1.4D EQUATORIAL MST RADARS: FURTHER CONSIDERATION

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INTRODUCTION

As an outcome of the Workshop on Equatorial Middle Atmosphere Measurements and Middle Atmosphere Radar held in Estes Park on May 10-12, 1982, the need for a new MST radar in the geographic equatorial region was proposed (KATO and HIROTA, 1982). It was also suggested that such a facility could be established and operated under international cooperation and the MST radar would be one of the activities of the future International Equatorial Observatory.

An equatorial MST radar is needed in equatorial latitudes for the investigation of the dynamics of equatorial waves, precise structure of tides, wave-mean flow interaction processes, MST interactions and other related atmospheric problems. The newly emerging radar techniques for MAP are very promising for detecting and studying shorter wavelength modes such as gravity and acoustic waves.

The equatorial region has unique properties. As the corialis force vanishes at the equator and increases with latitude, waves generated in this region will be trapped. Kelvin waves are such a trapped equatorial waves known to be an important source of westerly momentum in the semiannual oscillation (HIROTA, 1978, 1979; DUNKERTON, 1982). These waves are also believed to be important in the momentum budget of the quasi-biennial oscillation (WALLACE and KOUSKY, 1968). Likewise, Rossby and other equatorial waves must play important roles in the dynamics of the equatorial region and elsewhere.

The purpose of this note is to provide additional justification for establishing the new equatorial MST radar.

IMPACT OF EQUATORIAL ATMOSPHERE-OCEAN INTERACTION ON CLIMATE

The atmosphere and the ocean form the two most important fluid systems of a large heat engine that controls the fluctuations of our climate. Large-scale ocean-to-atmosphere influence has been put firmly into the forefront of research by the work of BJERKNES (1969) and NAMIAS (1976). In the equatorial region the ocean and the atmosphere are strongly coupled and consequently their interaction is more evident. Anomalous fluctuations in the atmosphere give rise to anomalous fluctuations in the ocean and viceversa. Sea to air heat transfer modulates cumulus convection with resulting release of latent heat of condensation aloft which then alters the large scale air circulation elsewhere through teleconnection mechanisms.

One of the most important examples of air-sea interaction, on time scale of a few years, is the El Nino phenomenon which takes place along the west coast of South America. The collapse of the wind field in the equatorial central Pacific as a cause of the ocean response is well understood (WYRTKI, 1975; O'BRIEN et al., 1981), but the reason for the collapse of the wind field is essentially unknown. Once the El Nino event has been established, the ocean has a large influence in the atmosphere to the extent of changing the climate in the equatorial region and elsewhere. But the mechanism of this ocean-to-atmosphere influence is not well understood. I wish to point out here the important role that the equatorial wave dynamics in the troposphere and stratosphere must play in the teleconnection mechanism. I think that with the availability of a new network of MST radar stations in the equatorial region many of these unsolved atmospheric problems could be elucidated.

Although previous studies of synoptic-scale wave motion in the equatorial stratosphere based on analysis of radiosonde data (WALLACE and KOUSKY, 1968) and in the equatorial stratosphere and mesosphere using meteorological rocket and satellite observations (HIROTA, 1978, 1979; SALBY et al., 1982) have provided interesting results on Kelvin waves, the radiosonde, rocket and satellite data alone cannot be sufficient to study the full range of equatorial wave dynamics. On the other hand, MST radars operated nearly continuously in the equatorial region can provide synoptically meaningful data for observing long- and short-period equatorial waves.

FURTHER EVIDENCE OF EQUATORIAL WAVES IN THE TROPOSPHERE AND STRATOSPHERE

In order to test the hypothesis that large anomalous perturbations in the zonal wind in the equatorial central Pacific can give origin to equatorial waves in the atmosphere, in addition to forcing Rossby and Kelvin waves in the ocean, radar measurements for deducing synoptic wind data were set up at Jicamarca for 30 days in November 1982. Daily radiosonde data from Callao (12° 00'S, 77° 07'W) about 50 km from Jicamarca were analyzed for comparison and for inferring the past and subsequent behavior of the atmosphere.

We have first subjectively and objectively analyzed the daily radiosonde data from Callao in the altitude region from ground to about 25 km and for the period October 1982-March 1983. The subjectively analyzed time-height section of zonal wind presents wind fluctuation with periods on the order of 5-15 days. Since the purpose of this note is only to indicate the existence of atmospheric fluctuation similar in structure to Kelvin waves, the analysis and interpretation will be discussed elsewhere. These data were also subjected to power spectrum analysis. Time series were prepared from the daily wind and temperature data at each reported level and the corresponding power spectra for each level were obtained. Peaks near the period of 10 and 15 days are prominent in the curves with the largest values occurring at 2 and 5 km, respectively.

Late in October 1982, when the oceanic and atmospheric conditions were such that the El Nino phenomenon was very likely to occur, a decision was taken to carry out wind measurements using the Jicamarca coherent-scatter technique for a period of 30 days in November 1982 in the 5-25 km height region and in a nearly continuous mode. The purpose was to observe a very intense Kelvin wave with a period of 10-15 days which could be associated with El Nino events as far away as 12° from the equator. Three antenna beams were used and observed for 20 minutes each hour. Figure 1 shows a sample of the east-west component of the wind data for 7, 10, 15 and 20 km altitude and for the period 3-22 November. Comparison of the two sets of data indicates that the radar technique gives more useful information for wave phenomena studies with periods from seconds to a few days. When radar data are averaged for an hour or more, radar measurements have been shown to produce data of a quality that is at least comparable to radiosonde data (BALSLEY and GAGE, 1982; LARSEN and ROTTGER, 1982).

SCIENTIFIC REQUIREMENTS FOR THE NEW EQUATORIAL MST RADAR

(1) Purpose: Observation of equatorial waves in the MST region.

(2) Location: It is desirable that two new facilities be established within 5° latitude. Possible locations could be either at Christmas Island (2°S, 157.5°W) or Canton Island (2.8°N, 171.7°W) and Talara (4.34°S, 81.15°W) During the IGY, Talara was used as an IGP ionospheric radiosounder.

(3) Height range: MST region.

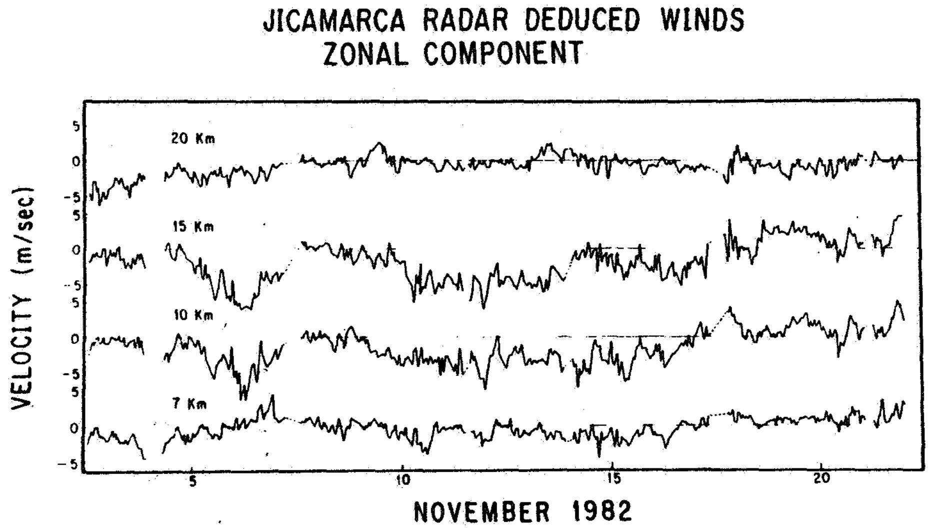

Figure 1

(4) Parameter to be observed: Three components of wind fluctuations.

(5) Height resolution: 500 m.

(6) Time resolution: At least two hours of continuous observation every six hours during 30 days and every three months. With this time resolution, acoustic, gravity, tidal, Rossby, Kelvin waves as well as semiannual, annual, biennial oscillations, can be studied in the equatorial MST region. Table 1 shows the main atmospheric time scale processes. However, an interrupted observation will be desirable.

Table 1

ATMOSPHERIC TIME SCALE PROCESSES

DAYS	PHYSICAL PROCESSES
10^{-4}	Acoustic waves
10^{-3}	
10^{-2}	Gravity waves
10^{-1}	
10^{0}	Tidal waves
10^{1}	Rossby and Kelvin waves
10^{2}	Seasonal cycle, monsoon, semiannual and annual cycle
10^{3}	Biennial oscillation El Nino
10^{4}	

CONCLUSION

The results presented in this note give additional support to the suggestion of the need of equatorial MST radars in order to obtain more information on the nature of equatorial waves in the MST region. Radar-deduced winds such as obtained at Jicamarca for periods of months indicate that with these data the full range of equatorial waves, with time scales of seconds to years, can be studied.

REFERENCES

Balsley, B. B. and K. S. Gage (1982), Bull. Am. Meteorol. Soc., 63, 1009.

Bjerknes, J. (1969), Monthly Weather Rev., 97, 163.

Dunkerton, T. (1982), J. Atmos. Sci. (to be published).

Hirota, I. (1978), J. Atmos. Sci., 35, 714.

Hirota, I. (1979), J. Atmos. Sci., 36, 217.

Kato, S. and I. Hirota (1982), Handbook for MAP, C. F. Sechrist, Jr., ed., vol. 7, p. 103.

Larsen, M. F. and J. Rottger (1982), Bull. Am. Meteorol. Soc., 63, 996.

Namias, J. (1976), Monthly Weather Rev., 104, 1107.

O'Brien, J. J., A. Busalacchi, and J. Kindle (1981), Resource Management and Environmental Uncertainty, Lesson from Coastal Upwelling Fisheries; M. H. Glantz and J. D. Thompson, eds., Wiley-Interscience, p. 159.

Salby, M. L., D. Hartmann, P. L. Bailey and J. C. Gille (1982), Handbook for MAP, C. F. Sechrist, Jr., ed., vol. 7, p. 119.

Wallace, J. M. and V. B. Kousky (1968), J. Atmos. Sci., 25, 900.

Wyrtki, K. (1975), J. Phys. Oceanog., 5, 572.