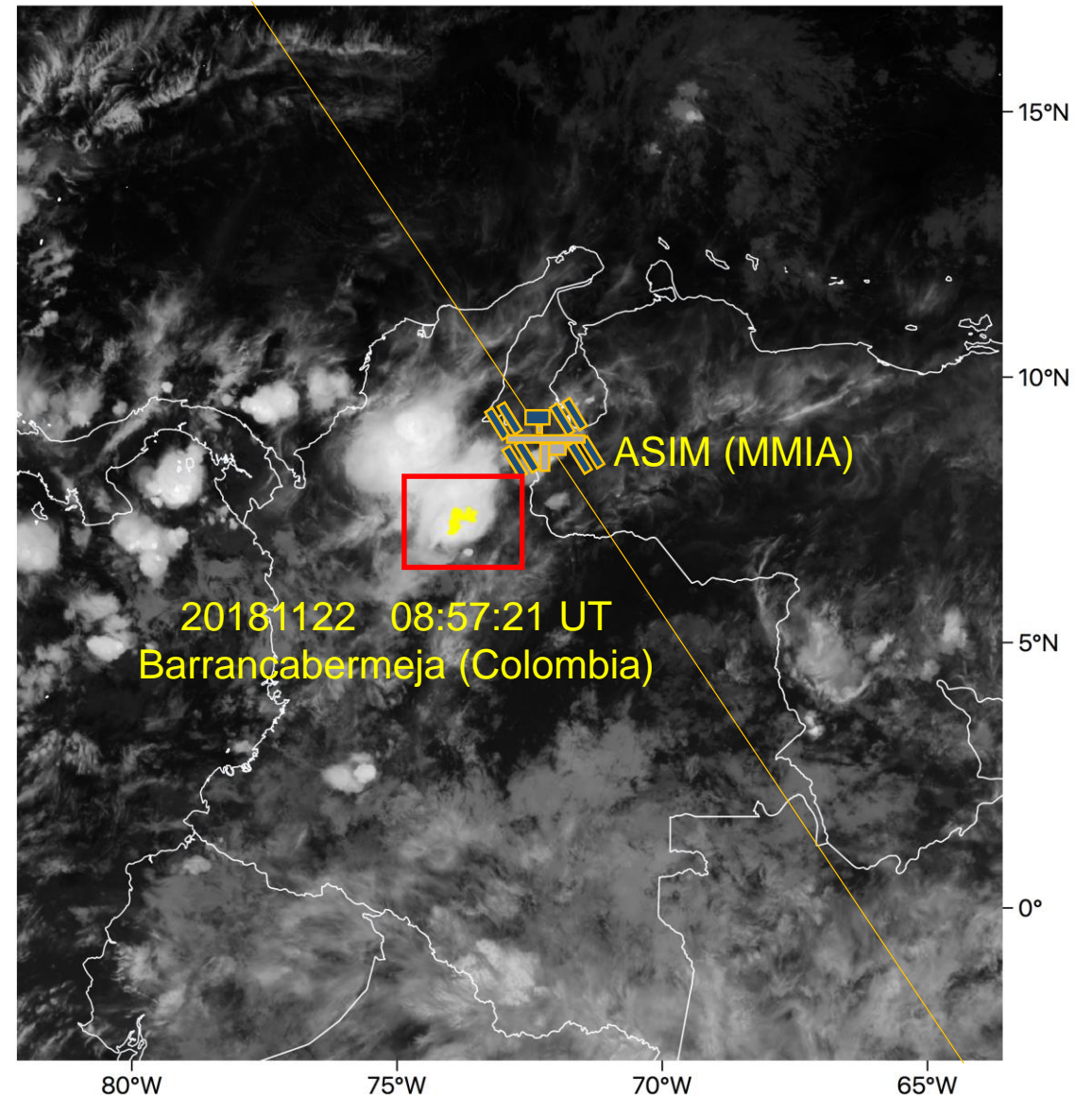


A simultaneous observation of lightning by ASIM, Colombia-Lightning Mapping Array, GLM and ISS-LIS

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2. Methods

- Optical detections of a lightning flash observed by **ASIM**, **GLM** and ISS-LIS are investigated.
- The **Colombia-Lightning Mapping Array (LMA)** provide locations of VHF sources associated with lightning leader breakdown: leader development, altitude polarity and speed.
- Cloud properties above the lightning channels are investigated using **C-band Doppler weather radar** data. Optical depth are calculated from cloud particle size distributions estimated from radar reflectivity and temperature using Heymsfield (2002&2013) parametrizations.

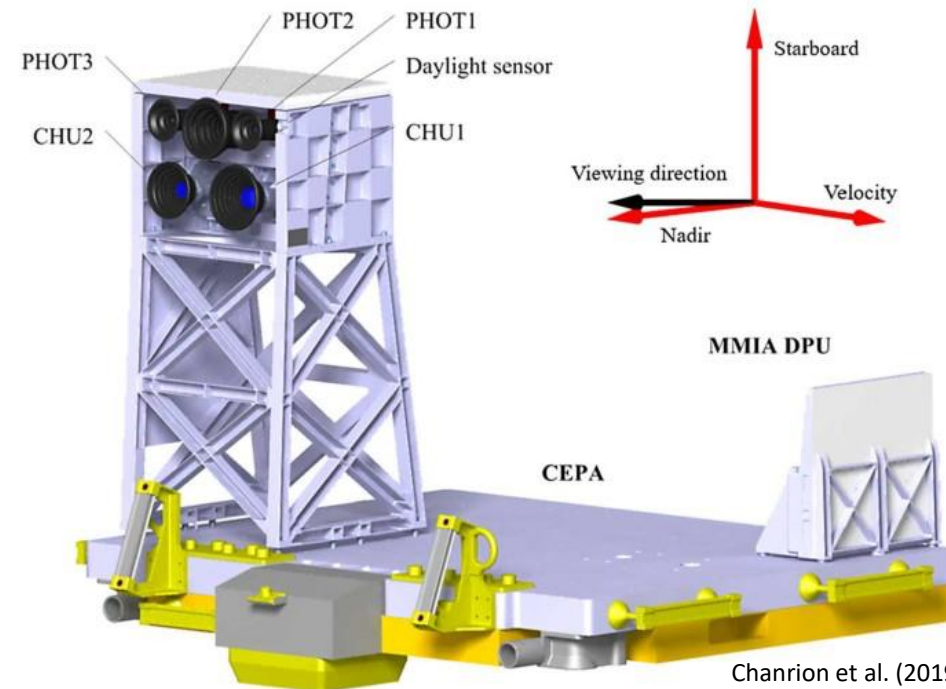
ASIM (MMIA) on the ISS

Photometers 100 kS/s

PHOT 1	337.0 nm (4 nm BW)	Blue
PHOT 2	180-230 nm	
PHOT 3	777.4 nm (5 nm BW)	Red

Mega pixel cameras 12 fps

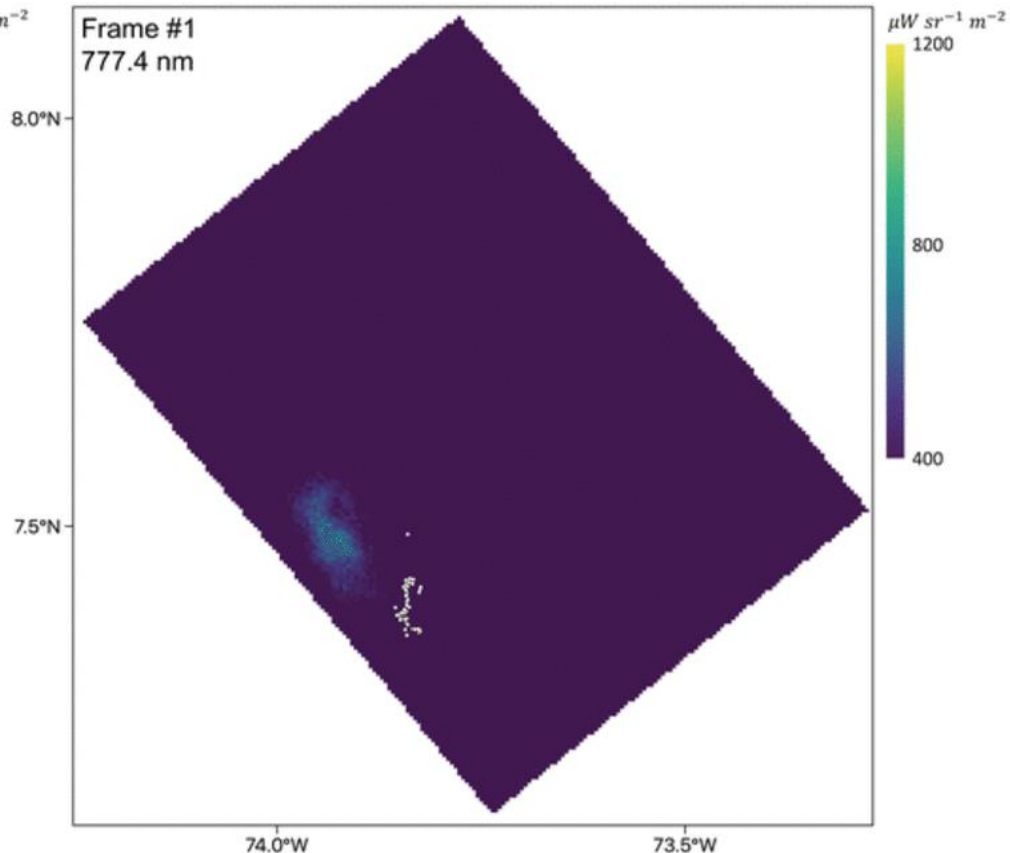
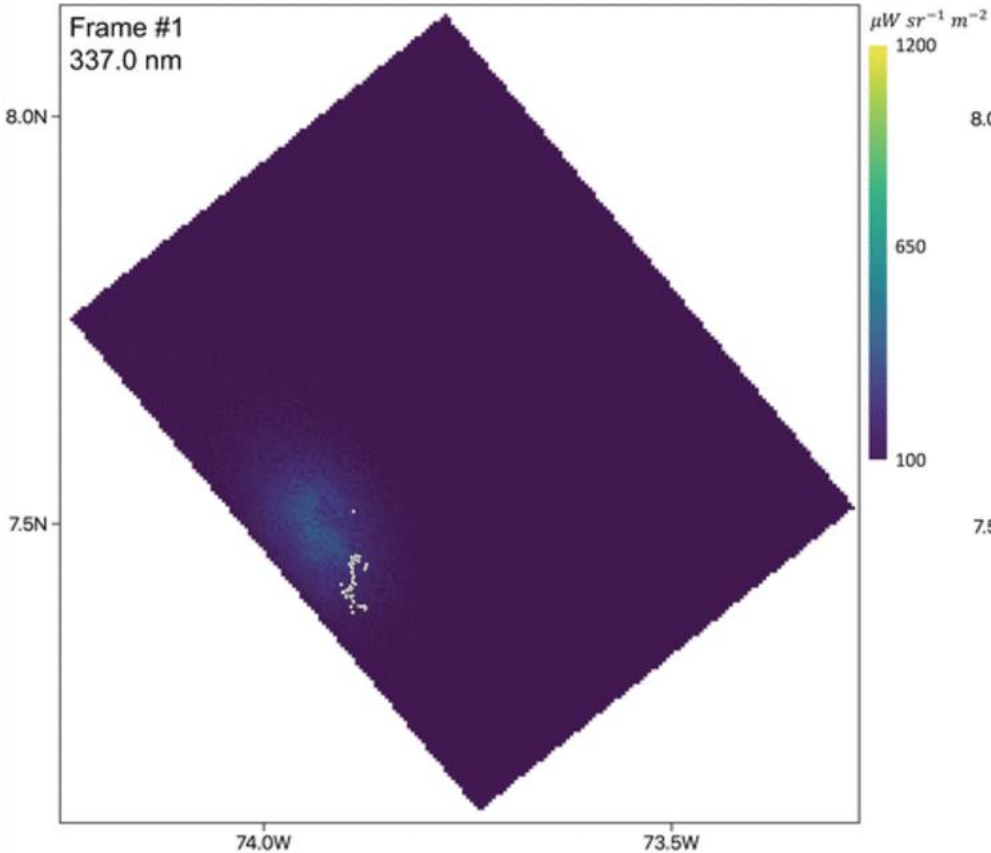
Camera 1	337.0 nm (5nm BW)	Blue
Camera 2	777.4 nm (3 nm BW)	Red



3. Results: ASIM images and GLM

337.0 nm (blue)

777.4 nm (red)

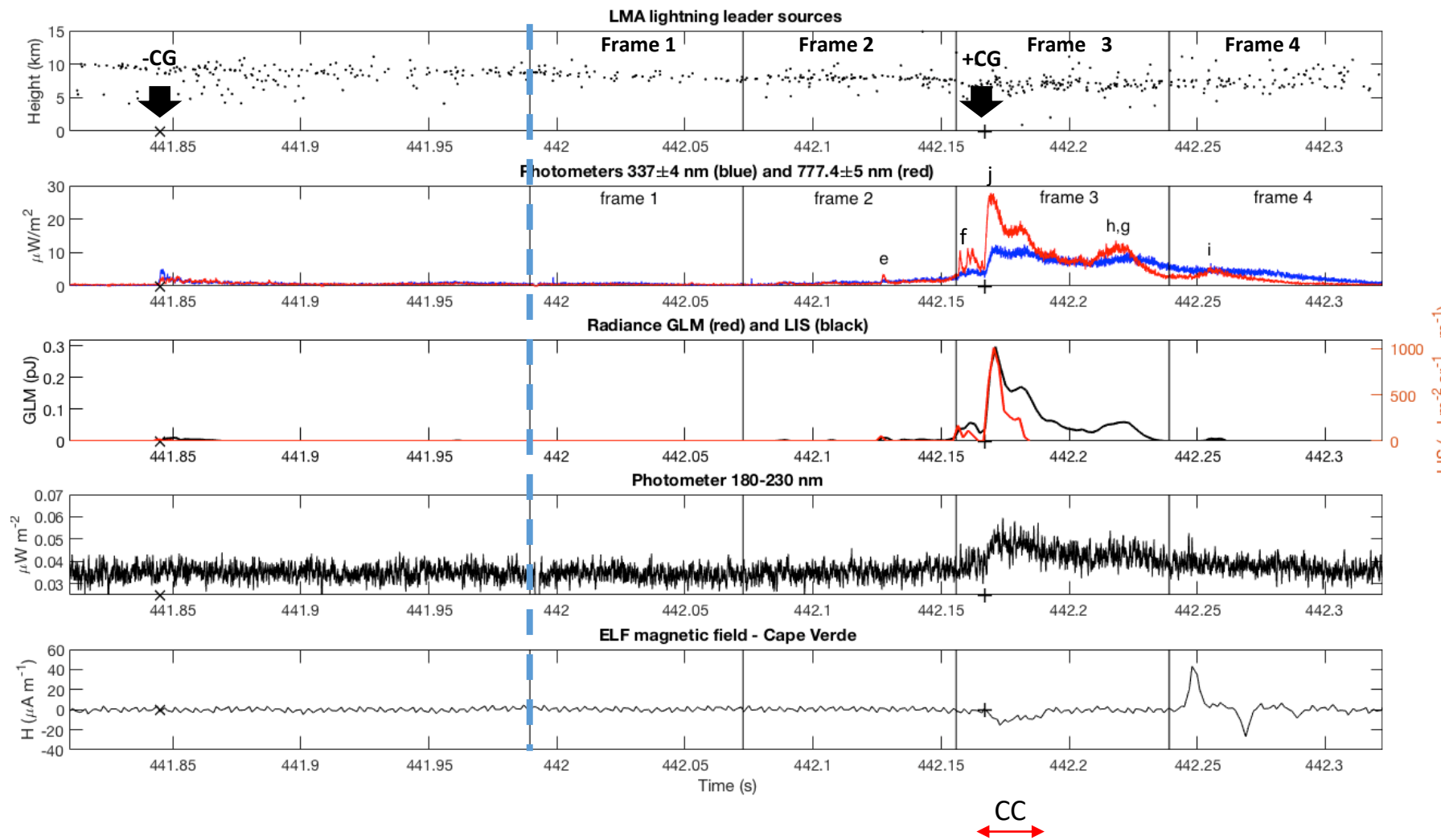


LMA: white dots

GLM: grey squares

- Frame 1: a leader branch starts to propagate from the location of the former -CG. GLM does not provide any event.
- Frame 2: A leader channel propagates into a more stratiform region and branches. GLM start to detect.
- Frame 3: A +CG stroke occurs followed by continuing current. Two fast leaders propagate.
- Frame 4: The north-east leader branch is well imaged by the red channel and GLM. The south-east branch is not imaged. In this case the leader is under the 20 dBZ echo top and the calculated cloud optical depth above the lightning channel is >2 times higher than in the north-east branch.

3. Results: Radiances



- Red luminosity correlate with the occurrence of impulse current events such as return stroke (marker j) and recoil leader (f) and the continuing current estimated from the ELF signal and supported by development of fast ($>10^5$ m/s) negative leaders. Not for the blue channel.
- Surges in the red channels are related with leader branching involving new leader development (markers e, h,g, i). These are not always noticed in the blue channel (337 nm).
- After the initial part of the continuing current, the blue channel dominated in the region of the CG strokes.

LIS ($\mu\text{J m}^{-2} \text{sr}^{-1} \mu\text{m}^{-1}$)

4. Conclusions

- Besides the position of the lightning leaders and the properties of the cloud above and around them, detection of optical emissions of lightning depends on the different lightning processes.
- Surges of luminosity in the red (777.4 nm), besides being associated with impulsive current events like return stroke and recoil leader processes, are also related with leader branching involving new leader development. These are not always noticed in the blue channel (337 nm). Red luminosity also correlate with continuing current.
- In general the flash was imaged in cloud areas with lightning channels located above the 20 dBZ echo top.
- Calculated relative cloud optical depth resulted consistent with the observations. In the areas of low cloud tops with lightning channels at similar altitudes as in other regions of the flash, an increase in a factor of 2 of the relative optical depth suppressed the detection of the flash in both red and blue bands.
- GLM detections of this flash are consistent with the ASIM video images and photometer radiances as well with the leader development provided by the Colombia-LMA.