Estimation of radiation doses received by aircraft passengers in a TGF photon beam

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Terrestrial gamma-ray flashes (TGFs) are bursts of high-energy photons originating from the Earth's atmosphere in association with thunderstorm activity [e.g., *Briggs et al.*, JGR, 118, 3805, 2013]. TGFs are associated with initial propagation stages of intracloud lightning, which represent the most frequent type of lightning discharges [e.g., *Cummer et al.*, GRL, 42, 7792, 2015, and references therein]. TGFs are known to be produced inside common thunderclouds [e.g., *Splitt et al.*, JGR, 115, A00E38, 2011] typically at altitudes ranging from 10 to 14 km [e.g., *Cummer et al.*, GRL, 41, 8586, 2014]. The global TGF occurrence rate is estimated to be 400,000 per year concerning TGFs detectable by Fermi-GBM (Gamma ray Burst Monitor) [*Briggs et al.*, 2013], but detailed analysis of satellite measurements [*Østgaard et al.*, JGR, 117, A03327, 2012] and theoretical studies [*Celestin et al.*, JGR, 120, 10712, 2015] suggest that it cannot be excluded that TGFs represent a part of a ubiquitous process taking place during the propagation of lightning discharges.

In this context, it is important to assess the risk induced by TGFs for airline passengers and crews on board aircraft approaching thunderstorms. *Dwyer et al.* [JGR, 115, D09206, 2010] have estimated that if an aircraft were to find itself in the source electron beam giving rise to a TGF, passengers and crews might receive effective radiation doses above the regulatory limit. Moreover, *Tavani et al.* [Nat. Hazards Earth Syst. Sci., 13, 1127, 2013] concluded that TGF-associated neutrons produced by photonuclear reactions would cause serious hazard on the aircraft electronic equipment. In this work, we will present a detailed simulation-based estimation of effective doses received by humans that would be irradiated by a typical TGF for various production altitudes and distances from the TGF source.