Relationship between seasonal variations in neutral winds and induced Sq currents

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Observed relatively periodic (ca. 1day cycle) geomagnetic variation (geomagnetic solar quiet daily variation, Sq) resulting from ionospheric dynamo current, called Sq current, originates in the interaction between the earth's main magnetic field and neutral winds associated with tides in the lower thermosphere, where the atmosphere is weakly ionized. It has long been known that Sq shows fluctuations in various timescales and considered that these fluctuations could owe not a little to neutral wind variations in the lower thermosphere.

To investigate the relationship between variations in neutral winds and induced Sq currents, we carried out numerical Sq current simulations using neutral winds in the lower thermosphere obtained from fine resolution version of Kyushu-GCM which is a general circulation model of the middle atmosphere covering the region from the ground through the lower thermosphere (ca. 150km). In this model, the solar radiation processes having a diurnal cycle are taken into account. Horizontal winds fluctuations are then generated by such heating processes for their amplitudes to reach of the order of 10[m/s] in the lower thermosphere. They are composed of not only in situ diurnal tides but also propagating diurnal and semi-diurnal tides, and other non-migrating tidal components, having seasonal, day-to-day, and time-to-time variations. Sq currents induced by such winds were simulated as height-integrated currents on a two-dimensional thin shell model taking asymmetric winds in dynamo action into account, with electric conductivity calculated using IRI95. In this study, we focus on the results of simulations using 1-month averaged parameters for every month over a year and discuss seasonal variations of simulated Sq currents associated with neutral wind variations.

The simulated Sq currents show several well-known Sq features: currents vortices are counterclockwise in the Nothern Hemisphere and clockwise in the Southern Hemisphere of which centers locate around 30 degrees north(south) and 12LT, the current intensity in the summer hemisphere is about twice as strong as that in the winter hemisphere and under the equinox condition the current intensities in both hemispheres are almost the same.

Semiannual variation in sum of the current intensites of both hemispheres is also revealed. This feature is reported in some papers dealing with observed Sq data.

As for the locations of the current vortex centers, no clear seasonal variation is found but vortex in the Northern Hemisphere calculated under August condition is shifted by about 2h in the afternoon side. This shift may be caused by non-migrating tides having relatively large amplitudes in August. For other months, we can also see the tendensy that the local time of the current vortex centers shift in the morning or afternoon side when non-migrating tides have not weak amplitudes. Such results suggest that Sq current should be sensitive to neutral wind condition and then we must treat it more strictly in researching the details of Sq currents.