P2-11 Gravity Wave Activity in the Equatorial Middle Atmosphere Observed with a Rayleigh Lidar in India

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1 Introduction

Atmospheric waves are recognized as having significant influence on global circulation of the middle atmosphere by transporting energy and momentum from lower altitudes. Especially, the middle atmosphere in equatorial regions is considered to affect global circulation strongly because the convective and cumulus activity is quite intensive in the tropical region.

The radar observations including radar Hauchercorne and Chanin showed that Rayleigh lidar observations are effective to measure the middle atmosphrer,especially at the altitude from 30km to 60km that cannot be observed by radars[Chanin and Hauchercorne, 1984]. Gravity waves in the middle atmosphere have been studied by investigating density and temperature fluctuations observed with Rayleigh Lidars at many locations, but mainly in middle and high latitudes, such as Haute Provence (OHP), France(44° N, 6° E) [Wilson et al., 1991], Biscarosse (BIS) $(44°N, 1°W)$, France [Wilson et al., 1991], Tsukuba$(36°N, 140°E)$, Japan[Murayama et al.,1993], Toronto$(44°E, 80°W)$, Canada[J. A. Whiteway and A. L. Carswell, 1995], Eureka, Canada$(80°N, 86°W)$ [J. A. Whiteway and A. L. Carswell,1995], and Aberystwyth, UK$(52.4°N, 4.1°W)$ [A. K. P. Marsh et al., 1991].

In this paper we analyzed Rayleigh lidar data obtained at Gadanki, India$(13°N, 79°E)$ in order to clarify the difference of gravity wave activity in the middle atmosphere between equatorial and mid-latitude regions.

2 Database

NMRF(National MST Radar Facility, India) and CRL (communication research Labrotory, Japan) installed a Rayleigh lidar system at Gadanki and have been operating it since March 1998. High power Nd:YAG laser with a transmition power of 11W at 532 nm and a large Newtonian telescope (75 cm ϕ) are used for observation. The data are sampled with a height resolution of 300 meters and integrated for 250 seconds (5000 shots).

Atmospheric density profiles are observed and using scale height of the density temperature profiles are deduced [Chanin and Hauchecorcn,1984]. Statistical error which is approximately inversely proportional to the square of signals becomes larger as increasing altitude. The relative error is typically 2% at 60km, less than 0.1% at 30km. We used the data obtained between March 1998 and January 1999 in this paper.

3 Data analysis

In order to analyze atmospheric waves gravity wave activity, we picked up the fluctuating component of density and temperature, ρ', T' as:

$$\rho' = \frac{\rho - \rho_0}{\rho_0}, \quad T' = \frac{T - T_0}{T_0}$$

where ρ_0, T_0 are night-time averaged atmospheric density and temperature, respectively. Available potential energy density per unit mass, E_p is defined as this;

$$E_p = \frac{1}{2}\left(\frac{g}{N}\right)^2 (\rho')^2 = \frac{1}{2}\left(\frac{g}{N}\right)^2 (T')^2$$

where g is the gravitational acceleration and N is the Brunt – Väisälä frequency [Wilson et al.,1991]. Using this equation, We can calculate E_p by both of atmospheric density and air temperature fluctuations, but the error of atmospheric density data is smaller than that of air temperature data, and therefore we calculated E_p with atmospheric density data.

The vertical wave number spectra of atmospheric density fluctuations are averaged over night time. Then spectral densities are integrated in the wavenumber range between 6.7×10^{-5} - 1×10^{-3} cyc/m (that equals 1–15 km in wavelength), and then the variance due to the noise from the integrated spectra. E_p are then calculated using Brunt – Väisälä frequency determined from the temperature profiles.

We could see the seasonal variation of E_p in the upper stratosphere(30km–45km) with maximum around in August and minimum around in January. This is different from the observation in the mid-latitudes, where maximum in winter and minimum in summer have been observed. [Wilson et al., 1991]. The monthly mean value of E_p at Gadanki was nearly as large as that at OHP and BIS in October–February, while in May–August the value in Gadanki was approximately 4 times as large.

In the higher altitude region (45 – 60 km) a seasonal variation is not evident in Gadanki, which is similar to the result at OHP ans BIS. The yearly average value in Gadanki was 68 J/kg, which was about twice as large as the result in OHP and BIS. This result means the difference of potential energy per unit mass associated with the atmospheric waves such as gravity waves between Gadanki and OHP or BIS becomes smaller as the altitude increases in the stratosphere and lower mesosphere.

It is considered that in the upper stratosphere the gravity wave activity depends on latitude but in the lower mesosphere such a difference is small. We obtained the similar results when we compared with the data of other places in mid-latitude and high-latitude regions. The details of energy profile and vertical wave number / frequency spectra will be also seen in the paper.

4 Summary

We analysed the density and temperature fluctuation observed with a Reileigh lidar observation at Gadanki, India. The potential energy per unit mass E_p in the upper stratosphere(30km–45km) and the lower mesosphere(45km–60km) are derived and compared with the result at other places. The nightly-averaged E_p had a maximum around in August and a minimum around in January in Gadanki, while the maximum in winter and the minimum in summer are more commonly seen in mid-latitudes. On the other hand, in the lower mesosphere (45km–60km) we could not see clear seasonal variations in Gadanki and the difference between Gadanki and other palces was smaller than in upper stratosphere.

5 References

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