UHU - another experiment to observe lightning and TLEs from the ISS

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Abstract

Several successful attempts have been made so far to utilize the uninterrupted view on the atmosphere from space and discover yet undocumented features of lightning activity and transient luminous events (TLEs), most recently the THOR and ILAN-ES (2022-2024) missions. As Hungary is considering sending an astronaut to the International Space Station (ISS) in 2025, an experiment has been proposed that aims at further enriching the existing set of space-borne targeted observations of nighttime electrical phenomena in the atmosphere. This is to be accomplished by an optical camera which is directed to preselected thunderstorm targets by the astronaut. This would be the UHU experiment which has been named after the Eurasian eagle-owl, a nighttime predator bird known for its extremely silent flight and exceptionally sharp eyes. The experiment is planned to be supported by a ground-based global observation and data collection campaign. One utterly desired achievement of the experiment and the accompanying observation campaign would be obtaining optical records of one or more TLEs taken simultaneously from the ISS and from a ground location. The experiment would also serve to elevate public awareness about the benefits of monitoring atmospheric electric parameters in studying the atmosphere and the near-Earth space environment. In this contribution, the motivation and the scientific aims behind organizing yet another TLE observation experiment from the ISS are presented and planning of the experiment as well as the supporting observation campaign are described.

Timeline of space-borne TLE observations conducted by astronauts

2001, Lightning and Sprite Observations (LSO), ISS,
19 h of observations, 17 possible sprites, 3 sprite halos, 9 superbolts, 180 lightning flashes, *Blanc et al., 2004*.
The first nadir-pointing TLE observations from space.

2003, Mediterranean Israeli Dust Experiment (MEIDEX), Columbia STS-107, 16-day mission, 7 ELVES, 7 sprites, *Price et al., 2004*; *Yair et al., 2004*.
Target forecasts and pointed observations:
proof of concept

2011, Cosmic Shore campaign, ISS, 24 Jul - 8 Aug, 8 sprites, 1 sprite halo, 1 gigantic jet (GJ), *Yair et al, 2013*
The first GJ observed from space.

2011 Aug - 2012 Apr, not TLE-specific Earth observations from the ISS, 15 sprites in 20 h of total observation time, *Jehl et al, 2013*.
Detailed analysis of the optical emission of sprites.

2015, THOR, ISS, 10 days, *Chanrion et al., 2017*
Blue emissions (245 in 160 s of video) including the first pulsating blue jet observed from space.

2022, ILAN-ES AX1, ISS, 12-day mission, >80 TLEs: sprites, ELVES and BLUEs, *Yair et al., 2023, 2024*
Detailed analysis of BLUE discharges.

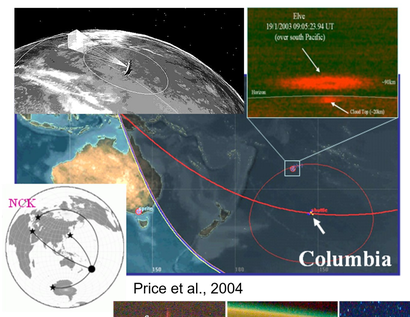
2024, ILAN-ES AX3, ISS, 13-day mission, >80 TLEs including 2 GJs (ongoing analysis).

Benefits of observing TLEs from space

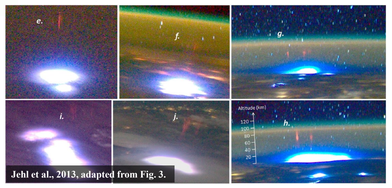
- Unobstructed view from above
- Large coverage
- Smaller spectral bias due to atmospheric scattering

Some highlights of research prompted by space-borne lightning and TLE observations

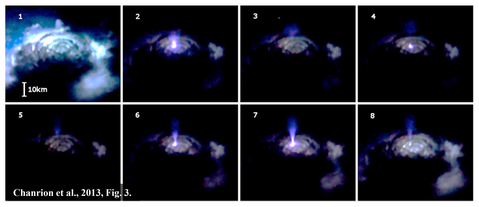
- Global survey of TLE occurrences, with highlight on events that appear close to the cloud tops.
- Studying the optical emission of TLEs (magnitude and spectral properties).
- Inferring the correspondences among thundercloud development, lightning activity (parent lightning), and the location and optical properties of the TLE.
- Supporting the development and refinement of remote TLE detection techniques based on the detection of radio signals and infrasound.
- Supporting the development of AI-based automatic lightning and TLE detection techniques.
- Identifying cloud regions of thunderstorms exhibiting outstanding electrical activity (extreme lightning rate, most powerful lightning discharges, concentration of electric charge) with a potential for initiating TLEs.
- Examination of the detection efficiency of various ground-based and space-borne lightning detection systems and instruments.



Price et al., 2004



Jehl et al., 2013, adapted from Fig. 3.



Chanrion et al., 2013, Fig. 3.

The UHU experiment

In the framework of the Axiom Space AX4 mission, the crew will attempt making observations of lightning activity and TLEs in and above forecasted thunderstorm targets, respectively, along the orbit of the ISS.

This experiment in the Earth observation module of the scientific payload of the mission has been proposed jointly by researchers of HUN-REN Institute of Space Physics and Earth Science (FI), Hungary and Reichman University (RUNI), Israel.

The AX-4 mission may start in May, 2025, TLE observations are expected to be made in a 10-day period during the mission.

Objectives of UHU

- To produce video footages containing as many and as various lightning lights and TLEs as possible.
- Achieve simultaneous capturing of the same TLE from space and from the ground.
- Collect a rich set of corresponding ground-based observations and datasets (optical observations, lightning data, electromagnetic fields, infrasound, meteorological data and satellite imagery).
- Thorough scientific analysis of the collected observations of data to maximize contribution to the corresponding fields of research.

Tools

- Target forecasts
  Will be issued 24-36 hours ahead of the event day using the methodology that proved to be successful in previous similar missions (originally developed by *Ziv et al., 2004*).
- Equipment
  Nikon D6 camera will be used with a 50 mm F1.2 lens to record videos in 60 FPS and 1920x1080 pixel resolution at 6400 ISO setting.

References and webpage URLs

Blanc et al., 2004, JGR, https://doi.org/10.1029/2003JA009972

Chanrion et al., 2017, JGR, https://doi.org/10.1002/2016GL071311

Price et al., 2004, GRL, https://doi.org/10.1029/2004GL020711

Yair et al., 2004, JGR, https://doi.org/10.1029/2003JD004497

Yair et al., 2013, JGR, https://doi.org/10.1016/j.jastp.2013.05.004

Jehl et al., 2013, JGR, https://doi.org/10.1029/2012JA018144

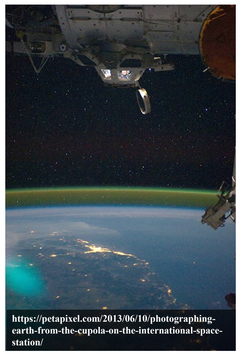
Yair et al., 2023, Acta Astronautica, https://doi.org/10.1016/j.actaastro.2023.06.051

Yair et al., 2024, Atmos. Res., https://doi.org/10.1016/j.atmosres.2024.107445

Ziv et al, 2004, https://doi.org/10.1175/2097.1

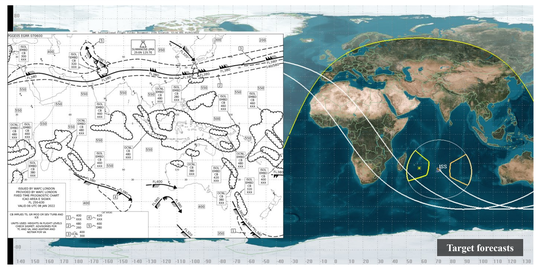
Spritacular, https://spritacular.org/

Facebook group of TLE observers:
https://www.facebook.com/groups/376355972487572



https://petapixel.com/2013/06/10/photographing-earth-from-the-cupola-on-the-international-space-station/

Joe Acaba performs Earth observation photography
Credit: NASA/Twitter/Joe Acaba



Your contribution is very welcome!
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Contributing Partners

Several individual researchers in research institutions around the world have already expressed their interest and willingness to contribute to the UHU experiment via participation in the corresponding collection of observations and measurements as well as by taking part in the subsequent scientific analysis.
The list of involved institutions includes:

- Tel-Aviv University, Israel
- Technion - Israel Institute of Technology, Israel
- ELTE University, Hungary
- Baja Observatory of the University of Szeged, Hungary
- NASA Goddard Space Flight Center, USA
- The Catholic University of America, USA
- Earth Networks, USA
- Parsons Laboratory, Department of Civil and Environmental Engineering, Massachusetts Institute of Technology, USA
- Centre for Space, Atmospheric and Oceanic Science, Department of Electronic and Electrical Engineering, University of Bath, UK
- Laboratory of Aérologie, Université de Toulouse (UT3), France
- The University of Electro-Communications (UEC), Japan
- Institute of Electronics, AGH University of Science and Technology, Poland
- Institute of Geophysics, Polish Academy of Sciences, Poland
- Instituto de Ciencias de la Atmósfera y Cambio Climático, Universidad Nacional Autónoma de México, Mexico
- Universitat Politecnica de Catalunya · BarcelonaTech, Spain
- National Institute for Space Research - INPE, Brazil
- University of Puerto Rico at Mayaguez, Puerto Rico
- DTU SPACE National Space Institute, Denmark

The project also welcomes contribution to citizen observers around the world. UHU is supported by the Spritacular citizen science project by NASA and expects support from the community of TLE observers, too, kept together by the group of „International Observers of Upper-Atmospheric Electric Phenomena" on Facebook.

https://www.space.com/iss-red-lightning-sprite-thunderstorm-image