Search for the solar wind parameters controlling the Poynting flux into the high-latitude ionosphere

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We used electric and magnetic field measurements of the Dynamics Explorer-2 satellite performed for one and half year period to find the spatial distribution of the Poynting vector $\mathbf{P} = [\mathbf{E}\times\mathbf{B}]/\mu_0$. DE2 measured only one horizontal electric field component directed along the satellite trajectory. Therefore, the Poynting flux was systematically underestimated. From model calculations we estimate the average error as ~15-50%. The global distribution was obtained by averaging the Poynting flux in spatial bins for various ranges of geomagnetic indices and solar wind parameters. The bin sizes are 2 degrees of latitude and 2 hours of local time. Under low activity, the flux is maximum in the cusp region. Under high activity, two maximums in the dawn and dusk auroral latitudes dominate. Small-scale (<100 km) structures appeared to yield significant (~75%) contribution to the Poynting flux. Integration over the whole ionosphere area yields the following empirical expressions relating the total field-aligned Poynting flux to geomagnetic indices: $Q = 0.212\ AE$, $Q = 26.9\ Kp - 15.1$, $Q = 34.3 - 1.04\ Dst$, where Q is expressed in GW. The underestimation of Q seems not to prevent to choose the best solar wind parameter controlling the Poynting flux flowing into the ionosphere. We considered several solar wind parameters. In particular, the Akasofu parameter ε appeared to correlate with the Poynting flux rather well. The corresponding relation has the form $Q = 45.7 + 0.00182\ \varepsilon$, where $\varepsilon = V B^2 \sin^4(\theta/2)$, solar wind velocity V is expressed in km/s, interplanetary magnetic field B in nT. However a better correlation was obtained with a linear combination of the duskward electric field $E_{yr} = -VB_s$ (B_s is the IMF southward component) and plasma energy flux pV where $p = m_p n V^2$ is the solar wind dynamic pressure, m_p and n are the proton mass and number density respectively. We obtained the following relationship: $Q = \omega \equiv 11.3+31.7\ E_{yr}+0.0163\ pV$, where E_{yr} is in mV/m, p is in nPa. The dependence $Q(\omega)$ in narrow ranges of ε appeared to be several times stronger than the dependence $Q(\varepsilon)$ in narrow ranges of ω.