chance, WRC, Thuller

IKONOS / MODIS Results

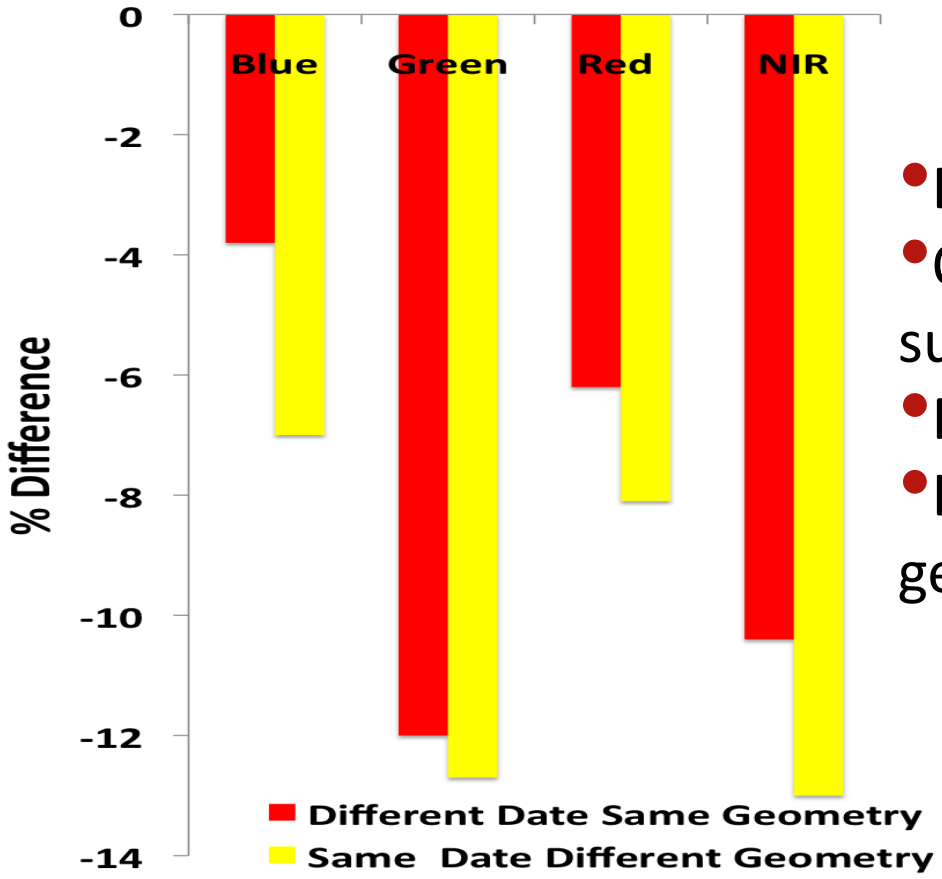
% difference among same channels for IKONOS and MODIS



1-(TOA P_{DG}/ TOA P_{MOD})

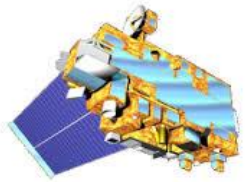
QuickBird/ MODIS Results

% difference for similar channel between QuickBird and MODIS



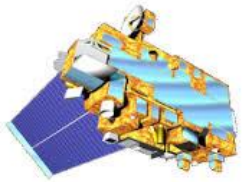
- Bias can be BRDF effect
- QB looking from NW back to sun
- MODIS is cross-track
- Looking for a better geometry match

Results



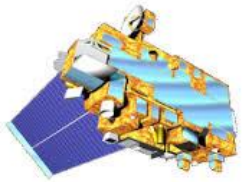
- IKONOS and MODIS produced acceptable results.
- QuickBird and MODIS showed bias; from sensor and satellite geometry information, bias can be attributed to BRDF effect.
- Coincident dates with similar geometry on the same orbit are acceptable cross calibration approach; however, non-coincident dates with similar geometry yield acceptable (if not better) results as well. We're looking into this.

Future Work



- Satisfied with Controlled Experiment and Approach (without removing any uncertainties)
  - Spectral correction
  - BRDF
  - More dates
- Minimizing uncertainties will yield better error budget and better idea of calibration status

Conclusions



Lessons learned:

- We can grab any available commercial images from USGS and NASA and cross-calibrate against daily imaged calibration site by MODIS; furthermore, our method shows that even large view difference works. We're only limited by the number of commercial images available for calibration work
- Vicarious calibration approach works and it's cost effective
- Commercial sensors need to continue to image calibration sites so that we can continue to calibrate and cross-calibrate sensors across platforms so that data are consistent