Study of equatorial convective clouds: Evolution and their coupling with meso- to large-scale precipitation systems - Outline of A03 project-
赤道域における対流雲発生機構と降水システムの研究 概要」

Toshiaki Kozu[1], Toyoshi Shimomai[1], Yasumasa Kodama[2], Yukari Takayabu[3], Yasushi Fujiyoshi[4], Hiroyuki Hashiguchi[5], Jun'ichi Furumoto[5], Yoshiaki Shibagaki[6], in collaboration with LAPAN, Indonesia, and CPEA A03-related scientists in Japan[7]

[1] Shimane University, [2] Hirosaki University, [3] University of Tokyo, [4] Hokkaido University, [5] Kyoto University, [6] Osaka Electro-Communication University, [7] *Refer to Acknowledgment*

1. Objective and outline

The goal of this project (CPEA sequential number A03) is to understand the behavior and mechanisms of convection-origin atmospheric waves as well as the hierarchical structure of equatorial convective activities and couplings between them as shown in Fig.1, through comprehensive observations of equatorial atmosphere at Koto Tabang, west Sumatra. To achieve this goal, studies are divided into four categories; (1) Evolution and structure of each convective cloud, (2) Hierarchical structure and coupling among meso-scale, synoptic scale and super cluster activities, (3) rainfall properties in Maritime Continent (MC) and its relation to global scale phenomena such as MJO and ENSO, and finally (4) Gravity wave and other coupling mechanisms from convective activities to upper atmospheres.

To provide necessary information to the project, a set of comprehensive observation systems have been developed at Koto Tabang, west Sumatra.

This system consists of the following instruments; (1) Equatorial Atmosphere Radar (EAR) (vertical profiles of wind and precipitation), (2) X-band rain radar (X-radar) (2D structure of rain field, and 3D structure in part), (3) Microwave radiometer (vertical profile of water vapor), (4) Radio Acoustic Sounding System (RASS) (vertical profiles of temperature and water vapor in combination with the EAR), (5) 2D Video Disdrometer (2DVD; raindrop size distribution), (6) Optical Rain Gauge (ORG), (7) Micro-Rain Radar (MRR, low altitude precipitation).

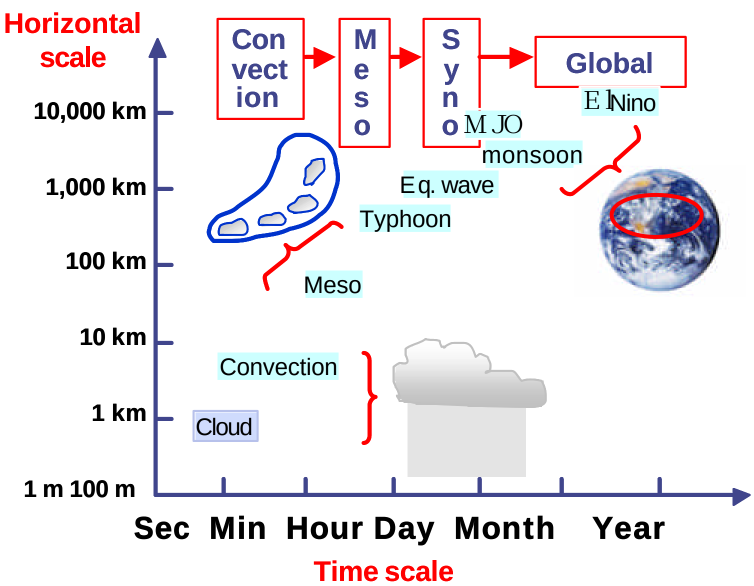

Fig.1. Diagram illustrating the concept of hierarchical structure of equatorial precipitation systems.

In addition, two international observation campaigns are scheduled in March-April, 2004, and November 2005 to obtain more information on horizontal structure of atmosphere. The campaign observation that combines both regional and wide area sounding networks will be invaluable to strengthen the ability to accomplish this goal.

Fig.2 shows overall project schedule from 2001 to 2006 Japanese fiscal year. Table 1 summarizes major instruments employed for this project. Figs.3 to 5 show outdoor units of instruments nearby the EAR observatory building, X-band rain radar and radiometer, respectively.

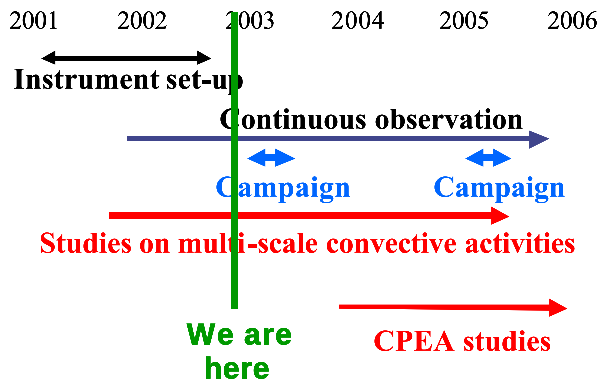

Fig.2. Overall project plan.

Table 1. Summary of major instruments.

Observation item	Instruments
Wind (VD)	EAR
Temp.(VD)	EAR/RASS
Water vapor (VD)	Radiometer
Rain (VD)	EAR, Micro-rain radar
Rain (2D)	X-band rain radar
Rain (ground)	Optical rain gage
Raindrop size distribution (ground)	Video disdrometer
Pressure field (ground)	Micro barograph (3)
Rain & Doppler (3D)	X-band Doppler radar*1

VD, 2D & 3D: Vertical, 2D & 3D distribution.
*1 Used only for the special campaign period.

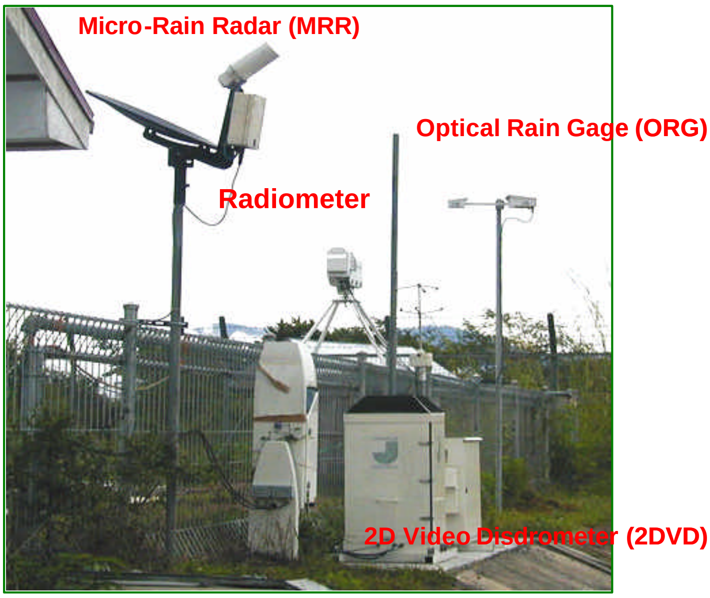

Fig.3. Micro-rain radar, (MRR-2), Optical Raingage (ORG-815), 2D video disdrometer (2DVD) and radiometer (WVP-1500).

Observation Radius: 30 - 60km
Frequency: 9.74 GHz
Peak power: 40 kW
Range resolution: 75m
Elevation angle: 0～30 °
Installed in Sept. 2002, in operation

Fig.4. Antenna and shelter of X-band rain radar, and major parameters.

Water vapor profiling
Time resolution 3 – 10 min.
Height resolution
100m (0-1km)
250m (1-10km)
Azimuth angle variable
GPS tracking
Installed in March 2002

Fig.5. Antenna and RF unit of water vapor radiometer, and major parameters.

2. Status of instrument installation and operation

A03 related instruments listed in Table 1 have been installed and basically in operation except the XDR, which will be installed in February 2004. As for the RASS, combination of 10 speakers with the EAR, have been developed step-by-step; the first experiment was conducted with 2 speakers, the second experiment with 6 speakers, etc. A "full system", namely 10 speakers, experiment was conducted in November 2002 and final integration to install many surge protectors is scheduled in March 2004 (Furumoto *et al*. 2003). Fig.6 shows a installation and operation status of the instruments.

The data acquired at Koto Tabang are first stored on data collection computers in the EAR observatory, and periodically transferred to RASC and/or Shimane University for archive, level-1 processing, scientific researches in Japan and Indonesia, and for public-release (for wider data release). To make the data search more convenient, ORG, RM and X-radar browse images are available on-line at the RASC and Shimane University Web site.

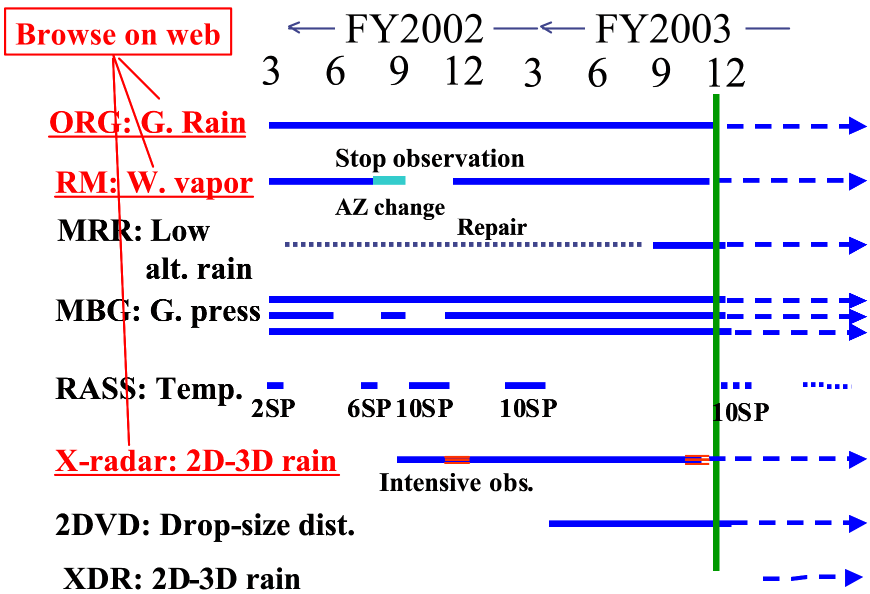

Fig.6. Summary of instrument installation and operation.

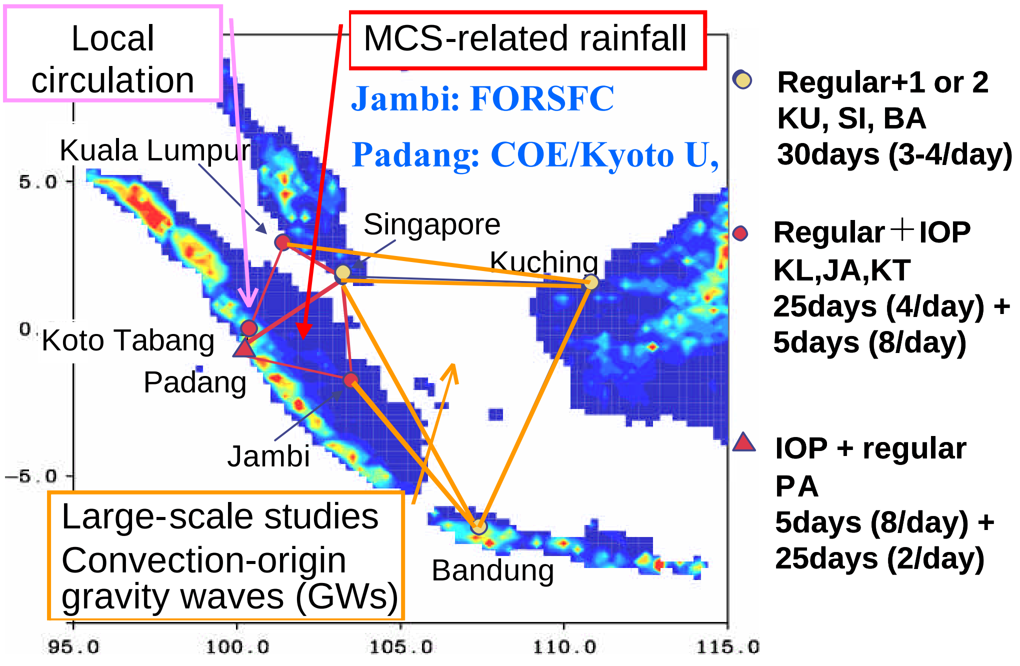

Fig.7 Location and conceptual diagram of radiosonde launches in the campain

3. International observation campaign

During the overall international observation campaign of CPEA (March and April 2004), A03 (tropospheric convection) and A04 (atmospheric waves and energy transport) related activities are planned in the latter half of the campaign period, 10th April to 9th May. Strategies of the A03 campaign are categorized into two programs:

(1) Triple-scale upper-sounding network centered at Koto Tabang (KT) is constructed to understand characteristics of local circulation (horizontal scale ~50 km), meso-scale convective systems (horizontal scale ~300 km), and MJO and gravity wave structures (horizontal scale ~1,000 km). Main objectives of radiosonde observations is to obtain profiles of temperature, pressure and horizontal wind velocity up to 30-35 km, as well as a humidity profile in the troposphere. This is a joint effort with the CPEA subproject A04, the CPEA Indonesian partner, LAPAN, and conducted in collaboration with FORSGC, Japan, with supports from BPPT and BMG, Indonesia. Malaysian Meteorological Service (MSS) and Meteorological Services Division, National Environment Agency (MSD/NEA), Singapore, will also collaborate with this campaign and will conduct special activities of their upper air sounding. Radiosondes will be launched every six hours during the period of 30 days (ITM30). During this period we choose a more intensive period of five days (ITM5) to catch heavy rain events, and will launch radiosondes every three hours. The launches will be from Koto Tabang(0.20° S, 100.32° E), Bandung (6.9° S, 107.6° E), Jambi (1.60° S, 103.65° E), Padang airport (1.0° S, 100.4° E), Kuala Lumpur (3.2° N, 101.7° E), Kuching (1.5° N, 110.3° E) and Singapore (1.3° N, 103.8° E). See Fig.7 for the location of launch sites and concept of the observation.

(2) Comprehensive rain and atmospheric observations at KT are conducted using various instruments such as the EAR, X-band Doppler radar, RASS, water vapor radiometer, X-band rain radar, and ground-based instruments, which make it possible to connect horizontal and vertical-scale characteristics in/around convective activities.

4. Scientific research activities

During fiscal year 2001 to 2002, studies have been focused to preparatory ones in which we have tried to characterize precipitation properties in Maritime Continent in comparison with other equatorial regions. These include (i) statistical properties of convective and stratiform precipitations in terms of rainfall amount, echo-top height, diurnal variation, and lightning activities, and (ii) characteristics of raindrop size distributions (DSD). These studies have been performed mainly using satellite data such as TRMM PR, and disdrometer data obtained at various tropical locations. Fig.8 illustrates a conceptual diagram of studies on-going in the framework of our project. Through the studies on (i) it was found that precipitation in Maritime Continent generally has ocean-land "mixed" characteristics, and influenced also by large scale precipitation systems such as MJO (Takayabu *et al.*, 2002; Takayabu *et al.*, 2003). From the studies on DSD, it was found that there are distinct differences between oceanic and land DSDs, especially in convective rains. Moreover, Koto Tabang DSDs appear to have clearer diurnal variations than those in Singapore suggesting more influence of local convective activities than in Singapore (Kozu *et al.*, 2002).

We have also been studying basic precipitation properties around Koto Tabang (Mori *et al.*, 2002), and hierarchical structures of cloud systems having a wide range of horizontal scales (several kilometers to several thousands of kilometers). From the analyses of GMS OLR, X-band rain radar and EAR-derived wind field, it was clarified that there are systematic hierarchical structures and couplings between Inter-Seasonal Variation (ISV), Super Cloud Cluster (SCC), Meso-α, Meso-β, and Meso-γ Cloud Systems, influenced by Kalimantan and Sumatra Islands (Shibagaki *et al.*, 2002; Shibagaki *et al.,* 2003).

In addition to the above studies on precipitation properties, remote sensing techniques utilizing the EAR and other instruments have been studied. These include humidity profile estimation from the EAR-RASS (Furumoto *et al.*, 2002; Furumoto *et al.*, 2003), and EAR-based estimation of vertical DSD profiles in order to obtain more insight into vertical structure of precipitation microphysics (Kozu *et al.*, 2003; Shimomai *et al.*, 2003).

Based on studies of precipitation characteristics of various scales mentioned above, we will study kinematical structures of equatorial convection related to atmospheric wave generation and momentum transport to upper atmosphere (Kodama, 2002).

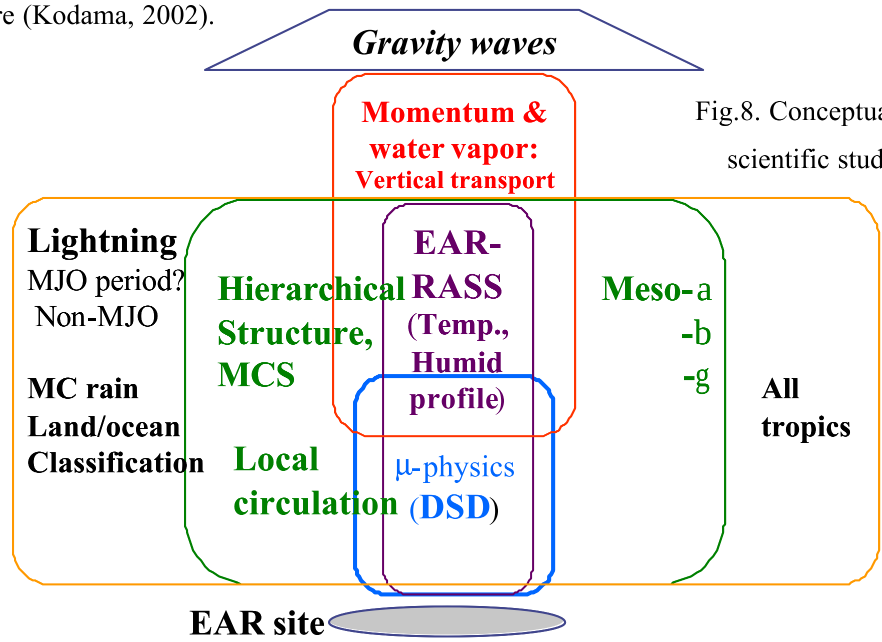

Fig.8. Conceptual framework of scientific studies on-going.

5. Summary

The major tasks of this project during the first 2 or 3 years have been to construct the comprehensive observation system at the EAR observatory, Koto Tabang, and to conduct preparatory studies to understand basic properties of precipitation in Maritime Continent. All instruments have been installed and basically in operation except the XDR, an important tool in the campaign, which will be installed in February 2004. For wider utilization of the data obtained, X-band rain radar, ORG and Radiometer browse images are available online; data are also available for scientific researches by contacting Shimane University and RASC. It should be noted that periodical instrument maintenance and calibration efforts are essential to keep the quality of the data.

We have found several interesting characteristics of precipitation in Maritime Continent, especially around Koto Tabang, ranging from cloud microphysics to large-scale cloud systems as summarized in Section 4. Hierarchical structures of cloud systems from Meso-γ cloud system to SCC have been elucidated through detailed data analyses. One of the next step would be to study correlations between small-scale precipitation properties (*e.g.* microphysical properties) and large-scale precipitation and other atmospheric environment. From such overall picture of the cloud systems in Maritime Continent, it would be possible to get more insight into the coupling of tropospheric convection and upper atmospheres.

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