Remote sensing the dynamics of the ionosphere-plasmasphere system by ground-based ULF wave observations

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1. Summary

Cross-spectral analysis of ULF wave measurements recorded at ground magnetometer stations closely spaced in latitude allows accurate determinations of magnetospheric field line resonance (FLR) frequencies. This is a useful tool for remote sensing temporal and spatial variations of the magnetospheric plasma mass density. The spatial configuration of the South European GeoMagnetic Array (SEGMA, 1.56 < L < 1.89) offers the possibility to perform such studies at low latitudes allowing to monitor the dynamical coupling between the ionosphere and the inner plasmasphere.

As an example of this capability we present the results of a cross-correlation analysis between FLR frequencies (recorded at SEGMA during 2001-2004) and solar EUV irradiance (as monitored by the 10.7-cm solar radio flux F10.7) which suggests that changes in the inner plasmaspheric density follow the short-term (27-day) variations of the solar irradiance with a time delay of 1-2 days. This delay likely comes from two contributions: (1) a retardation in the atomic oxygen concentration to follow solar radiation changes and (2) a retardation due to the ion/electron diffusion along the flux tube. Experimental results are also compared with those provided by a physical–numerical model of the ionosphere-plasmasphere system.

As an additional example we present the results of a comparative analysis of FLR measurements, ionospheric vertical soundings (Rome station) and vertical TEC measurements (from GPS ground stations of the European IGS network) during the development of the geomagnetic storm of 3-4 April 2004. The observations indicate a nearly 50% decrease in the ion concentration both in the ionosphere and the plasmasphere during the recovery phase of the storm. The enhanced ion loss rates in the ionosphere (which caused the density depletion at ionospheric level) likely led to a reduced upward ion flux from the ionosphere to the plasmasphere with respect to normal conditions and then caused the plasmaspheric depletion.

The present results show that low-latitude (L < 2) plasmaspheric flux tubes may be considered to be, in a diurnal average sense, in a diffusive equilibrium with the underlying ionosphere, i.e. variations in ionospheric density which take place on time scales larger than ~1 day are reflected in corresponding variations in the plasmasphere density. The solar activity control of the plasmaspheric density on a day-to-day basis has never been evidenced by whistler measurements. Therefore the present results demonstrate the usefulness of using the FLR technique for monitoring the dynamics of the plasmasphere.