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Outstanding Student & PhD candidate Presentation contest

Height Determination of a Blue Discharge Observed by ASIM/MMIA on the International Space Station

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Introduction

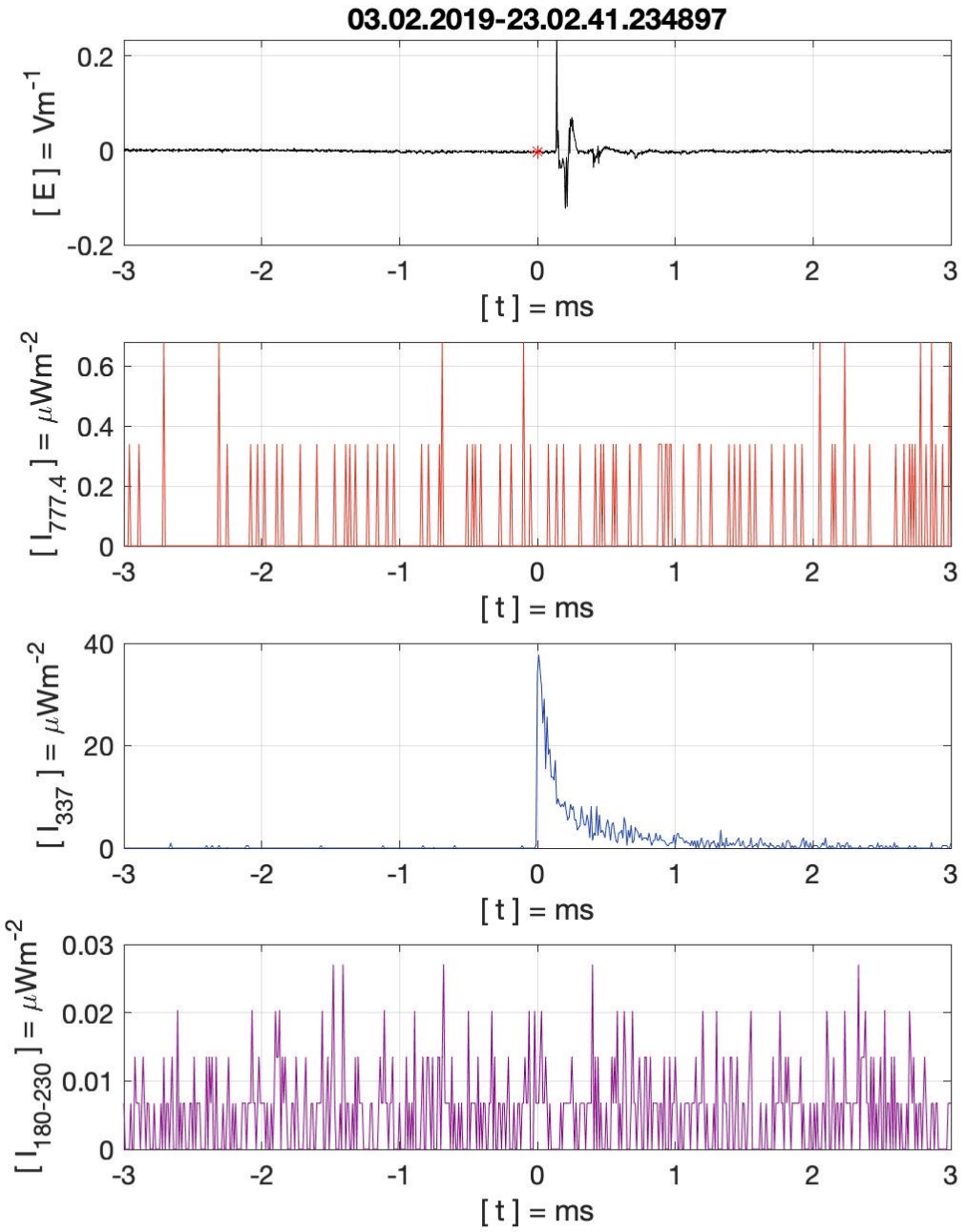
- Compare ASIM optical observations with ground based Low-Frequency (LF) measurements
- A thunderstorms system in South Africa during 23:00-23:05 UTC : 188 MMIA triggers + ~2000 lightning strokes
- One blue discharge at 23:02:41 UTC, on 3rd, February 2019 is studied in this work
- Objectives: determine the altitude of this kind of blue discharge to better understand how they can affect the upper troposphere

ASIM: Atmosphere-Space Interactions Monitor
MMIA: Modular Multispectral Imaging Array

Blue Discharge Event Measurements

- The blue discharge is caused by a narrow bipolar event (NBE)
- No red and UV PMT pulses are associated with it

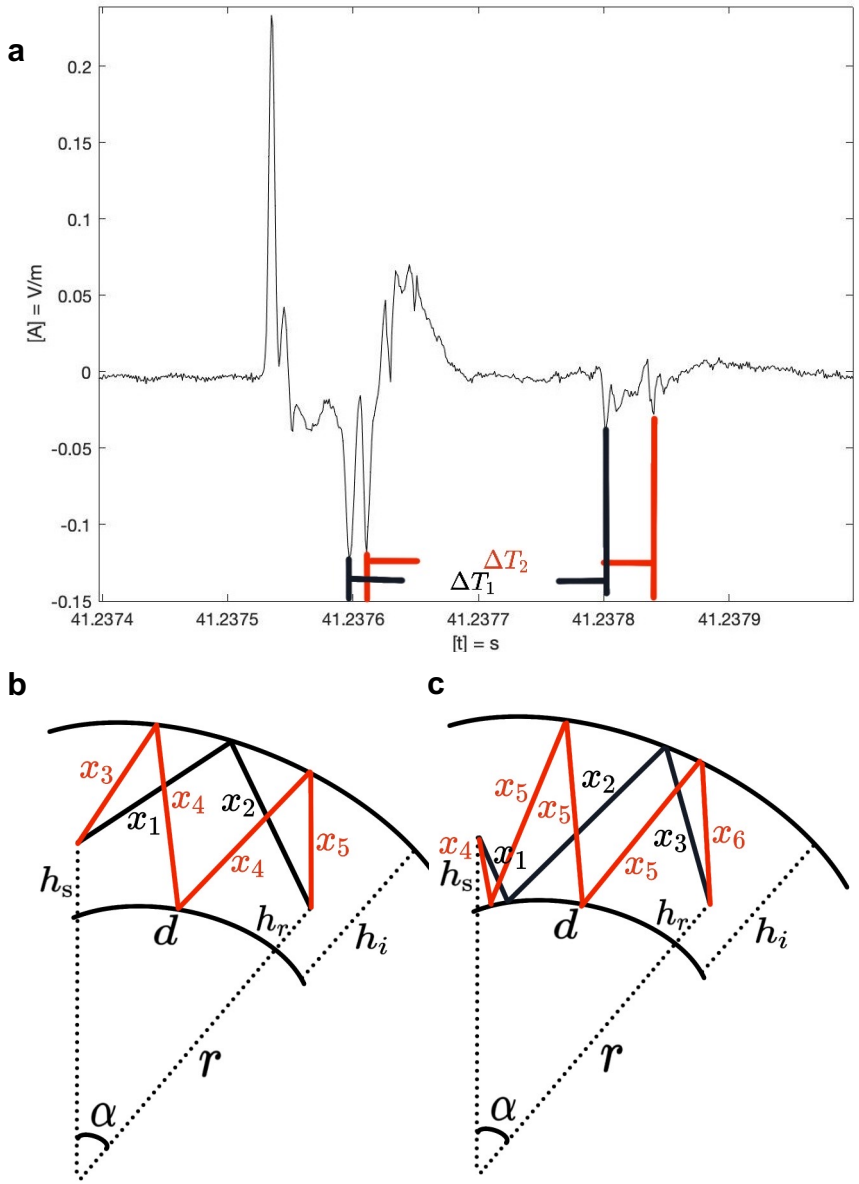
PMT: Photomultiplier tube



Electric field recordings and PMT recordings of the blue discharge

Ground Based Electric Field Measurements

- -NBE event distance: 768.78 km (-18.9 kA)
- Use skywave delay times to determine event height and ionospheric height



ΔT_1: Time delay of 1^{st} pulse of skywaves
ΔT_2: Time delay of 2^{nd} pulse of skywaves
h_s: Event source height (km)
h_i: Ionosphere height (km)
h_r: LF height (km)
d: Event distance (km)
α: Earth arc angle
r: Earth radius (km)

Fig a: Recorded –NBE event

Fig b: Ionosphere reflection model

Fig c :Ground reflection model

Black lines: 1^{st} skywave propagation path

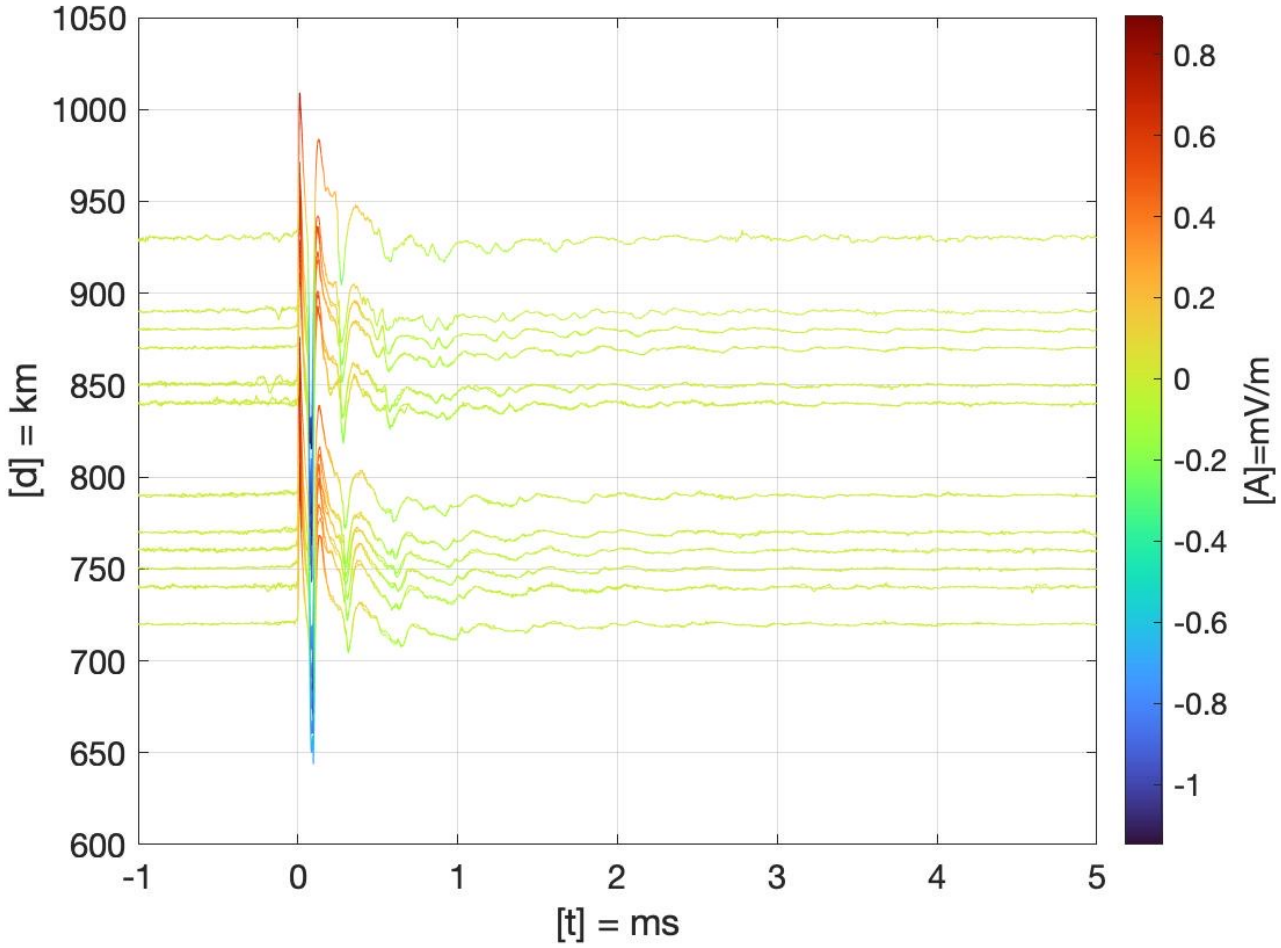
Red lines: 2^{nd} skywave propagation path

Height Results from LF

Height Results for Blue discharge:

- Ionosphere: 94.5-95.5 km
- **Blue discharge:16.0-18.8 km**

Ionospheric Height from amplitude waveform bank: 93.4 km

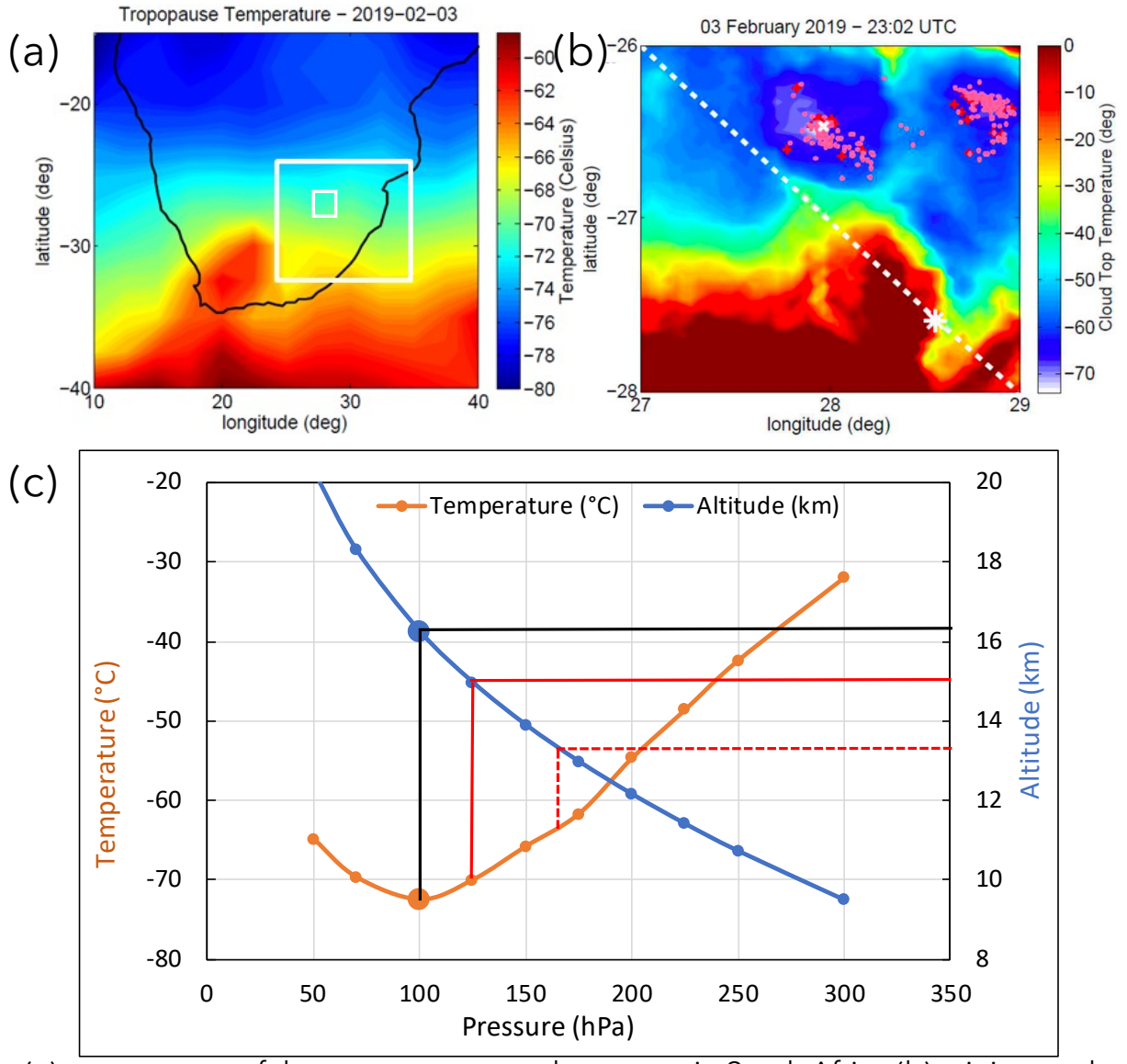


Amplitude waveform bank (-CGs only)

Meteorological Situation and Storm Structure

- The tropopause in SA: 16.25 km (-72.5℃ 100hPA)
- Cloud top altitude near the cell: 16.4 km (-74 ℃)
- The CTT observed at the location of blue discharge: ~ -70 ℃ (15 km)
- Consider CTT uncertainty (± 2.5 ℃) and the location uncertainty (5 km), **the cloud top altitude: 13.3-16.65 km**

SA: South Africa
CTT: Cloud Top Temperatures



(a) temperature of the tropopause on a large area in South Africa (b) minimum cloud top temperature on the thunder cell producing the blue discharge (c) Altitude and temperature versus pressure, at the location of the cell producing the discharge.

Estimation of the source altitude from the optical pulse (337nm)

$$I(t) = \frac{I_m}{\left(\frac{6Dt}{L^2}\right)^{\frac{3}{2}}} e^{\frac{3}{2} - \frac{L^2}{4Dt} - \gamma t} \quad (1)$$

$$I(t) = \frac{I_m}{\left(\frac{6Dt}{L^2}\right)^{\frac{3}{2}}} e^{\frac{3}{2} - \frac{L^2}{4Dt}} \quad (2)$$

$$L = 4041 \cdot 10^4 / r\sqrt{T_r / N_d} \quad (3)$$

I: photon intensity
I_m: maximal photon intensity
D: diffusion coefficient for photon scattering
L: cloud depth

γ: photon absorption frequency
T_r: pulse rise time (10% to 90%)
N_d: cloud particle concentration
r: the radius of the colliders

Estimate the optical pulse shape: the source locates at a cloud depth L km from Soler et al., (2020) → equation (1)

Absorption neglectable: γ varies between 10^{-5} and 10^{-4} ms^{-1} → equation (2)

The maximum reached at time: $L^2/6D$

$T_r = 0.0742\, L^2/D \rightarrow L = \sqrt{\frac{D \cdot T_r}{0.0742}}$ → equation (3)

Event altitude: 9.5-16.0 km

Soler, S., et al., Blue optical observations of narrow bipolar events by asim suggest corona streamer activity in thunderstorms, Journal of Geophysical Research: Atmospheres, 125 (16)

Conclusion

- Ground based electric field measurements: blue discharge: **16.0-18.8 km**, ionospheric height: **94.5-95.5 km**
- Meteorological situation and storm structure analysis cloud top at the blue discharge location: **13.3-16.65 km**
- Estimation of the source altitude from the optical pulse : **9.5–16.0 km**