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SYOWA STATION MF RADAR EXPERIMENT FOR STUDYING THE ANTARCTIC UPPER MIDDLE ATMOSPHERE: A PROPOSAL (EXTENDED ABSTRACT)

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With the advent of sophisticated radio and optical techniques for sounding the atmosphere, we have gradually unraveled dynamical and chemical processes that take place in the mesosphere and the lower thermosphere. Now it is known that long- and short-period gravity waves propagating from the lower atmosphere play an important role in the dynamics and energy budget of the middle atmosphere. For example, TSUDA *et al.* (1994) have summarized the characteristics of gravity waves in the middle atmosphere, revealed by accumulating recent observations with the MU radar at Shigaraki (35°N, 136°E), medium-frequency (MF) radars at Adelaide (35°S, 138°E) and Saskatoon (52°N, 107°W), a lidar at Haute Provence (44°N, 6°E), and rocketsondes at Uchinoura (31°N, 131°E). Among other results they have found that the gravity wave energy in the mesosphere with periods less than about 2 hours was larger in summer than in winter at all the stations and that energy values were generally larger at Shigaraki than at Saskatoon. This finding suggests that we need more observing stations at other latitudes, in particular at higher latitudes and in the equatorial region, to clarify the global gravity wave characteristics. At high latitudes, in addition to gravity waves, an energy input from the magnetosphere during substorm conditions may affect the middle atmosphere (*e.g.*, MANSON and MEEK, 1991), thus causing various phenomena that are more complex than those in the middle atmosphere at other latitudes.

In the past, winds and gravity waves in the altitude range between 80 and 100 km over Syowa Station, Antarctica (69.0°S, 39.6°E) were observed for short periods with a 50 MHz meteor radar and a 589.0 nm sodium lidar (OGAWA *et al.*, 1985, 1989; NOMURA *et al.*, 1987, 1988). These observations found some interesting features associated with auroral activity. However, because of scarce data-bases constructed from a limited number of observations, it was impossible to examine mean winds, waves such as atmospheric tides and planetary waves, and the climatology of gravity waves. Such studies are highly necessary for understanding global circulation, energy budget in the atmosphere, and thermosphere-middle atmosphere coupling, although they require a large amount of data obtained through continuous long-term observations.

Our current understanding of the middle atmosphere over Syowa Station is still very poor, mainly because of lack of equipment suitable for continuous wind observations. To overcome this, we propose an MF radar experiment for exploring the atmosphere between 60 and 100 km. With this radar, capable of providing a long-term data-base, we can measure both winds and electron density in the ionospheric *D* region. The *D* region electron density profile is controlled by dynamical and chemical processes in the mesosphere and also by auroral activity.

There are three candidates (meteor radar, MST radar, and MF radar) as radars for observing winds continuously in the upper middle atmosphere over Syowa Station. A meteor radar can detect long-period winds and tides at altitudes between 80 and 105 km and has high reliability for continuous long-term observations. Because of its wide antenna beam, wind data averaged over a large area (mainly in the horizontal plane) are obtained. The data quality is affected by the large diurnal variation of meteor echo occurrences and by unexpected echoes that are scattered by *E* region electron density irregularities (OGAWA *et al.*, 1989). An MST radar has time ($\leq$10 min) and spatial (typically, $\simeq$2 km in height and $\simeq$3 km in the horizontal plane) resolutions much better than a meteor radar (BALSLEY *et al.*, 1980), thereby making it possible to observe even short-period gravity waves and turbulence at altitudes of 70–100 km. This radar, however, cannot detect mesospheric echoes at night and is more expensive than the other two radars. Finally, an MF radar using a frequency between 2 and 3 MHz has time resolutions of 2–5 min and height resolutions of 3–4 km (and typically, $\simeq$50 km in the horizontal plane), and can detect echoes between 60 and 100 km during the day and between 80 and 100 km at night (*e.g.*, MANSON and MEEK, 1993; VINCENT, 1994). This radar also has high reliability for continuous long-term observations of long- and short-period waves and electron density profile although we need a large area (200 m $\times$ 200 m) to set it up. The 20 existing and planned MF radars are widely distributed from high latitudes to the equator.

The objective of the Syowa Station MF radar experiment is to study:

1) Dynamics of the Antarctic middle atmosphere (mean winds, tidal oscillations, planetary waves, and gravity waves).

2) *D* region electron density.

3) Thermosphere-mesosphere coupling.

4) Comparison of the Antarctic middle atmosphere with the Arctic middle atmosphere.

5) Air circulation, tidal modes, planetary wave modes, and climatology of gravity waves on a global scale by participating in the worldwide atmospheric radar network.

In Antarctica, two MF radars have been operated at Mawson Station (67°S, 63°E) (VINCENT, 1994) and Scott Base (78°S, 167°E) (FRASER, 1989), and five MF radars are being planned at Syowa Station, McMurdo Station (78°S, 167°E), Palmer Station (65°S, 64°W), Amundsen-Scott South Pole Station (90°S), and Davis Station (69°E, 78°E): the Mawson MF radar has been moved to Davis Station. Coordinated observations with these radars and our radar are highly important for understanding the Antarctic middle atmosphere dynamics.

The polar middle atmosphere may largely be disturbed during substorm conditions. To know how this atmosphere behaves under such conditions, in addition to the MF radar, we need other radio and optical remote sensors at Syowa Station capable of measuring the physical parameters in the thermosphere and the mesosphere.

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