

ISRO CAL-VAL ACTIVITIES

Dr.Ashok K.Shukla

Head, Calibration & Validation Division

Deputy Project Director, OCM2 CAL-VAL

Team Leader, Saral/AltiKa CAL-VAL

Space Applications Centre

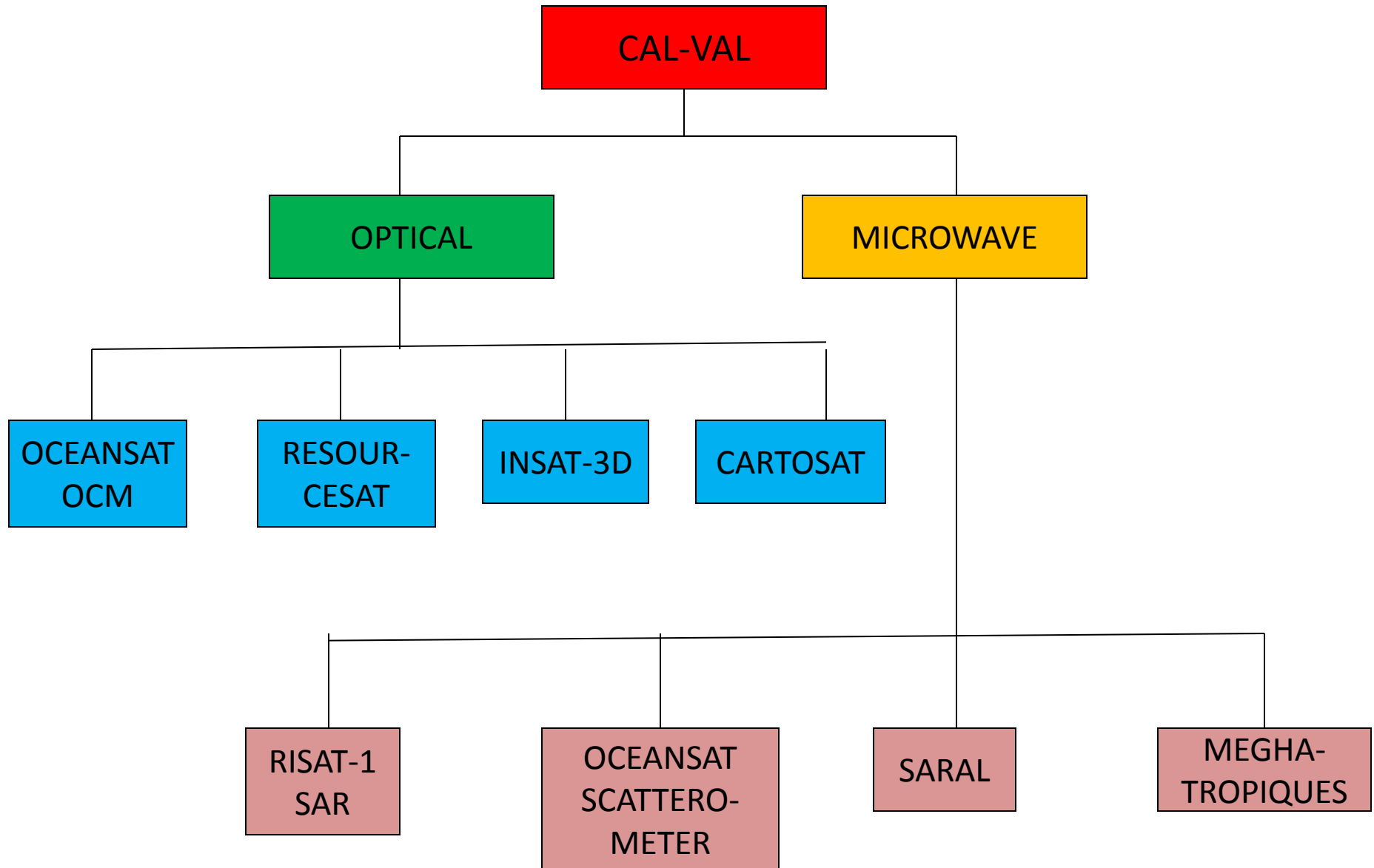
Indian Space Research Organisation

Ahmedabad, India

Outline

- **ISRO Cal-Val activities**
- **OCM2 Ocean color Cal-Val**
- **Kavaratti Cal-Val site in ocean**
- **Vicarious calibration of OCM2 using Kavaratti**
- **Briefs on other Cal-Val activities**

CAL/VAL activities for Land, Ocean & Atmosphere



ISRO missions

Satellite	Sensor(s)
IRS-1D	LISS-III , PAN , WiFS
OCEANSAT-1	OCM
TES	TES PAN
KALPANA-1	DRT-S&R , VHRR
INSAT-3A	CCD camera , DRT-S&R , VHRR
CARTOSAT-1	PAN
CARTOSAT-2	PAN
IMS-1	HySI (IMS-1) , MxT
RISAT-2	SAR-X
OCEANSAT-2	OCM , ROSA , Scatterometer

Air-borne	Sensor(s)
DMSAR	C-SAR
AHySI	Hyper-spectral

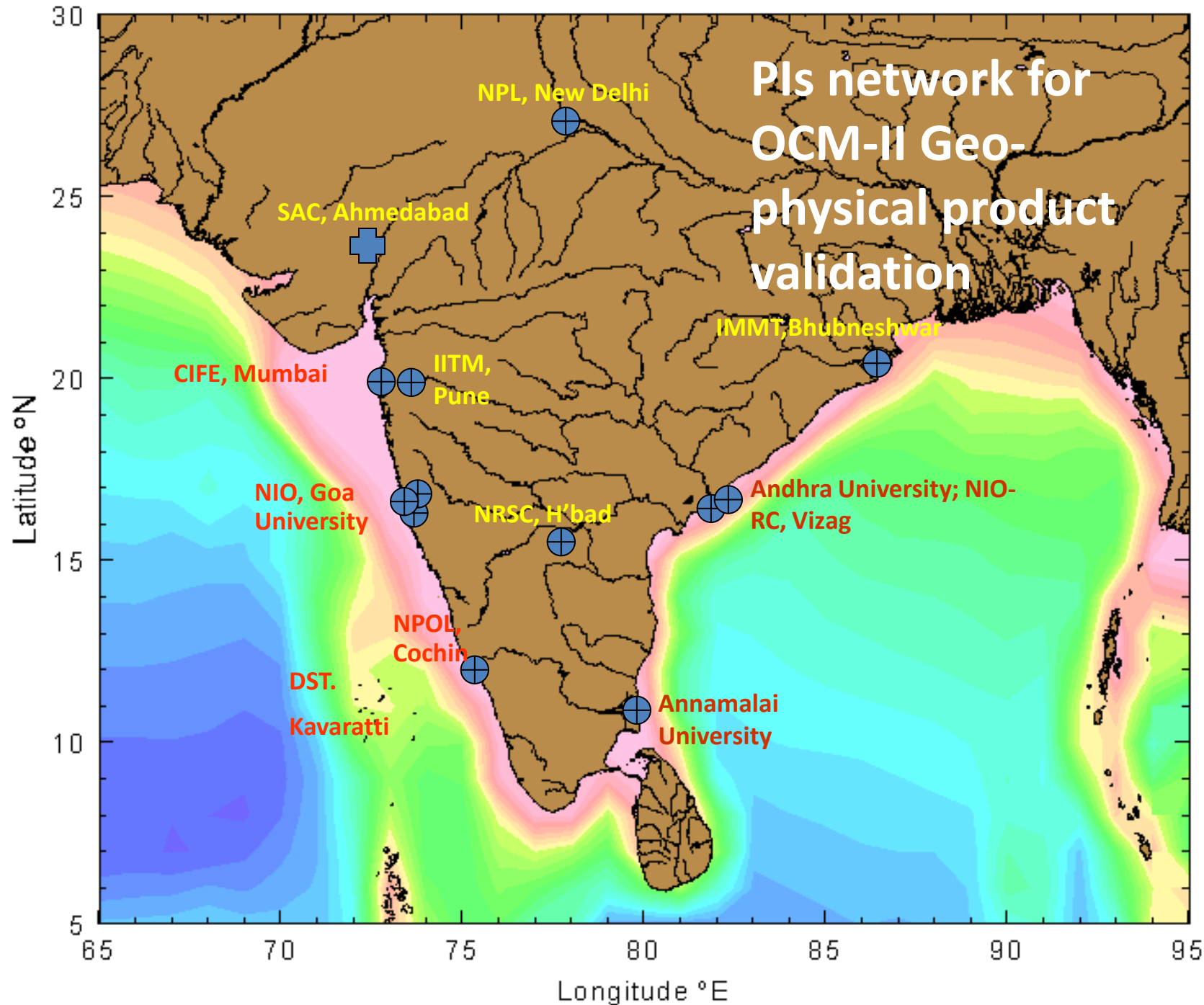
Satellite	Sensor(s)
RESOURCESAT-2	AWiFS , LISS-III , LISS-IV
Youthsat	LiVHySI
RISAT-1	SAR
MEGHA-TROPIQUES	MADRAS , SAPHIR , ScaRaB , ROSA
INSAT-3D	Imager , Sounder
SARAL	AltiKa , ARGOS
CARTOSAT-3	Panchromatic , VNIR , SWIR , LWIR
TES-HYS	HySI
OCEANSAT-3	OCM3
RESOURCESAT-3	AWiFS , LISS-III , LISS-IV
RISAT-L	SAR L

Sr.	Parameters	Satellites	Status	Sr.	Parameters	Status
1	Integrated water vapor	MT	operational	34	Surface reflectance	Research
2	Humidity profile	MT	operational	35	VI	Research
3	Temperature profile	MT	operational	36	LAI	Research
4	Wind speed	MT	operational	37	FAPAR	Research
5	Precipitation	MT	operational	38	Insolation	Research
6	SWR & LWR	MT	operational	39	Albedo	Research
7	Cloud liquid water	MT	operational	40	LST	Research
8	Wind speed	SARAL/AltiKa	operational	41	Net radiation	Research
9	Significant wave height	SARAL/AltiKa	operational	42	Evapotranspiration	Research
10	Sea surface height	SARAL/AltiKa	operational	43	Biomass	Research
11	Chlorophyll-a,	OCEANSAT-II	operational	44	NPP	Research
12	Total suspended matter	OCEANSAT-II	operational	45	Snow/Ice products	Research
13	Kd (490nm)	OCEANSAT-II	operational	46	Climate change index	Research

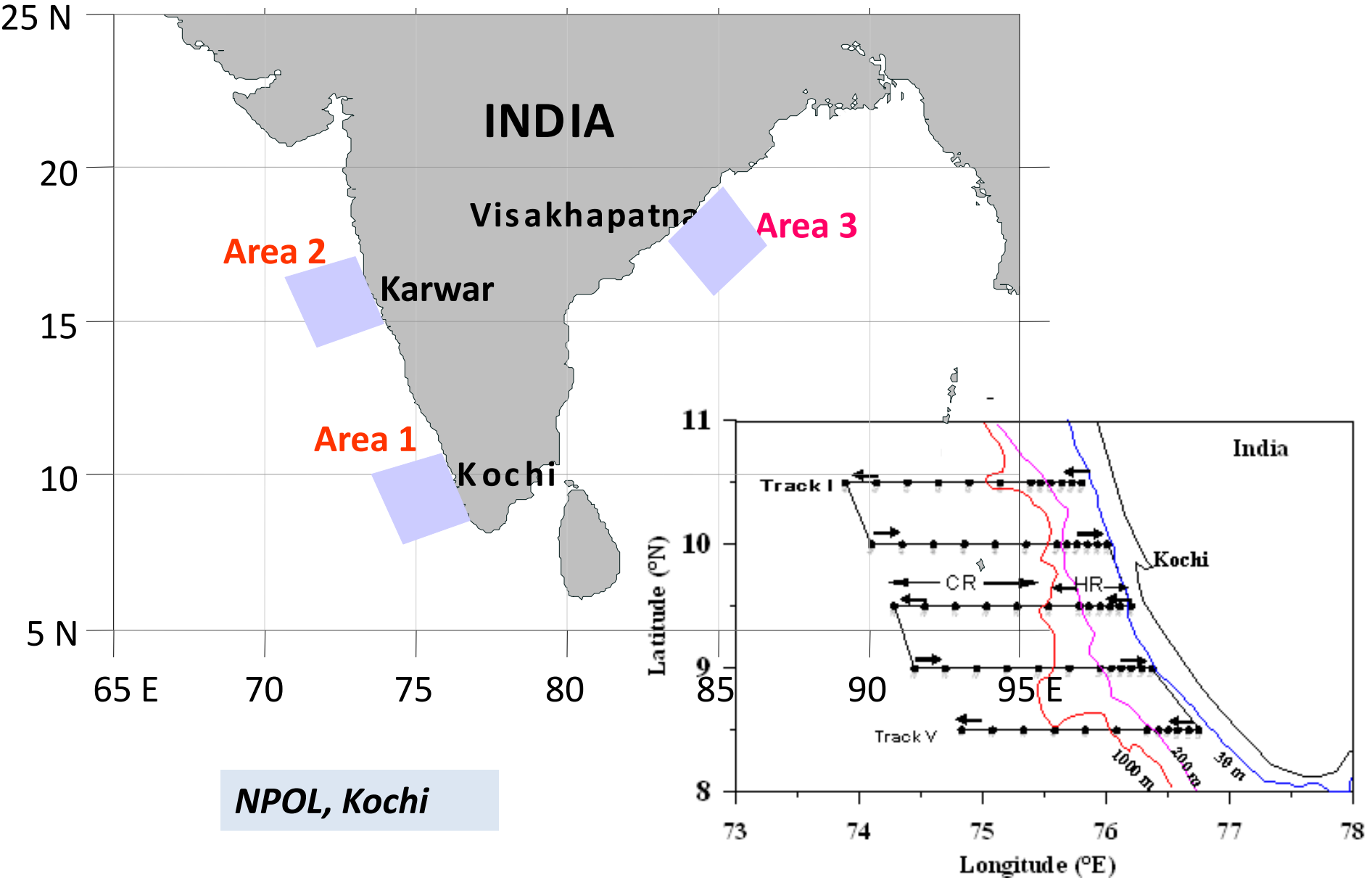
14	AOT(865nm)	OCEANSAT-II	operational
15	Wind speed	OCEANSAT-II	operational
16	Wind direction	OCEANSAT-II	operational
17	AMV (CMV,WVW)	INSAT-3D	operational
18	OLR	INSAT-3D	operational
19	UTH	INSAT-3D	operational
20	SST	INSAT-3D	operational
21	Aerosol,	INSAT-3D	operational
22	T, q – profile	INSAT-3D	operational
23	Stab. Indices	INSAT-3D	operational
24	Fire, Smoke	INSAT-3D	operational
25	Fog	INSAT-3D	operational
26	Rain	INSAT-3D	operational
27	Snow cover	INSAT-3D	operational
28	NDVI	INSAT-3D	operational
29	Ozone	INSAT-3D	operational
30	Wind Speed	RISAT	operational
31	Oil slick map	RISAT	operational
32	vegetation extent map	RISAT	Research
33	Soil moisture	RISAT	Research

**Geo-physical
parameters/products**

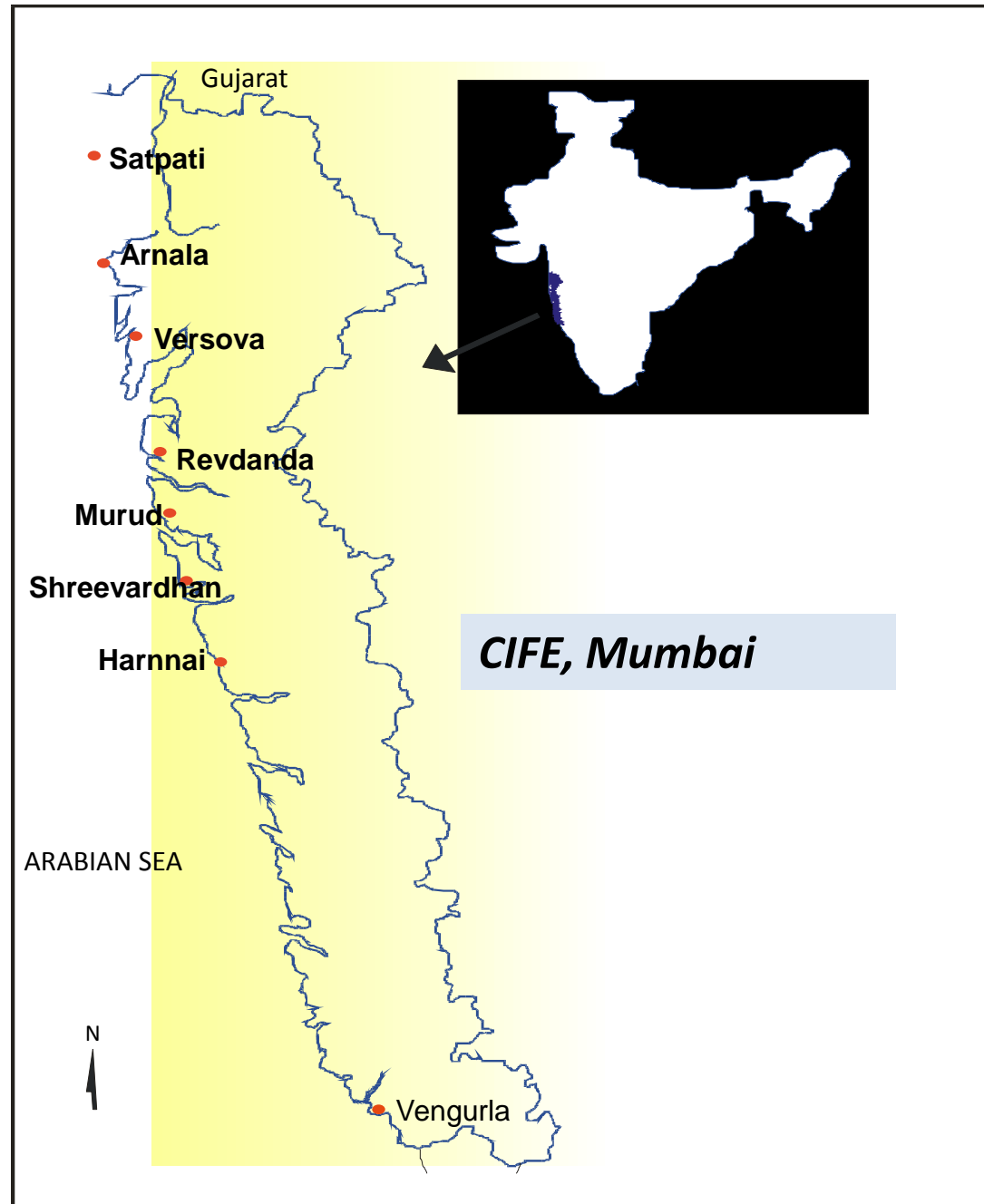
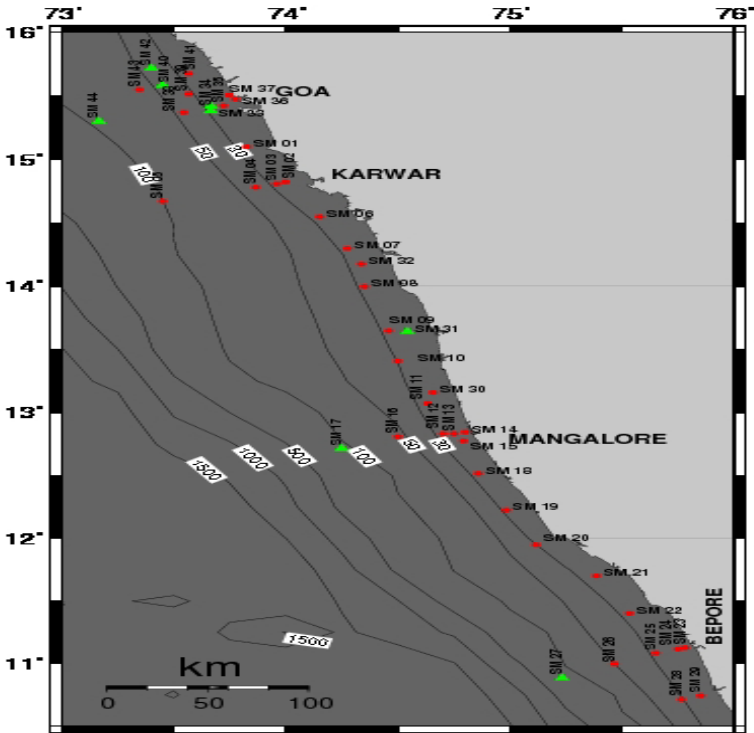
OCM2 OCEAN COLOR CAL-VAL



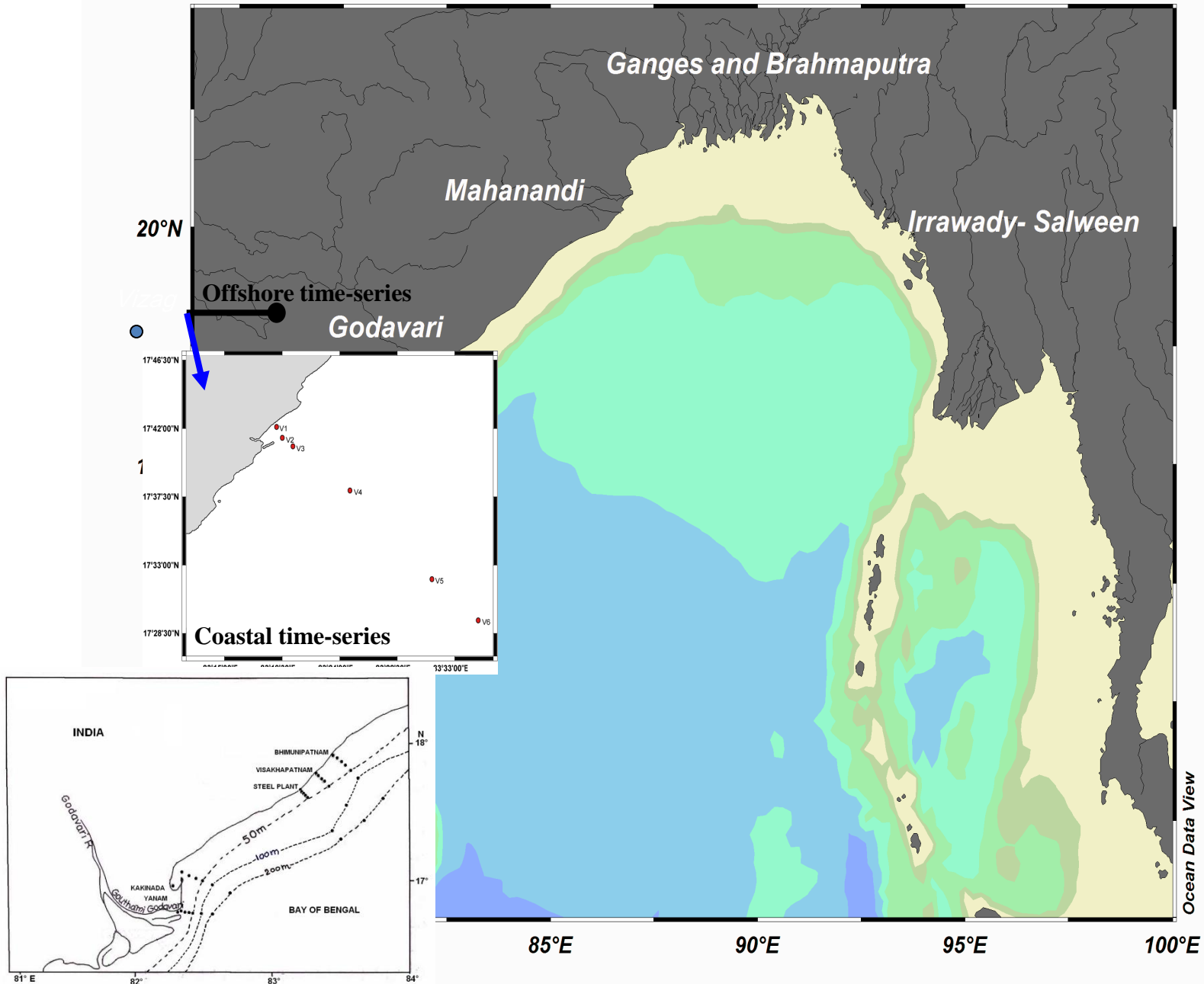
INS Sagardhwani – Field experiments



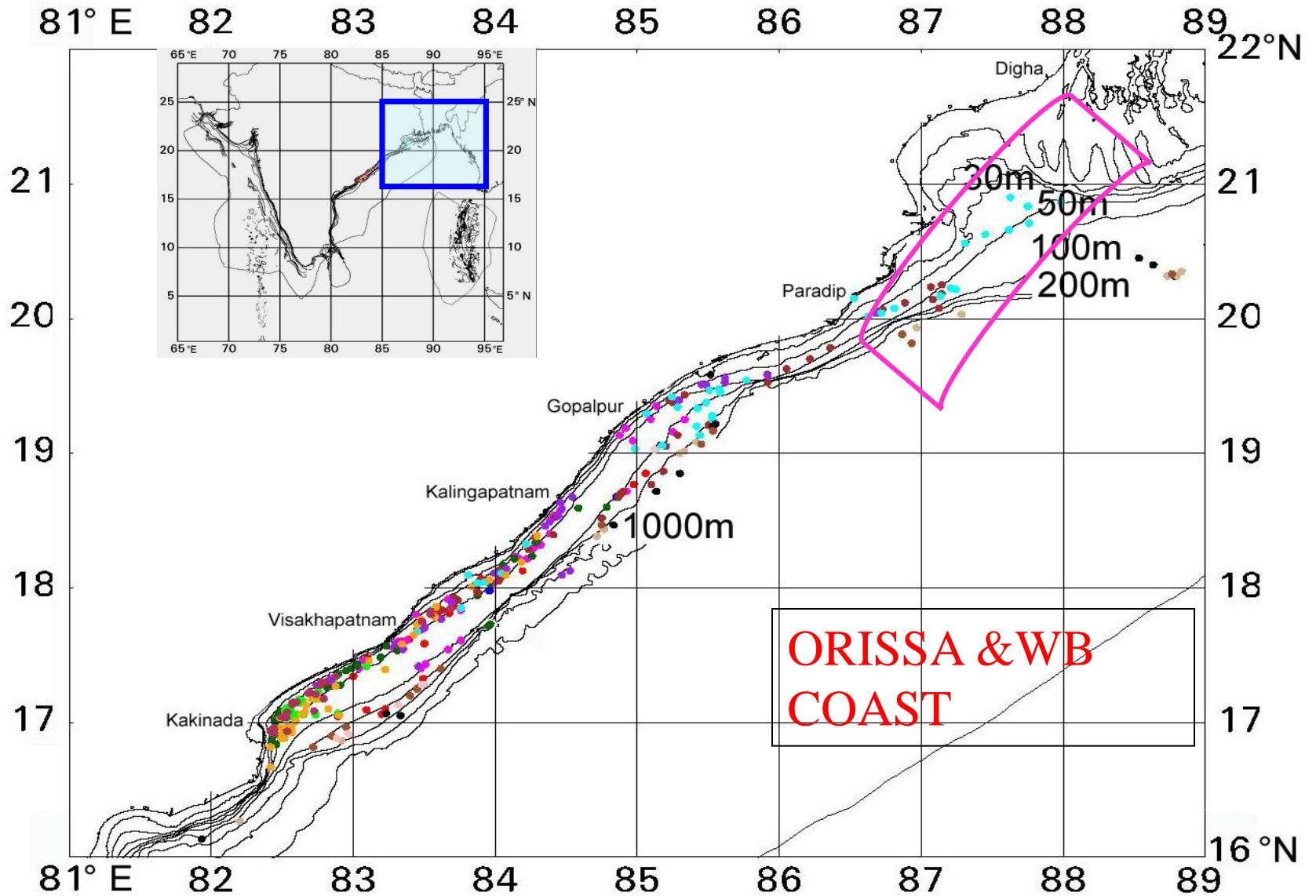
**Department of Marine
Sciences, Goa University**



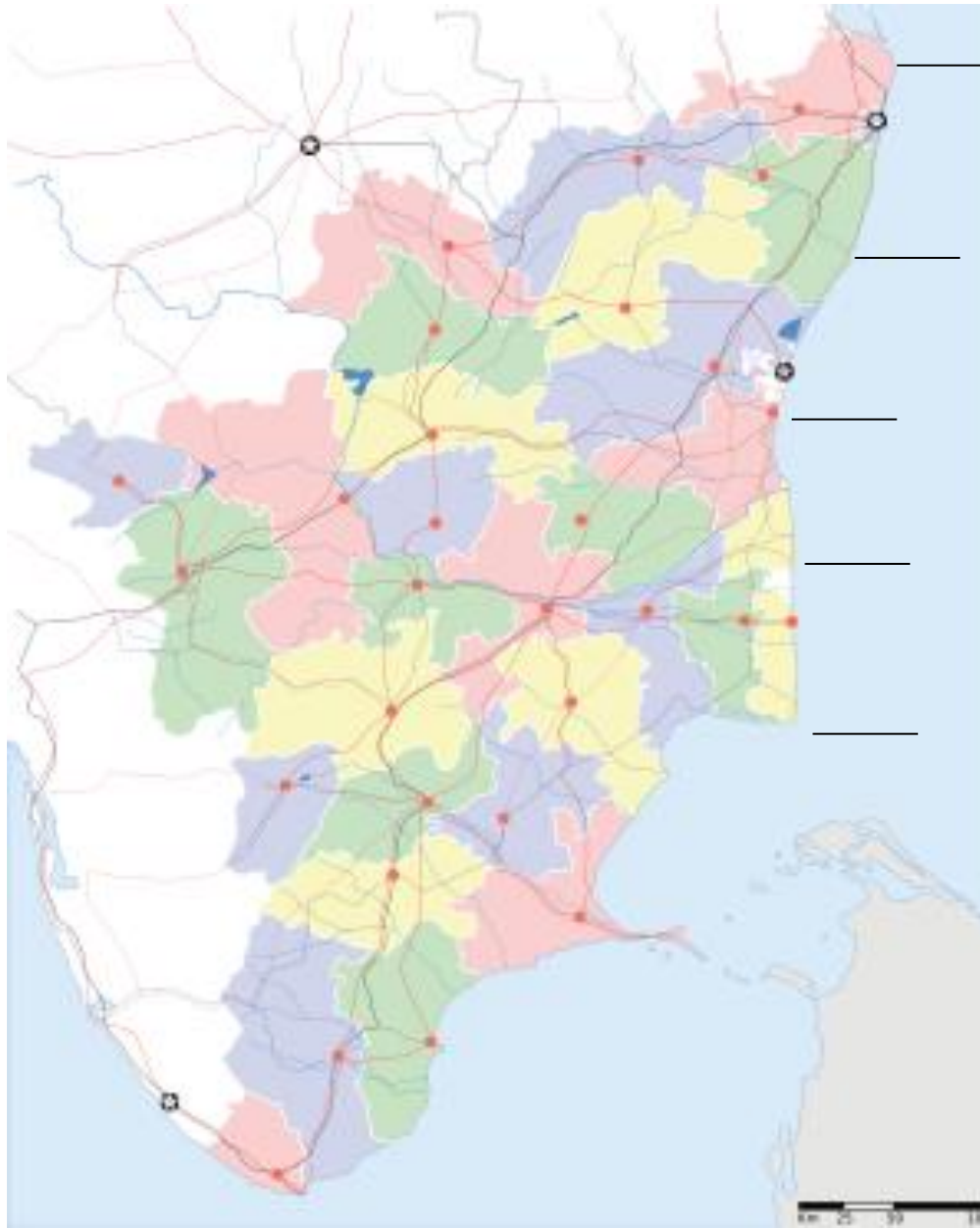
National Institute of Oceanography, Visakhapatnam



IMMT, Bhubaneswar



Centre for Advanced Study in Marine Biology, Annamalai University



Site 1 (20, 30, 50, 100, 200m)

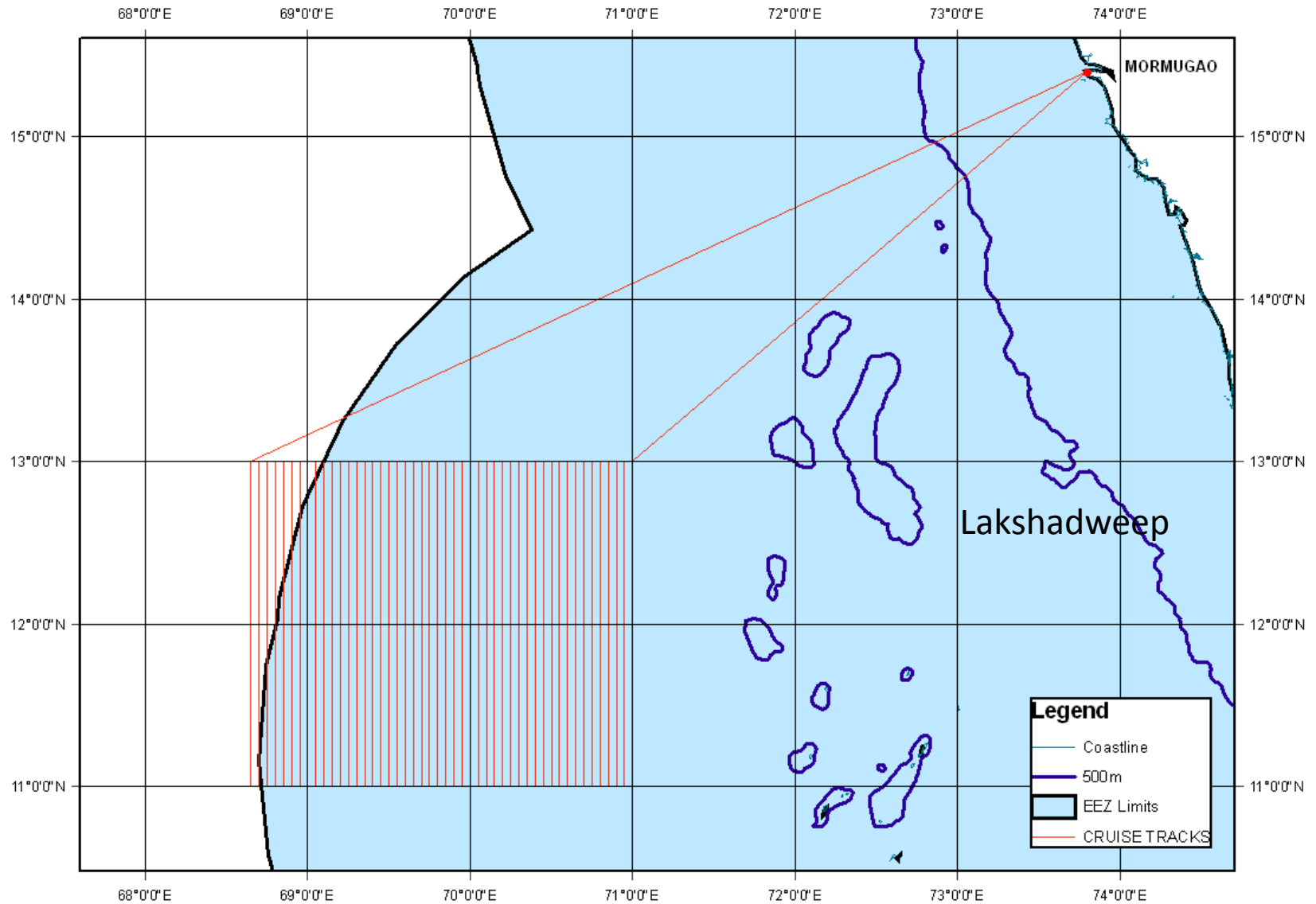
Site 2 (20, 30, 50, 100, 200m)

Site 3 (20, 30, 50, 100, 200m)

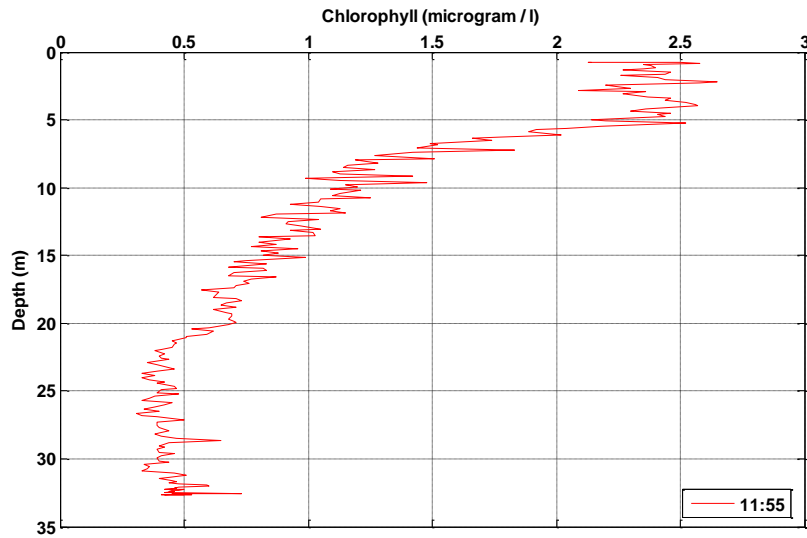
Site 4 (20, 30, 50, 100, 200m)

Site 5 (20, 30, 50, 100, 200m)

Sagar Kanya transect during Dec.09 – Jan.10,2010

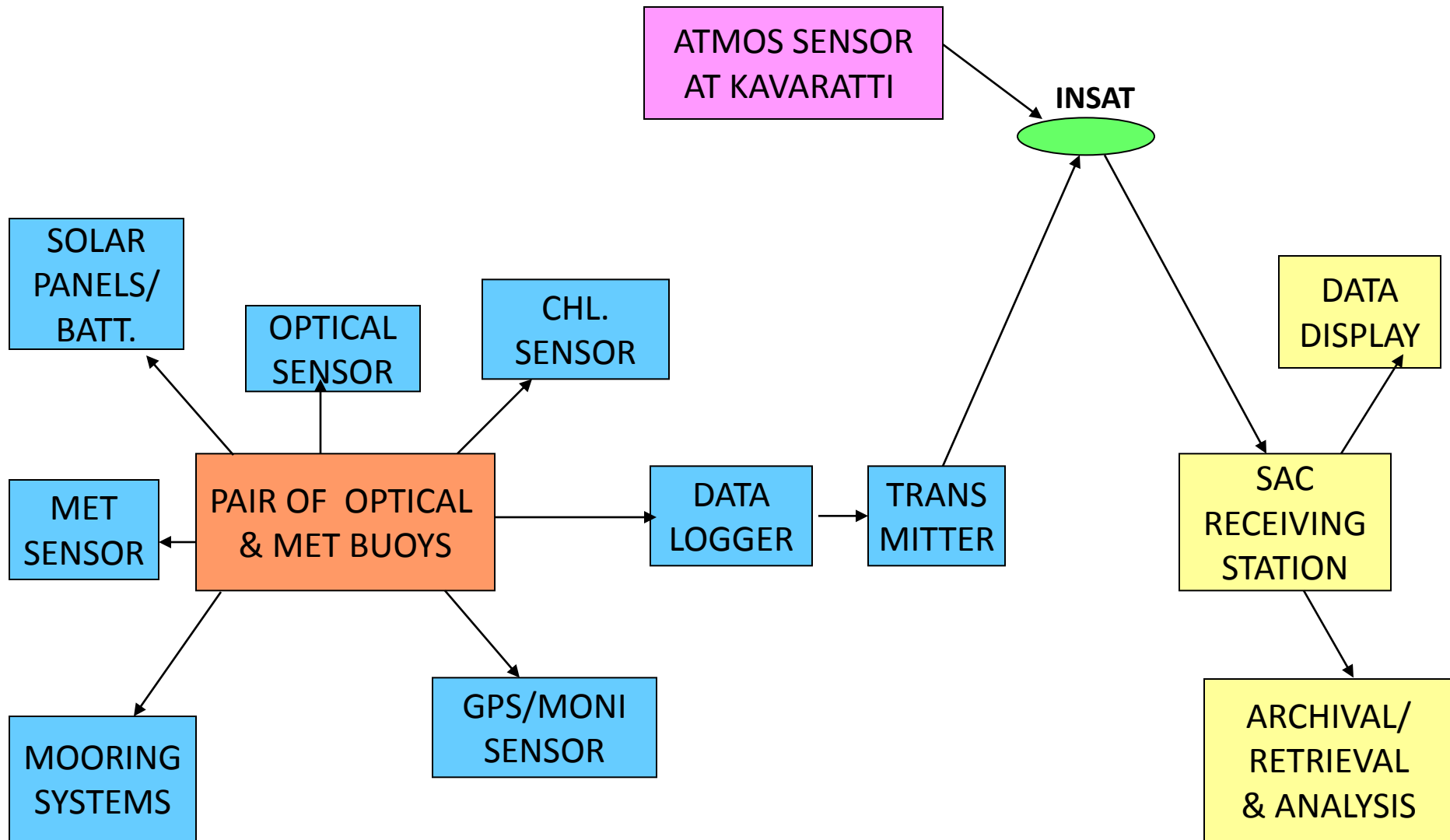


The Autonomous Vertical Profiler with Chl sensor

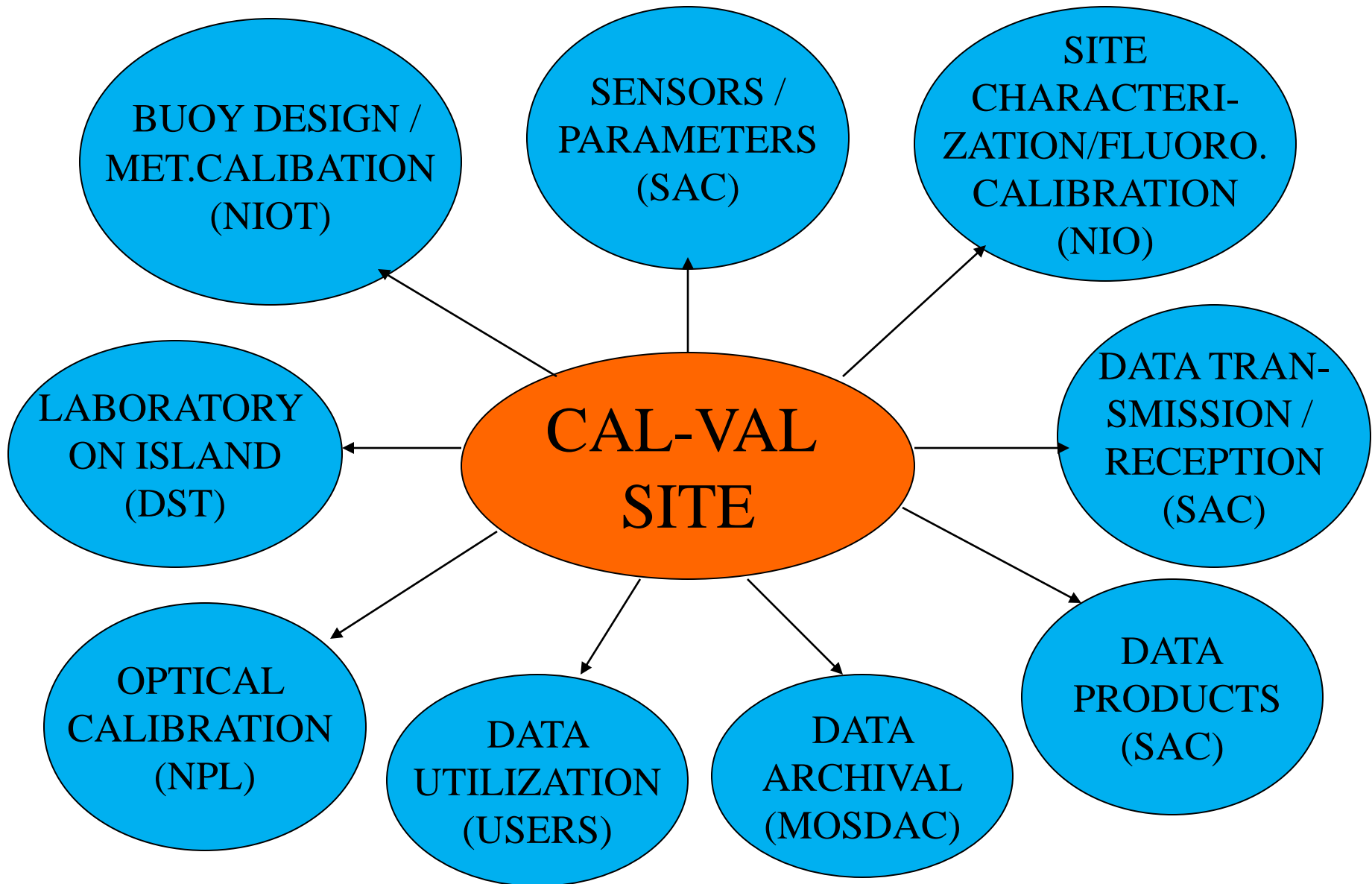


**KAVARATTI CAL-VAL SITE FOR
OCEAN COLOR**

Conceptualization of Kavaratti CAL-VAL site development



Kavaratti CAL-VAL site in deep ocean in Lakshadweep



GUIDE MAP OF KAVARATTI

A COMPLIMENT FROM

IXORA

(ENVIRONMENT FRIENDLY)

ASSN. OF ARTS, SPORTS, CULTURAL & SOCIAL ACTIVITIES

IXORA

Reg. No. CCCV. 97

Ph 63747

AREA-362.949 HECTORS

SCALE 1: ABOUT 27m



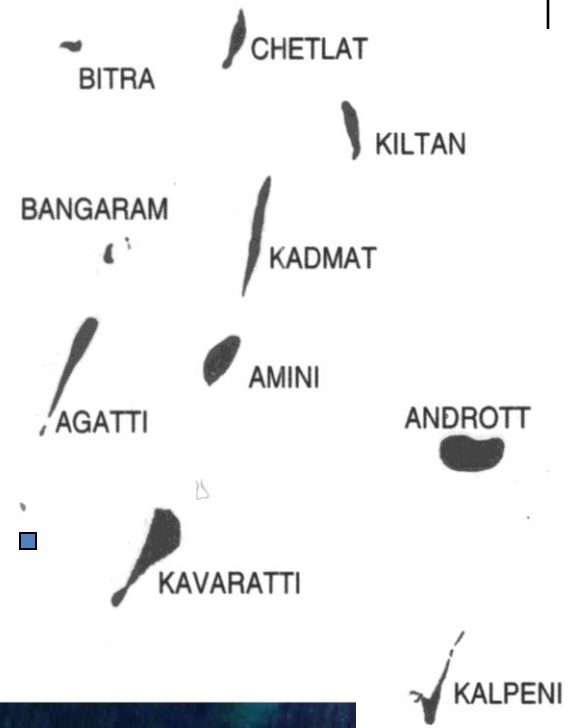
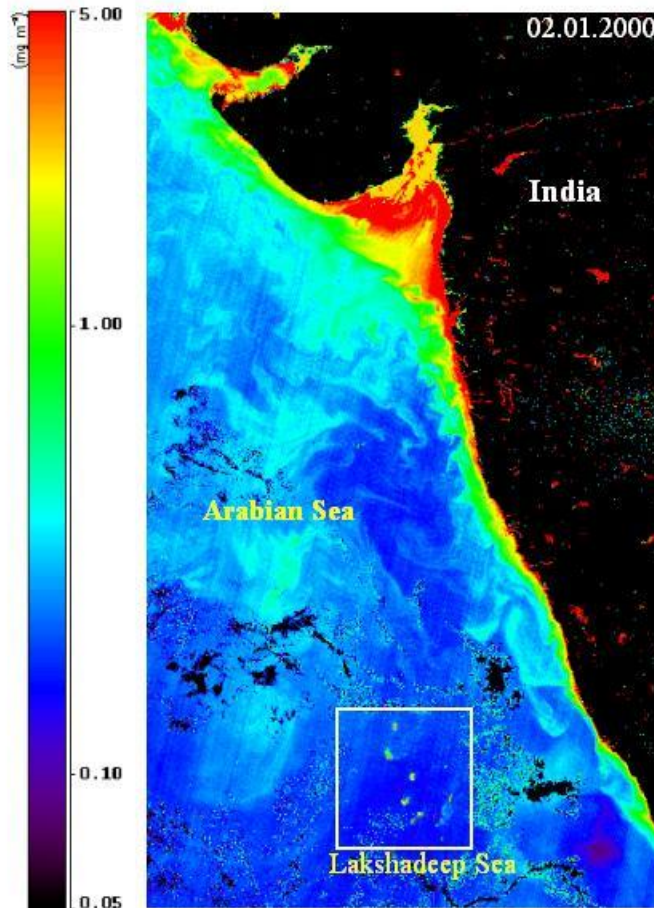
== CONCRETE ROAD
x BUS STOP

1. FISHRIES & MARKET
2. GOVT HOUSE
3. WATER PALLI
4. THARU ISLAM MADRASSA
5. JUMA MASJID
6. MUMYUDEETH PALLI
7. SAUMYATHALATHA MADRASSA
8. TOURIST HUT
9. KHADI BAZAR
10. I.I.I
11. CENTRAL LIBRARY
12. CO-OP SOCIETY
13. VILLAGE OF BANCHANETH
14. DENTAL CLINIC
15. SHAKHNAS STUDIO
16. I.B. SCHOOL
17. IXORA OFFICE
18. LIGHT HOUSE
19. SPORTS OFFICE
20. QZADHU ISLAM MADRASSA
21. S.V. SCHOOL
22. JANATHA DAL OFFICE
23. KHADI BAZAR
24. CONGRESS OFFICE
25. DIV. OF SOCIAL WELFARE
26. G.R.D.A
27. HANDICRAFT
28. LG HOSPITAL
29. SKATE PARK
30. WORKING WOMEN'S HOSTEL
31. POST OFFICE
32. S.P.'S OFFICE
33. DISTRICT COURT
34. JHAKKARATHI SADAK
35. DISTRICT PRINCIPAL'S OFFICE
36. POST/RES/DIST. TARIKHA
37. ENROL. EXCHANGE
38. M.D. LDCL / TRV & ACCOUNT
39. SECRETARIAT
40. LPWD CIRCLE OFFICE
41. ELECTION OFFICE
42. I.L.E. DIVISION OFFICE
43. SYNDICATE BANK
44. STD TELECOM
45. POST HOUSE
46. GOVT OFFICE
47. DAK BANGALOW
48. STAL OFFICE
49. STD OFFICE
50. POLICE STATION
51. STATION BR. ADD./A.H
52. GOVT. S.S. SCHOOL
53. STUDIO
54. ALL INDIA BLDG
55. CIVIL ENGINEER DEPT
56. R.O.'S OFFICE
57. VETERINARY
58. CHILDREN'S PARK
59. NAVAL DETACHMENT
60. HELI BASE

DEDICATED ON 15TH OCT '98
BY
SRI P. KAMARAJ, I.P.S.
SUPER. OF POLICE, I.I.I.

Location of Kavaratti Site

- Sea depth : 1900 mtrs.
- Case-1 water
- Low chlorophyll

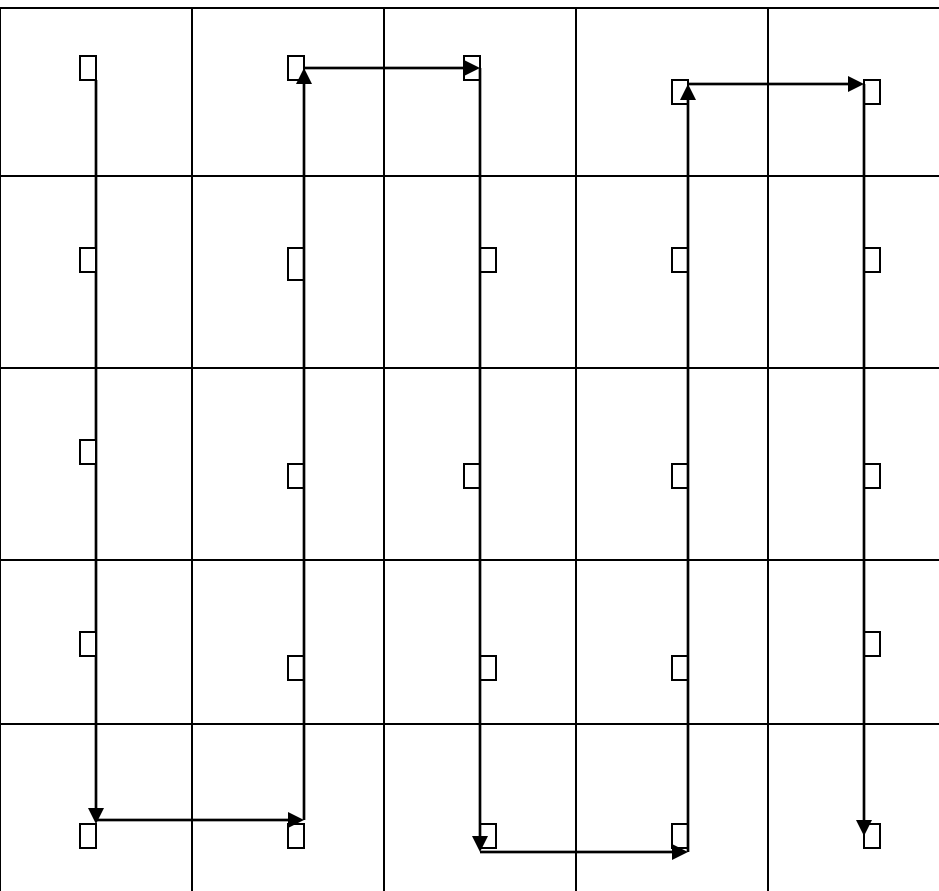


IRS-P4 OCM derived chlorophyll image showing the Lakshadweep Sea and its group of Islands surrounded by the Arabian Sea and west coast of India

Kavaratti island



Design of experiment for CAL-VAL Site characterization at Kavaratti using Saga-Sukti vessel



□ Station for data collection

DAY-1 : 25 Kms.x 25 Kms.

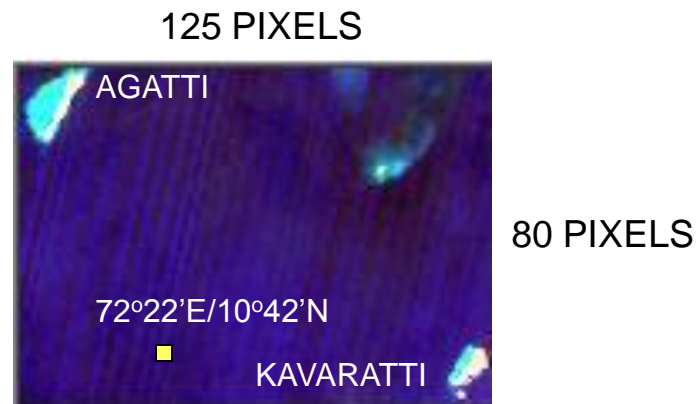
DAY-2 : 10 Kms.x 10Kms.

DAY-3 : 5 Kms.x 5 Kms.

DAY-4 : 5 Kms.x 5 Kms.

DAY-5 : 5 Kms.x 5Kms.

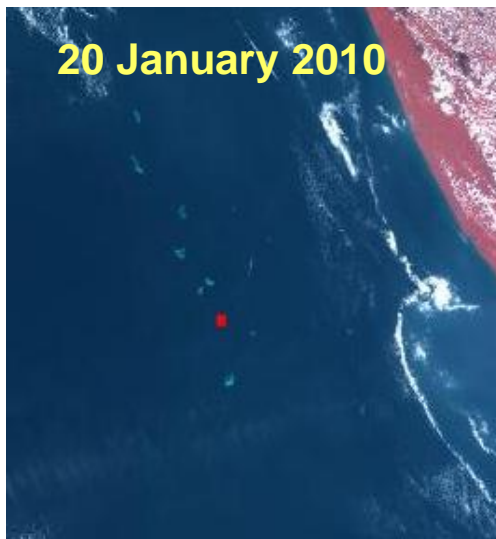
DAY-6 : 5 Kms.x 5Kms.



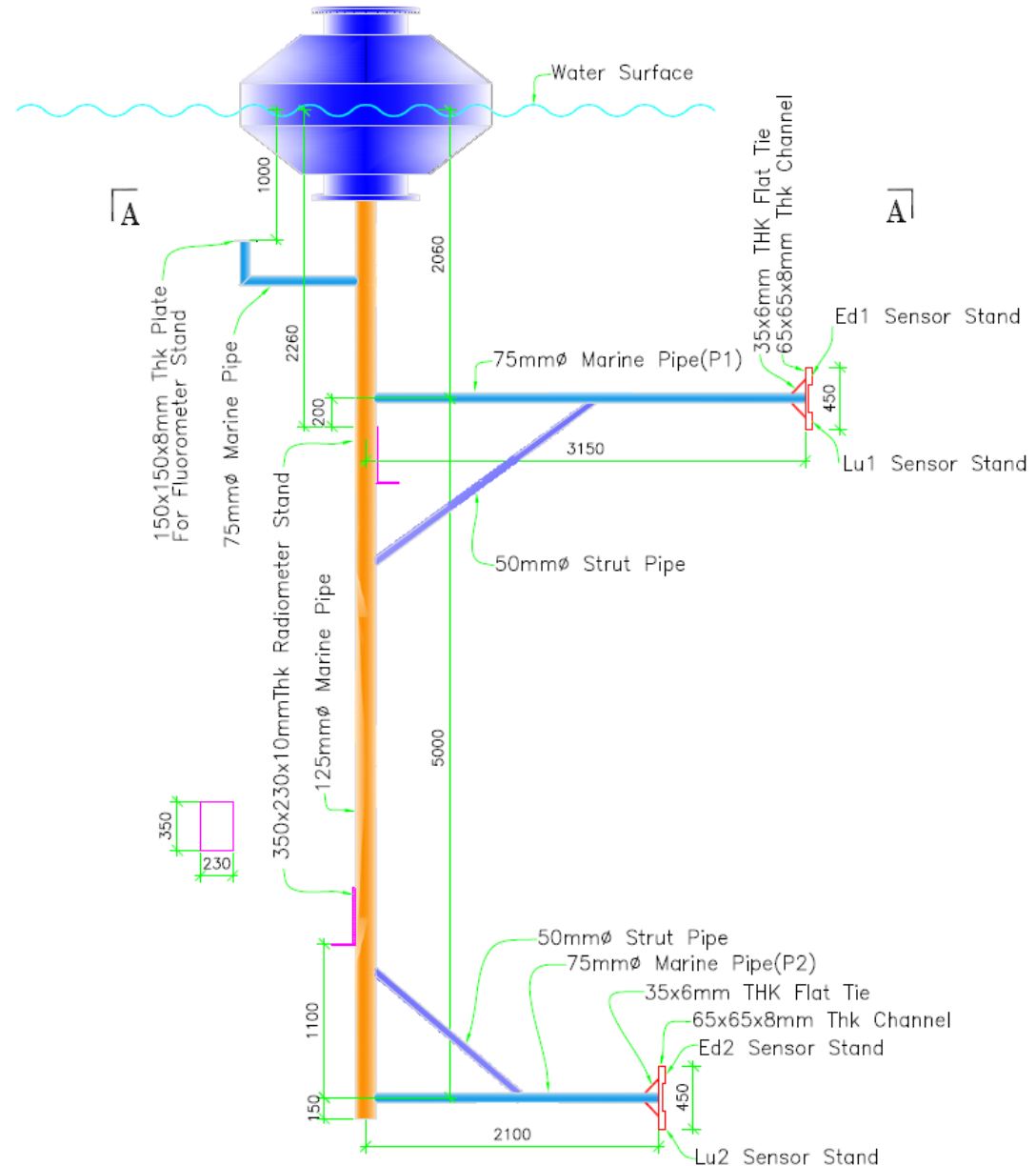
OPTICAL & MET buoy deployment on Kavaratti site



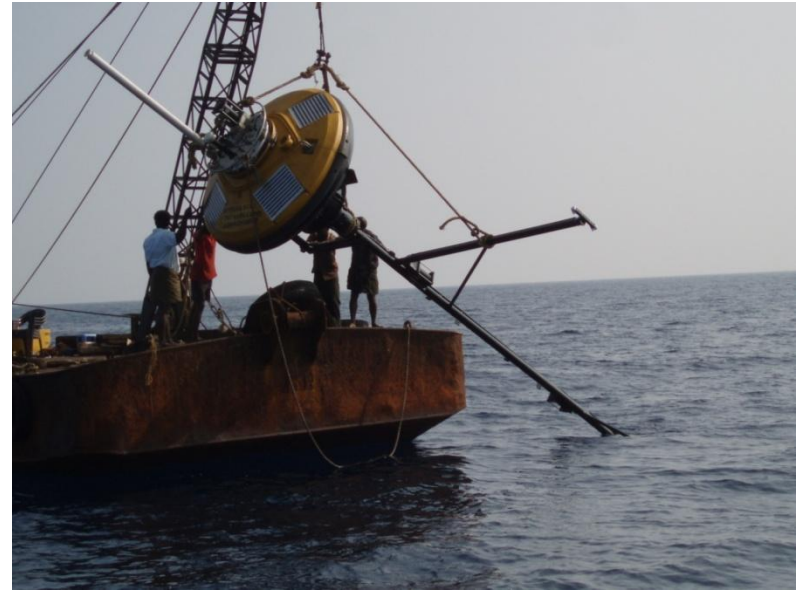
Kavaratti Optical buoy



Seen by OCM2

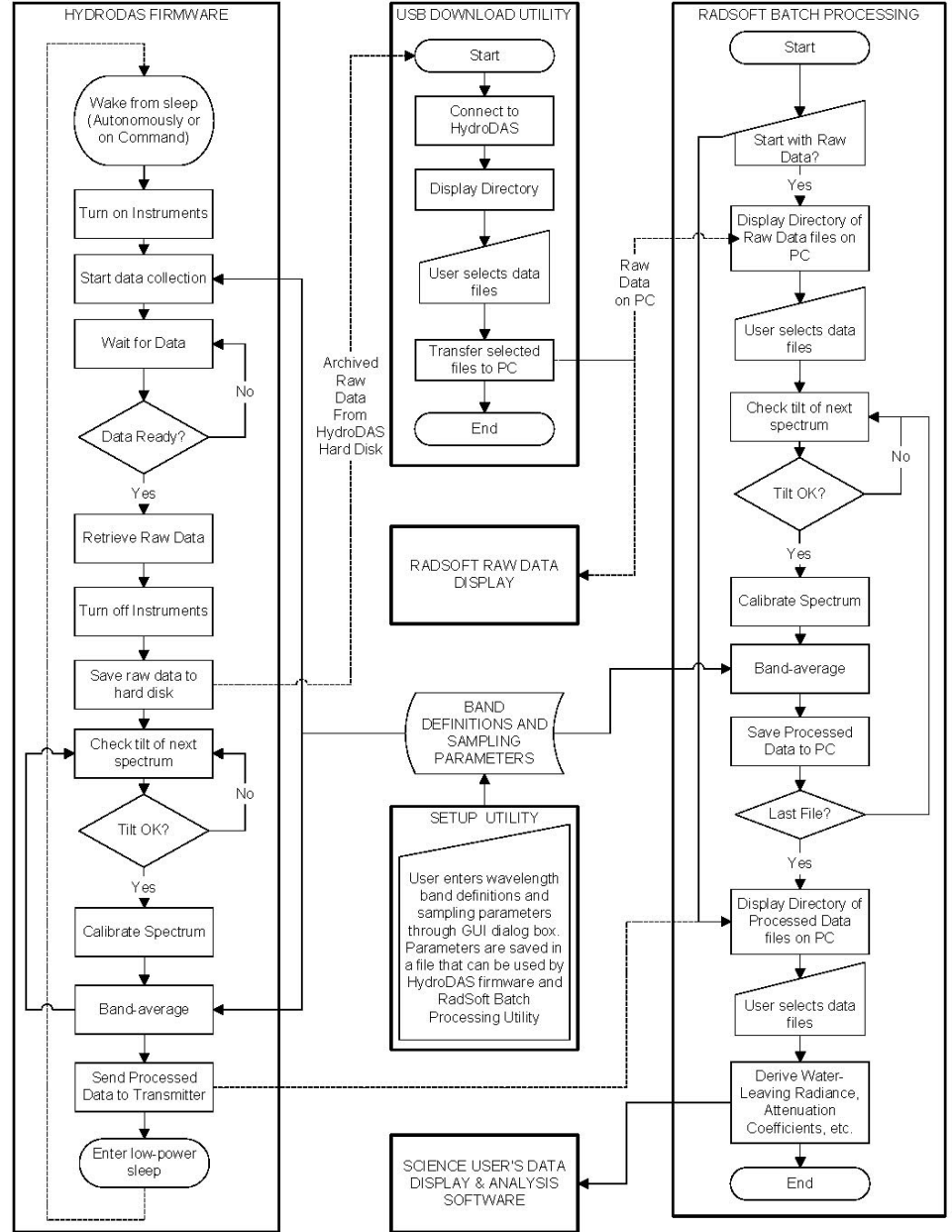
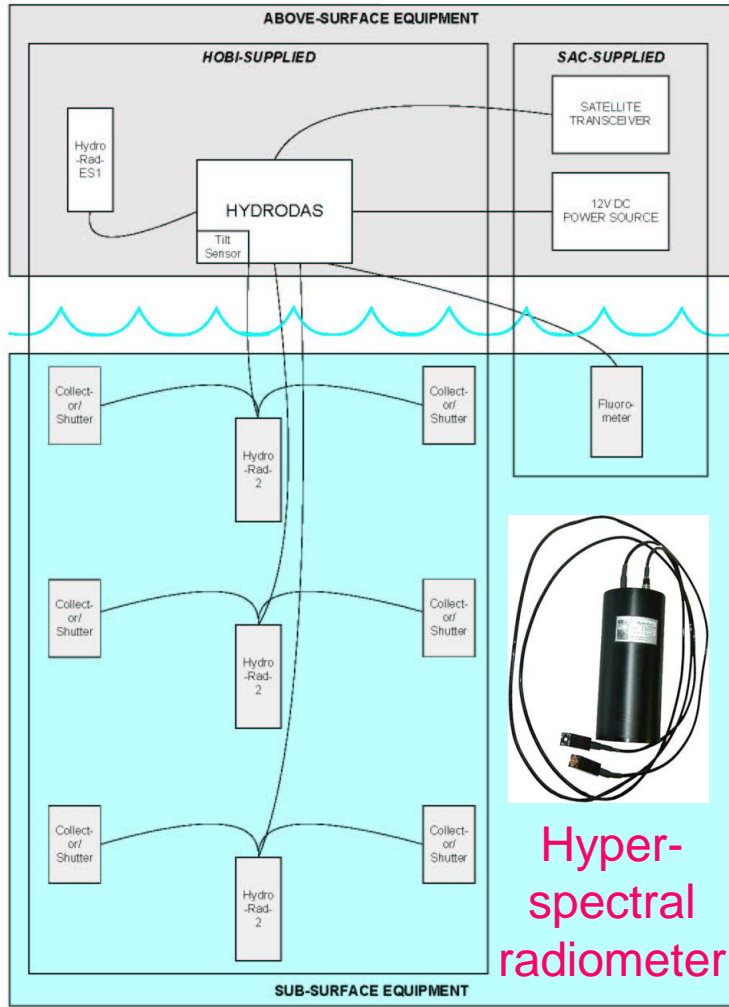


New OPTICAL and MET buoys

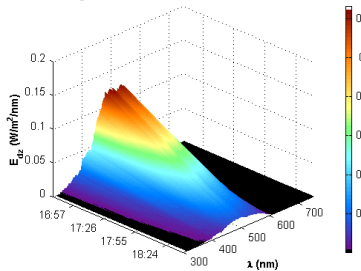


OPTICAL buoy

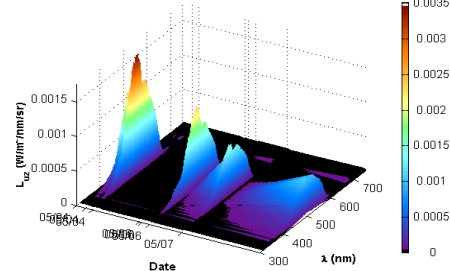
SAC / HYDRODAS / HYDRORAD SOFTWARE & DATA FLOW



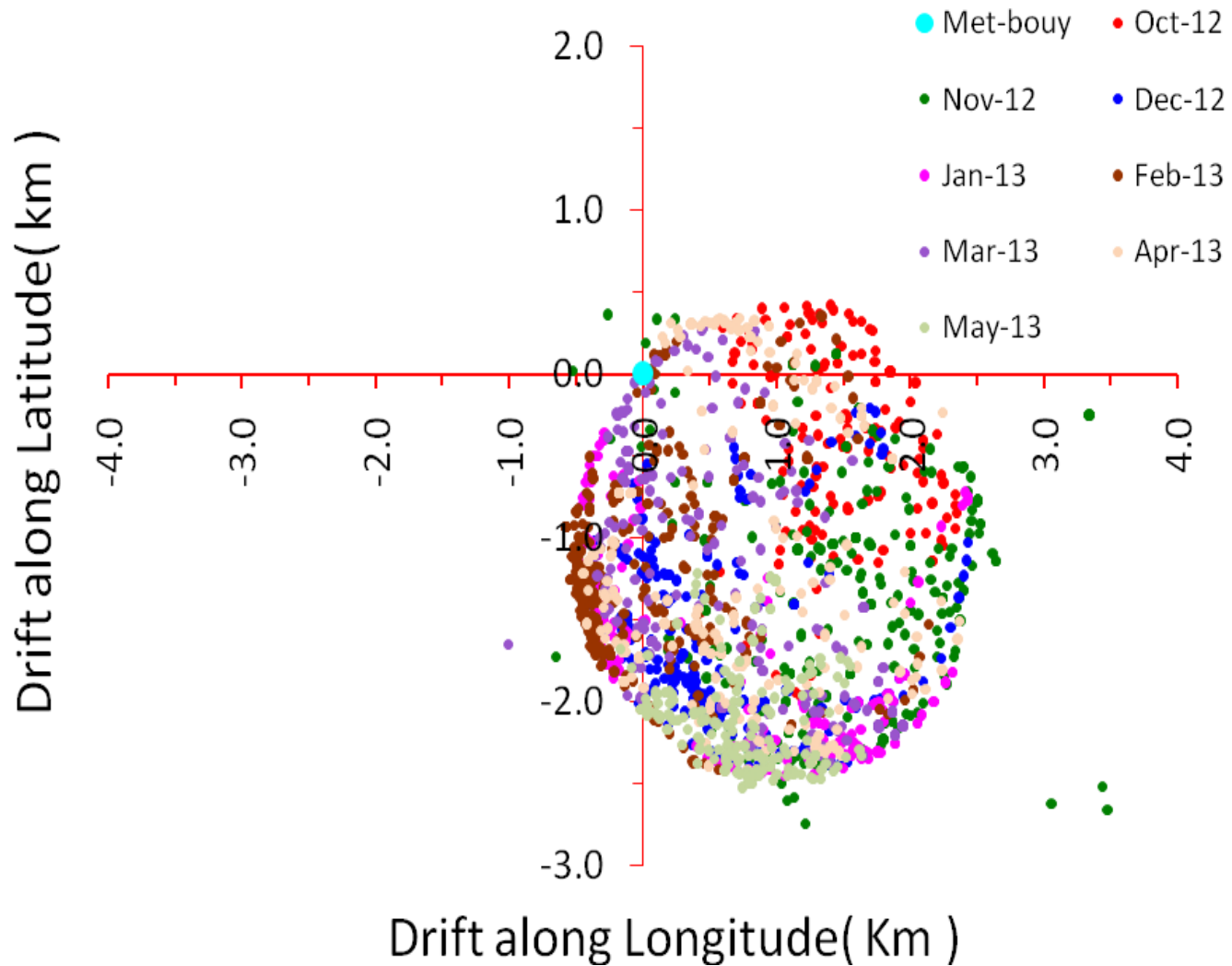
Downwelling Irradiance, Wet -- Channel 2 on HR2 at m1 at 10 m



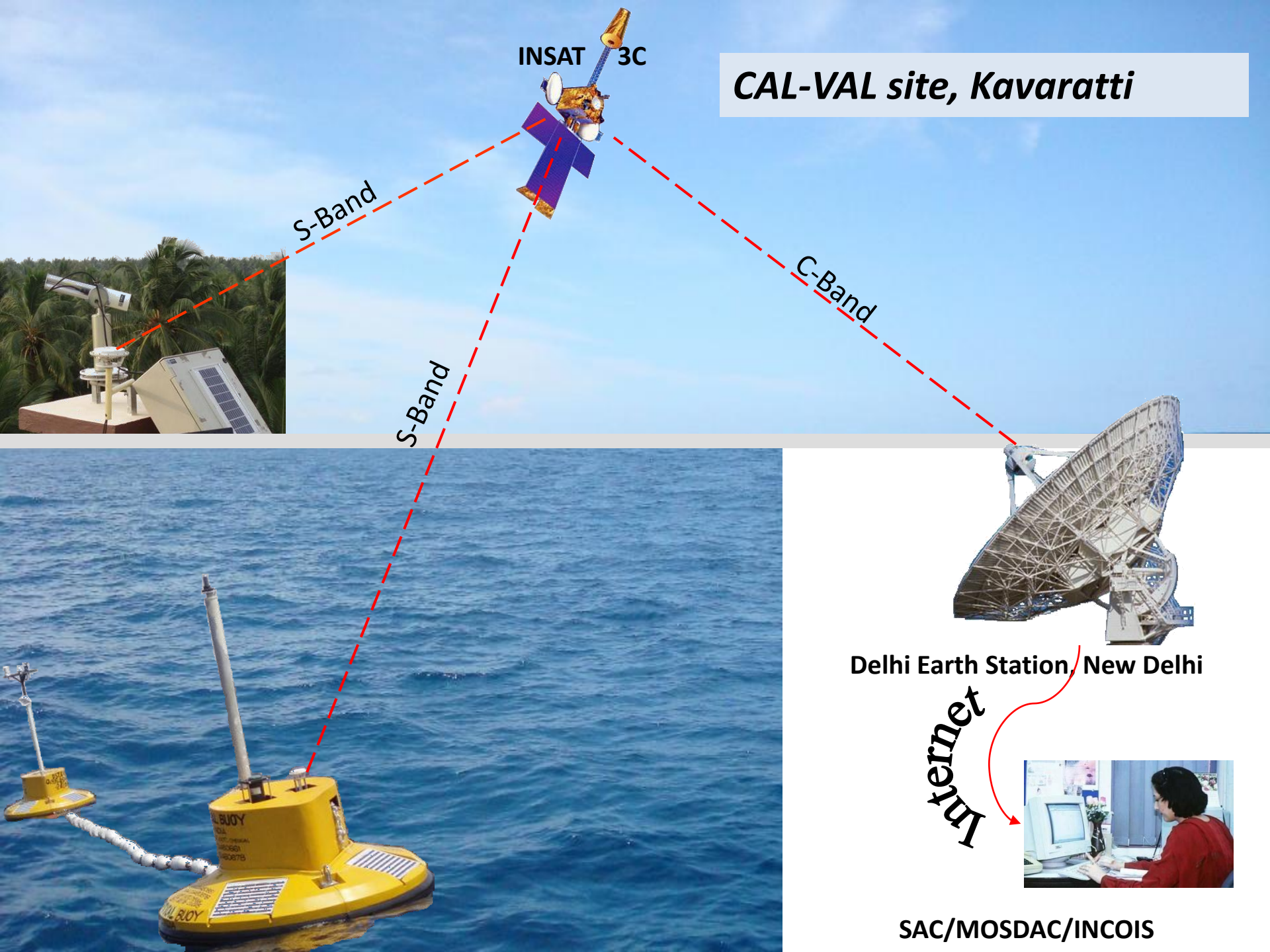
Upwelling Radiance, Wet -- Channel 1 on HR2 at m1 at 11 m



OPTICAL Buoy drift on Kavaratti site



CAL-VAL site, Kavaratti

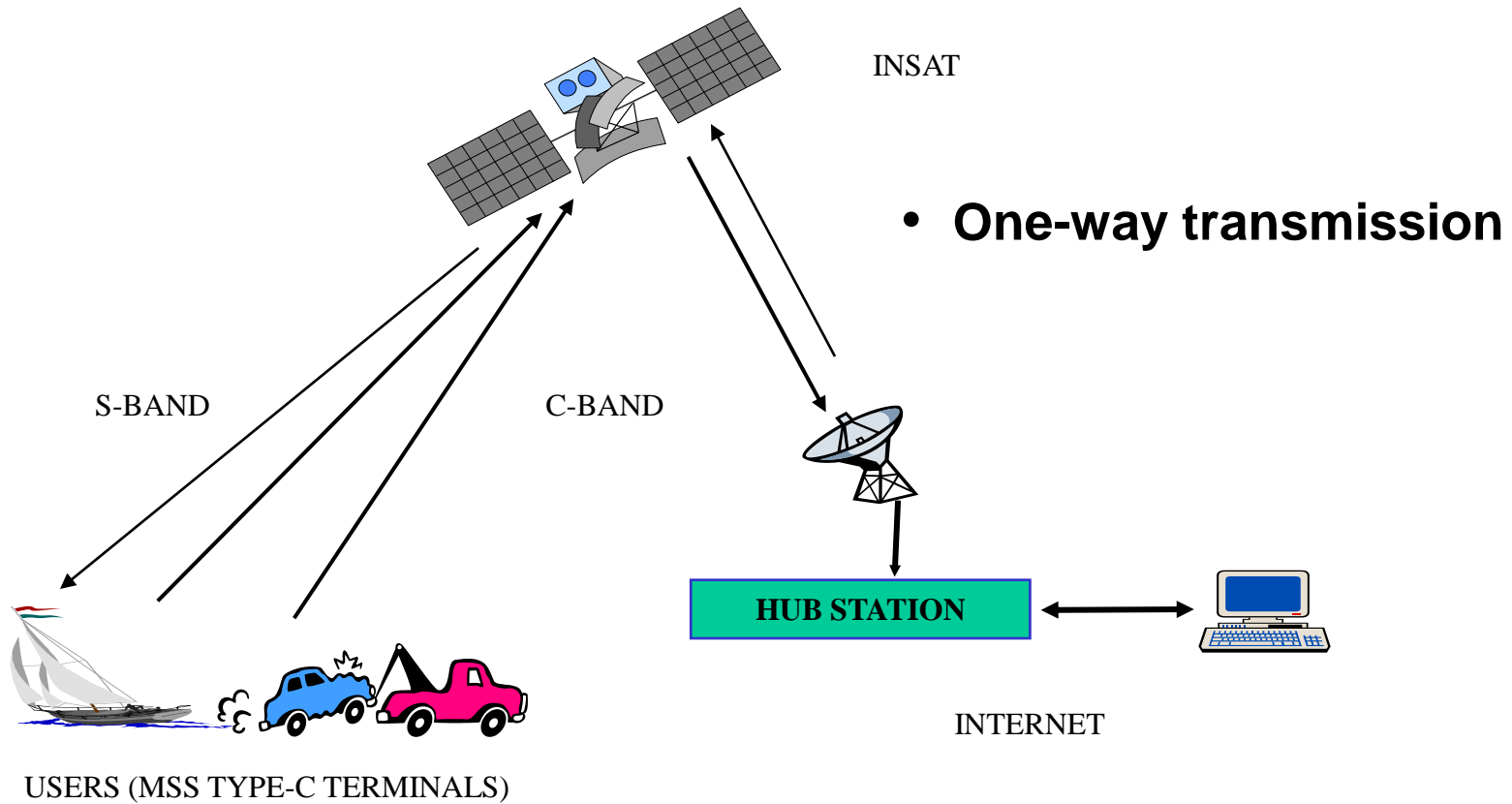


Delhi Earth Station, New Delhi

Internet

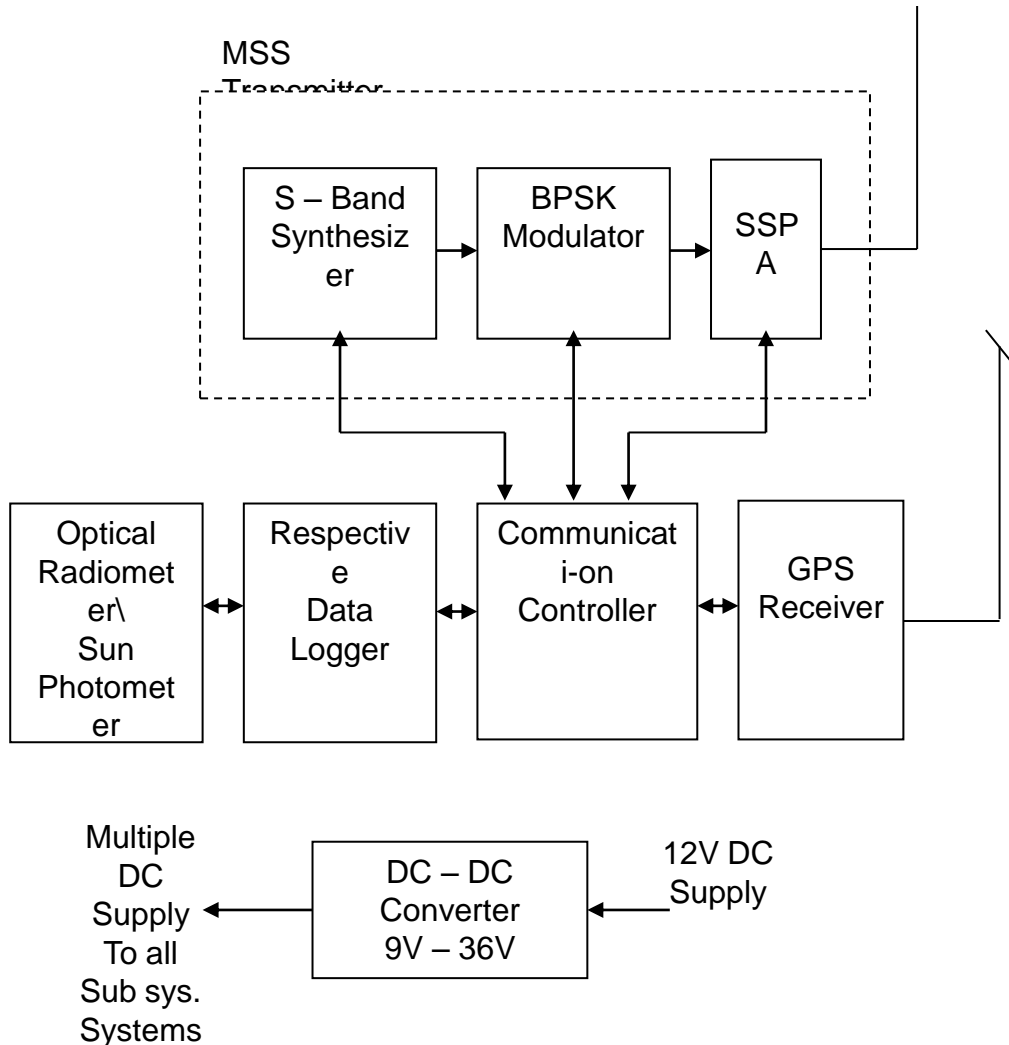
SAC/MOSDAC/INCOIS

INSAT MSS TYPE-C System



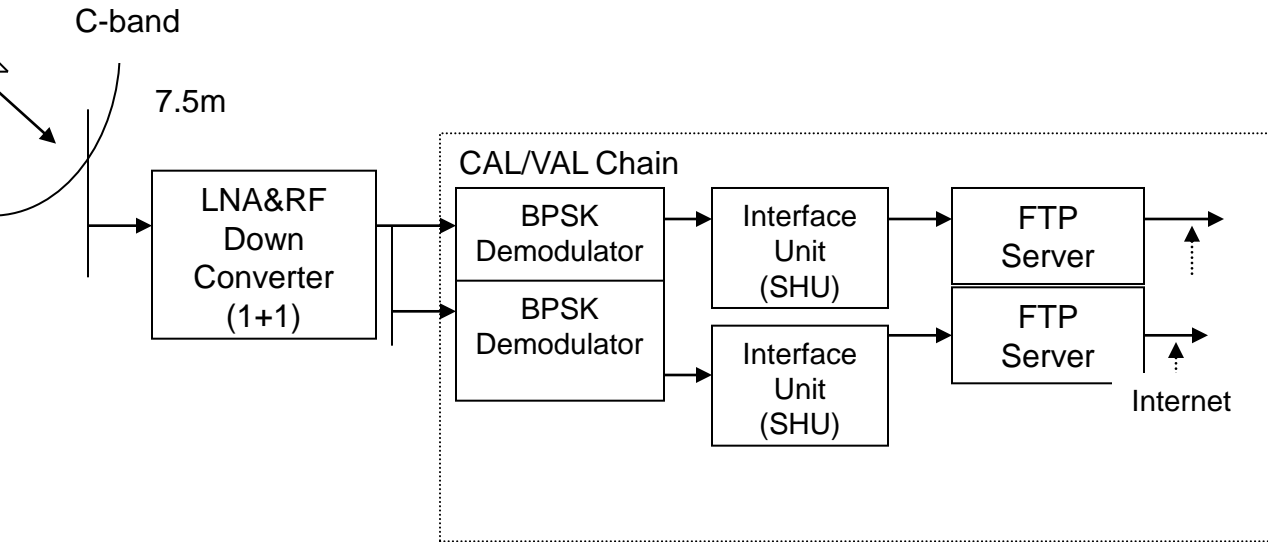
Data Transmission

- GPS acquisition
- Data collection
- Every hourly data transmission
- Re-transmission to avoid data loss
- Transmission time : 0800-1700 hrs.
- Sleep /wakeup mode feature
- Volume : 70kbytes/day



Block Diagram of CAL - VAL Site Transmitter

Data reception

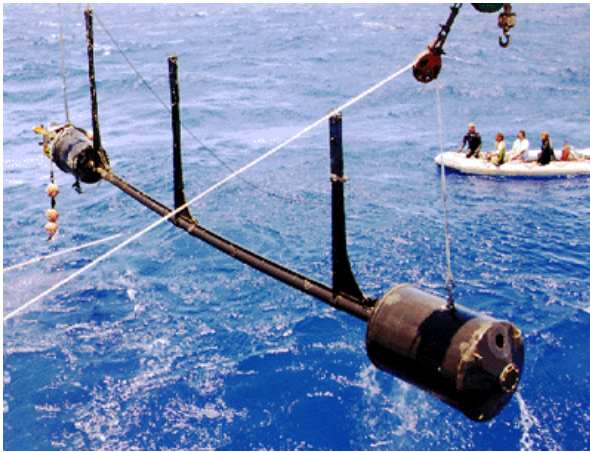
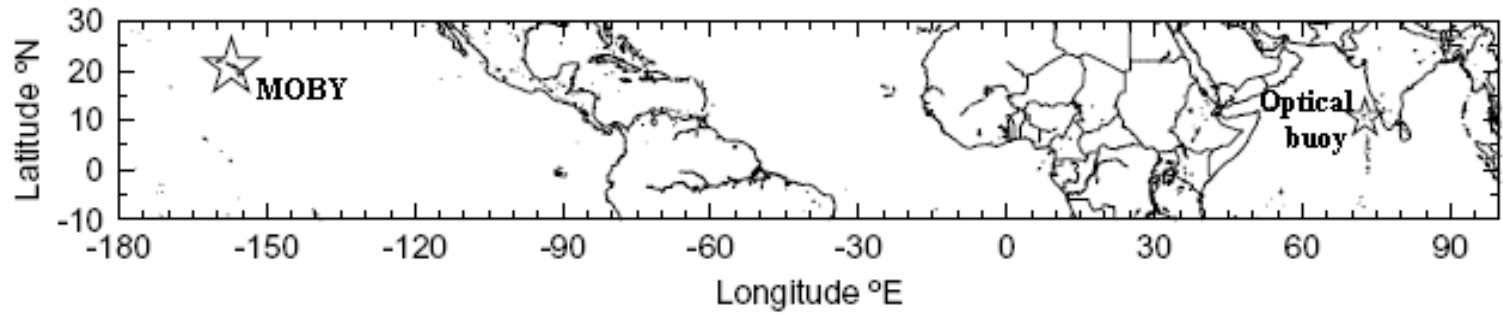


- Error free packets from two transmissions
- Data access through FTP server

MOBY

Vs

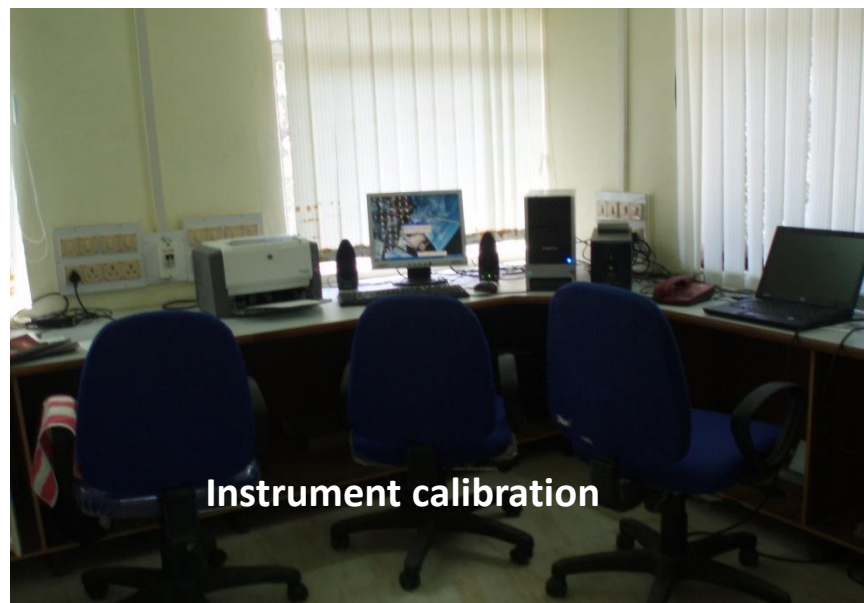
**OPTICAL
BUOY**



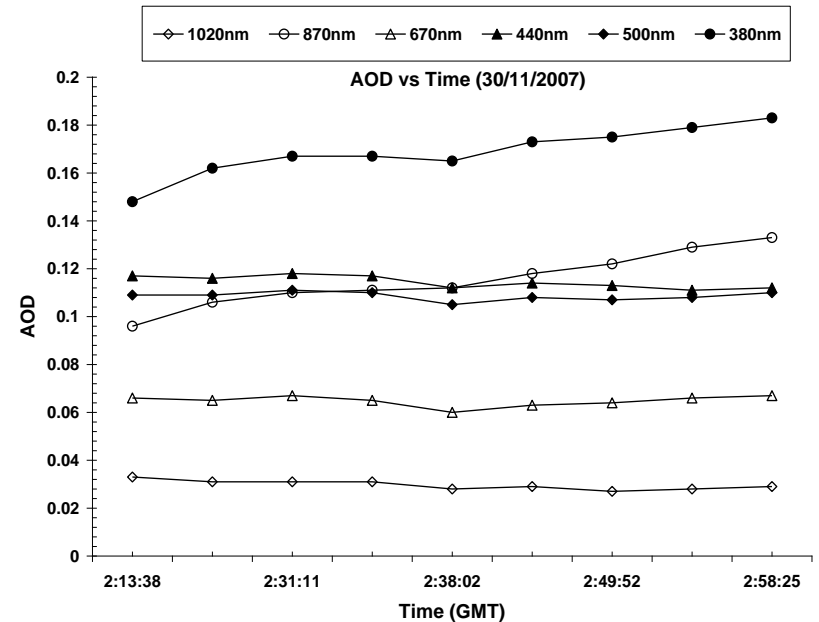
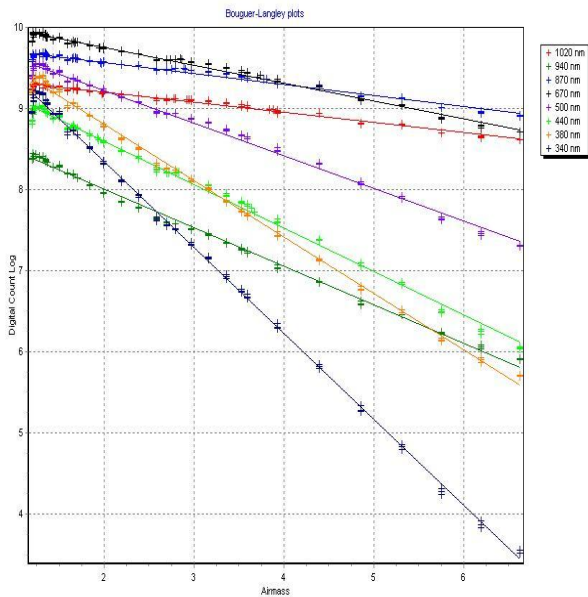
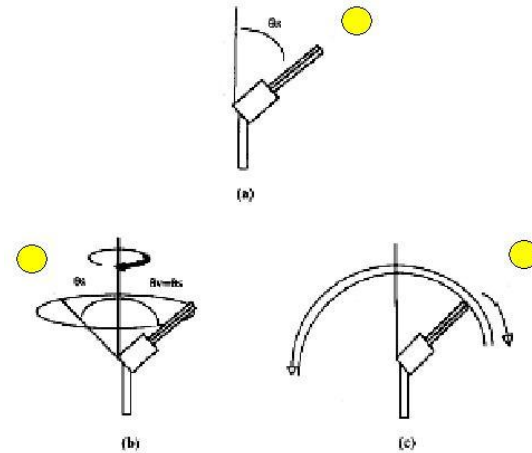
Ship version of OPTICAL BUOY

Spatial measurement

CAL-VAL setup on Kavaratti island



CIMEL Sun/sky Photometer on Kavaratti island



Parameters being measured at Kavaratti

Sr. No.	Instrument	Parameters
1	Hyper spectral radiometer	Spectral surface irradiance Spectral irradiance at 1.8m & 6.5m depth Spectral radiance at 2.26m & 7.2m depth Spectral attenuation coefficient for irradiance Spectral water leaving radiance Spectral normalized water leaving radiance Spectral remote sensing reflectance
2	Fluorometer	Chlorophyll-a concentration Normalized turbidity unit
3	Met buoy sensors	Air pressure Air temperature, Wind speed, Wind direction Relative humidity, Water temperature
4	Sun photometer	Aerosol optical depth Integrated water vapor
5	Micro rain radar	Rain rate
6	Disdrometer	Rain intensity, Rain amount Total rain amount
7	Dr.Pisharoty sonde	Air pressure, Air temperature, Relative humidity Wind speed, Wind direction

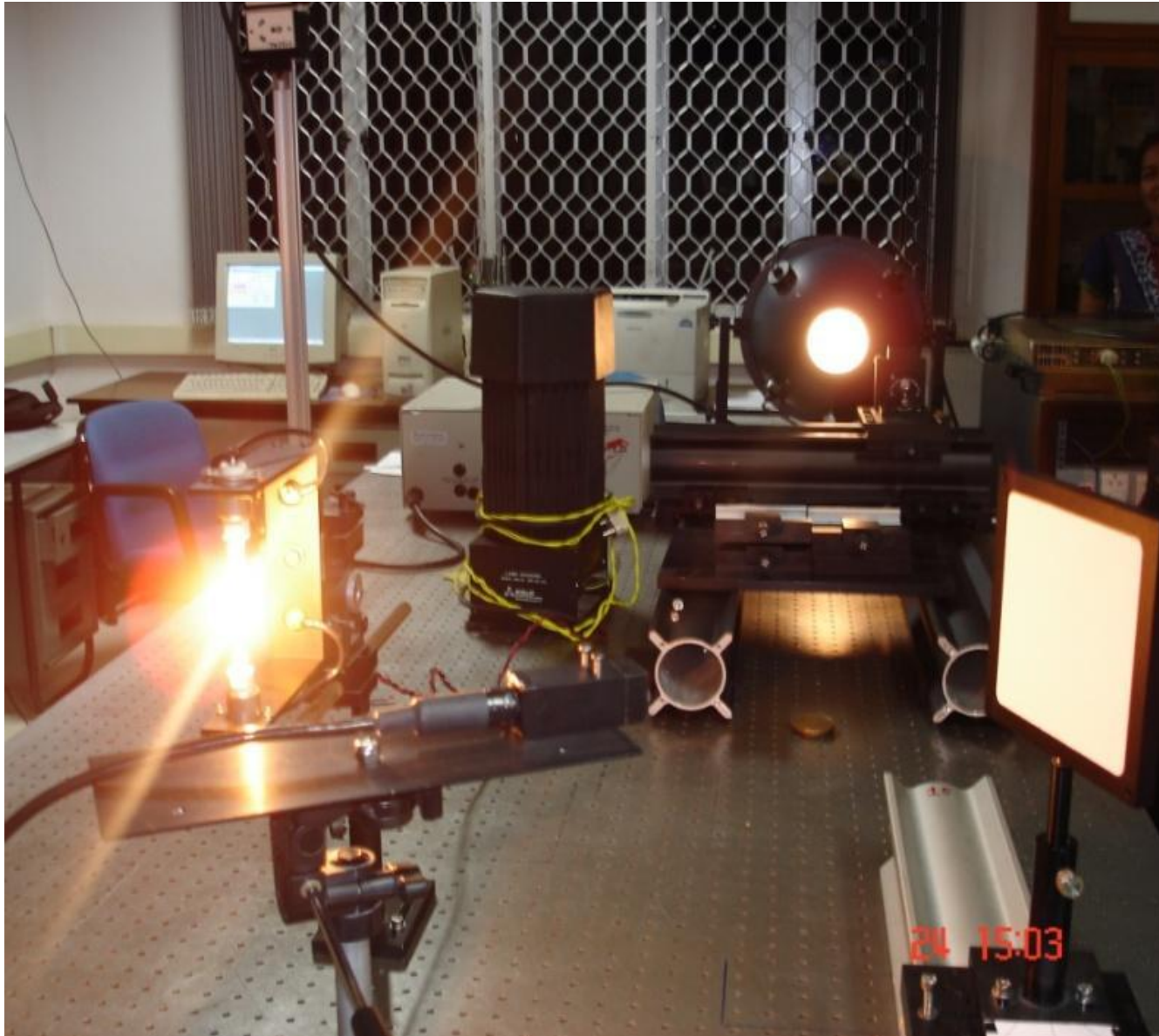
Accuracy of in-situ parameters

Sr.No.	Instrument	Parameter	Measurement error
1	In-air Hyper-spectral radiometer (350-850nm)	Down-welling irradiance	+/- 2%
2	In-water Hyper-spectral radiometer (350-850nm)	Up-welling radiance Down-welling irradiance	+/- 2% +/- 2%
3	Fluorometer	Chlorophyll-a concentration	0.02 µg/ltr.*
4	Turbidity sensor	Turbidity	0.1 NTU
5	Sun photometer	Direct-sun irradiance Sky radiance	+/- 2% +/- 2%
6	Anemometer	Wind speed Wind direction	+/- 2% +/- 1%
7	Air temperature sensor	Air temperature	+/- 0.1 °C
8	Hygrometer	% Relative Humidity	+/- 1%
9	Barometer	Air pressure	+/- 0.05%
10	Thermometer	Sea surface temperature	+/-0.005 °C

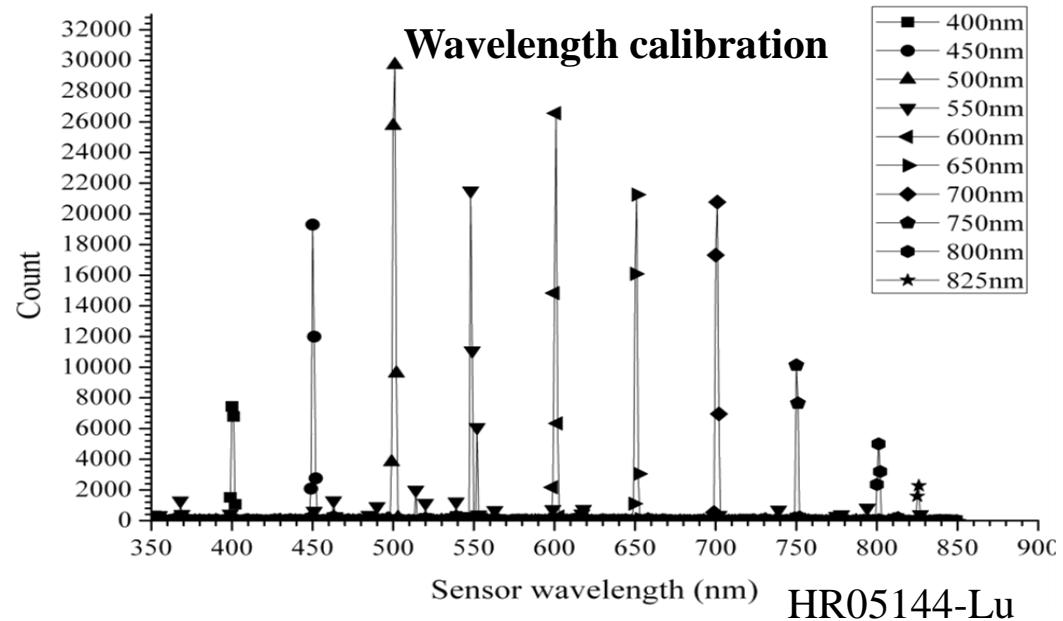
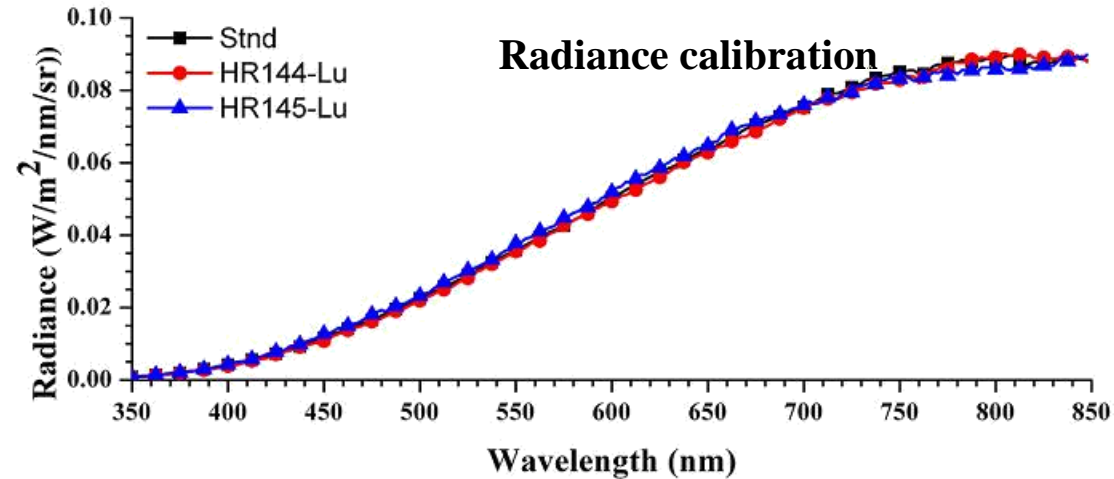
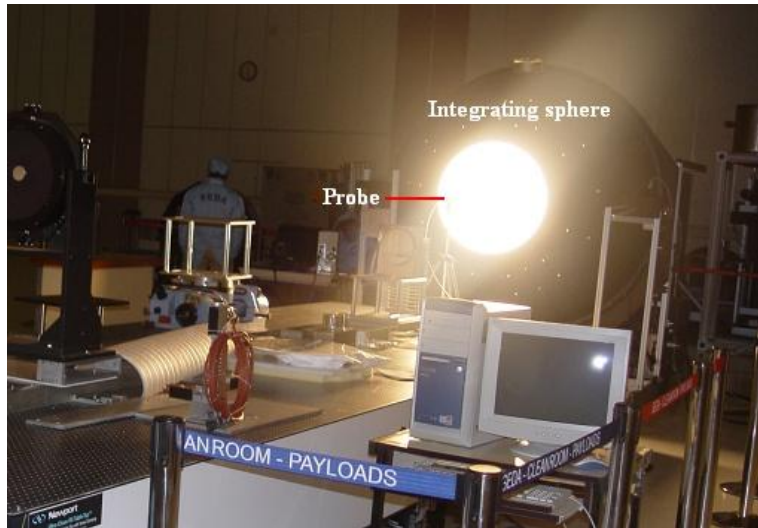
Integrating sphere for Radiance calibration



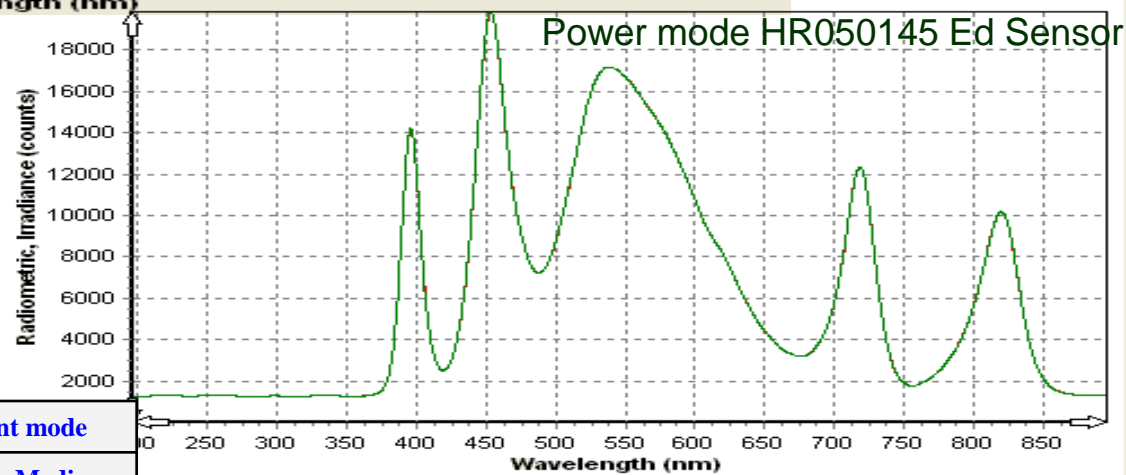
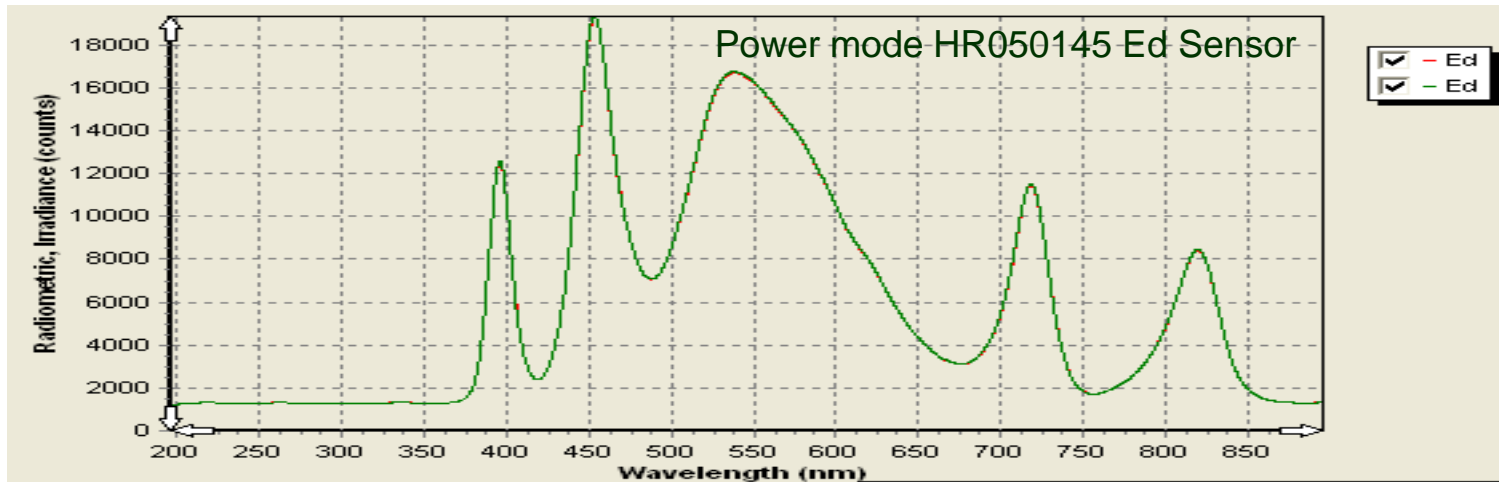
Calibration setup for irradiance calibration



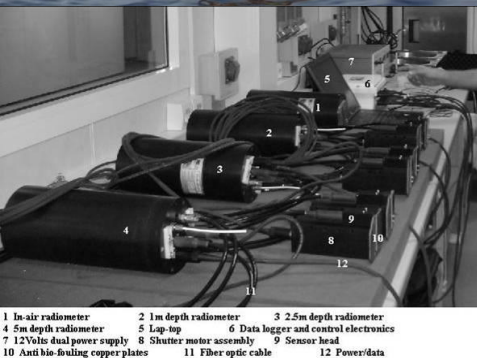
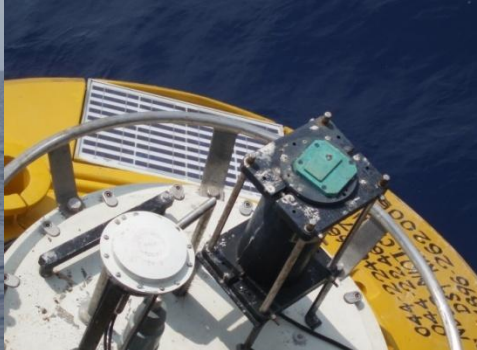
Absolute rad./wavelength calibration of radiometers



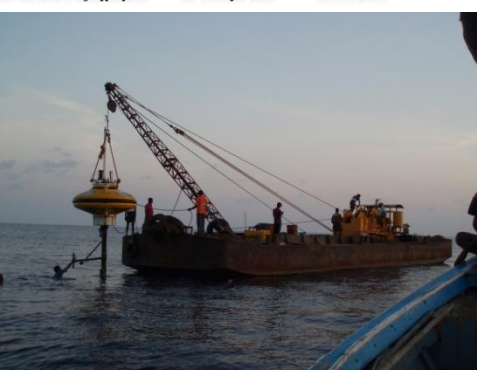
Temporal stability of radiometric sensor



Peak	Power mode		Current mode	
	RMS Error	Median Error	RMS Error	Median Error
UV (390-405nm)	0.3	0.3	0.2	0.2
Blue (440-470nm)	0.2	0.2	0.1	0.1
Green(500-610nm)	0.3	0.3	0.1	0.1
White(440-610nm)	0.3	0.3	0.1	0.1
Red(700-730nm)	0.6	0.6	0.1	-1.0
IR(800-830nm)	0.4	0.5	0.1	-0.1
Entire spectrum(390-830nm)	0.4	0.3	0.2	0.1



1 In-air radiometer 2 1m depth radiometer 3 2.5m depth radiometer
 4 5m depth radiometer 5 Lap-top 6 Data logger and control electronics
 7 12Vdc dual power supply 8 Shutter motor assembly 9 Sensor head
 10 Anti bio-fouling copper plates 11 Fiber optic cable 12 Power/data



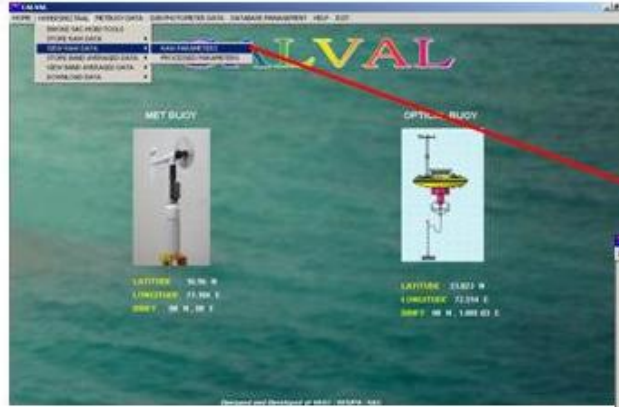
भारत सरकार
समुद्रीय केल-वल प्रयोगशाला OCEAN CAL-WAL LABORATORY
 अखिल विभाग
 भारतीय अंतरिक्ष अनुसंधान संस्थान
 अखिल अणुकेन्द्र केंद्र
 अहमदाबाद-380 015

Government of India
OCEAN CAL-WAL LABORATORY
 Department of Space
 Indian Space Research Organisation
 Space Applications Centre
 Ahmedabad-380 015

एशिया महाद्वीप
 समुद्रीय केल-वल प्रयोगशाला
 अखिल अणुकेन्द्र केंद्र
 अहमदाबाद-380 015

Established in association with
 Department of Science & Technology, Government of India
 Ministry of Earth Sciences, Government of India
 National Institute of Oceanography, Goa
 National Physical Laboratory, New Delhi

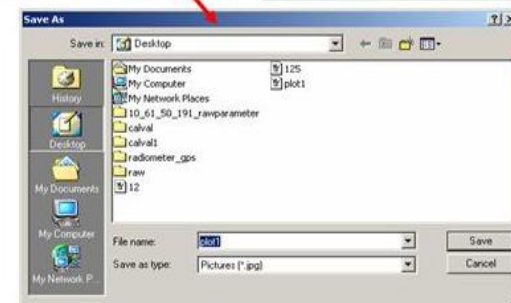
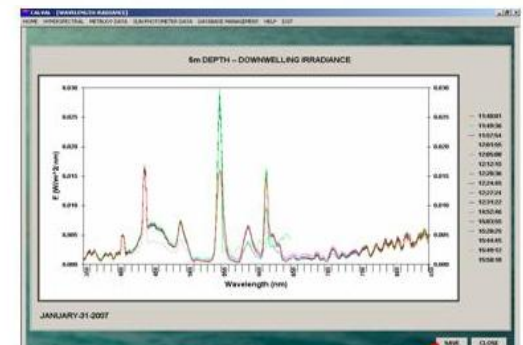
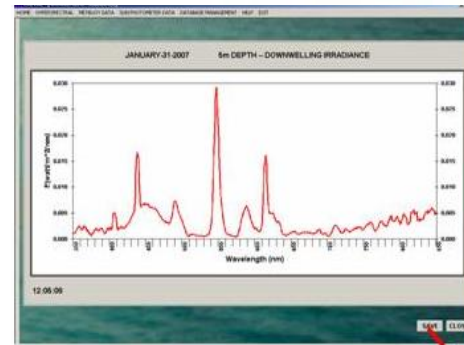
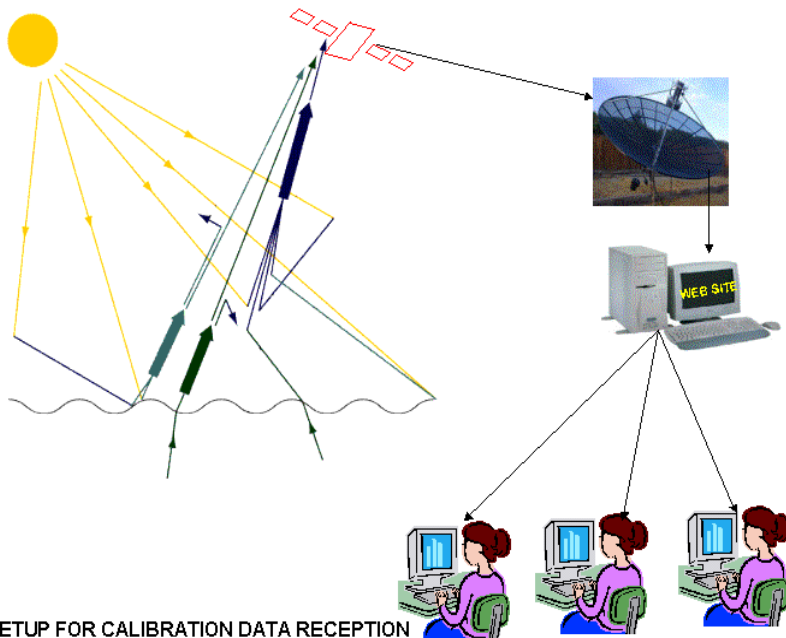
CAL-VAL Package for data archival/retrieval




On clicking **View Raw data – Raw parameters**, new window opens.



Before selecting any raw data parameter if user perform any activity then a message is being displayed i.e **select parameter first**



on clicking **SAVE** button, user can save these plots for future reference. On clicking **CLOSE** button control goes back to previous window.



CALIBRATION AND VALIDATION PROGRAM

Space Applications Centre, ISRO



Home	About Us	Site List	Tools & Information	FAQs	Contact Us
------	----------	-----------	---------------------	------	------------

Login

Welcome!

Please Login or Register.

Username

Password

[Forgot Password?](#)

Feedback

Name

Email

Message

Suggested links

[MOSDAC](#)

Hits - 4157


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 CALVAL Site



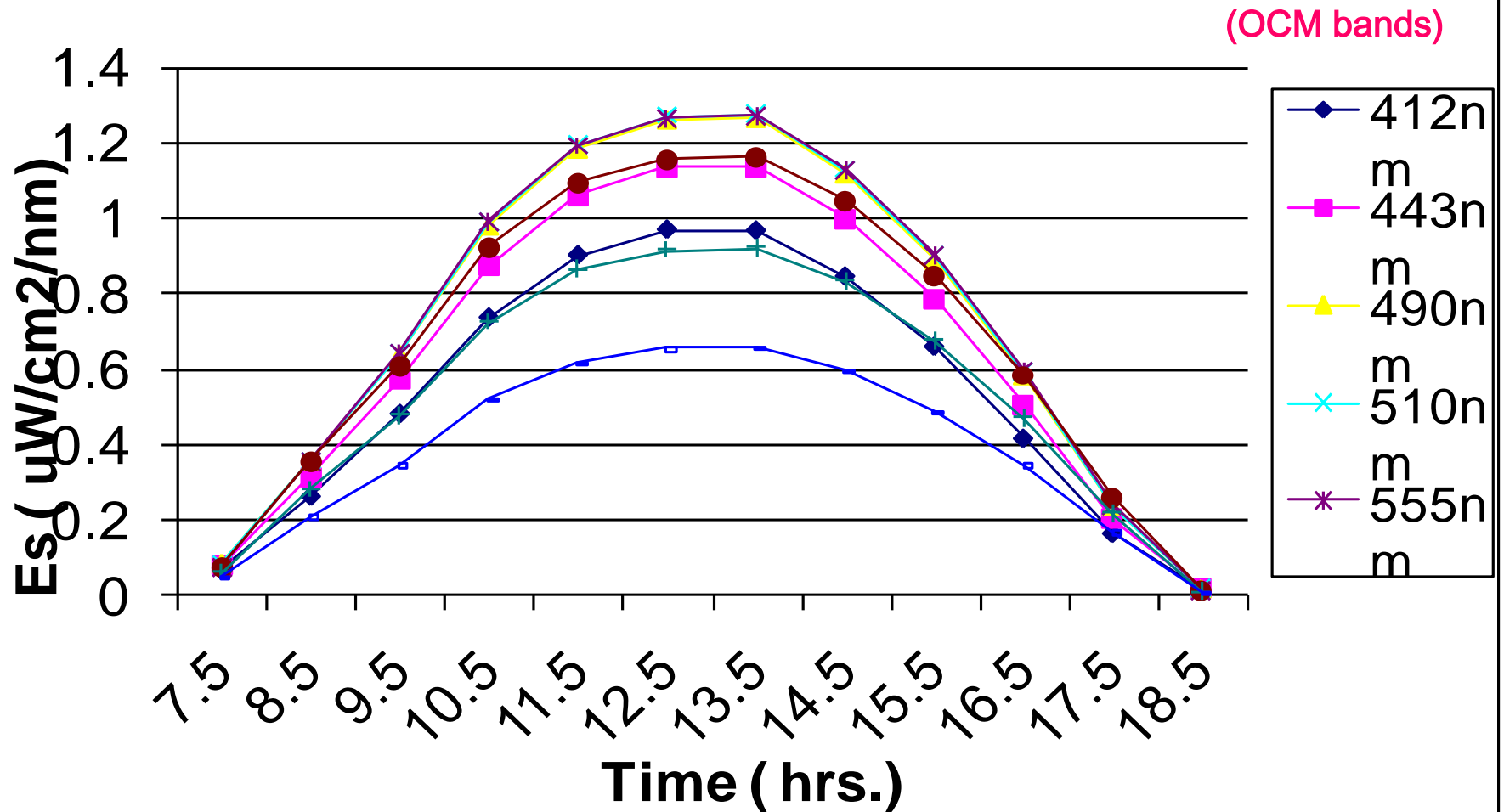
Sun/Sky Photometry on Island



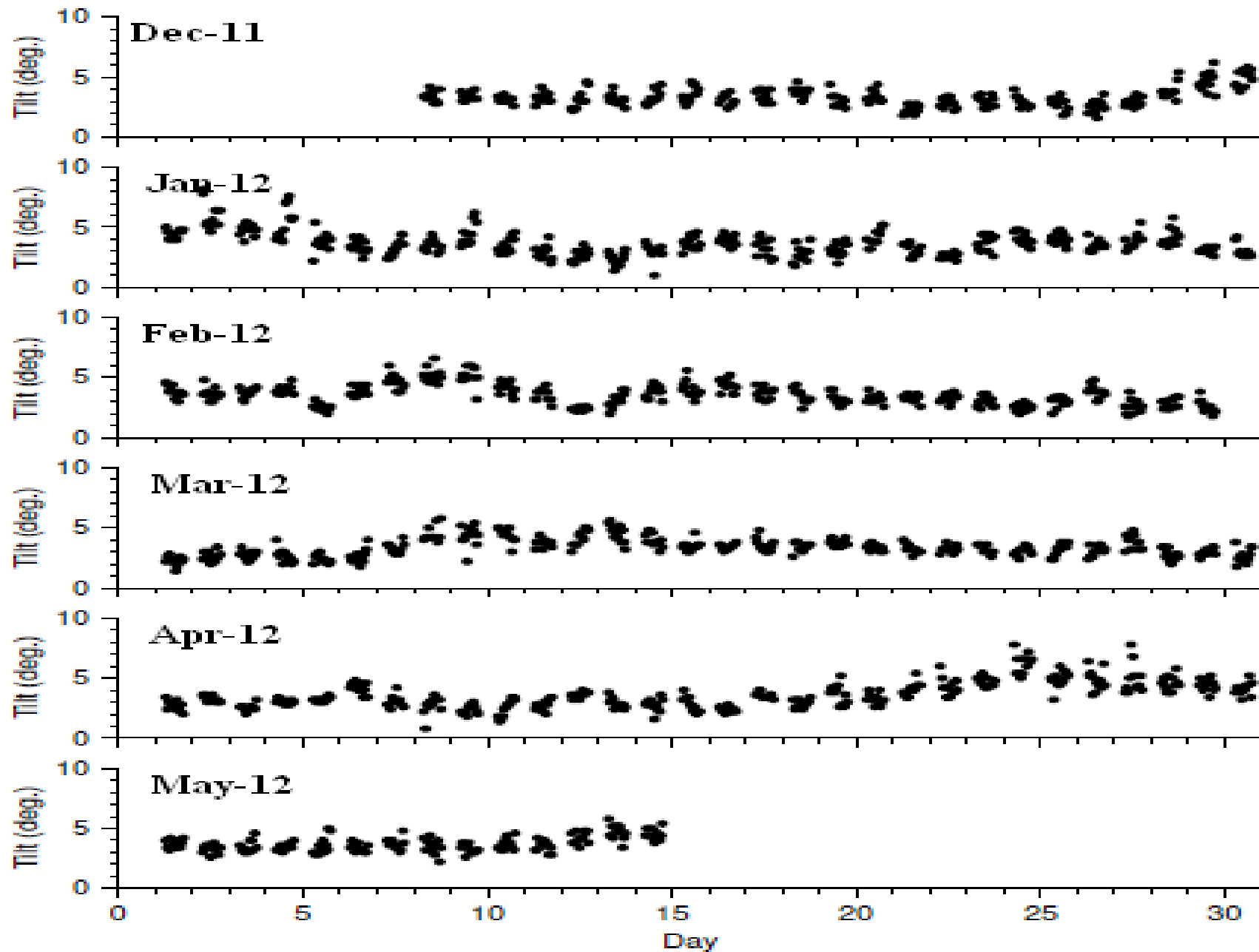
Optical Dismeter

**DATA ANALYSIS FOR VICARIOUS
CALIBRATION OF OCM2**

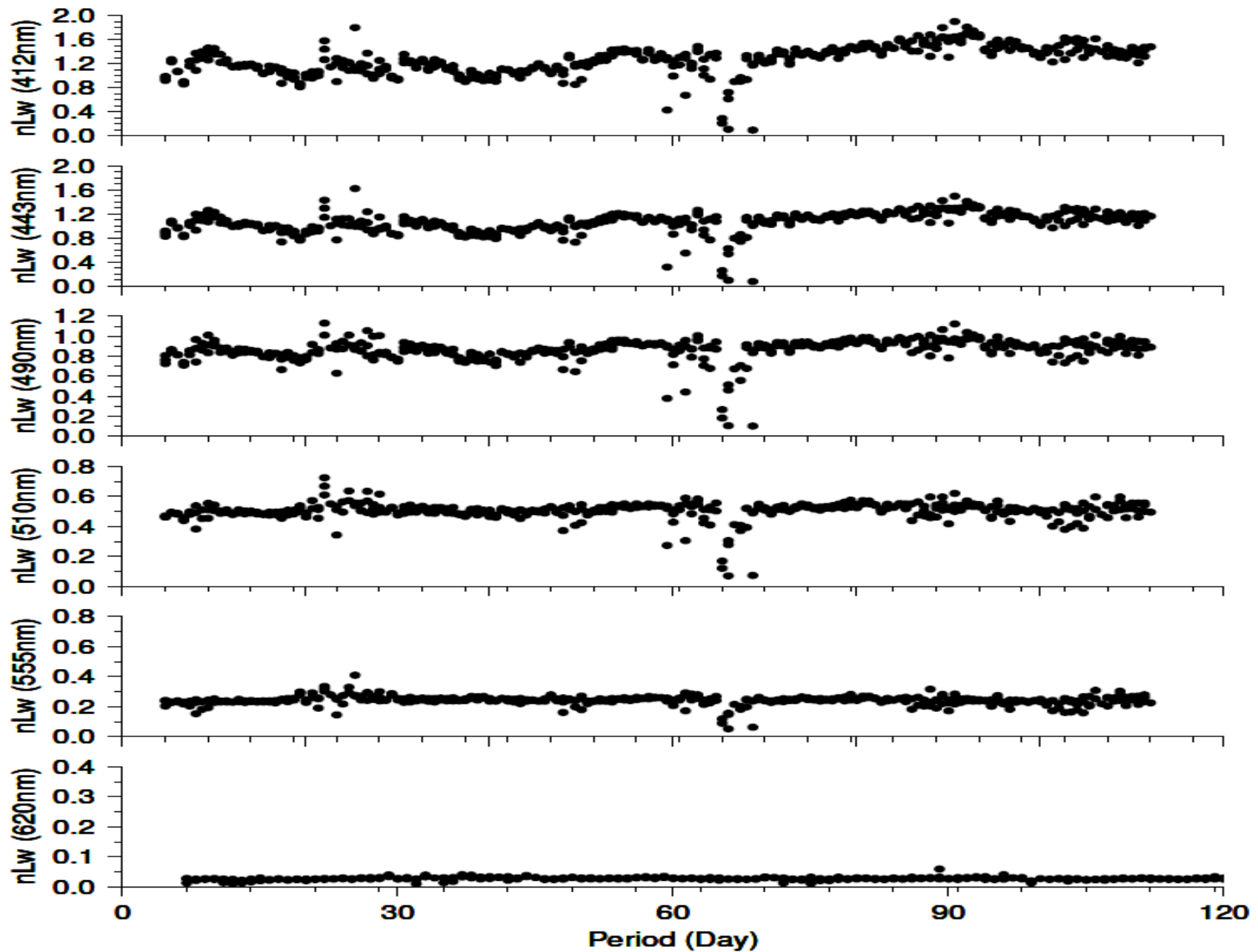
Solar irradiance at sea surface (Good day at Kavaratti)



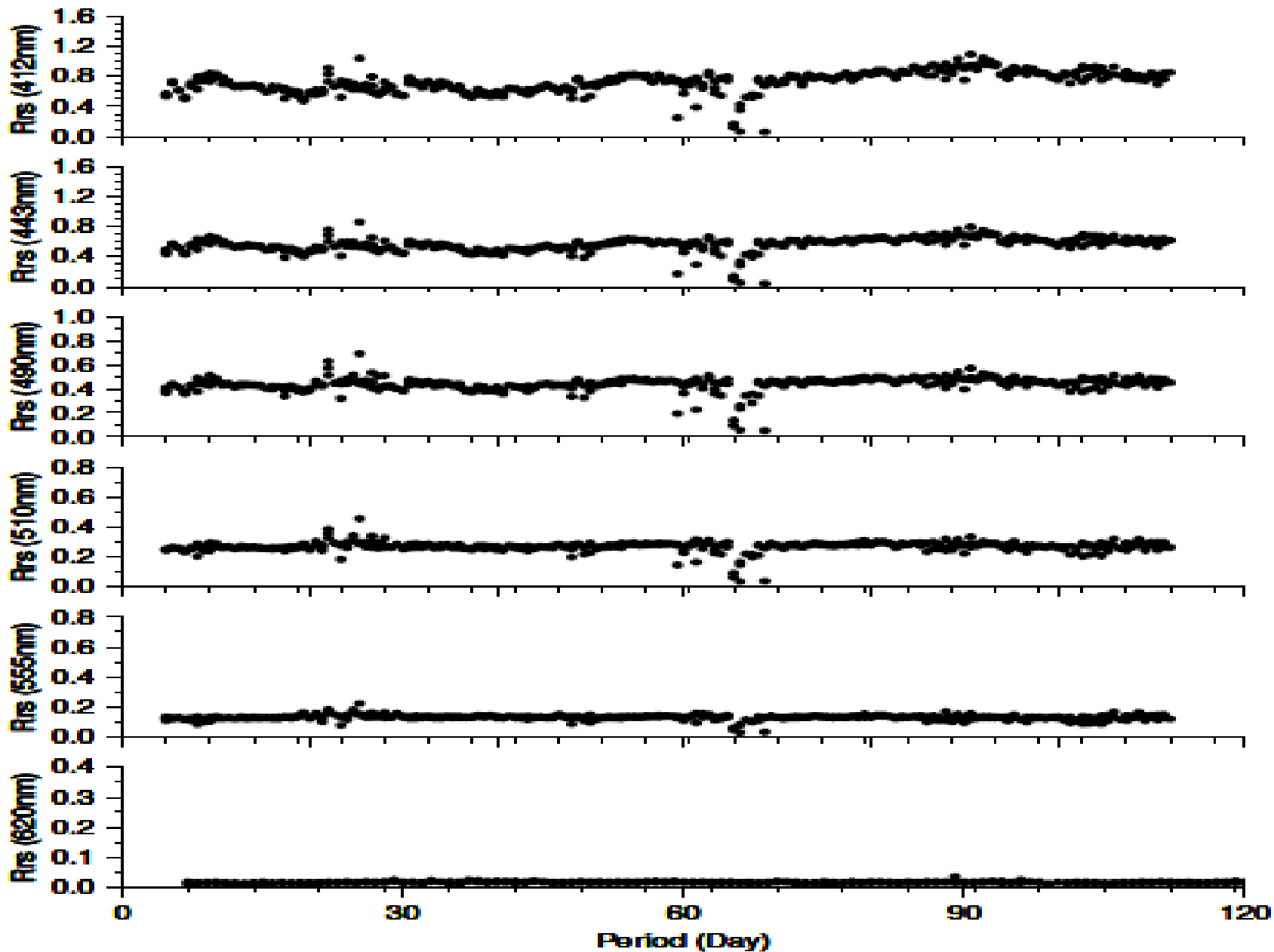
OPTICAL buoy tilt during deployment



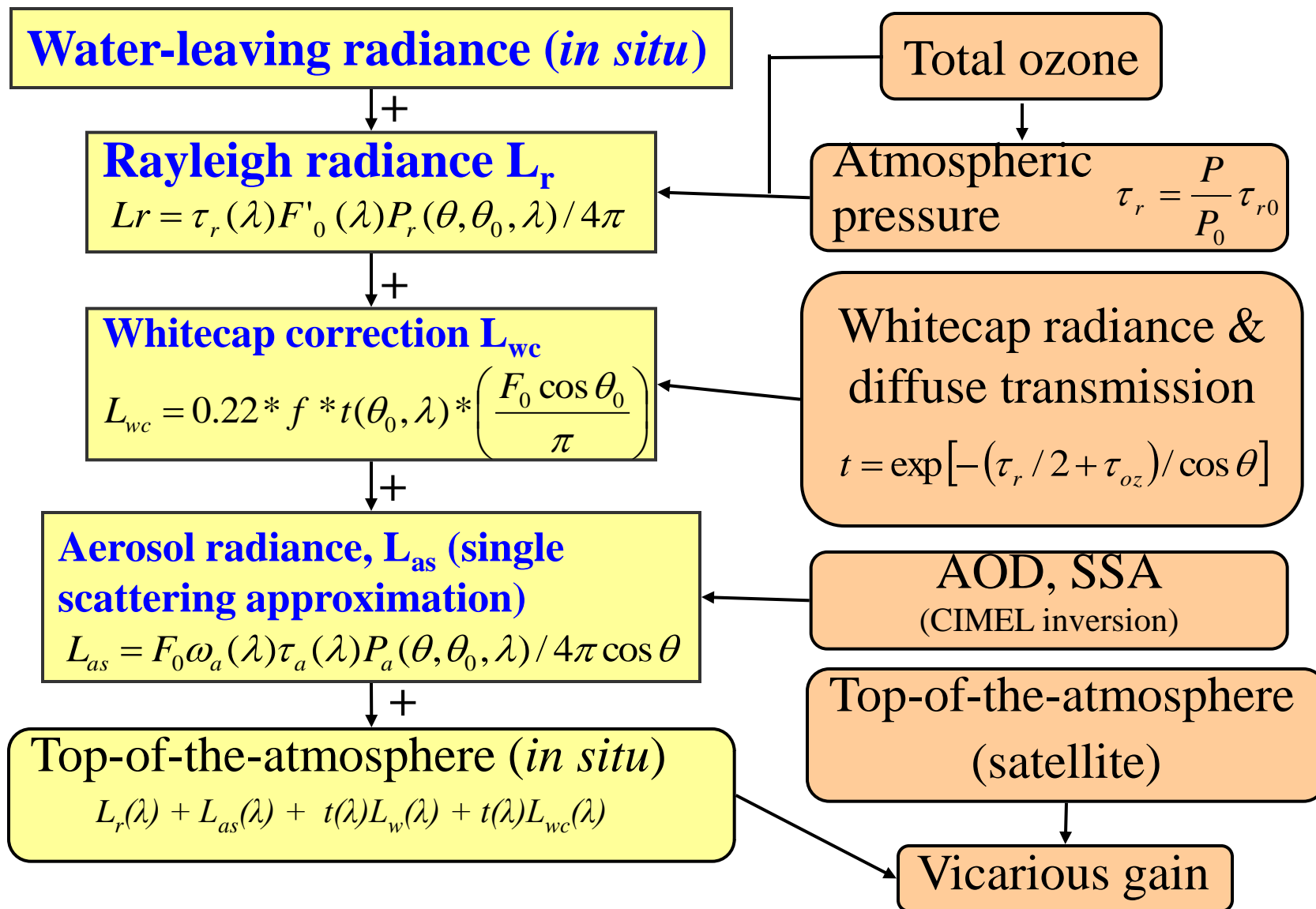
nLw from OPTICAL buoy during deployment



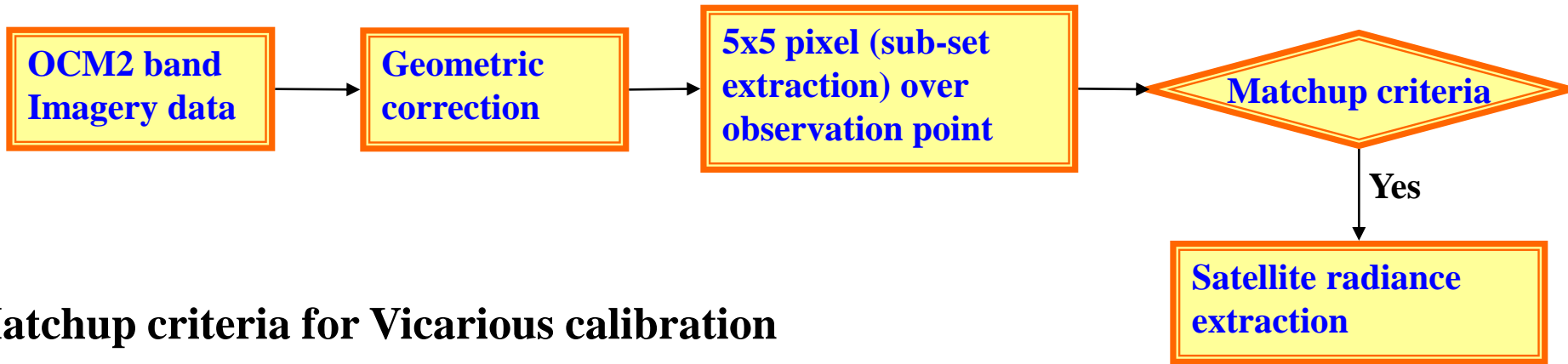
Rrs from OPTICAL buoy during deployment



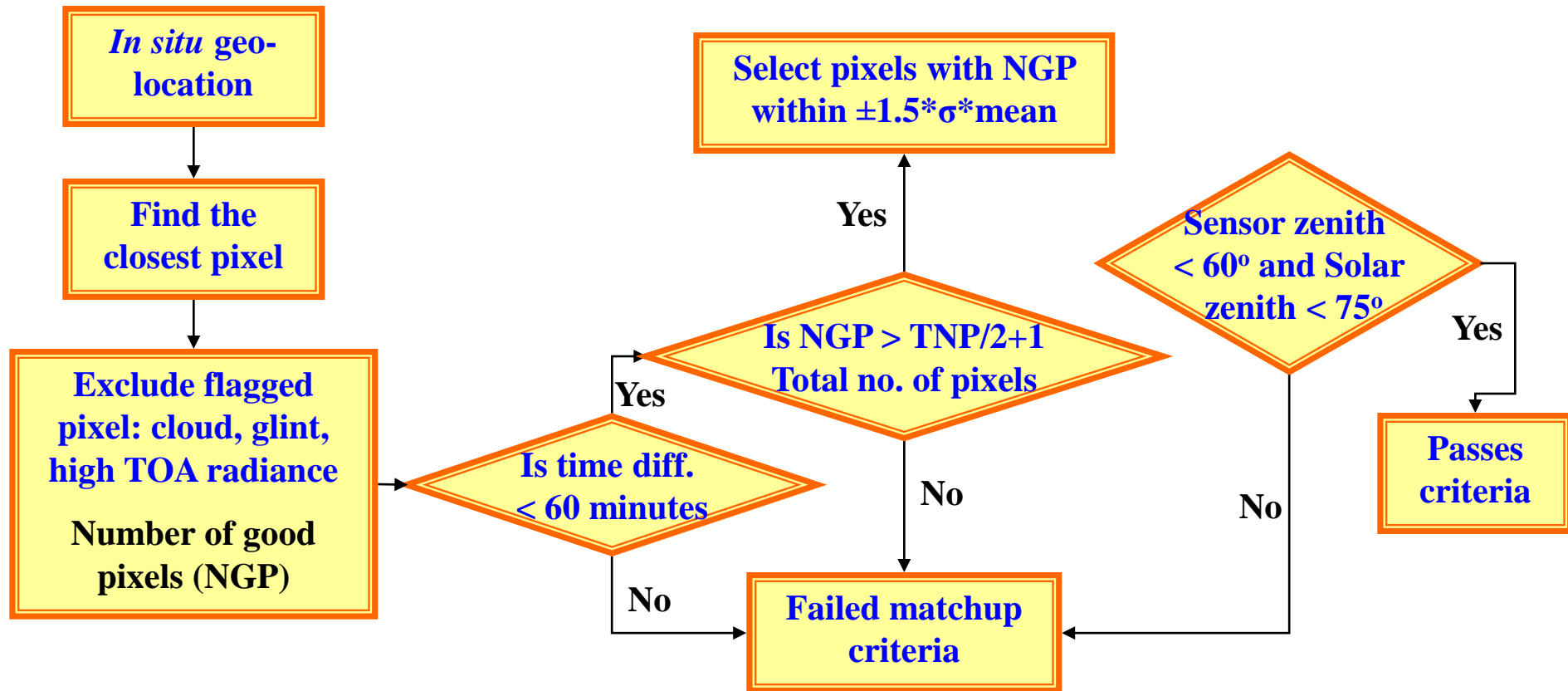
Vicarious calibration of OCM2 sensor



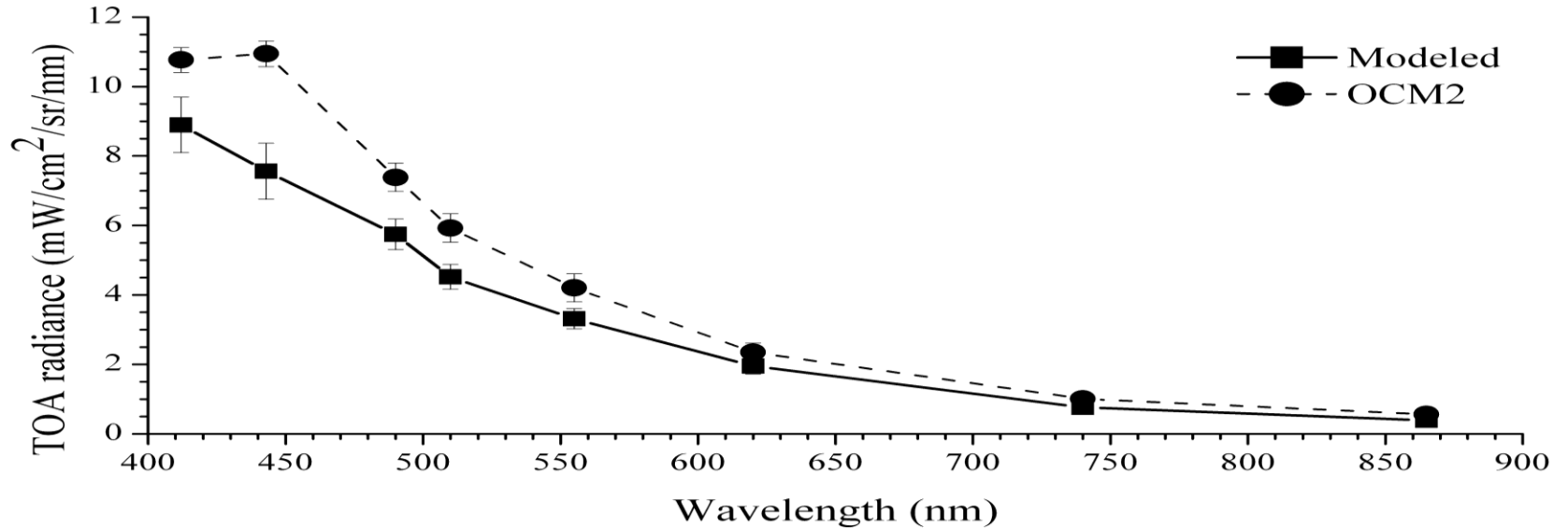
Satellite radiance extraction



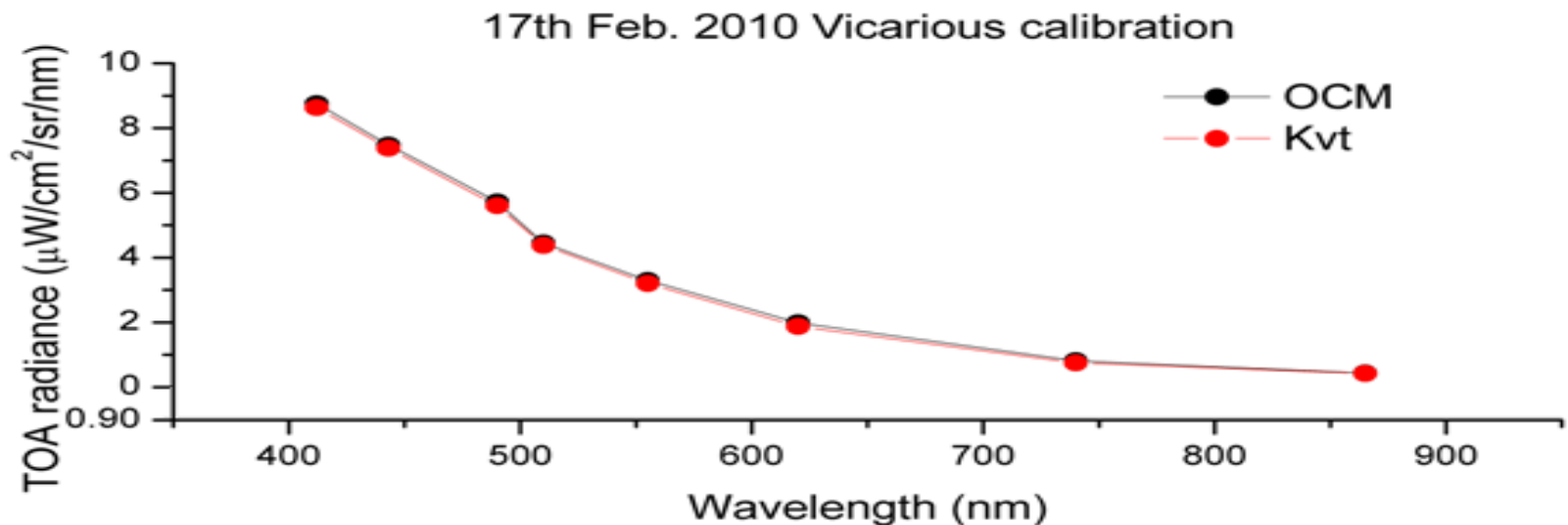
Matchup criteria for Vicarious calibration

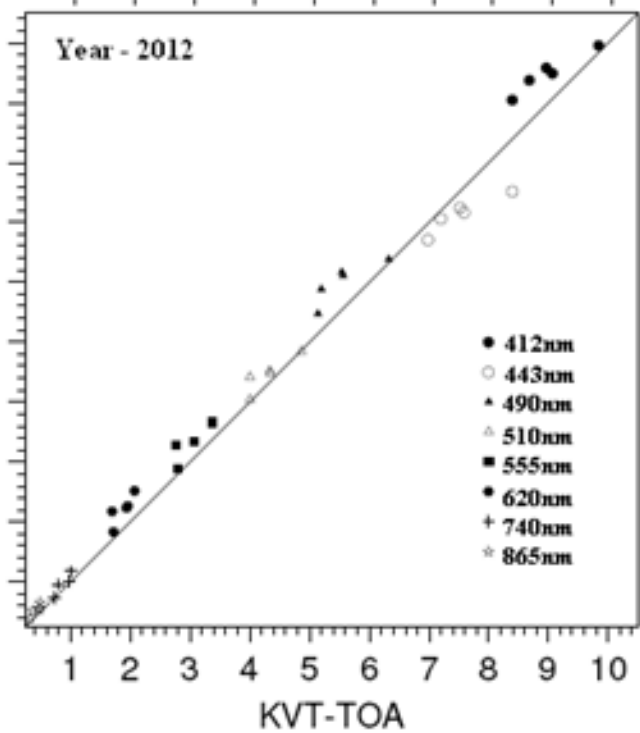
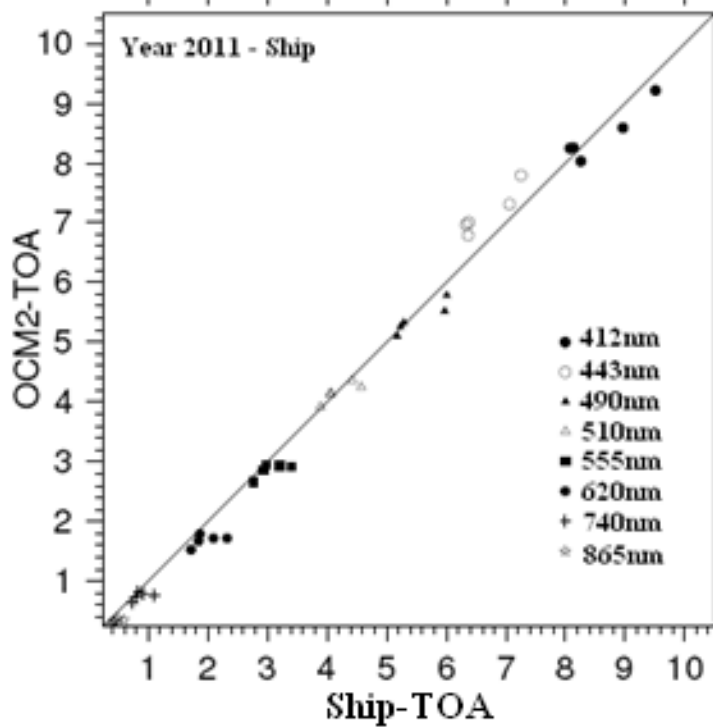
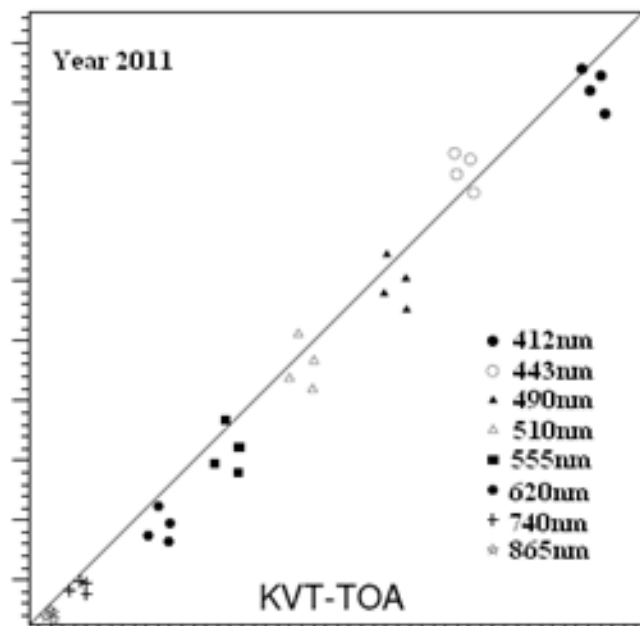
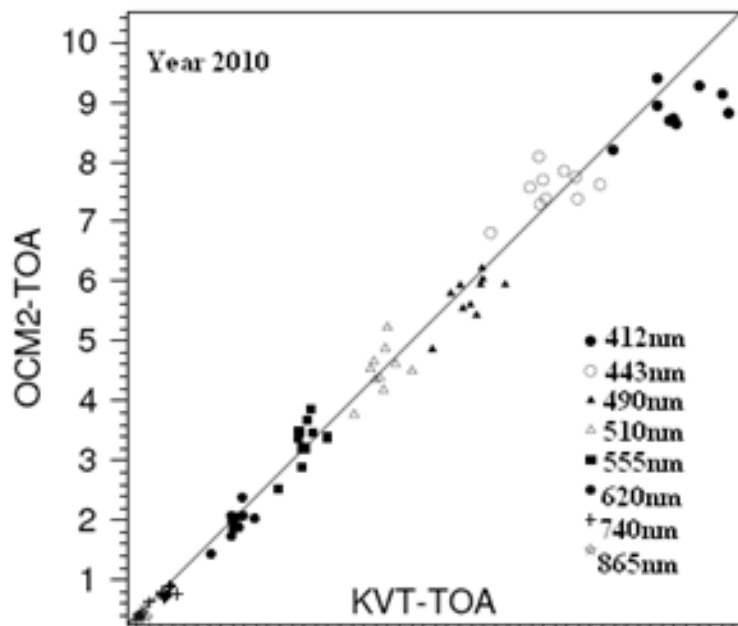


TOA radiance comparison before Vicarious calibration



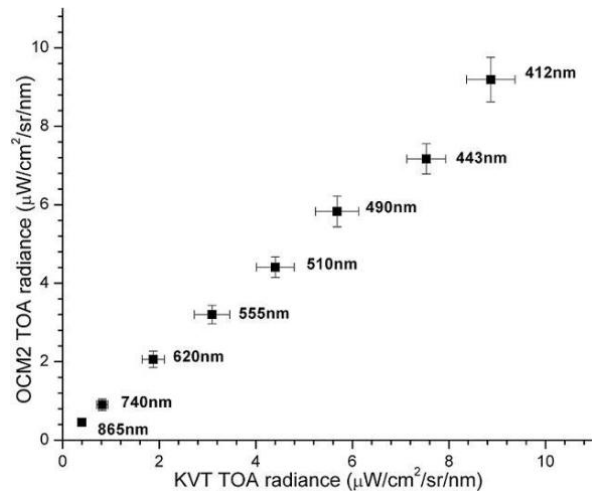
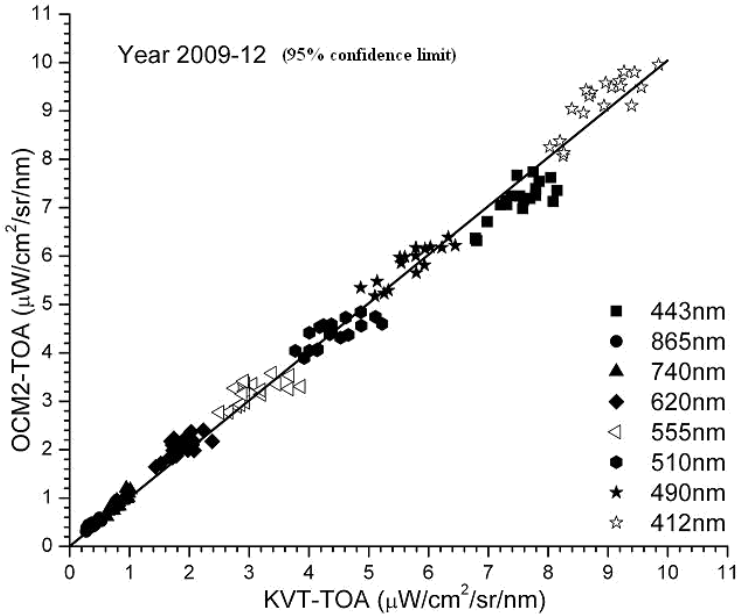
TOA radiance comparison after Vicarious calibration





Vicarious calibration of OCM2

TOA radiance with 95% confidence



Band No.	Total points	CC (R^2)	Mean TOA radiance ($\mu\text{W}/\text{cm}^2/\text{sr}/\text{nm}$)	
			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

Kavaratti vicarious calibration gain coefficients

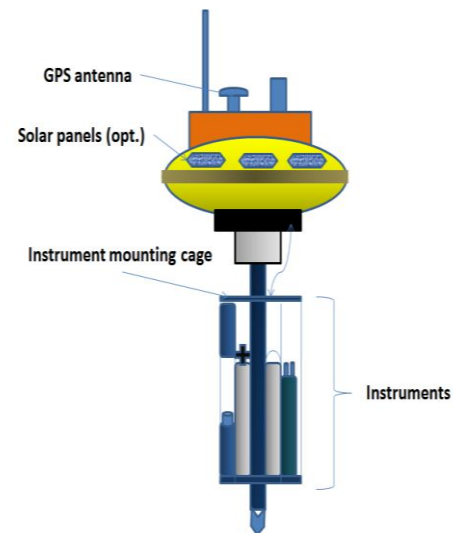
Band	Year 2009-10	Year 2011	Year 2012	Year 2010-12
	Gain \pm SD	Gain \pm SD	Gain \pm SD	Gain \pm SD
1	0.93 \pm 0.04	0.97 \pm 0.03	0.95 \pm 0.03	0.95 \pm 0.03
2	1.03 \pm 0.04	1.06 \pm 0.04	1.06 \pm 0.02	1.05 \pm 0.04
3	0.96 \pm 0.04	0.97 \pm 0.04	0.92 \pm 0.04	0.96 \pm 0.04
4	1.00 \pm 0.07	0.97 \pm 0.05	0.97 \pm 0.04	0.98 \pm 0.06
5	1.00 \pm 0.09	0.93 \pm 0.07	0.91 \pm 0.05	0.95 \pm 0.09
6	0.95 \pm 0.08	0.86 \pm 0.07	0.87 \pm 0.06	0.90 \pm 0.08
7	0.88 \pm 0.07	0.88 \pm 0.06	0.92 \pm 0.07	0.89 \pm 0.06
8	0.88 \pm 0.05	0.71 \pm 0.05	0.81 \pm 0.02	0.80 \pm 0.08

Scale factors for OCM 2 sensor radiance

Central wavelength (nm)	Year 2009-2010	Year 2011	Year 2012	Year 2013
	Scale factor, NRSC	Scale factor, NRSC	Scale factor, NRSC	Scale factor, NRSC
412	1.00	0.89	0.89	0.95
443	1.00	0.67	0.67	0.76
490	1.00	0.81	0.81	0.83
510	1.00	0.76	0.76	0.84
555	1.00	0.76	0.76	0.84
620	1.00	0.87	0.87	0.95
740	1.00	0.86	0.86	0.97
865	1.00	0.80	0.80	1.01

**OTHER CAL-VAL DEVELOPMENT
ACTIVITIES**

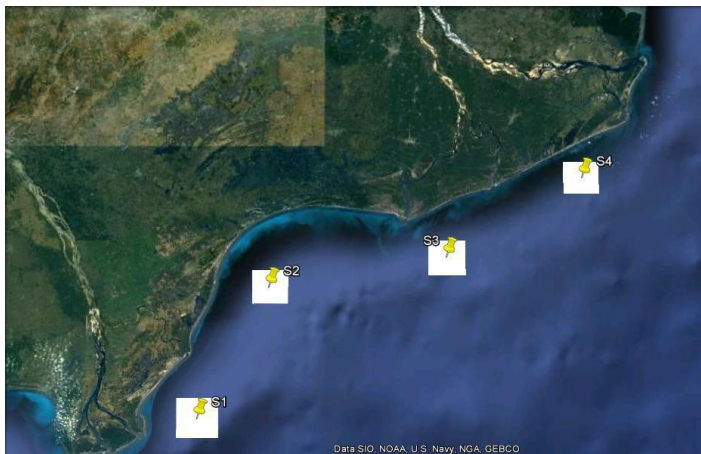
Development of Coastal CAL-VAL site in Krishna-Godavari basin (KG Site)



BACK SCATTERING SENSOR



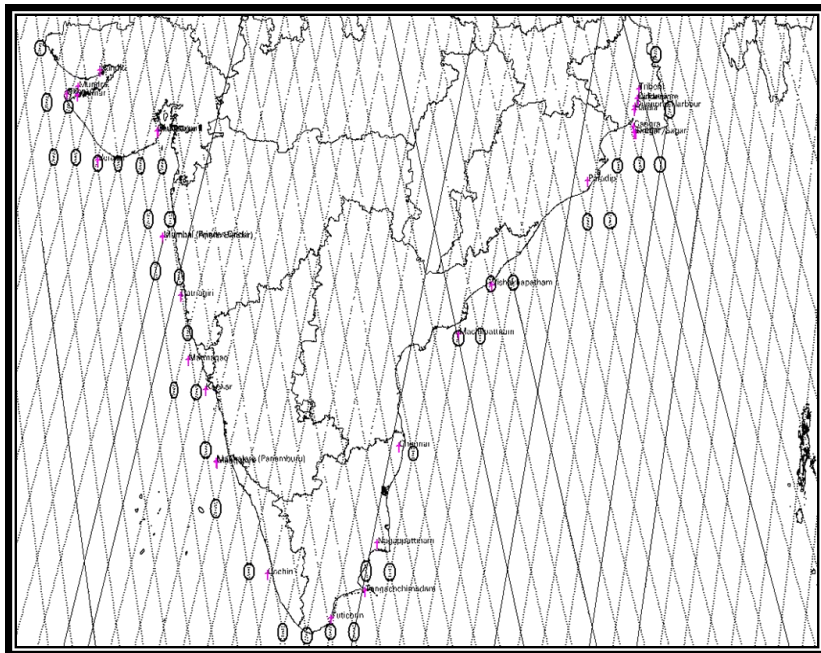
PAR SENSOR



Saral-Altika Calibration/Validation

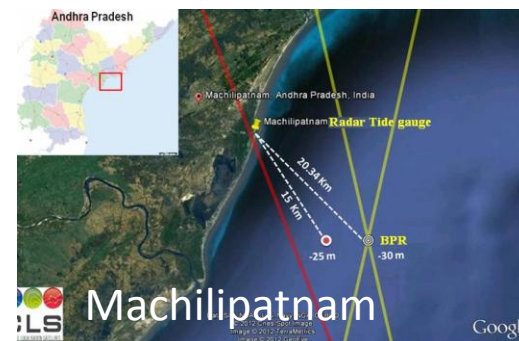
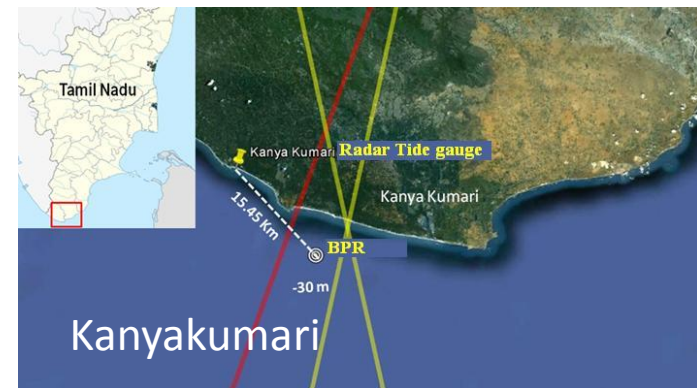
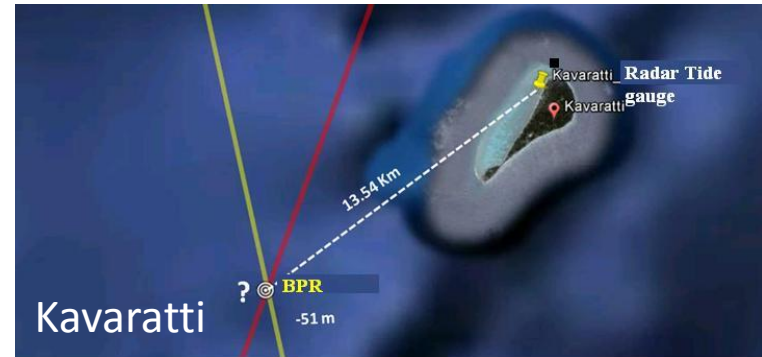
Parameters (accuracies)

- **Absolute calibration**
 - Sea surface height (2-3cm)
- **Geo-physical product validation**
 - Significant wave height (0.4-0.5m)
 - Wind speed (1.7-2m/s)



Saral pass

Calibration sites



SSH absolute calibration

GPS Buoy

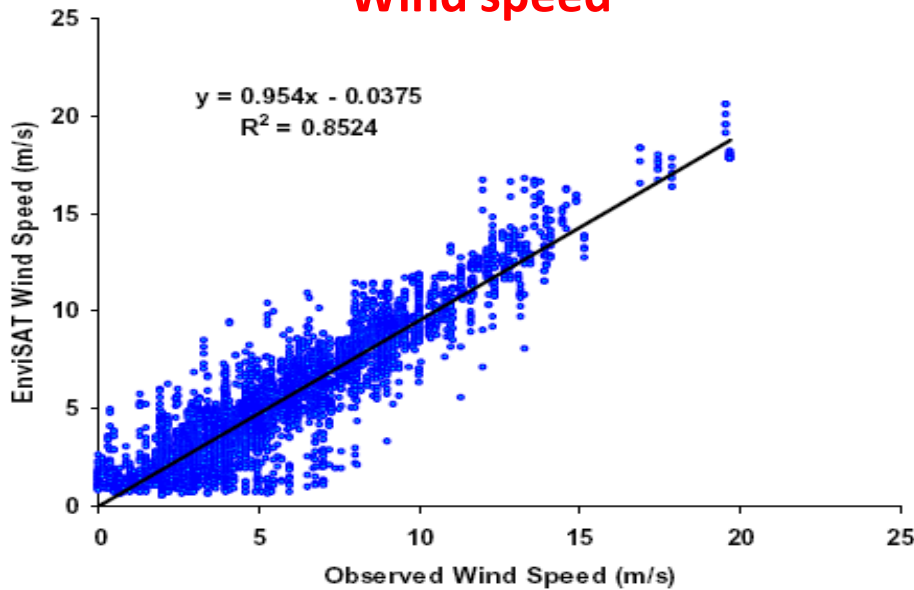


Radar gauge

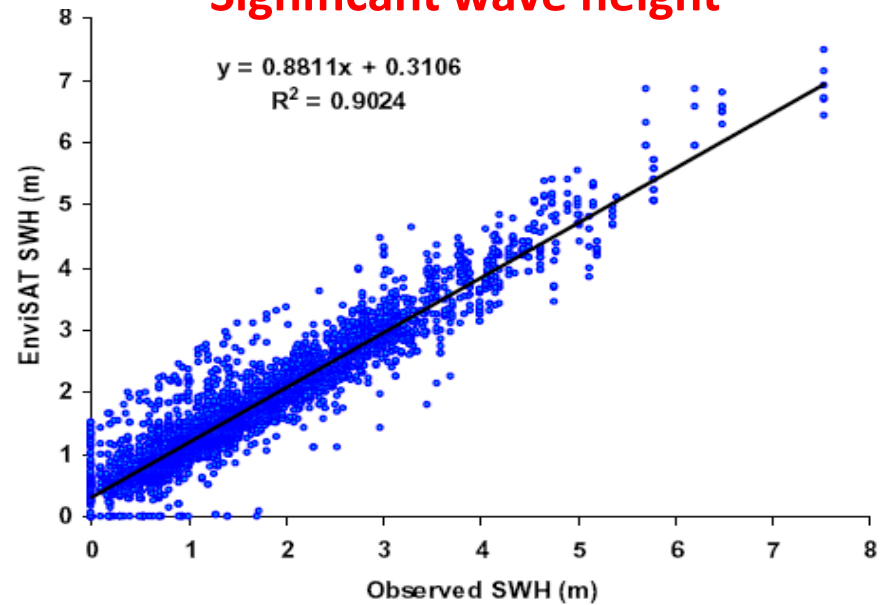


Geo-physical product validation

Wind speed



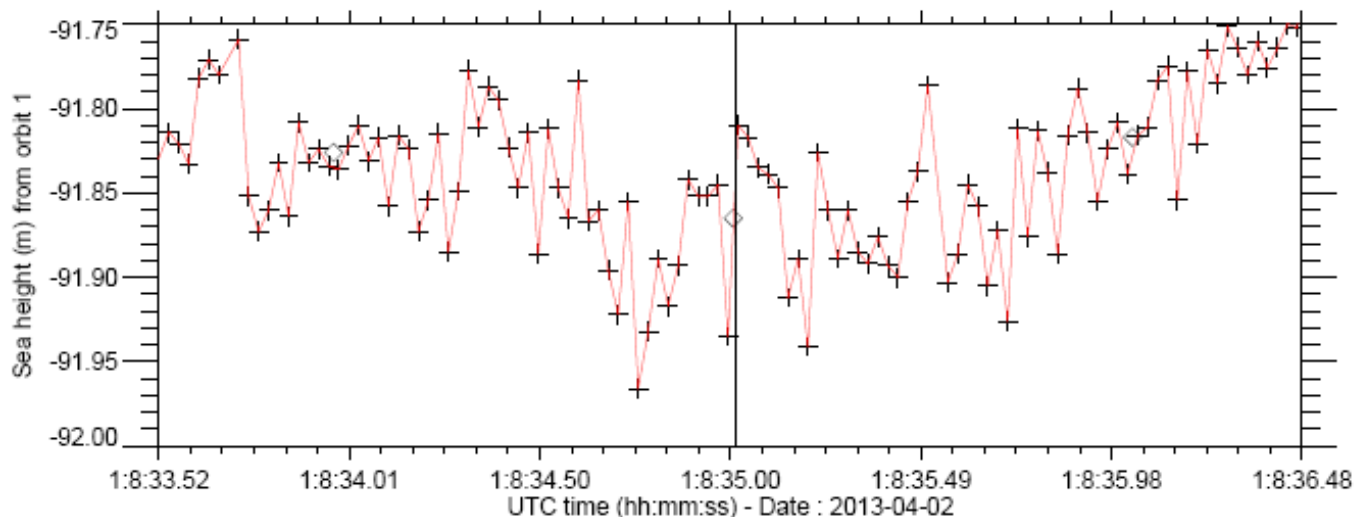
Significant wave height



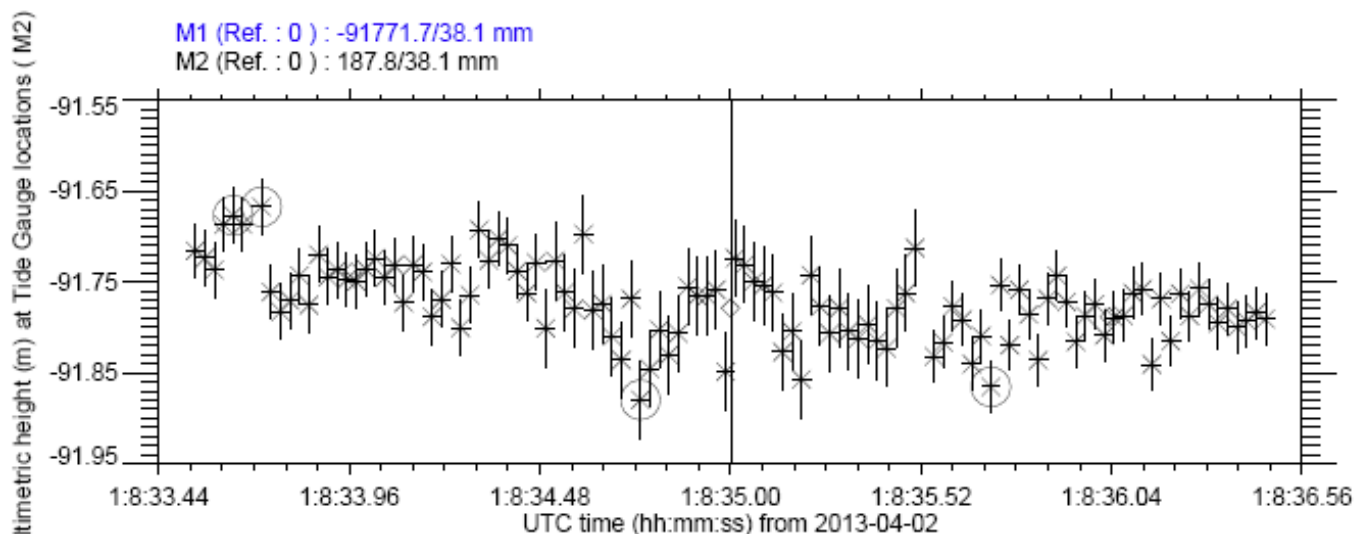
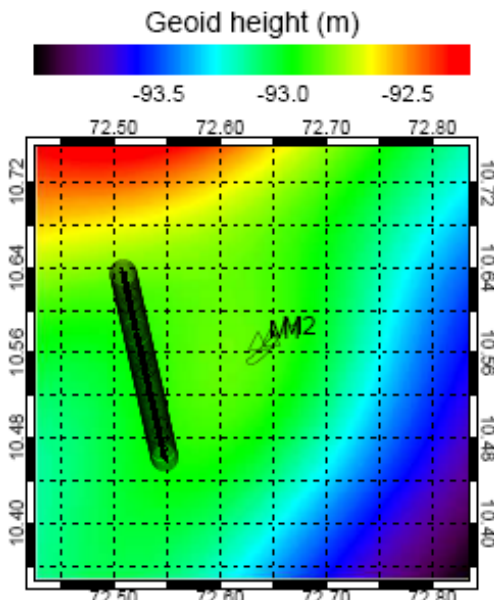
SARAL AltiKa: Calibration

IGDR

Absolute calibration result for SARAL OGDR on 2nd April 2013



1s resolution data : \diamond
 0.05s resolution data : $+$
 interpolated Tide Gauge data : \square
 eliminated data : \circ



M1 (Ref. : 0) : -91771.7/38.1 mm
 M2 (Ref. : 0) : 187.8/38.1 mm

PCA point : $*$
 Tide Gauge location : \triangle

Applied correction

Center of mass
 Dry tropospheric correction
 Wet tropospheric correction (radiometer)
 Ionospheric correction (Model)
 Sea State Bias correction (model 1)
 loading, solid and pole Tides

Point of Closest Measurement

-> Ref: M1
 Lat: 10.5490
 Lon: 72.5278
 Distance: 13.43 (Km)
 Time: 1:8:35.02 (UTC)

Point of Closest Approach

-> Ref: M1
 Lat: 10.5485
 Lon: 72.5279
 Distance: 13.43 (Km)
 Time: 1:8:35.01 (UTC)

Along track distance PCM-PCA

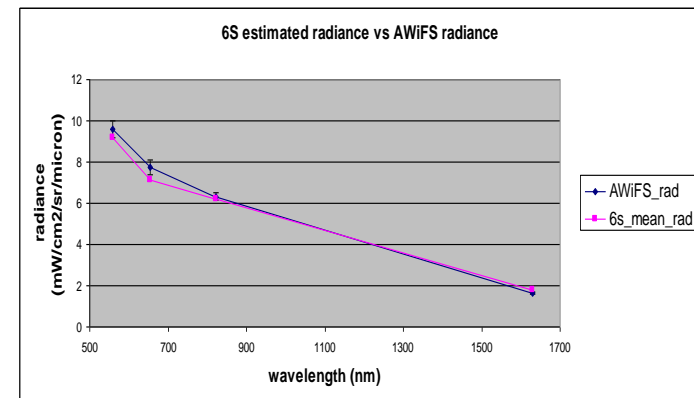
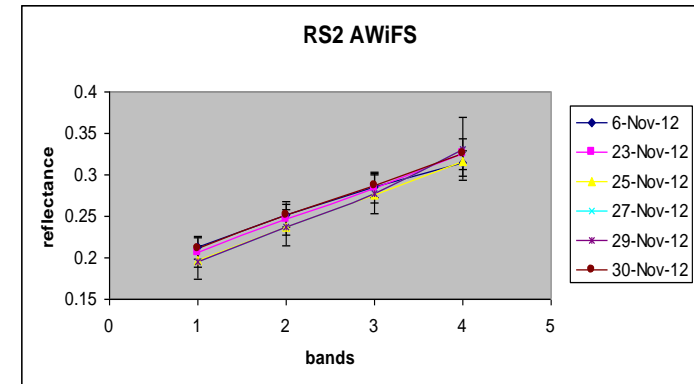
0.052 (Km)

Along track distance PCM-Coast

12.02 (Km)

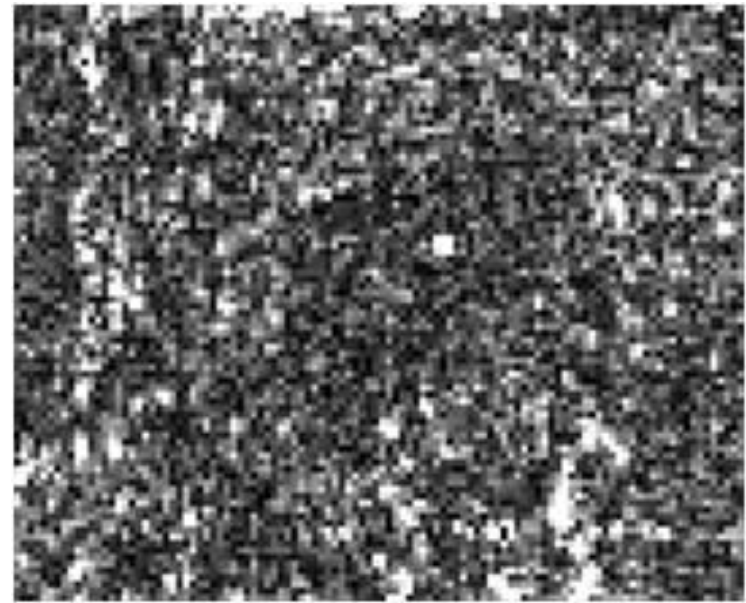
Vicarious calibration of Resourcesat-2

- Fully instrumented sites being developed (AWS, MRR, CIMEL,etc) in Rann of Kutch and SAC-Bopal campus
- Low aerosol loading $\sim 0.2 - 0.3$
- Inter-calibration of MODIS vs OCM2 and RS1, RS2 vs Landsat 7
- Vicarious calibration of RS1 LISS-III, LISS-IV, AWiFS
RS2 LISS-III, LISS-IV, AWiFS,OCM2 , Landsat-7, MODIS

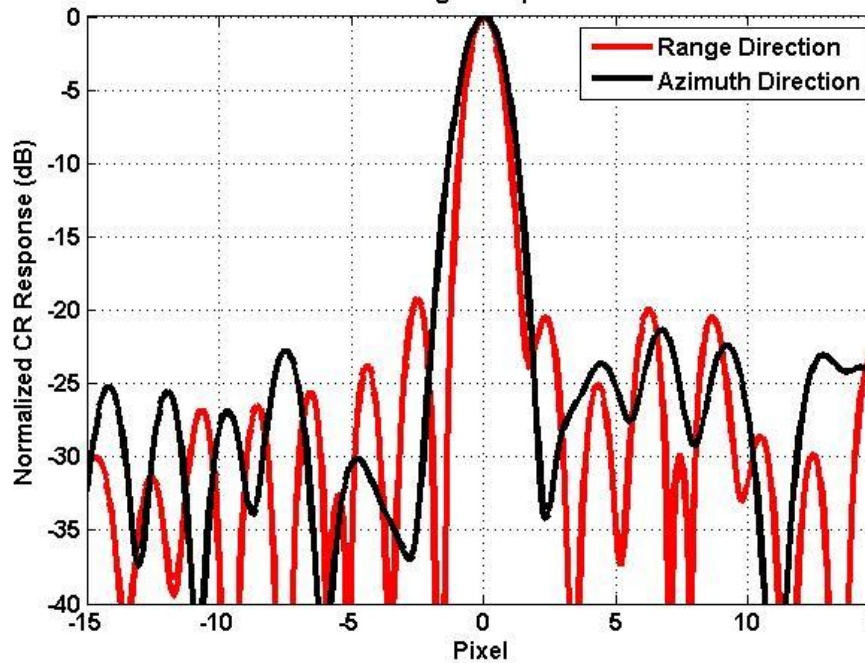


AWiFS	Spectral bands	Vicarious calibration coefficient
B1	520 – 590	0.96
B2	620 -680	0.92
B3	770 – 860	0.95
B4	1550-1750	1.11

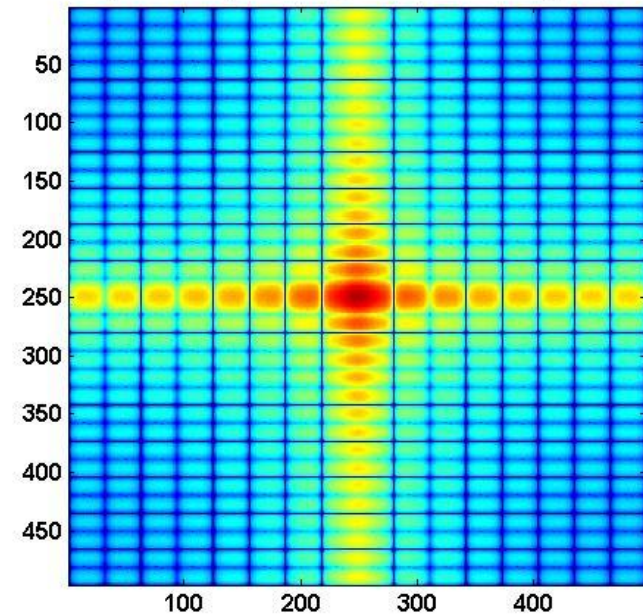
RISAT-1 SAR Calibration



Point Target Response CT



Expanded Impulse Response of Point Target - CT

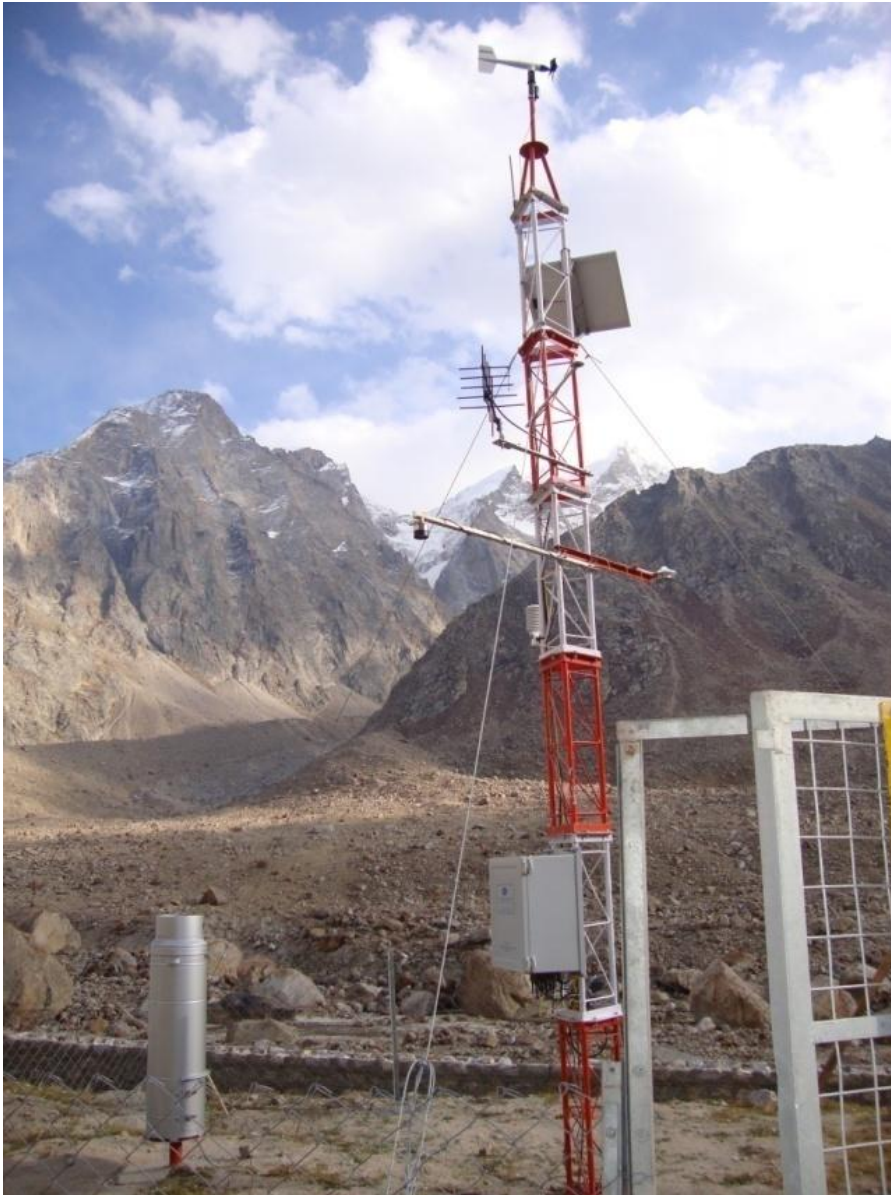


Meghatropiques Validation

- AWS, MRR & Disdrometer data collection at Kavaratti
- Dr.Pishroty Sonde data collection at Kavaratti
- Development of SAC-Bopal & Desalpar site in Rann of Kutch for in-situ measurements
- Validation of Meghatropiques products using site data
- Time series analysis of atmospheric parameters using Kavaratti, SAC-Bopal and Desalpar sites



Snow & Glacier - Chhota Shigri



Sr. No	Sensor
1	Net Radiation Sensor
2	Albedo Sensor
3	Air temperature sensor (ventilated)
4	Relative humidity sensor
5	Atmospheric pressure sensor
6	Wind Speed sensor (ultrasonic)
7	Wind Direction Sensor (ultrasonic)
8	Snow surface temperature sensor (ventilated)
9	Snow depth sensor (ultrasonic)

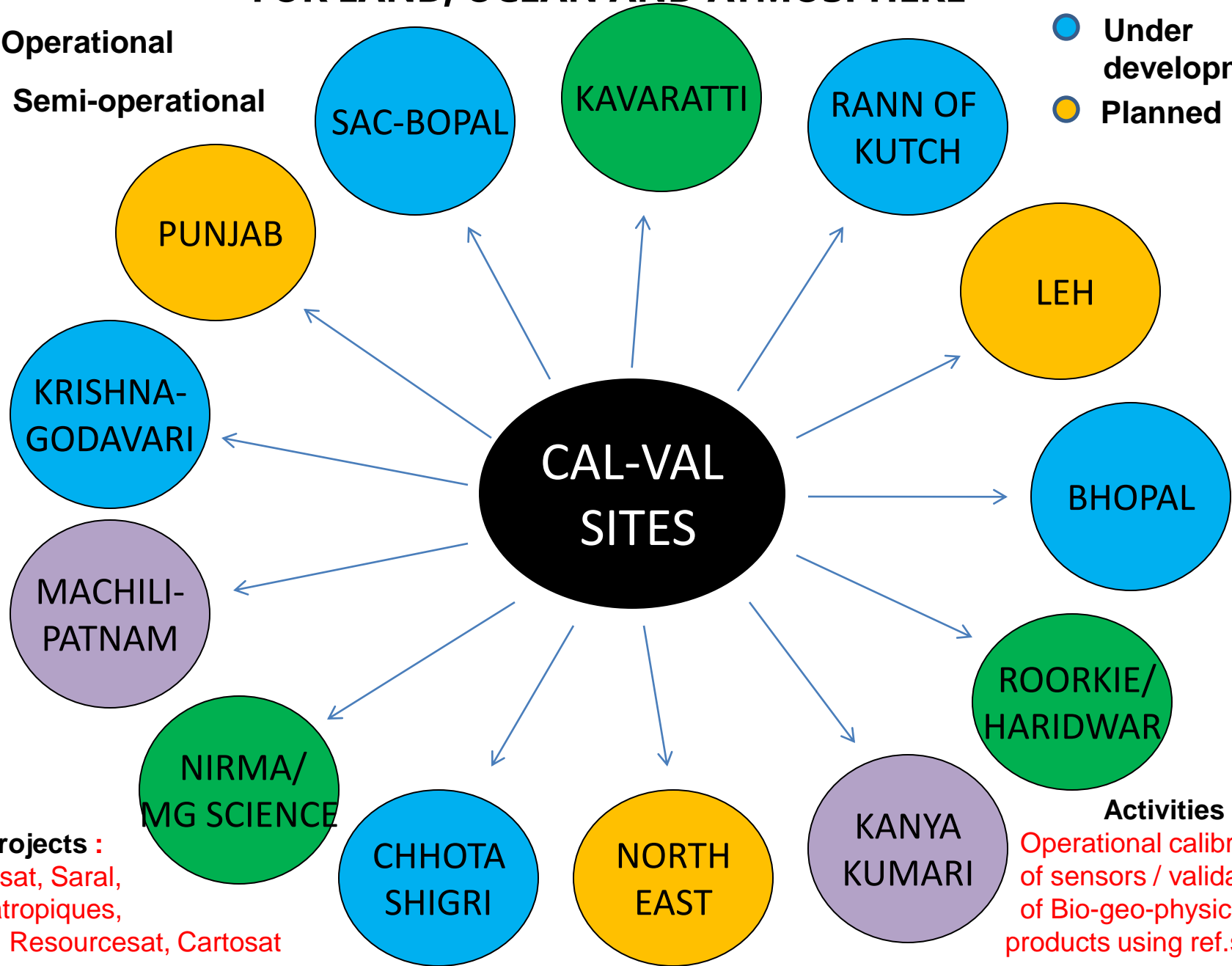
INCVSLOA – INDIAN NETWORK OF CALIBRATION & VALIDATION SITES FOR LAND, OCEAN AND ATMOSPHERE

● Operational

● Semi-operational

● Under development

● Planned



Projects :

Oceansat, Saral, Meghatropiques, RISAT, Resourcesat, Cartosat

Activities :

Operational calibration of sensors / validation of Bio-geo-physical products using ref.sites

Thank you