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Evaluation of the Diffusive Equilibrium Models by the IMAGE RPI

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Using measured field-aligned electron density profiles, this study investigates the validity of the diffusive equilibrium model in Earth's plasmasphere. This model which describes the electron and ion densities along a magnetic field line in the plasmasphere has been widely used for ray tracing and pitch-angle scattering calculations. It is based on the hydrostatic equilibrium with the electrostatic force that acts on ions and electrons along geomagnetic field lines while actually there is no motion or diffusion of the plasma involved. The model requires multiple input parameters: electron density and ion composition (H+, He+, O+) at a base level for a magnetic field line in the ionosphere, and the (electron or ion) temperature in the plasmasphere. It has been recognized that these input parameters have to be flexible from one field line to another so that the model output does not contradict some known observed relationships. However, while the flexibility provides the possibility to fit any individual observed density distribution which is measured across many different field lines, the model prediction becomes questionable along a single field line. Before the launch of the IMAGE satellite in 2000 no plasma density measurements along a single field line were available, and therefore the validity of the diffusive equilibrium models had not been independently verified. Our qualitative and quantitative analysis shows that the fundamental functional form of the diffusive equilibrium model is inconsistent with the large database of field-aligned electron density distributions obtained by the radio plasma imager (RPI) instrument onboard the IMAGE satellite. Review of the procedures used in the derivation of the original diffusive equilibrium model suggests that the physical processes described by the mathematical procedures are fundamentally incorrect.