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1.4B GENERAL CIRCULATION OF THE MIDDLE ATMOSPHERE

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In both the tropical and extratropical regions there are a large number of dynamical problems which can be addressed by MST radars. The distinct advantage the MST radar has over rocket observations is continuous data acquisition. Without a doubt, the time-space spectrum of the mesospheric flow field is rich in high frequency motions associated with gravity waves rather than turbulent (random) fluctuations, and these events are particularly amenable to analysis with continuous data sets. In addition to the high frequency motions there are longer period fluctuations in the upper stratosphere and mesosphere wind fields which; combined with temperature fields derived from satellite data or lidars, can greatly enhance our knowledge of the upper atmosphere.

Previously, it had been thought that the mesosphere, like the stratosphere, contained very large-scale waves (which propagated up from the stratosphere) and intermittent turbulent fluctuations associated with local shear or convective instabilities. However, HODGES (1969) and LINDZEN (1967) pointed out that the likely source for the turbulent field is the convective breakdown of vertically propagating gravity waves. The theoretical requirement of a large vertical flux of momentum carrying gravity waves for the mesospheric mean circulation models (LINDZEN, 1981), and the indirect observational evidence of a large zonal mean meridional wind which would require a huge drag on the zonal flow (possibly hundreds of meters per second per day) to balance the Coriolis torque both indicate that a large flux of gravity waves from the troposphere does penetrate to mesospheric heights. It further suggests that the dynamics of the mesosphere may be much more complex than previously thought, as the stress on the local flow, set up by the breaking gravity wave, could produce an entire sub-spectrum of Rossby and gravity waves which are free to propagate laterally and vertically to other regions. For example, consider a mountain wave which penetrates to the mesosphere. The convective breakdown of this wave produces a stationary torque and a secondary circulation which would generate a train of Rossby waves much like the barotropic wave trains observed in the troposphere as well as secondary gravity waves.

In addition to the subspectrum of forced disturbances, the turbulent fluctuations produced by the convective breakdown of the gravity wave can have a profound effect on the heat and constituent transport in the mesosphere. The depth of the turbulent layer determines the mixing scale for fast transport of constituents as well as potential temperature. Since the mesosphere is a radiatively stable region, the mixing due to turbulence produces a downward flux of heat and tends to push the mesospheric lapse rate toward adiabatic. Thus the total production of turbulence and the depth of the turbulent layers is a relevant question to the thermodynamic budget of the mesosphere. Unfortunately, a single MST radar site is not adequate to determine the "climatology of turbulence" as there could be as much spatial variation in the turbulent field as there is in the surface orography.

The upward flux of momentum by small-scale waves has been measured by dual-beam radars (e.g. VINCENT and REID, 1983). But the dual-beam radar lacks precision in measuring the momentum flux due to large horizontal scale gravity waves and it may be difficult to separate the momentum transport by waves from the transport of the basic shear momentum by the turbulent field. In other words, there may be a local redistribution of momentum due to the effect of turbulence on the mesospheric shear not associated with a flux of momentum from the troposphere.

In the equatorial zones, the dynamics of large-scale flows can be reduced to a two-dimensional problem (height and longitude). DUNKERTON (1982) has suggested that the mesopause semiannual oscillation could be induced by gravity waves. Unfortunately, the observations of the semiannual oscillation are not tremendously reliable and verification of the theory is difficult. A series of MST radars located along the equator would provide important input into our understanding of the dynamics of the tropical mesosphere.

To summarize, the MST radar can have tremendous impact on our understanding of the general circulation of the mesosphere and upper stratosphere. Single stations linked into networks could provide both continuous spatial and temporal information on medium and large scale waves in the mesosphere as well as the local climatology of turbulence. Multibeam stations can provide data on the vertical flux of momentum by small-scale (gravity) motions. Additional discussion of the impact of the MST radars on our understanding of the general circulation is discussed in FRITTS et al. (1984).

REFERENCES

Dunkerton, T. (1982), J. Atmos. Sci., 39, 2681-2690.
Fritts, D. C., M. A. Geller, B. B. Balsley, M. L. Chanin, I. Hirota, J. R. Holton, S. Kato, R. S. Lindzen, M. R. Schoeberl, R. A. Vincent and R. F. Woodman, (1984), Bul. Am. Meteorol. Soc., 65, 149-159.
Hodges, R. R., J. Geophys. Res., 74, 4087-4090.
Lindzen, R. S. (1967), Q. J. R. Meteorol. Soc., 93, 18-42.
Lindzen, R. S. (1981), J. Geophys. Res., 86, 9707-9714.
Vincent, R. A. and M. Reid (1983), J. Atmos. Sci., 40, 1321-1333.