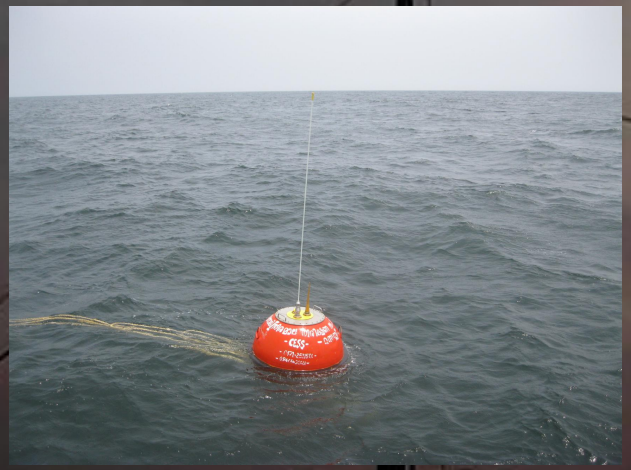
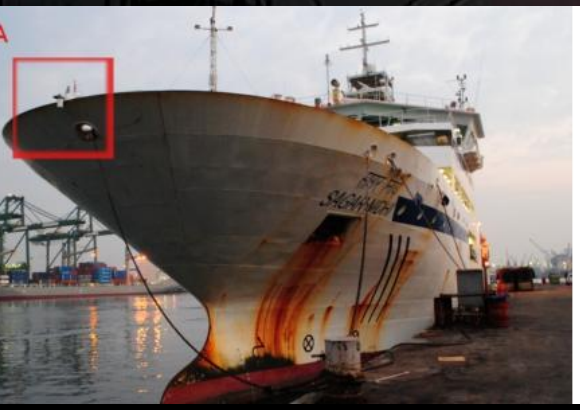
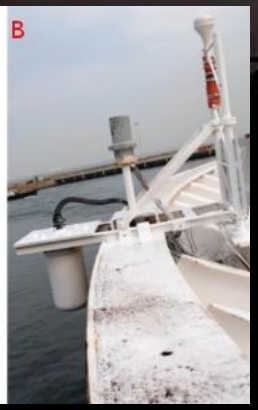
OCEAN FORECASTING
with special reference to
REAL-TIME OBSERVATION SYSTEMS

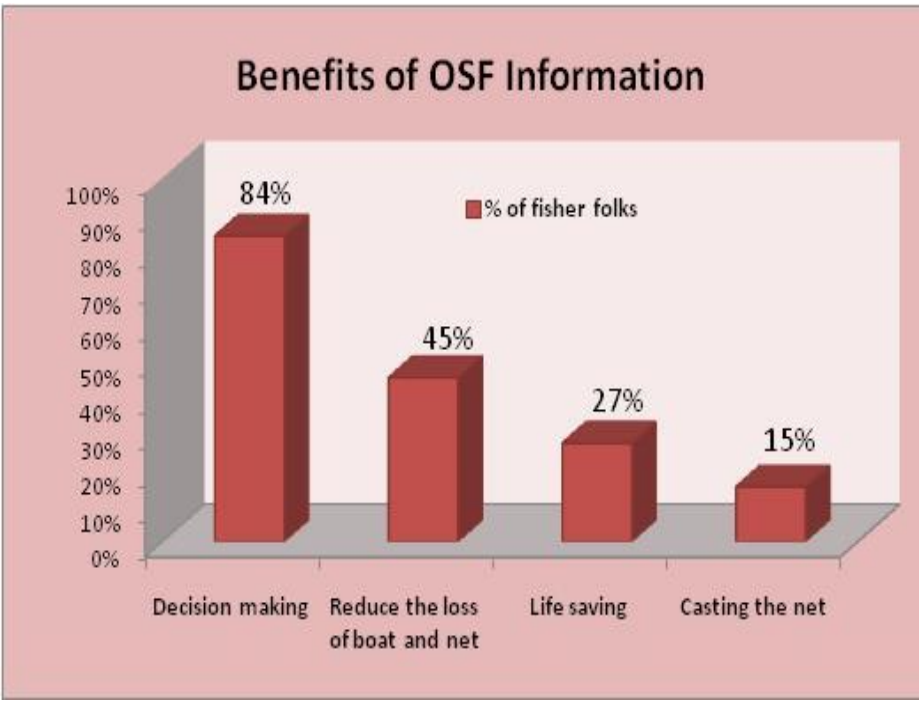


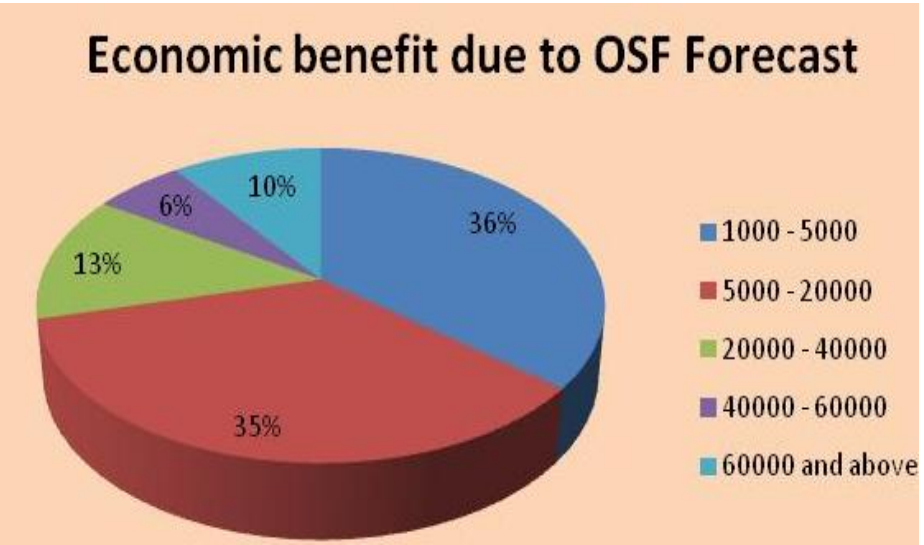




Dr. R. Harikumar
Scientist
(& In-charge, OSF)

OSF Benefit to Fisherman community-MSSRF study





Courtesy for MSSRF field survey

Recent Feedbacks on OSF services

We are blessed with the helpline facility for delivering OSF information and this facility plays a significant role in our lives in such a way it my team and me proceed for any fishing activity without any fear –

-Antony, 28, Fisherman, Kolachal, TN.

PMSSS on behalf of the target communities expresses its sincere appreciation and thanks to INCOIS for its valuable, timely advise, support and guidance during the emergency situation -

- PMSSS, TN.

The OSF data/images are very accurate and useful which keeps us updated during sailing. The OSF reports are very important for our passenger vessels sailing always in low pressure areas like Andaman sea-

-Master

MV Swarajdweep, SCI.

It has been observed during the recent operations that the forecast provided by INCOIS has closely matched with that of the actuals and has been well appreciated by the operation co-coordinator-

-Commander Mangal Kakkad, Navy.

INCOIS Ocean state Forecasts closely mimic the reality-

-DIG Thalha, Indian Coast Gaurd

Objectives of observational systems and real-time data reception

1. Evaluation/validation of input/forcing parameters on the Ocean forecast models in delayed mode and real time.
2. Data assimilation in high resolution atmospheric and ocean forecast models.
3. Validation of satellite data.
4. High Resolution coastal wind/wave Atlas.
5. Real-time vessel tracking and supply of forecasts.

OSF RELATED REAL-TIME OBSERVATIONS

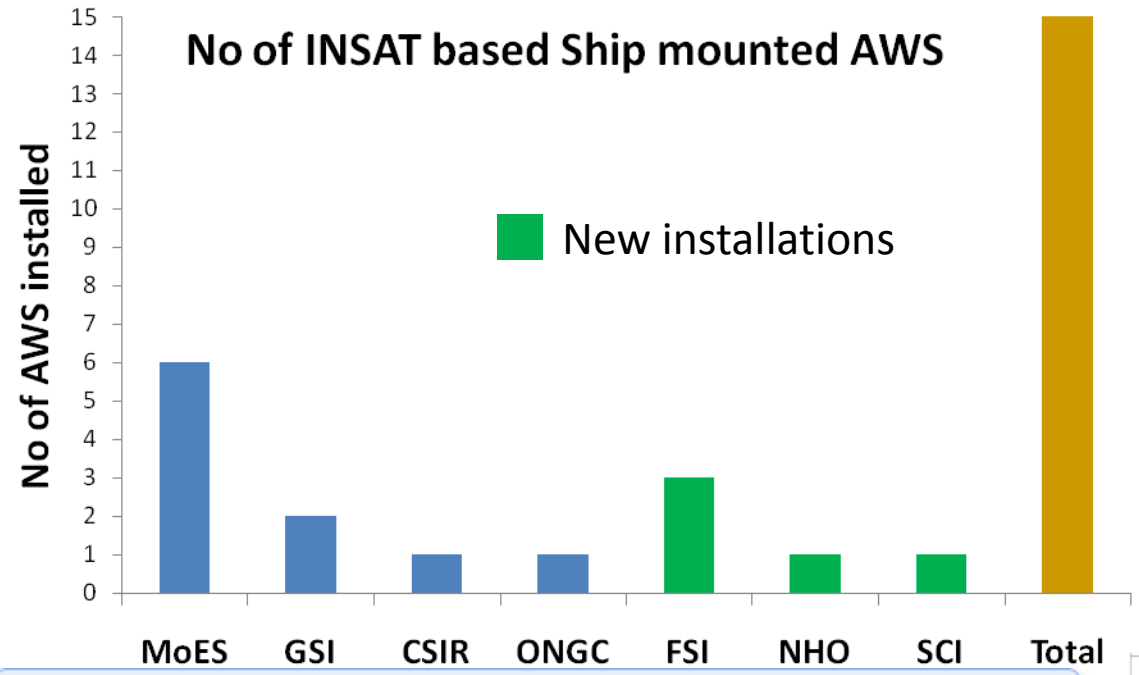
1. AWS onboard ships (existing 15 , Planned 05 (before November, 2013), 15 (in IIIrd phase).

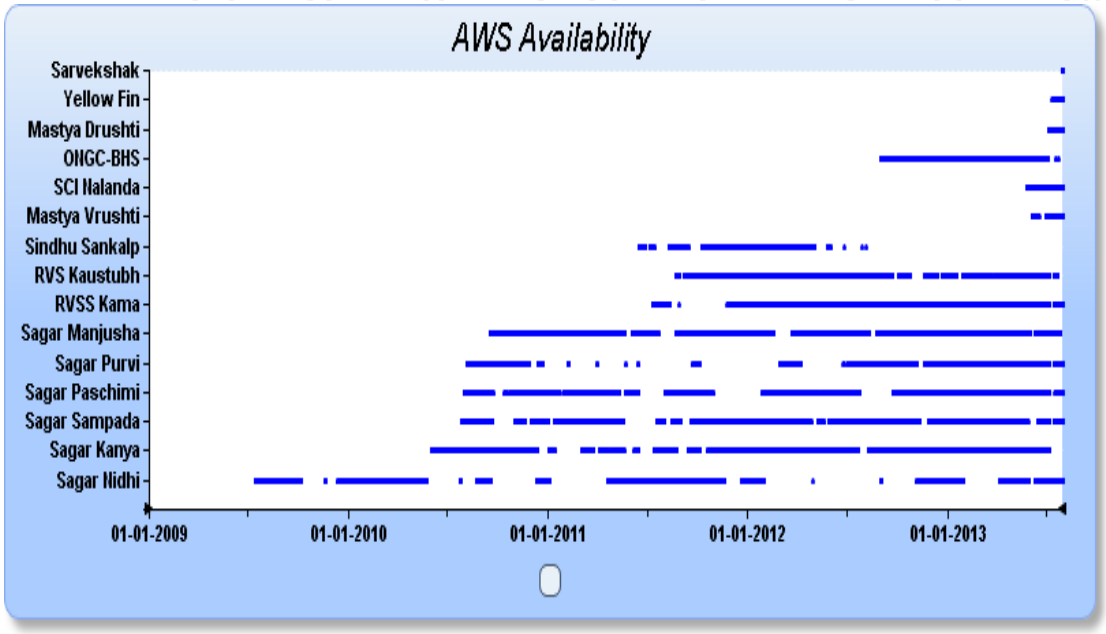
1. Wave Rider buoy net work (Existing 10, Planned 4)

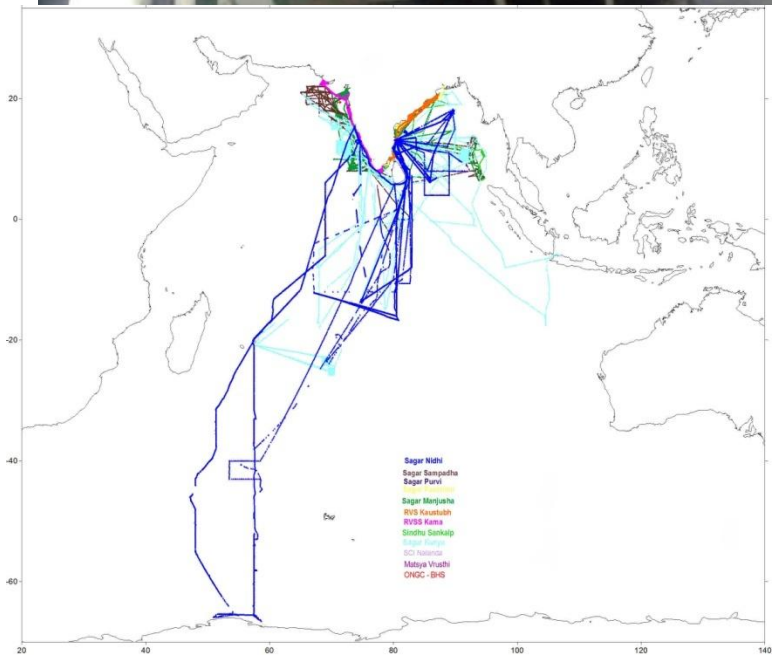
1. Wave Height Meter (Existing 1, Planned 1 for next year)

INCOIS REAL-TIME AUTOMATIC WEATHER STATIONS (I-RAWS)

I-RAWS

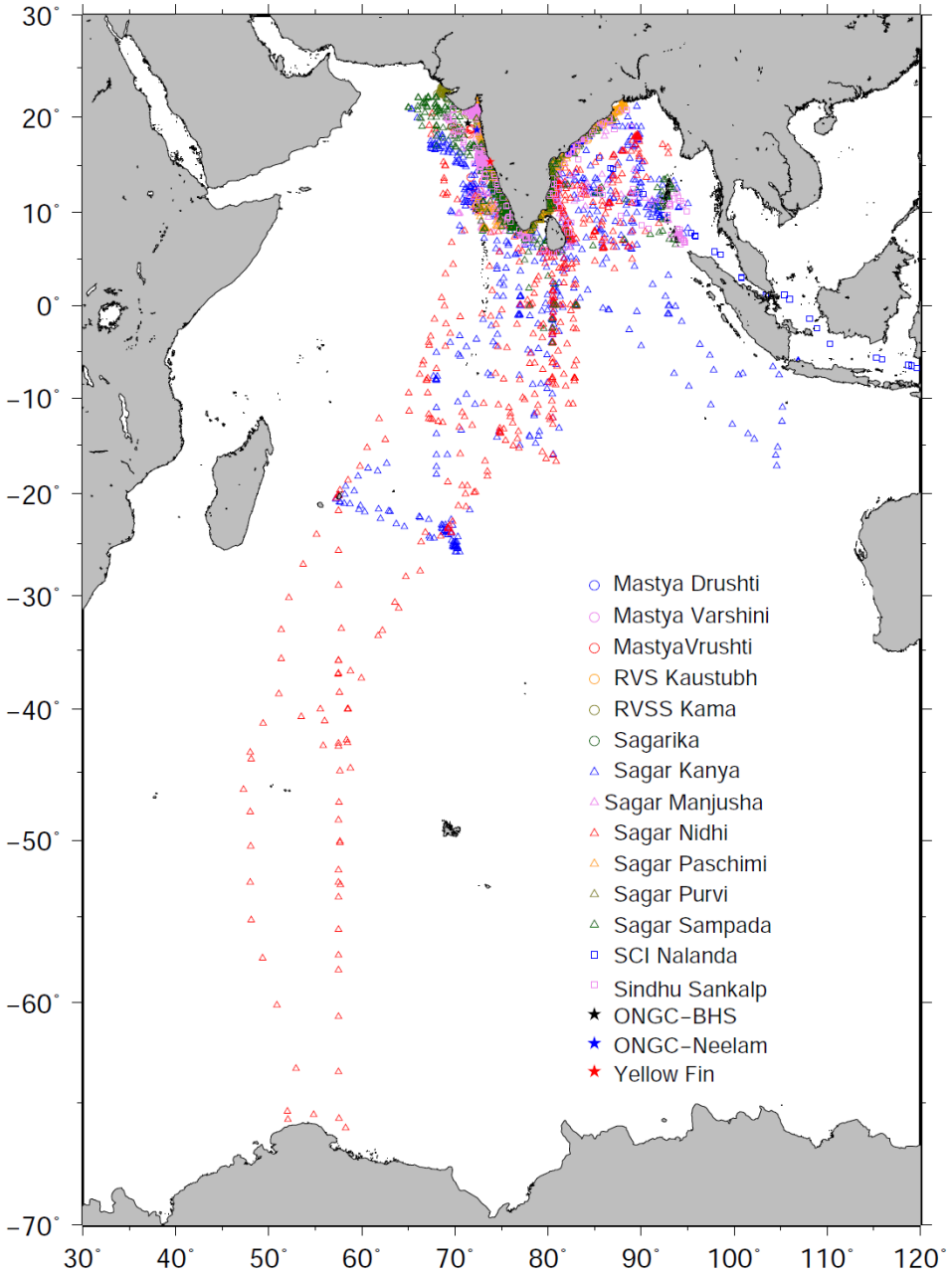






Available in GTS • Data used for validation of forcing parameters and Satellite Data (Harikumar etal., 2013; Anoop et al., 2013)

INCOIS Real-time AWS (I-RAWS) network



Ship-Mounted Real-Time Surface Observational System on board Indian Vessels for Validation and Refinement of Model Forcing Fields*

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Indian National Centre for Ocean Information Services, Ministry of Earth Sciences, Government of India, Hyderabad, India

G. S. BHAT

Indian Institute of Science, Bengaluru, India

SHAILESH NAYAK

Earth System Science Organisation, New Delhi, India

VENKAT SHESU REDDEM AND S. S. C. SHENOI

Indian National Centre for Ocean Information Services, Ministry of Earth Sciences, Government of India, Hyderabad, India

(Manuscript received 16 November 2011, in final form 30 October 2012)

doi: http://dx.doi.org/10.1175/JTECH-D-11-00212.1

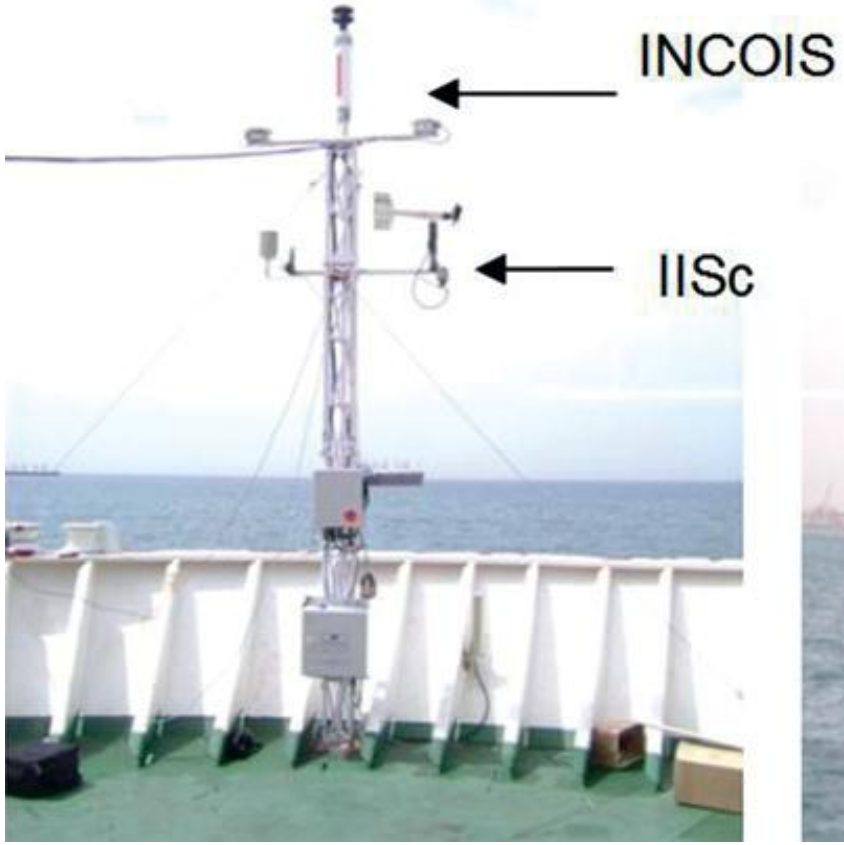
Uniqueness and relevance (words of reviewers…)

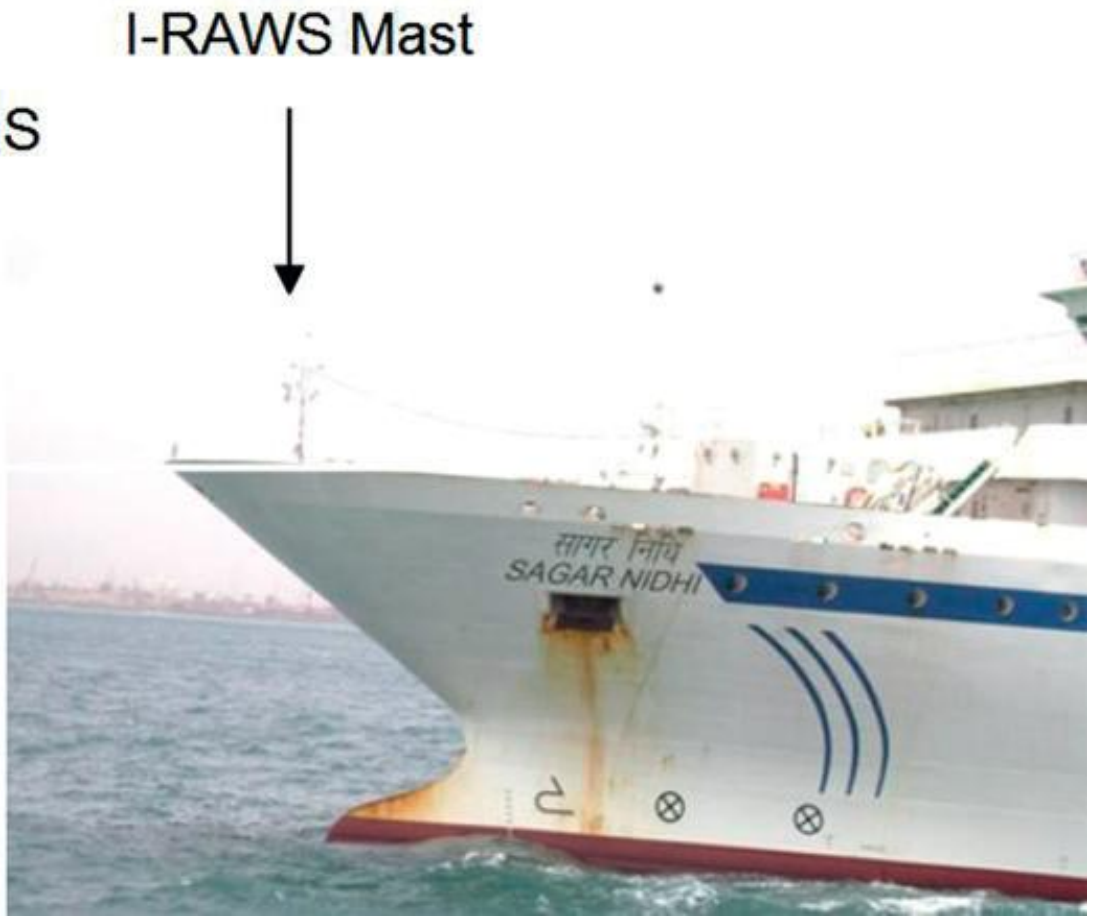
- INSAT integration and real-time data
- Data from data-sparse SO
- More data from coasts
- 6 marine met parameters-together

Methodology

1. The collocation of IRAWS data with NCMRWF and ECMWF data (0.5 X 0.5 degree) has been done (for a cruise data of 4 months).
2. The time-series has been plotted.
3. Scatter plots are made.
4. Statistical parameters have been derived.

I-RAWS & IISc AWS onboard Sagarnidhi



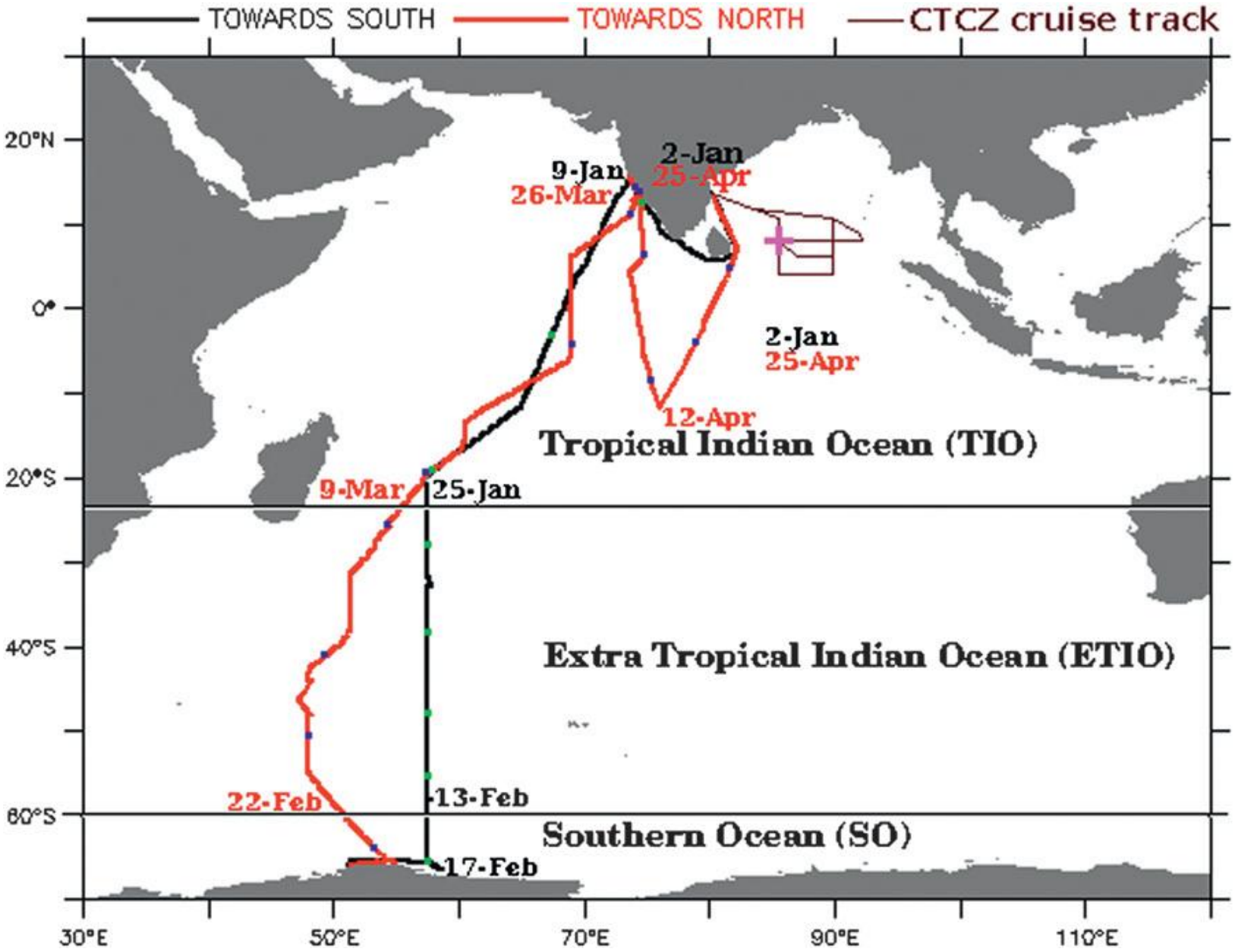


Specifications of I-RAWS

TABLE 1. Make and model, range of measurement, resolution, and accuracy of the sensors used in I-RAWS under the OOIS program of MoES, government of India.

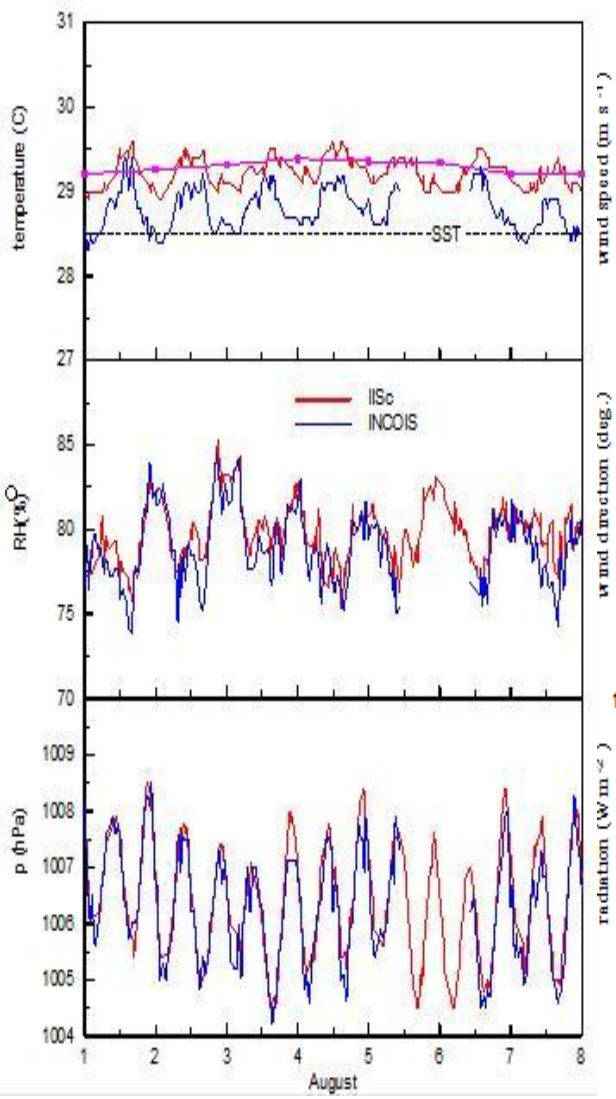
Serial No.	Parameter	Sensor make and model	Range of measurement	Resolution	Accuracy
1	Air pressure	SETRA-S1079W	800–1100 mb	0.1 mb	0.5 mb
2	Air temperature	Rotronics-S93211	−50° to 50°C	0.1°C	±0.2°C
3	RH	Rotronics-S93211	0%–100%	0.02%	<3%
4	Wind speed	Gill-S1510 (sonic wind monitor)	0–60 m s^{-1}	0.01 m s^{-1}	±2%
5	Downwelling LW radiation	Eppley-S1425W	0–700 W m^{-2}	0.1 W m^{-2}	±1%
6	Downwelling SW radiation	Eppley-S1092W	200–1200 W m^{-2}	0.4 W m^{-2}	±2%
7	SST	Weatherpak (thermistor with water temperature module convert)-S3338	−50° to 50°C	0.1°C	±0.2°C
8	GPS	GPS Trimble-S9922	—	—	—
9	Gyro	Fluxgate compass-S1085W	—	—	±0.1°

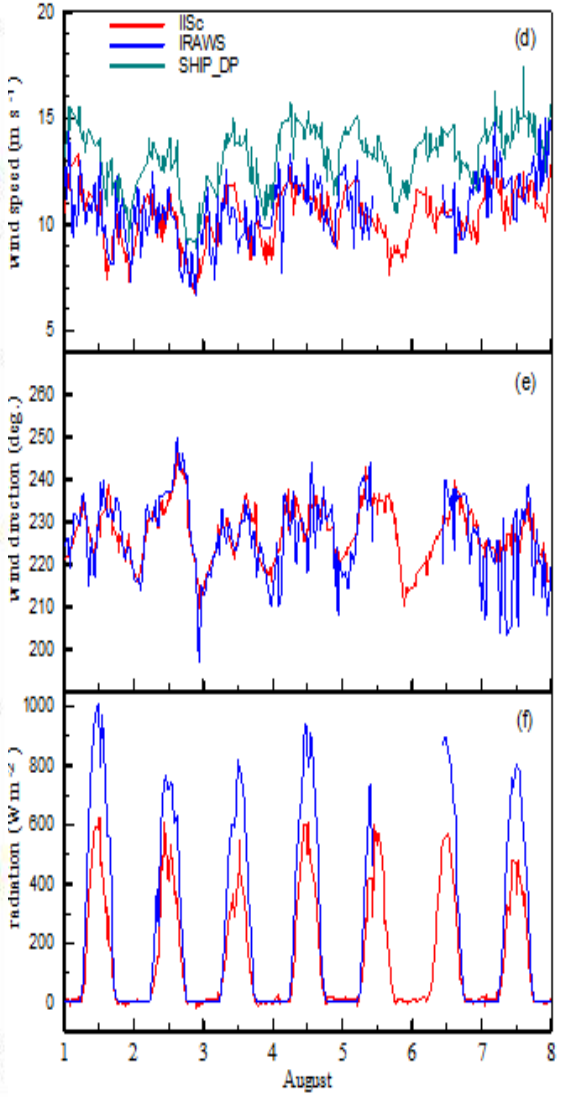
Cruise tracks

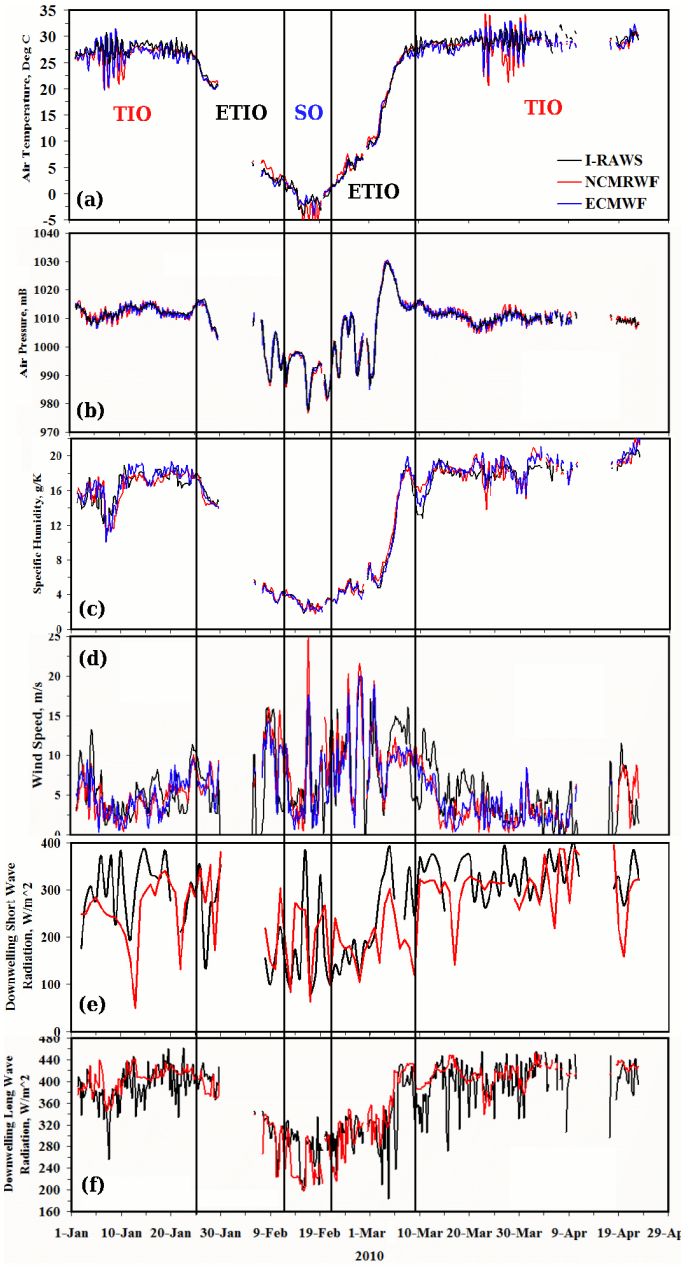


Inter-comparison

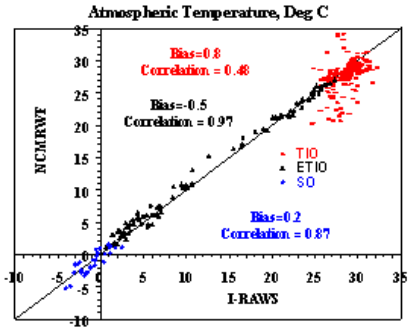
Models and IRAWS

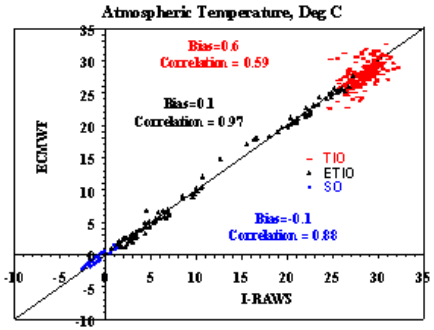


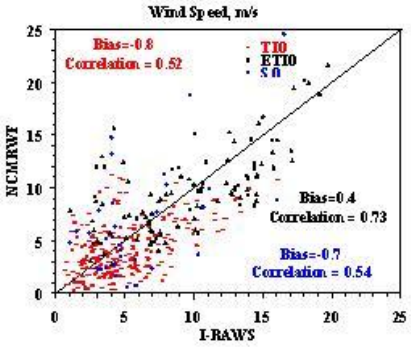


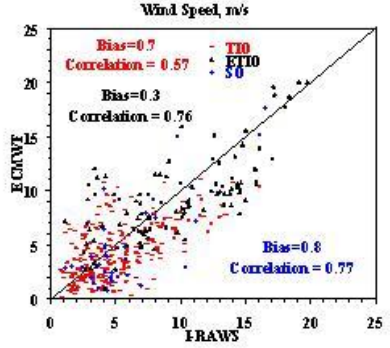


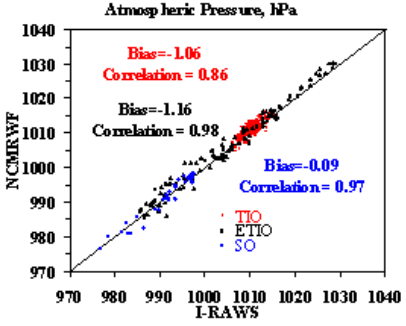
Scatter plots and Results

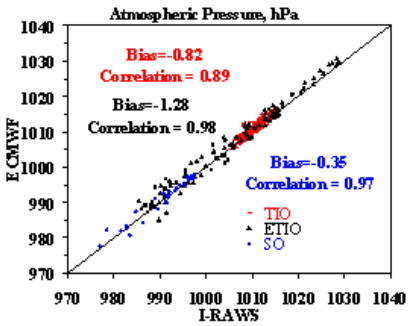


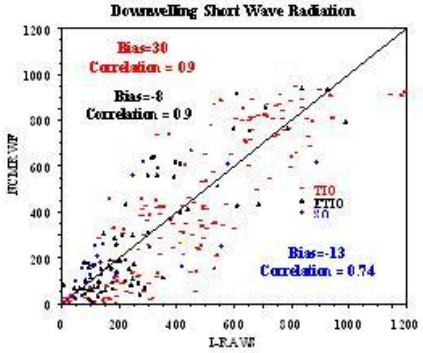


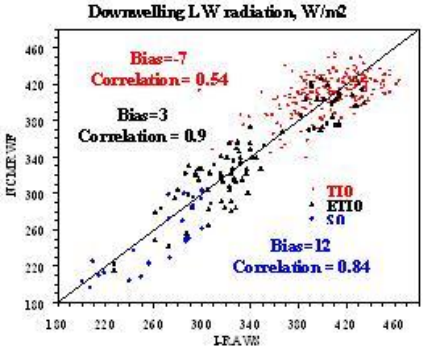


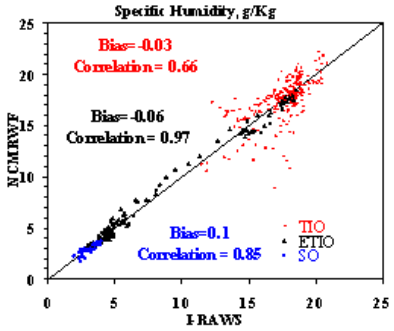


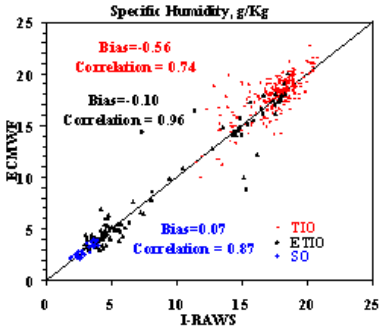


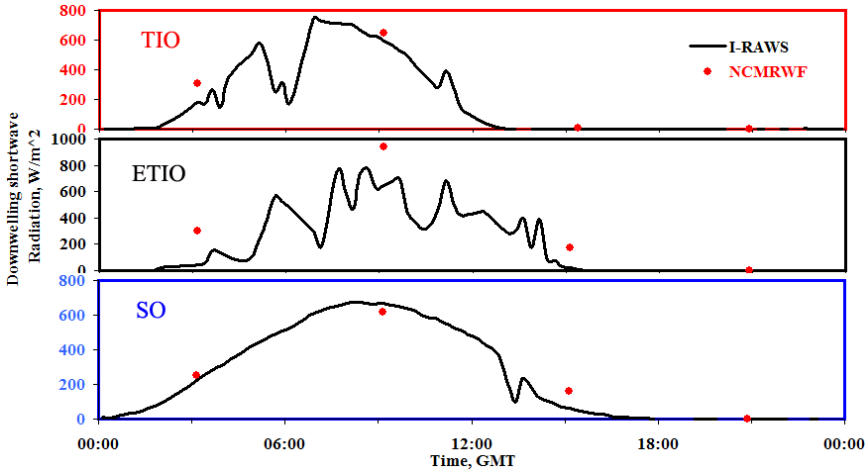












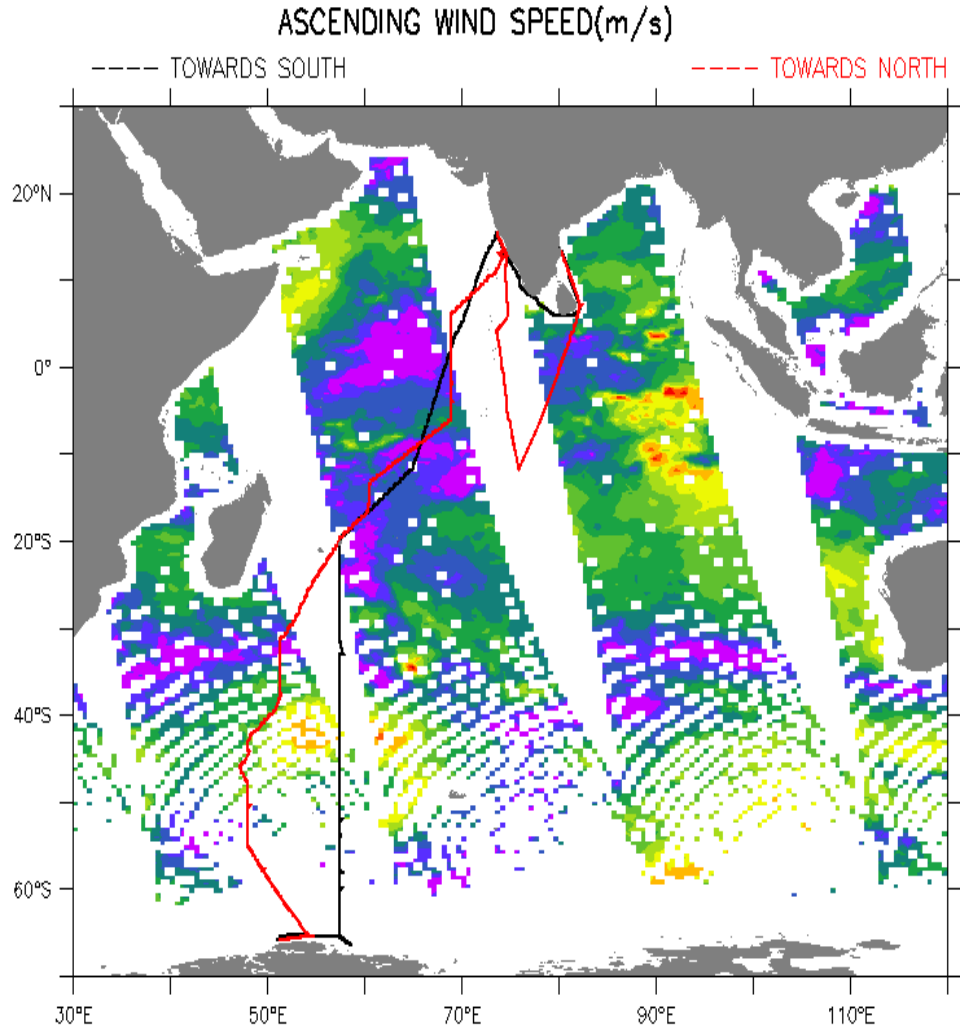
Statistical parameters

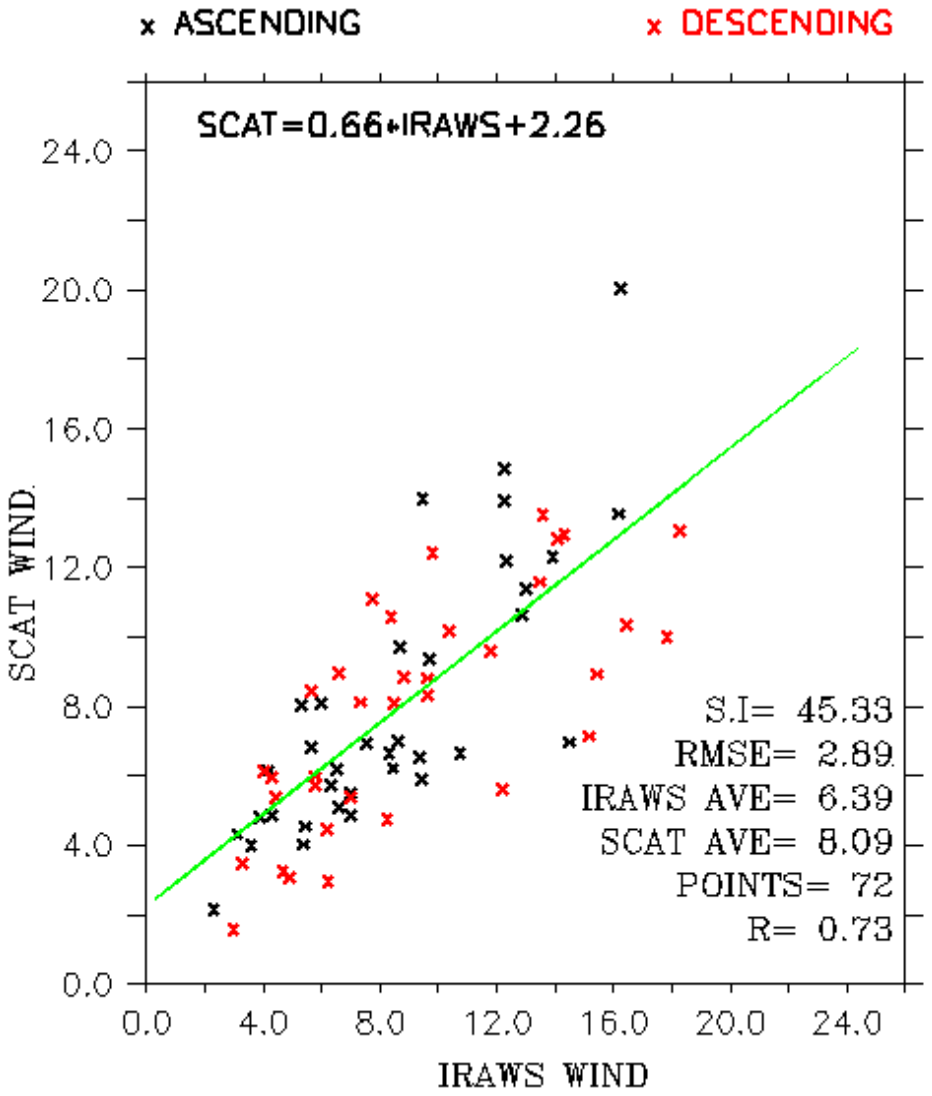
Parameter	Ocean	Mean			Bias		Correlation		RMSE		Scatter Index (%)	
		I-RAWS	NCMRWF	ECMWF	I-N	I-E	I & N	I & E	I & N	I & E	I & N	I & E
Air Temperature (Deg C)	TIO	28.53	27.75	27.95	0.8	0.6	0.48	0.59	2.1	1.8	7.36	6.31
	ETIO	11.83	12.37	11.71	-0.5	0.1	0.97	0.97	1.0	0.6	8.45	5.07
	SO	-0.96	-1.14	-1	0.2	0.0	0.87	0.88	0.8	0.6	45.90	34.42
Pressure (hPa)	TIO	1010.3	1011.39	1011.16	-1.1	-0.8	0.86	0.89	1.7	1.3	0.16	0.13
	ETIO	1005.2	1006.36	1006.48	-1.2	-1.3	0.98	0.98	2.2	2.3	0.22	0.23
	SO	991.18	991.27	991.53	-0.1	-0.4	0.97	0.97	1.4	1.3	0.15	0.13
Specific Humidity (g/Kg)	TIO	17.44	17.46	18	0.0	-0.6	0.66	0.74	1.6	1.4	9.29	8.20
	ETIO	8.29	8.44	8.29	-0.2	0.0	0.97	0.96	1.0	0.9	11.82	11.10
	SO	2.98	2.88	2.91	0.1	0.1	0.85	0.87	0.3	0.3	11.41	9.73
Wind Speed (m/s)	TIO	4.95	4.13	4.23	0.8	0.7	0.52	0.57	2.8	2.6	56.57	52.53
	ETIO	9.65	9.69	9.31	0.4	0.3	0.73	0.76	3.5	3.3	36.27	34.20
	SO	6	6.64	5.23	-0.7	0.8	0.54	0.77	4.6	2.9	76.67	48.33
Downwelling SW Rad (W/m^2)	TIO	341.91	311.51	---	30.0	---	0.9	---	142.9	---	41.79	---
	ETIO	199.09	207.28	---	-8.0	---	0.9	---	111.6	---	56.08	---
	SO	187.39	200	---	-13.0	---	0.74	---	155.0	---	82.69	---
Downwelling LW Rad (W/m^2)	TIO	403.95	410.77	---	-7.0	---	0.54	---	56.9	---	14.08	---
	ETIO	341.7	339.1	---	3.0	---	0.9	---	22.3	---	6.54	---
	SO	262.92	251.27	---	12.0	---	0.84	---	23.2	---	8.83	---

Though the performance of ECMWF and NCMRWF are almost equal, ECMWF air temperature at ETIO and wind speed (especially in SO) is marginally more close to reality compared to that of NCMRWF.

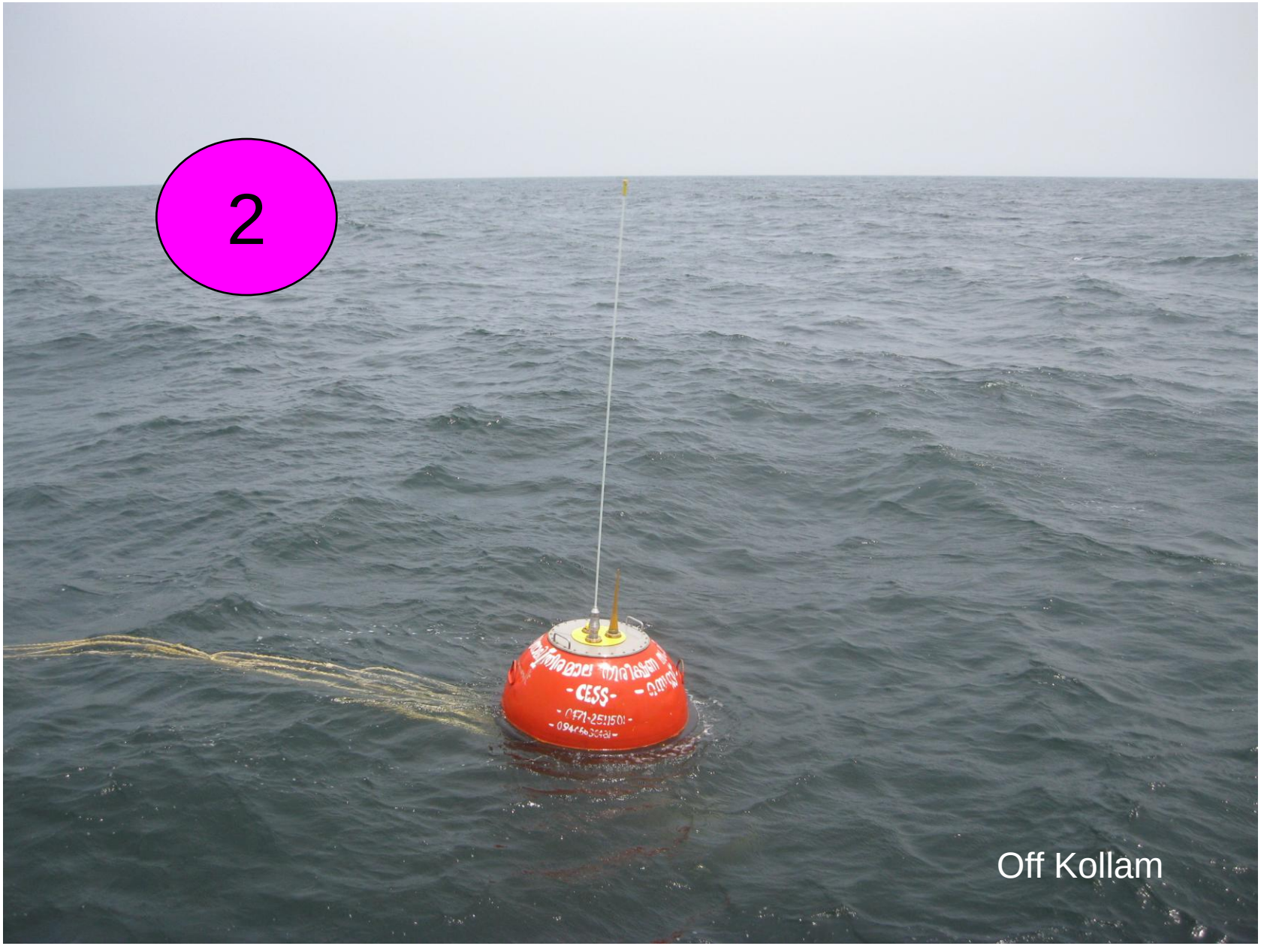
Validation of OSCAT winds using I-RAWS

Data collected by IRAWS installed in ORV Sagar Nidhi, for a duration 01-jan-2010 to 15-may-2010 is used for the validation



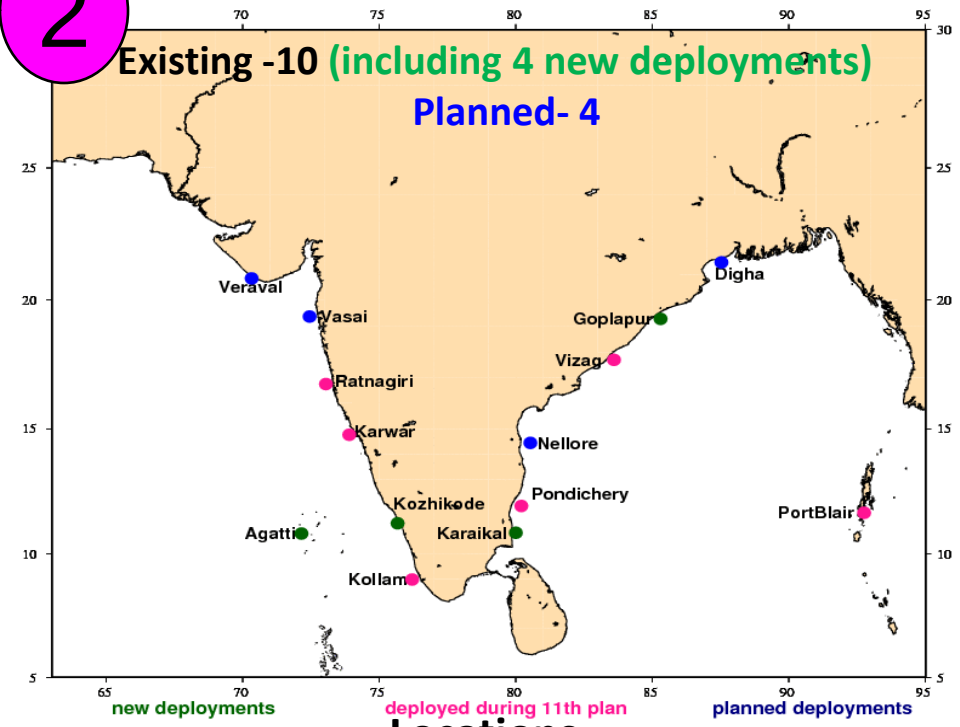


WAVE RIDER BUOYS

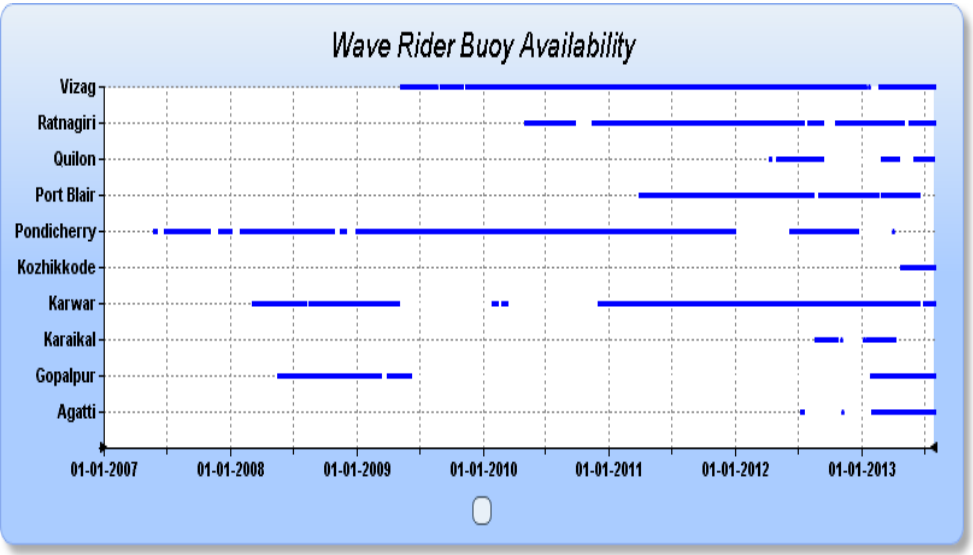


Wave Rider Buoy

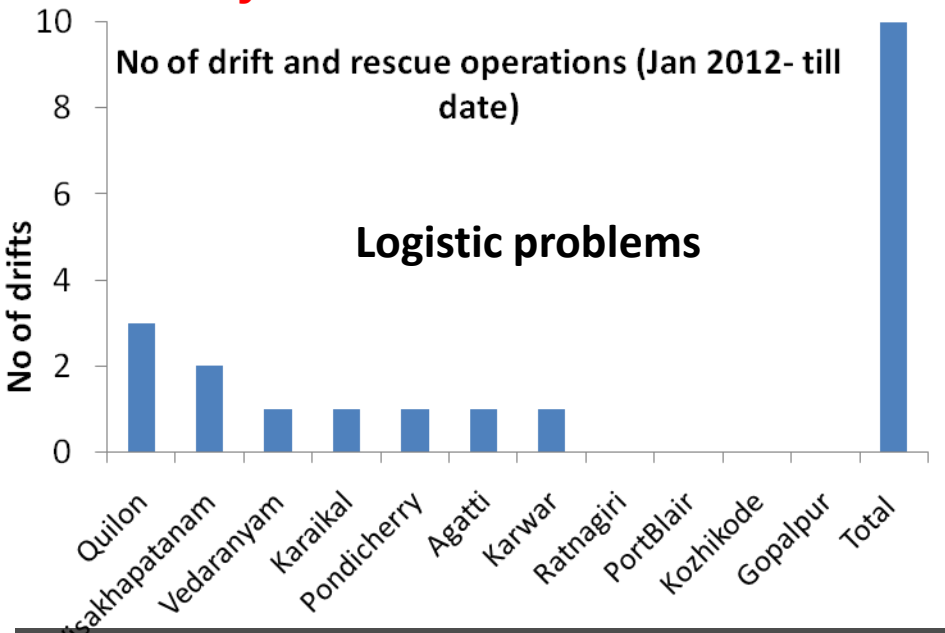
2



Locations



Data Availability



1. Coastal Forecasting & High Wave monitoring (Balakrishnan Nair et al., 2013).
1. Setting up location specific forecast models (Sirisha et al.,2013, Sandhya et al., 2013).
1. Identifying Shamal swell propagation to Indian Coasts (Glejin et al., 2013)
1. Estimating the wave power potential (Sanil et al.,2013),
1. Validating the storm surge predictions (Prasad et al. 2013),
2.
3. Costal engineering application & Value added products (IVL)
1. Consultancy projects (Technical reports: Balakrishnan Nair et al., 2013 Sandhya et al., 2012, Sirisha et al.,2012)
1. Ph. D , M. Sc. Dissertations, Other R &D activities (Glejin et al, 2012)

Data Usage

Comparison of Grid Averaged Altimeter with Buoy Significant Wave Heights in the Northern Indian Ocean

- Validity of gridded SWH data from Altimeters (ASWH) with an aim to use it for spatially validating the Wave Forecast.
- Altimeter derived SWH is underestimated by 0.20 m, RMSE by 0.30 m and scatter index by 20%.
- Good agreement even during the high wave conditions that prevail during JJAS.
- There is no regional dependency for the altimeter derived significant wave height
- Cyclone time – poor.
- Merged altimeter SWH from different satellite missions provided by AVISO can be used for long-term basin scale validation of the model simulated significant wave heights except during cyclone condition.

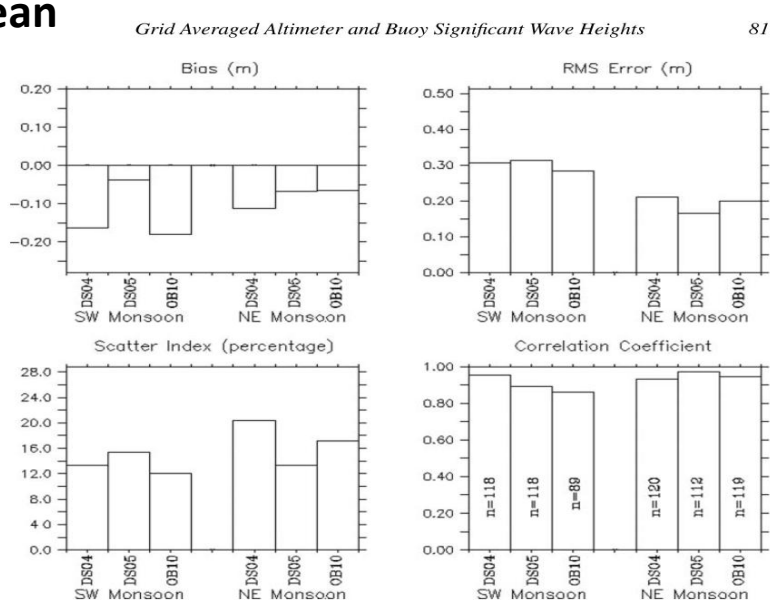
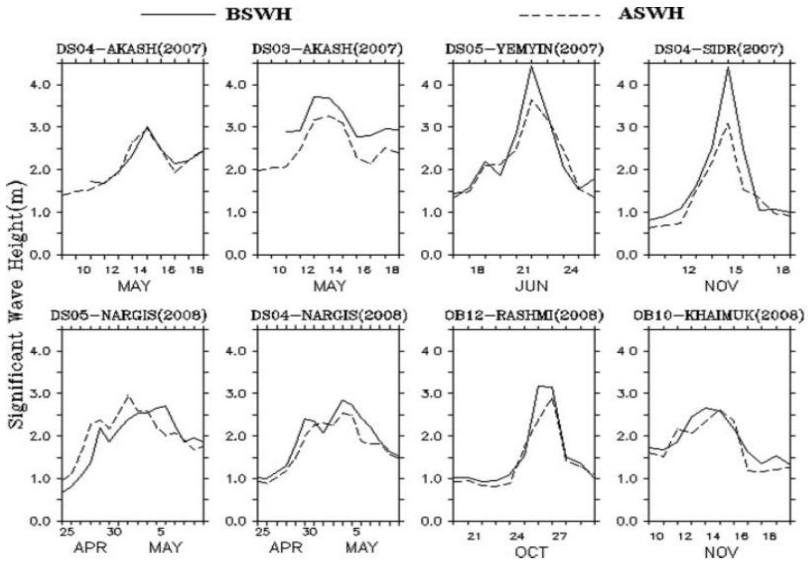


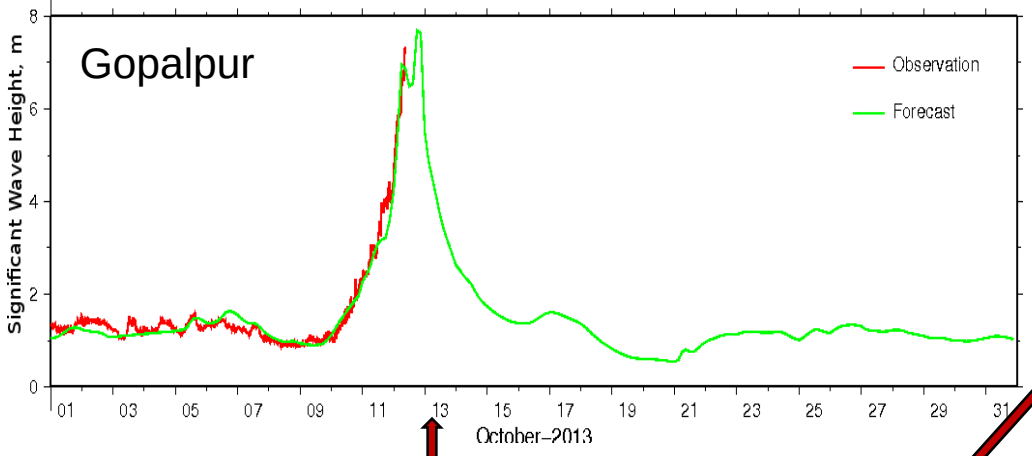
Figure 5. Comparative statistics between ASWH and BSWH for NE and SW monsoon.

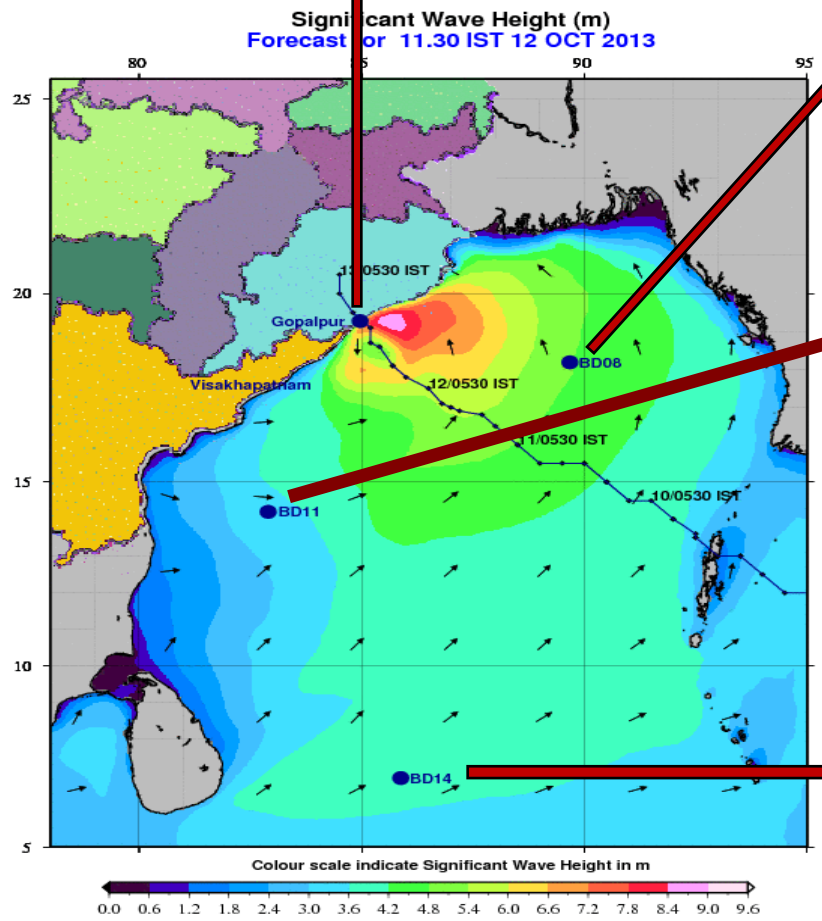


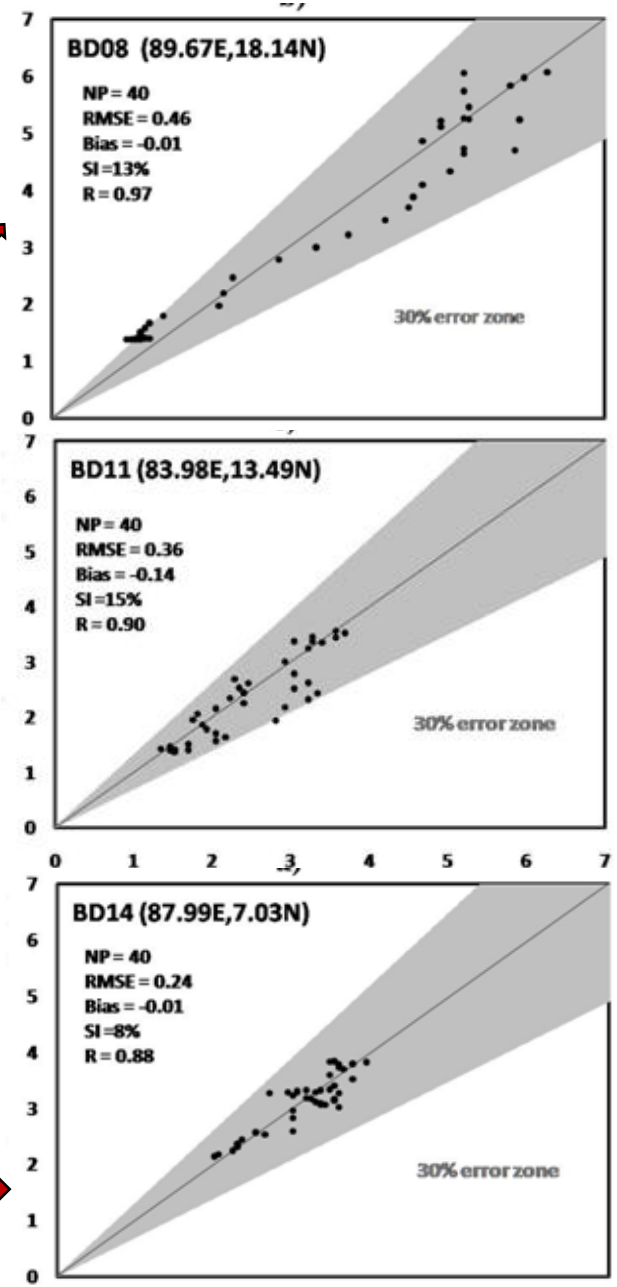
Comparison of BSWH and ASWH during different cyclones in the Indian Ocean

Sabique et al., (2013), Marine Geodesy

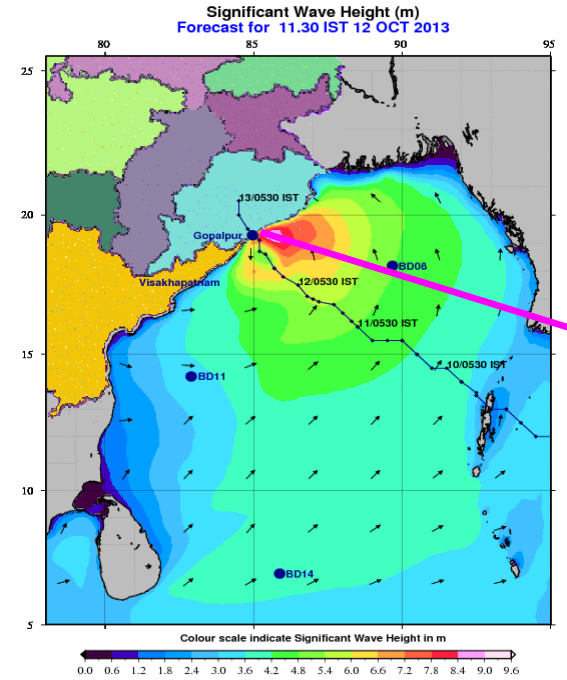
Performance of Ocean State Forecast system during VSC “Phailin”

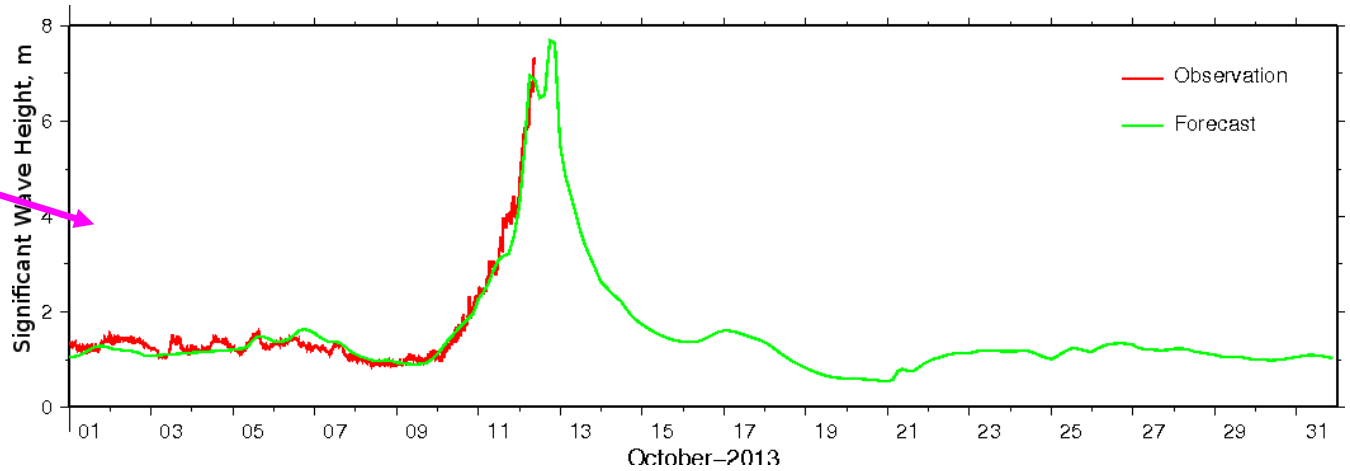


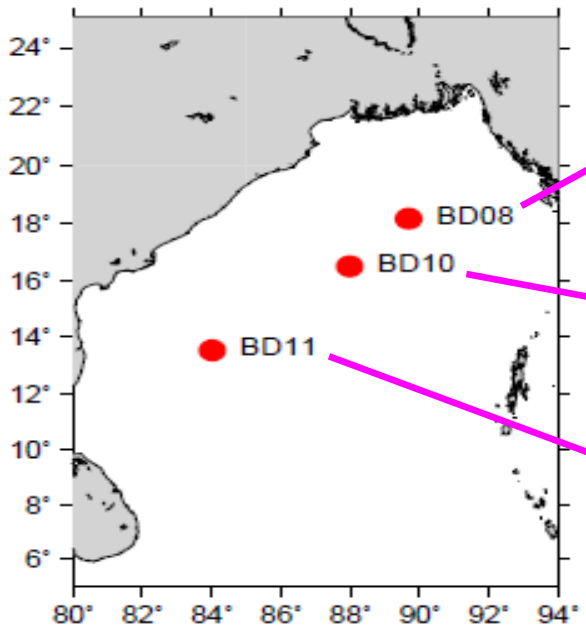


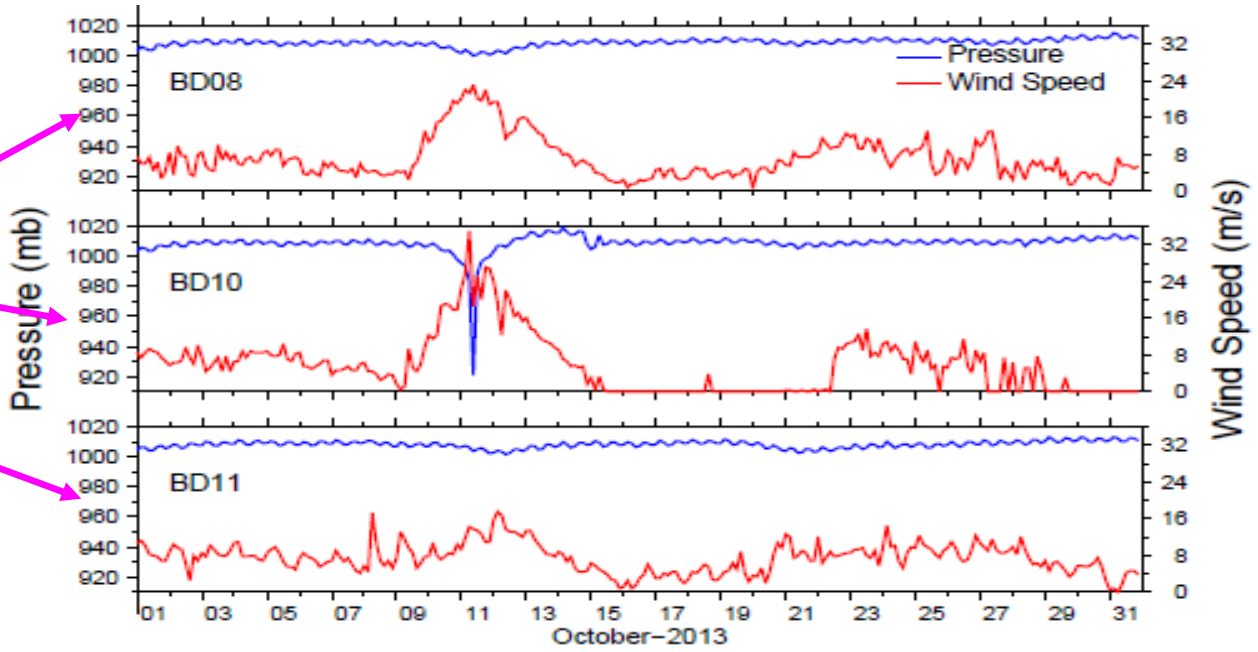


INCOIS High Wave Alert and Atmospheric status during VSCS “Phailin”









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Wave forecasting and monitoring during very severe cyclone *Phailin* in the Bay of Bengal

T. M. Balakrishnan Nair[1,*], P. G. Remya[1], R. Harikumar[1], K. G. Sandhya[1], P. Sirisha[1], K. Srinivas[1], C. Nagarju[1], Arun Nherakkol[1], B. Krishna Prasad[1], C. Jeyakumar[1], K. Kaviyazhahu[1], N. K. Hithin[1], Rakhi Kumari[1], V. Sanil Kumar[2], M. Ramesh Kumar[1], S. S. C. Shenoi[1] and Shailesh Nayak[3]

[1]Information Services and Ocean Sciences Group, Indian National Centre for Ocean Information Services, 'Ocean Valley', Pragathi Nagar (BO), Nizampet (SO), Hyderabad 500 090, India
[2]CSIR-National Institute of Oceanography, Dona Paula, Goa 403 004, India
[3]Earth System Science Organization, New Delhi , India

Wave fields, both measured and forecast during the very severe cyclone *Phailin*, are discussed in this communication. Waves having maximum height of 13.54 m were recorded at Gopalpur, the landfall point of the cyclone. The forecast and observed significant

6 days from 8 to 14 October 2013 and it made landfall on 12 October at 1700 UTC in Gopalpur, Odisha (Figure 1). During the Odisha super cyclone of 1999, no quantitative OSF system was in place for forewarning the coastal communities, but for *Phailin*, the warnings were issued five days in advance. This helped the maritime authorities and users to take maximum precautions well in advance and save lives and properties. *Phailin* also provided a unique opportunity to study instrumentally recorded extreme wave data and evaluate the forecast.

Monitoring of extreme wave fields and evaluation of its forecast (issued from ESSO–INCOIS) have been done using data from the directional wave rider buoy[3,4] (DWRB) network of ESSO–INCOIS, including off Gopalpur (19.28°N, 84.97°E at 12 m water depth), the landfall location of *Phailin*. Wave data obtained from deep-sea moored buoys BD08 (18.14°N, 89.67°E), BD11 (13.49°N, 83.98°E) and BD14 (7.03°N, 87.99°E) eployed by the ESSO–National Institute of Ocean Technology (ESSO–NIOT) have also been used for validating the forecast wave parameters (Figure 1).

The buoy measures horizontal (roll and pitch) and vertical (heave) acceleration using accelerometers and compasses to give the directional displacement in horizontal

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भारत मौसम विज्ञान विभाग
INDIA METEOROLOGICAL DEPARTMENT

IMD BULLETTIN

FROM: RSMC – TROPICAL CYCLONES, NEW DELHI
TO: STORM WARNING CENTRE, YANGAON (MYANMAR)
STORM WARNING CENTRE, BANGKOK (THAILAND)
STORM WARNING CENTRE, COLOMBO (SRILANKA)
WARNING CENTRE, DHAKA (BANGLADESH)
STORM STORM WARNING CENTRE, KARACHI (PAKISTAN)
METEOROLOGICAL OFFICE, MALE (MALDIVES)
OMAN METEOROLOGICAL DEPARTMENT, MUSCAT (THROUGH RTH JEDDAH)
TROPICAL CYCLONE ADVISORY
RSMC – TROPICAL CYCLONES, NEW DELHI

TROPICAL STORM PHAILIN ADVISORY NO. TWENTY SIX ISSUED AT 1700 UTC OF 12TH OCTOBER 2013 BASED ON 1500 UTC CHARTS of 12TH OCTOBER 2013.

THE VERY SEVERE CYCLONIC STORM, PHAILIN OVER WESTCENTRAL & ADJOINING NORTHWEST BAY OF BENGAL MOVED NORTH-NORTHWESTWARDS DURING PAST 3 HOURS WITH A SPEED OF 15 KMPH AND LAY CENTRED AT 1500 UTC OF TODAY, THE 12TH OCTOBER 2013 OVER NORTHWEST ADJOINING WESTCENTRAL BAY OF BENGAL NEAR LATITUDE 19.1^{0}N AND LONGITUDE 85.0^0 E, CLOSE TO GOPALPUR. LATEST OBSERVATIONS INDICATE THAT LANDFALL PROCESS HAS STARTED AND IT WILL BE COMPLETED WITHIN NEXT ONE HOUR. AT THE TIME OF LANDFALL, MAXIMUM SUSTAINED WIND SPEED WOULD BE 200-210 KMPH.

ACCORDING TO SATELLITE IMAGERIES, THE INTENSITY OF THE SYSTEM IS T 6.0. INTENSE TO VERY INTENSE CONVECTION IS SEEN NORTH OF LAT 15.0^0 N AND WEST OF LONG 88.0^0 E ALONG ODISHA AND NORTH COASTAL ANDHRA PRADESH. THE LOWEST CLOUD TOP TEMPERATURE (CTT) IS ABOUT -78^{0}C.

DWR VISAKHAPATNAM IS TRACKING THE SYSTEM AND REPORTED CENTRE AS LATITUDE 19.1 ^{0}N AND LONGITUDE 85.0^{0}E AT 1500 UTC. GOPALPUR (43049) HAS REPORTED MAXIMUM 24 HOURS PRESSURE FALL OF 24.4 HPA, MAXIMUM WIND SPEED OF 98 KNOTS FROM NORTHEASTERLY DIRECTION HAS BEEN REPORTED OVER GOPALPUR (ODISHA).

MAXIMUM SUSTAINED SURFACE WIND SPEED IS ESTIMATED TO BE ABOUT 105 KNOTS GUSTING TO 120 KNOTS AROUND THE SYSTEM CENTRE. THE STATE OF THE SEA IS PHENOMENAL AROUND THE SYSTEM CENTRE. THE ESTIMATED CENTRAL PRESSURE IS ABOUT 940 HPA.

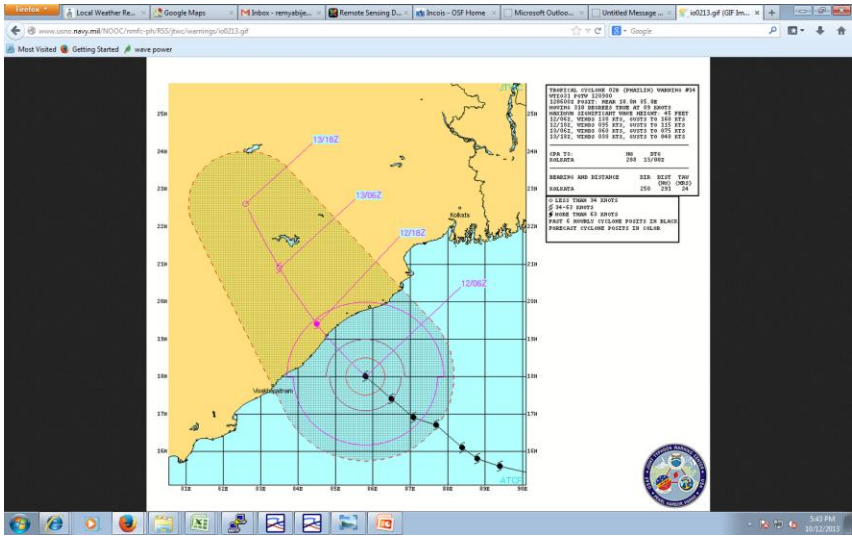
ESTIMATED TRACK AND INTENSITY OF THE SYSTEM ARE GIVEN IN THE TABLE BELOW:

DATE/TIME(UTC)	POSITION (LAT. °N LONG. °E)	SUSTAINED MAXIMUM SURFACE WIND SPEED (KMPH)	CATEGORY
13-10-2013/1500	19.1/85.0	200-210 GUSTING TO 230	VERY SEVERE CYCLONIC STORM
13-10-2013/1800	20.3/84.3	170-180 GUSTING TO 200	VERY SEVERE CYCLONIC STORM
13-10-2013/0000	21.2/84.0	80-90 GUSTING TO 100	CYCLONIC STORM
13-10-2013/0600	22.0/83.5	50-60 GUSTING TO 70	DEEP DEPRESSION

(NARESH KUMAR)

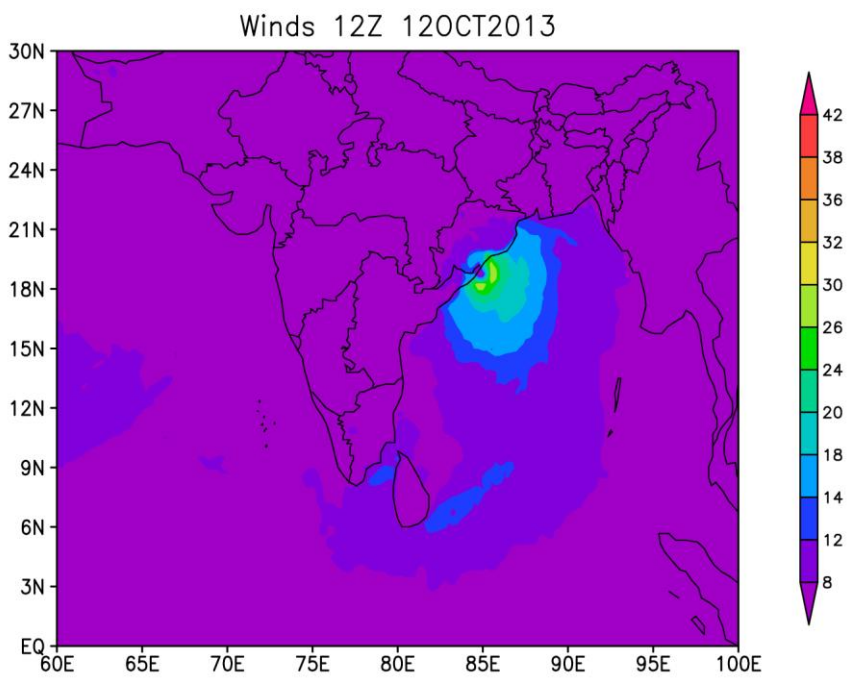
TOO:2130 HRS IST

JTWC TRACK PREDICTION & BULLETITIN



Bias correction/Uncertainty removal

Before



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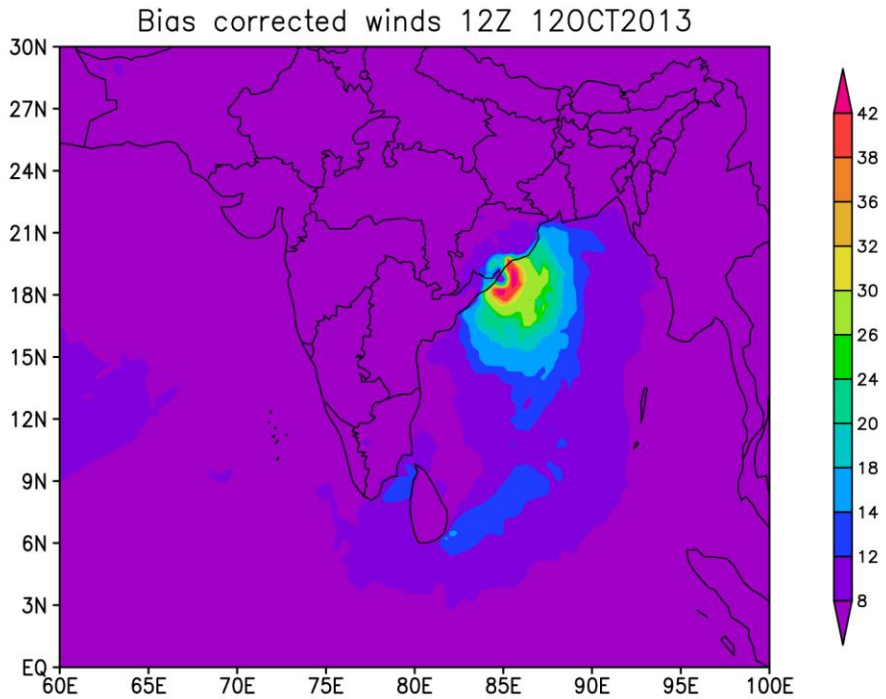
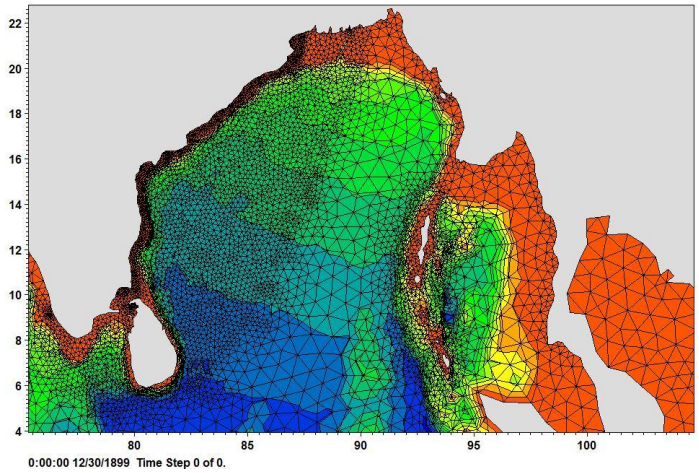


Wave forecasting at INCOIS



SWH

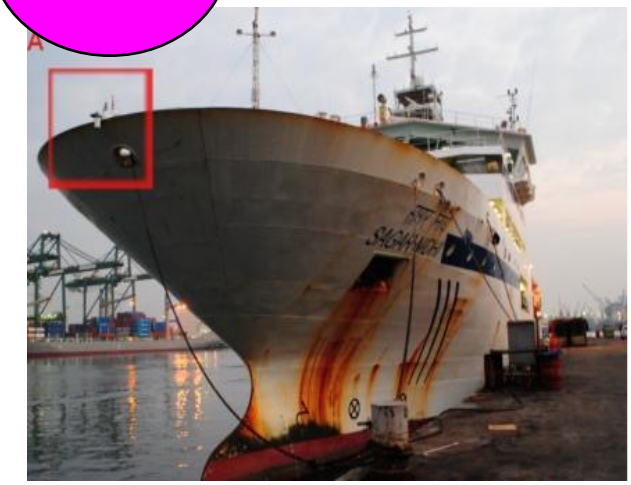
buoy normal setup corrected

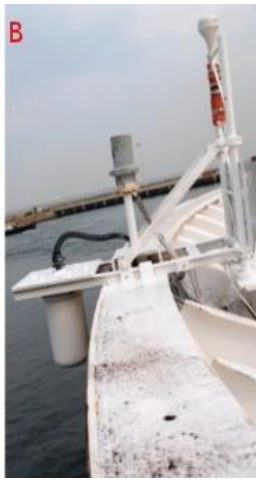
Landfall day of Phailin, 12 October 2013

Ship-mounted Wave height meter

3

Validation of forecast through ship routes



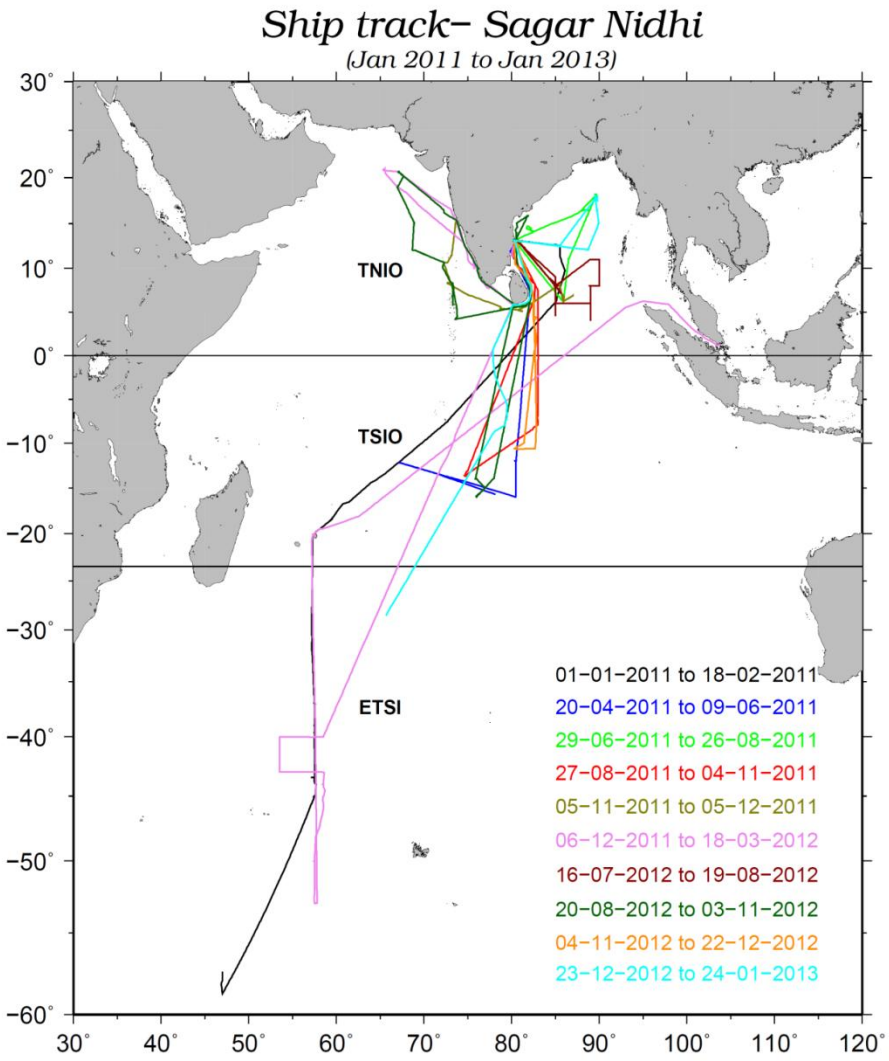


Wave Height Meter Installed in ORV Sagar Nidhi

TNIO – Tropical Northern Indian Ocean

TSIO – Tropical Southern Indian Ocean

ETSI – Extra Tropical Southern Indian ocean



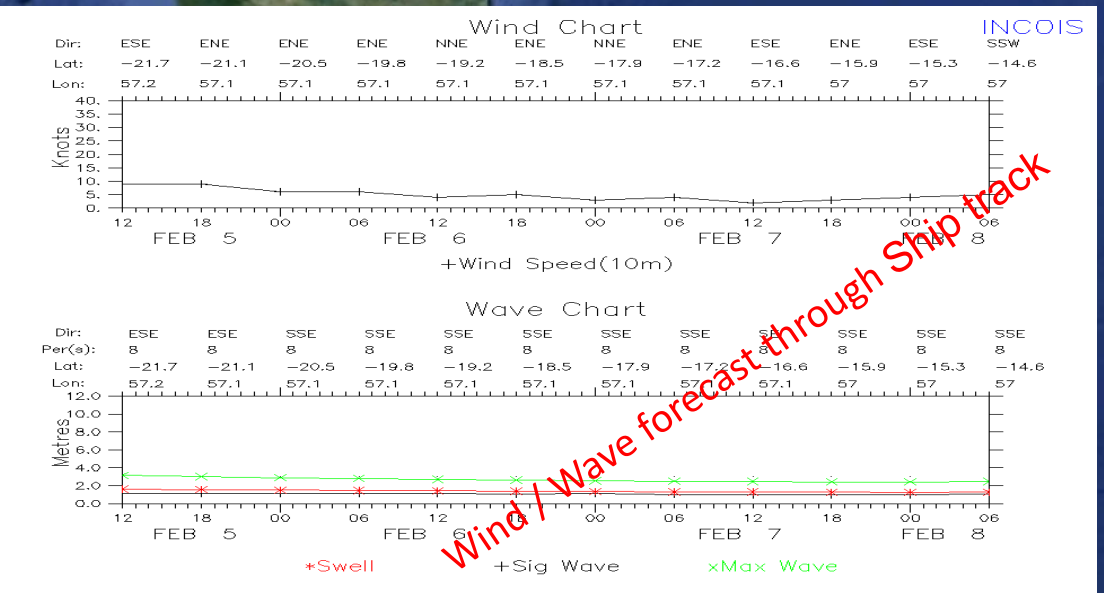
Forecast for Shipping Industry

Notes:PLEASE CONTINUE TO UPDATE US YOUR POSITION. REGARDS. DUTY FORECASTER.

Forecast:

ValidAt	Lon	Lat	Wind Dir	Wind speed	Wave	Swell Dir	Swell Height	Swell period	Sig Height	Max Wave
05-FEB-2012 12	57.20	-21.79	ESE	9	1.14	ESE	1.63	7.92	1.15	3.14
05-FEB-2012 18	57.18	-21.15	ENE	9	1.06	ESE	1.56	7.95	1.15	3.02
06-FEB-2012 00	57.17	-20.50	ENE	6	0.95	SSE	1.51	7.84	1.16	2.90
06-FEB-2012 06	57.16	-19.85	ENE	6	0.89	SSE	1.46	7.81	1.15	2.81
06-FEB-2012 12	57.15	-19.20	NNE	4	0.80	SSE	1.42	7.75	1.16	2.72
06-FEB-2012 18	57.14	-18.55	ENE	5	0.86	SSE	1.38	8.02	1.07	2.64
07-FEB-2012 00	57.12	-17.90	NNE	3	0.71	SSE	1.34	7.72	1.13	2.57
07-FEB-2012 06	57.11	-17.25	ENE	4	0.81	SSE	1.31	7.89	1.02	2.51
07-FEB-2012 12	57.10	-16.60	ESE	2	0.80	SE	1.28	7.90	1.00	2.46
07-FEB-2012 18	57.09	-15.96	ENE	3	0.79	SSE	1.27	7.80	0.98	2.43
08-FEB-2012 00	57.08	-15.31	SE	4	0.76	SSE	1.26	7.68	1.00	2.42
08-FEB-2012 06	57.06	-14.66	SSW	5	0.67	SSE	1.27	7.52	1.07	2.45

Notes: Wind speeds are in Knots. Wave heights are in metres. The significatnt wave height is defi
the average of the highest 1/3rd of waves.The Maximum wave height is the average of the highest
Forecaster: Krishna Prasad B - INCOIS



Wind / Wave forecast through Ship track

THE SHIPPING CORPORATION OF INDIA LIMITED
(A Govt. of India Enterprise)
Jawahar Building 17, Rajaji Salai, Chennai - 600 001.
Phone: 2523 1401 (10 Lines)
Fax: 044 - 2523 1218

MV.SWARAJDWEEP
AT: PORTBLAIR
DATE: 23-06-2012

TO

Dr.K.SRINIVAS (SCIENTIST),
OSF LAB,
INCOIS,
HYDERABAD

Respected Sir,

I, the Master of MV.Swarajdweep would like to thank you and your entire team for sending weather report data with clear images to our vessels. The weather data/images are very accurate and useful which keeps us updated during sailings. The weather report is very important for our passenger vessels sailing always in low pressure areas like Andaman sea.

I, behalf of my Officer's and Crew members of MV.Swarajdweep sincerely appreci[illegible] thank you and your entire team for rendering us your valuable services for last many [illegible]

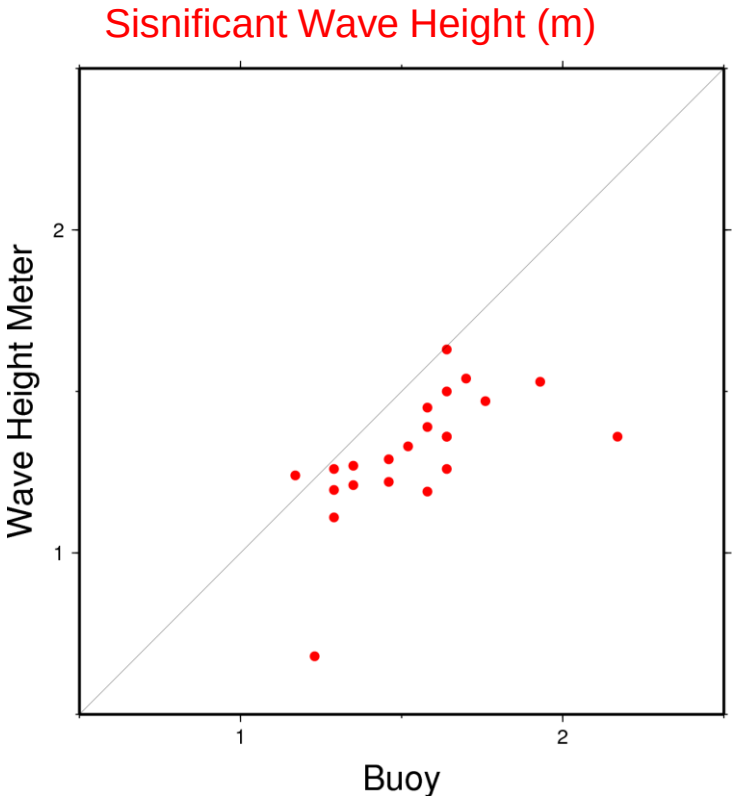
Thanking you,

With Best Regards,
Master MV.Swarajdweep.

MASTER
MV SWARAJ DWEEP

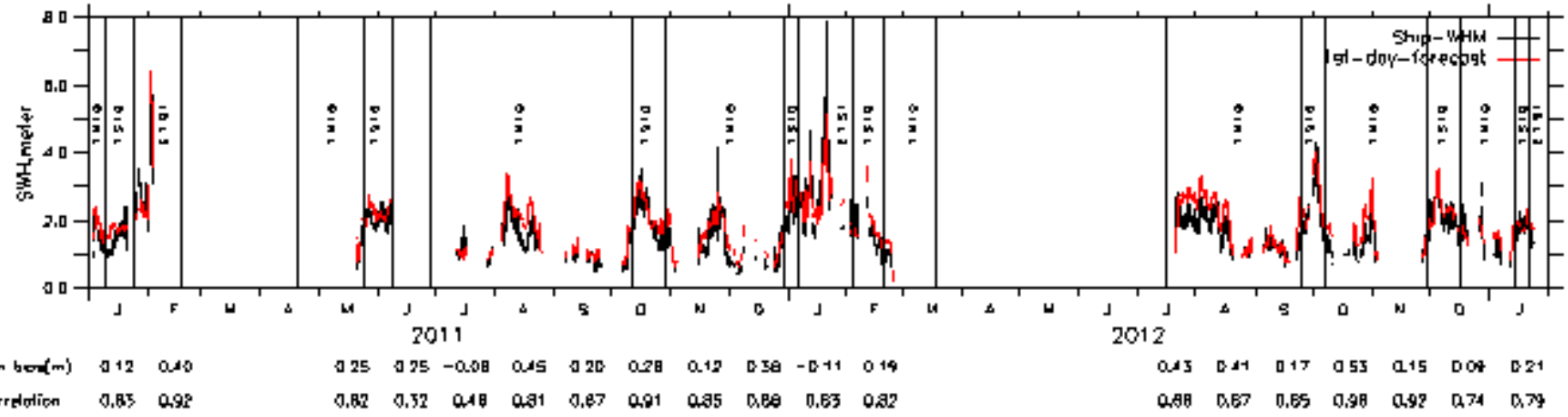
Recent feedback...

Comparison of Wave Height (Wave Height Meter & Buoy)

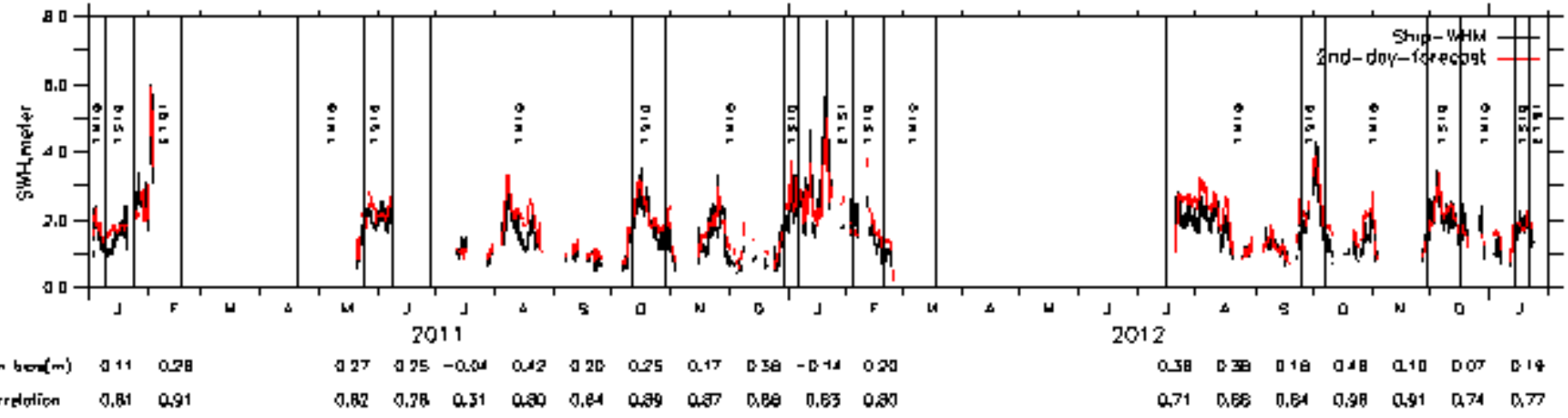


Buoy ID	Date	Time	WHM distance from Buoy location (km)	Buoy_swh (m)	WHM_swh (m)	Bias (m)
BD-08	2011/08/14	14:00	0.1999877	2.17	1.36	0.81
	2011/08/14	15:00	0.05516423	1.76	1.47	0.29
	2011/08/14	16:00	0.06697537	1.64	1.63	0.01
	2011/08/14	18:00	0.10444973	1.7	1.54	0.16
	2011/08/14	20:00	0.260172	1.64	1.26	0.38
	2011/08/14	21:00	0.3922688	1.64	1.36	0.28
	2011/08/14	22:00	0.597553	1.58	1.45	0.13
	2011/08/15	02:00	0.4655442	1.52	1.33	0.19
	2011/08/15	03:00	0.003589498	1.64	1.5	0.14
	2011/08/15	04:00	0.002877589	1.46	1.22	0.24
	2011/08/15	05:00	0.001467653	1.58	1.39	0.19
	2011/08/15	06:00	0.001191531	1.46	1.29	0.17
	2011/08/15	08:00	0.004124692	1.64	1.36	0.28
	2011/08/16	08:00	0.0347314	1.58	1.19	0.39
	2011/08/16	09:00	0.000897402	1.35	1.27	0.08
	2011/08/16	10:00	0.001359809	1.35	1.21	0.14
	2011/08/16	11:00	0.00497838	1.29	1.11	0.18
	2011/08/16	13:00	0.009691055	1.29	1.19	0.095
	2011/08/16	14:00	0.03817572	1.29	1.26	0.03
	2011/08/16	15:00	0.02981198	1.17	1.24	-0.07
	2011/08/23	04:00	0.323763	1.93	1.53	0.4
	2011/12/15	12:00	0.1187263	1.23	0.68	0.55

First and Second day Forecast

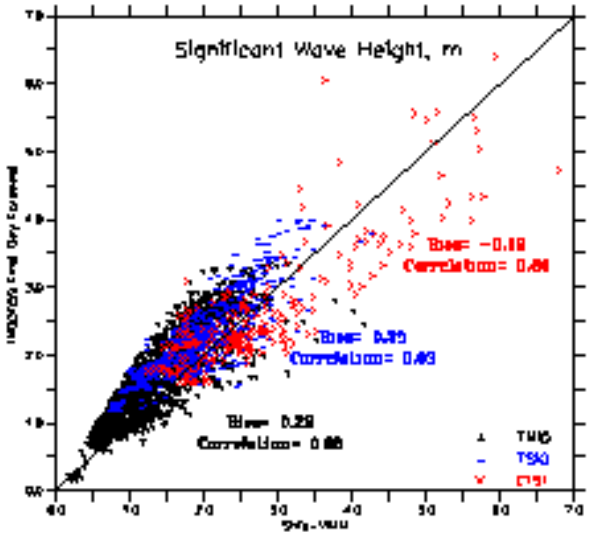


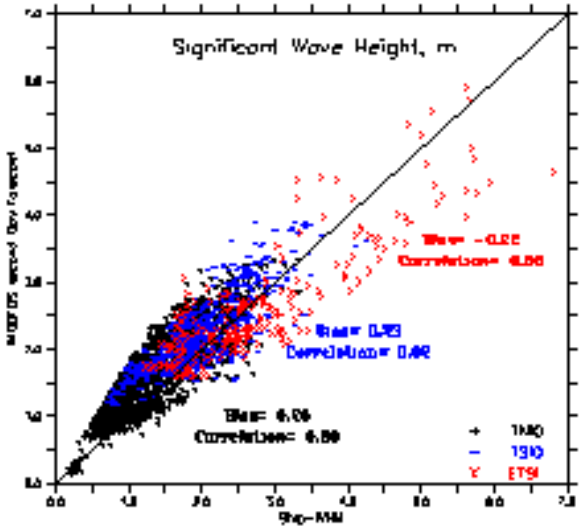
ean bias(m)	0.12	0.40		0.25	0.25	-0.08	0.45	0.20	0.28	0.12	0.58	-0.11	0.19		0.43	0.41	0.17	0.53	0.15	0.09	0.21	
Correlation	0.85	0.92		0.82	0.32	0.48	0.81	0.87	0.91	0.85	0.89	0.83	0.82		0.88	0.87	0.85	0.98	0.92	0.74	0.79	



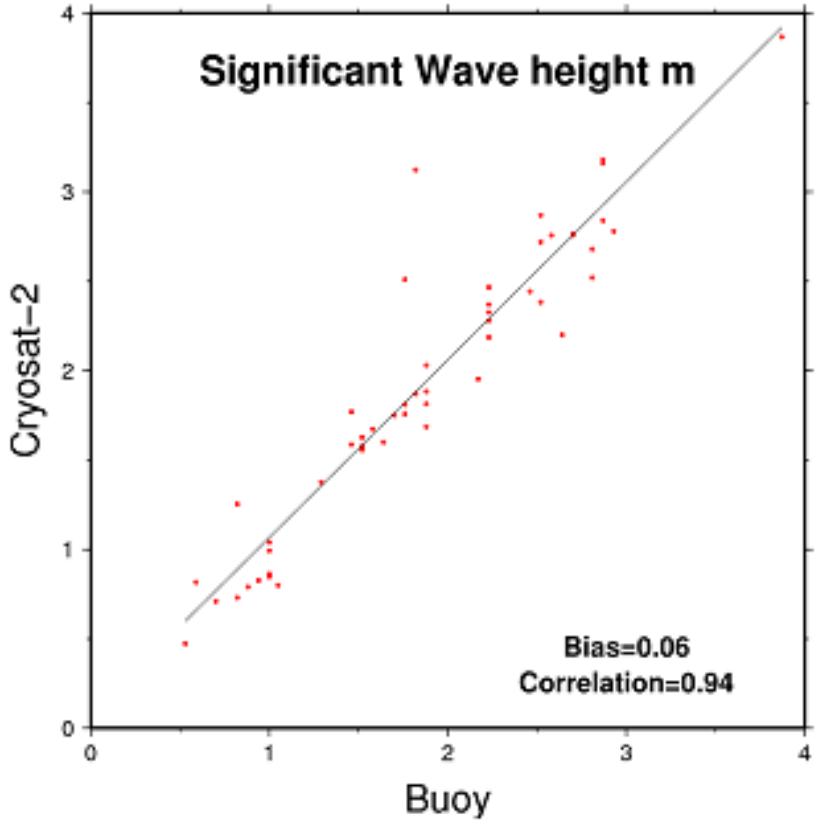
ean bias(m)	0.11	0.28		0.27	0.25	-0.04	0.42	0.20	0.25	0.17	0.58	-0.14	0.20		0.38	0.38	0.18	0.48	0.10	0.07	0.19	
Correlation	0.81	0.91		0.82	0.28	0.31	0.80	0.84	0.89	0.87	0.89	0.83	0.80		0.71	0.66	0.64	0.98	0.91	0.74	0.77	

Forecast vs Ship_WHM



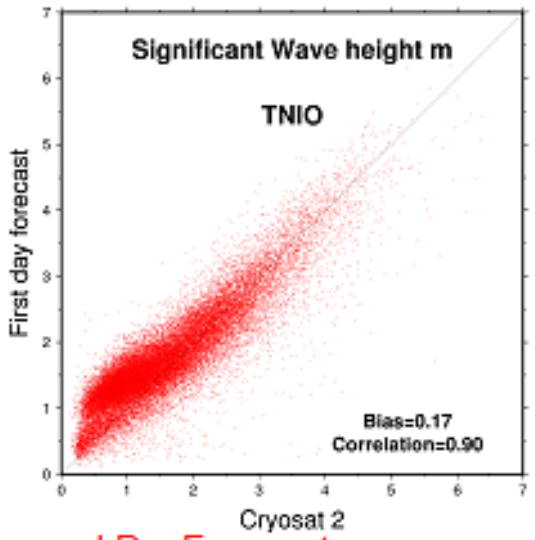


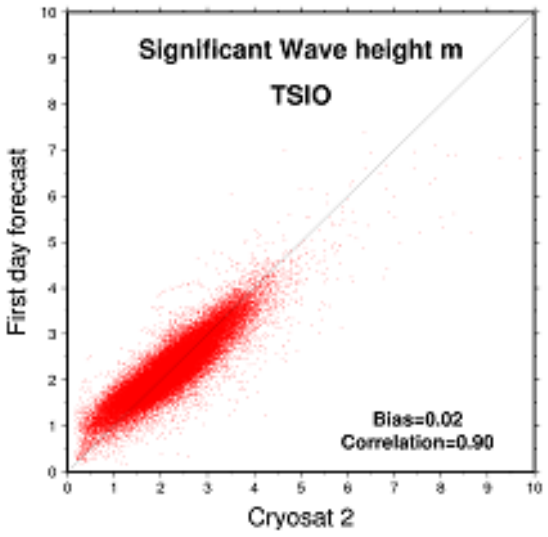
Validation of Satellite data using in-situ measurements

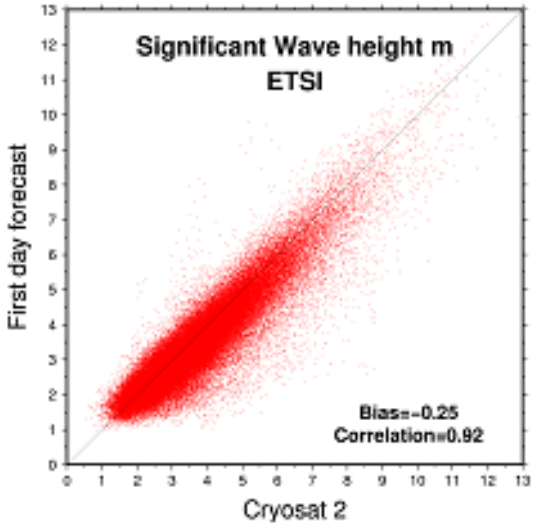


Validation of forecast through Satellite tracks during 2011-2012

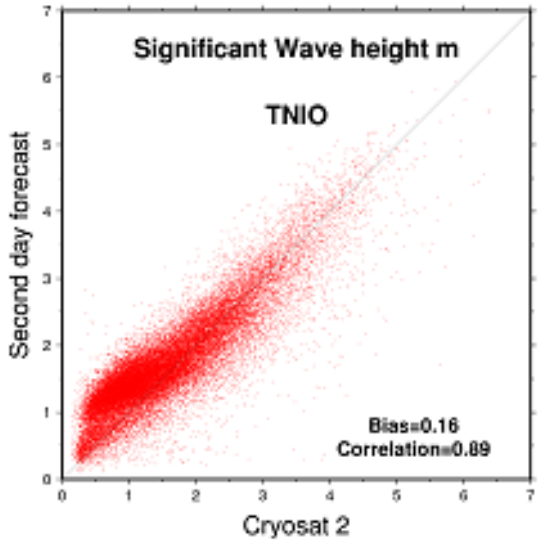
First day forecast

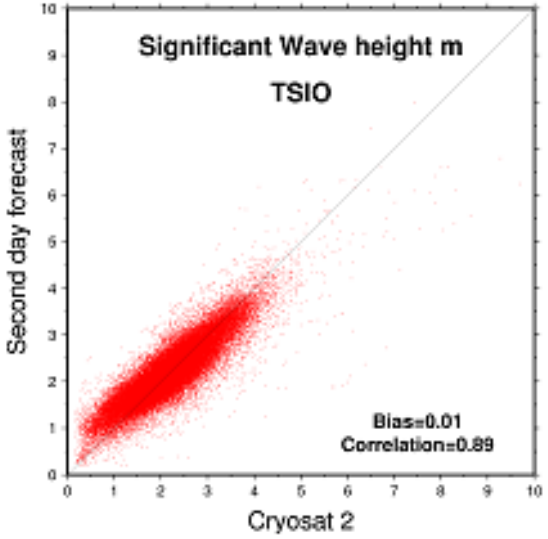


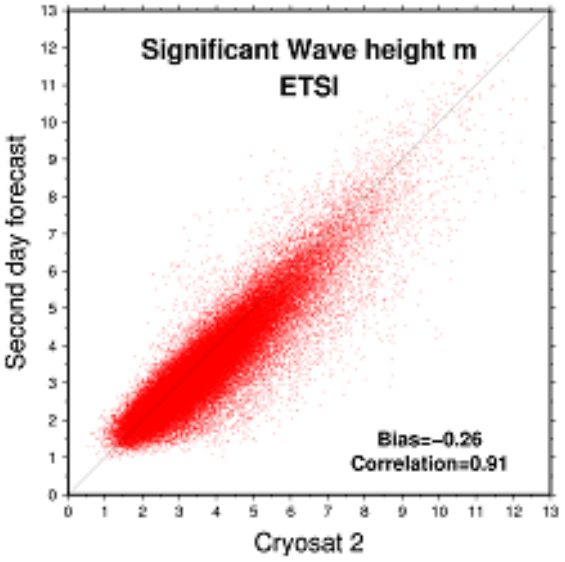




Second DayForecast

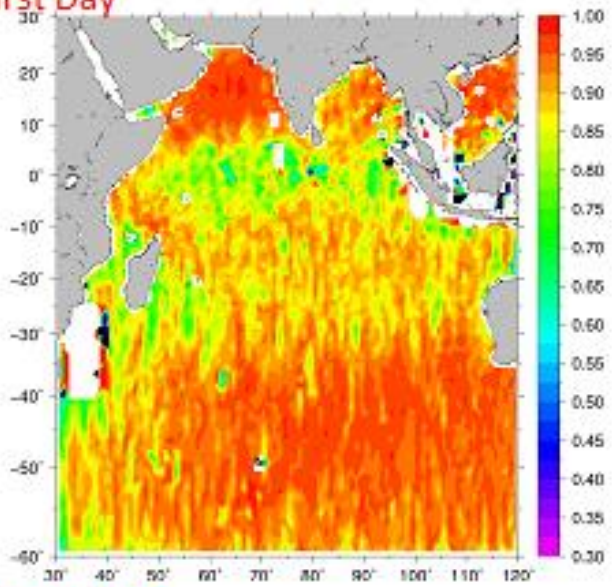


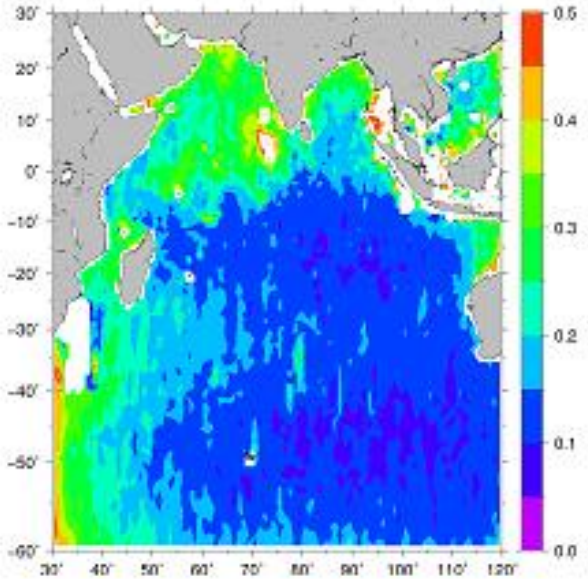


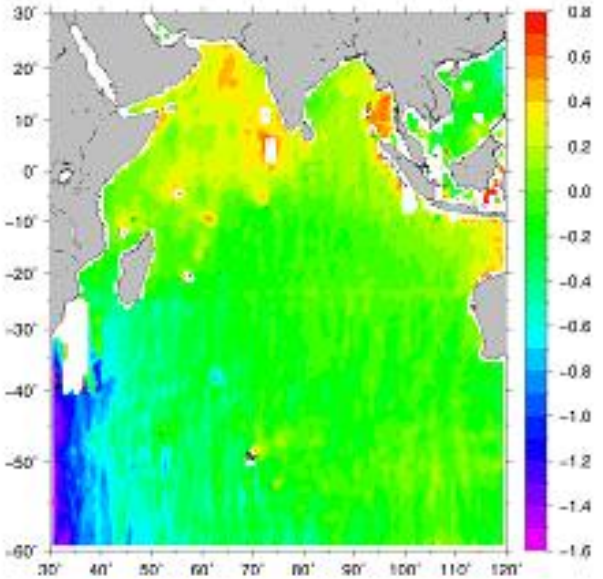


Spatial Validation of forecast with Cryosat-2 satellite

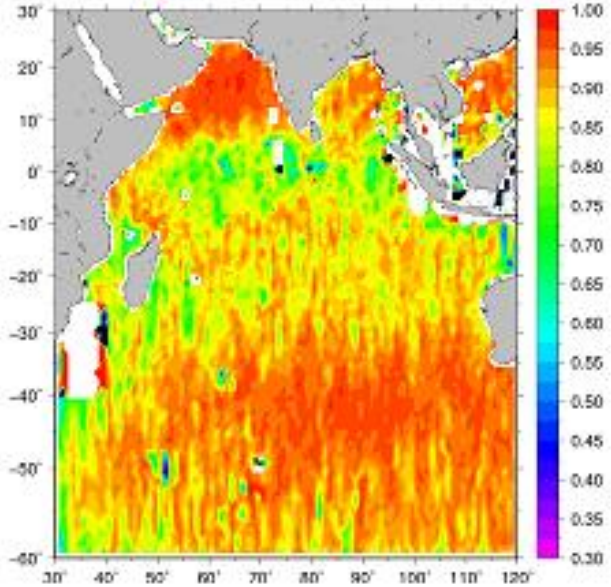
First Day

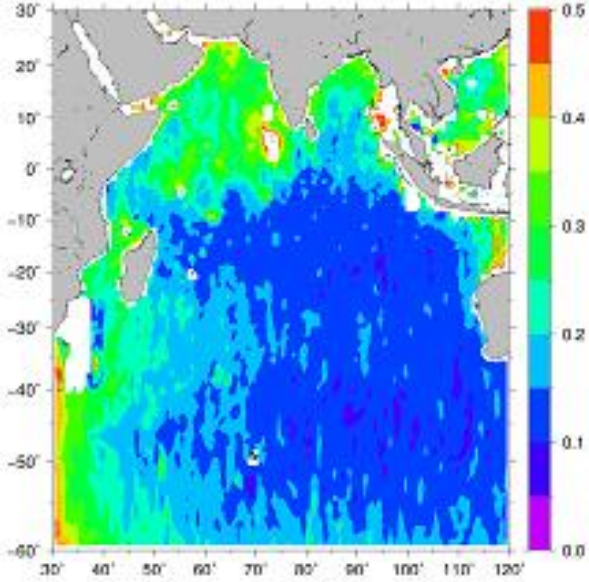


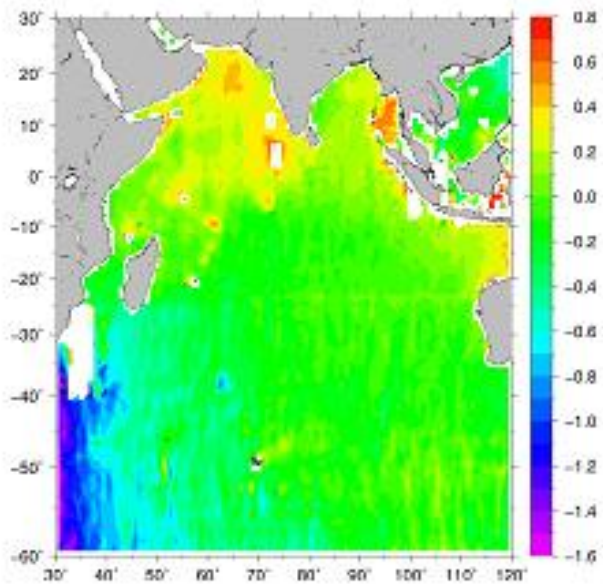




Second day







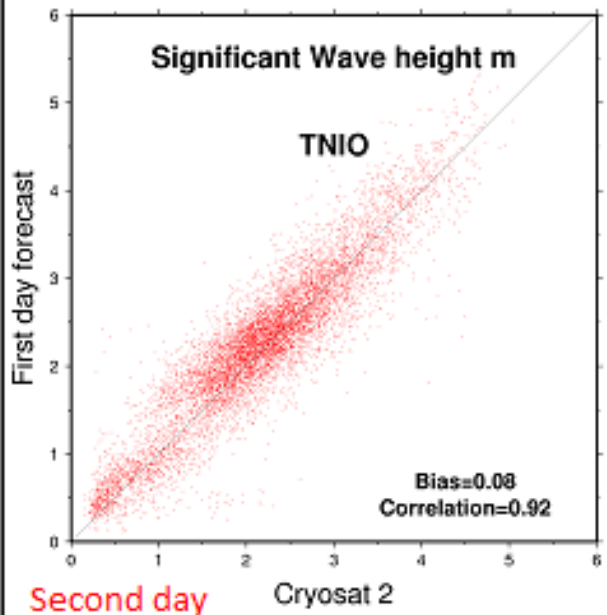
Correlation coefficient

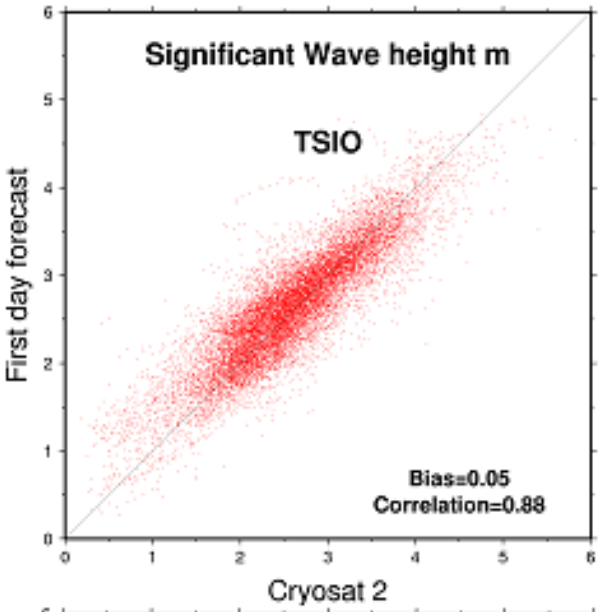
Scatter Index

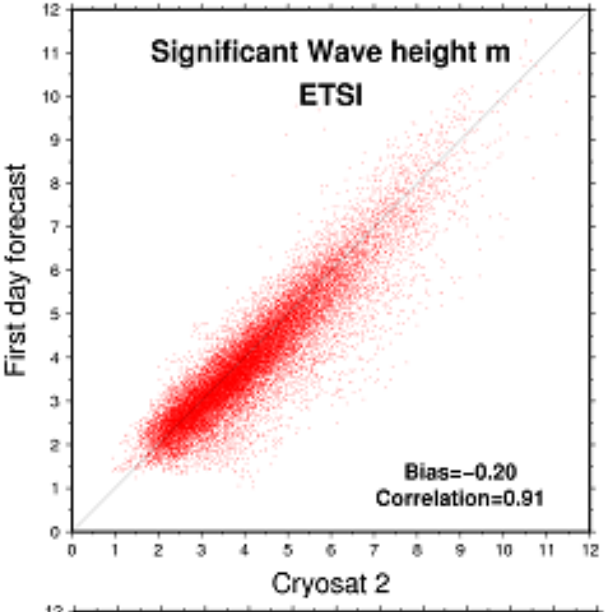
Mean Bias

Validation of forecast with Cryosat-2 satellite during South-west monsoon

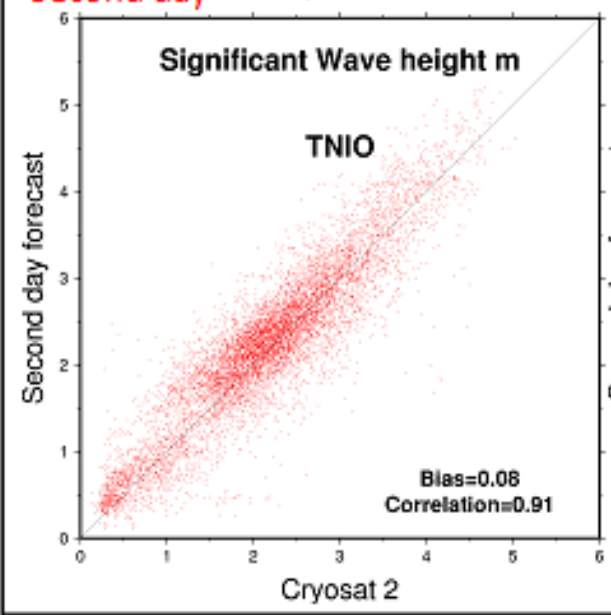
First Day

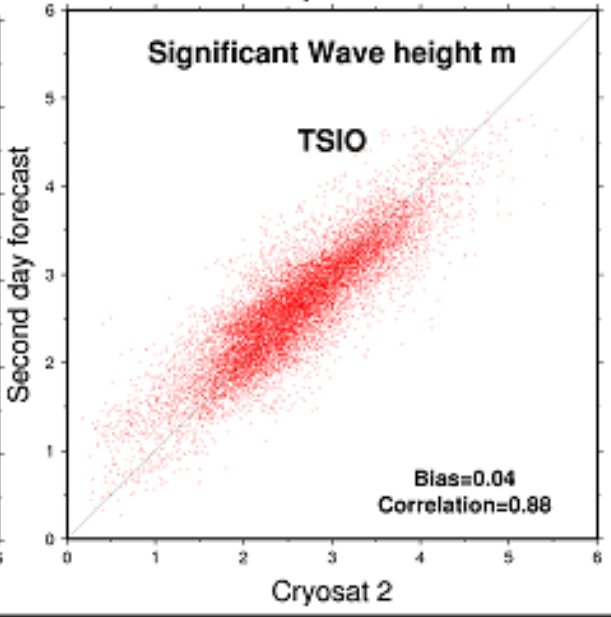


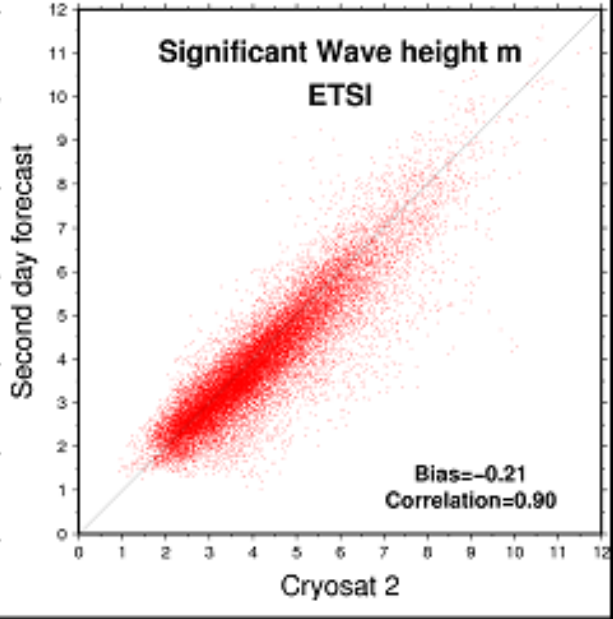




Second day

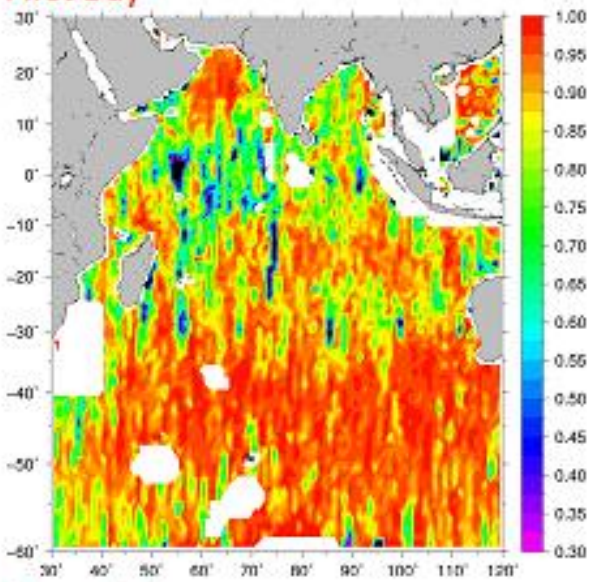


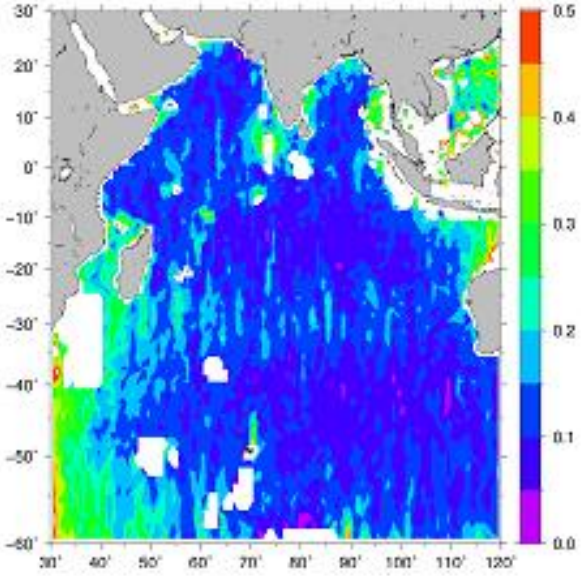


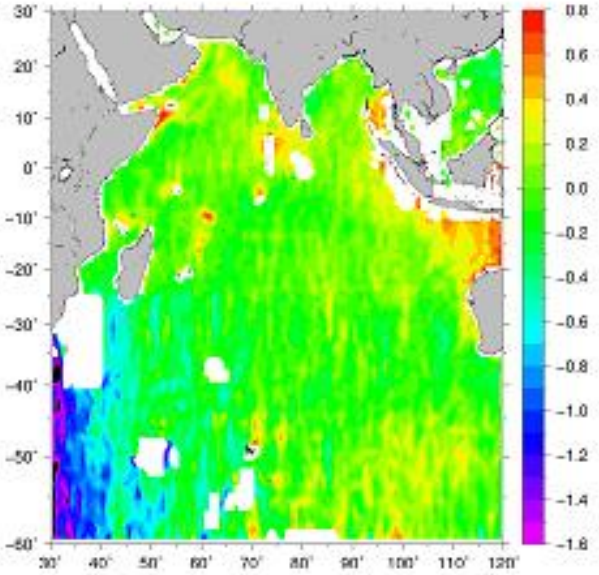


Spatial Validation of forecast with Cryosat-2 satellite

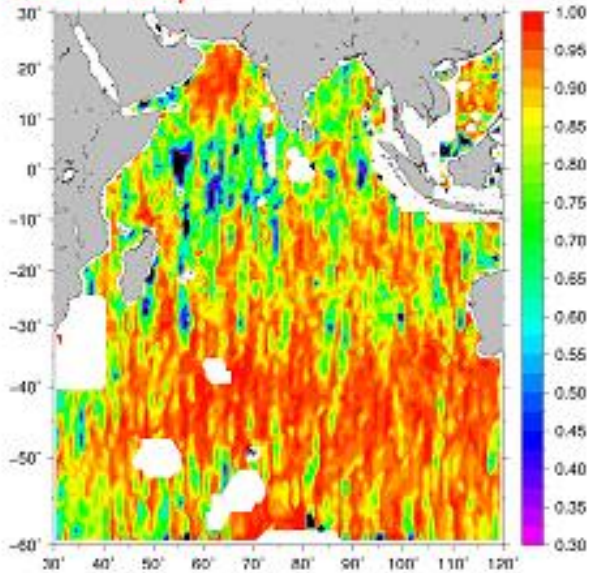
First Day

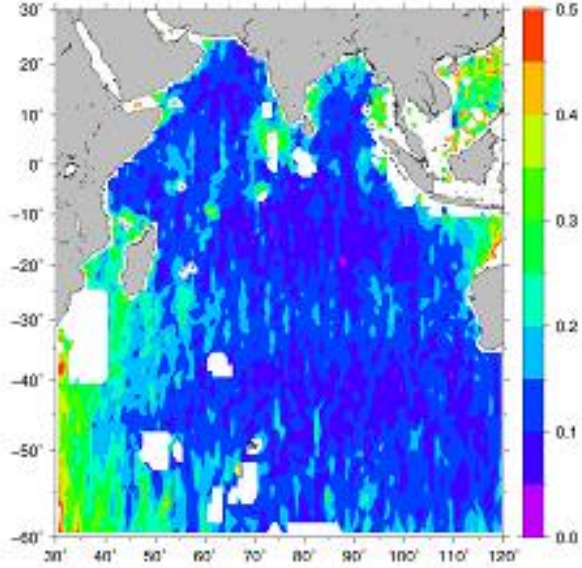


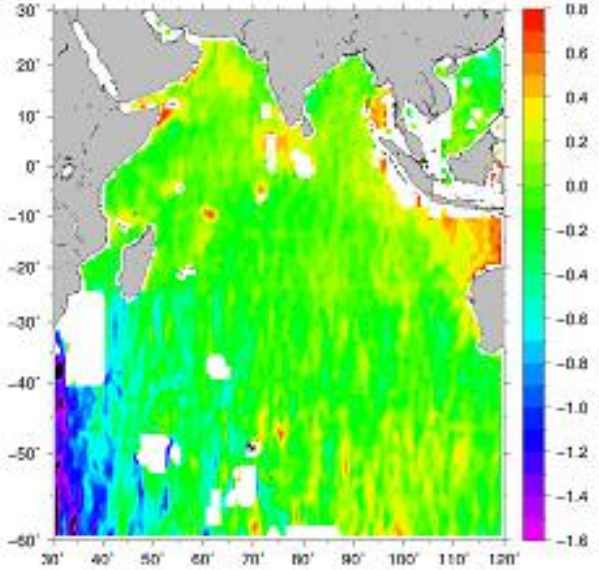




Second day





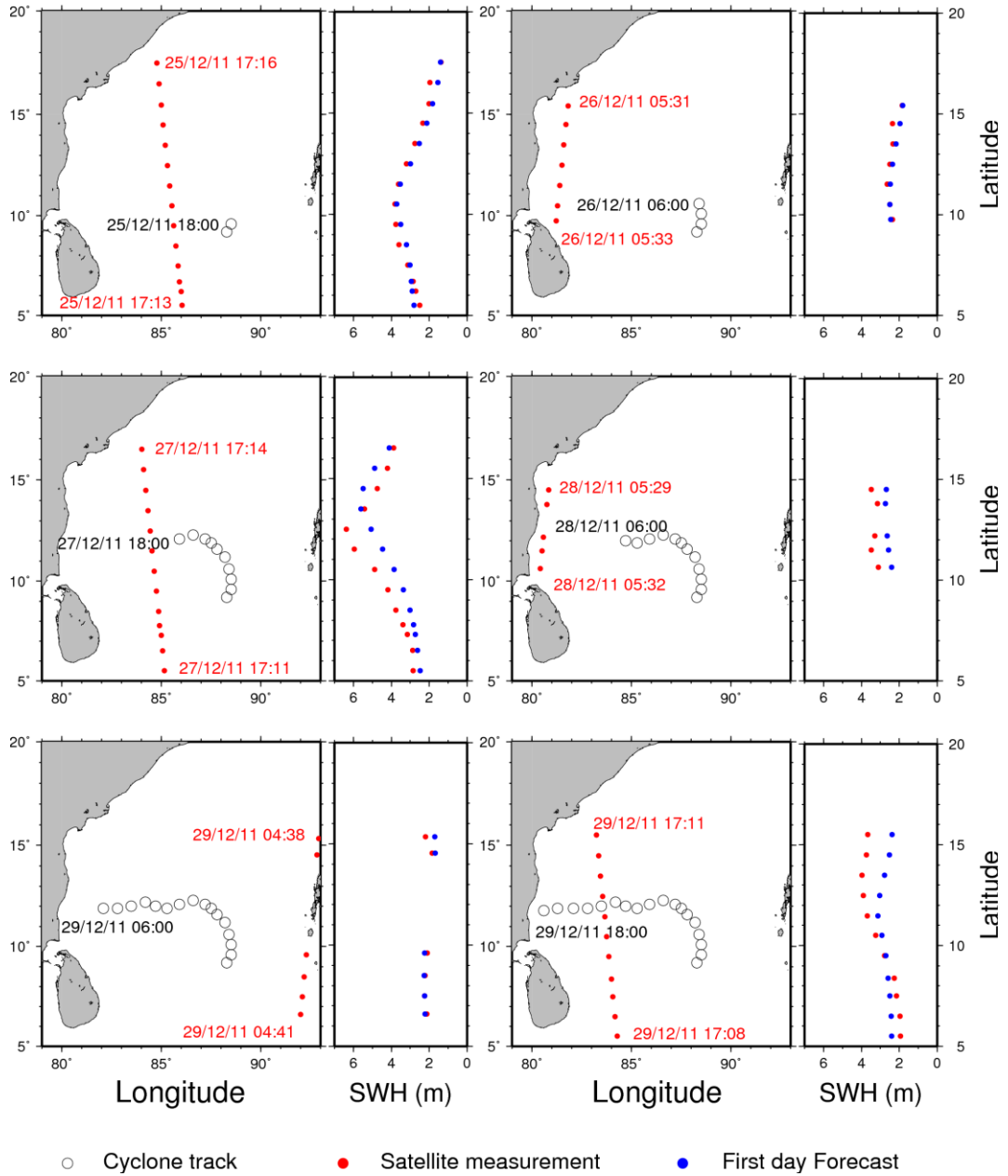


Correlation coefficient

Scatter Index

Mean Bias

Validation of forecast with Cryosat-2 satellite during Thane Cyclone 25/12/2011 to 30/12/2011



Thank you very much…

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Scientist

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