1. Abstract

We analyzed the climatological behavior of horizontal winds, vertical winds, and temperatures above Alaska using line-of-sight Doppler shifts of 630nm optical airglow emission, which originates from atomic oxygen in Earth’s thermosphere at around 240 km altitude. Spectra of this emission were recorded over a wide geographic region above Poker Flat, Alaska (65.12N, 147.47W) using a ground based all-sky wavelength scanning Doppler Fabry-Perot interferometer (SDI). This wide field was divided (in software) into multiple zones (115 used here), allowing independent spectra to be sampled from many directions simultaneously. As a result, it is capable of recording the wind field’s time history over a wide geographic region with high spatial resolution. Although such climatological studies have been performed previously using satellites, models, and narrow field Fabry-Perot interferometers, there are no published climatological studies of thermospheric winds and temperatures using either SDI data or any other technique with comparable geographic coverage and resolution. Wind summary analysis plots were produced to depict the climatology of the horizontal winds and temperatures for different geomagnetic conditions and orientation of interplanetary magnetic field (IMF). Results show that horizontal winds and temperatures had a strong dependence on geospace activity; and a small but detectable dependence on orientation of IMF. The latitudinal shears in horizontal winds were stronger when geospace conditions were active compared to the latitudinal shears for quiet geospace conditions. Also, shears appeared earlier over Poker Flat when geospace conditions were active. The vertical winds showed no dependence on the geospace activity and orientation of IMF.

2. Data and Analysis

We used observations of the 630nm red line optical emission from atomic oxygen with an all-sky SDI located at Poker Flat in Alaska (local time = UT – 9, magnetic local time = UT + 11.8). The line-of-sight wind measurement is obtained from the Doppler shifts of emission peak wavelengths measured simultaneously for the 115 independent look directions (zones), from which a two dimensional horizontal wind vector was derived by applying a “monostatic” wind fit. Temperature fields were calculated using the spectral line width. Vertical wind was measured directly from the LOS wind at the station zenith (central zone). We used 2012 data for the horizontal wind and temperature analysis. We produced wind dial plots to show the climatology of the horizontal wind and temperature fields under various geospace and IMF conditions. Each wind dial plot summarizes the average wind patterns and temperatures as a function of latitude and local time, at an altitude of 240 km as derived from 2012 Poker Flat SDI data. They show an overview of the evolution of the horizontal wind and temperature fields with time above the observing station (as seen by a space based observer located some distance above the geomagnetic north pole). In these summary wind dial plots, the Sun is always at the top of the figure and the observatory moves anticlockwise around geomagnetic north pole in a circular arc. As the SDI observations have latitudinal extent, they trace out an annular ring around the geomagnetic north pole. For the vertical wind analysis, we used 2011 and 2012 data from Poker Flat. The magnitude of vertical wind was taken into consideration.

3. Quiet Geomagnetic Conditions

4. Active Geomagnetic Conditions

5. Vertical Wind

6. Summary

- Upper atmospheric horizontal winds and temperatures showed strong dependence on geomagnetic activity and orientation of IMF.
- Winds as well as shears were stronger when geomagnetic conditions were active.
- Shears appeared earlier above Alaska when geomagnetic conditions were active.
- Shears moved to lower latitudes under geomagnetic active conditions.
- Under quiet geomagnetic conditions, shears were stronger for positive By and negative Bz.
- Under active geomagnetic conditions, shears were stronger when By was positive.
- Thermospheric temperatures were higher when geomagnetic conditions were active than quiet geomagnetic conditions.
- Thermospheric temperature was higher in pre-magnetic midnight than post-magnetic midnight for both active and quiet geomagnetic conditions.
- The behavior of the magnitude of vertical wind was similar under both geomagnetic conditions and orientations of IMF.