May 30, 1984

Dr.
Helmuth Bauer
Gesellschaft fur Strahlen und
Umweltforschung MBH Munchen
Bereich Projekttragerschaften
Josephspitalstr. 15
8000 Munchen 2
Federal Republic of Germany

Dear Dr. Bauer:

Enclosed you will find an abstract of my paper to be presented at the meeting on "Current Issues in our Understanding of the Stratosphere and the Future of the Ozone Layer". I hope it makes it before June 1st.

Sincerely,

Ronald F. Woodman

RW/gch

Enc.

RADAR OBSERVATIONS OF THE STRATOSPHERE - IMPLICATIONS FOR MODELLING

R.F. Woodman
Instituto Geofísico del Perú
June, 1984

During the last decade there has been a rapid development of radar techniques and installations for the study of middle atmospheric dynamics. Of special interest to this meeting are the capabilities of the technique to measure gravity waves and turbulence.

The outstanding advantage of the technique is the possibility of long continuous monitoring of the velocity field and turbulence morphology , with temporal resolutions of the order of one minute or better and a vertical spatial resolution of 30-150 meters.

Measured velocities show, in general, a very caotic behaviour at freq-- uencies from days to a few minutes. Very seldom, discrete monocromatic events are observed. This makes the interpretation of origin and decay difficult, especially with the current limitation of single observing installations. Nevertheless, efforts have been made to statistically characterize the energetics of these waves via frequency power spectra .They show monotonically decreasing power densities with and enhancement shortly before cut-off around the Brunt-Väisala frequency. Of special relevance to the meeting is the potentiality of measuring momentum flux through a direct measurement of $\overline{u'w'}$.

The power intensity of a radar echo is directly proportional to the variance of temperature (index of refraction) - fluctuations at a wavelength equal to half a wavelength of the probing electromagnetic wave , and hence, a fairly direct measurement of the intensity of turbulence . This relationship has been used to obtain the morphology of turbulence in the stratosphere. Figure 1 is a sample of such picture. The existance of turbulence in narrow, long lasting layers is evident. The layers have a thickness of 30 to 300 meters and occur at vertical dis-- tances from several hundred meters to a few kilometers. Some of the layers preserve their identity for several hours. If we assume they are transported with the background wind they would have a few hundreds of kilometers of horizontal extent. Figure 2 shows the vertical flux , of an hypothetical passive additive with unit gradient produced - by mixing - by the temporal observed behaviour of turbulence shown in figure 1. The average of such flux is a measure of the effective vertical eddy diffusivity produced by turbulence alone. From it, one can infer vertical diffusivities of the order of 0.2 m^2sec^{-1}, i.e. compa -- rable to the values inferred from resident times or radioactive debris and distribution of stable chemical tracers.

The radar technique also permits the direct measurement of the variance of turbulent velocity fluctuations,i.e. of the turbulent kinetic energy content. It is obtained from the Doppler spectrum widening of the ra-- dar echoes. From it, using theoretical relationships between turbulent energy and energy dissipation, one can obtain estimations of the latter. Values of the order of 2×10^{-4} m^2sec^{-3} have been reported.

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The energy dissipation is in turn theoretically related to the vertical diffusivity through $K_n = \bar{\varepsilon}/3N^2$, permitting an independent and alterna-- tive way of estimating the latter. Values estimated this way are com-- parable to the ones obtained from the space-time statistics of turbu -- lence mentioned above.

Figure Captions

Figure 1. A map showing the evolution of thin turbulent layers over 9-28 km from radar observations at Arecibo.

Figure 2. Flux per unit gradient for a hypothetical passive scalar produced by the empirical realization of turbulent layers shown in Fig. 1. (After Woodman and Rastogi; 1984 GRL, 11/3, 243-246).

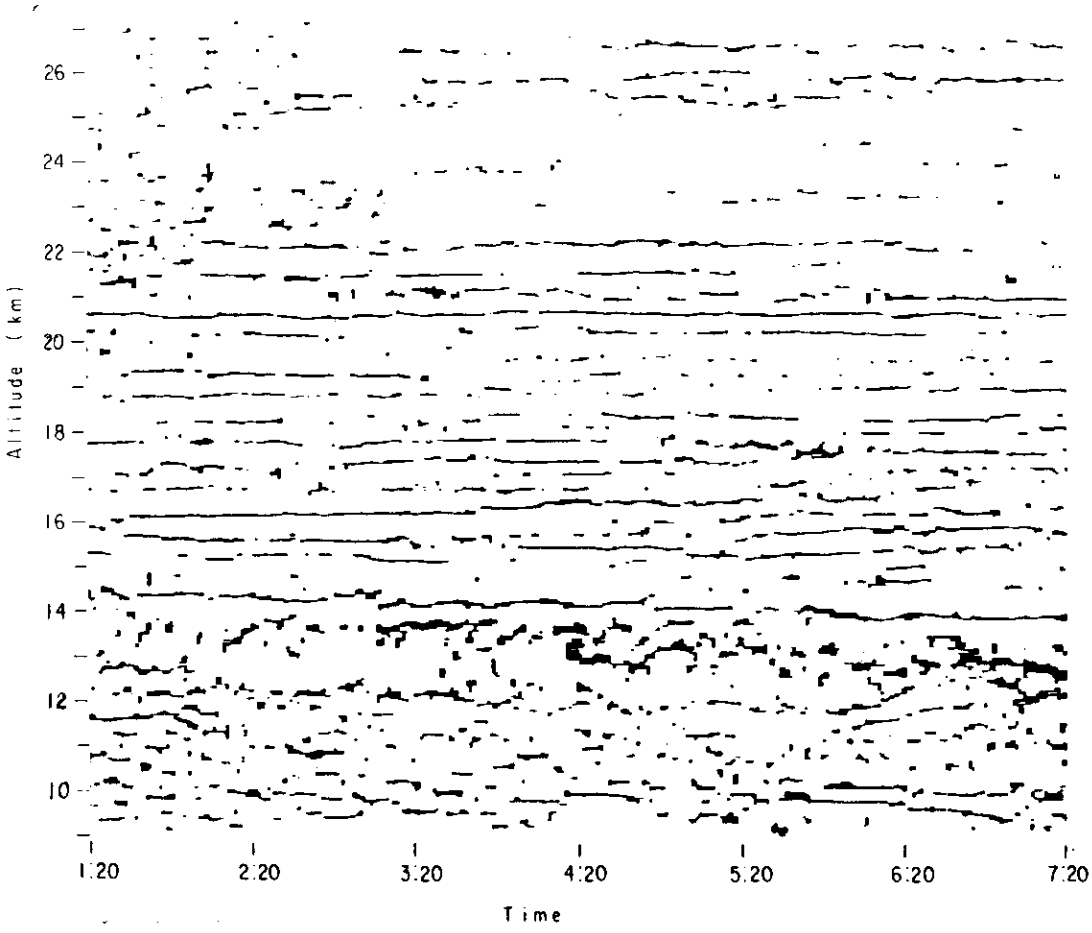

FIGURE 1.

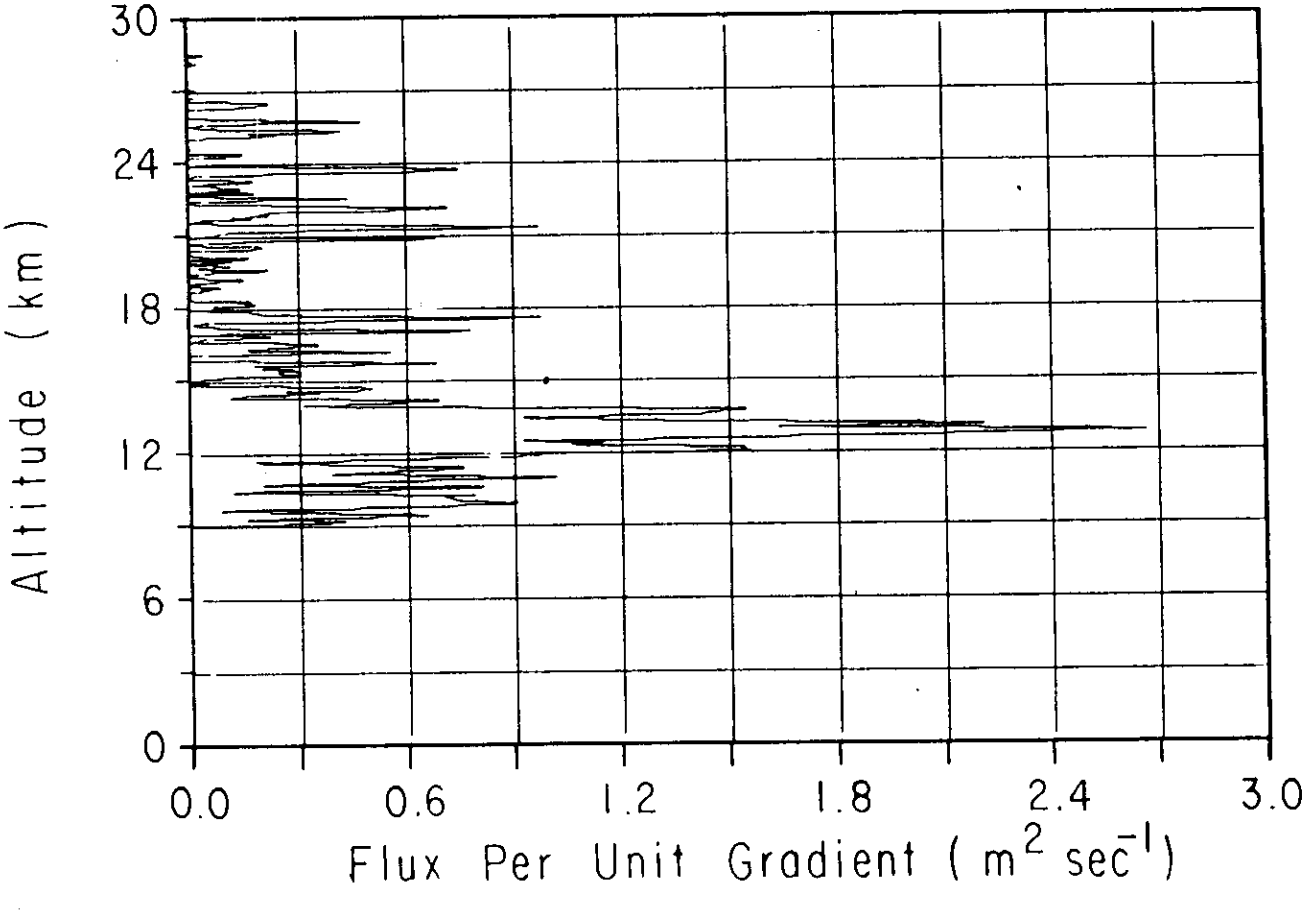

FIGURE 2.