Correlation between Optical and Current Signatures of Electrical Discharges with Special Attention to Remote Sensing of Lightning Flashes

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Abstract

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Temporal variability of the optical emissions of several selected spectral lines was studied together with the discharge current for four different laboratory discharges. The types of discharges studied differ by their peak currents, current rise times, wave shapes, gap lengths and electrode geometries etc. It is shown that for all four types of discharges, the optical emissions corresponding to the spectral lines 486, 500, 554, 510, 554, 559, 568, 594 and 799 nm are correlated to the current with a coefficient of correlation either exceeding or close to 0.9 during the rising portion. Four of these wavelengths, 500, 510, 517 and 568 nm were analysed further with two types of laboratory discharges to study the correlation of the peak value of the discharge current signal to that of monochromatic optical signal. A weak correlation was evident between the current and optical peaks, indicating the possibility of remote sensing the discharge channel peak current and its rise times using these wavelengths to a good accuracy. A verification with ten triggered lightning return strokes indicate the current / optical-intensity relationship holds till current reaches its peak for the four spectral lines investigated. After reaching the peak, these spectral lines decayed at a faster rate than the current. The rate of decay was dependent on the emission, with some spectral lines having a faster decay than the others. This indicates that the processes that are responsible for generating some spectral lines are only associated with the initial growth mechanisms of the channel. The peak optical intensities of these spectral lines did not show any significant correlation to the peak return stroke current probably due to varying atmospheric conditions at the time of the return strokes. Two other spectral lines (656 nm and 778 nm) indicated a poor correlation to the current in the case of laboratory discharges, reaching their peaks at a later time than the current. It is suggested that the longer decay times of the broadband optical signals observed in other studies could be due to this type of spectral emissions that is embedded in the broadband signal. It was not possible to predict the variation of the discharge current beyond the current peak, using the spectral emissions considered.