Summary of Discussion

Below are comments on MISMO results and CINDY2011 scientific plan discussed in the plenary session as well as the selected results presented during the 2-day MISMO workshop.

A. Brief summary of MISMO

1 Unique high resolution in-situ data.

Various atmospheric and oceanic data in the equatorial Indian Ocean especially during the positive Indian Ocean Dipole event were obtained. These data are now available from MISMO web site at http://www.jamstec.go.jp/iorgc/mismo/. Fine temporal and spatial scale features were captured especially in the lower troposphere, which could not be obtained from current satellites. Combination of the in-situ data with large-scale data such as satellite, RAMA buoy, re-analysis, and numerical simulation products will afford a great opportunity for understanding various atmospheric and oceanic phenomena in the Indian Ocean.

2 Atmospheric studies

2.1 MJO-convection onset

Large-scale convective system was observed. The system was diagnosed as an MJO, following the method by Wheeler and Weickman (2001), although it dissipated before arriving at the Indonesian maritime continent.

2.2 Budget analysis

Heat and moisture budgets were calculated over the triangle array of radiosonde. Peak in the lower troposphere was remarkable, compared with that obtained during TOGA COARE.

2.3 Meso-scale convective systems

Several eastward propagating meso-scale convective systems were observed before and during the convectively active phase of MJO. In particular, analyses demonstrated that the moistening of middle and upper troposphere were caused by these systems.

2.4 Mechanism of the MJO-convection onset

MISMO and relevant data analyses stressed the importance of large-scale equatorial waves for the initiation process, as they (Kelvin and equatorial Rossby waves) arrived over the MISMO area when the MJO-convection was initiated. However, as noted in 2.3, meso-scale convective systems might also play an important role for moistening of upper troposphere. Thus, the relationship between meso-scale convective systems and equatorial waves might be a key issue to be addressed by future analyses and observation.

2.5 Numerical simulation

Numerical experiment on the MJO events in November 2006 - January 2007 was conducted, making use of a global cloud-resolving model (NICAM). The integration started in the inactive period, and the MJO onset was well simulated. Some sensitivity tests will reveal which is most important to the MJO onset. Further use of NICAM products is encouraged.

3 Oceanic studies

3.1 Indian Ocean Dipole event

MISMO took place in the Indian Ocean Dipole event and data showed unique features particularly for oceanic condition. In contrast to the climatology in this period, surface current was westward. In addition, strong vertical shear of zonal currents with sub-surface eastward current was observed above the thermocline.

3.2 Equatorial wave

Short-term (14-20 day) variability was observed in the meridional component of the surface current and it was speculated that this might be a mixed Rossby-gravity wave. Strong upwelling was observed below 90 m depth in the early November by the moored buoy array, and it was shown that meridional current variation mainly contributed on this upwelling.

3.3 Biogeochemical analysis

Deepening and thickening of sub-surface Chlorophyll maximum layer was observed. Relationship to the physical strong upwelling was suggested.

4 Air-sea interaction studies

4.1 Sea skin temperature (SSTskin) and convection

The increase of precipitable water and radar echo coverage (rainfall) in the daytime corresponds to the large SSTskin rise during the undisturbed period, and the oceanic forcing to the atmospheric convection is revealed.

4.2 Mechanical mixing

Argo float data revealed that the SST decreased to the west of the MJO convective center, in association with higher wind speed and enhanced vertical mixing. The westerly wind in the basic field would be essential to the air-sea coupling through the changes in the scalar wind speed.

B. Observational plan of CINDY

1 Main target of CINDY

The aim of the experiment is to understand the initiation processes of MJO-convection in the equatorial Indian Ocean. In particular, the following themes should be addressed by the

experiment; 1) the evolution of heating profile associated with the MJO, 2) relationship between meso-scale convective systems and equatorial waves, and 3) relationship between convective activity and sea surface conditions.

2 Observational Period

The intensive observation period will be scheduled from October to January, because 1) onset of MJO-convection is often observed in October-November period, and 2) MJO-convection initiated in December-January period strongly influences the Australian monsoon onset. Moreover, four-month period will surely capture the whole cycle of the intraseasonal variation.

3 Sounding Array

The location of 80E on the equator is suitable to monitor the onset of MJO-convection in October-January period based on several statistical analyses. One of the key issues in CINDY is the evolution of the heat profile associated with MJO onset. It was pointed out that radiosonde sounding array with rectangle or diamond shape configuration is much better than MISMO's triangle configuration to reduce the error in the estimate of the heat over sounding array.

<Action item>

As well as research vessel, land-based sites for radiosonde sounding consist of basic network due to the restriction of the ship-time. Therefore, site survey including negotiation with local weather services to enhance the radiosonde observation frequency during CINDY should be started.

4 Oceanic observation

If we deploy sub-surface ADCP moorings without surface buoys to construct a diamond (or square) buoy array, it is difficult to calculate a budget for ocean surface due to its strong vertical shear in the equatorial Indian Ocean. Rather we had best concentrate on obtaining data along the equator as well as contributing to maintain RAMA buoy array. In addition, if we deploy any buoys during CINDY, it should be longer than one year so that we can understand the oceanic conditions during CINDY in terms of stronger impact phenomena found in Indian Ocean such as monsoon, Indian Ocean Dipole mode phase, and so on.

As for the on-board oceanic studies, biogeochemical measurements in addition to frequent CTD observations are also required especially in terms of vertical mixing processes.

5 Collaboration with the modeling group

Model simulation gave us considerable insight into the analysis of the MISMO data, and in-situ data demonstrated that the meso-scale features in the model are realistic. Therefore, collaboration with the modeling group is desired and they should be involved in the experiment from the initial stage of planning.

6 Current and potential participants

Japan (R/V Mirai), U.S. (R/V Ronald H. Brown), Australia (R/V Southern Surveyor), and India (ORV Sagar Kanya) are trying to get ship time to participate in CINDY. To construct longer and wider observation network, other possible ships should be sought.

<Action Item>

Contact to those who are interested in MJO and other phenomena in Indian Ocean. How about China, Korea, and any other countries?

7 Relevant observational campaigns

While WOCE-type cruise along I02(~8S) and I10 is planned by JAMSTEC (led by Dr. A. Murata) after CINDY cruise in early 2012, French project TRIO (Thermocline Ridge of the Indian Ocean; led by Dr. J. Vialard and Dr. J.-P. Duvel) is planned to be carried out along the same 8S line in early 2011. Collaboration not only between these two cruises but also between their two cruises and CINDY is strongly required in terms of data exchange and operational effort such as buoy maintenance. It is also pointed out that expected accuracy of oceanic measurements (i.e., WOCE-level or not) and kind of parameters to be measured should be examined.

8 Public relations and data open policy

CINDY home page will be created in JAMSTEC (It is expected to open in January 2009). Data obtained during CINDY should be opened timely with easy access. CINDY home page is one of candidates for data site. Links to other popular sites will be encouraged.

As for the data format and data release (data policy) will be discussed later in detail.

9 Activities in the near future

9.1 Working group

A working-group (which consists of site-scientists, numerical model experts, satellite experts, and so on) will be organized. Basically, they will discuss through e-mail communication, but it may request them to come together somewhere to discuss more practically.

<Action Item>

Select appropriate persons for WG and let Yoneyama know his/her name.

9.2 Documents

The first document on “Science (and implementation) plan” will be summed up as soon as possible and be distributed to scientific communities by March 2009.

<Action Item>

A manuscript draft will be sent from Yoneyama to working group members within December 2008.