



## ISUAL multi-band photometric measurement of TLEs in limb view observation from space

Cheng-Ling Kuo<sup>(1)</sup>, Yen-Jung Wu<sup>(2)</sup>, Jung-Kuang Chou<sup>(2)</sup>, Shu-Chun Chang<sup>(2)</sup>,  
Alfred Bing-Chih Chen<sup>(3)</sup>, Han-Tzong Su<sup>(2)</sup>, and Rue-Ron Hsu<sup>(2)</sup>

(1) Institute of Space Science, National Central University, Taoyuan, Taiwan

(2) Department of Physics, National Cheng Kung University, Tainan, Taiwan

(3) Institute of Space, Astrophysical and Plasma Sciences, National Cheng Kung University, Tainan, Taiwan

### Abstract

The ISUAL (Imager of Sprites and Upper Atmospheric Lightning) is first satellite project for the global survey of transient luminous events (TLEs) as one of the mission objectives. For the 2004-2015 data, >40,000 of TLEs, including elves, sprites, sprite-halos, blue jets and gigantic jets, have been recorded from this space platform. The ISUAL payload contains three sensor packages: a filter-wheel equipped intensifier CCD imager, a six-channel spectrophotometer (SP) and a dual-band array photometer (AP). For the TLE events reported in this paper, the imager data were recorded through the 623-750 nm N<sub>2</sub>1P filter and with an image frame integration time of 29 ms. The ISUAL SP consists of six bandpass-filtered PMTs that cover the major emission bands of nitrogen. The bandpass selections are SP1 (150-290 nm; FUV; N<sub>2</sub> LBH band), SP2 (centered at 337 nm with a bandwidth 5.6 nm; for N<sub>2</sub>2P (0-0)), SP3 (centered at 391.4 nm with a bandwidth 4.2 nm; for N<sub>2</sub><sup>+</sup>1N (0-0)), SP4 (608.9-753.4 nm; for N<sub>2</sub>1P band), SP5 (centered at 777.4 nm; for lightning OI emission) and SP6 (228.2-410.2 nm; for N<sub>2</sub>2P band). The SP passing bands and their relation to the molecular nitrogen emission bands are shown in figure1. The ISUAL AP includes a blue (370-450 nm) and a red (530-650 nm) arrays; each has 16 vertically stacked PMTs that provide temporal and spatial variations of emissions along the vertical direction. The past efforts on ISUAL recorded TLEs include the estimated electric field and energy in sprite streamers and diffuse regions in carrot sprites, luminosity of sprites and charge moment charge of their parent lightning, D-region ionization due to elves and morphologies and photometric emission of elves (especially for FUV emissions), characteristic studies of negative/positive gigantic jets, the global distribution and the occurrence rates of TLEs, and the TLE energy deposition to the upper atmosphere. Besides, we review our calculations for major band emissions (including N<sub>2</sub> 1P, 2P and N<sub>2</sub><sup>+</sup> 1N emissions) of TLEs. The calibrations include the percentage of emission band into the N<sub>2</sub>1P-filtered imager and SP/AP multi-band photometer, and the atmospheric transmittance between TLEs and ISUAL. Due to the above relevant factors and others (e.g., the variability of spacecraft height), we present the error analyses for the ISUAL recorded TLE emission and estimate the major band emissions of TLEs.