Localized magnetosphere-ionosphere coupling system along open magnetic field lines in association with airglow patches

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Although airglow patches are traditionally regarded as high-density ionospheric plasma following large-scale convection, we find that they are often associated with a localized magnetosphere-ionosphere coupling system embedded within the large-scale background. Using imager-RISR-N conjunctions, we observe that the optical 630.0-nm patches well correspond to enhanced plasma density that is about twice of the background density in the F-region ionosphere. Instead of propagating in a uniform convection, the patches are collocated with and transported by localized fast anti-sunward flows. The flows are a-few-hundred-km wide channels which effectively transfer plasma in the anti-sunward direction. They originate from the dayside cusp, transport patches across the polar cap, and are precursors of disturbances in the nightside auroral oval. These flows are driven by processes in the magnetotail lobes because using Swarm-RISR-N conjunctions, we identify localized Region-1 sense field-aligned currents (FAC) of 0.1-0.2 $\mu A/m^{-2}$ around the flows in comparison to the otherwise quiet background. The FACs are closed by Pedersen currents across the flows. The Pedersen currents are contributed by the convection electric field of the flows rather than the conductivity of the patch, since the latter is only ~10% higher than the background. Therefore the magnetosphere-ionosphere coupling along open magnetic field lines can be multi-scale, and patches can signify a localized system where the magnetosphere imposes FACs and enhanced dawn-dusk electric fields onto the patches.