OMM Training Workshop and Discussion Meeting (21 – 28 January, 2020)

SAC hosted the January 2020 OMM workshop (4 days) and discussion meeting (2 days). A 4-day (21-24 Jan, 2020) workshop and 2-day (27-28 Jan, 2020) discussion meeting of Ocean Mixing and Monsoon (OMM) project were successfully conducted at Space Applications Centre (SAC), ISRO with the participation of researchers from USA and India. This project is multi-institutional endeavour, which is led by Prof Debasis Sengupta of IISc Bangalore. SAC has been participating in this project through satellite data applications for the Bay of Bengal studies. SAC scientists have participated in several ship cruises undertaken in this project. OMM workshops and discussion meetings have been held at various institutes with SAC hosting it this time.

Workshop was primarily conducted for the 22 young researchers of various institutes (SAC, IITM, NCMRWF, IIT Madras, IISc, IISER, IIT Bhubaneswar, Brown University, INCOIS, NIOT etc). There were 6 mentors drawn from USA and India who designed the hands-on modules for these students. The primary objective of the workshop was to understand the **air-sea interaction processes in the Bay of Bengal**, making use of satellite, *in situ* and model data. The participants were divided into 5 groups and each group were assigned a short problem to work on making use of available dataset. The description of problems and group members is provided in Appendix-1. At the end there were presentations by the participants and certificates were distributed.

Discussion meeting was attended by around 50 eminent scientists from USA and India (See Appendix-2). The agenda of the meeting is provided as Appendix-3. There were deliberations on fine scale oceanic processes, air sea interactions, coupled ocean-atmosphere modelling and process studies in the Bay of Bengal. It was highlighted that there is a need of space-borne salinity sensor and ISRO should look in to feasibility of development of this sensor, as post SMAP there is no plan of salinity sensor by any other space agency. Bay of Bengal being very fresh basin, large scale salinity mapping by space-borne sensors are critical in understanding coupled ocean-atmospheric processes to predict active/break cycles of Indian summer monsoon. Issues and limitations of coupled regional model and the role of fine-scale oceanic features to parameterize the mixing processes, was also discussed at length.

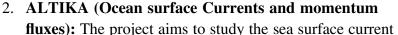Details of this workshop/meeting are provided in Appendix 1, 2 and 3.

APPENDIX-1: WORKSHOP PROJECT THEMES & TEAM MEMBERS

What is the relationship between air-sea fluxes and the ocean's response in the Bay of Bengal, especially during the summer Monsoon?

1. **AQUARIUS (Rainfall and salinity):** This project will explore the distribution of precipitation and corresponding co-variability of salinity over the Bay of Bengal during the 2019 summer monsoon. Questions to be addressed include: How well do satellite precipitation products represent the observed precipitation signals at individual stations (e.g., from mooring or ship records)? Under what conditions is a measurable sea surface salinity signal associated with precipitation? This project will use data from INSAT and the Global Precipitation Mission (IMERG), sea surface salinity from SMAP, and surface fields (precipitation/salinity) from the NIOT moorings.

Emily Shroyer, Seena G., Lijin J., Abhijit Raj, V. Kiran

2. **ALTIKA (Ocean surface Currents and momentum fluxes):** The project aims to study the sea surface current variability in the Bay of Bengal. The total currents from satellite will be validated against the buoy observations. The project also aims to compute the momentum fluxes using TOGA-COARE flux formulation and study the impact of ocean surface currents on wind stress. It will also investigate the effect of geostrophic currents from altimeter on wind stress.

Mani Mathur, Preethi Rajput, R Sundar, Devang Falor, Aakash Sane

3. **INSAT (Heat flux and SST):** This project aims to evaluate the relationship between the flux of heat into the ocean and the change in SST, the surface heat flux. This will be evaluated 1) on a broad scale using operational data and 2) on a much smaller scale using ship and buoy data. The analyses on each scale and the differences will provide insight into the different physical processes on these different space and time scales as well as possible errors in both measurements and products. The project will use ERA-5 and satellite SST products and data from the 2018 and 2019 MISOBoB program.
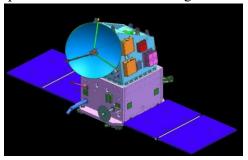
Eric D'Asaro, Daniel Simon, Keerthivasan, Nihar Paul, Ashin Kuriakose

4. **SCATSAT (MLD variability):** This project aims to evaluate mixed layer depth variability in the Bay of Bengal. Mixed layer depths will be calculated using different

methodologies and applied to oceanographic observations. The calculated MLDs can then be compared with observed surface forcing (winds, heat flux, precipitation) to evaluate the temporal and spatial variability between the two. This project will use data from the global argo array, NIOT moorings, ship-based measurements as well as satellite and reanalysis surface fluxes

Leah Johnson & Jossia Joseph, Jofia Joseph, Heramb Siva, Ankur Gupta, Jithendra Raju, Nagendra Jaiganesh

5. **Megha-Tropiques (Effect of different fluxes on upper ocean simulations):** The project aims to analyze the effect of two different flux (turbulent) formulations on upper ocean thermal structure from model simulations. The flux formulations are different in such a way that one formulation includes the effect of sea surface currents (called the relative wind effect) while the other formulation is without the effect

of sea surface currents in the bulk flux formulation used to compute the momentum, heat and freshwater fluxes. For this, model simulations of temperature from 3-D SAC Model will be used. These simulations are available for a two year period (2017 - 2018). In addition to model simulations, satellite observations of SST and buoy observations of temperature profiles for the same period will be used in order to evaluate which formulation simulates upper ocean thermal structure closer to the observations.

Neeraj Agarwal, R Janini, Suraj Singh, Jai Kumar, Mahesh Kalshetti

APPENDIX -2: LIST OF PARTICIPANTS

S No.	Name	ID
1	R. Venkatesan	NIOT ID
2	Ashish K Mitra	NCMRWF
3	Rajib Chattopadhyay	IITM Pune
4	Joseph Mani Neena	IISER Pune
5	D Sengupta	IISc Bangalore
6	M Ravichandran	NCPOR
7	Vamsi Krishna Chalamalla	IIT-Delhi
8	G.S. Bhatt	IISc Bangalore
9	Girish Kumar	INCOIS
10	Praveen Kumar	INCOIS
11	Maheshwar pradhan	IITM Pune
12	Scott Lee Harper	ONR
13	Sutanu Sarkar	UCSD
14	Robert E. Todd	WHOI
15	Michael James McPhaden	NOAA
16	Louis St Laurent	Univ of Washington
17	Craig M Lee	Univ of Washington
18	Hyodae Seo	WHOI
19	Harper Lightfoot Simmons	Univ. of Alaska
20	Burton H. Jones	KAUST
21	Amala Mahadevan	WHOI
22	Amit Tandon	Univ. Of Mass.
23	Mr Nihar Paul	IISc
24	Lijin J	IIT-Madras
25	Jithendra Raju Nadimpalli	IIT-Kgp
26	Suraj Singh	IIT-Madras
27	Devang Falor	IISc Bangalore
28	Ms. R. Janani	NIOT
29	Mr. R. Keerthivasan	NIOT

30	Mr. K. N. Navaneeth	NIOT
31	Ms. Seena G	NIO Kochi
32	Aakash Sane	Brown Univ.
33	Abhijit Raj	INCOIS
34	Jofia Joseph	INCOIS
35	Siva Heramb Peddada	IIT-Delhi
36	V Kiran	IITM Pune
37	Mr. Ankur Gupta	NCMRWF
38	Mr Daniel Simon	IISER Pune
39	Mr Mahesh Kalshetti	IITM Pune
40	Shri Sundar	NIOT
41	Ashin Kuriakose	INCOIS
42	Jai Kumar	SAC/ISRO
43	Preeti Rajput	SAC/ISRO
44	Jai Ganesh	SAC/ISRO
45	Prof. M Mathur	IIT-Madras
46	Prof. E A D Asaro	APL, Univ. Of Washington
47	Dr. L. Johnson	Brown Univ.
48	Prof. E. Shroyer	Oregon State Univ.
49	Dr. N. Agarwal	SAC/ISRO
50	Dr. R. Sharma	SAC/ISRO
51	Dr. Raj Kumar	SAC/SIRO

APPENDIX-3: MEETING AGENDA

Bay of Bengal Air-Sea Interactions
Discussion meeting 27 – 28th January 2020

27th January 2020

0915 – 0945	Registration	
Inaugural Session		
0945 – 0950	Welcome (DD, EPSA)	
0950 – 1000	Introductory Remarks (AD, SAC)	
1000 – 1015	About OMM (Prof. D. Sengupta, IISc)	
1015 – 1030	About MISOBOB (Dr. Louis St. Laurent, ONR/Prof. Amit Tandon)	
1030 - 1035	Release of booklet on "Satellite Oceanography"	
1035-1040	Vote of Thanks	
1040 - 1115	High Tea	
Technical Sessions -1 (Session Chair: Prof. Eric D Asaro)		
1115 – 1130	Bay of Bengal studies from satellite perspective	Dr. Raj Kumar (SAC)
1130-1145	An overview of MISOBOB and the Bay's response during the 2018 cruise from OMNI buoy network	Prof Amit Tandon (University of Massachusetts Dartmouth)
1145-1200	Effect of surface current on stratification in the Bay of Bengal	Dr. Hyodae Seo (WHOI)
1200-1215	Upper Ocean Processes Affecting the Surface Layer Heat and Salt Balance in the Bay of Bengal	Prof Michael J McPhaden (NOAA)
1230 – 1245	2019 MISOBOB Cruise	Dr. Emily Shroyer (Oregon State Univ.)
1215-1230	Sustained sampling in the Northern Indian Ocean: Eight Years of Glider operations in the Bay of Bengal and Arabian Sea	Dr Craig Lee (Univ. of Washington)
1245- 1300	Consolidated Presentation of Workshop projects	
1300 – 1400	Lunch	
Technical Sessions-2 (Session Chair: Dr AS Rajawat)		
1400 – 1415	Long-term moored observations-indo-US Collaborative efforts	Dr. Venkatesan (NIOT)
1415 - 1430	SST, Heat Flux, Mixing Depths and Monsoon Variations	Prof. Eric D'Asaro (APL, University of Washington)

1430 - 1445	Links between stratification, upwelling and SST in a fresh, warm and wet Bay of Bengal	Dr. Amala Mahadevan (WHOI)
1445 - 1500	LES of rapid, multiscale upper-ocean processes	Dr. Sutanu Sarkar (UCSD)
1500 - 1515	Microstructure turbulence from gliders during MISOBOB 2019	Dr. Lou St. Laurent (University of Washington)
1515 - 1530	Creation and destruction of upper ocean stratification and fronts in the Bay of Bengal	Dr. Harper Lightfoot Simmons (University of Alaska)
1530 – 1700	Tea + Posters	
1700 – 1800	Discussions : Dr. Amit Tandon, Dr. Emily Shroyer, Dr. Rashmi Sharma, Prof Michael J McPhaden, Prof. Manikandan Mathur	
1830	Departure for Dinner (Gujarati Village Theme restaurant)	

28th January, 2020

Technical Session-1 (Session Chair: Dr. Emily Shroyer)		
0930 – 0945	**NCMRWF Coupled Model: Bay of Bengal Features**	**Dr. A K Mitra (NCMRWF)**
0945 – 1000	**Equatorial circulation in the western Indian Ocean during onset of the 2018 summer monsoon and links to the Bay of Bengal**	**Dr. Robert E. Todd (WHOI)**
1000 – 1015	**Atmospheric Boundary Layer during the 2019 BoB-ASIRI Campaign**	**Prof. GS Bhatt (IISc)**
1015 – 1030	**Surface Current feedback on momentum flux and impact on ocean model simulations**	**Dr. Rashmi Sharma (SAC)**
1030 – 1045	**INCOIS contributions to the In-Situ Ocean Observation Network in the Indian Ocean: Current status and future plan**	**Dr. Girish Kumar (INCOIS)**
1045 – 1100	**Characterization of Eddies in the Red Sea**	**Dr. Burton H Jones (KAUST)**
1100 – 1200	**Tea + posters**	
Technical Session-2 (Session Chair: Dr. CM Kishtawal)		
1200 – 1215	**Sub seasonal Prediction Skill of MJO in a Coupled and Uncoupled Version of CFS/GFS**	**Dr. Rajib Chattopadhyay (IITM Pune)**
1215 – 1230	**Modelling the upper ocean response to monsoon forcing**	**Dr. Leah Johnson (Brown University)**
1230 – 1245	**Predictability of MISO initiations over Indian Ocean**	**Dr. Neena Joseph (IISER, Pune)**
1245 – 1300	**Discussions**	
1300 – 1400	**Lunch (VIP CANTEEN, SAC)**	
1400 – 1500	**Concluding remarks and discussions: Dr. Raj Kumar, Prof. D. Sengupta , Dr. Amala Mahadevan, Prof. Eric D' Asaro, Prof. Craig Lee**	