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TITLE: RETURN STROKE CURRENT AND OPTICAL WAVE SPEED STUDY WITH TIME DOMAIN FRACTAL LIGHTNING MODELLING

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ABSTRACT BODY: Time domain fractal lightning modeling is capable of handling both the complex geometry of the lighting channel and the dynamic evolution of the charge and current distribution along the channel. Recent enhancement improves the model by including more accurate treatment of the thermodynamics of the lighting channel during the return stroke. Specifically, the model uses realistic high temperature air plasma properties and self-consistently solves Maxwell's equations coupled with equations of air plasma thermodynamics. Moreover, the model takes a two fluid view of the plasma in the core of the lightning channel and allows temperature separation between the electron gas and the gas formed by the other heavier particles. This is achieved by taking into account of the finite rate of kinetic energy transfer between the two gases.

With these features at hand, we present numerical simulations of the current and the optical wave propagations along the lightning channel during the return stroke. This study is of particular interest because a broad range of applications including lightning geolocation, aviation safety, and lightning-ionospheric coupling are based on the predicted electromagnetic pulse of the return stroke, which are derived with assumptions on the return stroke current wave speed.

A wide range of optical recordings of the return stroke is available, based on which the optical wave speed along the return stroke channel is consistently measured to be in the range of 1/3 – 2/3 of the speed of light. Direct measurement of the current wave speed is not available and it is commonly assumed to be the same as the optical wave speed. However, our model predicts a significantly higher current wave speed than the optical wave speed, as well as a finite time delay between the two waves. We also present comparisons between the observed and model predicted optical wave rise time, peak optical power decay rate with altitude, peak temperature and pressure, as well as the correlation between the ground current peak and the maximum optical power.

KEYWORDS: 3324 ATMOSPHERIC PROCESSES Lightning, 0654 ELECTROMAGNETICS Plasmas, 0639 ELECTROMAGNETICS Nonlinear electromagnetics, 0684 ELECTROMAGNETICS Transient and time domain.

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Additional Details

Previously Presented Material: About 50% of the work has been presented previously. In last AGU meetings, we presented a lightning model that uses a simple model to capture the channel thermodynamics during the return stroke. Recent enhancement has significantly improved the treatment of the thermodynamics.

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