14B.2 PRELIMINARY RESULTS FROM THE SOUTH CHINA SEA MONSOON EXPERIMENT SOUNDING NETWORK

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1. INTRODUCTION

During the May-June 1998 South China Sea Monsoon Experiment (SCSMEX), a sounding network was established in the South China Sea (SCS) and surrounding region to investigate the onset and development of the East Asian monsoon. This network was contained within the larger domain of the GEWEX Asian Monsoon Experiment (GAME). Sounding sites within the SCSMEX/GAME domain are shown in Fig. 1. Numbers at the station locations indicate the number of soundings received and decoded at the Colorado State University (CSU) soundings-monitoring facility at Hong Kong University of Science and Technology (HKUST). For SCSMEX, six-hourly soundings were obtained during two Intensive Observing Periods (IOPs) (5-25 May and 5-25 June) from the two research vessels *Kexue #1* and *Shiyan #3*, several islands and coastal stations surrounding the SCS.

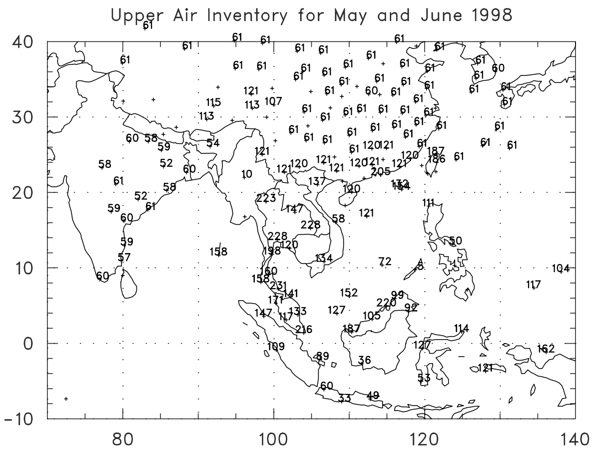

Figure 1: Number of upper-air soundings that were received and decoded within the SCSMEX/GAME domain during May and June 1998.

Most of the sounding data were transmitted onto the Global Telecommunications System (GTS). GTS and other SCSMEX sounding data were ingested and processed in realtime by CSU staff at HKUST. Gridded sounding analysis products were prepared in realtime and made available to the SCSMEX Operations Center in Guangzhou. In this paper, we present some preliminary findings from the SCSMEX/GAME sounding network.

2. MONSOON ONSET: TRANSITION OF THE LARGE-SCALE FLOW

The Asian summer monsoon is a major component of the Northern Hemisphere summertime circulation system. Its precipitation affects over half the world's population. The initial onset of the summer monsoon over Asia in early to mid-May occurs over the South China Sea (SCS) region (Tao and Chen 1987; Lau and Yang 1997). In early spring, convection begins a transition northward from the Indonesian "maritime continent" toward southeast Asia. The path of the monsoon rains is typically across the Borneo-Malaysia-Indo-China land bridge from mid-April until mid-May, followed by a rapid jump across the SCS during mid-to-late May. The subsequent arrival of the rains over central China and Japan marks the beginning of the Mei-Yu and Baiu rainy seasons over those respective areas.

The actual timing of the monsoon onset can vary by two to three weeks and the amount of precipitation over the SCS region can also vary considerably from year to year (e.g., Lau and Yang 1997). The 1998 monsoon onset over the SCS occurred in mid-May. Streamline analyses at 850 and 200 hPa prior to the onset (11 May) are shown in Fig. 2. At 200 hPa the pre-onset flow was characterized by westerlies over India and China with generally northwesterly flow over the SCS. At 850 hPa a subtropical ridge extended from the western Pacific across Indo-China with east-to-southeasterly flow over the SCS. As the monsoon set it, dramatic changes in the large-scale flow occurred. Just ten days later (21 May) a 200-hPa anticyclone built northward along the Indo-China peninsula, while at 850 hPa the subtropical ridge retreated eastward and westerly low-level flow enveloped the SCS (Fig. 3). During this period, convection shifted northward along the Indo-

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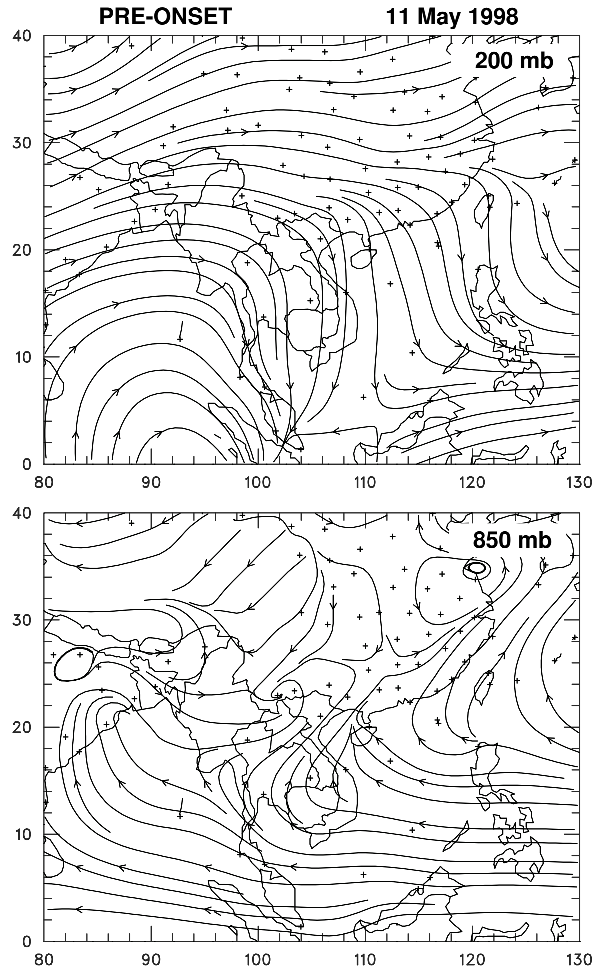

Figure 2: Streamline analysis at 200 mb (top panel) and at 850 mb (bottom panel) for 00 UTC 11 May 1998 showing pre-onset flow conditions. Plus signs indicate locations where data were present to produce this analysis.

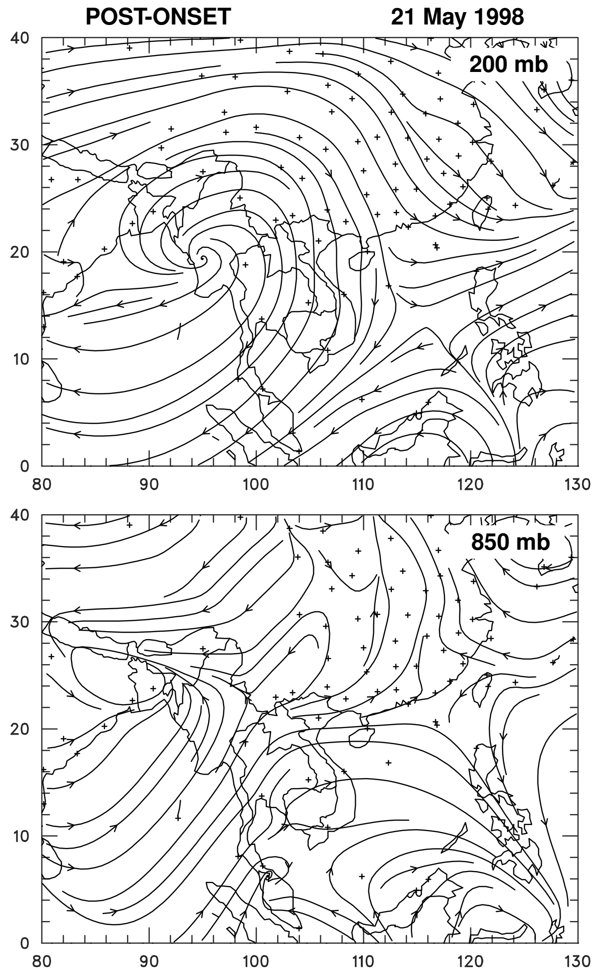

Figure 3: Streamline analysis at 200 mb (top panel) and at 850 mb (bottom panel) for 00 UTC 21 May 1998 showing post-onset flow conditions. Plus signs indicate locations where data were present to produce this analysis.

China peninsula.

3. ONSET CHARACTERISTICS OVER THE SOUTH CHINA SEA

Figures 2 and 3 indicate marked transitions of the flow over the southern SCS between 11 and 21 May. These transitions are further illustrated in Fig. 4, a time series of the filtered zonal component of the flow at *Kexue #1* (6°N 110°E). The time series shown in Figures 4–7 were constructed by applying a 5-point running mean filter to 6-hourly sounding data. In the upper troposphere the flow shifted from westerly to easterly flow around 12-13 May as the upper-level anticyclone built northward. At low levels, a shift from easterly to westerly flow occurred on 20 May. Since monsoon onset is generally linked to the behavior of the low-level flow, 20 May may be regarded as the date of the monsoon onset over the southern SCS.

Although very little precipitation occurred at *Kexue #1* accompanying the monsoon onset, there were several changes in the humidity profile associated with the flow reversal in that region (Fig. 5). Prior to the onset, in early May, the relative humidity (RH) structure in the easterly low-level flow resembled that of the tradewind regime, with a low-level moist region below 800-700 hPa capped by very dry air aloft. During a 10-day period prior to the monsoon onset, this moist layer deepened with time, presumably in response to the weakening subtropical ridge and corresponding weakening subsidence, which allowed the shallow cumulus clouds to grow to progressively greater depths. When the low-level

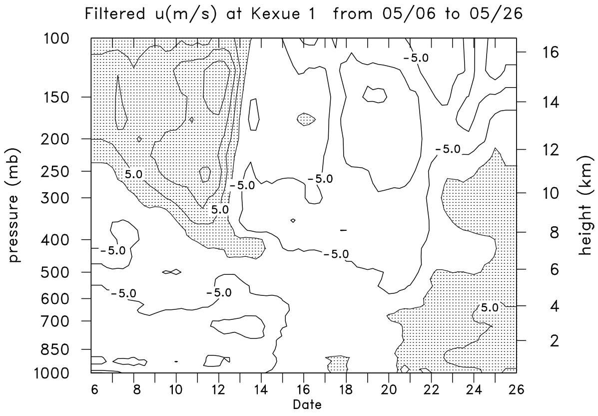

Figure 4: Time series of the filtered zonal wind component (ms^{-1}) at *Kexue #1* from 00 UTC 6 May 1998 to 00 UTC 26 May 1998. Contour interval is 5 ms^{-1} with westerly winds shaded.

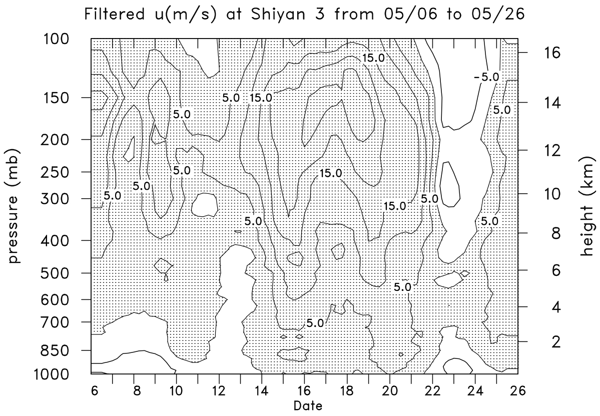

Figure 6: Time series of the filtered zonal wind component (ms^{-1}) at *Shiyan #3* from 00 UTC 6 May 1998 to 00 UTC 26 May 1998. Contour interval is 5 ms^{-1} with westerly winds shaded.

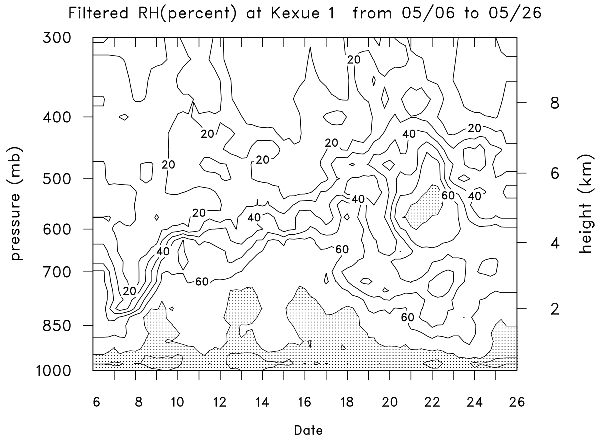

Figure 5: Time series of the filtered relative humidity (percent) at *Kexue #1* from 00 UTC 6 May 1998 to 00 UTC 26 May 1998. Contour interval is 10% with values greater than 70% shaded.

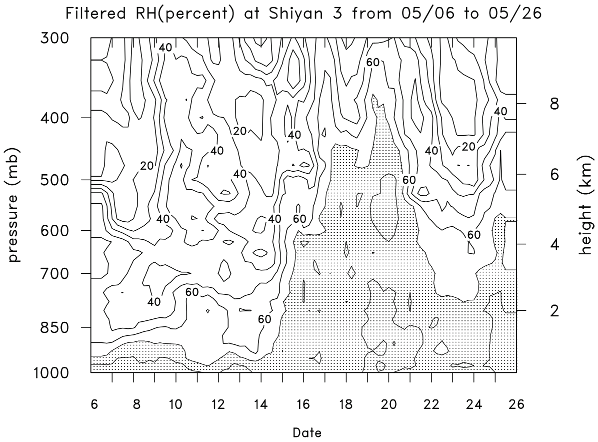

Figure 7: Time series of the filtered relative humidity (percent) at *Shiyan #3* from 00 UTC 6 May 1998 to 00 UTC 26 May 1998. Contour interval is 10% with values greater than 70% shaded.

westerly flow commenced around 20 May, the RH structure changed to one of moist conditions in the mid-to upper troposphere with somewhat drier conditions near 700 hPa.

The monsoon onset over the northern SCS exhibited a markedly different behavior. A reversal of the zonal component of the flow aloft at *Shiyan #3* (21°N 117°E) did not occur until 22 May (Fig. 6). However, a strenghening of the low-level flow occurred one week earlier, around 15 May. This latter date may be regarded as the onset date for this region of the northern SCS.

The monsoon onset in the northern SCS is accompanied by a distinct change in the RH profile (Fig. 7). Relatively dry tropospheric conditions above a moist boundary layer existed prior to the onset. However, following the onset virtually the entire troposphere became moist as precipitation developed in this region.

4. SUMMARY AND CONCLUSIONS

Observations from the SCSMEX/GAME sounding domains have been used to document several features of the onset of the 1998 East Asian summer monsoon. Marked transitions of the low-level and upper-level flow occurred in the vicinity of the South China Sea (SCS) in mid-May as the summer monsoon became established over this region. Over the northern SCS, the onset of westerly monsoon flow occurred around 15 May, whereas over the southern SCS the onset was on 20 May. Deep tropospheric moistening accompanied the monsoon onset in the northern SCS as precipitation began in that region. Changes in the moisture profile in the SCS were more complex, although there appeared to be a transition from a tradewind-like structure (moist trade cumulus layer capped by dry air aloft) to a moistening of the mid-to-upper troposphere accompanying onset.

Preliminary results from SCSMEX indicate that the monsoon onset over the South China Sea is rather complex and far from homogeneous over this oceanic region. Further work is underway to understand the characteristics of the monsoon onset in greater detail.

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5. REFERENCES

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