

# **Observations of 5-8-day Wave in the Tropical Atmosphere During CPEA Campaign**

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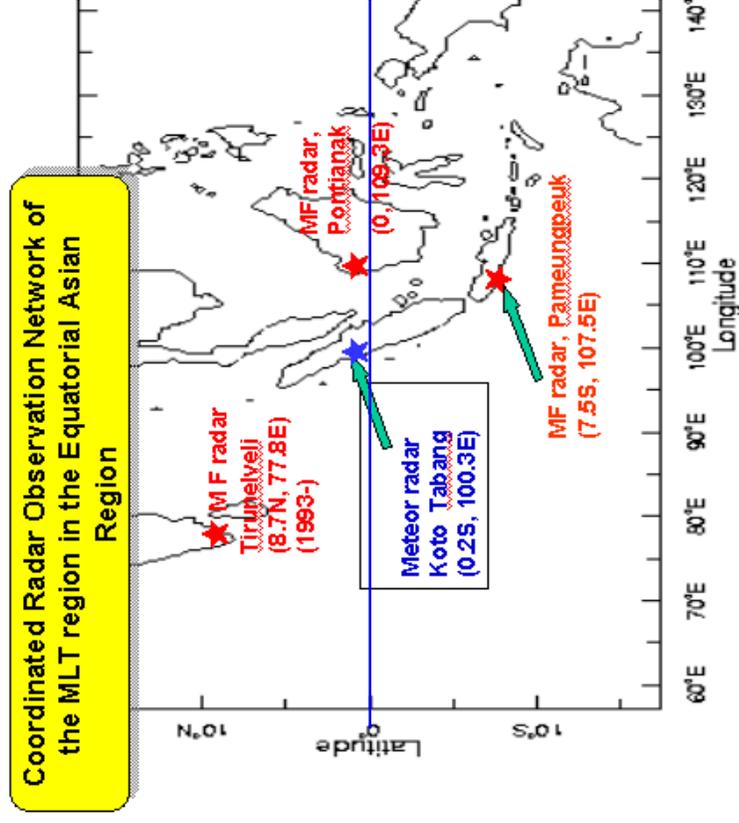
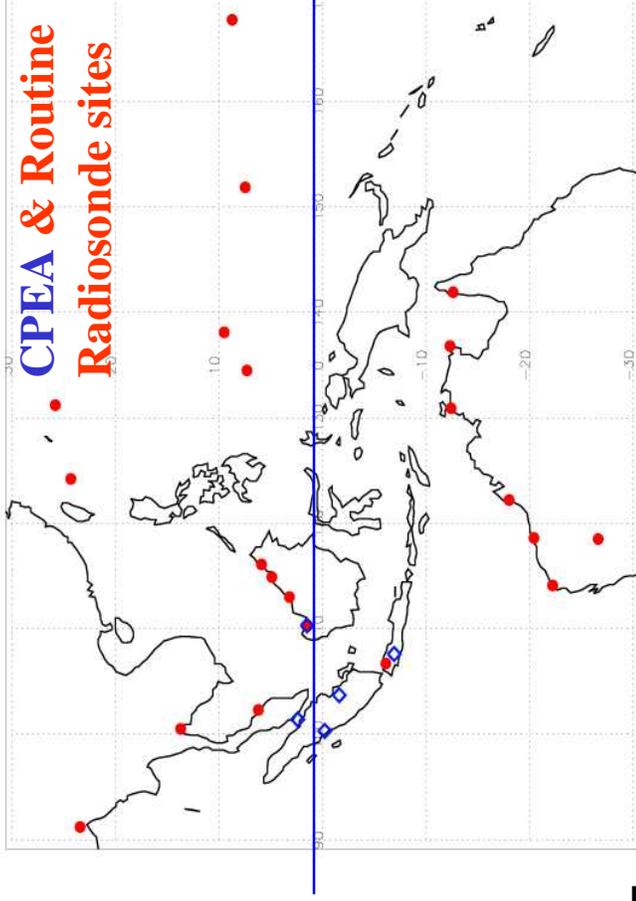
**Objective:** Horizontal structure and height variations of atmospheric waves with period of 5-8 days in the equatorial atmosphere

**Data used in the study**

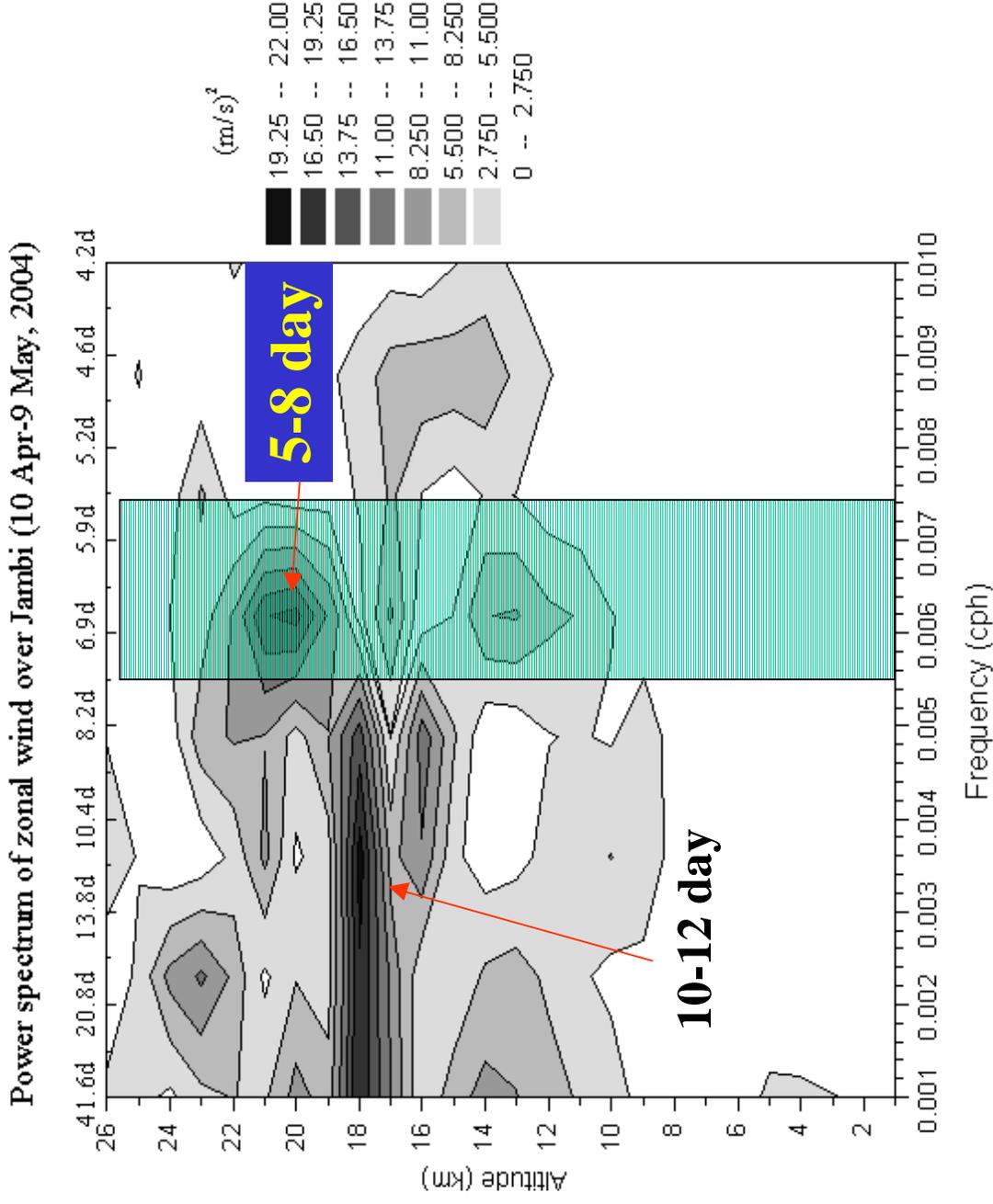
- (a) Radiosonde profiles ( 0-30 km ) during the 1<sup>st</sup> CPEA Campaign from April 10 to May 9, 2004 and operational radiosonde data
- (b) MLT radars (80-100km) : 2 MF and 1 meteor radars in Indonesia, 1 MF radar in India
- (c) Satellite: TIMED/SABER data (temperature, 20 – 120 km) and OLR data as proxy for convection



**TIMED/  
SABER**

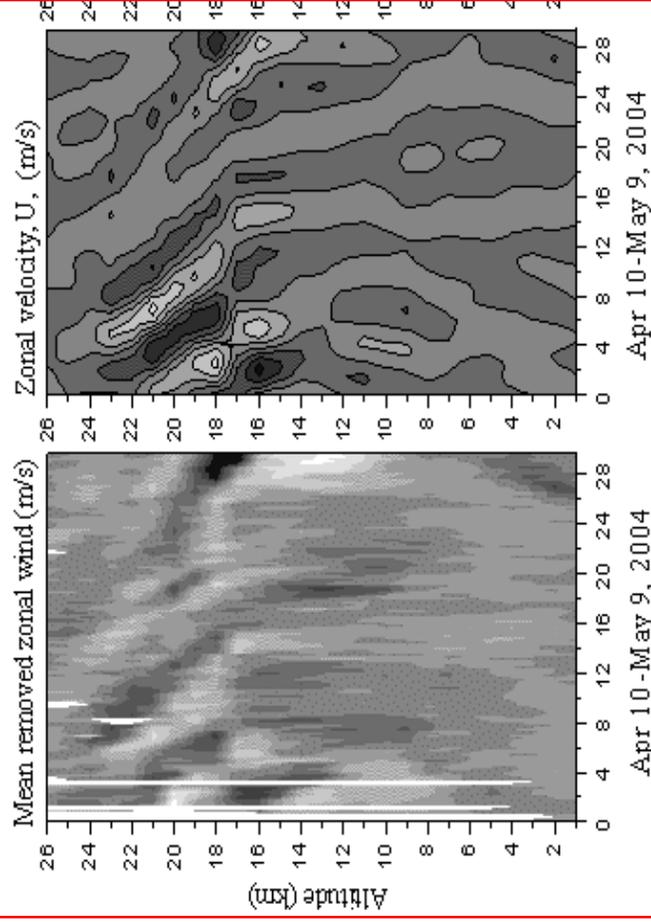


# Frequency spectra of zonal wind velocity from radiosonde profiles



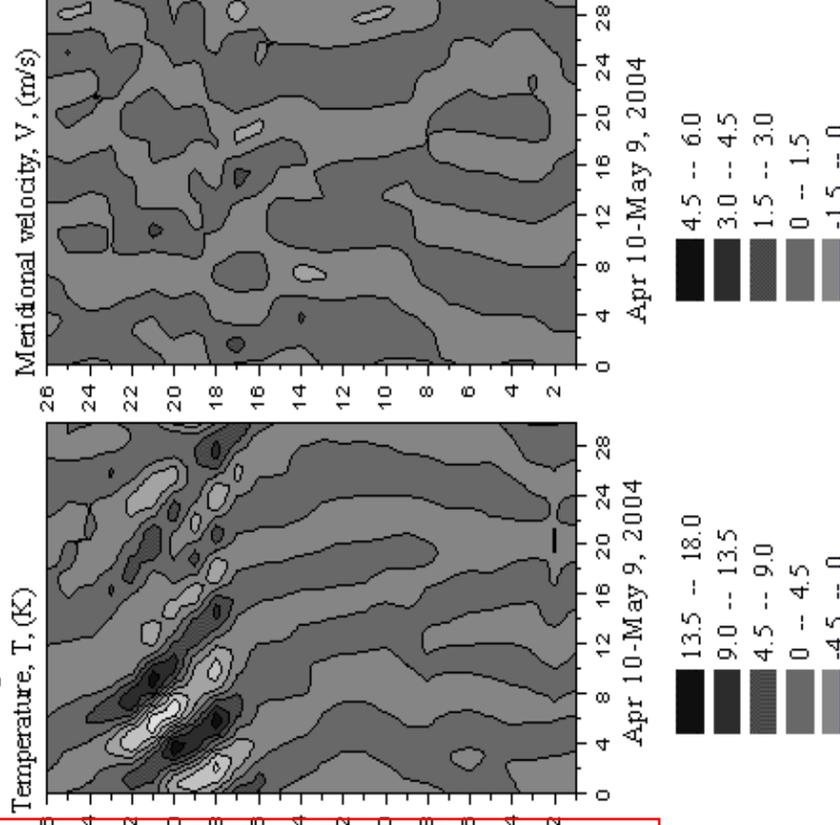
- Dominant wave period was about 7 days (ranging from 5 to 8 days)
- The wave energy enhanced at 20-21 km, but it became smaller above 23 km

## Eastward wind velocity (Raw and Band-pass-filtered)



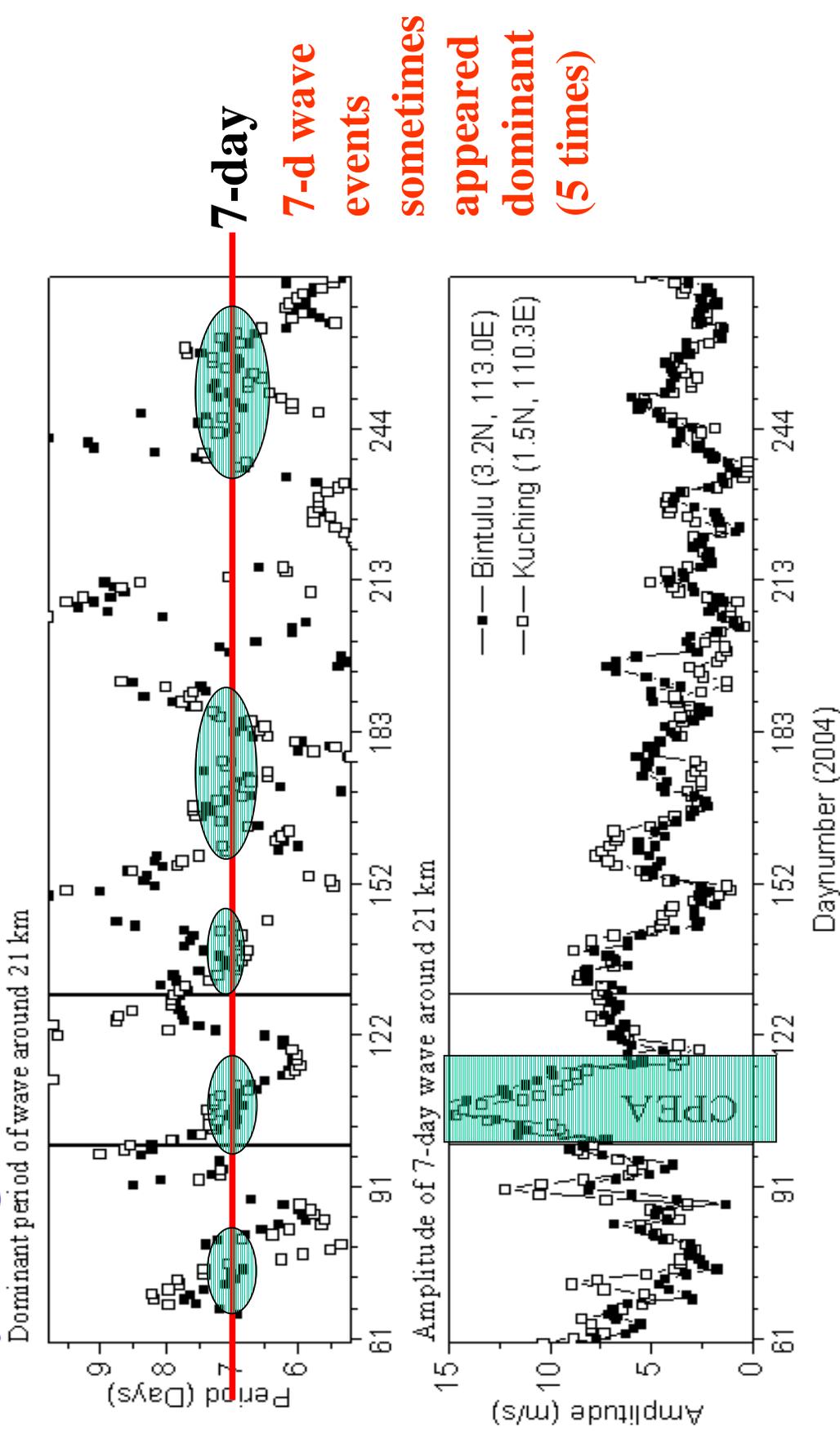
## Temperature (BPF) Northward wind velocity (BPF)

5.0-9.0-d band-pass filtered U, T and V



- Downward phase propagation with  $\lambda_z = 5-6$  km.
  - Large energy appeared only in zonal winds and temperature
  - Temperature phase leads zonal wind phase by about 90 deg
- Consistent with the characteristics of Kelvin waves

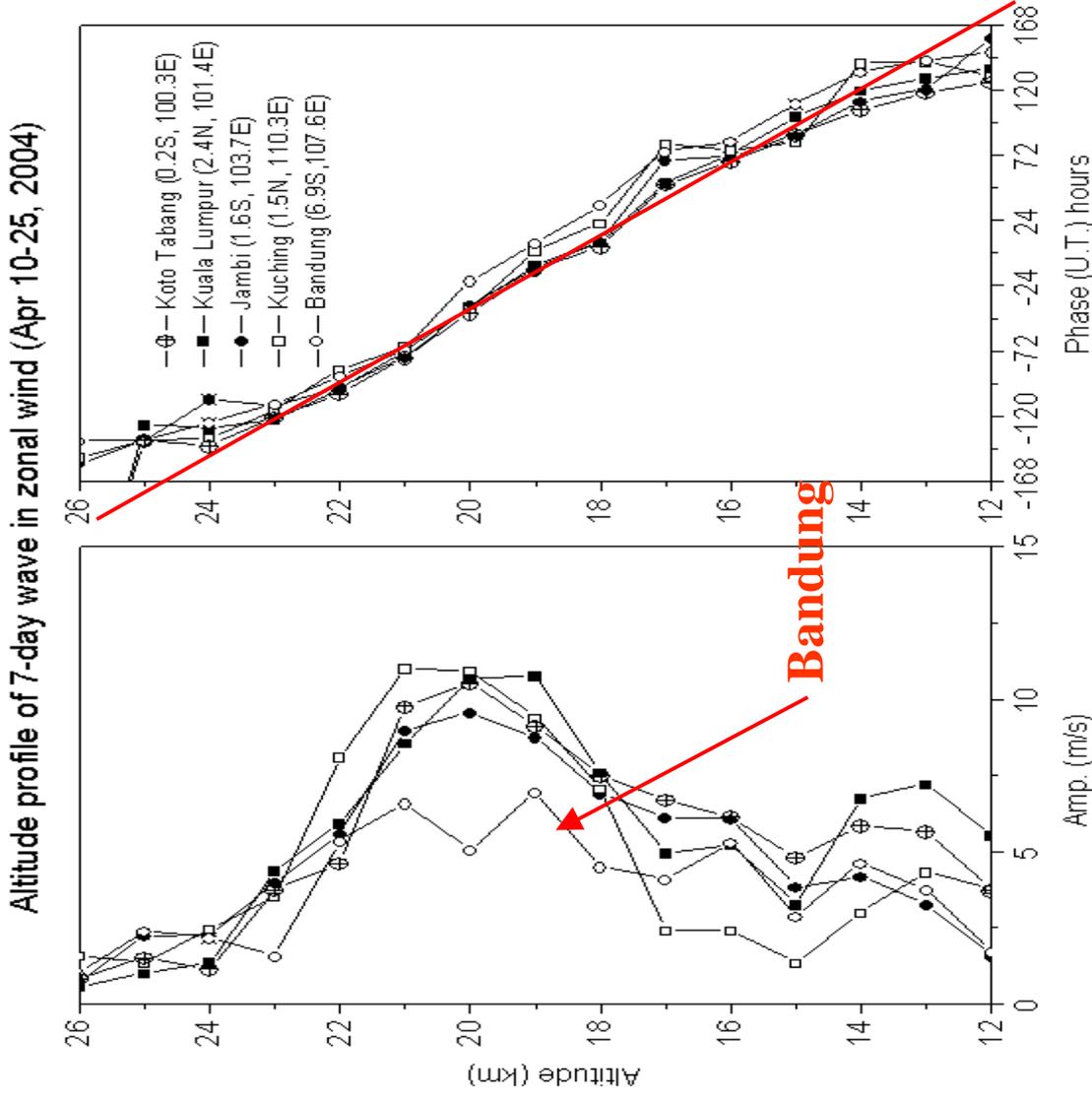
# Long-term variations of the dominant wave period inferred by the periodogram analysis (top) and the amplitudes (bottom) at 21 km by using routine radiosonde data at Borneo



**7-day wave events sometimes appeared dominant (5 times)**

**The largest enhancement occurred during the 1st half of CPEA campaign**

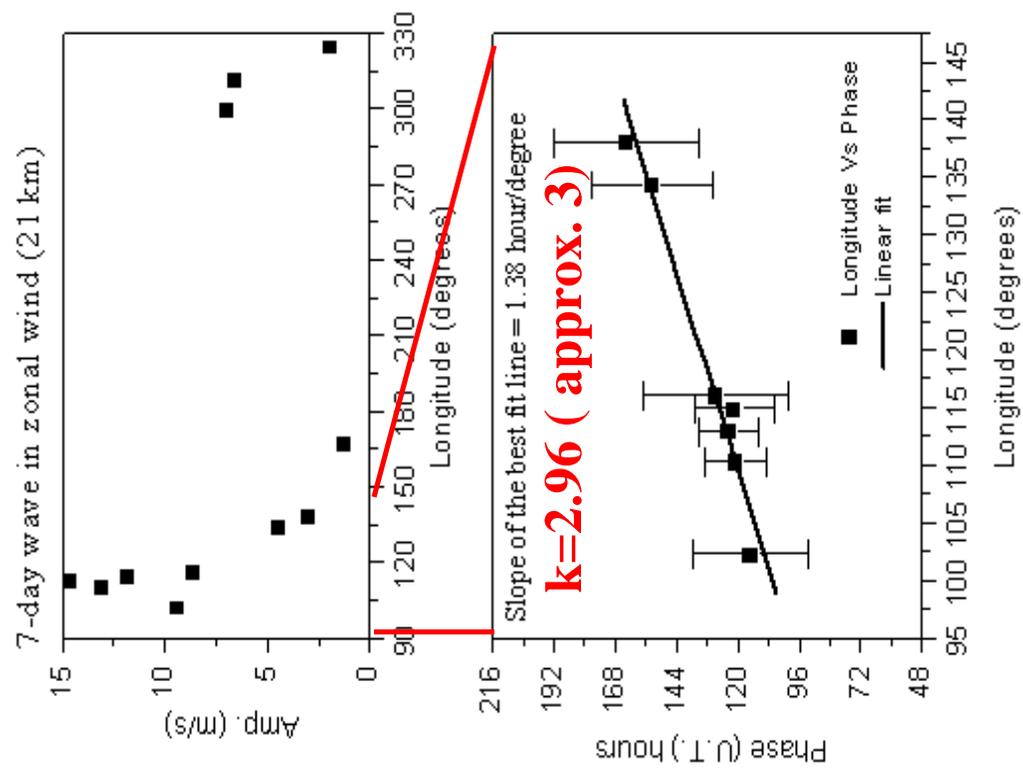
# Profiles of the 7-day wave amplitude (left) and relative phase (right) for the zonal wind velocity during the 1<sup>st</sup> half of CPEA campaign



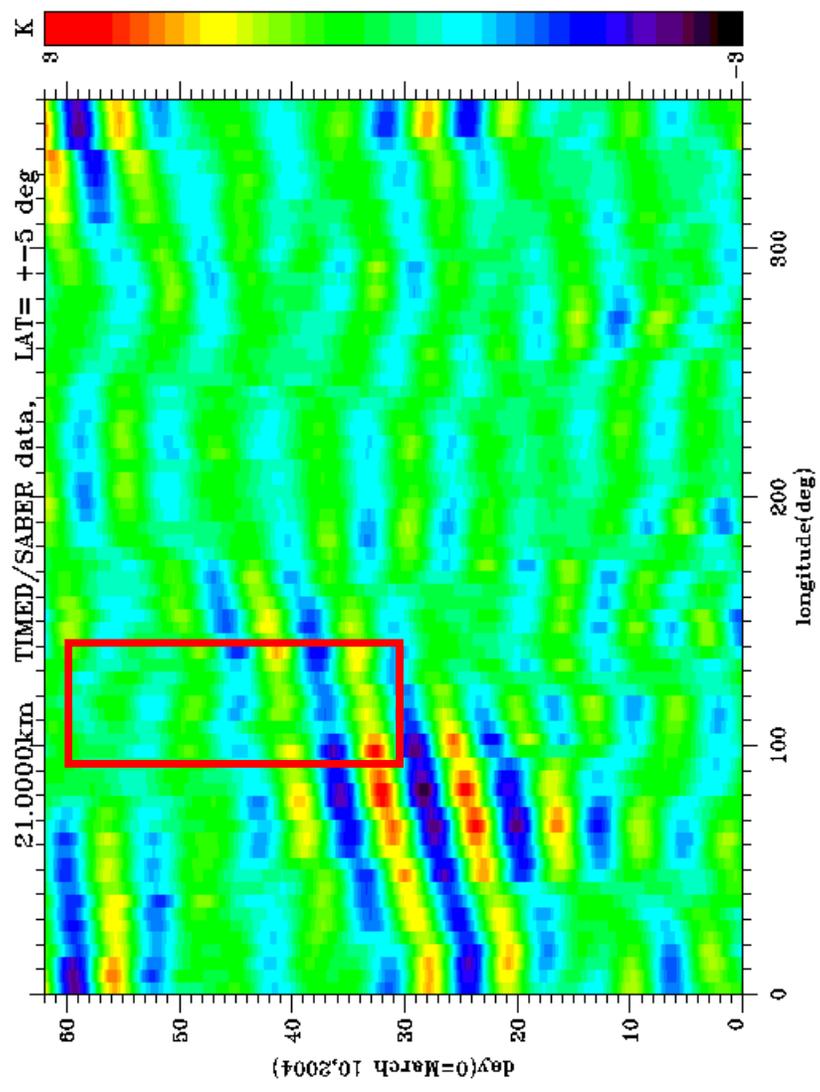
- Maximum amplitude ~10 m/s at 20 km
- Profiles are consistent among the 7 radiosonde sites over Indonesian maritime-continent
- At Bandung (7S), the amplitude was smaller (6 m/s), compared to other equatorial sites
- Phases are coherent for the 7 sites

wave length = about 6km

Longitude variations of the zonal wind amplitudes and relative phase from routine radiosonde results



### TIMED/SABER Filtered Temperature

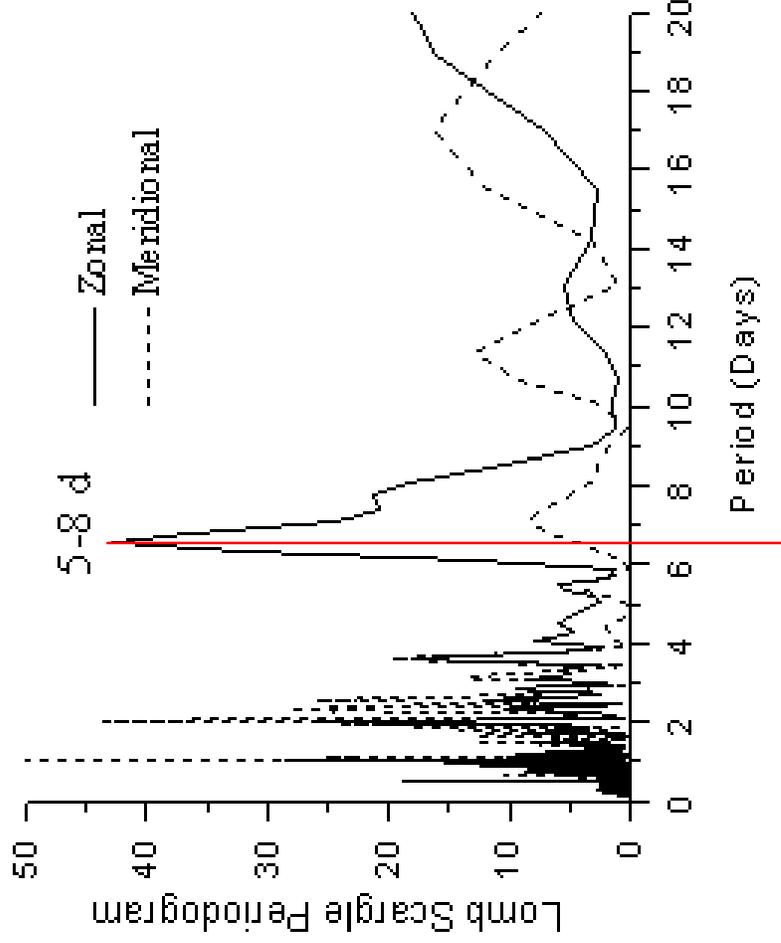


During the CPEA campaign period, the 7-day wave was evident in the eastern hemisphere with a zonal wave number 3 structure.

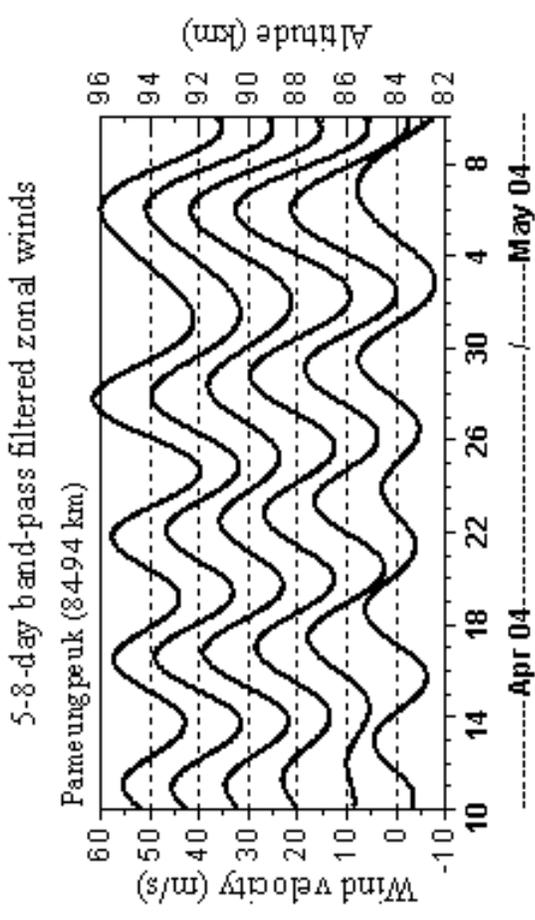
# Atmospheric waves in the MLT region during the CPEA-1 campaign

**Lomb-Scargle periodogram of zonal wind velocity at 90 km observed with the MF radar in Pameungpeuk, west Jawa (7.5S, 107.5E), Indonesia.**

Pameunpeuk, 90 km (Apr 10-May 9, 2004)



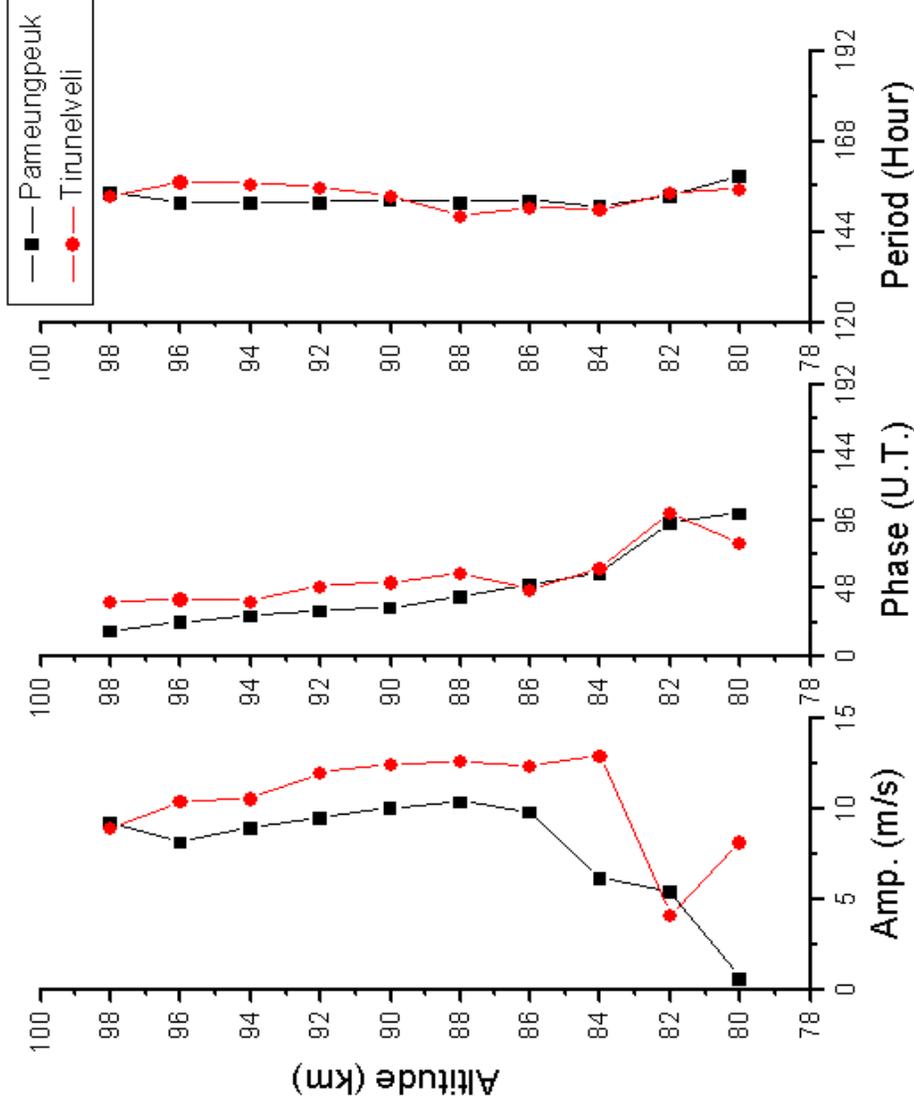
**6.5–7 day**



- A 7-day wave is detected with a consistent downward phase progression (upward energy propagation).
- The wave amplitudes became larger in the 2<sup>nd</sup> half of the campaign.

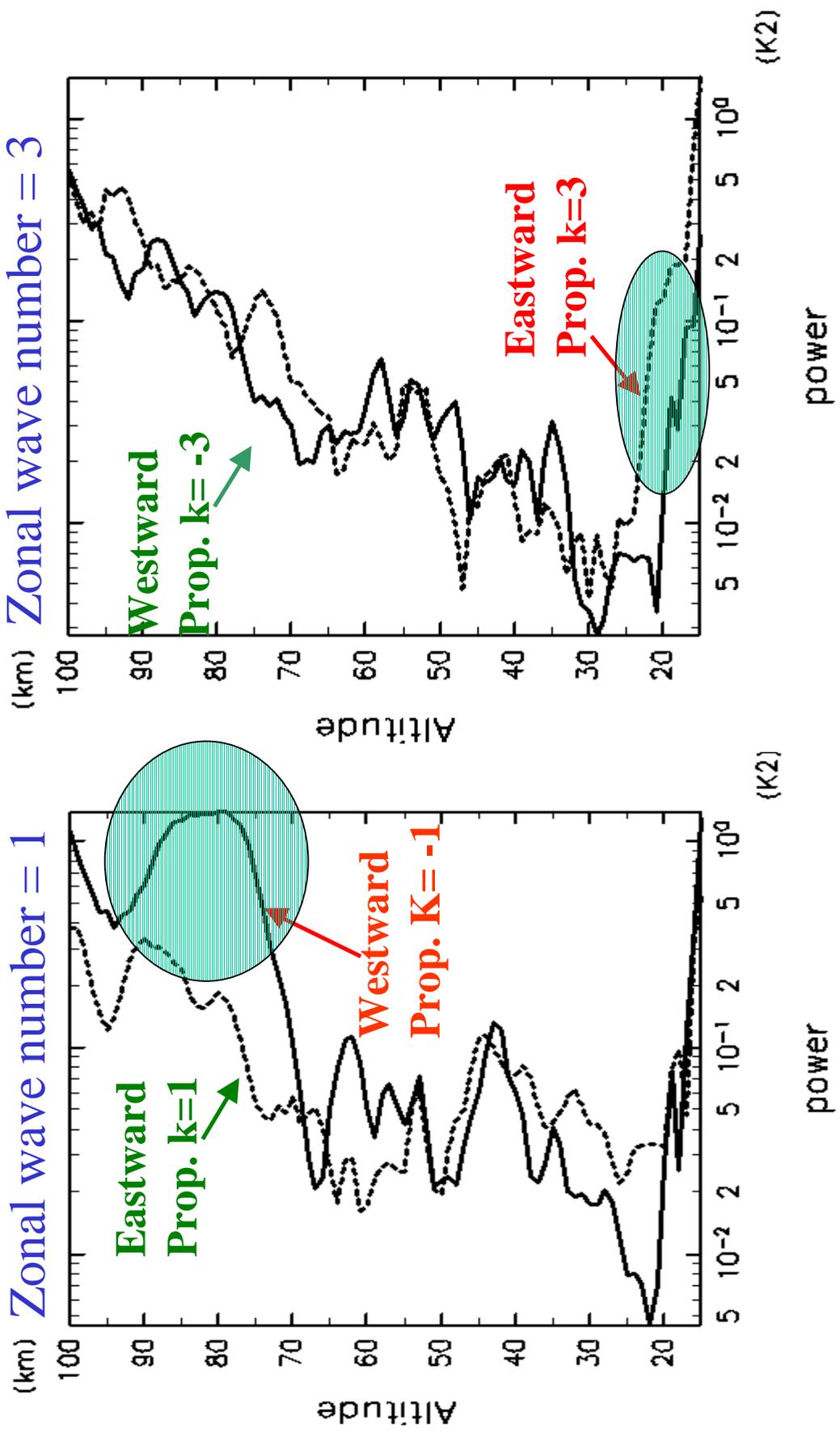
**Amplitudes and relative phase of 5-8 day wave observed in the MLT region with MF radars at Pameungpeuk (7.5S, 108E, Indonesia) and Tirunelveli (8.7N, 78E, India)**

Altitude profile of 5-8-day wave in zonal wind (Apr 15-May 10, 2004)



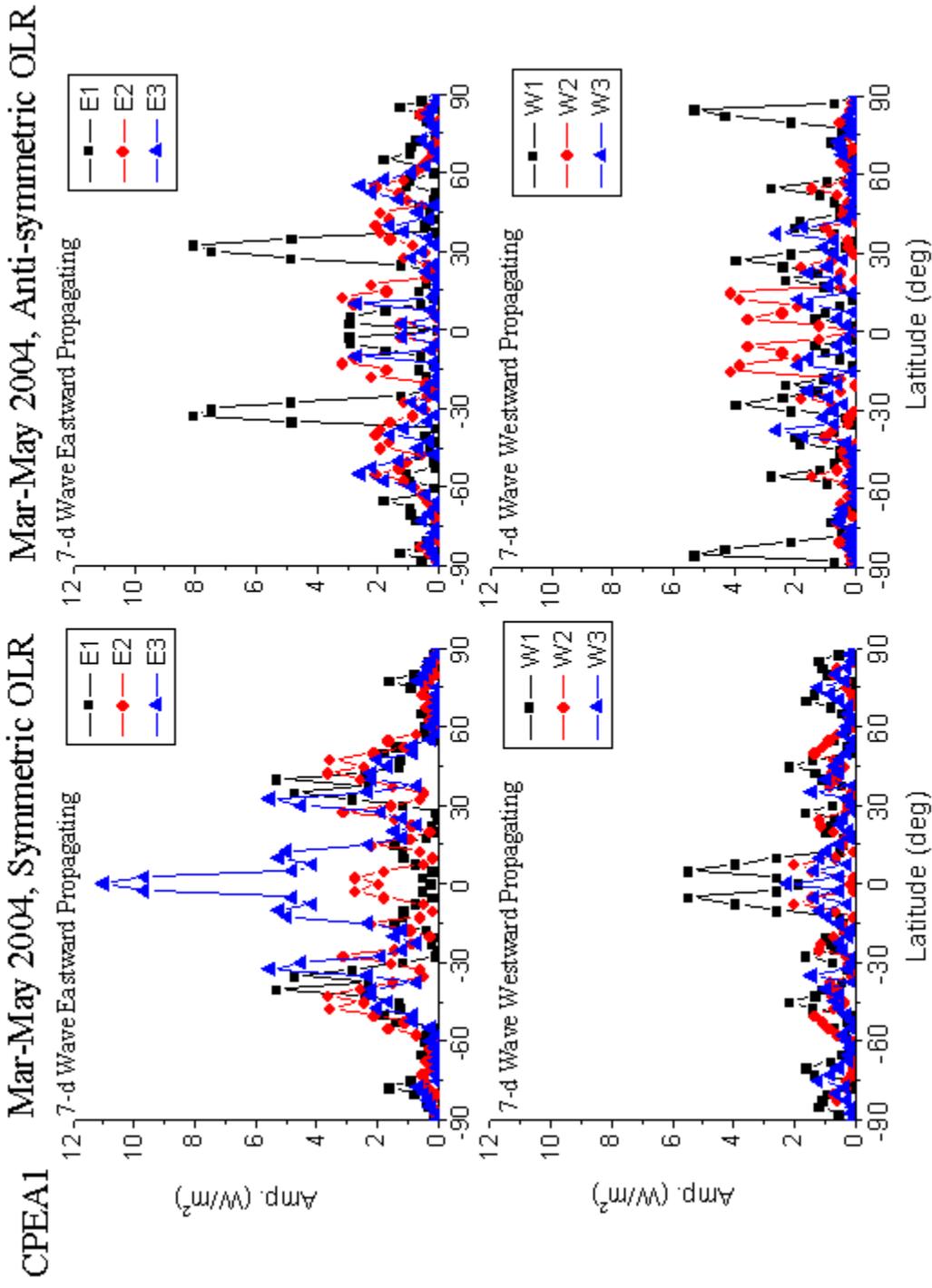
- Dominant wave period = 154hr (6.5 day)
- Downward phase progression with a long vertical wavelength (approx. 50 km)
- Phase relation indicates that Pameungpeuk leads Tirunelveli, consistent with westward propagation with a zonal wave number (k) 1

Altitude profiles of 5-8d wave energy with  $k=1$  (left) and  $k=3$  (right) from TIMED/SABER temperature data



7-day wave with  $k=3$  was dominant at lower heights (0-25 km), but in the MLT region (70-90km) the wave with  $k=-1$  became dominant.

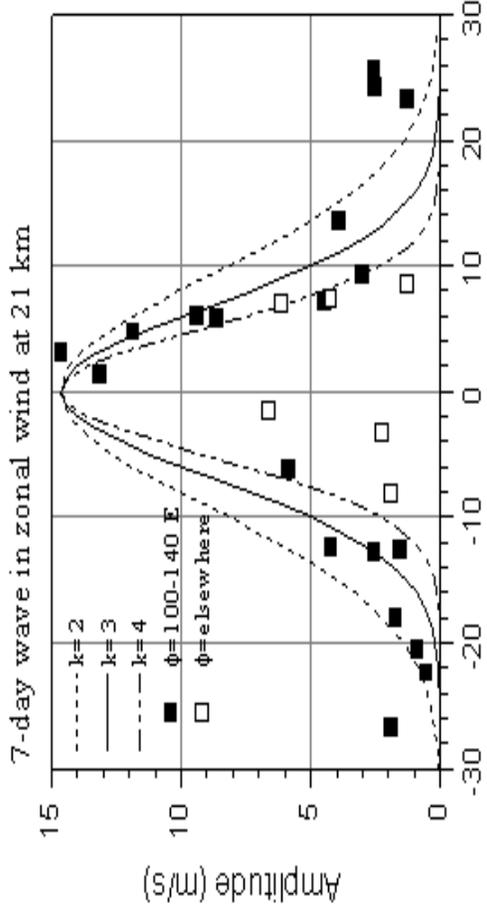
# CPEA-1 OLR



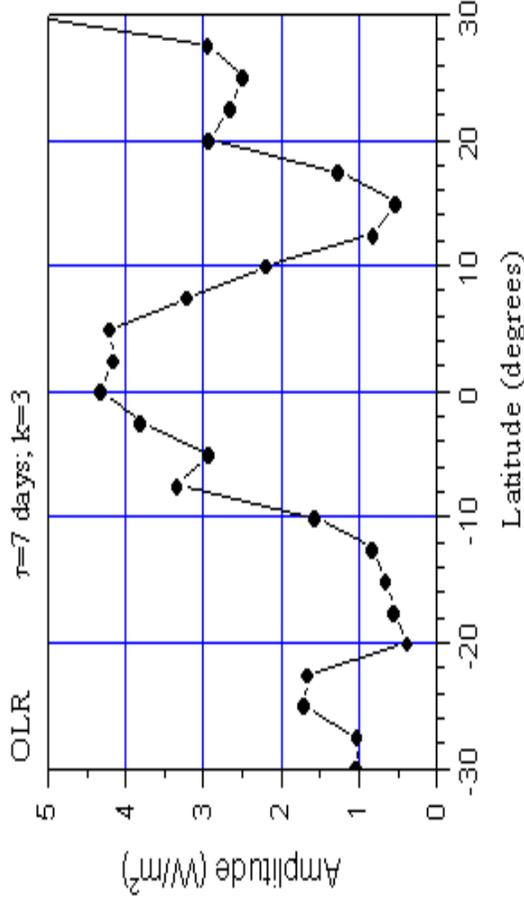
**OLR distribution was decomposed into Space-Time Fourier components. For eastward propagation, 7-day oscillation with  $k=3$  was dominant, and for westward propagation 7-day and  $k=-1$  was recognized.**

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### Latitude structure of 7-day wave

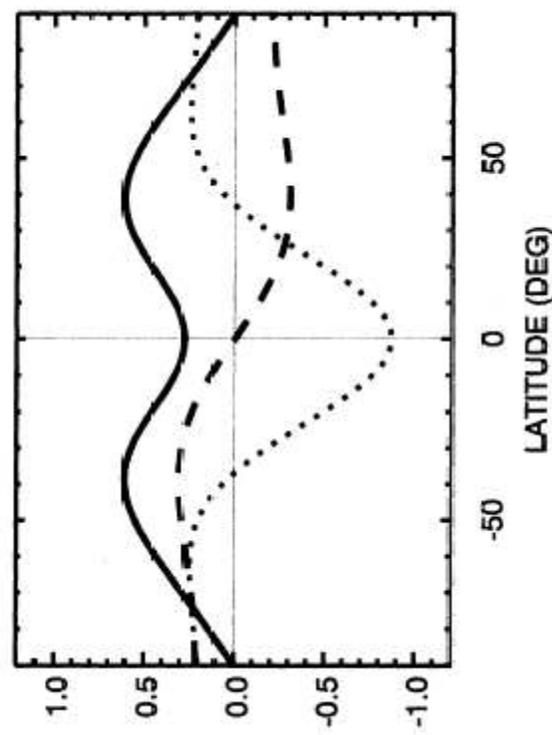
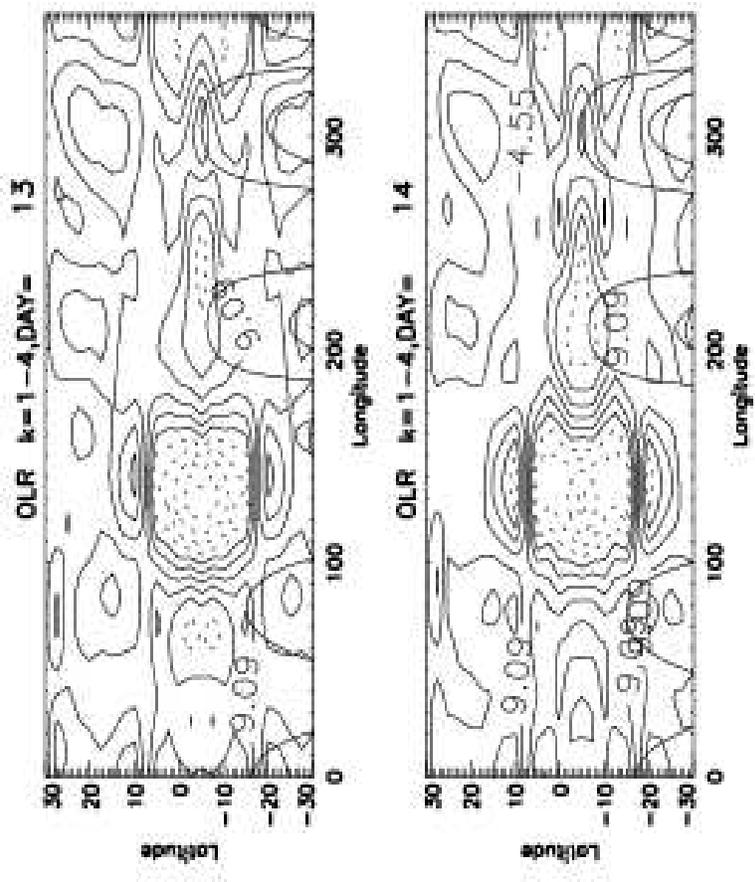


**Latitude distribution of the 7-day wave amplitude (zonal winds) at 21 km from radiosondes, together with a theoretical e-folding shape (Gaussian) for  $k=2, 3$  and 4. The  $k=3$  structure describes the observed distribution at 100-140°E very well.**



**Latitude distribution of OLR for 7-day and  $k=3$**   
**The latitude distribution is consistent between the zonal winds (top) and OLR**

# Gill's pattern



**Figure 3.** Theoretical Rossby wave first symmetric mode,  $(s, n - s) = (1, 1)$ , latitudinal structures corresponding to a period of 6.5 days, with Hough function solution (solid line), zonal wind (dotted line), and meridional wind (dashed line).

## Summary

1. We have studied the behavior of a 7-day wave during the **CPEA campaign (April-May 2004)** using radiosonde, MF radar and TIMED/SABER measurements.
2. In the lower stratosphere (at about 20km), **a 7-day wave with eastward propagation (k=3)** was dominant over the Indian Ocean to Indonesia, whose characteristics are consistent with those of equatorial Kelvin wave.
3. In the MLT region (80-100km), a wave with similar periodicity (5-8 days) simultaneously appeared in the zonal winds over India and Indonesia, but it showed **westward propagation (k=-1)**.
4. TIMED-SABER temperature results clarified the height variations of the 7-day waves. The component with k=3 was dominant in the lower atmosphere, while the wave k= -1 became larger in the MLT region.
5. OLR distribution in the tropics shows the presence of 7-day periodicity with k=3 and k=-1 in the troposphere, suggesting tropical convection could be the source for these waves.
6. Presence of two waves of similar periodicity but different in the zonal propagation characteristics could be explained by the Gill's pattern; **i.e., as a steady response to the equatorial heat source in finite area, Kelvin and Rossby wave-type perturbations appear simultaneously with eastward and westward propagation, respectively.**