The Failed Search for Runaway Electrons in South Africa

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C.T.R. Wilson and B.F.J. Schonland interacted for an entire decade (by virtue of their respective affiliations at the Cavendish Laboratory in England) prior to the first published search for runaway electrons from thunderclouds In South Africa (Schonland, 1930).Wilson's (1925) concept for electron runaway on kilometer scales in thunderclouds was based on cloud chamber evidence on centimeter scales for the straightening of electron tracks with increasing energy, with maximum available electron energies of tens of keV.Schonland's laboratory measurements of electron scattering at the Cavendish (supervised by E. Rutherford) showed a decline in scattering with energy for electron energies up to 80 keV.Both sets of laboratory observations available at the time, supported a monotonic decline in the electron "friction curve" with increasing energy (a behavior then referred to as Whiddington's Law), and hence supported unimpeded runaway.

This retrospective contrasts the findings in Schonland (1930) with the uncontested prevalence of Thunderstorm Ground Enhancements at Aragats in Armenia (Chilingarian et al. 2020) and many other locations, and identifies three reasons for the earlier failure:

(1) The ionization chamber designed by Wilson and constructed by Schonland for detection of electrons and gammas anticipated runaway electrons in the GeV range, not the MeV range
(2) The altitude of Johannesburg, South Africa (1780 m, MSL) was insufficiently high to overcome the effects of the intervening atmosphere on runaway products in the MeV range.
(3) No measurements were possible in 1930 within or above the South African thunderstorms

The great irony of this failed search is that the two scientists most interested in confirming electron runaway at the time came up empty-handed, and thereby set the field back half a century.

Dual Broadband VHF Interferometer Observations of TGFs Over the Telescope Array

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Several downward terrestrial gamma-ray flashes (TGFs) are typically detected each year by some of the 507 surface detectors which comprise the Telescope Array (TA) in Utah. At least 20 downward TGFs have been bserved by the New Mexico Tech broadband VHF interferometer (NMT INTF) since it was deployed a few kilometers to the east of the TA in July of 2018. The 3 broadband VHF (14-87 MHz) flat plate antennas of the NMT INTF are augmented by a fast antenna. The majority of the TGFs occur during fast negative breakdown (FNB) within strong initial breakdown pulses (IBPs). Significant off-vertical orientations of the FNB have been observed by the NMT INTF which have been reflected in the TGF footprint on the TA.

In September of 2020, a 2nd VHF broadband interferometer was deployed a few kilometers to the west of the TA, permitting highly-detailed 3D reconstructions of the TGF parent discharges. In 2021, there were 8 TGFs for which dual interferometery data was obtained. Furthermore, 5 of them were augmented by high speed video data collected at the NMT INTF site. The estimated high energy electron fluence from at least one of the TGFs observed in 2021 was close to that of upward TGFs detected by satellites. This, in combination with detailed observations of FNB within the IBPs of intracloud flashes, provides evidence that a common mechanism may be present for high energy electron acceleration within upward and downward TGFs.

On the Nature of the Optical Emission During Intense Electron Fluxes in the Low Atmosphere

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Starting in 2014, we performed 24/7 monitoring of the skies above Aragats with panoramic cameras which have high sensitivity in the visible wavelength band of 300-700 nm. During these years when we observe large enhancements of the gamma ray and electron fluxes i.e., numerous relativistic runaway electron avalanches in the skies above the station, simultaneously on the 1-minute and 1-sec time series of the camera shots we see light spots of different size and shape. Strong electric field ≈ 2.0 kV/cm continued down to ≈100 m above the earth's surface. The cloud height usually was approximately the same. The maximum energy of electrons reaches 50 MeV. In the report, we will present the typic patterns of the light spots and their dynamics and discuss the possible origin of these lights.

Gamma-ray Glows in Winter Thunderstorms: Catalog Analysis and Multi-sensor Observation

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Winter thunderstorms in Japan are one of the best targets to observe high-energy atmospheric phenomena on the ground, including gamma-ray glows and downward terrestrial gamma-ray flashes. Since 2015, the Gamma-Ray Observation of Winter Thunderclouds collaboration have operated an observation network of gamma rays in Ishikawa Prefecture, Japan. The network has as many as 10 radiation monitors. By the four-years observation from 2016 October to 2020 March, a total of 70 gamma-ray glows were detected in the cities of Kanazawa and Komatsu, Ishikawa Prefecture. The detection of the glows concentrates from December to February. 77 percents of events were detected at night. Based on count-rate histories, the detected events can be classified into three types: temporally-symmetric, temporally-asymmetric, and lightning-terminated types. The temporally-symmetric type could be interpreted as a passage of a single and simple radiation area of gamma-ray glows, while the temporally-asymmetric type could be a superposition of several radiation area. Also some of the events were analyzed jointly with an X-band radar, a disdrometer, and a ceilometer. During the detection of glows, a strong echo region exist overhead the detectors, and precipitation of graupels is common. Therefore, graupels in the lower layer of thunderclouds could play an important role to form strong electric field responsible for electron acceleration. We will show a summary of the four-years observation campaign and multi-sensor analyses of gamma-ray glows.

Observation of Downward TGFs in Japan and their Distinct Radio Pulses

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We observed two downward TGFs on the ground exactly one year apart on the NW coast of Japan, with accompanying VHF, LF, and optical observations. The associated flashes produced sferics resembling the Compact Return Strokes reported by Wu et. al 2021, including the small pulses they saw superimposed on the stroke pulse itself. We examine if these features have a possible relationship with Energetic In-cloud Pulses (Lyu et al 2015) and Slow Pulses (Pu et al 2019), and whether or not these features are a direct result of the RREA current.

TGF Observations From the Ground and Air With the New Terrestrial High-energy Observations of Radiation (THOR) Arrays

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The TGF research group at the University of California, Santa Cruz, has just completed a set of 6 arrays of gamma-ray detectors made to be deployable at ground sites (including isolated sites with no power or internet) and on aircraft. Each THOR unit features: three plastic scintillators of very different sizes to expand the dynamic range between the faintest and brightest events that can be successfully observed; a NaI detector for spectroscopy of glows and radioactive byproducts of nearby TGFs; continuous data collection in a time-tagged photon list mode, plus capture of the full PMT waveforms during TGFs or other extreme increases in count rate; GPS timing giving absolute timing accuracy on the order of 1 microsecond; and a design meant to minimize sensitivity to RF interference, with ability to identify any residual RF noise through the full captured waveforms.

THOR units have been deployed over the past year to one of the NOAA Hurricane Hunter aircraft and to ground sites at Uchinada, Japan, Mt. Santis, Switzerland, and the campus of the Florida Institute of Technology. A predecessor instrument to THOR detected three TGFs at Mt. Santis in the summer of 2021 and has been transferred to the campus of the University of Split in Croatia, on a part of the Adriatic coast that experiences powerful winter lightning, as does the west coast of Japan around the Uchinada site.

This presentation will review the three Mt. Santis TGFs -- which differ remarkably in their parent lightning as seen in the radio -- and review the THOR instrument design. The first TGF observed by a THOR installation, from the Uchinada site, will be presented in detail in the presentation by Ortberg et al.

First Results of the Joint Ground-space TLE Campaign with LEONA Network and the ILAN-ES Mission

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Transient Luminous Events (TLEs) are hybrid atmospheric-space plasmas of short duration and low luminosity signaling the coupling of all atmospheric layers, neutral and ionized, among themselves and with the Near-Earth space region. Sprites, halos, elves, blue jets and gigantic jets are the most well-known types of TLEs. They are one of the two classes of FAIRIES: *E**F**fects Sign**A**lIng the Elect**R**odynamic Coupl**I**ng between the Atmospher**E** and **S**pace*. The second is formed by the High Energy Emissions from Thunderstorms (HEETs), i.e. hard radiation emitted by energetic electrons accelerated by lightning and thunderstorms' electric fields, such as gamma-rays, X-rays, neutrons and electron-positron pairs. In February 2022 we performed a coordinated campaign to record TLEs from space and from the ground simultaneously. The space component was carried on by the Israeli astronaut, Mr. Eytan Stibbe, onboard the International Space Station (ISS) within the *Imaging of Lightning And Nighttime Electrical phenomena from Space* (ILAN-ES) mission. The ground component was carried on in South America with the *Transient **L**uminous **E**vent and Thunderst**O**rm High Energy Emissio**N** Coll**A**bortive Network* – LEONA. We will present the results obtained with the initial analysis of the data, and some comparison with previously observed TLEs and their parent thunderstorms in South America, obtained during the 2018 and 2019 campaigns with LEONA Network. Southern South America is consider to be the region of the world with the most intense and severe thunderstorms, according with satellite based studies, the results of this work may help advance the knowledge on severe storms, TLE production and the electrodynamic coupling of the whole atmospheric system with the space region near the planet.

13 Years of Gigantic Jet Observation in the Southern Caribbean Sea and Colombia: What Have We Learned About Their Meteorological Conditions?

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Since 2009 the UPC has been operating low-light cameras at various sites in and around Colombia, a region that hosts the highest lightning activity in the world, to study the occurrence of gigantic jets, sprites and elves in the tropics. Gigantic jets (GJ) are unique transient luminous events that originate as lightning inside the cloud, leave the cloud top and connect to the ionosphere, which are produced almost solely by tropical airmass thunderstorms.

Remotely operated camera sites include San Andres island (2009-2013), Curaçao (2014-2018), Santa Marta (since 2016) and Barranquilla cities (2019-2021)at the Caribbean coast of Colombia, and Manizales city (since 2019) monitoring western Colombia. In-person campaigns for high-speed camera observations were done from Curaçao, Santa Marta, Barranquilla and Cartagena, and Manizales, in 2014, 2017, 2018 and 2021 respectively.

Until 2022, 70 gigantic jets (GJ) have been detected in 48 nights. We divided them by region: Caribbean Sea (24 events, 17 nights), northern Colombia (24 GJ events in 20 nights) and western Colombia (22 GJ events, 12 nights). The camera monitoring the arid region of northwestern Venezuela and Lake Maracaibo from Curaçao did not detect any gigantic jets.

The resulting catalog of GJ events and null events (nights with distant thunderstorms under clear sky conditions but without GJ) offers a unique chance to study the storm scale and larger scale meteorological contributions to the production of gigantic jets. It is believed that an unbalanced thunderstorm charge configuration is a key factor in production of gigantic jets (Krehbiel et al. 2008, Nat. Geosc.). Recent studies confirm the GJ as a streamer zone extending from a lightning leader tip that remains in the 18-21 km altitude range (e.g. van der Velde et al. 2019, Nat. Comm.) implying hundreds of MV of negative electric potential are needed to bridge the gap. Factors as upper level wind shear, turbulence, overshooting tops, tropical cyclones and fast anvil expansion have been considered possible contributing factors, connected to the larger scale meteorological environment.

We statistically compared vertical profiles extracted from the Copernicus Climate Change Service ERA5 reanalysis data. Representative profiles were taken in proximity in time (up to a few hours) and space (0.5 degree) relative to the real-world occurrence. Parameters include instability, wind shear and humidity, at different vertical levels. Satellite and Geostationary Lightning Mapper are also investigated.

The results show that none of the upper level parameters were statistically significant at the 99% level. While gigantic jet cases often had moderate vertical shear between mid and upper levels, so have null cases. However, gigantic jet cases had greater warm cloud depth, less CAPE, weaker downdraft buoyancy, weaker low level shear, as well as higher relative humidity across northern Colombia. In western Colombia, the null cases occupied the same parameter space as the GJ cases, except for slightly increased low level absolute humidity in the latter. The data suggest a role for single cell storm development in environments with the largest warm cloud depths.

Thunderstorm Conditions Required for Terrestrial Gamma-ray Flashes Production by Relativistic Runaway Electron Avalanches

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Relativistic Runaway Electron Avalanches (RREA) is one of the possible sources of such a bright high-energy atmospheric physics phenomenon as Terrestrial Gamma-ray Flashes (TGF). One way to produce a TGF is an intense and almost instant source of seed energetic electrons. Another possibility is positive feedback processes occurring in RREA dynamics. Thunderstorms radiate TGFs when the feedback becomes infinite: runaway breakdown is self-sustainable and RREAs multiply rapidly. According to Relativistic Feedback Discharge Model, in quasi-uniform thunderstorm electric fields, RREAs can multiply by the relativistic feedback.

In complex electric structures, additional positive feedback appears - the reactor feedback. The reactor feedback is the multiplication of RREAs by high-energy particles exchange between separate thunderstorm RREA-accelerating regions. Such regions are called cells. Distant cells amplify each other mostly by gamma-ray photons exchange due to their high penetrating power in the air. For cells located close to each other, the reactor feedback works mostly by runaway electron exchange as RREAs consist mainly of runaway electrons.

The effectiveness of the relativistic feedback depends on electric field strength and electric region length. The reactor feedback also depends on thunderstorm electric structure: the more complex it is, the more cells there are within the reactor thundercloud, more effective reactor feedback is. Moreover, in complex electric structures, the reactor feedback dominates the relativistic feedback.

In this research, RREAs dynamics with positive feedback is studied in several thunderstorm electric structures. For each considered electric field geometry a criterion for infinite positive feedback is derived. With the criterion, thunderstorm electric field parameters necessary for TGF production via positive feedback are obtained. TGF gamma-ray radiation pattern for each model is received and gamma-ray spectrum is discussed.

The Feasibility of a 3D Time-dependent Model for Predicting the Area of Possible Sprite Inception in the Mesosphere Based on an Analytical Solution to Poisson's Equation

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We present a formulation for calculating the electric field from the ground to the lower boundary of the ionosphere that is based on an analytical solution to Poisson's equation in three dimensions, combined with a numerical solution to the equation of charge continuity/conservation. This formulation allows one to follow the spatial and temporal evolution of the distribution of free charges and the electric field in the atmosphere and thus predict areas of possible sprite inception in the mesosphere in a quasi-electrostatic fashion for any thunderstorm charge distribution. The main advantages of this formulation are: (1) for a given spatial resolution, the analytical solution to Poisson's equation is more numerically stable and accurate than a numerical solution to Poisson's equation that includes finite differencing in space; (2) unlike a numerical solution to Poisson's equation that includes finite differencing in space, the numerical stability is insensitive to the choice of spatial resolution; (3) no artificial side boundary condition need be applied; (4) no symmetry, cylindrical or otherwise, of the charge distributions nor the electric field distributions need be prescribed; and (5) the computation is readily parallelizable on multiple processors. The main limitation of the present formulation is that the electric field based on the electrostatic potential with upper and lower boundary conditions needs to be calculated for each charge in the domain, such that the larger the number of charges, the slower the computation. However, the computation is readily parallelizable on multiple processors. Moreover, the computation can be made even more efficient by reducing the number of image charges included and by adopting a threshold value of charge considered overall, while still obtaining very accurate simulations. In this presentation, we will show that using our new formulation, we successfully reproduce the results from previous studies, and we will demonstrate the utility of our new formulation in investigating the evolution of the area of possible sprite inception in cases of consecutive lightning discharges that are separated from one another in space as well as in time.

Parameterization and global distribution of sprites based on the WWLLN data

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We consider the formation of electric fields in the atmosphere at altitudes of 50-70 km after especially powerful tropospheric cloud-to-ground discharges, leading to the initiation of high-altitude discharges in a daytime conditions. It is known that a necessary condition for initiation of a nighttime sprite is the electric field of uncompensated charge in a cloud of more than 128 Td at an altitude of about 75–80 km, while the field 80–100 Td leads to the development of a halo. High conductivity in daytime conditions does not allow the electric field to penetrate to altitudes of 75–80 km, and the region of a possible initiation of high-altitude discharges shifts lower. The normalized field required for the discharge initiation is the same as for nighttime conditions. Thus, for the initiation of the atmospheric discharge at daytime several times more intense lightning discharge in the troposphere is needed. Perturbations of the concentrations of ions, neutral compounds,excited atoms and molecules along with disturbances of the atmospheric conductivity and electric field are studied. The uncompensated charge of a parent flash is typically characterized by the impulse charge moment (ICM) of several hundred C·km for nighttime discharges. Modeling of daytime conditions was carried out in the range of 2000–4000 C·km, which leads to the formation at an altitude of 50–70 km of a normalized electric field of a near-breakdown value. It is shown that there are two scenarios of development of the discharge, with and without a rapid increase in electron concentration, which are studied in detail by assuming ICM values of 3750 C·km and 2750 C·km respectively. During a discharge with an ICM of 2750 C·km, the decrease in the concentration of electrons in the electric field is caused by their attachment to molecular oxygen, and no sharp increase in electron concentration occurs; the concentrations of the most significant ions and electrons reach unperturbed values in less than a second. The normalized electric field reaches a maximum value of 100 Td, and this scenario corresponds to the development of a halo. For an ICM of 3750 C·km, an initial decrease in the electron concentration is followed by the formation of an avalanche of electrons characterized by an increase in their concentration by more than an order of magnitude relative to the initial value. The maximum normalized electric field reaches 128 Td, this scenario corresponds to the development of a sprite. Thus, the possibility of the initiation of high-altitude discharges (presumably sprites and halos) in daytime conditions at altitudes of 50-70 km after especially powerful lightning discharges in the troposphere is shown, the dynamics of the disturbance of the chemical balance and atmospheric conductivity is studied.

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Cubespark-RF: Designing the Radio Frequency Payload for Space-borne 3-D Observations of Lightning

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CubeSpark is a new concept for three-dimensional observations of lightning using a constellation of CubeSats in low Earth orbit. The concept is currently under development at NASA Marshall Space Flight Center and Los Alamos National Laboratory. CubeSpark will use radio frequency (RF) sensors for traditional time-of-arrival three-dimensional geolocation, while complementary optical imagers will be leveraged to enhance mission performance and reduce uncertainties. This capability will enable three-dimensional lightning measurements on a global scale that will advance knowledge of thunderstorm structure, dynamics, and microphysics, as well as lightning's interaction with climate. While there are several ground and space-based technologies that sample lightning globally, they only provide a two-dimensional representation of a lightning flash. The key to adding the altitude dimension is coordinated radio frequency measurements.

In this presentation, we introduce the concept and design for the CubeSpark RF sensor. The RF sensor is being developed by Los Alamos National Laboratory, which has decades of experience with designing, building, and operating RF sensors for space missions. The CubeSpark RF sensor will receive broadband emissions in the lower part of the very high frequency range (VHF) using a circularly polarized antenna to reject one of the ionospheric wave modes. The receiver's field-programmable gate array (FPGA) will detect impulsive waveforms using a sub-band trigger method, which enables detection of impulsive events with low signal-to-noise ratio. On-board processing will characterize the ionospheric dispersion in the signal and remove first order effects to estimate the vacuum time of arrival. The resulting arrival times will be downlinked to ground for time-of arrival processing. Using this method, the uncertainty in source altitudes is expected to be less than 2 km, which is sufficient for resolving the general charge structure of a thunderstorm.

Monte Carlo Simulations for Evaluating the Accuracy of GLM Detection Efficiency and False Alarm Rate Retrievals

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The performance of the Geostationary Lightning Mapper has been evaluated through comparison with other satellite lightning sensors and ground-based networks. However, because the performance of these reference sensors is both imperfect and imperfectly known, the true performance of GLM can only be estimated through such a process. In particular, GLM performance metrics such as detection efficiency (DE) and false alarm rate (FAR) retrieved through comparison with reference networks are affected by those networks' own DE, FAR, and spatiotemporal accuracy, as well as the selected flash matching criteria. This study uses a Monte Carlo simulation-based inversion technique to quantify the effect on retrieved GLM performance of a reasonable range of reference network DE, FAR, spatiotemporal accuracy, and the associated geographic patterns of each. These results help quantify and bound the actual performance of GLM and the attendant uncertainties when comparing GLM to imperfect reference networks.

Schumann Resonance on Titan: Huygens Reconsidered and Prospects for the Dragonfly Mission

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The Huygens probe to Titan in 2005 was the first planetary probe or lander to feature ELF electric field sensing and atmospheric conductivity measurements. The atmospheric electricity community showed great interest in the claimed detection of a Schumann resonance signal on another world (despite its unexpected dominant frequency of 36 Hz), and the planetary science community embraced an interpretation of the altitude dependence of the signal as evidence of a theoretically-anticipated internal water ocean beneath an ice crust many tens of km thick. Quantitative scrutiny suggests that prospects of detecting a Schumann signal at Titan with the Huygens experiment were in fact very poor, due to short measurement time, a horizontal antenna orientation, a lack of lightning, and the likely presence of severe dynamical effects on the probe. Although the latter three objections were considered, and arguments developed against them (notably the novel postulation of a Saturn-magnetospheric excitation of the resonance), we have re-examined the data in the light of a better understanding of the probe dynamics. The evolution of the 36Hz power shows a very strong correlation with accelerometer records of short-period motions of the probe under its small stabilizer parachute, suggesting that mechanical oscillations of the probe and/or the antenna booms were actually the cause. The 'signal' ramped up just as the probe accelerated from the much more quiescent main parachute, and ceased abruptly a couple of seconds after impact. While the Huygens signal may therefore have been an artifact, this does not mean that a Schumann resonance does not occur on Titan. Most likely if it occurs, it may be very sporadic, responding to the infrequent rainstorms on Titan. A search for such signals should therefore be a long-duration monitoring exercise (not unlike using seismic signals to probe the interior). The Dragonfly mission to Titan, currently in development for launch in 2027 with arrival planned by 2034, provides an opportunity to perform such monitoring. Between rotorcraft flights, the Dragonfly lander will perform measurements with its Geophysics and Meteorology package ('DraGMet') which includes electric field antennas to search for signals due to the Schumann resonance, blowing sand, or other activity. These signals may be correlated with other DraGMet data such as seismic motions and cloud shadows. Lorenz, R.D. and A. Le Gall, 2020. Schumann Resonance on Titan : A Critical Reassessment and Implications for future missions, Icarus, 351, 113942 https://doi.org/10.1016/j.icarus.2020.113942 Lorenz, R., E. Clarke, 2020. Influence of the MultiMission RadioIsotope Thermoelectric Generator (MMRTG) on the local Atmospheric Environment, Planetary and Space Science, 193, 105075 https://doi.org/10.1016/j.pss.2020.105075 Lorenz, R. D., 2021 The Low Electrical Conductivity of Titan's Lower Atmosphere, Icarus, 354, 114092. https://doi.org/10.1016/j.icarus.2020.114092 dragonfly.jhuapl.edu

Optical Flash Detection in Venus by AKATSUKI and Ground Telescope

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Mainly due to the lack of conclusive observational evidence, the existence of lightning discharge in Venus has reached a consensus in about forty years. There had been no satellite-borne sensor optimized for the detection of optical flash with a short duration such as lightning-related phenomena or bolide. LAC, lightning and airglow camera, onboard Akatsuki spacecraft, is the first optical detector designed for the lightning flash measurement in planets other than the Earth. The unique performance of LAC, the high-speed sampling rate at 20 kHz, may enable us to distinguish the natural optical phenomena from other pulsing noises, including artificial electrical noise and cosmic rays. In order to detect lightning flash in Venus efficiently, the narrowband filter centering at OI 777 nm line is used, which is expected to be the most prominent emission in the CO2-dominant atmosphere based on the laboratory experiments.

We have been conducting a lightning search in about 70 passes of AKATSUKI around Venus with triggering parameter sets optimized for the light curve similar to the typical lightning and also to sprite type with longer duration in the Earth. On March 1, 2020, LAC recorded a signal, which seems like a kind of optical flash. The total coverage of the LAC lightning hunt up to now is about 185 [million km2-hr]. If the flash is originated from lightning discharge, the occurrence rate could be equivalent to that with a ground-based telescope reported by Hansell et al. (1995). On the other hand, we are also examining the possibility of the bolide, since the duration of that event can be explained by a short-lived bolide. If it's bolide, the magnitude observed on the ground might be 10 times brighter than a full moon on the ground of Earth.

We are trying the detection of the transient optical flash also with a ground-based telescope using a photometer with a 777 nm filter. Some candidates for the optical flash have been detected but careful examination is needed to distinguish the natural phenomena, such as lightning or bolide, from pulsive noises. Here we discuss the further strategy to confirm the occurrence of lightning in Venus with those instruments.

Detection Efficiency of ISS/LIS in Different Conditions of Storm Development in Catalonia (Spain)

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We have analyzed a set of 12 storm periods of 2019 corresponding with ISS/LIS passes above the region of Catalonia by using several Lightning Location Systems (LLS) and radar data. The different LLS provide information about signals produced by lightning flashes in LF for Météorage (MTRG), VLF for GLD, VHF for LMA and XDDE, optical for LIS. The data from the radar network in Catalonia and from the radiometer SEVIRI onboard the MSG satellite were used for the description of the thundercloud in terms of vertical and horizontal extents and structures. The analysis focused on comparison of detections by LIS and the LLS at the ground in different conditions of storm developments and locations. Out of the 12 storm periods including a total of 852 LIS flashes, 8 (4) were during the day (night) and 10 were between July and October.The number of flashes detected by LIS for one pass (about 2 minutes) above the study area ranges in a very wide interval, from 5 for a winter storm to 416 for a summer storm. The flash detection efficiency (DEf) for LIS was better during the night overpasses (the two larger DEf values, 85% and 77% of MTRG flashes detected by LIS, correspond with night periods). DEf for LIS strongly decreased when the storm is located at the edge of the ISS/LIS footprint. DEs for LIS is larger for lightning strokes with large peak currents, especially for positive strokes. Thus, 57% (43%) of MTRG positive (negative) strokes are detected by LIS and classified as groups. The best conditions for LIS detection correspond with storms that are strongly developed, both vertically and horizontally. Finally, the worst conditions for detection of lightning by LIS should be a small cell in development during the day and far from ISS/LIS nadir.