OCEANSAT-2
Ocean Colour Monitor (OCM-2)

Pre-launch calibration & Post-launch performance

presented by

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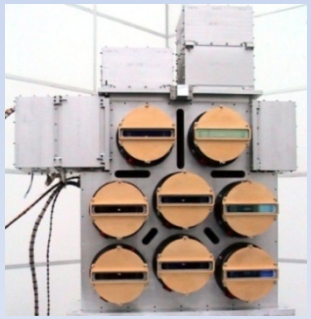
Oceansat-2

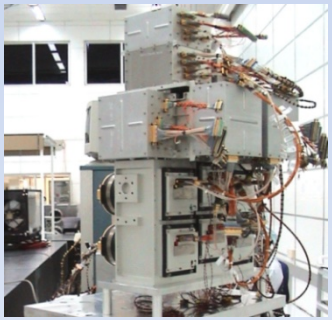
Launched : 23 Sept 2009
Orbit : 720 Km
Inclination : 98.28 deg
Revisit cycle : 2-days
Swath/Resolution : 1420 Km/
360 m X 236m
Time of Pass : 12 noon
Along track Steering : ± 20 deg

Instruments on Oceansat-2

- OCM-2: Ocean Colour Monitor
- OSCAT: Ku-band Scatterometer
- ROSA: ASI's Radio Occultation Sounder for Atmosphere



(OCM-2 Optics side)



(detector head side)

OCM-2 Design

(8 VNIR spectral bands)

- 8-element telecentric lens assembly per band
- f-length: 20 mm ; f/no. = 4.3
- FOV: ± 43 deg
- 2-element bandpass filter + 1 thermal filter
- 3730 of 6k element linear array CCD device
- 12 – bit quantisation
- Exposure (gains) : 16 levels
- SNR > 512 at saturation (land reflectance)
- Band-to-band registration : ± 0.25 pixel
- MTF > 0.26
- 4 LED's as onboard cal source per band

OCM-2 Data Products

LEVEL-1 Product: Basic Data Products

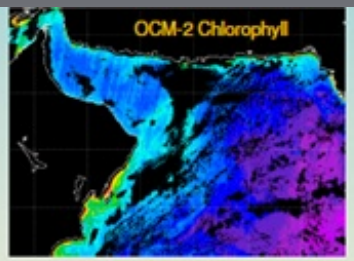
- L1A RAW Products
- L1B Radiance Product
- L1C Radiometrically and Geometrically corrected

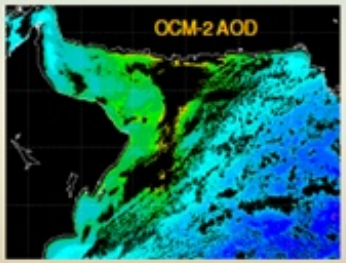
LEVEL-2 Product: Geo-Physical Parameters

- Chlorophyll-a concentration
- Total Suspended Matter (TSM)
- Diffused Attenuation Coefficients (K_d-490 nm)
- Aerosol Optical Depth (AOD) at 865 nm

LEVEL-3 Product: Binned Products (4 km)

- Weekly
- Monthly
- Yearly



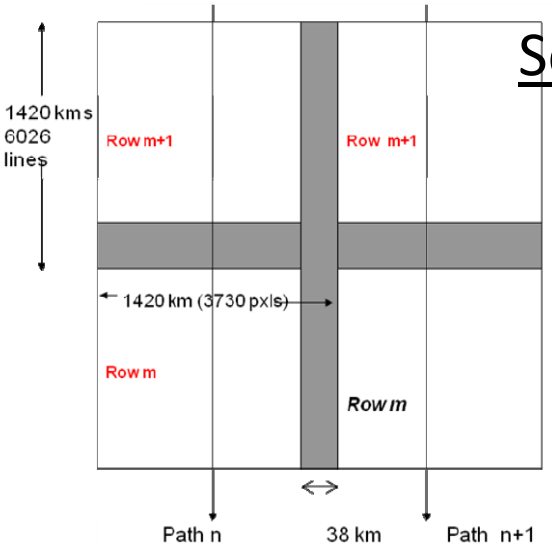


LAC Coverage

360 m Spatial Resolution

Real time transmission

Scene Layout



GAC Coverage

1 Km/ 4 Km Spatial resolution

Onboard recording and Playback

Sensor Characterisation

- Pre-launch Spatial & Radiometric
- Onboard calibration using LEDs
- Vicarious calibration using Ocean Buoy
- Lunar Calibration
- Spatial & Radiometric Image based characterization

System Performance

A) Geometric/ Spatial Parameters
- MTF / SWR
- Band-to-Band Registration
- Payload cube alignment
- IGFOV as a fn of look angle

A) Radiometric Parameters
- Relative Spectral Response
- Saturation Radiance
- Signal-to-Noise Ratio
- Temperature Response at 5 deg to 25 deg C

Pre-launch Performance (Radiometric / Spatial)

Uncertainty in radiometric calibration:

- Veiling Glare of Lens Assembly : < 1.6 %
- Polarization of lens assembly: < 2.3 %
- Absolute calibration of standard source @ 655 nm < 2.4 %
- Transfer radiometer uncertainty < 2.0 %
- Non uniformity of integrating sphere < 4.0 %

Overall Absolute Radiometric Uncertainty(1σ) < 6 %

Instrument Spectral Bands	Wavelength Range (nm)	SNR @ Ref Radiance	Nominal reference radiance of Sea (mW/cm²/sr/µm	Saturation radiance (mW/cm²/sr/µm)
C1	402-422	356	9.1	70.2
C2	433-453	386	8.4	36.5
C3	480-500	380	6.6	29.6
C4	500-520	324	5.6	25.8
C5	545-565	311	4.6	21.2
C6	610-630	240	2.5	16.0
C7	725-755	286	1.6	1.9
C8	845-885	141	1.1	14.3

MTF Performance @ nadir (360m X 360 m)

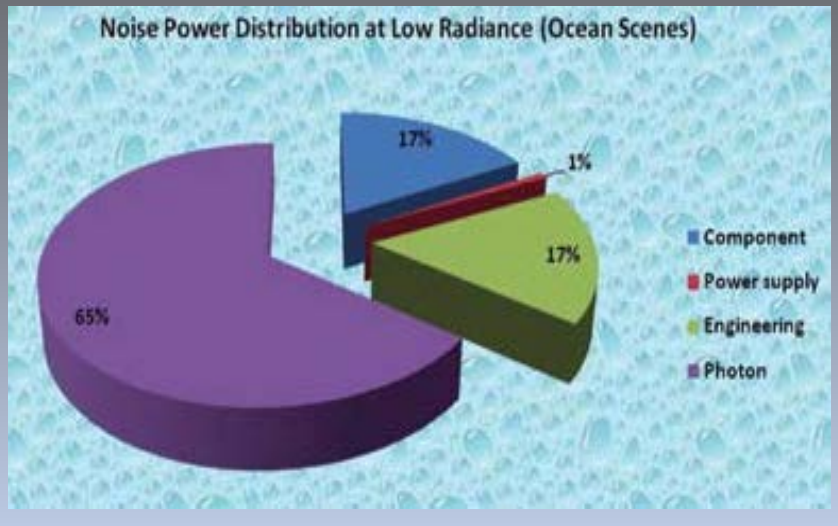
- Lens MTF 0.55
- Device MTF
  - Along Track 0.75
  - Across track 0.57
- Due to alignment & Envir. 0.84
- System MTF
  - Along Track 0.34
  - Across Track 0.26

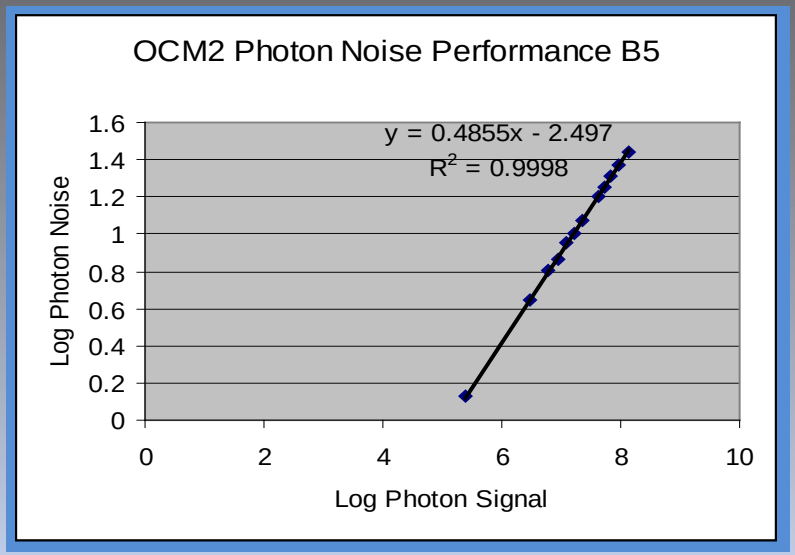
Mis-registration (Band-to-Band) in pixel

- BBR @ Ambient ± 0.16
  - Format matching (+test set up) ± 0.15
  - Distortion ± 0.05
- BBR Stability (environment) rss ± 0.16
  - Collinearity ± 0.10
  - Format Change ± 0.10
  - Structural stability ± 0.05
  - Distortion change due to environment ± 0.05

Overall mis-registration (band-to-band) ± 0.23

OCM-2 System Noise performance



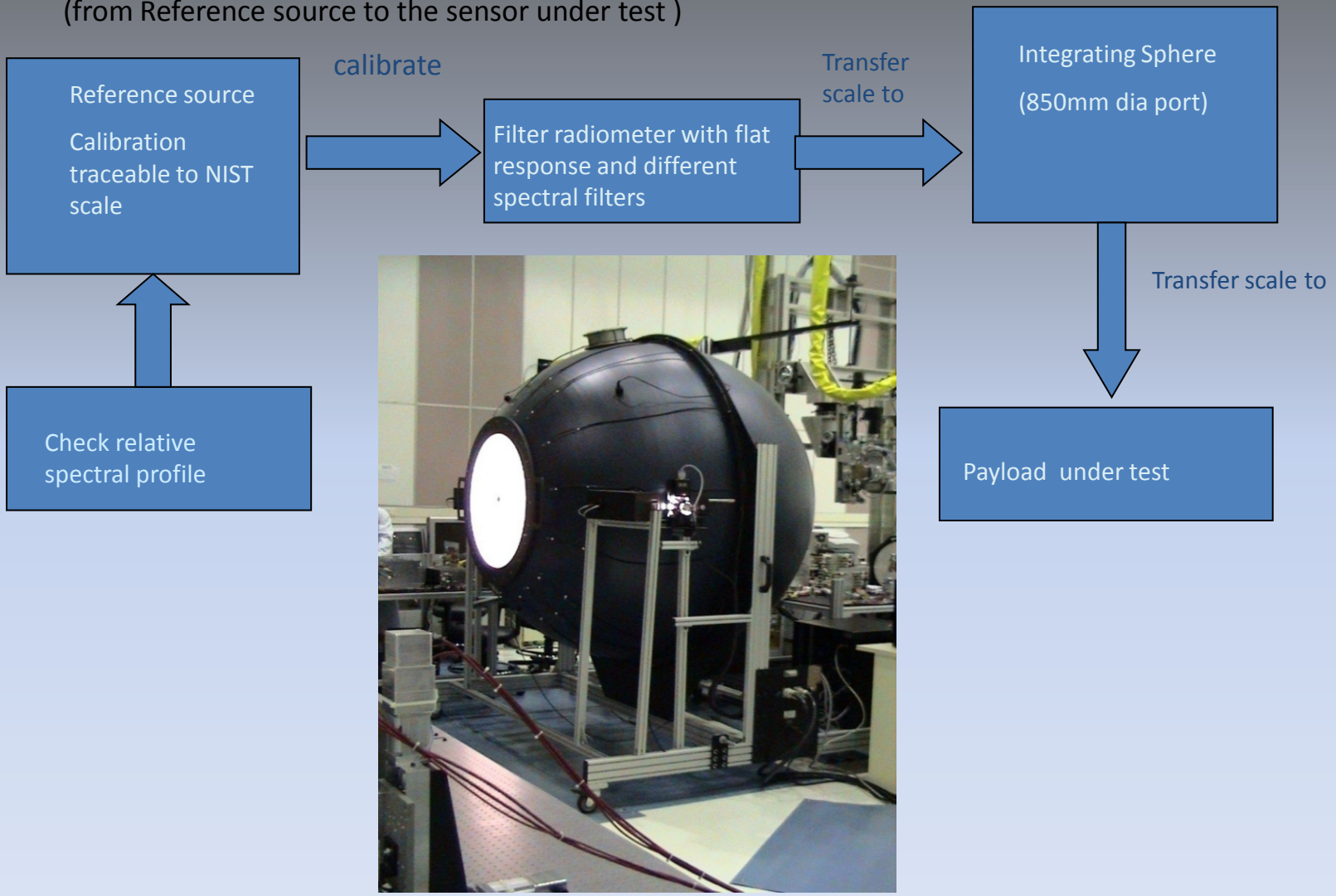


OCM-2 Noise Equivalent Spectral Radiance ($mW/cm^2/sr/\mu$)

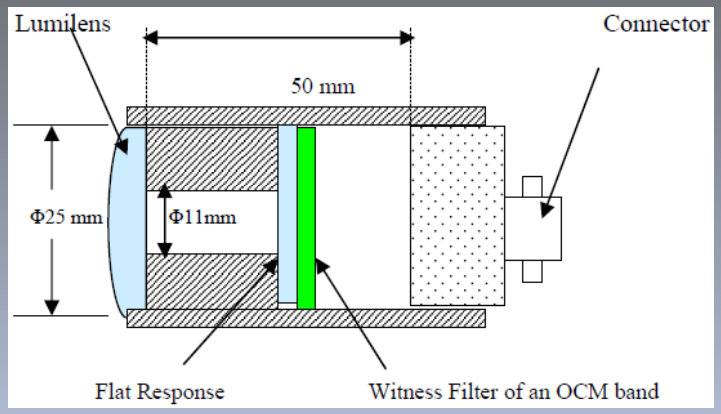
Band	Ocean Ref Rad.	$NE\Delta L_{noise}$	SNR (noise)	$NE\Delta L_{norm}$	$NE\Delta L_{quant}$	$NE\Delta L_{prod}$	SNR (prod)
C1	9.1	0.033	274	0.013	0.005	0.036	254
C2	8.4	0.025	334	0.027	0.003	0.037	228
C3	6.6	0.017	397	0.015	0.002	0.023	290
C4	5.6	0.015	379	0.016	0.002	0.022	254
C5	4.6	0.013	357	0.014	0.002	0.019	239
B6	2.5	0.007	357	0.006	0.001	0.009	270
B7	1.6	0.005	345	0.005	0.001	0.007	224
B8	1.1	0.004	256	0.007	0.001	0.008	135

Transfer of radiance scale (Vis-NIR-SWIR)

(from Reference source to the sensor under test)



Laboratory Radiometer & NMI Traceable Reference Sources



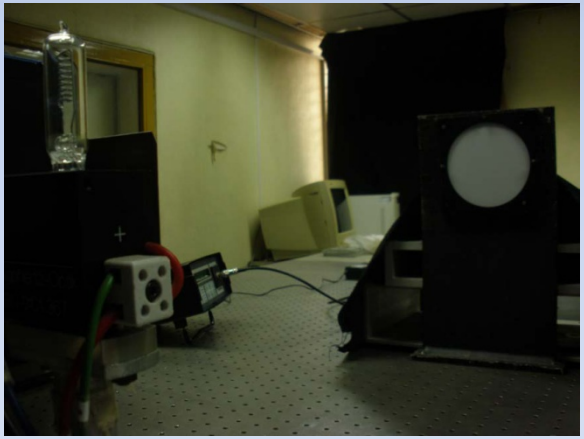
VNIR Radiometer Head – UDT Inc. make

The calibration factor of the radiometer is given by

$$\text{Cal.Factor} = \left(\frac{\text{Band.avg.sp.rad}_{\text{Ref.source}}}{\text{Radiometer.photocurrent}} \right), \quad \text{mW/cm}^2\text{-sr-}\mu \quad \text{per} \quad \mu\text{A}$$

12” Integrating Sphere
Labsphere Inc. USA

6” Integrating Sphere
Calibrated at FASCAL Facility NIST



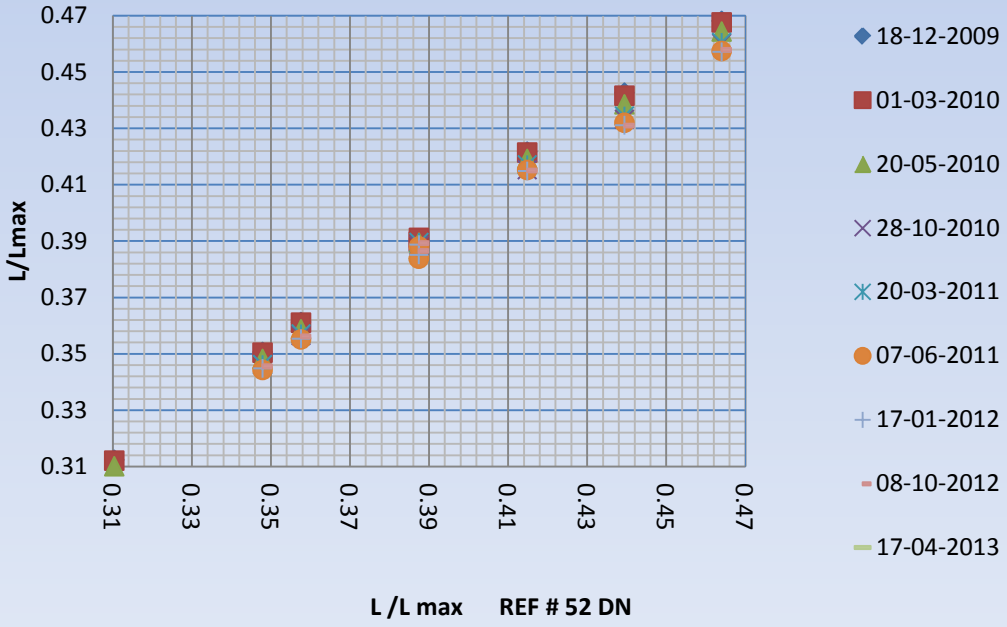
FEL lamp + diffuser
(EG&G Gamma Scientific, USA)

Post-launch Performance

In-flight Calibration :

- Monitors system degradation; optics not covered
- Four LEDs in each band mounted at 71 deg to detector array plane
- Generates 16 intensity levels through exposure control mechanism of CCD
- 128 lines used to compute statistical parameter of individual pixel on the detector
- Criteria applied for detector flagging is based in Chi-squared fit statistics

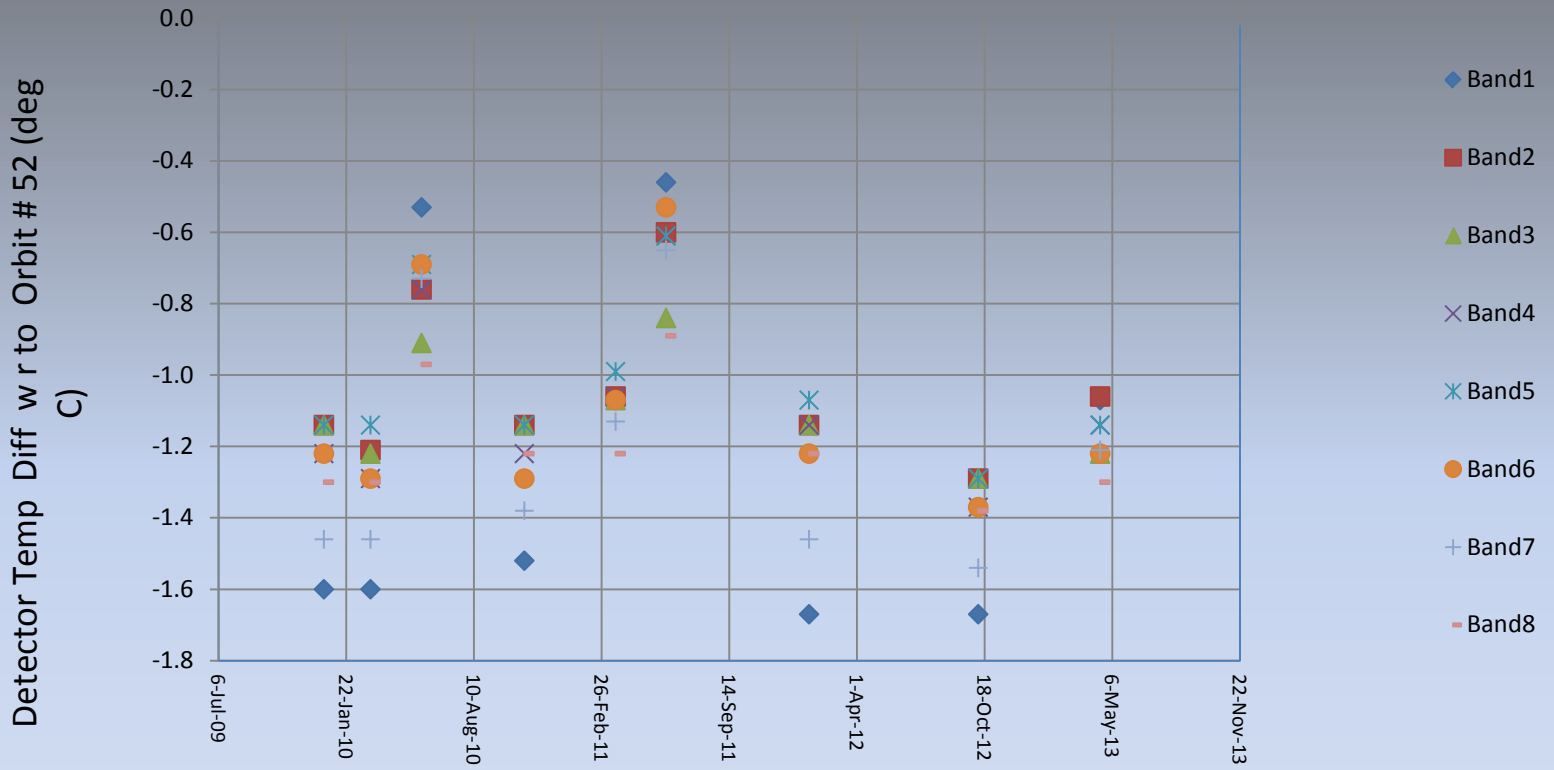
OCM2 Band wise array mean wrt Ref Orbit 52 (Exp-16)



% Variation after Day # 1300 of launch to first day ref. data

Band No	% Variation
B1	- 0.3
B2	- 0.7
B3	- 0.2
B4	- 0.6
B5	- 0.6
B6	2.3
B7	0.4
B8	- 2.3

OCM-2 detector Temp varying through diff orbit



- Shows diurnal variation in CCD temperature
- Last data on 17-April-2013

Data Quality Evaluation

Geometric & Radiometric Performance: (monitored on regular basis)

- **Geometric parameters (specs)**
  a) Location accuracy (< ± 3.8 km)
  b) Scale variation (< 0.05 %)
  c) Internal Distortion (< ± 3 pixel)
  d) Residual attitude bias
  e) Band-to-band Registration (BBR)
  i) Rad product (± 0.5 pixel)
  ii) Geometric product (+ 0.25 pixel)

Radiometric parameters

a) Scene Dynamic Range
b) Signal-to-Noise Ratio
c) Relative band behaviour
d) Inter-sensor comparison
i) OCM-2 with OCM-1
ii) OCM-2 with Aqua MODIS

Results

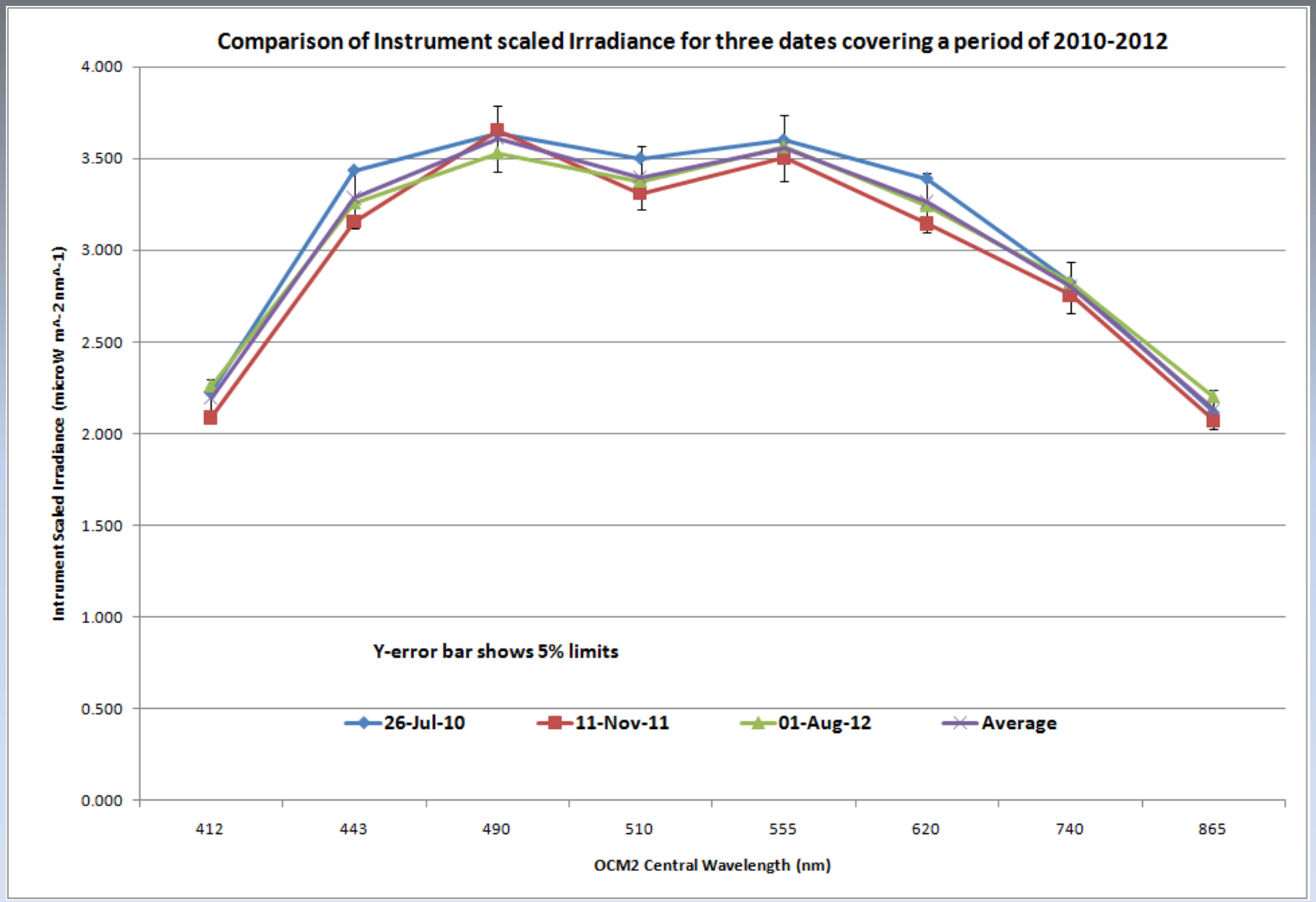
Location accuracy for L1C product: Within 2-3 pixels
Internal Distortion: Within 1.5 pixel
Side lap (gives info on orbit drift): 9 % to 17.3 % (for 90 % of products) (2009- 2011)

- Algorithms for band-to-band registration (a) Sequential Similarity Detection (b) Mean bias correlation
- BBR quantifies per pixel classification based on along and across track computation
- Features like desert, barren land, lake water used to check linearity, dynamic range, SNR
- Along the pixel array direction BBR is within specs L1C ±0.5 pixel ; along track it is about 0.8 pixel

Platform is stable and Products are found to meet specs

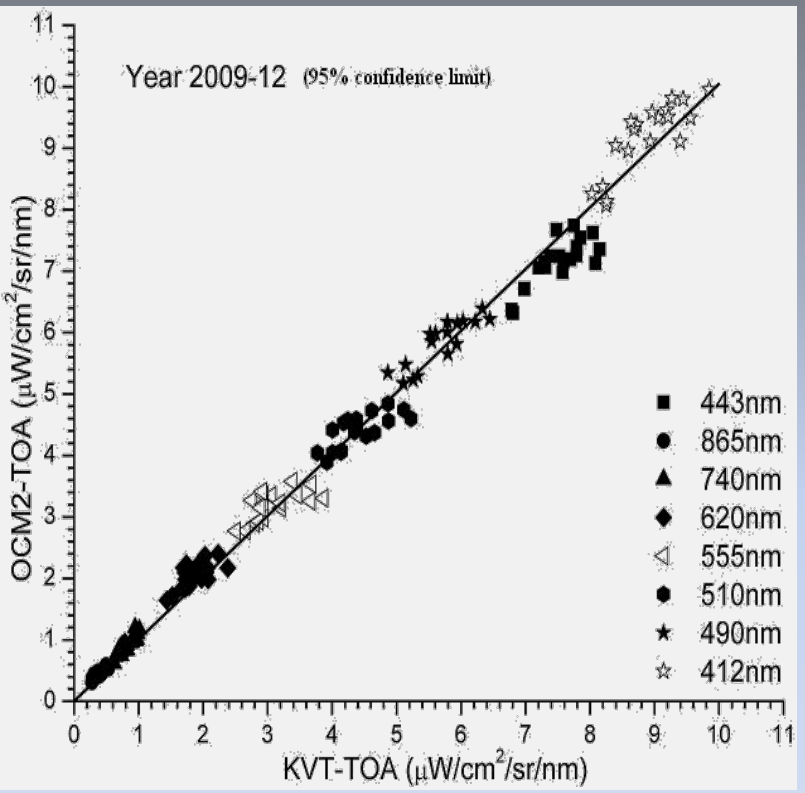
International Colour Science (IOCS-IOCCG) Meet May 6-8, 2013 Darmstadt, Germany

Lunar Observation



Vicarious calibration results of OCM2

TOA radiance with 95% confidence



Band No.	Total points	CC (R^2)	Mean TOA radiance (μW/cm²/sr/nm)	
			KVT	OCM2
1	20	0.978	8.865	9.191
2	19	0.977	7.530	7.169
3	17	0.976	5.684	5.830
4	21	0.936	4.402	4.410
5	19	0.876	3.094	3.202
6	20	0.873	1.873	2.059
7	21	0.929	0.817	0.904
8	15	0.910	0.392	0.455

Band	Year 2009-10	Year 2011	Year 2012
	Gain± SD	Gain± SD	Gain± SD
1	0.93±0.04	0.97±0.03	0.95±0.03
2	1.03±0.04	1.06±0.04	1.06±0.02
3	0.96±0.04	0.97±0.04	0.92±0.04
4	1.00±0.07	0.97±0.05	0.97±0.04
5	1.00±0.09	0.93±0.07	0.91±0.05
6	0.95±0.08	0.86±0.07	0.87±0.06
7	0.88±0.07	0.88±0.06	0.92±0.07
8	0.88±0.05	0.71±0.05	0.81±0.02

Gain coefficients measured at Kavaratty site

Data dissemination and web portal

CALVAL

CALIBRATION AND VALIDATION PROGRAM
Space Applications Centre, ISRO

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Calibration & Validation Program

ISRO has taken multi pronged initiatives for understanding key issues concerning global changes. This activity requires validation for all the products generated thereby.

A high-tech site is developed at Kavaratti with sensors installed in the ocean for measuring various parameters. Similarly, Principal Investigators and Collaborating Agencies also collect data at field level. Other sites and sub sites are being developed at Kolkata, Gadanki and so on for collecting in-situ data and supporting CALVAL activity for all ISRO Science Missions.

This web site facilitates the archival, visualisation and dissemination of the in-situ data for scientific interpretation and analysis of data from these and future missions.

OCEANSAT-2 INSAT-3D MEGHA TROPIQUES SARAL/ALTIKA

OCEANSAT-II is India's second satellite launched for the study of the oceans as well as the interaction of oceans and the atmosphere to facilitate climatic studies. It carries two major payloads viz. Scatterometer (Ku band) and ROSA (GPS receiver).

View More..

Sensors

Met & Optical buoys on CAL-VAL Site

Sun/Sky Photometry on Island

Optical Disdrometer

Lessons Learnt

- **Interoperability of Ocean Colour sensors is a necessity**
- **Validation of pre- and post-launch calibration**
- **Contingency plan to guard against test instrument failure**
- **Follow set processes and guidelines in laboratory practices**
- ***Detector based* traceability chain to be implemented**
- **Image evaluation as part of pre-launch calibration prior to launch**
- **Specify 'quality' indicators**

Contributions from

National Remote Sensing Centre - Hyderabad

- **A Senthilkumar** — **Time Series data with onboard LEDs**
- **B Santhisree**

Space Applications Centre - Ahmedabad

- **B Kartikeyan** — **In-orbit Spatial & Radiometric charact. &**
- **Yogdeep Desai** — **Lunar Cal (used ROLO model)**
- **Bankim Shah**

- **A K Shukla** — **CalVal (Ocean buoy – Kavaratty Islands)**
- **K N Babu**

- **Nitant Dubey** — **Data Products software & Lunar observation**

- **Prakash Chauhan** — **Estimate of ocean parameters & Intercomparison OCM-2 with Aqua MODIS**