

Global electric circuit implications of combined aircraft storm electric current measurements and satellite-based diurnal lightning statistics.

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Using rotating vane electric field mills and Gerdien capacitors, we measured the electric field profile and conductivity during 850 overflights of thunderstorms and electrified shower clouds (ESCs) spanning regions including the Southeastern United States, the Western Atlantic Ocean, the Gulf of Mexico, Central America and adjacent oceans, Central Brazil, and the South Pacific. The overflights include storms over land and ocean, and with positive and negative fields above the storms. Over three-quarters (78%) of the land storms had detectable lightning, while less than half (43%) of the oceanic storms had lightning. Integrating our electric field and conductivity data, we determined total conduction currents and flash rates for each overpass. With knowledge of the storm location (land or ocean) and type (with or without lightning), we determine the mean currents by location and type. The mean current for ocean thunderstorms is 1.7 A while the mean current for land thunderstorms is 1.0 A. The mean current for ocean ESCs 0.41 A and the mean current for land ESCs is 0.13 A. We did not find any significant regional or latitudinal based patterns in our total conduction currents. By combining the aircraft derived storm currents and flash rates with diurnal flash rate statistics derived from the Lightning Imaging Sensor (LIS) and Optical Transient Detector (OTD) low Earth orbiting satellites, we reproduce the diurnal variation in the global electric circuit (i.e., the Carnegie curve) to within 4% for all but two short periods of time. The agreement with the Carnegie curve was obtained without any tuning or adjustment of the satellite or aircraft data. Given our data and assumptions, mean contributions to the global electric circuit are 1.1 kA (land) and 0.7 kA (ocean) from thunderstorms, and 0.22 kA (ocean) and 0.04 (land) from ESCs, resulting in a mean total conduction current estimate for the global electric circuit of 2.0 kA. Mean storm counts are 1100 for land thunderstorms, 530 for ocean ESCs, 390 for ocean thunderstorms, and 330 for land ESCs.