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The INCOIS-Real time Automatic Weather Station(IRAWS) program was started in the year 2009 and was first installed onboard ORV Sagar Nidhi. Currently, there are 36 ships carrying IRAWS setup. Apart from storing one minute observations in the log onboard the ship, hourly averaged observations are reported through INSAT satellite communication. This report briefs about the hourly dataset of IRAWS and its quality control. In this report, QC results of SST and all meteorological parameters except radiation parameters is discussed. Specific quality check was applied to wind speed (WS) and sea surface temperature (SST) observations. The WS observations measured onboard few ships had a dimensional correction and SST was observed only on few ships. As SST observations are required to compute meteorological variables like DBT, RH, WS to standard height of 10 m, level-3 dataset of AVHRR SST was utilized in place of IRAWS SST wherever the data is found to be faulty. On similar terms bias correction could not be applied to IRAWS SST with the help of AVHRR SST as the error in SST observations are due to the failure of sensor. However all those IRAWS SST observations that passed the QC check were observed to be of high quality and have a correlation coefficient of 0.5 with AVHRR SST and is significant at 95% significant level. Apart from SST and radiation observations, all other parameters observations are found out to be of good quality with 70 to 90 QC pass percentage . Apart from the details of QC check, significance of representing climate variable at a homogeneous standard height is also shown in this report.

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INCOIS-Real time Automatic Weather Station(IRAWS) dataset - Quality control and significance of height correction

by

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Abstract

The INCOIS-Real time Automatic Weather Station(IRAWS) program was started in the year 2009 and was first installed onboard ORV Sagar Nidhi. Currently, there are 36 ships carrying IRAWS setup. Apart from storing one minute observations in the log onboard the ship, hourly averaged observations are reported through INSAT satellite communication. This report briefs about the hourly dataset of IRAWS and its quality control. In this report, QC results of SST and all meteorological parameters except radiation parameters is discussed. Specific quality check was applied to wind speed (WS) and sea surface temperature (SST) observations. The WS observations measured onboard few ships had a dimensional correction and SST was observed only on few ships. As SST observations are required to recompute meteorological variables like DBT, RH, WS to standard height of 10 m, level-3 dataset of AVHRR SST was utilized in place of IRAWS SST wherever the data is found to be faulty. On similar terms bias correction could not be applied to IRAWS SST with the help of AVHRR SST as the error in SST observations are due to the failure of sensor. However all those IRAWS SST observations that passed the QC check were observed to be of high quality and have a correlation coefficient of 0.5 with AVHRR SST and is significant at 95% significant level. Apart from SST and radiation observations, all other parameters observations are found out to be of good quality with 70 to 90 QC pass percentage . Apart from the details of QC check, significance of representing climate variable at a homogeneous standard height is also shown in this report.

1. Description about the data

The real-time data of IRAWS is obtained through GTS. The data observed through IRAWS is basically Marine-Meteorological dataset. The data is spanning from July 2009, to the latest. Harikumar *et.al* 2013 describes the utility of IRAWS dataset at INCOIS and details the primary reason for the beginning of this program. In the present study observations spanning from July 2009 to October 2018 is used for processing and performing quality control. The total number of observation records available during the period under consideration are 17,86,087(actual number of obs). Table 1 gives the details of ship names, duration of observations available, number of records, metadata regarding instrument height. Table 2 gives the details of list of parameters observed. The spatial coverage of the dataset is shown in Figure 1.

S.No	ship name	duration	number of records	instrument height (m)
1	CRVSagarPaschimi	31/07/2010 - 30/12/2016	41673	10.9
2	CRVSagarPurvi	06/08/2010 - 08/10/2018	79460	8
3	FORVSagarSampada	26/07/2010 - 14/07/2018	67234	10
4	FSIBlueMarlin	03/11/2014 - 12/05/2018	22625	12.4
5	FSIMastyaDrushti	05/07/2013 - 06/10/2018	18345	13
6	FSIMastyaVarshini	05/10/2013 - 08/10/2018	56810	13
7	FSIMastyaVrushti	05/06/2013 - 07/10/2018	40880	12.4
8	FSISagarika	29/08/2013 - 08/10/2018	36167	12.4
9	FSIYellowFin	17/07/2013 - 08/10/2018	60702	12.4
10	INSDarshak	06/10/2015 - 04/08/2017	12202	40
11	INSNirupak	15/12/2015 - 08/10/2018	36074	35

12	INSSandhayak	16/12/2015 - 08/10/2018	66010	26
13	INSSarvekshak	30/07/2013 - 08/10/2018	40081	13
14	INSSutlej	07/10/2015 - 27/09/2018	6406	10
15	MGSSagar	26/10/2015 - 11/04/2018	68027	35
16	MVCampbellBay	05/08/2015 - 10/08/2018	57250	30
17	MVChowra	14/09/2015 - 08/10/2018	64673	20
18	MVDering	10/09/2015 - 08/10/2018	74262	24
19	MVIvanPapanin	19/01/2015 - 21/02/2017	1251	14
20	MVKalighat	15/09/2015 - 08/10/2018	70647	15
21	MVNancowry	10/06/2015 - 08/10/2018	74446	33
23	MVNicobar	21/11/2014 - 08/10/2018	60278	32
24	MVSentinel	09/09/2015 - 08/10/2018	65650	18
25	MVSwarajDweep	01/05/2015 - 08/10/2018	41401	52
26	ONGCBHS	02/09/2012 - 10/09/2013	22835	67.4
27	ONGCNeelam	10/08/2013 - 05/12/2014	4246	47
28	ORVSagarKanya	20/10/2009 - 08/10/2018	82438	13.9
29	ORVSagarManjusha	17/09/2010 - 06/10/2018	64052	13
30	ORVSagarNidhi	14/07/2009 - 08/10/2018	103612	20
31	RVSamudraKaustubh	22/08/2011 - 07/09/2018	82748	10
32	RVSamudraSaudikama	11/07/2011 - 18/09/2018	86240	12
33	RVSindhuSankalp	18/06/2011 - 04/05/2018	53223	25
34	SCIKundan	29/07/2015 - 22/04/2016	3510	20
35	SCIMukta	24/08/2015 - 31/05/2017	36717	25
36	SCINalanda	25/05/2013 - 08/10/2018	61833	33
37	SCIYamuna	03/06/2016 - 11/09/2018	22079	31

Table 1 : Details of IRAWS ships and observations made onboard the ships

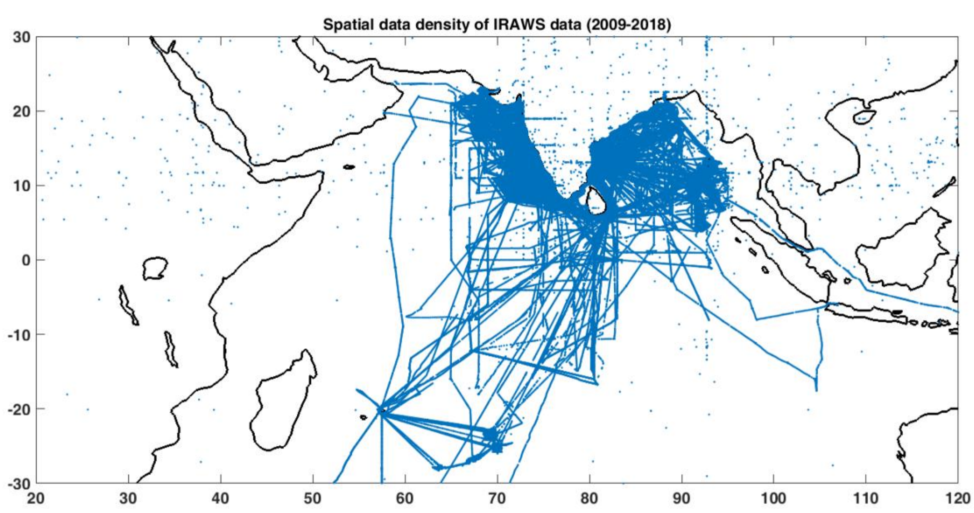

Figure 1 : Spatial density of IRAWS data excluding the Indian Navy ships data

S.No	Parameter
1	Sea level pressure
2	Air temperature
3	Relative humidity
4	Sea surface temperature (on few ships)
5	Wind speed and direction
6	Rain
7	Shortwave radiation
8	Longwave radiation
9	Chlorophyll and Turbidity (on few ships)

Table 2 : List of parameters observed onboard IRAWS ships.

2. Methodology

Based on the metadata of the IRAWS setup, WS observations are supposed to be in ms^{-1}. But some of the WS observations made onboard few ships were in knots (1 knot = 0.5144 ms^{-1}) and rest all were in ms^{-1}. The period during which WS observations were in knots was personally intimated and the correction is applied accordingly.

Table 3 gives the details of the timestamp of observations made onboard the corresponding ship from when the WS is to be taken in ms^{-1}. Figure 2 shows the difference in the WS observations before and after the dimensional correction. The plot shown is of the ship 'CRV Sagar Purvi'. Similar pattern (not shown here) was observed for the remaining ships in Table 3.

Ship name	**Date from which WS are in ms^{-1}**
Sagar Nidhi	20/8/12
Sagar Kanya	01/07/11
Sagar Sampadha	21/9/11
Sagar Paschimi	01/09/2012
CRVSagarPurvi	01/10/2012
Sagar Manjusha	14/03/2013
Sindu Sankalp	03/1/2013
Samudra Saudikama	01/10/2014

Table 3 : Details of ships onboard where the WS dimensional correction is applied

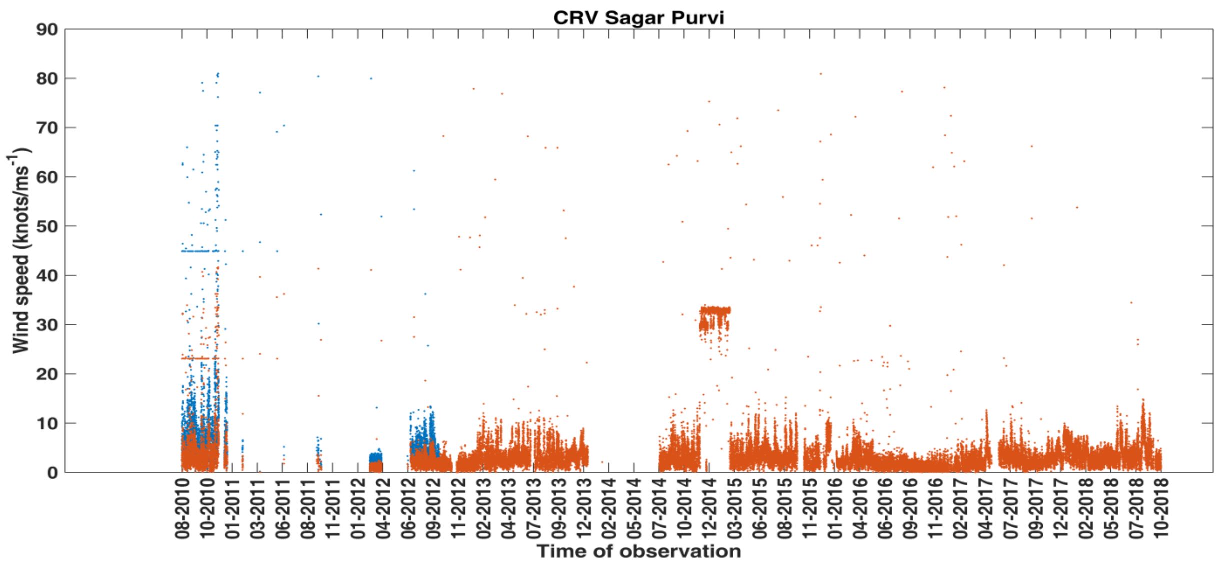

Figure 2 : WS measurement obtained from CRV Sagar Purvi before(blue) and after(orange) correction for dimensions from knots to ms^{-1}

2.1 Quality control procedure

To ensure qualitative utility of the dataset, the dataset has to be thoroughly checked for spurious and outlier values. Therefore a firm quality control procedure is to be applied upon the dataset. The present QC procedure removes the observation failing the QC steps 1, 2, 3 and from QC step 4 onwards a QCflag value '1' is allotted if the observation passes the QC check and '8' is allotted if the observation fails to pass the QC check. The QC steps 1,2, and 3 checks the observation for reliability on technical terms (like duplicates, etc.) and step 4 onwards the check is based on scientific reliability. The dataset upon which the QC check is performed, is the one consisting of WS with dimensional correction applied and Air pressure converted to sea level pressure (described in next section). These corrections are applied to prior QC check because for example, WS observations in knots is approximately double of the value in ms^{-1}. If such observations are passed for QC check then most of them would be wrongly detected as outliers. Hence data has to be corrected for such errors prior to QC check. The steps involved in the quality control check of the IRAWS dataset is outlined below.

1. Check of reporting time

   If the difference between reporting time and observation time is greater than one hour then such records are neglected from further processing.
2. Checking organizational data

   This check includes checking of correct time and location of observation. In the case of time, year(2009-2018), month(1-12), date(1-31), hour(0-24), minutes(1-60) and seconds(1-60) are checked whether they are in range. In the case of location, the latitude(-90 to 90) and longitude (0 to 360 or -180 to 180) values are checked whether they are in range. If the observation time or location is in permissible range then the QC flag of all the parameters is assigned '1' otherwise '8'.
3. Duplicate check

Here duplicate implies the entire record being repeated more than once. There is always a chance of occurrence of such kind of duplicates within the data.

4. Range check

In this step, all the variables are checked whether their value is within the permissible limit. Table 4 gives the details of permissible ranges of the variables present in Table 2. If the parameter values in the records are not within the permissible range as mentioned in the third column then the qcflag assigned is '8' .

S. No	Parameter		Permissible range	Dimension
1	SLP		950 to 1040	hPa
2	DBT	Tropics	15 to 50	^{o}C
		Midlatitudes	-40 to 50	^{o}C
3	RH		55 to 100	%
4	SST	Tropics	12 to 40	^{o}C
		Midlatitudes	-10 to 50	^{o}C
5	WS		0.5 to 40	ms^{-1}
6	WDIR		0 to 360	Degrees
7	Rain		0 to 50	mm
8	LWR		0 to 700	W/m^2
9	SWR		0 to 1500	W/m^2

Table 4 : Details of upper and lower limits of marine and meteorological variables used in QC - Range check

5. Spike test

Spikes are sudden increase or decrease in parameter value at a particular time step whose magnitude is very much different from the rest of its neighbors. The spike test employed here is the standard deviation test. The method is as follows. Three observations made before and after the observation in query are considered along with the one in query and the difference between the 7 consecutive observations must not be greater than 12 hours. The qcflag of the observations is assigned '8' if the value under query is greater than 1.6 times the stdev of the seven values.

6. Stuck value test

Stuck values are those which keep repeating continuously more than thrice. The qcflags of all such observations is assigned '8'.

7. STDEV trimming

There could be values which come under permissible range for a given parameter but however they still remain as outliers because there exists very less possibility of occurrence of such magnitude in that region and time instant. A method similar to the one followed by Slutz *et al.* (1985)., is followed for standard deviation trimming.

8. Polygon QC

Each parameter is plotted against its latitude where it was observed and is overlaid upon a standard climatology. All the isolated points falling outside the polygon formed by the climatology were considered as outliers and were removed (Figure 4). This is a method described in Bhaskar *et al.* (2017).

Figure 3 shows the data after each step of QC check. Here the example taken is SLP data from FORV Sagar Sampada. Appendix I shows the plots with spatial density of data observed onboard each ship of IRAWS after passing all the QC procedures.

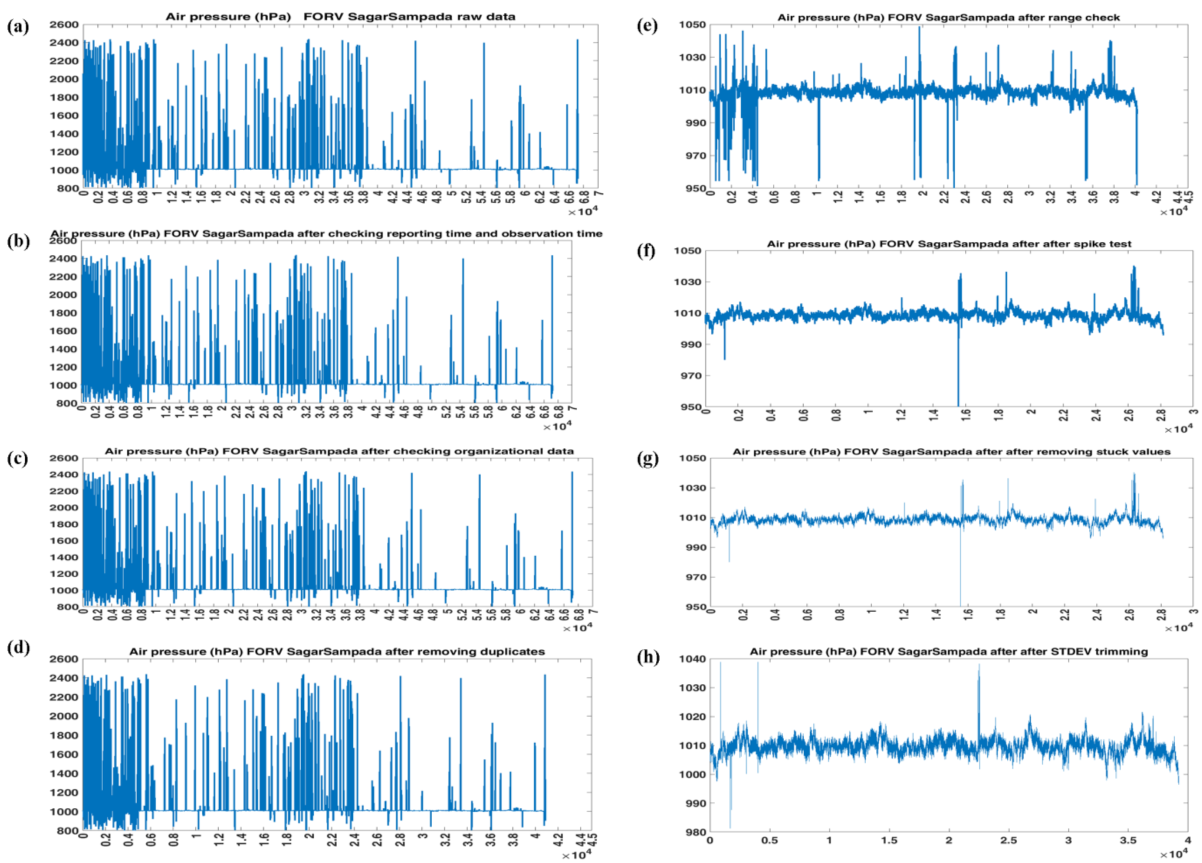

Figure 3 : SLP observed onboard FORV Sagar Sampada after each step of QC check . Each plot corresponds to each step of QC discussed above : (a) -1; (b)-2; (c)-3; (d)-4; (e)-5;(f)-6; (g)-7

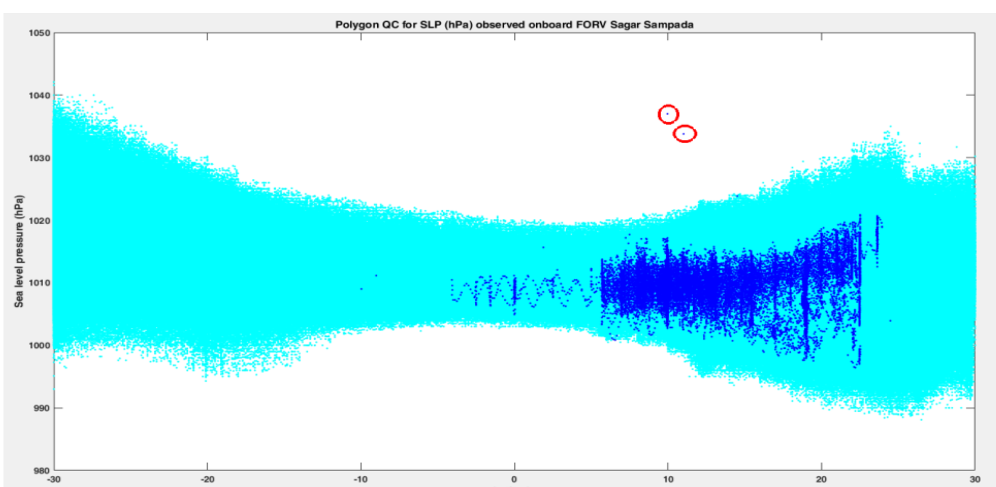

Figure 4 : SLP observed onboard FORV Sagar Sampada(blue) under Polygon QC (Observations falling outside the climatological polygon(cyan color) are outliers.

2.2 Height correction

The mast on to which the sensors are fixed is placed at those places on the ship where there is minimal flow distortion and influence of ship body on the sensors. Depending on the type of ship and its structure the height at which the mast is placed varies. Thus the observations so obtained from various ships are actually a heterogeneous collection having different measurement height. As the standard height of representation of meteorological variables is 10 m, observations like WS,DBT,RH are supposed to be recomputed to 10 m height. The ships carrying IRAWS setup have different heights at which the mast is placed. Height correction is applied to those observations observed at height less that 8 m and greater than 13 m. In case of air pressure where SLP is of interest, air pressure has to be recomputed to sea level. The formulation required to calculate SLP is given below,

$$P_o = P_H \mathrm{e}^{\frac{g_o * H}{R_d * T_v}}$$

The detailed height conversion procedure for DBT, RH, WS is described in Kameshwari *et al*.,2016. Inorder to recompute DBT, RH and WS to 10 m height, SST is essential. But SST wasn't observed onboard all the ships. So, SST from AVHRR is taken wherever required. The same is described in the Section 4.

3. Results and Discussions

This section details each variable, it's method of observation and outcome of quality control procedure. Analysis describing the importance of height correction is described in the following section.

3.1 Method of measurement and QC outcome

Sea level pressure

SLP is measured by Barometer of make 'Setra'. Approximately on average 88% of data was found to pass the entire QC procedure. Details of the same for each ship are given in table 5.

Air Temperature (Dry bulb temperature) :

DBT is measured by Hygroclip temperature and humidity sensor. Approximately 80% of the entire DBT measurements combined from all the ships has passed the QC check. Table 5 details the number of observations that passed QC for each ship.

Relative Humidity

RH is also measured by Hygroclip temperature and humidity sensor. The average percentage of observations combined from all ships that have passed QC procedure is around 75 %. The percentage of ship wise observations that have passed QC is presented in Table 5.

Sea Surface Temperature:

SST was observed on few ships with SST sensor of make 'Wetlab'. Table 6 gives the percentage of data observed onboard these ships that has passed the QC procedure. As SST is not available in all observation records, AVHRR SST has been mapped at these observations to carry out some computations (ex: height correction) where availability of SST is mandatory. The same is described in sub section 3.2 and 4.

Wind speed and Direction

WS and WDIR are measured using ultrasonic wind sensor of make by 'Gill'. The percentage of WS and WDIR observations that have passed QC check are 71% and 75% respectively. The percentage of observations observed on each ship that have passed the QC check is given in Table 6.

Rain

Rain was observed using rain gauge of make 'Young'. The pass percentage is less in all the ships with the highest being around 32% onboard MV Chowra and MV Dering.

Ship name	**Sea level pressure**		**Air Temperature**		**Relative Humidity**		**NumObs reported**
	NumObs passed QC	**Percentage (%) of obs passed QC**	**NumObs passed QC**	**Percentage (%) of obs passed QC**	**NumObs passed QC**	**Percentage (%) of obs passed QC**	
CRVSagarPaschimi	27033	96.59	20467	73.13	12375	44.22	27986
CRVSagarPurvi	41548	87.45	32368	68.13	32025	67.41	47511
FORVSagarSampada	39106	96.01	35922	88.20	33982	83.43	40730
FSIBlueMarlin	11606	98.13	11384	96.25	11007	93.07	11827
FSIMastyaDrushti	9188	98.82	8854	95.22	8003	86.07	9298
FSIMastyaVarshini	30785	99.23	30077	96.95	23628	76.16	31023
FSIMastyaVrushti	23107	95.57	22346	92.42	17765	73.48	24178
FSISagarika	19974	95.46	19703	94.17	18721	89.48	20923
FSIYellowFin	26543	84.55	16925	53.92	18885	60.16	31392
INSDarshak	3216	42.75	3161	42.02	3074	40.87	7522
INSNirupak	2781	21.44	2235	17.23	2825	21.78	12972
INSSandhayak	4910	26.51	4274	23.07	4651	25.11	18524
INSSarvekshak	20285	93.80	19790	91.51	18951	87.63	21626
INSSutlej	3717	99.52	3646	97.62	3339	89.40	3735
MGSSagar	20374	94.98	17966	83.76	18159	84.66	21450
MVCampbellBay	18497	79.94	15710	67.89	17010	73.51	23140
MVChowra	20927	90.85	19442	84.41	21011	91.22	23034
MVDering	25428	98.32	23600	91.25	24504	94.75	25863
MVIvanPapanin	505	67.79	578	77.58	305	40.94	745
MVKalighat	21131	94.10	19749	87.94	15753	70.15	22457

MVNancowry	22890	83.19	18832	68.44	13200	47.97	27516
MVNicobar	29719	93.70	21089	66.49	22035	69.47	31718
MVSentinel	17654	87.18	17128	84.58	18067	89.22	20251
MVSwarajDweep	18507	93.61	13468	68.12	12165	61.53	19771
ONGCBHS	19964	98.79	15451	76.46	6968	34.48	20208
ONGCNeelam	2426	99.18	2273	92.93	2192	89.62	2446
ORVSagarKanya	47646	96.16	45149	91.12	40403	81.54	49550
ORVSagarManjusha	36191	93.91	30472	79.07	28393	73.68	38537
ORVSagarNidhi	65708	89.57	56994	77.70	54655	74.51	73356
RVSamudraKaustubh	47621	97.69	45071	92.46	42519	87.22	48747
RVSamudraSaudikama	47930	97.18	46140	93.55	39833	80.76	49321
RVSindhuSankalp	30615	95.12	27879	86.62	26348	81.86	32187
SCIKundan	1768	97.46	1597	88.04	1540	84.90	1814
SCIMukta	10239	83.93	9124	74.79	7924	64.95	12200
SCINalanda	35643	91.23	34235	87.62	29528	75.58	39071
SCIYamuna	11508	96.62	9358	78.57	8470	71.11	11911

Table 5 Shipwise details of percentage of observations passing QC procedure for variables sea level pressure, Air temperature, Relative humidity

Ship name	Sea Surface Temperature		Wind speed		Wind direction		NumObs reported
	NumObs passed QC	Percentage (%) of obs passed QC	NumObs passed QC	Percentage (%) of obs passed QC	NumObs passed QC	Percentage (%) of obs passed QC	
CRVSagarPaschimi			12715	45.43	14127	50.4788	27986
CRVSagarPurvi	--	0.0	34142	71.86	37005	77.88	47511
FORVSagarSampada	427	1.04	30394	74.62	33169	81.44	40730
FSIBlueMarlin			10080	85.23	10536	89.08	11827
FSIMastyaDrushti			5725	61.57	6968	74.94	9298
FSIMastyaVarshini			27683	89.23	29120	93.87	31023
FSIMastyaVrushti			21475	88.82	21751	89.96	24178
FSISagarika			15934	76.16	16731	79.96	20923
FSIYellowFin			19820	63.14	22358	71.22	31392
INSDarshak			2714	36.08	2740	36.43	7522
INSNirupak			2540	19.58	2592	19.98	12972
INSSandhayak			4310	23.27	4375	23.62	18524
INSSarvekshak	170	0.79	16267	75.22	17482	80.84	21626
INSSutlej	--	0.0	3376	90.39	3483	93.25	3735
MGSSagar	259	1.21	13514	63.00	14480	67.51	21450
MVCampbellBay			16229	70.13	16467	71.16	23140
MVChowra			17965	77.99	19857	86.21	23034

MVDering			23011	88.97	23609	91.28	25863
MVIvanPapanin			551	73.96	557	74.77	745
MVKalighat			18857	83.97	19056	84.86	22457
MVNancowry			14527	52.79	15758	57.27	27516
MVNicobar			24638	77.68	25953	81.82	31718
MVSentinel			17796	87.88	18197	89.86	20251
MVSwarajDweep			16387	82.88	16730	84.62	19771
ONGCBHS			19036	94.20	19030	94.17	20208
ONGCNeelam			1935	79.11	2093	85.57	2446
ORVSagarKanya	3197	6.45	36823	74.31	40207	81.14	49550
ORVSagarManjusha	1187	3.1	25570	66.35	30916	80.22	38537
ORVSagarNidhi	3975	5.42	60481	82.45	61339	83.62	73356
RVSamudraKaustubh			39842	81.73	41167	84.45	48747
RVSamudraSaudikama			41574	84.29	43452	88.10	49321
RVSindhuSankalp			27138	84.31	27827	86.45	32187
SCIKundan			32	1.764	86	4.74	1814
SCIMukta			7757	63.58	7887	64.65	12200
SCINalanda			32672	83.62	33379	85.43	39071
SCIYamuna			10154	85.25	10390	87.23	11911

Table 6 Shipwise details of percentage of observations passing QC procedure for variables sea surface temperature, wind speed, wind direction

3.2 Affect of Height correction

The bottom layer of atmosphere boundary layer is called the surface layer. The height of surface layer is usually few 10s of meters. Though the fluxes almost remain constant within this layer (change by less than 10%), there are significant changes that arise in the independent parameters such as WS, DBT and RH due to surface effects. Two experiments are conducted inorder to identify the error that would creep into the variable values of DBT, WS and RH when not recomputed to 10m height considering stability conditions.

1. The first experiment is about the error involved in observations used for gridding. Here gridding is considered because it is the process where several observations are brought together irrespective of their height of observation. To possibly reduce the error all the observations are recomputed to 10 m height. Here the stdev of observations (before and after height conversion) that come within 1 ^{o} radius of influence around each grid point in the EEZ area are compared. EEZ area is focused as the concentration of IRAWS data density is high in this region. Figure 5 shows the grid locations of EEZ. The spatial average of STDEV is reduced from 2.73 ^{o} C to 1.93 ^{o} C in case of DBT and from 3.68 ms^{-1} to 2.62 ms^{-1} in case of WS after the conversion, showing the significance of height conversion.

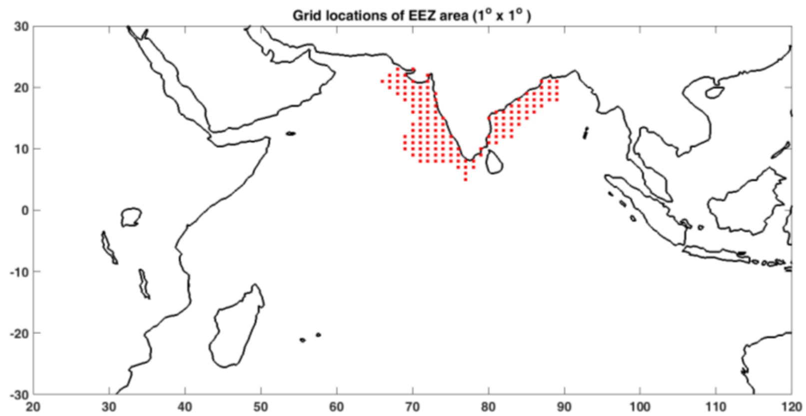

Figure 5 : 1° x 1° grid locations of Exclusive economic zone (EEZ) area

2. In contrary to the above experiment where STDEV of observations is checked, here the statistics of the gridded fields of Northern Indian Ocean(NIO) are compared. The deviation of calculated grid value from the observations is calculated. The spatial average of this deviation is observed to be reduced from 3.78 ms^{-1} to 2.88 ms^{-1} in case of WS and 2.19 ^{o} C to 1.72 ^{o} C in case of DBT. Figure 6 shows the gridded fields of WS before and after height conversion. Figure 6a shows the gridded field of WS where some unrealistically high magnitudes of WS are observed at location 5 ^{o}N-65 ^{o}E. Such high magnitude contours are found to be absent in WS recomputed at 10m height (Figure 6b) and also the gridded field is observed to be relatively smoothened when compared to the first plot. This signifies the importance of homogenizing the parameters like WS to 10 m height considering stability. Figure 6c shows the deviation at each grid point from its observations in vicinity. The deviation is also found to be reduced after recomputation to 10 m height. Point to be noted is that all the gridded fields shown in Figure 6 doesn't seem to be smooth, as the data of IRAWS is not evenly distributed in the entire space considered here and the data is observed to be concentrated more in the EEZ region.

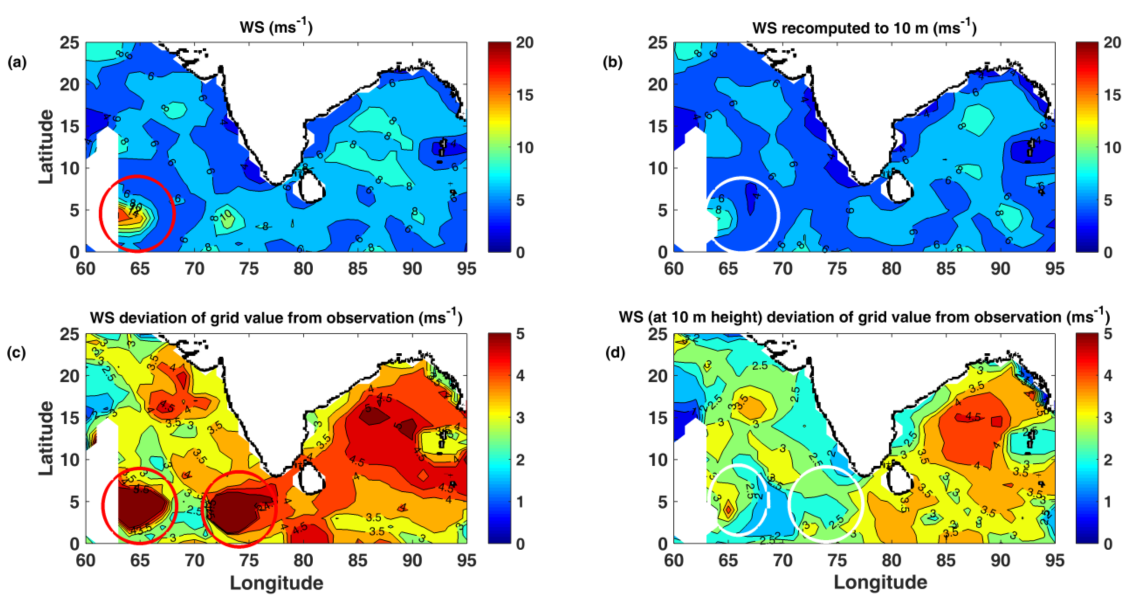

Figure 6 : Gridded fields of WS (left-top), WS 10m (right-top) and deviation of grid point from observations for WS(left-bottom) and WS 10 (right- bottom).

4. Comparison between IRAWS-SST and AVHRR-SST :

Advanced Very High resolution Radiometer (AVHRR) is an imager that remotely detects the radiation emitted from any surface be it a cloud top surface or an ocean surface, etc. AVHRR was first carried by TIROS-N launched in 1978. The latest AVHRR/3 instrument consists of 6 detectors and was carried by NOAA-15 launched in 1998. The 6 detectors also called as channels scan 6 different wavelengths bands. The last three channels 3B, 4 and 5 detect the infrared wavelength bands namely 3.55-3.93 µm, 10.30-11.30 µm and 11.50-12.50 µm and hence the heat radiation from different surfaces such as sea surfaces, land surface, water bodies and cloud upper surface. The AVHRR dataset used in the present study is a level-3 daily dataset gridded on 0.25 degree gridded field. For the present study, AVHRR SST observed from 2009 to 2018 is used. This AVHRR dataset has been downloaded from INCOIS-LAS (Devender et al. 2012) website.

As SST wasn't available from all the ships, a small experiment was conducted to check how well the good SST observation of IRAWS and AVHRR are matching and whether AVHRR SST can be used in place of actual SST for height computation wherever the ship-SST is missing. The SST observation from AVHRR that lies within 0.5 ^{o} distance from the ship observation and observed on the same day is paired with the ship SST. Wherever the difference between AVHRR SST and IRAWS SST is less than 6 ^{o} C, correlation coefficient between such pairs was calculated and was found to be 0.5 and is found to be significant at 95 % significant level. The limit for the difference was fixed at 6 ^{o} C as the limit of 4.5 * STDEV of AVHRR SST is 6.3 ^{o} C.

Figure 7 shows the entire AVHRR SST (color : magenta) extracted at the location and time of observation and the IRAWS ship SST observations which are not different from AVHRR SST by more than 6 ^{o}C. Also these are the ships which provided few number of SST observations. On the basis of reliable correlation coefficient of 0.5 between both the datasets, SST observations of IRAWS are replaced by SST observations from AVHRR wherever the difference between AVHRR SST and IRAWS SST is greater than 6 ^{o}C. This process enabled to avoid losing a significant amount of data of DBT,WS and RH which otherwise would have been lost while recomputing DBT, RH and WS to 10 m height. Table 7 shows the comparison between IRAWS ship SST and AVHRR SST. Comparison is made only between selected observations(difference is < 6^{o}C).

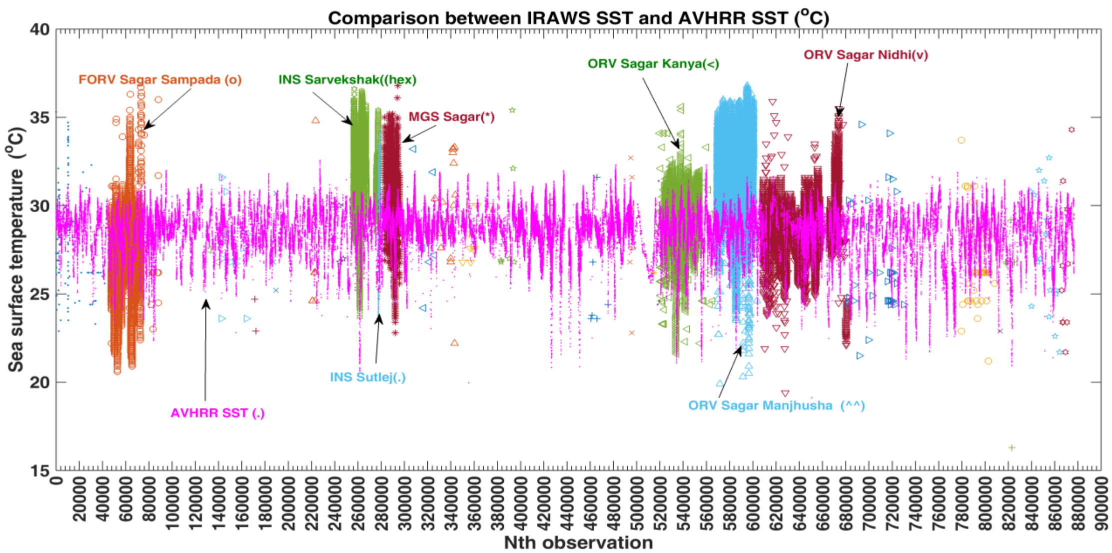

Figure 7 : Comparison between AVHRR SST and IRAWS SST

Ship name	**Correlation coefficient with AVHRR SST** (Comparison is made between those observations where the difference between IRAWS SST and AVHRR SST is < 6°C)
ORV Sagar Manjusha (Engine Room)	0.62
ORV Sagar Kanya (Engine Room)	0.91
FORV Sagar Sampada (Laundry Room)	0.67
INS Sutlej (AC unit Room)	0.42
ORV Sagar Nidhi (Moon pool)	0.60
INS Sarvekshak (Engine Room)	0.73
MGS Sagar (Back Deck)	0.55

Table 7 : Comparison between IRAWS SST and AVHRR SST

Conclusions:

The INCOIS-Real time Automatic Weather station namely IRAWS real time dataset collected till October,2018 is extracted, processed, quality controlled. The IRAWS setup is installed in 37 ships and the data from these ships is now available for the user community. The total number of records that are available from IRAWS dataset is about 9,00,000. The average number of observations that passed the QC procedure combining all the parameters comes out to be more than 7,00,000 records. On an average the QC pass percentage of observations of each variable are 88%, 80%, 75%, 71%,75% for SLP, DBT, RH, WS and WDIR respectively.

As the measurement heights at which certain parameters are measured among all the 37 ships are different, these have to be converted to a standard height inorder to have a homogeneous representation of a parameter. In those observation records where SST observation is absent, AVHRR-SST is taken inorder to convert DBT, WS, RH to standard height of 10 m. Additionally, good SST observations i.e. those observations that are flagged as '1' after QC check are found to be very well correlating with AVHRR SST. Significance of height conversion of meteorological parameters is discussed where in the STDEV and deviation (deviation of grid value from the observations mean) is observed to be reduced by more than 25 % indicating that representing these parameters at a common height is very vital for utilizing the data in scientific analysis. Quality control check of Longwave and shortwave radiation requires additional steps of QC check along with the steps mentioned in Section 2.1, which is currently being carried out and will soon be reported.

As the quality of dataset is found to be reliable the marine meteorological dataset from IRAWS can serve several utilities. One of the usage is to add these observations into Marine Meteorological Atlas for Tropical Indian Ocean (MaMetAtTIO)(Kameshwari *et.al* 2018). In turn the individual observations of MaMetAtTIO dataset goes into the background database of Marine Meteorological Atlas Tool (MaMetAT) being used by Indian Navy onboard their ships.

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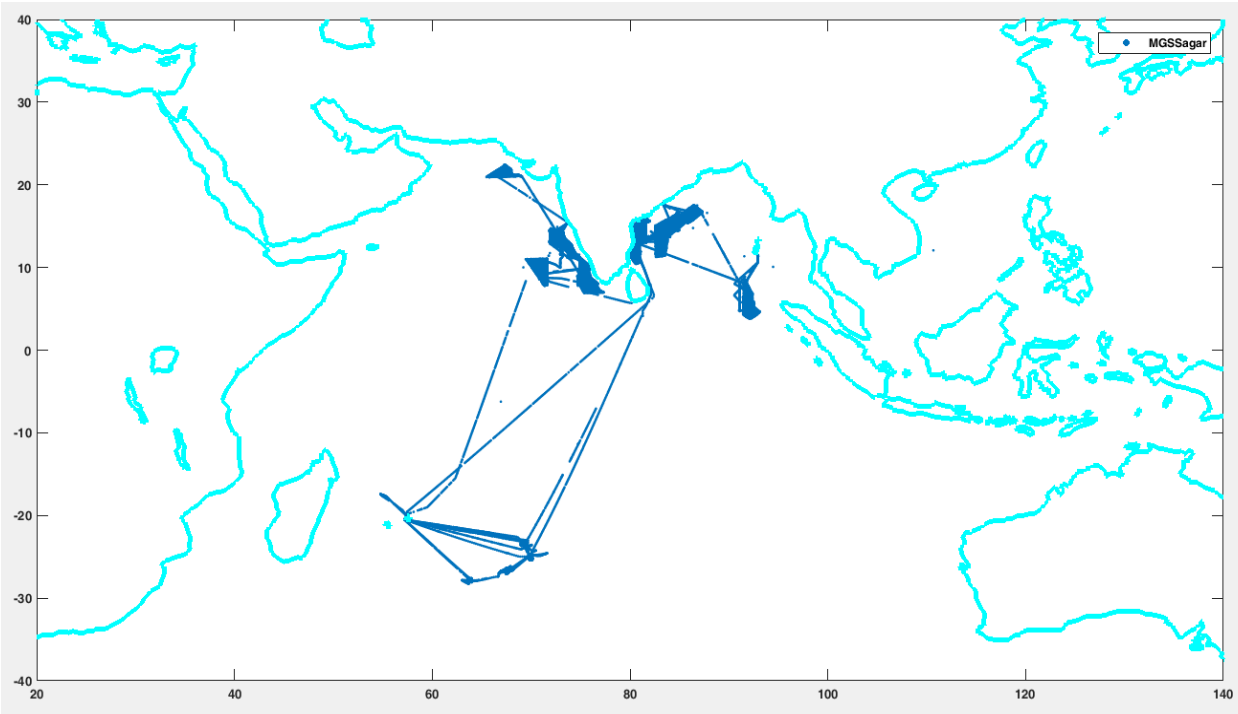
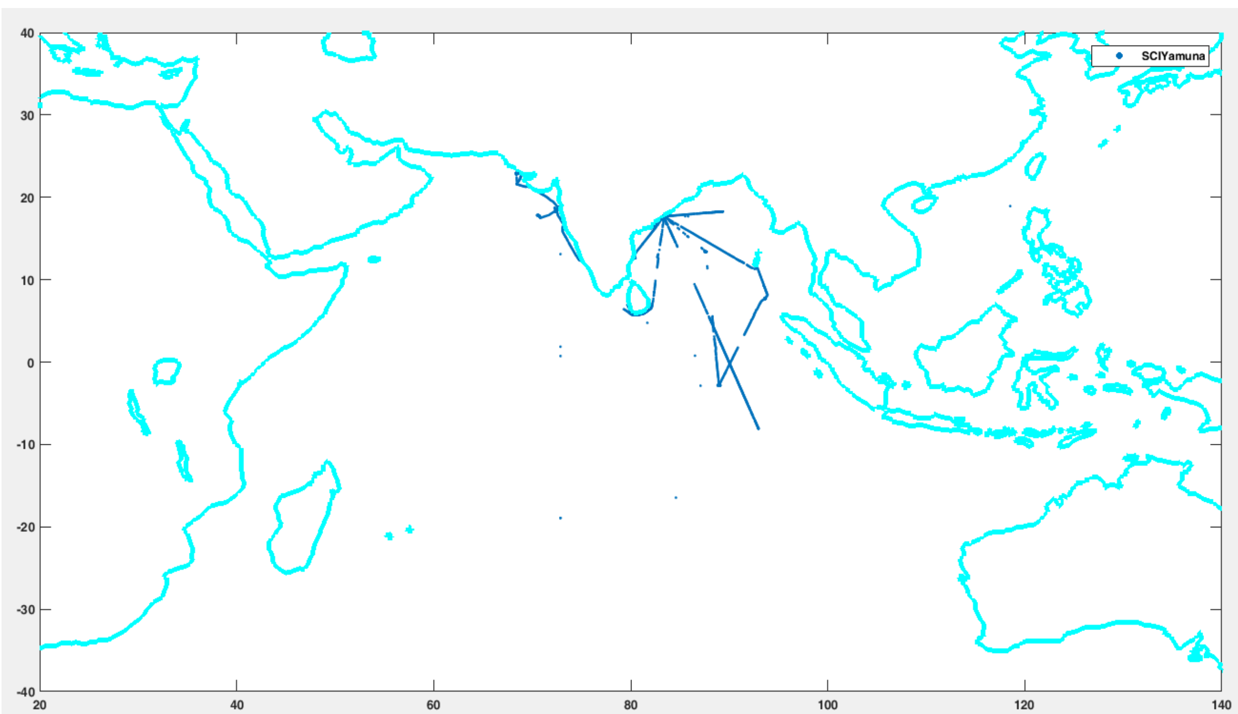
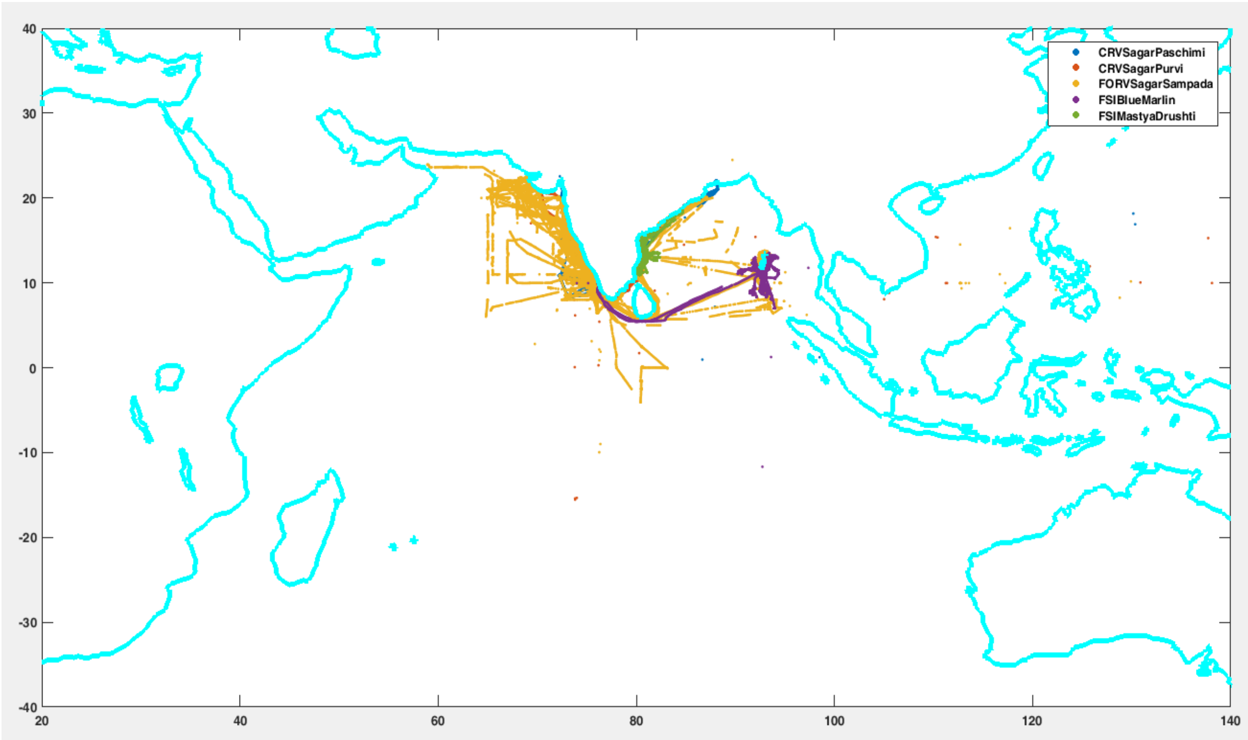
Appendix I

Spatial distribution of data observed onboard each ship under IRAWS (except INS ships)



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CRVSagarPurvi
FORVSagarSampada
FSIBlueMarlin
FSIMastyaDrushti
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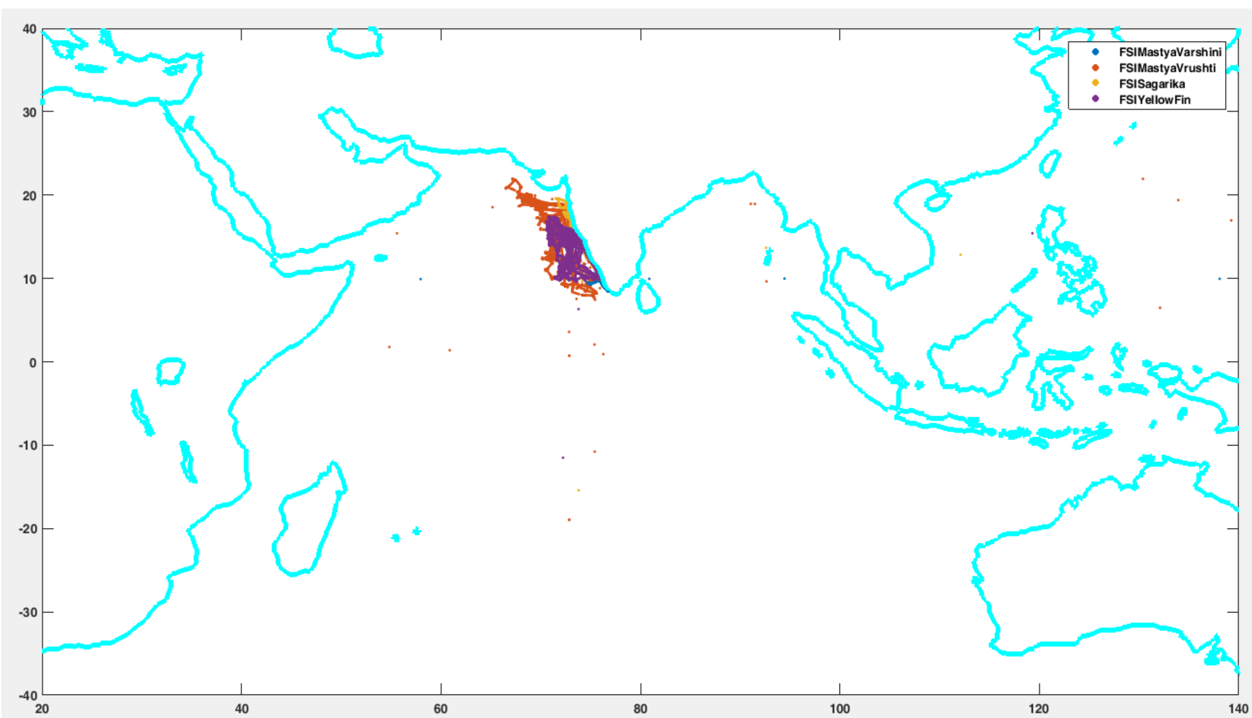
-20
-30
-40
20
40
60
80
100
120
140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FSIMastyaVrushti
FSISagarika
FSIYellowFin
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60
80
100
120
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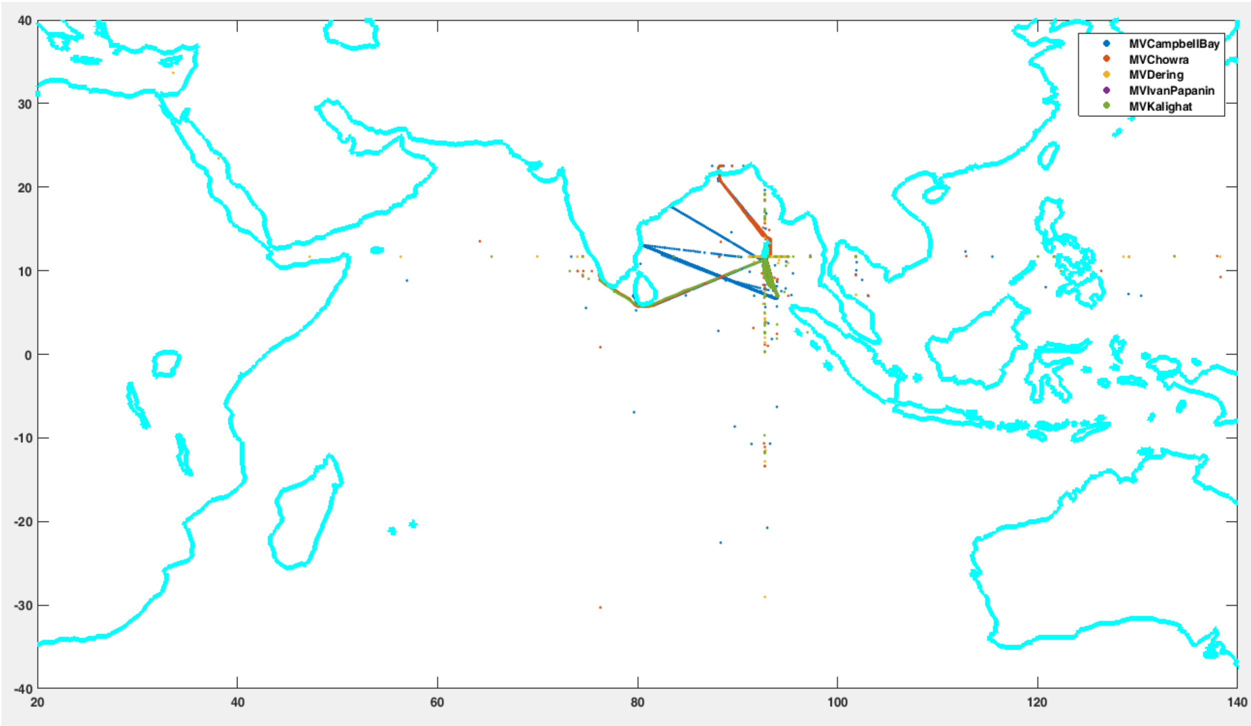
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MVChowra
MVDering
MVIvanPapanin
MVKalighat
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-10
-20
-30
-40
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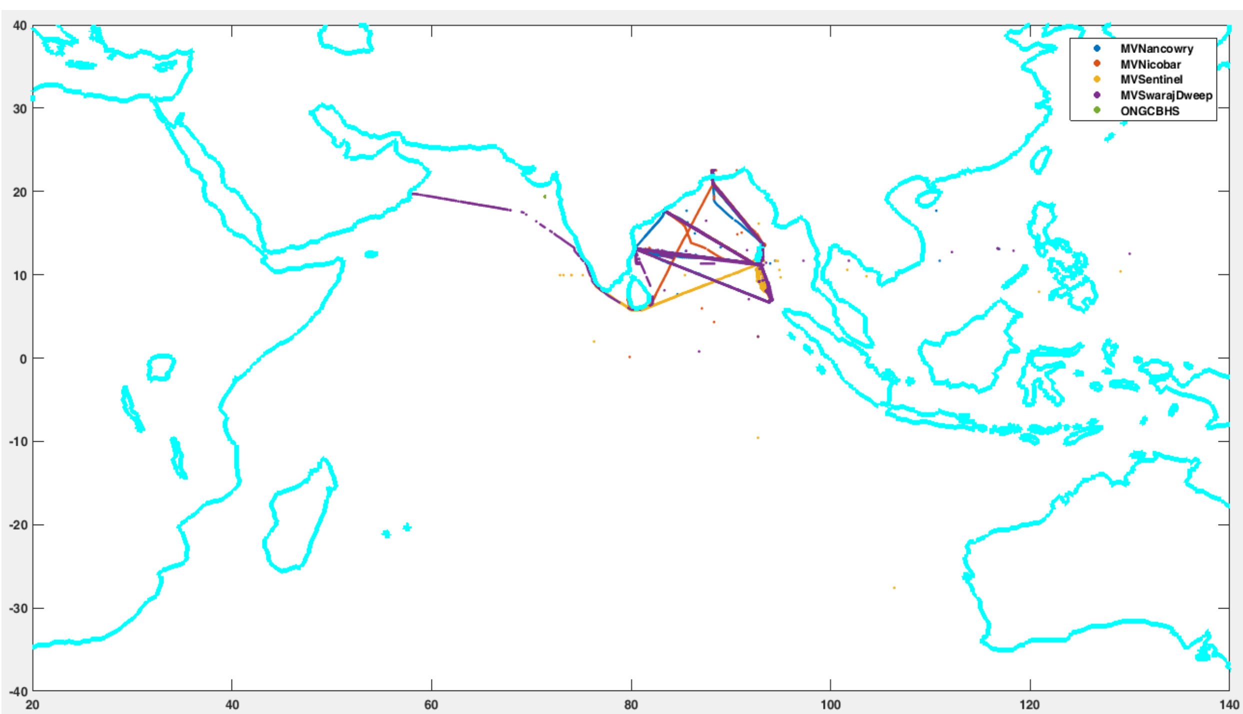
60
80
100
120
140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MVNicobar
MVSentinel
MVSwarajDweep
ONGCBHS
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-40
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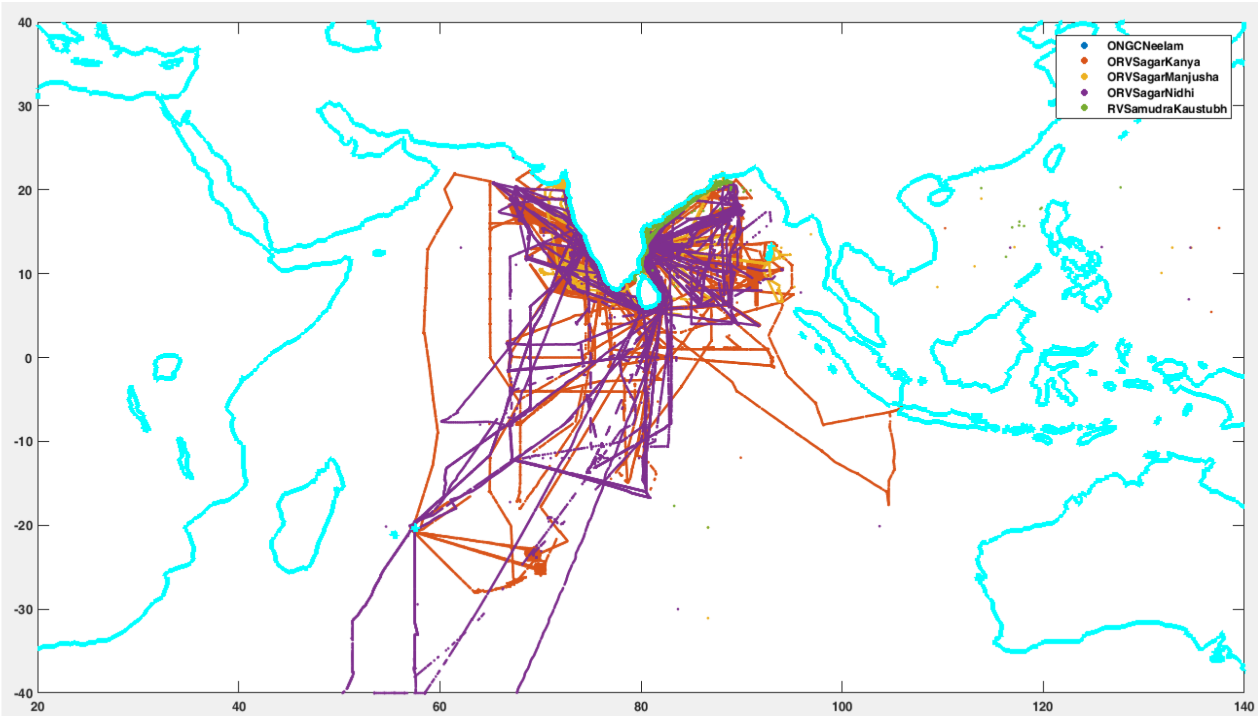
ONGCNeelam
ORVSagarKanya
ORVSagarManjusha
ORVSagarNidhi
RVSamudraKaustubh
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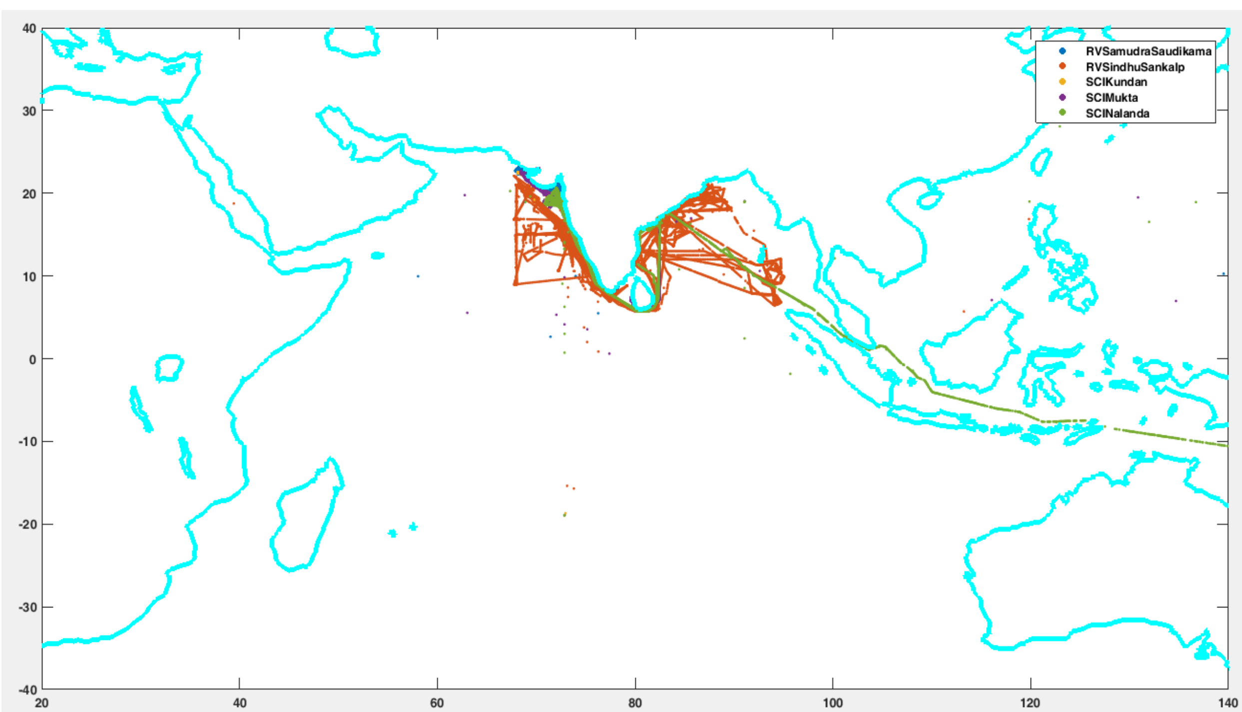
RVSamudraSaudikama
RVSindhuSankalp
SCIKundan
SCIMukta
SCINalanda
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-30
-40
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