Thunderstorm high-energy radiation measured in-flight

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High-Energy Atmospheric Physics is a newly emerging branch of physics actively developing at the edge of particle physics, optics, electrodynamics and engineering. Although the thundercloud generation process involves electrostatic charging, a multitude of very dynamic lightning-related discharge processes have been identified recently in and above thunderclouds. They are Terrestrial Gamma-Ray Flashes (TGFs) and Electron Beams (TEBs), a number of Transient Luminous Events (TLEs), and Thundercloud Ground Enhancements (TGEs). The TGFs have immediately after discovery been recognized as the most energetic electromagnetic events in terrestrial atmosphere. Besides it, due to significant advance in optical and electrical registration techniques, lightning initiation, propagation and attachment mechanisms have been only recently understood in better detail.

At the same time the number of passengers carried by air transport rose by more than 1000% from 0.3 to 3.4 billion in 1970 - 2015. Aircraft themselves greatly progressed in using new materials and sophisticated electronic systems. However, the last public campaign dedicated to the study of lightning interaction with aircraft was ended in the 1980's. None of the above-mentioned phenomena was even known by then.

From 2011 till 2016 Airbus factory test aircraft performed intentional thundercloud-penetrating flights in the frame of natural icing test campaigns. The aircraft were equipped with a dedicated in-flight lightning damage assessment system (ILDAS, http://ildas.nlr.nl). The system's main objectives are to detect any lightning interaction with the aircraft, to localise entry and exit points and to assess the stroke intensity and waveform. From 2013 onwards, the system also carries two $LaBr_3$ scintillation detectors to measure X- and Gamma-Ray radiation synchronously with lightning current. In this work we show experimentally collected data inside the aircraft on various flights near and through thunderstorms. Microsecond-short gamma-ray bursts are detected in association with lightning recoil processes.

Particular new results came in January 2016, when an Airbus A340 factory test aircraft was performing intentional flights through thunderstorms over Northern Australia. While being at 12 km altitude the ILDAS system detected a 30-fold gamma-ray flux enhancement. It lasted for 20 seconds and was abruptly terminated by a lightning flash. The terminating flash hit the aircraft and its parameters were recorded with 10 ns sampling time including gamma radiation. Ground-based lightning detection network WWLLN detected 4 strikes in the nearby region, all in association with the same flash. The ILDAS system also recorded the time-resolved spectrum of the glow. Approximately 6 minutes later, the aircraft turned towards another thunderstorm region and a glow with less gamma-ray enhancement was detected.

In the presentation we will show the mapped event timeline including airplane, gamma-ray glow, WWLLN, and cloud data. We will discuss the glow's properties, i.e. intensity and differential spectrum, and its possible origin. This result will be compared to previous observations.