Geophysical Research Abstracts
Vol. 20, EGU2018-8539, 2018
EGU General Assembly 2018

Vertical wind response to increased geomagnetic activity derived from GOCE linear and angular accelerations

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Over the years, the linear accelerations measured by gravity missions have become an important source for thermospheric neutral density and horizontal wind data. By reducing the measured acceleration by models of thrust and radiation pressure, the aerodynamic acceleration remains, which is iteratively solved for the wind and density. A similar approach has now been taken to derive thermospheric wind from GOCE's angular accelerations. In this case supplementary models were required for the magnetic torque (including attitude control) and gravity gradient torque. Because not all magnetic properties of GOCE were available to us, daily estimates were made of several magnetic dipoles on the satellite.

On top of that a new iterative algorithm was developed that solves the residual force or torque for the neutral density and horizontal and vertical crosswind. The algorithm allows the use of any set of forces and torques. Horizontal winds derived from torques are found to agree up to a large extent with those derived from forces. Both the vertical force and the pitch torque reveal vertical wind signals near the poles. By combining wind data derived from forces with that derived from torques, a reliable vertical wind data set can be established.

It is clear from the combined product that the vertical wind responds to increased geomagnetic activity. During geomagnetic storms, peak speeds are observed of up to 150 m/s upward and 100 m/s downward, a factor 5 smaller than the observed horizontal winds. Vertical wind structures are also spatially smaller than their horizontal counterparts, and therefore seem to have a more erratic nature. A correlation is occasionally found between horizontal and vertical wind peaks which is mostly lost when activity increases to high levels. Overall the newly derived data confirms the view that vertical wind structures are usually more local and short-lived than horizontal ones and might be a good indicator of small-scale wave activity.