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Diagnosis and Prediction of Some Extreme Rain Events over Southeast Asia.

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1. Introduction

One of the major forecast problems over the tropics of south east Asia is prediction of heavy rain events. The impacts of these events are, of course, immense. Key characteristics of the tropical atmosphere that make these events so devastating and difficult to forecast are the potential moisture availability and the inherent conditional instability. These allow (i) very large rainfall totals to occur, (ii) rapid communication between upper and lower levels, and (iii) the response to any large scale forcing to usually develop on the mesoscale. Thus extreme rain events often develop rapidly, can be devastating, and occur over relatively small scales.

The study presented here is a first attempt to assemble local expertise from various countries to make a unified attempt at investigating some extreme rain events. By sharing our skills and increasing the data base for significant, but relatively infrequent events, we know there will be broad research and operational benefits to the meteorological services in each country.

2. Synoptic-Scale Circulation Features

We have investigated observational and prediction aspects of four heavy rain events that occurred near Manila, Kuala Lumpur, Hanoi and central Java. Some preliminary observations regarding possible causes of the heavy rainfall are described below.

Event 1 occurred just north of Manila on July 4 2001 and was associated with the passage to the north of Luzon by Typhoon Utor, which was undergoing intensification and asymmetric structure change. The event coincided with the arrival near the Philippines of both a monsoon westerly wind burst (possibly associated with an eastward propagating Madden-Julian Oscillation, MJO), and the westward propagating Typhoon Utor.

Event 2 occurred as a flash flood near Kuala Lumpur on April 26 2001 and was associated with the development of a mesoscale circulation and sustained conditional instability often observed in the region during extreme rainfall events. On larger scales, it coincided with the arrival of an eastward propagating MJO and a trade wind surge over the South China Sea.

Event 3 occurred near Hanoi around August 2 2001 as two days of drenching rain with over 300 mm recorded. The event was characterised by deep convergence, and was associated with the overlaying of a rapidly-sharpening upper trough of midlatitude origin, with a weak, westward-propagating disturbance in the low level monsoon trough.

Event 4 occurred over central Java on November 3 2000 and was associated with the development of a mesoscale circulation over the Java Sea. On larger scales, it coincided with simultaneous surges in the trades of both hemispheres, the development of the near-equatorial troughs (in both hemispheres), and the strengthening of equatorial monsoon westerlies.

3. An Illustrative Example: the Malaysia Event

Figures 1 and 2 show 850 hPa wind fields, two days before, and at the time of the heavy rain event. The similarity in large-scale structure is evident, however there has been a strengthening in all major wind systems in each hemisphere. The heavy rain appears associated with low level convergence between the accelerating westerlies (in turn associated with an MJO event, see later) and a trade wind surge, with strengthening north east winds over the South China Sea (SCS).

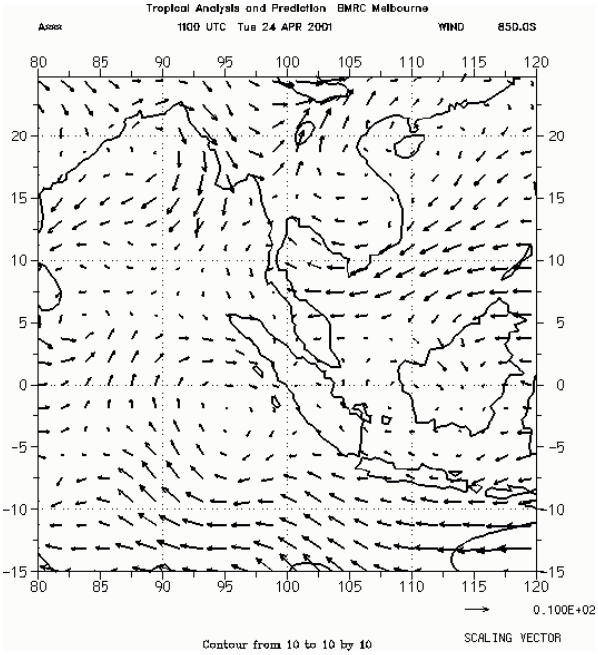

Figure 1. 850 hPa windfield valid 1100UTC, 24 April 2001

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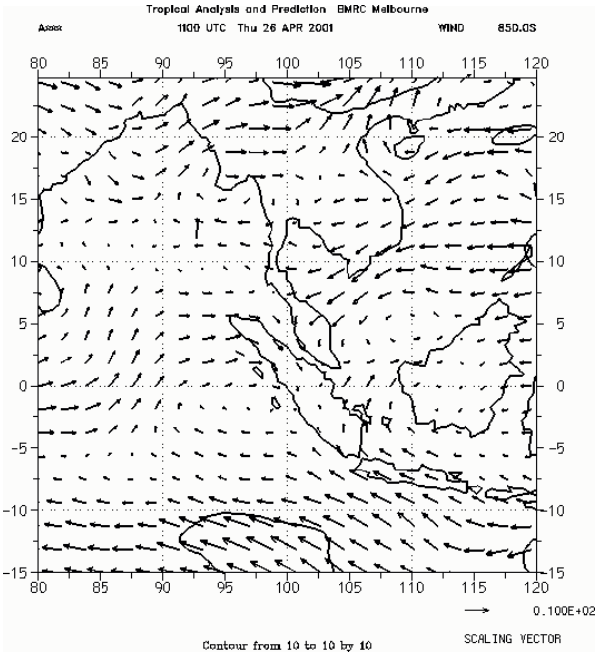

Figure 2. 850 hPa windfield valid 1100UTC, 26 April 2001

Figure 3 shows a time-longitude section of infrared satellite cloud imagery (cloud top temperatures) between 80E and 180E over the latitude band 5S to 5N. Temperatures less than 250^0K are dashed. The figure shows that the heavy rain event coincided with the arrival of a large-scale eastward propagating cloud band over Malaysia. However what appeared to make this event unique was also the simultaneous development of a trade wind surge over the SCS.

Figure 4 shows a 60 day time series beginning 1 April 2001 over Malaysia, of 24 hour accumulated rainfall over the second 24 hours of a 48 hour forecast from the Australian Bureau of Meteorology's operational Tropical Limited Area Prediction System, TLAPS (Puri *et al.*, 1998). The model has identified the major rain episode in late April and in fact the largest rainfall predicted for this entire period corresponds with the heavy rain event. Similar prediction quality has been obtained for the other heavy rain events.

3. Conclusion

Investigation of a limited number of heavy rain events over south east Asia suggests that (i) there are large-scale controls on such events, (ii) they occur as an interaction between at least two major circulation features (MJO, trades, monsoon, tropical depressions/cyclones, mid-latitude weather systems), and (iii) relative to its own climatology, a sophisticated NWP system can provide very useful guidance on precipitation for these events. Rain totals were underestimated and details in the precise location and timing of the rain contained errors, but peaks in forecast large-scale 24 hour accumulated rainfall (relative to other forecast times) clearly coincided with the actual events. Although these results are rather encouraging, and suggest that the large scale forcing was accurately depicted, recent mesoscale prediction experiments suggest improvements in mesoscale initialisation and representation of physical processes are necessary before routine, detailed prediction of similar events is achieved

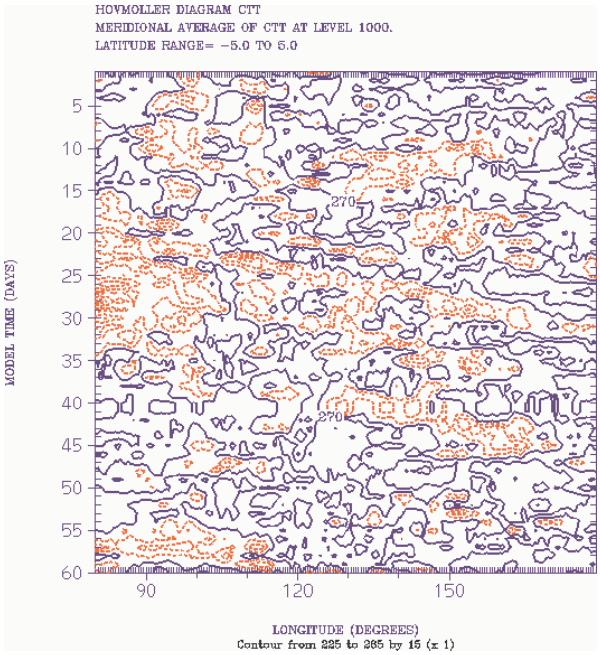

Figure 3. Time-longitude section from 80E-180E of cloud top temperature for 5S-5N band from 1 April 2001.

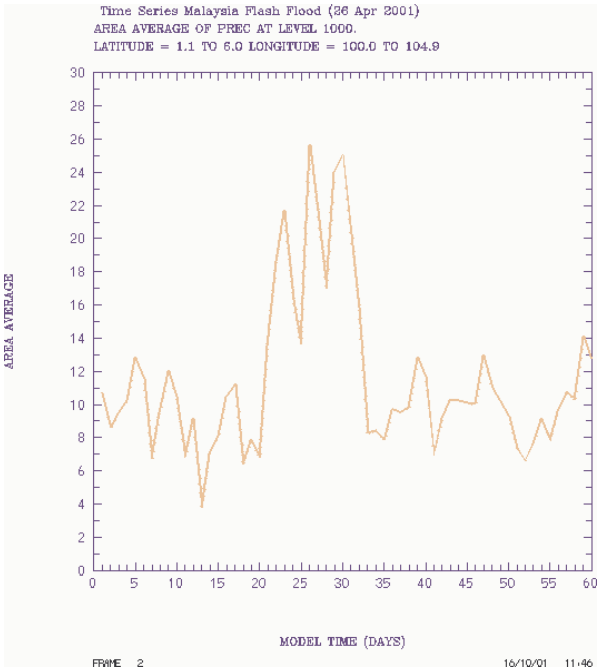

Figure 4. Time series of forecast precipitation over Malaysia (see text).

References

Puri, K., G.S. Dietachmayer, G.A. Mills, N.E. Davidson, R.A Bowen and L.W. Logan, 1998: The new BMRC Limited Area Prediction System, LAPS. *Aust.Met.Mag.*, **47**, 203-223.