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Studies on the acoustic, infrasonic and gravity waves since the 1960s

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Since the basic theory of acoustic gravity wave was established in the 1960s, many small dynamic disturbances in the upper atmosphere, taking place either naturally or artificially, have been well understood in terms of these waves. Particularly, travelling ionospheric disturbances (TID) were found to be a manifestation of gravity waves. Later, nuclear explosions have been considered to be detected as the acoustic gravity wave sources. Also aurora particles has been found to be the wave sources. Recently, tsunami produced by earth quakes has been interested as acoustic gravity wave sources though the precise detection system has been far from complete. In understanding gravity waves whose propagating velocity, is as slow as local winds, we have to consider the frequencies to be often seriously Doppler-shifted by local winds. In the 1980s gravity waves, propagating from the lower to upper atmosphere, are considered to be saturated dynamically and thermodynamically, resulting to release the angular momentum to the ambient atmosphere, contributing to the peculiar mesosphere general circulation.

As to atmospheric tides which are gravity waves with global scales and with periods of one solar-day or its submultiples, the classical tidal theory was established in the 1960s clarifying tides and other planetary-scale wave structures as consisting of both positive and negative modes, each of which depends on either positive and negative sign of the eigen value of the fundamental equation i.e. the Laplace tidal equation, respectively. The classical tidal theory has solved an outstanding problem on the geomagnetic Sq variation which is the geomagnetic variation originating in the ionosphere being observed on the earth's surface. Thus, we have realized that various atmospheric waves contribute to coupling between the lower and upper atmosphere.

We saw since the 1980s remarkable steps forwards in observation of the atmospheric waves particularly by radars and lidars. The Mesosphere, Stratosphere and Troposphere (MST) radars have been constructed in many places in the world providing observational supports of the theories. Particularly, the MU radar Kyoto University, constructed in 1984, has played an important role in showing the saturation spectrum and momentum release of gravity waves for contributing to the mesosphere general circulation. It should be remarked that while a lot of observation data about atmospheric waves is available now, very often the data analysts may be lacking in clear understanding the basic theories. Hopefully, the present paper may help them improve the lacking.

Keywords: acoustic waves, gravity waves, atmosphere, tide, MST radar, propagation