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Infrared signature of transient luminous events in the middle atmosphere simulated for a limb line of sight observation

sebastien payan (2), Frederic Romand (1), and Croizé Laurence (1)

(2) LATMOS, UPMC Case 102, Paris cedex 05, France (sebastien.payan@upmc.fr), (1) ONERA, Chemin de la Hunière et des Joncherettes, F91123, Palaiseau

Transient Luminous Events (TLE) are electrical and optical events which occurs above thunderstorms. Their occurrence is closely linked with the lightning activity below thunderstorms. TLEs are observed from the base of the stratosphere to the thermosphere (15 – 110 km). They are a very brief phenomenon which lasts from 1 to 300 milliseconds. At a worldwide scale, some to some tenths of TLEs occurs each minute. The energy deposition, about some tenths of megajoules, is able to ionize, dissociate and excite the molecules of the atmosphere. Then, a phase of recombination and relaxation starts.

The interest of their study is multiple. In atmospheric chemistry we know that lightening are important sources of NO_x in the troposphere, which indirectly influence the concentrations of O_3 and OH. We wonder what could be the chemical effects of TLEs in the stratosphere and mesosphere. Experimentally, the HALESIS (High altitude Luminous Events Studied by Infrared Spectro-imagery) project aims to load a spectro-imager in a stratospheric balloon in order to measure atmospheric radiances in the moments following the electrical discharge of a TLE and then, to estimate the concentration of some components of interest (CO_2, NO, O_3, OH…) with spectrum inversions. In a Defense point of view, some airborne detection or guiding devices are equipped with infrared sensors, which may be disturbed by the TLEs infrared signal.

The objective is to provide a tool which will describe the TLE phenomenon from the electric discharge to the detection threw an infrared sensor.

To achieve this work we first compute the Non Local Thermodynamic Equilibrium population of a background atmosphere with the code SAMM2. The starting atmosphere comes from the Whole Atmosphere community Climate Model (WACCM). Then, we apply a TLE perturbation to a region of the background atmosphere. To do so we compute the plasma and atmospheric chemistry consecutive to the discharge of a TLE with the codes BOLSIG+ and ZDPlaskin using the kinetic model from F. J. Gordillo-Vazquez, 2008. Finally, we will propagate the resulting infrared signal from the disturbed area, threw the atmosphere, to an instrument placed in a limb line of sight. Starting with a Sprite case, we will then extend our work to other kinds of TLEs.

Our results will contribute to the understanding of the local chemical budget in the middle/high atmosphere, to the sizing of the spectro-imager of the HALESIS project and to the reduction of false alarm rates threw airborne infrared sensors.