Geophysical Research Abstracts
Vol. 15, EGU2013-2042-1, 2013
EGU General Assembly 2013

Response of the Fair Weather Atmospheric Electrical Current to Geomagnetic Storms

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The Global Electric Circuit (GEC) is a conceptual model that integrates the observed electrical properties of the atmosphere in the Earth-ionosphere cavity. An average potential difference of 250 kV exists between these two conducting layers, leading to a surface electric field (Ez, sometimes also named the Potential Gradient or PG) of $\sim$130 V/m, and a nearly constant downward flowing direct current density (Jz) of $\sim$2 pA m-2. This is known as the DC component of the GEC. The Jz is an extremely sensitive parameter whose magnitude and fluctuations can be used for monitoring local and global conductivity changes due to aerosols, air-pollution and solar activity. The AC part of the circuit is driven by $\sim$50 lightning flashes per second generating the global Schumann resonances (SR) in the ELF range. There are two time-scales for identifying solar effects on the GEC. On the longer scale, an 11-year modulation by solar activity, likely due to changes in ionization, was reported by several authors. For example, Satori et al. (2005) noted a decrease in the frequency of the first 3 modes of the SR band in conjunction with the solar minimum of 1995-6. On shorter time scales typical of solar activity (e.g. CMEs, solar flares and SEP events), observations show marked perturbations in Jz and in the ionospheric potential at the surface. Cobb (1967) observed an increase of Jz by 75% for $\sim$ 6 h in measurements made at Mauna Loa in Hawaii, during a period of multiple solar flares. Reiter (1989) observed an increase in Jz of about 50%-60% following large solar flares, persisting for 4 days (at the Zungspietze station in the Alps). Belova et al. (2001) reported increased Jz for about 2 hours before T=0 (time of minimum in Bx) as well as enhanced average fluctuations.
This talk will review the effects of solar storms on the GEC, and present new results from continuous measurements of Jz conducted at the Wise Observatory in Mitzpe-Ramon, Israel (30°35'N, 34°45'E). During 3 different CMEs, which included solar proton events (SPE) on 26/09/2011, 25/10/2011 and 08/03/2012, we found clear periods of increased fluctuations in Jz, which cannot be explained by local or meteorological conditions. An increase in the ULF 0.01Hz spectrum was observed at the same period of time. These low-latitude observations probably represent a response of the GEC to the SPE, perhaps due to a synergy of several mechanisms. We will review several possible explanations.