Cruise report on Sagar Nidhi Cruise-128 (SN-128)

Location:	**Arabian Sea**
Duration	**12 January, 2018 to 12 February, 2018**
Port embarkation	**Mangalore**
Port disembarkation	**Mangalore**
Name of project:	**INCOIS ocean observation Network (OON) and "Ocean Observation Network" and "Ocean-Modelling,Data Assimilation and Process Specific Observations (O-MASCOT)**
Funding Agency:	**Ministry of Earth Sciences, Govt. of India**
Coordinating Agency:	**INCOIS, Hyderabad**
Captain:	**Mr. P. K. Singh**
Chief Scientist:	**Dr. Girishkumar M. S.**
Deputy Chief Scientist:	**Mr. Sureshkumar N.**

Background

The Arabian Sea, the semi-enclosed basin in the northern Indian Ocean, sea surface temperature and near surface circulation is primarily modulated by seasonally reversing monsoon winds. Moreover, the large evaporation over precipitation, particularly in the northern region of the Arabian Sea, and nearby marginal seas; the Persian Gulf and Red Sea; leads to the formation of several water masses and it occupies upper 1000 m in the Arabian Sea and it leads to the presence of rich structure of thermohaline interleaving layers (alternating layers of warm-saline and cold-fresh water) in the thermocline and formation of double diffusive layering has been shown by earlier observational studies in the Arabian Sea. In addition, the Arabian Sea is one of the highest biologically productive and thickest Oxygen Minimum Zone in the world ocean.

Small scale turbulent mixing across isopycanal has significant role in physical and biological processes in the ocean, such as redistribution of various properties of ocean, such as, heat, salt and nutrients. In the near surface layer the turbulent mixing primarily generated by wind, current shear and buoyancy flux and in the interior ocean the major source of energy are internal tides, near-inertial motions and double diffusive convection. Recently, several observation campaigns were carried out in the Bay of Bengal, the eastern counterpart of Arabian Sea in the north Indian Ocean, to collect fine scale turbulent measurements in the upper ocean. However, no systematic measurements of fine-scale, fast evolving turbulent mixing processes in the Arabian Sea exist to the best of our knowledge. Though Arabian Sea and Bay of Bengal exists in the same latitude band the hydrographic structure shows striking difference particularly in the upper ocean salinity field in the northern part of these basins and it is attributed to difference in the fresh water flux into these two basins.

In order to document the turbulence characteristics in the Arabain Sea, A scientific cruise onboard research vessel *Sagar Nidhi* (SN-128) was conducted in the northern Arabian Sea during 12 January, 2018 – 12 February, 2018, the peak phase of winter cooling. This scientific expedition was part of the INCOIS-Process Specific Observation Programme and INCOIS Ocean Observation Network, funded by Ministry of Earth Sciences (MoES). During this cruise a 9-day time series (16-17, January, 2018 and 26 January, 2018 to 5 February, 2018) turbulence measurements in a 3 hour interval were collected in the upper 280 m of water column near to the northern most Ocean Moored buoy Network for Northern Indian Ocean (OMNI) buoys at 19°N, 67°E in the Arabian Sea.

Objective

(1) To collect time series of Vertical Microstructure profiler at northern most operational mooring in the Arabian Sea (AD06) to document diurnal variability of vertical distribution of turbulence and factors that modulate them.
(2) To collect biogeochemical measurements along a transect through analysis of water sample to document meridional variability of biogeochemical parameter in the winter Arabian Sea.
(3) Deployment of 10 Argo floats with CT sensors and 1 Argo float with biogeochemical sensors.
(4) Recovery and deployment of tsunami buoy (TB12) at 17.5°N and 67.5°E in the north-eastern Arabian Sea.
(5) To estimate mixed layer heat and salt budget at AD06 location using mooring/ship based flux, horizontal gradient of temperature and salinity from underway CTD (uCTD)/TSG and mooring temperature and salinity measurements.
(6) Time series of biogeochemical measurements at AD06 (~19°N and 67°E) to document the modulation of chlorophyll variability in the

winter Arabian Sea in response to physical and dynamical factors.

The cruise track and waypoints are presented in the Figure-1. The instruments were used in the cruise is summarized below.

Instruments operated/Data Collected

INCOIS

Vertical microstructure profiler
Underway CTD
Water sample collection for chlorophyll, Dissolved Oxygen and Nutrients
Zooplankton collection.
ASIMET sensors for near surface meteorological parameters (Air temperature, Air humidity, downwelling shortwave radiation, downwelling longwave radiation, wind speed and direction, air pressrure). Measurement height 14m.

Ship-based

TSG
300 Khz ADCP
Ship AWS
INCOIS AWS

Day-to-Day activity

Scientific cruise in the Arabian Sea is commenced from Mangalore port on 12/01/2018. Scientific team consists of 3 scientists and 1 Ph.D students from INCOIS, 2 scientists and 2 scientific assistant from NIOT, 2 Ph.D students from Bhermpur University, 2 Ph.D. students from IIT-Mumbai, 2 Master students from Cochin University of Science and Technology, 3 supporting staff from Vessel management cell (VMC)-NIOT and 6 deployment assistants.

12/01/2018

12:00 P. M. Sign-on completed
01:00 P.M. All the 23 participants were onboard and room is allotted for all the participants.
02:00 P.M. The entire scientific instruments onboard were verified by scientific crew.
04:00 P.M. Chief scientist briefed overall cruise plan to captain and team and instructed to proceed waypoint BGC-1.
06:00 P.M. Vessel started from Mangalore port.

13/01/2018

11.00 A.M. A mock drill has been conducted and subsequently captain explained about the safety measurements in the ship.
04.00 P.M. Chief Scientist presented overall cruise objective and data collection plan to captain, Chief-Officers and scientific team.

14/01/2018
06:00 A.M. Reached at the waypoint BGC-1 (15.67N and 71.39E) reached. CTD, water sample collection for nutrients, chlorophyll, Dissolved oxygen and Total sediment matters at 12 depths. Near surface water samples collected using bucket. Zooplankton is collected through net.
05:05 P.M. Reached at the waypoint (16.42N and 67.44E) reached. CTD, water sample collection for nutrients, chlorophyll, Dissolved oxygen and Total sediment matters at 12 depths. Near surface water samples collected using bucket. Zooplankton is collected through net.
7.30 P.M. 4 Argo floats were tested and examined satellite communication.

15/01/2018
05:42 A.M. Reached at the waypoint BGC-3 (17.23N and 69.36E). CTD, water sample collection for nutrients, chlorophyll, Dissolved oxygen and Total sediment matters at 12 depths. Near surface water samples collected using bucket. Zoo plankton collection through net.
08:31 A.M Deployment of Argo floats at 17 15.986°N and 69 20.213°E (WMO ID 2902253).
12:44 P.M. Reached at the waypoint BGC-4 (18.02N and 68.35E). CTD, water sample collection for nutrients, chlorophyll, Dissolved oxygen and Total sediment matters at 12 depths. Near surface water samples collected using bucket. Zooplankton is collected through net.
20:32 P.M. Deployment of Argo float at 18 01.267□N and 68 20.650□E (WMO ID 2902254)

16-01-2018
07:17 A.M. Deployment of Argo floats at 18°23.168N, 67°25.60 E (WMO ID 2902255).
08:28 A.M. Deployment of Argo floats at 18°26.895 N, 67°21.122 E (WMO ID 2902256).
09:42 A.M. Deployment of Argo floats at 18°30.663 N, 67°25.106 E (WMO ID 2902257).
11:00 A.M. Deployment of Argo floats at 18°26.817 N, 67°29.058 E (WMO ID 2902258).
11:48 A. M. TS-01-D01 (18.44□N and 67.41□E). CTD, water sample collection for nutrients, chlorophyll, Dissolved oxygen and Total sediment matters at 12 depths. Near surface water samples collected using bucket. Zoo plankton collection through net. One profile of Radiometer.
03:00 P.M. Try to deploy an argo float with biogeochemical sensors and deployment is aborted due to communication failure.
16:30 P.M. VMP/uCTD measurements at every 3-hr interval starated.

17-01-2018
VMP/uCTD measurements at every 3-hr interval.
13.50 P.M. TS-01-D02 (18.42N, 67.41E). CTD, water sample collection for nutrients, chlorophyll, Dissolved oxygen and Total sediment matters at 12 depths. Near surface water samples collected using bucket. Zoo plankton collection through net. One profile of radiometer.
VMP/uCTD measurements at every 3-hr interval.

18-01-2018
01:00 A.M Vessel heading towards TB-12 location.

19-01-2018
07:30 A.M. Vessle postioned in DP at BPR drop location
07:40 A. M. Communication established with BPR with a slant range of 3030 m.
07:50 A. M. BPR release command was executed.
08:54 A.M. BPR sighted.
09:40 A.M. Boat lowered.
09:55 A.M. BPR onboard.
09:58 A.M. Boat onboard
10:30 to 16:00 P.M. A search operation for TB12 surface buoy was conducted.
16:00 to 17:50 P.M. Bathymetry survey of the TB12 deployment lcoateion was conducted.
17:50 P.M Vesse was put on drift.

20-01-2018
09:37 Buoy on water 20 17.30N and 67 35.233E.
11:26 Anchor dropped 20 19.23N and 67 36.06E.
14:30 BPR lowered in water using winch.
16:24 BPR released into water
18:01 P.M. TB12 (20.32N, 67.67E) CTD, water sample collection for nutrients, chlorophyll, Dissolved oxygen and Total sediment matters at 12 depths. Near surface water samples collected using bucket. Zooplankton collection through net.
19:30 to 20:50 Communication with BPR was attempted 1.5 nm away from BPR drop location, but could not be established
21:30 onwards Vessel was put on drift at safe distance from buoy.

21-01-2018
07:30 A.M. Vessel postioned at BPR drop.
07:35 A.M. Acoustic modem/dunker lowered in water
07:42 A.M. BPR rebooted and issue resolved.
07:42 A.M. to 12:20 P.M. Waited for TB-12 data confirmation from NIOT.
12:20 P.M . Vessel heading towards to Mumbai port for VMP rectification.

23-01-2018

05:00 P.M. Vessel reached Mumbai outer anchorage.
06:00 P.M. VMP OEM technician arrived onboard.
11:00 P.M. VMP problem rectified and few bench tests were performed with dummy probes.

24-01-2018
Vessel in the Mumbai outer anchorage and waiting for clearance.

25-01-2018
06:00 P.M Vessel started from Mumbai port and heading towards TS1.

26-01-2018
08-00 A.M. Republic day celebration.
08:00 P.M. 4 Argo float tested.

27-01-2018 to 04-02-2018
VMP time series in every three hour
CTD, water sample, radiometer and zooplankton (please see below table-1).

06-02-2018
04:00 A.M. 16°43.711N, 67°56.992E CTD, water sample collection for nutrients, chlorophyll, Dissolved oxygen and Total sediment matters at 12 depths. Near surface water samples collected using bucket. Zooplankton collection through net.
07:08 A.M. Deployment of Argo floats at 16°43.711N, 67°56.992E (WMO ID 2902259)
02:27 P.M. Deployment of Argo floats at 16°43.711N, 67°56.992E (WMO ID 2902260)
08:22 P.M. Deployment of Argo floats at 16°43.711N, 67°56.992E (WMO ID 2902261)

07-02-2018
3:10 A.M. Deployment of Argo floats at 16°43.711N, 67°56.992E (WMO ID 2902262)

08-02-2018
VMP operation started at 11 08.829N and 73 23.387E (please refer table-2)

Table-1 VMP, uCTD, CTD, water sample and radiometer operation log at AD06 location (TS1-Time series stations).

Date IST	VMP 01:30-02:30	Uctd/TSG 02:30-04:30	VMP 04:30-05:30	Uctd/TSG 05:30-07:30	VMP 07:30-08:30	Uctd/TSG 08:30-10:30	VMP 10:30-11:30	Uctd/TSG 11:30-13:30	VMP 13:30-14:30	Uctd/TSG 14:30-16:30	VMP 16:30-17:30	Uctd/TSG 17:30-19:30	VMP 19:30-20:30	Uctd/TSG 20:30-22:30	VMP 22:30-23:30	Uctd/TSG 23:30-01:30
16-Jan-2018											5 profile	N to X	5 profile	S to X	6 profile	E to X
17-Jan-2018	5 Profile	W to X	5 profile. 1 hour delay	N to X	5 profile	S to X (10Km transect)	5 profile	Ship CTD & all	5 profile	E to X	5 profile	W to X				
27-Jan-2018					5 profile	N to X	5 profile	No ship CTD	5 profile	S to X	5 profile	E to X	7 profile	W to X	5 profile	N to X
28-Jan-2018	5 profile	S to X	5 profile	E to X	5 profile	W to X	5 profile	Ship CTD & all	5 profile	N to X	5 profile	S to X	5 profile	E to X	5 profile	W to

																X
29-Jan-2018	5 profile	N to X	5 profile	S to X	5 profile	E to X	5 profile	Ship CTD & all	5 profile	W to X	5 profile	N to X	5 profile	S to X	5 profile	E to X
30-Jan-2018	5 profile	W to X	5 profile	N to X	5 profile	S to X	5 profile	Ship CTD & all	5 profile	E to X	5 profile	W to X	5 profile	No UCTD	5 profile @ N	N to X
31-Jan-2018	5 profile	S to X	5 profile	E to X	5 profile	W to X	5 profile	Ship CTD & all	5 profile	N to X	5 profile	S to X	5 profile	E to X	5 profile	W to X
1-Feb-2018	5 profile	N to X	5 profile	S to X	5 profile	E to X	5 profile	Ship CTD & all	5 profile	W to X	5 profile	N to X	5 profile	S to X	6 profile	E to X
2-Feb-2018	5 profile	W to X	5 profile	N to X	5 profile	S to X	5 profile	Ship CTD & all	6 profile	E to X	5 profile	W to X	5 profile	N to X	5 profile	S to X
3-Feb-2018	5 profile	E to X	5 profile	W to X	5 profile	N to X	5 profile	Ship CTD & all	6 profile	S to X no uctd(winch problem)	6 profile	E to X	5 profile	W to X	5 profile	N to X
4-Feb-2018	6 profile	S to X	6 profile	E to X	5 profile	W to X	5 profile	Ship CTD & all	6 profile	N to X	6 profile	S to X	5 profile			

Table-2. VMP operation log during 8-Feb to 10-Feb, 2018.

08-Feb-2018 21:24
08-Feb-2018 21:36
08-Feb-2018 21:47
08-Feb-2018 21:59
08-Feb-2018 22:10
08-Feb-2018 22:23

08-Feb-2018 23:19

08-Feb-2018 23:43
08-Feb-2018 23:54
09-Feb-2018 00:05
09-Feb-2018 00:17
09-Feb-2018 00:29
09-Feb-2018 01:27
09-Feb-2018 01:38
09-Feb-2018 01:49
09-Feb-2018 01:59
09-Feb-2018 02:10
09-Feb-2018 03:00

09-Feb-2018 03:11
09-Feb-2018 03:21
09-Feb-2018 03:31
09-Feb-2018 03:42

09-Feb-2018 04:30
09-Feb-2018 04:41
09-Feb-2018 04:51
09-Feb-2018 05:01
09-Feb-2018 05:12
09-Feb-2018 05:54
09-Feb-2018 06:09
09-Feb-2018 06:20
09-Feb-2018 06:30
09-Feb-2018 14:25
09-Feb-2018 14:35
09-Feb-2018 14:45
09-Feb-2018 14:55
09-Feb-2018 15:05
09-Feb-2018 15:50
09-Feb-2018 16:00
09-Feb-2018 16:09
09-Feb-2018 16:20
09-Feb-2018 16:30
09-Feb-2018 17:12

09-Feb-2018 17:22
09-Feb-2018 05:33
09-Feb-2018 05:43
09-Feb-2018 05:53
09-Feb-2018 18:35
09-Feb-2018 18:46
09-Feb-2018 18:56
09-Feb-2018 19:07
09-Feb-2018 19:20
09-Feb-2018 20:06
09-Feb-2018 20:17
09-Feb-2018 20:28
09-Feb-2018 20:39
09-Feb-2018 20:50
09-Feb-2018 21:02
09-Feb-2018 21:50
09-Feb-2018 22:01
09-Feb-2018 22:11
09-Feb-2018 22:22
09-Feb-2018 22:35
09-Feb-2018 23:21
09-Feb-2018 23:31
09-Feb-2018 23:43
09-Feb-2018 23:55
10-Feb-2018 00:06

10-Feb-2018 00:19

10-Feb-2018 01:08
10-Feb-2018 01:19
10-Feb-2018 01:29
10-Feb-2018 01:39
10-Feb-2018 01:50
10-Feb-2018 02:51
10-Feb-2018 03:01
10-Feb-2018 03:11
10-Feb-2018 03:22
10-Feb-2018 03:33
10-Feb-2018 04:24
10-Feb-2018 04:34
10-Feb-2018 04:44
10-Feb-2018 04:54
10-Feb-2018 05:05
10-Feb-2018 05:53
10-Feb-2018 06:03
10-Feb-2018 06:13
10-Feb-2018 06:23
10-Feb-2018 06:35
10-Feb-2018 07:24
10-Feb-2018 07:35
10-Feb-2018 07:46

10-Feb-2018 07:57
10-Feb-2018 08:08

10-Feb-2018 08:56
10-Feb-2018 09:07
10-Feb-2018 09:18
10-Feb-2018 09:30
10-Feb-2018 09:43
10-Feb-2018 10:28
10-Feb-2018 10:38
10-Feb-2018 10:49
10-Feb-2018 11:00
10-Feb-2018 11:12
10-Feb-2018 11:44
10-Feb-2018 13:47
10-Feb-2018 13:58
10-Feb-2018 14:09
10-Feb-2018 14:20
10-Feb-2018 14:30
10-Feb-2018 14:41
10-Feb-2018 15:46
10-Feb-2018 15:57
10-Feb-2018 16:09
10-Feb-2018 16:20
10-Feb-2018 16:31

10-Feb-2018 16:41
10-Feb-2018 16:52
10-Feb-2018 17:03
10-Feb-2018 17:14
10-Feb-2018 17:25

Table-3 Location of CTD/water sample collection stations. (BGC-BGC waypoint; TS-Time series station)

BGC1	15 40.79 N	071 23.99 E	14-Jan-2018 00:17:43
BGC1	15 40.79 N	071 23.99 E	14-Jan-2018 01:53:29
BGC1	15 40.79 N	071 23.99 E	14-Jan-2018 02:26:57
BGC2	16 25.76 N	070 27.00 E	14-Jan-2018 11:47:58
BGC2	16 25.76 N	070 27.00 E	14-Jan-2018 13:07:19
BGC3	17 13.79 N	069 21.60 E	15-Jan-2018 00:12:37
BGC3	17 13.80 N	069 21.59 E	15-Jan-2018 01:45:22
BGC4	18 01.44 N	068 21.28 E	15-Jan-2018 12:52:38
BGC-04	18 01.44 N	068 21.28 E	15-Jan-2018 14:12:33
TS-01	18 26.90 N	067 25.08 E	16-Jan-2018 06:21:40
TS-01	18 26.89 N	067 25.08 E	16-Jan-2018 07:36:25
TS-1	18 25.52 N	067 24.84 E	17-Jan-2018 08:20:23
TS-1	18 25.52 N	067 24.84 E	17-Jan-2018 08:58:49
TB12	20 19.48 N	067 40.72 E	20-Jan-2018 12:32:21
TB12	20 19.49 N	067 40.72 E	20-Jan-2018 13:51:58
TS1_Phase2	18 27.25 N	067 24.66 E	28-Jan-2018 06:37:31
TS1_Phase2	18 27.26 N	067 24.65 E	28-Jan-2018 07:11:02
TS1_Phase2	18 27.80 N	067 24.52 E	29-Jan-2018 06:43:07
TS1_Phase2	18 27.80 N	067 24.51 E	29-Jan-2018 07:27:26
TS1_Phase2	18 26.72 N	067 24.49 E	30-Jan-2018 06:56:43
TS1_Phase2	18 26.72 N	067 24.48 E	30-Jan-2018 07:38:16
TS1_Phase2	18 26.72 N	067 24.63 E	31-Jan-2018 07:35:50
TS1_Phase2	18 26.71 N	067 24.64 E	31-Jan-2018 06:55:14
TS1_Phase2	18 26.25 N	067 24.49 E	01-Feb-2018 06:39:21
TS1_Phase2	18 26.25 N	067 24.49 E	01-Feb-2018 07:14:58
TS1_Phase2	18 25.49 N	067 24.99 E	02-Feb-2018 06:42:20

TS1_Phase2	18 25.49 N	067 24.99 E	02-Feb-2018 07:28:01
TS1_Phase2	18 25.56 N	067 25.06 E	03-Feb-2018 06:37:09
TS1_Phase2	18 25.29 N	067 25.01 E	04-Feb-2018 06:46:06
TS1_Phase2	18 25.56 N	067 25.06 E	03-Feb-2018 07:21:43
TS1_Phase2	18 25.29 N	067 25.01 E	04-Feb-2018 07:26:39
BGC-05(BAST1)	16 44.27 N	067 56.04 E	06-Feb-2018 00:20:03
BGC-05(BAST1)	16 44.27 N	067 56.04 E	06-Feb-2018 01:00:28

List of participants (all participants from India)

S.No.	Participant's Name	Designation	Institution
1	GIRISH KUMAR MADATHIL SIVASANKARAN	Scientist	INCOIS-HYD
2	NEELAKANDAN SURESH KUMAR	Scientist	INCOIS-HYD
3	MURALI BODDEPALLI	Scientist	INCOIS-HYD
4	JOFIA JOSEPH	Research Fellow	INCOIS-HYD
5	ASHIN KURIAKOSE	Student	CUSAT-COCHIN
6	CHANDANLAL PARIDA	Research Scholar	BERHAMPUR-UNIV
7	MADHUSMITA DASH	Research Scholar	BERHAMPUR-UNIV
8	REBEKAH SHUNMUGAPANDI	Research Scholar	IIT-MUMBAI
9	SRINIVAS KOLLURU	Research Scholar	IIT-MUMBAI
10	JIMNA JANARDHANAN CHANDANAPURATH MULLOLI	Student	CUSAT-COCHIN

11	ANAND KISORE	Scientist	NIOT
12	SUNDRAVADIVELU NAGARAJAN	SC. ASST.	NIOT
13	SRIDHAR ARAVINDKUMAR	TECHNITIAN	NIOT
14	SARAVANAN JAYAVELU	ENGINEER	NIOT
15	NISHANT	SHIP ONBOARD ASST.	NIOT-VMC
16	MOHAN RAJ	SHIP ONBOARD ASST.	NIOT-VMC
17	AKBAR NAQUI	SHIP ONBOARD ASST.	NIOT-VMC
18	SUBRAMANIAN NATESAN	Deployment Asst.	NIOT
19	THIVAKAR SANKAR	Deployment Asst.	NIOT
20	DEEPAK MOHAN	Deployment Asst.	INCOIS-HYD
21	JAGAN KUMAR	Deployment Asst.	INCOIS-HYD
22	PRAVEENKUMAR KUMAR	Deployment Asst.	INCOIS-HYD
23	PUSHPALINGAM SIVANANDAM	Deployment Asst.	NIOT

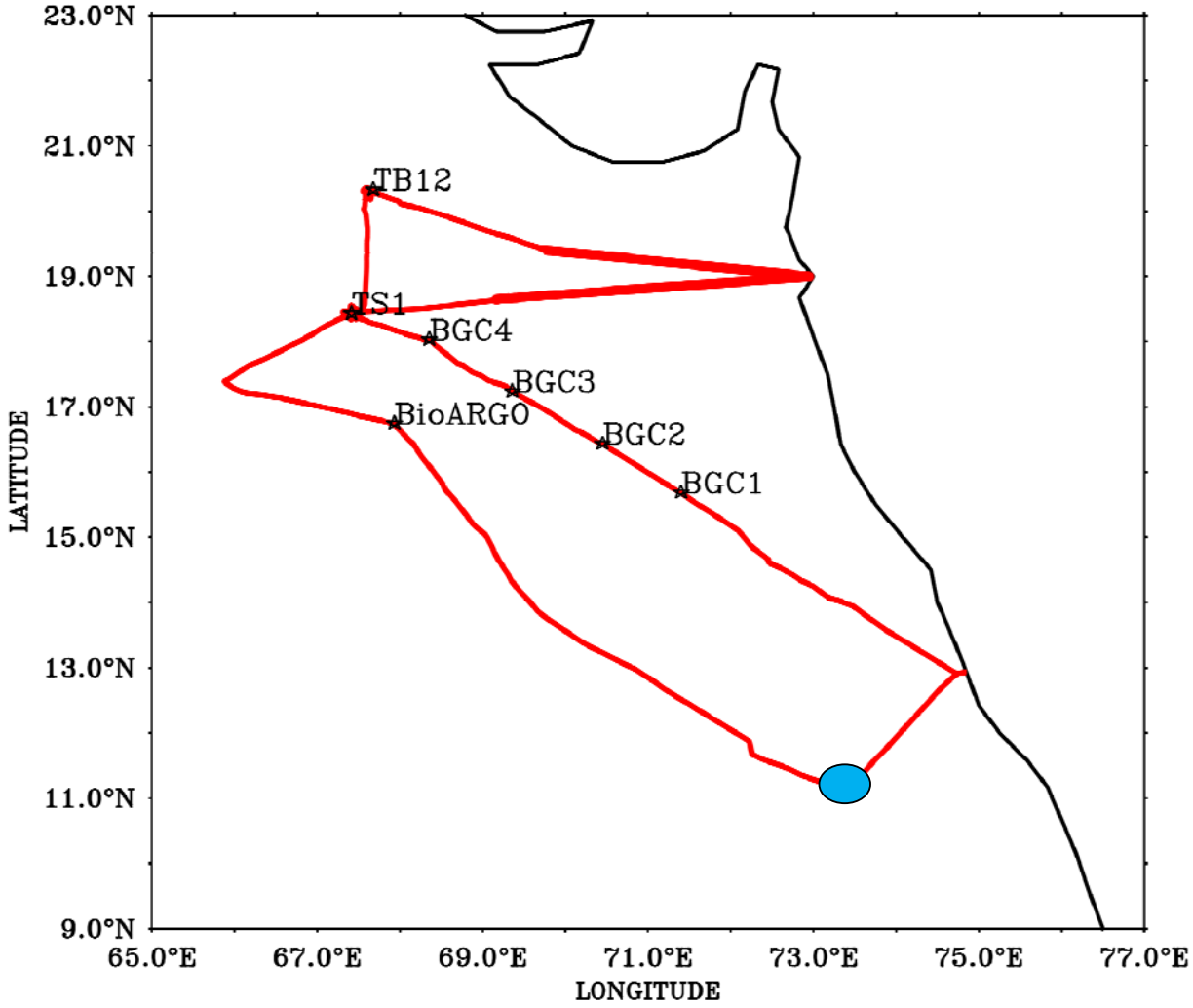

Figure 1. The track SN-128 cruise on-board Sagar Nidhi. The TS1 indicates time series station of VMP. BGC-1 to BGC-4 represents Ship CTD/biogeochemical sensor measurements locations. TB12 represents Tsunami buoy deployment/recovery site. BIO-Argo represents water sample collection location close to Bio-Argo (WMOID 2902202). The blue circle represents TS-2 time series stations.

Preliminary data analysis.

One of the major achievements during this cruise was the nine day time series (27 Jan-4 Feb, 2018) measurements of the microstructure of temperature, conductivity and shear using Vertical Microstructure Profiler (VMP-250) in every 3 hour interval in the upper 300 m of northern Arabian Sea (19°N, 67°E). Our preliminary analysis shows that, the rate of dissipation of turbulent kinetic energy (ε; 10^{-5}-10^{-7} W kg^{-1}) trapped in thin surface layer (15 m) during morning hours due to stratification associated with net surface heat flux into the ocean and during night, the high ε layer penerates into deeper depth (60 m) due to net surface heat loss from ocean. A region of relatively high value of ε (~10^{-8}) is observed in the depth range between 190 to 230 m throughout the observation period, which is approximately one order magnitude higher than region above.

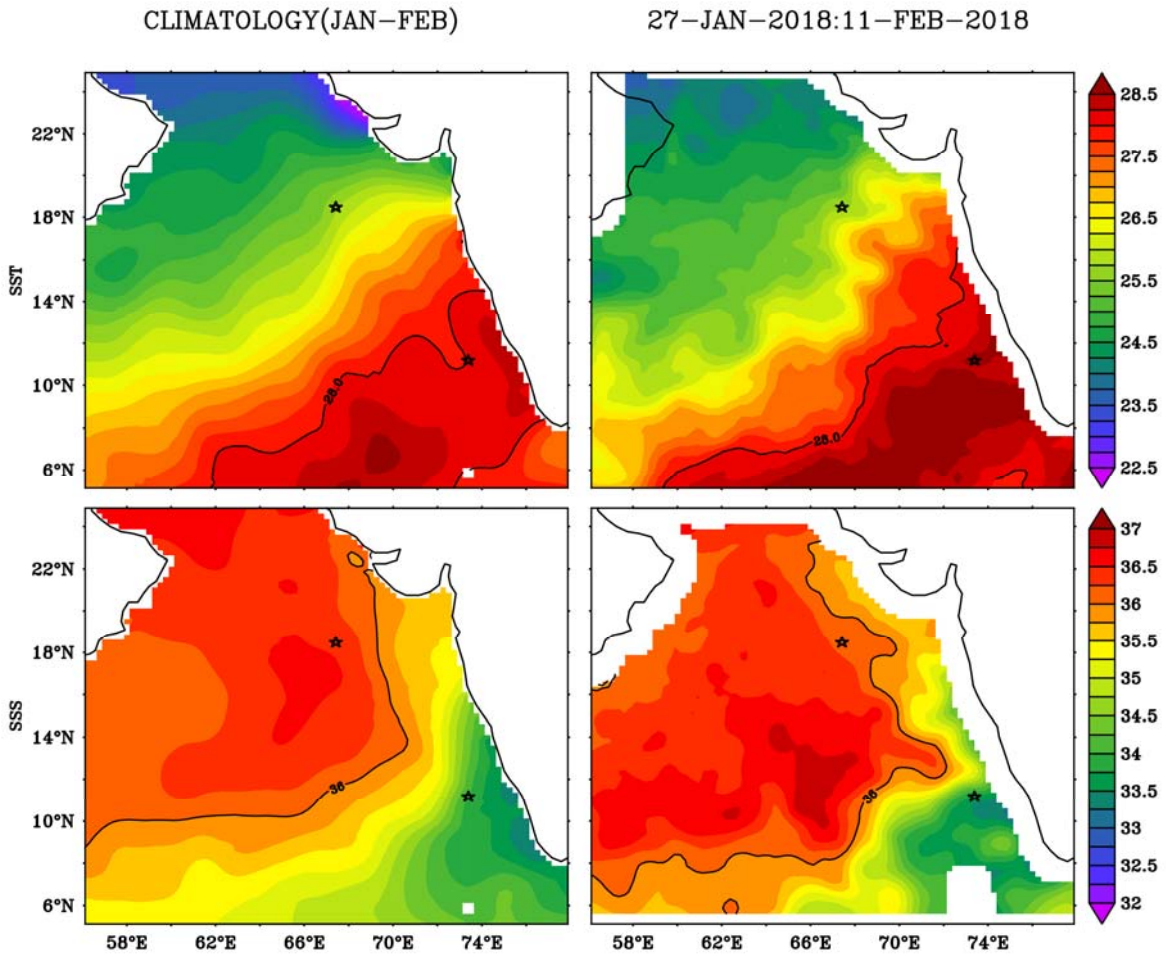

Figure. **SST (°C, top panel) and SSS (psu, bottom panel) WOA09 climatology (left panel); MW-OI SST and SMAP during 27 Jan-11 Feb, 2018 Star represents VMP time series station.**

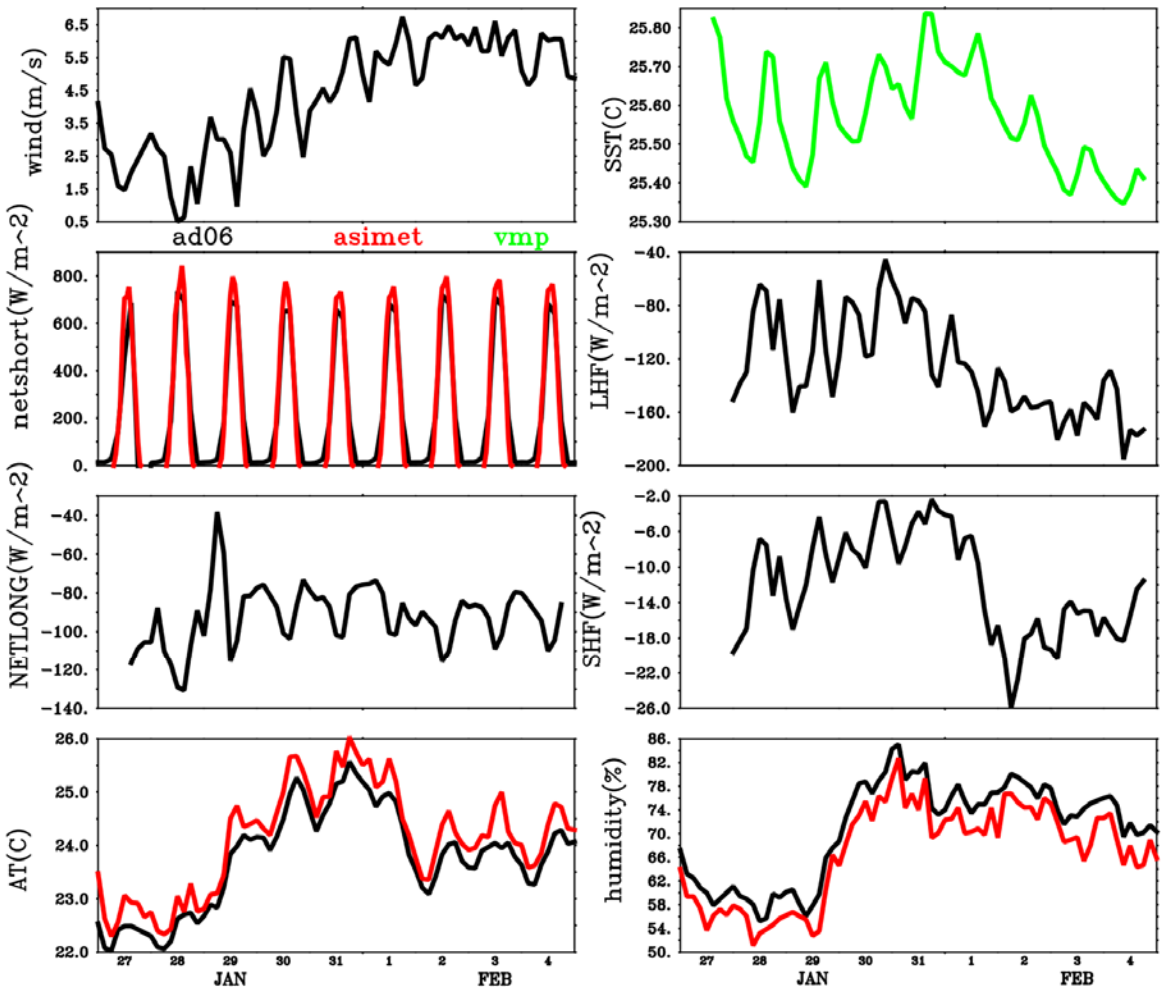

Figure. Near surface meteorological and oceanographic parameter during the period Time series station at TS-1. **ASIMET (red colour; SHIP;@14 m) and AD06 (black colour @3 m) near surface meteorological parameters. SST from VMP 3m (green color) temperature data.**

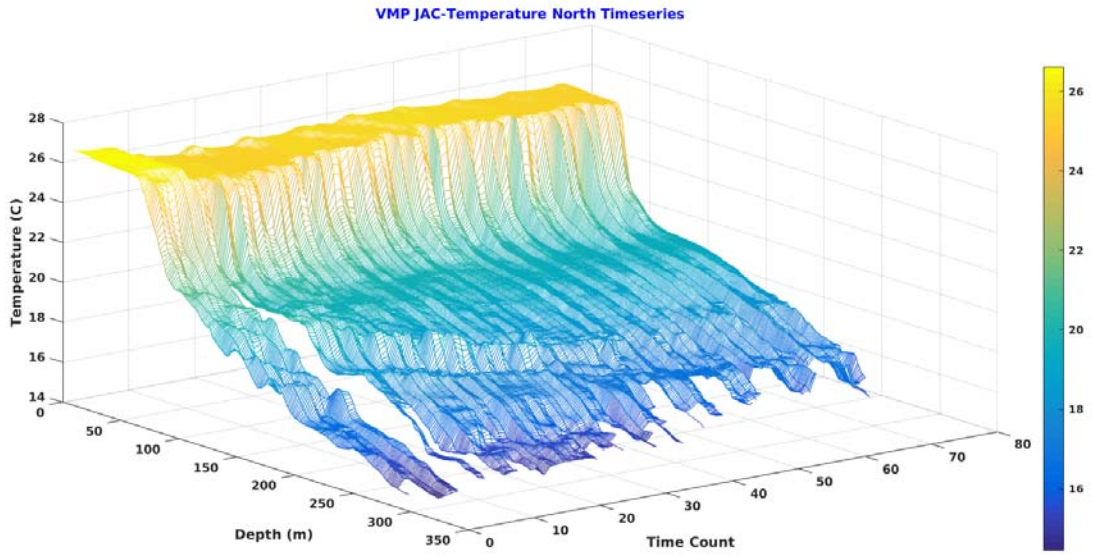

Figure Waterfall diagaram of temperature from VMP during the time series station.

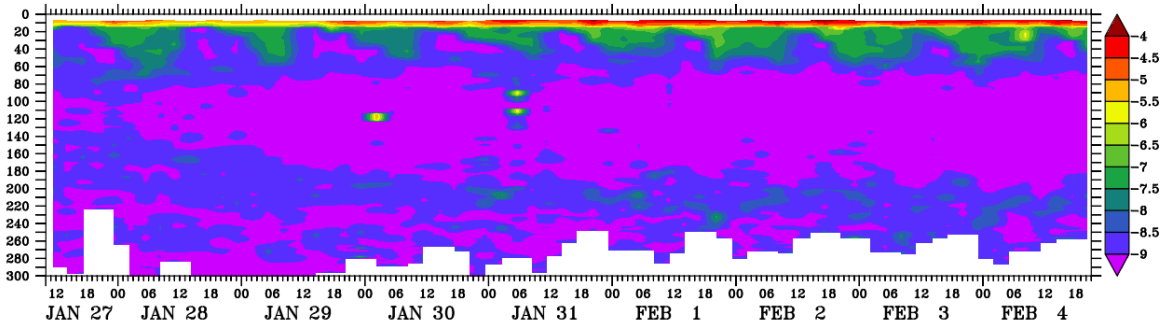

Figure. Temporal evolution of vertical profiles of the turbulent kinetic energy dissipation rate (log ε; W Kg^{-1}) estimated from VMP-250 at 18.481N, and 67.445E in the Arabian Sea.

Figure. INCOIS research team with VMP-250

Acknowledgements

On behalf of the scientific team of this cruise SN-128, I would like to thank Director, NIOT for providing the research vessel "ORV-Sagar Nidhi" and all the facilities onboard for our operations. I sincerely thank to Master Sagar Nidhi, Chief Officer, Chief Engineer and all Officers, Electrical Engineers and Crew members onboard ORV-Sagar Nidhi for their excellent cooperation and good team work throughout the cruise in making this voyage a very successful,

I wish to thank Mr. D Rajasekhar (VMC-NIOT, Head) and Mr. Ravi for all the cruise administrative and supports during the cruise.

Dr. Girishkumar M. S.