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Plasma injections arising out of dynamic ionosphere

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We propose ionospheric plasma injections to the magnetosphere (ionospheric injection) as a new plasma process in the polar ionosphere. The ionospheric injection is first triggered by westward electric fields transmitted from the convection surge in the magnetosphere in association with dipolarization onset. Localized westward electric fields yield electrostatic potential in the ionosphere as a result of differing electron and ion mobility in the E-layer. To ensure quasi-neutrality of ionospheric plasmas, excess charges are released as injections out of the ionosphere, specifically electrons from positive potential region in higher latitudes and ions from negative potentials in lower latitudes. Potential difference on the order of 10 kV in north-south directions produces southward electric fields (100mv/m) at the footprint of the convection surge in both northern and southern hemispheres. Resultant geomagnetic field lines are not in equipotential equilibrium during ionospheric injections but instead develop downward electric fields in positive potential regions in higher latitudes to extract electrons and upward electric fields in negative potential regions in lower latitudes to extract ions. Parallel electric fields can exist in the magnetic mirror geometry of auroral field lines if the magnetospheric plasma follows quasi-neutral equilibrium. Because ionospheric injection has inherent dynamo processes as well as load, we term the polar ionosphere “dynamic ionosphere”.

Cold plasmas injected out of the dynamic ionosphere are transported along the dynamical trajectories to the magnetosphere conserving the total energy (including electrostatic potentials) and first adiabatic invariant. Electrons/ions traveling in downward/upward electric fields lose perpendicular and lower velocities in parallel component, leaving only the energetic part of ionospheric plasmas collimated along the field lines. Steady-state and one-dimensional dynamical trajectory shows that ion and electron temperatures at the ionosphere initially at 1 eV increased parallel temperatures to 202 eV and decreased perpendicular temperatures to 0.001 eV at geosynchronous altitudes where the electrostatic potential difference between ionosphere and magnetosphere was assumed to be 200 V. When potential difference increased to 600 V, the parallel temperatures increased to 602 eV, while perpendicular temperatures remain unchanged. Parallel potentials preferentially heated the ionospheric cold plasmas in parallel directions and transported tailward to feed the magnetosphere.