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Long-term thermospheric neutral wind observations over the northern polar cap

Q. Wu [a,*], D. McEwen [b], W. Guo [b], R.J. Niciejewski [c], R.G. Roble [a], Y.-I. Won [d]

[a] High Altitude Observatory, National Center for Atmospheric Research, P. O. Box 3000, Boulder, CO 80307-3000, USA
[b] Department of Physics and Engineering Physics, University of Saskatchewan, 116 Science Place, Saskatoon, Saskatchewan, Canada S7N 5E2
[c] Space Physics Research Laboratory, The University of Michigan, 2455 Hayward Street, Ann Arbor, MI 48109-2143, USA
[d] RSIS, Goddard Earth Science DISC, NASA Goddard Space Flight Center, Mailstop 610.2, Greenbelt, MD 20771, USA

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ABSTRACT

We study the solar dependence of the thermospheric dynamics based on more than 20 years Fabry–Perot interferometer O 6300 Å emission observation of polar cap thermospheric wind from three stations: Thule (76.53°N, 68.73°W, MLAT 86N), Eureka (80.06°N, 86.4°W, MLAT 89N), and Resolute (74.72°N, 94.98°W, MLAT 84N) in combination with the National Center for Atmospheric Research Thermosphere Ionosphere Electrodynamics General Circulation Model (NCAR-TIEGCM). All three stations showed a dominant diurnal oscillation in both the meridional and zonal components, which is a manifestation of anti-sunward thermospheric wind in the polar cap. The three-station observations and the TIEGCM simulation exhibit varying degree of correlations between the anti-sunward thermospheric wind and solar F10.7 index. The diurnal oscillation is stronger at Eureka (~150 m/s) than that at Resolute (~100 m/s) according to both observations and TIEGCM simulation. The semidiurnal oscillation is stronger at Resolute (~20 m/s) than that at Eureka based (~10 m/s) on data and model results. These results are consistent with a two-cell convection pattern in the polar cap thermospheric winds. The Thule results are less consistent between the model and observations. The simulated meridional wind diurnal and semidiurnal oscillations are stronger than those observed.

1. Introduction

The high-latitude thermospheric winds are affected by day–night pressure gradient, ion drag, and the Coriolis force. The day–night pressure gradient is related to the thermosphere day–night temperature difference, which is directly connected with solar activity. Ion convection is closely controlled by the cross-polar cap potential, which is affected by the magnetosphere–ionosphere coupling. Hence, the polar cap thermospheric winds tend to manifest both solar and geomagnetic activities. There have been numerous high-latitude thermospheric wind studies in the past (e.g. Killeen et al., 1995; Meriwether et al., 1988; McCormac and Smith, 1984).

What was lacking is a decadal scale long-term study of the solar dependence study at very high latitudes. Some past studies have examined solar dependence with shorter data sets. Won (1994) and Killeen et al. (1995) examined Thule, Greenland Fabry–Perot interferometer (FPI) O(*D*) 6300 Å nightglow neutral wind data from 1985 to 1989 to study the solar and geomagnetic dependence of the thermospheric neutral winds and temperature. They reported a strong correlation between the F10.7 index and thermospheric neutral winds. Even though the length of

* Corresponding author.
E-mail address: qwu@ucar.edu (Q. Wu).

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the data (4 years) is shorter than a solar cycle, the underlying fact is that a long-term data set is hard to obtain given the harsh condition in the polar region and the effort required operating an instrument on a long-term basis.

At somewhat lower latitudes, Aruliah et al. (1991, 1996) have analyzed the FPI thermospheric wind data from Kiruna, Sweden (67.8°N, 20.4°E, MLAT 65N) for solar and seasonal and geomagnetic dependences. Probably because the latitude is lower, the changes associated with the solar F10.7 index are much smaller than these observed at Thule by Killeen et al. (1995). At the vicinity of the Kiruna, Sweden, the EISCAT incoherent scatter radar (70°N, 19°E) has been operated over a long time. From the EISCAT radar measurement, one can deduce the thermospheric meridional winds. Using data from January 1984 to March 1995, Witasse et al. (1998) analyzed the solar and season dependence of the meridional winds. They extracted the diurnal and semidiurnal oscillations from the thermospheric winds and noted that the amplitude of the 24-h oscillation in the winter season increased with the solar F10.7 index.

There are reports on thermospheric wind observations at the South Pole, Antarctica, which is on edge of the polar cap (MLAT 75S) (Hernandez et al., 1990; Hernandez et al., 1991; Smith et al. 1994). Hernandez and Roble (2003) reported storm time observations over both South Pole and Arrival Heights (77.8°S, 166.66°E, MLAT 80S). Arrival Heights is a polar cap observatory. Comparisons between observations at Arrival Heights and the Thermosphere Ionosphere Mesosphere Electrodynamics General Circulation Model (NCAR-TIMEGCM) model run show mostly consistent anti-sunward wind patterns. There is no analysis of long-term trends in the Arrival Heights data yet.

Other Antarctic thermospheric wind observations were made on the edge of the polar cap or lower latitudes. For example, Conde and Dyson (1995) and Greet et al. (1999) reported thermospheric wind measurements from Mawson (67.6°S, 62.9°E, MLAT 70S) and Davis (68.6°S, 78.0°E, MLAT 74.5S), Antarctica. Long-term analysis on these data sets has not been reported yet.

Emmert et al. (2006a, b) examined the high-latitude thermospheric winds during geomagnetically quiet conditions. They examined thermospheric winds at various latitudes. In the northern high latitudes, they also analyzed the Thule thermospheric wind data. An increase in the thermospheric wind due to the solar activity was clearly demonstrated from the Thule data at all local times.

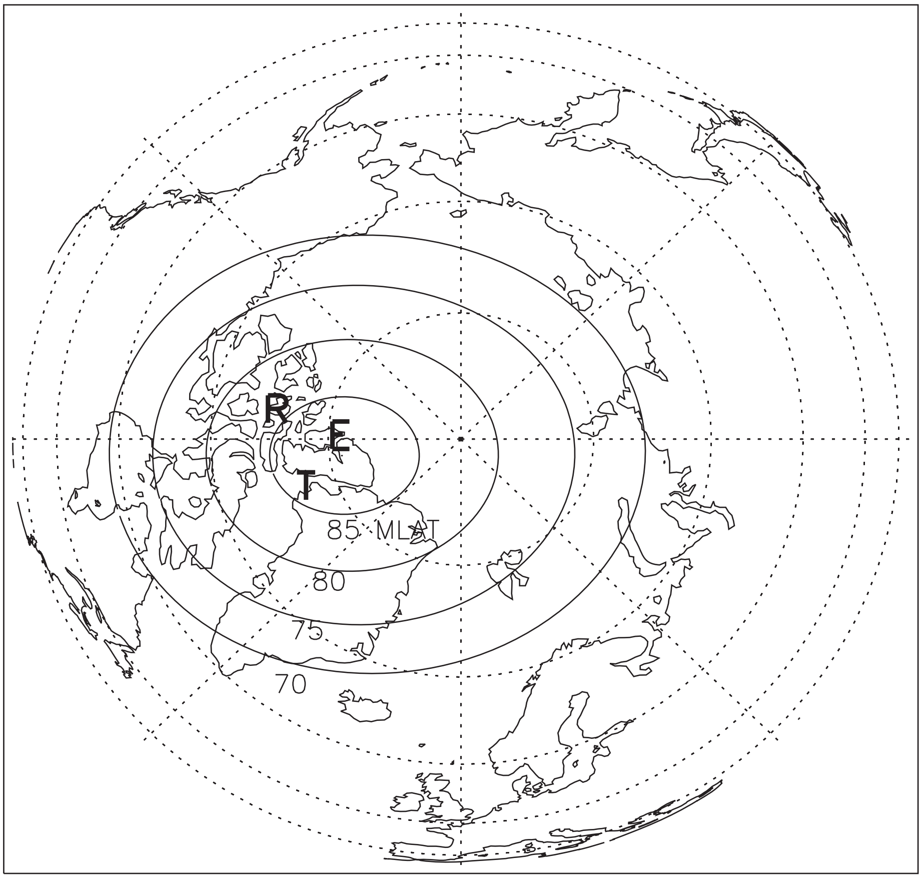

Fig. 1. Location of Thule, Eureka, and Resolute. The locations of the Thule (T), Eureka (E), and Resolute (R) are plotted. The magnetic latitudes from APL PACE program are also shown in the plot.