A Preliminary Report on Observations of Equatorial Atmosphere Dynamics in Indonesia with Radars and Radiosondes

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Abstract

Through collaboration between Japan and Indonesia, a radar observatory was established near Jakarta, Indonesia in November 1992, where we installed a meteor wind radar (MWR) and a boundary layer radar (BLR). Horizontal wind velocity and temperature fluctuations at 75–100 km were determined with the MWR with time and height resolution of 1 hour and 4 km, respectively. The BLR provided three components of wind velocity every minute in the planetary boundary layer (0.3–5 km) with a height resolution of 100 m. In addition, by combining an acoustic transmitter, temperature profiles were also obtained with the BLR by means of the RASS (radio acoustic sounding system) technique. Observations with the radars have been continued over 2 years since November 1992.

Profiles of horizontal wind velocity, temperature and humidity were measured with radiosondes up to 35 km, with a height resolution of 150 m, four times a day during November 1992–April 1993 at LAPAN in Bandung. Further, radiosonde sounding has been routinely continued once a day after October 1993.

Preliminary data analysis showed some new aspects of the equatorial atmosphere dynamics over Indonesia, such as the structure of the tropical planetary boundary layer and the behavior of atmospheric waves in the middle atmosphere. We report in this paper a description of the radar equipment, the current status of observations and the fundamental characteristics of equatorial atmosphere dynamics during the TOGA/COARE campaign.

Fig. 1. The radar observatory in Indonesia. Three parabolic antennas for the BLR (right-bottom) and four five-element Yagi antennas for the MWR were constructed. Loudspeakers are used for the RASS temperature measurements. All the radar equipment except for antennas is stored in two containers. Instruments for surface weather measurements, including the anemometer, are also installed in the observatory.

1. Introduction

It is recognized that large year-to-year variations in cloud convection over a maritime continent around Indonesia are closely related to the behavior of an anomalous weather condition known as El Niño. Recent studies further revealed that active cloud convection generates various atmospheric waves, such as Kelvin waves, mixed Rossby gravity waves, atmospheric tides and gravity waves [*e.g.*, Andrews *et al.*, 1987]. The wave energy thus deposited is transported both vertically and horizontally for a long distance.

While, tall cumulus clouds, exclusively generated near Indonesia, sometimes penetrate above the tropopause, which transport the tropospheric air into the stratosphere, resulting in upward flux of various minor constituents [Holton, 1982]. Although it has become widely recognized that the equatorial atmosphere over Indonesia plays an important role in global change of the earth's atmosphere, its detailed characteristics remain unresolved, since there are not so many accurate observations in this region so far.

Through collaboration between Japan and Indonesia, we proposed to observe atmosphere dynamics in the troposphere and middle atmosphere over Indonesia by means of ground-based observation techniques. A radar observatory was established in PUSPIPTEK (Indonesian National Center for Research, Science and Technology), Serpong (6.4°S, 106.7°E, 50 m MSL), located about 27 km south-west of Jakarta, where we constructed a meteor wind radar (MWR) and a boundary layer radar (BLR) as shown in Fig. 1. The MWR and BLR measure wind velocity and temperature profiles in the mesosphere (75–100 km) and lower troposphere (0.3–5 km), respectively. In addition, radiosonde sounding of horizontal winds, temperature and humidity at 0–35 km altitude was conducted at LAPAN in Bandung (6.9°S, 107.6°E, 740 m MSL), about 100 km east of the radar site.

We aim to study the characteristics of cloud convections in a planetary boundary layer, generation and propagation of atmospheric waves in the troposphere and stratosphere, and mechanisms of wave dissipation and dynamical forcing in the mesosphere, which could be simultaneously observed by

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Table 1. Basic Parameters of the Boundary Layer Radar

Parameter	Value
Operating frequency	1357.5 MHz (L band)
Antenna	three parabolic antennas
aperture	~3 m^2 (2 m in diameter)
beam width	7.6°
beam directions	fixed into three directions
Transmitter	three solid state amplifiers
peak power	~1 kW (maximum)
average power	~20 W (duty ratio 2%)(maximum)
bandwidth	~4 MHz(maximum) (pulse width: 0.67–2 μs variable)

Table 2. Basic Parameters of the Meteor Wind Radar

Parameter	Value
Operating frequency	31.57 MHz (VHF band)
Antenna	TX: 5-element Yagi
	RX: three 5-elements Yagi's (interferometer)
beam directions	45° off the zenith
Transmitter	dual solid state amplifier
peak power	~10 kW (maximum)
average power	~0.5 kW (duty ratio 5%)(maximum)
bandwidth	~400 kHz(maximum) (pulse width: 10 μs)

combining the BLR, radiosondes and MWR. Using these results, we can study dynamical coupling of different atmospheric layers due to convection and atmospheric waves.

Intensive observations were carried out from November 1992 to April 1993, in cooperation with international campaigns of TOGA/COARE as well as CADRE (Coupling and Dynamics in Regions Equatorial) and MLTCS (Mesosphere Lower Thermosphere Coupling Study) of STEP (Solar Terrestrial Energy Program). In the following, we summarize descriptions of the radars, together with preliminary results of the observed atmosphere dynamics. Note that the results of the BLR observations during TOGA/COARE period are reported elsewhere [Hashiguchi *et al.*, 1995].

2. Description of equipment and observation schedule

2.1 Boundary Layer Radar (BLR)

A small Doppler radar, named as a boundary layer radar (BLR), was designed and constructed by RASC for observations of the bottom part of the atmosphere, where convection is actively generated. The fundamental observation technique of the BLR is the same as an MST (mesosphere-stratosphere-troposphere) radar, operated in VHF or UHF, which detects radiowave scattering from refractive index fluctuations due to the effects of turbulence on humidity and atmospheric stability structure. However, the operating frequency was chosen at 1,357.5 MHz in the L-band in order to keep the antenna compact, so that the radar can easily be transported. Basic system parameters are summarized in Table 1 [Fukao *et al.*, 1994]. Three parabolic antennas with a diameter of 2 m are pointed into the vertical and two oblique directions aligned to the east and north at a zenith angle of 15°.

The BLR provides three components of wind velocity profiles in a height range of 0.3–5 km, depending on the atmospheric condition, with a typical time and height resolution of 1 minute and 100 m, respectively. By additionally combining an acoustic transmitter, refractive index fluctuations are artificially produced whose propagation speed (sound speed) can be measured by the BLR. Then, the (virtual) temperature can be estimated from the sound speed, since the former is proportional to a square of the latter. This technique, called RASS (radio acoustic sounding system), is useful to determine rapid variations of temperature structure, such as atmospheric stability, although the measurable height range was limited to about 1.5 km due to severe attenuation of sound waves by atmospheric turbulence.

2.2 Meteor Wind Radar (MWR)

When a meteorite impinges into the earth's atmosphere, it interacts with the atmosphere, producing an ionized meteor trail at 70–120 km altitude, which efficiently scatters VHF radiowaves. Since a meteor trail drifts following the motion of ambient atmosphere, radial wind velocity can be determined by using a Doppler radar.

An MWR was constructed at Kyoto University in 1977, and successfully continued operation for

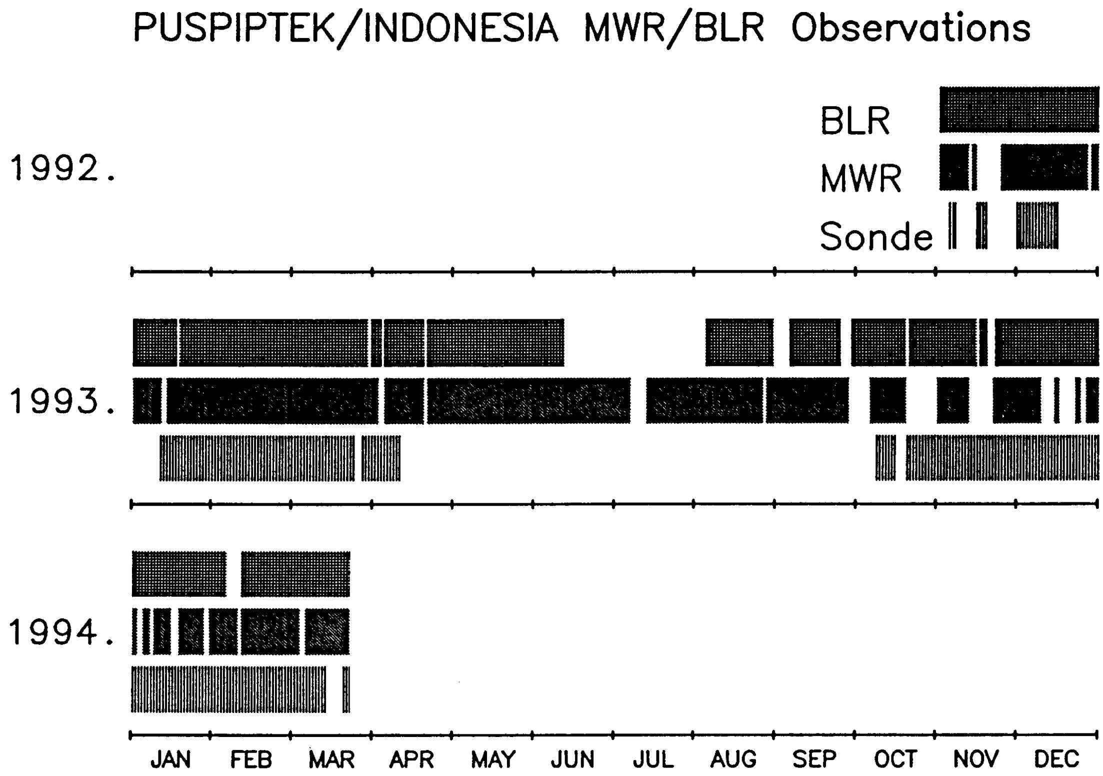

Fig. 2. Observation periods of the MWR and BLR in PUSPIPTEK, and radiosonde soundings at LAPAN in Bandung (as of March 1994).

over 10 years in Shigaraki, Japan [*e.g.*, Tsuda *et al.*, 1988]. It was transported to Indonesia after replacing the transmitter and system-installed computers. System parameters of the MWR are summarized in Table 2. One and three five-element Yagi antennas were employed for transmitting and receiving antennas, respectively, where the latter compose an interferometer for accurate determination of echo arrival angles [Nakamura *et al.*, 1991].

A new measurement technique for temperature perturbation was recently developed by utilizing a relation between the decay time constant of meteor echo intensity and ambipolar diffusion coefficient, where the latter can further be related to the atmospheric density and temperature [Tsutsumi *et al.*, 1994].

2.3 Observation periods

Observations with the radars can be continued automatically under the supervision of a system computer without the full-time attendance of an operator, except for exchange of data tapes every 4–5 days. When electric power is somehow shut down, the computer, driven by a backup battery (UPS), automatically stops radar operation. After such an eventuality, an operator needs to reboot the operating system to restart the radar. Therefore, a daily system-check has been regularly repeated by a technician of PUSPIPTEK to report the system condition.

Observations with the BLR and MWR were carried out fairly continuously, as shown in Fig. 2, except for several major gaps, such as in June–July, 1993 for the BLR, and in September–December, 1993 for the MWR. Some of accidents were caused by nearby lightning. An intensive observation campaign using the radars was carried out from November 1992 to April 1993, cooperating with TOGA/COARE and CADRE. Although Fig. 2 shows the observation period as up to March 20, 1994, radar operation will be continued, at least, until the end of 1994, in order to cover one full cycle of the QBO.

In association with radar observations, we conducted radiosonde measurements of horizontal wind velocity, temperature and humidity, with a height resolution of 150 m, at LAPAN in Bandung. We employed a Väisälä DigiCORA (MW11) sounding system with meteorological balloons provided by TOTEX Co. Ltd. (type TA-1000, TX-1000 and CR-600). Radiosondes were launched four times a day at 5, 11, 16 and 23 LT (or 22, 4, 9 and 16 GMT) during November 16, 1992 and April 10, 1993. Three of the launch timings were chosen so that a balloon could reach the tropopause during daylight hours, where the balloon would be warmed due to solar radiation [Tsuda *et al.*, 1992]. Although the very low temperature near the tropopause sometimes caused

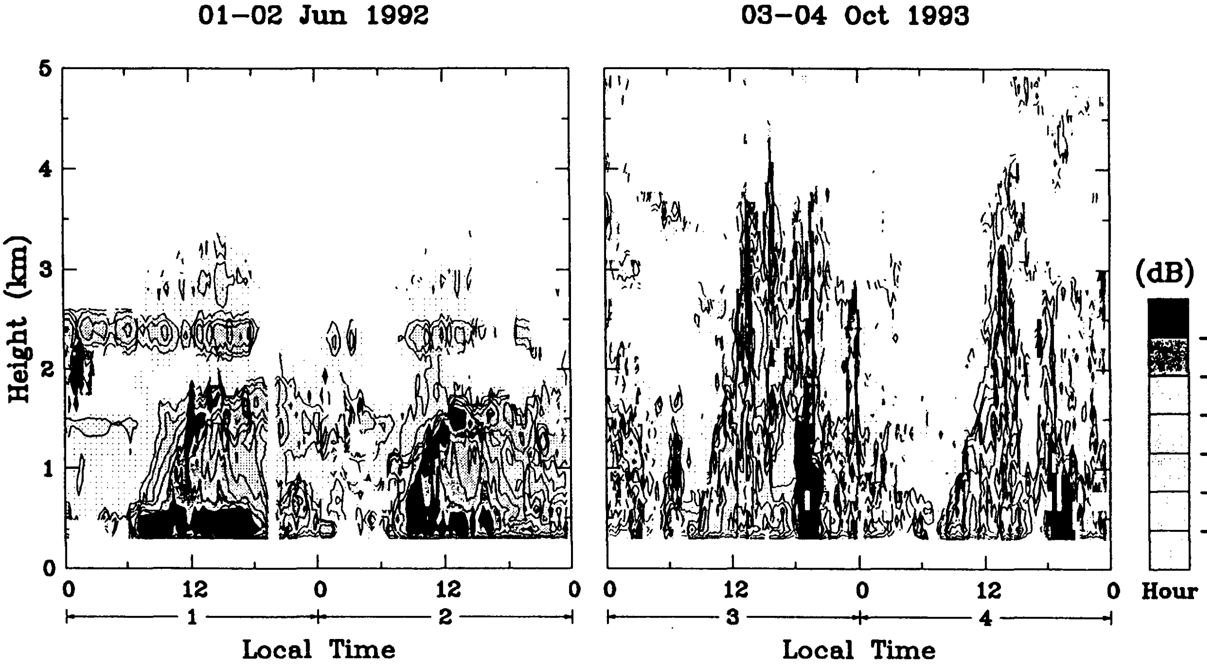

Fig. 3. Time-height variations of vertical echo power observed with the BLR at Shigaraki on June 1–2, 1992 (left) and at PUSPIPTEK, Indonesia on October 3–4, 1993 (right).

a balloon burst at night, the TX-1000 balloon normally reached above the tropopause.

Unfortunately, the soundings were stopped due to a malfunction of a receiver on November 20–30, 1992, and from December 17 to January 11, 1993. In total, 411 balloons were launched, where 362 (88 %) and 293 (71 %) out of them reached 18 and 30 km, respectively.

Besides international campaigns, we conducted intensive observations in dry and rainy seasons in order to study differences in the behavior of dry and wet atmosphere in the tropics. The dry and rainy season campaigns were successfully conducted on October 8–15, 1993, and February 15–22, 1993, respectively. Over 50 radiosondes were launched, one every 3 hours from the radar site. Fundamental meteorological parameters were also monitored on the ground with an anemometer (surface winds), rain gauge, pyranometer (solar radiation), net pyrradiometer (net radiation), and temperature and humidity sensors.

Daily sounding of radiosondes was commenced by LAPAN in Bandung, but only once a day at 7 LT (0 GMT), from October 1993. Results of routine radiosonde sounding collected at Singapore (1.3°S, 103.9°E) in the last few decades have clarified the behavior of equatorial waves [*e.g.*, Maruyama, 1994: Sato *et al.*]. We hope the new data set in Bandung will also contribute to the studies of equatorial atmosphere dynamics.

3. Preliminary results

3.1 Planetary boundary layer in tropics

We present in Fig. 3 typical examples of time-height variations of echo intensity observed with the BLR at Shigaraki, Japan, and at PUSPIPTEK, Indonesia. Note that the large echo intensity, indicated by a shaded area, corresponds to a region of active turbulence. A regular diurnal cycle was clearly recognized at Shigaraki for two consecutive days, showing that a boundary layer was set-up in the morning, and disappeared at night. The top of the observable layer was, however, limited to 1.5–1.8 km.

In Indonesia, a diurnal pattern was also detected in Fig. 3, but the smaller scale variations were more complicated [Hashiguchi *et al.*, 1994]. A sharp rise of the boundary layer occurred during 8–12 LT, showing a maximum height above about 4 km, implying that the boundary layer was twice as thick in the tropics as in Shigaraki. It is noteworthy that the largest turbulence intensity was observed at about 20 LT in Indonesia, which was not seen at Shigaraki.

Figure 4 shows an example of temperature measurements with the BLR-RASS on October 10, 1993 in PUSPIPTEK, in comparison with a simultaneous radiosonde measurement. It is noteworthy that the RASS determines virtual temperature, T_v, which was higher than atmospheric temperature, T, by 2–4 K because of the high humidity in the tropical boundary layer, as shown in Fig. 4. Comparing the RASS profile with T_v estimated from radiosonde

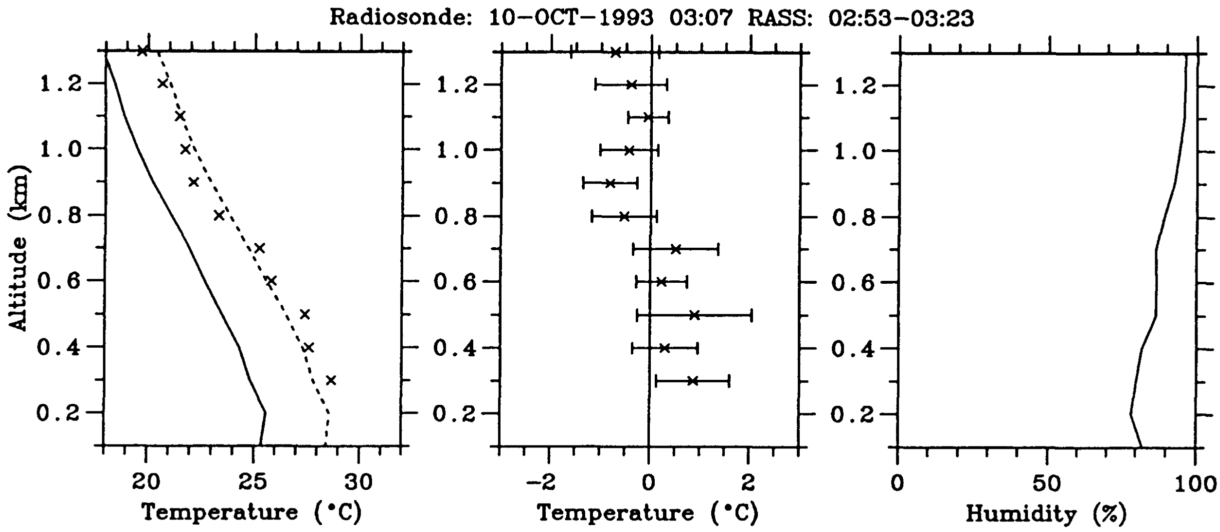

Fig. 4. Measurements of temperature profile with the BLR-RASS during 02:53–03:23 LT on October 10, 1993 in Indonesia. Left: comparison of the RASS temperature determinations (cross symbol) with atmospheric (solid line) and virtual (dotted line) temperature profiles obtained with a radiosonde launched at 03:07 LT. Center: Difference between the RASS and radiosonde measurements of virtual temperature, together with the standard deviation for the RASS results within 30 min. Right: the humidity profile obtained with a radiosonde.

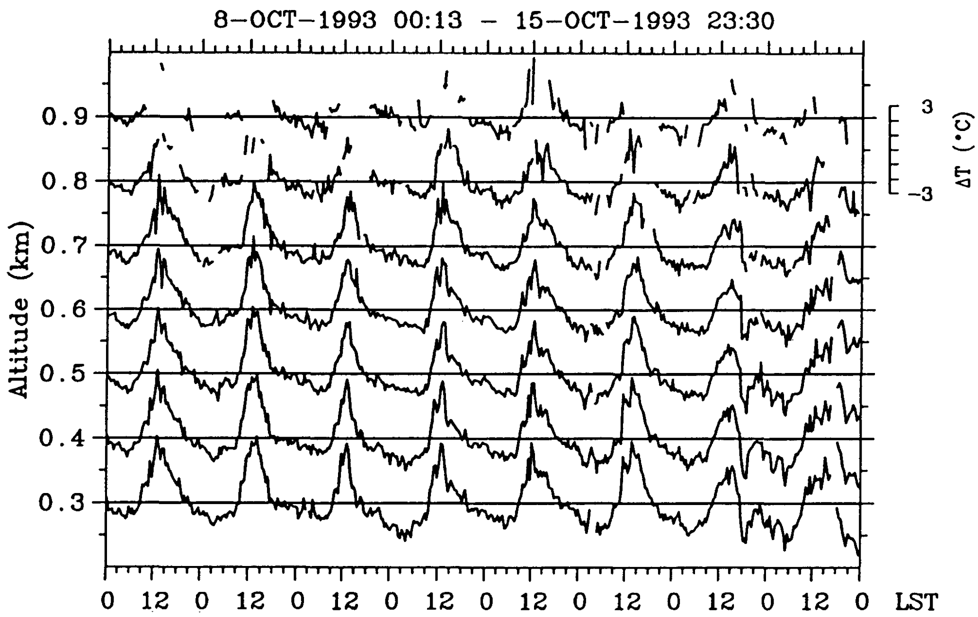

Fig. 5. Diurnal variations of virtual temperature fluctuations at 0.3–0.9 km altitude, measured with the BLR-RASS on October 8–15, 1993.

measurements of T and humidity, we found that a typical difference between the two results was about 0.5 K. The standard deviation in Fig. 4 represents the range of T_v perturbations within 30 minutes for RASS measurements.

Since the vertical gradient of T_v is a direct measure of atmospheric stability, the RASS measurement is useful in investigating the characteristics of convection. In fact, the Brunt-Väisälä frequency squared at about 0.5 km, that was derived from the gradient of T_v observed with the RASS (not presented here), became nearly zero during daytime, indicating that the atmosphere was convectively unstable due to intense solar heat input.

Time variations of temperature fluctuations were detected with the BLR-RASS, as plotted in Fig. 5, which were almost in-phase at 0.3–0.9 km altitudes. The temperature rapidly increased at 9–13

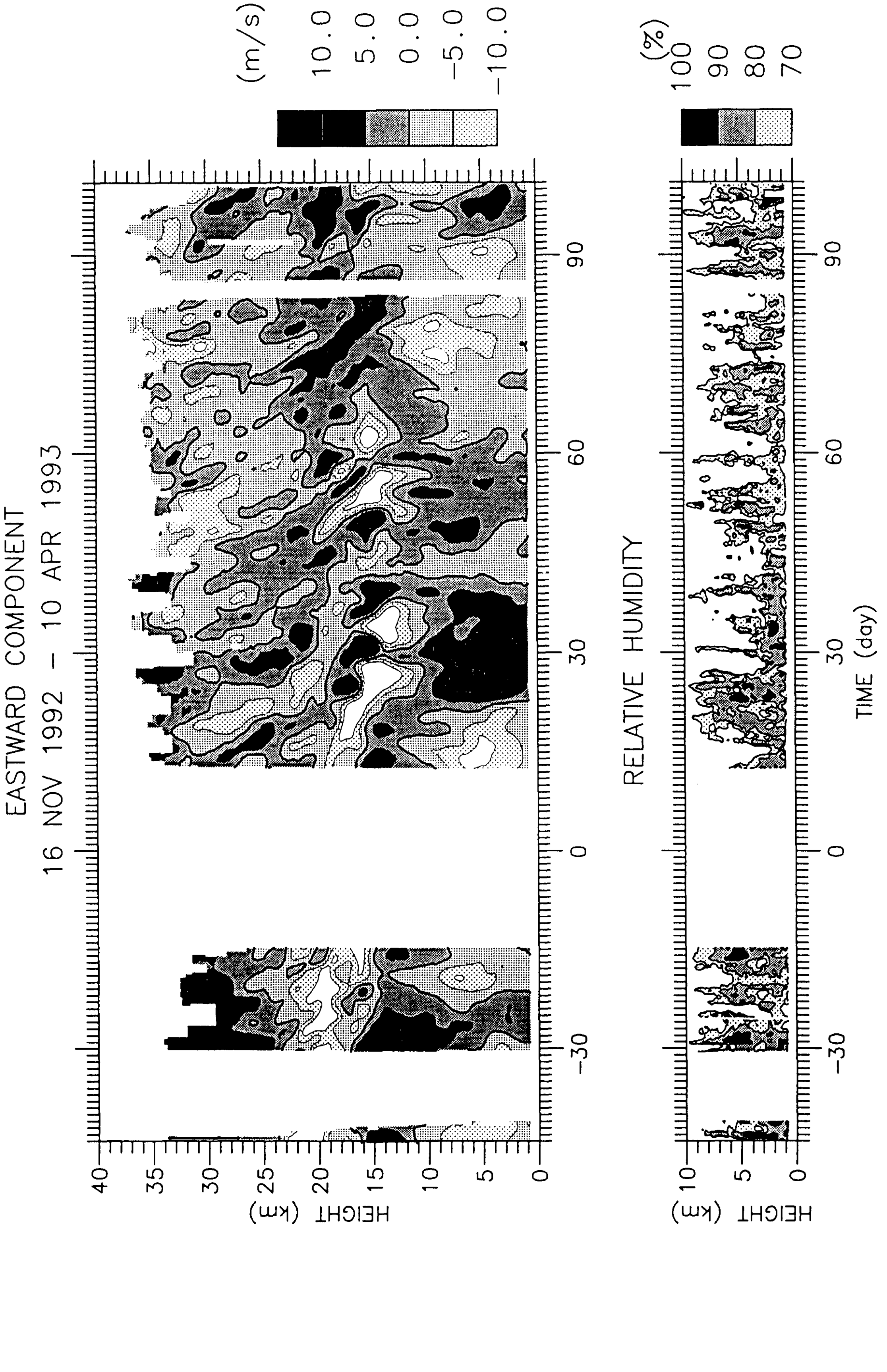

Fig. 6. Fluctuating components of eastward winds (top), after processing by a low-pass filter with a cutoff of 4 days at each altitude, and relative humidity (bottom). The horizontal axis indicates the day number relative to January 1, 1993.

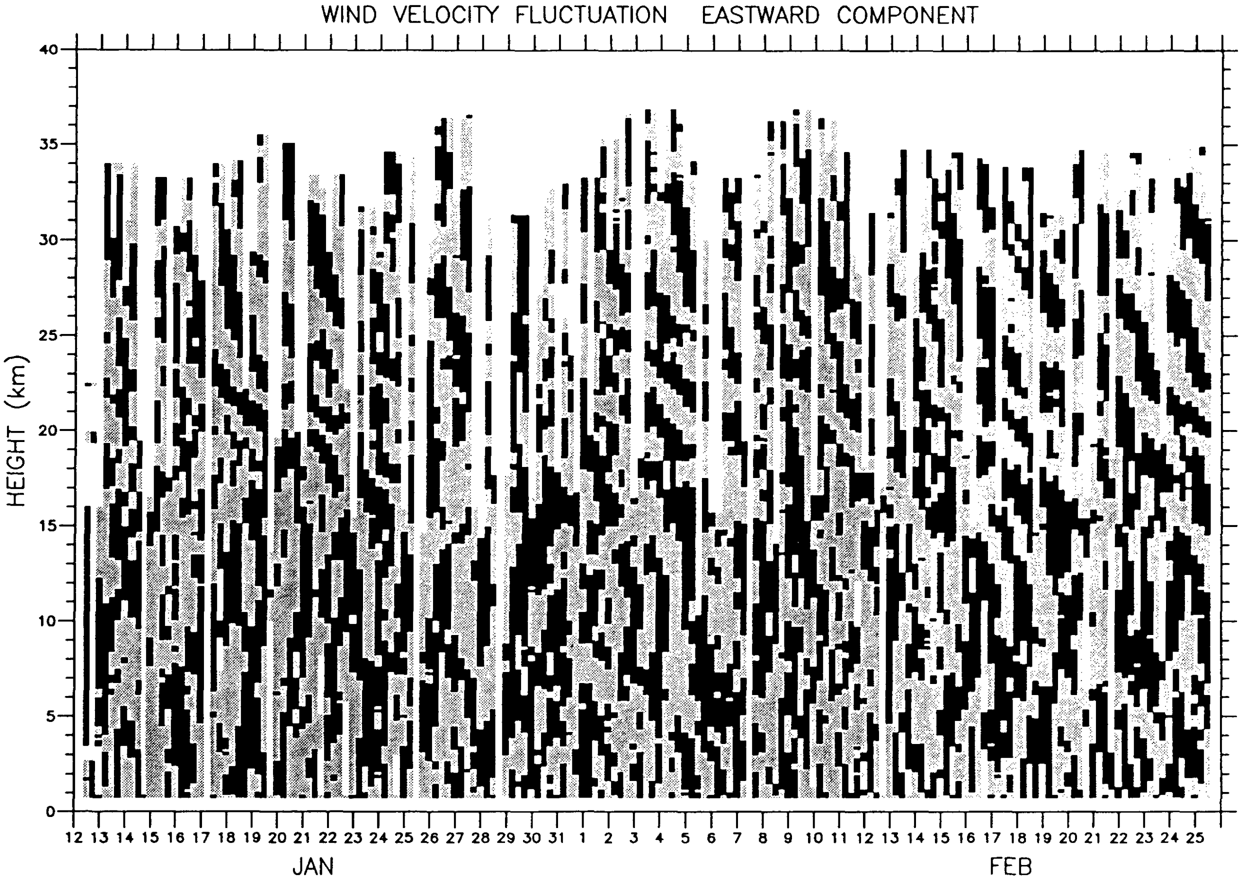

Fig. 7. Fluctuating components of the eastward winds, after processing with a high-pass filter with a cutoff of 4 days, observed with radiosondes during January 12 and February 25, 1993. Note that a darkly shaded area indicates positive deviations.

LT, reached a maximum at around 14 LT, sharply dropped by 18 LT, then gradually decreased at night. The maximum temperature difference in the diurnal variation was as large as 10 K at 0.3 km, and decreased to 6 K at 0.8 km.

3.2 Atmospheric waves observed with radiosondes

Analyzing profiles of wind velocity and temperature fluctuations observed with radiosondes during November 1992 and April 1993, we study here the characteristics of atmospheric waves in the troposphere and lower stratosphere. Figure 6 shows a contour plot of low-pass filtered zonal winds, with a cut-off period at 4 days, together with relative humidity. Note that the tropopause was located at about 17 km.

In Fig. 6, we could detect a variety of wave activities in both the troposphere and stratosphere. In January–February 1993, a fairly long period oscillation seemed to be dominant below about 10 km. Since the duration of the observation was not long enough, we applied a least-square fitting to the time variations of zonal winds at each altitude, and detected an oscillation with a period of about 27 days. The amplitudes of the oscillation decreased with time during Days 20–60 in Fig. 6. It is noteworthy that the relative humidity profile, which seems to represent the cloud activity, also included a long-period variation, with periods similar to those found in the zonal winds. These phenomena could be a manifestation of a 30–60 day oscillation in the tropical troposphere, although we need further analysis before reaching a conclusion.

Above about 15 km, phase progression of the zonal wind perturbations became evident in Fig. 6, with the phase velocity being faster above about 20 km. We also analyzed wind fluctuations in the meridional winds and temperature, and found that the oscillation in the stratosphere could be interpreted as an equatorial Kelvin wave with periods of 10–20 days. The 20-day wave was greatly enhanced in a narrow height range at 15–20 km near the tropopause, which was also detected during an earlier radiosonde campaign [Tsuda *et al.*, 1994a]. The dominant wave period became as short as about 10 days above 20 km. It is noteworthy that the amplitudes of Kelvin waves became smaller after days 60 in Fig. 6, which seemed to correlate with time variation of the zonal wind perturbations be-

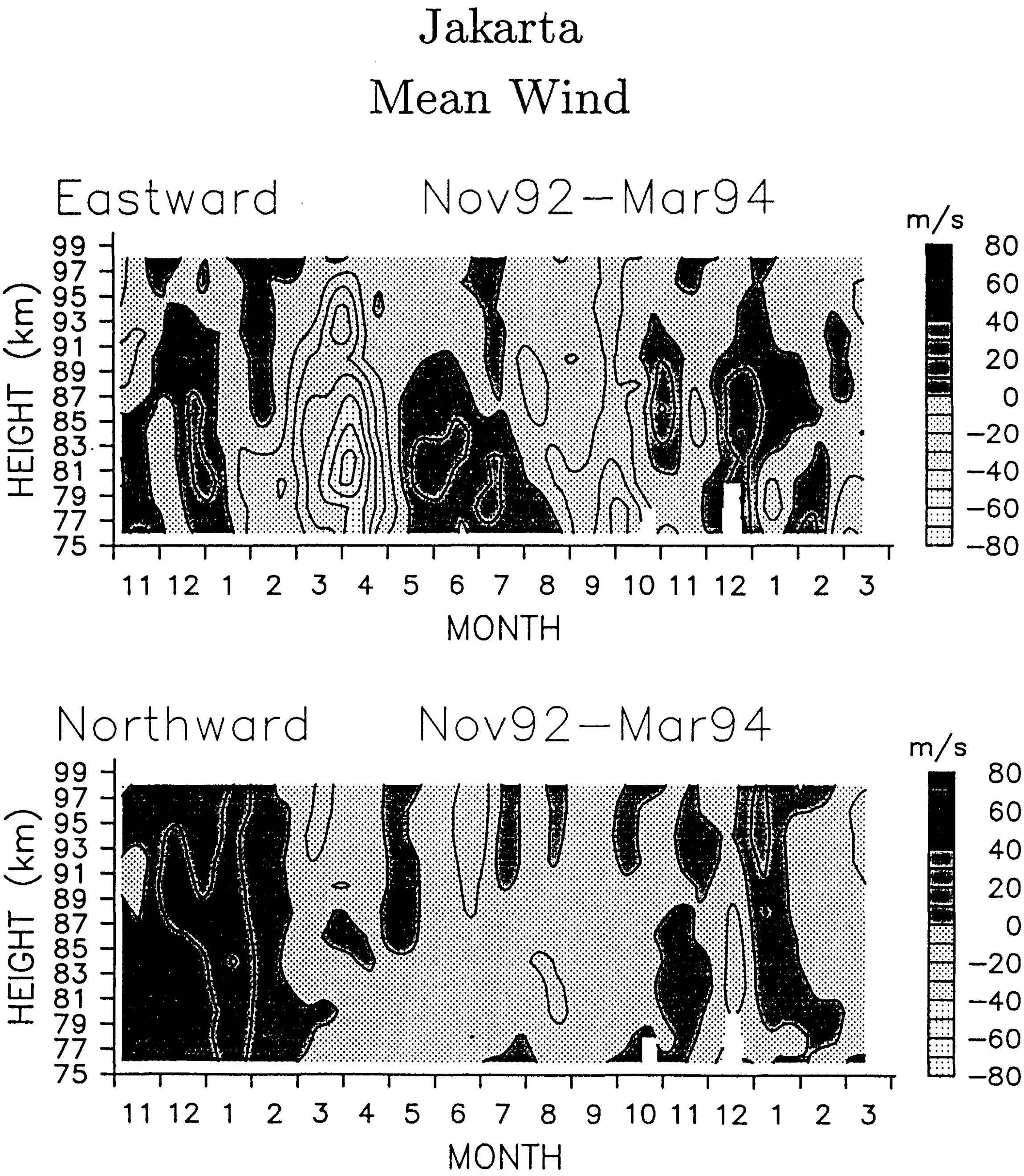

Fig. 8. Eastward (top) and northward (bottom) components of the 10-day mean winds observed with the MWR in Indonesia from November 1992 to August 1993.

low about 10 km, suggesting that the excitation of Kelvin waves is closely related to tropospheric convection [*e.g.*, Salby and Garcia, 1987].

We further found that the Kelvin waves also produced large temperature fluctuations near the tropopause, causing periodic variations in both the tropopause height and minimum temperature. Since the exchange of air between troposphere and stratosphere is largely affected by the tropopause structure, it can be considered that the Kelvin wave activity could modulate the upward flux of minor constituents in the equatorial region [Tsuda *et al.*, 1994a].

Short-period fluctuations in the zonal winds were also extracted, as seen in Fig. 7, by applying a high-pass filter with a cut-off of 4 days on time series, considering that the Coriolis period at the site is 99.9 hours (4.16 days). Perturbations in the stratosphere were clearly characterized by a downward phase progression with vertical scales of 2–5 km, being consistent with the behavior of upward energy-propagating gravity waves. In the troposphere, both

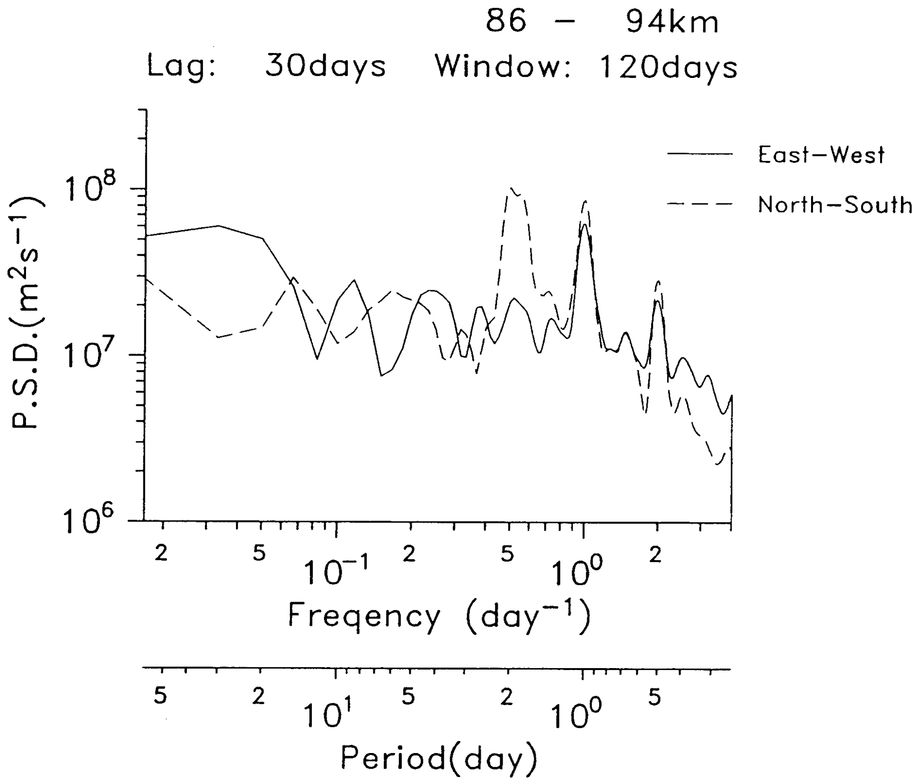

Fig. 9. Frequency spectra of zonal (solid line) and meridional wind velocity (dashed line) observed with the MWR during November 1992 to February 1993.

upward and downward propagation coexisted, showing complicated structures. These results imply that the gravity waves were generated in the troposphere, probably due to active convection [Tsuda *et al.*, 1994b].

3.3 Mesosphere dynamics observed with the MWR

We here describe the behavior of atmospheric waves in the mesosphere, where wave dissipation becomes significant, resulting in the deposition of dynamical energy to background mean flow.

Horizontal winds observed with the MWR at 75–100 km were averaged every 10 days, the effects of atmospheric tides being removed beforehand. Mean zonal wind, shown in Fig. 8, was generally westward for about three months around equinoxes, and was reversed to eastward in solstices, showing the characteristics of a semi-annual oscillation evident in the equatorial mesosphere. The maximum amplitudes of the westward wind were, however, larger than 60 m/s in March–April, but were less than 40 m/s in September–October, showing a clear difference between the first and second half of a year cycle.

Mean meridional winds were as small as 10 m/s, with a maximum occurring in December–January, and were generally directed from the summer to the winter hemisphere, although an irregular pattern appeared in December 1993.

The wind fields in the mesosphere are generally characterized as various waves, such as an equatorial wave, atmospheric tides and gravity waves, superposing each other with similar amplitudes. Moreover, the amplitudes of these waves grow large enough to be comparable to the background mean winds.

Figure 9 shows frequency spectra of zonal and meridional winds observed with the MWR from November 1992 to February 1993. The spectral density for wave periods longer than about 10 days was larger for the zonal component. There existed several peaks in a wave period range from 3 to 10 days for both zonal and meridional components. Spectral peaks at 24 and 12 hr, corresponding to diurnal and semidiurnal atmospheric tides, were conspicuous, with slightly larger amplitudes for the meridional component. The spectral slope was negative for wave periods shorter than 1 day, reflecting the characteristics of gravity waves.

One of peculiar phenomena among mesospheric waves is a two-day oscillation in December 1992, which showed a clear spectral peak in Fig. 9 for the meridional component. In Fig. 10 we present variations of the two-day oscillation at 86–94 km observed in December 1992, after processing with a band-pass filter. Although the meridional component had larger amplitudes, the zonal one also showed a corresponding perturbation. Downward phase progres-

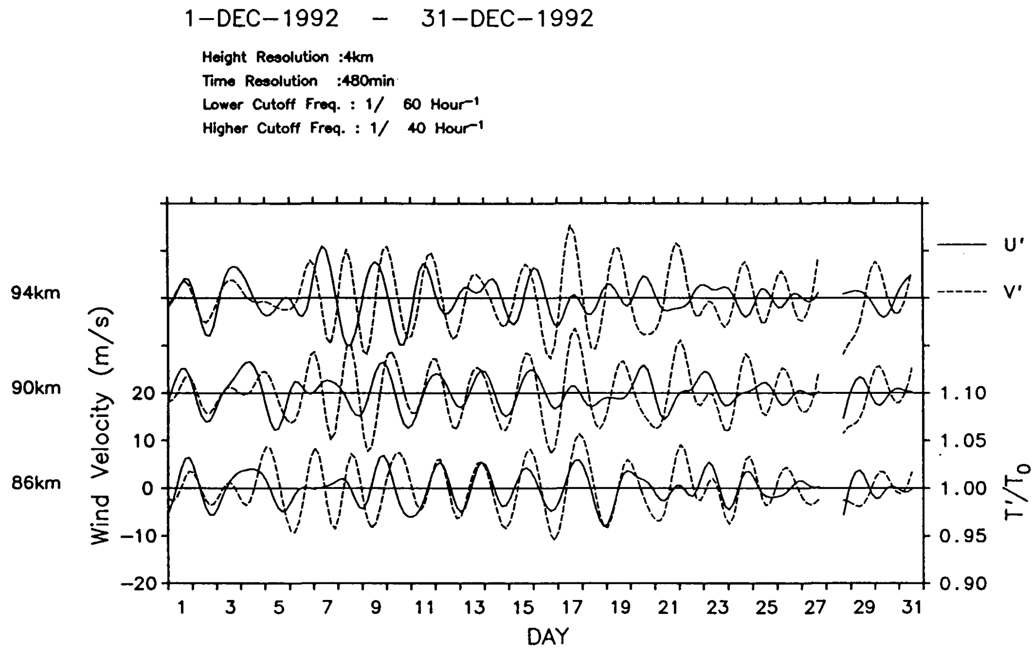

Fig. 10. Band-pass-filtered (40–60 hours) fluctuations of eastward (solid line) and northward (dotted line) wind velocity at 86, 90 and 94 km altitudes observed with the MWR in December 1992.

sion was generally detected for both components. However, phase relations between zonal and meridional components were rather irregular, such that they showed in-phase, and out-of-phase as well as quadrature phase lags. The global feature of the wave should be investigated by utilizing a coordinated network of radar stations.

We examined profiles of diurnal tidal winds, combining radiosonde and MWR measurements from November 1992 to April 1993. A 24-hour oscillation was detected at 0–35 km, by fitting a sinusoidal curve to the entire time series of both the zonal and meridional wind velocity observed every 6 hours with radiosondes. Tidal amplitudes and phases were determined by using MWR observations at 75–100 km. The results are simultaneously plotted in Fig. 11, together with a numerical prediction by Forbes [1982].

Note that the model assumes only migrating tides. Although considerable deviations may be found, the overall structure of the observed profiles above about 20 km agreed quite well with the model, showing a rapid increase in amplitudes from stratosphere to mesosphere, and a vertical wavelength of 25–30 km. However, disagreements appeared below 20 km, showing significantly larger amplitudes and complicated phase structures, which seem to be attributable to local (or non-migrating) tides [Tsuda and Kato, 1989].

4. Concluding remarks

We constructed a BLR and MWR in a newly established radar observatory near Jakarta, Indonesia, as a collaborative project between RASC, BPPT and LAPAN. The BLR and MWR have been continuously measuring wind velocity and temperature in the planetary boundary layer (0.3–5 km) and the mesosphere (70–100 km), respectively, over two years since November 1992. In addition, radiosonde sounding of horizontal winds, temperature and humidity was carried out four times a day during the TOGA/COARE period at LAPAN in Bandung.

Preliminary data analysis clarified interesting characteristics of the equatorial atmosphere dynamics over Indonesia, as summarized in the following.

1. Investigating some typical examples of time-height variations of echo intensity detected by the BLR, we found that the maximum height of the planetary boundary layer over the radar site in Indonesia exceeded 4 km, which was about twice as high as at Shigaraki.

2. Detailed diurnal variations of the temperature profile at 0.3–0.9 km in the planetary boundary layer were observed with the BLR-RASS.

3. Radiosonde measurements clarified the characteristics of various atmospheric waves, such as gravity waves, Kelvin waves and other long-period oscillations. Zonal winds in the troposphere involved a fairly long-period oscillation (about 27 days), showing a correlation between

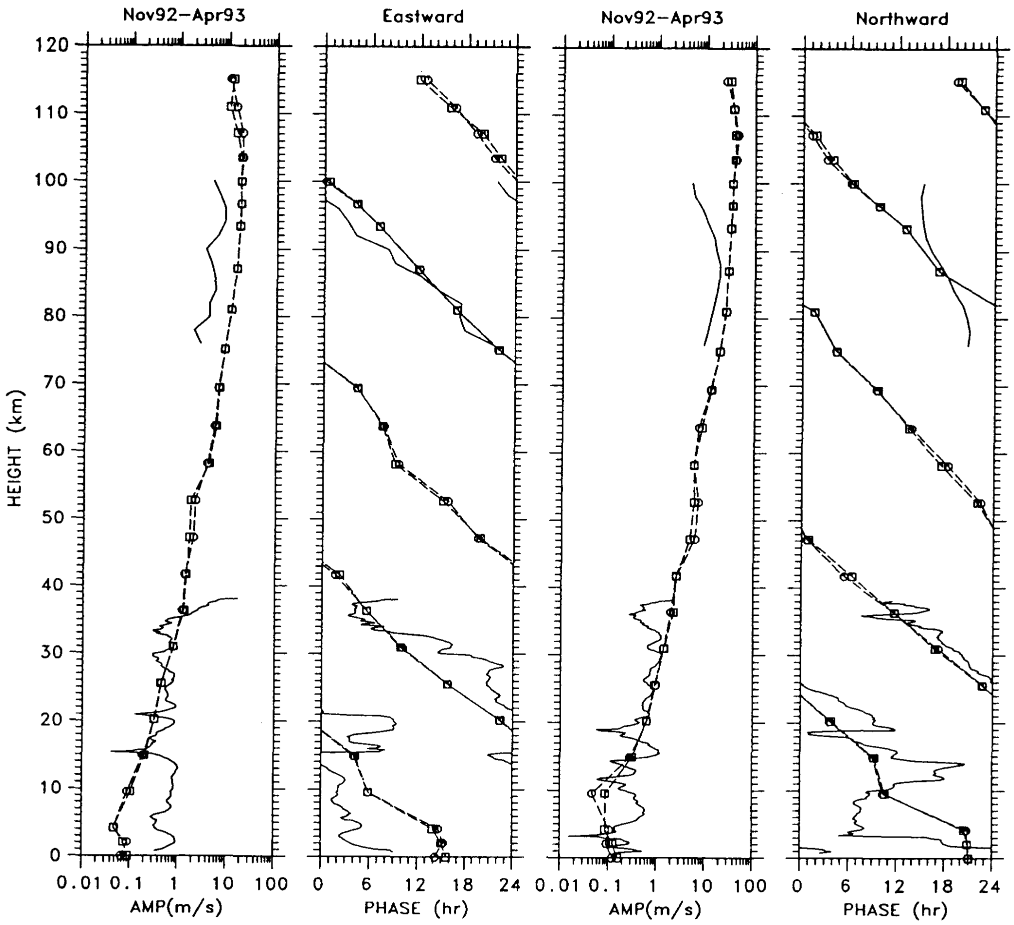

Fig. 11. Mean profiles of amplitudes and phases of diurnal tides observed from November 1992 to April 1993 at 0–35 km and 75–100 km with radiosondes and the MWR, respectively. Eastward and northward components are shown in the left- and right-hand panels, respectively. Lines with square and circular symbols correspond to a numerical model in March and December at 6°S [Forbes, 1982].

its amplitudes and time variation of relative humidity. Kelvin waves with periods of 20 and 10 days became evident near the tropopause and lower stratosphere, respectively.

4. Gravity waves with typical wavelength of 2–5 km were detected both in the troposphere and lower stratosphere. Phase progression indicated that most of the waves showed upward energy propagation in the stratosphere, suggesting the generation of gravity waves in the troposphere due to active convection.

5. In the mesosphere, mean winds were determined from MWR observations, where the zonal wind was affected by a semi-annual oscillation. The meridional wind normally blew from the summer to the winter hemisphere.

6. An event of two-day wave enhancement occurred in December 1992, with larger amplitudes for the meridional component. However, the phase relation between the zonal and meridional winds was rather irregular.

7. Propagation of diurnal tides was determined at 0–35 km and 75–100 km by means of radiosonde and MWR observations, respectively, showing a relatively good agreement with a numerical model above 25 km. However, effects due to non-migrating tides can be anticipated in the troposphere.

An international cooperation of radar stations is important to depict globals feature of the middle-atmosphere dynamics. The new radar observatory in Indonesia is useful in interpolating a meridional chain between Shigaraki, Japan (35°N, 136°E) and Adelaide, Australia (35°S, 136°E), which are located almost exactly on conjugate points relative to the equator [Vincent *et al.*, 1988]. Moreover, longitudinal variations of the equatorial atmosphere can be investigated by comparing results obtained by another radar on Christmas Island in the central Pacific (2°N, 158°W). Thus, observations in Indonesia, located at a cross point between the latitudinal and longitudinal coordination, are very valuable. Long-term operation of radars in PUSPIPTEK is therefore highly desirable.

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インドネシアにおけるレーダーとラジオゾンデを用いた赤道大気力学の観測：—速報—

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日本とインドネシアの協力により1992年11月にジャカルタ近郊に赤道大気の観測所(6.4°S、106.7°E)が開設され、流星レーダー(MWR)と境界層レーダー(BLR)が設置された。MWRにより高度75–100 kmにおける水平風と温度変動が1時間と4 kmの分解能で測定された。一方、BLRを用いて高度0.3–5 kmの大気層の風速三成分を毎分100 mの分解能で観測した。さらにBLRに音響発信器を併用したRASS(電波音響探査システム)技術により温度変動の微細構造をも測定した。これらのレーダーの運用は1992年11月のTOGA/COAREの強化観測期間に開始され、その後2年以上にわたって連続観測が続けられている。また、レーダー観測所から約100 km東に位置するバンドン市のLAPAN(国立航空宇宙局、6.9°S、107.6°E)において、1992年11月から1993年4月にかけて、ラジオゾンデを一日に4回放球し、高度約35 kmまでの風速・温度変動を150 mの高度分解能で測定した。その後、1993年10月から一日一回の定時観測(0GMT)も継続されている。

この論文では観測所における研究活動の概要を紹介するとともに、観測結果の初期的な解析で分かった、TOGA/COARE期間中の熱帯惑星境界層の構造、対流圏内の積雲対流、ならびに赤道域中層大気における各種の大気波動の振る舞いについて速報する。