5. ROLE OF SOUTHERN HEMISPHERE IN THE INDIAN SUMMER MONSOON

5.1 Origin of the monsoon

Classical concept : The classical theory of the Indian summer monsoon lays stress on the importance of the south Indian Ocean in the development and maintenance of the monsoon. As the pressure falls over the land in the northern hemisphere, the pressure rises over the ocean in the southern hemisphere. The air over the south Indian Ocean, under the influence of this pressure distribution and of the rotation of the earth, moves towards the northwest as far as the equator. At the equator, the air comes under the influence of the circulation around the low pressure system in the northern hemisphere, and moves towards the northeast. The southwesterly flow north of the equator is, therefore, a continuation of the southeasterly flow from south of the equator. In consequence, the air that reaches the Indian subcontinent has travelled for 4000 miles over the ocean and is,therefore, charged with aqueous vapour (Simpson, 1921).

Some recent concepts : After the International Indian Ocean Expedition, valuable data about the monsoon circulation have been collected. The results of some studies based on these data seem to deviate from the classical theory referred to above. Of particular interest are the field experiments in which radioactive nuclei of randon and thoron are usedas tracers of large-scale air movement. These tracers are short-lived and their source areas are known to be continental land masses. The output of randon from the ocean surface is about two orders of magnitude less than that from land area. Measurements made of concentrations of randon in the surface air over the Arabian sea and the Indian Ocean suggested that the monsoon air is of land origin; possibly from Arabia and the middle East (Rama, 1967). Other studies which involved computations of fluxes of water vapour and of evaporation over the Arabian sea only (Pisharoty, 1965) indicated that the south west monsoon is primarily of northern hemispheric origin, rather than being the deflected southeast trades of the southern hemisphere as envisaged in the classical theory.

However, recent observational studies based on satellite data (Godbole et al, 1970) seem to suggest that, if clouds are regarded as an indication of the trajectory of moisture-laden winds, the monsoon has its origin south of the equator. Studies reported on the low-level jet near the east coast of Africa (Findlater, 1969) have indicated a large-scale cross equatorial flow between the longitudes 38° E and 55°E during the Indian summer monsoon period. Also, studies reported on the interhemispheric mass exchange between 20°W to 160° E indicated a large-scale transport from south to north across the equator in the lower troposphere(Rao, 1960 and 1961). Further, it has also been pointed out with regard to the hypothesis put forward by randon measurements that if the monsoon air was of continental origin, with high randon content, it would not have sufficient time to pick up an adequate supply of moisture during its travel across the Arabian Sea (Desai,1968). Therefore, it appears from above that the randon measurements made, are more representative of the westerly flow from Arabia than the main monsoon current.

Suggested simulation experiment : Simulation experiments may help answer this fundamental question as regards the origin of the Indian Summer Monsoon. For this purpose, the present two-dimensional model has to be extended to a more realistic three-dimensional one so that it would permit computations and analyses of fluxes of heat,momentum, and moisture across any latitude, say equator, at various longitudes. Such computations are necessary in view of the recent finding (Findlater, 1969) that large scale cross-equatorial flow takes place in certain longitudinal belts.

It is considered that useful information about the role of the south Indian Ocean in the development and maintenance of the monsoon could be obtained even with the present two-dimensional model by extending it, in the first place, to the southern hemisphere and subsequently by substituting land mass south of the equator in the place of the Indian Ocean. As only the first part of the experiment became possible but not the latter for want of Computer time, the results obtained of the first part of the experiment are reported below.

5.2 Simulation Experiment as Extended to the Southern Hemisphere

As a preliminary step, the region north of the equator considered in chapter 4 is shifted southward, as stated earlier, such that the southern boundary coincides with latitude 37.5°S and the northern boundary at 57.5° N. The distribution of water vapour for the region concerned is obtained by using Monthly Climatic Data for the world for July 1964-65. The values of mixing ratio above 500 mb were extrapolated as explained in Sections 2.3. and 4.4. The mixing ratio of carbon dioxide is assumed to be constant at 0.456 gm/kgm at all the levels and for all the latitudes as is done in the earlier experiment. The ozone distribution is obtained as given by Kulkarni* (1969).

5.3 Results and Discussions

The results of the analyses are presented for the region from 20°S to 40°N.

5.3.1 Wet model with the Himalayas

In this experiment, the presence of moisture as well as the presence of the Himalayas are taken into account. The mixing ratio at the earth's surface is considered to correspond to $\beta = 0.4$ (equation 4.4.1). The vertical cross section obtained of simulated zonal wind is shown in Figure 5.3.1. The TEJ with a core speed of 35 m sec^{-1} is situated

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* based on personal communication.

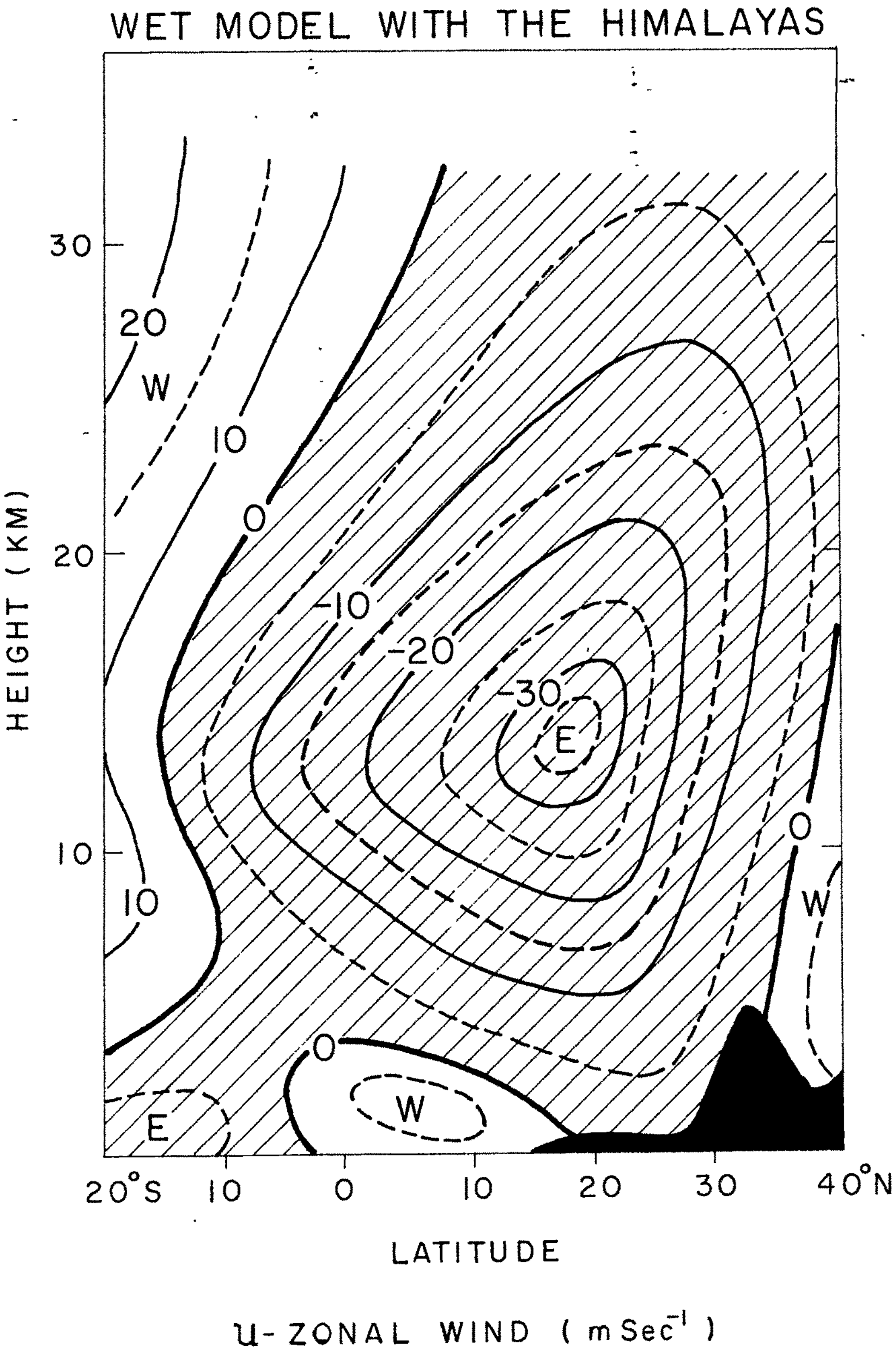

Figure 5.3.1 Vertical cross section of simulated zonal wind (m sec^{-1}) along 80°E from 20°S to 40°N for wet model with the Himalayas. Easterly (E) regime is hatched.

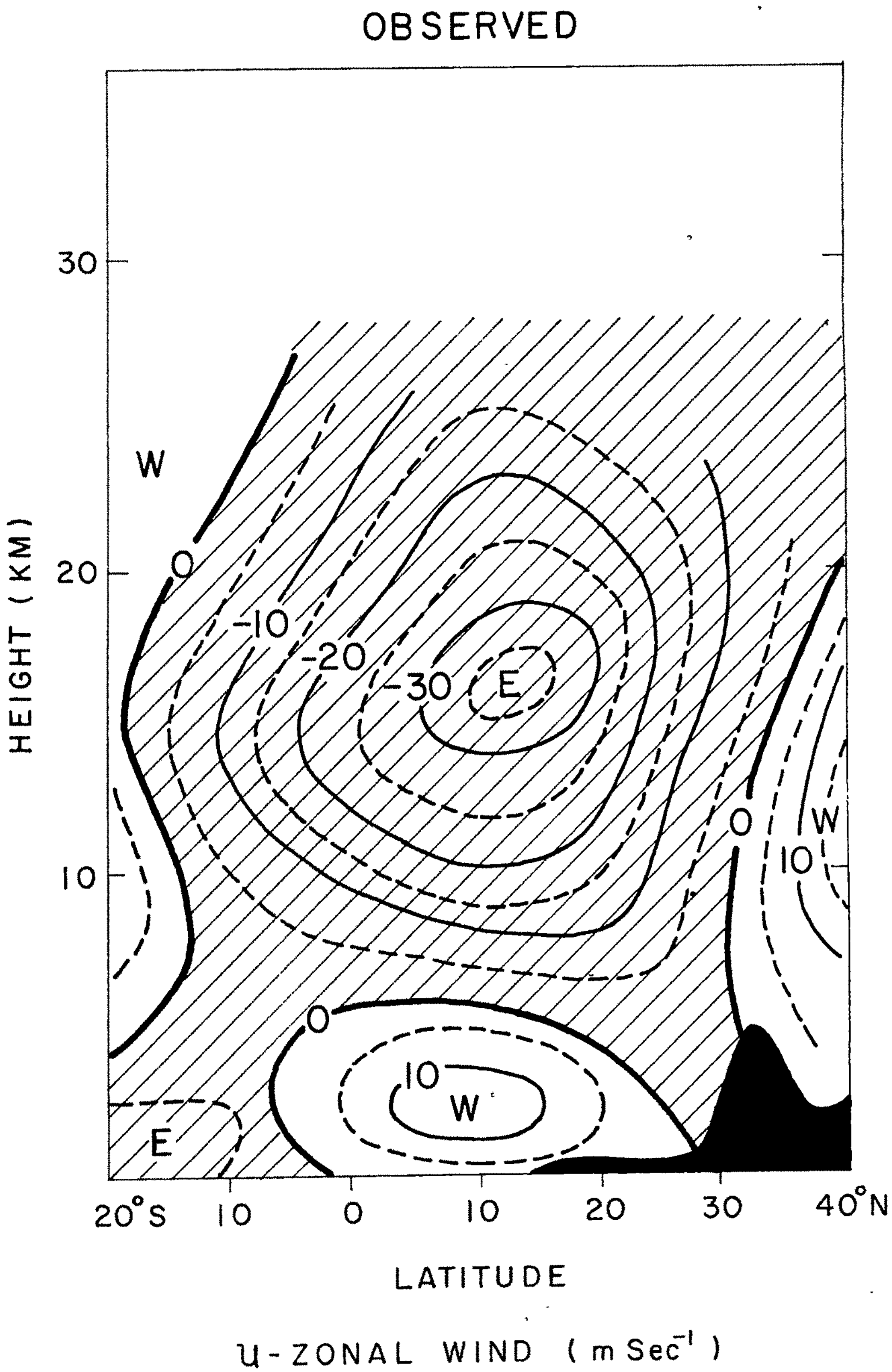

Figure 5.3.2 Vertical cross section of observed zonal wind (m sec^{-1}) along 80°E from 20°S to 40°N. Easterly (E) regime is hatched.

at 14 km at 20°N. The low-level westerly has speed of more than 5 m sec^{-1} and is confined to the region between about 5°S to 20°N. Its maximum depth is 4 km over the equator and it decreases north and south of it. From a few degrees south of the equator there is easterly in the lower levels with westerly aloft.

The vertical cross section of the observed zonal wind is shown in Figure 5.3.2. The pattern closely resembles that of Figure 5.3.1. The TEJ has core speed of 35 m sec^{-1} occuring at 16 km and at 15°N. The observed low-level westerly is twice as strong (10 m sec^{-1}) as the one obtained by simulation. Its depth at the equator (6 km) is one and half times the simulated depth.

Comparing the simulated pattern of Figures 5.3.1 and 4.5.1 (Chapter 4), it is seen that the conspicuous change brought about by the present experiment is in the nature of variation of the depth of the westerly with latitude which is definitely an improvement in the right direction over the earlier experiment.

The vertical cross section of the simulated and observed meridional winds are shown in Figures 5.3.3 and 5.3.4 respectively. Southerly is noticed in the lower levels at all latitudes as observed. The simulated southerly is stronger in the southern hemisphere than in the northern hemisphere which agrees with the observed. However, the

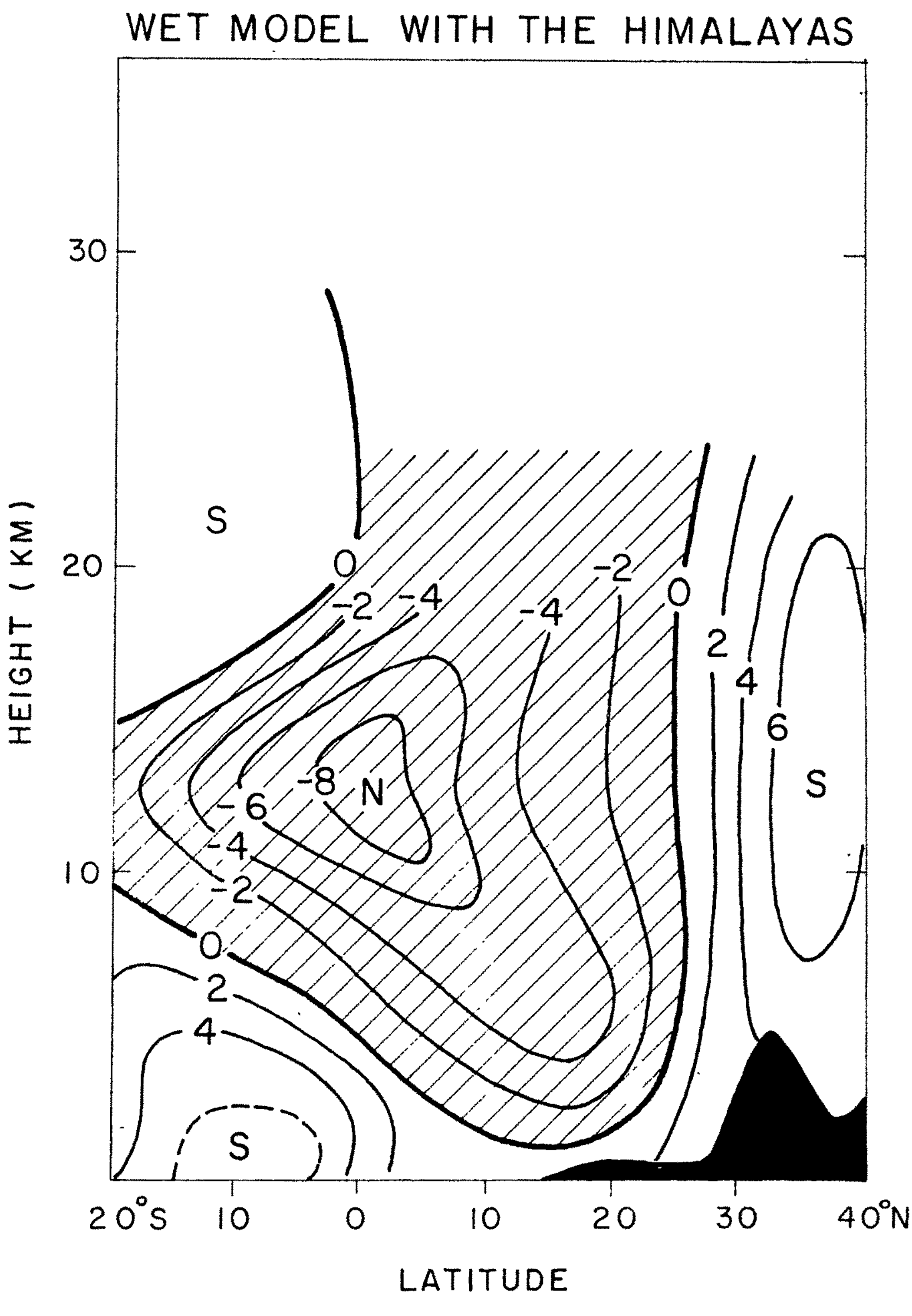

Figure 5.3.3 Vertical cross section of simulated meridional wind (m sec^{-1}) along 80 E from 20 S to 40 N for wet model with the Himalayas. Northerly (N) regime is hatched.

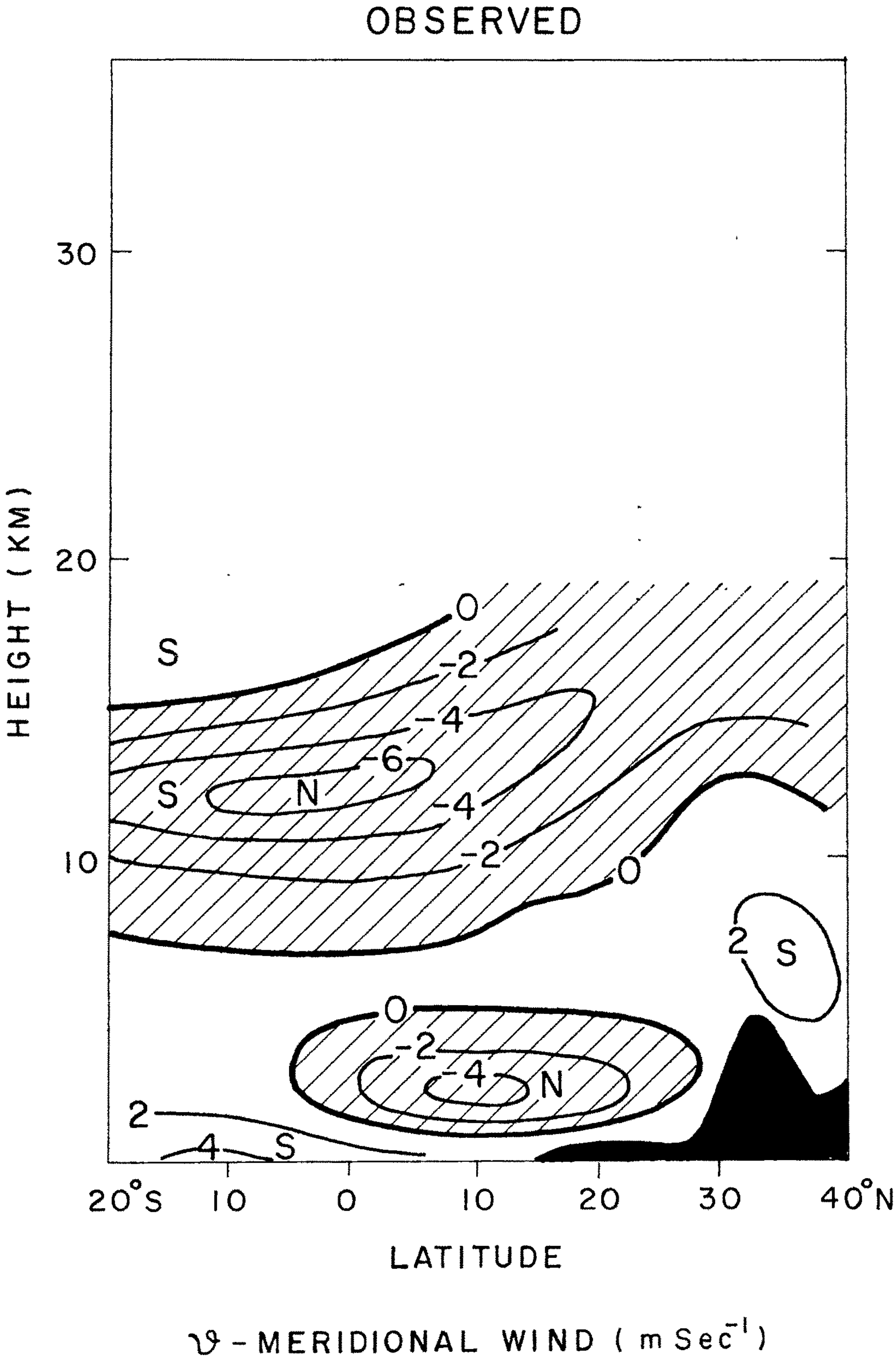

Figure 5.3.4 Vertical cross section of observed meridional wind (m sec^{-1}) along 80°E from 20°S to 40°N. Northerly (N) regime is hatched.

weak mid-tropospheric southerly which is there in the observed pattern is missing in the simulated pattern. Northerly is obtained at higher levels south of 20° N. The pattern in Figure 5.3.3 exhibits a simple one-cell circulation with the return monsoon current extending into the southern hemisphere as indicated by mass transport studies reported by Subbaramayya et al (1966).

REFERENCES

Desai, B.N. 1968 Use of Radon Measurements to Determine source of the South-West Monsoon Current Over the Arabian Sea. Current Science.37.pp.339-340.

Findlater, J. 1969 Interhemispheric Transport of Air in the Lower Troposphere Over the Western Indian Ocean. Quart.J.Roy. Met. sOc.95. pp. 362-380

Godbole, R.V., Bh.V.Ramanamurty 1970 The Indian Summer Monsoon as seen by Weather Satellite. J.Met. Soc. of Japan.48 pp. 360-368.

Pisharoty, P.R. 1965 Evaporation from the Arabian Sea and Indian Sothwest Monsoon. Proc.symp. on met. results of I.I.O.E., Bombay. pp.43-50.

Rama, P. 1966 Proposal for Radiometric Studies on Indian Summer Monsoons. Indian J.Met. and Geophys.17. pp.651-652

Rao, Y.P. 1960 Interhemispherical Features of the General Circulation of the Atmosphere. Quart. J. Roy. Met. Soc. 86. pp.

Rao, Y.P. 1961 Some Characteristics of the Southwest Monsoon Circula--tion. Indian J.Met. and Geophys. 12. pp. 413-418

Simpson, G.C. 1921 The Southwest Monsoon, Quart. J.Roy. Met. Soc. 47 pp. 151-172.

Subbaramayya, I., R.Ramanadham 1966 The Asian Summer-Monsoon Circulation J.Met.Soc. of Japan 44. pp. 167-172