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## 2.3 WAVE PROPAGATION INTO THE MIDDLE ATMOSPHERE

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Recent observations of various types of waves propagating into the middle atmosphere are reviewed. Emphasis is made on the excitation processes in the lower atmosphere and their vertical propagation through the background flow as a function of the latitude, height and season. The following subjects are discussed: 1. Vertical propagation of quasi-stationary forced Rossby waves into the winter stratosphere in connection with the sudden warming. 2. Spectral distribution and seasonal characteristics of normal mode (free) Rossby waves and the asymmetry of the Northern and Southern Hemispheres. 3. Seasonal variation of internal gravity waves in the middle atmosphere. Further discussions will be presented for future studies based on accumulated observational data during the MAP period.

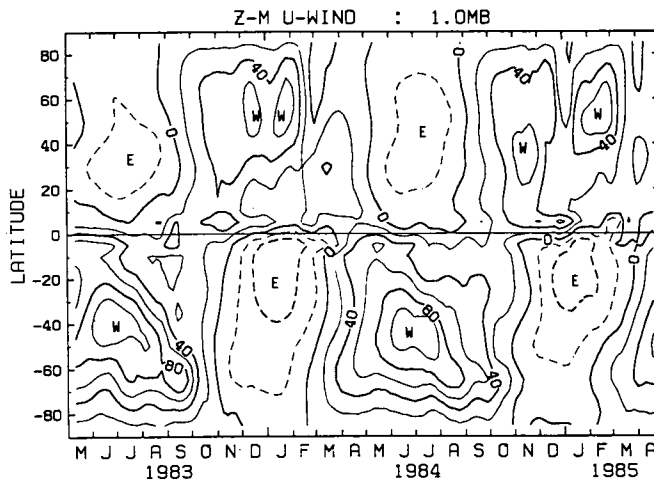


Figure 1. Latitude-time section of the zonal mean geostrophic wind at the 1 mb level estimated from the 20-day average height field. Units are m/s. Positive values denote westerly winds.

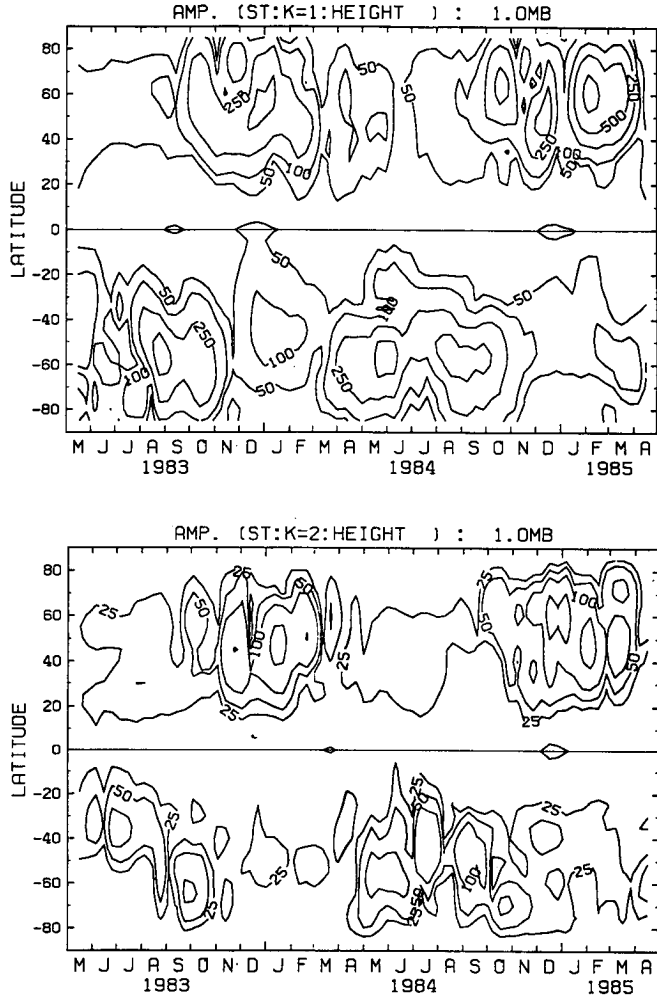


Figure 2. Latitude-time section of the quasi-steady wave amplitude of wave number 1 (upper) and wave number 2 (lower) at the 1 mb level. Units are meters.

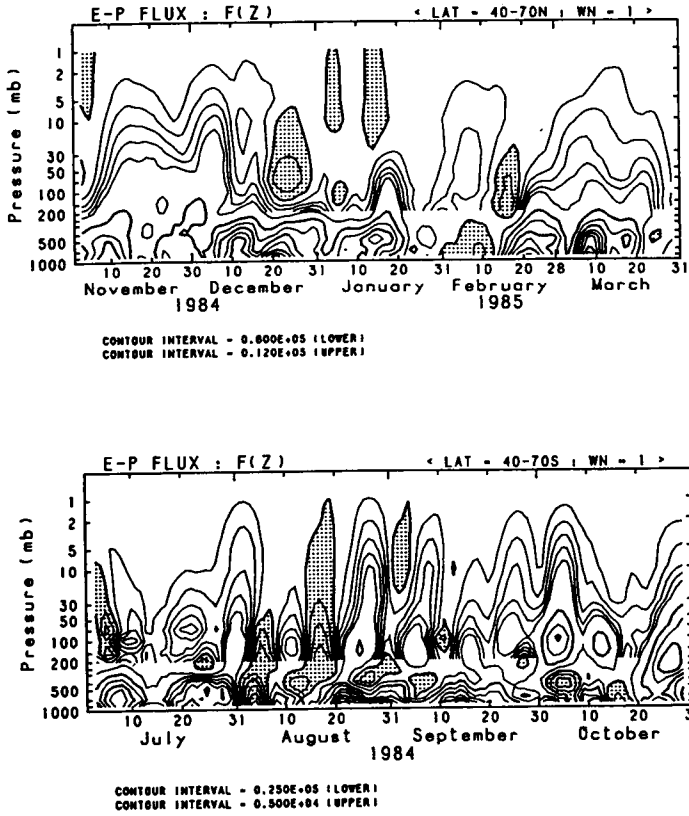


Figure 3. Time-height section of vertical component of the E-P flux,  $F(z)$ , averaged over 40°N to 70°N (upper) and 40°S to 70°S (lower) for wave number 1.

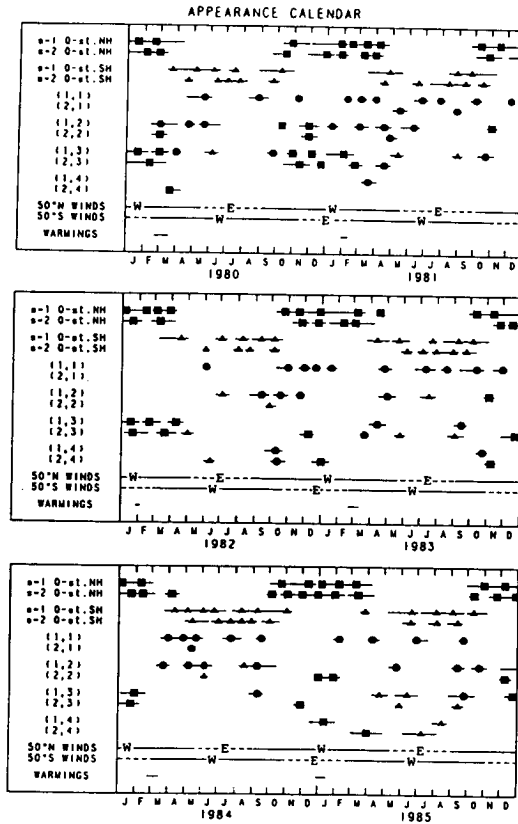


Figure 4. Appearance calendar of various normal mode Rossby waves and quasi-stationary waves at 1 mb, along with the change of the 1 mb zonal mean wind regime at 50°N and 50°S. See Hirooka and Hirota [1988, to be published in PAGEOPH] for more detail.

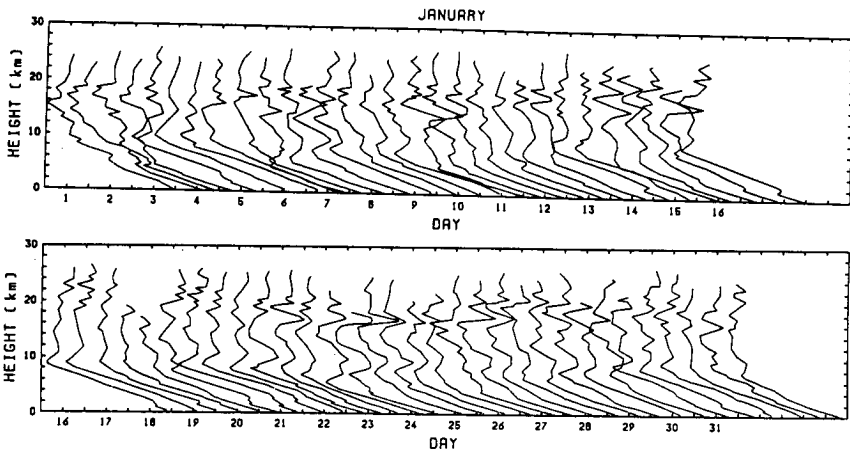


Figure 5. Vertical distribution of temperature by daily balloon observations at Akita (40°N) for January 1986. Note that small-scale fluctuations are observed mainly above the tropopause level.

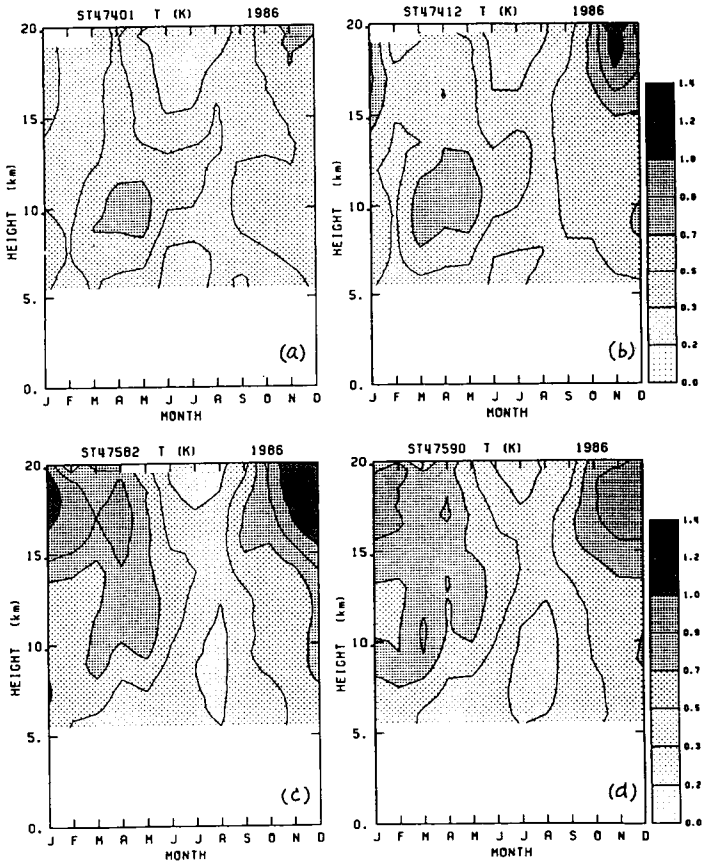


Figure 6. Seasonal variation of gravity wave amplitudes in temperature observed by balloon at four stations: (a) Wakkanai, 45°N, (b) Sapporo, 43°N, (c) Akita, 40°N, (d) Sendai, 38°N.

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