SPACE SURVEY OF INTERNAL ATMOSPHERIC WAVES

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It is now well appreciated that internal gravity waves (IGW) play a crucial role in determining the circulation and mean state of the atmosphere. IGW can occur at all altitudes in the Earth atmosphere and are important for several reasons: They can transport energy and momentum from one region of the atmosphere to another; they can initiate and modulate convection and subsequent hydrological processes; they disturb the balanced state through injection of energy and momentum into the mean flow; and, when the waves break, turbulence hazardous to aviation is generated and chemical species are mixed; IGW and wave breaking may be responsible for the formation of the ionospheric sporadic E layers. These wave breaking processes occur globally and significantly affect climate of the mesosphere and stratosphere. Internal gravity waves affect atmospheric dynamics, temperature and composition from microscales to planetary scales.

Space survey (MODIS-Terra and Aqua, ASAR and MERIS-Envisat) has revealed signatures consistent with horizontally propagating large-scale IGW which are frequently observed during the winter season. The horizontal structure of atmospheric IGW was examined using satellite imagery. However, up to now, space survey is not capable to measure vertical energy and momentum fluxes associated with IGW propagation.

The advantage of using radio occultation satellite measurements for gravity wave research is their extensive geographic and temporal coverage. It allows seasonal and latitudinal variations of gravity wave activity to be identified. However, it was assumed earlier that it is impossible to estimate gravity wave parameters such as the intrinsic frequency or phase velocities that are necessary to quantify the IGW effects because the observed quantities are only temperature and atmospheric density. In this connection, we propose a new technique that can be used to derive all wave parameters from only a single vertical temperature profile without requiring any additional information not contained in the profile. It seems likely that applications of the proposed method for the analysis of radio occultation data will provide powerful, self-contained and potentially important source of information on gravity waves and their effects in the troposphere and lower stratosphere of the Earth.

In order to derive internal gravity wave characteristics we have analyzed small-scale fluctuations of normalized temperature in the Earth stratosphere using radio occultation data. The criterion for the positive identification of the observed fluctuations as wave-induced is formulated. An analysis technique for the derivation of the IGW intrinsic frequency and other wave parameters is proposed. This technique is based upon a comparison of the experimental and theoretical values of the relative amplitude threshold which is defined as the wave amplitude required for shear instability. In the case when the analyzed fluctuations are positively identified as wave-induced, then the intrinsic frequency of the monochromatic gravity wave can be determined from only a single vertical temperature profile. The results of the determination of the wave characteristics are presented. The practical application of the proposed method is demonstrated by using the GPS/FORMOSAT radio holographic retrievals of temperature profiles in the Earth stratosphere. For the experimental examination of the efficiency of the proposed technique, the results of the simultaneous temperature and wind velocity measurements obtained in a high-resolution balloon experiment were used. By using the experimental temperature data only, we reconstructed all wave parameters. An intercomparison between observed and reconstructed wave parameters shows good agreement.

We assume that this method can be widely applied for the analysis of vertical temperature profiles measured by other techniques (Rayleigh lidar, rocket and radiosonde soundings et al).

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