中間圏および下部熱圏における重力波の発生と潮汐波との関係

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In-situ generation of gravity waves in the mesosphere and lower thermosphere and its relation with tides

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The contribution of gravity waves to the momentum budget in the mesosphere and lower thermosphere (MLT) is examined using simulation data from a whole atmosphere model GAIA. Regardless of relatively coarse model resolution, gravity waves appeared in the MLT region. The resolved gravity waves largely contribute to the MLT momentum budget. In particular, a pair of positive and negative Eliassen-Palm flux divergence for the resolved gravity waves is observed in the summer MLT region. These features suggest that the resolved gravity waves are likely in-situ generated in the MLT region. In the summer MLT region, mean zonal winds have a strong vertical shear which is likely formed by parameterized gravity wave forcing. The Richardson number sometimes becomes less than a quarter suggesting that the resolved gravity waves are generated by shear instability (Fig. 1). In addition, shear instability occurs in the low (middle) latitudes of the summer (winter) MLT region associated with diurnal (semi-diurnal) migrating tides. The resolved gravity waves are also radiated by the shear instability there (Fig. 2). In our presentation last year, it was shown that Rossby waves in the summer MLT region are also radiated by barotropic and/or baroclinic instability formed by parameterized gravity wave forcing. These results strongly suggest that forcing by gravity waves originating from the lower atmosphere causes the mesospheric barotropic/baroclinic and shear instability which respectively generate Rossby and gravity waves, and that in-situ generation and dissipation of the Rossby waves and gravity waves play important roles in the momentum budget in the MLT region.

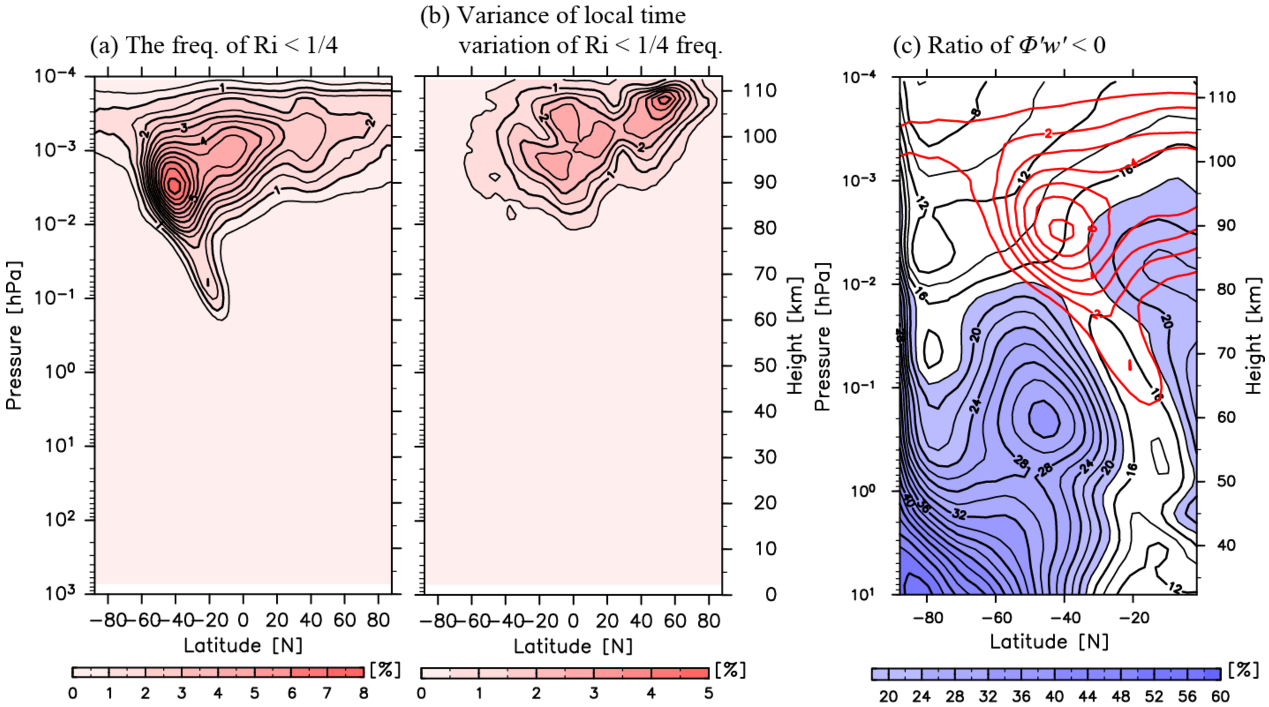
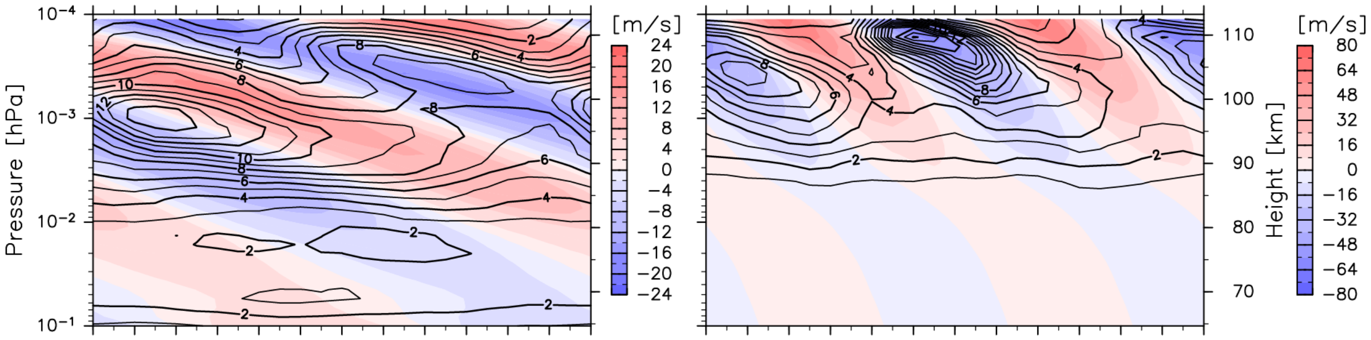


Figure 1. The latitude-height sections of (a) the occurrence frequency of Richardson number (Ri) smaller than 1/4 in January and (b) its local time variance. (c) The latitude-height section of the ratio of Φ'w' < 0 for resolved gravity waves, namely the ratio of gravity waves propagating energy downward in January in the Southern Hemisphere. Here, Φ' and w' denote geopotential and vertical wind anomaly from zonal mean values, respectively.

(a) Ri < 1/4 freq. and DW1 (U) at 20.9°S

(c) Ri < 1/4 freq. and SW2 (U) at 54.4°N



(b) Ri < 1/4 freq. and ratio of $\Phi'w' < 0$ at 20.9°S

(d) Ri < 1/4 freq. and ratio of $\Phi'w' < 0$ at 54.4°N

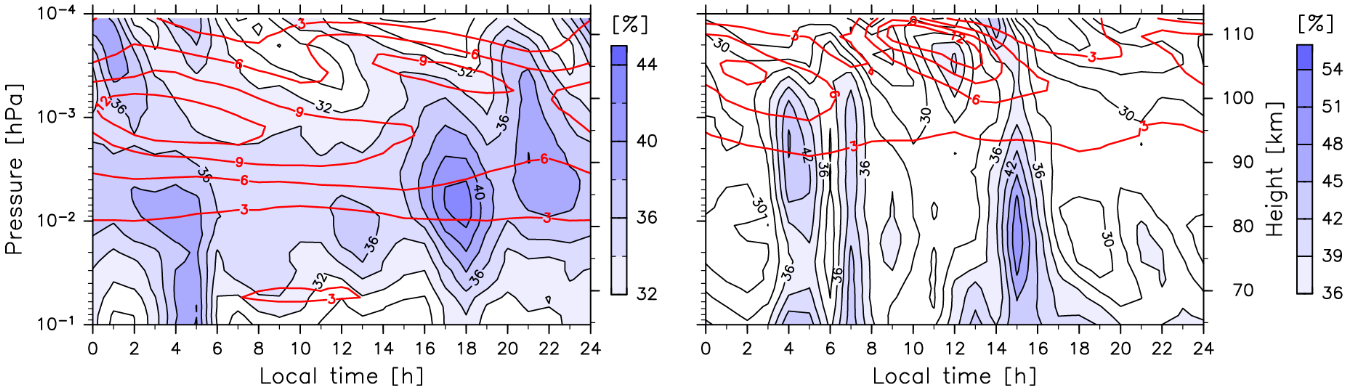


Figure 2. (a) The local time and height section of Ri < 1/4 freq. (contour) and the zonal wind component of DW1 (color) at 20.9°S in January. (b) The local time and height section of Ri < 1/4 freq. (red contour) and the ratio of $\Phi'w' < 0$ (color) at 20.9°S in January. (c) As in the case with Fig. 2a, but color represents the zonal wind component of SW2 at 54.4°N. (d) As in the case with Fig. 2b, but red contour represents Ri < 1/4 freq. at 54.4°N.