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Stagnation of a polar cap patch and decay of the accompanying plasma irregularities

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We report an event in which a polar cap patch, as detected by an all-sky imager (ASI) at Resolute Bay, Canada, stopped its anti-sunward motion and wandered around within the field-of-view of the ASI for more than 1 h. During the wandering motion of the patch, a significant reduction of the cross-polar cap plasma convection was observed by the SuperDARN radars. 10-15 min before the stop of the patch, the IMF observed by the Geotail spacecraft showed a clear northward turning. Such a change in the IMF orientation could lead to the halt of the cross-polar cap convection and resultant stagnation of the patch.

When the patch stagnated, its luminosity decreased gradually, which allows us to investigate how the patch plasma decayed in a quantitative manner. The decay of the patch can be quantitatively explained by the loss through recombinations of O+ with ambient N2 and O2 molecules, if we assume the altitude of the optical patch to be around 295 km. The derived altitude of the patch around 295 km is much higher than the nominal value at 235 km obtained from the MSIS-E90/IRI2007 models. This is probably because the loss process was much faster in the lower-altitude part of the patch; thus, the peak altitude of the patch increased as it traveled across the polar cap due to rapid recombination at the bottomside of the F region.

During the interval of interest, one of the SuperDARN radars at Rankin Inlet, Canada observed a cluster of field-aligned irregularities (FAIs) in the region of enhanced 630.0 nm airglow associated with the patch. These patch-associated FAIs promptly decayed following the weakening of the optical patch, which was obviously due to a convolution effect of the decrease in the patch-associated density gradient and the reduction in the background convection caused by the northward turning of the IMF. However, the decay of the FAIs was much quicker than that of the optical patch. This suggests that the abrupt reduction of the convection probably played a more important role than the gradual decrease of the patch-associated density gradient in causing the prompt decay of the patch-associated FAIs. This indicates that the strength of the background electric field is very crucial in maintaining small-scale density structures in the polar cap.

Keywords: Polar Cap Patches, Polar Cap Ionosphere, Plasma Convection