LIGHTNING-INDUCED ELECTRON PRECIPITATION DRIVEN BY GLOBAL THUNDERSTORM ACTIVITY

U. S. Inan[(1)], T. Wood[(2)], J. Bortnik[(3)], J. B. Blake[(4)], H. Christian[(5)], D. Boccippio[(6)]

[(1)]Space, Telecommunications and Radioscience Laboratory, Stanford University, STAR laboratory, Stanford University, Stanford, CA 94305-9515, USA; E-mail inan@nova.stanford.edu

[(2)]As (1) above, but E-mail twood@nova.stanford.edu

[(3)]As (1) above, but E-mail jbortnik@nova.stanford.edu

[(4)]The Aerospace Corporation, Space Sciences Department, Los Angeles, CA 90009, USA; E-mail JBernard.Blake@aero.org

[(5)] NASA Marshall Space Flight Center, Hunstville, AL, USA; E-mail hugh.christian@msfc.nasa.gov

[(6)]As (4) above, but E-mail Dennis.Boccippio@msfc.nasa.gov

ABSTRACT

The fact the intense whistler-mode waves injected into the magnetosphere by lightning precipitates trapped energetic electrons by scattering them in pitch angle has long been known and individual lightning-induced precipitation (LEP) events have been observed on both satellites and the ground. However, it has only recently been realized that low altitude satellites, that are not necessarily there at the time of the occurrence of the transient LEP event, can measure the sum total of electrons driven into the drift-loss-cone by the sum total of all lightning activity at longitudes to the west of the satellite up to that of the South Atlantic Magnetic anomaly. This ability to measure accumulated LEP activity presents an opportunity to quantify the relationship between global thunderstorm activity and the LEP process on a global scale.

SAMPEX OBSERVATIONS OF LIGHTNING-DRIVEN PRECIPITATION IN THE DRIFT LOSS CONE

SAMPEX observations of energetic electron flux enhancements in the drift-loss-cone suggest that lightning-generated whistler waves originating in thunderstorms world wide continually precipitate energetic (>500 keV) electrons from their trapped orbits over L-shells ranging from L=1.5 to up to L=3. Data from several SAMPEX electron detectors that, provideing integral counts of electrons with energies >150 keV,>500 keV, and >1 MeV are analyzed for daily passes over narrow a broad range of longitudes in the western Pacific region so that where the satellite is positioned to only observe electrons in the drift loss cone. In this way, day-to-day comparisons of drift-loss-cone fluxes can be made. Analysis of data from the Lightning Imaging Sensor (LIS) on the Tropical Rainfall Measurement Mission (TRMM) satellite is used to document the lightning position, rate and other characteristics (e.g., intensity and ultiplicity of flashes) in active thunderstorms located west of the satellites. Such thunderstorms, typically located in Southern Africa and/or in Australia, are found to continually inject lightning-generated whistler waves into the magnetosphere, which in turn precipitate energetic electrons that are observed in the drift-loss-cone energetic electron precipitation enhancements observed by SAMPEX. Simultaneous analysis of SAMPEX and TRMM/LIS indicates that enhancements of >500 keV electrons in the drift-loss-cone are nearly always observed and can be plausibly related to lightning activity in thunderstorms located to the west of the spacecraft. Furthermore, detailed analysis clearly reveals a causative association, with significantly larger enhancements being observed on days when the multiplicity and/or intensity of lightning flashes in African and Australian flashes are observed to be high. On days of exceptionally high lightning activity, drift-loss-cone enhancements are also observed in the higher energy (>1 MeV) consistent with more extensive whistler-induced scattering of energetic electrons. The energetic electrons precipitated by the lightning-generated whistlers originate from radial diffusion of electrons from higher L values than where they are scattered; therefore the intensity of this lightning-driven precipitation depends not only upon thunderstorm activity but also upon time-varying magnetospheric processes in the outer magnetosphere. Theoretical modeling of cases in which isolated thunderstorms drive most of the precipitation indicate that the L-dependence of the drift-loss-cone flux enhancements are remarkably consistent with that expected on the basis of cyclotron resonant pitch angle scattering by non-ducted and magnetospherically reflecting whistler waves.