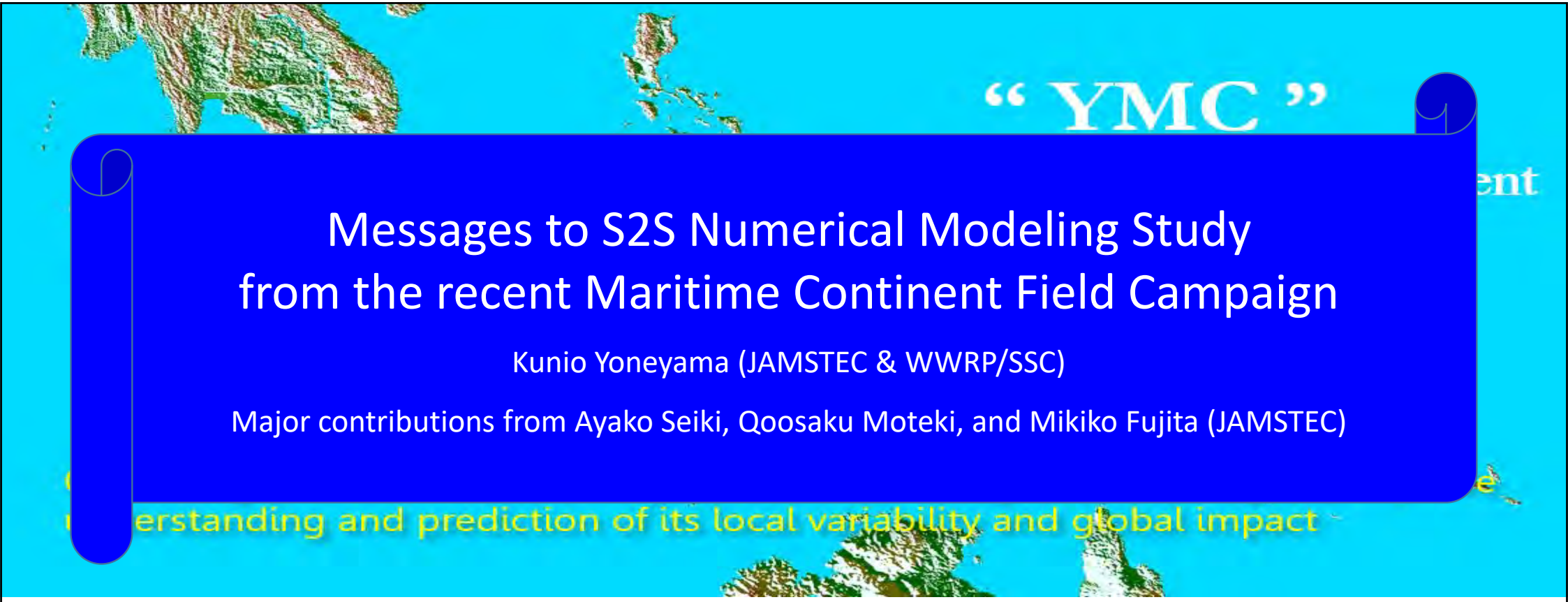

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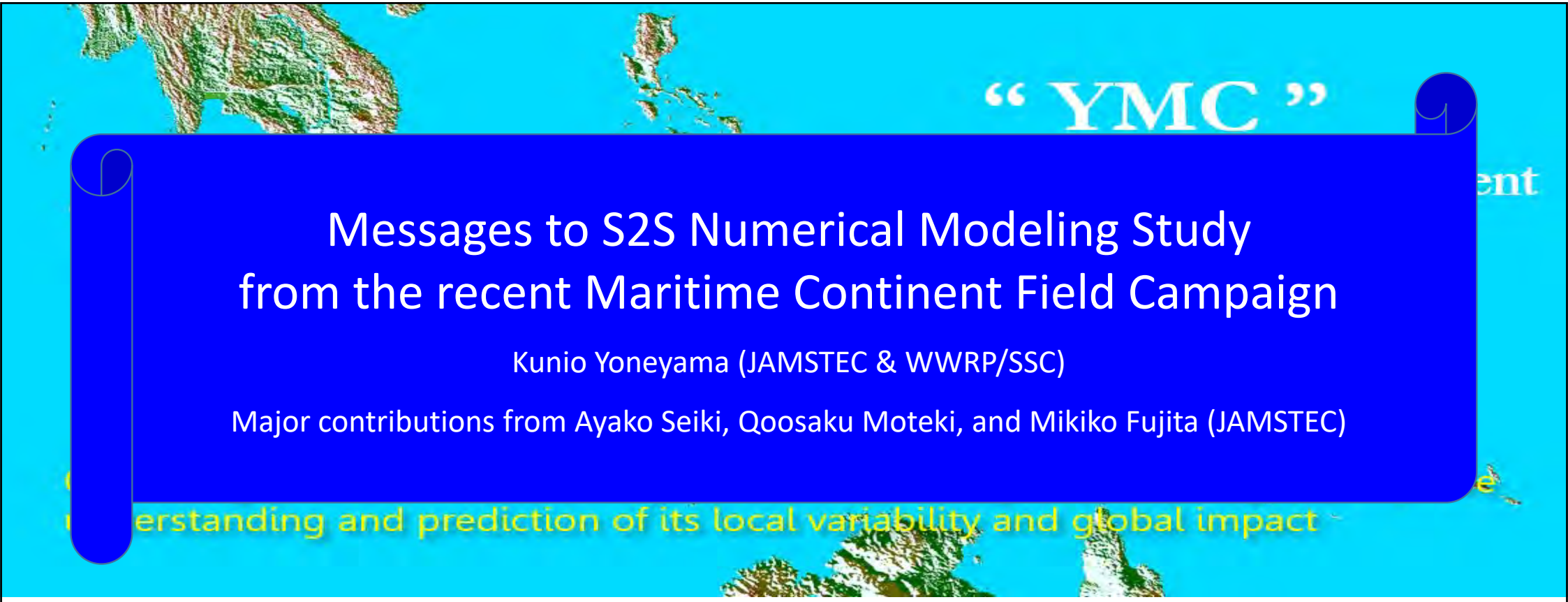

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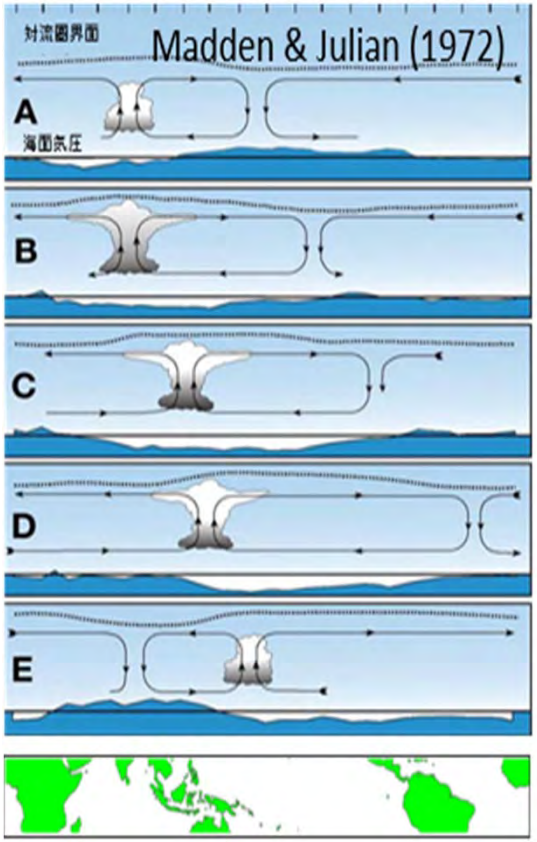
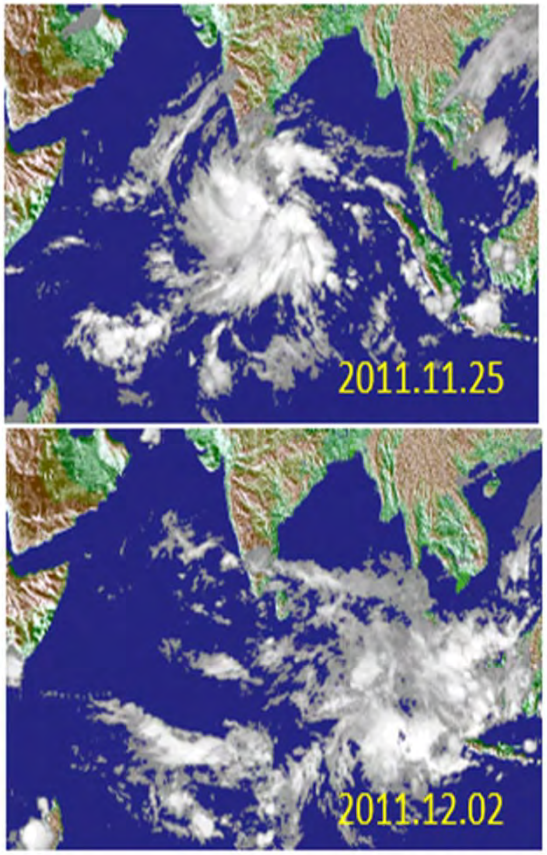
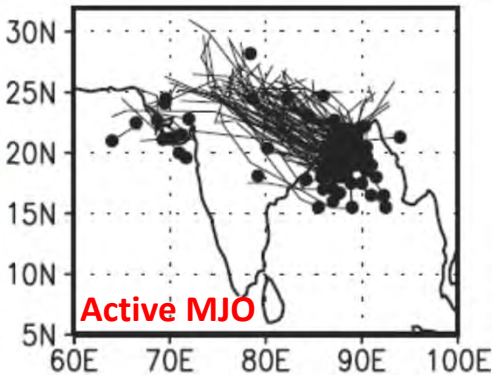
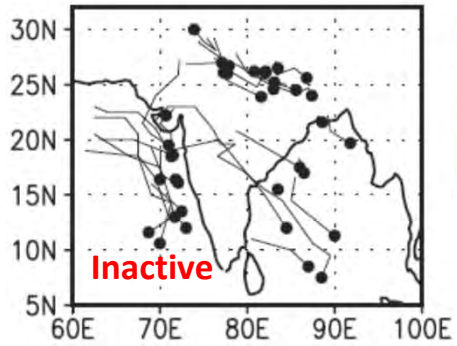
MJO Impact onto TC Activity





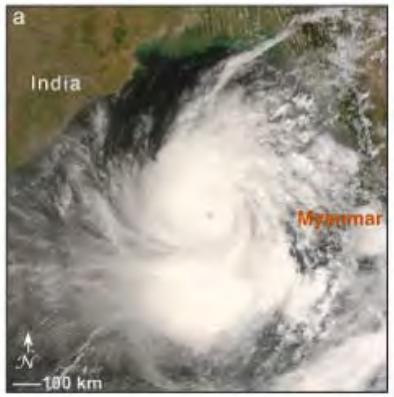
Tracks of Monsoon Low (=Rain)





Goswami et al. (2003)

MJO caused cyclone Nargis.
138,000 dead & missing
$ 4 billion loss



McPhaden et al. (2009)

MJO Determines the onset of Indian Monsoon
Causes tropical cyclones
Causes heavy rainfall with a flood over Asia
Influences mid-latitude weather via teleconnection, etc.

Background : Previous Field Campaign for the MJO-convection Onset Study

CINDY2011/DYNAMO/AMIE Campaign

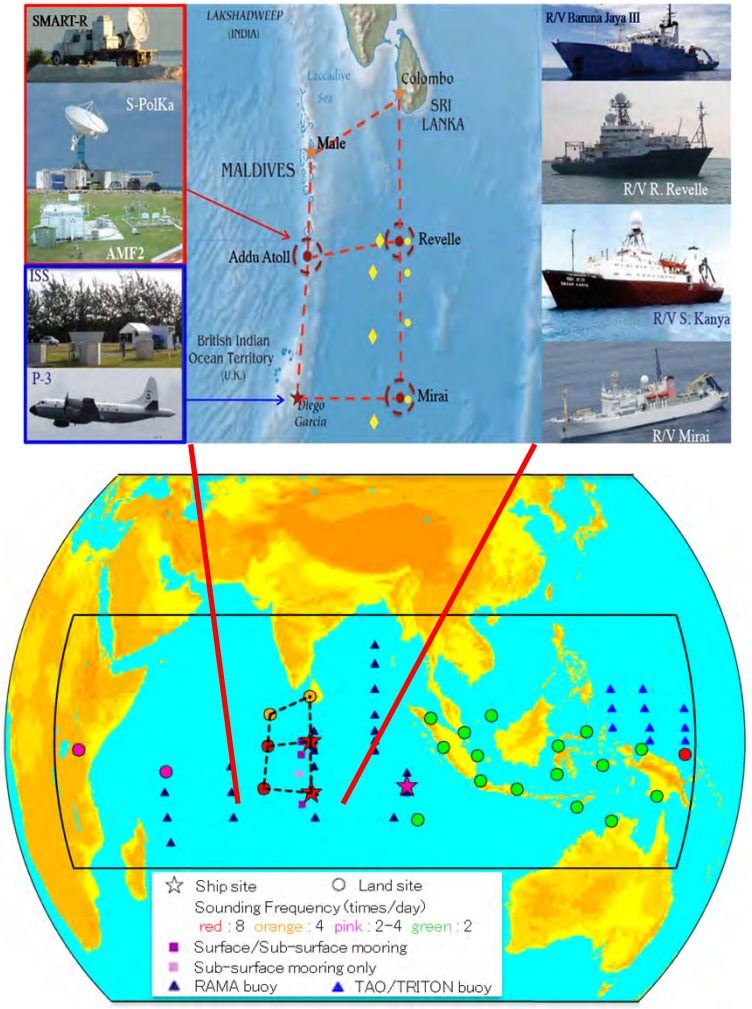
Period :
Oct. 2011 - Jan. 2012 (IOP)

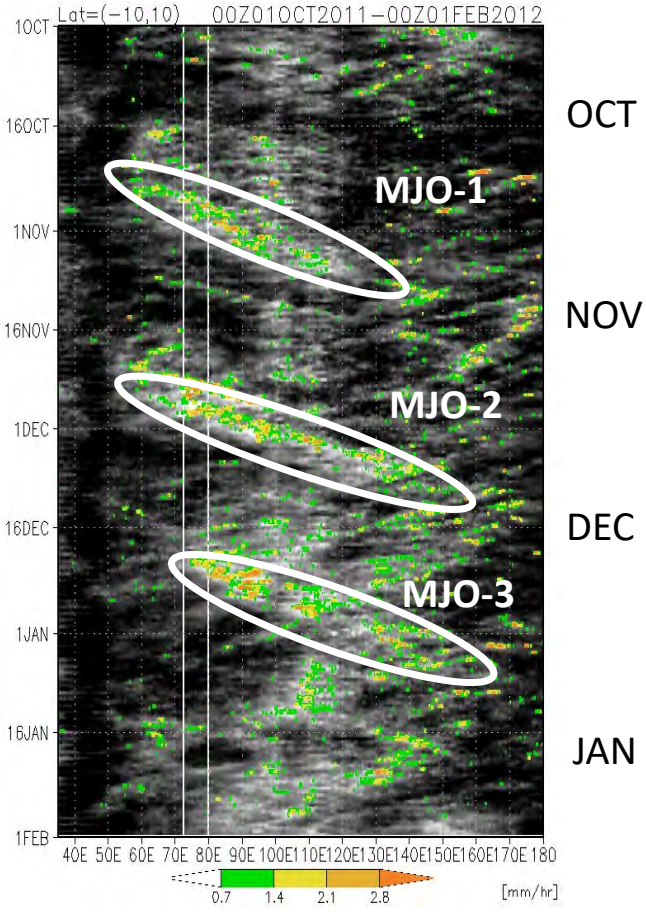
Participants:
69 Institutes/universities
from 15 countries/regions

Platforms:
4 ships, 2 aircrafts, 4 islands,
RAMA array, Sfc/sub-sfc moorings,
Radiosonde sounding network

Publications:
Over 200 papers

Websites:
http://www.jamstec.go.jp/cindy/
https://www.eol.ucar.edu/field_projects/dynamo



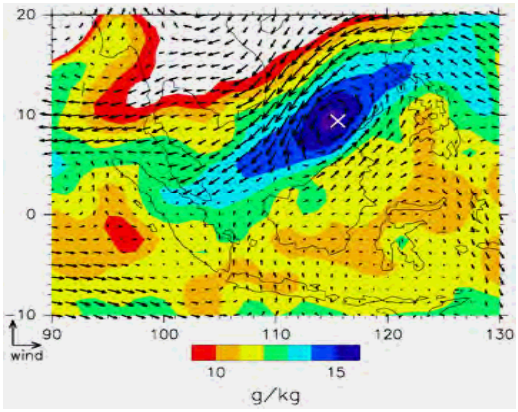


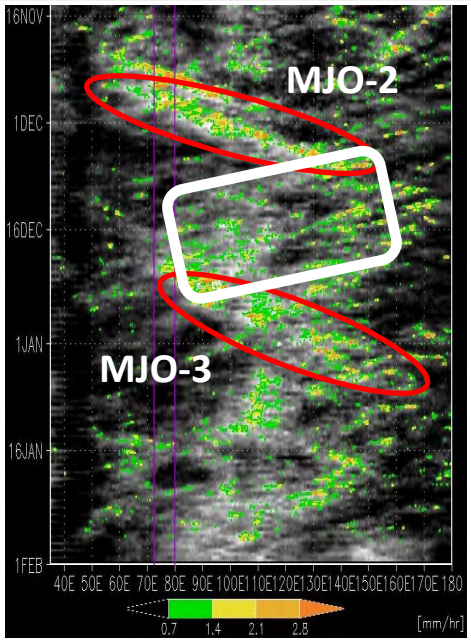
TBB & Rainfall

Yoneyama et al. (2013, BAMS)

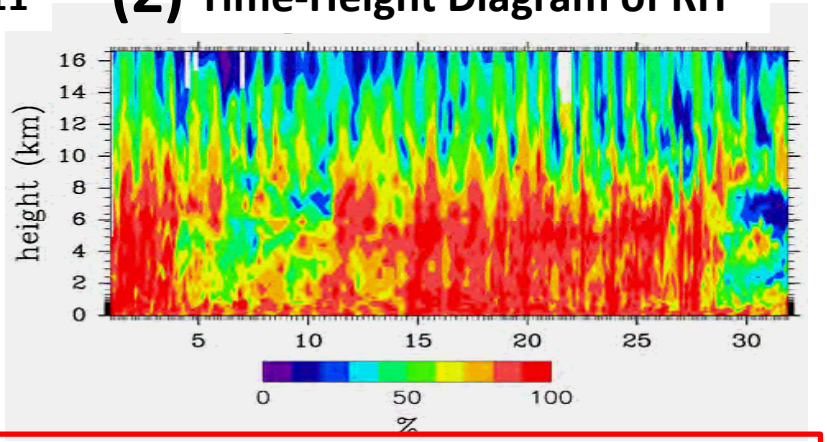
Background : MC is the source of westward cloud system over IO?

(1) TC over South China Sea on Dec 11





(2) Time-Height Diagram of RH



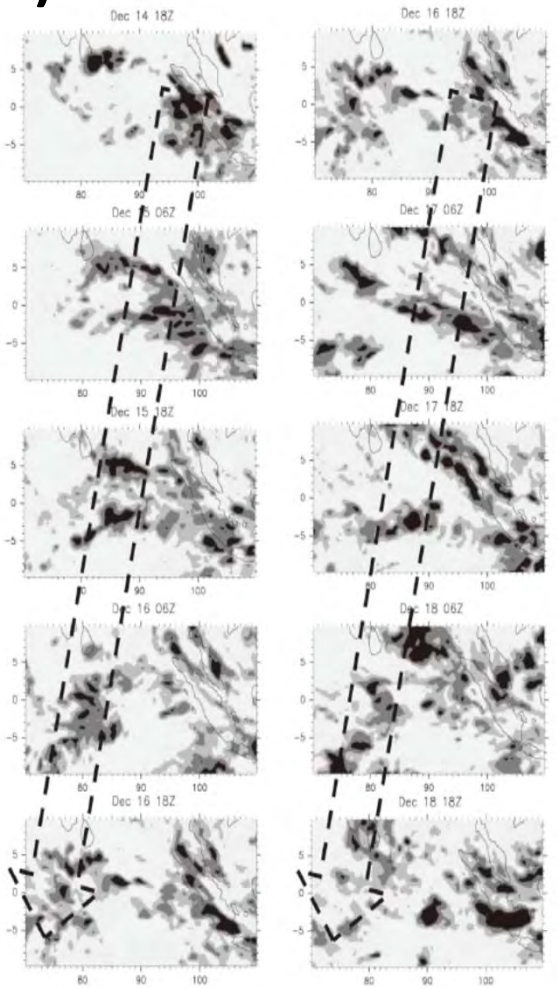
(1) Moist air associated with TC over SCS arrived at Sumatra on Dec 11

(2) Convection with diurnal cycle became active over Sumatra from Dec 11

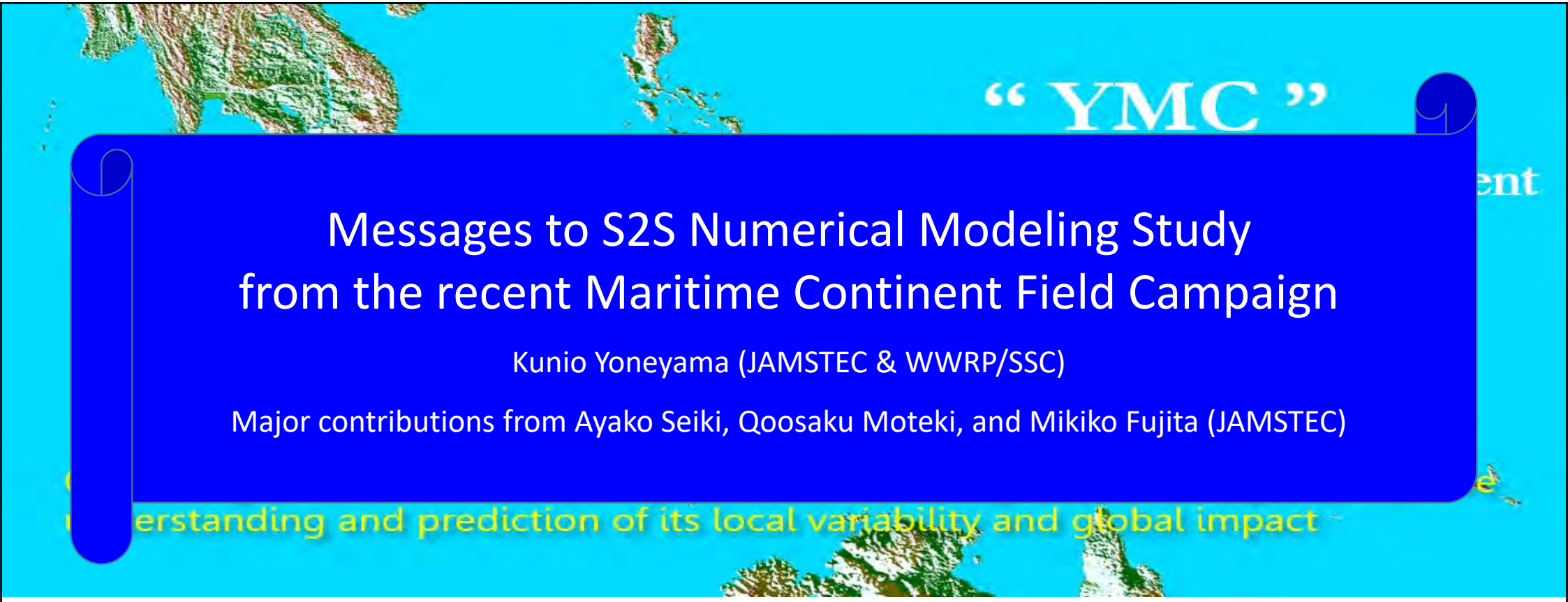
(3) Cloud cluster developed over Sumatra moved westward with 2-day cycle.

(4) After several cloud clusters arrived over the central Indian Ocean, MJO convection developed in late December.

(3) 2-day Inertio-gravity wave



Kubota et al. (2015, JMSJ)



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Seiki et al. (2021, JMSJ) : MC and Upscale Effect ?

"The impact of diurnal precipitation over Sumatra Island, Indonesia, on Synoptic Disturbances and its Relation to the Madden-Julian Oscillation"

Data

- GSMaP (the Global Satellite Mapping of Precipitation) RNL
  Precipitation data : 0.1° / hourly
- JRA-55 : atmospheric variables (u, v, etc) : 1.25° / daily
- Reynolds OI SST : 0.25° / daily

Period : Mar. 2000～Feb. 2014
Sept. - Apr. (rainy season)

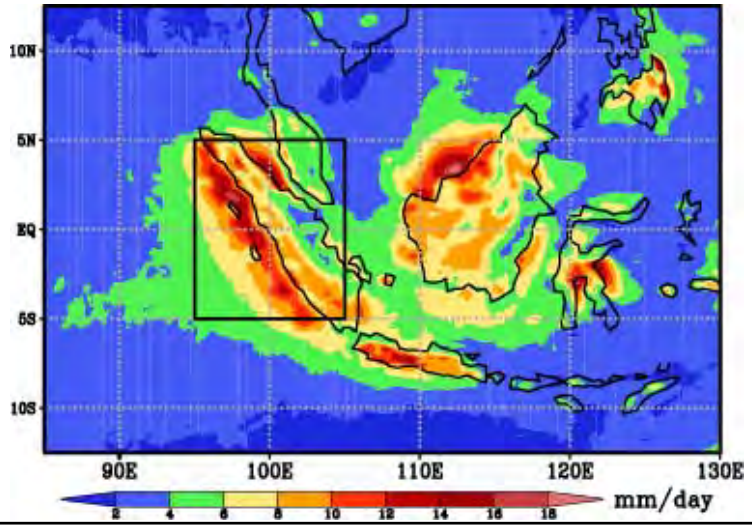
Definition of MJO : RMM index (Wheeler & Hendon 2004)
- MJO days : RMM Amp > 1 for consecutive 15 days
- Non MJO days : RMM Amp < 0.63 (= Mean - 1 std)

Definition of Diurnal events

Amp.

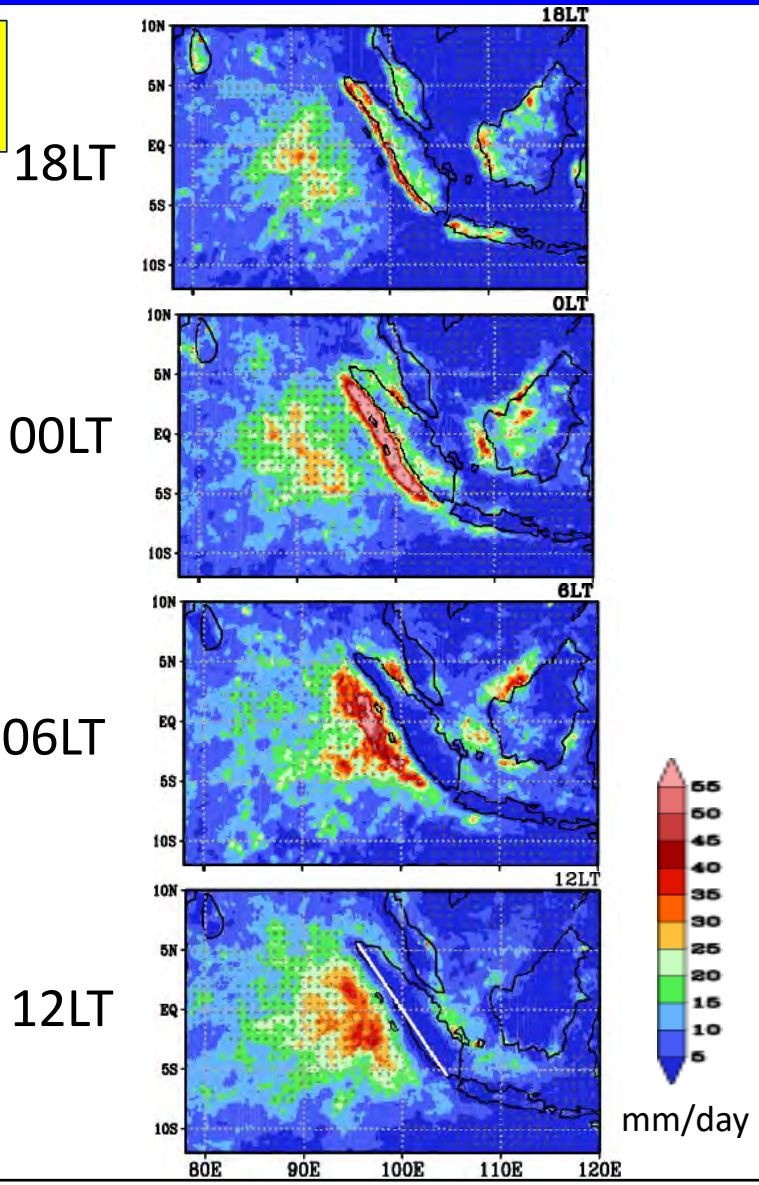
$$r = \bar{r} + A\cos\left\{\frac{2\pi(t - t0)}{24}\right\}$$

Strong diurnal events
Area-mean A ＞ mean + 1.0 Std
Weak Diurnal events
＜ mean - 1.0 Std

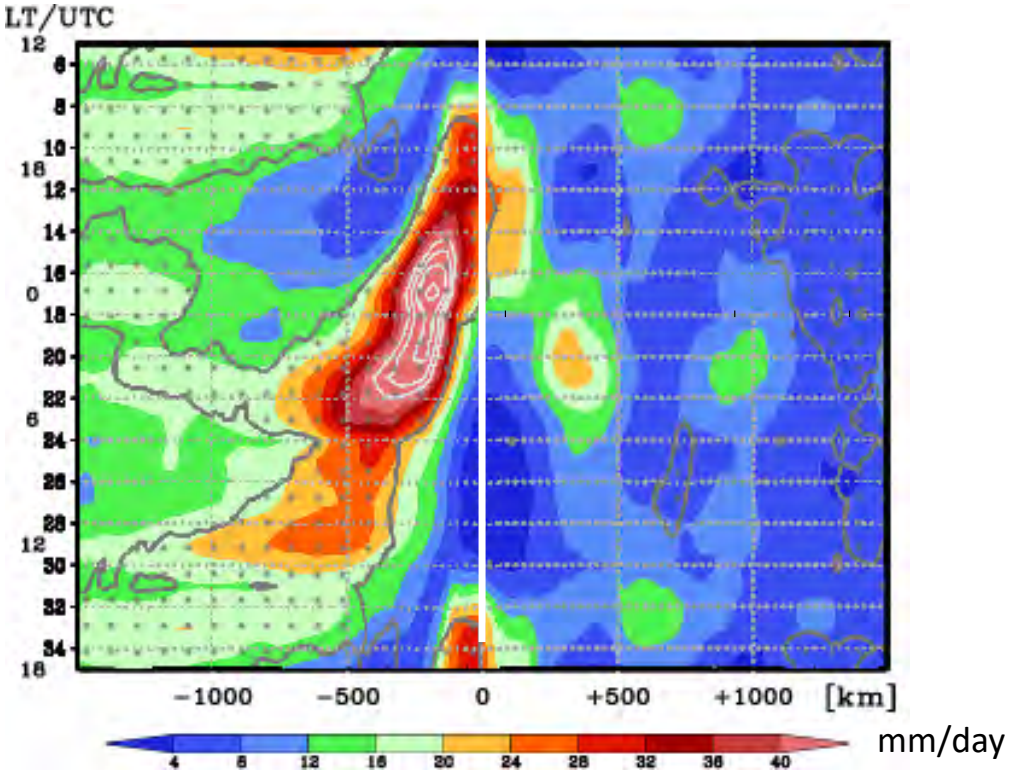


Seiki et al. (2021, JMSJ) : Offshore propagation of diurnal rain

Composite hourly PR



Composite diurnal cycle of hourly PR for the **strong** DEs as a function of distance from the coastline



（hatch = significant at 95% level）

Seiki et al. (2021, JMSJ) : Upscale Effect ?

Eddy Kinetic Energy $K' = \dfrac{\overline{u'^2} + \overline{v'^2}}{2}$

mean ($\bar{}$) = 11-day running mean
= **ISV-scale and longer**

eddy (') = residual
= **synoptic scale**

$$\frac{\partial \bar{K}'}{\partial t} = -\overline{V'_h (V' \cdot \nabla) \bar{V}_h} - \bar{V} \cdot \nabla \bar{K}' - \overline{V' \cdot \nabla K'} - \frac{R}{p} \overline{\omega' T'} - \nabla \cdot (\overline{V' \Phi'}) + D$$

advection

redistribution

residual

Energy conversion from mean to eddy (K→K')

$-\overline{u'u'}\partial \bar{u} / \partial x$
$-\overline{u'v'}\partial \bar{u} / \partial y$

(dominant terms)

Associated with mean horizontal shear

eddy available potential energy to eddy KE (APE'→K')

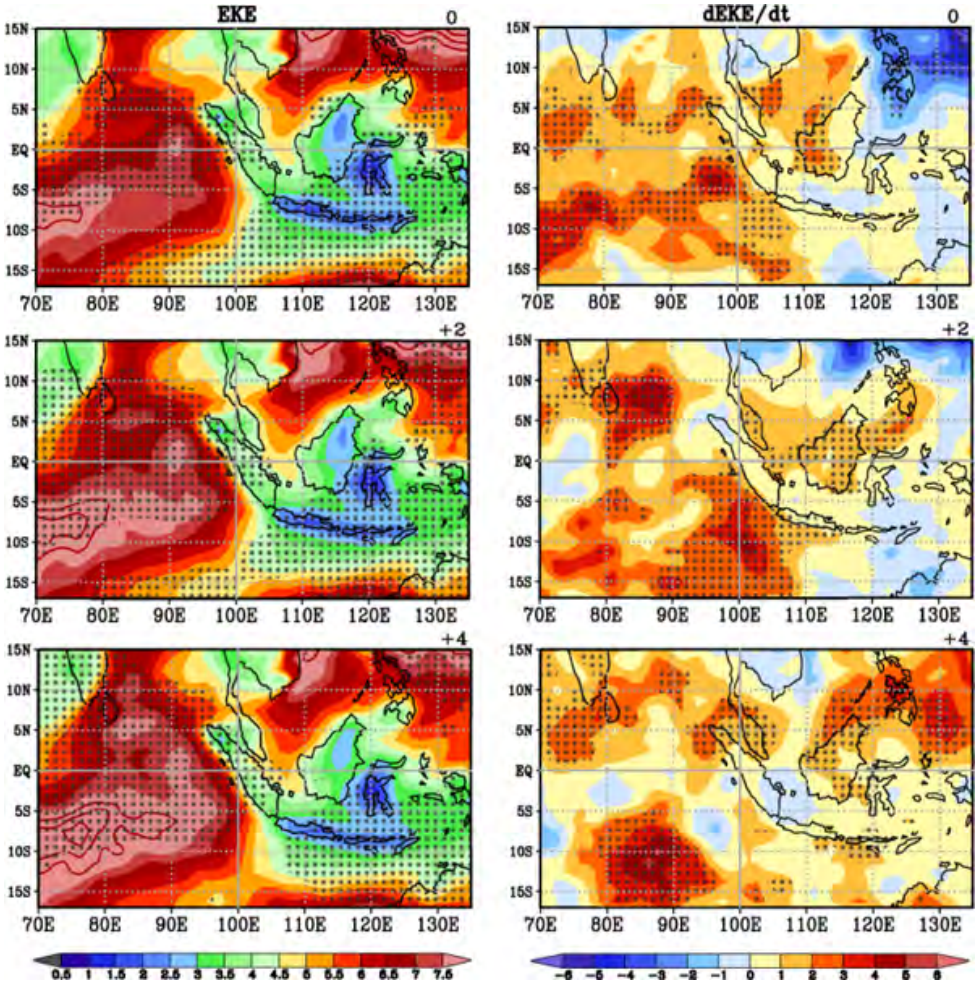
Associate with synoptic convection

Seiki et al. (2021, JMSJ) : Upscale Effect ?

Strong D Event

EKE

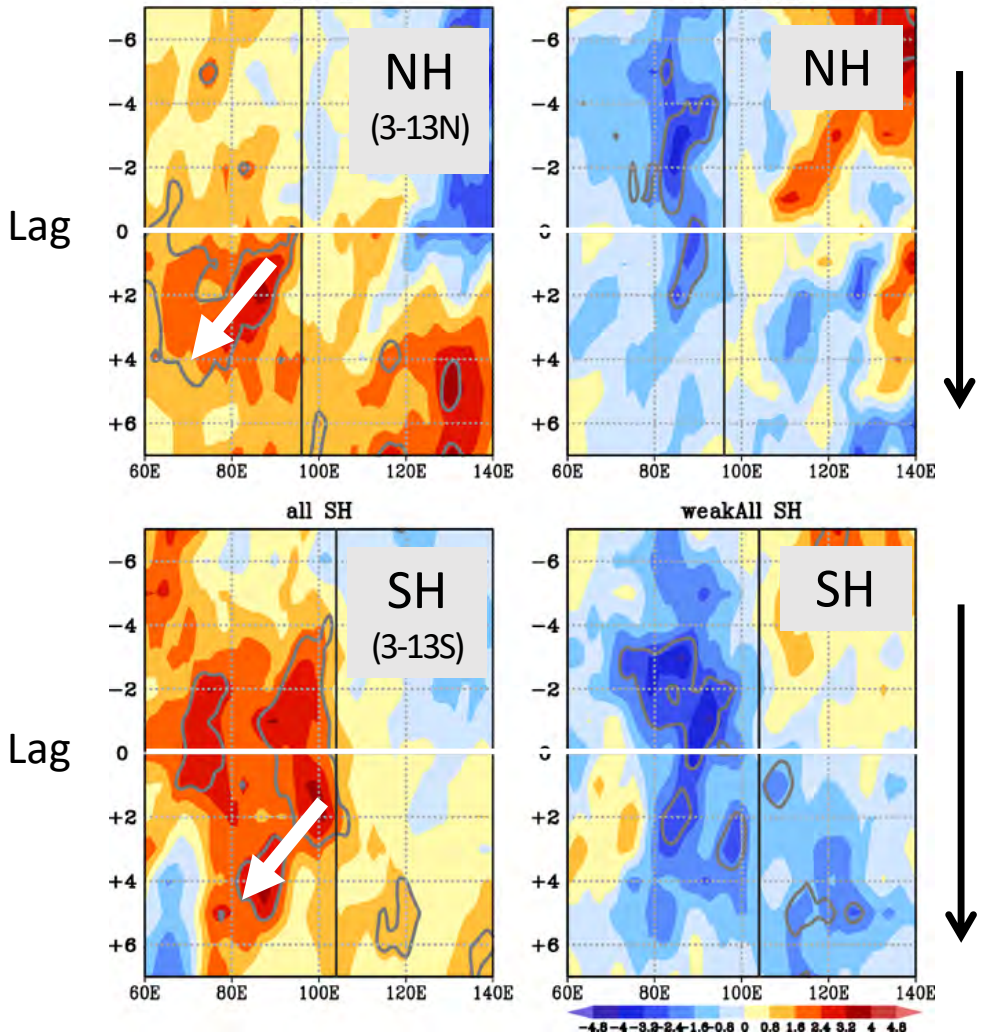
dEKE/dt



dEKE/dt

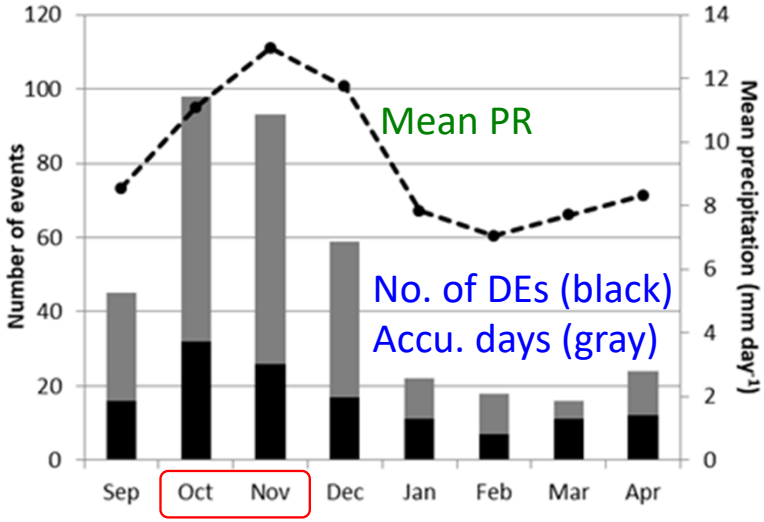
Strong D Event

Weak D Event

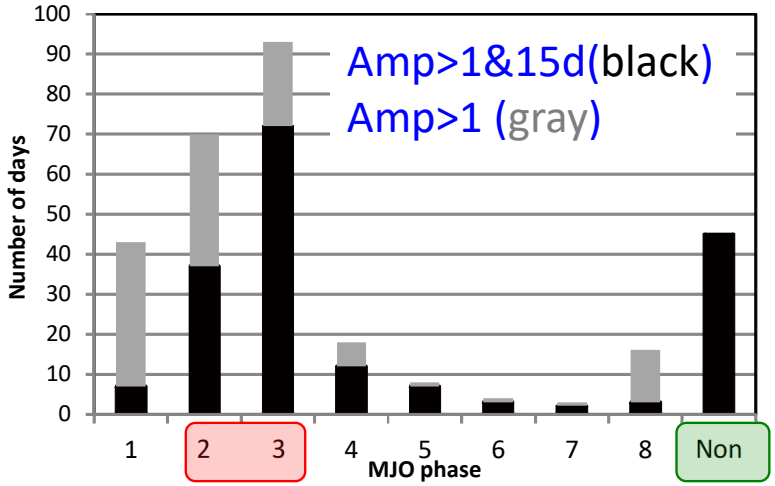


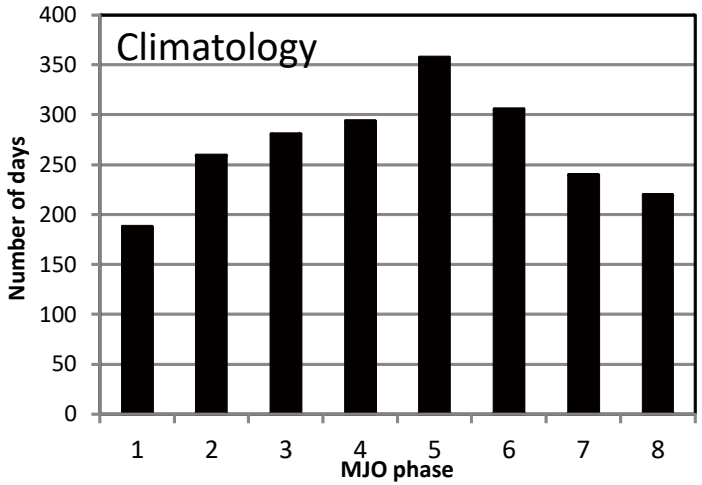
Seiki et al. (2021, JMSJ) : Statistical Features of the Strong Diurnal Events

Monthly distribution of the diurnal events (black bar) and mean PR (line) averaged for the Sumatra area (95-105E, 5S-5N)



Accumulated days for the diurnal events in each MJO phase



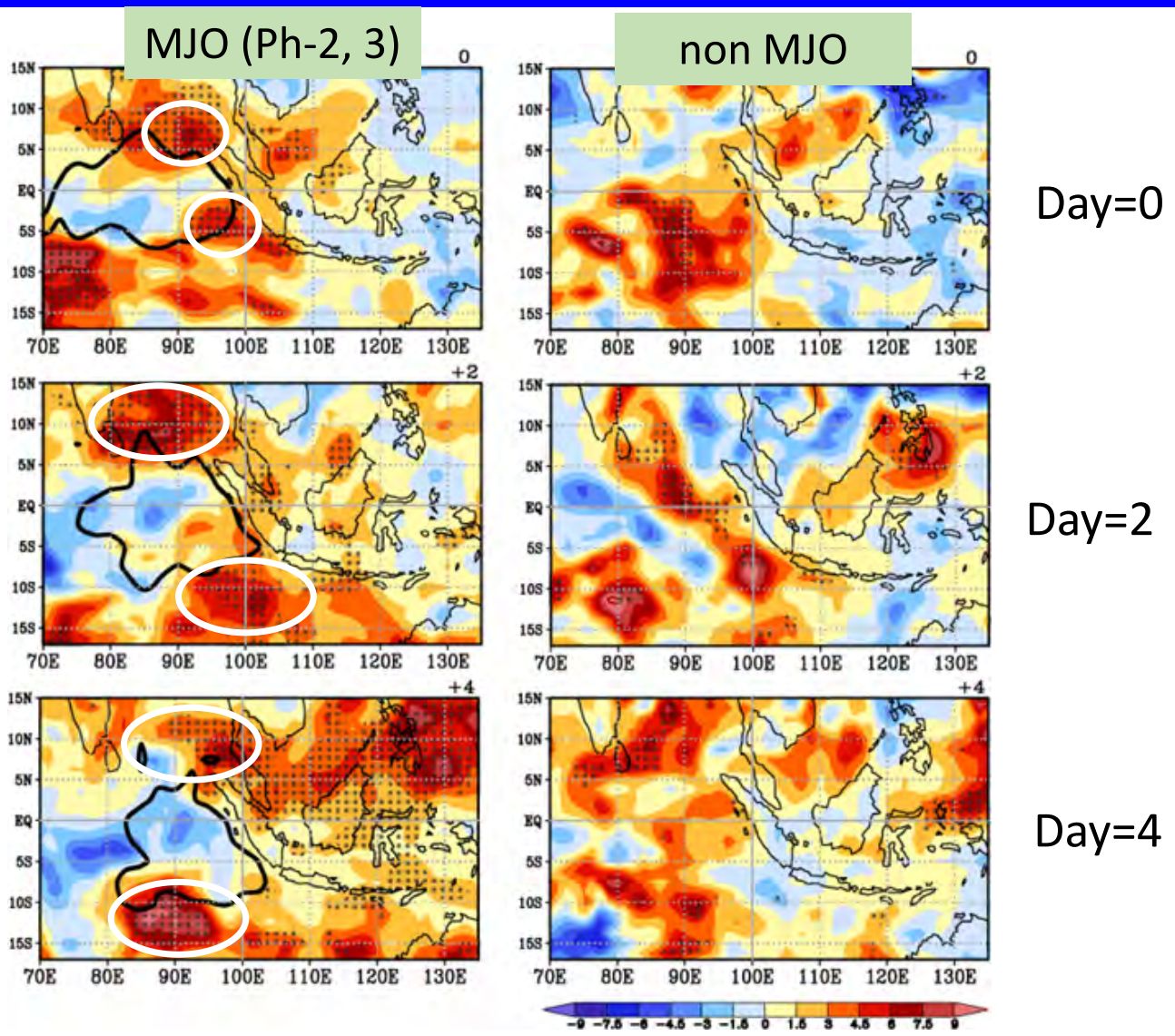


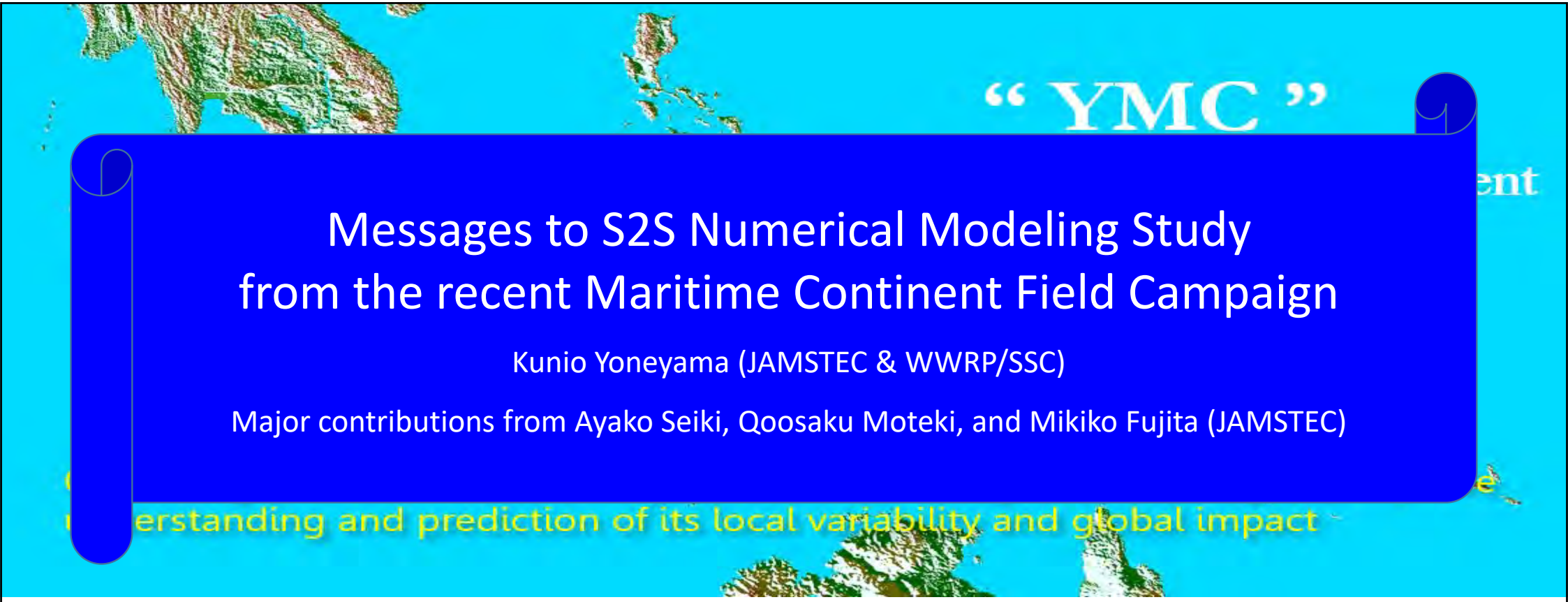
Seiki et al. (2021, JMSJ) : dEKE/dt < MJO-IO (Ph-2, 3) vs. non-MJO >

Composite of dEKE/dt at 850hPa
for strong diurnal rainfall events

(Left) MJO Phase - 2, 3
(Right) non-MJO (weak signal)

Twin disturbances across
the EQ develop & migrate
westward/poleward only
when the MJO-convection
is located in the IO





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YMC - Years of the Maritime Continent

Purpose

To expedite progress of improving our understanding and prediction skill of local multi-scale variability of the MC weather-climate systems and its global impact.

Participants

Over 70 institutes/universities from
Australia, China, France, FSM, Germany,
Indonesia, Japan, Malaysia, Palau, Philippines,
Singapore, Taiwan, UK, US, Vietnam, and more.

Period

Phase-1 July 2017 – Feb 2020 (IOPs)
Phase-2 Mar 2020 - Mar 2023 (Feedback + IOPs)

Main Science Themes

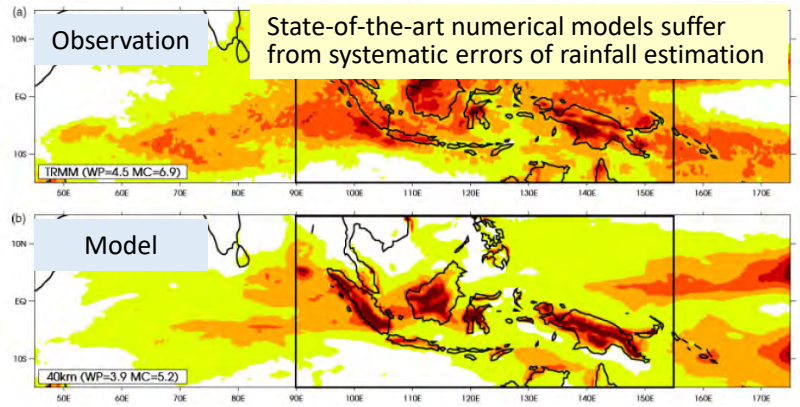
1) Atmospheric convection (ex. Diurnal cycle, MJO, monsoon)
2) Ocean and air-sea interaction
3) Stratosphere-troposphere interaction
4) Aerosols
5) Prediction

Main Activities

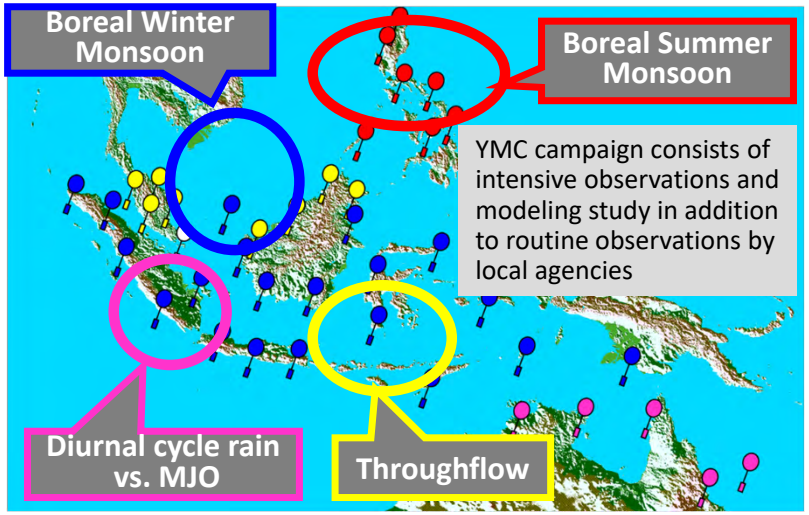
1) Data sharing
2) Field campaign
3) Modeling
4) Prediction and applications
5) Outreaching and capacity building

Websites

http://www.jamstec.go.jp/ymc/
http://www.bmkg.go.id/ymc/



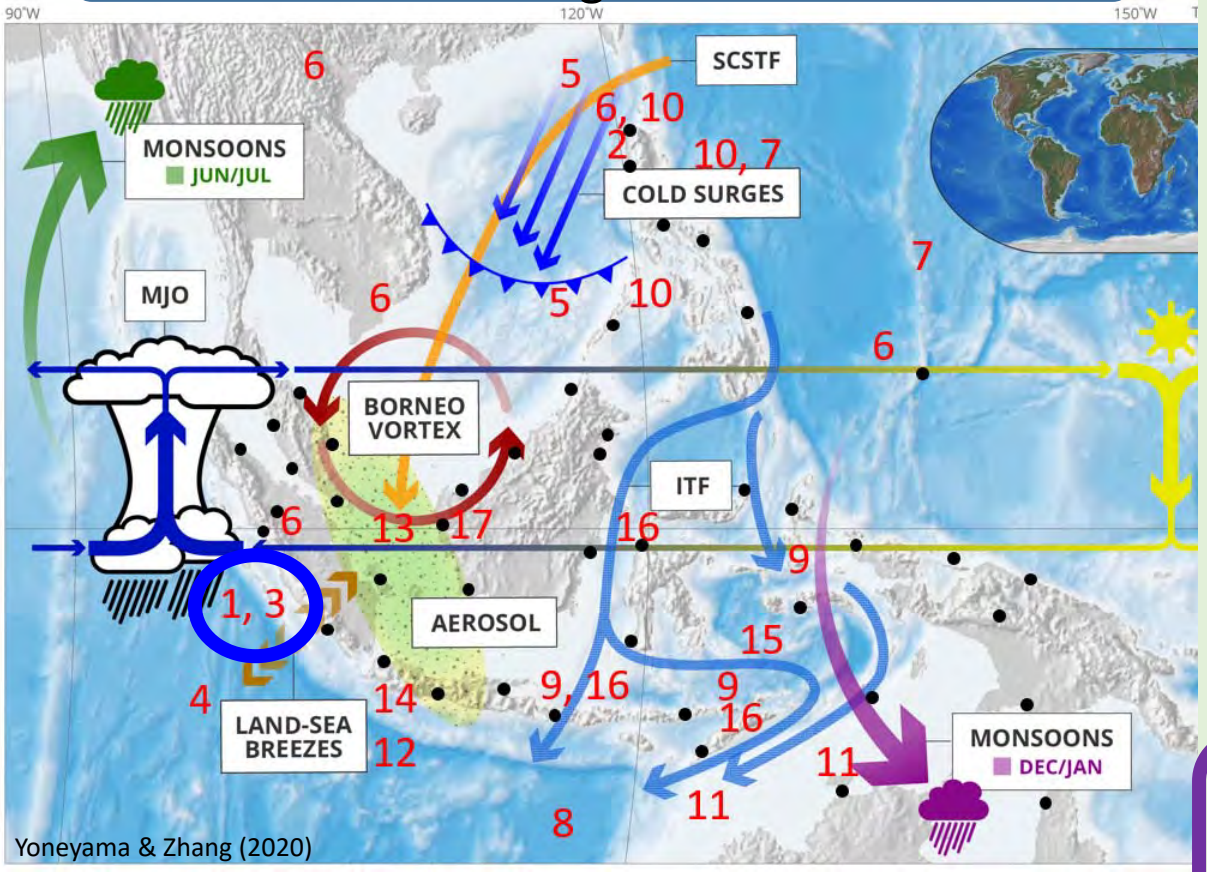
Comparison of monthly mean rainfall for February.
Taken from Love et al. (2011)



Routine sounding sites ( ) & Intensive observation areas ( )

Intensive Observations (including relevant projects)

YMC field campaign consists of intensive observations and long-term measurements.



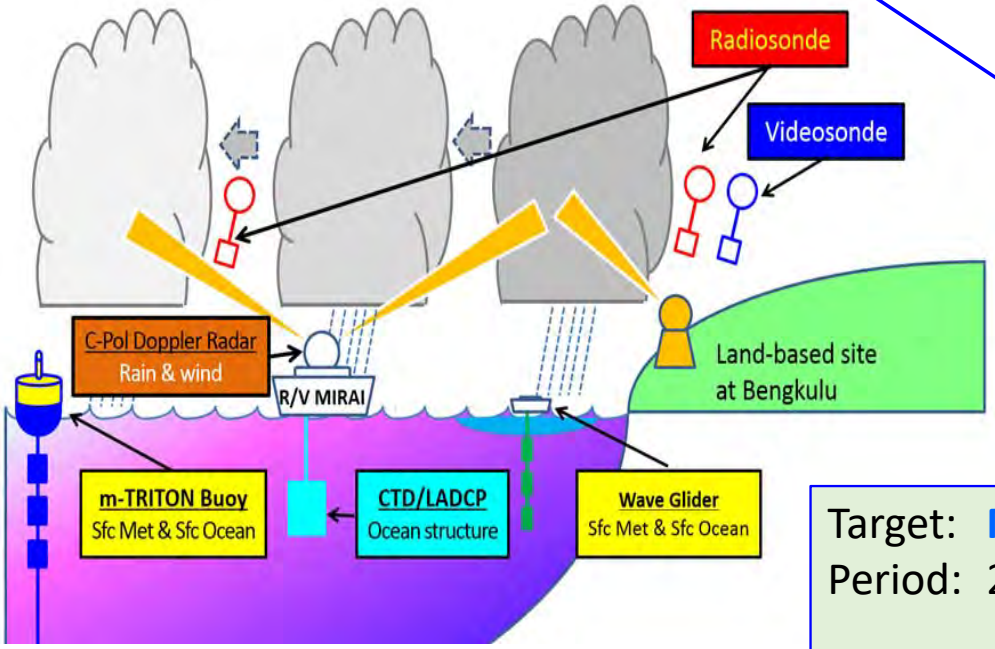
Number Conducted or Planned Intensive Observation Areas

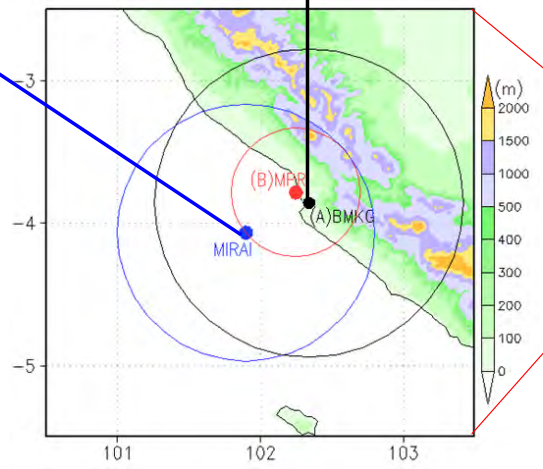
● Radiosonde sounding stations

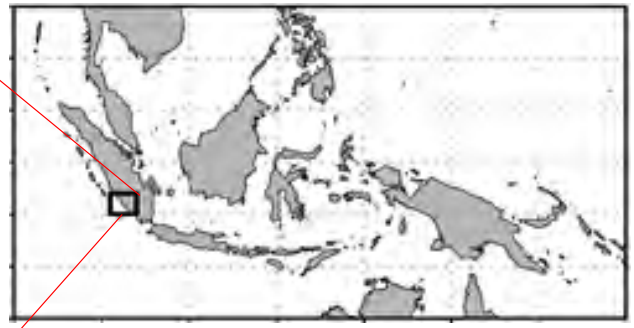
2015.10-12	1	Pre-YMC in Sumatra
2017.08	2	RSVP (air-sea)
2017.11-01	3	Sumatra (MJO, DC)
2017.11-02	4	EIOURI (Upwelling)
2017.12	5	SCSTIMX (monsoon)
2018.03-04	5	SCSTIMX (monsoon)
2018.05-06	5	SCSTIMX (monsoon)
2018.06-08	6	BSM (monsoon)
2018.08-10	7	PISTON (DC, ISV)
2018.11	8	MAMOS/CWPDIP (MJO, Monsoon)
2019.01-04	12	ELO (ocean)
2019.02-03	9	OM/CAT (ITF, tide)
2019.08-10	10	CAMP2Ex (Aerosol)
2019.09	7	PISTON (DC, ISV)
2019.10-12	11	Investigator(MJO, DC)
2020.08-09	6	BSM (monsoon)
2020.12-02	12	ELO (Ocean)
2021.12-02	14	TerraMaris (DC, MJO)
2021.12-02	13	ELO-O (Cold Surge)
2022.01-02	15	Banda Sea (air-sea)
2022.01	16	MINTIE (ITF)

Postponed due to COVID-19

YMC-Sumatra 2015 (Pilot Study) and 2017



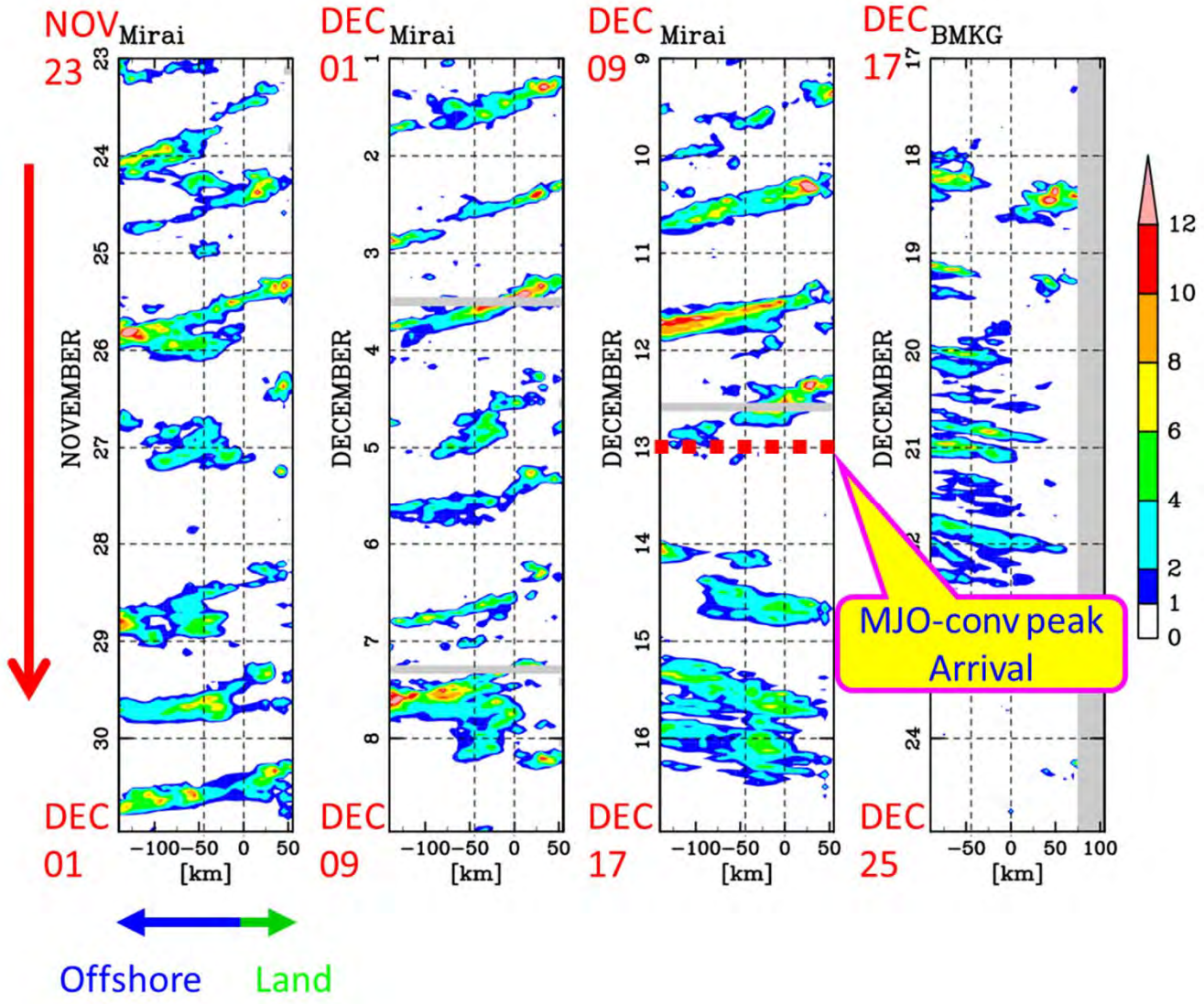


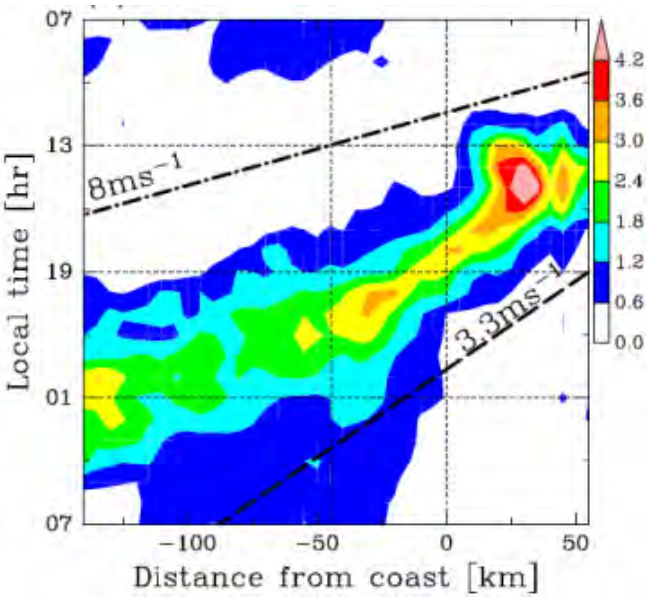


Target: **MJO vs. Diurnal cycle rain near the coast line**

Period:	2015	Land	Nov 9, 2015 - Dec 20, 2015 (42 days)
		Ship	Nov 23, 2015 - Dec 17, 2015 (25 days)
	2017	Land	Nov 16, 2017 – Jan 15, 2018 (61 days)
		Ship	Dec 5, 2017 – Jan 1, 2018 (26 days)

Offshore Propagation of DR during the 2015 campaign



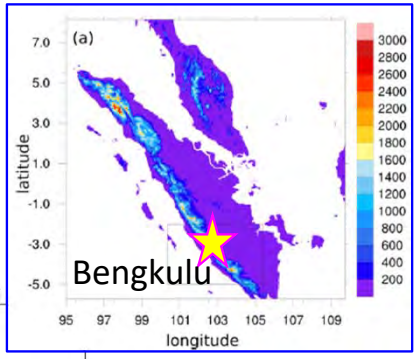


Composite of offshore propagation of diurnal rainfall events

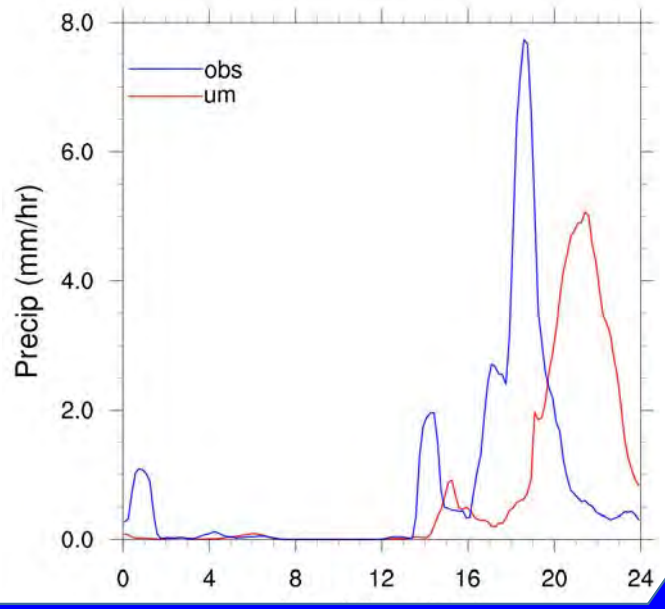
Yokoi et al. (2017, MWR)

Improvement of Numerical Model Skill

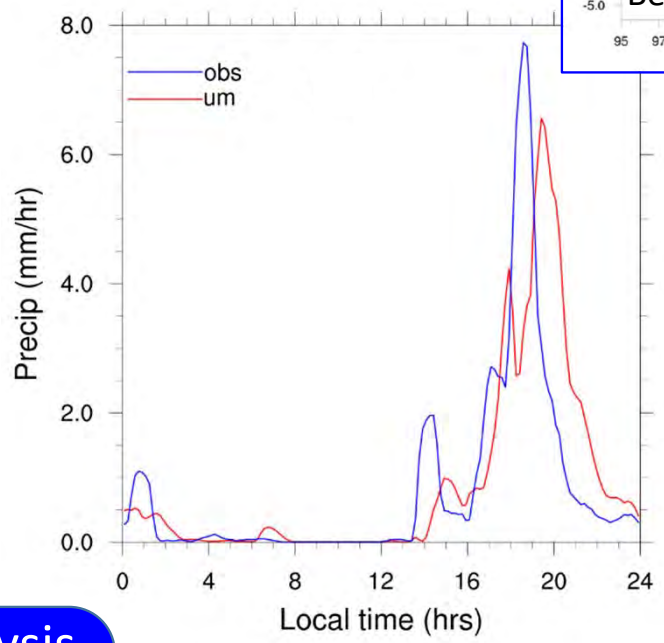
Meteorological Service Singapore used YMC in-situ data and confirmed their modeling skill of diurnal cycle of rain can be improved .



Mean Diurnal Cycle of Rain at Bengkulu



$SST_{control}$ + 2K



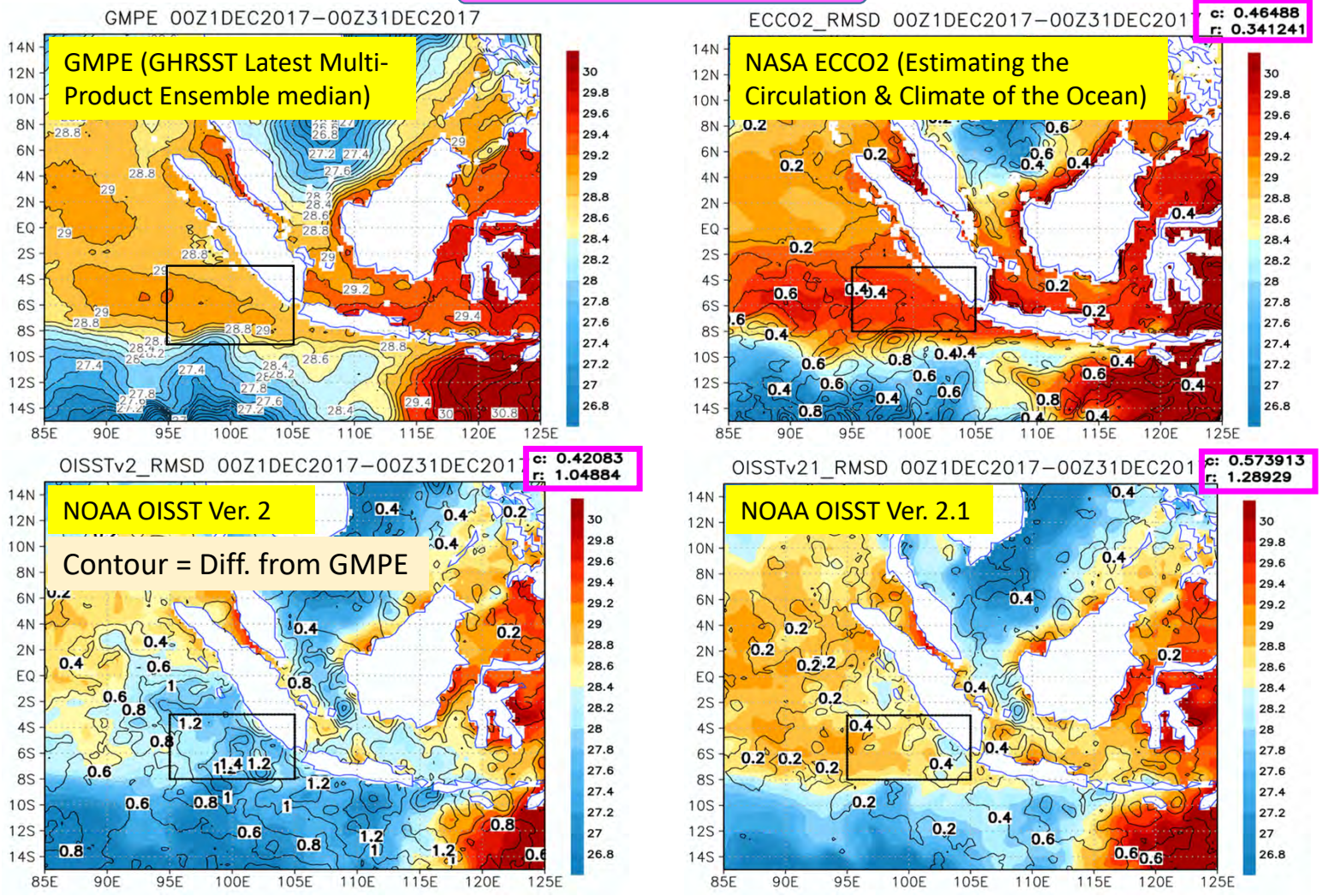
When they changed initial condition data from analysis product to YMC in-situ data, model-result was much improved. This suggests a low-SST bias in initial condition caused a delay of simulated rain over land.

Dipankar et al. (2019, MWR)

Model: SINGV Tropical Ver. of UK Met Office Unified Model (UM) (res =1.5km)

SST Bias in Analysis Products ?

Mean SST (Dec. 2017)



Moteki (2021, to be submitted)

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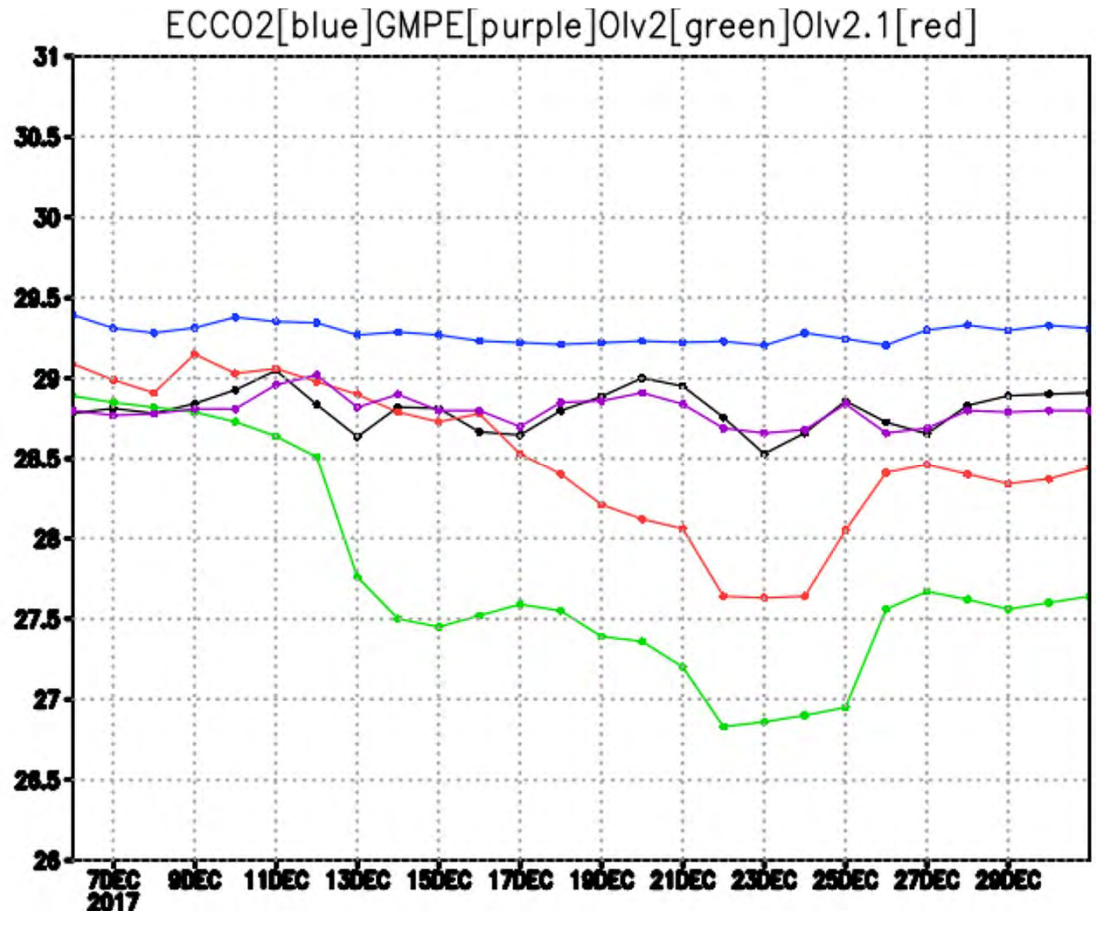


ECCO2

MIRAI (in-situ data)

GMPE

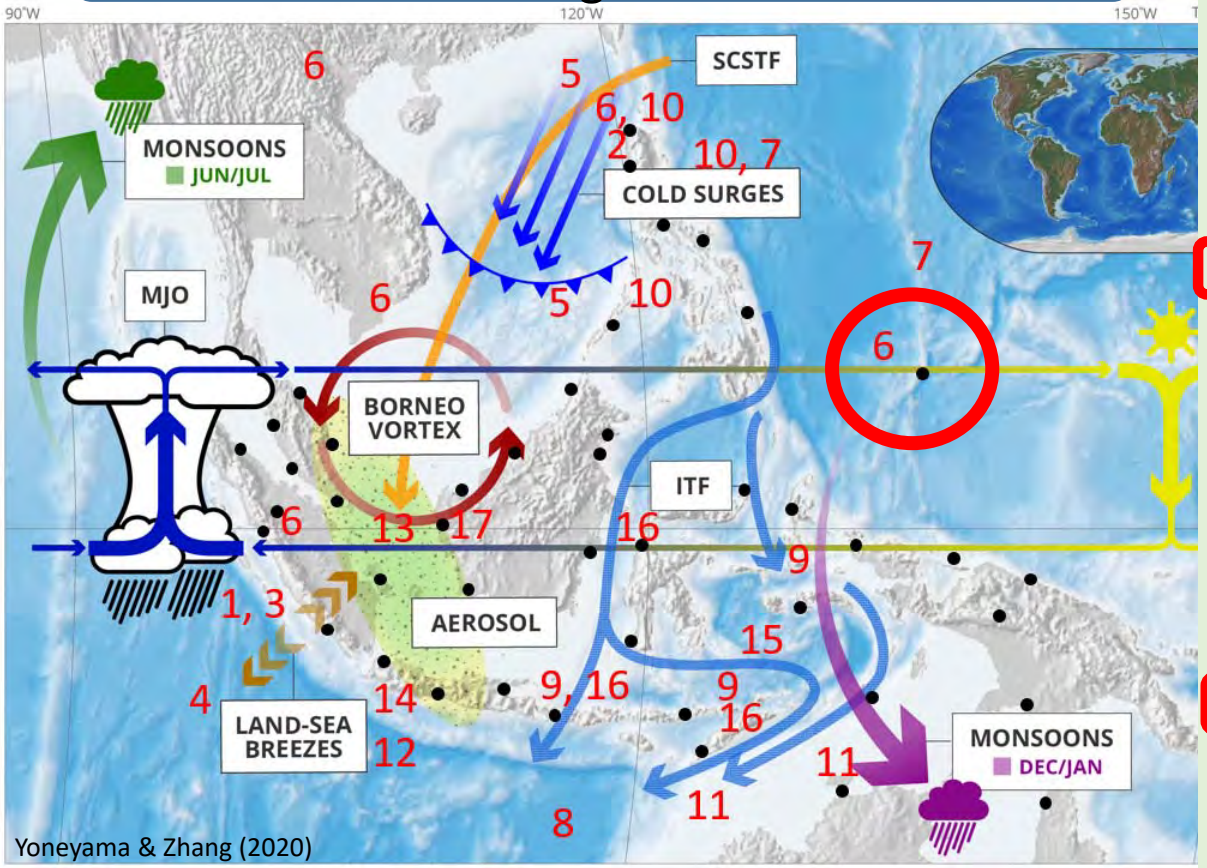
OISST v.2.1

OISST v.2

Moteki (2021, to be submitted)

Intensive Observations (including relevant projects)

YMC field campaign consists of intensive observations and long-term measurements.



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2018.05-06	5	SCSTIMX (monsoon)
2018.06-08	6	BSM (monsoon)
2018.08-10	7	PISTON (DC, ISV)
2018.11	8	MAMOS/CWPDIP (MJO, Monsoon)
2019.01-04	12	ELO (ocean)
2019.02-03	9	OM/CAT (ITF, tide)
2019.08-10	10	CAMP2Ex (Aerosol)
2019.09	7	PISTON (DC, ISV)
2019.10-12	11	Investigator(MJO, DC)
2020.08-09	6	BSM (monsoon)
2020.12-02	12	ELO (Ocean)
2021.12-02	14	TerraMaris (DC, MJO)
2021.12-02	13	ELO-O (Cold Surge)
2022.01-02	15	Banda Sea (air-sea)
2022.01	16	MINTIE (ITF)

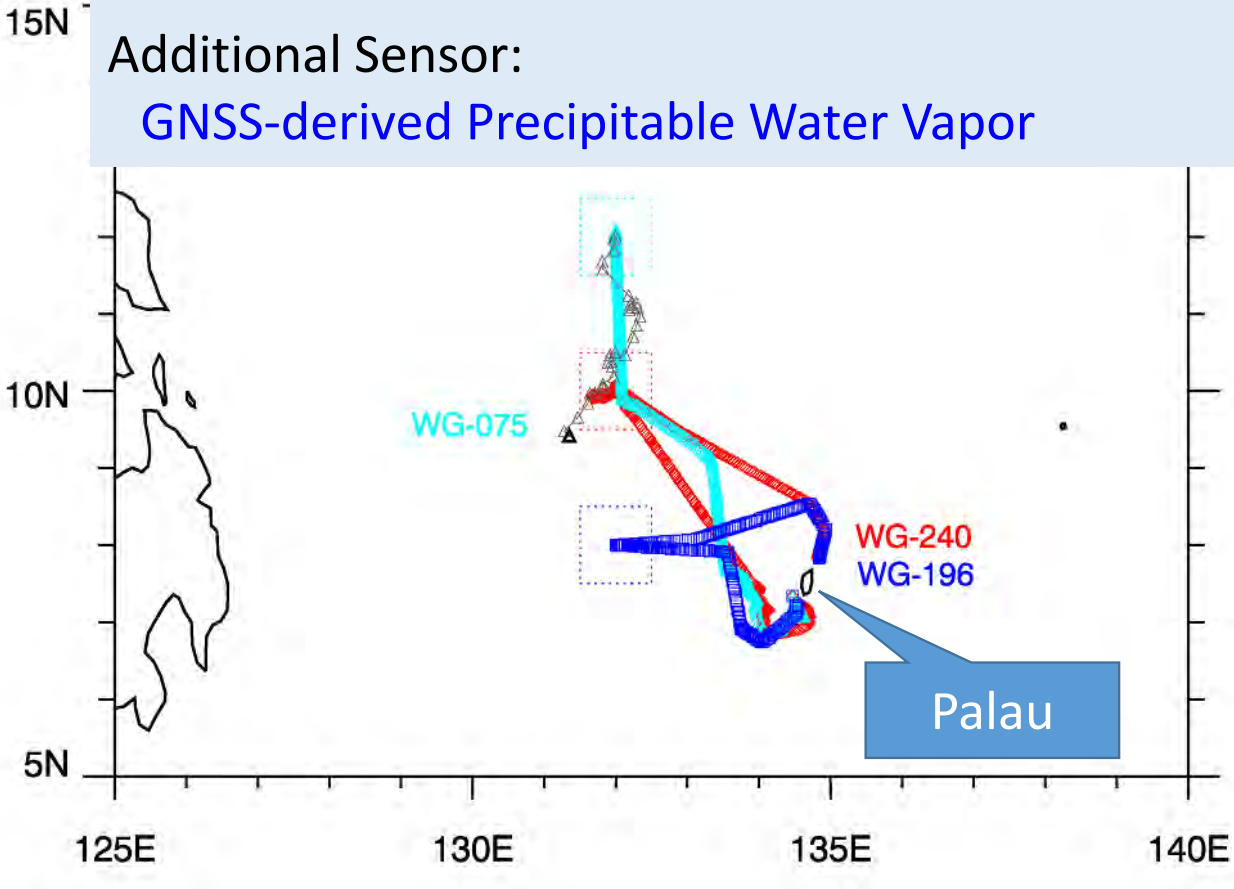
Boreal Summer Monsoon Study in 2018

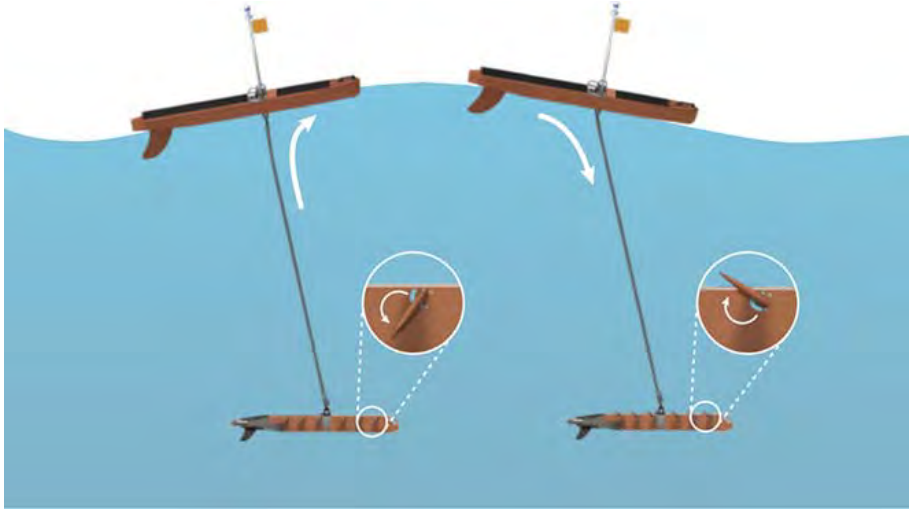
Standard Parameters:

- Surface Meteorology (P, T, RH, Rain, Wind, SW/LW)
- Sea Surface Temperature & Salinity
- ADCP

Additional Sensor:

- GNSS-derived Precipitable Water Vapor



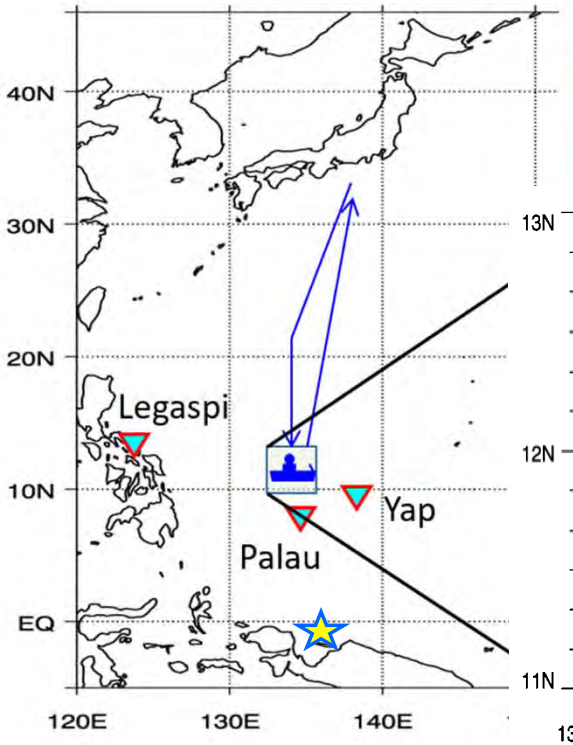


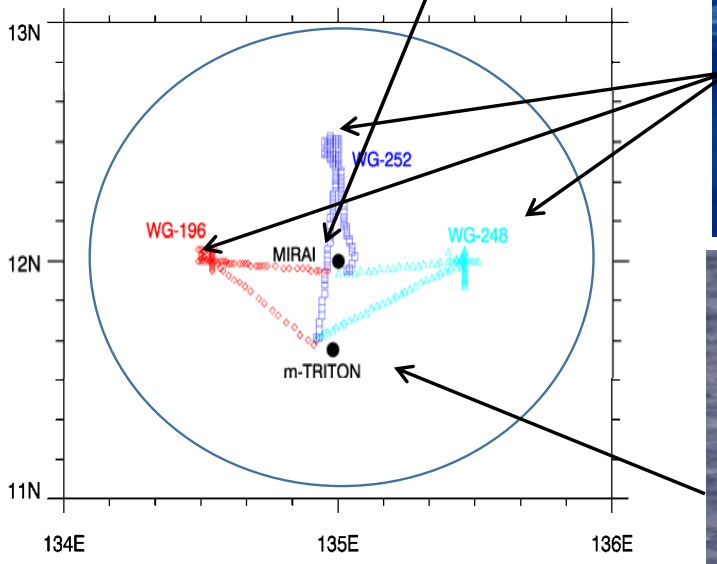
Converting wave motion into propulsion.
Taken from https://www.liquid-robotics.com/

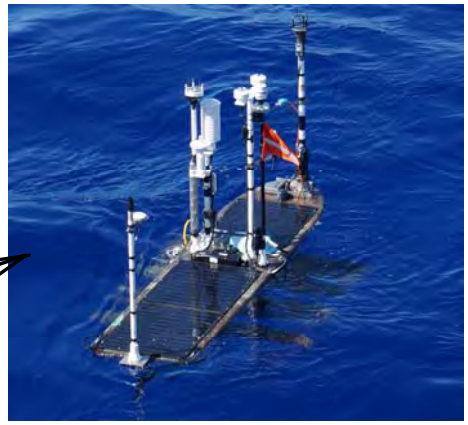
Boreal Summer Monsoon Study in 2020

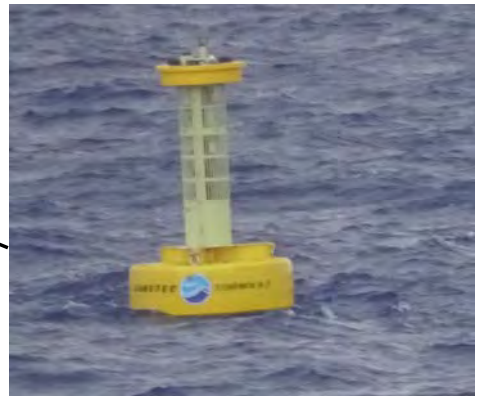
Period: Aug. 1 - Sept. 14, 2020

IOP: Aug. 8 - Sept. 4, 2020









ASV captured surface meteorology well

Tair
SST

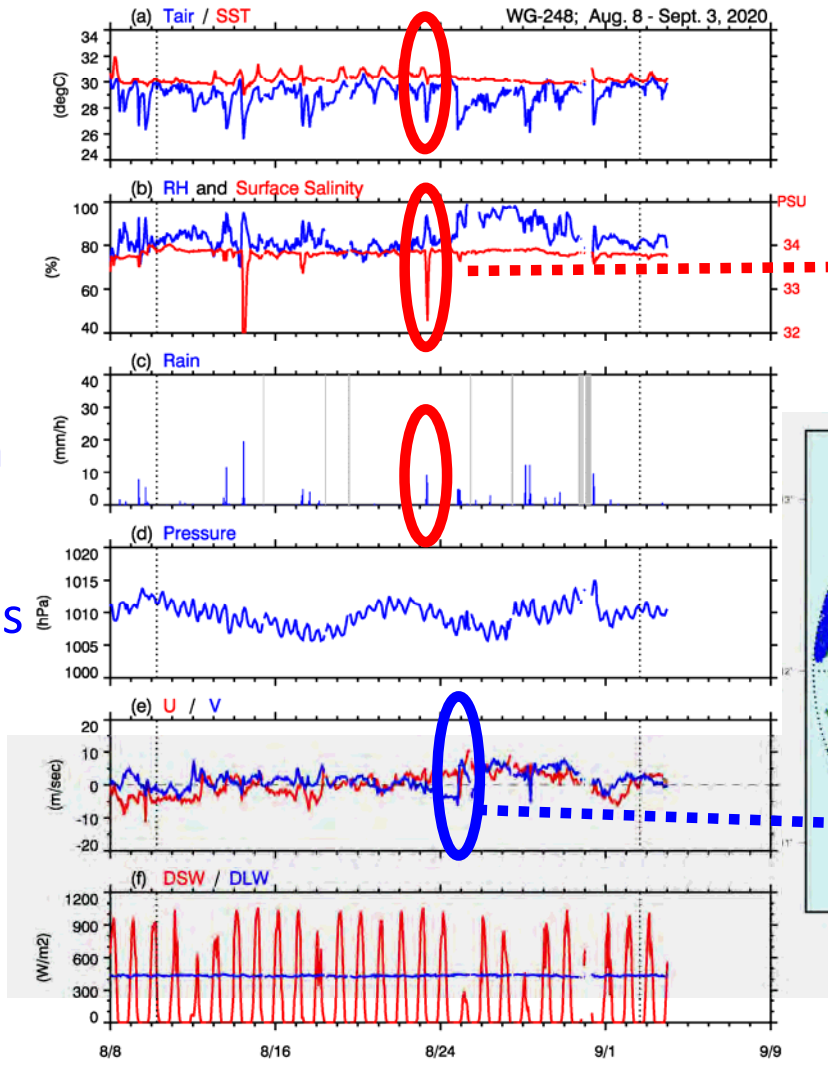
RH
SSS

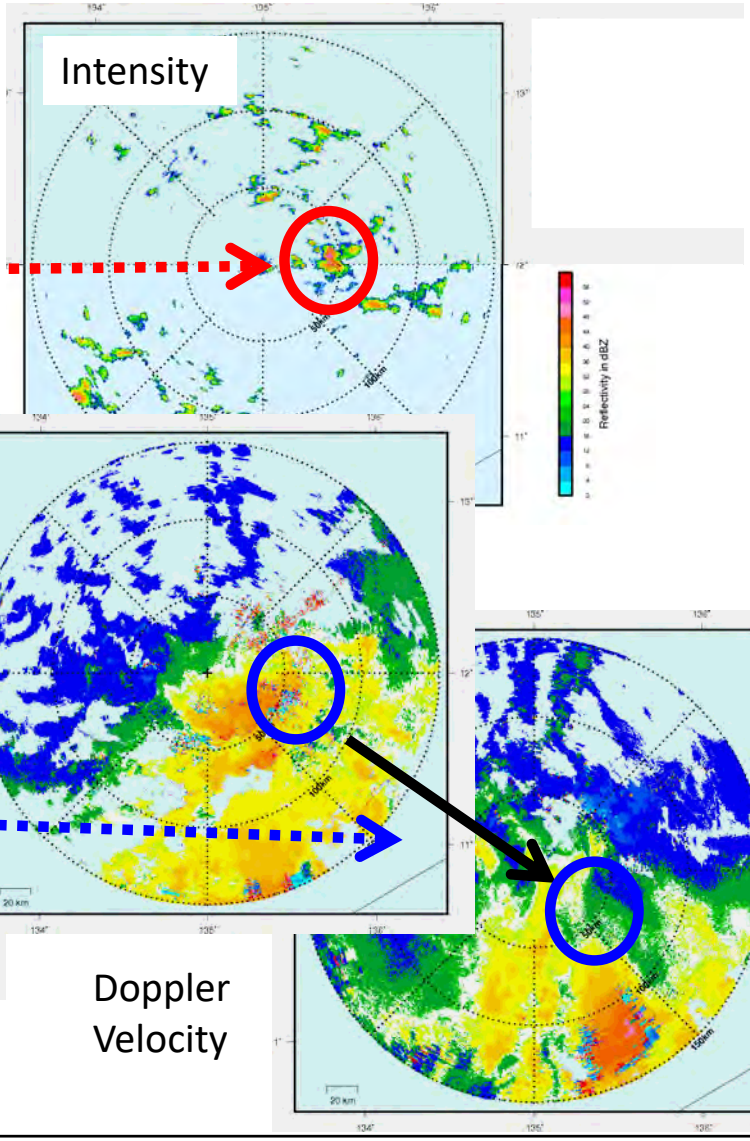
Rain

Press

U
V

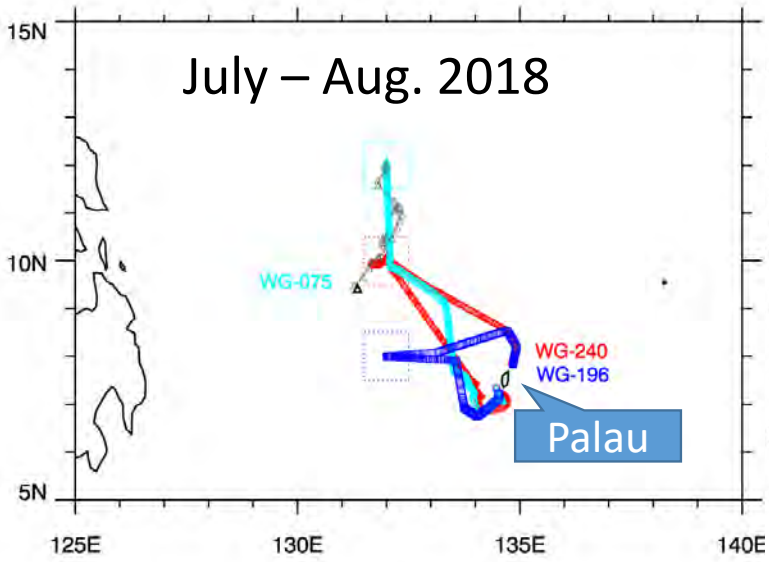
SW
LW

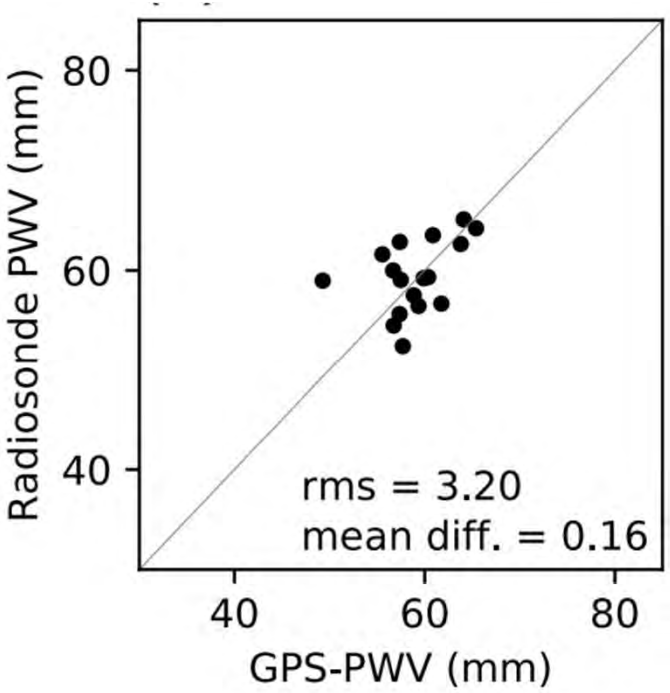


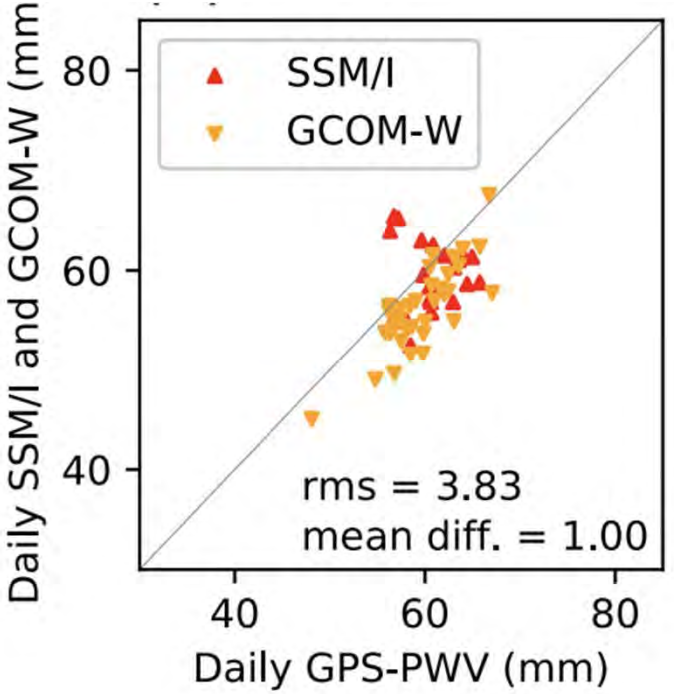


GNSS-derived Precipitable Water Vapor during BSM 2018

Comparison of PWV between GNSS-derived and (a) Radiosonde within 50 km from Palau
(b) Microwave-based satellite data (daily)





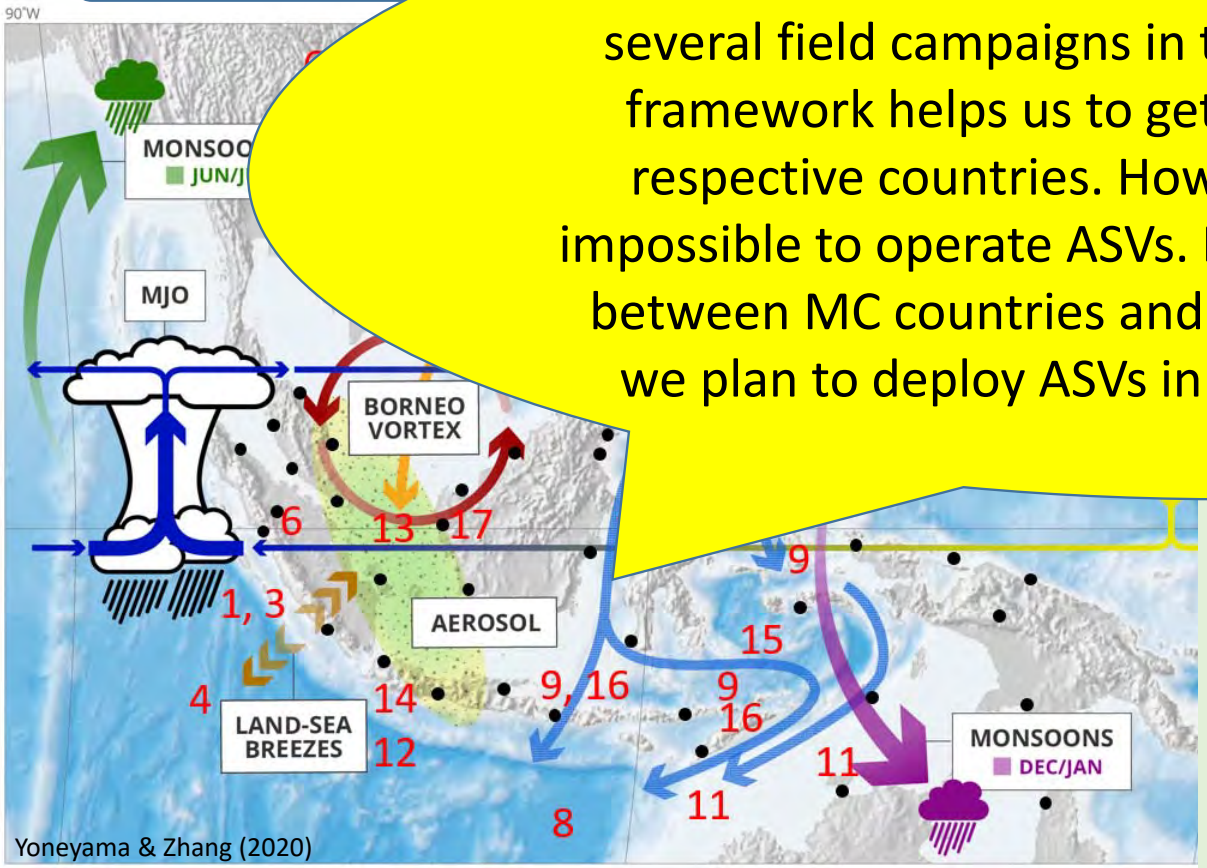


Fujita et al. (2020, SOLA)

Intensive Observations (including relevant projects)

YMC field campaign co… … Sumatra
observations a…

Under the framework of YMC, currently we are conducting several field campaigns in the Maritime Continent. This framework helps us to get research permissions from respective countries. However, even now, it it almost impossible to operate ASVs. Based on the tight relationship between MC countries and YMC scientists through YMC, we plan to deploy ASVs in future by the MC scientists.



Number Conducted or Planned Intensive Observation Areas
● Radiosonde sounding stations

…, Monsoon)

	5	OM/CAT (ITF, tide)
2019.08-10	10	CAMP2Ex (Aerosol)
2019.09	7	PISTON (DC, ISV)
2019.10-12	11	Investigator(MJO, DC)
2020.08-09	6	BSM (monsoon)
2020.12-02	12	ELO (Ocean)
2021.12-02	14	TerraMaris (DC, MJO)
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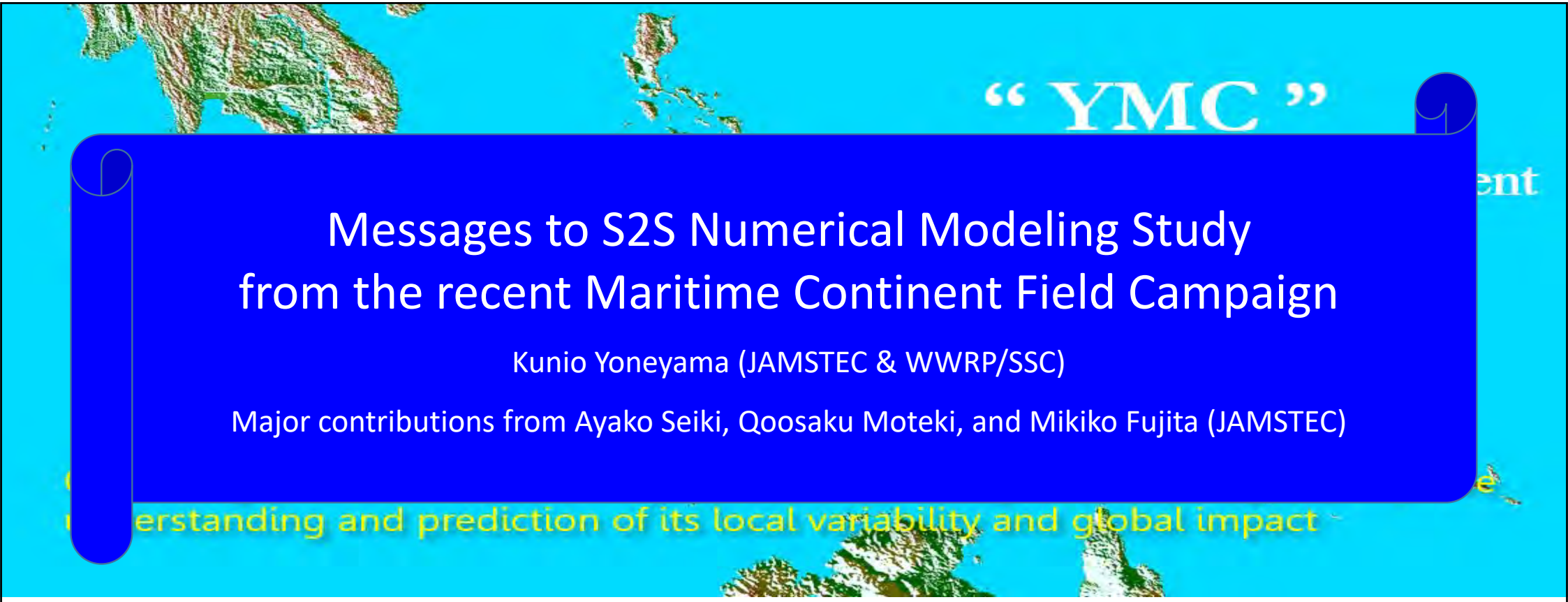
2022.01	16	MINTIE (ITF)



Messages to S2S Numerical Modeling Study from the recent Maritime Continent Field Campaign

Kunio Yoneyama (JAMSTEC & WWRP/SSC)

Major contributions from Ayako Seiki, Qoosaku Moteki, and Mikiko Fujita (JAMSTEC)

< Outline >

1) Introduction - The reason why I will talk about MC campaign in the South Asia session
2) Upscale effect - Diurnal cycle to synoptic-scale disturbances
3) What we learned from the YMC (Years of the Maritime Continent) campaign so far
4) Concluding remarks

Concluding Remarks

1. Several field campaigns in the Indian Ocean and the Maritime Continent aim at understanding the Madden-Julian Oscillation.
2. Recent studies suggested atmospheric convection developed diurnally over the MC coast might affect synoptic-scale convective activity over the eastern Indian Ocean. ⇨ Upscale effect, MC effect
3. Above mentioned emphasizes a simulation of diurnal cycle of rain in the MC is a key. However, even now state-of-the-art numerical models suffer from systematic error in simulating DCR. ⇨ Progress by YMC
4. A recent study indicated simulation of diurnal cycle of rain can be improved using realistic SST distribution. ⇨ Precise SST
5. Field researchers are trying to establish in-situ SST and other air-sea measurement systems using Autonomous Surface Vehicles. This may help to improve SST analysis product, then DC simulation.