Causes and Consequences of Energetic Particle Beams in the Atmosphere

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The recent discovery of transient luminous events, terrestrial gamma ray flashes and energetic charged particle beams in the Earth's atmosphere warrants a quantification of their importance. The current state of scientific knowledge in this area is summarised to propose areas of future research. The review specifically reflects presentations delivered by the members of a novel Franco-British consortium during a meeting at the French Embassy in London held in November 2011.

1. Background

Society increasingly relies on sensitive automated technological systems. One of the grand challenges of our time is to ensure that technological systems operate securely, in particular for safety critical applications. The French Embassy in London brought together a Franco-British team of experts to discuss recently discovered transient luminous events (e.g. Pasko, 2010), terrestrial gamma ray flashes (e.g. Tavani et al., 2011) and energetic charged particle beams (e.g. Carlson et al., 2011) in the Earth's atmosphere and their impact on technology. The scientists reviewed and assessed the current state of scientific knowledge which ranged from laboratory plasma physics to plasmas in the natural environment and satellite design (Füllekrug et al., 2012). Based on this assessment, the expert panel identified a set of key science themes to push forward the boundaries of knowledge on energetic processes in the Earth's atmosphere.

2. Key Science Themes

The existence of energetic charged particle beams in the Earth's atmosphere clearly warrants a quantification of their importance. The basis for such an assessment is a broader understanding of the causes and consequences of energetic particle beams. For example, have energetic particle beams an impact on technological systems or are energetic particle beams in part caused by anthropogenic activity? It is currently not possible to answer these big science questions without speculation. But it is possible to clarify and reduce the current uncertainties in three key thematic science areas:

Theme 1: Ionization of plasmas and electrical discharge processes, i.e. the propagation of ionization fronts, small scale streamer discharges, electromagnetic radiation from electron beams, electrification of sporadic aerosol layers in the stratosphere, electrification of dust in the upper troposphere and the electrification of dusty extra-solar environments.

Theme 2: Observations of electrical discharge processes, i.e. optical observations of transient luminous events, optical observations of sprite induced transient luminous events in the F-region ionosphere, infrasound from transient luminous events, observation of lightning discharges with spiral array, observations of transient luminous events above thunderstorms from space and observations of radio signatures of lightning and transient luminous events in space.

Theme 3: Energetic particles and their impact on the Earth's atmosphere, i.e. SuperDARN and energetic charged particles, perturbations of ambient atmospheric chemistry, radio remote sensing of upward relativistic electron beams, energetic charged particle observations from space and lightning effects on the radiation belts.

3. References

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