Ionospheric ion response to the space weather event during 6-8 September 2017

A. Schillings[1,2], M. Yamauchi[1], H. Nilsson[1], T. Sergienko[1], C.-F. Enell[3], R. Slapak[3], P. Wintoft[1], M. Wik[1], M.G. Johnsen[4], I. Dandouras[5]

[1]Swedish Institute of Space Physics (IRF), Sweden, [2]Division of Space Technology, Luleå University of Technology, Kiruna, Sweden, [3]EISCAT Scientific Association Headquarter, Kiruna, Sweden, [4]Tromsø Geophysical Observatory (TGO), UiT the Arctic University of Norway, Tromsø, Norway, [5]Institut de Recherche en Astrophysique et Planétologie, CNRS and University of Toulouse, Toulouse, France

Recent studies of ionospheric ion escape show that the escaping ion flux from the polar region increases exponentially with Kp up to Kp=7, and even sharper for higher Kp, in contrast to only a factor of 2 difference between northward and southward IMF. The same non-linear (exponential) dependence is also expected for energy extraction from the solar wind to the ionosphere by the mass-loading effect of these escaping ions. This indicates that the energy input to the polar ionosphere during severe space weather events can be higher than what reconnection-based coupling function method predicts. Thus, atmospheric erosion is important even the space weather problem.

One immediate question is: which element of space weather events most significantly affects the ionospheric response among, e.g., enhanced UV, solar energetic particle (SEP) events, arrival of interplanetary coronal mass ejections (ICMEs), flux of trapped energetic particles in the inner magnetosphere (e.g., at geosynchronous orbit), strong interplanetary magnetic field (IMF), the main phase of major magnetic storm with enhanced ring current, severe substorms (AL < -2000 nT), and possible combinations of these elements. We here restrict our discussion to ion energization and subsequent outflow among many types of ionospheric responses. While past statistics showed clear correlation between the ion upflow and these potential factors, we need continuous monitoring to identify the most important external parameters that influences ionospheric ions and subsequent upflow.

The September 2017 event is an ideal event to study this problem because a series of X-flares occurring before two ICMEs separated by one day, where the first had northward IMF on arrival, and the second had southward IMF arrival, with only the second one causing a severe substorm with AL < -2000 nT and a geomagnetic storm. The season is also ideal because Cluster covers the cusp region (the main route of the ion escape) only near equinoxes (in this sense October-November events 2003 were not optimal). EISCAT Svalbard radar was located near local noon (cusp) when the X9.2 solar flare took place on 6 September, and near local midnight when two ICMEs accompanied by flux enhancements of energetic particle in the solar wind arrived on 7 September and 8 September.

We show observations by Cluster and EISCAT. Both Cluster and EISCAT results during this event strongly suggest that high flux of energetic particles in the solar wind or ICME arrival causes more directly influence the ionospheric heating and upflow than sudden increases of EUV flux by the X-flare or southward turning of the IMF direction.