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6.15 THE FIRST OPERATION AND RESULTS OF THE CHUNG-LI VHF RADAR

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It was decided that the Chung-Li VHF radar would be used in dual-mode operation, applying Doppler beam-swinging as well as the spaced-antenna-drift method. The original plans of this radar were discussed by BROSNAHAN et al. (1983). The total system was developed and constructed by Tycho Technology Inc. in Boulder, CO, under supervision of the Department of Atmospheric Science of the National Central University in Chung-Li, and the National Science Council of the Republic of China, advised by an international advisory committee. In May 1985, the radar was set up at the campus of the National Central University in Chung-Li and the first echoes were recorded on May 29, 1985.

The design of the radar was based on a proposal by ROTTGER (1981) to use three phase-coherent transmitters feeding three separate antenna modules with vertical beams; each can be used as the three receiving antennas of the spaced-antenna-drift and interferometer method (see Table 1). In the Doppler beam-swinging mode, either of the three antennas can be steered independently to five directions (vertical, 12° off-vertical to north, south, east or west) or all three antenna modules can be steered into the same direction. Three antenna modules of 64 four-element Yagis are used (see Figure 1), which are set up in a T-shape. The total aperture is about 2500 m^2. Three transmitters (Tycho MST-50-TX-3), each with a peak power of 50 kW, can be operated at a duty cycle of 2% and shortest pulse length of 1 μs. The final power-aperture product should be close to 10^7 Wm^2. Each transmitter has its own transmit/receive switch, from which the received signals are fed to three independent receiver ADC and preintegrator channels. The ADCs can be set optionally to 8, 10 or 12 bits accuracy. The preintegration is done in a new high speed signal processor (BROSNAHAN and WOODARD, 1984) and it allows coherent additions up to 32 bits. Through a multichannel bus, the coherently integrated raw data for up to 400 range gates are transferred to a Codata 3300 computer from where they are dumped on tape (Cipher F880 tape drive). The Codata computer with the preintegration signal processor can be used later for on-line decoding and/or further data processing. The radar control is performed by a system synchronizer (Tycho MST-50-1APC) which generates also complementary codes (up to 16 bits) and controls the antenna beam steering. The raw data on tape are analysed with the CYBER-720 and the VAX 11/750 computers at the University campus. The latter computer is used also for image processing of power and velocity plots (e.g., ROTTGER et al., 1986). More technical details of the Chung-Li VHF radar will be presented elsewhere by BROSNAHAN et al.

During the first system tests, the radar was operated with one vertically beaming antenna module, one transmitter and one receiver channel. Single pulse operation with shortest pulse length of 1 μs was tested at a duty cycle up to

Table 1.

Chung-Li VHF Radar
National Central University, Chung-Li, R.O.C.
Dual-Mode: Doppler beam swinging and spaced-antenna at 52.0 MHz
3 transmitters, each 50 kW (peak), 1 μs shortest pulse (compl. code), 2% duty cycle, phase coherent.
3 antenna modules of 64 four-element Yagis each, ∿ 2500 m^2 total effective aperture, vertical and four off-vertical directions.
3 independent receiver -- and preprocessor channels (max 400 range gates each)
1 system synchronizer, Codata computer Cipher tape drive
(transmitters, receivers, antennas, system synchronizer and preprocessor made by Tycho Technology, Inc.)

1%. It was shown during the acceptance tests that this system configuration, comprising less than 1/10 of the final system sensitivity, is suitable for quite a variety of experiments, although improvements of the system performance are necessary, such as elimination of some digital noise, receiver saturation at short ranges and occasional data transfer failures, besides the addition of antenna beam steering. Using the vertical beam, ground clutter was not a problem, although the facility is built on a flat area sloping into a large valley with many buildings and power lines. Also, high mountains at about 20 km distance did not show up as strong clutter. Part of the time, interference was encountered and echoes from aircraft spoiled some range gates for a small fraction of time.

Figure 2 shows some first spectra of tropospheric signals detected with the vertically beaming Chung-Li VHF radar. The ground clutter was obtained from a longer time series and was subtracted before the spectra were computed. Range gate KH=6 corresponds to 3-km altitude, the range gate separation is 300 m, thus, range gate 25 is at 8.7 km. The spectra are normalized which can be seen by the noise level varying from gate to gate. They show the well known features of narrow and broad spectrum width due to dominance of scattering or partial reflection. Figure 3a shows the distribution of signal plus noise power as a function of height. Due to receiver transition effects (causing an attenuation out to delays of 40 μs (≃ 6 km range)), the absolute power at the lower heights is incorrect. However, a layered structure is clearly noticed.

A first physical result, which we regard as a new finding, is the lack of an enhanced echo from the tropopause (the enhanced power in the upper range

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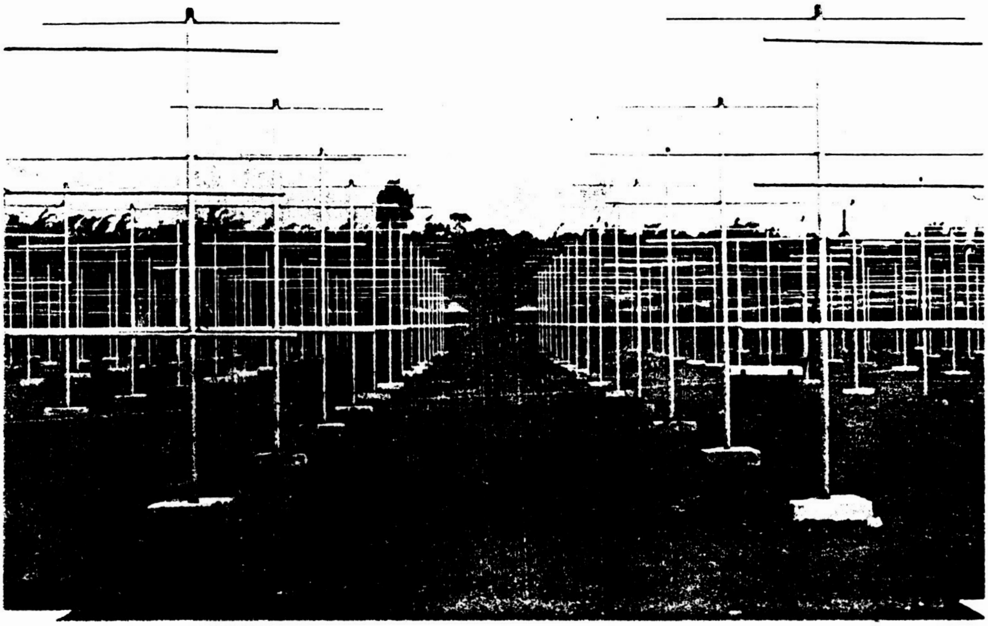

Figure 1. Part of the antenna field of the Chung-Li VHF radar, consisting of 192 four-element Yagi antennas.

gate 40 is due to preprocessor or data transfer problems. The tropopause height was between 12 km and 13 km, but no echo was seen at these altitudes. This evidence was checked also with other pulse schemes. FUKAO (personal communication, 1985) reported an analysis of MU-radar observations where he apparently did not find such clear indications of the tropopause as seen in mid- and high-latitude observations (e.g., ROTTGER, 1981). The latitude of the MU-radar (35°N) and of the Chung-Li radar (25°N) are in the region of the tropopause break separating the tropical and midlatitude tropopause. Since the tropopause is dissimilar here as compared to higher latitudes, we would expect its characteristics with respect to VHF radar reflectivities to be quite different. This may be a possible reason why we did not see the enhanced tropopause echo with the Chung-Li VHF radar.

In Figure 3b, the distribution of radial velocity is displayed. Single velocity data were deduced (after ground clutter and instrumental dc-elimination) from 4 sec averages of the first lag of the complex auto-correlation function. The distributions in Figure 3b cluster around zero velocity with rms variations of about 10 cm s^{-1}. The mean radial (vertical) velocity is close to zero, as expected, and it increases continuously in the upper troposphere up to 10 cm s^{-1} at 11 km altitude. Analysis of the velocity time series indicates that part of the velocity variation is due to short-period gravity waves. Above range gate 34, the velocity estimates are random, which is expected because the signal had disappeared in the noise.

We regard our first tests and observations as well as the results of the preliminary analyses to prove the relevance and applicability of the Chung-Li VHF radar. It will comprise another essential tool to study the subtropical atmosphere.

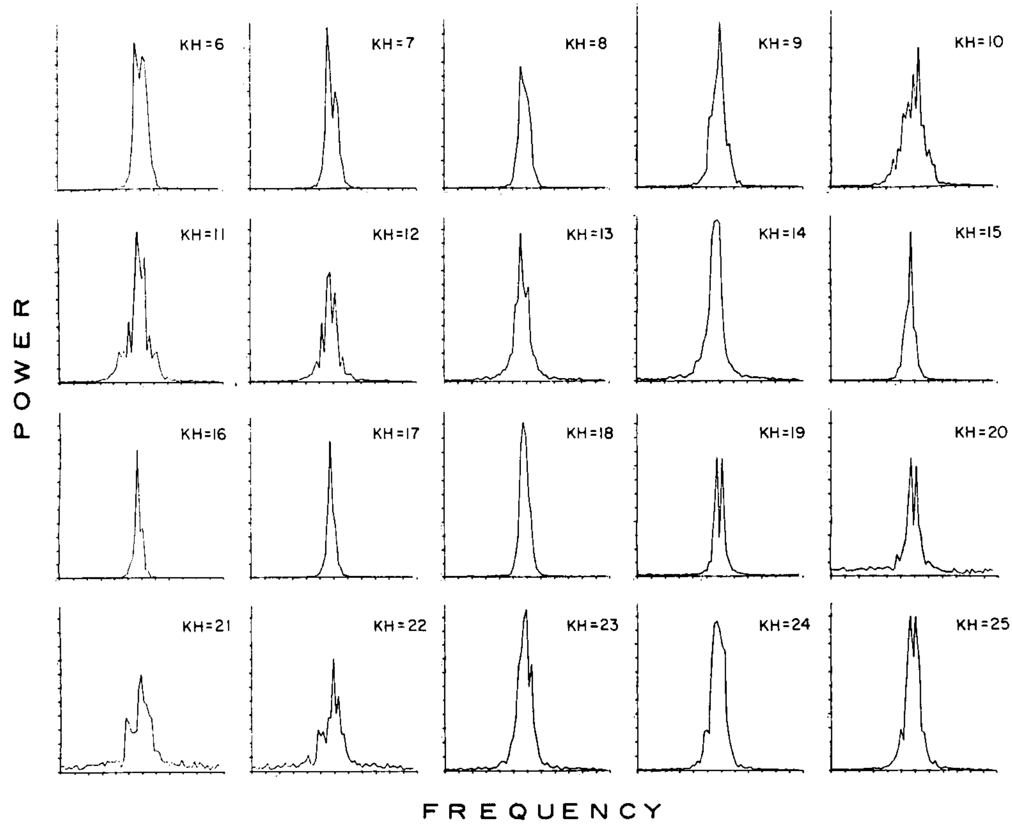

Figure 2. Normalized spectra of tropospheric returns with vertical beam. KH = 6 corresponds to 3 km altitude and the range gate separation is 300 m.

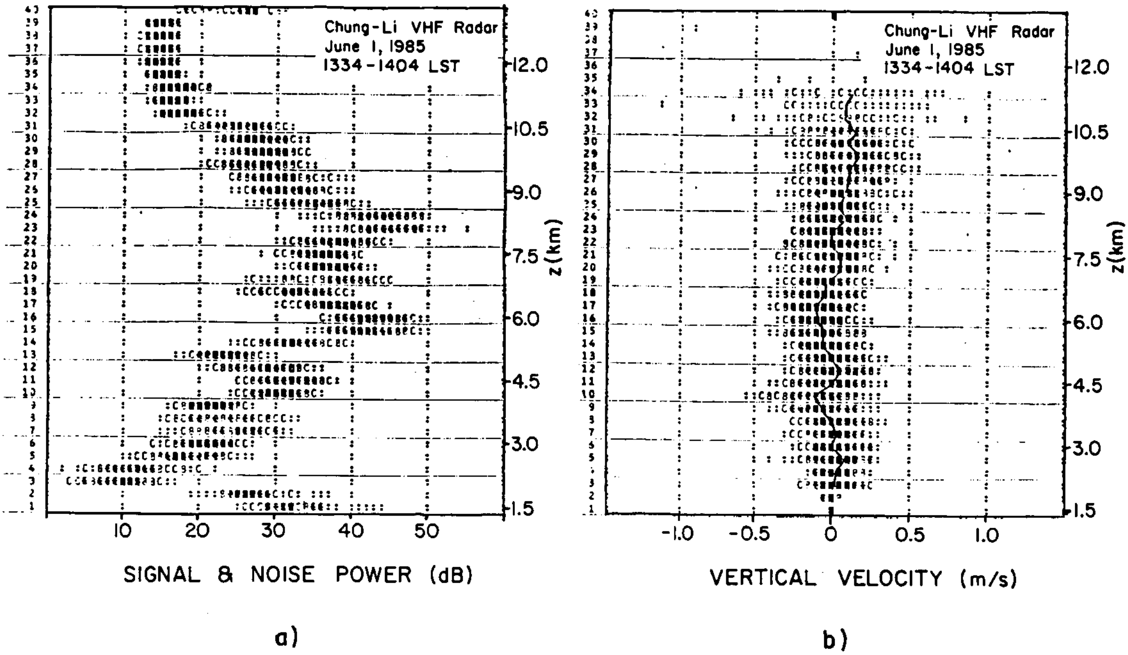

Figure 3. Distributions of a) signal plus noise power, b) radial (vertical) velocity.

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