Years of the Maritime Continent (YMC) Implementation Plan

Ver. 2.2 (March 15, 2018)

Table of Contents

Executive Summary

Years of the Maritime Continent (YMC) is a two-year field campaign project starting from July 2017 through the early 2020. Its overarching goal is to expedite the progress of improving understanding and prediction of local multi-scale variability of the Maritime Continent (MC), whose complex land-sea distribution and topography with surrounding warm waters make prediction of high-impact events in the region extremely challenging. YMC includes five science themes: Atmospheric Convection, Upper-Ocean Processes and Air-Sea Interaction, Stratosphere-Troposphere Interaction, Aerosol, Prediction improvement. Detailed background, justification, and hypotheses of the five science themes are described in the YMC Science Plan.

YMC will address these science themes through five main activities: Data Sharing, Field Campaigns, Modeling, Prediction and Applications, and Outreach and Capacity Building.

YMC data sharing is built upon the existing observing networks in the MC region. They include networks of radiosondes, radars, surface meteorological stations, rain gauges, aerosol stations, buoys/moorings/marine stations, river discharge gauges, and land surface stations.

Field campaigns of YMC will consist of several intensive observations periods (IOPs). The YMC pilot study was conducted at the western coast of Sumatra near Bengkulu during November - December 2015. The first main YMC IOP will be in the same region during November 2017 – January 2018. Following that, several confirmed and planned IOPs will take place in various areas of the MC. These areas include the Timor and Banda Seas, the west coast of the Philippines, the South China Sea, the East Indian Ocean, the northern Philippines and Palau, Kalimantan/Borneo, the western Pacific, equatorial Sumatra and Borneo, Southwest Sumatra and Java, the Karimata Strait and Java Sea. Each of these IOPs will focus on its specific scientific objectives. A common objective is the diurnal cycle in convection and its interaction with the large-scale phenomena, including the Madden-Julian Oscillation (MJO).

Considering the complexity of ocean-land-terrain distributions and interaction in the MC region, interpreting observations from a single site or a limited area would be challenging. Observationally validated high-resolution (e.g., cloud-permitting) numerical models will be useful tools to complement observations in understanding physical processes. In particular, assimilating observations from the regional networks and IOPs into high-resolution data products will be an effective way to synthesize observational data. This will also provide observationally based initial conditions for forecast or hindcast by high-resolution regional models to demonstrate possible improvement of short-term prediction of rainfall when unconventional observations are included.

Experimental new prediction products will be developed and tested for their utility.

YMC data include observations from the regional networks and special measurement during IOPs, selected numerical prediction and simulation products, selected satellite observations, and selected global and region data assimilation products. These data will be archived at two YMC data centers. They will be available to YMC investigators for July 2017 – June 2019 and open to public use afterward.

During YMC, efforts of outreaching, capacity building and education will be made to enrich the experience of the regional work force and raise the public awareness of local and global weather-climate issues. Workshops, trainings, lectures, open houses will be organized at the time and location of certain IOPs.

YMC share tremendous synergy with many other programs of regional and global focuses in observations and modeling.

1. Introduction

The Maritime Continent (MC), a unique mixture of land and ocean straddling the equator in the center of Indian and Pacific warm pool, hosts one of the major equatorial atmospheric convection centers and it results in playing a role of heat engine of the global atmospheric circulation. Thus, exact knowledge of weather and climate systems over the MC is crucial to understand weather and climate even for higher latitudes. Its complex land-sea distribution and topography as well as surrounding warm waters, however, make prediction of extreme events in this region challenging. Moreover, the state-of-the-art climate models and numerical weather prediction models are still suffering from persistent systematic errors of precipitation and limited prediction skill of convection development (Fig. 1.1). Models fail to produce diurnal cycle convection; its amplitude and peak time. They over/underestimate rainfall amount over the land/ocean, and their peak is faster than that of observations by a quadrature or so (ex. Love et al. 2011, Peatman et al. 2014). In addition, modulation process of the Madden-Julian oscillation (MJO) over the MC is a remained big challenge, because its relation to local circulation such as diurnal cycle is still unclear (ex. Birch et al. 2016, Hagos et al. 2016, Peatman et al. 2014, Vincent and Lane 2016, Zhang et al. 2016). Recent quasi-biennial oscillation (QBO) studies also suggest a difficulty to fully understand the behavior of the MJO, as it indicates the stratosphere impacts onto the activity of the MJO over the MC region (Yoo and Son 2016, Son et al. 2017). Furthermore, it is well known that MC weather and climate are influenced by monsoons from both hemispheres, and causes heavy precipitation events upon interaction with other phenomena (Chang et al. 2004). These suggest a multi-scale interaction in space and time is essential to understand the weather-climate systems over the MC region.

"Years of the Maritime Continent (YMC)" is a challenge for these perennial issues. Its overarching goal is to expedite the progress of improving understanding and prediction of local multi-scale variability of the MC weather-climate system and its global impact through observations and modeling exercises. YMC will cover a two-year period including both winter and summer East Asian/Australian monsoons starting from mid-2017 through the early 2020. During this campaign period, two types of observations will be conducted; several intensive observations focusing on specific scientific topics and long-term measurement including routine observations done by the MC local operational agencies. YMC offers opportunities for coordination among international community to conduct observations as well as modeling studies.

At first, mitigating the precipitation bias found in models motivated the necessity of field campaigns over the MC to collect in-situ observations to describe precipitation features as a first step. As noted above, however, various temporal and spatial scale phenomena interact each other and such multi-scale interaction is essential to understand the weather-climate systems over the MC. By considering this fact, YMC sets five science themes: 1) atmospheric convection including phenomena from diurnal cycle rain to monsoon, 2) upper ocean processes and air-sea interaction, 3) stratosphere-troposphere interaction, 4) aerosol-cloud interaction, and 5) prediction improvement for above mentioned four specific themes. Since the MC region undergoes multi-scale variability on the mesoscale, diurnal, synoptic, intraseasonal, and seasonal scales. Mechanisms for the multi-scale variability and their cross-scale interactions are at the center of atmospheric convection theme. In particular, dominant processes controlling the diurnal cycle, barrier effect of the MC to the MJO propagation, boreal winter interactions between the East and Southeast Asia and MC, and northward propagation of MC convection in the boreal summer should be revealed through this campaign. As for the upper ocean processes and air-sea interaction theme, what processes control the sea surface temperature cycle and upper ocean stratification from diurnal to seasonal time scales, and to what degree the role of air-sea fluxes, lateral advection, mixing, upwelling and other processes on each time scale should be intensively studied. In particular, the key for those studies is the fact that such observations should be done in both inland sea region and open oceans. For the stratosphere-troposphere interaction theme, dehydration process is the most attractive research topics over decades, and the following components should be studied as they are thought to be key; deep convection, organized convection and equatorial waves, and large-scale disturbances such as Asian monsoon and diurnal atmospheric tide. In addition, to study the effect of stratosphere onto the troposphere, the relationship QBO and the MJO will be one of hot topics. These research topics require long-term measurements rather than intensive observations within a couple of months. This observation strategy with long-term observation needs can be applied to the aerosol-cloud interaction studies, as aerosol associated with biomass burning, which is unique according to the season, is a key factor to be intensively studied through the campaign.

YMC will engage five main activities: 1) Data sharing, 2) Field campaigns, 3) Modeling, 4) Prediction improvement, and 5) Outreach/capacity building. The main anticipated outcomes of YMC would be: (a) a two-year comprehensive data archive from regional observing networks, satellite observations, and field campaigns. This data archive will include diverse observations needed to document the detailed multi-scale variability in the MC; (b) advanced understanding of physical processes of the weather-climate system of the MC that are key to its local multi-scale variability and global impact; (c) improved model capability of simulating and predicting the weather-climate system of the MC and demonstration of its benefit to the society; and (d) a new generation of scientists and technicians who will be the intellectual core of operation and research in the MC for years to come.

In this implementing plan, information about observation plan of intensive observations and long-term measurement, and numerical research activities is summarized, in addition to description of relevant expected social activities such as outreach and capacity building.

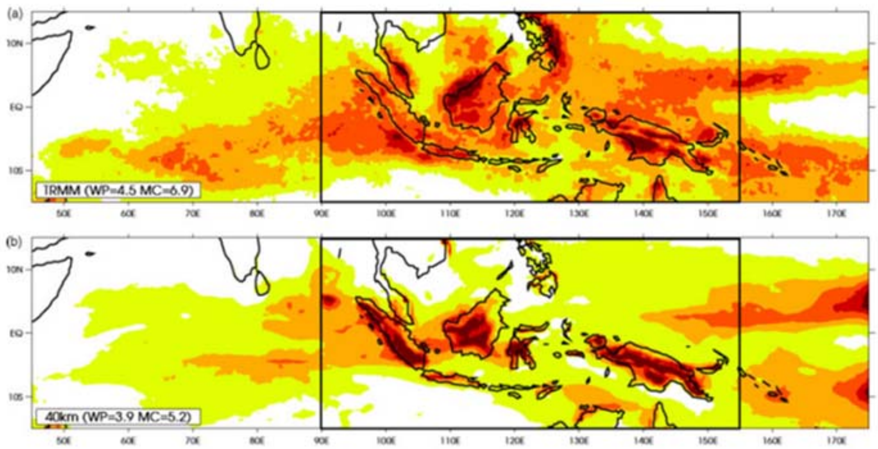

Fig. 1.1. Daily mean precipitation rate from (upper) TRMM observation and (lower) UK Met Unified model with 40 km resolution. Taken from Love et al. (2011).

2. Regional Observing Networks

In this section, basic information about routine observations done by participating MC meteorological agencies as well as long-term measurements deployed by international research agencies/institutes/universities is briefly summarized.

2.1 Soundings:

Routine radiosonde soundings have been done by MC local meteorological agencies as once or twice-daily basis, and basic parameters at conventional heights are immediately sent to numerical prediction centers via GTS, so that data can be used for weather forecasting as well as analysis product. Table 2.1 summarizes basic information and Fig. 2.1 provides rough locations.

Table 2.1. Summary of radiosonde stations.

	Site	ICAO Code	Station No.	longitude	latitude	Height	Frequency	Manufacturer	Type
Australia	Darwin	YPDN	94120	130.87E	12.40S	30m	2/day	Vaisala	RS41
	Gove Airport	YDGV	94150	136.82E	12.27S	54m	1/day	Vaisala	RS41
	Weipa Amo	9999	94170	141.90E	12.63S	0m	1/day	Vaisala	RS41
	Broome Airport	YBRM	94203	122.22E	17.95S	9m	1/day	Vaisala	RS41
	Townsville	YBTL	94294	146.75E	19.25S	6m	1/day	Vaisala	RS41
	Willis Island	9999	94299	149.98E	16.30S	9m	1/day	Vaisala	RS41
Indonesia	Banda Aceh	WITT	96011	95.42E	5.52N	21m	2/day	Modem	M10
	Medan	WIMM	96035	98.68E	3.57N	25m	2/day	Meisei	iMS-100
	Ranai	WION	96147	108.38E	3.95N	2m	2/day	Modem	M10
	Padang	WIMG	96163	100.35E	0.88S	3m	2/day	Meisei	iMS-100
	Pangkalpinang	WIKK	96237	106.13E	2.17S	33m	2/day	Meisei	iMS-100
	Bengkulu	WIPL	96253	102.33E	3.87S	16m	2/day	Meisei	iMS-100
	Tarakan	WRLR	96509	117.57E	3.33N	6m	2/day	Modem	M10
	Pontianak	WIOO	96581	109.40E	0.15S	3m	2/day	Meisei	iMS-100
	Pangkalan Bun	WRBI	96645	110.70E	2.70S	25m	2/day	Meisei	iMS-100
	Banjarmasin	WRBB	96685	114.75E	3.45S	20m	2/day	Meisei	iMS-100
	Cengkareng	WIII	96749	106.65E	6.12S	8m	2/day	Meisei	iMS-100
	Cilacap	WIIL	96805	109.02E	7.73S	6m	2/day	Modem	M10
	Surabaya	WRSI	96935	109.02E	7.37S	3m	2/day	Meisei	iMS-100
	Manado	WAMM	97014	124.92E	1.53N	80m	2/day	Meisei	iMS-100
	Palu	WAML	97072	119.73E	0.68S	6m	2/day	Meisei	iMS-100
	Makassar	WAAA	97180	119.55E	5.07S	14m	2/day	Meisei	iMS-100
	Kupang	WRKK	97372	123.67E	10.17S	108m	2/day	Meisei	iMS-100
	Sorong	WASS	97502	131.12E	0.93S	2m	2/day	Modem	M10
	Biak	WABB	97560	136.12E	1.18S	11m	2/day	Meisei	iMS-100
	Ambon	WAPP	97724	128.08E	3.70S	12m	2/day	Meisei	iMS-100
	Saumlaki	WAPI	97900	131.30E	7.98S	24m	2/day	Meisei	iMS-100
	Merauke	WAKK	97980	140.38E	8.47S	3m	2/day	Meisei	iMS-100
Malaysia	Penang	WMKP	48601	100.27E	5.30N	4m	2/day	Graw	DFM-09
	Kota Bharu	WMKC	48615	102.28E	6.17N	5m	2/day	Graw	DFM-09
	Kuala Lumpur	9999	48650	101.70E	2.73N	17m	2/day	Graw	DFM-09
	Kuantan	WMKD	48657	103.22E	3.78N	16m	2/day	Graw	DFM-09
	Kuching	WBGG	96413	110.33E	1.48N	27m	2/day	Graw	DFM-09
	Bintulu	WBGB	96441	113.03E	3.20N	5m	2/day	Graw	DFM-09
	Kota Kinabalu	WBKK	96471	116.05E	5.93N	3m	2/day	Graw	DFM-09
	Tawau	WBKW	96481	117.88E	4.27N	20m	2/day	Graw	DFM-09
Philippines	Laoag	RPLI	98223	120.53E	18.18N	5m	2/day	Graw	DFM-09
								LMS	LMG6
	Baguio	RPUB	98328	120.60E	16.41N	1501m	2/day	LMS	LMG6
	Tanay	9999	98433	121.36E	14.56N	614m	2/day	LMS	LMG6
	Legaspi	RPMP	98444	123.73E	13.13N	17m	2/day	Vaisala	RS41
	Puerto Princesa	RPVP	98618	118.73E	9.75N	15m	2/day	LMS	LMG6
	Mactan	RPMT	98646	123.96E	10.30N	24m	2/day	Vaisala	RS41
	Guiuan	9999	98558	126.73E	11.03N	61m	1/day	Modem	M10
Singapore	Singapore	WSSS	48698	103.98E	1.37E	16m	2/day	Vaisala	RS41

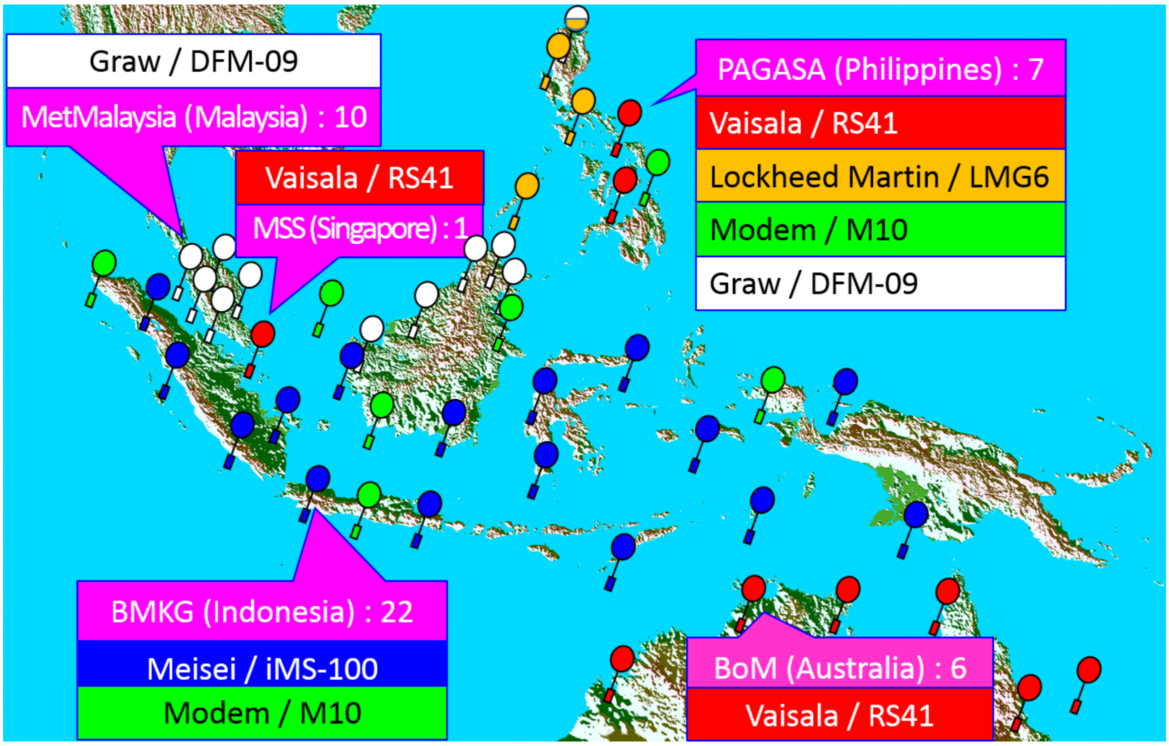

Fig. 2.1. Locations of routine radiosonde sounding stations.

2.2 Radars:

Weather radars operated in Indonesia, Philippines, and Malaysia are summarized in Table 2.2 and their locations are plotted in Figs. 2.2a-c.

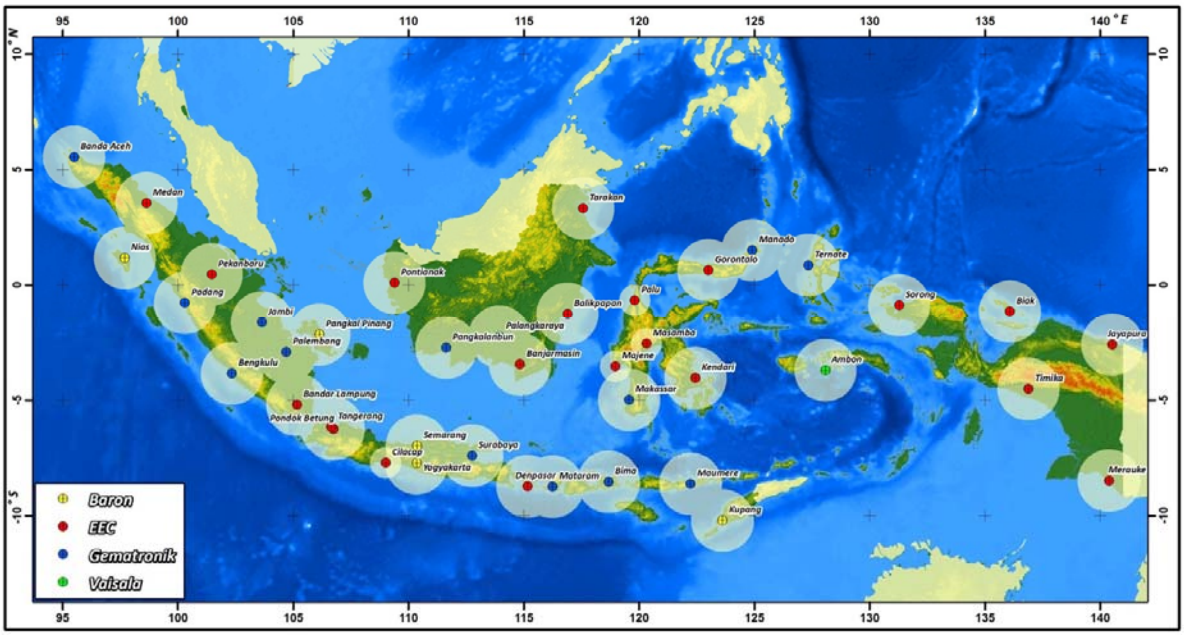

Fig. 2.2a Locations of operational weather Doppler radars in Indonesia. Courtesy of BMKG.

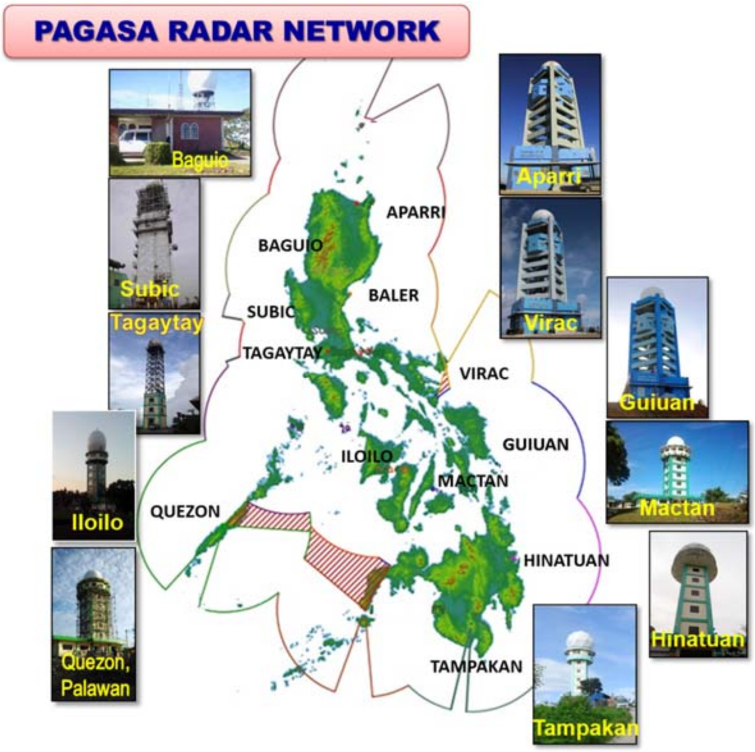

Fig. 2.2b. Locations of operational weather Doppler radars in Philippines. Courtesy of PAGASA.

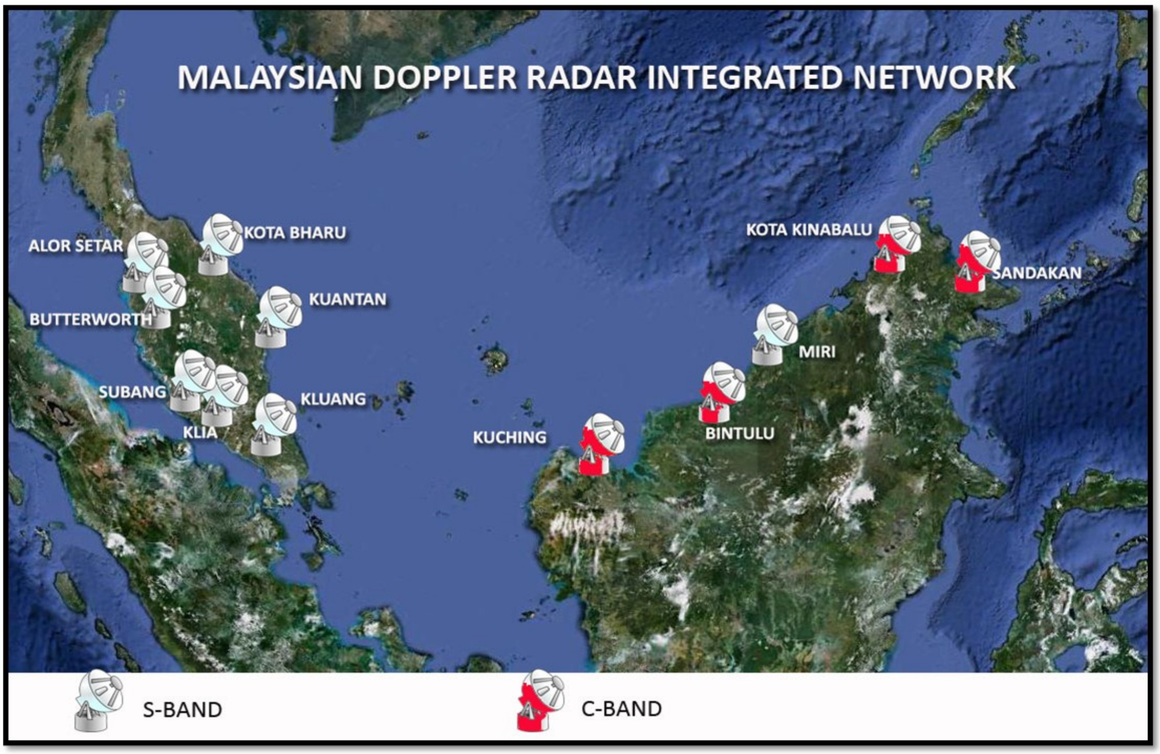

Fig. 2.2c. Locations of operational weather Doppler radars in Malaysia. Courtesy of MetMalaysia.

Table 2.2. Summary of operational weather Doppler radars in Indonesia, Philippines, and Malaysia. Courtesy of BMKG (Indonesia), PAGASA (Philippines), and MetMalaysia (Malaysia). Locations are not strict ones due to rounding.

Country	Site	longitude	latitude	Freq. band	Manufacturer
Indonesia	Ambon	128.08E	3.70S	C	Vaisala
	Balikpapan	116.89E	1.27S	C	EEC
	Banda Aceh	95.42E	5.52N	C	Selex (Gematronik)
	Bandar Lampung	105.18E	5.24S	C	EEC
	Banjarmasin	114.75E	3.45S	C	EEC
	Bengkulu	102.33E	3.87S	C	Selex (Gematronik)
	Biak	136.12E	1.18S	C	EEC
	Bima	118.69E	8.54S	C	Selex (Gematronik)
	Cilacap	109.02E	7.73S	C	EEC
	Denpasar	115.17E	8.75S	C	EEC
	Gorontalo	122.85E	0.64N	C	EEC
	Jambi	103.64E	1.64S	C	Selex (Gematronik)
	Jayapura	140.52E	2.58S	C	EEC
	Kendari	122.58E	3.97S	C	EEC
	Kupang	123.67E	10.17S	C	Baron
	Majene	119.00E	2.50S	X	EEC
	Makassar	119.55E	5.07S	C	Selex (Gematronik)
	Manado	124.92E	1.53N	C	Selex (Gematronik)
	Masamba	120.37E	2.55S	X	EEC
	Mataram	116.10E	8.56S	C	Selex (Gematronik)
	Maumere	118.69E	8.54S	C	Selex (Gematronik)
	Medan	98.68E	3.57N	C	EEC
	Merauke	140.38E	8.47S	C	EEC
	Nias	97.53E	1.10N	C	Baron
	Padang	100.35E	0.88S	C	Selex (Gematronik)
	Palangkaraya	112.97E	2.22S	C	Selex (Gematronik)
	Palembang	104.70E	2.90S	C	Selex (Gematronik)
	Palu	119.73E	0.68S	X	EEC
	Pangkalpinang	106.13E	2.17S	C	Baron
	Pangkalanbun	110.70E	2.70S	C	Selex (Gematronik)
	Pekanbaru	101.44E	0.46N	C	EEC
	Pontianak	109.40E	0.15S	C	EEC
	Semarang	110.38E	6.98S	C	Baron
	Sorong	131.12E	0.93S	C	EEC
	Surabaya	109.02E	7.37S	C	Selex (Gematronik)
	Tangerang	106.63E	6.18S	C	EEC
	Tarakan	117.57E	3.33N	C	EEC
	Ternate	127.38E	0.83S	C	Selex (Gematronik)
	Timika	136.89E	4.53S	C	EEC
	Yogyakarta	110.43E	7.79S	C	Baron
Malaysia	Alor Setar	100.40E	6.19N	S	EEC
	Butterworth	100.39E	5.46N	S	EEC
	Subang	101.56E	3.13N	S	Selex (Gematronik)
	Kuala Lumpur (KLIA)	101.70E	2.75N	S	Mitsubishi E.
	Kluang	103.30E	2.04N	S	EEC
	Kota Bharu	102.28E	6.12N	S	EEC
	Kuantan	103.21E	3.78N	S	EEC
	Kuching	110.34E	1.48N	C	EEC
	Bintulu	113.02E	3.12N	C	EEC
	Miri	113.98E	4.33N	S	EEC
	Kota Kinabalu	116.05E	5.94N	C	EEC
	Sandakan	118.06E	5.90N	C	EEC
Philippines	Aparri	121.63E	18.36N	S	JRC
	Baguio	120.56E	16.36N	S	EEC
	Subic	120.36E	14.82N	S	EEC
	Tagaytay	121.02E	14.14N	C	EEC
	Virac	124.33E	13.63N	S	JRC
	Guiuan	125.76E	11.05N	S	JRC
	Mactan	123.98E	10.32N	C	EEC
	Iloilo	122.58E	10.77N	S	
	Quezon, Palawan	118.01E	9.23N	S	
	Hinatuan	126.34E	8.37N	S	EEC
	Tampakan	125.03E	6.42N	S	EEC

Kyoto University (Japan) has deployed Equatorial Atmosphere Radar (EAR) at the Equatorial Atmosphere Observatory (100.32E, 0.20S, 865 MSL) in Kototabang, Sumatra since 2001, and has been operating under the collaboration with LAPAN, Indonesia. EAR can measure wind and turbulence between 1.5 - 20 km and echoes from ionospheric irregularity over 90 km vertically. Their data are available from http://www.rish.kyoto-u.ac.jp/ear/index-e.html.

Fig. 2.2d. EAR in Kototabang. Courtesy of Kyoto University.

2.3 Surface Meteorology:

Surface meteorological data (temperature, humidity, wind, etc.) are taken by SYNOP stations and Automated Weather Stations (AWSs). Here shows examples of such stations deployed in Indonesia, Philippines, and Malaysia.

Fig. 2.3a. AWSs in Indonesia. In total, there are 361 stations, and 178 are BMKG stations. Courtesy of BMKG.

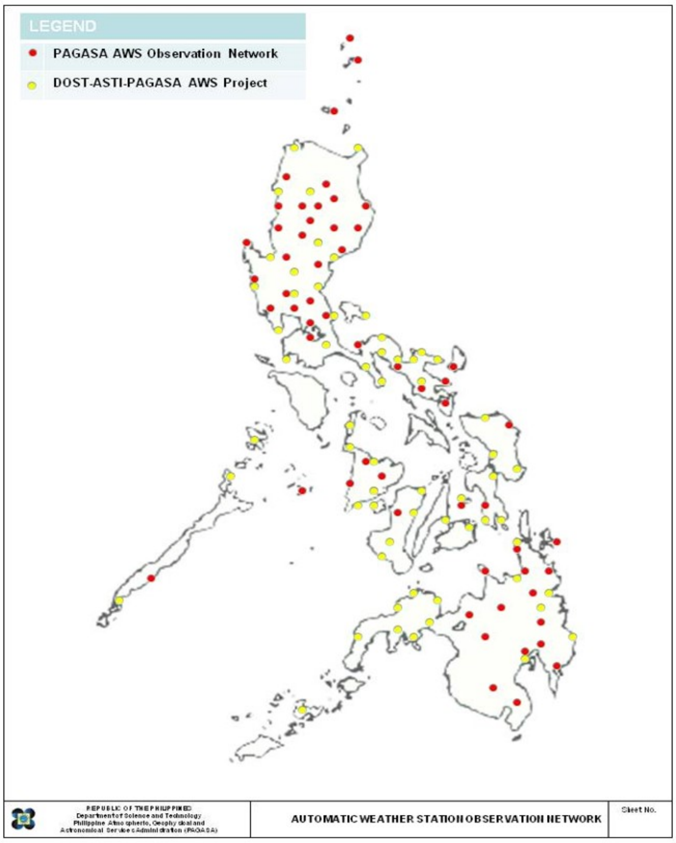

Fig. 2.3b. AWSs in Philippines. 158 sites in total. Courtesy of PAGASA.

Fig. 2.3c. 42 Principal meteorological stations in Malaysia. In addition, MetMalaysia has 394 auxiliary weather stations (201 are automated). Courtesy of MetMalaysia.

***2.4 Aerosols*:**

NASA has been leading two long-term aerosol measurement programs; MPLNET(Micro-Pulse Lidar Network, https://mplnet.gsfc.nasa.gov/) and AERONET (Aerosol Robotic Network, https://aeronet.gsfc.nasa.gov/).

Fig. 2.4. MPLNET (●) and AERONET (★) stations. Courtesy of NASA.

3. Intensive Observation Periods (IOPs)

During 2-year field campaign period, several intensive observations will be conducted. Figure 3.1 and Table 3.1 summarize the planned and proposed campaigns. In this section, only brief descriptions of these campaigns such as period and main targets are provided. Details of each project can be found in Appendix A.

Notes.

1) While the campaign period is set to 2-year, YMC does not limit its activity strictly within 24 months. Thus, the time frame shown in Table 3.1 is regarded as the YMC campaign period.

2) Some projects have proposed several different observation sites as possible plans (Plan-A, B, etc.), because they may need to change the site due to research permission status.

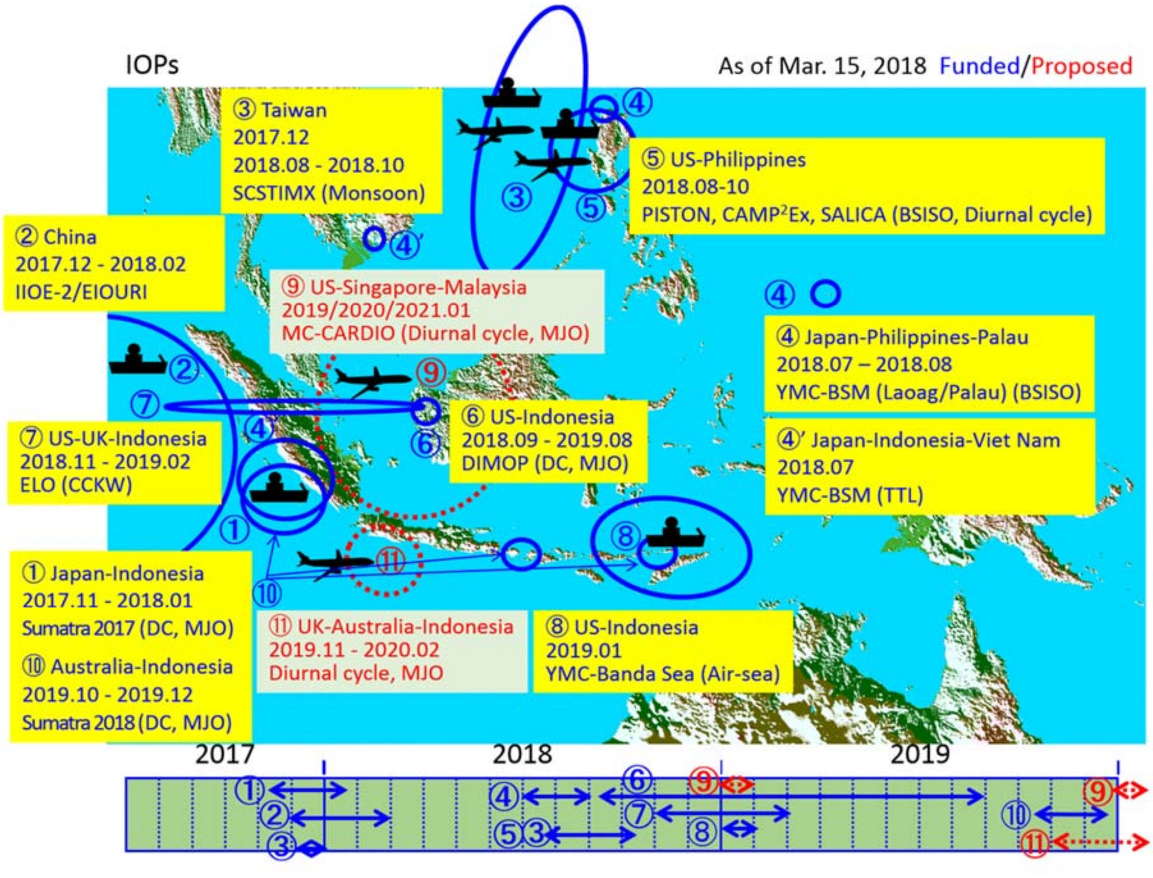

Figure 3.1. Rough locations and periods of the funded/proposed IOPs.

Table 3.1. Proposed and planned Intensive Observation Periods (IOPs). Bold indicates funded projects as of March 15, 2018.

Time	Project	Location	YMC Theme/ Objectives	Platform/ Main Instruments	Contacting PI
2015.11-12	**Pre-YMC**	**W. Sumatra**	**Convection/ MJO-Diurnal cycle**	**Ship, land/ Soundings, C-band radar, etc**	**Kunio Yoneyama**
2017.08	**SALICA**	**W. Philippines**	**Upper Ocean**	**Ship**	**Cesar Villanoy**
2017.11-2018.01	**YMC-Sumatra**	**W. Sumatra**	**Convection/ MJO-Diurnal cycle**	**Ship, land/ Soundings, C-band radar, etc**	**Kunio Yoneyama**
2017.11-12	**STEAM/GAIA**	**W. Pacific**	**Upper Ocean**	**Ship/buoy/drifter**	**Jae Hak Lee**
2017.12	**SCSTIMX IOP-W 2017**	**SCS**	**Convection/ Interaction with L-scale circulation**	**Land, buoy, ship, UAV/ soundings, C-/X-band radar**	**Chung-Hsiung Sui**
2017.12-2018.02	**FIO**	**E. Indian Ocean**	**Upper Ocean/ upwelling**	**Ship**	**Weidong Yu**
2018.01-12	**FIO**	**E. Indian Ocean**	**Upper Ocean**	**Buoy**	**Weidong Yu**
2018.05	**NOAA**	**Java and Banda Seas**	**Convection/ Land-sea breezes**	**Ship, UAV**	**Chidong Zhang**
2018.07	**YMC-BSM (Monsoon)**	**Vietnam Indonesia**	**Stratosphere-Troposphere**	**ECC, CFH**	**Shin-Ya Ogino**
2018.07-08	**YMC-BSM (Laoag, Palau)**	**N. Philippines Palau**	**Convection/ BSISO**	**Soundings, Radar, Wave glider**	**Kunio Yoneyama**
2018.08-09	**CAMP^{2}Ex**	**W. Philippines**	**Aerosol/ interaction with cloud**	**Aircraft**	**Jeff Reid**
2018.08-10	**PISTON**	**W. Philippines**	**Convection, upper ocean, air-sea interaction/ BSISO, diurnal cycle**	**Ship, buoys/C-band radar, soundings, air-sea fluxes, upper-ocean mixing**	**Jim Moum**
2018.08-10	**SCSTIMX IOP-S 2018**	**SCS**	**Convection/ Interaction with L-scale circulation**	**Land, buoy, ship, UAV/ soundings, C-/X-band radar**	**Chung-Hsiung Sui**
2018.09-10	Aeroclipper	W. Pacific	Convection/TC	Aeroclipper	Jean-Philippe Duvel
2018.09-2019.09	**ARM-DIMOP**	**Borneo**	**MJO**	**Surface Met**	**Samson Hagos**
2018.11-2019.02	**Rutgers**	**E. Indian Ocean**	**Upper Ocean**	**Glider**	**Scott Glenn**
2018.11-2019.02	**ELO**	**Eastern IO - W. Sumatra - Borneo**	**Convection/ Kelvin waves, diurnal cycle**	**Sea glider, land-based, buoy**	**Piotr Flatau**
2019.10-2019.12	**Australia-Indonesia project**	**W. Sumatra**	**Convection/ MJO-Diurnal cycle**	**Ship/C-band radar, soundings, etc**	**Matthew Wheeler**
2019.11-2020.02	TerraMaris	SW. Java, Xmas Island	Convection/ MJO-Diurnal cycle	Aircraft, land-based, sea-glider	Adrian Matthews
2019/20/21. 11-12	MC-CARDIO	SCS, Java Sea	Convection/ MJO-Diurnal cycle	Aircraft/dropsonds Lidar, etc.	Shuyi Chen

3.1 Diurnal Cycle vs. the MJO

Diurnal cycle is the most key component in understanding weather-climate system over the MC region (Yamanaka 2016). Thus, many field campaigns aim at studying its features and its relation to other phenomena. In particular, its interaction with the MJO is one of hot research topics (e.g., Kerns and Chen 2016, Zhang and Ling 2017). The first intensive observation targeting the diurnal cycle over the MC region will be conducted by the joint effort of Indonesian and Japanese research groups from mid-November 2017 through mid-January 2018 in the western coast of Sumatra Island. This project is led by JAMSTEC, BMKG, and BPPT and is designed to study the diurnal cycle convection and its relation to the MJO by deploying land-based site at Bengkulu, research vessel, moored buoy, and unmanned surface vehicle. Similar observation is also proposed by Australian group (led by Bureau of Meteorology) using their research vessel in the period of October - December 2019. In the same period, UK research consortium is proposing another field campaign TerraMaris in the south of Java, Indonesia. Observations focusing on diurnal cycle convection will be made using aircraft, sea-glider, and two land based sites.

Another trial to study the MC barrier effect to the MJO propagation is proposed as a joint effort among US, Malaysia, and Singapore. This project MC-CARDIO (Maritime Continent Convective Heartbeat Diurnal Cycle for Global Weather) plans to deploy an aircraft from Malay Peninsula to Borneo Island in January for successive three years from 2019.

It is worth noting these campaigns data can be compared with previous studies including a pilot study done in November - December 2015 by Japanese and Indonesian groups as pre-YMC which captured significant diurnal cycles as well as the MJO passage (e.g., Wu et al. 2017, Yokoi et al. 2017) and their data are also available to use freely.

3.2 Monsoon Study Focusing on Intraseasonal Oscillation in the South China Sea and Philippines Sea

Several intensive observations will be conducted in the South China Sea (SCS) and Philippines Sea to study monsoon. U.S. ONR's PISTON (Propagation of Intra-Seasonal Tropical Oscillations) project is designed to study air-sea-land interaction focusing on diurnal cycle and boreal summer intraseasonal oscillation (BSISO) near the west coast of Luzon Island, Philippines. A research ship and several moorings will be deployed in the SCS from August to October 2018. PISTON will be conducted in conjunction with other relevant projects including U.S. NASA's CAMP^{2}Ex (Clouds, Aerosol, and Monsoon Processes-Philippines Experiment), which will operate aircraft over the SCS to study aerosol issues, and University of the Philippines project SALICA (Sea-Air-Land Interactions in the Context of Archipelago). SALICA project has conducted their pilot study using a ship in August 2017. In addition, JAMSTEC and PAGASA are planning to conduct intensive observation at Laoag by enhancing radiosonde sounding from 12-hourly to 6-hourly and deploying mobile X-band Doppler radar during July - August 2018. At that time, JAMSTEC also plans to enhance sounding to 6-hourly in Palau, where they operate a lidar and surface meteorological station. To incorporate these two land-based observations, unmanned surface vehicles will be operated to collect observations of surface meteorology, GNSS-derived water vapor, and ocean surface current in the Philippine Sea. They are called as YMC-Laoag and YMC-Palau respectively, and collectively YMC-BSM 2018.

While above mentioned projects focus on the boreal summer monsoon period, Taiwanese project SCSTIMX (SCS Two-Island Monsoon Experiment) covers both monsoon periods and their intensive observations are planned to take place in December 2017 - January 2018 and May

- June 2018. To study the interaction between atmospheric convection and large-scale flow, they deploy a ship, moorings, and an aircraft in addition to land-based site in two islands, where enhanced radiosonde sounding and radar observations will be performed.

Collaboration between Chinese and Malaysian groups has started long-term measurement to study boreal winter monsoon especially focusing on heavy rain associated with cold surge in the northern coast of Malay Peninsula. University of Malaya and First Institute of Oceanography (FIO) of China have already set up a joint research center at Bachok, and they also have deployed a moored buoy in the SCS.

3.3 Ocean Surface Structure and Air-Sea Interaction Studies

While above two subsections showed intensive observations focusing on atmospheric convection, intensive observations focusing to capture oceanic features are also planned. The FIO of China will have a cruise in the eastern Indian Ocean from December 2017 through February 2018, and CTD/water sampling as well as buoy recovery/deployment will be intensively conducted as part of IIOE-2 (Second International Indian Ocean Expedition) program.

Rutgers University has been conducting glider/model validation mission in the Indian Ocean as their Challenger project. Gliders measure ocean temperature and salinity from the surface to 1000-m depth. It is expected to cruise in the eastern Indian Ocean, where the YMC researchers are studying, in the period from December 2018 through February 2019.

KIOST will start 5-year project using a ship, moorings, and drifters to study low-latitude western boundary currents and air-sea interaction in the western Pacific. Their first cruise is expected to take place in October - November 2017.

Above mentioned three funded cruises are planned to take place in the so-called open oceans. On the other hand, several cruises have been proposed to conduct observations inland sea region. U.S. NOAA's research vessel is planned to cruise from the Indian Ocean through the western Pacific in the early boreal summer of 2018. During the cruise in Java and Banda Seas, air-sea interaction study using an unmanned aircraft vehicle (UAV) and Indonesian Through Flow (ITF) study using moored buoys are proposed in addition to standard CTD observations. Another unique project proposed by US and UK researchers is Equatorial Line Observations (ELO) campaign. ELO is designed to capture the features of convectively coupled equatorial Kelvin waves, which are thought to be a leading mode of eastward propagating convective systems and also interact with local circulations, by deploying various instruments along the equator. Their measuring tools include sea gliders and mooring in the oceans and land-based site in Sumatra and Borneo. This campaign is proposed to conduct from November 2018 through February 2019.

3.4 Stratosphere-Troposphere Interaction

In Sumatra Island, Indonesia, Equatorial Atmospheric Radar (EAR) deployed by Kyoto University, Japan in collaboration with LAPAN, has measured atmosphere from the surface to middle atmosphere (~90 km) over 15 years as noted in Section 2.2. EAR has offered opportunities of intensive observations (ex. Fukao 2006). During the YMC campaign period, several research groups will conduct observation using EAR. Japanese and Indonesian research group (JAMSTEC, Kyoto University, LAPAN, etc.) is planning to conduct ozone-sonde observations at Kototabang EAR site in July 2018. In addition, JAMSTEC will conduct simultaneous ozone-sonde observation at Ho Chi Minh, Vietnam with the help of NHMS, in order to study meridional circulation associated with monsoon as a part of YMC-BSM 2018.

4. Modeling

4.1 Model Coordination

There is a significant modelling effort associated with YMC, with a number of active groups. Most groups, however, are focusing on different regions and periods, and have a diversity of scientific motivation, approach and level of activity. For example, many modeling groups are restricting their focus to certain intensive observational periods during YMC with the primary purpose of alignment with specific observations. This range of activities precludes a true model intercomparison, but there remains significant value in coordination of modelling activities to exploit synergies across modeling groups. The purpose of this document is to lay the groundwork to facilitate coordination between interested parties.

4.2 Overview of Modeling Activities

This table provides a summary of planned YMC modeling activities and points of contact; further details are found below.

Country	Organization	Model	Location(s)	Contact
UK	Met Office	Unified Model	Global. Nesting over Indonesia, Malaysia, Philippines	Prince Xavier
UK	TerraMaris group	Unified Model (MetUM-GOML)	Entire Maritime Continent and Global	Steve Woolnough
Australia	CLEX	WRF / Unified Model	Entire Maritime Continent. Nesting over Sumatra and potentially Java	Claire Vincent
Japan	JAMSTEC	NICAM/ NICOCO	Global	Tomoe Nasuno
China	Beijing Climate Center	BCC_AGCM2.2/ BCC_CSM1.2	Entire Maritime Continent and Global	Hongli Ren
USA	PISTON group	Various	Entire Maritime Continent and Western Indian Ocean. Nesting over Philippines.	Sue Chen
France	Météo France	CNRM-CM6	Global	Romain Roehrig

<u>*4.2.1 UK - Met Office (Operational)*</u>

Organization: Met Office UK
Primary contact: Prince Xavier, Met Office, prince.xavier@metoffice.gov.uk
Model: Met Office Unified Model
Periods: It is operational, so any period of interest.
Regions: Global, with nesting over Southeast Asia.
Highest resolution: 10 km global, 1.5 km over Indonesia, Malaysia and Philippines.
Focus: Diurnal cycle, forecast skill, extreme rainfall, interaction of large scale dynamics and convection

4.2.2 UK - TerraMaris Group

Organizations:	TerraMaris (University of East Anglia, University of Reading, University of Leeds, Met Office)
Primary contact:	Steve Woolnough, NCAS-Climate, University of Reading, UK. s.j.woolnough@reading.ac.uk
Model:	MetUM-GOML (Unified Model atmosphere coupled to 1-D mixed layer ocean model)
Periods:	Nov 2019 - Feb 2020 for IOP; multiple DJF seasons; multi-year simulations
Regions:	West Java (1000 x 200 km); all MC; global
Model resolution:	200 m; 2 km; 15 km; 60 km, depending on domain
Focus:	IOP; diurnal cycle; effect of intraseasonal variability on local processes such as diurnal cycle; global impacts of MC

4.2.3 Australia

Organizations:	ARC Centre of Excellence for Climate Extremes (CLEX) collaborating with Bureau of Meteorology.
Primary contact:	Claire Vincent, CLEX and University of Melbourne claire.vincent@unimelb.edu.au
Models:	WRF, some case studies with the UK Unified model
Periods:	Nov 2019 –Feb 2020 for RV Investigator IOP. Other Nov - Feb periods during YMC
Regions:	Entire MC. Nesting over Sumatra and potentially Java
Model resolution:	1.33 km, 4 km
Focus:	Coordination with IOPs, diurnal cycle, gravity waves, diabatic processes, intraseasonal variability

4.2.4 Japan

Organizations:	Japan Agency for Marine-Earth Science and Technology (JAMSTEC) and Atmosphere and Ocean Research Institute (AORI), The University of Tokyo
Primary contact:	Tomoe Nasuno, JAMSTEC, nasuno@jamstec.go.jp
Models:	Nonhydrostatic Icosahedral Atmospheric Model (NICAM) and NICOCO (Ocean-coupled NICAM)
Periods:	Nov 2017 - Jan 2018, July 2018
Region:	Global
Model resolution:	7 km (forecasts), 3.5 km (hindcasts)
Focus:	IOPs (by JAMSTEC), diurnal cycle, multi-scale interactions (ISO, equatorial waves, local convection), air-sea interaction

4.2.5 China

Organization:	Beijing Climate Center
Primary contact:	Hongli Ren, renhl@cma.gov.cn:
Model:	BCC_AGCM2.2 and BCC_CSM1.2
Periods:	Nov - Dec 2018 and other periods of interest
Regions:	Entire Maritime Continent, or Global
Model resolution:	110 km
Focus:	Forecast skill, impact of MC

4.2.6 USA – PISTON Group

Organizations:	Colorado State University, Columbia, University of Connecticut, Oregon State University, Florida Tech, United State Naval Academy, NRL Monterey, and NRL Stennis
Primary contact:	Sue Chen, Naval Research Laboratory, sue.chen@nrlmry.navy.mil
Models:	RAMS, WRF-ARW, ALEMC, WRF coupled with ROMS, COAMPS, NAVGEM coupled with HYCOM
Periods:	Aug-Oct 2016, 2017, and 2018.
Region:	Entire Maritime Continent + Western Indian Ocean. The high-resolution nest will cover Luzon, Philippine
Model resolution:	10-100 m (ALEMC LES model); 1-45 km for the reginal RAMS, WRF, and COAMPS; global NAVGEM (T359L50) coupled with HYCOM (1/12 degree)
Focus:	Large-scale control, convective process, diurnal cycle, ocean diurnal layers, 3-D ocean process, atmosphere-ocean-land interaction

4.2.6 – France

Organizations:	CNRM, Météo-France/CNRS
Primary contact:	Romain Roehrig, romain.roehrig@meteo.fr
Model:	CNRM-CM6 (climate and hindcast configurations)
Periods:	Several years for the climate configurations, specific IOPs/events depending on the situation.
Region:	Global
Model resolution:	150 km (potentially as fine as 50 km)
Focus:	Diurnal cycle, convection and coupling with the large-scale circulation, MJO forecast skill, IOPs

4.3 Datasets

At this stage there are no plans for a central server to host YMC modelling data. Sharing of data can, of course, occur through collaboration between individuals. It is certainly desirable for model data to be shared amongst the YMC community as much as is practical (within the rules of each organization and funding agency). Moreover, it has become common for some funding agencies to support (or sometimes require) the 'publication' of significant datasets on public servers or data repositories. Publication of model datasets maximise their use and value to the global scientific community. The YMC website can be used to provide links to published datasets and also can provide information about other datasets that are available for collaborative purposes and how to obtain them.

4.4 Common Analysis

To facilitate qualitative and quantitative comparisons between modeling experiments it is suggested that a small set of standard diagnostics be constructed. These diagnostics can be shared amongst all modelling groups to explore and expose systematic errors across regions and models. These common analyses will continue to be developed and may include maps of average rainfall accumulation, composite diurnal cycles of precipitation (separated between land and sea points), and maps of the timing of the peak in the diurnal cycle and its amplitude. Examples of these can be found in Vincent and Lane (2017), i.e., Figs. A1, 2, 3, 4.

5. Prediction and Data Assimilation

In addition to modeling activities described in the previous section, several modeling groups also plan to run their model focusing on prediction and data assimilation. Below are the examples introduced at the 3rd YMC science and planning workshop held in Malaysia in March 2017.

<u>*BMKG*</u>

GCM:	GFS 0.25 deg; ICON 14 km
RCM:	WRF and COSMO with data assimilation
Domain (nested):	20S - 20N, 90E-150E
Model resolution:	WRF (27-9-3 km), COSMO (14-7 km)
Lead time:	3 days every 3 hours
Data Assimilation:	Synoptic - Yes Radiosonde - Yes Radar - Yes Satellite - Yes
Output Format:	Image and Binary
Remarks:	Temporary website output are “puslitbang.bmkg.go.id/wrf” and “puslitbang.bmkg.go.id/cosmo”

<u>*MSS*</u>

GCM:	GFS
RCM:	WRF (downscaler), UM (downscaler and data assimilation)
Domain (nested):	5S - 8N, 95E - 109E
Model resolution:	4.5 km, 1.5 km
Lead time:	WRF (72 hr), UM (12, 36 hr)
Data Assimilation:	Synoptic - Yes Radiosonde - Yes Radar - Yes Satellite - Yes Aircraft: Yes
Output Format:	NetCDF (for WRF) and Image

Currently, several research groups form a team and have started their discussion to collaborate to demonstrate how regional weather prediction may improve by including radar data assimilated into initial conditions. So far, this team consists of the following members.

<u>*MetMalaysia:*</u>	Radar data - Mahluddin Shahrin Data assimilation - Mohamad Sofian Yusoff Regional model prediction - Muhammad Firdaus Ammar Abdullah
<u>*MSS:*</u>	Radar data - Xiangming Sun Data assimilation - Hans Huang Regional model prediction - Jeff Lo

<u>*BMKG:*</u>	Radar data - Riris Adriyanto Data assimilation - Donaldi Permana, Wahyu Argo Regional model prediction - Wido Hanggoro
<u>*BOM:*</u>	Radar data - Alain Protat Data assimilation - Susan Rennie
<u>*TWB:*</u>	Radar data - Pao-Liang Chang Data assimilation - Jing-Shan Hong Other data from SCS - Po-Hsiung Lin
<u>*NRL:*</u>	Radar data - Paul Harasti Data assimilation - Allen Zhao Regional model prediction - Teddy Holt, Sue Chen

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6. Data Management and Archive

6.1 Data Policy:

YMC adopts timely release and free/open sharing data policy. Indeed, the YMC data policy should be in compliance with the World Meteorological Organization (WMO) Resolution 40 on the policy and practice for the exchange of meteorological and related data and products including guidelines on relationships in commercial meteorological activities: *"As a fundamental principle of the World Meteorological Organization (WMO), and in consonance with the expanding requirements for its scientific and technical expertise, the WMO commits itself to broadening and enhancing the free and unrestricted international exchange of meteorological and related data and products."* Additional YMC data policy requires:

- YMC Data (field observations, operational observations, satellite data, reanalyses, and model output) Archive Centers (YDACs) will be established and maintained at several institutes with links to each other.
- Within 12 months following the end of the field campaign, all data shall be promptly provided by YMC investigators responsible for data acquisition to other YMC investigators upon request and notification of the intent of data use.
- All YMC investigators participating in the field campaign are required to submit their field data to one of the YDACs no later than 12 months following the end of the field campaign.
- During the first 12 months following the end of the field campaign, all YMC data will be accessible only to YMC investigators to facilitate inter-comparison, quality control checks and inter-calibrations, as well as an integrated interpretation of the combined data set. No public release of the data (sharing with non-YMC colleagues, conference presentations, publications, commercial and media use, etc.) is allowed without the permission of the YMC PIs who are responsible for collecting the data.
- Quality control procedures should be carried out by YMC investigators within 12 months following the end of the field campaign, unless unforeseeable issues emerge. After that, YMC field data will be made available to the broader scientific community. Any remaining data quality issues and information about data whose release will be delayed beyond 12 months following the end of the field campaign should be made clear in the data documentation files. Improving YMC data quality will be a continuous effort. The suitability of the released data for scientific investigations and publications should be decided at the discretion of the YMC investigators responsible for field data collection and quality control and data users.
- The authorship decision for publications resulting from using YMC data should follow the ethic rules of the journals and professional organizations (e.g., AMS, AGU, and MSJ). YMC investigators responsible for field data collection are encouraged to make contributions to data analysis and writing of manuscripts, in addition to providing the data, to be co-authors of publications using YMC data.
- The following acknowledgements are suggested to be included in all publications using YMC data: The xxxx data were collected as part of YMC by investigator(s) YYYY under the support by wwww (if YYYY is not a co-author)]. The data are archived at the YMC Data Archive Center maintained by ZZZZ.

6.2 Data Archive:

As noted in the YMC data policy, YDACs will be established and maintain all data. Currently, the following two agencies are responsible for this mission and provide YMC web sites, where all data can be retrieved. Note that some data will be opened to the public through their own sites due to technical reasons. However, the inventory for all data sets is provided at the following sites and they link to such individual site. Namely, it is possible for users to find and access all data via the following sites.

YMC web site: http://www.bmkg.go.id/ymc/
Contact point (ymc@bmkg.go.id)

Ancillary site: http://www.jamstec.go.jp/ymc/
Contact point (ymc-joffice@jamstec.go.jp)

7. Outreach, Capacity Building, and Education

As noted in the YMC Science Plan, general public support and new generations of scientists with advanced knowledge and skill for improving forecast of the MC weather-climate system are essential for the success and lasting legacy of YMC.

To obtain public support, YMC activities as well as advanced knowledge should be shared in a timely manner through TV, radio, newspapers, internet, brochures, school visits, and so on. Interactions between local people and on-site scientists are strongly encouraged. In Indonesia, for instance, BMKG has opened their secretariat office and hosted the launching meeting on July 17, 2017. At that time, they advertised the YMC activity through many media, so that public people can know what is happening as YMC and what are expected to be brought out through the 2-year campaign. Indeed, media reported what and how the YMC will bring the benefit to Indonesia. In addition, during the intensive observation period of YMC-Sumatra 2017 (November 2017 - January 2018), several seminars and lectures at the local site Bengkulu will be arranged and local government staffs, airport authorities, university students and others will be invited. This forum is meant not only to introduce the observational activities but also to explain why their location is chosen for the intensive observation by telling its scientific importance for global climate. Similar activities will be arranged in other intensive observation sites.

Training the next generation of scientists, forecasters, and technicians for future research, operations, and applications of prediction and simulation tools is the only way to make YMC research directly benefit society in a timely fashion. In particular, college and graduate students should be involved in all levels of YMC activities. As mentioned above, they will be invited to various meetings, which will be arranged to learn about the MC weather-climate systems. It is also expected that elevated YMC research will allow more talented and motivated students to enroll in MS and PhD programs at home or abroad. Many universities in US, Japan, Australia, and so on are ready to take those applicants. In addition, it is a good opportunity to obtain those skills through actual practice, and indeed the field requires participation from young generation. Below are the examples of collaboration with local students and staffs during the intensive observation periods.

During the campaign period, many radiosondes will be launched as a basis for atmospheric profile measurement. However, since their systems are different among the observation sites as shown in Fig. 2.1, quality control should be made to produce the same high quality data sets for different sensors. Thus, researchers are planning to conduct intercomparison of different sensors and develop a correction scheme. For Indonesian sites, BMKG staffs will join this intercomparison experiment and learn the methods. For the Philippines, master course students from the University of the Philippines are expected to visit local stations to collect raw data and then perform data correction. Since they are expected to join the intensive observation at Laoag in the boreal summer of 2018 (YMC-Laoag 2018), they will conduct intercomparison launch with JAMSTEC colleagues and sum up those procedures as well as correction scheme as a part of their MS thesis.

As to the training for local forecasters, through the several training workshops held in the MC region, it is one idea to write a “MC forecaster’s handbook”, which can be used for future guidance. Because the knowledge of non-hydrostatic models, data assimilation, ensemble and probabilistic forecasts must be obtained for future use, interaction with those experts are required. To engage this, lectures and seminars will be arranged accordingly. For example, not only observation experts but also modeling scientists are planned to join the field campaigns as an on-site member. At that time, lectures/seminars by numerical modelers will be arranged in collaboration with the local agencies. For example, JAMSTEC numerical modelers are scheduled to have lectures during their stay in Indonesia for YMC-Sumatra 2017 period. Those opportunities will be announced through the YMC mailing list, webs, and so on.

8. Synergy

YMC shares common scientific interests with many projects. By coordinating the YMC activity with those projects, it is highly expected to obtain foremost and unprecedented knowledge owing to their synergy and leverage. Below are the same descriptions taken from YMC Science Plan document, which describes basic information about each project focusing on relevant topics.

8.1 Subseasonal-to-Seasonal Prediction Project (S2S) / MJO Task Force (MJOTF) Joint Maritime Continent Initiative

The WGNE MJOTF has the goal to facilitate improvements in the representation of the MJO in weather and climate models in order to increase the predictive skill of the MJO and related weather and climate phenomena. The main goal of the S2S project under the WWRP/THORPEX-WCRP sponsorship is to improve forecast skill and understanding on the subseasonal to seasonal timescale, and promote its uptake by operational centers and exploitation by the applications community. The S2S and MJOTF highlighted the interaction of the Maritime Continent with the MJO as a high priority research question that has significant bearing on assessing shortcomings and improving operational MJO predictions, and hence developed a joint research initiative for the MC. This joint effort was initiated not only as a means of addressing basic science questions on process and prediction, but also as a means of contributing to and helping guide YMC and taking advantage of the unprecedented data for process-oriented diagnostics of modeling experiments that YMC will provide. This project and YMC will share a similar modeling experiment design that focuses on understanding interactions between the MJO and the MC.

8.2 CORDEX-Southeast Asia (CORDEX SA)

This is a project under the WCRP Coordinated Regional Climate Downscaling Experiment (CORDEX) with a focus on the Southeast Asia. With the MC covered by its domain, CORDEX SA is poised to address the following questions: What are the key processes and mechanisms in the MC that are not captured by the regional climate model, resulting to poor model performance and inability to capture seasonal dynamics? What are the appropriate adjustments and modifications to cumulus parameterization schemes for the model to properly simulate rainfall and rainfall dynamics in the MC region? How do variations in SSTs affect the simulated model climatology in the MC? Does the model adequately capture the diurnal cycle, MJO, and the extreme rainfall events associated with MJO and ENSO events and are the associated physical dynamics simulated well? The downscaling exercise of CORDEX SA is an integrated component of the YMC modeling theme. YMC observations will provide unprecedented validate data for CORDEX SA models.

8.3 7 Southeast Asian Studies (7SEAS)

The 7SEAS program was initiated in 2007 to study the extent to which aerosol particles impact regional weather, climate, and the environment. It covers aerosol lifecycle and air quality, tropical meteorology, radiation and heat balance, clouds and precipitation, land processes and fire, physical and biological oceanography, and environmental characterization through satellite analyses, model predictions, and verification. While 7SEAS may nominally disestablish by the

YMC time, associations between investigators and networks are firmly in place and can quite easily work within a YMC construct. Their expertise and experience are invaluable to the planning and operation of the YMC field campaign and modeling work.

8.4 Tropical Pacific Observing System (TPOS) 2020

This project was proposed to sustain the Tropical Pacific Observing System to support ENSO research, modeling and forecasting. TPOS 2020 recognizes the importance of the MC as its western boundary region and the crucial roles of the ITF in ocean dynamics and climate variability on both regional and global scales. It regards the MC as an integral part of the TPOS and recommends that observations in the MC need to be adequately covered by the TPOS. Observations to be taken by YMC and TPOS will contribute to both projects.

8.5 International Indian Ocean Expedition 2 (IIOE-2)

This project is proposed to be the second phase of the highly successful IIOE. Its overarching goal is to advance our understanding of interactions between geologic, oceanic and atmospheric processes that give rise to the complex physical dynamics of the Indian Ocean region, and to determine how those dynamics affect climate, extreme events, marine biogeochemical cycles, ecosystems and human populations. Its themes of Boundary current dynamics, upwelling variability and ecosystem impacts (Theme 2) and Monsoon Variability and Ecosystem Response (Theme 3) share common interests with the YMC themes of Ocean and Air-Sea Interaction and Atmospheric Convection. Observations of upwelling along the west coast of Sumatra and Java directly contribute to both IIOE-2 and YMC. Monsoon variability over the MC is a study target of both projects. YMC observations of MC convection and its connection to the SE Asian monsoon will complement IIOE-2 observations over the Indian Ocean.

8.6 Stratosphere-troposphere Processes and their Role in Climate (SPARC)

Activities of the WCRP SPARC project are organized under three overarching themes that call for an integration of process studies, observations and modeling. SPARC activities are directly related to YMC Theme 3 “Stratosphere-Troposphere Interactions”, of which the objective is to improve understanding of processes governing the dynamical coupling of the stratosphere and troposphere and their mass exchanges over the MC. The dynamical coupling processes include not only the upward influence of tropospheric convection on the stratospheric circulation through multi-scale tropical waves but also possible downward influence of stratospheric variations (such as stratospheric cooling trend, QBO, and sudden warming events) on the tropical deep convection, its organization, and multi-scale interactions. The transport of gas and particles in the Tropical Tropopause Layer (TTL) is the key process that controls the ozone layer and global climate. Deep convection and its organization, equatorial waves, the Asian monsoon, and their multi-scale variations largely control the transport processes. Coordinated observations, data analyses and numerical model studies will be promoted in the YMC activities.

8.7 Strateole-2

Observations from this long-duration balloon campaign is expected to take place its test flights in November 2018 - April 2019, which will overlap the YMC period and will provide global observations of the tropical tropopause region. The balloons represent a Lagrangian platform at altitudes just above the tropical tropopause from which numerous measurements will be made related to the dynamics and composition of the tropopause region and lower stratosphere. Planned measurements include water vapor, ozone, clouds, aerosols, winds and temperatures at very high spatial and temporal resolution. The suite of instruments and the unique nature of the numerous balloon platforms, each with durations of several months, will advance scientific inquiries in gravity wave and equatorial wave dynamics, fluxes of trace gases, clouds and aerosols, stratospheric dehydration, and validation of satellite simulations that will be synergistic with the goals of YMC.

8.8 Year of Polar Prediction (YOPP)

This project, which is a central activity of WWRP's Polar Prediction Project (PPP), has been launched from May 15, 2017 as a 2-year campaign coincidently with the YMC. It is designed to enable a significant improvement in environmental prediction capabilities for the polar region and beyond, by encompassing intensive observations, modeling/forecast experiments, verification of forecast, and a special educational effort. As for the observations, coordination with the international field experiment called the Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC) will be a major component. In particular, after the 2-year campaign, based on the enhanced observations as well as improved skill of the modeling and prediction, it is planned to produce a special high-resolution global reanalysis. YMC observations will contribute to this special reanalysis. Coordination with YOPP and YMC will bring a new synergy covering from the source to the sink of global circulation, where both are sensitive to the climate change and key areas to understand the global weather and climate.

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Appendix - A

Details Description of IOPs including relevant projects

- YMC-Sumatra 2017
- YMC-BSM 2018
- Australia-Indonesia Project
- TerraMaris
- SCSTIMX
- PISTON
- ELO
- ARM-DIMOP
- STEAM/GAIA

YMC-Sumatra 2017

Contact point:
Kunio Yoneyama (JAMSTEC)

Overview:
This is a joint effort by Indonesia and Japan to study precipitation mechanism along the western coast of Sumatra Island by forming an observation network with a ship, moored buoys, glider, and land-based site at Bengkulu, as well as numerical modeling study. It is known that diurnal cycle rain dominates over the coastal region with afternoon peak over the land and its offshore propagation in the early morning, which results in another peak of rain over the ocean in the morning. However, this diurnal cycle is modulated by large-scale atmospheric disturbances such as the MJO, while the MJO is also affected by the local diurnal cycle. Thus, this project focuses on the interaction between diurnal cycle rain and the MJO.

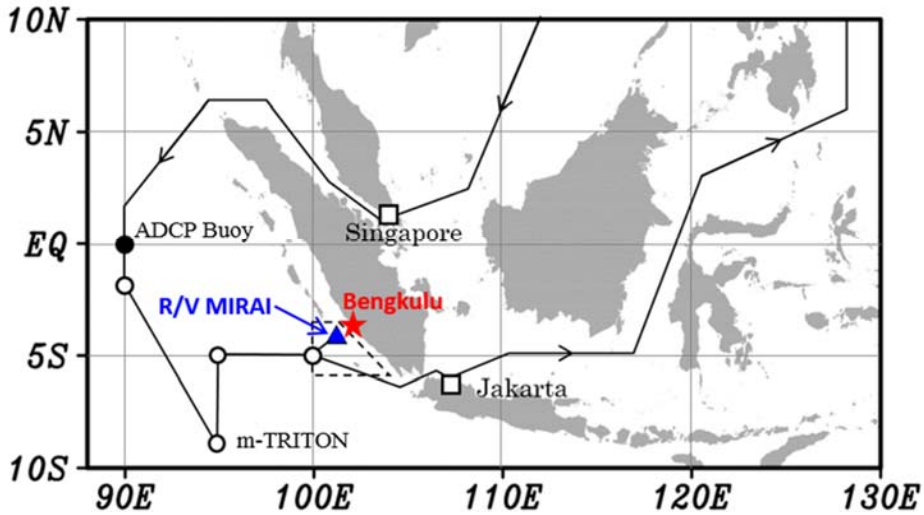
Objective:
Study on interaction between diurnal cycle rain and the MJO

Period:
November 16, 2017 - January 15, 2018

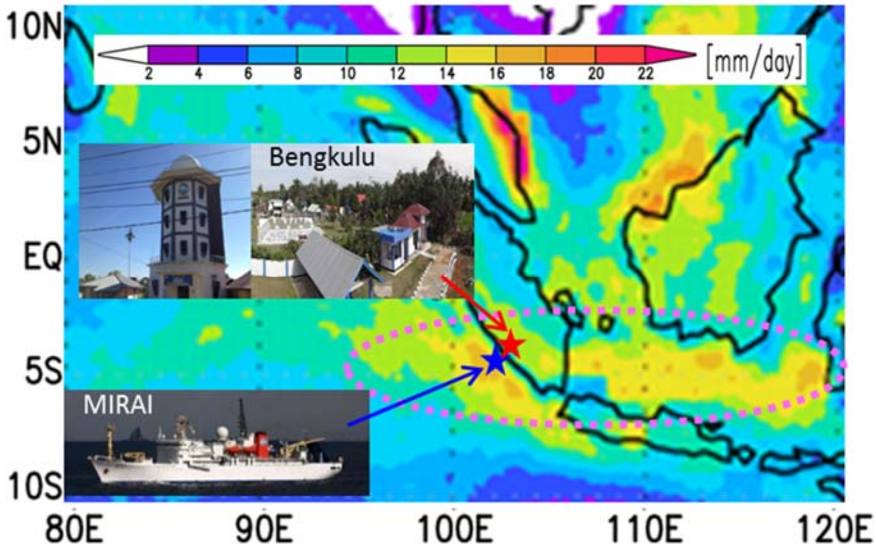
Participants:

Indonesia	- BMKG, BPPT, LAPAN, ITB, University of Bengkulu, etc.
Japan	- JAMSTEC, University of Tokyo, University of Toyama, Kyoto University, Yamaguchi University, NME Ltd., MWJ Ltd., etc.
US	- University of Hawaii/IPRC

Location:



R/V Mirai is scheduled to conduct stationary observation off Bengkulu from December 3, 2017 to January 1, 2018. Prior to that, moored buoys as part of RAMA array will be recovered/deployed.



Observation network. Shading indicate climatology of monthly mean precipitation observed by TRMM for December.

Observations:

Land-site:
C-band Doppler radar, radiosonde (8/day for 2 months), surface meteorology, GNSS water vapor, Water vapor-Ozone-Cloud particle sonde, videosonde, lighting detector, rain/water vapor isotope

Onboard:
C-Pol Doppler radar, radiosonde (8/day for 1 month), surface meteorology, GNSS water vapor, lidar, ceilometer, micro-rain radar, MAX-DOAS (aerosol),
CTD with water sampling (chemical analyses), ADCP, LADCP, Ocean microstructure profiler

Others:
Wave-glider, moored buoys (as part of RAMA array)

Numerical study:
Two types of forecast run (global 7-/14-km mesh for 14-/30-day forecast) using NICAM will be performed. In addition, several numerical studies using WRF are planned by several research groups.

YMC-BSM 2018

Contact point:
Kunio Yoneyama (JAMSTEC)

Overview:
YMC-BSM (Boreal Summer Monsoon study in) 2018 consists of three major components. The first one is the ozone-sonde observations under the collaboration among JAMSTEC, Kyoto University (Japan), LAPAN (Indonesia), and NHMS (Vietnam) in July 2018. The second one is YMC-Laoag, which is a joint effort by PAGASA, University of the Philippines and JAMSTEC to study precipitation mechanism around Laoag, northern part of Luzon Island focusing on diurnal cycle of rain and northward propagating intraseasonal oscillation in July - August 2018. The last one is observations at Palau Island (YMC-Palau). Those observations collect data to study boreal summer monsoon.

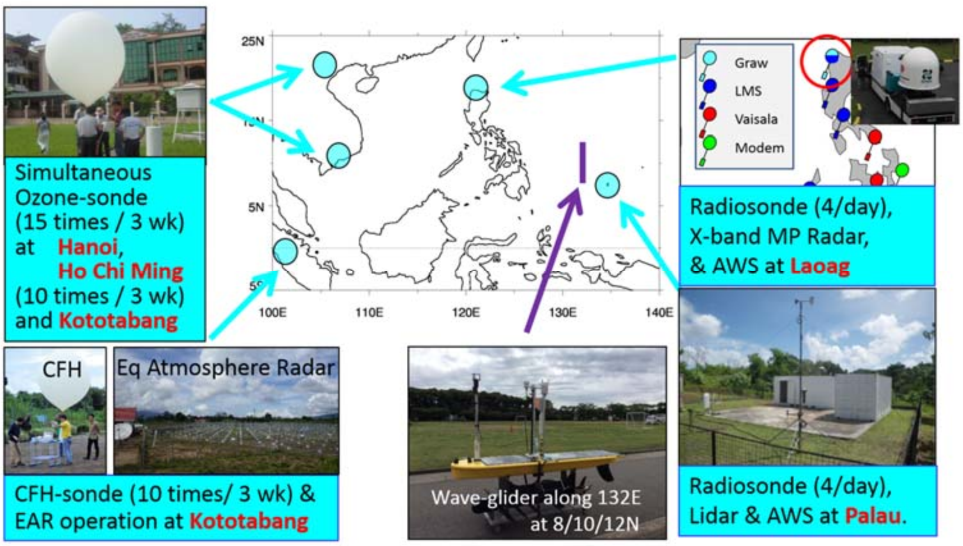
Objective:
Study on precipitation associated with boreal summer intraseasonal oscillation (BSISO) and meridional circulation features associated with the monsoon. While the former will focus on the phenomena observed in the troposphere, the latter will focus on the interaction between the lower stratosphere and the upper troposphere.

Period:
July 1 - August 31, 2018

Participants:

Philippines	- The Philippine Atmospheric Geophysical and Astronomical Services Administration (PAGASA), University of the Philippines
Palau	- Koror Weather Service Office
Indonesia	- National Institute of Aeronautics and Space (LAPAN)
Vietnam	- National Hydro-Meteorological Service (NHMS)
Japan	- JAMSTEC, Kyoto University

Location:



Observations:

Laoag:	X-band Doppler radar (August 1 - 31, 2018)
	Six-hourly radiosonde, surface meteorology (July 1 - August 31, 2018)
Kototabang:	Ozone/CFH/CPS-sonde, 10 times (July 2018),
	Equatorial Atmosphere Radar (July 1 - 31, 2018)
Hanoi:	Ozone-sonde, 15 times (July 2018)
Ho Chi Minh:	Ozone-sonde, 15 times (July 2018)
Palau:	Six-hourly Radiosonde, lidar, surface meteorology, disdrometer (July 1 - August 31, 2018)
	Wave gliders (in the Philippine Sea) (July - August 2018)

Numerical study:
Real-time forecast using NICAM is planned.

Australia-Indonesia project: Maritime Continent observations of atmospheric convection, biogenic emissions, ocean vertical mixing, and the Indonesian Throughflow

Contact point:
Matthew Wheeler (Bureau of Meteorology, Australia)

Overview:
This is a joint effort led by Australia and Indonesia to study atmospheric convection, biogenic emissions, ocean vertical mixing, and the Indonesian Throughflow, using the *R/V Investigator*. The primary intent is to make near continuous measurements of the oceanic and atmospheric environment throughout the diurnal cycle as atmospheric convection develops, or does not develop, in the vicinity of Sumatra or Java. Measurements on days where convection does not occur are equally important for the improvement of model parameterizations. The offshore propagation of organized convective systems is of particular interest. The intention is to remain within 50km of the one location for the majority of the cruise as well as spend several days making detailed ocean measurements when passing through the Indonesian straits (either outbound or inbound or both).

Objective:
Detailed study of atmospheric and oceanic processes to aid development of new and improved parameterizations of physical processes in order to reduce model biases and increase prediction skill.

Period:
58-days voyage time in October 19 - December 18, 2019.

Participants:

Australia	- Bureau of Meteorology, CSIRO, University of Melbourne, Monash University, Deakin University
Indonesia	- BPPT, BMKG
UK	- University of East Anglia
Japan	- University of Tokyo
USA	- Woods Hole Oceanographic Institution
Taiwan	- NTU
Malaysia	- Xiamen University Malaysia

Location:
Start and ending port will be at Darwin, with a possible mid-way stop at Christmas Island. The location for detailed long-term convection measurements will likely be offshore from Bengkulu, but may also be on the Christmas Island-Java line or offshore from northern Australia.

Observations:
Dual-Pol C-band Doppler weather radar, 6-hourly balloon soundings, cloud radar and lidar, Surface meteorology, Atmospheric chemistry, ADCP, CTD, LADCP, TRIAXUS; thermosalinograph, vertical microstructure profilers, drifters, and sea-gliders.

TerraMaris

Contact point
Adrian Matthews (UEA)

Overview
The overall aim is to determine, quantify and model the atmospheric convective and atmospheric and oceanographical dynamical processes that govern the generation of precipitation and heating over the Maritime Continent and determine their global impacts. Specific objectives are to: (1) Make detailed observations of the convective-dynamical atmospheric systems and their land and ocean interactions over the Maritime Continent by taking a leading role in the international Years of the Maritime Continent field experiment. (2) Quantify the complex interactions that govern the diurnal cycle of precipitation and heating over the Maritime Continent, particularly the development of the boundary layer and convection over the large islands, the generation of land-sea breezes and gravity wave circulations, and the offshore convective response to those circulations. (3) Model the convective systems in a carefully designed hierarchy of numerical modelling experiments to transform our understanding of the Maritime Continent system, and to understand the mechanisms behind the systematic errors in global climate models that stem from deficiencies in their representation of the Maritime Continent.

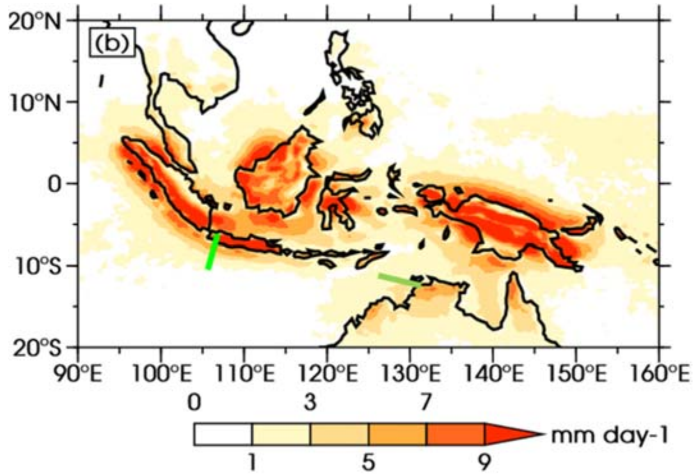
Project status
An outline proposal for a NERC Large Grant was submitted in January 2017. This was successful, and a full proposal will be submitted in November 2017. The funding decision will be made in May 2018.

Period
November 2019 – February 2020 for ocean measurements, and 5-6 weeks in Jan-Feb 2020 for aircraft measurements

Participants
- UK: University of East Anglia (UEA), University of Reading, University of Leeds, Met Office, Facility for Airborne Atmospheric Measurements (FAAM)
- Indonesia: BMKG, LAPAN
- Australia: BoM

Location
- Plan A: Jakarta, Java, Indonesia and Christmas Island, Australia
- Plan B: Darwin, Australia

Figure shows amplitude of diurnal cycle of precipitation, and proposed aircraft sections for Plan A and B.



Observations

- Aircraft (FAAM)
- Land-based: surface fluxes, radiosondes, X-band radar, scanning radiometer, Doppler Aerosol LiDAR
- Ocean: Shallow water Seaglider, regular Seaglider, Waveglider. Planned coordination with R/V Investigator, contingent on funding.

Modelling

Hierarchy of model experiments using Met Office Unified Model (MetUM-GOML): atmospheric model coupled to high resolution KPP mixed-layer ocean model. Cloud-resolving simulations with ~200 m horizontal resolution, 1000 x 2000 km domain size. Convection-permitting simulations at ~2 km resolution, 8000 x 2000 km pan-MC domain. Limited-domain parametrized convection simulations at 15 km resolution. Global model simulations at 60 km resolution.

The South China Sea Two-Island Monsoon Experiment (SCSTIMX)

Contact point:
Chung-Hsiung Sui (NTU)

Overview:
SCSTIMX is designed to study the interaction of convection over the MC-SCS with large-scale flow, by deploying observation platforms in the SCS as well as performing numerical modeling.

Observations:
Two types of observational tasks will be carried out by PIs in Taiwan's universities. The first is intensive observation during the periods (IOPs: Dec. 2017 – Jan. 2018; May-June, 2018) at Taiping Island and Dongsha Island, and the second is extended observation during the periods (EOP: Aug.-Oct. 2018), in coordination with the international projects, "Propagation of Intra-Seasonal Tropical Oscillations" (PISTON) and "Years of the Maritime Continent" (YMC). During the winter IOP (Dec. 2017 – Jan. 2018) and the summer IOP (May-June, 2018), Surface Weather Station, Ceilometer, Microwave Radiometer, Wind Profiler and intensive balloon soundings will be set off at Dongsha Island and Taiping Island (4 times a day), along with soundings at the southern part of Taiwan and countries around the SCS and MC regions. In addition, we also plan to carry out missions of target-aiming jet aircraft dropsondes and unmanned aerial vehicle (UAV aerosonde). A couple series of flight will be deployed in Central Weather Bureau (dropsonde) and in Taiwan Typhoon and Flood Research Institute (TTFRI, Aerosonde) during the IOPs to obtain environmental parameters over an expanded area between Taiping Island and Taiwan. We also propose to set up cloud and precipitation radars at Taiping Island supersite in the IOPs. These can be a relocation of the MOST TEAM radar/or NTU X-band dual polarization radar. These radars will be operated in conjunction with the microwave rain radars and/or ceilometers nearby when there are mesoscale convective systems approaching the site, to obtain a more complete monitoring of the cloud microphysics, convection structure, and precipitation intensity. During the EOP (Aug.-Oct., 2018), data will be measured regularly by surface weather station, boundary layer wind profilers, and upper-air balloon sounding.

Remarks:
To prepare for the field observations, we have conducted two pre-experiments. One was completed during December 11-21, 2016, through the research cruise from Kaohsiung to Taiping Island by the NTU RV OR1 voyage 1156. The cruise took place during the La Nina phase following the warm winter of 2015/2016 El Nino/Southern Oscillation (ENSO) event. The equatorial eastern and central Pacific was about 0.5-2 C colder than the climate mean. The second pre-experiment was completed during May 12 –June 12, 2017. The climate background was close to normal climate condition. Accompanied by the climate background, synoptic and intraseasonal oscillations in the SCS and surrounding warm oceans are analyzed and numerical simulations are made to explore the multi-scale interaction processes.
The observations collected during the SCSTIMX will provide valuable observations for both convective systems and large-scale events to be used by six projects funded to support the SCSTIMX observations.

PISTON (Propagation of Intra-Seasonal Tropical Oscillations)

Overview:
The PISTON observations will be from the R/V Thompson and two ocean moorings. These meteorological and ocean measurements will include the Sea-Pol radar, surface meteorology, turbulent flux, atmospheric soundings, and detailed profiling of the upper ocean temperature, salinity, current and ocean turbulence (Table 1). The PISTON ship IOPs will be off the West Coast of Luzon from mid-August to mid-October.

Observations:

Table 1 R/V Thompson Shipboard Observations

Instrument	Description
SEA-POL polarimetric, C-band Doppler radar	20' seatainer / antenna and radome installed on top of van. Peak transmit power - 250 kW.
Vaisala sounding system	8 per day soundings. Approx. 55 He tanks per cruise
Gill sonic anemometer	PSD Flux Measurement System
Systron Donner Motion Pack	PSD Flux Measurement System
Riegl Laser wave ht sensor	PSD Flux Measurement System
ORG rain gauge	PSD Flux Measurement System
Vaisala T/RH	PSD Flux Measurement System
Licor7500 (CO2&H2O)	PSD Flux Measurement System
Eppley solar/IR Radiometers	PSD Flux Measurement System
Vaisala Barometer	PSD Flux Measurement System
Sea surface temperature	PSD Flux Measurement System
PSD Wband Cloud	ESRL cloud/boundary layer observing system
CSD Doppler Lidar	ESRL cloud/boundary layer observing system
Vaisala CL31K ceilometer	ESRL cloud/boundary layer observing system
Radiometrics MP-200 microwave radiometer	ESRL cloud/boundary layer observing system
Vaisala HMP-155 temperature/ relative humidity	OSU flux system
RM Young barometer	OSU flux system
Campbell sonic anemometer	OSU flux system
inertial motion sensor/gyro	OSU flux system
LICOR-7500 open path H2O	OSU flux system
solar radiometer	OSU flux system
longwave infrared radiometer	OSU flux system
Moorings	SCRIPT subsurface moorings
Chameleon turbulence profiler	fantail from A-frame mounted block
Biosonics 120 kHz echosounder	1 ping per second
SurfYak near surface CT / ADCP otter board	upper 3 m continuous tow / 20 m outboard at 45 deg angle

Modeling:
The real time short-range (1-3 days) atmosphere, ocean, and wave model forecast support will be provided by the NRL Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) via COAMPS-OS. The PISTON modeling group will provide weekly short- and extended-range (30 days) forecast brief and daily forecast summaries to support the ship observations.

Remarks:
Detailed information about the field campaign can be found at http://onrpiston.colostate.edu/

ELO (Equatorial Line Observations)

Contact points:

Piotr Flatau (SIO, NSF PI), Janet Sprintall (SIO, NSF PI), Adrian Matthews (University of Reading, NERC PI), Karen Heywood (University of Reading, NERC co-PI)

Overview

In this project, the interactions within atmospheric equatorial convectively coupled Kelvin waves (CCKWs), the leading modes of eastward moving convection on time scales between several days and three weeks, will be investigated. CCKWs and other equatorial waves form the "building blocks" of the active phase of MJO. The main effort will be to organize and execute the Equatorial Line Observations (ELO) field campaign during the winter of 2018/2019 – as a component of the International Years of the Maritime Continent (YMC) program. Based on collected in-situ data as well as other observational, remote sensing and modeling datasets, the key physical mechanisms responsible for multi-scale interactions associated with the propagating atmospheric convection over the Maritime Continent will be analyzed.

Field Campaign description

We propose to organize ELO as part of the international YMC program, to study convective-dynamical atmospheric systems and their land and ocean interactions over the MC.

Approach: The ELO experiment is proposed to take place between 1 November 2018 and 28 February 2019 during the international YMC program. ELO is designed to fill in critical gaps in observations of multi-scale interactions between propagating and stationary modes of convection. The main objective is to collect atmospheric and oceanic data that characterize diurnal cycles of atmospheric convection and upper ocean temperature during CCKW and MJO propagation across the MC region. The observational network will consist of three land-based and two ocean-based stations (Figure 1). We will deploy meteorological and oceanographic instruments to measure upper ocean dynamics and thermodynamics, surface fluxes and precipitation and atmospheric stratification to characterize their intraseasonal variability.

The experimental design of the ELO field campaign is to comprise of four components along the equator, which will allow for coherent observations of dynamical and thermodynamical properties of the atmosphere and ocean during CCKW and MJO events across the MC.

The first component, west of the Sumatra coast in the eastern Indian Ocean (Figure 1), will measure the oceanic upper layer temperature and salinity using two autonomous Seagliders that will act as virtual moorings at stations on the equator at 95°E and 97°E. These locations are both within the range of the atmospheric convective systems that propagate westwards offshore from Sumatra as part of the diurnal cycle (Love et al., 2011). The goal is to understand the variability in the development and evolution of the warm layer and diurnal cycle before the CCKW approaches the land. The Seagliders will continuously dive to 1000 m and ascend to the surface, approximately every 3 hours, taking high vertical resolution (~0.5 m) measurements of temperature, salinity, pressure, dissolved oxygen and chlorophyll concentration, along with dive-average currents.

Figure 1: Map of the location of the ELO field campaign ocean stations (yellow squares) and land stations (orange circles) in the Maritime Continent.

Two land-based meteorological stations in Western Sumatra serve as the second component: they include an Indonesian government meteorological office (BMKG) station in Padang and a nearby Earth Atmospheric Radar (EAR) mountain station. The two stations are separated by only a short distance (100 km), but have a large vertical displacement that will enable a better characterization of the diurnal evolution of convection during its propagation away from the mountain range. Atmospheric measurements will include upper level soundings, precipitation, continuous local remote sensing profiles of atmospheric temperature, humidity and water vapor, cloud base and cloud cover, evolution of convection and vertical structure of rainfall, solar and infrared radiation, wind speed and turbulent fluxes from meteorological masts. We will work with BMKG, as well as Kyoto University researchers (who have relevant instrumentation at the EAR station), to obtain access to their observations and we will augment these observations with several instruments (flux tower, MPL Lidar, Ceilometer, microwave radiometer, wind profiler).

The third component has been submitted separately to NSF Ocean by Dr. Janet Sprintall. It consists of a moored thermister chain that will be deployed within the shallow waters of Karimata Strait that are unsuitable for Seaglider operations. The mooring will have high vertical resolution near the surface with thermistors at 10 cm, 50 cm and 1 m depths, and 1 m vertical resolution down to 15 m, and 5 m resolution below 15 m. The purpose is to study evolution of the upper ocean temperature warm layer associated with the diurnal convection and its variability during the propagation of the CCKWs and MJOs.

The final and fourth component is the land station on the west coast of Borneo in Pontianiak. This station has similar instrumentation to that of the Sumatra stations. The purpose of this station is to study the dynamical and thermodynamical properties of the diurnal cycle of the convection over relatively flat topography, and compare its variability associated with enhanced convection expected over Sumatra and its relationship to CCKW activity.

Expected Outcomes: The ELO field campaign will create a unique dataset of atmospheric and oceanic in-situ and remotely sensing measurements targeted at multi-scale interactions between the propagating convection and the local environment. The data will greatly advance our understanding of the non-linear processes and feedbacks responsible for convection propagation blocking in the MC region, along the equator from the eastern Indian Ocean to Borneo within the MC. During the four-month deployment period we expect (based on climatology) to measure approximately 14 CCKW and 2 MJO events. The collected data will include about 2000 ocean stratification profiles from the Seagliders, 700 atmospheric soundings along with a continuous 4-month record of surface fluxes, remotely sensed atmospheric profiles as well as the upper ocean temperature profiles from Karimata Strait. The quality controlled observations will be analyzed using time series statistical analysis and data-model comparisons. All data will be made publically available to the community in a timely fashion.

Atmospheric Radiation Measurement-Diurnal Cycle Interactions with Madden-Julian Oscillation Propagation (ARM-DIMOP)

Contact point:
Samson Hagos (Pacific Northwest National Laboratory)

Overview:
In this campaign, we plan to investigate radiative and turbulent flux processes before, during and after the passage of MJO episodes with the aim at explaining why some events of the MJO successfully cross the MC while others do not. Specifically we will explore the mechanism that controls the strength of the diurnal cycle over the MC. We hypothesize that land surface conditions (ground moisture) and cloudiness (deep clouds) ahead of MJO convection centers modulate the diurnal cycle in land convection and hence subsequent MJO propagation across the MC. Paired with operational ground radar, satellite observations and measurements from the broader International YMC field observations, the surface-based data collected by our deployment of US Department of Energy's Atmospheric Radiation Measurement Program instruments will help quantify the comparative roles of these and possibly other processes key to the barrier effect of the MC on MJO propagation. The field campaign will collect measurements of precipitation, soil moisture, surface radiation and turbulent fluxes for a one-year period. As the first step in testing the proposed hypothesis, MJO events during the observation year will be grouped into propagating and disrupted based on whether they successfully cross the MC. We will use the collected observations to make composite diurnal cycles of the various variables for the two types of MJO events to examine their possibly distinct features during all the phases of the MJO events. The surface flux and soil moisture measurements will be used to identify those features. The second task is to extend the analysis to about 50 MJO events initiated over the Indian Ocean during the TRMM era by examining the relationship between the one-year-long point measurements of surface radiation with (i) areal mean precipitation (~220 km diameter) estimated from the BMKG C-Band radar, (ii) TRMM precipitation, and (iii) geostationary satellite infrared brightness temperature measurements. A correlation of the point measurement with these spatial and long-term measurements would allow us to generalize the findings from the first step via satellite proxies to a large number of MJO episodes.

Observations:
We propose to deploy the following instruments at BMKG weather station in Pontianak, Kalimantan for one year.

- Upwelling Radiation (GNDRAD)
- Down-welling Radiation (SKYRAD)
- Eddy Correlation Flux Measurement System (ECOR)
- Surface Energy Balance System (SEBS)
- Surface Meteorology Systems (MET)
- Tipping Bucket Rain Gauge (RAIN)
- Ceilometer (CEIL), particularly the newer Vaisala model CL31

Period:
September 2018 - September 2019

STEAM/GAIA project

Contact point:
Jae Hak Lee (KIOST)

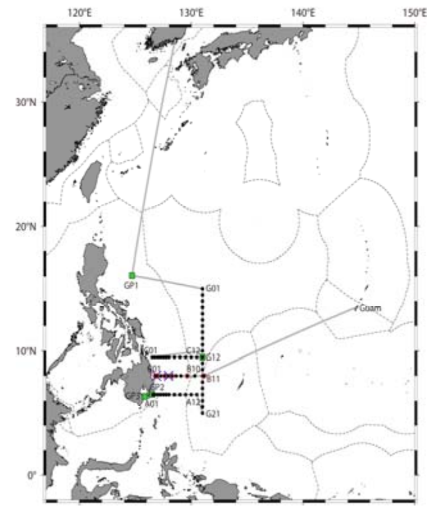
Overview:
This is a joint effort by Philippines and Korea to monitor low latitude western boundary currents and to study air-sea heat flux in the south Philippine Sea. Heat-flux study is focusing more on understanding diurnal cycle and regional differences.

Objective:
Monitoring low latitude western boundary currents and air-sea interaction in the south Philippine Sea

Period:
November 17 - December 12, 2017
Warm season, 2018, 2019

Participants:
Korea - KIOST, Inha University, Hanyang University
Philippines - University of the Philippines

Location:



Observation sites.

Observations:
Current meter/CTD moorings, CTD casting, radiosonde, surface meteorology