D41-46
J.4.

3.7.1 EFFECTS OF ANISOTROPY ON THE FREQUENCY SPECTRUM OF GRAVITY WAVES OBSERVED BY MST RADAR

C. H. Liu

Department of Electrical and Computer Engineering
University of Illinois at Urbana-Champaign
Urbana, IL 61801

In the investigation of gravity waves using MST radar data, model gravity-wave spectra have been used. In these model spectra, one usually assumes azimuthal symmetry. The effect of spectral anisotropy on the observed spectrum is studied in this paper. It will be shown that for a general Garrett-Munk-type spectrum, the anisotropy does not affect the frequency spectrum observed by the vertically beamed radar. For the oblique beam, however, the observed frequency spectrum is changed.

Let us consider a general gravity wave spectrum including azimuthal anisotropy:

$$E(\vec{k},\omega) = \frac{1}{4\pi k_h} E_0 A(k_z) B(\omega)F(\phi)\delta[k_h-(\frac{\omega^2-\omega_i^2}{\omega_b^2-\omega^2})^{1/2}|k_z|] \quad (1)$$

Next, let us consider the following two parameter model of anisotropy:

$$F(\phi) = 1+a \cos 2(\phi-\phi_0) \quad (2)$$

Then it can be shown that the observed spectrum is given by (SCHEFFLER and LIU, 1985),

$$E_{0_b}(\omega) = E_0 H(\omega) \cdot B(\omega) \quad (3)$$

where
$$H(\omega) = \frac{\omega^2-\omega_i^2}{\omega_b^2-\omega_i^2} \cos^2\theta_B + \frac{\omega_b^2-\omega^2}{\omega_b^2-\omega_i^2} \sin^2\theta_B[1-\frac{1}{2}(1-\omega_i^2/\omega^2)(1-\frac{a}{2}\cos 2(\phi_B-\phi_0))] \quad (4)$$

θ_B: zenith angle of radar beam, ϕ_B: azimuth angle of radar beam. The effects of anisotropy are included in (4). It is possible to determine a and ϕ_0 of the anisotropy model in the following manner.

For any $\theta_B \neq 0$, take three beam measurements at $\phi_{B1}=0°$, $\phi_{B2}=90°$ and $\phi_{B3}=45°$.

Let
$$A = \langle v_{0_{b1}}^2\rangle - \langle v_{0_{b2}}^2\rangle \quad (5)$$

$$B = 1/2\,[\langle v_{0_{b1}}^2\rangle + \langle v_{0_{b2}}^2\rangle] \quad (6)$$

$$C = \langle v_{0_{b3}}^2\rangle - B \quad (7)$$

where $\langle v_{0_{bj}}^{2}\rangle$ is the variance of observed velocity fluctuation along the j-th beam position.

Then we have

$$\phi_0 = \tfrac{1}{2} \tan^{-1} \left(\frac{2C}{A}\right) \tag{8}$$

$$a = \frac{3A}{E_0 \cos 2\phi_0 \sin^2\theta_B} \tag{9}$$

E_0, the total power associated with the wave spectrum, can be determined from the spectrum, or additional vertical beam measurement.

We note from equation (4), for vertical beam, $\theta_B=0°$, the anisotropy does not affect the observed spectrum. The two parameter anisotropy model, equation (2) is a rather simple one. It does, however, contain some of the most important features of an anisotropic spectrum. Therefore, the results in (3) and (4) are expected to present some of the important effects on observed gravity-wave spectrum due to anisotropy.

REFERENCE

Scheffler, A. O., and C. H. Liu (1985), On observation of gravity wave spectrum in the atmosphere by using MST radar, Radio Sci., 20, 1309-1322.