Atmos. Chem. Phys. Discuss., 13, C9530–C9537, 2013
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Atmospheric Chemistry and Physics Discussions

ACPD

13, C9530–C9537, 2013

Interactive Comment

Interactive comment on "Borneo vortex and meso-scale convective rainfall" *by* S. Koseki et al.

Anonymous Referee #2

Received and published: 2 December 2013

General comments:

This paper describes analysis of Borneo vortex and precipitation under cold surge conditions. The first part of the manuscript demonstrates the climatology of Borneo vortex and associated precipitation in the presence of strong cold surge. The second part presents dynamical analysis of Borneo vortex simulated in a semi-idealized numerical experiment. Based on budget analysis of vorticity and divergence, the authors try to explain generation and maintenance of meso-alpha scale cyclone (i.e., Borneo vortex) and meso-beta scale precipitating region that appear in the northeast quadrant of the vortex. They conclude that the deviatoric strain inherent in the confluent flow field was essential to the manifestation of both meso-alpha and meso-beta scale features.

The motivation is clear and scientifically meaningful. The detailed analysis of dynamics provides new insights into the mechanisms of Borneo vortex. In contrast, analysis

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Interactive Discussion
Discussion Paper

of moist convection is less systematic and does not support some of the arguments. Critical problems appear to be; 1) Mechanisms of Boneo vortex and deep convection are rather separately discussed. Relationship between them is not fully elucidated by the dynamical analysis. 2) The discussion on deep convection is focused on the tail region of the comma-shaped rainband in the northeast quadrant. However, most intense convection appeared close to the cyclone center (i.e., comma-head). Which is essential to the whole system is not clear. 3) Hierarchical structure (meso-beta scale precipitating systems in the meso-alpha scale rainband) should not be limited in the northeast sector of the cyclone (e.g., comma-head and intense precipitation in the northwest sector). Separation by horizontal scale and by axisymmetry in the current manuscript is rather confusing. 4) Discussion on Borneo vortex (meso-alpha scale cyclone) in analogy with a tropical cyclone is inadequate in some points (not acceptable for publication). I recommend this manuscript to be eventually published in ACP after revision on these points.

Specific comments

p.80 L.9-10, L.12-17

These descriptions focus on the northeast sector of the cyclone. However, deep convection (upward motion, condensates, and intense precipitation) are most prominent close to the cyclone center (Figs. 10b, 11), where cyclostrophic balance is dominant (Fig. 13a,b). If this is important to the growth and maintenance of the whole system, it should be stated in the abstract. Moreover, intense precipitation in the northwest sector is also a major part of the comma-shaped rainband but in different dynamical conditions (i.e., meridional gradient of zonal wind is significant; p.96 L.1-3) from that in the northeast sector.

p.80 L.10-11, L.16-18

The effects of moist convection indirectly appear in vorticity and divergence equations (e.g., acceleration of horizontal convergence and increase in horizontal pressure gradient force by latent heat release, etc.). Addressing the relationship between dynamics and moist convection is highly requested. Another point to take into account is that budget analysis in a quasi-stationary state (e.g., mature stage) explains balance among the forcing terms but not the reason for the growth of the quantity (Figs. 13, 16).

p.81 L.16-22

In view of the mechanism of generation and organization of deep convection in the tropics, diagnosis of heat, moisture, and energy (e.g., Yanai et al. 1973) provides useful information. If the authors prefer to confine their quantitative analysis to dynamical aspects, it is recommended to give explanations for 1) the selection of vorticity and divergence diagnosis and 2) how to understand the mechanisms of convective organization from the diagnosis, somewhere in the manuscript.

p.86 L.12-19

Distributions of specific humidity (q) and convergence (upward motion) will be more relevant to the location of deep convection than moisture flux divergence. "Clausius-Clapeylon . . ." is difficult to understand. Additional explanations are requested.

p.86 L.20-23

This is not presented in Fig. 3. Again, description of moist static energy itself rather than flux divergence will be more informative. p.86 L.25 "diurnal cycle" I am not sure the diurnal cycle (Fig. 5 and 9b) is relevant to the objective of this study, although the findings here are quite interesting.

p.87 L.26-27

Colocation of vorticity flux convergence (Fig. 3a) and rainfall (Fig. 4) does not seem to be evident.

p.91 L.16-27

Precipitation in the northeast quadrant of the vortex center (Fig. 10b) is not necessarily clear in the composite TRMM precipitation (Fig. 7b). Since this is the major target of the discussion given in the following sections, the matching with observation is preferable. Are there any typical cases with a comma-shaped rainband in the 55 days of the composite analysis?

p.92 -93 meso-alpha cyclone, analogy with tropical cyclone

Warm core structure and maximum tangential wind in the lower troposphere are similar between the cyclone and a tropical cyclone (TC). In TCs deep convection (latent heat release) is maximized in the eyewall which is maintained by frictional convergence mechanism (Ooyama 1964; Yamasaki 1983). An eye is cloud free and warm by compensating subsidence. The cyclone in this paper was under cyclostrophic balance and warm anomalies were caused by convection which was more pronounced in the western part. The positive feedback between vertical motion (upward transport of moisture and low-level convergence that transport angular momentum to accelerate tangential wind) and deep moist convection (latent heat release) occurred close to the cyclone center (large contribution from the deep convection in the western part is expected). This may drive the growth of the cyclone (may appear in SELF term in the divergence equation). The question is the role of the STRN term to the establishment of this feedback system.

p.94 L.11-13

The effects of deep convection primarily appear in stretching term in the vorticity equation (Eq.1). Large contribution of stretching term in the western part of the cyclone (Fig. 12) is consistent with the low-level convergence (Figs. 13, 14a) and organization of deep convection (Figs. 10b, 11, 14d) there. It is recommended to state this fact in the manuscript.

p.97 L. 1-2

The generation of deviatoric strain by the northeasterly surge and northwesterly cross-

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ing the equator (to the west of the cyclonic center; Fig. 14f) is not fully explained. Does the turning of zonal wind component enhance zonal convergence? The dynamics here seem to be quite different from those in the northeastern sector.

p.97 L.25-p.98 L.2

Transport of rain cells that formed in the northeast sector to the northwest sector is not evidenced by the materials presented here. The distribution of horizontal divergence suggests that deep convection was also organized in the downstream parts of the comma-shaped rainband (i.e., low-level convergence in the western part of the cyclone). This description should be carefully reexamined.

p.98 L.22-27 (Fig. 15)

This is a very good approach to understand the convective organization. Figure 15 support the argument that the positive feedback between the rising motion (low-level convergence) and the deep convection (latent heat release) at the thermodynamical front was essential to the growth and maintenance of the rainband system. The effects of deep convection mainly appear in self enhancement (SELF), pressure Laplacian (LAP), and vertical advection (VMOM) terms in the divergence equation (Eq. 2), of which SELF was dominant representing the positive feedback described above. The deviatoric strain (meridional confluence) may contribute to the formation of the frontal structure, but thermodynamical aspect seems to be most important here.

Technical comments

p.80 L.12 “rainfall patches”

Please use meteorologically well-defined terms.

p.80 L.17 “deviatoric strain”

This term would be unfamiliar to many of readers. Substitution by explanatory description may increase readability. “deformation less the effect of the horizontal divergence”

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(p. 95, L21; Appendix B) is difficult to understand.

p.80 L.26

Fig. 2g is cited before Fig. 1.

p.81 L.1

monsoon –> monsoonal flow?

p.87 L.22-24.

This description is difficult to follow. p. 90 L.22 Figure 10 –> Figure 8l?

p.93 L.5 "cloud cluster can be categorized as the anvils"

"cloud cluster" is a category of convective system, whereas "anvil" is a category of cloud type, and these do not match.

p. 93 L.8 "not unlike"

Please write in a straight manner.

p.94 L.5

Figure 10l –> Figure 8l?

p.96 L.5

It is recommended to state that positive (negative) values in these terms indicate acceleration of divergence (convergence), which at 850 hPa roughly means downward (upward) motion in the free atmosphere.

p.97 L.9-10

and but –> but?

p.98 L.28-29

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This sentence is difficult to understand.

p.99 L.26

southwesterly cyclonic wind –> southeasterly? (inconsistent with the description in abstract)

Figures

Fig. 2

It is recommended to indicate the area of CS Index (described in the caption of Fig1).

Fig. 3

The former (d) in the captions of contour intervals will be (c).

Fig. 5

It is recommended to indicate the area of average in Fig. 4.

Fig. 6 caption

Marine the Borneo vortex –> the Marine Borneo vortex?

Fig. 13 caption

(c)-(h) are not properly captioned.

Fig. 15 caption

the confluence line in Fig. 14e –> the confluence line (zero meridional lines in Fig. 14e)?

Fig. 16

It is recommended to indicate the domain of Fig. 16 in Fig. 14d.

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Yanai, M., S. Esbensen, and J.-H. Chu, 1973: Determination of bulk properties of tropical cloud clusters from large-scale heat and moisture budgets. J. Atmos. Sci., 30, 611–627.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 21079, 2013.